3 AIR QUALITY IMPACT STUDY

3.1 Introduction

3.1.1 The purpose of this section is to investigate the extent of operational air quality impacts from existing and future pollution sources associated with the Project. The impacts from traffic emissions are assessed based on the available traffic data. Construction phase air quality impacts are covered in Section 7.

3.1.2 Air quality impacts and predicted future pollutant concentrations at the air sensitive receivers (ASRs) are assessed based on emission sources associated with R9. Appropriate new and existing road sections for the purpose of traffic impact assessment have been included. At present it is not expected that existing road sections will undergo major modification. The broad assumptions, which have been made, are presented in the text.

3.1.3 Existing and future planned land uses have been presented in Chapter 10 to identify receptors in the study area potentially affected by emissions from the construction and operation of the Project. Background air pollution levels at the Study Area are established for assessment of cumulative air impacts and used in the assessment of construction and operational impacts.

3.1.4 Net and cumulative air pollution impacts of the Project to receptors have been assessed by dispersion modelling. A detailed methodology and key assumptions of selected models, including emission factors and other input parameters has been presented to for comment at the IAR stage. Whereas the modelling suites at IAR stage were reasonably straightforward, the complex terrain at the tunnel portals and nearby viaduct sections included in this EIA requires clarification. A combination of CALINE4 (traffic) and ISCST3 (volume sources) modelling has been used for the dispersion modelling. Air pollution isopleths are produced in Figures 3.1 to 3.9.

3.1.5 An assessment of the air quality implications of any proposed noise mitigation measures was included in the Study Brief. If noise mitigation in the form of total enclosures is proposed, both portal emissions and air quality inside enclosures need to be addressed.

3.2 Background Air Quality

3.2.1 In the vicinity of R9 there are numerous chimneys on the southern portion of Tsing Yi associated with several factories. Air quality is influenced by these chimneys and by vehicular emissions on the roads all over the Study Area. In addition, the dust levels in the vicinity are aggravated by the construction and demolition activities nearby. The container terminals, PCWAs, shipyards and godown / container handling yards are potential nuisances, but these are generally located well away from sensitive receivers. The main air pollution sources in the area therefore include but are not necessarily limited to the existing chimneys in the hinterland, other industrial sources, traffic on roads and construction work.

3.2.2 The Study Area covers several district areas including Tsing Yi Island, Stonecutters Island, West Kowloon Reclamation etc. Variation of air quality is experienced in different parts of the Study Area due to the geographical differences and adjacent land-uses. In order to monitor the quality of the air over Hong Kong, the Environmental Protection Department (EPD) is currently operating nine fixed measuring stations for

gaseous and particulate pollutants. The closest EPD station to the Study Area is at Sham Shui Po which is located a few kilometres away.

3.2.3 Whereas some other local monitoring data is available the data suite was gathered in 1988 and at this stage these are no longer considered relevant due to the relocation of numerous air pollution sources away from the Tsing Yi area. At this stage it is intended that data from the nearest permanent air quality monitoring station will be used to reflect the likely air conditions. The measured annual average of major pollutants at Sham Shui Po station in 1996 are tabulated in Table 3.1.

Table 3.1 : 1996 Measured Pollutant Levels at Sham Shui Po Station

Pollutant	Measured Level, µg/m
Sulphur Dioxide (SO_2)	20
Nitrogen Dioxide (NO_2)	70
Carbon Monoxide (CO)	Unavailable
Total Suspended Particulates (TSP)	95

3.2.4 In order to take into account the background air pollutant levels, the above measured data has been used in the air quality predictions.

3.3 Legislation and Air Quality Criteria

3.3.1 Major component air pollutants from industrial sources, traffic and construction work include SO_2, NO_2 and particulates respectively. An assessment of air quality over the whole of the R9 area has been undertaken using emissions and motor vehicle data to determine whether the air quality in the vicinity of SRs will meet Air Quality Objectives (AQOs) for NO_2 and SO_2. Hong Kong AQOs for SO_2, NO_2 and Respirable Suspended Particulates (RSP) are given in Table 3.2.

3.3.2 The Air Pollution Control Ordinance (APCO) is the principal legislative tool to manage the air quality over Hong Kong. Under the APCO, AQOs for seven major air pollutants were established in 1987 and apply to the whole territory. In addition, a non-statutory hourly TSP concentration of 500 µg/m^3, as recommended by EPD are used for construction dust impact assessment.

Table 3.2 : Air Quality Objectives

Pollutant	Concentration in mg/m [(a)]				
	Averaging Time				
	1 hour [(b)]	8 hours [(c)]	24 hours [(c)]	3 months [(d)]	1 year [(d)]
SO_2	800		350		80
TSP	500 [(g)]		260		80
RSP [(e)]			180		55
NO_2	300		150		80
CO	30,000	10,000			
O_3 [(f)]	240				
Pb				1.5	

Note : (a) Measured at 298K (25oC) and 101.325 kPa (one atmosphere).

(b) Not to be exceeded more than three times per year.

(c) Not to be exceeded more than once per year.

(d) Arithmetic means.

(e) Respirable suspended particulates means suspended particulates in air with a nominal aerodynamic

diameter of 10 micrometers or smaller.

(f) Photochemical oxidants are determined by measurement of ozone only.

(g) EPD recommended guideline for construction dust assessment

3.4 Air Sensitive Receivers

3.4.1 Domestic premises, hospitals, clinics, nurseries, temporary housing accommodation, schools, educational institutions, offices, factories, shops, shopping centres, places of public worship, libraries, courts of law, sports stadia or performing arts centres are all considered to be ASRs.

3.4.2 In order to facilitate this air quality assessment, the study area has been sub-divided into five sensitive zones which are defined by the geographical position and the location of sensitive receivers. In each sensitive zone, existing and planned ASRs have been identified with regard to site observations and Outline Zoning Plans. Following the guidelines, a list of ASRs within the Study Area has been compiled and is shown in Table 3.3. All existing ASRs are subject to air pollution nuisances at both operational and construction stages (Section 7). Planned ASRs are also assumed to be vulnerable to the operational impacts.

Table 3.3 : Existing and Planned Air Sensitive Receivers

Sensitive Zone	Nature	Sensitive Receivers	Horizontal Distance	Elevation
Lai Wan Interchange	Existing Residential	Mei Foo Sun Chuen	~ 200 m	Overlooking the Route 9 alignment
	Future Residential	Planned residential development in Site 10 at WKR	~ 95 m	Overlooking the Route 9 alignment
	Future G/IC	Stadium *	~ 50 m	Overlooking the Route 9 alignment
	Future Residential	Planned residential development in Site 6 at WKR	~ 65 m	Overlooking the Route 9 alignment
Stonecutters Island Zone	Existing Residential or Barracks	Several isolated building scattering on the northern slope of the stonecutters Island	~ 80 m	~ 57 m below the viaduct
Eastern Tunnel Portal Zone	Existing factories or office buildings	Adjacent Areas underneath the eastern portal of Nam Wan Tunnel (such as Dow Chemicals, Factory Building)	Immediately adjacent to and below the viaduct	~ 43 m below the viaduct
CT9 Terminal Zone	Existing educational institution	Technical College (Tsing Yi)	~ 68 m	Overlooking the Route 9 slip road to CT9
	Existing Residential	Mayfair Garden consisting of 8 residential blocks	~ 200 m	Overlooking the Route 9 slip road to CT9
	Future and container-related industry	Area to be developed into container-related building and a potential site for commercial development	~ 40 m	Overlooking the Route 9 slip road to CT9
Western Tunnel Portal Zone	Existing industrial uses	Adjacent Areas near west portal of Nam Wan Tunnel including office building at Caltex, Highways and Maintenance Yard	~ 75 m	~ 20 m below the viaduct
	Future industrial uses	Immediately areas underneath the west portal of Nam Wan Tunnel planned for industrial uses	~ 10m	To be planned

Note : CT9 denotes Container Terminal No. 9

Tentative landuse proposal only

3.5 Air Quality Modelling

Major Air Quality Concerns

3.5.1 Traffic emissions are the key environmental issue to be addressed. The purpose of this element of the assessment is to quantify the likely air quality impact on the existing ASRs and recommend suitable mitigation measures. For the future ASRs, appropriate recommendations will be provided to guide on the planning of future landuses in the vicinity of the Route 9, particularly in Lai Wan Interchange Zone.

Methodology

3.5.2 Likely impacts were assessed using the air dispersion model, CALINE4 and the several assumptions have been made in establishing the computer model. Past project experience suggests that nitrogen dioxide (NO_2) is the pollutant of major concern and detailed modelling has been undertaken for atmospheric emissions of NO_2 from traffic.

3.5.3 Detailed modelled data were provided for the years 2006 and 2011. The traffic data were further reviewed and it was established that by 2021 peak hour flows would be at capacity on Route 9. Therefore data for the year 2021 were used as represent worst-case scenario for assessment purposes. The data for use in the EIA were agreed with Transport Department.

Emission Factors

3.5.4 The composite emission factors for traffic on different sections of roads were estimated from the latest Euro III fleet averaged emission factors as issued by EPD. It is assumed that the NO_x emission factors for goods vehicles and non-goods vehicle are 3.84 g/km/veh and 0.71 g/km/veh respectively for Year 2021 (assumed to be the same as the on 2011 emissions factors). It should be noted that through implementation of emission controls, the emission factors may be expected to reduced, however, no data are available to substantiate any decrease. The NO_2 concentrations have been taken as 20 percent of the total NO_x concentration.

Meteorology

3.5.5 Typical worst-case meteorological conditions were assumed as follows:-

Wind direction	:	Worst-case selected by model
Wind speed	:	1 m/s
Directional variability	:	18 ^{o}
Stability class	:	D
Mixing height	:	500 m
Temperature	:	25 ^{o}C

Modelling

3.5.6 Vehicle emissions from traffic on the proposed alignment of Route 9 are the sources of the air pollution. Therefore the geometry of the road alignment is definitely a contributing factor to determine the air quality. For the Project, almost all of the traffic routes of Route 9 are on high viaduct structures or bridge structures at higher levels above the ASRs than would normally be the case for this type of urban air quality impact assessment.

3.5.7 CALINE4 model is able to accommodate line sources such as bridges but the source height is limited up to 10 m above the local ground level. To overcome this limitation, the height of traffic links on viaduct or bridge was set to 10 m. However in practice is clear that much more potential dispersion is likely to occur due to the height of the viaducts. Thus the modelling is generally likely to reflect a conservative estimate of the worst case scenario, due to the modelling limitations.

3.6 Operational Air Quality Impact - Nam Wan Tunnel

3.6.1 Modelling has been undertaken for atmospheric emissions from the portal of the tunnel. The analysis was undertaken to determine the likely contravention of AQOs across the Eastern and Western Tunnel Portal Zones). Modelling results are presented in terms of pollution contours (isopleths) or in table format and the associated implication are discussed in the following paragraphs.

Modelling Assumptions

3.6.2 Due to the proximity to the portals of Nam Wan Tunnel, the air quality in the Eastern Tunnel Portal Zone and Western Tunnel Portal Zone are required to be assessed to ascertain the cumulative effect arising from traffic emissions and tunnel portal emissions. Section 3.7 discusses the results for sensitive receivers in other zones along the alignment.

3.6.3 The Nam Wan Tunnel will be approximately 1.2 km long. Point emission sources are confined only to the tunnel portal as no vent shafts are proposed at this stage. The following assessment indicates the likely impact on the ASRs in the vicinity of the tunnel portal in order to determine whether the vent shafts are required during the operation phase.

3.6.4 The Preliminary Environmental Review (PER) raised air quality inside the tunnel and the vehicular emissions from the tunnel portals as significant concerns. The design methodology of the tunnel ventilation system will follow PIARC (1991) and advice from EPD on Control of Air Pollution in Vehicle Tunnels (November 1995). The proposed concentration limits are shown in Table 3.4.

Table 3.4 : Air Quality Guidelines for Vehicle Tunnels

	Air Pollutant	Averaging Time	Maximum Concentration	
			Micrograms Per Cubic Metre (µg/m3)*	Part Per Million (ppm)
(a)	Carbon monoxide	5 minutes	115,000	100
(b)	Nitrogen dioxide	5 minutes	1,800	1
(c)	Sulphur dioxide **	5 minutes	1,000	0.4

*Note : * Expressed at the reference condition of 298 K and 101.325 kPa*

*** Not used*

3.6.5 The traffic data provided by the traffic workstream indicates that the tunnel will carry up to approximately 9,000 vehicles per hour. Such high traffic flows combined with the length of the tunnel will require an efficient ventilation system with exhaust points such that the ambient and tunnel air quality standards are not exceeded. The air pollutants emitted inside the tunnel must be thoroughly vented.

3.6.6 The portal emissions which were calculated based on Year 2021 traffic with alternative free flowing and congested scenarios, are tabulated in Table 3.5. Since the NO_2 emissions are higher for the case of free flow traffic, the corresponding emission rates were used in the subsequent air quality modelling.

Table 3.5 : Tunnel Portal Emissions

Tunnel Portal	NO_2 emission (20% NO_2/NO_x)	
	Congested Traffic	Free Flow Traffic
East Exit Portal	0.91 g/s	1.12 g/s
West Exit Portal	0.56 g/s	0.79 g/s

3.6.7 Portal emissions were modelled for NO_2 using the US EPA ISCST3 (Version 2.2) model with the following assumptions.

- A jet length of 100m was assumed,
- Portal emissions were simulated as a series of volume sources,
- NO_2 modelling included hourly averages of NO_2 levels,
- Pollution contours were be produced,
- Typical worst-case meteorological conditions (refer 3.5.5) were assumed.

3.6.8 The traffic emissions from open road sections were simulated by CALINE4 model together with the typical worst-case meteorological conditions as stated in 3.5.5. The cumulative impacts on the ASRs were evaluated by summing up the predicted concentrations due to traffic emissions from open road sections and portal emissions. EPD background monitoring data (Table 3.1) were included to reflect existing pollutant level in the study area.

Western Tunnel Portal Zone

3.6.9 In this sensitive zone, the Route 9 alignment emerging from the western exit portal runs on viaducts under the Tsing Yi Road (west), over the vacant land designated for industrial uses and then joins the Cheung Ching Highway. The ASRs in this area include industrial buildings of about 3-4 storey high along the western coast of the Tsing Yi Island and are at an elevation of approximately 20m below the Route 9 viaduct.

3.6.10 Three scenarios were simulated to illustrate the likely air quality impacts in this study area. The first case as shown in Figure 3.1 depicts the air quality impacts associated with traffic emissions on open road sections alone. It can be seen that no breach of the AQOs would be anticipated. Neither do the portal emissions bring about any exceedance of the AQO (Figure 3.2). Figure 3.3 depicts the cumulative impacts arising from both open road and portal emissions. All of the existing ASRs will comply with the respective standards. However there is an area of influence at approximately 18m above and on either side of the Sai Tso Wan Road where the emissions exceed the AQO up to approximately 20%. The area is approximately 1.5ha.

3.6.11 There is no planning programme for the permanent use of these sites and Planning Department has indicated that it will consider the uses in greater detail after the alignment of R9 is finalised. If the future uses of these areas are restricted to non-ASR uses, the land use will not be in conflict with the road design and alignment as currently envisaged. If ASR uses are a priority for these areas then the current designs will need to be modified and possibly to include a dedicated traffic fume exhaust ventilation system to disperse the tunnel emissions to a higher level. If industrial open storage uses are selected, for these sites in line with other local uses, dispersion of traffic fumes will not be restricted and land use impacts will be minimised to a small area.

Eastern Tunnel Portal Zone

3.6.12 Air quality arising from traffic emissions only is acceptable as identified in Figure 3.4 and emissions do not exceed the AQO.

3.6.13 Air quality associated with both traffic emissions + portal emission (Figure 3.5) shows a minor exceedance above the area underneath the viaduct, which is used for a CLP substation and storage. The exceedance is detected at 18m above ground. There is no resident staff and this is not considered to be a sensitive use under the EIAO TM.

3.6.14 Vertical separation between ASR and viaduct is approximately 40m, which is significantly greater than that which can be simulated in the CALINE4 model. Such large vertical buffer would greatly enhance the dispersion of emissions in addition to that indicated at the boundaries of the model.

3.6.15 The cumulative effect is sum of the worst-case of open road traffic and worst-case of portal emission. The worst-case wind direction from the roads to SRs will not coincide with that for the portal emissions, therefore such cumulative concentrations are most unlikely to occur.

3.6.16 Through more stringent emission controls, the NO_2 emission rate would be further reduced by 2021. Therefore in reality the modelled worst-case situation is most unlikely to occur and given the predominance of non-sensitive uses in the small area of influence there does not appear to be a need to introduce dedicated tunnel exhaust ventilation

stacks given the present alignment and tunnel designs. The air quality impact is therefore not significant and no mitigation is required.

3.7 Operational Air Quality Impact Assessment along the Alignment

3.7.1 Modelling results are presented in terms of pollution contours or in table format and the associated implication are discussed in the following paragraphs.

CT9 Terminal Zone

3.7.2 This sensitive zone comprises existing ASRs at the Tsing Yi Technical College (TYTC), Mayfair Gardens and the planned future landuses (e.g. commercial accommodation associated with container-related facilities, Figure 1.3). Vehicular emissions mainly arise from the Tsing Yi Road and the CT9 slip road. The air dispersion modelling demonstrated that these ASRs would comply with the HKAQO standards. Figure 3.6 shows the NO_2 contours at 1.5 m above ground. Concentrations are less at higher elevations due to dispersion.

Stonecutters Island Zone

3.7.3 A total of six representatives ASRs have been identified on the northern side of Stonecutters Island. Figure 1.4 shows the location of the representative ASRs. Prediction of NO_2 levels were undertaken at these ASRs and are shown in Table 3.6.

3.7.4 The modelling results indicate that the NO_2 exposure levels at these ASRs range from 161 $\mu g/m^3$ to 205 $\mu g/m^3$ and would comply with the standard of 300 $\mu g/m^3$. As a result, the setback distance and the vertical separation of the viaduct from the ASRs are sufficient to dilute the traffic emission to avoid excessive adverse impact in the Stonecutters Island Zone.

Table 3.6 : Maximum Hourly NO_2 Concentration(Stonecutters Island Zone)

Sensitive Receptor	Receptor Height	Predicted NO2 Level, $\mu g/m^3$
SC1	40 m below viaduct	205
SC2	40 m below viaduct	203
SC3	30 m below viaduct	175
SC4	25 m below viaduct	159
SC5	25 m below viaduct	162
SC6	35 m below viaduct	161

Note : Predicted level has already included a conservative background level of 70 $\mu g/m^3$

Lai Wan Interchange Zone

3.7.5 Mei Foo Sun Chuen is included as the existing ASR area in this sensitive zone. Figure 3.7 shows the isopleths of NO_2 at 1.5m above ground. It can be seen that the worst affected ASRs were identified at the southern tip of Mei Foo Sun Chuen. The predicted NO_2 levels at this location are compliant with the AQO.

Site 10

3.7.6 Further to the east of Mei Foo Sun Chuen is Site 10, located on the northern part of the West Kowloon Reclamation. The development assumed for this assessment includes schools and residential blocks (Figure 1.5). Figure 3.8 illustrates that the resulting NO_2

levels at 1.5 m and 15m will comply with the 300 $\mu g/m^3$ AQO and there will be no constraints on the site.

Site 6

3.7.7 Site 6 comprises residential uses and a primary school development, which were assumed for assessment purposes. These ASRs are predominantly affected by the traffic emissions from the WKH with a relatively small contribution from the Route 9 slip road. The NO_2 contour of 300 $\mu g/m^3$ as illustrated in Figure 3.8 at 1.5m above ground indicates a constraint on the site, with approximately 25m of the southern section non-compliant with the AQO. At 15m above ground, there is compliance with the AQO.

3.7.8 Without details for the location, layout and design of the stadium, it is not possible to state the impacts. However, analysis for the Mei Foo area indicates that dispersion of traffic emissions from the existing roads and the new elevated sections of Route 9 would not result in exceedances of the AQO over the Regional Stadium site. In general terms, in order to minimise impacts; the stadium should be designed to maximise the setback from Lai Wan Interchange Route 9, Route 16 and the WKH. The high stands would prevent a direct route for traffic pollutants, thus increasing dispersion. Intermittent use would reduce the probability of exposing patrons to adverse air quality when worst case meteorological conditions prevail (although no exceedances of the AQOs are expected).

3.8 Summary

3.8.1 As a dual-three lane trunk road, linking several other major trunk roads such as R16, R3 and WKH, R9 is expected to carry high traffic flows of over 8000 vehicles/hour under the worst-case scenario. The proposed alignment and the 1.2 km twin tube Nam Wan Tunnel would be expected to give rise to significant quantities of traffic emissions. However, the open road sections are elevated or on viaducts for much of the alignment, which will help to dissipate and disperse emissions such that concentrations of pollutants will not accumulate at sensitive receivers to levels which would exceed the AQOs.

3.8.2 Modelling indicates that it is not essential for the tunnel section to require vent shafts for exhaustion of routine traffic emissions, but that there are some minor limitations to further revisions of land use in the vicinity of the portals if ventilation shaft is not included. Smoke extractors will not be near enough to ASRs to create any significant impact to be of concern in terms of air quality in the operational phase.

3.8.3 Developments to the north east of the CT9 and the associated port back-up uses are immediately adjacent to the proposed alignment but modelling indicates that these sites will not be subject to inferior air quality or that pollutants would exceed the AQOs. However, when the detailed design of these sites is progressed it is recommended that ASRs are located in the most favourable locations with regard to air quality.

3.8.4 Stonecutters Base has several dwellings in proximity to the alignment and there are offices associated with other industrial uses in the broad vicinity of the Ngong Shuen Chau viaduct section. Modelling indicates that these sites will not be subject to inferior air quality and traffic related pollutants will not cause the AQOs to be exceeded.

3.8.5 Air quality constraints are identified at Site 6 at 1.5m above ground (Figure 3.8). Sensitive uses (including active recreation) should be avoided in this area. At 15m there should be compliance with AQOs (Figures 3.9 –3.11). In these areas further review is

recommended at the detailed design layout of this site to accommodate these constraints. There is compliance with the AQO at Site 10.