Appendix 4.4d   **Detailed Calculations of In-Tunnel Air Quality under Tuen Mun Town Plaza along Tuen Mun Road**

Normal Condition

Tunnel Parameter

Tunnel length (m), L	=	96
Tunnel height (m), H	=	6
Tunnel width (m), W	=	36.5 (Averaged width)
Tunnel size (m2), At	=	H * W
		219
Equivalent diameter (m), dt	=	$(4*At/\pi)^{0.5}$
		16.69849
Effective length of the tunnel (m), Le	=	L + 2*3*dt
		196.191

Emission Data

Traffic Breakdown (%)

Tunnel traffic (Link no.)	Traffic flow (veh/hr)	Motor Cycles	Petrol PC &LGV	Taxi	Non-franchised Buses <6.4t	Non-franchised Buses 6.4-15t	Non-franchised Buses >15t	Private Light Buses <3.5t	Private Light Buses >3.5t	Diesel PC&LGV <2.5t	Diesel LGV 2.5-3.5t	Diesel LGV >3.5t	HGV<15t	HGV>15t	Single Deck Franchised Buses	Double Deck Franchised Buses	Public Light Buses
126-125+179	878	0.01	0.35	0.13	0.00	0.03	0.00	0.00	0.01	0.01	0.06	0.04	0.26	0.02	0.00	0.02	0.04
109	2828	0.01	0.38	0.07	0.00	0.02	0.00	0.00	0.01	0.01	0.05	0.04	0.36	0.02	0.00	0.01	0.02
110	3485	0.01	0.42	0.03	0.00	0.01	0.00	0.00	0.00	0.01	0.07	0.05	0.36	0.02	0.00	0.01	0.01
149	903	0.01	0.30	0.22	0.00	0.03	0.00	0.00	0.01	0.01	0.07	0.05	0.05	0.01	0.01	0.09	0.14
Total	8094	0.01	0.39	0.08	0.00	0.02	0.00	0.00	0.01	0.01	0.06	0.05	0.31	0.02	0.002	0.02	0.03
NOx Emission Factor (g/mile)		1.14	0.28	0.28	0.00	7.07	0.00	0.00	0.82	1.07	0.59	3.76	7.89	10.01	5.44	5.81	0.77

Weighted NOX E.F. (g/km/veh)	=	2.0575
NO2 emission factor per unit length (g/m/s), w1	=	12.5% * Weight NOX E.F. * Traffic flow
	=	5.78E-04
NO2 emission transferring from neighboring enclosures (g/s)	=	20% * (IN C2) (Note: For the amounts of IN C2 in normal condition, please refer to Appendix 4.4)
	=	8.51E-03
Length of Enclosure E1 (m)	=	96
NO2 emission transferring from neighboring enclosures (g/m/s), w2	=	8.87E-05
Total NO2 emission factor per unit length (g/m/s), w	=	w1+w2
	=	6.67E-04

Vehicle Data

Nominal dimensions of vehicles are given in Transport Planning and Design Manual, Vol. 2 as:

	W	H	L
Motor Cycles	1.7	1.5	4.6
Total Maximum NO2 concentration under	1.7	1.5	4.6
Tuen Mun Town Plaza (Normal Speed)	1.7	1.5	4.6
Non-franchised Buses <6.4t	2.5	3.5	12
Non-franchised Buses 6.4-15t	2.5	3.5	12
Non-franchised Buses >15t	2.5	3.5	12
Private Light Buses <3.5t	2	3	6.5
Private Light Buses >3.5t	2	3	6.5
Diesel PC&LGV <2.5t	2.1	1.6	5.2
Diesel LGV 2.5-3.5t	2.1	1.6	5.2
Diesel LGV >3.5t	2.1	1.6	5.2
HGV<15t	2.5	4.6	16
HGV>15t	2.5	4.6	16
Total Maximum NO2 concentration under	2.5	3.5	12

Appendix 4.4d   **Detailed Calculations of In-Tunnel Air Quality**
under Tuen Mun Town Plaza along Tuen Mun Road

Normal Condition

Tuen Mun Town Plaza (Worse Case)	2.5	4.6	12
Public Light Buses	2	3	6.5

* No dimensions for motor cycles and non-franchised buses are provided.
* For the purpose of this study, the dimensions of motor cycles and taxi are assumed to be the same as private car
and the dimension of non-franchised buses are assumed to be the same as single deck franchised buses.

Nominal cross-sectional area (m2)	=	(1.7*1.5*0.01)+(1.7*1.5*0.39)+(1.7*1.5*0.08)+(2.5*3.5*0.02)+(2*3*0.01)+(2.1*1.6*0.01)+(2.1*1.6*0.06)+(2.1*1.6*0.05)+(2.5*4.6*0.31)+(2.5*4.6*0.02)+(2.5*3.5*0.002)+(2.5*4.6*0.02)+(2*3*0.03)
	=	6.059148
Number of lanes per direction, nl	=	5
Equivalent cross-sectional area for each direction (m2), Av	=	30.29574
Equivalent diameter of vehicle (m), dv	=	(4*Av/π)^0.5
	=	6.210778

Traffic density (traffic flow /s), N	=	2.248333
Average vehicle speed (m/s), v	=	50 km/hr
	=	13.88889
Head to head distance on a lane (m), l	=	2*nl*v/N
	=	61.77415

Diffusion Parameters

Reynolds number, Re	=	(v*dv)/σ	where σ = 15.6*10^-6
	=	5529539	
According to Figure 16 (Ohashi and Koso)			
Since l / dt	=	3.699385	
D / (N * dt^2 * Re^0.13)	=	0.34	
Longitudinal			
diffusion coefficient (m2/s) , D	=	0.34 * (N * dt^2 * Re^0.13)	
	=	1604.146	

Maximum Concentration of NO2

Cmax (µg/m3)	=	w * Le^2 / (8 * D * At)
(without background)	=	9

Appendix 4.4d **Detailed Calculations of In-Tunnel Air Quality under Tuen Mun Town Plaza along Tuen Mun Road**

Worse Condition

Tunnel Parameter

Tunnel length (m), L	=	96
Tunnel height (m), H	=	6
Tunnel width (m), W	=	36.5 (Averaged width)
Tunnel size (m2), At	=	H * W
		219
Equivalent diameter (m), dt	=	$(4*At/\pi)^{0.5}$
		16.69849
Effective length of the tunnel (m), Le	=	L + 2*3*dt
		196.191

Emission Data

Traffic Breakdown (%)

Tunnel traffic (Link no.)	Traffic flow (veh/hr)	Motor Cycles	Petrol PC &LGV	Taxi	Non-franchised Buses <6.4t	Non-franchised Buses 6.4-15t	Non-franchised Buses >15t	Private Light Buses <3.5t	Private Light Buses >3.5t	Diesel PC&LGV <2.5t	Diesel LGV 2.5-3.5t	Diesel LGV >3.5t	HGV<15t	HGV>15t	Single Deck Franchised Buses	Double Deck Franchised Buses	Public Light Buses
126-125+179	878	0.01	0.35	0.13	0.00	0.03	0.00	0.00	0.01	0.01	0.06	0.04	0.26	0.02	0.00	0.02	0.04
109	2828	0.01	0.38	0.07	0.00	0.02	0.00	0.00	0.01	0.01	0.05	0.04	0.36	0.02	0.00	0.01	0.02
110	3485	0.01	0.42	0.03	0.00	0.01	0.00	0.00	0.00	0.01	0.07	0.05	0.36	0.02	0.00	0.01	0.01
149	903	0.01	0.30	0.22	0.00	0.03	0.00	0.00	0.01	0.01	0.07	0.05	0.05	0.01	0.01	0.09	0.14
Total	8094	0.01	0.39	0.08	0.00	0.02	0.00	0.00	0.01	0.01	0.06	0.05	0.31	0.02	0.002	0.02	0.03
NOx Emission Factor (g/mile)		1.02	0.38	0.38	0.00	10.41	0.00	0.00	1.21	1.55	0.86	5.57	11.82	15.06	9.45	10.26	1.14

Weighted NOX E.F. (g/km/veh)	=	3.0834
NO2 emission factor per unit length (g/m/s), w1	=	12.5% * Weight NOX E.F. * Traffic flow
	=	8.67E-04
NO2 emission transferring from neighboring enclosures (g/s)	=	20% * (IN C2) (Note: For the amounts of IN C2 in worse condition, please refer to Appendix 4.4)
	=	1.36E-02
Length of Enclosure E1 (m)	=	96
NO2 emission transferring from neighboring enclosures (g/m/s), w2	=	1.42E-04
Total NO2 emission factor per unit length (g/m/s), w	=	w1+w2
	=	1.01E-03

Vehicle Data

Nominal dimensions of vehicles are given in Transport Planning and Design Manual, Vol. 2 as:

	W	H	L
Motor Cycles	1.7	1.5	4.6
Total Maximum NO2 concentration under	1.7	1.5	4.6
Tuen Mun Town Plaza (Normal Speed)	1.7	1.5	4.6
Non-franchised Buses <6.4t	2.5	3.5	12
Non-franchised Buses 6.4-15t	2.5	3.5	12
Non-franchised Buses >15t	2.5	3.5	12
Private Light Buses <3.5t	2	3	6.5
Private Light Buses >3.5t	2	3	6.5
Diesel PC&LGV <2.5t	2.1	1.6	5.2
Diesel LGV 2.5-3.5t	2.1	1.6	5.2
Diesel LGV >3.5t	2.1	1.6	5.2
HGV<15t	2.5	4.6	16
HGV>15t	2.5	4.6	16
Total Maximum NO2 concentration under	2.5	3.5	12
Tuen Mun Town Plaza (Worse Case)	2.5	4.6	12
Public Light Buses	2	3	6.5

* No dimensions for motor cycles and non-franchised buses are provided.
* For the purpose of this study, the dimensions of motor cycles and taxi are assumed to be the same as private car and the dimension of non-franchised buses are assumed to be the same as single deck franchised buses.

Appendix 4.4d   **Detailed Calculations of In-Tunnel Air Quality**
                        under Tuen Mun Town Plaza along Tuen Mun Road

Worse Condition

Nominal cross-sectional area (m2)	=	(1.7*1.5*0.01)+(1.7*1.5*0.39)+(1.7*1.5*0.08)+(2.5*3.5*0.02)+(2*3*0.01)+(2.1*1.6*0.01)+(2.1*1.6*0.06)+(2.1*1.6*0.05)+(2.5*4.6*0.31)+(2.5*4.6*0.02)+(2.5*3.5*0.002)+(2.5*4.6*0.02)+(2*3*0.03)
	=	6.059148
Number of lanes per direction, nl	=	5
Equivalent cross-sectional area for each direction (m2), Av	=	30.29574
Equivalent diameter of vehicle (m), dv	=	(4*Av/π)^0.5
	=	6.210778

Equivalent length of each vehicle (m)	=	(4.6*0.01)+(4.6*0.39)+(4.6*0.08)+(12*0.02)+(6.5*0.01)+(5.2*0.01)+(5.2*0.06)+(5.2*0.05)+(16*0.31)+(16*0.02)+(12*0.002)+(12*0.02)+(6.5*0.03)
	=	8.834445
Distance between vehicle (m)	=	1 (worst case)
Head to head distance on a lane (m), l	=	9.834445
Traffic density (traffic flow /s), N	=	2.248333
Average vehicle speed (m/s), v	=	l*N/(2*nl)
	=	2.211111

Diffusion Parameters

Reynolds number, Re	=	(v*dv)/σ	where σ = 15.6*10^-6
	=	880302.6	
According to Figure 16 (Ohashi and Koso)			
Since l / dt	=	0.588942	
D / (N * dt^2 * Re^0.13)	=	0.14	
Longitudinal			
diffusion coefficient (m2/s) , D	=	0.14 * (N * dt^2 * Re^0.13)	
	=	520.1702	

Maximum Concentration of NO2

Cmax (μg/m3)	=	w * Le^2 / (8 * D * At)
(without background)	=	43

Appendix 4.4d   **Detailed Calculations of In-Tunnel Air Quality**
                                 under Tuen Mun Town Plaza along Tuen Mun Road

Overall Concentrations

Six assessment points (ASRs F1-F6) at the boundary of the deckover are chosen.
Using CALINE4 and ISCST3 model, the air pollutants concentrations at the 6 assessment points at different levels are calculated.
The highest concentration among the six assessment points is assumed to be the background
concentration inside the deckover section.

Elevation	NO2 Concentrations (ug/m3) at Various Levels	
	(mAG)	**NO_2**
F1	0.0	300
	3.0	294
	6.0	284
F2	0.0	281
	3.0	288
	6.0	291
F3	0.0	312
	3.0	301
	6.0	285
F4	0.0	246
	3.0	243
	6.0	237
F5	0.0	332
	3.0	315
	6.0	280
F6	0.0	254
	3.0	247
	6.0	245

Therefore, the NO2 background concentration inside the deckover is   332 ug/m^3

Total Maximum NO2 concentration under
Tuen Mun Town Plaza (Normal Speed)   **=**   **9 + 332**
                                            =   **341**   **ug/m3**

Total Maximum NO2 concentration under
Tuen Mun Town Plaza (Worse Case)   **=**   **43 + 332**
                                            =   **375**   **ug/m3**