Calculation of Open Road Emission Rates

Estimation of Vehicular Emission for the Study Area with EMFAC-HK model

Open road emission contributes to the cumulative air quality impact in the Study Area. Ultra-low sulphur fuel is used for all vehicles in Hong Kong. Therefore, NO_2, PM10 and PM2.5 are considered as the key air pollutant parameters and were selected for the assessment of air quality impact associated with vehicular emissions. EMFAC-HK v4.3 model is adopted to estimate the vehicular emission rates of NO_X and particulate matters.

The detailed procedures and assumptions for the EMFAC-HK modelling are summarised as below.

Model Year

EMFAC-HK generates emission factors and vehicle activity for vehicles for 45 model years i.e. from the assessment year back 44 years. **Table 1** summarizes the starting and final model years of the assessment years implemented in EMFAC-HK.

Table 1 Starting and Final model years in EMFAC-HK

Scenario Year	Starting Model Year	Final Model Year
Construction Phase		
2025	1981	2025
2028	1984	2028
Operational Phase		
2028	1984	2028
2035	1991	2035
2043	1999	2043

Vehicle Emission Standard Implementation Programme and Technology Fraction

According to EPD's Guideline on Modelling Vehicle Emissions - Appendix III, default vehicle emission standard implementation programme and technology fraction in EMFAC-HK was used.

In different years each vehicle class has a different exhaust technology group index and technology fraction. Each technology group represents a distinct emission control technology. The technology fractions input to the model are based on the "2018 Licensed Vehicle by Age and Technology Group Fractions" provided by EPD. Since the exhaust technology fractions are only presented up to the year 2018, those after this time have been projected in accordance with the EPD Guideline on Modelling Vehicle Emissions Appendix III - "Implementation Schedule of Vehicle Emission Standards in Hong Kong (Updated as at May 2020)" and Appendix IV - "HK Technology Group Indexes (Updated as at January 2021)".

Vehicle Population

As recommended in the EPD's Guideline on Modelling Vehicle Emissions, default vehicle populations forecast in EMFAC-HK was used.

Vehicle Accrual

The default accrual rates in EMFAC-HK are estimated from the local mileage data adjusted to reflect the total VKT for each vehicle class. The default value was used.

Trips

Start emissions occur at where vehicles are parked. Its impact is normally limited to those air sensitive receivers at close proximity (up to several tens metres) to the vehicle parking site. The magnitude of impact depends on the vehicle type (e.g. heavy goods vehicles and buses have higher NOx/NO2 start emissions than private cars) and the duration of soaking time of the vehicles at the parking site.

Therefore, start emissions of vehicles in the assessment were estimated by two approaches, namely broad-brush approach and precise approach.

To avoid any underestimation of air quality impact arising from parking sites having high air quality concern, precise approach was adopted to estimate start emission from public transport interchanges (PTIs) and bus termini for Franchised Buses Single-Deck (FBSD), Franchised Buses Double-Deck (FBDD), Non-Franchised Buses (NFB) and Public Light Buses (PLB), and parking sites for Heavy Goods Vehicle (HGV) or NFB identified within the assessment area.

For other vehicle classes, the start emission factors are minimal when compared to NFB, PLB, HGV, FBSD and FBDD. Furthermore, the duration of soaking time (5 – 720min) which generates the highest start emission factor was adopted to give conservative estimates. Therefore, the broad-brush approach gives reasonable and conservative estimate of start emissions from other vehicle classes. It is assumed that the number of trips on roads with post speed greater than 50 km/hr would be zero as no cold start would be anticipated on these roads.

Start emission from FBSD, FBDD, NFB, PLB and HGV are included in the precise approach at the identified major parking sites. In order to avoid underestimate the start emission from NFB on-street parking spaces and HGV parked at road side for loading/ unloading, the start emission from NFB and HGV are also included in the broad-brush approach.

Therefore, start emission from HGV and NFB have been included in both precise and broad-brush approaches.

Precise Approach

All PTIs, Bus Termini, NFB and HGV Parking Sites were identified within the assessment area and presented in **Appendix 3.7**. As AsiaWorld-Expo Bus Terminus will be decommissioned before the construction of the Project, emission from AsiaWorld-Expo Bus Terminus is excluded in the quantitative assessment. The number of trips for FBSD, FBDD, PLB, NFB and HGV was obtained by on-site survey and estimated by the project traffic consultant. Calculations of start emissions associated with these termini and parking sites were referenced to the "*Calculation of Start Emissions in Air Quality Impact Assessment*" published by EPD.

Broad-brush Approach

Start emissions of vehicles were distributed on local and rural roads with post speed of 50km/hr and the roads connecting to the parking sites with the number of trips for each vehicle class except FBDD, FBSD and PLB. It is assumed that the number of trips is directly proportional to VKT and estimated by the following formula:

$$\begin{aligned} &Trip\ for\ local\ and\ rural\ roads\ within\ the\ study\ area \\ &= VKT\ for\ Local\ and\ Rural\ Roads\ within\ the\ Study\ Area \\ &\times \frac{Trip\ for\ Local\ and\ Rural\ Roads\ within\ Hong\ Kong}{VKT\ for\ Local\ and\ Rural\ Roads\ within\ Hong\ Kong} \end{aligned}$$

Trip within Hong Kong and VKT within Hong Kong were obtained from the default values from EMFAC-HK, while the proportion of local and rural roads within Hong Kong (12.86%) was extracted from the Annual Traffic Census 2020 prepared by Transport Department (TD), which provides a more conservative approach for estimation of the start emission when compared with using the latest traffic data in Annual Traffic Census 2021 (13.73%). VKT within the study area was calculated by multiplying the number of vehicles by the distance travelled within the study area. The highest NOx (and the

corresponding NO and NO2), TSP, RSP and FSP start emission factor for each vehicle class among different soaking time were adopted as a conservative approach.

There are parking sites at Shun Hang Road and Shun Ming Road and no HGV and coach would be parked within the parking sites. The proposed automated car parks of the Passenger Clearance Building, parking sites at Shun Hang Road and Shun Ming Road are for private cars, and hence corresponding start emissions were considered in board-brush approach.

Vehicle Kilometre Travel (VKT)

The "vehicle fleet" refers to all motor vehicles being operated on roads within this assessment area. The modelled fleet is classified into 18 vehicle classes based on the type of vehicle, weight class and fuel type. The number of vehicles in each class is based on an analysis of the TD registration data.

Vehicle-kilometer-travelled (VKT) represents the total distance travelled on a weekday. The VKT is calculated by multiplying the number of vehicles from the forecast hourly traffic flow and the length of road travelled in the assessment area.

Vehicle Speed

Vehicle speed on each road link at each hour was provided by the project traffic consultant. All the vehicle classes on the same road link were assumed to have the same travelling speed, except medium goods vehicles, heavy goods vehicles, coaches, buses and public light buses. In accordance with the Road Traffic Ordinance, for any road with design speed limit of 70 kph or above, the speed limit for coaches, medium goods vehicles, heavy goods vehicles and buses would be limited to not more than 70 kph. Thus, the speeds of coaches, medium goods vehicles, heavy goods vehicles and buses from the flow speed or 70 kph, whichever is lower, were adopted. For the public light buses, the speed limit should be limited to post speed of the carriageway or 80 kph, whichever is lower, were adopted.

Temperature and Humidity Profile

Year 2021 meteorological data for hourly temperature and relative humidity profiles were adopted from the Hong Kong Observatory's Chek Lap Kok Weather Station which is the closest to the Site.

For the estimation of 1-hour average of NO_2, the daily profile of the lowest temperature and relative humidity in each hour for each month (i.e. 24 hours data in each month and for 12 months) were adopted to calculate the vehicular emission factors in the corresponding period on hourly basis.

For the estimation of annual average of NO_2, the daily profile of the averaged temperature and relative humidity in each hour for each month (i.e. 24 hours data in each month and for 12 months) were adopted to calculate the vehicular emission factors in the corresponding period on hourly basis.

For the estimation of short-term and long-term air quality impact of TSP, RSP and FSP, the lowest temperature and relative humidity in the whole year were adopted to calculate the vehicular emission factors in the corresponding period on hourly basis.

Estimation of Composite Vehicular Emission Factor

Referring to the EPD's Guideline on Modelling Vehicle Emissions, "Emfac mode" generates emission factors in terms of grams of pollutant emitted per vehicle activity. It was applied for this Project, since it can provide hourly vehicular emissions, taking into account of ambient conditions and speeds combined with vehicle activity.

Assuming that NOx is comprised of NO and NO_2 only, the hourly emission of NO was calculated as the difference in NOx and NO_2 extracted from EMFAC-HK for each vehicle type.

The hourly emissions of NO, NO_2, TSP, RSP and FSP were divided by the number of vehicles and the distance travelled to obtain the emission factors in gram per miles per vehicle. The calculated 24-hour composite emission factors of 18 vehicle classes for each road link were adopted in the subsequent air dispersion modelling.

Vehicular Emission (Construction Phase)

Vehicular emission for TSP, RSP and FSP are calculated based on the traffic forecast and EMFAC-HK v4.3 model and are summarized in **Table 2**:

Table 2 Vehicular Emission of Open Road Source (PM)

Year	Vehicular Emission (kg/day)		
	RSP	FSP	TSP
2025	21.96	20.18	22.00
2028	26.95	24.79	27.03

According to the results, 2028 PM emission factors will be adopted in the model to demonstrate the worst case scenario.

Vehicular Emission (Operational Phase)

Vehicular emission, including running and start emissions, for NOx, RSP and FSP are calculated based on the traffic forecast and EMFAC-HK v4.3 model and are summarized in **Table 3a** and **Table 3b**:

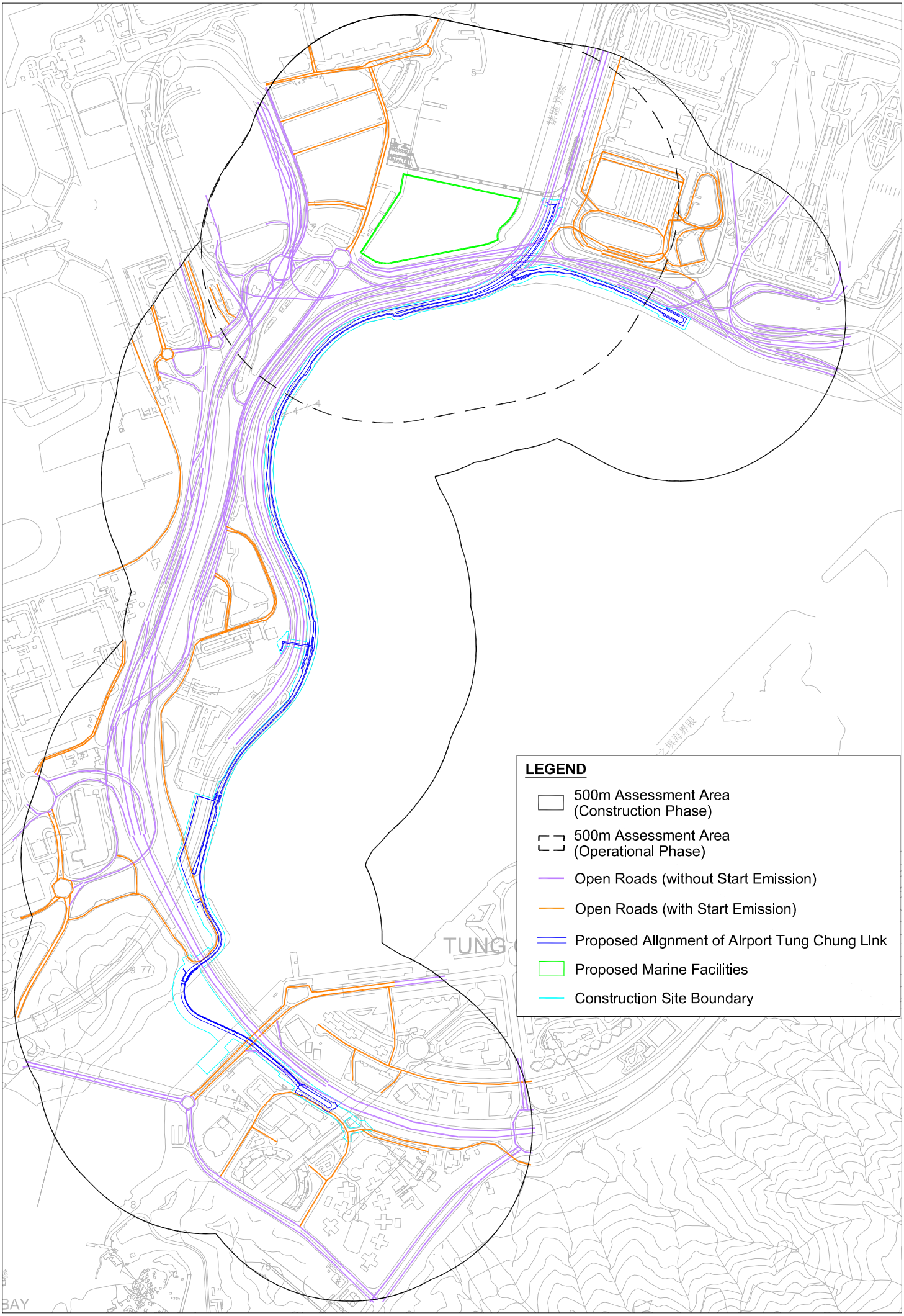
Table 3a Vehicular Emission of Open Road Source (NOx)

Year	Vehicular Emission (kg/day) under the Lowest Temperature and Relative Humidity											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2028	220	208	203	196	180	180	178	181	179	197	213	218
2035	96	90	88	85	78	78	77	78	77	85	92	95
2043	102	95	92	89	82	81	81	82	81	89	97	100
Year	**Vehicular Emission (kg/day) under the Averaged Temperature and Relative Humidity**											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
2028	203	189	180	174	159	156	155	156	157	171	189	195
2035	88	82	78	75	69	68	67	68	68	74	81	84
2043	92	85	81	79	72	71	71	71	71	77	85	88

Table 3b Vehicular Emission of Open Road Source (PM)

Year	Vehicular Emission (kg/day)	
	RSP	FSP
2028	8.83	8.12
2035	3.54	3.27
2043	3.49	3.22

According to the results, 2028 NOx emission factors and 2028 PM emission factors will be adopted in the model to demonstrate the worst case scenario.


LEGEND
500m Assessment Area (Construction Phase)
500m Assessment Area (Operational Phase)
Open Roads (without Start Emission)
Open Roads (with Start Emission)
Proposed Alignment of Airport Tung Chung Link
Proposed Marine Facilities
Construction Site Boundary
TUNG
BAY