9.3.2 Reduction of Air Pollutant Emission from Motor Vehicles

Motor Vehicles are the major contributor to CO and NOx air pollution in the Kelang Valley Region. Exhaust gas regulation is the most important of the control measures for motor vehicles mentioned in the previous section. Other measures are considered to enforce the exhaust gas regulation. Besides, it is difficult to estimate their effect quantitatively on reducing air pollutant emission from vehicles. So, this section will examine only the effect of vehicle exhaust gas regulation on air pollution load on the assumption that both the introduction of mass transportation system and improvement of the road network in KVR (measures for traffic and transportation) will be completed by 2005.

(1) Traffic Volume

1) Major Roads

Traffic volume on major roads was based on the study conducted by JICA (#6008). Since the assigned traffic volume was that of 24-hour total by four different vehicle types, namely motorcycles, motor cars (including taxis), buses and trucks (including vans, lorries and trailers), the traffic volume was further subdivided into 9 vehicle types and 24 time-zones. The major road network in 2005 is shown in Fig. 9.3.1. The total distance of the major roads is 1,274.6 km.

2) Minor Roads

Traffic volume and distance travelled on minor roads were estimated as explained in Section 5.2.2.

(2) Average Vehicle Speed

For the average vehicle speed for different regions, the classification for the current year was used with the addition of several expressways in Zone 4 (Table 9.3.3).

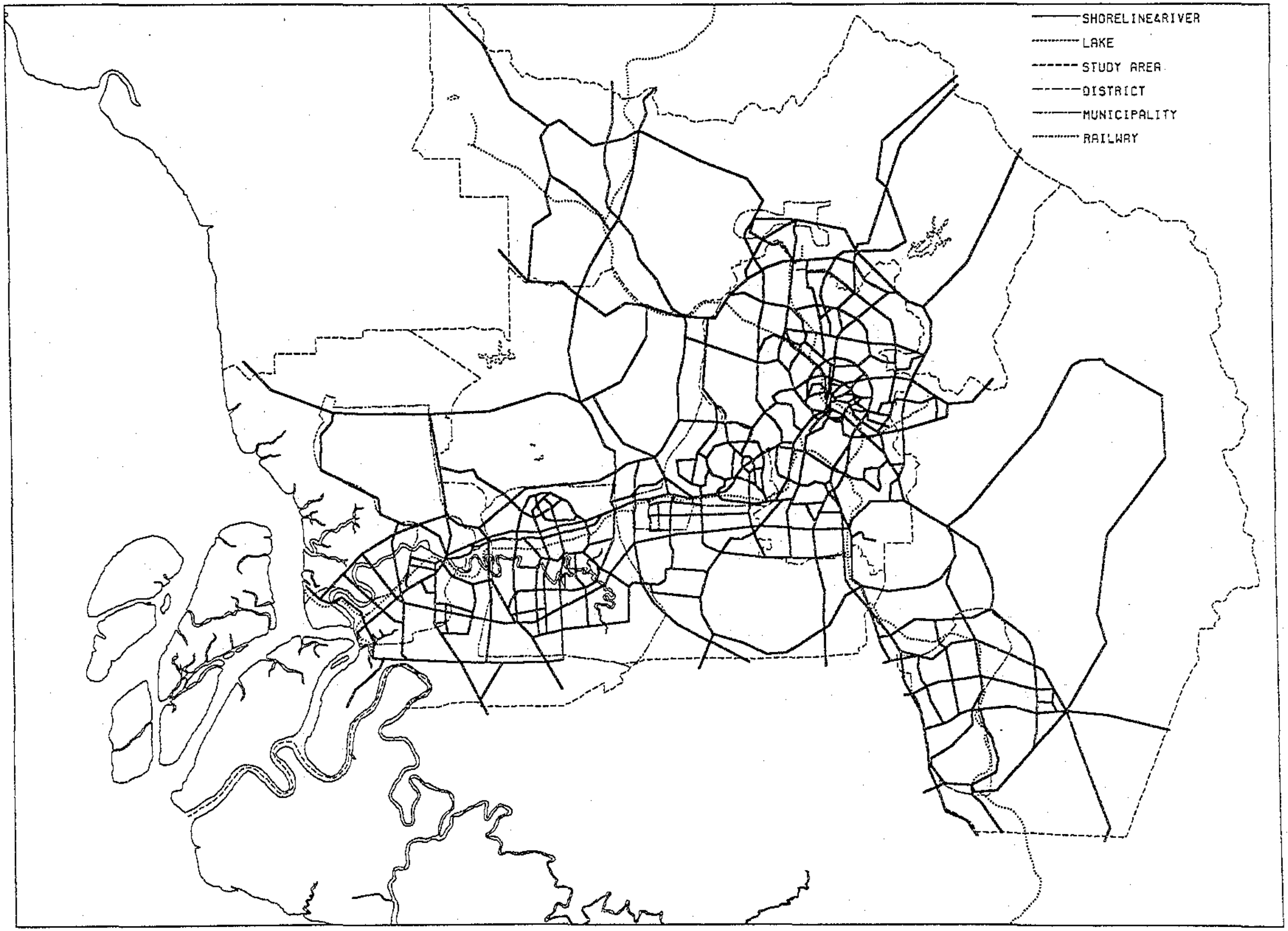


Fig 9.3.1 Future Major Road Network (2005)

Table 9.3.3 Classification of Regional Average Speed during Weekdays (2005)

Time Zone		07-09	10-15	16-20	21-06
General Roads	Zone 1	20	20	15	20
	Zone 2	25	25	20	25
	Zone 3	30	35	25	35
	Zone 4	35	40	35	40
Express Way Zone 4	Federal Highway	40	50*	40	50*
	KL-Seremban Exp. KL-Tg. Malim Exp. New Kelang Valley Exp. North-South Exp.	50*	65*	50*	65*

*: Motorcycle: 40 km/h

Zone classification

Zone 1: Inside Inner Ring Road

Zone 2: Zone between Inner Ring Road and Middle Ring Road

Zone 3: Kuala Lumpur(outside of Middle Ring Road) and Petaling Jaya (Urban area)

Zone 4: Kelang Valley Region(outside of Kuala Lumpur and Petaling Jaya (Suburban area)

(3) Emission Factor

Emission factors were set for five (5) pollutants; HC, CO, NOx, SOx and PM. The technique to determine emission factors in the future (2005) is same as that applied to the current emission factors.

1) Exhaust Emission Controls

The Malaysian Government implemented Regulation ECE. No. 15.04 (Table 9.3.4) on petrol vehicles and Regulation ECE. No. 49 (Table 9.3.5) and Regulation ECE. No. 24 (PM concentration) on diesel vehicles in June, 1992. Also in 1994, Regulation 91/441/EEC (Table 9.3.6) will be enforced on petrol vehicles. These regulations were taken into consideration when formulating the emission factors in the year 2005. The regulations have both limits for type approval and checks on production conformity, of which the latter limit was observed in this study. Regulation 91/441/EEC was assumed to come into effect on Jan. 1, 1995. In Table 9.3.7, a summary of regulations by vehicle type considered for the establishment of future emission factors is shown.

Table 9.3.4 Regulation No. 15.04

	Limit Value			
	Type approval		Checks on production conformity	
Reference mass RW(kg)	CO (g/test)	HC + NOx (g/test)	CO	HC + NOx
RW≦1020	58	19.0	70	23.8
1020<RW≦1250	67	20.5	80	25.6
1250<RW≦1470	76	22.0	91	27.5
1470<RW≦1700	84	23.5	101	29.4
1700<RW≦1930	93	25.0	112	31.3
1930<RW≦2150	101	26.5	121	33.1
2150<RW	110	28.0	132	35.0

ECE mode (average speed: 18.7km/h)
4.052km/test

Table 9.3.5 Regulation No. 49

Pollutant	Limit Value (g/kWh)
HC	3.5
CO	14
NOx	18

Table 9.3.6 Regulation 91/441/EEC

Pollutant	Limit Value(g/km)	
	type approval	checks on production conformity
CO	2.72	3.16
HC+NOx	0.97	1.13

Test mode: urban cycle + extra-urban cycle
Average speed: 33.6 km/h

Table 9.3.7 Regulation for Different Vehicles Considered in Setting Future Emission Factors

Type of Vehicle	1993 - 1994	1995 -2005
Petrol Motor Car Taxi Van Small Truck	No. 15.04	91/441/EEC
Diesel Taxi Van Mini Bus Medium/Large Bus Medium/Large Truck Lorry/Trailer	No. 49	No. 49

2) Types of Vehicles and Engines

The engine types used by different vehicles, the ratios of engine types used by vans and taxis, and the ratios of medium and large trucks were assumed to remain the same as those at present (See Tables 5.2.16, 5.2.17 and 5.2.18).

3) Emission Factors

The detailed process for setting emission factors is shown in Section 3.2.8 in the Supporting Report. The emission factors for each type of vehicle at various speeds are shown in Table 9.3.8.

4) Air Pollution Load

The future distance travelled and air pollution load in KVR were estimated based on the traffic volume, the average vehicle speed in different regions, and the emission rates by various vehicle types and speeds.

1) Total Distance Travelled Annually

The distance travelled annually by various types of vehicles on different types of roads are shown in Table 9.3.9. The total distance travelled annually is 31.6 billion kilometers, with motor cars accounting for 53% of the total, followed by motorcycles (20%).

Table 9.3.8 Average Emission Factors for Motor Vehicles (2005) (with control measures)

(Unit: g/km)

Vehicle Type		Average Travel Speed(km/h)										
		15	20	25	30	35	40	45	50	55	60	65
Motorcycle	HC	25.45	19.46	16.20	14.15	12.66	11.57					
	CO	41.72	32.13	26.55	23.20	20.75	18.74					
	NOx	0.18	0.17	0.17	0.17	0.18	0.18					
	SOx	0.002	0.002	0.002	0.002	0.002	0.002					
	PM	0.205	0.205	0.205	0.205	0.205	0.205					
Motor Car	HC	1.42	1.09	0.89	0.76	0.66	0.58	0.51	0.45	0.40	0.36	0.33
	CO	14.46	11.22	9.21	7.85	6.78	5.93	5.18	4.55	4.03	3.59	3.24
	NOx	1.51	1.48	1.46	1.46	1.45	1.46	1.46	1.46	1.47	1.48	1.50
	SOx	0.005	0.004	0.004	0.004	0.004	0.004	0.004	0.003	0.003	0.003	0.003
	PM	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027
Van	HC	1.40	1.12	0.94	0.80	0.70	0.62	0.55	0.49	0.44	0.39	0.37
	CO	27.16	20.67	16.79	14.23	12.26	10.73	9.37	8.26	7.31	6.58	5.97
	NOx	2.03	1.98	1.94	1.91	1.90	1.90	1.90	1.91	1.91	1.92	1.94
	SOx	0.119	0.104	0.096	0.089	0.085	0.081	0.080	0.078	0.076	0.074	0.072
	PM	0.069	0.069	0.069	0.069	0.069	0.069	0.069	0.069	0.069	0.069	0.069
Taxi	HC	0.83	0.71	0.62	0.55	0.48	0.43	0.38	0.34	0.31	0.28	0.26
	CO	7.22	6.22	5.36	4.64	4.05	3.51	3.08	2.69	2.39	2.10	1.85
	NOx	2.12	1.96	1.83	1.72	1.64	1.59	1.55	1.51	1.50	1.49	1.50
	SOx	0.371	0.324	0.296	0.278	0.263	0.253	0.247	0.241	0.234	0.230	0.226
	PM	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103
Mini Bus	HC	3.33	2.89	2.53	2.25	1.99	1.79	1.62	1.49	1.36	1.27	1.19
	CO	7.24	5.85	4.85	4.04	3.46	3.00	2.66	2.39	2.19	2.04	1.92
	NOx	3.52	3.17	2.91	2.70	2.54	2.43	2.35	2.30	2.30	2.30	2.35
	SOx	1.518	1.399	1.325	1.274	1.240	1.218	1.195	1.178	1.167	1.155	1.144
	PM	0.995	0.874	0.638	0.638	0.638	0.638	0.638	0.638	0.638	0.638	0.638
Medium/Large Bus	HC	6.30	5.46	4.78	4.22	3.77	3.37	3.05	2.81	2.57	2.41	2.25
	CO	20.79	16.89	13.86	11.59	9.96	8.66	7.58	6.82	6.28	5.85	5.52
	NOx	17.03	15.38	14.11	13.09	12.33	11.69	11.31	11.18	11.06	11.18	11.44
	SOx	3.300	3.041	2.881	2.770	2.696	2.647	2.598	2.561	2.536	2.512	2.487
	PM	3.941	3.461	2.526	2.526	2.526	2.526	2.526	2.526	2.526	2.526	2.526
Small Truck	HC	2.68	2.12	1.80	1.56	1.38	1.21	1.06	0.94	0.84	0.75	0.69
	CO	29.55	24.01	20.80	18.41	16.51	14.65	12.87	11.26	10.02	9.05	8.40
	NOx	2.06	2.03	2.03	2.05	2.08	2.12	2.16	2.20	2.23	2.26	2.30
	SOx	0.007	0.006	0.006	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.004
	PM	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032
Medium/Large Truck	HC	2.96	2.58	2.25	1.99	1.77	1.59	1.44	1.32	1.21	1.13	1.05
	CO	6.27	5.08	4.20	3.50	3.00	2.60	2.29	2.06	1.90	1.77	1.66
	NOx	4.98	4.50	4.13	3.83	3.60	3.44	3.32	3.27	3.25	3.27	3.34
	SOx	1.776	1.636	1.547	1.495	1.451	1.421	1.399	1.376	1.362	1.354	1.340
	PM	0.402	0.402	0.402	0.402	0.402	0.402	0.402	0.402	0.402	0.402	0.402
Lorry/Trailer	HC	4.78	4.14	3.62	3.19	2.86	2.56	2.31	2.13	1.95	1.83	1.70
	CO	15.89	12.91	10.59	8.85	7.61	6.62	5.79	5.21	4.80	4.47	4.22
	NOx	17.20	15.53	14.25	13.22	12.45	11.81	11.43	11.30	11.17	11.30	11.55
	SOx	3.246	2.989	2.827	2.732	2.651	2.597	2.556	2.516	2.489	2.475	2.448
	PM	1.182	1.182	1.182	1.182	1.182	1.182	1.182	1.182	1.182	1.182	1.182

Table 9.3.9 Annual Distance Travelled by Various Types of Vehicles on Different Types of Roads in 2005 (with control measures)

(Unit: million km)

Vehicle Type	Major Roads	Minor Roads	Total
Motorcycle	4509.0	1767.6	6276.6 (19.9)
Motor Car	12481.8	4122.1	16603.9 (52.6)
Van	2149.9	552.5	2702.4 (8.5)
Taxi	1624.3	556.7	2181.0 (6.9)
Mini Bus	264.5	113.9	378.4 (1.2)
Medium/Large Bus	286.1	143.1	429.2 (1.3)
Small Truck	1103.4	277.8	1381.2 (4.4)
Medium/Large Truck	742.7	168.9	911.6 (2.9)
Lorry/ Trailer	592.1	126.8	718.9 (2.3)
Total	23753.8	7829.4	31583.2 (100.0)

Table 9.3.10 shows a comparison of region-by-region annual distance travelled in 1992 with that in 2005 (with control measures). The total distance travelled annually increases 1.96 times from 1992 to 2005 when the measures for traffic and transportation are taken. The growth rate of annual distance travelled from 1992 to 2005 is 2.95 times for Gombak and 3.11 times for Klang. They are very high compared with that for Kuala Lumpur (1.39) whose share in the total distance travelled drops sharply from 40.2% in 1992 to 28.5% in 2005. The shares of Gombak and Klang will increase remarkably.

Table 9.3.10 Regional Annual Distance Travelled in 1992 and 2005 (with control measures)

(Unit: million km/year)

Region	1992 (A)	2005 (B)	B/A
Hulu Langat	1864.4 (11.5)	4054.0 (12.8)	2.17
Gombak	2242.2 (13.9)	6610.4 (20.9)	2.95
Kuala Lumpur	6488.2 (40.2)	8989.5 (28.5)	1.39
Petaling	4094.8 (25.4)	7426.3 (23.5)	1.81
Klang	1449.9 (9.0)	4503.6 (14.3)	3.11
Total	16139.5 (100.0)	31583.8 (100.0)	1.96

2) Air Pollution Load

Table 9.3.11 summarizes the annual air pollution load from motor vehicles expected in 2005 when Regulation 91/441/EEC is enacted.

The annual total amount of air pollutant emission is 104,000 tons for HC, 321,000 tons for CO, 56,000 tons for NOx, 5,800 tons for SOx and 4,800 tons for PM respectively. As for HC, motorcycles are the major contributor (80% of the total). For CO, motorcycles and motor cars are the major contributors accounting for 42% and 35% respectively. As for NOx, the greatest contributor is motor cars (44%). For SOx, diesel vehicles such as medium/large trucks, lorry/trailer and medium/large buses are the main sources. As for PM, motorcycles are the main contributors (27%), followed by medium/large buses (23%) and lorry/trailers (18%).

Table 9.3.11 Future Air Pollution Load from Various Types of Vehicles (2005) (with control measures)

(Unit: ton/year)

Vehicle Type	HC	CO	NOx	SOx	PM
Motorcycle	82626 (79.5)	134979 (42.0)	1121 (2.0)	13 (0.2)	1291 (27.0)
Motor Car	10804 (10.4)	110733 (34.5)	24334 (43.7)	64 (1.1)	450 (9.4)
Van	1841 (1.8)	32205 (10.0)	5190 (9.3)	229 (4.0)	187 (3.9)
Taxi	1012 (1.0)	8417 (2.6)	3588 (6.4)	573 (10.0)	226 (4.7)
Mini Bus	752 (0.7)	1323 (0.4)	972 (1.7)	473 (8.2)	246 (5.2)
Medium/Large Bus	1608 (1.5)	4299 (1.3)	5335 (9.6)	1166 (20.3)	1106 (23.2)
Small Truck	1810 (1.7)	21559 (6.7)	2930 (5.3)	7 (0.1)	44 (0.9)
Medium/Large Truck	1551 (1.5)	2643 (0.8)	3288 (5.9)	1321 (22.9)	368 (7.7)
Lorry/Trailer	1969 (1.9)	5272 (1.7)	8970 (16.1)	1909 (33.2)	857 (18.0)
Total	103973 (100)	321430 (100)	55728 (100)	5755 (100)	4775 (100)

Figures in parenthesis are percentage values.

Table 9.3.12 summarizes comparisons of the annual total air pollution loads in 2005 from motor vehicles between cases in which both for traffic and transportation measures and the exhaust gas regulation are taken and not taken. By taking these measures, total distance travelled is expected to decrease by 14%. Decrease of Pollution load is the highest for CO (51%), followed by HC (38%), PM (35%) and NOx (32%).

Table 9.3.12 Effect of Control Measures on Air Pollution Load in 2005

	Total Distance Traveled Million km/year	Pollution Load (ton/year)				
		HC	CO	NOx	SOx	PM
Without measures (A)	36,636.2	166,720	659,223	82,199	7,079	7,359
With measures (B)	31,583.2	103,973	321,430	55,728	5,755	4,775
B/A	0.86	0.62	0.49	0.68	0.81	0.65

Comparisons of the air pollution loads from motor vehicles in 2005 with control measures with those in 1992 are shown in Table 9.3.13. The growth rate from 1992 to 2005 is the lowest for CO (11%) and the highest for SOx (85%).

Table 9.3.13 Comparison of Annual Air pollution Loads from Vehicles with Control Measures in 2005 with Those in 1992

Year	Total Distance Traveled Million km/year	Pollution Load (ton/year)				
		HC	CO	NOx	SOx	PM
1992 (A)	16,172.6	73,445	290,407	36,212	3,117	3,243
2005(B)	31,583.2	103,973	321,430	55,728	5,755	4,775
B/A	1.96	1.42	1.11	1.54	1.85	1.47

9.3.3 Total Air Pollution Load

Table 9.3.14 summarizes air pollution loads from various sources in 2005 when control measures are taken. The annual total pollution load is 27,000 tons for SOx, 85,000 tons for NOx, 12,000 tons for PM, 322,000 tons for CO and 104,000 tons for HC.

The regional air pollution load from factories, motor vehicles, airplanes and ships is shown in Table 9.3.15.

Table 9.3.14 Future Air Pollution Load from Various Sources (2005)
(with control measures)

(Unit: ton/year)

	SOx	NOx	PM	CO	HC
Factories					
Power stations	12,759	22,758	828	-	-
General factories	5,345	4,364	5,451		
Sub-total	18,104 (66.9)	27,122 (31.7)	6,279 (54.1)	-	-
Motor vehicles	5,755 (21.3)	55,728 (65.2)	4,775 (41.2)	321,430 (100)	103,973 (100)
Airplanes	360 (1.3)	574 (0.7)	123 (1.1)	-	-
Ships	2,836 (10.5)	1,840 (2.1)	365 (3.1)	-	-
Households	0 (0.0)	226 (0.3)	62 (0.5)	-	-
Total	27,055 (100)	85,490 (100)	11,604 (100)	321,430 (100)	103,973 (100)

Figures in parenthesis are percentage values(%). Air pollutant emission from open burning activities and earthworks are not included, but that from PS-C Power Station outside KVR is included in this Table.

Table 9.3.15 Regional Annual Air Pollution Load from Factories, Motor Vehicles, Airplanes and Ships (2005)
(with control measures)

(unit: ton/year)

Pollutant	Region	Factories	Motor Vehicles	Airplanes	Ships	Total
SOx	Hulu Langat	1,045	717			1,762 (6.5)
	Gombak	459	1,087			1,546 (5.7)
	Kuala Lumpur	322	1,765			2,087 (7.7)
	Petaling	1,964	1,434	360		3,758 (13.9)
	Klang	14,314	751		2,836	17,901 (66.2)
	Total	18,104	5,754	360	2,836	27,054 (100)
NOx	Hulu Langat	799	6,968			7,767 (9.2)
	Gombak	1,576	11,187			12,763 (15.0)
	Kuala Lumpur	101	16,480			16,581 (19.6)
	Petaling	839	13,529	574		14.942 (17.6)
	Klang	23,338	7,565		1,840	32,743 (38.6)
	Total	26,653	55,729	574	1,840	84,796 (100)
PM	Hulu Langat	2,183	629			2,812 (24.4)
	Gombak	228	949			1,177 (10.2)
	Kuala Lumpur	248	1,374			1,622 (14.1)
	Petaling	805	1,126	123		2,054 (17.8)
	Klang	2,788	697		365	3,850 (33.4)
	Total	6,252	4,775	123	365	11,515 (100)

Figures in parenthesis are percentage values.

Change of the annual total air pollution load in 2005 by taking the proposed control measures is shown in Table 9.3.16. By taking the control measures, the reduction rate of the total emission is 48% for SOx, 26% for NOx, 37% for PM, 51% for CO and 38% for HC.

Table 9.3.16 Reduction of Total Air Pollution Load by Taking Control Measures (2005)

	Pollution Load (ton/year)				
	SOx	NOx	PM	CO	HC
Without measures(A)	51,598	115,292	18,495	659,223	166,720
With measures(B)	27,055	85,490	11,604	321,430	103,973
B/A	0.52	0.74	0.63	0.49	0.62

Table 9.3.17 shows change of air pollution load from all sources between 1992 and 2005. Emission of all pollutants except SOx and PM is expected to increase even when the control measures are taken.

Table 9.3.17 Change of Annual Total Air Pollution Load from 1992 to 2005

(Unit: ton/year)

Pollutant	1992	2005	
		without measures	with measures
SOx	35,654 (1.0)	51,598 (1.45)	27,055 (0.76)
NOx	54,454 (1.0)	115,292 (2.12)	85,490 (1.57)
PM	12,605 (1.0)	18,495 (1.47)	11,604 (0.92)
CO	290,407 (1.0)	659,223 (2.27)	321,430 (1.11)
HC	73,445 (1.0)	166,720 (2.27)	103,973 (1.42)

9.3.4 Concentration at Monitoring Stations and Maximum Concentration Point

Predicted annual average concentration of each pollutant with control measures at monitoring stations and the maximum concentration point is shown in Table 9.3.18. Note that the background concentration contained in the predicted value is the same as the present (Table 6.2.2).

Though SO_2 concentration is reduced by control measures at each predicted points and monitoring stations, concentration of the maximum concentration point exceeds the target value (20 ppb) (Refer to 9.3.7).

NO_2 concentration at all predicted points satisfies the target value (37 ppb).

CO concentration at all predicted points satisfies the target value (4 ppm).

Table 9.3.18 Computed Annual Average Concentration with Control Measures (2005)

Items / Stations	SO_2 (ppb)	NOx (ppb)	NO_2 (ppb)	CO (ppm)
A. City Hall	9.2	85.2	22.2	2.20
B. UPM	4.5	20.7	10.5	1.19
C. Petaling Jaya	8.5	51.9	17.1	1.51
D. Shah Alam	8.7	44.7	15.8	1.33
E. Klang	6.1	27.1	12.1	1.21
Cmax Point Mesh Index	29.0 (76,15)	137.2 (58,40)	28.6 (58,40)	2.84 (59,38)
Target Value	20	-	37	4

Comparisons in pollutant concentrations for 1992, 2005 (without control measures) and 2005 (with control measures) are shown in Figs. 9.3.2 through 9.3.4.

If no control measures are taken, SO_2 concentration will increase in the future according to increase of fuel consumption by factories and traffic volume, and the concentrations at some areas will exceed the target.

However, if proposed control measures are taken, the concentrations at monitoring stations will remain at the present level, and the maximum concentration will decrease to a lower level.

If no measures are taken, NO_2 concentration in 2005 will increase as well. However, if control measure are taken, the concentration will remain at the current level or below, and the target value will be satisfied the at all points.

CO concentration will also increase in future if no control measures are taken. However, if control measures are taken, the concentration will remain at the current level or below, and the target value will be satisfied at all points.

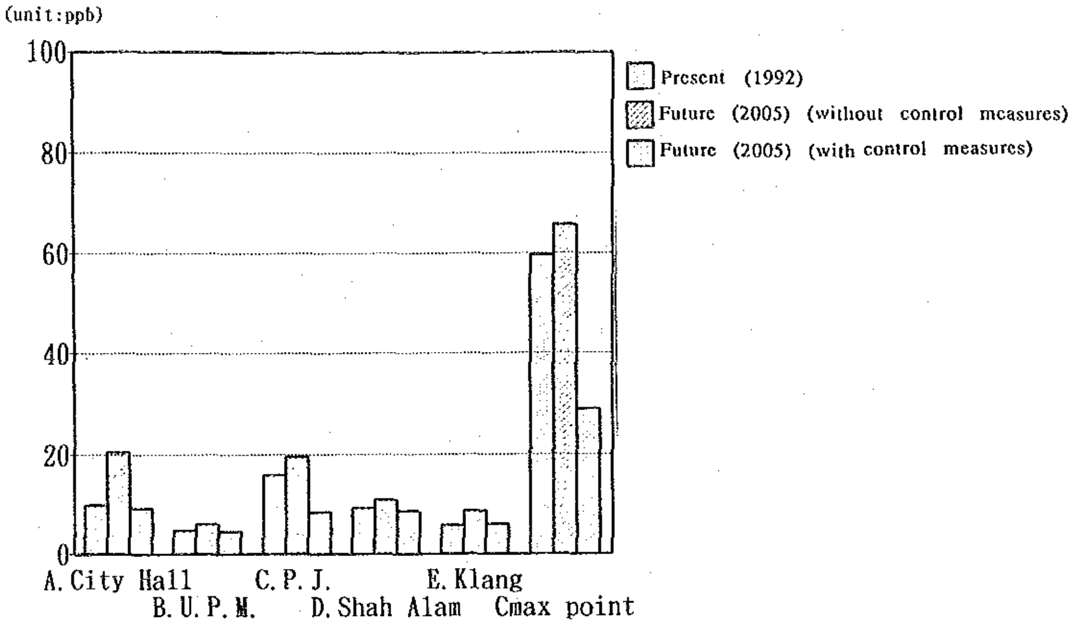


Fig. 9.3.2 Change of SO_2 Concentration from 1992 to 2005

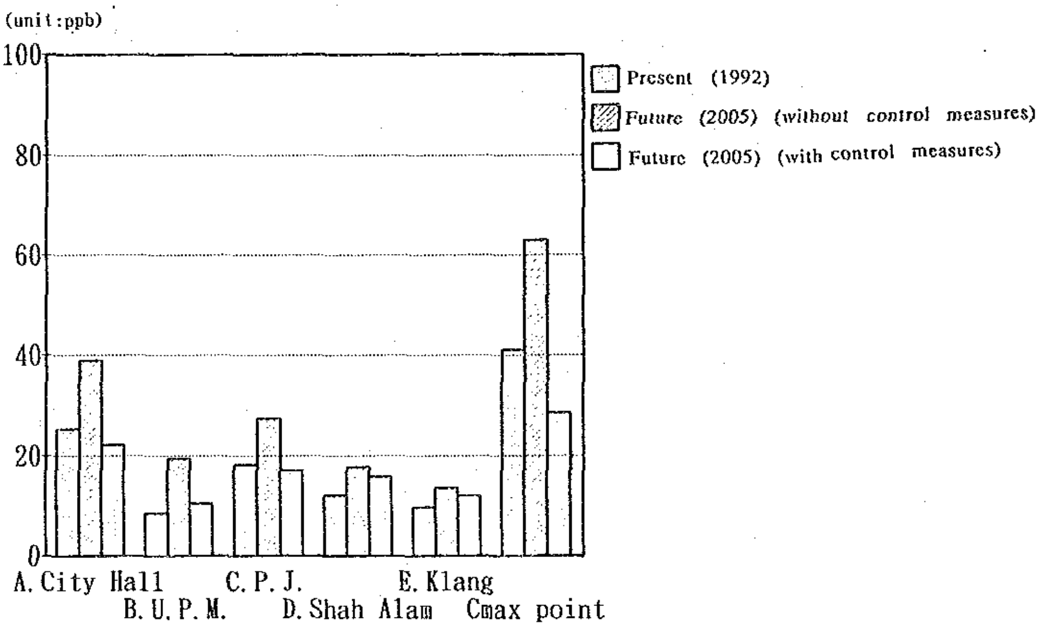


Fig. 9.3.3 Change of NO_2 Concentration from 1992 to 2005

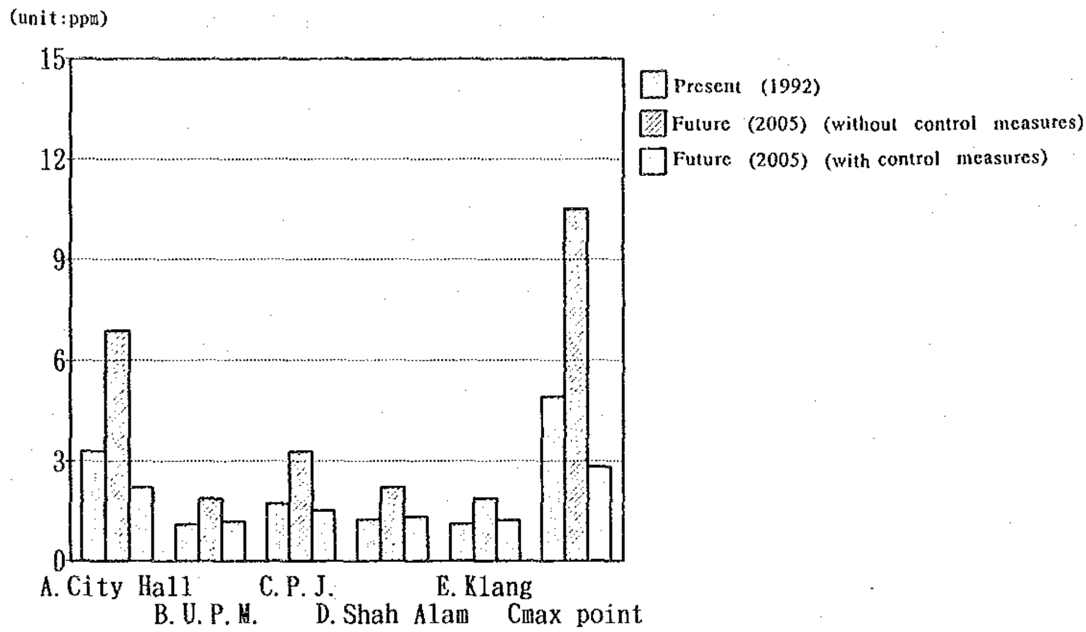


Fig. 9.3.4 Change of CO Concentration from 1992 to 2005

9.3.5 Concentration Distribution

The plane distribution of pollutant annual average concentration in 2005 with the control measures described in the previous section is summarized as follows.

The contribution concentration distribution by source is described in Section 4.1.1 in the Supporting Report.

① SO_2

The result of prediction on SO_2 plane concentration distribution in 2005 with control measures is shown in Fig. 9.3.5. A concentration of 10 ppb or more is distributed in some parts of Kuala Lumpur, Petaling Jaya, Shah Alam, Klang and Hulu Langat, with the maximum concentration at 29.0 ppb in the mesh index (75,15).

② NOx and NO_2

The result of prediction on NOx plane concentration distribution in 2005 with control measures is shown in Fig. 9.3.6. A concentration of 100 ppb or more is distributed in parts of Kuala Lumpur with the maximum at 137.2 ppb concentration in the mesh index (58,40).

The result of prediction on NO2 plane concentration distribution in 2005 with control measures is shown in Fig. 9.3.7. The situation is similar to NOx, and the maximum concentration is 28.6 ppb in the mesh index (58,40).

③ CO

The result of prediction on CO plane concentration distribution in 2005 with control measures is shown in Fig. 9.3.8. A concentration of 2 ppm or more is distributed in the center area of Kuala Lumpur, with the maximum concentration at 2.8 ppm in the mesh index (59,38).

Fig. 9.3.5 Annual Average Concentration Isopleth for SO_2 (All sources) (2005) (with control measures)

X : C max. Point Unit : ppb

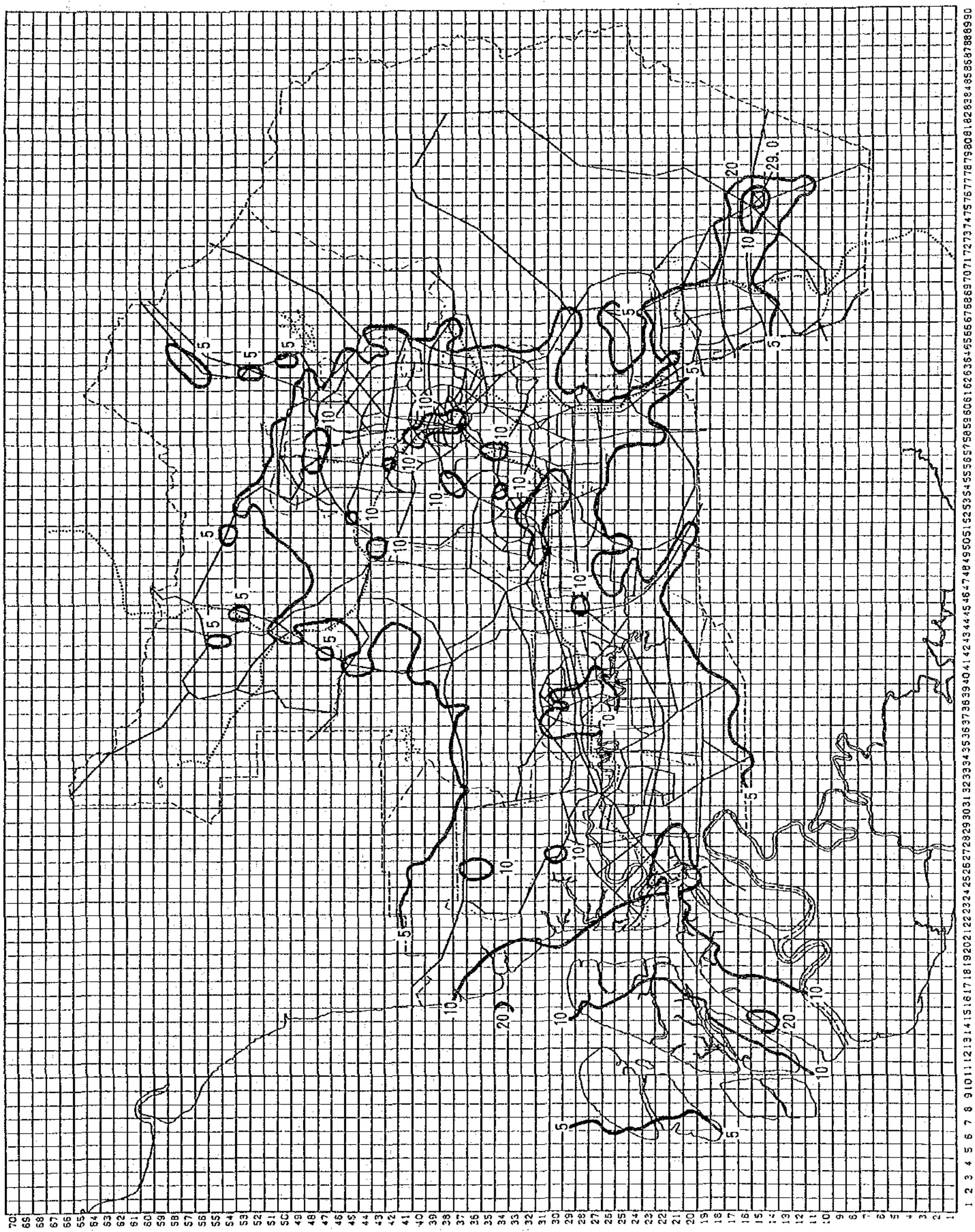


Fig. 9.3.6 Annual Average Concentration Isopleth for NOx (All sources) (2005)
(with control measures) X : C max. Point Unit : ppb

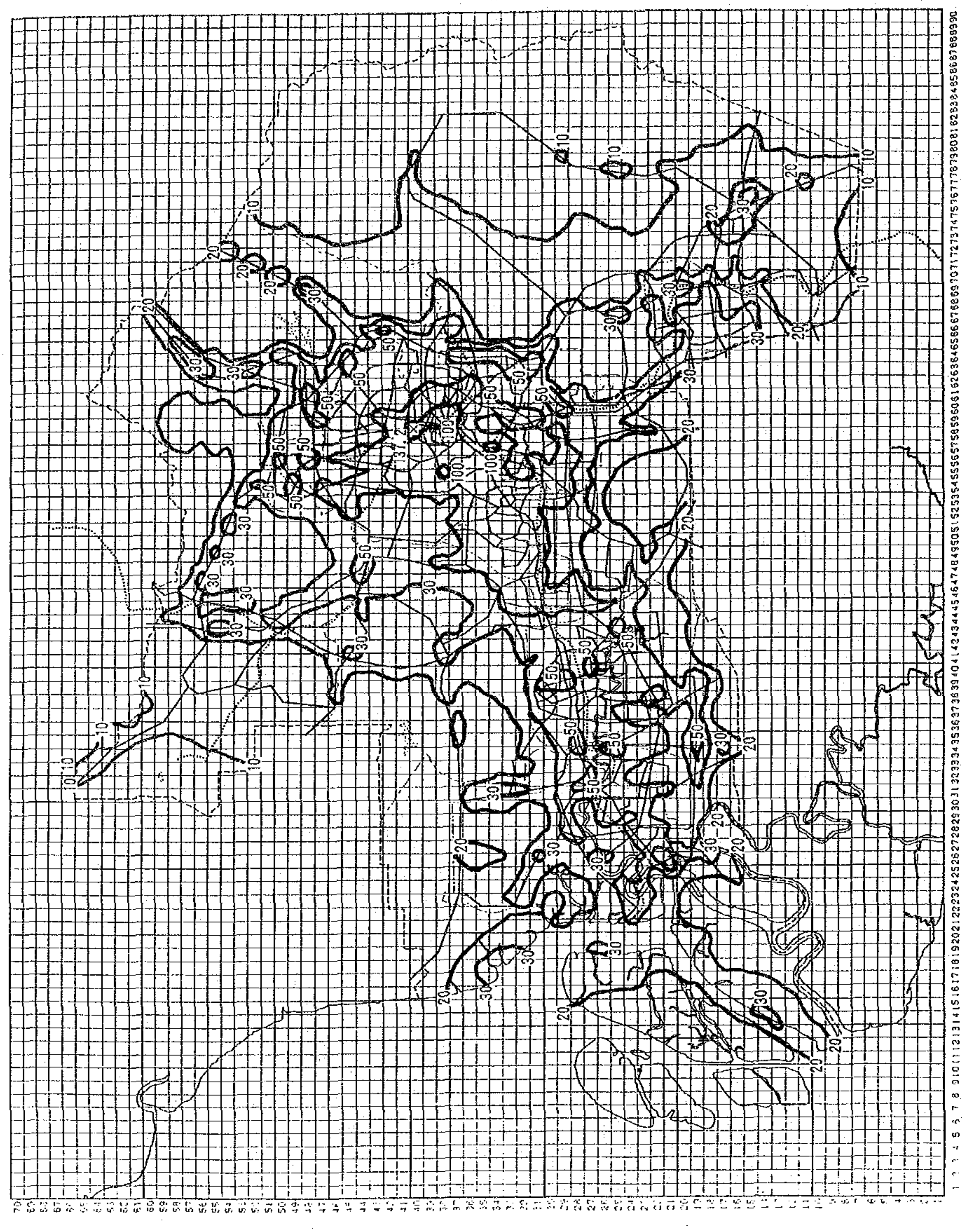


Fig. 9.3.7 Annual Average Concentration Isopleth for NO_2 (All sources) (2005)
(with control measures)
X : C max. Point Unit : ppb

Fig. 9.3.8 Annual Average Concentration Isopleth for CO (All sources) (2005)
(with control measures)

X : C max. Point Unit : ppm

9.3.6 Case Study for Effect of Control Measures for Motor Vehicles

(1) Case of Study

In order to evaluate the effect of control measures for motor vehicles, a case study was made for two cases as shown below.

① Case 1 (Control measures for traffic and transportation only)
The traffic volume and road network predicted for 2,005 was used, but emission factor remained the same as at present.

② Case 2 (Control measures for exhaust gas only)
The emission factor predicted for 2,005 with effect of exhaust gas regulation was used. The road network remained the same as at present with traffic volume of 2.27 times of that at present.

(2) Predicted Result

Predicted results of Pollutant concentration by case are shown in Table 9.3.19.

① Case 1
NO_2 concentration at the maximum concentration point satisfies the target value but that of CO exceeds the target value.

② Case 2
CO at City Hall and the maximum concentration point exceed the target value. For NO_2, the concentration at the maximum concentration point exceeds the target.

In conclusion, either control measures for traffic and transportation or exhaust gas is not sufficient to observe the target values for CO and NO_2. Both measures should be taken simultaneously. The plane distribution of concentration of NO_2 and CO by case is shown in Fig. 9.3.9 - Fig. 9.3.12.

Table 9.3.19 Computed Concentration with Control Measures by Case

Control Measure Case	Case 1		Case 2	
Items / Stations	NO_2 (ppb)	CO (ppm)	NO_2 (ppb)	CO (ppm)
A. City Hall	24.3	3.5	35.7	4.2
B. UPM	11.7	1.7	11.1	1.3
C. Petaling Jaya	19.3	2.2	24.1	2.1
D. Shah Alam	17.8	1.9	15.7	1.5
E. Klang	13.3	1.7	12.3	1.3
Cmax Point Mesh Index	32.1 (57,34)	4.6 (59,38)	53.2 (54,33)	5.3 (59,37)

Fig. 9.3.9 Annual Average Concentration Isopleth for NO_2 (All sources) (Case 1)

X : C max. Point Unit : ppb

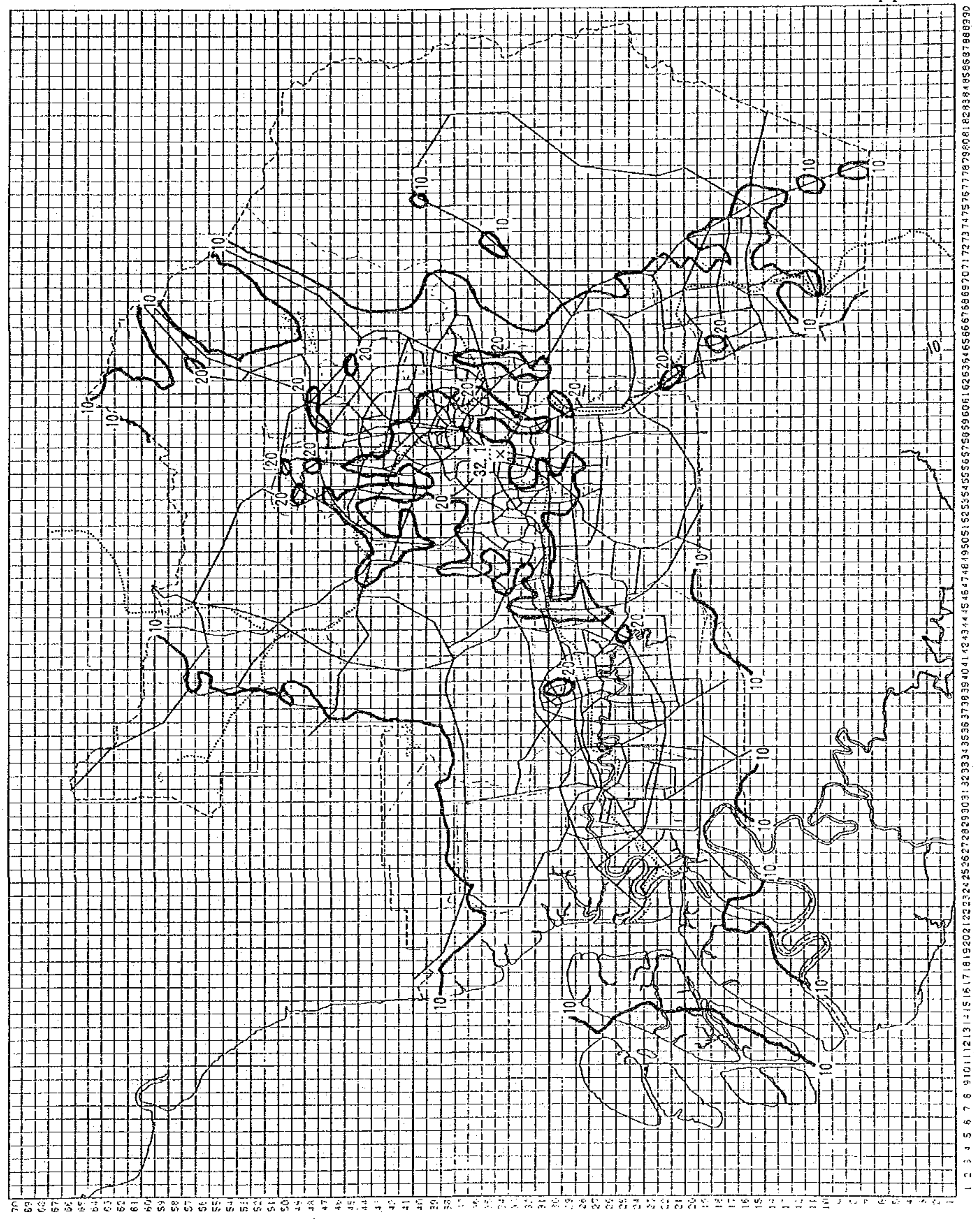


Fig. 9.3.10 Annual Average Concentration Isopleth for CO (All sources) (Case 1)

X : C max. Point Unit : ppm

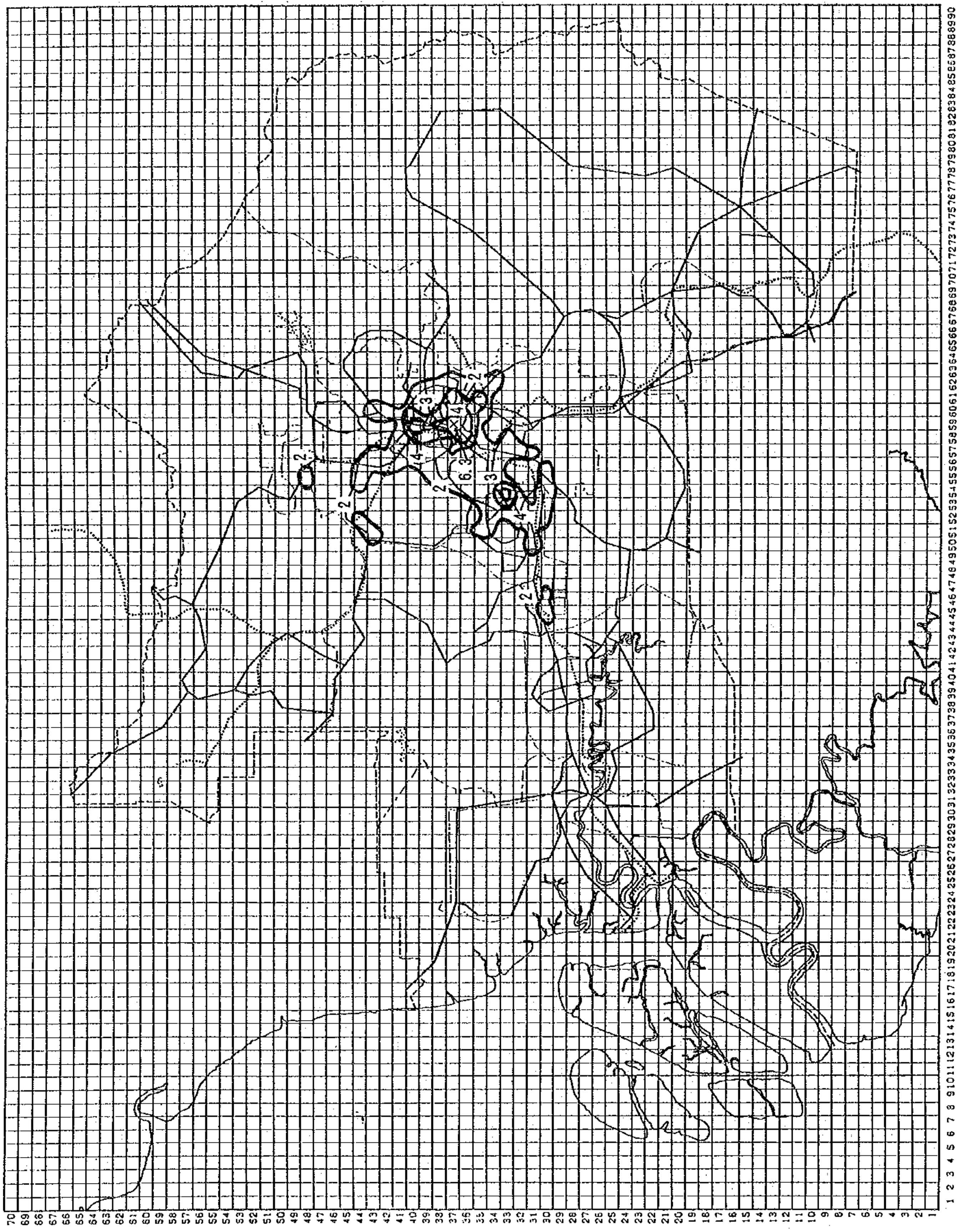


Fig. 9.3.11 Annual Average Concentration Isopleth for NO_2 (All sources) (Case 2)

X : C max. Point Unit : ppb

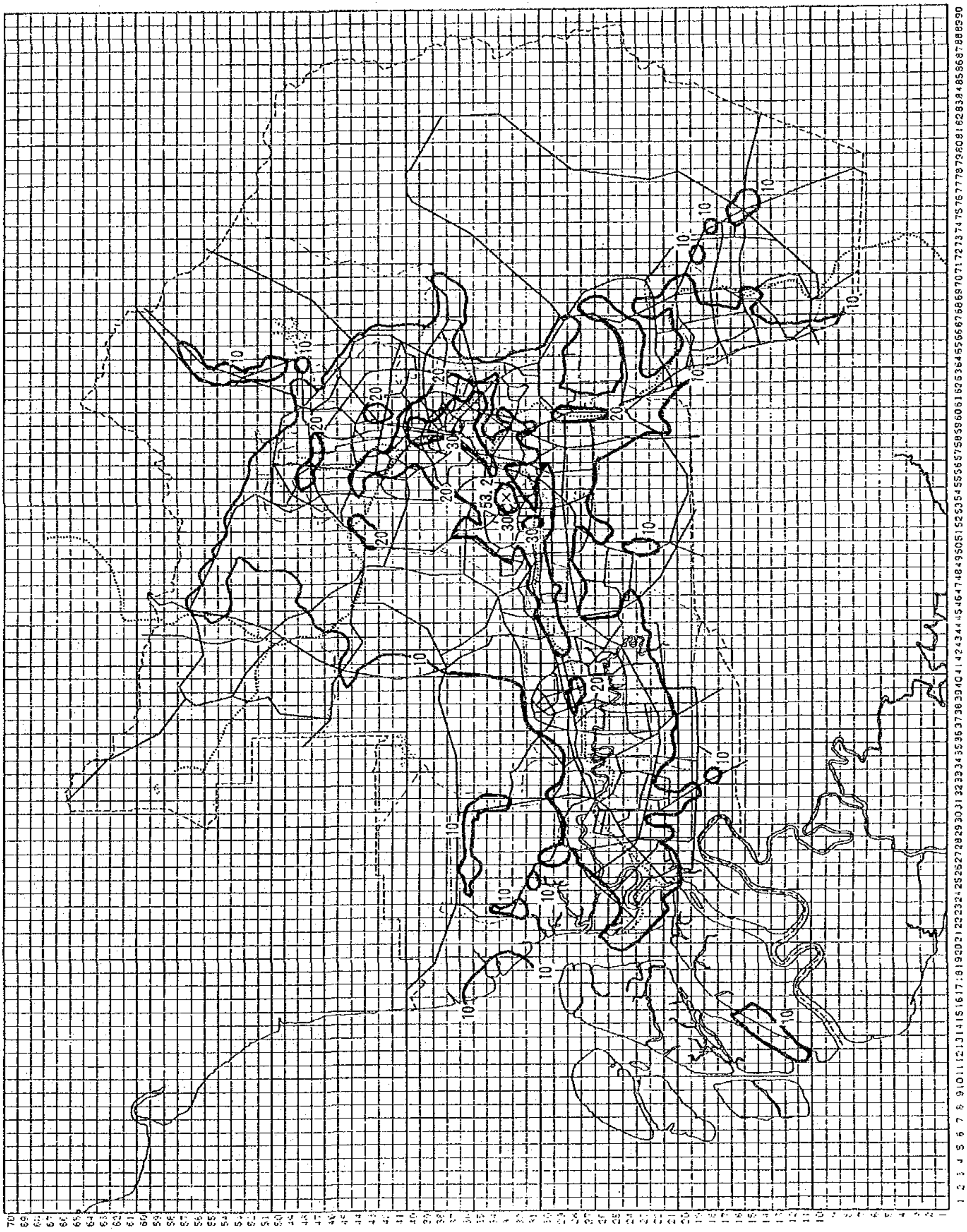
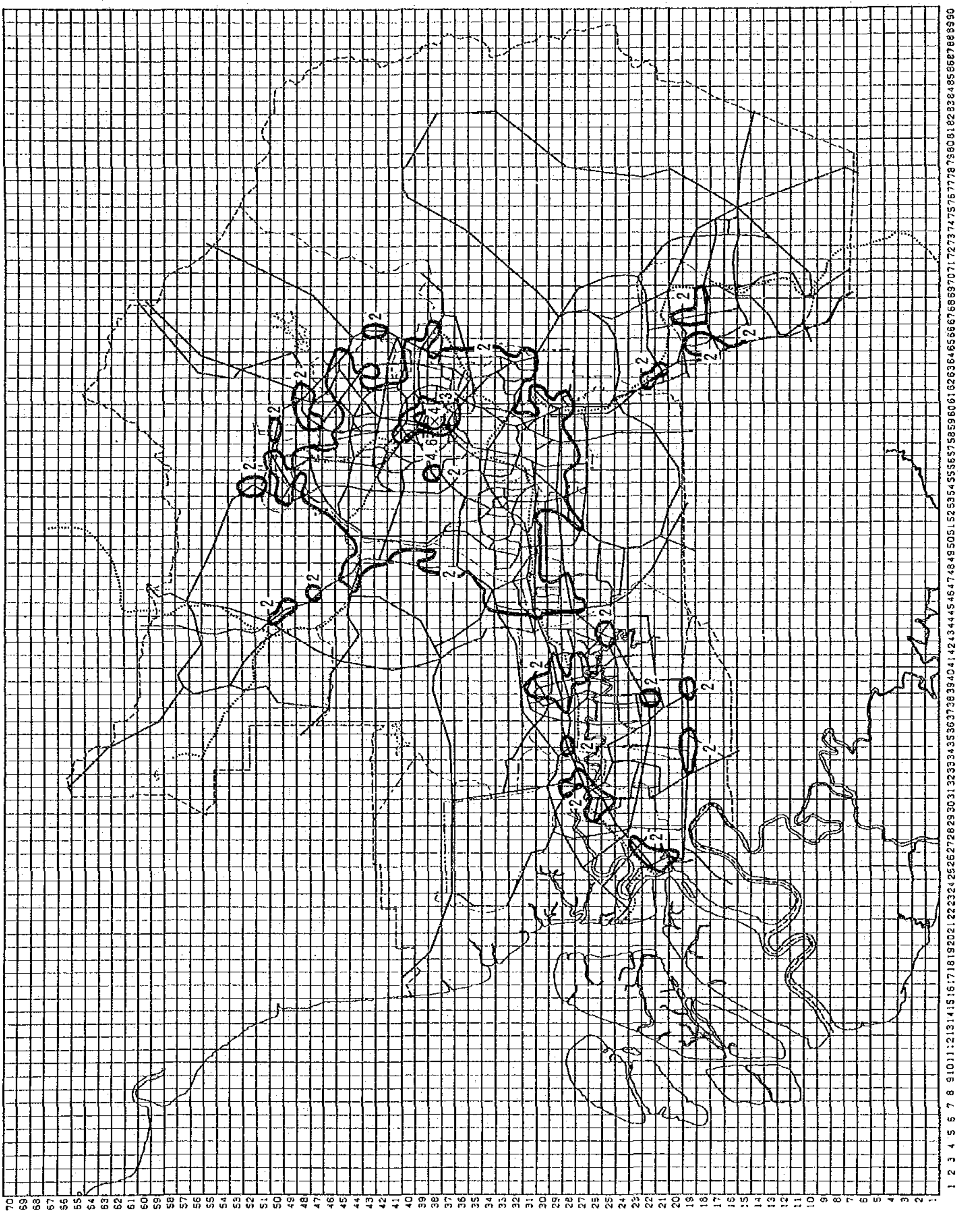


Fig. 9.3.12 Annual Average Concentration Isopleth for CO (All sources) (Case 2)
X : C max. Point Unit : ppm



9.3.7 Evaluation of Control Measures

According to the simulation result in Sections 9.3.4 and 9.3.5, for SOx, there are two sites with SOx concentration exceeding the target value even after control measures are taken. They are very close to or in the territories of PS-A and a palm factory in Hulu Langat. If these have to strictly satisfy the target value, either #3 or #4 boiler of PS-A should be converted from coal to natural gas, and the palm factory to install higher stacks. Further, there are still other places with SOx concentration exceeding the target value. They are located in the Port Klang district. If these places also have to satisfy the target value, ships should use low-sulphur content oil.

For CO and NO_2, the case study in Section 9.3.5 showed that if their target values had to be satisfied in KVR, both measures, namely, the measures for traffic and transportation and vehicle exhaust gas regulation, would have to be implemented simultaneously.

9.4 Open Burning

9.4.1 Solid Waste

Open burning is one method of solid waste disposals. It is allegedly causing nuisance and air pollution in KVR.

Table 2.2.2 and Table 2.2.14(1) in Chapter 2 indicate that one person in the KVR has evenly discarded about 1.6 kg/day of solid waste in 1990-1991. One average Japanese threw away around 1.0 kg/day of garbage/refuse plus 7.0 kg/day of industrial waste in 1985 (#Japan Develop. Bank's Research No. 166, Sept./92). An average 2.5 kg of urban refuse and garbage was collected per capita per day in the United States. Together, uncollected urban and industrial wastes contributed at least 2.0 kg per capita per day in 1968 (#EPA AP-42, 1985).

According to the two questionnaires surveyed by the Ministry of Housing and Local Government, one in 1987 on the solid waste management and the next in 1989 on the solid waste final disposal, the compositions of the solid waste in Klang and Petaling Jaya were 44-48% of food and vegetables, 24-28% of papers, 8-9% of plastics and rubbers, 5-6% of metals, 5-10% of wood and 6-8% of others.

These figures may not be representatives in the current KVR. There may be more waste from building construction sites, office work, agricultural activities or else. The majority of the solid waste is combustible.

Urban garbage and refuse are collected and disposed in two dump areas in KVR. No owner or occupier of industrial or trade premises should burn or cause to be burnt combustible materials, refuse and produce or waste except in an incinerator of such type and design approved by the Director-General of DOE, according to the Malaysian Environmental Quality (Clean Air) Regulations (1978). In spite of this regulation, a large amount of the industrial waste is said to be illegally dumped or burnt in Malaysia.

Central and local governments have realized the problems associated with the solid waste disposals and have been planning or constructing centralized and managed facilities for treatment, storage and disposal.

9.4.2 Air Pollution from Open Burning

Solid waste in dump can cause fire under the sunshine focused through curved glasses or else, if the dump area is not well managed. Or scavengers may reportedly fire them for easy recovery of profitable materials.

Open burning emits such air pollutants as SOx, NOx, particles, metal and halogen compounds, and others. Generation of SOx, NOx and particles by burning is described in Section 9.1.3 of this Report. Metal compounds in the dump evaporate after possible chemical reactions in the intense heat of open burning. Among the metals, concerned as hazardous are arsenic, cadmium, chromium, copper, lead, mercury, zinc, etc. They can be found in dumped chemicals, metals, batteries, fluorescent tubes, pigments, coated paint, and so on. Halogen as chlorine and fluorine compounds found in plastic sheets and resins, emitted into atmosphere by burning, is hazardous to the environment and causes stimulative odor. Mal-odor is also from biodegradation of sulphur and organic compounds in the dump.

Amounts and concentrations of these emissions intermingledly depend on volumes and compositions of the burning waste, durations and intensities of the burning, wind velocities and others. These data can be measured. However, the data is correct only for the specific open burning sites and periods. Possibility of the data generalization to simulate their contributions to wider air pollution is vague and doubtful in consideration of available analytical equipment, manpower, time and budget. Restriction of open burnings and provision of alternatives for them currently seem more rational from the practical standpoint.

9.4.3 Management of Open Burning

In order to restrict open burning to the minimum, open dump areas must be managed for earth covering, water spraying, prohibition of trespassers and others, and also useful materials should not be abandoned there.

The Japanese fire regulation authorizes fire departments to prohibit or restrict any open burning including smoking for the fire precaution. People should not make open burnings at places designated by the chiefs of local fire departments. At other places, people should provide fire extinguishers or other precautions, before the start of open burning. According to the regulation, an open storage of an amount of more than one ton of paper, or 10 m^3 of wood has to follow restrictions not to cause fire damage to outsides. Large open burning, which may induce fire or smoke misled to be a fire, should be reported for the permission from the fire department beforehand.

Although the Japanese solid waste management law permits people to dispose (including open burning) solid waste by themselves, it states that the disposals shall not cause damages to the living environment.

9.4.4 Municipal Incinerator

As an alternative method to dumping combustible waste, incinerators are commonly employed in municipalities. Municipal incinerators are better to avoid from burning such materials as those emitting environmentally harmful substances and damaging incinerator construction materials. And also it is better to reduce waste amount in order to save its investment and operation costs for the incinerators.

Therefore, the waste collection system should be arranged to collect combustible waste separately from harmful, incombustible and/or recyclable ones. The harmful waste has to be disposed under control methods.

Nevertheless, it is unavoidable to have contaminations of harmful waste in the incinerators. They are designed to tolerate these contaminations. As for air pollution, there is usually a train of apparatuses attached to a municipal incinerator to control. Followings are examples of the control measures.

ammonia or urea spray	:	to decompose NOx
lime spray	:	to absorb SOx and halogen
ESP or bag filter	:	to remove particles of metal and lime compounds, ash & others

Heat from incinerating solid waste can be recovered as electricity, although the recovery rate is low. One Japanese municipality is generating 1200 kw of electricity by burning 230 t/day of solid waste having around 2500 kcal/kg of combustion heat. This is just equivalent to the electricity requirement for the incinerator operation.

CHAPTER 10 AIR QUALITY AND POLLUTION SOURCE MONITORING

CHAPTER 10 AIR QUALITY AND POLLUTION SOURCE MONITORING

10.1 Outline of Air Quality and Pollution Source Monitoring

10.1.1 Present State of Air Pollution Monitoring

Malaysia does not have air quality standards at present. It has only the guidelines stipulating the recommended air quality value.

Standards for stationary sources are set as Environmental Quality (Clean Air) Regulations issued under the Environmental Quality Act. These regulations define the emission standards of air pollutants and harmful substances from fuel combustion facilities. Vehicle emissions, such as smoke etc are controlled under the Road Traffic Ordinance. There also is regulation of lead content in petrol based on the Environmental Quality Act. Additional regulation of petrol vehicle exhausts is scheduled for next year.

Thus, Malaysia does have laws and regulations concerning exhaust gas, to some extent. However, the effect of these regulations on air pollution has not been sufficient, as there has been weak enforcement of the regulations, and no preventive measures, such as a vehicle inspection and maintenance system, have been adopted.

Under such conditions, the existing air pollution monitoring system can not be said to be complete. There are three air quality monitoring stations belonging to UPM in Kelang Valley Region, to measure SPM, CO, NOx, SO_2 and O_3, but their reliability has been low.

In the Study, we rehabilitated the three existing monitoring stations and established two additional new stations. As a result, the monitoring system now consists of five stations as shown in Table 10.1. The characteristics of each station based on the present and future land use are shown in Table 10.2. The station at City Hall should be regarded as a vehicle exhaust monitoring station. Besides that, the monitoring by two monitoring cars and by a simplified method was also carried out in the Study.

Table 10.1 Items Monitored at Each Fixed Station

Station	SPM	SO_2	CO	NO_2	O_3	NMHC
City Hall	O	O	O	O	O	
UPM	O	O		O	O	
P.J(MMS)	O	O	O	O	O	O
Shah Alam	O	O	O	O	O	O
Klang	O	O		O	O	

Note ; O : indicates the monitoring items

Table 10.2 Condition of Monitoring Stations

Monitoring Station	Present Condition	Future Condition	Feature of the Station
City Hall	Located in a dense commercial area and faces a heavy traffic street. The general pollution level is higher than other stations.	Future land use will be the same as the present one. However, more commercial activities are expected.	It is considered as a vehicle exhaust monitoring station in a metropolitan region, mainly consisting of commercial areas.
UPM	Located in the extensive site of a public university and surrounded by residential and agricultural areas. The general pollution level is lower than at other stations.	Future land use will be the same as the present one. However, an industrial area is planed for the north east of the station.	It is considered as a background monitoring station at present. Development of an industrial area is nearly expected and the pollution level will become higher.
P.J(MMS)	Located in a residential area but industrial areas are the north and south. The general pollution level is higher than other stations like City Hall.	Future land use will be the same as the present one. However, the spread of the industrial area to the south of the station is expected.	It is considered as a general station in a residential-industrial mixed area.
Shah Alam	Located at the playground of a primary school in a residential area. It seems to form a small independent city, having a multi land use pattern. The general pollution level is lower than at other stations except SPM.	Future land use will be the same as the present one. This area can already be considered as a small independent city.	It is considered as a general monitoring station comparable to an independent city.
Klang	Located in a good residential area, surrounded by an agricultural area. The general pollution level is low but relatively higher than UPM, because of some industrial areas located at some distance.	Through extensive decrease of agricultural area, the residential area will grow. Industrial, commercial, public and green buffer zone are also planned. This area is expected to form an independent city like Shah Alam.	It is considered as a general monitoring station comparable to an independent city, though the scale is smaller than that of Shah Alam.

10.1.2 Objective of the Monitoring System

Malaysia is promoting various projects for balanced development of industry and economy, to realize the Plan 2020.

However, there are some apprehensions. Such development may bring about various and complicated air pollution problems caused by urbanization, increase in energy consumption and rapid increase in traffic volume.

Therefore, an air pollution monitoring system should be established as soon as possible, before the pollution level rises and becomes a serious problem.

The major objective of the air pollution monitoring system is to gather data from stationary and mobile sources for the use by regulatory authorities. These data will be effective in accomplishing the following objectives:

-1. To confirm the state of compliance with the air quality guidelines
-2. To monitor the effects of the air pollution control program
-3. To promote countermeasures against urgent air pollution problems
-4. To serve as basic data for use in planning pollution control programs and air quality management programs.
-5. To serve as basic data for environmental impact assessment
-6. To serve as basic data for research and investigation that elucidates the mechanism of complex air pollution.
-7. To serve as basic data for formation of traffic policies.

10.1.3 Central Monitoring System

(1) Function of Central Monitoring System

The main functions of the system regarding air pollution monitoring are as follows.

-1. To provide an understanding of the condition of air quality and pollution sources so as to enable authorities to cope with emergency that threatens the human health.

-2. To exchange data monitored in KVR with the adjacent areas and meteorology stations in order to understand the condition of air pollution over a wider region.

-3. To inform local residents of the current air quality by means of indicators placed along the streets.

-4. To observe the operating condition of the monitoring instruments centrally and deal with any breakdowns.

-5. To assure, announce, and provide requested information on the collected data that is being monitored.

The monitoring data on environment and pollution sources should be collected at a Central Monitoring Center by means of a telemetric system (Fig. 10.1). Therefore, the establishment of an on-line real time system is needed.

The organizations which should be included in the on-line system are administrative organizations which will have responsibility for environmental matters, MMS which will be in charge of emergency weather predictions in respect of regional air pollution, and UPM, and others, which will implement research and study about regional air pollution mechanism.

It takes a while to ensure the quality of data obtained after the monitoring system has been established, as there is the possibility that the abnormal data will be generated by the instruments or other unspecified factors. Therefore, the on-line organizations should be limited to prevent confusion of information.

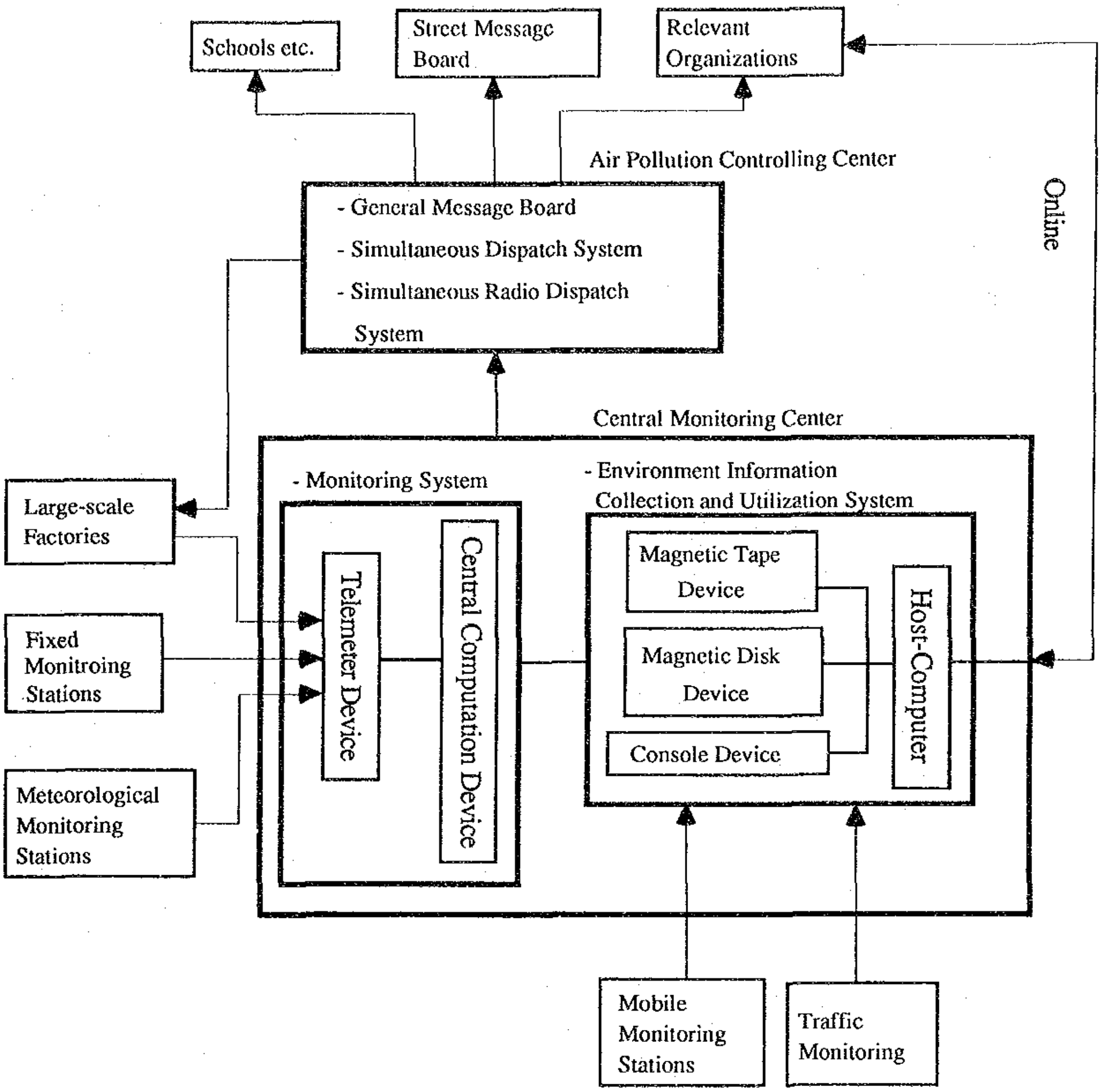


Fig. 10.1 Flowchart of the Central Monitoring System for Air Pollution

(2) Maintenance and Management of Monitoring Stations

To maintain and manage fixed and mobile stations, it will be necessary to operate various kinds of monitoring instruments with stable accuracy for a long period, to ensure the reliability of monitoring data, and to establish a fixed monitoring system that meets certain standards for rapid and economic data publication .

Operational requirements of maintenance and management of the monitoring stations are as follows.

- -1. Regularity of maintenance.
- -2. Calibration with standard gas.
- -3. Examination of the monitoring instruments regularly and at the time of an emergency.
- -4. Arrangement of the monitoring instruments and test of their efficiency.
- -5. To read out and compare the monitoring data, and to compile the daily, monthly, annual reports.
- -6. Assessment of the monitoring data.
- -7. General management of the location, maintenance, and management of monitoring stations.

The following items are important to maintain and manage the stations and data efficiently and rationally.

1) Development and Assurance of the Availability of Engineers

Appointment of proper engineers for monitoring items and scales is necessary for maintenance and management, and the management by DOE is appropriate in this case.

In view of the condition in Malaysia, it is not an exaggeration to say that the development and assurance of the availability of the engineers is the key to the establishment of the monitoring system at an early stage. There will be vital to establish a qualification program for the engineers, and to secure their position and mobility in order to develop and guarantee the availability of the engineers. Moreover, the establishment of a Training Center will be necessary in order to train these engineers using actual monitoring instruments.

2) Education and Training

The operation of any kind of monitoring instrument with stable accuracy for a long period is necessary to maintain the reliability of the monitoring system . The quality of the results, however, depends on the efficiency and maintenance of the monitoring instruments. High technology and know-how are required because of the recent improvements in monitoring methods and instruments. Acquisition of the latest technology and the accumulation of data are needed to maintain accuracy of the monitoring data and the accumulation rate.

It is an important role for the Training Center to collect information on the latest technology, educate, and train the engineers.

3) Maintenance

Besides establishment of above operation, maintenance and management systems, it will be necessary to invite manufacturers of monitoring equipment and materials to open their branches in Malaysia to do such repair services as maintenance, exchange of parts and prompt supply of expandable supplies regularly and in emergency.

10.2 Air quality Monitoring System

10.2.1 Adequate Arrangement of Monitoring Stations

(1) Basic Concept of Adequate Arrangement

The ideal system of air pollution monitoring will trace the concentration of pollutants continuously in KVR over both time and space. Continuous monitoring over space so as to obtain useful information, however, is extremely difficult because pollutants in air move ceaselessly. Therefore, a realistic system will be as follows: to establish some monitoring stations in population of air changing over space, then to take samples in order to estimate population. That is, the aim in seeking an adequate arrangement of monitoring stations is to estimate the spatial distribution of pollutant concentration in KVR as precisely as possible.

(2) Characteristics of Air Pollution in the Kelang Valley Region

According to results of regional numerical simulation, the current air pollution in this region is limited. SO_2, for example, affects the area near the location of pollution sources because the pollutant emission is from stationary sources, namely with the low smokestacks in many factories, under the very calm weather conditions. NO_2 has the same effect as SO_2 does, and its effect can be seen mostly in the area close to main roads with heavy traffic.

Because pollution is limited, contour lines of SO_2 concentration tend to be centered on each pollution source. NO_2 concentration is expected along the Federal Highway from K.L to P.J, where is very heavy traffic.

(3) Basic Plan for Adequate Arrangement

The most important objective in air pollution monitoring is to obtain a precise understanding of conditions in the region where pollution is a present or potential problem. Understanding of the polluted condition is useful as basic data for assurance of the effectiveness of air pollution control effects, and for facilitating pollution control at the time of an emergency, or the establishment of an air quality management plan and the research and study to solve air pollution mechanism.

As there are many areas which have limited air pollution, a number of monitoring stations are needed to gain an understanding of the condition of pollution in KVR. As it is unrealistic to implement continuous monitoring, given the present condition of the monitoring system in Malaysia, the authorities are expected to use the mobile stations effectively in addition to the fixed monitoring stations and to do as much monitoring as possible. If monitoring using mobile stations is implemented for about a month in both the rainy and dry seasons, the collected data will be close to the annual average data.

The objectives of establishing the monitoring stations are to gain a clear understanding of the present condition of high concentrations that has been predicted by numerical simulation, and an assurance of the effects of air pollution control. The monitoring stations should be arranged by taking the following items into consideration: the impact on the residential areas which are the main objective of protection, and the land use plan in the present and future (Fig. 10.2 and Fig. 10.3).

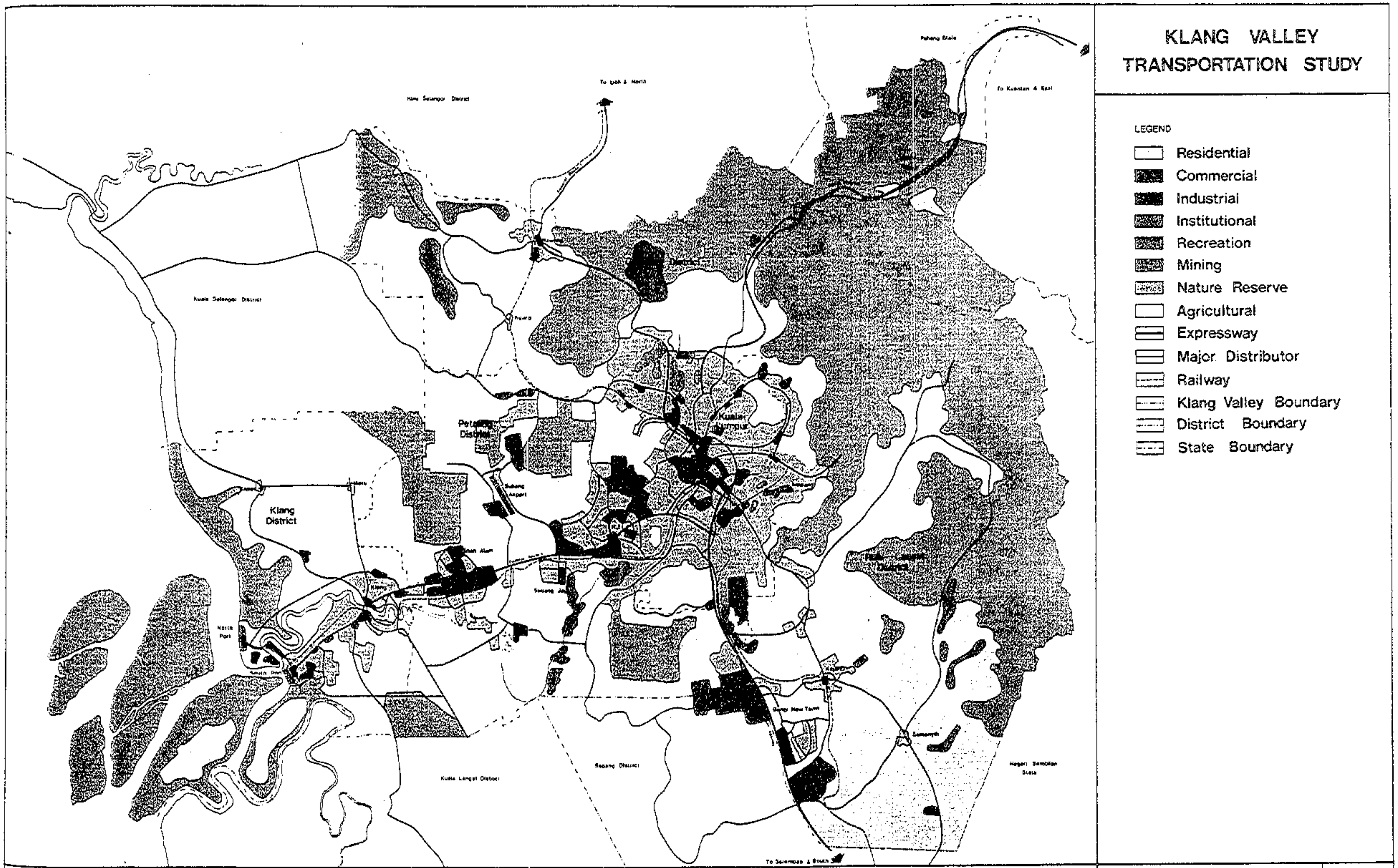
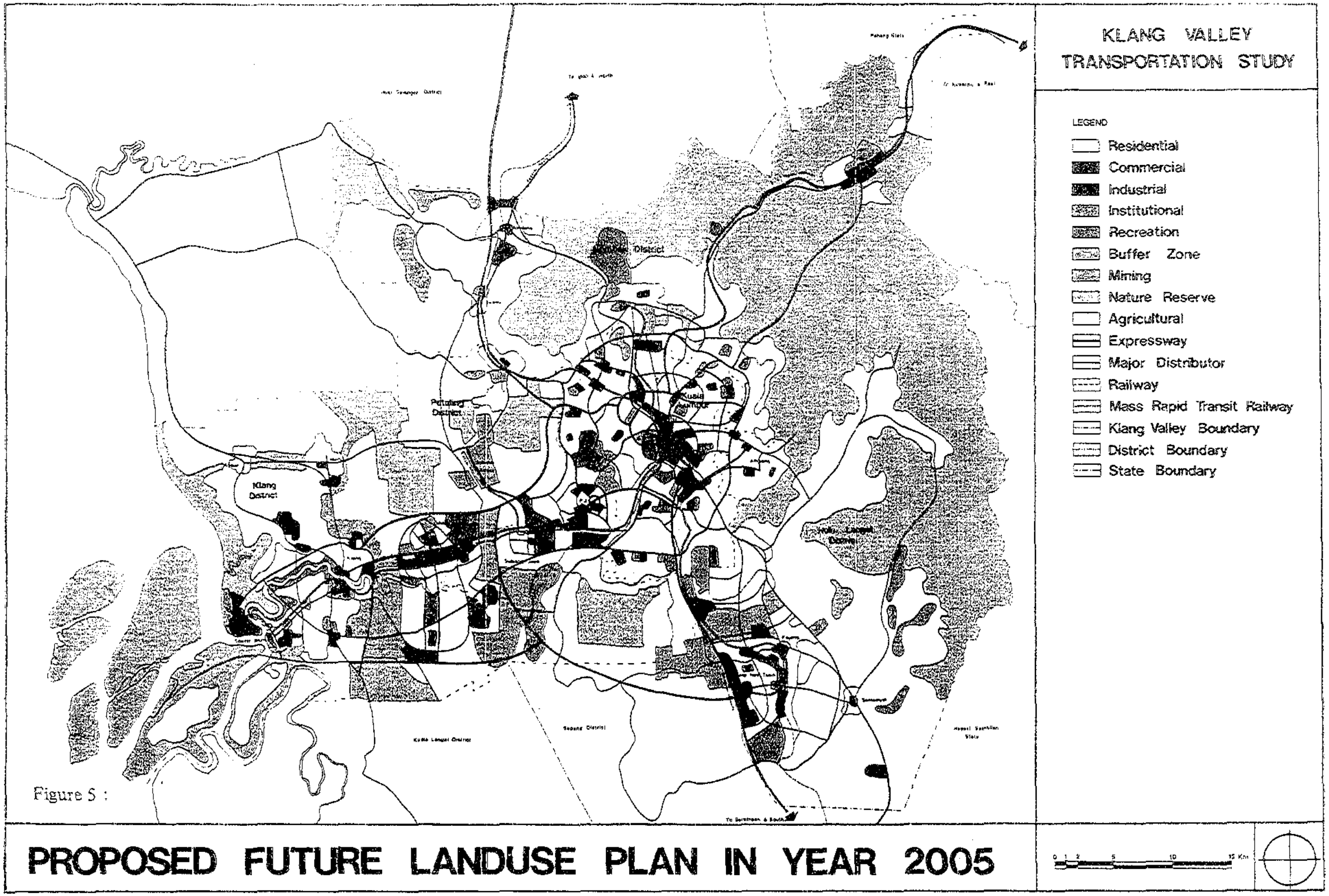


Figure 1 . 1 **EXISTING LANDUSE IN 1985**

Source: KLANG VALLEY TRANSPORTATION STUDY, 1987, JICA

Fig. 10.2 Existing Landuse in 1985



Source: KLANG VALLEY TRANSPORTATION STUDY, 1987, JICA

Fig. 10.3 Future Landuse in 2005

(4) Arrangement Plan for the Monitoring Stations

The main concept underlying arrangement of the monitoring stations is to understand precisely the present condition of pollution in the high concentration areas. The method for this arrangement is as follows, and the arrangement of the monitoring stations is shown in Table 10.3 and Fig. 10.4.

-1. The five existing fixed monitoring stations should be maintained to provide continuity of monitoring data, because they are not affected by specific emission sources and have a tendency to show the average concentration in each area (Table 10.2). City Hall, however, is the monitoring station for vehicle exhaust gas. The monitoring items should not be changed.

-2. Three fixed monitoring stations will be established at the high SO_2 concentration points in the Federal Highway belt area close to large residential areas. Industrialization is expected to continue in this belt area.

Four mobile stations will be established at high concentration points in areas that in the future is expected to be residential area.

In addition to SO_2, SPM and NO_2 should be monitored because they could pollute in a large area in the future.

-3. Three fixed monitoring stations will be established along highways with heavy traffic and a high concentration of NO_2, and four mobile monitoring stations will be established at points where data collection will be valuable as support for the functions of these three stations.

In addition to NO_2, CO, NMHC, and SPM should be monitored. CO and NMHC are present in high concentrations in vehicle exhaust gas and SPM is important as a future broad-area pollutant, but NMHC should be monitored only at the fixed monitoring stations.

-4. In the area around the monitoring stations mentioned in 1.~3., twelve mobile stations will be established where large residential areas now exist or are expected to be built in the future. SPM, SO_2, and NO_2 should be monitored because they have the possibility of causing pollution in broad areas.

Table 10.3 Proposed Items of Each Monitoring Station

Fixed Station (11 stations)		SPM	SO_2	CO	NO_2	O_3	NMHC	WIND
Residential area (4)	UPM	O	O		O	O		O
	P.J	O	O	O	O	O	O	O
	S.A	O	O	O	O	O	O	O
	Klang	O	O		O	O		O
Road Side (4)	C.H	O	O	O	O	O	O	O
	NEW	O		O	O		O	O
High concentration area (3)	NEW	O	O		O			O

Mobile Stations (20 stations)		SPM	SO_2	CO	NO_2	O_3	NMHC	WIND
Residential area (12)	NEW	O	O		O			O
Road Side (4)	NEW	O		O	O			O
High Concentration area (4)	NEW	O	O		O			O

Note; 'O' indicates the monitoring items.

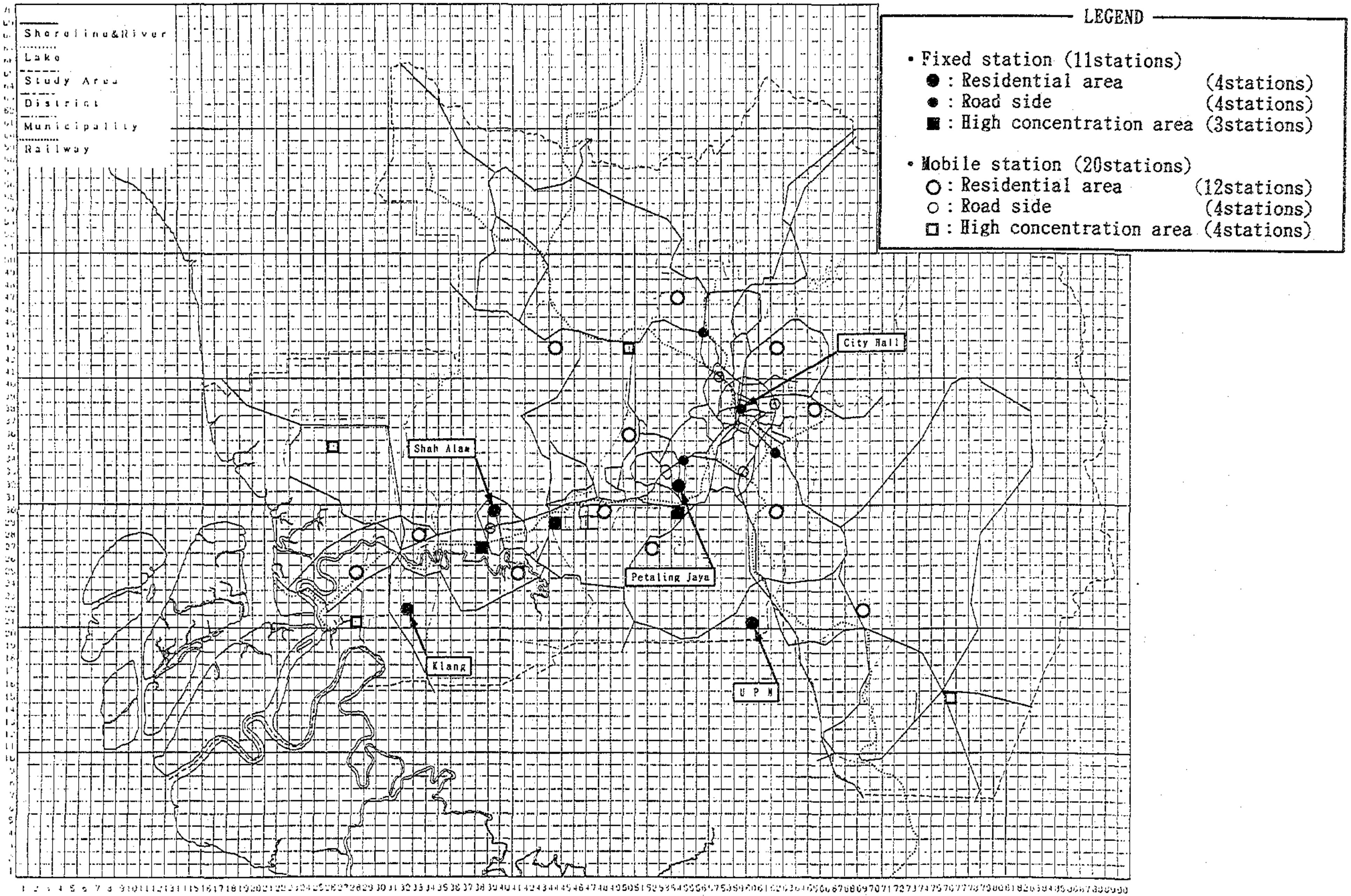


Fig.10.4 Location Plan of Monitoring Stations

10.2.2 Requirement for Establishment of Monitoring Stations

The following requirements should be met when establishing the monitoring stations.

-1. Items to be monitored.
-2. Selection and layout of the monitoring instruments.
-3. Location, scale, structure, facilities of the monitoring stations.
-4. The future plan.
-5. The efficiency of maintenance and management.
-6. Economy and safety, etc.

Moreover, the following should be given attention in establishing each monitoring station.

1) They should be established in places little affected from designated pollution sources. The examples of designated pollution sources are as follows: On the ground or in the lower layer of air, parking lots, small incinerators, gas stations, garbage incinerators, chemical laboratories, kitchens, bathrooms, and livestock huts. In the middle and upper layers, smokestacks of the boiler for air conditioning and oil supply, cooling towers, exhaust vents, mechanical rooms. Monitoring stations in middle and high-rise buildings should be established in consideration of the inter-relationship between the monitoring stations and the roads and the influence from air currents around the buildings, because many buildings face the roads.

2) The intakes should be 1.5~10m high in residential areas. Where there are high buildings around the monitoring stations, the intakes should be on the roof so as not to be influenced from those buildings. The intakes should not be built in especially dense areas, because there are possibilities that pollutants could be downwashed in peculiar wind turbulence that may occur on leeside of emission sources.
The distance between the intakes and the measuring instruments should be within 5m if possible in consideration of chemical reaction of pollutants.

3) Wind direction and speed should be monitored at 10m height in open spaces, but they should be monitored at least above 5m from the buildings when monitorings are done on the roofs.

4) Monitoring instruments run effectively about seven years on average although there are a few differences on monitoring items. Therefore, adequate renovation of monitoring instruments considering their durable length of time is needed to get reliable monitoring data.

10.3 Pollution Source Monitoring System

10.3.1 Basic Items for Pollution Source Monitoring

(1) Objectives of Pollution Source Monitoring

Air pollution sources are fundamentally classified into the stationary sources from factories and the mobile sources from vehicles.

The main objective is to obtain proper knowledge of the emission conditions of pollution sources and to assure if the legal emission standards are observed. It is also important also as a means to get basic data in order to establish an air pollution control plan and to draft out air quality management plan.

(2) Priority Pollutants for Monitoring

Standards for stationary sources are established as Environmental Quality (Clean Air) Regulations issued under the Environmental Quality Act. It defines the emission standards of air pollutants and harmful substances from fuel combustion facilities. Vehicle exhausts such as smoke are controlled under the Road Traffic Ordinance. Lead content in petrol too is regulated based on the Environmental Quality Act. Additional regulation of petrol vehicle exhausts is scheduled.

Although the regulations under these laws should be observed, a first priority is to monitor some limited pollutants, according to the present monitoring system and the laws related to the emission standards, because the present conditions of pollution sources have not been understood yet.

The following are proper pollutants for immediate priority.

-Stationary sources / SOx, NOx, Dust
-Mobile sources / CO, NOx, SPM, HC

(3) Priority Monitoring Area

According to our study, as already described, air pollution is observed in particular areas of the Region. SO_2 is dispersed in each industrial area with many stationary sources, and NO_2 is dispersed in KL with heavy traffic and along the Federal Highway. The area along the Federal Highway is affected by both SO_2 and NO_2, and effects of both pollutants is considered remarkable especially in the P.J area.

The area from KL to Federal Highway has a broad residential area as well as an industrial area, and these areas are expected to grow according to the land use plan (Fig. 10.2 and Fig. 10.3).

Therefore, the area from KL to Federal Highway should be given the priority in air pollution control in order to conserve human health and living environment in the area, and controls here would have the most remarkable effects.

Judging from the above, the air quality monitoring and pollution source monitoring system should be given high priority in this area.

10.3.2 Stationary Source Monitoring

(1) Procedures for Pollution Source Monitoring

The procedure for monitoring pollution from stationary sources is shown in the flow diagram in Fig. 10.5. Various aspects of emissions from extra large-scale pollution sources can be monitored by the automatic monitoring systems from the Central Monitoring Center. The Central Monitoring Center can request factories to cooperate in controlling pollution during an emergency period when there is potential for producing high concentration, and in the control of emission rate in weather condition which might favour high concentration. Other pollution sources are classified into two types according to an emission scale, and the frequency of on-site investigation (flue gas measurement) for them is to be established.

Based on the results of investigation of emission rate, and the air quality monitoring data reviewed every three years, control measures are to be assessed and changes of annual plans will be required if pollution has not been reduced.

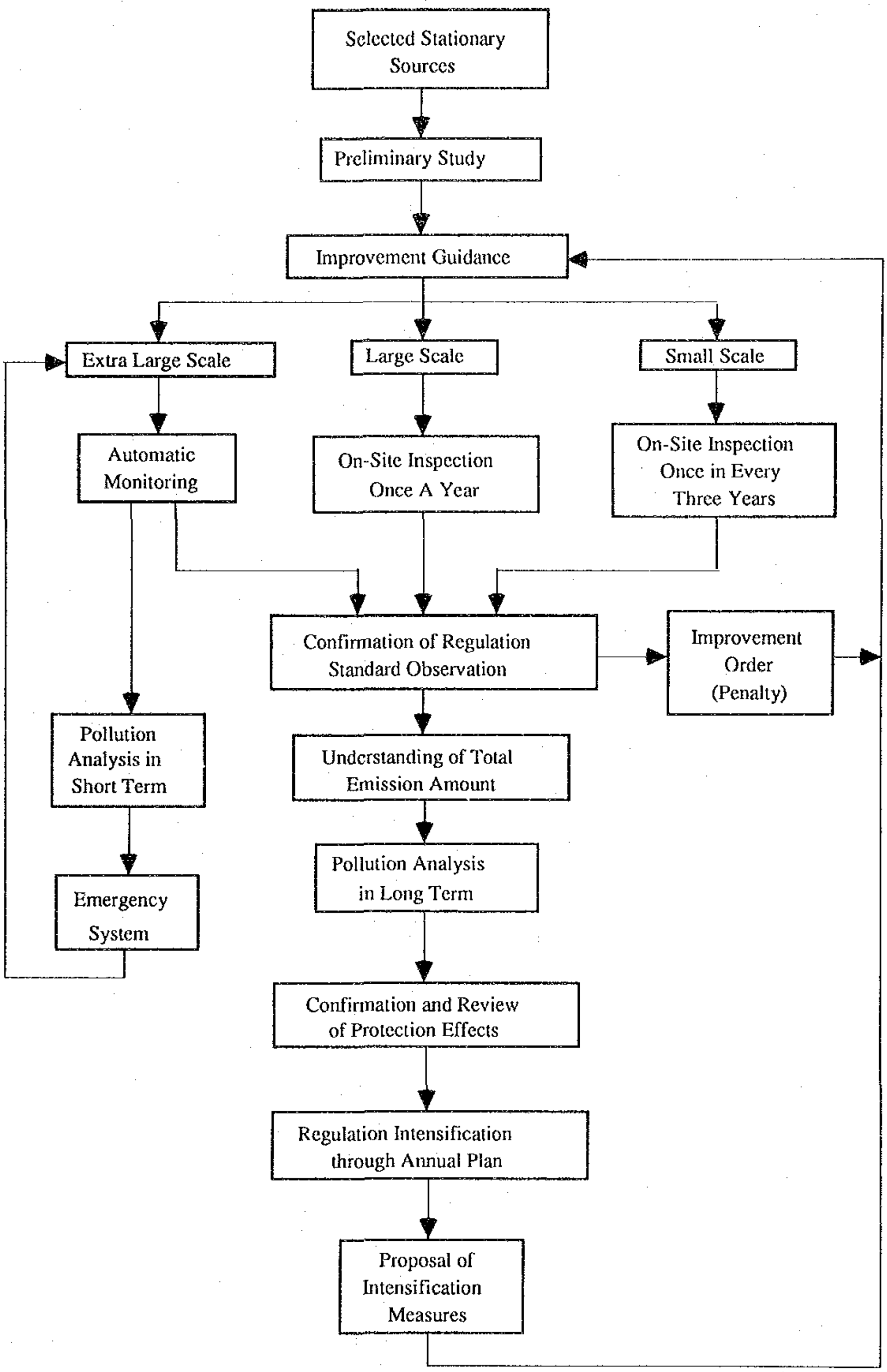


Fig. 10.5 Flow Diagram for Monitoring Pollution from Stationary Sources

(2) Pollution Sources for Monitoring

Air pollutant emission from classified factories in 1992 is shown in Table 10.4. 86 facilities in 4 industry types; food and kindred products, lumber and wood products, palm oil mill, and electricity supply, emit 81 ~ 91% of total pollutant amount. 10 electric power plants, which emit the highest pollutant amount, emit 22 ~ 81% of total pollutant amount.

Therefore, the 10 power plants should be defined as extra large-scale pollution sources shown in Fig. 10.5, and 76 facilities and other types with high emission amount should be defined as large-scale pollution sources.

Table 10.4 Air Pollutant Emission by Industry Type (1992)

Industry Code & Industry Type		NO. of Facilities	Pollutant Amount(ton/y)		
			SOx	NOx	Dust
101	Food and kindred products	36	2,357	128	642
108	Lumber and wood products	22	935	660	2,094
113	Palm oil mill	18	1,909	734	2,815
129	Electricity supply	10	19,522 [64%]	12,792 [81%]	1,969 [22%]
	sub total	86	24,723 [81%]	14,314 [91%]	7,518 [84%]
Others		162	5,846	1,457	1,484
	Total	248	30,569	15,771	9,002

Note; Figures in parentheses indicate percentage of the pollutant amount to the total.

(3) Monitoring Methods

An integrated monitoring system should be established for extra large-scale pollution sources, using automatic measuring instruments and a telemetric system.

Large-scale and small-scale pollution sources should be monitored by on-site investigation. It will be implemented once a year for large-scale, and once in every three years for small-scale pollution sources by patrol cars. Two monitoring teams, each of whom has four members and one patrol car, should be established. They should patrol regular monitoring points and courses of pollution sources.

The objectives of this patrol are not only on-site investigations but also the monitoring of harmful sources of smoke and soot. Furthermore, monitoring points for open burning are necessary in the patrol course, and open burning should be banned.

10.3.3 Mobile Source Monitoring

(1) Monitoring Items

The state of vehicle traffic in KVR is as follows. While diesel buses are the main public transportation, most commuters use motor cars and 50cc motorcycles. They create enormous traffic jams in KL city and on Federal Highway. Especially on Federal Highway from KL to PJ, the traffic volume exceeds 350,000 vehicles a day. Since rapid increase in traffic volume is expected from now on, air pollution caused by vehicle exhaust gas could be a serious problem. Therefore, the Malaysian government is planning the construction of bypasses to disperse the traffic volume, establishment of new public traffic facilities to reduce car commuters, and so forth.

A research outline for investigation and design of traffic policies is shown in Fig. 10.6. Fundamental data such as present traffic volume and driving pattern are necessary to determine the nature and features of exhaust gas from motor vehicles. Therefore, the data should be collected by traffic census.

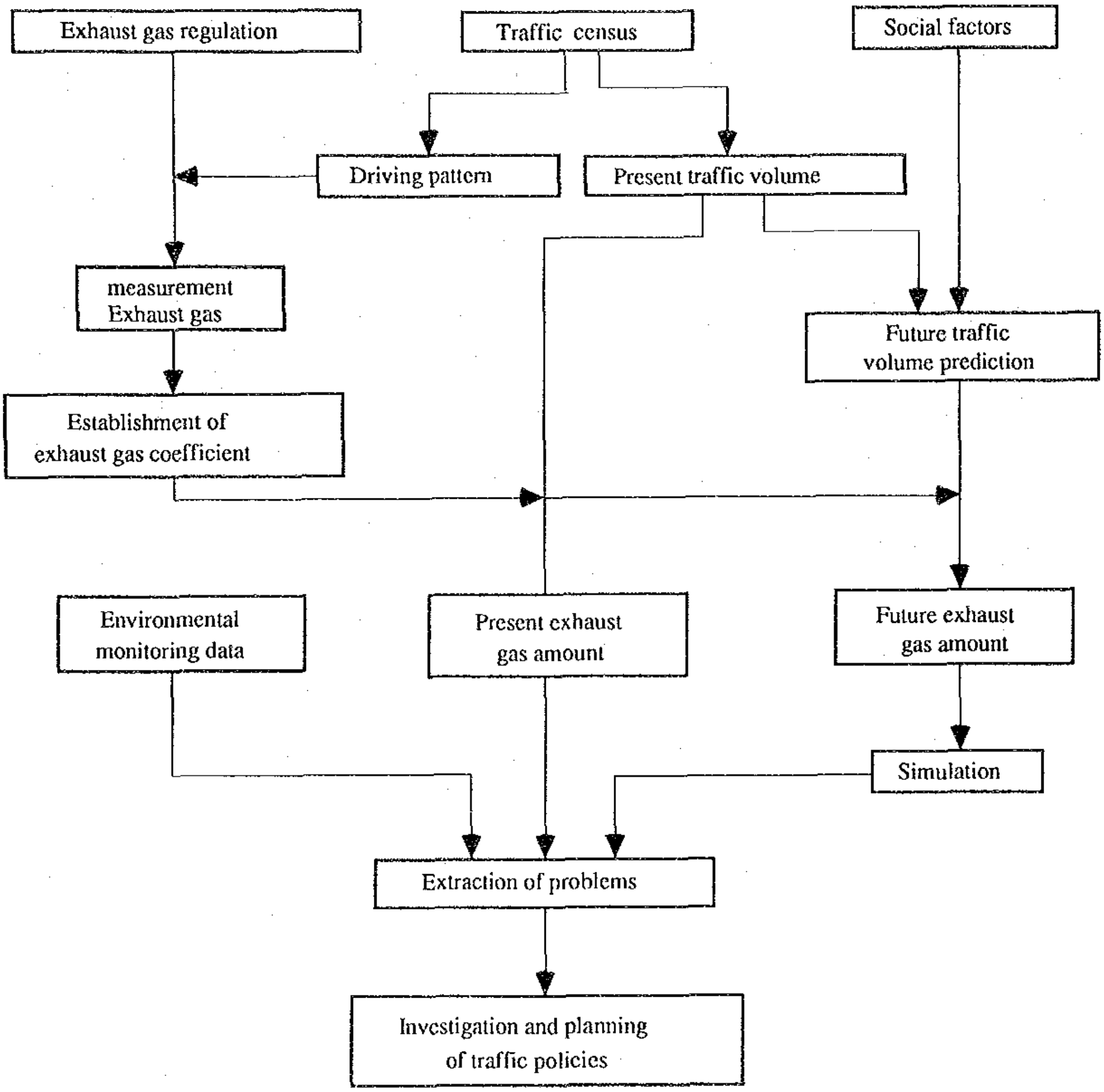


Fig 10.6 Research Outline for Investigation and Planning of Traffic Policies

(2) Monitoring Transportation Networks

The 50 monitoring points in the Study are shown in Fig. 10.7. At least this numbers are necessary to get continuous data. Other points would be added in keeping with investigations of future traffic policies.

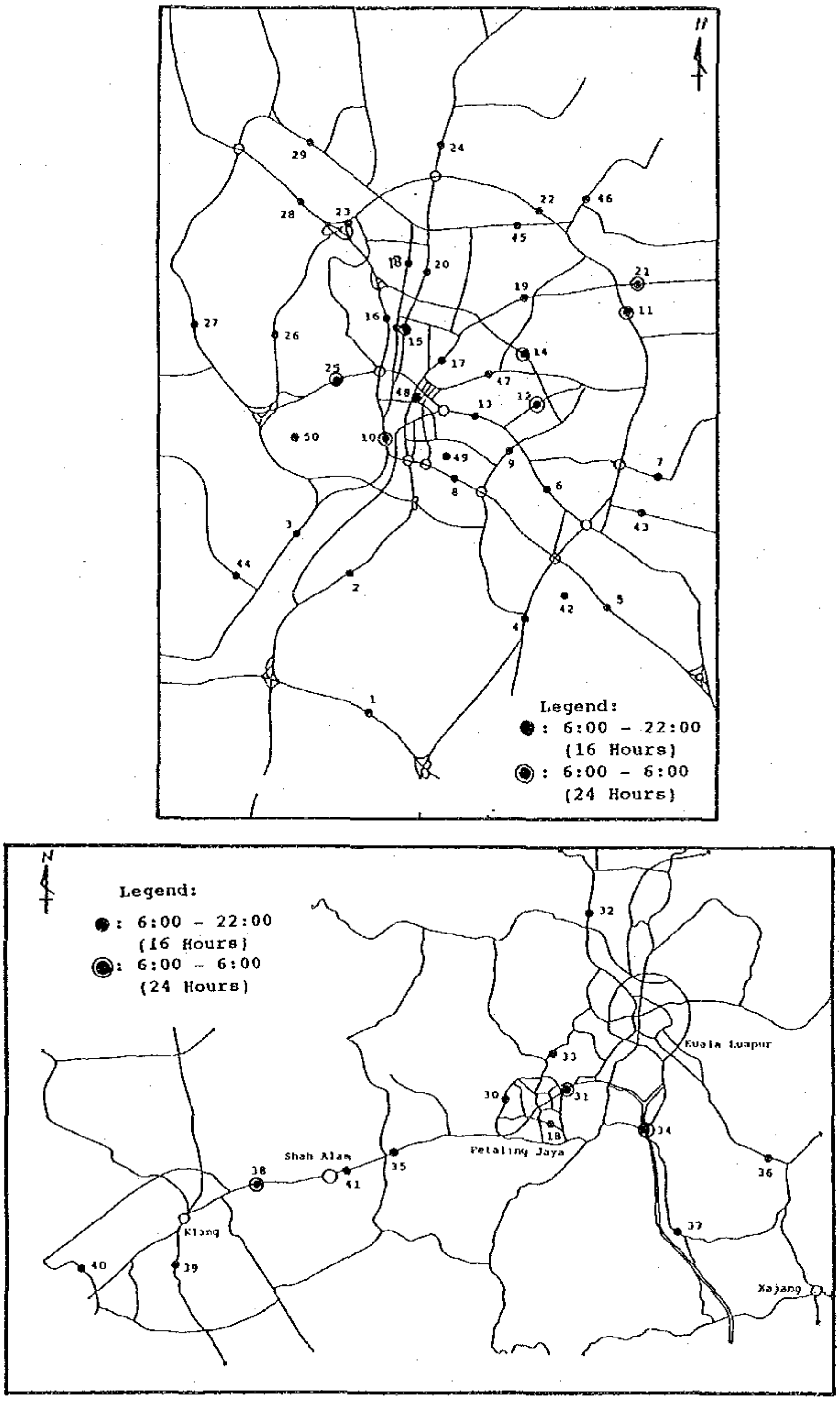


Fig. 10.7 Location Map of Traffic Volume Survey Points in KVR

(3) Monitoring Methods

Among the 50 points, 24-hours recording of data should be conducted at 10 points once a year and integrated research at other points once in every three years. Those data would be combined with the data from stationary sources and be integrated for review every three years.

Moreover, these data should be collected at a Central Monitoring Center. Such a Center, that is expected to be established, would undertake continuous monitoring of traffic volume at main points on trunk roads. It would also be necessary, in relation to the traffic information system, to increase traffic efficiency and to cope with traffic accidents or problems that may be caused by large scale disasters.

(4) Review of Vehicle Emission Factor

The amount of pollutants in vehicle exhaust gas vary widely depending on complicated factors. There are two types of factor that influence the amount of exhaust gas. One is attributed to the vehicles themselves, such as suitable fuels, combustion types, adherence to exhaust gas regulations, method of reduction of exhaust gas, vehicle age, state of maintenance, exhaust gas amount and vehicle weight. The other is attributed to driving practices and conditions, such as, for example, speed, vehicle load, slope of roads, heating of engine and driving method. They also differ from the standard value depending on the driving practices that are determined by law, namely speed. Therefore, chassis dynamometer tests for various driving patterns are necessary to ascertain the exhaust gas amount accurately.

It is impossible, however, to analyze and measure the exhaust gas amount concerning all of those factors. The following classification is adequate to get average exhaust gas coefficients for the motor vehicles driving on general roads.

-1. vehicle types
-2. years of exhaust gas regulation
-3. driving patterns

10.4 Staff, Costs, and Processes for Monitoring System

10.4.1 Staff for Monitoring System

Desirable staffing for the Central Monitoring System, for work related to both the air quality and pollution sources, are shown in Table 10.5. Approximately 21 specialists are necessary in each field. Thirty or more persons would be necessary for effective utilization of monitoring data, such as review of vehicle emission factor through chassis dynamometer test.

Table 10.5 Organization and Staff for Monitoring System

Organization		Staff
Central monitoring center		5
	Central monitoring for air pollution	2
	Central monitoring for measuring instruments	1
	Total management of monitoring data	1
	System management of CMC	1
Maintenance and management of monitoring stations		7
	Investigation of instruments	4
	Collection and assessment of data	2
	Total management of monitoring stations	1
Monitoring of pollution sources		9
	Stationary sources monitoring	8
	Mobile sources monitoring	1

10.4.2 Costs for Monitoring System

Table 10.6 shows rough cost estimates necessary for the monitoring center and the indicators on the streets, and Table 10.7 and Table 10.8 show the cost necessary for the air quality monitoring and the patrol cars to monitor stationary sources.

Table 10.6 Required Instruments and Space for Environment Monitoring Center

Instruments	Rough Estimated Costs (1,000M$)	Required space
Monitoring center	960	
Data transmission	60	Office : 50 sqm
Data processiong	300	Computer center : 100 sqm Stock room of materials : 50 sqm
Data exchange	400	
Simultaneous information	200	
Indicater on the streets (2m*4m)	2sets*@800=1,600	-

Table 10.7 Rough Cost Estimates for Monitoring of Air Quality and Stationary Sources

(unit:1,000M$)

Monitoring stations			No.of stations	Instruments cost	maintenance cost	Total Cost
Fixed stations			11	-	-	7,740
	Residential area	UPM	1	@590*1	@70*1	660
		P.J (MMS)	1	@760*1	@90*1	850
		Shah Alam	1	@760*1	@90*1	850
		Klang	1	@590*1	@70*1	660
	Road side	City Hall	1	@760*1	@90*1	850
		New Station	3	@660*3	@30*3	2,070
	High con-centration area	New Staion	3	@560*3	@40*3	1,800
Mobile stations			4	-	-	4,000
	Exsisting cars		2	@960*2	@40*2	2,000
	New cars		2	@960*2	@40*2	2,000
Patrol cars for pollution sources			2	-	-	580
	Exsisting cars		1	@240*1	@50*1	290
	New cars		1	@240*1	@50*1	290

Notes: 1. The costs for instruments of fixed stations cover meteorological meters, containers, air conditioners etc.

2. The maintenance and management costs indicate annual requirement.

Table 10.8 Costs of Instrumens for Air Quality Monitoring

(unit : 1,000M$)

Instrument Item	Instrument Cost	Notes
Container for fixed station	200	4.0m(L)x2.0m(W)x2.0m(H)
Car for mobile station	400	7.0m(L)x2.3m(W)x2.9m(H)
Stabilizer	20	instrument of stabilizing voltage
Data logger	46	air monitoring data accquisition equipment
Modem	2	communication enabling on-line data processing

Table 10.9 Cost of Instruments and Maintenance

(unit : 1,000M$)

Measuring item	Instruments Cost	Maintenance Cost (annual)
SO_2	60	18
NOx	60	9
SPM	54	4
O_3	34	39
CO	70	4
HC	95	11
Weather	110	1

10.4.3 Future Processes for Monitoring System

Future processes for the Central Monitoring System are as follows; to educate the engineers by establishing a Training Center at the early stage, to maintain and manage the five existing monitoring stations, to establish additional stations, to shift gradually to the Central Monitoring System from telemetric devices in 2000, and to complete this system by 2005.

CHAPTER 11 GUIDELINES FOR THE AIR QUALITY MANAGEMENT FOR KELANG VALLEY REGION

CHAPTER 11 GUIDELINES FOR THE AIR QUALITY MANAGEMENT FOR KELANG VALLEY REGION

11.1 Introduction

This chapter has two main themes. The first is to establish Guidelines which is the most important role in the chapter, and the second is to summarize this study in order to clarify the motivation for the guidelines aimed at air pollution control and target problems to mitigate air pollution in the Kelang Valley Region.

11.2 Overview of Kelang Valley Region

11.2.1 Natural Condition

KVR is located on the west coast of Peninsula Malaysia, facing the straits of Malacca as shown in Fig. 11.1. Kelang valley is situated along the Kelang river, which is approximately east-west in direction from Kelang to Petaling Jaya and north-south in Kuala Lumpur. Such a geomorphologic feature is one of the contributing factors of air pollution in the Region (see Fig. 11.2).

The climate of the Region is tropical rain forest. There are two monsoon seasons, namely Southwest Monsoon (June to September) and Northeast Monsoon (December to March). The transition periods between the monsoon seasons, i.e April - May and October - November are called the intermonsoon period and typically during these intermonsoon period KVR recieves a lot of rainfall. The temperature and humidity are high, almost throughout the year. (see Table 11.1) The wind condition shown as daily average wind speed in Fig. 11.3 indicates that the wind over KVR is generally weak about one meter per second.

Table 11.1 Climate in Kelang Valley Region

Station	Height	Temperature		Humidity	Rainfall	
	(m)	Max.	Min.	(%)	Total (mm)	No. of days
K.L.	17	32.5	23.3	82.2	2551.4	195
P.J.	46	32.8	23.8	80.0	2694.7	200

* Average of 1980, and 1987-1990. (Source: Malaysia Year Book of Statistics 1990)

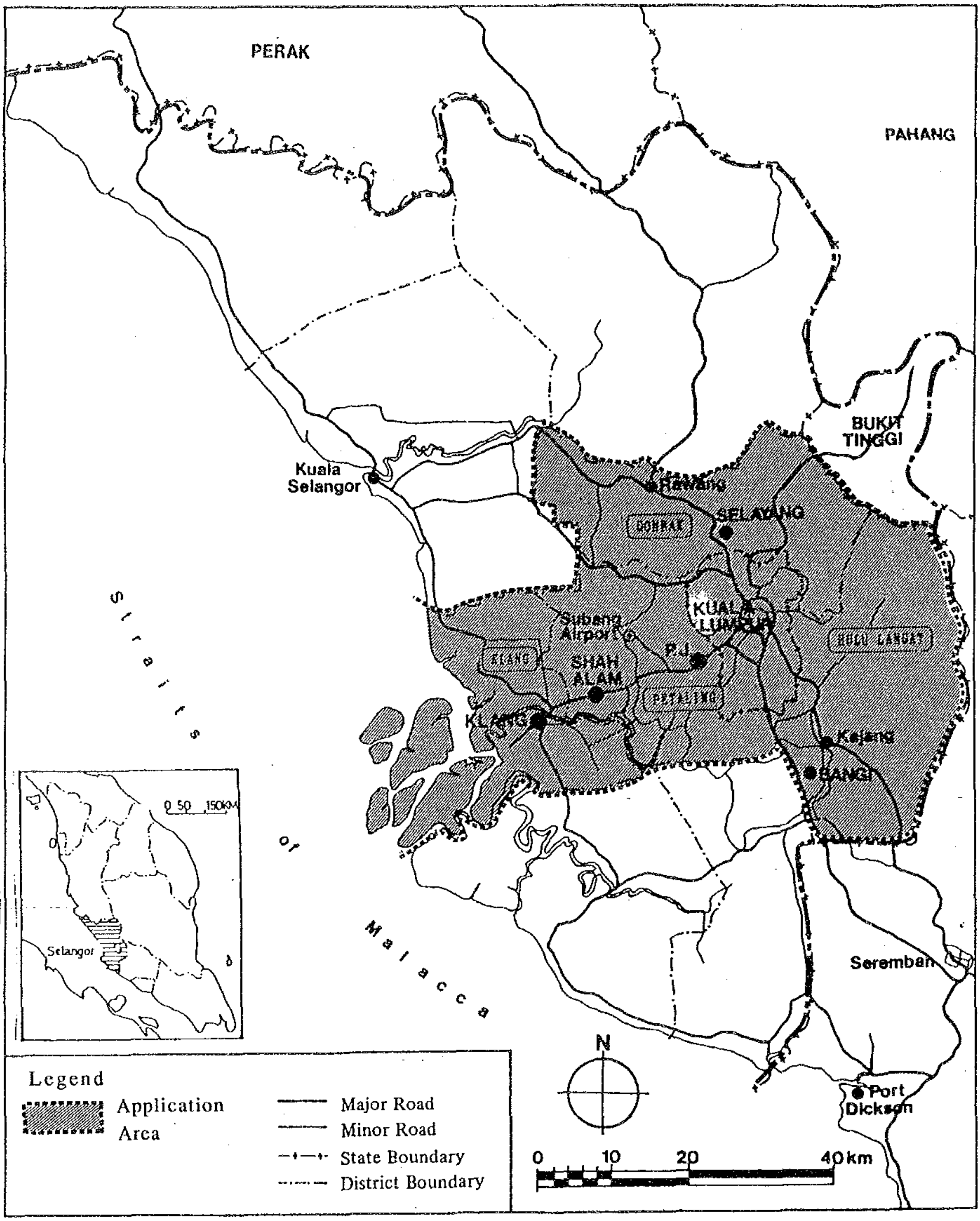


Fig. 11.1 Location Map of Application Area for the Guidelines

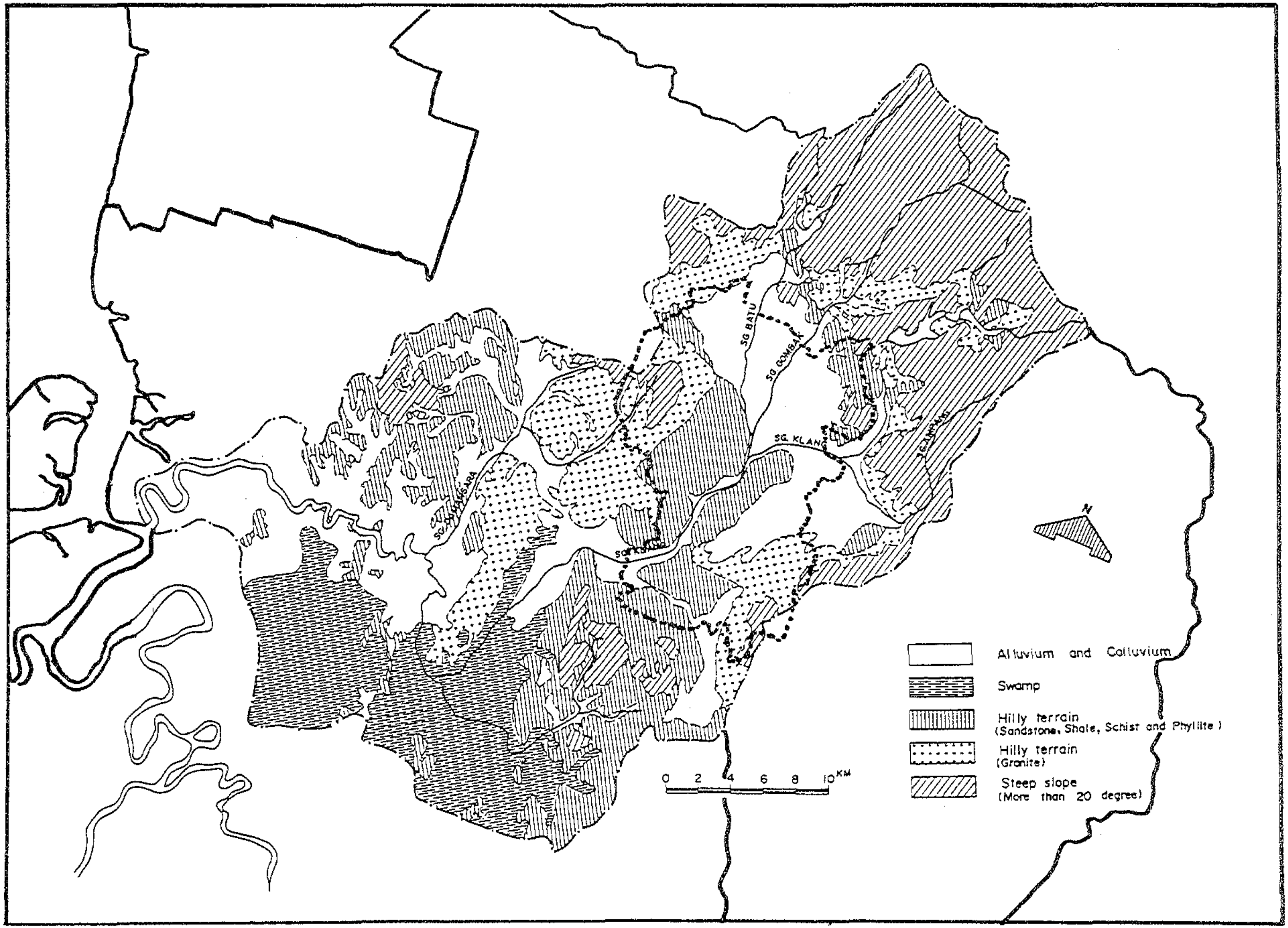


Fig. 11.2 Geomorphologic Map of Kelang Valley

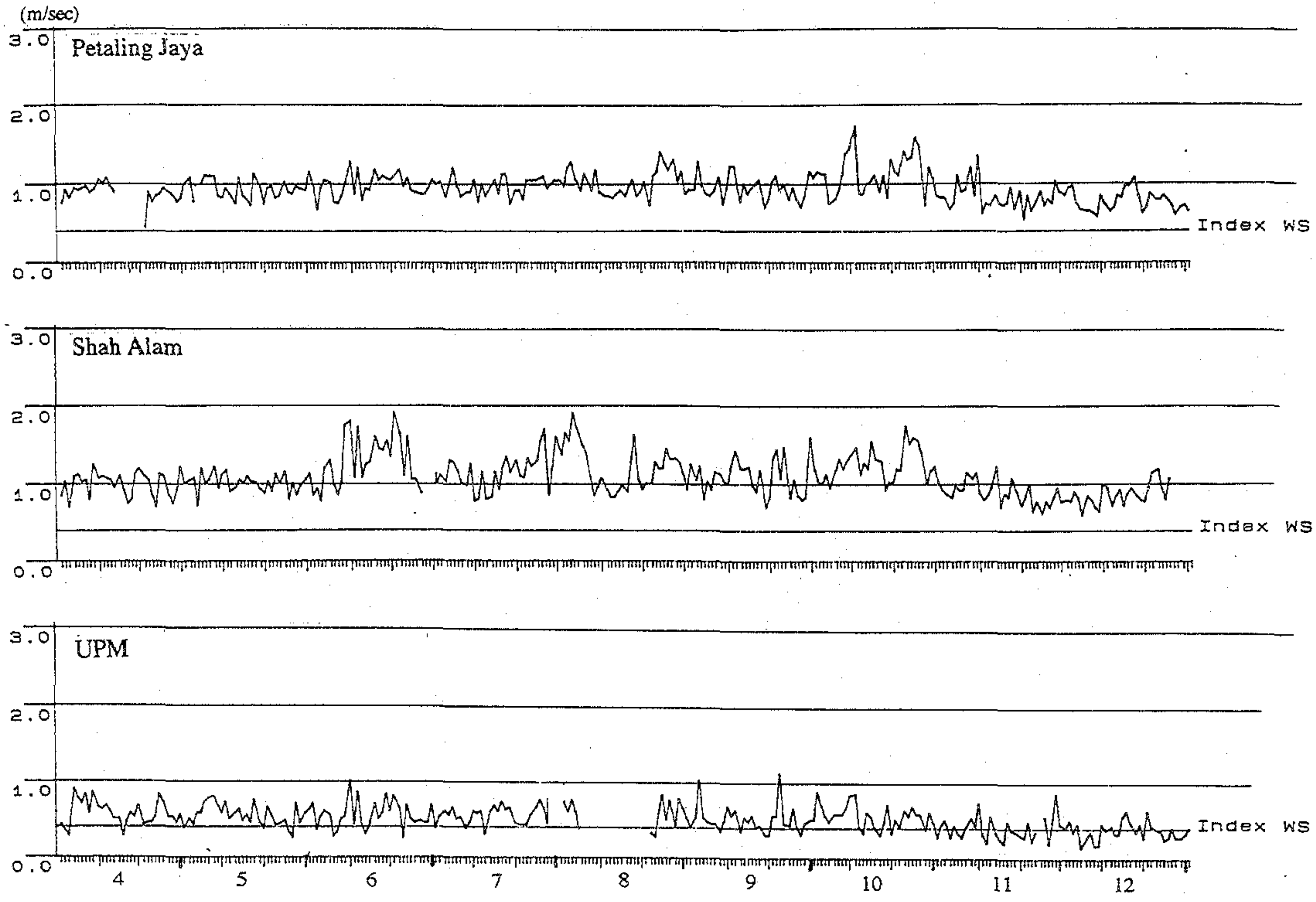


Fig. 11.3 Daily Average of Wind Speed During May to December in 1992

11.2.2 Socio-economic Condition

Kuala Lumpur is the political, economical and cultural center of Malaysia. About 9% of the total number of industrial establishments, 6.5% of the population and 11.4 % of the registered vehicles are concentrated in this city which occupies only 0.07 % of the land area in the country. On the other hand, KVR where the guidelines will be enforced comprising KL city in the center has an area of 2,830 Km^2 (0.86%) and a population of 2.95 million (16.8%). The result of such rapid urbanization will make air pollution a serious problem in and around Kuala Lumpur city.

Though the Malaysian Government have implemented various measures but they are not sufficient. Since with socio-economic growth, the population and developmental infrastructure will increase further, measures through regulations against air pollution must be enforced continuously to maintain and preserve a clean environment.

11.3 Objectives of the Guidelines

The air pollution in KVR has been serious; the Study showed air pollutant concentrations have already exceeded the air quality guidelines in limited areas in KVR. Moreover without new measures the situation will more worsen. Enforcement of the measures against air pollution is very difficult because air pollution is mainly caused by socio-economic activity, and to mitigate air pollution means to restrain the daily activities. Therefore, it is important to enforce the measures systematically with the agreement and assistance of the people. These Guidelines were therefore prepared to be implemented in the area taking into consideration the above facts in order to maintain high ambient air quality for the present moment and the future.

11.4 Application Area of the Guidelines

The application area of the Guidelines covers Federal Territory of Kuala Lumpur and four districts: Gombak, Hulu Langat, Petaling and Klang. Their location is shown in Fig.11-1.

11.5 Target Level of Ambient Air Quality

Usually ambient air quality over a large area is assessed by the annual mean value (AMV). The long-term air pollution value such as AMV is a valuable index to check the harmful effects on human health and other living organisms. It is therefore reasonable to control air pollution sources with reference to their long-term values.

"The Malaysian Air Quality Guidelines" (MAQG) established in 1989 should be applied to the air quality target value in this Region. But the MAQG recommends hourly or daily values except for SPM (PM10). Therefore, the air quality target values were established in this Guidelines. Table 11-2 shows the main air quality values of MAQG and AMV calculated on the basis of MAQG and ambient air quality standard of Japan and WHO's guidelines. According to the empirical rule of Environmental Protection Agency (EPA) and Japan Environment Agency (JEA), annual mean value is half DAHV. Data from the ambient air quality monitoring in KVR between Feb. 1992 and Mar. 1993 supports this rule (see Section 8.4.2).

- SO_2: Daily average of hourly values(DAHV) =0.04ppm or 105 μg/m³ in MAQG; 0.02ppm (52.5 μg/m³).
- NO_2: Since MAQG has hourly value only, therefore, AMV must be obtained from other standards. These Guidelines applied WHO's guidelines to the target value of NO_2.
  DAHV=150 μg/m³ (WHO)
  ---------> AMV=DAHV/2=75 μg/m³(0.037ppm)
- CO: Since MAQG and WHO have no DAHV, Japanese standard is applied to the target value. DAHV=10ppm(12.5 μg/m³)
  --------> AMV=DAHV/2=4ppm (5.0 μg/m³)
  (in consideration of monitoring result about CO)
- PM10 = 50 μg/m³

Pollutant concentrations by computer simulation were evaluated using these values.

Table 11.2 Malaysian Air Quality Guidelines and Air Quality Target Values

	SO_2		NO_2		CO	
	DAHV	AMV	DAHV	AMV	8HAHV	AMV
MAQG	0.04ppm 105 μg/m³	- -	- -	- -	9 ppm -	- -
Japan	0.04ppm -	- -	0.04-0.06ppm (82-123 μg/m³)	(0.02-0.03ppm) (41-61 μg/m³)	- -	- -
WHO	- 100-150 μg/m³	- 40-60 μg/m³	(0.073ppm) 150 μg/m³	- -	- -	- -
Target Value	0.04ppm 105 μg/m³	0.02ppm 52.5 μg/m³	(0.073ppm) 150 μg/m³	0.037ppm 75 μg/m³	9 ppm (11.3 μg/m³)	4 ppm 5.0 μg/m³

MAQG: Malaysian Air Quality Guidelines, DAHV: Daily Average of Hourly Values, AMV: Annual Mean Value
8HAHV: Eight-Hour Average of Hourly Value

11.6 Target Year of the Guidelines

The target year of the Guidelines was set for 2005.

11.7 Air Pollution Condition

11.7.1 Present Air Pollution Condition (1992)

(1) Ambient Air Quality at Monitoring Stations

Table 11.3 shows the concentration of major air pollutants at five fixed stations. In Fig.11.4 pollutant concentrations monitored at these stations (Fig. 11.5) in KVR for SO_2, NO_2, CO and PM10 respectively are presented. It is to be noted that, except for PM10 the air pollution levels at the fixed stations satisfied the air quality target values in 1992.

PM10 at all monitoring stations except UPM has reached the target level. The average composition of SPM from various sources illustrated in Fig. 11.6 indicates that diesel vehicles should be regulated immediately on SPM pollution.

Table 11.3 Annual Mean Value of Pollutants at Monitoring Stations (1992)

	SO2	NO2	CO	PM10
City Hall	0.0104	0.0217	2.73	42
UPM	0.0080	0.0086	–	20
Petaling Jaya	0.0133	0.0193	2.84	48
Shah Alam	0.0077	0.0152	0.70	55
Klang	0.0085	0.0114	–	50
Unit	ppm	ppm	ppm	ug/m3

Note: Monitoring Duration = Mar.1992 - Feb.1993

Fig. 11.4 (1) Annual Mean Value of SO_2 (1992)

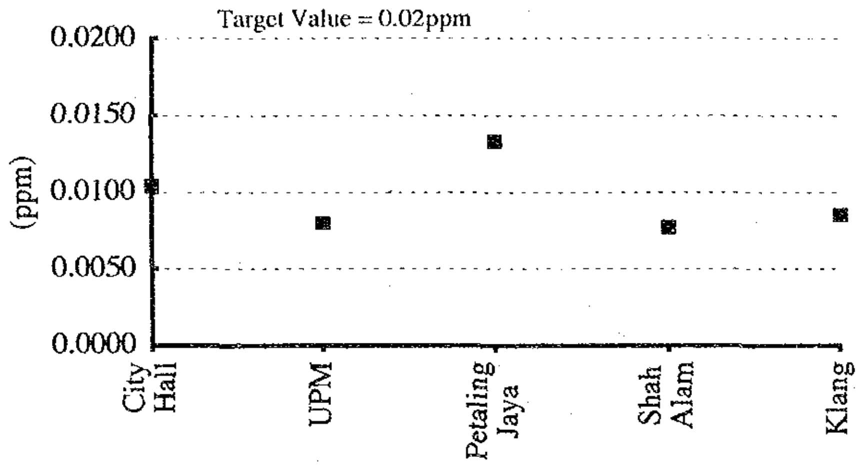


Fig. 11.4 (2) Annual Mean Value of NO_2 (1992)

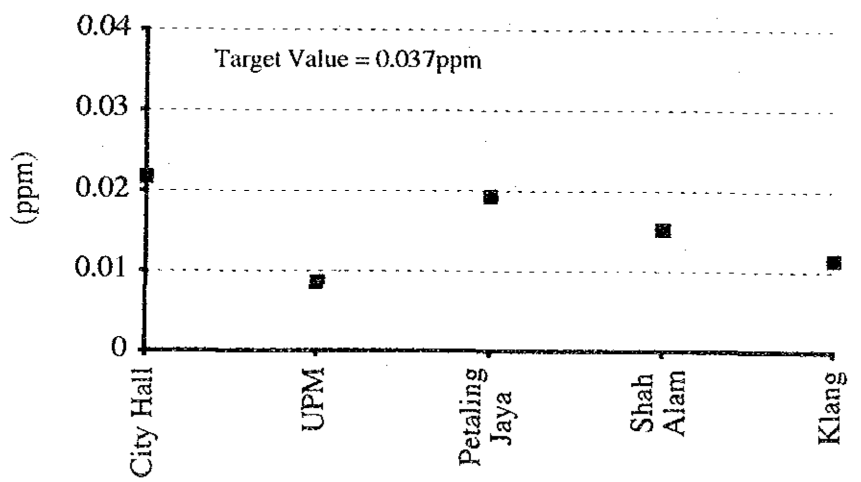


Fig. 11.4 (3) Annual Mean Value of CO (1992)

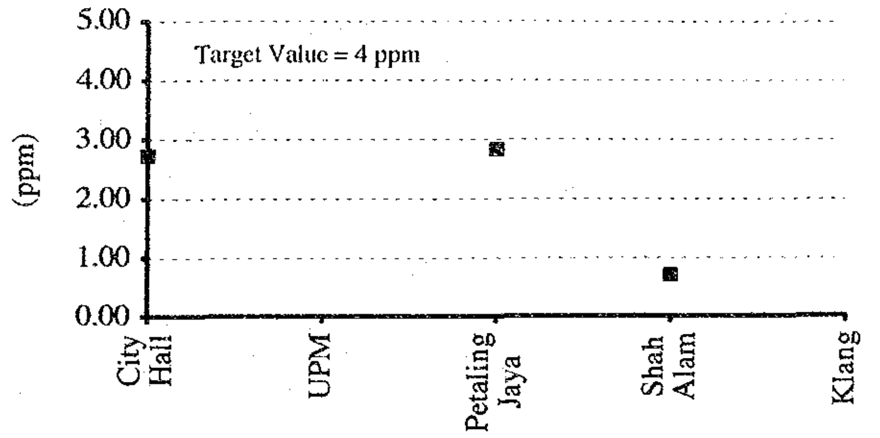
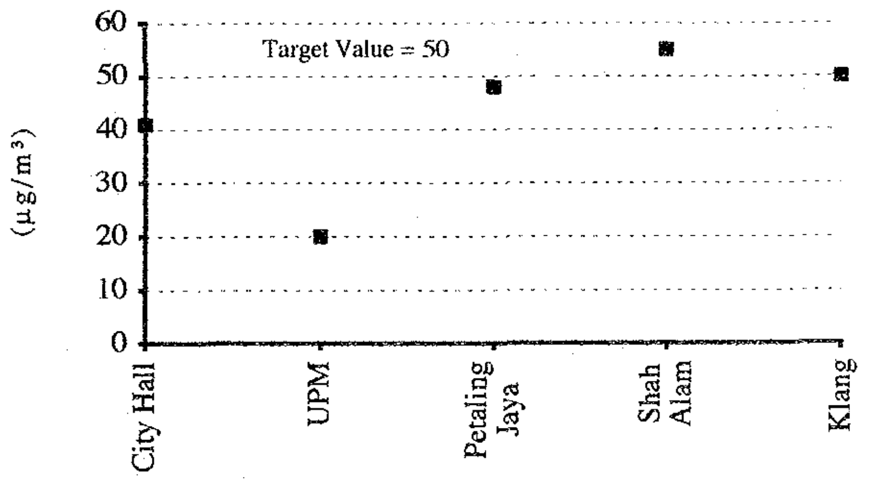


Fig. 11.4 (4) Annual Mean Value of PM10 (1992)



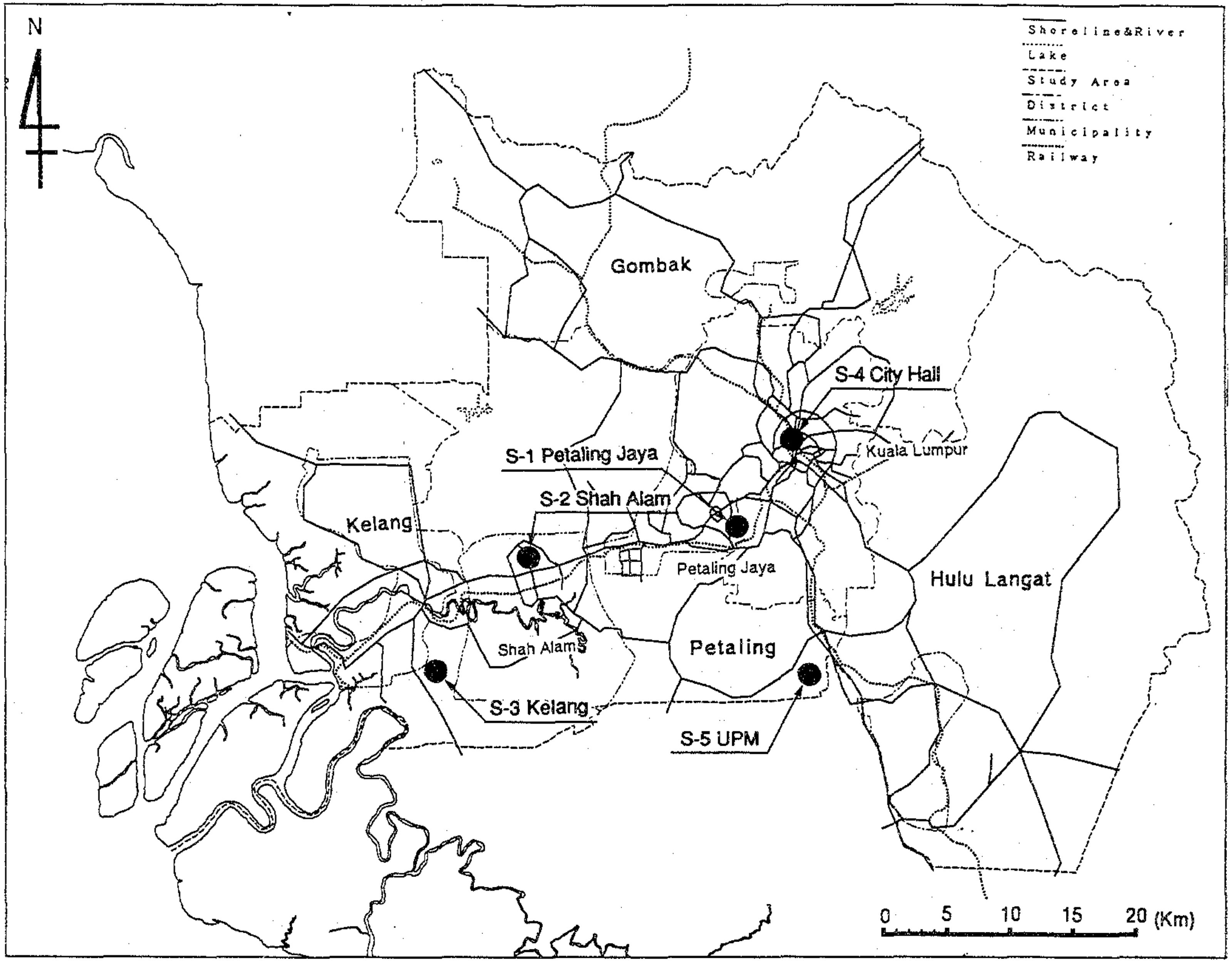
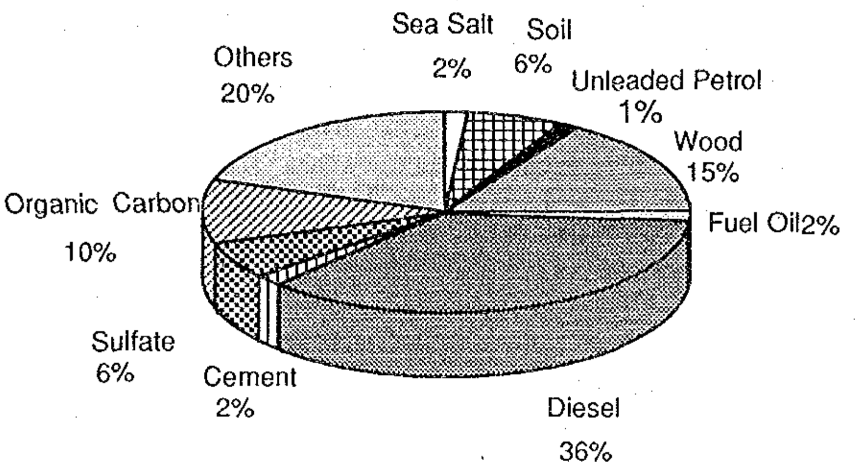


Fig. 11.5 Location Map of Ambient Air Quality Monitoring Stations

Fig. 11. 6 Average Composition of SPM



(2) Air Pollution Load (1992)

For a comprehensive understanding of the present distribution of pollution in KVR, the pollution loads for the various districts in KVR are given in Table 11.4 and in Fig.11.7 for easy visual comparison. The air pollution loads from various sources in KVR are shown in Table 11.6 and Fig. 11.8. We note that motor vehicles are the main source of HC, CO and NOx, whose contribution to pollutant emission is nearly 100% for CO, 100% for HC and 67% for NOx.

On the other hand factories are the main cause of SOx and PM pollution contributing about 86% of SOx and 71% of PM respectively. Among the factories, thermal power plants are the main source of air pollution except for PM. To investigate the relative contribution from the various types of vehicles, their emission rate is presented in Table 11.7 and its graphical presentation in Fig.11.9.

The most important feature is that motorcycles generate a large portion of CO (29%) and HC (70%). Most of CO (47%) and NOx (43%) are emitted by motor cars.

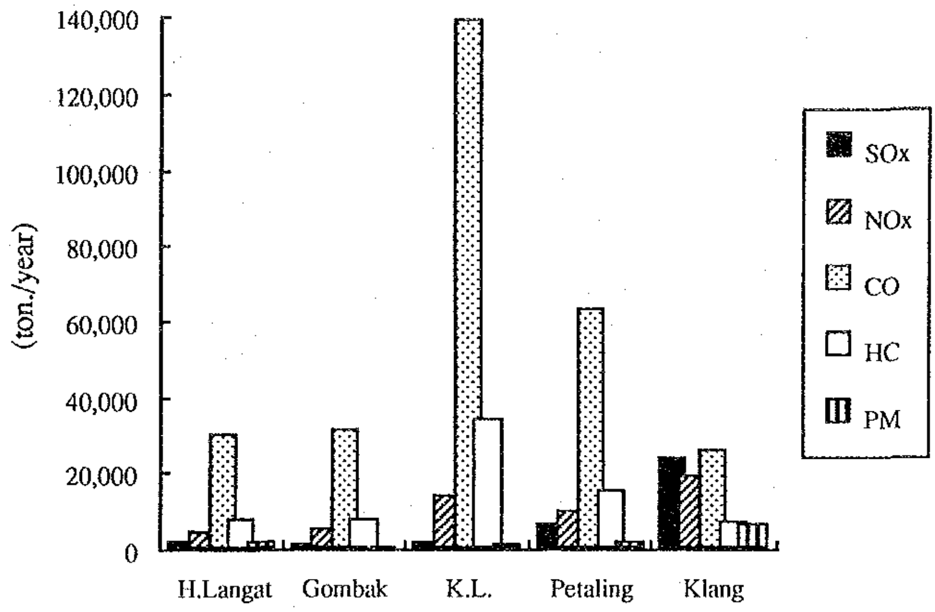
Table 11.4 Pollution Loads by District in Kelang Valley Region (1992)

Unit: (ton/year)

	SOx	NOx	HC	CO	PM
H.Langat	1,594	4,911	8,034	29,077	2,339
Gombak	1,085	6,165	9,300	35,796	712
K.L.	1,670	13,620	33,120	136,058	1,516
Petaling	6,736	11,404	15,775	65,841	2,572
Kelang	24,572	18,191	7,216	23,634	5,399
KVR	35,656	54,291	73,445	290,406	12,558

Pollution loads from open burning activities and earthworks are not included in this Table.

Fig. 11.7 Pollution Loads by District in KVR (1992)



NOx, CO and HC are mainly caused by motor vehicles and this is the reason for their higher concentration in KL than in other districts. On the other hand SOx and PM are mainly emitted from stationary sources. Factories and power plants are mainly located in the Petaling and Klang districts, which explains the reason for the high emission of SOx and PM in these two districts.

It is significant to compare the air pollution loads in KVR with those in a different large polluted city so that we may get a better understanding of the seriousness of the general air pollution condition in KVR. Tokyo Region in Japan was chosen for comparison and the results are shown in Table 11.5. We chose total pollution load, population and area for comparison. Three pertinent points are as follows.

- SOx and CO (annual emission amount) of KVR is twice Tokyo.
- NOx emission per unit area of KVR are half of Tokyo.
- Pollutant emissions per unit population of KVR are from four to eight times of that of Tokyo.

In general, this means that pollutant concentration in KVR is less than that in Tokyo, but delay in implementing air pollution control measures may indicate deterioration of ambient air quality in the future.

Table 11.5 Comparison of Present Air Pollution Loads in KVR with Those in Tokyo

	Area(Km^2)	Population (M.)	SOx	NOx	CO	Unit	Remarks
Tokyo Region	*1,430	11.82	18,200	66,900	163,000	ton/year	1985
			12.7	46.8	114.0	$t/y/km^2$	
			1.5	5.7	13.8	t/y/1,000person	
Kelang Valley	2,830	2.95	35,655	54,472	290,407	ton/year	1992
			12.6	19.2	102.6	$t/y/km^2$	
			12.1	18.1	98.4	t/y/1,000 person	

* Note: 77% of Tokyo Metropolitan Area

(3) Simulation Result of Present Ambient Air Quality

Fig. 11.10 shows the present ambient air quality in KVR from simulation using the whole year's air pollution and meteorology data at fixed stations. NO_2 concentration over KVR satisfied the target value except over a small area in Petaling Jaya. For SO_2, areas exceeding the target value are distributed in industrial areas such as Petaling Jaya, Shah Alam and Klang. There is a maximum concentration of SO_2 in Petaling Jaya with a concentration of 0.06ppm higher than the target value (0.02ppm). For CO, an area exceeding the target value appears around Klang Bus Station in the center of KL city, which is caused mainly by large buses and other vehicles.

Table 11.6 Present Air Pollution Load by Source (1992)

	SOx	NOx	PM	HC	CO
Factories	30,569	15,771	9,003	–	–
Power stations	19,522	12,792	1,969	–	–
General factories	11,047	2,979	7,034	–	–
Motor vehicles	3,117	36,212	3,243	73,445	290,407
Airplanes	416	1,320	115	–	–
Ships	1,552	989	200	–	–
Households	–	162	44	–	–
Total	**35,654**	**54,454**	**12,605**	**73,445**	**290,407**

Unit:(ton/year)

Fig.11.8 Present Air Pollution Load by Source (1992)

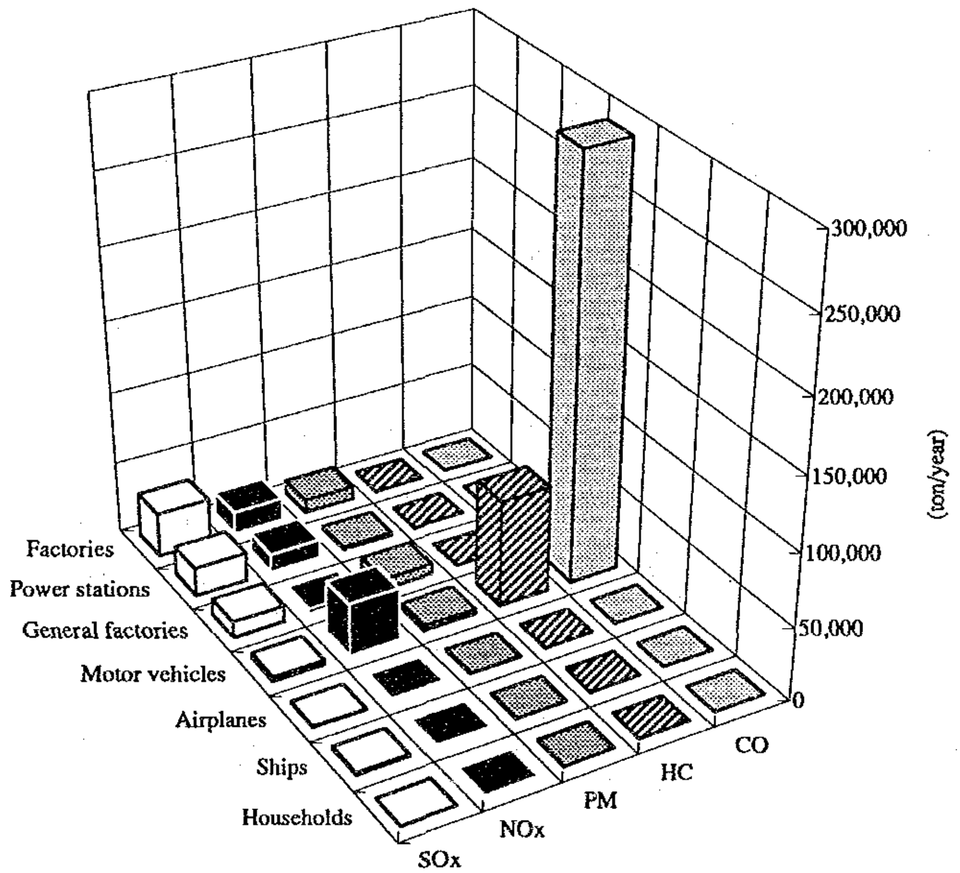
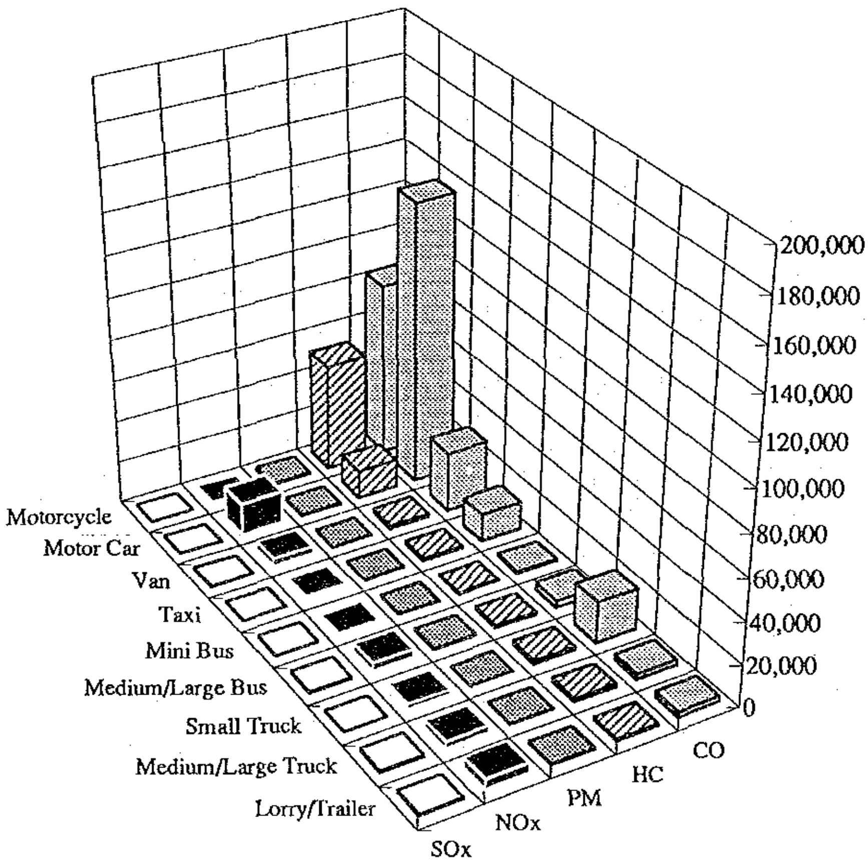


Table 11.7 Present Air Pollution Load by Vehicle Type (1992)

	SOx	NOx	PM	HC	CO
Motorcycle	7	720	735	51,448	83,413
Motor Car	31	15,518	369	13,423	136,052
Van	96	3,633	114	1,543	28,586
Taxi	229	1,640	199	1,114	13,259
Mini Bus	180	525	152	512	854
Medium/Large Bus	678	3,854	737	1,136	3,254
Small Truck	3	2,248	25	1,740	19,731
Medium/Large Truck	1,036	3,195	456	1,573	2,592
Lorry/Trailer	857	4,879	456	956	2,666
Total	**3,117**	**36,212**	**3,243**	**73,445**	**290,407**

Unit:(ton/year)

Fig. 11.9 Present Air Pollution Load by Vehicle Type (1992)



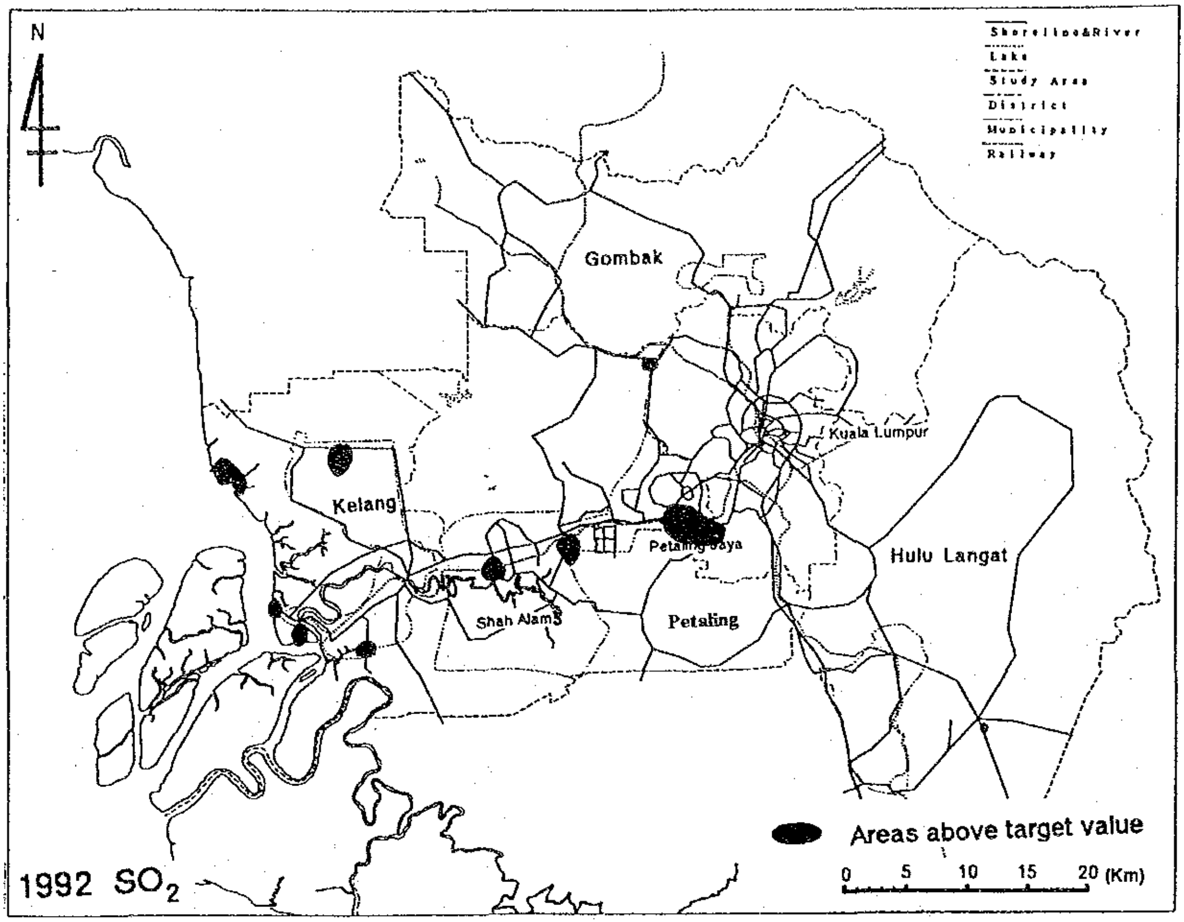


Fig. 11.10 (1) Simulated SO_2 Concentration in 1992

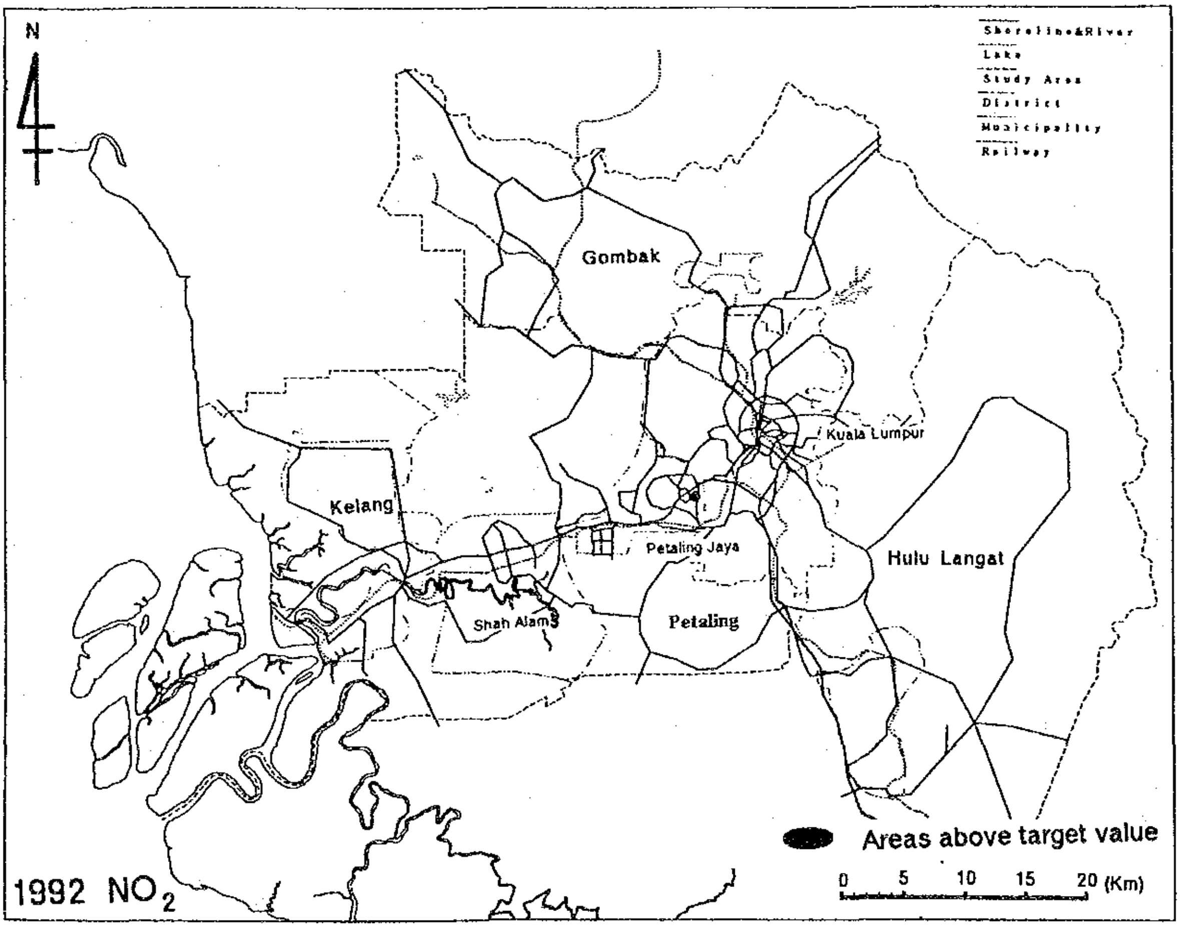


Fig. 11.10 (2) Simulated NO_2 Concentration in 1992

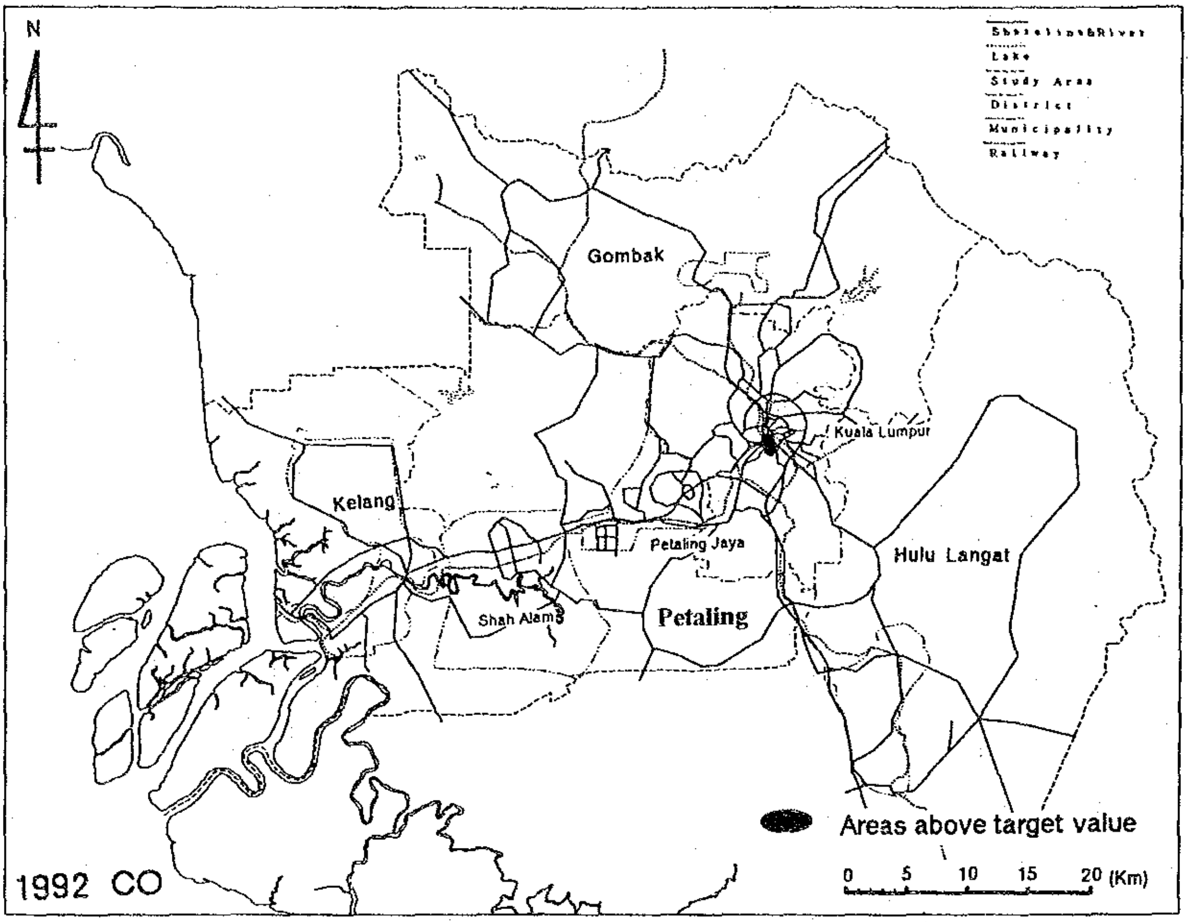


Fig. 11.10 (3) Simulated CO Concentration in 1992