Table 4.2.1.14(2) Results in Cruising (Departure) by Ship Type in Year 2011

Port	Fully Cellular Container										Semi-Container									
		Main Diesel			Sub Diesel			Sub Boiler				Main Diesel			Sub Diesel			Sub Boiler		
	Number of Voyger	Fuel Consumption (kg)	NO2 Emission (kg)	SO2 Emission (kg)	Fuel Consumption (kg)	NO2 Emission (kg)	SO2 Emission (kg)	Fuel Consumption (kg)	NO2 Emission (kg)	SO2 Emission (kg)	Number of Voyger	Fuel Consumption (kg)	NO2 Emission (kg)	SO2 Emission (kg)	Fuel Consumption (kg)	NO2 Emission (kg)	SO2 Emission (kg)	Fuel Consumption (kg)	NO2 Emission (kg)	SO2 Emission (kg)
Bangkok	1,681	2,217,037	167,540	75,379	433,181	7,797	14,728	201,154	14,081	6,839	164	77,345	4,763	2,630	18,171	327	618	13,674	957	465
Klong Toey Wharf	1,161	1,580,784	119,483	53,747	308,422	5,551	10,486	143,220	10,025	4,869	107	52,568	3,238	1,787	12,328	222	419	9,277	649	315
Klong Toey Pole																				
Bang Hua Suer Pole											3	769	47	26	187	3	6	141	10	5
Sathupradit Buoy																				
Tmn Wharf																				
Private Wharves	515	629,785	47,567	21,413	123,497	2,223	4,199	57,347	4,014	1,950	50	22,147	1,363	753	5,220	94	177	3,928	275	134
Others	5	6,468	489	220	1,262	23	43	586	41	20	4	1,861	115	63	436	8	15	328	23	11
Provincial Area	1,712	493,574	36,410	16,782	112,292	2,021	3,818	52,144	3,650	1,773	321	33,235	1,998	1,130	9,088	164	309	6,839	479	233
Chachoengsao	7	1,998	147	68	455	8	15	211	15	7	2	180	11	6	49	1	2	37	3	1
Chanthaburi																				
Chon Buri																				
Ko Sichang	10	2,940	217	100	669	12	23	311	22	11	24	2,467	148	84	675	12	23	508	36	17
Laem Chabang	1,096	315,884	23,302	10,740	71,866	1,294	2,443	33,372	2,336	1,135	150	15,574	936	530	4,259	77	145	3,205	224	109
Sattahip	2	490	36	17	111	2	4	52	4	2										
Sri Racha	12	3,430	253	117	780	14	27	362	25	12	48	4,934	297	168	1,349	24	46	1,015	71	35
Others																				
Chumporn																				
Krabi																				
Nakhon Si Thammarat																				
Khanom																				
Pakpanang																				
Tha Sala											2	178	11	6	49	1	2	37	3	1
Phetchaburi																				
Cha-am																				
Others																				
Phuket	19	5,443	401	185	1,238	22	42	575	40	20										
Prachuap Khiri Khan																				
Bang Saphan																				
Thap Sakae																				
Others																				
Rayong																				
Maptaphut	4	1,120	83	38	255	5	9	118	8	4	4	403	24	14	110	2	4	83	6	3
Others	37	10,636	785	362	2,420	44	82	1,124	79	38	33	3,422	206	116	936	17	32	704	49	24
Samut Sakhon																				
Mahachai																				
Thachalom																				
Thachin																				
Others																				
Samut Songkhram																				
Maeklong																				
Satun																				
Songkhla	526	151,633	11,186	5,156	34,498	621	1,173	16,019	1,121	545	59	6,077	365	207	1,662	30	57	1,251	88	43
Surat Thani																				
Trang																				
Katang																				
Total	3,392	2,710,611	203,949	92,161	545,473	9,818	18,546	253,298	17,731	8,612	485	110,580	6,762	3,760	27,259	491	927	20,512	1,436	697

Table 4.2.1.14(3) Results in Cruising (Departure) by Ship Type in Year 2011

Port	Ro-Ro										Conventional									
		Main Diesel			Sub Diesel			Sub Boiler				Main Diesel			Sub Diesel			Sub Boiler		
	Number of Voyger	Fuel Consumption (kg)	NO2 Emission (kg)	SO2 Emission (kg)	Fuel Consumption (kg)	NO2 Emission (kg)	SO2 Emission (kg)	Fuel Consumption (kg)	NO2 Emission (kg)	SO2 Emission (kg)	Number of Voyger	Fuel Consumption (kg)	NO2 Emission (kg)	SO2 Emission (kg)	Fuel Consumption (kg)	NO2 Emission (kg)	SO2 Emission (kg)	Fuel Consumption (kg)	NO2 Emission (kg)	SO2 Emission (kg)
Bangkok	54	55,948	4,020	1,902	9,915	178	337	10,552	739	359	1,090	634,835	40,767	21,584	138,162	2,487	4,697	114,218	7,995	3,883
Klong Toey Wharf	42	44,214	3,177	1,503	7,827	141	266	8,330	583	283	345	208,105	13,367	7,076	45,218	814	1,537	37,382	2,617	1,271
Klong Toey Pole											108	65,355	4,198	2,222	14,201	256	483	11,740	822	399
Bang Hua Suer Pole											45	14,845	949	505	3,343	60	114	2,764	193	94
Sathupradit Buoy											98	76,980	4,952	2,617	16,553	298	563	13,684	958	465
Tmn Wharf											9	5,826	375	198	1,260	23	43	1,041	73	35
Private Wharves	12	11,734	843	399	2,088	38	71	2,222	156	76	476	257,991	16,559	8,772	56,341	1,014	1,916	46,577	3,260	1,584
Others											10	5,733	368	195	1,246	22	42	1,030	72	35
Provincial Area	337	75,390	5,287	2,563	15,562	280	529	16,563	1,159	563	3,995	510,459	31,999	17,356	129,335	2,328	4,397	106,921	7,484	3,635
Chachoengsao											149	19,039	1,194	647	4,824	87	164	3,988	279	136
Chanthaburi																				
Chon Buri																				
Ko Sichang	7	1,523	107	52	314	6	11	335	23	11	1,219	155,709	9,761	5,294	39,452	710	1,341	32,615	2,283	1,109
Laem Chabang	256	57,387	4,025	1,951	11,846	213	403	12,608	883	429	696	88,962	5,577	3,025	22,540	406	766	18,634	1,304	634
Sattahip	2	381	27	13	79	1	3	84	6	3	24	3,040	191	103	770	14	26	637	45	22
Sri Racha	10	2,284	160	78	471	8	16	502	35	17	270	34,530	2,165	1,174	8,749	157	297	7,233	506	246
Others											3	434	27	15	110	2	4	91	6	3
Chumporn											2	220	14	7	56	1	2	46	3	2
Krabi	11	2,352	165	80	485	9	17	517	36	18	180	23,033	1,444	783	5,836	105	198	4,824	338	164
Nakhon Si Thammarat																				
Khanom											67	8,552	536	291	2,167	39	74	1,791	125	61
Pakpanang											3	439	27	15	111	2	4	92	6	3
Tha Sala											24	3,070	192	104	778	14	26	643	45	22
Phetchaburi																				
Cha-am																				
Others																				
Phuket	31	7,046	494	240	1,455	26	49	1,548	108	53	77	9,849	617	335	2,495	45	85	2,063	144	70
Prachuap Khiri Khan																				
Bang Saphan											178	22,796	1,429	775	5,776	104	196	4,775	334	162
Thap Sakae																				
Others											173	22,094	1,385	751	5,598	101	190	4,628	324	157
Rayong																				
Maptaphut	4	870	61	30	180	3	6	191	13	6	610	77,901	4,883	2,649	19,738	355	671	16,317	1,142	555
Others											62	7,939	498	270	2,011	36	68	1,663	116	57
Samut Sakhon																				
Mahachai											12	1,515	95	51	384	7	13	317	22	11
Thachalom											2	303	19	10	77	1	3	63	4	2
Thachin																				
Others											17	2,120	133	72	537	10	18	444	31	15
Samut Songkhram																				
Maeklong																				
Satun											18	2,236	140	76	567	10	19	468	33	16
Songkhla	16	3,548	249	121	732	13	25	779	55	27	162	20,646	1,294	702	5,231	94	178	4,324	303	147
Surat Thani											2	219	14	7	56	1	2	46	3	2
Trang																				
Katung											46	5,814	364	198	1,473	27	50	1,218	85	41
Total	391	131,338	9,307	4,465	25,476	459	866	27,115	1,898	922	5,084	1,145,295	72,766	38,940	267,497	4,815	9,095	221,139	15,480	7,519

Table 4.2.1.14(4) Results in Cruising (Departure) by Ship Type in Year 2011

Port	Others										Total									
	Number of Voyger	Main Diesel			Sub Diesel			Sub Boiler			Number of Voyger	Main Diesel			Sub Diesel			Sub Boiler			Total		
		Fuel Consumption (kg)	NO2 Emission (kg)	SO2 Emission (kg)	Fuel Consumption (kg)	NO2 Emission (kg)	SO2 Emission (kg)	Fuel Consumption (kg)	NO2 Emission (kg)	SO2 Emission (kg)		Fuel Consumption (kg)	NO2 Emission (kg)	SO2 Emission (kg)	Fuel Consumption (kg)	NO2 Emission (kg)	SO2 Emission (kg)	Fuel Consumption (kg)	NO2 Emission (kg)	SO2 Emission (kg)	Fuel Consumption (ton)	NO2 Emission (kg)	SO2 Emission (kg)
Bangkok	162	51,399	2,933	1,748	16,560	298	563	6,920	484	235	4,048	3,509,075	249,789	119,309	717,136	12,908	24,383	495,258	34,668	16,839	4,721	297,365	160,530
Klong Toey Wharf	5	1,588	91	54	511	9	17	213	15	7	1,675	1,895,511	159,876	64,447	376,170	6,771	12,790	199,892	13,992	6,796	2,472	160,639	84,033
Klong Toey Pole											127	75,670	4,847	2,573	16,330	298	562	13,576	950	462	106	6,094	3,596
Bang Hua Suer Pole	1	175	10	6	58	1	2	24	2	1	62	19,767	1,254	672	4,519	81	154	3,663	256	125	28	1,592	950
Saithupradit Buoy	11	4,970	284	169	1,581	28	54	661	46	22	243	176,755	11,207	6,010	39,322	708	1,337	31,047	2,173	1,056	247	14,088	8,402
Tran Wharf	14	5,381	307	183	1,721	31	59	719	50	24	27	13,337	828	460	3,504	63	119	2,173	152	74	19	1,044	653
Private Wharves	124	37,379	2,132	1,271	12,077	217	411	5,047	353	172	1,877	1,304,542	90,234	44,354	272,009	4,896	9,248	299,956	16,797	8,199	1,817	111,927	61,761
Others	6	1,906	109	65	613	11	21	256	18	9	37	23,293	1,543	792	5,082	91	173	4,951	347	168	33	1,981	1,133
Provincial Area	1,557	110,227	6,140	3,748	41,318	744	1,405	17,267	1,209	587	16,026	2,171,826	140,289	73,842	532,858	9,591	18,117	672,125	47,049	22,852	3,377	196,928	114,812
Chachoengsao	66	4,661	260	158	1,747	31	59	730	51	25	528	61,821	3,828	2,102	15,258	275	519	26,759	1,873	910	104	5,976	3,531
Chanthaburi	2	154	9	5	58	1	2	24	2	1	2	154	9	5	58	1	2	24	2	1	0	11	8
Chon Buri																							
Ko Sichang	7	481	27	16	180	3	6	75	5	3	1,820	226,896	14,175	7,714	57,964	1,043	1,971	48,440	3,391	1,647	333	18,609	11,332
Laem Chabang	72	5,130	286	174	1,923	35	65	804	56	27	2,458	504,712	35,465	17,160	117,819	2,121	4,006	77,046	5,393	2,620	700	42,979	23,786
Sattahip	14	963	54	33	361	6	12	151	11	5	48	5,660	355	192	1,521	27	52	1,166	82	40	8	464	284
Sri Racha	15	1,083	60	37	406	7	14	170	12	6	1,671	200,578	12,445	6,820	47,929	863	1,630	91,240	6,387	3,102	340	19,694	11,591
Others											3	434	27	15	110	2	4	91	6	3	1	36	22
Chumporn											2	220	14	7	56	1	2	46	3	2	0	18	11
Krabi	84	5,948	331	202	2,229	40	76	932	65	32	392	44,827	2,769	1,524	12,082	217	411	9,321	652	317	66	3,638	2,252
Nakhon Si Thammarat																							
Khanom	19	1,337	74	45	501	9	17	209	15	7	173	20,154	1,243	685	5,075	91	173	7,438	521	253	33	1,855	1,111
Pakpanang	3	243	14	8	91	2	3	38	3	1	7	682	41	23	202	4	7	130	9	4	1	54	34
Tha Sala	10	729	41	25	273	5	9	114	8	4	67	7,528	462	256	2,035	37	69	1,531	107	52	11	605	377
Phetchaburi																							
Cha-am																							
Others																							
Phuket	175	12,363	689	420	4,634	83	158	1,937	136	66	544	63,182	3,958	2,148	16,410	295	558	22,238	1,557	756	102	5,810	3,462
Prachuap Khiri Khan																							
Bang Saphan	11	777	43	26	291	5	10	122	9	4	250	30,514	1,898	1,037	7,895	142	268	6,337	444	215	45	2,484	1,521
Thap Sakae																							
Others	5	389	22	13	146	3	5	61	4	2	214	26,584	1,658	904	6,824	123	232	5,540	388	188	39	2,169	1,324
Rayong																							
Maptaphut	25	1,787	100	61	670	12	23	280	20	10	3,621	431,884	26,718	14,684	101,724	1,831	3,459	216,445	15,151	7,359	750	43,709	25,502
Others	10	687	38	23	258	5	9	108	8	4	1,062	130,908	8,199	4,451	30,623	551	1,041	65,211	4,565	2,217	227	13,315	7,769
Samut Sakhon																							
Mahachai	119	8,392	467	285	3,146	57	107	1,315	92	45	216	19,724	1,165	671	6,105	110	208	3,781	265	129	30	1,540	1,007
Thachalom											2	303	19	10	77	1	3	63	4	2	0	25	15
Thachin																							
Others	154	10,910	608	371	4,090	74	139	1,709	120	58	199	16,349	945	556	5,431	98	185	3,622	254	123	25	1,296	864
Samut Songkhram																							
Maeklong																							
Satun	61	4,337	242	147	1,626	29	55	679	48	23	79	6,573	382	223	2,192	39	75	1,148	80	39	10	502	337
Songkhla	111	7,851	437	267	2,943	53	100	1,230	86	42	1,774	294,924	20,005	10,027	70,517	1,269	2,398	70,525	4,937	2,398	436	26,211	14,823
Surat Thani											2	219	14	7	56	1	2	46	3	2	0	18	11
Trang																							
Katang	593	42,005	2,340	1,428	15,745	283	535	6,580	461	224	893	76,995	4,495	2,618	24,895	448	846	13,937	976	474	116	5,919	3,938
Total	1,718	161,626	9,073	5,495	57,878	1,042	1,968	24,187	1,693	822	20,074	5,680,902	390,078	193,151	1,249,994	22,499	42,500	1,167,383	81,717	39,691	8,098	494,293	275,341

Table 4.2.1.15 Number and Average PS of Fishing Boats in Year 2011

Province	Number of Boat	Working hours (/year)	Rated Power (PS)	Fuel Consum-ption (ktons)	SOx (ton/y)	NOx (ton/y)
Krabi	92	785	41	0.2	0.1	4
Chanthaburi	521	785	101	2.3	1.4	66
Chachoengsao	84	785	85	0.3	0.2	9
Chon Buri	751	785	61	2.1	1.2	53
Chumporn	925	785	97	4.0	2.4	111
Trang	321	785	142	2.0	1.2	60
Trat	1,342	785	83	5.0	3.0	135
Nakhon Si Thammarat	873	785	84	3.3	2.0	89
Narathiwat	48	785	61	0.1	0.1	3
Prachuap Khiri Khan	682	785	66	2.0	1.2	53
Pattani	577	785	96	2.5	1.5	69
Bangkok	0	785	0	0.0	0.0	0
Phangnga	141	785	126	0.8	0.5	23
Phetchaburi	589	785	99	2.6	1.5	72
Phuket	244	785	47	0.5	0.3	13
Ranong	225	785	87	0.9	0.5	24
Rayong	986	785	66	2.9	1.8	76
Songkhla	1,375	785	74	4.6	2.7	121
Satun	717	785	37	1.3	0.8	29
Samut Prakan	830	785	215	7.6	4.6	249
Samut Songkhram	662	785	147	4.2	2.5	128
Samut Sakhon	897	785	165	6.4	3.8	198
Surat Thani	381	785	142	2.4	1.4	71
Total	13,263			58	35	1,657

Note: workig hours 5 hours/day based on interview with Officer of Fishery Department,
Working day:157days/year based on " The 2011 Intercensal Survey of Marine Fishery".

Table 4.2.1.16 Number of trips and SOx, NOx emission of Express Boat in Chao Phraya River in Year 2011

Kind of Boat	destination	Length (km)	Time (hr)	Trips (/day)	Triprs (day/week)	Trips (/year)	GRT	Rated Power(PS)	Fuel Consumption (ktons)	NOx Emission (ton)	SOx Emission (ton)
Rapid Express Boat	Nonthaburi-BigC (A)	23.3	1.00	26	5	6,677	30	263	0.09	3	3
Normal Express Boat	Nonthaburi-Wat Rajsingkorn(Orange Flag) (B)	20.1	1.00	213	5	55,470	30	263	0.78	27	27
	Nonthaburi-Satorn(Yellow Flag) (C)	17.8	0.75	150	5	39,034	30	263	0.41	14	14
	Nonthaburi-Wat Rajsingkorn(No Flag) (D)	20.1	1.00	154	7	56,086	30	263	0.79	27	27
Total				541.75					2.09	70.58	70.96

Source: Harbor Department
Note: Time and GRT of boat is based on interview with express boat company.

Table 4.2.1.17 Number of trips and SOx, NOx emission of Ferry Boat in Chao Phraya River in Year 2011

No.	Pier	Time(hr)	Trips (/day)	Trips (/week)	Trips (/year)	GRT	Rated Power (PS)	Fuel Consumption (ktons)	NOx Emission (ton)	SOx Emission (ton)
1	Pak Kret - Wat Bang Tay	0.08	358	1,789	130,579	40	313	0.2	6.4	6.2
2	Pak Kret - Watchareewong	0.08	419	2,094	152,870	40	313	0.2	7.4	7.2
3	Nonthaburi - Bang Sri Muang	0.08	597	2,985	217,872	40	313	0.3	10.6	10.3
4	Wat Khama - Dao Pong Suwan	0.08	184	920	67,159	40	313	0.1	3.3	3.2
5	Wat Khama - Wat Kang Khoa	0.08	221	1,105	80,677	40	313	0.1	3.9	3.8
6	Keat Kay - Wat Chat Kaew	0.08	122	611	44,581	40	313	0.1	2.2	2.1
7	Phayap - Wat Arwut	0.08	156	782	57,093	40	313	0.1	2.8	2.7
8	Thawet - Wat Borwormongkol	0.08	201	1,007	73,487	40	313	0.1	3.6	3.5
9	Thawet - Wat Kharuhabudee	0.08	230	1,150	83,985	40	313	0.1	4.1	4.0
10	Wisukasat - Ban Pun	0.08	89	447	32,645	40	313	0.0	1.6	1.5
11	Banglumpoo - Bang Yee Khun	0.08	83	414	30,200	40	313	0.0	1.5	1.4
12	Pra Arthit - Wat Daowadeng	0.08	235	1,174	85,711	40	313	0.1	4.2	4.1
13	Pra Arthit - Pin Khoa	0.08	194	969	70,755	40	313	0.1	3.4	3.4
	Sub Total	0.08	3,089	15,447	1,127,614	40	313	1.6	54.9	53.4
14	North Phrachan - Pin Khoa	0.08	157	784	57,236	40	313	0.1	2.8	2.7
15	North Phrachan - Thonburi Station	0.08	301	1,505	109,871	40	313	0.2	5.4	5.2
16	North Phrachan - Wang Lang	0.08	347	1,734	126,553	40	313	0.2	6.2	6.0
17	Tha Chang - Wang Lang	0.08	344	1,720	125,546	40	313	0.2	6.1	5.9
18	Tha Chang - Wat Rakhang	0.08	185	926	67,591	40	313	0.1	3.3	3.2
19	Tha Tain - Wat Arun	0.08	254	1,271	92,757	40	313	0.1	4.5	4.4
20	Pak Klong Talad - Wat Kurechan	0.08	189	946	69,029	40	313	0.1	3.4	3.3
21	Pak Klong Talad - Wat Kalayamit	0.08	191	955	69,748	40	313	0.1	3.4	3.3
22	Rama I Bridge (Bangkok Side - Thonburi Side)	0.08	151	756	55,223	40	313	0.1	2.7	2.6
23	Ratchawong - Tha Dindaeng	0.08	328	1,641	119,794	40	313	0.2	5.8	5.7
24	Thong Sawad - Wat Thong Thamachat	0.08	212	1,058	77,226	40	313	0.1	3.8	3.7
	Sub Total	0.08	2,659	13,296	970,574	40	313	1.4	47.3	46.0
25	Si Phraya - Klong San	0.08	576	2,880	210,250	40	313	0.3	10.2	10.0
26	Orienral Hotel - Wat Suwan	0.08	312	1,562	114,041	40	313	0.2	5.6	5.4
27	Saun Phu - Dumax	0.08	229	1,147	83,697	40	313	0.1	4.1	4.0
28	Sathon Bridge - Taksin	0.08	208	1,040	75,932	40	313	0.1	3.7	3.6
29	Se Ta - Wat Sawachchat	0.08	143	717	52,347	40	313	0.1	2.5	2.5
30	Klong Tay - General	0.08	180	898	65,577	40	313	0.1	3.2	3.1
31	Bang Na - Num pung Nok	0.08	139	693	50,621	40	313	0.1	2.5	2.4
32	Bang NA - Kamsuntee	0.08	104	518	37,822	40	313	0.1	1.8	1.8
33	Phratra - Prapadang	0.08	54	270	19,702	40	313	0.0	1.0	0.9
34	Wibunsri - Phrasumutchadee	0.08	403	2,015	147,118	40	313	0.2	7.2	7.0
	Sub Total	0.08	2,348	11,741	857,108	40	313	1.2	41.7	40.6
	Grand Total	0.08	8,097	40,484	2,955,296	40	313	4.1	143.9	140.0

Source: Harbor Department

Note: Time and GRT of boat is based on interview with ferry boat company.

Table 4.2.1.18 Number of trips and SOx, NOx emission of Long-tailed Boat in Chao Phraya River in Year 2011

No.	Pier	Trip (/day)	time/trip (mim)	Distance (km)	kW	Rated Power(PS)	Fuel Consumption(ktons)	NOx Emission (ton)	SOx Emission (ton)
201	Pak Kret - Bang Khuwad	83	10	1.49	108	202	0.06	1.79	0.03
202	Pak Kret - Tha It	461	10	2.77	108	202	0.31	9.97	0.19
203	Pak Kret - Pak Klong Bang Bua Thong	191	20	4.24	108	202	0.26	8.26	0.15
204	Pak Kret - Bang Bua Thong	87	20	3.98	108	202	0.12	3.75	0.07
205	Pak Kret - Phra Udom	151	10	2.96	108	202	0.10	3.26	0.06
206	Nonthaburi - Bang Yai (1)	287	40	11.58	108	202	0.77	24.80	0.46
207	Nonthaburi - Bang Yai (1)	150	40	11.59	108	202	0.40	12.98	0.24
208	Nonthaburi - Bang Yai (1)	35	30	8.33	108	202	0.07	2.27	0.04
209	Khun Koii - Chimplee	60	10	0.44	108	202	0.04	1.29	0.02
210	Tha Chang - Bang Yai	249	60	16.31	108	202	1.01	32.35	0.60
211	Tha Chang - Bang Chak Nung	52	30	8.86	108	202	0.10	3.37	0.06
212	Tha Bang Noi	18	30	7.59	108	202	0.04	1.18	0.02
213	Rachini - Bang Wak	139	30	7.33	108	202	0.28	9.05	0.17
214	Rama I Bridge - Bang Wak	111	30	7.33	108	202	0.22	7.21	0.13
215	Sathupradit - Phra Phra Daeng	266	10	1.07	108	202	0.18	5.76	0.11
217	Klong Tay - Ladtanong	32	10	0.96	108	202	0.02	0.70	0.01
216	Klong Tay - Bang Ko Bua	192	10	1.85	108	202	0.13	4.16	0.08
218	Bang Kae - Klong Bang Wak	221	20	4.32	108	202	0.30	9.56	0.18
		2,787					4.40	141.71	2.64

Source: Harbor Department

Note: Time and Kw of boat is based on interview with long-tailed boat company.

2) Parameter for Emission Calculation

The parameters like average GRT, load factor, number of operating engine, mooring time and so on, which are used for emission calculation of vessels in mooring, are shown in Table 4.2.1.19 - 4.2.1.20.

The parameters like load factor, number of operating engine, cruising time and so on, which are used for emission calculation of vessels in cruising, are shown in Table 4.2.1.21 - 4.2.1.22.

The parameters like load factor and number of operating engine used for emission calculation of fishing boat are shown in Table 4.2.1.23.

The parameters like load factor and number of operating engine used for emission calculation of small boats are shown in Table 4.2.1.24 - 4.2.1.25.

Table 4.2.1.19 Parameter in Mooring(Arrival) by Ship Type in Year 2011

			Liquid Bulk		Solid Bulk		Fully Cellular Container		Semi-Container		Ro-Ro		Conventional		Others	
			Sub Diesel	Sub Boiler	Sub Diesel	Sub Boiler	Sub Diesel	Sub Boiler	Sub Diesel	Sub Boiler	Sub Diesel	Sub Boiler	Sub Diesel	Sub Boiler	Sub Diesel	Sub Boiler
Load factor	Unloading		0.37	0.19	0.42	0.48	0.42	0.48	0.42	0.48	0.42	0.48	0.42	0.48	0.42	0.48
	Loading		0.45	0.76	0.46	0.56	0.00	0.00	0.46	0.56	0.46	0.56	0.46	0.56	0.46	0.56
Number of operating engines	Unloading		1		1		1		1		1		1		1	
	Loading		1		2		0		2		2		2		2	
Rate of loading/mooring	International		0.23		0.23		0.00		0.23		0.23		0.23		0.00	
	Domestic		1.00		1.00		0.00		1.00		1.00		1.00		0.00	
Mooring time(hr)	0	500	12		12		12		12		24		12		12	
	500	3,000	12		16		12		16		24		16		12	
	3,000	6,000	12		16		12		16		34		16		12	
	6,000	10,000	20		20		16		20		36		20		12	
	10,000	100,000	24		40		16		40		36		40		12	
Equation(A*GRT^B)	A		20	0.29	15.4	0.27	4.4	0.27	15.4	0.27	15.4	0.27	15.4	0.27	0.178	0.27
	B		0.37	0.88	0.4	0.67	0.6	0.67	0.4	0.67	0.4	0.67	0.4	0.67	1	0.67
Sulfur Contents	(%,wt)		1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%
NOx Emission	(kg/kg)			0.0700		0.0700		0.0700		0.0700		0.0700		0.0700		0.0700
Spec Gravity				0.9487		0.9487		0.9487		0.9487		0.9487		0.9487		0.9487

Source:NOX emission is based on IPCC/OECD(1996).
Sulfur contents and spec gravity : DCR, 2000

Type of Vessel	GRT	Mooring Time(s)	Sub Diesel			Sub Boiler	
			Rated Power (PS/engine)	Fuel Consumption (kg/vessel)	NOx Emission (kg/vessel)	Fuel Consumption Rate (kg/hr)	Fuel Consumption (kg/vessel)
Liquid Bulk	9,500	20	1,114	1,303	62	871	5,592
Solid Bulk	9,100	20	1,110	1,784	86	115	1,147
Fully Cellular Container	13,100	16	2,443	2,430	133	147	1,128
Semi-Container	7,700	20	1,038	1,671	80	103	1,026
Ro-Ro	26,800	36	1,710	4,905	254	237	4,258
Conventional	10,800	40	1,189	3,816	187	129	2,574
Others	2,900	12	970	737	35	53	308

Table 4.2.1.20 Parameter in Mooring(Departure) by Ship Type in Year 2011

			Liquid Bulk		Solid Bulk		Fully Cellular Container		Semi-Container		Ro-Ro		Conventional		Others	
			Sub Diesel	Sub Boiler	Sub Diesel	Sub Boiler	Sub Diesel	Sub Boiler	Sub Diesel	Sub Boiler	Sub Diesel	Sub Boiler	Sub Diesel	Sub Boiler	Sub Diesel	Sub Boiler
Load factor	Unloading		0.37	0.19	0.42	0.48	0.42	0.48	0.42	0.48	0.42	0.48	0.42	0.48	0.42	0.48
	Loading		0.45	0.76	0.46	0.56			0.46	0.56	0.46	0.56	0.46	0.56	0.46	0.56
Number of operating engines	Unloading		1		1		1		1		1		1		1	
	Loading		1		2				2		2		2		2	
Rate of loading/mooring	International		0.23		0.23				0.23		0.23		0.23			
	Domestic		1.00		1.00				1.00		1.00		1.00			
Mooring time(hr)		500	12		12		12		12		24		12		12	
	500	3,000	12		16		12		16		24		16		12	
	3,000	6,000	12		16		12		16		34		16		12	
	6,000	10,000	20		20		16		20		36		20		12	
	10,000	100,000	24		40		16		40		36		40		12	
Equation(A*GRT^B)	A		20	0.29	15.4	0.27	4.4	0.27	15.4	0.27	15.4	0.27	15.4	0.27	0.178	0.27
	B		0.37	0.88	0.4	0.67	0.6	0.67	0.4	0.67	0.4	0.67	0.4	0.67	1	0.67
Sulfur Contents	(%,wt)		1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%
NOx Emission	(kg/kg)			0.0700		0.0700		0.0700		0.0700		0.0700		0.0700		0.0700
Spec Gravity				0.9487		0.9487		0.9487		0.9487		0.9487		0.9487		0.9487

Source:NOX emission is based on IPCC/OECD(1996).
Sulfur contents and specific gravity : DCR,2000

Type of Vessel	GRT	Mooring Time(s)	Sub Diesel			Sub Boiler	
			Rated Power (PS/engine)	Fuel Consumption (kg/vessel)	NOx Emission (kg/vessel)	Fuel Consumption Rate (kg/hr)	Fuel Consumption (kg/vessel)
Liquid Bulk	9,800	20	1,127	1,318	63	895	5,747
Solid Bulk	9,100	20	1,110	1,784	86	115	1,147
Fully Cellular Container	13,200	16	2,454	2,441	133	148	1,134
Semi-Container	10,300	40	1,166	3,746	183	125	2,493
Ro-Ro	27,400	36	1,725	4,947	257	241	4,322
Conventional	10,900	40	1,193	3,830	187	130	2,589
Others	2,900	12	970	737	35	53	308

Table 4.2.1.21 Parameter in Cruising(Arrival) by Ship Type in Year 2011

			Liquid Bulk			Solid Bulk			Fully Cellular Container			Semi-Container			Ro-Ro			Conventional			Others		
			Main Diesel	Sub Diesel	Sub Boiler	Main Diesel	Sub Diesel	Sub Boiler	Main Diesel	Sub Diesel	Sub Boiler	Main Diesel	Sub Diesel	Sub Boiler	Main Diesel	Sub Diesel	Sub Boiler	Main Diesel	Sub Diesel	Sub Boiler	Main Diesel	Sub Diesel	Sub Boiler
Load factor	Half		0.32	0.37	0.19	0.32	0.42	0.48	0.32	0.42	0.48	0.32	0.42	0.48	0.32	0.42	0.48	0.32	0.42	0.48	0.32	0.42	0.48
	Slow		0.17	0.37	0.19	0.17	0.42	0.48	0.17	0.42	0.48	0.17	0.42	0.48	0.17	0.42	0.48	0.17	0.42	0.48	0.17	0.42	0.48
Number of operating engines	Unloading			1			1			1			1			1			1			1	
	Loading			1			2						2			2			2			2	
Rate of loading/mooring	International			0.23			0.23						0.23			0.23			0.23				
	Domestic			1.00			1.00						1.00			1.00			1.00				
Mooring time(hr)		500		12			12			12			12			24			12			12	
	500	3,000		12			16			12			16			24			16			12	
	3,000	6,000		12			16			12			16			34			16			12	
	6,000	10,000		20			20			16			20			24			20			12	
	10,000	100,000		24			40			16			40			36			40			12	
Equation(A*GRT^B)	A		12	20	0.29	19	15.4	0.27	1.9	4.4	0.27	19	15.4	0.27	19	15.4	0.27	19	15.4	0.27	33	0.178	0.27
	B		0.7	0.37	0.88	0.65	0.4	0.67	0.97	0.6	0.67	0.65	0.4	0.67	0.65	0.4	0.67	0.65	0.4	0.67	0.61	1	0.67
Sulfur Contents	(%,wt)		1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%
NOx Emission	(kg/kg)				0.0700			0.0700			0.0700			0.0700			0.0700			0.0700			0.0700
Spec Gravity					0.9487			0.9487			0.9487			0.9487			0.9487			0.9487			0.9487

Source:NOX emission is based on IPCC/OECD(1996).
Sulfur contents and specific gravity : DCR,2000

Port	Time(hr)	
	Half Mode	Slow Mode
Bangkok		
Klong Toey Wharf	1.6	0.2
Klong Toey Pole	1.6	0.2
Bang Hua Suer Pole	0.8	0.2
Sathupradit Buoy	2.1	0.2
Tmn Wharf	1.8	0.2
Private Wharves	1.4	0.2
Others	1.6	0.2
Local Port	0.3	0.2

Table 4.2.1.22 Parameter in Cruising (Departure) by Ship Type in Year 2011

			Liquid Bulk			Solid Bulk			Fully Cellular Container			Semi-Container			Ro-Ro			Conventional			Others		
			Main Diesel	Sub Diesel	Sub Boiler	Main Diesel	Sub Diesel	Sub Boiler	Main Diesel	Sub Diesel	Sub Boiler	Main Diesel	Sub Diesel	Sub Boiler	Main Diesel	Sub Diesel	Sub Boiler	Main Diesel	Sub Diesel	Sub Boiler	Main Diesel	Sub Diesel	Sub Boiler
Load factor	Half		0.32	0.37	0.19	0.32	0.42	0.48	0.32	0.42	0.48	0.32	0.42	0.48	0.32	0.42	0.48	0.32	0.42	0.48	0.32	0.42	0.48
	Slow		0.17	0.37	0.19	0.17	0.42	0.48	0.17	0.42	0.48	0.17	0.42	0.48	0.17	0.42	0.48	0.17	0.42	0.48	0.17	0.42	0.48
Number of operating engines	Unloading			1			1			1			1			1			1			1	
	Loading			1			2						2			2			2			2	
Rate of loading/mooring	International			0.23			0.23						0.23			0.23			0.23				
	Domestic			1.00			1.00						1.00			1.00			1.00				
Mooring time(hr)		500		12			12			12			12			24			12			12	
	500	3,000		12			16			12			16			24			16			12	
	3,000	6,000		12			16			12			16			34			16			12	
	6,000	10,000		20			20			16			20			24			20			12	
	10,000	100,000		24			40			16			40			36			40			12	
Equation(A*GRT^B)	A		12	20	0.29	19	15.4	0.27	1.9	4.4	0.27	19	15.4	0.27	19	15.4	0.27	19	15.4	0.27	33	0.178	0.27
	B		0.7	0.37	0.88	0.65	0.4	0.67	0.97	0.6	0.67	0.65	0.4	0.67	0.65	0.4	0.67	0.65	0.4	0.67	0.61	1	0.67
Sulfur Contents	(%,wt)		1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%
NOx Emission	(kg/kg)				0.0700			0.0700			0.0700			0.0700			0.0700			0.0700			0.0700
Spec Gravity					0.9487			0.9487			0.9487			0.9487			0.9487			0.9487			0.9487

Source:NOX emission is based on IPCC/OECD(1996).
Sulfur contents and specific gravity : DCR,2000

Port	Time(hr)	
	Half Mode	Slow Mode
Bangkok		
Klong Toey Wharf	1.6	0.2
Klong Toey Pole	1.6	0.2
Bang Hua Suer Pole	0.8	0.2
Sathupradit Buoy	2.1	0.2
Tmn Wharf	1.8	0.2
Private Wharves	1.4	0.2
Others	1.6	0.2
Local Port	0.3	0.2

Table 4.2.1.23 Parameter of Fishing Boats in Year 2011

Load factor	Half	0.32
Number of Operating engines		1
Sulfur Contents	(%,wt)	0.03
NOx	kg/kg	0.07

Note: NOx emission based on IPCC/OECD(1996)

Table 4.2.1.24 Parameter of Express Boats and Ferry Boats in Year 2011

Load factor	Half	0.32
Number of Operating engines		1
Equation(A*GRT^B)	A	33
	B	0.61
Sulfur Contents	(%,wt)	1.7

Note: NOx emission based on method of NOx Manual

Table 4.2.1.25 Parameter of Long-tailed Boats in Year 2011

Load factor	Half	0.32
Sulfur Contents	(%,wt)	0.03
NOx	kg/kg	0.07

Note: NOx emission based on IPCC/OECD(1996)

4.2.1.4 Aircraft

1) Traffic Data and Estimated Emission

The annual aircraft movement and the estimated NOx and SOx emission of aircraft of the international airport in the Year 2011 are shown in Table 4.2.1.26.

Table 4.2.1.26(1) Annual Aircraft Movement in Year 2011 and NOx,SOx Emission

Bangkok International Airport

Type of Aircraft	Year 2011(flights)			Emission Nox(tons)			Emission Sox(tons)		
	International	Domestic	Total	LTO cycle	Takeoff+ Climb	Approach	LTO cycle	Takeoff+ Climb	Approach
A-300	24,992	26,470	51,462	12,775.88	10,890.51	1,653.44	374.47	237.54	101.65
A-310	7,310	7	7,317	1,975.87	1,653.60	281.79	50.29	31.21	14.18
A-319	45	0	45	12.19	10.20	1.74	0.31	0.19	0.09
A-320	6,086	0	6,086	565.11	468.15	81.60	20.33	12.75	5.51
A-321	340	0	340	31.60	26.18	4.56	1.14	0.71	0.31
A-330	19,153	6,361	25,514	2,369.20	1,962.69	342.12	85.24	53.46	23.10
A-340	11,854	0	11,854	1,100.72	911.86	158.95	39.60	24.84	10.73
B-707	203	0	203	59.04	34.15	7.77	3.09	1.84	0.87
B-717	547	0	547	158.94	91.94	20.93	8.31	4.96	2.35
B-727	10	0	10	0.98	0.80	0.15	0.05	0.03	0.01
B-737	14,649	29,439	44,088	3,532.18	2,815.54	591.59	159.63	96.51	43.75
B-747	14,769	75	14,844	16,371.27	14,355.24	1,759.43	421.34	262.22	115.87
B-747SP	439	0	439	484.47	424.81	52.07	12.47	7.76	3.43
B-747-400	41,473	1,384	42,857	47,266.08	41,445.53	5,079.73	1,216.47	757.07	334.52
B-757	3,537	0	3,537	775.01	670.84	88.74	19.12	11.93	5.27
B-767	13,007	0	13,007	3,415.05	2,866.95	490.68	97.18	61.51	27.38
B-777	29,496	1,757	31,253	8,205.95	6,888.94	1,179.04	233.51	147.81	65.79
Beech350	0	683	683	2.12	1.08	0.89	0.17	0.08	0.06
F-28	1,219	1,985	3,203	154.46	126.01	24.25	8.04	4.59	2.21
MD-11	13,428	169	13,598	8,157.92	6,955.15	1,060.57	236.50	153.77	62.52
L-1011	839	0	839	489.31	425.76	54.75	12.33	7.46	3.40
DC-10	2,321	0	2,321	1,400.84	1,214.10	163.12	34.67	21.72	9.46
BAE-146	653	0	653	49.91	37.13	10.27	3.07	1.88	0.84
TU-154	31	0	31	2.94	2.40	0.44	0.15	0.09	0.04
IL-62	122	0	122	134.04	117.54	14.41	3.45	2.15	0.95
IL-76	16	0	16	1.19	0.89	0.25	0.07	0.04	0.02
IL-86	35	0	35	38.30	33.58	4.12	0.99	0.61	0.27
IL-96	153	0	153	168.51	147.76	18.11	4.34	2.70	1.19
ATR-42	1,175	1,478	2,654	174.55	144.18	25.50	4.36	2.64	1.22
ATR-72	6,782	21,109	27,890	1,834.61	1,515.38	267.98	45.86	27.73	12.77
DO-328	0	31	31	0.10	0.05	0.04	0.01	0.00	0.00
AN-26/M	137	0	137	9.02	7.45	1.32	0.23	0.14	0.06
AN-12/M	457	0	457	30.04	24.81	4.39	0.75	0.45	0.21
Others	1,295	3,976	3070	9.56	4.87	4.01	0.78	0.37	0.26
Total	216,572	94,923	309,295	111,756.98	96,276.08	13,448.72	3,098.32	1,938.77	850.28

Note: For ATMOS2, height of Climb-out and Approach is 6000m.

Table 4.2.1.26(2) Annual Aircraft Movement in Year 2011 and NOx,SOx Emission

Chiang mai International Airport

Type of Aircraft	Year 2011(flights)			Emission Nox(tons)			Emission Sox(tons)		
	International	Domestic	Total	LTO cycle	Takeoff+ Climb	Approach	LTO cycle	Takeoff+ Climb	Approach
A-300	888	11,212	12,100	3,003.81	2,560.53	388.75	88.04	55.85	23.90
A-310	4	0	4	1.13	0.95	0.16	0.03	0.02	0.01
A-319	622	0	622	167.90	140.52	23.95	4.27	2.65	1.20
A-320	190	0	190	17.69	14.65	2.55	0.64	0.40	0.17
A-330	0	6,038	6,038	560.71	464.50	80.97	20.17	12.65	5.47
ATR-42	934	26	959	63.10	52.12	9.22	1.58	0.95	0.44
ATR-72	0	3,922	3,922	257.99	213.10	37.68	6.45	3.90	1.80
B-737	971	11,694	12,666	1,014.73	808.85	169.95	45.86	27.73	12.57
B-744	8	333	342	377.00	330.58	40.52	9.70	6.04	2.67
B-747	13	21	33	36.48	31.99	3.92	0.94	0.58	0.26
B-747SP	4	0	4	4.62	4.05	0.50	0.12	0.07	0.03
B-767	142	0	142	37.38	31.38	5.37	1.06	0.67	0.30
B-777	0	1,003	1,003	263.34	221.07	37.84	7.49	4.74	2.11
F-28	0	221	221	10.64	8.68	1.67	0.55	0.32	0.15
F-70	63	0	63	3.61	3.02	0.47	0.16	0.10	0.04
MD-11	8	144	152	91.20	77.76	11.86	2.64	1.72	0.70
L-1011	54	0	54	31.76	27.63	3.55	0.80	0.48	0.22
L-1011	4	0	4	2.44	2.13	0.27	0.06	0.04	0.02
Others	220	1,354	633	1.97	1.00	0.83	0.16	0.08	0.05
Total	4,126	35,968	39,153	5,947.50	4,994.51	820.03	190.74	118.99	52.11

Note: For ATMOS2, height of Climb-out and Approach is 6000m.

Hat Yai International Airport

Type of Aircraft	Year 2011(flights)			Emission Nox(tons)			Emission Sox(tons)		
	International	Domestic	Total	LTO cycle	Takeoff+ Climb	Approach	LTO cycle	Takeoff+ Climb	Approach
A-300	2,630	2,449	5,079	1,260.85	1,074.78	163.18	36.96	23.44	10.03
A-319	189	0	189	51.06	42.73	7.28	1.30	0.81	0.37
A-320	18	0	18	1.63	1.35	0.23	0.06	0.04	0.02
A-330	0	4	4	0.36	0.30	0.05	0.01	0.01	0.00
ATR-42	0	4	4	0.26	0.21	0.04	0.01	0.00	0.00
B-737	606	6,437	7,043	564.26	449.78	94.51	25.50	15.42	6.99
B-747	0	8	8	8.56	7.51	0.92	0.22	0.14	0.06
DC-10	11	0	11	6.34	5.49	0.74	0.16	0.10	0.04
F-70	179	0	179	10.26	8.60	1.35	0.47	0.27	0.13
MD-11	63	0	63	37.81	32.24	4.92	1.10	0.71	0.29
Lear Jet	6,338	0	6,338	305.60	249.30	47.98	15.91	9.07	4.38
F-28	333	0	333	16.04	13.08	2.52	0.83	0.48	0.23
L-1011	14	0	14	8.17	7.11	0.91	0.21	0.12	0.06
Others	168	638	425	1.32	0.67	0.56	0.11	0.05	0.04
Total	10,547	9,540	19,706	2,272.51	1,893.16	325.18	82.83	50.66	22.63

Note: For ATMOS2, height of Climb-out and Approach is 6000m.

Table 4.2.1.26(3) Annual Aircraft Movement in Year 2011 and NOx,SOx Emission

Phuket International Airport

Type of Aircraft	Year 2011(flights)			Emission Nox(tons)			Emission Sox(tons)		
	International	Domestic	Total	LTO cycle	Takeoff+ Climb	Approach	LTO cycle	Takeoff+ Climb	Approach
A-300	5,943	8,138	14,081	3,495.71	2,979.84	452.41	102.46	65.00	27.81
A-310	22	0	22	6.04	5.06	0.86	0.15	0.10	0.04
A-319	692	0	692	186.82	156.35	26.64	4.76	2.95	1.34
A-320	2,517	0	2,517	233.76	193.65	33.76	8.41	5.27	2.28
A-321	515	0	515	47.79	39.59	6.90	1.72	1.08	0.47
A-330	2,333	1,468	3,800	352.89	292.34	50.96	12.70	7.96	3.44
ATR-42	78	122	201	13.20	10.90	1.93	0.33	0.20	0.09
ATR-72	99	2,413	2,511	165.20	136.45	24.13	4.13	2.50	1.15
B-737	3,480	3,821	7,301	584.92	466.25	97.97	26.43	15.98	7.25
B-747	136	1,040	1,176	1,297.47	1,137.69	139.44	33.39	20.78	9.18
B-757	720	0	720	157.72	136.52	18.06	3.89	2.43	1.07
B-767	1,622	0	1,622	425.95	357.59	61.20	12.12	7.67	3.41
B-777	1,669	959	2,628	690.07	579.32	99.15	19.64	12.43	5.53
DC-10	254	0	254	153.03	132.63	17.82	3.79	2.37	1.03
F-28	198	0	198	9.53	7.77	1.50	0.50	0.28	0.14
F-70	140	0	140	8.03	6.74	1.06	0.37	0.21	0.10
IL-62	19	0	19	20.57	18.03	2.21	0.53	0.33	0.15
IL-86	9	0	9	10.28	9.02	1.11	0.26	0.16	0.07
MD-11	7	32	39	23.53	20.06	3.06	0.68	0.44	0.18
MD-90	351	0	351	210.32	179.31	27.34	6.10	3.96	1.61
Others	589	827	1,417	4.41	2.25	1.85	0.36	0.17	0.12
Total	21,392	18,821	40,213	8,097.25	6,867.36	1,069.35	242.72	152.29	66.47

Note: For ATMOS2, height of Climb-out and Approach is 6000m.

Chiang Rai International Airport

Type of Aircraft	Year 2011(flights)			Emission Nox(tons)			Emission Sox(tons)		
	International	Domestic	Total	LTO cycle	Takeoff+ Climb	Approach	LTO cycle	Takeoff+ Climb	Approach
A-300	0	1,536	1,536	381.26	325.00	49.34	11.18	7.09	3.03
A-330	0	451	451	41.88	34.69	6.05	1.51	0.94	0.41
B-737	98	3,709	3,807	305.00	243.12	51.08	13.78	8.33	3.78
B-747	0	5	5	5.10	4.47	0.55	0.13	0.08	0.04
B-747-400	0	2	2	2.55	2.24	0.27	0.07	0.04	0.02
B-757	7	0	7	1.52	1.32	0.17	0.04	0.02	0.01
B-777	0	5	5	1.21	1.02	0.17	0.03	0.02	0.01
F-28	88	0	88	4.24	3.46	0.67	0.22	0.13	0.06
MD-11	2	0	2	1.39	1.18	0.18	0.04	0.03	0.01
Others	0	108	108	0.33	0.17	0.14	0.03	0.01	0.01
Total	195	5,815	6,010	744.49	616.67	108.63	27.02	16.70	7.37

Note: For ATMOS2, height of Climb-out and Approach is 6000m

The annual aircraft movement and the estimated NOx and SOx emission of aircraft of the local airport in the Year 2011 are shown in Table 4.2.1.27.

Table 4.2.1.27 Annual Aircraft Movement in Year 2011 and NOx,SOx Emission

Local Airport

Airport	Annual Aircraft Movement in Year 2011					Emission Nox(LTO Cycle) (tons)					Emission Sox(LTO Cycle) (tons)				
	Medium Jet A-300	Small Jet B-737	Turbo Prop ATR-72	Stol DO-328	Total	Medium Jet A-300	Small Jet B-737	Turbo Prop ATR-72	Stol DO-328	Total	Medium Jet A-300	Small Jet B-737	Turbo Prop ATR-72	Stol DO-328	Total
Betong			1,460		1,460			96		96			2.4		2.4
Buri Ram			1,461	730	2,191			96	2	98			2.4	0.2	2.6
Chantaburi			730		730			48		48			1.2		1.2
Chumphon				491	491				2	2				0.1	0.1
Hua Hin			17,881		17,881			1,176		1,176			29.4		29.4
Khon Kaen	7,958	723			8,681	1,976	58			2,034	57.9	2.6			60.5
Krabi		3,027	3,027		6,054		243	199		442		11.0	5.0		15.9
Lampang	2,765		691		3,456	686		45		732	20.1		1.1		21.3
Loei		1,606		803	2,409		129		2	131		5.8		0.2	6.0
Mae Hong Son	4,561				4,561	1,132				1,132	33.2				33.2
Mae Sariang			730		730			48		48			1.2		1.2
Mae Sot			1,190	1,190	2,380			78	4	82			2.0	0.3	2.3
Nakhon Phanom		1,707			1,707		137			137		6.2			6.2
Nakon Ratchasima (korat)	3,120		624	624	4,368	775		41	2	818	22.7		1.0	0.2	23.9
Nakhon Si Thammarat		3,986			3,986		319			319		14.4			14.4
Nan		1,489	745	745	2,979		119	49	2	171		5.4	1.2	0.2	6.8
Narathiwat		1,218	609		1,827		98	40		138		4.4	1.0		5.4
Pattani			26		26			2		2			0.0		0.0
Phechabun		1,135		568	1,703		91		2	93		4.1		0.1	4.3
Phitsanulok	6,617	1,103	2,206	1,103	11,028	1,643	88	145	3	1,880	48.1	4.0	3.6	0.3	56.1
Pharae		4,052	2,026		6,079		325	133		458		14.7	3.3		18.0
Ranong		2,319			2,319		186			186		8.4			8.4
Roi Et		1,443	361		1,804		116	24		139		5.2	0.6		5.8
Sakhon Nakhon		2,917			2,917		234			234		10.6			10.6
Surat Thani	2,866				2,866	711				711	20.9				20.9
Sukhothai		1,602			2,083		128			128		5.8			5.8
Samui		12,306			15,998		986			986		44.6			44.6
Tak			15		15			1		1			0.0		0.0
Trang		8,527			8,527		683			683		30.9			30.9
Ubon Ratchathani	3,582		448		4,029	889		29		919	26.1		0.7		26.8
Udon Thani	4,147		1,037		5,183	1,029		68		1,098	30.2		1.7		31.9
Mukdahan		2,190			2,190		175			175		7.9			7.9
Utapao		5,480			5,480		439			439		19.8			19.8
Total	35,614	56,833	33,806	6,253	136,678	8,841	4,553	2,224	19	15,638	259.1	205.8	55.6	1.6	522.1

Note: For ATMOS2, height of Climb-out and Approach is 6000m.
Source: Annual Aircraft Movement in Year 2011: Department of Aviation, Ministry of Transportation and Communication

4.2.2 Mobile Source Inventory of the Year 2011 in BMR

4.2.2.1 Vehicle

1) Traffic Data

Traffic volumes of Year 2011 by link in BMR, which are estimated using the Airviro database updated based on the traffic assignment data in URMAP report of OCMLT, are shown in Figure 4.2.2.1.

Share of bus and heavy truck of Year 2011 by link in BMR is shown in Figure 4.2.2.2.

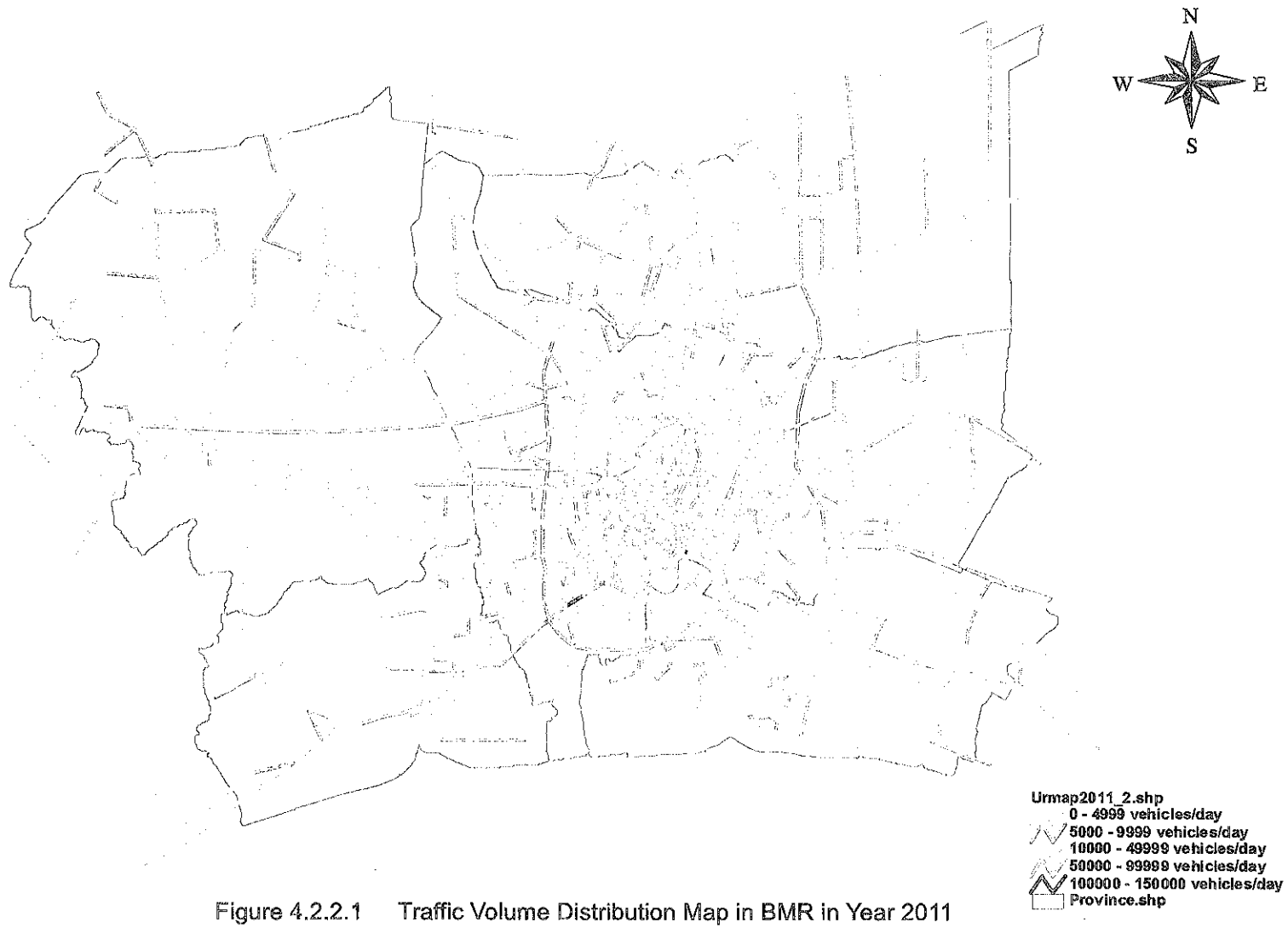


Figure 4.2.2.1 Traffic Volume Distribution Map in BMR in Year 2011

Figure 4.2.2.2 Share of Bus and Heavy Truck in BMR in Year 2011

2) Emission Factor

The NOx emission factors were calculated from the quadratics approximated to the calculation results of MOBILE 5a, as shown in Table 4.2.2.1 and Figure 4.2.2.3.

Table 4.2.2.1 Coefficients of NOx Emission Factor Formulas of the vehicles at 2011 (BAU Case)

$EF = a V^2 + b V + c$

EF :NOx Emission Factor (g/km) V :Vehicle Speed (km/h)

	LDGV	Taxi(G)	Taxi(L)	LDDV	LDDT	Bus	H-Truck	MC
a	0.00021	0.0001	8E-05	0.0003	0.0003	0.0055	0.0055	0.0000
b	- 0.0192	-0.0087	- 0.0071	- 0.0376	- 0.0325	- 0.604	- 0.604	- 0.0005
c	+ 1.6858	0.7692	0.6226	+ 1.9272	+ 1.6711	30.984	30.984	0.1212

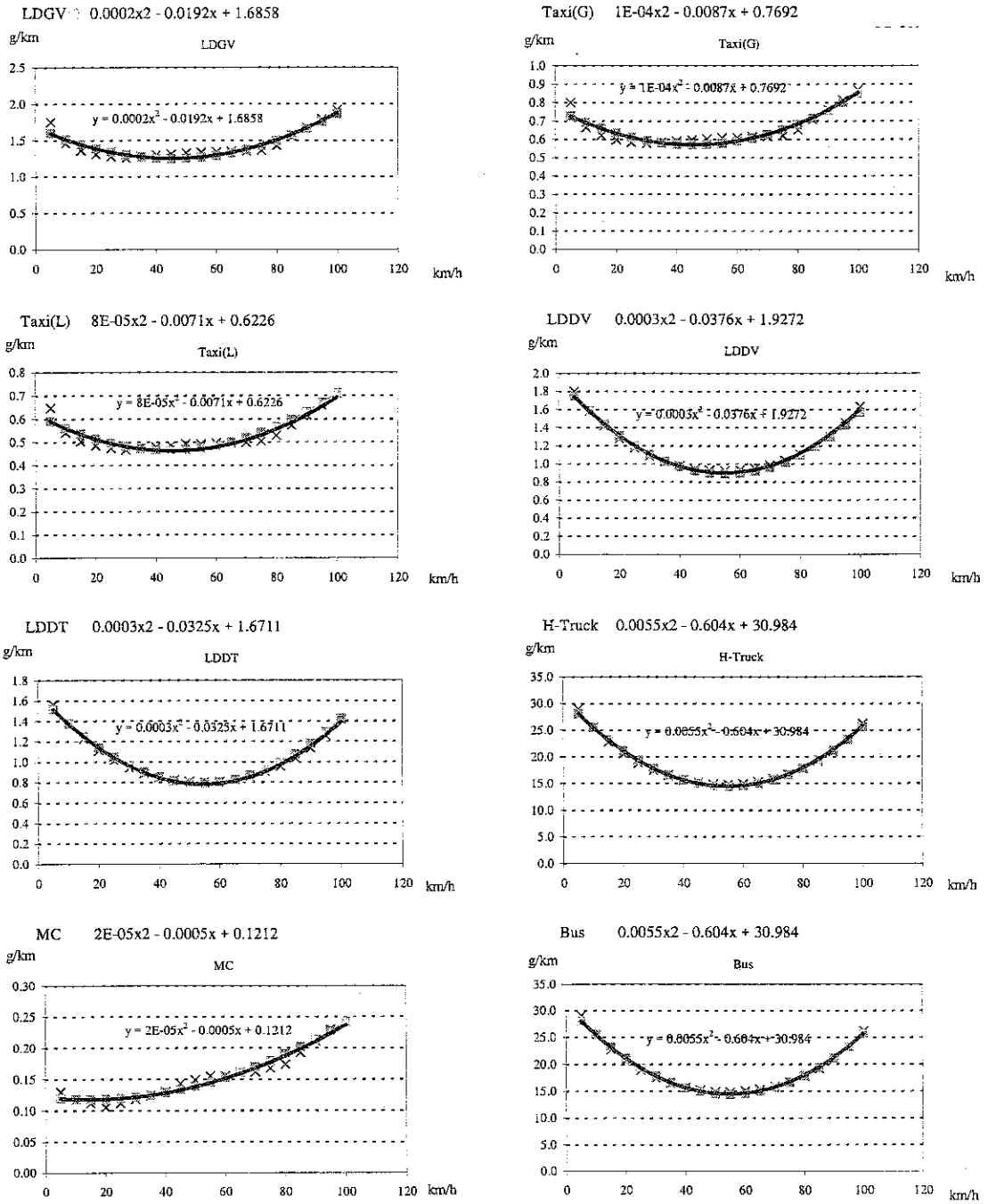


Figure 4.2.2.3 NOx Emission Factor of the vehicles at 2011 (BAU Case)

3) Estimated Emission

The estimated NOx and SOx emission of vehicle of the Year 2011 in BMR are shown in Table 4.2.2.2 - 4.2.2.3.

Table 4.2.2.2 NOx Emission of Vehicle in BMR in Year 2011

Province	NOx Emission (ton/year)									
	PS(G)	Taxi (G)	Taxi (LPG)	PS(D)	Light Truck	Bus	Heavy Truck	MC	Tuk-Tuk	total
Bangkok	21,926	311	177	1,544	4,887	39,032	56,787	551	75	125,291
Nonthaburi	3,846	55	31	318	836	9,298	13,188	99	13	27,684
Pathum Thani	5,861	83	48	527	1,068	12,144	15,917	160	19	35,827
Samut Prakan	5,001	71	41	368	1,076	9,985	14,547	141	18	31,247
Nakhon Pathom	3,698	53	30	415	2,303	11,733	23,128	255	32	41,648
Samut Sakhon	2,238	32	18	222	692	4,779	7,159	99	13	15,252
Total	42,571	605	345	3,393	10,863	86,971	130,727	1,305	170	276,949

Table 4.2.2.3 SOx Emission of Vehicle in BMR in Year 2011

Province	SOx Emission (ton/year)							
	PS(G)	Taxi (G)	PS(D)	Light Truck	Bus	Heavy Truck	MC	total
Bangkok	353	10	49	228	301	503	43	1,488
Nonthaburi	57	2	10	39	70	115	7	299
Pathum Thani	70	2	16	46	81	128	8	351
Samut Prakan	67	2	11	49	71	122	9	332
Nakhon Pathom	55	2	13	105	92	205	16	488
Samut Sakhon	31	1	7	31	35	61	6	172
Total	633	19	108	498	649	1,134	89	3,129

5. Model Simulation

5.1 Comparison with Critical Load

1) Critical Load

Critical load values are referred as a trial even though there are some disputes on critical load evaluation in Asia.

The critical load values around Thai referred from the RAINS-Asia project are shown in Figure 5.1.1.1, Figure 5.1.1.2, and Figure 5.1.1.3. The critical loads are estimated with certain damaging probabilities and 25, 50 and 70 % values are adopted here. The damaging probability of 25 % means that the sulfur deposition amount of the critical load value would cause damages in 25 % of deposited area.

The critical load values at the grid including Bangkok are 608, 1168 and 2851 mg-S/m^2/year as 25, 50, and 70 % values.

2) Deposition / Critical Load Ratio (The D/C Ratio) of Year2000

The deposition / critical load ratio is defined as the follows;

The Deposition / Critical Load Ratio (The D/C ratio) = Sulfur Deposition/Critical Load

The ratio below 1.0 means that the critical load mentioned is satisfied, and subtracting the reciprocal from 1.0 result in the necessary reduction ratio. As an example, the D/C ratio of 3.0 results in necessity of 67 % reduction, 1.0-(1/3.0)=0.67.

The D/C ratios in whole Thai are shown in from Figure 5.1.1.4 to Figure 5.1.1.6 according to the critical load of 25, 50, and 70%.

In case with 25 % critical load value, the grid over Chaochoensao and Chonburi provinces shows D/C value of 2.4, and it means that 58 % of the sulfur deposition on the grid should be reduced.

The D/C ratios in the urban area are shown in from Figure 5.1.1.7 to Figure 5.1.1.9. Because only the critical load values with resolutions of 1.0 degree are obtained, two values are used for the totally 231 urban grids divided at latitude 14.0 N. Then, artificial discrepancy can be seen in the maps.

In case with 25 % critical load values, the grids around Bangkok result in more than 5 D/C ratios, which need more than 80 % reductions.

3) The D/C Ratio of Year 2011

The D/C ratios in whole Thai of year 2011 are shown in from Figure 5.1.1.10 to Figure 5.1.1.12 according to the critical load of 25, 50, and 70%.

In case with 25 % critical load value, the grid over Chaochoensao and Chonburi provinces shows D/C value of 3.0 increased from 2.4 of year 2000, and it means that around 66 % of the sulfur deposition on the grid should be reduced.

The D/C ratios in the urban area are shown in from Figure 5.1.1.13to Figure 5.1.1.15. Compared with the results of year 2000, the D/C ratios distribution in the urban areas will slightly change to 4.9 (=80% reduction) in year 2011 and wide areas need drastic reductions.

4) The D/C Ratio of Year 2011 Under the Control

The D/C ratios in whole Thai of year 2011 are shown in from Figure 5.1.1.16 to Figure 5.1.1.18 according to the critical load of 25, 50, and 70%.

In case with 25 % critical load value, the D/C ratio at the grid over Chaochoensao and Chonburi provinces decrease to 2.6 by the control.

The D/C ratios in the urban area are shown in from Figure 5.1.1.19 to Figure 5.1.1.21. Compared with the results of the year 2011 BaU case, the D/C ratios in the urban areas will relatively decrease to 3.9 (=75% reduction) by the control.

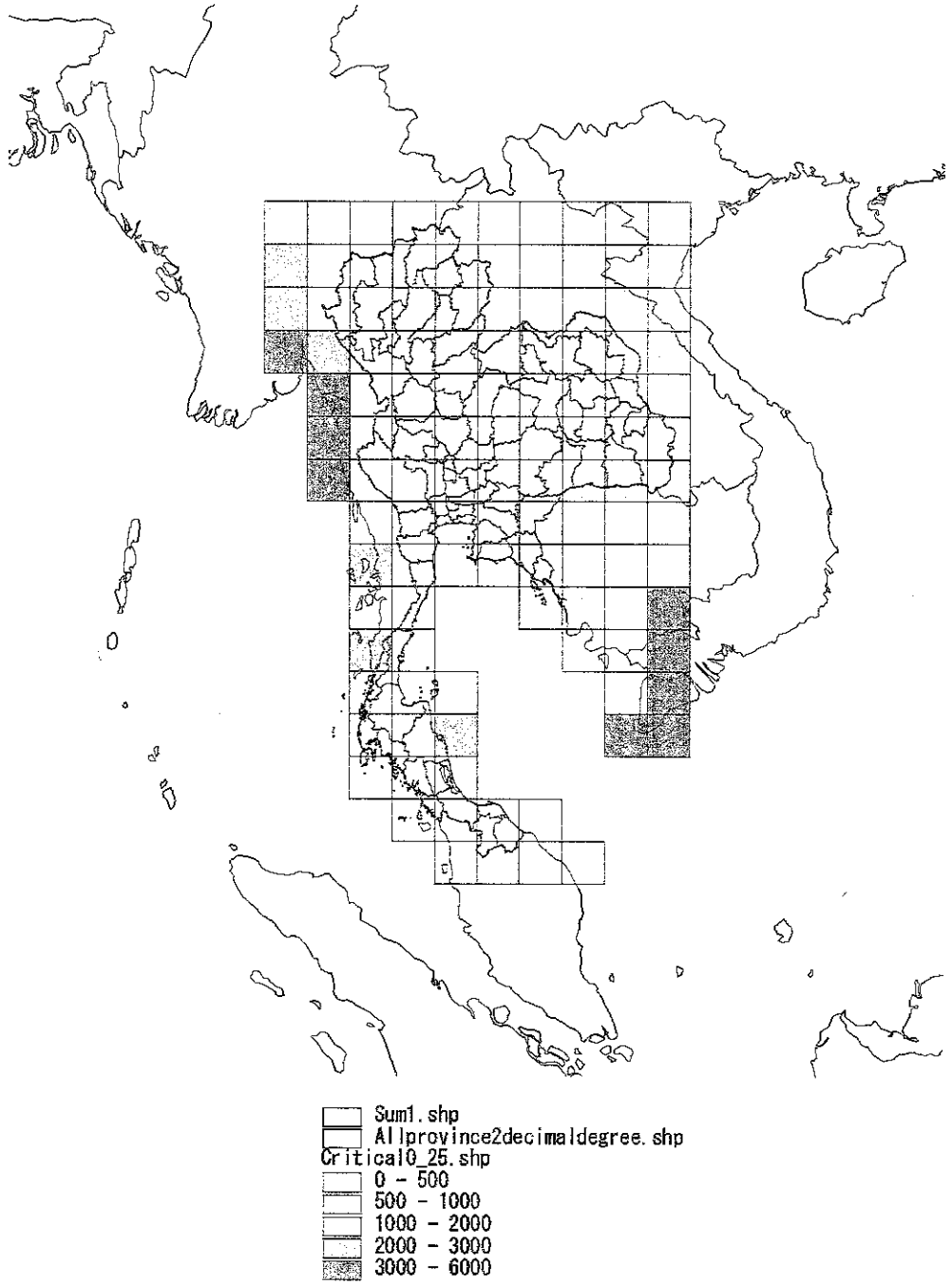


Figure 5.1.1.1 Critical Load of 25 % Around Thai

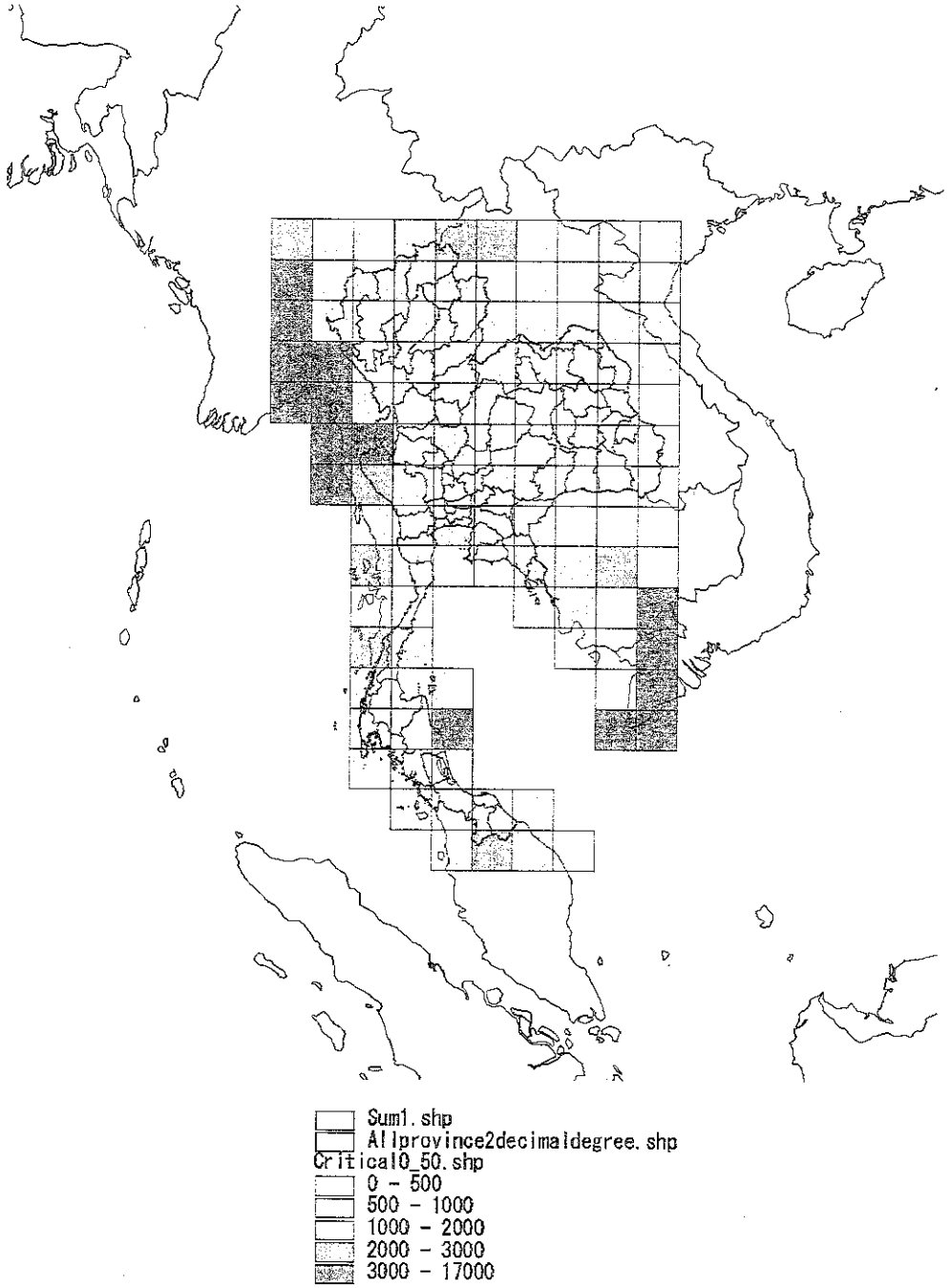


Figure 5.1.1.2 Critical Load of 50% Around Thai

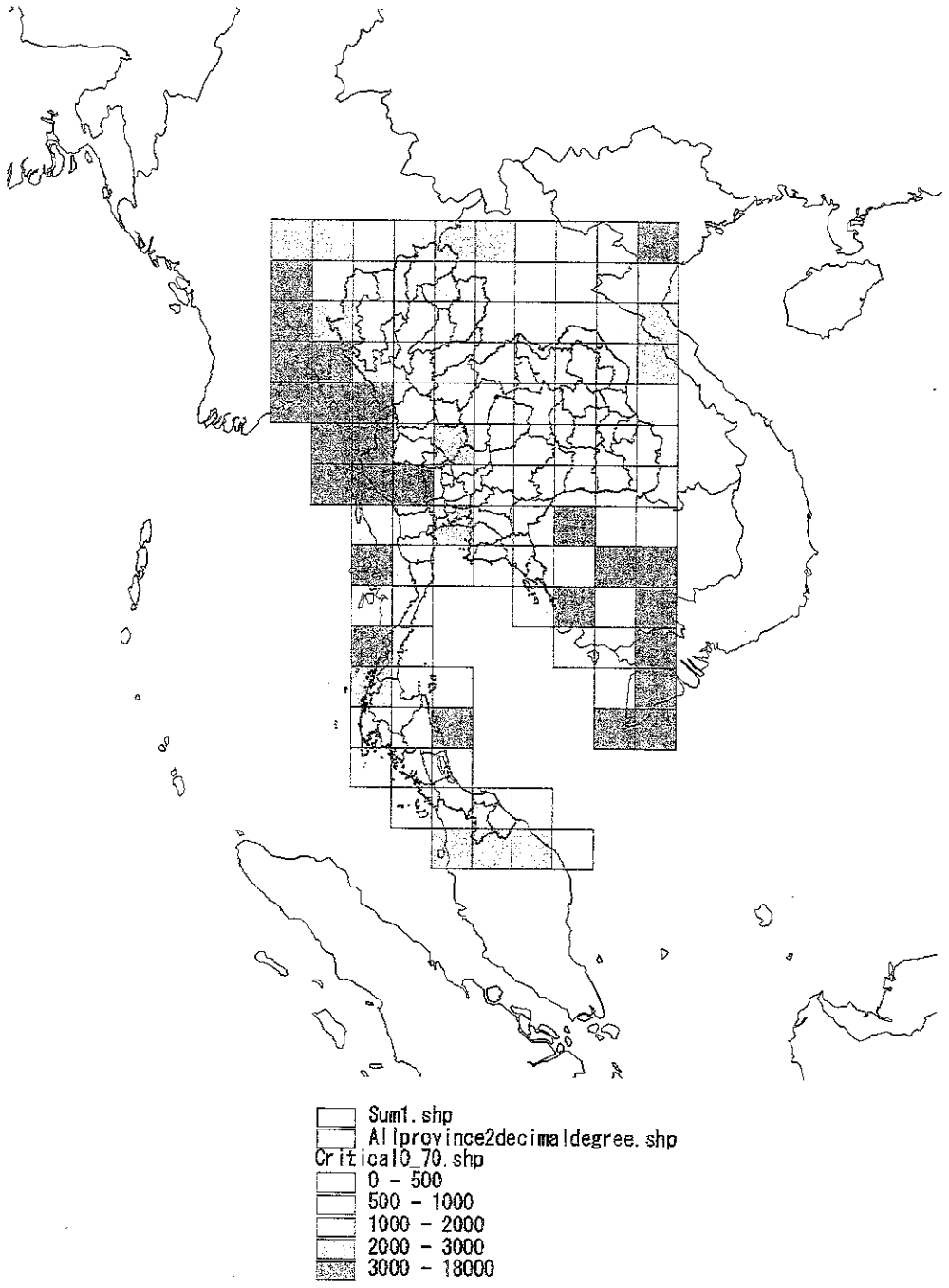


Figure 5.1.1.3 Critical Load 70% Around Thai

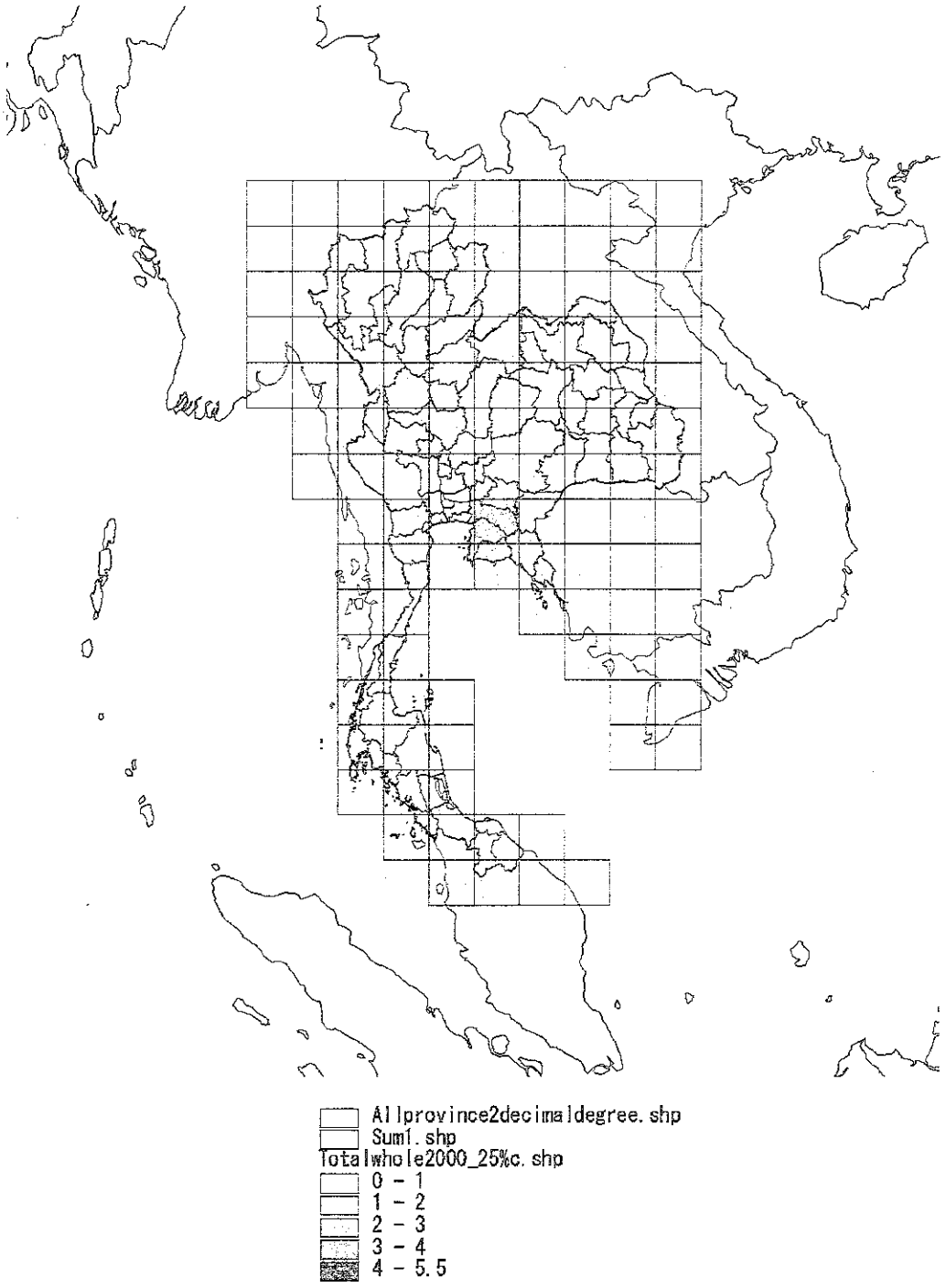


Figure 5.1.1.4 The D/C Ratio in Whole Thai of Year 2000 with 25 % Critical Load

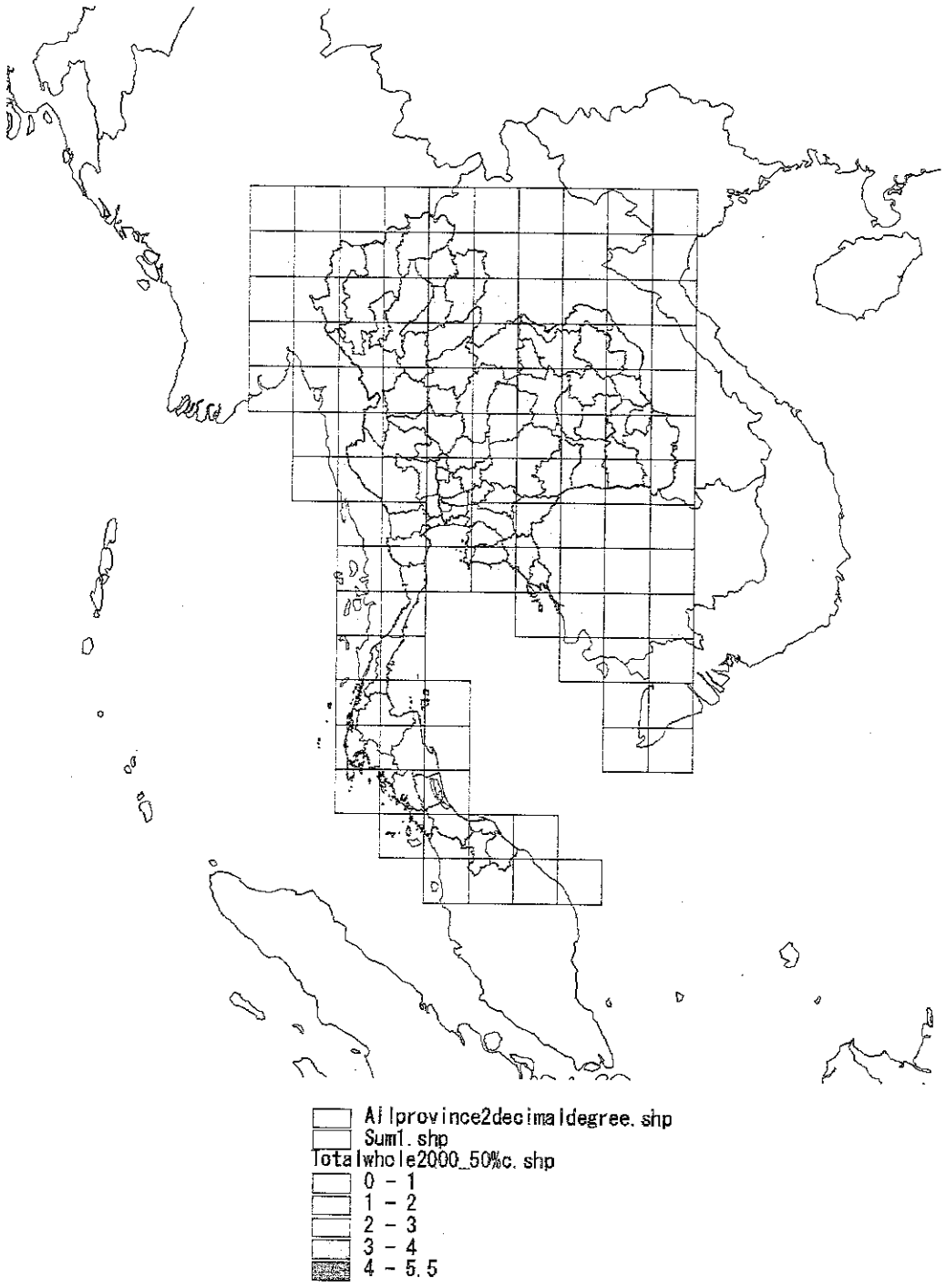


Figure 5.1.1.5 The D/C Ratio in Whole Thai of Year 2000 with 50 % Critical Load

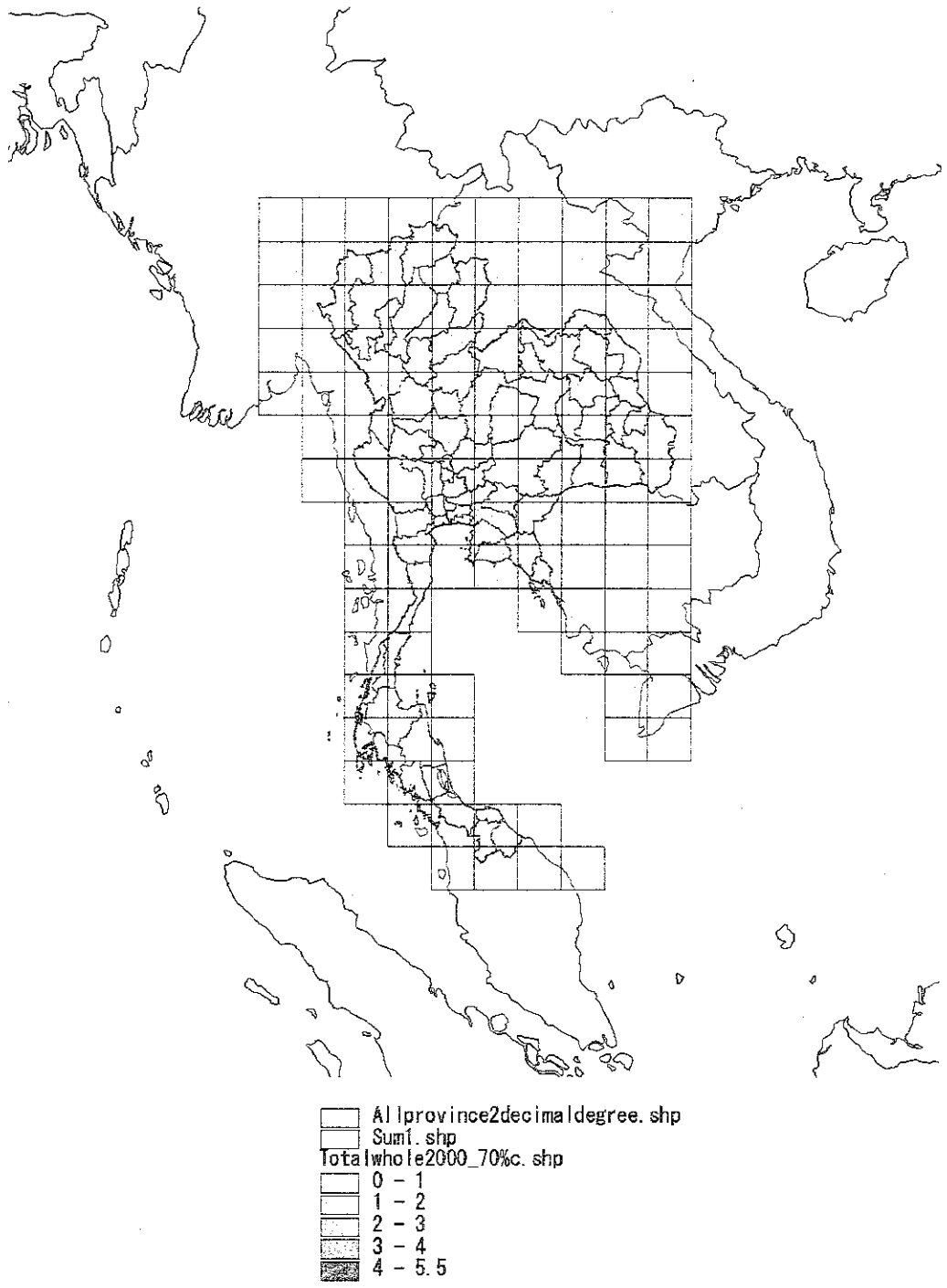


Figure 5.1.1.6 The D/C Ratio in Whole Thai of Year 2000 with 70 % Critical Load

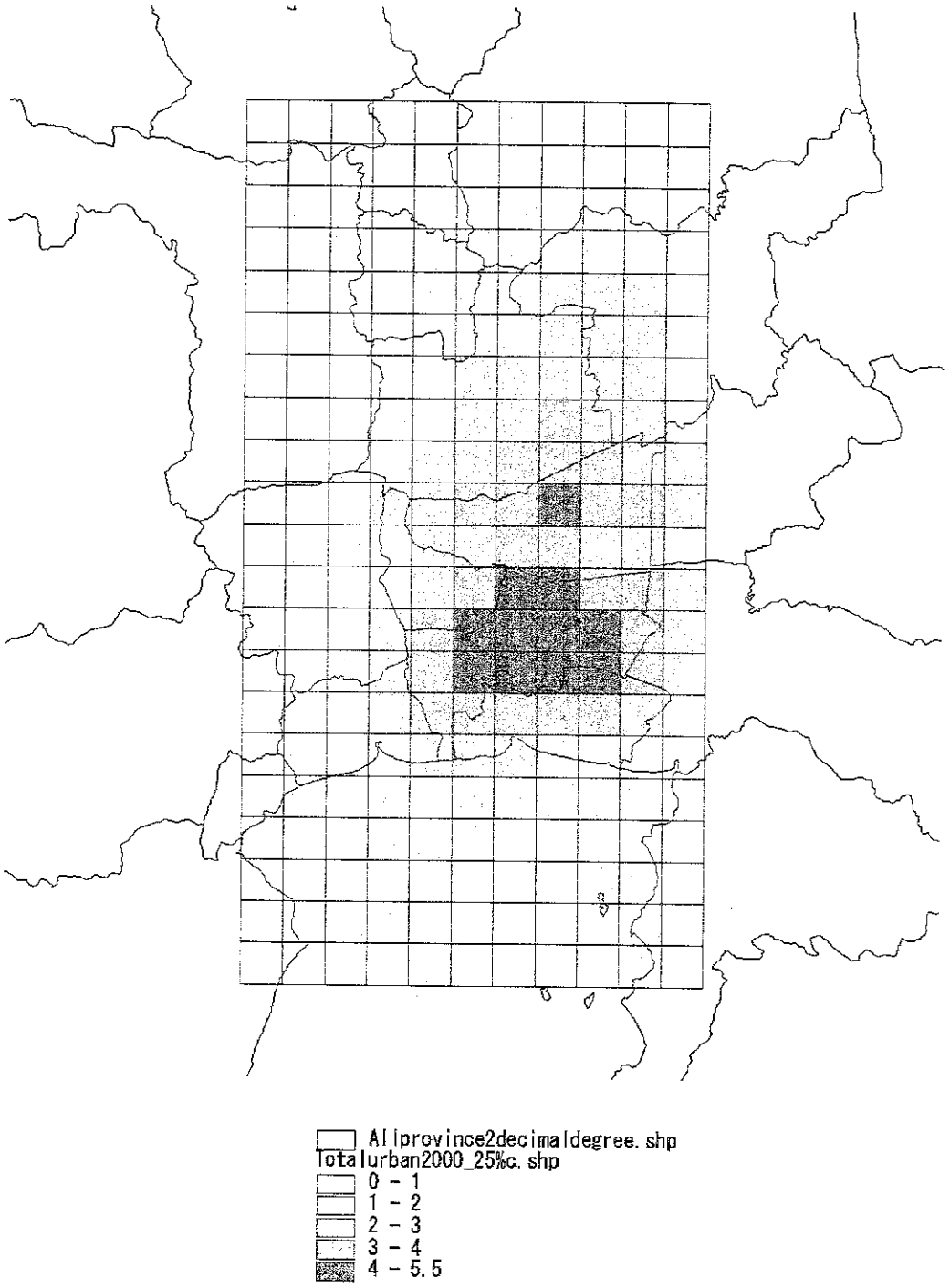


Figure 5.1.1.7 The D/C Ratio in Urban Area of Year 2000 with 25 % Critical Load

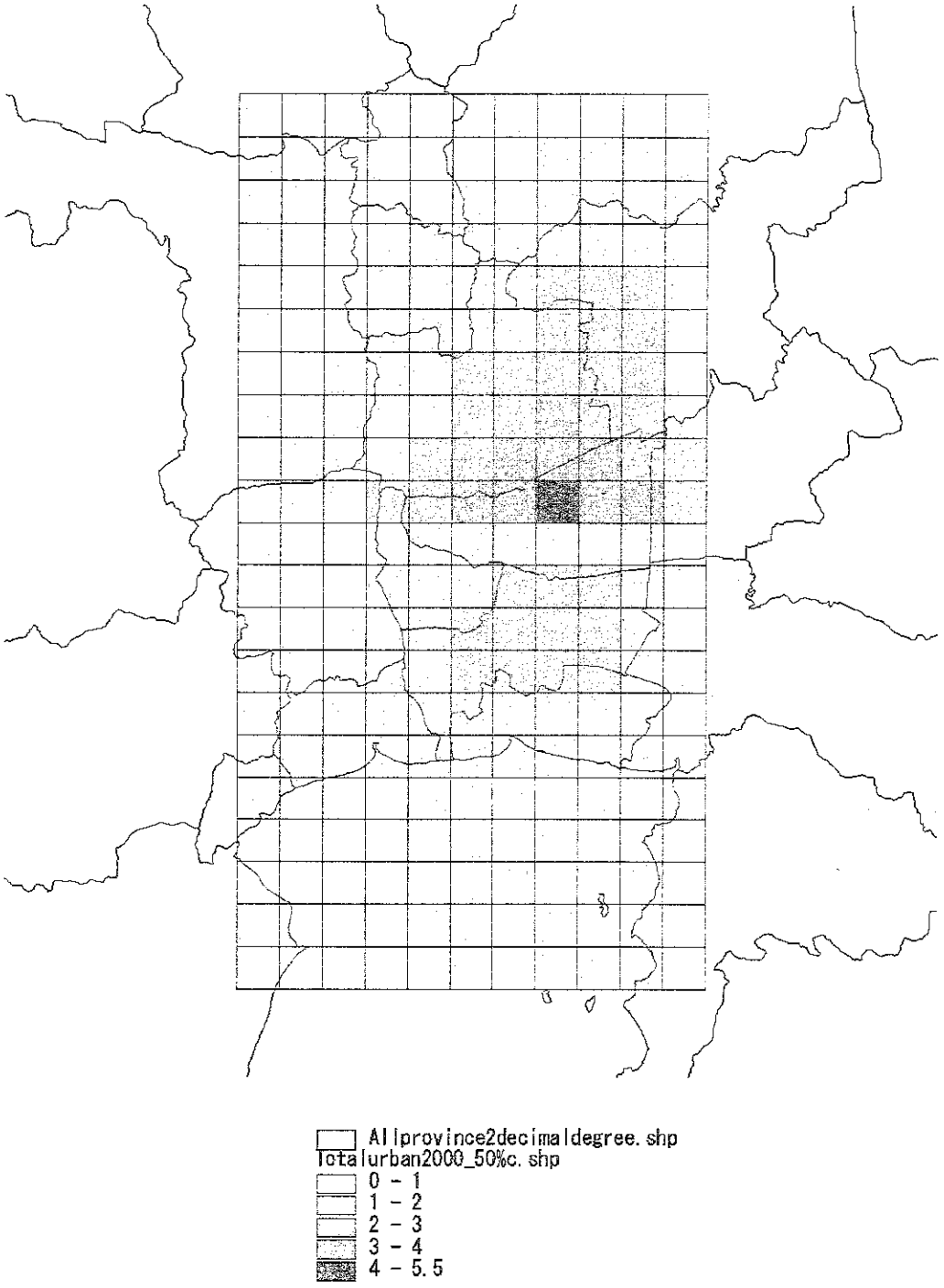


Figure 5.1.1.8 The D/C Ratio in Urban Area of Year 2000 with 50 % Critical Load

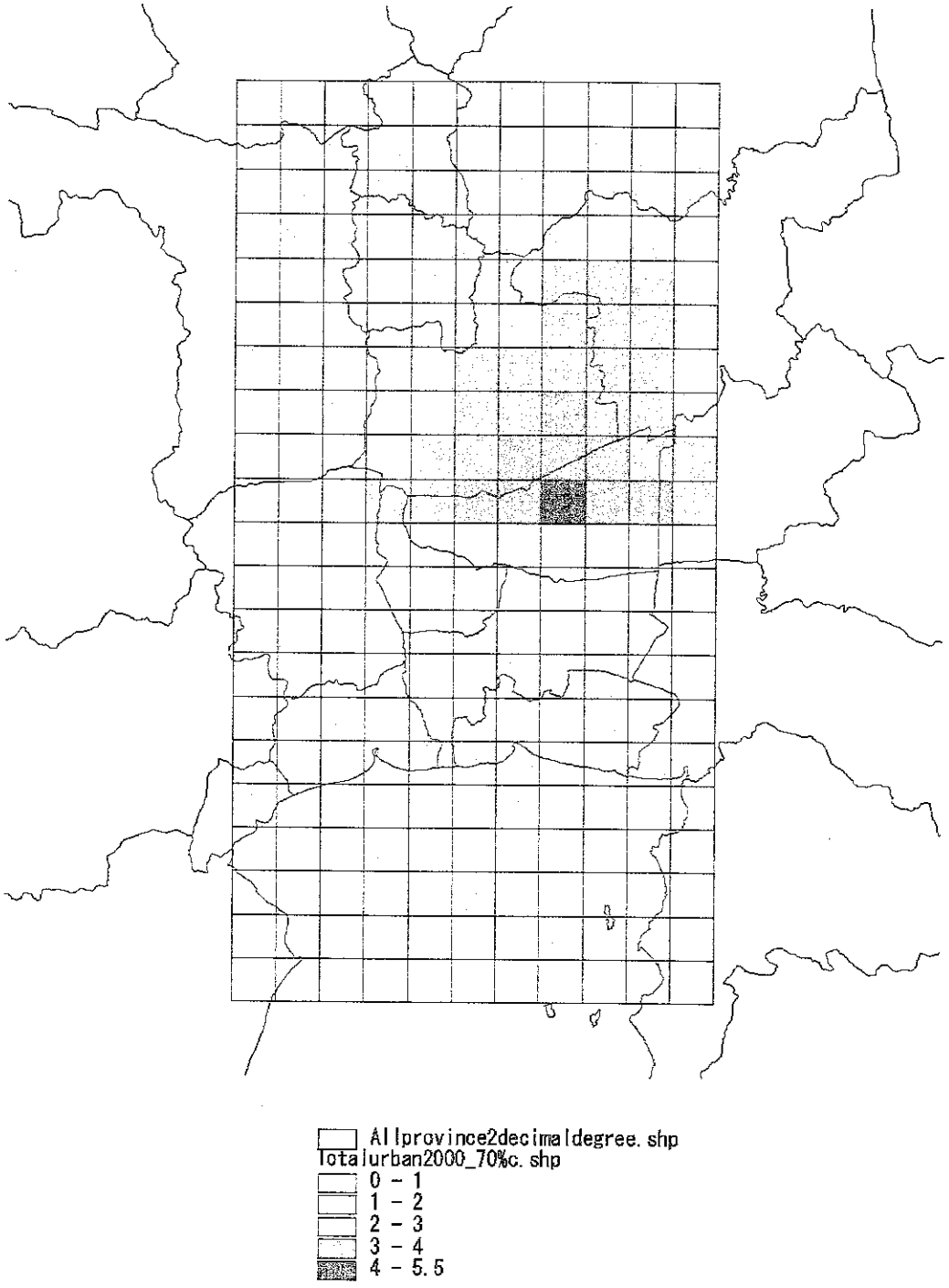


Figure 5.1.1.9 The D/C Ratio in Urban Area of Year 2000 with 70 % Critical Load

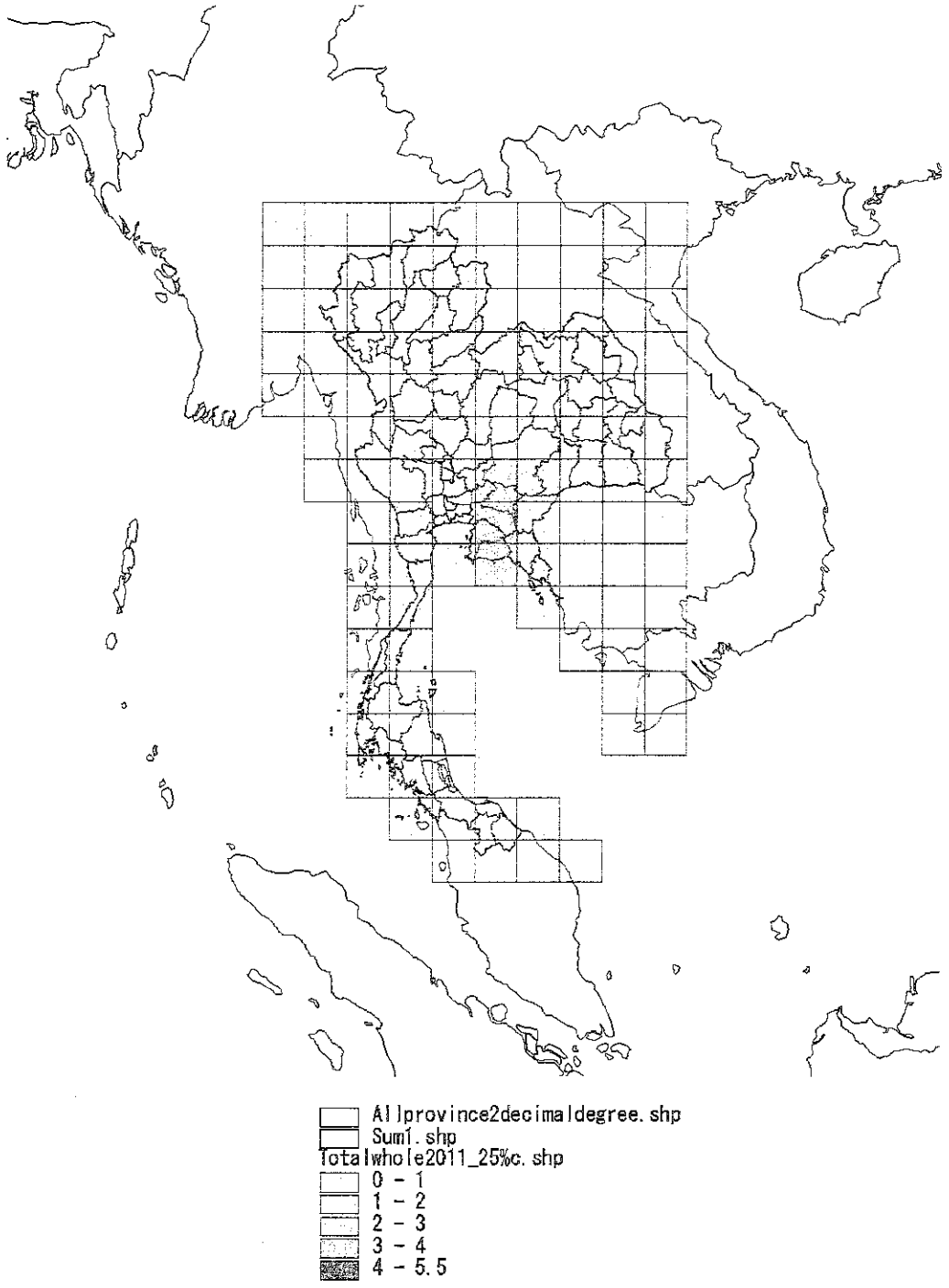


Figure 5.1.1.10 The D/C Ratio in Whole Thai of Year 2011 with 25 % Critical Load

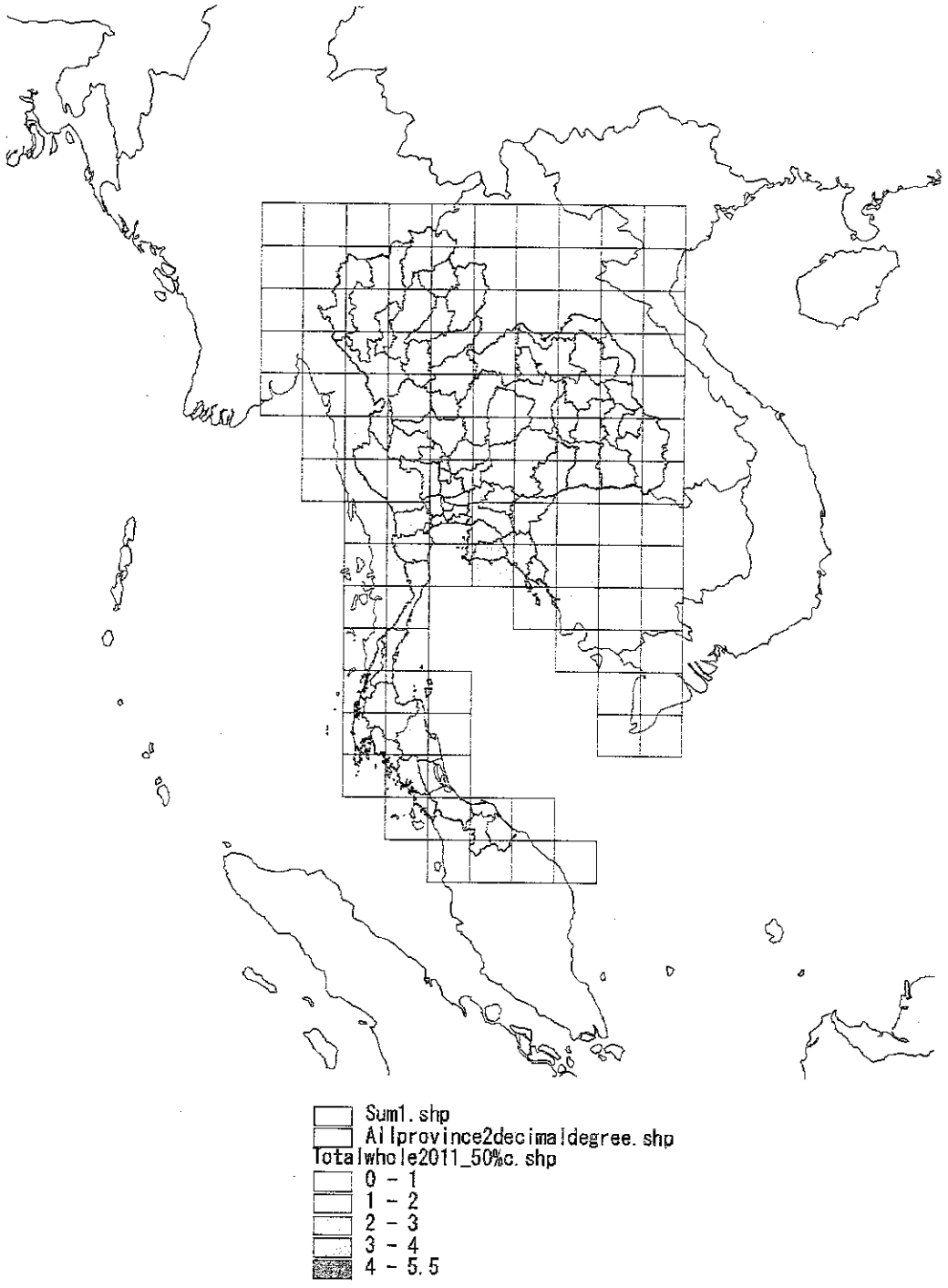


Figure 5.1.1.11 The D/C Ratio in Whole Thai of Year 2011 with 50 % Critical Load

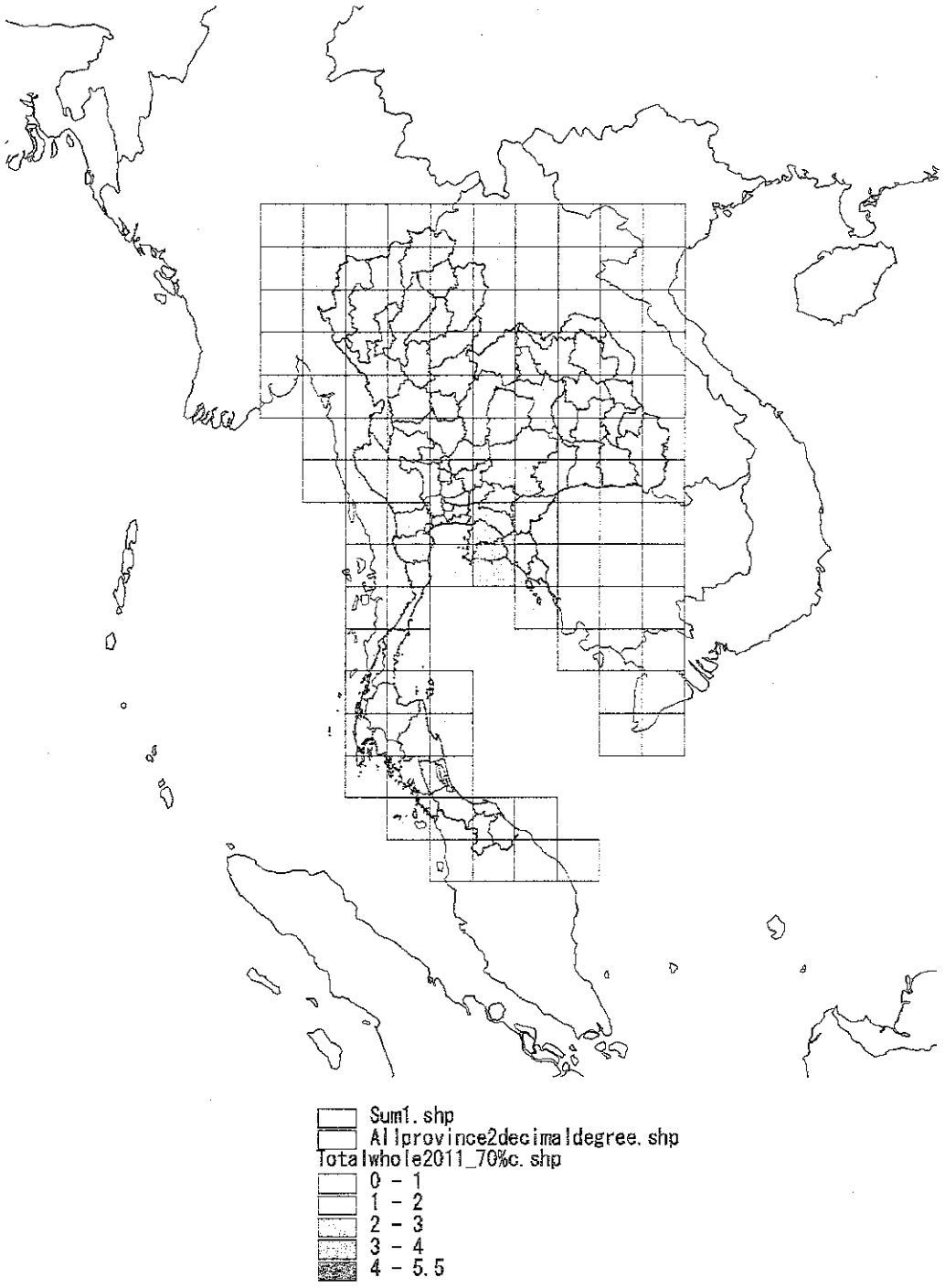


Figure 5.1.1.12 The D/C Ratio in Whole Thai of Year 2011 with 70 % Critical Load

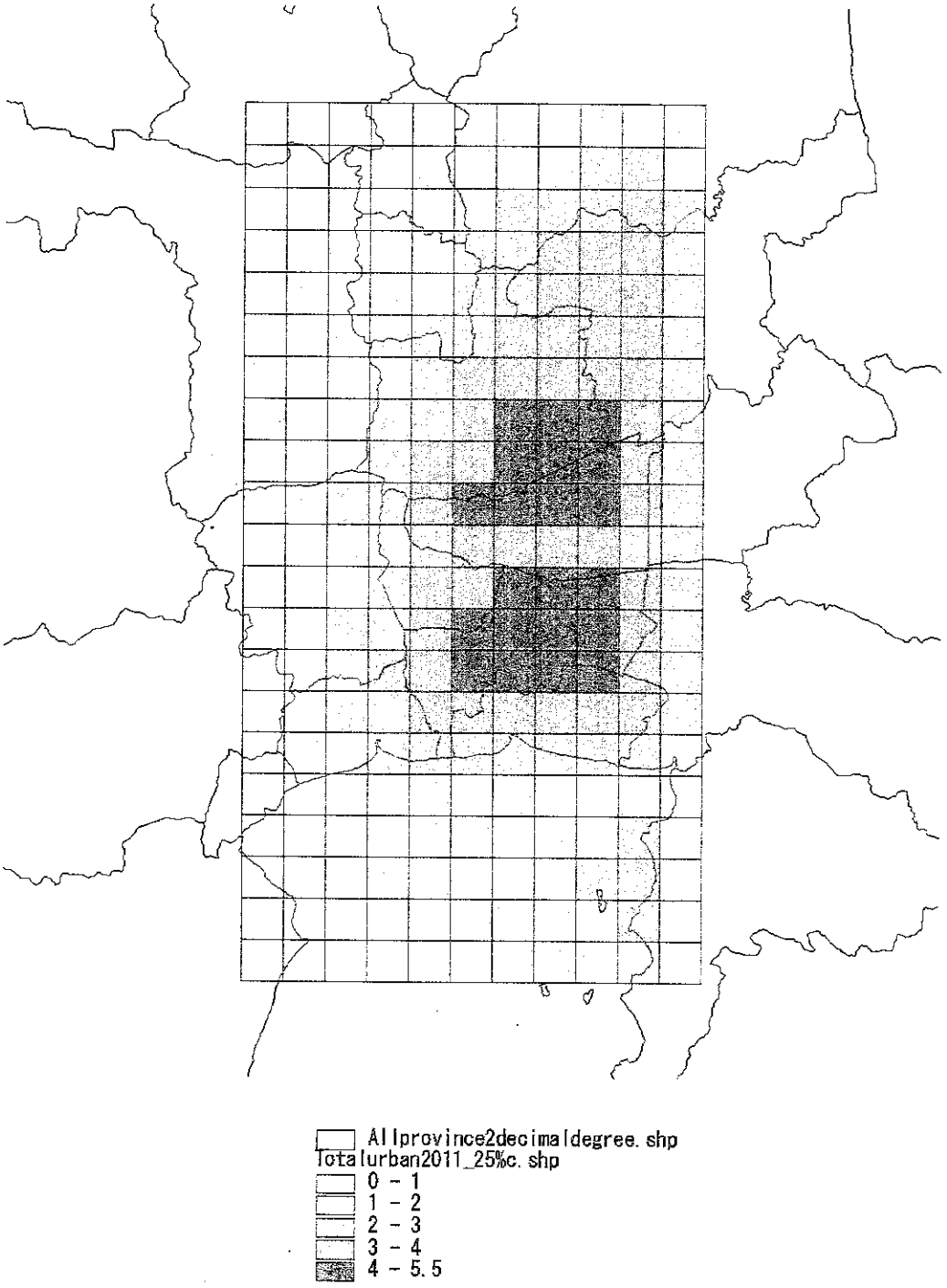


Figure 5.1.1.13 The D/C Ratio in Urban Area of Year 2011 with 25 % Critical Load

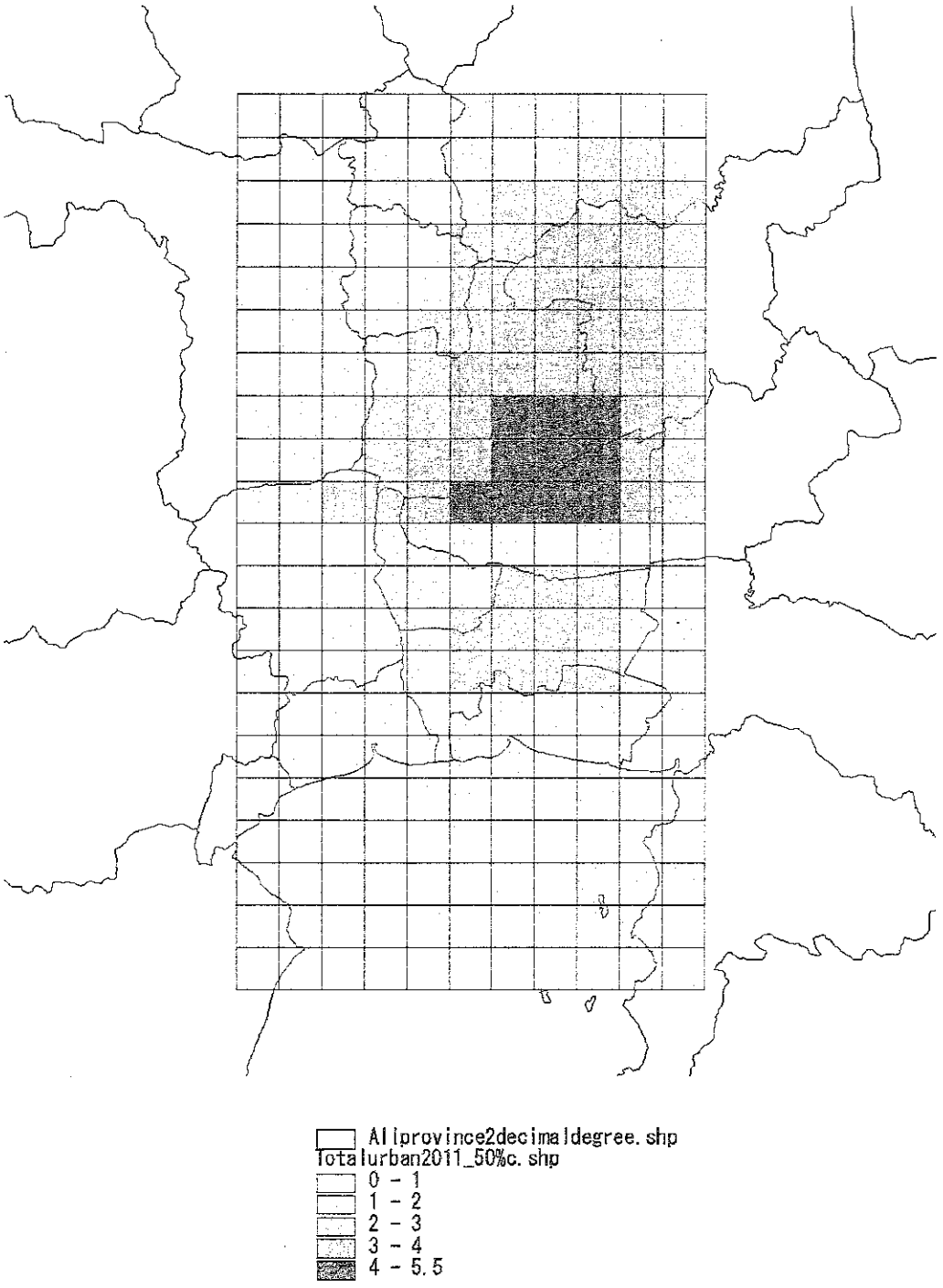


Figure 5.1.1.14 The D/C Ratio in Urban Area of Year 2011 with 50 % Critical Load

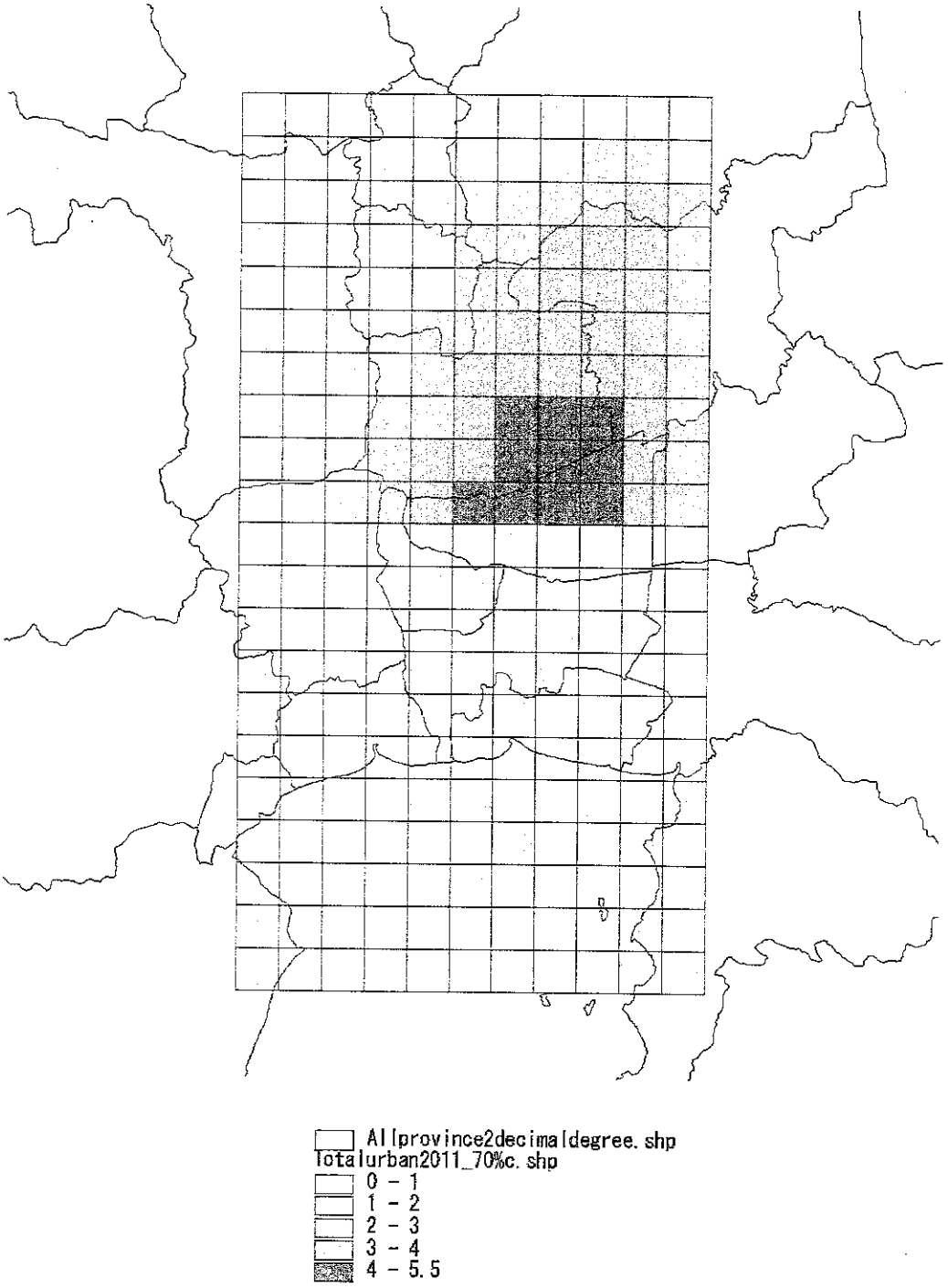


Figure 5.1.1.15 The D/C Ratio in Urban Area of Year 2011 with 70 % Critical Load

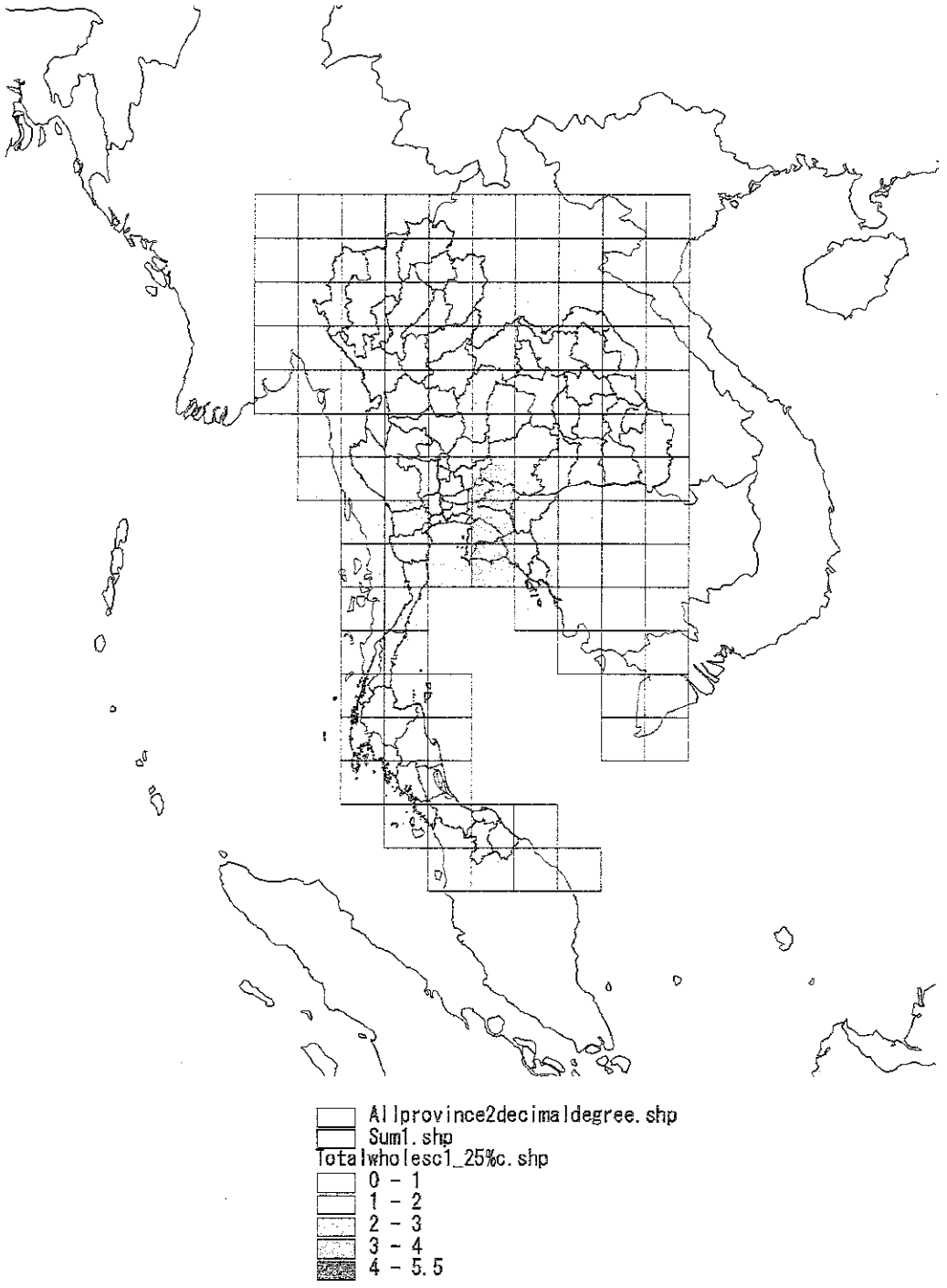


Figure 5.1.1.16 The D/C Ratio in Whole Thai with The Control with 25 % Critical Load

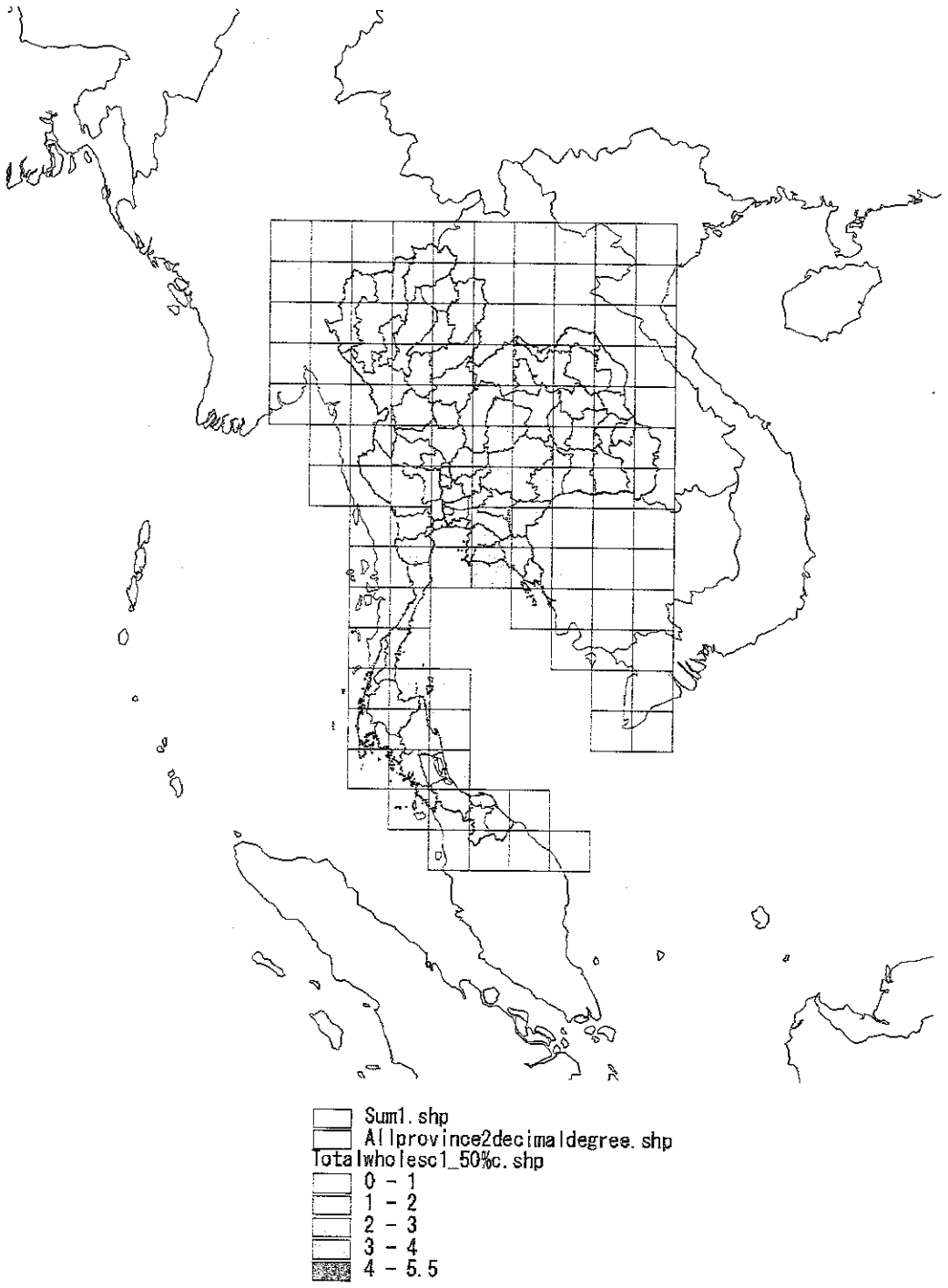


Figure 5.1.1.17 The D/C Ratio in Whole Thai under The Control with 50 % Critical Load

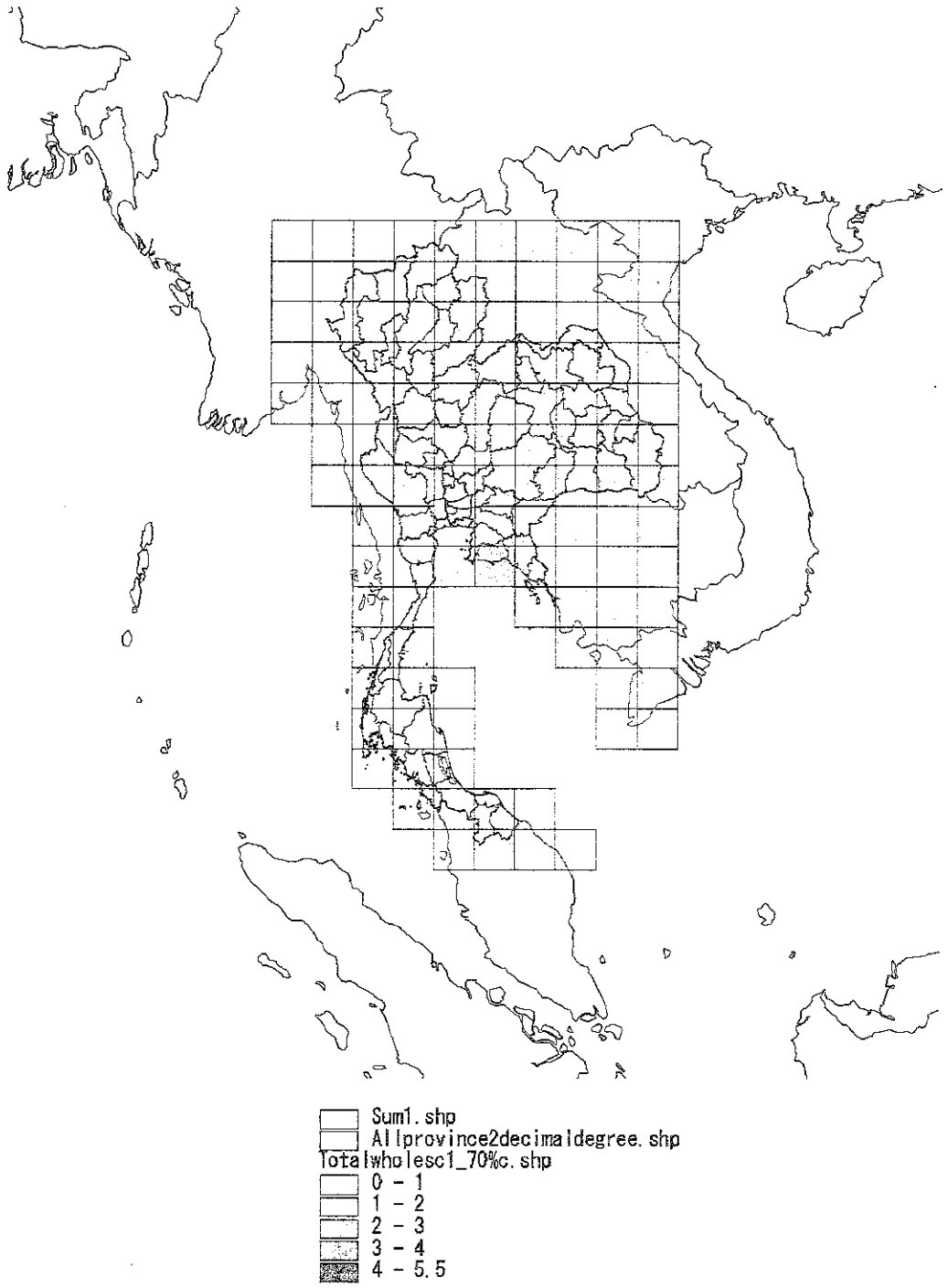


Figure 5.1.1.18 The D/C Ratio in Whole Thai under The Control with 70 % Critical Load

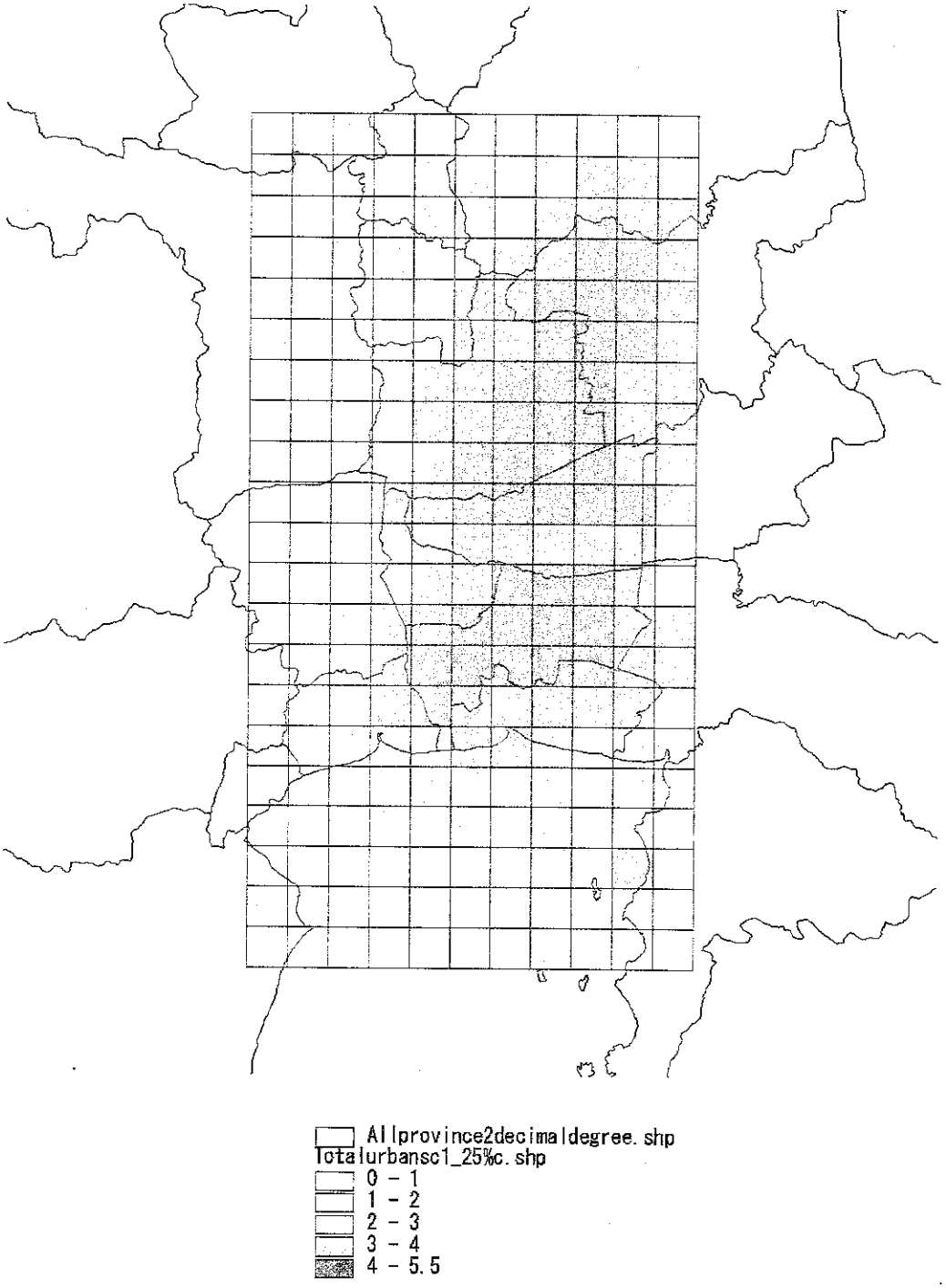


Figure 5.1.1.19 The D/C Ratio in Urban Area under The Control with 25 % Critical Load

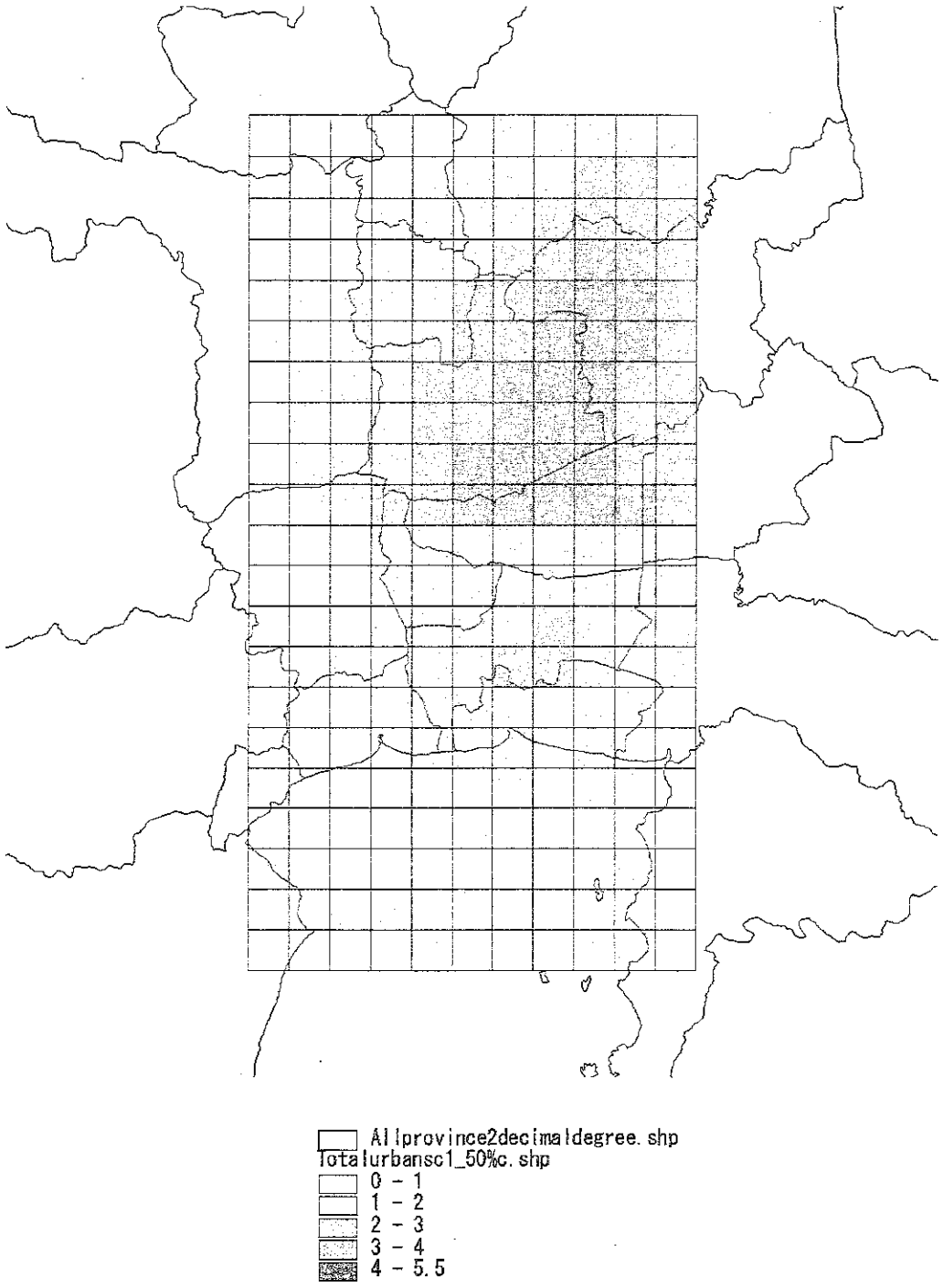


Figure 5.1.1.20 The D/C Ratio in Urban Area under The Control with 50 % Critical Load

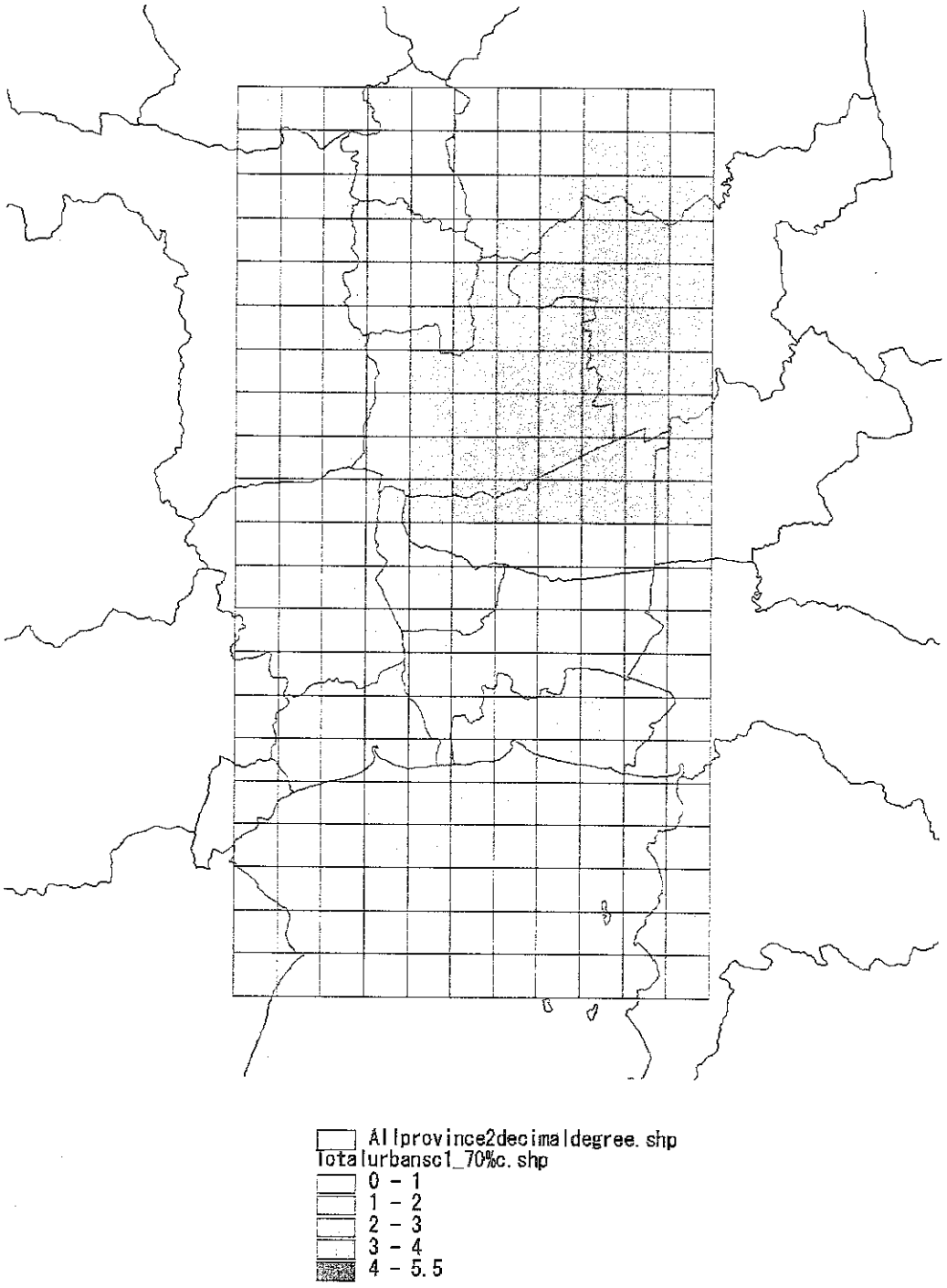


Figure 5.1.1.21 The D/C Ratio in Urban Area under The Control with 70% Critical Load

5.2 Wet Deposition Coefficient

In section 6.1.4.1 of Main Report, an attempt of model calibration was done as Step-2. The calibrated deposition coefficients used in this project are in the range of the coefficients used by the similar type models summarized in Table 5.2.1.1. Taking into account adjustment to the monitoring data, the original wet deposition coefficients were calibrated as follows.

Original; $Kw_{SO2} = 2.00 \times 10^{-5} \times P$

$Kw_{SO4} = 5.00 \times 10^{-5} \times P^{0.83}$

Calibrated; $Kw_{SO2} = \underline{3.00} \times 10^{-5} \times P$

$Kw_{SO4} = \underline{7.50} \times 10^{-5} \times P^{0.83}$

Table 5.2.1.1 Examples of Wet Deposition Coefficients

Model Name	Target Region	Wet Deposition Coefficient		Ref.
		SO_2	SO_4	
EURMAP-1, 2	Europe	$6.00 \times 10^{-5} \times P$	$1.94 \times 10^{-5} \times P$	Johnson[1] Bhumralkar[2]
Statistical LRT	N. America	$3.00 \times 10^{-5} \times P$	$10.00 \times 10^{-5} \times P$	Venkatram[3]
MOE-L	N. America	$3.00 \times 10^{-5} \times P$	$7.50 \times 10^{-5} \times P$	Ellenton[4]
Analytical Model	N. America	$0.089 \times 10^{-5} \times P$	$1.67 \times 10^{-5} \times P$	Fay[5], [6]

1) Johnson, W. B. et al., Atmospheric Environment, vol. 12(1978), p511
2) Bhumralkar C. M. et al., Tellus, vol. 33(1981), p142
3) Venkatram, A., et al., Atmospheric Environment, vol. 16(1982), p249
4) Ellenton, G. et al., Atmospheric Environment, vol. 19(1985), p727
5) Fay, J. A. et al., Atmospheric Environment, vol. 14(1980), p355
6) Fay, J. A. et al., Atmospheric Environment, vol. 19(1985), p1773

When the studies on the parameterizations, not only wet deposition coefficient but also the other parameters, will be accumulated in Thailand, the parameterizations of current ATMOS2 model should be revised.

5.2 Airviro

5.2.1 Point Source and Area Source

5.2.1.1 Working Pattern

Pattern formula of point sources and area sources can describe as daily patterns and hourly patterns for working date. Sixty-one patterns are used for point sources and area sources in BMR. Sample of working pattern is shown in Table 5.2.1.1.

Table 5.2.1.1 No.1 Working Pattern for Point Sources and Area Sources

Formula name: H24D7-1 (1)

Emission per year (%):

Scenario:	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
	100	100	100	100	100	100	100	100	100	100

Relative emission:

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
100	100	100	100	100	100	100	100	100	100	100	100

Average emission (%):

Mo-Th	Fr	Sa	Su
100.0	100.0	100.0	100.0

Emission (%)

	Mo-Th	Fr	Sa	Su
00.00	100	100	100	100
01.00	100	100	100	100
02.00	100	100	100	100
03.00	100	100	100	100
04.00	100	100	100	100
05.00	100	100	100	100
06.00	100	100	100	100
07.00	100	100	100	100
08.00	100	100	100	100
09.00	100	100	100	100
10.00	100	100	100	100
11.00	100	100	100	100
12.00	100	100	100	100
13.00	100	100	100	100
14.00	100	100	100	100
15.00	100	100	100	100
16.00	100	100	100	100
17.00	100	100	100	100
18.00	100	100	100	100
19.00	100	100	100	100
20.00	100	100	100	100

21.00	100	100	100	100
22.00	100	100	100	100
23.00	100	100	100	100

Emission depending on air temperature (%):

-30—28: 0	-28—26: 0	-26—24: 0	-24—22: 0	-22—20: 0
-20—18: 0	-18—16: 0	-16—14: 0	-14—12: 0	-12—10: 0
-10—8: 0	-8—6: 0	-6—4: 0	-4—2: 0	-2 - 0: 0
0 - 2: 0	2 - 4: 0	4 - 6: 0	6 - 8: 0	8 - 10: 0
10 - 12: 0	12 - 14: 0	14 - 16: 0	16 - 18: 0	18 - 20: 0
20 - 22: 0	22 - 24: 0	24 - 26: 0	26 - 28: 0	28 - 30: 0

Gasflow depending on emission (%):

	+0%	+5%	+10%	+15%	+20%
0%	100	100	100	100	100
25%	100	100	100	100	100
50%	100	100	100	100	100
75%	100	100	100	100	100

5.2.1.2 Searchkey

Airviro uses searchkey system for emission inventory. There are five groups of searchkeys with different property. Searchkey1 is source type code, Searchkey2 is amphore code, Searchkey3 is province code, Searchkey4 is industrial estate code and Searchkey 5 is emission estimation code. Searchkeys in BMR are shown in from Table 5.2.1.2 to Table 5.2.1.6.

Table 5.2.1.2 List of Searchkey1

NO.	Source Type	NO.	Source Type	NO.	Source Type	NO.	Source Type
1	TEA TOBACC	29	LEATHER TANNING	57	CEMENT LIME PLA	85	MUSIC INSTR. MF
2	MISC AGRICUL	30	FUR BLEACH/DYE	58	OTHER NONMETALL	86	SPORT GOODS MF
3	CONSTR MAT MIN	31	FUR/SKIN RUGS,	59	IRON&STEEL BAS	87	OTHER PRODUCTS
4	SLAUGHTER MEAT	32	LEATHER PRODUCT	60	NON FERROUS MET	88	EL.POWER GENER.
5	DAIRY MANUFACT.	33	FOOTWEAR	61	CUTLERY,HANDTOO	89	GAS MAN./DISTRI
6	AQUATIC ANIMAL	34	WOOD PROCESSING	62	FURNITURE METAL	90	WATER WORKS SUP
7	VEGETABLE MANUF	35	WOOD/CANE CONT.	63	STRUCT METAL PR	91	PACK OPEN
8	FRUITS AND VEGE	36	WOOD/CORK PROD.	64	OTHER FABR META	92	COLD STORAGE RO
9	GRAIN MILL/ROOT	37	FURNITURE/FIX/F	65	MF REPAIT ENG T	93	REPAIR LEATHER
10	FLOUR FOOD PROD	38	PULP&PAPER+BOAR	66	AGRI MACHINE EQ	94	REP. E.HOME APP
11	SUGAR FACTORY	39	PAPER CONTAINER	67	WOOD/MET WORK M	95	REP.MOTOR VEHIC
12	COCOA, CHOC.TEA	40	OTHER PAPER ART	68	SPEC.IND.MACH P	96	REP. WATCH JEWE
13	FLAVOURING PROD	41	PRINTING, PUBL	69	OA EQUIPMENT	97	REPAIR OTHER TY
14	ICE MANUFACTURE	42	BASE CHEMICALS	70	OTH.MACH.EXL.EL	98	LAUNDRIES
15	LIVESTOCK FEED	43	FERTILIZER,PEST	71	ELEC.IND.MACH/A	99	EXP.AMM..WEAPON
16	SPIRITS DISTILL	44	SYNTHET. RESINS	72	RADIO/TV/COMM.E	100	DECOR/MOD CHAIR
17	OTHER ETHANOL M	45	PAINTS,VARNISHE	73	OTH.EL.APP.HOUS	101	COM WASTE TREAT
18	WINE BREWERIES	46	PHARMACEUT.PROD	74	EL.APP.SUPPLY	102	STEAM GENERATI.
19	BEER/MALT BREW.	47	SOAPS&COSMETIC	75	SHIP BULIDING	103	SALT PRODUCTION
20	SOFT DRINK WATE	48	CHEM.PROD.OTHER	76	RAIL/TRAIN REP	104	RP MOD BOILER
21	TOBACCO MANUFAC	49	PETROLEUM REF.	77	AUTOMATION IND.	105	RESIDENTALAREA
22	TEXTILE INDUSTR	50	PETROL.&COAL PR	78	2-3 MOTORCYC.MF	106	GEMATORIUM
23	MADE UP TEXTILE	51	TIRES,INNER TUB	79	AIRCRAFT MF	107	PETROL.SER.ST.
24	KNITTING MILLS	52	RUBBER PROD,OTH	80	OTH. TRANSP.EQU	108	AIRPORT
25	CARPETS & RUGS	53	PLASTIC PROD.MA	81	SCIEN-ME.AS.EQUI	109	Landfill
26	CORD ROPE TWINE	54	GLASS	82	PHOTO-OPT.GODS	110	Road_source
27	NONWOW TEXTILES	55	POTTERY MANUF.	83	CLOCK-MECH TIME		
28	WEARING APPAREL	56	STRUCTURAL CLAY	84	JEWELRY MF		

Table 5.2.1.3 List of Searchkey2

NO.	Amphore	NO.	Amphore	NO.	Amphore
1	PHRANAKORN	30	BANG KHO LAEM	59	BANG KARUY
2	DUSIT	31	PRAWET	60	BANG YAI
3	NONG CHOK	32	KLONG TOEI	61	BANGBUATHONG
4	BANGRAK	33	CHOMTONG	62	SAI NOI
5	BANGKHEN	34	DON MUANG	63	PAKKREAD
6	BANGKAPI	35	RATCHATHEWI	64	MUN OF MUANGBA
7	PATHUMWAN	36	LATPHRAO	65	MUN OF MUANGNO
8	POMPRABSUTTPRU	37	DIN DAENG	66	MUANG NAKAKORN
9	PHRA KHANONG	38	SUAN LUANG	67	KAM PHAENGSAN
10	MINBURI	39	LAKSI	68	NAKORNCHAISRI
11	LATKRABANG	40	SAI MAI	69	DON TOOM
12	YAN NAWA	41	KHAN NA YAO	70	BANG LANE
13	SAMPHANTHAWONG	42	SAPHAN SUNG	71	SAM PHRAN
14	PHAYATHAI	43	WANG THONG LANG	72	BUDDHA MONDHON
15	THONBURI	44	KHLONG SAM WA	73	MUN OF MUANGNAK
16	BANGKOK YAI	45	BANGNA	74	MUANG SAMUTSAK
17	HUAY KHWANG	46	WATTHANA	75	KRATOOMBAN
18	KLONG SAN	47	TAWIWATTHANA	76	BAAN PHAEW
19	TALINGCHAN	48	BANGBON	77	MUN OF KRATOOM
20	BANGKOK NOI	49	BANGKHAE	78	MUN OF MUANGSA
21	BANG KHUN THIAN	50	THUNGKHRU	79	MUANG PATHUMTH
22	PHASI CHAROEN	51	MUANG SAMUTPRAK	80	KLONG LHAUNG
23	NONG KHAEM	52	BANG BO	81	THANYABURI
24	RAT BURANA	53	BANG PHLI	82	NONG SUEY
25	BANGPHLAT	54	PHRA PRA DAENG	83	LARDLUMKAEW
26	BUNG KUM	55	PHRASAMUT CHEDI	84	LAMLUKKA
27	SATHON	56	BANGSAOTHONG BR	85	SAMKOK
28	BANG SUE	57	MUN OF SAMUTPR	86	MUN OF MUANGPA
29	CHATUCHAK	58	MUANG NONTHABUR	87	Other(road_source)

Table 5.2.1.4 List of Searchkey3

NO.	Province
1	BANGKOK
2	SAMUT PRAKARN
3	NONTHABURI
4	NAKHON PATHOM
5	SAMUT SAKHON
6	PATHUM THANI
7	Other(ROAD etc.)

Table 5.2.1.5 List of Searchkey4

NO.	Industrial Estate
1	OTHER AREA O
2	BANGCHAN IE.
3	LATKRABANG IE.
4	BANGPOO IE.
5	BANGPLEE IE.
6	SAMUTSAKHON IE.
7	NAVA NAKHON IE.
8	Other(Road_source etc.)

Table 5.2.1.6 List of Searchkey5

NO.	Estimation Method
1	SERVEYING
2	ESTIMATION

5.2.1.3 Database of Point and Area Source

Source inventory database of point sources and area sources are same structure. Sample of point source database is shown in Table 5.2.1.7.

Table 5.2.1.7 Sample of Airviro Point Source Database

```
X1 693150
Y1 1523038
X2 0
Y2 0
NAME "Company A"
INFO ""
INFO2 ""
ADDRESS ""
POSTADDRESS ""
INFOGIVER ""
DATE  990901
CHANGED          2
MISC "PISTON   & PIN"
MAXEFFECT 0.000000
CHIMNEY HEIGHT  15.00
GASTEMPERATURE  150.00
GAS FLOW    0.1421
FUEL  0
FORMULA  6
SEARCHKEY1  77
SEARCHKEY2  11
SEARCHKEY3  1
SEARCHKEY4  3
SEARCHKEY5  1
CHIMNEY OUT    0.298
CHIMNEY IN     0.295
HOUSE WIDTH      0.0
HOUSE HEIGHT     0.0
POINT0 ELEMENT 3      VALUE      0.4600
POINT1 ELEMENT 15     VALUE      0.0100
POINT2 ELEMENT 25     VALUE      0.0200   (Dummy)
POINT3 ELEMENT 40     VALUE      0.0000   (Dummy)
POINT4 ELEMENT 70     VALUE      0.0000   (Dummy)
```

5.2.2 Line Source

5.2.2.1 Hourly Pattern and Vehicle Type Composition

Relation between roadtype number, hourly pattern number and vehicle type composition is shown in Table 5.2.2.1. Sample of road database is shown in Table 5.2.2.2. The roadtype database is composed of nine types of cars, hourly patterns and vehicle type composition.

Table 5.2.2.1 Relation between Roadtype Number, Pattern and Composition

Year 2000

Roadtype NO.	Hourly Pattern	Vehicle Type Composition	Number of Road Links
1	1	1	298
2	1	3	758
3	1	4	1277
4	1	11	95
5	1	12	47
6	1	13	47
7	1	14	576
8	1	15	112
9	6	1	54
10	6	3	76
11	6	4	265
12	6	12	6
13	6	13	22
14	6	14	76
15	6	15	4
16	7	1	2
17	7	3	60
18	7	4	44
19	7	14	14
20	7	15	1
21	10	1	34
22	10	3	63
23	10	4	60
24	10	12	4
25	10	14	79
26	13	1	45
27	13	3	257
28	13	4	218
29	13	12	37
30	13	14	56
31	13	15	25
32	14	3	1
33	14	14	58
34	15	1	12
35	15	3	19
36	15	4	34
37	15	14	357
38	16	3	7
39	16	14	26
40	16	15	1
41	21	1	85
42	21	3	376
43	21	4	267
44	21	11	1
45	21	12	11
46	21	13	36
47	21	14	440
48	21	15	43
49	22	1	5
50	22	3	43
51	22	4	23
52	22	14	47
53	23	1	60
54	23	3	47
55	23	4	159
56	23	12	7
57	23	14	69
58	23	15	9
59	24	1	2
60	24	3	100
61	24	4	70
62	24	14	14
63	27	3	29
64	27	4	312

Year 2011

Roadtype NO.	Hourly Pattern	Vehicle Type Composition	Number of Road Links
1	1	1	333
2	1	3	784
3	1	4	1411
4	1	11	101
5	1	12	56
6	1	13	42
7	1	14	619
8	1	15	123
9	6	1	56
10	6	3	86
11	6	4	308
12	6	12	6
13	6	13	25
14	6	14	89
15	6	15	4
16	7	1	2
17	7	3	60
18	7	4	45
19	7	14	14
20	7	15	1
21	10	1	34
22	10	3	72
23	10	4	64
24	10	12	4
25	10	14	87
26	13	1	52
27	13	3	291
28	13	4	239
29	13	12	37
30	13	14	59
31	13	15	26
32	14	3	4
33	14	14	92
34	15	1	10
35	15	3	19
36	15	4	39
37	15	11	2
38	15	14	660
39	15	15	1
40	16	3	9
41	16	14	41
42	16	15	1
43	21	1	76
44	21	3	445
45	21	4	272
46	21	12	11
47	21	13	36
48	21	14	530
49	21	15	42
50	22	1	5
51	22	3	43
52	22	4	23
53	22	14	44
54	23	1	60
55	23	3	58
56	23	4	175
57	23	12	8
58	23	14	77
59	23	15	12
60	24	1	2
61	24	3	92
62	24	4	86
63	24	14	22
64	27	3	42
65	27	4	376
66	27	14	6

Table 5.2.2.2 Roadtype NO.1 Database

NAME	RdType 001													
INDEX	1													
VEHICLE	1						VEHICLE	2						
TYPEDAY	35	35	35	35			TYPEDAY	35	35	35	35			
	32	32	32	32				32	32	32	32			
	29	29	29	29				29	29	29	29			
	28	28	28	28				28	28	28	28			
	45	45	45	45				45	45	45	45			
	86	86	86	86				86	86	86	86			
	160	160	160	160				160	160	160	160			
	200	200	200	200				200	200	200	200			
	190	190	190	190				190	190	190	190			
	155	155	155	155				155	155	155	155			
	140	140	140	140				140	140	140	140			
	136	136	136	136				136	136	136	136			
	126	126	126	126				126	126	126	126			
	123	123	123	123				123	123	123	123			
	132	132	132	132				132	132	132	132			
	137	137	137	137				137	137	137	137			
	152	152	152	152				152	152	152	152			
	149	149	149	149				149	149	149	149			
	141	141	141	141				141	141	141	141			
	139	139	139	139				139	139	139	139			
	130	130	130	130				130	130	130	130			
	108	108	108	108				108	108	108	108			
	83	83	83	83				83	83	83	83			
	53	53	53	53				53	53	53	53			
MONTH	100	100	100	100	100	100	MONTH	100	100	100	100	100	100	
	100	100	100	100	100	100		100	100	100	100	100	100	
SCENARIO	50	100	100	100	100	100	SCENARIO	1	100	100	100	100	100	
	100	100	100	100	100	100		100	100	100	100	100	100	
MINSPEED	1	MAXSPEED	11				MINSPEED	1	MAXSPEED	11				
VEHICLE	3						VEHICLE	4						
TYPEDAY	35	35	35	35			TYPEDAY	35	35	35	35			
	32	32	32	32				32	32	32	32			
	29	29	29	29				29	29	29	29			
	28	28	28	28				28	28	28	28			
	45	45	45	45				45	45	45	45			
	86	86	86	86				86	86	86	86			
	160	160	160	160				160	160	160	160			
	200	200	200	200				200	200	200	200			
	190	190	190	190				190	190	190	190			
	155	155	155	155				155	155	155	155			
	140	140	140	140				140	140	140	140			
	136	136	136	136				136	136	136	136			
	126	126	126	126				126	126	126	126			
	123	123	123	123				123	123	123	123			
	132	132	132	132				132	132	132	132			
	137	137	137	137				137	137	137	137			
	152	152	152	152				152	152	152	152			
	149	149	149	149				149	149	149	149			
	141	141	141	141				141	141	141	141			
	139	139	139	139				139	139	139	139			
	130	130	130	130				130	130	130	130			
	108	108	108	108				108	108	108	108			
	83	83	83	83				83	83	83	83			
	53	53	53	53				53	53	53	53			
MONTH	100	100	100	100	100	100	MONTH	100	100	100	100	100	100	
	100	100	100	100	100	100		100	100	100	100	100	100	
SCENARIO	1	100	100	100	100	100	SCENARIO	6	100	100	100	100	100	
	100	100	100	100	100	100		100	100	100	100	100	100	
MINSPEED	1	MAXSPEED	11				MINSPEED	1	MAXSPEED	11				

VEHICLE	5					
TYPEDAY	35	35	35	35		
	32	32	32	32		
	29	29	29	29		
	28	28	28	28		
	45	45	45	45		
	86	86	86	86		
	160	160	160	160		
	200	200	200	200		
	190	190	190	190		
	155	155	155	155		
	140	140	140	140		
	136	136	136	136		
	126	126	126	126		
	123	123	123	123		
	132	132	132	132		
	137	137	137	137		
	152	152	152	152		
	149	149	149	149		
	141	141	141	141		
	139	139	139	139		
	130	130	130	130		
	108	108	108	108		
	83	83	83	83		
	53	53	53	53		
MONTH	100	100	100	100	100	100
	100	100	100	100	100	100
SCENARIO	16	100	100	100	100	100
	100	100	100	100	100	100
MINSPEED	1	MAXSPEED	11			

VEHICLE	6					
TYPEDAY	35	35	35	35		
	32	32	32	32		
	29	29	29	29		
	28	28	28	28		
	45	45	45	45		
	86	86	86	86		
	160	160	160	160		
	200	200	200	200		
	190	190	190	190		
	155	155	155	155		
	140	140	140	140		
	136	136	136	136		
	126	126	126	126		
	123	123	123	123		
	132	132	132	132		
	137	137	137	137		
	152	152	152	152		
	149	149	149	149		
	141	141	141	141		
	139	139	139	139		
	130	130	130	130		
	108	108	108	108		
	83	83	83	83		
	53	53	53	53		
MONTH	100	100	100	100	100	100
	100	100	100	100	100	100
SCENARIO	2	100	100	100	100	100
	100	100	100	100	100	100
MINSPEED	1	MAXSPEED	11			

VEHICLE	7					
TYPEDAY	35	35	35	35		
	32	32	32	32		
	29	29	29	29		
	28	28	28	28		
	45	45	45	45		
	86	86	86	86		
	160	160	160	160		
	200	200	200	200		
	190	190	190	190		
	155	155	155	155		
	140	140	140	140		
	136	136	136	136		
	126	126	126	126		
	123	123	123	123		
	132	132	132	132		
	137	137	137	137		
	152	152	152	152		
	149	149	149	149		
	141	141	141	141		
	139	139	139	139		
	130	130	130	130		
	108	108	108	108		
	83	83	83	83		
	53	53	53	53		
MONTH	100	100	100	100	100	100
	100	100	100	100	100	100
SCENARIO	3	100	100	100	100	100
	100	100	100	100	100	100
MINSPEED	1	MAXSPEED	11			

VEHICLE	8					
TYPEDAY	35	35	35	35		
	32	32	32	32		
	29	29	29	29		
	28	28	28	28		
	45	45	45	45		
	86	86	86	86		
	160	160	160	160		
	200	200	200	200		
	190	190	190	190		
	155	155	155	155		
	140	140	140	140		
	136	136	136	136		
	126	126	126	126		
	123	123	123	123		
	132	132	132	132		
	137	137	137	137		
	152	152	152	152		
	149	149	149	149		
	141	141	141	141		
	139	139	139	139		
	130	130	130	130		
	108	108	108	108		
	83	83	83	83		
	53	53	53	53		
MONTH	100	100	100	100	100	100
	100	100	100	100	100	100
SCENARIO	20	100	100	100	100	100
	100	100	100	100	100	100
MINSPEED	1	MAXSPEED	11			

VEHICLE	9					
TYPEDAY	35	35	35	35		
	32	32	32	32		
	29	29	29	29		
	28	28	28	28		
	45	45	45	45		
	86	86	86	86		
	160	160	160	160		
	200	200	200	200		
	190	190	190	190		
	155	155	155	155		
	140	140	140	140		
	136	136	136	136		
	126	126	126	126		
	123	123	123	123		
	132	132	132	132		
	137	137	137	137		
	152	152	152	152		
	149	149	149	149		
	141	141	141	141		
	139	139	139	139		
	130	130	130	130		
	108	108	108	108		
	83	83	83	83		
	53	53	53	53		
MONTH	100	100	100	100	100	100
	100	100	100	100	100	100

5.2.2.2 Line Source Database

Sample of line source database is shown in Table 5.2.2.3. Line database of BMR is composed of road name, traffic vehicle, vehicle speed, pattern number, searchkeys and location.

Table 5.2.2.3 Sample of Airviro Road Database

NAME "Sanam Chai Rd."
INFO "Main Road"
INFO2 ""
VEHICLES 15989
CORRFACTOR 1.000000
NOLANES 3
SPEED 8
ROADTYPE 2
SEARCHKEY1 110
SEARCHKEY2 87
SEARCHKEY3 7
SEARCHKEY4 8
SEARCHKEY5 1
X0 662181 Y0 1520371
X1 662173 Y1 1520440

5.2.3 Airviro Model Parameter

To run case and specific hour the following files are set up only the important entries are shown as below.

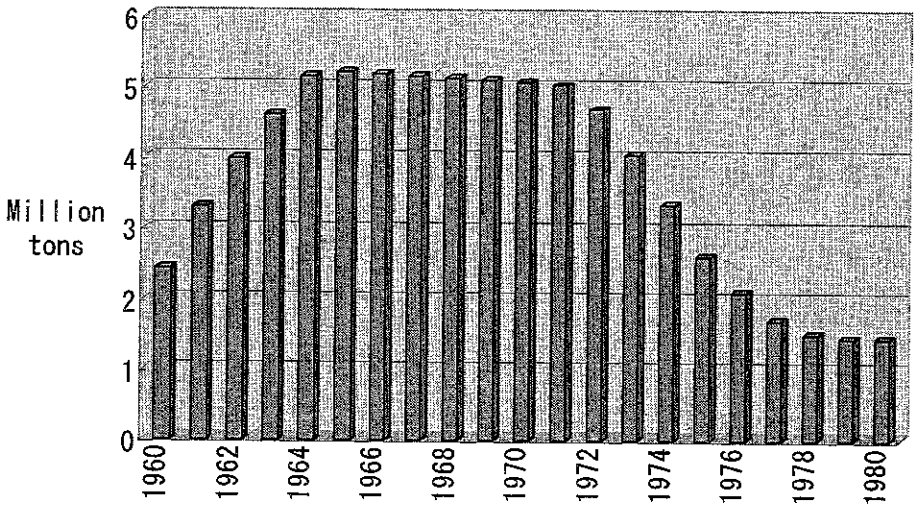
```
? clim.rf
clim.lat_lon:      13.75      100.5
!
!          "season" classes (max 20)
!
clim.NS:                4
clim.season1:    1016 0215       WINTER
clim.season2:    0216 0531       SUMMER
clim.season3:    0601 1015       RAINY
clim.season3:    0101 1231       Annual
!
!          stability classes (max 10)
!
clim.NCLASS:            6
clim.stabclass1:        -0.0261          UNSTABLE
clim.stabclass2:        -0.00505         MOD.UNSTABLE
clim.stabclass3:        0.0              NEUTRAL_NEG
clim.stabclass4:        0.00455          NEUTRAL_POS
clim.stabclass5:        0.0244           MOD.STABLE
clim.stabclass6:        99.9999          VERY_STABLE
!
!          no. of direction classes
!
clim.NDDKL:             60
!
clim.PERIOD:            000101 001231
!
!  CASE          stability classes (max 10)
!
case.NCLASS:            6
case.class1:     -0.100  UNSTABLE          425.   0.5 10. -0.35   14.0
case.class2:     -0.020  MOD.UNSTABLE      395.   0.5 10. -1.00   14.0
case.class3:     -0.002  NEUTRAL_NEG       375.   0.5 20. -0.15   10.0
case.class4:      0.002  NEUTRAL_POS       270.   0.5 20.   0.15  10.0
case.class5:      0.020  MOD.STABLE        165.   0.5 10.   1.00   6.0
case.class6:      0.100  VERY_STABLE       120.   0.5 10.   4.00   6.0
!                   1/L                      mixh   ff1 ff2   dt/dz temp
case.sigy1:      0.32*x1/sqrt(1.+0.0004*x1)
case.sigy2:      0.22*x1/sqrt(1.+0.0004*x1)
case.sigy3:      0.16*x1/sqrt(1.+0.0004*x1)
case.sigy4:      0.16*x1/sqrt(1.+0.0004*x1)
case.sigy5:      0.11*x1/sqrt(1.+0.0004*x1)
case.sigy6:      0.11*x1/sqrt(1.+0.0004*x1)
case.sigz1:      0.24*x1*sqrt(1.+0.001*x1)
case.sigz2:      0.20*x1
case.sigz3:      0.14*x1/sqrt(1.+0.0003*x1)
case.sigz4:      0.14*x1/sqrt(1.+0.0003*x1)
case.sigz5:      0.08*x1/sqrt(1.+0.00015*x1)
case.sigz6:      0.08*x1/sqrt(1.+0.00015*x1)
```

```
? realwind.rf
!
!       A. Physiography. Filenames and grid data
!
real.swampzon:          3
!
phys.NB.file:           /usr/airviro/data/thailand/wnd/new_BMR.fys
phys.NB.limit:          610000 704000 1489000 1559000
phys.NB.grid:           188 140
!
!       B. Boundary Layer data for Met. preprocessor and analyses.
!
mpp.bls1:               mast 05M
!
!                   Only station with temp difference:
!
mast.stn1:              05M
mast.05M.name:                  Chatujak Ban
mast.05M.z0_devh:       0.05    0.1
mast.05M.win_zon:       24        1
mast.05M.lfzones:       1. 1. 1.
mast.05M.temp:          05M+MTEMP002
mast.05M.temp:          05M+MTEMP050
mast.05M.temp:          05M+MTEMP075
mast.05M.temp:          05M+MTEMP100
mast.05M.dtemp:         05M+MDTMP008
mast.05M.dtemp:         05M+MDTMP020
mast.05M.dd:            05M+MWDIR010
mast.05M.dd:            05M+MWDIR050
mast.05M.dd:            05M+MWDIR100
mast.05M.ff:            05M+MWSPD010
mast.05M.ff:            05M+MWSPD050
mast.05M.ff:            05M+MWSPD100
mast.05M.hum:           05M+MRHUM000
mast.05M.gstr:          05M+MGLOB000
!
!           E. Influence areas
!
influence.zon1:         Dummy (all the same)
influence.zon2:         Dummy (all the same)
influence.zon3:         Dummy (all the same)
!
!           Constants for z0 from physiogr. fields
!           (sea, urban area, open field and forest)
!
phys.z01.c0:    0.0005
phys.z01.c1:    0.5
phys.z01.c2:    0.05
phys.z01.c3:    0.0
!
phys.z02.c:     0.0
phys.z0.min:    0.0005
```

```
? const_met.rf
!
!      Common parameters in meteorology
!
met.grav:        9.81
met.omega:       7.29E-5
met.Rd:          287.
met.cp:          1004.
met.karman:      0.35
!
met.lat1:        13.75
!
!      Danard's model
!
danard.vkc:              0.35
danard.step_time:        20
danard.no_step:          10
danard.no_step_init:      1
danard.adv_fact:          1
danard.ff_min:           0.5
!
!      Grid model constants
!
grid.ztak:               1000.0
grid.nz:                 10
grid.stretching:         0.5
grid.filtcoef:           0.15
grid.dt_fakt:            1.0
grid.road_height:        2.0
grid.area_height:        2.0
grid.vsed_vel:           0.0
grid.wr_ratio:           0.0
!
!       Analyse
!
analys.mixh:               50.+10.*sqrt(x1+1.0)
analys.Zi_mixh:            1
analys.Zi_min_sea:         30.
analys.Zi_min_land:        60.
!
!       Wind shift classes
!
wnd.dir.no:      11
! Default wind shift are calculated for lat=54.
! Can be adjusted with factor sin(lat)/sin(54).
! korrigerat med lat 13.75 grader for BMR, faktor 0.29
!
wnd.dir.class1:          0.          10.    11.5
wnd.dir.class2:          10.         40.    11.5
wnd.dir.class3:          40.         100.   10.3
wnd.dir.class4:          100.        200.    8.2
wnd.dir.class5:          200.        1000.   5.3
wnd.dir.class6:          1000.    3.4E+38    3.5
wnd.dir.class7:          -12.          0.    3.5
wnd.dir.class8:          -40.        -12.    3.5
wnd.dir.class9:          -200.       -40.    2.9
wnd.dir.class10:         -1000.      -200.   2.6
wnd.dir.class11:      -3.4E+38       -1000.  3.5
!                    Lmo lower      upper     del-dd(200m)
```

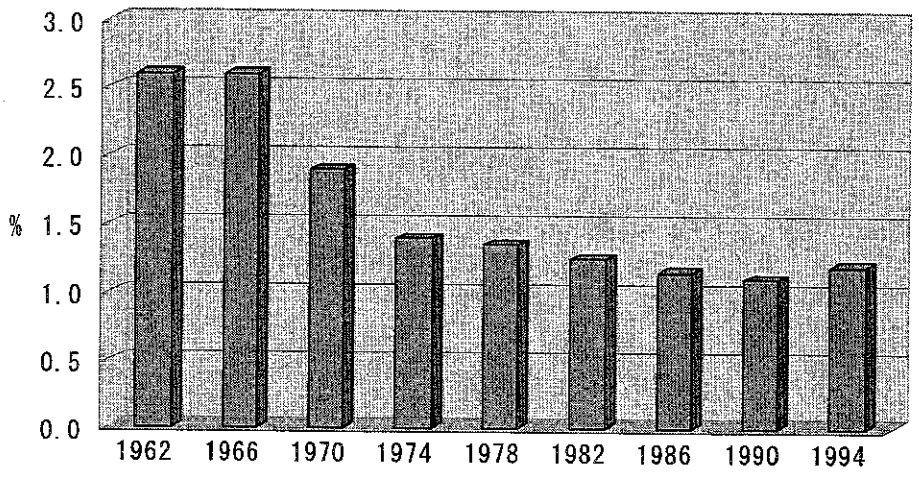
6. Countermeasures for SO_2 in BMR

6.1 Sulfur Dioxide Emission Volume in Japan



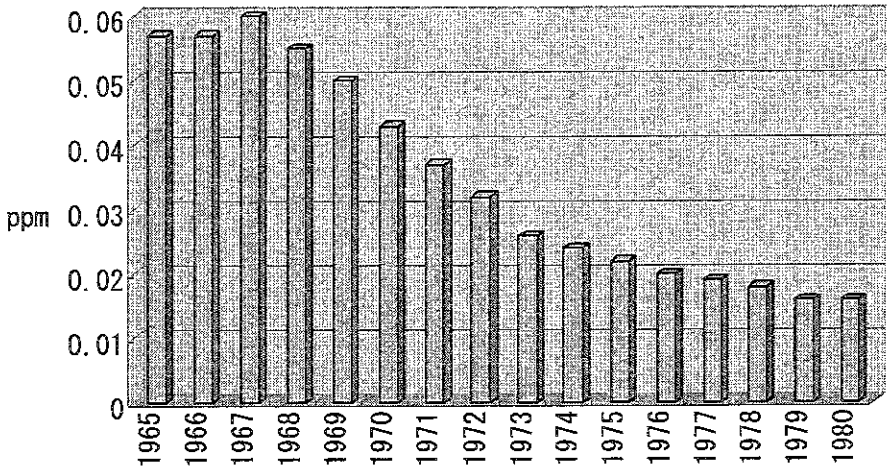
Source : Japan's Experience in the Battle against Air Pollution

6.2 Sulfur Content in Fuel Oil, Japan



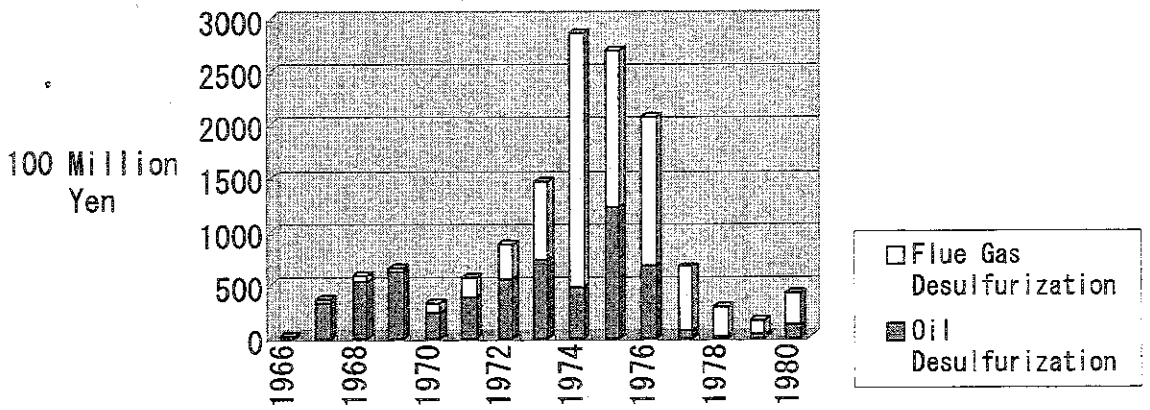
Source: Oil Data (Petroleum Association of Japan)

6.3 Average Sulfur Dioxide Concentration in Japan



Source : Quality of the Environment in Japan (1996)

6.4 Actual Production of Air Pollution Prevention Devices



Source : Data from the Japan Society of Industrial Machinery Manufacturers