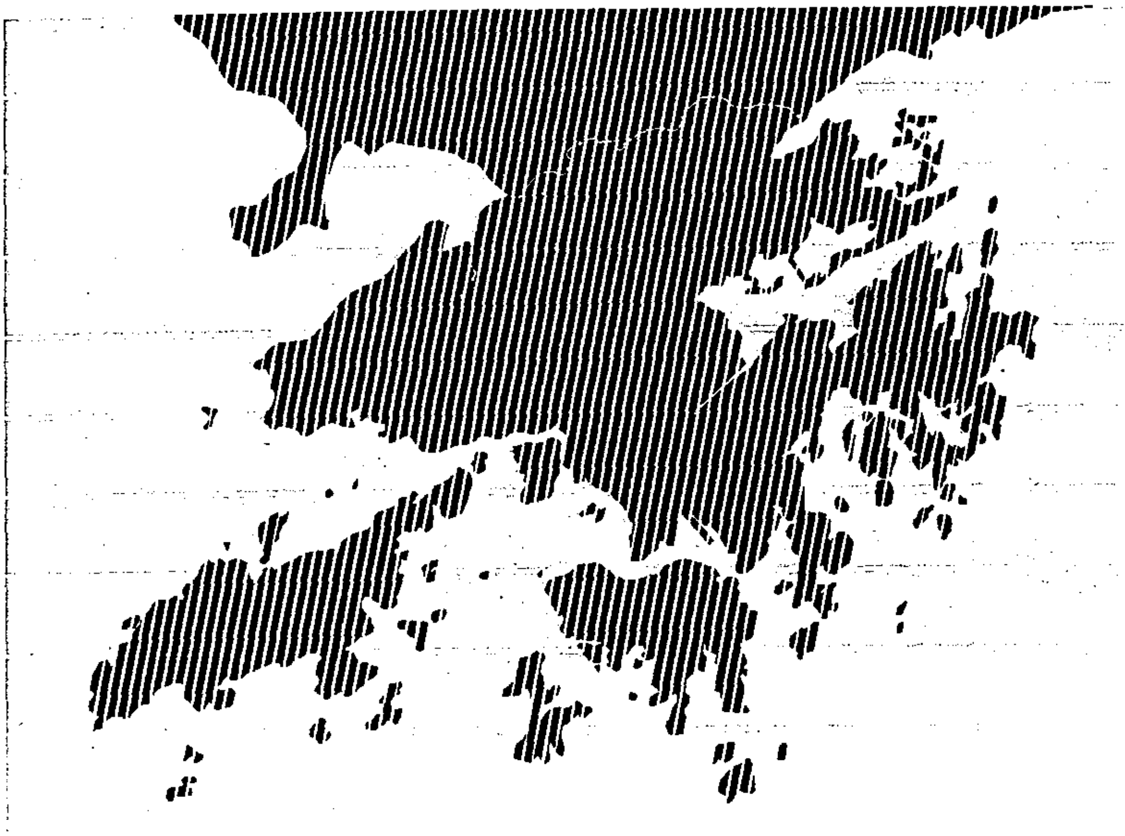

Air Quality Impact Assessment
for
Proposed Flyover (Road 3/2) across Castle Peak Road
at Sha Tsui Road

(Final)

September 1994

Scott Wilson Kirkpatrick
CONSULTING ENGINEERS
史偉高顧問工程師

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in association with
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Consultants in Environmental Management

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SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

1. Scott Wilson Kirkpatrick, in association with Aspinwall & Company, has been commissioned by Territory Development Department (TDD) to undertake an air quality assessment of a proposed road traffic flyover at Castle Peak Road.

2. The objective of the study is to identify potential air quality impacts generated by the proposed new road, the associated increase in vehicle emissions, and their possible mitigation measures.

3. The affected Air Sensitive Receivers (ASRs) are those residential blocks along both sides of Tsuen King Circuit namely Kam Fung Garden, Tsuen Tak Gardens and Joyful Building.

4. To predict the impacts from both dust emissions at the construction stage and exhaust gas emissions at the operation stage of the road flyover, air dispersion modelling was conducted for the study.

5. To assess the dust impact at the construction stage the Fugitive Dust Model (FDM) was used. CALINE 4 was employed to assess the traffic emissions along the open road part of the flyover, whereas the emissions dispersing from the tunnel portals were modelled using the Industrial Source Complex Short Term Model (ISCST).

6. Predicted construction dust levels (total suspended particulates) show that the 24-hour AQO limit value of $260\mu g/m^3$ is exceeded at a number of the ASRs after mitigation practices and background levels are taken into consideration. However the predicted levels of dust are significantly reduced at 10 m above ground level.

7. An effective watering programme (twice daily with complete covering) is estimated to reduce construction dust emissions by 50%. It is likely that the particle size fraction for the site will be similar to that of crushed concrete, as the area is largely urban. Background levels were taken as the highest annual mean recorded between 1988 and 1992 at Tsuen Wan Monitoring Station. The reduction in air borne dust due to mitigation measures was taken to be 50%, this is considered to be conservative and a greater reduction could be expected in situations where increased effort was made uncontrolling the dust.

8. In addition to water suppression methods for dust control at the site surface, it is also recommended that the following mitigation measures be applied to ensure that relevant guidelines and AQOs are not exceeded:

   - Work should be carried out in such a manner that avoidable dust is not generated. Screens, dust sheets, tarpaulins or other methods agreed by the employer should be used to prevent generation of dust.

   - Materials, including earthworks material, from which dust may be generated when being transported to or from the site should be wetted and covered.

   - In the process of material loading or unloading, any material which has the potential to create dust should be treated with water or wetting agent sprays prior to being loaded into or unloaded from a vehicle.

   - Any vehicle with an open load carrying area used for moving materials which have the potential to create dust should have properly fitting side and tail boards. Materials having the potential to create dust should not be loaded to a level higher than the side and tail boards, and should be completely covered by a clean tarpaulin which should be properly secured.

   - Dust on hard surfaced routes and road edges within the site should be removed regularly. Access roads to the site should be kept entirely free of dust, mud or other wastes.

   - Water sprays should be provided and used both to dampen stored materials and when receiving construction material.

- ASRs which may suffer from excessive dust exposure may be protected by erecting a screen to provide a physical shield against wind driven dust.
- To reduce the risk of exceeding the 24-hour TSP AQO close to receptors 2, 5 and 17 it is recommended that the number of hours in which dust generating activities are carried out is restricted to 6 hours in a single day, in an area 50m adjacent to the receptors.

9. Predicted dust levels (respirable suspended particulates) resulting from vehicle emissions at the operational stage of the flyover are not expected to exceed relevant AQOs, and no particular mitigation measures to control ambient levels are recommended.

10. Maximum predicted 1-hour CO levels of 672µg/m^3 are significantly below the AQO 1-hour level of 30,000 µg/m^3. Therefore predicted levels are not likely to be detrimental to human health, and no particular mitigation measures to control ambient CO levels are recommended.

11. Maximum predicted NO_x levels of 372µg/m^3 (NO plus NO_2) may be adjusted for predicted NO_2 levels. A worst case 20% conversion factor has been used previously. Therefore by applying this adjustment factor, the maximum predicted 1-hour level is 74µg/m^3. The 90th percentile value monitored background levels for the Tsuen Wan monitoring station for 1992 (the last complete year of monitoring) is 105 µg/m^3. This can be taken as worst case background. If the monitored background NO_2 level and predicted 1-hour maximum NO_2 level are added together then the 1-hour AQO of 300 µg/m^3 is not exceeded. Table 7.5 shows that the levels of pollutant emissions predicted at 10 m above ground level for each ASRs modelled are significantly reduced.

12. The predicted NO_2 1-hour maximum value of 74µg/m^3 represents the combined impact from the tunnel portals and open road emissions. This predicted level represents the worst case and may not occur as the wind direction that gives the highest level from emissions on open roads at any ASR is unlikely to coincide with the wind direction that gives the highest level from emissions at tunnel portals.

13. The predicted 1-hour RSP levels obtained in the modelling studies cannot be directly compared to the 24-hour AQO of 180µg/m^3. Taking the 90th percentile RSP value for 1992 (the last complete year of monitored data) of 94µg/m^3 as a worst case background level, the maximum predicted total RSP level (predicted and background) for 1-hour average is 184µg/m^3. Assuming a 50% conversion factor for 1-hour to 24-hour levels, a predicted total RSP level for 24-hours is 139µg/m^3 which is in compliance with the AQO.

1. INTRODUCTION

1.1 Scott Wilson Kirkpatrick, in association with Aspinwall & Company, have been commissioned by Territory Development Department (TDD) to undertake an air quality assessment of a proposed road traffic flyover at Castle Peak Road following the noise assessment for this proposed flyover which was completed in September 1993 (Ref 1).

1.2 The proposed flyover is to be constructed to connect the western end of Tsuen King Circuit and Sha Tsui Road. At present the western end of Tsuen King Circuit terminates at a level of approximately 15mPD between Kam Fung Garden and Tsuen Tak Gardens, while Sha Tsui Road joins Castle Peak Road from the south this junction being controlled by traffic lights.

1.3 The proposed flyover will pass over Tsuen King Circuit at an elevation of approximately 14.5 mPD, and there will no longer be vehicular access directly between Castle Peak Road and Sha Tsui Road.

1.4 The location of the proposed flyover is shown on the site location plan (Appendix I). A general plan of the proposed flyover is included in Appendix II, as are the approximate boundaries of the area of study, and the existing road plan (without the flyover) is included as Appendix III.

1.5 An air quality impact assessment has been carried out to evaluate the effect of vehicle emissions and dust emissions on Air Sensitive Receivers (ASRs) in the immediate locality to the development area. The objective of the study is to identify potential air quality impacts generated by the proposed new road, the associated increase in vehicle emissions, and their possible mitigation measured through screening and traffic control measures.

2. SENSITIVE RECEIVERS

2.1 Appendix 1 shows the site location plan of the proposed flyover. Table 2.1 identifies ASRs in close proximity to the development area.

Table 2.1 Air Sensitive Receivers (ASRs)

Receptor No:	Location	User Ground Floor	User First Floor	Ground Level mPD	Coordinates E	N
1	Joyful A	Shop	Resident	+29.5	828913	826367
2	Joyful A	Lobby	Resident	+28.5	828920	826380
3	Joyful A	Shop	Resident	+27.5	828935	826375
4	Joyful B	Shop	Resident	+25.5	828949	826381
5	Joyful B	Lobby	Resident	+24.5	828956	826393
6	Joyful B	Shop	Resident	+23.5	828969	826389
7	Tsuen Tak A	Lobby	Resident	+16.1	829004	826396
8	Tsuen Tak A	Lobby	Resident	+16.1	829018	826392
9	Tsuen Tak B	Lobby	Resident	+16.1	829034	826386
10	Tsuen Tak B	Lobby	Resident	+16.1	829048	826383
11	Tsuen Tak C	Lobby	Resident	+16.1	829068	826375
12	Tsuen Tak C	Shop	Resident	+16.1	829076	826371
13	Tsuen Tak C	Empty Shop	Kindergarten	+16.1	829073	826355
14	Kam Fung 2	Lobby	Resident	+15.0	829115	826357
15	Kam Fung 1	Lobby	Resident	+15.0	829143	826321
16	Kam Fung 2	Lobby	Resident	+15.0	829129	826348
17	Tsuen Tak D	Empty Shop	Kindergarten	+16.1	829083	826329
18	Tsuen Tak D	Empty Shop	Kindergarten	+16.1	829081	826320

3. ENVIRONMENTAL STANDARDS AND GUIDELINES

Statutory Limits

3.1 Legislative controls over the emission of pollutants are defined as Air Quality Objectives (AQOs) under the Air Pollution Control Ordinance 1987 and are reproduced in Table 3.1.

3.2 The implementation of the Fuel Restriction Regulations in 1990, which limited the sulphur fuel content in fuel oil to 0.5%, has had a significant effect on improving air quality in Hong Kong including the Tsuen Wan area.

Table 3.1 Hong Kong Air Quality Objectives

Pollutant	Average Time				
	1 Hour	8 Hour	24 Hour	3 Months	1 Year
1. Sulphur Dioxide	800	--	350	--	80
2. Total Suspended Particulates (TSP)	--	--	260	--	80
3. Respirable Suspended Particulates (RSP)*	--	--	180	--	55
4. Nitrogen Dioxide	300	--	150	--	80
5. Carbon Monoxide	30,000	10,000	--	--	--
6. Photochemical Oxidants (as ozone)	240	--	--	--	--
7. Lead	--	--	--	1.5	--

Note : All concentrations in micrograms per cubic metre (µg/m^3), measured at 298°K (25°C) and 101.325 kPa (one atmosphere).
1 hour concentrations not to be exceeded more than three times per year.
8 and 24 hour concentrations not to be exceeded more than once per year.
3 month and 1 year concentrations are arithmetic means.
**Respirable suspended particulates (RSP) means suspended particles in air with a nominal aerodynamic diameter of 10 microns (µm) or less.*

4. BACKGROUND AIR QUALITY

4.1 The nearest EPD ambient air quality monitoring station to the proposed flyover across Castle Peak Road is at the Tsuen Wan Princess Alexandra Community Centre in Tai Ho Road which is approximately 1 kilometre (km) from the site. The site is situated 21mPD (17m above ground level). Table 4.1 summarises the available data for the Tsuen Wan monitoring station.

Table 4.1 Air Quality Data for the Tsuen Wan Monitoring Station (Ref 2)

Year	Air Pollutants ($\mu g/m^3$)				
		SO_2	NO_2	TSP	RSP
1988[1]	mean	35	64	126	77
	1-hour max	432	221		
	24-hour max	124	127	291	188
	90%ile	82	109	199	127
1989[2]	mean	28	67	98	55
	1-hour max	418	266		
	24-hour max	156	163	228	124
	90%ile	69	112	147	90
1990[3]	mean	41	52	87	48
	1-hour max	805	207		
	24-hour max	294	127	193	100
	90%ile	87	85	134	76
1991[4]	mean	36	57	90	57
	1-hour max	672	210		
	24-hour max	200	121	187	138
	90%ile	64	96	141	92
1992[5]	mean	36	63	107	64
	1-hour max	959	203		
	24-hour max	262	117	300	201
	90%ile	71	105	156	94
1993[6] June - Dec	mean	49	55	101	57
	1-hour max	929	225		
	24-hour max	300	133	201	114
	90%ile	117	91	154	90
1994[6] Jan- March	mean	95	71	113	73
	1-hour max	185	228		
	24-hour max	88	122	175	112
	90%ile	67	112	156	106

Note: *90%ile - 90th percentile*

1. *TSP 24-hour AQO exceeded once*
   RSP 24-hour AQO exceeded once
2. *NO_2 24-hour AQO exceeded once*
   TSP Annual AQO exceeded
3. *SO_2 1-hour AQO exceeded once*
   TSP Annual AQO exceeded
4. *TSP and RSP annual AQO exceeded*
5. *SO_2 1-hour AQO exceeded three times*
   TSP and RSP annual AQO exceeded as well as the 24-hour AQO.
6. *The data for 1993 and 1994 is not complete and therefore direct comparison with the annual AQOs can not be given. Nevertheless data shows that the $SO_2$1-hour AQO was exceeded in 1993.*

4.2 Table 4.1 shows that the background SO_2, NO_2 and TSP AQOs have all previously been exceeded in the monitored area. No site specific background air quality monitoring has been conducted for this study, as agreed with EPD.

5. AIR QUALITY IMPACTS

Dust

5.1 The nuisance potential of any dust produced during construction activities will be determined by the degree of effort placed upon dust control. Therefore dust control and mitigation measures should be adopted and enforced, through the use of statutory powers and contractual requirements. The nuisance from dust emissions is of particular concern due to the close proximity of ASRs (See Table 2.1) to the development site. The reduction of dust emissions can be achieved by :

- Employing methods of working to minimise dust generation or impact;
- Dampening down work surfaces;
- Providing and using water spray bowers, mobile sweeping plant and vehicle wash (wheel and body) facilities; and
- Routing of vehicles and plant at a maximum distance from sensitive receivers.

5.2 Dust control and mitigation measures should be strictly applied to minimise dust impacts during construction.

5.3 Although the dust emission rate (see Section 6) is considered to be worst case, by allowing for the number of wet days (ie 118.6 days at > 0.254 mm rainfall), dust emission rates may be reduced by up to 32.5%. Similarly, an effective watering programme (twice daily watering over the entire site) is estimated to reduce emissions by up to 50% (Ref 4) from ground surfaces. Another study (Ref 5) has found water to be up to 96% effective but only when surfaces are still thoroughly wet or the 'crust' on materials is unbroken. Water is the most readily available means of suppressing dust.

5.4 To control dust by removing it from the atmosphere one can use fine water sprays/mists, mobile vapour mass or additives (surfactants or wetting agents).

5.5 If the application of these mitigation measures fails to reduce dust levels to below acceptable limits then construction activity should cease temporarily until the dust source has been identified and appropriate steps have been taken to control emissions. Unacceptable impacts may also arise during a period of particularly dry and windy conditions and, similarly, operations should cease temporarily in order to protect affected ASRs.

Motor Vehicles

5.6 The combustion of the hydrocarbon fuel in air produces mainly carbon dioxide (CO_2) and water vapour (H_2O). However, the imperfect nature of internal combustion engines gives rise to amounts of hydrocarbons (HC), carbon monoxide (CO) and carbon (soot) being present in exhaust emissions. In addition, at the high temperatures and pressures found in the engine cylinders, some of the nitrogen in the air and fuel is oxidised, forming mainly nitric oxide (NO) with a small amount of nitrogen dioxide (NO_2).

5.7 CO is rapidly absorbed by blood, reducing its oxygen carrying capacity. The observed responses to low levels of carbon monoxide are :

30ppm	10-hour exposure for non-smokers leads to impaired reactions.
50ppm	90-minute exposure for non-smokers gives poor time interval discrimination
250ppm	headaches and nausea (Ref 6)

5.8 Most of the nitrogen oxides (NO_x) emitted by road traffic are in the form of nitric oxide which in the atmosphere will oxidise to NO_2. NO_2 is the more harmful of the two forms. As the chemical reaction to convert NO_x in the atmosphere does not occur immediately following emission, dispersion usually reduces the ambient concentration of NO_x. The main concern therefore is the NO_2 emitted directly to atmosphere. Some of the health effects of NO_2 include:

less than 0.1ppm	impairment of dark adaptation, some epidemiological effects
0.5ppm	some changes in lung morphology and biochemistry
1.5ppm	increased airway resistance in bronchial patients
2.5ppm	increased airway resistance in normal individuals
13ppm	eye and nasal irritation (Ref 6)

5.9 The term hydrocarbon is used generally to include all organic compounds emitted both in the exhaust and by evaporation from the fuel system. It embraces many hundreds of different compounds. Some are toxic or carcinogenic (e.g. benzene and 1,3 butadiene).

5.10 Tetra-alkyl lead compounds and scavengers are added to some types of petrol to improve combustion properties. Reactions inside the engine cause the emission of volatile lead halide compounds which are expelled in the exhaust gas. The majority of lead is emitted as fine particles of inorganic lead compounds. These can penetrate deep into the lungs, from where they can enter the blood and other body tissues. A small proportion is emitted as volatile organic lead compounds. These are very toxic and are rapidly absorbed by the body as they dissolve in fatty tissue.

6. AIR ASSESSMENT METHODS

6.1 In order to predict the impact from both dust emissions at the construction stage and exhaust gas emissions at the operation stage of the flyover, an approach using air dispersion modelling was adopted. The impacts at chosen air sensitive receivers (ASRs) of the road flyover were calculated. The ASRs included in the assessment are listed in Table 2.1.

Construction Stage

6.2 To assess the dust impact at the construction stage the Fugitive Dust Model (FDM) was used. FDM is a computerised air quality model specifically designed for computing concentrations and depositional impacts from fugitive dust sources.

6.3 The model is generally based on the well-known Gaussian plume formulation for computing concentrations, but the model has been specifically adapted to incorporate an improved gradient-transfer deposition algorithm. Emissions for each source are apportioned by the user into a series of particle size classes. A gravitational settling velocity and a deposition velocity are calculated by FDM for each class.

6.4 For the purpose of this study the model was run with a size distribution and density that approximated to crushed concrete. This is because concrete is the major material used in construction. A particle size distribution curve for crushed concrete is shown in Figure 6.1.

6.5 The study made the assumption that the whole area over which construction would occur was an active construction site emitting dust at a rate of 0.00012 $g/m^2/sec$ which corresponds to 1.2 tons/acre/month (Ref 4). The assumption that the whole site would be emitting dust at this rate at any single time is the worst case scenario.

6.6 The activities that create dust on the construction site are assumed to take place at ground level. It is also assumed there are no obstacles between the point of emission and the receptors. This being the case it is appropriate to predict the dust concentrations at ground level at the sensitive receptors. An estimation is made of the concentration levels at 10 m above ground level as this is the level which residences will be exposed to.

6.7 The meteorological input was a 1-year recorded data set, taken from Hong Kong International Airport in 1990. The data was processed by the model in hourly values for wind speed, wind direction, atmospheric stability class and atmospheric boundary height.

6.8 Table 6.1 lists the assumed model input parameters.

Table 6.1 Model Parameters

Particle size density - concrete (crushed)	1.85 g/cm^3
Surface roughness coefficient	0.375 m
Hong Kong International Airport Meteorological Data	
Particle size classes - Figure 6.1	

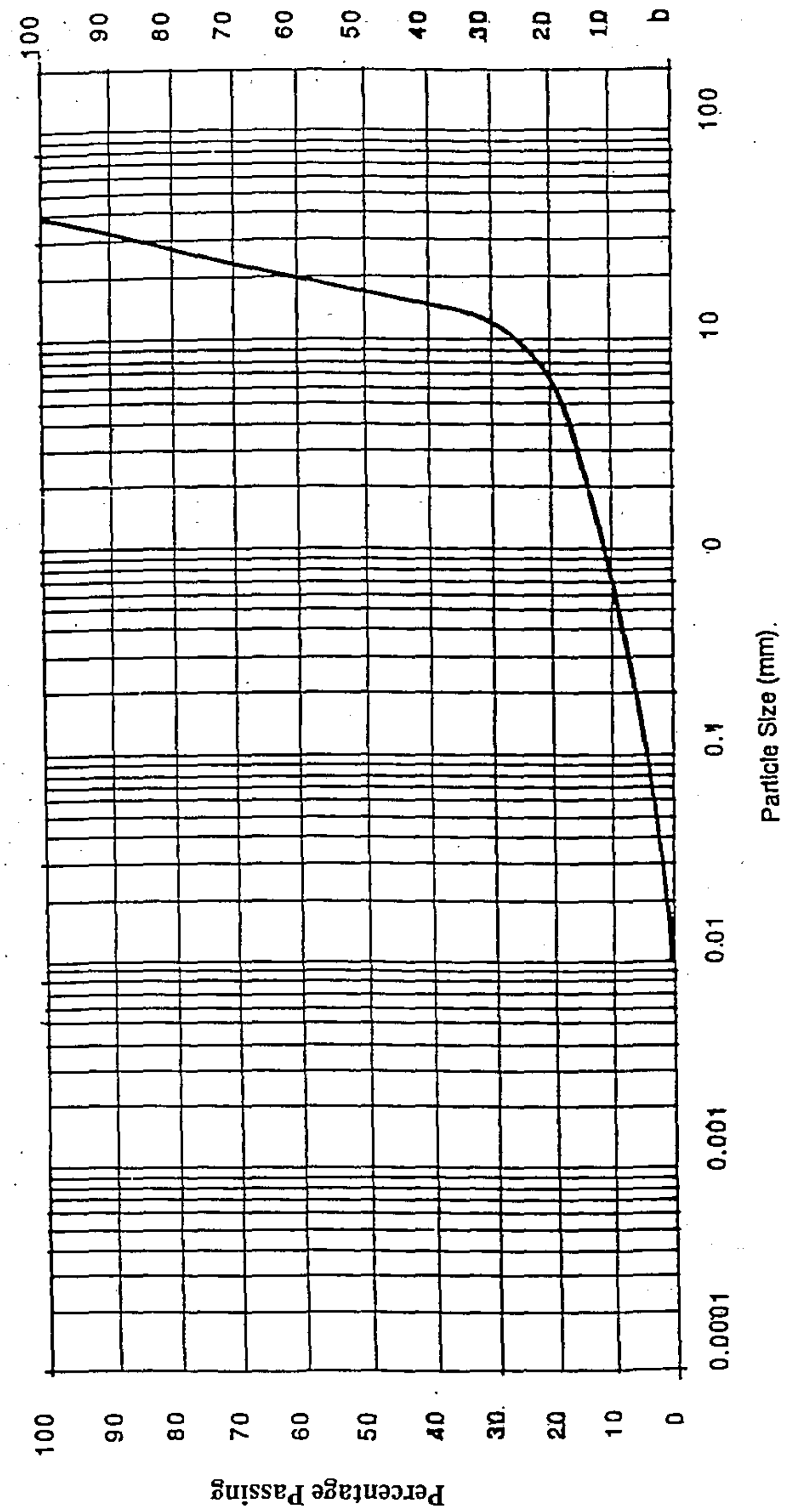

Figure 6.1
Particle Size Distribution Curve for Crushed Concrete

6.9 The main impact from the operational stage of the development will be from pollutants emitted by motor vehicle exhaust created by traffic using the flyover. The pollutants examined in this study were CO, NO_x and RSP. The vehicle emission rates on which the study is based were supplied by the Air Services Group of the Environmental Protection Department. The traffic flow data for Castle Peak Flyover were provided by the Transport Department. The data were presented in Passenger Car Units (PCU) which represent the predicted traffic flow in 2011. The distribution of emissions from different types of traffic were calculated from the traffic mix which was derived from a previous traffic count conducted in the vicinity of the study area and the emission factors given by EPD. The split between private cars and taxis as taken to be the same as for Harcourt Road in Ref 7. Both the emission data and traffic flow data are presented in Appendix IV and V respectively.

6.10 As the traffic travelling on the flyover must pass through tunnels, the modelling study has taken into account the dispersion of vehicle emissions at the tunnel portals. The traffic emissions along the open road part of the flyover were modelled using CALINE4. The emissions dispersing from the tunnel portals were modelled using the Industrial Source Complex Short Term Model (ISCST).

6.11 CALINE4 is a line source air quality model developed by the California Department of Transportation (Caltrans). It is based on the Gaussian diffusion equation and employs a mixing zone concept to characterise pollutant dispersion over a roadway. The traffic travelling in both directions was represented by a line source in the centre of the proposed road. Only the traffic within the study area (Apendix II) was included in the modelling study.

6.12 The ISCST model was developed by the US Environmental Protection Agency (USEPA). The model uses the Gaussian diffusion equation to calculate the dispersion of pollutants over a short period of time. The ISCST model allows emissions to be expressed as an area source. The vehicle emissions emerging from the tunnel portals were represented in the model as area sources. The area source had the same width as the tunnel portal and a length of 15 m. The length chosen is equivalent to the distance of the traffic-induced air flow that will displace the pollutant gases at the tunnel portals. The vehicle exhaust emitted within the tunnel is assumed to vent equally between both tunnel portals.

6.13 The dispersion of pollutants from the flyover will be effected by the presence of barriers situated at road side in order to reduce the propagation of noise from the road traffic (Ref 1). At sensitive receptors adjacent to the noise barriers only residences at a level above that of the barriers were considered.

6.14 Both models used assumed meteorological data consisting of:

- wind speed 2m/s
- atmospheric stability class D
- atmospheric mixing height 500 m
- wind directions taken every 10°
- ambient temperature of 25°C

6.15 By adding together the highest concentration given at each receptor by each model, levels will tend to be over estimated. The reason for this is that for any given receptor the wind direction that gives the highest level from emissions on open roads may not coincide with the wind direction that gives the highest level from emissions at tunnel portals.

7. RESULTS

7.1 Table 7.1 shows the dust (TSP) concentrations calculated using FDM. Values are given for maximum 24-hour and average annual concentrations at ground level.

Table 7.1 Predicted Dust Concentrations at Ground Level for the Flyover ($\mu g/m^3$)

Receptor	Max 24 Hours	Annual Average
1	96	41
2	577	104
3	164	45
4	185	51
5	626	119
6	214	60
7	172	59
8	136	53
9	124	56
10	144	68
11	169	113
12	341	138
13	285	118
14	298	53
15	197	45
16	188	41
17	529	206
18	476	198

7.2 Table 7.2 shows the predicted dust (TSP) concentration given in Table 7.1 reduced by 50% to represent the reduction due to mitigation measures and including background concentration from the Tsuen Wan Monitoring Station (taking highest recorded annual mean as background [126 μg/m^3]).

Table 7.2 Predicted Dust Concentrations at the Flyover Allowing for Mitigation and Background Levels (μg/m^3)

Receptor	Max 24 Hours	Annual Average
1	174	147
2	415	172
3	208	149
4	219	152
5	439	186
6	233	156
7	212	156
8	194	153
9	188	154
10	198	160
11	211	183
12	297	195
13	269	185
14	275	153
15	225	149
16	210	147
17	391	129
18	364	225

7.3 By considering the equations used in the algorithms in the FDM, which are given in ref 8, an estimation of a 30% reduction in dust concentrations between ground level and 10m above ground level can be considered a conservative assumption. Table 7.3 shows the results given in Table 7.2 reduced by 30% to represent a 10m increase in height.

Table 7.3 Predicted Dust Concentrations at Receptors 10m above Ground Level (μg/m^3)

Receptor	Max 24 Hours	Annual Average
1	122	103
2	291	120
3	146	104
4	153	106
5	307	130
6	163	109
7	148	109
8	136	107
9	132	108
10	139	112
11	148	128
12	208	137
13	188	130
14	193	107
15	158	104
16	147	103
17	274	96
18	255	158

7.4 Receptors 2, 5 and 17 are predicted to exceed the TSP 24-hour average AQO. In order to ensure that these receptors are safe guarded against excessive TSP exposure it is recommended that the areas within 50m of these receptors be restricted to a 6 hours working day for dust generating activities. Table 7.4 shows the predicted dust levels at these receptors assuming that a 30% reduction in TSP levels over a 24-hour period is achieved.

Table 7.4 **Predicted Dust Concentration with the Working Day Reduced to 6 Hours ($\mu g/m^3$)**

Receptor	Max 24 Hours
2	203.7
5	214.9
17	191.8

7.5 Table 7.5 and Table 7.6 show the combined results from the CALINE4 and ISCST modelling predictions for pollutant emissions at the operational stage. The values given in Table 7.5 represent the maximum annual 1-hour concentrations for those ASRs at a level above that of the road barriers (ie lowest exposure levels), and Table 7.6 gives the combined results for the predictions for pollutant emissions at 10 m above the ground level of each ASRs modelled (ie highest exposure levels).

Table 7.5 **Predicted Maximum 1-hour Concentrations from Vehicle Emissions for the Lowest Exposure Levels at the ASRs**

Receptor	CO concentration (ppm)	NO_X concentration (ppm)	RSP concentration ($\mu g/m^3$)
1	0.27 (315)	0.10 (193)	31.8
2	0.41 (474)	0.15 (282)	45.0
3	0.30 (355)	0.11 (207)	36.2
4	0.30 (355)	0.12 (223)	40.6
5	0.47 (553)	0.16 (310)	56.0
6	0.44 (514)	0.15 (295)	57.0
7	0.20 (278)	0.07 (139)	24.0
8	0.20 (278)	0.06 (121)	22.0
9	0.17 (198)	0.06 (111)	20.9
10	0.17 (198)	0.05 (102)	19.8
11	0.17 (198)	0.06 (116)	24.0
12	0.58 (672)	0.19 (372)	90.0
13	0.20 (238)	0.06 (123)	23.0
14	0.55 (632)	0.19 (369)	56.0
15	0.27 (315)	0.09 (174)	35.1
16	0.34 (395)	0.12 (228)	45.0
17	0.27 (315)	0.10 (190)	35.1
18	0.24 (276)	0.09 (167)	31.8

Note: values in brackets are in ug/m*^{3}

Table 7.6 **Predicted 1-hour Concentrations from Vehicle Emissions for the Highest Exposure Levels (10m above ground level) at the ASRs**

Receptor	CO concentration (ppm)	NO_x concentration (ppm)	RSP concentration ($\mu g/m^3$)
1	0.17 (193)	0.06 (113)	20.0
2	0.21 (245)	0.07 (139)	24.0
3	0.15 (175)	0.06 (110)	21.0
4	0.15 (175)	0.05 (100)	18.46
5	0.17 (193)	0.06 (116)	21.0
6	0.11 (123)	0.06 (107)	18.46
7	0.18 (210)	0.06 (113)	20.0
8	0.14 (158)	0.05 (100)	17.5
9	0.14 (158)	0.05 (92)	16.5
10	0.15 (175)	0.05 (87)	17.5
11	0.14 (158)	0.05 (97)	18.5
12	0.14 (158)	0.05 (103)	18.5
13	0.14 (158)	0.06 (108)	21.0
14	0.18 (210)	0.07 (144)	25.4
15	0.20 (228)	0.07 (129)	24.4
16	0.18 (210)	0.06 (110)	23.4
17	0.18 (210)	0.06 (115)	21.0
18	0.14 (158)	0.06 (107)	20.0

Note: values in brackets are in ug/m^3*

Table 7.7 shows the RSP levels obtained in the modelling study expressed as maximum 24-hour averages so they can be directly compared with the relevant AQO. A background level of 94 μg/m^3 was taken, this is the 90th percentile RSP value for 1992 (last complete year of monitored data) taken from Tsuen Wan monitoring station. A 50% conversion factor has been assumed to convert 1-hour maximum averages to 24-hour maximum averages.

Table 7.7 Predicted Maximum 24-hour Concentration for RSP at the Lowest Exposure Levels

Receptor	RSP Concentration (μg/m^3)
1	109.9
2	116.5
3	112.7
4	114.3
5	122
6	122.5
7	106
8	105
9	104.5
10	103.9
11	106
12	139
13	105.5
14	122
15	111.6
16	116.5
17	111.6
18	109.9

8. MONITORING AND AUDIT REQUIREMENT

8.1 The Government departments, or designated contractors responsible for the Castle Peak Road Flyover should also be responsible for monitoring the air quality related to the construction and operation of the sites.

8.2 Auditing of monitoring results will be required to ensure that the construction and operation of the site is compliant with relevant environmental standards and guidelines, and performance criteria.

8.3 The roles of monitoring and auditing are distinct, and responsibilities for monitoring and audit should be determined by the respective Government departments. It is recommended that the monitoring and audit role should be independent from the Government department or designated contractor.

8.4 The environmental monitoring programme should have the following characteristics:

(i) It must provide adequate baseline information which to determine practical trigger and action levels;

(ii) It should provide continuity of environmental management throughout the baseline construction and operational monitoring phases of the development; and

(iii) It should provide high quality information which can be utilised via a feedback loop to assess compliance with legislative standards, appropriate guidelines and performance criteria.

8.5 The key requirements of the auditing role are as follows:

(i) It should be independent of the relevant Government departments, or designated site contractor;

(ii) It should provide regular and independent reports on the standard of performance of the development; and

(iii) The cost of the auditing role should be met by the relevant Government departments, or designated site contractor. In the latter case costs should be based on terms established by Government and set out in the tender document.

8.6 Contract Specification for the construction and operation development should include a specification and programme for atmospheric monitoring and audit role. Details of monitoring regimes and monitoring and audit responsibilities should be set out in a site operations manual prepared by the relevant Government departments.

8.7 The role of the independent auditor should be as follows:

(i) To establish the degree of compliance with legislative standards, appropriate guidelines and environmental performance criteria.

(ii) To review changes in measured air quality parameters to detect any deterioration in environmental conditions associated with the construction and operation of the development.

(iii) To review management practices critical to the environmental integrity of the development site.

(iv) To recommend improvements to the management practices and specify mitigation measures in the form of Action Plans to reduce adverse environmental impacts which are in breach of Trigger, Action and Target (TAT) levels.

(v) To conduct review meetings with the site contractor(s) and EPD representatives to consider environmental performance.

(vi) To conduct audits on a regular and frequent basis during construction of the development.

8.8 Trigger, Action and Target levels are defined as follows:

- Trigger level: the trigger level is to provide an indication that environmental parameters are exceeding normal expected variability;
- Action level: the action level is to provide an indication that appropriate remedial actions should be implemented to prevent unacceptable deterioration in the environmental quality of a parameter; and
- Target level: the target level is based on legislative standards and/or recognised environmental performance guidelines and represents the maximum level of an environmental parameter at which the works can proceed.

8.9 The establishment of trigger levels is dependent on the collection of a comprehensive and scientifically robust environmental data set on baseline ambient conditions. Existing available data should be supplemented by additional baseline monitoring data collected just prior to the commencement of construction, so that the monitoring period is of sufficient duration to allow for the collection of representative data. Normal temporal and spatial variations in an environmental parameter need to be established, such that the trigger level can be set at the appropriate statistical boundary of the data range. Action levels should be set a mid-value (approximately) of the trigger and target levels (as defined by legislative standards and/or recognised environmental performance guidelines). Trigger and action levels should be specified in a manner which is sensitive to genuine environmental deterioration, but such that they do not result in the unnecessary interference or cessation of works.

8.10 It is important that remedial actions are implemented in a positive manner by the contractors representative (e.g. site environmental officer) to the progress of the works, and should involve pragmatic and cost-effective solutions to environmental impacts. Environmental protection measures related to exceedance of trigger and action levels should be implemented in a timely and efficient manner so as to avoid breaches of the appropriate target levels. Remedial action should be implemented through Action Plans, which are specific to the final sequence of works and *Modus operandi* of the construction and operational phases of the development. A framework for the Action Plans is shown in Table 8.1, and it is recommended that these be finalised by the Contractors(s), and approved by the Employer, following completion of the baseline monitoring programme and design of works. Remedial actions should be based upon mitigation measures specified in the individual chapters of this report, as related to working practices and physical control measures.

Table 8.1 Action Plans for Exceedance of Trigger, Target and Action Levels

Performance Level	Action 1	Action 2	Action 3
Trigger	Notify contractor. Identify source of exceedance, review working practice	With cooperation of contractor, specify simple remedial measures to alleviate impact, as related to working practices and proximity to sensitive receivers.	Notify exceedance in regular monitoring reports, together with any remedial steps taken.
Action	Notify contractor. Commence additional monitoring in the proximity of the source and at nearest sensitive receiver(s).	Instruct contractor of remedial action required in relation to working practices or physical measures to prevent further deterioration in environmental quality.	Notify exceedance to Employer and in regular monitoring report, together with additional monitoring data and remedial steps taken.
Target	Notify contractor and Employer immediately. Continue additional monitoring at increased frequency and locations until it is proven that environmental impact has reverted back to acceptable level.	Implement immediate remedial measures to curtail environmental impact and notify contractor and Employer of potential cessation of works failing any measured improvement.	Provide detailed report to Contractor and Employer relating to exact data and reasons for exceedance. Include description of remedial action taken and present monitoring data to demonstrate abatement of impact to acceptable impact following implementation of remedial measures. Provide reference instructions to avoid repeat of similar adverse impact.

Baseline Monitoring

8.11 The purpose of baseline monitoring is to establish the ambient air quality prior to development. This will allow assessment of the magnitude of predicted impacts as a result of the development. Baseline monitoring also permits the determination of environmental performance criteria and the suitable setting of trigger and action levels.

8.12 The key impacts during the construction stage will be total suspended particulates, the environmental impact assessment has shown that not insignificant concentration levels may be expected at a number of the sensitive receptors. Baseline dust levels, therefore, are an important parameter to establish.

8.13 Monitoring of nitrogen dioxide and respirable suspended particulates should be carried out to establish baseline levels. These results will be analysed in association with results from operational monitoring.

8.14 One monitoring location is required to establish the baseline situation as the site is of a limited size and limited background variation in air quality may be expected within it.

8.15 Frequency and performance criteria for baseline monitoring are given in Table 8.2

Construction Monitoring

8.16 The purpose of construction monitoring is to detect any unacceptable environmental impacts according to legislative standards, appropriate guidelines and establish environmental performance criteria.

8.17 The key issues during the construction stage is total suspended particulate. It is important that appropriate action plans are implemented in order to contain and control problems that stem from dust generating activities during construction.

8.18 It is desirable to monitor at at least two sites in order to ensure representative data is obtained. The sites should be positioned as near as possible to sensitive receivers close to the proposed highway.

8.19 Further details on frequency and performance criteria of construction monitoring are given in Table 8.3

Operational Monitoring

8.20 The purpose of monitoring in the operational phase is to establish the exactitude of air quality predictions made in this report. It will provide insight to the necessity for further mitigation measures.

8.21 A single monitoring site should be used to gather data on nitrogen dioxide and respirable suspended particulates. The site should be positioned to allow compassion of the resulting analysis of the data to predictions made in the impact assessment.

8.22 Further details on frequency and performance criteria of monitoring to be undertaken in the operational stage are given in Table 8.4

Table 8.2 Summary of Requirements for Baseline Monitoring

Parameter	Location	Frequency
TSP, RSP, NO_2	One location site positioned at least 25m from road side.	Continous monitoring for two week period. 1 hour measurement 3 times/day and 24 hour measurement.

Table 8.3 Summary of Standards, Guidelines and Performance Criteria for Construction Monitoring

Parameter	Location	Frequency	Compliance Objectives
TSP	Two locations at sensitive receptors close to construction site	Continuously through working hours. 1 hour measurements 3 times/day and 24 hour measurements.	Hourly average concentration not to exceed 500µg/m. 24 hours concentration not to exceed 260µg/m more than once per year.

Table 8.4 Summary of Standards, Guidelines and Performance Criteria for Operational Monitoring

Parameter	Location	Frequency	Compliance Objectives
RSP	One location of a sensitive receptor close to Highway	for two week period	24 hour concentration not to exceed 180 μg/m^3
NO_2	as above	as above	Maximum hourly concentration not to exceed 300 μg/m more than three times in a year. 24 hour concentration not to exceed 150 μg/m more than once per year.

9. CONCLUSIONS & RECOMMENDATIONS

9.1 An effective watering programme (twice daily with complete covering) is estimated to reduce construction dust emissions by 50%. By applying a 50% reduction to predicted levels the majority of the ASRs, are within the Air Quality Objectives (AQOs) of 260 and 80µg/m for 24-hour and annual means respectively. Nevertheless, as seen in Table 7.2, the addition of monitored background levels of TSP cause the predicted levels to exceed the AQO at a number of ASRs. However the predicted levels of TSP are significantly reduced at 10 m above ground level as per indicated in Table 7.3. Nevertheless, to ensure that the AQOs are not exceeded, it is recommended that particular consideration and care should be given to dust mitigation measures.

9.2 In addition to water suppression methods for dust control at the site surface, it is also recommended that the following mitigation measures be applied to ensure that relevant guidelines and AQOs are not exceeded:

- Work should be carried out in such a manner that avoidable dust is not generated. Screens, dust sheets, tarpaulins or other methods agreed by the employer should be used to prevent generation of dust.
- Materials, including earthworks material, from which dust may be generated when being transported to or from the site should be wetted and covered.
- In the process of material loading or unloading, any material which has the potential to create dust should be treated with water or wetting agent sprays prior to being loaded into or unloaded from a vehicle.
- Any vehicle with an open load carrying area used for moving materials which have the potential to create dust should have properly fitting side and tail boards. Materials having the potential to create dust should not be loaded to a level higher than the side and tail boards, and should be completely covered by a clean tarpaulin which should be properly secured.
- Dust on hard surfaced routes and road edges within the site should be removed regularly. Access roads to the site should be kept entirely free of dust, mud or other wastes.
- Water sprays should be provided and used both to dampen stored materials and when receiving construction material. Increasing the watering programme will reduce the generation of air borne dust.
- ASRs that the study has shown may suffer from excessive dust exposure may be protected by the erecting of a screen that would provide a physical sheild against wind driven dust.
- To reduce the risk of exceeding the 24-hour TSP AQO close to receptors 2, 5 and 17 it is recommended that the number of hours in which dust generating activities are carried out is restricted to 6 hours in a single day, in an area 50m adjacent to the receptors.

9.3 Predicted dust levels (respirable suspended particulates) resulting from vehicle emissions at the operational stage of the flyover are not expected to exceed relevant AQOs, and no particular mitigation measures to control ambient levels are recommended.

9.4 Table 7.4 gives the predicted gas concentrations from vehicular emissions. Maximum predicted 1-hour CO levels of 672µg/m^3 is significantly below the AQO 1-hour level of 30,000 µg/m^3. Therefore predicted levels are not likely to be detrimental to human health, and no particular mitigation measures to control ambient CO levels are recommended.

9.5 Maximum predicted NO_x levels of 372µg/m^3 (NO and NO_2) may be adjusted for predicted NO_2 levels. A worst case 20% conversion factor has been previously used. Therefore by applying this adjustment factor, the maximum predicted 1-hour level is 74µg/m^3. The 90th percentile value monitored background levels for the Tsuen Wan monitoring station for 1992 (last complete year of monitoring) is 105µg/m^3 (see Table 4.1). This can be taken as worst case background. If the monitored background NO_2 level and predicted 1-hour maximum NO_2 level are added together then the 1-hour AQO of 300µg/m^3 is not exceeded. Table 7.5 shows that the levels of pollutant emissions predicted at 10 m above ground level for each ASRs modelled are significantly reduced.

9.6 The predicted NO_2 1-hour maximum value of 74µg/m^3 represents the combined impact from the tunnel portals and open road emissions. This predicted level is worst case and may not occur as the wind direction that gives the highest level from emissions on open roads at any ASR is unlikely to coincide with the wind direction that gives the highest level from emissions at tunnel portals.

9.7 The predicted 1-hour RSP levels obtained in the modelling studies cannot be directly compared to the 24-hour AQO of 180 µg/m^3. Taking the 90th percentile RSP value for 1992 (last complete year of monitored data) which is 94 µg/m^3 as a worst case background level the maximum predicted total RSP level (predicted and background) for 1-hour average is 184 µg/m^3. Assuming a 50% conversion factor for 1-hour to 24-hour levels, a predicted total RSP level for 24-hours is 139 µg/m^3 which is in compliance with the AQO.

REFERENCES

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5. Bennett J.H. et al, Assessment of Fugitive Emissions from Sand and Gravel Processing Operations, 73rd Annual Meeting of the Air Pollution Control Association, Montreal, June 1980.

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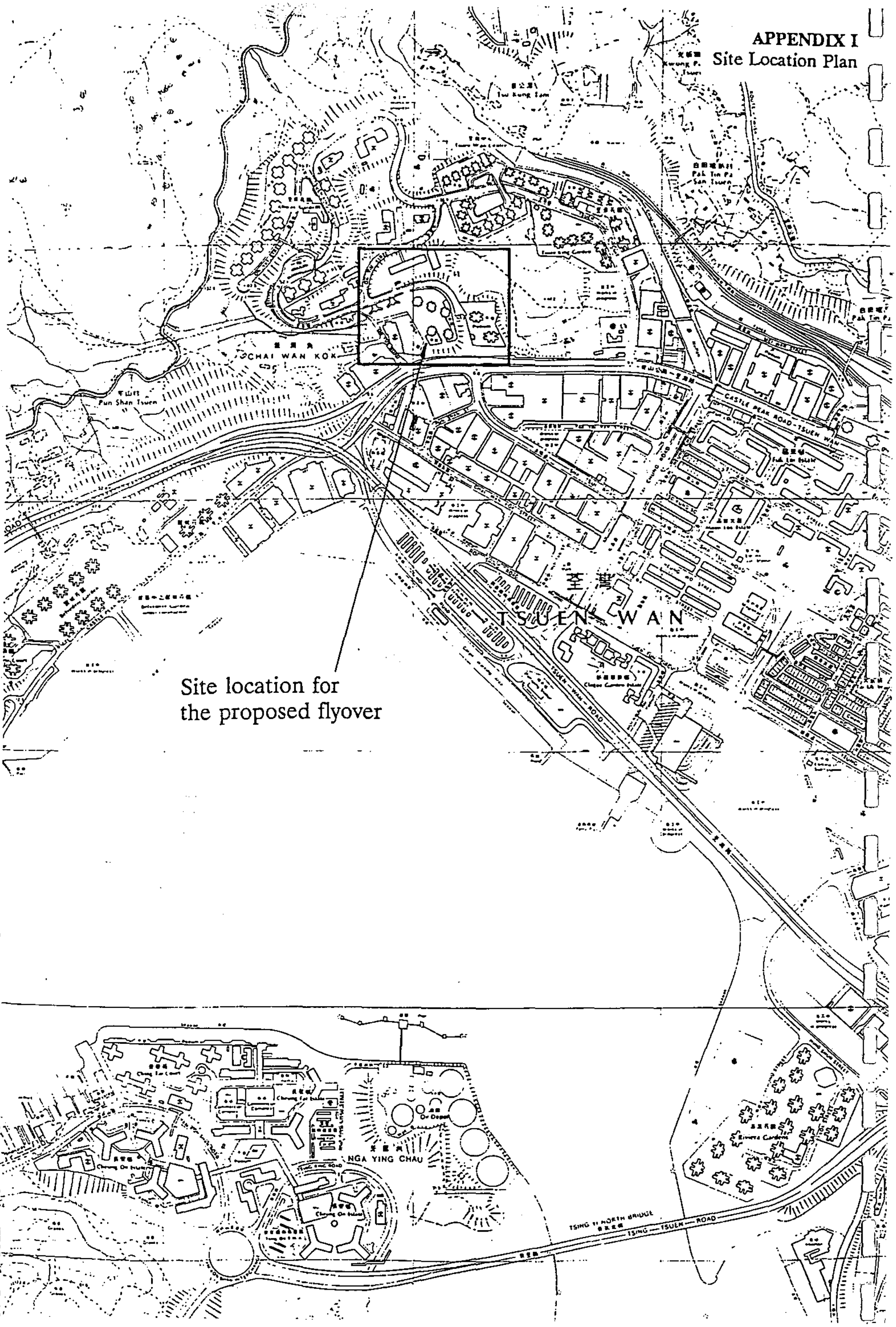
8. Trinity Consultants, Manual for Fugitive Dust Model 1992.

APPENDICES

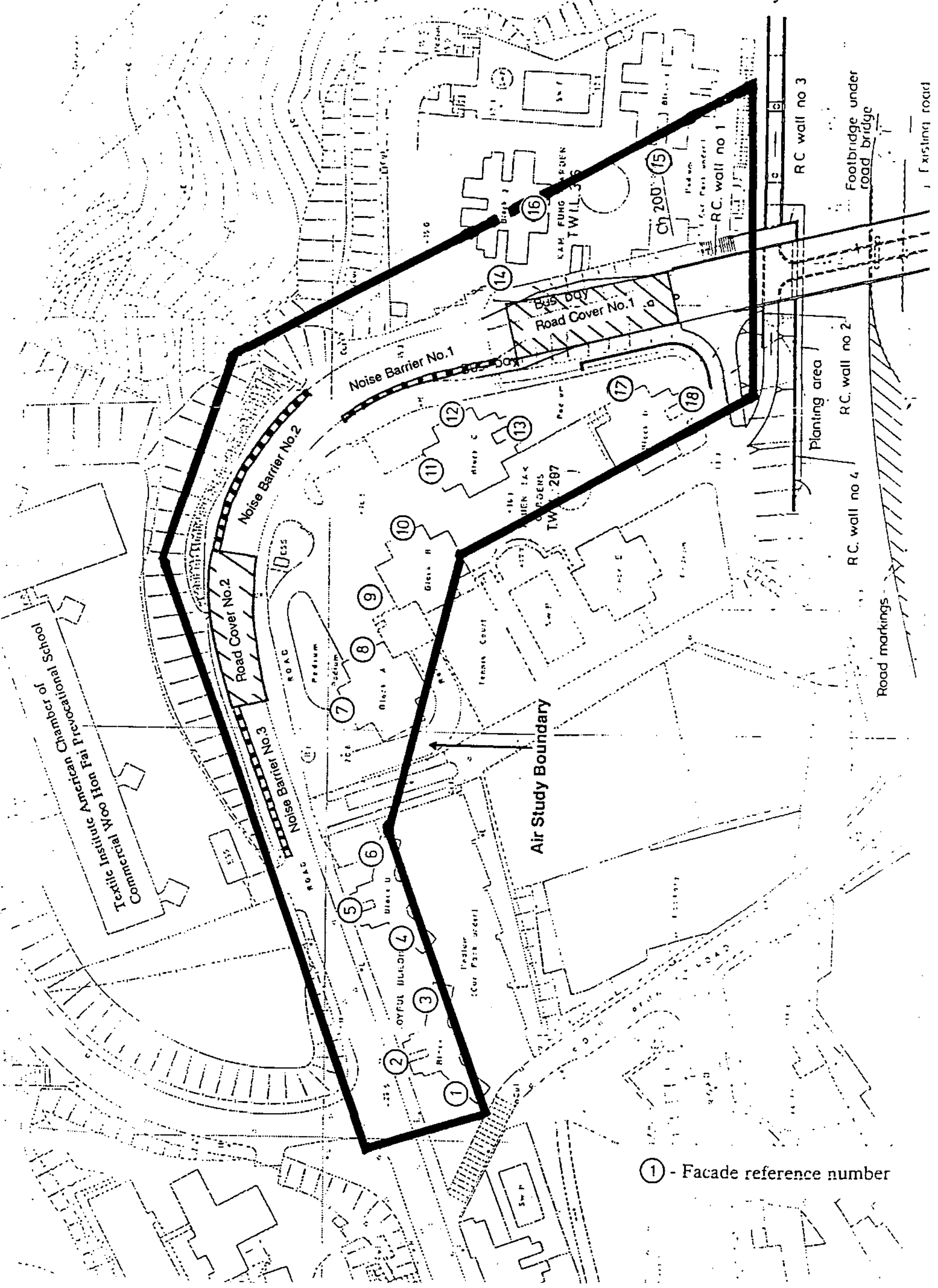
APPENDIX I
Site Location Plan



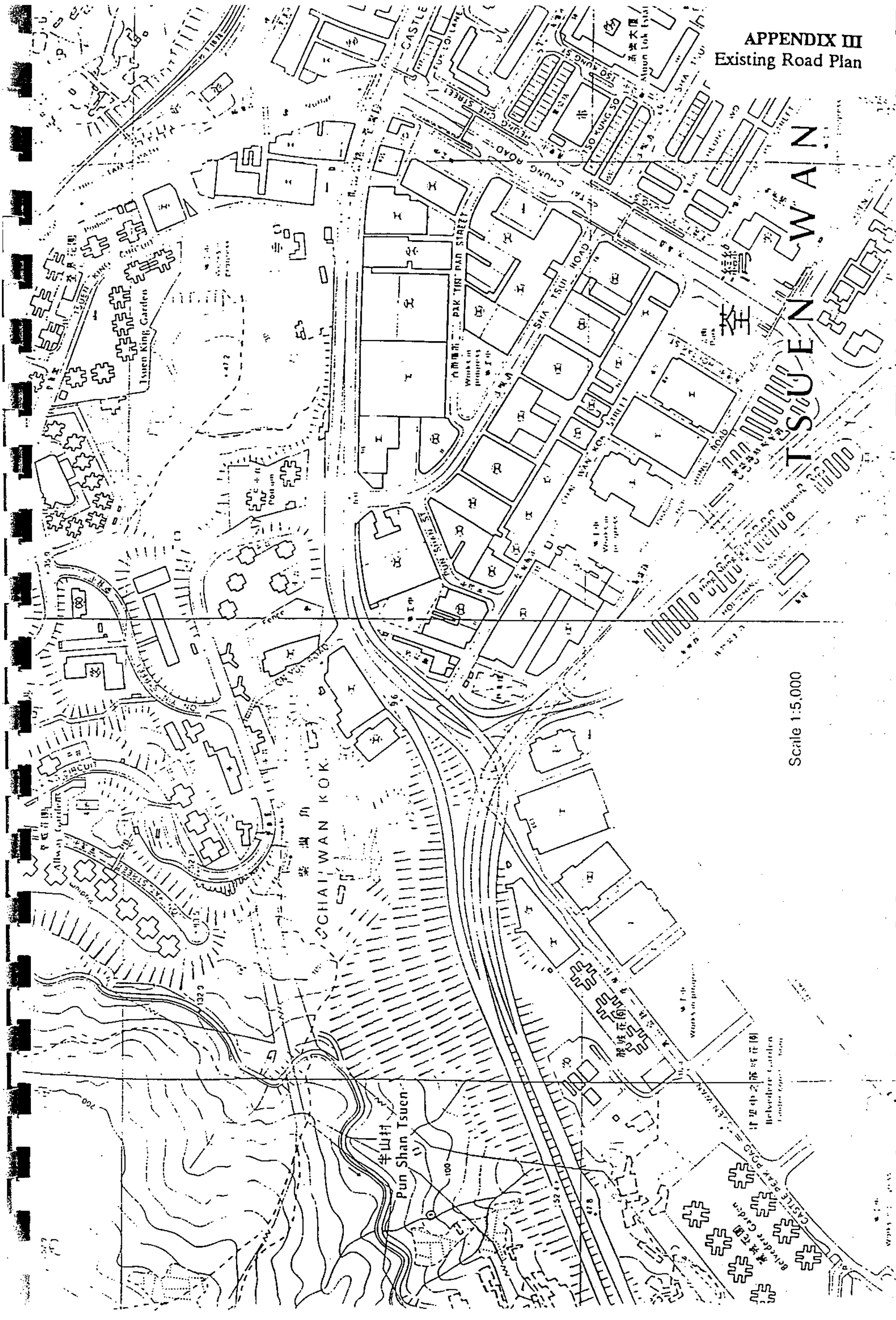
Site location for
the proposed flyover

APPENDIX II

General Plan of Proposed Flyover and Area of Study



APPENDIX III
Existing Road Plan



Scale 1:5,000

APPENDIX IV

Vehicle Emission Factors (1992 - 2011)
(Part 1)

Pollutant: PM 10 (RSP)
Gross Factor: Y
I&M: N

Year	M/C	P/C-p	P/C-d	Taxi	PuBus	PrBus	PuLB	PrLB	LGV-pI	LGV-dI	LGV-pII	LGV-dII	MGV	HGV
1992	0.040	0.040	0.765	0.730	1.491	1.445	0.752	0.739	0.039	0.750	0.039	0.751	1.442	1.442
1993	0.040	0.041	0.766	0.728	1.495	1.447	0.752	0.738	0.039	0.752	0.039	0.755	1.443	1.443
1994	0.040	0.041	0.757	0.730	1.500	1.447	0.752	0.740	0.039	0.753	0.039	0.752	1.444	1.444
1995	0.040	0.041	0.753	0.721	1.494	1.445	0.752	0.734	0.039	0.740	0.039	0.742	1.440	1.440
1996	0.040	0.041	0.711	0.627	1.489	1.418	0.695	0.671	0.039	0.668	0.039	0.700	1.422	1.421
1997	0.040	0.041	0.684	0.528	1.507	1.401	0.638	0.611	0.039	0.626	0.039	0.650	1.388	1.389
1998	0.040	0.041	0.640	0.433	1.498	1.374	0.581	0.544	0.039	0.574	0.039	0.609	1.373	1.371
1999	0.040	0.041	0.596	0.334	1.488	1.346	0.523	0.477	0.039	0.525	0.039	0.568	1.349	1.353
2000	0.040	0.041	0.552	0.238	1.480	1.319	0.466	0.411	0.039	0.474	0.039	0.528	1.336	1.334
2001	0.040	0.041	0.507	0.237	1.471	1.291	0.409	0.344	0.039	0.422	0.039	0.486	1.317	1.315
2002	0.040	0.041	0.455	0.239	1.481	1.256	0.352	0.341	0.039	0.370	0.039	0.443	1.294	1.295
2003	0.040	0.041	0.413	0.239	1.471	1.256	0.352	0.342	0.039	0.317	0.039	0.402	1.275	1.276
2004	0.040	0.041	0.370	0.239	1.461	1.256	0.352	0.342	0.039	0.255	0.039	0.359	1.256	1.255
2005	0.040	0.041	0.326	0.239	1.451	1.257	0.352	0.341	0.039	0.266	0.039	0.360	1.260	1.257
2006	0.040	0.041	0.285	0.239	1.441	1.257	0.352	0.342	0.039	0.266	0.039	0.360	1.258	1.258
2007	0.040	0.041	0.282	0.238	1.411	1.257	0.352	0.341	0.039	0.265	0.039	0.360	1.255	1.257
2008	0.040	0.041	0.283	0.238	1.403	1.257	0.352	0.342	0.039	0.265	0.039	0.360	1.259	1.258
2009	0.040	0.041	0.283	0.238	1.393	1.257	0.352	0.341	0.039	0.266	0.039	0.360	1.257	1.259
2010	0.040	0.041	0.284	0.238	1.383	1.257	0.352	0.342	0.039	0.266	0.039	0.360	1.261	1.259
2011	0.040	0.041	0.282	0.238	1.375	1.257	0.352	0.342	0.039	0.265	0.039	0.361	1.259	1.260

Pollutant: NOx
Gross Factor: Y
I&M: N

Year	M/C	P/C-p	P/C-d	Taxi	PuBus	PrBus	PuLB	PrLB	LGV-pI	LGV-dI	LGV-pII	LGV-dII	MGV	HGV
1992	0.547	2.221	1.782	1.727	13.214	12.298	2.332	2.311	1.802	1.786	3.604	2.346	7.926	12.306
1993	0.547	2.142	1.702	1.531	13.148	12.299	2.332	2.310	1.684	1.761	3.601	2.348	7.928	12.309
1994	0.548	2.057	1.621	1.348	13.087	12.299	2.332	2.311	1.568	1.734	3.607	2.348	7.930	12.312
1995	0.548	1.981	1.539	1.155	12.849	12.263	2.332	2.301	1.451	1.707	3.525	2.326	7.932	12.214
1996	0.548	1.900	1.457	0.968	12.665	11.908	2.253	2.214	1.334	1.679	3.278	2.270	7.935	11.951
1997	0.549	1.849	1.395	0.777	12.603	11.597	2.175	2.132	1.200	1.644	3.020	2.199	7.915	11.626
1998	0.549	1.762	1.309	0.778	12.394	11.236	2.096	2.040	1.086	1.617	2.795	2.144	7.923	11.372
1999	0.549	1.676	1.222	0.777	12.178	10.874	2.018	1.949	0.969	1.591	2.570	2.086	7.918	11.114
2000	0.549	1.593	1.136	0.778	11.974	10.513	1.939	1.857	0.853	1.564	2.342	2.032	7.928	10.854
2001	0.549	1.504	1.049	0.777	11.763	10.151	1.861	1.765	0.736	1.537	2.112	1.975	7.930	10.592
2002	0.548	1.403	0.956	0.779	11.718	9.773	1.782	1.761	0.735	1.537	1.881	1.915	7.926	10.324
2003	0.548	1.317	0.871	0.780	11.585	9.774	1.782	1.762	0.734	1.537	1.646	1.859	7.928	10.060
2004	0.549	1.319	0.872	0.779	11.452	9.774	1.782	1.762	0.735	1.538	1.416	1.801	7.930	9.794
2005	0.548	1.320	0.872	0.779	11.318	9.774	1.782	1.761	0.737	1.539	1.415	1.802	7.938	9.796
2006	0.548	1.319	0.872	0.779	11.185	9.774	1.782	1.762	0.737	1.539	1.417	1.802	7.934	9.798
2007	0.548	1.318	0.871	0.779	10.984	9.775	1.782	1.761	0.736	1.538	1.415	1.801	7.930	9.794
2008	0.548	1.319	0.872	0.778	10.860	9.775	1.782	1.762	0.736	1.538	1.416	1.802	7.937	9.797
2009	0.548	1.318	0.872	0.779	10.732	9.775	1.782	1.761	0.739	1.539	1.416	1.802	7.934	9.799
2010	0.549	1.320	0.873	0.778	10.601	9.775	1.782	1.762	0.737	1.540	1.418	1.802	7.940	9.800
2011	0.548	1.321	0.870	0.779	10.475	9.775	1.782	1.762	0.738	1.540	1.417	1.803	7.937	9.802

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Key : MC = Motor Cycle (Petrol)
PC-p = Private Car (Petrol)
PC-d = Private Car (Diesel)
Taxi = Taxi (Diesel)
PuBus = Public Bus (Diesel)
PrBus = Private Light Bus (Diesel)
PuLB = Public Light Bus (Diesel)

PrLB = Private Light Bus (Diesel)
L-pI = Light Goods Vehicle below 2.5 ton GVW (Petrol)
L-dI = Light Goods Vehicle below 2.5 ton GVW (Diesel)
L-pII = Light Goods Vehicle 2.5T (GVW (5.5T (Petrol)
L-dII = Light Godds Vehilce 2.5T (GVW (5.5T (Diesel)
MGV = Medium Goods Vehicle
HGV = Heavy Goods Vehicle

APPENDIX IV

Vehicle Emission Factors (1992 - 2011) (Part 2)

Pollutant: CO
Gross Factor: Y
I&M: N

Year	M/C	P/C-p	P/C-d	Taxi	PuBus	PrBus	PuLB	PrLB	LGV-pI	LGV-dI	LGV-pII	LGV-dII	MGV	HGV
1992	25.146	19.331	1.027	0.909	8.892	8.318	1.089	1.064	10.968	0.986	10.975	1.117	8.392	8.392
1993	25.188	18.368	1.028	0.908	8.902	8.319	1.089	1.063	9.734	0.987	9.678	1.119	8.395	8.396
1994	25.275	17.342	1.029	0.909	8.918	8.319	1.089	1.064	8.508	0.988	8.532	1.119	8.398	8.398
1995	25.258	16.415	1.029	0.908	8.925	8.319	1.089	1.063	8.157	0.988	8.178	1.119	8.401	8.401
1996	25.335	15.425	1.030	0.909	8.935	8.320	1.089	1.064	7.803	0.989	7.764	1.120	8.405	8.404
1997	25.671	15.524	1.039	0.908	9.003	8.338	1.089	1.067	7.303	0.984	7.312	1.115	8.379	8.380
1998	25.721	15.219	1.040	0.909	9.005	8.338	1.089	1.067	6.972	0.984	6.972	1.116	8.398	8.384
1999	25.724	14.913	1.040	0.908	9.004	8.338	1.089	1.067	6.620	0.985	6.627	1.115	8.381	8.388
2000	25.728	14.645	1.040	0.910	9.008	8.338	1.089	1.067	6.279	0.986	6.279	1.118	8.396	8.392
2001	25.731	14.300	1.040	0.909	9.010	8.338	1.089	1.067	5.957	0.987	5.927	1.119	8.399	8.395
2002	25.465	13.752	1.033	0.911	9.054	8.320	1.089	1.063	5.928	0.987	5.939	1.118	8.392	8.395
2003	25.462	13.430	1.034	0.912	9.064	8.320	1.089	1.064	5.892	0.987	5.921	1.119	8.395	8.398
2004	25.516	13.477	1.034	0.911	9.064	8.320	1.089	1.064	5.953	0.988	5.961	1.119	8.398	8.400
2005	25.491	13.489	1.035	0.911	9.054	8.321	1.089	1.063	5.963	0.989	5.944	1.120	8.409	8.403
2006	25.505	13.472	1.035	0.911	9.064	8.321	1.089	1.054	5.972	0.989	5.980	1.120	8.403	8.405
2007	25.449	13.457	1.034	0.910	9.009	8.321	1.089	1.063	5.940	0.988	5.939	1.120	8.398	8.401
2008	25.499	13.471	1.034	0.909	9.013	8.321	1.089	1.064	5.951	0.988	5.950	1.120	8.408	8.403
2009	25.480	13.457	1.034	0.910	9.014	8.322	1.089	1.063	5.998	0.989	5.960	1.121	8.403	8.406
2010	25.527	13.497	1.036	0.909	9.013	8.322	1.089	1.064	5.959	0.990	5.991	1.121	8.412	8.408
2011	25.508	13.508	1.032	0.910	9.017	8.322	1.089	1.064	5.978	0.990	5.977	1.122	8.407	8.410

Pollutant: HC
Gross Factor: Y
I&M: N

Year	M/C	P/C-p	P/C-d	Taxi	PuBus	PrBus	PuLB	PrLB	LGV-pI	LGV-dI	LGV-pII	LGV-dII	MGV	HGV
1992	11.552	1.319	0.384	0.295	2.437	2.338	0.726	0.707	1.481	0.353	2.012	0.748	2.349	2.349
1993	11.583	1.271	0.385	0.294	2.439	2.338	0.726	0.706	1.419	0.354	2.006	0.749	2.350	2.350
1994	11.646	1.219	0.385	0.295	2.405	2.330	0.726	0.703	1.359	0.355	1.982	0.736	2.328	2.328
1995	11.634	1.174	0.386	0.294	2.381	2.253	0.684	0.653	1.299	0.355	1.891	0.706	2.271	2.271
1996	11.689	1.124	0.386	0.295	2.359	2.176	0.641	0.606	1.238	0.355	1.789	0.675	2.214	2.214
1997	11.932	1.099	0.392	0.294	2.362	2.107	0.599	0.561	1.154	0.352	1.678	0.637	2.144	2.144
1998	11.968	1.046	0.393	0.295	2.334	2.029	0.556	0.511	1.097	0.352	1.591	0.607	2.090	2.088
1999	11.971	0.993	0.393	0.294	2.306	1.950	0.514	0.462	1.037	0.353	1.502	0.576	2.029	2.032
2000	11.973	0.943	0.393	0.295	2.280	1.872	0.471	0.412	0.978	0.354	1.412	0.546	1.977	1.976
2001	11.976	0.887	0.393	0.294	2.252	1.793	0.429	0.412	0.918	0.354	1.322	0.516	1.919	1.919
2002	11.758	0.822	0.389	0.296	2.243	1.789	0.429	0.410	0.917	0.354	1.231	0.484	1.860	1.860
2003	11.781	0.769	0.389	0.296	2.214	1.789	0.429	0.411	0.912	0.354	1.135	0.453	1.802	1.803
2004	11.820	0.771	0.389	0.295	2.185	1.789	0.429	0.411	0.921	0.355	1.141	0.453	1.803	1.803
2005	11.802	0.772	0.389	0.296	2.157	1.789	0.429	0.410	0.922	0.355	1.139	0.454	1.805	1.804
2006	11.812	0.771	0.389	0.295	2.128	1.790	0.429	0.411	0.924	0.355	1.144	0.454	1.804	1.804
2007	11.772	0.770	0.389	0.295	2.083	1.790	0.429	0.410	0.919	0.355	1.138	0.454	1.803	1.803
2008	11.808	0.771	0.389	0.295	2.056	1.790	0.429	0.411	0.921	0.355	1.140	0.454	1.805	1.804
2009	11.794	0.770	0.389	0.295	2.028	1.790	0.429	0.410	0.928	0.356	1.141	0.454	1.804	1.804
2010	11.828	0.772	0.390	0.295	2.000	1.790	0.429	0.411	0.925	0.356	1.146	0.454	1.805	1.805
2011	11.814	0.773	0.388	0.295	1.972	1.790	0.429	0.411	0.925	0.356	1.144	0.455	1.805	1.805

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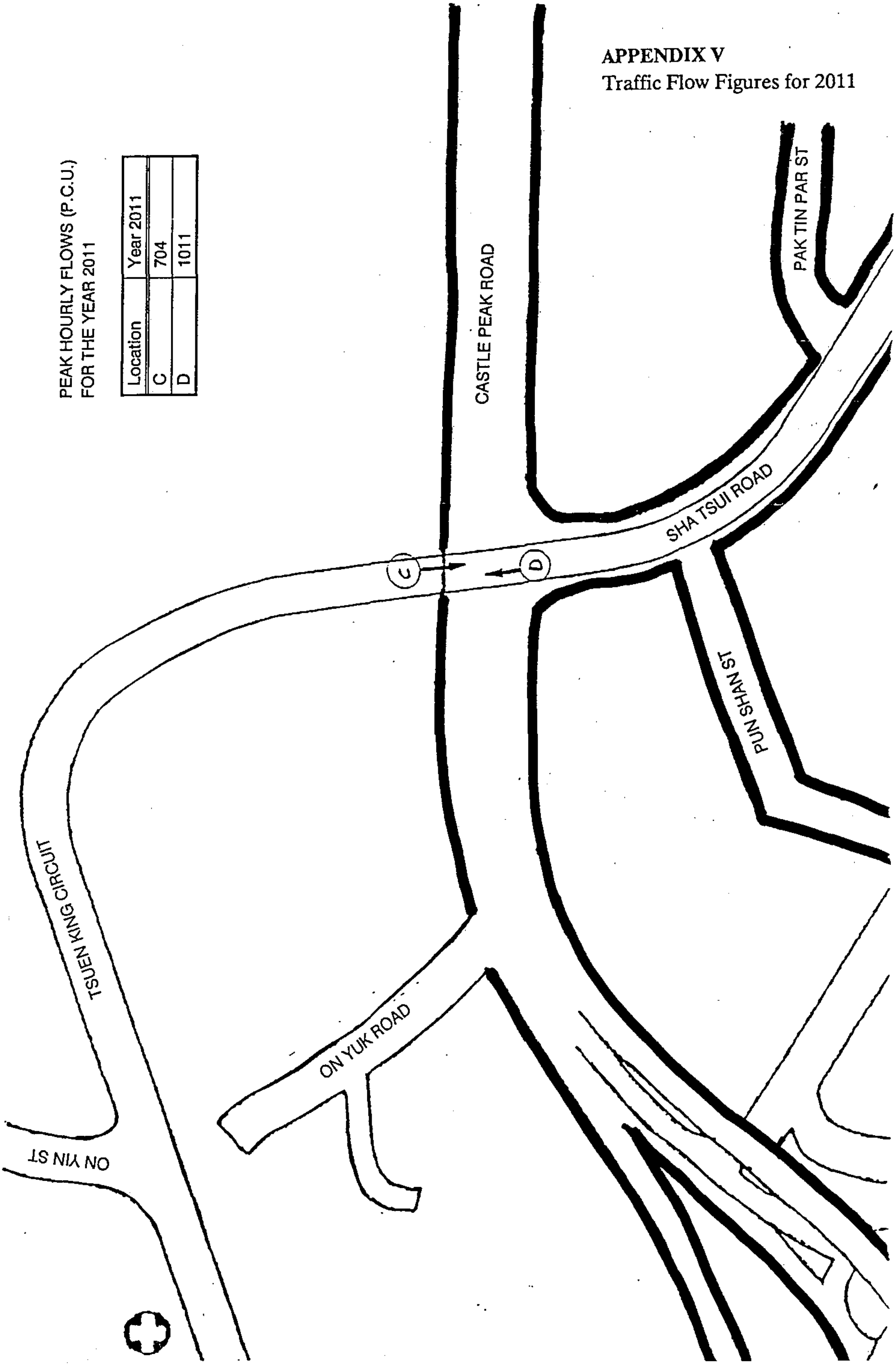
APPENDIX V

Traffic Flow Figures for 2011

PEAK HOURLY FLOWS (P.C.U.)
FOR THE YEAR 2011

Location	Year 2011
C	704
D	1011



Scott Wilson Kirkpatrick · 38th Floor Metroplaza Tower 1 · 223 Hing Fong Road · Kwai Fong · Hong Kong
Telephone (852) 428 8866 · Fax (852) 428 9922