Environmental Impact Assessment (Final)

Project Number: 51274-001
October 2017

THA: Bangkok Mass Rapid Transit (Pink Line) (Part 2 of 5)

Prepared by The Mass Rapid Transit Authority of Thailand.

CHAPTER 3

PROJECT DESCRIPTION

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3.1 PHYSICAL ALIGNMENT

Pink Line Mass Rapid Transit Project, Khae Rai-Min Buri section, with 34.5 km in total length, has been defined as a minor mass transit system in the form of elevated straddle monorail. The alignment of Pink Line Mass Rapid Transit (MRT) Project starts on Rattanathibet Road in front of Nonthaburi Government Center where the Pink Line will connect to the Purple Line, Bang Yai-Bang Sue section. Then the Line turns left at Khae Rai intersection onto Tiwanon Road and goes along Tiwanon Road. It will pass Central Chest Institute of Thailand, Sanambin Nam intersection and Wat Chonlaprathanrangsarit until reaching Pak Kret intersection. The Line then turns right onto Chaeng Watthana Road, passing Impact Arena, Muang Thong Thani, the 2nd stage expressway (Si Rat), Bangkok Government Complex, and Laksi intersection where it will connect to the Red Line, Bang Sue-Rangsit section. The Pink Line crosses under Uttraphimuk Tollway (formerly Don Muang Tollway) and passes Phithak Ratthathammanun Monument Circle where another interchange station-Wat Phra Si Maha That station-is located. At this interchange, the Pink Line passengers can connect to the Dark Green Line, Mo Chit-Saphan Mai section, which was approved by the National Environment Board (NEB) on 31 October 2012. After that, the Line follows Ram Inthra Road, crosses over Chalong Rat expressway at Watcharaphon intersection, and runs further until Min Buri intersection. The route alignment continues toward Min Buri town along Sihaburanukit Road, goes across Khlong Sam Wa and then turns right to cross over Khlong Saen Saep, passing vacant land. The Line then turns onto Ramkhamhaeng Road (Sukhaphiban 3) and finally ends at Rom Klao intersection near Soi Ramkhamhaeng 192 where there is an interchange station linking to the Orange Line, Bang Kapi-Min Buri section. The project components include:

- 30 stations,
- 1 depot and park & ride building.

3.2 MONORAIL SYSTEM AND SERVICE

Monorail is a rubber-wheeled mass rapid transit running on a single beam and the car is wider than the beam. Monorail system was inaugurated in 1901 in Germany (Schwebebahn) and has been continuously developed ever since.

Monorail is a public rail transport system using rubber tires and running on a single beam with private right-of-way (PROW). It is one kind of light rail transit system, capable of carrying 10,000-40,000 passengers per hour per direction. Nowadays, some manufacturers have developed their technology and their monorails are capable of carrying up to 48,000 passengers per hour per direction. Car body and monorail track are small and light, enabling the construction to be expedited. The construction cost is relatively lower

than other comparable elevated conventional rail lines. Monorail systems are also quieter as rubber tires are used, creating less noise compared with other steel–wheeled trains running on steel rails. At present, there are two types of monorail: straddle monorail, as shown in ***Figure 3.2-1***, and suspension monorail, as presented in ***Figure 3.2-2***.

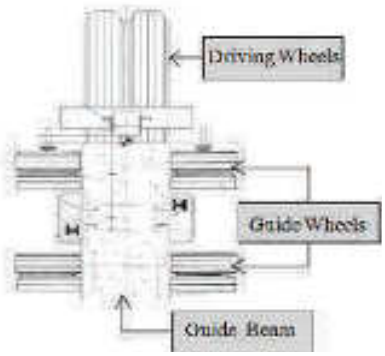
Figure 3.2-1 : Straddle Monorail

Figure 3.2-2 : Suspension Monorail

3.2.1 Straddle Monorail System

Straddle monorail has been developed from the Suspended Monorail. Its rubber wheels run on a 0.6-0.9 m–wide beam. The first type of straddle monorail ran on a concrete beam (Alweg type), but its modern versions run on an iron beam (Japanese type). It is suitable for urban areas and has a higher speed capability than Suspended Monorail. Currently, it is widely used in many countries, namely Japan (Tokyo Monorail with 10 stations and a total distance of 17.8 kilometers, Kitakyusyu Monorail with 13 stations and 8.8 kilometers in total distance, and Osaka Monorail with 18 stations and 28 kilometers in length); Malaysia (KL Monorail with 11 stations and 8.6 kilometers in total distance); China (Chongqing Monorail with 62 stations and 55.5 kilometers in total distance); Brazil (Sao Paulo with 17 stations and a total distance of 24 kilometers), etc.

3.2.2 General Characteristics of Monorail



Monorail is a single–beam, rubber-wheeled rail system that runs on a concrete or steel guideway. However, a concrete beam is generally used and its width is about one-fourth of the car width due to center-of-gravity concerns. The car has 2 wheel types: driving wheels on the guideway beam which supports the vehicle loads, and guide wheels which straddle both sides of the beam and run along the beam. The design

of guideway beam must be consistent with the car size, taking into account the difference in car size of each manufacturer.

Generally, monorail train is composed of motor-car (Mc) and passenger–car (M). A train set has between 2 and 8 cars depending on the passenger demand. ***Figure 3.2-3*** illustrates the various train formations.

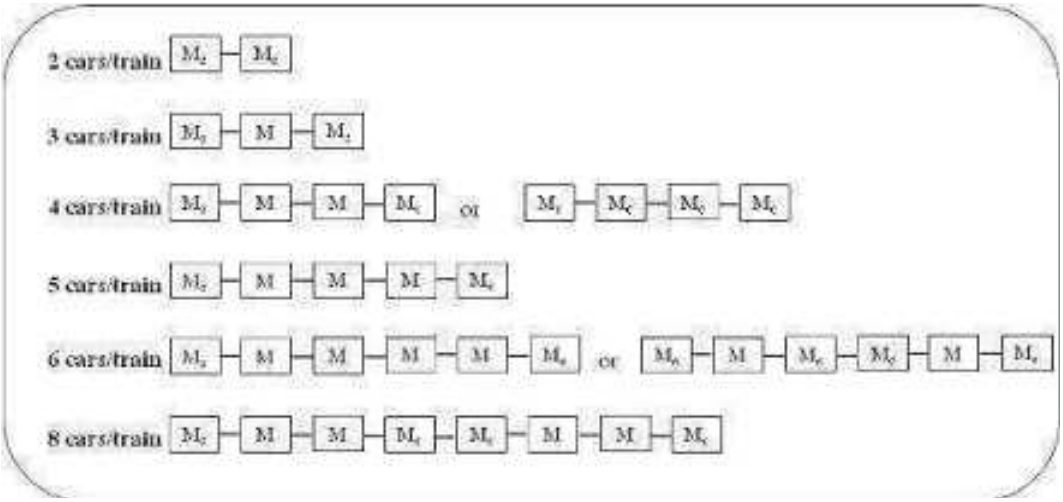


Figure 3.2-3 : Train Formation of Monorail System

3.2.3 Monorail Performance

Monorail system has a maximum design speed of 80 kilometers per hour and a maximum service speed of 70 kilometers per hour while the average speed is 35 kilometers per hour. The monorail's maximum gradient shall not exceed 6% and the minimum horizontal radius shall be not less than 45-70 meters (40 meters for the depot). Because of its rubber tires, the monorail's acceleration and deceleration rates are better than steel-tired systems. However, the comfort of passengers, particularly standees, must be considered as well.

3.2.4 Monorail Technical Information

Monorail has two-or four-axle bogies, driven by 750 Vdc and 1,500 Vdc traction power supplied from the power rail system.

3.2.5 Monorail Track Beam

The monorail track beam is normally I-beam placed upon the pier with a span length of about 20-30 meters. The column is on the pile cap, with a diameter of 1.5-1.8 meters, or Barette pile. The horizontal clearance from the track centerline to the support column should be about 3.70 meters in the straight line section while the clearance should increase in the curve line section.

3.2.6 Monorail Capacity

The monorail capacity depends on the number of cars per trainset and frequency. A monorail car can serve 16-26 seated passengers and has 17-29.6 m^2 of standing area, thus carrying a total of 122-200 passengers per car (at a standing passenger density of 6 pp/m^2).

As Pink Line MRT System, Min Buri-Khae Rai section, will serve urban areas throughout its total length of 34.5 kilometers, monorail is ideal for urban transit services. Nowadays, there are a broad range of straddle monorail manufacturers, with carrying capacity ranging from 3,000 to 30,000 passengers per hour per direction (pphpd).

When considering the forecast of medium-high ridership level, the Pink Line requires a large-type monorail system with a passenger load capacity of over 30,000 pphpd. At present, there are three manufacturers offering large straddle monorail system with a proven track record widely recognized in many countries, namely Hitachi Ltd., Scomi Group Bhd, and Bombardier Incorporation. The characteristics of large-type straddle monorail are summarized in ***Table 3.2-1***.

3.2.7 System Safety

Monorail runs on a grade-separated guideway beam, thus eliminating the potential of collisions with other public transport vehicles. Moreover, the design of monorail system also ensures that derailment is impossible. For these reasons, the monorail is a highly safe system.

Tokyo Monorail is the first monorail system in Japan, constructed in 1964, to link Haneda Airport with downtown Tokyo with a total length of 17.8 kilometers. Like other monorails in Japan, it has no accident record since commencement of operation. It is therefore a safe mass rapid transit, comparable to other mass transit systems.

3.2.8 Safety in Emergency Case

(1) Fire Protection System

Monorail cars are made of non-flammable materials. If fire is detected, trains will automatically and immediately stop at the station, and in case of fire on running train, the train will stop at the next station. Since the average distance between stations is about 1 km and the running speed is 30 km/h, the train can reach the nearest station within 2 minutes after a fire occurrence. For 48 years (since 1966) from commencement of operation, there is no fire accident record with the Japanese monorail system.

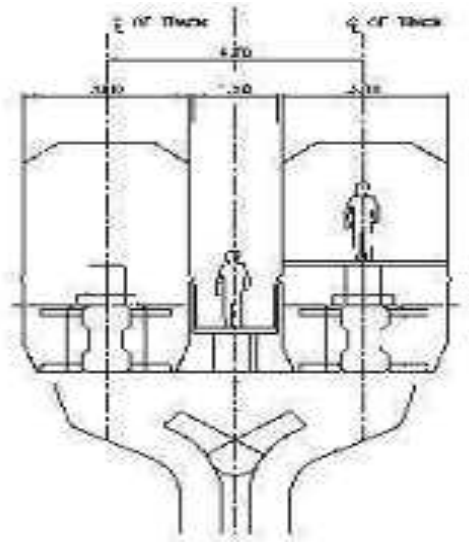
(2) Passenger Evacuation

The track beam of monorail cannot be used for passenger evacuation. To reduce the weakness of monorail system, various evacuation methods have been developed as described below.

Table 3.2-1 Summary of Large-Type Straddle Monorail Characteristics of 3 Manufacturers

	Hitachi	Scomi	Bombardier
			
Size			
Motor Car Length (m.)	15.10	10.4	13.03
Middle Car Length (m.)	13.80	9.50	11.84
Coupler (m.)	0.70	1.30	0.36
Width (m.)	2.98	3.00	3.14
Height (m.)	5.20	4.30	3.40
Door Width (m.)	1.27	1.50	1.63
Door Height (m.)	2.03	1.90	1.93
Max. Gross Axle Load (t.)	11	10	10
Tare Weight of Car (Metric ton)	11	10	
Performance			
Min. Curve Radius (m.)	70 (40 depot)	50 (40 depot)	45
Max. Gradient (%)	6	6	10
Max. Design Speed (km/hr)	90	90	85
Max. Operate Speed (km/hr)	80	80	75
Normal Accel. Rates (m/s^2)	0.97	1.1	1.0
Normal Decel. Rates (m/s^2)	1.1	1.1	1.0
Emerg. Decel. Rates (m/s^2)	1.25	1.3	1.3
Technical			
Bogie Placement	Under Center Seat	Under Center Seat	End of Cars
Axles per Car	4	2	2
Power (VDC)	750/1500	750/1500	750/1500
Walk through	Yes	Yes	Yes
Structure			
Guideway beam width (m.)	0.85	0.80	0.66
Guideway beam height (m.)	1.50	1.6 (mid)/ 2.2 (end arch)	1.5 (mid)/ 2.1 (end arch)
Crosshead width (m.)	5.15	5.10	5.10
Typical Column Base (m. × m.)		1.2 × 1.6	0.81 × 1.42
Span Length (m.)	25	30	30
Capacity			
Motor Car-Seat (seat)	26	22	16
Middle Car-Seat (seat)	24	20	16
Motor Car-Standing Space (m^2)	29.00	17.00	18.58
Middle Car-Standing Space (m^2)	29.68	17.00	18.58
Train-Capacity @ 4 cars-train; 4 pp/m^2 (pp)	569	356	361
Train-Capacity @ 4 cars-train; 6 pp/m^2 (pp)	804	492	509
Train-Capacity @ 4 cars-train; 7 pp/m^2 (pp)	921	560	584
Ave. capacity per car (pp)	178	123	127

- **Emergency Walkway**



An emergency walkway will be installed on a track side or between two track beams, with guard rails between tracks and walkway. In case of an emergency, passengers will be evacuated via this emergency walkway and then walk to the nearest station, as depicted in ***Figure 3.2-4***.

- **Train to Train Evacuation**

An evacuation train may run from the same or in opposite direction to the train in trouble.

- **Train to Ground Evacuation**

Passengers may be evacuated from train to ground by using crane truck, rope, or spiral chute.

Figure 3.2-4 : Emergency Walkway

3.3 STATION DESIGN AND STANDARD

3.3.1 Station Design Concept

The station design shall be consistent with MRT operation system. Design considerations include interconnection with both present and future mass rapid transit systems, convenient and safe access to and egress from station for passengers as well as station entrance-exit facilities. This will facilitate passengers' travel to their destinations.

The design of station elements is in compliance with NFPA 130: Standard for Fixed Guideway Transit and Passenger Rail Systems regarding fire prevention, NFPA 101: Life Safety Code regarding passenger evacuation, and Thailand's relevant ministerial regulations.

The Pink Line is an elevated monorail system, with an average distance between stations of approximately 1,200 meters, which will offer traffic convenience to residents along Tiwanon, Chaeng Watthana and Ram Inthra roads until Min Buri intersection. At present, traffic congestions are quite prominent in those areas. Consequently, the locations of Pink Line stations were determined, taking into account densely-populated areas with high travel demand. ***Table 3.3-1*** presents the distance between stations.

With the adjustment of the originally-planned station locations and an increase in the number of stations, the Consultant conducted field surveys of environmentally sensitive areas within a radius of 500 meters from the centerline of project route, with details given in ***Table 3.3-2***.

Land use survey was carried out within a 500-m radius from the centerline of project alignment of Pink Line MRT Project, Khae Rai-Min Buri section, at the sites of 30 stations, depot and park & ride building at Romklao intersection. The total distance is 34.5 kilometers. Field surveys were conducted in July 2013, with the results summarized as follows:

Table 3.3-1 Distance between the Pink Line Stations

From	To	Distance between Stations (m)
PK01 Nonthaburi Government Center station (CH.0+224.208)	PK02 Khae Rai station	1,080.3
PK02 Khae Rai station (CH.1+304.521)	PK03 Sanambin Nam station	1,360.6
PK03 Sanambin Nam station (CH.2+665.140)	PK04 Samakkhi station	1,787.6
PK04 Samakkhi station (CH.4+452.705)	PK05 Royal Irrigation Department station	945.0
PK05 Royal Irrigation Department station (CH.5+397.665)	PK06 Pak Kret station	1,054.1
PK06 Pak Kret station (CH.6+451.742)	PK07 Pak Kret Bypass station	1,156.7
PK07 Pak Kret Bypass station (CH.7+608.439)	PK08 Chaeng Watthana-Pak Kret 28 station	1,515.2
PK08 Chaeng Watthana-Pak Kret 28 station (CH.9+123.692)	PK09 Muang Thong Thani station	1,227.5
PK09 Muang Thong Thani station (CH.10+351.182)	PK10 Si Rat station	1,091.1
PK10 Si Rat station (CH.11+442.308)	PK11 Chaeng Watthana 14 station	1,358.2
PK11 Chaeng Watthana 14 station (CH.12+800.522)	PK12 Bangkok Government Complex station	829.5
PK12 Bangkok Government Complex station (CH.13+630.034)	PK13 TOT station	973.1
PK13 TOT station (CH.14+603.126)	PK14 Lak Si station	834.4
PK14 Lak Si station (CH.15+437.534)	PK15 Phranakhon Rajabhat University station	865.7
PK15 Phranakhon Rajabhat University station (CH.16+303.281)	PK16 Wat Phra Si Maha That station	1,042.0
PK16 Wat Phra Si Maha That station (CH.17+345.333)	PK17 Ram Inthra 3 station	719.2
PK17 Ram Inthra 3 station (CH.18+064.570)	PK18 Lat Pla Khao station	1,889.4
PK18 Lat Pla Khao station (CH.19+953.984)	PK19 Ram Inthra 31 station	1,026.7
PK19 Ram Inthra 31 station (CH.20+980.659)	PK20 Maiyalap station	753.8
PK20 Maiyalap station (CH.21+734.420)	PK21 Watcharaphon station	1,316.4
PK21 Watcharaphon station (CH.23+050.775)	PK22 Ram Inthra 40 station	923.7
PK22 Ram Inthra 40 station (CH.23+974.485)	PK23 Khu Bon station	1,043.4
PK23 Khu Bon station (CH.25+017.884)	PK24 Ram Inthra 83 station	1,206.0
PK24 Ram Inthra 83 station (CH.26+223.932)	PK25 East Outer Ring Road station	1,454.5
PK25 East Outer Ring Road station (CH.27+678.432)	PK26 Nopparat Rajathanee station	1,618.4
PK26 Nopparat Rajathanee station (CH.29+296.837)	PK27 Bang Chan station	1,683.2
PK27 Bang Chan station (CH.30+980.047)	PK28 Setthabutbamphen station	1,049.3
PK28 Setthabutbamphen station (CH.32+029.353)	PK29 Min Buri Market station	1,429.3
PK29 Min Buri Market station (CH.33+458.617)	PK30 Min Buri station (CH.34+348.266)	889.6

Table 3.3-2 Environmentally Sensitive Areas in 500-m Radius from the Centerline of Project Alignment

No.	Environmentally Sensitive Areas	Address	Station	Distance from the Project Alignment	
				m	ft
1	Nonthaburi Government Center	Rattanathibet Road, Bang Kraso subdistrict, Muang district, Nonthaburi	PK01 Nonthaburi Government Center station	361	1184
2	NBTC Area 1 Nonthaburi	Rattanathibet Road, Bang Kraso subdistrict, Muang district, Nonthaburi		67	220
3	Siam Business Administration Nonthaburi Technological College	Rattanathibet Road, Bang Kraso subdistrict, Muang district, Nonthaburi		98	321
4	Boromarajanani College of Nursing	Tiwanon Road, Talat Khwan sub-district, Muang district, Nonthaburi		57	187
5	Central Chest Institute of Thailand	Tiwanon Road, Talat Khwan sub-district, Muang district, Nonthaburi		127	417
6	Nonthaburi Phitthayakhom School	Tiwanon Road, Tha Sai subdistrict, Muang district, Nonthaburi	PK02 Khae Rai station	323	1059
7	Santiwan School, Nonthaburi	Tiwanon Road, Bang Kraso subdistrict, Muang district, Nonthaburi		55	180
8	Ban Samrit Health Promoting Hospital, Tha Sai subdistrict	Tiwanon Road, Tha Sai subdistrict, Muang district, Nonthaburi		465	1525
9	Central Preventorium for Children, Nonthaburi	Tiwanon Road, Bang Kraso subdistrict, Muang district, Nonthaburi		77	253
10	Than Samrit Witthaya School	Tiwanon Road, Tha Sai subdistrict, Muang district, Nonthaburi		352	1155
11	Quartermaster Department, Royal Thai Army	Tiwanon Road, Muang district, Nonthaburi	PK03 Sanambin Nam station	264	866
12	Saman Phichakon School	Tiwanon Road, Tha Sai subdistrict, Muang district, Nonthaburi		79	259
13	Masjid Darulmuttakeen	Tiwanon Road, Tha Sai subdistrict, Muang district, Nonthaburi		57	187
14	Chonprathansongkhro School	Tiwanon Road, Bang Talat subdistrict, Pak Kret district, Nonthaburi	PK04 Samakkhi station	145	476
15	Royal Irrigation Department	Tiwanon Road, Bang Talat subdistrict, Pak Kret district, Nonthaburi		249	817
16	Chonprathanwittaya School	Tiwanon Road, Bang Talat subdistrict, Pak Kret district, Nonthaburi	PK05 Royal Irrigation Department station	236	774
17	Wat Chonlaprathanrangsarit	Tiwanon Road, Bang Talat subdistrict, Pak Kret district, Nonthaburi		246	807
18	Watthana Phrueksa Kindergarten	Pak Kret subdistrict, Pak Kret district, Nonthaburi		470	1542
19	Watthana Phrueksa School	Pak Kret subdistrict, Pak Kret district, Nonthaburi		456	1496
20	Suankularb Wittayalai Nonthaburi School	Tiwanon Road, Pak Kret subdistrict, Pak Kret district, Nonthaburi	PK06 Pak Kret station	387	1269
21	Church of Jesus Christ	Pak Kret subdistrict, Pak Kret district, Nonthaburi	PK07 Pak Kret Bypass station	71	233
22	The World Medical Center	Chaeng Watthana Road, Pak Kret subdistrict, Pak Kret district, Nonthaburi		87	285
23	The Royal Thai Police Band	Chaeng Watthana Road, Pak Kret subdistrict, Pak Kret district, Nonthaburi		165	541
24	Tambon Bang Talat Health Promoting Hospital	Chaeng Watthana Road, Bang Talat subdistrict, Pak Kret district, Nonthaburi		334	1096
25	Ministry of Justice	Chaeng Watthana Road, Bang Talat subdistrict, Pak Kret district, Nonthaburi		126	413
26	Panyapiwat Institute of Management	Chaeng Watthana Road, Bang Talat subdistrict, Pak Kret district, Nonthaburi	PK08 Chaeng Watthana-Pak Kret 28 station	133	436
27	Khlong Kluea School	Chaeng Watthana Road, Khlong Kluea subdistrict, Pak Kret district, Nonthaburi	PK09 Muang Thong Thani station	63	207
28	Mongkutwattana General Hospital	Chaeng Watthana Road, Thung Song Hong subdistrict, Lak Si district, Bangkok	PK11 Chaeng Watthana 14 station	145	476
29	Department of Consular Affairs	Chaeng Watthana Road, Lak Si district, Bangkok	PK12 Bangkok Government Complex station	211	692
30	1st Antiaircraft Artillery Regiment	Chaeng Watthana Road, Thung Song Hong subdistrict, Lak Si district, Bangkok		296	971
31	The Administrative Court	Chaeng Watthana Road, Thung Song Hong subdistrict, Lak Si district, Bangkok		85	279
32	Department of Juvenile Observation and Protection, Bangkok	Chaeng Watthana Road, Thung Song Hong subdistrict, Lak Si district, Bangkok		51	167
33	Government Complex Commemorating His Majesty the King's 80th Birthday Anniversary	Chaeng Watthana Road, Thung Song Hong subdistrict, Lak Si district, Bangkok		281	922

Table 3.3-2 (Cont'd)

No.	Environmentally Sensitive Areas	Address	Station	Distance from the Project Alignment	
				m	ft
34	Lak Si District Office	Chaeng Watthana Road, Bang Khen subdistrict, Lak Si district, Bangkok	PK13 TOT station	130	426
35	Chulabhorn Research Institute	Vibhavadi-Rangsit Road, Lak Si district, Bangkok		363	1191
36	Wat Lak Si	Vibhavadi-Rangsit Road, Talat Bang Khen subdistrict, Lak Si district, Bangkok		385	1263
37	Wat Lak Si School	Vibhavadi-Rangsit Road, Talat Bang Khen subdistrict, Lak Si district, Bangkok		502	1647
38	Rattanakosin Technological College	Chaeng Watthana Road, Lak Si district, Bangkok	PK14 Lak Si station	196	643
39	Charoenphon Witthaya School	Chaeng Watthana Road, Talat Bang Khen subdistrict, Don Muang district, Bangkok		49	161
40	Phranakhon Rajabhat University	Chaeng Watthana Road, Anusaowari subdistrict, Bang Khen district, Bangkok	PK15 Phranakhon Rajabhat University station	189	620
41	Wat Phra Si Maha That Demonstration Secondary School	Chaeng Watthana Road, Anusaowari subdistrict, Bang Khen district, Bangkok		76	249
42	Wat Phra Si Maha That	Chaeng Watthana Road, Anusaowari subdistrict, Bang Khen district, Bangkok		461	1512
43	College of Buddhist Studies and Philosophy	Chaeng Watthana Road, Anusaowari subdistrict, Bang Khen district, Bangkok		71	233
44	Thainiyomsongkroa School	Chaeng Watthana Road, Anusaowari subdistrict, Bang Khen district, Bangkok		326	1069
45	Bang Khen District Office	Phahonyothin Road, Anusaowari subdistrict, Bang Khen district, Bangkok		94	308
46	Prachapiban School	Phahonyothin Road, Anusaowari subdistrict, Bang Khen district, Bangkok	PK16 Wat Phra Si Maha That station	106	348
47	Office of Disease Prevention and Control 1, Bangkok	Phahonyothin Road, Anusaowari subdistrict, Bang Khen district, Bangkok		197	646
48	Krirk University	Ram Inthra Road, Anusaowari subdistrict, Bang Khen district, Bangkok		72	236
49	2nd Infantry Battalion	Ram Inthra Road, Anusaowari subdistrict, Bang Khen district, Bangkok	PK17 Ram Inthra 3 station	245	804
50	Pramot Witthaya Ram Inthra School	Ram Inthra Road, Anusaowari subdistrict, Bang Khen district, Bangkok		85	279
51	Iamphanit Witthaya School	Ram Inthra Road, Anusaowari subdistrict, Bang Khen district, Bangkok		237	777
52	Thai Police Aviation Division	Ram Inthra Road, Km.5, Tha Raeng subdistrict, Bang Khen district, Bangkok	PK20 Maiyalap station	332	1089
53	Ramborirug Ram Inthra School	Ram Inthra Road, Km.5, Tha Raeng subdistrict, Bang Khen district, Bangkok		434	1424
54	Association of Army Welfare Development Village	Ram Inthra Road, Tha Raeng subdistrict, Bang Khen district, Bangkok		268	879
55	Bureau of Personnel Competency Development, Office of the Vocational Education Commission	Ram Inthra Road, Tha Raeng subdistrict, Bang Khen district, Bangkok		82	269
56	Pramot Phatthana Kindergarten	Ram Inthra Road, Tha Raeng subdistrict, Bang Khen district, Bangkok	PK21 Watcharaphon station	203	666
57	Saiaksorn School	Ram Inthra Road, Khlong Kum subdistrict, Bueng Kum district, Bangkok		63	207
58	Chao Mae Suea Shrine	Ram Inthra Road, Khan Na Yao subdistrict, Khan Na Yao district, Bangkok	PK22 Ram Inthra 40 station	28	92
59	Chatr Wittaya School	Ram Inthra Road, Khan Na Yao subdistrict, Khan Na Yao district, Bangkok		108	354
60	Masjid Al-Aokof School	Ram Inthra Road, Khan Na Yao subdistrict, Khan Na Yao district, Bangkok		370	1214
61	Masjid Al-Aokof	Ram Inthra Road, Khan Na Yao subdistrict, Khan Na Yao district, Bangkok		353	1158
62	Synphaet General Hospital	Ram Inthra Road, Khan Na Yao subdistrict, Khan Na Yao district, Bangkok	PK23 Khu Bon station	76	249
63	Nopparat Rajathanee Hospital	Ram Inthra Road, Khan Na Yao subdistrict, Khan Na Yao district, Bangkok	PK25 East Outer Ring Road station	283	928
64	Taksina Business Administration and Technological College	Ram Inthra Road, Khan Na Yao subdistrict, Khan Na Yao district, Bangkok	PK26 Nopparat Rajathanee station	77	253
65	Setthabutbamphen School	Ram Inthra Road, Min Buri subdistrict, Min Buri district, Bangkok	PK28 Setthabutbamphen station	134	440
66	Seriruk Hospital	Serithai Road, Min Buri subdistrict, Min Buri district, Bangkok		185	607

Table 3.3-2 (Cont'd)

No.	Environmentally Sensitive Areas	Address	Station	Distance from the Project Alignment	
				m	ft
67	Navaminthra Hospital	Sihaburanukit Road, Min Buri subdistrict, Min Buri district, Bangkok		204	669
68	Minburi Technical College	Sihaburanukit Road, Min Buri subdistrict, Min Buri district, Bangkok		152	499
69	Navamin 9 Hospital	Sihaburanukit Road, Min Buri subdistrict, Min Buri district, Bangkok		104	341
70	Min Buri Business School	Sihaburanukit Road, Min Buri subdistrict, Min Buri district, Bangkok		507	1663
71	Suknet School	Sihaburanukit Road, Min Buri subdistrict, Min Buri district, Bangkok		100	328
72	Min Buri Sueksa School	Sihaburanukit Road, Min Buri subdistrict, Min Buri district, Bangkok		232	761
73	Health Center 43, Min Buri	Sihaburanukit Road, Min Buri subdistrict, Min Buri district, Bangkok	PK29 Min Buri Market station	218	715
74	Min Buri District Office	Sihaburanukit Road, Min Buri subdistrict, Min Buri district, Bangkok		367	1204
75	Min Buri Remand Prison	Suwinthawong Road, Min Buri subdistrict, Min Buri district, Bangkok		495	1624
76	Office of Min Buri Public Prosecution	Sihaburanukit Road, Min Buri subdistrict, Min Buri district, Bangkok	PK29 Min Buri Market station (cont'd)	133	436
77	Minburi School	Min Buri subdistrict, Min Buri district, Bangkok		210	689
78	Satri Setthabutbamphen School	Min Buri subdistrict, Min Buri district, Bangkok		435	1427
79	Min Prasat Witthaya School	Ramkhamhaeng Road, Min Buri subdistrict, Min Buri district, Bangkok		288	945
80	Kasem Bundit University, Romklao Campus	Rom Klao Road, Min Buri subdistrict, Min Buri district, Bangkok	PK30 Min Buri station	720	2362

Land use within a 500-m radius mainly consists of urban and built-up areas as the project alignment is located in urban areas. Land use types comprise about 18,848.14 rai of urban land or 79.24% of the study areas, followed by 4,746.26 rai of other land use types or 19.94%, and 196.26 rai of agricultural land which is equivalent to 0.82%. The details of land use types are presented in ***Figure 3.3-1*** and ***Table 3.3-3*****.**

Table 3.3-3 Land Use within 500-m Radius in the Project Study Areas

Land Use	Symbol	Study Areas		
		Sq.km.	rai	%
Urban and Built-Up Areas				
Commercial areas	U1	5.51	3,441.25	14.47
Residential areas	U2	16.37	10,231.25	43.01
Government/state enterprise areas	U3	5.06	3,160.63	13.29
Educational institutes	U4	0.90	563.75	2.38
Religious/archaeological and historical places	U5	0.41	255.63	1.07
Medical facilities	U6	0.31	196.25	0.82
Industrial plants	U7	1.17	733.13	3.08
Public parks/golf driving ranges/sports ground/ amusement parks	U8	0.41	256.25	1.08
Abandoned factories	U9	0.02	10.00	0.04
Total	-	30.16	18,848.14	79.24
Agricultural Lands				
Paddy fields	A1	0.17	105.63	0.44
Grass farms	A2	0.08	52.50	0.22
Mixed fruit orchards	A4	0.01	8.13	0.03
Vegetable gardens	A5	0.04	22.50	0.10
Fish ponds	A6	0.01	7.50	0.03
Total	-	0.31	196.26	0.82
Other Land Uses				
Abandoned land	M1	5.50	3,438.13	14.45
Water sources	W1	0.37	229.38	0.96
Roadways	-	1.73	1,078.75	4.53
Total	-	7.59	4,746.6	19.94
Grand Total	-	38.07	23,790.66	100.00

Source: TEAM Consulting Engineering and Management Co., Ltd., July 2013

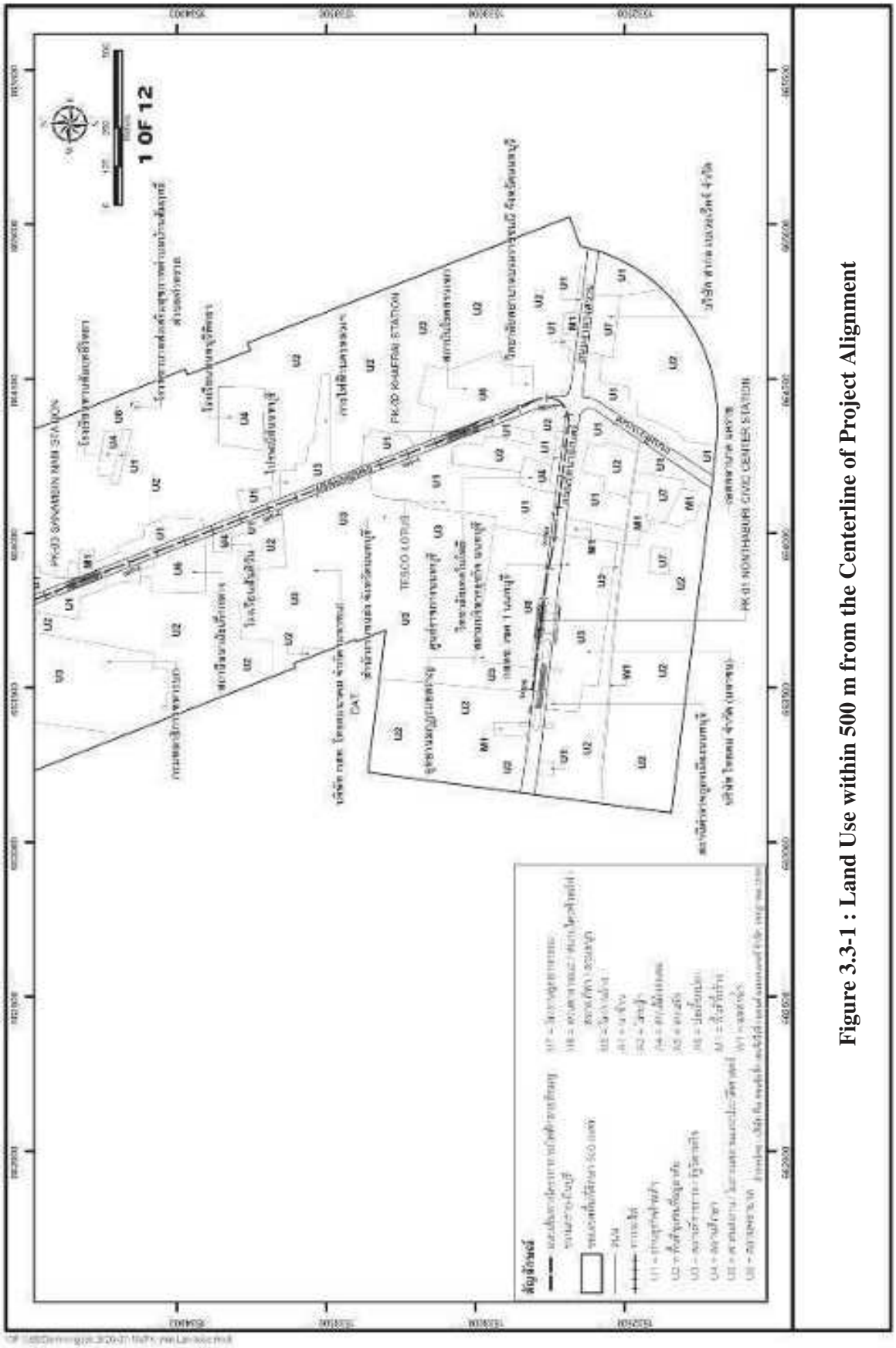


Figure 3.3-1 : Land Use within 500 m from the Centerline of Project Alignment

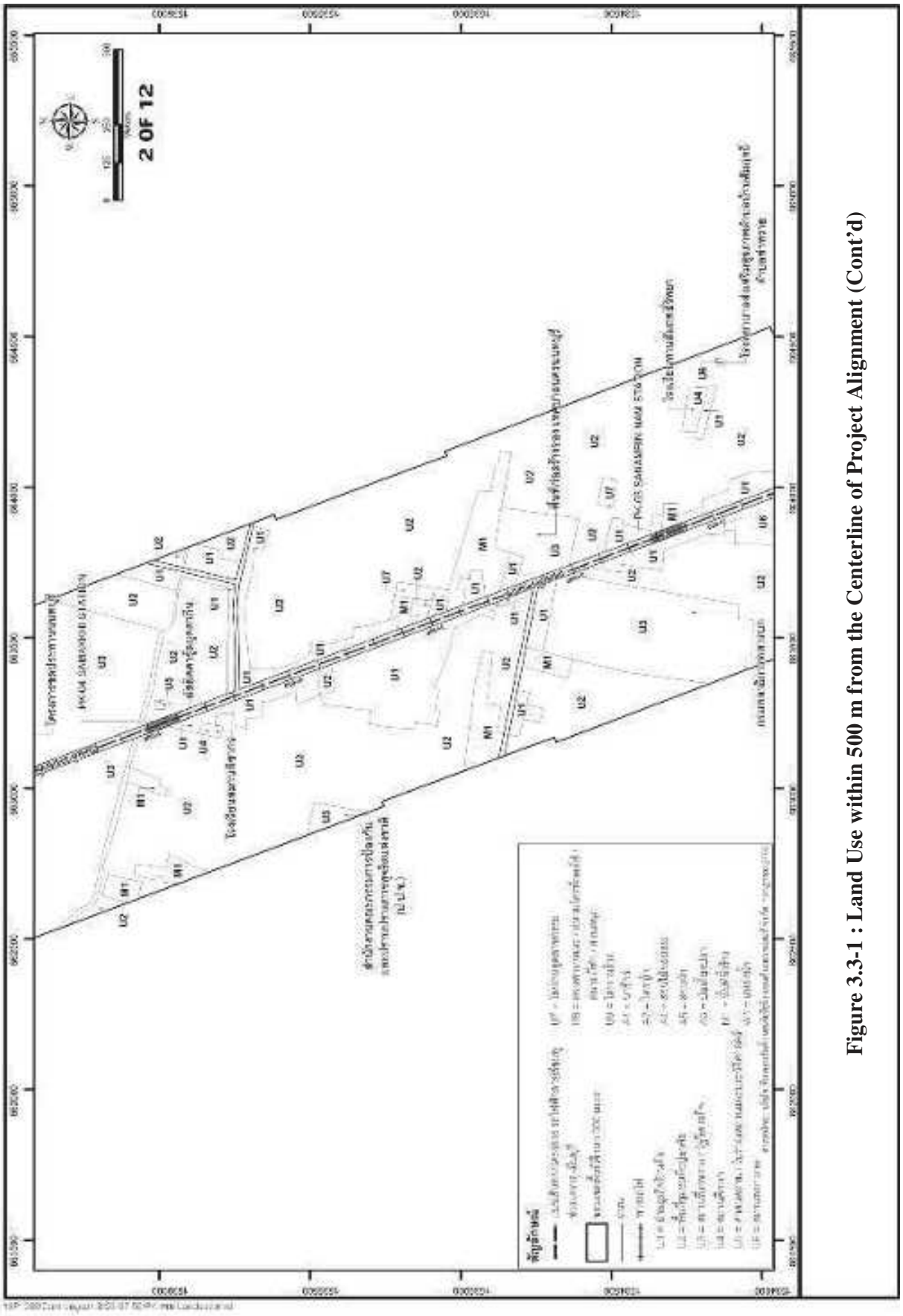


Figure 3.3-1 : Land Use within 500 m from the Centerline of Project Alignment (Cont'd)

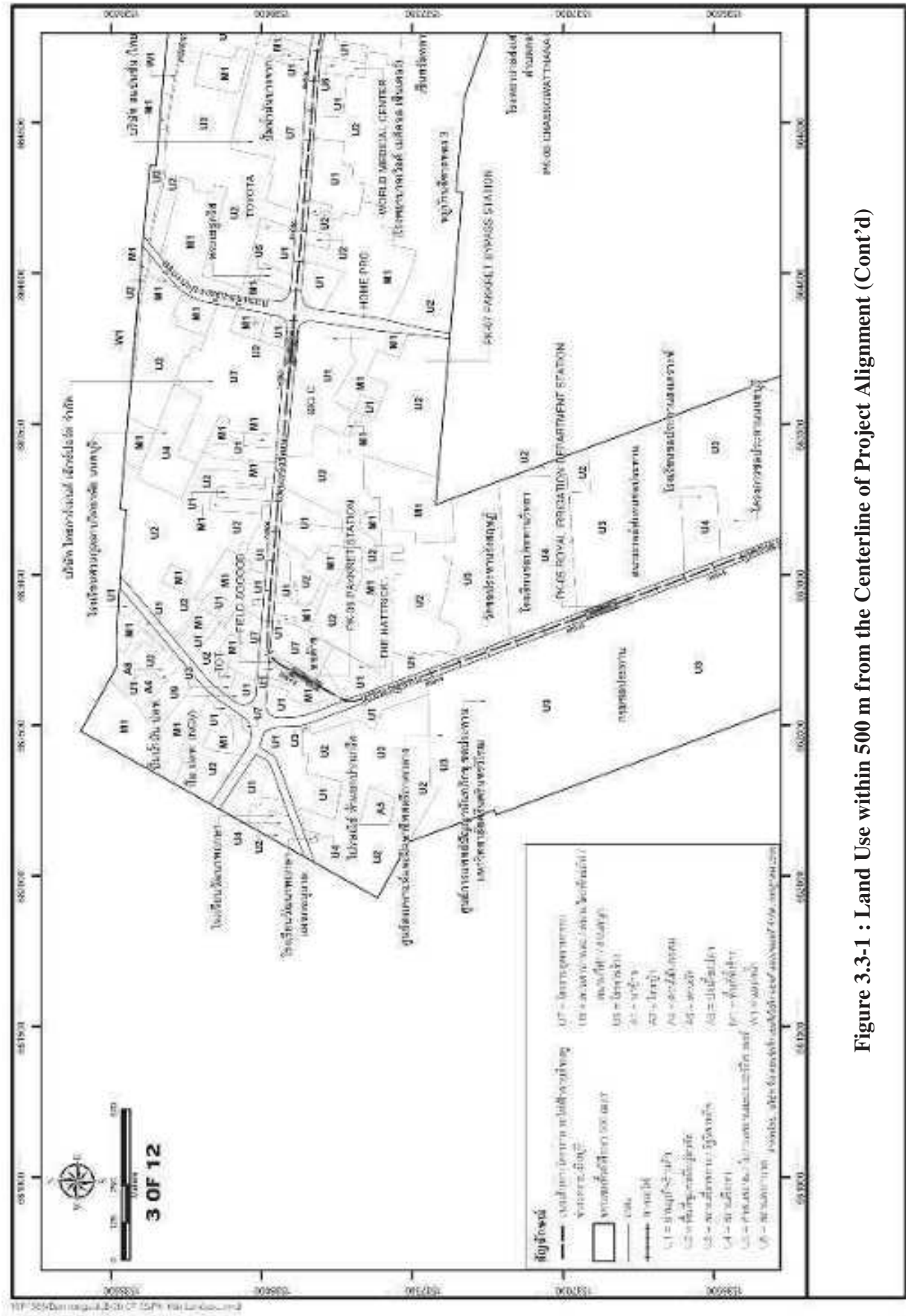


Figure 3.3-1 : Land Use within 500 m from the Centerline of Project Alignment (Cont'd)

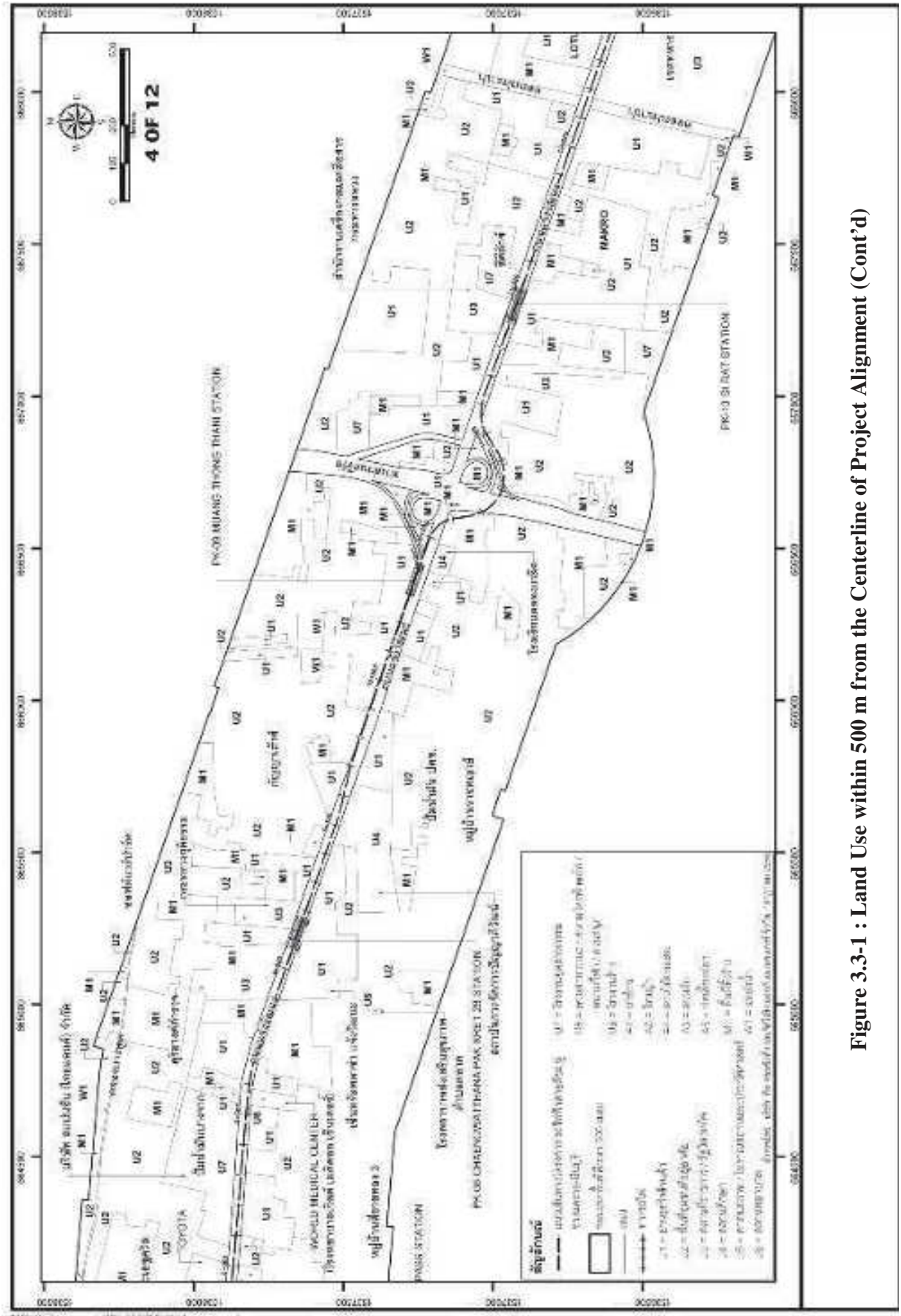


Figure 3.3-1 : Land Use within 500 m from the Centerline of Project Alignment (Cont'd)

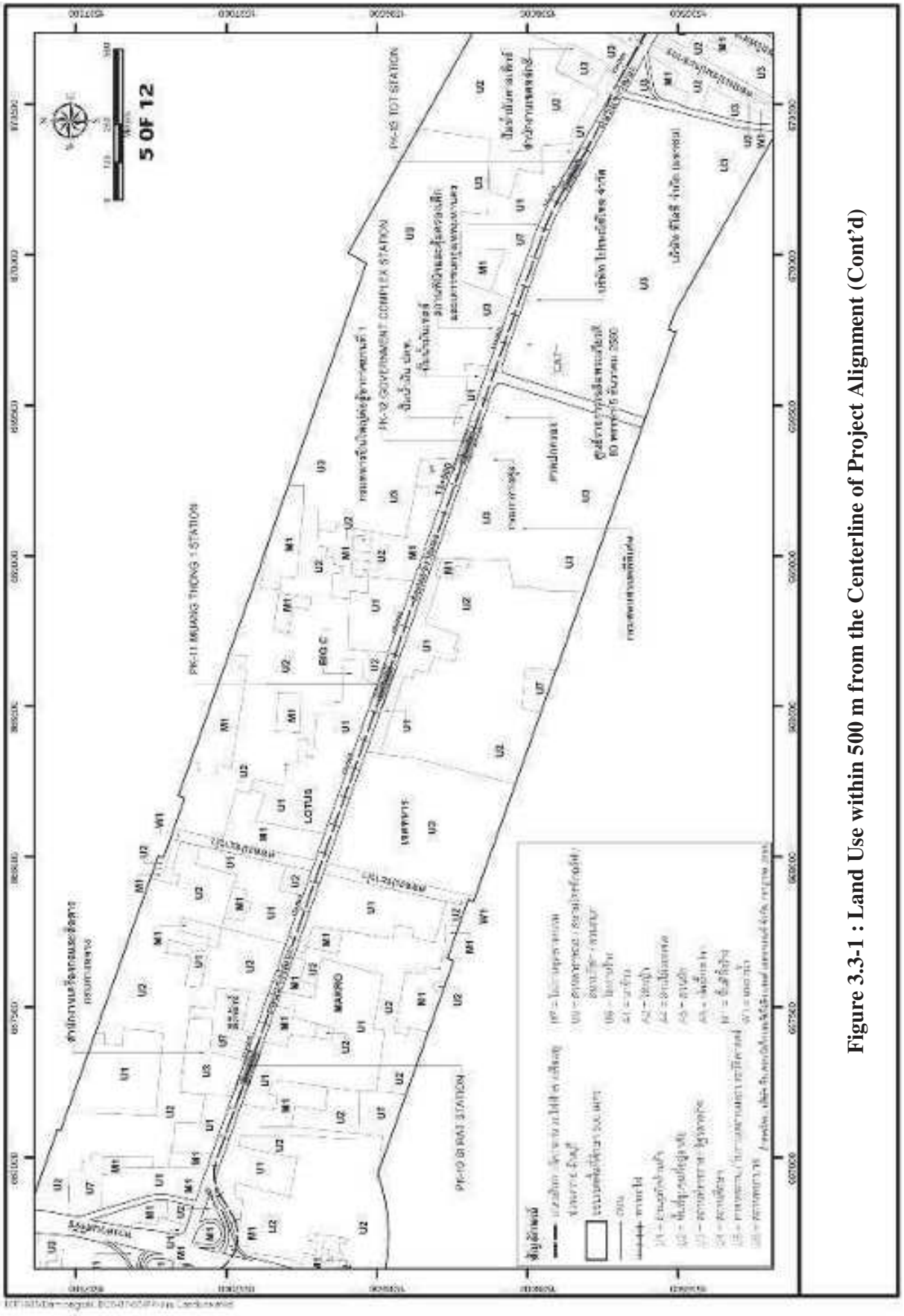


Figure 3.3-1 : Land Use within 500 m from the Centerline of Project Alignment (Cont'd)

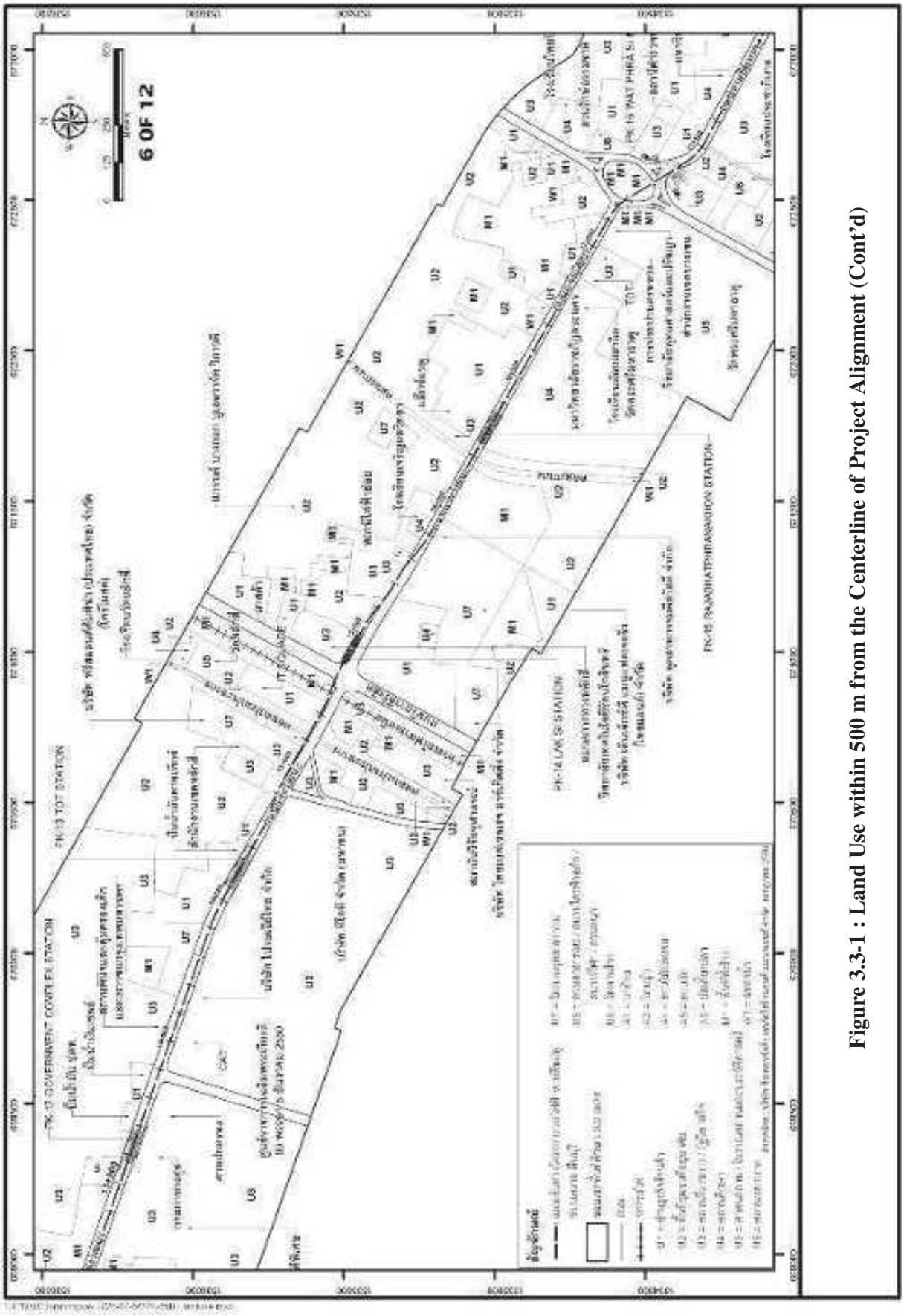


Figure 3.3-1 : Land Use within 500 m from the Centerline of Project Alignment (Cont'd)

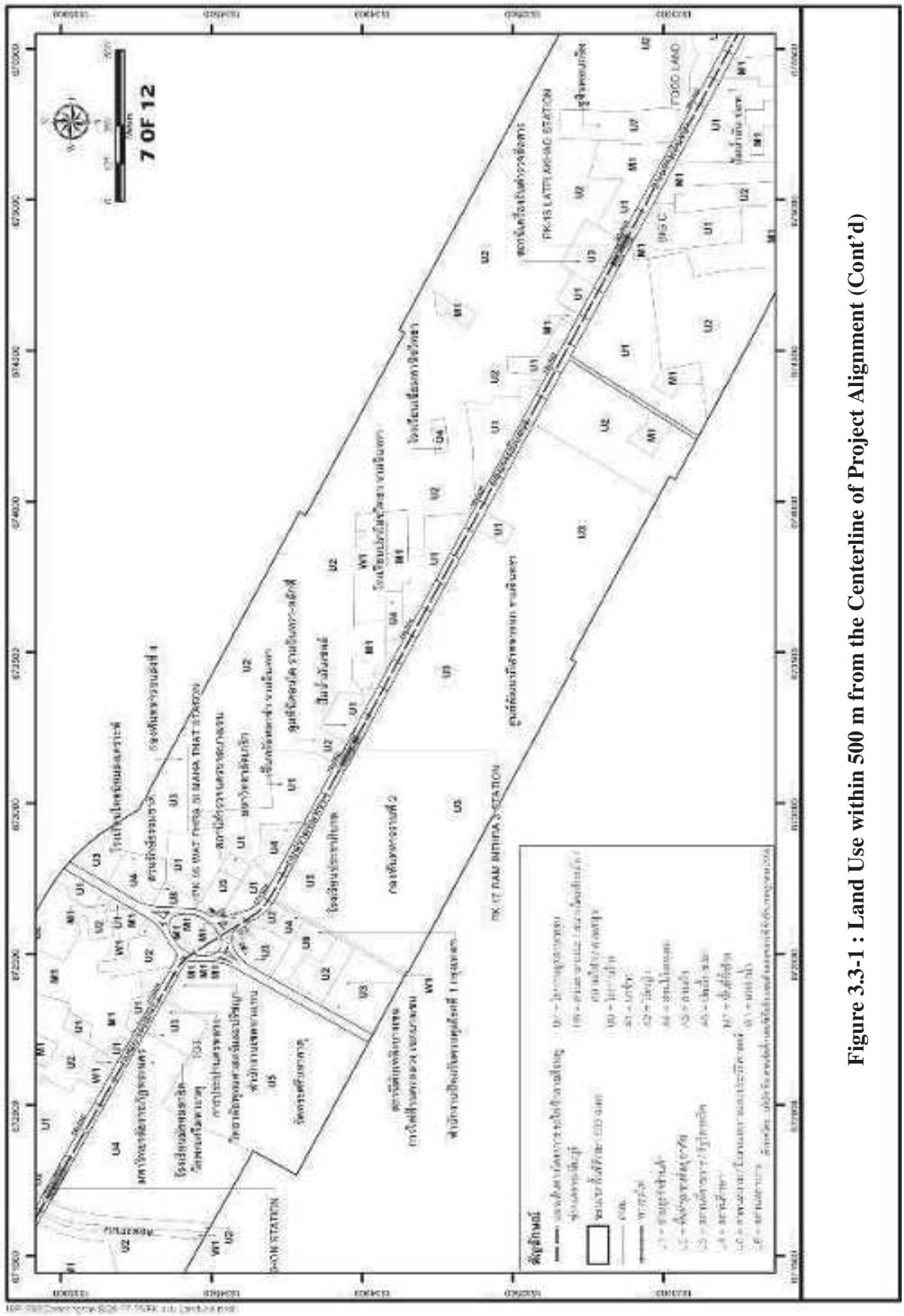


Figure 3.3-1 : Land Use within 500 m from the Centerline of Project Alignment (Cont'd)

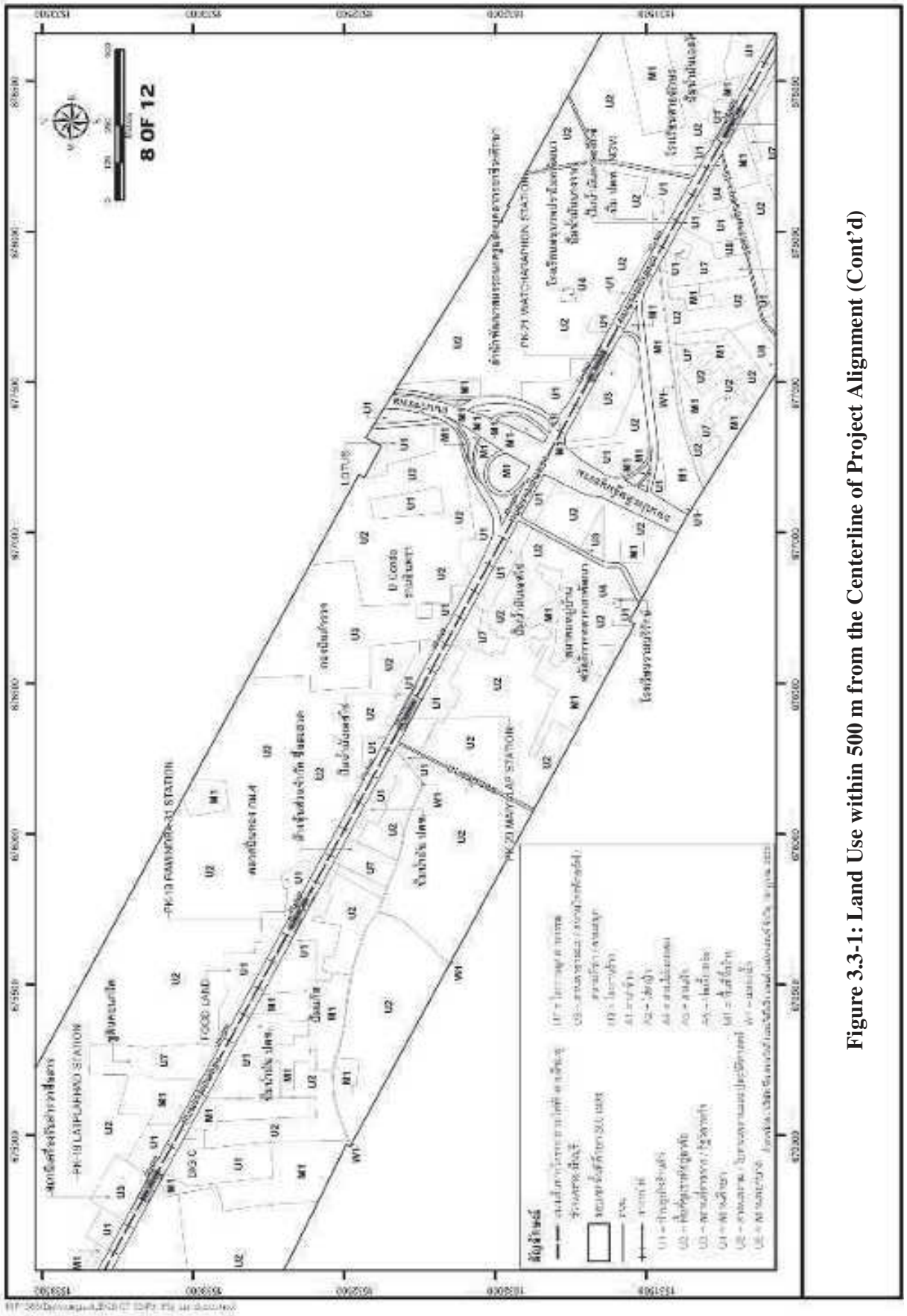


Figure 3.3-1: Land Use within 500 m from the Centerline of Project Alignment (Cont'd)

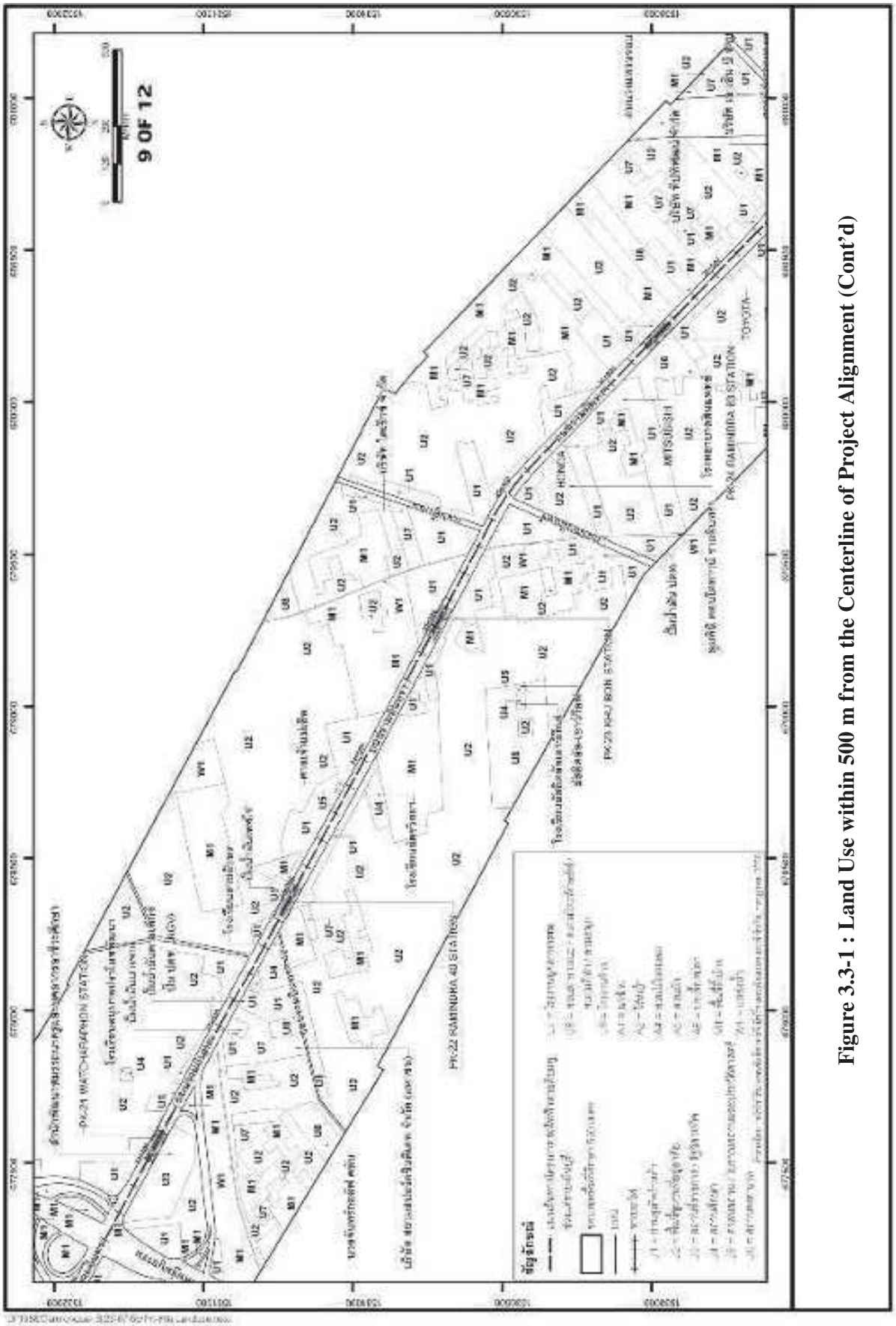


Figure 3.3-1 : Land Use within 500 m from the Centerline of Project Alignment (Cont'd)

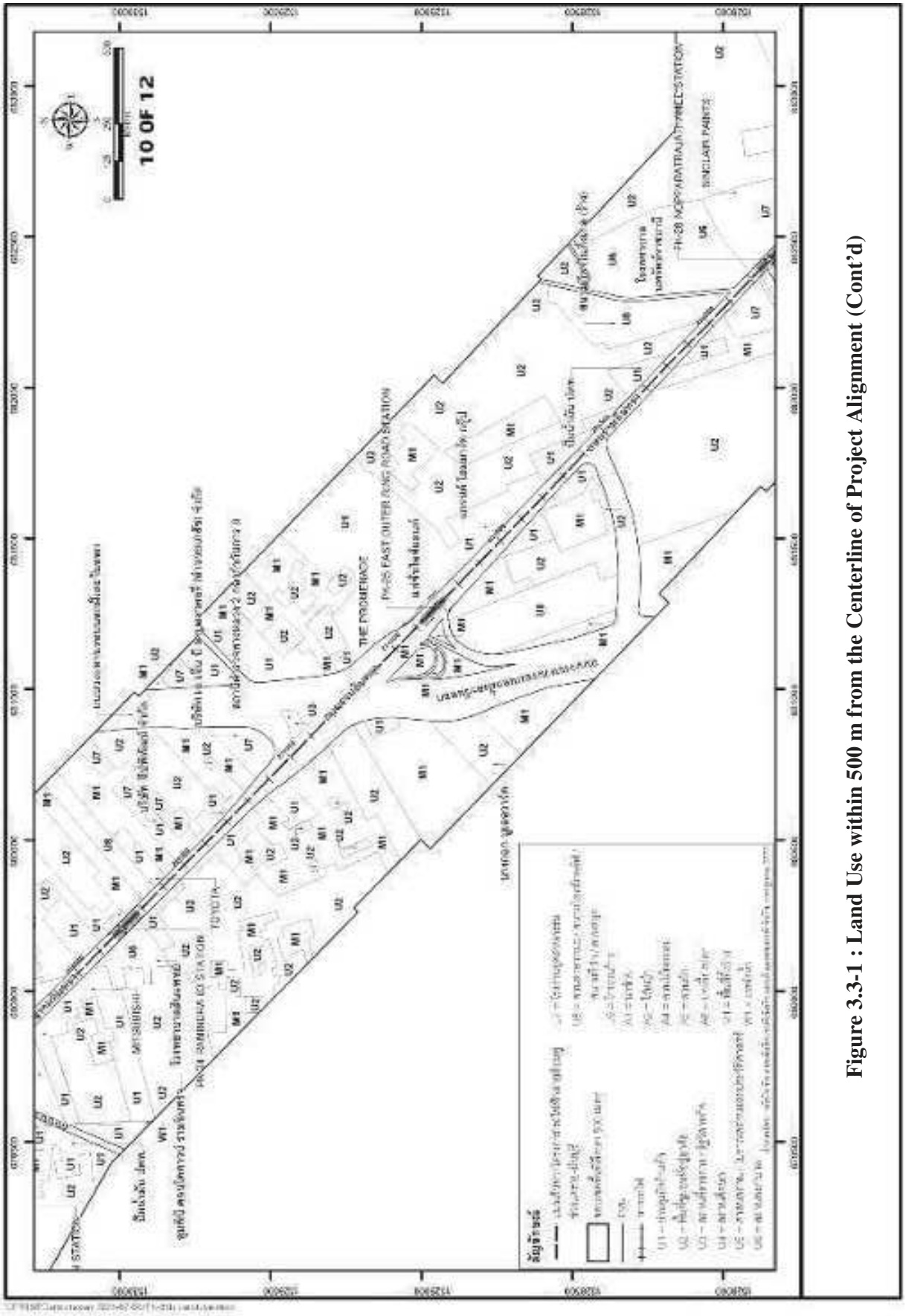


Figure 3.3-1 : Land Use within 500 m from the Centerline of Project Alignment (Cont'd)

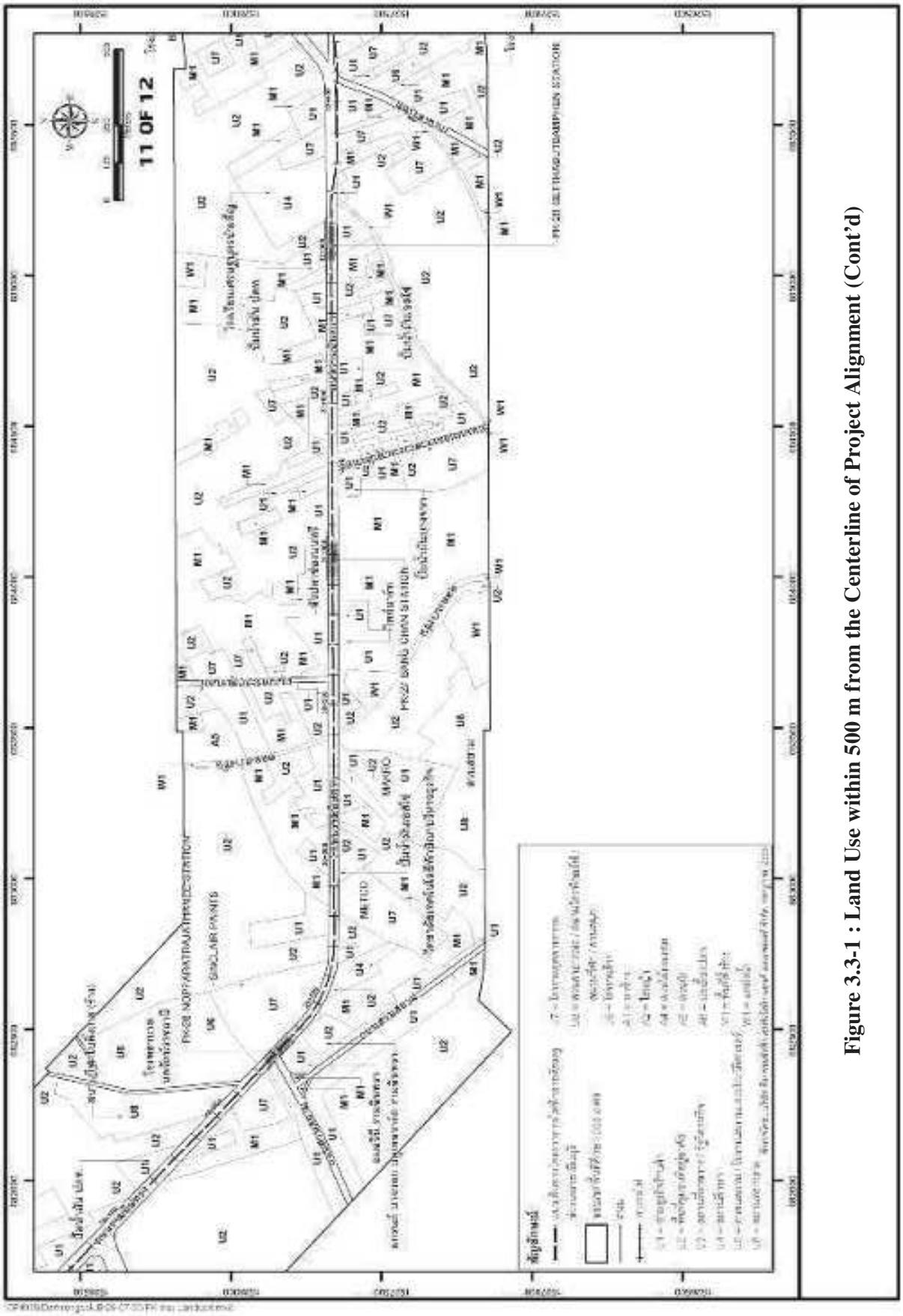


Figure 3.3-1 : Land Use within 500 m from the Centerline of Project Alignment (Cont'd)

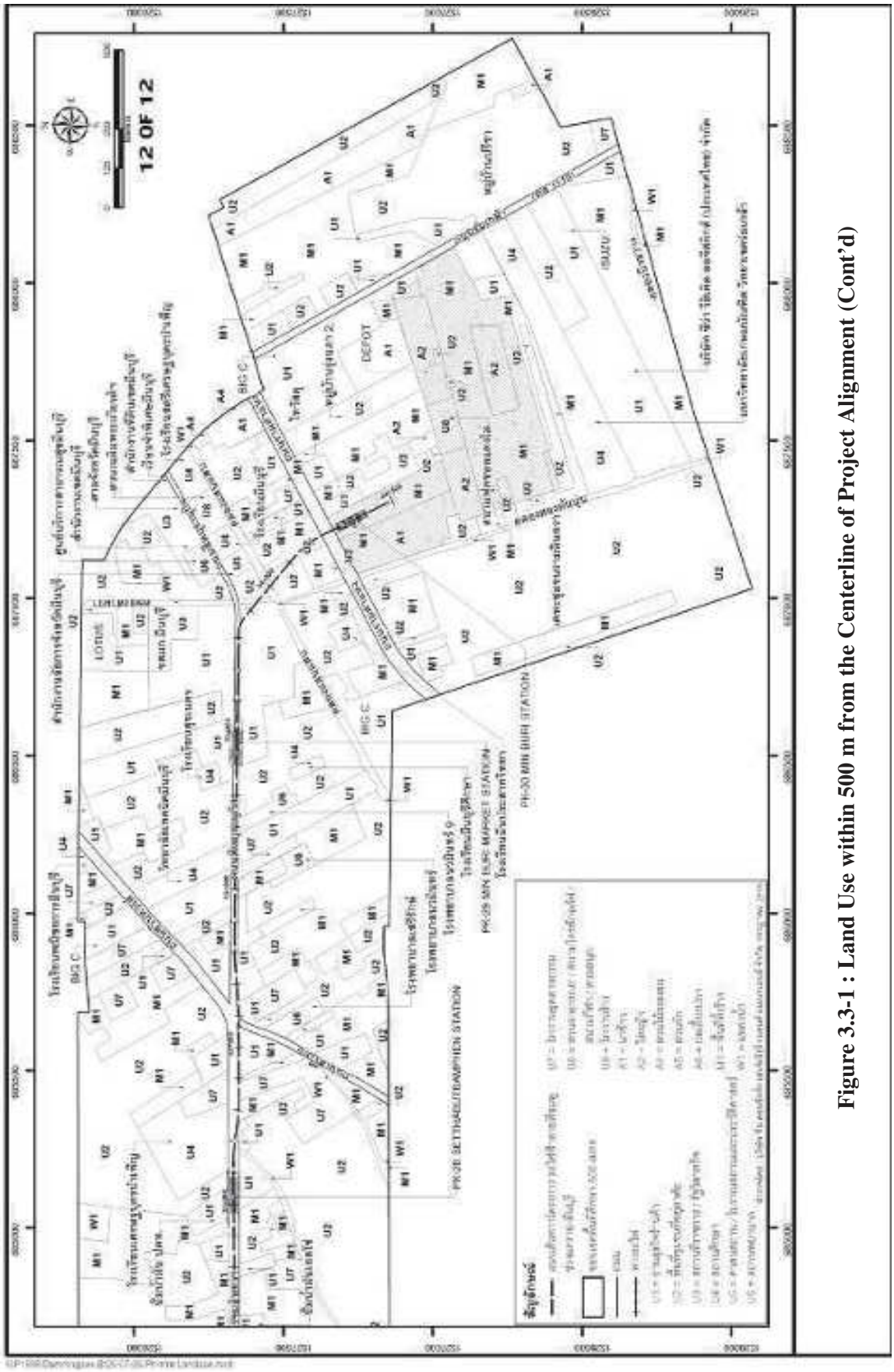


Figure 3.3-1 : Land Use within 500 m from the Centerline of Project Alignment (Cont'd)

- Urban and Built-Up Land: This is the major land use type in the study areas, occupying 18,848.14 rai or 79.24% of the total land. The land uses comprise 10,231.25 rai of residential area or 43.01%, followed by 3,441.25 rai of commercial areas or equivalent to 14.47%, 3,160.63 rai of government/state enterprise land or 13.29%, 733.13 rai of industrial plants or 3.08%, 563.75 rai of educational institutes or 2.38%, 256.25 rai of public parks/golf courses/sports ground/amusement parks or 1.08%, 255.63 rai of religious/archaeological places or 1.07%, 196.25 rai of medical facilities or 0.82%, and 10.00 rai of abandoned factories or 0.04%.

- Agricultural Land: This land use type occupies the smallest portion of land, covering 196.26 rai or 0.82% of the total land. Agricultural lands include 105.63 rai of paddy fields or 0.44%, 52.50 rai of grass farms or 0.22%, 22.50 rai of vegetable gardens or 0.10%, and 8.13 rai of mixed fruit orchards or 0.03 as well as 7.50 rai of fish ponds or 0.03%.

- Other Land Uses: This type is second largest after the urban and built-up land, with 4,746.6 rai or equivalent to 19.94% of the total. These lands consist of 3,438.13 rai of abandoned land or 14.45%, 1,078.75 rai of roadways or 4.53%, and 229.38 of water sources or 0.96%.

In addition, drainage conditions along Chaeng Watthana and Ram Inthra roads were studied, taking into account the 2011 flood, for the design of the Pink Line stations and elevated structures, as depicted in ***Figure 3.3-2***. The study was aimed at avoiding the obstruction of road drainage along the Pink Line alignment, with the following results.

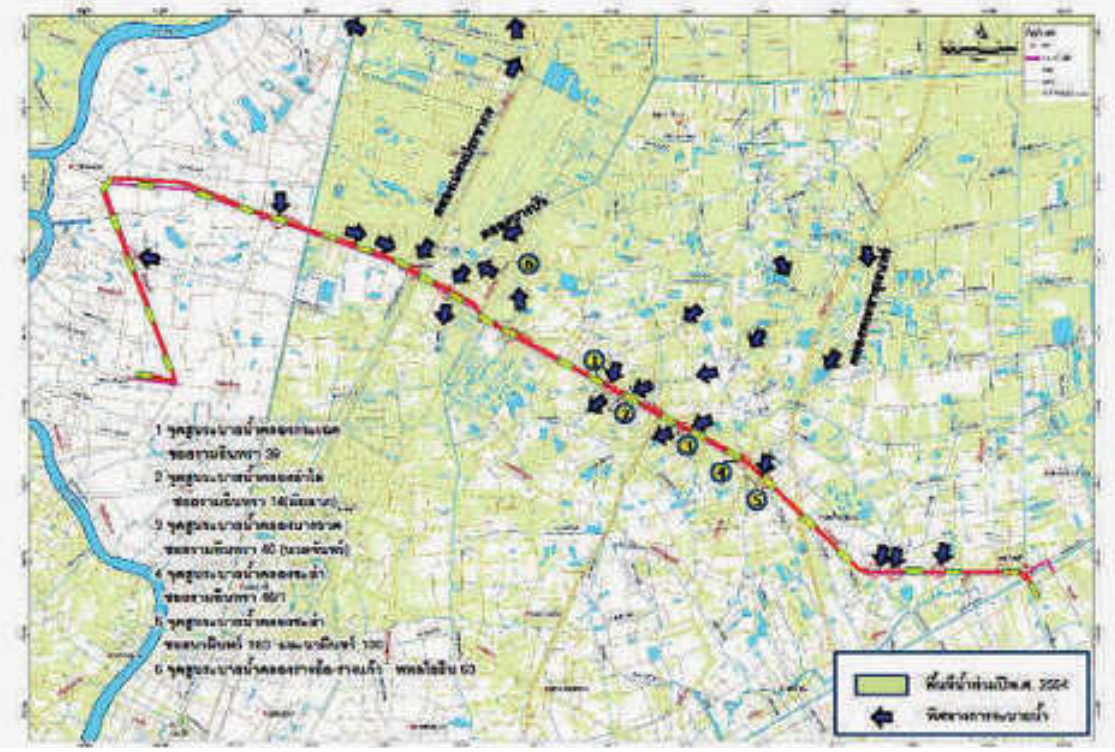


Figure 3.3-2 : Drainage Alignment and Direction in 2011

(1) Drainage from the Areas North of Ram Inthra Road

The areas north of Ram Inthra Road are encircled by Phahonyothin, Sai Mai, Hathairat and Ram Inthra roads. In particular, Ram Inthra road is designated as Bangkok's outer flood protection dike in accordance with JICA's flood protection system study. During the 2011 flood, it was difficult and slow to drain floodwaters from some parts of these areas which are low lying without any major canal. As Ram Inthra road hampers flows of water, the flows from north of the areas will inundate the northern traffic lanes while part of the water will flow over the road median to the southern part from time to time.

Drainage through the road alignment requires pumping of water into small canals around the perimeter of the areas, which have very limited drainage capacity, compared to the flood volume. Water will be drained into main canals: Khlong Lat Phrao and Khlong Saen Saep. Mobile pumps are generally installed at 6 locations as shown in ***Figure 3.3-3***.

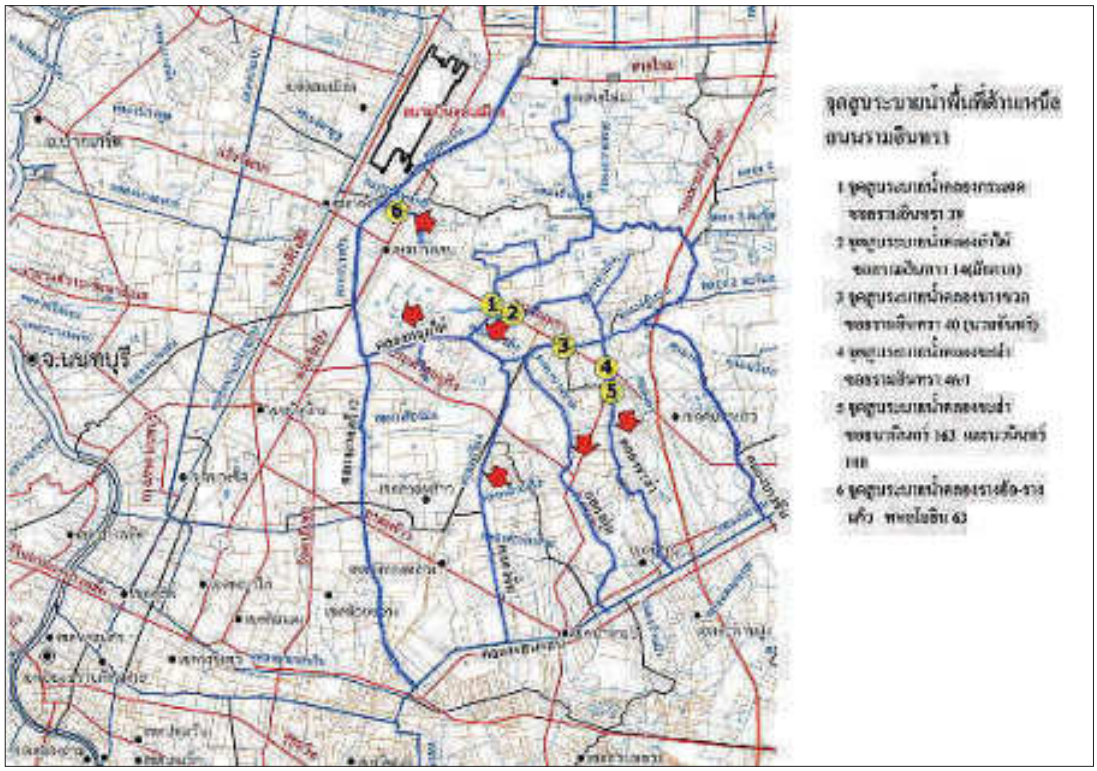


Figure 3.3-3 : Pumping Locations North of Ram Inthra Road

(a) Pump Location 1: Khlong Krachet, Soi Ram Inthra 39

(b) Pump Location 2: Khlong Lam Phai, Soi Ram Inthra 14 (Soi Maiyalap)

(c) Pump Location 3: Khlong Bang Khuat, Soi Ram Inthra 40 (Nuan Chan)

(d) Pump Location 4: Khlong Chala, Soi Ram Inthra 46/1

(e) Pump Location 5: Khlong Chala, Soi Nawamin 163 and 100

(f) Pump Location 6: Khlong Rang Lo-Rang Kaeo, Soi Phahonyothin 63

For the construction of the Pink Line elevated stations along Ram Inthra road, no station overlaps with the alignment of canals that were used to drain floodwaters in 2011. Moreover, no station structure will be built in drainage canals.

It is therefore concluded that the station structures of Pink Line MRT Project, Khae Rai-Min Buri section, will not impede drainage of water from the areas north of Ram Inthra road in case of inundation similar to the 2011 flood.

(2) Drainage from the Areas North of Chaeng Watthana Road

During the 2011 flood period, the areas north of Chaeng Watthana road were submerged by the overflows from Rangsit siphon via Khlong Prapa in combination with water overtopping the Khlong Rangsit flood dike. Floodwaters had to be drained mainly via Khong Prem Prachakon into Khlong Bang Khen and Khlong Bang Sue while part of the flood was pumped into Khlong Ban Mai to discharge into the Chao Phraya River. Generally, when the water level in the Chao Phraya River drops, some water will flow back into Khlong Rangsit and will be then pumped into the Chao Phraya River. Floodwaters in Chaeng Watthana Road will be drained into Khong Prem Prachakon mainly via drains on both sides of the road as well as pumping into Khong Prem Prachakon.

For the construction of the Pink Line elevated stations along Chaeng Watthana road, there is no station overlying the alignment of canals that were used to drain floodwaters in 2011. Besides, no station structure will be built in drainage canals.

Consequently, it is concluded that the station structures of Pink Line MRT Project, Khae Rai-Min Buri section, will not hamper drainage of water from the areas north of Chaeng Watthana road in case of inundation similar to the 2011 flood.

3.4 STATION DESIGN AND FUNCTIONAL SPACE LAYOUT

3.4.1 Station Architectural Design

(1) Station Design and Level

The design concept emphasizes the minimization of MRT station footprint to allow natural ventilation at the ground level because the areas along the Pink Line route are mainly residential areas. The alignment of station building is mainly located in road medians to minimize land acquisition. There are 5 station types, with 2 levels or 3 levels, as follows:

(a) Type 1

Station Design: This type is a three-level elevated station, consisting of at grade floor, concourse level on the 2nd floor, and platform level on the 3rd floor. There are a total of 22 stations, with 2 types of platform height, i.e. 15 m, as presented in ***Figures 3.4-1 to 3.4-5***, and 14 m, as shown in ***Figures 3.4-6 to 3.4-10*****.**

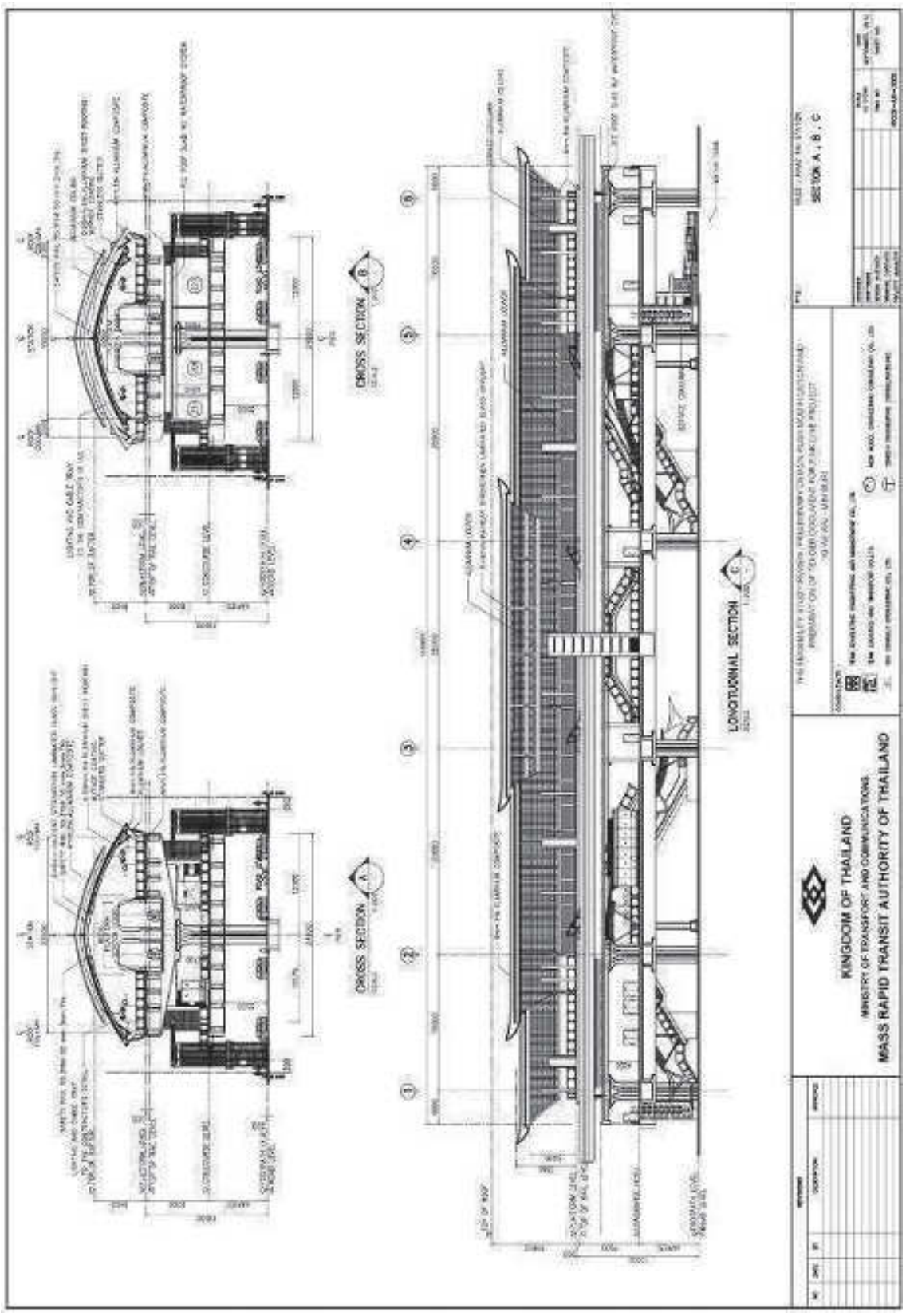


Figure 3.4-1 : Cross Section and Longitudinal Section of Station Building Type 1 with 15-m Height

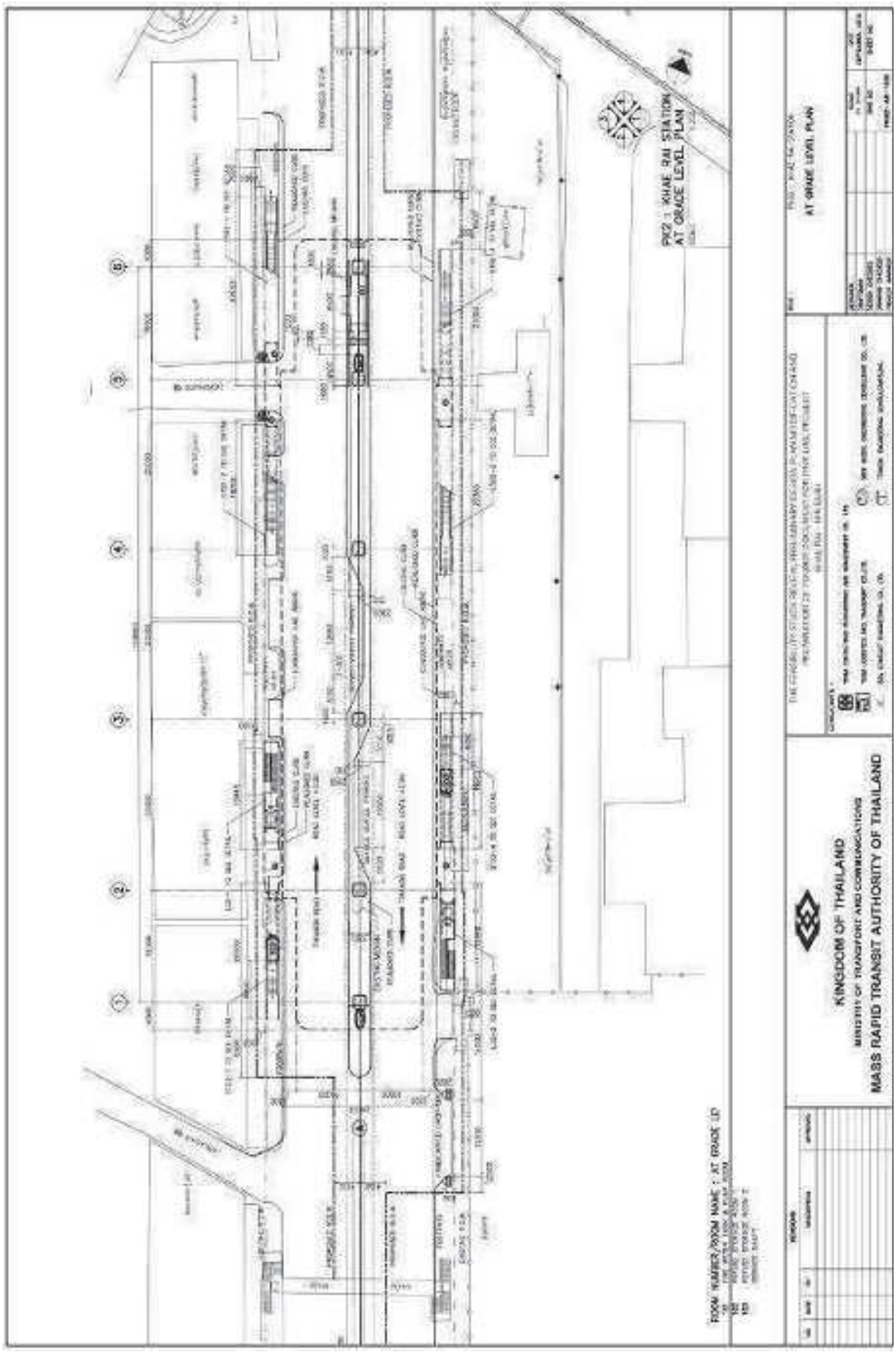


Figure 3.4-2 : At Grade Floor of Station Building Type 1 with 15-m Platform Height

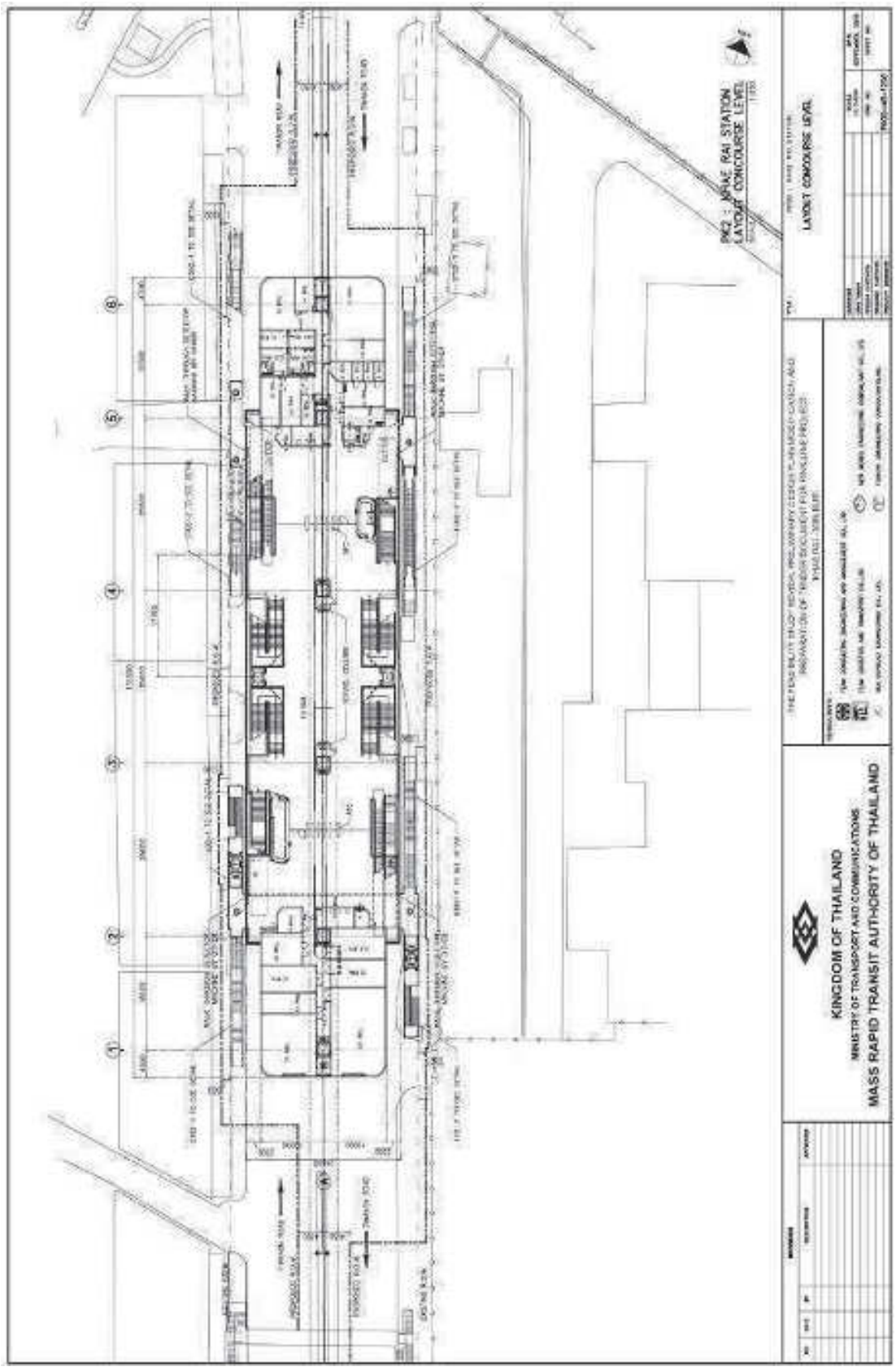


Figure 3.4-3 : Concourse Level of Station Building Type 1 with 15-m Platform Height

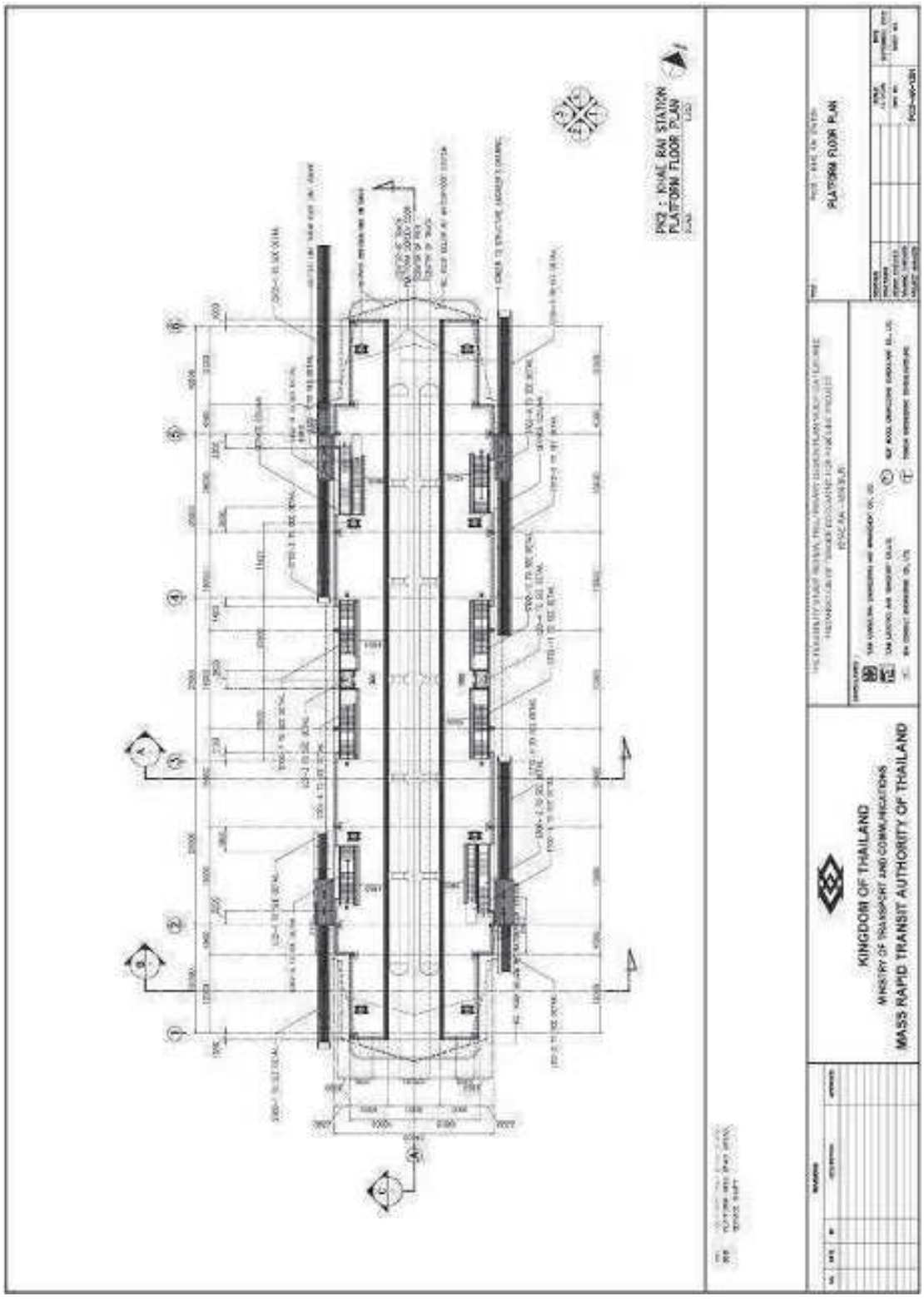


Figure 3.4-4 : Platform Level of Station Building Type 1 with 15-m Platform Height

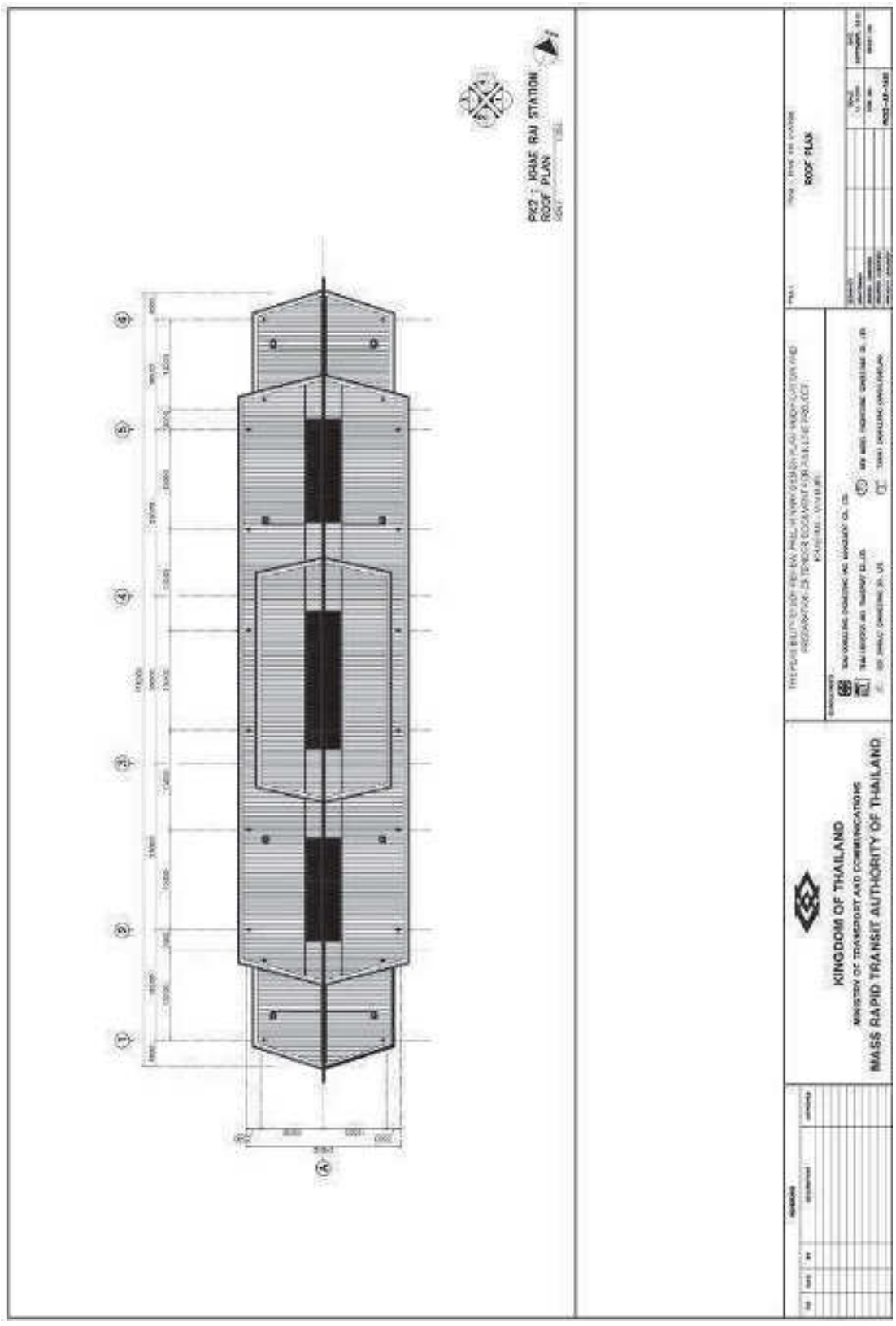


Figure 3.4-5 : Roof Plan of Station Building Type 1 with 15-m Platform Height

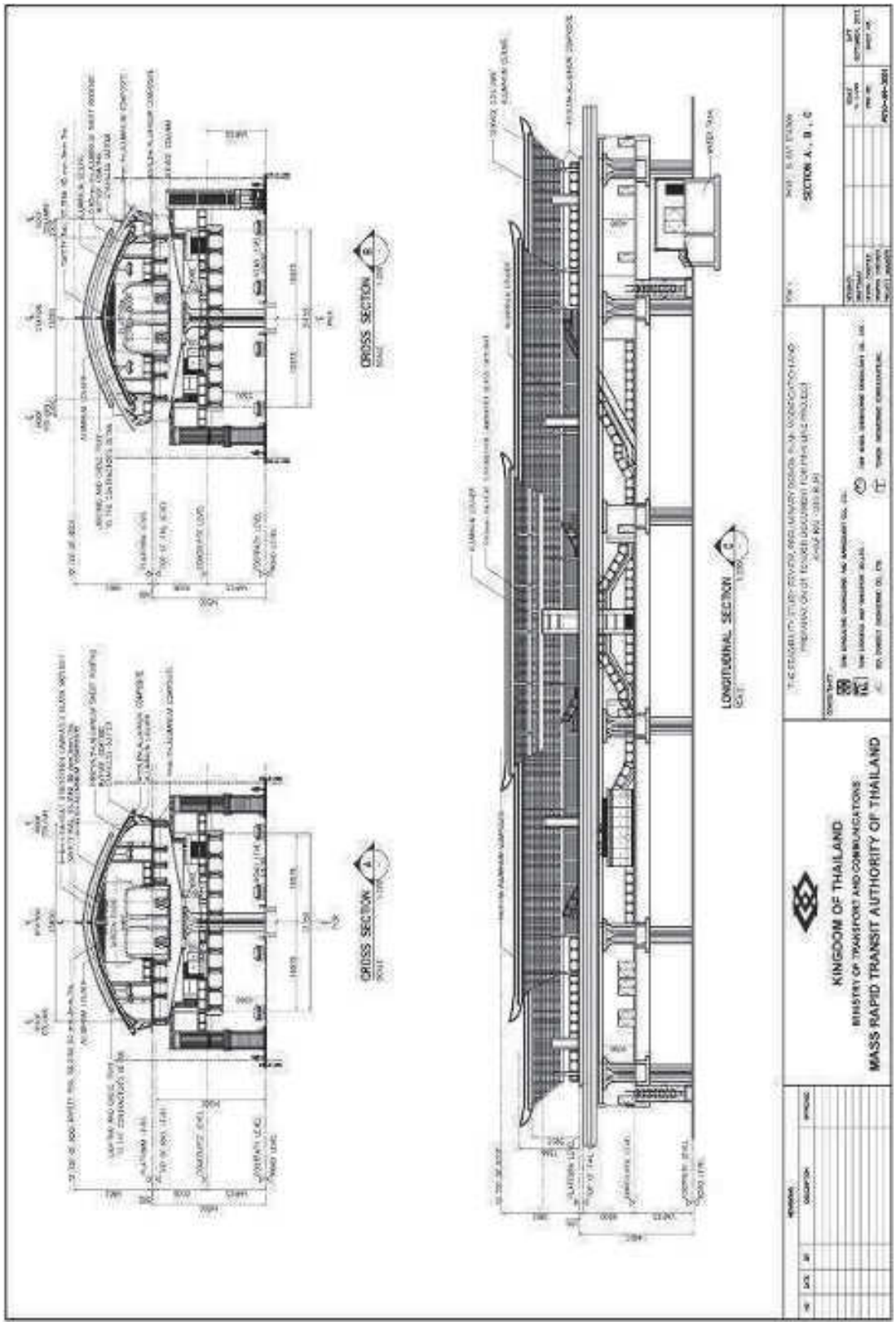


Figure 3.4-6 : Cross Section and Longitudinal Section of Station Building Type 1 with 14-m Platform Height

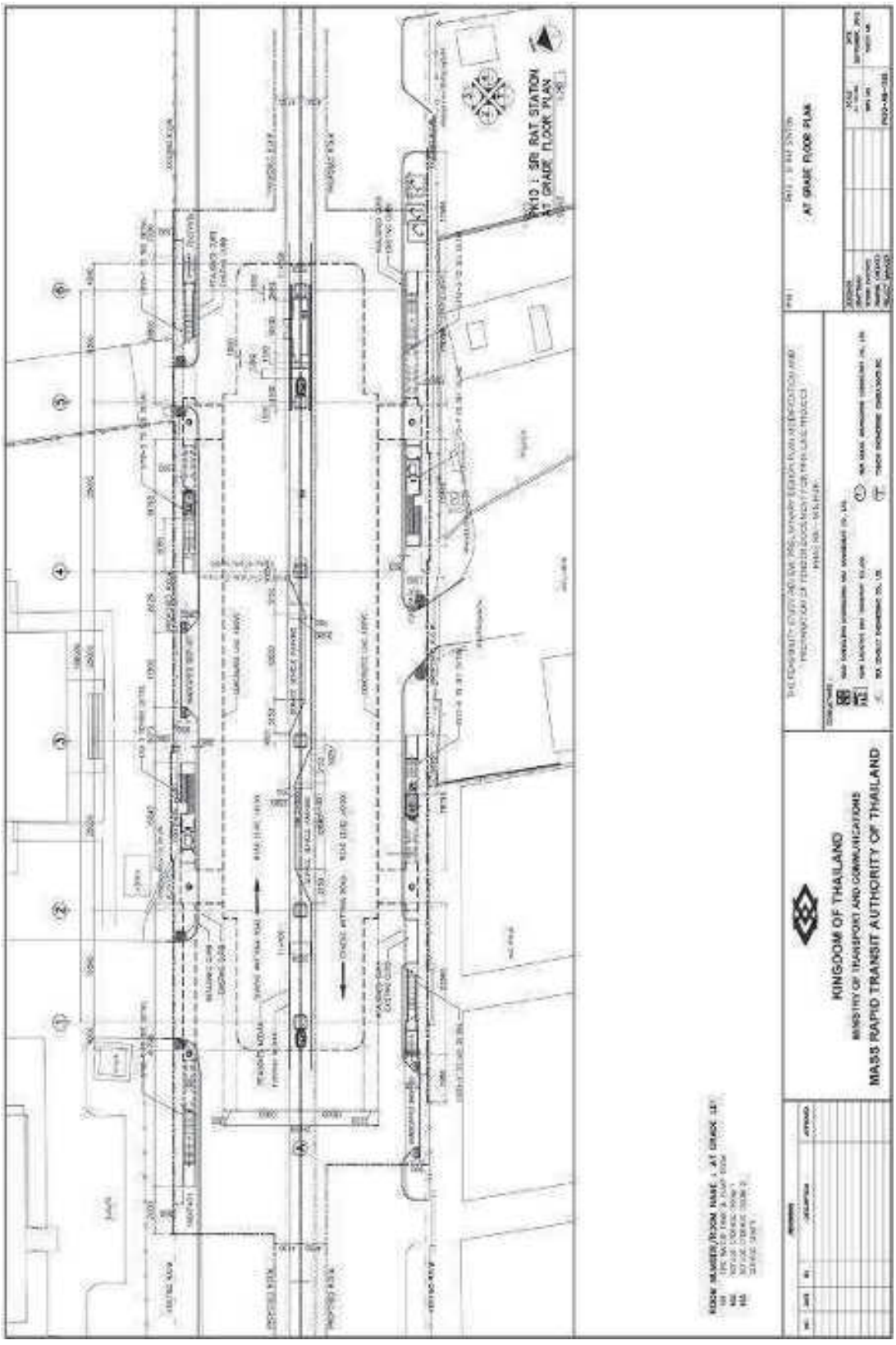


Figure 3.4-7 : At Grade Floor of Station Building Type 1 with 14-m Platform Height

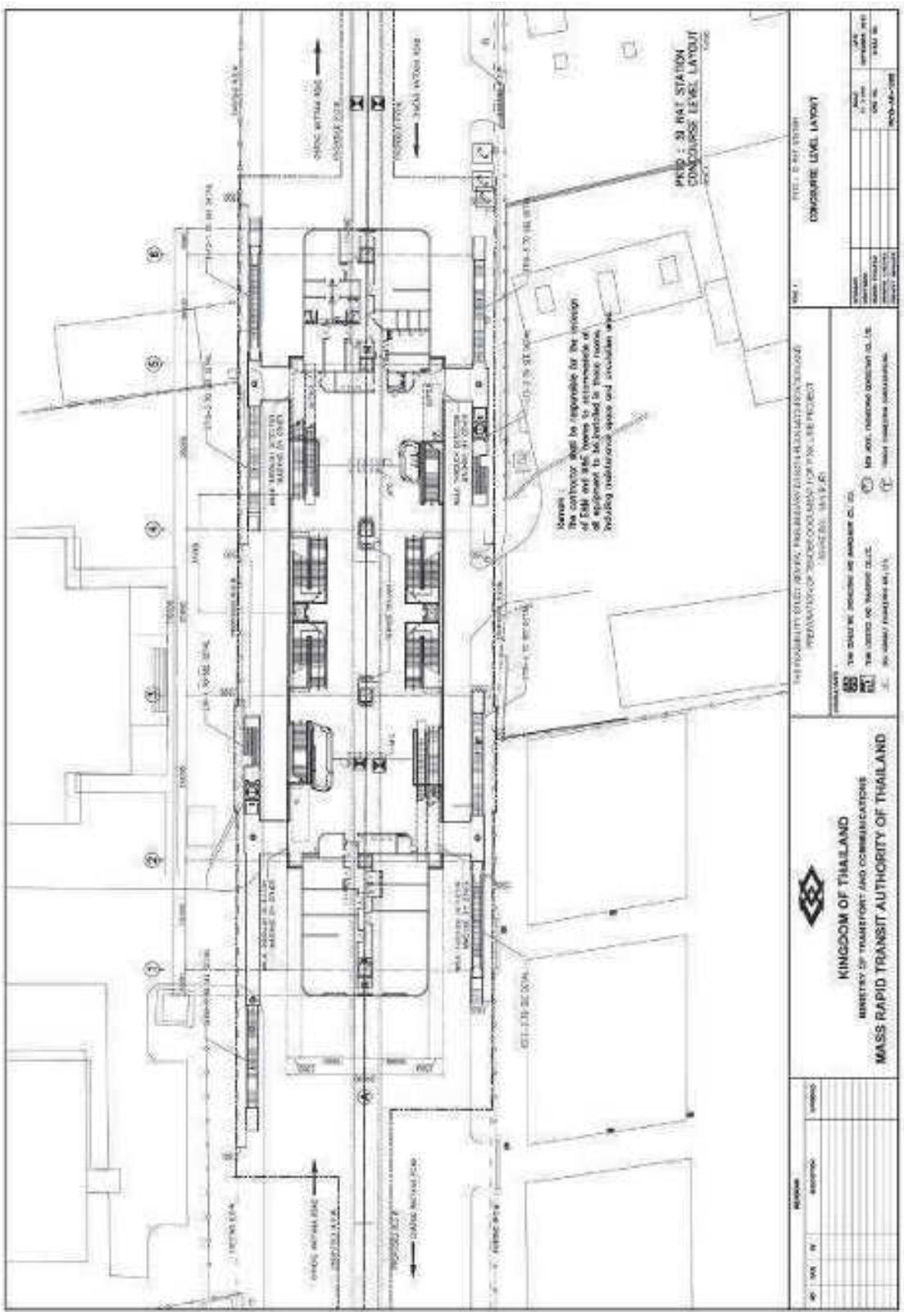


Figure 3.4-8 : Concourse Level of Station Building Type 1 with 14-m Platform Height

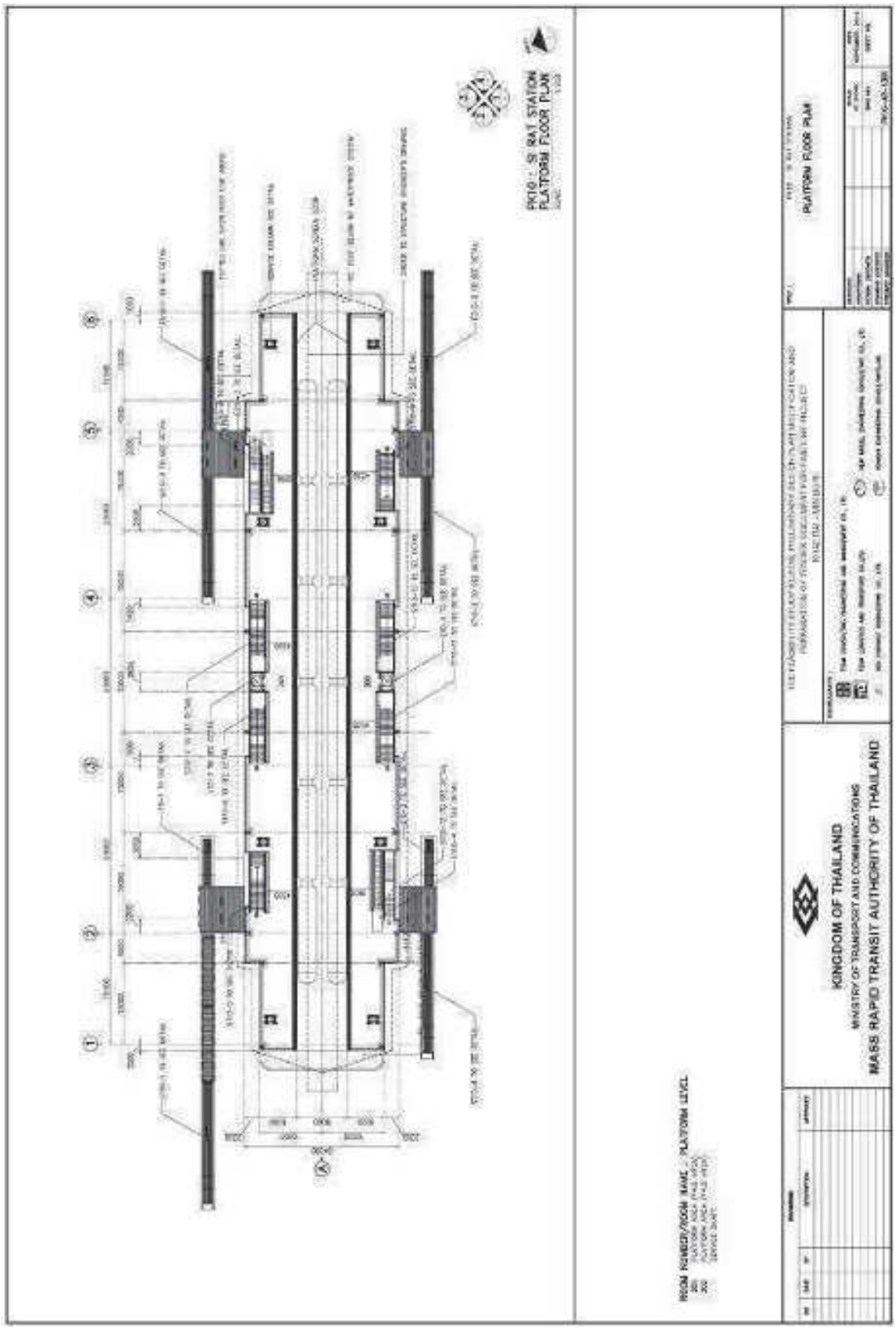


Figure 3.4-9 : Platform Level of Station Building Type 1 with 14-m Platform Height

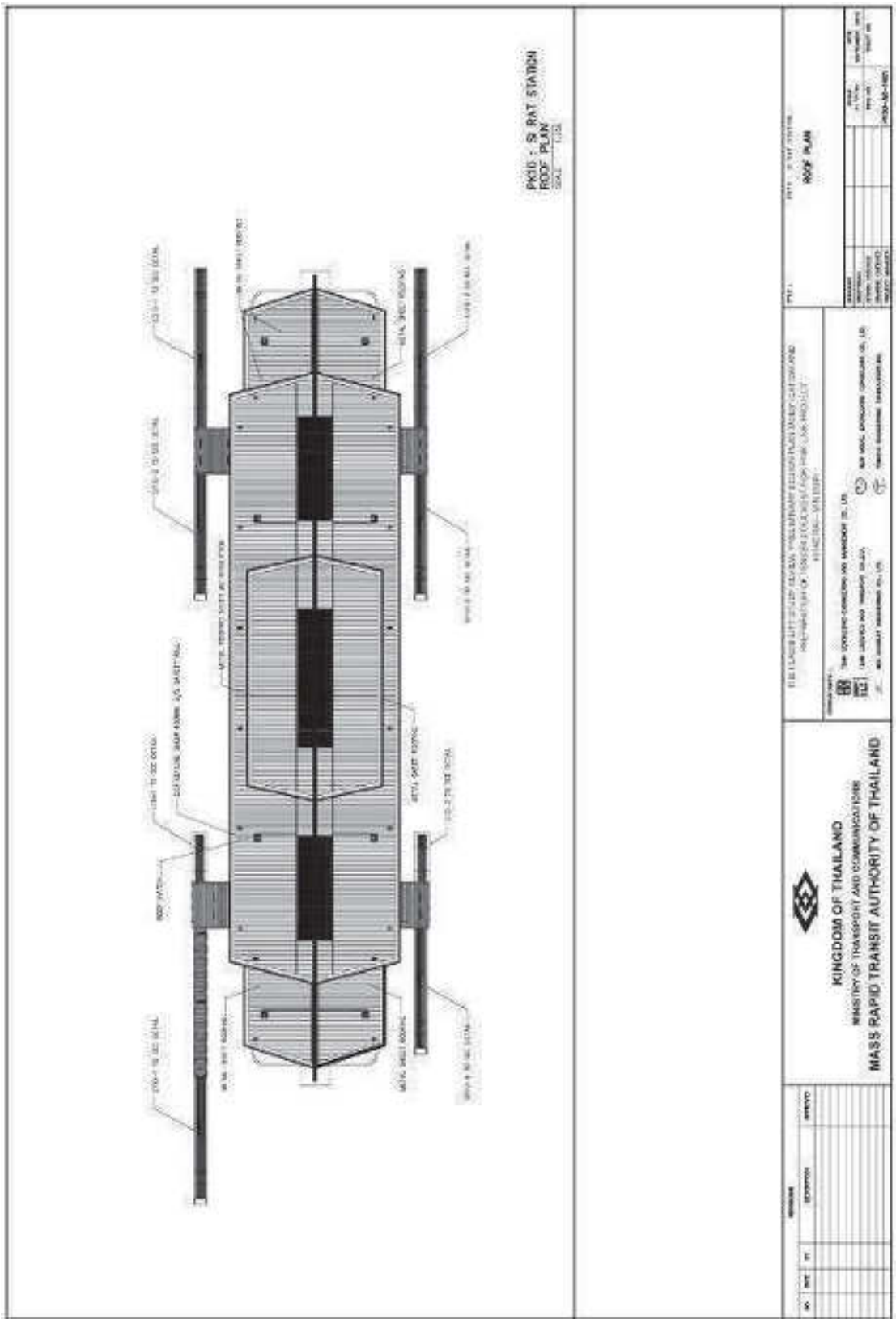


Figure 3.4-10 : Roof Plan of Station Building Type 1 with 14-m Platform Height

Station Size: 3rd floor is platform level, 24.6 m wide and 110 m long

2nd floor is concourse level, 24.6 m wide and 116 m long

1) PK01 Nonthaburi Government Center station
2) PK02 Khae Rai station
3) PK03 Sanambin Nam station
4) PK04 Samakkhi station
5) PK05 Royal Irrigation Department station
6) PK06 Pak Kret station
7) PK07 Pak Kret Bypass station
8) PK08 Chaeng Watthana-Pak Kret 28 station
9) PK11 Chaeng Watthana 14 station
10) PK12 Bangkok Government Complex station
11) PK18 Lat Pla Khao station
12) PK19 Ram Inthra 31 station
13) PK20 Maiyalap station
14) PK21 Watcharaphon station
15) PK22 Ram Inthra 40 station
16) PK23 Khu Bon station
17) PK24 Ram Inthra 83 station
18) PK25 East Outer Ring Road station

Number of Stations: 15-m height, totaling 22 stations:

19) PK26 Nopparat Rajathanee station
20) PK27 Bang Chan station
21) PK28 Setthabutbamphen station
22) PK29 Min Buri Market station

14-m height, totaling 4 stations:

1) PK10 Si Rat station
2) PK13 TOT station
3) PK15 Phranakhon Rajabhat University station
4) PK17 Ram Inthra 3 station

(b) Type 2

Station Design: This is a two-level elevated station, consisting of at grade floor which is concourse level, and the 2nd floor which is platform level. Train operation and building systems are located in a separate building (2 stories) adjacent to station building, as illustrated *in **Figures 3.4-11 to 3.4-14***.

Station Size: 2nd floor is platform level, 19 m wide and 110 m long

At grade floor is concourse level, 12 m wide and 143.5 m long

Number of Stations: 1 station: PK09 Muang Thong Thani station

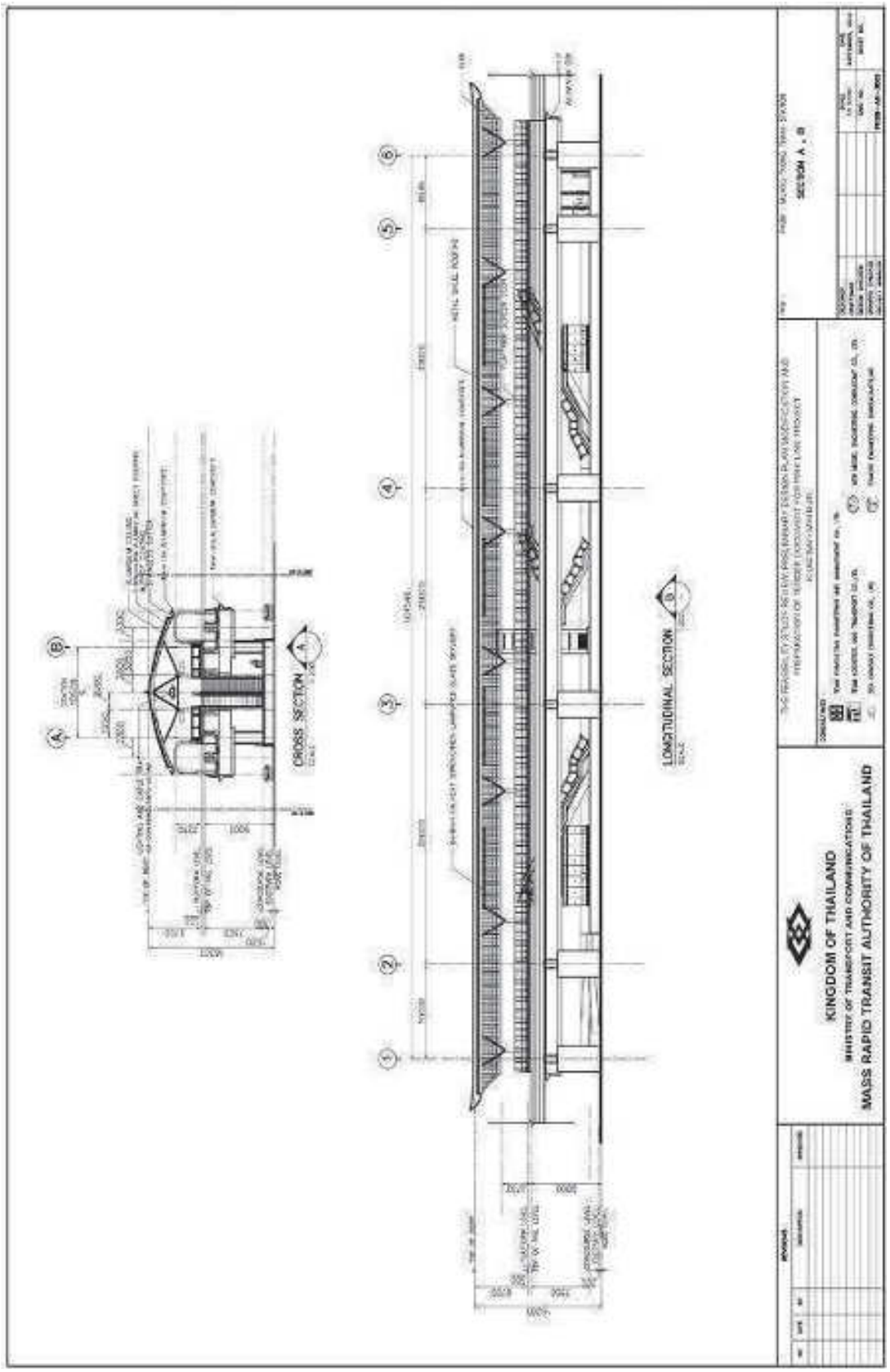


Figure 3.4-11 : Cross Section and Longitudinal Section of Station Building Type 2 with 9-m Platform Height

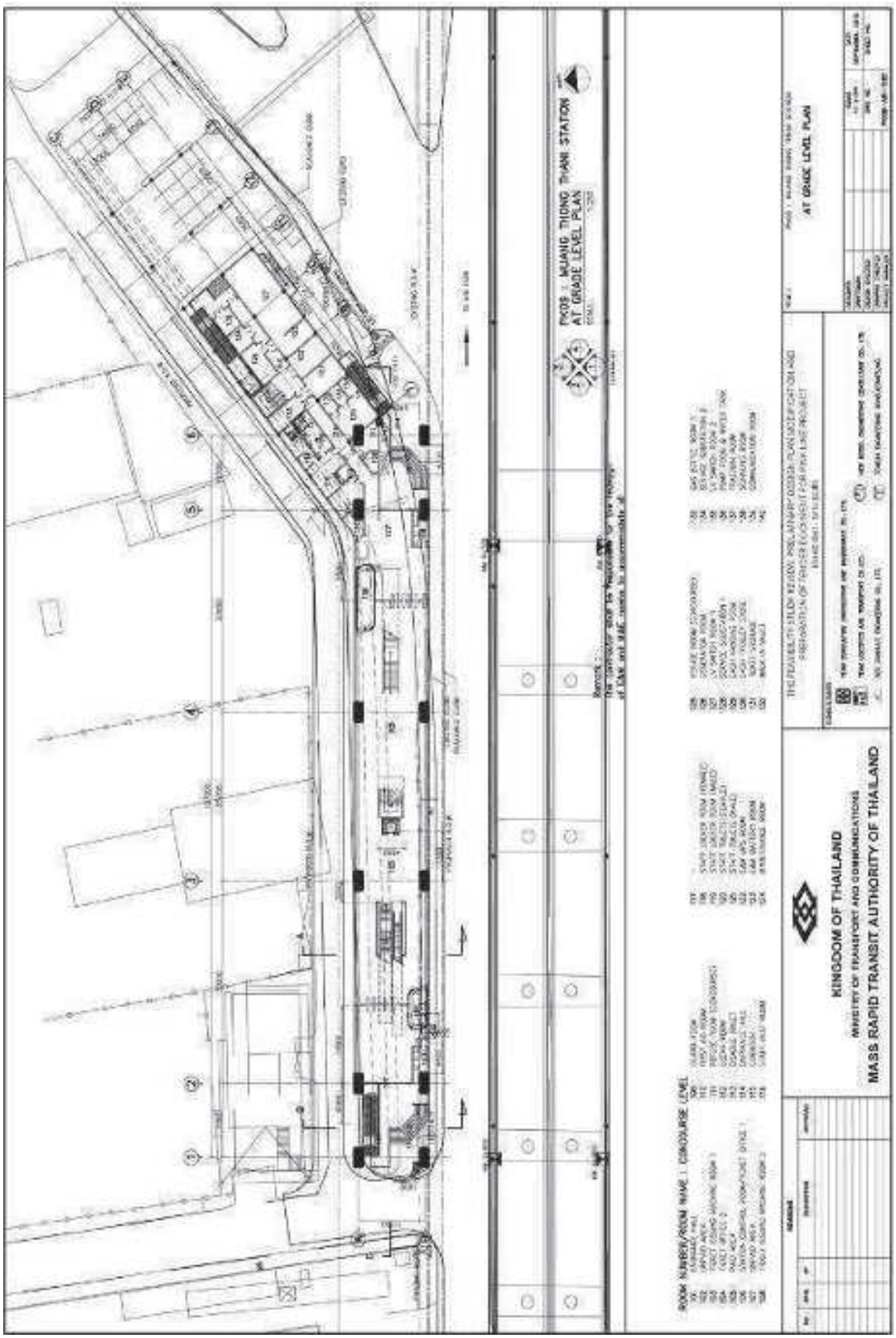


Figure 3.4-12 : At Grade Floor of Station Building Type 2 with 9-m Platform Height

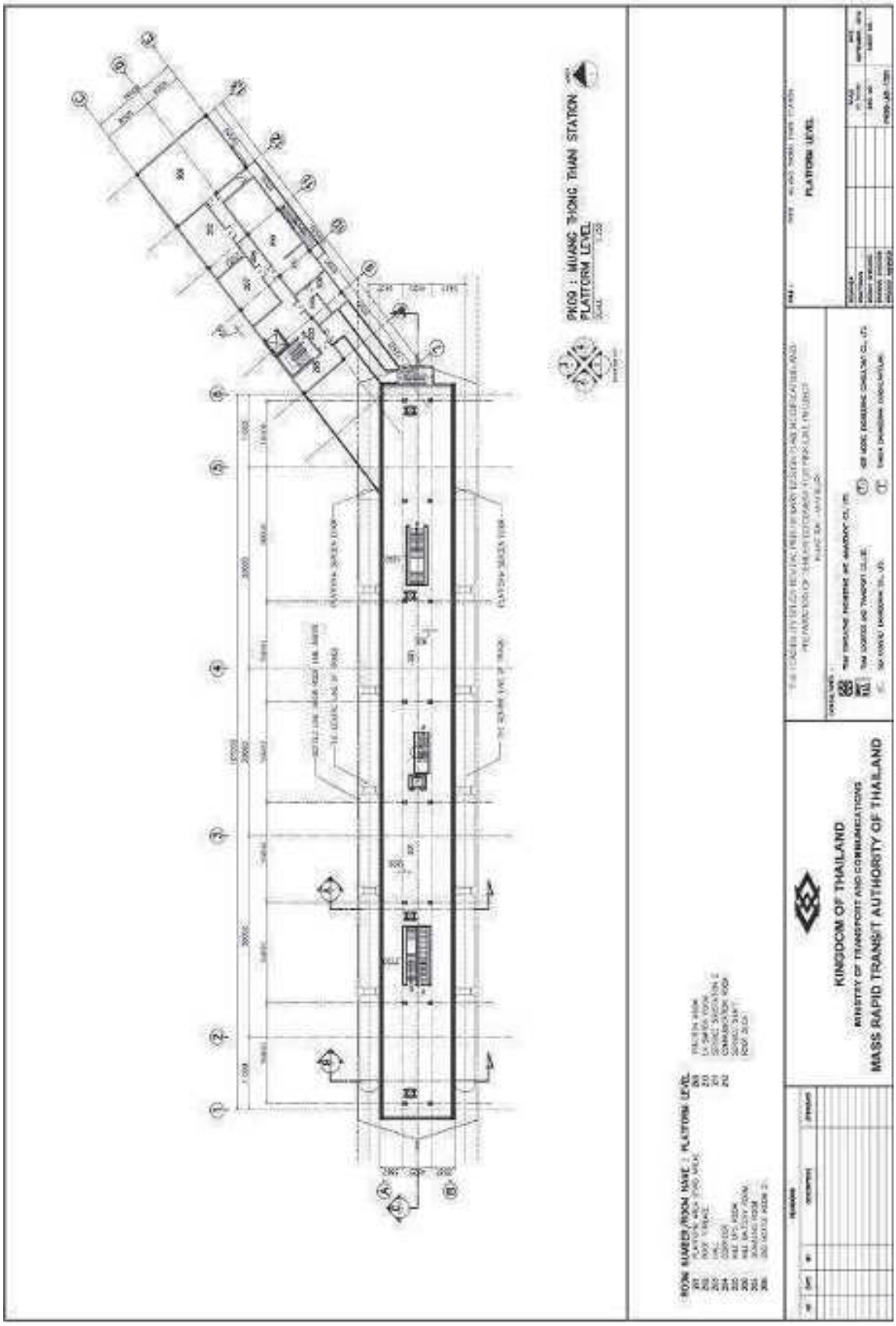


Figure 3.4-13 : Platform Level of Station Building Type 2 with 9-m Platform Height

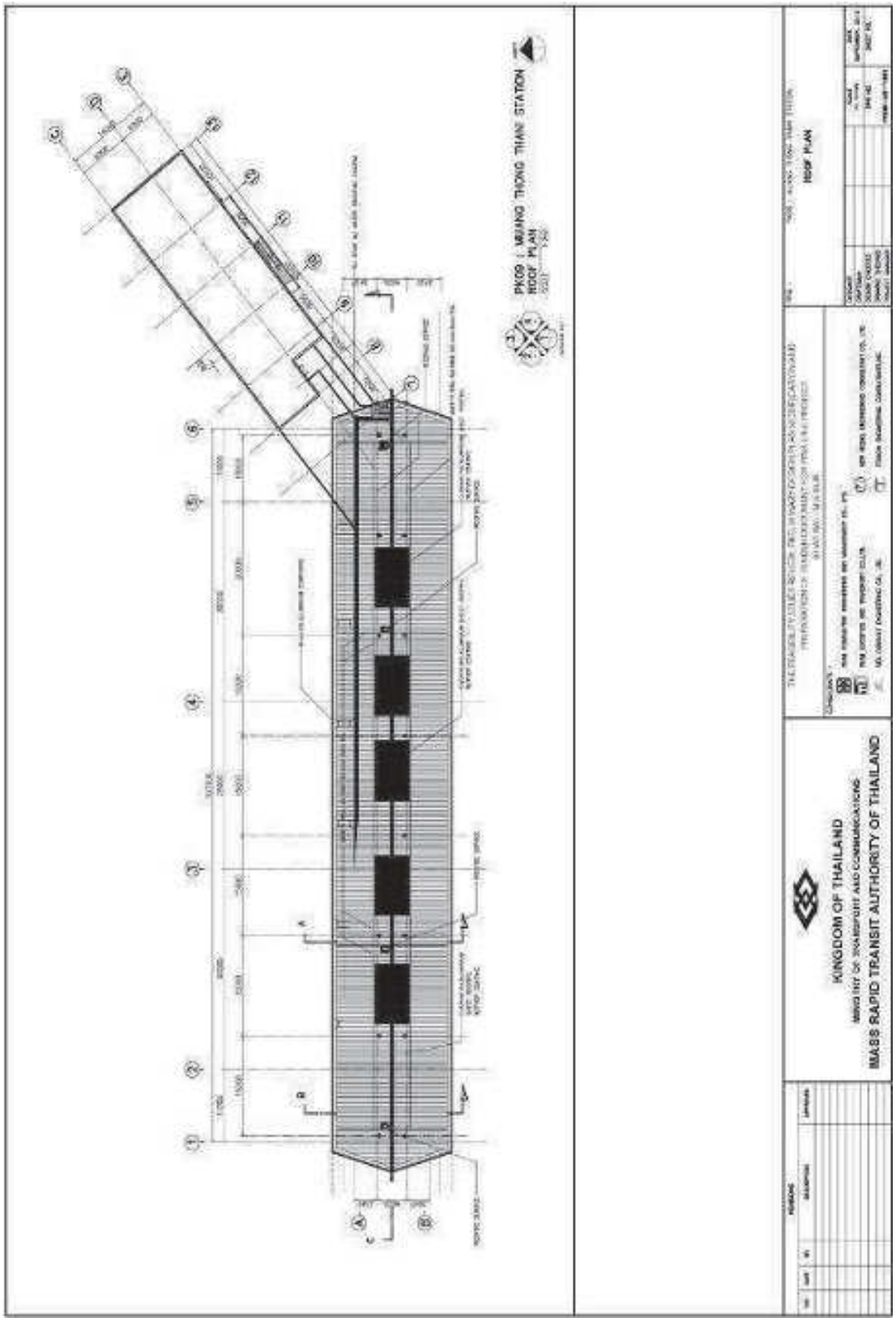


Figure 3.4-14 : Roof Plan of Station Building Type 2 with 9-m Platform Height

(c) Type 3

Station Design: This is a two-level elevated station, consisting of at grade floor which is concourse level, and the 2nd floor which is platform level. The station is located parallel to the existing road, as shown in ***Figures 3.4-15 to 3.4-18.***

Station Size: At grade floor is concourse level, 28.5 m wide and 98 m long

2nd floor is platform level, 30 m wide and 110 m long

Number of Stations: 1 station: PK14 Lak Si station

(d) Type 4

Station Design: This is a two-level elevated station, consisting of at grade floor which is concourse level, and the 2nd floor which is platform level, with a skywalk connecting to the Orange Line in the future, as depicted in ***Figures 3.4-19 to 3.4-22.***

Station Size: At grade floor is concourse level, 24.6 m wide and 110 m long

2nd floor is platform level, 24.6 m wide and 110 m long

Number of Stations: 1 station: PK30 Min Buri station

(e) Type 5

Station Design: This elevated station building has two levels. At grade floor will house concourse level and building system. The 2nd floor is platform level, as depicted in ***Figures 3.4-23 to 3.4-26.***

Station Size: At grade floor is concourse level, 132.5 m wide and 184.5 m long

2nd floor is platform level, 132.5 m wide and 184.5 m long

Number of Stations: 1 station: PK16 Wat Phra Si Maha That station

(2) Uniqueness of Stations

To create uniqueness of stations, building elements feature the unique Thai architecture such as station roof where curved lines will be applied to the station design in order to create a sense of gracefulness, aesthetics and modernity, as presented in ***Figures 3.4-27*** *and* ***3.4-28***.

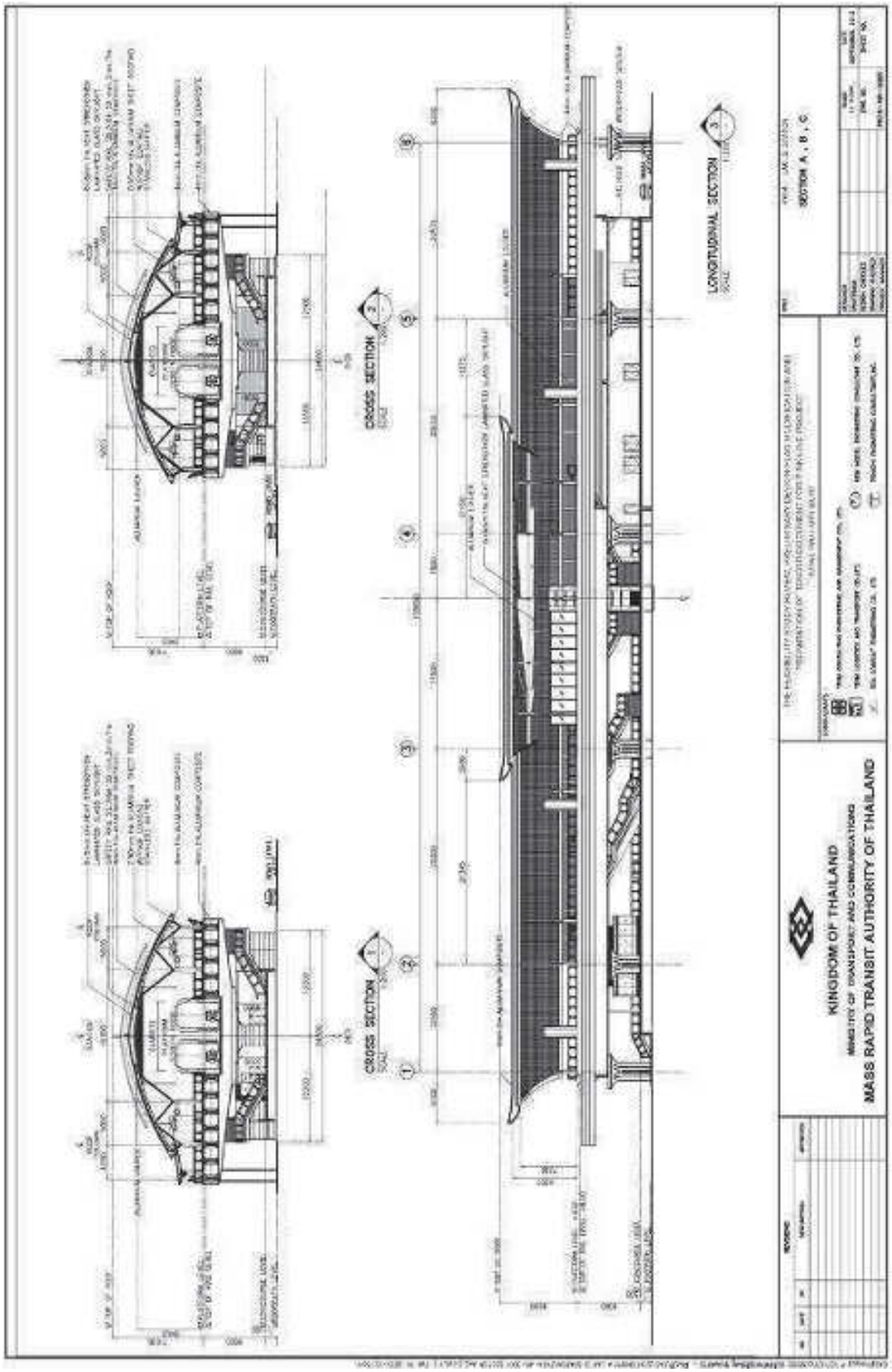


Figure 3.4-15 : Cross Section and Longitudinal Section of Station Building Type 3 with 9-m Platform Height

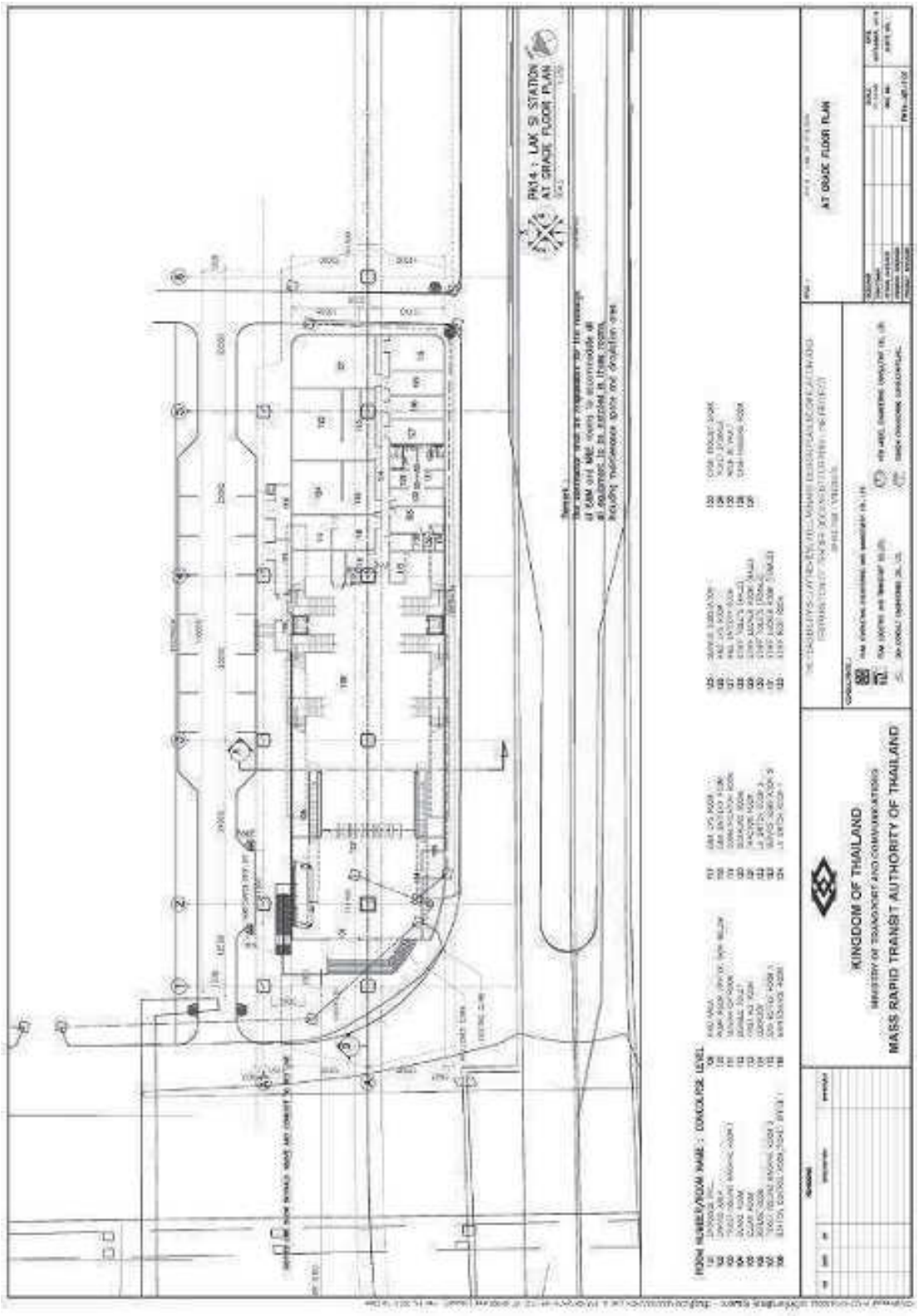


Figure 3.4-16 : At Grade Floor of Station Building Type 3 with 9-m Platform Height

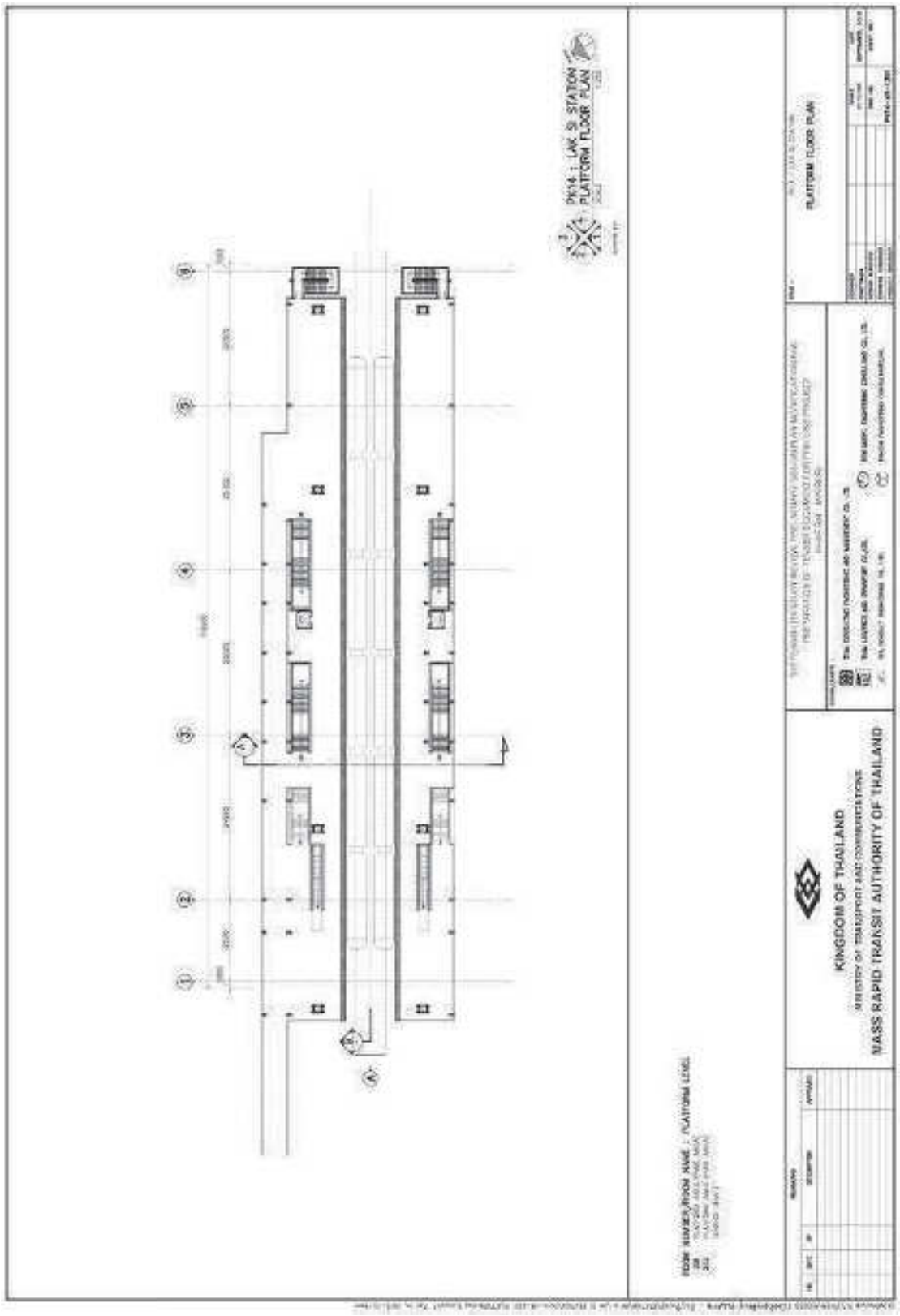


Figure 3.4-17 : Platform Level of Station Building Type 3 with 9-m Platform Height

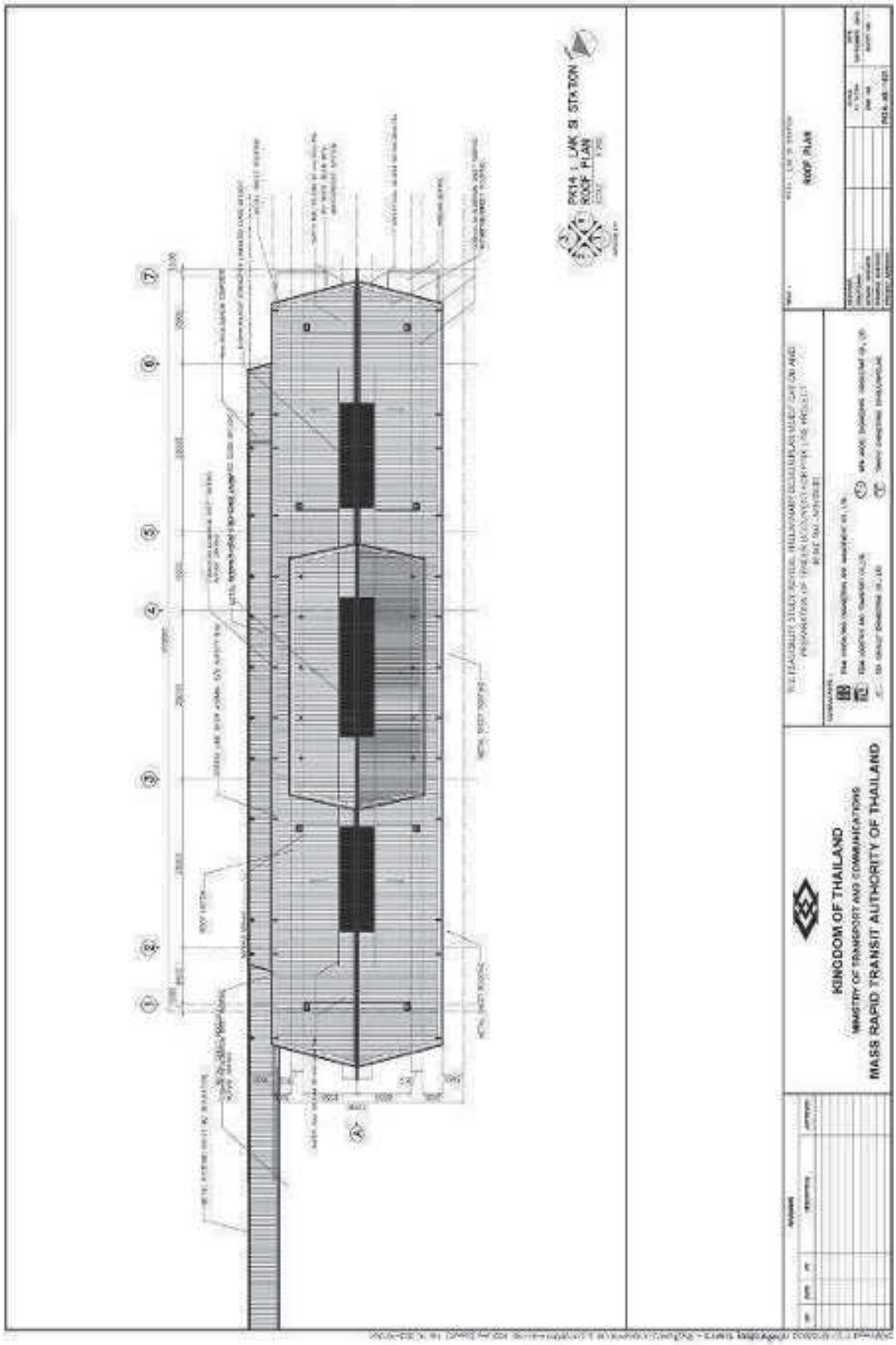


Figure 3.4-18 : Roof Plan of Station Building Type 3 with 9-m Platform Height

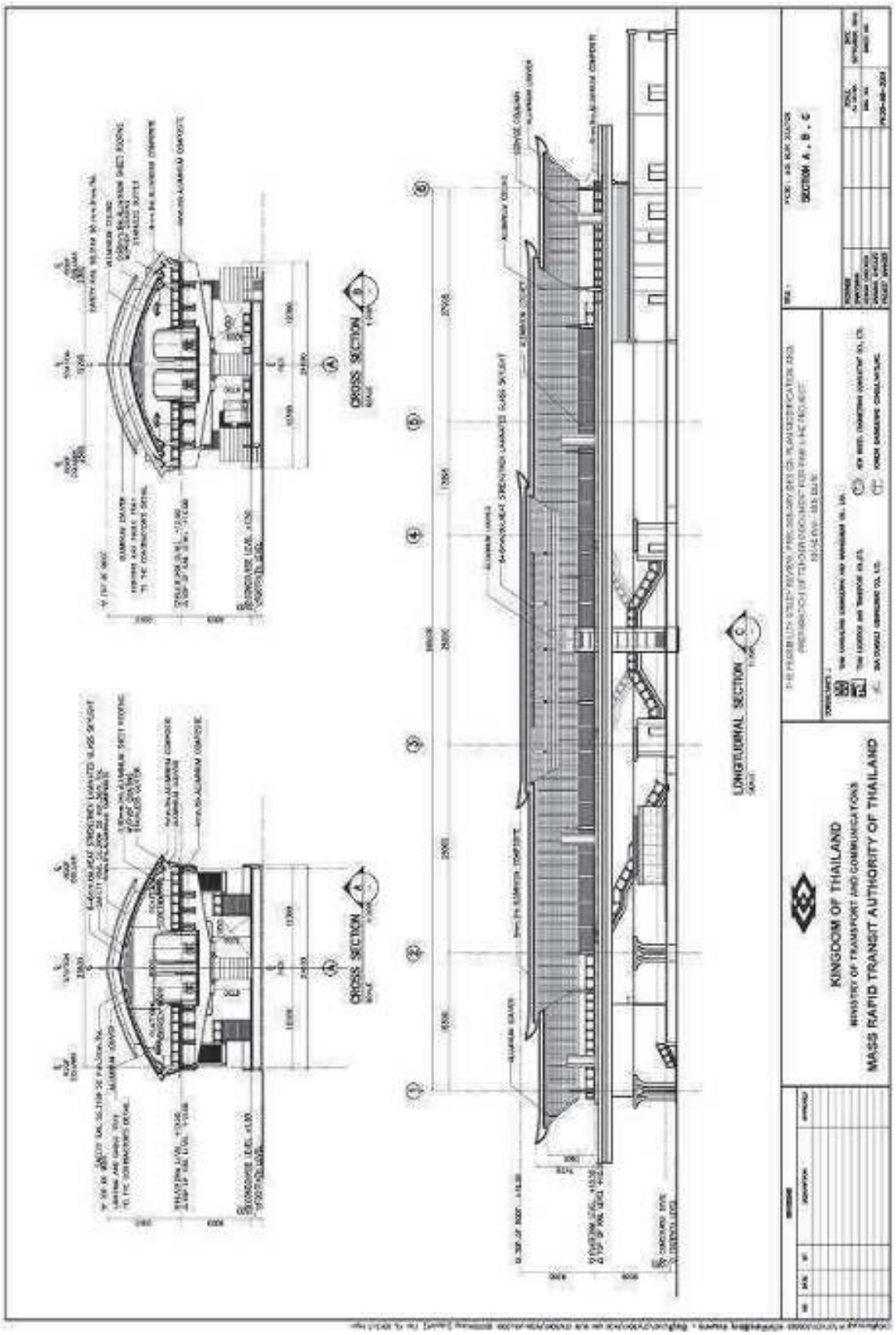


Figure 3.4-19 : Cross Section and Longitudinal Section of Station Building Type 4 with 9-m Platform Height

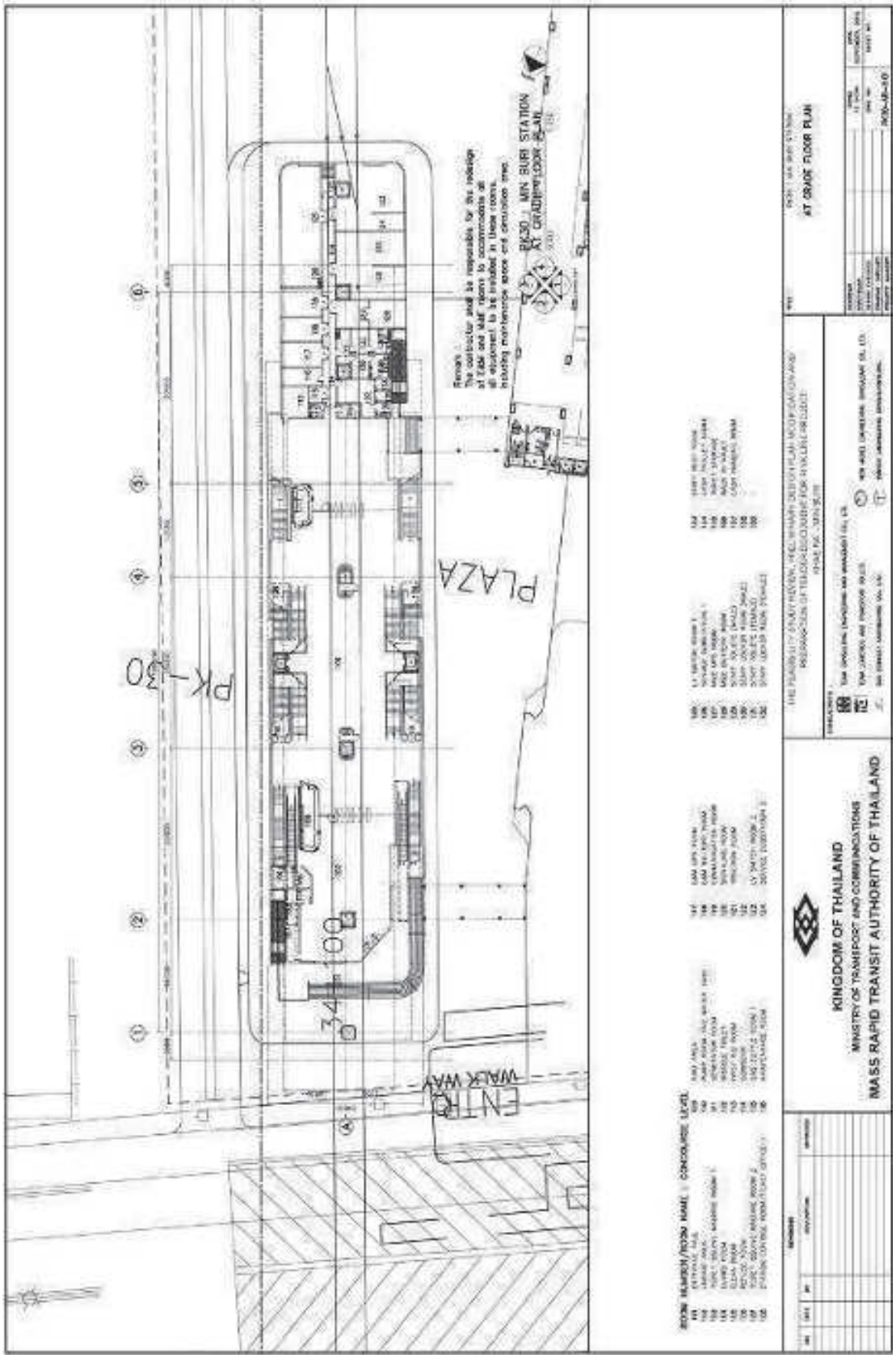


Figure 3.4-20 : At Grade Floor of Station Building Type 4 with 9-m Platform Height

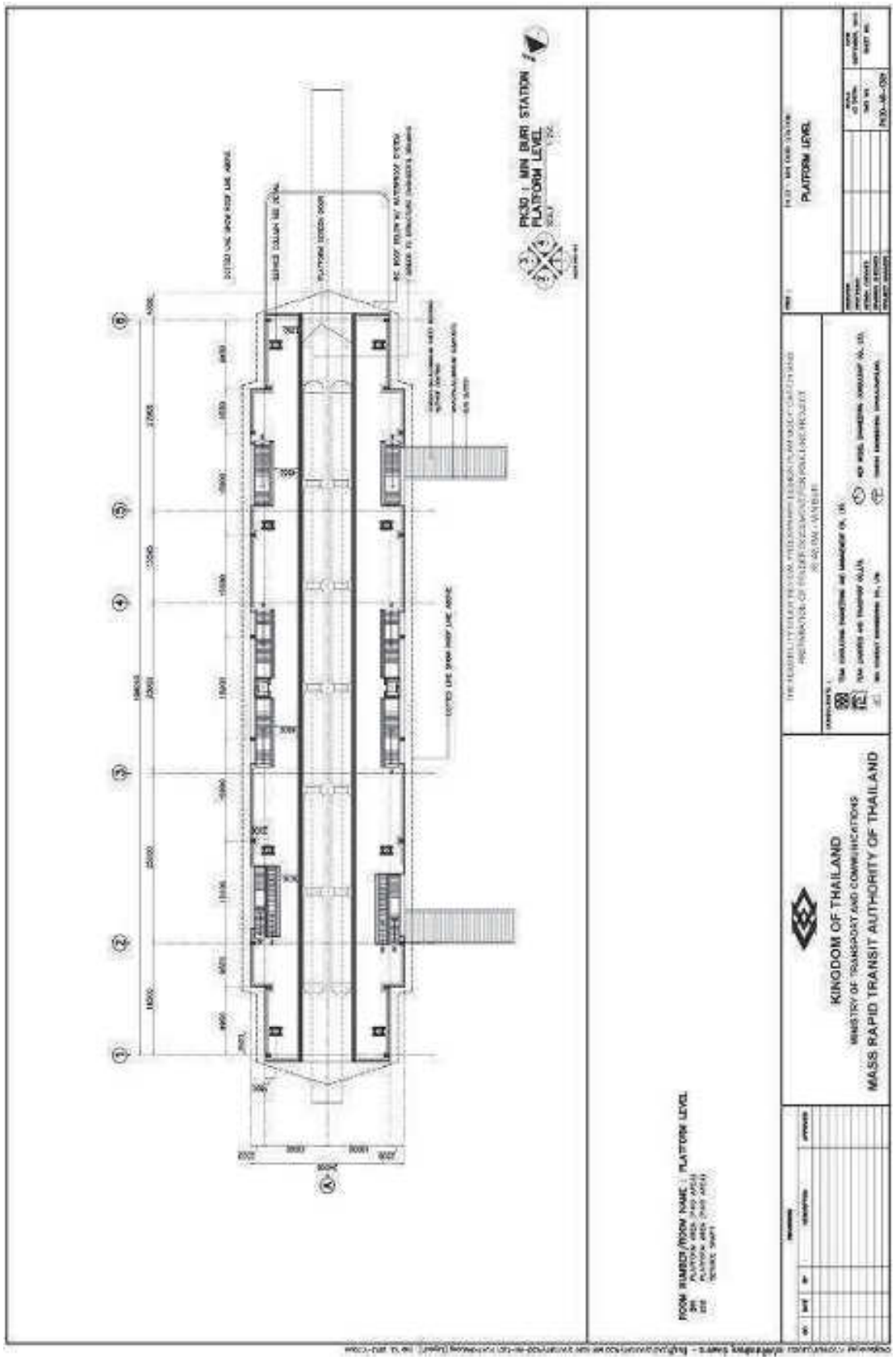


Figure 3.4-21 : Platform Level of Station Building Type 4 with 9-m Platform Height

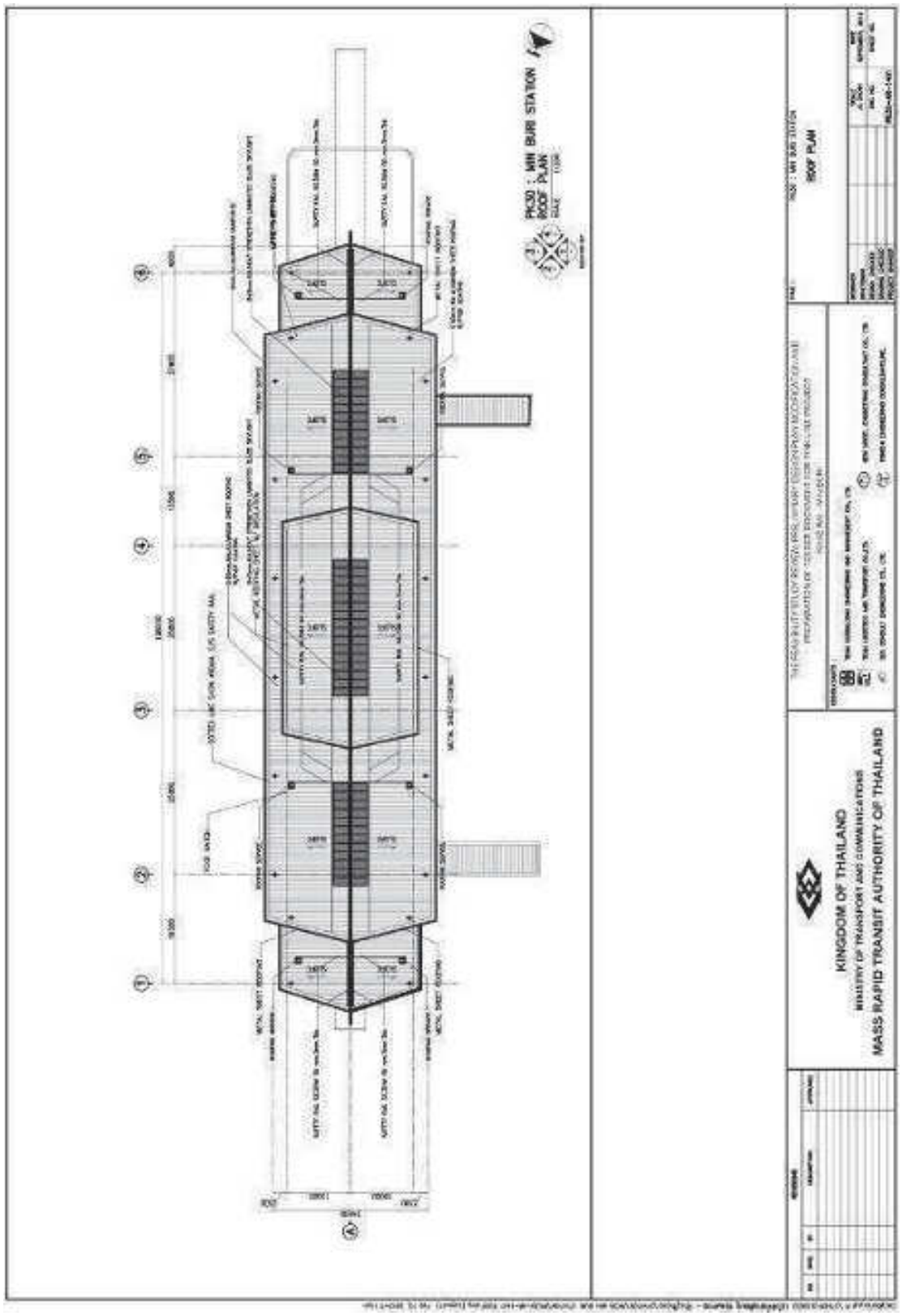


Figure 3.4-22 : Roof Plan of Station Building Type 4 with 9-m Platform Height

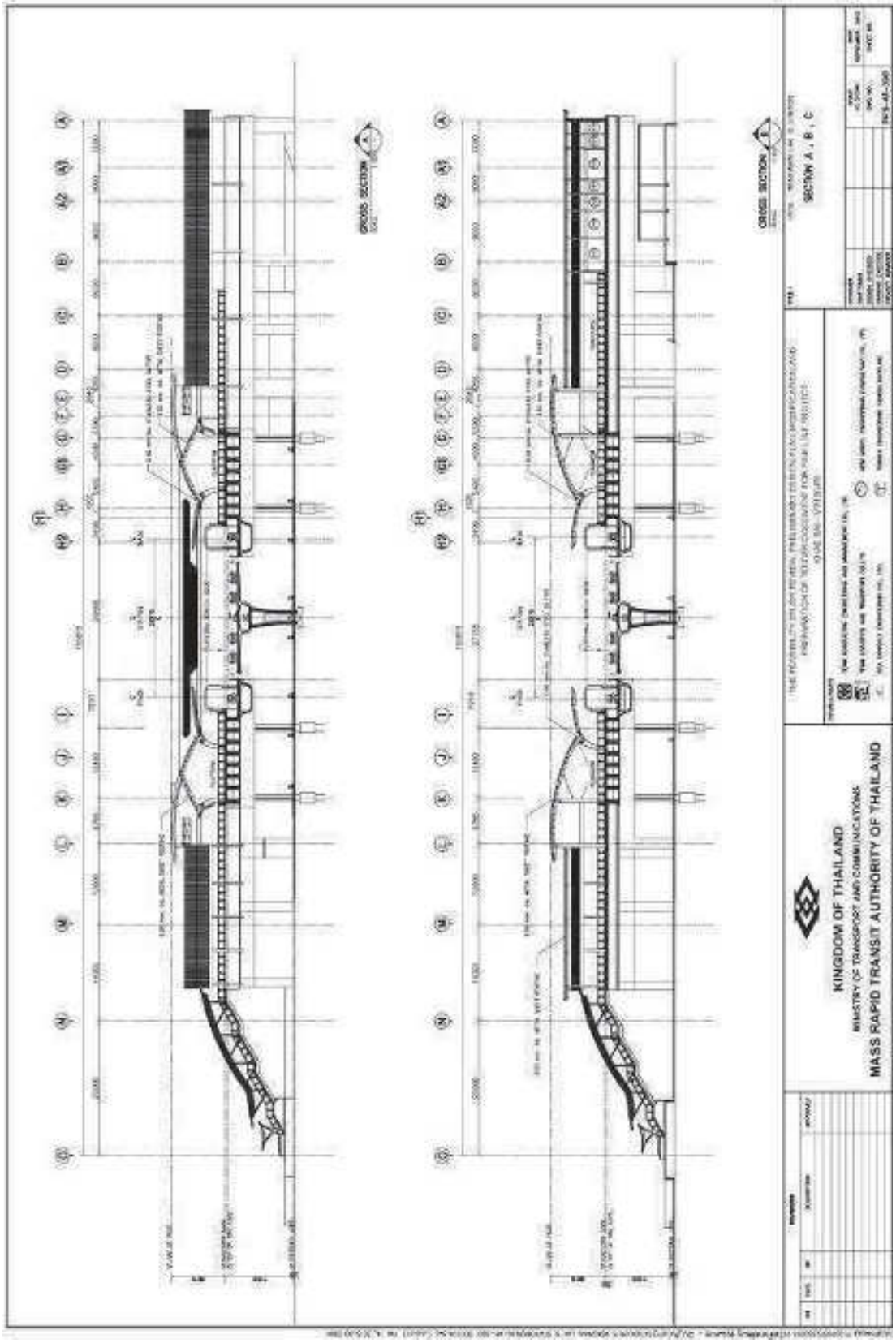


Figure 3.4-23 : Cross Section and Longitudinal Section of Station Building Type 5 with 11.10-m Platform Height

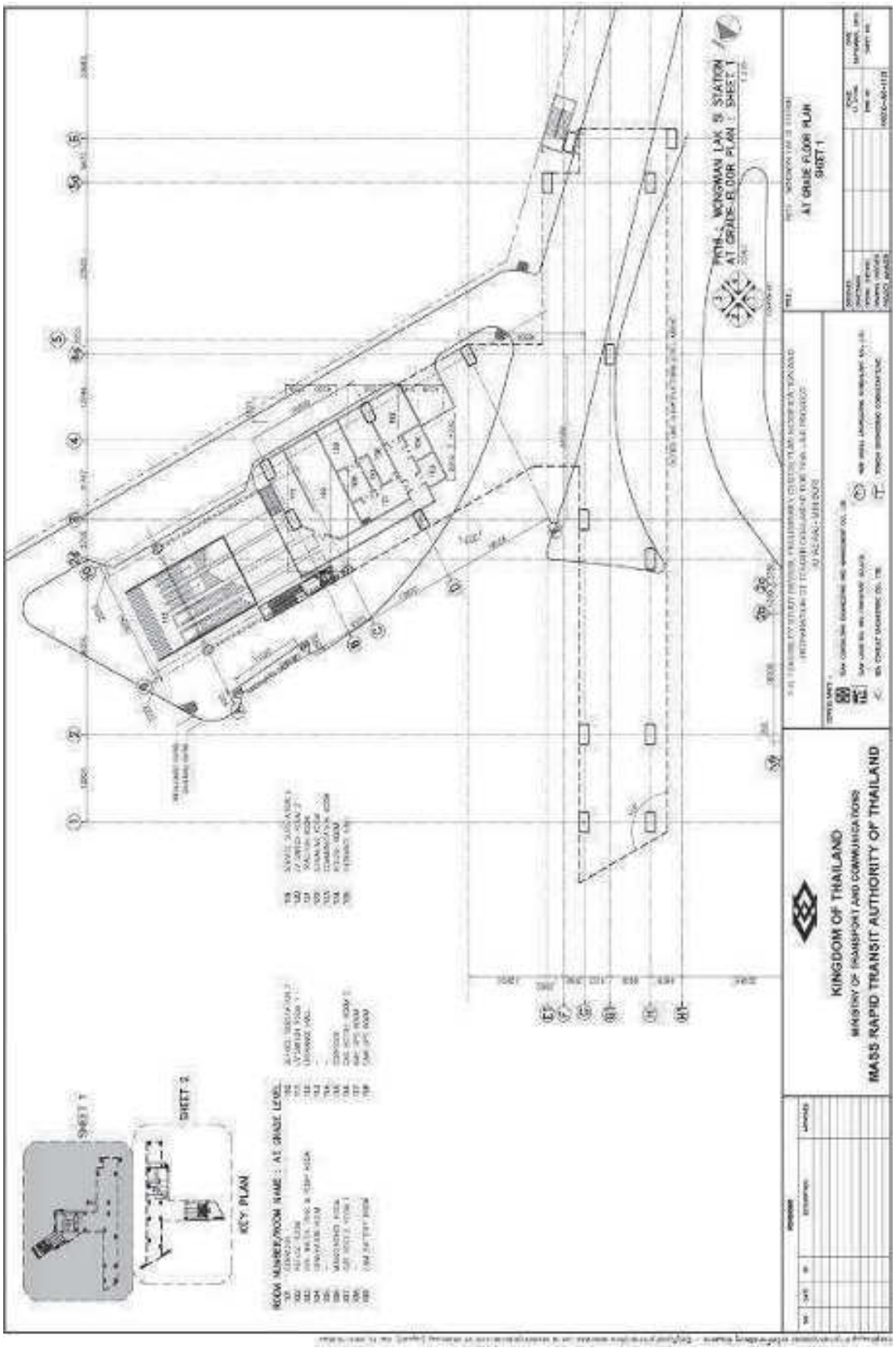


Figure 3.4-24 : At Grade Floor of Station Building Type 5 with 11.10-m Platform Height

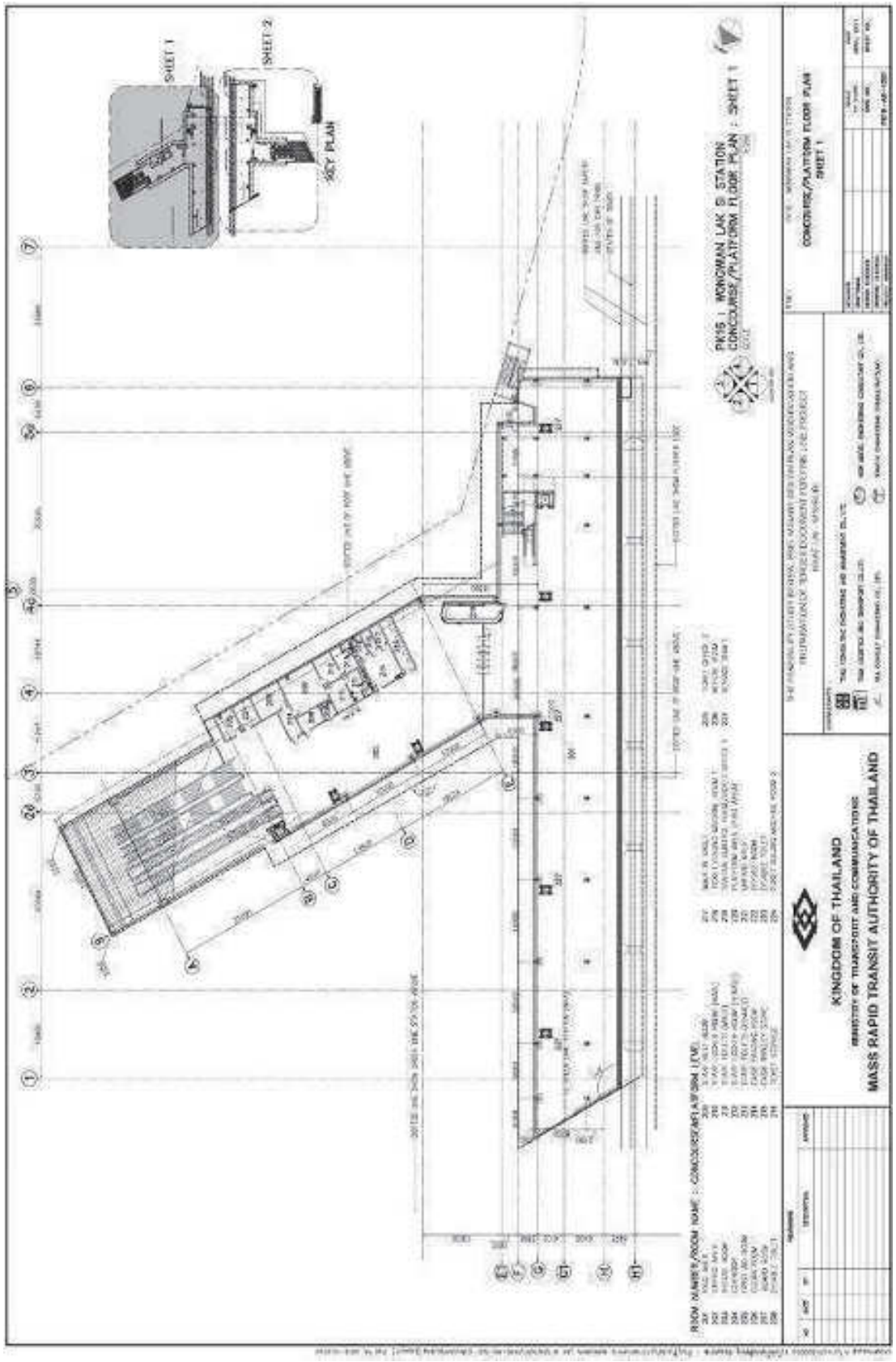


Figure 3.4-25 : Concourse/Platform Level of Station Building Type 5 with 11.10-m Platform Height

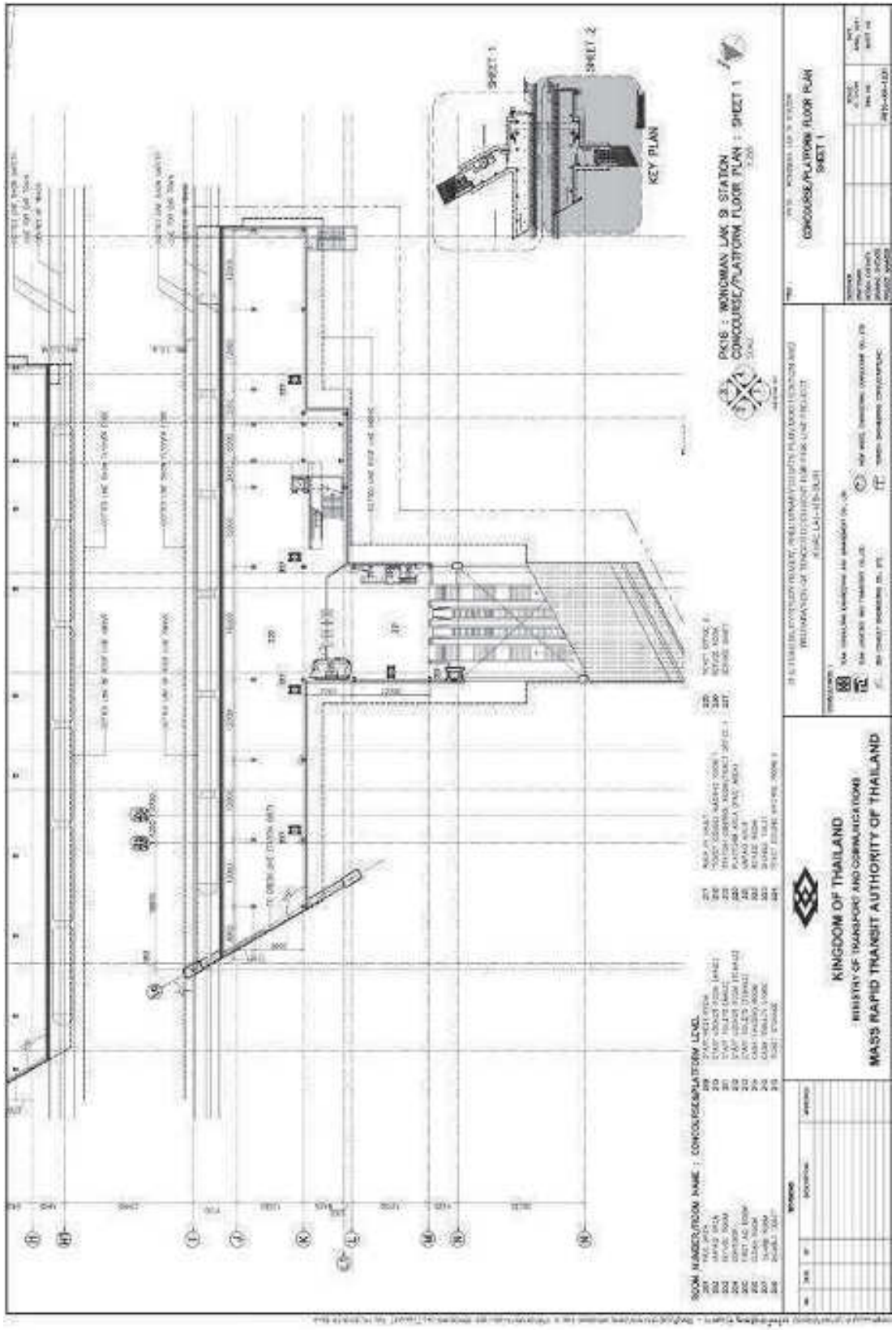


Figure 3.4-25 : Concourse/Platform Level of Station Building Type 5 with 11.10-m Platform Height

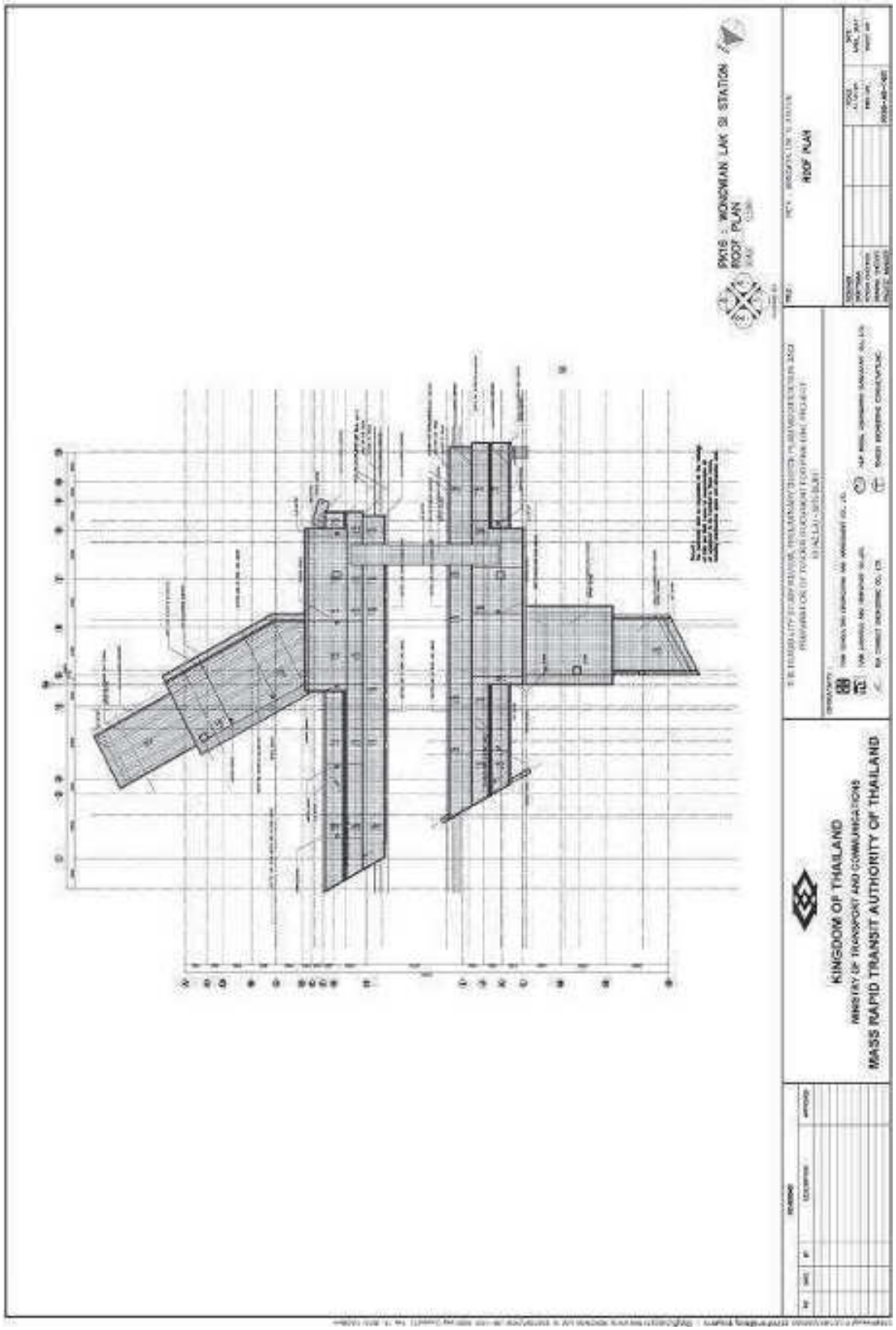


Figure 3.4-26 : Roof Plan of Station Building Type 5 with 11.10-m Platform Height

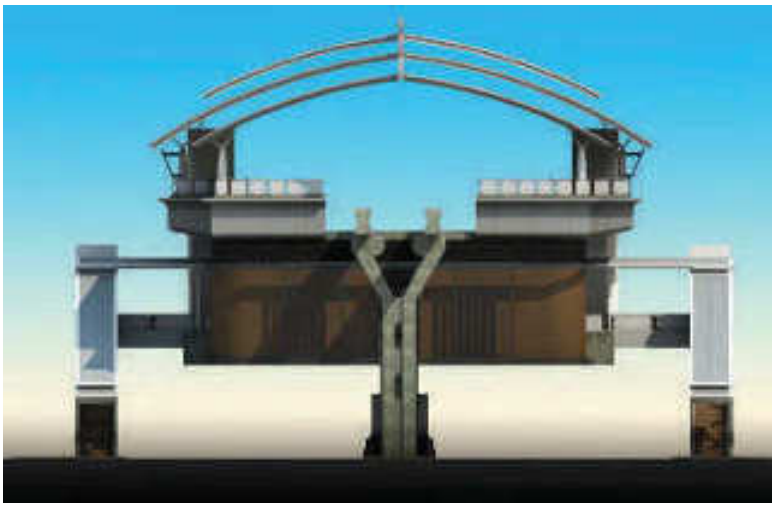


Figure 3.4-27 : Cross Section of Station

Figure 3.4-28 : Example of Station after Completion of Construction

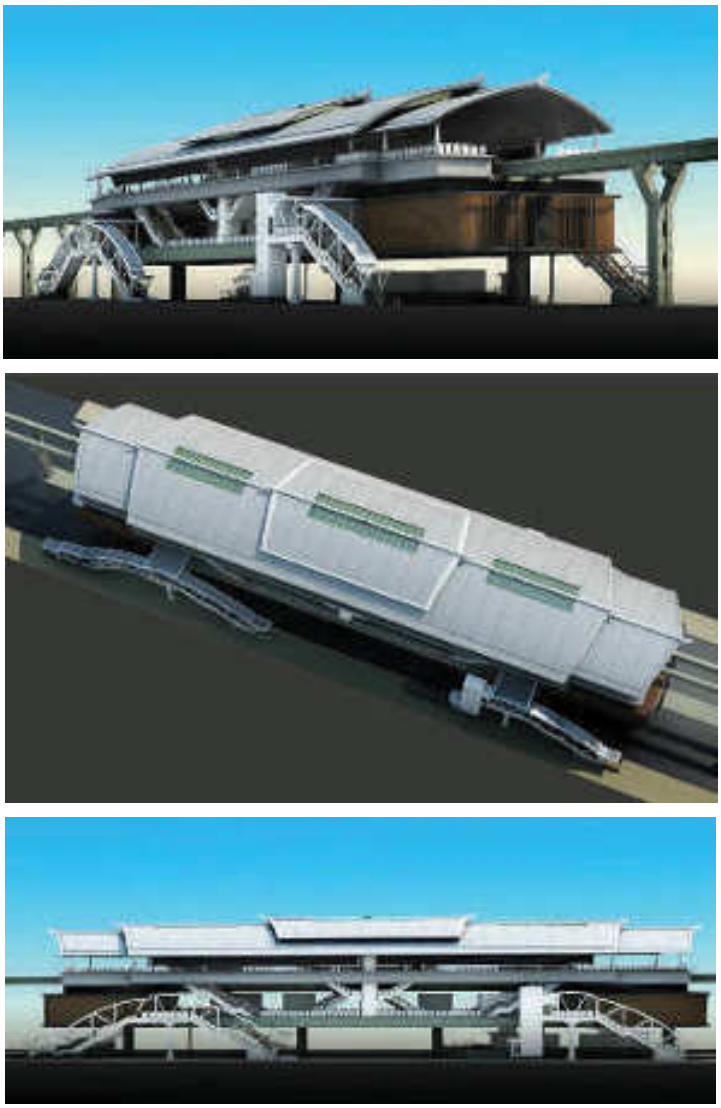


Figure 3.4-28 Example of Station after Completion of Construction (Cont'd)

(3) Functional Area Design Concept

Main concepts of the functional area design are as follows:

- Rooms and station components shall be carefully organized. Passenger area shall be separated from staff area and station equipment room. Zoning of station shall be clear according to functions.
- Stairs connecting concourse and platform, i.e. stairways, escalators, accessible lifts for the disabled, shall be suitably located to accommodate 6-car trains. Stairways and escalators shall conveniently serve passengers in both Normal Operation Movement and Emergency Evacuation Movement.
- Functional areas shall be arranged in accordance with the train operating system and building equipment system.

- In order to achieve cost effectiveness, size of stations shall be designed to suitably accommodate the number of passengers in each station.
- To renovate and expand footpaths near the stations in order to provide convenient entrance and exit.

The station layout arrangement is dependent upon the train operating system, services, and related building system as well as various factors such as passenger movement, etc. The station layout arrangement is presented in ***Table 3.4-1*****.**

Table 3.4-1 Functional Area Design Concept

Space		No.	Room Name	Area (sq.m)	
		A	At Grade Level		
Service Space		1	Refuse (Street Level) 2 Rooms	30	Store trash and waste waiting to be taken away
		2	Water Pump Room	30	water supply reserve
		3	Water Tank	30	Water storage tank
		B	Concourse Level		
Station Staff		4	Station Operation room /Ticket Office 1	25	Total system control for train operation, communication, elevator
		5	Ticket Office 2	15	Ticketing and change
		6	Cash handling Area	30	Store cash and important document waiting to deliver
			Cash Trolley Store	4	
			Ticket Storage room	4	
			Walk in vault	4	
		7	Staff Locker Room	20	Locker room for staff
			Staff Rest Room	40	Canteen /Rest Area
		8	Staff Toilet	30	Toilet room and shower for staff
		9	Disabled Toilet	6	Toilet for Disabled person
		10	First Aid/Stretcher Store	12	Store or cupboard to accommodate stretchers and first aid
		11	Guard Rm	6	Security Room
		12	Ticket Vending Machine 1	6	Ticket vending machines
		13	Ticket Vending Machine 2	6	Automatic ticket machines
		14	Refuse (Concourse)	6	Store trash and waste waiting to be taken away
		15	Maintenance	20	Room for mechanical maintenance technicians
		16	Clean Room	4	Store cleaning tool and detergent, tob should be hung up
Service Space	E&M	17	E & M UPS room	15	Installation of batteries for power back up
		18	E & M Battery Room	15	Installation of UPS&DC charger
		19	Service Substation room1	25	
			LV Switch Room	55	Installation of power supply equipments for the operation - Auxiliary Tranformers - Control equipment and relay panels - 24 kV. Swithcgear - LV Switchboard
		20	Generator Room	14	Area for the installation of generator and fuel storage tank
		21	Gas Bottle Room 1	6	
		22	Gas Bottle Room 2	6	
	M&E	23	Communication Room	32	Installation of communication equipment
		24	M&E UPS Room	25	Installation of batteries for power back up
		25	M&E Battery Room	25	Installation of UPS&DC charger
		26	Service Substation room 2	25	Installation of power supply equipments for the operation
		27	LV Switch Room	80	- Auxiliary Tranformers - Control equipment and relay panels - 24 kV. Swithcgear - LV Switchboard
		28	Signaling room	30	Installation of signaling equipments
		29	Traction Room	101	Installation of electrical supply equipments for train operation - Rectifier Transformers - Rectifiers -DC Switchgear -Control equipment and reply panels - 24 kV. Swithcgear
Paid Area		30	Concourse paid Area	Varied	
Unpaid		31	Concourse Free Area	Varied	
		C	Platform Level		
Service Space		32	Emergency Stair, Escalator & Lift	-	
		33	Platform Service Column	-	
		34	Platform area		

(4) Signage

(a) Standard Signs in Stations

- There are five types of station signage according to the following communication purposes.

(1) Directional Signs

Directional signs shall direct passengers to their destination inside and outside of the stations.

- Materials: Stainless steel frame, Aluminum Composite surface or Color Acrylic;
- Location: At entrances, exits, junctions, way-up and way-down;
- Installation: Hanging from upper structure;
- Color: Standard color of the background shall be white, with black letters.

(2) Identification Signs

Identification signs shall indicate room names, such as function of rooms/areas, e.g. public telephone, ticketing office; locations of facilities, etc.

- Materials: Laminate panel with stainless steel mounting;
- Installation: Wall fixing or hanging from upper structure;
- Color: White surface with black letters.

(3) Information Signs

Information signs shall provide information to passengers, e.g. route map, station location map, fare signs etc.

(4) Statutory and Warning Signs

Statutory and warning signs shall be installed in prohibited or hazardous areas, i.e. No entry signs, Do not enter track area signs, Wait here signs, etc.

(5) Notice Board

Notice board displays public messages to passengers such as announcement, general standard boards.

3.4.2 Accessible Facilities

The station design of Pink Line MRT Project has taken into consideration accessibility for the disabled and elderly, with accessible facilities such as ramps, lifts and toilets as well as accessible parking spaces and toilets at the park & ride building.

Persons with Disabilities Empowerment Act, B.E.2550 defines that “persons with disabilities/disabled persons” shall mean persons who encounter certain limitations in performing their daily activities or social participation due to impairment in vision, hearing, mobility, communication, mind, emotion, behavior, intellect, learning or any other impairment along with various difficulties, and specifically need some assistance to perform their daily activities or participate in social activities as ordinary persons.

There are 5 types of disabled persons who are eligible for MRT fare exemption, namely:

- Visual impairment
- Hearing or communication impairment
- Physical or mobility impairment
- Mental or behavioral impairment
- Intellectual or learning impairment

Universal Design for Mass Transit System is design for all user groups in the society, targeted at creating an accessible environment. For the design of mass transit system : an important public transport mode, accessibility shall be integrated into the building and facility design. This is to accommodate travel needs of all people including the elderly, disabled and disadvantaged people who have limitations to use or access to mass transit services in order to enable equitable use by all people.

(1) Universal Design

Universal Design, as illustrated in ***Figures 3.4-29***, is an environmental design concept of universally and equitably usable buildings and products for everyone in the society without any need for adaptation or specialized design for any particular group of people, whether they be female or male, persons with normal walking ability or requiring wheelchairs, persons with normal vision or visual impairment, a child or an adult, literate or illiterate persons, etc. The Universal Design takes into account usability and accessibility for everyone. Consideration is first given to address how to offer equal opportunity to people with different abilities to access buildings and facilities, such as the elderly, people with health problems, expectant mothers, short-statured persons, baby on pushchair, children, and persons with disabilities, e.g. visual impairment, hearing impairment, physical impairment, mental impairment, or illiterate persons, etc. Even though these people may have physical, intellectual or mental limitations, they are part of the society which should be taken care of so that they can happily live among persons with normal abilities. For example, ramps should be provided for sidewalks and public buildings to facilitate wheelchair users or tactile ground surface indicators for visually impaired persons. This will enable these people to conveniently and safely undertake outdoor activities.

Figure 3.4-29 Universal Design

Universal Design has broad meanings and incorporates great details. However, in summary, Universal Design is the design of environments, places and products

to be conveniently and safely usable by all people. The principles of Universal Design are presented in ***Figure 3.4-30.***

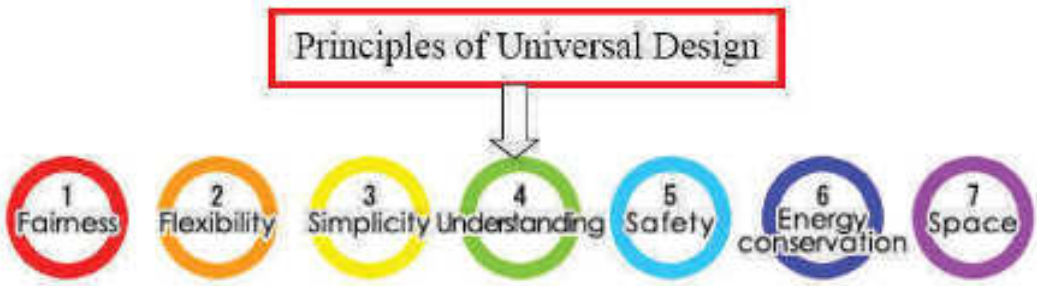


Figure 3.4-30 Elements and Principles of Universal Design

(2) Elements and Principles of Universal Design

The Principles of Universal Design are explained as follows:

(a) Fairness: The design provides equitable access for all people in the society without discrimination such as installation of public phones at 2 accessible levels: for adults and wheelchair users;

(b) Flexibility: The design accommodates right- or left-handed access and use or height adjustability;

(c) Simplicity: Use of the design is simple and easy to understand, such as pictures, explanation or international symbols for all groups of users, regardless of the user's knowledge or literacy level;

(d) Understanding: Necessary information is provided in a form that is easy to understand, with adequate explanation or pictogram;

(e) Safety: The design minimizes hazards and the adverse consequences of accidental or unintended actions such as provision of protective system in case of error, including fail-safe features;

(f) Energy Conservation: The design can be used efficiently and comfortably with minimum fatigue such as water tap with lever handle instead of twist handle;

(g) Space: Appropriate size and space is provided for approach, reach, manipulation, and use regardless of user's body size, posture, or mobility such as adequate size of toilet compartment and water closet for large persons, users of large wheelchairs, particularly sufficient turning space.

(3) Examples of Accessible Facilities for MRT Services

(a) Accessible telephones, taking into consideration different height of users and adjustability.

(b) Accessible telephones, taking into account wheelchair users and the elderly including people in general.

(c) Accessible ATMs, taking account of wheelchair users and wheelchair clearance beneath the ATM.

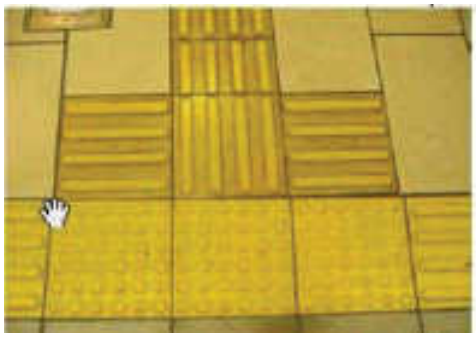
(d) Accessible ramp design for wheelchair users and the elderly

(e) Accessible toilets for wheelchair users, the elderly and expectant mothers

- Stainless steel bars will be installed in toilets for the elderly and expectant mothers. At least one accessible toilet will be provided for wheelchair users in public toilets (this can be used by expectant mothers, persons with children or baby pushchair, including diaper changing station).

Accessible Toilet Design with Braille Indicators on the Floor for Visually Impaired Persons

(f) Accessible walkway design for visually impaired persons will include tactile ground surface indicators to guide visually impaired persons to safe walkways. For example, ramps will be provided at walkway edges at intersections to facilitate wheelchair users, and tactile indicator tiles will be installed in the MRT station areas for visually impaired persons.

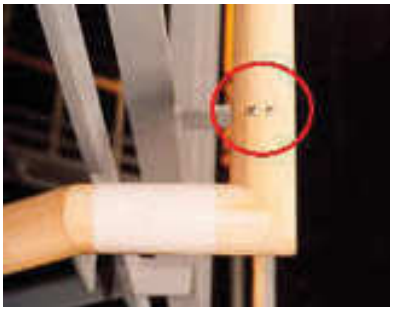



(g) Tactile floor surface will be designed and installed to provide inter-connectivity to public facilities around the station, resulting in safe and barrier-free circulation for visually impaired persons

(h) Accessible lifts will be provided for all people, with installation of call and control buttons for the disabled and wheelchair users as well as buttons with Braille marking indicators and tactile blocks for visually impaired persons

(i) Staircase Design

- Height of each step will be reduced and color strips installed to provide greater visibility. There will be several levels of stair handrails to facilitate people of different height such as children, adults, the hunchback elderly, etc.

- 
- 

- Braille indicators will be provided on stair handrails, giving information on the number of steps

(j) Station Entrance-Exit Design

- At least one large entrance-exit will be provided at the station building for wheelchair users or baby carriages.

(k) Design of On-Board Facilities

- For seating arrangement, a separate zone—clearly marked in yellow—will be specifically designated for expectant mothers, the disabled and the elderly. However, use of telephone will be prohibited in this zone as the telephone signal may pose danger to passengers in this zone.

(4) Design and Services

MRT station staff will facilitate the 4 types of the disabled who wish to use MRT services as follows:

(a) Persons with Visual Impairment

- Accessible lifts with Braille indicators will be provided at every station for visually impaired persons;
- Tactile floor surface will be designed for landings so as to facilitate visually impaired persons by indicating difference in floor level;
- Station staff will assist the disabled by offering an arm to visually impaired persons and then guiding the way;
- Station staff will warn visually impaired persons of every change in walking path level that may affect the safety such as ramp, different floor level or escalator;
- Station staff will facilitate the entry to the MRT via a special entrance gate;
- Station staff will assist passengers on the platform to enter a train;
- Staff at the departure station will coordinate with those at the destination station to take care of passenger safety when alighting from the train until leaving the station.

(b) Persons with Hearing or Communication Impairment

- Hearing impaired persons is incapable of verbal communication; therefore, it is essential to provide communication media such as leaflets, diagrams or pictures to explain how to request assistance and reply to frequently asked questions;
- Hearing impaired persons cannot hear announcements of station staff such as departure time, change of train schedule, change of platform, accidents, etc. It is necessary to provide visual announcements (Variable Message Signs) or special devices such as LCD monitors displaying a route map to inform passengers of current locations.

Upon arriving at stations, announcement will be made to inform passengers;

- Station staff will communicate with passengers via written message on paper to enquire about the destination;
- Station staff will facilitate disabled people's entry and exit from trains via special gate;
- Hearing impaired passengers while on board cannot hear verbal announcements of the next station; therefore, they do not know what station is next and whether it is their destination. During the nighttime when hearing impaired persons cannot see places or they may travel to a place where they have never been before, visual announcements (Variable Message Signs) are very vital on trains to inform passengers of the next station where the train is going to stop;
- Installation of rotating beacons inside the station for hearing impaired persons in case of an emergency so that they will be informed of an emergency situation and evacuation.

(c) Persons with Physical or Mobility Impairment

- Ramps will be provided for wheelchair users. Accesible lifts will be provided at every station;
- Road-level lifts will be closed at every station, with a signboard in front of the lift giving details about how to request use of lift. When a passenger wants to use a lift, he/she has to contact station staff;
- Station staff will assist disabled people's entry to trains from the station entrance via passenger lift;
- Station staff will facilitate the entry to the MRT via a special entrance gate;
- Station staff will assist passengers on the platform to get onto a train and lock the wheelchair;
- Staff at the departure station will coordinate with those at the destination station to take care of passenger safety while exiting the train until leaving the station.

(d) Persons with Intellectual or Learning Impairment

- A relative or carer must accompany a person with intellectual or learning impairment during travel. Station staff will facilitate the entry and exit from trains via a special entrance gate

For Pink Line MRT Project, facilities in the station building are designed for the elderly and persons with disabilities in accordance with the Ministerial Regulation on Accessible Facilities in Buildings for Disabled Persons and the Elderly, B.E.2548 (2005) (which was announced in the Royal Gazette Vol. 122, Part 52 (a) on 2 July 2005).

3.4.3 Landscape Architecture

Since the station length is not very long, landscape at traffic medians and footpaths shall be designed as hardscape. Two main reasons are low maintenance cost and convenience for disabled people.

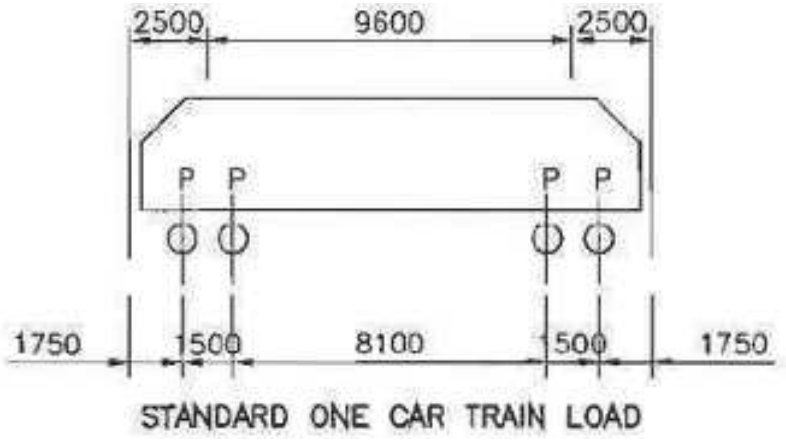
For stations with sufficient space for softscape, such as interchange stations, plants shall be selected taking into account ease of maintenance. Landscape design shall emphasize pleasant atmosphere and softened appearance of the station and structures.

3.5 TRACK BEAM DESIGN

The concrete I-Girder is the most suitable type for viaduct. As the viaduct is constructed on the traffic island, the construction period shall be as minimum as possible. This track beam will have some effects during transportation and lifting for installation only. Further, efficient quality control can be made in the manufacturing process because it was manufactured in the efficiently environmental control factory. In the installation step, components will be assembled on job site, the traffic will not be blocked or just partially be blocked while lifting components. Apart from affecting the traffic at minimum, the installation of this track beam can be made in an orderly manner with the least construction time compared to other designs. The concrete pier of viaduct is 2.0 meters in width, with the span length of approx. 25 meters. The pier is laid on a pile cap with the bored pile of 2.0 meters diameter.

3.5.1 Suitable Span Length of Monorail Track Beam

The design load of the monorail track beam shall be as shown in ***Figure 3.5-1.***



Remark: P = 110 kN for Crush load
= 80 kN for Empty train base on 5 kN/m over 3.2 m wide and 14.5 m long
Maximum operating speed 80 km/three or six cars per track

Source: Consultants, 2012

Figure 3.5-1 : Design Load for Monorail Track Beam

Typically, the track beam is a double track on a single pier. It consists of a guideway beam and a pier. A pier comprises crossbeam, column, footing and pile. The track beam will be impacted by loads, such as its own weight, train load, wind load, braking force, earthquake, etc. based on the conditions of combined stresses according to design criteria. The typical span length of 20.0 22.5 25.0 27.5 and 30.0 meters is shown in ***Figure 3.5-2*.**

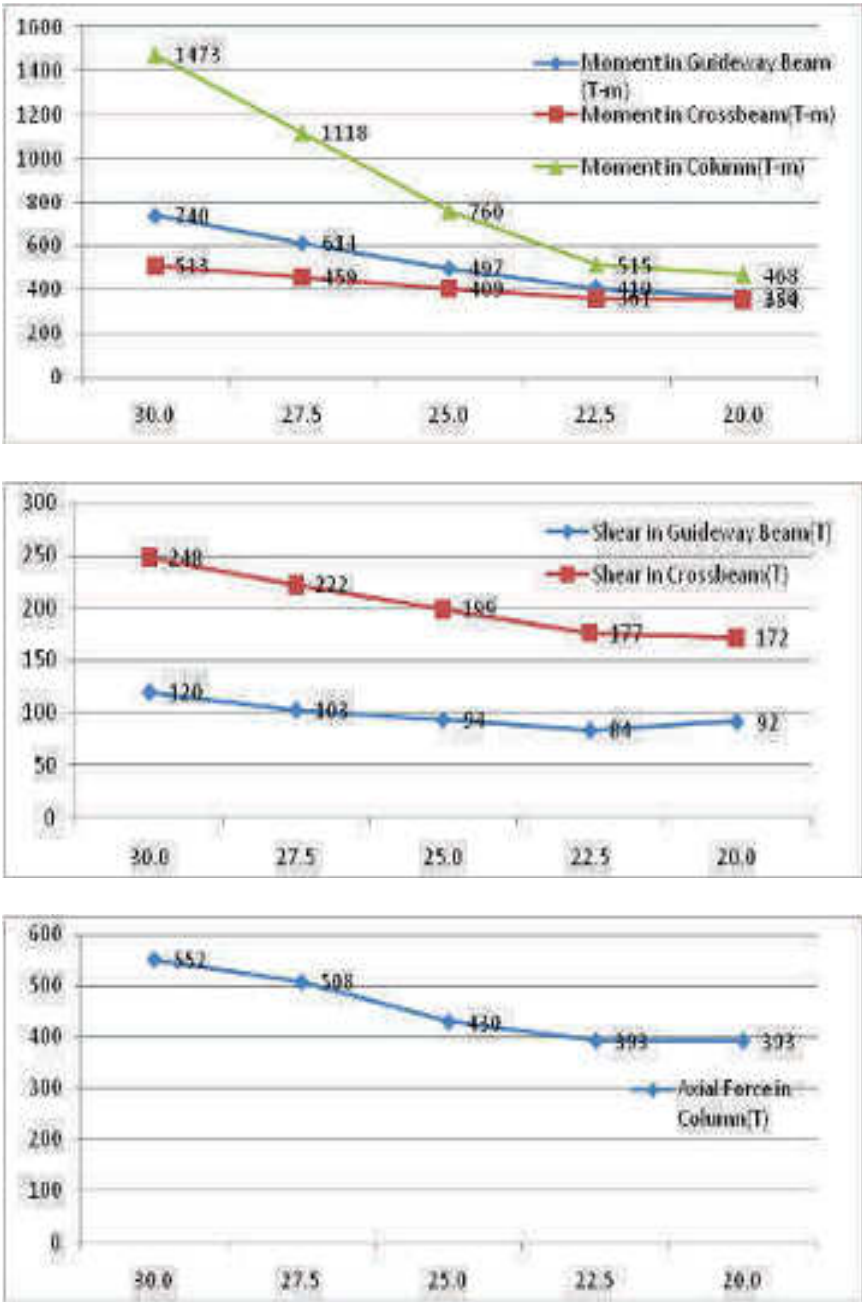


Figure 3.5-2 : Comparison of Forces of Track Beam for Span Length of 20.0, 22.5, 25.0, 27.5 and 30.0 meters

From ***Figure 3.5-2*** when the span length increases from 20 meters to 30 meters, main forces like moment, shear force, axial force, etc. which influence the size of the track beam will be greater. When the span length is longer than 25 meters, the moment in pier will be greater than when the span length is less than 25 meters. Large pier and footing make it more difficult for construction. In addition to this, it may be difficult to transport the pre-stressed concrete guideway beamthat is longer than 25 meters. Thus, the suitable span length should not be longer than 25 meters. A steel girder which is lighter than a concrete girder may be used to make smaller structure. Nonetheless, the construction and maintenance costs will increase. Regarding the typical span of the track beam,5 span continuous beams, which are suitable, and consistent with the structure of the Pink Line Project (Khae Rai-Min Buri section)are applied.

In brief, the pre-stressed concrete guideway beam should be constructed as it has suitable span length. Also, it is more durable and the maintenance cost is much less than the steel structure.

In the case that the guideway beam is constructed with the pre-stressed concrete girder of 20 meters in span length, the construction cost will be expensive due to the requirements of a large number of footings, earthworks and piers. This also causes poor vision on the ground.

In the case that the guideway beam is constructed with the pre-stressed concrete girder of30 meters in span length, it will be difficult to transport structural components. Furthermore, the long span, that requires the large footing, causes problems while constructing on restricted traffic islands. Moreover, the construction cost of this span length is approx. 50% higher than the span length of 20 meters and approx.30 % higher than the span length of25 meters.

Due to the aforesaid reasons, the Consultants chose the pre-stressed concrete girder of 25 meter long for the construction of the guideway beam. This is because the longest pre-stressed concrete girder of this size will not cause transportation problem. Besides, the footing size is not too huge for the construction on traffic islands. Even though the construction cost of this span length is about 20% higher than the span length of 20 meters, it is worth investing in terms of good view and better environment.

Track beam is composed of guideway beam and substructure.

3.5.2 Guideway Beam

The selection of such track beam makes it possible for efficient control of component manufacturing. The superstructure of the monorail is the precast girder. There are 2 types of beam based on the span length. Pre-stress concrete girder shall be applied for the guideway beam that does not exceed 25 meter long and steel girder bridge shall be applied for the guideway beam that is longer than 25 meters.

Type 1 As for the standard span that does not exceed 25 meter long, pre-stress concrete girder shall be applied as shown in ***Figure 3.5-3.***

Type 2 Regarding the long span with the span length of more than 25 meters, steel girder bridge shall be applied as illustrated in ***Figure 3.5-4.***

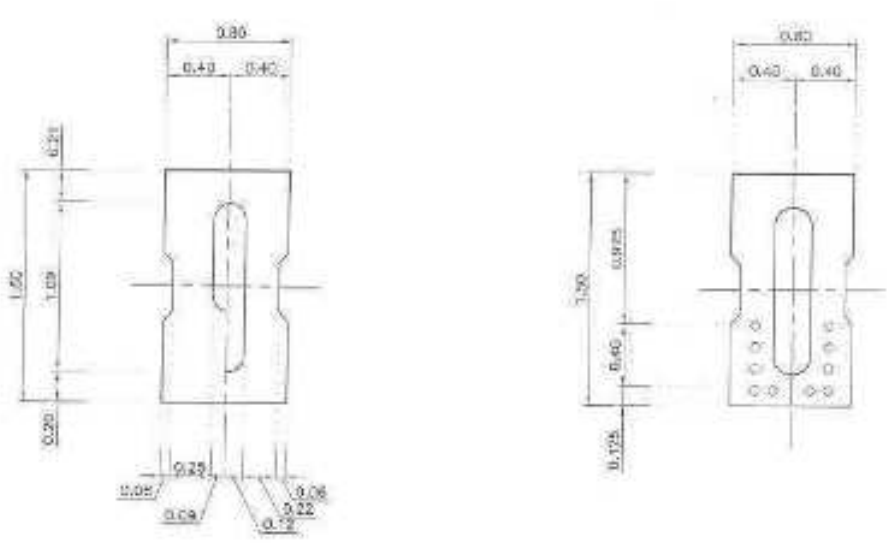


Figure 3.5-3 : Pre-stress Concrete Girder

3.5.2.1 Pre-stressed Concrete Guideway Beam

Pre-stress concrete I-Girder or steel girder bridge with the depth of 1.50 to 2.00 meters and the length of not more than 25 meters shall be used.

3.5.2.2 Steel Girder

It is used when the steel girder bridge is exceptionally long, that is, longer than 25 meters to 80 meters. The steel girder is applied in the sections that require long span like road crossing or canal crossing. It shall also be applied to the highway right-of-way of 30 meter wide or more as shown in ***Figure 3.5-4***.

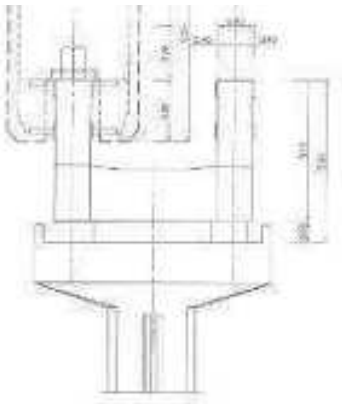


Figure 3.5-4 : Steel Girder Bridge

3.5.3 Substructure

Figure 3.5-5 and ***Figure 3.5-6*** show the cross section and dimension of the viaduct. There are 6 structures of pier that support the viaduct.

- One track on single pier : Concrete girder or steel girder bridge is used.
- One track on eccentric single pier : Concrete girder or steel girder bridge is used to support the one track monorail. The eccentric single pier is laid to avoid barriers.
- Double track on single pier : Concrete girder or steel girder bridge is used to support the double track monorail. The distance of the guideway beam is 4.3 meters.
- Double track on eccentric single pier: Concrete girder or steel girder bridge is used to support the double track monorail. The eccentric single pier is laid to avoid barriers. The distance of the guideway beam is 4.3 meters.
- Portal structure with 2 piers with one track and double track
- Portal structure with 3 piers and double track

The applied concrete pier of viaduct shall have the cross section of approx. 2.0×2.0 meters with approx. span length of 25 meters. Pile cap with a single pile of 2.0 meters diameter supports a concrete pier of viaduct as shown in ***Figure 3.5-5*** and ***Figure 3.5-6***.

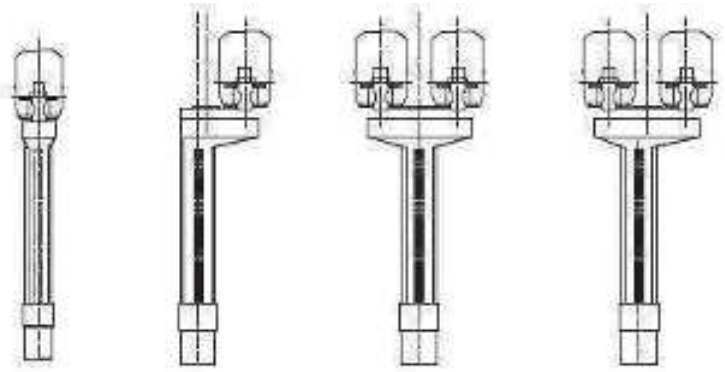


Figure 3.5-5 : Cross Section of Single Pier of Viaduct

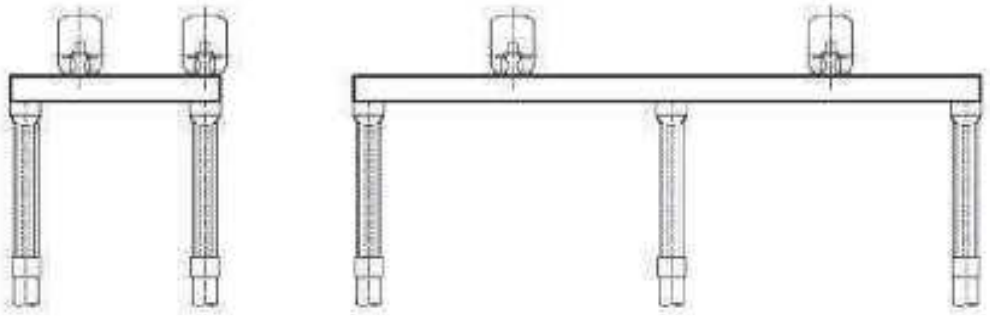


Figure 3.5-6 : Cross Section of Viaduct with Portal Structure

3.5.4 Construction Process of Viaduct

The civil works of the viaduct that passes over the road beneath start with the construction of bored pile, foundation, pier and installation of guideway beam, respectively. As bored pile work and the installation of guideway beam need the cut and cover, it is unavoidable to use some traffic lanes for the construction of retaining structure and bored pile. Therefore, some traffic mitigation measures are established.

(1) Coordinating with involved agencies for traffic planning for vicinities of construction area and suggesting other routes to avoid construction area;

(2) Controlling construction area making it impede the traffic as minimal as possible, managing lane transition and providing sign of construction area;

(3) Coordinating with all involved parties when traffic diversion is required; and

(4) Establishing traffic management plan that is consistent with the construction work plan, construction process and construction method of the track beam. Construction will be divided into sub-process to minimize impact on traffic flow during construction. Considerations will be made for important factors like road capacity before and during construction, soil transfer, construction material transportation, security and safety, etc. Traffic management plan during construction shall be considered and approved by directly involved agencies like Traffic and Transportation Department, Bangkok Metropolitan Administration, Royal Thai Police, etc. prior to starting construction.

3.5.4.1 Construction of Footing

A single large bored pile or two bored piles lining up in the same row shall be used in the Project as shown in ***Figure 3.5-7.*** This pattern of bored pile laying makes pile cap smaller than the width of typical traffic island which is approx. 4 meters. In the areas of considerable restrictions, barrette piles shall be used. An excavator with the narrow side of approx. 0.8to1.0 meter shall be operated instead of a drill bit. The advantages of using barrette piles include capability to work in limited area, horizontally and vertically. Also, larger size of the piles can be used through more excavation. However, the cost of barrette pile is more expansive than bored pile. In regard to pier, a single pier is typical as it is convenient and fast for construction. This is exceptional in some areas where the track centerline is not in the line of traffic island. In such areas, portal structure will be used instead of single pier structure. The construction process is detailed below.

The construction of pile, footing and pier for track starts with stripping of approx. 4 meter with the allowance of 2 meters on lateral sides for operation. As a result, the required construction area is about8meters.The construction area will intrude approx. 2 meters of the rightmost lane; so it remains 4 lanes on the road where the construction proceeds (2 lanes per direction). The construction in this part will last about 45 days: 28 days for pile work, 5 days for pier, 9 days for 3 viaduct piers(3 days for each pier) and 3surplus days. The construction zone of specific phase will be isolated for not exceed 150 meter long.

As for portal structure, the pier position is in the pavement line. The construction of footing and piers, which covers the area of approx. 8 meters in width,

requires lane closure on the pavement sides. The construction will be proceeded on the alternate side to avoid traffic problem. Then piers are constructed and the beam formwork of portal structure is installed. The installation will be made at nighttime with traffic closure for 1-2 hours while lifting the beam formwork for safety reason. Then the concrete beam is cast and pre-stressed, respectively when it has unconfined compressive strength as designed.

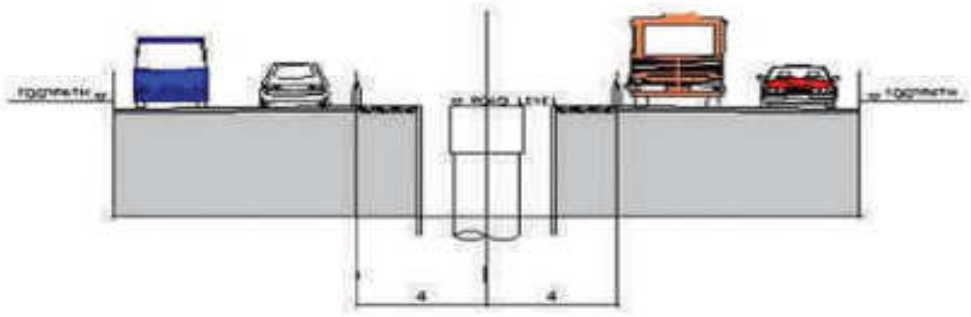


Figure 3.5-7 : Construction Area for Pile, Footing and Pier

3.5.4.2 Installation of Precast Girder when Track Passes Traffic Island Line

The installation of precast girder for monorail needs the area of approx. 4 meter wide for safety reason while casting closure joint. In this step, resurfacing work can be done concurrently. Once the precast girder is installed, road surface return can be done shortly.

3.5.4.3 Construction of Portal Structure when Track does not Passes Traffic Island Line

Portal structure shall be applied when the track centerline deviates from traffic island line. In this case, piers and footing shall be laid on the pavement line. The construction of portal structure needs traffic closure on the pavement side in order to build footing and piers in the area of approx. 5.0 meter wide. The construction will be proceeded on the alternate side to avoid traffic problem. Then piers are constructed and the beam formwork of portal structure is installed. The installation will be made at nighttime with traffic closure for 1-2 hours while lifting the beam cast for safety reason. Next, cast and pre-stress concrete beam, respectively when the concrete beam has unconfined compressive strength as designed as shown in ***Figure 3.5-8***.

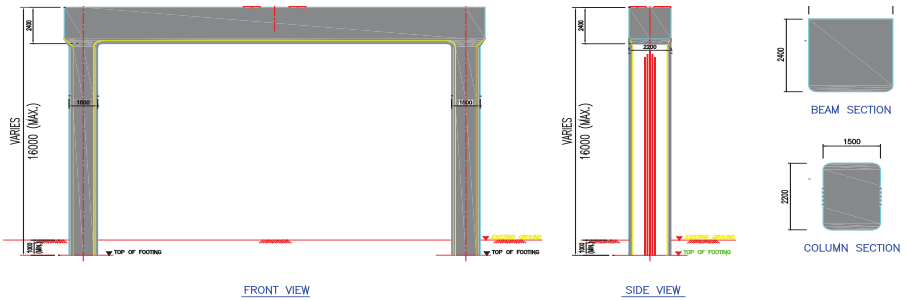


Figure 3.5-8 : Portal Structure with 2 Piles

3.5.4.4 Drop-Off Areas

The drop-off areas of the Pink Line Project (Khae Rai-Min Buri section) were designed at concave pavement. It is 15.0 meters long and 2.8 meters wide. The drop-off areas on both sides of the road are provided for 29 stations (PK01-PK29) as illustrated in ***Figure 3.5-9.*** After the completion of construction of drop-off areas for 29 stations, the pavement width shall be at least 1.50 meters. This distance complies with Building Control Act, B.E.2552 (2009). Drop-off areas are provided for personal cars, taxis, vans and public carriers that carry passengers to rail stations. Passengers will be dropped in a short period of time. Vehicles are not allowed to park in drop-off areas. The size of the designed drop-off areas is suitable for the current road condition where the project alignment passes. Drop-off areas were designed to avoid traffic disturbance. In addition, bicycle parking is provided at the ramp of stations on both sides of the road.

As for Min Buri station (PK30) which is the terminus of the Pink Line Project (Khae Rai-Min Buri section), the Consultants determined drop-off area at the Park & Ride of the Project. The drop-off area of Min Buri station (PK30) is about 30 meters away from the ramp of the station as shown in ***Figure 3.5-10.*** Therefore, it does not intrude current pavements. Besides, it is more convenient and safer for people to use the service.

The criteria for size and adequacy of drop-off area are as follows:

Criteria for Size and Adequacy of Drop-off Area

The Pink Line Project (Khae Rai-Min Buri section) which covers the distance of 34.5 kilometer sconsists of 30 stations. All stations were designed to be a public transport interchange so that rail users can be connected to other public transportation systems like buses, taxis, vans, personal cars and public carriers. Typically, intermodal transport facilities emphasize the design of drop-off areas. Drop-off area design requires the analysis and forecast of the number of passengers travelling in different modes to rail stations. Land use in the sub-areas around 30 stations shall be evaluated using Nonthaburi Comprehensive Plan and Bangkok Comprehensive Plan. Passenger transfer will be involved with related road network, car access and wayfaring, bus stop, temporary parking and connectivity to other mass rapid transit projects. The analysis and forecast of facilities procedures are given below:

(1) Evaluate the proportion of utilization of station vicinities applying Nonthaburi Comprehensive Plan and Bangkok Comprehensive Plan. Utilization of station vicinities, which plays an important role in determining travel modes of rail users, can be classified as follows : low density residential area, medium density residential area, high density residential area, agricultural land and official places, etc.

(2) Study the proportion of entry into and exit from stations such as wayfaring, by bus, by taxi, by motorcycle, etc. from other projects such as the Green Line Project (Mo Chit-Saphan Mai Section) and Airport Rail Link.

(3) Analyze the proportion of travel modes to stations and forecast the ridership of each station.

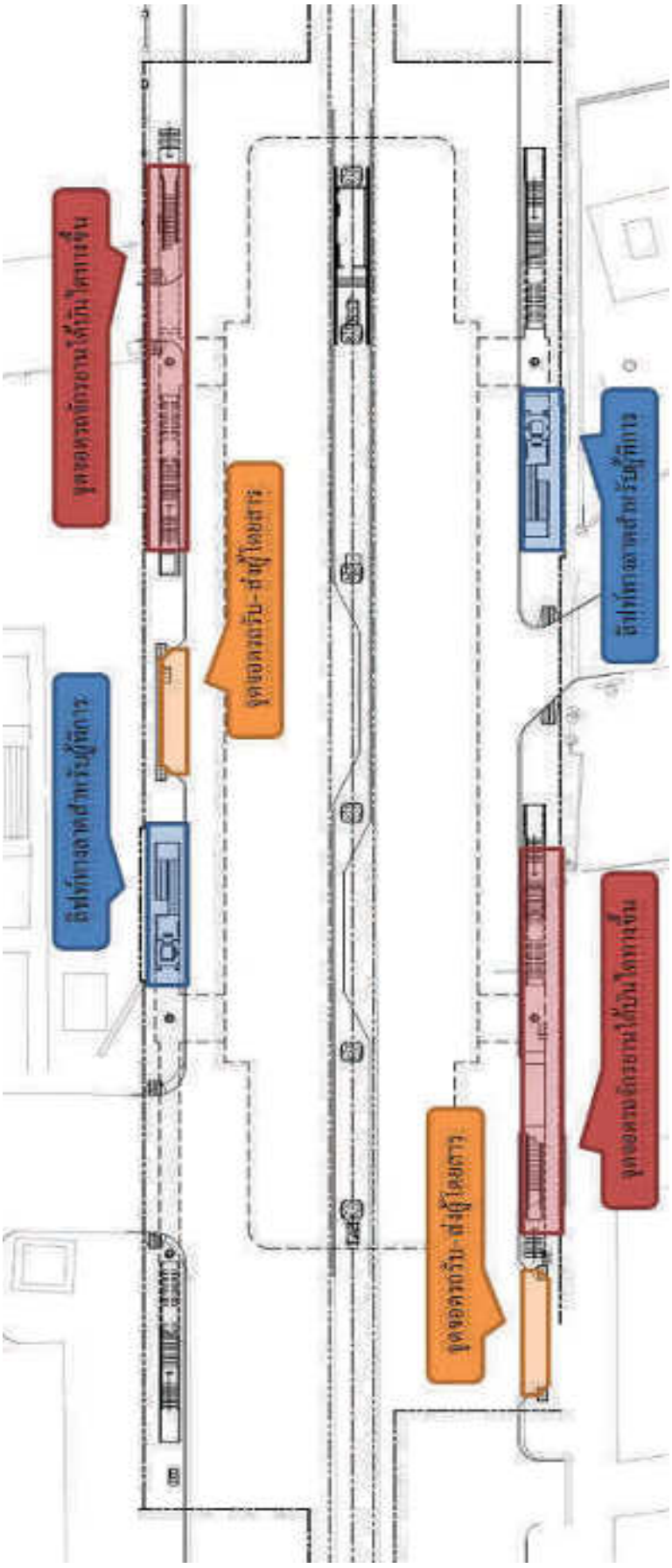


Figure 3.5-9 : Drop-off Area, Bicycle Parking and Elevator for Disabled Person at Station

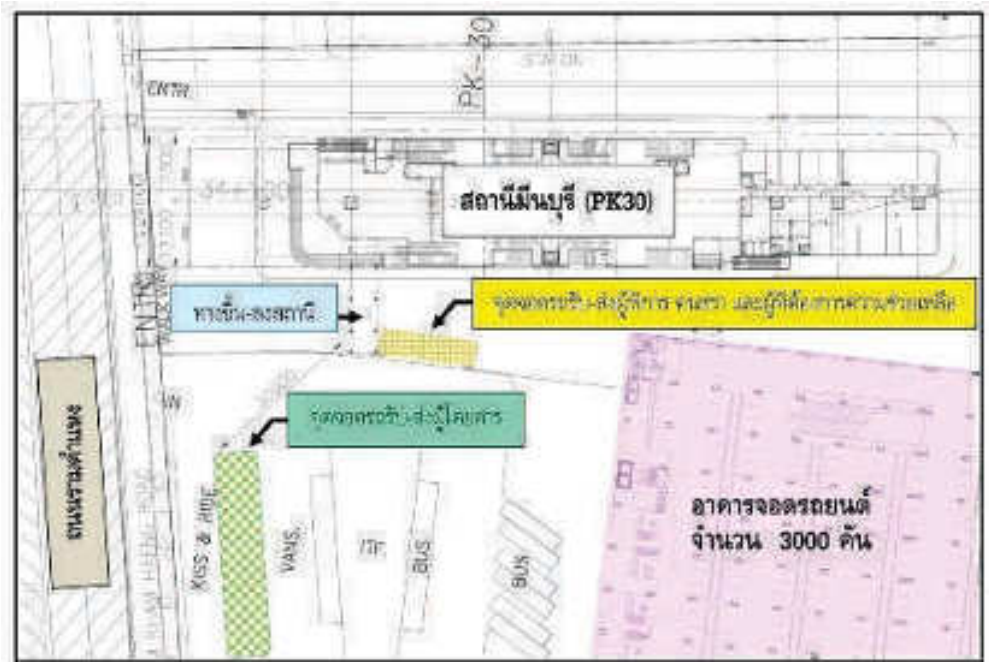


Figure 3.5-10 : Drop-off Area at Min Buri Station (PK30) in Front of Park & Ride

(4) Study an Average Vehicle Occupancy departure and arrival using case study projects. The resulting outcome will be used to calculate the number of vehicles of any kind for the whole day and peak hours.

(5) Study the time spent to pick up and drop off passengers of different modes of travel such as by car, by taxi, by bus, by public carrier, etc. to calculate service capability.All required data which are obtained are used for calculation of the requirement for facilities of each station for passengers of the Pink Line Project (Khae Rai-Min Buri Section). All required data are used for calculation of requirement for facilities of each station for passengers of the Pink Line Project (Khae Rai-Min Buri Section). These facilities consist of the stop and parking lot for buses, parking lot for van and minibus, the stop for public carriers and drop-off area.

It is necessary to design the Park & Ride for passengers of the Pink Line Project (Khae Rai-Min Buri Section) to reduce use of personal cars. According to this study, one Park & Ride at Rom Klao Intersection is required. This Park & Rideshares the area with the depot of the Project.

The 3-storey Park & Ride can accommodate 3,000 cars (1,000 cars/storey). Apart from this, the Consultants improved the open space of Pak Kret station (PK06) for use as outdoor car parking which can accommodate about 30 cars.

As not all 30 stations are located near bus stops and the request for additional bus stops needs to be approved by involved agencies such as Bangkok Metropolitan Administration (BMA) and Bangkok Mass Transit Authority (BMTA), the Consultants assigned the drop-off areas beneath 29 stations (PK01-PK29) on both sides of the road, 1 Park & Ride (Min Buri station-PK30) and 1 car parking (Pak Kret station-PK06) for the convenience of the public.

The environmental impact preventive and mitigation measures of transportation during operation period were recommended as follows:

- Coordinating with involved agencies such as Bangkok Mass Transit Authority (BMTA) and other mass transit systems for efficient transfer of passengers;
- Performing traffic management on the roads where the project alignment passes for consistency with mass transit systems;
- Providing staff members for facilitation at stations and providing U-Turns and road signs in proper areas; and
- Performing structural design for the convenience and safety of way farers, such as designing pavement with adequate width for the safety of pedestrians, designing the skywalk that connects rail stations with other mass transit systems, etc.

To prevent traffic congestion during rush hours in the morning and in the evening at rail stations during operation period, the Consultants established environmental impact preventive and mitigation measures of transportation as follows:

- Installing no-parking sign on existing road network at rail stations starting from the entry to rail stations and 50 meters next to rail stations; and
- Allowing public carriers, personal cars and taxis to pick up and drop passengers at the designed drop-off areas only.

3.5.4.5 Road Settlement and Solution Approach

(1) Assessment of road settlement along the project alignment

Roads laid on Bangkok Clay have always faced settlement after they are in service because of the low strength of soil, low permeability and high compressibility. Road settlement, in general, is caused by consolidation. This is because the weight of road structure and traffic lead to excess pore water pressure, which will be drained gradually.

Apart from consolidation and the weight of road structure which press the pier, land subsidence in Bangkok Metropolitan and its vicinity area results from 2 main factors below.

(a) Human beings behavior : Excessive use of groundwater for a long period of time can cause land subsidence in wide areas. The subsequent impacts from land subsidence include flooding, cracks in buildings and the national economic loss.

(b) Natural cause : Bangkok Metropolitan and its vicinity area are situated in the lower Chao Phraya Basin which consists of Bangkok clay having natural compressibility. Therefore, soil fatigue due to the long support of the weight of the structure can cause land subsidence.

The construction of footing of the project located on existing road may cause differential settlement. As piers are laid on piles, they have small-scale settlement. However, roads have large-scale settlement. The large-scale settlement may cause deformation of road surface as illustrated in ***Figure 3.5-11***. As a result, it is necessary to evaluate potential road settlement and design the prevention system of road surface

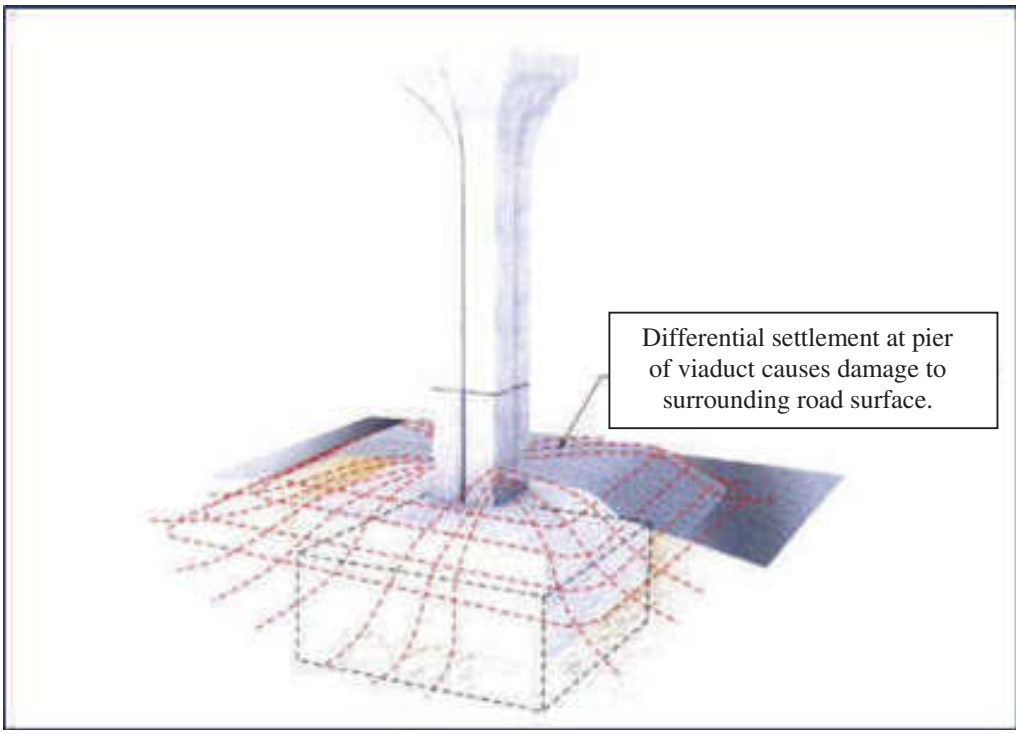


Figure 3.5-11 : Impact from Differential Settlement at Pier of Viaduct and Road

damage resulting from differential settlement. Owing to the fact that the road in the project area was constructed and has been used for a very long time, it is implied that the consolidation settlement of the Bangkok clay because of the weight of the embankment and the pavement structure no longer occurs. Thus, the potential long-term settlement will be resulted from groundwater pumping and natural compressibility. This settlement evaluation refers to land subsidence level in Bangkok Metropolitan due to groundwater pumping, 2002-2007 as shown in ***Figure 3.5-12*.** The study reveals that land subsidence level along the project alignment will be less than1 centimeter/ year. Considering road settlement in 50 year-service life prior to resurfacing, it will subside for not more than50 centimeters.

However, soil boring shall be determined in the detailed design. Furthermore, the data of land subsidence as a result of groundwater pumping shall be collected for the clear analysis of subsidence.

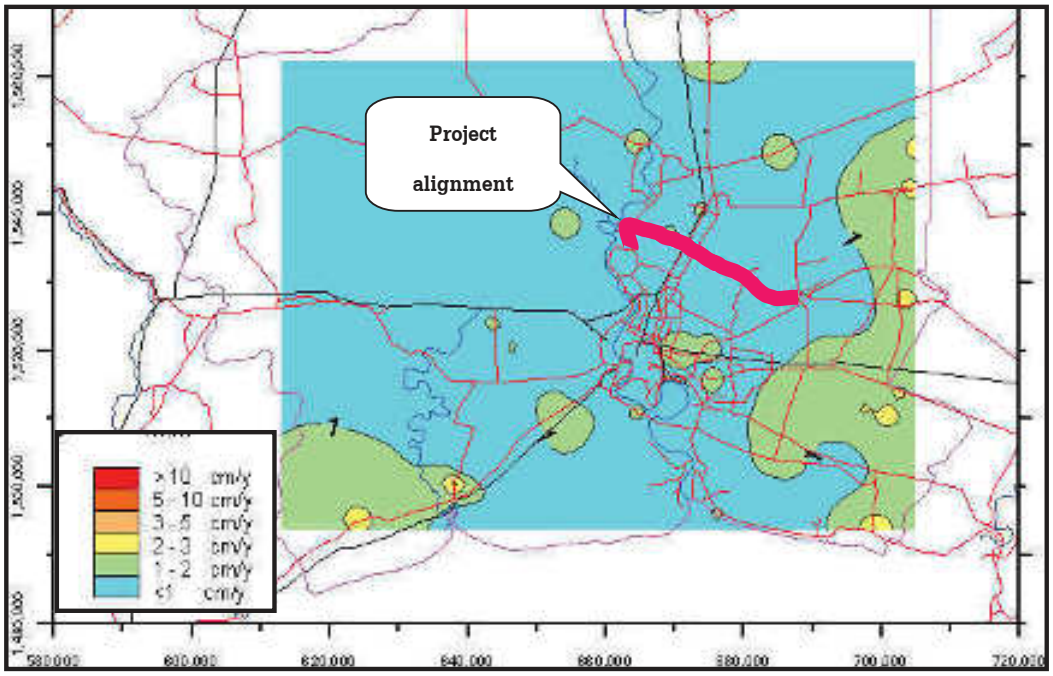


Figure 3.5-12: Contour Line of Land Subsidence due to Groundwater Pumping in Bangkok from 2002 to 2007

(2) Solution approach

To solve the problem of differential settlement between the piers of viaduct and the road, both structures shall be separate so that the settlement of one structure affects the other at minimal. The concept is the least strain and stress transfer should happen between the piers of viaduct and the road with the most independent movement in vertical direction.

The transition structure that minimizes differential settlement and reduces damage to road surface is shown in ***Figure 3.5-13(a)***. The separate structures of road and the pier of viaduct are shown in ***Figure 3.5-13(b)***. The transition structure covers the pier of viaduct that is overlapped with road surface. The transition structure has space designed for differential settlement in the vertical direction of the road and the pier of viaduct. This structure contributes to the avoidance of damage to road surface.

(3) Settlement between piers

As the pier of viaduct is constructed on piles of approx. 50 meter long, less settlement occurs. In the design, it is determined that differential settlement not exceed $L/1500 \leq 30$ mm. where L is the distance between piers. The differential settlement was included in the analysis of secondary loads in the structure design.

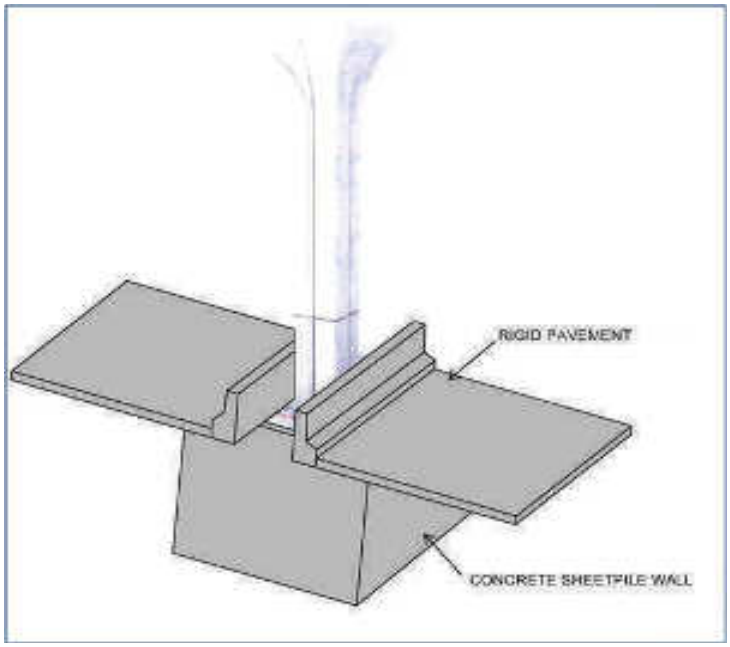


Figure 3.5-13(a) : Transition Structure for Differential Settlement at Pier and Roads Surrounding Pier

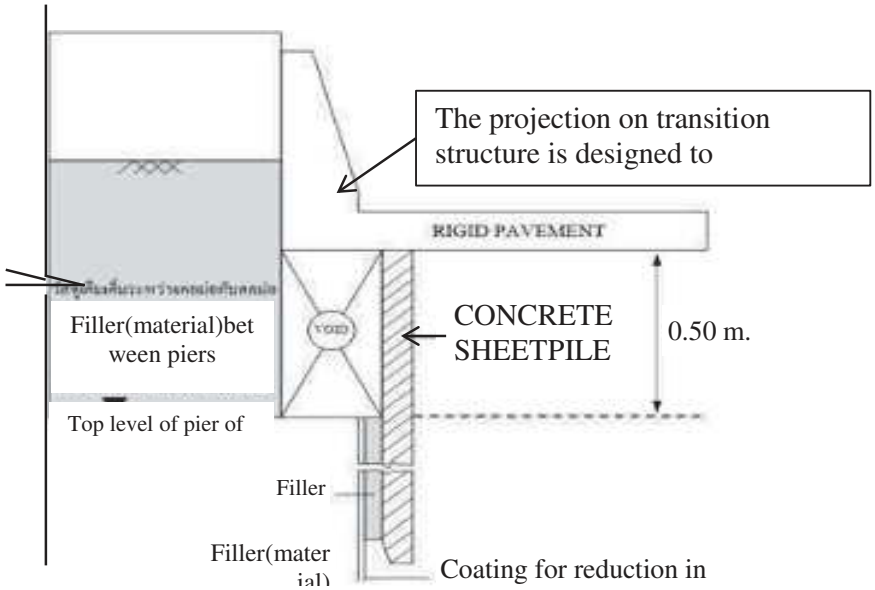


Figure 3.5-13(b) : Separate Structures Minimizing Settlement of Road and Pier of Viaduct

There are 2 causes of pile settlement: immediate settlement due to load and consolidation settlement due to land subsidence and constant load. As the end of the pile is deeper than 50 meters, pile settlement in the long-term will be minimal. Load test will be conducted for immediate settlement. The service load (pile capacity) shall not make pile settlement exceed 25 millimeters. That is to say settlement from the service load of each pier shall not exceed 12.5 millimeters. Combined with consolidation settlement, it shall not exceed 25 millimeters. Differential settlement throughout the project life shall not exceed $L/1500 \leq 30$ millimeters within 100 years of the service life of structure.

3.6 DEPOT AND PARK & RIDE BUILDING

3.6.1 Selection of Site and Size of Depot and Park & Ride Building

The criteria for depot site selection include the following.

(1) Sufficient space for stabling all trains and for necessary maintenance facilities, as well as a safe area specifically for Monorail operation management;

(2) Appropriately arranged facilities for maintenance and repair, such as stabling track, main workshop with separate areas for heavy and light maintenance, other structural systems, stabling yard, train washing plant, workshop, office for maintenance and operation control staff, etc.;

(3) Flat area with no slope because stabling tracks must be constructed in a flat area;

(4) The site will be closest to the main line for convenience and shortening the approach track as well as reduction of operation costs;

(5) Connection of the approach track with the main line of monorail;

(6) Adjacent to an access road for convenient inbound and outbound transport of monorail cars and spare parts.

The site selection study shows that there is one suitable site for depot and park & ride building, i.e. the area at the end of the project route near Rom Klao intersection which is a large parcel of flat land, with an area of about 366,400 sq.m or 229 rai. It is adjacent to Ramkhamhaeng Road and Rom Klao Road which will be convenient for inbound and outbound transport of monorail cars and spare parts. Monorail patrons can reach the depot and park & ride building via two routes: Ramkhamhaeng Soi 192 and Rom Klao Road. The location of depot at Rom Klao intersection is depicted in ***Figure 3.6-1***, and the existing conditions of the site are shown in ***Figure 3.6-2***.

Feasibility Study of Depot and Park & Ride Building

The National Environment Board approved the Environmental Impact Assessment Report of Pink Line MRT Project of Office of the Transport and Traffic Policy and Planning (currently implemented by MRTA) on March 16, 2012. The previous study identified 2 depots and park & ride buildings for Pink Line MRT Project, Khae Rai-Min Buri section, i.e. Sanambin Nam intersection and Rom Klao intersection. However, the current study reveals that the site at Sanambin Nam intersection was a land lot under non-performing loan (NPL) of a commercial bank and was bought by Nonthaburi City Municipality for construction of a recreation center for the elderly and a warehouse. The center and warehouse are currently under construction. Therefore, this area cannot be used as the site of depot and park & ride building.

The survey of surrounding areas along the 34.5-km project alignment shows that there is no land lot that is large enough to be an alternative site to replace the land at Sanambin Nam intersection. If a large area is still required for construction of depot and park & ride building, a large number of land lots and built structures need to be expropriated. This will result in resettlement and land acquisition impacts with high acquisition costs. Therefore, to avoid such effects, the Consultants have designed a larger depot and park & ride building which will be built at Rom Klao intersection. The originally-planned area of 50.57 rai has been expanded by another 178.43 rai; therefore, the total area for the depot and park & ride building is 229 rai. This land size is sufficient

Figure 3.6-1 Location of Depot and Park & Ride Building at Rom Klao Intersection

Figure 3.6-2 Existing Conditions of Depot and Park & Ride Building Site at Rom Klao Intersection

to accommodate all trains of the Pink Line, a total of 56 trains, and 3,000 car parking spaces as well as an increased number of trains resulting from the government's policy of 20-baht flat fare. A larger building can be built because the existing land uses at Rom Klao intersection are paddy fields and grass farms. To reduce the operation and maintenance (O&M) costs arising from the operation of empty morning trains from the terminal station PK30 Min Buri to the first station PK01 Nonthaburi Government Center, a stabling area for 4 trains is provided at Nonthaburi Government Center so that trains can park in the nighttime and start services right away in the morning.

Therefore, there is only one depot and park & ride building at Rom Klao intersection for Pink Line MRT Project, Khae Rai–Min Buri section. It has potential to adequately provide services to the Pink Line patrons in the future. In addition, the large park & ride building that can accommodate 3,000 cars will attract more people to use MRT services. This will also help reduce the use of private cars and alleviate the current traffic congestions.

Additionally, the Consultants have arranged a vacant area at PK06 Pak Kret Station to be car parks for private cars and public cars to cater for MRT passengers. The parking area for private cars is at grade open area for 30 cars. A parking area is also provided for public cars such as vans, taxis, etc. Passengers can access the MRT station through 2 routes: Tiwanon Road and Chaeng Watthana Road. Internal road system in the station has been designed for passengers' convenience and safety, with details presented in ***Figure 3.6-3***.

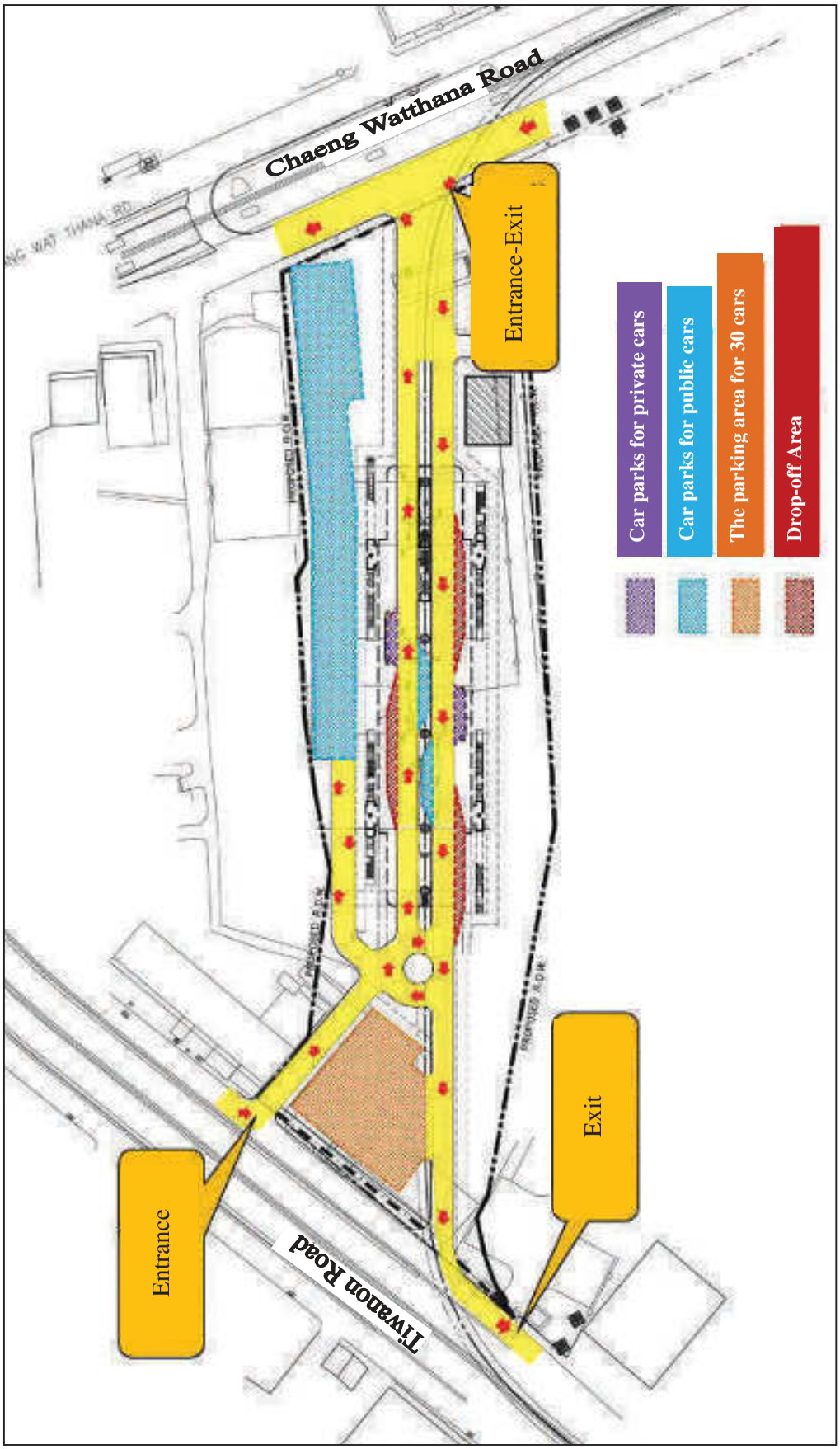


Figure 3.6-3 Car Park and Public Car Park at PK06 Pak Kret Station

Pink Line MRT Project, Khae Rai-Min Buri section, is one of the mass rapid transits incorporated into the Mass Rapid Transit Master Plan in Bangkok Metropolitan Region (M-MAP) with interconnection with 4 mass rapid transit projects, i.e. Purple Line, Bang Yai–Bang Sue section; Commuter Train System (Red Line), Bang Sue–Rangsit section; Green Line, Mo Chit–Saphan Mai section; and Orange Line, Bang Kapi–Min Buri section. A park & ride building has been designed for each of the 4 lines that intersect the Pink Line alignment in order to facilitate passengers, with details as follows:

Purple Line, Bang Yai–Bang Sue section, has 2 park & ride buildings. One is located at Nonthaburi Intersection 1 Station, with 470-car parking capacity. The other is located at Bang Rak Noi- Tha It Station with 1,244-car capacity. Passengers living around Rattanathibet Road, Bangkok-Nonthaburi Road and vicinity can park their cars at the two park & ride buildings to use the Purple Line and then can connect to the Pink Line at PK01 Nonthaburi Government Center Station-the starting station of Pink Line MRT Project, Khae Rai–Min Buri section.

Commuter Train System (Red Line), Bang Sue–Rangsit section, has 1 park & ride building, located at Bang Sue Grand Station with 1,000-car capacity. Passengers living in Bang Sue and vicinity can park their cars to use the Red Line and get on the Pink Line at PK14 Lak Si Station.

Green Line, Mo Chit–Saphan Mai section, has 2 park & ride buildings, located at Km. 25 Station with 1,043-car capacity and at Khu Khot Station with 713-car capacity. Passengers living in Rangsit, Lam Luk Ka, Pathum Thani, and vicinity can park their cars to board the Green Line and then connect to the Pink Line at PK16 Wat Phra Si Maha That Station.

Orange Line, Bang Kapi–Min Buri section, has 2 park & ride buildings, located at Min Buri Station with 3,000-car capacity (a joint facility with the Pink Line), and at Khlong Ban Ma Station with 1,200-car capacity. Passengers living in Ramkhamhaeng, Hua Mak, Bang Kapi, Saphan Sung, Bueng Kum and vicinity can park their cars to connect to the Orange Line and Pink Line at PK30 Min Buri Station.

Therefore, people will be able to park their cars at the park & ride buildings provided by these four projects, with service area coverage in Bangkok and Nonthaburi. The parking areas are sufficient to meet the passengers' need. As a result, expropriation of additional land and built structures along the alignment of Pink Line MRT, Khae Rai–Min Buri section, is not required, leading to the reduction of resettlement and land acquisition impacts.

3.6.2 Design Criteria for Depot and Park & Ride Building

(1) Track Design Criteria

The design criteria for monorail track inside the depot and stabling yard are as follows:

- Minimum curve radius: 50 m
- Maximum gradient of approach track: 50%
- Minimum track center: 3.7 m

(2) Minimum Distance between Tracks

- Distance between stabling tracks: 8.0 m

- Distance between train inspection tracks and monthly inspection tracks: 10.0 m
- Distance between workshop tracks: 12.0 m

(3) With the limited workshop area, the storage for spare parts will be located on the first floor beneath the workshop floor.

(4) Maintenance vehicles will park in the depot and the stabling yard.

(5) The Operation and Control Center (OCC) will comprise the following.

- Operation and Control Center
- Administration Office
- Operation Department
- Car Maintenance Department
- Track Maintenance Department
- Electrical Maintenance Department
- Signaling and Telecommunication Maintenance Department
- Meeting rooms/Conference rooms
- Visitor rooms
- Accommodation facilities for drivers
- A bulk substation will be located inside the depot.

(6) All workshop equipment in the depot is shown on ***Table 3.6-1***.

Table 3.6-1 Workshop Equipment in the Depot

Shop	Equipment & Facility
Train Air Blowing Shop	Air Blowing Facility
	Oil Free Air Compressor with Air Tank
	Compressed Air Piping with Header(coupler)
	Air Hose, Quick Coupler and Air Blow Nozzle
	Cabin Access Step Ladder
	Manual Movable Work Platform with Wheel Lock
	General Tools
	Dust Respirator and Protection Glass
Train Washing Shop	Semi-Automatic Train Washing Plant
	Portable Work Gangboard (Front/Rear Hand Cleaning)
	Water Jet
	Industrial Wet/Dry Vacuum Cleaner
	Floor Cleaning Mop
	Handy Washing Mop
Maintenance Service Vehicle Shop	75kN Overhead Traveling Crane
	Traverser
	Maintenance Service Vehicle (self drive)
	Shunting Vehicle (self drive)
	Construction Gauge Inspection Trolley
	Crane Trolley (towed by MSV)
	Oil Free Air Compressor with Air Tank
	Carbody Lifting Beam (2 units/set)
	Carbody Support Stand with Spring Back Caster

Table 3.6-1 Workshop Equipment in the Depot (Cont'd)

Shop	Equipment & Facility
Maintenance Service Vehicle Shop (Cont'd)	Cabin Access Step Ladder
	Battery Boom Lift (with Battery Charger)
	Manual Movable Work Platform with Wheel Lock
	Portable Welding Machine (onboard)
	Portable Electric Tools (grinder/drill/cutter/etc)
	Portable Manual Fuel Pump
	Work Bench with Vice
	Sling Wire and Shackle
	General Tools
Tyre Replacement Shop	75kN Overhead Traveling Crane
	Bogie Drop
	Carbody Support Stand (2 units/set)
	Tire Clamping & Lifting Jig
	Nitrogen Gas Charging Facility
	Cabin Access Step Ladder
	Skirt Support Stand
	Portable Work Platform
	General Tools (bar/hammer/etc)
Train Inspection Shop	Cabin Access Step Ladder
	Nitrogen Gas Charging Facility
	20kN Monorail Hoist with I-beam Runway
	High Level Platform with Ladder (building scope)
	Portable Roof Access Gang board
	Manual Movable Work Platform with Wheel Lock
	Special Designed Inspection Devices (Hitachi)
	General Tools
Car Body Maintenance Shop	150 kN Overhead Traveling Crane
	Carbody Lifting Beam (2 units/set)
	Carbody Support Stand with Spring Back Caster
	Cabin Access Step Ladder
	Battery Boom Lift (Battery Charger)
	Coupler Testing Stand
	Spring Coil Testing Stand
	Air Cock Testing Stand
	Pantograph Bearing Disassembling Jig
	Pantograph Testing Stand
	Air Conditioning Unit Cleaning Stand
	Permanent Coupler Assembling Jig
	Permanent Coupler Buffer Assembling Jig
	Center Pin Assembling Jig
	Rubber Buffer Assembling Jig
	Coupler Assembling Jig
	Hand Lifter
	Manual Movable Work Platform with Wheel Lock
	General Tools
Bogie Maintenance Shop	Bogie Air Blowing Booth
	Bogie Inspection Stand (2 bogies/unit)
	Gear Unit Inspection Stand
	TIG Welding Machine
	Manual Parts Washing Basin
	Magnetic Flaw Inspection Device
	Bearing Hydraulic Press
	Heat Shrinking Oven
	Ultrasonic Inspection Device

Table 3.6-1 Workshop Equipment in the Depot (Cont'd)

Shop	Equipment & Facility
Bogie Maintenance Shop (Cont'd)	Running Wheel Bearing Box Disassembling Jig
	Slip Ring Alignment Measuring Jig
	Gear Case Assembling Jig
	Emergency Wheel Assembling Jig
	TD Coupling Assembling/Disassembling Jig
	Tyre Changer (stabilizing/guide tyres)
	General Tools
Motor Maintenance Shop	Traction Motor Testing Stand
	Traction Motor Assembling & Disassembling Unit
	Traction Motor Support Stand
	Di-Electric Testing Unit
	Small Scale Motor Testing Stand
	General Tools
Pneumatic Component Maintenance Shop	Air Brake Testing Stand
	Pneumatic Electric Converter Testing Stand
	Pneumatic Valve Testing Stand
	Air Compressor Testing Stand
	Ultrasonic Cleaning Unit
	Parts Storage Racks
	Working Table with Vice
	Various Standard Gauges
	General Tools
Carbody Painting Shop	Air Ventilation Facility
	Carbody Trolley
General Electric Electronics Maintenance Shop	General Purpose Device
	Battery Charging & Discharging Unit
	Parts Storage Racks
	Working Table with Vice
	General Tools for Electrical Work
General Mechanical Maintenance Shop	General Purpose Device
	Working Table with Vice
	Parts Storage Racks
	General Tools
General	Compressed Air Supply System
	Effluent Treatment Facility
	Portable Winch
	Battery Forklift (battery charger)
	Floor Cleaning Sweeper
	Pallet for Component Transportation

3.6.3 Location and Design Concept of Depot and Operation and Control Center, and Park & Ride Building

(1) Location of Depot and Park & Ride Building

The depot and park & ride building of Pink Line MRT Project, Khae Rai–Min Buri section, are located on a 229–rai land lot on Ramkhamhaeng Road near Ramkhamhaeng Soi 192. The north side of the land is adjacent to Ramkhamhaeng Road which is 38 m wide. Its east side adjoins Ramkhamhaeng Soi 192. Its west side is adjacent to Khlong Song Ton Nun which is about 20 m wide. Irrigation canal and agricultural areas are located to the south. The location of depot and park & ride building at Rom Klao intersection is depicted in ***Figure 3.6-1***.

The layout of depot and park & ride building was determined, taking into account convenient use and functional relationship between buildings and activities, so as to achieve optimum utilization and continuous flow of functions. Emphasis is also given to provision of necessary facilities for staff, maximum safety and efficient evacuation in case of an emergency. The management of the depot and park & ride building is explained in details as follows:

(2) Layout Arrangement of Depot and Park & Ride Building

The internal management of the depot and park & ride building at Rom Klao intersection is divided into two main activities: park & ride building and depot, with details as follows:

Park & ride building is a 3-storey building, located adjacent to Ramkhamhaeng Road. The total area is about 50.57 rai, with parking capacity of 3,000 cars (1,000 cars/floor).

Depot is located behind the park & ride building, on 178.43 rai of land. The depot consists of Administration and OCC Building, main workshop, bulk substation, hazardous building, storm water pump house, wastewater treatment plant, guard house, stabling yard for 56 trains, and canteen. The details of layout arrangement are presented in ***Table 3.6-2***, and ***Figures 3.6-4 to 3.6-13***.

Table 3.6-2 Components of Depot and Park & Ride Building

No.	Building/Office	Number of Floors	Usable Area (m^2)	Building Size (m) (W x L)
DE01	Administration and OCC building	5	3,965	13x61
DE02	Main workshop	1	12,782	77x166
DE03	Park & ride building	3	95,064	136x233
DE04	Bulk substation	2	924	21x22
DE05	Hazardous building	1	136	8x17
DE06	Storm water pump house	1	27	5x5.40
DE07	Wastewater treatment plant	2	221	6.50x17
DE08	Guard house	1	8.32	2.60x3.20
DE09	Stabling yard	1	31,240	142x220
DE10	Canteen	1	960	24x40

Source: The Consultants, 2012

(3) DE01: Administration and OCC Building

It is a 5-storey building, with a total area of approximately 3,965 m^2, 13 m wide and 61 m long. The perspective of Administration and Operation Control Center (OCC) building is shown in ***Figure 3.6-14*** and the perspective inside the OCC building is presented in ***Figure 3.6-15***.

In the OCC building, there are meeting room, power supply control room, transformer room, chilled water and water pump room, battery room, emergency generator room, low voltage power supply room, OCC room, and SCADA system. It is the center that controls and monitors the overall power supply during and after the service. The staff can control the following systems

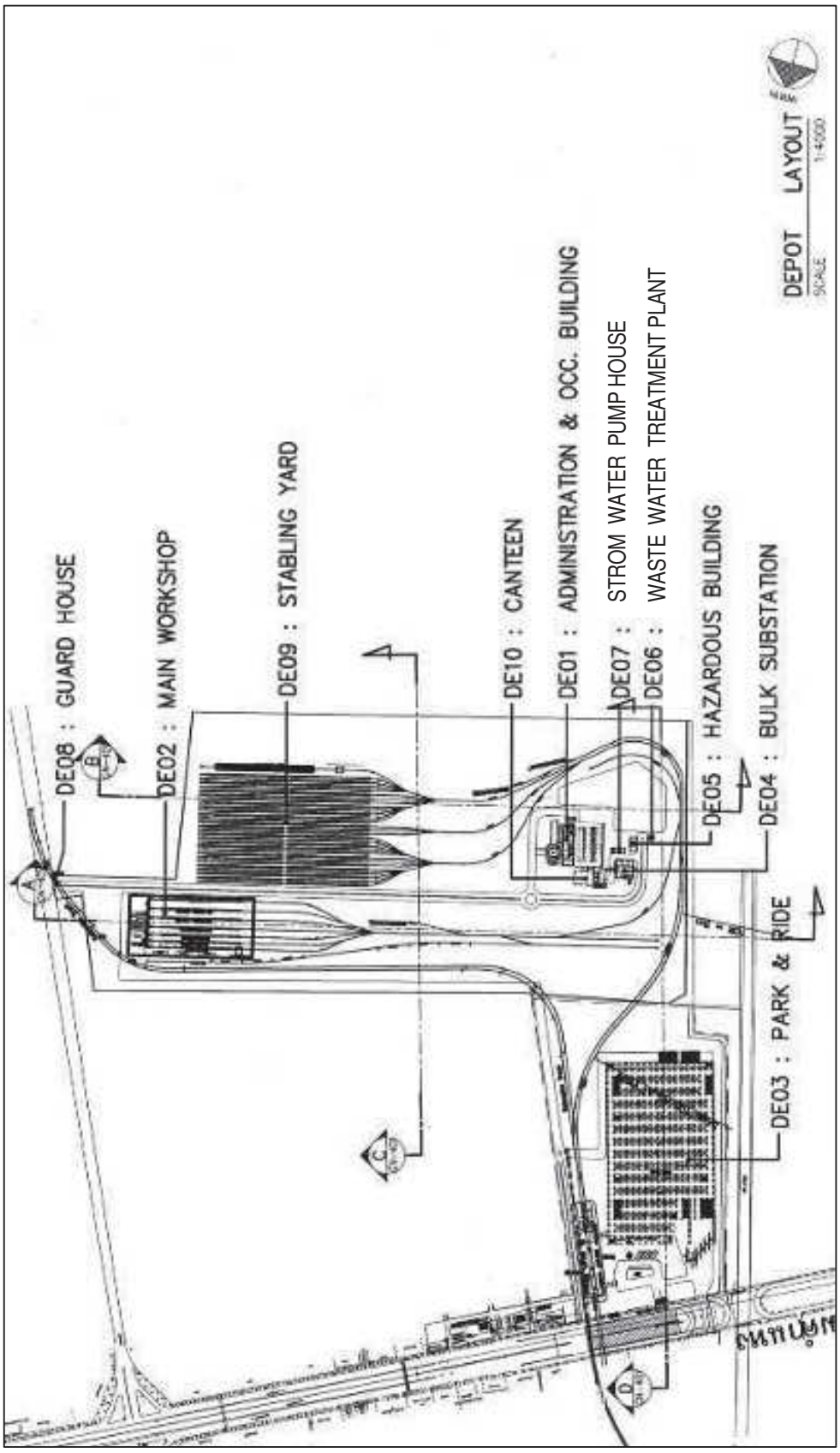


Figure 3.6.4 Layout of Depot and Park & Ride Building

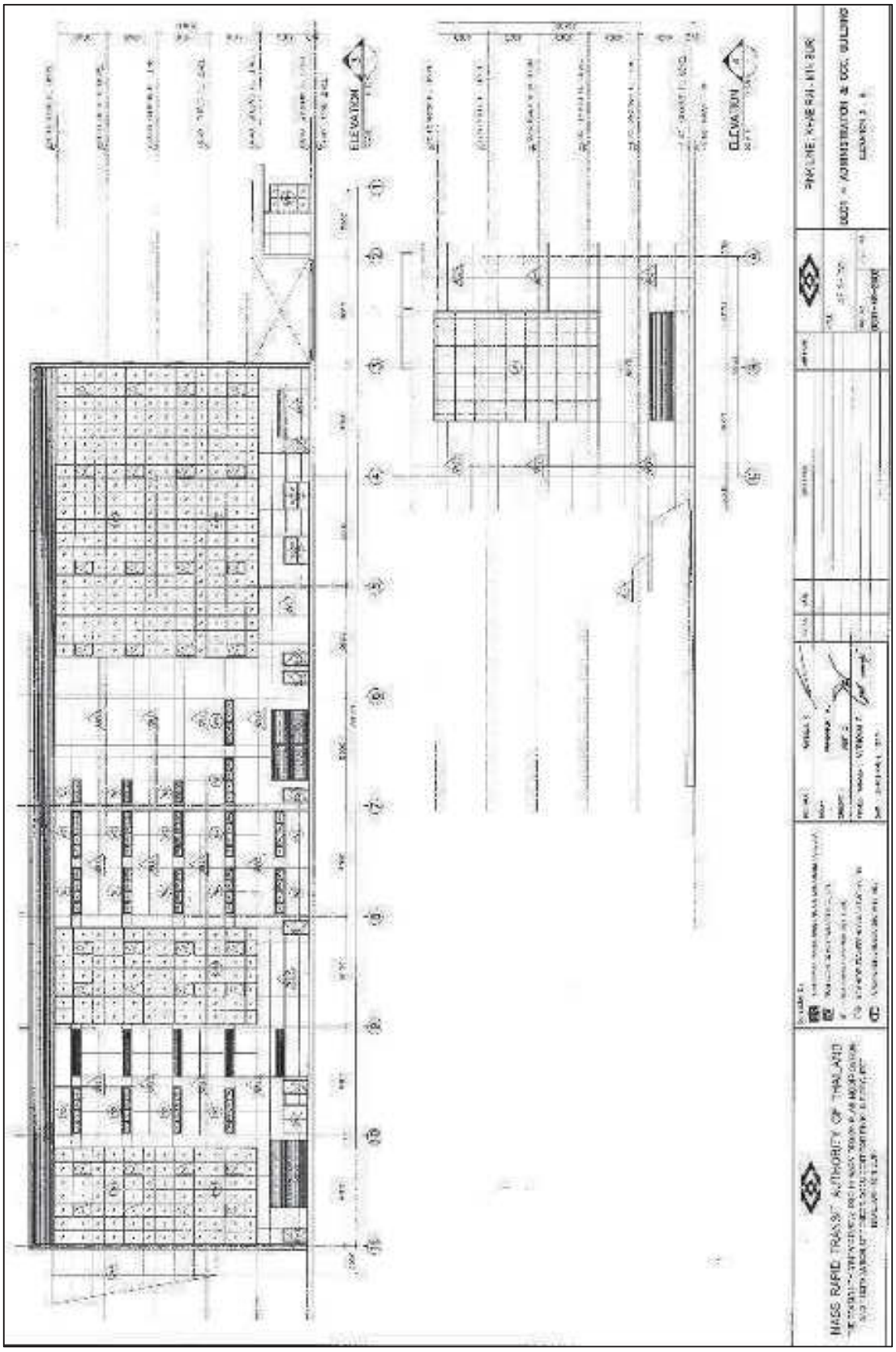


Figure 3.6.5 Layout of Administration & OCC Building

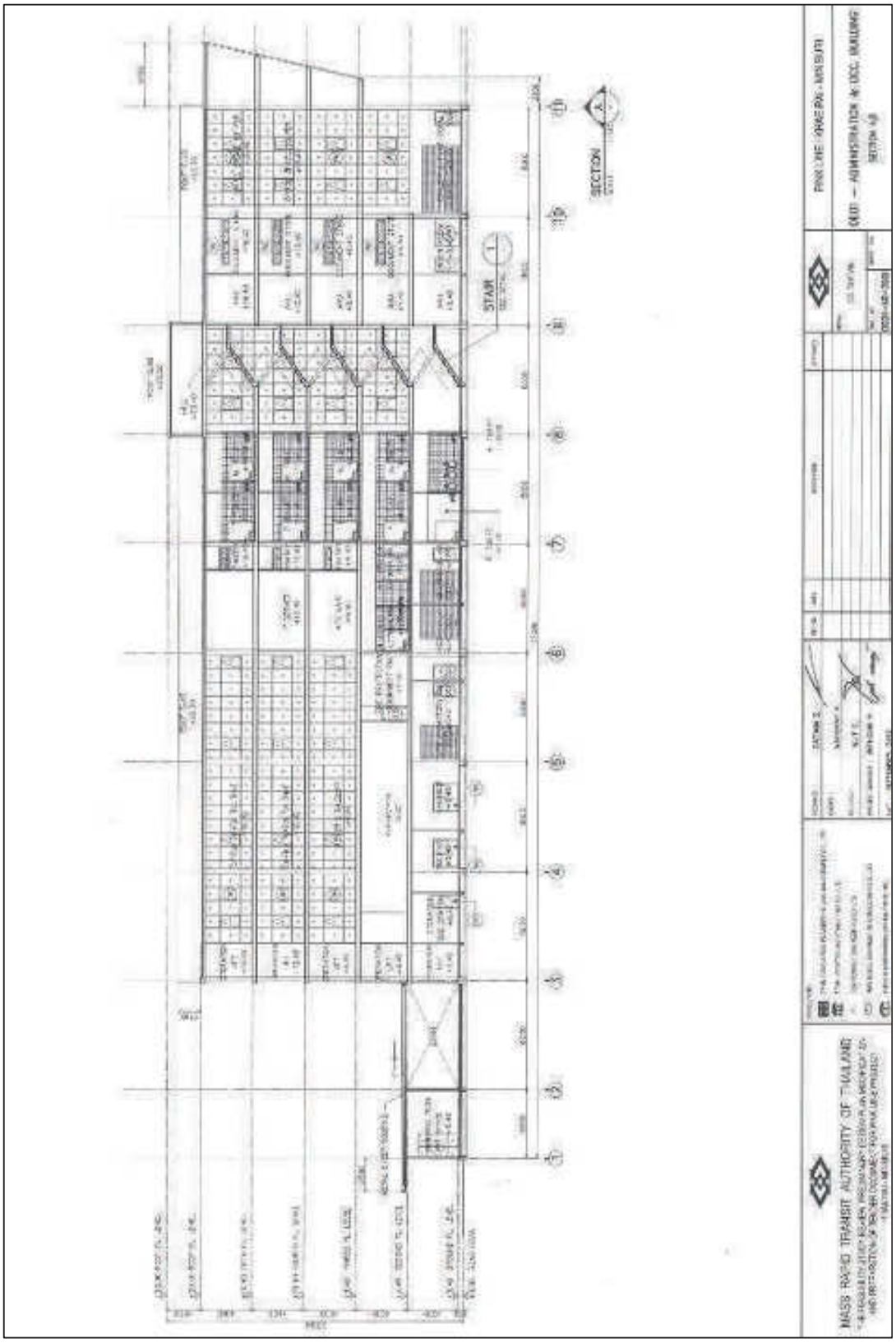


Figure 3.6.5 Layout of Administration & OCC Building (Cont'd)

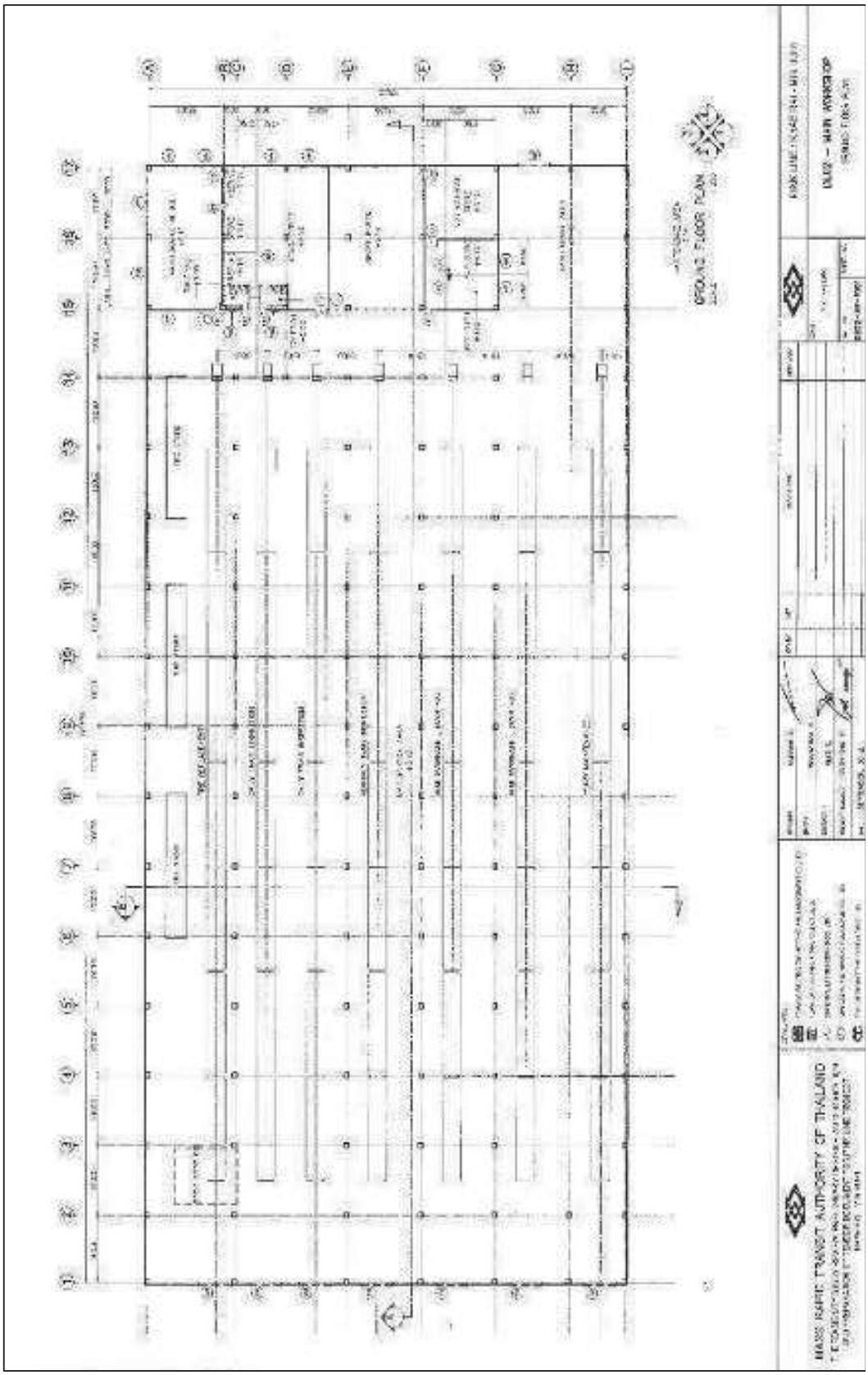


Figure 3.6-6 Plan of Main Workshop

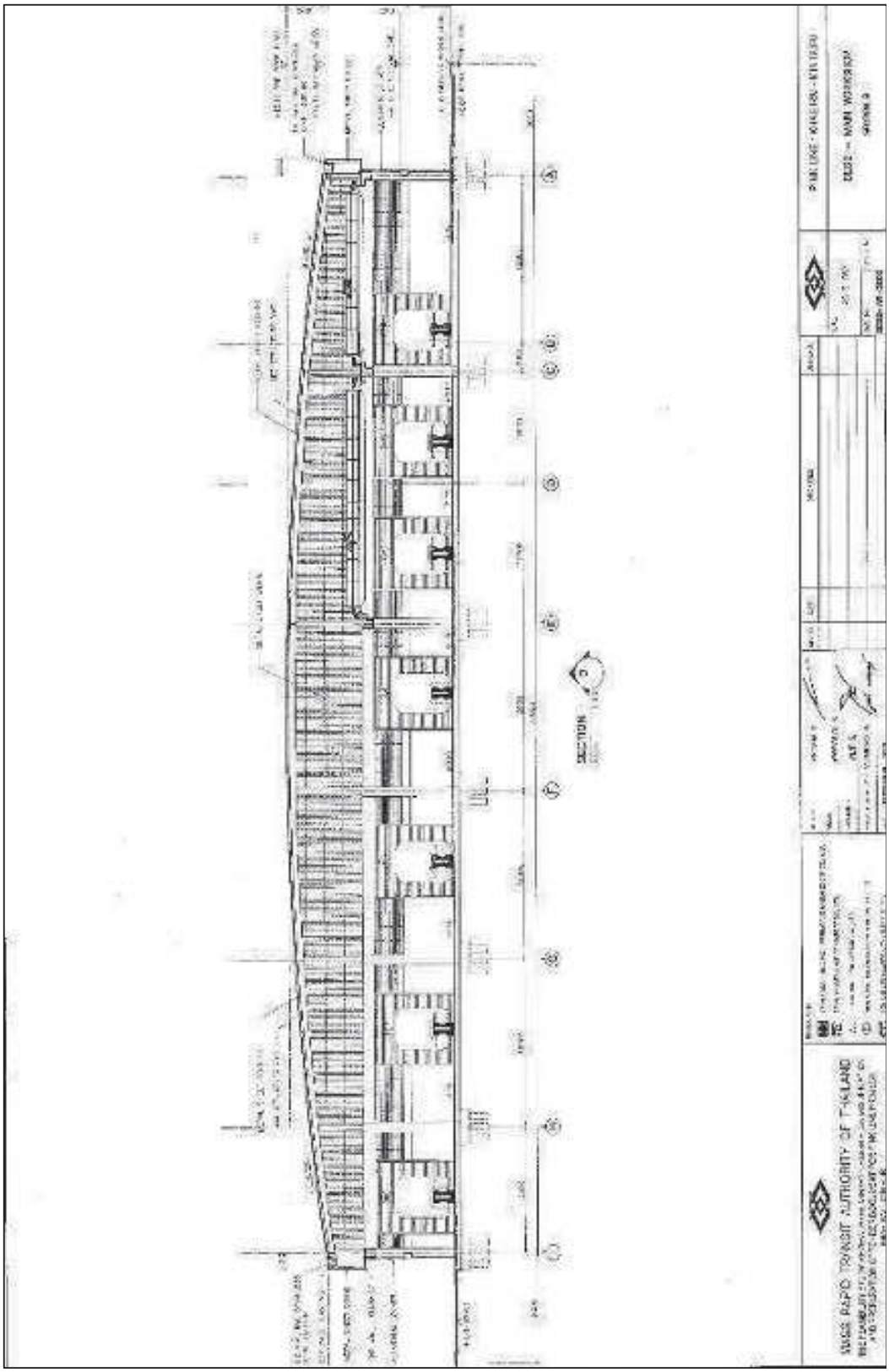


Figure 3.6-6 Plan of Main Workshop (Cont'd)

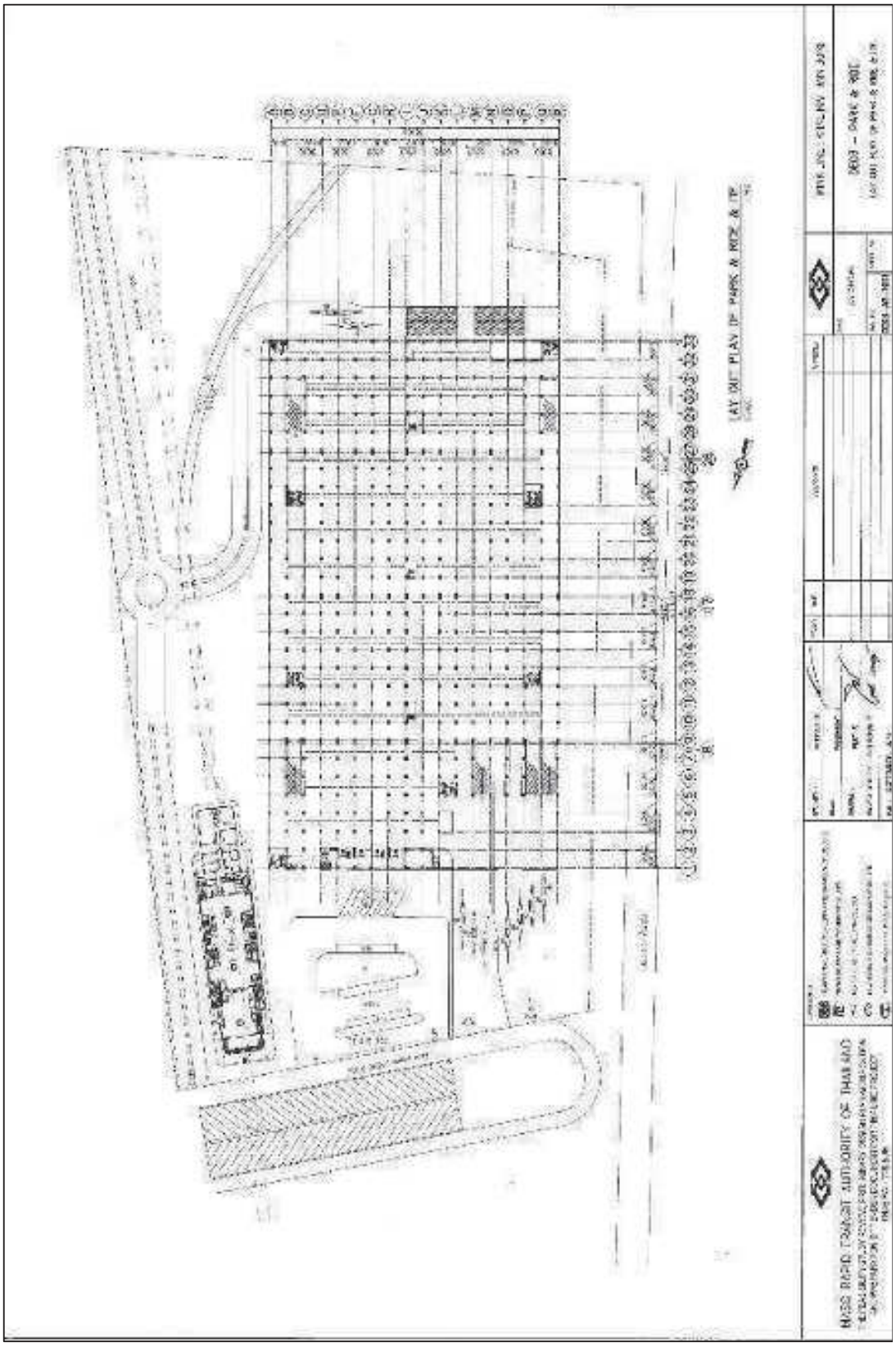


Figure 3.6-7 Layout of Park & Ride Building

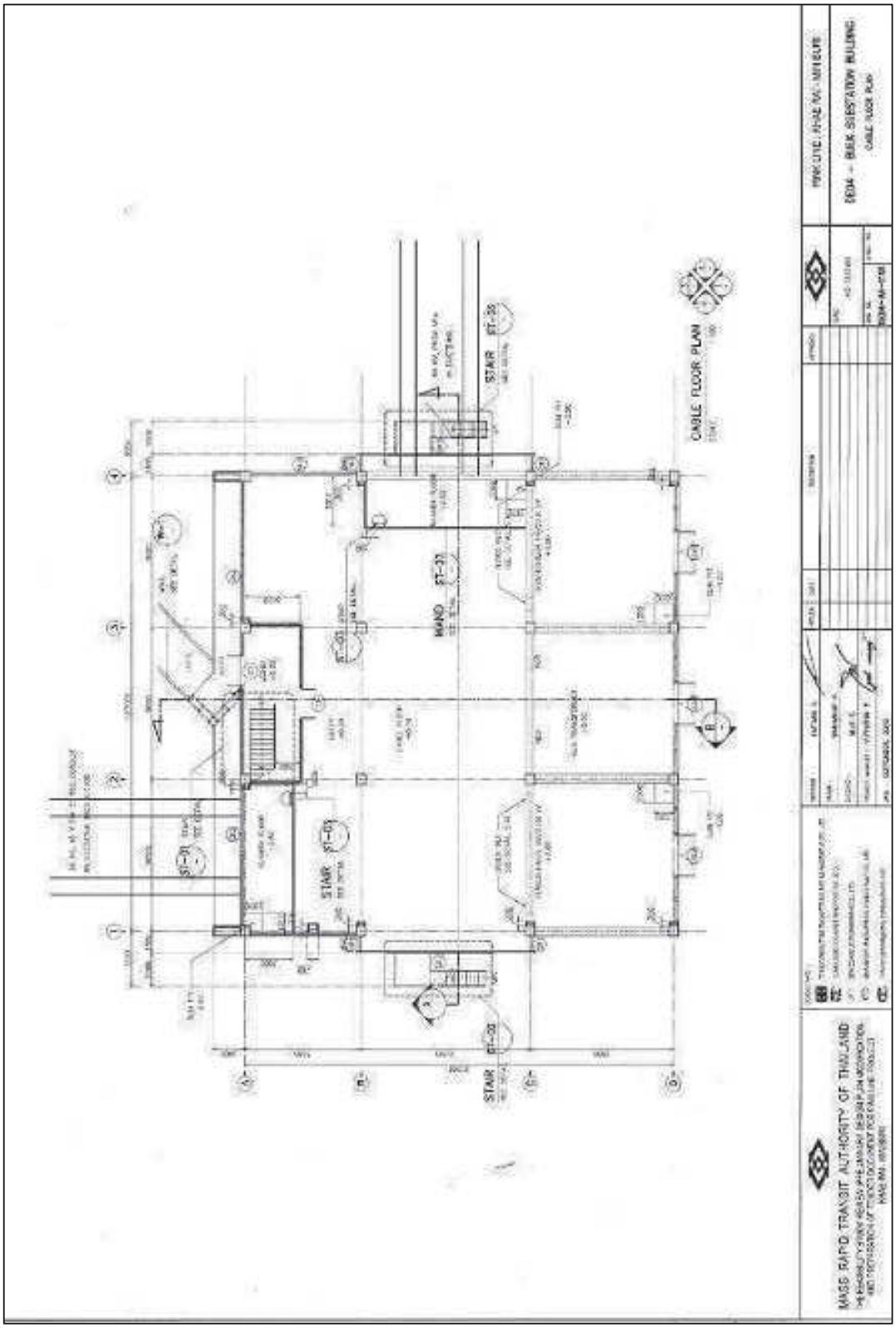


Figure 3.6.8 Plan of Bulk Substation

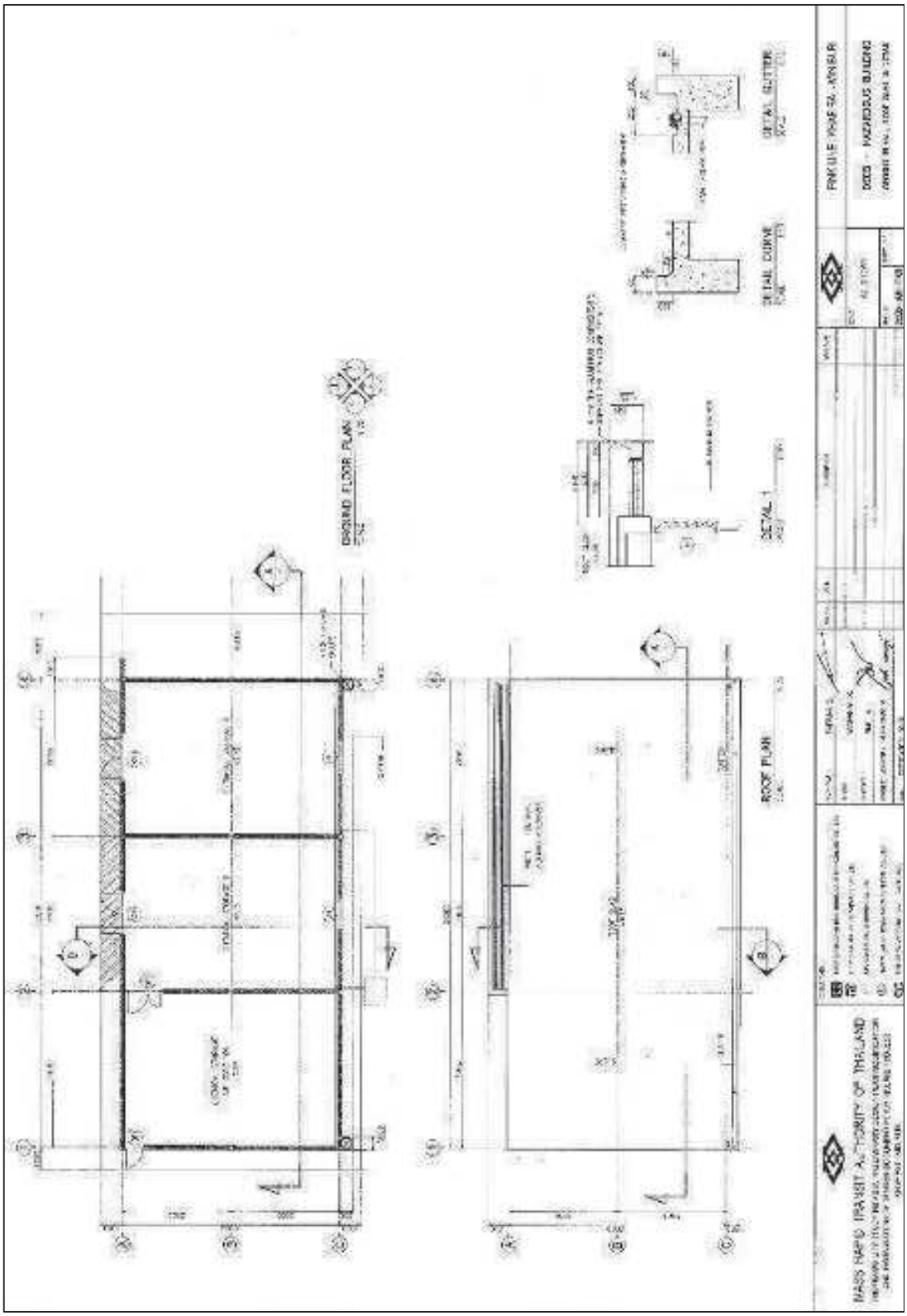


Figure 3.6-9 Layout of Hazardous Building

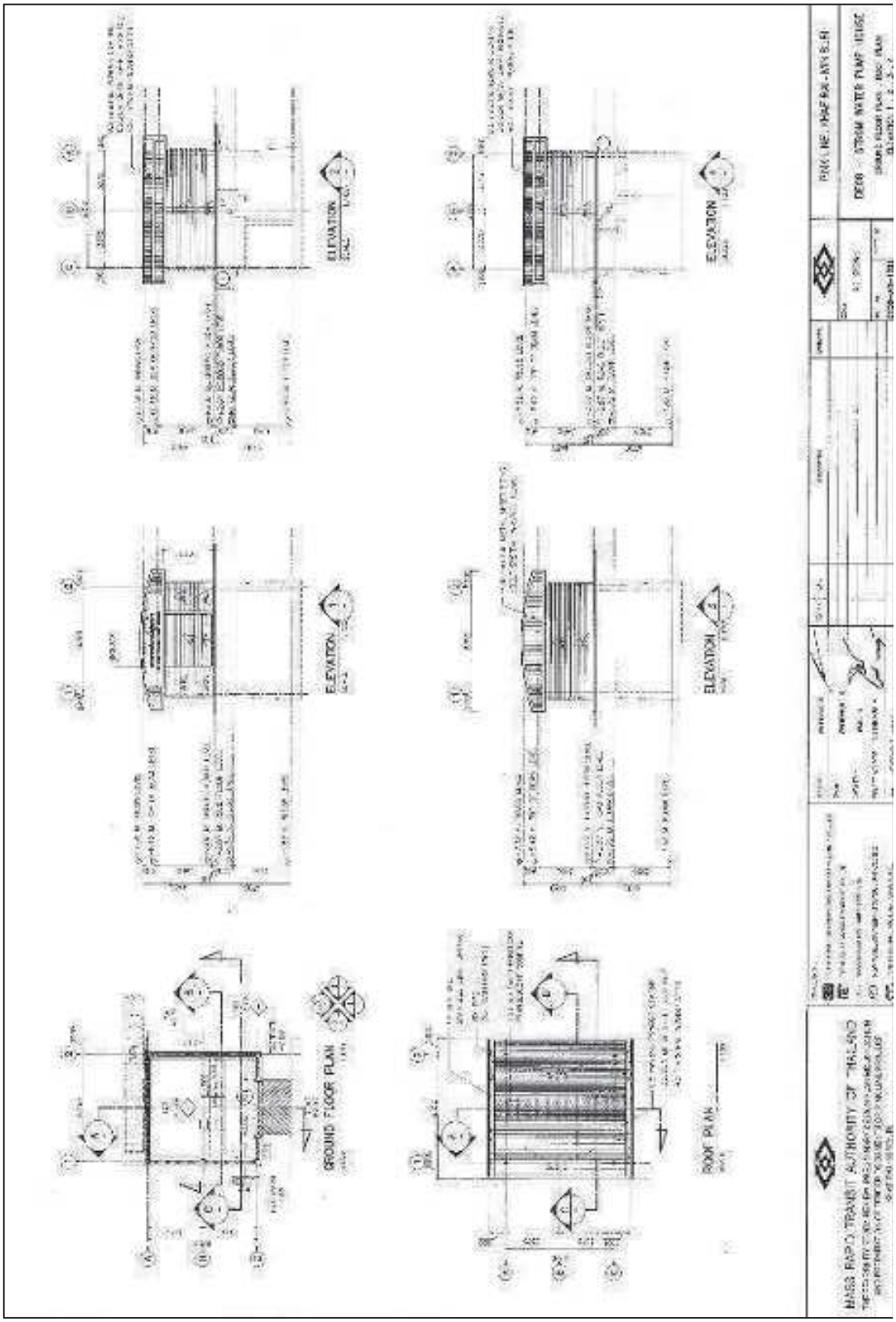


Figure 3.6-10 Layout of Storm Water Pump House

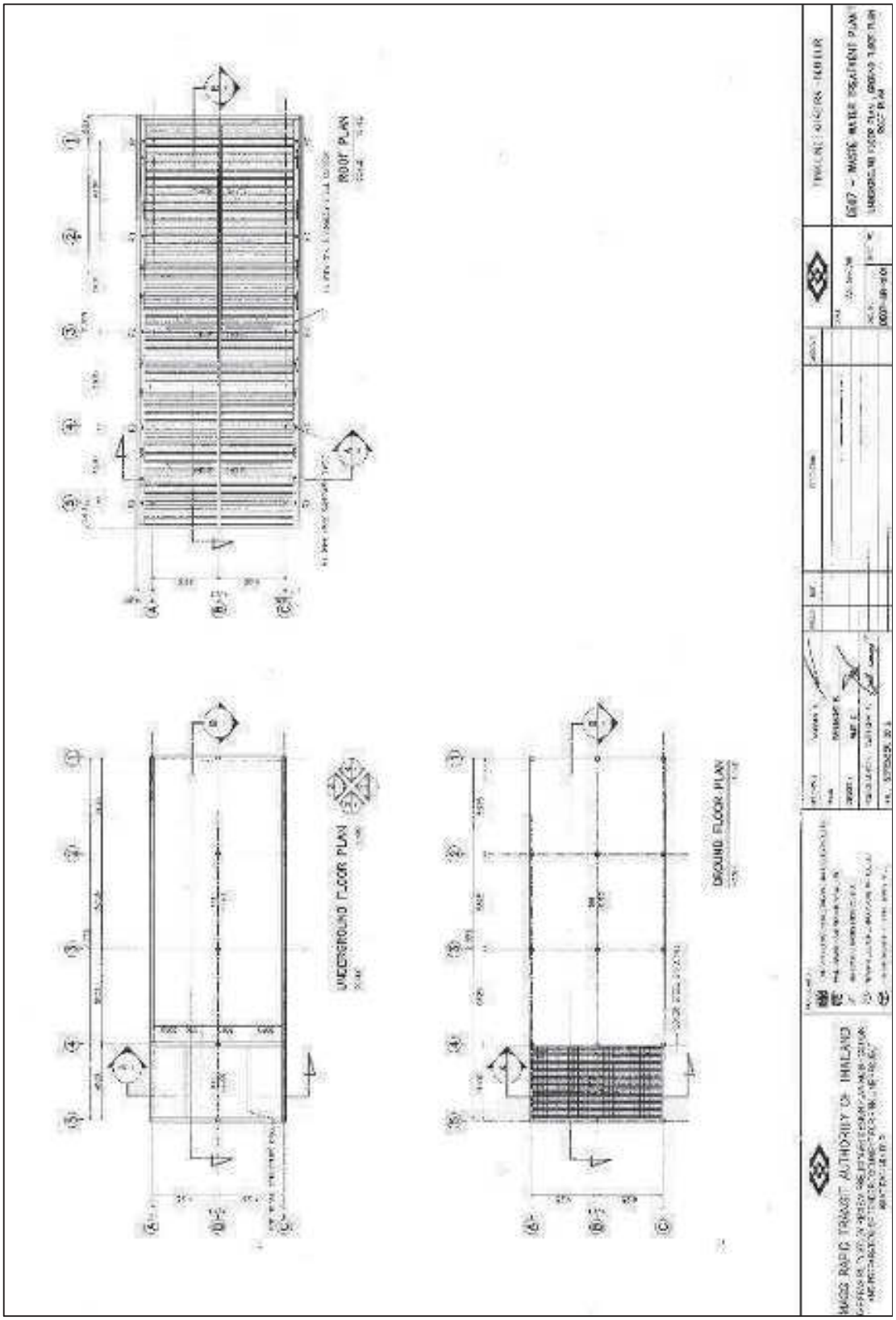


Figure 3.6-11 Layout of Wastewater Treatment Plant

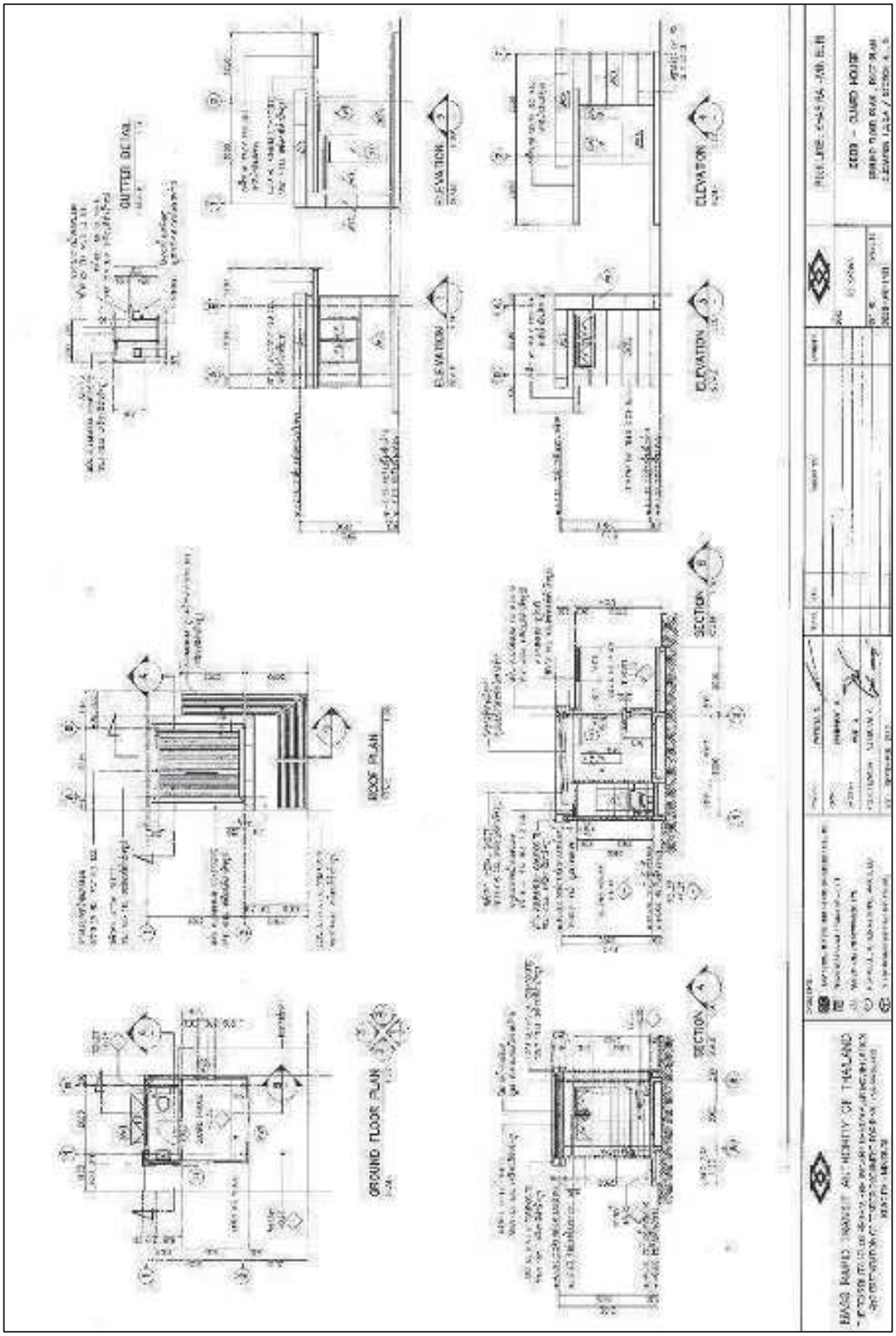


Figure 3.6-12 Layout of Guard House

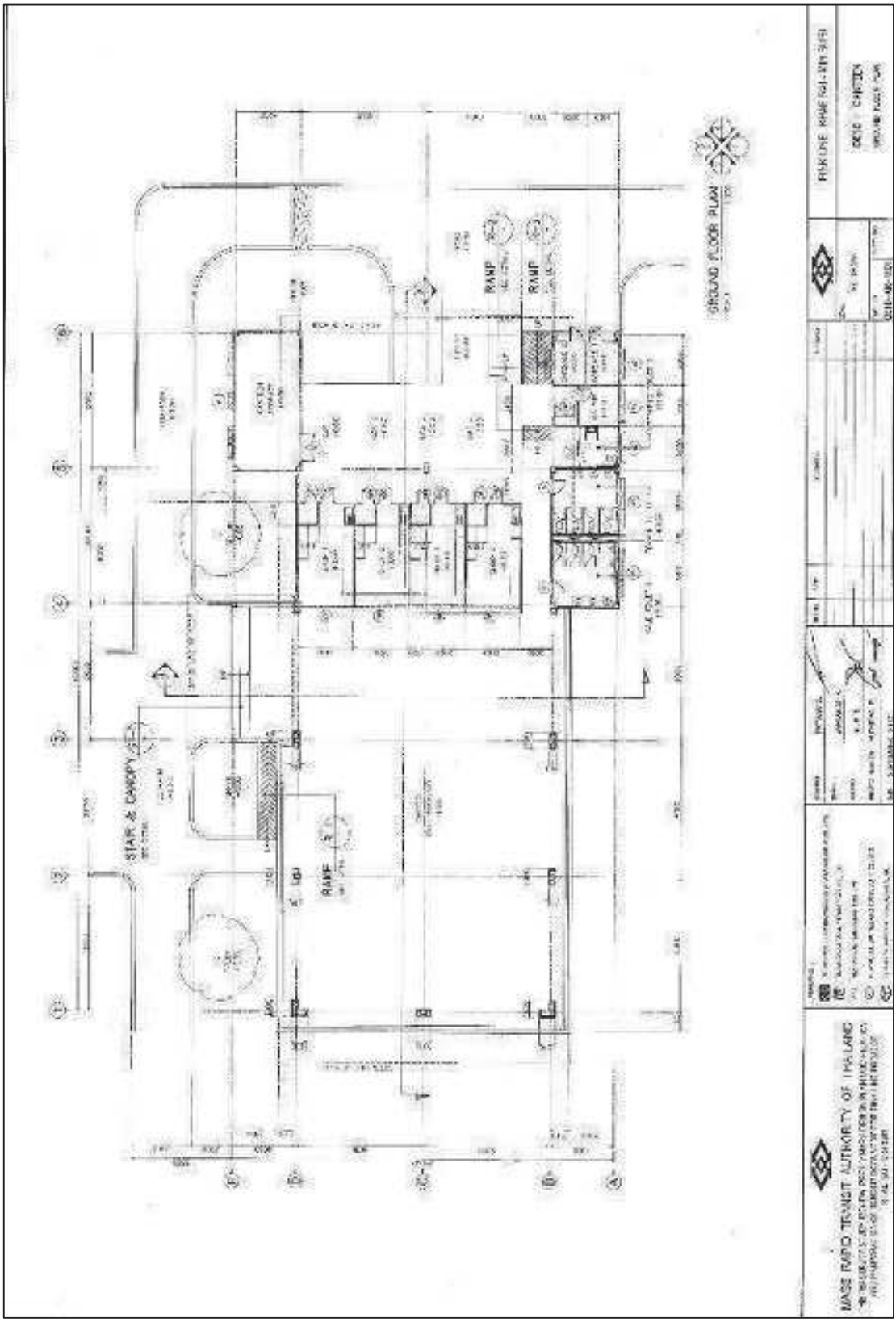


Figure 3.6-13 Layout of Canteen

Figure 3.6-14 Perspective of Administration and OCC Building

Figure 3.6.15 Perspective of OCC Room

- Operation control in line with the operational schedule in normal hours and to be able to respond to any abnormal situation including an emergency to ensure maximum operational efficiency and passenger safety;
- Control of operation support systems such as power supply system and air ventilation system;
- Control of communication among the staff and with passengers;
- Staff dormitory as a temporary accommodation for train drivers, operation control staff, and maintenance staff;
- Train Driver Office will be close to the stabling yard for their convenience in reaching the trains;
- Train Driver Office consists of a room for signing on to work and receiving work orders, office of scheduling staff and office assistant, locker inspector, and internal bulletin board, train driver supervisor room, meeting room, and train driver room.
- Driver School consists of instructor room, training room, dressing room and simulation room, etc.

(4) DE02 : Main Workshop

It is a one-storey building, with a total area of 12,782 m^2, 77 m wide and 166 m long. The building houses light maintenance workshop, heavy maintenance workshop, office and small workshop, material storage, bogie repair facility, tyre replacement, underfloor wheel lathe, and paint shop, with details described as follows:

(a) Main Workshop consists of light and heavy maintenance workshops, office and small workshop, material storage, bogie repair facility, tyre replacement, underfloor wheel lathe, and paint shop as follows:-

- Light Maintenance Workshop: Activities include checking of train readiness for the next service round, e.g. windshield water, lubricant inspection, and routine work such as inspection, internal and external train cleaning, repair, and replacement of roof-mounted equipment, e.g. air conditioner. There is an elevated area for working on the train roof;
- Heavy Maintenance Workshop: Routine works include major maintenance, bogie replacement or repair, heavy repair (replacement of underfloor heavy equipment), general maintenance, replacement of parts, e.g. battery, compressor and electronics equipment, train car repair, tyre replacement.
- Office and Workshop, e.g. training room, meeting room, brake repair room, and room for door-window repair and other parts;
  - Workshop is designed to be on ground floor between light and heavy maintenance workshops because it is not a very clean area, compared to the office area on the upper floor.
  - Engineering Office and Maintenance Office are separated and located between light and heavy maintenance workshops for close supervision of workshops.

- Rolling Stock Maintenance Office is on the ground floor and second floor of the main workshop. The supervisor office has windows to allow supervisors to see all activities in both light and heavy maintenance workshops. On the ground floor there are locker room, toilets for maintenance staff, and a small living room.

- Light and Heavy Maintenance Workshops are designed to be located together for efficient use of space. Both workshops consist of maintenance tables, tool box, spare parts shelf, and testing and calibration equipment. The equipment must be consistent with the trains to be procured. Near the bogie repair facility, working space is provided for maintenance of brakes, motor and power supply equipment, power collector, battery, main switch, power and electronic equipment, such as door equipment, air pump, signaling device, and electronics equipment, e.g. train control equipment, radio, information dissemination to passengers, mirror, and interior design, etc.

- Material Storage will store materials for use in car maintenance, using pallet storage system. There are two types of forklift trucks: electric powered truck and reach truck as shown in ***Figure 3.6-16***.

Figure 3.6-16 Electric Powered Forklift Truck and Reach Truck

- Bogie Repair Facility will be used for lifting bogie from the car body. Monorail bogie will be removed by bogie drop system and then latched on to the main track beam which can turn up or down as shown in ***Figure 3.6-17***. The engineering specifications of Bogie Repair Facility for Monorail System are illustrated in ***Figure 3.6-18***.

- Wheel Diagnostic and Tyre Replacement Facility: After a certain period of operation, wear and tear of wheel tyre will happen due to wheel and tyre friction. As a result, the construction of wheel diagnostic facility is necessary for periodical wheel inspection according to the time duration or distance specified in the tyre manufacturer's maintenance schedule. Equipment for wheel diagnostic and tyre replacement is shown in ***Figure 3.6-19*** and the internal condition of wheel diagnostic facility is presented in ***Figure 3.6-20***.

- Permanent Way Workshop Building is located close to the main workshop, and will store tracks and third rails. It will serve as maintenance workshop, and parking and refueling area for service vehicles. The permanent way workshop building is shown in ***Figure 3.6-21***. In this building, there are tools and equipment for track and switching replacement, with adequate space for welding works. There are also outdoor material storage and roofed storage for tracks. On the other side of the building, there are track repair workshop, rail storage, signaling equipment storage and related offices.

Figure 3.6-17 Turning and Lifting up-down of Monorail Main Track Beam

- Test Track Shelter is located at both ends of the test track in order that the inspection team is able to go up and down, with roof to protect the inspection team and equipment from the rain.

• Paint Shop: The MRT system will occasionally need repainting due to accident and the environment as follows:-

- The paint shop inside the depot is provided for checking and maintaining the car paint that was applied in the manufacturing process of foreign manufacturer. The painting is mainly done by applying stickers to the sides of car body. The paint shop is designed to be dust free to facilitate the work and ensure the quality of work. Car repainting will be carried out in the case that an accident occurs and the car has been scratched, but this situation rarely happens. Or repainting will be done according to the paint life, which is every 10-15 years. The paint shop is fully enclosed, with paint-related pollution treatment system so that pollution will not affect other areas. The paint is water-based color or other types of color with low pollution according to the techniques of monorail manufacturers. Waste from paint spraying process will be collected and stored in a separate container, and will be sent together with hazardous waste for disposal by a special hazardous waste disposal unit.

(3) DE03 : Park & Ride Building

This 3-level building has a usable area of about 95,064 m^2. It is 136 m wide and 233 m long and has a parking capacity of 3,000 cars (1,000 cars/floor). It is located adjacent to Ramkhamhaeng Road and can be reached via 2 routes: Ramkhamhaeng Road and Rom Klao Road.

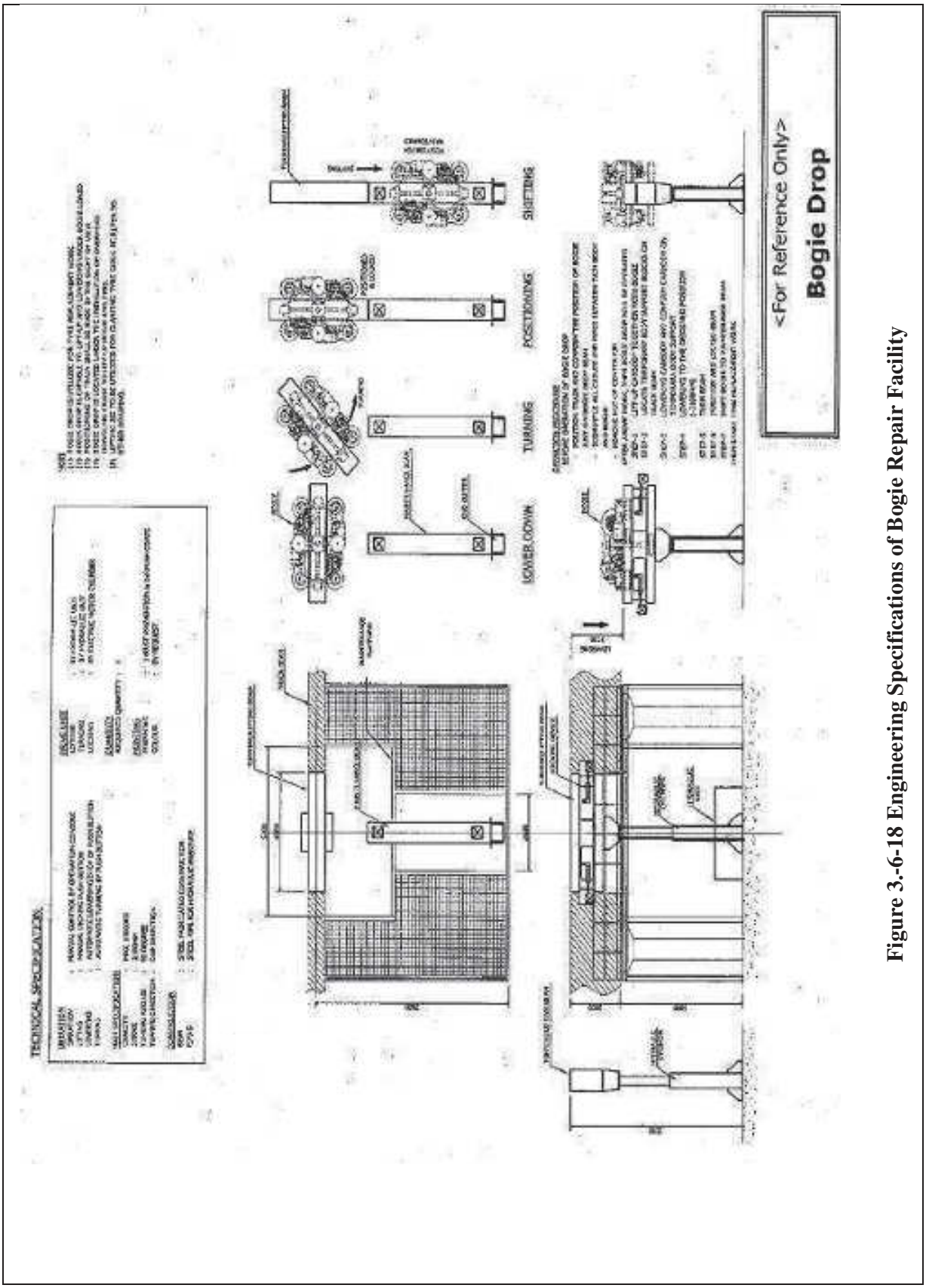


Figure 3.-6-18 Engineering Specifications of Bogie Repair Facility

Figure 3.-6-19 Wheel Diagnostic and Tyre Replacement Equipment

Figure 3.6-20 Internal Conditions of Wheel Diagnostic Facility

Figure 3.6-21 Permanent Way Workshop Building

(4) DE04 : Bulk Substation

It is a 2-storey building, with an area of 924 m^2, 21 m wide and 22 m long. It will supply power to train operation system. The Metropolitan Electricity Authority (MEA) will supply electricity to the substation in the depot for train operations. In addition, standby diesel generator will be provided in case of power failure, as shown in ***Figure 3.6-22.***

Figure 3.6-22 Typical Bulk Substation

(5) DE05 : Hazardous Building

It is a one-floor hazardous building, with an area of approximately 136 m^2, 8 m wide and 17 m long. It is a temporary storage for oil, grease and chemicals which are to be disposed later. Roofed pallet racking system may be adopted. The building is designed for easy and safe operation of cranes and trucks.

- Waste Storage: Waste generated from interior train cleaning, workshop and office, dust particles from road and sidewalk, scraps from lathe and workshop, and waste from wastewater treatment system will be stored at the temporary waste storage waiting to be collected by garbage truck for further disposal. The waste storage is also designed for ease of access by garbage trucks from the service road. Washing basin is also provided at the side of the building.

(6) DE06 : Storm Water Pump House

This one-floor building, 5 m wide and 5.40 m long, has an area of approximately 27 m^2. It is located close to the wastewater treatment plant of the depot and park & ride building.

(7) DE07 : Wastewater Treatment Plant

It is a 2-storey building, with an area of 221 m^2, 6.50 m wide and 17 m long for treating wastewater from all activities within the depot and park & ride building.

(8) DE08 : Guard House

This is a one-floor building, with an area of approximately 8.32 m^2, 2.60 m wide and 3.20 m long. It is located at the entrance-exit for checking and inspection of persons coming to contact the office as well as checking of other entrances and exits via CCTVs which are installed around the depot and park & ride building.

(9) DE09 : Stabling Yard

It is a one-floor building, with an area of approximately 31,240 m^2, 142 m wide and 220 m long, for train stabling and interior cleaning. Train cleaner rooms are located at both ends of this building for the convenience of cleaning staff. The stabling yard as shown in ***Figure 3.6-23 (a)*** has a stabling capacity of 336 cars (56 x 6–car trains) and the stabling area is shown in ***Figure 3.6-23 (b)***.

Figure 3.6-23 (a) Stabling Yard

Figure 3.6-23 (b) Stabling Area

Train Washing Plant: Trains will be washed in this building and the tracks inside the plant are about 150 m long. A 6-car train will slowly move into the train washing plant, and the washing process will be done by automatic washing machine. Wastewater from the washing process will be stored in a tank and treated by the wastewater treatment system installed in the washing plant where oil and mud will be separated from water. The effluent will be used for watering plants or floor cleaning. The typical train washing plant is presented in ***Figure 3.6-24***.

Figure 3.6-24 Train Washing Plant

(10) DE10 : Canteen

It is a one-storey building, with an area of about 960 m^2, 24 m wide and 40 m long. This building consists of kitchen, cleaning room, cold storage, and dining room, serving the depot staff on duty only.

- **Design of Retention Pond in the Depot and Park & Ride Building at Rom Klao Intersection**

The depot and park & ride building at Rom Klao intersection is a 3-storey reinforced concrete structure, with an area of 229 rai or 336,400 m^2, which will be built on former agricultural land. To prevent drainage problem, the Consultants have designed retention ponds for the depot and park & ride building. Consideration was given to topography, slope of land, and nearby catchment to avoid obstructing the existing flows of water. The catchment is divided into 2 zones, as illustrated in ***Figure 3.6-25***, and each zone will drain stormwater into a retention pond before discharging into Khlong Song Ton Nun, with the following details.

- Zone A: Park & Ride building, with an area of about 50.57 rai or 80,916 m^2;
- Zone B: Depot, with an area of approximately 178.43 rai or 285,484 m^2.

- **Design of Drainage Structure**

Drainage structure is designed to accommodate a peak discharge resulting from the maximum rainfall of specified return period. Therefore, the results of rainfall frequency analysis were adopted as the design rainfall, based on the rainfall records over a long period, which were obtained from various rainfall gauging stations. The relevant agencies are Royal Irrigation Department, Electricity Generating Authority of Thailand, and Department of Alternative Energy Development and Efficiency. The relationship of rainfall intensity, duration and frequency is graphically presented as rainfall intensity-duration-frequency curve or IDF curve.

Figure 3.6-25 Catchment in Depot and Park & Ride Building at Rom Klao Intersection

(c) Normal traffic condition and Traffic Management Guidelines in Depot

- **Normal traffic condition around Depot**

The Depot of Rom Klao Intersection is located at the edge of Ramkhamhaeng Road, which has 8 traffic lanes. In 2008, there are 5,874 cars and 1,500 cars passing through this road in the morning rush hours (7.00-8.00 a.m.) and evening hours (5.00-6.00 p.m.), respectively. It is forecast that 1,500 cars/1 day will pass through the Depot and affect Ramkhamhaeng Road in the above mentioned hours only. The number of vehicles will have no impact on the traffic condition due to the number of traffic lanes. Moreover, the road inside the Depot is made of reinforced concrete with 2 directions. The width of the entrance-exit connecting to the road is 22 m. The entrance-exit traffic lane is 18 m. wide for both directions. The pavement on both side of the roads is 2 m. wide.

- **Traffic Management Guidelines in Depot of Rom Klao Intersection**

The road and the entrance-exit in the Depot has 2 directions and the road is divided into 3 main parts as follows:-

- Office Building and Operation Control Center of Rom Klao Intersection. It is found that the Office Building and Operation Control Center are located in Depot, separating from Park & Ride Building and Service Vehicle Parking Lot,

adjacent to Ramkhamhaeng Road. The staff parking lot is provided near Office Building and Operation Control Center

- Depot and Stabling yard. To access these areas, the trains have to run on the ramp passing the front door checking point only. The Platform road connects buildings that need service road for forklift and trucks, Wheel Turning Plant, Wheel Diagnostic Facility, Hazardous Building, Garbage Storage Building, Train Washing Plant, Heavy Maintenance Workshop, Light Maintenance Workshop, Material Storage Building, Permanent Way Workshop Building and Bulk Substation. The road inside is approximately 6-15 m. in width and used as transportation route of equipment and machinery, such as trains, power supply, etc. The road can be used before the Project commencement and when additional equipment and machinery are ordered.

- Service roads around the Depot-Service roads are provided for safety reason. These service roads connect Administration and Operation Control Center Building (OCC), Train Operation Control Staff Dormitory and Office. Service roads can be in the same level or almost in the same level of to the road outside the Depot. The two types of service roads are designed for the access of fire engine to all buildings.

(d) Traffic Management for Depot and Park & Ride

- Traffic Management of Depot and Park & Ride

- The traffic management of Depot and Park & Ride Building of Rom Klao Intersection. The Project designed the entrance-exit that passengers can access the Park & Ride Building through 2 main roads, Ramkhamhaeng Road and Rom Klao Road.

- Traffic Management of Entrance-Exit through 2 main roads

Entrance-Exit No.1: The entrance from Ramkhamhaeng Road can lead to the Park & Ride Building in 2 ways below:

- Directional Ramp: There is the left diversion from Ramkhamhaeng Road, on Khlong Song Ton Nun bridge for the passengers access to Park & Ride Building as shown in ***Figure 3.6-26*** and ***Figure 3.6.27***.

- Level road: When driving past Suwinthawong Intersection, passengers can turn left to Depot to enter in to and exit from Park & Ride Building.

Entrance-Exit No.2: Preliminarily, traffic lights are provided for the entrance from Rom Klao Road as shown in ***Figure 3.6.28***. In the future when the traffic is more congested, there will be the directional ramp from Depot and Park & Ride Building to Rom Klao Road for both entry and exit points.

Figure 3.6.26 Traffic Management of Entrance-Exit from Ramkhamhaeng Road

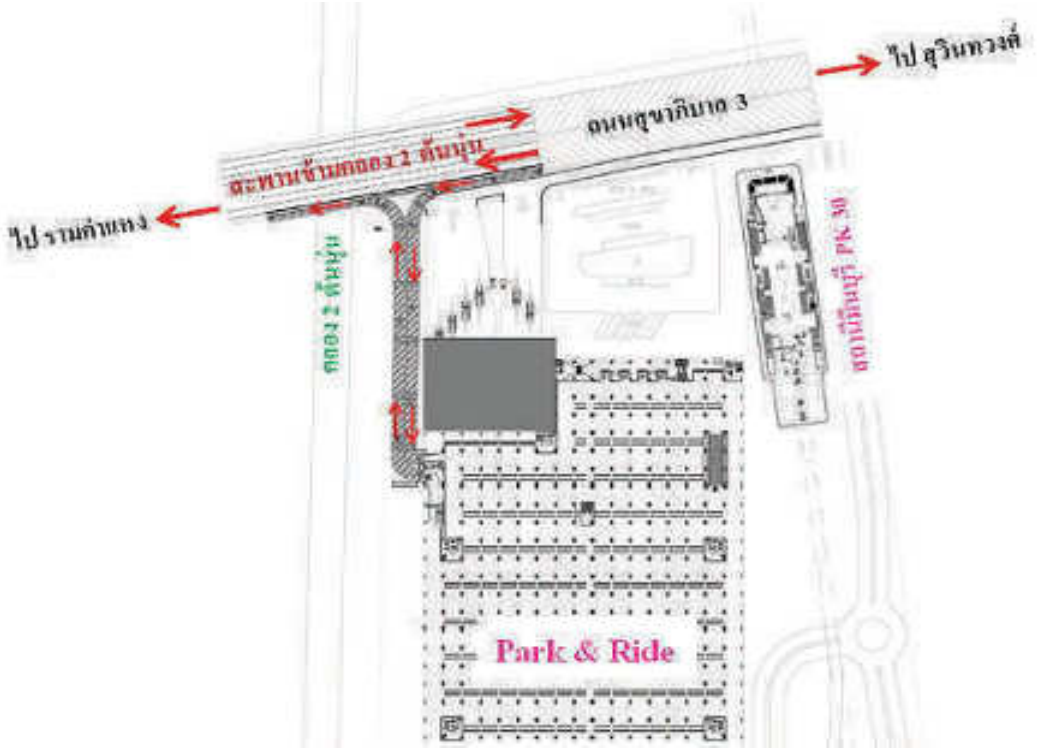


Figure 3.6.27 Directional Ramp for Entrance from Ramkhamhaeng Road

Figure 3.6.28 Traffic Management of Entrance from Rom Klao Road

(e) Management of Hazardous Waste stored at Hazardous Building of Depot

The details of hazardous waste management in Depot are as follows:

- Types of hazardous waste in Depot are:
  - Train tires, e.g. load tires and guide tires
  - Flammable substances or any inflammable materials

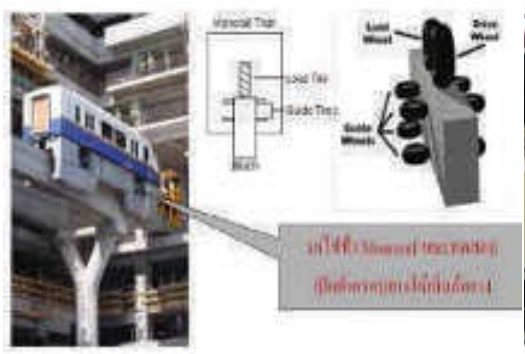
  as detailed below

  - Train tires shown in ***Figure 3.6.29***
    - Quantity of tires stored in Maintenance Workshop
    - Load tires 100
    - Guide tires 150

    Preventive measures for storage of Monorail tires:

    - Separating the tire room from flammable substance storage room;
    - Installing fire extinguisher in the tire room; and
      Moving expired tires out of Maintenance Workshop

  - Flammable substances or any inflammable materials. In combustion, the evaporation of flammable substances will be in the form of gas and then combine with oxygen in the air. If there is any flame, such substances, e.g. oil removal solvent, lubricant, refrigerant, hydraulic oil, tire products etc. will be flammable immediately.



Load Tire and Guide Tire
Sample of Monorail Wheels Tire

Under side View of Monorail
Balance of Train with Guide

Figure 3.6-29 Load Tire and Guide Tire of Monorail

- The quantity of flammable substances stored in Maintenance Workshop shall be adequate for 1 week only (as they are easily obtainable) to limit the quantity and for maximum safety when use. Suitable quantity of flammable substances are given below:

Oil removal solvent	2 tanks (200 liters/tank)
Lubricant	2 tanks (200 liters/tank)
Grease	1 tank (200 liters/tank)
Hydraulic oil	3 tanks (200 liters/tank)
Refrigerant	500 liters

- A low intake of any hazardous substances may even destroy tissues and cause mutation and cancer. Hazardous substances can enter into the body in 4 ways:

  - Breathing in (the most frequent and dangerous one)
  - The intake through digestive tract
  - Skin absorption to bloodstream
  - Injection (rarely found)
  - Storage and Inspection of Hazardous Waste

- Storage of hazardous waste

- Hazardous waste shall be stored in Hazardous Building, which is separate from other buildings for safety reason. Hazardous waste includes tires, flammable substances or inflammable materials used within Depot and Park & Ride Building. Hazardous waste can be stored in the Building for 90 days before disposal. The location of Hazardous Building is shown in ***Figure 3.6-30***.

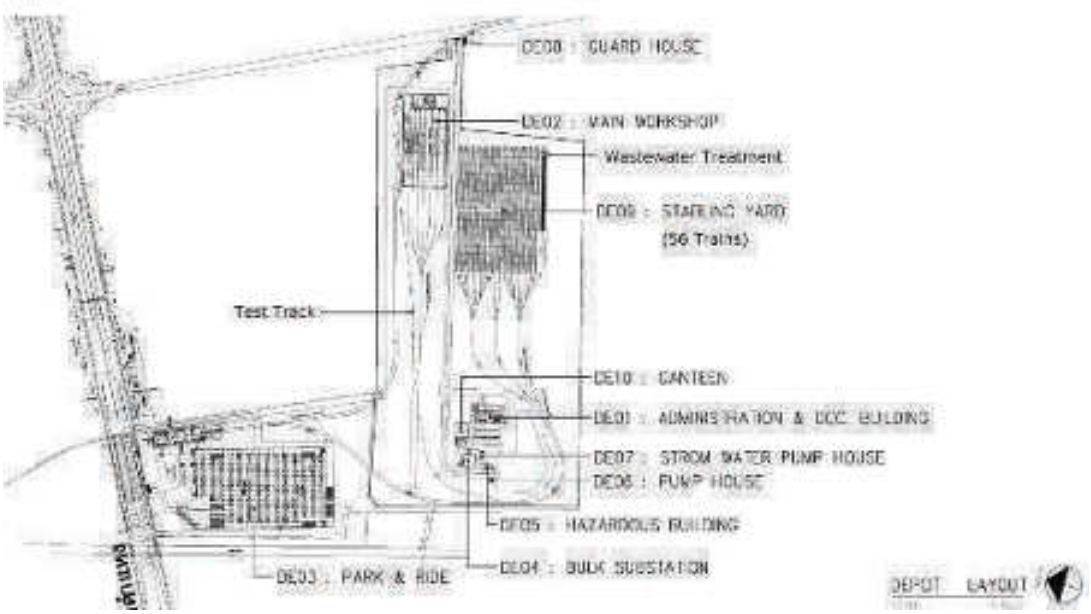


Figure 3.6-30 Layout of Depot and Park & Ride Building at Rom Klao Intersection

Dangerous goods shall be collected and stored in Dangerous Goods Building for disposal by concerned disposal agencies such as Samae Dum Industrial Waste Disposal Services Center, Bang KhunThien, Bangkok.

- Survey of safety condition and inspection

The survey of safety condition and inspection is essential to build safety confidence in the workplace in order to prevent risk of injury or ailment.

- The survey of safety condition aims at inspecting the working environment to identify hazard. The Safety Committee of the Depot will perform inspection on a weekly basis.

- The quality of safety work plan shall be assessed. The Safety Committee of the Depot shall establish more efficient hazard control for continual improvement.

- The checklist of flammable and inflammable substances consists of items below:

- Having possession of any flammable scraps or not; if yes, remove them from the work environment;

- Method of storing flammable and inflammable substances is provided to reduce risk of inflammation;

- Container of flammable and inflammable substances are approved for use;

- Lid or open-close pipe of container or tank of flammable substances is in a good condition;

- All tanks of unused flammable substance shave a tight lid;

- All piled up tanks of unused flammable substances are connected with ground wire to avoid static electricity;
- The flammable liquid storage room is installed with a light bulb that prevents bulb explosion;
- The flammable substance storage room is installed with mechanical or natural ventilation system;
- Used solvent and flammable liquid are always kept in fireproof container until they are removed from Depot;
- Fire extinguishers are installed and available in the specified place;
- No barrier or obstacle is encountered when fire extinguishers are required for use;
- "No Smoking" sign is installed in the storage and usage area of flammable substances;
- In case of leakage, flammable substances are removed immediately.

(f) Wastewater Treatment from Train Washing

1) Wastewater from train washing

- Characteristics of wastewater from train washing

The wastewater from train washing is the mix of water and shampoo which is neutral. After the train washing process, the wastewater has to be treated through Water Treatment Plant inside Depot and Park & Ride Building and it will be recycled.

- Water usage for train washing

For the train washing, the clean water of approx. 1.045 m^3/ train/day will be used (relating to Bangkok Mass Transit extension, B.E.2543). Therefore, the water usage ratio for 56 trains is 58.52 m^3/day and 46.82 m^3/day (80% of the water usage)

- Water Treatment methods for wastewater from train washing

The onsite treatment is used in Depot and Park & Ride Building at Rom Klao Intersection. It is a combination of Anaerobic Filter and Contact Aeration Process, with capacity of 100.0 m^3/each (300 m^3/ capacity). The amount of wastewater from activities within Administration, Operation Control Center and Staff Dormitory will be collected and directly transmitted to the onsite treatment. Also the amount of wastewater from a canteen will flow through the grease trap while the amount of wastewater from maintenance and train washing will flow through the oil interceptor for removal of grease and oil before flowing through the whole water treatment plant, where the wastewater can be kept at least 1 day before drainage to public drainage pipe. The location that the water treatment plant is installed at Depot and Park & Ride Building is shown in ***Figure 3.6-30***.

The amount of wastewater treated at the water treatment plant shall have the quality according to Notification of Ministry of Natural Resources and Environment on Designating Control Standards for Wastewater Drainage from Some Types and Sizes of Buildings, dated November 7, B.E.2548, announced in Royal Thai Government Gazette Vol.122, Chapter 125Ngo, dated December 29, B.E.2548, as shown on ***Table 3.6-3***.

Table 3.6-3 Building Effluents Standards

Parameter	Unit	Range or Maximum Permitted Values for these Categories					Method for Examination
		A	B	C	D	E	
1. pH	-	5-9	5-9	5-9	5-9	5-9	pH Meter
2. BOD	mg/l	20	30	40	50	200	Azide Modification at 20°C, 5 days
3. Soilds - Suspended Soilds	mg/l	30	40	50	50	60	Glass Fibre Filter Disc
- Settleable Solids	ml/l	0.5	0.5	0.5	0.5	-	Imhoff Cone 1,000 cm^3 1 hour
- Total Dissolved Solid (TDS)*	mg/l	500*	500*	500*	500*	-	Dry Evaporation 103-105 °C, 1 hour
4. Sulfide	mg/l	1.0	1.0	3.0 -	4.0	-	Titration
5. Nitrogen as TKN	mg/l	35	35	40	40	-	Kjeldah
6. Fat, oil and grease (FOG)	mg/l	20	20	20	20	100	Sovent Extraction by Weight

Remarks : 1. Base on: Standard Methods for the Examination of Water and Wastewater recommended by APHA : American Public Health Association, AWWA : American Water Works Associaton and WPCF : Water Pollution Control Federation
*= These values are in addition to the TDS of the water used.
2. Notification of the Ministry of Science, Technology and Environment : Building Effluents Standards dated January 10, B.E.2537 was revoked by a)
3. Notification of the Ministry of Science, Technology and Environment issued under the Enhancement and Conservation of the National Enviromental Quality Act, B.E.2535 (1992)and Notification of the Ministry of Science, Technology and Environment issued under the Enhancement and Conservation of the National Enviromental Quality Act, No. 2 B.E.2538 (1995) dated January 10, B.E.2537 was revoked by b)

Sources : a) Notification of the Ministry of Natural Resources and Environment : Building Effluents Standards dated November 7, B.E.2548 (2005) published in the Royal Government Gazette, Vol. 122 Part 125 D, dated December 29, B.E. 2548 (2005)
b) Notification of the Ministry of Natural Resources and Environment issued under the Enhancement and Conservation of the National Enviromental Quality Act,dated November 7, B.E. 2548 (2005) published in the Royal Government Gazette, Vol. 122 Part 125 D, dated December 29, B.E. 2548 (2005)

2) Measures for wastewater treatment from train washing

The train washing activity shall be performed every 3 days and it requires a large amount of water. Therefore, water conservation and reuse is the process that reduces wastewater amount. The process contributes to mitigation of environmental impacts. The following international measures of water conservation shall be performed.

Train washing procedures

- Spray water before washing train with automatic sprinkler;
- Wash train by spraying water mixed with shampoo or solution;
- Spray water to wash the lower body of train with high pressure nozzle; brush or high pressure spray is at the side or the lower part of train;
- Spray to wash for the first round with high pressure nozzle;
- Spray wax or coating substance to glossy body of the train;
- Spray to wash for the final round with low pressure nozzle;
- Blow until dry; and
- Wipe by hands;

Measures/Techniques for water conservation

- Installing small nozzle instead of the large one for low water pressure while maintaining good washing;
- Regularly inspecting the position of nozzle; if the nozzle inclines to the wrong position, the train will not be well cleaned;
- Inspecting and repairing if any leakage found;
- Using stainless steel or ceramic nozzle which is durable for hard work;
- Providing water drainage channel for water reuse or water tank to stored effluent for tree watering;
- Planting trees enduring train washing water in landscape garden; and
- Performing regular maintenance of nozzle, especially nozzle for train washing for maximum efficiency.

Measures for wastewater treatment

- Installing the small onsite wastewater treatment plant, a combination of Anaerobic Filter and Contact Aeration Process, with the capacity of 100 M3/piece, 3 pieces in total with the volume of 300 M3for wastewater treatment before draining into public drain and to Khlong Song Ton Nun.
- Collecting and storing dangerous goods, e.g. oil, grease and chemicals at Dangerous Goods Building for disposal by concerned disposal agencies such as Samae Dum Industrial Waste Disposal Services Center, Bang Khun Thien, Bangkok. The Dangerous Goods Building has to be designed as Pallet Racking System with roof in order that cranes and trucks are able to come in and out safely and conveniently.

3) Measures for water saving

The following measures for water saving can reduce clean water usage. Clean water of 1.045 m^3/train/day is required for train washing (according to Bangkok Mass Transit Extension, B.E.2543). If water saving measures are implemented, water recycle will be possible through water filtration system. This helps reduce water use by 20% or about 0.836 m^3 /train/day.

(a) Activity requiring a large volume of water: Water volume and characteristics are considered. As the activity in Washing Plant needs a large volume of water, an automatic washing machine should be used for water saving.

(b) Reuse: Water characteristics in Washing Plant are considered. The reuse will be for the next train washing and floor cleaning to reduce clean water usage.

(c) Water recycling: For this Project, treated wastewater will be used for tree watering. The project has designed diversion pond, water pump, and water distribution system for tree watering within Depot and Park & Ride Building. Therefore, the central wastewater treatment system of Depot and Park & Ride Building will store wastewater from activities of Washing Plant and Workshop. The wastewater treatment system disposes oil and grease as well as sludge and contaminants efficiently in compliance with the standards of Pollution Control Department, Ministry of Industry.

4) Measures for selection of environmentally friendly cleaning agents

The environmentally friendly cleaning agents or the ones with minimal impacts on the environment to be the content of washing shampoo should have the following properties:

- Free phosphate
- Free petrochemical ingredients
- Free artificial fragrance
- Non-GMO-Enzyme

5) Measures for effluent quality monitoring

Effluent quality monitoring shall be conducted for compliance with Notification of National Environment Board No. 8 (B.E.2537) issued under National Environmental Conservation and Promotion Act B.E.2535 on Designating Quality Standard of Surface Water. During operation period, effluent quality monitoring shall be executed for 2 retention ponds of zones A and B once a month (at the same time as the inspection of effluent quality in canal).

(g) Preparation of green area and improvement of landscape within Depot

The improvement of Depot internal environment includes preparation of green area and landscape in accordance with area planning and Project surroundings, to have outdoor spaces and landscape view for good environment. The issues below are considered.

- Area management: It should be convenient and easy for maintenance. Water use for tree watering should be reduced by selecting trees which are durable, clean and easy to maintain, e.g. using grass blocks, solid floor with tree holes and security guard throughout the area.

- Usage of open space in the central area of the front of Depot and surroundings: It was considered that the landscape is convenient for maintenance. This area shall be connected with open space and surroundings. This central area is important for the following reasons.

  - Being reserved as beautifully shady landscape;
  - Being a safety area;
  - Being used as buffer area of Project's external area;
  - Being connected with internal and external activities;
  - Being used for through traffic and Depot's parking area.

- Improvement of landscape: Large perennial plants should be grown for good view, aesthetics and covering of unpleasant view.

- Improvement of environment: The improvement helps lessen the heat, particles which contributes to aesthetic and unique area, and reduce reflection.

- Improvement of landscape of Depot Office Building: Axial rectangular coordinate system was considered for the layout of the area with the Central Depot. The Office Building is close to side of landscape. The improvement of landscape is focused on low maintenance and decoration in the central area around the Office Building.

- Improvement of landscape of Depot: Large perennial plants, which make the area shady, should be grown as buffer zone of the communities. Enduring tall trees that could hide any unpleasant view with not much leave shedding and easy for maintenance, e.g. Alstonia scholaris, Melodorum fruticosum Lour, Polyalthia longifolia, Cerberia adollam, etc. should be grown.

- Improvement of landscape of Office Building: Colorful yard will be built in front together with perennial plants which are sparse to reduce view of large building and create shady atmosphere. Perennial plants should be grown at the edge of the road and the Project fence or surrounding spaces. Planting enduring shrubberies, which are easy to trim, makes the area tidy. Also usage of chipped stone and concrete blocks in the narrow open space for grass growing could be done for convenient maintenance and reduction in rigidity.

- Planting suitable trees in front of Depot: Tall perennial trees, e.g. Millingtonia hortensis Linn f., Areca catechu, Ptychosperma, etc. shall be planted. The trees around the Building and surrounding area like Alstonia scholaris, Tabebuia argentea Britt., Melodorum fruticosum Lour, or Cerberia adollam, which are perennial and oval shrubs that soften the view of gigantic building should be grown.

(h) Depot Staff and Operational Control Staff

The number of Depot Staffs and Operational Control Staffs for Pink Line MRT Project, Khae Rai–Min Buri section, is shown in ***Figure 3.6-4***.

Table 3.6-4 Number of Depot Staffs and Operational Control Staffs

Description	Number (Person)
1. Number or Permanent Staffs in Office Building	
1.1 Staffs in Operation Control Center, calculated from Manager Operations, Operation Planning/Timetables and Operations Control	100
1.2 Staffs in Administration, calculated from Training and Documentation, Business Administration, Personnel Affairs, Office Cleaning	150
1.3 Staffs in Depot Platform, i.e. Main Workshop Building, Permanent Way Workshop Building, Calculated from Maintenance Managers, Engineers, Quality and Safety Team, RST Maintenance Supervisors, Vehicle Light Maintenance Staffs, Main Repair Staffs, Civil Works Maintenance Staffs, Building Service Staffs, Infrastructure Managers	400
1.4 Staffs in other building and train control staffs of trains using building area, train control staffs	300
Total staffs from 1.1-1.4	**950**
2. Number of staffs temporarily dwell in staff dormitory	
2.1 Train control staffs: 3 shifts/day, starting hour: 04.00 hr, finishing hour: 24.00 hrs.	15
2.2 Operation control center staffs: 3 shifts (5 persons each)/day	15
2.3 Operation staff/Train staff supervisors: 3 shifts (3 persons each)/day	9
2.4 Yard supervisor: 3 shifts/day (1 person each)	9
2.5 Engineering and Maintenance Staffs; There are 12 rooms/dormitory for staffs. Each room consists of a toilet and a bathroom.	12
Total staffs from 2.1-2.5	**60**

(i) Management of Water Consumption

The consumable water supply of Depot at Rom Klao Intersection is supplied by Metropolitan Waterworks Authority through water pipes to the reserved underground water tank. Then water is distributed to all buildings within Depot and Park & Ride Building for all activities.

For the size of reserved water tank within Depot and Park & Ride Building at Rom Klao Intersection, 4 tanks of 50 m^3, totaling 200 m^3/day were replaced with **4 tanks of 150 m^3, totaling 600 m^3** for 3 days. In addition, water tank for reserved water shall be provided for firefighting for at least 30 minutes at Depot and Park & Ride Building. This matter is added in management of water consumption, safety and security and fire protection as follows:

The consumable water of Depot and Park & Ride Building at Rom Klao Intersection is supplied from Metropolitan Waterworks Authority through water pipes to reserved underground water tank of 4 tanks of 150 m^3, totaling 600 M^3 .Water is then pumped to all buildings within the Depot and Park & Ride Building for all activities. The volume of consumable water of Depot and Park & Ride Building at Rom Klao Intersection can be divided by types of activities below:-

- Administration and Operation Control Center

- The Operation Control Center has approximately 100 staffs and water use ratio is 70 liters/person/day (according to Design of Wastewater and Storm Drainage System Guidelines, Engineering Institute of Thailand, under H.M. the King's Patronage, B.E.2549), totaling 100 x 70 = 7,000 liters/ day or equivalent to 7.00 m^3/ day.

- The Administration has approximately 150 staffs and water use ratio is 70 liters/person/day (according to Design of Wastewater and Storm Drainage System Guidelines, Engineering Institute of Thailand, under H.M. the King's Patronage, B.E.2549), totaling 150 x 70 = 10,500 liters/day or equivalent to 10.50 m^3/day.

- The Depot Platform has 400 staffs at maximum and water use ratio is 70 liters/ person/day (according to Design of Wastewater and Storm Drainage System Guidelines, Engineering Institute of Thailand, under H.M. the King's Patronage, B.E.2549), totaling 400 x 70 = 28,000 liters/day or equivalent to 28.00 m^3/ day.

- Staffs in other buildings and train control staffs who use the building area are approximately 300 persons and water use ratio is 70 liters/person/day (according to Design of Wastewater and Storm Drainage System Guidelines, Engineering Institute of Thailand, under H.M. the King's Patronage, B.E.2549), totaling 300 x 70 = 21,000 liters/day or equivalent to 21.00 m^3/day.

- Dormitory is to be used by 60 staffs at maximum and water usage ratio is 200 liter/1 person/1 day (as per Guidelines for Reporting of Environmental Impact Assessment of Accommodation for Community Services and Resort Project of Office of Natural Resources and Environmental Policy and Planning, B.E.2542), totaling 60 x 200 = 12,000 liters/day or equivalent to 12.00 m3/day.

- Canteen at the ground floor of OCC Building is to be used by 950 staffs at maximum and water use ratio is 50 liters/person/day (as per Guidelines for Reporting of Environmental Impact Assessment of Accommodation for Community Services and Resort Project of Office of Natural Resources and Environmental Policy and Planning, B.E.2542), totaling 950 x 50 = 47,500 liters/day or equivalent to 47.50 m^3/day.

- Train Washing Plant will have 56 procured trains (Year 2047) at maximum and water use ratio will be1,045 m^3/day (according to Bangkok Mass Transit, Extension Project, B.E.2543), totaling 56x 1,045 = 58.52 m^3/day.

Therefore, water requirement of Depot and Park & Ride Building will be equivalent to 184.52 m^3/day or approximately 200 m^3/day. If water needs to be reserved for consumption for at least 3 days, it is necessary to use 4 reserved water tanks of 150 M^3/tank, totaling 600 m^3.

(j) Wastewater Collection and Treatment Systems

Wastewater of Depot and Park & Ride Building at Rom Klao Intersection originates from Administration and Operation Control Building, Dormitory, Canteen and Train Washing Plant and which account for 80% of total used water (as per Guidelines for Reporting of Environmental Impact Assessment of Accommodation for Community Services and Resort Project of Office of Natural Resources and Environmental Policy and Planning, B.E.2542). The wastewater can be divided into 2 types: wastewater from activities of staffs, and wastewater from maintenance and train washing activities. The total volume of wastewater from Depot and Park & Ride Building at Rom Klao Intersection is equivalent to 184.52 x 0.80 = 147.62 m^3/day as detailed in ***Table 3.6-5*** and ***Figure 3.6-31***.

Table 3.6-5 Classification of Buildings within Depot and Park & Ride Building at Rom Klao Intersection

Types of Buildings	Wastewater Volume (m^3/ day)
1. Administration and Operation Control Center	53.20
2. Staff dormitory	9.60
3. Canteen	38.00
4. Train washing plant	46.82
Total	**147.62**

Remark : Guidelines for Reporting of Environmental Impact Assessment of Accommodation for Community Services and Resort Project of Office of Natural Resources and Environmental Policy and Planning, B.E.2542)

Figure 3.6-31 Summary of Wastewater Volume within Depot and Park & Ride Building at Rom Klao Intersection

The onsite treatment of wastewater treatment system is used in Depot and Park & Ride Building at Rom Klao Intersection. The onsite treatment is built or installed for the treatment of wastewater released from buildings, i.e. houses, condominiums, schools or office buildings. The onsite treatment aims at reducing filthiness before releasing to the environment. The onsite treatment is a combination of Anaerobic Filter and Contact Aeration Process, with capacity 100.0 m^3/3 filters (totaling 300 m^3). Wastewater generated from activities within Administration, Operation Control Center and Staff Dormitory will be collected through the onsite treatment directly. Wastewater generated from canteen will flow through the grease trap while wastewater from maintenance and train washing activities will flow through the oil interceptor for separation of grease and oil before flowing through the central wastewater treatment system. Wastewater will be hold at the central wastewater treatment system at least 1 day before drainage to public drain.

The effluent quality shall meet Notification of Ministry of Natural Resources and Environment on Designating Control Standards for Wastewater Drainage from Some Types and Sizes of Buildings, Issued on November 7, B.E.2548, announced in Royal Thai Government Gazette Vol.122, Chapter 125 Ngo, dated December 29, B.E.2548.

(k) Garbage Management

The garbage generated within Depot is classified into 2 types: general waste and hazardous waste. Garbage generating in each building of Depot is as follows:

- Administration and OCC Building

- The OCC Building has 100 staffs at maximum and garbage generation ratio is 3 liters/person/day (as per Guidelines for Reporting of Environmental Impact Assessment of Accommodation for Community Services and Resort Project of Office of Natural Resources and Environmental Policy and Planning, B.E.2542), equivalent to 100 x 3 = 300 liters/day or 0.30 m^3/day.

- The Administration has 150 staffs at maximum and garbage generation ratio is 3 liters/person/day (as per Guidelines for Reporting of Environmental Impact Assessment of Accommodation for Community Services and Resort Project of Office of Natural Resources and Environmental Policy and Planning, B.E.2542), equivalent to 150 x 3 = 450 liters/day or 0.45 m^3/day.

- The Depot Platform has 400 staffs at maximum and garbage generation ratio is 3 liters/person/day (as per Guidelines for Reporting of Environmental Impact Assessment of Accommodation for Community Services and Resort Project of Office of Natural Resources and Environmental Policy and Planning, B.E.2542), equivalent to 400 x 3 = 1,200 liters/day or 1.20 m^3/day.

- Staffs in other buildings and Operations staffs who use the building area consist of 300 persons at maximum and garbage generation ratio is 3 liters/person/day (as per Guidelines for Reporting of Environmental Impact Assessment of Accommodation for Community Services and Resort Project of Office of Natural Resources and Environmental Policy and Planning, B.E.2542), equivalent to 300 x 3 = 900 liters/1 day or 0.90 m^3/day.

- Dormitory will be used by 60 staffs at maximum and garbage generation ratio is 3 liters/person/day (as per Guidelines for Reporting of Environmental Impact Assessment of Accommodation for Community Services and Resort Project of Office of Natural Resources and Environmental Policy and Planning, B.E.2542), equivalent to 60 x 3 = 180 liters/day or 0.18 m3/day.

- Canteen at the ground floor of OCC Building will be used by 950 staffs at maximum and garbage generation ratio is 3 liters/person/day (as per Guidelines to Reporting Environmental Impact Assessment of Accommodation for Community Services and Resort Project of Office of Natural Resources and Environmental Policy and Plan, B.E.2542), equivalent of 950 x 3 = 2,850 liter/1 day or 2.85 m3/1 day.

Therefore, the quantity of garbage within Depot and Park & Ride Building is equivalent to 5.88 M^3/day. To collect garbage produced by each building of the Depot, the 240 liter dustbin with a tight lid is provided, separating dry, wet, and hazardous and recycle types for various buildings of Depot. The buildings of Depot will be provided with 4 dustbins/area (totaling 22 areas).Staffs will collect and store garbage at Garbage Storage Building waiting at least 3 days for collection by responsible agencies, i.e. Min Buri District Office, Bangkok, for disposal outside the Depot (151.59 m^3)

(l) Drainage and Flood Prevention Systems

The Depot for Pink Line MRT Project, Khae Rai–Min Buri section at Rom Klao Intersection (end point) is a reinforced concrete building, approximately 2-4 meters higher than existing ground or +3.50 meters from mean sea level. This height is higher than maximum flood level of approx. +2.40 meters from mean sea level in Bangkok. The Depot covers the area of approx. 366,400 square meters. Regarding current land use, it comprises agricultural land and residential area. Currently, there is no drainage system. Storm drain to Khlong Song Ton Nun can be done through the slope of the area. Khlong Song Ton Nun is the canal located in the southwest of the Depot. With-project case, reinforced concrete drains of 60 centimeter long (with manhole at standard interval) will be designed and constructed. The pipes will be laid underground around the Depot. The drains will accommodate rainfall in Depot. The drainage system may be in the form of retarding pond or retention pond for excess rainfall. The speed of drainage shall be controlled making it similar to current drainage prior to releasing to Khlong Song Ton Nun.

(j) Safety and Security Operations and Fire Protection

Safety Guard and Fire Protection System within Depot

The safety and security system and fire protection within Depot at Rom Klao Intersection are detailed below:-

- As the center of Operation control and train maintenance, the Depot shall have strict safety measures. Security guards shall strictly look around the building, Moreover, CCTV shall be installed around the Depot fence, above or beneath platform, to prevent intrusion. In addition adequate lighting shall be provided for safety and security operations. Staffs who work in Administration Building and Operation Control Center shall always wearan employee card. Staffs shall always show the employee card to security guards when they enter into the building. Additionally, for the security around Depot and Park & Ride Building, security guards are able to perform inspection through CCTV and riding their bicycles to look around the area.

- The following fire protection and fire alarm systems shall be provided to prevent any damage caused by fire to the assets of Depot.

- Standpipe and fire hose
- Automatic sprinkler system
- Clean agent suppression system
- Portable fire extinguisher

The fire protection system consists of water fire extinguisher which has quantity of reserved water for its work not less than 30 minute and 2 sets of fire water pump with each automatic electric motor, size: 95 liter/minute; and then its pressure switch will supply water to fire pipe system outside the Building to Standpipe and fire hose cabinets, each of which will be installed to cover the 30-meter long hose. In addition, the external pipe will supply water to the automatic sprinkler system while the clean agent suppression system will be provided for firefighting in Electrical Room, Control Room, Communication Room or Uninterruptable Power Supply Room, etc.

- The fire protection and suppression plan is established for response to fire. The plan is also used as guideline for protection and reduction of any possible fire or quick suppression of fire. Moreover, fire drill and evacuation should be executed once a year in order to provide knowledge and understanding of the danger of fire and meet with the fire protection and suppression plan guidelines according to ministerial regulation of the Industry Ministry on Designating Standards of Administration and Operation of Occupational Safety, Health and Environment Regarding Fire Protection and Firefighting B.E. 2013, Section 4 of Office of Labour Safety, Department of Labour Protection and Welfare (www.oshthai.org), January 2556. The samples of issues for training on basic firefighting for construction workers are shown in ***Table 3.6-6*****.**

Table 3.6-6 Issues for Training on Basic Firefighting

Training Issues	Place
- Theoretical Part	Lecture Room
- Theory of Fire Incident	
- Classes of Fire	
- Psychology of Fire Incident	
- Protection of Fire Sources	
- Fire Protection and Fire Suppression System and Application of System and Equipment in Organization	
- Types of Firefighting	
- Usage of Fire Fighting Equipment	
- How to Use Personal Protective Equipment in Fire Fighting	
- Practical Part	Firefighting Training Ground
- Technique for Firefighting with Portable Fire Extinguisher	
- Technique for Firefighting caused by Gas	
- Technique for Firefighting with Fire Hose	
- Training Evaluation	Lecture Room

Accident Prevention Plan and Emergency Response Plan for Loss

1) The prevention of rail transit system from terrorism and violent crime is detailed below:-

a) Establishment of comprehensive safety plans

- Providing plan for each level of warning and upfront safety measures;
- Providing emergency plan and drills regularly;
- Cooperating with the local agencies and involved officers; and
- Reviewing safety plans regularly for consistency with particular situation.

b) Brainstorming for threat assessment

- Organizing meeting with safety and security agencies; and
- Analyzing crime patterns of mass rapid transit system.

c) Design of general stations and terminal stations

- Being in compliance with international safety standards of mass rapid transit system;
- Selecting incombustible materials with no toxic fumes or sparks when burning;
- Providing reversible fan for ventilation in normal condition and in case of fire;
- Designing for open space with no blind spot;
- Designing for good vision and good observation of incidents by security guards;
- No blind spot or place to hide any object;
- Providing sufficient emergency exits for passenger evacuation in case of emergency;
- Clearly specifying evacuation routes;
- Providing sufficient lighting system;
- Installing closed circuit television (CCTV) throughout the station areas;
- Designing stations that are easy for maintenance; and
- Providing transparent trash cans and frequently collecting garbage.

d) Design of train

- Being in compliance with international safety standards of Mass Rapid Transit System;
- Selecting incombustible materials with no toxic fumes or sparks when burning;

- Having no space to hide any object in passenger seat;
- Installing closed circuit television (CCTV) within the train bogie.

e) Provision of barricades or physical shields

- for parking lot and the structure;
- for Depot and Park & Ride Building;
- for important facilities such as bulk substation;
- for track;
- for rail turnout; and
- for signaling control box.

f) Entrance-exit control and intrusion Detection

- Headquarters and Operation Control Center;
- Power substation;
- Power Station for Heating, Ventilation and Air Conditioning (HVAC);
- Depot;
- Entrance-exit of Train Station; and
- Entrance-exit checkpoint by closed circuit television (CCTV).

g) Installation of closed circuit televisions (CCTVs), throughout the following train station areas, Depot and Park & Ride Building, using high quality colored recorder even at night time, which directly delivers data to the nearby police stations

- Train stations;
- Public telephone booths and concourses;
- Entrance of train station buildings;
- Parking areas;
- Entrance-exit gate; and
- Inside trains.

2) Warning and protective measures against sabotage

Warning is divided into 4 levels below:-

1st Level: Adjusting the operation plan day by day for more safety;

2nd Level: Instructing staffs and passengers to follow safety measures strictly;

3rd Level: Having reliable source of information of treat or attack of Mass Rapid Transit System;

4th Level: Having an intelligence assuring treat or attack of Mass Rapid Transit System.

Samples of Operation Plans for 1st level warning:-

1. Drills according to safety operation plan and Warning;
2. No disclosure of information to any unconcerned person;
3. Strict adherence to the highest safety measures for Operation Control Center and Main Workshop;
4. Test of the planned safety measures and system.

Samples of Operation Plans for 2ndlevel warning:-

1. Thorough safety inspection of Mass Rapid Transit System, integration of safety inspection to routine activities, request for observation from passengers of any suspects or abnormalities and notification to the station security guards;
2. Regular and thorough inspection of suspected objects inside all trains;
3. Coordination with the national safety agencies for support in the event that 3rd level warning is required.

Samples of Operation Plans for 3rd level warning:-

1. Reliability for treat, attack and sabotage of Mass Rapid Transit system;
2. Maintaining safety measures in collaboration with the national security agency for weeks to ensure safety from any treat;
3. Strict control of transportation of hazardous materials such as trucks carrying LPG, oil trucks, hazardous chemical trucks, which transport such materials to rail routes; if it is necessary to transport such materials, inspection shall be performed for maximum transportation level; and
4. Continual inspection of the effectiveness and the duration of sabotage protection of Mass Rapid Transit system.

Samples of Operation Plan for 4th level warning:-

1. Availability of intelligence assuring treat or attack of Mass Rapid Transit System;
2. Announcement of the controlled areas for safety (partial or whole routes or whole network or specific areas);
3. Announcement of the 4th level warning for at least 72 hours;
4. Continual assessment of the sabotage risk;
5. Close the train service to prevent attack, if necessary.

(2) Concepts of Architectural Design

(a) Concept of Site Planning

The building location overall is determined by specialists based on related requirements and optimization of area utilization. Apart from specialists, architects are involved in the determination of each building location, which is separated from rail track laying, within the area. Each building is linked for convenient use. The

building site shall not block the sunlight and the wind so that it can make use of the nature, making the area shady, comfortable with energy-saving and beautiful view. Site planning contributes to the excellence of this project in terms of utilization, esthetics and energy saving as shown in ***Figure 3.6-32***.

(b) Concept of Architectural Design

The Project buildings are for administration, train operation and maintenance. Utility space, size and relation of each building, the number of staffs and organization were determined by specialists. The information is important for planning inside the building. Regarding planning inside the building, architects create the layout that meets requirements for optimization of technical utilization. Besides, secondary utility space is added for operation of staffs and other engineering works. The buildings should support technical works, and be convenient for building users. Buildings shall be associated with outside environment and sunlight and wind direction which contribute to energy saving. Suitable materials shall be selected for the floor, wall, and ceiling for utility space that needs special care, i.e. special equipment room, operation room, etc. in order to control the light and the noise. Moreover, the height of utility space is vitally important. The height of utility space shall be suitable for utilization and the size of the room. The height of utility space affects the feelings of building users. For example, a lobby should boost the feelings of relief, joy and relaxation, etc., which contribute to working efficiency. A canteen should create the feeling of relaxation. A meeting room should be calm and tranquil with the light, sound and temperature that encourage meeting environment, creativity and initiatives. Utility space, utilization and the atmosphere inside buildings will influence the shape of the outside of the building, determination of opaque wall, fanlight, and the shape of roof. Applied materials of the Project shall be controlled for suitability and neatness. Although there are a lot of buildings, the buildings, overall, shall be in harmony. Modern, durable, nice and enduring materials shall be selected.

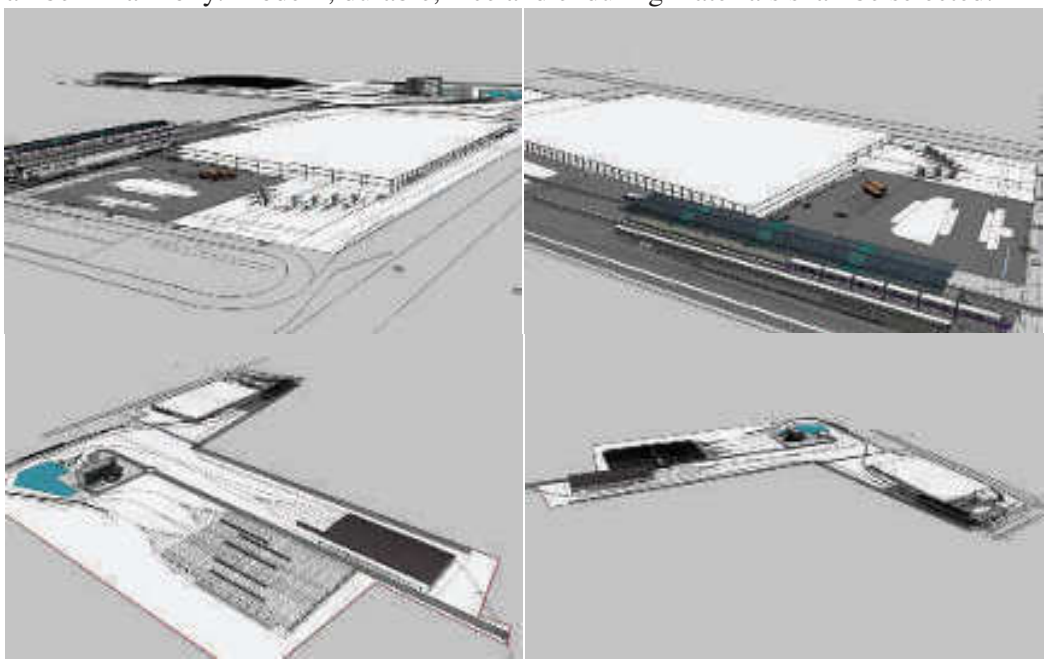


Figure 3.6-32 Design concepts of Depot and Park & Ride Building at Rom Klao Intersection

(c) Concept of Project Appearance

The Project appearance has to be exquisite and modern which is suitable as the national project. The project appearance shall communicate technology, movement and travel. **Therefore, architects chose the geometric shape which is simple and different from industrial buildings**. Additionally, positioning of buildings related to the environment, utility space and utilization, communicates the intention of respect of the nature, efficiency and energy saving.

(d) Concept of Landscape Architecture

The concept of landscape architecture contributes to a comprehensive project. Architects determined that landscape architecture visually defines the project boundary and the travelling routes both on foot and by car. Landscape architecture will be the eye rest area and the shadow for buildings and building users. The Depot is located along the area boundary which is far from the operation area. Trees planted around the Depot shall be disliked by birds so that they will not build the nest on them. Tree branches shall not cause trouble to buildings or operation area. Trees will serve as the eye rest area. Furthermore, trees should not be too dense so that fence surrounding areas shall be seen clearly. The trees should also be convenient to take care of. It should be easy to observe any person or animal coming in this restricted area. Landscape architecture should make the front building of the Project elegant, warm, relaxing and friendly to people.

- **Major elements and details of Project**

Major elements of Depot and Park & Ride Building of Pink Line Khae Rai-Min Buri Project consist of:

1. Administrations & OCC Building
2. Operation, Maintenance & Park & Ride Building
3. Bulk Substation Building
4. Hazardous Material Store
5. Wastewater Treatment Plant
6. Storm Water Pump

and the following details:-

1. Administrations & OCC Building

It is the administration building of the unit responsible for all businesses of all train operation routes and within the project area. It is composed of train operation supervision and all other operations supervision, including technical operation, administration and human resources.

2. Operation, Maintenance & Park & Ride Building consist of sub-elements below.

- Main workshop: The building for 7-track car maintenance. Maintenance is determined by specialists. Major maintenance is divided into two categories: light maintenance and overall maintenance. Apart from maintenance, the main workshop is involved with office building and other tasks for car.

- Stabling yard: The area for 28-track train parking, totaling 56 trains (6 cars). The stabling yard has no roof with platform level at the yard's side. In addition to serving as the daily parking lot, which is the main task, the stabling yard is for preliminary inspection for repair and daily train washing.

- Train washing plant: Automatic washing machines are installed in this building together with a control room. The washing yard has no roof. When trains are already washed by automatic washing machines, they will run to the stabling yard. The train washing plant is a heat-proof building.

- Park & Ride building: It is a 3-storey building and is a PTI system. The Park & Ride building is characterized as follows:

  - The front area is provided for PTI and the entrance- exit of Park & Ride Building.
  - A car park: It serves approx. 3,000 cars with the entrance-exit of Park & Ride Building, office building, engine room and parking area.
  - The office building is for safety and security system and parking fee collection.
  - The engine room is for electrical system and water supply, sanitary affairs, storeroom and office waste storage.

3. Bulk substation: This building of the Project controls power supply within the Project. It is a heat and humidity-proof building because it stores most of electronic equipment.

4. Hazardous material store: Chemical materials are stored in this building. It is focused on prevention of chemical leakage and fire caused by stored materials. This building is designed based on NFPA standard.

5. Project supporting buildings are constructed for utilities systems of the Project. They consist of the following structures.

- Wastewater Treatment Plant
- Storm Water Pump
- Guard House

6. Two (2) retention ponds of Depot and Park & Ride Building at Rom Klao Intersection: Min Buri. The retention pond at Zone A holds water at 2,031 m^3while the one at Zone B has a holding capacity of 9,095 m^3.

- Sufficiency of Park & Ride Building

Since Pink Line MRT Project, Khae Rai–Min Buri section has passed main roads such as Tiwanon Road, Chaeng Watthana Road, Ram Indra Road and Srihaburanukit Road; the passengers can travel conveniently by bus or public carrier to use the train services. If the Park & Ride Building is far from the train route, and it is required to provide a shuttle bus to transport passengers to the train station, it becomes inconvenient and unpopular because they have to spend more time to travel back and forth.

For Pink Line MRT Project, Khae Rai–Min Buri section, one (1) Park & Ride Building is designed. It is located in the same area of Depot at Rom Klao

Intersection. The Park& Ride Building is a 3-floor reinforced concrete structure that accommodates approx. 3,000 cars (1,000 cars/floor) as shown in ***Figure 3.6-33***. It will serve passengers living around Ramkhamhaeng Road and Rom Klao Road. Moreover, the Project has provided an additional parking lot at Pak Kret Station (PK06) as shown in ***Figure 3.6-34.*** This outdoor parking lot on the ground level is for approx. 30 cars and public carriers, such as van, taxi, and others for passengers travelling from Tiwanon Road and Chaeng Watthana Road.

(e) Usage of Park & Ride Building with other Mass Rapid Transit Projects

The Pink Line MRT Project, Khae Rai–Min Buri section is one of the Mass Rapid Transit Master Plan in Bangkok Metropolitan Region that links other four (4) projects such as Mass Rapid Transit Purple Line, Bang Yai-Bang Sue section, Commuter Train Project (Red Line), Bang Sue-Rangsit section, Mass Rapid Transit Green Line, Moe Chit-Saphan Mai section and Mass Rapid Transit Orange Line, Bang Ka Pi-Min Buri section. The Park & Ride Building is designed for all projects for the convenience of passengers with the following details:

Commuter Train System Project (Red Line), Bang Sue-Rangsit section: One (1)

Park & Ride Building at Bang Sue Grand Station is provided for 1,000 cars for passengers living around Bang Sue and nearby areas to park their cars before traveling by Commuter Train (Red Line) which links to Pink Line MRT Project at Lak Si Station (PK14).

Figure 3.6-33 Location of Depot and Park & Ride Building at Rom Klao Intersection

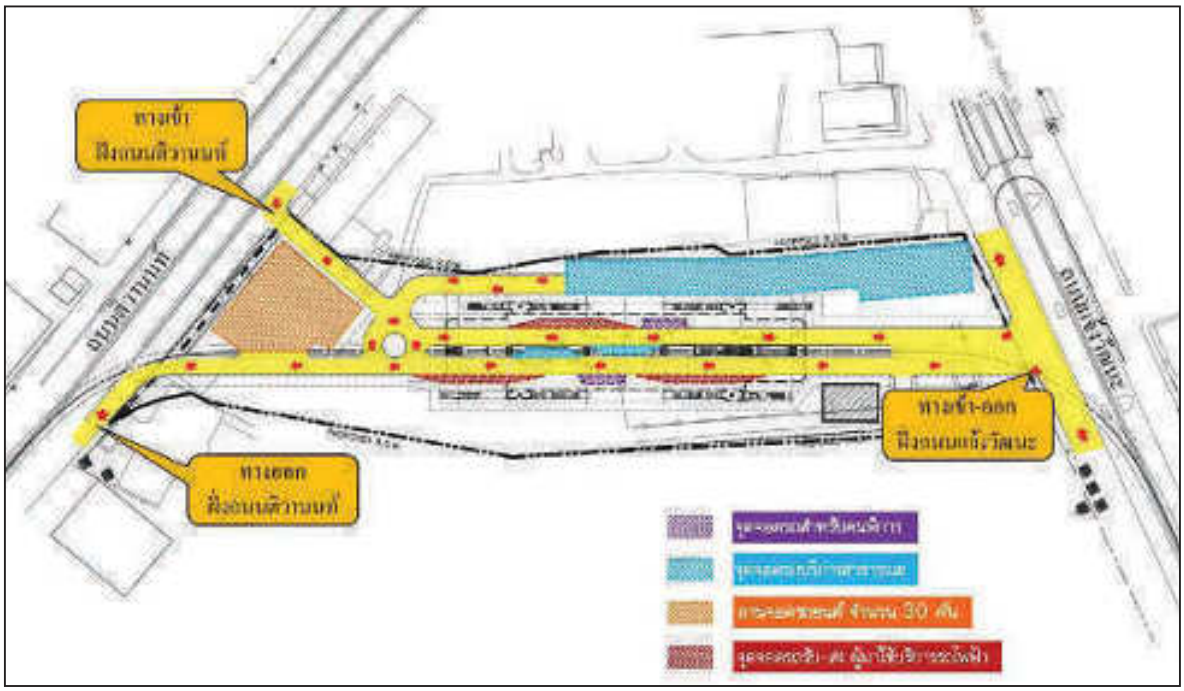


Figure 3.6-34 Parking Lot for Cars and Public Carriers at Pak Kret Station (PK06)

Mass Rapid Transit Green Line, Moe Chit-Ku Kot section: Two (2) Park & Ride Buildings are provided at Kor. Mor. 25 Station for 1,043 cars and at Ku Kot Station for 713 cars. Therefore, passengers living around Rangsit, Lum Look Ka, Pathumthani, and nearby areas are able to park their cars at both Park & Ride Buildings before traveling by Mass Rapid Transit Green Line which links to Mass Rapid Transit Pink Line at Wat Phra Si Maha That Station (PK16).

Mass Rapid Transit Orange Line, Bang Kapi-Min Buri section: Two (2) Park & Ride Buildings are provided at Min Buri Station for 3,000 cars (shared with Pink Line MRT Project, Khae Rai–Min Buri section) and at Klong Ban Ma Station for 1,200 cars. Therefore, passengers living around Ramkhamhaeng, Hua Mak, Bang Kapi, Saphan Sung, Bung Kum, and nearby areas are able to park their cars at both Park & Ride Buildings before traveling by Mass Rapid Transit Orange Line and Pink Line at Min Buri Station (PK30).

As passengers can park their personal cars at Park & Ride Buildings provided by all 4 Mass Rapid Transit Projects, which cover Bangkok and Nonthaburi and as Park & Ride Buildings are sufficient for their needs, land acquisition and removal of buildings of people living around Pink Line MRT Project, Khae Rai–Min Buri section are not required. Therefore, it alleviates impacts from land acquisition and relocation.

For more convenience of train passengers who access the rail station by bus, van, and taxi, etc., the Pink Line MRT Project, Khae Rai-Min Buri section, has provided intermodal passenger transportation facilities. At PK01-PK29 stations, the Consultants assigned Drop-off areas under the stations on both sides of the road. Rail passengers will be picked up and drop off in these areas by personal cars, vans and taxis in order to travel to the destination. Moreover, at Min Buri station (PK30), which is the terminal station, the Park & Ride Building is designed for approx. 3,000 cars. At Pak Kret station (PK06), the outdoor parking lot is provided for approx. 30 cars. Vans, taxis and other public carriers can be parked inside the station.

3.7 MANAGEMENT OF WORKER CAMPSITE

Based on the forecast that the Pink Line (Khae Rai–Min Buri Section) Project will require about 200 workers, estimation of water consumption, wastewater and solid waste is described follows.

Water Consumption

Number of workers = 200 persons

Water consumption = 200 liters/person/day (Kriangsak, 1996)

Or = 40 m^3/day

Wastewater

Based on the estimate that water consumption will be 200/liters/person/day (Kriangsak, 1996), wastewater from toilets and other activities will be 80% of the daily water usage (Kriangsak, 1996).

Wastewater = 32 m^3/day

Regarding management of wastewater and solid waste during the construction and operation periods, the proper wastewater treatment system was designed for the project. Treated wastewater will be released into the sump provided in the project area before being discharged into the public sump.

Since the project construction will take about 4 years, the Engineering Institute of Thailand's Standards (EIT Standard 1010-30) about temporary buildings for construction workers have been applied to design the layout of the project's worker campsite. This is to ensure it will be arranged in an orderly fashion without causing any impact to local communities in the project's environs. Each campsite will cover an area of 1 rai and accommodate about 200 workers as illustrated in ***Figure 3.7–1***. Details of the worker campsite are as follows.

- There are five 1-floor row house buildings. Each consists of 20 rooms (10 rooms in the front row and another 10 on the back row). Each room is for 2 persons. Therefore, each building can house 40 persons.
- There are 20 toilets built in accordance with the relevant standards. 1 sanitary toilet is for 10 workers.
- Two common bathing and washing areas and four water storage tanks, each with a 4.8 m^3 capacity, are provided.
- Temporary ditches are provided around the campsite. There are also sediment traps.
- Refuse containers should be sufficiently provided at workers' houses. There is also a waste collection site for the responsible agency to collect for further disposal.
- Eight dry chemical fire extinguishers (15 lbs) are arranged for each building.
- Guardhouses are located at the campsite.
- Sufficient public utilities, e.g. electricity, water supply, etc., are provided.

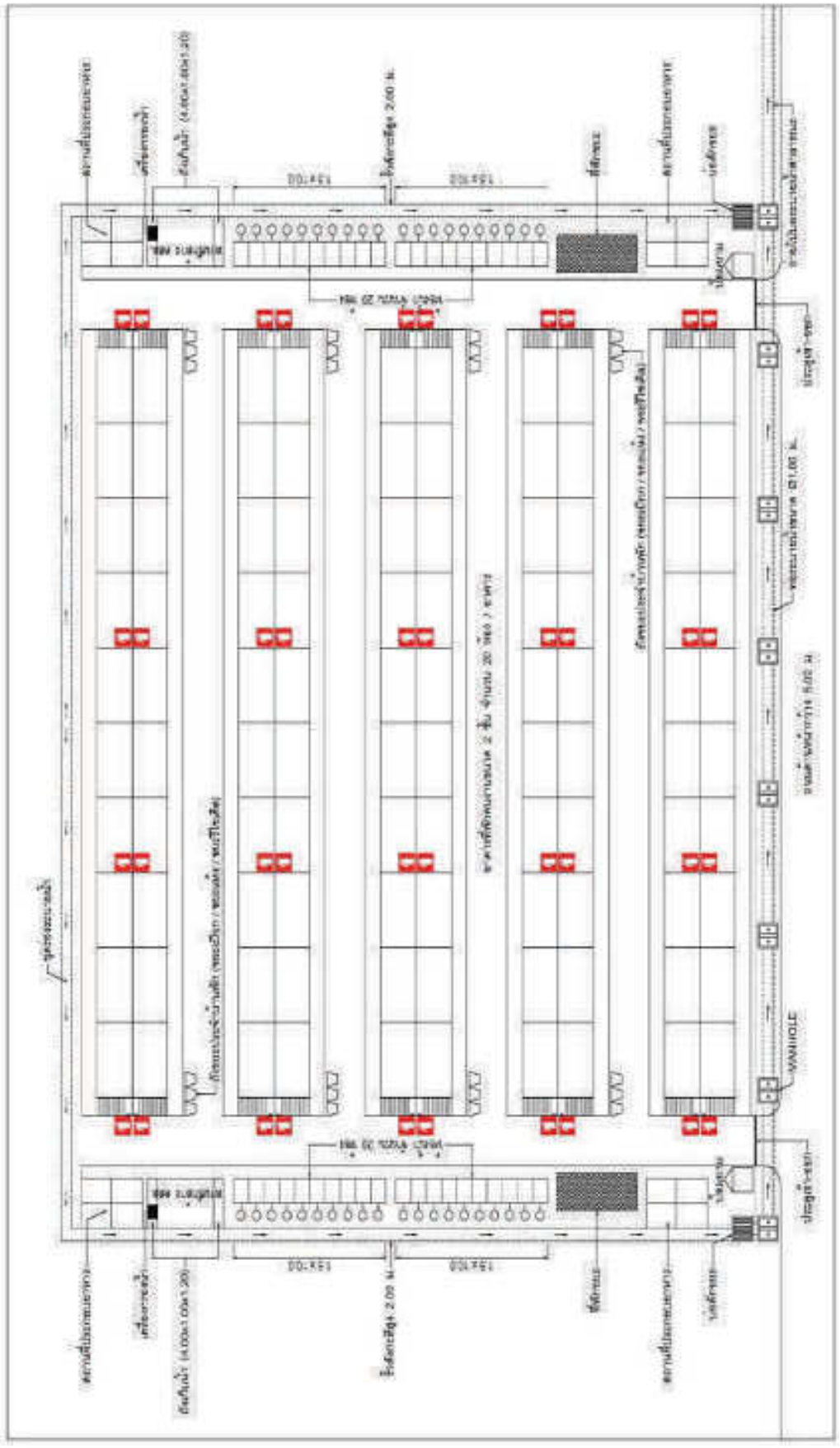


Figure 3.7-1 : Layout of Worker Campsite

As for daily construction activities, a temporary shed for workers will be provided near the construction site as depicted in ***Figure 3.7-2***. Each shed should at least consist of the following.

(1) A temporary shed of suitable size should be provided for workers to have lunch and take a break. However, cooking is not allowed.

(2) Two temporary toilets with built-in septic tanks are arranged for workers. There should be toilet cleaning staff, and sewage should be removed every 1-2 weeks.

(3) Clean water for drinking and consumption should be adequately provided for workers. Also clean water for face and hand washing should be arranged but bathing is not allowed.

(4) Dry waste and wet waste containers should be prepared. Solid waste should be transferred every 5-10 days for disposal.

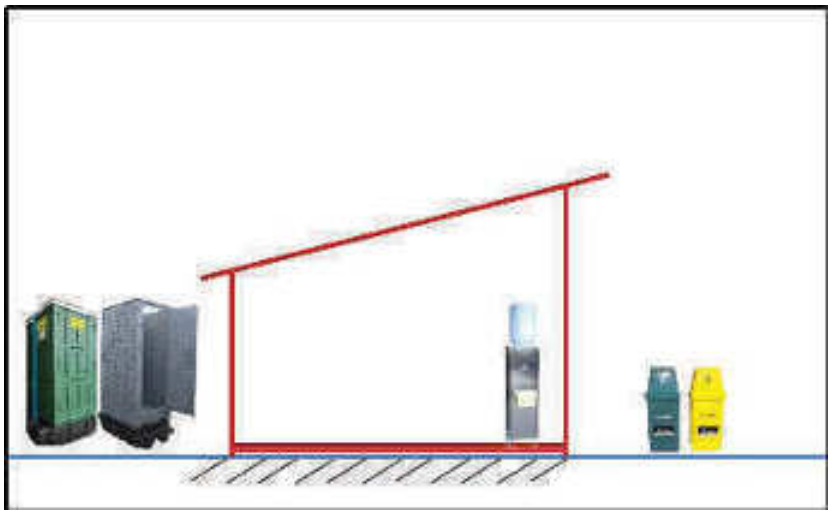


Figure 3.7-2 : Temporary Shed for Construction Workers

Solid Waste

Solid waste in the project site is divided into two major types: refuse and construction waste.

Refuse consists of food scraps, wastepaper, plastic scraps, etc. Considering the workers' consumption activities, the waste generation rate was estimated at about 0.5 kg/person/day. Therefore, the amount of solid waste was computed as follows.

Number of workers	=	200 persons
Waste generation rate	=	0.5 kg/person/day
Amount of solid waste	=	100 kg/day

Construction waste comprises rubble, including pieces of bricks, concrete, wood, cement bags, and scarp metal. The generation rate of this waste is not certain. Some materials can be reused (e.g. formworks) and some can be sold for recycling.

All solid waste generated in the project site will be collected and disposed of at the sites specified by the Bangkok Metropolitan Administration (BMA) or the project staff will contact BMA to collect solid waste from the project site for proper disposal. According to the statistics on solid waste collection during 2012-2013, the quantities of solid waste in Lak Si, Bang Khen, Bueng Kum, Khan Na Yao, and Min Buri districts were 159.86-156.39 tons/day, 248.33-252.73 tons/day, 175.51-187.60 tons/day, 125.03-128.01 tons/day, and 178.80-186.76 tons/day respectively (Environment Department, BMA). Domestic waste in Bangkok are collected and transferred to 3 solid waste transfer stations in Sai Mai, Nong Khaem, and On Nut districts as shown in ***Figure 3.7-3***. Refuse is normally conveyed to the landfills in Kamphaeng Saen district, Nakhon Pathom province, and in Phanom Sarakham district, Chachoengsao province. Organic waste is used to make compost at fertilizer plan in On Nut. As for infectious waste and hazardous waste, BMA has assigned private companies to transfer and dispose of by using specific method.

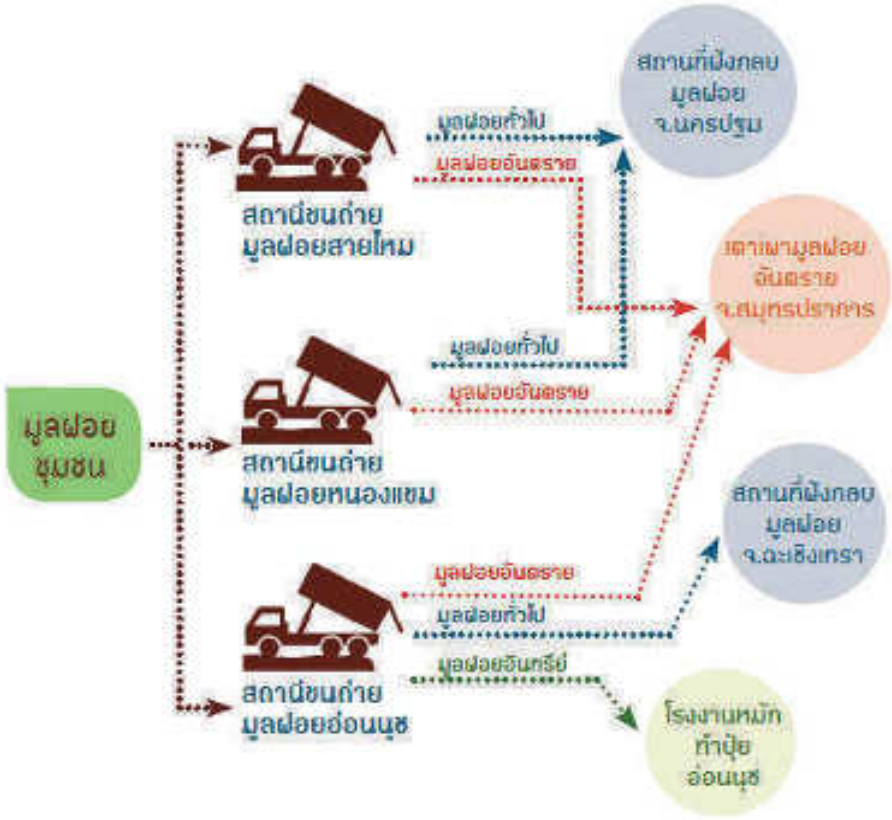


Figure 3.7-3 : Transfer of Domestic Waste in Bangkok

Upon commencement of construction activities for the Pink Line (Khae Rai-Min Buri Section) Project, about 100 kg/day of solid waste will be generated. This amount is considered slight when compared to the total waste in the aforementioned districts. The responsible agency will be contacted to collect solid waste for proper disposal.

Pursuant to Clause 4 in the Ministerial Regulations Prescribing the Standards for Administration and Management of Occupational Safety, Health, and Environment in Relation to Fire Prevention and Control, B.E.2555, in the workplace having ten employees or more, the employer shall prepare the fire prevention and control plan,

including inspection, training, and campaign on fire prevention, firefighting, fire evacuation, and relief. The employer shall keep the fire prevention and control plan at the workplace and be ready for safety inspection officers to check. The guidelines for fire prevention and control plan established by the Occupational Safety Bureau, Department of Labor Protection and Welfare, are presented below.

Fire Prevention and Control Plan

The fire prevention and control plan is aimed to prepare employees to respond to fire emergency. The plan also provides guidelines for preventing and reducing fire risks. In case of fire occurrence, fire will be quickly extinguished, thus controlling damage and maintaining fire safety. A fire drill should be organized at least once a year to ensure employees have knowledge and understanding about fire hazards and are able to efficiently follow the fire prevention and control plan. Presented below are the guidelines for preparing the fire prevention and control plan established by the Occupational Safety Bureau, Department of Labor Protection and Welfare (www.oshthai.org), January 2013.

Objectives

(1) To prevent loss of life and property from fire damage
(2) To create confidence about safety among employees in case of fire
(3) To reduce fire risks
(4) To create employees' good attitude towards workplace

Fire Prevention and Control Plan consisting of

(1) Inspection Plan
(2) Training Plan
(3) Fire Prevention Plan
(4) Fire Extinguishing Plan
(5) Fire Evacuation Plan
(6) Relief Plan

(1) Inspection Plan

Fire risks must be surveyed and inspected to prevent and get rid of causes of fire. Data on fuels, chemicals, flammable substances, and ignition sources should be collected for arranging the inspection plan. Fire characteristics, quantities of hazardous substances which are mostly found, required types and quantities of extinguisher agents should be also recorded.

The inspection plan should contain responsible people, responsible area, items and locations to be checked, duration, frequency, report checker, and report on inspection result.

Example of list of items for inspection

- Location of fire risk
- Use and storage of flammable substances
- Flammable waste
- Fuel
- Source of heat
- Firefighting equipment
- Fire exit

(2) Training Plan

The training is aimed to equip employees with the fire prevention knowledge and response to fire emergency. Fire in a workplace causes both direct and indirect damages to business, including property, suspension of operations and services, loss of sales opportunities, and even injury and death. Therefore, training on prevention and minimization of fire risks is essential. Responsible person, duration and budget for training courses should be clearly specified in the plan.

Examples of Training Courses that Must Be Included in the Training Plan

- Basic firefighting training course
- Firefighting practice and fire drill course

Examples of Training Courses that Should Be Included in the Training Plan

- First aid training course
- Cardiopulmonary resuscitation training course

(3) Fire Prevention Plan

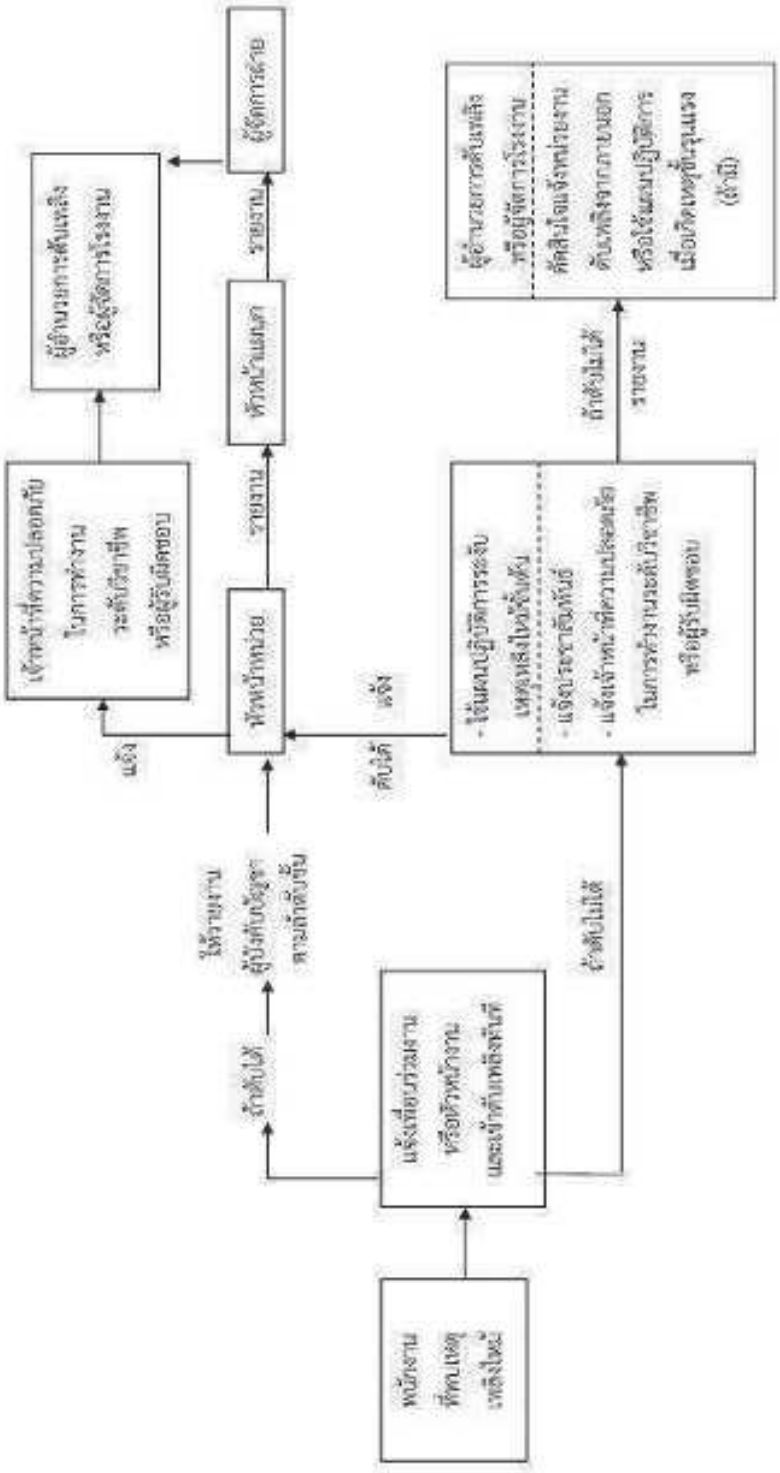
It is aimed to campaign for fire prevention in a workplace and promote awareness about fire prevention among all levels of employees. The plan should contain responsible person, duration and budget.

Examples of activities for fire prevention campaign

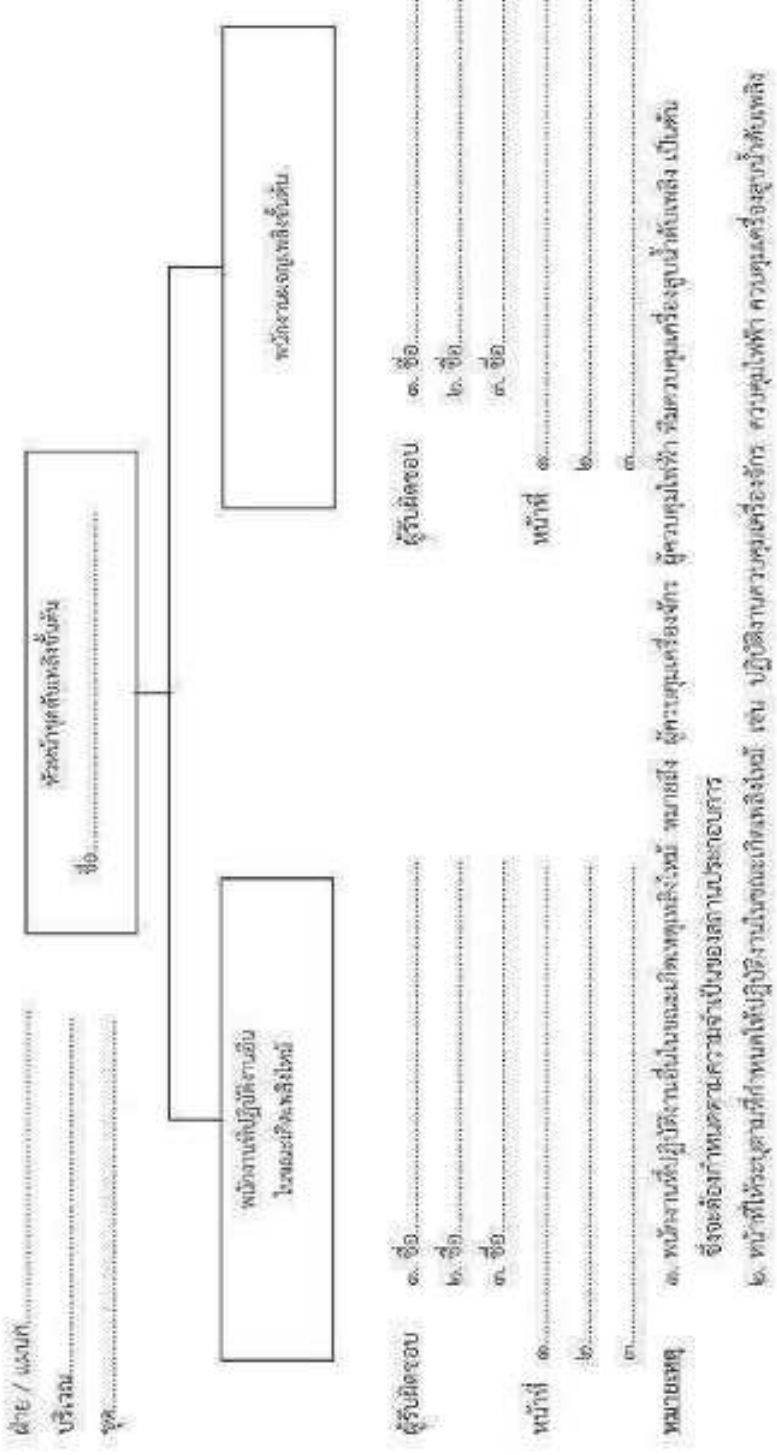
- 5S activities
- Reduction of public smoking
- Exhibitions
- Posters
- Other materials

(4) Fire Extinguishing Plan

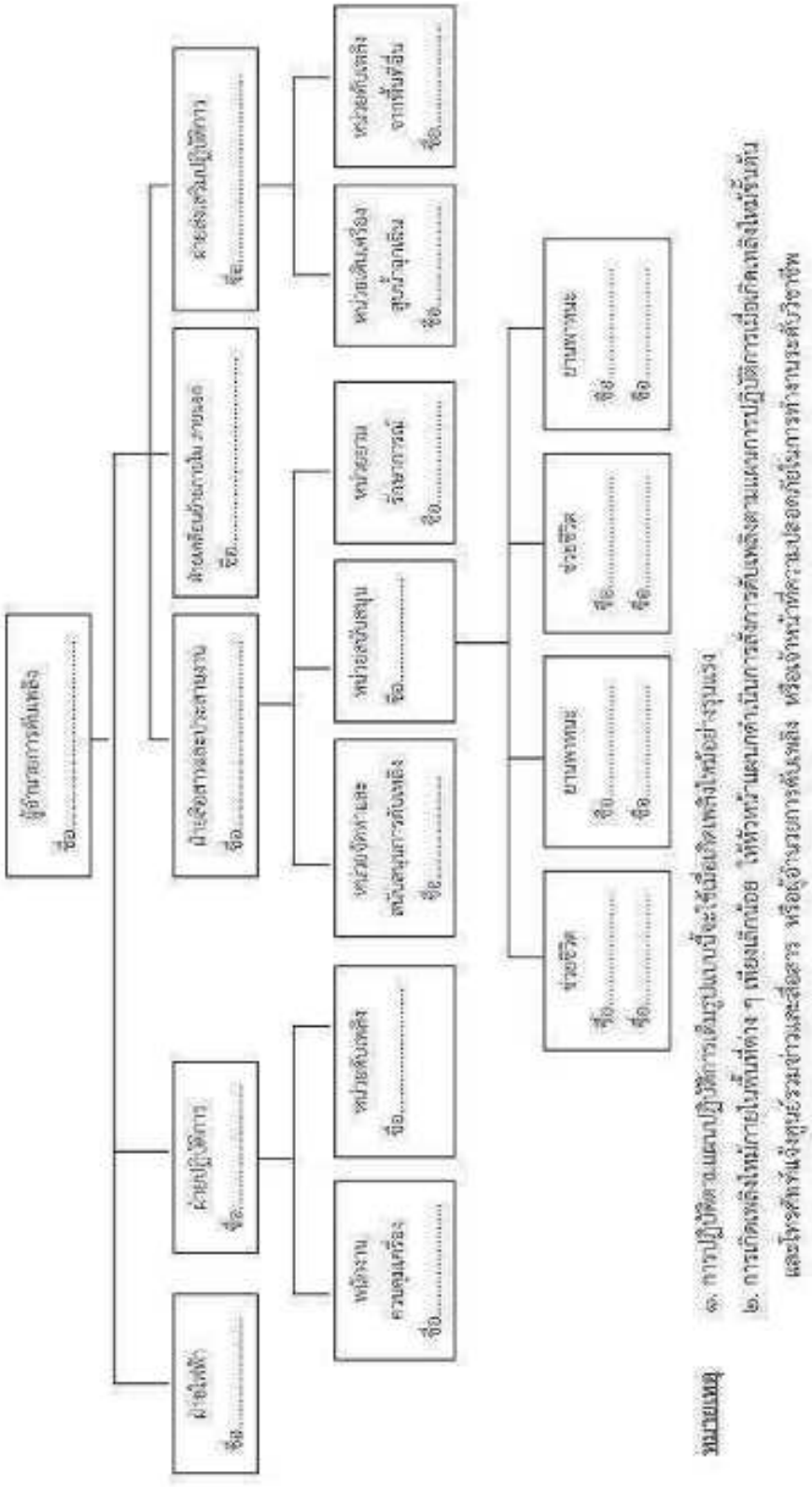
Example of the Action Employees Should Take if They Discover a Fire



Example of Form which Specifies Firefighting Team and Duties



Example of Firefighting Team Structure in Case of Severe Fire (if any)



Duties of Operators in Firefighting Team Structure in Case of Severe Fire (if any)

Operators	Duties
Firefighting Director	1. Listen to the reports on the situation and order implementation of firefighting plan. 2. Request for assistance from related organizations. 3. Report the firefighting result to the superior 4. Provide information on fire event to mass media.
Electrical Department	1. In case of fire, rush to the scene and receive order to cut electricity from the Operations Department. 2. Receive instructions from the Firefighting Director.
Operations Department	Head of Operations Department must perform the following. 1. In case of fire, the Head of Operations Department must divide his staff into two groups: Machine Control Group and Firefighting Group. a. Machine Control Group: In case of fire, the group must continue machine operations until the Head of Operations Department orders to stop. In case of obtaining order to stop machine operations or inability to operate machines, the group will join the Firefighting Group. b. Firefighting Group: In case of fire whether slight or severe, this group will leave the machines without stopping them and rush to immediately extinguish fire. They will follow the instructions of the Head of Operations Department. In case assistance from other units is needed, the Head of Operations Department will have to order first. 2. Upon being notified of fire, immediately contact safety officers, the Firefighting Director, and the Press Center to inform of the emergency.
Communications and Coordination Department	1. Provide assistance and coordination with related persons. 2. Receive instructions from the Firefighting Director and contact the Press Center. 3. Give instructions on behalf of the Firefighting Director if assigned.
Firefighting Procurement and Support Unit **- Coordinator**	1. Provide assistance and coordination between the Firefighting Director, security guards, and related parties. 2. Receive instructions from the Firefighting Director and contact the Press Center. 3. Give instructions on behalf of the Firefighting Director if assigned.
- Security Guards	1. Rush to the scene, and receive instructions from the Firefighting Director and the Head of Communications and Coordination Department. 2. Prevent unauthorized persons from entering the place. 3. Safeguard the assets and materials moved by the Internal-External Transfer Department.
Internal-External Transfer Department	1. Responsible for identifying the safe places for keeping materials and assets. 2. Provide convenience for transfer of materials and assets. 3. Provide vehicles and equipment for transfer of materials and assets.
Operations Support Department **- Unit Responsible for Contacting other Fire Stations**	1. Send safety order system (SOS) message. 2. Employees who wish to help extinguish the fire have to report to the Firefighting Director who will assign them to the Operations Support Department. 3. In case of fire near machines, the firefighting team members should be those who normally work in the area. Others should assist in conveying firefighting equipment. 4. Be around the scene of fire, waiting for orders from the Firefighting Director.
- Fire Pump Operation Unit	1. Start the fire pump immediately upon being informed of the fire occurrence. 2. Control the fire pump during firefighting procedures. 3. In normal situation, regularly perform maintenance of firefighting equipment in accordance with maintenance schedule.
Press/Communications Center	1. Upon being notified of fire, check whether the news is true. 2. Inform of fire event. 3. Regularly follow up and update the event. 4. Request for help from related organizations. 5. Inform of the result after fire suppression.

Responsible Persons Assigned to the Firefighting Team

Position	Office Hours (Working Day) 08.00-17.00 hrs.	After-Office Hours (Working Day) 17.00-08.00 hrs.	Day Off 08.00-24.00-08.00 hrs.
1. Firefighting Director	- Operations Director or Assigned Person	- Department/Unit Head of the Area or Nearby Area	- Department/Unit Head of the Area or Nearby Area
2. Head of Electrical Department	- Head of Electrical Department	- Night Shift Staff.....	- Night Shift Staff.....
3. Head of Operations Department - Machine Control Unit	- Factory Manager or Assigned Person - Machine Control Staff - Emergency Response Team ……	- ..... - Machine Control Staff - Emergency Response Team ……	- ..... - Machine Control Staff - Emergency Response Team ……
4. Head of Communications and Coordination Department - *Support Unit* - Nurse - Vehicle Staff - Press and Communications Center Staff - *Firefighting Procurement and Support Unit* - Coordinator - Distributor of Firefighting Equipment - Communicate information via the Press/Communications Center - Security Guard Unit	- Human Resources Manager or Assigned Person - Office Nurse - Ambulance Driver - Telephone Operator - Safety Officer (Waiting for firefighting equipment) - Head of Operations Department (at the beginning) Safety Officer (upon arrival at the place) - Person Responsible for Coordination with Security Guards	- ..... - First Aid Team - Ambulance Driver - ……. - Head of Security Guards	- ..... - First Aid Team - Ambulance Driver - ……. - Head of Security Guards
5. Head of Internal-External Transfer Department	- Head of General Administration Department or Assigned Person	- Duty Officer	- Duty Officer
6. Head of Operations Support Department - Fire Pump Operation Unit - Unit Responsible for Contacting other Fire Stations - Use Safety Order System (SOS) alarm.	- Department Manager - From General Administration/ Maintenance Unit Name..... - Press SOS alarm……	- ..... - From General Administration/ Maintenance Unit Name..... - Press SOS alarm……	- ..... - From General Administration/ Maintenance Unit Name..... - Press SOS alarm……

(5) Fire Evacuation Plan

The plan is aimed to prevent loss of life and property of employees and a workplace in the event of fire.

The fire evacuation plan should comprise the head count unit, evacuation wardens, assembly point, rescue unit and vehicles, etc. The responsible persons for all units should be specified. They should directly report to the Firefighting Director or Fire Evacuation Director.

- Name of Firefighting Director or Fire Evacuation Director…….
- Name of Assistant Firefighting Director or Assistant Fire Evacuation Director…….

Fire evacuation procedures should be included in the plan.

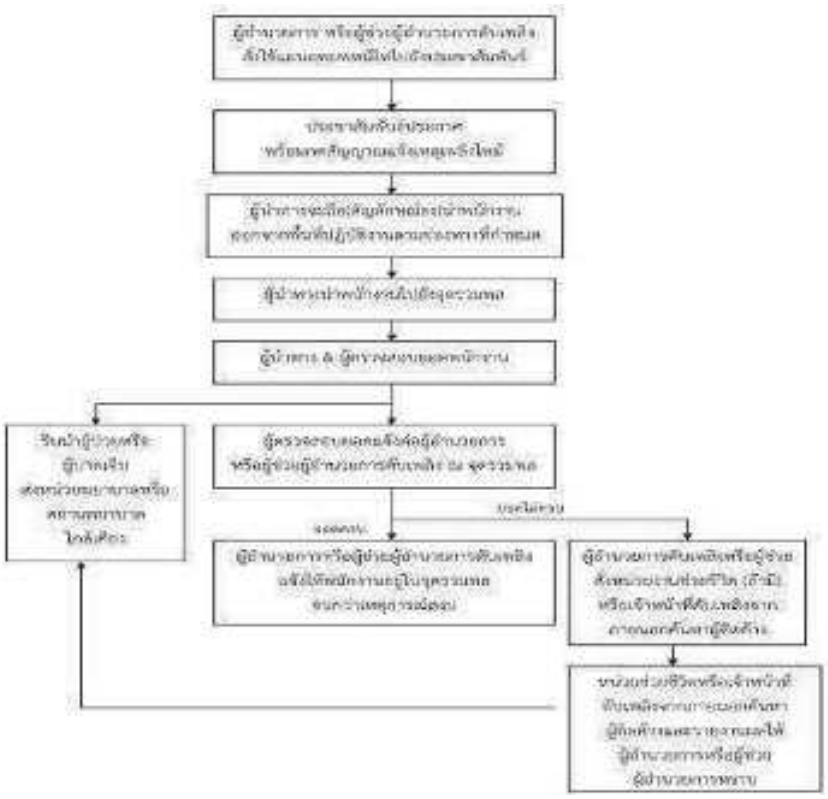
(a) Fire wardens are responsible for leading employees to escape the place via the pre-determined fire evacuation route.

(b) Assembly point must be safe for a roll call of employees.

(c) Head count unit is responsible for ensuring all employees escaping the workplace.

(d) Rescue unit is responsible for searching for employees who may remain in the workplace and providing first-aid treatment to those who are faint or injured. Vehicle unit will be contacted to transfer the injured to hospital according to the instruction of a nurse or doctor.

Example of Fire Evacuation Flow Chart



(6) Relief Plan

The relief plan consists of the following.

- Coordination with related government agencies
- Survey of damage
- Presence of all firefighting team members at the pre-determined meeting point to receive orders
- Rescue and search for fire victims
- Transfer of property, the injured, and the death
- Assessment of damage, operation result, and report on fire situation
- Assistance to fire victims
- Improvement and solution to the facing problems as soon as possible to resume business

Example of Duties and Responsibilities of Operators in the Relief Plan

Duties and Responsibilities	Operators
1. Coordination with related government agencies	Team Leader..... Team Member.....
2. Survey of damage	Team Leader..... Team Member.....
3. Presence of all firefighting team members at the pre-determined meeting point to receive orders	Team Leader..... Team Member.....
4. Rescue and search for fire victims	Team Leader..... Team Member.....
5. Transfer of property, the injured, and the death	Team Leader..... Team Member.....
6. Assessment of damage, operation result, and report on fire situation	Team Leader..... Team Member.....
7. Assistance to fire victims	Team Leader..... Team Member.....
8. Improvement and solution to the facing problems as soon as possible to resume business	Team Leader..... Team Member.....

Management of Narcotics and Quarrel

Since there are many workers residing in the campsite, the camp boss should be appointed to keep peace in the premise and look after workers' living conditions. Also, room occupancy of workers must be noted and each room should be allowed for only 2 persons or 1 family. This is to prevent workers' gathering for narcotics use and quarrels. Workers' behavior should be regularly observed. In case any irregular behavior is found, necessary action should be immediately taken and related parties, such as profession safety officers, should be informed of the matter. The signs containing company's instructions or policies, and accommodation rules should be installed in front of the worker campsite. The drug-free area signs should be placed at each of the workers' accommodations. Penalties in case narcotics are found must be also notified to all workers.

3.8 GREEN AREA

The Environment Department (Public Park Department) , Bangkok Metropolitan Administration established street tree planting criteria as follows:

(1) Street tree panting

(a) Street with traffic island

- Perennial plants shall be grown, with the distance of 4-8 meters each as appropriate depending on types of trees, on the traffic island ofmore than 3 meters in width onwards.Alternatively, grass paving, shrubberies or flowering and ornamental plants (not more than 3 types), as appropriate.

- Small Perennial plants of which bushes are not wider than the width of the traffic island, shall be grownon the traffic island of2-3 meters in width. Also, considerations may be made for grass paving, shrubberies or flowering and ornamental plants which are easy to enrich (not more than 3 types), as appropriate.

- Grass paving and/or flowering and ornamental plants which are easy to enrich or floor materials shall be considered for the traffic island of less than 2 meters in width.

(b) Pavement

- Perennial plants shall be grown, with the distance of more than 4-8 meters each as appropriate depending on types of trees near pavement of more than 3 meters in width onwards. Moreover, gardening may be possible in the space behind the pavement, wall line or fence line. However, it shall not obstruct access to houses.

If an electric wire is on the pavement, the slow growing trees which can be trimmed but are misshapen should be planted.

- Perennial plants shall not be planted near the pavement of less than 3 meters in width. Pergola or small beds of flowering and ornamental plants should be created depending on the suitability of each area.

The Consultants determined the kinds of trees to be planted along the alignment of Pink Line project (Khae Rai-Min Buri section) in Section 1.10 Forest Resource (construction phase), sub-section (c) environmental impact preventive and mitigation measures. The green area or small garden shall be added under stations(If there is space) or along the line of the mass transit system in order to increase the balance of ecological system, better view or decrease air pollution, noise and others. The following shrubberies should be planted: *Cassia surattensis* Burm.f., *Tecomastans* (L.) *Juss. Ex Kunth*, *Aglaia Odorata* Lour, *Duranta eracta L.*, *Melodorum fruticosum* Lour, etc. Alternatively, the wooden pergola, steel pergola, or pergola of other materials may be created so as to be clung, bound or rambled by middle-sized vine and large-sized vine like A*rtabotrys siamensis Miq.*, *Quisqualisindica* L*., Bauhinia winitii* Craib, *Allamanda cathartica* Linn., *Passiflora x alato-caerulea*, *Jasminum multiflorum* (Burm. F.) Andr, etc.

Large perennial trees shall be planted to hide pillars. Wide bushes with thick leaves shall be planted to conceal pillars. The selected perennial trees such as *Ficusbenjamina* L. var. variegata, *Licuala paludosa*, *Aglaonema modestum* Schott., and *Dypsis lutescens*, etc. shall grow well in shady places or dim light and small amount of water.

The construction company shall coordinate with the responsible agency in the area such as Environment Department, Bangkok Metropolitan Administration, Regional Environment Office 6 (Nonthaburi), etc. to select suitable trees for planting. The landscape architecture concept is shown in ***Figure3.8-1.***The example of tree planting at the piers of track beam along the rail alignment as illustrated in ***Figure 3.8-2.***

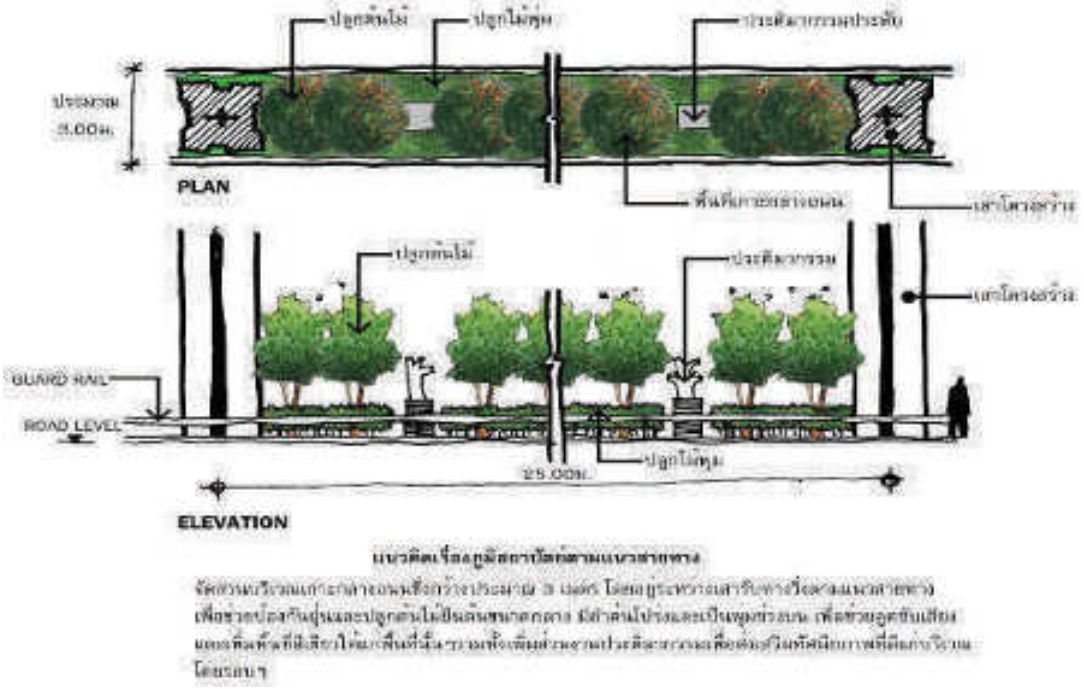


Figure 3.8-1 Landscape Architecture Concept alongside the Railway

Figure 3.8-2 Example of Tree Planting at the Piers of Track Beam along the Rail Alignment

3.9 DESIGN FOR INTERMODAL TRANSPORT FACILITIES

The design of rail stations needs to include intermodal passenger transport facilities for convenient entry into and exit from the stations to the destination.

3.9.1 Design for Intermodal Transport Facilities

The design for intermodal transport facilities, in general, is focused on pick-up and drop-off area. It is necessary to analyze and forecast the rider ships and travel modes to rail stations. Land use in the sub-areas around 30 rail stations shall be evaluated using Nonthaburi Comprehensive Plan and Bangkok Comprehensive Plan. Passenger transfer will be involved with road network, car access and wayfaring, bus stop, bus parking, temporary parking and connectivity to other mass rapid transit projects.

The analysis and forecast of facilities procedures are given below:

(1) Evaluate the proportion of utilization of station vicinities applying Nonthaburi Comprehensive Plan and Bangkok Comprehensive Plan .Utilization of station vicinities, which plays an important role in determining travel modes of rail users, can be classified as follows: low density residential area, medium density residential area, high density residential area, agricultural land and official places, etc.

(2) Study the proportion of entry into and exit from stations such as way faring, by bus, by taxi, by motorcycle, etc. from other projects such as the Green Line Project (Mo Chit-Saphan Mai Section) and Airport Rail Link.

(3) Analyze the proportion of travel modes to stations and forecast the ridership of each station.

(4) Study an Average Vehicle Occupancy departure and arrival using case study projects. The resulting outcome will be used to calculate the number of vehicles of any kind for the whole day and peak hours.

(5) Study the time spent to pick up and drop off passengers of different modes of travel such as by car, by taxi, by bus, to calculate service capability.

When all required data are obtained, then calculate the requirement for facilities of each station for passengers of the Pink Line Project (Khae Rai-Min Buri Section). These facilities consist of the stop and parking lot for buses, parking lot for van and minibus, and temporary stop for public carrier, and parking lot. It is necessary to design the Park and Ride to reduce use of personal cars. This study determines 1 Park and Ride, i.e. Min-Buri station (PK30) which shares the area with the depot of the Project.

3.9.2 Train Operation Plans

The train operation plans of the Pink Line Project (Khae Rai-Min Buri Section) are designed to accommodate the ridership along the routes and they are consistent with the train capacity to accommodate the ridership. The train speed and frequency of service meet international standards. The detailed train operation plans are given below.

3.9.2.1 Train Operation Plans in Normal Conditions

(1) Train operation plans, frequency and headway during peak hours

The calculation of train operation plans during peak hours is based on the assumption that the congestion ratio is not greater than 180% or 7 persons standing/ square meter. This is the internationally accepted standard for train operation plans during peak hours. Based on the assumption, the train frequency and headway that meet travel requirements are shown in ***Table 3.9-1***.

Table 3.9-1 Train Operation Plans during Peak Hours

Section	Item	Unit	Year	2018	2022	2027	2032	2037	2047	Remarks
Central Section	Peak Demand per Hour	Persons/Hour·Direction	a1	8,569	16,820	20,275	21,844	27,060	32,989	PK16-17(Westbound)
	Train Composition *1	Cars/Train	b1	4	4.97	6	6	6	6	Average in 2022 (Mixed 4/6 Car-Train)
	Train Capacity (Normal) *1	Persons/Train	c1	460	581	702	702	702	702	
	Congestion Ratio	%	d1	155%	161%	160%	156%	161%	168%	
	Train Operation Frequency	Trains/Hour·Direction	e1=a1/(c1*d1)	12	18	18	20	24	28	
	Train Operation Headway	min.	f1=60/e1	5.00	3.33	3.33	3.00	2.50	2.14	
Other Section	Peak Demand per Hour	Persons/Hour·Direction	a2	4,029	7,151	8,007	9,701	11,584	14,123	
	Train Composition *1	Cars/Train	b2	4	4.97	6	6	6	6	
	Train Capacity (Normal) *1	Persons/Train	c2	460	581	702	702	702	702	
	Congestion Ratio	%	d2	146%	137%	127%	138%	138%	144%	
	Train Operation Frequency	Trains/Hour·Direction	e2=a2/(c2*d2)	6	9	9	10	12	14	Half of Frequency at Central Section
	Train Operation Headway	min.	f2=60/e2	10.00	6.67	6.67	6.00	5.00	4.29	

Remarks: (*1): 4car-Train=Mc-M-M-Mc, 6car-Train=Mc-M-T-T-M-Mc

Car Capacity=109persons (Mc), 121persons (M,T)

Sources: Consultants, 2012

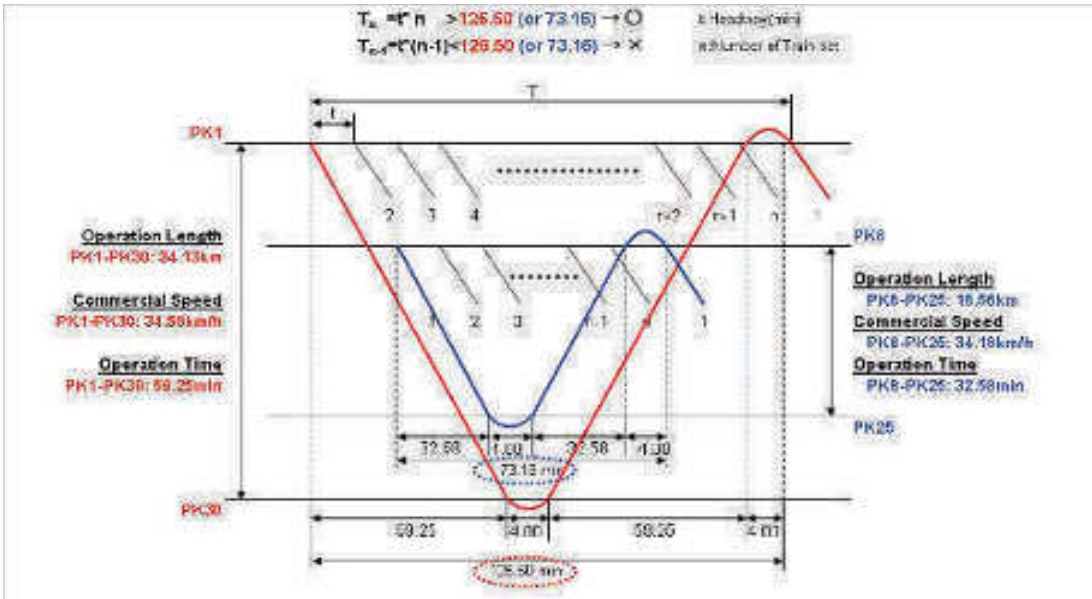
(2) Number of Rolling Stocks

The required rolling stocks for service are calculated from the number of trains for operation during peak hours and the number of trains for spare as shown in ***Figure 3.9-1***. The calculated number of rolling stocks that are in operation are presented in ***Table 3.9-2***. The assumptions of the required rolling stocks are given below.

- Trains for spare shall be available in case of repair. (overhaul)
- Trains for spare shall be available in case of damage or accident.
- Trains for spare shall be available in case of system development in the future.

(3) Whole Train Operation Plans

Train operations will be available from 5.00-24.00 hrs. for 19 hours. The conditions of hourly train operation plans are presented in ***Table 3.9-3***. The hourly train operation plans of Monorail with 20-Baht Flat Rate are shown in ***Table 3.9-4***.



Source : Consultants, 2012

Figure 3.9-1 Calculation Method of Required Rolling Stocks during Peak Hours

Table 3.9-2 The Number of Rolling Stocks that are in Operation

Items	Supplier	2561 (2018)	2565 (2022)	2570 (2027)	2575 (2032)	2580 (2037)	2590 (2047)
Peak Demand per Hour (pphpd)		8,569	16,820	20,275	21,844	27,060	32,989
Train for Operation (Trains)	Hitachi	21	34	42	34	40	47
	Bombardier	21	35	42	34	42	50
	Scomi	21	37	43	35	43	53
Train for Spare (Trains)	Hitachi	2	2	4	3	4	4
	Bombardier	2	3	4	3	4	4
	Scomi	2	3	4	3	4	4
Total Number (Trains)	Hitachi	23	36	46	37	44	51
	Bombardier	23	38	46	37	46	54
	Scomi	23	40	47	38	47	57
Train Composition (Cars/Train)	Hitachi	4	4	4	6	6	6
	Bombardier	6	6	6	8	8	8
	Scomi	6	6	6	8	8	8
Total Number (Cars)	Hitachi	92	144	184	222	264	306
	Bombardier	138	228	276	296	368	432
	Scomi	138	240	282	304	376	456

Remark: In 2570 (2027), (1) 19 Trains of 4 cars/train and (2) 18 Trains of 6 cars/train shall apply.

Source : Consultants, 2012

Table 3.9-3 Hourly Train Operation Plan Conditions

Time Section	Name of Section	Basic Method for Calculating Train Operation *
5-6	Starting	Indispensable Service Level (Every 10-20 min.)
6-7	Morning Time	Same to Daytime
7-8	Morning Transition	Average of Morning Peak and Daytime
8-9	Morning Peak	Transport Peak Demand within Permitted Congestion Ratio
9-10	Morning Transition	Average of Morning Peak and Daytime
10-16	Daytime	Half of Morning Peak
16-17	Evening Transition	Average of Daytime and Evening Peak
17-19	Evening Peak	Same to Morning Transition
19-21	Evening Transition	Average of Daytime and Evening Peak
21-22	Night Time	Same to Daytime
22-23	Late Night	Average of Night Time and Midnight
23-24	Midnight	Same to Starting

Remark: *There are some exceptions depending on a calculation result.

Table 3.9-4 Hourly Train Operation Schedule

Year	2561 (2018)				2565 (2022)				2570 (2027)				2575 (2032)				2580 (2037)				2590 (2047)			
Section	Central Section (PK07-PK25)		Other Section (PK01-07,PK25-30)		Central Section (PK07-PK25)		Other Section (PK01-07,PK25-30)		Central Section (PK07-PK25)		Other Section (PK01-07,PK25-30)		Central Section (PK07-PK25)		Other Section (PK01-07,PK25-30)		Central Section (PK07-PK25)		Other Section (PK01-07,PK25-30)		Central Section (PK07-PK25)		Other Section (PK01-07,PK25-30)	
Peak Demand	8,569		4,029		16,820		6,526		20,275		7,797		21,844		9,397		27,060		11,516		32,989		14,040	
Congestion Ratio	155%		146%		183%		142%		174%		134%		156%		134%		161%		137%		168%		143%	
Time	Frequency /direction	Headway (min)	Frequency /direction	Headway (min)	Frequency /direction	Headway (min)	Frequency /direction	Headway (min)	Frequency /direction	Headway (min)	Frequency /direction	Headway (min)	Frequency /direction	Headway (min)	Frequency /direction	Headway (min)	Frequency /direction	Headway (min)	Frequency /direction	Headway (min)	Frequency /direction	Headway (min)	Frequency /direction	Headway (min)
5-6	4	15	3	20	5	12	4	15	5	12	4	15	5	12	4	15	5	12	4	15	6	10	4	15
6-7	8	7.5	4	15	10	6	5	12	10	6	5	12	10	6	5	12	12	5	6	10	15	4	8	7.5
7-8	10	6	5	12	15	4	8	7.5	15	4	8	7.5	15	4	8	7.5	18	3.33	9	6.67	21	2.86	11	5.45
8-9	12	5	6	10	20	3	10	6	20	3	10	6	20	3	10	6	24	2.5	12	5	28	2.14	14	4.29
9-10	10	6	5	12	15	4	8	7.5	15	4	8	7.5	15	4	8	7.5	18	3.33	9	6.67	21	2.86	11	5.45
10-11	8	7.5	4	15	10	6	5	12	10	6	5	12	10	6	5	12	12	5	6	10	15	4	8	7.5
11-12	8	7.5	4	15	10	6	5	12	10	6	5	12	10	6	5	12	12	5	6	10	15	4	8	7.5
12-13	8	7.5	4	15	10	6	5	12	10	6	5	12	10	6	5	12	12	5	6	10	15	4	8	7.5
13-14	8	7.5	4	15	10	6	5	12	10	6	5	12	10	6	5	12	12	5	6	10	15	4	8	7.5
14-15	8	7.5	4	15	10	6	5	12	10	6	5	12	10	6	5	12	12	5	6	10	15	4	8	7.5
15-16	8	7.5	4	15	10	6	5	12	10	6	5	12	10	6	5	12	12	5	6	10	15	4	8	7.5
16-17	9	6.67	5	12	12	5	6	10	12	5	6	10	12	5	6	10	15	4	8	7.5	18	3.33	9	6.67
17-18	10	6	5	12	15	4	8	7.5	15	4	8	7.5	15	4	8	7.5	18	3.33	9	6.67	21	2.86	11	5.45
18-19	10	6	5	12	15	4	8	7.5	15	4	8	7.5	15	4	8	7.5	18	3.33	9	6.67	21	2.86	11	5.45
19-20	9	6.67	5	12	12	5	6	10	12	5	6	10	12	5	6	10	15	4	8	7.5	18	3.33	9	6.67
20-21	9	6.67	5	12	12	5	6	10	12	5	6	10	12	5	6	10	15	4	8	7.5	18	3.33	9	6.67
21-22	8	7.5	4	15	10	6	5	12	10	6	5	12	10	6	5	12	12	5	6	10	15	4	8	7.5
22-23	6	10	4	15	8	7.5	5	12	8	7.5	5	12	8	7.5	5	12	8	7.5	5	12	10	6	6	10
23-24	4	15	3	20	5	12	4	15	5	12	4	15	5	12	4	15	5	12	4	15	6	10	4	15
TOTAL	157		83		214		113		214		113		214		113		255		133		308		163	

(4) Summary of Operation Distance

The operation distance (Train-km, Car-km)in each forecast year is presented in ***Table 3.9-5***.

Table 3.9-5 Daily and Annual Operation Distance (Train-km, Car-km)

Daily/Yearly	Item	2561 (2018)	2565 (2022)	2570 (2027)	2575 (2032)	2580 (2037)	2590 (2047)
Daily Operation Distance (km/day)	Train-km	8,911	12,154	12,154	12,154	14,433	17,521
	Car-km	35,643	48,616	60,770	72,924	86,600	105,125
Annual Operation Distance * (1000km/year)	Train-km	3,145	4,290	4,290	4,290	5,095	6,185
	Car-km	12,582	17,162	21,452	25,742	30,570	37,109

Remark : Assumption for calculation method of operation distance: Operation distance on weekend accounts for 90% of operation distance on weekday.

3.9.3 Contingency and Emergency Plans for Train Operation

3.9.3.1 Contingency Plan

The contingency plan aims at maintaining operation in the event that the operation does not meet normal operation plan. However, it is desirable to use the normal train operation plan as quick and efficient as possible. The contingency plan consists of the steps below.

(1) Report abnormalities

Quick report on abnormalities helps shorten potential delay. The train driver can notify the operation control center through radio. Then the operation control staff records, follows up and solves the detected problems until normal train operation can be conducted. In case of technical failure, SCADA will notify directly to the depot so that the technician fixes the problem. Furthermore, the station staff can report the operation control center or relevant depots if the malfunction of E&M equipment is detected and it may affect train operation of each station. The train operation center will evaluate abnormality in each situation and provide suitable solution. Sometimes, operation levels may be reduced.

(2) Notify passengers

In all cases where the contingency plan is applied, the train operation center shall notify passengers on board and boarding stations using PA system. The train driver or the station staff may also give the information to passengers

(3) Types of contingency plans

In the case that any track is inapplicable for whatever reason, the contingency plans will be used shortly. The selected type of contingency plans will depend on factors including the environmental conditions, scope and severity of problem. Types of contingency plans are as follows:

- Move the trains from the alignment using refuge facilities,
- Temporarily limit the train speed,
- Go back to the nearest station, and
- Use emergency bus service.

3.9.3.2 Operation Plans in Case of Emergency

(1) Emergency guideline

When the train driver faces a dangerous situation, he/she shall stop the train immediately and shortly report to the train operation center. In the case that the alarm signal is heard, the train operation staff shall radio the train driver so as to stop the train.

(2) Guideline for evacuation of passengers

Generally, in the case that the train cannot continue anymore, the train driver shall move the train to the next station. The train may be towed by another train. However, in the case that it is impossible to tow the train, the passengers shall be evacuated through the following methods.

- Move passengers from one train to another train which may be on the same track or on the track on the opposite side.
- Move passengers from the train to the ground using ground service vehicle, slow down rope, spiral chute and an emergency walkway.

3.9.4 System Maintenance Plans

3.9.4.1 General Information

Regarding the maintenance policy of the monorail of the Pink Line Project (Khae Rai-Min Buri Section), the Time Base Maintenance: TBM shall apply for inspection. The real operation time obtained from the monorail operator will be taken into account.

Due to the unique characteristics of the monorail structure, track maintenance needs specially designed maintenance vehicles. These maintenance vehicles are self-operable by battery or diesel engine as maintenance work will be conducted at nighttime when the track has no driving power.

These maintenance vehicles will be kept in the stabling yard for "deployment-site works-pullout" process for approx. 5 maintenance hours, which are between the last train of the day and the first train of the following day.

3.9.4.2 Rolling Stock Maintenance

Considering general characteristics of the monorail, the maintenance policy for damage prevention shall apply. The inspection period and real operation time will be obtained from the monorail operator.

(1) Types of inspection and maintenance

Types of rolling stock inspection and maintenance are presented in ***Table 3.9-6***.

(2) Required period for track inspection

The required period for track inspection epends on the number of vehicles, inspection period and needed inspection time. The non-scheduled track repair was planned. However, as it was considered that the frequency of vehicle damage is low, it is unnecessary to fix the track that way. In the case that the non-scheduled track repair is needed, damaged vehicles will be stored in the workshop and sent to heavy maintenance workshop. The summary is shown in ***Table 3.9-7***.

Table 3.9-6 Types of Rolling Stock Inspection

Inspection	Periods	Description
Inspection prior to the commencement of work	every day	Daily inspection prior to the commencement of work
Inspection of train	8days	Visual inspection for the appearance of the equipment involved with feeding, i.e. combined energy system, grounding, connection between the wheels and the trains, brake, connection link between trains and door opening and closing
Monthly inspection	3months	Inspection of conditions and functionality of main equipment, i.e. combined energy system, towing engine, braking system, signaling system on ATO, connection link between trains and door opening and closing as well as insulation inspection of power supply system and wiring
Inspection of main components	4 years	Inspection of conditions and functionality of main equipment, such as combined energy system, towing engine, braking system, signaling system on ATO, connection link between trains, communication system and other systems as well as insulation inspection of power supply system and wiring
General inspection	8years	Thorough inspection of main equipment, i.e. combined energy system, towing engine, braking system, signaling system onATO, connection link between trains, door opening and closing, rotation assisting device, battery and other systems, insulation resistance test)and dielectric stress test after heavy maintenance; inspection of assemble and commissioning test
Tyre replacement	as required	Inspection of tyre deterioration, fracture and deformation and make regular tyre replacement as necessary The “bogie drop pit” of the rail is available in a tyre replacement room.

Table 3.9-7 The Number of Times Required for Track Inspection

Track Inspection	Periods	Inspection Time/ Rail/Train	Capacity/Track/Period	Number of Tracks
Inspection of the starting point	every day	10minutes	at stabling tracks	
Inspection of train	8 days	1/4 day	32	2
Monthly inspection(*)	3 months	2 days	52	1
Inspection of main components	4 years	30 days	35	2
General inspection	8 years	45 days	55	
Tyre replacement				1
Manual train washing				1

Remark:(*) The calculation is based on the assumption that there are22workdays/month and monthly inspection is performed for 2 tracks. However, as the to be inspected (2 tracks) are not used all the time and the working time of maintenance staff is likely to change, the Consultants suggest that 1 track be required for monthly inspection for smaller workshop and less investment.

(3) Track maintenance

The Pink Line Project (Khae Rai-Min Buri Section) made the track maintenance plan below as presented in ***Table 3.9-8***.

Table 3.9-8 Track Maintenance Plan

Types of Inspection	Main Components for Inspection	Inspection periods
Inspection of travel on main routes	Main routes	everyday (together with contact line inspection)
Track	Track	1year
Track structure	Bridges and other structures forming track	2 years
Equipment for vertical movement	Elevators, escalators	0.5-1.0 years
General construction structure	Stations, platforms, PSD Station Building, platform level, PSD	as may be reasonable
Passenger terminal	Inspection and cleaning of water vending machine and AFC equipment; replace deteriorated parts and conduct insulation test.	as may be reasonable

(4) Maintenance of electronic equipment

Maintenance Plan for Electronic Equipment is shown in ***Table 3.9-9.***

Table 3.9-9 Maintenance Plan for Electronic Equipment

Types of Inspection	Main Components of Inspection	Inspection Periods
Power supply apparatus	Contact line	everyday (together with track inspection)
	Switch, automatic circuit breaker, arrester, protective equipment in substations	1year
Signaling system	Signaling device, train system interface, switch, and clamping	1 year
Communication system	Communication equipment	1 year
Measuring equipment	Measuring equipment attached to power supply, communication equipment and other safety equipment	1 year
Disaster prevention system	Fire alarm box, sprinkler, smoke detector, fire extinguisher, etc.	0.5 year (visual inspection and functionality inspection),1 year (visual inspection and functionality inspection)
Other equipment	Inspection devices of stations, symbols and lighting	as may be reasonable
Voluntary inspection	Cleaning of filters at substations.	as may be reasonable

3.9.5 Operation Standard

According to the review and compilation of data relating to the evaluation of operation standard quality of international Mass Transit Railways, such as MTR (Mass Transit Railway) Hong Kong, SMRT Singapore and BTS Thailand, etc.,5 evaluation criteria were used: operation, information, service reliability, comfort and convenience and safety and security.

The Pink Line Project (Khae Rai-Min Buri Section) applies the criteria of BTS operation targets as the criteria have already been applied in Thailand. The service requirements and threshold of unacceptable level are presented in ***Table 3.9-10***.

3.9.6 Communication network connectivity

The Pink Line Project (Khae Rai-Min Buri Section) can be connected to other 4 mass rapid transit projects that pass through the project alignment.

- The Purple Line Project (Bang Yai-Bang Sue Section) (at Nonthaburi Government Center station)
- The Red Line Mass Transit Project(Bang Sue-Rangsit Section) including Bang Sue Grand Station (at Lak Si station)
- The Green Line Project(Mo Chit-Saphan Mai Section) (at Wat Phra Si Maha That Station)
- The Orange Line Project (Bang Kapi-Min Buri section) (at Min Buri station)

Table 3.9-10 Service Requirements and Threshold of Unacceptable Level

	Service Requirements	Threshold of Unacceptable Level
1. Operation		
1.1 Operating Hours	- The operation shall be available everyday including Sunday and holidays from 6.00-24.00 hrs.	- Operating hours shall be the same as the train timetable. - In the case that the first train and the last train do not operate based on the timetable, it is acceptable only when the error is uncontrollable.
1.2 Frequency	- The operation frequency shall be every 4 minutes during peak hours in the morning/evening and out of normal operating hours.	- The number of times that the trains do not meet operation frequency during peak hours and normal operating hours shall not exceed 1time/month.
1.3 Acquisition on Network	- Adequacy of automatic ticket vending machines/ticket sales staff - Adequacy of all types of spare tickets at all stations	- The queue for ticket buying shall not exceed 3 minutes. - Ticket vending machines shall not be out of order longer than or equal to 24 hours. - More than 2 ticket vending machines in the same area shall not be out of order simultaneously longer than 20 minutes.
2. Information		
2.1 Boarding and Alighting	- All stations shall provide the clear signs and symbols of routes on the access road to stations. - All stations shall provide the clear signs and symbols of lines on platform. The lines shall be seen clearly while standing in the train that stops at the platform.	- Equipment/signs showing information shall not be damaged consecutively for more than 24 hours. - Passenger satisfaction shall be evaluated. The number of satisfied passengers shall not be less than half of the surveyed passengers.
2.2 Vehicle Direction Sign	- Passengers waiting at platforms of all stations shall be notified of vehicle direction sign.	- Passenger satisfaction shall be evaluated. The number of satisfied passengers shall not be less than half of the surveyed passengers.
2.3 Route	- Essential information, such as route map, intermodal transport, etc., shall be disseminated through brochure, at the station area or website.The information shall be provided both in Thai and English languages.	- The information shall be always updated. Any changes shall be updated within 2 weeks.
3. Service Availability		
3.1 Reliability	- When it is impossible for trains to operate normally, spare trains shall be available within 30 minutes. - If the failure causes more than 5 minutes delay in train service based on the timetable, the system shall be improved for normal operation within 20 minutes.	- Use of spare trains during peak hours shall not exceed 1 time/month. - The delayed service of more than 5 minutes shall not exceed 2 times/month. - The accumulative delay of more than 20 minutes both during peak hours and normal hours shall not exceed 1 hour/month.
3.2 Punctuality	- 97.5% of the trains shall be available according to the timetable within 5 minutes. - 95% of the trains shall be available according to the timetable within1 minute.	- The percentage of the average number of times that trains delay shall not exceed the criteria.
3.3 Regularity	- Trains shall maintain approximate time between trains. - Train service frequency shall not be too frequent.	- Failure times that require staff to solve problems shall not exceed 2 times/month. - Passenger satisfaction shall be evaluated. The number of satisfied passengers shall not be less than half of the surveyed passengers.
4. Comfort and Convenience		
4.1 Vehicle Loading Factor	- The vehicle loading factor shall not exceed 8persons/square meter. - During peak hours, The vehicle loading factor shall not exceed7persons/square meter for the travels that exceed3stations.	- The vehicle loading factor which is greater than the setting one shall not exceed 1 day/week and 1 week/month.

Table 3.9-10 Service Requirements and Threshold of Unacceptable Level (Cont'd)

	Service Requirements	Threshold of Unacceptable Level
4.1 Vehicle Loading Factor (Cont'd)	- The vehicle loading factor shall not exceed 6 persons/square meter for the travels of6 stations during peak hours and 3 stations during normal hours.	
4.2 Comfort and Convenience of Passenger - at Station	- Stations shall have escalators designed with suitable speed for stations of the mass transit. At least 2 steps shall be provided at the end of both sides of escalator including handrails which move at the same speed of the steps. - The failure of escalator shall not exceed 200 hours/100,000 hours of service. - Passenger elevators shall display clear directions at suitable height. - Seats shall be provided for passengers on platforms as necessary. - There shall be sufficient space for passengers standing on platforms. The density of standing passengers per square meter shall be at minimum. This excludes the area of approx. 0.5 meter along the entire track edge from the track side for safety reason. - Ticket gate failure shall not exceed 5 times/ 100,000 passengers for both magnetic ticket and contactless smartcard.	- The density of passengers on station shall not exceed 1.5 persons/square meter except for during boarding and alighting. - The failure of escalator shall not exceed the number of hours specified. - Passenger satisfaction shall be evaluated. The number of satisfied passengers shall not be less than half of the surveyed passengers. - The number of times of ticket gate failure shall not exceed the setting criteria.
4. Comfort and Convenience of Passenger -On train	- Instruction sign for emergency kit shall be provided for passengers. - Wheel chair locks shall be provided with instruction sign. - Each car shall have at least 40 seats. - At least 1 special seat shall be provided for the disabled/children/pregnant women. - Each car shall have connecting corridor so that passengers can walk to uncrowded cars. - Railings shall be provided inside the trains at the level that passengers can grab them when stretching their arms.	- Passenger satisfaction shall be evaluated. The number of satisfied passengers shall not be less than half of the surveyed passengers.
4.4 Ride Comfort between Station	- Tracks shall be designed for the least centrifugal force to passengers when trains travel at normal speed. - Wheels shall be designed to be in the middle position to prevent the sudden sideways movement of trains. - The train control system shall be designed for acceptable maximum speed while running on the curve. - Rails and wheels shall be regularly inspected and maintained to prevent malfunction.	- Malfunctioning rails and wheels shall be inspected and shall receive maintenance within 14 days. - Passenger satisfaction shall be evaluated. The number of satisfied passengers shall not be less than half of the surveyed passengers.
4.5 Ride Comfort at Starting and Stopping	- The vehicle acceleration and deceleration control systems shall be designed for minimum jerk in case of changes in acceleration or traction.	- Passenger satisfaction shall be evaluated. The number of satisfied passengers shall not be less than half of the surveyed passengers.
4.6 Atmosphere	- The design inside stations shall be executed for good ventilation. - Two air conditioning systems shall be provided for each car so that when either of them is broken, the other still operates.	- When one or both of the air conditioning systems are out of order, the train shall be stopped within 30 minutes. - Passenger satisfaction shall be evaluated. The number of satisfied passengers shall not be less than half of the surveyed passengers.

Table 3.9-10 Service Requirements and Threshold of Unacceptable Level (Cont'd)

	Service Requirements	Threshold of Unacceptable Level
4.7 Cleanliness	- Daily sweep shall be done inside the car. - Weekly washing shall be done inside the car. - It is required to wash outside the car every 3 days. - It is required to clean stains on the wall at stations or trains within 3 days.	- Passenger satisfaction shall be evaluated. The number of satisfied passengers shall not be less than half of the surveyed passengers.
5. Safety and Security		
5.1 Safety	- The number of severely injured passengers from the service shall not exceed 0.1 person/1 million passengers for 12 months on average. - The number of severely injured staff members shall not exceed 0.1 person/million hours for 12 months on average.	- The number of times that passengers/staff members are injured shall not exceed the setting criteria.
5.2 Crime-Free	- The station area shall have adequate light and the electricity shall be turned on all the time. - CCTV shall be provided for checks at the station area and public area. - Security guards shall be available 24 hours on stations. During peak hours, at least 3 security guards shall be on duty.	- Passenger satisfaction shall be evaluated. The number of satisfied passengers shall not be less than half of the surveyed passengers.
5.3 Accident-Free	- Warning signs shall be provided in all risk areas so that passengers and staff members have special precautions. - An obviously seen safety distance line shall be provided 0.5 meter away from the track edge. Furthermore, the warning sign and the alarm sound shall be provided for the safety of passengers standing behind the line. - The warning sign and the alarm of door opening and closing shall be provided so that passengers stay away from the door.	- The safety inspection report by the inspector shall not present any weakness or things that need to be improved for the security system.
5.4 Emergency Management	- The fire exit symbol shall be provided at the station area according to NFPA 130. - The station area shall be installed with insulation, fire alarm and fire protection equipment. - All involved staff members shall be trained and additional trainings are required every 2 years.	- The safety inspection report by the inspector shall not present any weakness or things that need to be improved for the security system.

The Pink Line Project (Khae Rai-Min Buri Section) has 4 interchange stations below.

(1) Interchange with the Purple Line Project (Bang Yai-Bang Sue Section) : Passengers can be connected to the Purple Line Project (Bang Yai-Bang Sue Section) at Nonthaburi Government Center Station, which is the starting station of the Pink Line Project (Khae Rai-Min Buri Section), on the 2nd floor (concourse level) through skywalk for the distance of approx.30 meters as illustrated in ***Figure 3.9-2*** and ***Figure 3.9-3***.

(2) Interchange with the Red Line Mass Transit Project (Bang Sue-Rangsit Section) including Bang Sue Grand Station : Passengers can be connected to the Red Line Mass Transit Project(Bang Sue-Rangsit Section) including Bang Sue Grand Stationat Lak Si station through the approx. 60 meter long sky walk on Vibhavadi-Rangsit Road at the platform level as illustrated in ***Figure 3.9-4*** and ***Figure 3.9-5***.

Figure 3.9-2 : Illustration of Connectivity to the Purple Line Project (Bang Yai-Bang Sue Section) at Nonthaburi Government Center

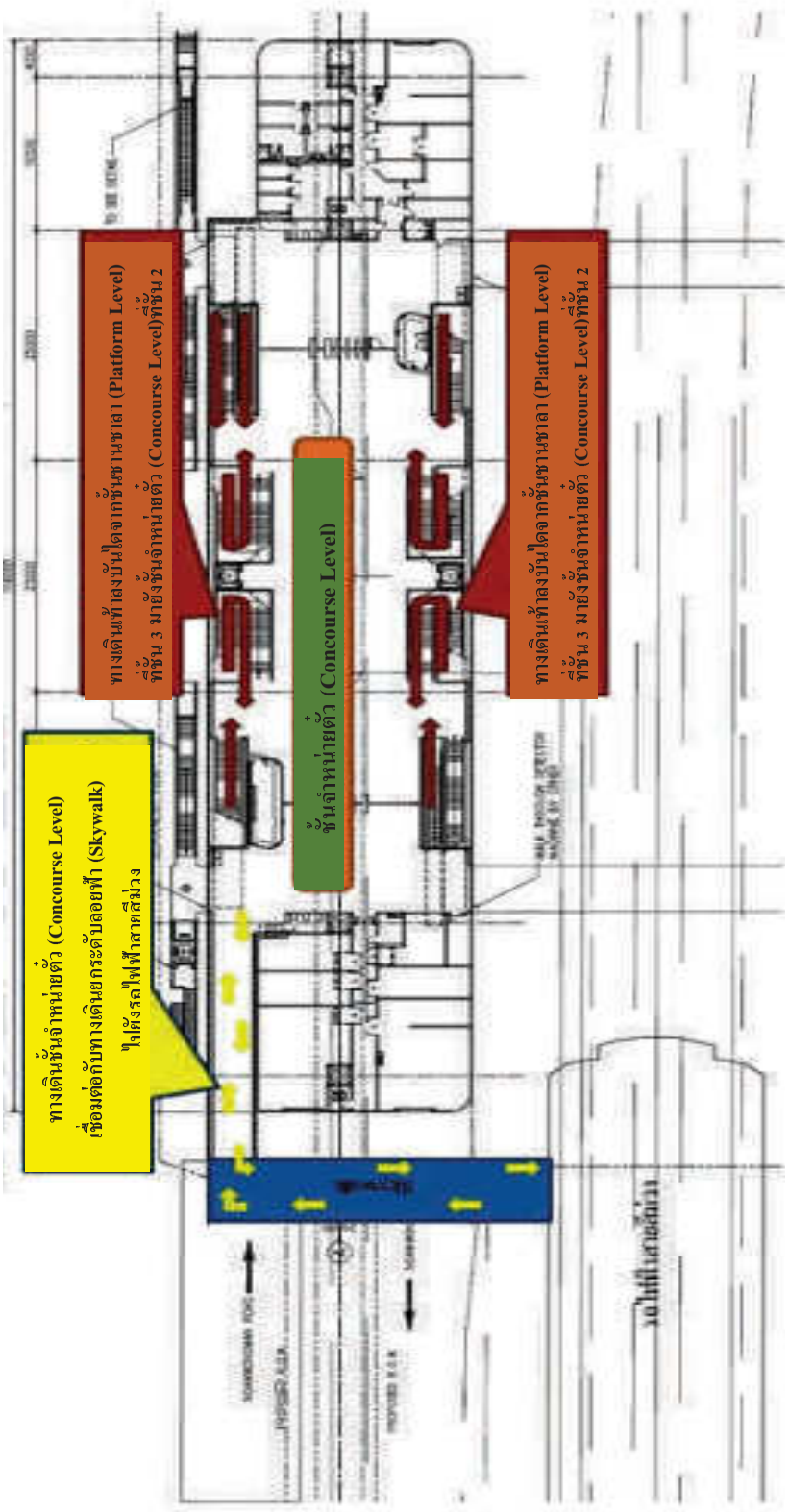


Figure 3.9-3 : Connectivity to the Purple Line Project (Bang Yai-Bang Sue Section)

Figure 3.9-4 : Illustration of Connectivity to the Red Line Mass Transit Project (Bang Sue-Rangsit Section) including Bang Sue Grand Station at Lak Si Station

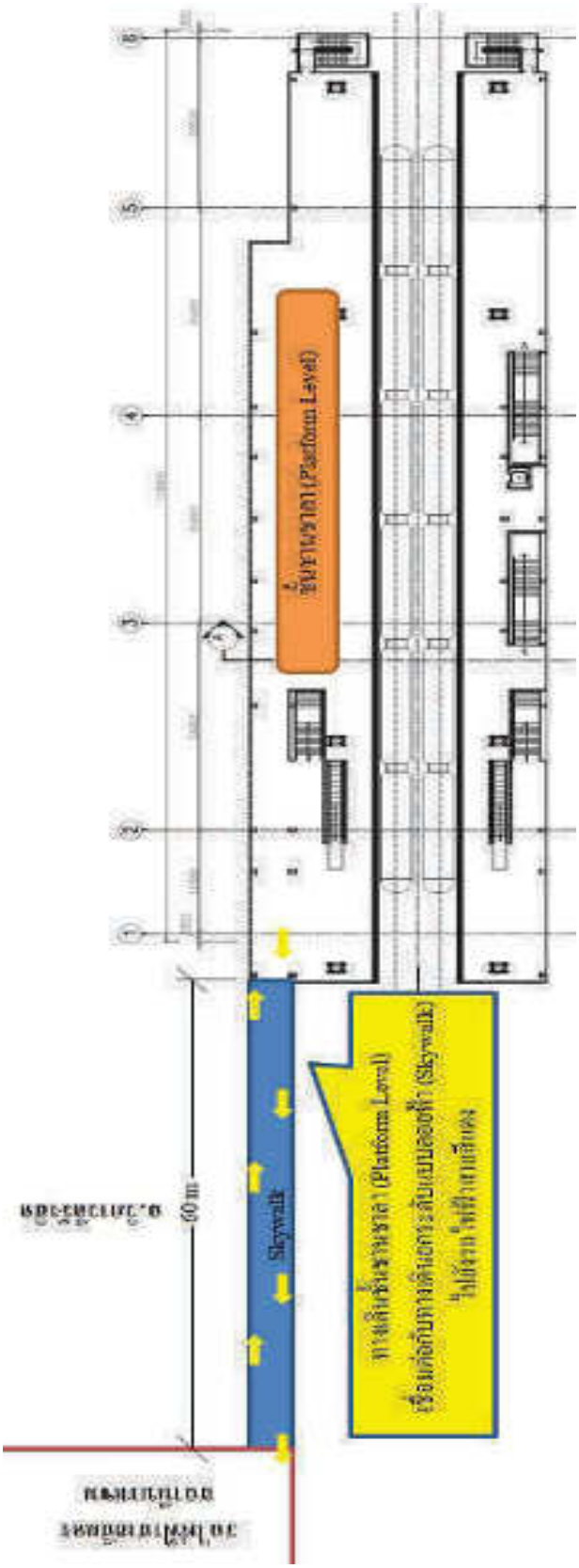


Figure 3.9-5 : Connectivity to the Red Line Mass Transit Project (Bang Sue-Rangsit Section) including Bang Sue Grand Station

(3) Interchange with the Green Line Project (Mo Chit-Saphan Mai Section) : Passengers can be connected to the Green Line Project (Mo Chit-Saphan Mai Section) at Wat Phra Si Maha That Station walking from the platform level of Wat Phra Si Maha That Station of The Pink Line Project (Khae Rai-Min Buri Section)to the concourse level of Wat Phra Si Maha That Station of the Green Line Project(Mo Chit-Saphan Mai Section)as illustrated in ***Figure 3.9-6*** and ***Figure 3.9-7*****.**

(4) Interchange with the Orange Line Project (Bang Kapi-Min Buri section) : Passengers can be connected to the Orange Line Project (Bang Kapi-Min Buri section) at Min Buri station, which is the terminus of the Pink Line Project (Khae Rai-Min Buri Section)at the concourse level as illustrated in ***Figure 3.9-8*****.**

3.9.7 Coordination for Land Acquisition

MRTA and the Consultants of the Pink Line Project (Khae Rai-Min Buri Section) had the meeting at the Department of Highways (DOH) Meeting Room chaired by Mr. Sarawut Songsivilai, Deputy Director General for Engineering, on August 29, 2013 at 15.00 hrs. The Consultants presented utilization of DOH areas for the construction of stations at Lak Si Highway Station (Lak Si Intersection) and Thanyaburi Highway Station 2 (the Safeguarding the Constitutional Monument) . In this regard, DOH informed meeting participants that they would make a discussion and keep MRTA informed the results of discussion.

Later, Bangkok Highway District issued the official letter No. kor kor 0626.2/ Bor.1.1/3044 dated November 28,2013inviting MRTA to participate in the meeting of the rail station design for suitability for both proposed areas under the responsibility of Bureau of Highway 1 1 .The meeting chaired by Mr. Pramon Sathapornnanon, Director, Bureau of Highway 11was held on Monday December 2, 2013 at 14.00 hrs. at Highway District 1 Meeting Room (Bangkok) , 1st floor, Vibhavadi-Rangsit Road, Don Muang district, Bangkok.The main points of the meeting are given below.

(1) Bureau of Highway 1 1 (Bangkok) permitted MRTA to use DOH area of 9 8 square wah for the construction of Lak Si station (PK14). MRTA, however, shall prepare for place management so that Lak Si Highway Station operates properly and the entry into and exit from the place shall be possible from Vibhavadi-Rangsit Roadand Chaeng Watthana Road. Furthermore, the traffic management plan under the stations shall be established in order to reduce traffic congestion caused by other transportation systems. Bangkok Highway District Director proposed that MRTA coordinate with BMTA to make the bus stop under Lak Si Intersection Overpass for passengers from Don Muang with special route for buses from Chaeng Watthana Roadto stop at the station area.

(2) Bureau of Highway 11 (Bangkok) permitted MRTA to use DOH area of 3 rai 7 6 square wah for the construction of Wat Phra Si Maha That station (PK16).Bureau of Highway 1 1 (Bangkok) permitted MRTA touse the whole area. Nonetheless, MRTA shall re-construct the office building for Thanyaburi Highway Station 2. Also, the office building of Lak Si Highway Station will be relocated to such area. Both office buildings will be constructed on the opposite side of existing areas, which are adjacent to Bang Khen Police Station and Thainiyomsongkroa School. Furthermore, the traffic management plan under the stations shall be established in order to reduce traffic congestion caused by

Figure 3.9-6 : Illustration of Connectivity to the Green Line Project at Wat Phra Si Maha That Station

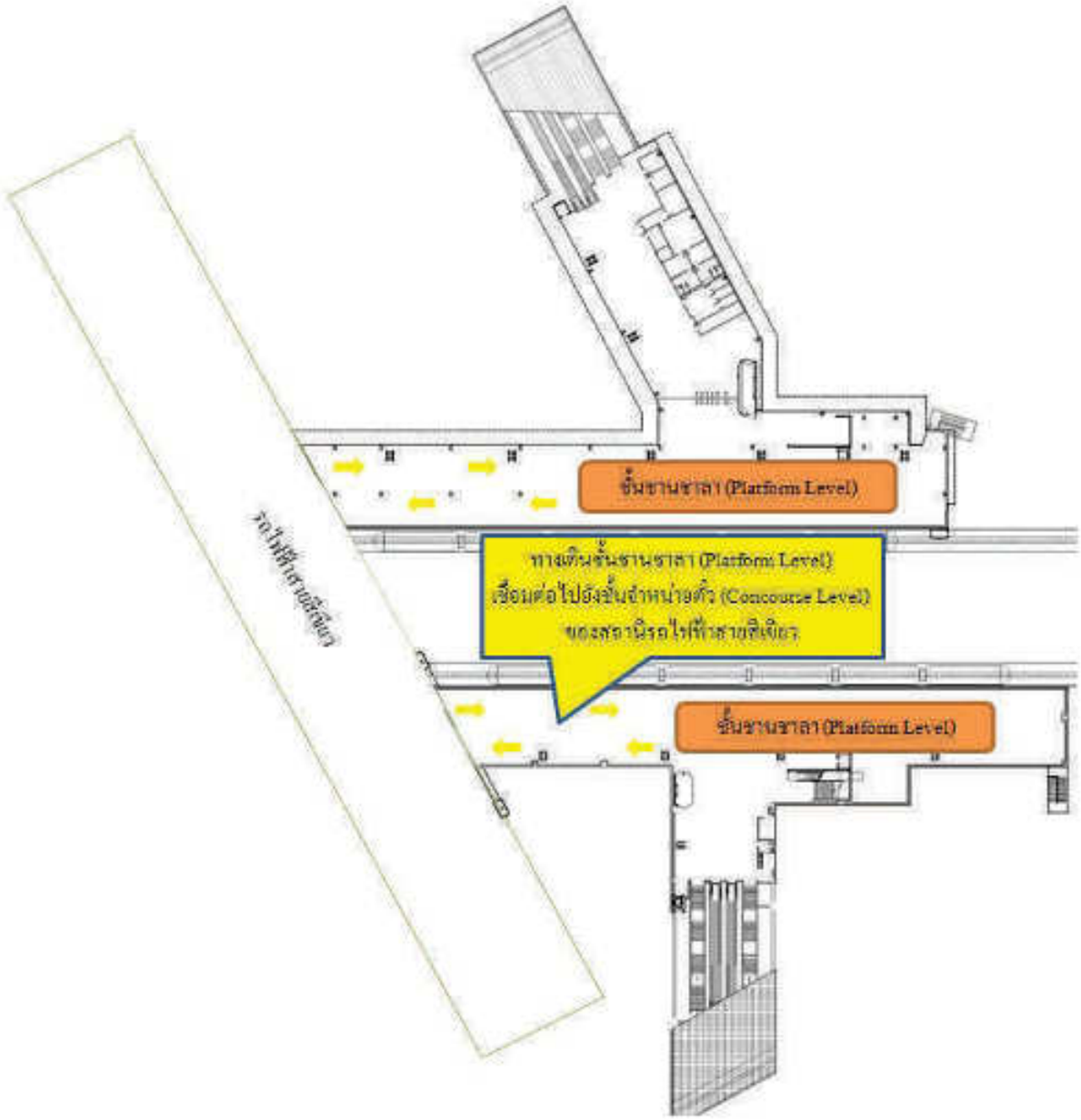


Figure 3.9-7 Connectivity to the Green Line Project (Mo Chit-Saphan Mai Section)

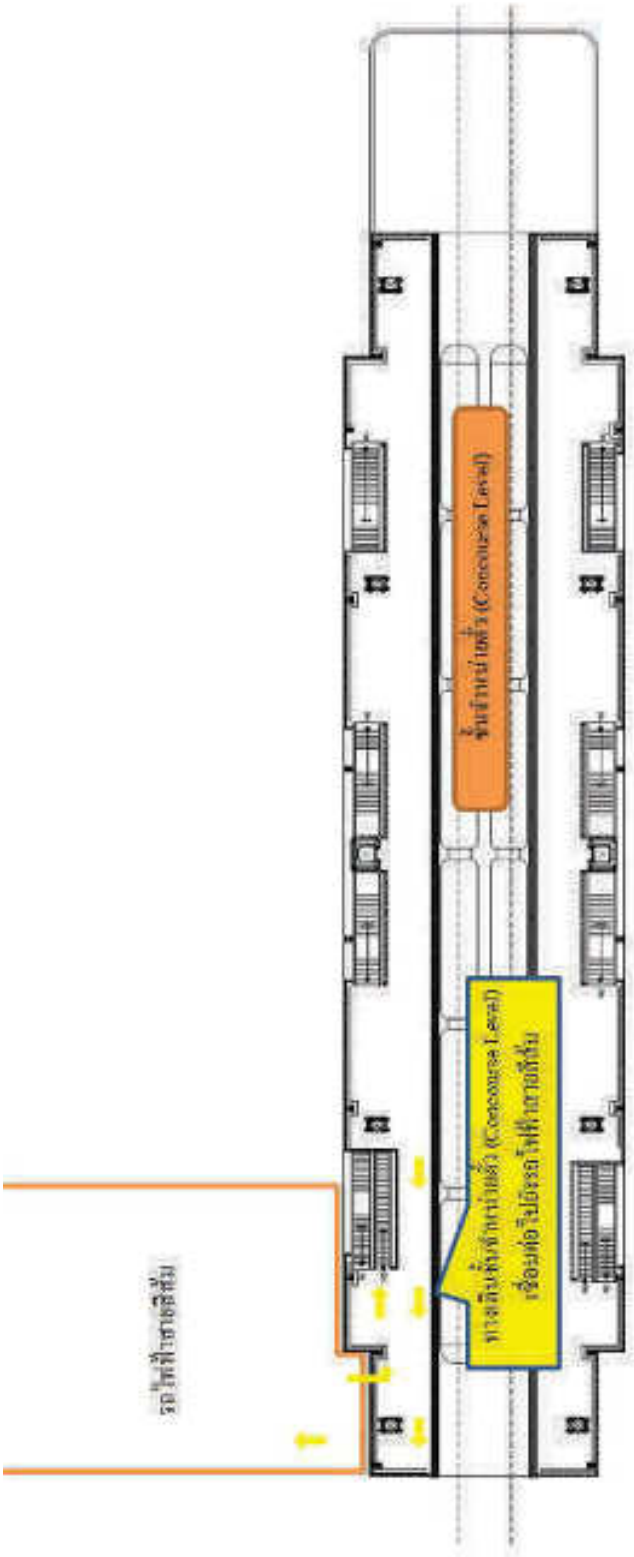


Figure 3.9-8 : Connectivity to the Orange Line Project (Bang Kapi-Min Buri Section)

other transportation systems. Bangkok Highway District Director proposed that MRTA allow buses to stop in the areas to reduce traffic congestion at the station and the roundabout.

The meeting chairman assigned MRTA to coordinate with engineers of both Highway Districts for operations after approval from the Cabinet. The meeting minutes between MRTA and Bureau of Highway 1 1 (Bangkok) for a discussion of rail station design for the Pink Line Project (Khae Rai-Min Buri Section) is shown in ***Appendix 3A***.

Land acquisition approach determined by MRTAforLak Si Highway Station and Thanyaburi Highway Station 2is similar to the one for MRT Blue Line (under construction) . The land acquisition approach will be attached to TOR and bidding documents. Contractors shall coordinate with Lak Si Highway Station and Thanyaburi Highway Station 2 for the conclusion of building type and the locations for new office building construction. Construction budgeting shall be prepared and proposed to MRTA for approval prior to operation.

In addition to this, Mass Rapid Transit Authority of Thailand (MRTA) sent a letter of request to Electricity Generating Authority of Thailand (EGAT) for preliminary cost estimate for the construction of the structure of high voltage posts on both sides of Chaeng Watthana Road for the Pink Line Project (Khae Rai-Min Buri Section). The Director (Operation) of Electricity Generating Authority of Thailand (EGAT) consented for the request with approval letter to MRTA as shown in ***Appendix 3C***.

3.10 STUDY OF ECONOMIC FEASIBILITY

3.10.1 Overall Analysis of Socio-Economic Aspect of the Project

The project economic analysis is aimed at managing the limited resources in the most efficient manner. The project economic analysis is quite similar to the financial analysis since both of them assess the benefits from project investment. However, the economic analysis involves assessment of the project benefits with regard to the national economy. In other words, the economic analysis will evaluate the project impacts on the welfare of all people in the society.

The economic analysis results are generally taken account of to determine the economic viability of a project. If the project's benefits to the entire society are higher than the resources or costs invested, it can be concluded that the project is economically viable for investment. The economic analysis results are regarded the important factor for making decision whether the project should be implemented. Moreover, the analysis results can be used by the government sector to select which project should be supported when the government has limited resources and budget. The projects which are not economically viable will be rejected or suspended. The projects which are viable in economic aspect will be selected for further study.

3.10.2 Criteria for Socio-Economic Aspects of the Project

3.10.2.1 Assumptions for Socio-Economic Aspects of the Project

Table 3.10-1 Requirements for Project Economic Analysis

Items	Quantity	Unit	Notes
Price	At constant 2012 price		
Project analysis period	30	Year	Excluding construction period
Discount rate	12%		
Annualization factors			
Passenger demand	330	Days/Year	
Supply of services	350	Days/Year	
Asset life			
Civil works			
- Structures incl. stations & depots	50	Year	
- Buildings	30	Year	
E & M works			
- Power supply system	30	Year	
- Mechanical, signaling, train operation & ICT systems	15	Year	
Rolling stock	30	Year	
Mid-life refurbishment			
Rolling stock	15	Year	15 years after the start of services
Cost of refurbishment	33%		
Exchange rate	35	(Baht/USD)	

Source: Proposal of the Subcommittee on Financial and Operation Consideration

3.10.2.2 Criteria for Socio-Economic Aspects of the Project

The socio-economic analysis of the Pink Line Project (Khae Rai-Min Buri Section) consists of the following steps (***Figure 3.10-1***):

- Project cost evaluation,
- project benefit evaluation,
- economic viability analysis, and
- project sensitivity analysis.

3.10.3 Socio-Economic Value of the Project

3.10.3.1 Project Cost Evaluation

Project capital costs consist of land acquisition, civil works, track works, signaling system, mechanical and electrical systems, operations and maintenance, and other direct expenses. In the project economic analysis, the real costs of resources used in the project were estimated by deducting the underlying distortions, e.g. tax, import and export duties, interest, compensation, etc. The financial value was converted into economic value by using the following conversion factors taken from the World Bank's study of Thailand.

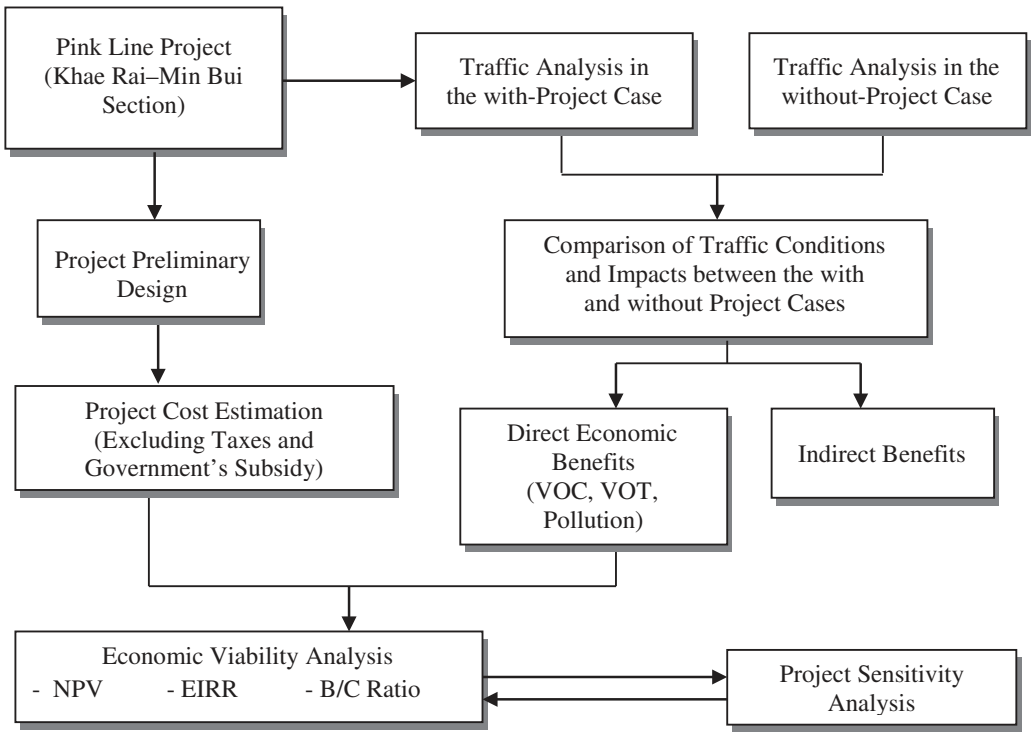


Figure 3.10-1 Economic Analysis Procedures

- Detailed design cost 0.92
- Building compensation cost 0.92
- Land compensation cost 1.00
- Construction cost 0.88
- Construction supervision cost 0.92
- Environmental cost 0.92

(Source: Sadig Ahmed; Shadow Prices for Economics Appraisal of Project: An Application to Thailand, World Bank Staff Working Paper, Number 609, Year 1983)

The capital costs of the Pink Line Project (Khae Rai-Min Buri Section) were converted into economic value as presented in ***Table 3.10-2***.

Table 3.10-2 Summary of Project Capital Costs

Description	Value (Million Baht)	
	Monorail	Heavy Rail
Consultant Cost	1,905	2,063
Construction Cost	20,225	27,417
E & M Cost (Including Rolling Stocks)	23,516	20,267
Land Acquisition Cost	6,755	4,410
Total Construction Cost	52,401	54,157
Maintenance Cost (throughout 30-year project life)	57,764	55,714
AdditionalRolling Stocks (every10 years after operation)	6,989	5,329
Total	**117,154**	**115,200**

Source: The Consultants, 2012

Salvage Value of the Project

Salvage value is the benefit gained in the last year of the project in accordance with MRT Standardization.

3.10.3.2 Project Benefit Evaluation

The project benefits were considered by comparing the with-project case to the without-project case to derive the benefits from the project implementation. The project benefits comprise direct benefits or tangible benefits, and indirect benefits or intangible benefits as follows.

Direct Benefits of the Project

The Pink Line Project (Khae Rai–Min Buri Section) will bring about the traffic benefits to road users in the project's influence areas. That is, the project will provide travel convenience to those living in Khae Rai and Min Buri areas, as well as direct benefits to the overall society in the forms of reduced travel cost and time and lower air pollution as people will change from traveling by road to by rail. The direct benefits were considered into two cases: collection of fare at 20 Baht flat rate; and collection of fare at the distance-based rate as follows.

(1) Vehicle Operating Cost Savings (VOC Savings)

VOC savings are considered as the major economic benefit gained from improvement of transportation network. VOC analysis must be based on the current conditions of topography, traffic, and proportion of vehicle types in the project areas. In this study, VOC was calculated using the internationally-accepted Highway Development & Management Model (HDM-4). VOC savings are gained from the difference between VOC (multiplied by vehicle kilometers travelled (VKT)) of the with-project case and VOC (multiplied by VKT) of the without-project case. The following is the equation for calculating VOC savings.

$$VOC_{savings} = (VOC_{rep\ vehicle} \times VKT_{without\ project}) - (VOC_{rep\ vehicle} \times VKT_{with\ project})$$

Where

$VOC_{savings}$ = Vehicle operating cost savings (Baht)

$VOC_{representative\ vehicle}$ = Vehicle operating cost of representative vehicle (Baht/PCU-km)

$VKT_{without\ project}$ = Vehicle kilometers travelled in the without-project case (PCU-km)

$VKT_{with\ project}$ = Vehicle kilometers travelled in the with-project case (PCU-km)

With reference to the Feasibility Study Report for the Pink Line (Khae Rai-Min Buri) (September 2009), VOC unit was adjusted to be the value at the base year (2011) as presented in ***Table 3.10-3***.

Table 3.10-3 Vehicle Operating Costs at Different Speeds

Speed (km/hr)	10	20	30	40	50	60	70	80	90	100
VOC (Baht/PCU-km.)	16.4	9.79	7.70	6.74	6.21	5.97	5.88	5.90	6.03	6.27

Source: The Consultants, 2012

(2) Value of Time Savings (VOT Savings)

VOT means the value of time (in monetary terms) that road users lose while traveling. If the travel time is used for other economic activities, it will generate value addition to the economy. Therefore, improvement of road network will result in direct benefit, VOT savings to all travelers in the project route and road network in the study area and vicinities as the project will enable the faster journey. The value of time was applied to analyze the project benefits, using vehicle hours traveled (VHT) to assess the difference of VOT savings between the with-project and the without-project cases. The resultant difference constitutes the benefit in the form of VOT savings in the with–project situation.

$$VOT_{savings} = (VOT \times VHT_{without\ project}) - (VOT \times VHT_{with\ project})$$

Where

$VOT_{savings}$ = Value of time savings, Baht

VOT = Value of time of travelers in the study area, Baht/PCU-hr

$VHT_{without\ project}$ = Vehicle hours traveled in the without-project case, PCU-hr

$VHT_{with\ project}$ = Vehicle hours traveled in the with-project case, PCU-hr

VOT unit was adjusted, in reference to the Feasibility Study Report for the Pink Line (Khae Rai-Min Buri) (September 2009), to be the value at the base year (2011), 231.67 Baht per PCU-hr. (However, the average household income which is a factor used to calculate VOT is not based on the minimum wage of 300 Baht.)

(3) Savings of Environmental Cost

When comparing the fuel consumption between road and rail transportation, the latter requires less fuel than the former at the equal amount of usage. This is because the rail transportation can accommodate more passengers and takes less time than traveling by road. Therefore, the number of trips by rail is higher than by road when spending the same period of travel time. The rail mass transit will help reduce air pollution emission.

The savings of environmental costs were computed by multiplying the pollution elimination cost by the difference of vehicle kilometers travelled of road and rail transportation between the without-and with-project cases. With reference to the Final Report of the Study of the Master Plan for Railway System and High Speed Train Development (2010) and the MRT Assessment Standardization report (Public Debt Management Office and MRT Red Line Project), the pollution elimination cost is equal to 5 Baht/PCU-km.

Table 3.10-4 Direct Benefits of the Project

Unit: Million Baht

Year	20-Baht Flat Rate				Distance-Based Fare Rate			
	VOC Savings	VOT Savings	Pollution Savings	Total	VOC Savings	VOT Savings	Pollution Savings	Total
2018	3,051	4,808	712	8,571	2,094	3,240	459	5,793
2022	4,038	6,483	876	11,409	3,059	4,836	663	8,558
2027	5,784	8,835	1,076	15,649	4,335	6,980	894	12,210
2032	7,351	11,466	1,295	20,112	5,918	9,388	1,139	16,445
2037	9,489	14,446	1,551	25,545	7,647	12,254	1,431	21,331

Source: The Consultants, 2012

Indirect Benefits of the Project

In addition to the project's direct benefits, implementation of the Pink Line Project (Khae Rai–Min Buri section) will have broad positive impacts on the economy as it will bring about more convenient transportation, and development of land along the project alignment and around stations. This will attract the private investment, thus leading to a greater demand for and a higher price of land along the project alignment. Consequently, the land use will be more efficient and economic activities will eventually grow. The economic expansion will benefit people who will have more employment opportunities and higher household income.

3.10.4 Socio-Economic Returns of the Project

3.10.4.1 Socio-Economic Viability Analysis Results

The project costs and benefits were compared in the form of economic values by using the economic indicators from MRT Assessment Standardization of the Finance Ministry. The project's economic viability analysis was carried by taking into account the following economic indicators.

(1) Net Present Value (NPV)

NPV is the difference between benefits and costs in different years at the present value throughout the project life. Normally, a discount rate is applied to derive the present value.

If NPV is positive or greater than zero, the project is worth investing. In other words, the investment will create benefits that exceed the costs over the project period.

However, evaluation of the project viability by considering only NPV is not sufficient for comparing the projects with much different capital investments. This is because the large-scale project will yield higher NPV than the one of much smaller scale. It is necessary to take other economic indicators into account. NPV calculation is shown below.

$$NPV = \sum_{t=1}^{n} \frac{B_t - C_t}{(1+i)^t}$$

Where *NPV* = Net present value
B_t = Project benefits in year t
C_t = Project costs in year t
i = Interest rate or project's return rate
n = Project life

(2) Benefit Cost Ratio (B/C Ratio)

B/C ratio is the ratio of the total present value of benefits to the total present value of costs of the project. Generally, a discount rate is used to obtain the present value.

If the B/C ratio is greater than 1, the project is viable for investment. B/C ratio calculation is as follows.

$$B/C = \frac{\sum_{t=1}^{n} \frac{B_t}{(1+i)^t}}{\sum_{t=1}^{n} \frac{C_t}{(1+i)^t}}$$

Where *B/C* = Benefit cost ratio
B_t = Project benefits in year t
C_t = Project costs in year t
i = Interest rate or project's return rate
n = Project life

(3) Economic Internal Rate of Return (EIRR)

It is a discount rate which equates the present value of benefits with the present value of costs.

The opportunity cost of the capital adopted for this project is 12% per annum which is the rate taken from the study in Thailand by the World Bank and NESDB. As a result, the project with EIRR greater than 12% per year is considered viable for investment.

$$EIRR = i;\ NPV = \sum_{t=1}^{n} \frac{B_t - C_t}{(1+i)^t} = 0$$

Where *EIRR* = Economic internal rate of return
B_t = Project benefits in year t
C_t = Project costs in year t
i = Interest rate or project's return rate
n = Project life

The economic analysis results indicate economic viability of the project in all cases as economic indicators are greater the criteria. Also, it is indicated that the monorail with 20-baht flat rate is more economically viable than the other case.

Table 3.10-5 Economic Investment Costs: Monorail

ค่าลงทุนโครงการ มูลค่าทางเศรษฐกิจ (ล้านบาท)

ปีที่	ปี พ.ศ.	ค่าสำรวจอสังหาริมทรัพ	ค่าควบคุมงาน	ค่าชดเชยที่ดิน	ค่าก่อสร้าง	E & M	ค่าบำรุงรักษารายปี	รวมค่าลงทุนรายปี
1	2556	-	-	705.0	-	-	-	705.0
2	2557	-	253.9	4,989.0	3,909.0	2,126.1	-	11,278.0
3	2558	-	470.1	1,060.8	6,194.3	4,429.9	-	12,155.1
4	2559	-	805.9	-	6,260.3	12,044.6	-	19,110.8
5	2560	-	375.4	-	3,861.4	4,915.7	-	9,152.5
6	2561	-	-	-	-	-	1,172.9	1,172.9
7	2562	-	-	-	-	-	1,220.1	1,220.1
8	2563	-	-	-	-	-	1,269.3	1,269.3
9	2564	-	-	-	-	-	1,320.4	1,320.4
10	2565	-	-	-	-	-	1,373.7	1,373.7
11	2566	-	-	-	-	-	1,429.0	1,429.0
12	2567	-	-	-	-	-	1,486.6	1,486.6
13	2568	-	-	-	-	-	1,546.5	1,546.5
14	2569	-	-	-	-	-	1,608.8	1,608.8
15	2570	-	-	-	-	4,583.0	1,673.7	6,256.7
16	2571	-	-	-	-	-	1,720.5	1,720.5
17	2572	-	-	-	-	-	1,768.7	1,768.7
18	2573	-	-	-	-	-	1,818.3	1,818.3
19	2574	-	-	-	-	-	1,869.2	1,869.2
20	2575	-	-	-	-	-	1,921.5	1,921.5
21	2576	-	-	-	-	-	1,975.4	1,975.4
22	2577	-	-	-	-	-	2,030.7	2,030.7
23	2578	-	-	-	-	-	2,087.6	2,087.6
24	2579	-	-	-	-	-	2,146.0	2,146.0
25	2580	-	-	-	-	2,406.1	2,206.1	4,612.2
26	2581	-	-	-	-	-	2,241.8	2,241.8
27	2582	-	-	-	-	-	2,277.9	2,277.9
28	2583	-	-	-	-	-	2,314.7	2,314.7
29	2584	-	-	-	-	-	2,352.1	2,352.1
30	2585	-	-	-	-	-	2,390.1	2,390.1
31	2586	-	-	-	-	-	2,428.7	2,428.7
32	2587	-	-	-	-	-	2,467.9	2,467.9
33	2588	-	-	-	-	-	2,507.8	2,507.8
34	2589	-	-	-	-	-	2,548.2	2,548.2
35	2590	-	-	-	-	-	2,589.4	2,589.4
รวม		-	1,905	6,755	20,225	30,505	57,764	117,154

Source: The Consultants, 2012

Table 3.10-6 Economic Viability Analysis Result: Monorail with 20-Baht Flat Rate

ราคาด้านเศรษฐศาสตร์ของค่าลงทุนโครงการ (ราคา ณ ปี 2555)			เปิดใช้โครงการ ปี พ.ศ. 2561		
ค่าควบคุมงาน	1,905	ล้านบาท	อัตราผลตอบแทนทางเศรษฐกิจ (EIRR)	17.3%	
ค่าก่อสร้างและ E & M	50,730	ล้านบาท	มูลค่าปัจจุบันสุทธิ (NPV)	28,031	ล้านบาท
ค่าจัดกรรมสิทธิ์ที่ดินและค่าสำรวจอสังหาริมทรัพย์	6,755	ล้านบาท	อัตราส่วนประโยชน์ต่อค่าใช้จ่าย (B/C)	1.59	
ค่าบำรุงรักษา (ตลอดอายุโครงการ)	57,764	ล้านบาท			

หน่วย: ล้านบาท

ปี พ.ศ.	ปีที่ดำเนินการ	ต้นทุน			ผลประโยชน์				มูลค่าสุทธิ
		ค่าลงทุนก่อสร้าง	ค่าใช้จ่ายในการดำเนินงานและค่าบำรุงรักษา	รวม	มูลค่าการประหยัดค่าใช้จ่ายจากการใช้ยานพาหนะ	มูลค่าเวลาที่ประหยัดของผู้ใช้ยานพาหนะ	มูลค่าการลดผลภาวะสิ่งแวดล้อม	ผลประโยชน์รวม	
2556	1	(705.00)	-	(705.00)	-	-	-	-	(705.00)
2557	2	(11,024.04)	-	(11,024.04)	-	-	-	-	(11,024.04)
2558	3	(11,685.00)	-	(11,685.00)	-	-	-	-	(11,685.00)
2559	4	(18,304.88)	-	(18,304.88)	-	-	-	-	(18,304.88)
2560	5	(8,777.12)	-	(8,777.12)	-	-	-	-	(8,777.12)
2561	6	-	(1,172.85)	(1,172.85)	3,051.26	4,808.03	711.69	8,570.98	7,398.13
2562	7	-	(1,220.12)	(1,220.12)	3,264.06	5,175.36	752.17	9,191.59	7,971.47
2563	8	-	(1,269.29)	(1,269.29)	3,491.70	5,570.76	794.95	9,857.41	8,588.12
2564	9	-	(1,320.44)	(1,320.44)	3,735.22	5,996.36	840.16	10,571.74	9,251.30
2565	10	-	(1,373.65)	(1,373.65)	4,038.29	6,482.88	887.95	11,409.12	10,035.47
2566	11	-	(1,429.01)	(1,429.01)	4,365.94	7,008.88	913.75	12,288.58	10,859.56
2567	12	-	(1,486.60)	(1,486.60)	4,720.18	7,577.56	952.93	13,250.67	11,764.07
2568	13	-	(1,546.51)	(1,546.51)	5,103.16	8,192.38	993.79	14,289.33	12,742.82
2569	14	-	(1,608.84)	(1,608.84)	5,517.22	8,384.31	1,036.40	14,937.92	13,329.09
2570	15	(4,583.04)	(1,673.68)	(6,256.72)	5,783.82	8,789.47	1,075.81	15,649.11	9,392.39
2571	16	-	(1,720.55)	(1,720.55)	6,063.32	9,214.20	1,116.73	16,394.25	14,673.70
2572	17	-	(1,768.74)	(1,768.74)	6,356.31	9,659.46	1,159.20	17,174.98	15,406.24
2573	18	-	(1,818.27)	(1,818.27)	6,663.47	10,126.23	1,203.29	17,993.00	16,174.72
2574	19	-	(1,869.20)	(1,869.20)	6,985.47	10,895.07	1,249.06	19,129.60	17,260.40
2575	20	-	(1,921.55)	(1,921.55)	7,351.34	11,465.71	1,294.93	20,111.98	18,190.43
2576	21	-	(1,975.36)	(1,975.36)	7,736.37	12,066.23	1,342.49	21,145.10	19,169.74
2577	22	-	(2,030.69)	(2,030.69)	8,141.57	12,698.21	1,391.80	22,231.58	20,200.90
2578	23	-	(2,087.56)	(2,087.56)	8,567.99	13,363.29	1,442.92	23,374.20	21,286.64
2579	24	-	(2,146.02)	(2,146.02)	9,016.74	13,782.84	1,495.92	24,295.50	22,149.48
2580	25	(2,406.10)	(2,206.13)	(4,612.22)	9,489.00	14,504.72	1,550.87	25,544.59	20,932.37
2581	26	-	(2,241.75)	(2,241.75)	9,986.00	15,264.42	1,607.83	26,858.24	24,616.49
2582	27	-	(2,277.95)	(2,277.95)	10,509.02	16,063.90	1,666.88	28,239.81	25,961.86
2583	28	-	(2,314.73)	(2,314.73)	11,059.44	16,905.26	1,728.11	29,692.81	27,378.07
2584	29	-	(2,352.11)	(2,352.11)	11,638.68	17,790.69	1,791.58	31,220.95	28,868.84
2585	30	-	(2,390.09)	(2,390.09)	12,248.27	18,722.49	1,857.38	32,828.14	30,438.05
2586	31	-	(2,428.69)	(2,428.69)	12,889.78	19,703.09	1,925.60	34,518.48	32,089.79
2587	32	-	(2,467.90)	(2,467.90)	13,564.89	20,735.06	1,996.33	36,296.28	33,828.37
2588	33	-	(2,507.75)	(2,507.75)	14,275.36	21,821.07	2,069.65	38,166.09	35,658.33
2589	34	-	(2,548.25)	(2,548.25)	15,023.04	22,963.96	2,145.67	40,132.68	37,584.43
2590	35	7,509.24	(2,589.40)	4,919.84	15,809.89	24,166.72	2,224.48	42,201.09	47,120.93
NPV		**(39,407.19)**	**(7,969.56)**	**(47,376.75)**	**27,390.69**	**42,766.22**	**5,250.45**	**75,407.36**	**28,030.61**

Source: The Consultants, 2012

Table 3.10-7 Economic Viability Analysis Result: Monorail with Distance-Based Fare Rate

ราคาด้านเศรษฐศาสตร์ของค่าลงทุนโครงการ (ราคา ณ ปี 2555)			เปิดใช้โครงการ ปี พ.ศ. 2561		
ค่าออกแบบและค่าที่ปรึกษา	1,905	ล้านบาท	อัตราผลตอบแทนทางเศรษฐกิจ (EIRI	14.2%	
ค่าก่อสร้างและ E & M	50,730	ล้านบาท	มูลค่าปัจจุบันสุทธิ (NPV)	11,237	ล้านบาท
ค่าจัดกรรมสิทธิ์ที่ดินและค่าสำรวจอสังหาริมทรัพย์	6,755	ล้านบาท	อัตราส่วนประโยชน์ต่อค่าใช้จ่าย (B/C	1.24	
ค่าบำรุงรักษา (ตลอดอายุโครงการ)	57,764	ล้านบาท			

หน่วย: ล้านบาท

ปี	ปีที่	ต้นทุน			ผลประโยชน์				มูลค่าสุทธิ
พ.ศ.	ดำเนินการ	ค่าลงทุนก่อสร้าง	ค่าใช้จ่ายในการดำเนินงานและค่าบำรุงรักษา	รวม	มูลค่าการประหยัดค่าใช้จ่ายจากการใช้ยานพาหนะ	มูลค่าเวลาที่ประหยัดของผู้ใช้ยานพาหนะ	มูลค่าการลดมลภาวะสิ่งแวดล้อม	ผลประโยชน์รวม	
2556	1	(705.00)	-	(705.00)	-	-	-	-	(705.00)
2557	2	(11,024.04)	-	(11,024.04)	-	-	-	-	(11,024.04)
2558	3	(11,685.00)	-	(11,685.00)	-	-	-	-	(11,685.00)
2559	4	(18,304.88)	-	(18,304.88)	-	-	-	-	(18,304.88)
2560	5	(8,777.12)	-	(8,777.12)	-	-	-	-	(8,777.12)
2561	6	-	(1,172.85)	(1,172.85)	2,094.36	3,239.65	458.67	5,792.68	4,619.83
2562	7	-	(1,220.12)	(1,220.12)	2,320.76	3,609.26	508.04	6,438.05	5,217.94
2563	8	-	(1,269.29)	(1,269.29)	2,571.63	4,021.04	562.72	7,155.38	5,886.09
2564	9	-	(1,320.44)	(1,320.44)	2,849.61	4,479.79	623.28	7,952.69	6,632.25
2565	10	-	(1,373.65)	(1,373.65)	3,058.96	4,835.72	663.44	8,558.12	7,184.46
2566	11	-	(1,429.01)	(1,429.01)	3,283.68	5,219.93	706.18	9,209.79	7,780.77
2567	12	-	(1,486.60)	(1,486.60)	3,524.91	5,634.67	751.67	9,911.25	8,424.64
2568	13	-	(1,546.51)	(1,546.51)	3,783.87	6,082.35	800.09	10,666.31	9,119.80
2569	14	-	(1,608.84)	(1,608.84)	4,061.84	6,565.61	851.64	11,479.09	9,870.25
2570	15	(4,583.04)	(1,673.68)	(6,256.72)	4,334.69	6,980.46	894.49	12,209.65	5,952.93
2571	16	-	(1,720.55)	(1,720.55)	4,625.87	7,421.52	939.51	12,986.90	11,266.35
2572	17	-	(1,768.74)	(1,768.74)	4,936.61	7,890.45	986.78	13,813.85	12,045.11
2573	18	-	(1,818.27)	(1,818.27)	5,268.22	8,389.01	1,036.44	14,693.68	12,875.41
2574	19	-	(1,869.20)	(1,869.20)	5,622.11	8,919.08	1,088.60	15,629.79	13,760.59
2575	20	-	(1,921.55)	(1,921.55)	5,917.81	9,388.18	1,139.31	16,445.30	14,523.75
2576	21	-	(1,975.36)	(1,975.36)	6,229.06	9,881.96	1,192.38	17,303.40	15,328.04
2577	22	-	(2,030.69)	(2,030.69)	6,556.69	10,401.71	1,247.92	18,206.32	16,175.63
2578	23	-	(2,087.56)	(2,087.56)	6,901.54	10,948.80	1,306.05	19,156.39	17,068.83
2579	24	-	(2,146.02)	(2,146.02)	7,264.53	11,622.09	1,366.88	20,253.51	18,107.49
2580	25	(2,406.10)	(2,206.13)	(4,612.22)	7,646.62	12,253.98	1,430.55	21,331.15	16,718.93
2581	26	-	(2,241.75)	(2,241.75)	8,048.80	12,920.23	1,497.19	22,466.21	20,224.46
2582	27	-	(2,277.95)	(2,277.95)	8,472.13	13,622.69	1,566.93	23,661.76	21,383.81
2583	28	-	(2,314.73)	(2,314.73)	8,917.73	14,363.35	1,639.92	24,921.00	22,606.27
2584	29	-	(2,352.11)	(2,352.11)	9,386.76	15,144.29	1,716.31	26,247.36	23,895.25
2585	30	-	(2,390.09)	(2,390.09)	9,880.47	15,967.67	1,796.26	27,644.40	25,254.31
2586	31	-	(2,428.69)	(2,428.69)	10,400.14	16,835.83	1,879.93	29,115.90	26,687.21
2587	32	-	(2,467.90)	(2,467.90)	10,947.14	17,751.19	1,967.50	30,665.83	28,197.93
2588	33	-	(2,507.75)	(2,507.75)	11,522.92	18,716.31	2,059.15	32,298.38	29,790.62
2589	34	-	(2,548.25)	(2,548.25)	12,128.97	19,733.91	2,155.06	34,017.95	31,469.70
2590	35	7,509.24	(2,589.40)	4,919.84	12,766.91	20,806.84	2,255.45	35,829.19	40,749.04
NPV		**(39,407.19)**	**(7,969.56)**	**(47,376.75)**	**20,977.71**	**33,384.38**	**4,251.25**	**58,613.34**	**11,236.59**

Source: The Consultants, 2012

Table 3.10-8 Summary of Economic Viability Analysis Results

Cases	Economic Indicators		
	EIRR (Percentage)	NPV (Million Baht)	B/C Ratio (Ratio)
Monorail with 20-Baht Flat Rate	17.3%	28,031	1.59
Monorail with Distance-Based Fare Rate	14.2%	11,237	1.24

Source: The Consultants, 2012

3.10.4.2 Project Sensitivity Analysis Results

The project sensitivity analysis was performed on the basis of the base case to support the decision making. Consideration was made on the likely impacts of changes in key parameters on the project, e.g. traffic volume, economic growth rate, fuel price, foreign exchange rate, etc. The adopted assumptions may result in increase and/or decrease in economic investment costs and/or project benefits. The following three scenarios were analyzed.

(1) Project investment costs are constant and project benefits decrease by 20%.

(2) Project investment costs increase by 20% and project benefits are constant.

(3) Project investment costs increase by 20% and project benefits decrease by 20%.

(4) Further analysis of environmental economics is conducted.

Table 3.10-9 Sensitivity Analysis Results

Case1: Monorail with 20-Baht Flat Rate				Case 1: Monorail with Distance-Based Fare Rate			
Project benefits decrease by 20%		Project investment costs increase by 20%	Project benefits decrease and project investment costs increase by 20%	Project benefits decrease by 20%		Project investment costs increase by 20%	Project benefits decrease and project investment costs increase by 20%
EIRR (%)	14.62%	15.09%	12.62%	EIRR (%)	11.90%	12.30%	10.16%
NPV (MB)	12,949	18,555	3,474	NPV (MB)	-486	1,761	-9,961
B/C ratio	1.27	1.33	1.06	B/C ratio	0.99	1.03	0.82
Case 2: Monorail with 20-Baht Flat Rate				**Case 2: Monorail with Distance-Based Fare Rate**			
Project benefits decrease by 20%		Project investment costs increase by 20%	Project benefits decrease and project investment costs increase by 20%	Project benefits decrease by 20%		Project investment costs increase by 20%	Project benefits decrease and project investment costs increase by 20%
EIRR (%)	14.12%	14.58%	12.17%	EIRR (%)	11.51%	11.91%	9.81%
NPV (MB)	11,009	16,260	1,017	NPV (MB)	-2,460	-577	-12,453
B/C ratio	1.22	1.27	1.02	B/C ratio	0.95	0.99	0.79
Case 3.1: Monorail with 20-Baht Flat Rate				**Case 3.1: Monorail with Distance-Based Fare Rate**			
Project benefits decrease by 20%		Project investment costs increase by 20%	Project benefits decrease and project investment costs increase by 20%	Project benefits decrease by 20%		Project investment costs increase by 20%	Project benefits decrease and project investment costs increase by 20%
EIRR (%)	13.61%	14.05%	11.71%	EIRR (%)	11.14%	11.53%	9.48%
NPV (MB)	8,693	13,480	-1,763	NPV (MB)	-4,491	-2,999	-14,946
B/C ratio	1.17	1.21	0.97	B/C ratio	0.91	0.95	0.76
Case 3.2: Monorail with 20-Baht Flat Rate				**Case 3.2: Monorail with Distance-Based Fare Rate**			
Project benefits decrease by 20%		Project investment costs increase by 20%	Project benefits decrease and project investment costs increase by 20%	Project benefits decrease by 20%		Project investment costs increase by 20%	Project benefits decrease and project investment costs increase by 20%
EIRR (%)	13.72%	14.17%	11.81%	EIRR (%)	11.24%	11.62%	9.56%
NPV (MB)	9,214	14,106	-1,137	NPV (MB)	-3,969	-2,374	-14,321
B/C ratio	1.18	1.23	0.98	B/C ratio	0.92	0.96	0.77
Case 4 Further analysis of environmental economics(Monorail with 20-Baht Flat Rate)				**Case 4 Further analysis of environmental economics (Monorail with Distance-Based Fare Rate)**			
Case	**EIRR (%)**	**NPV (MB)**	**B/C ratio**	**Case**	**EIRR (%)**	**NPV (MB)**	**B/C ratio**
Case 1	17.3%	28,226	1.60	Case 1	14.2%	11,232	1.24

Source: The Consultants, 2012