Table 2.1 VIET NAM NATIONAL ACCOUNT

	1988	1989	1990	1991	1992	1993 Est
(At current prices)						
GDP (In billion of Dong)	13266	24308	38166	69959	101870	125074
Agriculture	5928	9841	14717	28551	35183	38666
Industry	2775	4568	7167	13515	23019	28402
Construction	352	872	1468	2328	3965	5715
Trade	1371	2995	5056	8833	12559	15095
Transport, portal service	275	599	1233	2652	4228	5116
Finance, insurance, banking			657	1026	1748	2318
Housing, tourism, hotels, repairs			3641	6034	9872	13460
Other material production	143	215	329	687	1045	1202
Science, health, education, etc.	2422	5218	3898	6333	10251	15100
(At constant 1989 prices)						
GDP (In billion of Dong)	23893	25754	27014	28623	30988	33477
Agriculture, forestry	10041	10739	10898	11135	11832	12193
Industry	5140	4935	5058	5557	6256	6882
Construction	946	981	1027	1030	1125	1374
Trade	2896	3065	3226	3383	3589	3801
Transport, postal services	602	603	632	674	711	771
Finance, insurance, banking			469	571	713	757
Housing, tourism, hotels, repairs			2619	2899	3132	3419
Other material production	211	215	223	229	236	248
Growth Rate	6.5	7.8	4.9	6	8.3	8

Source: National Statistic Office

Table 2.2 FOREIGN TRADE

(US$ Million)

	Total	Exports	Imports
1986	2,944.10	789.00	2,155.10
1987	3,309.30	854.20	2,455.10
1988	3,795.10	1,038.40	2,756.70
1989	4,511.80	1,946.00	2,565.80
1990	5,158.40	2,404.00	2,752.40
1991	4,361.20	2,087.00	2,274.20
1992	5,079.00	2,571.00	2,508.00

Source: National Statistics Office

Table 2.3 EXCHANGE RATE (DONG/US$)

Year	End of the year	Average of the year
1987	368	NA
1988	3,000	NA
1989	4,000	NA
1990	6,500	5,595
1991	13,870	9,767
1992	10,680	11,307
1993	10,810	NA

Source : National Statistic Office

Table 2.4 RETAIL PRICE INDEX

(RAGE OF CHANGE FROM THE PREVIOUS YEAR; IN PERCENT)

Item	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
GENERAL PRICE INDEX	125.2	169.5	195.4	149.5	161.9	191.6	487.2	316.7	310.9	76	87.8	87.7	17.7
Foodgrain and Foodstuff	133.8	152	182	155.1	155	191.6	553.2	338.6	354.6	73.3			
Foodgrain	121	146.8	152.8	134.4	162	288.3	254.2	435.9	405.6	54.8			
Foodstuff	138.5	152.6	185.6	157.3	152	181.8	591.6	309.9	341.7	81.1			
Other Consumer Goods	117.8	195.1	205.4	138.8	179.8	190.8	422.7	296.8	255.4	79.8			
Agr. Production Materials	131.8	127	194.3	119.7	139.3	204.4	650.8	303.2	353.1	95.9			

Source: National Statistic Office

Table 2.5 RGDP, HANOI CITY (AT 1989 FIXED PRICE)

	1988	1989	1990	1991	1992	1993
TOTAL	1,355,763	1,480,058	1,755,083	1,886,315	2,133,000	2,372,000
I. MATERIAL MANUFACTURING AREAS	961,057	1,015,895	1,160,290	1,156,463	1,348,260	
1. Industry	480,779	398,611	418,370	438,493	490,909	603,000
2. Basic Construction	79,545	74,269	90,907	68,109	76,069	111,000
3. Agriculture / Forestry	161,001	153,608	126,367	119,470	132,541	144,000
4. Transportation & Communication	79,784	73,703	76,725	78,789	99,812	
5. Trade *	146,637	302,667	423,887	425,693	521,067	1,498,000
6. Others	13,311	13,037	24,034	25,909	27,759	16,000
II. NON-MATER IAL MANUFACTURING AREAS	394,760	464,163	594,793	729,852	940,915	
Per-capita GDP (US$) **	364	388	442	470	517	565
GROWTH RATE OF RGDP	5.50%	9.20%	18.60%	7.50%	13.10%	11.20%

* Includes : 1) Housing, Public Service, Tour; 2) Science; 3) Education; 4) Health, Social Insurrance; 5) Finance State Insurrance, and 6) Others.

** US$ = 1,192 Dong (1989)

Table 2.6 POPULATION PROJECTION OF THE STUDY AREA

	Quan/ Phuong	Area (ha)	1,992 Population	*1 (%)	Study Area	Study Area Population	Growth -2000	2,000 Population	Growth -2005	2005 Population	Growth -2010	2010 Population
	URBAN AREA											
	Dong Da											
1	Van Mieu	23.0	11,288	100.0	23.0	11,288	0.30	11,562	0.28	11,725	0.20	11,842
2	Van Chuong	43.0	12,787	100.0	43.0	12,787	0.30	13,097	0.28	13,282	0.20	13,415
3	Cat Linh	46.2	13,126	100.0	46.2	13,126	2.30	15,745	1.07	16,605	1.02	17,470
4	Quoc Tu Giam	22.7	7,726	100.0	22.7	7,726	2.30	9,267	1.07	9,774	1.02	10,283
5	Hang Bot	27.8	14,313	100.0	27.8	14,313	2.30	17,169	1.07	18,107	1.02	19,050
6	O Cho Dua	84.5	17,356	100.0	84.5	17,356	1.12	18,973	0.11	19,078	2.51	21,596
7	Nam Dong	40.2	14,209	100.0	40.2	14,209	0.03	14,243	1.97	15,702	3.09	18,283
8	Quang Trung	50.2	9,475	100.0	50.2	9,475	0.03	9,498	1.97	10,471	3.09	12,192
9	Trung Liet	91.1	13,216	100.0	91.1	13,216	0.52	13,776	2.78	15,800	2.99	18,308
10	Tho Quan	24.2	12,338	100.0	24.2	12,338	0.30	12,637	0.28	12,815	0.20	12,944
11	Kham Tien	16.0	9,292	100.0	16.0	9,292	0.30	9,517	0.28	9,651	0.20	9,748
12	Trung Phung	24.1	11,104	100.0	24.1	11,104	0.30	11,373	0.28	11,533	0.20	11,649
13	Phuong Lien	34.3	11,636	100.0	34.3	11,636	0.30	11,918	0.28	12,086	0.20	12,207
14	Phuong Mai	43.9	12,478	100.0	43.9	12,478	0.15	12,629	2.60	14,358	2.96	16,612
15	Phuong Liet	65.0	11,256	100.0	65.0	11,256	6.50	18,629	7.73	27,031	4.31	33,381
16	Kim Lien	33.9	11,790	100.0	33.9	11,790	0.15	11,932	2.60	13,566	2.96	15,696
17	Trung Tu	74.3	13,056	100.0	74.3	13,056	0.03	13,087	1.97	14,428	3.09	16,800
18	Khuong Thuor	35.1	10,080	100.0	35.1	10,080	0.15	10,202	2.60	11,599	2.96	13,420
19	Nguyen Trai	42.5	21,082	100.0	42.5	21,082	6.24	34,215	2.21	38,167	0.73	39,580
20	Thinh Quang	38.3	14,321	100.0	38.3	14,321	1.31	15,892	3.94	19,280	3.23	22,601
21	Lang Ha	80.7	13,113	100.0	80.7	13,113	1.14	14,358	2.46	16,213	2.45	18,299
22	Lang Thuong	123.0	11,851	100.0	123.0	11,851	0.87	12,701	3.71	15,239	2.76	17,461
23	Thuong Dinh	35.8	10,195	100.0	35.8	10,195	0.87	10,927	0.66	11,292	0.96	11,839
24	Thang Xuan	72.0	8,982	100.0	72.0	8,982	5.43	13,712	0.97	14,390	1.34	15,380
25	Kim Giang	44.0	6,978	100.0	44.0	6,978	6.24	11,325	2.21	12,633	0.73	13,101
26	Thang Xuan B:	146.0	20,987	100.0	146.0	20,987	10.79	47,638	1.97	52,519	0.91	54,953
	Officials*2	122.8	10,321	100.0	122.8	10,321	0.00	10,321	0.00	10,321	0.00	10,321
	Quan Total	**1464.6**	**334,356**	**84.2**	**1,464.6**	**334,356**	**2.47**	**408,343**	**1.86**	**447,885**	**1.76**	**488,429**
	Ba Dinh											
27	Trung Truc	18.9	9,951	100.0	18.9	9,951	-1.74	8,647	-1.59	7,981	-0.76	7,683
28	Dien Bien	134.2	10,868	100.0	134.2	10,868	0.35	11,176	0.51	11,464	1.06	12,085
29	Cau Giay	99.0	14,574	100.0	99.0	14,574	0.15	14,750	0.18	14,863	1.14	15,751
30	Ngoc Ha	99.2	13,741	100.0	99.2	13,741	2.10	16,226	1.52	17,498	1.30	18,665
31	Truc Bach	38.7	12,358	100.0	38.7	12,358	-1.74	10,739	-1.59	9,912	-0.76	9,541
32	Yen Phu	95.5	13,911	58.7	56.1	8,166	-0.93	7,578	2.18	8,440	0.07	8,470
33	Phuc Xa	50.0	12,316	6.4	3.2	788	-0.93	731	2.18	815	0.07	818
34	Quan Thanh	56.0	10,670	100.0	56.0	10,670	-0.81	9,998	-0.57	9,716	0.17	9,799
35	Thuy Khe	51.5	12,195	100.0	51.5	12,195	-3.42	9,232	-14.97	4,103	-12.94	2,052
36	Buoi	106.0	14,047	100.0	106.0	14,047	-0.26	13,757	-0.70	13,283	0.00	13,283
37	Giang Vo	53.5	14,349	100.0	53.5	14,349	0.18	14,557	-0.20	14,412	0.27	14,608
38	Thanh Cong	63.6	16,332	100.0	63.6	16,332	1.14	17,882	2.46	20,193	2.45	22,791
39	Kim Ma	76.0	13,308	100.0	76.0	13,308	0.18	13,501	-0.20	13,366	0.27	13,548
40	Doi Can	38.0	12,907	100.0	38.0	12,907	1.13	14,121	1.56	15,257	1.30	16,275
41	Cong Vi	136.7	18,474	100.0	136.7	18,474	0.08	18,593	2.75	21,294	3.71	25,548
	Officials*3	39.0	3,728	100.0	39.0	3,728	0.00	3,728	0.00	3,728	0.00	3,728
	Officials*4	13.0	0	100.0	13.0	0	0.00	00	0.00	0	0.00	0
	Quan Total	**1166.6**	**203,729**	**92.6**	**1,082.6**	**186,456**	**-0.06**	**185,216**	**0.12**	**186,345**	**0.88**	**194,642**
	Hoan Kiem											
42	Cua Nam	34.2	11,971	100.0	34.2	11,971	-0.67	11,344	-0.42	11,108	-0.20	10,997
43	Tran Hung Dai	36.0	10,511	100.0	36.0	10,511	-0.95	9,738	-0.47	9,512	-0.05	9,488
44	Hang Bai	29.4	9,348	100.0	29.4	9,348	-0.95	8,661	-0.47	8,459	-0.05	8,438
45	Phan Chu Trinl	53.5	7,861	100.0	53.5	7,861	-2.21	6,574	0.29	6,670	0.28	6,764
46	Ly Thai To	27.8	8,176	100.0	27.8	8,176	-0.41	7,912	-0.38	7,762	-0.34	7,631
47	Trang Tien	7.4	6,612	100.0	7.4	6,612	-0.95	6,126	-0.47	5,983	-0.05	5,968
48	Hang Bac	22.0	8,082	100.0	22.0	8,082	-0.41	7,821	-0.38	7,673	-0.34	7,544
49	Hang Buom	13.2	11,186	100.0	13.2	11,186	-0.95	10,364	-0.47	10,122	-0.42	9,912
50	Dong Xuan	12.6	11,936	100.0	12.6	11,936	-0.41	11,550	-0.47	11,281	-0.42	11,046
51	Hang Dao	8.0	7,466	100.0	8.0	7,466	-0.38	7,242	-0.47	7,073	-0.42	6,926
52	Hang Ma	21.7	8,520	100.0	21.7	8,520	-0.38	8,264	-0.47	8,072	-0.42	7,904
53	Hang Bo	7.3	9,222	100.0	7.3	9,222	-0.38	8,945	-0.47	8,737	-0.42	8,555
54	Cua Dong	13.5	8,406	100.0	13.5	8,406	-0.38	8,154	-0.47	7,964	-0.42	7,798

	Quan/ Xa	Area (ha)	1,992 Population	*1 (%)	Study Area	Study Area Population	Growth -2000	2,000 Population	Growth -2005	2005 Population	Growth -2010	2010 Population
55	Hang Bong	14.8	8,278	100.0	14.8	8,278	-0.41	8,010	-0.38	7,859	-0.34	7,727
56	Hang Gai	12.0	10,220	100.0	12.0	10,220	-0.38	9,913	-0.47	9,683	-0.42	9,481
57	Hang Trong	37.6	9,471	100.0	37.6	9,471	-0.41	9,165	-0.38	8,992	-0.34	8,840
58	Phuc Tan	36.0	9,302	0.0	0.0	0	-0.38	0	-0.47	0	-0.42	0
59	Chuong Duong	30.0	12,441	0.0	0.0	0	-0.41	0	-0.38	0	-0.34	0
	Quan Total	**417.6**	**171,961**	**84.2**	**351.0**	**147,266**	**-0.47**	**141,783**	**-0.40**	**138,986**	**-0.28**	**137,020**
	Quan Hai Ba Trung											
60	Le Dai Hang	83.6	13,807	100.0	83.6	13,807	-1.39	12,344	-1.12	11,668	-0.08	11,622
61	Nguyen Du	29.3	9,438	100.0	29.3	9,438	-0.95	8,744	-0.47	8,541	-0.05	8,519
62	Dong Nhan	21.7	10,262	100.0	21.7	10,262	-2.21	8,582	0.29	8,707	0.28	8,830
63	Ngo Thi Nham	18.1	11,347	100.0	18.1	11,347	-2.21	9,489	0.29	9,628	0.28	9,763
64	Pham Dinh Ho	23.5	8,128	100.0	23.5	8,128	-2.21	6,797	0.29	6,896	0.28	6,994
65	Thanh Nhan	58.5	15,477	100.0	58.5	15,477	-0.64	14,702	-2.87	12,710	0.26	12,876
66	Quynh Loi	29.0	10,900	100.0	29.0	10,900	-0.64	10,354	-2.87	8,951	0.26	9,068
67	Bach Khoa	29.0	10,460	100.0	29.0	10,460	-0.69	9,896	-1.06	9,383	-0.07	9,350
68	Dong Mac	17.0	8,658	100.0	17.0	8,658	-2.21	7,241	0.29	7,346	0.28	7,450
69	Thanh Luong	91.2	13,222	44.2	40.3	5,844	0.29	5,981	1.10	6,317	0.27	6,403
70	Bach Dang	54.4	14,172	35.2	19.1	4,989	-2.21	4,172	0.29	4,233	0.28	4,292
71	Giap Bat	64.5	9,367	100.0	64.5	9,367	3.30	12,145	1.71	13,220	2.24	14,768
72	Minh Khai	51.0	12,797	100.0	51.0	12,797	-0.64	12,156	-2.87	10,509	0.26	10,646
73	Bui Thi Xuan	16.5	10,463	100.0	16.5	10,463	-1.39	9,355	-1.12	8,842	-0.08	8,807
74	Vinh Tuy	109.0	17,406	100.0	109.0	17,406	0.12	17,574	0.24	17,786	0.31	18,063
75	Quynh Mai	37.6	11,319	100.0	37.6	11,319	-0.64	10,752	-2.87	9,295	0.26	9,417
76	Tuong Mai	45.5	15,427	100.0	45.5	15,427	3.03	19,588	2.97	22,675	2.00	25,035
77	Dong Tam	18.8	12,076	100.0	18.8	12,076	-0.69	11,425	-1.06	10,832	-0.07	10,795
78	Mai Dong	82.5	10,993	100.0	82.5	10,993	0.06	11,046	-0.11	10,985	0.33	11,168
79	Cau Den	24.0	8,872	100.0	24.0	8,872	-0.69	8,394	-1.06	7,958	-0.07	7,931
80	Bach Mai	29.5	14,505	100.0	29.5	14,505	0.78	15,435	-0.15	15,320	1.16	16,229
81	Tan Mai	63.7	15,259	100.0	63.7	15,259	3.90	20,723	0.54	21,268	1.71	23,172
82	Truong Dinh	30.0	14,882	100.0	30.0	14,882	2.91	18,721	2.49	21,170	2.56	24,023
83	Pho Hue	20.1	13,578	100.0	20.1	13,578	-2.21	11,355	0.29	11,521	0.28	11,683
84	Hoang Van Th	60.0	7,557	100.0	60.0	7,557	0.06	7,593	-0.11	7,552	0.33	7,677
	Quan Total	**1106.0**	**300,972**	**92.2**	**1,021.0**	**283,011**	**0.03**	**284,568**	**-0.09**	**283,338**	**0.78**	**294,580**
	Urban Total	**4178.4**	**1,089,458**	**94.3**	**3940.0**	**951,889**	**0.84**	**1,017,909**	**0.74**	**1,056,301**	**1.08**	**1,114,641**

	Huyen/ Xa	Area (ha)	1992 Population	*1 (%)	Study Area	Study Area Population	Growth -2000	2000 Population	Growth -2005	2005 Population	Growth -2010	2010 Population
	SUBURBAN AREA											
	Thanh Tri											
1	*Tran Van Dien*	68.6	9,744	100.0	68.6	9,744	3.19	12,527	3.19	14,656	3.19	17,148
2	*Khuong Dinh*	240.4	7,103	100.0	240.4	7,103	2.97	8,977	2.97	10,392	2.97	12,029
3	*Dinh Cong*	239.4	5,723	100.0	239.4	5,723	4.18	7,941	4.18	9,746	4.18	11,960
4	*Vinh Tuy*	180.6	5,922	100.0	180.6	5,922	0.70	6,262	0.63	6,462	0.63	6,668
5	*Thanh Tri*	260.4	7,660	46.4	120.8	3,554	1.50	4,004	1.35	4,281	1.35	4,578
6	*Tran Phu*	357.9	4,591	39.4	141.0	1,809	1.30	2,006	1.17	2,126	1.17	2,253
7	*Yen So*	710.7	8,359	41.2	292.8	3,444	2.20	4,099	1.98	4,521	1.98	4,987
8	*Tu Hiep*	467.2	7,299	8.3	38.8	606	1.90	704	1.71	767	1.71	834
9	*Thinh Liet*	301.8	8,670	100.0	301.8	8,670	3.13	11,094	3.13	12,943	3.13	15,099
10	*Thanh Liet*	334.2	6,024	51.5	172.1	3,102	2.10	3,664	1.89	4,023	1.89	4,418
11	*Dai Kim*	250.4	5,894	100.0	250.4	5,894	1.50	6,640	1.35	7,100	1.35	7,592
12	*Linh Nam*	552.1	9,976	27.2	150.2	2,713	1.70	3,105	1.53	3,350	1.53	3,614
13	*Tam Hiep*	343.2	7,809	9.7	33.3	757	-0.70	716	-0.63	694	-0.63	672
14	*Tan Trieu*	313.2	10,072	100.0	313.2	10,072	2.45	12,224	2.45	13,797	2.45	15,572
15	*Hoang Liet*	467.2	8,227	100.0	467.2	8,227	1.60	9,341	1.44	10,033	1.44	10,777
16	*Yen Mai*	498.4	3,748	100.0	498.4	3,748	0.60	3,932	0.54	4,105	0.54	4,286
	Huyen Total	5585.7	116,821	62.8	3509.0	81,089	2.30	97,235	2.31	108,996	2.36	122,487
	Tu Liem											
17	*Tran Ngia Do*	132.7	10,319	100.0	132.7	10,319	11.63	24,882	4.32	30,741	0.28	31,174
18	*Tran Cau Giay*	94.4	13,635	100.0	94.4	13,635	11.63	32,878	4.32	40,620	0.28	41,192
19	*Tran Cau Dien*	240.5	8,350	53.7	129.1	4,484	8.4	8,549	6.72	11,834	10.33	19,346
20	*Tu Lien*	344.0	5,089	41.2	141.7	2,097	-0.93	1,946	2.18	2,167	0.07	2,175
21	*Quang An*	188.2	4,651	65.7	123.6	3,056	4.62	4,386	2.18	4,885	0.07	4,902
22	*Nhat Tan*	299.6	6,350	37.1	111.2	2,356	-2.36	1,946	0.00	1,946	0.00	1,946
23	*Mai Dich*	187.9	12,025	100.0	187.9	12,025	5.50	18,455	-7.91	12,223	0.00	12,223
24	*Dich Vong*	349.1	9,450	100.0	349.1	9,450	9.55	19,603	0.65	20,249	1.20	21,493
25	*My Dinh*	460.6	7,505	100.0	460.6	7,505	2.30	9,002	2.07	9,973	1.84	10,926
26	*Dong Nhac*	366.4	14,554	66.4	243.3	9,664	5.50	14,831	4.95	18,883	4.40	23,420
27	*Xuan La*	213.5	6,089	100.0	213.5	6,089	2.87	7,636	10.71	12,700	4.43	15,773
28	*Xuan Dinh*	557.5	12,570	100.0	557.5	12,570	4.50	17,876	4.05	21,801	3.60	26,018
29	*Co Nhue*	543.5	14,635	52.2	283.7	7,639	5.00	11,287	4.50	14,066	4.00	17,113
30	*Yen Hoa*	186.0	8,440	100.0	186.0	8,440	5.50	12,953	11.11	21,935	11.15	37,211
31	*Trung Hoa*	234.1	7,454	100.0	234.1	7,454	5.50	11,440	7.00	16,045	0.00	16,045
32	*Trung Van*	289.2	6,761	100.0	289.2	6,761	3.50	8,903	3.15	10,396	2.80	11,936
33	*Nhan Chinh*	254.3	7,900	100.0	254.3	7,900	0.28	8,079	1.44	8,677	-0.17	8,604
34	*Me Tri*	706.6	12,632	100.0	706.6	12,632	2.90	15,878	2.61	18,061	2.32	20,256
35	*Phu Thuong*	609.5	8,567	65.6	399.8	5,620	2.80	7,009	2.52	7,938	2.24	8,868
36	*Thuy Phuong*	249.0	6,448	20.0	49.8	1,290	4.20	1,792	3.78	2,158	3.38	2,545
37	*Ngai Tan*	53.6	13,318	100.0	53.6	13,318	6.00	21,227	-0.99	20,197	0.10	20,298
	Huyen Total	6560.2	196,742	78.3	5,201.8	164,303	5.93	260,556	3.37	307,494	2.83	353,463
	Ha Tay											
1	*Van Yen*	322.0	5,400	100.0	322.0	5,400	2.60	6,631	2.34	7,444	2.08	8,251
	Suburban Total	12467.9	318063.0	72.4	9032.8	250,792	4.78	364,422	3.07	423,933	2.78	484,201
	Study Area Total	16646.3	1,328,421	77.9	12872.8	1,202,881	1.76	1,382,331	1.38	1,480,234	1.55	1,598,882

Study Area Excluding Ho Tay (567 ha)

*1 Percentage of the area inside the study area
*2 Bach Mai Airbase
*3 Government and military area
*4 Ho Chi Minh Square

Table 2.7 LAND CHANGE OF THE STUDY AREA, 1993 & 2010

(ha)

		City * Centre	%	Residential Urban	%	Residential Village	%	Industry	%	Green & Park	%	Lake & Pond	%	Agriculture Land	%	District Total
1993 Present Land Use	URBAN	860	6.4	1,900	14.0	510	3.8	150	1.1	150	1.1	260	1.9	110	0.8	3,940
	SUBURBAN	60	0.4	1,100	8.1	1,290	9.5	450	3.3	0	0.0	2,010	14.8	4,690	34.6	9,600
	STUDY AREA	920	6.8	3,000	22.2	1,800	13.3	600	4.4	150	1.1	2,270	16.8	4,800	35.5	13,540
2010 Master Plan	URBAN	860	6.4	1,970	14.5	510	3.8	230	1.7	150	1.1	220	1.6	0	0.0	3,940
	SUBURBAN	120	0.9	3,360	24.8	1,780	13.1	420	3.1	210	1.6	1,710	12.6	2,000	14.8	9,600
	STUDY AREA	980	7.2	5,330	39.4	2,290	16.9	650	4.8	360	2.7	1,930	14.3	2,000	14.8	13,540
1993-2010 Change	URBAN	0	0.0	70	0.5	0	0.0	80	0.6	0	0.0	-40	-0.3	-110	-0.8	0
	SUBURBAN	60	0.4	2,260	16.7	490	3.6	-30	-0.2	210	1.6	-300	-2.2	-2,690	-19.9	0
	STUDY AREA	60	0.4	2,330	17.2	490	3.6	50	0.4	210	1.6	-340	-2.5	-2,800	-20.7	0

*: City Centre includes Ancient Area, Public, Office and Commercial

Source Existing Land Use Map, JICA Study Team, 1993

Master Plan Map, HUPI, 1992

Table 2.8 DAILY RAINFALL OF PAST MAJOR FLOODS (LANG STATION)

unit : mm

Year	Mon.	Date	Rainfall			Ratio
1955	9	25	5.6	total	310.1	
		26	224.4	1-day	224.4	0.72
		27	80.1	2-day	304.5	0.98
1958	6	15	0.6	total	184.6	
		16	184.0	1-day	184.0	1.00
				2-day	184.6	1.00
1959	7	25	17.8	total	288.7	
		26	29.3	1-day	199.8	0.69
		27	19.3	2-day	201.7	0.70
		28	20.6			
		29	1.9			
		30	199.8			
1967	6	7	5.9	total	162.0	
		8	156.1	1-day	156.1	0.96
				2-day	162.0	1.00
1967	7	22	11.6	total	253.4	
		23	6.2	1-day	175.7	0.69
		24	23.5	2-day	199.2	0.79
		25	175.7			
		26	6.6			
		27	29.8			
1968	8	13	18.3	total	205.6	
		14	182.5	1-day	182.5	0.89
		15	4.8	2-day	200.8	0.98
1972	8	20	9.3	total	345.8	
		21	3.6	1-day	205.7	0.59
		22	54.8	2-day	260.5	0.75
		23	205.7			
		24	43.0			
		25	29.4			
1975	9	20	5.6	total	182.4	
		21	176.2	1-day	176.2	0.97
		22	0.6	2-day	181.8	1.00
1978	9	21	41.6	total	226.6	
		22	185.0	1-day	185.0	0.82
				2-day	226.6	1.00

Year	Mon.	Date	Rainfall			Ratio
1984	11	9	165.5	total	604.7	
		10	394.9	1-day	394.9	0.65
		11	0.0	2-day	560.4	0.93
		12	1.2			
		13	16.8			
		14	23.6			
		15	2.7			
1986	6	18	164.0	total	310.7	
		19	128.4	1-day	164.0	0.53
		20	18.3	2-day	292.4	0.94
1989	6	10	41.9	total	348.4	
		11	66.1	1-day	220.6	0.63
		12	220.6	2-day	286.7	0.82
		13	18.8			
		14	1.0			
1989	10	13	10.1	total	229.3	
		14	161.6	1-day	161.6	0.70
		15	57.6	2-day	219.2	0.96
1992	6	29	68.4	total	233.7	
		30	165.3	1-day	165.3	0.71
				2-day	233.7	1.00
1994	5	17	25.0	total	312.0	
		18	41.0	1-day	169.0	0.54
		19	57.0	2-day	226.0	0.72
		20	169.0			
		21	20.0			
1994	8	29	170.4	total	319.3	
		30	130.6	1-day	170.4	0.53
		31	16.1	2-day	301.0	0.94
	9	1	2.2			

1-day rainfall / total rainfall	=	73% (average)
2-day rainfall / total rainfall	=	91% (average)

Table 2.9 SELECTION OF OBJECTIVE FLOOD FOR THE DRAINAGE PLAN

Flood Type	Rainfall at Lang station (mm)			Cause of Rainfall	Data Availability				Remarks
	2 days	Storm Total	Return Period (2 days)		Hourly Rainfall	Water Level: Rivers in Hanoi	Water Level: Inner Water	Water Level: Nhue River	
Aug. 23, 1972	260.5 (1.190)	345.8	6-year	Low pressure	X Imperfect	-	-	X	There exist few information about flooding
Sep. 22, 1978	226.6 (1.368)	226.6	4-year	Typhoon (No.7 and 8)	X	-	-	X	There exist few information about flooding
Nov. 10, 1984	560.4 (0.553)	604.7	Less than 200-year	Typhoon (No.9)	X	- * 5.45 m	X	X	Extremely big flood Flooding caused heavy damage
Jun. 12, 1989 (Objective Flood)	286.7 (1.081)	348.4	8-year	Typhoon (No.3)	X	X * 5.37 m	X	X	Rainfall is nearly 10-year Flooding caused heavy damage Intensive hyetgraph pattern
May 20, 1994	226.0 (1.372)	312.0	4-year	Typhoon	X	X * 5.15 m	X	X	
Aug 29, 1994	301.0 (1.030)	317.1	9-year	Typhoon	X	X * 5.70 m	X	X	Rainfall is nearly 10-year Flooding caused heavy damage Scattering hyetgraph pattern

Data Availability : X ; exist, - ; no exist
( ) : enlarging factor for making design hourly hyetgraph of 10-year (310 mm, 2 days)
* : peak water level at downstream side of Thanh Liet floodgate

Table 2.10 LANDSIDE WATER LEVELS UNDER PRESENT CONDITIONS

unit : m,MSL

Basin		Area	EL. min.	Return Period (year)						
No.	Name	(km²)	(m,MSL)	1.2	2	5	10	20	30	50
TO LICH RIVER BASIN (POND; ALTERNATIVE 1)										
1	T1	1.30	7.40	-	7.43	7.51	7.80	8.02	8.05	8.09
2	T2	4.36	5.90	-	6.01	6.20	6.35	6.50	6.59	6.70
3	T3	3.12	5.80	-	5.83	6.02	6.08	6.15	6.19	6.23
4	T4	1.22	5.80	-	-	6.01	6.07	6.15	6.20	6.27
5	T5	3.30	5.80	-	5.86	6.04	6.11	6.18	6.23	6.28
6	T6	2.50	5.90	-	6.00	6.08	6.14	6.21	6.24	6.29
7	T7	1.06	5.80	-	5.82	5.91	5.99	6.03	6.06	6.09
8	T8	2.34	4.00	4.12	4.46	4.85	5.11	5.36	5.50	5.68
9	T9	0.80	4.00	4.12	4.46	4.85	5.11	5.36	5.50	5.68
10	L1	2.15	5.90	-	5.95	6.06	6.12	6.18	6.22	6.26
11	L2	1.75	5.70	5.71	5.83	6.01	6.07	6.12	6.16	6.20
12	L3	0.92	5.70	-	5.71	5.78	5.84	5.91	5.96	6.01
13	L4	1.05	5.70	-	5.80	5.97	6.04	6.10	6.13	6.16
14	L5	0.75	4.90	-	5.00	5.09	5.16	5.36	5.50	5.68
15	L6	3.58	4.00	4.12	4.46	4.85	5.11	5.36	5.50	5.68
16	K1	3.47	6.40	-	7.01	7.23	7.40	7.57	7.66	7.78
17	K2	1.22	5.40	-	5.45	5.55	5.75	5.95	6.02	6.06
18	K3	1.59	5.60	-	5.71	5.87	5.98	6.04	6.08	6.11
19	K4	1.26	4.60	-	4.64	4.85	5.11	5.36	5.50	5.68
20	K5	2.77	4.70	-	4.70	4.87	5.11	5.36	5.50	5.68
21	K6	6.99	4.60	-	-	4.85	5.11	5.36	5.50	5.68
22	S1	2.17	5.90	5.99	6.09	6.22	6.31	6.41	6.46	6.52
23	S2	1.99	5.30	-	5.35	5.50	5.82	6.03	6.07	6.12
24	S3	1.50	4.60	4.63	4.81	5.03	5.11	5.36	5.50	5.68
25	S4	1.44	4.00	4.12	4.46	4.85	5.11	5.36	5.50	5.68
26	H1	5.62	4.00	4.12	4.46	4.85	5.11	5.36	5.50	5.68
27	H2	2.48	4.00	4.12	4.46	4.85	5.11	5.36	5.50	5.68
28	Y	5.50	4.00	4.12	4.46	4.85	5.11	5.36	5.50	5.68

Table 2.11 LANDSIDE WATER LEVELS UNDER FUTURE CONDITIONS

unit : m,MSL

Basin No.	Basin Name	Area (km²)	EL. min. (m,MSL)	Return Period (year) 1.2	2	5	10	20	30	50
TO LICH RIVER BASIN (ALTERNATIVE 6)										
1	T1	1.30	7.40	-	-	-	-	7.41	7.42	7.44
2	T2	4.36	5.90	-	-	-	-	6.05	6.10	6.16
3	T3	3.12	5.80	-	-	-	-	5.94	6.01	6.05
4	T4	1.22	5.80	-	-	-	-	5.94	6.02	6.05
5	T5	3.30	5.80	-	-	-	-	5.93	6.01	6.06
6	T6	2.50	5.90	-	-	-	-	6.00	6.03	6.07
7	T7	1.06	5.80	-	-	-	-	5.82	5.84	5.87
8	T8	2.34	4.00	-	-	-	-	4.57	5.00	5.06
9	T9	0.80	4.00	-	-	-	-	4.01	4.07	4.17
10	L1	2.15	5.90	-	-	-	-	6.03	6.06	6.11
11	L2	1.75	5.70	-	-	-	-	5.72	5.75	5.79
12	L3	0.92	5.70	-	-	-	-	5.71	5.72	5.74
13	L4	1.05	5.70	-	-	-	-	5.76	5.82	5.90
14	L5	0.75	4.90	-	-	-	-	4.94	5.01	5.03
15	L6	3.58	4.00	-	-	-	-	4.17	4.30	4.46
16	K1	3.47	6.40	-	-	-	-	7.00	7.05	7.12
17	K2	1.22	5.40	-	-	-	-	5.41	5.41	5.42
18	K3	1.59	5.60	-	-	-	-	5.69	5.75	5.82
19	K4	1.26	4.60	-	-	-	-	4.63	4.67	4.72
20	K5	2.77	4.70	-	-	-	-	4.75	4.80	4.89
21	K6	6.99	4.60	-	-	-	-	4.76	4.88	5.00
22	S1	2.17	5.90	-	-	-	-	6.04	6.08	6.14
23	S2	1.99	5.30	-	-	-	-	5.37	5.42	5.49
24	S3	1.50	4.60	-	-	-	-	4.70	4.78	4.89
25	S4	1.44	4.00	-	-	-	-	4.06	4.11	4.17
26	H1	5.62	4.00	-	-	-	-	4.11	4.18	4.27
27	H2	2.48	4.00	-	-	-	-	4.07	4.12	4.18
28	Y	5.50	4.00	-	-	-	-	4.08	4.14	4.20
NHUE RIVER BASIN (ALTERNATIVE 1)										
Co Nhue		19.7	5.2	-	-	-	-	5.62	5.85	6.04
My Dinh		13.6	4.7	-	-	-	-	5.02	5.08	5.14
Me Tri		14.7	4.7	-	-	-	-	5.02	5.07	5.13
Ba Xa		9.9	4.5	-	-	-	-	4.72	4.85	5.00

Table 2.12 WATER QUALITY IN LAKES, RIVERS, AND CHANNELS DURING THE DRY SEASON OF 1993-1994 (1/3)

SAMPLING POINTS:

TO LICH SYSTEM
- 02.4.01 Phan Dinh Phung Outlet
- 04.4.01 Trinh Hoai Duc
- 00.2.05 Cau Moi Bridge

LU RIVER SYSTEM
- 06.1.02 Van Chuong Lake
- 00.2.06 Tau Bay Bridge
- 00.2.02 Cau Dau Bridge

SET RIVER SYSTEM
- 05.1.02 Bay Mau Lake
- 05.4.01 Ba Trieu Outlet

KIM NGUU RIVER SYSTEM
- 03.1.02 Hoan Kiem Lake
- 03.4.01 Lac Trung Bridge
- 00.2.04 Hoang Van Thu
- 00.2.03 Phap Van

THANH LIET SYSTEM
- 00.2.01 Cau Son Bridge
- 00.2.07 Nhue River
- 00.2.08 Cau To Bridge

	TOLICH SYSTEM			LU RIVER SYSTEM			SET RIVER SYSTEM		KIM NGUU RIVER SYSTEM				THANH LIET SYSTEM		
	02.4.01	04.4.01	00.2.05	06.1.02	00.2.06	00.2.02	05.1.02	05.4.01	03.1.02	03.4.01	00.2.04	00.2.03	00.2.01	00.2.07	00.2.08
TEMPERATURE oC															
DEC. 93	18,5	20,5	17,0	21,0	18,0	16,0	20,0	21,0	17,0	22,0	16,0	17,0	16,0	18,0	18,0
JAN. 94 SDCo.	25,3	23,8	22,5	22,7	23,3	23,1	22,0	23,0	22,0	24,0	22,8	22,4	23,1	22,1	21,8
AVERAGE	21,9	22,1	19,7	21,8	20,7	19,6	21,0	22,0	19,5	23,0	19,4	19,7	19,5	20,0	19,9
DISSOLVED OXYGEN mg/l															
DEC. 93	2,2	0,9	0,3	0	0,9	0	1,2	0,8	3,9	0	2,6	1,4	1,6	7,1	6,6
JAN. 94 SDCo.	0,8	0	0	0	0	0	1,4	0	11,3	0	0	0	0	7,1	7,3
AVERAGE	1,5	0,4	0,1	0	0,5	0	1,3	0,4	7,6	0	1,3	0,7	0,8	7,1	6,9
pH															
DEC. 93	7,8	7,7	7,5	7,3	7,6	7,5	7,7	7,9	9,5	7,2	7,6	7,6	7,5	8,0	8,0
JAN. 94 SDCo.	7,8	7,6	7,5	7,3	7,5	7,4	7,7	7,8	9,6	7,0	7,3	7,5	7,4	7,8	7,9
AVERAGE	7,8	7,7	7,5	7,3	7,6	7,5	7,7	7,9	9,6	7,1	7,4	7,5	7,5	7,9	8,0
CONDUCTIVITY µ∫/cm															
DEC. 93	877	895	741	700	900	767	690	960	210	840	666	733	690	222	220
JAN. 94 SDCo.	907	904	710	710	796	730	730	1.040	200	680	759	710	737	213	207
AVERAGE	892	900	726	705	848	749	710	1.000	205	760	713	722	714	218	214

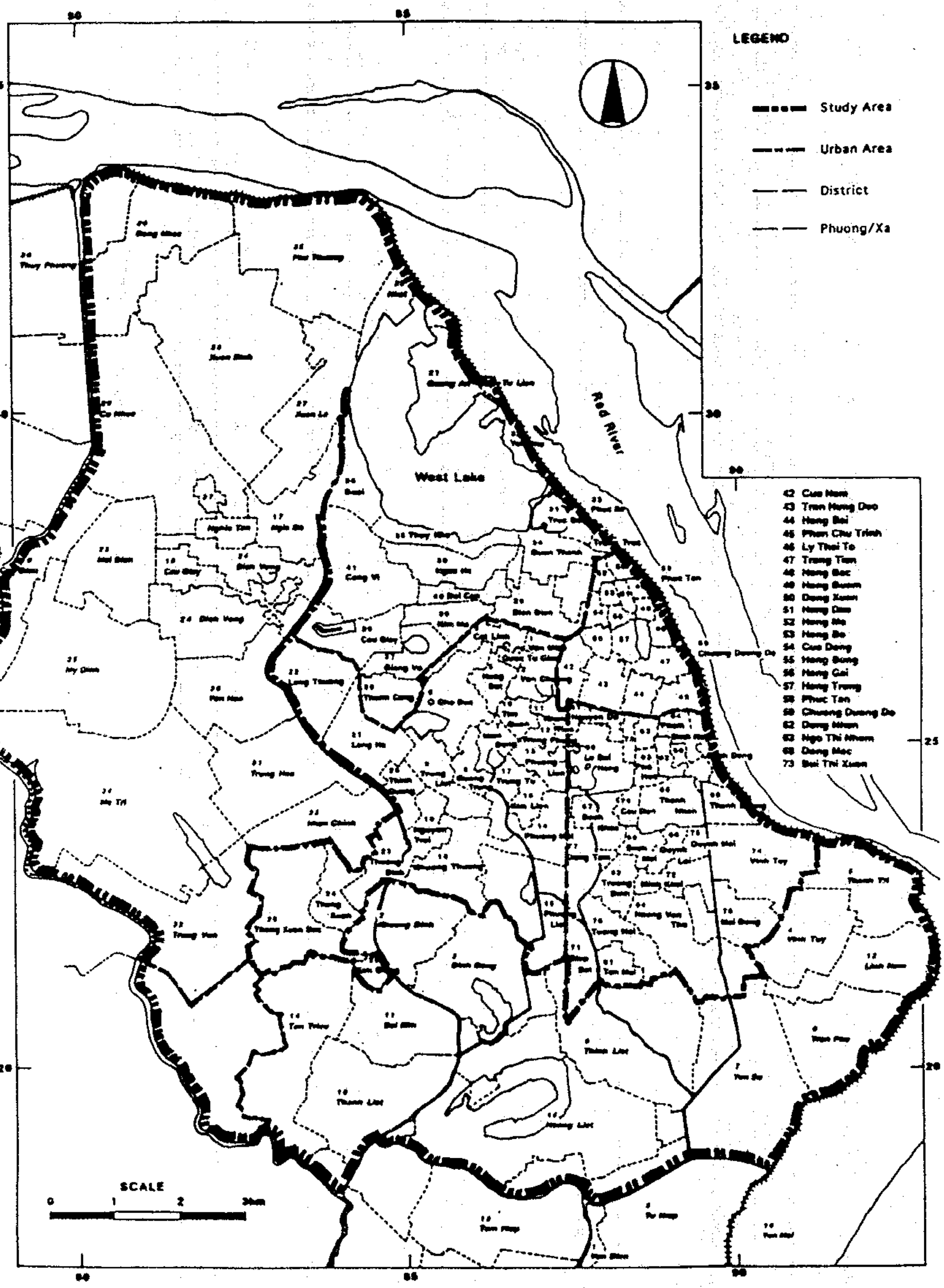
Table 2.12 WATER QUALITY IN LAKES, RIVERS, AND CHANNELS DURING THE DRY SEASON OF 1993-1994 (2/3)

	TOLICH SYSTEM			LU RIVER SYSTEM			SET RIVER SYSTEM		KIM NGUU RIVER SYSTEM				THANH LIET SYSTEM		
	02.4.01	04.4.01	00.2.05	06.1.02	00.2.06	00.2.02	05.1.02	05.4.01	03.1.02	03.4.01	00.2.04	00.2.03	00.2.01	00.2.07	00.2.08
NO2 - N mg/l															
DEC. 93	0,327	0,012	0,030	0,012	0,010	0,206	2,508	0,017	0,383	0,008	0,533	0,353	0,761	0,025	0,831
JAN. 94	0,031	0,022	0,026	0,009	0,006	0,094	0,928	0,021	0	0,002	0,032	0,022	0,013	0,033	0,916
AVERAGE	0,179	0,017	0,028	0,011	0,008	0,108	1,718	0,019	0,192	0,005	0,283	0,189	0,387	0,029	0,874
NO3 - N mg/l															
DEC. 93	0,46	0,85	1,18	0,44	0,24	0,48	4,60	0,70	3,20	0,71	2,61	2,51	0,89	0,73	1,81
JAN. 94	3,39	2,63	3,40	0,49	4,47	1,37	8,86	0,73	3,24	0,73	1,79	4,46	1,47	0,98	2,74
AVERAGE	1,93	1,74	2,29	0,47	2,36	0,93	6,73	0,71	3,22	0,72	2,20	3,49	1,18	0,86	2,28
NH4 - N mg/l															
DEC. 93	3,56	3,73	3,35	4,58	4,23	4,38	1,98	5,85	0,98	3,48	2,77	1,32	2,78	0,92	2,21
JAN. 94	6,15	4,79	4,74	6,79	5,18	5,30	3,59	7,94	0,99	5,85	4,61	2,75	3,14	0,57	3,26
AVERAGE	4,85	4,26	3,91	5,68	4,73	4,84	2,78	6,89	0,99	4,66	3,69	2,03	2,96	0,75	2,74
T - N mg/l															
DEC. 93	19,2	14,8	10,9	10,7	17,6	13,1	9,3	11,5	6,8	21,1	8,5	8,1	7,7	1,0	4,8
JAN. 94	17,9	17,4	14,5	13,9	15,8	10,5	12,0	15,2	4,1	16,5	10,3	10,0	7,1	0,6	9,9
AVERAGE	18,6	16,1	12,7	12,3	16,7	11,8	10,7	13,4	5,5	18,8	9,4	9,0	7,4	0,8	7,4
T - P mg/l															
DEC. 93	3,2	2,2	1,8	3,4	3,6	2,5	1,8	2,8	0,7	3,9	2,6	1,6	1,8	0,2	1,6
JAN. 94	4,3	2,4	2,4	3,6	2,5	1,1	1,2	3,9	0,7	2,8	3,9	3,9	2,2	0,2	2,1
AVERAGE	3,8	2,3	2,1	3,5	3,1	1,8	1,5	3,4	0,7	3,4	3,3	2,8	2,0	0,2	1,9
BOD5 mg/l															
DEC. 93	60	51	40	81	64	42	13	79	52	64	47	37	33	5	31
JAN. 94	69	73	59	70	60	50	34	86	28	74	57	45	43	6	30
AVERAGE	64	62	50	76	62	46	24	83	40	69	52	41	38	6	31
COD mg/l															
DEC. 93	95	121	82	151	155	91	82	145	144	179	116	131	78	15	62
JAN. 94	121	151	107	131	170	105	96	121	137	150	107	172	98	19	90
AVERAGE	108	136	95	141	163	98	89	133	141	165	112	152	88	17	76
TURBIDITY FTU															
DEC. 93	40	17	40	34	75	38	24	43	105	112	134	104	30	68	75
JAN. 94 SDCo.	46	41	39	51	46	36	35	61	125	63	85	101	50	35	32
AVERAGE	43	29	40	43	61	37	30	52	115	88	110	103	40	52	54

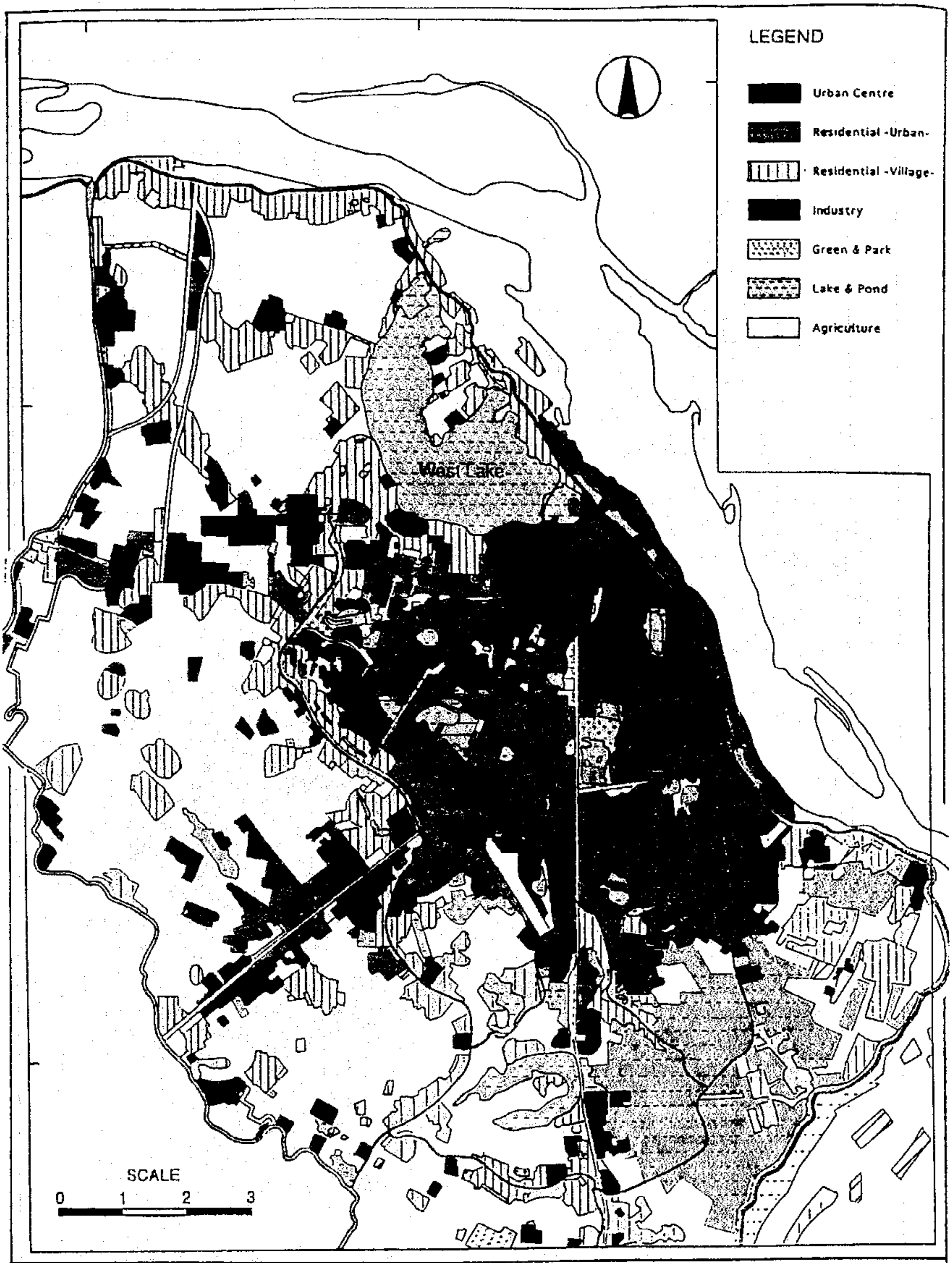
Table 2.12 WATER QUALITY IN LAKES, RIVERS, AND CHANNELS DURING THE DRY SEASON OF 1993-1994 (3/3)

	TOLICH SYSTEM			LU RIVER SYSTEM			SET RIVER SYSTEM		KIM NGUU RIVER SYSTEM				THANH LIET SYSTEM		
	02.4.01	04.4.01	00.2.05	06.1.02	00.2.06	00.2.02	05.1.02	05.4.01	03.1.02	03.4.01	00.2.04	00.2.03	00.2.01	00.2.07	00.2.08
SUSPENDED SOLIDS mg/l															
DEC. 93	108	81	105	103	131	50	32	116	87	79	147	132	73	58	62
JAN. 94	115	102	114	31	123	64	18	136	15	132	98	108	68	40	80
AVERAGE	112	92	110	67	127	57	25	126	51	105	123	120	71	49	71
TOTAL DISSOLVED SOLIDS mg/l															
DEC. 93	449	148	370	350	454	384	350	490	110	430	334	368	345	113	111
JAN. 94 SDCo.	454	453	360	360	398	370	370	530	100	350	380	356	369	107	104
AVERAGE	452	300	365	355	426	377	360	510	105	390	357	362	357	110	108
TOTAL COLIFORM PCS/100ml															
DEC. 93	700	3 600	1 500	10 100	900	400	900	5 900	420	4 200	1 500	2 800	1 100	130	600
JAN. 94	11 000	6 000	8 500	9 200	4 900	3 100	8 700	10 200	1 100	11 000	9 000	7 000	9 500	400	4 200
AVERAGE	5 850	4 800	5 000	9 650	2 900	1 750	4 800	8 050	710	7 100	5 250	4 900	5 300	265	2 400
HETEROTROPHIC PLATE COUNT/100ml															
DEC. 93	1 300	5 000	1 900	9 800	2000	2000	1 400	7 000	700	4 100	2 400	3 100	1 900	600	2 200
JAN. 94	9 000	4 600	7 900	8 800	4 300	4000	7 000	11 000	1 000	9 000	9 400	6 100	8 000	390	4 700
AVERAGE	5 150	4 800	4 800	9 300	3 150	3000	4 200	9 000	850	6 550	5 900	4 600	4 950	485	3 450

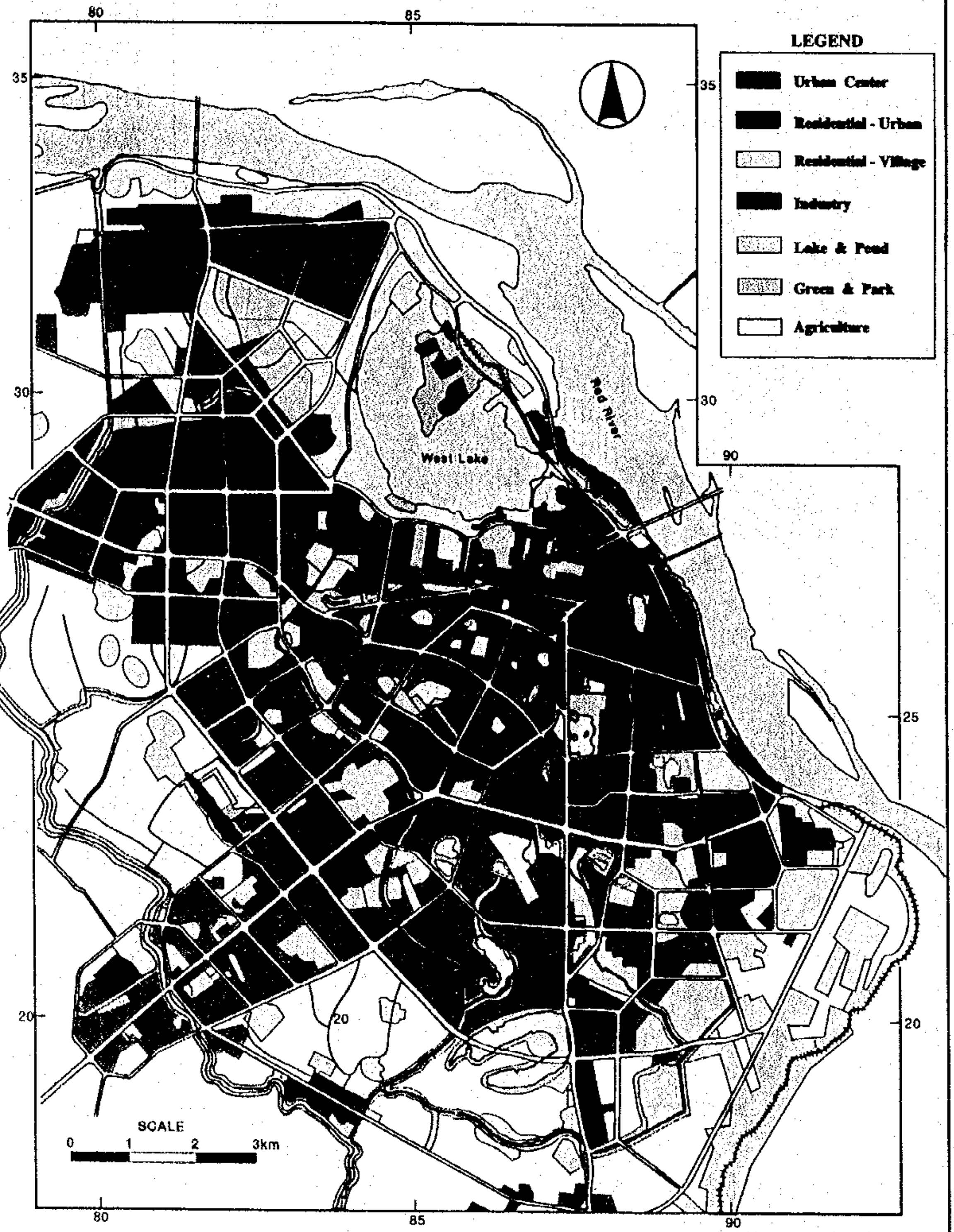
Analyzed in the "Environmental Laboratory of Center for Management and Control of Atmospheric and Water Environment Viet Nam".



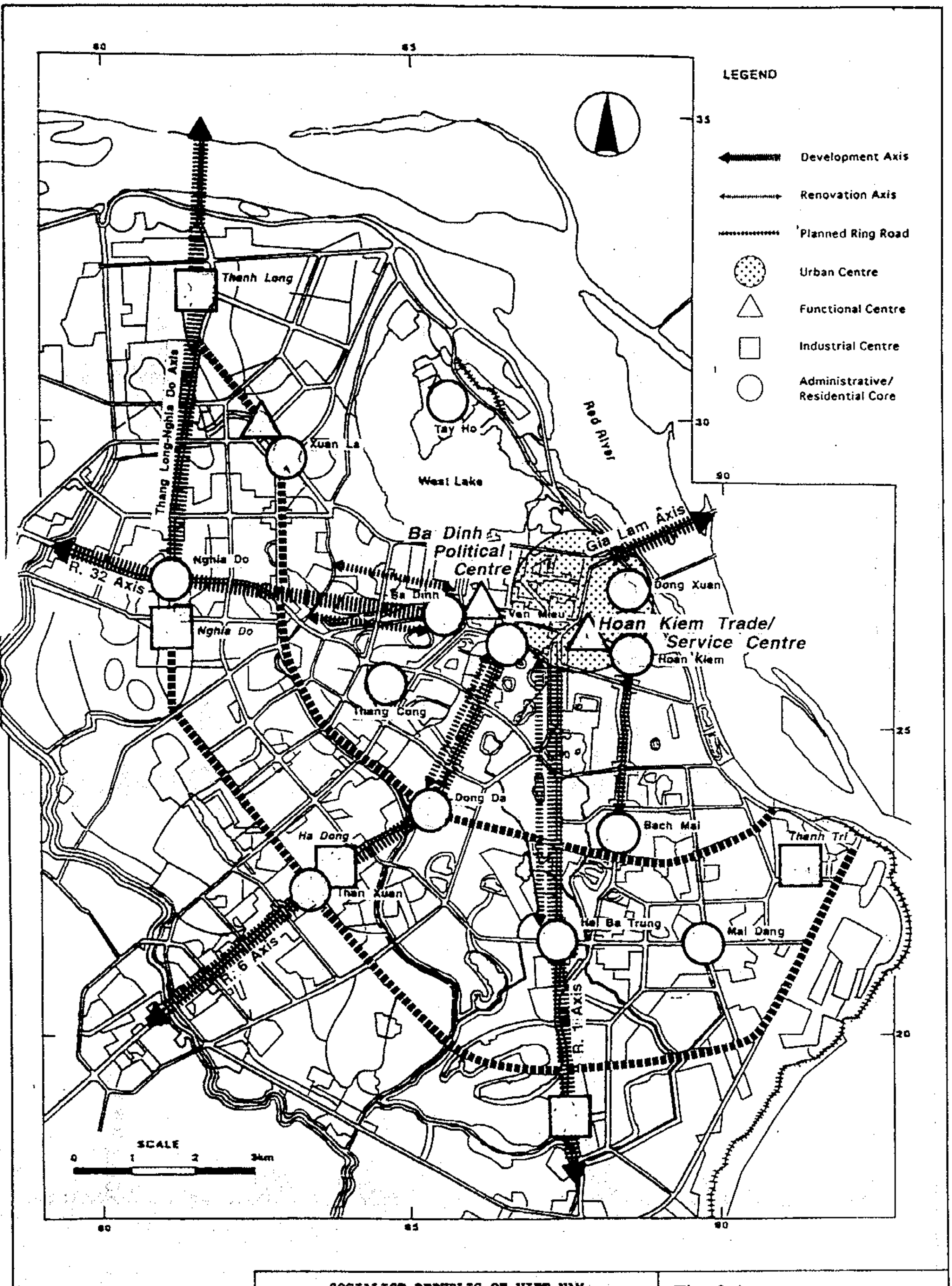
SOCIALIST REPUBLIC OF VIET NAM THE STUDY ON URBAN DRAINAGE AND WASTEWATER DISPOSAL SYSTEM IN HANOI CITY JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 2.1 STUDY AREA AND ADMINISTRATIVE BOUNDARY



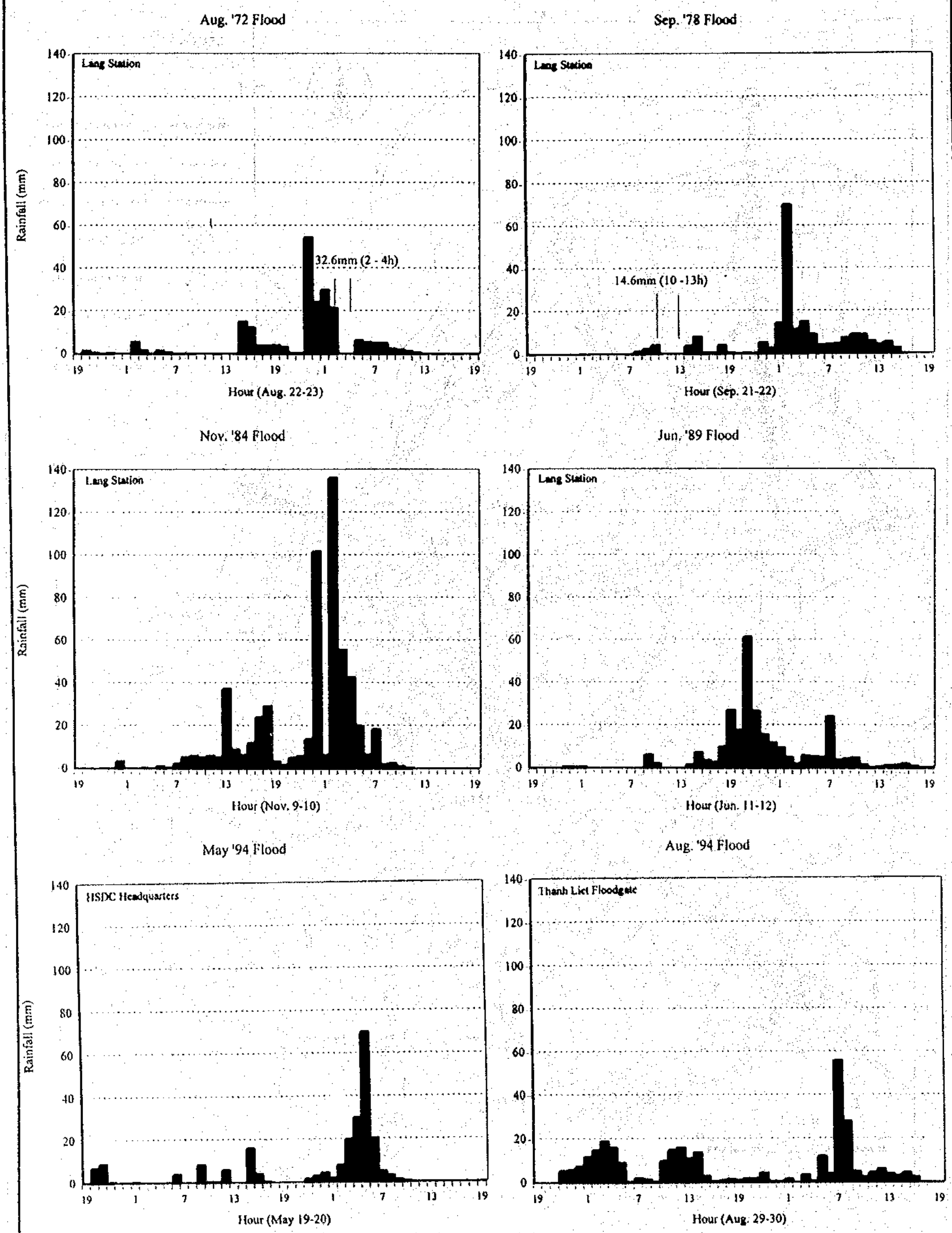
SOCIALIST REPUBLIC OF VIET NAM THE STUDY ON URBAN DRAINAGE AND WASTEWATER DISPOSAL SYSTEM IN HANOI CITY	Fig. 2.2 Present Land Use, 1993
JAPAN INTERNATIONAL COOPERATION AGENCY	



SOCIALIST REPUBLIC OF VIET NAM THE STUDY ON URBAN DRAINAGE AND WASTEWATER DISPOSAL SYSTEM IN HANOI CITY JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 2.3 Hanoi Master Plan Land Use, 2010

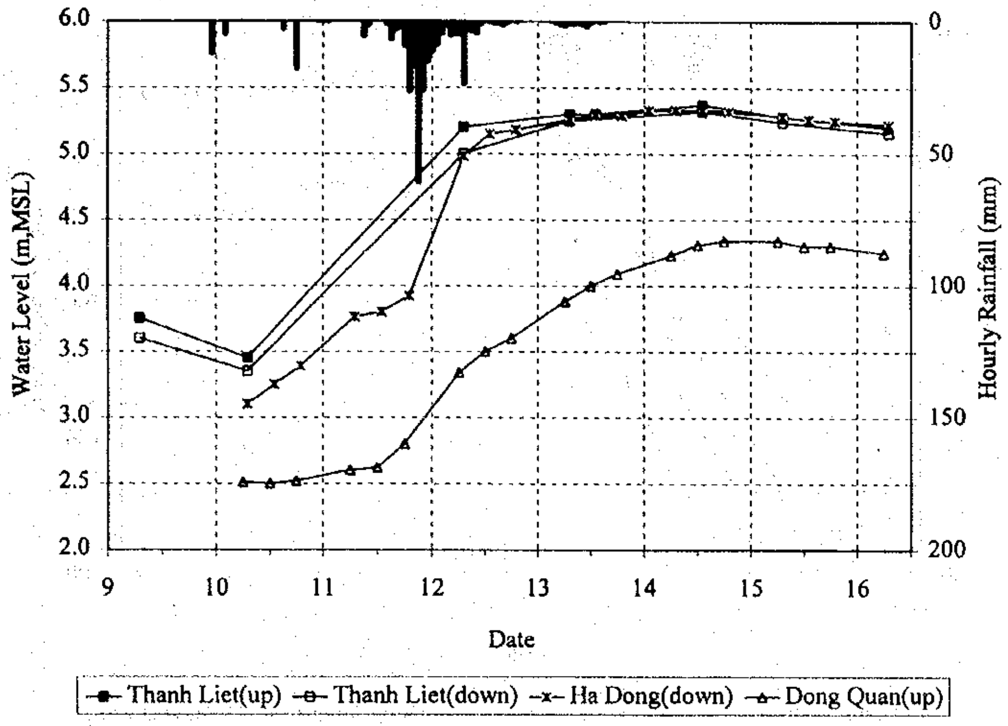


SOCIALIST REPUBLIC OF VIET NAM THE STUDY ON URBAN DRAINAGE AND WASTEWATER DISPOSAL SYSTEM IN HANOI CITY JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 2.4 URBAN STRUCTURE OF HANOI CITY, 2010

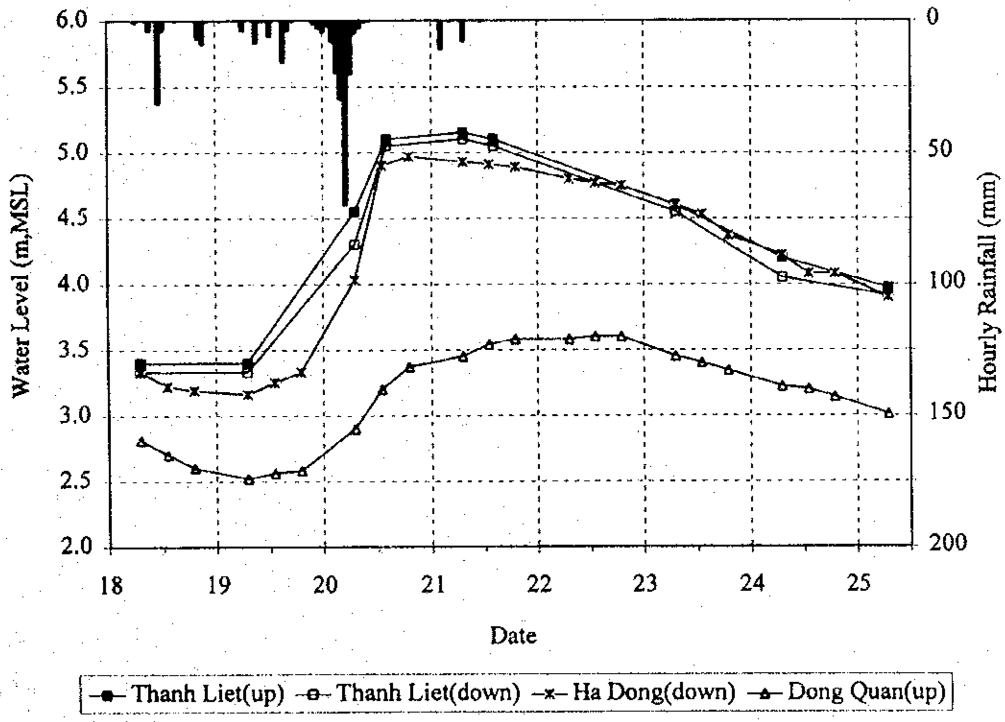


SOCIALIST REPUBLIC OF VIET NAM THE STUDY ON URBAN DRAINAGE AND WASTEWATER DISPOSAL SYSTEM IN HANOI CITY	Fig. 2.5 **HOURLY RAINFALLS OF MAJOR FLOODS IN THE PAST**
JAPAN INTERNATIONAL COOPERATION AGENCY	

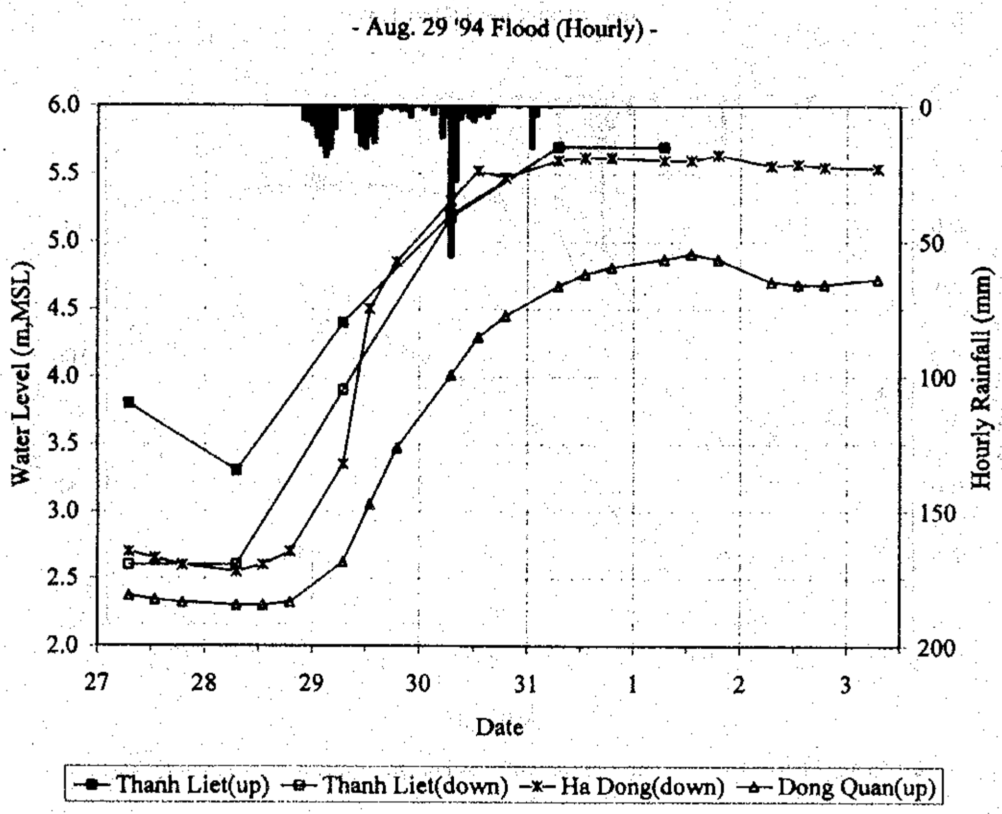
- Jun. 12 '89 Flood (Hourly) -



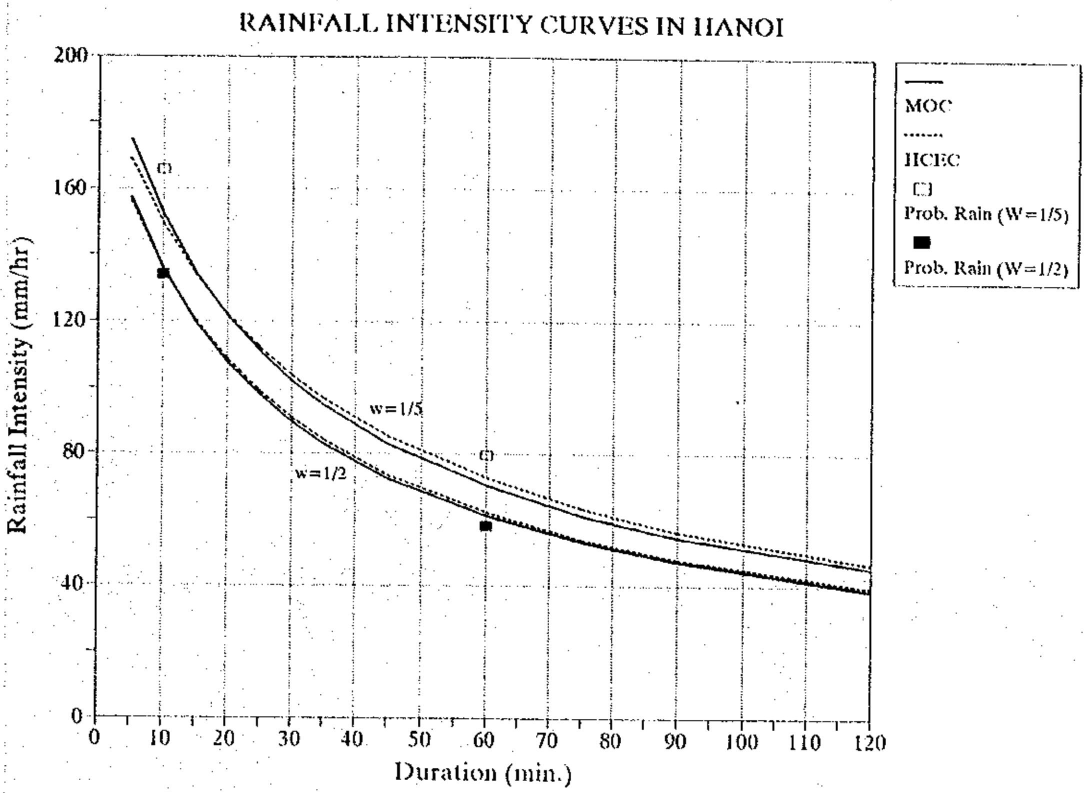
- May 20 '94 Flood (Hourly) -



SOCIALIST REPUBLIC OF VIET NAM THE STUDY ON URBAN DRAINAGE AND WASTEWATER DISPOSAL SYSTEM IN HANOI CITY JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 2.6 RELATIONSHIP BETWEEN RAINFALL AND WATER LEVELS OF FLOODS (1/2)



SOCIALIST REPUBLIC OF VIET NAM THE STUDY ON URBAN DRAINAGE AND WASTEWATER DISPOSAL SYSTEM IN HANOI CITY	Fig. 2.6 RELATIONSHIP BETWEEN RAINFALL AND WATER LEVELS OF FLOODS (2/2)
JAPAN INTERNATIONAL COOPERATION AGENCY	



Rainfall Intensities proposed by MOC

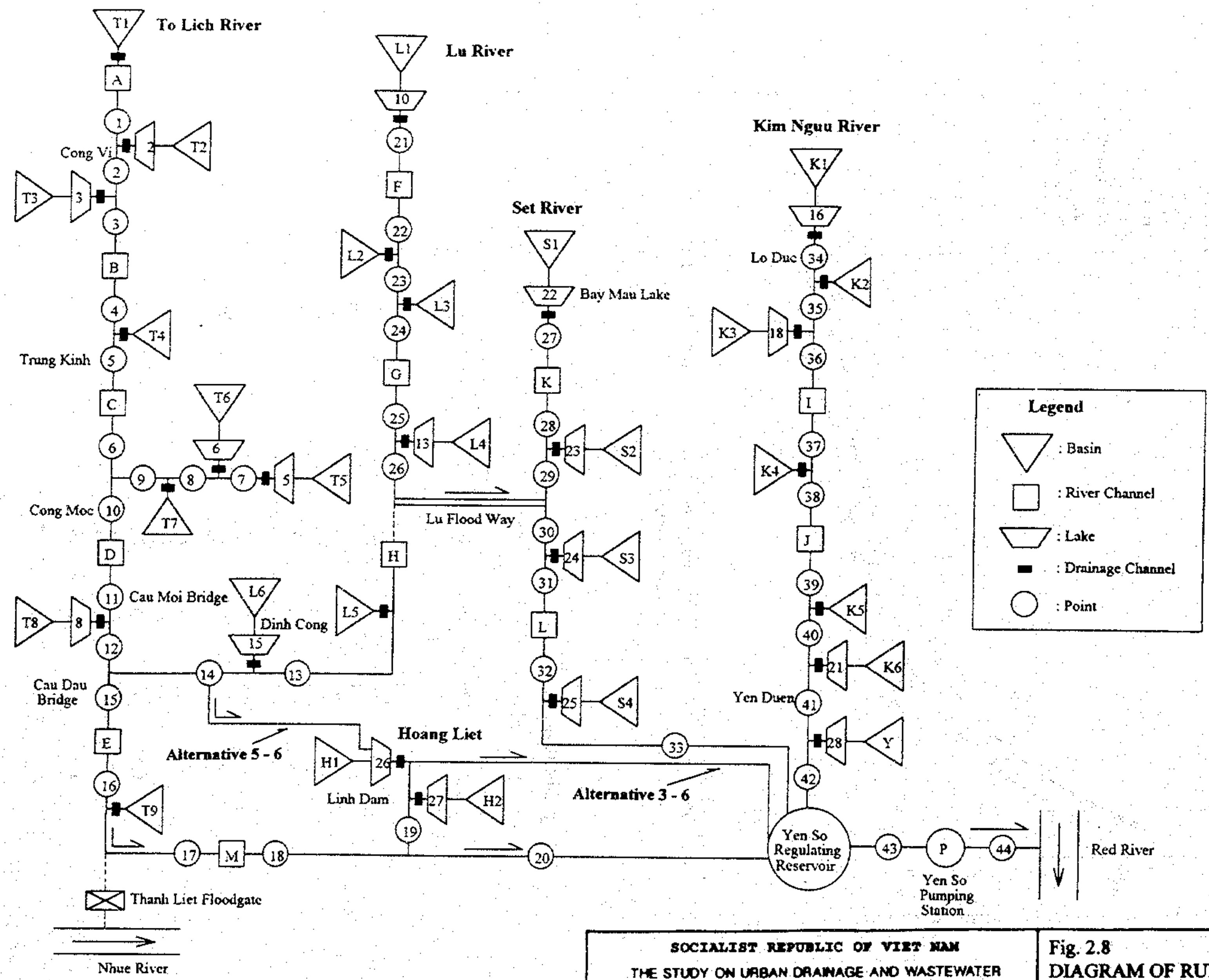
unit ; mm/hr

Duration (min.)	Return Period (year) 50	20	10	5	3	2	1
5	219	202	188	175	165	157	144
10	194	177	165	152	143	136	123
15	174	158	147	135	127	120	108
20	157	143	132	122	114	107	97
25	144	131	121	111	103	98	88
30	133	121	111	102	95	90	80
35	124	112	103	95	88	83	74
45	109	99	91	83	77	72	64
60	93	84	77	70	65	61	54
75	82	74	68	61	57	53	47
90	73	66	60	55	51	47	42
120	61	55	50	45	42	39	34
180	47	42	38	34	31	29	25
240	38	34	31	28	25	24	20
360	29	25	23	21	19	17	15
480	23	21	19	17	15	14	12

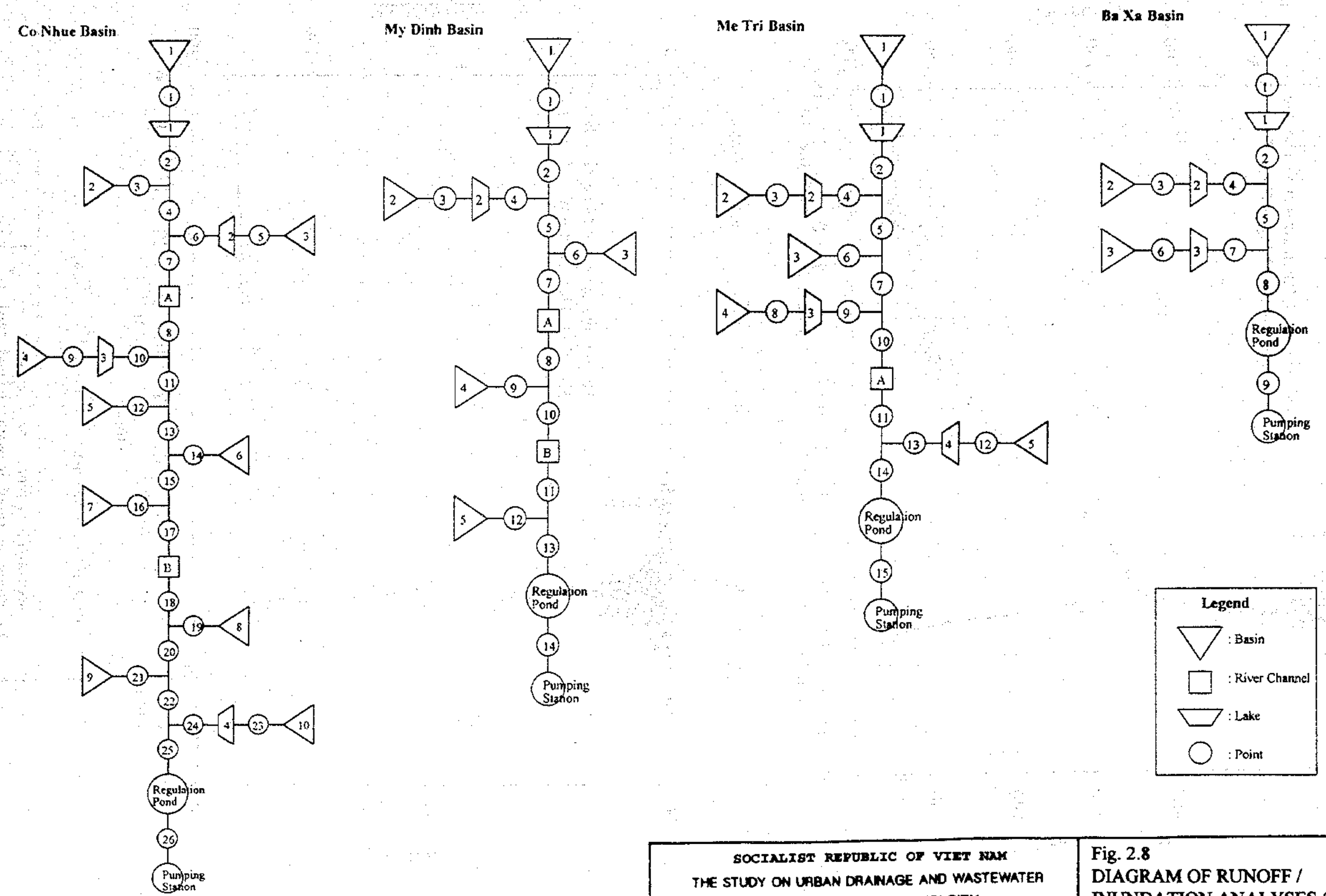
SOCIALIST REPUBLIC OF VIET NAM
THE STUDY ON URBAN DRAINAGE AND WASTEWATER DISPOSAL SYSTEM IN HANOI CITY

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 2.7
RAINFALL INTENSITY CURVES IN HANOI

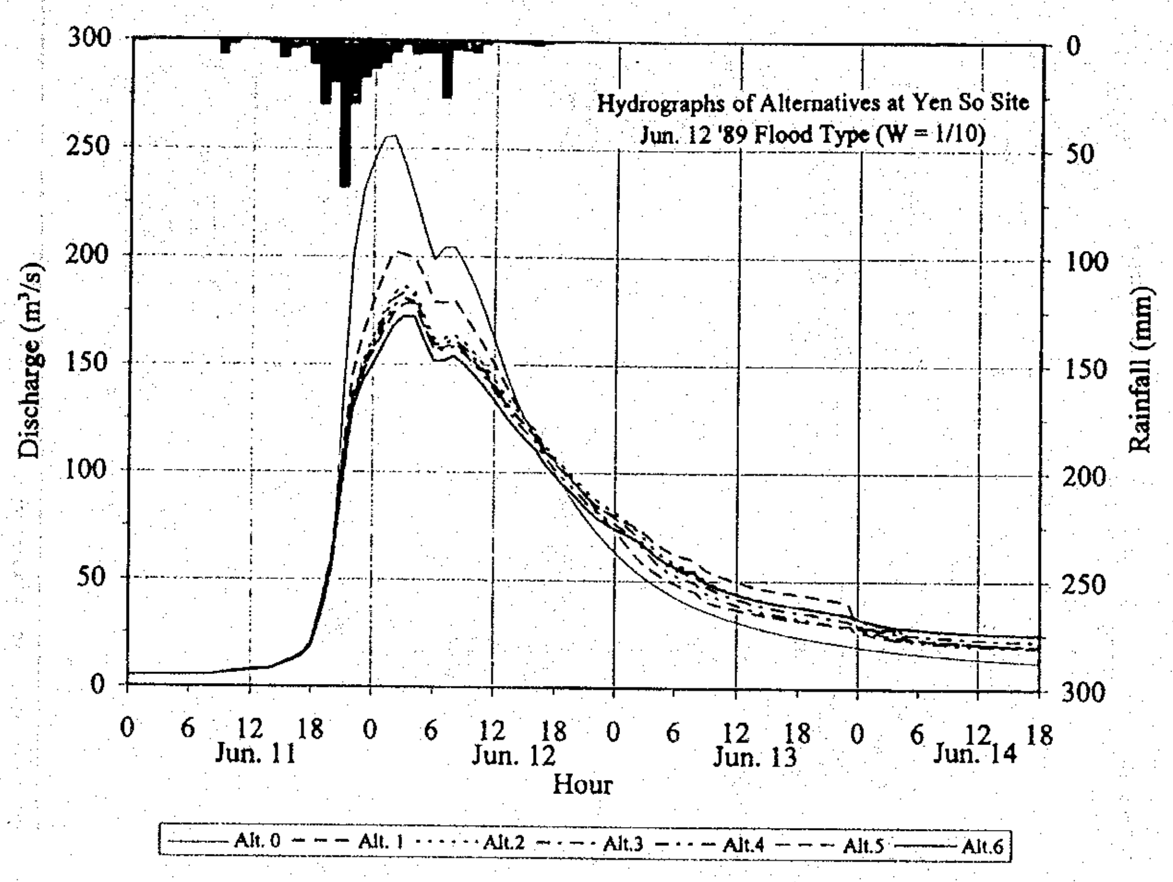


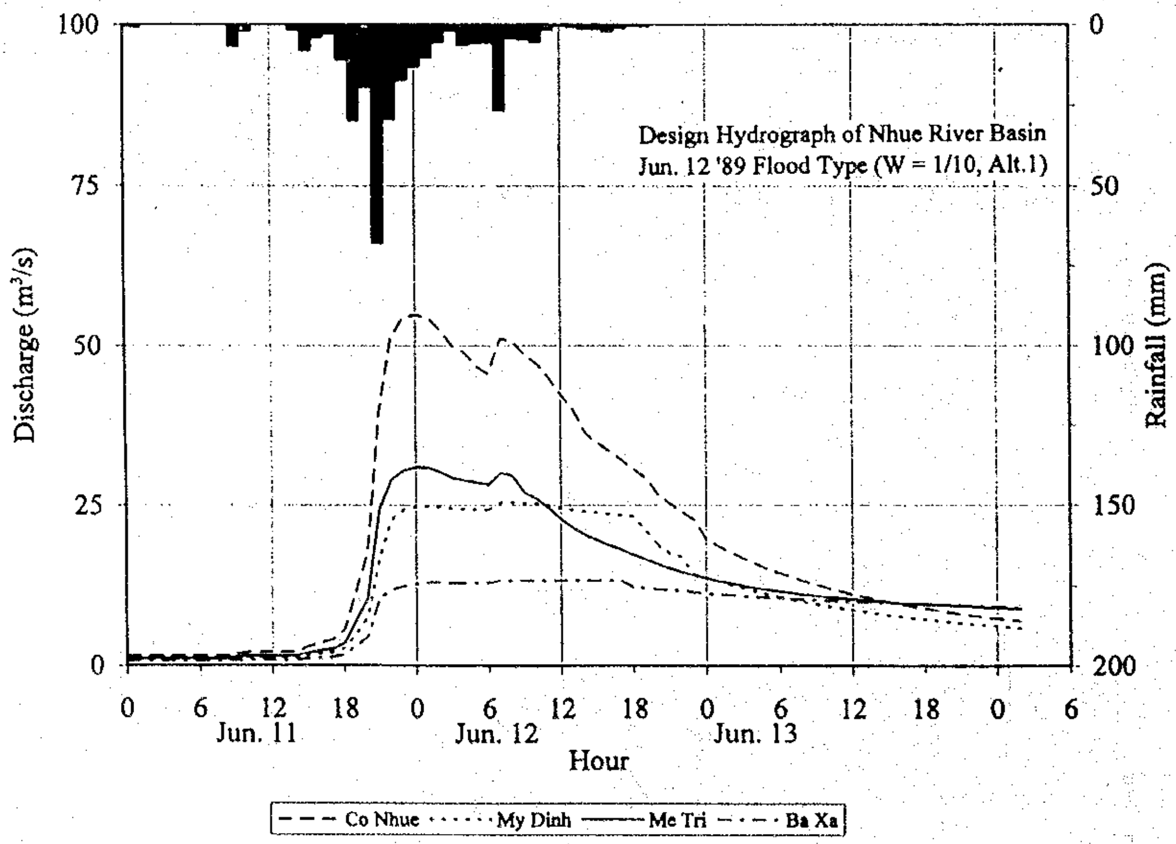
SOCIALIST REPUBLIC OF VIET NAM THE STUDY ON URBAN DRAINAGE AND WASTEWATER DISPOSAL SYSTEM IN HANOI CITY JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 2.8 DIAGRAM OF RUNOFF / INUNDATION ANALYSES (1/2) - To Lich River Basin -



SOCIALIST REPUBLIC OF VIET NAM
THE STUDY ON URBAN DRAINAGE AND WASTEWATER DISPOSAL SYSTEM IN HANOI CITY
JAPAN INTERNATIONAL COOPERATION AGENCY

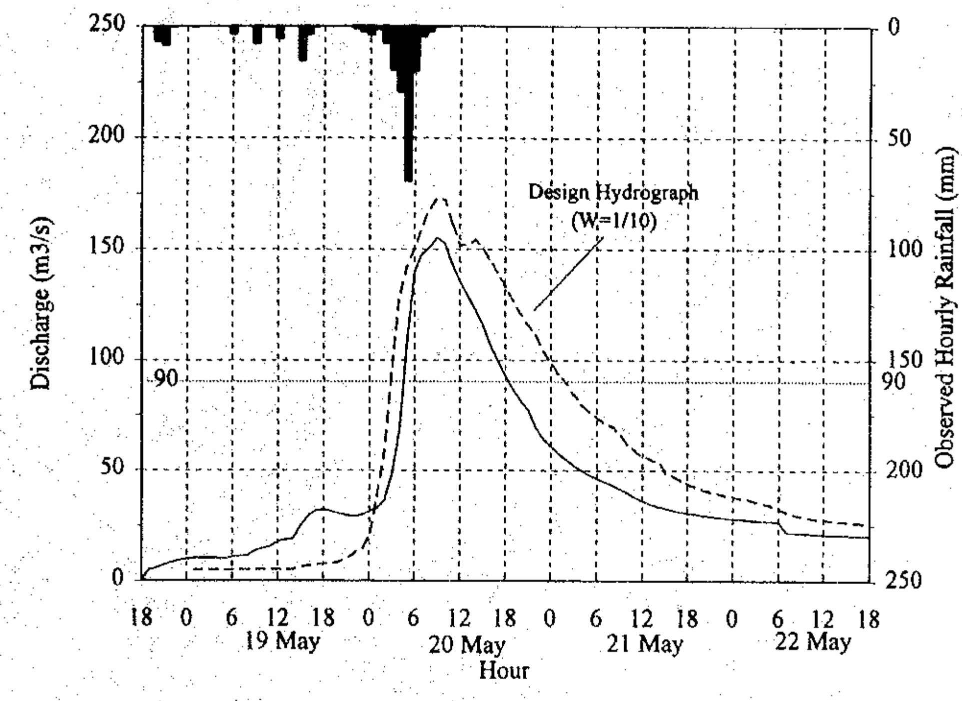
Fig. 2.8
DIAGRAM OF RUNOFF / INUNDATION ANALYSES (2/2)
- Nhue River Basin -



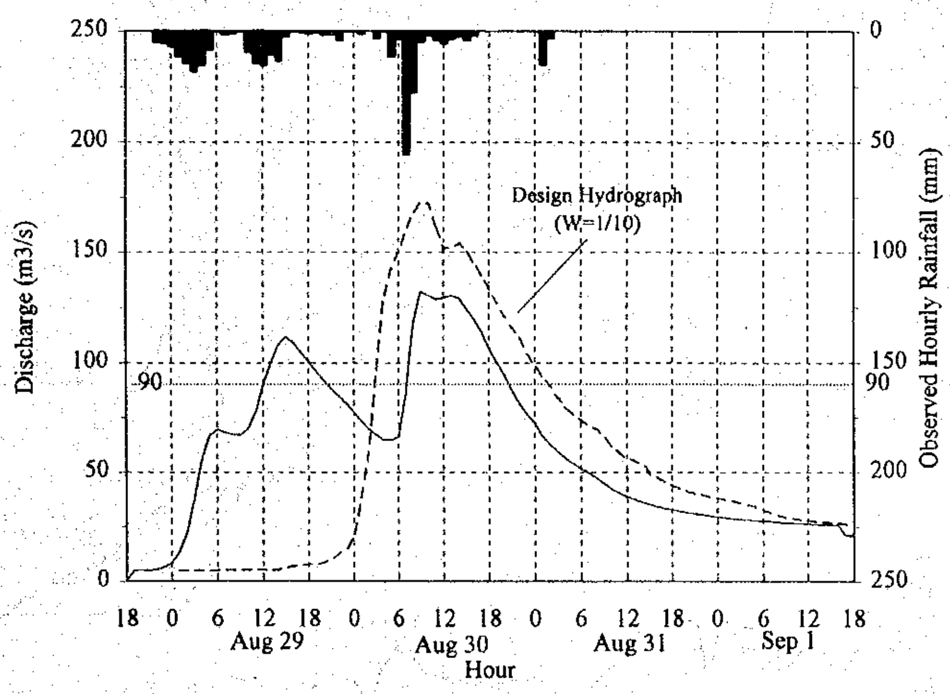


SOCIALIST REPUBLIC OF VIET NAM THE STUDY ON URBAN DRAINAGE AND WASTEWATER DISPOSAL SYSTEM IN HANOI CITY JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 2.9 DESIGN HYDROGRAPHS

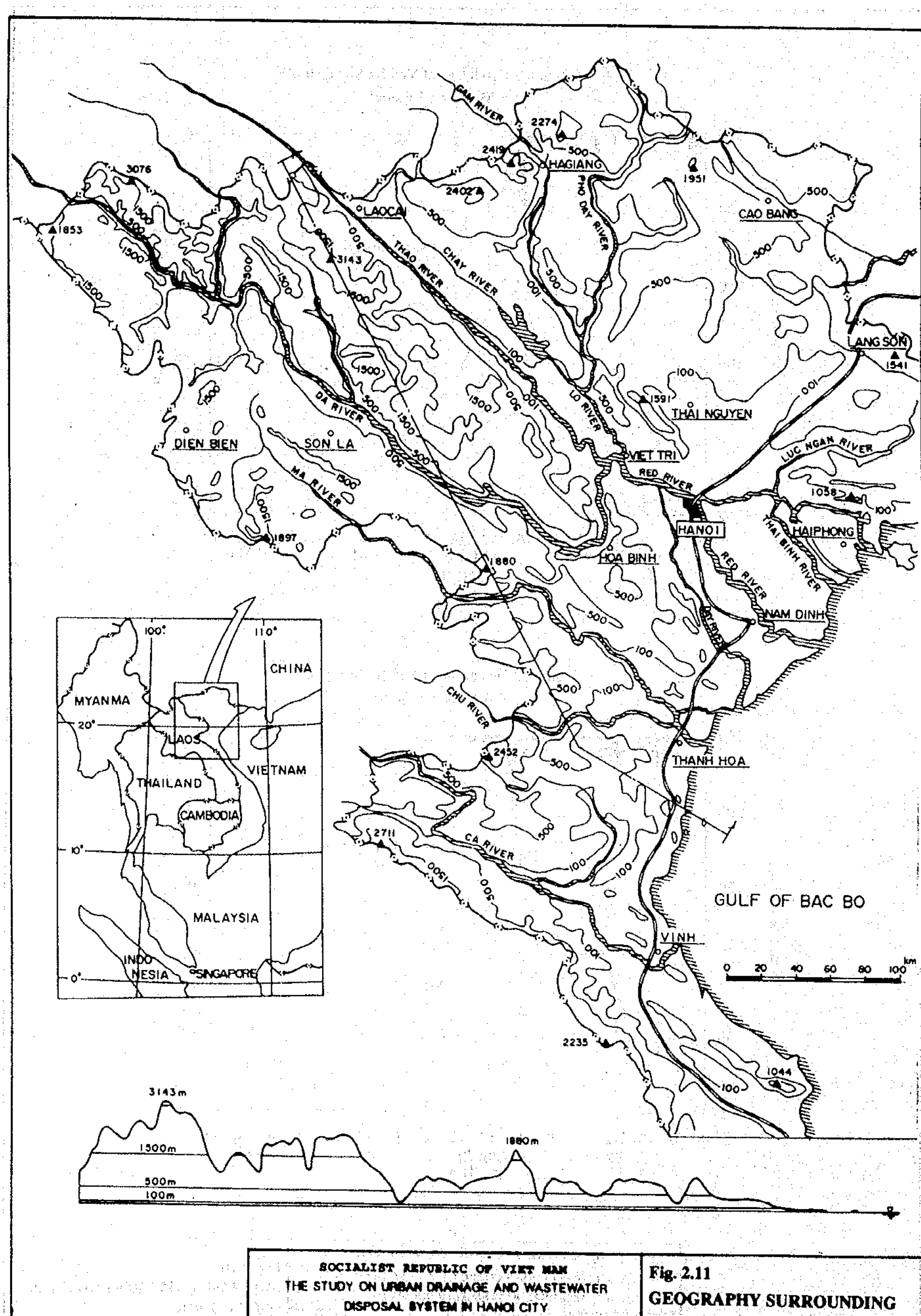
Estimated Discharge at Yen So Site (Alt.6)
May 20 '94 Flood



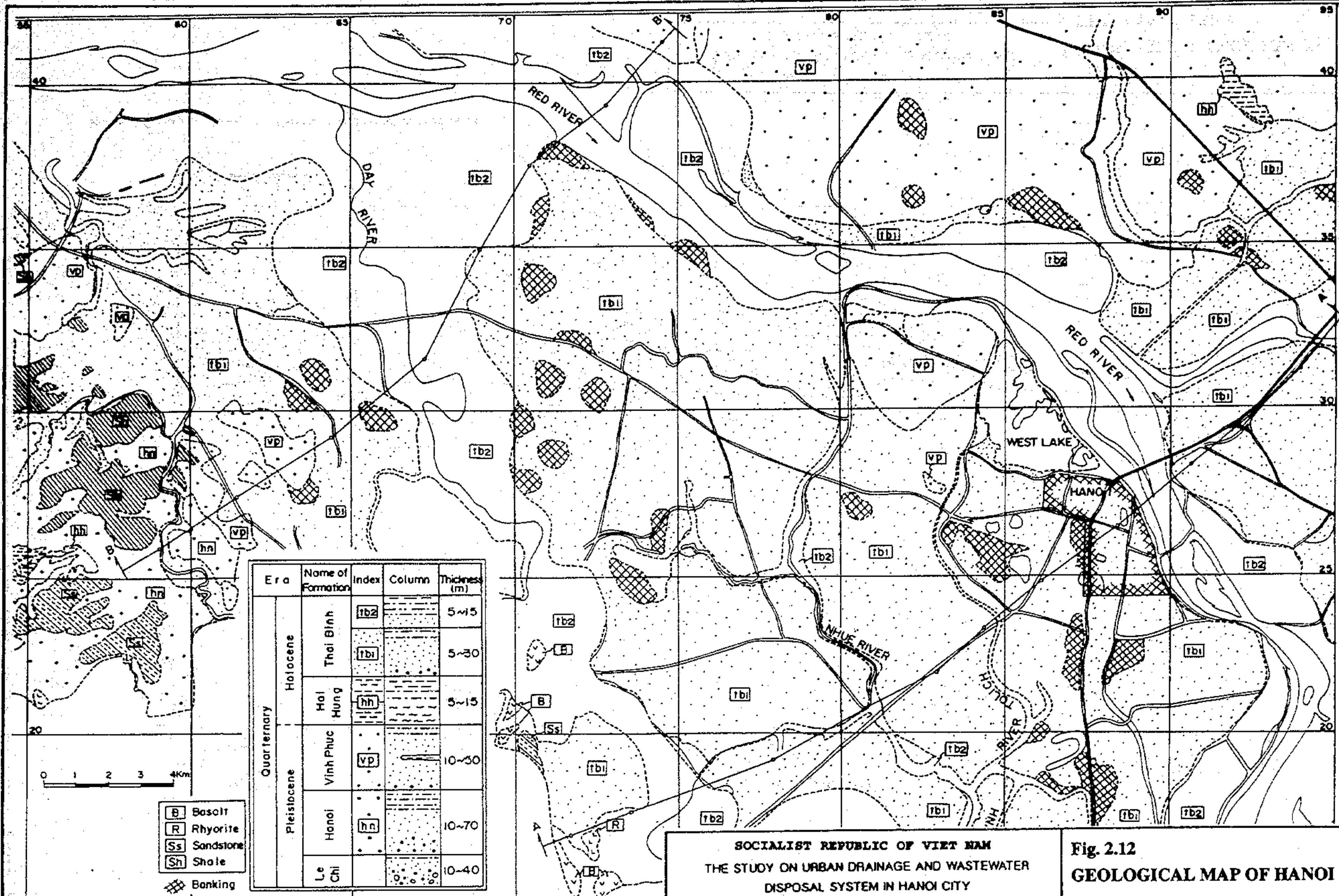
Estimated Discharge at Yen So Site (Alt.6)
Aug 29 '94 Flood



SOCIALIST REPUBLIC OF VIET NAM THE STUDY ON URBAN DRAINAGE AND WASTEWATER DISPOSAL SYSTEM IN HANOI CITY JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 2.10 ESTIMATED HYDROGRAPHS OF 1994 FLOODS



SOCIALIST REPUBLIC OF VIET NAM THE STUDY ON URBAN DRAINAGE AND WASTEWATER DISPOSAL SYSTEM IN HANOI CITY JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 2.11 GEOGRAPHY SURROUNDING HANOI

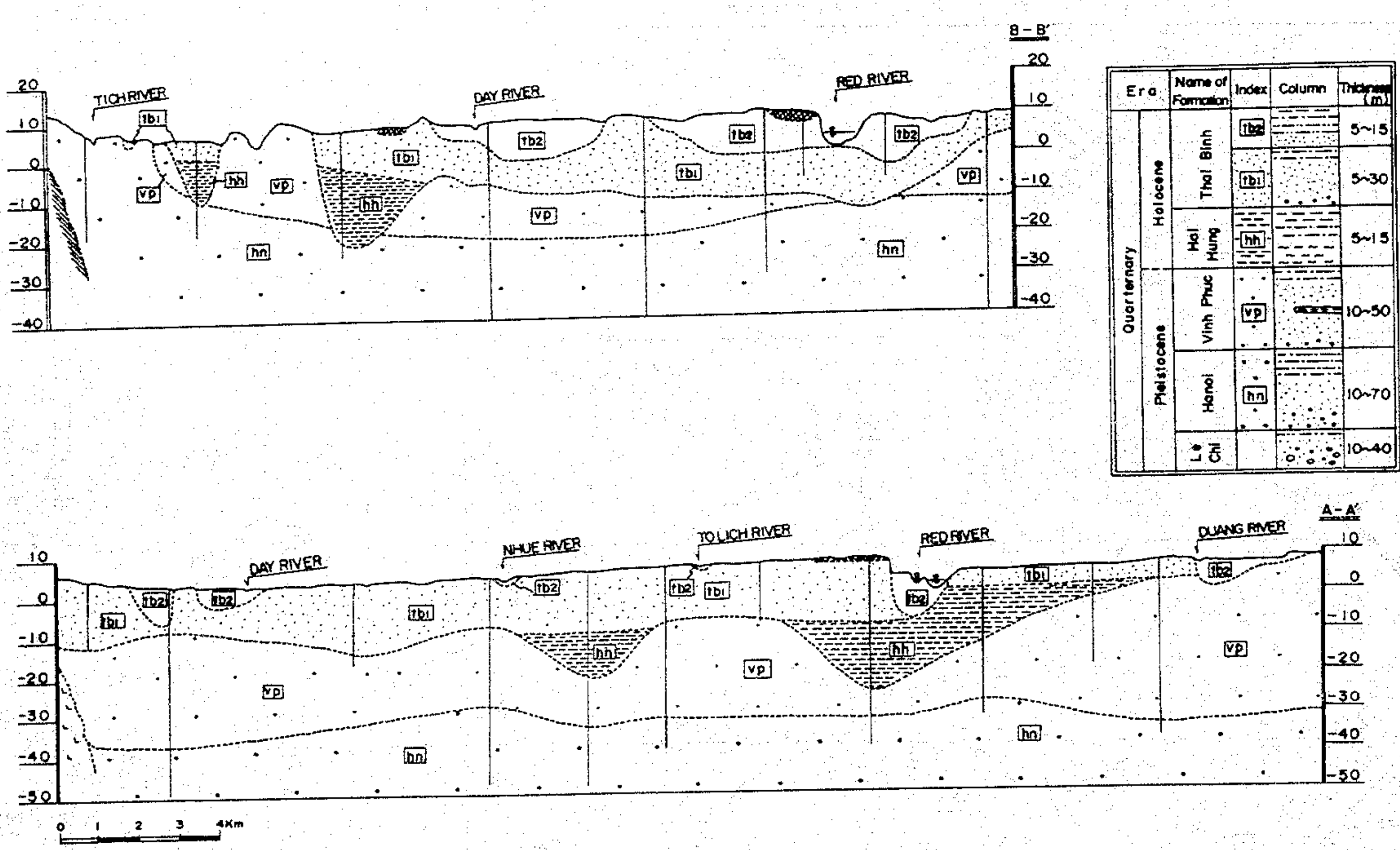


Era		Name of Formation	Index	Column	Thickness (m)
Quarternary	Holocene	Thai Binh	tb2		5~15
			tb1		5~30
		Hai Hung	hh		5~15
	Pleistocene	Vinh Phuc	vp		10~30
		Hanoi	hn		10~70
		Le Chi			10~40

Source : Geological Survey of Vietnam, Hydrogeological Division No.2

SOCIALIST REPUBLIC OF VIET NAM
THE STUDY ON URBAN DRAINAGE AND WASTEWATER DISPOSAL SYSTEM IN HANOI CITY
JAPAN INTERNATIONAL COOPERATION AGENCY

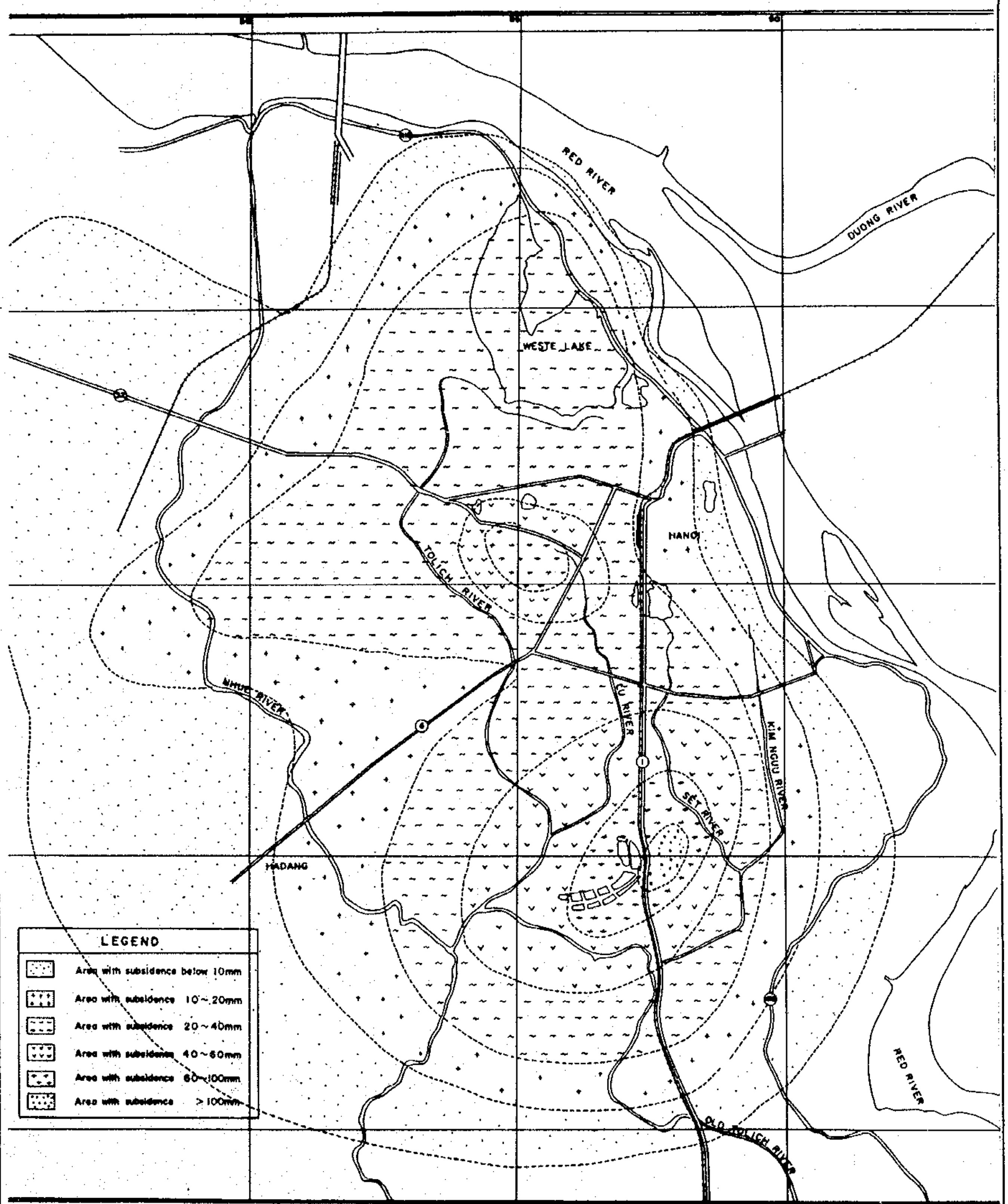
Fig. 2.12
GEOLOGICAL MAP OF HANOI



Source : Geological Survey of Vietnam, Hydrogeological Division No.2

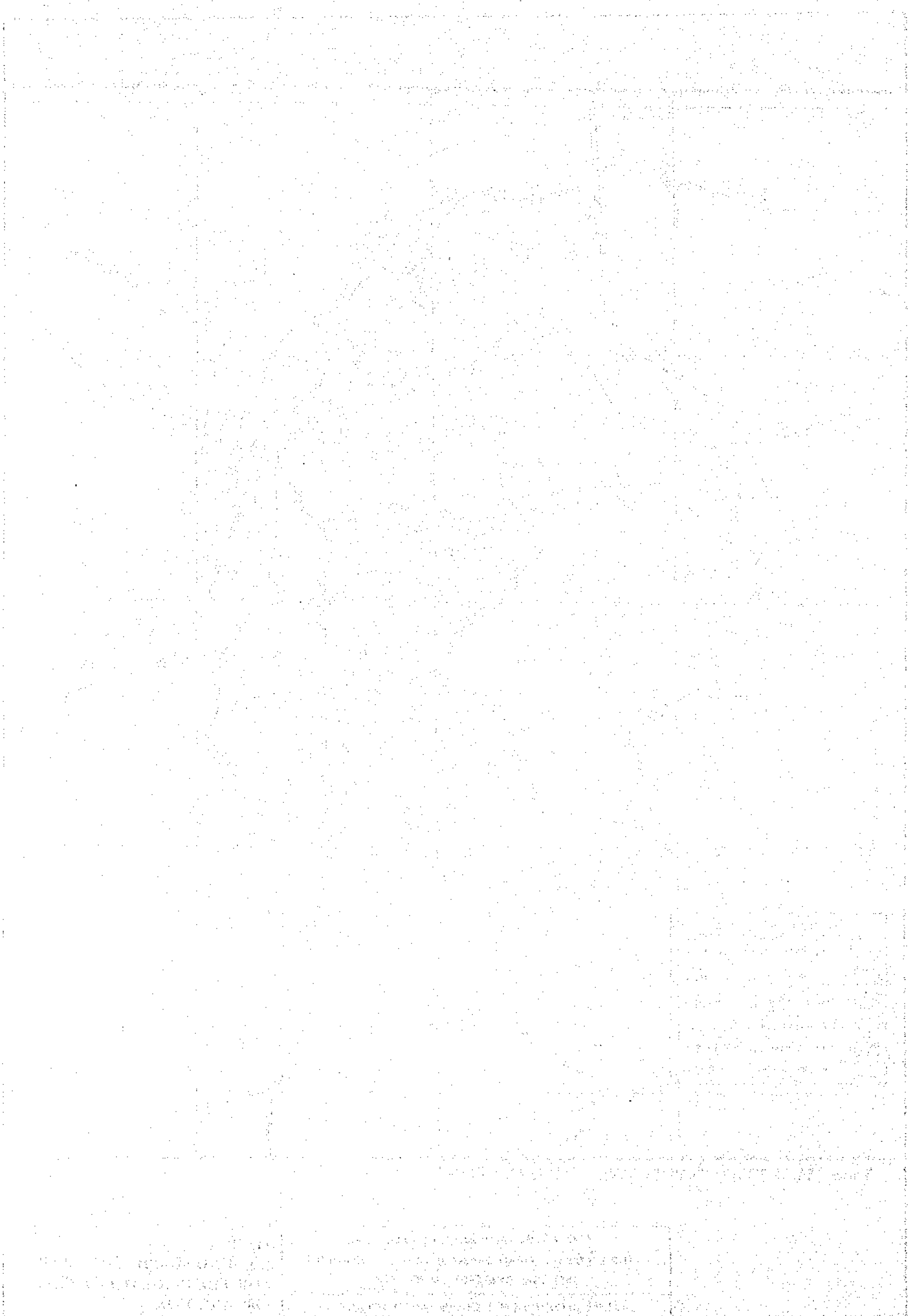
SOCIALIST REPUBLIC OF VIET NAM
THE STUDY ON URBAN DRAINAGE AND WASTEWATER DISPOSAL SYSTEM IN HANOI CITY
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 2.13
GEOLOGICAL PROFILES OF THE HANOI AREA



Souce : WATER MASTER PLAN IN HANOI CITY (1993) FINNIDA

SOCIALIST REPUBLIC OF VIET NAM THE STUDY ON URBAN DRAINAGE AND WASTEWATER DISPOSAL SYSTEM IN HANOI CITY	**Fig. 2.14** **GROUND SUBSIDENCE MAP FOR THE PERIOD BETWEEN 1988 AND 1992**
JAPAN INTERNATIONAL COOPERATION AGENCY	



3. DRAINAGE MASTER PLAN

3.1. PRESENT CONDITIONS

3.1.1 Watersheds

The Study Area (135.4 km^2) is bordered by the Red River in the north and east and the Nhue River in the west, and is situated in the eastern uppermost area of the Nhue River basin, whose catchment area is approximately 1,075 km^2. (Immediately upstream of the confluence of the To Lich River, the catchment area is approximately 188 km^2.) The Study Area is generally classified, by a series of natural levees extending along the right bank of To Lich River, into two: To Lich River basin (77.5 km^2) covering the center of Hanoi, and the basin directly discharging into the Nhue River (57.9 km^2), which still remains as a suburb of the City. (See Figure 3.1.)

3.1.2 Channel and Lake System

(1) Rivers

There are four rivers and one floodway in the To Lich River basin as shown below, while no major rivers exist in the Nhue River basin (refer to Figure 3.2):

(a) To Lich River	:	14.6 km
(b) Lu River	:	5.6 km
(c) Kim Nguu River	:	11.8 km
(d) Set River	:	5.9 km
(e) Lu floodway	:	1.0 km
Total		38.9 km

These rivers play an important role in the drainage of the To Lich River basin and also constitute water sources for agriculture and fishery. The flow sections of these rivers, even at present, are relatively large except at the places where roads cross. However, increasing garbage/rubbish dumping into rivers, and even encroachment of them by houses, may not merely jeopardize the present drainage system but also worsen the quality of the water. The present flow capacities are estimated as follows:

River	Flood Probability Corresponding to the Present Flow Capacity
To Lich River	3-yr to 5-yr
Lu River	1.2-yr
Kim Nguu River	1.6-yr
Set River	1.1-yr
Overall To Lich River System	1.2-yr

(2) Drainage Channels

Investigation of the aerophotographs, as well as topographic maps, and the field reconnaissance have identified the drainage system in the Study Area as shown in Figure 3.2, with their channel codes. The total length of the drainage channels, which are more than 5 m wide, is 143.3 km. These drainage channels have mostly small flow capacities to cope with the prospected design discharges, especially at places where roads cross since the width of channels becomes narrower. Due to the above, under the drainage plan crossing (bridges and box/pipe culverts) may have to be widened and channel beds dug.

(3) Lakes and Ponds

Even in a limited area of 1 ha, as many as 111 lakes have been identified on the aerophotographs. (See Figure 3.3) The largest is a group of fishponds at Yen So (830.4 ha), followed by West Lake (567.0 ha). The total lake area is 21.8 km^2 which accounts for about 16 % of the Study Area as observed below:

River Basin	Catchment (km^2)	Lake Area (km^2)	Share of Lakes (%)
To Lich	77.5	20.1	26
- West Lake	9.3	5.9	63
- Others	68.2	14.2	21
Nhue	57.9	1.7	3
Total	135.4	21.8	16

These lakes and ponds are important in terms of flood retardation in the Study Area, as well as for other purposes such as wastewater treatment, fishery, aqua-planting, rice growing, washing, recreation, and brick-making. However, the number and area of such lakes and ponds have been remarkably decreased, especially in recent years, by land reclamations (whether legal or not), and dumping of garbage/rubbish into them. This also results in water quality decreasing.

To clarify these conditions, a survey on the present usage and water quality of the 111 lakes and ponds was conducted. Based on the survey, the existing lakes and ponds are classified as shown in Table 3.1. Lakes 6 and 19 are being reclaimed and will be completely reclaimed by the year 2010. 86 lakes will not be reclaimed even by the year 2010. The existence of such lakes and ponds will be taken into account in the formulation of the drainage plan, especially with respect to their flood retarding effect.

3.1.3 Sewer System

Runoff from the existing urbanized area is collected by the sewers of the combined system which drain both stormwater and wastewater (see Figure 3.4). Then, the water is discharged into drainage channels and further into the four main rivers. Only in a few areas such as Kim Lien, is a separate system provided.

From a drainage viewpoint, the existing sewer system is less than the acceptable service level in terms of both service coverage (area-wise only 28% of the whole Study Area as shown in Table 3.2) and discharge capacity (not capable of draining even small storms which occur several times a year).

3.1.4 Flooding Condition

Through the interview survey carried out in this stage of the Study, three flood maps were drawn as shown in Figures 3.5 to 3.7. The details of these floods are shown below:

Flood	2-day Rainfall		Nhue River Water Level *	
	Depth (mm)	Probability	Highest Stage EL (m)	Duration above EL 5.0 m (days)
Nov. 1984	560	Less than 1/100	5.4	10
Jun. 1989	287	Approx. 1/8	5.3	5
Annual	Approx. 150	Approx. 1/1.5	—	—

* At Ha Dong weir

The 1984 and 1989 floods are well-known flood events which took place during the recent decade, and inflicted serious damage on the Hanoi area. As can be observed in Figures 3.5 and 3.6, during the floods most of the Study Area was covered with water (although the 1984 flood was much more severer than the 1989 flood). Inundation was a maximum of 1 m deep and lasted more than a week.

Shown in Table 3.3 is the estimated damage caused by the 1984 and 1989 floods to the To Lich River basin, except West Lake basin. The estimation was carried out on the assumption that the land use pattern and production activity of the area during the floods were the same as those in 1994, and by the same procedure as described in Section 3.6. The total amount of damage is estimated at about US$ 83 million and US$ 45 million for the 1984 and 1989 floods, respectively. Furthermore, it is noted that the rate of indirect damage versus direct damage is 0.35, according to the calculation results in Table 3.3.

3.2 Basic Concepts for the Formulation of Plan

3.2.1 Planning Conditions

(1) Target Year

This Drainage Master Plan, formulated on the basis of the City Master Plan, which has set targets for the year 2010, has been approved by GOV.

(2) Protection Levels

The protection levels of the Drainage Master Plan have been set at a 10-year return period (10%) for the river / drainage channel system, and at a 5-year return period (20%) for the sewer system.

3.2.2 Fundamental Planning for Flood Control and Drainage

(1) Common Items

(a) Method of Drainage

For the To Lich River basin, it is almost impossible to drain out the design flood by gravity, to the Nhue River. This is substantiated by the following facts: during the 1978, 1984 and 1989 floods the water level was over an EL.5 m, which continued for 5 to 20 days, along the Nhue River hence the design high water level has been set approximately at an EL.5.8 m in this area, while in order to prevent serious inundation in the Hanoi City area, the water level in the lower reaches of the To Lich River should be confined to under an EL. 3.5 m as previous studies stated. When the mechanical drainage method is used for the To Lich River basin, it is more economical to drain water from the Yen So site into the Red River. In addition, in order to reduce the design pump capacity for minimizing the cost, the construction of regulating reservoirs near the pumping station should be taken into account.

On the other hand, both mechanical and natural drainage methods will be examined for the Nhue River basin (comprising four sub-basins), where the ground elevations (EL. 4.5 to 9.5 m) are not so low compared to the high water level of the river (EL.5.8m more or less). Mechanical drainage, if applied, will be supported by the construction of regulating reservoirs for the same reason as above. Due to topographic limitation, water should be drained into the Nhue River.

The following table summarizes the above discussions:

River Basin	Present Land Use	Drainage Method	Direction of Drainage
To Lich	Urban	Mechanical drainage combined with regulating reservoirs	To the Red River from the Yen So site
Nhue	Suburban	Mechanical drainage combined with regulating reservoirs, or natural drainage combined with the same accompanied by land reclamation works	To the Nhue River from the outlets of respective drainage basins

(b) Allowable Discharges to Nhue River

According to a brief report on the Drainage Project for the Nhue River and Hanoi Urban Area, the basic design principles for the improvement of the Nhue River are as follows:

- Protection Level : 10-year (10%)
- Design Discharges : Calculated at a specific discharge, 0.6 $m^3/s/km^2$
- High Water Level : EL. 5.8m at Hadong weir

Natural drainage from the To Lich River basin to the Nhue River is virtually impossible for large-scale floods, but not for small-scale floods. The maximum discharge from To Lich to Nhue should, even during small-scale floods, be limited to 0.6 $m^3/s/km^2$ judging from the above basic design principles for the Nhue River. For the Nhue River basin, on the other hand, discharge must always be confined to under 0.6 $m^3/s/km^2$, whether natural or mechanical drainage methods are applied. The following table shows the determined allowable discharge and the high water levels of the Nhue River at the outlets of the relevant basins:

Basin	Catchment Area (km^2)	Allowable* Discharge (m^3/s)	HWL of the Nhue River at the Outlets EL. (m)
To Lich	77.5	45	5.7
Co Nhue	19.7	12	6.0
My Dinh	13.6	8	5.9
Me Tri	14.7	9	5.8
Ba Xa	9.9	6	5.7

* To be agreed officially by the Ministry of Water Resources in the near future.

(c) Interface between Drainage Channels and Sewers

In this Master Plan, it is assumed that sewer systems will cover the areas whose catchments are smaller than 1km^2, and drainage channels will be improved, or constructed, in order to receive all the discharge from sewer systems. (Sewers will be constructed beneath the main roads.) This criterion is based on economic considerations and takes into account the difficulty of land acquisition due to the construction of open channel in small areas. Delineated in Figure 3.11 are the drainage channels to be provided under the Master Plan. The channel density is about 1 km/1km^2, which indicates that they are evenly distributed throughout the whole Study Area.

(2) River / Drainage Channel System in To Lich River Basin

(a) Treatment of West Lake

Drainage of the To Lich River basin will be achieved primarily by the combination of pump facilities and regulating reservoirs at the Yen So site. However, it is economically essential that the floodwater flowing down to Yen So from the upper reaches be limited as much as possible. On the other hand, there are many lakes/ponds scattered throughout the basin, of which the most substantial is West Lake (5.7 km^2). In this case, when gate structures at the outlets of the lake are provided for maintaining the normal water level at EL. 6.0 m, all the floodwater from the catchment area (9.3 km^2) can be contained under the high water level of EL. 6.5 m without affecting the shore areas. (It is noteworthy that after the floods, the gates are opened and water level of the lake returns to the normal stage.) These gates will be the minimal cost and will contribute largely to the reduction of flood discharge at the Yen So site.

(b) Diversion of Upper Lu and Hoang Liet Basins

A bridge is now being constructed along National Road Route No.1 which will cross the Kim Nguu River at the 3.9 K point. The bridge may not be sufficient to pass all the floodwaters from the To Lich, Lu, and Hoang Liet basins towards the Yen

So site. To cope with this restriction, the following two diversion plans were conceived:

- Diversion of the Upper Lu River basin to the Set River in use of the existing Lu floodway to the maximum extent of the flow capacity of another bridge of National Road Route No.1 across the floodway; and

- Diversion of water from the Hoang Liet drainage basin to the Set River by expanding the existing box culvert under National Road Route No.1.

(c) Normal and High Water Levels

Under an agreement among the agencies concerned the normal water level of the To Lich River system was set at EL. 3.5 m. This water level was decided taking into account the multipurpose use of the rivers such as flood control, water supply for agricultural lands, and fishponds, etc. This agreed water level will remain valid for this Master Plan, since lowering the water level below an EL. 3.5 m will result in an excessive drawdown of the water levels of upstream channels, which is not recommended from an environmental point of view.

On the other hand, the design high water level is generally recommended not to exceed the ground elevations on both sides, in order to ensure easy drainage from the basin. Hence, the design high water levels of the To Lich River system were established starting at an EL. 3.5m (same as the normal water level) at the Yen So site, with the following longitudinal gradients:

- To Lich River : 1/7,000 (1/15,000)
- Lower Lu River : 1/8,000
- Set River : 1/3,000
- Lu Floodway and Upper Lu River : 1/4,500
- Kim Nguu River : 1/1,500

(3) Drainage Channel Systems in Nhue River Basin, High Water Levels

High water levels at the outlets of the drainage channel systems in the Nhue River basin are determined by the ground elevations when applying mechanical drainage, while the high water levels of the Nhue River when applying natural drainage are as follows:

Drainage Basin	High Water Level at Outlet, EL. (m)	
	In the Case of Mechanical Drainage	In the Case of Natural Drainage
Co Nhue	5.2	6.0
My Dinh	4.7	5.9
Me Tri	4.7	5.8
Ba Xa	4.5	5.7

Note: Longitudinal gradients of the drainage channels are commonly 1 / 5,000 in accordance with the average ground slope.

(4) Sewer System

The layout plan for the urban drainage development system is shown in Figure 3.8. The proposed development plan for the Study Area is composed of the following:

(a) Improvement of the existing pipes of the combined system by a total length of 40 km, including manholes;

(b) Installation of new pipes, with a total length of 344 km, in the northern area of the To Lich River basin (consisting of four sub-basins To Lich, Lu, Kim Nguu, and Set);

(c) Installation of new pipes, with a total length of 69 km, in the southern area of the To Lich River basin (consisting of two sub-basins Hoan Liet and Yen So);

(d) Installation works of new pipes, with a total length of 28 km, in the West Lake sub-basin ;

(e) Installation of new pipes, with a total length of 384 km, in the Nhue River basin (consisting of four sub-basins Co Nhue, My Dinh, Me Tri, and Ba Xa) ; and

(f) Installation of new street drains, with a total length of 1,051 km, along the new road network planned by UPI.

3.3 Comparison of Alternative Plans

3.3.1 Flood Control and Drainage for To Lich River Basin

(1) Alternatives Suggested

The most fundamental issue pertaining to the drainage Master Plan for the To Lich River basin is the capacity of the pumping station, flood control volume, and location and size of the regulating reservoirs at (or near) the Yen So site. An alternative study has been carried out based on the following:

(a) A regulating reservoir at the Yen So site be contained within the approved area of 203 ha (the net lake area is assumed to be 130 ha, approximately 65% of the lot area) because:

- The area and location of the Yen So reservoir have been fixed in the Hanoi City Master Plan already approved by the Government. Therefore, land acquisition outside the area must cause difficulties; and

- The land use potential around the Yen So site is quite high taking into account the City's expansion towards the south, hence the reservoir should be as small as possible.

(b) If the area is unable to fulfill the hydrological requirements, the use of the Linh Dam and Dinh Cong lakes will be examined, instead of expanding the Yen So reservoir area.

(c) Lake dredging for maintaining the normal water level at EL. 3.5 m for flood control purposes, will be studied at 18 major lakes in the City area.

Taking the above into account the following six alternatives were suggested:

Alternative	18 Major Lakes in the City Area	Use of Linh Dam Lake (103 ha)		Use of Dinh Cong Lake (25 ha)	
		Channel to Yen So	Lake	Channel to Linh Dam	Lake
1	As they are	—	As they are	—	As they are
2	To be dredged	—	- do -	—	- do -
3	- do -	To be provided	- do -	—	- do -
4	- do -	- do -	To be dredged	—	- do -
5	- do -	- do -	As they are	To be provided	- do -
6	- do -	- do -	To be dredged	- do -	To be dredged

(2) Study and Conclusion

The cost of each alternative including operation and maintenance for the Yen So pumping station, was estimated based on e pumping capacity. Then, pump capacity vs. cost curves were delineated as shown in Figure 3.9. From the figure, it is observed that Alternative 6 with a pump capacity of 90 m^3/s is the most economical. Therefore, it is recommended that this alternative be used in the Drainage Master Plan for the To Lich River basin.

3.3.2 Flood Control and Drainage for Nhue River Basin

(1) Alternatives Suggested

The total lake / pond area of the Nhue River basin accounts for only 3% of its catchment area (compared to 21% in the To Lich River basin, except the West Lake basin). In this case, even if dredging is conducted in the lakes and ponds, the retardation effect will not increase very much. Hence, no alternative study concerning the dredging of lakes/ponds will be carried out for this basin. Moreover, allowable discharge to the Nhue River has been presented in its design standard. Thus, no study is required to determine the optimal combination of pump capacities and regulating reservoir dimensions.

On the other hand, the possibility of natural drainage should be examined for this basin, together with mechanical drainage. The natural drainage method entails reclamation, construction of regulating reservoirs, and drainage channel improvement; while the mechanical drainage method entails provision of pumping stations, and the same as the last two (which require the same dimensions and costs, respectively). Further, the mechanical drainage method may necessitate the construction of the left levee of the Nhue River to prevent the Nhue floodwaters from intruding the study area. However, this will be reviewed in the feasibility study for the Nhue River basin drainage project suggesting several alternatives.

(2) **Studies and Conclusions**

Capacities, dimensions, and costs of the necessary structures for the two alternatives, a pump scheme and a reclamation scheme, are tabulated below:

Alternative	Item	Drainage Basin				Total
		Co Nhue	My Dinh	Me Tri	Ba Xa	
1. Pump Scheme	Pump capacity (m^3/s)	12	8	9	6	35
	Cost ($ mil)	9.4	6.7	7.3	5.2	28.6
2. Reclamation Scheme	Area to be Reclaimed (ha)	1,150	680	770	540	3,140
	Cost ($ mil)	66.3	62.4	92.5	59.6	280.8
Common Structure	Regulating Reservoir ($1,000m^3$)	3,020 (76 ha)	1,590 (40 ha)	1,600 (40 ha)	1,070 (27 ha)	7,280 (183 ha)
	Drainage Channel (km)	19.2	13.4	13.5	8.7	54.8

From the above table, it is observed that the reclamation scheme is about 10 times more expensive than the pump scheme. Further more, reclamation works on the presently urbanized areas may cause problems for society, industries, and residents. Therefore, the pump scheme is recommended to be applied for the Nhue River basin.

3.3.3 River/Lake Conservation Plan

(1) West Lake

West Lake, which is the largest water body in the study area (its lake surface is approximately 5.7 km^2), has the most potential in terms of water environment improvement. Presently, the lake is widely used as one of the most popular recreational spots in the city of Hanoi. Hence, several projects can be expected to enhance the water environment, e.g., lake shore road/park project, and lake sediment dredging project. However, taking into account the following points, a comprehensive environmental study should be done prior to the commencement of these projects:

(a) Dredging work may create a long term effect on tourism, recreation, and fishing, (on account of its large water area), and may threaten the existence of a special species of turtle living on the lake;

(b) The water quality is rather good in comparison to the city area lakes, so direct introduction of diluting water from other sources, e.g., Red River, may reduce the water quality, particularly the turbidity, of the lake;

(c) Presently, the greater part of the perimeter is paved with shoreline roads that contribute to the prevention of house encroachment on the lake ; and

(d) there are several parks, amenity zones, and recreational facilities surrounding the lake, which may not require further development as yet.

(2) Other Lakes and Rivers

(a) Water Quality Betterment

A fundamental solution to the worsening water quality of rivers and lakes in the To Lich River basin, can be achieved by preventing the wastewater inflow from the sources. This could be done by constructing treatment plants and collecting systems. However, construction would be very expensive and quite long term. Hence, to temporarily improve water quality in the basin, at a crucial stage due to heavy urbanization, by the time of completion of the wastewater treatment systems, the introduction of flushing water is examined hereunder.

The source of the flushing water is presumed to be the Red River which is near to the To Lich River basin and has a large enough flow rate ($3.5\ m^3/s$ corresponding to the estimated wastewater discharge in the year 2010). Three alternative routes are studied as shown in Figure 3.10. Cost comparison among the three routes concluded that Alternative 1 is the most effective and economical route. However, even this will require about $10 million (direct cost only, 1994 price) for the pipeline, a settling basin to remove turbidity, pump facilities, and control gates/valves to regulate the outflow to the rivers. Besides, about $50 thousand is necessary for annual operation. Moreover, the introduction of flushing water will only reduce BOD to half of the 96 ppm estimated in the year 2010. This level of water quality is still under the allowable standard for a better future environment. In conclusion, the Master Plan does not include flushing water introduction, although there is a possibility of applying Alternative 1 if the construction of the wastewater treatment systems is delayed far beyond the year 2010.

(b) Improvement of the Waterfront Environment

This item describes the study results on the improvement of the waterfront environment, and includes preventive measures against house encroachment, along and around the rivers and lakes in the study area. The countermeasures suggested are as follows:

- Construction of riveline and lakeshore roads;
- Construction of environmental revetments;
- Planting trees; and
- Provision for parks and promenades.

3.4 Proposed Master Plan

3.4.1 Structural Measures

<u>To Lich River Basin</u> (See Figure 3.11)

(1) Yen So Pumping Station

(a) Pumping Station

- Pump Capacity : 90 m^3/s
- Design Pump Head : 10 m

(b) Outlet Sluiceway : 60 m^2 of steel roller gates

(c) Inlet Structure : 200 m wide

(d) Inlet/Outlet Channels : 1,200 m and 1,600 m

(e) Ordinary Drainage Channel : 1,900 m

(2) Yen So Regulating Reservoir

(a) Regulating Water Volume : 3,870,000 m^3

(b) Bottom Elevation : EL 0.5 m

(c) Normal Water Level : EL 1.5 m (1.0 m water depth for the use of fish farming, recreation, etc.)

(d) High Water Level : EL 4.5 m (3.0 m water depth for the flood control)

(e) Net Reservoir Area : 130 ha

(f) Total Lot Area : 203 ha (73 ha for park and housing areas)

(g) Spillway : 3 places (165 m in total with automatic deflating rubber gates)

(h) Yen So Channel : 3,400 m (to shift the Kim Nguu River along the western perimeter of Yen So regulating reservoir)

(3) Linh Dam and Dinh Cong Lakes

	Linh Dam	Dinh Cong
(a) Flood Control Volume	1,070,000 m^3	250,000 m^3
(b) High Water Level	EL. 4.5 m	EL. 4.5 m
(c) Low Water Level	EL. 3.5 m	EL. 3.5 m
(d) Lake Area	107 ha	25 ha

Note : Associated with Linh Dam and Dinh Cong channels with lengths of 1.0 km and 0.4 km, respectively.

(4) River Improvement

(a) Lower Kim Nguu, To Lich and Lower Lu Rivers and Thank Liet Channel	:	22,100 m with 4 floodgates, 6 bridges and 11 box culverts
(b) Set and Upper Lu Rivers, and Lu-Set Floodway	:	7,500 m with 8 bridges and one box culvert
(c) Upper Kim Nguu River	:	3,400 m with 3 bridges
(d) West Lak Basin	:	2 control gates at the outlets of West Lake
Total		33,000 m with 6 gates, 17 bridges and 12 box culverts

(5) Drainage Channel Improvement

(a) To Lich and Lower Lu River Basins, and Hoang Liet Drainage Basin	:	16,400 m with 1 floodgate, 16 bridges and 24 box culverts
(b) Set and Upper Lu River Basins	:	3,700 m with 1 bridge and 14 box culverts
(c) Kim Nguu River Basin	:	10,700 m with 21 box culverts
Total		30,800 m with 1 floodgate, 17 bridges and 64 box culverts

(6) Lake Dredging : 18 lakes

(7) Lake Conservation Works : 11 lakes (other than Item (6) above)

(8) Sewer Construction (Refer to Figure 3.8)

(a) West Lake Basin	:	480 ha
(b) To Lich River Basin	:	2,000 ha
(c) Lu River Basin	:	1,020 ha
(d) Kim Nguu River Basin	:	1,280 ha
(e) Set River Basin	:	710 ha
(f) Hoang Liet Drainage Basin	:	460 ha
(g) Yen So Drainage Basin	:	250 ha
Total		6,200 ha

Nhue River Basin (See Figure 3.11)

(1) Pumping Stations

(a) Co Nhue Drainage Basin	:	12 m^3/s
(b) My Dinh Drainage Basin	:	8 m^3/s
(c) Me Tri Drainage Basin	:	9 m^3/s
(d) Ba Xa Drainage Basin	:	6 m^3/s
Total		35 m^3/s

Note: Each with an outlet sluiceway for outflow from the pumping station and a floodgate for natural drainage.

(2) Regulating Reservoirs

Drainage Basin	Co Nhue	My Dinh	Me Tri	Ba Xa	Total
(a) Regulating Water Volume (1,000 m^3)	3,020	1,590	1,600	1,070	7,280
(b) Net Reservoir Area (ha)	76	40	40	27	183
(c) Total Lot Area (ha)	84	44	44	30	202
(d) Spillway (m)	55	26	31	14	126

Note: 1) Normal water depth 1.0^m
2) Flood control depth 4.0^m
3) Area other than the net reservoir area will be used as a park.

(3) Drainage Channel Improvement

(a) Co Nhue Drainage Basin	:	19,200^{m} with re-construction of 30 bridges/culverts
(b) My Dinh Drainage Basin	:	13,400^{m} with re-construction of 24 bridges/culverts
(c) Me Tri Drainage Basin	:	13,500^{m} with re-construction of 22 bridges/culverts
(d) Ba Xa Drainage Basin	:	8,700^{m} with re-construction of 16 bridges/ culverts
Total		54,800^{m} with re-construction of 92 bridges/culverts

(4) Sewer Construction (Refer to Figure 3.8)

(a) Co Nhue Drainage Basin	:	1,970 ha
(b) My Dinh Drainage Basin	:	670 ha
(c) Me Tri Drainage Basin	:	870 ha
(d) Ba Xa Drainage Basin	:	440 ha
Total		3,950 ha

3.4.2 Non-structural Measures

(1) Land Use Control

Land use control as a non-structural flood mitigation measure, generally comprises two aspects, zoning control, and building and development control. For the study area, zoning control will require modification of the city development plan prepared by HPC in regard to flood control and drainage. The application of this idea would be of a limited extent, because;

- The city development plan was established after careful examination on all aspects not only flood control; and

- Urbanization of the city toward the south and west (serious inundation areas) suggested in the city plan is inevitable after taking into account the rapid rate of expansion and the limitation of land.

Alternatively, building and development control can be applied to the study area considering the following measures:

(a) Control of Reclamation Height;
(b) Provision of Access Roads;
(c) Flood Proofing of Buildings;
(d) Conservation of Rivers and Lakes; and

(e) Preservation of Paddy Fields and Fishponds.

(2) On-site Storage

On-site storage refers to measures used to regulate the outflow from the catchment to rivers or channels; it compensates for the decrease in flood retardation of the original land due to urbanization. This is mainly composed of the following:

(a) Retention Measures

- Permeable pavements;
- Infiltration trenches and catch basins;
- Infiltration wells; and
- Infiltration gutters.

(b) Detention Measures

- Storage ponds for the development area;
- Ponding in an athletic field or parking lot; and
- Roof storage and rainwater tanks at individual houses.

The provision of storage ponds in newly developed areas is relevant, and concerned agencies should encourage the developers to construct (a) storage pond(s) when they are intending to develop new housing areas.

(3) Flood Forecasting and Warning

Due to the rather complex network of flood control and drainage facilities close coordination will be required, particularly between the Yen So pumping station and the Thanh Liet floodgate. Therefore, the following stations should be linked with a telemetering system, which is included in the project cost:

(a) HSDC / MOWR Headquarters;
(b) Yen So pumping station;
(c) Thanh Liet floodgate;
(d) West Lake control gates (A) and (B);
(e) Co Nhue pumping station;
(f) My Dinh pumping station;
(g) Me Tri pumping station; and
(h) Ba Xa pumping station.

(4) Public Information and Education

Public information and education with respect to flood control and drainage may comprise of the following items:

(a) Preparation of a flood risk map, showing the expected inundation depths for a certain flood magnitude. The inundation maps of the 1984 and 1989 floods delineated in this study might be helpful;

(b) Establishment of flood warning boards showing the maximum water levels in past major floods; and

(c) A campaign to promote awareness among the people on the importance of the flood control and drainage projects.

3.5 URGENT PROJECTS

3.5.1 Selection of Urgent Projects

By, (a) reviewing the need and problems identified in the previous studies and (b) the Study Team's own on field observation, the Study has concluded that reinforcement of the HSDC's sewer/channel maintenance capacity would have top priority in the drainage/sewerage sector. The proposed reinforcement will be in the form of supplying equipment required for increasing sewer cleaning and channel dredging capabilities.

The main reasons are as follows:

(1) Most the majority of prior studies have emphasized the urgent need of clearing the sediment and sludge accumulated in the sewers and channels. They have also commented on the lack of HSDC's maintenance capacity.

(2) A preliminary survey carried out under this study revealed that sediment deposits in sewers totals 26,000 m^3, or 32 % of the sewer inner space. Therefore, the discharge capacity of the sewer can be increased by 32 % if the sediment is cleared. At present, constant flooding occurs in all urban areas.

(3) The Study Team observed the present condition of the urban drainage channels in the upper reaches, as heavily deteriorated from the deposition of sludge and sewage fungi, decreasing the discharge capacity and causing unpleasant odors. This condition needs to be immediately improved.

(4) According to the results of the socio-economic survey carried out, all households interviewed had complaints on the existing drainage conditions and recognized the urgent need to improve drainage and sewerage. Major reasons for the improvement are:

(a) eradication of odors;
(b) eradication of mosquitoes and germs; and
(c) conservation of safe drinking water (fear of groundwater contamination).

The Study Team also observed people carrying out dredging by themselves, suggesting their strong desire for an improved hygienic water environment.

(5) According to the same survey, the majority of households interviewed have suffered from frequent flooding, (50 %: more than 5 times/year, 71 %: 2 - 5 times, 82 %: more than once). The major source of the flooding from the inadequate functioning of drainage facilities for inland water. This suggests the people's need for well-maintained sewer/channel facilities.

Alternative projects were noted, but were ruled out in view of a less urgent need and/or constraints involved. A preliminary comparison among the projects is shown in Table 3.4.

The proposed project area (area of equipment use) is shown in Figure 3.12.

3.5.2 Plan Formulation of Urgent Project

(1) Selection of Equipment Type

Taking into account the site conditions in the proposed work areas (sewers and channels), use of the following equipment is planned and examined:

Work Area	Type of Equipment	Objective Section
Sewer	S-1: Water jet cleaner	Sewers of less than 0.8 m in diameter
	S-2: High vacuum truck, with manpower at dredging front	Sewers of 0.9-1.2 m in diameter
	S-3: Winch-operated bucket with manpower	Sewers of large diameter
Channel	D-1: Grab-bucket excavator working from the bank	Channel section where bank access is available
	D-2: Grab-bucket excavator mounted on working barge	Channels having a width of more than 5 m
	D-3: High vacuum truck, with manpower at dredging site	Relatively narrow channels with width of less than 5 m
	D-4: Excavation by manpower, with use of small barge	Narrow channels where access by equipment is difficult

Table 3.5 describes further details of the work method for each of the above.

(2) Work Volume

The initial dredging work will remove the present deposition of sediment and sludge in the sewers and channels. The work volume is estimated as follows:

Sewer Diameter / Channel Width	Length (Km)	Sediment Volume (1,000 m3)	Type of Equipment Use
Sewer:			
- Less than 0.8 m dia.	91.9	13.0	S-1
- 0.9 - 1.2 m dia	18.1	5.3	S-2
- Larger than 1.3 m dia.	10.0	7.6	S-3
Total	120.0	25.9	---
Drainage Channel:			
- Less than 3 m width	10.6	17.7	D-4
- 3.1 - 4.9 m width	8.4	24.5	D-3/D-4
- 5.0 - 8.9 m width	9.6	33.6	D-2/D-3
- More than 9.0 m width	2.7	14.7	D-2/D-1
Total	31.3	89.5	---

Total work volume is about 25,900 m^3 in sewers, 32 % of the total sewer inner volume, and 89,500 m^3 in drainage channels, or 24 % of the channel spatial volume.

(3) Required Equipment Numbers

Based on the work volume and conditions above, the required equipment numbers is summarized in Table 3.6.

(4) Proposed Scope of Urgent Project

(a) Scope of the Project

The proposed urgent project will consist of the following three (3) components:

- Supply of equipment including technical guidance services:

- Consultation services relevant to the above, covering detailed design, procurement services and overall planning / supervision of field works

- Provision of a long-term, (2 years), expatriate expert to oversee the transfer of technology relevant to the operation and maintenance of the sewerage facilities.

A tentative implementation schedule of the proposed urgent project is shown in Figure 3.13. The schedule expects the supplier's guidance service to be provided in 3 successive stages. 6 months for the initial training of workers and secondary, supplemental guidances for; the rainy season (3 months) and the dry season (2 months), where working conditions differ markedly.

(b) Undertaking by the Implementing Agency

Associated with the implementation of the project, the Implementing Agency (HSDC) will be required to undertake the following:

- Provision of a motor pool and repair shop for accommodation and operation of the equipment

- Provision of spoil banks

- Provision of a counterpart budget to include employment of technicians and labor (estimated to be around 7.3 billion Dong annually)

- Other supporting procedures including the importing of equipment.

3.5.3 Effects and Benefits of the Urgent Projects

The scope of the proposed Urgent Project is to supply equipment, which does not directly produce benefits.

With the supplied equipment, HSDC will carry out cleaning of the existing sewers and dredging of the existing urban channels. The main objective of the work is to restore the function of the existing facilities. Since the existing sewers and channels are not capable of dealing with small storms of less than one-year frequency, the work alone cannot completely solve all urban flood issues. Nevertheless, the work will certainly contribute to reducing the frequency of flooding which occurs several times a year.

Effects and benefits accrued from the urgent project can be described as;

(1) Sewer cleaning

Increase sewer drainage capacity by removing sludge and sediment (present deposition rate : approx. 32 % of inner sectional area) = 32 % increase in discharge capacity

⇩

Decrease in urban area inundation frequency

⇩

Improvement of sanitary conditions in urban area (through the prevention of overflow from septic tanks/cesspools, and spill-out of sewer sludge, discharge of solid wastes, etc.)

(2) Channel dredging

Increase existing drainage channel capacity by removing sediments (present accumulation rate : 2 - 60 % of sectional area, average 24 %) = 24 % increase in discharge capacity

and

Improvement of channel water-front environment (removal of odors and elimination of stagnated water)

The proposed urgent project is an advanced component of the proposed Hanoi City Drainage Project (see Section 5.5). Therefore, EIRR of the Urgent Project is 11.6 % of the EIRR evaluated for the whole project.

3.6 Flood Damage and Expected Benefits

In this study, direct damage to properties including houses, household goods, shops, merchandise, public/government buildings and factories, and to the production of farm and fishery products are estimated by studying the damage potential and flood frequency, and by applying the damage ratio (refer to Table 3.7). Further, indirect damage (35 % of the direct damage) is also taken into account. This includes damage to transportation, communication, loss of income for factory owners, shop owners and employees, etc.

Based on the results of the inundation analysis and the relationship between the inundation water level and flood damage including indirect damage, flood damage for a different return period was calculated under without-project and with-project conditions (Table 3.8). The annual average flood damage was then estimated by applying the average occurrence probability to the corresponding flood damage. The expected benefit was calculated as the difference between damages without-project and that of with-project conditions (Table 3.9).

(US$ 1,000)

River Basin	Annual Average Flood Damage		Expected Benefit
	Without-project	with-project	
To Lich	12,836	273	12,563
Nhue	2,787	99	2,688

Table 3.1 CLASSIFICATION OF EXISTING LAKES AND PONDS

Classi-fication	Present Lake Use Condition					Numbers of Lakes				
	Drainage (Waste-water)	Fishery	Recre-ation	Rice Growing	Brick-making	To Lich River Basin			Nhue River Basin	Total
						West Lake Basin	Other Basins	Total		
A	X	X	X			2	11	13	0	13
B	X	X				0	24	24	7	31
C	X		X			0	1	1	2	3
D	X			X		0	5	5	0	5
E	X					0	4	4	0	4
F		X				0	4	4	22	26
G					X	0	0	0	4	4
(Sub-total)						(2)	(49)	(51)	(35)	(86)
H	To be reclaimed by year 2010					0	14	14	5	19
I	Already reclaimed up to date					0	6	6	0	6
Total	-					2	69	71	40	111

Table 3.2 SERVICE COVERAGE

NAME OF DISTRICT	AREA (ha)	POPULATION (persons)	POPULATION DENSITY(p/ha)	LENGTH OF SEWER (m)	LENGTH OF OPEN CHANNEL (m)	COVERAGE PER CAPITA(m/p)	COVERAGE PER AREA(m/ha)	LENGTH OF ROAD (m)	COVERAGE PER AREA (m/ha)
BA DINH	1,095.7	188,437	172.0	24,191	9,140	0.18	30.4	54,860	50.1
HOAN KIEM	351.0	147,266	419.6	39,403		0.27	112.3	58,220	165.9
HAI BA TRUNG	1,035.0	286,212	276.5	34,838	10,650	0.16	43.9	44,280	42.8
DONG DA	1,484.6	334,356	225.2	21,575	12,710	0.10	23.1	29,530	19.9
SUB TOTAL	3,966.3	956,271	241.1	120,007	32,500	0.16	38.5	186,890	47.1
TU LIEM	5,523.5	172,355	31.2					65000	11.8
THAN TRI	3,719.5	84,632	22.8					40000	10.8
HA TAY	322.0	5,400	16.8					5600	17.4
TOTAL	13,531.3	1,218,658	90.1	120,007	32,500	0.13	11.3	297,490	22.0

Table 3.3 ESTIMATED DAMAGE CAUSED BY THE 1984 AND 1989 FLOODS

(To Lich River Basin except West Lake Basin)

Category of Damage	Basin	Sub-Basin	Lowest Ground Elevation (m)	1984 Flood Actual Inundation Water Level EL. (m)	1984 Flood Damage ($1000)	1989 Flood Actual Inundation Water Level EL. (m)	1989 Flood Damage ($1000)
Direct Damage	To Lich River Basin	T1	7.4	7.7	240	7.6 (7.8)*1	120
		T2	5.9	6.7	2,520	6.5 (6.4)	1,365
		T3	5.8	6.4	2,100	6.1 (6.1)	598
		T4	5.8	6.5	1,540	6.1 (6.1)	559
		T5	5.8	6.6	4,130	6.3 (6.1)	2,340
		T6	5.9	6.8	5,600	6.4 (6.1)	2,990
		T7	5.8	6.6	2,450	6.2 (6.0)	1,183
		T8	4.0	6.1	1,040	5.9 (5.5)	637
		T9	4.0	5.8	180	5.6 (5.5)	117
	Lu River Basin	L1	5.9	6.6	2,800	6.4 (6.1)	1,640
		L2	5.7	6.3	3,360	6.2 (6.1)	2,535
		L3	5.7	6.3	1,880	6.0 (5.8)	858
		L4	5.7	6.2	1,330	6.1 (6.0)	858
		L5	4.9	6.0	1,150	5.6 (5.5)	546
		L6	4.0	6.0	1,020	5.6 (5.5)	468
	Kim Nguu River Basin	K1	6.4	7.2	990	7.0 (7.4)	440
		K2	5.4	6.1	1,680	5.9 (5.8)	936
		K3	5.6	6.3	2,550	6.1 (6.0)	1,508
		K4	4.6	6.0	2,490	5.6 (5.5)	1,339
		K5	4.7	6.0	3,990	5.6 (5.5)	2,470
		K6	4.6	5.8	1,920	5.5 (5.5)	1,131
	Set River Basin	S1	5.9	6.7	1,650	6.4 (6.3)	610
		S2	5.3	6.2	2,380	6.0 (5.8)	1,300
		S3	4.6	5.8	3,680	5.4 (5.5)	2,080
		S4	4.0	5.8	1,710	5.4 (5.5)	884
	Hoang Liet Drainage Basin	H1	4.0	5.8	2,160	5.4 (5.5)	1,261
		H2	4.0	5.7	3,010	5.4 (5.5)	2,262
	Yen So Drainage Basin	Y	4.0	5.7	1,010	5.5 (5.5)	832
	Total($1000)			-	60,560	-	33,867
Indirect Damage ($1000)*2					22,479		11,239
Total Damage ($1000)					83039		45106
Rate of Indirect Damage vs. Direct Damage					0.37		0.33
					0.35 (on average)		

*1 Simulated Inundation Water Level
*2 G x P x A x D/365
where G : GDP per Capita in Hanoi ($565/head/year)
P : Population Dencity (241 head/ha)
A : Productive Area excluding Fishponds & Agricultural Land (4,304 ha)
D : Duration of Interruption for Production Activity due to Inundation (14 days in 1984 Flood and 7 days in 1989 Flood)

Table 3.4 ALTERNATIVE PLANS OF THE URGENT PROJECTS

Project	Effect / Benefit	Beneficiaries		Implemen-tation Period	Approx. Cost	Constraints
		Area	Population			
1. Supply of Equipment for Sewer Cleaning / Channel Dredging	- Increase of discharge capacity of sewers and channels, thus alleviating urban flood - Removal of sewage funguses, thus mitigating odors	30 km^2	800,000	2 years (supply of equipment & guidance services)	US$ 10 mil. (depending on number of equipment procured)	- Need of on-the-job training for equipment operation and repair - No other particular constraints
2. Kim Lien Sewerage Rehabilitation Project	- Improvement of drainage / sewerage condition in Kim Lien area	26 ha	25,000	2 years	US$ 5 - 6 mil	- Difficulty in constructing the wastewater treatment in view of limited land available in densely populated area. - Number of beneficiaries is small
3. Rehabilitation of Sewers in Ancient City Area	- Improvement of drainage / sewerage condition in the most populated and cultural area	4 km^2	160,000	3 - 4 years	US$ 8 mil	- Urgency is less, compared with 1. above - Needs a feasibility study and detailed design
4. Dredging of City Lakes (16 lakes)	- Increase of stormwater retardation capacity	140 ha (lake area)	(Not estimated)	2 - 3 years	US$ 6 mil	-Urgency is less, compared with 1. above - Needs a detailed environmental assessment
5. Construction of Roads along the Urban Drainage Channels	- Prevention of illegal encroachment by people - Improvement of hygienic condition along the channels	25 km (channel length)	(Not estimated)	5 - 6 years (due to resettlement issue)	Varying by road length to be improved	- Involves housing resettlement issue, presumably over 4,000 - Better to be implemented in conjunction with channel improvement
6. Conservation of Lakes, including Aeration for Selected Lakes	- Improvement of water quality and lake environments	140 ha (lake area)	(Not estimated)	1 - 2 years (Aeration facilities)	US$ 2 -3 mil (Aeration facilities)	- Urgency is less, compared with 1. above - Aeration to be in conjunction with 4. above - Other conservation measures will need a longer period

Table 3.5 (1) CLEANING AND DREDGING METHODS AND EQUIPMENT REQUIRED (1/2)

	Methods of Works	Objective Sections	Descriptions of Works	Equipment Required
CLEANING AND DREDGING OF SEWER	S-1 Cleaning and dredging of sewer by using water jet cleaner	Sewer with size of 0.3 to 0.8 m in dia. and bottom width of 0.8 m or less	After preparation for traffic control and sewage diversion if necessary, the sediments in sewer will be muddied, dredged and collected by using high pressure water jetting through nozzle and rubber hose from water jet cleaner, then sucked, dehydrated and dumped into dump truck by vacuum truck with dehydrator, and transported to disposal site(s).	1) Water jet cleaner 2) Vacuum truck with dehydrator and lift 3) Water tanker 4) Dump truck 5) Truck with crane 6) Submersible pump for construction use 7) Diesel generator 8) Gas detector 9) Flood light 10) Blower 11) Transceiver 12) Pickup
	S-2 Cleaning and dredging of sewer by using vacuum truck with high vacuum	Sewer with bottom width of 0.9 to 1.2 m, where enable workers to enter	After preparation of the same as mentioned above, the temporary weirs at both ends of the work section will be built for sewer diversion and dewatering of the section. The sewer diversion and dewatering will be made by using submersible pump. The sediments in sewer will be sucked into sludge tank truck through rubber suction hose connected to vacuum truck and transported to disposal sites. The handling of hose will be made by manpower.	1) Vacuum truck with high vacuum 2) Sludge tank truck 3) Truck with crane 4) Submersible pump for construction use 5) Diesel generator 6) Gas detector 7) Floodlight 8) Blower 9) Transceiver 10) Pickup truck
	S-3 Cleaning and dredging of sewer by using winch and manpower	Sewer with bottom width of 1.3 m or more, where enable workers to enter and wok freely	After preparation of the same as mentioned above S-2, the sediments will be excavated by manpower, collected by using portable winch with engine set near manhole/inlet/outlet of sewer sucked by vacuum truck or loaded by manpower, and transported to disposal site(s).	1) Portable winch with engine 2) Hand tools 3) Vacuum truck 4) Dump truck 5) Truck with crane 6) Submersible pump for construction use 7) Diesel generator 8) Gas detector 9) Floodlight 10) Blower 11) Transceiver 12) Pickup truck

Table 3.5 (2) CLEANING AND DREDGING METHODS AND EQUIPMENT REQUIRED (2/2)

	Methods of Works	Objective Sections	Descriptions of Works	Equipment Required
CLEANING AND DREDGING OF DRAINAGE CANAL	C-1 Cleaning and dredging of drainage canal by using grab bucket excavator on canal bank	Drainage canal where enable excavator to access canal bank and excavate from land side	Grab bucket set on bank will clear and dredge the canal and dump into dump truck or sludge settling vessel. The sludge in vessel will be sucked by vacuum truck after unwatering and transported to disposal sites. But, the excavator will also be used for C-2 work in accordance with work schedule. The total sediment volume to be excavated with this method is estimated at 20 % of whole volume.	1) Grab bucket excavator 2) Settling vessel 3) Dump truck 4) Vacuum truck 5) Truck with crane 6) Trailer 7) Pickup truck The equipment other than settling vessel and dump truck will also be used for C-2 wok below.
	C-2 Cleaning and dredging of drainage canal by using grab bucket excavator on working barge	Drainage canal with bottom width of 5 m or more, where unenable excavator to access canal bank and excavate from barge	The grab bucket excavator set on working barge will dredge the sediments and dump into sludge handling barge. The barge will be towed to bank by manpower, then transported to disposal site by dump truck with solid material or by vacuum truck with sludge respectively. The handling volume by this method is estimated at 80 % of whole volume in canal with width less than 5 m and 100 % of canal more than 9 m.	1) Grab bucket excavator 2) Working barge 3) Sludge handling barge (large) 4) Material hauling barge (small) 5) Vacuum truck 6) Truck with crane 7) Rough terrain crane 8) Tractor and trailer 9) Pickup truck
	C-3 Cleaning and dredging of drainage canal by using vacuum truck with high vacuum and manpower	Drainage canal with narrow width less than 5 m and with considerably heavy sediment, where unable the equipment to access canal bank	The vacuum truck set at the crossing point of canal and road will suck the sediment in canal unwatered (by submersible pump, if necessary) through steel pipes and suction hose and load to sludge tank truck which will transport to disposal site(s). The solid and large size sediment will be transported by dump truck of other working group.	1) Vacuum truck with high vacuum 2) Sludge tank truck 3) Hand tools 4) Truck with crane 5) Submersible pump for construction use 6) Diesel generator 7) Gas detector 8) Transceiver 9) Pickup truck Rough terrain crane and trailer may be used for handling the piping materials.
	C-4 Cleaning and dredging of drainage canal by using small barge and manpower	Drainage canal where is narrow and shallow, and with light sediment	The sediment dredged and collected by using small barge and manpower will be loaded into dump truck by manpower and transported to disposal site(s). The work section may be unwatered by using submersible pump.	1) Sludge hauling barge (small) 2) Hand tools 3) Dump truck 4) Submersible pump for construction use 5) Diesel generator 6) Pickup truck

Table 3.6 LIST OF EQUIPMENT AND MATERIALS

GROUP	EQUIPMENT/SPECIFICATION	PURPOSE OF USE	QUANTITY
A-01	Swampdozer, 7t	Disposal sites	2 units
A-02	Excavator, grab bucket, 0.2 m3	Dredging	2 units
A-03	Working barge for the above	Dredging	2 units
A-04	Sludge hauling barge, 6 m3	Sludge hauling	4 units
A-05	Sludge hauling barge, 2m3	Sludge hauling	8 units
A-06	Sludge settling vessel, 6 m3	Sludge hauling	2 nos.
A-07	Dump truck, 4 t w/extension	Clean/dredging	12 units
A-08	Water jet cleaner, 4 t truck	Cleaning	2 units
A-09	Water tanker, 4 m3	Cleaning	5 units
A-10	Vacuum truck, 8 t w/high vacuum	Dredging	2 unit
A-11	Vacuum truck, 4 t w/dehydrator	Cleaning	2 units
A-12	Vacuum truck, 4 t	Dredging	14 units
A-13	Sludge tank truck 4 t	Dredging	6 units
A-14	Portable winch for sewer	Dredging	2 sets
A-15	Truck, 4 t w/crane 3 t	Clean/dredging	7 units
A-16	Rough terrain crane, 30 t	Dredging/etc.	1 unit
A-17	Tractor & Trailer, 20 t	Dredging/etc.	1 unit
A-18	Pick-up truck, 1 t	SV/F-service	8 units
A-19	Submersible pump, 150 mm dia.	Clean/dredging	6 units
A-20	Submersible pump, 100 mm dia.	Clean/dredging	9 units
A-21	Diesel generator, 30 kVA	Clean/dredging	6 sets
A-22	Diesel generator, 20 kVA	Clean/dredging	4 sets
A-23	Spare parts for the above	15 % of CIF	1 lot
B-01	Portable gas detector, 3 gases	Cleaning	7 nos.
B-02	Floodlight, 300 W, W/tripod	Cleaning	10 sets
B-03	Blower, 300 mm dia..	Cleaning	11 nos.
B-04	Transceiver	Clean/dredging	7 sets
B-05	Hand tools for Dredging/Cleaning small canal, collector basin, small connection pipes, etc.	Clean/dredging	1 lot
B-06	Equipment & tools for maintenance and repair shop	M & R shop	1 lot
C-01	Dredge suction pipe (steel) set, 150 mm dia. x 200 m	Dredging	3 sets
C-02	Suction hose, 150 mm x 5 m	Dredging	6 pcs
C-03	Delivery hose, 150 mm dia. x 50 m	Clean/dredging	30 sets
C-04	Delivery hose, 100 mm dia. x 50 m	Clean/dredging	45 sets
C-05	Cabtyre cable, 100 m w/cable reel	Clean/dredging	30 sets
C-06	Fuel and lubricant (for 1 year)	Clean/dredging	600 m3

Table 3.7 DIRECT DAMAGE PER HECTARE WITH INUNDATION DEPTH ACCORDING TO LAND USE

Land Use	Item	Unit Price ($/ha)	Inundation Depth (m)									
			Shallower than 0.2		0.2 to 0.5		0.5 to 1.0		1.0 to 2.0		Deeper than 2.0	
			Damage Rate	Damage ($/ha)	Damage Rate	Damage ($/ha)	Damage Rate	Damage ($/ha)	Damage Rate	Damage ($/ha)	Damage Rate	Damage ($/ha)
Office/Public Facilities	Building	900,000	0.030	27,000	0.053	47,700	0.072	64,800	0.109	98,100	0.152	136,800
Ancient Area	House	461,100	0.030	13,800	0.053	24,400	0.072	33,200	0.109	50,300	0.152	70,100
	Household Goods	317,900	0.000	0	0.086	27,300	0.191	60,700	0.331	105,200	0.499	158,600
	Total	779,000	-	13,800	-	51,700	-	93,900	-	155,500	-	228,700
Urban Residential Area	House	168,200	0.030	5,000	0.053	8,900	0.072	12,100	0.109	18,300	0.152	25,600
	Household Goods	115,900	0.000	0	0.086	10,000	0.191	22,100	0.331	38,400	0.499	57,800
	Total	284,100	-	5,000	-	18,900	-	34,200	-	56,700	-	83,400
Suburban Residential Area	House	40,100	0.030	1,200	0.053	2,100	0.072	2,900	0.109	4,400	0.152	6,100
	Household Goods	23,900	0.000	0	0.086	2,100	0.191	4,600	0.331	7,900	0.499	11,900
	Total	64,000	-	1,200	-	4,200	-	7,500	-	12,300	-	18,000
Industrial Area	Building	315,000	0.030	9,500	0.053	16,700	0.072	22,700	0.109	34,300	0.152	47,900
Fishpond /Lake Area	-	1,350	0.300	410	0.500	680	0.75	1,010	1.000	1,350	1.000	1,350
Agricultural Land	-	660	0.360	240	0.360	240	0.5	330	0.640	420	0.640	420
Green Area /Un-used Land	-	0	-	0	-	0	-	0	-	0	-	0

Table 3.8 (1) CALCULATION OF FLOOD DAMAGE (1/2)

Basin	Sub-Basin	Without Project													
		Return period; 1.2 years		Return period; 2 years		Return period; 5 years		Return period; 10 years		Return period; 20 years		Return period; 30 years		Return period; 50 years	
		Water level	Damage (x1000$)	Water level	Damage (x1000$)	Water level	Damage (x1000$)	Water level	Damage (x1000$)	Water level	Damage (x1000$)	Water level	Damage (x1000$)	Water level	Damage (x1000$)
To Lich River Basin	T1	7.40	0	7.43	15	7.51	75	7.80	555	8.02	1,095	8.05	1,215	8.09	1,320
	T2	5.90	0	6.01	15	6.20	660	6.35	1,305	6.50	2,205	6.59	2,835	6.70	3,645
	T3	5.80	0	5.83	15	6.02	210	6.08	870	6.15	1,215	6.19	1,425	6.23	1,620
	T4	5.80	0	5.80	0	6.01	510	6.07	765	6.15	1,020	6.20	1,170	6.27	1,425
	T5	5.80	0	5.86	15	6.04	1,620	6.11	2,235	6.18	2,835	6.23	3,645	6.28	3,450
	T6	5.90	0	6.00	1,020	6.08	1,620	6.14	2,235	6.21	2,835	6.24	3,240	6.29	3,645
	T7	5.80	0	5.82	15	5.91	300	5.99	465	6.03	1,020	6.06	1,095	6.20	1,380
	T8	4.20	15	4.60	15	5.10	45	5.50	300	5.80	765	5.90	990	6.20	1,830
	T9	4.20	15	4.60	15	5.10	45	5.50	150	5.80	270	5.90	330	6.20	480
Lu River Basin	L1	5.90	0	5.95	15	6.06	270	6.12	645	6.18	1,035	6.22	1,425	6.26	1,695
	L2	5.71	0	5.83	15	6.01	2,130	6.07	2,835	6.12	3,240	6.16	3,645	6.20	3,855
	L3	5.70	0	5.71	15	5.78	15	5.84	15	5.91	510	5.96	1,140	6.20	2,235
	L4	5.70	0	5.80	180	5.97	705	6.04	810	6.10	1,140	6.13	930	6.20	1,950
	L5	4.90	0	5.00	60	5.10	150	5.50	690	5.80	1,260	5.90	1,500	6.20	2,025
	L6	4.20	30	4.60	195	5.10	285	5.50	600	5.80	1,035	5.90	1,215	6.20	2,025
Kim Ngu River Basin	K1	6.40	0	7.01	690	7.23	1,500	7.40	2,430	7.57	3,645	7.66	4,455	7.78	5,475
	K2	5.40	0	5.45	15	5.55	195	5.75	885	5.95	1,740	6.02	2,130	6.20	2,940
	K3	5.60	0	5.71	15	5.87	795	5.98	1,620	6.04	2,025	6.08	2,235	6.20	3,045
	K4	4.60	0	4.64	15	5.10	525	5.50	1,950	5.80	2,835	5.90	3,090	6.20	4,455
	K5	4.70	0	4.70	0	5.10	1,290	5.50	3,450	5.80	4,860	5.90	5,475	6.20	6,885
	K6	4.60	0	4.60	0	5.10	735	5.50	2,025	5.80	3,645	5.90	3,240	6.20	2,430
Set River Basin	S1	5.99	45	6.09	165	6.22	405	6.31	690	6.41	1,020	6.46	1,215	6.52	1,500
	S2	5.30	0	5.35	15	5.50	210	5.82	1,140	6.03	2,235	6.07	2,430	6.20	2,640
	S3	4.63	0	4.81	405	5.10	1,830	5.50	3,855	5.80	5,475	5.90	5,880	6.20	7,290
	S4	4.20	75	4.60	270	5.10	855	5.50	1,695	5.80	2,430	5.90	2,835	6.20	3,855
Hoang Liet Drainage Basin	H1	4.20	90	4.60	480	5.10	1,290	5.50	2,235	5.80	3,240	5.90	3,450	6.20	4,455
	H2	4.20	270	4.60	1,050	5.10	2,640	5.50	3,855	5.80	4,860	5.90	5,070	6.20	5,880
Yen So Drainage Basin	Y	4.20	90	4.60	360	5.10	930	5.50	1,290	5.80	1,545	5.90	1,620	6.20	1,830
Total		-	630	-	5,085	-	21,840	-	41,595	-	61,035	-	68,925	-	85,260

Basin	Sub-Basin	With Project							
		Return period; 10 years		Return period; 20 years		Return period; 30 years		Return period; 50 years	
		Water level	Damage (x1000$)	Water level	Damage (x1000$)	Water level	Damage (x1000$)	Water level	Damage (x1000$)
To Lich River Basin	T1	7.40	0	7.41	15	7.42	15	7.44	15
	T2	5.90	0	6.05	15	6.10	15	6.16	480
	T3	5.80	0	5.94	15	6.01	195	6.05	585
	T4	5.80	0	5.94	405	6.02	615	6.05	705
	T5	5.80	0	5.93	570	6.01	1,170	6.06	1,830
	T6	5.90	0	6.00	810	6.03	1,215	6.07	1,545
	T7	5.80	0	5.82	15	5.84	135	5.87	225
	T8	4.00	0	4.57	15	5.00	30	5.06	30
	T9	4.00	0	4.01	15	4.07	15	4.17	15
Lu River Basin	L1	5.90	0	6.03	15	6.06	270	6.11	465
	L2	5.70	0	5.72	15	5.75	15	5.79	15
	L3	5.70	0	5.71	15	5.72	15	5.74	15
	L4	5.70	0	5.76	105	5.82	210	5.90	480
	L5	4.90	0	4.94	15	5.01	60	5.03	60
	L6	4.00	0	4.17	30	4.30	45	4.46	75
Kim Ngu River Basin	K1	6.40	0	7.00	690	7.05	855	7.12	1,035
	K2	5.40	0	5.41	15	5.41	15	5.42	15
	K3	5.60	0	5.69	15	5.75	15	5.82	405
	K4	4.60	0	4.63	15	4.67	15	4.72	45
	K5	4.70	0	4.75	15	4.80	15	4.89	405
	K6	4.60	0	4.76	165	4.88	450	5.00	510
Set River Basin	S1	5.90	0	6.04	60	6.08	135	6.14	210
	S2	5.30	0	5.37	15	5.42	30	5.49	180
	S3	4.60	0	4.70	15	4.78	210	4.89	975
	S4	4.00	0	4.06	15	4.11	45	4.17	60
Hoang Liet Drainage Basin	H1	4.00	0	4.11	15	4.18	75	4.27	150
	H2	4.00	0	4.07	150	4.12	180	4.18	255
Yen So Drainage Basin	Y	4.00	0	4.08	45	4.14	60	4.20	90
Total		-	0	-	3,300	-	6,120	-	10,875

Note: Damage = Direct Damage x 1.35

Table 3.8 (2) CALCULATION OF FLOOD DAMAGE (2/2)

Basin	Sub-Basin	Without Project														With Project							
		Return period; 1.2 years		Return period; 2 years		Return period; 5 years		Return period; 10 years		Return period; 20 years		Return period; 30 years		Return period; 50 years		Return period; 10 years		Return period; 20 years		Return period; 30 years		Return period; 50 years	
		Water level	Damage (x1000$)	Water level	Damage (x1000$)	Water level	Damage (x1000$)	Water level	Damage (x1000$)	Water level	Damage (x1000$)	Water level	Damage (x1000$)	Water level	Damage (x1000$)	Water level	Damage (x1000$)	Water level	Damage (x1000$)	Water level	Damage (x1000$)	Water level	Damage (x1000$)
Co Nhue Drainage Basin	C	4.70	0	4.90	0	5.40	120	5.80	675	6.10	1,665	6.20	2,190	6.50	3,855	5.20	0	5.60	270	5.90	915	6.00	1,260
My Dinh Drainage Basin	D	4.60	0	4.80	75	5.30	1,320	5.70	3,750	6.00	6,885	6.10	8,505	6.40	12,960	4.70	0	5.00	360	5.10	630	5.10	630
Me Tri Drainage Basin	M	4.50	0	4.70	0	5.20	930	5.60	4,350	5.90	8,400	6.00	9,930	6.30	14,580	4.70	0	5.00	270	5.10	510	5.10	510
Ba Xa - Drainage Basin	B	4.30	0	4.50	0	5.00	690	5.40	2,130	5.70	3,945	5.80	4,755	6.10	7,500	4.50	0	4.70	270	4.90	510	5.00	690
Total		-	0	-	75	-	3,060	-	10,905	-	20,895	-	25,380	-	38,895	-	0	-	1,170	-	2,565	-	3,090

Note: Damage = Direct Damage x 1.35

Table 3.9 CALCULATION OF AVERAGE ANNUAL BENEFITS (1/5)
– To LICH RIVER BASIN

Without - project Condition

Return Period	Flood Damage (US$1000)	Average Flood Damage (US$1000)	Expectation of Occurrence	Annual Average Flood Damage (US$1000)
1.2 years	630			
		2,858	0.333	952
2 years	5,085			
		13,463	0.300	4,039
5 years	21,840			
		31,718	0.100	3,172
10 years	41,595			
		51,315	0.050	2,566
20 years	61,035			
		64,980	0.017	1,105
30 years	68,925			
		77,093	0.013	1,002
50 years	85,260			
Total	-	-	-	12,836

With - project Condition

Return Period	Flood Damage (US$1000)	Average Flood Damage (US$1000)	Expectation of Occurrence	Annual Average Flood Damage (US$1000)
1.2 years	0			
		0	0.333	0
2 years	0			
		0	0.300	0
5 years	0			
		0	0.100	0
10 years	0			
		1,650	0.050	83
20 years	3,300			
		4,710	0.017	80
30 years	6,120			
		8,498	0.013	110
50 years	10,875			
Total	-	-	-	273

Expected Annual Average Benefit= US$ 12,563 thousand

Table 3.9 CALCULATION OF AVERAGE ANNUAL BENEFITS (2/5)
– NHUE RIVER BASIN, CO NHUE

Without - project Condition

Return Period	Flood Damage (US$1000)	Average Flood Damage (US$1000)	Expectation of Occurrence	Annual Average Flood Damage (US$1000)
1.2 years	0			
		0	0.333	0
2 years	0			
		60	0.300	18
5 years	120			
		398	0.100	40
10 years	675			
		1,170	0.050	59
20 years	1,665			
		1,928	0.017	33
30 years	2,190			
		3,023	0.013	39
50 years	3,855			
Total	-	-	-	189

With - project Condition

Return Period	Flood Damage (US$1000)	Average Flood Damage (US$1000)	Expectation of Occurrence	Annual Average Flood Damage (US$1000)
1.2 years	0			
		0	0.333	0
2 years	0			
		0	0.300	0
5 years	0			
		0	0.100	0
10 years	0			
		135	0.050	7
20 years	270			
		593	0.017	10
30 years	915			
		1,088	0.013	14
50 years	1,260			
Total	-	-	-	31

Expected Annual Average Benefit = US$ 158 thousand

Table 3.9 CALCULATION OF AVERAGE ANNUAL BENEFITS (3/5)
– NHUE RIVER BASIN, MY DINH

Without - project Condition

Return Period	Flood Damage (US$1000)	Average Flood Damage (US$1000)	Expectation of Occurrence	Annual Average Flood Damage (US$1000)
1.2 years	0			
		38	0.333	12
2 years	75			
		698	0.300	209
5 years	1,320			
		2,535	0.100	254
10 years	3,750			
		5,318	0.050	266
20 years	6,885			
		7,695	0.017	131
30 years	8,505			
		10,733	0.013	140
50 years	12,960			
Total	-	-	-	1,012

With - project Condition

Return Period	Flood Damage (US$1000)	Average Flood Damage (US$1000)	Expectation of Occurrence	Annual Average Flood Damage (US$1000)
1.2 years	0			
		0	0.333	0
2 years	0			
		0	0.300	0
5 years	0			
		0	0.100	0
10 years	0			
		180	0.050	9
20 years	360			
		495	0.017	8
30 years	630			
		630	0.013	8
50 years	630			
Total	-	-	-	25

Expected Annual Average Benefit= US$ 987 thousand

Table 3.9 CALCULATION OF AVERAGE ANNUAL BENEFITS (4/5)
- NHUE RIVER BASIN, ME TRI

Without - project Condition

Return Period	Flood Damage (US$1000)	Average Flood Damage (US$1000)	Expectation of Occurrence	Annual Average Flood Damage (US$1000)
1.2 years	0			
		0	0.333	0
2 years	0			
		465	0.300	140
5 years	930			
		2,640	0.100	264
10 years	4,350			
		6,375	0.050	319
20 years	8,400			
		9,165	0.017	156
30 years	9,930			
		12,255	0.013	159
50 years	14,580			
Total	-	-	-	1,038

With - project Condition

Return Period	Flood Damage (US$1000)	Average Flood Damage (US$1000)	Expectation of Occurrence	Annual Average Flood Damage (US$1000)
1.2 years	0			
		0	0.333	0
2 years	0			
		0	0.300	0
5 years	0			
		0	0.100	0
10 years	0			
		135	0.050	7
20 years	270			
		390	0.017	7
30 years	510			
		510	0.013	7
50 years	510			
Total	-	-	-	21

Expected Annual Average Benefit= US$ 1017 thousand

Table 3.9 CALCULATION OF AVERAGE ANNUAL BENEFITS (5/5)
– NHUE RIVER BASIN, BA XA

Without - project Condition

Return Period	Flood Damage (US$1000)	Average Flood Damage (US$1000)	Expectation of Occurrence	Annual Average Flood Damage (US$1000)
1.2 years	0			
		0	0.333	0
2 years	0			
		345	0.300	104
5 years	690			
		1,410	0.100	141
10 years	2,130			
		3,038	0.050	152
20 years	3,945			
		4,350	0.017	74
30 years	4,755			
		6,128	0.013	80
50 years	7,500			
Total	-	-	-	551

With - project Condition

Return Period	Flood Damage (US$1000)	Average Flood Damage (US$1000)	Expectation of Occurrence	Annual Average Flood Damage (US$1000)
1.2 years	0			
		0	0.333	0
2 years	0			
		0	0.300	0
5 years	0			
		0	0.100	0
10 years	0			
		135	0.050	7
20 years	270			
		390	0.017	7
30 years	510			
		600	0.013	8
50 years	690			
Total	-	-	-	22

Expected Annual Average Benefit= US$ 529 thousand