Appendix 4.3

Details of In-tunnel Air Quality

1.1 In-tunnel Air Quality

1.1.1 Air quality within the tunnel is to be monitored and a tunnel ventilation system installed so that air quality within the tunnel complies with stated air quality standards. This appendix describes how the air pollutant within the proposed CKR tunnel is derived for this EIA study.

1.1.2 The tunnel ventilation system is designed with the objective to remove/dilute vehicle emissions to achieve the air quality standards specified in EPD's "Practice Note on Control of Air Pollution in Vehicle Tunnels" given in the table below. The air quality inside the tunnel should meet the EPD recommended standard as listed in **Table 1.1**.

Table 1.1 Tunnel Air Quality Guidelines

Pollutant	Average Time	Maximum Concentration	
		($\mu g/m^3$) [1]	ppm
Carbon Monoxide, CO	5 minutes	115,000	100
Nitrogen Dioxide, NO_2	5 minutes	1,800	1
Sulphur Dioxide, SO_2	5 minutes	1,000	0.4
Visibility	**Average Time**	**Distance (m^{-1})**	
Extinction Coefficient Limit	5 minutes	0.005	

Note:

[1] Measured at reference condition of 298 K and 101.325 kPa (one atmosphere)

1.1.3 However, given characteristics of modern fuels and vehicles, NO_2 will be the index pollutant, although to be consistent with the EmFAC v2.1 emission data the tunnel air quality modeling is done using NO_x and PM10, with in-tunnel NO_2 levels derived based on the NO_2:NO_x ratio of 7.5 %, which is consistent with the requirements in EPD's Guidelines on Choice of Models and Model Parameters.

Traffic Conditions, Traffic Volume, Vehicle Type and Emissions

1.1.4 Traffic flow, mix, and emission factors for each operating hour are based on the emission calculation for EmFAC v2.1 for Year 2021.

Tunnel Ventilation Design and Rate

1.1.5 A longitudinal system with point exhaust is proposed for normal operating conditions, with jet fans provided for the congested operations (non-fire incident). No mechanical ventilation supply to the tunnel will be required.

1.1.6 Recognising that the need to maintain limited portal emissions means that significant ventilation rates are required from the tunnel to the ventilation buildings far greater ventilation rates than those needed to meet the Criteria noted in **Table 1.1**.

1.1.7 Air quality within the tunnels is maintained by varying the number and configuration of operating fans to ensure the rate of airflow matches tunnel air quality and portal emission criteria. During all traffic conditions, the fans will ensure that in-tunnel air is extracted through the ventilation buildings. A separate simulation has been performed for each hour corresponding to the traffic and emission data as per **Clause 1.1.3** and **1.1.4** above.

1.1.8 In conjunction with off-site air quality studies, the preliminary design of the tunnel ventilation system requires extraction of air at a maximum of approximately 250 m^3/s from a location at approximately the mid-point of each tunnel bore (i.e. at Ho Man Tin) 625 m^3/s at locations approximately 50 m from the exit tunnel portals of each tunnel bore to maintain acceptable air quality inside the tunnel and to prevent significant discharge of vitiated air from the portals.

Calculation for Pollution Levels

1.1.9 The in-tunnel airflows and pollution levels are calculated by using the proprietary road tunnel simulation (CFD) program – "Roads Program". The Roads Program is capable of modelling transient flows and calculating pollution levels in a complex network of tunnels.

1.1.10 The Roads Program calculates airflow and velocities in a quasi-one-dimensional tunnel system. It divides the tunnel network into elements, each with an area, perimeter, friction factor, length and gradient. In this system of elements it solves the unsteady compressible equations for conservation of mass and momentum. Fans and traffic are added as discrete sources of momentum or as boundary conditions at the ends of tunnels. The equations are marched forward in time by the Method of Characteristics.

1.1.11 Quasi steady state simulations are carried out based on the assumption that constant traffic data is being used for each assessment period and wind effects at the tunnel portals/landscaped decks are not being considered.

1.1.12 The actual operation of the tunnels will include continually changing traffic and wind flows which the tunnel ventilation system will respond to through the measurement of airflow in the tunnel sections. However, due to limitations with regard to the control of tunnel ventilation fans, a change in the ventilation response will be delayed.

1.1.13 The complex three-dimensional flow patterns caused by the geometry of the Western Landscaped Deck (including wind and temperature effects) means that Roads Program will not be used to examine conditions under the landscaped deck in detail nor to establish emissions from the different openings of the landscaped deck for the air quality modeling local to the Western Landscaped Deck. The Roads Program will however includes the Western Landscaped Deck as the airflow from the Western Landscaped Deck forms the intake to the East Bound Tunnel – and thus directly affects the emissions from the Central and Eastern Ventilation Buildings.

1.1.14 The Roads Program simulates airflow, through the tunnels, generated by traffic and ventilation. It establishes pollution deposited within the tunnels, such that the pollution emitted from the ventilation buildings can be assessed.

1.1.15 The air pollutant loading within tunnel is determined based on the traffic volume, exhaust technology and vehicle age mix during the assessment year. The ventilation system is designed and operated to ensure that vehicle emissions from within the tunnel can be expelled efficiently, without adversely affecting air sensitive uses near the tunnel portals.

1.1.16 For each operational hour, the ventilation response required to achieve no portal emissions under a quasi steady-state condition is established though a manual iteration process. The pollution levels within the tunnel are then established with reference to the EmFAC v2.1 data and the theoretical emissions from the ventilation shafts established.

1.1.17 As part of the post-processing of the data from the Roads Program when deriving emissions from the portal ventilation shafts, the air quality modelling assumed 10% carry-over through the portal.