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REPUBLIC OF GUATEMALA

MINISTERIO DE COMUNICACIONES,
TRANSPORTE Y OBRAS PUBLICAS

DIRECCION GENERAL DE
AERONAUTICA CIVIL

STUDY ON THE DEVELOPMENT PROJECT OF LA AURORA AND SANTA ELENA AIRPORTS

FINAL REPORT

VOLUME - II : APPENDICES

MARCH 1990

JAPAN INTERNATIONAL COOPERATION AGENCY

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GUATEMALA DEVELOPMENT OF LA AURORA AND SANTA ELENA AIRPORTS Vol. II JI

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APPENDIX - A

SELECTED DATA ON ECONOMICS AND TRANSPORTATION

List of Tables

Table A-01 Estimated Population

(1,000)

Department	1985	1988	1990	1995	2000	2005
TOTAL	7,963	8,631	9,197	10,621	12,222	13,931
Guatemala	1,696	1,854	1,963			
El Progreso	96	102	106			
Sacotepéquez	151	165	175			
Chimaltenango	289	316	334			
Escuiutla	454	496	526			
Santa Rosa	237	252	262			
Solola	201	220	235			
Totonicapán	251	273	289			
Quetzaltenango	473	513	543			
Suchitegéquez	308	334	352			
Retalhuleu	200	219	232			
San Marcos	593	645	682			
Huehuctenango	591	650	694			
Quiché	477	523	557			
Baja Verapáz	157	170	180			
Alta Verapáz	491	539	574			
Petén	182	215	240			
Izabal	270	297	316			
Zacapa	145	153	159			
Chiquimula	233	237	247			
Jalapa	165	177	186			
Jutiapa	313	322	347			

Source : Instituto Necional de Estadística

Table A-02 Gross Domestic Product
(Million of 1982 Quetzales)

	1980	1985	1986	1987	1988	(%)
Agriculture	1,958	1,933	1,917	1,986	2,045	(25.6)
Mining	38	17	22	22	22	(0.3)
Manufac. Industry	1,312	1,183	1,192	1,210	1,241	(15.5)
Construction	248	126	131	144	171	(2.1)
Electricity, gas, water	135	143	161	174	186	(2.3)
Transport, Communic.	547	534	536	560	587	(7.3)
Commerce	2,128	1,902	1,861	1,908	1,967	(24.6)
Banking, insurance	270	275	282	293	308	(3.9)
Housing	351	395	402	410	420	(5.3)
Public Adm., Defense	413	489	507	532	548	(6.9)
Private Services	479	478	474	481	498	(6.2)
TOTAL	7,879	7,475	7,485	7,720	7,993	(100.0)

Source : Banco de Guatemala

Table A-03 Value Added in Transportation Sector
(Million of 1982 Quetzales)

	1980	1985	1986	1987	(%)
Air Transport	22.8	15.1	14.4	18.1	(4.2)
Road Transport	364.4	332.4	328.2	337.0	(78.1)
Railway Transport	14.9	8.9	9.9	10.2	(2.4)
Maritime Transport	57.1	54.6	57.8	63.8	(14.8)
Travel Agency	2.5	1.6	1.8	2.2	(0.5)
Sub-Total	461.7	412.6	412.1	431.3	(100.0)
Storage	n.a	3.3	3.2	3.3	
Communications	n.a	118.4	121.0	125.5	
TOTAL	547.2	534.3	536.3	560.1	

Source : Banco de Guatemala

Table A-04 Export by Modes of Transport

(US$10 million)

	1980	1985	1986	1987	(%)
Export by Air	53.0	40.6	43.6	44.5	(4.6)
Export by Road	412.2	217.3	198.1	247.9	(25.3)
Export by Sea	1,007.6	733.7	827.7	694.9	(71.1)
Sub-Total	1,472.8	991.6	1,061.6	987.3	(101.0)
Adjust/discrepancy		68.1	-17.8	-9.4	(-1.0)
TOTAL		1,059.7	1,043.8	977.9	(100.0)

Source : Banco de Guatemala

Table A-05 Export Value

(US$10 million)

	1985	1986	1987	1988
Coffee	451.5	502.3	354.5	386.8
Cotton	73.1	24.3	16.2	36.9
Sugar	46.5	51.7	51.3	78.0
Banana	70.9	73.4	74.6	76.4
Meat	9.9	4.3	14.5	14.8
Cardamom	60.7	47.7	45.1	37.6
Petroleum	11.9	27.0	19.3	12.0
Chemical Products	24.1	20.9	24.5	n.a
Tobacco	13.1	10.6	11.3	n.a
Plant, seed, flower	10.4	9.1	11.3	n.a
Fruits	3.2	6.1	8.3	n.a
Vegetables	10.3	11.1	16.2	n.a
Others	66.3	70.0	100.2	194.5
Sub-Total	851.9	858.5	747.3	837.0
Export to Central America	207.8	185.3	230.6	236.4
TOTAL	1,059.7	1,043.8	977.9	1,073.4

Source : Banco de Guatemala

Table A-06 Tourists/Visitors by Origine

(1,000 Persons)

	1980	1985	1986	1987	(%)
USA, Canada	90.0	57.8	71.6	90.6	(25.7)
Mexico	68.8	23.5	25.7	31.4	(8.9)
El Salvador	152.9	79.4	75.5	88.6	(25.1)
Other Central America	59.8	36.5	49.1	60.5	(17.1)
South America & Caribbean	20.9	14.2	17.3	18.2	(5.2)
Europe	64.7	33.2	39.0	53.2	(15.1)
Other countries	9.0	7.4	9.2	10.2	(2.9)
TOTAL	466.1	252.0	287.4	352.7	(100.0)

Source: Instituto Guatemalteco de Turismo

Table A-07 Annual Commercial Flight Operations at La Aurora (Landing and Take-off)

	1982	1983	1984	1985	1986	1987
[Mixed Flight]						
AVIATECA	2,266	151	1,024	1,081	1,148	1,310
PAN AM	1,432	1,458	1,323	668	992	2,568
TACA	1,754	1,380	1,286	1,431	1,822	2,500
SAHSA	752	758	683	622	660	670
COPA	720	726	724	722	746	724
LACSA	314	36	570	693	568	820
MEXICANA	664	1,318	1,458	1,486	1,458	1,466
IBERIA	206	205	207	212	210	212
KLM	102	100	104	108	100	162
SAM	224	336	336	306	312	338
EASTERN	-	-	-	267	718	728
AIR FLORIDA	452	586	258	-	-	-
AERONIICA	-	-	-	-	12	50
(Sub-Total)	8,886	7,054	7,973	7,596	8,746	11,548
[Cargo Flight]						
AVIATECA	164	140	174	172	158	274
PAN AM	84	-	-	6	-	-
TACA	198	89	-	10	22	42
SAHSA	82	68	36	31	-	8
COPA	34	-	-	-	-	18
LACSA	-	57	22	-	-	-
IBERIA	-	2	-	-	-	-
(Sub-Total)	562	356	232	219	180	342
TOTAL	9,448	7,410	8,205	7,815	8,926	11,890

Source: DGAC

Table A-08 Monthly Commercial Flight Operations at La Aurora
(Landing and Take-off in 1987)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
[Mixed Flight]													
AVIATECA	118	96	102	111	101	101	126	108	68	124	122	126	1,303
PAN AM	218	202	223	221	230	217	228	230	212	226	180	178	2,565
TACA	178	184	215	198	218	207	214	214	214	230	222	204	2,498
SASHA	62	54	60	53	57	60	58	58	48	56	52	50	668
COPA	62	66	55	52	62	59	62	58	60	62	64	60	722
LACSA	66	34	30	44	45	72	90	70	72	68	90	138	819
MEXICANA	126	112	124	120	124	119	126	124	120	128	118	124	1,465
IBERIA	16	16	18	20	18	16	18	18	16	22	16	18	212
KLM	8	8	10	8	10	14	18	18	16	16	18	18	162
SAM	28	24	26	25	26	26	28	26	26	26	36	40	337
EASTERN	62	56	62	57	62	60	62	62	60	62	60	62	727
AERONICA	-	-	-	-	-	-	-	-	-	-	22	28	50
Total	944	852	925	909	953	951	1,030	986	912	1,020	1,000	1,046	11,528 /1

Note: /1 Not coincide with Table A-07

Source: DGAC-MCTPW, Estadísticas de Transporte de Guatemala

Table A-09 Annual International Passengers at La Aurora
(Entry and Departure)

	1982	1983	1984	1985	1986	1987	1988
AVIATECA	100,247	93,023	94,090	92,476	81,127	96,712	114,104
PAN AM	120,825	124,741	111,541	63,182	80,037	148,879	165,845
TACA	52,591	41,833	40,666	52,841	88,935	83,639	81,951
SAHSA	29,151	29,912	29,997	29,321	26,903	28,278	33,098
COPA	35,460	33,200	41,351	33,137	31,969	37,285	41,352
LACSA	6,096	1,028	18,116	23,076	19,888	20,997	32,410
MEXICANA	26,078	49,226	60,777	83,877	75,955	68,211	79,099
IBERIA	12,882	14,697	18,904	18,412	19,120	18,087	24,625
KLM	4,509	4,288	6,070	5,520	7,133	12,358	18,352
SAM	7,455	10,819	10,870	12,390	10,067	11,356	20,533
AIR FLORIDA	20,156	23,451	13,134	-	-	-	-
EASTERN	-	-	-	14,554	58,837	73,569	73,606
CONTINENTAL	-	-	-	-	-	-	28,588
AERONICA	-	-	-	-	-	1,183	15,279
AEROQUETZAL	-	-	-	-	-	-	1,999
TOTAL	415,450	426,218	445,516	428,786	499,998	600,554	730,841

Source: DGAC

Table A-10 International Passengers at La Aurora

	1987			1988		
	Entry	Departure	Total	Entry	Departure	Total
AVIATECA	46,328	50,384	96,712	57,241	56,863	114,104
PAN AM	77,781	71,098	148,879	83,122	82,723	165,845
TACA	41,550	42,089	83,639	41,131	40,820	81,951
SAHSA	14,691	13,587	28,278	17,969	15,129	33,098
COPA	21,585	15,700	37,285	26,250	15,102	41,352
LACSA	11,568	9,429	20,997	17,390	15,020	32,410
MEXICANA	33,474	34,737	68,211	38,583	40,516	79,099
IBERIA	9,408	8,679	18,087	14,350	10,275	24,625
KLM	6,045	6,313	12,358	9,230	9,122	18,352
SAM	5,923	5,433	11,356	11,896	8,637	20,533
EASTERN	35,895	37,674	73,569	35,658	37,948	73,606
CONTINENTAL	-	-	-	14,204	14,384	28,588
AERONICA	892	291	1,183	12,363	2,916	15,279
AEROQUETZAL	-	-	-	966	1,033	1,999
Total	305,140	295,414	600,554	380,353	350,488	730,841
Chartered			1,309			1,802
TOTAL			601,863			732,644

Source: DGAC

Table A-11 Monthly International Passengers at La Aurora

	1987	1988	1989
January	48,712	61,429	74,240
February	37,731	48,420	54,151
March	41,083	58,029	69,736
April	49,851	56,696	63,339
May	42,241	49,723	59,027
June	46,434	57,375	66,659
July	55,349	71,328	80,510
August	57,800	68,200	77,082
September	44,869	53,219	
October	49,446	58,906	
November	63,741	70,652	
December	64,606	78,667	
TOTAL	601,863	732,644	

Source: DGAC

Table A-12 International Air Passenger at La Aurora by Air Routes

Year Route	1982	1983	1984	1985	1986	1987	1988
North America/Mexicc	273,153	277,362	275,703	257,538	320,305	392,451	474,843
New York	5,395	1,887	1,076	443	373	6,260	12,289
Miami	144,191	145,632	148,830	141,683	170,313	198,700	222,016
San Francisco	192	n.a.	n.a.	n.a.	764	5,750	4,330
Los Angeles	29,614	40,986	40,116	50,452	71,028	88,242	109,750
New Orleans	21,669	22,698	32,080	8,994	8,274	9,127	3,651
Houston	19,190	5,500	10,213	19,826	23,305	23,614	49,593
Mexico	46,890	57,415	43,788	36,140	46,226	60,758	71,215
Merida/Cancun	6,012	3,244	-	-	-	-	-
Central America	122,122	127,871	142,217	145,913	150,846	172,781	204,153
El Salvador	40,125	44,035	48,096	54,732	56,771	62,338	69,832
San Pedro Sula	1,543	3,134	3,190	1,477	2,059	5,090	8,308
Tegucigalpa	28,763	26,342	26,447	27,671	24,727	23,188	25,064
Managua	10,914	9,477	15,715	10,272	11,318	19,049	36,978
San Jose	24,828	29,015	32,084	35,077	37,854	45,922	48,126
Panama	15,551	15,447	16,498	16,483	17,474	16,442	15,804
Belize	398	421	187	201	643	752	41
Caribbean	4,141	3,738	1,475	3,823	6,150	8,993	15,178
Santo Domingo	848	1,355	1,024	1,342	1,605	2,106	5,765
Puerto Rico	-	-	-	-	713	48	-
Curacao	128	173	202	132	468	1,481	2,233
Aruba	120	78	230	16	-	-	-
San Andries	3,045	2,132	19	2,333	3,364	5,358	7,180
South America	3,485	4,533	5,591	4,560	4,441	4,094	7,296
Bogota	3,141	4,297	5,393	4,548	4,441	4,094	7,296
Caracas	344	236	198	12	-	-	-
Europe	12,549	12,718	20,530	16,952	18,278	22,232	29,371
Madrid	8,739	9,013	13,774	11,904	11,622	11,355	14,046
Amsterdam	3,609	3,597	6,473	5,020	6,656	10,877	15,325
Lisbon	201	108	283	28	-	-	-
TOTAL	415,450	426,222	445,516	428,786	499,998	600,554	730,841

Source: DGAC

Table A-13 Origin and Destination of Passengers at La Aurora (1988)

	NYC	MIA	SFO	LAX	MSY	IAH	MEX	SAL	SAP	TGU	MGA	SJO	PTY	BZE	SDQ	CUR	ADZ	BOG	MAD	AMS	CUN	TOTAL
AVIATECA	-	50,620	-	18,438	3,617	21,154	20,197	42	-	-	-	36	-	-	-	-	-	-	-	-	-	114,104
PAN AM	-	97,660	4,330	57,650	-	-	-	6,187	-	-	-	12	-	6	-	-	-	-	-	-	-	165,845
TACA	-	130	-	21,870	34	14	-	59,226	-	240	-	292	113	32	-	-	-	-	-	-	-	81,951
SASHA	-	-	-	-	-	-	-	-	8,308	24,790	-	-	-	-	-	-	-	-	-	-	-	33,098
COPA	-	-	-	-	-	-	-	4,214	-	34	21,699	5,319	10,083	3	-	-	-	-	-	-	-	41,352
LACSA	12,289	-	-	8,039	-	-	-	-	-	-	-	12,082	-	-	-	-	-	-	-	-	-	32,410
MEXICANA	-	-	-	3,753	-	-	51,018	-	-	-	-	24,328	-	-	-	-	-	-	-	-	-	79,099
IBERIA	-	-	-	-	-	-	-	-	-	-	-	-	4,814	-	5,765	-	-	-	14,046	-	-	24,625
KLM	-	-	-	-	-	-	-	-	-	-	-	-	794	-	-	2,233	-	-	-	15,325	-	18,352
SAM	-	-	-	-	-	-	-	-	-	-	-	6,057	-	-	-	-	7,180	7,296	-	-	-	20,533
EASTERN	-	73,606	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	73,606
CONTINENTAL	-	-	-	-	-	28,425	-	163	-	-	-	-	-	-	-	-	-	-	-	-	-	28,588
AERONICA	-	-	-	-	-	-	-	-	-	-	15,279	-	-	-	-	-	-	-	-	-	-	15,279
AEROQUETZAL	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,999	1,999
Total	12,289	222,016	4,330	109,750	3,651	49,593	71,215	69,832	8,308	25,064	36,978	48,126	15,804	41	5,765	2,233	7,180	7,296	14,046	15,325	1,999	730,841

Source: DGAC

Table A-14 Cargo Traffic at La Aurora

(tons)

	1981	1982	1983	1984	1985	1986	1987
[Export]							
Mixed flights	3,584	3,641	5,323	9,414	8,214	6,215	11,517
Cargo flights	4,727	4,106	2,185	2,056	2,452	1,908	3,816
Total	8,311	7,747	7,508	11,470	10,666	8,123	15,333
[Import]							
Mixed flights	3,637	2,501	4,543	5,126	3,320	3,242	4,881
Cargo flights	4,904	3,808	2,152	2,425	2,175	1,838	3,348
Total	8,541	6,309	6,695	7,551	5,495	5,080	8,229
[Total]	16,852	14,056	14,203	19,021	16,161	13,203	23,562

Source: DGAC

Table A-15 International Cargo at La Aurora in 1987

(tons)

	Export	Import	Total
[Mixed Flight]			
AVIATECA	2,621.4	673.0	3,294.4
PAN AM	2,570.4	1,743.4	4,313.8
TACA	1,556.2	185.3	1,741.5
SAHSA	449.1	359.0	808.1
COPA	164.8	21.8	186.6
LACSA	177.9	60.3	238.2
MEXICANA	470.1	310.5	780.6
IBERIA	1,658.9	1,173.7	2,832.6
KLM	1,076.4	309.4	1,385.8
SAM	19.2	-	19.2
EASTERN	752.7	44.6	797.3
(Sub-Total)	11,517.1	4,881.0	16,398.1
[Cargo Flight]			
AVIATECA	3,472.9	3,122.0	6,594.9
TACA	252.0	150.7	402.7
SAHSA	37.0	36.0	73.0
COPA	53.7	39.6	93.3
(Sub-Total)	3,815.6	3,348.3	7,163.9
TOTAL	15,332.7	8,229.3	23,562.0

Source: DGAC

Table A-16 Road Length by Department

(km)

Department	Total	Highways	National Road	Departmental Road	Rural Road
Guatemala	749	121	110	475	43
El Progreso	322	127	90	99	6
Sacatepéquez	159	24	66	69	-
Chimaltenango	524	55	81	243	145
Escuintla	825	180	11	634	-
Santa Rosa	626	91	53	482	-
Sololá	289	54	96	129	10
Totonicapán	367	58	47	103	159
Quetzaltenango	485	60	102	202	121
Suchitepéquez	549	66	30	453	-
Retalhuleu	259	28	68	163	-
San Marcos	868	53	297	369	149
Huehuetenango	922	96	244	303	278
Quiché	695	8	159	373	156
Baja Verapáz	360	53	131	169	7
Alta Verapáz	947	41	226	680	-
Petén	895	164	-	731	-
Izabal	348	196	44	108	-
Zacapa	504	110	25	369	-
Chiquimula	639	144	32	463	-
Jalapa	416	-	153	96	167
Jutiapa	688	145	52	482	9
TOTAL	12,436	1,874	2,117	7,195	1,250

Source: Dirección General de Caminos

Table A-17 Highway Traffic (1987)

Section		Highway Length (km)	Traffic Counted Length (km)	Estimated Traffic (1,000 vehicle-km)
(Pan American Highway)				
CA-1	Occidente	343.5	310.3	144,625
CA-1	Oriente	175.2	158.7	117,894
(Central American Highway)			175.2	
CA-2	Occidente	239.7	54.3	45,898
CA-2	Central		114.0	154,069
CA-2	Oriente	110.3	58.0	26,843
CA-8		49.5	28.0	8,743
CA-9	Norte	312.0	212.3	181,013
CA-9	Sur	125.0	81.8	114,461
CA-10		101.0	86.0	43,589
CA-12		21.7		
CA-13		71.8	68.2	9,074
CA-14		131.1	45.0	19,349
CA-17		18.4		
	Total	1,699.2	1,216.6	865,558

Source: Dirección General de Caminos

Table A-18 Cargo Transport by Railway

(tons)

	1980	1985	1986	1987
Cargo Transport	678	505	588	582
O/D				
Pto. Barrios - Bananera				292
Bananera - Zacapa				11
Zacapa - El Rancho				1
El Raucho - Guatemala				16
Guatemala - Escuintla				128
Escuintla - Mazatenango				73
Mazatenango - Tecún U.				61

Source: MCTPW, Estadísticas de Transporte

Table A-19 Marine Transport in 1987

(1,000 tons)

	Puerto de Castilla	Puerto Barrios	Puerto Quetzal	Puerto Champerico
EXPORT:				
Coffee	184.2	-	15.0	-
Sugar	-	5.5	304.3	-
Banana	382.5	1.6	-	
Cotton	-	-	-	12.9
Oil, gas	186.0	-	-	-
Fuel	-	0.3	-	-
Molasses	-	-	-	-
Others	337.5	6.5	14.4	-
Total	(1,090.2)	(13.9)	(333.7)	(12.9)
IMPORT:				
Fertilizer/pesticide	93.0	-	243.5	-
Diesel, lubricant	156.0	6.8	-	-
Gasoline	91.2	-	-	-
Paper products	117.0	-	-	-
Wheat	-	39.5	-	-
Metal products	-	-	63.9	-
Others	945.8	10.3	56.3	0.7
Total	(1,403.0)	(56.6)	(363.7)	(0.7)

Source: MCTPW, Estadísticas de Transporte

Table A-20 Price Index

	1983	1984	1985	1986	1987	1988
Consumers Price in the Republic						
Index	105.2	108.8	129.1	176.8	198.6	220.1
(Inflation Rate %)		(3.4)	(18.7)	(36.9)	(12.3)	(10.8)
Consumers Price in Guatemala City						
Index	106.1	107.4	128.0	169.9	188.4	207.8
(Inflation Rate %)		(1.2)	(19.2)	(32.7)	(10.8)	(10.8)
Transport & Communic.						
Index	102.6	105.7	123.4	173.3	178.8	
(Inflation Rate %)		(3.0)	(16.7)	(40.4)	(3.2)	
Local Construction Materials						
(Inflation Rate %)	(-0.2)	(5.0)	(8.4)	(28.0)		

Note: Mar. - Apr. 1983 = 100
Source: Banco de Guatemala & Instituto Nacional de Estadística

APPENDIX - B

METEOROLOGICAL DATA

List of Tables

Table B-01 Temperature at La Aurora

(°C)

YEAR	ITEM \ MONTH	1	2	3	4	5	6	7	8	9	10	11	12
'78	Monthly Average	16.0	17.2	19.1	20.2	21.9	19.3	19.*	19.8	18.4	18.6	18.3	17.8
	Average Minimum	11.9	12.2	14.0	15.4	16.0	16.2	15.4	16.0	15.3	15.2	14.8	13.7
	Absolute Minimum	4.0	6.3	10.2	11.3	12.9	15.0	14.2	14.6	13.8	11.0	12.7	10.0
	Average Maximum	22.4	25.1	26.5	27.5	27.1	24.9	23.9	24.9	23.8	23.7	23.5	23.2
	Absolute Maximum	25.8	29.9	31.1	30.2	29.5	27.6	26.6	26.7	26.0	26.0	26.6	26.5
'79	Monthly Average	16.9	17.4	18.9	20.1	19.8	19.1	19.4	18.9	18.2	19.2	17.5	16.4
	Average Minimum	12.4	13.2	14.6	15.8	16.2	16.2	16.0	15.9	16.0	15.9	13.8	13.2
	Absolute Minimum	10.5	9.5	11.8	13.0	14.1	14.3	14.0	13.8	14.1	14.4	11.4	9.2
	Average Maximum	23.3	24.1	25.5	26.9	25.7	24.2	24.9	23.8	23.0	24.1	22.9	22.7
	Absolute Maximum	27.0	28.1	28.5	29.0	28.5	27.4	27.4	26.5	25.2	26.2	28.5	26.0
'80	Monthly Average	17.9	17.5	19.8	19.9	21.4	19.8	19.7	19.3	19.1	19.0	18.0	16.1
	Average Minimum	13.3	13.1	14.4	15.8	17.3	16.7	16.3	16.0	16.2	15.9	14.2	12.3
	Absolute Minimum	10.0	9.2	9.8	13.3	15.5	15.0	15.5	14.6	15.0	13.8	10.8	7.4
	Average Maximum	24.4	24.1	27.3	27.2	28.4	24.7	25.0	24.7	24.2	24.0	23.6	21.6
	Absolute Maximum	28.5	28.2	31.5	31.0	31.2	28.5	28.2	28.2	24.4	24.4	28.0	25.4
'81	Monthly Average	15.8	17.6	19.8	20.0	20.8	19.1	19.2	19.2	19.3	18.7	17.2	17.7
	Average Minimum	11.2	13.0	14.9	15.6	16.6	16.4	16.2	16.2	16.2	15.9	13.2	13.6
	Absolute Minimum	8.4	10.0	11.0	11.9	14.4	14.8	15.4	15.2	15.2	14.0	11.0	10.3
	Average Maximum	22.4	24.0	27.0	26.7	27.4	24.1	24.1	24.3	24.6	23.5	22.5	23.2
	Absolute Maximum	25.7	28.6	30.6	30.0	30.2	27.4	26.0	27.4	26.0	25.6	25.7	27.8
'82	Monthly Average	17.8	18.8	19.5	20.6	20.4	19.6	18.9	19.4	18.6	18.2	18.1	17.4
	Average Minimum	13.2	14.0	14.6	15.7	16.6	16.4	15.7	15.7	15.8	15.1	14.1	13.3
	Absolute Minimum	10.9	12.2	12.2	13.8	14.8	15.0	14.8	14.0	14.6	11.8	11.4	9.6
	Average Maximum	23.8	24.6	26.4	27.8	26.5	24.7	23.6	24.4	22.8	22.6	23.4	23.2
	Absolute Maximum	27.6	27.0	30.8	31.4	30.4	29.2	25.6	26.2	25.6	25.7	26.6	27.7
'83	Monthly Average	17.2	18.1	19.1	20.8	22.0	20.1	19.6	19.6	19.1	18.9	18.7	17.7
	Average Minimum	12.9	13.7	14.1	16.4	17.3	16.7	16.4	16.2	15.8	15.3	15.0	13.3
	Absolute Minimum	8.0	9.5	9.8	13.4	14.2	15.0	14.8	15.0	14.4	12.2	13.4	8.6
	Average Maximum	23.2	24.3	25.6	27.0	28.9	25.8	24.5	24.6	24.4	23.7	24.0	23.1
	Absolute Maximum	28.7	27.2	28.6	29.8	31.4	28.2	26.4	27.2	26.4	25.6	28.2	26.8

(Cont'd) (°C)

YEAR	ITEM \ MONTH	1	2	3	4	5	6	7	8	9	10	11	12
´84	Monthly Average	16.4	17.6	18.9	19.8	18.8	18.8	18.2	18.6	17.8	18.6	16.8	16.5
	Average Minimum	12.5	13.3	13.8	15.0	15.5	15.7	15.2	15.2	15.1	15.1	12.6	12.6
	Absolute Minimum	7.4	7.7	8.4	11.3	14.5	14.6	14.2	13.4	14.4	13.2	9.0	9.5
	Average Maximum	21.6	23.8	25.6	26.9	24.4	23.9	22.8	23.3	22.5	23.4	22.1	21.2
	Absolute Maximum	24.8	27.5	28.6	29.6	29.2	25.4	24.8	24.4	24.8	25.6	25.0	24.5
´85	Monthly Average	15.9	17.0	18.6	19.8	19.9	19.0	19.0	19.2	19.4	18.9	18.0	17.7
	Average Minimum	11.7	12.7	14.2	14.8	16.0	16.0	15.7	16.0	16.0	16.0	14.6	13.8
	Absolute Minimum	8.0	9.2	11.6	10.0	13.3	14.3	14.2	14.6	15.2	14.0	12.9	11.6
	Average Maximum	21.8	22.9	24.9	26.4	26.4	24.2	24.3	24.4	24.3	24.1	22.9	22.9
	Absolute Maximum	25.8	26.0	29.0	29.0	28.7	26.5	26.2	26.2	27.0	25.9	28.7	26.9
´86	Monthly Average	16.4	18.2	17.6	19.8	20.2	19.9	19.4	17.6	17.2	18.3	18.1	19.1
	Average Minimum	12.0	13.0	12.3	13.8	14.9	14.9	14.8	14.0	14.0	13.9	13.2	13.1
	Absolute Minimum	6.0	10.4	8.0	11.6	11.8	12.6	13.0	12.0	12.9	11.0	12.0	9.6
	Average Maximum	22.4	25.4	24.7	27.8	26.6	25.1	24.0	24.8	23.7	24.3	23.9	24.0
	Absolute Maximum	26.0	28.1	28.9	31.6	30.3	30.5	25.9	26.5	26.0	27.1	26.9	27.0
´87	Monthly Average	15.8	17.5	20.0	21.7	21.5	21.2	18.8	19.2	19.4	18.1	18.3	18.1
	Average Minimum	10.6	12.3	14.4	15.7	16.8	18.0	15.8	15.8	16.2	14.1	14.1	13.9
	Absolute Minimum	6.6	8.8	11.0	10.4	15.0	16.2	14.0	14.0	14.8	11.8	11.1	10.6
	Average Maximum	23.0	25.8	26.2	26.8	28.0	26.6	23.7	24.4	25.2	23.6	25.1	25.1
	Absolute Maximum	29.0	31.0	31.5	30.5	30.5	28.2	25.4	26.3	28.0	27.0	27.4	28.9
´88	Monthly Average	16.5	18.0	19.3	21.1	21.4	19.2	19.4	18.7	18.9	18.6	18.8	16.9
	Average Minimum	12.5	13.1	14.0	16.6	16.5	16.4	16.2	16.1	15.7	15.3	14.9	13.1
	Absolute Minimum	7.0	10.7	9.8	13.9	13.1	14.2	14.9	14.8	14.1	13.9	12.2	9.8
	Average Maximum	23.1	25.3	26.7	28.0	28.3	25.7	24.7	24.1	23.7	23.2	24.3	22.0
	Absolute Maximum	26.8	29.2	29.8	31.3	31.2	29.4	26.1	26.8	26.4	26.6	26.6	24.8
1978 ~1988 TOTAL	Monthly Average	16.6	17.7	19.1	20.3	20.7	19.6	19.1	19.0	18.7	18.6	18.0	17.8
	Average Minimum	12.2	13.1	14.1	15.5	16.3	16.3	15.8	15.7	15.7	15.2	14.1	13.3
	Absolute Minimum	4.0	6.3	8.0	10.0	11.8	12.6	13.0	12.0	12.9	11.0	9.0	7.4
	Average Maximum	22.9	24.5	26.0	27.2	27.1	24.9	24.1	24.3	23.8	23.7	23.5	22.9
	Absolute Maximum	29.0	31.0	31.5	31.6	31.4	30.5	28.2	28.2	28.0	27.1	28.7	28.9

Table B-02 Relative Humidity at La Aurora

Month Year	1	2	3	4	5	6	7	8	9	10	11	12	Annual
1980	77	75	74	75	78	83	80	85	89	83	78	76	79
1981	75	74	75	74	80	90	86	86	84	84	75	77	80
1982	77	73	74	75	81	85	82	78	89	83	78	78	79
1983	75	77	74	76	71	84	83	85	91	83	78	73	79
1984	71	76	75	77	87	87	87	84	92	83	79	80	81
1985	76	76	76	71	78	84	82	80	83	84	82	77	79
1986	69	68	64	59	80	81	76	77	82	73	70	64	72
1987	66	69	72	65	68	85	84	82	88	79	79	80	76
1988	79	74	75	80	76	87	83	90	88	82	81	79	81
Average	74	74	73	72	78	85	83	83	87	82	78	76	78

Source: INSIVUMEH

Table B-03 Monthly Precipitation at La Aurora

(mm)

Month Year	1	2	3	4	5	6	7	8	9	10	11	12	Annual
1980	18.7	2.1	0.0	3.8	120.9	158.7	103.9	176.1	192.7	106.4	9.1	2.7	895.1
1981	13.5	0.4	11.3	6.1	73.1	106.8	161.8	158.8	234.2	248.5	33.9	9.0	1057.4
1982	4.6	0.5	0.3	2.2	146.0	305.8	149.9	37.2	244.0	96.1	0.0	3.2	989.8
1983	0.7	64.2	44.3	20.9	50.4	307.2	113.8	93.4	260.0	66.0	69.9	15.2	1106.0
1984	0.4	1.3	6.5	11.5	152.1	211.3	227.5	81.8	308.8	77.9	2.3	1.2	1082.6
1985	0.5	13.2	4.4	1.2	164.5	146.2	271.6	172.4	193.9	87.5	10.4	1.6	1067.4
1986	3.6	5.0	0.0	15.4	104.0	174.7	142.4	170.5	245.8	119.6	8.2	0.0	989.2
1987	0.0	0.0	52.9	52.6	91.8	289.6	204.0	153.3	220.0	12.2	1.0	1.7	1079.1
1988	3.4	0.9	26.5	5.7	66.4	426.3	226.9	458.4	250.4	173.3	2.8	13.6	1654.6
Average	5.0	9.7	16.2	13.3	107.7	236.3	189.1	166.9	238.9	109.7	15.3	5.4	1113.5

Source: INSIVUMEH

Table B-04 Visibility at La Aurora in 1981-88
(Occurrence Probability in %)

	0 < 1	1 < 2	2 < 3	3 < 4	4 < 5	5 < 7	7 < 10	≥ 10
January	0.8	0.6	0.5	0.3	0.4	1.9	5.5	90.0
February	1.3	0.9	0.7	1.0	1.1	3.2	10.7	81.2
March	1.5	0.6	1.0	2.3	2.3	8.8	18.7	64.8
April	0.8	1.1	3.3	7.6	8.4	16.5	26.1	36.2
May	0.8	1.9	5.6	9.0	8.8	19.9	25.1	28.9
June	0.5	0.7	1.0	1.9	1.6	3.9	13.2	77.2
July	0.1	0.3	0.4	0.8	1.0	2.2	6.0	89.2
August	0.6	0.5	0.9	1.4	1.5	2.8	7.0	85.3
September	0.6	0.6	1.3	1.7	1.9	4.6	11.1	78.2
October	0.3	0.2	0.4	0.8	1.1	2.3	5.9	89.0
November	0.7	0.6	0.4	0.6	0.7	2.1	6.1	88.8
December	0.9	0.4	0.3	0.7	0.5	1.7	7.8	87.7
Annual	0.7	0.8	1.3	2.3	2.4	5.8	11.9	74.7

Note: Internals in kilometers
Source: INSIVUMEH

Table B-05 Wind Direction at La Aurora

Month Year	1	2	3	4	5	6	7	8	9	10	11	12	Annual
1980	NNE	NNE	S	S	S	NNE	NNE	NNE	NNE	NNE	NNE	N	NNE
1981	NNE	NNE	NNE	NNE	SSW	SSW	NNE	NNE	NNE	NNE	NNE	NNE	NNE
1982	NNE	NE	NNE	S	NE	NNE	NNE	NNE	NNE	NNE	NNE	NNE	NNE
1983	NNE	S	S	S	S	N	N	N	N	NB	N	N	N
1984	N	N	N	S	N	N	N	N	S	N	N	N	N
1985	N	N	N	N	N	N	N	N	N	N	N	N	N
1986	N	SW	N	N	SSE	N	N	N	NNE	NNE	NNE	N	N
1987	NNE	N	S	N	NNE	NNE	NNE	N	-	NNE	N	NNE	NNE
1988	NNE	NNE	NNE	SW	WSW	SW	NNE	SW	NNE	NNE	NNE	NNE	NNE

Source: INSIVUMEH

Table B-06 Wind Velocity at La Aurora

(km/hr)

Month Year	1	2	3	4	5	6	7	8	9	10	11	12	Annual
1980	12.3	15.1	13.2	14.3	10.1	11.4	13.3	10.2	9.7	12.9	13.9	17.9	12.9
1981	14.5	16.9	12.5	14.6	9.6	9.8	10.8	10.7	9.2	10.6	14.5	12.3	12.2
1982	13.0	13.8	12.2	10.6	9.7	9.5	14.5	15.2	10.4	12.9	15.1	13.7	12.5
1983	15.0	12.4	13.4	12.1	10.6	7.6	13.1	12.3	9.5	12.7	10.0	13.2	11.8
1984	15.2	13.9	18.9	11.4	9.0	9.1	10.2	11.4	8.5	11.9	14.5	17.5	12.6
1985	13.8	15.9	14.8	12.1	9.2	8.5	10.7	10.5	9.6	11.0	12.9	14.1	11.9
1986	16.4	11.2	15.9	12.2	10.3	12.8	14.8	12.5	12.0	12.6	14.3	14.6	13.3
1987	14.2	12.2	11.9	13.1	12.3	8.0	12.5	13.2	8.8	15.9	14.1	14.2	12.5
1988	17.0	16.5	14.6	11.3	10.4	6.8	11.6	7.8	10.2	13.9	13.5	16.4	12.5

Source: INSIVUMEH

Table B-07 Frequency of Wind Direction and Velocity at La Aurora

Rank Knot (m/sec) Wind Direction	0 - 5 (0-2.57)		5 - 10 (2.57-5.14)		10 - 13 (5.14-7.72)		13 - 20 (7.72-10.29)		20 - (10.29-)		Total	
		%		%		%		%		%		%
N	381	(12.11)	893	(28.38)	232	(7.37)	63	(2.00)	0	(0.00)	1,569	(49.86)
NNE	143	(4.54)	334	(10.61)	27	(0.86)	2	(0.06)	0	(0.00)	506	(16.08)
NE	97	(3.08)	168	(5.34)	15	(0.48)	0	(0.00)	0	(0.00)	280	(8.90)
ENE	16	(0.51)	7	(0.22)	0	(0.00)	1	(0.03)	0	(0.00)	24	(0.76)
E	42	(1.33)	10	(0.32)	0	(0.00)	0	(0.00)	0	(0.00)	52	(1.65)
ESE	3	(0.10)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	3	(0.10)
SE	34	(1.08)	32	(1.02)	5	(0.16)	0	(0.00)	1	(0.03)	72	(2.29)
SSE	19	(0.60)	23	(0.73)	6	(0.19)	1	(0.03)	0	(0.00)	49	(1.56)
S	93	(2.96)	115	(3.65)	32	(1.02)	3	(0.10)	0	(0.00)	243	(7.72)
SSW	71	(2.26)	67	(2.13)	17	(0.54)	1	(0.03)	0	(0.00)	156	(4.96)
SW	51	(1.62)	86	(2.73)	24	(0.76)	2	(0.06)	0	(0.00)	163	(5.18)
WSW	7	(0.22)	5	(0.16)	1	(0.03)	0	(0.00)	0	(0.00)	13	(0.41)
W	5	(0.16)	5	(0.16)	1	(0.03)	0	(0.00)	0	(0.00)	11	(0.35)
WNW	2	(0.06)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	2	(0.06)
NW	4	(0.13)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	4	(0.13)
NNW	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)
TOTAL	968	(30.76)	1,745	(55.45)	360	(11.44)	73	(2.32)	1	(0.03)	3,147	(100.00)

Table B-08 Temperature of Santa Elena

(°C)

YEAR	ITEM \ MONTH	1	2	3	4	5	6	7	8	9	10	11	12
´78	Monthly Average	21.3	22.0	23.2	26.1	27.9	26.1	25.5	25.0	25.4	23.7	23.6	22.4
	Average Minimum	16.1	16.2	18.3	18.7	21.7	21.6	20.9	20.9	21.4	20.5	20.5	18.9
	Absolute Minimum	10.4	9.4	12.6	12.6	17.4	19.4	19.4	18.4	18.4	16.2	17.4	15.6
	Average Maximum	27.9	29.9	31.1	34.3	35.8	33.2	32.1	32.3	32.1	30.4	29.7	29.5
	Absolute Maximum	33.0	34.8	38.2	37.0	41.0	36.5	34.4	34.6	35.0	33.0	33.0	33.0
´79	Monthly Average	21.6	22.9	24.6	27.9	28.1	26.0	26.2	25.6	25.7	25.4	23.4	22.4
	Average Minimum	17.5	17.6	19.3	21.0	22.4	22.1	22.1	21.8	22.1	21.9	20.1	18.3
	Absolute Minimum	14.4	14.0	15.6	17.2	18.0	20.4	19.8	20.6	20.6	19.4	15.8	13.0
	Average Maximum	27.3	29.1	31.3	35.9	35.4	32.8	32.8	32.2	30.7	31.2	28.8	27.8
	Absolute Maximum	32.6	32.8	36.4	39.8	39.4	37.2	35.6	34.4	34.0	34.4	33.4	33.0
´80	Monthly Average	23.4	23.6	27.0	26.9	30.0	27.0	26.8	27.2	26.7	25.7	23.9	21.6
	Average Minimum	18.1	18.1	19.1	20.4	22.6	22.5	21.3	21.8	22.2	21.5	19.8	17.5
	Absolute Minimum	13.2	12.6	11.8	16.4	20.0	19.6	19.6	20.4	20.4	19.6	16.2	11.0
	Average Maximum	29.5	28.7	33.4	32.8	36.2	32.5	32.9	33.1	32.5	30.9	28.8	26.6
	Absolute Maximum	32.6	34.0	37.2	38.0	38.6	36.2	35.0	35.4	34.0	34.0	31.8	30.2
´81	Monthly Average	21.5	23.0	26.5	27.3	29.4	26.9	26.5	28.1	26.5	26.0	24.0	23.4
	Average Minimum	16.0	17.9	19.5	19.5	21.6	22.8	21.6	22.2	22.0	21.7	19.2	18.5
	Absolute Minimum	9.8	13.0	14.6	16.0	16.2	21.0	20.0	20.4	20.6	19.4	14.0	14.4
	Average Maximum	27.8	28.4	32.4	33.7	35.8	32.0	32.1	32.5	32.2	31.5	29.6	28.9
	Absolute Maximum	31.4	33.0	37.2	35.8	38.0	36.0	33.8	34.8	34.4	33.6	32.6	32.2
´82	Monthly Average	24.2	23.4	25.6	27.7	28.0	28.3	25.6	25.4	25.5	25.2	24.5	23.9
	Average Minimum	18.6	18.8	19.2	20.5	21.9	22.6	21.5	21.1	22.1	21.4	19.8	18.7
	Absolute Minimum	13.6	15.4	16.8	17.4	18.6	20.4	19.4	19.4	20.6	18.4	17.6	12.4
	Average Maximum	29.9	30.9	32.6	35.6	35.0	33.4	32.1	32.3	31.7	30.8	29.7	29.2
	Absolute Maximum	32.4	33.6	38.6	38.2	37.0	37.8	34.4	34.0	34.4	33.8	32.0	33.4
´83	Monthly Average	22.8	23.4	26.4	27.8	29.0	27.6	25.8	25.2	25.7	25.5	25.4	24.3
	Average Minimum	18.2	18.5	19.5	22.1	22.6	23.5	22.1	21.8	22.2	21.6	20.7	19.5
	Absolute Minimum	10.4	14.4	13.0	18.6	19.2	22.2	20.2	20.0	20.6	19.8	18.0	16.0
	Average Maximum	27.8	28.9	32.7	34.9	37.3	34.6	32.2	32.8	32.3	30.5	30.2	28.7
	Absolute Maximum	34.0	33.8	38.8	41.4	39.2	39.4	34.8	34.8	34.6	33.0	33.2	31.6

(Cont'd) (°C)

YEAR	MONTH ITEM	1	2	3	4	5	6	7	8	9	10	11	12
'84	Monthly Average	22.8	23.9	25.7	28.5	27.2	26.8	25.7	26.2	25.0	26.1	23.2	22.6
	Average Minimum	17.9	19.0	19.2	20.9	22.6	22.3	21.5	21.6	22.4	21.2	18.3	18.1
	Absolute Minimum	13.2	14.4	11.6	15.4	19.8	20.2	19.8	18.0	21.0	19.6	11.8	14.4
	Average Maximum	26.7	27.8	32.3	36.4	33.9	32.3	31.0	32.0	31.6	31.2	28.7	28.0
	Absolute Maximum	31.4	34.2	41.2	40.2	40.8	35.0	34.6	33.6	34.6	34.0	31.2	31.6
'85	Monthly Average	21.2	22.6	24.9	25.5	27.0	26.6	25.7	25.5	24.9	24.5	23.7	21.9
	Average Minimum	16.3	18.3	19.1	19.9	21.6	21.5	20.8	21.2	21.2	20.7	19.6	19.3
	Absolute Minimum	12.4	13.4	16.0	13.2	18.0	19.0	19.6	19.4	19.0	18.0	16.0	14.4
	Average Maximum	27.5	28.9	32.3	33.7	35.6	33.4	32.3	32.2	31.6	31.5	29.8	27.8
	Absolute Maximum	33.2	34.0	37.6	36.6	38.4	36.6	34.6	36.4	34.2	33.9	35.2	31.8
'86	Monthly Average	19.9	23.3	23.1	27.6	28.8	27.0	25.4	24.7	24.8	25.7	24.9	24.1
	Average Minimum	17.0	18.3	16.9	18.4	21.5	22.2	21.2	21.6	21.5	20.8	20.2	19.0
	Absolute Minimum	10.4	12.6	9.0	11.8	17.6	20.4	20.0	20.0	19.4	18.6	15.6	15.0
	Average Maximum	25.9	30.9	31.1	34.5	34.7	32.6	31.9	32.2	31.5	30.7	29.9	29.0
	Absolute Maximum	30.6	33.4	38.4	37.4	38.4	35.4	34.0	33.0	34.4	33.0	33.0	32.4
'87	Monthly Average	22.5	23.3	24.9	25.6	30.0	28.0	26.4	26.5	27.3	24.3	23.8	23.6
	Average Minimum	15.8	17.4	19.8	19.6	21.1	23.0	22.4	22.0	22.3	20.4	19.5	18.8
	Absolute Minimum	10.0	13.0	10.0	12.4	16.6	21.0	18.4	20.4	21.0	17.0	15.4	13.0
	Average Maximum	27.5	31.4	32.8	32.1	36.5	34.7	32.8	32.7	33.0	29.4	29.0	28.5
	Absolute Maximum	33.2	28.0	41.4	37.6	39.0	38.6	35.2	35.0	35.6	31.0	33.2	32.2
'88	Monthly Average	22.6	23.3	24.9	28.5	29.2	25.4						
	Average Minimum	18.7	18.5	18.8	21.2	21.8	21.9						
	Absolute Minimum	13.4	14.0	13.0	14.4	15.6	20.6						
	Average Maximum	26.3	28.5	30.9	36.0	36.5	32.5						
	Absolute Maximum	33.4	33.6	36.4	42.0	40.4	35.0						
1978 ~1987 TOTAL	Monthly Average	22.1	23.1	25.2	27.1	28.5	27.0	26.0	25.8	25.8	25.2	24.0	23.0
	Average Minimum	17.3	18.1	19.0	20.2	21.9	22.4	21.5	21.6	21.9	21.2	19.8	18.7
	Absolute Minimum	9.8	9.4	9.0	11.8	15.6	19.0	18.4	18.0	18.4	16.2	11.8	11.0
	Average Maximum	27.8	29.5	32.2	34.4	35.6	33.2	32.2	32.4	31.9	30.8	29.4	28.4
	Absolute Maximum	34.0	38.0	41.4	42.0	41.0	38.6	35.6	36.4	35.6	34.4	35.2	33.4

Table B-09 Relative Humidity at Santa Elena

Month Year	1	2	3	4	5	6	7	8	9	10	11	12	Annual
1980	81	79	69	71	67	82	82	81	85	86	85	85	79
1981	82	83	72	69	67	85	84	82	83	85	81	85	80
1982	82	77	74	65	68	76	79	82	83	81	82	81	77
1983	81	85	70	64	58	80	87	89	90	84	81	82	79
1984	84	82	71	64	77	80	82	79	81	82	81	83	79
1985	80	77	71	64	64	76	87	86	84	84	84	91	79
1986	93	83	65	62	66	80	80	81	83	81	83	81	78
1987	76	65	54	47	58	71	72	74	72	71	78	78	68
1988	81	72	62	61	59	-	79	-	-	-	-	-	
Average	82	78	68	63	65	79	81	82	83	82	82	83	

Source: INSIVUMEH

Table B-10 Monthly Precipitation of Santa Elena

(mm)

Month Year	1	2	3	4	5	6	7	8	9	10	11	12	Annual
1980	25.1	111.3	0.4	24.8	189.8	176.2	191.3	158.2	192.8	339.0	210.5	144.2	1,763.6
1981	12.3	184.0	3.8	19.4	89.2	248.3	278.9	226.0	250.7	185.7	18.7	95.8	1,612.8
1982	100.2	55.6	42.6	6.1	95.4	225.0	177.8	210.3	200.0	177.5	88.6	44.4	1,423.5
1983	47.4	61.4	38.9	15.5	75.3	278.4	228.9	239.3	246.9	209.8	173.8	119.7	1,735.3
1984	94.6	35.8	11.1	8.7	223.4	181.2	183.5	149.6	129.0	188.1	94.0	78.0	1,377.0
1985	20.6	66.3	99.6	8.7	73.3	163.9	224.3	239.2	252.0	86.6	94.0	91.1	1,419.6
1986	142.2	4.4	78.6	13.0	532.1	260.0	195.4	141.8	134.7	210.2	84.3	21.9	1,818.6
1987	15.5	15.2	96.6	37.1	0.3	153.3	175.3	205.3	100.0	115.6	137.4	46.4	1,098.0
1988	143.2	28.8	19.9	22.6	39.2	-	203.3						
Average	66.8	62.5	43.5	17.3	146.4	210.8	206.5	196.2	188.3	189.1	112.7	80.2	1531.1

Source: INSIVUMEH

Table B-11 Visibility at Santa Elena in 1987-88 (Occurrence Probability in %)

	0 < 1	1 < 2	2 < 3	3 < 4	4 < 5	5 < 7	7 < 10	≥ 10
January	0.3	0.9	0.3	0.4	0.5	1.3	9.3	87.0
February	0.1	0.6	0.3	0.3	0.7	0.9	6.8	90.3
March	0.0	0.1	0.4	0.2	0.9	2.0	23.0	73.4
April	0.0	0.2	0.2	0.8	1.8	5.5	37.0	54.5
May	0.0	1.8	1.6	1.6	3.5	12.6	57.0	22.0
June	0.0	0.1	0.0	0.1	0.1	0.9	9.8	89.3
July	0.0	0.0	0.1	0.1	0.1	0.5	5.5	93.1
August	0.4	0.2	0.1	0.1	0.2	1.0	5.5	91.7
September	0.1	0.1	0.6	0.2	0.4	1.1	3.0	94.5
October	0.0	0.0	0.3	0.7	0.7	1.7	9.5	87.1
November	0.1	2.6	0.1	0.2	0.5	1.4	7.2	87.9
December	0.3	0.6	0.2	0.3	0.6	1.0	7.5	89.5
Annual	0.1	0.6	0.4	0.4	0.8	2.5	15.1	80.1

Note: Internals in kilometer
Source: INSIVUMEH

Table B-12 Wind Direction at Santa Elena in1982 - 86
(Occurrence Probability in %)

	N	NNE	NE	ENE	E	ESE	SSE	SE	S	SSW	SW	WSW	SW	WNW	NW	NNW	C
January	14	3	1	2	9	3	0	0	2	0	1	1	2	2	1	3	55
February	15	5	2	2	14	3	0	1	1	0	0	0	2	2	1	3	50
March	18	5	3	4	22	2	1	1	1	0	0	0	2	1	1	2	36
April	15	5	3	8	21	33	0	1	2	0	0	0	1	1	1	2	37
May	15	5	4	4	18	4	0	1	2	0	0	0	1	0	0	0	45
June	8	4	2	3	17	2	1	1	2	1	0	0	1	0	0	1	57
July	5	2	2	2	20	2	0	0	2	1	0	0	0	0	0	1	61
August	8	3	2	2	14	2	0	0	3	1	0	0	0	0	0	1	64
September	9	3	2	0	11	2	0	0	1	0	0	0	1	1	0	1	67
October	16	3	2	1	5	1	0	0	1	0	0	2	3	0	0	2	63
November	15	3	2	1	5	2	0	0	1	0	0	1	3	3	1	3	59
December	11	2	1	1	9	1	1	0	1	0	0	0	2	2	0	2	65

Note: Intervals in knots
Source: INSUVUMEH

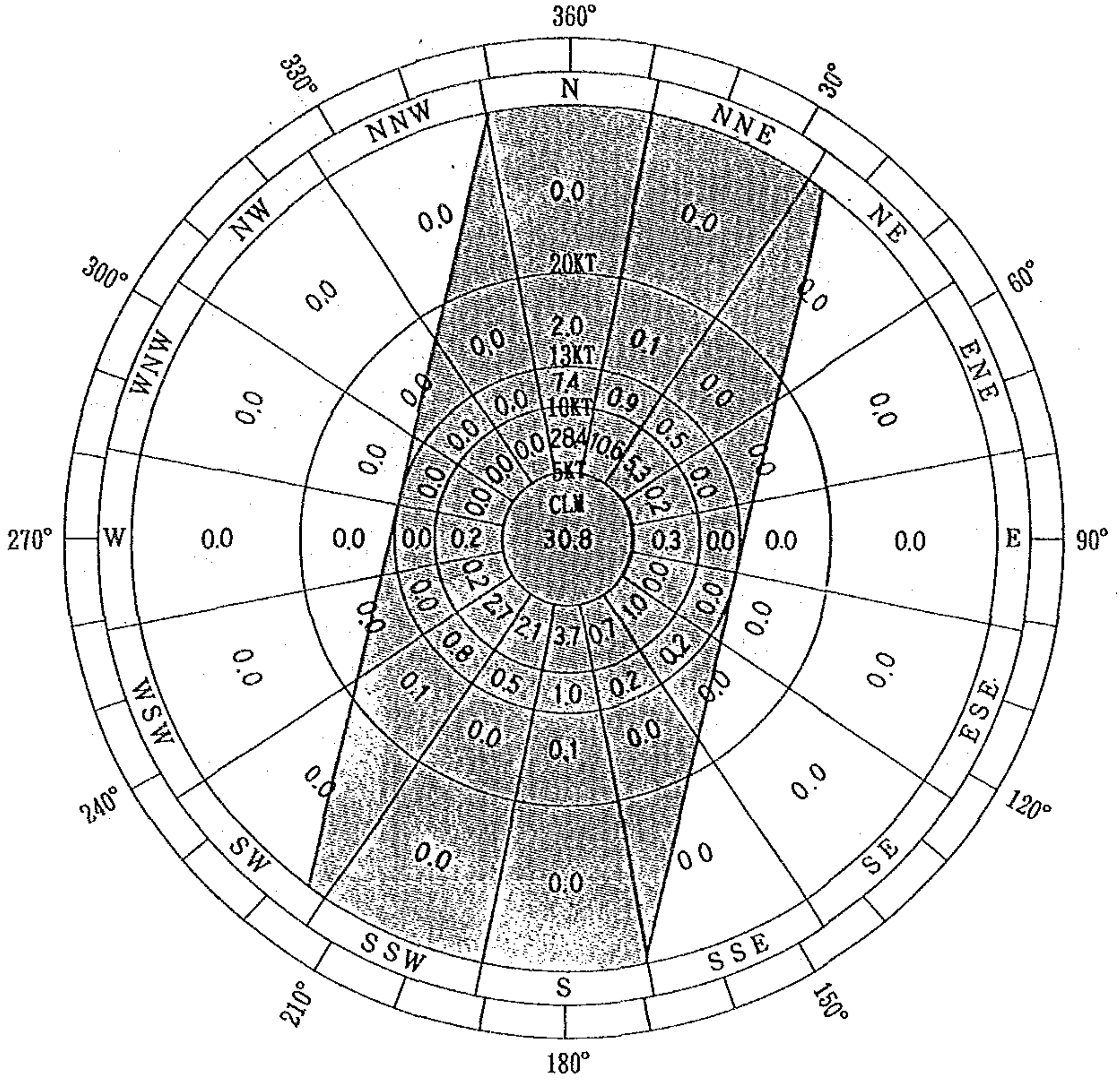
Table B-13 Wind Velocity at Santa Elena in 1982-86
(Occurrence Probability in %)

	≤ 5	5 - 10	10 - 15	15 - 20	20 - 25	25 - 30	≥ 30	Calm
January	23	21	1	0	0	0	0	55
February	24	25	1	0	0	0	0	50
March	28	33	2	0	0	0	0	36
April	32	30	11	3	0	0	0	37
May	29	25	1	0	0	0	0	45
June	21	20	13	0	0	0	0	57
July	19	19	1	0	0	0	0	61
August	19	17	1	0	0	0	0	64
September	19	14	0	0	0	0	0	67
October	25	12	0	0	0	0	0	63
November	24	17	0	0	0	0	0	59
December	20	15	0	0	0	0	0	65

Note: Intervals in knots
Source: INSUVUMEH

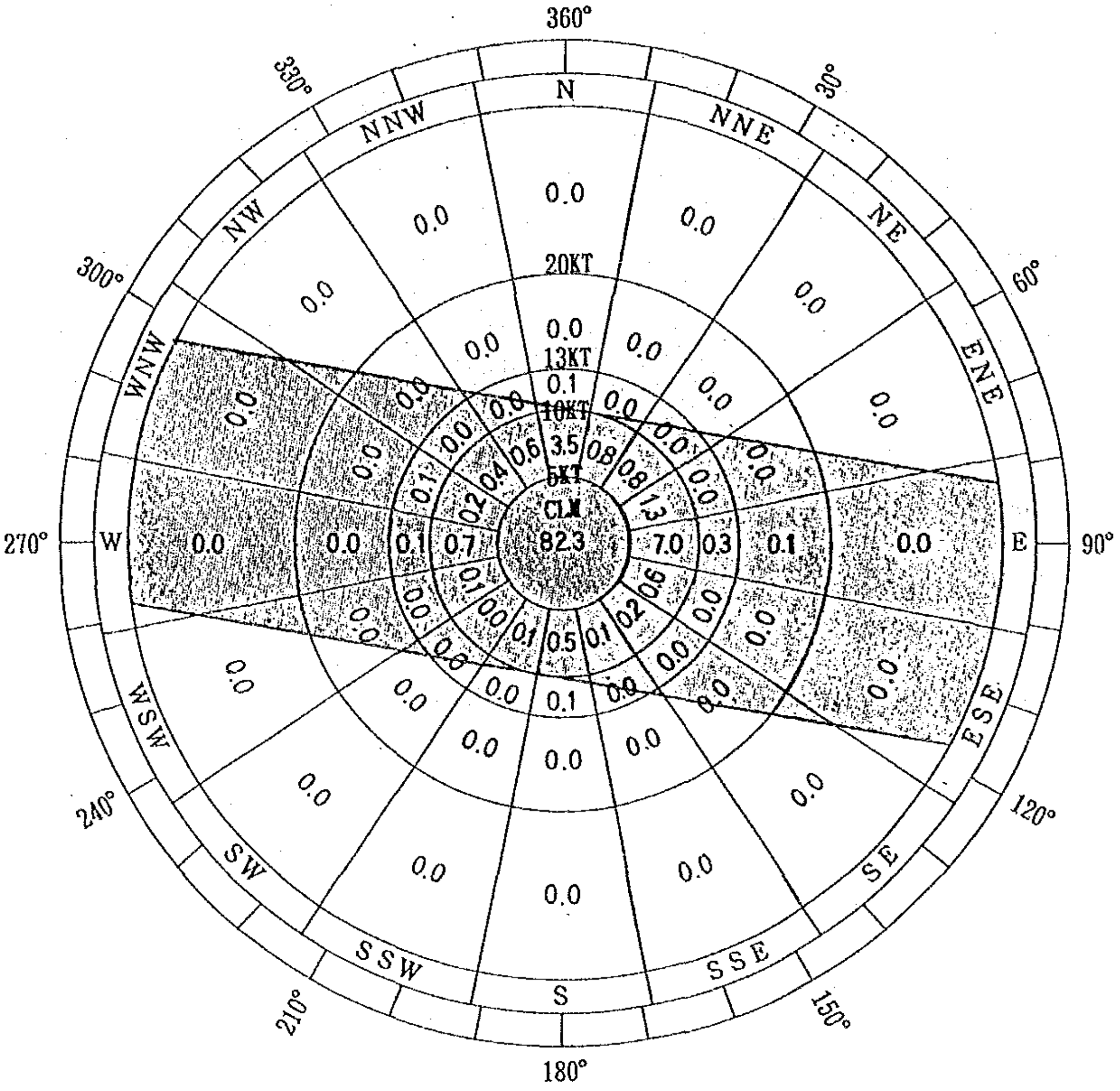
Table B-14 Frequency of Wind Direction and Velocity at Santa Elena

Rank Knot (m/sec) Wind Direction	0 - 5 (0-2.57)		5 - 10 (2.57-5.14)		10 - 13 (5.14-7.72)		13 - 20 (7.72-10.29)		20 - (10.29-)		Total	
		%		%		%		%		%		%
N	2,224	(67.66)	115	(3.50)	4	(0.12)	0	(0.00)	0	(0.00)	2,343	(71.28)
NNE	45	(1.37)	27	(0.82)	1	(0.03)	0	(0.00)	0	(0.00)	73	(2.22)
NE	18	(0.55)	26	(0.79)	1	(0.03)	1	(0.03)	0	(0.00)	46	(1.40)
ENE	33	(1.00)	41	(1.25)	10	(0.30)	0	(0.00)	0	(0.00)	75	(2.28)
E	162	(4.93)	231	(7.03)	0	(0.00)	2	(0.06)	0	(0.00)	405	(12.32)
ESE	34	(1.03)	18	(0.55)	0	(0.00)	0	(0.00)	0	(0.00)	52	(1.58)
SE	7	(0.21)	7	(0.21)	0	(0.00)	0	(0.00)	0	(0.00)	14	(0.43)
SSE	7	(0.21)	2	(0.06)	0	(0.00)	0	(0.00)	0	(0.00)	9	(0.27)
S	35	(1.06)	17	(0.52)	3	(0.09)	1	(0.03)	0	(0.00)	108	(3.29)
SSW	4	(0.12)	2	(0.06)	0	(0.00)	0	(0.00)	0	(0.00)	6	(0.18)
SW	11	(0.33)	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)	11	(0.33)
WSW	13	(0.40)	2	(0.06)	0	(0.00)	0	(0.00)	0	(0.00)	15	(0.46)
W	47	(1.43)	23	(0.70)	2	(0.06)	0	(0.00)	0	(0.00)	72	(2.19)
WNW	19	(0.58)	6	(0.18)	2	(0.06)	1	(0.03)	0	(0.00)	28	(0.85)
NW	7	(0.21)	12	(0.37)	0	(0.00)	0	(0.00)	0	(0.00)	19	(0.58)
NNW	42	(1.28)	21	(0.64)	0	(0.00)	0	(0.00)	0	(0.00)	63	(1.92)
TOTAL	2,708	(82.39)	550	(16.73)	23	(0.70)	5	(0.15)	0	(0.00)	3,287	(100.00)



WIND COVERAGE 100 %

WIND ROSE AT LA AURORA AIRPORT



WIND COVERAGE 99.8 %

WIND ROSE AT SANTA ELENA AIRPORT

APPENDIX - C

GEOTECHNICAL CONDITIONS

C.1 GENERAL GEOLOGY AT LA AURORA

The geology of La Aurora airport area is composed of pumiceous volcanic ash layer and talus deposit. In the course of the Study, four (4) boreholes have been drilled and their core samples have been tested. Location and profiles of the boreholes is shown in Figure C-1 and C-2, and outlined hereunder.

Borehole-1 (BH-1) :	Near the proposed control tower, between DGAC building and cargo hanger (18 m in depth)
Borehole-2 (BH-2) :	Near the Runway 01 threshold (15 m in depth)
Borehole-3 (BH-3) :	Near the Runway 19 threshold (15 m in depth)
Borehole-4 (BH-4) :	In the Apron expansion area (11 m in depth)

In general, the geologic layers observed in the area are composed of:

Talus deposit:

(1) Tuffaceous sand layer II (Vs2)
(2) Tuffaceous clay layer II (Vc2)
(3) Tuffaceous sand layer I (Vs1)
(4) Tuffaceous clay layer I (Vc1)

Basement layer:

(5) Pumiceous volcanic ash layer (V)

On the basis of laboratory tests of core samples, as shown in Table C-01, the geologic characteristics of each layer are observed as summarized below.

1) Tuffaceous sand layer II (Vs2)

The tuffaceous sand layer II (Vs2) is observed as a lens layer in the tuffaceous clay layer (Vc2) in the surrounding area of the borehole BH-1. According to the results of SPT, this layer shows N-value of about 20, and corresponds to cohesionless soil of medium relative density. Besides, this layer is classified into SW-SM based on the results of grain-size analysis.

2) Tuffaceous clay layer II (Vc2)

The tuffaceous clay layer II (Vc2) is observed in the surrounding areas of BH-1 and BH-4. This layer shows N-value of 11 to 23, which corresponds to hard cohesive soil, and is classified into ML.

3) Tuffaceous sand layer I (Vs1)

The tuffaceous sand I (Vs1) is observed in the surrounding areas of BH-1 and BH-4. This layer shows N-value of 13 to 17, corresponds to cohesionless soil of medium relative density and is classified into SM.

4) Tuffaceous clay layer I (Vc1)

The tuffaceous sand I (Vc1) is observed in the surrounding areas of all boreholes BH-1, BH-2, BH-3, and BH-4, which is distributed in the shallow zones near the BH-2 and BH-3. The thickness of this layer is 2.4 meters in maximum, near the BH-4. This layer shows N-value of (10) to 24, corresponds to hard - very hard cohesive soil, and classified into ML.

5) Pumiceous volcanic ash layer (V)

The pumiceous volcanic ash layer (V) is the basement layer of the project area and a foundation layer of the existing runway of the airport. This layer is sandy, shows N-value of more than 16. N-value increases toward deeper zone in the boreholes BH-1, BH-3, and BH-4, and is about 20 in the BH-2. This layer may be pumice flow deposit.

The slope stability in the airport area might be low, because plasticity of these layers is estimated to be zero (0). Therefore, when a steep slope cut is required during excavation works, some countermeasures will be needed to protect sliding. Besides, when embankment works are required on the talus deposit, further detailed study on the embankment materials and foundation subsidence will be necessary.

C.2 PAVEMENT STRENGTH AT LA AURORA

2.1 SAMPLING AND TESTS (LA AURORA)

2.1.1 Sampling at Existing Pavement Area

The location of investigation points in La Aurora Airport is shown in Figure C-1.

1) Bituminous Courses

For sampling the bituminous layer at each site (Point No. 4, 5 and 6), three core drilled samples were obtained with a diameter of 10.2 cm with variable depth equal to the thickness of the said bituminous layer. The extracted samples were appropriately identified and sent to the Laboratory for the required Marshall stability and flow test. Core drilled samples were not obtained in those areas where pavement were removed for sampling, but they were obtained at sites nearby, as indicated in detail in Figure C-1, because it was possible to work at site only during the night time.

2) Base

After removal of the bituminous layer on top of the base surface, field density of the layer of the same was obtained (Sand Cone method). At the same time, materials necessary to carry out the required grain size analysis were obtained.

3) Subbase

After excavation and careful removal by hand of the base layer, field density in the surface layer of the subbase was obtained (Sand method). At Site No. 4 no defined subbase was found, and it was supposed that the upper part of the fill material was used as subbase, or as subgrade below the base. At this Site the upper part of the possible fill was not taken as subbase, because it was considered and analyzed as subgrade.

4) Subgrade

After removal of the subbase layer, or the base as in the case of Site No. 4, unaltered samples were taken from the surface of the subgrade. Sample consists of a cut block of approximately 0.20 m each side, and it was weighed in the field and later covered with paraffin. The sample thus prepared was sent to the Laboratory to determine the unit weight and moisture content in the field (in situ) by the paraffin method. In the case of La Aurora airport, samples of the subgrade material were taken to carry out the necessary tests to determine the physical properties and to perform CBR tests.

In the case of the subgrade of the existing pavement of La Aurora airport, samples were also taken to make dynamic compaction CBR tests.

Profiles of the Existing Pavement Areas are shown in Figure C-2.

2.1.2 Sampling at Future Pavement Area

1) Subgrade

Samples were taken at the site contemplated for the future pavement areas at approximately 0.50 m below the soil surface, so that the samples obtained will be of natural soil and not fill material. Sampling method was similar to the item (4) above. Field density was obtained in situ, and altered samples were taken to conduct CBR tests.

2.1.3 Laboratory and Field Tests at Existing Pavement

1) Bituminous Course

Three drilled core samples of the existing asphaltic pavement were obtained at each Site No. 4A, 5, and 6, and resistance to plastic flow tests were carried out by means of Marshal apparatus. As different layers were noted in the samples, probably laid at different times, a greater number of tests were conducted so as to obtain representative results. The results of these tests, including Marshall stability and flow tests, as well as the density of the specimens, are shown in Table C-02.

2) Base and Subbase

Grain size analyses (washed in sieve No. 200) were conducted on samples obtained from the base and subbase of Site No. 5 and 6. In situ densities of the samples were determined using the Sand Cone Method. A summary of the results of tests is shown in Table C-03 and C-04.

3) Subgrade

Following tests were made on samples obtained from material from the subgrade at Site No. 4, 5, and 6 to determine physical properties:

Specific Gravity
Moisture Content
Grain Size Analysis using sieves and hydrometer
Liquid and Plastic Limits and Plastic Index.

Compaction tests and CBR (AASHTO T-193), in accordance with the specifications of AASHTO Method T-180 for the dynamic compaction of the specimens, were also made. (CBR tests with dynamic compaction were not required for these subgrades.) The results of the tests are shown in Table C-05.

Additionally, two CBR tests were made by compacting the specimens statically with the density and field (in situ) moisture content. In each test, penetrations (0.254 mm) were made in the upper and lower faces of the specimens, in which in various cases the values differed. In Table C-06, the average values of the CBR, obtained with the densities and average moisture contents in the laboratory, are indicated.

2.1.4 Laboratory and Field Tests at Future Pavement Areas

1) Subgrade

Following tests were made on samples obtained from subgrade materials at Site No. 1, 2, and 3:

Specific Gravity
Moisture Content
Grain Size Analysis using sieve and hydrometer
Liquid and Plastic Limits and Plastic Index

Compaction tests and CBR (AASHTO T-193), in accordance with the specifications of AASHTO Method T-180 for the dynamic compaction of the specimens, were made on the samples taken.

As for the subgrade at Site No. 1, 2, and 3, two CBR tests were also made at each Site, compacting the specimens statically with the density and in situ moisture content. The results of these tests are presented in Table C-07 to C-10.

2.2 DESIGN CBR AND "K" VALUE OF SUBGRADE (LA AURORA)

2.2.1 Summary Result of CBR Test

On the basis of the laboratory tests for La Aurora described in Section 2.1.3 hereinabove, the results of CBR tests are summarized as follows:

Summary Results of CBR Test

		Existing Pavement Area			Future Pavement Area		
		1	2	3	4	5	6
Undisturbed Sample		35.8	0.8	24.8	41.3	3.8	47.6
Disturbed Sample	90% Compaction	34.6	1.8	1.2	70.3	44.4	20.0
	95% Compaction	41.7	2.8	2.4	99.8	65.8	49.5

Notes:
1) The above values are the average of 2 test points in a pit.
2) The shaded values will not be used for determination of the design CBR values in the following section.

2.2.2 Determination of Design CBR

On the basis of the test data of undisturbed and disturbed samples (max. dry density x 90%) as noted above, the design CBR values can be obtained by the following equation:

$$\text{Design CBR} = \text{Average test value} - \frac{\text{Max. CBR - Min. CBR}}{d_2'}$$

where, d2' are the coefficient given in the following table:

n	d_2'
3	2.547
4	3.089
5	3.489
6	3.801
7	4.059
8	4.271
9	4.455
10	4.617

Design CBR (undisturbed)

$$= \frac{35.8 + 24.8 + 41.3 + 47.3}{4} - \frac{47.3 - 24.8}{3.089}$$

$$= 37.3 - 7.3 = 30.0\%$$

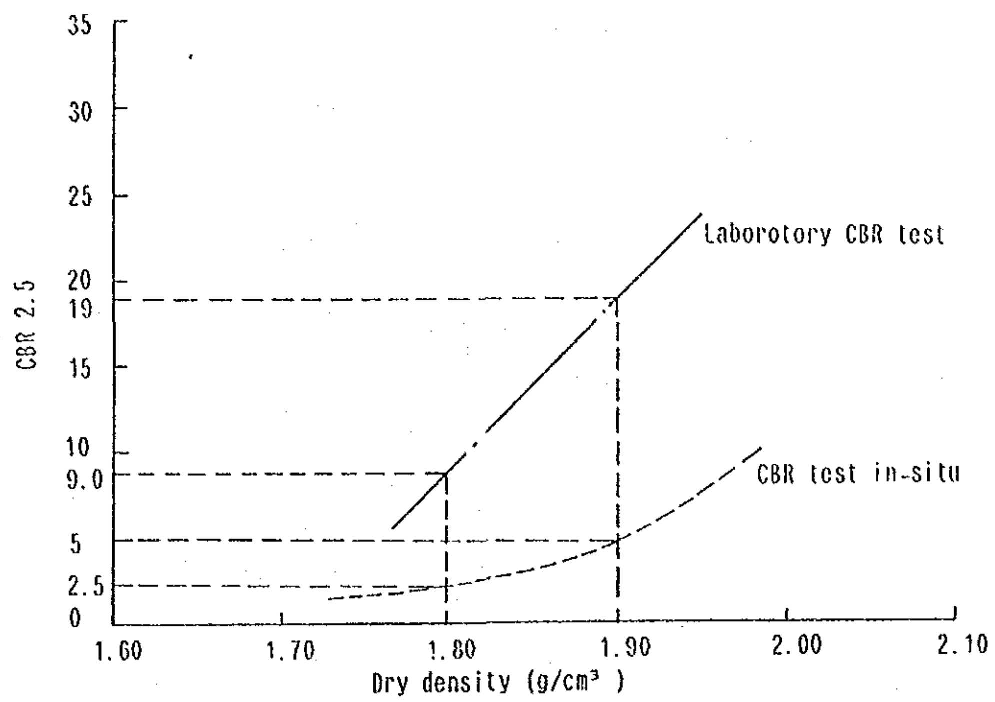
Design CBR (disturbed - 90%)

$$= \frac{34.6 + 70.3 + 44.44 + 20.0}{4} - \frac{70.3 - 20.0}{3.089}$$

$$= 42.3 - 16.3 = 26.0\%$$

As seen above, the laboratory analysis gives considerably high CBR values of the subgrade. It is, however, generally recognized that in case of sandy silt or sand subgrade, laboratory tests tend to give higher values than in-situ tests.

This is due to the fact that the mold used in the laboratory test tends to restrict the movement of soil. Taking this into consideration, the values obtained by the above equation should be adjusted applying reduction factors which have been empirically established as shown in the following figure:



Relationship between CBR Test in Situ and Laboratory CBR Test (Fine Sand)

Referring to the above figure, the reduction factor in this case is found to be 0.4. Then, the adjusted design CBR values turn out to be as follows:

Adjusted design CBR:

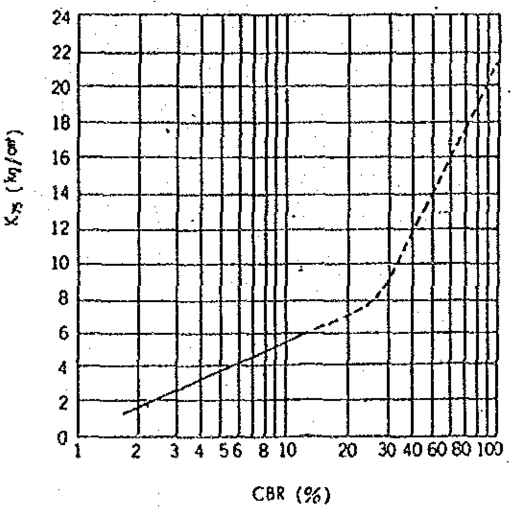
Undisturbed samples : 30% x 0.4 = 12.0%

Disturbed samples : 26.0% x 0.4 = 10.4%

Further, in view of the fact that the number of test samples are rather small, it is recommended to use a conservative value. Consequently, the design CBR value is calculated to be 10%.

2.2.3 Design K Value

The design K values can be determined in relation to the CBR values by applying the following:



Relation between CBR and K_{75}

From the above chart, the design K value is determined to be as follows:

K_{75} = 5.0 kgf/cm^3 (181 pci)

2.3 EVALUATION OF EXISTING PAVEMENT (LA AURORA)

Airport pavement strength is expressed in PCN value as the international standard, since ACN-PCN (Aircraft Classification Number - Pavement Classification Number) was established by ICAO in 1981. On the basis of the field investigation and tests as explained before, the pavement strength of La Aurora airport has been evaluated in terms of PCN value.

2.3.1 Evaluation of Flexible Pavement (Asphalt Pavement)

PCN value of the existing asphalt pavement at La Aurora is evaluated as explained hereunder.

1) Existing Pavement Composition

On the basis of the profile of existing asphalt pavement examined at Site No. 4, No. 5 and No. 6 as shown in Figure C-3, the average pavement thickness of each layer is calculated as follows:

Bituminous (t_1) : (0.2 + 0.22 + 0.25) x 1/3 = 0.22 m
Base Course (t_2) : (0.2 + 0.08 + 0.15) x 1/3 = 0.14 m
Sub-base (t_3) : (0.2 + 01 + 0.2) x 1/3 = 0.17 cm

2) Equivalent Total Pavement Thickness

Total pavement thickness, after on-going overlay, is calculated by means of equivalent conversion factors applicable to the pavement materials, as shown below.

Bituminous surface : = 0.130 m
Base and Sub-base : (0.22-0.03) x 1.5 + (0.14+0.17) x 1 = 0.595 m
Total 0.725 m

Note: Equivalent Conversion Factor: 1.5 for bituminous surface
1.0 for aggregate base course

3) PCN Value

On the basis of the equivalent pavement thickness estimated to be 0.725 m above and the subgrade CBR value estimated to be 10% in Section 2.2.2 above, PCN value is obtained through the monogram n Figure C-4, to be PCN 46.

2.3.2 Evaluation of Rigid Pavement (Concrete Apron)

PCN value of the existing concrete pavement in the terminal apron area is calculated on the basis of the following pavement structures:

Concrete surface	:	0.30 m in thickness
Base course	:	0.15 m in thickness

Further, the design K value and concrete flexural strength are evaluated as follows:

K_{75} value on the base	:	10 kgf/cm^3
Concrete Flexural Strength	:	25 kgf/cm^2

On the basis of the monogram shown in Figure C-3, the PCN value of the concrete pavement in the terminal apron area is estimated to be PCN 40.

C.3 GENERAL GEOLOGY AT SANTA ELENA

In the course of the Study, three (3) boreholes have been drilled and their core samples have been tested. Location and profile of the boreholes is shown in Figure C-5 and C-6, and outlined hereunder.

Borehole-1 (BH-1)	:	Eastern side of runway, about 400 m from the Lake Peden (15 m in depth)
Borehole-2 (BH-2)	:	Possible future parallel taxiway alignment, 177 m apart from the runway (15 m in depth)
Borehole-3 (BH-3)	:	Possible future parallel taxiway alignment, 178 m apart from the runway, near existing service road (30 m in depth)

In general, the geology of Santa Elena airport area is composed of Mesozoic limestone and lake deposit. The major layers ar as follows:

Lake deposit
(1) Sand and gravel deposit II (Lg2)
(2) Clay layer (Lc)
(3) Silt layer (Lm)
(4) Sand and gravel deposit I (Lg1)

Base rock
(5) Limestone (LS)

The foundation of the existing Santa Elena runway is in the lake deposit. On the basis of laboratory tests of core samples, as shown in Table C-11, the characteristics of each layer are observed as summarized below.

1) Sand and gravel deposit II (Lg2)

The sad and gravel layer II (Lg2) is observed in the surrounding area of the borehole BH-1 in the north part of the existing runway near Lago Peten, which is composed of yellowish brown clayey sand and gravel. The thickness of this layer is 4.7 meters in the BH-1.

2) Clay layer (Lc)

The clay layer (Lc) is distributed just below the existing runway. The thickness of this layer increases toward west. In the west side of the runway, this layer is observed 2 meters below ground surface with 13 meters in thickness. While N-value of this layer shows comparatively irregular values, 7 to 35, the layer condition is hard in general. This is classified into CH-CL based on the results of grain-size analysis.

3) Silt layer (Lm)

The silt layer (Lm) is distributed below the clay layer (Lc). The thickness of this layer increases toward east. This layer shows N-value of 14 to 26, very hard and is classified into MH.

4) Sand and gravel layer I (Lg1)

The sand and gravel layer I (Lg1) is distributed just above the limestone (LS), which is observed in the surrounding area of the BH-3. This layer is cohesive soil containing limestone gravel.

5) Limestone (LS)

Mesozoic limestone. Karstic topography and many solution cavities are observed in the northern mountainous area of the airport which is formed mainly by this limestone.

It is observed that the foundation layers are mostly fine-grained and cohesive soil. Therefore, further detailed study on the land subsidence will be required. Further, the test result indicates that soils are sensitive to swelling, and it will be recommendable to design sub-drains in the subgrade layer in the construction of the parallel taxiway.

C.4 PAVEMENT STRENGTH AT SANTA ELENA

4.1 SAMPLING AND TESTS (SANTA ELENA)

4.1.1 Sampling at Existing Pavement Area

The location of investigation points in Santa Elena airport is shown in Figure C-5.

1) Portland Cement Concrete Slabs

   For sampling of the concrete pavement in each Site of Investigation No. 1 and 2, three core drilled samples were extracted with a rotary drill to make bore holes for the soil investigation using a special core sampler. Cylindrical samples were obtained with a diameter of 12.10 cm and a generally uniform height of 30 cm equal to the thickness of the concrete slabs at the point of investigation. The extracted samples were appropriately identified and sent to the Laboratory to conduct necessary compression tests.

2) Base

   After removal of materials from the shoulder adjacent to the concrete pavement on top of the surface of the base, a field density was obtained in the layer of the base (Sand method). At the same time, samples of materials to conduct grain size analysis were taken.

3) Subbase

   After extraction and careful removal by hand of the base layer, no definite subbase layer was found. It is supposed that the top part of the fill material was used as subbase, or as subgrade under the base. Below the base with its thickness of approximately 0.30 m, fill materials considered to be subgrade is found to be similar to the fill material of the lower part, unless large fragments of rock are contained. It is understood that the fill material below the base has a thickness ranging from 1.20 m to 10.0 m.

4) Subgrade

After removal of the base layer, unaltered samples were taken from the surface of the subgrade. They consist of a cut block of approximately 0.20 m each side, and they were weighted in the field and later covered with paraffin. The sample thus prepared was sent to the Laboratory to determine the unit weight and moisture content in the field (in situ) by the paraffin method.

Profiles of the Existing Pavement Areas in Santa Elena are shown in Figure C-7.

4.1.2 Sampling at Future Pavement Areas

1) Subgrade

Sampling of subgrade materials in the future pavement areas in Santa Elena was carried out in the same way as described in Section 2.1.2 above.

4.1.3 Laboratory and Field Tests at Existing Pavement Area

1) Portland Cement Concrete Slabs

Compression tests were made for three drilled core samples obtained at Site No. 1 and 2. The results of these tests are shown in Table C-12.

2) Base

Grain size analysis (washed in sieve No. 200) were made on the samples obtained from the base at Site No. 1 and 2. In situ density thereof was obtained by the Sane Cone method. The results of these tests are indicated in Table C-13 and C-14.

3) Subgrade

The same field and laboratory tests were made on the samples obtained from subgrade at Site No. 1 and 2, and the test results are shown in Table C-15 and C-16.

4.1.4 Laboratory and Field Test at Future Pavement Areas

1) Subgrade

The same laboratory and field tests were conducted on the samples obtained from subgrade material at Site No. 1 and 2. The results of laboratory tests are shown in Table C-17 to C-19.

4.2 EVALUATION OF EXISTING PAVEMENT (SANTA ELENA)

The existing pavement composition is shown in Figure C-5. It is observed that the average thickness of portland cement concrete slab is 0.30 m at each investigation site. It is similar to those evaluated for the rigid pavement of La Aurora terminal apron area as noted in Section 2.3.2 above.

As in the case of La Aurora pavement, evaluation, PCN value of the existing runway concrete pavement is evaluated to be PCN 40.

C.5 GEOHYDROLOGICAL OBSERVATION AT SANTA ELENA

There has been an opinion that the cracks on the Santa Elena airport runway were caused by the rise in water level of the Lake Petén. To clarify the relation between the lake water level and the runway cracks, a geohydrological investigation has been carried out by measuring the lake water level and groundwater table near the runway.

The observation of groundwater table was carried out at the borehole-1 (BH-1) which was located to the north of the runway and closest to the lake among four boreholes. The groundwater table was measured at the intervals of about 10 days during the period from March to September 1989. At the same time, water level of the Lake Petén was recorded. Table C-20 and Figure C-8 show the result of records.

From the result of measurement, preliminary observations are made as summarized below.

a) During the observation period, groundwater table varied by nearly 2 m at maximum, while the variation of the Petén lake water was 0.6 m.

b) Pattern of variation at groundwater table and lake water is similar in general. However, the rise in water level at both borehole-1 and Lake Petén is considered to be attributable to rainfall and an increase in inflow at both site. Direct infiltration of the lake water into the runway subsoil was not detectable through the investigation.

c) As noted in the groundwater table on September 20, 1989, the water table was high enough to intrude onto the elevation of the runway subgrade. As noted in Section C.3, subsoils are sensitive to swelling in this area.

d) It is therefore considered that the rise in groundwater table attributable to intensive rainfall would be a major cause for the runway cracks, and the cracks would have been also aggravated by infiltration of water from the runway surface to the subsoils.

e) As noted in Section C.3, the subsoils in the area are sensitive to swelling, and it might have been desirable to install sub-drains in the subgrade layer to control the rise in groundwater table along the runway.

Table C-01 Laboratory Test of Core Samples at La Aurora

Strata	Bore Hole No.	Sample	Depth (m)	Tube or JAR	Grain Consistency					Classif-ication ASTM	Specific Gravity	Natural Moisture Content	Dry Unit Weight	Unconfined Compression	SPT (N)	Others
					Gravel	Sand	Clay & Silt	Liquid Limit	Plast-icity Index							
								WL	Ip							
					%	%	%	%	%			%	kg/m3	kg/cm2		
Vc2	1	J-1-2	4 ~ 4.45	JAR	0.6	45.5	51.5	36.4	5.7	ML	2.58	35.9	–	–	11	
Vc2	4	J-4-2	1.15 ~ 1.6	JAR	0.1	46.7	53.2	34.8	5.7	ML	2.67	31.1	–	–	23	
Vc2	4	MS-4-1	1.6 ~ 2.1	Tube	3.1	43.7	53.2	34.6	1.7	ML	2.5	34.3	1081.2	0.3333	(20)	
Vs2	1	J-1-1	2 ~ 2.45	JAR	4.5	86.5	10.4	NL	0	SW-SM	2.32	45.5	–	–	20	
Vs1	1	MS-1-1	5 ~ 5.6	Tube	5.6	82.3	12.1	NL	0	SM	2.43	43.2	862.76	–	(15)	
Vs1	4	J-4-3	3 ~ 3.45	JAR	7.3	79.8	12.9	NL	0	SM	2.44	74.6	–	–	13	
Vs1	4	J-4-4	4 ~ 4.45	JAR	6.3	68.3	25.4	NL	0	SM	2.43	33.2	–	–	17	
Vc1	1	MS-1-1A	5.6 ~ 5.7	Tube	–	–	–	–	–	ML	2.63	37.4	1054.7	–	(10)	
Vc1	4	J-4-5	5 ~ 5.45	JAR	0.3	43	56.7	45.6	8.1	ML	2.72	48.9	–	–	24	
Vc1	4	MS-4-2	9.3 ~ 6.45	Tube	0	56	44	37.5	2.6	ML	2.7	43	1217.7	1.4076	(25)	
V	1	J-1-3	6 ~ 6.45	JAR	1.8	61.8	38.2	NL	0	SM	2.45	31	–	–	19	
V	1	MS-1-2	10 ~10.39	Tube	0	77.9	22.1	NL	0	SM	2.63	17.6	–	–	(28)	
V	1	J-1-5	10.39 ~10.81	JAR	2.3	79.9	20.1	NL	0	SM	2.7	16.5	–	–	31	
V	1	J-1-7	14.4 ~14.85	JAR	6.4	72.5	25.2	NL	0	SM	2.74	12.6	–	–	77	
V	2	J-2-2	4 ~ 4.45	JAR	0	76.9	16.7	NL	0	SM	2.3	9.6	–	–	26	FINE SAND
V	2	MS-2-1	5 ~ 5.6	Tube	8.4	79.1	12.5	NL	0	SM	2.27	10.4	811.39	–	16	FINE SAND
V	2	MS-2-2	8.9 ~ 9.6	Tube	8.4	44.8	46.8	NL	0	SM	2.56	13.4	1245.93	–	20	
V	2	J-2-5	9.6 ~10.05	JAR	1.7	48.3	43.3	NL	0	SM	2.54	11.1	–	–	19	
V	2	J-2-7	13.6 ~14.05	JAR	1.4	57.4	40.9	NL	0	SM	2.52	9.9	–	–	18	
V	3	J-3-1	1 ~ 2.45	JAR	0.1	20.4	78.2	NL	0	ML	2.48	22.1	–	–	22	
V	3	MS-3-1	5 ~ 5.7	Tube	1.8	53.8	44.4	NL	0	SM	2.54	18.9	1368.62	–	(15)	FINE SAND
V	3	J-3-3	6 ~ 6.45	JAR	0.8	52.7	45.5	NL	0	SM	2.53	19.1	–	–	24	
V	3	MS-3-2	9.3 ~ 9.65	Tube	2.1	73.3	21.6	NL	0	SM	2.64	10.3	1206.03	–	(35)	
V	3	J-3-6	12 ~12.45	JAR	2.2	67.6	30.3	NL	0	SM	2.56	11.8	–	–	40	
V	4	J-4-5	10 ~10.45	JAR	1.3	65.2	33.5	NL	0	SM	2.63	15.5	–	–	24	

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Table C-02: LABORATORY TEST RESULTS
MARSHALL STABILITY TEST
DRILLED CORE SAMPLES

ASPHALTIC CONCRETE SURFACE OF EXISTING PAVEMENT

Investigation site No.	Sample No.	Total Thickness of Bituminous surface cm.	Thickness of sample cm.	Depth of test sample cm.	Diameter of test sample cm.	Height of test sample cm.	Compacted Density Lb/cft	Compacted Density gr/cm^3	Marshall Stability Kg	Marshall Stability Lbs	Flow 0.01"	Flow mm.
4	4-1	32.0	32.0	6.0-13.0	10.2	6.7	139.0	2.227	2046	4511	15	3.8
	4-2		27.0	12.0-19.0	10.2	7.1	134.0	2.146	1770	3903	18	4.6
	4-2-A		27.0	19.0-26.0	10.2	6.3	132.3	2.119	1664	3668	16	4.1
	4-3		20.0	6.5-13.0	10.2	6.5	138.6	2.220	1536	3386	17	4.3
5	5-1	22.0	22.0	5.0-12.0	10.2	7.3	131.9	2.113	1485	3273	15	3.8
	5-2	22.0	22.0	5.0-12.0	10.2	6.7	131.8	2.111	1504	3315	15	3.8
	5-2-A	22.0	22.0	11.0-18.0	10.2	5.6	138.8	2.224	2390	5269	13	3.3
	5-3	22.0	22.0	11.0-18.0	10.2	5.9	130.7	2.094	1733	3820	17	4.3
6	6-1	12.0	12.0	3.5- 9.0	10.2	6.3	133.7	2.142	1417	3124	15	3.8
	6-2	11.0	11.0	3.5- 9.0	10.2	5.3	132.9	2.129	2039	4495	15	3.8
	6-3	10.0	10.0	3.5- 9.0	10.2	4.8	133.1	2.132	1815	4002	16	4.1
6 A	6-4	25.0	25.0	5.0-11.5	10.2	6.2	140.4	2.249	1230	2712	24	6.1
	6-4-A		25.0	17.5-24.0	10.2	6.7	137.5	2.202	1628	3588	18	4.6

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Table C-03: LABORATORY TEST RESULTS
GRAIN SIZE ANALYSIS WITH SIEVES AND HYDROMETER
BASE, SUBBASE AND SUBGRADE

EXISTING PAVEMENT AREAS

Investigation Site No.	Layer or Course	Sample	Percent Passing Sieve No. (by weight) 2 1/2"	2"	1 1/2"	1"	3/4"	1/2"	3/8"	No. 4	No. 10	No. 40	No. 80	No. 200
4	Base	M-4BA				100.0	97.0	86.3	80.2	65.5	55.2	37.8	26.9	18.6
	Subbase													
	Subgrade	M-4SGA					100.0	98.6	97.6	92.2	83.4	61.5	46.4	32.0 (x)
5	Base	M-5BA		100.0	95.2	70.0	52.9	48.4	46.3	41.4	33.1	17.1	7.3	3.1
	Subbase	M-5SBA	100.0	96.1	94.0	87.3	82.1	72.7	67.5	56.8	50.1	34.6	26.7	18.9
	Subgrade	M-5SGA							100.0	99.5	95.5	76.0	58.8	39.2 (x)
6	Base	M-6BA				100.0	99.5	79.0	64.2	37.2	25.2	11.8	6.6	3.4
	Subbase	M-6SBA		100.0	95.2	88.6	83.2	76.3	72.4	64.3	55.2	35.0	23.0	13.0
	Subgrade	M-6SGA		100.0	96.4	89.1	86.2	81.7	78.2	70.6	62.2	44.7	31.3	19.4 (x)

Nb: (x) Grain Size analysis also made with hydrometer.
See attached curves.

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Table C-04: LABORATORY TEST RESULTS

NATURAL MOISTURE CONTENT, DRY UNIT WEIGHT, SPECIFIC GRAVITY, ATTERBERG LIMITS AND ASTM CLASSIFICATION

BASE, SUBBASE AND SUBGRADE

EXISTING PAVEMENT AREAS

Investigation Site No.	Layer or Course	Sample No.	Depth Below surface Meter	Field Moisture Content %	Field Dry unit weight Kg/m^3		Specific Gravity	Liquid limit %	Plasticity Index %	Classification ASTM
					Sand cone method	Paraffin coated method				
4	Base	M-4BA	0.20-0.40	17.6	1,819.9					SM
	Subbase Subgrade	M-4SGA	0.40-0.60	32.5		1,100.2	2.55	NL	0.0	SM
5	Base	M-5BA	0.22-0.30	4.9	2,017.4					GP
	Subbase	M-5SBA	0.30-0.40	7.9	2,185.2					SM
	Subgrade	M-5SGA	0.40-0.60	25.9		1,044.5	2.79	NL	0.0	SM
6	Base	M-6BA	0.25-0.40	6.7	2,071.6					GP
	Subbase	M-6SBA	0.40-0.60	11.2	1,814.8					SM
	Subgrade	M-6SGA	0.60-0.80	15.2		1,751.1	2.63	NL	0.0	SM

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Table C-05: LABORATORY TEST RESULTS

COMPACTION AND C.B.R. TESTS IN SUBGRADE SAMPLES

STATICALLY COMPACTED SPECIMENS WITH FIELD DENSITY AND MOISTURE CONTENT

EXISTING PAVEMENT AREAS

		FIELD CONDITIONS				C.B.R. TEST		
Investigation Site No.	Sample No.	Depth Below Surface Meter	Natural Moisture Content %	Natural Dry Density Kg/m^3	Average Compaction Moisture Content %	Average Compaction Dry Density Kg/m^3	Average CBR at	Average Moisture Content %
4	M-4SGA-S1	0.40-0.60	32.5	1,100.2	33.0	1,091.3	40.0	33.3
	M-4SGA-S2	0.40-0.60	32.5	1,100.2	33.0	1,062.9	42.5	33.3
5	M-5SGA-S1	0.40-0.60	25.9	1,044.5	27.4	1,031.7	4.3	26.0
	M-5SGA-S2	0.40-0.60	25.9	1,044.5	27.4	1,031.6	3.3	26.5
6	M-6SGA-S1	0.60-0.80	15.2	1,751.1	15.9	1,736.6	46.5	16.3
	M-6SGA-S2	0.60-0.80	15.2	1,751.1	15.9	1,738.2	48.7	15.6

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Table C-06: LABORATORY TEST RESULTS

COMPACTION AND C.B.R. TESTS IN SUBGRADE SAMPLES

DYNAMICALLY COMPACTED SPECIMENS (ASTM D 1557-78, MODIFIED)

EXISTING PAVEMENT AREAS

Investigation Site No.	Sample No.	Depth Below Surface Meter	Compaction Test		C.B.R. Test			
			Optimum Moisture Content %	Maximum Dry Density Kg/m^3	Penetration 0.254 mm.		Swelling - %	
					90% Compaction	95% Compaction	90% Compaction	95% Compaction
4	M-4SGA-D1	0.40-0.60	22.4	1,350.5	66.5	104.0	0.06	0.05
	M-4SGA-D2	0.40-0.60	22.4	1,350.5	74.0	95.5	0.06	0.05
5	M-5SGA-D1	0.40-0.60	25.7	1,465.8	49.5	79.5	0.11	0.04
	M-5SGA-D2	0.40-0.60	25.7	1,465.8	39.2	52.0	0.09	0.07
6	M-6SGA-D1	0.60-0.80	12.0	1,882.4	19.9	46.0	0.04	0.03
	M-6SGA-D2	0.60-0.80	12.0	1,882.4	20.0	53.0	0.00	0.00

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Table C-07: LABORATORY TEST RESULTS

GRAIN SIZE ANALYSIS WITH SIEVES AND HYDROMETER

SUBGRADE

FUTURE PAVEMENT AREAS

Investigation Site No.	Layer or Course	Sample	Percent Passing Sieve No. (by weight)											
			2 1/2"	2"	1 1/2"	1"	3/4"	1/2"	3/8"	No. 4	No. 10	No. 40	No. 80	No. 200
1	Subgrade	M-1SGA						100.0	99.7	99.5	99.1	86.5	43.5	5.6
2	Subgrade	M-2SGA							100.0	99.6	98.3	82.6	67.0	54.6 (x)
3	Subgrade	M-3SGA								100.0	99.5	93.1	82.8	73.2 (x)

Nb: (x) Grain Size Analysis also made with hydrometer.
See attached curves.

LOCATION: AURORA AIRPORT
GUATEMALA

Table C-08:

LABORATORY TEST RESULTS

NATURAL MOISTURE CONTENT, DRY UNIT WEIGHT, SPECIFIC GRAVITY, ATTERBERG LIMITS AND ASTM CLASSIFICATION

SUBGRADE

FUTURE PAVEMENT AREAS

Investigation Site No.	Layer or Course	Sample No.	Depth Below surface Meter	Field Moisture Content %	Field Dry unit weight Kg/m^3		Specific Gravity	Liquid limit %	Plasticity Index %	Classification ASTM
					Sand cone method	Paraffin coated method				
1	Subgrade	M-1SGA	0.55-0.85	17.7		992.7	2.31	NL	0.0	SP-SM
2	Subgrade	M-2SGA	0.45-0.70	23.5		1,355.5	2.70	49.7	16.1	ML
3	Subgrade	M-3SGA	0.50-0.80	29.8		1,271.9	2.80	50.3	18.8	MH

LOCATION: AURORA AIRPORT
GUATEMALA

Table C-09:

LABORATORY TEST RESULTS

COMPACTION AND C.B.R. TESTS IN SUBGRADE SAMPLES

STATICALLY COMPACTED SPECIMENS WITH FIELD DENSITY AND MOISTURE CONTENT

FUTURE PAVEMENT AREAS

		FIELD CONDITIONS				C.B.R. TEST		
Investigation Site No.	Sample No.	Depth Below Surface Meter	Natural Moisture Content %	Natural Dry Density Kg/m^3	Average Compaction Moisture Content %	Average Compaction Dry Density Kg/m^3	Average CBR at	Average Moisture Content %
1	M-1SGA-S1	0.55-0.85	17.7	992.7	18.6	1,004.4	34.5	17.1
	M-1SGA-S2	0.55-0.85	17.7	992.7	15.7	1,019.2	37.1	16.2
2	M-2SGA-S1	0.45-0.70	23.5	1,355.5	25.3	1,344.1	11.9	25.3
	M-2SGA-S2	0.45-0.70	23.5	1,355.5	24.2	1,361.7	9.6	24.2
3	M-3SGA-S1	0.50-0.80	29.8	1,271.9	27.7	1,304.0	24.0	27.7
	M-3SGA-S2	0.50-0.80	29.8	1,271.9	27.5	1,300.8	25.6	27.5

LOCATION: AURORA AIRPORT
GUATEMALA

Table C-10: LABORATORY TEST RESULTS
COMPACTION AND C.B.R. TESTS IN SUBGRADE SAMPLES
DYNAMICALLY COMPACTED SPECIMENS (ASTM D 1557-78, MODIFIED)
FUTURE PAVEMENT AREAS

			Compaction Test		C.B.R. Test			
					Penetration 0.254 mm.		Swelling - %	
Investigation Site No.	Sample No.	Depth Below Surface Meter	Optimum Moisture Content %	Maximum Dry Density Kg/m^3	90% Compaction	95% Compaction	90% Compaction	95% Compaction
1	M-1SGA-01	0.55-0.85	30.9	1,177.5	32.0	42.4	-0.02	-0.05
	M-1SGA-02	0.55-0.85	30.9	1,177.5	37.1	41.0	0.11	0.12
2	M-2SGA-01	0.45-0.70	21.5	1,638.8	1.9	2.7	5.4	5.0
	M-2SGA-02	0.45-0.70	21.5	1,638.8	1.7	2.8	5.7	5.2
3	M-3SGA-01	0.50-0.80	26.0	1,520.3	1.2	2.3	3.5	3.1
	M-3SGA-02	0.50-0.80	26.0	1,520.3	1.1	2.5	4.4	3.4

Table C-11 Laboratory Test of Core Samples at Santa Elena

Strata	Bore Hole No.	Sample	Depth (m)	Tube or JAR	Grain			Consistency		Classification ASTM	Specific Gravity	Natural Moisture Content	Dry Unit Weight	Unconfined Compression	SPT (N)	Others
					Gravel %	Sand %	Clay & Silt %	Liquid Limit WL %	Plasticity Index Ip %			%	kg/m3	kg/cm2		
Lg2	1	J-1-1	2 ~ 2.25	JAR	17.2	42.8	40	22.5	9	SC	2.73	12.5	–	–	—	
Lc	1	MS-1-1	4.7 ~ 5.35	Tube	0	15.2	84.8	25.9	10.4	CL	2.73	24.7	1591	0.2539	—	
Lc	1	J-1-2	6.5 ~ 6.95	JAR	0	6.2	93.8	87	49.4	CH	2.88	34.3	–	–	16	
Lc	1	HS-1-2	9.7 ~ 10.4	Tube	0	1.8	98.2	100.1	63.1	CH	2.9	38	1353.7	1.6019	20	
Lc	1	J-1-5	12.5 ~12.95	JAR	0	1.6	98.4	106.1	63.3	CH	2.81	39	–	–	26	
Lc	2	J-2-1	1 ~ 1.45	JAR	0	6.6	93.4	103.4	61	CH	2.72	36.8	–	–	12	
Lc	3	HS-3-1	1 ~ 1.7	Tube	0	20.8	79.2	80.7	43	MH	2.88	31.8	1459.8	0.4303	—	
Lc	3	J-3-1	1.7 ~ 2.05	JAR	0	11.8	88.2	77.4	44.7	CH	2.82	31.6	–	–	7	
Lc	3	J-3-1A	2.05 ~ 2.15	JAR	–	–	–	–	–	–	–	35.7	–	–	—	
Lc	3	J-3-2	3.7 ~ 4.15	JAR	0	6.4	93.6	107	66.1	CH	2.9	35.4	–	–	10	
Lc	3	J-3-3	6.5 ~ 6.95	JAR	0	22.3	77.7	44.2	20.7	CL	2.81	22.6	–	–	35	
Lc	3	J-3-5	11 ~11.45	JAR	0	24.6	75.4	52	26.9	CH	2.84	21.1	–	–	31	
Lm	1	HS-1-3	13.85 ~14.55	Tube	0	1.8	98.2	96.1	45.3	MH	2.91	38	1351.1	0.89617	(26)	
Lm	2	MS-2-1	2.5 ~ 3.2	Tube	0	16.6	83.4	88.5	50.1	MH	2.56	40.5	1355	1.35455	(20)	
Lm	2	J-2-3	5 ~ 5.45	JAR	0	2	98	111.2	62.7	MH	2.82	41.2	–	–	16	
Lm	2	MS-2-2	7 ~ 7.7	Tube	0	1	99	104.8	54.1	MH	2.9	40.7	1312.4	2.2912	(16)	
Lm	2	J-2-4	7.7 ~ 8.15	JAR	0	15.6	84.4	72.5	31.1	MH	2.56	78.2	–	–	16	
Lm	2	J-2-6	11.7 ~12.15	JAR	0	1.4	98.6	128.5	74.2	MH	2.84	41.6	–	–	14	
Lm	2	MS-2-3	13 ~ 13.7	Tube	0	2.6	97.4	118.8	67.3	MH	2.87	41.3	1297.8	0.95838	(17)	
Lm	2	J-2-7	14.55 ~ 15	JAR	0	5.8	94.2	121.9	78.5	CH	2.84	46.1	–	–	18	

LOCATION: SANTA ELENA AIRPORT
GUATEMALA

Table C-12: LABORATORY TEST RESULTS
COMPRESSIVE STRENGHT OF DRILLED CORES
CONCRETE SAMPLES
PORTLAND CEMENT CONCRETE EXISTING PAVEMENT

Investigation site	Sample No.	Total Thickness of slabs cm.	Thickness of test sample cm.	Diameter of test sample cm.	Density Kg/m^3	Total Load Kg	Compressive Strenght Kg/cm^2
1	1-1	30.0	22.3	12.09	2.389	53.400	459.6
	1-2	30.0	23.9	12.11	2.311	52.200	452.5
	1-3	30.0	26.3	12.10	2.368	52.600	457.7
2	2-1	30.0	26.9	12.10	2.312	56.000	487.4
	2-2	30.0	21.5	12.10	2.387	50.900	435.2
	2-3	30.0	25.8	12.10	2.387	53.800	468.2

LOCATION: SANTA ELENA AIRPORT
GUATEMALA

Table C-13: LABORATORY TEST RESULTS
GRAIN SIZE ANALYSIS WITH SIEVES AND HYDROMETER
BASE, SUBBASE AND SUBGRADE
EXISTING PAVEMENT AREAS

			Percent Passing Sieve No. (by weight)											
Investigation Site No.	Layer or Course	Sample	2 1/2"	2"	1 1/2"	1"	3/4"	1/2"	3/8"	No. 4	No. 10	No. 40	No. 80	No. 200
1	Base	M-1BSE		100.0	97.1	89.2	84.7	74.1	66.7	50.8	34.3	21.0	17.5	14.7
	Subbase Subgrade	M-1SGSE	100.0	90.7	87.4	75.5	68.3	59.0	53.4	43.8	36.2	29.8	26.8	23.9 (x)
2	Base	M-2BSE			100.0	93.7	79.6	65.5	58.5	43.8	32.5	22.8	19.7	16.8
	Subbase Subgrade	M-2SGSE		100.0	96.1	81.2	73.2	62.0	55.0	42.1	33.0	26.4	23.6	20.6 (x)

NB: (x) Grain Size Analysis also made with hydrometer.
See attached curves.

LOCATION: SANTA ELENA AIRPORT
GUATEMALA

Table C-14: LABORATORY TEST RESULTS

NATURAL MOISTURE CONTENT, DRY UNIT WEIGHT, SPECIFIC GRAVITY, ATTERBERG LIMITS AND ASTM CLASSIFICATION

BASE, SUBBASE AND SUBGRADE

EXISTING PAVEMENT AREAS

Investigation Site No.	Layer or Course	Sample No.	Depth Below surface Meter	Field Moisture Content %	Field Dry unit weight Kg/m^3		Specific Gravity	Liquid limit %	Plasticity Index %	Classification ASTM
					Sand cone method	Paraffin coated method				
1	Base	M-1BSE	0.30-0.50	5.0	2,162.7					GM
	Subbase Subgrade	M-1SGSE	0.50-0.80	7.1	2,403.0		2.78	21.1	5.0	GC-GM
2	Base	M-2BSE	0.30-0.50	5.4	2,324.5					GM
	Subbase Subgrade	M-2SGSE	0.50-0.80	4.4	2,404.6		2.76	18.7	4.1	GC-GM

LOCATION: SANTA ELENA AIRPORT
GUATEMALA

Table C-15: LABORATORY TEST RESULTS

GRAIN SIZE ANALYSIS WITH SIEVES AND HYDROMETER

SUBGRADE

FUTURE PAVEMENT AREAS

Investigation Site No.	Layer or Course	Sample	Percent Passing Sieve No. (by weight)											
			2 1/2"	2"	1 1/2"	1"	3/4"	1/2"	3/8"	No. 4	No. 10	No. 40	No. 80	No. 200
3	Subgrade	M-3SGSE								100.0	99.5	96.8	94.9	92.4 (x)
4	Subgrade	M-4SGSE					100.0	99.4	98.9	96.3	93.8	88.0	84.5	78.2 (x)

NB: (x) Grain Size Analysis also made with hydrometer.
See attached curves.

LOCATION: SANTA ELENA AIRPORT
GUATEMALA

Table C-16: LABORATORY TEST RESULTS

NATURAL MOISTURE CONTENT, DRY UNIT WEIGHT, SPECIFIC GRAVITY, ATTERBERG LIMITS AND ASTM CLASSIFICATION

SUBGRADE

FUTURE PAVEMENT AREAS

Investigation Site No.	Layer or Course	Sample No.	Depth Below surface Meter	Field Moisture Content %	Field Dry unit weight Kg/m^3		Specific Gravity	Liquid limit %	Plasticity Index %	Classification ASTM
					Sand cone method	Paraffin coated method				
3	Subgrade	M-3SGSE	0.60-0.80	37.8		1,225.3	2.73	85.5	43.6	MH
4	Subgrade	M-4SGSE	0.60-0.80	32.2		1,450.6	2.80	49.9	27.6	CL

LOCATION: SANTA ELENA AIRPORT
GUATEMALA

Table C-17: LABORATORY TEST RESULTS

COMPACTION AND C.B.R. TESTS IN SUBGRADE SAMPLES

STATICALLY COMPACTED SPECIMENS WITH FIELD DENSITY AND MOISTURE CONTENT

EXISTING PAVEMENT AREAS

		FIELD CONDITIONS				C.B.R. TEST		
Investigation Site No.	Sample No.	Depth Below Surface Meter	Natural Moisture Content %	Natural Dry Density Kg/m^3	Average Compaction Moisture Content %	Average Compaction Dry Density Kg/m^3	Average CBR at	Average Moisture Content %
1	M-1SGSE-S1	0.50-0.80	7.1	2,403.0	8.0	2,358.1	62.3	6.5
	M-1SGSE-S2	0.50-0.80	7.1	2,403.0	8.0	2,351.7	77.7	7.5
2	M-2SGSE-S1	0.50-0.80	4.4	2,404.6	4.7	2,393.0	179.0	4.7
	M-2SGSE-S2	0.50-0.80	4.4	2,404.6	4.7	2,390.2	181.8	4.9

Table C-18: FUTURE PAVEMENT AREAS

			FIELD CONDITIONS			C.B.R. TEST		
Investigation Site No.	Sample No.	Depth Below Surface Meter	Natural Moisture Content %	Natural Dry Density Kg/m^3	Average Compaction Moisture Content %	Average Compaction Dry Density Kg/m^3	Average CBR at	Average Moisture Content %
3	M-3SGSE-S1	0.60-0.80	37.8	1,225.3	37.1	1,203.1	13.6	37.1
	M-3SGSE-S2	0.60-0.80	37.8	1,225.3	37.1	1,203.1	11.8	37.0
4	M-4SGSE-S1	0.60-0.80	32.2	1,450.6	33.3	1,437.0	1.1	33.1
	M-4SGSE-S2	0.60-0.80	32.2	1,450.6	33.3	1,437.0	1.3	32.5

Table C-19: LABORATORY TEST RESULTS

COMPACTION AND C.B.R. TESTS IN SUBGRADE SAMPLES

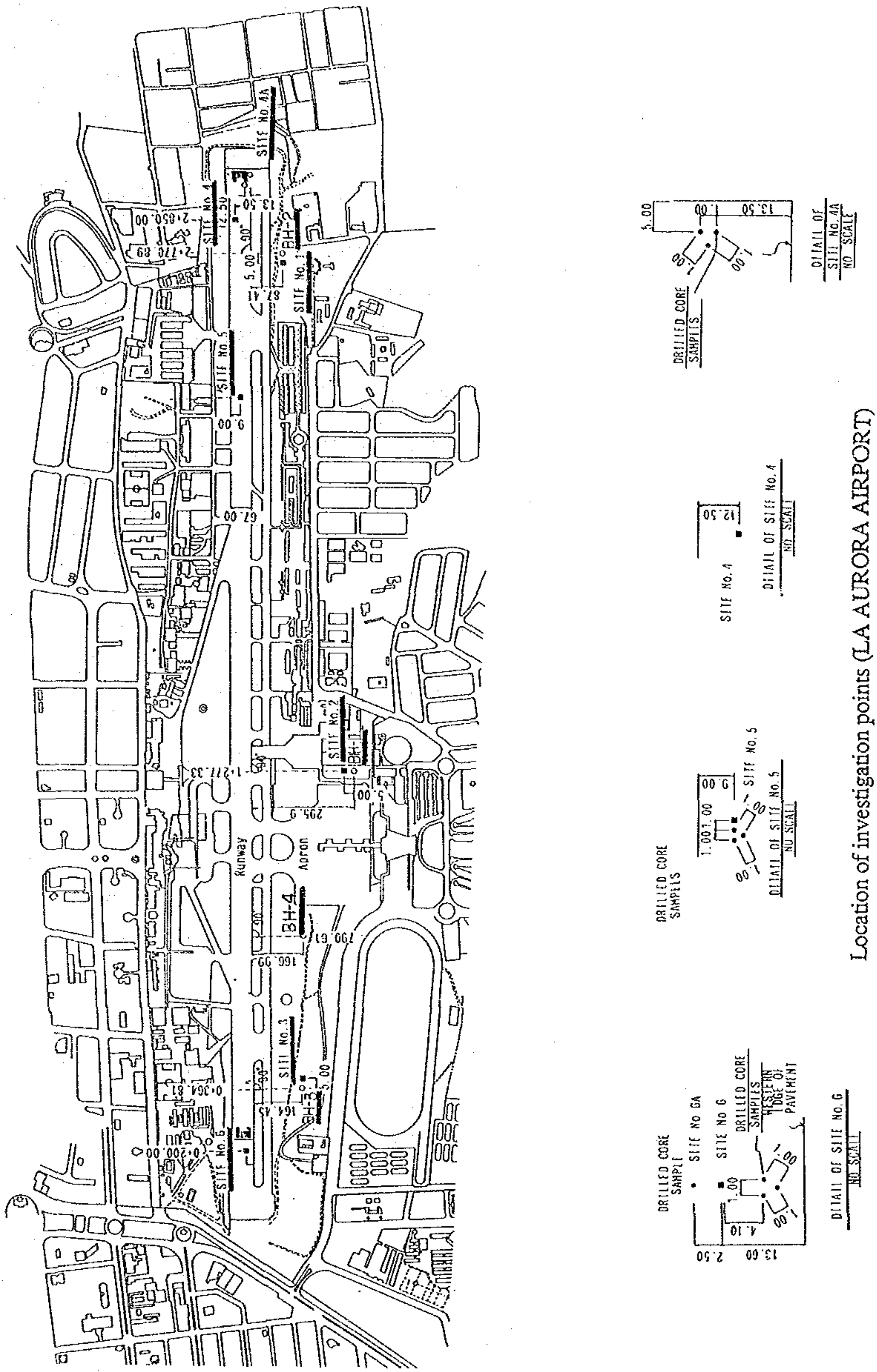
DYNAMICALLY COMPACTED SPECIMENS (ASTM D 1557-78, MODIFIED)

FUTURE PAVEMENT AREAS

			COMPACTION TEST		C.B.R. TEST			
					Penetration 0.254 mm.		Swelling %	
Investigation Site No.	Sample No.	Depth Below Surface Meter	Optimum Moisture Content %	Maximum Dry Density Kg/m^3	90% Compaction	95% Compaction	90% Compaction	95% Compaction
3	M-3SGSE-D1	0.60-0.80	31.2	1,448.2	5.95	9.98	4.3	4.0
	M-3SGSE-D2	0.60-0.80	31.2	1,448.2	3.60	6.90	5.1	5.2
4	M-4SGSE-D1	0.60-0.80	16.0	1,765.4	0.85	0.89	11.3	9.9
	M-4SGSE-D2	0.60-0.80	16.0	1,765.4	0.85	0.89	11.3	11.1

Table C-20 Lake Petén and Borehole No. 1 Water Level

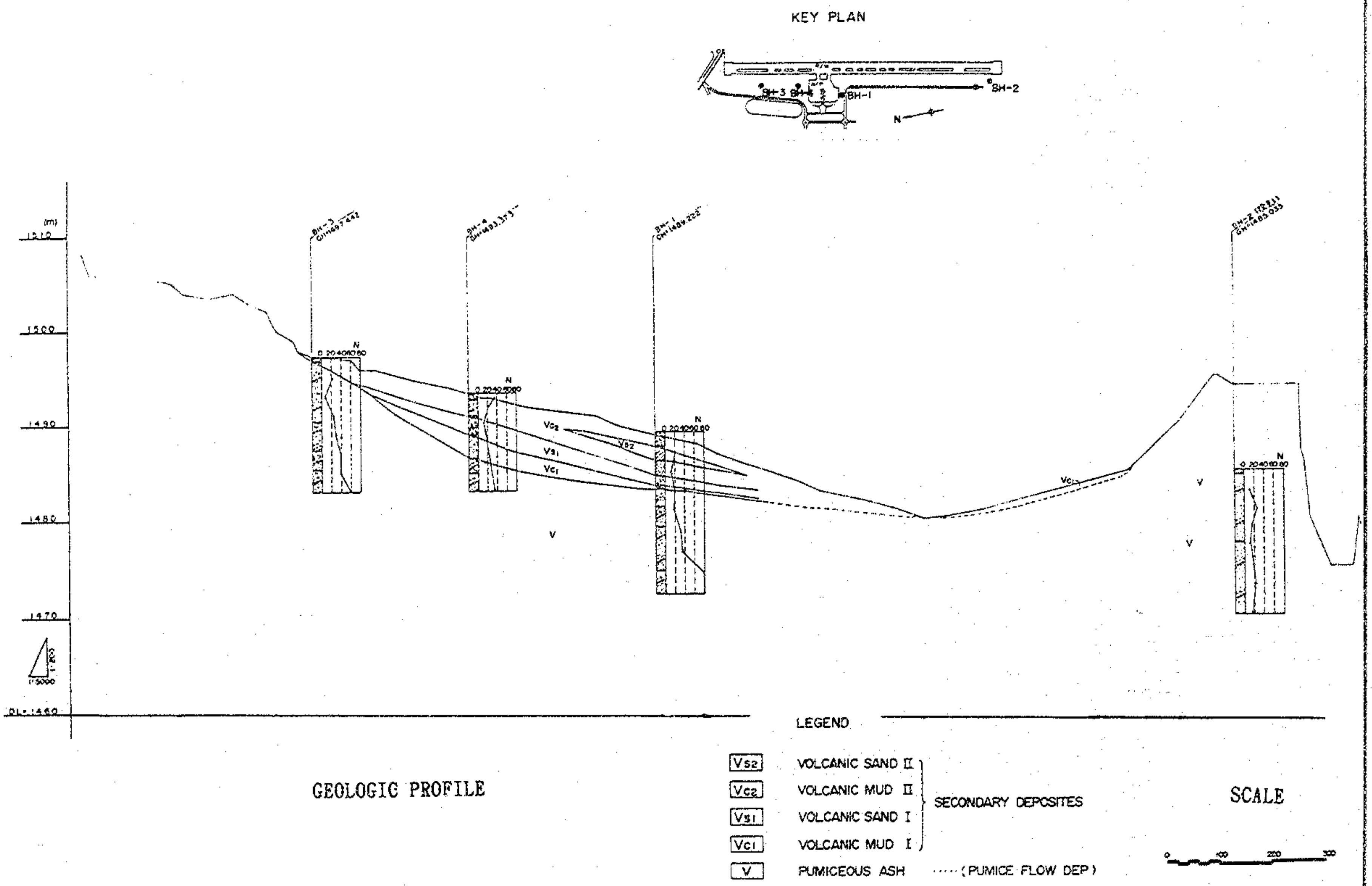
Number	Date	Borehole No. 1 Groundwater Level (m)	Lake Water Elevation (m)
1	2/3/89	EL. 116.68	EL. 113.67
2	15/3/89	117.23	113.66
3	27/3/89	117.09	113.65
4	6/4/89	116.74	113.65
5	21/4/89	117.27	113.57
6	4/5/89	116.18	113.47
7	16/5/89	117.33	113.49
8	28/5/89	117.23	113.48
9	9/6/89	116.83	113.39
10	19/6/89	117.60	113.43
11	20/6/89	117.78	113.54
12	10/7/89	117.90	113.48
13	20/7/89	117.50	113.54
14	31/7/89	117.54	113.54
15	20/8/89	117.60	113.42
16	21/8/89	117.41	113.37
17	31/8/89	117.32	113.37
18	10/9/89	117.43	113.34
19	20/9/89	118.12	113.52



Location of investigation points (LA AURORA AIRPORT)

DEVELOPMENT PROJECT OF LA AURORA AND SANTA ELENA AIRPORTS

Figure C－1

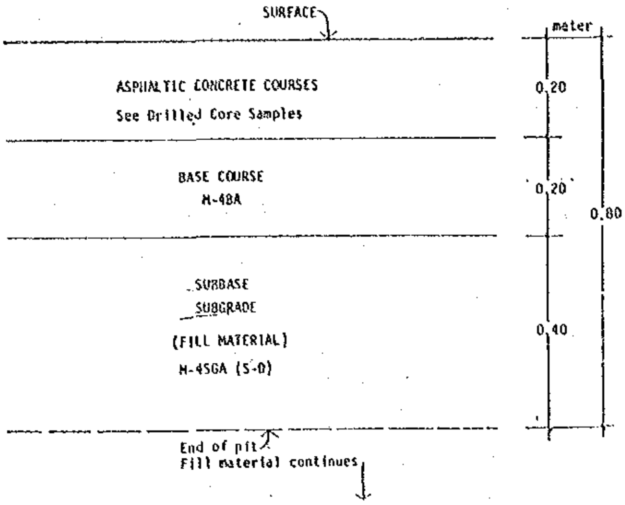


GEOLOGIC PROFILE

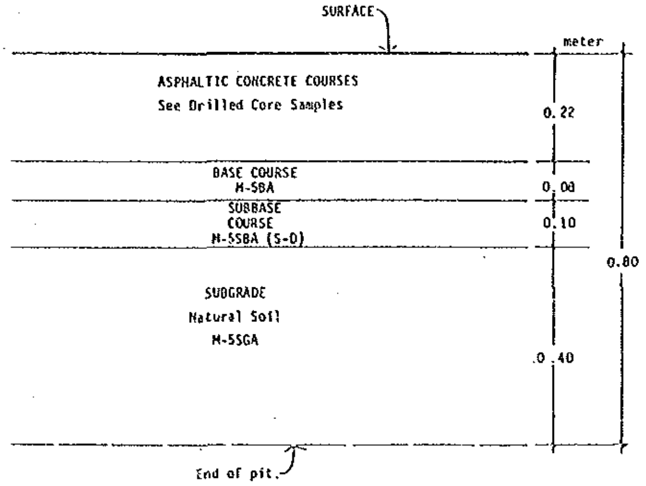
DEVELOPMENT PROJECT OF LA AURORA AND SANTA ELENA AIRPORTS

Figure C – 2

INVESTIGATION POINT PROFILES
EXISTING PAVEMENT AREAS
LA AURORA AIRPORT



SITE No. 4



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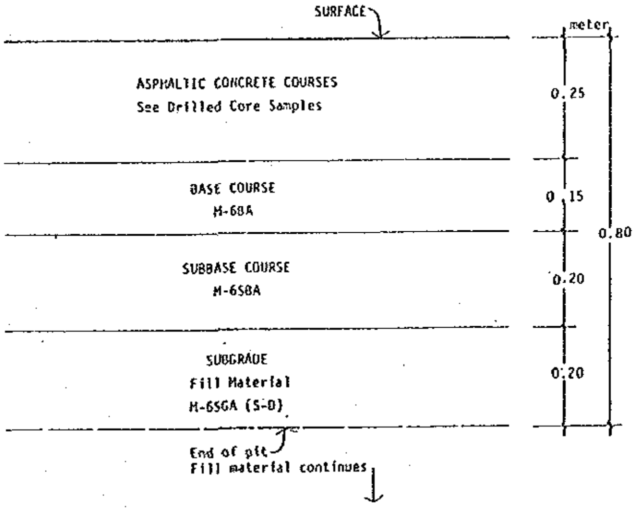
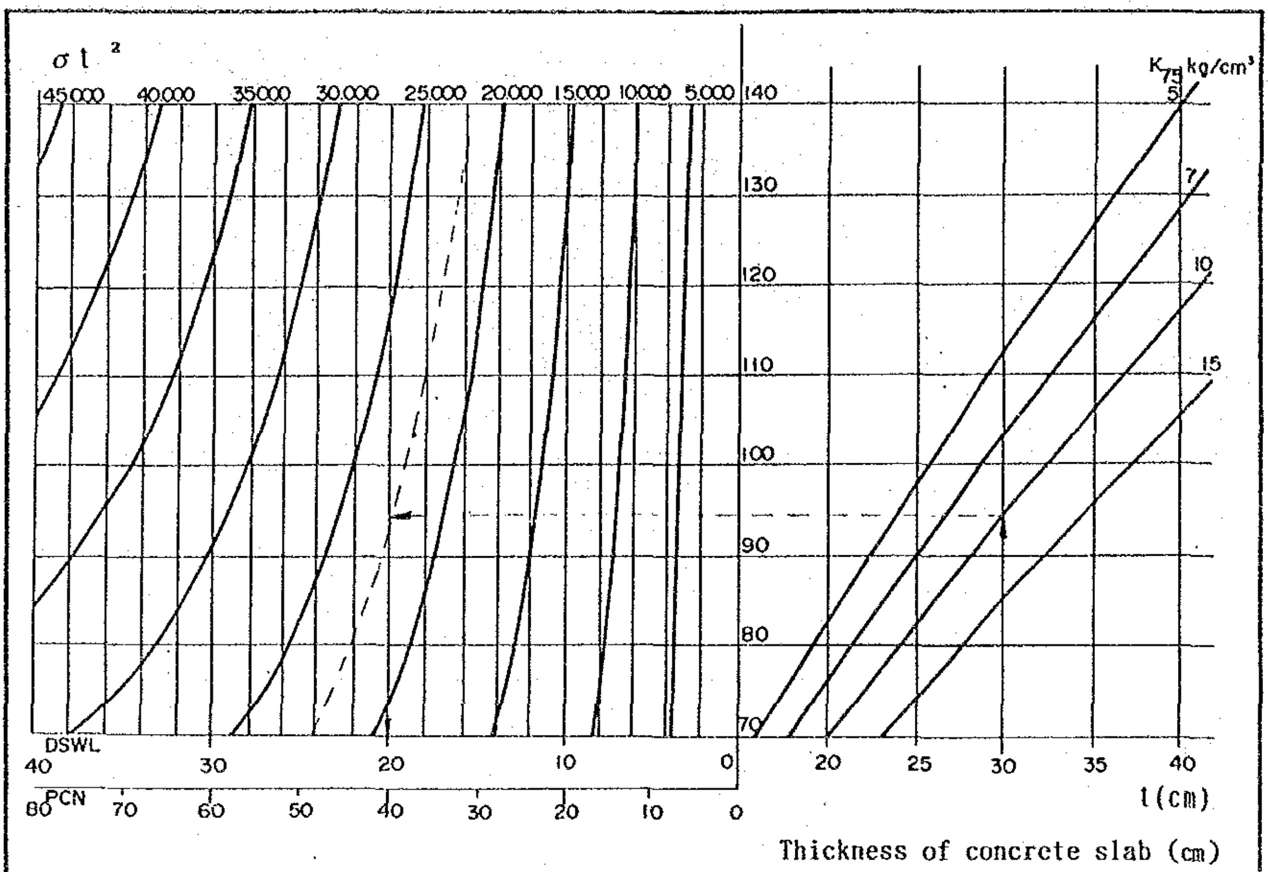
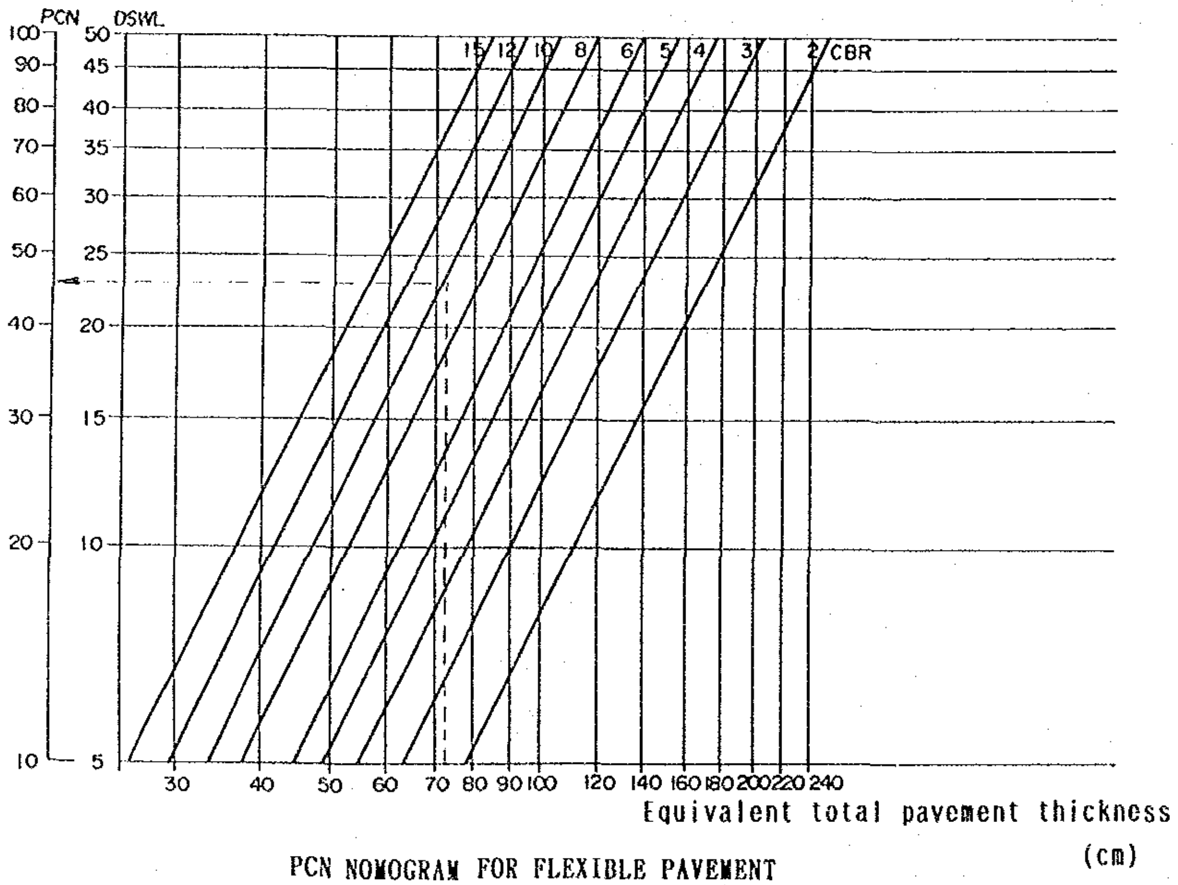


SITE No. 6

DEVELOPMENT PROJECT OF LA AURORA AND SANTA ELENA AIRPORTS | Figure C – 3

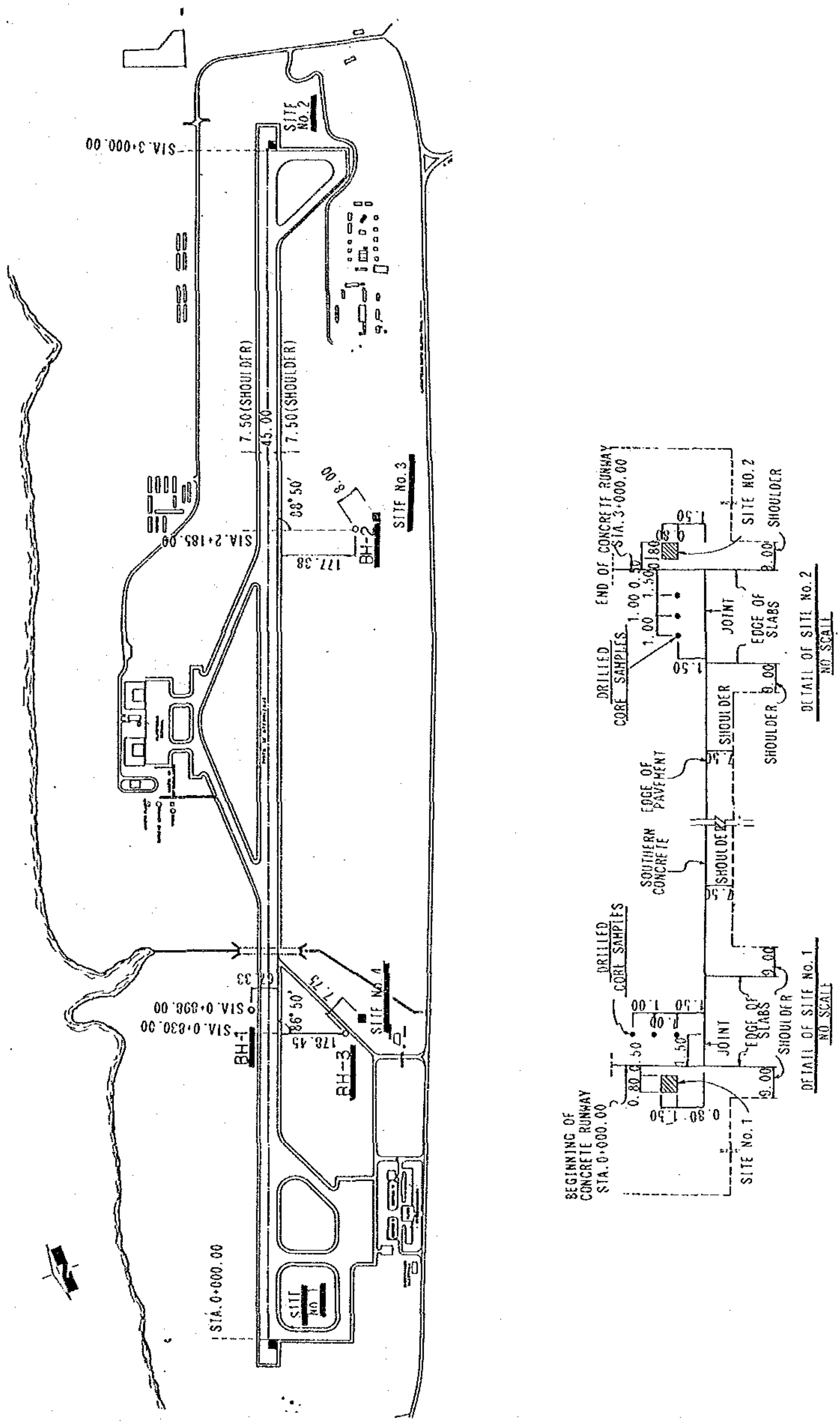


PCN NOMOGRAM FOR RIGET PAVEMENT



PCN NOMOGRAM FOR FLEXIBLE PAVEMENT

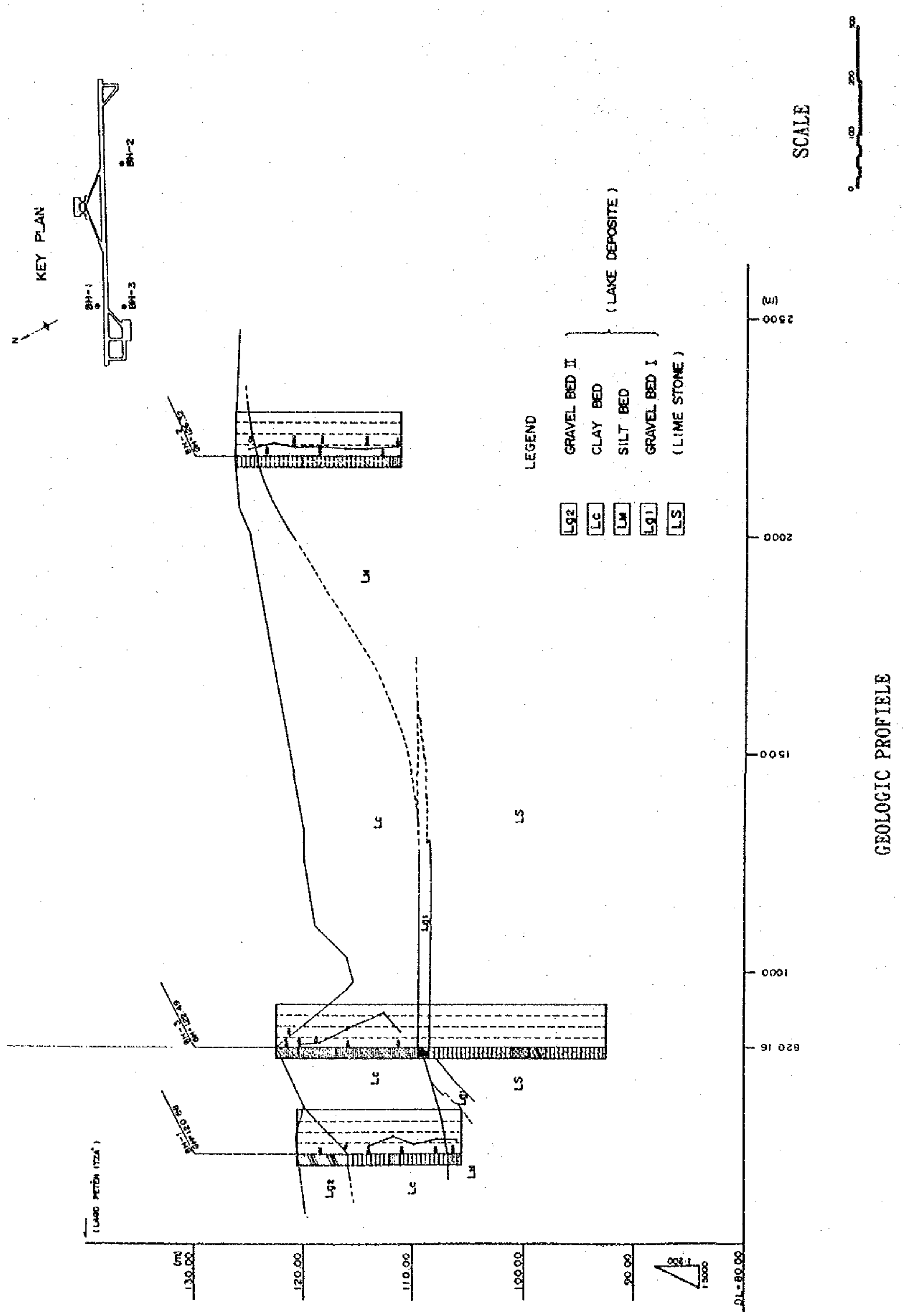
DEVELOPMENT PROJECT OF LA AURORA AND SANTA ELENA AIRPORTS	Figure C-4



Location of investigation points (SANTA ELENA AIRPORT)

DEVELOPMENT PROJECT OF LA AURORA AND SANTA ELENA AIRPORTS

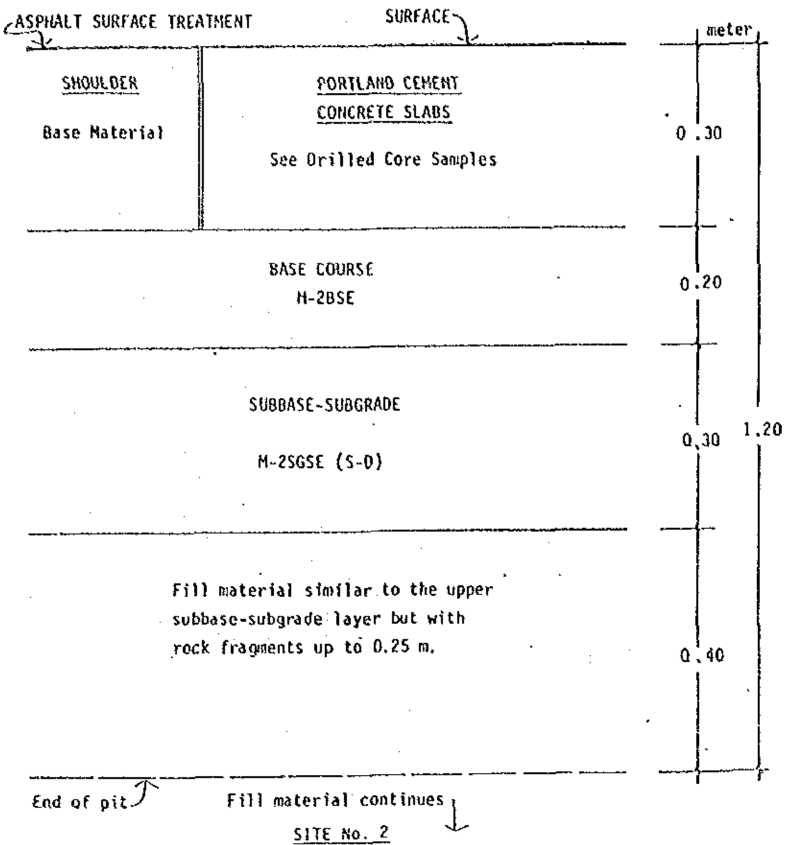
Figure C – 5



GEOLOGIC PROFIELE

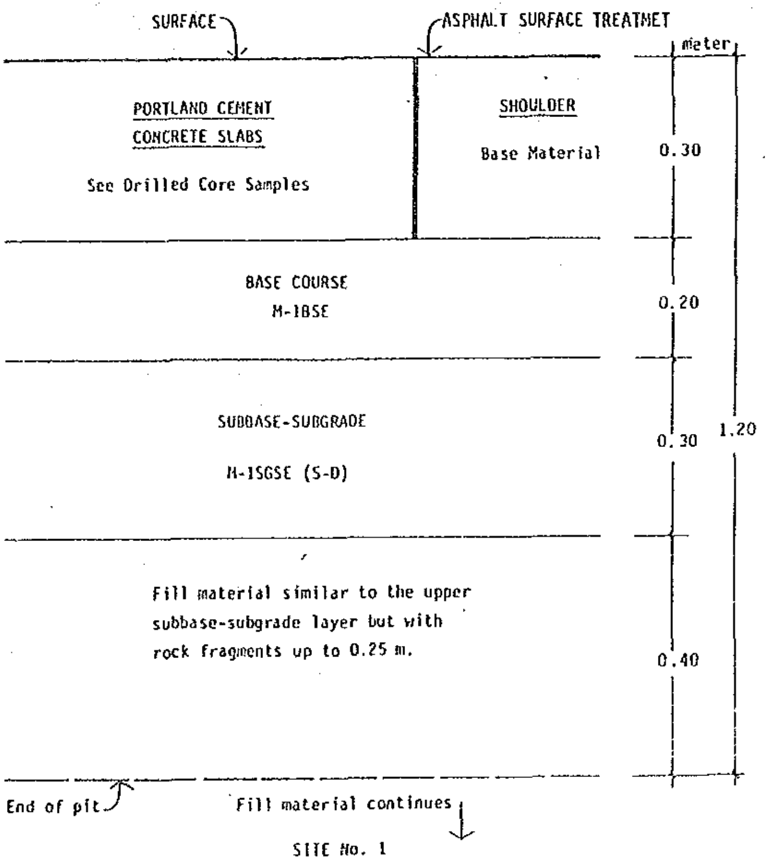
DEVELOPMENT PROJECT OF LA AURORA AND SANTA ELENA AIRPORTS

Figure C − 6



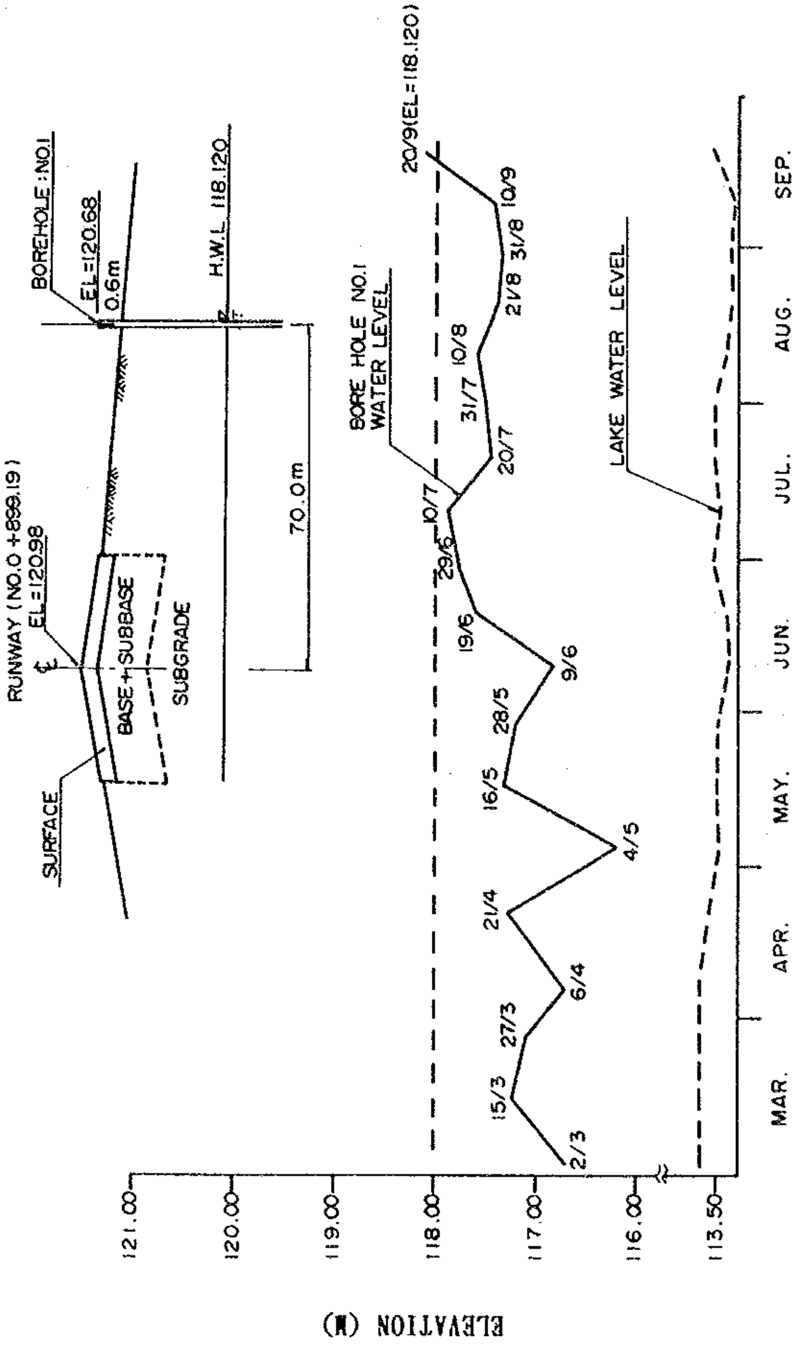
SITE No. 2

INVESTIGATION POINT PROFILES
EXISTING PAVEMENT AREAS
SANTA ELENA AIRPORT



SITE No. 1

DEVELOPMENT PROJECT OF LA AURORA AND SANTA ELENA AIRPORTS	Figure C – 7



WATER LEVELS IN SANTA ELENA AREA

DEVELOPMENT PROJECT OF LA AURORA AND SANTA ELENA AIRPORTS | Figure C-8

APPENDIX - D

ANALYSIS ON RUNWAY LENGTH

(LA AURORA)

AND LOCATION OF RAPID-EXIT TAXIWAY

ANALYSIS ON RUNWAY LENGTH (LA AURORA) AND LOCATION OF RAPID-EXIT TAXIWAY

D.1 ANALYSIS ON RUNWAY LENGTH (LA AURORA)

The extension of the runway at La Aurora is not practically feasible due to topographic conditions and land use to the north and south of the airport. Under such conditions, some weight limitations will have to be imposed in accordance with the air range. The relation between weight and air range has been analyzed herein.

In analyzing the relation, following aerodrome data and aircraft data have been utilized:

a) Aerodrome Characteristics

Aerodrome elevatin	: 1,509,639 m AMSL
Aerodrome reference temperature	: 27.10°C
Temperature in standard atmosphere or aerodrome elevation	: 5.187°C
Slope or runway	: 0.757%

b) Aircraft Characteristics : Shown in Table D-1:

The relation between take-off weight and air range for each type of aircrafts is illustrated in Figure D-1. For major destinations, the extent of the maximum take-off weight against the structural payload is summarized also in Table D-2.

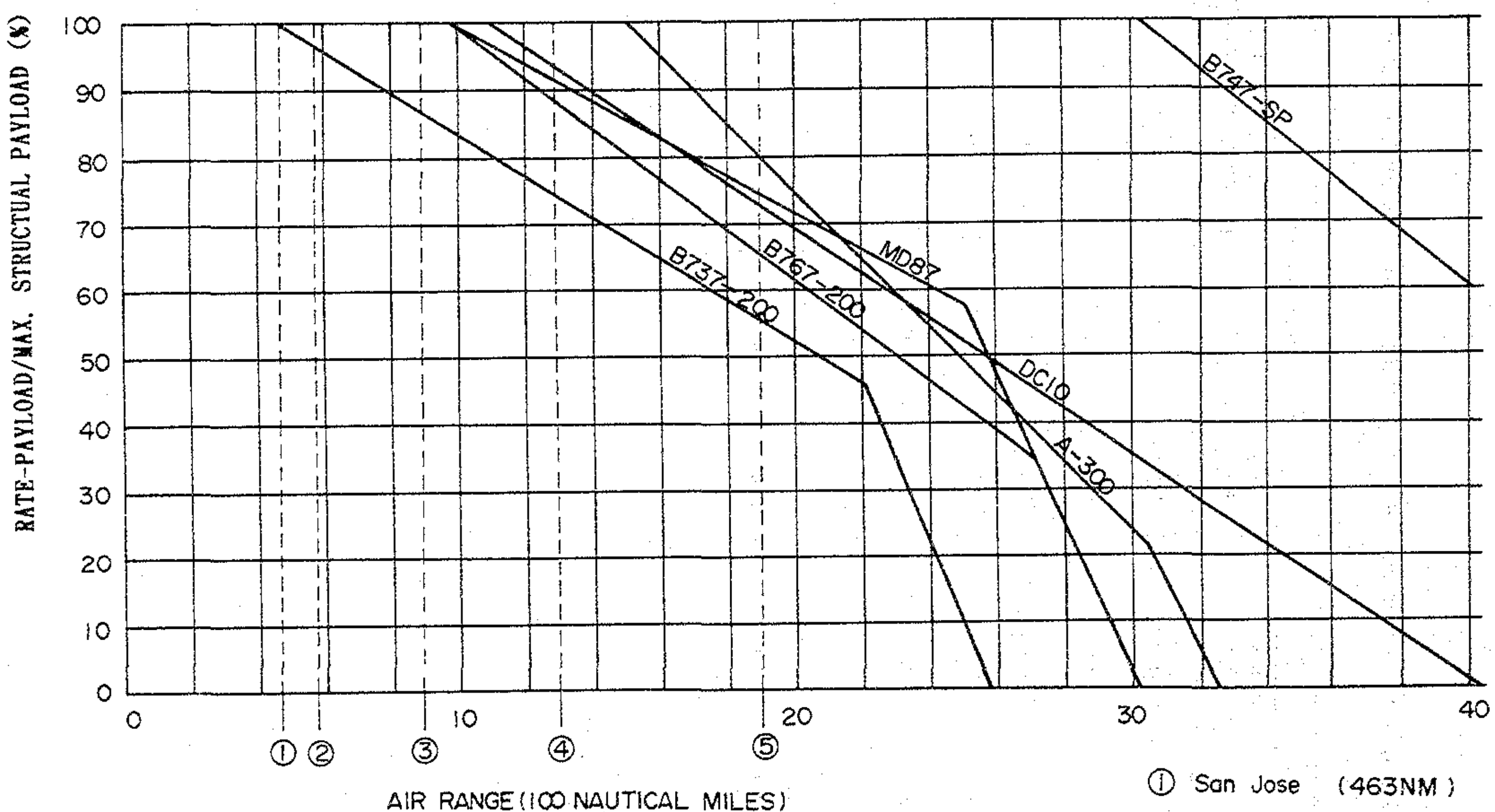
Table D-1 AIRCRAFT CHARACTERISTICS

		AIRCRAFT					
CHARACTERISTIC	UNIT	B737-200	MD87	B767-200	A-300	DC-10-40	B747-SP
MAXIMUM RAMP WEIGHT	POUNDS (KILOGRAMS)	116,000 (52,660)	150,500 (68,266)	282,000 (127,900)	365,740 (165,900)	558,000 (253,105)	703,000 (318,800)
MAXIMUM TAKEOFF WEIGHT	POUNDS (KILOGRAMS)	115,500 (52,440)	149,500 (67,812)	280,000 (127,000)	363,756 (165,000)	555,000 (251,744)	696,000 (315,600)
MAXIMUM LANDING WEIGHT	POUNDS (KILOGRAMS)	103,000 (b) (46,760)	130,000 (58,967)	255,000 (115,700)	295,414 (134,000)	403,000 (182,798)	450,000 (204,100)
ZERO-FUEL WEIGHT	POUNDS (KILOGRAMS)	95,000 (43,130)	112,000 (50,802)	240,000 (108,900)	273,369 (124,000)	368,000 (166,922)	410,000 (185,940)
OPERATING EMPTY WEIGHT (SPEC)	POUNDS (KILOGRAMS)	60,170 (27,320)	74,880 (33,965)	177,830 (80,700)	195,117 (88,505)	270,213 (122,567)	326,270 (147,970)
MAXIMUM STRUCTURAL PAYLOAD	POUNDS (KILOGRAMS)	34,830 (15,810)	37,120 (16,837)	62,170 (28,200)	78,252 (35,495)	97,787 (44,356)	83,730 (37,970)
MAXIMUM SEATING CAPACITY	PASSENGERS	130	139	211 (221)	269	255 (399)	331 (297)
MAXIMUM CARGO VOLUME-BELOW DECK	CUBIC FEET (CUBIC METERS)	875 (24.8)	695 (19.7)	3,100 (88.0)	4,944 (140.0)	4,618 (130.77)	3,500 (99.0)
MAXIMUM CARGO VOLUME--MAIN DECK	CUBIC FEET (CUBIC METERS)	-	-	-	-	-	400 (11.0)
USABLE FUEL CAPACITY	U.S. GALLONS (LITERS)	5,151 (19,500)	6,981 (21,215)	11,000 (33,400)	11,623 (58,100)	36,652 (137,509)	48,780 (184,630)

Table D-2 Maximum Take-Off Weight Against Structural Payload

Aircraft	Destination (Distance)				
	San Jose (463 NM)	Mexico City (571 NM)	Miami (571 NM)	Atlanta (1,292 NM)	Los Angeles (1,905 NM)
B737-200	100 %	97 %	87 %	75 %	55 %
MD87	100	100	100	91	74
A300-B4	100	100	100	100	73
B767-200	100	100	100	89	65
DC-10-40	100	100	100	92	72
B747-SP	100	100	100	100	100

Maximum Take-off Weight / Structural Payload = %



RELATION BETWEEN TAKE OFF
WEIGHT AND FLIGHT RANGE

D.2 ANALYSIS ON LOCATION OF RAPID-EXIT TAXIWAY

In the Master Plan improvement for La Aurora, as well as in the Intermediate improvement for Santa Elena, it is proposed to provide the rapid-exit taxiways for more efficient airport operations.

In this relation, analysis has been made on the location of such rapid-exit taxiways at La Aurora and Santa Elena, as explained hereunder.

2.1 Conditions of Analysis

1) Assumed Types of Aircraft

B-737-200
A-300 B4
DC-10-30
B747-200

2) Touch Down Speed (V_1)

Touch down speed is 1.3 times larger than strolling speed at maximum aircraft landing weight.

B-737-200	68.2 m/sec	(132.6 kt)
A-300 B4	70.6 m/sec	(137.3 kt)
DC-10-30	76.1 m/sec	(148 kt)
B747-200	73.1 m/sec	(142 kt)

3) Distance from the Threshold to Touch Down (S_1)

$S_1 = 450$ m

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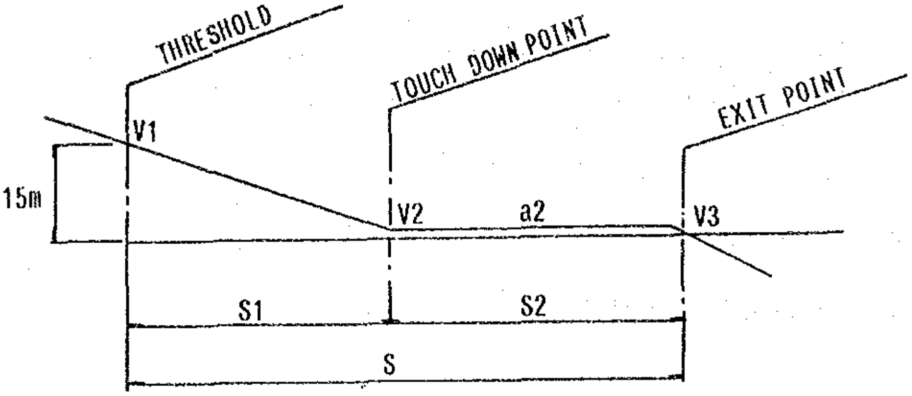
4) Deceleration Ratio from touch down point to runway end (a_1)

$a_1 = 0.88$ m/sec^2
ICAO AERODROME MANUAL, 2nd 1965
FAA AC 150/5335-1, 1965



5) Deceleration Ratio from touchdown point to beginning point of exit curve (a_2)

$a_2 = 1.52$ m/sec^2(±20%)
ICAO AERODROME DESIGN MANUAL PART 2, 2nd 1983

6) Exit speed (v_3)

$V_3 = 93$ km/hr $= 25.8$ m/sec

7) Sea level elevation and temperature

Airport	Sea Level Elevation (m)	Temperature (°C)
La Aurora	1,478	27.1
Santa Elena	128	35.6

2.2 Calculation for Exit Point

1) Touch Down Speed (V_2)

$$\begin{aligned} V_2 &= \sqrt{V_1^2 - 2a_1s_1} \\ &= \sqrt{V_1^2 - 2 \times 0.88 \times 450} \end{aligned}$$

Types of Aircraft	V_2 (km/hr)
B737-200	62.1
A300-B4	64.7
DC10-30	70.7
B747-200	67.5

2) Calibration for sea level elevation and temperature

a) Sea level elevation calibration (c_1)

The calibration at a rate of 3% shall be made to every 300 m (1,000 ft) of elevation increment.

$c_1 = 1 + 0.03 \times H/300$
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b) Temperature calibration (c_2)

The temperature above 15°C (59°F) shall be calibrated at 1% against an increase of 5.6°C (10°F).

$C_2 = 1 + 0.01 \times (T - 15 + 0.0065 \times H)/5.6$
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c) Calibration for sea level elevation and temperature

Airport	$c_1 = 1 + 0.03xH/300$	$c_2 = 1 + 0.01x(T-15)15.6$	$c_2 = c_1 \times c_2$
La Aurora	1.148	1.022	1.173
Santa Elena	1.013	1.037	1.050

2.3 Location of Exit Point

Airport	Aircraft	v_1 (m/sec)	a_1 (m/sec^2)	s_1 (m)	v_2 (m/sec)	a_2 (m/sec^2)	v_3 (m/sec)	s_2 (m)	s_1+s_2 (m)	c x (s_1+s_2) (m)
La Aurora	A300-B4	70.6	0.88	450	64.7	1.52	25.8	1,158	1,608	1,886
	DC10-30	76.1	0.88	450	70.7	1.52	25.8	1,425	1,875	2,199
	B747-200	73.1	0.88	450	67.5	1.52	25.8	1,280	1,730	2,029
Santa Elena	B737	68.2	0.88	450	62.1	1.52	25.8	1,050	1,500	1,575
	DC10-30	76.1	0.88	450	70.7	1.52	25.8	1,425	1,875	1,970

APPENDIX - E

RUNWAY CAPACITY ESTIMATION

(LA AURORA)

RUNWAY CAPACITY ESTIMATION (LA AURORA)

E.1 BASIS FOR RUNWAY CAPACITY ESTIMATION OF INTERNATIONAL CARRIER

1.1 Definition for Estimation

1.1.1 Abbreviations

In this report, following abbreviations will be used:

A/C : Aircraft
A : Arrival
D : Departure
DME : Distance Measuring Equipment
FAL : Final Approach Leg
IFR : Instrument Flight Rules
IMC : Instrument Meteorological Condition
LOC : Localizer
OM : Outer Marker
ROT : Runway Occupancy Time
RUP : Runway Use Probability
RWY : Runway
TWY : Taxiway
VMC : Visual Meteorological Condition

1.1.2 Runway Occupancy Time (ROT)

(1) Arrival (A)

a. Occupancy Start time : When a landing aircraft passes over the landing runway threshold.

b. Occupancy End Time : When a landed aircraft's tail clears off the runway.

(2) Departure (D)

a. Occupancy Start Time : When a take-off aircraft enters the runway. If the aircraft is instructed "taxi into position and hold" by a controller, the time "take off clearance" is issued.

b. Occupancy End Time : When a take-off aircraft passes over the far end of the runway.

1.1.3 Data for Estimation of Runway Occupancy Time

Data were taken by observation for 7 days during the First Study Period in Guatemala from January to March 1989. This period represented neither the wet season nor the whole year. However, ROT in relation to the taxiway can be used for the whole year because the efficient taxiways for turning off the runway after an aircraft landing are taxiways Q and F. Other taxiways, G, H, I, J, K, L, M, N, O, and P are not adequate. Runway Occupancy Time is shown in 5 second increments, since the observation error tolerance is assumed to be within 3 seconds. It is difficult to confirm if a landing aircraft is over the threshold or clear off the runway, because of the low tower eye level and lack of lighted guide mark signs on the runway edge leading into the exist taxiway at night. Calm wind component is 14%.

		RWY	Wind	Exit TWY	ROT
(1)	A:	01	> 5 kts	A	55"
			< 5 kts or Calm	RWY 19 End	70"
		19	> 5 kts	F	55"
			< 5 kts or Calm	RWY 01 End	70"

Average ROT of both RWYs: 55" x 0.86 + 70" x 0.14 = 60"

(2) D: Full length of both RWYs is used for takeoffs.
RWYs 01 and 19: 70"

1.2 A/C Speed and Time Required on FAL

LOC DME fixes are used instead of OM to show the distances to the ends of both RWY 01 and 19, since no OM exist. LOC DME is provided at the RWY 19 end, thus the distance to the RWY 01 THY should be reduced by 2,987 m (1.6 NM). The RWY 19 THR is displaced 225 m inside the RWY.

VMC : 2 NM on FAL
IMC : over DME, DME fix for RWY 01 : 6 NM IORA LOC
RWY 19 : 5 NM and 2.4 NM IAGU LOC
(use the longer distance, 5 NM)

(1) RWY 01

		Dist.	Time Req.	Speed
a.	2 NM short FAL to RWY THR:	2.0 NM	55"	130 kts (1.17 NM/min.)
b.	DME 6 NM to RWY THR:	4.4 NM	113"	140 kts (2.3 NM/min.)
c.	DME 6 to 2 NM FAL + 2 NM FAL to RWY THR:	4.4 NM	120"	2.4 NM/140 kts + 2.0 NM/ 130 kts

(2) RWY 19

		Dist.	Time Req.	Speed
a.	2 NM short FAL to RWY THR:	2.0 NM	55"	130 kts (1.17 NM/min.)
b.	DME 5 NM to RWY THR:	5.0 NM	129"	140 kts (2.3 kts/min.)
c.	DME 5 to 2 NM FAL + 2 NM FAL to RWY THR:	5.0 NM	135"	3.0 NM/140 kts + 2.0 NM/ 130 kts

Note: Almost of international carrier jets clear the RWYs at TWY Q or F, when the wind condition is of a head-wind component.

1.3 Separation between Takeoffs

Standard Instrument Departure Routes (SIDs) as explained below are taken into account to provide separations:

(1) RWY 01

	SIDs	Descriptions
a.	IZATAPA 2	Climb on AUR R-012 until reaching 7,000 ft. Turn right to intercept a 167 deg. bearing from RNB.
b.	PALMA 1	Climb on AUR R-021. Cross Palma at or above 8,600 ft. Continue to climb to 10,000 ft or above.
c.	RABINAL 2	Climb on AUR R-003. Cross RNB at or above 9,000 ft. Thence, transition routes.
d.	PALENCIA 2	Climb on AUR R-012 until reaching 7,000 ft. Turn right to a 150 deg. bearing to intercept R-644/UR-644.
e.	CANALES 2	Climb on AUR R-169 to cross Canales Intersection at or above 9,000 ft. Thence, transition routes.

All SIDs require the minimum climb gradient of 152 ft per min., because of the existence of a high mountainous configuration around the airport. Taking into account SIDs characteristics that all departure have to make straight-out climb until 7,000 ft - 9,000 ft (the airport elevation: approx. 5,000 ft), the departure separation will be;

a. RWY 01 in Use : 3 min.
b. RWY 19 in Use : 3 min.

1.4 RWY Use Probability (RUP)

Analysis of meteorological data recorded at the airport indicates that the north wind is predominant, representing approx. 68% of the time, and the south wind representing 18%. The remaining 14% of the observations are classified as calm. At such time controller's discretion is used for determining an active RWY.

a. RWY 01 : 68 + 14 x 68/86 = 79%
b. RWY 19 : 18 + 14 x 14/86 = 21%

1.5 Weather Conditions

Analysis of meteorological data also indicates the following;

(1) Wind Velocity < 5 kts. : 14%

(2) Cross Wind Component > 20 kts : RWY 01 - 0.01%
RWY 19 - 0.06%

(3) Proportion of Visual Meteorological Condition (VMC) and Instrument Meteorological Condition (IMC) : VMC (> 5 km) : 74.8%
IMC (< 5 km) : 25.2%

(4) Visibility Occurrence:

a. Data of Visibility from 1981 to 1988 at the airport indicates;

	0<1	1<2	2<3	3<4	4<5	5<7	7<10	>10
Annual average (%)	0.7	0.8	1.3	2.3	2.4	5.8	11.9	74.8

b. Visibility (km) in Respect to Minimum Decision Altitude (MDA)

A/C Class		Standard Terminal Arrival Routes (STARS)		
		ARC (LOC+VOR)	VOR (Procedure Turn)	NDB (Procedure Turn)
RWY 01:	A	1.6 (1)	2.0 (1-1/4)	2.3 (1-7/16)
	B	1.6 (1)	2.0 (1-1/4)	2.8 (1-3/4)
	C	2.8 (1-1/4)	5.5 (3-7/16)	4.5 (2-13/16)
	D	4.8 (3)	5.5 (3-7/16)	4.8 (3)
RWY 19:	A	1.6 (1)	2.0 (1-1/4)	2.3 (1-7/16)
	B	1.6 (1)	2.0 (1-1/4)	2.8 (1-3/4)
	C	2.4 (1-1/2)	4.5 (2-13/16)	5.5 (3-7/16)
	D	3.6 (2-1/4)	4.8 (3)	5.5 (3-7/16)

Note 1: Visibility in km. ( ) stands for Statute Mile (SM)
2: A : DHC-6, Do228, etc.
B : HS-748, F-28, etc.
C : B-727, B-737, DC-9, etc.
D : B-747, B-707, DC-10, A-300, etc.

Most of A/C being operated as international carriers at the airport belong to Class C & D, thus the lowest visibility on critical FAL is considered to be 5.5 km. The occurrence probability of 5.5 km or less will be 9.2% a year.

1.6 Disadvantageous Factor for Operations

The factor which severely limits the capacity of the existing runway-taxiway complex is the insufficient separation of the present parallel TWY, 70 m from the RWY. A/C movements in relation to the RWY and TWY are conducted along the following lines:

When a B-747 is using the RWY, no other A/C can use the TWY. In the cases of DC-10 or smaller A/C, those small A/C of Codes 1A to 3A can use the TWY. DC-10, A-300, B-767, B--757, B-737, B-707, B--727, B-720 and other planes of this type cannot simultaneously be operated with any other A/C in this category.

(1) Taxiing Time on TWY

The length from the Gate A or B to

a. The TWY 01 End : 1,820 m + 107 m = 1,927 m

b. The TWY 19 End : 945 m + 107 m = 1,052 m

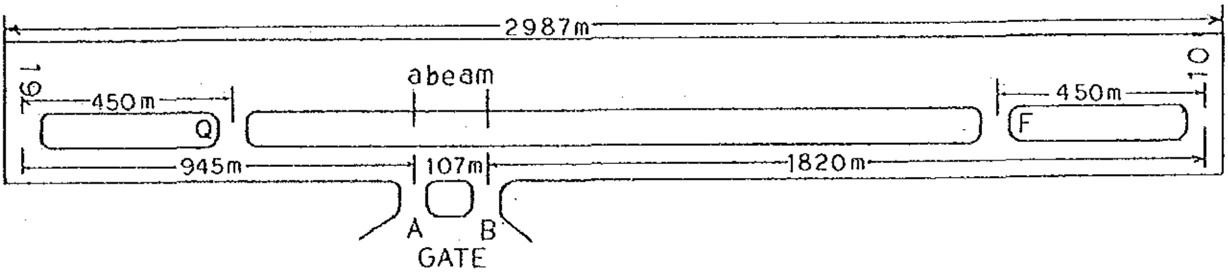
An average taxiing speed is assumed as 50 kts.

Taxiing time from A to

The TWY 01 End : 75" + 30" = 105"

The TWY 19 End : 40" + 30" = 70"

Note: 30" is the time needed from commencing a taxiout at the Gate after holding short of the TWY to reach the TWY end, including the turning speed to line up into the TWY.



(2) Timing in relation to a landed A/C and a taxiing A/C on the TWY

At the time a landed A/C clears out of the section on the RWY abeam Gates A or B, a departure A/C can commence taxiout from these Gates.

a. RWY 01 : Time from the landing THR to the section abeam Gate A : 30"

b. RWY 19 : Time from the landing THR to the section abeam Gate B : 15"

The time a landed A/C needs from clearing off the Exit TWYs, Q or F, or the RWY Ends until coming into the apron through Gate A or B.

c. RWY 01 : Time from Q or RWY 19 End through Gate B : 30"/1 + 30"/3 = 60"

d. RWY 19 : Time from F or RWY 01 End through Gate A : 65"/2 + 30" /3 = 95"

Notes: * The longer distance to Gate A or B, is taken, thus, the Gate B is for RWY 01 landing and the Gate A for RWY 19.

** Times of c. and d. are calculated as follows:

		Distance	Time Req.
RWY 19 End thru Gate B	:	1,052 m	40"
Q thru Gate B	:	602 m	25"
RWY 01 End thru Gate A	:	1,927 m	75"
F thru Gate A	:	1,477 m	60"

Taking into account the calm wind component of 14%, the average times are;

40" x 0.14 + 25" x 0.86 = 30"/1 for RWY 01 in use
75" x 0.14 + 60" x 0.86 = 65"/2 for RWY 19 in use

Added 30"/3 is the time needed for taxiing on the Exist TWYs, and turning into the parallel TWY and into the apron with the slow turning speed.

1.7 Profiles for Determining Capacity

		Profile				Profile		
	RWY	Number	Letter	WX	Profile	Letter	WX	Profile
DD : D only	01	(1)	(a)	VMC	1xD + 1xD	(b)	IMC	1xD + 1xD
DD : D only	19	(2)	(c)	VMC	1xD + 1xD	(d)	IMC	1xD + 1xD
AA : A only	01	(3)	(e)	VMC	1xA + 1xA	(f)	IMC	1xA + 1xA
AA : A only	19	(4)	(g)	VMC	1xA + 1xA	(h)	IMC	1xA + 1xA
SM : Single Mix	01	(5)	(i)	VMC	1xD + 1xA	(j)	IMC	1xD + 1xA
SM : Single Mix	19	(6)	(k)	VMC	1xD + 1xA	(l)	IMC	1xD + 1xA
MM : Multi Mix	01	(7)	(m)	VMC	1xD + 2xA	(n)	IMC	1xD + 2xA
MM : Multi Mix	19	(8)	(o)	VMC	1xD + 2xA	(p)	IMC	1xD + 2xA
MM : Multi Mix	01	(9)	(q)	VMC	2xD + 1xA	(r)	IMC	2xD + 1xA
MM : Multi Mix	19	(10)	(s)	VMC	2xD + 1xA	(t)	IMC	2xD + 1xA

E.2 PARAMETERS FOR CAPACITY DETERMINATION

2.1 Calculation Elements

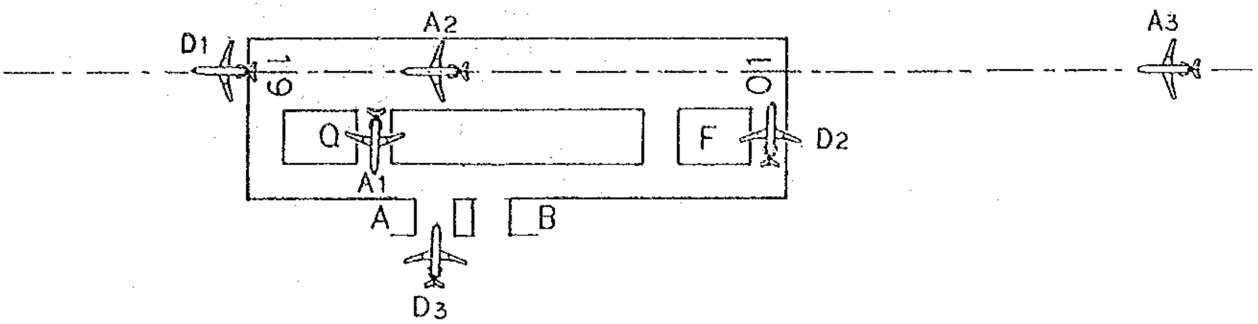
The standards applicable for IFR (Instrument Flight Rule) operation under VMC or IMC condition are summarized as follows:

RWY in use:		01		19		Refer to: 1
WX condition:		VMC	IMC	VMC	IMC	
ROT:	D	70"	70"	70"	70"	1.2.(2)
	A	60"	60"	60"	60"	1.2.(1)
A2 Position when D over THR & A1 clear Exist TWY:		2 NM (55")	DME 4.4 (120")	2 NM (55")	DME 5.0 (135")	2.(1) & (2)
D Separation:		180"	180"	180"	180"	3.

	RWY 01	RWY 19	
RUP:	79.0%	21.0%	4.
VMC:	59.1%	15.7%	4.a. x 5.(3)
IMC:	19.9%	5.3%	4.b. x 5.(3)
Calm Wind (14%), VMC:	8.3%	2.2%	VMC x 5.(1)
Calm wind (14%), IMC:	2.79%	0.74%	IMC x 5.(1)
Cross Wind (> 20 kts):	0.01%	0.06%	5.(2)
VMC/IMC Occurrence:	VMC - 74.8%, IMC - 25.2%		5.(3)
Poor Visibility (< 5 km)	75%		5.(4)

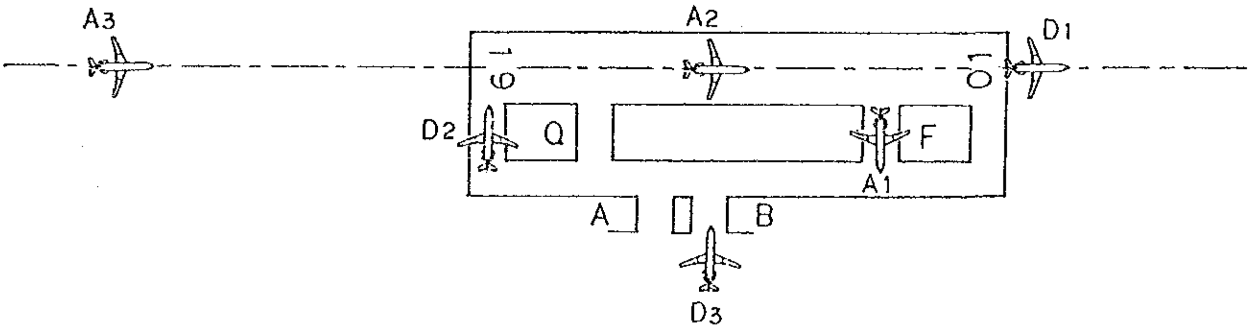
2.2 General Traffic Configuration

(1) RWY 01, VMC



				Time Required
a.	D1	:	No. 1 D over THR	70" to take off
b.	A1	:	No. 1 A clear off RWY @ Q or RWY 19 End	60" after landing
c.	A2	:	No. 2 A abeam Gate A	30" after landing
d.	D2	:	No. 2 D holding short of RWY	70" to take off
e.	A3	:	No. 3 A on 2 NM FAL	55" to land
f.	D3	:	No. 3 D holding short of parallel TWY	105" to TWY End

(2) RWY 19, VMC

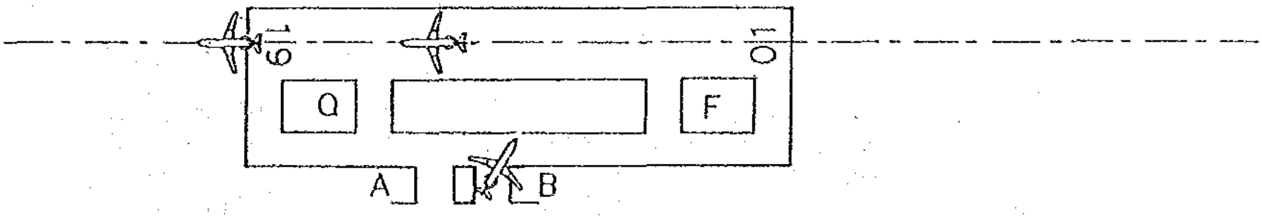


				Time Required
a.	D1	:	No. 1 D over THR	70" to take off
b.	A1	:	No. 1 A clear off RWY @ F or RWY 01 End	60" after landing
c.	A2	:	No. 2 A abeam Gate B	15" after landing
d.	D2	:	No. 2 D holding short of RWY	70" to take off
e.	A3	:	No. 3 A on 2 NM FAL	55" to land
f.	D3	:	No. 3 D holding short of parallel TWY	70" to TWY End

2.3 Calculation of Capacity (Refer to 1.7.)

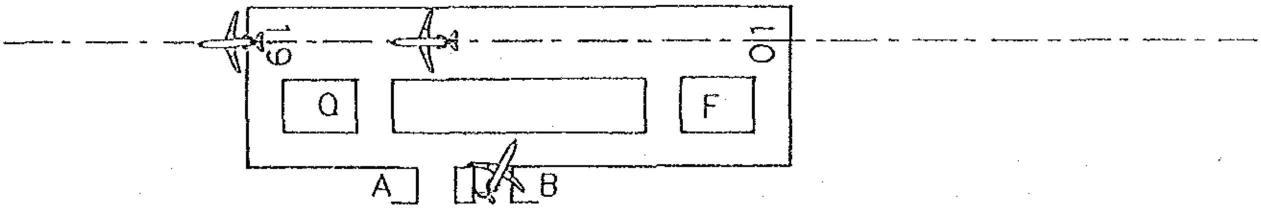
Profile	RWY	WX		Time Req.	Delay (sec.)
(DD)-(1)(a): 1xD+1xD	01	VMC	D1 over THR	70"	
			D1 abeam Gate A	45"	
			D2 to TWY End	105"	
			Total:	220"	
			A/C per Hr.:	16.36	

Note: The departure separation is 180". The time lost of A2 is 40".



(DD)-(1)(b): 1xD+1xD	01	IMC	D1 over THR	70"	
			D1 abeam Gate A	45"	
			D2 to TWY End	105"	
			Total:	220"	
			A/C per Hr.:	16.36	

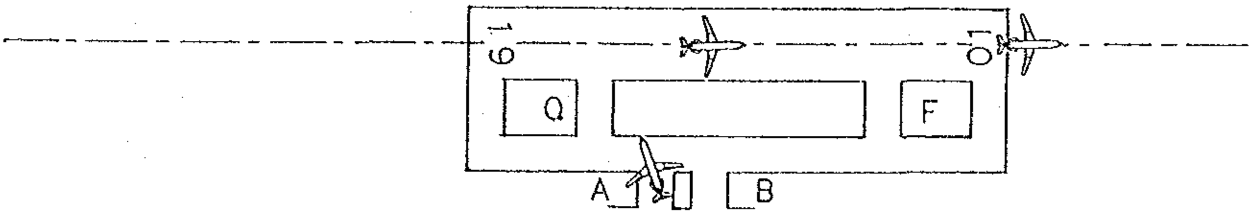
Note: Same as (1) (a).



(DD)-(2)(c): 1xD+1xD 19 VMC

D1 over THR	70"
D1 abeam Gate B	30"
D2 to TWY End	70"
Total:	170"*
A/C per Hr.:	21.18

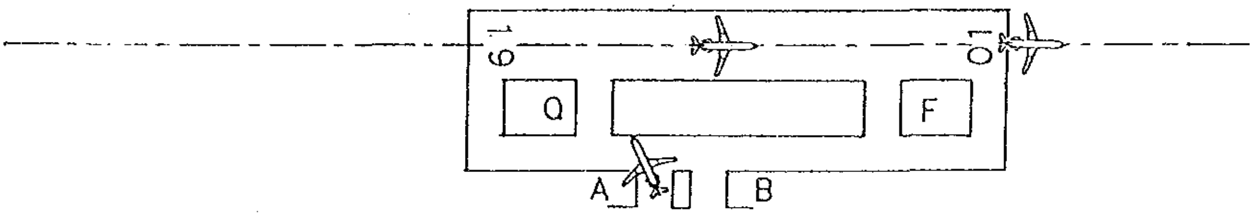
Note *: 3600"/155"=23.23. However, No.2 D has to wait 10" @ TWY End, since the departure separation is 180" ; (180"-170").



(DD)-(2)(d): 1xD+1xD 19 IMC

D1 over THR	70"
D1 abeam Gate B	30"
D2 to TWY End	70"
Total:	170"
A/C per Hr.:	21.18

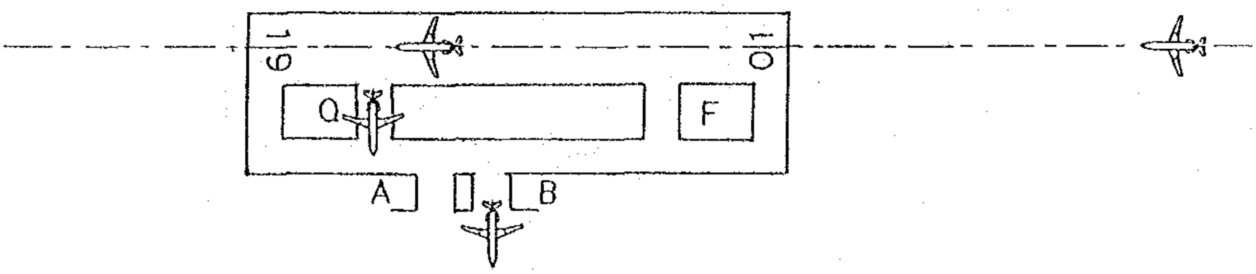
Note: Same as (2) (c).



(AA)-(3)(e): 1xA+1xA 01 VMC

A1 to clear THR	60"
A1 to clear Gate B	60"
A2 2 NM FAL*	55"
Total:	175"*
A/C per Hr.:	20.57

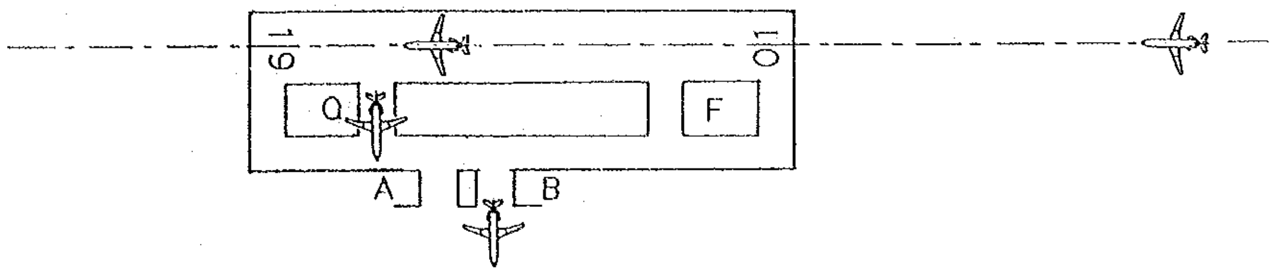
Note *: A2 is supposed be on 2.2 NM FAL instead of 2 NM (VMC) when A1 clears off RWY, and proceeds 0.2 NM until A1 clears off Gate, since No.2 A/C cannot land before A1 clears off Gate.
(5"/3600" x 140 kts = 0.2 NM; 2 NM + 0.2 NM = 2.2 NM)



(AA)-(3)(f): 1xA+1xA 01 IMC

A1 to clear RWY	60"
A1 to clear Gate B	60"
A2 over DME 4.4*	120"
Total:	240"
A/C per Hr.:	15.0

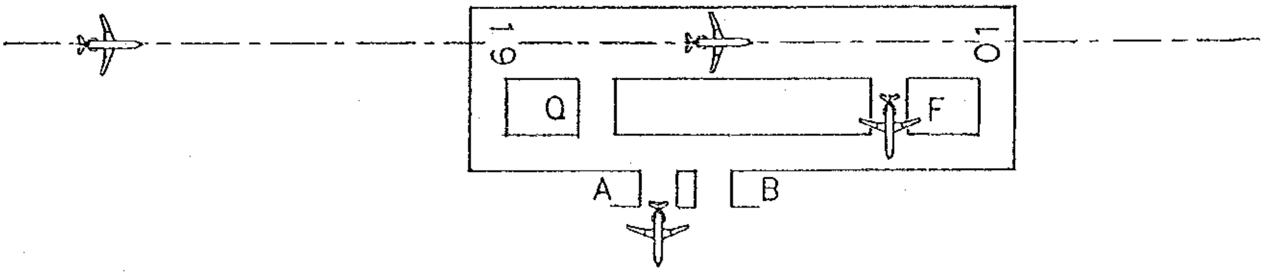
Note *: A2 is supposed be over DME 6.7 instead of DME 4.4 when A1 clears off RWY, and proceeds 2.3 NM until A1 clears off Gate.
(60"/3600" x 140 kts = 2.3 NM; 4.4 NM + 2.3 NM = 6.7 NM)



(AA)-(4)(g): 1xA+1xA 19 VMC

A1 to clear RWY 50"
A1 to clear Gate A 95"
A2 on 2 NM FAL 55"
Total: 200"
A/C per Hr.: 18.0

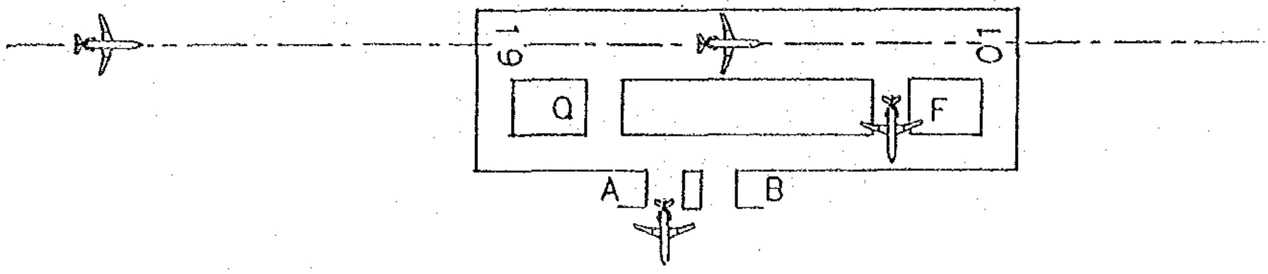
Note *: A2 is supposed be over 5.7 NM FAL instead of 2 NM when A1 clears off RWY, and proceeds 3.7 NM until A1 clears off Gate. (95"/3600" x 140 kts = 3.7 NM; 2 NM + 3.7 NM = 5.7 NM)



(AA)-(4)(h): 1xA+1xA 19 IMC

A1 to clear RWY 50"
A1 to clear Gate A 95"
A2 over DME 5* 135"
Total: 280"
A/C per Hr.: 12.85

Note *: A2 is supposed be over DME 8.7 instead of DME 5 when A1 clears off RWY, and proceeds 3.7 NM until A1 clears off Gate. (95"/3600" x 140 kts = 3.7 NM; 5 NM + 3.7 NM = 8.7 NM)

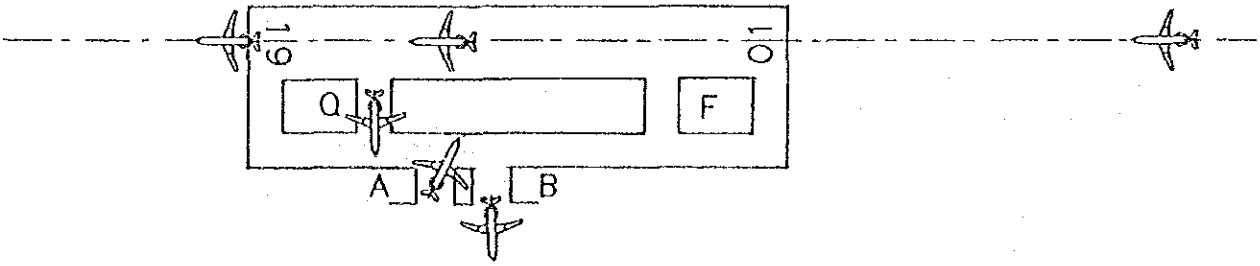


(SM)-(5)(i): 1xD+1xA 01 VMC

D1 over THR	70"
A1 on 2 NM FAL	55"
*[A1 abeam Gate A	30"]*
*[D2 taxiout to TWY End	105"]**
105" - (60" - 30") =	75"
A1 to clear RWY	60"
A1 to clear Gate B	60"
[D2 take off]**	
Total:	320"
A/C per Hr.:	11.25

2 operations per Hr.: 15.32 x 2 = 22.50

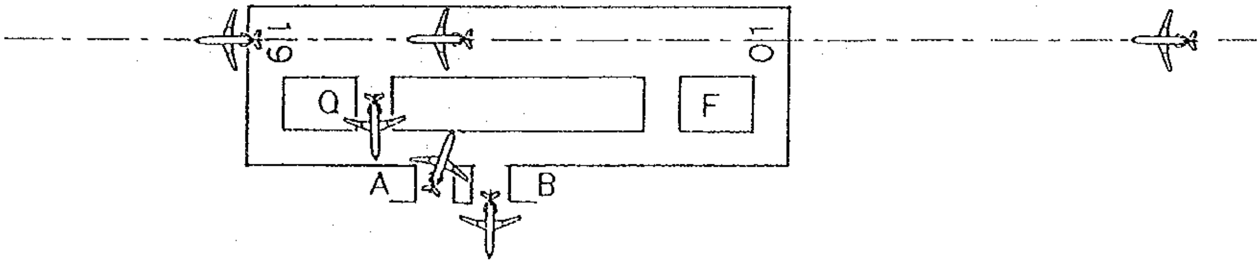
Note *: Times in [ ] are not accumulated to the total.
**: D2 has to wait for 85" (55"+30") to taxiout and hold for 60" at TWY End.



(SM)-(5)(j):	1xD+1xA	01	IMC	D1 over THR	70"
				A1 over DME 4.4	120"
				*[A1 abeam Gate A	30"]
				*[D2 taxiout to TWY End	105"]**
				105" - (60" - 30") =	75"
				A1 to clear RWY	60"
				A1 to clear Gate B	60"
				[D2 take off]**	
				Total:	385"
				A/C per Hr.:	9.30

2 operations per Hr.: 9.30 x 2 = 18.60

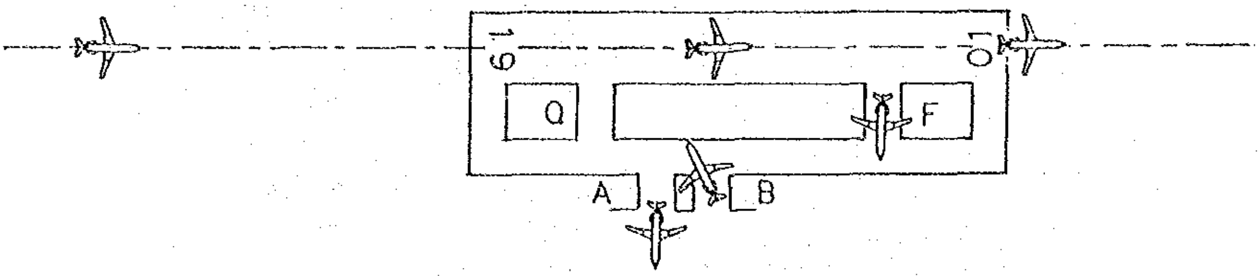
Note *: Times in [ ] are not accumulated to the total.
**: D2 has to wait for 150" (120"+30") to taxiout
and hold for 60" at TWY End.



(SM)-(6)(k):	1xD+1xA	19	VMC	D1 over THR	70"
				A1 on 2 NM FAL	55"
				*[A1 abeam Gate B	15"]
				*[D2 taxiout to TWY End	70"]**
				70" - (60" - 15") =	25"
				A1 to clear RWY	60"
				A1 to clear Gate A	95"
				[D2 take off]**	
				Total:	385"
				A/C per Hr.:	9.35

2 operations per Hr.: 9.35 x 2 = 18.70

Note *: Times in [ ] are not accumulated to the total.
**: D2 has to wait for 150" (135"+15") to taxiout and hold for 95" at TWY End.

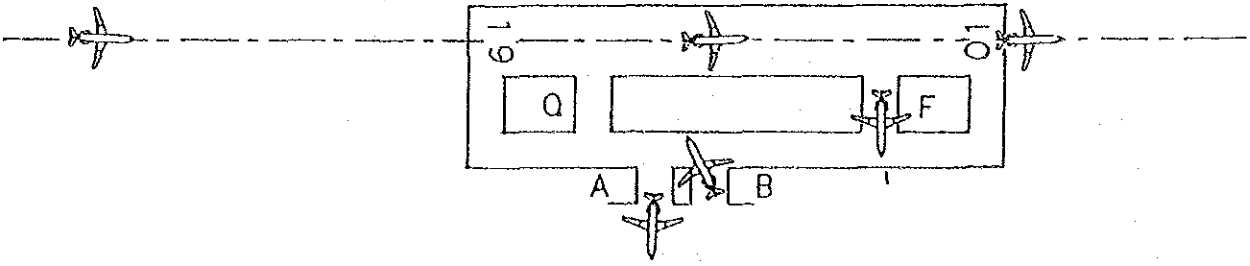


(SM)-(6)(I): 1xD+1xA 19 IMC

D1 over THR	70"
A1 over DME 5	135"
*[A1 abeam Gate B	15"]
*[D2 taxiout to TWY End	70"]**
70" - (60" - 15") =	25"
A1 to clear RWY	60"
A1 to clear Gate A	95"
[D2 take off]**	
Total:	385"
A/C per Hr.:	9.35

2 operations per Hr.: 9.35 x 2 = 18.70

Note *: Times in [ ] are not accumulated to the total.
**: D2 has to wait for 150" (135"+15") to taxiout and hold for 95" at TWY End.



(MM)-(7)(m): 1xD+2xA 01 VMC

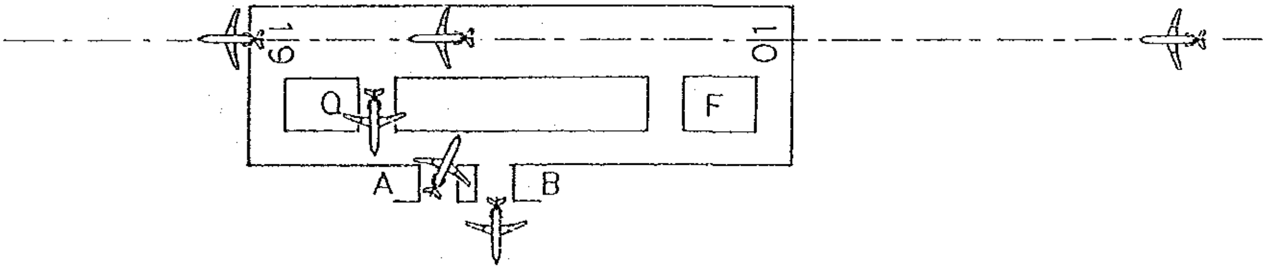
A1 to clear RWY	60"
*[A1 abeam Gate A	30"]
*[D1 taxiout to TWY End	105"]**
105" - (60" - 30") =	75"
A1 to clear Gate B	60"
A2 on 2 NM FAL	55"***
A2 to clear RWY	60"
*[A2 abeam Gate A	30"]
*[D2 taxiout to TWY End	105"]
*[105" - (60" - 30") =	75"]
A2 to clear Gate B	60"
D1 over THR	70"
*[D2 over THR]	
*[A3 on 2 NM FAL]	
Total:	440"
A/C per Hr.:	8.18

3 operations per Hr.: 8.18 x 3 = 24.54

Note *: Times in [ ] are not accumulated to the total.

**: D1 has to wait for 90" (60"+35") and D2 for 205" to taxiout.

***: A2 is supposed to be on 4.3 NM FAL instead of 2 NM when A1 clear off RWY, and proceed 2.3 NM until A1 clear off Gate, since No.2 A/C cannot land before A1 clear off Gate.
(60"/3600" x 140 kts = 2.3 NM; 2 NM + 2.3 NM = 4.3 NM)



(MM)-(7)(n): 1xD+2xA 01 IMC

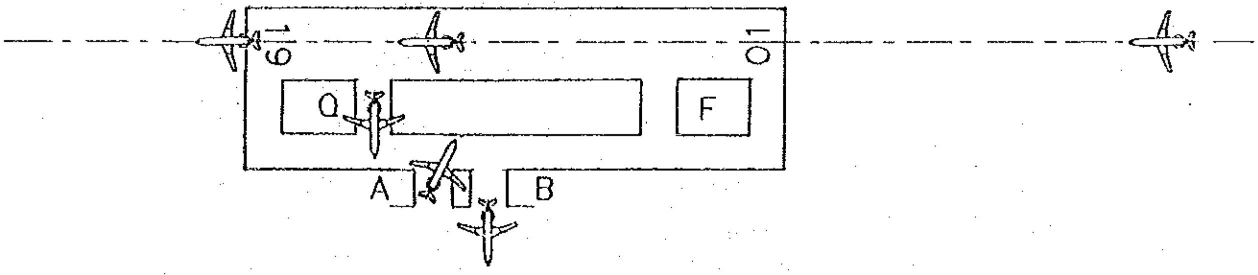
A1 to clear RWY	60"
*[A1 abeam Gate A	30"]
*[D1 taxiout to TWY End	105"]**
105" - (60" - 30") =	75"
A1 to clear Gate B	60"
A2 over DME 4.4	120"***
A2 to clear RWY	60"
*[A2 abeam Gate A	30"]
*[D2 taxiout to TWY End	105"]
*[105" - (60" - 30") =	75"]
A2 to clear Gate B	60"
D1 over THR	70"
*[D2 over THR]	

*[A3 on DME 4.4]	
Total:	505"
A/C per Hr.:	7.13

---

3 operations per Hr.: 7.13 x 3 = 21.39

Note *: Times in [ ] are not accumulated to the total.
**: D1 has to wait for 90" (60"+35") and D2 for 210" to taxiout.
***: A2 is supposed to be over DME 6.7 instead of DME 4.4 when A1 clear off RWY, and proceed 2.3 NM until A1 clear off Gate.



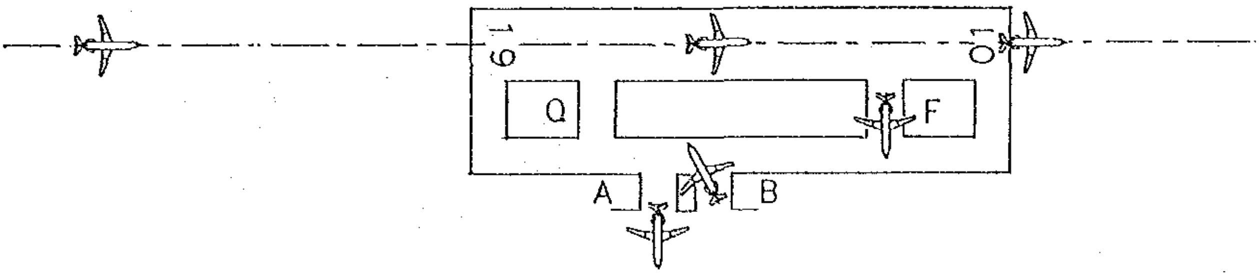
(MM)-(8)(o): 1xD+2xA 19 VMC

A1 to clear RWY	60"
*[A1 abeam Gate B	15"]
*[D1 taxiout to TWY End	70"]**
70" - (60" - 15") =	25"
A1 to clear Gate A	95"
A2 on 2 NM FAL	55"***
A2 to clear RWY	50"
*[A2 abeam Gate B	15"]
*[D2 taxiout to TWY End	70"]
*[70" - (60" - 15") =	25"]
A2 to clear Gate A	95"
D1 over THR	70"
*[D2 over THR]	

*[A3 on 2 NM FAL]	
Total:	460"
A/C per Hr.:	7.83

3 operations per Hr.: 7.83 x 3 = 23.49

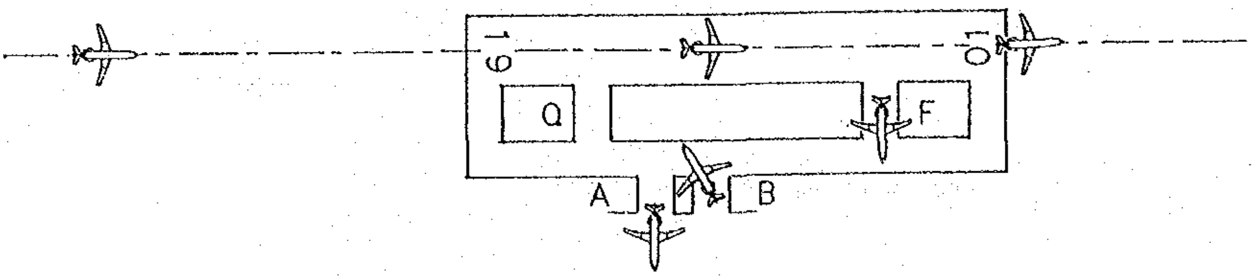
Note *: Times in [ ] are not accumulated to the total.
**: D1 has to wait for 70" (60"+15") and D2 for 130" to taxiout.
***: A2 is supposed to be on 5.7 NM FAL instead of 2 NM when A1 clear off RWY, and proceed 2.3 NM until A1 clear off Gate. (95"/3600" x 140 kts = 3.7 NM; 2 NM + 3.7 NM = 5.7 NM)



(MM)-(8)(p):	1xD+2xA	19	IMC	A1 to clear RWY	60"
				*[A1 abeam Gate B	15"]
				*[D1 taxiout to TWY End	70"]**
				70" - (60" - 15") =	25"
				A1 to clear Gate A	95"
				A2 over DME 5	135"
				A2 to clear RWY	60"
				*[A2 abeam Gate B	15"]
				*[D2 taxiout to TWY End	70"]
				*[70" - (60" - 15") =	25"]
				A2 to clear Gate A	95"
				*[D2 over THR]	
				*[A3 on DME 5]	
				Total:	470"
				A/C per Hr.:	7.66

3 operations per Hr.: 7.66 x 3 = 22.98

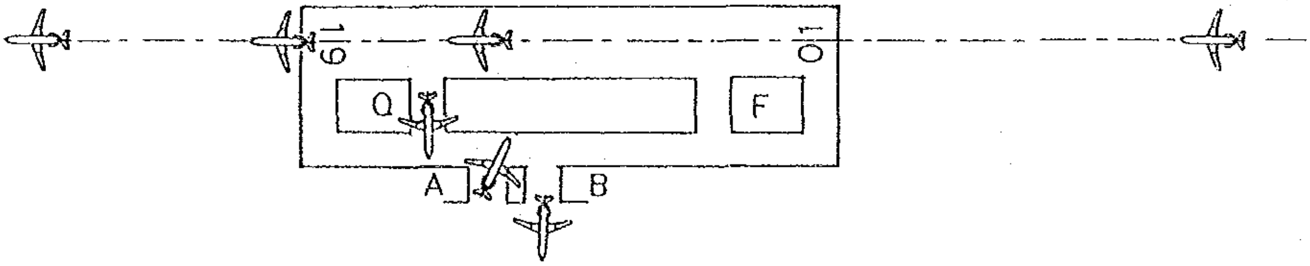
Note *: Times in [ ] are not accumulated to the total.
**: D1 has to wait for 85" (70"+15") and D2 for 210" to taxiout.
***: A2 is supposed to be over DME 8.7 instead of DME 5 when A1 clears off RWY, and proceed 3.7 NM until A1 clear off Gate, since No.2 A/C cannot land before A1 clear off Gate. (95"/3600" x 140 kts = 3.7 NM; 5 NM + 3.7 NM)



(MM)-(9)(q): 2xD+1xA	01	VMC	D1 & D2 Separation	180"
			A1 on 2 NM FAL	55"
			A1 to clear RWY	60"
			*[A1 abeam Gate A	30"]**
			*[D3 taxiout to TWY End	105"]
			A1 to clear Gate B	60"
			*[D3 over THR]	
			Total:	350"
			A/C per Hr.:	10.14

3 operations per Hr.: 10.14 x 3 = 30.42

Note *: Times in [ ] are not accumulated to the total.
**: D3 has to wait for 85" (55"+30") to taxiout.

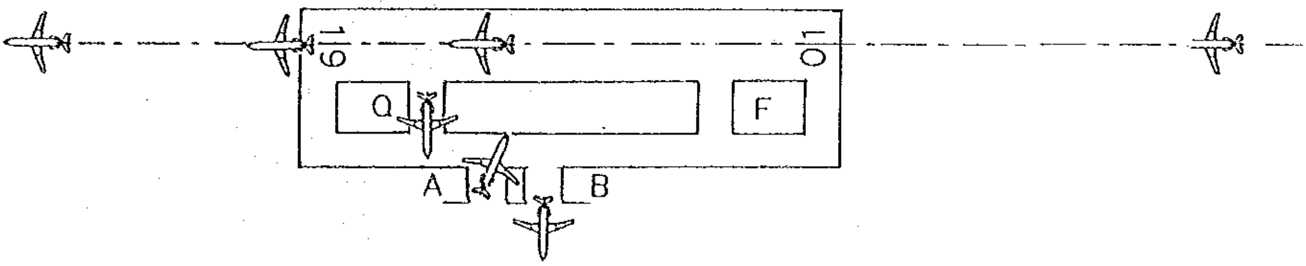


(MM)-(9)(r): 2xD+1xA 01 IMC

D1 & D2 Separation	180"
A1 over DME 4.4	120"
A1 clear RWY	60"
*[A1 abeam Gate A	30"]
*[D3 taxiout to TWY End	105"]**
A1 to clear Gate B	60"
*[D3 over THR]	
Total:	420"
A/C per Hr.:	8.57

3 operations per Hr.: 8.57 x 3 = 25.71

Note *: Times in [ ] are not accumulated to the total.
**: D3 has to wait for 150" (120"+30") to taxiout.

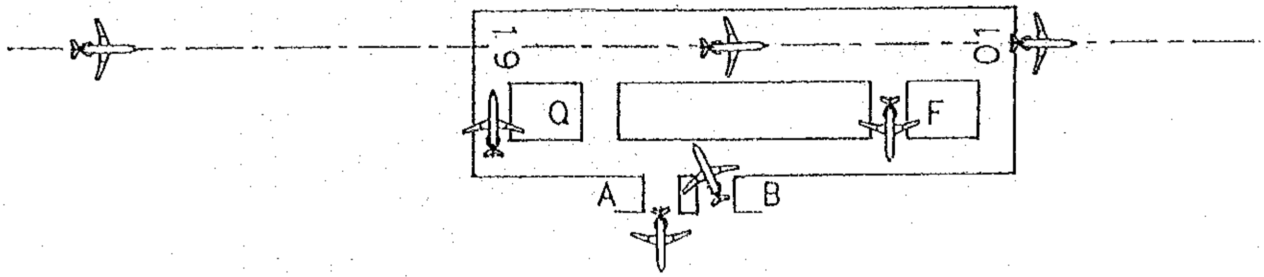


(MM)-(10)(s): 2xD+1xA 19 VMC

D1 & D2 Separation	180"
A1 on 2 NM FAL	55"
A1 clear RWY	60"
*[A1 abeam Gate B	15"]
*[D3 taxiout to TWY End	70"]**
A1 to clear Gate A	95"
*[D3 over THR]	
Total:	390"
A/C per Hr.:	9.23

3 operations per Hr.: 9.23 x 3 = 27.69

Note *: Times in [ ] are not accumulated to the total.
**: D3 has to wait for 70" (55"+15") to taxiout.



(MM)-(10)(t):	2xD+1xA	19	IMC	D1 & D2 Separation	180"
				A1 over DME 5	135"
				A1 clear RWY	60"
				*[A1 abeam Gate B	15"]
				*[D3 taxiout to TWY End	70"]**
				A1 to clear Gate A	95"
				*[D3 over THR]	
				Total:	470"
				A/C per Hr.:	7.66

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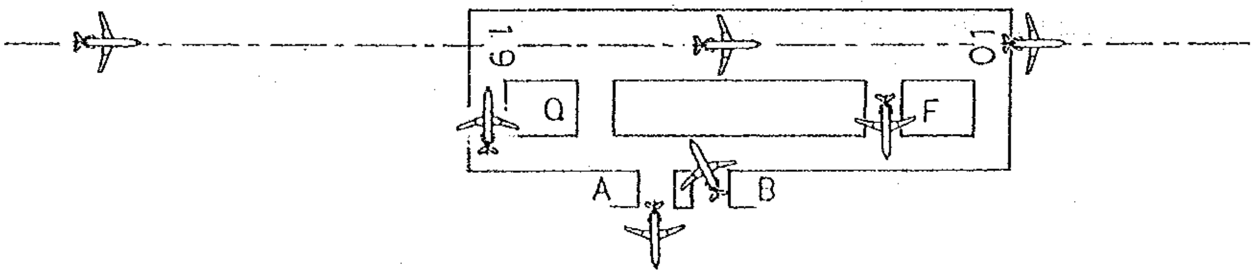
3 operations per Hr.: 7.66 x 3 = 22.98

Note *: Times in [ ] are not accumulated to the total.
**: D3 has to wait for 150" (135"+15") to taxiout.



E.3 RUNWAY CAPACITY UNDER EXISTING CONDITION

By referring to parameters noted in Section 2.3 hereinabove, the runway capacity under the existing condition is estimated as follows:

						Operation per Hr.
Profile (DD)	Departure only					
	(1)	1 x D + 1 x D	(a)	RWY 01,	VMC	16.36
		1 x D + 1 x D	(b)	RWY 01,	IMC	16.36
	(2)	1 x D + 1 x D	(c)	RWY 19,	VMC	21.18
		1 x D + 1 x D	(d)	RWY 19,	IMC	21.18
Profile (AA)	Arrival only					
	(3)	1 x A + 1 x A	(e)	RWY 01,	VMC	20.57
		1 x A + 1 x A	(f)	RWY 01,	IMC	15.0
	(4)	1 x A + 1 x A	(g)	RWY 19,	VMC	18.0
		1 x A + 1 x A	(h)	RWY 19,	IMC	12.85
Profile (SM)	Single Mix					
	(5)	1 x C + 1 x A	(i)	RWY 01,	VMC	22.5
		1 x C + 1 x A	(j)	RWY 01,	IMC	18.6
	(6)	1 x C + 1 x A	(k)	RWY 19,	VMC	23.6
		1 x C + 1 x A	(l)	RWY 19,	IMC	18.7
Profile (MM)	Multi Mix					
	(7)	1 x D + 2 x A	(m)	RWY 01,	VMC	24.54
		1 x D + 2 x A	(n)	RWY 01,	IMC	21.39
	(8)	1 x D + 2 x A	(o)	RWY 19,	VMC	23.49
		1 x D + 2 x A	(p)	RWY 19,	IMC	22.98
	(9)	2 x D + 1 x A	(q)	RWY 01,	VMC	30.42
		2 x D + 1 x A	(r)	RWY 01,	IMC	25.71
	(10)	2 x D + 1 x A	(s)	RWY 19,	VMC	27.69
		2 x D + 1 x A	(t)	RWY 19,	IMC	22.98

Profile of Single Mixed Operation (SM) is the representative pattren as a whole in a day. The other profiles of Multi Mixed Operation (MM) represent a combinaton of Single Mixed Operations.

Data for Calculation	Refer to: 1
RWY 01, VMC, RUP x VMC% = 0.79 x 0.748 = 0.591	4.a. x 5.(3)
RWY 01, IMC, RUP x IMC% = 0.79 x 0.252 = 0.199	4.a. x 5.(3)
RWY 19, VMC, RUP x VMC% = 0.21 x 0.748 = 0.157	4.b. x 5.(3)
RWY 19, IMC, RUP x IMC% = 0.21 x 0.252 = 0.053	4.b. x 5.(3)

The RWY capacity was derived from the following:

RWY 01, VMC, 22.50 x 0.591 = 13.28, 13.28/2 = 6.64

Arrival : 6.64 - [6.64 x (0.083 + 0.0001)] = 6.01
Departure : = 6.64
Total 12.65

RWY 19, VMC, 23.60 x 0.157 = 3.71, 3.71/2 = 1.36

Arrival : 1.36 - [1.36 x (0.022 + 0.0006)] = 1.33
Departure : = 1.36
Total 2.69

RWY 19, IMC, 18.7 x 0.053 = 0.99, 0.99/2 = 0.50

Arrival : 0.50 - [0.50 x (0.0074 + 0.075)] = 0.46
Departure : = 0.50
Total 0.96

Grand Total 18.80

The present runway capacity is determined to be 19 operation per hour.

E.4 RUNWAY CAPACITY FOR INTERMEDIATE PLAN (1995)

The Intermediate Plan will provide a parallel taxiway with the separation of 180 m from the runway centerline for the northern portion, from the Runway 19 end to the apron area. With this projection, the runway capacity is estimated, without the provision of a rapid-exit taxiway to connect the runway at an angle of 30 degree.

4.1 Basic Parameter

Mix	Runway	Weather	Aircraft Status	Time
1 x D + 1 x A	01	VMC	D1 over THR	70"
			A on 2 NM FAL	55"
			* [A abeam Gate A	30"]
			* [D2 taxiout to TWY End	105"]
			105" - (60" - 30") =	75"
			A to clear RWY	60"
			* [A to clear Gate B	60"]
			* [D2 take off]	
			Total	260"
			A/C per Hr.	13.85
			2 operations per Hr: 13.85 x 2	27.70 .... a.

Note *: Times in [ ] are not accumulated to the total.

1 x D + 1 x A	01	IMC	A over DME 4.4	120"
			* [A abeam Gate B	30"]
			* [D2 taxiout to TWY End	105"]
			105" - (60" - 30") =	75"
			A to clear RWY	60"
			* [A to clear Gate B]	60"]
			* [D2 take off]	
			Total	325"
			A/C per Hr.	11.08
			2 operations per Hr.: 11.08 x 2	22.16 .... b.

Note *: Times in [ ] are not accumulated to the total.

1 x D + 1 x A	19	VMC		D1 over THR	70"
				A on 2 NM FAL	55"
				A abeam Gate B	15"
			*	[D2 taxiout to TWY End	70"]
				A to clear RWY	60"
				A to clear Gate B	60"
			*	[D2 take off]	
				Total	260"
				A/C per Hr.	13.85
				2 operations per Hr.:	13.85 x 2 = 27.70 .... c.

Note *: Times in [ ] are not accumulated to the total.

1 x D + 1 x A	19	IMC		D1 over THR	70"
				A over DME 5	135"
				A abeam Gate B	15"
			*	[D2 taxiout to TWY End	70"]
				A to clear RWY	60"
				A to clear Gate B	60"
			*	[D2 take off]	
				Total	340"
				A/C per Hr.:	10.59
				2 operations per Hr.:	10.59 x 2 = 21.18 .... d.

5.2 Runway Capacity

a. RWY 01, VMC, 27.70 x 0.591 = 16.37, 16.37/2 = 8.19

Arrival : 8.19 -[8.19 x (0.083 + 0.0001)] = 7.51
Departure : = 8.19
Total 15.70

b. RWY 01, VMC, 22.16 x 0.119 = 2.64, 2.64/2 = 1.32

Arrival : 1.32 - [1.32 x (0.0279 + .075)] = 1.18
Departure : = 1.32
Total 2.50

c. RWY 19, VMC, 27.70 x 0.157 = 4.35, 4.35/2 = 2.18

Arrival : 2.18 - [2.18 x (0.022 + 0.0006) = 2.13
Departure : = 2.18
Total 4.31

d. RWY 19, IMC, 21.18 x 0.053 = 1.12, 1.12/2 = 0.56

Arrival : 0.56 - [0.56 x (0.0074 + 0.075)] = 0.51
Departure : = 0.56
Total 1.07
Grand Total 23.58

The runway capacity for 1995 is estimated as 24 operations per hour.

E.5 RUNWAY CAPACITY FOR MASTER PLAN (2005)

5.1 Basic Parameter

Mix	Runway	Weather	Aircraft Status	Time	
1 x D + 1 x A	01	VMC	D over THR	70"	
			A on 2 NM FAL	55"	
			A to clear RWY	40"	
			Total	165"	
			A/C per Hr.	21.82	
			2 operations per Hr.	43.64	.... a.
1 x D + 1 x A	01	IMC	D over THR	70"	
			A over DME 4.4	120"	
			A to clear RWY	40"	
			Total	230"	
			A/C per Hr	15.65	
			2 operations per Hr.	31.30	.... b.
1 x D + 1 x A	19	VMC	D over THR	70"	
			A on 2 NM FAL	55"	
			A to clear RWY	40"	
			Total.	165"	
			A/C per Hr	21.82	
			2 operations per Hr.	43.64	.... c.
1 x D + 1 x A	19	IMC	D over THR	70"	
			A on 2 NM FAL	135"	
			A to clear RWY	40"	
			Total.	245"	
			A/C per Hr	14.69	
			2 operations per Hr.	29.38	.... d.

5.2 Runway Capacity

a. RWY 01, VMC, 43.64 x 0.591 = 25.79, 25.79/2 = 12.40

Arrival : 12.40 - [12.4 x (0.083 + 0.0001)] = 11.37

Departure : = 12.40

Total 23.77

b. RWY 01, IMC 31.30 x 0.119 = 3.72, 3.72/2 = 1.86
Arrival : 1.86 - [1.86 x (0.0279 + 0.075)] = 1.67
Departure : = 1.86
Total 3.53

c. RWY 19, VMC 43.64 x 0.157 = 6.85, 6/85/2 = 3.43
Arrival : 3.43 - [3.43 x (0.022 + 0.0006)] = 3.35
Departure : = 3.43
Total 6.78

d. RWY 19, IMC 29.38 x 0.053 = 1.56, 1.56/2 = 0.78
Arrival : 0.78 - [0.78 x (0.0074 + 0.075)] = 0.72
Departure : = 0.78
Total 1.50
Grand Total 35.58

The runway capacity for 2005 is estimated to be 36 operations per hour.

APPENDIX - F

ESTIMATE OF LOADING APRONS AND APRON BERTH

(LA AURORA)

F.I METHOD OF ESTIMATE

1.1 Nature of Traffic Peaks

Annual forecast in terms of passengers, aircraft movements and cargo are essential for determining the overall dimensions of the airport and estimating potential revenues. The size of specific facilities and the geometry of the airside, however, are related to flows over a much shorter period of time.

Most airports display peaking patterns that may be related to a particular time base and La Aurora Airport is no exception. In general terms, the most important factors that affect peaking at any airport are:

1) Chartered/Scheduled ratio: Scheduled flights cater mostly to the regular traveller, e.g. businessman, who are geared to maximising his working day at his destination or to provide interlinking at major hub airports. Hence timing and frequency are the important considerations in scheduled operations. Charter flights are timed to maximise aircraft usage and are not necessarily operated during peak periods.
2) Sectors served: Short haul scheduled flights normally peak during mornings and late afternoons because they mainly serve the business community and, again, aim to maximise the working day. Long haul flights are scheduled to allow convenient arrival and departure times and avoid night curfews or landing fee penalties at airports.
3) Nature of catchment areas: Airports that serve holiday resorts display significant *peaks during holiday periods. In contrast metropolitan airport, or airports serving* industrial areas, tend to have steady flows throughout the year.

1.2 Method of Measuring Peaking

The demand profile and peaking can be related to a particular time base such as a month, week or day which are important measures that airport operators rely upon for determining levels of manning and required sophistication of equipment. The design of the runway system, terminal buildings and aprons is normally based on a much shorter time span, usually the hour.

The appropriate measure of hourly flows has to be defined because airports operate over a wide range of traffic flows. If a facility is designed to handle maximum volumes that will occur during the design year, it is obvious that demand and supply of facilities would not be closely matched, for the overwhelming portion of the year, resulting in wasteful use of resources.

There are different ways to approach the problem of peaking, but basically the design flows are the absolute peaks. Two of the most commonly used methods of measurement of peaking are:

1) The Standard Busy Rate (SBR): The SBR is defined as the 30th highest hour of passenger flow in the year, i.e. the designed capacity is exceeded for only 29 hours in the design year.
2) The Busy Hour Rate (BHR): The BHR was introduced to overcome the problem of different peaking at various airports and it is computed by ranking busy hours in order of magnitude and expressing their cumulative sums as a percentage of the annual throughput. The BHR is normally set between 3 and 5 percent depending on traffic characteristics and on the policy of the operating authority.

1.3 Analysis of Air Traffic Control (ATC) Records

In attempting to predict future hourly flows in both passenger and aircraft movement it is essential that present traffic characteristics are fully understood and factors that may change or influence future patterns are taken into account.

In spite of variations between airport peaks, as a result of the factors mentioned above, there are overall similarities among airports because airport operations are interrelated. It is, therefore, possible to establish empirical relationships between busy hour flows and annual volumes in both aircraft and passengers movements which, combined with other relevant parameters, can be used to estimate the magnitude of future hourly passenger flows.

Due to lack of detailed data on passengers movements and international and domestic aircraft movements in the past, the ATC records of aircraft operations during the period from Feb. 1988 to Jan. 1989 has been extracted and analysed by the Study Team.

The Tables, annexed to this Appendix, demonstrate the extracted and processed ATC records. It is noted, that:

a) With respect to the number of international carrier aircraft operations on each day of each month, the Table shows that the busiest month during this period was Dec. 1988 with 1,446 operations and the 2nd busiest month Jan. 1989 with 1,364 movement.

b) The busy days in December are, in order, the 24th, 15th, 31st and 10th with operations of 60, 58, 42 and 50, respectively. However, with respect to peak hour, the 15th is the busiest. January had, in order, 53 operations on the 7th, 52 on the 8th, 51 on the 15th and 50 on both the 19th and 28th.

c) Number of movements of each aircraft type operating at the airport, was derived for each operational hour of these busy days.

d) Also, information on the origins and destinations for each aircraft type with its corresponding movements was developed.

1.4 Calculation of Required Air Traffic Data

As noted in the Main Text, Chapter 3.3, the review of ATC logs for the period Feb. 1988 through Jan. 1989 yielded approximately a difference of about 4,600 in annual commercial aircraft operations, as compared to DGAC data (DGAC: 18,962 operations, while, ATC logs: 14,372). The following derivation are based on the ATC Logs:

1) Busy Month:	Peak Month (Dec. 1988)	2nd Busiest Month (Jan. 1989)
Operations:	1,446	1,364
Annual Operations: (Feb. 1988 thru Jan. 1989)	14,371	

2) Peak Month Coefficient:

Month	Month/Annual		Ratio
Dec. 1988	1,446/14,371	=	0.1006 (1/10)
Jan. 1988	1,364/14,371	=	0.0949 (1/11)

3) Peak Day Coefficient:

Busy Days:	24 Dec. 1988		7 Jan. 1989	
Operations:	60		53	
	Day/Month		Ratio	
	Dec.: 60/1,446	=	0.0415	
	Jan.: 53/1,364	=	0.0389	
Coefficient:	0.1006 x 0.0415	=	0.00417	(1/240)
	0.0949 x 0.0389	=	0.00369	(1/270)

4) Peak Hour Coefficient:

24 Dec. 1988	6/60 = 0.100	(5+6)/60 = 0.183	0.183/2 = 0.09
7 Jan. 1989	8/53 = 0.151	(8+5)/53 = 0.245	0.245/2 = 0.12
15 Dec. 1988	10/57 = 0.175	(10+6)/57 = 0.281	0.281/2 = 0.14
19 Jan. 1989	8/50 = 0.160	(8+6)/50 = 0.280	0.280/2 = 0.14
16 Feb. 1989*	6/40 = 0.150	(6+6)/40 = 0.300	0.300/2 = 0.15

Note * : Surveyed in the first study period in Guatemala.

5) Average Operation per Day:

It is calculated by dividing the monthly operation by number of days of each corresponding month.

Month	Traffic	Average Traffic per Day
January, 1989	1,364	44.0
February, 1988*	991	34.2
March, 1988	1,117	36.0
April, 1988	1,102	36.7
May, 1988	1,147	37.0
June, 1988	1,159	38.6
July, 1988	1,230	39.6
August, 1988	1,238	39.9
September, 1988	1,163	38.8
October, 1988	1,203	38.8
November, 1988	1,211	40.4
December, 1988	4,446	46.6
Total		470.6
Annual average per day: 470.6/12 =		39.2

Note *: There were 29 days in February of the leap year 1988. Busy days' operation at La Aurora are in the range 50 - 60.

1.5 Load Factor

With respect to load factor, cargo movements will be excluded.

(1) Composition of International Passenger Aircraft Types in Busy Hour

Aircraft	B-747s	DC-10	A-300	B-767	B-707	B-720	B-727	B-737	Total
Busy day:									
24 Dec.	0	1	6	4	0	0	51	13	55
15 Dec.	0	4	6	4	0	0	29	10	53
7 Dec.	0	1	5	4	0	0	31	9	50
31 Dec.	0	1	6	5	0	0	26	11	49
28 Jan.	0	2	6	4	0	4	23	9	48
8 Jan.	0	2	6	4	0	0	24	11	47
19 Jan.	0	2	6	0	2	5	20	12	47
10 Dec.	0	2	5	4	0	0	28	7	46
15 Jan.	0	2	5	4	0	0	24	11	46
Total	0	17	51	33	2	9	236	92	441
Composition Percentage	0	3.85	11.56	7.48	0.45	2.04	53.51	21.11	100
A/C per Day	0	1.89	5.67	3.67	0.22	1.00	26.22	10.33	
(Average)	0	2	6	4		28		11	51

(2) Seat Per Aircraft

A/C type \ Source	World A/C Diary	FAA	Seat Number Adopted for the Study
B-747-200/300	348 - 496		360
B-747-SP	281 - 315		240
DC-10	339 - 380	281 - 340	260
A-300	251 - 267	211 - 288	220
A-310	218		170
B-767	211		160
B-757	186		140
B-707/720	147 - 202		130
B-727	163 - 189	111 - 160	130
A-320	164		130
MD-80s	137		110
B-737	115	110	90

Note: The adopted seat number for each aircraft is made with an assumption that the belly cargo loading percentage to the seat number of aircraft is an average of 20%.

(3) Passenger for Aircraft Type per Day, 1988

A/C Type	A/C per Day (A)		Adopted Seat No. (S)	Passenger Seats per Day per A/C (A x S)
DC-10	1.89	(3.86%)	260	491
A-300	5.67	(11.57%)	220	1,247
B-767	3.67	(7.49%)	170	624
B-707	0.22	(0.45%)	130	29
B-720	1.00	(2.04%)	130	130
B-727	26.22	(53.51%)	130	3,409
B-737	10.33	(21.08%)	90	930
Total	49.00	(100%)		6,860

Average Seat Number: 6,860/49 = 140

(4) Determination of Load Factor

As noted earlier, data on monthly passenger flows were not easily available. Therefore, the load factor was calculated by correlating annual passenger movements and aircraft operations in 1988.

Year Parameters	1988	1987	1986	1985	1984	1983
a. Annual Passenger	754,876	600,551	499,998	786,445	445,516	426,222
b. Annual Aircraft Operation (w/o Cargo)	12,907	11,890	8,930	7,815	8,25	7,410
c. Passenger per Operation (a/b)	58.49	50.51	55.99	54.87	54.30	57.52
d. Average Seat Number	140	*135	*135	*135	*135	*135
e. Average Load Factor (d/c)	41.8%	41.1%	41.5%	40.6%	40.2%	42.6%

Note: * Estimation

The load factor seems to be low. It may be because of the nature of La Aurora Airport, as a hopping station along air routes.

1.6 Estimation of Future Aircraft Type with Load Factor and Composition

For estimating load apron requirements, the sizes of aircraft types are the most important element. The estimation of future grouping of aircraft types in 5 year increment, for 1995, 2000 and 2005, is shown below. B-707/720/727 series are destined to retire gradually, and A-310, A-320, B-767, B-757 and MD-80 series will take place in service instead.

(1) 1995

A/C Type Grouping	Seat x L.F	= Passenger/ Aircraft	Composition	
			Actual (1988)	Future
Large Jet				
B-747S	360 x 0.44	158	-	1.0%
DC-10	260 x 0.44	114	(3.86%)	4.0%
Medium Jet				
A-300	220 x 0.44	97	(11.57%)	10.0%
B-767	160 x 0.44	70	(7.49%)	10.0%
Small Jet				
B-757	150 x 0.44			5.0%
B-727	130 x 0.44	72	(53.51%)	40.0%
B-737	90 x 0.44	40	(21.08%)	25.0%

(2) 2000

A/C Type Grouping	Seat x L.F	= Passenger/ Aircraft	Composition	
			Actual (1988)	Future
Large Jet				
B-747s	360 x 0.47	169		1.0%
DC-10	260 x 0.47	122		4.0%
Medium Jet				
A-300	220 x 0.47	103		7.0%
A-310	170 x 0.47	80		8.0%
B-767	160 x 0.47	75		15.0%
Small Jet				
B-757	150 x 0.47	71		10.0%
B-727	130 x 0.47	61		15.0%
A-320	130 x 0.47	61		5.0%
MD-80s	110 x 0.47	52		5.0%
B-737	90 x 0.47	42		30.0%

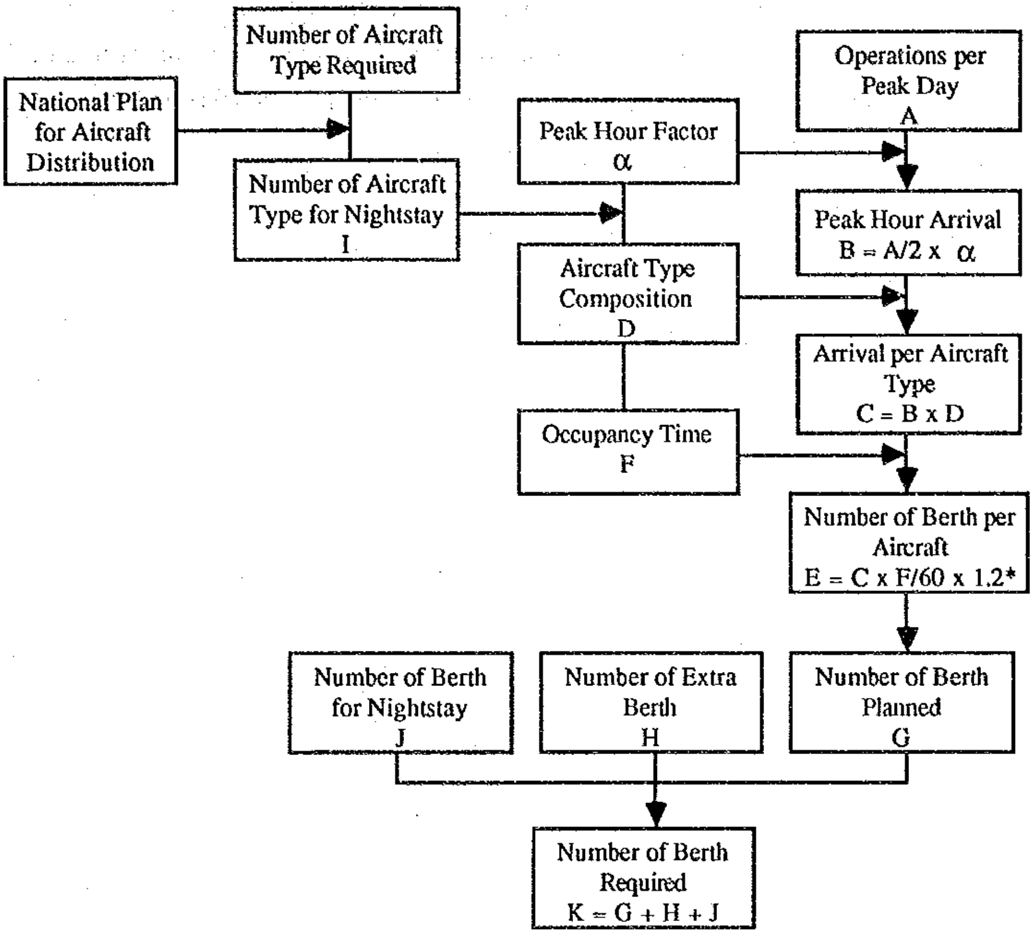
(2) 2005

A/C Type Grouping	Seat x L.F	=	Passenger/ Aircraft	Composition	
				Actual (1988)	Future
Large Jet					
B-747s	360 x 0.50		180		1.0%
DC-10	260 x 0.50		130		2.0%
Medium Jet					
A-300	220 x 0.50		110		5.0%
A-310	170 x 0.50		85		10.0%
B-767	160 x 0.50		80		15.0%
Small Jet					
B-757	150 x 0.50		75		15.0%
A-320	130 x 0.50		65		10.0%
MD-80s	110 x 0.50		55		10.0%
B-737	90 x 0.50		45		32.0%

As the data indicate, the Study Team predicts only modest and gradual changes in the composition of the aircrafts serving La Aurora.

1.7 Facility Design Criteria

The following are the criteria adaptable to the apron projection for La Aurora airport, which is specially developed from the methodology of JCAB (Japan Civil Aviation Bureau).



Note: 1.2*: To secure 20% extra berth for biased operations at a peak hour, or for prolonged parking time due to a ship change or mechanical trouble.

H: 1 additional berth for the maximum sized aircraft per 10 aircraft to be provided, to cope with such unforeseeable situations as long delay, diversion, malfunction of aircraft, etc.

1/2 of berth number will also be used by aircraft staying overnight.

1.8 Dimension of Standard Configuration for Loading Apron

Though there are 2 parking procedures, one referred to as "Nose-in" and the other "Self-manoeuvering", the space for providing new loading aprons is very limited at La Aurora airport. Therefore, the "Nose-in" procedure is recommended for the projection.

Tables below and Figure attached hereto show the standard configuration of a loading apron, under the condition that the apron elevation is not the same as that of the runway centerline and that the separation between the runway centerline and the taxiway centerline is 180 meter.

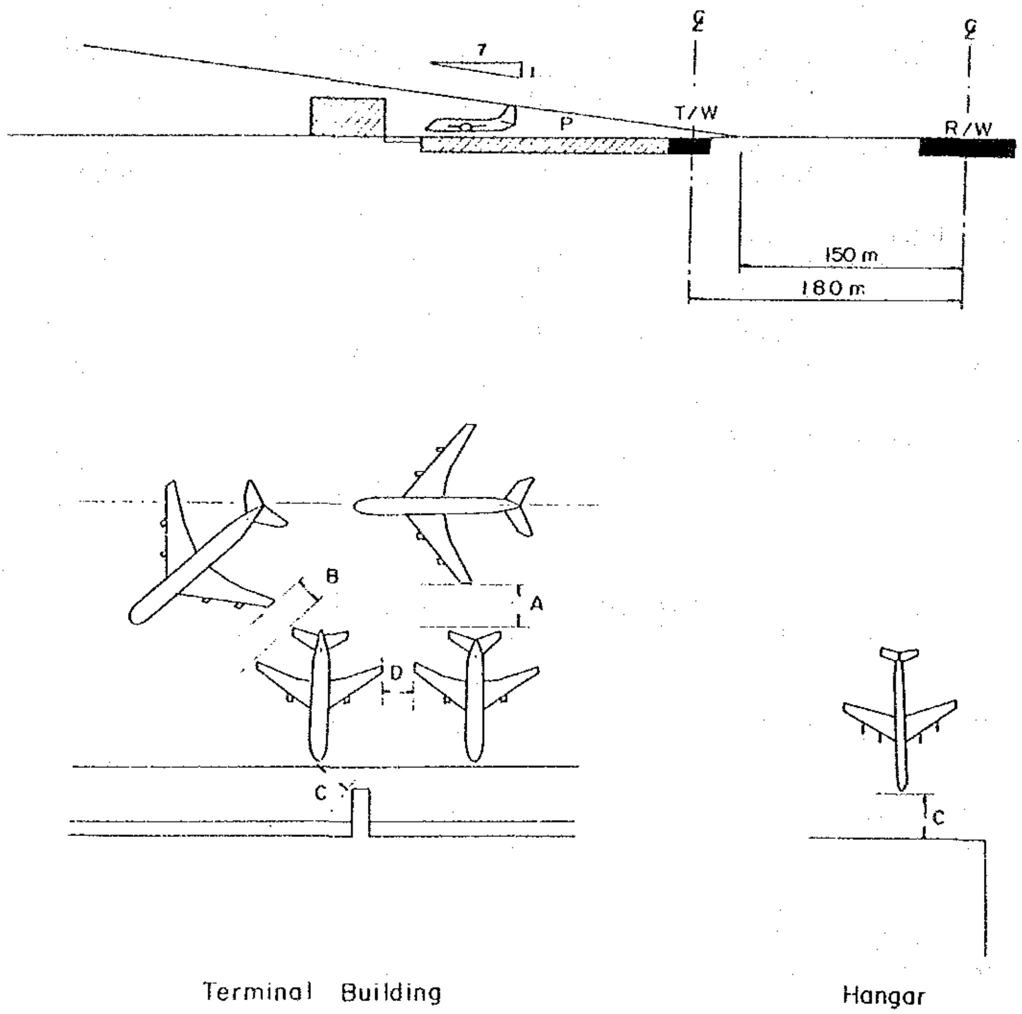
STANDARD CONFIGURATION

Aircraft Type		Nose-in Procedure		
		A m	B m	Dimension sq.m
Large Jet	B-848	70	130	9,100
	DC-10	70	130	9,100
Medium Jet	A-300	60	110	6,600
	B-767	60	110	6,600
Small Jet	A-310*	50	100	5,000
	B-757*	45	90	4,050
	A-320*	45	90	4,050
	MD-80s*	45	90	4,050
	B-737*	45	90	4,050

Note *: As recommended.

CLEARANCE BETWEEN AIRCRAFT

Separation between:	Code	Large and Medium Jets	Small Jet	Propeller	Small
Moving A/C on apron, taxiway and parking A/C	A	15 m	15 m	10 m	10 m
Moving A/C on apron and parking A/C, bldg. or vehicle lane	B	10 m	7.5 m	7.5 m	4.5 m
Parking A/C and bldg.					
C1: in case of fueling	C1	15 m	15 m	15 m	15 m
C2: in case of no fueling	C2	10 m	7.5 m	7.5 m	4.5 m
Parking A/C	D	10 m	7.5 m	7.5 m	4.5 m



Relationship between RWY and TWY and Aircraft

DEVELOPMENT PROJECT OF LA AURORA AND SANTA ELENA AIRPORTS

Figure F - 1

F.2 ESTIMATE OF APRON BERTH FOR 1995

As in the case of estimated apron berth for year 2005, the requirement of apron berths for the estimated annual passengers of 1,214,000 in the year 1995 has been calculated as follows:

2.1 Basic Parameter

The basic parameter applied herein is summarized as follows:

a. Peak Day Factor: 1/240 (0.00415)
b. Peak Hour Factor: 0.130 (Consecutive 2 Busy Hour)
c. Load Factor (L.F): 0.44

Note: Load Factor 0.44 was derived, based on the average annual growth mentioned.

2.2 Operations (Arrival and Departure) per Aircraft

Passenger Composition with A/C Type Q (Seat)	Annual Passenger P Total xQ	Annual Operation τ P/Seat/L.F	Peak Day Factor β Day/Month	Peak Day Operation A τx β	Peak Hour Factor α Hour/Day	Peak Hour Operation R Ax α
B747s 1% (360)	12,140	77	1/240	0.321	0.14	0.045
DC10 4% (260)	48,560	424	"	1.769	"	0.248
A300 10% (220)	121,400	1,254	"	5.225	"	0.732
B767 10% (160)	121,400	1,724	"	7.185	"	1.006
B757 5% (150)	60,700	920	"	3.832	"	0.536
B727 40% (130)	485,600	8,490	"	35.373	"	4.952
B737 25% (90)	303,500	6,744	"	28.10	"	3.934
Total:	1,214,000	19,633	"	81.805	"	11.453

Peak Hour Operation: 12

2.3 Required Number of Apron Berths (Peak Hour) for International Carriers

Aircraft Type International	Peak Hour Arrival B=R/2	Occupancy Time (min.) F	No. of Berth per Aircraft E=BxF/60x1.2	Planned No. of Berth G	Extra Berth H	Required No. of Berth K
B747s	0.023	70	0.032	0	1	1
DC10	0.124	70	0.174	1	0	1
A300	0.366	70	0.512	1	0	1
B767	0.503	70	0.704	1	0	1
B757	0.268	45	0.241	1	0	1
B727	2.476	45	2.228	3	0	3
B737	1.967	45	1.770	2	0	2
Total:	5.727	50(Average)		9	1	10

Note: Occupancy times is taken from the actual survey at the first study period in Guatemala.

The number of gates, including loading bridges and bus gates. need not necessarily be coincident with the number of apron berths, in order to avoid a wasteful use of resources. It is more practical that 4/5 of the required number of berths be used for both schedule and non-scheduled aircraft well as planes staying overnight. The required number for 1995 should be set at 8 - 9.

F.3 ESTIMATE OF APRON BERTH FOR 2005

On the basis of data and method explained hereinabove, the requirement of apron berths for the estimated annual passengers of 2,500,000 in the year 2005 has been calculated as follows:

3.1 Basic Parameter

The basic parameter applied herein is summarized as follows:

a. Peak Day Factor: 1/250 (0.003922)
b. Peak Hour Factor: 0.120 (Consecutive 2 Busy Hour)
c. Load Factor (L.F): 0.50

Note: Peak Day Coefficient 1/250 is the estimation for 2005.
: Load Factor 50% was derived, based on the average annual growth mentioned in 1.4.(4) e.

3.2 Operations (Arrival and Departure) per Aircraft

Passenger Composition	Annual Passenger	Annual Operation	Peak Day Factor	Peak Day Operation	Peak Hour Factor	Peak Hour Operation
with A/C	P	τ	β	A	α	R
Type Q (Seat)	Total xQ	P/Seat/L.F	Day/Month	τx β	Hour/Day	Ax α
B747s 1% (360)	25,000	139	1/250	0.556	0.12	0.067
DC10 2% (260)	50,000	385	"	1.540	"	0.185
A300 5% (220)	125,000	284	"	1.136	"	0.136
A310 10% (170)	250,000	2,941	"	11.764	"	1.412
B767 15% (160)	375,000	4,688	"	18.752	"	2.250
B757 15% (150)	375,000	5,000	"	20.000	"	2.400
A320 10% (130)	250,000	3,846	"	15.384	"	1.846
MD-80s 10% (110)	250,000	4,545	"	18.180	"	2.182
B737 32% (90)	800,000	17,778	"	71.112	"	8.533
Total: 100%	2,500,000	39,606	"	158.424	"	19.011

Peak Hour Operation: 19

Note: B727 is scheduled to be retired from service.

3.3 Required Number of Apron Berths (Peak Hour) for International Carriers

Aircraft Type International	Peak Hour Arrival B=R/2	Occupancy Time (min.) F	No. of Berth per Aircraft E=BxF/60x1.2	Planned No. of Berth G	Extra Berth H	Required No. of Berth K
B747s	0.035	70	0.049	0	1	1
DC10	0.091	70	0.127	1	0	1
A300	0.067	70	0.094	1	0	1
A310	0.192	70	0.269	1	0	1
B767	1.103	70	1.544	2	0	2
B757	1.177	45	1.059	2	0	2
A320	0.905	45	0.815	1	0	1
MD-80s	1.020	45	0.918	1	0	1
B737	4.183	45	3.765	4	1	5
Total:	8.773	50(Average)		13	2	15

Note: Occupancy times for A320 and MD-80s are estimates according to aircraft type group.

The number of gates, including loading bridges and bus gates. need not necessarily be coincident with the number of apron berths, in order to avoid a wasteful use of resources. The required number for 2005 should be set at 13 - 15 gates.

F.4 ALTERNATIVE ESTIMATE OF APRON BERTH

The estimate of apron berth or gate discussed in Section II and III for the year 2005 as 1995 has been reviewed by applying an alternative simplified method, as summarized hereunder.

$$\text{Required No. of Gates} = \frac{\text{Design PH Movements}}{\text{Gate Utilization Factor}}$$

$$\text{Gate Utilization Factor} = \frac{\text{Peak Hour Movements}}{\text{Active Gates}} = \frac{10}{7} = \underline{1.43}$$

YEAR	P.H. Ops.		GATE UT. FACT.	REQ. No. GATES
1995	12	:	1.43	9
2005	19	:	1.43	14

GATES BREAKDOWN:

GATE TYPE	1995	2005
1 (Wide Body)	3	6
2 (Standard)	6	8
TOTAL GATES	9	14

The results of analysis by different methods have proved to be coincidental, in any way.