4.0 AIR QUALITY IMPACT ASSESSMENT

4.1 Introduction

In this chapter, the air quality impacts during the construction and operation phases of the proposed Lei Yue Mun Road Underpass and associated work will be assessed. Dust is the major potential impact during construction phase, and vehicle emission is the key air quality concern during operation phase of the Project. Air quality inside the underpass will also be evaluated.

4.2 Environmental Legislation, Policies, Standards & Criteria

Air Quality Objectives

The criteria and guideline for air quality assessment are laid out in Annex 4 and Annex 12 of the *Technical Memorandum on Environmental Impact Assessment Process (EIAO-TM)*, respectively.

The Air Pollution Control Ordinance (APCO) provides the statutory authority for controlling air pollutants from a variety of sources. The ordinance encompasses a number of Air Quality Objectives (AQOs) which stipulate maximum concentrations for a range of pollutants, of which Carbon Monoxide (CO), Nitrogen Dioxide (NO_2), Respirable and Total Suspended Particulates (RSP & TSP) and Sulphur Dioxide (SO_2) are relevant to this study. The relevant AQOs are listed in the following table.

Table 4.1 Hong Kong Air Quality Objectives

Parameter	Maximum Average Concentration (μgm^{-3})[1]			
	1-Hour[2]	8-Hour[3]	24-Hour[3]	Annual[4]
CO	30,000	10,000	-----	-----
NO_2	300	-----	150	80
RSP	-----	-----	180	55
SO_2	800	-----	350	80
TSP	500[5]	-----	260	80

1 Measured at 298 K and 101.325 kPa.
2 Not to be exceeded more than three times per year.
3 Not to be exceeded more than once per year.
4 Arithmetic mean.

The EIAO-TM also stipulated that the hourly TSP level should not exceed 500 μgm^{-3} TSP (measured at 25°C and one atmosphere) for construction dust impact assessment. Mitigation measures from construction sites have been specified in the Air Pollution Control (Construction Dust) Regulation.

In addition, according to the EPD's *Practice Note on Control of Air Pollution in Vehicle Tunnels 1995*, the criteria for tunnel quality are presented in Table 4.2.

Table 4.2 Tunnel Air Quality Criteria

Parameter	Maximum Concentration[1, 2]	
CO	115,000 μgm^{-3}	100 ppm
NO_2	1,800 μgm^{-3}	1 ppm
SO_2	1,000 μgm^{-3}	0.4ppm

1 Averaging time is 5 minutes
2 Measured at 298 K and 101.325 kPa.

According to the EPD's Practice Note on Control of Air Pollution in Vehicle Tunnels, the visibility in tunnel should be controlled to a level equivalent to an extinction coefficient of 0.005 per metre or less during any 5-minute interval.

4.3 Description of the Environment

Baseline Condition

In view of the heavy traffic on Eastern Harbour Crossing and Lei Yue Mun Road, vehicular emissions would be the major air quality impacts to the air sensitive receivers (ASRs) along Lei Yue Mun Road. High concentration of air pollutants, such as NO_2 and RSP are expected.

The current redevelopment of Yau Tong Estate and EHC housing site would generate considerable amount of dust. However, future dust levels are expected to diminish with the completion of the major construction works. Hence, no cumulative dust impact is anticipated during the construction of the Lei Yue Mun Road Underpass.

The air quality monitoring data at the Kwun Tong EPD monitoring station, which is the nearest station to the Lei Yue Mun Road Underpass, have been used as the baseline data for the air quality impact assessment. The annual averages of pollutants for the year 1997 at the Kwun Tong monitoring station are presented in Table 4.3.

Table 4.3 Background Air Quality

Parameter	Annual Average Concentration (μgm^{-3})
NO	81
NO_2	74
RSP	59
SO_2	16
TSP	93
O_3	17

Air Sensitive Receivers

Eleven representative air sensitive receivers (ASRs) have been identified according to the criteria set out in the EIAO-TM. The designated representative ASRs include schools, existing and planned residential developments, open space and sitting-out area located along Lei Yue Mun Road. A description of the ASRs is summarized in Table 4.4. Locations of the ASRs are shown in Figure 4.1.

Table 4.4 Description of Air Sensitive Receivers (ASRs) during Construction and Operation Phases

ASRs	Description	Approximate Horizontal Distance from the Kerb of Lei Yue Mun Road (m)	Sensitive Receiver Levels (mAG)	
			G/F or 1/F	5/F
A1	Block 9, Sceneway Garden	50	19.5	30.7
A2	Block 8, Sceneway Garden	40	19.5	30.7
A3	SKH Kei Hau Secondary School	20	1.5	15.7
A4	Ping Shun House	148	4.5	15.7
A5	Rest Garden	26	1.5	—[1]
A6	Sin Fat Road Tennis Court	100	1.5	—[1]
A7	Lam Tin Ambulance Depot	6	10.5	21.7
A8	St. Antonius Primary School	24	1.5	15.7
A9	Playground near Ko Chiu Road	10	1.5	—[1]
A10	Yau Tong Estate Redevelopment	10	18.5	29.7
A11	EHC housing site	46	4.5	15.7

[1] For the recreational areas, no sensitive receiver is expected at higher levels.

In order to reflect the reality, first sensitive receiver level (G/F or 1/F) has been used in the assessment. The 5/F level was also selected to show the vertical variation of the pollutant concentrations.

4.4 Description of Assessment Methodologies

Construction Phase

A number of dusty construction activities is expected during the construction of the Project and they include:

- excavation;
- slope works; and
- road work.

Fugitive Dust Model (FDM) was used to assess the potential dust impacts from construction activities. Prediction of dust emissions was modelled based on emission factors from the *USEPA Compilation of Air Pollution Emission Factors (AP-42), 5th Edition*. For a conservative simulation, general construction activities (which include bulldozing, grading, loading and unloading of materials and plant vehicles travelling on unpaved site roads) and wind erosion of open sites were considered the major dust emission sources from the construction works in this study.

Table 4.5 lists the dust emission factors adopted in this assessment. Detailed calculations of the emission factors are given in Appendix 4.1.

Table 4.5 Dust Emission Factors used in this Assessment

Activities	Emission Rate
General construction activities	2.69 mg/hectare/month*
Wind erosion of open site	0.85 mg/hectare/year**

* Source: AP-42, 5th ed., Section 13.2.3.
** Source: AP-42, 5th ed., Table 11.9.4.

Since the works area is quite lengthy, the whole site will not be actively worked at any one time. Taking into account the horizontal extent of the construction site, it was assumed that a maximum of 50 percent of the construction site area would be actively operated at any one time during the construction period.

Hourly average and 24-hour average TSP concentrations were predicted at the designated air sensitive receivers. As a worst-case scenario, 12-hour working day was assumed.

The dispersion modelling was undertaken using 288 predefined separate meteorological conditions. The following meteorological conditions have been assumed in the modelling:

Wind speed	:	1 m/s and 2 m/s
Wind direction	:	worst case
Resolution	:	5°
Stability class	:	B & D (day time) or D & F (night time)
Surface roughness	:	1 m
Mixing height	:	500 m

The annual average TSP concentration for the year 1997 as measured at EPD's Kwun Tong monitoring station was 93 μgm^{-3}. For the purpose of this assessment, this value has been used as the background TSP concentration.

A sample output file of the FDM model run, which includes all the input parameters for this assessment, is included in Appendix 4.2.

Operation Phase

Line Source Dispersion Model

The US EPA CALINE4 model, which is based on the Gaussian diffusion equation to characterise pollutant dispersion over the roadway, has been used to model air quality at the air sensitive receivers. As air pollutants of prime concern from vehicle emissions are Nitrogen Dioxide (NO_2) and Respirable Suspended Particulate (RSP), the model has been employed to predict 1-hour and 24-hour concentrations of these two parameters.

The EPD's Fleet Average Emission Factor (EURO3) contains emission factors for various types of vehicles in different years of operation. Sensitivity tests were conducted for the projected traffic flows between 2007 and 2022, and the results indicated that the worst scenario in terms of air pollution from vehicle emissions is found in year 2007. Projected 2007 morning peak hour traffic flows and vehicle composition of the roads are shown in Figure 4.2. A comparison of the combined effects of traffic flow and emission factors for years 2007 and 2022 are shown in Appendix 4.3. Detailed calculations of the composite emission factors for each road link in year 2007 are given in Appendix 4.4.

Discrete Parcel Method (i.e. NO_2 option) was used to predict NO_2 concentration for daytime period, and Ambient Ratio Method is considered more appropriate to predict the NO_2 concentration for nighttime. For the calculation of RSP concentration, the particulate option was used in the CALINE4.

Peak hour traffic flow of the study area will occur during daytime. With reference to the *Annual Traffic Census 1997*, the lowest PM hour traffic flow is generally around 1/7 of AM peak hour traffic flow. The highest predicted hourly concentration between daytime and nighttime is assumed to be the maximum 1-hour average concentration. With reference to the Screening Procedures for Estimating the Air Quality Impact of Stationary Source (EPA-454/R-92-019), a conversion factor of 0.4 is used to convert the 1-hour average concentrations to 24-hour average concentrations.

The following summarizes the meteorological conditions adopted in the air quality modelling using the CALINE4 model:

- Wind speed : 1 m/s
- Wind direction : worst case
- Wind variability : 24° (day time) or 6° (night time)
- Stability class : D (day time) or F (night time)
- Surface roughness : 1 m
- Mixing height : 500 m
- Ozone concentration : 62 μgm^{-3} *
- Photodissociation rate : 0.004 s^{-1}

* This ozone concentration is extracted from the draft modelling guidelines for the urban area provided by EPD.

Portal emissions from the underpass and the deck-over of Sceneway Garden were modelled in accordance with the *Permanent International Association of Road Congress Report* (PIARC, 1991). The volume of pollutants was assumed to eject from the portal as a portal jet such that 2/3 of the total emissions was dispersed within the first 50m of the portal and 1/3 of the total emissions within the second 50m. In the case where the dispersion area is less than 50m in length (i.e. the opening between the two underpass sections), the portal emission was assumed to disperse evenly within the section.

Potential air quality impacts from implementation of proposed roadside noise mitigation measures were incorporated into the air quality model. The proposed noise mitigation measures include cantilevered noise barrier, noise semi-enclosures and noise canopies.

With the installation of cantilevered noise barriers and noise semi-enclosures, the source of emissions was adjusted by shifting the road section by a distance equal to the width of the road section covered by the noise semi-enclosures. In the air quality model, the road type was set to 'fill' and the relative height was set to the height of the enclosures. For the proposed noise canopies in this study, since there is only supporting structures located on the roadsides, the traffic pollutants can disperse through both sides of the enclosures. In the model, the source of the emissions was assumed to be evenly distributed on both sides of the noise canopies and the relative height was set to the height of the canopies.

As mentioned in Section 4.3, the background concentrations for NO_2 and RSP were taken as 74 μgm^{-3} and 59 μgm^{-3}, respectively, which were added to the corresponding predicted concentrations.

Appendix 4.5 provides computer output files from the CALINE4 model generated for the vehicle emissions impact assessment.

Tunnel Air Quality Model

The one-way Lei Yue Mun Road Underpass consists of two sections of about 48m and just less than 230m long. The air quality inside the two sections of the underpass will be modelled as a tunnel since it confines air pollutants in the space underneath the underpass with longitudinal transport of pollutants. A conversion factor of 12.5% including tailpipe NO_2 emission (taken as 7.5% of NO_x) plus 5% of NO_2/NO_x for tunnel air recommended in PIARC for air expelled from the tunnel was taken in this assessment as the inside underpass conversion factor. Two scenarios were considered for the underpass, i.e. normal traffic flow condition and congested traffic flow condition. Appendices 4.6a and 4.6b show the detailed calculation of the inside tunnel air quality assessments for the two sections of the underpass, which also include the air quality impact after the implementation of the proposed noise mitigation measures.

The ratio of guideline standard of CO (5-minutes) concentration to NO_2 (5-minutes) concentration in μgm^{-3} is 64 to 1, however, the emission rate of CO is less than 64 times NO_2 emission rate. Therefore, CO would comply with the tunnel air quality limit if NO_2 concentration is shown to comply with the standard. Under the Air Pollution Control (Motor Vehicle Fuel) Regulation, the sulphur content of diesel fuel is required to be less than 0.05%. In view of the low emission rates and the high statutory limit, SO_2 would also comply with the tunnel air quality limit.

4.5 Identification, Prediction and Evaluation of Air Quality Impacts

Construction Phase

Unmitigated Scenario

Without any dust suppression measures, the predicted maximum 1-hour average and 24-hour average TSP concentrations at the representative ASRs are tabulated in Table 4.6.

Table 4.6 Predicted 1-hour Average and 24-hour Average TSP Concentrations at the Representative ASRs (Unmitigated)

ASRs	1-Hour Average TSP Concentrations (μgm^{-3})* At Various Levels		24-Hour Average TSP Concentrations (μgm^{-3})* At Various Levels	
	G/F or 1/F	5/F	G/F or 1/F	5/F
A1	148	121	121	107
A2	160	125	127	109
A3	403	182	257	138
A4	258	168	179	131
A5	**533**	—[1]	**324**	—[1]
A6	204	—[1]	151	—[1]
A7	467	465	**285**	**284**
A8	281	231	193	164
A9	388	—[1]	249	—[1]
A10	148	125	121	110
A11	278	200	190	148

Value in bold type indicates that the TSP concentration exceeds the HKAQO or the guideline level of 500 μgm^{-3}.

* Background TSP concentration of 93 μgm^{-3} is included.

[1] For the recreational areas, no sensitive receiver is expected at higher levels.

From the results, it is found that some of representative ASRs are predicted to exceed the guideline level and AQO limit. The highest predicted 1-hour and 24-hour average TSP concentrations are 533 μgm^{-3} and 324 μgm^{-3} at ASR A5 (Rest Garden adjacent to Lei Yue Mun Road Roundabout). Since exceedances of both TSP guideline level and AQO limit are predicted, dust suppression measures will be required.

The predicted 1-hour average and 24-hour average TSP concentration contours at 1.5m above local ground are shown in Figures 4.3 and 4.4.

Mitigated Scenario

According to AP-42, 4th edition, Section 11.2.4, a 50 percent reduction of the dust generated from wind erosion and general construction activities could be achieved with watering of the site areas with complete coverage twice a day.

Calculations of the dust emissions after dust suppressions are given in Appendix 4.1. The following table lists the predicted TSP concentrations after implementation of the above mentioned dust suppression measures.

Table 4.7 Predicted 1-hour Average and 24-hour Average TSP Concentrations at the Representative ASRs (Mitigated)

ASRs	1-Hour Average TSP Concentrations (μgm^{-3})* At Various Levels		24-Hour Average TSP Concentrations (μgm^{-3})* At Various Levels	
	G/F or 1/F	5/F	G/F or 1/F	5/F
A1	121	107	107	100
A2	126	109	111	101
A3	248	137	180	116
A4	176	130	138	113
A5	313	—[1]	214	—[1]
A6	148	—[1]	124	—[1]
A7	280	279	191	191
A8	187	162	146	129
A9	240	—[1]	175	—[1]
A10	121	109	108	101
A11	185	146	143	121

* Background TSP concentration of 93 μgm^{-3} is included.

[1] For the recreational areas, no sensitive receiver is expected at higher levels.

Figures 4.5 and 4.6 show contours of 1-hour average and 24-hour average TSP concentrations at 1.5 m above ground. With the implementation of the proposed mitigation measures, dust emission would be suppressed and dust levels at ASRs are expected to be within the 1-hour and 24-hour average TSP guideline level and AQO limit.

In conclusion, the implementation of the proposed mitigation measures is required throughout the construction phase in order to minimize the adverse dust nuisance to the nearest ASRs. To further ensure compliance with the AQOs at the ASRs at all time, requirements of the *Air Pollution Control (Construction Dust) Regulation* shall be adhered to during the construction period. In addition, good site practices and a comprehensive dust monitoring and audit programme are recommended to minimize cumulative dust impacts.

Operation Phase

Open Roads Air Quality (Without the proposed noise barriers)

Having considered the open roads emissions and the effect of portal emissions from the underpass and the deck-over of Sceneway Garden, the predicted maximum 1-hour average NO_2, 24-hour average NO_2 and RSP concentrations for the representative ASRs have been evaluated and are summarized in Table 4.8. The predicted hourly average NO_2, 24-hour average NO_2 and RSP concentration contours at 1.5m above local ground are shown in Figures 4.7 to 4.9.

Table 4.8 Predicted 1-hour Average NO_2, 24-hour Average NO_2 and RSP Concentrations at the Representative ASRs (Without the proposed noise barriers)

ASRs	1-Hour Average NO_2 Concentrations (μgm^{-3})* At Various Levels		24-Hour Average NO_2 Concentrations (μgm^{-3})* At Various Levels		24-Hour Average RSP Concentrations (μgm^{-3})* At Various Levels	
	G/F or 1/F	5/F	G/F or 1/F	5/F	G/F or 1/F	5/F
A1	161	128	109	96	81	72
A2	172	142	113	101	80	73
A3	167	131	111	97	77	70
A4	153	137	106	99	72	70
A5	210	—[1]	128	—[1]	83	—[1]
A6	153	—[1]	106	—[1]	74	—[1]
A7	203	170	126	112	88	82
A8	163	137	110	99	76	71
A9	201	—[1]	125	—[1]	78	—[1]
A10	122	110	93	88	67	65
A11	170	164	112	110	80	79

* Background NO_2 concentration of 74 μgm^{-3} and RSP concentration of 59 μgm^{-3} are included.

1 For the recreational areas, no sensitive receiver is expected at higher levels.

As shown in the above table, the predicted 1-hour concentrations of NO_2 range between 122-210 μgm^{-3}; 24-hour concentration of NO_2 range between 93-128 μgm^{-3} and 24-hour RSP range between 67-88 μgm^{-3} at the first sensitive receiver level (G/F or 1/F).

In Figures 4.7 to 4.9, ASRs A1 and A2 are shown to exceed the AQO limits. However, the ground levels of these ASRs are podium which are not considered as air sensitive uses. Therefore, no sensitive use at 1.5m above ground is expected in the predicted AQO exceedances areas.

In summary, all the pollutant concentrations are predicted to meet the relevant AQO limits at the air sensitive areas, and no mitigation measure is required.

Open Roads Air Quality (With the proposed roadside noise mitigation scheme)

With the implementation of proposed roadside noise mitigation scheme, the pollutants tend to disperse at a higher elevation above the noise barrier. In addition, portal emissions from the semi-enclosure in front of the At. Antonius Girls' College would also affect the ASRs. The predicted maximum 1-hour average NO_2, 24-hour average NO_2 and RSP concentrations for the ASRs, with the proposed roadside mitigation scheme, have been evaluated and are summarized in Table 4.9. The predicted maximum 1-hour average NO_2, 24-hour average NO_2 and RSP concentration contours at 1.5m above local ground are shown in Figures 4.10 to 4.12.

Table 4.9 Predicted 1-hour Average NO_2, 24-hour Average NO_2 and RSP Concentrations at the Representative ASRs (With the proposed noise barriers)

ASRs	1-Hour Average NO_2 Concentrations (μgm^{-3})* At Various Levels		24-Hour Average NO_2 Concentrations (μgm^{-3})* At Various Levels		24-Hour Average RSP Concentrations (μgm^{-3})* At Various Levels	
	G/F or 1/F	5/F	G/F or 1/F	5/F	G/F or 1/F	5/F
A1	162	129	109	96	81	72
A2	173	143	114	101	80	73
A3	168	132	112	97	77	70
A4	153	137	106	99	72	70
A5	210	—[1]	129	—[1]	83	—[1]
A6	153	—[1]	106	—[1]	73	—[1]
A7	203	170	126	112	88	82
A8	166	140	111	100	75	71
A9	181	—[1]	117	—[1]	76	—[1]
A10	124	111	94	89	67	65
A11	170	164	112	110	80	79

* Background NO_2 concentration of 74 μgm^{-3} and RSP concentration of 59 μgm^{-3} are included.

1 For the recreational areas, no sensitive receiver is expected at higher levels.

Similar to the findings in the scenario without the proposed noise mitigation measures, the predicted pollutant concentrations at all of the ASRs are below the AQO limits.

Tunnel Air Quality

Underpass Section

For the air quality assessment inside the underpass, two scenarios have been considered. Results of the predicted maximum NO_2 concentrations inside the two sections of the underpass during normal traffic condition and congested traffic condition are presented in Table 4.10. The implementation of the proposed noise mitigation measures has also been considered.

Table 4.10 Predicted Maximum NO_2 Concentrations within the Two Sections of the Underpass

Underpass	Maximum NO_2 Concentration (μgm^{-3})*			
	Without proposed noise barriers		With proposed noise barriers	
	Normal Condition	Worst Condition	Normal Condition	Worst Condition
Long Section (just < 230m)	451	520	451	520
Short Section (~ 48m)	539	695	539	695

- Background concentration is included.

As shown in Table 4.9, the maximum NO_2 concentration inside the two sections of the underpass is below the guideline level of 1,800 μgm^{-3}. Hence, no adverse air quality is anticipated inside the underpass.

From the results, it is also noted that the NO_2 concentration inside the short section of the underpass is higher than that inside the long section. This is mainly due to the higher pollutant concentration in the vicinity of the sort section of the underpass resulted from the nearby portal emissions underneath the podium of the Sceneway Garden.

Semi-enclosure in front of the St. Antonius Girls' College

Air quality inside the semi-enclosure in front of the St. Antonius Girls' College has been assessed. The semi-enclosure was considered as a completely enclosed tunnel as a worst case scenario. Both the scenarios of normal traffic condition and congested traffic condition for the semi-enclosure have been assessed and are presented in Table 4.11.

Maximum NO_2 Concentration (μgm^{-3})*	
Normal Condition	Worst Condition
291	315

* Background concentration is included.

Table 4.11 shows that the maximum NO_2 concentration inside the semi-enclosure is well within the guideline level of 1,800 μgm^{-3}, and adverse tunnel air quality is therefore not expected.

4.6 Environmental Monitoring and Audit

Construction Phase

In view of the close proximity of the works area to the ASRs, a comprehensive dust monitoring and audit program has been recommended to verify the implementation and effectiveness of the proposed measures. 1-hour and 24-hour TSP levels should be measured to indicate the impacts of construction dust on local air quality. The air quality monitoring location is proposed at the Lam Tin Ambulance Depot and SKH Kei Hau Secondary School as shown in Figure 4.13. Details of the monitoring requirements such as frequency of baseline and impact monitoring are presented in the EM&A Manual.

Operation Phase

As mentioned in Section 4.5, no exceedance of AQOs would be expected at all sensitive areas. Thus, no environmental monitoring and audit is required during operation phase.