18.2. FINANCIAL EVALUATION

18.2.1. TRUNK BUS OPERATION

Operation of large sized buses on exclusive bus ways or lanes will be a new transport business in Bogota. Exclusive bus ways and lanes will improve the performance of bus operation. In this Study, a fare rate of C$ 600 is suggested for the new trunk bus service. These are advantageous conditions to the operators of trunk buses. The prices of large sized bus fleet are significantly higher than those of conventional buses. Here, financial feasibility of the trunk bus business is examined, assuming all the trunk bus routes are managed by one company and bus facilities of bus ways and lanes are available free of charge.

(1) Demand and Revenue

According to the simulation analysis presented in Chapter 9, Demand for the trunk bus system and also for the existing services are summarized as shown in Table 18.2-1. Demand for the new service will increase significantly in 2005. This is because many trunk bus lines will start their service in this year and about five million passengers will shift to the new service. Conventional bus service will lose its share and therefore, more than half of the current operators have to be absorbed in the new system.

Table 18.2-1 Passengers of Trunk Bus System

(1000 pax/day)

Year	Trunk Bus	Express Bus	Total	Ordinary Bus
2000	1,198	816	2,014	7,892
2005	6,038	1,356	7,394	2,348
2015	6,980	1,584	8,564	2,589

Current bus fare is C$ 430 in average. Fare rate of new system is assumed to be a flat rate of C$ 600 per ride. Those rates are kept unchanged through the evaluation period in real term at 1999 price. Nominal fares will be changed naturally according to the inflation rate. Based on these fares and number of passengers above, annual fare revenue (proceeds) is easily estimated as in Table 18.2-2, assuming one year is 330 days and US$ 1.0 is equivalent to C$ 1,580.

Table 18.2-2 Annual Revenue of Trunk Bus System

(US$ Million)

Year	Trunk Bus	Express Bus	Total	Ordinary Bus
2000	150.1	102.3	252.4	708.8
2006	767.7	172.6	940.3	212.9
2015	874.7	198.5	1,073.2	232.5

Total proceeds including sales of ordinary buses will increase from US$ 962 million in 2000 to US$ 1,153 million in 2005. A part of this increase is attributed to natural increase of passengers and the other part to increase of transfer passengers under the new system.

(2) Operating Cost

The market price of a large bus with capacity of 100 passengers is US$ 140,000 and the price of an articulated bus for 200 passengers is US$ 198,000. This represents 3 to 4 times the price of conventional buses which cost of US$ 50,000 – 55,000. According to the VOC analysis stated in the previous section, operating cost of these buses are shown in Figure 18.2-1 , and they are almost proportional to their price.

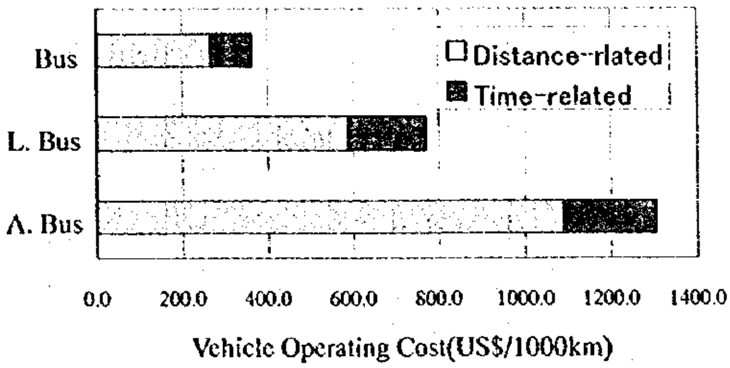

Figure 18.2-1 Comparison of Bus Operating Cost per 1000km

The said unit VOC includes depreciation cost and capital opportunity cost as well as running cost such as fuel cost and repair cost. Annual operating cost of the trunk and express buses is forecasted as shown in Table 18.2-3

Table 18.2-3 Annual Bus Operating Cost

(million us$/yr)

Year	Trunk Bus			Express Bus		
	Distance VOC	Time voc VOC	Total	Distance VOC	Time voc VOC	Total
2000	91	29	120	61	12	73
2005	336	129	465	83	17	100
2015	436	211	647	103	21	124

The Municipal Government of Bogota is now planning to set up a public transport corporation to administer and manage bus operators in the private sector. This public corporation will be composed of 50 – 60 personnel whose annual salary will amount to US$ 1.2 to 1.8 million inclusive of overhead cost.

(3) Cash Flow and Accumulated Balance

Comparing cost and revenue, Table 18.2-4 shows a cash flow of the trunk bus business. Capital cost for purchase of buses and interest payment are included in the operating cost in the form of depreciation and capital opportunity cost.

The profit and loss are almost balanced until 2005 under the proposed rate of 600 pesos per ride. After the year 2006 when all lines open, a slight loss will continue for three years but the accumulated loss will be canceled by 2011 and the balance will reach US$ 557 million in 2020 which is US$71 million at the present value. For the reference, the IRR for this cash flow is 44%. It suggests that this business is a very profitable one. Actually, however, bus operators in the private sector have to pay value added tax and other taxes.

When taking this factor into account, the actual FIRR would be in the range of 20% to 25%, which still shows that the business is financially sound.

Table 18.2-4 Cash Flow of Trunk Bus System Operation

Year	Revenue (Million US$/Year)			Operating Cost			Overhead Cost	Total Cost	Balance
	Trunk Bus	Exp.Bus	Total	Trunk Bus	Exp.Bus	Total			
1999	-	-	-	-	-	-	-		
2000	150.1	102.3	252.4	155.8	94.8	250.6	1.2	251.9	0.5
2001	185.7	105.1	290.8	192.8	97.5	288.8	1.2	290.1	0.8
2002	229.7	108.1	337.8	238.4	100.2	335.4	1.3	336.7	1.1
2003	284.0	111.1	395.2	294.9	103.0	392.5	1.3	393.8	1.4
2004	351.3	114.3	465.6	364.7	106.0	462.4	1.3	463.7	1.9
2005	434.5	117.5	552.0	451.0	108.9	548.2	1.3	549.5	2.5
2006	767.7	172.6	940.3	794.1	176.2	970.4	1.4	971.7	(31.4)
2007	778.9	175.3	954.2	799.1	174.5	973.8	1.4	975.2	(20.9)
2008	790.3	178.0	968.3	804.1	172.7	977.2	1.4	978.6	(10.3)
2009	801.8	180.8	982.7	809.2	171.0	980.6	1.5	982.0	0.6
2010	813.5	183.7	997.2	814.3	169.3	984.0	1.5	985.5	11.7
2011	825.4	186.5	1012.0	819.4	167.6	987.4	1.5	989.0	23.0
2012	837.5	189.5	1026.9	824.6	166.0	990.9	1.5	992.4	34.5
2013	849.7	192.4	1042.1	829.8	164.3	994.3	1.6	995.9	46.2
2014	862.1	195.4	1057.6	835.0	162.7	997.8	1.6	999.4	58.1
2015	874.7	198.5	1073.2	840.3	161.0	1001.3	1.6	1002.9	70.3
2016	887.5	201.6	1089.1	852.5	163.6	1016.1	1.7	1017.8	71.3
2017	900.4	204.8	1105.2	865.0	166.1	1031.1	1.7	1032.8	72.4
2018	913.6	208.0	1121.6	877.6	168.7	1046.3	1.7	1048.1	73.5
2019	926.9	211.2	1138.2	890.4	171.4	1061.8	1.8	1063.6	74.6
2020	940.5	214.5	1155.0	903.4	174.1	1077.5	1.8	1079.3	75.7
Total	14406.0	3551.3	17957.3	14256.3	3139.7	17368.4	31.4	17399.8	557.5

(4) Sensitivity Analysis of Fare Change

Figure 18.2-2 illustrates the changes of accumulated net profit (without tax) by the trunk and express bus business, under several fare levels. By the current fare of 430 pesos, this business will not pay. On the contrary, a fare rate higher than 600 pesos will cause a serious money shortage in the early stage, although the final balance will be much higher. By this analysis, it may be concluded that the appropriate fare level is in the range of C$ 550 to C$ 650.

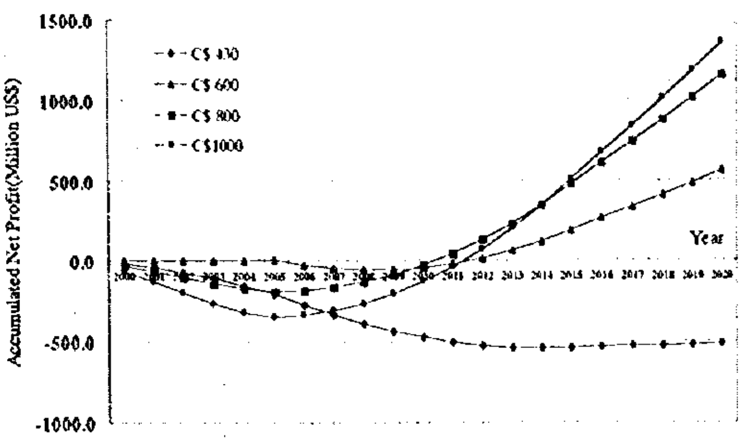

Figure 18.2-2 Net Accumulated Balance of Trunk Bus System Project under various Fares

18.2.2. Bus Terminal

Assuming the central terminal and other suburban terminals are managed by one entity, a financial analysis is made on the bus terminal business. Main purpose of analysis is to examine whether the terminal development is possible to implement by introducing private financing, and if the terminal operator can collect a terminal charge from every bus that enters the terminal.

(1) Investment and Operating Cost

Total investment amount is US$ 82 million, of which 73% is for the central terminal. Cost of maintenance and operation by the managing company with about 150 employees is in the range of US$ 1.6 – 1.7 million per annum.

(2) Terminal Charge and Revenue

The basic terminal charge is assumed to be 2,000 pesos for every trunk bus that enters a suburban terminal and 1.5 times of the rate is charged for an articulated bus for express service. The central terminal charges 1.5 times the charges by the suburban terminal. Total use will be 30,000 entrances a day in 2005 and 40,000 entrances in 2015. Thus, annual revenue will be US$ 15.5 million and US$ 20.9 million, respectively (Table 18.2-5).

The share of the central terminal is about 30 % in use (the number entering buses) and about 35% of total revenue. If comparing express bus and trunk bus, express buses occupy the share of 12% in 2006 and 18% of total use in 2015 respectively. This translates into 20% in 2006 and 25% in 2015 of total revenue.

Table 18.2-5 Patronage and Revenue of Terminal Company

Year	Number of terminal use by bus (1000 times/day)						Annual Toll Revenue(Million US$)					
	Central Terminal		Others Terminal		Total		Central Terminal		Others Terminal		Total	
	Express	Trunk	Express	Trunk	Express	Trunk	Express	Trunk	Express	Trunk	Express	Trunk
1999												
2000	0	0	143	473	143	473	0.0	0.0	0.9	2.0	0.9	2.0
2001	0	0	164	620	177	665	0.0	0.0	1.0	2.6	1.0	2.6
2002	0	0	188	813	220	936	0.0	0.0	1.2	3.4	1.2	3.4
2003	0	0	216	1066	273	1316	0.0	0.0	1.4	4.5	1.4	4.5
2004	0	0	248	1397	338	1851	0.0	0.0	1.6	5.8	1.6	5.8
2005	135	771	284	1832	419	2603	1.3	4.8	1.8	7.7	3.0	12.5
2006	143	787	298	1879	441	2666	1.3	4.9	1.9	7.8	3.2	12.8
2007	152	804	312	1927	464	2731	1.4	5.0	2.0	8.0	3.4	13.1
2008	161	821	328	1976	489	2797	1.5	5.1	2.1	8.3	3.6	13.4
2009	171	838	344	2027	514	2865	1.6	5.2	2.2	8.5	3.8	13.7
2010	181	855	360	2079	542	2934	1.7	5.4	2.3	8.7	4.0	14.0
2011	192	873	378	2132	570	3006	1.8	5.5	2.4	8.9	4.2	14.4
2012	204	892	396	2187	600	3078	1.9	5.6	2.5	9.1	4.4	14.7
2013	216	910	416	2243	632	3153	2.0	5.7	2.6	9.4	4.6	15.1
2014	229	929	436	2300	665	3230	2.2	5.8	2.7	9.6	4.9	15.4
2015	243	949	457	2359	700	3308	2.3	5.9	2.9	9.9	5.1	15.8
2016	258	969	479	2419	737	3388	2.4	6.1	3.0	10.1	5.4	16.2
2017	273	989	503	2481	776	3470	2.6	6.2	3.1	10.4	5.7	16.6
2018	290	1010	527	2545	817	3555	2.7	6.3	3.3	10.6	6.0	17.0
2019	307	1031	553	2610	860	3641	2.9	6.5	3.5	10.9	6.4	17.4
2020	326	1053	580	2677	905	3729	3.1	6.6	3.6	11.2	6.7	17.8
Total							32.7	90.7	47.7	167.3	80.4	258.0

(3) Cash Flow and IRR

Under the basic charge of 2,000 pesos, IRR is estimated at 7.5% for the central terminal and 48.3% for the suburban terminals. If aggregating them together, IRR becomes 16.0% and NPV is US$ 30.4 million. This rate is high enough to attract private capital. Due to the high construction cost, profitability of the central terminal is rather low, which is compensated by the profit of the suburban terminals. (Table 18.2-6 and Table 18.2-7)

Table 18.2-6 Cash Flow of Terminal Company

(US$ 1000)

Year	Central Terminal				Other Terminals(8)				All Terminals(9)			
	Const. Cost	M&O Cost	Revenue	Cash Flow	Const. Cost	M&O Cost	Revenue	Cash Flow	Const. Cost	M&O Cost	Revenue	Cash Flow
1999	0	0	0	0	179	0	0	-179	179	0	0	-179
2000	20,041	0	0	-20,041	3,723	0	0	-3,723	23,764	0	0	-23,764
2001	19,067	0	0	-19,067	2,443	526.57	5,427	2,458	21,509	526.57	5,427	-16,608
2002	16,515	0	0	-16,515	3,826	1053.1	6,863	1,983	20,341	1053.1	6,863	-14,532
2003	4,129	0	0	-4,129	4,941	1053.1	8,707	2,713	9,069	1053.1	8,707	-1,415
2004	0	554	8,882	8,328	5,678	1079	11,083	4,325	5,678	1634	19,965	12,653
2005	0	554	9,150	8,595	1,476	1095	14,148	11,577	1,476	1650	23,298	20,172
2006	0	554	9,417	8,863	0	1120	14,572	13,452	0	1674	23,989	22,315
2007	0	554	9,694	9,140	0	1120	15,010	13,890	0	1674	24,705	23,030
2008	0	554	9,983	9,428	0	1120	15,462	14,342	0	1674	25,445	23,770
2009	0	554	10,282	9,728	0	1120	15,929	14,809	0	1674	26,211	24,537
2010	0	554	10,593	10,039	0	1120	16,412	15,292	0	1674	27,005	25,330
2011	0	554	10,916	10,362	0	1131	16,910	15,780	0	1685	27,827	26,142
2012	0	554	11,253	10,698	0	1140	17,425	16,286	0	1694	28,678	26,984
2013	0	554	11,602	11,048	0	1140	17,958	16,818	0	1694	29,560	27,866
2014	0	573	11,966	11,393	0	1153	18,508	17,355	0	1726	30,474	28,748
2015	0	573	12,345	11,772	0	1161	19,076	17,915	0	1734	31,422	29,688
2016	0	573	12,740	12,167	0	1171	19,664	18,493	0	1744	32,404	30,660
2017	0	573	13,151	12,578	0	1171	20,272	19,100	0	1744	33,423	31,678
2018	0	573	13,579	13,007	0	1171	20,900	19,728	0	1744	34,479	32,735
2019	0	573	14,026	13,453	0	1171	21,550	20,378	0	1744	35,576	33,831
2020	0	573	14,492	13,919	0	1171	22,221	21,050	0	1744	36,713	34,969
Residual	-23,085	0	0	23,085	-13,576	0		13,576	-36,661	0	0	36,661
Total	36,666	9,554	194,072	147,852	8,690	21,988	318,097	287,419	45,356	31,542	512,169	435,271

Table 18.2-7 Financial Evaluation Result of Bus Terminal Project

Evaluation Indicator	Unit	Central Terminal	Other Terminals	All Terminals
IRR	%	11.9	84.3	23.8
B/C	-	1.05	4.48	2.09
NPV	M.US$	2.4	73.0	75.3

(4) Sensitivity Analysis

1) Changes in Cost and Benefit

A sensitivity analysis was made by changing cost and benefit, increasing and decreasing by 20% each. Table 18.2-8 shows the results. Central terminal becomes almost feasible only when cost is reduced by 20% and benefit is increased by 20%, while other suburban terminals are feasible under every case. All terminals become unfeasible only in case cost increase and benefit decrease happen at the same time. (Table 18.2-8)

Table 18.2-8 Sensitivity Analysis of Bus Terminal by changing Cost and Benefit

Terminal	Revenue Change	Cost Change -20%	- 10%	Base Case	+10	+20%
Central Terminal	+20%	11.9	10.5	9.4	8.4	7.5
	+10 %	10.9	9.6	8.5	7.5	6.7
	Base Case	9.8	8.6	7.5	6.6	5.9
	-10%	8.7	7.5	6.8	5.7	5.0
	-20%	7.5	6.4	5.5	4.7	4.0
Other 8 Terminals	+20%	84.3	71.6	61.9	54.4	48.3
	+10 %	74.7	63.5	55.0	48.3	42.9
	Base Case	65.5	55.7	48.3	42.5	37.8
	-10%	56.7	48.3	41.9	36.9	32.9
	-20%	48.3	41.2	35.8	31.6	28.2
All Terminals	+20%	23.8	21.3	19.2	17.5	16.0
	+10 %	21.9	19.6	17.7	16.0	14.6
	Base Case	20.0	17.8	16.0	14.5	13.2
	-10%	18.1	16.0	14.3	12.9	11.6
	-20%	16.0	14.1	12.5	11.2	10.0

2) *Change of Terminal Charge*

Basic terminal charge is assumed at C$ 2,000. By changing this rate, a sensitivity was made with result is shown in Table 18.2-9. Central terminal is feasible if the basic charge is over C$ 3,000. On the other hand, suburban terminals are still feasible under the basic charge of C$ 1,000

If the rate becomes below 1,500 pesos, IRR of all terminals will also be lower than 12% and application of a private financing incentive (PFI) scheme will become difficult. Nevertheless, it will be still financially viable if a non-profit public organization undertakes the project, using a bilateral or international soft loan.

Table 18.2-9 Sensitivity Analysis of Bus Terminal by changing Terminal Charge

Terminal Charge	Central Terminal	Other Terminals	All Terminals
500	-1.6	5.9	0.7
1000	2.0	19.2	6.6
1500	5.0	32.9	11.6
2000	7.5	48.3	16.0
2500	9.8	65.5	20.0
3000	11.9	84.3	23.8

18.2.3. INNER-RING EXPRESSWAY

It is assumed that a new organization such as the Bogota Metropolitan Expressway Corporation would construct, maintain and operate the expressway. Under such arrangement, the financial feasibility of the organization was examined.

(1) Investment and Operating Cost

A sum of US$ 638.5 million will be invested during 1999 – 2005 and the expressway will open in early 2006. Maintenance and operation cost is estimated at US$ 1.4 million which will gradually increase up to US$ 2.1 million in 2020.

(2) Patronage and Toll Revenue

At the opening in 2006, the number of vehicles using the expressway (patronage) will be 33,200 in pcu and grow rapidly due to a heavier congestion on the ordinary roads, to 130,000 in 2015. Assuming the toll rate at 2,000 pesos for year 2006 and 3,000 pesos for 2015, annual toll revenue will be US$ 14.6 million and US$ 81.3 million, respectively. (Table 18.2-10)

Table 18.2-10 Patronage and Toll Revenue of Inner-Ring Expressway Project

Year	PCU/Day				C$/pcu	Annual Revenue (Million US$)			
	Car	Taxi	Truck	Total		Car	Taxi	Truck	Total
1999									
2000	0	0	0	0	0	0.0	0.0	0.0	0.0
2001	0	0	0	0	0	0.0	0.0	0.0	0.0
2002	0	0	0	0	0	0.0	0.0	0.0	0.0
2003	0	0	0	0	0	0.0	0.0	0.0	0.0
2004	0	0	0	0	0	0.0	0.0	0.0	0.0
2005	18,539	7,025	3,032	28,596	2000	7.7	2.9	1.3	11.9
2006	21,519	8,283	3,451	33,252	2100	9.4	3.6	1.5	14.6
2007	24,978	9,765	3,927	38,671	2200	11.5	4.5	1.8	17.8
2008	28,993	11,514	4,470	44,976	2300	13.9	5.5	2.1	21.6
2009	33,653	13,575	5,087	52,315	2400	16.9	6.8	2.6	26.2
2010	39,062	16,005	5,790	60,857	2500	20.4	8.4	3.0	31.8
2011	45,341	18,870	6,590	70,801	2600	24.6	10.2	3.6	38.4
2012	52,629	22,248	7,500	82,377	2700	29.7	12.5	4.2	46.5
2013	61,088	26,231	8,536	95,856	2800	35.7	15.3	5.0	56.1
2014	70,908	30,927	9,715	111,550	2900	42.9	18.7	5.9	67.6
2015	82,305	36,464	11,057	129,826	3000	51.6	22.8	6.9	81.3
2016	82,305	36,464	11,057	129,826	3100	53.3	23.6	7.2	84.1
2017	82,305	36,464	11,057	129,826	3200	55.0	24.4	7.4	86.8
2018	82,305	36,464	11,057	129,826	3300	56.7	25.1	7.6	89.5
2019	82,305	36,464	11,057	129,826	3400	58.4	25.9	7.9	92.2
2020	82,305	36,464	11,057	129,826	3500	60.2	26.7	8.1	94.9
Total	890,539	383,228	124,441	1,398,207	-	548.0	237.1	76.0	861.2

(3) Evaluation Result

Although the expressway project is economically feasible, the financial IRR is 4.9% and the project hardly seems attractive to the private sector. With no special conditions, private capital will have no interest. As the project implies FIRR of almost 5% in real terms, a soft loan should be sought in order to bear a repayment of principal with interest. (Table 18.2-11).

Table 18.2-11 Cash Flow and FIRR of Inner-Ring Expressway Project

(Million US$)

Year	Investment and OM Cost				Toll Revenue	Net Cash Flow
	Construction	Maintenance	Operating	Total		
1999	0.0	0.0	0.0	0.0	0.0	0.0
2000	11.1	0.0	0.0	11.1	0.0	(11.1)
2001	26.1	0.0	0.0	26.1	0.0	(26.1)
2002	68.0	0.0	0.0	68.0	0.0	(68.0)
2003	205.6	0.0	0.0	205.6	0.0	(205.6)
2004	205.6	0.0	0.0	205.6	0.0	(205.6)
2005	122.2	0.0	0.0	122.2	0.0	(122.2)
2006	0.0	0.1	1.1	1.2	14.6	13.4
2007	0.0	0.1	1.1	1.2	17.8	16.6
2008	0.0	0.1	1.1	1.2	21.6	20.4
2009	0.0	0.1	1.1	1.2	26.2	25.0
2010	0.0	0.1	1.1	1.2	31.8	30.6
2011	0.0	0.3	1.1	1.4	38.4	37.0
2012	0.0	0.3	1.1	1.4	46.5	45.0
2013	0.0	0.3	1.1	1.4	56.1	54.6
2014	0.0	0.3	1.1	1.4	67.6	66.1
2015	0.0	0.3	1.1	1.4	81.3	79.9
2016	0.0	0.6	1.2	1.8	84.1	82.3
2017	0.0	0.6	1.2	1.8	86.8	85.0
2018	0.0	0.6	1.2	1.8	89.5	87.7
2019	0.0	0.6	1.3	1.9	92.2	90.3
2020	0.0	0.6	1.2	1.8	94.9	93.1
Residual	-365.2	0.0	0.0	-365.2	0.0	365.2
Total	273.4	5.0	17.0	295.4	849.2	553.9

IRR (%)	4.9%
B/C	0.41
NPV(M.US$)	-210.2

(4) Sensitivity Analysis

1) Sensitivity Analysis by Changing Cost and Benefit

The project becomes financially feasible only by 60% cost reduction or 40% reduction of cost accompanied with revenue increase more than 10%. (Table 18.2-12)

Table 18.2-12 Sensitivity Analysis of Expressway Project by changing Cost and Benefit

(percent)

Revenue Change	Cost Change				
	-60%	- 40%	-20%	Base Case	+20%
+20%	14.1	10.2	7.7	6.1	4.9
+10 %	13.2	9.4	7.1	5.5	4.3
Base Case	12.3	8.6	6.4	4.9	3.8
-10%	11.2	7.7	5.6	4.2	3.2
-20%	10.2	6.8	4.9	3.5	2.6

2) Sensitivity Analysis by changing Toll Rate

If the toll rate is changed, FIRR varies as shown in Table 18.2-13 and Figure 18.2-3. If the construction is postponed, the curve will shift upward. It may be an alternative to wait until the project matures financially

Table 18.2-13 Sensitivity Analysis of Expressway Project by Toll Rate

Toll (C$/use)	Patronage(1000 pcu /day) 2006	2015	IRR (%)	B/C	NPV (M.US$)
500	165	345	0.2	0.27	-274
1,000	89	240	2.1	0.35	-244
1,500	53	193	3.4	0.39	-229
2,000	34	156	4.2	0.41	-224
2,500	22	130	5.0	0.41	-222
3,000	15	130	5.8	0.49	-194
3,500	10	115	6.3	0.51	-186
4,000	7	100	6.5	0.51	-184
4,500	5	86	6.5	0.51	-185
5,000	3	74	6.6	0.50	-187
5,500	2	64	6.5	0.50	-190
6,000	2	55	6.4	0.48	-194
7,000	1	41	6.2	0.46	-204
8,000	0	31	6.0	0.43	-213
9,000	0	23	5.7	0.42	-219
10,000	0	18	5.4	0.39	-228

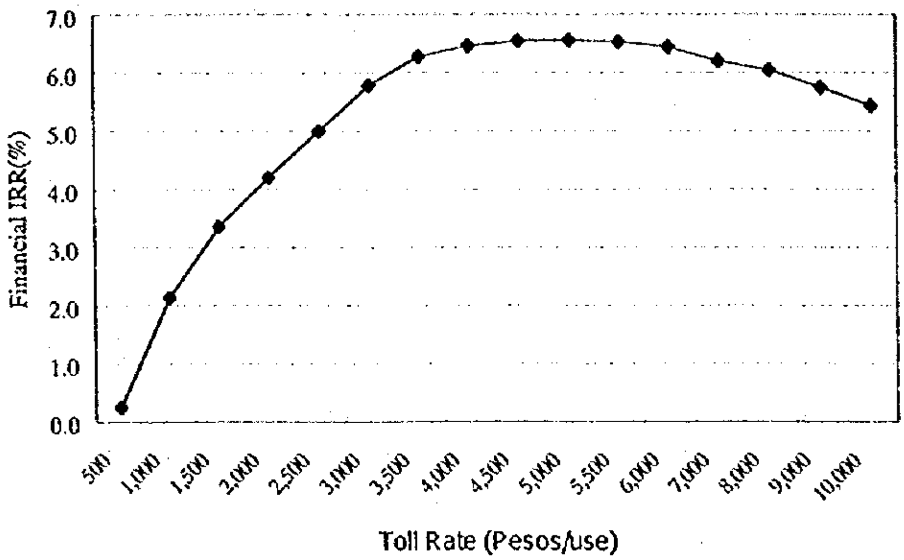

Figure 18.2-3 Change of FIRR of Inner-Ring Expressway Project by Toll Rate

(5) EIRR and FIRR

Figure 18.2-4 shows the relationship between Economic IRR and Financial IRR of the inner-ring expressway project by changing the toll rate. Generally, from this drawing, the financially and economically optimum toll rate is looked for. However, the curve of this project does not pass such area. As time passes, the curve expectedly shifts rightward, which suggests that "to wait" may be one solution.

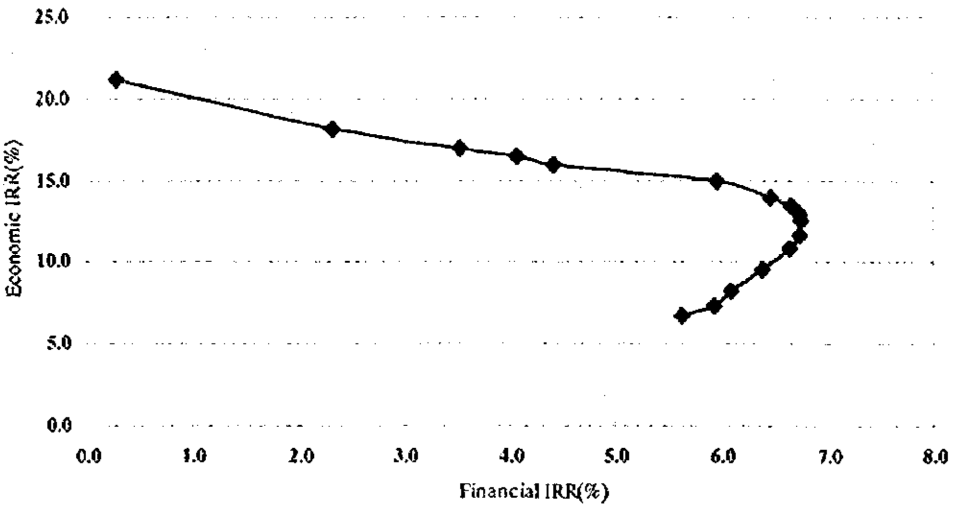

Figure 18.2-4 FIRR and EIRR of Inner-Ring Expressway Project

18.3. BUS FARE SYSTEM UNDER TRUNK BUS SYSTEM

18.3.1. GENERAL

In Chapter 5, the following two alternatives of fare system are examined:

1) Alternative-A: a flat rate system with an additional payment of the same rate at every transfer

2) Alternative-B: a flat rate system with no additional fee for transferring

In the Study, Alternative-A is employed in the proposed trunk bus fare system, instead of Alternative-B which allows transfer without any additional fare when passengers transfer. In Alternative-A, trunk and ordinary bus fare rates were examined on the assumption that total sales under new system should balance with those under current system, on this basis, and the optimum rates on the trunk bus system were proposed. As for Alternative-B, a sensitivity analysis was only conducted on some assumptions without considering some practical issues on operable ticketing system.

According to the system analysis for the trunk bus system, it is obvious that under the new system, the number of passengers transferring at bus stops and terminals increases more than that under the current system. Therefore, bus rate for some passengers who are forced to transfer to a trunk bus will be higher than at present. In general, it is said that in Bogota, passengers who belong to a low-income class take a long trip journey. It is necessary to study the fare system that does not impose a burden on many of those passengers. In this Section, the trip analysis by household income was also conducted based on the Person Trip Survey data.

18.3.2. TRUNK BUS FARE RATE

(1) Optimum Trunk Bus Fare Rate

Table 18.3-1 shows the change of trunk bus passengers naturally and total proceeds of the trunk bus under various fare rate. As can be seen, the passengers decrease as the fare becomes higher. On the other hand, total proceeds have a crest near a rate of 1000 pesos. Total amount of proceeds shows a maximum figure near this rate.

However, the current average rate weighted by an index of service frequency-km is approximately 430 $pesos. In case the rate of trunk bus is set at 1000 $pesos, the trunk bus rate will be too high to pay as a bus fare, comparing to the current rate. A trunk bus rate of 600 $pesos seems reasonable, taking into account a jump up from the current rate.

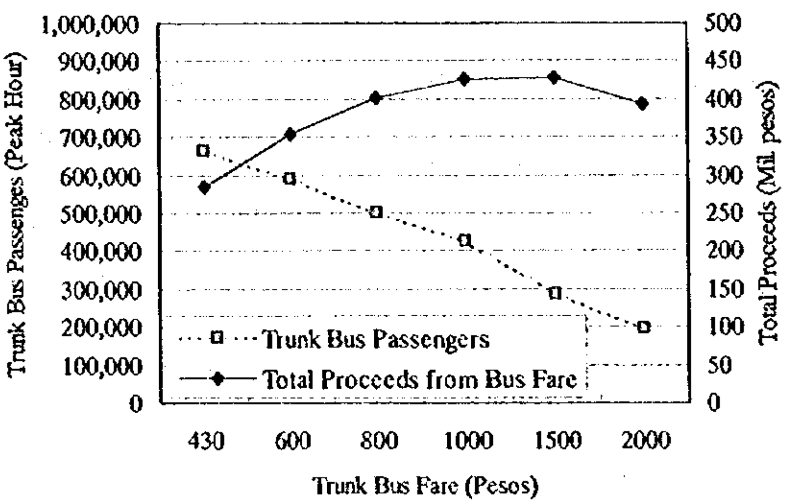

Figure 18.3-1 Distribution of Total Proceeds and Trunk Bus Passengers

(2) Proposed Bus Fare Rate on the Trunk Bus System

Table 18.3-1 summarizes total proceeds by With and Without cases in 2005. In With case, the trunk bus and ordinary bus rates employed 600 or 430 $pesos, respectively. Total proceeds in With case are approximately 480 million $pesos/ hour in the morning peak hour, in contrast to 391 million in Without case. The ratio of total proceeds in With to Without cases is approximately 1.22 times. This means that cost reduction by up to 12% is possible while maintaining the same proceeds.

The trunk and ordinary bus fare rates are examined on the assumption that total sales under current system balance with those under new system and the optimum rates on the trunk bus system are proposed. Assuming that an ordinary bus keeps the current rate to maintain the same revenue as at present, the trunk bus rate is assumed at 450 $pesos, which is 82% of 600 $pesos (see Table 18.3-2).

Table 18.3-1 Total Proceeds by With and Without Cases in 2005

	Without Case			Fare Rate of Trunk Bus = 600		
	Fare Rate	Passengers	Proceeds ($pesos)	Fare Rate	Passengers	Proceeds ($pesos)
Ordinary Buses	430	909,910	391,261,300	430	292,292	125,685,560
Trunk Buses		0	0	600	589,334	353,600,400
Total		909,910	391,261,300		881,626	479,285,960

Table 18.3-2 Proposed Bus Fare Rate

	Fare Rate of Trunk Bus = 450		
	Fare Rate	Passengers	Proceeds ($pesos)
Ordinary Buses	430	292,292	125,685,560
Trunk Buses	450	589,334	265,200,300
Total		881,626	390,885,860

(3) Transferred Passengers

Table 18.3-3 summarizes the number of transfer passengers by 1 and 2 times in With and Without cases. As can be seen, the numbers of transfers at bus stops and terminals become larger than under the current system. The difference of transfer passenger numbers between With and Without cases is 50,000, equivalent to 7.5% of total bus passengers in which 54,000 passengers make one time transfer, while passengers to transfer twice will decrease by 4,000.

Table 18.3-4 shows the difference in number of transfer passengers by bus type: ordinary and trunk buses. The passengers transfer from trunk to trunk are predominant and its ratio is approximately 45%, in contrast to 11% of ordinary to ordinary transfer.

Table 18.3-3 Difference in Transfer Passengers between With and Without Cases

	Without Case	With Case	Difference
1 Times	200,492	254,387	53,895
2 Times	23,357	19,358	-3,999
Total	223,849	273,745	49,896

Table 18.3-4 Difference in Transfer Passenger Number by Bus Type

	Ordinary	Trunk Buses	Total
Ordinary	5,484	11,058	16,542
Trunk Buses	11,058	22,296	33,354
Total	16,542	33,354	49,896

(4) Bus Passengers Who Have to Pay More

According to the above discussion, it is obvious that under the new system, the number of transfers is larger than that in the Without case. Therefore, the rate of passengers who have no choice but transfer from a trunk bus to another will be higher than at present.

Table 18.3-5 shows bus fare rate matrix table by transfer case: no-transfer, ordinary-trunk buses and , trunk -trunk buses. The total fare is the highest in case of trunk-trunk transfer. The passengers in this category have to pay 900 $pesos, in contrast to 860 $ pesos in the current system. The fare increase ratio is 1.05 times. The number of passengers in this category is estimated 22,000 per hour. Table 18.3-6 summarizes the above.

Table 18.3-5 Bus Fare Table by Transfer Case

From/to	No-Transfer	Ordinary	Trunk Buses
Ordinary	430	860	880
Trunk Buses	450	880	900

Table 18.3-6 Summary Table for Passengers who Transfer Trunk to Trunk Buses

Items		
(a) Bus Fare of Ordinary-Ordinary Transfer	860	pesos
(b) Bus Fare of Trunk- Trunk Transfer	900	pesos
(c) Fare Increase Ratio (b)/(c)	1.05	times
(d) Passengers who Transfer from Trunk to trunk Buses Trunk-Trunk Transfer Passenger	22,296	passengers
(e) Ratio of Applicant Passengers to Total Passengers	3.4%	

(5) Relationship between Trip Length and Income Level

In general, it is said that in Bogota, passengers who belong to a low-income class are making longer trips. In this Section, trip characteristics in terms of trip length were analyzed by income level based on the date of Person Trip Survey, carried out in the JICA Master Plan Study in 1996. The 'To work' purpose and 'Bus' mode trip data are chosen and analyzed.

Figure 18.3-2 shows the distribution of trip length by 5-income groups. As can be seen, the trip length of the low-income group (300,000 or less $pesos/month) is longer than that of others. Fifty percentile trip length of low income group is approximately 10 km, while that of high income group is 7.5km. Approximately 50% of total passengers in the low income are within a trip length of 10km, in contrast to 7.5km in the highest group (3,000,000 or over).

Figure 18.3-3 shows the composition of trip length by income group. This figure also shows that the longer the trip length is, the higher the composition of the low-income group is. In case of a trip length of 20km or longer, approximately 50% of total trips are accounted for the low-income group. It can be said that in Bogota, passengers who belong to a low-income level take a long trip journey.

If a longer trip has higher probability of transfer, many of the low income people will be forced to transfer under the new trunk bus system. If the 50% of passengers who are forced to extra transfer on the trunk bus system are in the low-income according to the composition of trip length by income group, it would mean that approximately 11,000 passengers, equivalent to 2% of the total, are in this group. They have to pay 900 $pesos. The increase ratio to the current system is approximately 1.05.

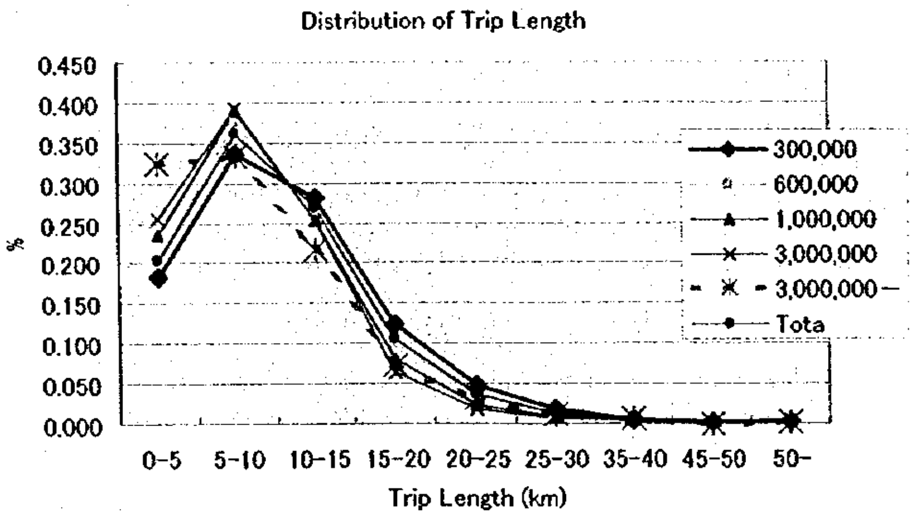

Figure 18.3-2 Distribution of Trip Length by Income Group

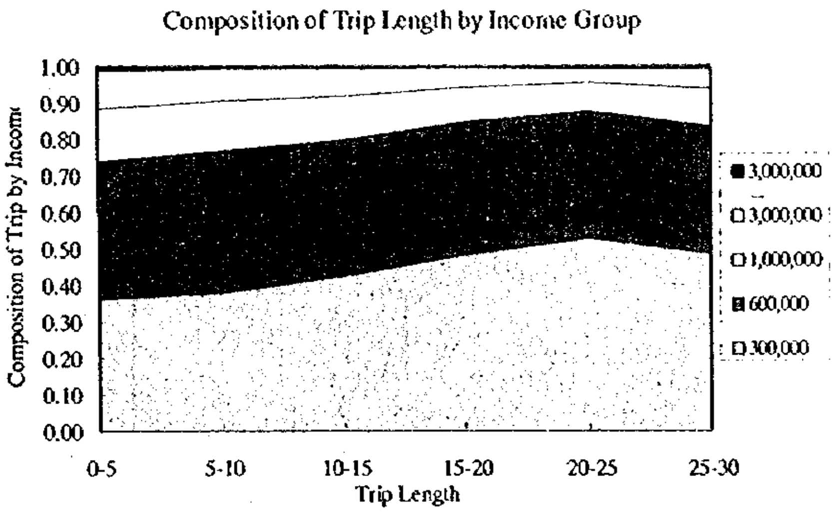

Figure 18.3-3 Composition of Trip Length by Income Group

(6) Fare System Without Payment of an Additional Fare

In this Section, Alternative-B, which allows transfer without any additional payment for transfer, is examined. A sensitivity analysis for fare rate on following three (3) assumptions is only conducted without considering some problems for actual ticketing system.

1) Case-1: fare system without payment of an additional fare when transferring (Free- transfer fare system)
2) Case-2: fare system of free transfer only for low income people
3) Case-3: fare system of free transfer only for trunk bus to trunk bus passengers

Table 18.3-7 summarizes three (3) fare systems without any additional payment. The fare rates in any cases are higher than that in Alternative-A. In Case-1 without any payment when anybody transfer, the rate for trunk bus rise at 500 $pesos, in contrast to 450 $pesos in Alternative-A. In Case-2 and Case-3, since only particular passengers do not pay an additional fare when transferring, the rate becomes somewhat lower.

Table 18.3-7 Fare Rate Cases Without Payment of an Additional Fare

Type of Bus	Bus Fare Rate ($pesos)		
	(1) Free- transfer fare system	(2) fare system of free transfer only for low income people	(3) fare system of free transfer only for trunk bus to trunk bus
Trunk Bus	500	470	470
Ordinary Bus	430	430	430

(7) Summary

Figure 18.3-4 and Figure 18.3-5 briefly summarizes the outline of discussion of bus fare system, respectively. Those figures sum up above-discussion in the form of flow chart.

A flat rate system with additional payment at every transfer point

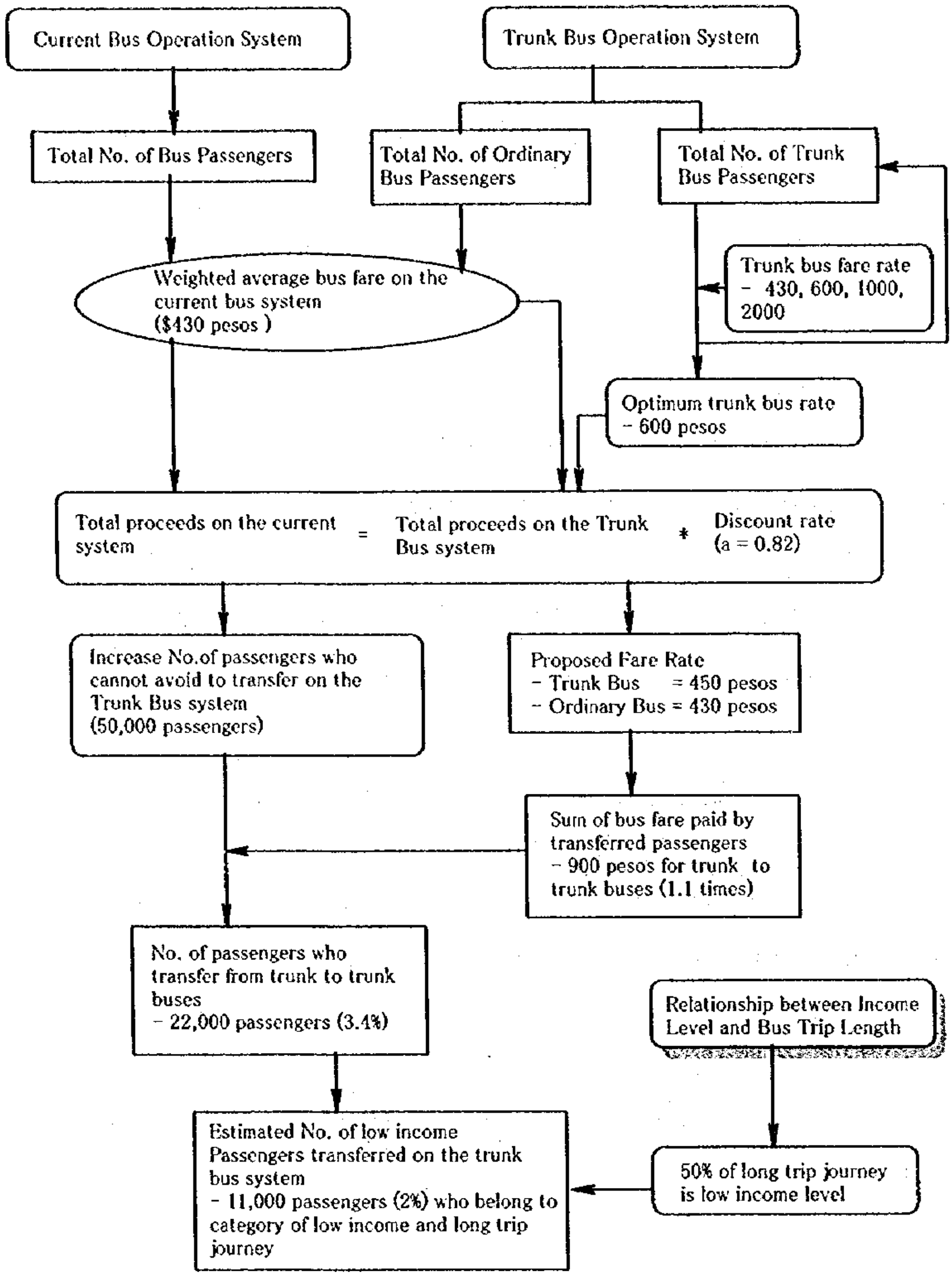

Figure 18.3-4 Summary of Alternative-A

A flat rate system with no additional payment for transferring

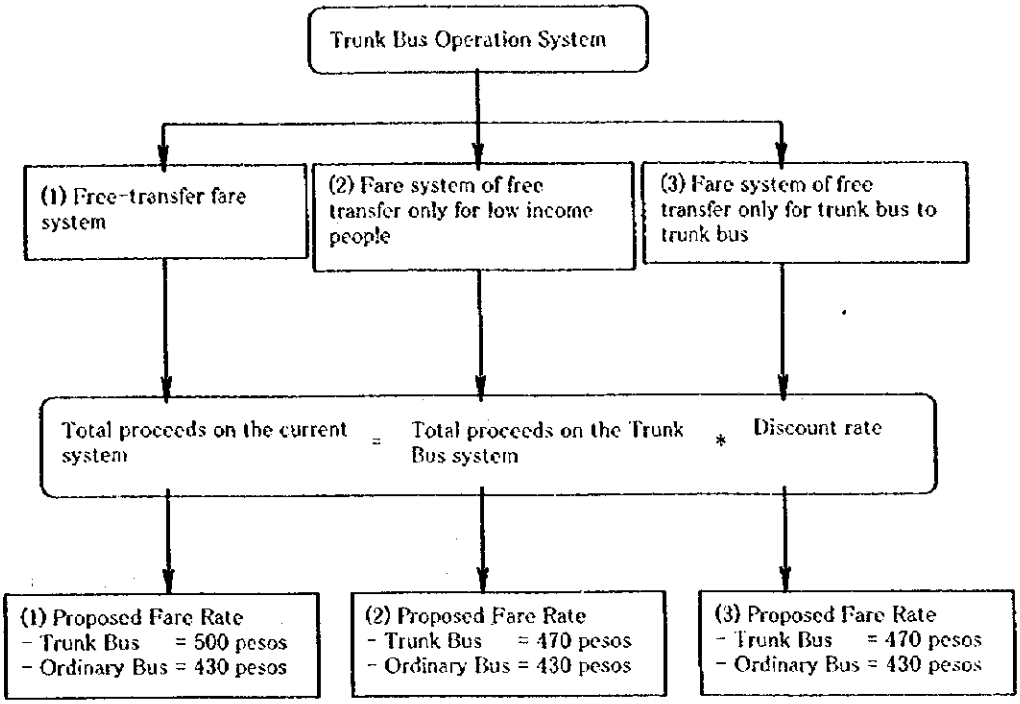

Figure 18.3-5 Summary of Alternative-B

CHAPTER 19
Environmental Impact Assessment

19. ENVIRONMENTAL IMPACT ASSESSMENT

19.1. IMPACT ASSESSMENT.

19.1.1. INTRODUCTION

Throughout the previous initial engineering evaluation of three alternative plans for the expressway project, described in Chapter 16, Alternative Route 3 was selected as the preferred route option while the elevated structural design option (no underpass but a combination of the flyover and the viaduct) was for the preferred structural one. By the same token, the elevated structural one was chosen for the bus way construction along Avenida Caracas, too. During the initial engineering evaluation process, it was concluded that the New Cirucunvaral Route is still a potentially good route option for the entire expressway and bus way project. Therefore, EIA will be undertaken for this route and its results will be attached in Appendix. Additionally, evaluations of seven suburban bus terminals and one Central Urban one along the bus way route were included in this assessment process.

Based on those selected best route, structural plan and attached bus terminal facilities, the environmental impacts regarding several environmental factors are summarized separately in the following section.

19.1.2. EXPRESSWAY AND BUS WAY ROUTE

(1) Soils

1) Potential for soil erosion during/and after the construction.

Most of the expressway and bus way facilities along the selected route option will be constructed within the current plain road space, so no major impact on soil erosion will occur.

(2) Seismicity

1) Risk of earthquake damage due to the existence of fault line (Falla Piedemonte Llonero)

Major faults such as Falla Piedemonte Llonero running parallel to the mountainside of the Oriental Mountains are identified, and some parts of the selected route option overlap with the fault line running parallel to the mountainside of the Oriental Mountains at several points. It is possible that more minor faults may be identified around the study area.

(3) Water Balance

1) Risk of water pollution to major tributaries during construction.

During the construction period, there will be a risk of the pollution to several tributaries running through the town, resulting from earthmoving activities which would contribute increased sediment. It would also be wise to prepare for the occurrence of spillage of oil, etc. It is essential that strict controls must be established on operations in storage of all potentially hazardous liquids such as oils. Emergency procedures should be developed in the event of an accidental spillage.

2) Excessive water blockage of drainage system due to the construction work and related local flood/or inundation.

During the construction, the earthwork along the selected route will provide a large-scale soil exposure to erosion that would generate extra sediments when the torrential rain hits the study area. Excessive water blockage may result, and consequently jeopardize the regional drainage system. Therefore, special care must be paid to avoid the local flood/or inundation to be caused by current poor drainage condition.

(4) Vegetation and Ecology.

1) Destruction of roadside vegetation.

The preferred route option will result in some loss of the roadside vegetation. Table19.1-1 summarizes the number of trees to be affected by construction activities along each major route. Decree of 1998 specifies the handling of trees, shrub and rung in public place [DAMA, personal communication, 1998]. In that decree, it is specified that environmental handling license is necessary prior to the construction when the total estimated volume of woods to be removed by the infrastructure project exceeds 20 m^3.

Table 19.1-1 Roadside Vegetation

Location		Number of Trees
7a	Calle 127 – Calle 116	5
	Calle 116 – Calle 100	38
Caracas	Calle 1 – Calle 78	427
	Calle 48 Sur – Calle 1	171
100	Glorieta – Norte	50
Quito	Calle 75 – Calle 64A	4
	Calle 64A – Calle 52	36
	Calle 52 – Calle 22	53
	Calle 22 – Calle 13	26
	Calle 6 – Cra. 2	28
Calle 6	Cra. 24 – Caracas	33

(5) Socio-Cultural Profile

1) Land Take due to road alignments and related facilities construction.

Most of the expressway and bus way facilities will be constructed within the existing road space, therefore no major land take will occur. The Central Urban Bus Terminal is planned to be constructed at San Victorino, densely - inhabited area. Seven suburban bus terminals will also be constructed at remote places around Bogota City. Therefore, it is likely that there will be several major land-take around those areas. Within this study, it is estimated that approximately 117,000 m^2 of private land must be expropriated for the entire project. More detailed discussion will be presented in Section 19.5.

2) Disruption to local development plan.

There are several on-going infrastructure development projects across Bogota City that might have some influences on this expressway and bus way project (Table19.1-2). The direct interference, cumulative or secondary impacts of those with this expressway and bus way project must be considered. Amongst, special cares must be paid for the structural design integrity of the expressway and bus way in order not to interfere with each other. Two road project sites (Cundinamarca Toll Road and Boyaca extension) are located far from this expressway and bus way project, so it is not likely to have major direct interference, but special care must be taken for the combined cumulative impact of the total vehicular emission of entire Bogota City in the future. Currently, control program of the city-wide total emission is under consideration by DAMA [DAMA, personal communication, 1998].

Table 19.1-2 Major development projects along the expressway and bus way routes.

Project	Remarks
Metro Line Project	Preferred expressway route option will cross the Metro Railway Line at two points.
National Railway Rehabilitation Project	Preferred expressway and bus way route option will partially overlap this rehabilitation line.
New Flyover	There is one new flyover project at the intersection of Quito and Avenida 6a.
Cundinamarca Toll Road Project	This project route is located far away from this expressway and bus way routes. Traffic increase will be induced.
Avenida Boyaca Extension Project	Same as above.
Centro Renewal Project	Central Urban Bus Terminal is planned at San Victorino (Centro), not included in this current renewal project.

3) Demolition of roadside houses.

As we mentioned earlier, most of the expressway and bus way facilities will be constructed within the current road space, so no major roadside house demolition will take place. However, Central Urban Bus Terminal planned site is located at San Victorino, a densely inhabited area, so it is likely there will be a block-wide house demolition within this area. Within this study, it is estimated that 215 houses must be demolished for the entire expressway and bus way project. More detailed resettlement plan related with this issue will be discussed in Section 19.5.

(6) Historic and Cultural

1) Conflict with the setting of historical/or monumental facilities

Most of the expressway and bus way facilities will be constructed within the current road space, therefore no conflict with the setting of historical/or monumental facilities will be expected. However, Central Urban Bus Terminal, as mentioned earlier, is planned at San Victorino, one of the oldest and densely inhabited area. Table 19.1-3 summarizes major historical/cultural/monumental buildings or facilities to be preserved by DAPD [DAPD personal communication, 1998] around Central Urban Bus Terminal planning site. Currently, more detailed investigation of the background of those facilities are under consideration. Locations and picture information of each of these facilities are summarized in drawing set within this study. As shown in that drawing, no relocation or demolition of those monumental facilities is necessary within this project.

Table 19.1-3 Major historical/cultural/or monumental facilities at San Victorino

	Address	Number of preserved facilities.
1	Cra. 17, #14-56	2 (Hotel Santa Ana)
2	Cra. 17A, #16-20	4
3	Cra. 17, #16-21	6
4	Cra. 16, #17-10	5
5	Cra. 16, #15-83	1
6	Calle 15, #16-17	5
7	Cra. 15, #15-55	2
8	Calle 16, Cr. 15	4
9	Calle 14, Cr. 15	1 (El Teatro SAN JORGE)
10	Av. Jimenez	2
11	Av. Jimenez 16-28	2
12	Calle 16, Cr. 17	2
13	Call 16, Entre Cra. 17, 19	1
14	Cra. 17 - 16	1 (Iglesia)

(7) Material Transport

1) *Increased traffic levels during the construction for the road material transport.*

Due to the transport of a large amount of the ready-mixed concrete and other road materials required for the entire construction (Table 19.1-4), temporary traffic increase or traffic jams are expected to occur at several sites.

Table 19.1-4 Major Materials Delivery

	Concrete [m^3]	Asphalt [t]	Excavation [m^3]	Back Fill [m^3]
Bus way (Bus way + Bus stop)	16,000	343,000	1,111,000 (90,000)	561,000
Bus way (Caracass Viaduct)	918,000	55,000	622,000	77,000
Bus way (Av. Sur – flyover)	87,000	6,000	72,000	49,000
Total	1,021,000	404,000	1,805,000 (90,000)	687,000
Total in Weight [t]	2,553,000	404,000	2,888,000 (207,000)	1,099,000
Estimate Transportation Cycle	255,000	40,000	289,000 (21,000)	110,000

Assume 10-t truck for each material transportation is used. Number in parenthesis indicates the amount of existing road pavement removal. Weight per unit volume of soil, asphalt and concrete are of 1.6 t/m^3, 2.3 t/m^3 and 2.5 t/m^3, respectively.

Several material sources such as asphalt, concrete, and aggregate plants and quarries are available around Bogota (more detailed descriptions are given in Chapter 10). If deliveries are spread throughout the entire project period, this might not result in significant increases in the road traffic. More detailed delivery plan is summarized in the construction planning (Chapter 16).

As we discussed in Chapter 16, following mitigation measures will be implemented to alleviate the traffic jam to be caused by the construction,

(1) The entire construction activities are planned to be conducted during the night time when the city traffic condition is relatively less.

(2) Two lanes are always kept for the bus transportation during the construction period.

(3) Temporary deck cover is planned to be used in order to cover the construction site during the day time, and thus, the current road structure will be maintained as much as possible.

2) Preparation of excavated soil dump-site.

As shown in Table 19.1-4, due to the poor soil quality for the construction-use, all excavated soils of 1,805,000 m^3 and other construction wastes of 90,000 m^3 will not be used and have to be dumped at any waste disposal sites. Industrial waste site should be prepared and be large enough for this excavated soil disposal. Table 19.1-5 summarizes several candidate sites for construction waste disposal. No information of the capacity of each site is available. More detailed investigation will be required prior to any construction activities. There are several large pits around upstream site of the Bogota River, and it is likely to dump some portions of construction wastes into those pits.

Table 19.1-5 Industrial Waste Disposal Sites

	Location	Comment
1	Santa Fe (Alaska)	Private
2	Santa Rita	Private
3	Suba	Public

(8) Noise

1) Noise and vibration during the construction period

Since construction activities will result in almost continuous noise from a mobile mechanical plant and others, the magnitude of the noise and vibration level will be significant to some extent during this period. As discussed in Chapter 16, entire construction activities are planned to be initiated during the night time, applications of special mitigation measures such as noise barriers or silent construction machinery (e.g., HFV Hammer) might be considered to alleviate the noise and vibration impact around schools or residential areas.

2) Noise generated from the flyover and the viaduct structure.

The elevated structural design (a combination of the flyover and the viaduct) was selected for the preferred structural option for expressway and bus way construction, therefore noise barrier installation must be prepared in order to lessen the noise impacts on some residential areas. Noise impact prediction will be carried out in section 19.4, using the predicted traffic volume for 2015 at several points.

3) Noise generated at Central Urban Bus Terminal.

According to the traffic volume estimation carried out within this study, 1,731 vehicles (264 for express bus, 1,361 for trunk bus, and 106 for local bus) are gathered at peak time in 2005. In this project, new type of bus that would be more environment-friendly than current one will be used for the express and trunk buses (more detailed description of this new model is given section 7.3.4). In addition, a 10 m - wide buffer zone is planned around the perimeter of each bus terminal facility. Thus, noise impacts on surrounding community would be less significant.

(9) Air Pollution

1) Dust during the construction period

Similar to the temporary noise problem which will occur during construction, it is likely there will be a dust problem to some extent during this period. Construction activities involve large-scale earthworks, but it is scheduled to be done within relatively short period, so the magnitude of the dust level will not be major during this period (see Chapter 16). It is also recommended that stock piles of sand and soil are well screened from residential areas. Usage of sprinklers would be inappropriate in Bogota due to the fine soil characteristics (e.g., silt or clay). Multi-directional fall-out buckets should be used to monitor dust levels during the construction period.

2) Local Air quality degradation around Central Urban Bus Terminal

As described earlier, a new type of bus that will be environmentally-friendly (much-less-emission-type engine) will be implemented, therefore it would be less likely to have severe local air quality degradation caused by the operation of the Central Urban Bus Terminal.

(10) Water Resources

1) Risk of pollution to the aquifer during the construction period

During the construction period, it would be wise to prepare for the occurrence of accidental spillage of oil and any hazardous solvents, with resultant regional groundwater contamination. So, it is essential that all potentially hazardous liquids such as oils must be stored in secure containers in a restricted area. Emergency procedures should be developed in the event of an accidental spillage. Table 19.1-6 summarizes the number of wells located within 50 m on both sides of each major route [DAMA, personal communication, 1998]

Table 19.1-6 Number of Wells located within 50 m on both sides.

	Route	Number of Wells
1	Av. Septima	16
2	Av. Caracas	7
3	Av. Quito	7
4	Apt. Sur	13
5	Suba	3
6	Av. 68	8

(11) Visual Issues

1) Visual conflict with surrounding community.

Most of the expressway (one inner ring expressway plan) and bus way facilities (five trunk busway plans) will be constructed within the current road space, so no severe visual conflict with the surrounding communities will occur. However, there would be some visual conflicts with surrounding townscape at the viaduct part of Avenida Caracas as well as the elevated part of Avenida Quito inner expressway. Table 19.1-7 summarizes the structural outline of the viaduct of Avenida Caracas Busway and the elevated structure of Avenida Quito inner expressway to be designed within this study. Figure 19.1-1 shows typical perspective view of viaduct to be planned at Avenida Caracas busway.

Table 19.1-7 Structural Type

	Avenida Caracas	Avenida Quito
Bridge Type	Concrete Bridge	Concrete Bridge
Structural Type	Elevated	Elevated
Span	30 - 40 m	30 - 40 m
Width	10 m	20 m
Height	7 - 11 m	11 - 14 m
Noise Barrier Installment	5 m Height on both sides.	3 m Height on both sides.

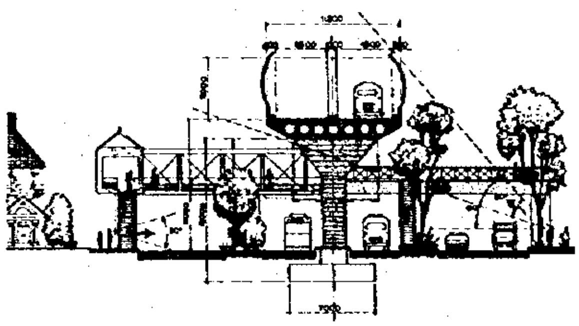

Figure 19.1-1 Viaduct Structure of Avenida Caracas busway

In general, people feels uncomfortable when their eyesight area within 60 degree of view angle are obstructed by building structures. Most of the structure of viaduct busway and the expressway only cause 30 degree coverage, therefore, from this point of view, the visual impact of those elevated structures are reasonably tolerable. Also, it is recommended to keep at least 6.5 m - clearance between the edge of the elevated structure and the nearest building structure as a common mitigation measure. Within this study, 15 m - clearance is always kept. Thus, it can be said that there are no major visual impacts from those elevated structures to be constructed at Avenidas Caracas and Quito.

Central Urban Bus Terminal, as mentioned earlier, is planned at San Victorino, where the amenity is in poor quality. It might be possible to accentuate and improve the amenity of this townscape by integrating the planning of Central Urban Bus Terminal into Centro Renewal Project, listed in Table 19.1-2.

2) Loss of visual continuity of townscape.

By the same token, no severe loss of visual continuity of townscape will occur. On the contrary, the visual continuity of townscape would be improved and accentuated by the linearity inherent to the expressway and the bus way facilities that will have a color-pavement structure (see Chapter 16) and by the "land-mark" feature of the bus terminal facilities. Especially, this would be true for the Central Urban Bus Terminal planning site where current town space amenity is in poor condition.

19.2. IMPACTS MITIGATION

19.2.1. INTRODUCTION

The comprehensive, effective measures of the mitigation (i.e., avoidance, reduction, and elimination) of negative impacts for the pre-construction and construction phases of the project are described in this chapter. The objectives of the mitigation plan are to review impacts identified through the environmental impact assessment (EIA), and incorporate probable working practices into the mitigation plan at the pre-construction and construction phases of the project in order to anticipate those issues which are likely to require close environmental management.

The mitigation plan addresses to the negative impacts caused by the construction works. The impacts are mostly of a temporary nature lasting only for the duration of the construction period, about 6 years. Detailed description of each mitigation measure is described in Tables 19.2-1 and 19.2-2, and cost effective mitigation measures have been recommended. Principal purposes of this mitigation measure are: as follows:

- Maintenance of clean roadside air quality and quiet environment throughout the project.

- Alleviation of disturbance of regional hydrological balance and to lessen related secondary impacts.

- Harmonization of new transport facilities with surrounding communities.

Mitigation measures must be incorporated into tender documents prepared under the engineering component of this project in order to ensure that the contractor is obliged to comply with measures in the EMP.

19.2.2. IMPLEMENTATION

Tables 19.2-1 and 19.2-2 summarize the mitigation measure of negative biophysical and socio-cultural impacts for selected expressway and bus way, identified in previous section, respectively. The organizations responsible for implementing and monitoring are identified.

Table 19.2-1 Summary of Mitigation Measures - Expressway

Element	Negative Impact	Mitigation Measure	Residual Impact	Responsibility	Monitoring Requirements	Implementation Schedule
Bio-Physical Environment						
Soils	Potential for soil erosion during/and after the construction.	All earth works should be undertaken as far as possible prior to the start of the wet season.	Soil erosion minimized, but not eradicated.	Contractor	Engineer to monitor soil erosion.	On-going during construction
Seismicity	Risk of earthquake damage due to the existence of fault line.	Implementation of anti-earthquake measures should be considered in order to lessen the potential earthquake damage to the facilities. It may be necessary to excavate test pits or trenches to investigate fault potential.	Risk of earthquake reduced but not eliminated.	Design Engineer, Contractor	N.A.	N.A.
Water Balance	Risk of exposure of major tributaries during construction to hazardous waste material.	Great care must be taken to ensure that potential contaminants do not enter any tributaries. All chemicals (oil, petrol etc.) must be kept in securely bounded areas with a capacity greater than the volume of chemical to be stored. Oily wastes must be stored at suitable disposal sites. The Contractor must submit written emergency procedures to be followed in the event of accidental spillage.	Risk of pollution reduced but not eliminated.	Contractor	Engineer	On-going during construction.
	Local flood/or inundation caused by excessive water blockage of drainage system due to the construction work.	Temporary and permanent drainage systems are designed to minimize the occurrence of local flood/or inundation and impact on the water quality of several tributaries. The drainage system must be periodically cleared so as to ensure smooth water flow.	Local flood/or inundation minimized but not eliminated.	Design Engineer.	Contractor.	On-going during construction.
Roadside Vegetation	Destruction of roadside vegetation.	Planting should be done wherever possible with native species which are likely to require little maintenance and may prove beneficial in maintaining ecosystem integrity with coordination of DAMA. In cases where non-native species are deemed essential, careful monitoring should be planned.	Removal/or relocation of roadside vegetation reduced to a minimum.	Contractor	Engineer	Site preparation stage.
Socio-Cultural						
Land Take	Land take due to road alignment along express-way route.	Approximately 5,013 m^2 of land (35 houses involved) will be used along the route. Alternative houses must be provided prior to the land take. Resettlement issues will be discussed in Section 19.5	Housing rebuilt in alternate location.	Government of Colombia	Government of Colombia	Before demolition begins.
Conflict with local development plan.	National Railway Rehabilitation Project.	Same as above	Same as above	Same as above	N.A.	N.A.
	New Flyover	Same as above	Same as above	Same as above	N.A.	N.A.

Table 19.2-1 Summary of Mitigation Measures – Expressway (continued)

Element	Negative Impact	Mitigation Measure	Residual Impact	Responsibility	Monitoring Requirements	Implementation Schedule
Socio-Cultural						
Material Transport.	Increased traffic level during construction for materials transport.	During construction period, trucks delivering materials to site should be thoroughly checked to ensure that they are road worthy and that the brakes are in full working order. Where feasible, trucks should avoid driving through the residential areas. Trucks used for the transportation of materials should be routed, where feasible, to avoid residential area. Re-use soil cut from earthwork for new expressway construction as much as possible in order to lessen long-distance deliveries.	Risk of accidents reduced but not eliminated.	Contractor	Engineer	On-going during construction
Noise	Noise and vibration during construction period	It is recommended that Bogota City Standards for Construction Sites be adhered to. Machinery and vehicles should be well maintained in order to keep their noise at a minimum.	Noise nuisance reduced and controlled.	Contractor	Engineer	On-going during construction
	Noise generated from expressway.	Vehicular noise can be reduced at source through vehicle construction process, selection of tires and exhaust system as well as vehicle maintenance. Also, the application of smooth, well-maintained surfaces is effective in reducing frictional noise. Noise barrier is the most common mitigative measure used. Note building façade insulation such as double window glazing is an option to dampen noise in building. More detailed discussion about noise impact prediction will be presented in section 19.4.	Same as above.	N.A.	N.A.	N.A.
Air Pollution	Dust during construction	Vehicles delivering materials should be covered to reduce the spill. Mixing equipment should be well sealed, and vibrating equipment should be equipped with dust-removal device. Operators should pay attention to their health.	Dust levels controlled.	Contractor	Engineer	On-going during construction

Table 19.2-1 Summary of Mitigation Measures -- Expressway (continued)

Element	Negative Impact	Mitigation Measure	Residual Impact	Responsibility	Monitoring Requirements	Implementation Schedule
Socio-Cultural						
Water Resources	Pollution of existing wells.	Contractor must take adequate steps to prevent pollution, including bounding area where any hazardous liquids such as oil or petrol are stored. Contractor must submit written details of the procedures to be implemented in the event of pollution incident.	Risk of groundwater pollution or depletion minimized but not eliminated.	Contractor	Engineer	On-going during construction
Visual Issues	Loss of visual continuity of townscape.	It is recommended that basic design and architectural elements (e.g., form, line, color and texture) typically used in surrounding community should be used or repeated in order to ensure the compatibility in urban area.	Townscape visual continuity kept.	Design Engineer	N.A.	N.A.
	Visual Conflict with surrounding community.	Provision of greenbelts around project sites is recommended. Also, provision of appropriate visual screens or barriers in viewscape to preclude unsightly intrusion from the project is efficient.	Visual conflict reduced to minimum.	Government of Colombia	N.A.	N.A.

Table 19.2-2 Summary of Mitigation Measures - Bus way

Element	Negative Impact	Mitigation Measure	Residual Impact	Responsibility	Monitoring Requirements	Implementation Schedule
Bio-Physical Environment						
Soils	Potential for soil erosion during/and after the construction.	All earth works should be undertaken as far as possible prior to the start of the wet season.	Soil erosion minimized, but not eradicated.	Contractor	Engineer to monitor soil erosion.	On-going during construction
Seismicity	Risk of earthquake damage due to the existence of fault line.	Implementation of anti-seismic measures should be considered in order to lessen the potential earthquake damage to the facilities. It may be necessary to excavate test pits or trenches to investigate fault potential.	Risk of earthquake reduced but not eliminated.	Design Engineer, Contractor	N.A.	N.A.
Water Balance	Risk of exposure of major tributaries during construction to hazardous waste materials.	Great care must be taken to ensure that potential contaminants do not enter any tributaries. All chemicals (oil, petrol etc.) must be kept in securely bounded areas with a capacity greater than the volume of chemical to be stored. Oily wastes must be stored at suitable disposal sites. The Contractor must submit written emergency procedures to be followed in the event of accidental spillage.	Risk of pollution reduced but not eliminated.	Contractor	Engineer	On-going during construction.
	Local flood/or inundation caused by excessive water blockage of drainage system due to the construction work.	Temporary and permanent drainage systems are designed to minimize the occurrence of local flood/or inundation and impact on the water quality of several tributaries. The drainage system must be periodically cleared so as to ensure smooth water flow.	Local flood/or inundation minimized but not eliminated.	Design Engineer.	Contractor.	On-going during construction.
Roadside vegetation	Destruction of roadside vegetation.	Planting should be done wherever possible with native species which are likely to require little maintenance and may prove beneficial in maintaining ecosystem integrity with coordination of DAMA. In cases where non-native species are deemed essential, careful monitoring should be planned.	Removal/or relocation of roadside vegetation reduced to a minimum.	Contractor	Engineer	Site preparation stage.
Socio-Cultural						
Land Take	Land take due to road alignment along bus way route.	Approximately 18,350 m^2 of land (47 houses involved) will be used along the route. Alternative houses must be provided prior to the land take. Resettlement issues will be discussed in Section 19.5.	Housing rebuilt in alternative location.	Government of Colombia	Government of Colombia	Before demolition begins.
	Land-take due to Central Urban Bus Terminal.	Approximately 23,750 m^2 of land (133 houses involved) will be used at this terminal site. Alternative houses must be provided prior to the land take. Resettlement issues will be discussed in Section 19.5.	Same as above	Same as above	Same as above	Same as above.

Table 19.2-2 Summary of Mitigation Measures - Bus way (continued)

Element	Negative Impact	Mitigation Measure	Residual Impact	Responsibility	Monitoring Requirements	Implementation Schedule
Socio-Cultural						
Conflict with local developme nt plans.	Metro Line Project	Direct interference between both projects must be avoided.	Both projects coordinated	Design Engineer	N.A.	N.A.
	National Railway Rehabilitation Project.	Same as above	Same as above	Same as above	N.A.	N.A.
	New Flyover	Same as above	Same as above	Same as above	N.A.	N.A.
	Centro Renewal Project.	Bus terminal project should be integrated within this renewal project.	Same as above	Same as above	N.A.	N.A.
Material Transport.	Increased traffic level during construction for materials transport.	During construction period, trucks delivering materials to site should be thoroughly checked to ensure that they are road worthy and that the brakes are in full working order. Where feasible, trucks should avoid driving through the residential areas. Trucks used for the transportation of materials should be routed, where feasible, to avoid residential area. Re-use soil cut from earthwork for new busway construction as much as possible in order to lessen long-distance deliveries.	Risk of accidents reduced but not eliminated.	Contractor	Engineer	On-going during construction
Noise	Noise and vibration during construction period	It is recommended that Bogota City Standards for Construction Sites be adhered to. Machinery and vehicles should be well maintained in order to keep their noise at a minimum.	Noise nuisance reduced and controlled.	Contractor	Engineer	On-going during construction
	Noise generated from bus way.	Vehicular noise can be reduced at source through vehicle construction process, selection of tires and exhaust system as well as vehicle maintenance. Also, the application of smooth, well-maintained surfaces is effective in reducing frictional noise. Noise barrier is the most common mitigative measure used. Note building façade insulation such as double window glazing is an option to dampen noise in building. More detailed discussion about noise impact prediction will be presented in section 19.4.	Same as above	N.A.	N.A.	N.A.
Air Pollution	Dust during construction	Vehicles delivering materials should be covered to reduce the spill. Mixing equipment should be well sealed, and vibrating equipment should be equipped with dust-removal device. Operators should pay attention to their health.	Dust levels controlled.	Contractor	Engineer	On-going during construction

Table 19.2-2 Summary of Mitigation Measures - Bus way (continued)

Element	Negative Impact	Mitigation Measure	Residual Impact	Responsibility	Monitoring Requirements	Implementation Schedule
Socio-Cultural						
Water Resources	Pollution of existing wells.	Contractor must take adequate steps to prevent pollution, including bounding area where any hazardous liquids such as oil or petrol are stored. Contractor must submit written details of the procedures to be implemented in the event of pollution incident.	Risk of groundwater pollution or depletion minimized but not eliminated.	Contractor	Engineer	On-going during construction
Visual Issues	Loss of visual continuity of townscape.	It is recommended that basic design and architectural elements (e.g., form, line, color and texture) typically used in surrounding community should be used or repeated in order to ensure the compatibility in urban area.	Townscape visual continuity kept.	Design Engineer	N.A.	N.A.
	Visual Conflict with surrounding community.	Provision of greenbelts around project sites is recommended. Also, provision of appropriate visual screens or barriers in viewscape to preclude unsightly intrusion from the project is efficient.	Visual conflict reduced to minimum.	Government of Colombia	N.A.	N.A.

19.3. VEHICULAR AIR POLLUTION

19.3.1. OBJECTIVES

The purpose of this analysis is to evaluate the amount of the total emission to be generated by the future traffic and transport condition, and carry out a comparative study between several scenarios. The following four case scenarios are of concern: i.e.; with- and without case at Years 2005 and 2015.

19.3.2. NUMERICAL PARAMETERS

Two pollutants such as NOX and SOX are of concern, and daily amounts of the total emission loading of each substance, **Wdi** (i = 1, 2), are computed by,

$$Wdi = \Sigma \ (Eij \ Nj) \quad (j = 1, n) \qquad (1)$$

where **Eij** is vehicle-type air pollution emission factor (Tables 19.3-1 and 19.3-2), **Nj** is the result of the future traffic and transport demand forecast (see Chapter 6) and **n** is the number of vehicle-type. Emission loadings are taken at 14 locations as sampling points of the air quality. Calculating points of the future traffic and transport prediction are in adjacent area. The air pollution prediction is carried out, using following Gaussian-type analytical models,

(i) Orthogonal wind.

$$C(x) = (2/\pi)^{0.5} (Q_l/U \sigma z) \exp(-He^2/2 \sigma z^2) \qquad (2)$$

where **U** is mean wind velocity, $\mathbf{Q_L}$ is pollutant loading intensity, **He** is the height of emission source and σz is the eddy diffusivity in the vertical direction.

(ii) Parallel wind.

$$C(y)|_{\Delta X} = Q/(\pi U \sigma y \sigma z) \exp(-y^2/2 \sigma y^2) \exp(-He^2/2 \sigma z^2) \qquad (3)$$

and

$$C(y) = \int C(y)|_{\Delta X} \, dx \qquad (4)$$

where $Q = \Delta X \, Q_L$, and σy is the eddy diffusivity in the horizontal direction.

The outline of this vehicular air pollution evaluation is summarized in Table 19.3-3.

Table 19.3-1 Vehicle Emission Factor (part 1)

	Pollutant	Vehicle Moving Speed (km/hr)								
		10	15	20	25	30	35	40	45	50
Car	NOX	1.26	1.12	1.06	1.07	1.13	1.21	1.31	1.40	1.49
	SOX	0.14	0.13	0.13	0.12	0.12	0.11	0.10	0.10	0.09
Bus	NOX	4.72	4.39	4.16	4.05	3.99	3.98	3.99	4.06	4.12
	SOX	1.01	0.85	0.77	0.73	0.69	0.67	0.66	0.64	0.63
Truck	NOX	7.44	6.91	6.47	6.16	5.92	5.76	5.62	5.61	5.59
	SOX	1.62	1.38	1.25	1.18	1.13	1.09	1.07	1.05	1.03

(g/km)

Table 19.3-2 Vehicle Emission Factor (part 2)

	NOX	SOX
100-passenger Bus (V = 20 km/hr)	5.456	0.919
200-passenger Bus (V = 30 km/hr)	4.296	0.734

(Unit: g/km)

Table 19.3-3 Numerical Conditions

	Comments
Air Pollution Emission Factor	For Car, Taxi, Truck and 30-passenger Bus, parameters summarized in the report, entitled "Study on Air Pollution Control Study in Santa Fe De Bogota City Area", Tokyo, JICA, 1992 are used. For 100-/and 200-passenger Buses, parameters summarized in Tokyo Metro Transport Bureau are used.
Target Year	Use the results of the future traffic and transport demand forecast (Years 2005 and 2015 with/or without 3000 peso).
Wind Velocity	Set 2.0 m/sec [Kawashima, 1998]
Eddy Diffusivity	Pasquill – Gifford Diagram.
Background Concentration	45 ug/m^3 for NOX and 24 ug/m^3 for SOX [Onursal and Gautam, 1997]

Table 19.3-4 summarizes the environmental standard concerned with the air quality, in particular, with SO_2 and NOX, implemented for Bogota City.

Table 19.3-4 Environmental Standard (Air Quality for SO_2 and NOX, Bogcta City).

	SO_2		NOX	
	$\mu g/m^3$	ppb	$\mu g/m^3$	ppb
Annual	76.8	<29	76.8	<24
Day	307.2	<116	*	*
3 hrs	1152	<434	*	*

19.3.3. Results

(1) Daily amount of vehicular emission

Tables 19.3-5 and 19.3-6 summarize the daily amount of vehicular emission at each point for four scenario cases. From this table, it can be seen that the total amount of the vehicular emission with-operation scenarios (Years 2005 and 2015) are less than those of without-operation ones.

Table 19.3-5 Daily Amount of Vehicular Emission (Year 2005)

		Point	node1	node2	B (m)	2005 Without		2005 With	
						NOX (g/day)	SOX (g/day)	NOX (g/day)	SOX (g/day)
1	1	Cr7a	255	273	35	141.8157583	22.66309069	122.70664	18.22056
2	3	Quito	285	309	59	283.3683247	45.45916387	218.70606	32.1568
3	4	Sur	417	419	35	273.564694	45.01893378	161.90735	22.49278
4	5	Cr68a	241	221	53	254.6366168	38.67919305	183.23661	23.90081
5	6	Cr68b	344	387	47	257.9997518	39.59018787	194.70782	27.02203
6	8	Calle170b	65	55	49	50.42016	6.68514	61.42016	8.68514
7	9	Av Suba1	170	1130	25	83.8568383	12.62165924	68.16241	9.20168
8	10	Av Suba2	114	125	41	129.4671801	21.19589783	84.53475	12.00283
9	11	Caracas1	172	1019	99	313.6430805	49.45029479	260.43868	38.02635
10	13	Caracas4	402	415	42	246.6001932	43.8046184	103.99464	15.67276
11	23	Sitm2	3042	3043	40	0	0	0	0
12	24	RailWay1	3058	3059	63	0	0	0	0
13	26	A.Norte	96	108	110	320.2321607	46.16505973	224.4684	27.03964
14	27	Caracas2	228	236	40	269.3403931	44.19045913	257.0349	40.24976

Table 19.3-6 Daily Amount of Vehicular Emission (Year 2015)

		Point	node1	node2	B (m)	2015 Without		2015 With	
						NOX (g/day)	SOX (g/day)	NOX (g/day)	SOX (g/day)
1	1	Cr7a	255	273	35	215.2640738	33.08222642	196.74288	28.78494
2	3	Quito	285	309	59	343.8754302	53.45401711	262.46088	37.75096
3	4	Sur	417	419	35	435.6627976	79.7359955	300.60962	53.0832
4	5	Cr68a	241	221	53	376.6637976	59.4927572	257.60242	37.53928
5	6	Cr68b	344	387	47	345.4037521	56.8665525	268.87392	41.54046
6	8	Calle170b	65	55	49	77.16666	11.03658	87.81414	12.88154
7	9	Av Suba1	170	1130	25	114.5065392	17.53158134	89.75979	13.06787
8	10	Av Suba2	114	125	41	183.0979168	30.54610002	129.79054	20.24738
9	11	Caracas1	172	1019	99	380.5872361	59.43555944	290.11648	40.93298
10	13	Caracas4	402	415	42	267.7444623	47.09158132	121.4044	17.54922
11	23	Sitm2	3042	3043	40	0	0	0	0
12	24	RailWay1	3058	3059	63	0	0	0	0
13	26	A.Norte	96	108	110	444.840244	71.23525864	314.40826	45.57256
14	27	Caracas2	228	236	40	390.5314998	60.52592193	350.36322	51.71834

(2) Roadside Air Quality Prediction

Based on the daily amount of vehicular emission summarized in Tables 19.3-5 and 19.3-6, pollutant emission intensity is calculated (Tables 19.3-7 and 19.3-8). Using the line-source type mathematical model, the roadside air quality of each point is predicted. Tables 19.3-9 to 19.3-16 summarize those computational results for each scenario. Within this study, it was found that only NOX at point 2 of Year 2015-without-opearation scenario exceeds the annual environmental standard (76.8 ug/m^3 or 0.0768 mg/m^3). Otherwise, all predicted results are below any air quality environmental standard of Bogota City within this study.

Table 19.3-17 summarizes the air quality prediction results at several typical points for all four cases. As shown from this table, it can be seen that the roadside air quality under operation scenarios for Years 2005 and 2015 tend to be better than those of without operation scenarios. This is due to the fact that local road traffic jams along major route are alleviated by this proposed project. Also, the roadside air quality of Year 2005 is better than that of Year 2015, as we expected.

Table 19.3-7 Emission Intensity for Year 2005 (mg/s/m)

						2005 Without		2005 With	
		Point	node1	node2	B (m)	Nox	Sox	Nox	Sox
1	1	Cr7a	255	273	35	0.046896745	0.007494408	0.040577593	0.006025317
*	*	*							
2	4	Sur	417	419	35	0.090464515	0.014887214	0.05354079	0.007438089
3	5	Cr68a	241	221	53	0.055607228	0.008446714	0.040014983	0.005219429
4	6	Cr68b	344	387	47	0.063534218	0.009749357	0.047948143	0.006654361
5	8	Calle170b	65	55	49	0.011909524	0.001579067	0.014507785	0.002051479
6	9	Av Suba1	170	1130	25	0.03882261	0.005843361	0.031556671	0.004260037
7	10	Av Suba2	114	125	41	0.036547872	0.005983485	0.023863694	0.003388333
8	11	Caracas1	172	1019	99	0.036667962	0.005781226	0.030447844	0.004445654
9	13	Caracas4	402	415	42	0.067956402	0.012071379	0.028658135	0.004318993
*	*	*							
*	*	*							
10	26	A.Norte	96	108	110	0.033694461	0.004857435	0.023618308	0.00284508
11	27	Caracas2	228	236	40	0.077934142	0.012786591	0.074373524	0.011646343

Note: Symbol "*" indicates that comparison between field data and computational result is not possible due to the insufficiency of either the traffic prediction results or the field data.

Table 19.3-8 Emission Intensity for Year 2015 (mg/s/m)

						2015 Without		2015 With	
		Point	node1	node2	B (m)	Nox	Sox	Nox	Sox
1	1	Cr7a	255	273	35	0.07118521	0.01093989	0.065060476	0.009518829
*	*	*							
2	4	Sur	417	419	35	0.144068385	0.026367723	0.099407943	0.017553968
3	5	Cr68a	241	221	53	0.082255372	0.012991954	0.056254896	0.008197777
4	6	Cr68b	344	387	47	0.085058056	0.014003781	0.066212057	0.010229625
5	8	Calle170b	65	55	49	0.018227197	0.002606902	0.020742191	0.003042692
6	9	Av Suba1	170	1130	25	0.053012287	0.008116473	0.041555458	0.00604994
7	10	Av Suba2	114	125	41	0.051687533	0.008622996	0.036639154	0.005715724
8	11	Caracas1	172	1019	99	0.044494393	0.006948602	0.033917471	0.004785468
9	13	Caracas4	402	415	42	0.073783196	0.012977177	0.033455798	0.004836095
*	*	*							
*	*	*							
10	26	A.Norte	96	108	110	0.046805581	0.007495292	0.033081677	0.004795093
11	27	Caracas2	228	236	40	0.113001013	0.017513288	0.101378247	0.014964797

Note: Symbol "*" indicates that comparison between field data and computational result is not possible due to the insufficiency of either the traffic prediction results or the field data.

Table 19.3-9 NOX (mg/m3) – 2005 With Case

Distance (m)			0	10	20	30	40	50
1 Cr 7a	Ortho	B	0.052196	0.050002	0.048797	0.048055	0.047555	0.047197
		D	0.054816	0.053358	0.051985	0.050963	0.050201	0.049616
		E	0.054762	0.054463	0.053365	0.05237	0.051562	0.050911
	Parallel	B	0.048959	0.047277	0.046483	0.046026	0.045734	0.045535
		D	0.052702	0.048643	0.046832	0.045923	0.045454	0.045214
		E	0.054102	0.048601	0.046432	0.045539	0.045187	0.045059
2 Sur	Ortho	B	0.054477	0.051588	0.050001	0.049024	0.048366	0.047893
		D	0.057929	0.056008	0.0542	0.052854	0.05185	0.05108
		E	0.057857	0.057464	0.056017	0.054707	0.053642	0.052785
	Parallel	B	0.050214	0.047999	0.046953	0.046352	0.045967	0.045704
		D	0.055144	0.049798	0.047413	0.046216	0.045598	0.045282
		E	0.056988	0.049743	0.046887	0.04571	0.045246	0.045077
3 Cr 68a	Ortho	B	0.050038	0.048796	0.04804	0.047534	0.047174	0.046903
		D	0.053307	0.051933	0.050905	0.05014	0.049555	0.049094
		E	0.054329	0.053267	0.052279	0.051473	0.050824	0.050297
	Parallel	B	0.047331	0.046505	0.046037	0.04574	0.045538	0.045396
		D	0.048814	0.046913	0.045965	0.045476	0.045226	0.045102
		E	0.048848	0.046535	0.045582	0.045204	0.045065	0.045018
4 Cr 68b	Ortho	B	0.05169	0.049922	0.04888	0.048201	0.047725	0.047372
		D	0.055527	0.053768	0.052417	0.051417	0.050658	0.050066
		E	0.056484	0.055311	0.054068	0.053036	0.052206	0.051533
	Parallel	B	0.048256	0.047041	0.046385	0.04598	0.045709	0.045521
		D	0.05068	0.047817	0.046424	0.045709	0.045341	0.045157
		E	0.051071	0.047435	0.045941	0.045338	0.045111	0.045033
5 Calle 170b	Ortho	B	0.047019	0.046498	0.046187	0.045983	0.045839	0.045732
		D	0.048231	0.047692	0.047282	0.046979	0.046748	0.046567
		E	0.048562	0.048181	0.047798	0.047483	0.047229	0.047023
	Parallel	B	0.045966	0.045612	0.045417	0.045296	0.045215	0.045158
		D	0.046651	0.045822	0.045415	0.045206	0.045099	0.045045
		E	0.046731	0.045694	0.045267	0.045095	0.045031	0.045009
6 Av Suba 1	Ortho	B	0.051936	0.049623	0.048371	0.047643	0.047172	0.046844
		D	0.052492	0.052141	0.050951	0.050023	0.049336	0.048817
		E	0.051357	0.0527	0.051961	0.051122	0.05042	0.049854
	Parallel	B	0.049499	0.047291	0.04642	0.045958	0.045675	0.045488
		D	0.054378	0.049077	0.047011	0.046017	0.045507	0.045245
		E	0.056861	0.049436	0.04678	0.045692	0.045251	0.045083

B: Unstable Pasquill - Gifford Stability Classification factor
D: Neutral
E: Stable

Table 19.3-9 NOX (mg/m3) - 2005, With Case (continued)

Distance (m)			0	10	20	30	40	50
7 Av Suba 2	Ortho	B	0.048736	0.047675	0.047072	0.046689	0.046426	0.046234
		D	0.050533	0.049629	0.04889	0.048344	0.047933	0.047615
		E	0.050807	0.050352	0.04971	0.049161	0.048718	0.04836
	Parallel	B	0.046924	0.046161	0.045774	0.045542	0.04539	0.045285
		D	0.048555	0.046731	0.045874	0.045438	0.045213	0.045099
		E	0.049005	0.046604	0.04563	0.045232	0.045078	0.045024
8 Caracas	Ortho	B	0.047151	0.046811	0.046564	0.046376	0.046229	0.046111
		D	0.049239	0.048711	0.048304	0.047981	0.047719	0.047502
		E	0.050264	0.049698	0.049241	0.048868	0.048559	0.048298
	Parallel	B	0.045701	0.045503	0.045368	0.045271	0.045201	0.045149
		D	0.045587	0.045287	0.045134	0.04506	0.045025	0.04501
		E	0.045322	0.045109	0.045034	0.045009	0.045002	0.045
9 Caracas	Ortho	B	0.049429	0.048186	0.047476	0.047022	0.04671	0.046481
		D	0.051634	0.050542	0.049663	0.049012	0.048522	0.048143
		E	0.052014	0.051427	0.050655	0.049999	0.049469	0.049041
	Parallel	B	0.047258	0.046373	0.045917	0.045644	0.045464	0.04534
		D	0.049135	0.04702	0.046021	0.045511	0.045248	0.045115
		E	0.049619	0.046851	0.045726	0.045266	0.045089	0.045027
10 A. Norte	Ortho	B	0.04656	0.046333	0.046164	0.046033	0.045929	0.045844
		D	0.048145	0.04778	0.047494	0.047265	0.047076	0.046919
		E	0.04895	0.048548	0.048222	0.047953	0.047728	0.047538
	Parallel	B	0.045466	0.045338	0.045249	0.045184	0.045136	0.045101
		D	0.045318	0.045152	0.045069	0.04503	0.045012	0.045005
		E	0.045144	0.045046	0.045013	0.045003	0.045001	0.045
11 Caracas	Ortho	B	0.056744	0.053369	0.051461	0.050257	0.049431	0.048831
		D	0.062188	0.059404	0.057093	0.055382	0.054098	0.053106
		E	0.062901	0.061601	0.059617	0.057907	0.056526	0.055411
	Parallel	B	0.051109	0.048662	0.047431	0.046699	0.046222	0.045894
		D	0.056393	0.050524	0.047789	0.046399	0.045682	0.045319
		E	0.057943	0.050176	0.047038	0.045753	0.045255	0.045078

B: Unstable — Pasquill – Gifford Stability Classification factor
D: Neutral
E: Stable

Table 19.3-10 NOX (mg/m3) – 2005 Without Case

Distance (m)			0	10	20	30	40	50
1 Cr 7a	Ortho	B	0.053249	0.050734	0.049353	0.048502	0.047929	0.047518
		D	0.056253	0.054581	0.053008	0.051836	0.050962	0.050292
		E	0.056191	0.055848	0.054589	0.053449	0.052522	0.051776
	Parallel	B	0.049538	0.04761	0.0467	0.046176	0.045841	0.045613
		D	0.053829	0.049176	0.0471	0.046058	0.04552	0.045246
		E	0.055434	0.049128	0.046642	0.045618	0.045214	0.045067
2 Sur	Ortho	B	0.060795	0.05598	0.053335	0.051706	0.050609	0.049822
		D	0.066548	0.063347	0.060334	0.058091	0.056417	0.055133
		E	0.066429	0.065773	0.063361	0.061178	0.059404	0.057975
	Parallel	B	0.05369	0.049998	0.048255	0.047253	0.046611	0.046174
		D	0.061907	0.052997	0.049022	0.047026	0.045996	0.045471
		E	0.064979	0.052904	0.048144	0.046184	0.04541	0.045129
3 Cr 68a	Ortho	B	0.052054	0.050315	0.049256	0.048548	0.048043	0.047665
		D	0.056629	0.054706	0.053267	0.052196	0.051376	0.050732
		E	0.05806	0.056574	0.055191	0.054062	0.053154	0.052415
	Parallel	B	0.048263	0.047107	0.046452	0.046036	0.045754	0.045554
		D	0.05034	0.047679	0.046351	0.045666	0.045316	0.045143
		E	0.050387	0.047149	0.045815	0.045285	0.045091	0.045026
4 Cr 68b	Ortho	B	0.05392	0.051562	0.050174	0.049268	0.048633	0.048163
		D	0.059036	0.056691	0.05489	0.053555	0.052544	0.051755
		E	0.060312	0.058747	0.05709	0.055715	0.054607	0.05371
	Parallel	B	0.049342	0.047722	0.046847	0.046306	0.045946	0.045694
		D	0.052574	0.048756	0.046899	0.045945	0.045454	0.045209
		E	0.053094	0.048247	0.046255	0.045451	0.045148	0.045043
5 Calle 170b	Ortho	B	0.046481	0.046099	0.045871	0.045721	0.045615	0.045537
		D	0.04737	0.046974	0.046674	0.046451	0.046282	0.046149
		E	0.047612	0.047333	0.047052	0.046821	0.046634	0.046483
	Parallel	B	0.045708	0.045449	0.045306	0.045217	0.045158	0.045116
		D	0.04621	0.045603	0.045305	0.045151	0.045072	0.045033
		E	0.04627	0.045509	0.045195	0.04507	0.045023	0.045007
6 Av Suba 1	Ortho	B	0.053454	0.050634	0.049109	0.048221	0.047647	0.047247
		D	0.05413	0.053703	0.052253	0.051122	0.050285	0.049652
		E	0.052748	0.054385	0.053484	0.052461	0.051605	0.050916
	Parallel	B	0.050483	0.047792	0.04673	0.046167	0.045823	0.045595
		D	0.05643	0.049968	0.047451	0.046239	0.045618	0.045298
		E	0.059455	0.050407	0.04717	0.045844	0.045306	0.045101

B: Unstable   Pasquill – Gifford Stability Classification Factor
D: Neutral
E: Stable

Table 19.3-10 NOX (mg/m3) - 2005, Without Case (continued)

Distance (m)			0	10	20	30	40	50
7 Av Suba 2	Ortho	B	0.05076	0.049124	0.048194	0.047604	0.047198	0.046902
		D	0.05353	0.052136	0.050997	0.050155	0.049521	0.049031
		E	0.053953	0.053251	0.052262	0.051415	0.050732	0.05018
	Parallel	B	0.047966	0.046791	0.046193	0.045835	0.045601	0.04544
		D	0.050481	0.047668	0.046348	0.045675	0.045329	0.045153
		E	0.051175	0.047472	0.045971	0.045358	0.045121	0.045037
8 Caracas	Ortho	B	0.047653	0.047233	0.046928	0.046697	0.046516	0.04637
		D	0.050228	0.049577	0.049075	0.048677	0.048354	0.048086
		E	0.051492	0.050794	0.050231	0.049771	0.049389	0.049068
	Parallel	B	0.045864	0.045621	0.045454	0.045335	0.045248	0.045183
		D	0.045724	0.045354	0.045166	0.045074	0.045031	0.045012
		E	0.045397	0.045135	0.045042	0.045011	0.045003	0.045001
9 Caracas	Ortho	B	0.055385	0.052471	0.050805	0.049742	0.049009	0.048473
		D	0.060556	0.057996	0.055933	0.054407	0.053259	0.052369
		E	0.061446	0.060071	0.058261	0.056721	0.055479	0.054475
	Parallel	B	0.050295	0.048219	0.047151	0.046509	0.046088	0.045796
		D	0.054696	0.049737	0.047394	0.046198	0.045582	0.045271
		E	0.055832	0.049341	0.046701	0.045624	0.045209	0.045063
10 A.Norte	Ortho	B	0.047209	0.046888	0.046648	0.046463	0.046316	0.046196
		D	0.049455	0.048938	0.048533	0.048208	0.047941	0.047718
		E	0.050596	0.050026	0.049564	0.049183	0.048865	0.048595
	Parallel	B	0.04566	0.045479	0.045352	0.04526	0.045193	0.045143
		D	0.045451	0.045215	0.045098	0.045043	0.045017	0.045007
		E	0.045204	0.045066	0.045019	0.045005	0.045001	0.045
11 Caracas	Ortho	B	0.057379	0.053821	0.051811	0.050541	0.049671	0.049038
		D	0.063117	0.060183	0.057747	0.055943	0.05459	0.053544
		E	0.063868	0.062498	0.060407	0.058605	0.057149	0.055974
	Parallel	B	0.051439	0.04886	0.047562	0.046791	0.046288	0.045942
		D	0.057009	0.050822	0.04794	0.046475	0.045719	0.045336
		E	0.058642	0.050456	0.047149	0.045794	0.045269	0.045082

B: Unstable Pasquill - Gifford Stability Classification Factor
D: Neutral
E: Stable

Table 19.3-11 NOX (mg/m3) – 2015, With Case

Distance (m)			0	10	20	30	40	50
1	Ortho	B	0.056408	0.05293	0.05102	0.049843	0.049051	0.048483
		D	0.060562	0.058251	0.056074	0.054454	0.053246	0.052318
		E	0.060476	0.060003	0.058261	0.056684	0.055403	0.054371
	Parallel	B	0.051276	0.048609	0.047351	0.046627	0.046164	0.045848
		D	0.057211	0.050776	0.047905	0.046463	0.045719	0.04534
		E	0.059429	0.050709	0.047271	0.045855	0.045296	0.045093
2	Ortho	B	0.062375	0.057078	0.054169	0.052377	0.05117	0.050304
		D	0.068703	0.065182	0.061867	0.0594	0.057559	0.056147
		E	0.068571	0.06785	0.065197	0.062796	0.060844	0.059272
	Parallel	B	0.054559	0.050497	0.048581	0.047478	0.046772	0.046291
		D	0.063598	0.053797	0.049424	0.047229	0.046098	0.045518
		E	0.066977	0.053695	0.048459	0.046302	0.045451	0.045142
3	Ortho	B	0.052054	0.050315	0.049256	0.048548	0.048043	0.047665
		D	0.056629	0.054706	0.053267	0.052196	0.051376	0.050732
		E	0.05806	0.056574	0.055191	0.054062	0.053154	0.052415
	Parallel	B	0.048263	0.047107	0.046452	0.046036	0.045754	0.045554
		D	0.05034	0.047679	0.046351	0.045666	0.045316	0.045143
		E	0.050387	0.047149	0.045815	0.045285	0.045091	0.045026
4	Ortho	B	0.054199	0.051767	0.050335	0.049401	0.048746	0.048262
		D	0.059474	0.057056	0.055199	0.053823	0.05278	0.051966
		E	0.06079	0.059177	0.057468	0.05605	0.054908	0.053983
	Parallel	B	0.049477	0.047807	0.046904	0.046347	0.045976	0.045716
		D	0.05281	0.048873	0.046958	0.045974	0.045468	0.045215
		E	0.053347	0.048348	0.046294	0.045465	0.045152	0.045045
5	Ortho	B	0.047827	0.047097	0.046662	0.046376	0.046175	0.046025
		D	0.049524	0.048769	0.048195	0.04777	0.047447	0.047194
		E	0.049987	0.049454	0.048918	0.048476	0.04812	0.047832
	Parallel	B	0.046352	0.045857	0.045584	0.045415	0.045301	0.045221
		D	0.047311	0.046151	0.045582	0.045289	0.045138	0.045063
		E	0.047424	0.045971	0.045373	0.045133	0.045043	0.045013
6	Ortho	B	0.054104	0.051067	0.049425	0.048469	0.047851	0.04742
		D	0.054833	0.054373	0.052811	0.051593	0.050691	0.05001
		E	0.053343	0.055107	0.054137	0.053035	0.052113	0.051371
	Parallel	B	0.050905	0.048007	0.046863	0.046257	0.045886	0.045641
		D	0.057309	0.050351	0.047639	0.046335	0.045666	0.045321
		E	0.060567	0.050823	0.047336	0.045909	0.045329	0.045109

B: Unstable Pasquill - Gifford Stability Classification factor
D: Neutral
E: Stable

Table 19.3-11 NOX (mg/m3) – 2015, With Case (Continued)

Distance (m)			0	10	20	30	40	50
7	Ortho	B	0.05076	0.049124	0.048194	0.047604	0.047198	0.046902
		D	0.05353	0.052136	0.050997	0.050155	0.049521	0.049031
		E	0.053953	0.053251	0.052262	0.051415	0.050732	0.05018
	Parallel	B	0.047966	0.046791	0.046193	0.045835	0.045601	0.04544
		D	0.050481	0.047668	0.046348	0.045675	0.045329	0.045153
		E	0.051175	0.047472	0.045971	0.045358	0.045121	0.045037
8	Ortho	B	0.047438	0.047052	0.046772	0.04656	0.046393	0.046259
		D	0.049804	0.049206	0.048745	0.048379	0.048082	0.047836
		E	0.050966	0.050324	0.049807	0.049384	0.049033	0.048738
	Parallel	B	0.045794	0.045571	0.045417	0.045307	0.045228	0.045169
		D	0.045666	0.045325	0.045152	0.045068	0.045029	0.045011
		E	0.045364	0.045124	0.045038	0.045011	0.045003	0.045001
9	Ortho	B	0.05004	0.048626	0.047817	0.047301	0.046945	0.046685
		D	0.052549	0.051307	0.050306	0.049565	0.049008	0.048576
		E	0.052981	0.052314	0.051435	0.050688	0.050085	0.049598
	Parallel	B	0.047569	0.046562	0.046044	0.045732	0.045528	0.045386
		D	0.049705	0.047299	0.046162	0.045582	0.045282	0.045131
		E	0.050257	0.047107	0.045826	0.045303	0.045102	0.045031
10	Ortho	B	0.047144	0.046832	0.0466	0.04642	0.046277	0.046161
		D	0.049324	0.048822	0.04843	0.048114	0.047855	0.047638
		E	0.050431	0.049878	0.04943	0.04906	0.048751	0.048489
	Parallel	B	0.045641	0.045465	0.045342	0.045253	0.045187	0.045139
		D	0.045438	0.045209	0.045095	0.045041	0.045017	0.045006
		E	0.045198	0.045064	0.045018	0.045005	0.045001	0.045
11	Ortho	B	0.06103	0.056422	0.053819	0.052175	0.051048	0.050228
		D	0.068459	0.064659	0.061505	0.05917	0.057417	0.056063
		E	0.069432	0.067658	0.064951	0.062616	0.060731	0.059209
	Parallel	B	0.053338	0.049998	0.048318	0.047319	0.046668	0.04622
		D	0.06055	0.052539	0.048807	0.04691	0.045931	0.045435
		E	0.062665	0.052064	0.047782	0.046028	0.045348	0.045107

B: Unstable — Pasquill – Gifford Stability Classification factor
D: Neutral
E: Stable

Table 19.3-12 NOX (mg/m3) – 2015 Without Case

Distance (m)			0	10	20	30	40	50
1		B	0.057461	0.053662	0.051575	0.05029	0.049425	0.048804
Cr 7a	Ortho	D	0.061999	0.059474	0.057097	0.055327	0.054007	0.052994
		E	0.061905	0.061387	0.059485	0.057763	0.056363	0.055236
		B	0.051856	0.048943	0.047568	0.046777	0.046271	0.045926
	Parallel	D	0.058338	0.051309	0.048173	0.046598	0.045786	0.045371
		E	0.060761	0.051236	0.04748	0.045934	0.045324	0.045102
2		B	0.070272	0.062569	0.058336	0.05573	0.053975	0.052715
Sur	Ortho	D	0.079477**	0.074356	0.069534	0.065945	0.063267	0.061213
		E	0.079286**	0.078236**	0.074378	0.070885	0.068046	0.06576
		B	0.058905	0.052996	0.050209	0.048604	0.047578	0.046878
	Parallel	D	0.072051	0.057796	0.051435	0.048242	0.046593	0.045753
		E	0.076967**	0.057647	0.050031	0.046894	0.045657	0.045206
3		B	0.055328	0.052783	0.051232	0.050196	0.049456	0.048902
Cr 68a	Ortho	D	0.062029	0.059212	0.057105	0.055536	0.054337	0.053394
		E	0.064124	0.061947	0.059922	0.05827	0.05694	0.055858
		B	0.049778	0.048086	0.047126	0.046516	0.046103	0.045812
	Parallel	D	0.052819	0.048922	0.046979	0.045976	0.045463	0.04521
		E	0.052888	0.048147	0.046193	0.045417	0.045133	0.045038
4		B	0.056848	0.053716	0.051871	0.050668	0.049825	0.049201
Cr 68b	Ortho	D	0.063641	0.060527	0.058135	0.056363	0.055019	0.053971
		E	0.065336	0.063258	0.061057	0.05923	0.05776	0.056569
		B	0.050766	0.048615	0.047453	0.046735	0.046256	0.045922
	Parallel	D	0.055059	0.049988	0.047522	0.046255	0.045603	0.045277
		E	0.05575	0.049312	0.046667	0.045599	0.045196	0.045058
5		B	0.047423	0.046798	0.046425	0.04618	0.046007	0.045878
Calle 170b	Ortho	D	0.048878	0.04823	0.047739	0.047374	0.047097	0.04688
		E	0.049275	0.048817	0.048358	0.047979	0.047674	0.047427
		B	0.046159	0.045734	0.045501	0.045355	0.045258	0.045189
	Parallel	D	0.046981	0.045987	0.045499	0.045247	0.045118	0.045054
		E	0.047077	0.045832	0.04532	0.045114	0.045037	0.045011
6		B	0.056488	0.052656	0.050584	0.049377	0.048597	0.048054
Av Suba 1	Ortho	D	0.057408	0.056828	0.054857	0.053319	0.052182	0.051322
		E	0.055529	0.057754	0.05653	0.05514	0.053976	0.053039
		B	0.052452	0.048794	0.047351	0.046586	0.046118	0.045808
	Parallel	D	0.060532	0.051752	0.048331	0.046684	0.04584	0.045405
		E	0.064644	0.052348	0.047948	0.046146	0.045415	0.045137

B: Unstable   Pasquill – Gifford Stability Classification Factor
D: Neutral
E: Stable

Note symbol "**" indicates computational result exceeds the environmental standard.

Table 19.3-12 NOX (mg/m3) -- 2015, Without Case (continued)

Distance (m)			0	10	20	30	40	50
7 Av Suba 2	Ortho	B	0.053095	0.050796	0.049489	0.04866	0.048089	0.047674
		D	0.056989	0.055029	0.053429	0.05224<	0.051354	0.050665
		E	0.057582	0.056595	0.055206	0.054016	0.053056	0.052281
	Parallel	B	0.049168	0.047516	0.046676	0.046174	0.045845	0.045618
		D	0.052703	0.04875	0.046894	0.045949	0.045462	0.045215
		E	0.053679	0.048475	0.046365	0.045503	0.045169	0.045052
8 Caracas	Ortho	B	0.048155	0.047656	0.047293	0.047018	0.046803	0.04663
		D	0.051217	0.050443	0.049846	0.049373	0.048988	0.04867
		E	0.05272	0.05189	0.05122	0.050673	0.050219	0.049837
	Parallel	B	0.046028	0.045738	0.04554	0.045398	0.045294	0.045218
		D	0.045862	0.045421	0.045197	0.045088	0.045037	0.045015
		E	0.045472	0.04516	0.045049	0.045014	0.045003	0.045001
9 Caracas	Ortho	B	0.056302	0.05313	0.051317	0.050161	0.049363	0.048779
		D	0.061929	0.059142	0.056898	0.055237	0.053987	0.053019
		E	0.062897	0.061401	0.059431	0.057755	0.056403	0.055311
	Parallel	B	0.050762	0.048503	0.047341	0.046642	0.046184	0.045866
		D	0.055551	0.050155	0.047605	0.046304	0.045633	0.045295
		E	0.056787	0.049724	0.046852	0.045679	0.045228	0.045069
10 A. Norte	Ortho	B	0.048054	0.04761	0.047279	0.047023	0.046819	0.046653
		D	0.051159	0.050444	0.049885	0.049435	0.049066	0.048757
		E	0.052735	0.051948	0.051309	0.050783	0.050343	0.049969
	Parallel	B	0.045913	0.045663	0.045487	0.04536	0.045267	0.045197
		D	0.045623	0.045298	0.045136	0.045059	0.045024	0.045009
		E	0.045282	0.045091	0.045026	0.045007	0.045002	0.045
11 Caracas	Ortho	B	0.062934	0.057779	0.054867	0.053027	0.051766	0.050849
		D	0.071247	0.066995	0.063466	0.060854	0.058893	0.057378
		E	0.072335	0.07035	0.067321	0.06471	0.0626	0.060898
	Parallel	B	0.054329	0.050592	0.048712	0.047595	0.046866	0.046364
		D	0.062397	0.053435	0.049259	0.047136	0.046041	0.045487
		E	0.064764	0.052904	0.048113	0.04615	0.04539	0.045119

B: Unstable   Pasquill – Gifford Stability Classification Factor
D: Neutral
E: Stable

Table 19.3-13 SOX (mg/m3) – 2005 With Case

Distance (m)			0	10	20	30	40	50
1 Cr 7a	Ortho	B	0.025053	0.024732	0.024556	0.024447	0.024374	0.024321
		D	0.025437	0.025223	0.025022	0.024873	0.024761	0.024676
		E	0.025429	0.025385	0.025224	0.025079	0.02496	0.024865
	Parallel	B	0.024579	0.024333	0.024217	0.02415	0.024107	0.024078
		D	0.025127	0.024533	0.024268	0.024135	0.024066	0.024031
		E	0.025332	0.024527	0.02421	0.024079	0.024027	0.024009
2 Sur	Ortho	B	0.025229	0.024854	0.024648	0.024522	0.024436	0.024375
		D	0.025676	0.025427	0.025193	0.025018	0.024888	0.024788
		E	0.025667	0.025616	0.025428	0.025258	0.02512	0.025009
	Parallel	B	0.024676	0.024389	0.024253	0.024175	0.024125	0.024091
		D	0.025315	0.024622	0.024313	0.024158	0.024077	0.024037
		E	0.025554	0.024615	0.024245	0.024092	0.024032	0.02401
3 Cr 68a	Ortho	B	0.02463	0.024475	0.02438	0.024317	0.024272	0.024238
		D	0.025038	0.024867	0.024738	0.024642	0.024569	0.024512
		E	0.025166	0.025033	0.02491	0.024809	0.024728	0.024662
	Parallel	B	0.024291	0.024188	0.02413	0.024092	0.024067	0.02405
		D	0.024477	0.024239	0.024121	0.024059	0.024028	0.024013
		E	0.024481	0.024192	0.024073	0.024025	0.024008	0.024002
4 Cr 68b	Ortho	B	0.02492	0.024677	0.024534	0.02444	0.024375	0.024326
		D	0.025447	0.025206	0.02502	0.024882	0.024778	0.024697
		E	0.025579	0.025418	0.025247	0.025105	0.024991	0.024898
	Parallel	B	0.024448	0.024281	0.02419	0.024135	0.024098	0.024072
		D	0.024781	0.024387	0.024196	0.024097	0.024047	0.024022
		E	0.024835	0.024335	0.024129	0.024046	0.024015	0.024004
5 Calle 170b	Ortho	B	0.024283	0.02421	0.024166	0.024138	0.024117	0.024102
		D	0.024452	0.024377	0.02432	0.024277	0.024245	0.024219
		E	0.024499	0.024445	0.024392	0.024348	0.024312	0.024283
	Parallel	B	0.024135	0.024086	0.024058	0.024041	0.02403	0.024022
		D	0.024231	0.024115	0.024058	0.024029	0.024014	0.024006
		E	0.024242	0.024097	0.024037	0.024013	0.024004	0.024001
6 Av Suba 1	Ortho	B	0.025	0.025	0.024	0.024	0.024	0.024
		D	0.025	0.025	0.025	0.025	0.025	0.025
		E	0.025	0.025	0.025	0.025	0.025	0.025
	Parallel	B	0.025	0.024	0.024	0.024	0.024	0.024
		D	0.025	0.025	0.024	0.024	0.024	0.024
		E	0.026	0.025	0.024	0.024	0.024	0.024

B: Unstable Pasquill – Gifford Stability Classification Factor
D: Neutral
E: Stable

Table 19.3-13 SOX (mg/m3) – 2005, With Case (continued)

Distance (m)			0	10	20	30	40	50
7 Av Suba 2	Ortho	B	0.024529	0.024379	0.024294	0.024239	0.024202	0.024175
		D	0.024784	0.024656	0.024551	0.024474	0.024415	0.02437
		E	0.024823	0.024758	0.024667	0.02459	0.024527	0.024476
	Parallel	B	0.024273	0.024165	0.02411	0.024077	0.024055	0.02404
		D	0.024504	0.024245	0.024124	0.024062	0.02403	0.024014
		E	0.024567	0.024227	0.024089	0.024033	0.024011	0.024003
8 Caracas	Ortho	B	0.024316	0.024266	0.024229	0.024202	0.02418	0.024163
		D	0.024622	0.024544	0.024485	0.024437	0.024399	0.024367
		E	0.024772	0.024689	0.024622	0.024567	0.024522	0.024484
	Parallel	B	0.024103	0.024074	0.024054	0.02404	0.024029	0.024022
		D	0.024086	0.024042	0.02402	0.024009	0.024004	0.024001
		E	0.024047	0.024016	0.024005	0.024001	0.024	0.024
9 Caracas	Ortho	B	0.024657	0.024472	0.024367	0.0243	0.024254	0.02422
		D	0.024984	0.024822	0.024691	0.024595	0.024522	0.024466
		E	0.02504	0.024953	0.024839	0.024741	0.024663	0.024599
	Parallel	B	0.024335	0.024204	0.024136	0.024095	0.024069	0.02405
		D	0.024613	0.0243	0.024151	0.024076	0.024037	0.024017
		E	0.024685	0.024274	0.024108	0.024039	0.024013	0.024004
10 A. Norte	Ortho	B	0.024182	0.024155	0.024136	0.024121	0.024108	0.024099
		D	0.024367	0.024324	0.024291	0.024264	0.024242	0.024224
		E	0.024461	0.024414	0.024376	0.024344	0.024318	0.024296
	Parallel	B	0.024054	0.024039	0.024029	0.024021	0.024016	0.024012
		D	0.024037	0.024018	0.024008	0.024004	0.024001	0.024001
		E	0.024017	0.024005	0.024002	0.024	0.024	0.024
11 Caracas	Ortho	B	0.025905	0.025357	0.025048	0.024852	0.024719	0.024621
		D	0.026787	0.026336	0.025961	0.025684	0.025475	0.025314
		E	0.026903	0.026692	0.02637	0.026093	0.025869	0.025688
	Parallel	B	0.024991	0.024594	0.024394	0.024276	0.024198	0.024145
		D	0.025847	0.024896	0.024452	0.024227	0.024111	0.024052
		E	0.026099	0.024839	0.024331	0.024122	0.024041	0.024013

B: Unstable   Pasquill – Gifford Stability Classification Factor

D: Neutral

E: Stable

Table 19.3-14 SOX (mg/m3) – 2005, Without Case

Distance (m)			0	10	20	30	40	50
1		B	0.025229	0.024854	0.024648	0.024522	0.024436	0.024375
Cr 7a	Ortho	D	0.025676	0.025427	0.025193	0.025018	0.024888	0.024788
		E	0.025667	0.025616	0.025428	0.025258	0.02512	0.025009
		B	0.024676	0.024389	0.024253	0.024175	0.024125	0.024091
	Parallel	D	0.025315	0.024622	0.024313	0.024158	0.024077	0.024037
		E	0.025554	0.024615	0.024245	0.024092	0.024032	0.02401
2		B	0.026457	0.025708	0.025297	0.025043	0.024873	0.02475
Sur	Ortho	D	0.027352	0.026854	0.026385	0.026036	0.025776	0.025576
		E	0.027333	0.027231	0.026856	0.026517	0.026241	0.026018
		B	0.025352	0.024777	0.024506	0.02435	0.024251	0.024183
	Parallel	D	0.02663	0.025244	0.024626	0.024315	0.024155	0.024073
		E	0.027108	0.02523	0.024489	0.024184	0.024064	0.02402
3		B	0.025	0.025	0.025	0.025	0.024	0.024
Cr 68a	Ortho	D	0.026	0.025	0.025	0.025	0.025	0.025
		E	0.026	0.026	0.025	0.025	0.025	0.025
		B	0.024466	0.024301	0.024207	0.024148	0.024108	0.024079
	Parallel	D	0.024763	0.024383	0.024193	0.024095	0.024045	0.02402
		E	0.02477	0.024307	0.024116	0.024041	0.024013	0.024004
4		B	0.025352	0.024995	0.024784	0.024647	0.024551	0.024479
Cr 68b	Ortho	D	0.026127	0.025772	0.025499	0.025297	0.025143	0.025024
		E	0.026321	0.026084	0.025832	0.025624	0.025456	0.02532
		B	0.024658	0.024413	0.02428	0.024198	0.024143	0.024105
	Parallel	D	0.025148	0.024569	0.024288	0.024143	0.024069	0.024032
		E	0.025227	0.024492	0.02419	0.024068	0.024022	0.024007
5		B	0.024215	0.02416	0.024127	0.024105	0.024089	0.024078
Calle 170b	Ortho	D	0.024345	0.024287	0.024243	0.024211	0.024186	0.024167
		E	0.02438	0.024339	0.024298	0.024265	0.024238	0.024216
		B	0.024103	0.024065	0.024045	0.024032	0.024023	0.024017
	Parallel	D	0.024176	0.024088	0.024044	0.024022	0.024011	0.024005
		E	0.024185	0.024074	0.024028	0.02401	0.024003	0.024001
6		B	0.025	0.025	0.025	0.024	0.024	0.024
Av Suba 1	Ortho	D	0.025	0.025	0.025	0.025	0.025	0.025
		E	0.025	0.025	0.025	0.025	0.025	0.025
		B	0.025	0.024	0.024	0.024	0.024	0.024
	Parallel	D	0.026	0.025	0.024	0.024	0.024	0.024
		E	0.026	0.025	0.024	0.024	0.024	0.024

B: Unstable   Pasquill – Gifford Stability Classification Factor

D: Neutral

E: Stable

Table 19.3-14 SOX (mg/m3)- 2005, Without Case (Continued)

Distance (m)			0	10	20	30	40	50
7 Av Suba 2	Ortho	B	0.024934	0.024669	0.024518	0.024422	0.024356	0.024308
		D	0.025383	0.025157	0.024973	0.024836	0.024733	0.024654
		E	0.025452	0.025338	0.025178	0.02504	0.02493	0.02484
	Parallel	B	0.024481	0.02429	0.024193	0.024135	0.024098	0.024071
		D	0.024889	0.024433	0.024219	0.02411	0.024053	0.024025
		E	0.025001	0.024401	0.024158	0.024058	0.02402	0.024006
8 Caracas	Ortho	B	0.024416	0.02435	0.024302	0.024266	0.024238	0.024215
		D	0.02482	0.024717	0.024639	0.024576	0.024526	0.024484
		E	0.025018	0.024908	0.02482	0.024748	0.024688	0.024638
	Parallel	B	0.024135	0.024097	0.024071	0.024052	0.024039	0.024029
		D	0.024114	0.024055	0.024026	0.024012	0.024005	0.024002
		E	0.024062	0.024021	0.024007	0.024002	0.024	0.024
9 Caracas	Ortho	B	0.025833	0.025318	0.025024	0.024837	0.024707	0.024613
		D	0.026745	0.026293	0.025929	0.02566	0.025457	0.0253
		E	0.026902	0.02666	0.02634	0.026068	0.025849	0.025672
	Parallel	B	0.024934	0.024568	0.02438	0.024266	0.024192	0.024141
		D	0.025711	0.024836	0.024422	0.024211	0.024103	0.024048
		E	0.025911	0.024766	0.0243	0.02411	0.024037	0.024011
10 A. Norte	Ortho	B	0.027184	0.026721	0.026376	0.026109	0.025897	0.025724
		D	0.030421	0.029676	0.029092	0.028624	0.028239	0.027917
		E	0.032064	0.031243	0.030577	0.030029	0.02957	0.029181
	Parallel	B	0.024952	0.024691	0.024508	0.024375	0.024278	0.024206
		D	0.02465	0.02431	0.024142	0.024061	0.024025	0.02401
		E	0.024294	0.024095	0.024027	0.024007	0.024002	0.024
11 Caracas	Ortho	B	0.026063	0.02547	0.025135	0.024924	0.024778	0.024673
		D	0.02702	0.02653	0.026124	0.025824	0.025598	0.025424
		E	0.027145	0.026916	0.026568	0.026267	0.026025	0.025829
	Parallel	B	0.025073	0.024643	0.024427	0.024299	0.024215	0.024157
		D	0.026001	0.02497	0.02449	0.024246	0.02412	0.024056
		E	0.026274	0.024909	0.024358	0.024132	0.024045	0.024014

B: Unstable Pasquill – Gifford Stability Classification Factor
D: Neutral
E: Stable

Table 19.3-15 SOX (mg/m3) – 2015, With Case

Distance (m)			0	10	20	30	40	50
1 Cr 7a	Ortho	B	0.025667	0.025159	0.02488	0.024708	0.024592	0.024509
		D	0.026275	0.025937	0.025619	0.025382	0.025205	0.02507
		E	0.026262	0.026193	0.025938	0.025708	0.02552	0.02537
	Parallel	B	0.024917	0.024528	0.024344	0.024238	0.02417	0.024124
		D	0.025785	0.024844	0.024425	0.024214	0.024105	0.02405
		E	0.026109	0.024834	0.024332	0.024125	0.024043	0.024014
2 Sur	Ortho	B	0.027089	0.026147	0.02563	0.025311	0.025097	0.024943
		D	0.028214	0.027588	0.026999	0.02656	0.026233	0.025982
		E	0.02819	0.028062	0.027591	0.027164	0.026817	0.026537
	Parallel	B	0.025699	0.024977	0.024637	0.024441	0.024315	0.02423
		D	0.027306	0.025564	0.024786	0.024396	0.024195	0.024092
		E	0.027907	0.025546	0.024615	0.024232	0.02408	0.024025
3 Cr 68a	Ortho	B	0.025033	0.024778	0.024623	0.02452	0.024446	0.02439
		D	0.025703	0.025421	0.02521	0.025054	0.024934	0.024839
		E	0.025912	0.025695	0.025492	0.025327	0.025194	0.025086
	Parallel	B	0.024478	0.024309	0.024213	0.024152	0.02411	0.024081
		D	0.024782	0.024392	0.024198	0.024098	0.024046	0.024021
		E	0.024789	0.024315	0.024119	0.024042	0.024013	0.024004
4 Cr 68b	Ortho	B	0.025394	0.025025	0.024808	0.024667	0.024568	0.024494
		D	0.026193	0.025827	0.025545	0.025337	0.025179	0.025055
		E	0.026392	0.026148	0.025889	0.025674	0.025501	0.025361
	Parallel	B	0.024678	0.024425	0.024289	0.024204	0.024148	0.024108
		D	0.025183	0.024587	0.024297	0.024148	0.024071	0.024033
		E	0.025265	0.024507	0.024196	0.02407	0.024023	0.024007
5 Calle 170b	Ortho	B	0.024404	0.0243	0.024237	0.024197	0.024168	0.024146
		D	0.024646	0.024538	0.024456	0.024396	0.02435	0.024313
		E	0.024712	0.024636	0.02456	0.024497	0.024446	0.024405
	Parallel	B	0.024193	0.024122	0.024083	0.024059	0.024043	0.024032
		D	0.02433	0.024164	0.024083	0.024041	0.02402	0.024009
		E	0.024346	0.024139	0.024053	0.024019	0.024006	0.024002
6 Av Suba 1	Ortho	B	0.025	0.025	0.025	0.024	0.024	0.024
		D	0.025	0.025	0.025	0.025	0.025	0.025
		E	0.025	0.025	0.025	0.025	0.025	0.025
	Parallel	B	0.025	0.024	0.024	0.024	0.024	0.024
		D	0.026	0.025	0.024	0.024	0.024	0.024
		E	0.026	0.025	0.024	0.024	0.024	0.024

B: Unstable   Pasquill – Gifford Stability Classification Factor
D: Neutral
E: Stable

Table 19.3-15 SOX (mg/m3) - 2015, With Case (continued)

Distance (m)			0	10	20	30	40	50
7 Av Suba 2	Ortho	B	0.024887	0.024635	0.024492	0.024401	0.024339	0.024293
		D	0.025314	0.025099	0.024924	0.024794	0.024696	0.024621
		E	0.025379	0.025271	0.025119	0.024988	0.024883	0.024798
	Parallel	B	0.024457	0.024276	0.024184	0.024129	0.024093	0.024068
		D	0.024844	0.024411	0.024208	0.024104	0.024051	0.024024
		E	0.024951	0.024381	0.02415	0.024055	0.024019	0.024006
8 Caracas	Ortho	B	0.024344	0.02429	0.02425	0.02422	0.024197	0.024178
		D	0.024678	0.024594	0.024529	0.024477	0.024435	0.0244
		E	0.024842	0.024752	0.024679	0.024619	0.024569	0.024528
	Parallel	B	0.024112	0.024081	0.024059	0.024043	0.024032	0.024024
		D	0.024094	0.024046	0.024021	0.02401	0.024004	0.024002
		E	0.024051	0.024018	0.024005	0.024001	0.024	0.024
9 Caracas	Ortho	B	0.024733	0.024527	0.02441	0.024335	0.024283	0.024245
		D	0.025098	0.024917	0.024772	0.024664	0.024583	0.02452
		E	0.025161	0.025064	0.024936	0.024827	0.02474	0.024669
	Parallel	B	0.024374	0.024227	0.024152	0.024107	0.024077	0.024056
		D	0.024684	0.024334	0.024169	0.024085	0.024041	0.024019
		E	0.024765	0.024306	0.02412	0.024044	0.024015	0.024004
10 A. Norte	Ortho	B	0.024312	0.024267	0.024233	0.024207	0.024186	0.024169
		D	0.024629	0.024556	0.024499	0.024453	0.024415	0.024384
		E	0.02479	0.02471	0.024644	0.024591	0.024546	0.024508
	Parallel	B	0.024093	0.024068	0.02405	0.024037	0.024027	0.02402
		D	0.024064	0.02403	0.024014	0.024006	0.024002	0.024001
		E	0.024029	0.024009	0.024003	0.024001	0.024	0.024
11 Caracas	Ortho	B	0.026381	0.025696	0.02531	0.025066	0.024898	0.024776
		D	0.027484	0.02692	0.026451	0.026104	0.025844	0.025643
		E	0.027629	0.027365	0.026963	0.026616	0.026336	0.02611
	Parallel	B	0.025238	0.024742	0.024493	0.024344	0.024248	0.024181
		D	0.026309	0.02512	0.024565	0.024284	0.024138	0.024065
		E	0.026624	0.025049	0.024413	0.024153	0.024052	0.024016

B: Unstable Pasquill - Gifford Stability Classification Factor
D: Neutral
E: Stable

Table 19.3-16 SOX (mg/m3) – 2015, Without Case

Distance (m)			0	10	20	30	40	50
1		B	0.025931	0.025342	0.025019	0.02482	0.024686	0.024589
Cr 7a	Ortho	D	0.026634	0.026242	0.025874	0.0256	0.025395	0.025239
		E	0.026619	0.026539	0.026244	0.025977	0.02576	0.025586
		B	0.025062	0.024611	0.024398	0.024275	0.024197	0.024143
	Parallel	D	0.026066	0.024977	0.024492	0.024248	0.024122	0.024058
		E	0.026442	0.024966	0.024384	0.024145	0.02405	0.024016
2		B	0.028563	0.027172	0.026408	0.025937	0.02562	0.025393
Sur	Ortho	D	0.030225	0.0293	0.02843	0.027782	0.027298	0.026927
		E	0.03019	0.030001	0.029304	0.028674	0.028161	0.027748
		B	0.026511	0.025444	0.02494	0.024651	0.024465	0.024339
	Parallel	D	0.028884	0.02631	0.025162	0.024585	0.024288	0.024136
		E	0.029772	0.026283	0.024908	0.024342	0.024119	0.024037
3		B	0.026	0.025	0.025	0.025	0.025	0.025
Cr 68a	Ortho	D	0.027	0.026	0.026	0.026	0.025	0.025
		E	0.027	0.027	0.026	0.026	0.026	0.026
		B	0.024757	0.024489	0.024337	0.02424	0.024175	0.024129
	Parallel	D	0.02524	0.024622	0.024314	0.024155	0.024073	0.024033
		E	0.02525	0.024499	0.024189	0.024066	0.024021	0.024006
4		B	0.025951	0.025436	0.025132	0.024934	0.024795	0.024692
Cr 68b	Ortho	D	0.02707	0.026557	0.026163	0.025871	0.02565	0.025478
		E	0.027349	0.027007	0.026645	0.026344	0.026102	0.025905
		B	0.02495	0.024595	0.024404	0.024286	0.024207	0.024152
	Parallel	D	0.025657	0.024822	0.024415	0.024207	0.024099	0.024046
		E	0.025771	0.02471	0.024275	0.024099	0.024032	0.02401
5		B	0.02435	0.02426	0.024206	0.02417	0.024145	0.024127
Calle 170b	Ortho	D	0.02456	0.024467	0.024396	0.024343	0.024303	0.024272
		E	0.024617	0.024551	0.024485	0.02443	0.024386	0.024351
		B	0.024167	0.024106	0.024072	0.024051	0.024037	0.024027
	Parallel	D	0.024286	0.024143	0.024072	0.024036	0.024017	0.024008
		E	0.0243	0.02412	0.024046	0.024016	0.024005	0.024002
6		B	0.026	0.025	0.025	0.025	0.025	0.024
Av Suba 1	Ortho	D	0.026	0.026	0.026	0.025	0.025	0.025
		E	0.026	0.026	0.026	0.026	0.025	0.025
		B	0.025	0.025	0.024	0.024	0.024	0.024
	Parallel	D	0.026	0.025	0.025	0.024	0.024	0.024
		E	0.027	0.025	0.024	0.024	0.024	0.024

B: Unstable　　Pasquill – Gifford Stability Classification Factor
D: Neutral
E: Stable

Table 19.3-16 SOX (mg/m3) - 2015, Without Case (continued)

Distance (m)			0	10	20	30	40	50
7		B	0.025339	0.024959	0.024742	0.024605	0.024511	0.024442
Av Suba 2	Ortho	D	0.025983	0.025659	0.025394	0.025198	0.025051	0.024937
		E	0.026081	0.025918	0.025688	0.025491	0.025332	0.025204
		B	0.024689	0.024416	0.024277	0.024194	0.02414	0.024102
	Parallel	D	0.025274	0.02462	0.024313	0.024157	0.024076	0.024036
		E	0.025435	0.024575	0.024226	0.024083	0.024028	0.024009
8		B	0.024495	0.024416	0.02436	0.024317	0.024283	0.024256
Caracas	Ortho	D	0.024975	0.024854	0.02476	0.024686	0.024625	0.024576
		E	0.025211	0.02508	0.024975	0.02489	0.024818	0.024759
		B	0.024161	0.024116	0.024085	0.024062	0.024046	0.024034
	Parallel	D	0.024135	0.024066	0.024031	0.024014	0.024006	0.024002
		E	0.024074	0.024025	0.024008	0.024002	0.024001	0.024
9		B	0.025985	0.025428	0.02511	0.024907	0.024766	0.024664
Caracas	Ortho	D	0.026974	0.026484	0.02609	0.025798	0.025579	0.025409
		E	0.027144	0.026881	0.026535	0.026241	0.026003	0.025811
		B	0.025012	0.024615	0.024411	0.024289	0.024208	0.024152
	Parallel	D	0.025854	0.024906	0.024458	0.024229	0.024111	0.024052
		E	0.026071	0.02483	0.024325	0.024119	0.02404	0.024012
10		B	0.024487	0.024416	0.024364	0.024323	0.02429	0.024264
A. Norte	Ortho	D	0.024983	0.024869	0.024779	0.024708	0.024649	0.0246
		E	0.025234	0.025109	0.025007	0.024923	0.024853	0.024793
		B	0.024146	0.024106	0.024078	0.024057	0.024043	0.024032
	Parallel	D	0.024099	0.024048	0.024022	0.024009	0.024004	0.024001
		E	0.024045	0.024014	0.024004	0.024001	0.024	0.024
11		B	0.026777	0.025979	0.025528	0.025243	0.025048	0.024906
Caracas	Ortho	D	0.028065	0.027406	0.02686	0.026455	0.026152	0.025917
		E	0.028233	0.027926	0.027457	0.027052	0.026726	0.026462
		B	0.025445	0.024866	0.024575	0.024402	0.024289	0.024211
	Parallel	D	0.026694	0.025306	0.02466	0.024331	0.024161	0.024075
		E	0.027061	0.025224	0.024482	0.024178	0.02406	0.024018

B: Unstable   Pasquill - Gifford Stability Classification Factor
D: Neutral
E: Stable

Table 19.3-17 Air Quality Prediction Summary

		Point	NOX (mg/m3)			
			2005-with	2005-w/o	2015-with	2015-w/o
1	1	Carrera septima	0.055	0.056	0.061	0.062
2	4	Avenida Quito	0.058	0.067	0.069	0.079
3	5	Avenida 68	0.054	0.058	0.058	0.064
4	6	Avenida 68	0.056	0.06	0.061	0.065
5	9	Avenida Suba	0.052	0.059	0.061	0.065
6	10	Avenida Suba	0.051	0.054	0.054	0.058
7	11	Avenida Caracas	0.05	0.051	0.051	0.053
8	13	Avenida Caracas	0.052	0.061	0.053	0.063
9	26	Avenida Caracas	0.049	0.051	0.05	0.053
10	27	Avenida Caracas	0.063	0.064	0.069	0.072

		Point	SOX (mg/m3)			
			2005-with	2005-w/o	2015-with	2015-w/o
1	1	Carrera septima	0.025	0.026	0.026	0.027
2	4	Avenida Quito	0.026	0.027	0.028	0.03
3	5	Avenida 68	0.025	0.026	0.026	0.027
4	6	Avenida 68	0.026	0.026	0.026	0.027
5	9	Avenida Suba	0.026	0.026	0.026	0.027
6	10	Avenida Suba	0.025	0.025	0.025	0.026
7	11	Avenida Caracas	0.025	0.025	0.025	0.025
8	13	Avenida Caracas	0.025	0.027	0.025	0.027
9	26	Avenida Caracas	0.024	0.032	0.025	0.025
10	27	Avenida Caracas	0.027	0.027	0.028	0.028

19.4. NOISE IMPACT PREDICTION

19.4.1. Objectives

The purpose of this analysis is to evaluate the sound pressure to be generated by the future traffic and transport condition along main routes such as Avenida Caracas and Quito, and try to find out suitable impact mitigation measures (e.g., noise barrier) within this project.

19.4.2. Numerical Parameters

The outline of this noise impact prediction is summarized in Table 19.4-1.

Table 19.4-1 Numerical Conditions

	Comments
Prediction Method	Use B-method defined in Acoustical Society of Japan.
Sections of concern	5 sections (2 for Caracas and 3 for Quito: i.e., Caracas 2, Caracas 4, Calle 100, Quito 2, and Quito 3). Note that the name of each section corresponds to that of the future traffic and transport demand forecast carried out within this study.
Target Year and Time to be examined	Peak time at day (7:00 a.m.) and night (6:00 a.m.), respectively. Peak time during the night (6:00 a.m., 4 %) is determined based on the results of 24-hour trip surveys conducted within Master Plan. Use the results of the future traffic and transport demand forecast (Year 2015 with/or without 3000 peso).
Power Level	$L_w = 65.1 + 20\log_{10} V + 10\log_{10}(a_1 + 7.9\,a_2)$ *1) where a_1 is ratio of small-sized vehicle, and a_2 is ratio of large-sized one. For 100 and 200-passenger bus; $L_w = 69.7 + 20\log_{10} V$ *2)
Simulation case	Following three cases are of concern; 1. WO (without operation at Year 2015). 2. WNB (with operation at Year 2015 but no noise barrier). 3. WB (with operation at Year 2015 and with noise barrier).
Evaluation point	Boundary between public and private property (H = 1.2, 3.5, 7.0 and 12 m, respectively).

*1) Master Plan Report [JICA, 1996], *2) 5th ASJ Acoustic Seminar [ASJ, 1996]

Table 19.4-2 summarizes the environmental standard concerned with the noise, implemented for Bogota City.

Table 19.4-2 Environmental Standard (Noise) for Bogota City

	Sound Pressure level (dBA)	
	Day Time (7:00-21:00)	Night Time (21:00-7:00)
Residential	65	45
Commercial	70	60
Industrial	75	75
Sites to be quiet.	45	45

19.4.3. RESULTS

(1) Daytime

Tables 19.4-3 to 19.4-5 summarize the sound pressure level at the receptor position (i.e., the boundary between public and private property, H = 1.2 m) for WO, WNB, and WB cases, respectively. In these results, the sound pressure component of each road section (i.e., the expressway, bus-lane viaduct, inside and outside local lane) are computed separately, and then, superimposed by following formula.

$$L_0 = 10\log(10^{L1/10} + 10^{L2/10} + \ldots + 10^{Ln/10}) \quad (1)$$

In WO case, it is found that predicted noise levels at all five points exceed the existing environmental standards of Bogota City. When the proposed busway and expressway are built, noise levels at Avenida Caracas tend to be decreased whereas those of Quito Expressway are increased. This is due to the following reasoning: the entire traffic condition of Caracas, in particular, that of local road will be organized due to this proposed busway project. Therefore, it is expected that entire roadside noise problem of Avenida Caracas will be improved by this proposed project.

New traffic volume is induced by the operation of the proposed expressway at Quito, and the entire roadside noise problem, in particular, that of local roads, tend to become worse.

Also, it can be said that noise contributions from both local road and trunk bus system are considerable, therefore, it would be difficult to alleviate the superimposed noise level at the receptor position to existing environmental standards even though certain amounts of noise impact reduction can be accomplished by the noise barrier installment. Figures 19.4-1 to 19.4-15 show the noise decay pattern for each road section.

(2) Night Time

Tables 19.4-6 to 19.4-8 summarize the sound pressure level at the receptor position (i.e., the boundary between public and private property, H = 1.2 m) for WO, WNB, and WB cases, respectively. Similarly, the sound pressure component of each road section (i.e., the expressway, bus-lane viaduct, inside and outside local lane) are computed separately, and then, superimposed by the formula described earlier in these results.

Due to the traffic volume decrease in nighttime, predicted noise levels at all five points are lower than those of daytime case. Similarly, it is found that noise levels at Avenida Caracas tend to be decreased whereas those of Quito Expressway are increased when proposed busway and the expressway are under operation. Figures 19.4-1 to 19.4-30 show the noise decay pattern for each result.

Table 19.4-3 Noise Impact (Year 2015, Without Case)

	Lane (inside)	Lane (outside)	Receptor @ Boundary
Caracas 2	66.7	74.1	74.8
Caracas 4	66.8	68.3	70.6
Calle 100	63.4	68.8	69.9
Quito 3	70.4	74.3	75.8
Quito 2	63.3	69.2	70.2

[dB A]

Table 19.4-4 Noise Impact, With Case (Year 2015, 3000 peso), Without Noise Barrier

	Local	Trunk	Express	Receptor @ Boundary
Caracas 2	72.2	65.2	70.1	74.8
Caracas 4	68.7	60.4	62.1	70.0
Calle 100	61.9 64.4	69.0	74.2	75.9
Quito 3	63.0 71.1	64.6	64.5	73.1
Quito 2	58.9 68.5	63.8	75.0	76.2

[dB A]

Table 19.4-5 Noise Impact, With Case (Year 2015, 3000 peso) – With Barrier

	Local	Trunk	Express	Receptor @ Boundary	Height of N/B [m]
Caracas 2	72.2	65.2	69.9	74.7	5.0
Caracas 4	68.7	60.4	57.6	69.6	5.0
Calle 100	61.9 64.4	69.0	71.8	74.4	8.0
Quito 3	63.0 71.1	64.6	60.2	72.8	1.6
Quito 2	58.9 68.5	63.8	66.2	71.6	6.0

[dB A]

Note the height of the noise barrier includes that of the bridge railing (H = 1 m).

Table 19.4-6 Noise Impact (Year 2015, Without Case) – Night Time

	Lane (inside)	Lane (outside)	Receptor @ Boundary
Caracas 2	63.4	70.5	71.2
Caracas 4	63.6	64.8	67.2
Calle 100	58.6	63.7	64.9
Quito 3	69.7	73.6	75.1
Quito 2	59.7	65.6	66.6

[dB A]

Table 19.4-7 Noise Impact With Case (Year 2015, 3000 peso) – Without Noise Barrier – Night Time

	Local	Trunk	Express	Receptor @ Boundary
Caracas 2	70.8	61.5	65.4	72.3
Caracas 4	64.4	55.3	56.1	65.5
Calle 100	56.7 58.9	62.9	71.5	72.4
Quito 3	62.5 67.6	61.0	61.3	70.1
Quito 2	53.7 64.8	60.2	72.3	73.2

[dB A]

Table 19.4-8 Noise Impact With Case (Year 2015, 3000 peso) – With Noise Barrier – Night time

	Local	Trunk	Express	Receptor @ Boundary	Height of N/B [m]
Caracas 2	70.8	61.5	60.3	71.6	5.0
Caracas 4	64.4	55.3	47.4	65.0	5.0
Calle 100	56.7 58.9	62.9	69.1	70.5	8.0
Quito 3	62.5 67.6	61.0	54.1	69.6	2.6
Quito 2	53.7 64.8	60.2	69.7	71.4	5.5

[dB A]

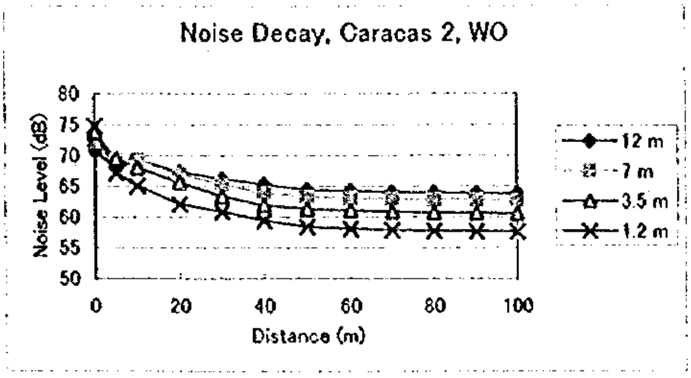

Figure 19.4-1 Noise Decay, Caracas 2, WO, Daytime

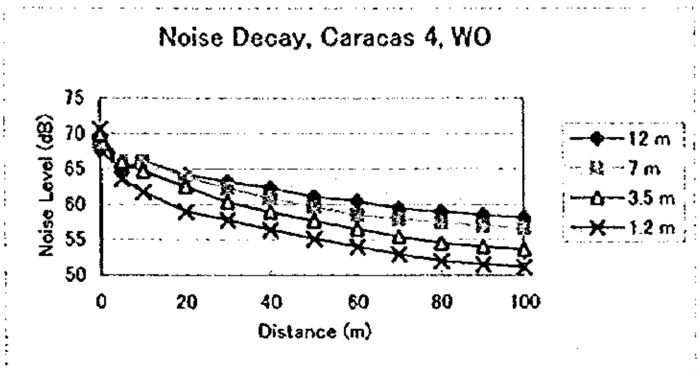

Figure 19.4-2 Noise Decay, Caracas 4, WO, Daytime

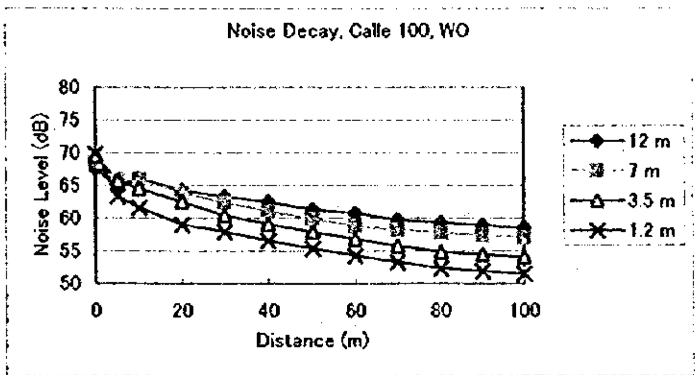

Figure 19.4-3 Noise Decay, Calle 100, WO, Daytime

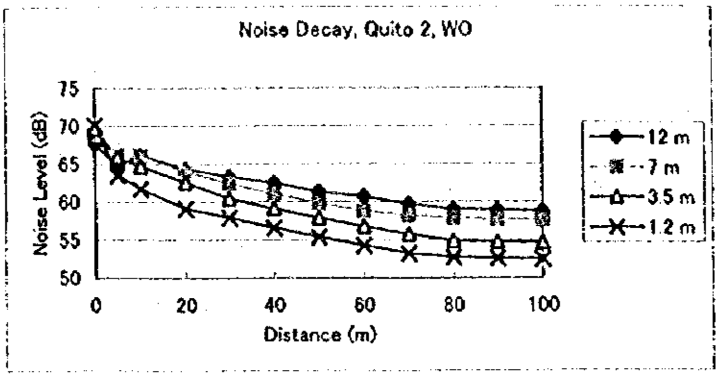

Figure 19.4-4 Noise Decay, Quito 2, WO, Daytime

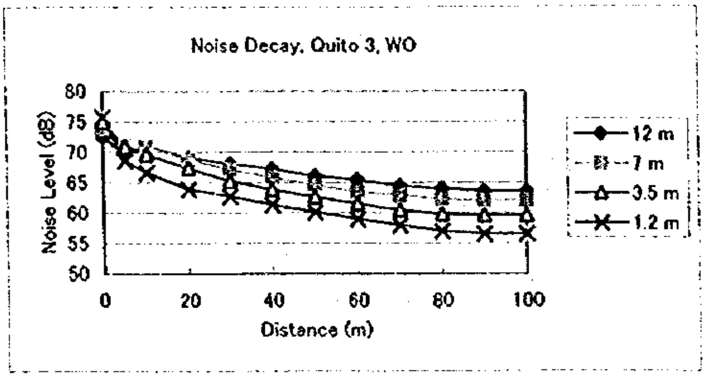

Figure 19.4-5 Noise Decay, Quito 3, WO, Daytime

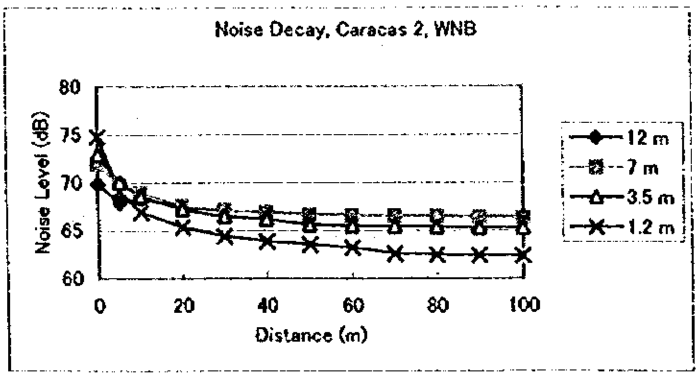

Figure 19.4-6 Noise Decay, Caracas 2, WNB, Daytime

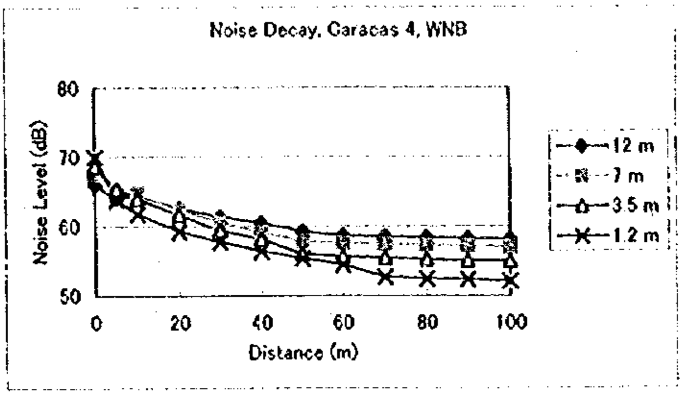

Figure 19.4-7 Noise Decay, Caracas 4, WNB, Daytime

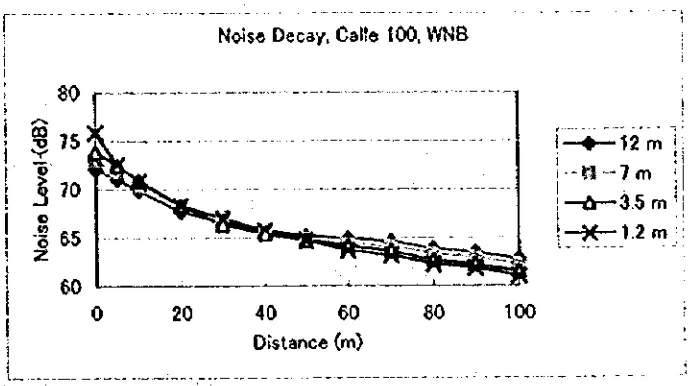

Figure 19.4-8 Noise Decay, Calle 100, WNB, Daytime

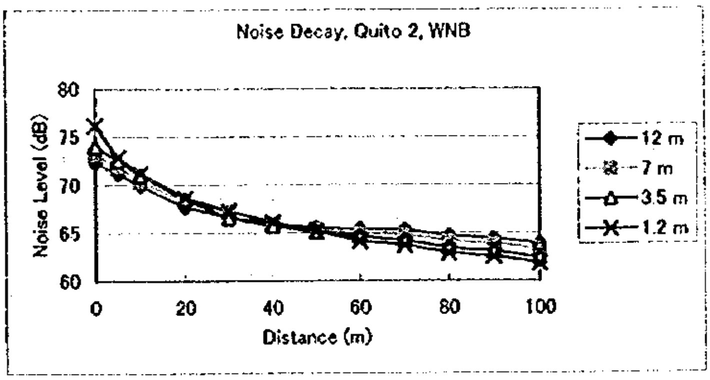

Figure 19.4-9 Noise Decay, Quito 2, WNB, Daytime

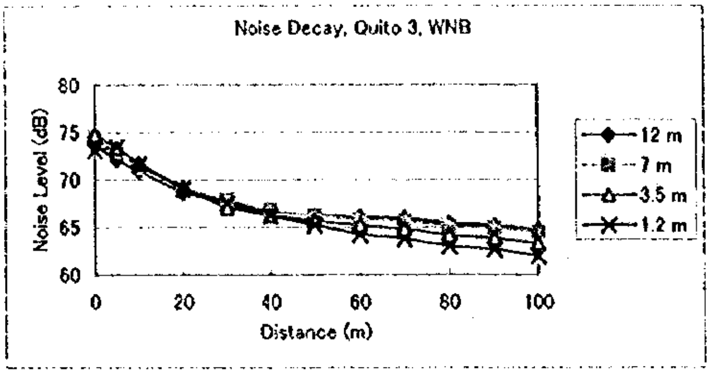

Figure 19.4-10 Noise Decay, Quito 3, WNB, Daytime

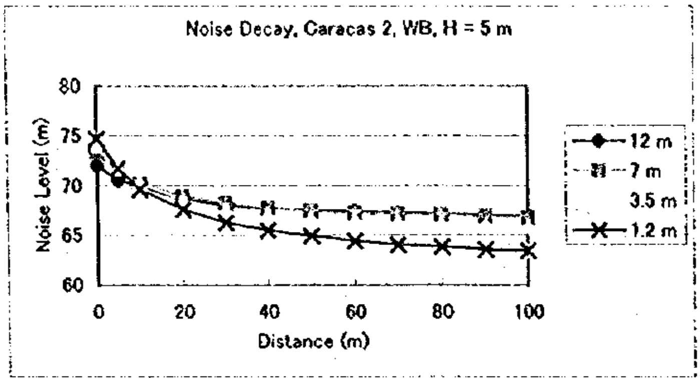

Figure 19.4-11 Noise Decay, Caracas 2, WB, H=5m, Daytime

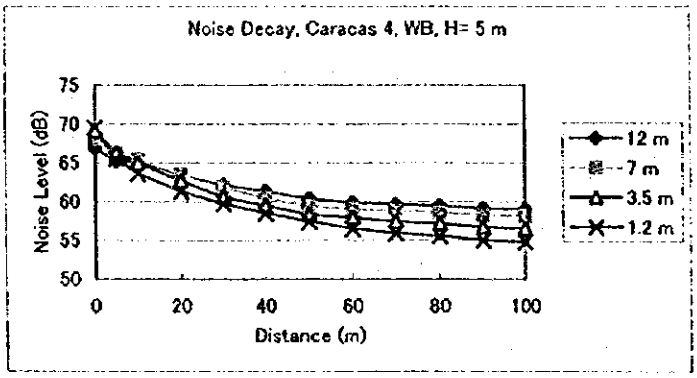

Figure 19.4-12 Noise Decay, Caracas 4, WB, H=5 m, Daytime

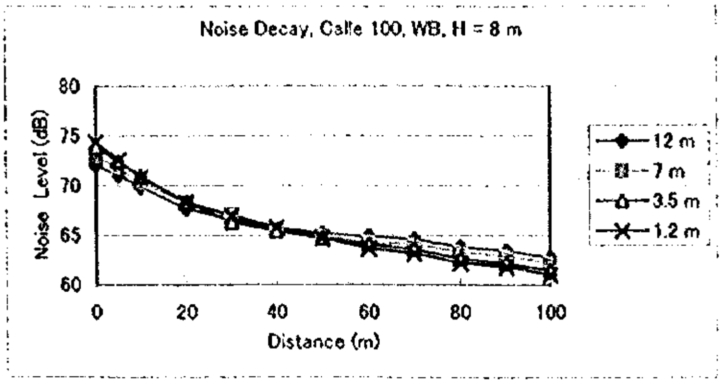

Figure 19.4-13 Noise Decay, Calle 100, WB, H=8 m, Daytime

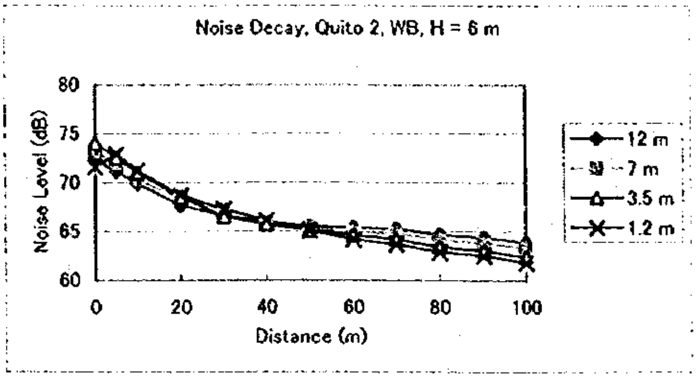

Figure 19.4-14 Noise Decay, Quito 2, WB, H=6 m

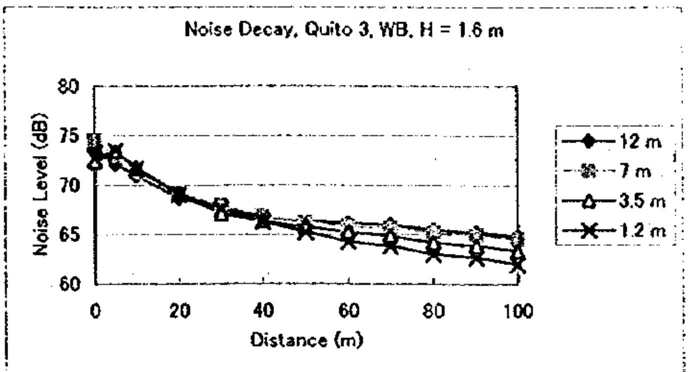

Figure 19.4-15 Noise Decay, Quito 3, WB, H=1.6 m, Daytime

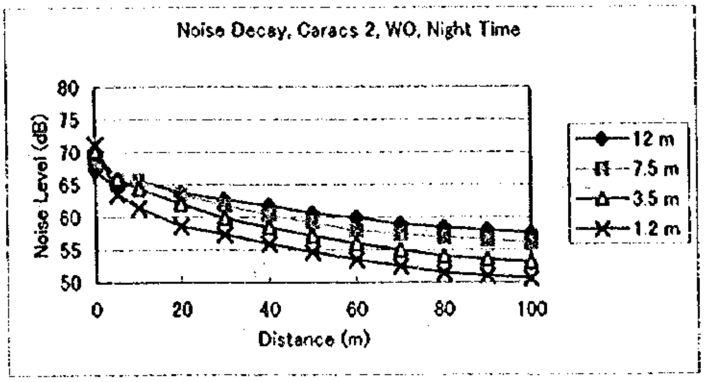

Figure 19.4-16 Noise Decay, Caracas 2, WO, Night Time

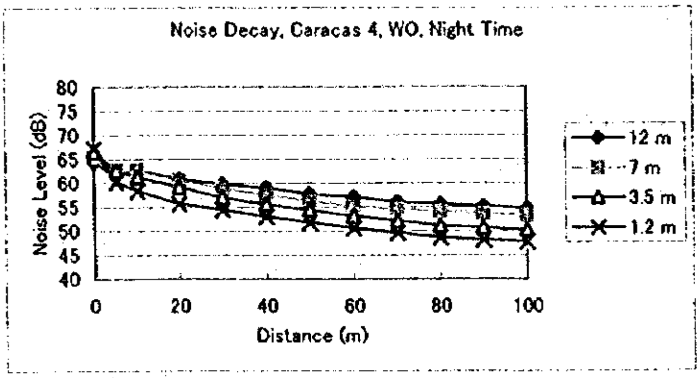

Figure 19.4-17 Noise Decay, Caracas 4, WO, Night time

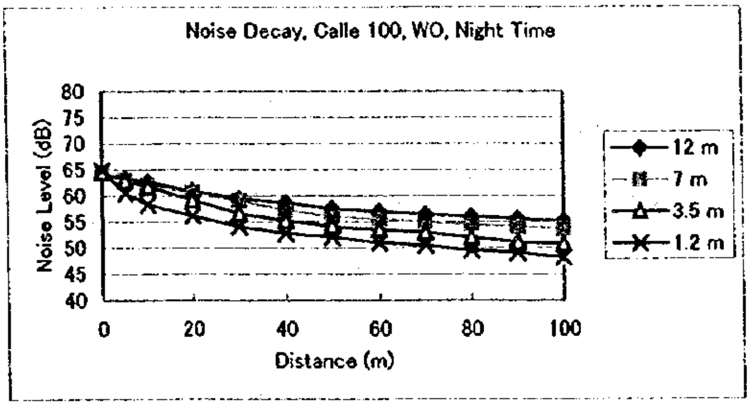

Figure 19.4-18 Noise Decay, Calle 100, WO, Night Time

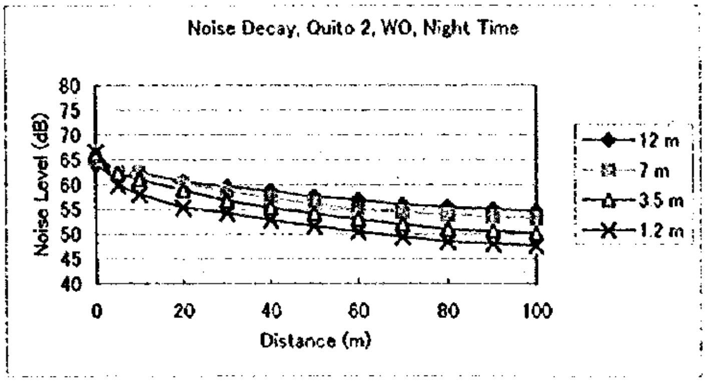

Figure 19.4-19 Noise Decay, Quito 2, WO, Night Time

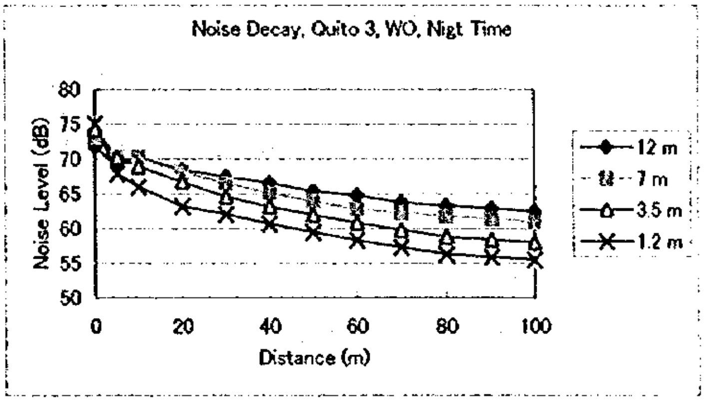

Figure 19.4-20 Noise Decay, Quito 3, WO, Night Time

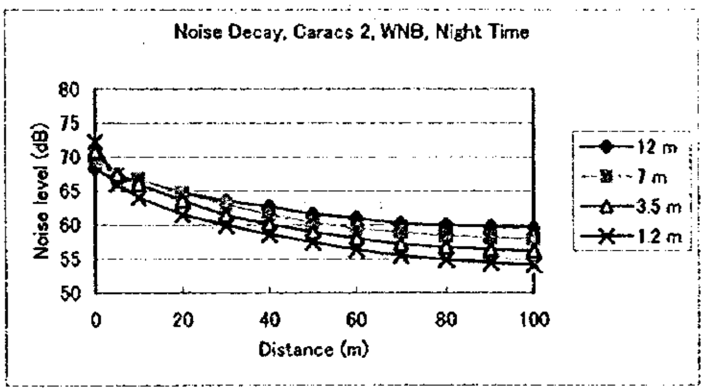

Figure 19.4-21 Noise Decay, Caracas 2, WNB, Night Time

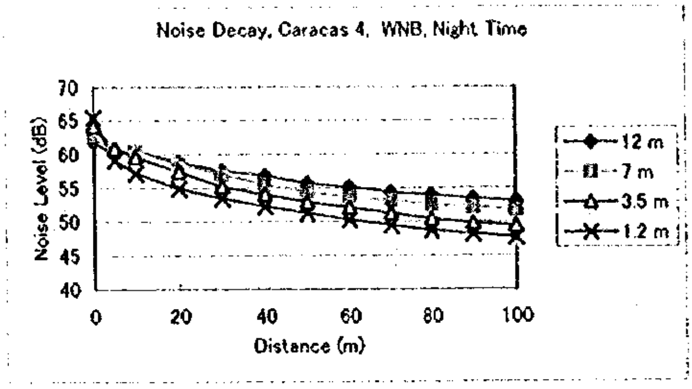

Figure 19.4-22 Noise Decay, Caracas 4, WNB, Night Time

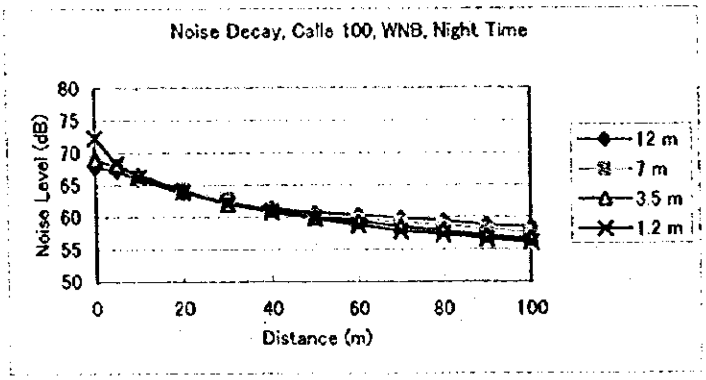

Figure 19.4-23 Noise Decay, Calle 100, WNB, Night Time

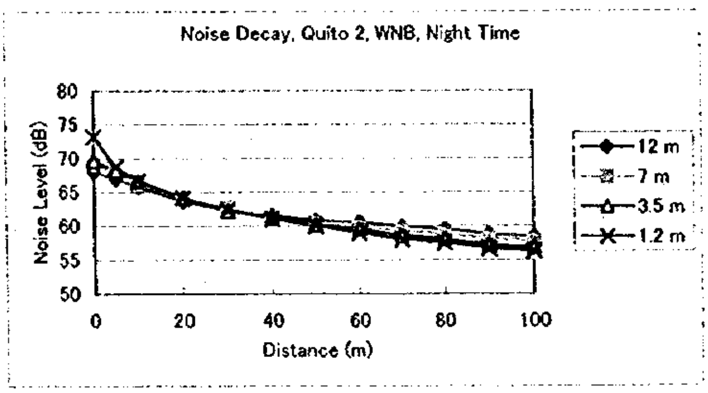

Figure 19.4-24 Noise Decay, Quito 2, WNB, Night Time

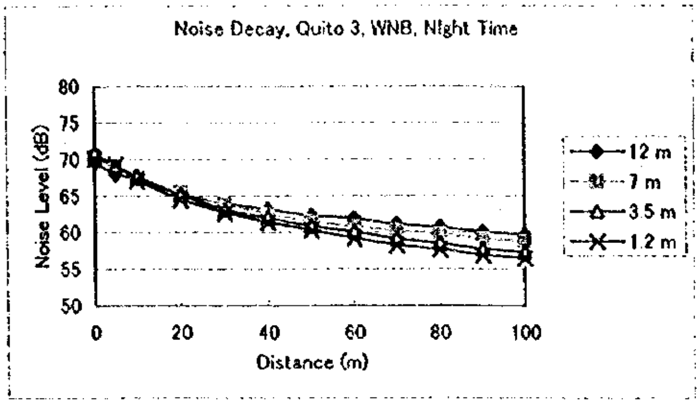

Figure 19.4-25 Noise Decay, Quito 3, WNB, Night Time

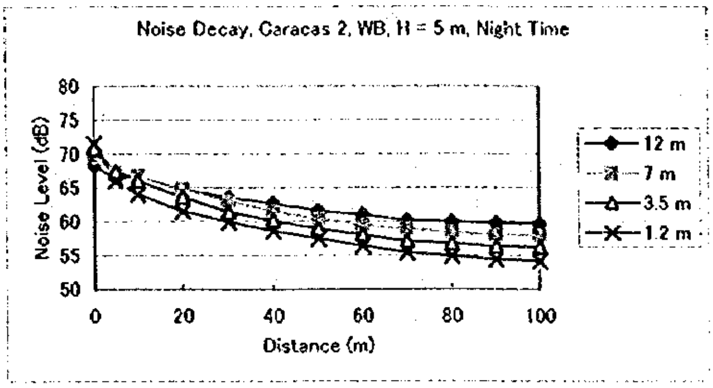

Figure 19.4-26 Caracas 2, WB, H=5 m, Night Time

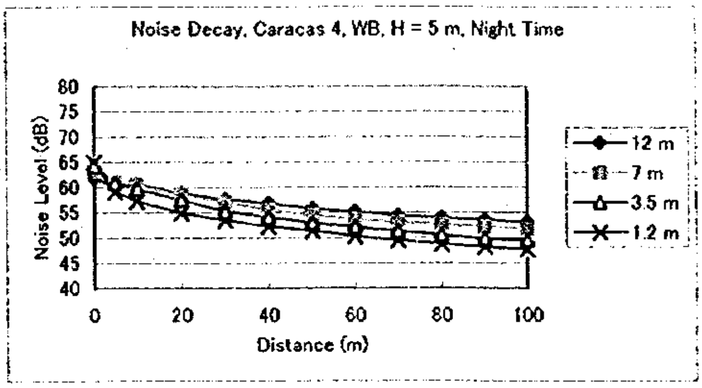

Figure 19.4-27 Noise Decay, Caracas 4, WB, H=5 m, Night Time

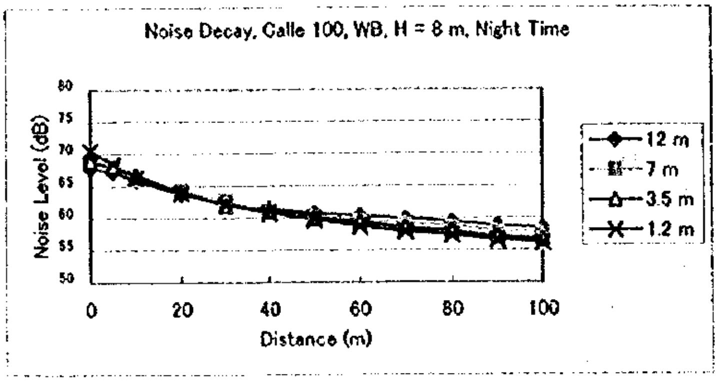

Figure 19.4-28 Noise Decay, Calle 100, H=8 m, Night Time

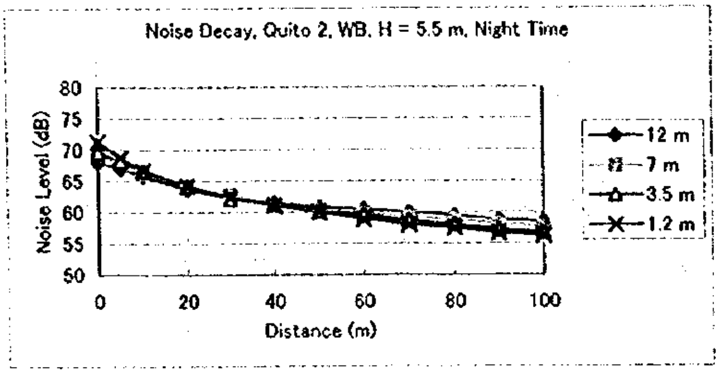

Figure 19.4-29 Noise Decay, Quito 2, WB, H=5.5 m, Night Time

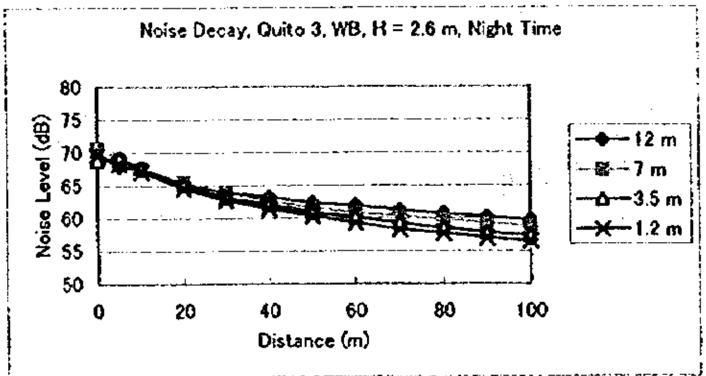

Figure 19.4-30 Noise Decay, Quito 3, WB, H=2.6 m, Night Time