Environmental Impact Assessment (Final)

Project Number: 51274-001
October 2017

THA: Bangkok Mass Rapid Transit (Pink Line) (Part 4 of 5)

Prepared by The Mass Rapid Transit Authority of Thailand.

CHAPTER 5

ENVIRONMENTAL IMPACT ASSESSMENT

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The Pink Line Project : Khae Rai-Min Buri Section is aimed to alleviate traffic problems in Bangkok and its vicinity. However, the project construction and operation inevitably have impacts on the environment. The Project EIA has considered the impacts during the construction and operation phases covering the main four components; physical environmental resources, ecological environmental resources, human use values and quality of life values.

The impacts, both positive and negative, have been considered and categorized into four levels:

- Severe: The Project implementation changes the structures and functions of the study areas and causes environmental impacts to the unrestorable level.
- Medium: The Project implementation changes the structures and functions of the study area and causes environmental impacts at the level that the restoration can be carried out in a certain period of time.
- Low: The Project implementation changes the structures and functions of the study area and causes environmental impacts for a short term and the restoration can be carried out in a short time.
- None: The Project implementation does not change the structures and functions of the study area or may make minor changes but does not cause other environmental impacts.

The EIA of the Pink Line Project : Khae Rai-Min Buri Section had been carried out and the EIA final report was submitted to the Office of Natural Resources and Environmental Policy and Planning (ONEP). The EIA was approved by the National Environmental Board in the meeting No.2/ B.E.2555 (2012) on 16 March B.E.2555 (2012) on the conditions that in case of changes to Project details or measures that did not have effects on significant elements of the EIA and the changes had more benefits than or equivalent to those measures already approved by the EIA Expert Committee, the changes can be submitted to the governing entities of the area as required by laws with a copy to ONEP for acknowledgement. On the other hand, in case those changes or modifications to measures had effects on significant elements of EIA, the EIA modification report relevant to the changes shall have to be submitted to ONEP for prior consideration by the EIA Expert Committee.

Under this study, the Project has been modified and the design has been made in terms of station locations, station addition, and changes in details of Depot and Park & Ride buildings. This EIA report therefore considers only the environmental impact due to the changes of the Project as follows:

5.1 PHYSICAL ENVIRONMENTAL RESOURCES

5.1.1 Topography

(1) Construction Phase

Land use survey has found that most of the Project alignment is on traffic islands of the roads; Rattana Thibet, Tiwanon, Chaeng Watthana and Ram Inthra, with foundation and structural construction on the roads. Eventhough there are changes in station locations or addition of stations, those changes are made on the Project alignment only. Furthermore, the stations are of elevated type, those changes thus do not affect the site conditions.

For the Depot and Park & Ride building at Rom Klao intersection, the design has been made to accommodate more area. As the site is on flat land and more land leveling may be slightly needed for building construction. There is no significant changes to the site conditions, therefore the impact is low.

(2) Operation Phase

During the operation phase, there are no activities that cause impact to the site conditions of the Project alignment, nor the stations, nor the Depot and Park & Ride building.

5.1.2 Surface Water Hydrology and Water Drainage

The construction of the elevated structure and stations, Depot and Park & Ride building at Rom Klao Intersection may affect surface water hydrology and water drainage. Details are as follows:

(1) Construction Phase

During construction phase, natural water flow system does not change because the construction of structures does not disturb surface water sources. However, there will be obstruction to surface runoff caused by other construction activities, such as stacking of construction materials. The construction of elevated structure and stations needs construction area of approximately 8 meters wide on traffic islands of Rattanathibet, Tiwanon, Chaeng Watthana, Ram Inthra, and Srihaburanukit roads, except for the alignment section which diverts from the traffic islands, such as at IT square shopping center at Lak Si, Ha Yaek Pak Kret, Sri Rat Expressway, Khlong Kluea school and Phranakorn Rajabhat University. Thus it was anticipated that there would be medium impact on surface runoff to public drainage system along the pavements on both sides of the roads. This is because, from construction activities, there would be construction wastes such as cement fractions and gravel/soil/sand. The construction materials stack and concrete barriers embanking construction zones can also obstruct and delay flowing of rain water from traffic surface to the drainage system. These obstructions causes flooding on traffic areas along the mass transit system alignment.

Under this present study, since the construction of the elevated structure and stations of Pink Line Project:Khae Rai-Min Buri Section is still on traffic islands and no parts of the structures encroach the canals nor surface water sources along the Project alignment. Therefore, there is no impact on surface runoff of the roads along the Project alignment.

For the Depot and Park & Ride building at Rom Klao intersection, it was anticipated that there would be no impact on surface water hydrology and water drainage. Eventhough at present, the area is left uncultivated, and there may be obstruction of surface runoff in rainy season due to inappropriate stacking of construction machinery and equipment as well as construction materials, flooding would not occur as there is Khlong Song Ton Noon passes by the area and acts as natural water basin for drainage.

(2) Operation Phase

It was anticipated that there would be no increase/decrease in the existing surface drainage areas of the roads along the Project alignment. Details are as follows:

- The mass transit system alignment of a total distance of 34.50 kilometers, with open structure having two parallel concrete tracks of 0.75 meter wide/track with the distance of 4.40 meters between the centerline of each track. The two concrete tracks lie over the existing traffic surface (1.50 meters wide). This would not reduce the existing surface drainage area but still accommodates rain water drainage without causing flooding. It was anticipated that the impact would be low.

- The thirty stations, each of 23.40 m wide x 100 m long, covering an area of 2,340 m^2/station, lie over the existing traffic surface but do not reduce the existing surface drainage area because the rooftop area of the stations can receive rain water in the same capacity as before the project development. Along the edge of the roof is a gutter collecting rain water which will be conducted via the downpipe of 0.15 m in diameter to receiving ponds under the traffic islands before flowing through steel pipe of 0.30 m in diameter to the existing drainage systems of the roads along the mass transit system alignment. It was anticipated that the impact would be low.

Following the investigation of the elevated structure and station construction of the Pink Line Project: Khae Rai-Min Buri Section, it was found that, at present, no stations lie over draining canals which were used for drainage in B.E.2554 (2011). It was also found that no parts of Project structures would be constructed in the canals. It can be concluded that the station structures of the Pink Line Project: Khae Rai-Min Buri Section do not obstruct drainage in the northern part of Chaeng Watthana and Ram Inthra roads if flood occurs as that in B.E.2554 (2011).

The Depot and Park & Ride building at Rom Klao Intersection has been designed with water retention ponds in 2 areas; the retention ponds in Zone A and Zone B as shown in ***Figure 5.1-1***. The estimate drainage rate before and after the project development is detailed as follows:

The calculation of maximum runoff by Rational Foumula is calculated from the excessive volume of rain water in the catchment area (volume of rain water left from evaporation, infiltration, evapotranspiration, absorption, and storage in water basins) based on the assumption that rainfall intensity is even across the catchment area throughout the rainfall duration of consideration. Such the assumption makes this formula appropriate for calculation of runoff of a not-too-large area. The larger the catchment area, the more difference of rain volume distribution across the area will be which results in less accuracy of calculation. The Rational Formula is widely used in both in Thailand and abroad. Particularly, in Thailand, this formula is used for the catchment area not larger than 25 square kilometers.

Figure 5.1-1 Retention Ponds in the Depot and Park & Ride Building Area, Rom Klao Intersection

The equation for calculating the runoff is:

$$\mathbf{Q = 0.278\ CIA}$$

When Q = Runoff in cubic meters per second at the point of consideration

C = Coefficient of runoff subject to characteristics of the catchment area

I = Rainfall intensity (millimeters per hour)

A = Catchment area (square kilometers)

Rainfall intensity is derived from rainfall intensity graph, showing relations between rainfall intensity and rainfall duration. The graph, sometimes called IDF Curve, is based on rainfall frequency analysis at various intensity and duration and requires data of rainfall continuously collected for years. The directly water-relevant agencies; the Royal Irrigation Department, the Electricity Generating Authority of Thailand, and the Department of Alternative Energy Development and Efficiency (DEDE), have prepared IDF Curve of rain stations scattered across the country. This study uses the rain stations nearest to the Project site.

Calculation of Water Storage Area

Outlet drainage rate of the Depot and Park & Ride building and volume of rainfall to be retained of the Project area is estimated as follows:

(a) Drainage Rate Before and After the Project Development

The calculation and design of rainfall drainage system of the Project was based on the rain equation of Queen Sirikit Convention Center rain station (455201) of heavy rain in 100 years. The flow rate of pipes and trenches in the design was derived from the maximum runoff of 100-year return period calculated by Rational Formula as follows:

Rational Formula

Runoff calculation from the equation Rational Formula

Q = 0.278CIA

when Q = Runoff in cubic meters per second at the point of consideration

C = Coefficient of runoff subject to characteristics of the catchment area

I = Rainfall intensity (millimeters per hour)

A = Catchment area (square kilometers)

Calculation for Rainfall Intensity (I) *

$I = 7226.829/(t+33)^{0.891628}$

t = Time of concentration (minutes)

*source: from heavy rain in 100 years of rain equation of Queen Sirikit Convention Center rain station (455201)

(b) Calculation for volume of water to be retained in Zone A

Coefficient of runoff (C) befor Project Development

Site conditions before development is deserted vacant land. Therefore the coefficient (C) was determined at 0.3 (recommended criteria for design of waste water collection system and community water treatment plant, Environmental Engineering Association of Thailand, B.E.2546 (2003)).

Coefficient of runoff (C) after Project development

The area of 80,916 m^2 can be divided according to the surface conditions and land use as follows:

- The coefficient (C) = 0.7 to 0.9 for the building area and roads in the Project area (criteria for design of waste water collection system and community water treatment plant, Environmental Engineering Association of Thailand, B.E.2546 (2003)). This study determined the C value for the Project = 0.85.

Building area and roads in the Project= 54,494 m^2

= 67.35% of Park & Ride building area

- The coefficient (C) = 0.30 for the deserted vacant area (criteria for design of waste water collection system and community water treatment plant, Environmental Engineering Association of Thailand, B.E.2546 (2003)).

Vacant area = 26,421 m^2

= 32.65% of Park & Ride building area

Therefore, average C value of the area after Project development

= [(0.85 x 67.35) + (0.25 x 32.65)] / 100

= 0.67 or 0.7

Duration of water retention was calculated at 1 hour.

A Table showing runoff and volume of retention water before and after Project development.

<u>Before</u> Project Development Zone A = 80,916 m^2

C = 0.30 (vacant land)

Time (min)	I (mm/hr)	Runoff (m^3/s)	Remaining water (m^3)	Accumulated remaining water (m^3)
15	229.04	1.5456	1,391.07	1,391.07
30	179.72	1.2128	1,091.56	2,482.63
45	148.56	1.0025	902.29	3,34.92
60	127.00	0.8570	771.32	4,156.24

<u>After</u> Project Development Zone A = 80,916 m^2

C = 0.70

Time (min)	I (mm/hr)	Runoff (m^3/s)	Remaining water (m^3)	Accumulated remaining water (m^3)
15	229.04	3.6065	3,245.83	3,245.83
30	179.72	2.8300	2,546.98	5,792.81
45	148.56	2.3393	2,105.34	7,898.15
60	127.00	1.9997	1,799.75	9,697.90

The calculation result for drainage rate before and after Project development of Zone A can be used to estimate capacity of water retention as follows:

Required volume of retention water = $(Q_{after} - Q_{before})$

= 9,697.90 - 4,156.24

= 5,541.66 cubic meters

Therefore, the minimum capacity of retention pond in Zone A for retaining rainfall at one-hour is 5,541.66 cubic meters.

(c) Calculation for volume of water to be retained in Zone B

Runoff coefficient (C) befor development

Conditions of the area before development is deserted vacant land. Therefore the coefficient (C) is determined at 0.3 (recommende criteria for design of waste water collection system and community water treatment plant, Environmental Engineering Association of Thailand, B.E.2546 (2003)).

Runoff coefficient (C) after Project development

The area of 285,484 m^2 can be divided according to the surface conditions and land use as follows:

- The coefficient (C) = 0.7 to 0.9 for the building area, concrete yard and roads in the Project area (criteria for design of waste water collection system and community water treatment plant, Environmental Engineering Association of Thailand, B.E.2546). This study determined the C value for the Project = 0.85.

Building area, concrete yard and roads in the Project = 53,020 m^2

= 18.57% of Depot area

- The coefficient (C) = 0.90 for rooftop area of the stabling building (criteria for design of waste water collection system and community water treatment plant, Environmental Engineering Association of Thailand, B.E.2546 (2003)).

Rooftop area of the stabling building = 36,481 m^2

= 12.78% of Depot area

- The coefficient (C) = 0.35 for the vacant area, platform and rail tracks areas (criteria for design of waste water collection system and community water treatment plant, Environmental Engineering Association of Thailand, B.E.2546 (2003)).

Vacant area, platform and rail track areas = 195,983 m^2

= 68.65% of Depot area

Therefore, average C value of the area after Project development

= [(0.85 x 18.57) + (0.90 x 12.78) + (0.35 x 68.65] / 100

= 0.51 or 0.50

Duration of water retention was calculated at 1 hour.

A Table showing runoff and volume of retention water before and after Project development

<u>Before</u> Project Development A = 285,484 m^2

C = 0.30 (vacant land)

Time (min)	I (mm/hr)	Runoff (m^3/s)	Remaining water (m^3)	Accumulated remaining water (m^3)
15	229.04	5.4532	4,907.91	4,907.91
30	179.72	4.2791	3,8051.20	8,759.10
45	148.56	3.5371	3,183.42	11,942.52
60	127.00	3.0237	2,721.34	14,663.87

<u>After</u> Project Development A = 285,484 m^2

C = 0.50

เวลา (min)	I (mm/hr)	Runoff (m^3/s)	Remaining water (m^3)	Accumulated remaining water (m^3)
15	229.04	9.09	8,179.85	8,179.85
30	179.72	7.13	6,418.66	14,598.51
45	148.56	5.90	5,305.70	19,904.20
60	127.00	5.04	4,535.57	24,439.78

The calculation result for drainage rate before and after Project development of Zone B can be used to estimate capacity of water retention as follows:

Required Volume of water retention = $(Q_{after} - Q_{before})$
= 24,439.78 - 14,663.87
= 9,775.91 cu m

Therefore, the minimum capacity of retention pond in Zone B for retaining rainfall at one-hour is 9,775.91 cubic meters.

The graph showing relations between rainfall intensity-duration-frequency at Queen Sirikit Convention Center rain station (455201) was presented in ***Figure 5.1-2***.

Calculation sheet of tile drains design in the sub-drainage areas in Zone A and Zone B was presented in ***Table 5.1-1*** and ***Table 5.1-2***. Monograph for surface runoff was presented in ***Figure 5.1-3***.

Flow direction of drainage water to retention ponds in Depot and Park&Ride building areas at Rom Klao Intersection was presented in ***Figure 5.1-4*** and vertical cross section of retention ponds was presented in ***Figure 5.1-5***.

5.1.3 Quality of Surface Water

(1) Elevated Structure and Stations

The development of elevated structure for a total distance of 34.50 kilometers and 30 stations may have effects on quality of surface water in 10 sources; Khlong Bang Talat, Khlong Prapa, Khlong Prem Prachakon, Khlong Khru, Khlong Lam Chala, Khlong Lum Phai, Khlong Lam Kret, Khlong Bang Chan, Khlong Ton Nun and Khlong Saen Saep. Details are as follows:

(a) Construction Phase

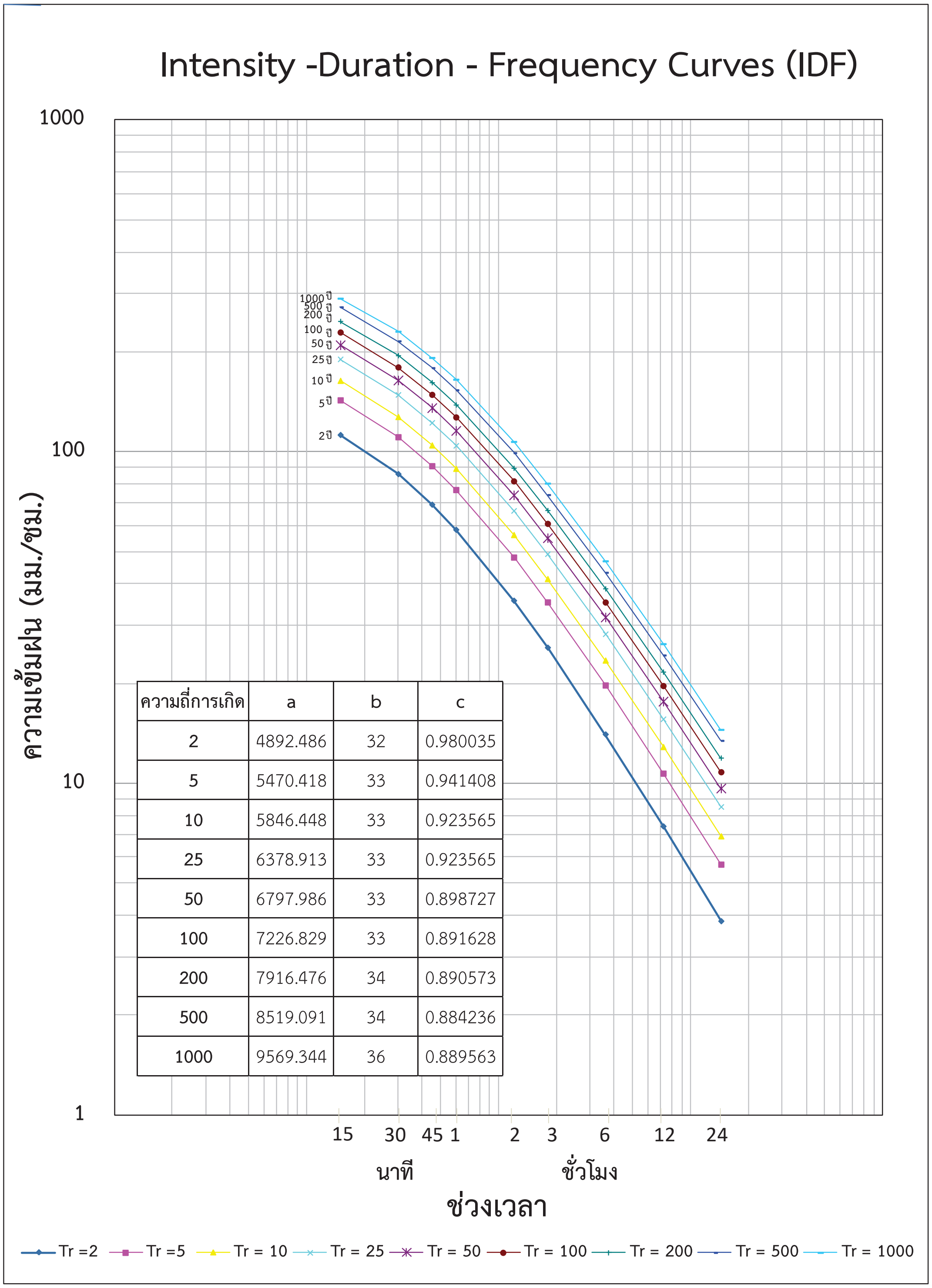
It was anticipated that construction activities especially excavation works, land grading and filling, foundation drilling of elevated structure and stations or mobilization of construction materials (for example, sand, gravel, cement, earth etc.) would have low impact because no parts of any construction works intruded into surface water sources. Therefore, no activities would affect quality of surface water except for those of the stations locating no further than 50 meters away from 10 surface water sources (i.e. PK04, PK10, PK11, PK14, PK15, PK20, PK21, PK23, PK29 และ PK30) which may have effects due to increasing turbidity from leachate but only for during foundation drilling and land grading works or contamination of machinery oil. However, it was anticipated that the impact would be low because the construction sites are limited to only at the traffic islands. Moreover, the analysis of quality of surface water from the sources along the mass transit system alignment revealed that quality of surface water from every source was rather poor because those water bodies receive wastewater from large urban communities with rather high contamination; dissolved oxygen (DO) at 2.6-3.0 mg/L, (BOD_5) at 7.2-7.6 mg/L and coliform bacteria at 1,220,000-2,440,000 MPN/ml.

Table 5.1-1 Calculation Sheet of Tile Drain Design in the Sub-Drainage Area in Zone A

ชื่อ	ตำแหน่ง		ขนาดท่อ		พื้นที่รับน้ำ	ความยาว	ระดับถนน	ระดับก้นท่อ	Slope	ระดับก้นท่อ	เวลาในการ	เวลาการไหล	คาบการ	ความเข้มฝน	สัมประสิทธิ์	พื้นที่รับน้ำย่อย	พื้นที่คูณ	พื้นที่คูณ	ความเร็ว	อัตราการไหล	อัตราการไหล	Condition	Safety Factor
ท่อ 1	วางท่อ		b	h	ตร.กม.	ท่อ	(ม.รทก.)	ต้นทาง		ปลายทาง	รวมจุด	ในเส้นท่อ	เกิดฝน	(มม./ชม.)	น้ำท่า	(ตร.กม)	สัมประสิทธิ์	สัมประสิทธิ์	ในเส้นท่อ	ในเส้นท่อ	สูงสุด		
						m.		(ม.รทก.)		(ม.รทก.)	(นาที)	(นาที)	T (ปี)		C		น้ำท่า	น้ำท่าสะสม	(ม./วินาที)	(ลบ.ม/วินาที)	(ลบ.ม/วินาที)		
A1	ขวา	φ	0.60		0.0021	82	0.00	-1.200	0.0010	-1.282	17.30	2.30	100	220	0.70	0.0021	0.0015	0.0015	0.595	0.168	0.091	O.K.	1.86
A2	ขวา	φ	1.00		0.0047	75	0.00	-1.682	0.0010	-1.757	18.79	1.49	100	214	0.70	0.0047	0.0033	0.0047	0.837	0.657	0.282	O.K.	2.33
A3	ขวา	box	1.20	1.20	0.0070	84	0.00	-1.957	0.0010	-2.041	20.27	1.48	100	209	0.70	0.0070	0.0049	0.0096	0.945	1.360	0.558	O.K.	2.44
A4	ขวา	box	1.20	1.20	0.0071	84	0.00	-2.041	0.0010	-2.125	21.75	1.48	100	204	0.70	0.0071	0.0050	0.0146	0.945	1.360	0.827	O.K.	1.65
A5	ขวา	box	1.20	1.20	0.0040	77	0.00	-2.125	0.0010	-2.202	23.11	1.36	100	199	0.70	0.0040	0.0028	0.0174	0.945	1.360	0.966	O.K.	1.41
A6	ขวา	box	1.20	1.20	0.0027	87	0.00	-2.202	0.0010	-2.289	24.65	1.53	100	195	0.70	0.0027	0.0019	0.0193	0.945	1.360	1.045	O.K.	1.30
A7	ซ้าย	φ	0.60		0.0015	60	0.00	-1.200	0.0010	-1.260	16.68	1.68	100	222	0.70	0.0015	0.0011	0.0011	0.595	0.168	0.067	O.K.	2.51
A8	ซ้าย	φ	0.80		0.0048	102	0.00	-1.460	0.0010	-1.562	19.04	2.36	100	213	0.70	0.0048	0.0033	0.0044	0.721	0.362	0.261	O.K.	1.39
A9	ซ้าย	φ	1.00		0.0059	84	0.00	-1.762	0.0010	-1.846	20.71	1.67	100	207	0.70	0.0059	0.0041	0.0085	0.837	0.657	0.492	O.K.	1.33
A10	ซ้าย	box	1.20	1.20	0.0059	84	0.00	-2.046	0.0010	-2.130	22.19	1.48	100	202	0.70	0.0059	0.0041	0.0127	0.945	1.360	0.713	O.K.	1.91
A11	ซ้าย	box	1.20	1.20	0.0033	77	0.00	-2.130	0.0010	-2.207	23.55	1.36	100	198	0.70	0.0033	0.0023	0.0150	0.945	1.360	0.825	O.K.	1.65
A12	ซ้าย	box	1.50	1.50	0.0022	70	0.00	-2.448	0.0010	-2.518	24.62	1.06	100	195	0.70	0.0022	0.0015	0.0321	1.096	2.467	1.739	O.K.	1.42
A13	ขวา	φ	0.80		0.0046	103	0.00	-1.400	0.0010	-1.503	17.38	2.38	100	219	0.70	0.0046	0.0032	0.0032	0.721	0.362	0.195	O.K.	1.86
A14	ขวา	φ	1.00		0.0044	84	0.00	-1.703	0.0010	-1.787	19.05	1.67	100	213	0.70	0.0044	0.0031	0.0063	0.837	0.657	0.372	O.K.	1.77
A15	ขวา	box	1.20	1.20	0.0052	84	0.00	-1.987	0.0010	-2.071	20.54	1.48	100	208	0.70	0.0052	0.0036	0.0099	0.945	1.360	0.572	O.K.	2.38
A16	ขวา	box	1.20	1.20	0.0082	77	0.00	-2.071	0.0010	-2.148	21.89	1.36	100	203	0.70	0.0082	0.0057	0.0156	0.945	1.360	0.883	O.K.	1.54
A17,12	ขวา	box	1.80	1.80	0.0079	79	0.00	-2.818	0.0011	-2.901	22.93	1.04	100	200	0.70	0.0079	0.0056	0.0570	1.270	4.115	3.168	O.K.	1.30

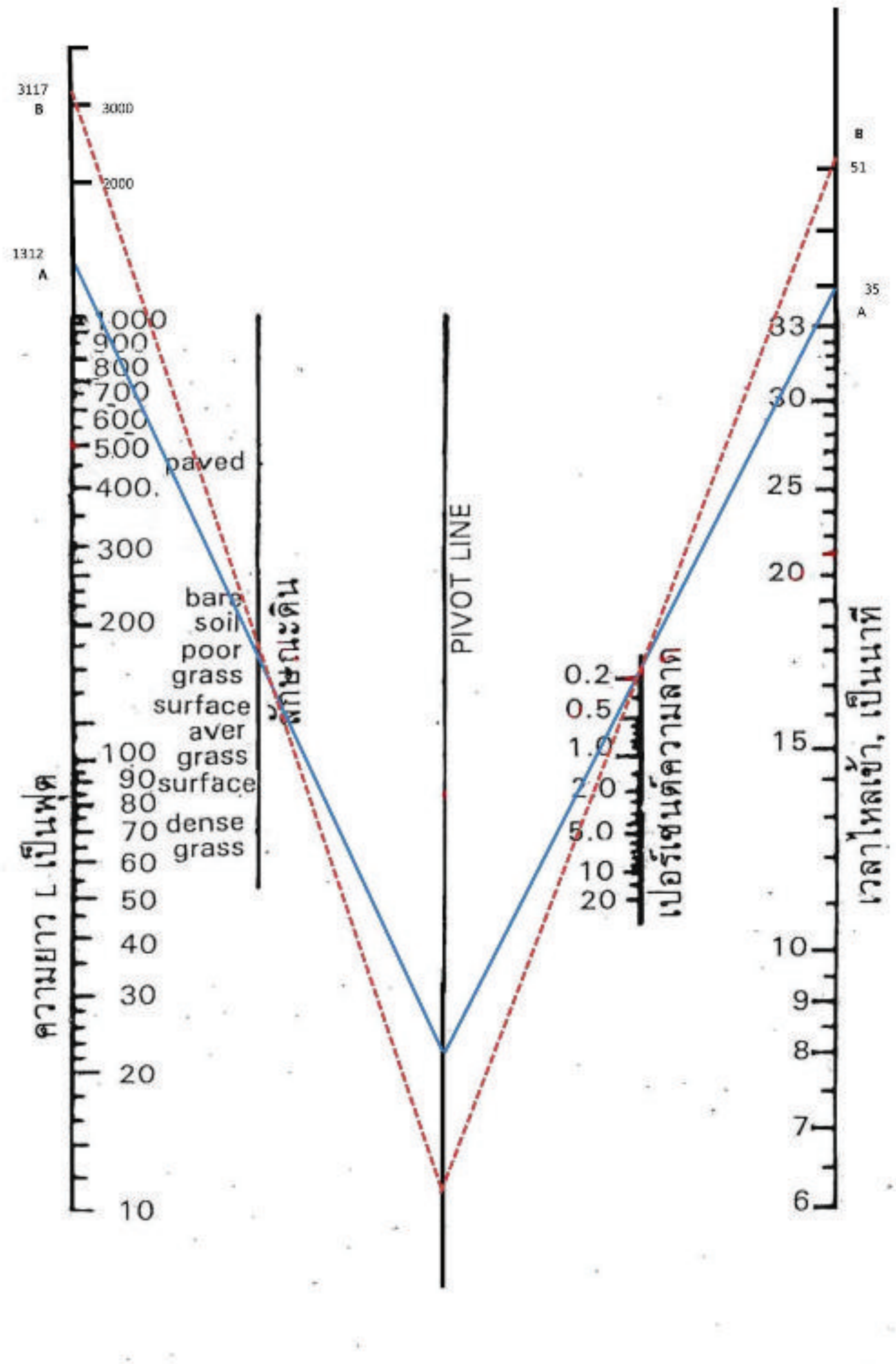
Table 5.1-2 Calculation Sheet of Tile Drain Design in the Sub-Drainage Area in Zone B

ชื่อ ท่อ 4	ตำแหน่ง วางท่อ		ขนาดท่อ b	ขนาดท่อ h	พื้นที่รับน้ำ ตร.กม.	ความยาว ท่อ m.	ระดับถนน (ม.รทก.)	ระดับก้นท่อ ต้นทาง (ม.รทก.)	Slope	ระดับก้นท่อ ปลายทาง (ม.รทก.)	เวลาในการ รวมจุด (นาที)	เวลาการไหล ในเส้นท่อ (นาที)	คาบการ เกิดฝน T (ปี)	ความเข้มฝน (มม./ชม.)	สัมประสิทธิ์ น้ำท่า C	พื้นที่รับน้ำย่อย (ตร.กม)	พื้นที่คูณ สัมประสิทธิ์ น้ำท่า	พื้นที่คูณ สัมประสิทธิ์ น้ำท่าสะสม	ความเร็ว ในเส้นท่อ (ม./วินาที)	อัตราการไหล ในเส้นท่อ (ลบ.ม/วินาที)	อัตราการไหล สูงสุด (ลบ.ม/วินาที)	Condition	Safety Factor
B3	ซ้าย	ϕ	0.60		0.0032	76	0.00	-1.200	0.0010	-1.276	17.13	2.13	100	220	0.50	0.0032	0.0016	0.0016	0.595	0.168	0.098	O.K.	1.72
B5	ซ้าย	ϕ	1.00		0.0084	146	0.00	-1.676	0.0010	-1.822	20.04	2.91	100	210	0.50	0.0084	0.0042	0.0058	0.837	0.657	0.338	O.K.	1.94
B7	ซ้าย	box	1.20	1.20	0.0082	146	0.00	-2.022	0.0007	-2.119	23.19	3.15	100	199	0.50	0.0082	0.0041	0.0099	0.771	1.111	0.548	O.K.	2.03
B9-1	ซ้าย	box	1.20	1.20	0.0040	73	0.00	-2.119	0.0007	-2.168	24.77	1.58	100	194	0.50	0.0040	0.0020	0.0119	0.771	1.111	0.641	O.K.	1.73
B13	ขวา	ϕ	0.60		0.0032	82	0.00	-1.200	0.0010	-1.282	17.30	2.30	100	220	0.50	0.0032	0.0016	0.0016	0.595	0.168	0.098	O.K.	1.71
B11	ขวา	ϕ	1.00		0.0079	60	0.00	-1.682	0.0010	-1.742	18.49	1.20	100	215	0.50	0.0079	0.0040	0.0056	0.837	0.657	0.333	O.K.	1.97
B9-2	ขวา	ϕ	1.00		0.0000	70	0.00	-1.742	0.0010	-1.812	19.89	1.39	100	210	0.50	0.0000	0.0000	0.0056	0.837	0.657	0.325	O.K.	2.02
B9,10	ขวา	box	1.50	1.50	0.0390	146	0.00	-2.468	0.0010	-2.614	26.99	2.22	100	188	0.50	0.0390	0.0195	0.0314	1.096	2.467	1.638	O.K.	1.51
B1	ซ้าย	ϕ	0.60		0.0016	60	0.00	-1.200	0.0010	-1.260	16.68	1.68	100	222	0.50	0.0016	0.0008	0.0008	0.595	0.168	0.049	O.K.	3.41
B2	ซ้าย	ϕ	0.60		0.0016	60	0.00	-1.260	0.0010	-1.320	18.36	1.68	100	216	0.50	0.0016	0.0008	0.0016	0.595	0.168	0.096	O.K.	1.75
B4	ขวา	ϕ	0.80		0.0036	93	0.00	-1.520	0.0010	-1.613	20.51	2.15	100	208	0.50	0.0036	0.0018	0.0034	0.721	0.362	0.196	O.K.	1.84
B6	ขวา	ϕ	1.00		0.0084	146	0.00	-1.813	0.0010	-1.959	23.42	2.91	100	198	0.50	0.0084	0.0042	0.0076	0.837	0.657	0.419	O.K.	1.57
B8	ขวา	box	1.20	1.20	0.0081	226	0.00	-2.159	0.0007	-2.310	28.30	4.88	100	184	0.50	0.0081	0.0041	0.0117	0.771	1.111	0.596	O.K.	1.86
B10	ขวา	box	1.80	1.80	0.0040	82	0.00	-3.174	0.0007	-3.229	28.34	1.35	100	184	0.50	0.0040	0.0020	0.0450	1.011	3.275	2.304	O.K.	1.42
B12	ขวา	box	1.80	1.80	0.0031	119	0.00	-3.229	0.0007	-3.308	30.30	1.96	100	179	0.50	0.0031	0.0016	0.0466	1.011	3.275	2.317	O.K.	1.41
B14	ขวา	box	1.80	1.80	0.0070	142	0.00	-3.308	0.0007	-3.403	32.64	2.34	100	173	0.50	0.0070	0.0035	0.0501	1.011	3.275	2.412	O.K.	1.36
B0	ซ้าย	ϕ	0.60		0.0000	160	0.00	-1.200	0.0010	-1.360	19.48	4.48	100	212	0.50	0.0000	0.0000	0.0000	0.595	0.168	0.000	O.K.	-
B17	ซ้าย	ϕ	0.80		0.0092	126	0.00	-1.560	0.0010	-1.686	22.39	2.91	100	202	0.50	0.0092	0.0046	0.0046	0.721	0.362	0.259	O.K.	1.40
B19	ซ้าย	box	1.20	1.20	0.0113	105	0.00	-2.086	0.0007	-2.156	24.66	2.27	100	194	0.50	0.0113	0.0056	0.0103	0.771	1.111	0.555	O.K.	2.00
B21-25	ซ้าย	box	1.20	1.20	0.0100	100	0.00	-2.156	0.0007	-2.223	26.82	2.16	100	188	0.50	0.0100	0.0050	0.0153	0.771	1.111	0.798	O.K.	1.39
B16	ซ้าย	ϕ	0.80		0.0080	215	0.00	-1.400	0.0010	-1.615	19.97	4.97	100	210	0.50	0.0080	0.0040	0.0040	0.721	0.362	0.233	O.K.	1.55
B18	ซ้าย	ϕ	1.00		0.0084	111	0.00	-1.815	0.0010	-1.926	22.18	2.21	100	202	0.50	0.0084	0.0042	0.0082	0.837	0.657	0.462	O.K.	1.42
B20	ซ้าย	box	1.20	1.20	0.0113	105	0.00	-2.126	0.0007	-2.196	24.45	2.27	100	195	0.50	0.0113	0.0057	0.0139	0.771	1.111	0.753	O.K.	1.48
B26	ซ้าย	box	1.20	1.20	0.0000	107	0.00	-2.196	0.0007	-2.267	26.76	2.31	100	188	0.50	0.0000	0.0000	0.0139	0.771	1.111	0.727	O.K.	1.53
B32	ซ้าย	ϕ	1.00		0.0124	81	0.00	-1.600	0.0010	-1.681	16.61	1.61	100	222	0.50	0.0124	0.0062	0.0062	0.837	0.657	0.385	O.K.	1.71
B30	ซ้าย	box	1.20	1.20	0.0105	107	0.00	-1.881	0.0007	-1.952	18.93	2.31	100	214	0.50	0.0105	0.0052	0.0115	0.771	1.111	0.680	O.K.	1.63
B21-30	ซ้าย	box	2.10	2.10	0.0729	220	0.00	-3.167	0.0008	-3.343	29.75	2.99	100	180	0.50	0.0729	0.0364	0.0618	1.227	5.412	3.098	O.K.	1.75
B27	ซ้าย	box	2.10	2.10	0.0000	105	0.00	-3.343	0.0008	-3.427	31.18	1.43	100	177	0.50	0.0000	0.0000	0.0770	1.227	5.412	3.786	O.K.	1.43
B31	ซ้าย	box	2.10	2.10	0.0129	81	0.00	-3.427	0.0008	-3.492	32.28	1.10	100	174	0.50	0.0129	0.0064	0.0835	1.227	5.412	4.042	O.K.	1.34



ความถี่การเกิด	a	b	c
2	4892.486	32	0.980035
5	5470.418	33	0.941408
10	5846.448	33	0.923565
25	6378.913	33	0.923565
50	6797.986	33	0.898727
100	7226.829	33	0.891628
200	7916.476	34	0.890573
500	8519.091	34	0.884236
1000	9569.344	36	0.889563

Figure 5.1-2 Rainfall Intensity-Duration-Frequency Curve at Queen Sirikit Convention Center Rain Station (455201)



Source: Manual for Wastewater and Rainwater Drainage System Design, Thongchai Phansawat, Engineering Institute of Thailand and Association of Thai Environmental Engineers

Figure 5.1-3 Monograph for Surface Runoff

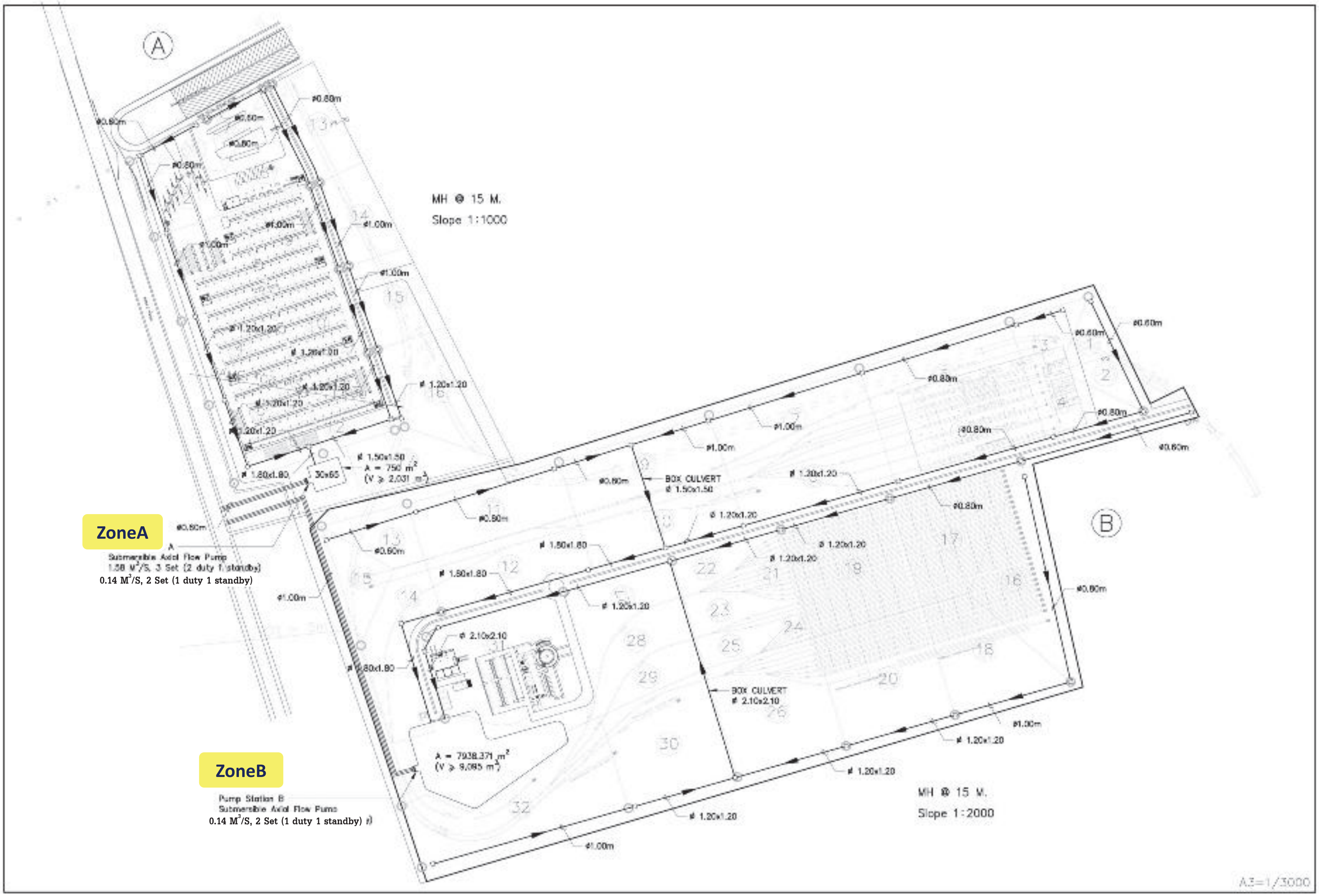


Figure 5.1-4 Flow Direction of Drainage Water to Retention Ponds in Depot and Park&Ride Building Areas at Rom Klao Intersection

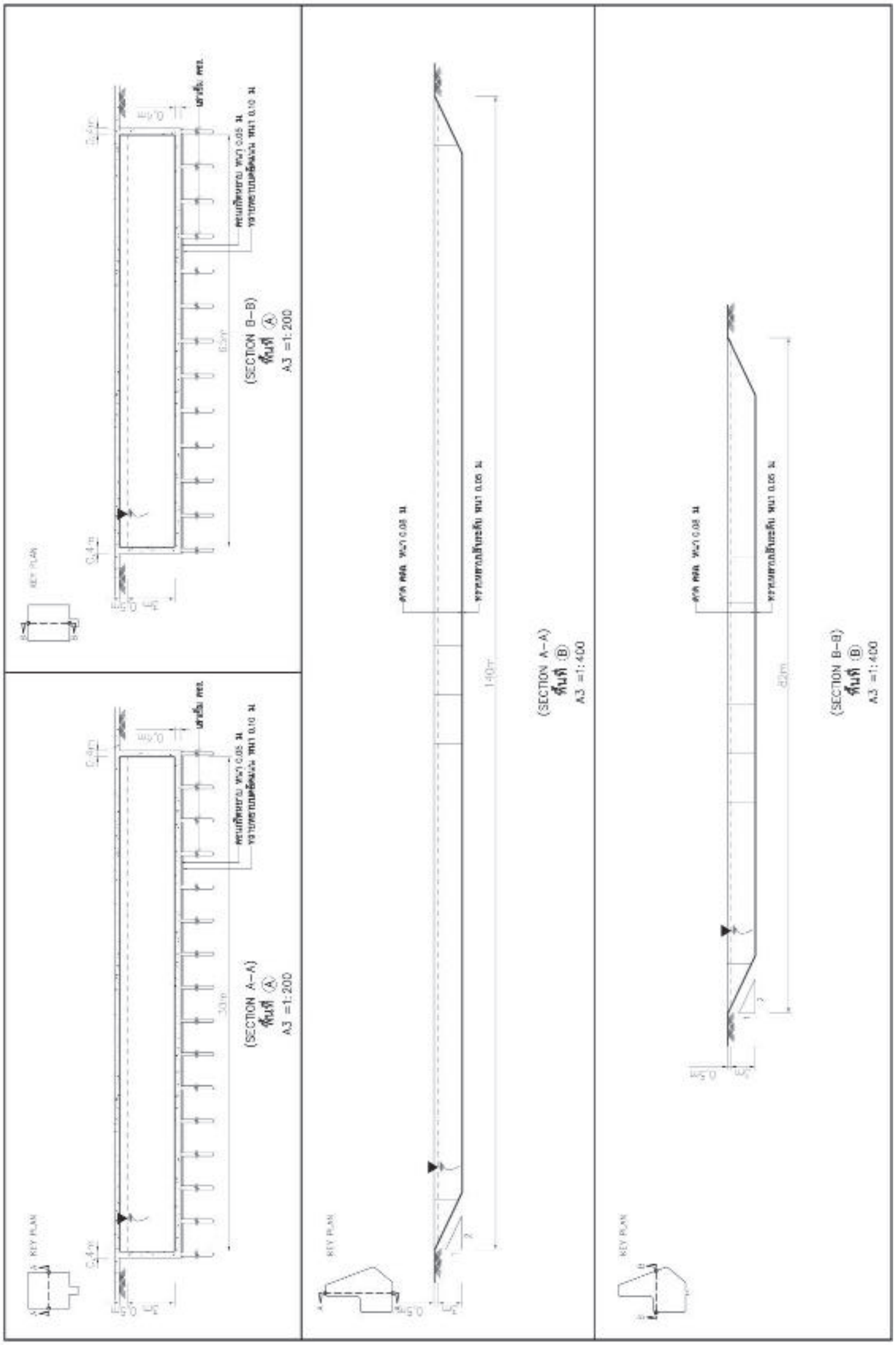


Figure 5.1-5 Vertical Cross Section of Retention Ponds

The impact from activities of Project office and worker camps have been considered in 2 cases as follows:

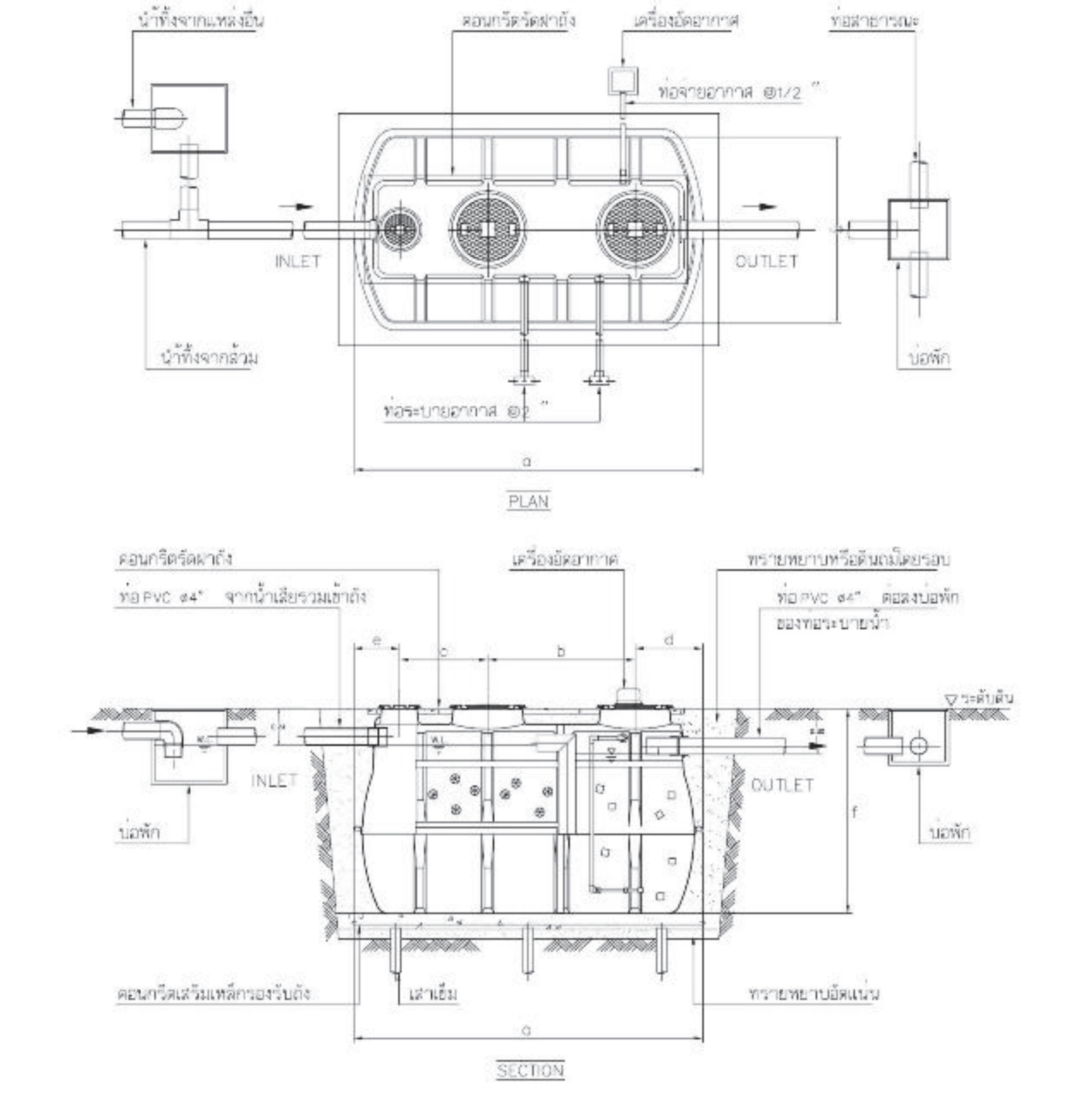
- Project office

  - Maximum Project staff at the Project site was limited to 200 persons (ref. Bangkok Mass Transit Construction Works: Sukhumwit Extension Section 1, B.E.2552 (2009). The Environmental Impact Evaluation Bureau of the Office of Natural Resources and Environment Policy and Planning (B.E.2542) (1999) has determined minimum water consumption standard for Project office (no overnight stay) at 50 litres/person/day. Wastewater and sewage from toilettes or food container cleaning of Project staff was computed as 50x200x0.80 = 8,000 litres/day or 8 cubic meters/day (wasterwater was computed at 8% of water consumption). Therefore, sanitary bathrooms and toilettes should be sufficiently provided (10 persons/unit) and 5 units of septic tanks at the capacity of 2 cubic meters/unit totaling 10 cubic meters should be installed for treatment of wastewater generated by activities at the Project office, as presented in ***Figure 5.1-6***.

  - The maximum number of staff at the Project site was approximately 200. The Environmental Impact Evaluation Bureau of the Office of Natural Resources and Environment Policy and Planning (B.E.2542) (1999) has determined solid waste generation rate at 3 litres/person/day. Solid waste from activities of the Project as computed as 200 x 3/1,000 = 0.60 cubic meters/day. To avoid careless waste dropping or waste falling into drainage trench around the Project office area which may cause obstruction and affect nearby surface water sources, garbage bins should be placed in various spots within the Project office area to collect solid waste for sanitary disposal by district offices of Bangkok Metropolitan Administration or local administration entities of Changwat Nonthaburi. The garbage bins should be in the size of 0.24 cubic meter or approximately 240 litres (square plastic bin with the outer size of 58 × 72 × 124 centimeters or equivalent) in 8 units, totaling volume of 0.24 × 8 = 1.92 cubic meters or approximately 1,920 litres.

- Project office together with worker camps

  - Number of Project staff at the Project office (200 persons – no overnight stay) and construction workers (1,200 persons – overnight stay) are approximately 1,400 persons (ref. Bangkok Mass Transit Construction Works: Sukhumwit Extension Section 1, B.E.2552 (2009)). The Environmental Impact Evaluation Bureau of the Office of Natural Resources and Environment Policy and Planning (B.E.2542) (1999) has determined water consumption standard for Project office (no overnight stay) at 50 litres/person/day and that for residential communities at 200 litrs/person/day. It was estimated that maximum wastewater and sewage from bathroom/toilettes, food container cleaning, or body washing during operation of Project staff and construction workers was computed as $[(200\times50+1,200\times200)\times0.80]/1,000 = 200$ cubic meters/day (total wastetater was computed at 80% of water consumption). Therefore, sanitary bathrooms and toilettes should be sufficiently provided (10 persons/unit) and 20 units of septic tanks at the capacity of 12 cubic meters/unit totaling 240 cubic meters should be installed for treatment of wastewater generated by activities at the Project office and worker camps, as presented in ***Figure 5.1-6***.



ระบบบำบัดน้ำเสียสำเร็จรูปชนิดเกรอะ-กรองเติมอากาศ

Figure 5.1-6 Installation Example of Septic Aerator Tank of the Size 2-12 Cubic Meters

- The Environmental Impact Evaluation Bureau of the Office of Natural Resources and Environment Policy and Planning (B.E.2542) (1999) has determined solid waste generation rate at 3 litres/person/day. Solid waste from activities of the Project staff and construction workers was computed as 1,200 x 3/1,000 = 0.60 cubic meters/day. To avoid careless waste dropping or waste falling into drainage trench around the Project office area and residential communities which may cause obstruction and affect nearby surface water sources, 50 units of garbage bins each in the size of 0.24 cubic meters or approximately 240 litres (square plastic bin with the outer size of 58 x 72 x 124 centimeters or equivalent), totaling volume of 0.24 x 50 = 12 cubic meters or approximately 12,000 litres shouldl be provided. The garbage bins should be placed in various spots within the Project office area and worker camps, each spot comprising a group of 10 units, to collect solid waste for sanitary disposal by district offices of Bangkok Metropolitan Administration or local administration entities of Changwat Nonthaburi. It was obvious that the establishment of Project office and worker camps in the same place along the mass transit system alignment would have rather high impact in terms of wastewater and solid waste management. It was thus recommended that only the Project office be established and "worker camps" be separated from Project office. The acquisition/construction of worker camps should be located further than approximately 5 kilometers away from the mass transit system alignment with approval from the Project owner and strict compliance with local laws and regulations governing housing construction or Building Control Act B.E.2522 (1979) or the Interior Ministry Regulation No. 55 B.E.2543 (2000).

It was estimate that subsequent construction activities such as washing and cleaning of construction tools, equipment, and vehicles etc. occurring within Project office area would require water consumption not higher than 12 cubic meters/day (ref. Bangkok Mass Transit Construction Works: Sukhumwit Extension Section 1, B.E.2552 (2009)), which would generate wastewater of 12 x 0.80=9.60 cubic meters/day. Therefore 2 units of septic tank of the size 6 cubic meters/unit, totaling 12 cubic meters should be provided for treatment of wastewater from those activities.

(b) Operation Phase

As the monorail mass transit system on the elevated structure is electricity-powered. There is no impact on quality of surface water on its way, especially Khlong Prapa. For the stations, the staff is limited to the maximum of 10 persons/day/station (for example, ticket officers, PR, security and communication officers, etc.). Water consumption was computed at 50 litres/person/day, turning into wastewater of 50 x 10 x0.80 = 400 litres/day or 0.40 cubic meters/day (Wastewater was computed at 80% of water consumption). This wastewater would be treated by septic tanks of the size 2 cubic meters installed at every station. It was epected that there would be no impact.

(2) Depot and Park & Ride Building

This study has cancelled the depot and park & ride building at Sanam Bin Nam and extended the area of that at Rom Klao Intersection to cover 229 Rai or approximately 366,400 m^2. The construction of depot and park & ride building at Rom Klao Intersection may have impact on quality of surface water as follows:

(a) Construction Phase

Construction activities at depot and park & ride building, Rom Klao Intersection are stripping works, land grading and filling, foundation drilling of 3-storey building structures or mobilization of construction materials (such as cement, sand, gravel and earth, etc.). It was anticipated that there would be low impact in terms of turbidity, BOD or contamination of machinery oil. Eventhough the construction area of the depot and park & ride building is adjacent to surface water source (Khlong Song Ton Nun), neither parts of the structure are constructed in Khlong Ton Nun nor any activities would affect quality of the water. During construction phase, a temporary trench of the size 0.60 × 0.60 meter would be digged up around the construction area and two sedimentation ponds of the size 1.00 × 1.00 × 1.00 meter would be provided at the end of the trench to receive wastewater from construction activities before discharge to Khkong Song Ton Nun.

(b) Operation Phase

At the depot and park & ride building, Rom Klao intersection, wastewater totaling 147.61 cubic meters/day would be generated from bathrooms, toilettes, and food container cleaning activities of the staff in the administration and control buildings, the dormitory, the restaurant including from train maintenance and cleaning, as presented in ***Figure 5.17***. Wastewater would be treated at 3 × 100 cubic meters (total capacity of 300 cubic meters) onsite treatment plants by anaerobic filter and contact aeration process. Wastewater from the administration and control buildings will be directly collected to the onsite treatment plants, whereas that of the restaurant and train maintenance and cleaning activities will be passed through a grease trap and an oil interceptor for separating grease, and oil before being collected to the onsite treatment plants. Wastewater will be retained in sump pits which has a holding capacity of at least one day with the installation of DOD online to the system, as presented in ***Figure 5.1-8***, before discharge to Khlong Song Ton Nun. It was anticipated that the impact would be low.

5.1.4 Meteorology and Air Quality

5.1.4.1 Meteorology

Air pollution study: Three major factors having influence to intensity of pollutants are emission source, atmosphere or meteorology and environment of receptors. Atmosphere absorbs air pollutants discharged from source of origin and acts as medium for dispersion of pollutants ro receptors with meteorological factors; air temperature, wind velocity and direction, or general weather condition at that time such as rain which will help reduce pollutant concentrations. These factors are important in determining nature of air pollutant dispersion. Meteorological statistical data during 30 years period (B.E.2525-2554) (1982-2011) has been collected from Don Moeng Meteorological Station, Thai Meteorological Department, the nearest station to the Project site. Construction activities during construction phase would be grading works, construction of foundation, structural works of stations and columns of the elevated structure. These activities have specific start and completion dates according to Proejct schedule. From the design of the station and the elevated structure, those structures of stations and columns are small when compared with the surrounding area. With the consideration given to obstruction of air movement, those structures may affect only the area beneath the station. The air ventilation system beneath the station has been designed to allow sufficient air movement. For consideration of overall meteorological impact from the Project structural

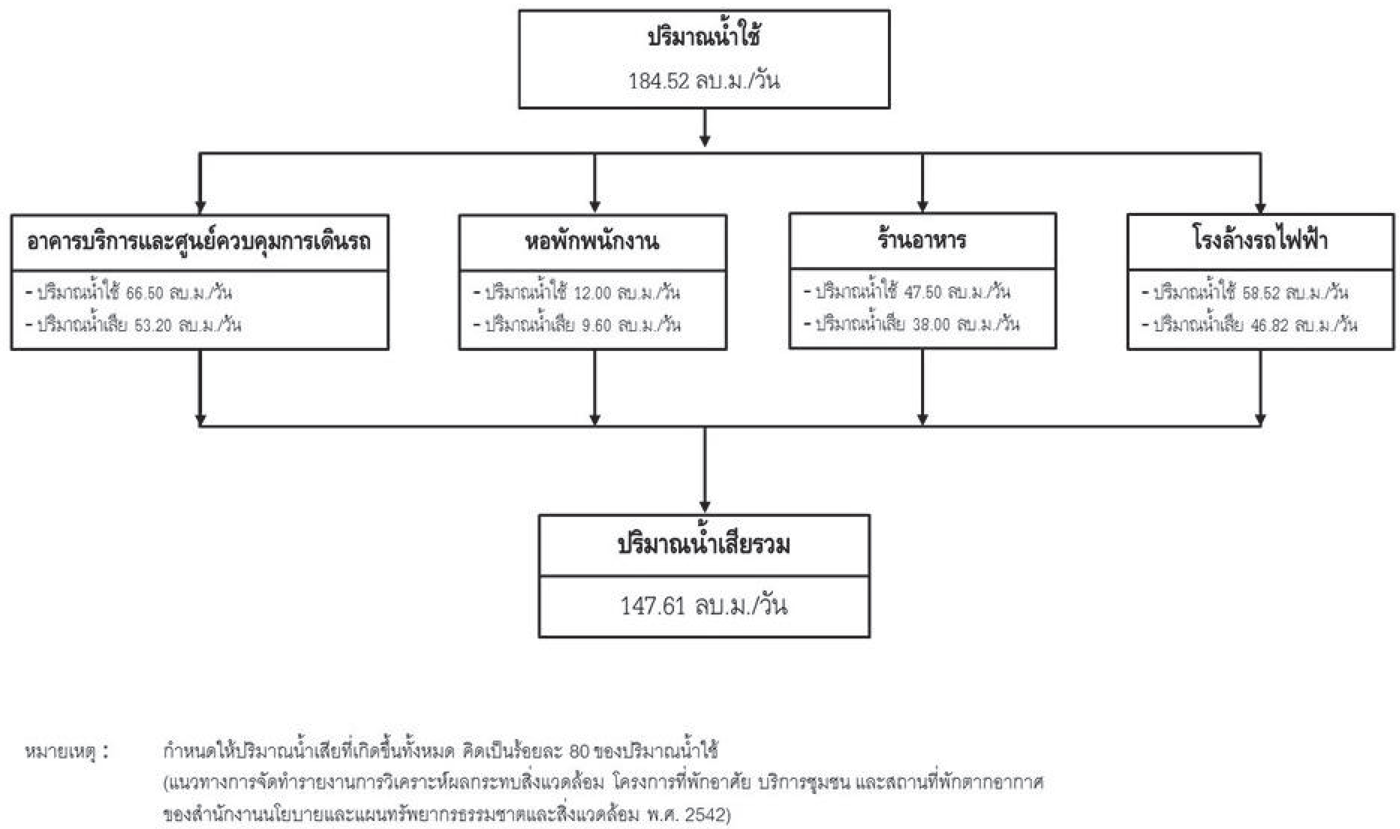


Figure 5.1-7 Summary of Quantity of Wastewater of the Depot and Park & Ride Building, Rom Klao Intersection

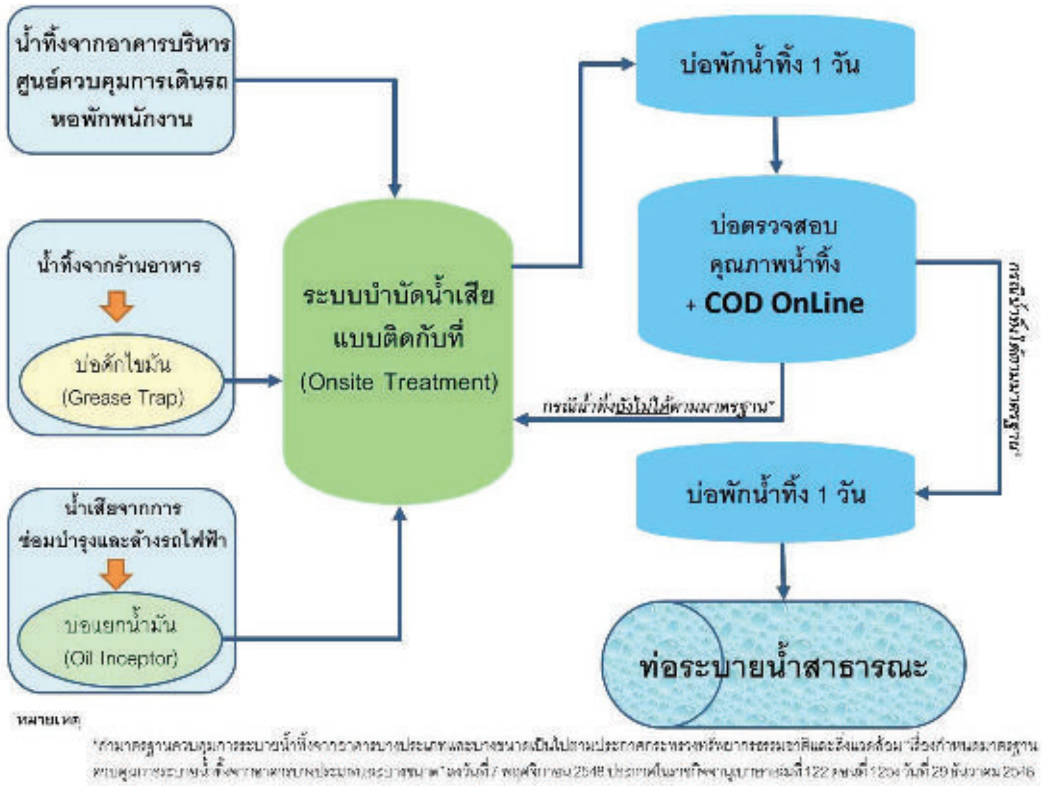


Figure 5.1-8 Wastewater Treatment Process of the Depot and Park & Ride Building, Rom Klao Intersection

works, it was anticipated the impact on meteorological conditions and the weather in the vicinity of the area would be low.

5.1.4.2 Air Quality

The Pink Line Project : Khae Rai-Min Buri Section may have impact on air quality in its vicinity area both during the construction and operation phases. Therefore, the study on meteorology and air quality is essential to assess the impact which may occur from pollutants generated from Project activities and to recommend preventive, corrective and mitigation measures including air quality impact monitoring measures during construction and operation phases.

(1) Construction Phase

(a) Total Suspended Particulate (TSP)

Major impact on air quality during monorail structural construction is generally caused by particulates and gas emitted from the engines in preparation of construction works and vehicles transporting construction materials to and from the construction site, particularly the impact from particulates due to mobilization and stacking of construction materials. For the construction of the Project elevated structure, particulates tend to be less than those generated from road construction. For general road construction, it needs to do stripping works throughout the project alignment. On the other hand, the main activity of the elevated structure is the structural construction of columns and the elevated tracks. As most of the elevated structure is of pre-fab type, there would be few activities related to stripping works in the Project construction area.

However, the area of column construction is the area of the main construction activities of the Project which may have air quality impact due to particulates and gas emitted from the engines in preparation of construction works and vehicles transporting construction materials to and from the construction site, particularly, the impact from particulates due to stripping works, mobilization and stacking of construction materials. Therefore, the important impact of consideration is the impact caused by particulates due to stripping works, traffic, mobilization of earth/gravel, construction materials, landfilling, compaction and grading.

The article "Compilation of Emission Factor, AP-42, 1995" from U.S. EPA documentation said that ventilation of particulates out of construction site was subject to the nature of activities, composition of soil, soil moisture, and meteorological conditions such as wind velocity and direction as well as duration of construction. The intensity of particulates in the air varies according to quantity of particulates from generating source and particles of dust in soil composition. However, the intensity varies inversely with soil moisture. US EPA has given Emission Factor measured within building construction area at 12 ton/acre of construction area/months of construction activities, determining that the particulate of consideration is Total Suspended Particulate (TSP). Most of the particulates are blown from material stacks by wind and from open surface areas. Quantity of particulates is subject to water spraying to reduce particulate diffusion and also coverage of material stacks.

During construction phase, the Project area will be open for construction activities at intervals according to the column position of the elevated structure. Construction activities at each interval change daily according to sequence of works. Besides, wind velocity, wind direction and air moisture changes everyday. Traffic is also another factor that causes dust diffusion. Quantitative analysis on the effect of particulates thus may be a lot deviated. This study has used the assumption of Box Model, determining wind velocity at 10 meters/second (wind speed lower than this can hardly move dust from surface or stacks), mixing height at 50 meters above ground level. At this level, pollutant dispersion will be blocked by the inversion layer which is the lowest level ever measured in Thailand. Mostly, this type of dispersion blockage occurs in the cool season when the earth is cooler than the atmosphere. The assumption is for the worst case analysis. The calculation is as follows:

$$C = \frac{Q}{D \times W \times M} \qquad \text{.................} \ \mathbf{(1)}$$

When C = TSP concentrations (milligram/cubic meter)
Q = TSP emission rate (milligram/second)
D = width perdendicular to wind direction (meter)
W = wind velocity (meter/second)
M = Mixing Height (meter)

Construction activities were determined at 8 hours/day. Therefore, TSP emission would be 12 ton/acre/month = $(1.2 \times 1{,}000{,}000{,}000)$ mg/[$(30 \times 8 \times 3{,}600)$ second/$4{,}046$ m^2 (1 Acre)] = 0.343 mg/second/m^2 of the construction areas. In case of stripping works by 20 meters width of construction areas on both sides of the elevated structure at intervals, construction activities by the distance of 100 meters at each interval were determined to occur simultaneously. TSP emission rate (Q) will be $0.343 \times 20 \times 100$ = 686 mg/second.

Therefore, particulate concentration generated from construction activities will be dispersed as calculated below:

$$C = \frac{686}{20 \times 10 \times 50}$$

$$= 0.069 \text{ mg/cubic meter}$$

Particulate concentration generated from construction activities would be 0.069 mg/cu.m or 69 micrograms/cu.m. which is lower than standard (not exceed 330 microgram/cu.m.). When combined with existing TSP concentration measured at Boromratchonnani nursing college (15.5 micrograms/cu.m.), the average 24 hourrs TSP concentration would become 224 microgramms/cu.m., which is still within the standard. Moreover, the construction activities would be 8 hours/day, when the construction is complete the impact from dust dispersion would decrease. Thus, it can be expected that the impact from TSP dispersion would e in lower level.

(b) Particulates Matter Less than 10 micron (PM-10)

U.S. EPA explained that the emission factor of TSP could be used for dispersion assessment of PM-10 as conservatively high estimates, by determining TSP dispersion rate equals to that of PM-10. However, following the measurement of existing TSP and PM-10 concentrations along the Project alignment, the average TSP to PM-10 ratio at three stations was 1 : 0.48 mg/m^2 (Air Quality Monitoring Result, presented in **Annex 4A**). Therefore, the estimation of PM-10 particulate concentrations in the ambient used TSP : PM-10 ratio which had been monitored along the Project alignment, as a factor for calculation. The estimate calculation result of TSP would be multiplied by the proportion of PM-10 obtained from the monitoring. Details are as follows:

The calculation result of TSP from construction activities by Box Model showed that TSP from such activities caused concentrations in the ambient air by 69 microgram/cubic meter at the average TSP to PM-10 ration of 1:0.49 mg/m^2at the three stations. Therefore PM-10 concentrations in the ambient shall be :

TSP concentrations × 0.49 = 69 × 0.49

= 33.8 microgram/cubic meter

Consequently, PM-10 concentrations in the ambient generated from construction activities shall be 33.8 microgram/cubic meter which is lower than ambient air quality standard (not higher than 120 microgram/cubic meter). When compiled with the highest concentrations among the three stations (the concentrations monitored at Boromarajonani College of Nursing Station), PM-10 concentrations shall be (33.8+62.0) = 95.8 microgram/cubic meter. The value is lower than the standard value (not higher than 120 microgram/cubic meter). Given that daily construction activities take 8 hours, after stopping construntion activities each day, the occurance generation of PM-10 will be lessen. Therefore, it was anticipated that the impact of construction activities on PM-10 diffusion would be low.

(c) Impact from Construction Machinery

Air pollutants during construction phase are from exhaust pipe of vehicles transporting construction materials and other engines which emitt CO, NO_x, and TSP. The document titled "Compilation of Air Pollutant Emission Factors" 3rd Edition (1977) of U.S. EPA. provided data and information on air pollutant dispersion from machines and construction equipmen, most of which were diesel-powered, as presented in ***Table 5.1-3***.

Table 5.1-3 Emission Factors (Gram/Hour) of Diesel-Machinery and Equipment for Construction Works

Type of Machinery and Equipment	Emission Factor of Each Pollutant (gram/hour)		
	CO	NO_2	TSP
Track-laying tractor	175	665	62.3
Wheeled tractor	973	451	40.9
Wheeled dozer	335	2290	158
Scraper	660	2820	210
Motor Grader	97.7	478	39
Wheeled loader	251	1090	82.5
Track-laying Loader	**72.5**	**265**	**34.4**
Off-Highway Truck	610	3460	206
Roller	83.5	474	30.5
Miscellaneous	188	1030	64.7

Source: Adapted from U.S.EPA. 1977, "Compilation of Air Pollutant Emission Factors" 3rd Edition

This study used the assumptions of Box Model to estimate air pollutant concentrations from construction machines during construction phase. Air quality index in ***Table 5.1-3*** shows Co, No_2, and TSP generated by a track-laying loader, the major machinery in construction activities. From ***Table 5.1-3***, wind velocity was determined at approximately 2.7 meters/second (5.3 knot) (data of annual average wind velocity for 30 years period (B.E.2525-2554) (1982-2011) from Don Mueng Meteorological Station). The data of mixing height is at 50 meter above ground level. At this level pollutant dispersion will be blocked by the inversion layer and is the lowest value ever measured in Thailand. Mostly, this type of dispersion blockage occurs in the cool season when the earth is cooler than the atmosphere. The assumption is for the worst case analysis. The calculation is as follows:

$$C = \frac{Q}{D \times W \times M}$$

When C = Air pollutant concentrations (milligram/cubic meter)
Q = Air pollutant emission rate (milligram/second)
D = width perpendicular to wind direction (meter)
W = wind velocity (meter/second)
M = Mixing Height (meter)

Construction activities were determined at 8 hours/day. Air pollutant emission rate by machinery was measured in milligram/second, as presented in ***Table 5.1-4***. The approximately 20 meters (D) wide side of the construction area lies perpendicular to wind direction. Wind velocity was determined at 2.7 meters/second (W), and mixing height at 50 meters (M). The calculation is as follows:

Table 5.1-4 Emission Factors (mg/second) of Diesel-Driven Machinery and Equipment for Construction Works

Type of Machinery and Equipment	Emission Factor of Each Pollutant (mg/second)		
	CO	NO_2	TSP
Track-laying tractor	48.6	184.7	17.3
Wheeled tractor	270.3	125.3	11.4
Wheeled dozer	93.1	636.1	43.9
Scraper	183.3	783.3	58.3
Motor Grader	27.1	132.8	10.8
Wheeled loader	69.7	302.8	22.9
Track-laying Loader	**20.1**	**73.6**	**9.6**
Off-Highway Truck	169.4	961.1	57.2
Roller	23.2	131.7	8.5
Miscellaneous	52.2	286.1	18.0

Source: Adapted from U.S.EPA. 1977, "Compilation of Air Pollutant Emission Factors" 3rd Edition

- **Average carbon monoxide (CO) in 1 hour**

Q = 20.1 milligram/second

$$C = \frac{20.1\,\text{mg/sec}}{(20.1\,\text{m.}) \times (2.7\,\text{m./sec}) \times (50\,\text{m.})}$$

C = 0.0074 milligram/cubic meter

The average 1-hour CO concentrations in the ambient emitted from machinery during construction phase is 0.0074 milligram/cubic meter. When compiled with 2.9775 milligram/cubic meter (***Table 5.1-3***), the highest CO measured among the three stations, CO shall become (0.0074+2.9775) = 2.9849 milligram/cubic meter or 8.7% of standard value (standard value of average CO in 1 hour shall not be higher than 34.2 milligram/cubic meter). Therefore, it was anticipated that the impact of machinery during construction phase on CO concentrations would be low.

- **Average nitrogen dioxide (NO_2) in 1 hour**

Q = 73.6 milligram/second

$$C = \frac{73.6\,\text{mg/sec}}{(20\,\text{m.}) \times (2.7\,\text{m./sec}) \times (50\,\text{m.})}$$

C = 0.0273 milligram/cubic meter

The average 1-hour NO_2 concentrations in the ambient emitted from machinery during construction phase is 0.0273 milligram/cubic meter. When compiled with 0.1849 milligram/cubic meter (***Table 5.1-3***), the highest NO_2 measured among the three stations, NO_2 shall become (0.0273+0.1849) = 0.2122 milligram/cubic meter or 66.3% of standard value (standard value of average NO_2 in 1 hour shall not be higher than 0.320 milligram/cubic meter). Therefore, it was anticipated that the impact machinery during construction phase on NO_2 concentrations would be low.

- **Average TSP in 1 hour**

Q = (9.6 milligram/second) × (12/24) ; maximum construction period: 12 hours/day

$$C = \frac{4.8\,\text{mg/sec}}{(20\,\text{m.}) \times (2.7\,\text{m./sec}) \times (50\,\text{m.})}$$

C = 0.0018 milligram/cubic meter

The average 24-h TSP concentrations in the ambient emitted from machinery during construction phase is 0.0273 milligram/cubic meter. When compiled with 0.1555 milligram/cubic meter (***Table 5.1-3***), the highest TSP measured among the three stations and 0.26 milligram/cubic meter from site preparation activities, TSP concentrations shall become (0.0018+0.155+0.069) = 0.2258 milligram/cubic meter or 68.4% of standard value (standard value of average TSP in 24 hours shall not exceen 0.330 milligram/cubic meter). Therefore, it was anticipated that the impact of machinery during construction phase on TSP concentrations would be low.

From the assessment of air quality impact from site preparation activities and machinery during construction phase, as presented in ***Table 5.1-5***, it was found that pollutants emitted by such activities would have low air quality impact to the vicinity area. In addition, construction activities would occur for a certain period of time while the machinery does not operate all day and not all at the same time. Moreover, the Project has set up measures to prevent, correct and mitigate environmental impact on air quality which will help prevent and reduce pollutant emission. It was anticipated that the impact on ambient air quality in the vicinity from construction activities would be low.

(2) Operation Phase

Activities of the Pink Line Project in operation phase comprise passenger transportation by monorail system. The whole system is of new technology, electricity-powered without engine-driven vehicles. Therefore, there is no direct pollutant source in the Project. However, the structure of the station platform may reduce the dilution of pollutants emitted by vehicles under the station. Anyway, the station has been designed with the efficient pollutant dilution system underneath the platform. The overall air quality impact of the Project was projected to be low.

Table 5.1-5 Projected Ambient Air Quality from Activities in Construction Phase

Air Quality Index	Air Pollutant Cconcentratios (milligram/cubic meter)				
	Site Preparation [1]	Machinery [2]	Actual Monitoring [3]	Total [1] + [2] + [3]	Standard Values
1-h average CO	-	0.0074	2.9775	2.9849	34.2 1/
1-h average NO_2	-	0.0273	0.1849	0.2122	0.320 1/
24-h average TSP	0.0690	0.0018	0.1550	0.2258	0.330 2/
24-h average PM10	0.0338	-	0.0620	0.0958	0.120 2/

Remarks: 1/ Notification of the National Environmental Board No. 10 (B.E.2538)
2/ Notification of the National Environmental Board No. 10 (B.E.2538) and No. 24 (B.E.2547)

5.1.5 Noise Level

(1) Construction Phase

The study of noise impact during construction phase has considered noise reduction by installation of 2-meter high solid fence based on the assumption that the barrier was located close to noise source to reduce noise emitted from noise source. Noise level measured at the given distance from the construction site compiled with the weighted equivalent continuous noise level (L_{eq} 24 hr) will be offset with transmission loss from installation of noise barriers. Details on noise impact assessment during construction phase are as follows:

Various types of construction equipment and machinery are used in the Project construction activities. Different equipment is used at different period of time. This study has considered the noise continuously and simultaneously generated by operation of construction equipment and machinery, at the reference distance of 15 meters (approximately 50 feet) from the construction equipment, assuming that construction activities continued for 8 hours per day, as presented in ***Table 5.1-6***.

Table 5.1-6 Noise Level Continuously Generated by Construction Equipment Measured at 15 meters (approximately 50 feet) Away

Construction Equipment and Machinery	Noise Level Measures at 15 m (ft) away (dB(A))	Acoustical Usage Factor: %
Backhoe	80	40
Impact Pile Driver	101	20
Grader	85	40
Roller (vibratory roller))	85	20
Dump Truck	84	40
Crane	85	16

Source: Adopted from Roadway Construction Noise Model User's Guide; 2006 (FHWA)

The assessment of noise impact during Project construction on the livelihood of people and environmentally sensitive areas along the Project alignment has used noise level measured at 15 m (approximately 50 ft) to represent noise level from noise source. Noise reduction has been calculated by the distance to receptors in environmentally sensitive areas along and on both sides of the Project alignment. The equation for calculation was referred to "Roadway Construction Noise Model User's Guide, 2006" of FHWA, as follows:

$$Lp_2 = Lp_1 - 20 \log (D/50) + 10 \log (U.F.\ \%/100) \quad (1)$$

When Lp_1 = the noise level at the distance of 50 feet (15 meters) from noise source

Lp_2 = the noise level at the given distance (D) from noise source

D = the distance from noise source (foot)

U.F. % = usage factor for the fraction of time the equipment is in use over the specified period (usage factor: %)

Noise level calculated in **Equation (1)** shall be noise level from construction activities along both sides of the Project alignment. Computaion of noise level of construction activities for a period of 8 hours to find out the average 24-h noise level (L_{eq}) in order to compare with the standard value. The computation is done by **Equation (2)** as follows:

$$Leq_T = Lp + 10 \log \frac{t}{T} \quad ....(2)$$

When Leq_T = Noise level in a specific period of time (T)
Lp = Noise level generated by noise source [dB(A)]
t = Duration of noise generation from noise source (hour)
T = Duration of generation of noise of consideration (hour)

The computation result will be compiled with the average 24-h noise level of the existing scenario which is derived from measurement. The compilation will be computed by **Equation (3)** as follows:

$$Lp_{total} = 10\log\left(\sum_{i=1}^{N} 10^{Lp_i/10}\right) \quad ....(3)$$

when Lp_{total} = Total noise levels
L_{pi} = Noise level generated at each noise source

The study result of noise level from construction activities to receptors at various distances from noise source was presented in ***Table 5.1-7***. Noise level during construction phase to receptors in environmentally sensitive areas along the Project alignment was presented in ***Table 5.1-8***.

The mitigation measure proposed by the Project was the installation of 2 meters high solid fence. According to the data from Environmental Protection Department and Highways Department, Government of the Hong Kong SAR., 2003, transmission loss of steel barrier with the thickness of 0.64 mm. is approximately 18 dB(A).

Details were presented in ***Table 5.1-9***. It was anticipated that after installation of noise barriers at the Project construction areas, noise level from construction activities to receptors in the vicinity along the Project alignment and in environmentally sensitive areas would be reduced.

In addition to noise reduction by installation of 2 meters high solid fence (noise barrier) around the Project construction areas, the increasing distance from noise source to the receptor was another factor that could reduce noise level. This factor was taken for computation of noise level from site preparation activities for construction while every piece of equipment was assumed to be operated simultaneously. In computation of noise level from construction activities, the noise to be taken for consideration was from foundation drilling and inspection/testing, which generated the loundest noise. The noise level would be reduced by the increasing distance from noise source to the receptor. Summary of projected noise levels from construction activities at various distances from noise source was presented in ***Table 5.1-10***.

Noise level assessment in the environmentally sensitive areas along the Project alignment has been conducted in 2 cases; with and without installation of noise barriers. Noise level generated by construction was presented in ***Table 5.1-7*** and ***Table 5.1-8***. In case of installation of noise barriers in the environmentally sensitive areas, noise level was calculated from compiling noise level from construction activities and maximum 24-hour noise level (average 24-h L_{eq}) at monitoring point. The total noise level wasl then substracted by noise level with transmission loss from 2 meters high steel solid fence (TL is 18 dB(A)), as summarized as follows:

Table 5.1-7 Projected Noise Level from Construction Equipment to Receptors at Various Distances

เครื่องจักร-อุปกรณ์ก่อสร้าง	ระดับเสียงที่ห่างจากเครื่องจักรอุปกรณ์ ที่ระยะ 50 ฟุต (15 เมตร) (เดซิเบล(เอ))	สัดส่วนการใช้งานของอุปกรณ์ (Acoustical Usage Factor: %)	ระดับเสียงที่ระยะทางต่าง ๆ จากแหล่งกำเนิดเสียง																
			ระดับเสียงจากการก่อสร้างที่ไม่ติดรั้วทึบ									ระดับเสียงจากการก่อสร้างที่ติดรั้วทึบ ความสูง 2 เมตร (ลดทอนเสียงลง 18 dB(A))							
			เมตร	10	20	50	100	200	300	400	500	10	20	50	100	200	300	400	500
			ฟุต	32.8	65.6	164.0	328.0	656.0	984.0	1312.0	1640.0	32.8	65.6	164.0	328.0	656.0	984.0	1312.0	1640.0
รถแบ็คโฮ (Backhoe)	80	40		79.7	73.7	65.7	59.7	53.7	50.1	47.6	45.7	61.7	55.7	47.7	41.7	35.7	32.1	29.6	27.7
เสาเข็มตอก (Impact Pile Driver)	101	20		97.7	91.7	83.7	77.7	71.7	68.1	65.6	63.7	79.7	73.7	65.7	59.7	53.7	50.1	47.6	45.7
รถปรับหน้าดิน (Grader)	85	40		84.7	78.7	70.7	64.7	58.7	55.1	52.6	50.7	66.7	60.7	52.7	46.7	40.7	37.1	34.6	32.7
รถอัดดิน (Roller (vibratory roller))	85	20		81.7	75.7	67.7	61.7	55.7	52.1	49.6	47.7	63.7	57.7	49.7	43.7	37.7	34.1	31.6	29.7
รถบรรทุกชนิดยกดัมพ์ (Dump Truck)	84	40		83.7	77.7	69.7	63.7	57.7	54.1	51.6	49.7	65.7	59.7	51.7	45.7	39.7	36.1	33.6	31.7
ปั้นจั่น (Crane)	85	16		80.7	74.7	66.7	60.7	54.7	51.2	48.7	46.7	62.7	56.7	48.7	42.7	36.7	33.2	30.7	28.7
ระดับเสียงรวมในขณะก่อสร้าง (ก่อสร้าง 8 ชั่วโมง/วัน)*				**98.3**	**92.3**	**84.3**	**78.3**	**72.3**	**68.7**	**66.2**	**64.3**	**80.3**	**74.3**	**66.3**	**60.3**	**54.3**	**50.7**	**48.2**	**46.3**
ระดับเสียง Leq เฉลี่ย 24 ชั่วโมง**				**93.5**	**87.5**	**79.5**	**73.5**	**67.5**	**64.0**	**61.5**	**59.5**	**75.5**	**69.5**	**61.5**	**55.5**	**49.5**	**46.0**	**43.5**	**41.5**

Remarks:

*Equation : $Lp_{รวมเฉลี่ย} = 10 \log \sum_{i=1}^{N} 10^{Lp_i/10}$

**Equation $LeqT = Lp + 10 \log T$

Table 5.1-8 Projected Noise Level from Construction Activities to Receptors in Environmentaly Sensitive Areas along the Project Alignment

ลำดับ	พื้นที่อ่อนไหว	ช่วงสถานี	ระยะห่างจากแนวเส้นทาง		ระดับเสียงในช่วงเวลาที่มีการก่อสร้าง, Leq 8 ชั่วโมง (เดซิเบล (เอ))	ระดับเสียงจากการก่อสร้างบริเวณพื้นที่อ่อนไหว, Leq 24 ชั่วโมง (เดซิเบล (เอ))	Leq 24 ชั่วโมง สูงสุดจากการตรวจวัด* (เดซิเบล (เอ))	ระดับเสียงจากการก่อสร้างรวมกับเสียงสูงสุดจากการตรวจวัด* Leq 24 ชั่วโมง (เดซิเบล (เอ))	ระดับเสียงเฉลี่ยในระยะก่อสร้าง ณ บริเวณพื้นที่อ่อนไหวต่อผลกระทบ, Leq 24 ชั่วโมง (เดซิเบล (เอ))	
			เมตร	ฟุต					กรณีไม่ติดตั้งกำแพงกันเสียง	กรณีติดตั้งกำแพงกันเสียง**
1	ศูนย์ราชการนนทบุรี	PK01	361	1184	67.1	62.4	70.5	71.1	71.1	**53.1**
2	กสทช. เขต 1 นนทบุรี		67	220	81.8	77.0	70.5	77.9	77.9	**59.9**
3	วิทยาลัยเทคโนโลยีสยามบริหารธุรกิจ นนทบุรี		98	321	78.5	73.7	70.5	75.4	75.4	**57.4**
4	วิทยาลัยพยาบาลบรมราชชนนี จังหวัดนนทบุรี		57	187	83.2	78.4	70.5	79.0	79.0	**61.0**
5	สถาบันโรคทรวงอก		127	417	76.2	71.4	70.5	74.0	74.0	**56.0**
6	โรงเรียนนนทบุรีพิทยา	PK02	323	1059	68.1	63.3	68.3	69.5	69.5	**51.5**
7	โรงเรียนสันติวัน		55	180	83.5	78.7	68.3	79.1	79.1	**61.1**
8	รพสต. บ้านสัมฤทธิ์ ต.ท่าทราย		465	1525	64.9	60.2	68.3	68.9	68.9	**50.9**
9	สถานีอนามัยเด็กกลาง		77	253	80.6	75.8	68.3	76.5	76.5	**58.5**
10	โรงเรียนทานสัมฤทธิ์วิทยา		352	1155	67.4	62.6	68.3	69.3	69.3	**51.3**
11	กรมพลาธิการทหารบก	PK03	264	866	69.9	65.1	66.4	68.8	68.8	**50.8**
12	โรงเรียนสมานพิชากร		79	259	80.3	75.6	66.4	76.1	76.1	**58.1**
13	มัสยิดดารุ้ลมุตตากีน		57	187	83.2	78.4	66.4	78.7	78.7	**60.7**
14	โรงเรียนชลประทานสงเคราะห์	PK04	145	476	75.1	70.3	66.4	71.8	71.8	**53.8**
15	กรมชลประทาน		249	817	70.4	65.6	66.4	69.0	69.0	**51.0**
16	โรงเรียนชลประทานวิทยา	PK05	236	774	70.8	66.1	66.4	69.2	69.2	**51.2**
17	วัดชลประทานรังสฤษฎ์		246	807	70.5	65.7	66.4	69.1	69.1	**51.1**
18	โรงเรียนวัฒนาพฤกษาแผนกอนุบาล		470	1542	64.8	60.1	66.4	67.3	67.3	**49.3**
19	โรงเรียนวัฒนาพฤกษา		456	1496	65.1	60.3	66.4	67.4	67.4	**49.4**
20	โรงเรียนสวนกุหลาบวิทยาลัย นนทบุรี	PK06	387	1269	66.5	61.8	66.4	67.7	67.7	**49.7**
21	พระเยซูคริส	PK07	71	233	81.3	76.5	66.4	76.9	76.9	**58.9**
22	โรงพยาบาลเวิลด์ เมดิคอล เซ็นเตอร์		87	285	79.5	74.7	66.4	75.3	75.3	**57.3**
23	ดุริยางค์ตำรวจ		165	541	73.9	69.2	66.4	71.0	71.0	**53.0**
24	โรงพยาบาลส่งเสริมสุขภาพตำบลตลาด		334	1096	67.8	63.0	66.4	68.0	68.0	**50.0**
25	กระทรวงยุติธรรม		126	413	76.3	71.5	66.4	72.7	72.7	**54.7**
26	สถาบันการจัดการปัญญาภิวัฒน์	PK08	133	436	75.8	71.0	66.4	72.3	72.3	**54.3**
27	โรงเรียนคลองเกลือ	PK09	63	207	82.3	77.5	66.4	77.8	77.8	**59.8**
28	โรงพยาบาลมงกุฎวัฒนะ	PK11	145	476	75.1	70.3	66.4	71.8	71.8	**53.8**

Remarks * Representative of maximum noise level for Station PK01 is maximum Leq24 measured at Siam Business Administration Nonthaburi Technological College monitoring station (70.5 decibel).
Representative of maximum noise level for Station PK02 is maximum leg24 measured at Boromarajonani College of Nursing monitoring station (68.3 decibel).
Representative of maximum noise level from Station PK03 to Station PK11 is maximum leg 24 measured at Quartermaster Department Royal Thai Army monitoring station (66.4 decibel).
Representative of maximum noise level from Station PK12 to PK17 is maximum leg24 measured at Phranakhon Rajabhat University monitoring station (85.7 decibel).
Representative of maximum noise level from Station PK20 to PK30 is maximum leg 24 measured at Synphaet General Hospital monitoring station (74.2 decibel).

** Noise level after transmission loss from noise barrier installation (reduced by 18 dB(A).)

Table 5.1-8 (Cont'd)

ลำดับ	พื้นที่อ่อนไหว	ช่วงสถานี	ระยะห่างจากแนวเส้นทาง		ระดับเสียงในช่วงเวลาที่มีการก่อสร้าง, Leq 8 ชั่วโมง (เดซิเบล (เอ))	ระดับเสียงจากการก่อสร้างบริเวณพื้นที่อ่อนไหว, Leq 24 ชั่วโมง (เดซิเบล (เอ))	Leq 24 ชั่วโมงสูงสุดจากการตรวจวัด* (เดซิเบล (เอ))	ระดับเสียงจากการก่อสร้างรวมกับเสียงสูงสุดจากการตรวจวัด* Leq 24 ชั่วโมง (เดซิเบล (เอ))	ระดับเสียงเฉลี่ยในระยะก่อสร้าง ณ บริเวณพื้นที่อ่อนไหวต่อผลกระทบ, Leq 24 ชั่วโมง (เดซิเบล (เอ))	
			เมตร	ฟุต					กรณีไม่ติดตั้งกำแพงกันเสียง	กรณีติดตั้งกำแพงกันเสียง**
29	กรมการกงศุล	PK12	211	692	71.8	67.0	85.7	85.8	85.8	**67.8**
30	กรมทหาร		296	971	68.9	64.1	85.7	85.7	85.7	**67.7**
31	ศาลปกครอง		85	279	79.7	74.9	85.7	86.0	86.0	**68.0**
32	สถานพินิจและคุ้มครองเด็กและเยาวชนกรุงเทพมหานคร		51	167	84.1	79.4	85.7	86.6	86.6	**68.6**
33	ศูนย์ราชการเฉลิมพระเกียรติ 80 พรรษา 5 ธันวาคม 2550		281	922	69.3	64.5	85.7	85.7	85.7	**67.7**
34	สำนักงานเขตหลักสี่	PK13	130	426	76.0	71.2	85.7	85.9	85.9	**67.9**
35	สถาบันวิจัยจุฬาภรณ์		363	1191	67.1	62.3	85.7	85.7	85.7	**67.7**
36	วัดหลักสี่		385	1263	66.6	61.8	85.7	85.7	85.7	**67.7**
37	โรงเรียนวัดหลักสี่		502	1647	64.3	59.5	85.7	85.7	85.7	**67.7**
38	วิทยาลัยเทคโนโลยีรัตนโกสินทร์	PK1 4	196	643	72.4	67.7	85.7	85.8	85.8	**67.8**
39	โรงเรียนเจริญผลวิทยา		49	161	84.5	79.7	85.7	86.7	86.7	**68.7**
40	มหาวิทยาลัยราชภัฏพระนคร	PK15	189	620	72.8	68.0	85.7	85.8	85.8	**67.8**
41	โรงเรียนมัธยมสาธิตวัดพระศรีมหาธาตุ		76	249	80.7	75.9	85.7	86.1	86.1	**68.1**
42	วัดพระศรีมหาธาตุ		461	1512	65.0	60.2	85.7	85.7	85.7	**67.7**
43	วิทยาลัยพุทธศาสตร์และปรัชญา		71	233	81.3	76.5	85.7	86.2	86.2	**68.2**
44	โรงเรียนไทยนิยมสงเคราะห์		326	1069	68.0	63.2	85.7	85.7	85.7	**67.7**
45	สำนักงานเขตบางเขน		94	308	78.8	74.1	85.7	86.0	86.0	**68.0**
46	โรงเรียนประชาภิบาล	PK16	106	348	77.8	73.0	85.7	85.9	85.9	**67.9**
47	สำนักงานป้องกันควบคุมโรคที่ 1 กรุงเทพฯ		197	646	72.4	67.6	85.7	85.8	85.8	**67.8**
48	มหาวิทยาลัยเกริก		72	236	81.1	76.4	85.7	86.2	86.2	**68.2**
49	กองพันทหารราบที่ 2	PK17	245	804	70.5	65.7	85.7	85.7	85.7	**67.7**
50	โรงเรียนปราโมชวิทยา รามอินทรา		85	279	79.7	74.9	85.7	86.0	86.0	**68.0**
51	โรงเรียนเอี่ยมพานิชวิทยา		237	777	70.8	66.0	85.7	85.7	85.7	**67.7**
52	กองบินตำรวจ	PK20	332	1089	67.9	63.1	74.2	74.5	74.5	**56.5**
53	โรงเรียนรามบริรักษ์		434	1424	65.5	60.8	74.2	74.4	74.4	**56.4**
54	สมาคมหมู่บ้านสวัสดิการทหารบกพัฒนา		268	879	69.7	64.9	74.2	74.7	74.7	**56.7**
55	สำนักพัฒนาสมรรถนะครูและบุคลากรอาชีวะศึกษา		82	269	80.0	75.2	74.2	77.8	77.8	**59.8**
56	โรงเรียนอนุบาลปราโมทพัฒนา	PK21	203	666	72.1	67.4	74.2	75.0	75.0	**57.0**
57	โรงเรียนสายอักษร		63	207	82.3	77.5	74.2	79.2	79.2	**61.2**

Remarks * Representative of maximum noise level for Station PK01 is maximum Leq24 measured at Siam Business Administration Nonthaburi Technological College monitoring station (70.5 decibel).
Representative of maximum noise level for Station PK02 is maximum leg24 measured at Boromarajonani College of Nursing monitoring station (68.3 decibel).
Representative of maximum noise level from Station PK03 to Station PK11 is maximum leg 24 measured at Quartermaster Department Royal Thai Army monitoring station (66.4 decibel).
Representative of maximum noise level from Station PK12 to PK17 is maximum leg24 measured at Phranakhon Rajabhat University monitoring station (85.7 decibel).
Representative of maximum noise level from Station PK20 to PK30 is maximum leg 24 measured at Synphaet General Hospital monitoring station (74.2 decibel).
** Noise level after transmission loss from noise barrier installation (reduced by 18 dB(A))

Table 5.1-8 (Cont'd)

ลำดับ	พื้นที่อ่อนไหว	ช่วงสถานี	ระยะห่างจากแนวเส้นทาง		ระดับเสียงในช่วงเวลาที่มีการก่อสร้าง, Leq 8 ชั่วโมง (เดซิเบล (เอ))	ระดับเสียงจากการก่อสร้างบริเวณพื้นที่อ่อนไหว, Leq 24 ชั่วโมง (เดซิเบล (เอ))	Leq 24 ชั่วโมง สูงสุดจากการตรวจวัด* (เดซิเบล (เอ))	ระดับเสียงจากการก่อสร้างรวมกับเสียงสูงสุดจากการตรวจวัด* Leq 24 ชั่วโมง (เดซิเบล (เอ))	ระดับเสียงเฉลี่ยในระยะก่อสร้าง ณ บริเวณพื้นที่อ่อนไหวต่อผลกระทบ, Leq 24 ชั่วโมง (เดซิเบล (เอ))	
			เมตร	ฟุต					กรณีไม่ติดตั้งกำแพงกันเสียง	กรณีติดตั้งกำแพงกันเสียง**
58	ศาลเจ้าแม่เสือ	PK22	28	92	89.3	84.6	74.2	85.0	85.0	**67.0**
59	โรงเรียนฉัตรวิทยา		108	354	77.6	72.8	74.2	76.6	76.6	**58.6**
60	โรงเรียนมัสยิดอัลเอาว์ก๊อฟ		370	1214	66.9	62.1	74.2	74.5	74.5	**56.5**
61	มัสยิดอัล-เอาว์ก๊อฟ		353	1158	67.3	62.6	74.2	74.5	74.5	**56.5**
62	โรงพยาบาลสินแพทย์	PK23	76	249	80.7	75.9	74.2	78.1	78.1	**60.1**
63	โรงพยาบาลนพรัตน์ราชธานี	PK25	283	928	69.2	64.5	74.2	74.6	74.6	**56.6**
64	วิทยาลัยเทคโนโลยีทักษิณาบริหารธุรกิจ	PK26	77	253	80.6	75.8	74.2	78.1	78.1	**60.1**
65	โรงเรียนเศรษฐบุตรบำเพ็ญ	PK28	134	440	75.7	71.0	74.2	75.9	75.9	**57.9**
66	โรงพยาบาลเสรีรักษ์		185	607	72.9	68.2	74.2	75.2	75.2	**57.2**
67	โรงพยาบาลนวมินทร์		204	669	72.1	67.3	74.2	75.0	75.0	**57.0**
68	วิทยาลัยเทคนิคมีนบุรี		152	499	74.6	69.9	74.2	75.6	75.6	**57.6**
69	โรงพยาบาลนวมินทร์ 9		104	341	77.9	73.2	74.2	76.7	76.7	**58.7**
70	โรงเรียนพณิชยการมีนบุรี		507	1663	64.2	59.4	74.2	74.3	74.3	**56.3**
71	โรงเรียนสุขเนตร		100	328	78.3	73.5	74.2	76.9	76.9	**58.9**
72	โรงเรียนมีนบุรีศึกษา		232	761	71.0	66.2	74.2	74.8	74.8	**56.8**
73	ศูนย์บริการสาธารณสุขมีนบุรี	PK29	218	715	71.5	66.7	74.2	74.9	74.9	**56.9**
74	สำนักงานเขตมีนบุรี		367	1204	67.0	62.2	74.2	74.5	74.5	**56.5**
75	เรือนจำพิเศษมีนบุรี		495	1624	64.4	59.6	74.2	74.3	74.3	**56.3**
76	สำนักงานอัยการจังหวัดมีนบุรี		133	436	75.8	71.0	74.2	75.9	75.9	**57.9**
77	โรงเรียนมีนบุรี		210	689	71.8	67.1	74.2	75.0	75.0	**57.0**
78	โรงเรียนสตรีเศรษฐบุตรบำเพ็ญ		435	1427	65.5	60.7	74.2	74.4	74.4	**56.4**
79	โรงเรียนมีนประสาทวิทยา		288	945	69.1	64.3	74.2	74.6	74.6	**56.6**
80	มหาวิทยาลัยเกษมบัณฑิต วิทยาเขตร่มเกล้า	PK30	720	2362	61.1	56.4	74.2	74.3	74.3	**56.3**

Remarks * Representative of maximum noise level for Station PK01 is maximum Leq24 measured at Siam Business Administration Nonthaburi Technological College monitoring station (70.5 decibel).

Representative of maximum noise level for Station PK02 is maximum leg24 measured at Boromarajonani College of Nursing monitoring station (68.3 decibel).

Representative of maximum noise level from Station PK03 to Station PK11 is maximum leg 24 measured at Quartermaster Department Royal Thai Army monitoring station (66.4 decibel).

Representative of maximum noise level from Station PK12 to PK17 is maximum leg24 measured at Phranakhon Rajabhat University monitoring station (85.7 decibel).

Representative of maximum noise level from Station PK20 to PK30 is maximum leg 24 measured at Synphaet General Hospital monitoring station (74.2 decibel).

** Noise level after transmission loss from noise barrier installation (reduced by 18 dB(A))

Table 5.1-9 Transmission Loss Capacity of Materials

Material	Thickness mm.	Surface Density kg/m^2	Transmission Loss*(TL) dB.
Polycarbonate	8 – 12	10 – 14	30 – 33
Acrylic [Poly-Methyl-Meta-Acrylate (PMMA)]	15	18	32
Concrete Block, 200x200x400 light weight	200	151	34
Dense concrete	100	244	40
Light concrete	150	244	39
Light concrete	100	161	36
Brick	150	288	40
Steel, 18 ga	1.27	9.8	25
Steel, 20 ga	0.95	7.3	22
Steel, 22 ga	0.79	6.1	20
Steel, 24 ga	0.64	4.9	18
Aluminium Sheet	1.59	4.4	23
Aluminium Sheet	3.18	8.8	25
Aluminium Sheet	6.35	17.1	27
Wood	25	18	21
Plywood	13	8.3	20
Plywood	25	16.1	23
Absorptive panels with polyester film backed by metal sheet	50-125	20-30	30-47

Source : Guidelines on Design of Noise Barriers, Environmental Protection Department and Highways Department, Government of the Hong Kong SAR., 2003
Remarks : * Values assuming no openings or gaps in the barriers

Table 5.1-10 Noise Level at Various Distances from Noise Source in Construction Phase

Distance (meter)	Construction Activities	
	Noise Level from Project (dB(A))	Noise Level from Project Activities compiled with maximum Leq24 hrs (dB(A))
15	89.0	89.0
20	86.5	86.5
25	84.6	84.6
30	83.0	83.0
35	81.6	81.6
40	80.5	80.5
45	79.5	79.5
50	78.5	78.5
60	77.0	77.0
70	75.6	75.6
80	74.5	74.6
90	73.4	73.5
100	72.5	72.6
200	66.5	66.9
300	63.0	63.8
400	60.5	61.8
500	58.5	60.5
700	55.6	58.9
1000	52.5	57.7

Remarks : Maximum Leq24 hrs.of existing measurement is 56.1 dB(A)
(at Kasem Bundit University, Rom Klao campus)

For noise level from construction activities at the distances between 10-500 meters from the Project alignment in case of no installation of 2 meters high steel solid fence, L_{eq24} was in the range of 59.5-93.5 dB(A) and L_{eq24} at the distance of 200 meters from the noise source was 67.5 dB(A), as presented in ***Table 5.1-7***. Such noise level was lower than the standard value (70 dB(A)). In case of installation of 2 meters high steel solid fence along the construction boundaries, L_{eq24} at the distance beween 10-500 meters from the Project alignment decreased to the range of 41.5-75.5 dB(A) and L_{eq24} at 200 meters from the noise source was 49.5 dB(A), lower than the standard value (70 dB(A)), as presented in ***Table 5.1-7***.

In case of no installation of 2 meters high steel solid fence, L_{eq24} from construction activities in environmentally sensitive areas and communities at the distance beyond 200 meters from the Project construction boundaries was lower than the standard value (not exceeding 70 dB(A)). However, when compiled with the maximum L_{eq24} measured along the Project alignment, most of the compilation results were higher than the standard value. The reason was that noise levels measured at many monitoring stations were higher than the standard value; Siam Business Administration Nonthaburi Technological College monitoring station (70.5 dB(A)), Phranakhon Rajabhat University monitoring station (85.7 dB(A)), and Synphaet General Hospital monitoring station (74.2 dB(A)), due to vehicular traffic on Tiwanon, Chaeng Watthana and Ram Inthra roads respectively.

Therefore the installation of 2 meters high steel solid fence along the construction boundaries can reduce noise level from construction activities in environmentally sensitive areas to be lower than the standard value, as presented in ***Table 5.1-8*** (Compilation of L_{eq24} and maximum L_{eq24} measured at monitoring stations subtracted by transmission loss factor of 2 meters high steel solid fence).

Computation of Noise Annoyance Level from Construction Activities

In case that level of construction noise in the communities or environmentally sensitive areas was higher than the existing noise level (residual noise level), it was implied that the construction activities caused annoyance to the receptor locations. Computation for level of annoyance at the receptor locations has been conducted takining into consideration noise annoyance level according to the Notification of National Environmental Board No. 29 (B.E.2550) on Noise Annoyance Level, which prescribed noise annoyance level at 10 dB(A). The equation used for the computation was:

Noise annoyance level = Specific noise level - Background noise level (L_{90})

The Notification of the Pollution Control Committee on “Measurement Method of Background Noise Level, Residual Noise Level, Computation of Specific Noise Level, Noise Annoyance Level and Form of Measurement Record” (issued on 31 August B.E.2550 (2007)) has prescribed computation method of specific noise level for field measurement. The method has been applied to compute noise annoyance level from construction activities of the Project as follows:

(a) Subtract the residual noise level (the existing L_{eq} measured at the nearest environmentally sensitive areas) from the projected noise level of Project activities (the projected noise in construction phase from construction activities compiled with noise level measured in the nearest environmentally sensitive areas). The result was the difference value of noise level.

(b) Compare the difference value from (a) with noise level adjustment factor (dB(A)) to find out the applicable adjustment factor, as presented in ***Table 5.1-11***.

Table 5.1-11 Noise Level Adjustment in Computation for Noise Annoyance Level

Difference in Noise Level (dB(A))	Noise Level Adjustment Factor (dB(A))
1.4 or less	7.0
1.5-2.4	4.5
2.5-3.4	3.0
3.5-4.4	2.0
4.5-6.4	1.5
6.5-7.4	1.0
7.5-12.4	0.5
12.5 or over หรือมากกว่า	0

Source : The Notification of the Pollution Control Committee on "Measurement Method of Background Noise Level, Residual Noise Level, Computation of Specific Noise Level, Noise Annoyance Level and Form of Measurement Record", (B.E.2550) (2007)

(c) Subtract the applicable adjustment value derived in (b) from the projected noise level of Project activities at the receptor location of interest (the projected noise in construction phase compiled with noise level measured in the nearest environmentally sensitive areas). The result is the specific noise level. In case the receptor locations required tranquility such as hospital, schools, religious places, libraries or othe places of the similar nature, 3 dB(A) would be added to the result of the subtraction above. The result after the addition was the specific noise level.

(e) Subtract background noise level (L_{90}) in the environmentally sensitive areas from the specific noise level from (c). The result was the noise annoyance level.

From the projection of noise annoyance level in the environmentally sensitive areas in construction phase along the Project construction alignment in case of no installation of 2 meters high solid fence, it was found that at the receptor locations at the beginning of the Project, from Station PK01 Nonthaburi Government Center to Station PK11 Chaeng Watthana 14, most of the noise level from construction activities in environmentally sensitive areas were higher than the actually-measured noise level. Therefore, it was projected that noise level from construction activities would cause noise annoyance level ranging between 4.1-21.3 dB(A) after the occurrence of construction activities. From Station PK12 Bangkok Government Complex to Station PK30 Min Buri, the last station, it was found that most of the computed noise level from construction activities was lower than the actually measured noise level, except for the noise level measured at the areas of Bureau of Personnel Competency Development, Sai Aksorn School and San Chao Mae Suea Shrine where noise levels from construction activities were computed at 75.2, 77.5 and 84.6 dB(A) respectively, which were higher than the actually measured noise level. The noise annoyance level after the occurance of construction activities was computed at 19 dB(A).

In case of installation of 2 meters high steel solid fence around the construction boundaries along the Project alignment, it was found that noise annoyance level in the environmentally sensitive areas during construction phase was within the standard value (10 dB(A)). Therefore, noise level generated by construction activities in case of installation of 2 meters high steel solid fence would not cause annoyance to environmentally sensitive areas. It was anticipated that noise impact from the Project construction activities would be low. The estimate noise annoyance level from construction activities in the environmentally sensitive areas along the Project alignment on both sides during construction phase was presentd in ***Table 5.1-12***.

Table 5.1-12 Projected Noise Annoyance Level in Environmentally Sensitive Ares in Construction Phase

ลำดับ	พื้นที่อ่อนไหว	ช่วงสถานี	กรณี	ระยะห่างจากแนวเส้นทาง		ระดับเสียงปัจจุบัน (ระดับเสียงขณะไม่มีการรบกวน) [1]	ระดับเสียงพื้นฐาน [2]	ระดับเสียงจากกิจกรรมการก่อสร้าง ณ แหล่งรับ [3]	ระดับเสียงเฉลี่ย ในระยะก่อสร้าง ณ บริเวณพื้นที่อ่อนไหว (ระดับเสียงขณะมีการรบกวน) [4]	ระดับเสียงขณะมีการรบกวนที่ปรับค่าแล้ว [5]	ค่าระดับเสียงรบกวนภายหลังมีกิจกรรมการก่อสร้าง [6] = [5] – [2]
				เมตร	ฟุต						
1	ศูนย์ราชการนนทบุรี	PK01	ไม่ติดตั้งกำแพงกันเสียง	361	1184	70.5	63.5	62.4	***		
			ติดตั้งกำแพงกันเสียง**					44.4	***		
2	กสทช. เขต 1 นนทบุรี		ไม่ติดตั้งกำแพงกันเสียง	67	220	70.5	63.5	77.0	77.9	76.9	**13.4**
			ติดตั้งกำแพงกันเสียง**					59.0	***		
3	วิทยาลัยเทคโนโลยีสยามบริหารธุรกิจ นนทบุรี		ไม่ติดตั้งกำแพงกันเสียง	98	321	70.5	63.5	73.7	75.4	76.9	**13.4**
			ติดตั้งกำแพงกันเสียง**					55.7	***		
4	วิทยาลัยพยาบาลราชชนนี จังหวัดนนทบุรี		ไม่ติดตั้งกำแพงกันเสียง	57	187	70.5	63.5	78.4	79.0	81.5	**18.0**
			ติดตั้งกำแพงกันเสียง**					60.4	***		
5	สถาบันโรคทรวงอก		ไม่ติดตั้งกำแพงกันเสียง	127	417	70.5	63.5	71.4	74.0	75.0	**11.5**
			ติดตั้งกำแพงกันเสียง**					53.4	***		
6	โรงเรียนนนทบุรีพิทยา	PK02	ไม่ติดตั้งกำแพงกันเสียง	323	1059	68.3	60.2	63.3	***		
			ติดตั้งกำแพงกันเสียง**					45.3	***		
7	โรงเรียนสันติวัน		ไม่ติดตั้งกำแพงกันเสียง	55	180	68.3	60.2	78.7	79.1	81.6	**21.4**
			ติดตั้งกำแพงกันเสียง**					60.7	***		
8	รพสต. บ้านสัมฤทธิ์ ต.ท่าทราย		ไม่ติดตั้งกำแพงกันเสียง	465	1525	68.3	60.2	60.2	***		
			ติดตั้งกำแพงกันเสียง**					42.2	***		
9	สถานีอนามัยเด็กกลาง		ไม่ติดตั้งกำแพงกันเสียง	77	253	68.3	60.2	75.8	76.5	79.0	**18.8**
			ติดตั้งกำแพงกันเสียง**					57.8	***		
10	โรงเรียนทานสัมฤทธิ์วิทยา		ไม่ติดตั้งกำแพงกันเสียง	352	1155	68.3	60.2	62.6	***		
			ติดตั้งกำแพงกันเสียง**					44.6	***		

** Noise level after transmission loss by solid fence installation (reduced by 18 dB(A)) = noise level from construction activities measured at receptor location-noise level reduced by transmission loss from solid fence installation

*** Noise level from Project construction activities at receptor location which is lower than existing level is considered not to cause annoyance to receptor locaton.

[1] = Representative of maximum noise level for Station PK01 is maximum Leq24 measured at Siam Business Administration Nonthaburi Technological College monitoring station (70.5 decibel). Representative of maximum noise level for Station PK02 is maximum leg24 measured at Boromarajonani College of Nursing monitoring station (68.3 decibel).

[2] = Representative of lowest L_{90} for Station PK01 is the level of L_{90} measured at Siam Business Administration Nonthaburi Technological College monitoring station (63.5 decibel). Representative of lowest L_{90} for Station PK02 is the level of L_{90} measured at Boromarajonani College of Nursing monitoring station (60.2 decibel).

[3] = Noise level in construction phase computed at the given distance (Leq 24 hrs. from computation) [4] = Compiled noise level of [1] and [3] computed from average compiled Lp Equation = $10\log\left(\sum_{i=1}^{N} 10^{Lp_i/10}\right)$

[5] = Compiled noise level [4] subtracted by noise adjustment factor (noise receptor locations require tranquility, added by 3 dB(A))

[6] = Noise annoyance level = specific noise level – background noise level

Table 5.1-12 (Cont'd)

ลำดับ	พื้นที่อ่อนไหว	ช่วงสถานี	กรณี	ระยะห่างจากแนวเส้นทาง		ระดับเสียงปัจจุบัน (ระดับเสียงขณะไม่มีการรบกวน) [1]	ระดับเสียงพื้นฐาน [2]	ระดับเสียงจากกิจกรรมการก่อสร้าง ณ แหล่งรับ [3]	ระดับเสียงเฉลี่ย ในระยะก่อสร้าง ณ บริเวณพื้นที่อ่อนไหว (ระดับเสียงขณะมีการรบกวน) [4]	ระดับเสียงขณะมีการรบกวนที่ปรับค่าแล้ว [5]	ค่าระดับเสียงรบกวนภายหลังมีกิจกรรมการก่อสร้าง [6] = [5] – [2]
				เมตร	ฟุต						
11	กรมพลาธิการทหารบก	PK03	ไม่ติดตั้งกำแพงกันเสียง	264	866	66.4	59.9	65.1	68.8	64.3	**4.4**
			ติดตั้งกำแพงกันเสียง**					47.1	***		
12	โรงเรียนสมานพิชากร		ไม่ติดตั้งกำแพงกันเสียง	79	259	66.4	59.9	75.6	76.1	78.6	**18.7**
			ติดตั้งกำแพงกันเสียง**					57.6	***		
13	มัสยิดดารุ้ลมุตตากีน		ไม่ติดตั้งกำแพงกันเสียง	57	187	66.4	59.9	78.4	78.7	81.2	**21.3**
			ติดตั้งกำแพงกันเสียง**					60.4	***		
14	โรงเรียนชลประทานสงเคราะห์	PK04	ไม่ติดตั้งกำแพงกันเสียง	145	476	66.4	59.9	70.3	71.8	73.3	**13.4**
			ติดตั้งกำแพงกันเสียง**					52.3	***		
15	กรมชลประทาน		ไม่ติดตั้งกำแพงกันเสียง	249	817	66.4	59.9	65.6	69.0	66.0	**6.1**
			ติดตั้งกำแพงกันเสียง**					47.6	***		
16	โรงเรียนชลประทานวิทยา	PK05	ไม่ติดตั้งกำแพงกันเสียง	236	774	66.4	59.9	66.1	***		
			ติดตั้งกำแพงกันเสียง**					48.1	***		
17	วัดชลประทานรังสฤษฎ์		ไม่ติดตั้งกำแพงกันเสียง	246	807	66.4	59.9	65.7	69.1	69.1	**9.2**
			ติดตั้งกำแพงกันเสียง**					47.7	***		
18	โรงเรียนวัฒนาพฤกษาแผนกอนุบาล		ไม่ติดตั้งกำแพงกันเสียง	470	1542	66.4	59.9	60.1	***		
			ติดตั้งกำแพงกันเสียง**					42.1	***		
19	โรงเรียนวัฒนาพฤกษา		ไม่ติดตั้งกำแพงกันเสียง	456	1496	66.4	59.9	60.3	***		
			ติดตั้งกำแพงกันเสียง**					42.3	***		
20	โรงเรียนสวนกุหลาบวิทยาลัย นนทบุรี	PK06	ไม่ติดตั้งกำแพงกันเสียง	387	1269	66.4	59.9	61.8	***		
			ติดตั้งกำแพงกันเสียง**					43.8	***		

** Noise level after transmission loss by solid fence installation (reduced by 18 dB(A)) = noise level from construction activities measured at receptor location– noise level reduced by transmission loss from solid fence installation

*** Noise level from Project construction activities at receptor location which is lower than existing level is considered not to cause annoyance to receptor locaton.

[1] = Representative of maximum noise level for Station PK-03 to PK-11 is maximum Leq24 measured at Quartermaster Department Royal Thai Army monitoring station (66.4 decibel)

[2] = Representative of lowest L_{90} for Station PK-03 to PK-11 is the level of L_{90} measured at Quartermaster Department Royal Thai Army monitoring station (59.9 decibel)

[3] = Noise level in construction phase computed at the given distance (Leq 24 hrs. from computation) [4] = Compiled noise level of [1] and [3] computed from average compiled Lp Equation = $10\log\left(\sum_{i=1}^{N} 10^{Lp_i/10}\right)$

[5] = Compiled noise level [4] subtracted by noise adjustment factor (noise receptor locations require tranquility, added by 3 dB(A))

[6] = Noise annoyance level = specific noise level – background noise level

Table 5.1-12 (Cont'd)

ลำดับ	พื้นที่อ่อนไหว	ช่วงสถานี	กรณี	ระยะห่างจากแนวเส้นทาง		ระดับเสียงปัจจุบัน (ระดับเสียงขณะไม่มีการรบกวน) [1]	ระดับเสียงพื้นฐาน [2]	ระดับเสียงจากกิจกรรมการก่อสร้าง ณ แหล่งรับ [3]	ระดับเสียงเฉลี่ย ในระยะก่อสร้าง ณ บริเวณพื้นที่อ่อนไหว (ระดับเสียงขณะมีการรบกวน) [4]	ระดับเสียงขณะมีการรบกวนที่ปรับค่าแล้ว [5]	ค่าระดับเสียงรบกวนภายหลังมีกิจกรรมการก่อสร้าง [6] = [5] – [2]
				เมตร	ฟุต						
21	พระเยซูคริส	PK07	ไม่ติดตั้งกำแพงกันเสียง	71	233	66.4	59.9	76.5	76.9	79.4	**19.5**
			ติดตั้งกำแพงกันเสียง**					58.5	***		
22	โรงพยาบาลเวิลด์ เมดิคอล เซ็นเตอร์		ไม่ติดตั้งกำแพงกันเสียง	87	285	66.4	59.9	74.7	75.3	77.8	**17.9**
			ติดตั้งกำแพงกันเสียง**					56.7	***		
23	ดุริยางค์ตำรวจ		ไม่ติดตั้งกำแพงกันเสียง	165	541	66.4	59.9	69.2	71.0	69.5	**9.6**
			ติดตั้งกำแพงกันเสียง**					51.2	***		
24	โรงพยาบาลส่งเสริมสุขภาพตำบลตลาด		ไม่ติดตั้งกำแพงกันเสียง	334	1096	66.4	59.9	63.0	***		
			ติดตั้งกำแพงกันเสียง**					45.0	***		
25	กระทรวงยุติธรรม		ไม่ติดตั้งกำแพงกันเสียง	126	413	66.4	59.9	71.5	72.7	71.2	**11.3**
			ติดตั้งกำแพงกันเสียง**					53.5	***		
26	สถาบันการจัดการปัญญาภิวัฒน์	PK08	ไม่ติดตั้งกำแพงกันเสียง	133	436	66.4	59.9	71.0	72.3	73.8	**13.9**
			ติดตั้งกำแพงกันเสียง**					53.0	***		
27	โรงเรียนคลองเกลือ	PK09	ไม่ติดตั้งกำแพงกันเสียง	63	207	66.4	59.9	77.5	77.8	80.3	**20.4**
			ติดตั้งกำแพงกันเสียง**					59.5	***		
28	โรงพยาบาลมงกุฎวัฒนะ	PK11	ไม่ติดตั้งกำแพงกันเสียง	145	476	66.4	59.9	70.3	71.8	74.3	14.4
			ติดตั้งกำแพงกันเสียง**					52.3	***		
29	กรมการกงศุล	PK12	ไม่ติดตั้งกำแพงกันเสียง	211	692	85.7	48.9	67.0	***		
			ติดตั้งกำแพงกันเสียง**					49.0	***		
30	กรมทหาร		ไม่ติดตั้งกำแพงกันเสียง	296	971	85.7	48.9	64.1	***		
			ติดตั้งกำแพงกันเสียง**					46.1	***		

** Noise level after transmission loss by solid fence installation (reduced by 18 dB(A)) = noise level from construction activities measured at receptor location– noise level reduced by transmission loss from solid fence installation

*** Noise level from Project construction activities at receptor location which is lower than existing level is considered not to cause annoyance to receptor locaton.

[1] = Representative of maximum noise level for Station PK-03 to PK-11 is maximum Leq24 measured at Quartermaster Department Royal Thai Army monitoring station (66.4 decibel)
Representative of maximum noise level for Station PK-12 to PK-17 is maximum Leq24 measured at Phranakhon Rajabhat University monitoring station.

[2] = Representative of lowest L_{90} for Station PK-03 to PK-11 is the level of L_{90} measured at Quartermaster Department Royal Thai Army monitoring station monitoring station (59.9 decibel).
Representative of lowest L_{90} for Station PK-12 to PK-17 is the level of L_{90} measured at Phranakhon Rajabhat University monitoring station (48.9 decibel).

[3] = Noise level in construction phase computed at the given distance (Leq 24 hrs. from computation) [4] = Compiled noise level of [1] and [3] computed from average compiled Lp Equation = $10\log\left(\sum_{i=1}^{N} 10^{Lp_i/10}\right)$

[5] = Compiled noise level [4] subtracted by noise adjustment factor (noise receptor locations require tranquility, added by 3 dB(A))

[6] = Noise annoyance level = specific noise level – background noise level

Table 5.1-12 (Cont'd)

ลำดับ	พื้นที่อ่อนไหว	ช่วงสถานี	กรณี	ระยะห่างจากแนวเส้นทาง		ระดับเสียงปัจจุบัน (ระดับเสียงขณะไม่มีการรบกวน) [1]	ระดับเสียงพื้นฐาน [2]	ระดับเสียงจากกิจกรรมการก่อสร้าง ณ แหล่งรับ [3]	ระดับเสียงเฉลี่ย ในระยะก่อสร้าง ณ บริเวณพื้นที่อ่อนไหว (ระดับเสียงขณะมีการรบกวน) [4]	ระดับเสียงขณะมีการรบกวนที่ปรับค่าแล้ว [5]	ค่าระดับเสียงรบกวนภายหลังมีกิจกรรมการก่อสร้าง [6] = [5] – [2]
				เมตร	ฟุต						
31	ศาลปกครอง	PK12 (ต่อ)	ไม่ติดตั้งกำแพงกันเสียง	85	279	85.7	48.9	74.9	***		
			ติดตั้งกำแพงกันเสียง**					56.9	***		
32	สถานพินิจและคุ้มครองเด็กและเยาวชน		ไม่ติดตั้งกำแพงกันเสียง	51	167	85.7	48.9	79.4	***		
	กรุงเทพมหานคร		ติดตั้งกำแพงกันเสียง**					61.4	***		
33	ศูนย์ราชการเฉลิมพระเกียรติ80พรรษา		ไม่ติดตั้งกำแพงกันเสียง	281	922	85.7	48.9	64.5	***		
	5 ธันวาคม 2550		ติดตั้งกำแพงกันเสียง**					46.5	***		
34	สำนักงานเขตหลักสี่	PK13	ไม่ติดตั้งกำแพงกันเสียง	130	426	85.7	48.9	71.2	***		
			ติดตั้งกำแพงกันเสียง**					53.2	***		
35	สถาบันวิจัยจุฬาภรณ์		ไม่ติดตั้งกำแพงกันเสียง	363	1191	85.7	48.9	62.3	***		
			ติดตั้งกำแพงกันเสียง**					44.3	***		
36	วัดหลักสี่		ไม่ติดตั้งกำแพงกันเสียง	385	1263	85.7	48.9	61.8	***		
			ติดตั้งกำแพงกันเสียง**					43.8	***		
37	โรงเรียนวัดหลักสี่		ไม่ติดตั้งกำแพงกันเสียง	502	1647	85.7	48.9	59.5	***		
			ติดตั้งกำแพงกันเสียง**					41.5	***		
38	วิทยาลัยเทคโนโลยีรัตนโกสินทร์	PK14	ไม่ติดตั้งกำแพงกันเสียง	196	643	85.7	48.9	67.7	***		
			ติดตั้งกำแพงกันเสียง**					49.7	***		
39	โรงเรียนเจริญผลวิทยา		ไม่ติดตั้งกำแพงกันเสียง	49	161	85.7	48.9	79.7	***		
			ติดตั้งกำแพงกันเสียง**					61.7	***		
40	มหาวิทยาลัยราชภัฏพระนคร	PK15	ไม่ติดตั้งกำแพงกันเสียง	189	620	85.7	48.9	68.0	***		
			ติดตั้งกำแพงกันเสียง**					50.0	***		

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*** Noise level from Project construction activities at receptor location which is lower than existing level is considered not to cause annoyance to receptor locaton.

[1] = Representative of maximum noise level for Station PK-12 to PK-17 is maximum Leq24 measured at Phranakhon Rajabhat University monitoring station.

[2] = Representative of lowest L_{90} for Station PK-12 to PK-17 is the level of L_{90} measured at Phranakhon Rajabhat University monitoring station (48.9 decibel).

[3] = Noise level in construction phase computed at the given distance (Leq 24 hrs. from computation) [4] = Compiled noise level of [1] and [3] computed from average compiled Lp Equation = $10\log\left(\sum_{i=1}^{N} 10^{Lp_i/10}\right)$

[5] = Compiled noise level [4] subtracted by noise adjustment factor (noise receptor locations require tranquility, added by 3 dB(A))

[6] = Noise annoyance level = specific noise level – background noise level

Table 5.1-12 (Cont’)

ลำดับ	พื้นที่อ่อนไหว	ช่วงสถานี	กรณี	ระยะห่างจากแนวเส้นทาง		ระดับเสียงปัจจุบัน (ระดับเสียงขณะไม่มีการรบกวน) [1]	ระดับเสียงพื้นฐาน [2]	ระดับเสียงจากกิจกรรมการก่อสร้าง ณ แหล่งรับ [3]	ระดับเสียงเฉลี่ย ในระยะก่อสร้าง ณ บริเวณพื้นที่อ่อนไหว (ระดับเสียงขณะมีการรบกวน) [4]	ระดับเสียงขณะมีการรบกวนที่ปรับค่าแล้ว [5]	ค่าระดับเสียงรบกวนภายหลังมีกิจกรรมการก่อสร้าง [6] = [5] – [2]
				เมตร	ฟุต						
41	โรงเรียนมัธยมสาธิตวัดพระศรีมหาธาตุ	PK15 (ต่อ)	ไม่ติดตั้งกำแพงกันเสียง	76	249	85.7	48.9	75.9	***		
			ติดตั้งกำแพงกันเสียง**					57.9	***		
42	วัดพระศรีมหาธาตุ		ไม่ติดตั้งกำแพงกันเสียง	461	1512	85.7	48.9	60.2	***		
			ติดตั้งกำแพงกันเสียง**					42.2	***		
43	วิทยาลัยพุทธศาสตร์และปรัชญา		ไม่ติดตั้งกำแพงกันเสียง	71	233	85.7	48.9	76.5	***		
			ติดตั้งกำแพงกันเสียง**					58.5	***		
44	โรงเรียนไทยนิยมสงเคราะห์		ไม่ติดตั้งกำแพงกันเสียง	326	1069	85.7	48.9	63.2	***		
			ติดตั้งกำแพงกันเสียง**					45.2	***		
45	สำนักงานเขตบางเขน		ไม่ติดตั้งกำแพงกันเสียง	94	308	85.7	48.9	74.1	***		
			ติดตั้งกำแพงกันเสียง**					56.1	***		
46	โรงเรียนประชาภิบาล	PK16	ไม่ติดตั้งกำแพงกันเสียง	106	348	85.7	48.9	73.0	***		
			ติดตั้งกำแพงกันเสียง**					55.0	***		
47	สำนักงานป้องกันควบคุมโรคที่ 1		ไม่ติดตั้งกำแพงกันเสียง	197	646	85.7	48.9	67.6	***		
	กรุงเทพฯ		ติดตั้งกำแพงกันเสียง**					49.6	***		
48	มหาวิทยาลัยเกริก		ไม่ติดตั้งกำแพงกันเสียง	72	236	85.7	48.9	76.4	***		
			ติดตั้งกำแพงกันเสียง**					58.4	***		
49	กองพันทหารราบที่ 2	PK17	ไม่ติดตั้งกำแพงกันเสียง	245	804	85.7	48.9	65.7	***		
			ติดตั้งกำแพงกันเสียง**					47.7	***		
50	โรงเรียนปราโมชวิทยา รามอินทรา		ไม่ติดตั้งกำแพงกันเสียง	85	279	85.7	48.9	74.9	***		
			ติดตั้งกำแพงกันเสียง**					56.9	***		

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*** Noise level from Project construction activities at receptor location which is lower than existing level is considered not to cause annoyance to receptor locaton.

[1] = Representative of maximum noise level for Station PK-12 to PK-17 is maximum Leq24 measured at Phranakhon Rajabhat University monitoring station.

[2] = Representative of lowest L_{90} for Station PK-12 to PK-17 is the level of L_{90} measured at Phranakhon Rajabhat University monitoring station (48.9 decibel).

[3] = Noise level in construction phase computed at the given distance (Leq 24 hrs. from computation) [4] = Compiled noise level of [1] and [3] computed from average compiled Lp Equation = $10\log\left(\sum_{i=1}^{N}10^{Lp_i/10}\right)$

[5] = Compiled noise level [4] subtracted by noise adjustment factor (noise receptor locations require tranquility, added by 3 dB(A))

[6] = Noise annoyance level = specific noise level – background noise level

Table 5.1-12 (Cont'd)

ลำดับ	พื้นที่อ่อนไหว	ช่วงสถานี	กรณี	ระยะห่างจากแนวเส้นทาง		ระดับเสียงปัจจุบัน (ระดับเสียงขณะไม่มีการรบกวน) [1]	ระดับเสียงพื้นฐาน [2]	ระดับเสียงจากกิจกรรมการก่อสร้าง ณ แหล่งรับ [3]	ระดับเสียงเฉลี่ย ในระยะก่อสร้าง ณ บริเวณพื้นที่อ่อนไหว (ระดับเสียงขณะมีการรบกวน) [4]	ระดับเสียงขณะมีการรบกวนที่ปรับค่าแล้ว [5]	ค่าระดับเสียงรบกวนภายหลังมีกิจกรรมการก่อสร้าง [6] = [5] – [2]
				เมตร	ฟุต						
51	โรงเรียนเอี่ยมพานิชวิทยา	PK17 (ต่อ)	ไม่ติดตั้งกำแพงกันเสียง	237	777	85.7	48.9	66.0	***		
			ติดตั้งกำแพงกันเสียง**					48.0	***		
52	กองบินตำรวจ	PK20	ไม่ติดตั้งกำแพงกันเสียง	332	1089	74.2	68.5	63.1	***		
			ติดตั้งกำแพงกันเสียง**					45.1	***		
53	โรงเรียนรามบริรักษ์		ไม่ติดตั้งกำแพงกันเสียง	434	1424	74.2	68.5	60.8	***		
			ติดตั้งกำแพงกันเสียง**					42.8	***		
54	สมาคมหมู่บ้านสวัสดิการทหารบกพัฒนา		ไม่ติดตั้งกำแพงกันเสียง	268	879	74.2	68.5	64.9	***		
			ติดตั้งกำแพงกันเสียง**					46.9	***		
55	สำนักพัฒนาสมรรถนะครูและบุคลากรอาชีวะศึกษา		ไม่ติดตั้งกำแพงกันเสียง	82	269	74.2	68.5	75.2	***		
			ติดตั้งกำแพงกันเสียง**					57.2	***		
56	โรงเรียนอนุบาลปราโมทพัฒนา	PK21	ไม่ติดตั้งกำแพงกันเสียง	203	666	74.2	68.5	67.4	***		
			ติดตั้งกำแพงกันเสียง**					49.4	***		
57	โรงเรียนสายอักษร		ไม่ติดตั้งกำแพงกันเสียง	63	207	74.2	68.5	77.5	***		
			ติดตั้งกำแพงกันเสียง**					59.5	***		
58	ศาลเจ้าแม่เสือ	PK22	ไม่ติดตั้งกำแพงกันเสียง	28	92	74.2	68.5	84.6	85.0	87.5	**19.0**
			ติดตั้งกำแพงกันเสียง**					66.6	***		
59	โรงเรียนฉัตรวิทยา		ไม่ติดตั้งกำแพงกันเสียง	108	354	74.2	68.5	72.8	***		
			ติดตั้งกำแพงกันเสียง**					54.8	***		
60	โรงเรียนมัสยิดอัลเอาร์ก๊อฟ		ไม่ติดตั้งกำแพงกันเสียง	370	1214	74.2	68.5	62.1	***		
			ติดตั้งกำแพงกันเสียง**					44.1	***		

** Noise level after transmission loss by solid fence installation (reduced by 18 dB(A)) = noise level from construction activities measured at receptor location– noise level reduced by transmission loss from solid fence installation

*** Noise level from Project construction activities at receptor location which is lower than existing level is considered not to cause annoyance to receptor locaton.

[1] = Representative of maximum noise level for Station PK-12 to PK-17 is maximum Leq24 measured at Phranakhon Rajabhat University monitoring station.

[2] = Representative of lowest L_{90} for Station PK-12 to PK-17 is the level of L_{90} measured at Phranakhon Rajabhat University monitoring station (48.9 decibel).

[3] = Noise level in construction phase computed at the given distance (Leq 24 hrs. from computation) [4] = Compiled noise level of [1] and [3] computed from average compiled Lp Equation = $10\log\left(\sum_{i=1}^{N} 10^{Lp_i/10}\right)$

[5] = Compiled noise level [4] subtracted by noise adjustment factor (noise receptor locations require tranquility, added by 3 dB(A))

[6] = Noise annoyance level = specific noise level – background noise level

Table 5.1-12 (Cont'd)

ลำดับ	พื้นที่อ่อนไหว	ช่วงสถานี	กรณี	ระยะห่างจากแนวเส้นทาง		ระดับเสียงปัจจุบัน (ระดับเสียงขณะไม่มีการรบกวน) [1]	ระดับเสียงพื้นฐาน [2]	ระดับเสียงจากกิจกรรมการก่อสร้าง ณ แหล่งรับ [3]	ระดับเสียงเฉลี่ย ในระยะก่อสร้าง ณ บริเวณพื้นที่อ่อนไหว (ระดับเสียงขณะมีการรบกวน) [4]	ระดับเสียงขณะมีการรบกวนที่ปรับค่าแล้ว [5]	ค่าระดับเสียงรบกวนภายหลังมีกิจกรรมการก่อสร้าง [6] = [5] – [2]
				เมตร	ฟุต						
61	มัสยิดอัล-เอาว์ก็อฟ	PK22 (ต่อ)	ไม่ติดตั้งกำแพงกันเสียง	353	1158	74.2	68.5	62.6	***		
			ติดตั้งกำแพงกันเสียง**					44.6	***		
62	โรงพยาบาลสินแพทย์	PK23	ไม่ติดตั้งกำแพงกันเสียง	76	249	74.2	68.5	75.9	***		
			ติดตั้งกำแพงกันเสียง**					57.9	***		
63	โรงพยาบาลนพรัตน์ราชธานี	PK25	ไม่ติดตั้งกำแพงกันเสียง	283	928	74.2	68.5	64.5	***		
			ติดตั้งกำแพงกันเสียง**					46.5	***		
64	วิทยาลัยเทคโนโลยีทักษิณาบริหารธุรกิจ	PK26	ไม่ติดตั้งกำแพงกันเสียง	77	253	74.2	68.5	75.8	***		
			ติดตั้งกำแพงกันเสียง**					57.8	***		
65	โรงเรียนเศรษฐบุตรบำเพ็ญ	PK28	ไม่ติดตั้งกำแพงกันเสียง	134	440	74.2	68.5	71.0	***		
			ติดตั้งกำแพงกันเสียง**					53.0	***		
66	โรงพยาบาลเสรีรักษ์		ไม่ติดตั้งกำแพงกันเสียง	185	607	74.2	68.5	68.2	***		
			ติดตั้งกำแพงกันเสียง**					50.2	***		
67	โรงพยาบาลนวมินทร์		ไม่ติดตั้งกำแพงกันเสียง	204	669	74.2	68.5	67.3	***		
			ติดตั้งกำแพงกันเสียง**					49.3	***		
68	วิทยาลัยเทคนิคมีนบุรี		ไม่ติดตั้งกำแพงกันเสียง	152	499	74.2	68.5	69.9	***		
			ติดตั้งกำแพงกันเสียง**					51.9	***		
69	โรงพยาบาลนวมินทร์ 9		ไม่ติดตั้งกำแพงกันเสียง	104	341	74.2	68.5	73.2	***		
			ติดตั้งกำแพงกันเสียง**					55.2	***		
70	โรงเรียนพณิชยการมีนบุรี		ไม่ติดตั้งกำแพงกันเสียง	507	1663	74.2	68.5	59.4	***		
			ติดตั้งกำแพงกันเสียง**					41.4	***		

** Noise level after transmission loss by solid fence installation (reduced by 18 dB(A)) = noise level from construction activities measured at receptor location– noise level reduced by transmission loss from solid fence installation

*** Noise level from Project construction activities at receptor location which is lower than existing level is considered not to cause annoyance to receptor locaton.

[1] = Representative of maximum noise level for Station PK-12 to PK-17 is maximum Leq24 measured at Phranakhon Rajabhat University monitoring station.

[2] = Representative of lowest L_{90} for Station PK-12 to PK-17 is the level of L_{90} measured at Phranakhon Rajabhat University monitoring station (48.9 decibel).

[3] = Noise level in construction phase computed at the given distance (Leq 24 hrs. from computation) [4] = Compiled noise level of [1] and [3] computed from average compiled Lp Equation = $10\log\left(\sum_{i=1}^{N} 10^{Lp_i/10}\right)$

[5] = Compiled noise level [4] subtracted by noise adjustment factor (noise receptor locations require tranquility, added by 3 dB(A))

[6] = Noise annoyance level = specific noise level – background noise level

Table 5.1-12 (Cont'd)

ลำดับ	พื้นที่อ่อนไหว	ช่วงสถานี	กรณี	ระยะห่างจากแนวเส้นทาง		ระดับเสียงปัจจุบัน (ระดับเสียงขณะไม่มีการรบกวน) [1]	ระดับเสียงพื้นฐาน [2]	ระดับเสียงจากกิจกรรมการก่อสร้าง ณ แหล่งรับ [3]	ระดับเสียงเฉลี่ย ในระยะก่อสร้าง ณ บริเวณพื้นที่อ่อนไหว (ระดับเสียงขณะมีการรบกวน) [4]	ระดับเสียงขณะมีการรบกวนที่ปรับค่าแล้ว [5]	ค่าระดับเสียงรบกวนภายหลังมีกิจกรรมการก่อสร้าง [6] = [5] – [2]
				เมตร	ฟุต						
71	โรงเรียนสุขเนตร	PK28 (ต่อ)	ไม่ติดตั้งกำแพงกันเสียง	100	328	74.2	68.5	73.5	***		
			ติดตั้งกำแพงกันเสียง**					55.5	***		
72	โรงเรียนมีนบุรีศึกษา		ไม่ติดตั้งกำแพงกันเสียง	232	761	74.2	68.5	66.2	***		
			ติดตั้งกำแพงกันเสียง**					48.2	***		
73	ศูนย์บริการสาธารณสุขมีนบุรี	PK29	ไม่ติดตั้งกำแพงกันเสียง	218	715	74.2	68.5	66.7	***		
			ติดตั้งกำแพงกันเสียง**					48.7	***		
74	สำนักงานเขตมีนบุรี		ไม่ติดตั้งกำแพงกันเสียง	367	1204	74.2	68.5	62.2	***		
			ติดตั้งกำแพงกันเสียง**					44.2	***		
75	เรือนจำพิเศษมีนบุรี		ไม่ติดตั้งกำแพงกันเสียง	495	1624	74.2	68.5	59.6	***		
			ติดตั้งกำแพงกันเสียง**					41.6	***		
76	สำนักงานอัยการจังหวัดมีนบุรี		ไม่ติดตั้งกำแพงกันเสียง	133	436	74.2	68.5	71.0	***		
			ติดตั้งกำแพงกันเสียง**					53.0	***		
77	โรงเรียนมีนบุรี		ไม่ติดตั้งกำแพงกันเสียง	210	689	74.2	68.5	67.1	***		
			ติดตั้งกำแพงกันเสียง**					49.1	***		
78	โรงเรียนสตรีเศรษฐบุตรบำเพ็ญ		ไม่ติดตั้งกำแพงกันเสียง	435	1427	74.2	68.5	60.7	***		
			ติดตั้งกำแพงกันเสียง**					42.7	***		
79	โรงเรียนมีนประสาทวิทยา		ไม่ติดตั้งกำแพงกันเสียง	288	945	74.2	68.5	64.3	***		
			ติดตั้งกำแพงกันเสียง**					46.3	***		
80	มหาวิทยาลัยเกษมบัณฑิต	PK30	ไม่ติดตั้งกำแพงกันเสียง	720	2362	74.2	68.5	56.4	***		
	วิทยาเขตร่มเกล้า		ติดตั้งกำแพงกันเสียง**					38.4	***		

** Noise level after transmission loss by solid fence installation (reduced by 18 dB(A)) = noise level from construction activities measured at receptor location– noise level reduced by transmission loss from solid fence installation

*** Noise level from Project construction activities at receptor location which is lower than existing level is considered not to cause annoyance to receptor locaton.

[1] = Representative of maximum noise level for Station PK-12 to PK-17 is maximum Leq24 measured at Phranakhon Rajabhat University monitoring station.

[2] = Representative of lowest L_{90} for Station PK-12 to PK-17 is the level of L_{90} measured at Phranakhon Rajabhat University monitoring station (48.9 decibel).

[3] = Noise level in construction phase computed at the given distance (Leq 24 hrs. from computation) [4] = Compiled noise level of [1] and [3] computed from average compiled Lp Equation = $10\log\left(\sum_{i=1}^{N} 10^{Lp_i/10}\right)$

[5] = Compiled noise level [4] subtracted by noise adjustment factor (noise receptor locations require tranquility, added by 3 dB(A))

[6] = Noise annoyance level = specific noise level – background noise level

(2) Operation Phase

Main activities in operation phase of the Pink Line Project are straddle monorail operation services. Noise impact in operation phase would be noises from interaction between rubber wheels and the rail. The estimate noise level from the monorail operation was computed by using the mathematical model developed by Federal Transit Administration (FTS) with the assessment and equation computation principles presented in FTA's Guidance Manual on Transit Noise and Vibration Impact Assessment (FTA-VA-90-1003-06, May 2006), disseminated in spreadsheet by Department of Transportation, United States of America. Example of projected noise level according to Noise Impact Assessment Spreadsheet Based on Federal Transit Administration General Transit Noise Assessment was presented in ***Figure 5.1-8***.

Data used was as follows:

- projected number of trains at 56 trains/day or maximum 3 trains/hr.
- maximum speed at 80 km/hr. (approximately 50 miles/hr).
- impact receptor locations determined at the distance of 15-500 meters from Project alignment and in environmentally sensitive areas in the vicinity of the Project

From the computation by the above mentioned mathematical model, it was found that the projected $L_{eq\ 24h}$ in operation phase at various distances of 10-500 meters from the Project alignment (at the height of the elevated structure) ranged from 34.6-60.1 dB(A), lower than the general standard (70 dB(A)), as presented in ***Table 5.1-13***.

Table 5.1-13 Projected Noise Level at Various Distances from the Project Alignment in Operation Phase Case 1 (Three Tracks) and Case 2 (Four Tracks) during B.E.2559-2579 (2016-2036)

Distance from Project alignment (meter)	Leq 24h from mathematical model (at the high of the elevated structure)
10	60.1
20	55.6
50	49.6
100	45.1
200	40.6
300	37.9
400	36.1
500	34.6
standard1/	**70**

Remarks : 1/Reference to Notification of National Environmental Board No. 15 (B.E.2540) on General Noise Standard

In the environmentally sensitive areas in the vicinity of the Project, it was found that $L_{eq\ 24\ h}$ from by Project noise source was lower than general noise standard (not exceeding 70 dB(A)). When compiled with maximum L_{eq} 24 h actually measured along the Project alignment, most L_{eq} 24 h was higher than the standard value (70 dB(A)). This was because the noise level actually measured was higher than the standard value. The measurement was conducted at Siam Business Administration Nonthaburi Technological College monitoring station (70.5 dB(A)), Phranakhon Rajabhat University monitoring station (85.7 dB(A)) and Synphaet General Hospital monitoring station (74.2 dB(A)). The noise source of noise level which is higher than the standard value is vehicular traffic on existing roads; Tiwanon, Chaeng Watthana and Ram Inthra respectively. Projected noise level in environmentally sensitive areas in the vicinity areas of the Project during operation phase was presented in ***Table 5.1-14***.

Federal Transit Administration
Noise Impact Assessment Spreadsheet
Copyright 2007 HMMH Inc.
version: 7/3/2007

Project:	Monorail Pink Line

Receiver Parameters	
Receiver:	10 meter
Land Use Category:	3. Institutional
Existing Noise (Measured or Generic Value):	dBA

Noise Source Parameters	
Number of Noise Sources:	1

Noise Source Parameters		Source 1
	Source Type:	Fixed Guideway
	Specific Source:	Monorail
Noisiest hr of Activity During Sensitive hrs	Number of Vehicles/train	7
	Speed (mph)	50
	Number of Events/hr	3
Distance	Distance from Source to Receiver (ft)	10
	Number of Intervening Rows of Buildings	
Adjustments	Noise Barrier?	No

Project Results Summary

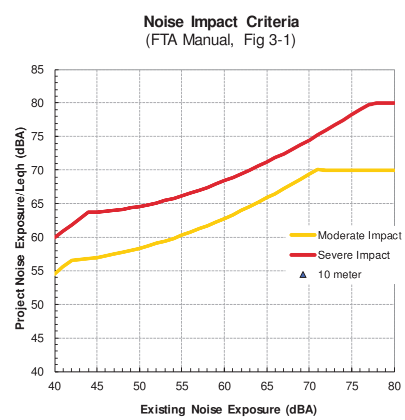
Existing Leqh:	dBA
Total Project Leqh:	60 dBA
Total Noise Exposure:	60 dBA
Increase:	60 dB
Impact?:	Severe

Distance to Impact Contours

Dist to Mod. Impact Contour (Source 1):	8137 ft
Dist to Sev. Impact Contour (Source 1):	3304 ft

Source 1 Results

Leqh:	60.1 dBA



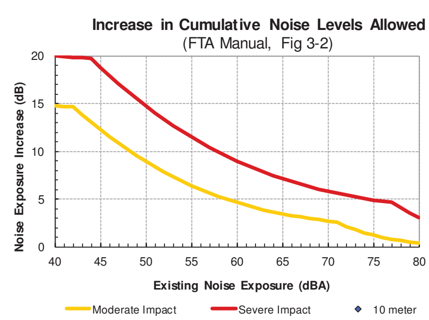


Figure 5.1-8 Example of Projected Noise Level from the Train according to Noise Impact Assessment Spreadsheet Based on Federal Transit Administration General Transit Noise Assessment

Table 5.1-14 Projected Noise Level in Environmentally Sensitive Areas in the Vicinity Areas of the Project during Operation Phase

ลำดับ	พื้นที่อ่อนไหว	ช่วงสถานี	ระยะห่างจากแนวเส้นทาง		ระดับเสียงจากแบบจำลองฯที่ระดับความสูงของโครงสร้างรางยกระดับ (เดซิเบล (เอ))		
			เมตร	ฟุต	ระดับเสียงเฉลี่ยในระยะดำเนินการ, Leq 24 (เดซิเบล (เอ))	เสียง Leq24 สูงสุดจากการตรวจวัด* (เดซิเบล (เอ))	ระดับเสียงในระยะดำเนินการรวมกับเสียงสูงสุดจากการตรวจวัด* Leq24 (เดซิเบล (เอ))
1	ศูนย์ราชการนนทบุรี	PK01	361	1184	36.7	70.5	70.5
2	กสทช. เขต 1 นนทบุรี		67	220	47.7	70.5	70.5
3	วิทยาลัยเทคโนโลยีสยามบริหารธุรกิจ นนทบุรี		98	321	45.2	70.5	70.5
4	วิทยาลัยพยาบาลราชชนนี จังหวัดนนทบุรี		57	187	48.8	70.5	70.5
5	สถาบันโรคทรวงอก		127	417	43.5	70.5	70.5
6	โรงเรียนนนทบุรีพิทยา	PK02	323	1059	37.5	68.3	68.3
7	โรงเรียนสันติวัน		55	180	49.0	68.3	68.4
8	รพสต. บ้านสัมฤทธิ์ ต.ท่าทราย		465	1525	35.1	68.3	68.3
9	สถานีอนามัยเด็กกลาง		77	253	46.8	68.3	68.3
10	โรงเรียนทานสัมฤทธิ์วิทยา		352	1155	36.9	68.3	68.3
11	กรมพลาธิการทหารบก	PK03	264	866	38.8	66.4	66.4
12	โรงเรียนสมานพิชากร		79	259	46.6	66.4	66.4
13	มัสยิดดารุ้ลมุตตากีน		57	187	48.8	66.4	66.5
14	โรงเรียนชลประทานสงเคราะห์	PK04	145	476	42.7	66.4	66.4
15	กรมชลประทาน		249	817	39.2	66.4	66.4
16	โรงเรียนชลประทานวิทยา	PK05	236	774	39.5	66.4	66.4
17	วัดชลประทานรังสฤษฏ์		246	807	39.2	66.4	66.4
18	โรงเรียนวัฒนาพฤกษาแผนกอนุบาล		470	1542	35.0	66.4	66.4
19	โรงเรียนวัฒนาพฤกษา		456	1496	35.2	66.4	66.4
20	โรงเรียนสวนกุหลาบวิทยาลัย นนทบุรี	PK06	387	1269	36.3	66.4	66.4
21	พระเยซูคริส	PK07	71	233	47.3	66.4	66.5
22	โรงพยาบาลเวิลด์ เมดิคอล เซ็นเตอร์		87	285	46.0	66.4	66.4
23	ดุริยางค์ตำรวจ		165	541	41.8	66.4	66.4
24	โรงพยาบาลส่งเสริมสุขภาพตำบลตลาด		334	1096	37.3	66.4	66.4
25	กระทรวงยุติธรรม		126	413	43.6	66.4	66.4
26	สถาบันการจัดการปัญญาภิวัฒน์	PK08	133	436	43.2	66.4	66.4
27	โรงเรียนคลองเกลือ	PK09	63	207	48.1	66.4	66.5
28	โรงพยาบาลมงกุฏวัฒนะ	PK11	145	476	34.9	66.4	66.4
29	กรมการกงศุล	PK12	211	692	40.2	85.7	85.7
30	กรมทหาร		296	971	38.0	85.7	85.7
31	ศาลปกครอง		85	279	46.2	85.7	85.7
32	สถานพินิจและคุ้มครองเด็กและเยาวชนกรุงเทพมหานคร		51	167	49.5	85.7	85.7
33	ศูนย์ราชการเฉลิมพระเกียรติ 80 พรรษา 5 ธันวาคม 50		281	922	38.4	85.7	85.7
34	สำนักงานเขตหลักสี่	PK13	130	426	43.4	85.7	85.7
35	สถาบันวิจัยจุฬาภรณ์		363	1191	36.7	85.7	85.7
36	วัดหลักสี่		385	1263	36.3	85.7	85.7
37	โรงเรียนวัดหลักสี่		502	1647	34.6	85.7	85.7
38	วิทยาลัยเทคโนโลยีรัตนโกสินทร์	PK14	196	643	40.7	85.7	85.7
39	โรงเรียนเจริญผลวิทยา		49	161	49.8	85.7	85.7
40	มหาวิทยาลัยราชภัฏพระนคร	PK15	189	620	41.0	85.7	85.7
41	โรงเรียนมัธยมสาธิตวัดพระศรีมหาธาตุ		76	249	46.9	85.7	85.7
42	วัดพระศรีมหาธาตุ		461	1512	35.2	85.7	85.7
43	วิทยาลัยพุทธศาสตร์และปรัชญา		71	233	47.3	85.7	85.7
44	โรงเรียนไทยนิยมสงเคราะห์		326	1069	37.4	85.7	85.7
45	สำนักงานเขตบางเขน		94	308	45.5	85.7	85.7
46	โรงเรียนประชาภิบาล	PK16	106	348	44.7	85.7	85.7
47	สำนักงานป้องกันควบคุมโรคที่ 1 กรุงเทพฯ		197	646	40.7	85.7	85.7
48	มหาวิทยาลัยเกริก		72	236	47.2	85.7	85.7
49	กองพันทหารราบที่ 2	PK17	245	804	39.3	85.7	85.7
50	โรงเรียนปราโมชวิทยา รามอินทรา		85	279	46.2	85.7	85.7
51	โรงเรียนเอี่ยมพานิชวิทยา		237	777	39.5	85.7	85.7

Remarks * Representative of maximum noise level for Station PK01 is maximum Leq24 measured at Siam Business Administration Nonthaburi Technological College monitoring station (70.5 dB(A)).
Representative of maximum noise level for Station PK02 is maximum leg24 measured at Boromarajonani College of Nursing monitoring station (68.3 dB(A)l).
Representative of maximum noise level from Station PK03 to Station PK11 is maximum leg 24 measured at Quartermaster Department Royal Thai Army monitoring station (66.4 dB(A))
Representative of maximum noise level from Station PK12 to PK17 is maximum leg24 measured at Phranakhon Rajabhat University monitoring station (85.7 dB(A)).
Representative of maximum noise level from Station PK20 to PK30 is maximum leg 24 measured at Synphaet General Hospital monitoring station (74.2 dB(A)).

Table 5.1-14 (Cont'd)

ลำดับ	พื้นที่อ่อนไหว	ช่วงสถานี	ระยะห่างจากแนวเส้นทาง		ระดับเสียงจากแบบจำลองฯที่ระดับความสูงของโครงสร้างรางยกระดับ (เดซิเบล (เอ))		
					ระดับเสียงเฉลี่ยในระยะดำเนินการ, **Leq 24** (เดซิเบล (เอ))	เสียง **Leq24** สูงสุดจากการตรวจวัด* (เดซิเบล (เอ))	ระดับเสียงในระยะดำเนินการรวมกับเสียงสูงสุดจากการตรวจวัด* **Leq24** (เดซิเบล (เอ))
			เมตร	ฟุต			
52	กองบินตำรวจ	PK20	332	1089	37.3	74.2	74.2
53	โรงเรียนรามบริรักษ์		434	1424	35.5	74.2	74.2
54	สมาคมหมู่บ้านสวัสดิการทหารบกพัฒนา		268	879	38.7	74.2	74.2
55	สำนักพัฒนาสมรรถนะครูและบุคลากรอาชีวะศึกษา		82	269	46.4	74.2	74.2
56	โรงเรียนอนุบาลปราโมทพัฒนา	PK21	203	666	40.5	74.2	74.2
57	โรงเรียนสายอักษร		63	207	48.1	74.2	74.2
58	ศาลเจ้าแม่เสือ	PK22	28	92	53.4	74.2	74.2
59	โรงเรียนฉัตรวิทยา		108	354	44.6	74.2	74.2
60	โรงเรียนมัสยิดอัลเอาว์ก๊อฟ		370	1214	36.6	74.2	74.2
61	มัสยิดอัล-เอาว์ก๊อฟ		353	1158	36.9	74.2	74.2
62	โรงพยาบาลสินแพทย์	PK23	76	249	46.9	74.2	74.2
63	โรงพยาบาลนพรัตน์ราชธานี	PK25	283	928	38.3	74.2	74.2
64	วิทยาลัยเทคโนโลยีทักษิณาบริหารธุรกิจ	PK26	77	253	46.8	74.2	74.2
65	โรงเรียนเศรษฐบุตรบำเพ็ญ	PK28	134	440	43.2	74.2	74.2
66	โรงพยาบาลเสรีรักษ์		185	607	41.1	74.2	74.2
67	โรงพยาบาลนวมินทร์		204	669	40.5	74.2	74.2
68	วิทยาลัยเทคนิคมีนบุรี		152	499	42.4	74.2	74.2
69	โรงพยาบาลนวมินทร์ 9		104	341	44.9	74.2	74.2
70	โรงเรียนพณิชยการมีนบุรี		507	1663	34.5	74.2	74.2
71	โรงเรียนสุขเนตร		100	328	45.1	74.2	74.2
72	โรงเรียนมีนบุรีศึกษา		232	761	39.6	74.2	74.2
73	ศูนย์บริการสาธารณสุขมีนบุรี	PK29	218	715	40.0	74.2	74.2
74	สำนักงานเขตมีนบุรี		367	1204	36.6	74.2	74.2
75	เรือนจำพิเศษมีนบุรี		495	1624	34.7	74.2	74.2
76	สำนักงานอัยการจังหวัดมีนบุรี		133	436	43.2	74.2	74.2
77	โรงเรียนมีนบุรี		210	689	40.3	74.2	74.2
78	โรงเรียนสตรีเศรษฐบุตรบำเพ็ญ		435	1427	35.5	74.2	74.2
79	โรงเรียนมีนประสาทวิทยา		288	945	38.2	74.2	74.2
80	มหาวิทยาลัยเกษมบัณฑิต วิทยาเขตร่มเกล้า	PK30	720	2362	32.2	74.2	74.2

Remarks * Representative of maximum noise level for Station PK01 is maximum Leq24 measured at Siam Business Administration Nonthaburi Technological College monitoring station (70.5 dB(A)).
Representative of maximum noise level for Station PK02 is maximum leg24 measured at Boromarajonani College of Nursing monitoring station (68.3 dB(A)l).
Representative of maximum noise level from Station PK03 to Station PK11 is maximum leg 24 measured at Quartermaster Department Royal Thai Army monitoring station (66.4 dB(A))
Representative of maximum noise level from Station PK12 to PK17 is maximum leg24 measured at Phranakhon Rajabhat University monitoring station (85.7 dB(A)).
Representative of maximum noise level from Station PK20 to PK30 is maximum leg 24 measured at Synphaet General Hospital monitoring station (74.2 dB(A)).

Computation of Noise Annoyance Level

In case noise level from Project activities in environmentally sensitive areas during operation phase was higher than noise level actually measured, which was the existing noise level (residual noise level), it was implied that Project activities would cause annoyance to impact receptor locations. Computaion for annoyance level at such impact receptor locations would take ito consideration the result of noise annoyance level computation according to the Notification of National Environmental Board No.29 (B.E.2550) (2007) on Determination of Noise Annoyance Level at dB(A). The equation used for the computation was :

$$\text{Noise annoyance level} = \text{Specific noise level} - \text{Background noise level } (L_{90})$$

The noise level from operation activities at receptor locations in the area of the Juvenile Observation and Protection Center of Bangkok, the nearest environmentally sensitive areas to the Project, was computed at 49.5 dB(A), at the distance of 51 meters (approximately 167 feet). When compiled with the noise level actually measured (85.7 dB(A)), the projected noise level in operation phase wouldl be close to the level actually measured of 85.7 dB(A), which was higher than the standard value (70 dB(A)). However, most of noise sources in operation phase would be from the operation of straddle monorail. As the specialty of this train type is traveling by straddling the track on rubber wheels, the sound from the train traveling is very low. Consequently, the average noise level from activities in the operation phase is very low ranging between 32.2-53.4 dB(A), much lower than the actually-measured level (66.4-85.7 dB(A)). Therefore, it was anticipated that the operation services of the Pink Line Project: Khae Rai-Min Buri Section would have low impact on the environmentally sensitive areas in the vicinity of the Project. Moreover, the projected noise level during operation phase was lower the general standard level (70 dB(A)), whereas the track is of single small rail powered by electricity, moving on the rail with rubber wheels, thus giving low noise than iron wheels. In addition, by the specific nature of a straddle monorail, the train straddles the track. This acts like a sound buffer while travelling, as presented in ***Figure 5.1-9***. These qualities generate much quieter and lower noise than that generated by heavy rail system.

Figure 5.1-9 Straddle Monorail Type, the Train Straddles the Track

From the above mentioned reasons, it was proposed to cancelled the installation of noise barriers of solid-walled tunnel type in 6 locations (200 meters long/location) along the mass transit system alignment. The 6 locations were Siam Business Administration Technological College (SBAC), Boromarajonani College of Nursing, Central Chest Institute of Thailand, Quartermaster Department Royal Thai Army, Phranakhon Rajabhat University and Synphaet General Hospital, as presented in ***Figure 5.1-10***. Moreover, the installation of such the solid-walled tunnels would increase negative visual impact on important places along the Project alignment. In case of accident and safety reasons, if fire breaks out, the tunnel would trap smoke and makes it difficult for fire fighters and rescuers to help the passengers.

From site survey of the existing conditions along the Pink Line Project; Khae Rai-Min Buri Section alignment, totaling 34.5 km, it was found that most of the areas are open space with buildings and shophouses standing along the mass transit system route. Those buildings and shophouses do not stand adjacent to the road boundaries along the Project alignment, except for PK04 Samakkhi station, which will be situated on Tiwanon road with road zone of 33 meters, and PK 15 Phranakhon Rajabhat University station on the pavement on the North direction of Chaeng Watthana road with road zone of 32 meters. The surrounding areas are 3-storey shophouses, educational institutes and governmental offices on both sides of the road. Threrefore, the areas are categorized as semi-closed space and there is opportunity for some sound resonance.

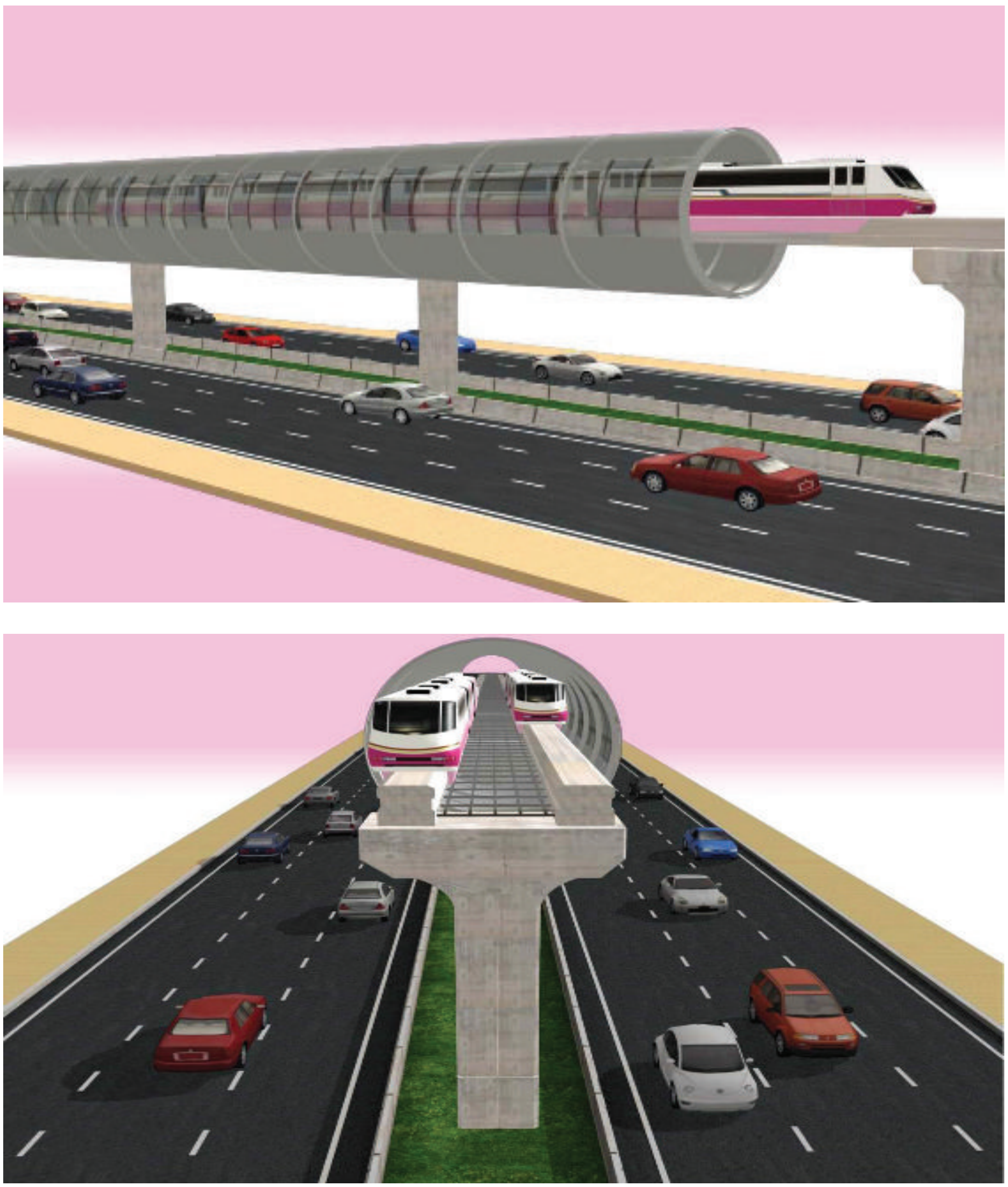


Figure 5.1-10 Noise Barrier of Solid-Wall Tunnel Type

Consequently, during construction phase, it was proposed to erect absorbtive material made of Fiberglass Reinforced Plastics: FRP or other type of material such as aluminium or metal sheets or celocrete, all in light-weighted type (less than 10 kg/sheet) with durable period of not less than 30 years. The absorption materials shall be installed on the underneath of two stations; PK04 Samakkhi station and PK15 Phranakhon Rajabhat University station. An example of absorption materials to be installed under the stations was presented in ***Figure 5.1-11***. Its qualifications are as follows:

Absorptive barrier will absorb noise and convert into internal heat, wiithout reflection to the outside. In the urban areas with high building density, this type of absorptive barrier is very appropriate. The disadvantage of it is that its durability does not last long due to its porous and light-weighted structure. In addition, the cost is very highly when compared with general absorptive barriers.

Types of Absorptive Barriers are such as:

(1) Fiber-reinforced Aluminium such as glass fiber, which has the absorption capacity of approzimately 57-93% (data from Chulalongkorn University and the United States of America). The cost of installation may be higher than 5,000 Baht/m^2.

Fiberglass

Fiberglass is made from the melting and coagulating of silica. The glass raw material will be melted in very high termperature, approximately higher than 1,000 degree celcius for 50-800 minutes.

Properties of fiberglass are

- non-combustibility and excellent electrical insulation
- very good heat resistance
- stability, inflexibility
- rotting and weathering resistance
- rustless and corrosion resistance
- unfrozen under extreme cold

(2) Glass Reinforce Cement : GRC GRC is produced by special glass fiber-reinforce cement production technology to reduce structural weights and made to serve the required purposes. The cost of GRC panel of the size 1m x 1m, 83 kg. is approximately 6,500 Baht/m^2. Example usage is such as Don Mueang Tollway Project, Lat Pla Khao road passunder Rap11 road.

Properties of Glass Reinforce Cement : GRC

Glass fiber has the properties of resistance to high tensil when compared with other type of fiber. Therefore, the reinforcement of glass to cement will have the combined properties of resistance to high tensil of glass fiber and the compressive strength of cement. This reinforcement led to a new interesting material type which was developed into Glass Reinforced Cement (GRC).

GRC is the mixture of hydraulic cement, silica sand, water and glass fiber in the proportion of 5% by weight which can be molded esily into a wide variety of complex shapes with high resistance to tensil and compression strength. The product produced can have the thickness of at least 6mm. When compared with the reinforced concrete which requires at least 2.5 cm. thickness as steel cladding materials, GRC is lighter than reinforced concrete with the same compression strength.

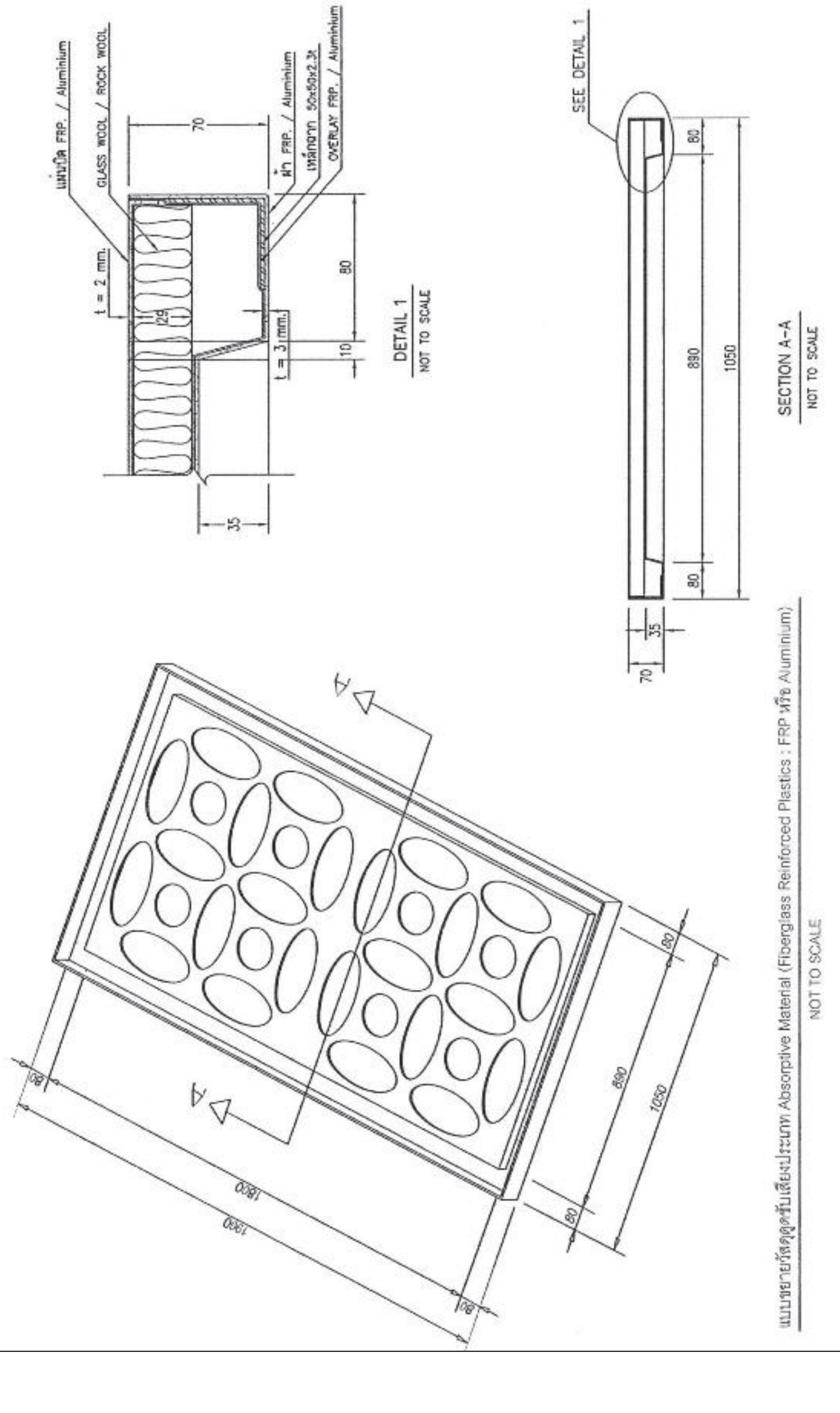


Figure 5.1-11 Example of Sound Absorbtive Material

Absorptive Barrier

Advantages of GRC

1. Versatile materials available to architects
2. Light weight
3. Strong, durable and safe
4. Good impact resistance, without brittle nor broken problems
5. Easy erection, suitable to all weather conditions and pollution free
6. Coating paintability like general concrete works
7. Availability for mass production
8. Non-combustibility, easy maintenance, asbestos free
9. Very little deformation when temperature changes
10. Not decay due to fungus, or insects, capable of integrating with other materials
11. Convenient and easy perforation by simple tool
12. Versatile surface texture

In consideration of fiberglass-reinforced-aluminium sheet as absorption material to the underneath of the station structure to reduce resonance from traffic, the sound absorption coefficient must not be less than 70 percentages at 400 Hz, and 80 percentages at 1,000 Hz. It was estimated that after installation of fiber-reinforced aluminum sheet, the Transmission Loss (TL) could be achieved at approximately at 23-27 dB(A)). According to the data of the Environmental Protection Department and Highways Department, Government of the Hong Kong SAR., 2003, aluminium of 1.59-6.35 mm thickness shall have a Transmission Loss (TL) of approximately 23-27 dB(A)).

5.1.6 Vibration

(1) Construction Phase

Vibration sources in construction phase are machinery, construction method, and construction tool and equipment. In operation phase, the operation of monorail causes disturbance to the vicinity areas along the Project alignment.

During construction phase, a lot of activities can cause vibration. The effect of vibration level is subject to type of equipment and machinery, construction method and distance from vibration source to receptor. Computation of vibration level from construction was computed by using reference vibration level from US EPA on Vibration Source Levels for Construction Equipment at 25 ft. (approx. 7.62 m.) fom Vibraton Source, as presented in ***Table 5.1-15***. Vibration level in close proximity to the Project was computed by the following equation:

$$PPV_{equip} = PPV_{ref} \times \left(\frac{25}{D}\right)^{1.5} \quad \text{..........................(1)}$$

When PPV_{equip} = is the peak particle velocity in in/sec of the equipment adjusted for distance

PPV_{ref} = is the reference vibration level in in/sec at 25 feet distance

D = is the distance from the equipment to the receptor (ft)

The Project activities are foundation and the elevated structue construction along the whole Project alignment. It was found that the activites or equipment that caused the highest construction vibration was pile driving equipment (impact type), having PPV at 25 ft. (approximately 7.62 m.) of 1.518 in/sec (38.557 mm/sec), as presented in ***Table 5.1-15***.

Table 5.1-15 Vibration Levels from Construction Equipment at 25 ft. (approx. 7.62 m.) from Vibration Source

Equipment	PPV at 25 ft (in/sec)
Pile Driver (Impact)	**1.518**
Pile Driver (sonic)	0.734
Vibratory Roller	0.210
Clam Shovel Drop (Slurry Wall)	0.202
Hydromill (Slurry Wall) (In soil)	0.008
Hydromill (Slurry Wall) (In rock)	0.017
Large Bulldozer	0.089
Caisson Drilling	0.089
Loaded Trucks	0.076
Jackhammer	0.035
Small Bulldozer	0.003

Source: Transit Noise and Vibration Impact Assessment, FTA 2006

Vibration from pile driving activities of the elevated structure construction will be transferred through the earth, acting as a medium, to receptors in the vicinity, as computed by the **Equation (1)**. The computation result was then compared with the recommended criteria of Whiffin and Leonard, as presented in ***Table 5.1-16*** and the Notification of the National Environmental Board No. 37, B.E.2553 (2010) on Vibration Standard for Impact Protection on Buildings, as presented in ***Table 5.1-17***.

Table 5.1-16 Effects of Vibration on People and Buildings

PPV (mm/sec) (in/sec)	Human Reaction	Effect on Buildings
0 - 0.15[2/] (0-0.006)	Imperceptible	Unlikely to cause damage of any type.
0.15 - 0.3[3/] (0.006-0.012)	Threshold of perception	Unlikely to cause damage of any type.
2.0[1/] (0.079)	Vibrations perceptible	Recommended upper level to which ruins and ancient monuments should be subjected.
2.5 (0.098)	Continuous exposure to vibrations begins to annoy	Virtually no risk of architectural damage to normal buildings.
5 (0.197)	Vibrations disturbing people in buildings (Complying to vibration level affecting people on bridges for a short period)	Threshold for risk of architectural damage in houses with plastered (mixture of cement, sand, waer and fiber) walls and ceilings. In case of flexible walls/ceiling, there would be minor damage.
10-15 (0.394-0.591)	Continuous vibrations which are unpleasant and unacceptable	Vibration level higher than normal traffic would cause architectural and possibly minor structural damage.

Source: Whiffin, A.C., and Leonard, D.R., A Survey of Traffic Induced Vibration, Eng., 1971.

The study of impact level of vibration from construction activities has considered the highest vibration level from pier construction of the elevated structure. The vibration source of consideration was pile driving (impact-type pile) activities, having PPV at 25 ft. (approximately 7.62 m.) of 1.518 in/sec (38.557 mm/sec), in the **Equation (1)**. The computation has shown impact levels at various distances from the Project construction boundaries, as presented in ***Table 5.1-18***. From the study, it was found that vibration level at 10 meters distance from vibration source was at the level that was unpleasant to human being if the vibration continued continuously. For the effect on buildings, the vibration level was higher than normal traffic and would possibly cause architectural and minor structural damage. However, there are no impact receptors or any buildings situated within the distance of 10 meters from the pier alignment of the elevated structure. Moreever, vibration level will decrease by the increasing distance.

Vibration level at impact receptors located close to the Project was presented in ***Table 5.1-19***. The receptor location exposed to vibration at the maximum level that vibration was perceptible for human being and the increase in vibration level would damage or have effects on archaeological site was at San Chao Mae Suea Shrine. The shrine is situated approximately 28 meters away from the Project alignment, with PPV of 0.2156 in/sec. However, vibration source occurs only for a short period, at intervals of the Project alignment. In addition, the structure of the buildings situated close in the impact receptor location area was stronger than the archaeological site and can resist the vibration without damage. Therefore, it was anticipated that vibration impact in construction would be low.

Table 5.1-17 Standard Vibration for Impact Protection on Buildings

Building Type	Measurement Locations	Frequency (Hertz)	Maximum PPV (mm/sec)	
			Vibration Case 1	Vibration Case 2
1	1.1 Foundation or ground floor of building	f ≤ 10	20	-
		10 < f ≤ 50	0.5 f + 15	
		50 < f ≤ 100	0.2 f + 30	
		f > 100	50	
	1.2 Top floor of building	Every frequency	40*	10*
	1.3 Each building floor	Every frequency	20**	10**
2	2.1 Foundation or ground floor of building	f ≤ 10	5	-
		10 < f ≤ 50	0.25 f + 2.5	
		50 < f ≤ 100	0.1 f + 10	
		f > 100	20	
	2.2 Top floor of building	Every frequency	15*	5*
	2.3 Each building floor	Every frequency	20**	10**
3	3.1 Foundation or ground floor of building	f ≤ 10	3	-
		10 < f ≤ 50	0.125 f + 1.75	
		50 < f ≤ 100	0.04 f + 6	
		f > 100	10	
	3.2 Top floor of building	Every frequency	8*	2.5*
	3.3 Each building floor	Every frequency	20**	10**

Remarks: 1) **Building Type 1** is 1) Building used as factory according to factory laws 2) Commercial building, office building, warehouse building, special building, and large building according to building control laws 3) Other buildings of the same use as those in 1) and 2).
Building Type 2 is 1) Residential buildings, common housing buildings, row-room buildings, row-house brick buildings, row-house buildings and duplex houses according to building control laws 2) Condomium according to condominium laws 3) Dormitories according to dormitory laws 4) Buildings used as place of treatment according to place of treatment laws, and buildings used as governmental hospitals 5) Buildings used as educational places according to private school laws, buildings used as governmental schools, buildings used as private universities according to private university law, and buildings used as governmental universities 6) Buildings used for religious activities 7) Other buildings of the same use as those in 1) 2) 3) 4) 5) and 6).
Building Type 3 is 1) Historic sites according to laws on historic sites, antiquities, artifact and national museum 2) Buildings or any construction works which are not strong but have cultural values.

2) **Vibration Case 1** is the vibration that does not cause fatique and resonance of building structures.
Vibration Case 2 is the vibration that causes fatique or resonance of building structures.

3) f = Frequency of vibration at PPV (hertz)

4) * = Standard specified for PPV on horizontal axis

5) ** = Standard specified for PPV on vertical axis

6) Measurement of maximum vibration for the Vibration case 2, in Item 1.2, 2.2 and 3.2 and shall be conducted on the top floor of the building or other floor which has maximum vibration.

7) Measurement of vibration on each floor of the buildings in Item 1.3, 2.3 and 3.3, except for measurement at the foundation or on the ground floor of the building.

Source : Notification of the National Environmental Board No. 37 (B.E.2553) on Standard Vibration for Impact Protection on Buildings, published in the Royal Government Gazette Vol. 127 Special Part 69D, dated 2 June B.E.2553.

Table 5.1-18 Level of Vibration Effect from Construction Activities at Various Distances

Distance from Vibration Source		PPV at 25 ft (in/sec)		Human Reaction	Effects on Buildings
m.	ft.	in/sec	mm/sec		
10	32.8	1.0101	25.657	f	F
15	49.2	0.5498	13.966	f	f
20	65.6	0.3571	9.071	e	E
30	98.4	0.1944	4.938	d	D
50	164	0.0903	2.295	c	C
100	328	0.0319	0.811	b	B
150	492	0.0174	0.442	b	B
200	656	0.0113	0.287	b	B
300	984	0.0061	0.156	a	A
400	1312	0.0040	0.101	a	A
500	1640	0.0029	0.073	a	A
1000	3280	0.0010	0.026	a	A
1200	3936	0.0008	0.020	a	A

Remarks : **Human Reaction**

a = Imperceptible b = Treshold of perception
c = Vibrations perceptible
d = Continuous exposure to vibration begins to annoy
e = Vibration annoying people in buildings
f = Continuous vibration unpleasant

Effects on Buildings

A = Unlikely to cause damage of any type
B = Unlikely to cause damage of any type
C = Recommended upper level to which ruins and ancient monuments should be subjected.
D = Virtually no risk of architectural damage to normal buildings.
E = Threshold for risk of architectural damage.
F = Vibration level higher than normal traffic would possibly cause architectural and minor structural damage.

Table 5.1-19 Level of Vibration Effect from Construction Activities on Receptors

Receptors	Distance from Vibration Sources		PPV		Human Reaction	Effects on Buildings
	meters	feet	in/sec	mm/sec		
Nonthaburi Government Center	361	1184.1	0.0047	0.1183	a	A
NBTC region 1, Nontha Buri	67	219.8	0.0582	1.4794	c	C
Siam Business Administration Nonthaburi Technological College, Nontha Buri	98	321.4	0.0329	0.8363	c	C
Boromarajonani College of Nursing, Nonthaburi	57	187.0	0.0742	1.8854	c	C
Central Chest Institute of Thailand	127	416.6	0.0223	0.5669	c	C
Nonthaburi Pittaya School	323	1059.4	0.0055	0.1398	a	A
Santiwan School	55	180.4	0.0783	1.9891	c	C
Ban Sam Rit Tambon Health Promoting Hospital, Tambon Tha Sai	465	1525.2	0.0032	0.0809	a	A
Dek Klang Health Station	77	252.6	0.0473	1.2008	c	C
Than Sam Rit Witthaya School	352	1154.6	0.0048	0.1229	a	A
Quartermaster Department Royal Thai Army	264	865.9	0.0074	0.1891	a	A
Saman Phichakon School	79	259.1	0.0455	1.1555	c	C
Masjid Darulmuttakeen	57	187.0	0.0742	1.8854	c	C
Chon Prathan Songkhro School	145	475.6	0.0183	0.4647	b	B
Royal Irrigation Department	249	816.7	0.0081	0.2065	b	B
Chon Prathan Witthaya	236	774.1	0.0088	0.2238	b	B
Wat Chon Prathan Rangsarit	246	806.9	0.0083	0.2103	b	B
Watthana Prueksa School-kindergarten division	470	1541.6	0.0031	0.0796	a	A
Watthana Prueksa School	456	1495.7	0.0033	0.0833	a	A
Suankularb Wittayalai School	387	1269.4	0.0042	0.1066	a	A
Phra Ye Su Krit	71	232.9	0.0534	1.3562	c	C
The World Medical Center Hospital	87	285.4	0.0394	0.9998	c	C
The Royal Thai Police Band	165	541.2	0.0151	0.3828	b	B
Ta Lat Tambon Health Promoting Hospital	334	1095.5	0.0052	0.1329	a	A
Ministry of Justice	126	413.3	0.0226	0.5737	b	B
Panyapiwat Institute of Management	133	436.2	0.0208	0.5290	b	B
Khlong Kluea School	63	206.6	0.0639	1.6225	c	C
Department of Consular	211	692.1	0.0104	0.2647	b	B
Khlong Kluea School	296	970.9	0.0063	0.1593	b	B
The Administrative Court	85	278.8	0.0408	1.0353	c	C
Juvenile Observation and Protection Center of Bangkok	51	167.3	0.0877	2.2277	c	C
The Government Complex	281	921.7	0.0068	0.1722	b	B
Lak Si District Office	130	426.4	0.0216	0.5474	b	B
Chulabhorn Research Institute	363	1190.6	0.0046	0.1173	a	A

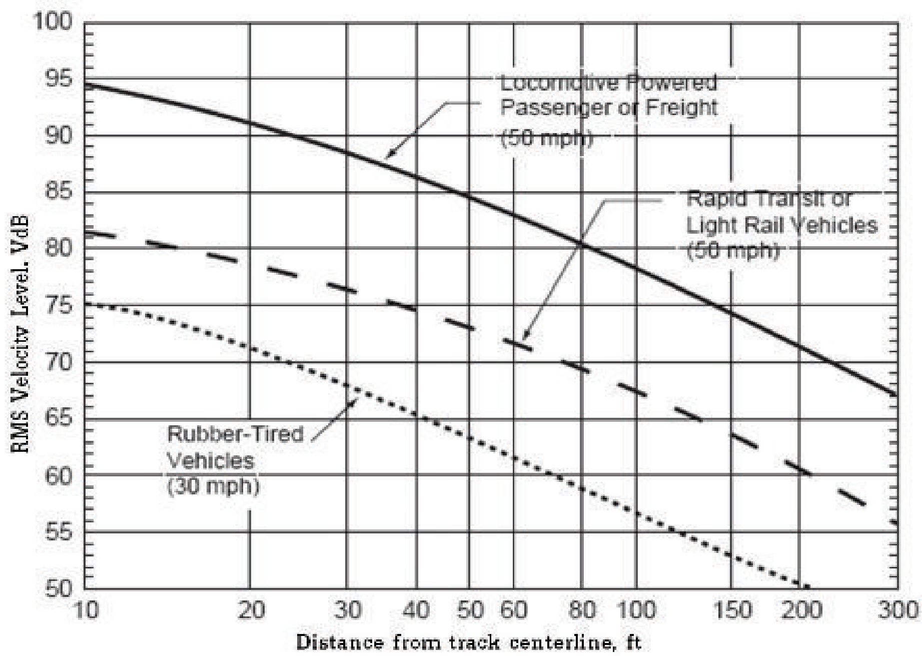
Table 5.1-19 (Cont'd)

Receptors	Distance from Vibration Sources		PPV		Human Reaction	Effects on Buildings
	meters	feet	in/sec	mm/sec		
Wat Lak Si	385	1262.8	0.0042	0.1074	a	A
Wat Lak Si School	502	1646.6	0.0028	0.0721	a	A
Rattanakosin Technological College	196	642.9	0.0116	0.2957	b	B
Charoenphon Witthaya School	49	160.7	0.0931	2.3654	c	C
Phranakhon Rajabhat University	189	619.9	0.0123	0.3123	b	B
Wat Phra Si Mahathat Secondary Demonstration School	76	249.3	0.0482	1.2246	c	C
Wat Phra Si Mahathat	461	1512.1	0.0032	0.0820	a	A
College of Buddhist Studies and Philosophy	71	232.9	0.0534	1.3562	c	C
Thai Niyom Songkhro School	326	1069.3	0.0054	0.1378	a	A
Bang Khen District Office	94	308.3	0.0350	0.8903	b	B
Prachaphiban School	106	347.7	0.0293	0.7434	b	B
The Office of Diesease Prevention and Control 1 Bangkok	197	646.2	0.0116	0.2934	b	B
Krirk University	72	236.2	0.0523	1.3280	c	C
2nd Infantry Battalion	245	803.6	0.0083	0.2116	b	B
Pramot Witthaya School, Ram Inthra	85	278.8	0.0408	1.0353	c	C
Aiamphanit Witthaya School	237	777.4	0.0088	0.2224	b	B
Thai Police Aviation Division	332	1089.0	0.0053	0.1341	a	A
Ram Borirak School	434	1423.5	0.0035	0.0897	a	A
Mu Ban Sawatdikan Thahanbok Phattana Association	268	879.0	0.0073	0.1849	b	B
Bureau of Personnel Competency Development	82	269.0	0.0430	1.0927	c	C
Pramot Patthana Kindergarden School	203	665.8	0.0110	0.2805	b	B
Sai Aksorn School	63	206.6	0.0639	1.6225	c	C
San Chao Mae Suea Shrine	28	91.8	0.2156	5.4761	d	D
Chat Witthaya School	108	354.2	0.0285	0.7229	b	B
Masjid An - Eao Kop School	370	1213.6	0.0045	0.1140	a	A
Masjid An - Eao Kop	353	1157.8	0.0048	0.1223	a	A
Synphaet General Hospital	76	249.3	0.0482	1.2246	c	C
Nopparat Rajathanee Hospital	283	928.2	0.0067	0.1704	b	B
Thaksina Business Administration Technological College	77	252.6	0.0473	1.2008	c	C
Setthabutbamphen School	134	439.5	0.0206	0.5231	b	B
Serirak Hospital	185	606.8	0.0127	0.3224	b	B
Navamin Hospital	204	669.1	0.0110	0.2785	b	B
Minburi Technical College	152	498.6	0.0170	0.4330	b	B
Navamin 9 Hospital	104	341.1	0.0301	0.7650	b	B
Minburi Commercial School	507	1663.0	0.0028	0.0711	a	A
Suk Net School	100	328.0	0.0319	0.8113	b	B
Minburi Sueksa School	232	761.0	0.0090	0.2296	b	B
Minburi Public Health Center	218	715.0	0.0099	0.2521	b	B
Minburi District Office	367	1203.8	0.0045	0.1154	a	A
Minburi Remand Prison	495	1623.6	0.0029	0.0737	a	A
Office of the Attorney General Changwat Minburi	133	436.2	0.0208	0.5290	b	B
Minburi School	210	688.8	0.0105	0.2666	b	B
Sattri Setthabutbamphen School	435	1426.8	0.0035	0.0894	a	A
Min Prasat Witthaya School	288	944.6	0.0065	0.1660	b	B
Kasembundit University, Rom Klao Campus	720	2361.6	0.0017	0.0420	a	A

(2) Operation Phase

Vibration during operation phase of the Pink Line Project: Khae Rai-Min Buri Section was from the train travelling on the single rail. The vibration will be transferred via the eath which acts as a medium to impact receptors in the vicinity.

From the book "Transit Noise and Vibration Impact Assessment" of Federal Transit Administration (FTA), it was determined that the levels of ground-surface vibration of rubber-tired vehicles on good road surface at 30 mph speed (approximately 48 km/h) will cause ground-surface vibration at 73 VdB (velocity level in decibel) at a distance of 15 meters (approximately 50 f) from the track centerline, as presented in ***Figure 5.1-12***.



Source : Federal Transit Administration (FTA)

Figure 5.1-12 : Generalized Ground Surface Vibration Curves

For the operation of this Project, it was considered that an LRT (Light Rail Vehicle) would travel at a speed of approximately 50 mph (approximately 80 km/h) and the projected ground-surface vibration level would be 73 VdB.

Conversion of VdB (RMS Vibration Velocity) to PPV (Peak Particle Velocity) is made by the following equation:

$$L_v = 20 \times \log_{10} (v/v_{ref})$$

When L_v = the velocity level in decibels (VdB)
v = rms velocity amplitude (in/sec)
v_{ref} = reference velocity amplitude (= 1×10^{-6} in/sec)

Source: Federal Transit Administration (FTA)

Represented by; $73 = 20 \times \log_{10} (v/1\times10^{-6})$
$73 = 20 \times (\log_{10} (v) - \log_{10}(1\times10^{-6}))$

$$73/20 = \log_{10}(v) - \log_{10}(1x10^{-6})$$
$$\log_{10}(v) = -2.35$$
$$v = 0.0045 \quad \text{in/sec}$$

Therefore, PPV from vibration source during operation phase would be 0.0045 in/sec. This vibration level occurred at the pier of the elevated structure, when compared with the recommended criteria of Whiffin and Leonard in ***Table 5.1-16*** and the Notification of the National Environmental Board No.37, B.E.2553 (2010) on Vibration Standard for Impact Protection on Buildings, as presented in ***Table 5.1-17***, was found that its effect along the Project alignment on human reaction was at the imperceptible level and unlikely to cause damage of any type on buildings. The vibration level would be decreased with the increasing distance.

From vibration measurement in the existing conditions of the receptor locatoions along the Project alignment; Boromarajonani College of Nursing in Nonthaburi Province, Synphaet General Hospital, and Phranakhon Rajabhat University, it was found that the maximum vibration level (on any axis) was 3.67 mm/sec (0.1445 in/sec) at Boromarajonani College of Nursing receiver. Continuous exposure to vibration of this level would begin to annoy people. However, this level does not impose a risk of architectural damage to normal buildings. Vibration source in the existing measurement was heavy vehicles travelling on Tiwanon road. It was obvious that the existing vibration level was higher than the projected level from the Project. In the actual conditions after the Project construction phase, vibration source is the train travelling on the elevated structure. The vibration will be transferred to the pier of the elevated structure deep in the ground. The vibration will be absorped underground and thus the surface vibration will decrease. Consequently, it was projected that vibration impact from the monorail system on the elevated structure would be low.

5.2 ECOLOGICAL ENVIRONMENTAL RESOURCES

5.2.1 Aquatic Ecosystem

(1) Elevated Structure and Stations

(A) Construction Phase

It was anticipated that construction activities, specifically the stripping works, land grading and filling, foundation drilling, or construction equipment and material mobilization (such as sand, gravel, cement, soil etc.) would not affect aquatic ecosystem of surface water sources. Eventhough the mass transit system alignment passes more than 20 surface water sources, no part of the pier construction of the elevated structure and station would encroach into surface water sources. Therefore, no activities would disturb the quality of surface water nor directly affect aquatic ecosystem, except for the construction activities of 10 stations situated no further than 50 meters from surface water sources. The construction of these stations may affect the turbidity of water from leachate but only during the foundation drilling and land grading and filling activities, and may cause contamination from machine oil. The 10 stations are PK04, PK10, PK11, PK14, PK15, PK20, PK21, PK23, PK29 and PK30. The turbidity and oil spill will obstruct the penetration of sunlight into the water for a certain level. This would reduce photosynthesis ability of phytoplankton which would result in less dissolved oxygen generated by phytoplankton. It was anticipated that there would be temporarily low impact in the construction phase because the construction areas are limited to traffic island areas only. Moreover, the review of quantity of suspended solids (B.E.2546-2550) (2003-2007) and the analysis of suspended solids (B.E.2551) (2008) of surface water sources along the mass transit system alignment, represented by Khlong Bang Talat, Khlong Prapa, Khlong Premprachakon, Khlong Khru, Khlong Lamchala, Khlong Lumphai, Khlong Lamkret, Khlong Bangchan, Khlong Song Ton Nun, and Khlong San Sap, has shown than quantity of suspended solids was 1.0-72.0 mg/litre, which is in the low-medium level (<25-100 mg/litre, Boyd, 1979) and does not affect aquatic lives and benthic animals.

(B) Operation Phase

The monorail mass transit system operating on elevated structure is powered by electricity, therefore there would be no aquatic ecosystem impact on surface water sources along the Project alignment, especially Khlong Prapa. For the 10 stations (PK04, PK10, PK11, PK14, PK15, PK20, PK21, PK23, PK29 and PK30) located no further than 50 meters from surface water sources, the quantity of sewage for maximum 10 staff/station (such as ticket officer, PR, security officer, and communication officer etc.) was computed at 0.40 cubic meters/day which would be treated by a 2 cubic meters sceptic tank installed at every station. The quality of discharge wastewater wil be in compliance with the Notification of the Ministry of Natural Resources and Environment on Building Effluents Standards, published in the Royal gazette Vol.122 Part 125 D, dated 29 December B.E.2548 (2005). Therefore, it was anticipated that there would be no aquatic ecosystem impact on surface water sources. .

The present study has designed 6 additional stations on the same route alignment with a total distance of 34.5 km. The 6 stations are Chaeng Watthana 28, TOT, Ram Inthra 3, Ram Inthra 31, Ram Inthra 40, and Ram Inthra 83. Therefore, construction activities affecting aquatic ecosystem in the area of the elevated structure and stations are of the same nature as those of the previous study.

(2) Depot and Park & Ride Building

The construction of Depot and Park & Ride Building at Rom Klao Intersection may have impact on aquatic ecosystem as described follows:

(a) Construction Phase

Surface water source adjacent to Rom Klao Intersection is Khlong Song Ton Nun. No structural construction encroaches into the water course. However, the turbidity of the water may increase due to leachate from only foundation drilling and land grading and filling activities or machine oil contamination from contruction machinery and equipment. The turbidity and oil spill would obstruct the penetration of sunlight into the water for a certain level. This would reduce photosynthesis ability of phytoplankton which results in less dissolved oxygen generated by phytoplankton. It was anticipated that there would be only temporarily low impact in the construction phase. In addition, a temporary drainage trench of 0.60×0.60 meters will be digged up around the construction areas, with 2 sedimentation ponds of 1.00×1.00×1.00 meters at the far end of the trench to receive wastewater from construction activities before discharge to Khlong Song Ton Nun.

(b) Operation Phase

This present study has cancelled Depot and Park&Ride Building at Sanambin Nam junction. Therefore, there would be no aquatic ecosystem impact at this location. For the Depot and Park&Ride Building at Rom Klao intersection, Ramkhamhaeng road, a wastewater treatment system will be equipped before discharge to Khlong Song Ton Nun. Therefore, it was anticipated that there would be no aquatic ecosystem impact.

5.3 HUMAN USE VALUES

5.3.1 Pattern of Land Use

(1) Elevated structure and Stations

(a) Construction Phase

The present study has designed 6 additional stations on the same Project alignment with a total distance of 34.5 km. The 6 stations are Chaeng Watthana 28, TOT, Ram Inthra 3, Ram Inthra 31, Ram Inthra 40, and Ram Inthra 83. Therefore, construction activities will permanently change pattern of land use from pavement and vacant areas to be the areas for construction of elevated structure and stations. Therefore, it was anticipated that the impact would be low.

(b) Operation Phase

The present study has designed 6 additional stations on the same Project alignment with a total distance of 34.5 km. The 6 stations are Chaeng Watthana 28, TOT, Ram Inthra 3, Ram Inthra 31, Ram Inthra 40, and Ram Inthra 83. Pattern of land use in the surrounding areas of the new 6 stations maybe changed to highly dense residential, commercial and business areas, such as large shopping centers, office buildings or entertainment spots, etc. Therefore, the impact would be in the medium-high level.

(2) Depot and Park&Ride Building

The construction of Depot and Park&Ride Building at Rom Klao Intersection may have effects on pattern of land use as follows:

(a) Construction Phase

This present study has cancelled Depot and Park&Ride Building at Sanambin Nam junction. Therefore there is no impact on pattern of land use in this area. The area of Depot and Park&Ride Building at Rom Klao Intersection has been extended to cover an area of 229 rai or 366,400 m^2. Pattern of land use thus needs to change from agricultural and vacant area (formerly rice fields) into area for construction of depot and park & ride building. Therefore, it was anticipated that the impact would be medium-high level.

(b) Operation Phase

This present study has cancelled Depot and Park&Ride Building at Sanambin Nam junction. Therefore, there is no impact on pattern of land use in the area. However, the pattern of land use at Rom Klao Intersection area, Ramkhamhaeng road needs to change, only in some part, from vacant area (formerly rice fields) to area for depot and park&ride building which covers wider area than that in the study of B.E.2555 (2012). As the present site condition is still a vacant area, therefore, it was anticipated that the impact would be medium-high.

5.4 QUALITY OF LIFE VALUES

5.4.1 Displacement and Expropriation

The present study of the impact on loss of land and constructions was detailed as follows:

- Loss of state enterprises' land along the mass transit system alignment of 15-3-42.88 (rai-ngan-wa^2) and land loss of the private sector of 33-1-12.75 (rai-ngan-wa^2), worth 5,112,129,757.00 Baht in total.
- Loss of buildings/constructions along the mass transit system line totaling 176 units, with 175 units owned by private sector and 1 unit by government sector/state enterprise. Buildings/constructions loss in the area of depot and park&ride building at Rom Klao Intersection comprises 9 units of buildings privately owned, total worth of 479,970,994.00 Baht.

Total expropriatation price was preliminary estimated at 5,592,100,751.00 Baht. The loss of land and buildings/constructions have mental effects on those who are displaced and whose properties are expropriated. They would feel anxious and concerned to lose the places or locations of doing budiness, or changing of educational places of their children. Those changes would affect more additional expenses, including emotional binding with their original communities and self-adjustment to new places. The impact was high.

CHAPTER 6

HEALTH IMPACT ASSESSMENT

CHAPTER 6

HEALTH IMPACT ASSESSMENT

6.1 INTRODUCTION

Project development in the past has caused impacts on health and the living of people around the Project. Physical health impacts are such as death, illness from communicable and non-communicable diseases. Mental health impacts are such as tension, anxiety, and feeling of loss. Therefore, the project owners, either be it the government, state enterprise or private sectors, are required to conduct Health Impact Assessment (HIA) on the respective project development. The results of the assessment will be used for formulation of prevention, correction and mitigation measures of environmental impact as well as health impact monitoring plan of the Environmental Impact Assessment (EIA) report. Moreover, the Environmental Quality Management Plan, B.E.2550-2554 (2007-2011) also emphasizes health impact assessment.

This health impact assessment of the Project has followed the HIA guidelines for an EIA report, issued in September B.E.2553 (2010) by the Office of Natural Resources and Environmental Policy and Planning, the Ministry of Natural Resources and Environment. Health determinants of the study have related to the Project activities in 3 phases; pre-construction, construction and operation. The consideration also covered potential helath impacts on communities and sensitive areas in the vicinity of the Project, including occupational health and safety impact on the Project construction workers in pre-construction and construction phases. The analysis has used secondary data on public health and individual health within the Project areas, including basic data of other relevant environmental factors, such as occupational health, accidents and safety, sanitation, and economic and social conditions. In addition, risk assessment was also conducted to anticipate impact levels.

The feasibility and detailed design study of the Pink Line MRT Project:, Khae Rai-Min Buri Section has estimated that there would be health impact on the people in the communities and sensitive areas close to the Project site. The Project would also affect occupational health of construction workers in the pre-construction and construction phases, particularly, the impact on air quality due to dust diffusion and air pollutants, annoyance noise and vibration from machines and construction equipment. In the operation phase, wastewater or solid waste would affect the quality of surface water sources near or along the Project alignment. Therefore, it was very essential to conduct the health impact assessment in order to determine measures and implementation plans of heal impact protection and correction as well as appropriate health impact monitoring plans.

6.2 OBJECTIVE OF THE STUDY

(1) To present data of the existing health status of the communities close to the Project areas, including communities' concerns, so that the decision making on the policy of the Project development would be on the actual and comprehensive information.

(2) To assess the impacts relevant to project development activities. The impacts are both positive and negative on health status of the communities and sensitive areas close to the Project in 3 phases; pre-construction, construction and operation phases, including the impact on health of construction workers in pre-construction and construction phases.

(3) To use the impact assessment result as an input for formulating health impact protection and correction measures and implementation plans, including effectient and appropriate health impact monitoring plan.

6.3 SCOPE AND METHOD OF STUDY

6.3.1 Scope of Study

The assessment of health impact of the Project emphasized on the projection of continuous impacts on health status of the people in the Project areas due to project development activities in 3 phases; pre-construction, construction and operation phases. The assessment was associated with the details of the Project and the data of the existing environmental conditions. The consideration has been made on health determinants, with the assumption that the project development activities would cause changes to health determinants of the people living in the communities and sensitive areas close to the Project.

6.3.2 Method of Study

The assessment of impacts from project development activities on the health of people living in communities and sensitive areas close to the Project alignment and that of construction workers was in accordance with the HIA guidelines. The guidelines, prepard by the Office of Natural Resources and Environmental Policy and Planning, the Ministry of Natural Resources and Environment, defined the health assessment method for an environmental impact assessment and was issued in September B.E.2553 (2010). The method began with the screening and scoping process, referring to secondary data in various aspects and existing basic information before commencement of project development. After that, health risk assessment was analysed to estimate impact level and likelihood of the impact happening. The assessment covered opportuntites of impact happening and severity of consequence. The health impact assessment result will be taken for formulation of health impact protection and correction measures and implementation plans, including appropriate health impact monitoring plans. Details are as follows:

(1) Screening

In the screening step, preliminary consideration was made on overall potential impacts generated by project development activities, based on the Project basic information, such as the principle, objective, target, project descriptions, population or groups of population in the vicinity of the Project. The impacts identified in this step may or may not have significant effects on health status of people in the communities and sensitive areas close to the Project site, as well as on health stutus of Project construction workers. The tools applied in the screening comprised general site survey, unofficially visiting public health officers and local administrative organization officers.

(2) Scoping Significant and Potential Impacts

The scoping of the previously identified impacts in the screening step would determine potential impacts which might cause changes to the health determinants of people in the communities and Project construction workers. The determination of potentials and significance of the impacts was to anticipate possible positive and negative impacts on construction workers and people in the communities close to the Project areas.

(3) Health Impact Analysis

Analytical method of health impact from project development activities in 3 phases; pre-construction, construction and operation, comprised quantitative and qualitative analyses.

(4) Formulation of Prevention and Correction Measures and Implementation Plans for Negative Health Impact and Measures and Implementation Plans for Increasing Potential of Positive Impact

The result of health impact analysis and evaluation will be applied for formulation of prevention, correction and mitigation measures and implementation plans for negative health impact and those for increasing potential of positive impact covering the 3 phases of project development; pre-construction, construction and operation.

(5) Formulation of Health Impact Monitoring Implementation Plan

In order to evaluate the effectiveness of the health impact prevention, correction and mitigation plans formulated by the Project during the pre-construction, construction and operation phases, it was thus essential to formulate health impact monitoring plan to evaluate the effectiveness of performance according to the prevention, correction and mitigation plans. The outcomes of the monitoring will be applied for improvement of the measures and plans on health impact prevention, correction and mitigation.

6.4 THE STUDY RESULT

6.4.1 Health Impact Screening

This step was a process with an aim to achieve a preliminary conclusion of overall potential impacts from Project development activities, areas with possible exposure to the impact. The process comprised surveying and collecting field data, considering Project development activities, and considering analysis result of preliminary environmental assessment. The outcomes of the screening process was summarized as follows:

(1) Communities and Sensitive Areas Close to the Project Alignment

The Project alignment passes across Bangkok Metropolitan Administration areas in 5 Khet; Khet Min Buri, Khen Bueng Kum, Khet Khan Na Yao, Khet Bang Khen and Khet Lak Si, and 7 Khwaeng; Khwaeng Min Buri, Khwaeng Khlong Kum, Khwaeng Khan Na Yao, Khwaeng Tha Raeng, Khwaeng Anu Saowari, Khwaeng Talat Bang Khen, and Khwaeng Thung Song Hong. In Changwat Nonthaburi, the Project alignment passes 2 Amphoe; Amphoe Pak Kret and Amphoe Mueang Nonthaburi, and 7 Tambon; Tambon Pak Kret, Tambon Khlong Kluea, Tambon Bang Talat, Tambon Tha Sai, Tambon Bang Kraso, Tambon Talat Khwan, and Tambon Bang Khen. The number of communities and sensitive areas within the radius of 500 meters from the centerline of the Project alignment has been summarized by grouping into Khet/Amphoe and Khwaeng/Tambon as follows:

(a) Communities with potential health impact: a total of 43 communities, as presented in ***Table 6.4-1***.

Table 6.4-1 Descriptions of Communities/Villages Exposed To Health Impact, within the Radius of 500 Meters from the centerline of the Project Alignment.

Changwat	Khet/Amphoe	Khwaeng/Tambon	Communities/Villages
Bangkok Metropolitan Administration	Min Buri	Min Buri	Chumchon Phatthana Buengkhwang
			Chumchon Bangchan Phatthana
			Chumchon Muban Pricha
			Chumchon Muban Sinthani
			Chumchon Minburi
	Bueng Kum	Khlong Kum	Chumchon Khang Rongrian Sai Akson
	Khan Na Yao	Khan Na Yao	Chumchon Muban Rangsiya
			Chumchon Muban Chuenkamon Nivet 4
			Chumchon Muban FineHome 3
			Chumchon Muban Premruethai 3
			Chumchon Muban Premruethai 1
			Chumchom Muban Bokothahansungsut
Bangkok Metropolitan Administration	Bang Khen	Tha Raeng	Chumchon Muban Ram Inthra 67
			Chumchon Muban Sukchai Village
			Chumchon Muban Dong Hiran
			Chuchon Muban Yuyen Pensuk
			Chumchon Muban Suksanti
			Chumchon Muban Kaosaengsong
			Chumchon Kheha Ram Inthra Komo 4
			Chumchon Muban Siwong
			Chumchon Muban Chaloemsuk 9

Table 6.4-1 Descriptions of Communities/Villages Exposed to Health Impact, within the Radius of 500 Meters from the Centerline of the Project Alignment. (Cont'd)

Changwat	Khet/Amphoe	Khwaeng/Tambon	Communities/Villages
Bangkok Metropolitan Administration (Cont'd)		Anu Saowari	Chumchon Muban Bangkhen Villa
			Chumchon Muban Phromsuk
			Chumchon Muban Iam Phanit
			Chumchon Muban Chaloemsuk Niwet 6
			Chumchon Muban Panthong 3
			Chumchon Phetcharawut
			Chumchom Phetcharawut Phan 1
			Chumchon Suksan Phatthana
			Chumchon Ruamphatthanatai
	Lak Si	Talat Bang Khen	Chumchon Lak Si
			Chumchon Kao Na
			Chumchon Talat Lak Si
		Thung Song Hong	Chumchon Kongsanphawutbao Phon Nueng Ro-o
			Chumchon Po-to-o (1)
			Chumchon Phongphet Chaeng Watthana 14
			Chumchon Sai Ngam
			Chumchon Lat Trawen
			Chumchon Thahan Suea
			Chumchon Chaeng Watthana Phasuk
			Chumchon Kong Thahan Phalathikan Kongphon Ti Nueng Raksa Phra-ong
Nonthaburi	Pak Kret	Pak Kret	Sala Khi Plot
		Khlong Kluea	Khlong Kluea

Source: From field servey of Team Consulting Engineering and Management Co,. Ltd., B.E.2555 (2012)

(2) Project Development Activities with Potential Health Impact

Activities during pre-construction, construction and operation phases which have potential health impact are as follows:

(a) Pre-construction and Construction Phases

Activities during pre-construction and construction phases were site preparation for construntion works, site preparation for an establishment of construction units, earth/gravel works, preparation and mobilization of construction materials/parts, transportation of construction waste, elevated structure and drainage system works, arrangement of public utility, sanitary, and security systems of worker camps and Project construction supervision office.

(b) Operation Phase

Activities durin operation phase were the using of transportation services at the stations by people and maintenance activities.

(3) Human Exposure Scenario

The major groups exposed to health impact were:

(a) Construction workers working in the construction areas were exposed to pollutants possibly emitted throughout working hours everyday (8 hours/day) during pre-construction and construction phases.

(b) People living in the communities and sensitive areas close to and around the Project areas. Inpatients of the places for medical treatment close to the Project alignment were the group with a high risk of pollutant exposure.

(c) Commuters passing by the Project construction areas during pre-construction and construction phases.

(4) Potential Health Impact on Construction Workers and People Living in the Communities and Sensitive Areas Close to the Project Areas is presented as follows:

(a) Pre-construction and Construction Phases

Physical health hazards were particulate matter from soil, smoke from vehicle exhaust gas, noise, and vibration. People living close to the Project construction sites were exposed to these hazards by breathing, seeing, hearing and feeling. Prolonged exposure would impose a risk of developing diseases, such as respiratory diseases, hearing system disease, including vision problems. Contributors to physical health hazards were the changes in soil resources, air quality, noise quality, surface water quality near the living areas of construction workers and construction supervision office building. The contributors included vibration, accidents and safety issue, sanitation management of worker camps and construction supervision office building, as well as inadequate public health and individual health services due to increasing of foreign workers and people' illnesses from Project activities.

Psychological hazards during pre-construction and construction phases were anxiety, annoyance, difficulties, tension and fear. These factors might lead to road accidents because the Project construction changed the environment around the construction areas and also lives of the people living in the vicinity of the Project construction site. These changes had impact on mental status of the people. The awareness level of the impact was subject to the severity of consequence of the impact and the exposure duration. Contributors to psychological hazards were soil resources, surface water hydrology and surface water quality, air quality, noise quality, vibration, transportation, drainage and flood controlling, socio-economic scenario, displacement and expropriation (Details as per ***Table 6.4-2***).

Risk groups to the above impacts were, firstly, construction workers who were directly exposed to health hazards. Secondly, people living in or around the Project construction areas; the communities and those in sensitive areas close to the Project area and commuters passing by during the occurrence of activities in pre-construction and construction phases.

(b) Operation Phase

Important physical hazards were the same things as those in the pre-construction and construction phases; particulate matter, noise, and vibration. Apart from that, effluent, wastewater and solid waste were additional health hazards from the train station operating sevices. These health hazards caused long-term impact when the operating services were provided. Exposure channels could be by breathing, hearing, and feeling. Prolonged exposure to the impact would cause disease development. Contributors to physical hazards in operation phase were water pollution, air pollution, noise pollution, vibration, safety and accidents.

Table 6.4-2 Health Hazard Impacts from Project Activities

Impact/Health Hazards	Relevant Project Activities
Pre-construction and Construction Phases	
1. Particulate Matter	• Clearing and grading • Excavation, cut-and-fill works, foundation soil stabilization • Construction materials/parts mobilization • Construction waste transportation • Traffic and transportation of the Project
2. Noise	• Construction machinery operation • Pier Construction • Elevated structure, foundation and column construction • Traffic and transportation of the Project
3. Vibration	• Construction machinery operation • Pier Construction • Foundation and pier column construction of the elevated structure • Traffic and transportation of the Project
4. Wastewater/impaired surface water quality	• Wastewater and effluent from worker camps and construction supervision office building
5. Occupational accidents and illnesses, and unsafe and inappropriate work environments	• Construction equipment/machinery transportation • Outdoor operation • Working without wearing personal protective equipment (PPE)
6. Entry of foreign workers affecting health services system	• Workers/staff using community public health services. • The spread of communicable and non-communicable diseases, and drug addiction by foreign workers
7. Inadequacy of public health facilities, public health officers and medical personnel	• Workers/staff using community public health services.
8. Road accidents	• Traffic and transportation of the Project.
9. Tension, anxiety, annoyance and fear	• Every activity causing changes around the Project construction areas or affecting the living of people in the vicinity of the Project
Operation and Maintenance Phase	
1. Particulate matter and air pollutants	• The train operating services.
2. Noise	• The train operating sevices.
3. Vibration	• The train operating services.
4. Wastewater/impaired surface water quality	• Effluent and solid waste from the train operating services.
5. Anxiety of the people in the Project areas	• Exposure to impact from pollution emitted by the train operating services.
6. Travelling conveniences	• The train operating services.
7. Increase in earnings of the local people	• The train operating services.

Psychological hazards that affected health in operation phase were anxiety, annoyance, difficulties, tension and fear, possibly inclusive of accidents. This was because in the operation phase, the Project would cause changes to the environments and the living of the people living close to or around the Project areas. . These changes would have impact on mental status of the affected. Contributors to psychological hazards were surface water hydrology and surface water quality, air quality, noise quality, vibration, transportation, drainage and flood controlling, socio-economic scenario, and communities separation (details as presented in ***Table 6.4-2***).

Risk groups to the above impacts were people living in or around the Project construction areas and commuters. Apart from psychological hazards, there were also social hazard in operation phase, for example, annoyance due to increasing noise of trains. However, threr was positive impact, such as conveniences in commuting, increasing in earnings of the local/people.

6.4.2 Impact Screening and Assessment Scoping

From field survey, research and review of information sources or secondary data and relevant documentation, including the study on implementation of public participation, it was found that health determinants to be taken for consideration were:

(1) Population Data and Vital Statistics

The preliminary screening has identified the scope of areas potentially exposed to health impact from the Project activities in 3 phases. Most of the areas were within 500-meter radius from the centerline of the Project alignment. Details of population data and vital statistics in B.E.2550-2554 (2007-2011) were summarized as follows (details as per ***Table 6.4-3***):

(a) Bangkok Metropolitan Administration

The Project alignment passed 5 Khet; Khet Min Buri, Khet Bueng Kum, Khet Khan Na Yao and Khet Lak Si. Details of population data and vital statistics, classified by Khwaeng where the Project alignment passed could be summarized as follows:

Khet Min Buri: The Project alignment passed 1 Khwaeng; Khwaeng Min Buri. Details were as follows:

Khwaeng Min Buri

From the vital statistics of Khwaeng Min Buri in the past 5 years (B.E.2550-2554) (2007-2011), number of population ranged between 88,148-93,907, with the maximum of 93,907 in B.E.2554 (2011). With consideration given to population tendency for the past 5 years, number of population has been increasing continuously since B.E.2550 (2007). The highest number of births and birth rates per 1,000 population were at 5,375 and 57.24 per 1,000 population in B.E.2554 (2011) respectively, with the lowest at 2,723 and 30.89 per 1,000 population in B.E.2550 (2007) respectively. The highest number of deaths and death rates per 1,000 population were at 416 and 4.47 per 1,000 population in B.E.2553 (2010), with the lowest at 364 and 4.04 per 1,000 population in B.E.2552 (2009) respectively.

For the increase/decrease rate per 100 population, it was found that during B.E.2550-2554 (2007-2011) number of births exceeded number of deaths, ranging at 26.76-52.87 per 100 population. In B.E.2554 (2011), the highest population increase rate was at 52.87 per 100 population, while in B.E.2550 (2007), the lowest was at 26.76 per 100 population.

Khet Bueng Kum : The Project alignment passed 1 Khwaeng; Khwaeng Khlong Kum. Details were as follows:

Khwaeng Khlong Kum

From the vital statistics of Khwaeng Khlong Kum in the past 5 years (B.E.2550-2554) (2007-2011), number of population ranged between 70,381-147,466, with the maximum of 147,466 in B.E.2551 (2008). With consideration given to population tendency for the past 5 years, number of population has been decreasing continuously since B.E.2550 (2007), except for the year B.E.2551 (2008) when number of population increased by 1.58 percentage compared to B.E.2550 (2007). The highest

Table 6.4-3 Popolation Data and Vital Statistics Classified by Khwaeng/Tambon along the Alignment of the Pink Line MRT Project : Khae Rai-Min Buri Section in the Past 5-year Period (B.E.2550-2554) (2007-2011)

Changwat	Khet/Amphoe	Khwaeng/ Tambon	Year (B.E.)	Population and Vital Statistics					
				Population	Births	Birth Rates/1000 population	Deaths	Death Rates/1000 population	Population increase/decrease rate per 100 population
Bangkok Metropolitan Administration	Min Buri	Min Buri	B.E.2550	88,148	2,723	30.89	364	4.13	26.76
			B.E.2551	90,405	3,152	34.87	376	4.16	30.71
			B.E.2552	91,729	4,089	44.58	371	4.04	40.53
			B.E.2553	93,052	4,828	51.88	416	4.47	47.41
			B.E.2554	93,907	5,375	57.24	410	4.37	52.87
	Bueng Kum	Khlong Kum	B.E.2550	145,172	290	2.00	618	4.26	-2.26
			B.E.2551	147,466	410	2.78	611	4.14	-1.36
			B.E.2552	122,949	373	3.03	617	5.02	-1.98
			B.E.2553	71,023	64	0.90	372	5.24	-4.34
			B.E.2554	70,381	1	0.01	365	5.19	-5.17
	Khan Na Yao	Khan Na Yao	B.E.2550	85,027	9,564	112.48	391	4.60	107.88
			B.E.2551	85,586	8,503	99.35	394	4.61	94.75
			B.E.2552	37,441	6,909	184.53	346	9.24	175.29
			B.E.2553	38,100	5,563	146.01	184	4.83	141.18
			B.E.2554	38,642	5,645	146.08	199	5.15	140.93
	Bang Khen	Tha Raeng	B.E.2550	81,703	4	0.05	355	4.35	-4.30
			B.E.2551	83,459	5	0.06	375	4.49	-4.43
			B.E.2552	85,808	4	0.05	347	4.04	-4.00
			B.E.2553	88,684	0	0.00	366	4.13	-4.13
			B.E.2554	90,034	0	0.00	400	4.44	-4.44
		Anu Saowari	B.E.2550	100,632	1,316	13.08	426	4.23	8.84
			B.E.2551	100,377	1,255	12.50	463	4.61	7.89
			B.E.2552	100,093	1,126	11.25	438	4.38	6.87
			B.E.2553	99,480	1,062	10.68	507	5.10	5.58
			B.E.2554	98,218	868	8.84	482	4.91	3.93
	Lak Si	Talat Bang Khen	B.E.2550	30,259	1	0.03	142	4.69	-4.66
			B.E.2551	30,176	2	0.07	129	4.27	-4.21
			B.E.2552	29,755	3	0.10	145	4.87	-4.77
			B.E.2553	29,530	42	1.42	164	5.55	-4.13
			B.E.2554	29,169	15	0.51	149	5.11	-4.59
		Thung Song Hong	B.E.2550	85,796	347	4.04	400	4.66	-0.62
			B.E.2551	85,342	279	3.27	398	4.66	-1.39
			B.E.2552	84,425	306	3.62	374	4.43	-0.81
			B.E.2553	83,378	776	9.31	441	5.29	4.02
			B.E.2554	81,951	1,544	18.84	443	5.41	13.43
Nonthaburi	Pak Kret	Pak Kret	B.E.2550	36,111	822	22.76	188	5.21	17.56
			B.E.2551	36,460	834	22.87	183	5.02	17.86
			B.E.2552	36,310	813	22.39	205	5.65	16.74
			B.E.2553	36,419	805	22.10	210	5.77	16.34
			B.E.2554	36,563	1,058	28.94	214	5.85	23.08
		Khlong Kluea	B.E.2550	8,887	0	0.00	39	4.39	-4.39
			B.E.2551	8,810	0	0.00	39	4.43	-4.43
			B.E.2552	8,763	0	0.00	47	5.36	-5.36
			B.E.2553	8,697	0	0.00	44	5.06	-5.06
			B.E.2554	8,671	1	0.12	44	5.07	-4.96
		Bang Talat	B.E.2550	49,049	2,168	44.20	326	6.65	37.55
			B.E.2551	48,720	2,268	46.55	285	5.85	40.70
			B.E.2552	48,522	2,210	45.55	309	6.37	39.18
			B.E.2553	48,169	2,304	47.83	320	6.64	41.19
			B.E.2554	47,791	2,355	49.28	309	6.47	42.81
	Mueang Nonthaburi	Tha Sai	B.E.2550	74,053	4	0.05	411	5.55	-5.50
			B.E.2551	74,108	0	0.00	414	5.59	-5.59
			B.E.2552	74,302	3	0.04	354	4.76	-4.72
			B.E.2553	74,229	1	0.01	473	6.37	-6.36
			B.E.2554	73,654	1	0.01	429	5.82	-5.81
		Bang Kraso	B.E.2550	55,666	4,356	78.25	303	5.44	72.81
			B.E.2551	55,488	4,486	80.85	302	5.44	75.40
			B.E.2552	55,323	4,246	76.75	310	5.60	71.15
			B.E.2553	55,203	3,965	71.83	307	5.56	66.26
			B.E.2554	54,954	4,130	75.15	359	6.53	68.62
		Talat Khwan	B.E.2550	54,650	1,415	25.89	312	5.71	20.18
			B.E.2551	54,007	1,226	22.70	281	5.20	17.50
			B.E.2552	53,426	971	18.17	290	5.43	12.75
			B.E.2553	52,629	1,051	19.97	294	5.59	14.38
			B.E.2554	51,410	727	14.14	335	6.52	7.62
		Bang Khen	B.E.2550	42,594	690	16.20	263	6.17	10.02
			B.E.2551	42,476	632	14.88	229	5.39	9.49
			B.E.2552	42,636	619	14.52	228	5.35	9.17
			B.E.2553	42,284	605	14.31	245	5.79	8.51
			B.E.2554	41,831	626	14.96	232	5.55	9.42

Source: Civil registration database, Department of Provincial Administration, Ministry of Interior B.E.2550-2554 (2007-2011) number of births was at 410 in B.E.2551 (2008) and the highest birth rate per 1,000 population was at 3.03 per 1,000 population in B.E.2552 (2009), with the lowest number of births and birth rate per 1,000 population at 1 and 0.01 per 1,000 population in B.E.2554 (2011) respectively. The highest number of deaths was at 618 in B.E.2550 (2007) and the highest death rate per 1,000 population was at 5.24 per 1,000 population in B.E.2553 (2010), with the lowest number of deaths at 365 in B.E.2554 (2011) and the lowest death rate per 1,000 population at 4.14 per 1,000 population in B.E.2551 (2008).

For the increase/decrease rate per 100 population, it was found that during B.E.2550-2554 (2007-2011) number of deaths exceeded number of births, ranging at 1.36-5.17 per 100 population. In B.E.2554 (2011), the highest population decrease rate was at 5.17 per 100 population, while in B.E.2551 (2008), the lowest was at 1.36 per 100 population.

Khet Khan Na Yao : The Project alignment passed 1 Khwaeng; Khwaeng Khan Na Yao. Details were as follows:

Khwaeng Khan Na Yao

From the vital statistics of Khwaeng Khan Na Yao in the past 5 years (B.E.2550-2554) (2007-2011), number of population ranged between 37,441-85,586, with the maximum of 85,586 in B.E.2551 (2008). With consideration given to population tendency for the past 5 years, it was found that in B.E.2552 (2009) number of population significantly decreased by 56.25 percentage compared to B.E.2551 (2008). The highest number of births of Khwaeng Khan Na Yao was at 9,564 in B.E.2550 (2007) and the highest birth rate per 1,000 population was at 184.53 per 1,000 population in B.E.2552 (2009), with the lowest number of births at 5,563 in B.E.2553 (2010) and the lowest birth rate per 1,000 population at 99.35 per 1,000 population in B.E.2553 (2010). The highest number of deaths was at 394 in B.E.2551 (2008) and the highest death rate per 1,000 population was at 9.24 per 1,000 population in B.E.2552 (2009), with the lowest number of deaths at 184 in B.E.2553 (2010) and the lowest death rate per 1,000 population at 4.60 per 1,000 population in B.E.2550 (2007).

For the increase/decrease rate per 100 population, it was found that during B.E.2550-2554 (2007-2011), number of births exceeded number of deaths, ranging at 94.75-175.29 per 100 population. In B.E.2552 (2009), the highest population increase rate was at 175.29 per 100 population, while in B.E.2551 (2008), the lowest was at 94.75 per 100 population.

Khet Bang Khen: The Project alignment passed 2 Khwaeng; Khwaeng Tha Raeng and Khwaeng Anu Saowari. Details were as follows:

Khwaeng Tha Raeng

From the vital statistics of Khwaeng Tha Raeng in the past 5 years (B.E.2550-2554) (2007-2011), number of population ranged between 81,703-90,034, with the maximum of 90,034 in B.E.2554 (2011). With consideration given to population tendency for the past 5 years, number of population has been increasing continuously since B.E.2550 (2007). The highest number of births and birth rates per 1,000 population were at 5 and 0.06 per 1,000 population in B.E.2551 (2008) respectively. In B.E.2553 (2010) and B.E.2554 (2011), number of births was not found. The highest number of deaths was at 400 in B.E.2554 (2011) and the highest death rate per 1,000 population was at 4.49 per 1,000 population in B.E.2551 (2008), with the lowest number of deaths and death rate per 1,000 population at 347 and 4.04 per 1,000 population in B.E.2552 (2009) respectively.

For the increase/decrease rate per 100 population, it was found that during B.E.2550-2554 (2007-2011), number of deaths exceeded number of births, ranging at 4.00-4.44 per 100 population. In B.E.2554 (2011), the highest population decrease rate was at 4.44 per 100 population, while in B.E.2552 (2009), the lowest was at 4.00 per 100 population.

Khwaeng Anu Saowari

From the vital statistics of Khwaeng Anu Saowari in the past 5 years (B.E.2550-2554) (2007-2011), number of population ranged between 98,218-100,632, with the maximum of 100,632 in B.E.2550 (2007). With consideration given to population tendency for the past 5 years, number of population has been decreasing continuously since B.E.2550 (2007). The highest number of births and birth rate per 1,000 population were at 1,316 and 13.08 per 1,000 population in B.E.2550 (2007) respectively. The lowest number of births and birth rate per 1,000 population were at 868 and 8.84 per 1,000 population in B.E.2554 (2011) respectively. The highest number of deaths and death rate per 1,000 population were at 507 and 5.10 in B.E.2553 (2010) respectively, with the lowest number of deaths and death rate per 1,000 population at 426 and 4.23 per 1,000 population in B.E.2550 (2007) respectively.

For the increase/decrease rate per 100 population, it was found that during B.E.2550-2554 (2007-2011), number of births exceeded number of deaths, ranging at 3.93-8.84 per 100 population. In B.E.2550 (2007), the highest population increase rate was at 8.84 per 100 population, while in B.E.2554 (2011), the lowest was at 3.93 per 100 population.

Khet Lak Si : The Project alignment passed 2 Khwaeng; Khwaeng Talat Bang Khen and Khwaeng Thung Song Hong. Details were as follows:

Khwaeng Talat Bang Khen

From the vital statistics of Khwaeng Talat Bang Khen in the past 5 years (B.E.2550-2554) (2007-2011), number of population ranged between 29,169-30,259, with the maximum of 30,259 in B.E.2550 (2007). With consideration given to population tendency for the past 5 years, number of population has been decreasing continuously since B.E.2550 (2007). The highest number of births and birth rate per 1,000 population were at 42 and 1.42 per 1,000 population in B.E.2553 (2010) respectively. The lowest number of births and birth rate per 1,000 population were at 1 and 0.03 per 1,000 population in B.E.2550 (2007) respectively. The highest number of deaths and death rate per 1,000 population were at 164 and 5.55 in B.E.2553 (2010) respectively, with the lowest number of deaths and death rate per 1,000 population at 129 and 4.27 per 1,000 population in B.E.2551 (2008) respectively.

For the increase/decrease rate per 100 population, it was found that during B.E.2550-2554 (2007-2011), number of deaths exceeded number of births, ranging at 4.13-4.77 per 100 population. In B.E.2552 (2009), the highest population decrease rate was at 4.77 per 100 population, while in B.E.2553 (2010), the lowest was at 4.13 per 100 population.

Khwaeng Thung Song Hong

From the vital statistics of Khwaeng Thung Song Hong in the past 5 years (B.E.2550-2554) (2007-2011), number of population ranged between 81,951-85,796, with the maximum of 85,796 in B.E.2550 (2007). With consideration given to population tendency for the past 5 years, number of population has been decreasing continuously since B.E.2550 (2007). The highest number of births and birth rate per 1,000 population were at 1,544 and 18.84 per 1,000 population in B.E.2554 (2011) respectively. The lowest number of births and birth rate per 1,000 population were at 279 and 3.27 per 1,000 population in B.E.2551 (2008) respectively. The highest number of deaths and death rate per 1,000 population were at 443 and 5.41 in B.E.2554 (2011) respectively, with the lowest number of deaths and death rate per 1,000 population at 374 and 4.43 per 1,000 population in B.E.2552 (2009) respectively.

For the increase/decrease rate per 100 population, it was found that during B.E.2550-2552 (2007-2009), number of deaths exceeded number of births, and during B.E.2553-2554 (2010-2011) number of births exceeded number of deaths. The population increase/decrease rate ranged at 1.39-13.43 per 100 population.

(b) Nonthaburi

The Project alignment passed 2 Amphoes; Amphoe Pak Kret and Amphoe Mueang Nonthaburi. Details of population and vital statistics, classified by Tambon where the Project alignment passes across, could be summarized as follows:

Amphoe Pak Kret: The Project alignment passed 3 Tambon; Tambon Pak Kret, Tambon Khlong Kluea, and Tambon Bang Talat. Details were as follows:

Tambon Pak Kret

From the vital statistics of Tambon Pak Kret in the past 5 years (B.E.2550-2554) (2007-2011), number of population ranged between 36,111-36,563, with the maximum of 36,563 in B.E.2554 (2011). With consideration given to population tendency for the past 5 years, number of population has changed differently. In B.E.2552 (2009), number of population decreased by 0.41 percentage compared in B.E.2551 (2008) before increasing continuously since B.E.2553 (2010). The highest number of births and birth rate per 1,000 population were at 1,058 and 28.94 per 1,000 population in B.E.2554 (2011) respectively. The lowest number of births and birth rate per 1,000 population were at 805 and 22.10 per 1,000 population in B.E.2553 (2010) respectively. The highest number of deaths and death rate per 1,000 population were at 214 and 5.85 in B.E.2554 (2011) respectively, with the lowest number of deaths and death rate per 1,000 population at 183 and 5.02 per 1,000 population in B.E.2551 (2008) respectively.

For the increase/decrease rate per 100 population, it was found that during B.E.2550-2554 (2007-2011), number of births exceeded number of deaths, ranging at 16.34-23.08 per 100 population. In B.E.2554 (2011), the highest population increase rate was at 23.08 per 100 population, while in B.E.2553 (2010) the lowest was at 16.34 per 100 population.

Tambon Khlong Kluea

From the vital statistics of Tambon Khlong Kluea in the past 5 years (B.E.2550-2554) (2007-2011), number of population ranged between 8,671-8,887, with the maximum of 8,887 in B.E.2550 (2007). With consideration given to population tendency for the past 5 years, number of population has been decreasing continuously since B.E.2550 (2007). . The highest number of births and birth rate per 1,000 population were at 1 and 0.12 per 1,000 population in B.E.2554 (2011) respectively. In B.E.2550-2553 (2007-2010), number of births in Tambon Khlong Kluea was not found. The highest number of deaths and death rate per 1,000 population were at 47 and 5.36 in B.E.2552 (2009) respectively, with the lowest number of deaths in B.E.2550 (2007) and B.E.2551 (2008) at 39, and the lowest death rate per 1,000 population in B.E.2550 (2007) at 4.39 per 1,000 population.

For the increase/decrease rate per 100 population, it was found that during B.E.2550-2554 (2007-2011), number of births exceeded number of deaths, ranging at 4.39-5.36 per 100 population. In B.E.2552 (2009), the highest population decrease rate was at 5.36 per 100 population, while in B.E.2550 (2007) the lowest was at 4.39 per 100 population.

Tambon Bang Talat

From the vital statistics of Tambon Bang Talat in the past 5 years (B.E.2550-2554) (2007-2011), number of population ranged between 17,791-49,049, with the maximum of 49,049 in B.E.2550 (2007). With consideration given to population tendency for the past 5 years, number of population has been decreasing continuously since B.E.2550 (2007). The highest number of births and birth rate per 1,000 population were at 2,355 and 49.28 per 1,000 population in B.E.2554 (2011) respectively. The lowest number of births and birth rate per 1,000 population were at 2,168 and 44.20 per 1,000 population in B.E.2550 (2007) respectively. The highest number of deaths and death rate per 1,000 population were at 326 and 6.65 in B.E.2550 (2007) respectively, with the lowest number of deaths and death rate per 1,000 population at 285 and 5.85 per 1,000 population in B.E.2551 (2008) respectively.

For the increase/decrease rate per 100 population, it was found that during B.E.2550-2554 (2007-2011), number of births exceeded number of deaths, ranging at 37.55-42.81 per 100 population. In B.E.2554 (2011), the highest population increase rate was at 42.81 per 100 population, while in B.E.2550 (2007) the lowest was at 37.55 per 100 population.

Amphoe Mueang Nonthaburi: The Project alignment passes 4 Tambon; Tambon Tha Sai, Tambon Bang Kraso, Tambon Talat Khwan, and Tambon Bang Khen. Details were as follows:

Tambon Tha Sai

From the vital statistics of Tambon Tha Sai in the past 5 years (B.E.2550-2554) (2007-2011), number of population ranged between 73,654-74,302, with the maximum of 74,302 in B.E.2552 (2009). With consideration given to population tendency for the past 5 years, in was found that in B.E.2550-2552 (2007-2009) number of population had been increasing continuously before decreasing continuously in B.E.2553-

2554 (2010-2011). The highest number of births and birth rate per 1,000 population were at 4 and 0.05 per 1,000 population in B.E.2550 (2007) respectively. In B.E.2551 (2008), the lowest number of births and birth rate per 1,000 population were not found. The highest number of deaths and death rate per 1,000 population were at 473 and 6.37 in B.E.2553 (2010) respectively, with the lowest number of deaths and death rate per 1,000 population at 354 and 4.76 per 1,000 population in B.E.2552 (2009) respectively.

For the increase/decrease rate per 100 population, it was found that during B.E.2550-2554 (2007-2011), number of deaths exceeded number of births, ranging at 4.72-6.36 per 100 population. In B.E.2553 (2010), the highest population decrease rate was at 6.36 per 100 population, while in B.E.2552 (2009) the lowest was at 4.72 per 100 population.

Tambon Bang Kraso

From the vital statistics of Tambon Bang Kraso in the past 5 years (B.E.2550-2554) (2007-2011), number of population ranged between 54,954-55,666, with the maximum of 55,666 in B.E.2550 (2007). With consideration given to population tendency for the past 5 years, number of population has been decreasing continuously since B.E.2550 (2007). The highest number of births and birth rate per 1,000 population were at 4,486 and 80.85 per 1,000 population in B.E.2551 (2008) respectively. The lowest number of births and birth rate per 1,000 population were at 3,965 and 71.83 per 1,000 population in B.E.2553 (2010) respectively. The highest number of deaths and death rate per 1,000 population were at 359 and 6.53 in B.E.2554 (2011) respectively, with the lowest number of deaths and death rate per 1,000 population at 302 and 5.44 per 1,000 population in B.E.2551 (2008) respectively.

For the increase/decrease rate per 100 population, it was found that during B.E.2550-2554 (2007-2011), number of births exceeded number of deaths, ranging at 66.26-75.40 per 100 population. In B.E.2554 (2011), the highest population increase rate was at 42.81 per 100 population, while in B.E.2550 (2007) the lowest was at 37.55 per 100 population.

Tambon Talat Khwan

From the vital statistics of Tambon Talat Khwan in the past 5 years (B.E.2550-2554) (2007-2011), number of population ranged between 51,410-54,650, with the maximum of 54,650 in B.E.2550 (2007). With consideration given to population tendency for the past 5 years, number of population has been decreasing continuously since B.E.2550 (2007). The highest number of births and birth rate per 1,000 population were at 1,415 and 25.89 per 1,000 population in B.E.2550 (2007) respectively. The lowest number of births and birth rate per 1,000 population were at 727 and 14.14 per 1,000 population in B.E.2554 (2011) respectively. The highest number of deaths and death rate per 1,000 population were at 335 and 6.52 in B.E.2554 (2011) respectively, with the lowest number of deaths and death rate per 1,000 population at 281 and 5.20 per 1,000 population in B.E.2551 (2008) respectively.

For the increase/decrease rate per 100 population, it was found that during B.E.2550-2554 (2007-2011), number of births exceeded number of deaths, ranging at 7.62-20.18 per 100 population. In B.E.2550 (2007), the highest population increase rate was at 20.18 per 100 population, while in B.E.2554 (2011) the lowest was at 7.62 per 100 population.

Tambon Bang Khen

From the vital statistics of Tambon Bang Khen in the past 5 years (B.E.2550-2554) (2007-2011), number of population ranged between 41,831-42,636, with the maximum of 42,636 in B.E.2552 (2009). With consideration given to population tendency for the past 5 years, number of population has been decreasing continuously since B.E.2550 (2007), except for the year B.E.2552 (2009) when numbe of population increased by 0.38 percentage compared to B.E.2551 (2008). The highest number of births and birth rate per 1,000 population were at 690 and 16.20 per 1,000 population in B.E.2550 (2007) respectively. The lowest number of births and birth rate per 1,000 population were at 605 and 14.31 per 1,000 population in B.E.2553 (2010) respectively. The highest number of deaths and death rate per 1,000 population were at 263 and 6.17 in B.E.2550 (2007) respectively, with the lowest number of deaths and death rate per 1,000 population at 228 and 5.35 per 1,000 population in B.E.2552 (2009) respectively.

For the increase/decrease rate per 100 population, it was found that during B.E.2550-2554 (2007-2011), number of births exceeded number of deaths, ranging at 8.51-10.02 per 100 population. In B.E.2550 (2007), the highest population increase rate was at 10.02 per 100 population, while in B.E.2553 (2010) the lowest was at 8.51 per 100 population.

(2) Healthcare Facilities and Public Health Centers

Data of healthcare facilities and public health centers available to general public along the Project alignment within 500 meters radius and in the vicinity of th Project was presented in ***Table 6.4-4*** as follows:

(a) Governmental healthcare facilities and public health centers were:

(i) Bangkok Metropolitan Administration : There were 2 community hospitals under supervision of the Medical Sevice Department, and 3 public health centers under the supervision of the Health Department, as follows:

- Wetchakarunrasm Hospital (formerly-Nong Chok Hospital) was a community hospital, supervised by the Medical Service Department, with 76 beds (and maximum capacity extended to 200 beds in the future). It was located on Liap Wari road, in Khwaeng Kra Thum Rai, Khet Nong Chok, approximately 14 km. from depot and park&ride building at Rom Klao Intersection. The medical services provided covered almost all fields, such as medicine, obstetrics and gynecology, paediatrics, general surgery, rehabilitation medicine and dentistry.

- Bangkok Metropolitan Administration Lat Krabang Hospital was a community hospital, supervised by the Medical Service Department, with 60 beds (and maximum capacity extended to 200 beds in the future). It was located on On Nut-Lat Krabang road, in Khwaeng Lat Krabang, Khet Lat Krabang, approximately 10 km. from depot and park&ride building at Rom Klao Intersection. The medical services provided covered almost all fields, such as medicine, obstetrics and gynecology, paediatrics, general surgery, orthopedics surgery, and dentistry, etc.

Table 6.4-4 Number of Beds and Medical Personnel in Governmental/Private Sectors along the Project Alignment

Healthcare Facilities	Number of Beds	Numbre of Medical Personnel					
		Physician	Dentist	Pharmacist	Registered Nurse	Technical Nurse	Others
1. Wetchakarunrasm Hospital (formery- Nong Chok Hospital))	76	32	3	8	99	13	36
2. Bangkok Metropolitan Administration Lat Krabang Hospital	60	19	4	6	116	2	41
3. Health Center 43 (Min Buri)	-	1	-	1	15	-	11
4. Health Center 53 (Thung Song Hong)	-	2	-	1	10	-	6
5. Health Center 56 (Thap Charoen)	-	2	-	2	11	-	3
6.Amphoe Mueang Nonthaburi Public Health	N/A	83	19	31	450	138	61
7.Amphoe Pak Kret Public Health	30	11	8	6	90	1	42
8.Bamrasnaradura Infectious Diseases Institute	330	46	2	11	187	12	92
9.Nopparat Rajathanee Hospital	580	60	15	21	283	158	104
10.Panyananthaphikkhu Mecidal Center (formerly Chonprathan Hospital)	340	148	13	19	287	5	89
11.Mongkutwattana General Hospital	400	142	24	32	232	-	76
12.Synphaet Hospital	350	137	27	25	215	10	190
13.Navamin Hospital	180	139	30	24	210	18	294
Total	2,346	822	145	187	2,204	357	1,045

- Public Health Centers, under supervision of Health Department of Bangkok Metropolitan Administration was responsible for providing healthcare and health promotion for people, focusing on general patients treatment, diseases control and prevention, health rehabilitation, family planning and providing health education both in-house and public trainings, etc.. There were 3 public health certers, i.e.,

- Public Health Center 43 (Min Buri), on Srihaburanukit road, in Khwaeng Min Buri, Khet Min Buri, no beds provided.

- Public Health Center 53 (Thung Song Hong), on Vibhavadi Rangsit road (in front of Kheha Thung Song Hong Witthaya 2 School), in Khwaeng Thung Song Hong, Khet Lak Si (approximately 2.50 km from Lak Si Station), no beds provided.

- Public Health Center 56 (Thup Charoen), on Nuan Chan road, in Khwaeng Khlong Kum, Khet Bueng Kum (approximately 1.85 km from Watcharaphon Station), no beds provided.

(ii) Ministry of Public Health: There were health stations and specialty healthcare facilities, with total 940 beds, focusing on providing healthcare, and general treatment for general public.

- Amphoe Mueang Nonthaburi Public Health, in Soi Rattana Thibet 6, on Rattana Thibet road, Tambon Bang Kraso, Amphoe Mueang, Nonthaburi Province, responsible for providing healthcare, health promotion, and basic general treatment for people.

- Amphoe Pak Kret Public Health, on Sukha Prachasan 2, in Tambon Bang Phut, Amphoe Pak Kret, Nonthaburi Province, with 30 beds (only at the community hospitals of the Ministry of Public Health), responsible for providing healthcare, health promotion, and basic general treatment for people.

- Bamrasnaradura Infectious Diseases Institute, on Tiwanon road, Tambon Talad Khwan, Amphoe Mueang, Nonthaburi Province, with 330 beds, focusing on infectious diseases patiests treatment and communicable diseases control.

- Nopparat Rajathanee Hospital, on Ram Inthra road (km. 13 + 000), Khwaeng Khan Na Yao, Khet Khan Na Yao, with 580 beds, focusing on providing medical treatment in almost all fields,such as occupational medicine, emergency medicine, obstetrics and gynecology, surgery, medicine, paediatrics, anesthesiology, ophthalmology, otolaryngology (ear, throat and nose diseases), orthopedics, rehabilitation medicine, dentistry, and radiology, etc..

(iii) Srinakharinwirot University, Ministry of Education: There was Panyananthaphikkhu Chonprathan Medical Center Srinakharinwirot University (formerly-Chonprathan Hospital), on Tiwanon road, Tambon Bang Talat, Amphoe Pak Kret, Nonthaburi Province, with 340 beds, providing medical treatment in almost all fields, such as medicine, orthopedics surgery, general surgery, urological surgery, paediatrics, obstetrics and gynecology, otolaryngology (ear, throat and nose diseases), ophthalmology (eye diseases), and general diseases, etc..

a) Private healthcare facilities and public health centers were:

- Mongkutwattana General Hospital, on Chaeng Watthana road, in Khwaeng Thung Song Hong, Khet Lak Si, with 400 beds, providing medical treatment in all fields, such as medicine, obstetrics and gynecology, paediatrics, cardiovascular system, plastic surgery, orthopaedic surgery, paediatric surgery, urological surgery, otolaryngology (ear, throat and nose diseases), ophthalmology (eye diseases), general diseases, dentistry, and rehabilitation medicine, etc..

- Synphaet Hospital, on Ram Inthra road (km.8+500), Khet Khan Na Yao, with 350 beds, providing medical treatment in all fields, such as medicine, general surgery, orthopaedic surgery, obstetrics and gynecology, paediatrics, eye-ear-throat-nose diseases, dentistry, and back-and-neck pain center, etc..

- Navamin Hospital, on Srihaburanukit road, khwaeng/Khet Min Buri, with 180 beds, providing medical treatment in all fields, such as medicine, paediatrics, eye-ear-throat-nose diseases, general surgery, orthopaedic surgery, and physical therapy, etc..

With the total number of 13 healthcare facilities and public health centers of the government and private sectors within 500 meters radius along the mass transit system alignment and its vicinity, it was anticipated that there would be adequate healthcare facilities/hospitals and public health centers to provide sevices to construction workers and general public along the mass transit system alignment and its vicinity in case of illnesses or injuries from construction accidents.

(3) Number of Public Health and Medical Personnel

The data on number of public health and medical personnel and number of population per 1 public health and medical personnel categorized by Khet/Amphoe along the Project alignment in B.E.2554 (2011) was presented in ***Table 6.4-4***. The data was summarized as follows:

The data of publc health personnel in healthcare facilities and public health centers owned by the government and private sectos within 500 meters radius along the mass transit system alignment and its vicinity was detailed as follows:

(a) Public health personnel of governmental organizations

1.1) Bangkok Metropolitan Administration

a) There were a total of 379 public health personnel in 2 community hospitals (Wetchakarunrasm Hospital and Bangkok Metropolitan Administration Lat Krabang Hospital), divided into 51 physicians, 7 dentists, 14 pharmacists, 215 registered nurses, 15 technical nurses, and other 77 officiers; 7 medical technologists, 3 social workers, 2 nutritionists and 2 phychologists.

b) There were a total of 65 public health personnel in 3 public health centers, divided into 5 physicians, 4 pharmacists, 36 registered/technical nurses, 4 social workers and other 16 officers.

1.2) Ministry of Public Health

There were a total 1,931 public health personnel in health stations/ hospitals/specialty healthcare facilities, divided into 200 physicians, 44 dentists, 69 pharmacists, 1,010 registered nurses, 309 technical nurses, and othe 299 public health officers.

1.3) Srinakharinwirot University, Ministry of Education

There were a total of 561 public health personnel in the hospital, divided into 148 physicians, 13 dentists, 19 pharmacists, 287 registered nurses, 5 technical nurses, and other 89 officers; 18 medical technologists, 3 nutritionists, and 1 social worker.

(b) Public health personnel of private organizations

There were a total of 1,825 public health personnel in 3 private hospitals, divided into 418 physicians, 81 dentists, 81 pharmacists, 657 registered nurses, 28 technical nurses, and other 560 public health officers.

With the total number of 4,760 public health personnel in 13 government and private organizations within 500 meters radius along the mass transit system alignment and its vicinity, it was anticipated that there would be adequate public health personnel to provide sevices to construction workers and general public along the mass transit system alignment and its vicinity in case of illnesses or injuries from construction accidents.

(3) Medical Equipment Data

According to the Geographic Information System Unit, Office of the Permanent Secretary, Ministry of Public Health, medical equipment has been classified into 7 categories; ambulance, CT scan, Magnetic Resonance Imaging-MRI, Extracorporeal Shock Wave Lithotripsy-ESWL, Gamma Knife, Ultrasound and Dialysis. Details of number of these 7 main categories of medical equipment in each province along the Project alignment were presented in ***Table 6.4-5***. The data was summarized as follows:

Table 6.4-5 Important Medical Equipment by Changwat, B.E.2553 (2010)

Province	CT Scan	MRI	ESWL	Gamma Knife	Ultrasound	Dialysis	Ambulance
BMA	83	20	32	88	486	857	364
Nonthaburi	7	-	2	-	44	103	50
รวม	**90**	**20**	**34**	**88**	**530**	**960**	**414**

Source: Bureau of Policy and Strategy, Office of the Permanent Secretary, Ministry of Public Health B.E.2553 (2010)

(a) Bangkok Metropolitan Administration

From medical equipment data collected by the Bureau of Policy and Strategy, Office of the Permanent Secretary, Ministry of Public Health, there were CT Scan 83 units, MRI 20 units, ESWL 32 units, Gamma Knife 88 units, Ultrasound 486 units, Dialysis 857 units, and ambulances 364 units.

(b) Nonthaburi

From medical equipment data collected by the Bureau of Policy and Strategy, Office of the Permanent Secretary, Ministry of Public Health, there were CT Scan 7 units, ESWL 2 units, Ultrasound 44 units, Dialysis 103 units, and ambulances 50 units. In Nonthaburi, there were not any MRI, and Gamma Knife.

(5) Data on Health Status of Population in the Project Area

Data on health status of population in the Project area was very important for health impact assessment from Project activities in pre-construction, construction and operation phases. The data could indicate illness situation of population in the Project areas and could be used as a basis for health impact assessment. Detials of data on health status of population in the Project areas were as follows:

- **Top 10 of acute diseases with the highest number of patients and highest morbidity rate per 100,000 population, according to outpatients report (memo ro ngo0504)**

The data collection on illness situation of the 10 important diseases was used as criteria for health status indicators of population within 500 meters radius of the mass transit system alignment and its vicinity, The collection covering overall data within Bangkok Metropolitan Administration area and its vicinity from the Strategy and Evaluation Department, Bangkok Metropolitan Administration (B.E.2554) (2011) and Public Health Strategy Development Group, Nonthaburi Provincial Public Health Office (B.E.2554) (2011) were as follows:

(a) Bangkok Metropolitan Administration

Health status of population in Bagkok Metropolitan Administration in the past 5 years (B.E.2550-2554) (2007-2011), based on only the data from governmental public health centers/healthcare facilities/ hospitals located in Khet Lak Si, Khet Bang Khen, Khet Bueng Kum, Khet Khan Na Yao, Khet Min Buri and its vicinity, was summarized as follows:

(i) 3 Public Health Centers

- Public Health Center 43 (Min Buri): In B.E.2550-2554 (2007-2011), number of inpatients and outpatients visiting the center ranged between 19,086-40,089 persons/year. Causes of visiting were classified by top 10 important diseases (B.E.2554) (2011); external causes of illness or death (9,917 persons), diseases of the circulatory system 7,454 persons), disease of the respiratory (6,745 persons), endocrine, nutrition and metabolic diseases (5,534 persons), diseases of the masculoskeletal system and connective tissue (1,370 persons), diseases of the skin and subcutaneous tissue(1,289 persons), diseases of the digestive system (926 persons), transport accidents and their sequence (504 persons), diseases of the genitourinary system (502 persons), and diseases of the eye and adnexa (471).

- Public Health Center 5 3 (Thung Song Hong): In B.E. 2550-2554 (2007-2011), number of inpatients and outpatients visiting the center ranged between 14,021-23,251 persons/year. Causes of visiting were classified by top 10 important diseases (B.E.2554) (2011); symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (5,959 persons), disease of the respiratory (3,812 persons), diseases of the circulatory system (3,041 persons), endocrine , nutrition and metabolic diseases (1,127 persons), diseases of the masculoskeletal system and connective tissue (771 persons), diseases of the skin and subcutaneous tissue (612 persons), certain infection and parasitic diseases (486 persons), diseases of the digestive system (45 8 persons), diseases of the eye and adnexa (280 persons), and external causes of illness and death (218 persons).

- Public Health Center 56 (Thap Charoen) : In B.E.2550-2554 (2007-2011), number of inpatients and outpatients visiting the center ranged between 21,186-33,488 persons/year. Causes of visiting were classified by top 10 important diseases (B.E.2554) (2011); diseases of the circulatory system (11,284 persons), disease of the respiratory (9,213 persons), symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (4,625 persons), diseases of the masculoskeletal system and connective tissue (3,037 persons), diseases of the nervous system (1,662), endocrine , nutrition and metabolic diseases (1,385 persons), diseases of the digestive system (1,351 persons), diseases of the skin and subcutaneous tissue (933 persons), and external causes of illness or death (921 persons), and diseases of the eye and adnexa (859 persons).

(ii) Wetchakarunrasm Hospital (formerly-Nong Chok Hospital) was a community hospital under supervision of Bangkok Metromplitan Administration, located approximately 14 km from depot and park&ride building at Rom Klao Intersection. In B.E.2550-2554 (2007-2011), number of inpatients and outpatients visiting the hospital ranged between 135,771-194,759 persons/year. With consideration given to the number of inpatients and outpatients visiting the hospital during B.E.2550-2554

(2007-2011), it was found that the number tended to be at a continually increasing rate every year, ranging between 6.98-12.59%. Causes of visiting to the hospital were classified by top 10 important diseases (B.E.2554) (2011); endocrine , nutrition and metabolic diseases (37,135 persons), diseases of the circulatory system (31,023 persons), disease of the respiratory (22,222 persons), diseases of the digestive system (18,250 persons), diseases of the masculoskeletal system and connective tissue (9,549 persons), symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (8,581 persons), diseases of the genitourinary system (7,644 persons), certain infection and parasitic diseases (7,036 persons), external causes of illness or death (5,549 persons), and diseases of the eye and adnexa (3,549 persons).

(iii) Bangkok Metropolitan Administration Lat Krabang Hospital was a community hospital with 60 beds under supervision of Bangkok Metropolitan Administration, located approximately 10 km from depot and park&ride building at Rom Klao Intersection. In B.E.2550-2554 (2007-2011), number of inpatients and outpatients visiting the hospital ranged between 132,592-151,839 persons/year. With consideration given to the tendency in number of inpatients and outpatients visiting the hospital during B.E.2550-2554 (2007-2011), the number tended to be increasing every other year, ranging between -3.09-14.52%. Causes of visiting to the hospital were classified by top 10 important diseases (B.E.2554) (2011); endocrine , nutrition and metabolic diseases (18,425 persons), diseases of the circulatory system (14,562 persons), disease of the respiratory system (12,525 persons), diseases of the masculoskeletal system and connective tissue (9,831 persons), diseases of the digestive system (7,852 persons), certain infection and parasitic diseases (6,429 persons), diseases of the genitourinary system (5,821 persons), symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (5,104 persons), diseases of the eye and adnexa (5,058 persons), and external causes of illness or death (4,662 persons).

(iv) Nopparat Rajathanee Hospital. In B.E.2550-2554 (2007-2011), number of inpatients and outpatients visiting the hospital ranged between 142,635-158,248 persons/year, at the increasing rate of 9.87% annually. Causes of visiting to the hospital were classified by top 10 important diseases (B.E.2553) (2010); diseases of the circulatory system (61,830 persons), disease of the respiratory system (61,658 persons), endocrine, nutrition and metabolic diseases (49,687 persons), diseases of the masculoskeletal system and connective tissue (36,507 persons), certain infection and parasitic diseases (20,952 persons), symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (19,455 persons), diseases of the genitourinary system (19,382 persons), diseases of the digestive system (18,149 persons), diseases of the eye and adnexa (15,591 persons), and external causes of illness or death (11,776 persons).

(b) Nonthaburi

Health status of population in Nonthaburi (based on only health stations and governmental hospitals located along the mass transit system alignment in Amphoe Mueang and Amphoe Pak Kret) in the past 5 years (B.E.2550-2554) (2007-2011) was summarized as follows:

(i) Amphoe Mueang Nonthaburi Public Health : Causes of visiting to healthcare facilities were classified by top 10 important diseases (B.E.2554) (2011); disease of the respiratory system (69,553 persons), endocrine, nutrition and metabolic diseases (55,566 persons), diseases of the circulatory system (48,532 persons), diseases of the masculoskeletal system and connective tissue (28,649 persons), symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (23,359 persons), diseases of the digestive system (22,574 persons), certain infection and parasitic diseases (16,364 persons), diseases of the skin and subcutaneous tissue (15,719), diseases of the genitourinary system (7,609 persons), and diseases of the eye and adnexa (6,121 persons).

(ii) Amphoe Pak Kret Public Health: Causes of visiting to healthcare facilities were classified by top 10 important diseases (B.E.2554) (2011); disease of the respiratory system (69,553 persons), endocrine , nutrition and metabolic diseases (55,566 persons), diseases of the circulatory system (48,532 persons), diseases of the masculoskeletal system and connective tissue (28,649 persons), symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (23,359 persons), diseases of the digestive system (22,574 persons), certain infection and parasitic diseases (16,364 persons), diseases of the skin and subcutaneous tissue (15,719), diseases of the genitourinary system (7,609 persons), and diseases of the eye and adnexa (6,121 persons).

(iii) Bamrasnaradura Infectious Diseases Institute: Causes of visiting to the healthcare facilities were classified by top 10 important diseases (B.E.2554) (2011); diseases of the digestive system (9,487 persons), certain infection and parasitic diseases (7,844 persons), symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (6,839 persons), diseases of the masculoskeletal system and connective tissue (5,724 persons), diseases of the skin and subcutaneous tissue (5,099), diseases of the eye and adnexa (3,657 persons), external causes of illness or death (3,278 persons), diseases of the genitourinary system (2,903 persons), Diseases of the ear and mastiod process (1,434 persons), and endocrine , nutrition and metabolic diseases (1,390 persons).

(iv) Chonprathan Hospital (at present-Panyananthaphikkhu Chonprathan Medical Center Srinakharinwirot University): In B.E.2550-2554 (2007-2011), number of inpatients and outpatients visiting the hospital ranged between 358,429-450,734 persons/year, at the increasing rate of 7.60-16.87% annually. Causes of visiting to the hospital were classified by top 10 important diseases (B.E.2554) (2011); diseases of the masculoskeletal system and connective tissue (73,710 persons), endocrine, nutrition and metabolic diseases (63,328 persons), diseases of the circulatory system (52,290 persons), disease of the respiratory system (43,453 persons), diseases of the digestive system (23,556 persons), diseases of the genitourinary system (22,973 persons), diseases of the eye and adnexa (19,907 persons), symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (16,910 persons), certain infection and parasitic diseases (14,931 persons), and diseases of the nervous system (8,809 persons).

(6) Mental Health Status

Apart from physical illness, mental illness was another factor of equal significance. From the statistical data collected by the Department of Mental Health, Ministry of Public Health for over years, it was indicated that mental health problem has drastically increased, reflected by increasing number of psychiatric patients each year. Therefore, the context of mental health status was essential for health impact assessment. As the Project duration is long, chronic mental health problems might be generated. Thus, the gathering of secondary data indicating mental health status of population in the Project areas, including adequacy in number of personnel responsible for psychiatric health was important. The data was used as a basis for mental health impact assessment in the subsequent step. The secondary data relevant to health status was as follows:

(a) Number of Patients and Morbidity Rate of Psychopathologic Disorders

Statistics on mental illness patients, classified by provinces in B.E.2550-2554 (2007-2011), was presented in ***Table 6.4-6***. The data was collected by the Information Technology Center, Planning Division, Department of Mental Health, Ministry of Public Health. Psychopathologic disorders have been divided into 8 categories; psychotic disorder, anxiety disorder, depressive disorder, mental retardation, epilepsy, substance-induced disorder, other mental illnesses, and attempted suicide or completed suidice. Later on in B.E.2552 (2009), the statistical collection of autistic disorder patients was conducted. Details were as follows:

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From statistical data on number of patients and morbidity rate of psychopathologic disorders in 8 categories during B.E.2550-2554 (2007-2011) (as presented in ***Table 6.4-6***) in Bangkok Metropolitan Administration area, collected by the Information Technology Center, Planning Division, Department of Mental Health, Ministry of Public Health, it was found that number of psychopathologic disorders patients and morbidity rate per 100,000 population ranged between 144,193-285,673 persons and 600.15-988.81 per 100,000 population respectively. Particularly, in B.E.2552 (2009), number of patients and morbidity rate of psychopathologic disorders were at the highest level, whereas the lowest level was in B.E.2550 (2007).

With consideration given to the diseases classified by category (exclusive of other mental illnesses of which no details were provided), it was found that the highest number of patients and morbidity rate per 100,000 population for the past 5 years (B.E.2550-2554) (2007-2011), fell on psychotic disorder, ranging between 34,306-56,463 persons and 600.15-988.81 per 100,000 population respectively. Particularly in B.E.2551 (2008), number of patients and morbidity rate of psychotic disorder per 100,000 population were at the highest level, whereas the lowest level was in B.E.2550 (2007). Subsequent orders were depressive disorder, anxiety disorder, epilepsy, substance-induced disorder, mental retardation, attempted suicide and completed suicide respectively. It should be noted that number of patients and morbidity rate per 100,000 population of depressive disorder, psychotic disorder, epilepsy and substance-induced disorder significantly increased in B.E.2551 (2008), compared to B.E.2550 (2007). In case of autistic disorder, from the data collected since B.E.2552 (2009), it was found that number of patients and morbidity rate per 100,000 population were at 771 persons and 13.50 per 100,000 population respectively. Number of patients and morbidity rate per 100,000 population of autistic disorder significantly increased in B.E.2554 (2011), compared to B.E.2553 (2010).

Table 6.4-6 Statistics of Patients and Morbidity Rate of Psychopathologic Disorder in BMA and Nonthaburi (B.E.2550-2554) (2007-2011)

Province	B.E.	Psychotic disorder		Anxiety disorder		Depressive disorder		Mental Retardation		Epilepsy		Substance-induced disorder		Other mental illness		Attempted Suicide/Suicide				Autistics**		Total	
																completed		attempted					
		No.	Rate*	No.	Rate*	No.	Rate*	No.	Rate*	No.	Rate*	No.	Rate*	No.	Rate	No	Rate*	No	Rate*	No	Rate*	No.	Rate*
Bangkok	2550	34,306	600.15	25,366	443.75	25,860	452.39	3,245	56.77	12,555	219.64	8,855	154.91	32,153	562.48	138	2.41	1,715	30.00	-	-	144,193	2,522.51
Metropolitan	2551	56,463	988.81	35,597	623.40	51,427	900.62	3,951	69.19	17,540	307.17	27,335	478.71	35,497	621.64	106	1.86	1,693	29.65	-	-	229,609	4,021.05
Administration	2552	53,834	942.54	45,992	805.24	50,995	892.84	6,047	105.87	25,689	449.77	24,781	433.87	75,735	1,325.99	97	1.70	1,829	32.02	771	13.50	285,673	5,001.65
	2553	43,518	763.21	36,641	642.60	24,377	427.52	4,780	83.83	21,400	375.31	17,799	312.15	99,316	1,741.78	142	2.49	2,333	40.92	791	13.87	251,053	4,402.90
	2554	40,092	704.84	34,030	598.26	26,580	467.29	4,587	80.64	22,068	387.97	21,085	370.68	122,010	2,145.00	136	2.39	2,248	39.52	1,805	31.73	274,641	4,828.33
Nonthaburi	2550	64,514	6,299.02	15,105	1,474.82	21,639	2,112.7	2,683	261.96	3,712	362.43	5,492	536.23	13,212	1,289.99	28	2.73	717	70.01	-	-	127,102	12,409.99
	2551	13,393	1,271.69	6,610	627.63	2,881	273.56	2,766	262.64	769	73.02	1,644	156.10	11,121	1,055.96	22	2.09	700	66.47	-	-	39,906	3,789.16
	2552	9,216	863.78	5,994	561.79	2,936	275.18	689	64.58	637	59.70	4,513	422.99	6,797	637.06	29	2.72	635	59.52	73	6.84	31,519	2,954.15
	2553	4,214	386.64	2,124	194.88	3,454	316.91	514	47.16	231	21.19	2,825	259.20	3,369	309.11	28	2.57	536	49.18	69	6.33	17,364	1,593.16
	2554	6,946	624.54	4,488	403.53	4,836	434.82	1,095	98.45	783	70.40	4,202	377.81	7,186	646.12	35	3.15	531	47.74	268	24.10	30,370	2,730.66

Source: Information Technology Center, Planning Division, Department of Mental Health, Ministry of Public Health, B.E.2550-2554 (2007-2011)

Remarks: * refers to morbidity rate of psychopathologic disorder per 100,000 population

** data collection of autistic patients and morbidity rate since B.E.2552 (2009)

In addition, with consideration given to number of patients and morbidity rate per 100,000 population classified by categories of psychopathologic disorders (exclusive of other mental illnesses of which no details were provided), it was found that, in B.E.2551 (2008) the categories with its highest number of patients and morbidity rate per 100,000 population were psychotic disorder (56,463 persons and 988.81), depressive disorder (51,427 persons and 900.62), and substance-induced disorder (27,335 persons and 478.71). In B.E.25522 (2009), anxiety disorder (45,992 persons and 805.24), metal retardation (6,047 persons and 105.87), and epilepsy (25,689 persons and 449.77) are the categories with the highest number of patients and morbidity rate per 100,000 population.

For completed suicide category, the highest suicides and suicide rate per 100,000 population were in B.E.2553 (2010), at 142 persons and 2.49. Whereas the highest attemptd suicides and attempted suicide rate per 100,000 population were in B.E.2553 (2010), at 2,333 persons and 40.92 respectively.

Nonthaburi

From statistical data on number of patients and morbidity rate of psychopathologic disorders in 8 categories during B.E.2550-2554 (2007-2011) (as presented in ***Table 6.4-6***) in Nonthaburi Province area, collected by the Information Technology Center, Planning Division, Department of Mental Health, Ministry of Public Health, it was found that number of psychopathologic disorders patients and morbidity rate per 100,000 population ranged between 17,364-127,102 persons and 1,593.16-12,409.99 per 100,000 population respectively. Particularly, in B.E.2550 (2007), number of patients and morbidity rate of psychopathologic disorders were at the highest level, whereas the lowest level was in B.E.2553 (2010).

With consideration given to the diseases classified by category (exclusive of other mental illnesses of which no details were provided), it was found that the highest number of patients and morbidity rate per 100,000 population for the past 5 years (B.E.2550-2554) (2007-2011), fell on psychotic disorder, ranging between 4,214-64,514 persons and 386.64-6,299.02 per 100,000 population respectively. Particularly in B.E.2550 (2007), number of patients and morbidity rate of psychotic disorder per 100,000 population were at the highest level, whereas the lowest level was in B.E.2553 (2010). Subsequent orders were depressive disorder, anxiety disorder, substance-induced disorder, mental retardation,epilepsy, attempted suicide and completed suicide respectively. In case of autistic disorder, from the data collected since B.E.2552 (2009), it was found that number of patients and morbidity rate per 100,000 population were at 73 persons and 6.84 per 100,000 population respectively. It should be noted that number of patients and morbidity rate per 100,000 population of autistic disorder significantly increased in B.E.2554 (2011), compared to B.E.2553 (2010).

In addition, with consideration given to number of patients and morbidity rate per 100,000 population classified by categories of psychopathologic disorders (exclusive of other mental illnesses of which no details were provided) between B.E.2550-2554 (2007-2011), it was found that, in B.E.2550 (2007) the categories with its highest number of patients and morbidity rate per 100,000 population were psychotic disorder (64,514 persons and 6,299.02), anxiety disorder (15,105 persons and 1,474.82), depressive disorder (21,639 persons and 2,112.7), epilepsy (3,712 persons and 362.43), and substance-induced disorder (5,492 persons and 536.23). In B.E.25521 (2008), mental retardation was the category with the highest number of patients and morbidity rate per 100,000 population (2,766 persons and 262.64).

For completed suicide category, the highest suicides and suicide rate per 100,000 population in B.E.2554 (2011) were at 35 persons and 3.15. Whereas the highest attemptd suicides and attempted suicide rate per 100,000 population in B.E.2550 (2007) were at 717 persons and 70.01 respectively.

(b) Number of Mental Health Personnel

Data on number of mental health personnel and number of mental health personnel per 100,000 population classified by professional fields, and by provinces during B.E.2548-2551 (2005-2008) was presented in ***Table 6.4-7***. The data was important for health impact assessment as a basis indicating adequacy of mental health personnel. The Department of Mental Health, Ministry of Public Health has classified mental health personnel into 5 categories; psychiatrist, psychiatrict nurse, psychologist, social worker and occupational therapist. Details were as follows:

Bangkok Metropolitan Administration

From the data on number of mental health personnel in Bangkok Metropolitan Administration area during B.E.2548-2551 (2005-2008) (as per ***Table 6.4-7***), it could be summarized as follows:

Table 6.4-7 Number and Rate of Mental Health Personnel per 100,000 Population in Bangkok and Nonthaburi, B.E.2548-2551 (2005-2008)

Province	B.E.	Psychiatrist		Psychiatric Nurse		Clinical Psychologist		Social Worker		Occupational Therapist	
		No.	Rate*	No.	Rate*	No.	Rate*	No.	Rate*	No.	Rate*
Bangkok Metropolitan Administration	B.E.2548	233	4.12	339	5.99	70	1.24	109	1.93	12	0.21
	B.E.2549	240	4.22	311	5.47	118	2.08	316	5.56	5	0.09
	B.E.2550	241	4.22	403	7.06	56	0.98	318	5.57	19	0.33
	B.E.2551	252	4.41	406	7.11	64	1.12	313	5.48	27	0.47
Nonthaburi	B.E.2548	43	4.32	246	25.2	29	2.98	21	2.06	4	0.41
	B.E.2549	42	4.26	251	25.46	30	3.04	18	1.83	3	0.30
	B.E.2550	49	4.84	167	16.49	30	2.96	21	2.07	3	0.30
	B.E.2551	51	4.75	175	16.53	32	2.95	23	2.09	4	0.29

Source: Survey by Department of Mental Health, Ministry of Public Health, B.E, 2548-2551 (2005-2008)
Remarks: * refers to rate of mental health personnel per 100,000 population
N/A : no data recorded

- Psychiatrist

During B.E.2548-2551 (2005-2008), there were 233-252 psychiatrists in BMA, with the highest number in B.E.2551 (2008), and the lowest number in B.E.2548 (2005). The rate of psychiatrists per 100,000 population ranged between 4.12-4.41, with the highest rate in B.E.2551 (2008), and the lowest rate in B.E.2548 (2005). The tendency in the number and the rate of psychiatrists per 100,000 population during B.E.2548-2551 (2005-2008) was continually increasing. Following to the comparison between the rate of psychiatrists per 100,000 population in BMA and the rate of 0.86 per 100,000 population of the whole country in B.E.2551 (2008), it was found that the rate of psychiatrists per 100,000 population in BMA was higher than that of the country. This implied that number of psychiatrists in BMA was sufficient to serve the population in the area.

- **Psychiatric Nurse**

During B.E.2548-2551 (2005-2008), there were 311-406 psychiatrict nurses in BMA, with the highest number in B.E.2551 (2008), and the lowest number in B.E.2549 (2006). The rate of psychiatrict nurses per 100,000 population ranged between 5.47-7.11, with the highest rate in B.E.2551 (2008), and the lowest rate in B.E.2549 (2006). The tendency in the number and the rate of psychiatrict nurses per 100,000 population during B.E.2548-2551 (2005-2008) was continually increasing. Following to the comparison between the rate of psychiatrict nurses per 100,000 population in BMA and the rate of 3.74 per 100,000 population of the whole country in B.E.2551 (2008), it was found that the rate of psychiatrict nurses per 100,000 population in BMA was higher than that of the country. This implied that number of psychiatrict nurses in BMA was sufficient to serve the population in the area.

- **Clinical Psychologist**

During B.E.2548-2551 (2005-2008), there were 56-118 clinical psychologists in BMA, with the highest number in B.E.2549 (2006), and the lowest number in B.E.2550 (2007). The rate of clinical psychologists per 100,000 population ranged between 0.98-2.08, with the highest rate in B.E.2549 (2006), and the lowest rate in B.E.2550 (2007). The tendency in the number and the rate of clinical psychologists per 100,000 population during B.E.2548-2551 (2005-2008) has been increased in B.E.2549 (2006), before declining continually since B.E.2550 (2007). Following to the comparison between the rate of clinical psychologists per 100,000 population in BMA and the rate of 0.45 per 100,000 population of the whole country in B.E.2551 (2008), it was found that the rate of clinical psychologists per 100,000 population in BMA was higher than that of the country. This implied that number of clinical psychologists in BMA was sufficient to serve the population in the area.

- **Social Worker**

During B.E.2548-2551 (2005-2008), there were 109-318 social workers in BMA, with the highest number in B.E.2550 (2007), and the lowest number in B.E.2548 (2005). The rate of social workers per 100,000 population ranged between 1.93-5.57, with the highest rate in B.E.2550 (2007), and the lowest rate in B.E.2548 (2005). The tendency in the number and the rate of social workers per 100,000 population during B.E.2548-2551 (2005-2008) has been doubly increased in B.E.2549 (2006), before dropping in B.E.2551 (2008). Following to the comparison between the rate of social workers per 100,000 population in BMA and the rate of 0.66 per 100,000 population of the whole country in B.E.2551 (2008), it was found that the rate of social workers per 100,000 population in BMA was higher than that of the country. This implied that number of social workers in BMA was sufficient to serve the population in the area.

- **Occupational Therapist**

During B.E.2548-2551 (2005-2008), there were 5-27 occupational therapists in BMA, with the highest number in B.E.2551 (2008), and the lowest number in B.E.2549 (2006). The rate of occupational therapists per 100,000 population ranged between 0.09-0.47, with the highest rate in B.E.2551 (2008), and the lowest rate in B.E.2549 (2006). The tendency in the number and the rate of occupational therapists per 100,000 population during B.E.2548-2551 (2005-2008) has been decreased by half in

B.E.2549 (2006), and increased by over 3 times in B.E.2550 (2007). Following to the comparison between the rate of occupational therapists per 100,000 population in BMA and the rate of 0.14 per 100,000 population of the whole country in B.E.2551 (2008), it was found that the rate of occupational therapists per 100,000 population in BMA was higher than that of the country. This implied that number of occupational therapists in BMA was sufficient to serve the population in the area.

Nonthaburi

From the data on number of mental health personnel in Nonthaburi Province during B.E.2548-2551 (2005-2008) (as per ***Table 6.4-7***), it could be summarized as follows:

- **Psychiatrist**

During B.E.2548-2551 (2005-2008), there were 42-51 psychiatrists in Nonthaburi, with the highest number in B.E.2551 (2008), and the lowest number in B.E.2549 (2006). The rate of psychiatrists per 100,000 population ranged between 4 .26-4.84, with the highest rate in B.E.2550 (2007), and the lowest rate in B.E.2549 (2006). The tendency in the number and the rate of psychiatrists per 100,000 population during B.E.2548-2551 (2005-2008) has been increasing continually, except in B.E.2549 (2006) when the number dropped slightly, compared to B.E.2548 (2005). Following to the comparison between the rate of psychiatrists per 100,000 population in Nonthaburi and the rate of 0.86 per 100,000 population of the whole country in B.E.2551 (2008), it was found that the rate of psychiatrists per 100,000 population in Nonthaburi was higher than that of the country. This implied that number of psychiatrists in Nonthaburi was sufficient to serve the population in the area.

- **Psychiatric Nurse**

During B.E.2548-2551 (2005-2008), there were 167-251 psychiatrict nurses in Nonthaburi, with the highest number in B.E.2549 (2006), and the lowest number in B.E.2550 (2007). The rate of psychiatrict nurses per 100,000 population ranged between 16.49-25.46, with the highest rate in B.E.2549 (2006), and the lowest rate in B.E.2550 (2007). The tendency in the number and the rate of psychiatrict nurses per 100,000 population during B.E.2548-2551 (2005-2008) has been increasing every other year. Following to the comparison between the rate of psychiatrict nurses per 100,000 population in Nonthaburi and the rate of 3.74 per 100,000 population of the whole country in B.E.2551 (2008), it was found that the rate of psychiatrict nurses per 100,000 population in Nonthaburi was higher than that of the country. This implied that number of psychiatrict nurses in Nonthaburi was sufficient to serve the population in the area.

- **Clinical Psychologist**

During B.E.2548-2551 (2005-2008), there were 29-32 clinical psychologists in Nonthaburi, with the highest number in B.E.2551 (2008), and the lowest number in B.E.2548 (2005). The rate of clinical psychologists per 100,000 population ranged between 2.95-3.04, with the highest rate in B.E.2549 (2006), and the lowest rate in B.E.2551 (2008). The tendency in the number and the rate of clinical psychologists per 100,000 population during B.E.2548-2551 (2005-2008) has been increasing continually since B.E.2548 (2005). Following to the comparison between the rate of clinical psychologists per 100,000 population in Nonthaburi and the rate of 0.45 per 100,000 population of the whole country in B.E.2551 (2008), it was found that the rate of clinical psychologists per 100,000 population in Nonthaburi was higher than that of the country. This implied that number of clinical psychologists in Nonthaburi was sufficient to serve the population in the area.

- **Social Worker**

During B.E.2548-2551 (2005-2008), there were 18-23 social workers in Nonthaburi, with the highest number in B.E.2551 (2008), and the lowest number in B.E.2549 (2006). The rate of social workers per 100,000 population ranged between 1.83-2.09, with the highest rate in B.E.2551 (2008), and the lowest rate in B.E.2549 (2006). The tendency in the number and the rate of social workers per 100,000 population during B.E.2548-2551 (2005-2008) has been continually increasing, except in B.E.2549 (2006) when the number dropped by 14.29 per cent, compared to B.E.2548 (2005). Following to the comparison between the rate of social workers per 100,000 population in Nonthaburi and the rate of 0.66 per 100,000 population of the whole country in B.E.2551 (2008), it was found that the rate of social workers per 100,000 population in Nonthaburi was higher than that of the country. This implied that number of social workers in Nonthaburi was sufficient to serve the population in the area.

- **Occupational Therapist**

During B.E.2548-2551 (2005-2008), there were 3-4 occupational therapists in Nonthaburi, with the rate of occupational therapists per 100,000 population ranging between 0 .29 -0 .4 7 . The tendency in the number and the rate of occupational therapists per 100,000 population during B.E.2548-2551 (2005-2008) ranged similarily every year. Following to the comparison between the rate of occupational therapists per 100,000 population in Nonthaburi and the rate of 0.14 per 100,000 population of the whole country in B.E.2551 (2008), it was found that the rate of occupational therapists per 100,000 population in Nonthaburi was higher than that of the country. This implied that number of occupational therapists in Nonthaburi was sufficient to serve the population in the area.

(c) Statistics on Completed Suicides and Rate of Completed Suicides

From the statistical data on number of completed suicides and rate of completed suicides per 100,000 population in Bangkok Metropolitan Administration and Nonthaburi Province during B.E.2550-2554 (2007-2011) (as per ***Table 6.4-8***), it could be summarized as follows:

Bangkok Metropolitan Administration

From the statistical data on completed suicides and rate of completed suicides per 100,000 population in Bangkok Metropolitan Administration during B.E.2550-2554 (2007-2011)(as presented in ***Table 6.4-8***), there were 97-142 completed suicides. The highest number was in B.E.2553 (2010), accounting for 142 suicides, 107 of which were male, and 35 female. The lowest number was in B.E.2552 (2009), accounting for 97 suicides, 78 of which were male, and 19 female. The rate of completd suicides per 100,000 population ranged between 1.70-2.49, with the highest rate in B.E.2553 (2010), and the lowest rate in B.E.2552 (2009). The tendency in the number and the rate of completed suicides per 100,000 population in Bangkok Metroplitan Administration in the past five years has been declining, except in B.E.2553 (2010) when the number increased by 46.39 per cent , compared to B.E.2552 (2009).

Table 6.4-8 Statistics on Completed Suicides and Rate of Completed Suicides per 100,000 Population in Bangkok Metropolitan Administration and Nonthaburi, B.E.2550-2554 (2007-2011)

Province	B.E.	Complete Suicides (person)			Rate of Completed Suicide per 100,000 Population	Increase/Decrease
		Male	Female	Total		
Bangkok Metropolitan Administration	2550	116	22	138	2.42	0.80
	2551	74	32	106	1.86	-0.56
	2552	78	19	97	1.70	-0.16
	2553	107	35	142	2.49	0.79
	2554	103	33	136	2.39	-0.10
Nonthaburi	2550	13	14	27	2.67	1.15
	2551	12	7	19	1.80	-0.87
	2552	14	6	20	1.87	0.07
	2553	19	9	28	2.57	0.70
	2554	26	9	35	3.15	0.58

Source: Information Technology Center, Planning Division, Department of Mental Health, Ministry of Public Health, B.E.2550-2554 (2007-2011)

Nonthaburi

From the statistical data on completed suicides and rate of completed suicides per 100,000 population in Nonthaburi during B.E.2550-2554 (2007-2011) (as presented in ***Table 6.4-8***), there were 19-35 completed suicides. The highest number was in B.E.2554 (2011), accounting for 35 suicides, 26 of which were male, and 9 female. The lowest number was in B.E.2551 (2008), accounting for 19 suicides, 12 of which were male, and 7 female. The rate of completd suicides per 100,000 population ranged between 1.80-3.15, with the highest rate in B.E.2554 (2011), and the lowest rate in B.E.2551 (2008). The tendency in the number and the rate of completed suicides per 100,000 population in Nonthaburi in the past five years has been increasing continually, except in B.E.2551 (2008) when the number decreased by 29.63 per cent, compared to B.E.2550 (2007).

(7) Data on Social Safety

The statistical collection and analysis of safety and accidents due to road traffic conditions of communication network along the mass transit system alignment and its vicinity by Metropolitan Police Bureau 2-3-4 and Provincial Police Region 1, Nonthaburi Province, as presented in ***Table 6.4-9***, was classified by provinces as follows:

(a) Bangkok Metropolitan Administration

The consideration was given to road accident statistics in Bangkok Metropolitan Administration of the areas under the responsibility of Metropolitan Police Bureau 2-3-4 only (covering an area along the mass transit system alignment). It was found that during B.E.2550-2554 (2007-2011), a total of 85,576 road accidents were reported to police. The highest number of reports was in B.E.2552 (2009) at 20.769. During B.E.2550-2553 (2007-2010), the reporting tendency was declining every other year, before continually declining since B.E.2553 (2010). In B.E.2554 (2011), there were

Table 6.4-9 Type of Road Accidents and Casualties Cases (B.E.2550-2554) (2007-2011) in Bangkok Metropolitan Administration and Nonthaburi

Limited to the Areas Along the Mass Transit System Alignment Only

Type of accidents/casualties	B.E.2550		B.E.2551		B.E.2552		B.E.2553		B.E.2554	
	BMA	Nonthaburi	BMA	Nonthaburi	BMA	Nonthaburi	BMA	Nonthaburi	BMA	Nonthaburi
1. Reported	**16,875**	**1,515**	**16,111**	**1,715**	**20,769**	**1,504**	**18,346**	**462**	**13,475**	**325**
2. Pedestrian	586	85	572	89	393	76	443	9	396	15
3. Bicycle	150	16	158	15	82	23	60	1	62	0
4. Tricycle	39	10	16	5	7	7	7	0	8	0
5. Motorcycle	8,527	1,149	7,951	1,204	5,194	1,093	5,658	58	4,418	20
6.Motorized tricycle	69	27	127	22	34	23	13	0	14	0
7. Passenger car	10,061	806	10,774	1,155	6,868	1,079	7,639	30	6,310	22
8.Van	415	135	374	99	277	47	289	0	263	1
9. Light truck (Pickup)	3,289	501	3,030	563	2,031	491	2,030	24	1,586	18
10.Heavy Bus	464	25	441	26	257	26	252	1	255	1
11.Six-wheel truck	289	43	298	68	190	57	192	4	192	2
12. Ten-wheel truck or Trailer	350	70	323	71	158	87	172	6	161	2
13.Farm vehicle	1	0	3	0	0	0	0	0	0	0
14. Taxi	2,059	172	2,360	176	1,220	110	1,187	6	1,170	6
15. Others	588	0	262	1	170	8	246	3	180	1
Total accident cases	**26,887**	**3,039**	**26,689**	**3,494**	**16,881**	**3,127**	**18,188**	**142**	**15,015**	**88**
	29,926		**30,183**		**20,008**		**18,330**		**15,103**	
Increase/decrease rate			0.86 %		-33.71 %		-8.39 %		-17.61 %	
Property damage (Baht)	920,069,353	15,862,500	1,357,392,280	17,181,800	29,824,137	28,893,200	38,754,654	470,000	59,931,833	278,500
Casualties to Person	**8,752**		**9,383**		**4,887**		**4,007**		**4,131**	
	7,760	**992**	**8,202**	**1,181**	**3,572**	**1,315**	**3,934**	**73**	**4,082**	**49**
Fatalities	265	130	291	125	124	123	133	32	151	33
Injuries	7,495	862	7,911	1,056	3,448	1,192	3,801	41	3,931	16
Number of the suspects	**14,414**		**12,802**		**11,208**		**11,440**		**8,306**	
	13,362	**1,052**	**11,627**	**1,175**	**10,248**	**960**	**11,287**	**153**	**8,224**	**82**
Arrested	13,257	999	11,510	1,079	10,230	937	11,270	149	8,200	81
Cannot arrest	105	53	117	96	18	23	17	4	24	1

Source : Royal Thai Police B.E.2550-2554 (2007-2011)

13,475 reports on road accidents, decreasing from B.E.2553 (2007) by 4,871 reports or 26.55 percent. With consideration given to accidents on communication network along the mass transit system alignment and its vicinity during B.E.2550-2554 (2007-2011) (details presented in ***Table 6.4-9***), it was found that there were a total of 103,659 road accidents, with the highest number in B.E.2550 (2007) at 26,887 cases. The tendency of road accidents has been decreasing continually, except for B.E.2553 (2008) when there were 18,888 road accidents, increasing from B.E.2552 (2009) by 1,307, or 7.74 per cent. In B.E.2554 (2011), there were 15,015 road accidents, decreasing from B.E.2553 (2007) by 3,173 or 17.45 per cent. With consideration given to types of vehicles associated with accidents during B.E.2550-2554 (2007-2011), it was found that passenger car was the type with the highest number of accidents, totaling 41,652. The highest number of accidents of passenger car in B.E.2551 (2008) was at 10,774 or 41.25 percent of all vehicles. Types of vehicles with accidents in subsequent ranking were motorcycle (31,748), light truck (11,966), and taxi (7,996). With consideration given to the values of damage to assets, it was found that during B.E.2550-2554 (2007-2011), the damage to assets had a value of 2,405.97 million Baht, with the highest value of 1,357.39 million Baht in B.E.2551 (2008). In B.E.2554 (2011), the damage was valued at 59.93 million Baht. For the casualties to people, during B.E.2550-2554 (2007-2011), there were a total of 27,550 people in the accidents, with 964 deaths and 26,586 injuries. In B.E.2551 (2008), the highest number of casualties were 8,202 people, dividing into 291 deaths and 7,911 injuries. The casualties to people in B.E.2554 (2011) were at 4,082 persons (151 deaths and 3,931 injuries). The top three causes of road accidents during B.E.2550-2554 (2007-2011) (exclusive of cases without reporting of causes and othe cases) (details as presented in ***Table 6.4-10***) were suddenly cutting in (7,481 cases), closely following the front vehicles (7,293 cases), and failure to yield the right of way (5,778 cases). However, in B.E.2552 (2009) only, the top 3 causes of accidents were closely following the front vehicles (2,626 cases), suddenly cutting in (2,373 cases), and exceeding speed limit (2,082 cases).

(b) Nonthaburi

The consideration was given to road accident statistics in Nonthaburi of the areas under the responsibility of Provincial Police Region 1, Nonthaburi Province (covering an area along the mass transit system alignment). It was found that during B.E.2550-2554 (2007-2011), a total of 5,521 road accidents were reported to police. The highest number of reports was in B.E.2551 (2008) at 1,715. During B.E.2550-2554 (2007-2011), the reporting tendency was declining continually, whereas the reporting of road accidents during B.E.2553-2554 (2010-2011) declined significantly. In B.E.2554 (2011) there were 325 reports, dropping from B.E.2553 (2010) by 137 reports or 29.65 per cent. With consideration given to accidents on communication network along the mass transit system alignment and its vicinity during B.E.2550-2554 (2007-2011) (details presented in ***Table 6.4-9***), it was found that there were a total of 9,890 road accidents, with the highest number in B.E.2551 (2008) at 3,494 cases. The tendency of road accidents has been decreasing significantly. In B.E.2554 (2011), there were 88 road accidents, decreasing from B.E.2553 (2007) by 54 or 38.03 per cent. With consideration given to types of vehicles associated with accidents during B.E.2550-2554 (2007-2011), it was found that motorcycle was the type with the highest number of accidents, totaling 3,524. The highest

Table 6.4-10 Type of Road Accidents Cases Classified by Causes (B.E.2550-2552) (2007-2009) in Bangkok Metropolitan Administration and Nonthaburi

(Limited to the Areas along the Mass Transit System Only)

Causes of Accidents	B.E.2550		B.E.2551		B.E.2552	
	BMA	Nonthaburi	BMA	Nonthaburi	BMA	Nonthaburi
1. Exceeding speed limit	2,035	163	1,659	191	2,082	299
2. Suddenly cutting in	2,375	315	2,733	307	2,373	239
3. Illigal overtaking	888	190	705	188	717	150
4. Failure to turn on headlights	18	15	19	15	10	-
5. Failure to give signal on parking/slowing down/making turn	553	163	564	168	835	126
6. Disregarding stop sign	375	35	387	28	402	62
7. Red light running	662	74	705	113	725	129
8. Failure to keep left	717	43	510	122	517	140
9. Failure to give signal when vehicle cannot function	15	18	20	8	15	2
10.Overloading	24	0	16	0	11	0
11. Unskilled driver	136	37	193	68	242	51
12. Defect vehicle	90	6	67	3	33	5
13. Drunken	731	52	540	62	1,388	27
14. Drownsiness	36	10	26	2	41	0
15. Taking mental-affected substance	0	0	2	0	13	0
16. Animals cutting in	11	0	15	2	37	0
17. Using incorrect lane	608	0	524	0	484	0
18. Closely following front vehicle	2,168	0	2,499	0	2,626	0
19. Failure to yield the right of way	643	0	827	0	980	0
20. Others	2,277	343	1,757	419	1,744	300
21. Unavailable causes	679	0	767	0	940	0
Total	**15,041**	**1,464**	**14,535**	**1,696**	**16,275**	**1,530**
	16,505		**16,231**		**17,805**	
Increase/decrease rate	**-15.89 %**		**-1.66 %**		**9.70 %**	

Source: Royal Thai Police B.E.2550-2552 (2007-2009) number of accidents of motorcycle in B.E.2551 (2008) was at 1,204 or 35.36 percent of all vehicles. Types of vehicles with accidents in subsequent ranking were passenger car (3,092), light truck (1,597), and taxi (470). However, with the consideration only of the year B.E.2554 (2011), the vehicle type with the highest accidents was passenger car, totaling 22, or 30.14 per cent of all vehicles associated with accidents of the year. The subsequent orders of the year were cotorcycle (20), light truck (18), and taxi (6). With consideration given to the values of damage to assets, it was found that during B.E.2550-2554 (2007-2011), the damage to assets had a value of 62.69 million Baht, with the highest value of 28.89 million Baht in B.E.2552 (2009). In B.E.2554 (2011), the damage was valued at 278,500 Baht. For the casualties to people, during B.E.2550-2554 (2007-2011), there were a total of 3,610 people in the accidents, with 443 deaths and 3,167 injuries. In B.E.2552 (2009), the highest number of casualties were 1,315 people, dividing into 123 deaths and 1,192 injuries. The casualties in B.E.2554 (2011) were at 49 persons (33 deaths and 16 injuries). The top three causes of road accidents during B.E.2550-2552 (2007-2009) (exclusive of cases without reporting of causes and othe cases) (details as presented in ***Table 6.4-10***) were suddenly cutting in (861 cases), exceeding speed limit (653 cases), and illegal overtaking (528 cases). However, in B.E.2552 (2009) only, the top 3 causes of accidents were exceeding speed limite (299 cases), suddenly cutting in (239 cases), and illegal overtaking (150 cases).

In conclusion, the statistics of safety and accidents due to road traffic conditions of communication network along the mass transit system alignment and its vicinity within the 5-year period (B.E.2550-2554) (2007-2011) tended to decrease continually. The exception was in B.E.2551 (2008) when there were a total of 30,183 road accidents, increasing from B.E.2550 (2007) by only 257 or 0.86 per cent. In B.E.2554 (2011), there were 15,103 road accidents, dropping from B.E.2553 (2010) by 3,227 or 17.61 per cent. The accidents were at 60.21 million Baht worth of damages or increasing by 53.50 per cent. For casualties to people, there were 4,131 people in accidents (184 deaths and 3,947 injuries), or decreasing from B.E.2551 (2008) by 124 people, or 3.09 per cent.

6.4.3 Significance Assessment of Health Impact

On the analysis of health impact, the assessment was conducted only on the impact with potential and significance to health of the people living in the communities close to the construction sites of the Project stations in sensitive areas (such as religious places, public health facilities, baby nurseries), and also to the health of Project construction workers. The potential and significance of the impact were based on the likelihood of happening and severity of consequence from Project activities during the pre-construction, construction and operation phases. The assessment considered both positive and negative impacts in relation to Project details (as described in ***Chapter 3***) and the existing environment (as described in ***Chapter 4***). This health impact assessment has been processed in accordance with the methodology of health impact assessment. The process comprised preliminary screening, scoping of potentially significant impacts on health status. From the results of the two procedures, potential positive and negative impacts could be identified.

(1) Impact Analysis Method

The analysis on potential and significance of impacts has considered both positive and negative aspects from Project development activities by qualitative analytical method, using Risk Matrix tool.

In order to assess the impact risks, especially negative risks, Risk Matrix was applied as a tool to assess level of impact. The impact likelihood and severity of consequence were considered. The levels of likelihood were based on probability of such incidents to happen and experts' opinions. The levels of severity was based on the main issues of risk groups (susceptibility/sensitivity to health impact due to factors regarding immunity system, development of body system) and subsequent loss and damage (by considering morbidity rate, number and severity of injuries, physical damages such as number and level of damages to public facilities system, requirement of care in emergency situation, community safety and impact on community environmental health). Details of Risk Matrix were presented in ***Table 6.4-11***. Scoring criteria for the likelihood and severity of consequence were presented in ***Table 6.4-12***.

Table 6.4-11 Table of Risk Matrix for Health Impact Analysis

Severity of Consequence	Likelihood			
	Rare (1)	**Unlikely (2)**	**Possible (3)**	**Likely (4)**
Low (1)	Very low (1)	(2)	(3)	(4)
Moderate (2)	(2)	Low (4)	(6)	(8)
High (3)	(3)	(6)	Moderate (9)	High (12)

Source : Guidelines for Health Impact Assessment at Project Level, Ministry of Public Health, B.E.2552 (2009) Adapted from http://www.doh.gov.ph/ehia.htm

Table 6.4-12 Criteria for Determination of Likelihook and Severity of Consequence

Likelihood of Impact		Severity of Consequence	
Scores	**Descriptions**	**Scores**	**Descriptions**
1	Rare : Incident never occurs. There are availability of prevention, correction and mitigation measures of environmental impact.	1	Few illnesses, without impact on morbidity rate increase. No need to stop working. No impact on local budget.
2	Unlikely: Existing data indicates tendency to occur, but is still short of obvious statistical evidences to support. There are availability of prevention, correction and mitigation measures of environmental impact.	2	Morbidity rate increases. Injuries occur. Cumulative risk groups occur. Need to stop working which affects production, and communities in the Project areas.
3	Possible: Existing statistical evidences support the projection of probability. There are no prevention, correction and mitigation measures of environmental impact, or the existing measures do not cover the occurrence.	3	Fatality occurs. Expenses incurred for restoration. Cumulative risk groups occur, having impact on communities in the Project areas and its vicinity.
4	Likely: Incident used to occur. There are no prevention, correction and mitigation measures of environmental impact, or the the existing measures are not sufficient.		

Source: Guidelines for Health Impact Assessment at Project Level, Ministry of Public Health, B.E.2552 (2009) Adapted from http://www.doh.gov.ph/ehia.htm

Level of impact was based on the result of likelihood scores multiplied by severity of consequence scores in Risk Matrix. Definitions of levels of impact were described in ***Table 6.4-13***.

Table 6.4-13 Definitions of Levels of Impact

Scores from Risk Matrix	Level of Impact	Descriptions
1	Very low	Do not cause damages to health status. Do not increase morbidity/fatality rates. Do not have effect on budget, production. No need to impose prevention, correction and mitigation measures of environmental impact.
2-4	Low	No need to impose additional prevention, correction and mitigation measures of environmental impact. Improvemnet of the existing measures may be considered without additional expenses. If necessary, the monitoring may be required, subject to necessity and possibility.
5-9	Moderate	Morbidity rate increases. Injuries occur. May affect local budget. Need to monitor the appropriateness and adequacy of the existing prevention, correction and mitigation measures of environmental impact. If necessary and applicable, additional measures or improvement of existing measures may be required to cope with the impact, taking expenses into consideration also.
10-12	High	Have wide impact on health status. Fatalities occur. More budget is needed. Need to have more prevention, correction and mitigation measures of environmental impact. If unavoidable, changes in implementation may be needed.

Source: Guidelines for Health Impact Assessment at Project Level, Ministry of Public Health, B.E.2552 (2009)
Adapted from http://www.doh.gov.ph/ehia.htm

6.4.4 Health Impact Assessment

Health impact was assessed by each health hazard. Additional health hazards on occupational accidents and illnesses due to inappropriate and unsafe work conditions and environment, as well as problems of entry of foreign workers were considered. The additional health hazards affected health services system during pre-construction and construcitn phases. In order to suit with the effects from Project activities which were hazardous to health, the health impact assessment has divided risk groups into two groups; construction workers and people living within 500 meters from construction sites of the staions. The assessment was conducted by each helath hazard as follows:

6.4.4.1 Project Development Scenario

(1) Pre-construction/Construction Phases

Air Pollution

- **Nature of Health Impact**

Particulate Matter

The inhalation of particulate matter will cause eye and respiratory irritations. Large particles are trapped by nasal vibrissae. The smaller particles can pass through the nose into the respiratory system, causing irration, burning nose, coughing, sneezing, sputum, or dust cumulation in pulmonary alveoli. Lung efficiency is reduced. Moeover, particulate matter can reduce visual acuity, causing dirt, and irritation. Worldwide studies have found that particulate matter can cause premature death, respiratory diseases, and cardiovascular system diseases.

Carbon Monoxide (CO)

Carbon Monoxide (CO) is directly dangerous to human beings. The inhalation of CO will cause unability of red blood cells in taking oxygen to every part of the body as usual because c*arbon monoxide* has 200-250 times greater affinity for *haemoglobin* than oxygen. Thus, the amount of oxygen to the organs and tissues of the body is reduced which is very dangerous to patients with heart valve disease. For general people, carbon monoxide will cause dizziness, blurred vision, breathing difficulty, nausea, vomiting, fainting, and unconsciousness. Inhaling much of carbon monoxide can cause death. Eventhough the amount of CO emission is not high, the increased amount of CO associates with reduction in visual acuity, learning and working on complex task abilities.

No specific symptom of CO intoxication is shown. There are no pathogonomic signs. Most symptoms result from hypoxia of nervous and cardiovascular systems. The often-appearing symptoms are headache (91%), dizziness (77%), nausea and vomittig (47%), others i.e. unconsciousness, seizure, flu-like illness, angina. A patient may show a slight symptom of dizziness, or may have a serious symptom of unconsciousness, seizure, stop breathing, and death. CO intoxication can cause delayed neuropsychiatric disorders, which is found among 10-30% of patients. The symptom can be presented within 3-240 days after taking CO. The symptoms range from appearing no sign of symptoms but detectable by neuropsychological lab test, upto cerebral palsy and death. The abnormalities that can be found are cronic headache, changes in personality, cognitive deficits, parkin-sonism, incontinence, aphasia, apraxia, cortical blindness, focal neurological deficits, dementia and psychosis. Approximately 50-75% of patients can get better or recover within 1 year, the rest would not get better and may get worse until death.

Nitrogen Dioxide (NO_2)

Oxide of nitrogen in atmosphere has No and NO_2 as important pollutants. The first NO_x occurring is No and the last in the atmosphere is NO_2 . NO_x has the qualifications of light absorption, making it an agent for visibility reduction, obstructing growth of some plants. Nitrogen dioxide (NO_2) causes irration to the lungs and immunity reduction. When nitrogen dioxide reacts with water, the outcome is nitric acid, which is dangerous to living things. Inhalation of high concentration nitrogen dioxide can directly damage the lungs, such as, causing pneumonia, lung tumors and bronchitis. Moreover, it can cause infection in respiratory system such as flu. The impact from NO_2 emission is still unclear in the short term. However, the continuous or very frequent emission would leave higher concentrations of NO_2 than the ambient which may be the cause of an increase in serious respiratory diseases in children.

- **Risk Groups to Health Impact**

Risk groups to the effects of particulate matter from the activities during pre-construction and construction phases were classified into two groups, comprising:

- Construction workers as the main risk group due to direct exposure to particulate matter.
- People living within 500 meters from construction site of the Project.

- **Health Impact Assessment**

Project activities which caused health impact from air quality were stripping works, traffic, mobilization and stacking of earth/gravel and work materials, land filling, earth compaction and grading. These activities caused particulate matter while transportation of construction materials and machinery including the operation of machinery caused emission of CO, NO_x, and TSP.

- **Likelihood of Health Impact**
  - **Construction Workers**

The likelihood of health impact on construction workers from inhalation of air pollution such as particulate matter, CO and NO_2 was possible (3). These workers work closest to the particulate matter sources. However, the Project would provide the workers directly exposed to air pollution with personnel protective equipment (PPE) such as dust mask.

- **People Living within 500 meters from Construction Site of the Project**

Health impact from inhalation of particulate matter during pre-construction and construction phases was possible (3). The existing data showed that, during B.E.2550-2554 (2007-2011), people living in the Project areas or its vicinity mostly suffered from respiratory diseases as the first priority. This statistical data satisfactorily supported the likelihood projection if there were no provision of prevention, correction and mitigation measures of environmental impact or the existing measures did not cover the occurrence.

- **Severity of Consequence**
  - **Construction Workers**

During pre-construction and construction phases, health impact from inhalation of particulate matter was originated by site preparation activities, stripping works, mobilization and stacking of earth/gravel and working materials, land filling, land compaction and grading. Level of particle concentrations of construction activities was at 69 mcg/cu.m which was lower than standard ambient air quality (not higer than 330 mcg/cu.m). In the appraisal of the impact from construction, the existing TSP concentrations measured at Boromarajonani College of Nursing Station, Synphaet Hospital, and Phranakhon Rajabhat University were incorporated for consideration. It was found that the highest concentrations measured were 155 mcg/cu.m. When compliled with the projected maximum TSP concentrations, the maximum 24-hour average TSP concentrations increased to 224 mcg/cu.m. This value was lower than the standard value (330 mcg/cu.m). The construction activities occurred for a duraton of approximately 8 hours/day and when the activities ceased, the impact from particulate matter would be reduced.

The 1-hour average CO concentrations in the ambient emitted by machinery in construction phase were 0.0074 mg/cu.m. When compiled with the the maximum measured value (2.9775 mg/cu.m.), CO concentrations would be 3.0049 mg/cu.m. As the standard value of 1-hour average CO concentrations were limited to 34.2 mg/cu.m., it was projected that the machinery operation in construction phase would have low effect on CO concentrations.

The 1-h average NO_2 concentrations in the ambient emitted from machinery during construction phase were 0.0273 mg/cu m. When compiled the maximum measured value (0.1849 mg/cu m), NO_2 concentrations would be 0.2122 mg/cu m. As the standard value of 1-hour average NO_2 was limited to 0.320 mg/cu m, it was projected that the machinery operation in construction phase would have low effect on NO_2 condentrations.

The 1-hour average TSP concentrations in the ambient emitted by machinery in construction phase were 0.0018 mg/cu.m. When compiled with the the maximum measured value (0.155 mg/cu.m) and TSP concentrations from site preparation activities (0.069 mg/cu m), TSP concentrations would be 0.2258 mg/cu.m. As the standard 24-hour average TSP was limited to 0.330 mg/cu.m., it was projected that the machinery operation in construction phase would have low effect on TSP concentrations.

From the measurement of particulate matter and air pollutants such as CO and NO_2 emitted by machinery, it was found that the amount of particulate matter, CO and NO_2 was under the standard value. It could be concluded that the severity of consequence on construction workers was low (1).

- **People Living within 500 meters from the Project Construction Areas**

From the premilinary air quality measurement in the above, it was found that air pollution such as particulate matter, CO and NO_2 emitted from construction activities was under the standard air quality in the ambient in every parameater of measurement. Thus, it could be concluded that the severity of consequence on people living in the vicinity of the Project construction areae was low (1).

- **Health Risk Assesment**

From the health risk assessment as detailed in ***Table 6.4-14***, the risk levels of health impact on each risk group could be classified as follows:

Table 6.4-14 Risk Assessment of Health Impact from Air Pollution during Pre-construction and Construction Phases

Severity of Consequences	Lilelihood of Impact			
	Rare (1)	Unlikely (2)	Possible (3)	Likely (4)
Low (1)			X_1, X_2	
Moderate (2)				
High (3)				

Remarks: X_1 : health risk level of construction workers
X_2 : health risk level of people living in communities and sensitive areas around the Project area

- **Health Risk Level of Construction Workers**

Health risk was low (level 3). At this level, there was no need to impose additional prevention, correction and mitigation measures of environmental impact. Some improvement to the existing measures might be required without additional expenses. If necessary, it might require monitoring taking into consideration the necessity and possibility.

- **Health Risk Level of People Living in Communities and Sensitive Areas around the Project Areas**

Health risk was low (level 3). At this level, there was no need to impose additional prevention, correction and mitigation measures of environmental impact. Some improvement to the existing measures may be required without additional expenses. If necessary, it might require monitoring taking into consideration the necessity and possibility.

(a) Noise

- **Nature of Health Impact**

The effects of noise pollution on physical health are destruction of hearing system efficiency and impairment of hearing ability due to inner ear damage. Other side effects are such as tension, headache, high blood pressure, fatique and heart diseases. Exposure to very loud noise only once can destroy hearing system for approximately 2-3 hours and cause tinnitus, temporary or permanent deaf. Regularly prolonged exposure to unusually loud noise for a continuous period has effects on hearing competency reduction, hearing loss or even deaf. From the study of the Pollution Control Department, it was found that exposure to sound level over 120 dB(a) imposes a high risk of deaf. While exposure to sound at average level of over 90 dB(a) for a period of over 8 hours/day or exposure to sound level over 70 dB(a) all the time imposes a risk of hearing loss and impair audiometry. Another noise impact on mental health is annoyance. Loud noise causes failure of inter-personnel communication, perception and understanding. Moreover, complex work which requires high concentration can be affected by noise during working hours. The noise also causes negative impact on emotion, relaxation feeling, and reduction in privacy opportunity. (Crocker, 1998)

- **Risk Groups to Health Impact**

Risk groups to noise impact from activities during pre-construction and construction phases were classified into two groups, comprising:

- Construction workers working close to the construction engines and machinery for a period of 8 hours.
- People living within 500 meters from construction site of the Project.

- **Health Impact Assessment**

The main activities during pre-construction and construction phases which were noise sources were land grading, building construction, construction materials and equipment transportation, drilling, pile driving, and operation of heavy machines, for example.

Noise sources with potential impacts were noises from drilling for foundation construction and finishing work/work inspection which were expected to generate the highest noise level of the Project during construction. However, as the drilling for foundation construction and finishing work/work inspection occurred temporarily for a short period of time, the impact during the pre-construction and construction phases were low. For noise level from other noise sources, the noise level during the construction phase was lower than the noise level from drilling for foundation construction and finishing work/work inspection and also occurred intermittently.

- **Likelihoon of Health Impact**

- **Construction Workers**

The significance of likelihood of health impact on construction workers were given the first pripority by the Project. This was because construction workers worked closest to the noise sources. With consideration given to the highest noise level of the construction at 101 dB(a) which was generated by impact pile driver, noise impact was projected to be likely (4).

- **People Living within 500 meters from the Project Construction Sites**

The highest noise level of construction activities was from the impact pile driver equipment which generated noise level of 101 dB(a). The longer the distance from the noise source, the less noise level became, as presented in ***Table 6.4-15***. Therefore, the likelihood of the impact was possible (3) because the sensitive area closest to the Project alignment was San Chao Mae Suea Shrine (approximately 28 meters from the Project alignment). Wen compared to noise levels at various distances in case of solid fence installation, noise level at San Chao Mae Suea Shrine ranged between 65.7-73.7 dB(a), higher than the standard.

Table 6.4-15 Projected Noise Levels at Various Distances from Machinery and Equipment during Construction Phases

Construction Equipment & Equipment	Noise Levels from Equipment & Machinery at 50 ft. (15 m.) (dB(A))	Noise Levels at Various Distances from Noise Sources															
		Noise Levels without Solid Fence Installation (meter)								Noise Levels with Solid Fence Installation (reduced by 18 dB(A)) (meter)							
		10	20	50	100	200	300	400	500	10	20	50	100	200	300	400	500
Backhoe	80	79.7	73.7	65.7	59.7	53.7	50.1	47.6	45.7	61.7	55.7	47.7	41.7	35.7	32.1	29.6	27.7
Impact Pile Driver	101	97.7	91.7	83.7	77.7	71.7	68.1	65.6	63.7	79.7	73.7	65.7	59.7	53.7	50.1	47.6	45.7
Grader	85	84.7	78.7	70.7	64.7	58.7	55.1	52.6	50.7	66.7	60.7	52.7	46.7	40.7	37.1	34.6	32.7
Roller (vibratory roller)	85	81.7	75.7	67.7	61.7	55.7	52.1	49.6	47.7	63.7	57.7	49.7	43.7	37.7	34.1	31.6	29.7
Dump Truck	84	83.7	77.7	69.7	63.7	57.7	54.1	51.6	49.7	65.7	59.7	51.7	45.7	39.7	36.1	33.6	31.7
Crane	85	80.7	74.7	66.7	60.7	54.7	51.2	48.7	46.7	62.7	56.7	48.7	42.7	36.7	33.2	30.7	28.7
Total Noise Levels during Constructoin Activities (construction of 8 hr./day) *		98.3	92.3	84.3	78.3	72.3	68.7	66.2	64.3	80.3	74.3	66.3	60.3	54.3	50.7	48.2	46.3
Leq_{24h}**		93.5	87.5	79.5	73.5	67.5	64.0	61.5	59.5	75.5	69.5	61.5	55.5	49.5	46.0	43.5	41.5

- **Severity of Consequence**

- **Construction Workers**

Noise levels measured at noise sources of construction equipment and machinery was 80 dB(a) up. However, according to the occupational health, safety and environmental implementation plan, staff are required to wear personnel protective equipment while working, such as ear plugs, ear muffes. Therefore, the severity of consequence was defined as moderate (2). At this level, there may be effects on morbidity rate increase, injuries, commulative risk groups, budget, workers stopping work, if no prevention, correction and mitigation measures regarding occupational health and safety carefully and adequately provided.

- **People Living within 500 meters from the Project Construction Areas**

From the projection of noise level during construction phase in environmentally sensitive areas along the Project alignment, it was found that noise level during construction phase compiled with the maximum Leq_{24h} obtained from measurement was higher than the standard in various areas. The existing noise levels already exceeded the standard, such as the noise levels at Siam Business Administration

Nonthaburi Technological College (70.5 dB(A)), Phranakhon Rajabhat University (85.7 dB(A)), and Synphaet Hospital (74.2 dB(A)). Noise sources of noise level higher than the standard values were vehicular traffic on Tiwanon, Chaeng Watthana and Ram Inthra roads . Therefore, severity of consequence was moderate (2). This level may have effects on morbidity rate increase, injuries and commulative risk groups, affecting budget, causing workers to stop working, if no prevention, correction and mitigation measures regarding occupational health and safety carefully and adequately provided.

- **Health Risk Assessment**

From the health risk assessment as detailed in ***Table 6.4-16***, the risk levels of health impact on each risk group could be classified as follows:

Table 6.4-16 Risk Assessment of Health Impact from Noise Level during Pre-Construction and Construction Phases

Severity of Consequences	Lilelihood of Impact			
	Rare (1)	Unlikely (2)	Possible (3)	Likely (4)
Low (1)				
Moderate (2)			X_2	X_1
High (3)				

Remarks: X_1 : health risk level of construction workers
X_2 : health risk level of people living in communities and sensitive areas around the Project areas

- **Construction Workers**

Health risk was moderate (level 6). At this level, there might be morbidity rate increase and injuries. It needed to monitor and investigate that existing prevention, correction and mitigation measures of environmental impact were appropriate and sufficient. If necessary and applicable, additional measures or improvement of existing measures might be required to cope with the impact, taking expenses into consideration also.

- **People Living within 500 meters from the Project Construction Areas**

Health risk was moderate (level 8). At this level, there might be morbidity rate increase and injuries. It needed to monitor and investigate that existing prevention, correction and mitigation measures of environmental impact were appropriate and sufficient. If necessary and applicable, additional measures or improvement of existing measures might be required to cope with the impact, taking expenses into consideration also.

(c) Vibration

- **Nature of Health Impact**

The effects of vibration on health are subject to the frequency of vibration, nature of vibration such as vibration on all body parts or only at hands, feet or the part exposed to vibration. The effects of vibration will make molecules in the cell shake until tiresome occurs and the body feels fatigue. Disturbance and irritation occurs to the tissues. Vibration causes losses to body balance and seeing ability, blurred vision, reduction in working capability, malfunction on internal organs such as stomach and kidney pain, spinal cord inflammation, destruction of soft tissues of the wrists, hand muscle inflammation, impaired nerve endings in the hands, constricted blood vessels as a symptom of Raynaud's Syndrome leading to dead fingers. These occurrences are caused by vibration frequency in the ranges of 40-300 hertz. For mental health, the effects are feeling annoyance, and loss of concentration in daily activities.

- **Risk Groups to Health Impact**

Risk groups to be affected by vibration from the activities during pre-construction and construction phases were classified into two groups, comprising:

- Construction workers working close to vibration-sources machinery.
- People living within 500 meters from the Project construction areas.

- **Health Impact Assessment**

Vibration sources during pre-construction and construction phases were foundation construction, transportation of construction materials and operation of equipment and machinery.

Levels of vibration effects were subject to the type of equipment and machinery as well as the distance from vibration sources to receptors. For the appraisal of the impact along the Project alignment as a result of Project development, the computed vibration level was compared to the recommended criteria of Whiffin and Leonard on Effects of Vibration on People and Buildings, as presented in ***Table 6.4-17***.

Table 6.4-17 Recommended Criteria of Whiffin and Leonard on Effects of Vibration on People and Buildings

PPV (mm/sec) (in/sec)	Human Reaction	Effects on Buildings
0 - 0.15 (0-0.006)	Imperceptible	Unlikely to cause damage of any type.
2.0 (0.079)	Vibrations perceptible	Recommended upper level to which ruins and ancient monuments should be subjected.
2.0 (0.079)	Vibrations perceptible	Recommended upper level to which ruins and ancient monuments should be subjected.
2.5 (0.098)	Continuous exposure to vibrations begins to annoy	Virtually no risk of architectural damage to normal buildings.
10-15 (0.394-0.591)	Continuous vibrations unpleasant and unacceptable for people walking on a bridge	Vibration level higher than normal traffic would cause architectural and possibly minor structural damage.
10-15 (0.394-0.591)	Continuous vibrations unpleasant and unacceptable for people walking on a bridge	Vibration level higher than normal traffic would cause architectural and possibly minor structural damage.

Source : Whiffin, A.C., and Leonard, D.R., A Survey of Traffic Induced Vibration, Eng., 1971.

The impact assessment has found that the approach of bored pile foundation construction adopted by the Project would cause vibration at the level of being unpleasant for a human being and continuous vibration was unacceptable for people walking on a bridge.

- **Likelihood of Health Impact**
  - **Construction Workers**

The likelihood of health impact from vibration on construction workers was given the first priority because the workers worked closest to the vibration sources. With consideration given to pile driver (impact), the equipment causing the highest vibration level, with PPV at the distance of 25 feet (7.62 m.) being 1.518 in/sec (38.557 mm/sec), it was found that the vibration from this vibration source had a dangerous effect on human beings, as presented in ***Table 6.4-17***, because the PPV was in the ranges of 10-15 mm/sec.

Therefore, the likelihood of vibration impact on construction workers was moderate (3).

- **People Living within 500 meters from Project Construction Areas**

From the study of vibration effects from construction activities at various distances from the project alignment, it was found that vibration level at 10 meters distance from vibration source was unpleasant to human beings. If the vibration , the level of which was higher than that of normal traffic, went on continuously, the vibration would cause architectural and possibly minor structural damage. However, at the 10 meters distance from the pier alignment of the elevated structure, there were no vibration receivers or any buildings. The longer the distance from the vibration sources, the less the vibration became. Therefore, the livelihood of vibration impact on people living within 500 meters from Project construction site was low (2).

- **Severity of Consequence**

Severity of consequence from vibration during pre-construction and construction phases was classified by risk groups to health impact as follows:

- **Construction Workers**

From vibration level measurement of the Project development activities, it was found that there was only single activity that caused vibration perceptibility. That activity was pile drilling activity. However, the activity did not occur all the time. Besides, the occupational health, safety and environment plan of the Project has determined that workers had to wear personnel protective equipment while on duties. Therefore, the severity of the consequence was moderate (level 2). At this level, morbidity rate might increase. There might be injuries, cumulative risk groups, effect on budget and workers' stop working.

- **People Living within 500 meters from Project Construction Areas**

At vibration receiver locations from the Project construction activities, the vibration was at the perceptible level to human beings. If the vibration level increased, there would be effects on the historic site i.e. San Chao Mae Suea Shrine, approximately 28 meters from the Project alignment, which received vibration level at 0.2156 in/sec. At this level, it was unpleasant to human beings. However, the vibration sources intermittently caused vibration for a short period. Therefore, the severity of consequency on people living close to the Project site was low (level 1). At this level, there might be few illnesses, having no effects on morbidity rate increase, no need to stop working and did not affect local budget.

- **Health Risk Assessment**

From the health risk assessment as detailed in ***Table 6.4-18***, the risk levels of health impact on each risk group could be classified as follows:

Table 6.4-18 Risk Assessment of Health Impact from Vibration during Pre-construction and Construction Phases

Severity of Consequence	Likelihood of Impact			
	Rare (1)	Unlikely (2)	Possible (3)	Likely (4)
Low (1)		X_2		
Moderate (2)			X_1	
High (3)				

Remarks: X_1 : health risk level of construction workers
X_2 : health risk level of people living in communities and sensitive areas around the Project area

- **Construction Workers**

Health risk was moderate (6). At this level, morbidity rate of construction workers might increase. It needed to monitor and investigate that the existing prevention, correction and mitigation measures of environmental impact were appropriate and sufficient. If necessary and applicable, additional measures or improvement of existing measures might be required to cope with the impact, taking expenses into consideration also.

- **People Living within 500 meters from Project Construction Area**

Health risk was low (2). At this level, there was no need to impose additional prevention, correction and mitigation measures of environmental impact. Some improvement to the existing measures migt be required without additional expenses. If necessary, it might require monitoring taking into consideration the necessity and possibility.

(d) Wastewater/Impaired Surface Water

- **Nature of Health Impact**

Health impact from water pollution or consumption of wastewater was subject to types of virus and bacteria. Details were as follows:

Bacteria

Most of bacteria found in surface water are :

1) *Salmonella* spp.

Salmonella is regarded as the most serious and dangerous to human beings. Normally, the genus Salmonella is in the family Enterobacteriaceae but it can biochemically change itself to be in the fourth subgenera. The study has found that only the bacteria in Sub-genera I is dangerous to human beings because of its Endotoxin, generated by this group of bacteria. The toxin will cause salmonellosis symptoms or salmonella-induced symptoms. A person will develop gastro-enteritis due to heavy vomiting or watery diarrrhea. Besides, the bacteria is related to abdominal cramps, fever, nausea, vomit, headache. In case of severity, a person may fall ill and die. However, how serious the symptoms will be is subject to the amount of bacteria in the human body. Compared to farm animals, the opportunity of becoming seriously ill in a person due to this bacteria-related symptoms is much less, and also varies according to the seasons. In addition, there were reports on relations between this type of bacteria and typhoid fever, paratyphoid fever, and food poisoning as well.

2) *Campylobacter* spp.

Campylobacter is a spiral shaped gram-negative bacteria, with 2-6 spirals and approximately 2,000-5,000 nanometers. It can moves with the help of Single Polar Flagellum. With its qualificaition as oxidase-positive, it can reduce nitrate but cannot produce acid when carbohydrate exists. Its toxin is the ability to cause gastro-enteritis (such as fever, nausea, abdominal pain, vomit and food poisoning). Campylobacter infection may lead to Guillan-Barr Syndrome which is a symptom of acute paralysis. Bacteria contamination in water has an effect on widespread epidemic (Mentzing, 1981; Vogt *et al*. 1982; Taylor *et al*. 1983; Bates *et al*. 1984). In case of contaminated water sources or incomplete treatment water, bacteria of this type is divided into 2 groups. The first group, Thermophilic including *C. jejuni* and *C. coli*., which is dangerous to human beings, can grow well at 42ºC temperature. Another group can grow well at only 25ºC. From doing the serotype, it was confirmed that *C. jejuni* is generally found in contaminated effluent which is regarded as significant source of the this bacteria.

3) *Shigella* spp.

This type of bacteria causes shigellosis or diarrhea. These bacteria infection symptoms are collectively called Shigellosis. Moreover, this bacteria also causes bloody stool due to inflammation and ulceration of the intestinal epithelium. *Shigella* spp. is a rod-shaped gram-negative nonmotile bacteria. It is categorized as an oxidase-negative type, except for *S. dysenteriae* type I. The other types are catalase positive. Generally, the spread of this bacteria is similar as that of *Salmonella* spp., except that *Shigella* spp. is not often found to be infectious in animals nor viable in the external environment. It is mostly found contagious from human to human, especially in risk groups such as children.

4) *Escherichia Coli*

Most strains of this type of bacteria are found in the gastrointentinal system of the warm-blooded animals including human beings. The *E. coli*. strain which is dangerous to human beings are classified into four main groups by natures of toxicity, clinical signs, epidemiology, and O:H serogrouping, as follows:

- Enterpathogenic *E. coli* (EPEC)
- Enteroinvasive *E. coli* (EIEC)
- Enterotoxigenic *E. coli* ZETEC)
- Enterohaemorrhagic *E. coli* (EHEC)

However, Guerrant and Thailman, 1995 have proposed the fifth group namely Enteroaggregative *E. coli* (EAggEC).

The Enteroaggregative *E. coli* (EAggEC) group also includes the serotype which causes gastro-enteritis due to heavy vomiting or diarrhea in human beings. The disease severity increases in risk groups such as the new born or children under 5 years of age. Somepeople may understand that this sign of symptoms is Traveller's Tummy, with diarrhea occurring to tourists visiting the temperate regions in Europe. In general, if the body is infected with this bacteria, the following signs will appear; diarrhea with few blood, nausea and dehydration. However, this type of bacteria does not cause fever, and does not have severe symptoms in adults. It is often found that up to 2-8 per cent of all the coliform bacteria group found in wastewater sources are Enterpathogenic *E. coli*. However, only 100 of this organism can be pathogenic. The conditions suitable for the growth of this organism is temperate regions with abundant nutrition. It is also found that this bacteria can well multiply itself in water sources.

Escherichia coli O157:H7 is in the fourth group of coliform bacteria group. It causes haemorrhagic colitis, haemolytic-uraemic syndrome. This organism is the main cause of kidney diseases for children.

Viruses

Generally, there are 140 virus types that are well known and dangerous to human beings. Virus group which casuses digestive diseases is called Enteric Viruses, comprising Enterovirus, Rotavirus, Astrovirus, Hepatitis A virus, Calcivirus, Norwalk virus and "Small Round" virus group (West, 1991). As these Enteric Viruses often involve with intestines, the diseases thus relate to gastroin testinal diseases (Sellwood and Dadswell, 1991). Anyway, health risk due to this virus group is not limited only to digestive diseases. There are a number of Enterovirus groups, such as Reovirun, Coxsackievirus and Echovirus that can cause infection to the respiratory system and can be found in feces of the infected people. Viruses found in general effluent can be classified as follows:

- Coxsackievirus Type A is often found in 23 serotypes. Receiving this virus will cause herpangia symptoms. The symptoms are swollen throat, fever, headache, stomachache, papules in the mouth and throat. These symptoms are generally found in children. However, these symptoms will alleviate in a short time. Moreover, this virua can cause meningitis, respiratory system diseases, paralysis, and fever.
- Coxsackievirun Type B. is often found in 6 serotypes. Receiving this virus will cause chest pain, infection to the respiratory system, meningitis, and pericarditis. Infants infected with this virus are often found to have inborn heart diseases. This virus also causes severe nephritis and fever.
- Echovirun is found in 34 serotypes. Receiving this virus will cause infection to the respiratory system, meningitis, diarrhea, pericarditis, myocarditis, fever and rash.
- Enterovirus is found in 4 serotypes. Receiving this virus will cause meningitis and respiratory system diseases.
- Hepatitis A virus (HAV) often causes hepatitis A.

- Reovirus is often found in 3 serotypes. Receiving this virus will cause respiratory system diseases.

- Rotavirus is often found in 4 serotypes. Receiving this virus will cause gastro-enteritis due to heavy vomiting or diarrhea.

- Adenovirus is often found in 41 serotypes. Receiving this virus will cause gastro-enteritis due to heavy vomiting or diarrhea, respiratory system diseases, and acute conjunctivitis.

- Norwalk agent (Calcivirus) is often found in 1 serotype. Receiving this virus will cause gastro-enteritis due to heavy vomiting or diarrhea.

- Astrovirus is often found in 5 serotypes. Receiving this virus will cause gastro-enteritis due to heavy vomiting or diarrhea.

- **Risk Groups to Health Impact**

Risk groups to be affected by impaired surface water quality from the activities during pre-construction and construction phases were classified into two groups;

- Construction workers living in the Project area during construction phase.

- People living within 500 meters from the Project construction areas, particularly the communities located close to surface water sources.

- **Health Impact Assessment**

Sewage and effluent from worker camps and construction supervision office building located close to surface water sourves was the main cause of deterioration of water quality of surface water sources. Most of the effluent was from bathing of workers and staff, toilettes of the construction supervision office and worker camps, washing of construction equipment, and mixing water. The effects would occurres if effluent and sewage was directly drained into surface water sources close to worker camps or the construction supervision office without prior treatment. This would deteriorate surface water quality in the area. If people living close to the construction areas bring water from these sources for consumption, bacteria and viruses could enter the body and affect their health.

- **Likelihood of Health Impact**

- **Construction Workers and People Living within 500 meters from the Project Construction Areas**

The likelihood of health impact from deteriorated surface water quality from Project construction activities was possible (3). As satistical evidences support the likelihood to occur if no prevention, correction and mitigation measures of environmental impact were pprovided, or the existing measures did not cover the occurrence.

- **Severity of Consequence**

- **Construction Workers and People Living within 500 meters from the Project Construction Areas**

Eventhough the mass transit system alignment passed through 20 surface water sources, none of the pier construction of the elevated structure and station construction works invaded into those surface water sources. Thus, no activities disturb ed surface water quality nor directly affected aquatic ecosystem. The exception was for the 10 stations located within 50 meters from surface water sources (i.e. PK04, PK10, PK11, PK14, PK15, PK20, PK21, PK23, PK29 and PK30). The activities at these stations may cause turbidity increase from leachate or cause some contamination from machine oil of construction equipment. However, the leachate occurred only during the foundation drilling and land grading and filling activitie. Therefore, it was projected that the impact would be temporary only during the construction phase because the construction area was limited to the traffic islands only. The review of suspended solids quantity (B.E.2546-2550) (2003-2007) and the analysis of suspended solids quantity (B.E.2551) (2008) of surface water sources along the mass transit system alignment, represented by Khlong Bang Talat, Khlong Prapa, Khlong Premprachakon, Khlong Lamchala, Khlong Song Ton Nun, and Khlong San Sap, has shown that the suspended solids quantity ranged 1.0-72.0 mg/litre. In addition, the analysis of suspended solids quantity in Khlong Song Ton Nun (B.E.2555) (2012) has found that the quantity was 30 mg/litre. From the analyses both in B.E.2551 (2008) and BE. 2555 (2012), the suspended solids quantity was in the low-moderate levels (<25-100 mg/litre, Boyd, 1979) and did not affect aquatic lives and benthic animals. Moreover, most of the people and construction workers used tap water for consumption, therefore the severity of consequency of health impact on construction workers and people living in the area was low (1). There might be few illnesses, no need to stop working and local budget not affected.

- **Health Risk Assessment**

From the health risk assessment as detailed in ***Table 6.4-19***, the risk levels of health impact on each risk group could be classified as follows:

Table 6.4-19 Risk Assessment of Health Impact from Deteriorated Suface Water Quality during Pre-construction and Construction Phases

Severity of Consequence	Likelihood of Impact			
	Rare (1)	Unlikely (2)	Possible (3)	Likely (4)
Low (1)			X_1, X_2	
Moderate (2)				
High (3)				

Remarks: X_1 health risk level of construction workers
X_2 health risk level of people living in communities and sensitive areas around the Project area

- **Construction Workers and People Living within 500 meters within Project Construction Areas**

Health risk was low (3). At this level, there was no need to impose additional prevention, correction and mitigation measures of environmental impact. Some improvement to the existing measures might be required without additional expenses. If necessary, it might require monitoring taking into consideration the necessity and possibility.

(e) Accidents and Injuries from Improper and Unsafe Working Conditions and Environment

- **Nature of Health Impact**

As the pre-costruction and construction phases last approximately 4 years, if the working conditions and environment at the Project areas are improper and unsafe for construction workers, it may have an effect in terms of accidents on construction workers. The effects can be injuries, falling ill, or death of the workers which would finally bring about shortage of skilled workers.

- **Risk Groups to Health Impact**

Risk groups to health impact from unsafe working conditions and environment were construction workers.

- **Health Impact Assessment**

The activities during pre-construction and construction phases which might cause an impact were:

➢ Particulate matter from land clearing and grading, excavation, cut-and-fill works, foundation soil stabilization, and construction waste transportation, etc.

➢ Exhaust gas from vehicles for transporting construction machinery/equipment and materials, mobilizing construction materials/parts such as transporting pier columns from concrete plants to construction site, and transporting construction wastes out of construction site when the construction is almost finished.

➢ Noise and vibration from the construction activities such as foundation and pier construction, and operation of machinery.

➢ Problems of working environment such as solar heat while working outdoor, too little light especially when working at night, working for over 8 hours continuously in order to speed up the work until the workers are fatigued and weary.

The problems of occupational unsafety from the Project construction activities would cause loud noise, dust, exhaust gas from heavy vehicles for transportation of construction machinery, parts, materials and equipment, and accidents from machinery malfunction. The improper implementation or control and prevention would cause harm to the health and life of construction workers. Particularly, the risk due to negligence, and failing to wear PPE in hazard areas, usage of defect equipment, or accidents from construction materials transportation.

- **Likelihood of Health Impact**
  - **Construction Workers**

The likelihood of health impact on construction workers from unsafe and inappropriate working conditions and environment was possible (3). The existing satistical evidences supported the likelihood projection. Furthermore, as the pre-construction and construction phases lasted for approximately 4 years, it was possible that the workers might have accidents and fall ill due to unsafe working conditions and environment, if the construction company did not properly manage occupational health and safety program.

- **Severity of Consequence**
  - **Construction Workers**

In the event the construction company did not sufficiently pay attention to or considered occupational health and safety for construction workers, the severity of consequence of the accidents or illnesses occurred to the workers due to unsafe or improper working conditions and environment was moderate (2). At this level, morbidity rate might increase and there might be injuries, cumulative risk groups, effect on budget and workers' stop working. This might affect construction works and the communities in the Project areas.

- **Health Risk Assessment**

From the health risk assessment as detailed in **Table 6.4-20**, the risk was moderate (6). At this level, morbidity rate might increase. It needed to monitor and investigate that the existing prevention, correction and mitigation measures of environmental impact were appropriate and sufficient. If necessary and applicable, additional measures or improvement of the existing measures might be required to cope with the impact.

Table 6.4-20 Risk Assessment of Health Impact from Inappropriate Occupational Environment during Pre-construction and Construction Phases

Severity of Consequence	Likelihood of Impact			
	Rare (1)	Unlikely (2)	Possible (3)	Likely (4)
Low (1)				
Moderate (2)			X	
High (3)				

Remarks: X health risk level of construction workers.

(f) Problems of Entry of Foreign Workers

- **Nature of Health Impact**

The entry of foreign workers during pre-construction and construction phases might have effects on the spread of communicable diseases and/or sexually transmitted diseases, and non-communicable diseases such as diarrhea, food poisoning, malaria, AIDS, and venereal diseases. In addition, the effects might be social problems such as drug problems and decrease in social safety if there was no proper and sufficiently efficient screening or management of foreign workers entering as construction workers. Furthermore, in case foreign works sustained injuries or fell ill from work and needed to be sent to hospital or local health facilities for treatment, this would disturb healthcare services provided for the communities and lead to inadequacy of public health services system.

- **Risk Groups to Health Impact**

  Risk groups to be affected by entry of foreigh workers were :

  - Construction workers
  - People living around the Project areas

- **Health Impact Assessment**

As the activities during pre-construction and construction phases lasted approximately 4 years and a large number of foreign workers were needed. The increase of foreign workers in the communities therefore caused health impact to people living in the Project areas and its vicinity as well as construction workers who were foreign workers themselves. Details were as follows:

- A scramble for public health sevices would arise. In case a large number of construction workers happened to fall ill or have accidents from work simultaneously and needed to be sent for emergency treatment, this would reault in shortage of public health services provided for the communities, being unable to serve the people's demand within the Project areas and its vicinity.

- The spread of communicable and non-comunicable diseases might arise with foreign workers as disease carriers.

- Social problems might arise such as the spread of drug, conflicts of thoughts and attitude with local people, and crime might increase, in case that there was no efficient screening or management of foreign workers.

- **Likelihood of Health Impact**

  - **Construction Workers and People Living within 500 meters from Project Construction Areas**

With consideration given to the duration of the Project pre-construction and construction phases which lasted approximately 4 years, there was a likelihood that the entry of foreign workers would have an effect on health of the people living in the Project areas and its vicinity including on health of the workers themselves. If the construction company did not have sufficiently efficient screening and management systems of foreign workers, the likelihood of health impact was possible (3).

- **Severity of Consequence**

  - **Construction Workers and People Living within 500 meters from Project Construction Areas**

In the event the construction company did not pay attention to screening foreign workers for working as construction workers or did not have efficient management of foreign workers, it might have effects on a spread of communicable and non-communicable diseases, as well as inadequacy of public health services for the communities, followed by solical problems. These problems were such as widespread of narcotic drugs, crime increase in the locality. With consideration given to the statistics of arrests of crime against the state classified by types of cases for the past 5 yeatrs (B.E.2550 - 2554) (2007-2011) within the station construction areas, it was narcotics cases that had the highest number of reports and arrests. The second in the rank was gambling cases.

Therefore, the severity of consequence for construction workers and people living within 500 meters from the Project construction areas was moderate (2). At this level, there might be some injuries or illnesses, morbidity rate increase, commulative risk groups, effect on budget, stop working, which affect production capacity and communities in the Project areas.

- **Health Risk Assessment**

From the health risk assessment as detailed in ***Table 6.4-21***, the risk levels of health impact on each risk group could be classified as follows:

Table 6.4-2 1 Risk Assessment of Health Impact from Entry of Foreign Workers during Pre-construction and Construction Phases

Severity of Consequence	Likelihood of Impact			
	Rare (1)	**Unlikely (2)**	**Possible (3)**	**Likely (4)**
Low (1)				
Moderate (2)			X_1, X_2	
High (3)				

Remarks: X_1 health risk level of construction workers

X_2 health risk level of people living in communities and sensitive areas around the Project area

- **Construction Workers and People Living within 500 meters from Project Construction Area**

From the health risk assessment as detailed in ***Table 6.4-21***, the risk was moderate (6). At this level, morbidity rate might increase and there might be injuries and effect on local budget. It needed to monitor and investigate that the existing prevention, correction and mitigation measures of environmental impact were appropriate and sufficient. If necessary and applicable, additional measures or improvement of the existing measures might be required to cope with the impact.

(g) Adequacy of Medical and Public Health Personnel and Public Health Facilities

- **Nature of Health Impact**

The adequacy of medical and public health personnel and public health facilities as well as the 7 important medical equipment was quite essential. If there was no sufficient provision of healthcare facilities and medical personnel off-site, it would have effects on construction workers and construction supervisors. In case that construction workers and the construction supervisors seriously fell ill or sustained injuries from work and immdiate treatment was required, and if, in the construction area, there was no public health facilities or the facilities did not have capable and well-experienced medical personnel nor the 7 important medical equipment, the effect coule be deadly. In addition, the inadequacy of public health facilities and medical personnel might affect the people in the Project areas. In case that construction workers and construction supervisors fell ill simultaneously, this might disturb the health services provided for the people living in the construction areas.

- **Risk Groups to Health Impact**

Risk grups to health impact from inadequacy of medical and public health personnel and public health facilities during pre-construction and construction phases were classified into 2 groups;

- Construction workers residing in the Project areas during Project construction phase
- People living within 500 meters of the Project construction areas

- **Health Impact Assessment**

The consideration was given to secondary data on number of public health and medical facilities, and number of important medical equipment.

- **Likelihood of Health Impact**

- **Construction Workers and People Living within 500 meters from Project Construction Areas**

In the Project areas, there were sufficient public health and medical facilities; 5 governmental hospitals with total 1,386 beds, 3 Public Health Centers of the BMA Health Department and 2 health stations of the Ministry of Public Health with total 30 beds, 3 private hospitals with total 930 beds. With consideration in terms of number of medical and public health personnel, there were sufficient physicians in the areas along the the mass transit system alignment to serve the local population. An exception was found in Khet Bueng Kum and Khet Bang Khen of Bangkok Metropolitan Administration, where there were no hospitals. However, as the Project areas were located in urban communities with complete communication network, eventhough there might be some traffic problems, in case of emergency due to illnesses or accidents from the Project, the patients could be sent for treatment at nearby medical facilities in time.

With consideration in terms of readiness of important medical equipment, there were 90 CT Scans, 20 MRIs, 34 ESWLs, 88 Gamma Knives, 530 Ultrasounds, 960 Hymodialysis, and 414 ambulances. With readiness of medical equipment and complete communication network, in emergency cases of illnesses or accidents from the Project, the patients could be sent to medical facilities in time.

Therefore, the likelihood of health impact due to inadequacy of medical and public health personnel and public health facilities was possible (3). The existing satistical evidences supported the likelihood projection. There were no prevention, correction and mitigation measures of the impact or the existing measures did not cover the occurrence.

Severity of Consequence

- **Construction Workers and People Living within 500 meters of the Project Construction Areas**

It was found that the areas along the Project alignment were still rather short of medical and public health personnel and public health facilities. Therefore the severity of consequence was moderate (2). At this level, there might be morbidity rate increase, commulative risk groups, effect on budget, and stop working, which affected production capacity and communities in the Project areas.

- **Health Risk Assessment**

From the health risk assessment as detailed in ***Table 6.4-22***, the risk levels of health impact on each risk group could be classified as follows:

Table 6.4-22 Risk Assessment of Health Impact from Adequacy of Medical and Public Health Prsonnel and Public Health Facilities during Pre-construction and Construction Phases

Severity of Consequence	Likelihood of Impact			
	Rare (1)	Unlikely (2)	Possible (3)	Likely (4)
Low (1)				
Moderate (2)			X_1, X_2	
High (3)				

Remarks: X_1 health risk level of construction workers

X_2 health risk level of people living in communities and sensitive areas around the Project area

- **Construction Workers and People Living within 500 meters from the Project Areas**

From the the health risk assessment as detailed in ***Table 6.4-22***, the risk was moderate (6). At this level, morbidity rate might increase and there might be injuries affecting local budget. It needed to monitor and investigate that the existing prevention, correction and mitigation measures of environmental impact were appropriate and sufficient. If necessary and applicable, additional measures or improvement of the existing measures might be required to cope with the impact provided that the expenses incurred had to be taken into consideration as well.

(h) Road Accidents

- **Nature of Health Impact**

Nature of health impact from road accidents caused by the activities during pre-construction and construction phases was in the form of injuries and death of commuters in the Project construction sites. The accidents were caused by heavy vehicles transporting construction materials and equipment in the whereabouts of the Project areas. The severity of accidents was subject to the size of vehicles associated with accidents as well as timing of accidents. In addition, mental health impact from road accidents often appeared in the form of being frightened, getting panic, and a shock.

- **Risk Groups to Health Impact**

Risk groups to health impact from road accidents during pre-construction and construction phases were the 2 groups as follows:

- Commuters passing by the Project construction areas
- Construction workers

- **Health Impact Assessment**

The main activities during the pre-construction and construction phases which causes health impact were large vehicles transporting construction materials and equipment to and from the Project construction areas.

- **Likelihood of Health Impact**

- **Construction Workers and People Living within 500 meters from Project Construction Areas**

With consideration given to road accident statistics during B.E.2550-2554 (2007-2011) classified by causes of accidents and types of casualties and suspects, it was found that passenger cars had the highest accidents in Bangkok Metropolitan Administration and motorcycles in Nonthaburi. For road accidents statistics during B.E.2548-2552 (2005-2009) classified by causes of accidents, it was found that the main cause of road accidents in the areas along the Project alignment was suddenly cutting in, followed by exceeding speed limit and illegal overtaking. However, number of reports to police and the amount of casualties to people during B.E.2550-2554 (2007-2011) had been decreasing continually, with only a slight increase in B.E.2552 (2009). Therefore, the likelihood of health impact from road accidents due to the Project development during pre-construciton and construction phases was possible (3). The existing satistical evidences supported the likelihood projection if no prevention, correction and mitigation measures of environmental impact were provided, or the existing measures did not cover the occurrence.

- **Severity of Consequence**

- **Construction Workers and People Living within 500 meters of the Project Construction Areas**

As the activities during the pre-construction and construction phases of the Projected last approximately 4 years, and the major activities causing road accidents were mostly contributed by large vehicles transporting construction materials and equipment, therefore the severity of consequence was moderate (2). At this level, there might be morbidity rate increase, injuries of people in the Project areas, commulative risk groups, effect on budget, and stop working, which affected production capacity and communities in the Project areas.

- **Health Risk Assessment**

From the health risk assessment as detailed in ***Table 6.4-23***, the risk levels of health impact on each risk group could be classified as follows :

Table 6.4-23 Risk Assessment of Health Impact from Road Accidents during Pre-construction and Construction Phases

Severity of Consequence	Likelihood of Impact			
	Rare (1)	Unlikely (2)	Possible (3)	Likely (4)
Low(1)				
Moderate (2)			X_1, X_2	
High (3)				

Remarks: X_1 health risk level of construction workers

X_2 health risk level of people living in communities and sensitive areas around the Project area

- **Construction Workers and People Living within 500 meters from the Project Construction Areas**

From the health risk assessment as detailed in ***Table 6.4-23***, the risk was moderate (6). At this level, morbidity rate might increase. It needed to monitor and investigate that the existing prevention, correction and mitigation measures of environmental impact were appropriate and sufficient. If necessary and applicable, additional measures or improvement of the existing measures might be required to cope with the impact, provided that the expenses incurred had to be taken into consideration as well.

(i) Tension, Anxiety, Annoyance and Fear

- **Nature of Health Impact**

The development in the Proejct areas would inevitably cause changes to the environmental quality of the areas. Those changes caused anxiety, tension and fear to the people living around the Project areas. The concerns of the directly affected people were deterioration of environmental quality; air quality, noise, vibration, and surface water quality due to the Project development during the pre-construction and construction phases. Those health impact could be regarded as mental health impact. If no prevention, correction and mitigation measures were efficiently determined, nor confidence built in the people living around the Project areas to make them feel relief, the impact would be accumulated and the psychiatric symptoms might develope such as tension disorder, panic disorder, or psychotic disorder if the symptoms became serious.

For the annoyance, it was mostly caused by particulate matter, loud noise and vibration from the Project activities during the pre-construction and construction phase which affected working concentration and daily living of the people around the Project areas.

- **Risk Groups to Health Impact**

Risk groups to health impact were the people living around the Project areas who were directly affected by the deterioration of environmental quality, whether be it surface water quality, air quality, noise level and vibration.

- **Health Impact Assessment**

The activities that caused changes or effects in terms of daily living disturbances of the people around the Project construction areas had mental impact in terms of anxiety, tension, panic, or annoyance to the changes.

- **Likelihood of Health Impact**

With consideration given to the duration of the pre-construction and construction phases of the Project which took rather long time, there was likelihood of mental impact on the people living around the Project areas, if no prevention, correction and mitigation measures were determined to alleviat the environmental impact on mental health of the people. In addition, the lack of providing details about the Project, construction sequences, and those measures for building confidence in the people also contributed to the likelihood of mental health impact. Therefore, the likelihood of health impact in terms of tension, anxiety, annoyance and fear from the Project development during the pre-construction and construction phases was possible (3). The existing satistical evidences supported the likelihood projection if no prevention, correction and mitigation measures of environmental impact were provided, or the existing measures did not cover the occurrence.

- **Severity of Consequence**

Eventhough the environmental quality in the present Project areas i.e. surface water quality, air quality, noise and vibration are within the environmental standards, indicating that the environmental conditions were capable of loading potential pollution, the lack in thorough public relations of Project details, and measures on environmental prevention, correction and mitigation would contribute to the severity of consequence. The public relations should be aimed particularly at the people living around the construction areas who were directly affected for them to have conficence in the Project and feel relief. Therefore, the severity of consequence of potential health impact was moderate (2). At this level, there might be morbidity rate increase, injuries of people in the Project areas, commulative risk groups, effect on budget, and stop working, which affected production capacity and communities in the Project areas.

- **Health Risk Assessment**

From the health risk assessment as detailed in ***Table 6.4-24***, the risk was moderate (6). At this level, morbidity rate might increase and there would be injuries. It needed to monitor and investigate that the existing prevention, correction and mitigation measures of environmental impact were appropriate and sufficient. If necessary and applicable, additional measures or improvement of the existing measures might be required to cope with the impact provided that the expenses incurred had to be taken into consideration as well.

Table 6.4-24 Risk Assessment of Health Impact from Tension, Anxiety, Annoyance during Pre-construction and Construction Phases

Severity of Consequence	Likelihood of Impact			
	Rare (1)	Unlikely (2)	Possible (3)	Likely (4)
Low (1)				
Moderate (2)			X	
High (3)				

Remarks: X health risk level of people living in communities and sensitive areas around the Project area

(2) Operation Phase

(a) Air Pollution

- **Nature of Health Impact**

Health impact from particulate matter and air pollutions in the operation phase varied. Details were as follows:

- **Particulate Matter**

Health impact from inhalation of particulate matter was the same as that during the pre-construction and construction phases.

- **Air Pollutants**

Air pollutants emitted from the activities in the operation phase were carbon monoxide (CO) and nitrogen dioxide (NO_2). The effects of the pollutans on health differed. Details were as follows:

Carbon Monoxide (CO)

Carbon Monoxide (CO) is directly dangerous to human beings. The inhalation of CO will cause unability of red blood cells in taking oxygen to every part of the body as usual because c*arbon monoxide* has 200-250 times greater affinity for *haemoglobin* than oxygen. Thus, the quantitiy of oxygen to the organs and tissues of the body is reduced which is very dangerous to patients with heart valve disease. For general people, carbon monoxide will cause dizziness, blurred vision, breathing difficulty, nausea, vomiting, fainting, and unconsciousness. Taking much of carbon monoxide can cause death. Eventhough the amount of CO emission is not high, the increased amount of CO associates withl reduction in visual acuity, learning and abilities to work on complex task.

No specific symptoms of CO intoxication are shown. There are no pathogonomic signs. Most symptoms are resulted from hypoxia of nervous and cardiovascular systems. The symptoms often appear are headache (91%), dizziness (77%), nausea and vomittig (47%), others i.e. unconsciousness, seizure, flu-like illness, angina. A patient may show a slight symptom of dizziness, or may have a serious symptom of unconsciousness, seizure, stop breathing, and death. CO intoxication can cause delayed neuropsychiatric disorders, which are found among 10-30% of patients. The symptoms will appear within 3-240 days after taking CO. The symptoms range from appearing no signs but detectable by neuropsychological lab test, upto cerebral palsy and death. The abnormalities that can be found are cronic headache, changes in personality, cognitive deficits, parkin-sonism, incontinence, aphasia, apraxia, cortical blindness, focal neurological deficits, dementia and Psychosis. About 50-75 % of patients can get better or recover within 1 year, the rest would not get better and may get worse until death.

Nitrogen Dioxide (NO_2)

Oxide of nitrogen in atmosphere has No and NO_2 as important pollutants. The first NO_x occurring is No and the last in the atmosphere is NO_2 . NO_x has the qualifications of light absorption, making it an agent for visibility reduction, obstructing growth of some plants. Nitrogen dioxide (NO_2) causes irration to the lungs and immunity reduction. When nitrogen dioxide reacts with water, the outcome is nitric acid, which is dangerous to living things. Inhalation of high concentration nitrogen dioxide can directly damage the lungs, such as, causing pneumonia, lung tumors and bronchitis. Moreover, it can cause infection in respiratory system such as flu. The impact from NO_2 emission is still unclear in the short term. However, the continuous or very frequent emission would leave higher concentrations of NO_2 than the ambient which may be the cause of the increase in serious respiratory diseases in children.

- **Risk Groups to Health Impact**

The main risk groups were people living around the Project areas and people using the services at the stations.

- **Health Impact Assessment**

Air pollution sources in the operation phase were mainly from exhaust gas of vehicles of people using the services. Health impact could be assessed by Risk Matrix as a tool.

- **Likelihood of Health Impact**
  - **People Living in the Project Areas**

In the operation phase, the Project activity was to transport passengers by monorail system. The whole system was of new technology, electricity-powered without engine-driven vehicles. Therefore, there was no direct air pollutant sources in the Project. However, the structure of the station platform might reduce the dilution of pollutants emitted by vehicles under the stations. Anyway, the stations have been designed with an efficient pollutant dilution system underneath the platform. Therefore, the likelihood of health impact from particulate matter was unlikely (2).

- **Severity of Consequence**
  - **People Living in the Project Areas**

In the operation phase, there was no direct air pollutant sources in the Project, therefore the severity of consequence from particulate matter was low (1). There might be some illnesses but without morbidity rate increase.

- **Health Risk Assessment**

The health risk assessment as detailed in ***Table 6.4-25*** was classified by duration of study as follows:

Table 6.4-25 Risk Assessment of Health Impact from Air Pollution during Operation Phase

Severity of Consequence	Likelihood of Impact			
	Rare (1)	Unlikely (2)	Possible (3)	Likely (4)
Low(1)		X		
Moderate (2)				
High (3)				

Remarks: X health risk level of people living in communities and sensitive areas around the Project areas and general public using services at the stations

- **People Living around the Project Areas**

The risk of health impact was low (2). At this level, there was no need to impose additional prevention, correction and mitigation measures. Some improvement to the existing measures might be required without additional expenses. If necessary, it might require monitoring taking into consideration the necessity and possibility.

(b) Noise

- **Nature of Health Impact**

Health impact from the increase in noise level in the operation phase was the same as that in the pre-construction and construction phases.

- **Risk Groups to Health Impact**

The main risk group was the people living around the Project areas and people using services at the stations and the staff working on the stations.

- **Health Impact Assessment**

The main activities in the operation phase which caused health impact due to increasing noise level were train maintenance activity, vehicles going to and from the park&ride building. Health impact assessment was performed by Risk Matrix, as detailed herebelow:

- **Health Risk Assessment**

From the health risk assessment as detailed in ***Table 6.4-26***, the risk levels of health impact on each risk group could be classified as follows :

Table 6.4-26 Risk Assessment of Health Impact from Noise during Operation Phase

Severity of Consequence	Likelihood of Impact			
	Rare (1)	Unlikely (2)	Possible (3)	Likely (4)
Low(1)				
Moderate (2)			X_1, X_2	
High (3)				

Remarks: X_1 health risk level of the staff on the stations
X_2 health risk level of people living in the Project areas and people using services at the stations

- **People Living around the Project Areas and People Using Services at the Stations**

From the health risk assessment as detailed in ***Table 6.4-26,*** the risk was moderate (6). At this level, morbidity rate might increase. There might be injuries, effect on local budger. It needed to monitor and investigate that the existing prevention, correction and mitigation measures of environmental impact were appropriate and sufficient. If necessary and applicable, additional measures or improvement of the existing measures might be required to cope with the impact.

(c) Vibration

- **Nature of Health Impact**

Health impact from the increase in vibration level in the operation phase was the same as that in the pre-construction and construction phases.

- **Risk Groups to Health Impact**

The main risk groups were people living around the Project areas, the people using services at the stations and the staff working on the stations.

- **Health Impact Assessment**

The main activities in the operation phase that caused health impact from the increase in vibration level were the services of the stations. The vibration was from the trains going to and from the stations. Health impact could be assessed by using Risk Matrix as detailed below:

- **Likelihood of Health Impact**

- **People Living around the Project Areas, People Using Services at the Stations and the staff Working on the Stations**

From computation by a mathematical model, it was found that Leq 24h emitted from the activities in the operation phase at the distance of 10-500 meters from the Project alignment (at the height of the elevated structure) ranged from 34.6-60.1 dB(a), lower than the general standard (70 dB(A)). For the noise level in the sensitive areas, Leq 24h emitted from the Project noise source was lower than the general standard (70 dB(A)). However, when compiled with the maximum Leq24 measured along the Project alignment, most of the compilation results were higher than the standard value. The reason was that noise levels measured at many monitoring stations were higher than the standard value; Siam Business Administration Nonthaburi Technological College monitoring station (70.5 dB(A)), Phranakhon Rajabhat University monitoring station (85.7 dB(A)), and Synphaet General Hospital monitoring station (74.2 dB(A)), due to vehicular traffic on Tiwanon, Chaeng Watthana and Ram Inthra roads respectively.

Nonetheless, noise level from the activities in the operation phase in the sensitive areas close to the Project areas along the Project alignment had the $L_{eq\ 24h}$ lower than the maximum $L_{eq\ 24h}$ measured at the present. This indicated that the activities in the operation phase did not cause disturbances to the sensitive areas.

From the projection of Leq_{24h} and and the noise annoyance from activities in the operation phase, it was found the level was lower than the standard value. However, when taking into consideration the noise level in the exising scenario before launching the Project development, the noise level was found to be higher than the standard. Therefore, it was projected that the likelihood of health impact from the overall noise levels during the operation phaset was moderate (3).

- **Severity of Consequence**

- **People Living around the Project Areas, People Using Services at the Stations, and the Staff Working on the Stations**

From the noise level projection of the Pink Line MRT Project, the general noise level and noise annoyance level were lower than the standard value. But when taking into consideration the noise level in the exising scenario before launching the Project development, the noise level in the Project areas was found to be higher than the standard. The noise sources were road-traffic vehicles. It was estimated that after the Project operation was launched, more vehicles would be on the roads. Therefore, it was projected that the potential severity of consequence would be moderate (2).

- **Likelihood of Health Impact**

- **People Living around the Project Areas, People Using Services at the Stations, and the Staff Working on the Stations**

In the operation phase of this Project, it was considered that the LRT (Light Rail Vehicle) would travel at a speed of approximately 50 mph (approximately 80 km/h), therefore the ground-surface vibration at the running speed of 80 km/h would be 0.0045 inch/sec. This vibration level occurred at the pier of the elevated structure, when compared with the recommended criteria of Whiffin and Leonard, it was found that the vibration along the Project alignment was imperceptible to human beings and the longer the distance the less vibration became. Therefore, the likelihood of health impact on the people living around the Project areas, the people using services at the stations, and the staff working on the stations was unlikely (2).

- **Severity of Consequence**

- **People Living around the Project Areas, People Using Services at the Stations, and the Staff Working on the Stations**

From the projection of vibration in the operation phase of the Pink Line MRT Project that the vibration was at the imperceptible level to human beings; therefore, the severity of consequence from vibration on health impact of the people living around the Project areas, people using services at the stations and the staff working on the stations was low (1). At this level, there might be some illnesses, without morbidity rate increase, no need to stop working and having no effect on local budget.

- **Health Risk Assessment**

From the health risk assessment as detailed in ***Table 6.4-27***, the risk levels of health impact on each risk group could be classified as follows:

Table 6.4-27 Risk Assessment of Health Impact from Vibration during Operation Phase

Severity of Consequence	Likelihood of Impact			
	Rare (1)	Unlikely (2)	Possible (3)	Likely (4)
Low(1)		X_1, X_2		
Moderate (2)				
High (3)				

Remarks: X_1 health risk level of staff working on the stations
X_2 health risk level of people living in communities and sensitive areas around the Project areas and general public using services at the stations

- **People Living around the Project Areas, People Using Services at the Stations, and the Staff Working on the Stations**

Health risk was low (2). Additional prevention, correction, and mitigation measures of environmental impact were not required. Some improvement to the existing measures might be required without additional expenses. If necessary, monitoring might be needed provided that it had to take into consideration the necessity and possibility.

(d) Impaired Surface Water Quality

- **Nature of Health Impact**

The nature of health impact from wastewater/impaired surface water quality was the same as that in the pre-construction and construction phases.

- **Risk Groups to Health Impact**

The main risk groups were people living around the Project areas, particularly those who used water from major surface water sources close to the Project alignment and stations.

- **Health Impact Assessment**

The main activities that caused health impact from wastewater/ impaired surface water quality were the direct drainage of effluent and sewage from the Project alignment and stations to surface water sources. Health impact could be assessed by using Risk Matrix as detailed below:

- **Likelihood of Health Impact**
  - **People Living around the Project Areas**

With consideration given to the existing environment, there were surface water sources on the way of Project alignment or close to the stations. Therefore, in the operation phase, there were opportunities that effluent or sewage from toilettes of the staff working on the stations and leachate from the track rail would be drained directly to surface water sources. This would affect the health of people, especially those who lived by the river and need to use the water for consumption. Therefore, the likelihood of health impact was possible (3). The existing satistical evidences supported the likelihood projection if no prevention, correction and mitigation measures of environmental impact were provided, or the existing measures did not cover the occurrence.

- **Severity of Consequence**
  - **People Living around the Project Areas**

At the depot and park&ride building at Rom Klao Intersection, wastewater totaling 142.60 cubic meters/day would be generated from bathrooms, toilettes, and food container cleaning activities of the staff in the administration and control buildings, the dormitory, the restaurant including from train maintenance and cleaning. Wastewater would be treated at 3 x 50 cubic meters (total capacity of 150 cubic meters) onsite treatment plants by anaerobic filter and contact aeration process. The quality of effluent would be in compliance with the Notification of the Ministry of Natural Resources and Environment on Building Effluents Standards, published in the Royal gazette Vol. 122 Part 125 D, dated 29 December B.E.2548 (2005) before discharge to public drainage system. Therefore, it was anticipated that there would be no aquatic ecosystem impact on surface water sources.

The present study has designed 6 additional stations on the same route alignment with a total distance of 34.5 km. The 6 stations were Chaeng Watthana 28, TOT, Ram Inthra 3, Ram Inthra 31, Ram Inthra 40, and Ram Inthra 83. Therefore, it was anticipated that Project activities in the operation phase would have effects on aquatic ecosystem at low level (1). At this level, there was no morbidity rate increase, no need to stop working and having no effect on local budget.

- **Health Risk Assessment**

From the health risk assessment as detailed in ***Table 6.4-28***, the risk levels of health impact on each risk group could be classified as follows:

Table 6.4-28 Risk Assessment of Health Impact from Deteriorated Surface Water Quality during Operation Phase

Severity of Consequence	Likelihood of Impact			
	Rare (1)	Unlikely (2)	Possible (3)	Likely (4)
Low(1)			X	
Moderate (2)				
High (3)				

Remarks: X health risk level of people living along the mass transit system alignment.

- **People Living around the Project Areas**

Health risk was low (3). At this level, there was no need to impose additional prevention, correction and mitigation measures of environmental impact. Some improvement to the existing measures might be required without additional expenses. If necessary, it might require monitoring taking into consideration the necessity and possibility.

(e) Tension, Anxiety, Annoyance and Fear

• **Nature of Health Impact**

The development of the Pink Line Mass Rapid Transit Project, Khae Rai-Min Buri Section would inevitably cause changes to the environmental quality in the areas. Those changes caused anxiety, tension and fear to the people living around the Project areas. The concern of the affected people was traffic congestion problem, particularly in the vicinity of the stations due to a large number of people using the services. Those health impact could be regarded as mental health impact. If no practicably prevention, correction and mitigation measures of environmental impact were efficiently determined, nor confidence built in the people living around the Project areas to make them feel relieved, the impact would be accumulated and the psychiatric symptoms might develope such as tension disorder, panic disorder, or psychotic disorder if the symptoms became serious.

• **Risk Groups to Health Impact**

Risk groups to health impact were the people living around the Project areas, particularly those living close to the Project alignment and commuters along the alignment.

• **Health Impact Assessment**

The activities that caused changes to the surroundings around the Project construction areas or had effects on daily living of the people around the Project areas would have mental impact in terms of anxiety, tension, panic, or annoyance to the changes.

• **Likelihood of Health Impact**

- **People Living around the Project Areas**

With consideration given to the duration of the operation phase of the Project which took rather long time, there was likelihood of mental impact on the people living around the Project areas, if no prevention, correction and mitigation measures were determined to alleviat the environmental impact on mental health of the people. In addition, the lack of providing details about the Project, construction sequences, and those measures to build confidence in the people also contributed to the likelihood of mental health impact. Therefore, the likelihood of health impact in terms of tension, anxiety, annoyance and fear from the Project operation was possible (3). The existing satistical evidences supported the likelihood projection if no prevention, correction and mitigation measures of environmental impact were provided, or the existing measures did not cover the occurrence.

- **Severity of Consequence**

  - **People Living around the Project Areas**

At present, the Project area has traffic congestions, especially on Tiwanon, Chaeng Watthana, and Ram Inthra roads. The taffic problem was the major cause of air pollution and the feelings of tension, anxiety, annoyance and fear of the people living in the areas. Therefore, in the operation phase of the Pink Line MRT Project, Khae Rai-Min Buri Section, traffic congestion would become worse, particularly in rush hours. The severity of consequence of mental health impact from tension, anxiety, annoyance and fear of the people was moderate (2). At this level, there might be a morbidity rate increase, injuries of people in the Project areas, commulative risk groups, effect on budget, and stop working, which affected production capacity and communities in the Project area.

- **Health Risk Assessment**

From the health risk assessment as detailed in ***Table 6.4-29***, the risk levels of health impact on each risk group could be classified as follows:

Table 6.4-29 Risk Assessment of Health Impact from Tension, Anxiety, Annoyance during Operation Phase

Severity of Consequence	Likelihood of Impact			
	Rare (1)	Unlikely (2)	Possible (3)	Likely (4)
Low(1)				
Moderate (2)			X	
High (3)				

Remarks: X health risk level of people living around the Project areas.

  - **People Living around the Project**

Health risk was moderate (6). At this level, morbidity rate might increase and there might be some injuries. It needed to monitor and investigate that the existing prevention, correction and mitigation measures of environmental impact were appropriate and sufficient. If necessary and applicable, additional measures or improvement of the existing measures might be required to cope with the impact, provided that the expenses incurred had to be taken into consideration as well.

(f) Conveniences in Travelling

In the operation phase of the Pink Line MRT Project, Khae Rai-Min Buri Section, people living in the areas along the Project alignment would have conveniences, save time and expenses in commuting. Tension due to being stranded for hours in traffic would be reduced. The impact was thus regarded positive to both physical and mental healths.

(g) Revenue Increase of Local Population

In the operation phase of the Pink Line MRT Project, Khae Rai-Min Buri Section, people would have more conveniences in commuting, resulting in urban communities expansion. It was noteworthy that the areas with accessibility to train stations would have rather high community economic expansion. There would be a rise of a lot of office and residential buildings such as condominiums. This would bring a lot more people to live in the areas, leading to an increase in money circulation in the communities, raising earnings of the local population and bettering their well being and quality of life. This was regarded as positive impact on mental health of the people living in the Project areas.

Summary of Health Impact Assessment of the Project, as presented in *Table 6.24-3*.

Table 6.24-30 Summary of Health Impact Assessment of the Project

Project Phases	Health Hazards	Nature of Impact	Project Activities	Risk Groups	Likelihood of Health Impact	Severity of Consequence	Risk Level of Health Impact	Prevntiion, Correction and Mitigation Measures of Environmental Impact
1. Pre-construction/ Construction Phases	Particulate Matter	- The inhalation of particulate matter will cause eye and respiratory irritations. - Most symptoms of CO intoxication result from hypoxia of nervous and cardiovascular systems. - Nitrogen dioxide (NO_2) causes irration to the lungs and immunity reduction.	- Stripping works, traffic, mobilization and stacking of earth/gravel and work materials, land filling, earth compaction and grading. - Transportation of construction materials and machinery including the operation of machinery	Construction workers	Possible (3 points)	Low (1 point)	Low (3 points)	-
				People living within 500 meters from construction areas of the stations.	Possible (3 points)	Low (1 point)	Low (3 points)	-
	Noise	- Destruction of hearing system efficiency and impairment of hearing ability - Tension, headache, high blood pressure, fatique and heart diseases. - Regularly prolonged exposure to unusually loud noise for a continuous period has effects on hearing competency reduction.	The main activities during pre-construction and construction phases which were noise sources were land grading, building construction, construction materials and equipment transportation, drilling, pile driving, and operation of heavy machines.	Construction workers	Likely (4 points)	Moderate (2 points)	Moderate (8 points)	- Instruct the staff/construction workers working in the construction area or the area with noise level higher than 90 dB(a) for continuous 8-10 hours to wear protective gear or noise reduction device such as ear muffs or ear plugs. The staff/construction workers working in the construction areas or the areas with continuously loud noise need to be rotated at least 15 days/team. - In order to reduce the risk of hearing system diseases such as deaf, hard of hearing, ruptured eardrum of the staff/construction workers working in the construction areas with loud noise from the operation of machinery and equipment for over 8 hours continuously, the employees are required to strictly comply with the prevention, correction and mitigation measures of noise impact during the construction phase.
				People living within 500 meters from construction areas of the stations.	Possible (3 points)	Moderate (2 points)	Moderate (6 points)	- The employees are required to install noise absorptive material under 2 stations i.e. Samakkhi Station PK04 and Phranakhon Rajabhat University Station PK15 to reduce noise impact. The area under the two stations is semi-open area (half tunnel), with opportunity of some resonance. The absorptive material should be fiberglass reinforced plastics type (FRP) or others auch as aluminium, metal sheets or celocrete which is lightweight (less than 10 kg/sheet) with life time of over 30 years. - The contractors need to regularly inform the public, especially the people living around the depot and park&ride building, of the construction activities which cause unusal loud noise or cause noise out of timing schedule. - In order to reduce the risk of hearing system diseases such as deaf, hard of hearing, ruptured eardrum of the people living close to the construction areas and having to work in the construction areas with loud noise from the operation of machinery and equipment for over 8 hours continuously, the employees are required to strictly comply with the prevention, correction and mitigation measures of noise impact during the construction phase.
	Vibration	- Irritation to tissues, losses of body balance and seeing ability, blurred vision, reduction in working capability - Body feeling fatique and annoyance. - Malfunction or failure of internal organs. - Impact on mental health in terms of annoyance, concentration loss in daily activities	- Foundation construction, transportation of construction materials - Machinery / equipment	Construction workers	Possible (3 points)	Moderate (2 points)	Moderate (6 points)	- Use the appropriate machinery and equipment and construction method ot reduce vibration impact such as using bored piles in stead of driven piles. - If there are construction activities which cause continuous vibration, particularly drilling works for foundation construction, it needs to reduce drilling force of each drilling by increasing number of drilling to reduce vibration level.
				People living within 500 meters from construction areas of the stations.	Unlikely (2 points)	Low (1 point)	Low (2 points)	-

TABLE 6.24-30 (Cont'd)

Project Phases	Health Hazards	Nature of Impact	Project Activities	Risk Groups	Likelihood of Health Impact	Severity of Consequence	Risk Level of Health Impact	Prevntiion, Correction and Mitigation Measures of Environmental Impact
1. Pre-construction/ Construction Phases (continued)	Wastewater/ Impaired surface water quality	- **Bacteria:** abdominal cramps, fever, nausea, vomit, headache. In case of severity, falling ill and death - **Virus**: gastroin testinal diseases	Wastewater and effluent from worker camps and construction supervision office buildings	Construction workers	Possible (3 points)	Low (1 point)	Low (3 points)	-
				People living within 500 meters from construction areas of the stations.	Possible (3 points)	Low (1 point)	Low (3 points)	-
	Occupational accidents and illnesses from inappropriate and unsafe work conditions and environment	- Presented in forms of injuries, illnesses or deaths of construction workers	- Particulate matter from land clearing and grading, excavation, cut-and-fill works - Exhaust gas from vehicles for transporting construction machinery/equipment and materials, mobilizing construction materials/parts. - Noise and vibration from the construction activities and operation of machinery - Problems of working environment such as solar heat while working outdoor and too little light	Construction workers	Possible (3 points)	Moderate (2 points)	Moderate (6 points)	- Reiterate to the staff and construction workers on wearing personal protective equipment (PPE) every time when working in the construction areas to prevent dangers and accidents from work, such as, safety helmet, gloves, dusk mask, ear muffs, ear plugs, sneakers/brogan shoes or safety shoes.
	Entry of Foreign Workers	- spread of communicable diseases and/or sexually transmitted diseases, and non-communicable diseases such as diarrhea, food poisoning, malaria, AIDS, and venereal diseases - social problems such as drug problems and decrease in social safety - Disturb healthcare services provided for the communities.	Activities during pre-construction and construction phases	Construction workers	Possible (3 points)	Moderate (2 points)	Moderate (6 points)	- Instruct the employees to screen and efficiently manage foreign workers.
				People living within 500 meters from construction areas of the stations.	Possible (3 points)	Moderate (2 points)	Moderate (6 points)	
	Inadequacy of public health facilities, public health officers and medical personnel	The adequacy of medical and public health personnel and public health facilities as well as the 7 important medical equipment was quite essential. If there was no sufficient provision of healthcare facilities and medical personnel off-site, it would have effects on construction workers and construction supervisors. In case that construction workers and the construction supervisors seriously fell ill or sustained injuries from work and immdiate treatment was required, and if, in the construction area, there was no public health facilities or the facilities did not have capable and well-experienced medical personnel nor the 7 important medical equipment, the effect coule be deadly. In addition, the inadequacy of public health facilities and medical personnel might affect the people in the Project areas	Construction activities of the Pink Line MRT Project; Khae Rai-Min Buri Section	Construction workers	Possible (3 points)	Moderate (2 points)	Moderate (6 points)	- Instruct the employees to provide an infirmary within the Project office with at least 1 registered nurse for basic reatment such as first aid to the staff and construction workers. - In case of severe work accidents, it needs to immediately send the victims to the nearest health facilities such as Panyananthaphikkhu Chonprathan Medical Center, Mongkutwattana General Hospital, Synphaet Hospital, Nopparat Rajathanee Hospital, Navamin Hospital, Wetchakarunrasm Hospital, and Bangkok Metropolitan Administration Lat Krabang Hospital.

TABLE 6.24-30 (Cont'd)

Project Phases	Health Hazards	Nature of Impact	Project Activities	Risk Groups	Likelihood of Health Impact	Severity of Consequence	Risk Level of Health Impact	Prevntiion, Correction and Mitigation Measures of Environmental Impact
		due to heavy burden of public health services providers of the communities.		People living within 500 meters from construction areas of the stations.	Possible (3 points)	Moderate (2 points)	Moderate (6 points)	
1. Pre-construction/ Construction Phases (continued)	Road accidents	Injuries and deaths of commuters in the accidents of heavy vehicles of the Project.	heavy vehicles transporting construction materials and equipment in the whereabouts of the Project areas.	Construction workers	Possible (3 points)	Moderate (2 points)	Moderate (6 points)	- Control and reiterate to drivers of vehicle transporting construction materials and equipment to strictly comply with traffic rules and regulations when passing the communities or environmental sensitive areas such as schoold, Wats, hospitals.
				People living within 500 meters from construction areas of the stations.	Possible (3 points)	Moderate (2 points)	Moderate (6 points)	
	Tension, anxiety, annoyance and Fear	The development of the Project would inevitably cause changes to the environmental quality in the areas. Those changes caused anxiety, tension and fear to the people living around the Project areas.	Particulate matter, noise, vibration increasing due to the activities during pre-construction and construction phases.	People living within 500 meters from construction areas of the stations.	Possible (3 points)	Moderate (2 points)	Moderate (6 points)	- Raise a campaign or awareness among general public and drivers of private cars to use more of mass transit system in order to reduce air and noise pollution problems. This would result in reduction in health problems, especially the respiratory and hearing systems diseases.
2.Operation Phase	Air Pollution	- The inhalation of particulate matter will cause eye and respiratory irritations. - Most symptoms of CO intoxication result from hypoxia of nervous and cardiovascular systems. - Nitrogen dioxide (NO_2) causes irration to the lungs and immunity reduction.	Exhaust gas from vehicles of people using services of the Project	People living within 500 meters from construction areas of the stations.	Unlikely (2 points)	Low (1 point)	Low (2 points)	-
	Noise	- Destruction of hearing system efficiency and impairment of hearing ability	Train maintenance and vehicles going to and from the park & ride building.	Staff working on the stations	Possible (3 points)	Moderate (2 points)	Moderate (6 points)	- The boundary of the depot and park & ride building at Rom Klao Intersection is adjacent to the land of private owners. It needs to plant at least 2 zig-zag rows of tall perennial plants, with dense foliage on the boundary as a buffer zone in order to reduce noise of vehicles/trains coming and going or noise from train maintenance activities. The perennial plants are such as the mast tree, white cheesewood, and mahogany.
		- Tension, headache, high blood pressure, fatique and heart diseases. - Regularly prolonged exposure to unusually loud noise for a continuous period has effects on hearing competency reduction.		People living within 500 meters from construction areas of the stations.	Possible (3 points)	Moderate (2 points)	Moderate (6 points)	-
	Vibration	- Irritation to tissues, losses of body balance and seeing ability, blurred vision, reduction in working capability	The services of the train stations, with vibration from trains going to and from the stations	Staff working on the staions	Unlikely (2 points)	Low (1 point)	Low (2 points)	-
		- Body feeling fatique and annoyance. - Malfunction or failure of internal organs. - Impact on mental health in terms of annoyance, concentration loss in daily activities		People living within 500 meters from construction areas of the stations.	Unlikely (2 points)	Low (1 point)	Low (2 points)	-

TABLE 6.24-30 (Cont'd)

Project Phases	Health Hazards	Nature of Impact	Project Activities	Risk Groups	Likelihood of Health Impact	Severity of Consequence	Risk Level of Health Impact	Prevntiion, Correction and Mitigation Measures of Environmental Impact
2.Operation Phase (Cont'd)	Impaired surface water quality	- **Bacteria:** abdominal cramps, fever, nausea, vomit, headache. In case of severity, falling ill and death - **Virus**: gastroin testinal diseases	Drainage of effluent and sewage from the Project alignment and stations to water sources	People living within 500 meters from construction areas of the stations.	Possible (3 points)	Low (1 point)	Low (3 points)	-
	Tension, anxiety, Annoyance and Fear		Traffic congestion problem, especially in the station areas due to a large number of people using the services.	People living close to the Project construction areas	Possible (3 points)	Moderate (2 points)	Moderate (6 points)	- Users of private vehicles who need to travel by using the old road network, especially, under the stations shall strictly comply with traffic rules and regulations to reduce traffic congestion problem. - Raise a campaign or awareness among general public and drivers of private vehicles to use more of mass transit system to reduce traffic congestion problem.

CHAPTER 7

ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES

CHAPTER 7

ENVIRONMENTAL IMPACT PREVENTION AND MITIGATION MEASURES

7.1 INTRODUCTION

To assess the project environmental impacts is to study the existing conditions of the project area and assess the impacts that may occur both during construction and operation phases in order to prevent the likely impacts. Environmental impact prevention and mitigation measures have been recommended for implementation by responsible parties of the project during construction and operation of the project.

7.2 PHYSICAL ENVIRONMENTAL RESOURCES

7.2.1 Soil Resource

(1) Construction Phase

(a) The project construction sites need to be clearly designated by enclosing the construction areas with temporary solid fences at least 2 m. high from the existing ground level in order to prevent sediment erosion from flowing into public drains or low-lying lands or surface water sources.

(b) To carry out activities of excavation/land leveling; relocation of public utilities, e.g. water pipelines, drains, electric poles, etc.; and drilling to construct the foundation during the dry season in order to avoid soil erosion.

(c) Earth piles and construction materials and equipment must be kept far from surface water sources as much as possible. Erosion-prone areas must be avoided, especially those near surface water sources, e.g. Khlong Bang Talat, Khlong Prapa, Khlong Prem Prachakon, Khlong Thanon/Khlong Bang Bua and Khlong Song Ton Nun.

(d) The project construction sites which are open space without soil cover must be stabilized by covering temporarily the surface with gravel/chipped stones, canvas or vegetative plants.

(e) Excavated soil from the foundation construction must be taken away to fill the construction area of depot and park & ride building at Rom Klao intersection or to be disposed in the area permitted by the MRTA. The soil piles should not be left in the construction area for a long period.

(f) It is required to dig temporary drainage ditches of 0.60×0.60 meters around the construction area of the depot and park & ride building at Rom Klao intersection, and 2 sediment traps of 1.00×1.00×1.00 meters at the end of the temporary drains in order to trap the sediment mixed with water/stormwater to prevent its flowing into surface water sources, public drains or low-lying lands.

(g) After completion of soil excavation or land leveling of the construction sites of viaduct, train stations, and depot and park & ride building at Rom Klao intersection, soil layers must tightly be compacted to be flat and smooth or covered with vegetative plants immediately. This aims to prevent soil erosion, especially in the rainy season.

(2) Operation Phase

There is no impact during the operation phase; therefore, no measure is established.

7.2.2 Geological Conditions and Earthquake

(1) Construction Phase

(a) Steel sheet piles will be installed around the construction site where piling is required. The sheet piles will be driven into the clay layer of medium hardness, with a depth of about 18 meters from ground level.

(b) Steel sheet piles shall be used in the construction areas near surface water sources, such as Khlong Bang Talat, Khlong Prapa, Khlong Prem Prachakon, Khlong Lam Chala and Khlong Song Ton Nun or in areas with loose soils so as to prevent soil erosion.

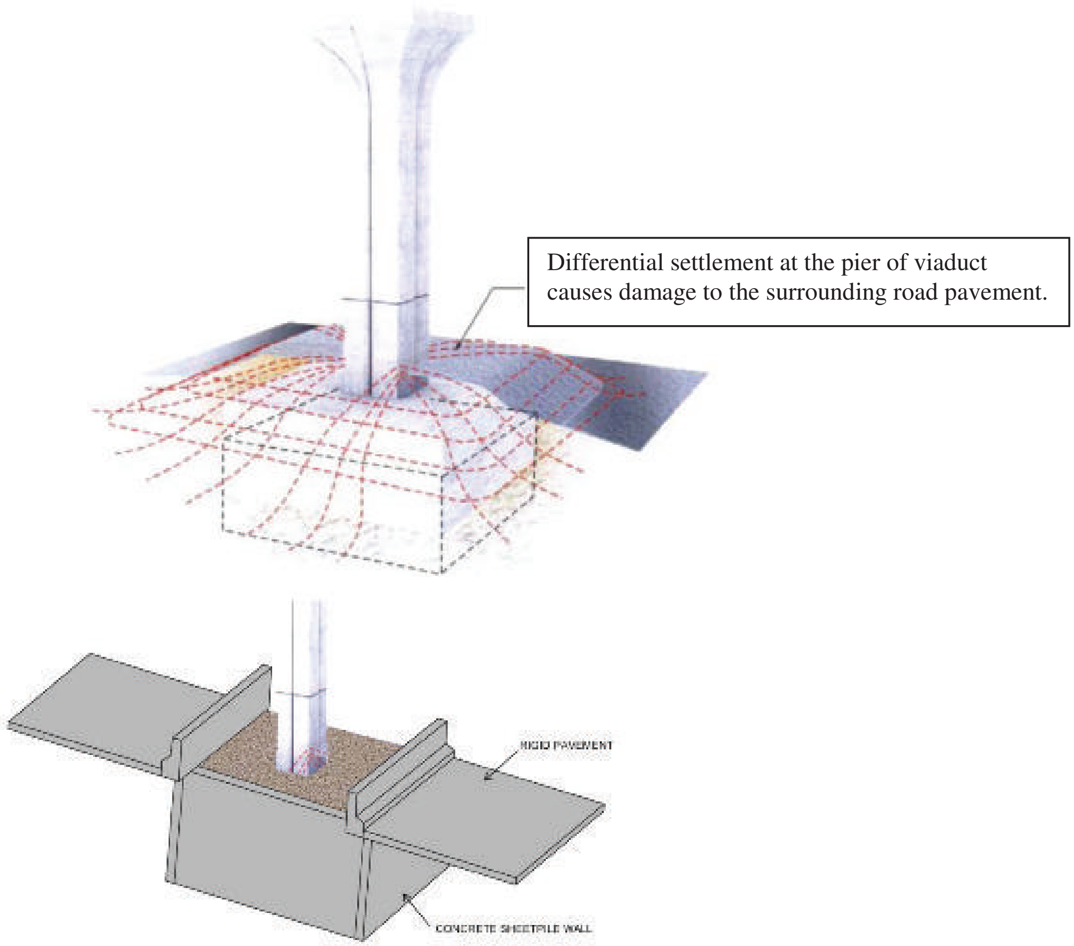
(c) In case of bored piles, polymer slurry solution shall be used to prevent soil erosion and stabilize the boreholes. This solution helps reduce sand layer permeability and enhance the adhesion of soil or sand particles enabling faster sedimentation.

(d) Design of settlement adjustment structures covering viaduct foundation that overlaps with traffic surface of roads at ground level: Such structure will be designed, with space provided to allow for differential settlement of road pavement and viaduct foundation. This will avoid causing any damage to road surface while preventing differential settlement problems of road pavement and viaduct foundation at road medians, as illustrated in ***Figure 7.2-1***.

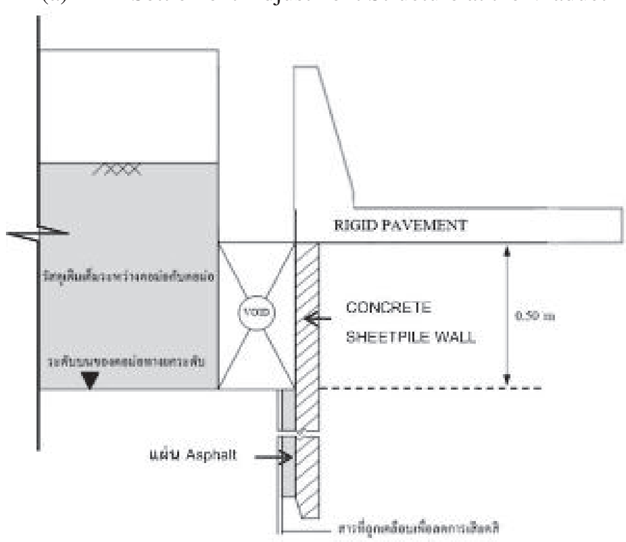
(e) For the structures where vibration tends to occur, the structures generally need to be secured into the position that can withstand horizontal forces as a result of an earthquake. Structural engineers must use seismic buffers or stoppers on the superstructure above the column heads to prevent the slipping of superstructure or bridge from the column heads. The seismic buffers must be safely secured to the concrete shear key box, as shown in ***Figure 7.2-2***.

(2) Operation Phase

No measure is established because there is no impact during the operation phase.



(a) Settlement Adjustment Structure at the Viaduct Footing and Surrounding Road Pavement



(b) Separate Structures for Differential Settlement of Road Pavement and Viaduct Footing

Figure 7.2-1 Cross-Section of Settlement Adjustment Structure at the Viaduct Footing and Surrounding Road Pavement

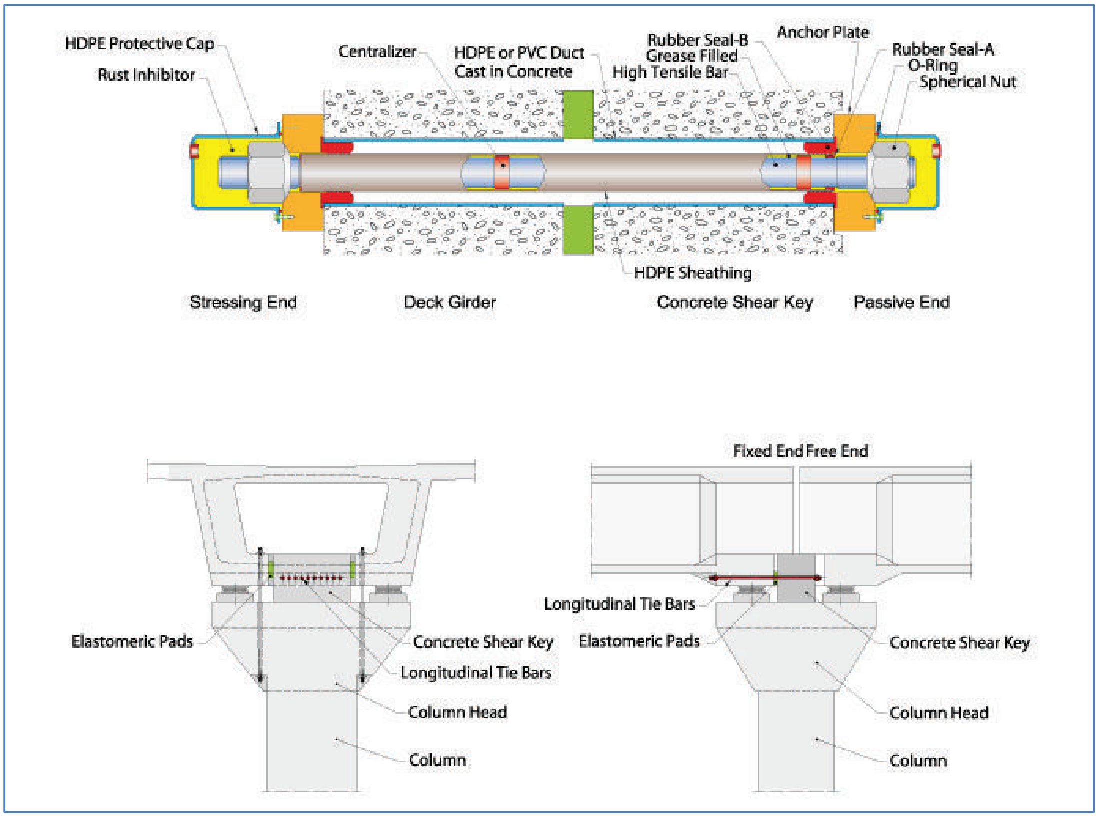


Figure 7.2-2 Seismic Buffers or Stopper on the Superstructure above the Column Head

7.2.3 Surface Water Hydrology

The construction and opening of mass transit system, depot and park & ride building at Rom Klao intersection, especially during the construction, may obstruct the water flow into public drainage system or low-lying lands or surface water sources. The impact is expected to be moderate and it is necessary to set out environmental impact prevention and mitigation measures as follows.

(1) Pre-Construction Period

Two water retention ponds were designed for the depot and park & ride building at Rom Klao intersection with a minimum capacity of 5,541.66 cubic meters for Zone A retention pond and 9,775.91 cubic meters for Zone B pond. In addition, 3 sets of pumps (2 on duty and 1 standby) will be installed at each zone, as shown in ***Figure 7.2-3*.** The longitudinal section of water retention pond is as depicted in ***Figure 7.2-4*.**

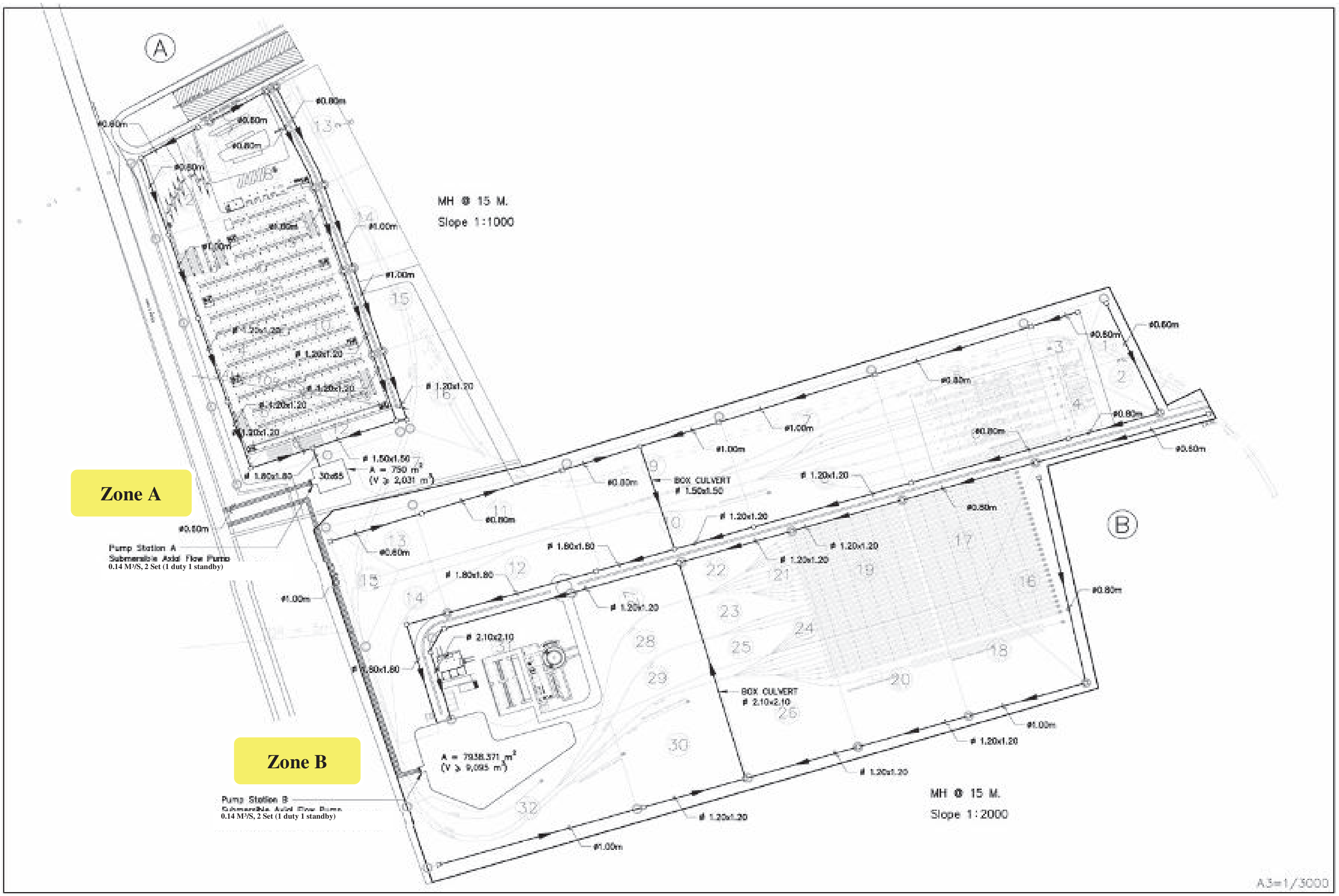


Figure 7.2-3 Water Flow Direction into Water Retention Ponds at Depot and Park & Ride Building at Rom Klao Intersection

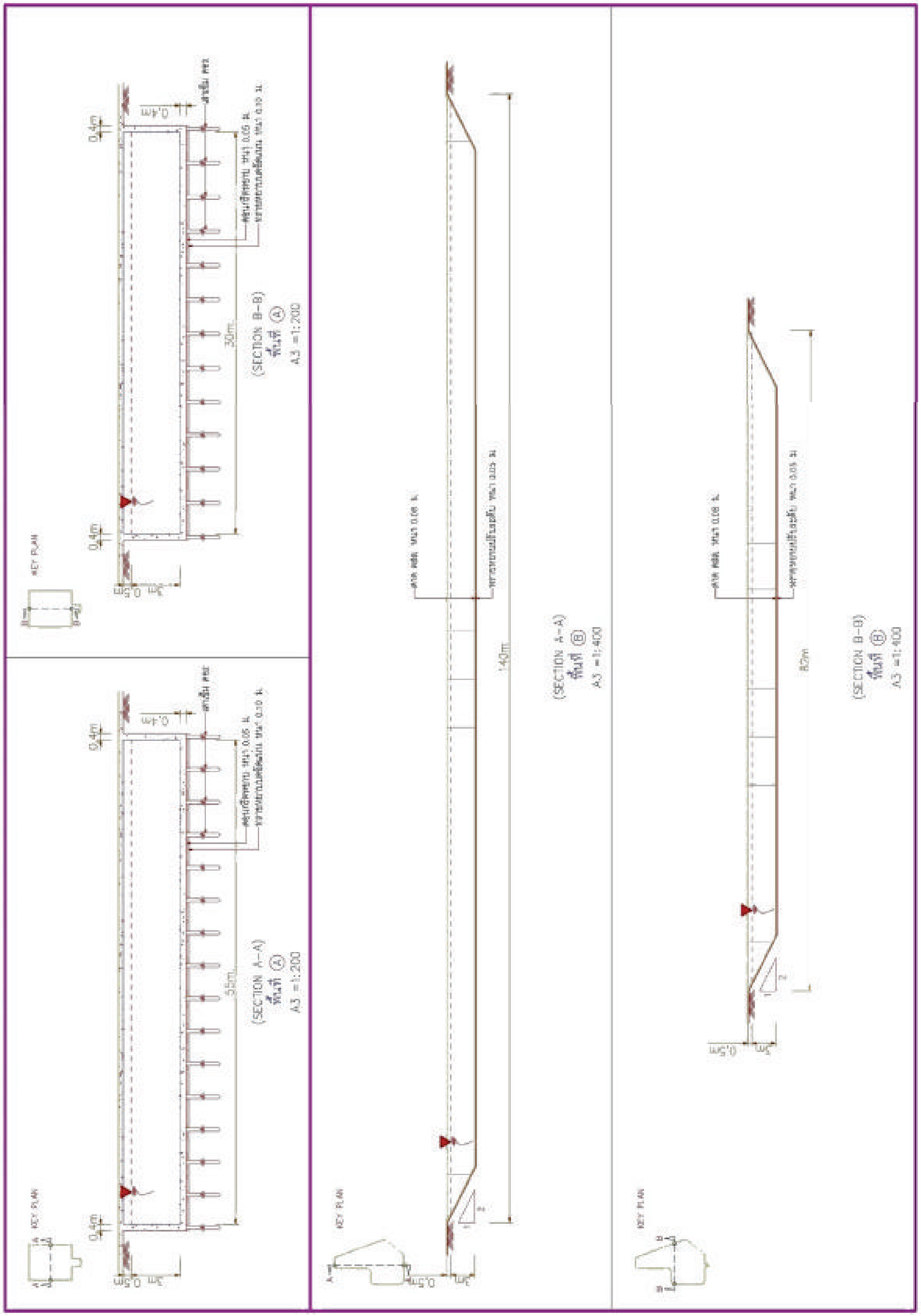


Figure 7.2-4 Longitudinal Section of Water Retention Pond

(2) Construction Phase

- Store construction materials, equipment and machines orderly to prevent dirt, sand, mud from falling into and contaminating water sources;
- Build earth embankment to prevent soil erosion as a result of soil stripping during construction;
- Complete the soil stripping before the start of rainy season. If inevitable to do so, soil layers must be tightly compacted and flattened smooth. Material transport must be carried out carefully, particularly soil and concrete, to prevent soil erosion, especially during the rainy season (May-November);
- Prohibit disposal of garbage and construction wastes into public water sources or public drains near the construction areas;
- Store construction wastes in suitable places, covered with canvas to prevent leaching into water sources as a result of rainfall;
- Carry out major construction activities during dry season, e.g. land leveling, soil excavation, etc. so as to avoid soil erosion into water sources during the rainy season;
- Build temporary drain ditches or a small pond to prevent flooding in the construction area and nearby areas;
- Excavated soil from foundation construction must be piled in a specific area and be closed or covered or stored in an enclosed area. The excavated soil will be transported by truck for disposal in the designated area within 24 hours;
- Prevent oil contamination from construction activities to water sources;
- Hazardous substances generated from construction activities such as oil-contaminated maintenance equipment must be properly disposed according to sanitary principles.
- Inspect pipes/drains throughout the construction area, if found to be sand-clogged or blocked by materials, the blocking materials or sand must be quickly removed to avoid obstructing the drainage ditches;
- If the surrounding areas are flooded due to the project, the contractors must provide pumps to quickly drain water out of the areas;
- Stormwater collection system must be provided to prevent the stormwater contaminated with construction wastes from flowing into the nearby water sources;
- Excavated soil in the construction areas must be placed and enclosed at the designated area far from water sources;
- Provide drainage system, gutters and a sedimentation pond of sufficient capacity to accommodate stormwater, especially in the area designated for the station expansion and improvement, before discharging into public drainage system. Regular maintenance and sediment dredging must be carried out to ensure the efficiency of drainage system at all times;
- Provide adequate sanitary toilets at temporary construction offices and worker accommodation;
- Maintenance of construction materials and equipment should be done inside the depot or workshop only;

- Provide a sump to gather wastewater from various activities such as machine and equipment washing;
- Build sufficient sanitary toilets for workers at a proportion of 10 workers/1 room;

(3) Operation Phase

- Provide sanitary toilets for employees and station staff;
- Provide wastewater treatment system at every station;
- Regularly check wastewater treatment system at the stations;
- Establish a proper solid waste collection and management system at the stations, preventing garbage from falling into rivers and canals.

7.2.4 Surface Water Quality

(1) Construction Phase

(a) Contractors are required to set up only the "Project Office" in the vicinity of construction area. “Construction staff housing community” must be separated from the Project Office. The staff housing community must be procured/built at least 5 km from the MRT alignment with prior approval from the Mass Rapid Transit Authority of Thailand (MRTA.). It must strictly comply with the laws/regulations of local authorities regarding housing construction or the Building Control Act, B.E. 2522 or the Ministerial Regulation of the Ministry of Interior No. 55, B.E. 2543 (2000).

(b) Mesh or canvas will be installed to cover the areas under the guideway beam structures and stations to prevent construction materials such as dirt/stone/sand/cement from falling into surface water sources, which will increase turbidity to the surface water sources, especially construction areas that are located less than 50 meters from water sources.

(c) Construction activities such as soil stripping, excavation/land leveling, etc. must be completed before the rainy season. If inevitable to do so, soil layers must be tightly compacted and flattened smooth. Concrete materials must be carefully transported to avoid increasing turbidity as a result of soil erosion or contamination of oil/lubricant from construction machinery and equipment.

(d) Sufficient sanitary bathrooms/toilets (10 workers/1 room) must be provided.

(e) Five prefabricated wastewater treatment plants, each with a capacity of 2 cubic meters, must be installed. These plants can treat 10.0 m^2/day of wastewater and sewage from bathrooms/toilets or dish washing in the daily work of 200 employees/staff per day in the Project Office.

(f) 240-liter covered waste bins must be provided, divided into dry waste, wet waste, hazardous waste, and recycled waste, at various places within the Project Office, with 4 bins for each type of waste. The contractors must coordinate with Bangkok Metropolitan Administration (BMA) or local government agencies in Nonthaburi to collect and transport the waste for proper disposal in accordance with the sanitation standard.

(g) Wastewater from construction activities, such as change of engine oil, washing and cleaning of construction tools/equipment or vehicles, etc, shall be collected in the project office area, at least 100meters away from surface water sources. Wastewater shall be treated by on-site system before being released into natural water sources. Two prefabricated wastewater treatment plants will be installed, each with capacity of 6 cubic meters, and the total treatment capacity is 12 cubic meters.

(h) At the construction site of depot and park & ride building at Rom Klao intersection, temporary drainage gutters, 0.60x0.60 meters in size, shall be built all around the area. Two sediment traps of 1.00x1.00x1.00 meters shall be built at the end of temporary drainage gutters to collect wastewater from construction activities, such as washing and cleaning of construction tools/equipment or vehicles, or to trap and prevent sediment mixed with water/stormwater from flowing directly into surface water sources or low-lying lands.

(2) Operation Phase

(a) Project Route and Stations

- Regularly check the operation of wastewater system at all stations;
- Provide covered waste bins, separated into wet waste, dry waste, hazardous waste, and recycled waste, in the stations;
- Coordinate with BMA and the local government unit of Nonthaburi for garbage collection and disposal;
- Depot and Park & Ride Building at Rom Klao Intersection
- Three onsite wastewater treatment plants using anaerobic filter and contact aeration process will be installed, each with capacity of 100.0 cubic meters. The total capacity is 300 cubic meters for on-site treatment before discharging into public drains and then to Khlong Song Ton Nun.
- Management of solid waste generated in the depot and park & ride building, such as waste from interior train cleaning, office supplies, dirt from streets and sidewalks, waste from lathe and workshop, and waste from septic tanks or food waste, etc., will be undertaken as follows.
  - Provision of 240-liter covered waste bins, separated into dry waste, wet waste, hazardous waste and recycled waste, to be located at various buildings in the depot. The waste bins must be placed in the areas where it is easy to use and transport.
  - Solid waste will be collected and stored at the solid waste storage building waiting to be collected and transported by the responsible unit for further disposal.
  - Solid waste storage building will have sufficient space and can store solid waste volume of at least 3 days (capacity of 151.59 cubic meters).
- Hazardous waste, such as oil, grease and chemicals, shall be collected and stored in the dangerous goods building waiting to be collected for further disposal by the responsible unit, e.g. General Environmental Conservation PCL, Samae Dam, Bang Khun Thian, Bangkok. Roofed pallet racking system has been designed for the dangerous goods building so that forklifts and trucks can go in and out conveniently and safely.

(b) Wastewater Management Measures for Train Wash

Train washing is an activity that shall be regularly performed every 3 days, requiring large volume of water. Water conservation, recycling and reuse is, therefore, a process that helps reduce wastewater volume in order to lessen the environmental impacts. This is a potential water conservation measure according to the international standard that can be implemented as follows.

- Train Washing Steps
  - Water spraying by automatic spray machine before washing
  - Washing train cars by spraying water mixed with shampoo or detergent
  - Water spraying to wash the underside of the car with high-pressure nozzles, brush or sprayers on the side and beneath the car
  - For the first spray, use high-pressure nozzles
  - Spraying wax solution or car body coating for cleaning and shining
  - For the final spray, use low-pressure nozzles
  - Blow drying
  - Hand drying
- Water Conservation Measures/Techniques for Train Washing
  - Installation of small-nozzle spraying system, which will allow the use of low-water pressure, while still retaining cleaning capability
  - Alignment of nozzles should be checked on a regular basis, if tilted out of position, train cleaning will be ineffective.
  - Checking and repairing all water leaks as they occur
  - Using stainless steel or ceramic heavy-duty nozzles
  - Provision of water reclaim system or storage tank to enable the reuse of reclaim water for watering plants
  - Growing of plants tolerant to car wash water in the landscape
  - Regular maintenance of spray nozzles in accordance with the maintenance requirements, especially those used at the car wash to assure maximum efficiency of water used
- Wastewater Management Measures
  - Installation of 3 small onsite treatment plants, using anaerobic filter and contact aeration process, each with capacity of 100.0 cubic meters. The total capacity of the 3 plants is 300 cubic meters for treating wastewater before discharging into public drains and then into Khlong Song Ton Nun canal.
  - Hazardous waste such as oil, grease and chemicals, shall be collected and stored in the dangerous goods building waiting to be collected for further disposal by the responsible unit, e.g. General Environmental Conservation PCL, Samae Dam, Bang Khun Thian, Bangkok. Roofed pallet racking system has been designed for

the dangerous goods building so that forklifts and trucks can go in and out conveniently and safely.

- Water Saving Measures

Water-saving measures contribute to the reduction of fresh water volume. Washing of one train requires about 1.045 cubic meter/train/day of water (according to the Extension of Bangkok Mass Rapid Transit System Project, 2000). If water-saving measures are utilized in car washes by conveying washing water to water filtration system, water recycling can reduce water use by 20 percent, or about 0.836 cubic meters/train/day. Water-saving measures are as follows:

- For the process requiring large water volume, water quantity and characteristics are taken into consideration. As a washing plant requires large volume of water, automatic water-efficient car wash machines should be selected.

- Water characteristics in the washing plant are considered for water reuse in the next wash as well as floor cleaning. This will reduce fresh water consumption.

- Regarding water recycling, the project is designed to use recycled water for watering trees. A polishing pond is also designed together with pump and water distribution system for watering plants in the depot and park & ride building. Wastewater from the washing plant and workshops will be treated in the central wastewater treatment plant in the depot and park & ride building, which can efficiently eliminate oil and fat and also remove sediment and contaminants in wastewater in accordance with the standards of Pollution Control Department and Ministry of Industry.

Measures for Selection of Environmentally Friendly Detergent Solution

Products that are environmentally friendly or cause less environmental impact to be used in car wash shampoos will have the following characteristics.

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

(c) Effluent Quality Monitoring Measures

To monitor the effluent quality in accordance with the Notification of the National Environment Board No. 8, B.E.2537 (1994) issued under the Enhancement and Conservation of National Environmental Quality Act B.E.2535 (1992) regarding Surface Water Quality Standards, in operation phase, it is required to monitor effluent quality in 2 water retention ponds in zone A and zone B once a month (during the same period as the monitoring of effluent quality in canals).

7.2.5 Hydrogeology and Land Subsidence

No measure was established due to no impact.

7.2.6 Air Quality

(1) Construction Phase

(a) Contractors must comply with the rules and regulations to control construction dust of various types specified by the Air Pollution Control Committee in Bangkok and Communities in Thailand.

(b) To complete installation of the light signals at intervals of 30 meters along the construction area before beginning of the construction and to dismantle or move the light signals out of the area immediately if construction in each area is completed.

(c) To use ready mixed concrete produced outside the construction area to prevent and mitigate potential impacts on communities around the project area.

(d) To spray water on surface of the existing road networks at least 3-4 times a day, or as appropriate, to reduce the spread of dust

(e) To move construction materials or excavated soil out of the construction area as soon as possible or within 24 hours

(f) To provide staff to gather construction materials and clean the construction area every day as well as organize pile of materials and equipment to prevent the spread of dust throughout the construction phase

(g) To provide a unit responsible for controlling, maintenance or inspection of engines and machines used in construction at least once a week to prevent emission of dust (TSP and PM-10) and emissions (such as CO,. NO_x, SO_2), and to fix the malfunction of engines and machines

(h) To sweep and clean or clear dirt/mud from vehicle wheels before leaving the construction site every time in the construction area of the guideway beam structures and stations

(i) To provide a place to wash and clean the wheels of cars/trucks and vehicles at all exits to prevent dirt and mud from the wheels falling to the traffic surface outside the construction site of the Depot and Park & Ride Building

(j) To set speeds of the trucks transporting equipment, which run through communities and sensitive area to environmental impacts, such as religious places, hospitals and schools, etc., at not exceeding 30 kilometers/hour to reduce the spread of dust and for traffic safety.

(k) Material piles in the construction area and the trucks carrying construction materials into the construction area shall be covered up to prevent scattered dust and debris falling.

(l) Staff/construction workers must wear protective equipment to prevent dust or other pollutants such as CO, NO_x, SO_x, etc. when working in the construction area where there is the spread of dust or pollutants from the use of construction equipment, especially the excavation of soil, excavation of foundation, demolition/removal of construction materials, or concrete mixing, for example.

(m) To cover the ground under the guideway beam structures, stations or the Depot and Park & Ride Building at 10 meters high above the ground with closed space meshes or canvases to accommodate construction materials/equipment that might fall or to prevent the scattered dust

(n) To clean traffic surface of the existing road networks along the routes with construction of the guideway structures and stations during the night at least 4 days a week. Cleaning time will be from midnight onwards up to 03.00 a.m. of the following day.

(2) Operation Phase

(a) The Mass Rapid Transit Authority of Thailand (MRTA) has to coordinate with other agencies as follows.

- To liaise with police stations in charge such as Nonthaburi Provincial Police Station, Lak Si/Bang Khen/Min Buri metropolitan police stations, etc., in planning and management of traffic on the existing road networks under the train stations for traffic flexibility and congestion reduction by installation of traffic signs to indicate directions and setting of speed limits under the train stations.
- To liaise with Bangkok Metropolitan Authority, Nonthaburi City Municipality, Pak Kret City Municipality or entities involved in cleanliness maintenance of the existing road networks under the guideway beam structures and stations. Cleaning and vacuuming of the dust from the road surface must be done every 3 months.

(b) From the dust analysis results in operation phase, if accumulation of the dust under any elevated train station is higher than the standard of normal air quality, according to the National Environment Board No. 24 B.E. 2547 (2004), installation of a water sprinkler system under the stations is required immediately to reduce the dust amount.

(c) To install no-parking signs for all kinds of vehicles, except buses, under the elevated train stations

(d) To install sprinkler nozzle systems under the PK04 Samakkhi Station and the PK15 Phranakhon Rajabhat University Station to reduce the dust amount; At other stations, it is required to provide spaces for installation of additional sprinkler nozzles if the accumulation of dust under the train stations in operation phase is detected over the air quality standard for general atmosphere, according to the Notification of the National Environment Board No.24 B.E 2547 (2004).

7.2.7 Noise Level

(1) Construction Phase

(a) To use the tools, equipment and machinery that do not produce noise and to use the devices to reduce or control the volume from machines, such as sound proofing pipes or casing cover, in the event that noise level exceeds 90 dB (A) at the origin for a period of one consecutive hour.

(b) To install concrete barriers with metal sheets of 2 meters high in construction area on the existing road networks to show the construction boundary. Also, to install solid steel fences of 2 meters high around the construction area of the Depot and

Park & Ride Building at Rom Klao Intersection to reduce the noise impacts caused by the construction.

(c) To examine any equipment, machinery or vehicles used in construction, to be in good condition throughout the construction phase so that the noise level not exceeding the criteria established by responsible agencies, e.g. Department of Transport, Office of Natural Resources and Environmental Policy (ONEP), Department of Pollution Control, or Bangkok Metropolitan Authority, etc.

(d) To set speed limits of the material trucks running through communities and areas prone to environmental impacts, such as hospitals, schools and religious places, up to 30 km/h for noise prevention.

(e) To set construction working time into 2 shifts as follows:

1st shift-during the day, to start working at 8.00 a.m. and off work no later than 6.00 p.m.to carry out construction of the main structures such as the guideway beam structures and stations, including foundation drilling, concrete pouring of piers /train station floors 2nd shift-during the night, to work from 9.00 p.m. to 5.00 a.m. in the following day, to perform the work that does not cause noise or cause low noise (24-hour L_{eq} < 70 dB (A) or L_{max}< 115 dB (A)). This is to reduce the disturbance of relaxation time of communities on the existing road networks, such as moving of concrete formwork/concrete beam/prestresseded concrete floor planks, or moving of remaining materials or construction equipment not used out of the construction area.

(f) Construction of the Depot and Park & Ride Building at Rom Klao Intersection on an empty space with a fence line showing the explicit boundary. Working shift is between 8.00 a.m.-6.00 p.m. without allowing construction over a given period, except for the moving of concrete formwork/columns/concrete beam/prestressed concrete floor planks, or the moving of remaining materials or equipment not used out of the construction area, etc., which will be carried out during 7.00-9.00 p.m.

(g) Staff /construction workers working in the construction area or the area where the noise level exceeds 90 dB (A) for a period of 8-10 consecutive hours must wear protective apparatus or equipment, such as ear muffs or ear plugs, to reduce the noise level. Staff /construction workers who work within the construction area or the prolonged noisy area at least for 15 days /group must be rotated.

(h) Contractors must complete the installation of sound absorbing materials under 2 train stations, i.e. PK04 Samakkhi and PK15 Phranakhon Rajabhat so as to reduce the noise level that occurs. Also, contractors must consider using the sound absorbing materials of aluminum sheet with pressed glass fiber to reduce the echo from the traffic against the ceilings installed under the stations. The materials to be used for the project must have sound absorption coefficient of no less than 70 per cent at a frequency of 400 Hz, and 80 percent at a frequency of 1,000 Hz.

(i) Any construction activities that will cause loud noise must be public released periodically, especially the communities around the construction area.

(j) To use rubber floor instead of steel plate for building of temporary roads in order to reduce the noise while vehicles are running through. Steel plates can be used temporarily when necessary only. Should there be complaints about the noise from the public, corrective action must be taken immediately.

(k) To use bored piles in construction areas,which are city or community areas in order to reduce the effects of sound level

(2) Operation Phase

(a) To check reliability, strength and efficiency of sound absorbing materials installed in the area underneath the stations once a month. If found defective or effective in noise absorption less than 40%, the new materials must be replaced immediately.

(b) If sound level monitoring, during the operation phase, in the area under any one of the stations is found higher than the standard normal sound level under the Notification of the National Environment Board No.15 B.E.2540 (1997) (<70 dB (A)), the sound absorptive materials must be installed in the area under the train stations immediately to reduce the noise level that occurs.

(c) The concessionaires or the bus operators must maintain the train wheels and tracks in good condition throughout the duration of service. If malfunction is found, modification or replacement must be done instantly.

(d) At the Depot and Park & Ride building at Rom Klao Intersection, 2 rows of tall trees with thick leaves such as *Polyalthia longifolia, Alstonia scholaris (Linn.) R. Br., Swietenia Macrocapa King.,* etc., must be planted in twisting form around the area, as a buffer zone, to reduce the noise level from vehicles/trains running in and out or from maintenance of the trains.

7.2.8 Vibration

The construction and launching of the mass transit system, the Depot and Park & Ride Building at Rom Klao Intersection may cause rising vibration level, especially during excavation activities and backfill, foundation drilling, or materials/equipment transport/handling, for instance. For effects in the operation phase, they may be caused by the vehicles passing by on the road networks underneath the guideway beam structures or the stations. The implemented transit system is the system driven by electricity with speed not exceeding 80 kilometers per hour. The vibratrion that occurs will pass through the train tracks and down to the guideway beam structures and the ground. The expected impact is, therefore, at low-medium levels. Environmental impact prevention and mitigation measures are required as follows.

(1) Construction Phase

(a) Detailed design for construction of the guideway beam structures, the train stations, and the Depot and Park & Ride Building at Rom Klao intersection must securely accommodate the vibration from earthquakes or geohazards in accordance with the Interior Ministerial Regulations regarding “Load, Resistance, Durability of Buildings and Ground for Earthquake Resistance” issued pursuant to the Building Control Act B.E. 2522 (1979).

(b) In construction of foundation to support the guideway beam structures, the train stations and the Depot and Park & Ride Building, circular bored piles or barrette piles must be used to reduce the vibration on sensitive areas to environmental impacts along the road networks with drilling space of 30 meters, at 14 locations including Siam Business Administraiton Technological College (SBAC), Boromarajonani College of Nursing, Central Chest Institute of Thailand, Saman Pichakorn School, Quartermaster Department Royal Thai Army, Cholaprathan Songkro School, Sri Sangwan School, Khlong Klua School, Apakorn Kindergarten, Charoenphol Wittaya School, Phranakhon Rajabhat University, Wat Phrasimahathat Secondary Demonstration School, The Constitution ProtectionMonument and Synphaet General Hospital.

(c) In driving steel sheet piles during construction of the foundation to support the guideway beam structures and the train stations, they need to be piled deep through the soft clay layer to mild moderate layer to the depth of about 18 meters. This will help block and reduce vibrationsin the deep level, not to disturb the area along the road networks, especially the areas prone to environmental impacts at a distance of 30 meters in 14 locations, including Siam Business Administraiton Technological College (SBAC), Boromarajonani College of Nursing, Central Chest Institute of Thailand, Saman Pichakorn School, Quartermaster Department Royal Thai Army, Cholaprathan Songkro School, Sri Sangwan School, Khlong Klua School, Apakorn Kindergarten, Charoenphol Wittaya School, Phranakhon Rajabhat University, Wat Phrasimahathat Secondary Demonstration School, The Constitution Protection Monument and Synphaet General Hospital.

(d) Construction activities to cause vibration need to be performed between 8.00 a.m.-6.00 p.m., such as excavation of foundation to support the guideway beam structures and stations or the Depot and Park & Ride Building, etc., to avoid disrupting any activities in daily life of the communities or the areas susceptible to environmental impacts.

(e) Should there be a construction activity that will cause continuing vibration, particularly foundation drilling, it needs to reduce the energy consumption in drilling rigs each time by increasing the drilling times to reduce the vibration occurred.

(f) Controlling transport trucks of construction materials and equipment to strictly follow the traffic rules, and speed limits not exceeding 30 km/h., and payload less than 25 tons in case of running through residential or commercial areas or sensitive areas to environmental impacts, such as hospitals, schools and religious places, and so on.

(g) In case of complaints received, it needs to investigate and analyze the damage occurred. If the damage was caused by the construction work, it is required to assess the damage and find a solution for or provide assistance urgently.

(h) If there are construction activities near susceptible areas to environmental impacts, e.g. hospitals, schools and religious places, it needs to make public relations in advance and ongoing.

(i) Before starting any construction works that will cause vibrations on dwellings or buildings, contractors need to have officials/civil engineers/structural engineers check and take current photos before working at all times in order to prevent damage to the public.

(2) Operation Phase

- To check strength and performance of the rubber track pins at the locations of train stations, or the rubber hubs of the trains 1-2 times a month. If damaged or efficiency reduced by over 40%, replacement must be done immediately.

7.3 BIOLOGICAL RESOURCES

7.3.1 Aquatic Ecosystem

In construction and opening of the mass transit system and the Depot and Park & Ride Building at Rom Klao Intersection, especially during excavation for space opening, foundation drilling may be oil contaminated from the use of construction machines and equipment, for instance.This could cause a low impact on aquatic ecosystem disturbance of surface water sources. During the construction phase, it is suggested that environmental impact prevention and mitigation measures be undertaken with the topic of "Surface Water Quality”. Meanwhile, during the operation phase, no impact is expected; it is, therefore, unnecessary to propose environmental impact prevention and mitigation measures.

7.3.2 Terrestrial Ecosystem

7.3.2.1 Forest Resources

(1) Construction Phase

(a) It needs to move the trees only those obstructing the construction out of the construction area by digging around method (not cutting) to be planted in the new areas determined by the MRTA. Also, species and numbers of all trees dug out must be noted.

(b) To move excavated soil from foundation drilling or from the construction materials, equipment and machines by the use of trucks of medium-large sizes needs to be done with special care, not to cause damage to the trees in the neighborhood.

(c) After completion of construction of the transit system, it is required to take actions as follows.

- Moving of those trees earlier dug around and taken out to replant in the empty spaces along the transit system or in the area inside the Depot and Park & Ride Building, as appropriate

- Growing of climbing plants of medium-large vines, e.g. Artabotrys siamesis Miq., Bougainvillea sp., Quisqualis indica L.,*Passiflora x alato caerulea Lindl.*, Jusminum multiflorum (Burm f.) Andr., Allamanda cathartica Linn. etc. to reduce hardness of the piers of the guideway beam structurse or stations.

- Increase in more green areas or a small gardens in the area under the train stations (if any), or along the transit system, in order to improve the balance of the ecosystem, increase the scenery or reduce the pollution of air, noise, and others by planting shrubs such as *Cassia surattensis Burm.f., Tecoma stans (L.) Kunth, Aglaia odorata Lour, Duranta repens L., Melodorum fruticosum Lour, etc.* otherwise, to build pergolas made of wood or steel or other materials so that medium -large vines can climb up, such as *Artabotrys siamesis Miq., Quisqualis indica L., Bauhinia winitii Craib, Allamanda cathartica Linn., Passiflora x alato-caerulea Lindl., Jusminum multiflorum (Burm. f.) Andr.*, etc. for example. Preliminary concept of landscape architectural design along the routes is as shown in ***Figure 7.3-1***.

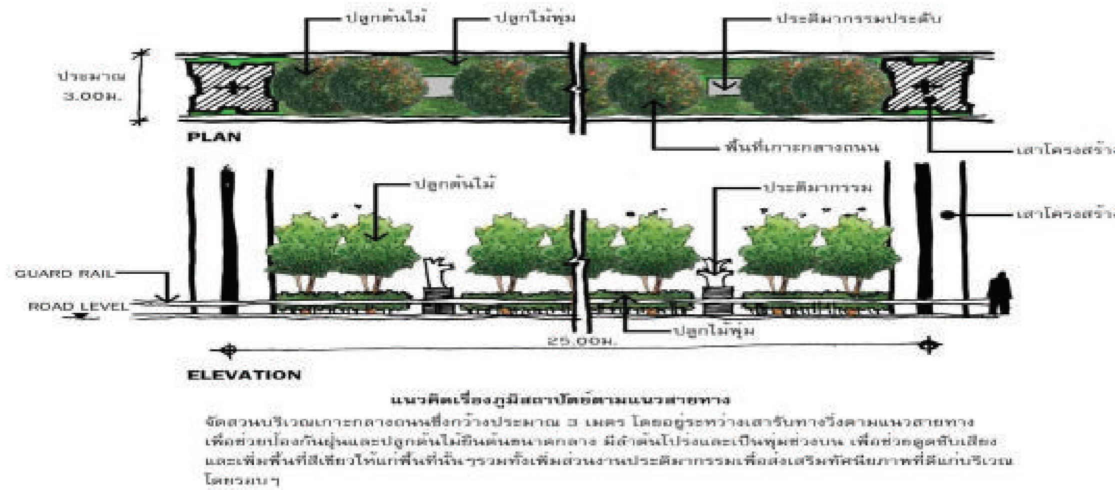


Figure 7.3-1 Preliminary Concept of Landscape Architectural Design along the Route

(2) Operation Phase

(a) All trees planted anywhere in the project area must be nourished with care. In case any plant dies, replacement of the new one is required.

7.3.2.2 Wildlife Resources

Construction and launching of the mass transit system and the Depot and Park & Ride Building at Rom Klao Intersection have been expected the cause of the losses of wildlife food sources and shelters. However, this was considered the low impact because these species of wildlife are familiar with the large city congestion that are able to adapt to the changing environment. Therefore, no environmental impact prevention and mitigation measure is required.

7.4 HUMAN USE VALUE

7.4.1 Land Use

(1) Construction Phase

None

(2) Operation Phase

MRTA co-ordinates with Department of Public Works and Town and country Planning to control urban growth to be in accordance with Bangkok Comprehensive Plan (B.E.2549) and Nonthaburi Comprehensive Plan (B.E.2548) because it is expected that the Mass Raip Transit would induce growth in investment on residential and commercial sector e.g., condominium, apartment, housing estate, department stores, shopping center, etc.

7.4.2 Transportation System

(1) Construction Phase

(a) Arranging the choices of traveling to the passers-by to reduce the number of vehicles on the road networks during construction phase, particularly the avoiding routes on the road networksas follows.

- Tiwanon Road (Ngam Wongwan Intersection-Pak Kret Intersection) and Chaeng Watthana Road (Pak Kret Intersection-Constitution Protection Monument Roundabout)

  - Through Prachachuen Road, turn into Samakkhi Road through Pak Kret Bypass Road, joining Tiwanon Road at the area before Ampornpaisarn School
  - Through Bond Street (Chaeng Watthana Road 33) joining Tiwanon Road at the area before Armory Division, Army Ordnance Department
  - Through Prachachuen Road, turn into Soi Chinnakhet through Chid Chon Road through Ratchapruek Golf Course to converge on Kamphaeng Phet 6 Road at the area before Tungsonghong Metropolitan Police Station
  - Through Soi Chaeng Watthana 14 through the intersection with Kaset Road to converge on Kamphaeng Phet 6 Road at the area before Soi Kosum Ruamjai 5
  - Through Soi Bangbua Housing 1 to converge on Phaholyothin Road at the entrance to Soi Bang Bua

- Ram Indra Road (Constitution Protection Monument Roundabout -End of Project)

  - Through Soi Ram Indra 19 (Sukhaphiban2) to converge on Phaholyothin Road at the entrance to Soi Phaholyothin 48

- Through Soi Wat Ladplakao through Kaset-Navamin Road to converge on Phaholyothin Road at Kaset Intersection

- Through Soi Ram Indra 14 to converge on Kaset-Navamin Road at the entrance to Soi Maiyalap

- Through Soi Ram Indra 23 (Sukhaphiban 4) through Sukhaphiban 5 (O Ngoen) through Soi Ram Indra 65, through Soi Ram Indra 40, through Soi Nuan Chan, through Nuan Chan Road to converge on Pradit Manutham at Chalongrat Expressway (Ram Indra – Art Narong)

- Through Khu Bon Road, through Navamin Road to converge on Kaset-Navamin Road at the entrance to Soi Chanachon 2

- Through Soi Ram Indra 62 to converge on Kaset-Navamin Road at the entrance to Soi Suwanprasit

- Through Panya-Natural Park Road, through Surao Khlong 1 Road to converge on Hathairat Road at the area opposite to Sammakon Village

- Through Phraya Suren Road, through Surao Khlong 1 Road to converge on Hathairat Road at the area opposite to Sammakon Village.

- Through Seri Thai Road (Sukhaphiban 2), through Min Pattana Road Intersection, through Suan Siam Intersection to converge on East Outer Ring Road at the area of Chuen Suk Village 1

(b) If it is necessary to improve physical conditions of the avoiding routes (as described in item (a)) to accommodate more traffic volume to allow the current traffic to move continuously, it needs to improve the road surface of the suggested avoiding routes in good condition at all times, including for example Soi Chinnakhet Road, Bond Street Road (Soi Chaeng Watthani 33), Soi Chaeng Watthana14 Road, Soi Bangbua Housing 1 Road, Wat Ladplakao Road and Soi Maiyalap Road. In addition, in physical management, it needs to take into account the lane sizes and the safe width of the turning radius in compliance with the turning radius standard of all types of vehicles. The standards according to the requirements of AASHTO and the Japanese standard are shown in ***Table7.4-1.***

Table7.4-1 Turning Radius of Vehicles

Vehicle Types	Turning Radius (meter)	
	AASHTO	Japan
1. Passenger cars	7.32	6.00
2. Trucks	12.80	12.00
3. Trailers	13.72	12.00

(c) Before reaching the construction area of the mass transit system at least 1 km., it is required to install traffic signs and information signs as shown in ***Figure 7.4-2,*** e.g.warning signs, route guidance signs, traffic lane suggested signs, or flashing lights, construction area boundary fence, traffic lines marking or cones placing, for instance. Such signs must be clear in accordance with the Traffic Safety Standard of Office of Transport and Traffic Policy and Planning, Ministry of Transport (OTP) to ensure safety and reduce confusion or delay in travelling.

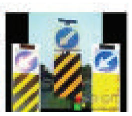
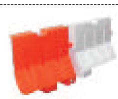
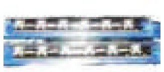
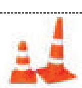
Signs	Interpretation	Appearance of Symbols	Use and Installation
	Construction Warning Sign	Sign size of 60 × 60 cm. Orange Background, Black Sign, Black Borders	Used to warn the vehicle drivers to know in advance that there are construction activiites at 1 km., 500 m. and 150 m. before reaching the construction area
	Right-lane Reduction Warning Sign	Sign size of 60 × 60 cm. Orange Background, Black Sign, Black Borders	Used to warn the vehicle drivers to know that the lanes ahead will be reduced from 3 to 2 lanes
	Warning Sign to Reduce Speed	Sign size of 80×120 cm. Yellow Background, Black Sign, Black Borders	Used to warn the vehicle drivers to drive at speed not exceeding 30 km/hr
	Warning Sign to Watch Out Workers	Sign size of 60 × 60 cm. Orange Background, Black Sign, Black Borders	Used to warn the vehicle drivers to watch out the workers under working
	Warning Sign to Watch Out Equipment under Operattion	Sign size of 60 × 60 cm. Orange Background, Black Sign, Black Borders	Used to warn the vehicle drivers to watch out equipment under operation
	Navigation Sign	Sign size Ø 60 cm. Blue Background, White Arrow Dign, White Borders.	Used to navigate the vehicle drivers to keep left
	Traffic Navigation Sign	Sign size of 4 m. high, at a distance view of 1,000 m., with warning arrow of 24 halogen lamps of RS2000 and parallel flashing lights	To be used with the label, ThroughThis Way
	End of Construction Zone Sign	Sign size of 80×120 cm. Orange Background, Black Sign, Black Borders	Used to warn the vehicle drivers to know that it is the end of the construction zone
	Concrete Barriers	Concrete barriers	Used to separate construction area between the traffic flow and the construction area
	Electric Lamps	Electric lamps	Used as navigation lines and warning for pedestrians and vehicle drivers. To be installed throughout the construction area
	Flashing Lights	with direct lights and reflective mirror attached to the lamp, with remote distance view	Installing the light fixtures straight onto the traffic that comes, each to be placed at. intervals of 3 m. away
	Rubber Cones	Orange rubber cones	Place 1-2 meters apart throughout the range to reduce traffic lanes with temporary work.

Figure7.4-2 Marks and Signs used during Mass Transit System Construction

(d) Due to the large number of passers-by travelling from east to west areas outside the city via the existing road networks, especially during the rush hours in the morning (7:00 a.m.- 9:00 a.m.), it is necessary to provide a reversible lane to release the inbound vehicles to the city with capacities equal to those before the construction. However, this will cause a bottleneck at the lane merging affecting the lane at the end of the reversible lane reduced. Thus, it needs to provide enough tapering space (40-150 meters), depending on the driving speeds of the vehicles, to allow the traffic flowing through construction areas with ease or smoothly, or integrated into the traffic flow safely without accidents. Also, it needs to coordinate with traffic police officers to help facilitate traffic in the said area to ensure traffic safety and agility.

(e) The Mass Rapid Transit Authority of Thailand (MRTA) and the contractors are obliged to carry out publicity or encourage people or the road-users to know the matters thoroughly through various media, such as notice boards, brochures, newspapers, radio, websites, and televisions, etc., as well as to coordinate provision of information and solicit for comments and feedback from relevant agencies. The issues for public release are as follows.

- Avoiding of traveling through the existing road networks and using of the avoiding /alternative routes recommended instead. Otherwise, asking for cooperation or encouraging the road users to follow the traffic management plan as prepared.
- Avoiding of traveling on the existing road networks during the rush hours, if unnecessary, so that secondary roads can accommodate enough traffic volumes that redirect from the existing road networks.
- Encouraging passers-by to use primarily the public bus services and emphasizing the use of public passenger boats in areas where service has been provided to travel in and out of Bangkok or Nonthaburi. Those who live on Tiwanon Road or Chaeng Watthana Road, at Pak Kret Intersection, can use the Chao Phraya Express Boat service instead, or those who live in Min Buri can use services of Khlong Saensab Canal Express Boat instead.

(f) Making publicity and campaigns for discipline and traffic rules respect. Violaters must be detected or fined, especially at the areas not allowed to make a turn or u-turn so that traffic can flow continuously without interruption.

(g) Contractors must prepare a traffic management plan in accordance with the mass transit system construction plans presented to the Mass Rapid Transit Authority of Thailand (MRTA) and agencies concerned, e.g. Bangkok Metropolitan Authority, Nonthaburi Province or police stations in responsible area before opening each construction area. The guidelines for traffic management on the road networks during construction are as follows.

- Rattanathibet Road, Chaeng Watthana Road (Pak Kret Intersection-Lak Si Intersection) and Ram Indra Road (including Sihaburanukit Road), with 40 meters right-of-way, eight traffic lanes (in-out), each with the width of 3.50 m. per direction, with a raised median of 4.20 m. wide. During construction phase, it needs to set aside the construction area of at least 7 m., divided into intervals, each with 500 m. In case of construction materials/equipment transport or soil excavation required, one more traffic lane must be set aside. However, in traffic management, the number of traffic lanes have been still reserved with the width of the traffic surface to be reduced, as shown in ***Figure7.4-2.*** After completion of construction, traffic conditions on Rattanathibet Road, Chaeng Watthana Road and Ram Indra Road to Sihaburanukit Road will be back to normal, as shown in ***Figure7.4-3.***

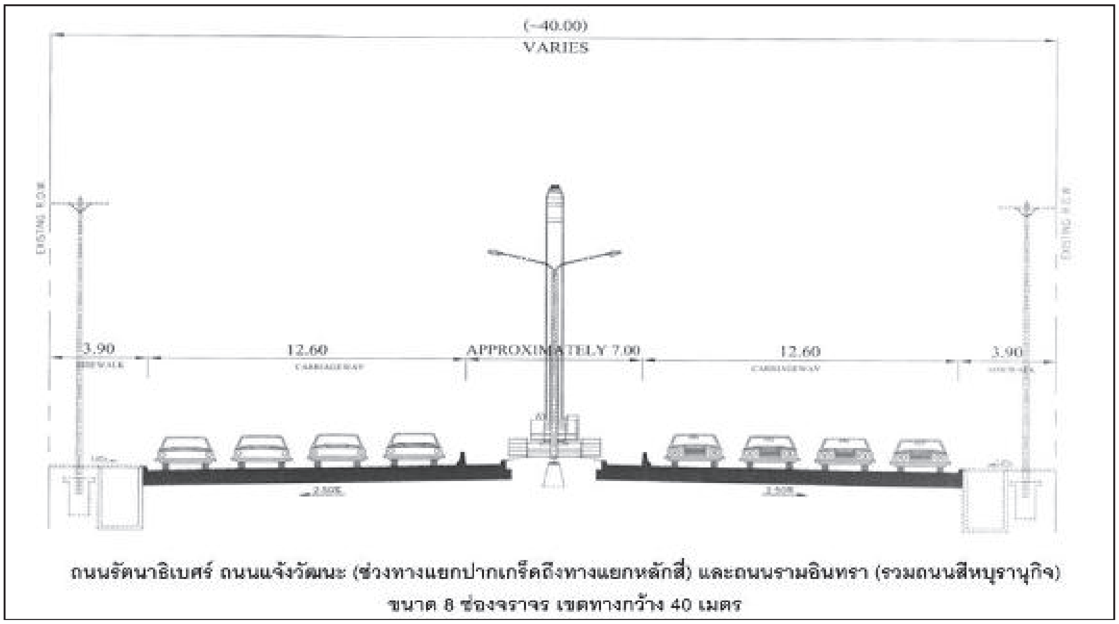


Figure7.4-2 Traffic Condition during Construction on Rattanathibet Road, Chaeng Watthana Road and Ram Indra Road to Sihaburanukit Road

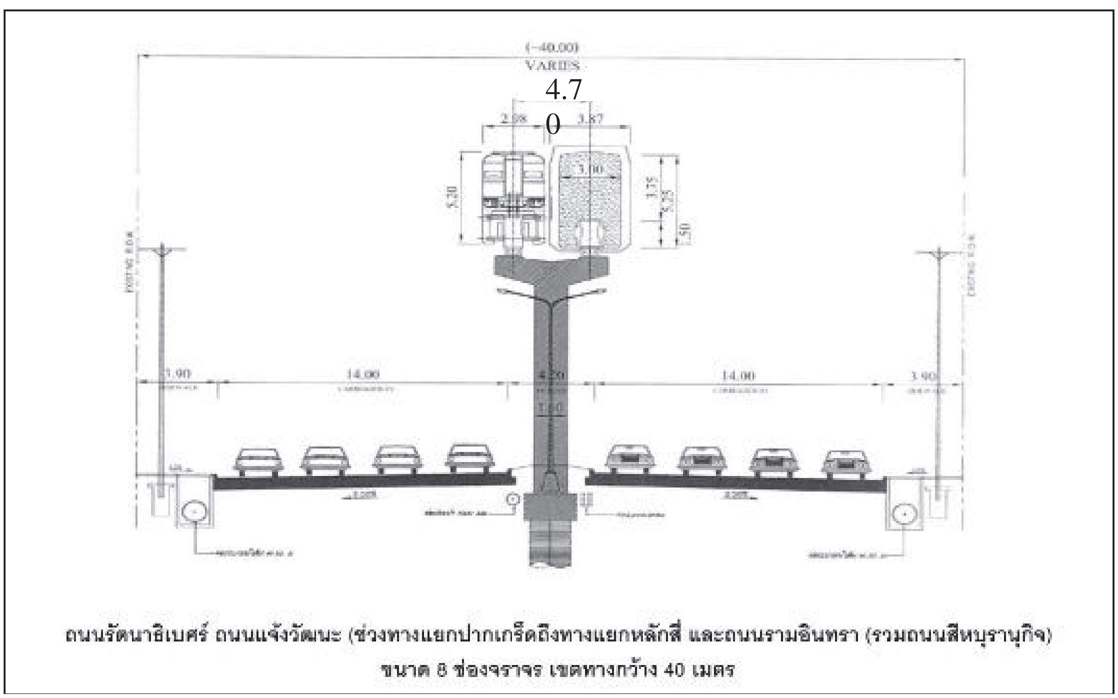


Figure7.4-3 Traffic Condition after Completion of Construction on Rattanathibet Road, Chaeng Watthana Road and Ram Indra Road to Sihaburanukit Road

- Chaeng Watthana Road from Lak Si Intersection to Constitution Protection Monument Roundabout has the right-of-way of 32 m., traffic lane of 3.25 m. wide/direction, with concrete barriers as line breaks. The number of traffic lanes will be reduced from 4 lanes/direction to 3 lanes /direction, without reducing the width of the lane, as shown in ***Figure7.4-4.*** After completion of construction, traffic conditions on Chaeng Watthana Road from Lak Si Intersection to Constitution Protection Monument Roundabout will be back to normal, as shown in ***Figure7.4-5.***

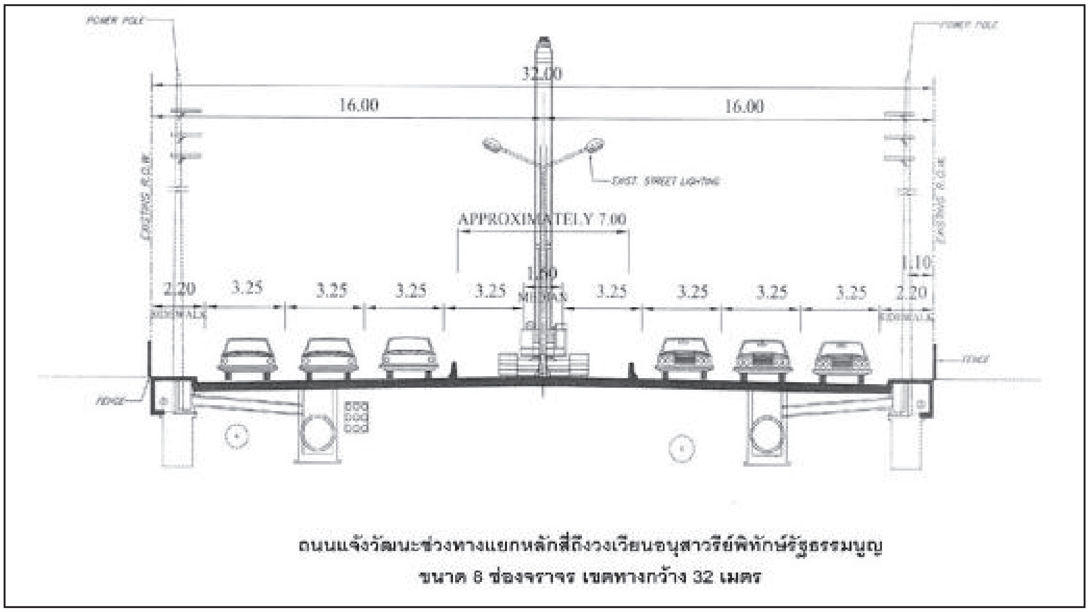


Figure7.4-4 Traffic Condition <u>during Construction</u> on Chaeng Watthana Road from Lak Si Intersection to Phithak Ratthathammanun Monument Roundabout

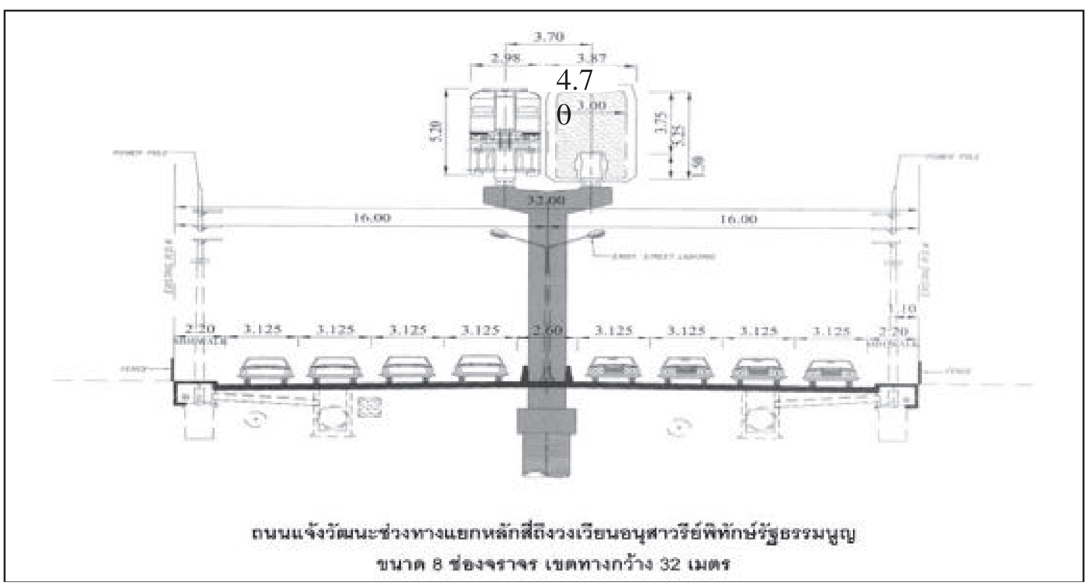


Figure7.4-5 Traffic Condition after Completion of Construction on Chaeng Watthana Road from Lak Si Intersection to Phithak Ratthathammanun Monument Roundabout

Tiwanon Road has 33 meters right of way, 6 traffic lanes (in-out), each with the width of 3.50 m/direction with a raised median of 4.20 m. wide. During construction, construction area must be set aside of at least 8.40 m., divided into intervals, each with 500 m. In case construction materials/equipment transport or soil excavation are required, one more traffic lanes must be set aside. However, in traffic management, the number of traffic lanes have been reduced from 3 lanes/direction to 2 lanes /direction, without reducing the width of the lane, as shown in ***Figure7.4-6.*** After completion of construction, traffic conditions on Tiwanon Road will be back to normal, as shown in ***Figure7.4-7.***

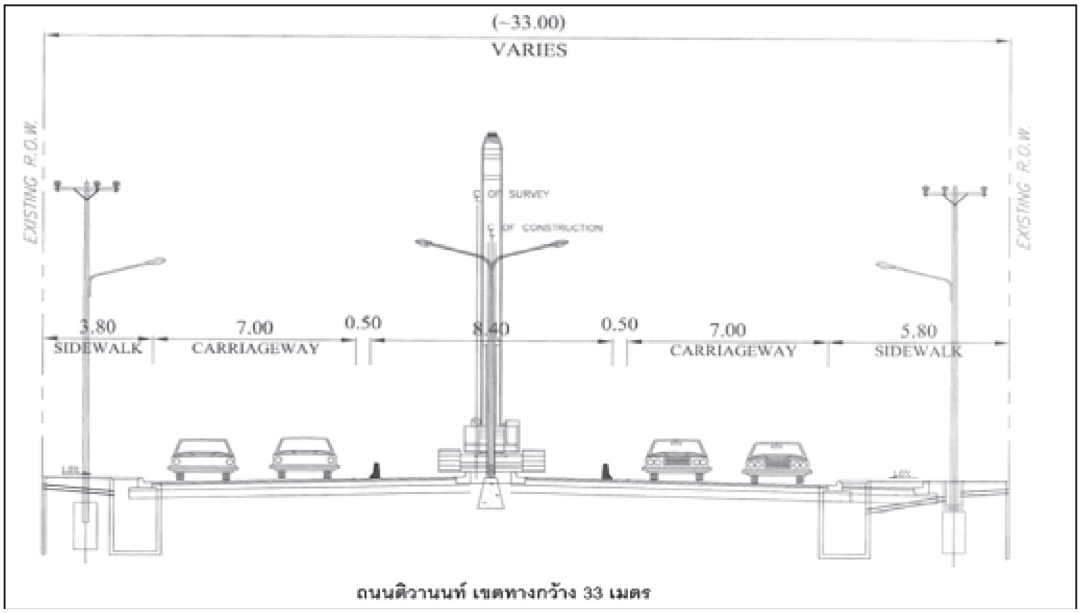


Figure7.4-6 Traffic Condition <u>during Construction</u> on Tiwanon Road

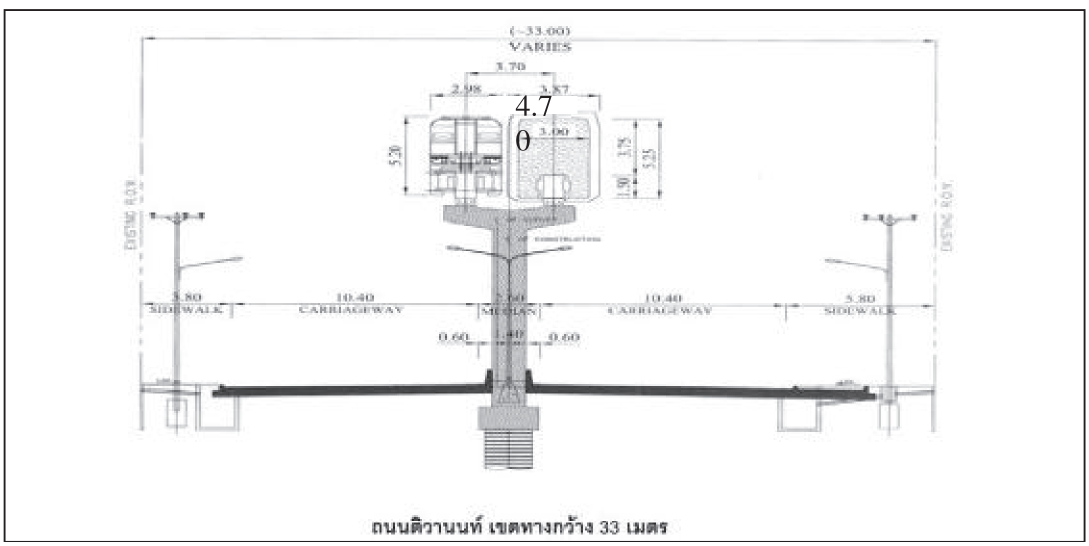


Figure 7.4-7 Traffic Condition <u>after Completion of Construction</u> on Tiwanon Road

(g) Controlling and insisting firmly the truck drivers of construction materials/ equipment to follow strictly the traffic rules and be more careful when driving past communities or areas susceptible to environmental impacts, such as hospitals, schools and religious places, etc., in order to prevent road accidents that may occur to the road users or the drivers, themselves.

(h) Setting speed limits for the trucks transporting construction materials/ equipment through communities, schools, hospitals and religious places, not to exceed 30 km/h.

(i) Improving traffic surface on the existing road networks under the structures of the guideway beam structures and stations and the adjacent areas to be smooth. Also, drawing clearly the roadway lines in each traffic lane, according to the lane sizes, after the return of the construction areas.

(j) Installing lightings around the area under the train stations and over the pavement areas on the road networks to give light to the traffic surface in accordance with the requirements of relevant agencies, such as Bangkok Metropolitan Authority, Department of Highways, Bangkok.

(2) Operation Phase

Development of the Pink Line MRT Project, Khae Rai–Min Buri section is part of the government's policy to solve the traffic problem in Bangkok (the north part) and surrounding areas, especially the road networks, and vicinity, for the transit system can move more than 200,000 passengers/day (in 2016), and will be rising to more than 480,000 passengers/day in the year 2025. In addition, a journey takes time relatively short (less than 45 minutes/route length). This is considered a major choice of users of the existing road networks and associated areas, and therefore becomes a positive effect providing overall traffic conditions on the existing road networks and related areas with high mobility. More important, the guideway beam structures and stations cause no reduction in the traffic surface because the project trails will use the median area of the existing road networks and certainparts of the pedestrian areas. Therefore, environmental impact prevention and mitigation measures have not been proposed. However, measures for benefit enhancement from the transport system on the existing road networks and connected areas will be suggested as an alternative as follows.

(a) Encouraging and promoting people and those who have personal vehicles turn to use the mass transit system

(b) Adding incentives from time to time, e.g. lower fares during festivals, or monthly fare cards cheaper than regular prices of at least 20%, or waived fares for the elderly or those older than 60 years, etc.

(c) Installing parking banning signs for all types of vehicles on the existing road networks throughout the length of the train stations approximately 250 meters starting from 50 meters before entering the train station and next to the stations for another 50 meters, except the public buses

(d) Cooperating with relevant agencies, especially the police stations in area of responsibility along the mass transit system alignment to enable correlation of traffic management on the existing road networks and connected areas with the in-out timing of the mass transit system.

(e) The bus companies need to coordinate with the relevant agencies to adjust locations of the bus stops close to the on/off ramp of every train station as much as possible to facilitate the public. Agencies involved include Department of Land Transport, Bangkok Mass Transit Authority (BMTA), for instance.

(f) Providing staff to facilitate the public traveling to use the trains at the stations.

7.4.3 Infrastructure and Public Utilities

(1) Pre-construction Phase

(a) The contractors shall begin all works before construction of the mass transit system as follows.

- Surveying details about infrastructure and preparing detailed drawings for relocation of the utilities and infrastructure, such as highway boundary, existing road networks, right-of-way to be expropriated, existing infrastructures and public utilities to be relocated, and layouts of the infrastructures and public utilities to be constructed/installed in their place.

- Preparing relocation plans for public utilities and infrastructure that will be affected in accordance with the construction plans of the mass transit system presented to MRTA and its related entities, such as Bangkok Metropolitan Administration (BMA), Department of Highways (DOH), Metropolitan Waterworks Authority (MWA), Metropolitan Electricity Authority (MEA), CAT Telecom Public Company Limited (CAT), or police stations in the area of responsibility, etc., to consider for approval of at least 30 days prior to relocation of utilities and infrastructure.

(2) Construction Phase

(a) Coordination and planning with local agencies responsible for infrastructure and utilities that must be relocated, e.g. MWA. MEA, DOH, TOT, and CAT, to make public relations plan for people/road users to know in advance at least 30 days.

(b) Installation of solid fences, at least 2 meters high or equivalent, to define a boundary that utilities and infrastructure will be relocated.

(c) Relocation of public utilities and infrastructure e.g. water pipes, drains, high-voltage electricity poles/electrical equipment/ power lines, telephone conduits and traffic signs out of the area needs to be carried out during the night from 9.00 p.m. to 5.00 a.m. of the following day, or to be operated only during holidays. Public relations campaign or notification will be carried out through such media as leaflets, traffic radio news, and notice boards in the area to be relocated so that people or road users will know at least 15 days in advance.

(d) Vehicles to be used for moving of utilities and infrastructure must be entirely covered with mesh or canvas to prevent the fall into the road surface. Speed limits to the storage of materials must not exceed 30 km/h.

(e) In case of complaints from the public or the road users that "utilities and infrastructure relocation," cause disturbance, or damages to existing utilities and infrastructure, the issue shall be resolved promptly.

(3) Operation Phase

None

7.5 VALUES FOR QUALITY OF LIFE

7.5.1 Socio-economic Conditions

(1) Construciton Phase

(a) It is required to make known the entry to work in construction area of the project to local authorities of BMA or Nonthaburi City Municipality/Pak Kret City Municipality, which are responsible for the area at least 30 days so that they will inform community leaders to convey directly the information to people in local communities.

(b) Contractors must control strictly employees and workers not to act or behave in a way creating a nuisance or causing controversy with people in local communities or passers-by on the existing road networks along the construction area.

(c) It is required to establish an Information and Complaints Center at the Project Office to receive information or complaints from people, and to make public relations about communication channels, such as Call Center Number/E-mail Address, etc. The Center also needs to provide staff throughout 24 hours as well as to gather and process complaints and suggestions of solutions to problems presented to MRTA once a month in order to help alleviate the suffering and annoyance of general public who are affected by the construction, as shown in ***Figure 7.5-1.***

(d) Contractors must construct with caution to avoid damage to life and property of people in the local communities located in the construction area, such as damage to the road surface resulting in major travelling obstacles or the use of the routes in communication between communities. If inevitable, it is required to remedy the impacts to the minimum or within a period of less than 3 days.

(e) Notification to the public, pedestrians, or passers-by on the existing road networks during the construction at least 7 days in advance before blocking the traffic in order to perform the construction or to transport large construction materials/equipment. Notification must be informed through public media such as notice boards, brochures, newspapers, radio, websites, or television, etc.

(f) Provision of security guards to maintain security in construction zone and help facilitate traffic during construction activities

(g) Provision of labor (about 70%), who must be domiciled or having evidences of living in Bangkok and its vicinity for more than five years

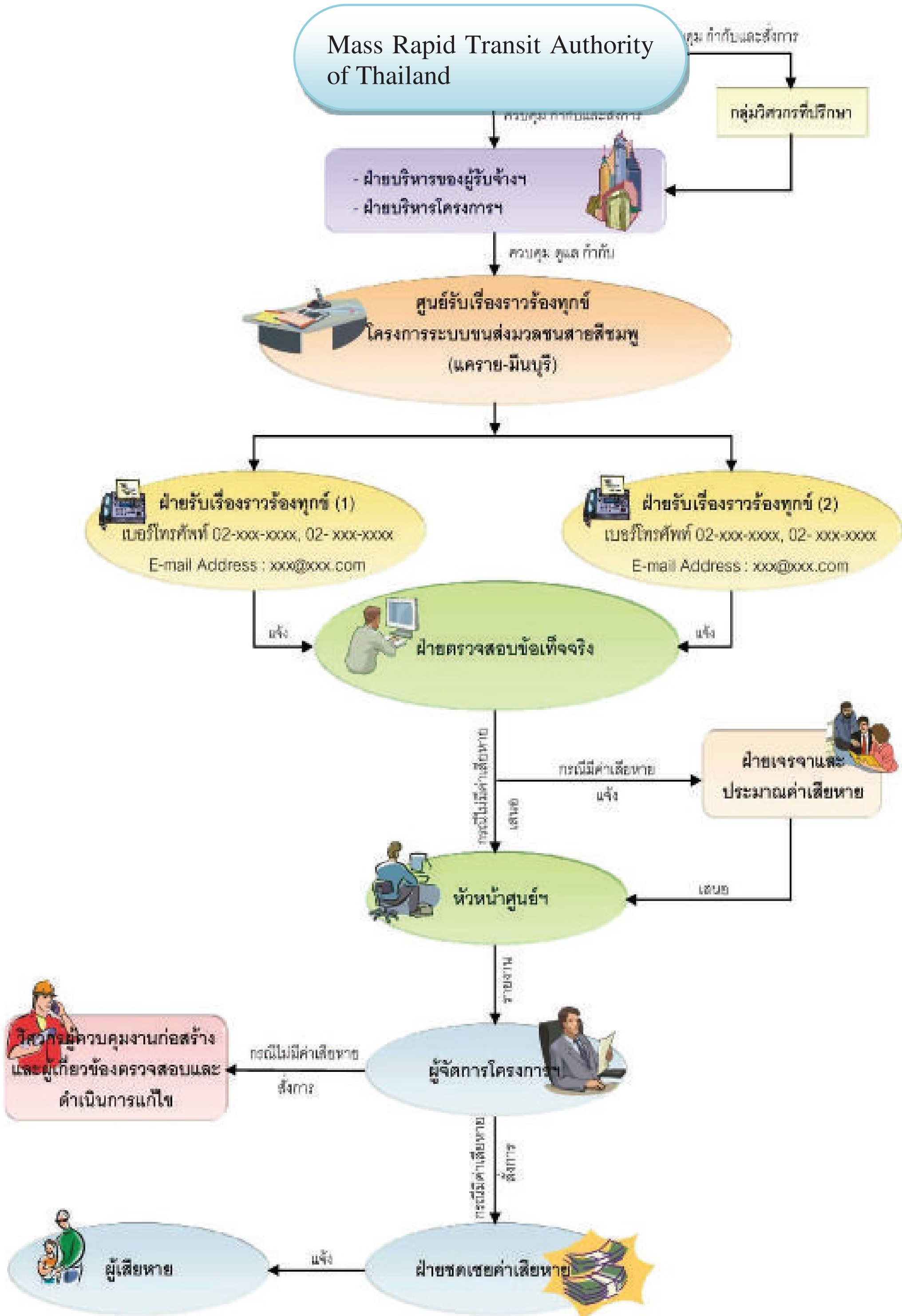


Figure7.5-1 Forms and Work Procedures within the Information and Complaints Center

(h) In case receiving of complaints from operators of existing trades along the construction area, those affected must be given an opportunity to make comments on how to solve or mitigate the problem under the principle of "Public Involvement", according to the rights defined in the Constitution of the Kingdom of Thailand B.E. 2550 (2007). Furthermore, it also needs to focus on how to fix or mitigate seriously and urgently the issues such as spiritual healing to those affected, or drawings revision if escalators, elevators, or ramps for the disabled have blocked out the front of the commercial establishments, etc.

(i) To make public relations periodically and create a better understanding between the contractors and local communities near the construction area through meetings that will clarify the construction nature and procedures, security system and monitoring system in order to avoid the impacts. Also, to make public hearings once a month to get the information to improve or mitigate the impacts occurred during the construction or to formulate a plan for construction activities to be clear and entirely consistent with the public demand

(j) To pay attention and participate in various activities in local communities along the construction area to build familiarity with and acceptance to local people, such as community development or careers building, grant of scholarships to children/students or schools in local communities, participation in sports or community development on special occasions, e.g. King's Birthday, religious holidays, etc.

(2) Operation Phase

(a) In case small business establishment nearby the 8 train stations, including PK02 Khae Rai Station, PK03 Sanambin Nam Station, PK11 Muaeng Thong Thani 1 Station, PK15 Phranakhon Rajabhat University Station, PK21 Watcharaphon Station, PK23 Khu Bon Station, PK27 Bang Chan Station and PK29 Min Buri Market Station, have to be completely affected or unavoidable to be so, they need to be psychologically healed as a special case, including for example, granting of privilege in earning a living or doing business on the train stations as a substitute, or entitlement to receive compensation/ psychological healing cost (opportunity cost) in the loss of business, etc.

7.5.2 Relocation and Expropriation

(1) Pre-construction and Construction Phases

The Mass Rapid Transit Authority of Thailand (MRTA) has to urgently complete relocation and expropriation activities before the start of construction work of the mass transit system and the Depot and Park & Ride Building as follows.

(a) To arrange a clarification meeting with those affected to inform of the project details, such as project features, anticipated benefits, expropriation steps and methods, rights and obligations of those who expropriate, etc., which needs to be completed before the commencement of construction of at least 18 months

(b) To issue a Royal Decree to demarcate the land for expropriation by identifying starting locality-end point and the area width, according to the Royal Decree

(c) To post the Royal Decree at the government agencies where the project route passes over such as Nonthaburi Government Center, Bangkok Metropolitan Administration, Nonthaburi Provincial Land Office, or Land Office Branch, Bangkok Land Office, or Bangkok Land Office Branch, Nonthaburi District Office/Pak Kret District, Lak Si District Office/Bangkhen/Bueng Kum/Kanna Yao/Min Buri and Nonthaburi Ciity Municipality or Pak Kret City Municipality, for example

(d) To explore the property to be expropriated such as land, buildings, and agricultural crops. The authorities need to send a notification of survey schedule to the property owners not less than 15 days. Also, to explore thoroughly the number of those directly affected in order to be aware of their needs for help from the government, methods/approaches/ compensation period, or suggestions on relocation. Such information will be served as guidelines that are consistent with the needs of those affected as much as possible.

(e) To establish a committee to determine compensation prices for the land, buildings and agricultural crops. The basic form of the committee must consist of representatives of those who are affected and local community leaders in expropriated area to join as members to consider and define the criteria for determining the property compensation cost, calculation methods or payment procedures, etc.

(f) Property compensation is determined to be initially provided to the parties as follows.

- Lawful owners or occupants of land to be expropriated
- Owners of houses and other buildings that cannot be demolished and located in expropriated land on the day enforcing the royal decree, or built later upon permission from the authorities
- Lessees of land, houses or other buildings on the land to be expropriated. However, in rental case, it would require evidences in writing, which were made before the day enforcing the royal decree or made after permission from the authorities.
- Owners of perennial trees in the land on the enforcement date of the royal decree.
- Owners of houses and other buildings that can be dismantled, which are located in expropriated land on the day enforcing the decree, but not to be the person who had to demolish such houses or buildings when notified by the landowner. The compensation will be given for only the demolition cost, relocation cost and construction cost of the new buildings (in its original condition).
- The person who loses the right to use the land to place water pipes, drains, electrical lines,or other similar things through expropriated land, according to Section 1349 or Section 1352 of the Civil and Commercial Code. (In case such a person already paid compensation for the use of such right to the landowners of expropriated land.)

(g) To set and distribute property compensation payment at fair, reasonable and acceptable rates to the people affected by necessarily taking into account the psychologically healing cost (opportunity cost) and psychological loss. In addition, compensation distribution period must be consistent with the project implementation plan, and must be completed before the start of construction. Furthermore, in compensation assessment for those affected, it needs to take into consideration the expenses incurred during the loss of the revenue earlier earned actually including the extra compensation to support living until getting back to normal.

(h) The criteria for determining compensation for expropriated property and the compensation amounts for the project extensions and the new lines of the MRTA are required to follow strictly the regulations of the MRTA.

(2) Operation Phase

None

7.5.3 Public Health and Safety

(1) Construction Phase

(a) The contractors must seriously comply with the environmental impact prevention and mitigation measures on air and noise quality during the construction phase.

(b) During construction, it is likely to have a chance of accidents from operation if the workers are careless and negligent. Therefore, to prevent the occurrence of any similar accidents at severe level, the contractors are required to do as follows.

- To establish a security committee to formulate security policies within the construction areas such as construction plans and safety measures, control and supervision of employees and construction workers to comply with the regulations or the safety laws, to investigate the cause of hazards as well as to suggest and provide trainings to staff and construction workers to work with caution, as shown in ***Figure 7.5-2*****.**
- To train staff and construction workers on how to use and maintain tools, machinery and equipment properly and appropriately to the type of the work. Also, it needs to provide responsible officers to maintain availability of tools, machinery and equipment at all times as well as to repair immediately if found damaged to prevent accidents from operation at all times.
- The staff and construction workers must wear Personal Protective Equipment (PPE) throughout the operation in construction area in order to prevent damage and accidents from operation in accordance with the Ministerial Rules regarding Standards for Security Management, Occupational Health and Environment of Construction Work B.E. 2551 (2008) and strict personal security protection.
- Controlling and prohibiting construction workers and transport drivers of construction materials and equipment, not to use drugs or stimulant, or drinking while working. Also, imposing severe punishment for violators, such as suspension of operations indefinitely, 50% salary cut, or dismissal.
- Controlling and instructing the truck drivers of construction materials and equipment to comply strictly with the traffic rules while driving through communities or areas susceptible to environmental impacts, such as hospitals, schools and religious places, etc., and using speeds not exceeding 30 kilometers per hour.

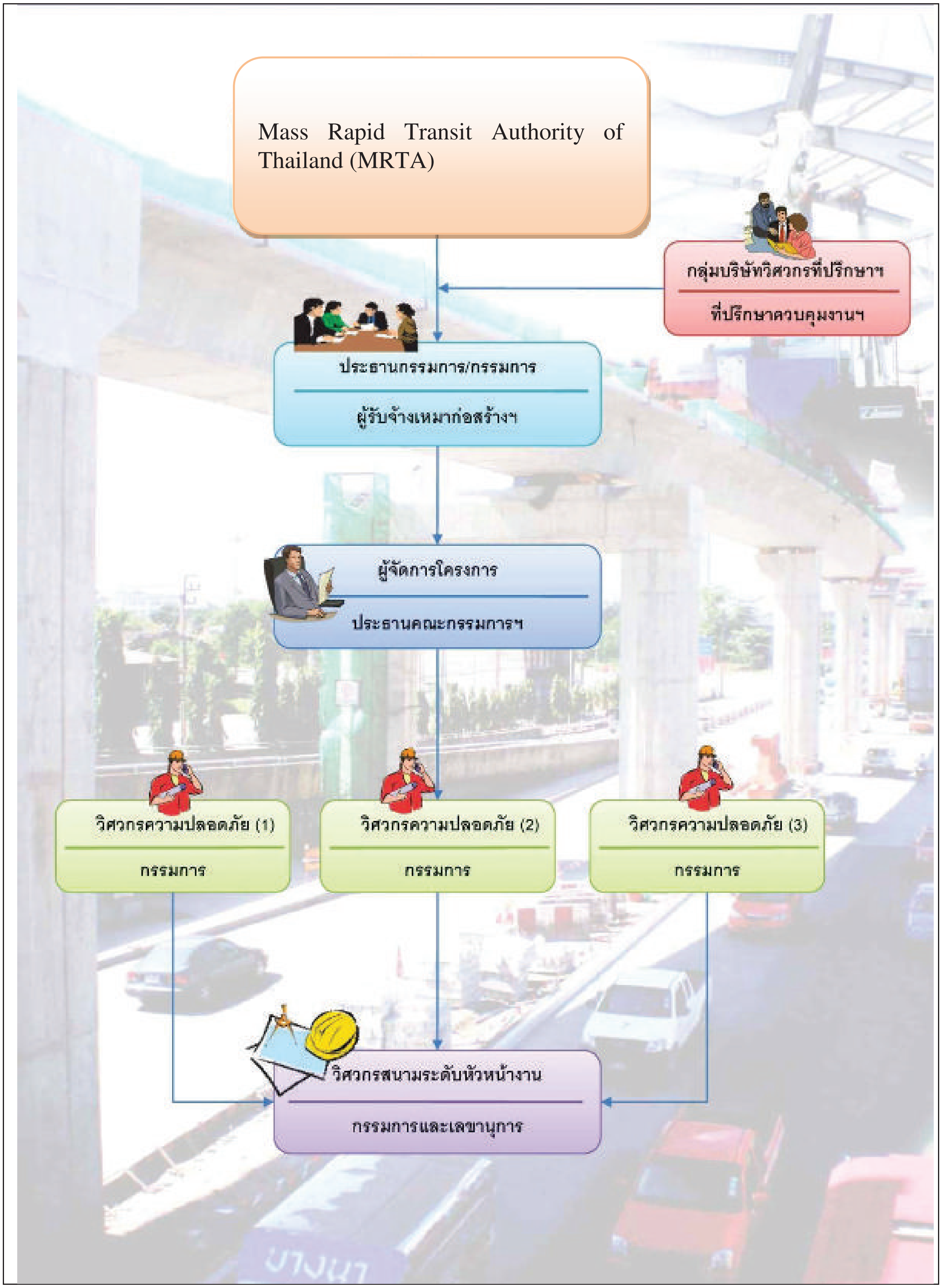


Figure 7.5-2 Example of Safety Committee during MRT Construction

- To install concrete barriers with metal sheet of 2 m. high in the construction area on the existing road networks to indicate boundary of the construction area, as shown in ***Figure7.5-3***, and to install solid fences of 2 m. high surrounding the construction area of the Depot and Park & Ride Building at Rom Klao Intersection to reduce the noise impacts caused by the construction.

- To make publicity through media such as notice boards, brochures, newspapers, radio, television and websites for the public or passers-by to know that there will b the blocking of the roads regularly used, e.g. Rattanathibet Road, Tiwanon Road, Chaeng Watthana Road, Ram Indra Road and Sihaburanukit Road, etc., in order to relocate public utilities and infrastructures, or to move large construction materials and equipment, or to place concrete beams, for instance.

- Establishing measures to control all construction areas by providing security guards to monitor and prevent those who are not allowed and not related to construction to enter the construction areas for prevention of damage and property loss.

- The area below the construction area of the guideway beam structures, the train stations and other components must be covered with mesh or canvas to prevent accidents caused by the fall of materials or equipment from the construction. Should there be complaints by the public or those affected, it needs to send staff concerned to inspect the damage and to be responsible for the damage cost, as appropriate, or at actual cost.

- To install adequate lightings inside the construction area appropriate to the construction activities for safety at work, and flashing lights to clearly show the construction area, especially during the night for safety of passers-by.

(c) Contractors have to arrange a medical room in the Project Office, with at least one registered nurse to provide basic medical care, such as provision of first aid to employees and contruction workers who are sick. In case of serious accidents during the operation, the injured must be sent to the nearest hospital as soon as possible, e.g. Panyananthaphikkhu Chonprathan Medical Center, Mongkutwattana Hospital, Synphaet General Hospital, Nopparat Rajathanee Hospital, Navamin Hospital, Wetchakarunrasm Hospital, Bangkok Metropolitan Administration Latkrabang Hospital, etc.

(d) Environmental health in construction area or the project office needs to be managed in accordance with the recommendation of the Engineering Institute of Thailand under H.M., the King's Patronage and Ministry of Public Health as follows.

- To provide adequate clean drinking water (5 liters/person/day), and water for use (50 liters/person/day) to meet the number of employees and construction workers on the construction site or in the project office. Also, to provide adequate bathrooms–toilets in the worker quarters (10 persons/room) and to install prefabricated waste water treatment system in the project office before releasing effluents into public drains.

- To provide a sufficient number of lidded garbage bins of 240-liter capacity in the construction area and the project office by separating into wet bins, dry trash bins, hazardous waste bins and recycled trash bins, and to liaise with local authorities to transport the waste for disposal in accordance with hygienic practices at least 3 times a week.

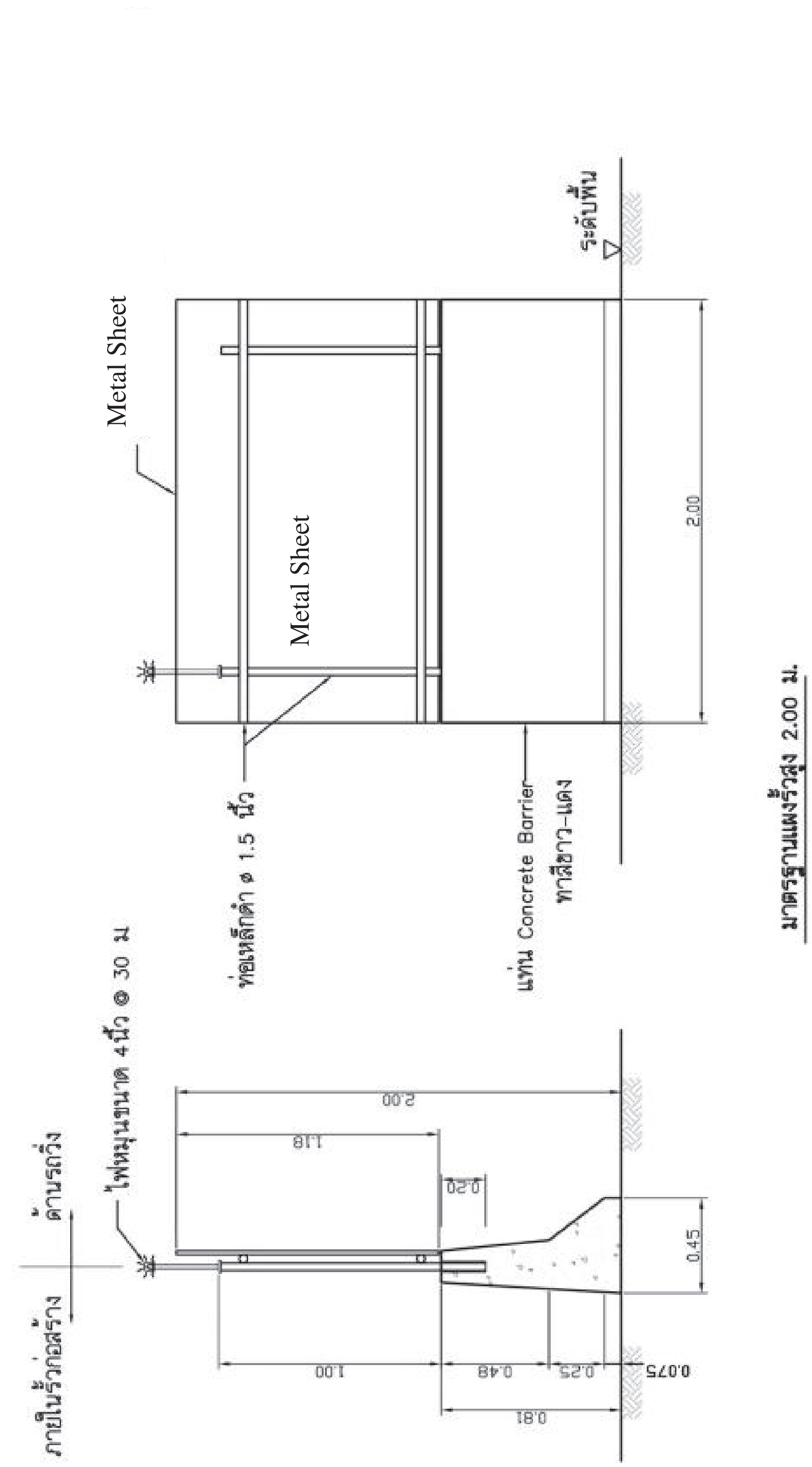


Figure 7.5-3 Example of Concrete Barriers with 2 m-high Metal Sheet in Construction Area on the Existing Road Networks

(e) Contractors are required to put in place measures for construction workers as follows.

(i) Measures for construction workers

- **Public health measures**

- To provide first aid and an ambulance unit for workers, and to coordinate with hospitals located near the project construction area in advance in case of emergency patients due to project construction work

- To provide training and knowledge on safety in construction area and worker quarter zone, as well as on the use of personal protective equipment

- Strictly controlling and enforcing driving rules and regulations

- **Occupational health and safety measures in working area for construction workers**

Safety measures for the use of construction tools and machinery

For safety purpose when it is required to use construction tools and equipment, contractors have to strictly supervise the workers to comply with the safety measures for the use of construction tools and equipment as follows.

- Sharp tools, such as dividers, iron bars, etc., must be held with the end down or must be covered not to be kept or carried in pockets.

- Damaged tools, such as chipped or cracked hammers, must not be used, for they may miss the target while banging or hitting.

- Working on high-ground, the tools must be tied, bundled or kept safely to prevent them falling down below.

- When operating machines used in construction, operators need to know how to stop those machines too.

- When changing the speeds of a machine or a gear belt, it is required to shut down or switch off the machine before every change.

- Do not try to stop the machines by hand or any part of bodies.

- Be aware of potentially harmful components of the machines, e.g. gears, belts, etc. Milling cutters must be covered or protected.

- Always check workpieces or milling cutters whether they are tightly fixed or in the right position before operation.

- When the work is done, switches must be cut power off every time.

Safety measures for lifting or carrying heavy objects

For safety purpose, when workers have to lift or carry heavy objects, contractors need to strictly supervise the workers to comply with the safety measures for lifting or carrying heavy objects as detailed below.

- Lifting of very heavy objects can cause serious harm. Helps from other people or use of a jack are needed. More important, when lifting very heavy objects off the ground, do not attempt to lift by bending forward, but bend one's hips and knees to squat down to the load instead.
- Use thigh muscles to lift the objects by standing in the position to load balance, that is, knees bent, back straight, head down, hold tightly and then stretch the legs up, as shown in ***Figure 7.5-4.***
- Try to avoid lifting sharp objects.
- After lifting up an object, it needs to see the way forward and around before walking.

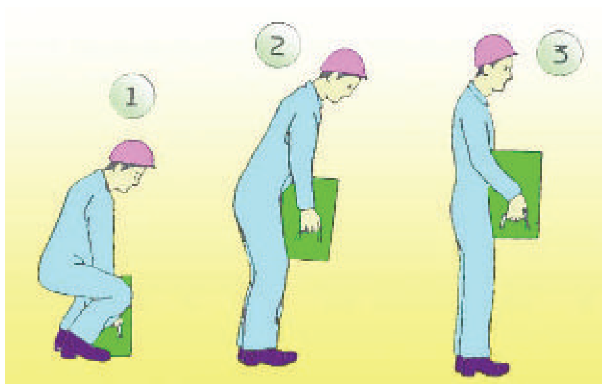


Figure 7.5-4 Steps of the right way to lift an object

Safety measures for working with electricity

For construction workers who have to work with electricity, contractors must strictly supervise the workers to comply with the safety measures for working with electricity as detailed below.

Cautions about working with electricity

- When a cover or a switch box is found damaged or broken, it needs to repair or replace with a new one immediately.
- Clean the area where the liht switch is located far away.
- Always check inside the light switch panel and electrical control cabinet not to have scrap of copper or conductive metal in the cabinet. Also, do not remove internal devices such as fuses out of the control cabinet.
- To change fuses, it is required to use those for specific task only. Prior to changing, switch on the circuit first.

- Do not use a cover made of materials that can be flammable.

Each switch cover must be labled with details as follows.

- Applied to DC or AC
- Electrical potential difference (or voltage/ electromotive force)
- Electric current
- Electrical appliance connected to the switch
- Recipient name

- It needs to switch on the circuit first, when requiring to check or repair a machine. Then mark or tag “Under Repair”on the switch.
- Before switching off the circuit, make sure that everything is all right and the right signal has been received. Before the trial run, it needs to inspect that no object is stuck within the machine.
- Signaling for switching on-off the circuits must be done with care.
- Do not switch on-off the circuits with wet hands.
- Before switching off the circuit, it needs to make sure that the signal is correct.
- Tightening of the bolts to secure the power lines must be tightly screwed.
- Do not ever use any damaged electrical equipment, for it may cause danger.

Cautions about circuit breakers using

- Circuit breakers used with highly dangerous threat must be checked on regular basis with clearly indicated labels.
- In the case of a machine check or repair, it needs to make a sign, “Under Repair” hanging next to the switch. Such sign will be taken out once the work is finished.
- Use of switches to control machines in construction by many people, requires the rules or signals for practice, which are the same standard.
- In collaboration between the two groups of workers, the group that uses a machine together must use with care, especially in case of repair; it needs to liaise well with technicians before on-off the electrical circuit.

Cautions about the use of electrical tools, machines and equipment

- Check electric wires. If found defective, wrap them completely with tape for insulation and check the wiring point too
- For movable electrical appliances, check carefully the joints, pole-mounted devices and electric wires. If found damaged, immediately change it into good condition

- Replacement or repair of electrical tools/equipment, though it is a trivial case, it needs to have electrician perform the work.

- Do not switch the power wire while there is a flow of electricity.

- Do not hang the wires on sharp objects, such as blades, saw blades, propellers, etc.

- In using certain types of electrical equipment, e.g. motor, transformer, it needs to have persons responsible for on – off the equipment.

- Electrical components that could cause harm must be clearly marked with labels, such as lighting signs, red flags, red tapes, for example.

- If abnormal conditions occur with electrical equipment, it needs to switch on the circuit. Then let those responsible know.

- Do not disconnect the electrical protective equipment, unless authorized to do so.

- When the work is done, switch should be flipped and make sure that the electrical circuit is open.

- Do not wrap the lights with paper or cloth.

- Do not bring flammable or combustible materials near electric switches or plugs.

- Do not use electrical tools/equipment with wet hands.

- Should there be the injured from electrical accident, it needs to switch on the electrical circuit immediately.

Cautions about installationof electrical equipment

- Installation of electrical devices must be supervised by qualified specialists or electricians, except the equipment with voltage below 50 volts, which was already grounded.

- Installation of electrical equipment must be carried out through consultation with experts, especially communication on prevention when there is a flow of electric current while operating, or in case an interruption occurs.

- Avoid working when electric current flows, except in case of necessity only.

- In installation of electrical equipment, in addition to compliance with electricity laws and standards, it needs to comply with more practices as follows.

- Do not turn on a piece of electrical equipment that there will be a flow of electricity or electric charge when turned on. It must be covered or insulated. However, if covering is impossible, it needs to make a danger tag hanging.

- Equipment or power lines installed on high position must be well insulated and require inspection on regular basis.

- Always inspect insulation wrapping the electrical equipment in the area where exposure may be made or in the working area.

- When there is electrical wiring on the road (though temporarily), it needs to provide protective systems that are used for specific work.
- In case of single working with electricity that may have been interrupted, extra cautions should be added as follows.
  - Certain types of machines after operated will not be switched to work back at the starting point. Such machines must therefore be lableled.
  - All machines must have a good grounding system.
  - When a problem occurs, it is required to consult electrical technicians or specialists.
  - Before switching to operate the machines, it needs to ensure that a short circuit will not occur and that the grounding system was already installed.

Rescue and first-aid measures

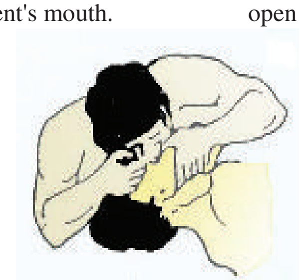
Contractors have to provide training on rescue and first aid in the event of an accident during the operation within the project area for the construction workers before the actual construction as detailed below.

In case breathing stopped

Details of rescue and first aid in case a worker stops breathing during working in the construction area are shown in ***Figure7.5-5*.**

(1) Lift up the neck, tilt the head back slightly, then sweep out the objects in the patient's mouth.

(2) Pull out the patient's jaw, press the nose and open the patient's mouth.



(3) Put your lips on the patient's mouth, then gradually blow the air to fill the lungs. Repeat several times until the patient is breathing spontaneously.

Figure7.5-5 Rescue and First Aid Process in case Construction Worker Stops Breathing

In case of electrocution

- Do not use bare hands to help.
- Immediately cut off electricity (switch/plug)
- Use insulating material to knock off the target. If there is no insulation, use dry wood instead.
- In case of power outage, immediately switch on the electrical circuit.
- In case of electrical shock or short circuit resulting in a fire, it needs to switch off the circuit immediately. Then extinguish the fire with the C-type fire extinguishers, e.g. dry chemical, CO_2, etc.
- Do not use water or fire extinguisher of water type to pull out a fire because it may be dangerous.
- In case of near-drowning victim, do not go to help until you are sure that the electricity is entirely cut out.
- If the patient is unconscious, immediately rescue by doing cardiopulmonary resuscitation instantly.

Stop of bleeding

Steps for stopping the bleeding in details are shown in ***Figure 7.5-6*,** with a summary as follows.

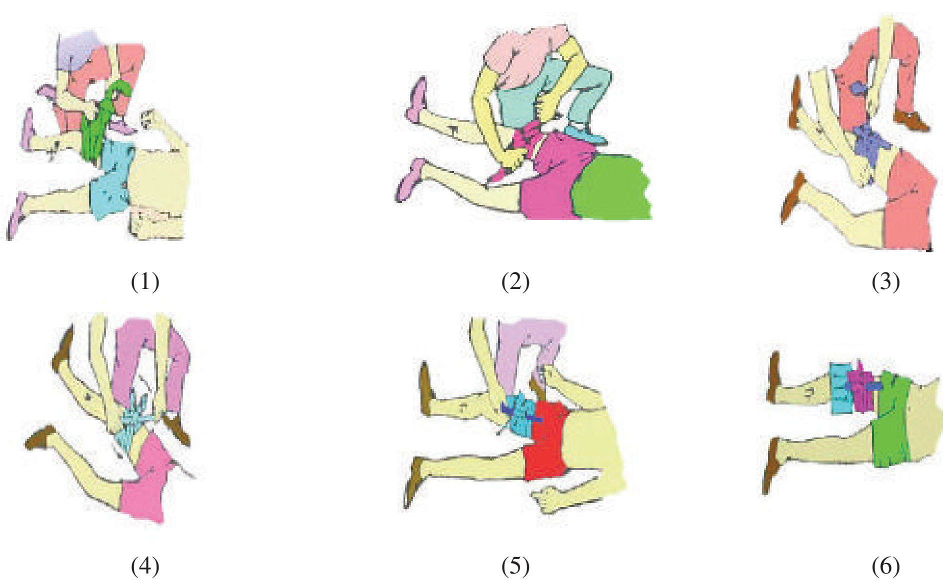


Figure7.5-6 Initial Steps to Stop the Bleeding with a Wrench

1) Use a clean piece of cloth to wrap around the arm or leg 2 rounds.
2) Tie the first knot.
3) Place a piece of wood on the knot. Then tie the second knot twice.

4) Turn the wrench until the blood stops flowing.

5) Tie up the end of the wood with a lanyard.

6) Note starting time of wrenching.

Measures to arrange a tidy workplace

- The workplace must be free of anything that will cuase harm, or obstacle to operation, and must have no waste, oil and water stains on the floor.
- The pathway must be clear to have access to work safely.
- The bathroom and sinks must be in clean and sanitary condition.
- Food must not be stored in the workplace.
- Garbage and waste must be removed outside the workplace every day.
- Do not place flammable materials near the installed lamps or the materials with heat or spark.
- Splashed oil and grease on the floor must be cleared away.
- Store materials on the level area in stable condition.
- Provide sleeper wedges to support materials with circle shape in order to block the move.

Measures for using of equipment to warn and isolate the area that may pose danger to workers

- Building fences around the construction zone with the signs,“Construction Zone, Outsiders not Permitted to Enter“around the construction area.
- Dangerous zone must be fenced with the signs "Danger Zone in Construction," and red lights clearly viewed at night.
- Higher areas and areas with openings must be provided with strong guard rails.
- Do not allow those who are not involved or not responsible to enter the construction area and dangerous zone in construction.
- No worker is permitted to stay in the construction zone.

Safety measures for working on high places

- Guard rails must be strong with the height of not less than 90 cm.
- Check all working devices such as cranes, wire slings, ropes, hooks, gaskets, etc. in good condition every time before starting work. If damaged, do not use.

- While there is a storm or rain, the workers must stop working and come down on the ground.

- When there is a risk of falling from the level of 4 m. high or more, construction supervisor must instruct the workers to use safety belts and lifelines throughout the operation.

Safety measures when using heavy machinery and cranes to move objects

- Providing only one experienced signaller
- Do not approach part of the machines that must be centrifuged.
- In the event of excavation, the area must be fenced around.
- It is strictly prohibited to get under the materials being raised.
- Working at night needs to have lightings provided throughout the area all the time at work.
- Modification or alteration of any part of the crane is prohibited.
- Providing sound signals and flashing lights to warn that the crane is moving.
- Providing operation manual on cranes in Thai for drivers to study and follow properly.

Safety measures for the use of ladders

- Always use ladders manufactured by the factory, especially the type to be used with heavy loads.
- Damaged or broken ladders are not allowed to be used, and should be labeled, "Do not use".
- Do not bring 2 ladders to tie together to make them longer.
- Do not set a ladder on slippery space or garbage area.
- The end of the ladder must be over 3 feet from the point leaning over.
- Face the ladders when climbing up and down.
- Do not lift or carry objects by using the ladders.
- Do not ever use metal ladders with electrical work.

Safety measures for the use of scaffolding

- Scaffolding must be used for working on the height in excess of 2.00 meters.

- Metal scaffolding must load at least four times of the user' weight.
- Scaffolding plank must be at least 35 centimeters wide.
- An access ladder must be provided for up and down into the scaffolding.
- Outer scaffolding must be covered by a canvas or a safety net.
- Scaffolding structure must be braced to prevent the staggering or falling. In case it is necessary to work near the uninsulated wires, the scaffolding must be spaced at the distance not less than specified, or contact the utility to temporarily install the wire insulation.
- Guard rails must be provided, at least 90 cm. high and no higher than 1.10 m., except during material loading and unloading.
- In case of overlapping operations, protective measures must be put in place to protect the workers at the lower level against danger from falling objects.
- To work on scaffolding higher than 4 m, supervisors must ensure that workers wear safety belts.

The structure of safe scaffolding is as shown in ***Figure 7.5-7***.

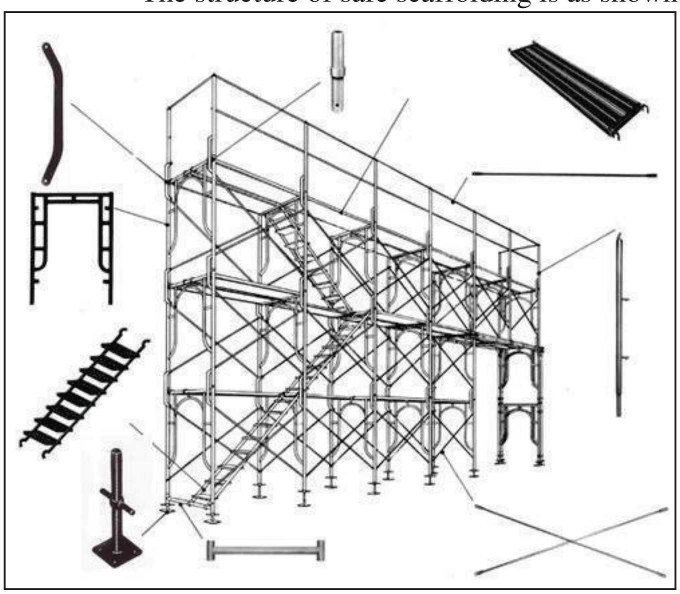


Figure 7.5-7 Safe Scaffolding

Safety measures for the use of hooks, lifting chains, clamps to securely fasten to the structure

- Use a hook in case there is one place to be secured for lifting, and use chains when there are more than two places for securing
- A hook must be attached to a safety pin. (Except for certain types of hooks)

- Use hooks to lift weights by having the material weight fallen straight at the grooves of the hooks.
- Request for supervisor's approval before binding materials to other structures to make sure that their weights do not exceed the limit of the structure.
- Do not use clamps for metal sheets, pliers, or hose clamps in place of the clamps used to hold the structure.
- It needs to inspect and approve the hooks, lifting chains and clamps used to hold the structure before using each time, and not to use them exceeding the specified weight ranges.
- Weight range to raise must be clearly identified on the device.
- Materials to be lifted must not be left in insecure condition, without surveillance, and hanging on the lifting chains.
- Do not stand or have any part of the body been below the materials being lifted by the chains.
- Do not use chains to girdle materials for lifting.
- Visually check the chains before using them to lift materials including the hooks that may be faulty as well as the damaged condition due to misuse.

Safety measures in excavation

- In digging of the ground or ditches at the depth of more than 1.5 meters, it requires shoring or sloping and must be checked by staff every day before entering for work and the checking must be recorded.
- It is necessary to have barricades and markers installed around the excavated area.
- Digging workers must wear helmets and safety shoes or brogans.
- Do not allow anyone to approach the edge of the excavated hole or any other materials while the machines are being operated.
- When digging the ground, ladders must be provided for entry into and exit from the area, and there must be a way out.
- Dirt or objects from the excavation, or any other materials must be stored at least 1 meter away from the edge of the excavation.
- The area of excavation must be inspected after rains and needs to be prevented from flooding.

Traffic safety measures in construction area and parking area arrangement

- Allow only those with a valid driver's license to drive vehicles in the construction zone.

- Speed limits in the construction zone at 20 km/h. and drivers to respect rules on the traffic signs.
- Reckless driving which may lead to harm is not permissible.
- Safely overtaking of vehicles is allowed to drive at specified speeds only.
- All drivers have to turn on the lights before dark.
- While driving motors, the drivers must wear seat belts, and every car must be equipped with seat belts.
- In construction zone, employees have to walk right on the road while vehicles have run counter to the employees.
- The drivers must comply with the rules on road signs and give way to people walking on the road.
- Staff and visitors need to park vehicles only in front of the office buildings, which are arranged as parking areas, or to park in a designated parking lot with traffic signs allowing parking installed.
- General rules and regulations on traffic must also be effective in construction zone too.

Fire protection measures and fire extinguishers

- Contractors have to provide training on fire protection and emergency plans for the employees.
- Construction workers need to know locations of a fire alarm and the proper way to use.
- Construction workers need to know different meanings of alarms, e.g. fire, evacuation or other disasters and also know the fire escape routes as well as the assembly points.
- Construction workers need to know the nearest position of a fire extinguisher and the proper way to use.
- Flammable or combustible materials must be kept away from sources of ignition.
- To fuel machinery and equipment, it is required to shut down the engines, or the engines must not be hot.
- To fuel machinery and equipment, it has to be done only when the machine is off, or the engine is not hot.
- Discard cigarette butts in the place provided. Do not throw it in a basket or general trash bins.
- Positions and places to install the alarm signs must be posted on Safety Public Relations Board.

- Person who first spot a fire must put out the fire by using the fire extinguishers installed at different points.

Safety measures for welding/grinding work

- Before making the cut with electricity or gas every time, the workers need to check surrounding area that there must be no combustible materials within the range of sparks flying from the operation to. Anyhow, this will include the welding on high where spark will fall through. Such combustible materials must be moved out of the way, or fireproof blankets must be provided.
- Flammable substances must be moved away from the area where the sparks from welding can splash to.
- In welding or cutting a container of flammable liquid, every time it is required to remove and clear flammable substances or gases that remain in the container beforehand. Then ventilate the air inside the container to ensure that there is no residue of flammable gases or substances, or that the residue must be only 0% of the lower explosive limit. After that the welding can be performed.
- In welding area, it is required to provide sufficient fire extinguishers that can be reached easily near the work in case of emergency.
- A gas tank is to be placed in vertical position, away from the welding area to prevent the sparks splashing. The tank needs to be secured firmly to prevent falling. All equipment needs to be checked for a condition available to use before starting work.
- Welding equipment using electricity must not be damaged or ruptured.
- Removal of welding sticks for a temporary break or stop using needs to switch off power at all times.
- Fuses of electrical welding used must be properly sized and put into place.
- Do not ever switch air hose with gas hose, for this may cause an explosion.
- Check air hose and gas hose as well as flashback arrestors for good working condition.
- Operators must wear gloves and goggles or masks every time and all the time at work.
- After completion of work, the working area needs to be inspected to make sure that there is no ignition.

Measures on Personal Protective Equipment

- All construction workers need to be aware of storage place of protection equipment and how to use it really.
- Provide helmets for all construction workers

- Eye and face protection equipment (such as the cap on full-face protection goggles for sanding and cutting work) must be used on the eyes and face that are likely to be harmed.

- All construction workers must wear leather safety shoes or sturdy and hard boots and helmets all the time at work.

- Contractors have to provide personal protective equipment, such as ear muffs or ear plugs to staff working in the area with loud noise. In addition, it is required for staff or construction workers working in noisy areas to take turn for a period of 30 consecutive days.

- Construction workers must wear ear muffs or ear plugs when performing the work of noisy type of greater than 60 dB (A) at the position 1 m. away from the noise origin Construction workers must wear safety belts in working at the height ofmore than 2 m.

Measures to prevent harm to construction machines, tools or equipment

- Install protective devices or making fences to separate the moving parts of machinery/tools, which in normal situation, individuals may be exposed to.

- Do not take protective equipment of machines/tools out of the machines/tools during operation.

- Before working, protective equipment earlier removed for repair or for other purposes must be re-installed properly.

- If it needs to use the tools of motor type for grinding/ cutting, the cover or protective equipment must be completely checked.

Punishment measures

Employees of the company and/or the contractor who violate the Occupational Health and Safety Measures of the Project are considered guilty according to the safety regulations, and will be punished with an admonition, putting on probation, and being dismissed in accordance with the articles of association of contractors and labor law (i.e.Labor Law B.E. 2541).

Measures on reporting of accidents and incidents

Any of the following events must be reported to superiors and the security department.

Accidents that either stop or not stop the working process, with people injured and treated at hospital.

Vehicle accidents (within the project construction area only).

Equipment/tools damaged in an accident

In case of a fire or an incident that could cause a trivial accident, unsafe action/circumstances, it is required to report immediately to the safety officer of the project.

Measures for occupational health and safety at work for contractors or construction companies

- Construction companies/contractors need to provide knowledge and advice to workers in prevention of diseases.

- Construction companies/contractors need to provide the proper working environment, such as heat, light, sound and equipment standards in accordance with the Notification of the Interior Ministry regarding Safety in Working Environment.

- Construction companies/contractors need to provide a Guidebook to Occupational Health and Operational Safety, with details specified at least in the Measures for Occupational Health and Operational Safety for the construction workers as aforesaid. They are also required to provide trainings and knowledges on safety and how to properly use the machines and equipment to the operators in accordance with the details specified in such guidebook before actual operation. Moreover, the guidebook must be placed near the construction workers, and there must be enough to meet the number of the construction workers in the project.

- Construction companies/contractors need to provide sufficient personal protective equipment including helmets, gloves, goggles, masks, ear muffs, safety shoes or other personal protective equipment to meet demands of the operators.

- Construction companies/contractors need to have the operators wear personal protective equipment under the conditions and characteristics of the work, and wear clothing that is neat, close-fitting, not tattered. In case of working on the use of electricity, the operators are required to wear clothing that is not wet. A uniform appropriate for wearing during operation involved in the construction machines is i.e. shirt and pant of the same piece in a neat condition, with all buttons fastened, not wearing jewelry such as necklaces, watches, rings, etc. To wear brogans or boots to prevent construction materials piercing. In addition, construction workers should not wear long hair. If to do so, they need to wear helmets during operation.

- Construction companies/contractors need to provide inspection officers on occupational health and safety in the construction area.

- Construction companies/contractors need to provide adequate first aid units in the construction area.

- Construction companies/contractors must comply with measures to reduce the impacts on noise, air quality and traffic management for safety during construction.

Measures for maintenance of environmental quality in worker quarters

- In choosing locations for worker quarters, construction companies/contractors need to prepare housing plans for construction workers, accommodation style, location, utilities and infrastructure arrangement, and other particulars presented to MRTA, the project owner, for information and approval before implementation. Anyhow, both the worker quarters and the Construction Supervision

Office should be situated away from a groundwater well at least 50 m. to avoid contaminated dirt into the groundwater sources.

- In preparation of an access way to the worker quarters and the Construction Control Office as well as the parking areas and other empty spaces, there should be improvement for its stability by scattering with gravel, topping with materials reducing dusts and erosion as well as planting of ground-cover trees, if possible.

- In management of drainage and flood protection, the contractors are required to install effective drainage systems for draining not only waste water from washing, toilets, bathrooms but also rainwater in the office area and the worker quarters that need to take into account the slope of the seepage area and the overflow of water as well as the drainage area. Anyhow, there must be no flooding in either housing area or neighboring area. To achieve this, application of water retention system may be introduced, such as by building a clarifier pond before draining water out.

- For water supply management and waste water treatment, the Mass Rapid Transit Authority of Thailand (MRTA), the project owner, has supervised the construction companies/contractors to handle as follows.

  - To provide adequate clean drinking water and water supply for consumption of at least 72 cubic meters/day/one worker quarter for construction workers to use daily.
  - To build hygienic and sufficient bathrooms – toilets for workers in the quarters with installation of finished waste water treatment system of septic tanks-anaerobic filter tank type for waste water treatment to the standards before releasing to the outside.
  - Control the waste water treatment system for maximum performance at all times, and pump sludge from the treatment system on regular basis every three months.

- For solid waste management, the contractors are required to do as follows.

  - To provide containers for general waste, which move along the construction routes with the lids completely closed. The contractors must collect the waste generated in the construction area for disposal at the project office every day.
  - To provide containers for general waste from daily activities of the construction workers in the worker quarters. These containers will be used to collect the garbage generated daily. They will be distributed throughout the area and must be trash cans with

closed lids, separated for wet waste, dry waste, hazardous waste and recyclable waste.

- Contact municipality or Sub-district Administration Organization (SAO), with waste disposal system, which have been situated nearby to take the garbage for disposal every week.

(2) Measures for residents around the construction area of the elevated train stations and train lines

- **Safety measures for the road users and communities nearby**

- Construciton companies/contracors need to provide a construction zone sign within the distance of 50 – 100 m.

- Construciton companies/contracors need to supervise the drivers to comply strictly with the traffic rules.

- Construciton companies/contracors must have life and property insurance coverage for the 3rd party who have been suffered/harmful because of the project construction.

- **Prevention and mitigation measures for impact of environmental quality changes**

Construciton companies/contracors must comply strictly with the environmental impact prevention and mitigation measures on air quality, noise, vibration, surface water quality and transportation in order to prevent and mitigate the impacts of the project implementation activities that will result in the deterioration of environmental factors as aforesaid, which may later affect the health of the public and workers.

(2) Operation Phase

(a) Encourage the general public and the drivers of personal vehicles to use more the mass transit system in order to reduce the air pollution and the noise level problems.

(b) The drivers of personal vehicles or the passengers of the mass transit system of other types who travel through the existing road networks, especially the area under the train stations must strictly comply with the traffic rules to reduce potential accidents.

(c) Public relations through such media as notice boards, brochures, newspapers, radio, websites, television, etc., and provision of knowledge and understandings to the general public and the non-users of the mass transit system to be aware of importance and potential dangers of the air pollution caused by the vehicles and to avoid direct exposure to the air pollution as well as to seriously take care of one’s hygiene and health.

(d) Preparation of a management plan for safety and occupational health in accordance with the international standard by providing testing and drills of emergency action plan for security in worse case scenarios, at least 2 times/year, such as a fire on the train stations/ground floor/concourse/platform floor, passengers evacuation out of the trains/train stations, emergency stop of the trains, provision of assistance to passengers during the evacuation/train derailment accident and so on.

(e) Provision of a vertical red line to indicate no-intrusion zone while the train is running alongside the platforms. In connection with this, the platform surface should be rough so that passengers can feel.

(f) Requirement for life and property insurance for the passengers and the 3rd party

Coordination cooperation with organizations concerned with security, which are located along the mass transit system and surrounding areas of the Depot and Park&Ride Building, such as police stations, hospitals, or disaster relief units, etc. by providing installation of coordination system and advanced communications system that can notify the emergency and transport assisting devices to the scene at once.

7.5.4 Aesthetics

(1) Pre-construction Phase

(a) The design process must be conducted as follows.

- In detailed design of the train stations, it needs to use the urban design principles, which emphasize public space and lightness in harmony with the existing environment, with modern form of engineering and architecture, but simplicity, to help reduce the effect and enhance scenery of the train stations to be more appropriate. Nevertheless, in detailed design of architecture and landscape architecture for each train station, it needs not to have the same characteristics, but may vary in agreement with the environment and the surrounding landscape at each location of the train stations in order to get the unique train station with beautiful appearance.
- Detailed design of columns and elevated structures must be in harmony with the existing environment or the scenery around. The column structures must be designed with a rounded, compact shape, well-ventilated, and with pole grooving to reduce the hardness.
- Using materials of soft tone or bright colors in order to make structures of the viaduct structure or the train stations in harmony with the environment and can reduce the hardness to the existing view around.

(2) Construction Phase

(a) Installation of solid fences of 2 m. high to define scope of the construction, with a sign of construction zone clearly shown. Also, to install a plate illustrating scenery of the mass transit project in the future to help reduce the impact on landscape in the construction area.

(b) Avoiding creating ugly or unsightly scenery within the construction area, such as allowing solid waste amount to overwhelm the garbage bins or placing objects or remaining construction materials into a mess or not covered with plastic or canvas, for instance. After completion of the construction of the mass transit, it needs to carry out the followings promptly.

- The planting of vines of medium – large types, such as *Artabotrys siamensis Miq., Bougainvillea* sp., *Bauhinia winitii Craib, Quisqualis indica L., Passsiflora x alatocaerulea Lindl.,Jasminum multiflorum (Burm. f.), Allamanda cathartica Linn.,* etc. in order to enhance the scenery and reduce the hardness of the piers of the viaduct structures or the train stations.

- Extension of green areas or small gardens inside the train stations or along the mass transit system to enhance the scenery or lower the hardness of the structural views. Meanwhile, small green gardens will bring about eye comfort enabling a quick adaptation in perception of the scenery that has changed from the original environment. It is designated to plant small shrubs, such as *Cassia surattensis Burm.f., Tecoma stans (L.) Kunth, Aglaia adorata Lour., Duranta repens L., and Melodorum fruticosum Lour, etc.*, or to build pergolas, which are made of wood, steel, or other materials to allow the climbing of medium-large vines, such as *Artabotrys siamensis Miq., Quisqualis indica L, Bauhinia winitii Craib, Allamanda cathartica Linn., Passsiflora x alatocaerulea Lindl and Jasminum multiflorum (Burm. f.), etc.*, for instance.

(3) Operation Phase

None