Table H 28 CALCULATION OF NET M&I WATER WITHDRAWAL BY BASIN DIVISIONS

Han River Basin (1967) Unit: 10^3 m^3/d

Basin Division	M&I Water Requirement		Return Flow		Local Source	Net Withdrawal		
	Main Depend.	Trib. Depend.	Main	Trib.		Main Depend.	Trib. Depend.	Total
H - 1	-	0.8	-	0.6	-	-	0.2	0.2
H - 2	-	1.2	-	0.8	-	-	0.4	0.4
H - 3	-	1.1	-	0.8	-	-	0.3	0.3
H - 4	-	0.9	-	0.6	-	-	0.3	0.3
H - 5	-	0.5	-	0.4	-	-	0.1	0.1
H - 6	-	0.9	-	0.6	-	-	0.3	0.3
H - 7-1	-	1.1	-	0.8	-	-	0.3	0.3
H - 7-3	0.3	10.8	0.2	7.6	-	0.1	3.2	3.3
H - 8	-	7.9	-	5.5	-	-	2.4	2.4
H - 9	-	5.4	-	3.8	-	-	1.6	1.6
H - 10-1	3.9	-	2.7	-	-	1.2	-	1.2
H - 10-2	18.3	-	12.8	-	-	5.5	-	5.5
H - 10-3	-	2.0	-	1.4	-	-	0.6	0.6
H - 11	-	7.2	-	5.0	-	-	2.2	2.2
H - 12	-	3.5	-	2.5	-	-	1.0	1.0
H - 13-1	0.1	2.7	0.1	1.9	-	-	0.8	0.8
H - 13-2	4.5	-	3.2	-	-	1.3	-	1.3
H - 13-3								
Inside	-	7.2	-	5.0	-	-	2.2	2.2
Outside	-	-	-	-	-	-	-	-
H - 15	-	1.7	-	1.2	-	-	0.5	0.5
Sub-total	27.1	53.2	19.0	37.3	-	8.1	15.9	24.5
H - 14								
Inside	547.1	33.8	351.4	23.7	-	195.7 /1	10.1	205.8
Outside	5.4	-	-	-	12.0	0	-	0 /1

Remarks; /1: In case the local water source supply exceeds the requirement outside the basin, the net withdrawal is indicated as nil.

Table H 28 Continued (2)

Han River Basin (1968)

Unit: 10^3 m^3/d

Basin Division	M&I Water Requirement		Return Flow		Local Source	Net Withdrawal		
	Main Depend.	Trib. Depend.	Main	Trib.		Main Depend.	Trib. Depend	Total
H - 1	-	0.8	-	0.6	-	-	0.2	0.2
H - 2	-	1.2	-	0.8	-	-	0.4	0.4
H - 3	-	1.4	-	1.0	-	-	0.4	0.4
H - 4	-	0.9	-	0.6	-	-	0.3	0.3
H - 5	-	0.5	-	0.4	-	-	0.1	0.1
H - 6	-	0.9	-	0.6	-	-	0.3	0.3
H - 7-1	-	1.2	-	0.8	-	-	0.4	0.4
H - 7-2	0.6	12.0	0.4	8.4	-	0.2	3.6	3.8
H - 8	-	7.7	-	5.4	-	-	2.3	2.3
H - 9	-	5.2	-	3.6	-	-	1.6	1.6
H - 10-1	4.4	-	3.1	-	-	1.3	-	1.3
H - 10-2	18.5	-	13.0	-	-	5.5	-	5.5
H - 10-3	-	2.0	-	1.4	-	-	0.6	0.6
H - 11	-	13.0	-	9.1	-	-	3.9	3.9
H - 12	-	3.4	-	2.4	-	-	1.0	1.0
H - 13-1	0.1	2.7	0.1	1.9	-	0	0.8	0.8
H - 13-2	6.6	-	4.6	-	-	2.0	-	2.0
H - 13-3								
Inside	-	7.2	-	5.0	-	-	2.2	2.2
Outside	-	-	-	-	-	-	-	-
H - 15	-	1.7	-	1.2	-	-	0.5	0.5
Sub-total	30.2	61.8	21.2	43.2	-	9.0	18.6	27.6
H - 14								
Inside	713.0	34.6	464.1	24.2	-	248.9	10.4	259.3
Outside	5.9	-	-	-	12.0	0	-	0

Table H 28 Continued (3)

Han River Basin (1971)

Unit: 10^3 m^3/d

Basin Division	M&I Water Requirement		Return Flow		Local Source	Net Withdrawal		
	Main Depend.	Trib. Depend.	Main	Trib.		Main Depend.	Trib. Depend.	Total
H - 1	-	0.8	-	0.6	-	-	0.2	0.2
H - 2	-	1.1	-	0.8	-	-	0.3	0.3
H - 3	-	1.8	-	1.3	-	-	0.5	0.5
H - 4	-	0.8	-	0.6	-	-	0.2	0.2
H - 5	-	0.4	-	0.3	-	-	0.1	0.1
H - 6	-	0.8	-	0.6	-	-	0.2	0.2
H - 7-1	-	1.2	-	0.8	-	-	0.4	0.4
H - 7-2	1.2	13.4	0.8	9.4	-	0.4	4.0	4.4
H - 8	-	7.2	-	5.0	-	-	2.2	2.2
H - 9	-	4.9	-	3.4	-	-	1.5	1.5
H - 10-1	4.7	-	3.3	-	-	1.4	-	1.4
H - 10-2	17.9	-	12.5	-	-	5.4	-	5.4
H - 10-3	-	1.9	-	1.3	-	-	0.6	0.6
H - 11	-	17.8	-	12.5	-	-	5.3	5.3
H - 12	-	4.3	-	3.0	-	-	1.3	1.3
H - 13-1	0.3	2.5	0.2	1.8	-	0.1	0.7	0.8
H - 13-2	11.7	-	8.2	-	-	3.5	-	3.5
H - 13-3								
Inside	-	6.8	-	4.8	-	-	2.0	2.0
Outside	-	-	-	-	-	-	-	-
H - 15	-	1.5	-	1.1	-	-	0.4	0.4
Sub-total	35.8	67.2	25.0	47.3	-	10.8	19.9	30.7
H - 14								
Inside	1,263.4	38.8	804.2	27.2	-	459.2	11.6	470.8
Outside	9.1	-	-	-	12.0	0	-	0

Table H 28 Continued (4)

Han River Basin (1976)

Unit: 10^3 m^3/d

Basin Division	M&I Water Requirement		Return Flow		Local Source	Net Withdrawal		
	Main Depend.	Trib. Depend.	Main	Trib.		Main Depend.	Trib. Depend.	Total
H - 1	-	0.6	-	0.4	-	-	0.2	0.2
H - 2	-	0.8	-	0.6	-	-	0.2	0.2
H - 3	-	2.3	-	1.6	-	-	0.7	0.7
H - 4	-	0.7	-	0.5	-	-	0.2	0.2
H - 5	-	0.3	-	0.2	-	-	0.1	0.1
H - 6	-	0.7	-	0.5	-	-	0.2	0.2
H - 7-1	-	1.1	-	0.8	-	-	0.3	0.3
H - 7-2	2.3	18.1	1.6	12.7	-	0.7	5.4	6.1
H - 8	-	5.5	-	3.9	-	-	1.6	1.6
H - 9	-	4.3	-	3.0	-	-	1.3	1.3
H - 10-1	8.5	-	6.0	-	-	2.5	-	2.5
H - 10-2	10.1	6.2	7.1	4.3	-	3.0	1.9	4.9
H - 10-3	-	1.5	-	1.1	-	-	0.4	0.4
H - 11	-	27.1	-	18.9	-	-	8.2	8.2
H - 12	-	4.7	-	3.3	-	-	1.4	1.4
H - 13-1	0.5	1.9	0.4	1.3	-	0.1	0.6	0.7
H - 13-2	17.0	-	11.9	-	-	5.1	-	5.1
H - 13-3								
Inside	-	5.2	-	3.6	-	-	1.6	1.6
Outside	-	-	-	-	-	-	-	-
H - 15	-	1.5	-	1.1	-	-	0.4	0.4
Sub-total	38.4	82.5	27.0	57.8	-	11.4	24.7	36.1
H - 14								
Inside	2,476.4	57.8	1,585.9	40.5	-	890.5	17.3	907.8
Outside	45.7	-	-	-	16.0	29.7	-	29.7

Table H 28 Continued (5)

Han River Basin (1981)

Unit: 10^3 m^3/d

Basin Division	M&I Water Requirement: Main Depend.	M&I Water Requirement: Trib. Depend.	Return Flow: Main	Return Flow: Trib.	Local Source	Net Withdrawal: Main Depend.	Net Withdrawal: Trib. Depend.	Net Withdrawal: Total
H - 1	-	0.5	-	0.4	-	-	0.1	0.1
H - 2	-	2.3	-	1.6	-	-	0.7	0.7
H - 3	-	2.9	-	2.0	-	-	0.9	0.9
H - 4	-	2.2	-	1.5	-	-	0.7	0.7
H - 5	-	0.3	-	0.2	-	-	0.1	0.1
H - 6	-	0.6	-	0.4	-	-	0.2	0.2
H - 7-1	-	1.0	-	0.7	-	-	0.3	0.3
H - 7-2	4.8	26.8	3.4	18.8	-	1.4	8.0	9.4
H - 8	-	4.8	-	3.4	-	-	1.4	1.4
H - 9	-	4.2	-	2.9	-	-	1.3	1.3
H - 10-1	16.7	-	11.7	-	-	5.0	-	5.0
H - 10-2	10.4	6.7	7.3	4.7	-	3.1	2.0	5.1
H - 10-3	-	1.3	-	0.9	-	-	0.4	0.4
H - 11	-	31.1	-	21.8	-	-	9.3	9.3
H - 12	-	5.2	-	3.6	-	-	1.6	1.6
H - 13-1	1.1	1.7	0.8	1.2	-	0.3	0.5	0.8
H - 13-2	27.7	-	19.4	-	-	8.3	-	8.3
H - 13-3								
Inside	1,761.4	4.5	-	3.2	-	1,761.4	1.3	1,762.7
Outside	130.1	-	-	-	12.0	118.1	-	118.1
H - 15	-	1.7	-	1.2	-	-	0.5	0.5
Sub-total	1,952.2	97.8	42.6	68.5	12.0	1,897.6	29.3	1,926.9
H - 14								
Inside	1,760.0	84.8	2,109.1	171.6	-	-349.1 /2	-86.8 /2	-435.9 /2
Outside	7.7	-	-	-	4.0	3.7	-	3.7

Remarks; /2: Since the return flow of the water pumped from Basin-division H-13-3 and drained in Basin-division H-14 exceeds the requirement, the net withdrawal is negative (see H 6.1.2).

Table H 28 Continued (6)

Han River Basin (1986)

Unit: 10^3 m^3/d

Basin Division	M&I Water Requirement		Return Flow		Local Source	Net Withdrawal		
	Main Depend.	Trib. Depend.	Main	Trib.		Main Depend.	Trib. Depend.	Total
H - 1	-	0.5	-	0.4	-	-	0.1	0.1
H - 2	-	2.7	-	1.9	-	-	0.8	0.8
H - 3	-	3.5	-	2.5	-	-	1.0	1.0
H - 4	-	2.5	-	1.8	-	-	0.7	0.7
H - 5	-	0.2	-	0.1	-	-	0.1	0.1
H - 6	-	0.5	-	0.4	-	-	0.1	0.1
H - 7-1	-	0.9	-	0.6	-	-	0.3	0.3
H - 7-2	6.6	32.8	4.6	23.0	-	2.0	9.8	11.8
H - 8	-	4.2	-	2.9	-	-	1.3	1.3
H - 9	-	4.1	-	2.9	-	-	1.2	1.2
H - 10-1	22.9	-	16.0	-	-	6.9	-	6.9
H - 10-2	10.7	6.8	7.5	4.8	-	3.2	2.0	5.2
H - 10-3	-	1.2	-	0.8	-	-	0.4	0.4
H - 11	-	40.8	-	28.5	-	-	12.3	12.3
H - 12	-	5.9	-	4.1	-	-	1.8	1.8
H - 13-1	1.4	1.5	1.0	1.1	-	0.4	0.4	0.8
H - 13-2	41.1	-	28.8	-	-	12.3	-	12.3
H - 13-3								
Inside	2,517.8	4.0	-	2.8	-	2,517.8	1.2	2,519.0
Outside	274.3	-	-	-	12.0	262.3	-	262.3
H - 15	-	1.7	-	1.2	-	-	0.5	0.5
Sub-total	2,874.8	113.8	57.9	79.8	12.0	2,804.9	34.0	2,838.9
H - 14								
Inside	1,804.3	82.5	2,486.8	222.8	-	-682.5	-140.3	-822.8
Outside	9.5	-	-	-	4.0	5.5	-	5.5

Table H 28 Continued (7)

Han River Basin (1991)

Unit: 10^3 m^3/d

Basin Division	M&I Water Requirement		Return Flow		Local Source	Net Withdrawal		
	Main Depend.	Trib. Depend.	Main	Trib.		Main Depend.	Trib. Depend.	Total
H - 1	-	0.5	-	0.4	-	-	0.1	0.1
H - 2	-	2.9	-	2.0	-	-	0.9	0.9
H - 3	-	3.8	-	2.7	-	-	1.1	1.1
H - 4	-	3.0	-	2.1	-	-	0.9	0.9
H - 5	-	0.2	-	0.1	-	-	0.1	0.1
H - 6	-	0.5	-	0.4	-	-	0.1	0.1
H - 7-1	-	0.9	-	0.6	-	-	0.3	0.3
H - 7-2	7.9	37.6	5.5	26.3	-	2.4	11.3	13.7
H - 8	-	4.3	-	3.0	-	-	1.3	1.3
H - 9	-	4.3	-	3.0	-	-	1.3	1.3
H - 10-1	25.9	-	18.1	-	-	7.8	-	7.8
H - 10-2	11.8	6.9	8.3	4.8	-	3.5	2.1	5.6
H - 10-3	-	1.2	-	0.8	-	-	0.4	0.4
H - 11	-	47.2	-	33.1	-	-	14.1	14.1
H - 12	-	6.7	-	4.7	-	-	2.0	2.0
H - 13-1	1.7	1.5	1.2	1.1	-	0.5	0.4	0.9
H - 13-2	49.7	-	34.8	-	-	14.9	-	14.9
H - 13-3								
Inside	3,443.9	4.0	-	2.8	-	3,443.9	1.2	3,445.1
Outside	494.7	-	-	-	12.0	482.7	-	482.7
H - 15	-	2.1	-	1.5	-	-	0.6	0.6
Sub-total	4,035.6	127.6	67.9	89.4	12.0	3,955.7	38.2	3,993.9
H - 14								
Inside	1,825.6	75.9	2,937.9	297.7	-	-1,112.3	-221.8	-1,334.1
Outside	10.7	-	-	-	4.0	6.7	-	6.7

Table H 28 Continued (8)

Han River Basin (1996)

Unit: 10^3 m^3/d

Basin Division	M&I Water Requirement		Return Flow		Local Source	Net Withdrawal		
	Main Depend.	Trib. Depend.	Main	Trib.		Main Depend.	Trib. Depend.	Total
H - 1	-	0.5	-	0.4	-	-	0.1	0.1
H - 2	-	3.2	-	2.2	-	-	1.0	1.0
H - 3	-	4.1	-	2.9	-	-	1.2	1.2
H - 4	-	3.2	-	2.2	-	-	1.0	1.0
H - 5	-	0.2	-	0.1	-	-	0.1	0.1
H - 6	-	0.5	-	0.4	-	-	0.1	0.1
H - 7-1	-	0.9	-	0.6	-	-	0.3	0.3
H - 7-2	9.5	41.6	6.7	29.1	-	2.8	12.5	15.3
H - 8	-	4.3	-	3.0	-	-	1.3	1.3
H - 9	-	4.5	-	3.2	-	-	1.3	1.3
H - 10-1	29.9	-	20.9	-	-	9.0	-	9.0
H - 10-2	12.3	7.5	8.6	5.3	-	3.7	2.2	5.9
H - 10-3	-	1.1	-	0.8	-	-	0.3	0.3
H - 11	-	53.8	-	37.7	-	-	16.1	16.1
H - 12	-	7.3	-	5.1	-	-	2.2	2.2
H - 13-1	1.9	1.5	1.3	1.1	-	0.6	0.4	1.0
H - 13-2	59.1	-	41.4	-	-	17.7	-	17.7
H - 13-3								
Inside	4,638.0	4.0	-	2.8	-	4,638.0	1.2	4,639.2
Outside	896.6	-	-	-	12.0	884.6	-	884.6
H - 15	-	2.0	-	1.4	-	-	0.6	0.6
Sub-total	5,647.3	140.2	78.9	98.3	12.0	5,556.4	41.9	5,598.3
H - 14								
Inside	1,845.1	75.9	3,500.2	406.9	-	-1,655.1	-331.0	-1,986.1
Outside	12.4	-	-	-	4.0	8.4	-	8.4

Table H 28 Continued (9)

Han River Basin (2001)

Unit: 10^3 m^3/d

Basin Division	M&I Water Requirement		Return Flow		Local Source	Net Withdrawal		
	Main Depend.	Trib. Depend.	Main	Trib.		Main Depend.	Trib. Depend.	Total
H - 1	-	0.5	-	0.4	-	-	0.1	0.1
H - 2	-	3.5	-	2.5	-	-	1.0	1.0
H - 3	-	4.6	-	3.2	-	-	1.4	1.4
H - 4	-	3.8	-	2.7	-	-	1.1	1.1
H - 5	-	0.2	-	0.1	-	-	0.1	0.1
H - 6	-	0.5	-	0.4	-	-	0.1	0.1
H - 7-1	-	0.8	-	0.6	-	-	0.2	0.2
H - 7-2	11.0	46.5	7.7	32.6	-	3.3	13.9	17.2
H - 8	-	4.2	-	2.9	-	-	1.3	1.3
H - 9	-	4.5	-	3.2	-	-	1.3	1.3
H - 10-1	33.5	-	23.5	-	-	10.0	-	10.0
H - 10-2	13.1	8.1	9.2	5.7	-	3.9	2.4	6.3
H - 10-3	-	1.1	-	0.8	-	-	0.3	0.3
H - 11	-	60.4	-	42.3	-	-	18.1	18.1
H - 12	-	8.2	-	5.7	-	-	2.5	2.5
H - 13-1	2.2	1.5	1.5	1.1	-	0.7	0.4	1.1
H - 13-2	68.2	-	47.7	-	-	20.5	-	20.5
H - 13-3								
Inside	6,207.7	3.9	-	2.7	-	6,207.7	1.2	6,208.9
Outside	1,722.3	-	-	-	12.0	1,710.3	-	1,710.3
H - 15	-	2.1	-	1.5	-	-	0.6	0.6
Sub-total	8,058.0	154.4	89.6	108.4	12.0	7,956.4	46.0	8,002.4
H - 14								
Inside	1,866.6	75.5	4,210.1	565.7	-	-2,2343.5	-490.2	-2,833.7
Outside	13.3	-	-	-	4.0	9.3	-	9.3

Table H 28 Continued (10)

Nagdong River Basin (1967)

Unit: 10^3 m^3/d

Basin Division	M&I Water Requirement		Return Flow		Local Source	Net Withdrawal		
	Main Depend.	Trib. Depend.	Main	Trib.		Main Depend.	Trib. Depend.	Total
N - 1	-	2.4	-	1.7	-	-	0.7	0.7
N - 2	-	3.2	-	2.2	-	-	1.0	1.0
N - 3	-	4.4	-	3.1	-	-	1.3	1.3
N - 4-1	4.6	-	3.2	-	-	1.4	-	1.4
N - 4-2	-	-	-	-	-	-	-	-
N - 4-3	2.2	41.2	1.5	28.8	-	0.7	12.4	13.1
N - 5								
Inside	-	0.3	-	0.2	-	-	0.1	0.1
Outside	-	2.1	-	-	2.1	-	0	0
N - 6-1	43.0	-	51.8	-	-	-8.8 /3	-	-8.8 /3
N - 6-2	-	46.8	-	11.1	-	-	35.7	35.7
N - 7	-	3.6	-	2.5	-	-	1.1	1.1
N - 8-1	0.2	3.2	0.1	2.2	-	0.1	1.0	1.1
N - 8-2	0.3	3.5	0.2	2.5	-	0.1	1.0	1.1
N - 9	-	5.1	-	3.6	-	-	1.5	1.5
N - 10	-	5.2	-	3.6	-	-	1.6	1.6
N - 11								
Inside	5.1	4.5	3.6	3.2	-	1.5	1.3	2.8
Outside	5.4	-	-	-	8.3	0	-	0
N - 12	0.4	8.4	0.3	5.9	-	0.1	2.5	2.6
N - 13	0.6	8.8	0.4	6.2	-	0.2	2.6	2.8
N - 14								
Inside	2.4	15.4	1.7	10.8	-	0.7	4.6	5.3
Outside	193.2	-	-	-	119.5	123.7	-	123.7
N - 15	-	3.8	-	2.7	-	-	1.1	1.1
Inside Basin	58.8	159.8	62.8	90.3	-	-4.0	69.5	65.5
Outside Basin	198.6	2.1	-	-	129.9	123.7	-	123.7
Area Total	257.4	161.9	62.8	90.3	129.9	119.7	69.5	189.2

Remarks; /3: Since the return flow of the water pumped from Basin divisions N-6-1, N-6-2 and N-7 and drained in Basin division N-6-1 exceeds the requirement, the net withdrawal is indicated in negative (see H 6.1.2).

Table H 28 Continued (11)

Nagdong River Basin (1968)

Unit: 10^3 m^3/d

Basin Division	M&I Water Requirement		Return Flow		Local Source	Net Withdrawal		
	Main Depend.	Trib. Depend.	Main	Trib.		Main Depend.	Trib. Depend.	Total
N - 1	-	2.4	-	1.7	-	-	0.7	0.7
N - 2	-	3.2	-	2.2	-	-	1.0	1.0
N - 3	-	4.4	-	3.1	-	-	1.3	1.3
N - 4-1	5.1	-	3.6	-	-	1.5	-	1.5
N - 4-2	-	-	-	-	-	-	-	-
N - 4-3	2.2	41.5	1.5	29.1	-	0.7	12.4	13.1
N - 5								
Inside	-	0.3	-	0.2	-	-	0.1	0.1
Outside	-	3.3	-	-	3.3	-	0	0
N - 6-1	49.1	-	55.8	-	-	-6.7	-	-6.7
N - 6-2	-	46.8	-	11.1	-	-	35.7	35.7
N - 7	-	3.6	-	2.5	-	-	1.1	1.1
N - 8-1	0.2	3.2	0.1	2.2	-	0.1	1.0	1.1
N - 8-2	0.3	3.5	0.2	2.5	-	0.1	1.0	1.1
N - 9	-	5.1	-	3.6	-	-	1.5	1.5
N - 10	-	5.2	-	3.6	-	-	1.6	1.6
N - 11								
Inside	5.3	4.5	3.7	3.2	-	1.6	1.3	2.9
Outside	5.2	-	-	-	8.1	0	-	0
N - 12	0.4	8.5	0.3	6.0	-	0.1	2.5	2.6
N - 13	0.6	9.0	0.4	6.3	-	0.2	2.7	2.9
N - 14								
Inside	2.5	15.4	1.8	10.8	-	0.7	4.6	5.3
Outside	208.5	-	-	-	139.5	129.0	-	129.0
N - 15	-	3.8	-	2.7	-	-	1.1	1.1
Inside Basin	65.7	160.4	67.4	90.8	-	-1.7	69.6	67.9
Outside Basin	213.7	3.3	-	-	150.9	129.0	-	129.0
Area Total	279.4	163.7	67.4	90.8	150.9	127.3	69.6	196.9

Table H 28 Continued (12)

Nagdong River Basin (1971) Unit: 10^3 m^3/d

Basin Division	M&I Water Requirement		Return Flow		Local Source	Net Withdrawal		
	Main Depend.	Trib. Depend.	Main	Trib.		Main Depend.	Trib. Depend.	Total
N - 1	-	2.3	-	1.6	-	-	0.7	0.7
N - 2	-	3.1	-	2.2	-	-	0.9	0.9
N - 3	-	5.3	-	3.7	-	-	1.6	1.6
N - 4-1	5.0	-	3.5	-	-	1.5	-	1.5
N - 4-2	-	-	-	-	-	-	-	-
N - 4-3	21.1	46.1	14.8	32.3	-	6.3	13.8	20.1
N - 5								
Inside	-	0.3	-	0.2	-	-	0.1	0.1
Outside	-	12.5	-	-	84.5	-	0	0
N - 6-1	50.9	-	102.1	-	-	-51.2	-	-51.2
N - 6-2	-	46.3	-	10.7	-	-	35.6	35.6
N - 7	64.7	4.1	0.5	2.9	-	64.2	1.2	65.4
N - 8-1	0.3	3.1	0.2	2.2	-	0.1	0.9	1.0
N - 8-2	0.4	3.4	0.3	2.4	-	0.1	1.0	1.1
N - 9	-	5.1	-	3.6	-	-	1.5	1.5
N - 10	-	5.1	-	3.6	-	-	1.5	1.5
N - 11								
Inside	12.8	4.4	9.0	3.1	-	3.8	1.3	5.1
Outside	6.6	-	-	-	13.7	0	-	0
N - 12	0.6	8.5	0.4	6.0	-	0.2	2.5	2.7
N - 13	0.5	8.3	0.4	5.8	-	0.1	2.5	2.6
N - 14								
Inside	2.8	15.2	2.0	10.6	-	0.8	4.6	5.4
Outside	421.2	-	-	-	189.5	312.5	-	312.5
N - 15	-	4.2	-	2.9	-	-	1.3	1.3
Inside Basin	159.1	164.8	133.2	93.8	-	25.9	71.0	96.9
Outside Basin	427.8	12.5	-	-	287.7	312.5	0	312.5
Area Total	586.9	177.3	133.2	93.8	287.7	338.4	71.0	409.4

Table H 28 Continued (13)

Nagdong River Basin (1976)

Unit: 10^3 m^3/d

Basin Division	M&I Water Requirement		Return Flow		Local Source	Net Withdrawal		
	Main Depend.	Trib. Depend.	Main	Trib.		Main Depend.	Trib. Depend.	Total
N - 1	-	6.3	-	4.4	-	-	1.9	1.9
N - 2	-	2.9	-	2.0	-	-	0.9	0.9
N - 3	-	6.2	-	4.3	-	-	1.9	1.9
N - 4-1	9.4	-	6.6	-	-	2.8	-	2.8
N - 4-2	-	-	-	-	-	-	-	-
N - 4-3	58.6	54.0	41.1	37.8	-	17.5	16.2	33.7
N - 5								
Inside	-	0.3	-	0.2	-	-	0.1	0.1
Outside	-	69.6	-	-	84.5	-	0	0
N - 6-1	51.4	-	182.3	-	-	-130.9	-	-130.9
N - 6-2	-	47.4	-	11.5	-	-	35.9	35.9
N - 7	179.6	5.2	1.1	3.6	-	178.5	1.6	180.1
N - 8-1	0.2	3.0	0.1	2.1	-	0.1	0.9	1.0
N - 8-2	0.5	3.2	0.4	2.2	-	0.1	1.0	1.1
N - 9	-	4.0	-	2.8	-	-	1.2	1.2
N - 10	-	4.8	-	3.4	-	-	1.4	1.4
N - 11								
Inside	17.3	4.1	12.1	2.9	-	5.2	1.2	6.4
Outside	15.8	-	-	-	21.4	0	-	0
N - 12	0.6	8.8	0.4	6.2	-	0.2	2.6	2.8
N - 13	1.0	9.2	0.7	6.4	-	0.3	3.8	4.1
N - 14								
Inside	4.2	13.9	2.9	9.7	-	1.3	4.2	5.5
Outside	877.9	-	-	-	199.5	679.3	-	679.3
N - 15	-	3.9	-	2.7	-	-	1.2	1.2
Inside Basin	322.8	177.2	247.7	102.2	-	75.1	76.0	151.1
Outside Basin	893.7	69.6	-	-	305.4	679.3	0	679.3
Area Total	1,216.5	246.7	247.7	102.2	305.4	754.4	76.0	830.4

Table II 28 Continued (14)

Nagdong River Basin (1981) Unit: 10^3 m^3/d

Basin Division	M&I Water Requirement		Return Flow		Local Source	Net Withdrawal		
	Main Depend.	Trib. Depend.	Main	Trib.		Main Depend.	Trib. Depend.	Total
N - 1	-	13.4	-	9.4	-	-	4.0	4.0
N - 2	-	2.7	-	1.9	-	-	0.8	0.8
N - 3	-	6.8	-	4.8	-	-	2.0	2.0
N - 4-1	16.2	-	11.3	-	-	4.9	-	4.9
N - 4-2	-	-	-	-	-	-	-	-
N - 4-3	106.5	66.2	74.6	46.3	-	31.9	19.9	51.8
N - 5								
Inside	-	0.3	-	0.2	-	-	0.1	0.1
Outside	-	198.1	-	-	84.5	-	113.6	113.6
N - 6-1	53.5	-	373.4	-	-	-319.9	-	-319.9
N - 6-2	-	87.8	-	11.8	-	-	76.0	76.0
N - 7	411.7	5.4	2.0	3.8	-	409.7	1.6	411.3
N - 8-1	1.4	2.7	1.0	1.9	-	0.4	0.8	1.2
N - 8-2	3.6	2.9	2.5	2.0	-	1.1	0.9	2.0
N - 9	-	7.6	-	5.3	-	-	2.3	2.3
N - 10	-	4.4	-	3.1	-	-	1.3	1.3
N - 11								
Inside	51.3	3.8	35.9	2.7	-	15.4	1.1	16.5
Outside	36.7	-	-	-	22.7	14.0	-	14.0
N - 12	1.4	9.2	1.0	6.4	-	0.4	2.8	3.2
N - 13	1.6	11.5	1.1	8.1	-	0.5	3.4	3.9
N - 14								
Inside	8.2	28.5	5.7	20.0	-	2.5	8.3	11.0
Outside	1,996.1	-	-	-	199.5	1,796.6	-	1,796.6
N - 15	-	4.0	-	2.8	-	-	1.2	1.2
Inside Basin	655.4	257.2	508.5	130.5	-	146.9	126.7	273.6
Outside Basin	2,032.8	198.1	-	-	306.7	1,810.6	113.6	1,924.2
Area Total	2,688.2	455.3	508.5	130.5	306.7	1,957.5	240.3	2,197.8

Table H 28 Continued (15)

Nagdong River Basin (1986)

Unit: 10^3 m^3/d

Basin Division	M&I Water Requirement		Return Flow		Local Source	Net Withdrawal		
	Main Depend.	Trib. Depend.	Main	Trib.		Main Depend.	Trib. Depend.	Total
N - 1	-	16.5	-	11.6	-	-	4.9	4.9
N - 2	-	2.6	-	1.8	-	-	0.8	0.8
N - 3	-	7.4	-	5.2	-	-	2.2	2.2
N - 4-1	38.3	-	26.8	-	-	11.5	-	11.5
N - 4-2	-	-	-	-	-	-	-	-
N - 4-3	169.9	74.9	118.9	52.4	-	51.0	22.5	73.5
N - 5								
Inside	-	0.3	-	0.2	-	-	0.1	0.1
Outside	-	330.2	-	-	110.2	-	220.0	220.0
N - 6-1	54.9	-	486.8	-	-	-431.9	-	-431.9
N - 6-2	-	88.2	-	12.0	-	-	76.2	76.2
N - 7	573.3	5.9	2.7	4.1	-	570.6	1.8	572.4
N - 8-1	2.0	2.6	1.4	1.8	-	0.6	0.8	1.4
N - 8-2	4.7	2.8	3.3	2.0	-	1.4	0.8	2.2
N - 9	-	8.8	-	6.2	-	-	2.6	2.6
N - 10	-	4.2	-	2.9	-	-	1.3	1.3
N - 11								
Inside	77.2	3.6	54.1	2.5	-	23.1	1.1	24.2
Outside	78.4	-	-	-	22.7	55.7	-	55.7
N - 12	1.7	9.7	1.2	6.8	-	0.5	2.9	3.4
N - 13	2.1	13.1	1.5	9.2	-	0.6	3.9	4.5
N - 14								
Inside	10.6	28.3	7.4	19.8	-	3.2	8.5	11.7
Outside	2,635.3	-	-	-	199.5	2,435.8	-	2,435.8
N - 15	-	4.2	-	2.9	-	-	1.3	1.3
Inside Basin	934.7	273.1	704.1	141.4	-	230.6	131.7	362.3
Outside Basin	2,713.7	330.2	-	-	332.4	2,491.5	220.0	2,711.5
Area Total	3,648.4	603.3	704.1	141.4	332.4	2,722.1	351.7	3,073.8

Table H 28 Continued (16)

Nagdong River Basin (1991)

Unit: 10^3 m^3/d

Basin Division	M&I Water Requirement		Return Flow		Local Source	Net Withdrawal		
	Main Depend.	Trib. Depend.	Main	Trib.		Main Depend.	Trib. Depend.	Total
N - 1	-	18.1	-	12.7	-	-	5.4	5.4
N - 2	-	2.5	-	1.8	-	-	0.7	0.7
N - 3	-	7.8	-	5.5	-	-	2.3	2.3
N - 4-1	42.6	-	29.8	-	-	12.8	-	12.8
N - 4-2	-	-	-	-	-	-	-	-
N - 4-3	231.9	83.3	162.4	58.3	-	69.5	25.0	94.5
N - 5								
Inside	-	0.3	-	0.2	-	-	0.1	0.1
Outside	-	422.3	-	-	202.3	-	220.0	220.0
N - 6-1	55.8	-	591.7	-	-	-535.9	-	-535.9
N - 6-2	-	88.4	-	12.2	-	-	76.2	76.2
N - 7	722.8	6.0	3.1	4.2	-	719.7	1.8	721.5
N - 8-1	2.4	2.4	1.7	1.7	-	0.7	0.7	1.4
N - 8-2	5.2	2.6	3.6	1.8	-	1.6	0.8	2.4
N - 9	-	9.5	-	6.7	-	-	2.8	2.8
N - 10	-	4.1	-	2.9	-	-	1.2	1.2
N - 11								
Inside	100.2	3.4	70.2	2.4	-	30.0	1.0	31.0
Outside	115.2	-	-	-	22.7	92.5	-	92.5
N - 12	2.1	9.8	1.5	6.9	-	0.6	2.9	3.5
N - 13	2.4	14.0	1.7	9.8	-	0.7	4.2	4.9
N - 14								
Inside	12.6	27.8	8.8	19.5	-	3.8	8.3	12.1
Outside	3,177.8	-	-	-	199.5	2,978.3	-	2,978.3
N - 15	-	4.3	-	3.0	-	-	1.3	1.3
Inside Basin	1,178.0	284.3	874.5	149.6	-	303.5	134.7	438.2
Outside Basin	3,293.0	422.3	-	-	424.5	3,070.8	220.0	3,290.8
Area Total	4,471.0	706.6	874.5	149.6	424.5	3,374.3	354.7	3,729.0

Table H 28 Continued (17)

Nagdong River Basin (1996) Unit: 10^3 m^3/d

Basin Division	M&I Water Requirement		Return Flow		Local Source	Net Withdrawal		
	Main Depend.	Trib. Depend.	Main	Trib.		Main Depend.	Trib. Depend.	Total
N - 1	-	20.0	-	14.0	-	-	6.0	6.0
N - 2	-	2.5	-	1.8	-	-	0.7	0.7
N - 3	-	8.2	-	5.7	-	-	2.5	2.5
N - 4-1	48.2	-	33.7	-	-	14.5	-	14.5
N - 4-2	-	-	-	-	-	-	-	-
N - 4-3	249.3	91.1	174.6	63.8	-	74.7	27.3	102.0
N - 5								
Inside	-	0.3	-	0.2	-	-	0.1	0.1
Outside	-	442.9	-	-	222.9	-	220.0	220.0
N - 6-1	56.9	-	706.0	-	-	-649.1	-	-649.1
N - 6-2	-	89.2	-	12.7	-	-	76.5	76.5
N - 7	885.9	6.5	3.6	4.6	-	882.3	1.9	884.2
N - 8-1	2.6	2.4	1.8	1.7	-	0.8	0.7	1.5
N - 8-2	5.8	2.7	4.1	1.9	-	1.7	0.8	2.5
N - 9	-	10.6	-	7.4	-	-	3.2	3.2
N - 10	-	4.1	-	2.9	-	-	1.2	1.2
N - 11								
Inside	121.5	3.4	85.0	2.4	-	36.5	1.0	37.5
Outside	151.8	-	-	-	22.7	129.1	-	129.1
N - 12	2.2	10.1	1.5	7.1	-	0.7	3.0	3.7
N - 13	2.6	15.3	1.8	10.7	-	0.8	4.6	5.4
N - 14								
Inside	14.0	28.1	9.8	19.7	-	4.2	8.4	12.6
Outside	3,751.1	-	-	-	199.5	3,551.6	-	3,551.6
N - 15	-	4.5	-	3.2	-	-	1.3	1.3
Inside Basin	1,389.0	299.0	1,021.9	159.8	-	367.1	139.2	506.3
Outside Basin	3,902.9	442.9	-	-	445.1	3,680.7	220.0	3,900.7
Area Total	5,291.9	741.9	1,021.9	159.8	445.1	4,047.8	359.2	4,407.0

Table H 28 Continued (18)

Nagdong River Basin (2001)

Unit: 10^3 m^3/d

Basin Division	M&I Water Requirement		Return Flow		Local Source	Net Withdrawal		
	Main Depend.	Trib. Depend.	Main	Trib.		Main Depend.	Trib. Depend.	Total
N - 1	-	22.3	-	15.6	-	-	6.7	6.7
N - 2	-	2.4	-	1.7	-	-	0.7	0.7
N - 3	-	8.9	-	6.2	-	-	2.7	2.7
N - 4-1	53.4	-	37.4	-	-	16.0	-	16.0
N - 4-2	-	-	-	-	-	-	-	-
N - 4-3	271.9	99.0	190.3	69.3	-	81.6	29.7	111.3
N - 5								
Inside	-	0.3	-	0.2	-	-	0.1	0.1
Outside	-	463.0	-	-	243.0	-	220.0	220.0
N - 6-1	58.2	-	819.7	-	-	-761.5	-	-761.5
N - 6-2	-	89.6	-	13.0	-	-	76.6	76.6
N - 7	1,048.0	6.9	4.3	4.8	-	1,043.7	2.1	1,045.8
N - 8-1	3.1	2.3	2.2	1.6	-	0.9	0.7	1.6
N - 8-2	6.6	2.5	4.6	1.8	-	2.0	0.7	2.7
N - 9	-	11.4	-	8.0	-	-	3.4	3.4
N - 10	-	3.9	-	2.7	-	-	1.2	1.2
N - 11								
Inside	146.4	3.3	102.4	2.3	-	44.0	1.0	45.0
Outside	187.1	-	-	-	22.7	164.4	-	164.4
N - 12	2.5	10.4	1.8	7.3	-	0.7	3.1	3.8
N - 13	2.9	16.6	2.0	11.6	-	0.9	5.0	5.9
N - 14								
Inside	16.0	27.8	11.2	19.5	-	4.8	8.3	13.1
Outside	4,316.8	-	-	-	199.5	4,117.3	-	4,117.3
N - 15	-	4.7	-	3.3	-	-	1.4	1.4
Inside Basin	1,609.0	312.3	1,75.9	168.9	-	433.1	143.4	576,5
Outside Basin	4,503.9	463.0	-	-	465.2	4,281.7	220.0	4,501.7
Area Total	6,112.9	775.3	1,175.9	168.9	465.2	4,714.8	363.4	5,078.2

Table H 28 Continued (19)

Seomjin River Basin (1967)

Unit: 10^3 m^3/d

Basin Division	M&I Water Requirement		Return Flow		Local Source	Net Withdrawal		
	Main Depend.	Trib. Depend.	Main	Trib.		Main Depend.	Trib. Depend.	Total
S - 1	-	3.5	-	2.4	-	-	1.1	1.1
S - 2	-	2.2	-	1.2	-	-	1.0	1.0
S - 3	-	2.9	-	1.9	-	-	1.0	1.0
S - 4	-	13.5	-	9.4	-	-	4.1	4.1
S - 5-1	0.2	5.7	0.1	4.0	-	0.1	1.7	1.8
S - 5-2 Outside	-	-	-	-	-	-	-	-
Inside Basin	0.2	27.8	0.1	18.9	-	0.1	8.9	9.0
Outside Basin	-	-	-	-	-	-	-	-
Area Total	0.2	27.8	0.1	18.9	-	0.1	8.9	9.0

Seomjin River Basin (1968)

Unit: 10^3 m^3/d

Basin Division	M&I Water Requirement		Return Flow		Local Source	Net Withdrawal		
	Main Depend.	Trib. Depend.	Main	Trib.		Main Depend.	Trib. Depend.	Total
S - 1	-	3.5	-	2.4	-	-	1.1	1.1
S - 2	-	2.1	-	1.1	-	-	1.0	1.0
S - 3	-	2.9	-	1.9	-	-	1.0	1.0
S - 4	-	13.3	-	9.3	-	-	4.0	4.0
S - 5-1	0.2	5.6	0.1	3.9	-	0.1	1.7	1.8
S - 5-2 Outside	-	-	-	-	-	-	-	-
Inside Basin	0.2	27.4	0.1	18.6	-	0.1	8.8	8.9
Outside Basin	-	-	-	-	-	-	-	-
Area Total	0.2	27.4	0.1	18.6	-	0.1	8.8	8.9

Table H 28 Continued (20)

Seomjin River Basin (1976)

Unit: 10^3 m^3/d

Basin Division	M&I Water Requirement		Return Flow		Local Source	Net Withdrawal		
	Main Depend.	Trib. Depend.	Main	Trib.		Main Depend.	Trib. Depend.	Total
S - 1	-	3.0	-	2.0	-	-	1.0	1.9
S - 2	-	1.8	-	0.8	-	-	1.0	1.0
S - 3	-	2.5	-	1.5	-	-	1.0	1.0
S - 4	-	13.7	-	9.6	-	-	4.1	4.1
S - 5-1	0.6	5.1	0.4	3.6	-	0.2	1.5	1.7
S - 5-2 Outside	33.7	-	-	-	39.8	0	-	0
Inside Basin	0.6	26.1	0.4	17.5	-	0.2	8.6	8.8
Outside Basin	33.7	-	-	-	39.8	0	-	0
Area Total	34.3	26.1	0.4	17.5	39.8	0.2	8.6	8.8

Seomjin River Basin (1981)

Unit: 10^3 m^3/d

Basin Division	M&I Water Requirement		Return Flow		Local Source	Net Withdrawal		
	Main Depend.	Trib. Depend.	Main	Trib.		Main Depend.	Trib. Depend.	Total
S - 1	-	3.8	-	2.6	-	-	1.2	1.2
S - 2	-	3.3	-	2.3	-	-	1.0	1.0
S - 3	-	2.1	-	1.1	-	-	1.0	1.0
S - 4	-	18.5	-	13.0	-	-	5.5	5.5
S - 5-1	2.9	6.0	2.0	4.2	-	0.9	1.8	2.7
S - 5-2 Outside	341.9	-	-	-	54.8	299.4	-	299.4
Inside Basin	2.9	33.7	2.0	23.2	-	0.9	10.5	11.4
Outside Basin	341.9	-	-	-	54.8	299.4	-	299.4
Area Total	344.8	33.7	2.0	23.2	54.8	300.3	10.5	310.8

Table H 28 Continued (21)

Seomjin River Basin (1986)

Unit: 10^3 m^3/d

Basin Division	M&I Water Requirement		Return Flow		Local Source	Net Withdrawal		
	Main Depend.	Trib. Depend.	Main	Trib.		Main Depend.	Trib. Depend.	Total
S - 1	-	3.9	-	2.7	-	-	1.2	1.2
S - 2	-	3.5	-	2.5	-	-	1.0	1.0
S - 3	-	2.0	-	1.0	-	-	1.0	1.0
S - 4	-	19.4	-	13.6	-	-	5.8	5.8
S - 5-1	3.3	6.1	2.3	4.3	-	1.0	1.8	2.8
S - 5-2								
Outside	662.8	-	-	-	54.8	608.0	-	608.0
Inside Basin	3.3	34.9	2.3	24.1	-	1.0	10.8	11.8
Outside Basin	662.8	-	-	-	54.8	608.0	-	608.0
Area Total	701.0	34.9	2.3	24.1	54.8	609.0	10.8	619.8

Seomjin River Basin (1991)

Unit: 10^3 m^3/d

Basin Division	M&I Water Requirement		Return Flow		Local Source	Net Withdrawal		
	Main Depend.	Trib. Depend.	Main	Trib.		Main Depend.	Trib. Depend.	Total
S - 1	-	4.0	-	2.8	-	-	1.2	1.2
S - 2	-	3.6	-	2.5	-	-	1.1	1.1
S - 3	-	1.9	-	0.9	-	-	1.0	1.0
S - 4	-	20.3	-	14.2	-	-	6.1	6.1
S - 5-1	3.8	6.1	2.6	4.3	-	1.2	1.8	3.0
S - 5-2								
Outside	941.0	-	-	-	54.8	886.2	-	886.2
Inside Basin	3.8	35.9	2.6	24.7	-	1.2	11.2	12.4
Outside Basin	941.0	-	-	-	54.8	886.2	-	886.2
Area Total	944.8	35.9	2.6	24.7	54.8	887.4	11.2	898.6

Table H 28 Continued (22)

Seomjin River Basin (1996)

Unit: 10^3 m^3/d

Basin Division	M&I Water Requirement		Return Flow		Local Source	Net Withdrawal		
	Main Depend.	Trib. Depend.	Main	Trib.		Main Depend.	Trib. Depend.	Total
S - 1	-	4.1	-	2.9	-	-	1.2	1.2
S - 2	-	3.9	-	2.7	-	-	1.2	1.2
S - 3	-	1.8	-	0.8	-	-	1.0	1.0
S - 4	-	21.9	-	15.3	-	-	6.6	6.6
S - 5-1	4.3	6.3	3.0	4.4	-	1.3	1.9	3.2
S - 5-2								
Outside	1,174.4	-	-	-	54.8	1,119.6	-	1,119.6
Inside Basin	4.3	38.0	3.0	26.1	-	1.3	11.9	13.2
Outside Basin	1,174.4	-	-	-	54.8	1,119.6	-	1,119.6
Area Total	1,178.7	38.0	3.0	26.1	54.8	1,120.9	11.9	1,132.8

Seomjin River Basin (2001)

Unit: 10^3 m^3/d

Basin Division	M&I Water Requirement		Return Flow		Local Source	Net Withdrawal		
	Main Depend.	Trib. Depend.	Main	Trib.		Main Depend.	Trib. Depend.	Total
S - 1	-	4.3	-	3.0	-	-	1.3	1.3
S - 2	-	4.1	-	2.9	-	-	1.2	1.2
S - 3	-	1.8	-	0.8	-	-	1.0	1.0
S - 4	-	23.4	-	16.4	-	-	7.0	7.0
S - 5-1	4.9	6.5	3.4	4.6	-	1.5	1.9	3.4
S - 5-2								
Outside	1,409.0	-	-	-	54.8	1,354.2	-	1,354.2
Inside Basin	4.9	40.1	3.4	27.7	-	1.5	12.4	13.9
Outside Basin	1,409.0	-	-	-	54.8	1,354.2	-	1,354.2
Area Total	1,413.9	40.1	3.4	27.7	54.8	1,355.7	12.4	1,368.1

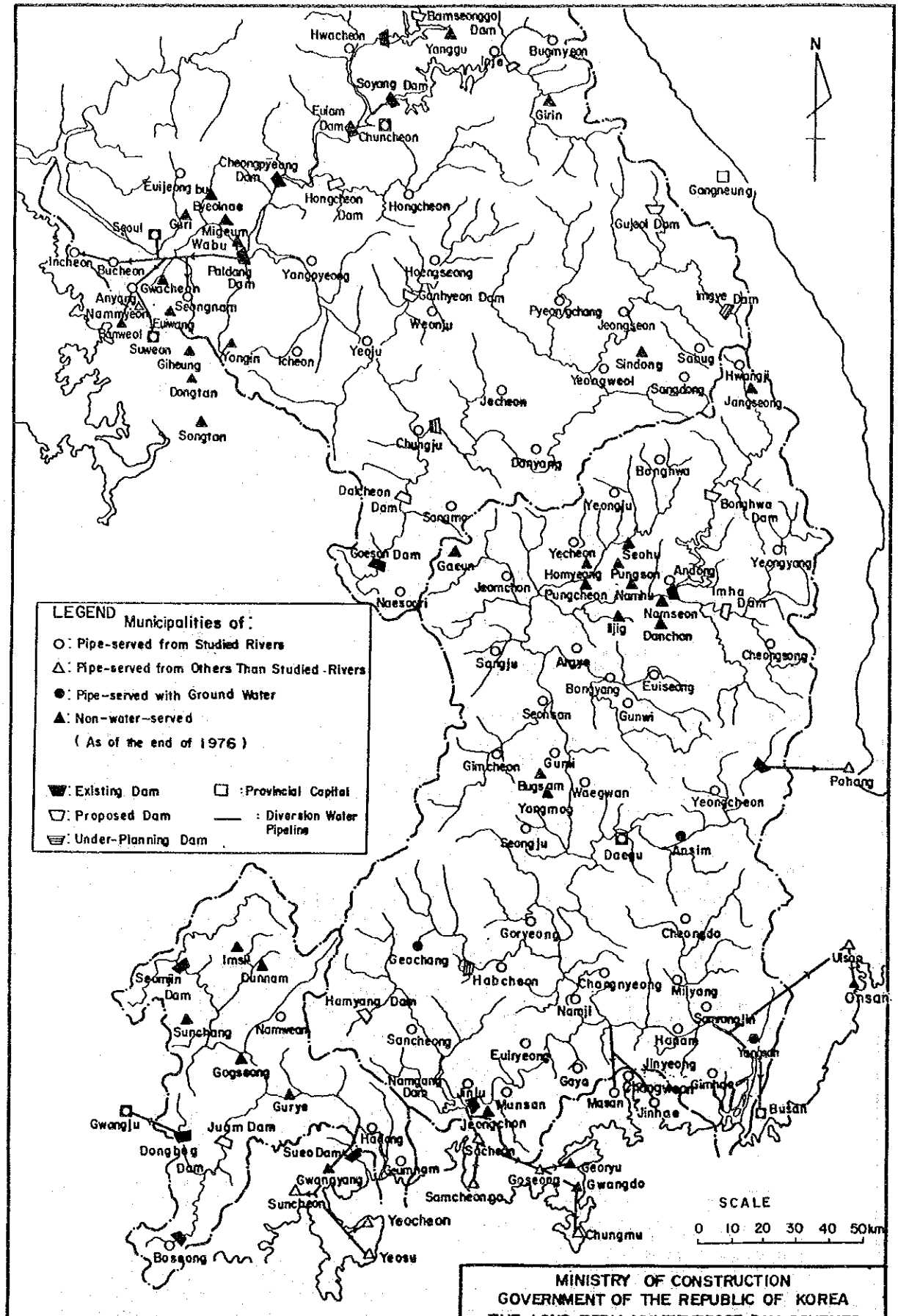

Fig. H I Location of M & I-Water Demand Centers

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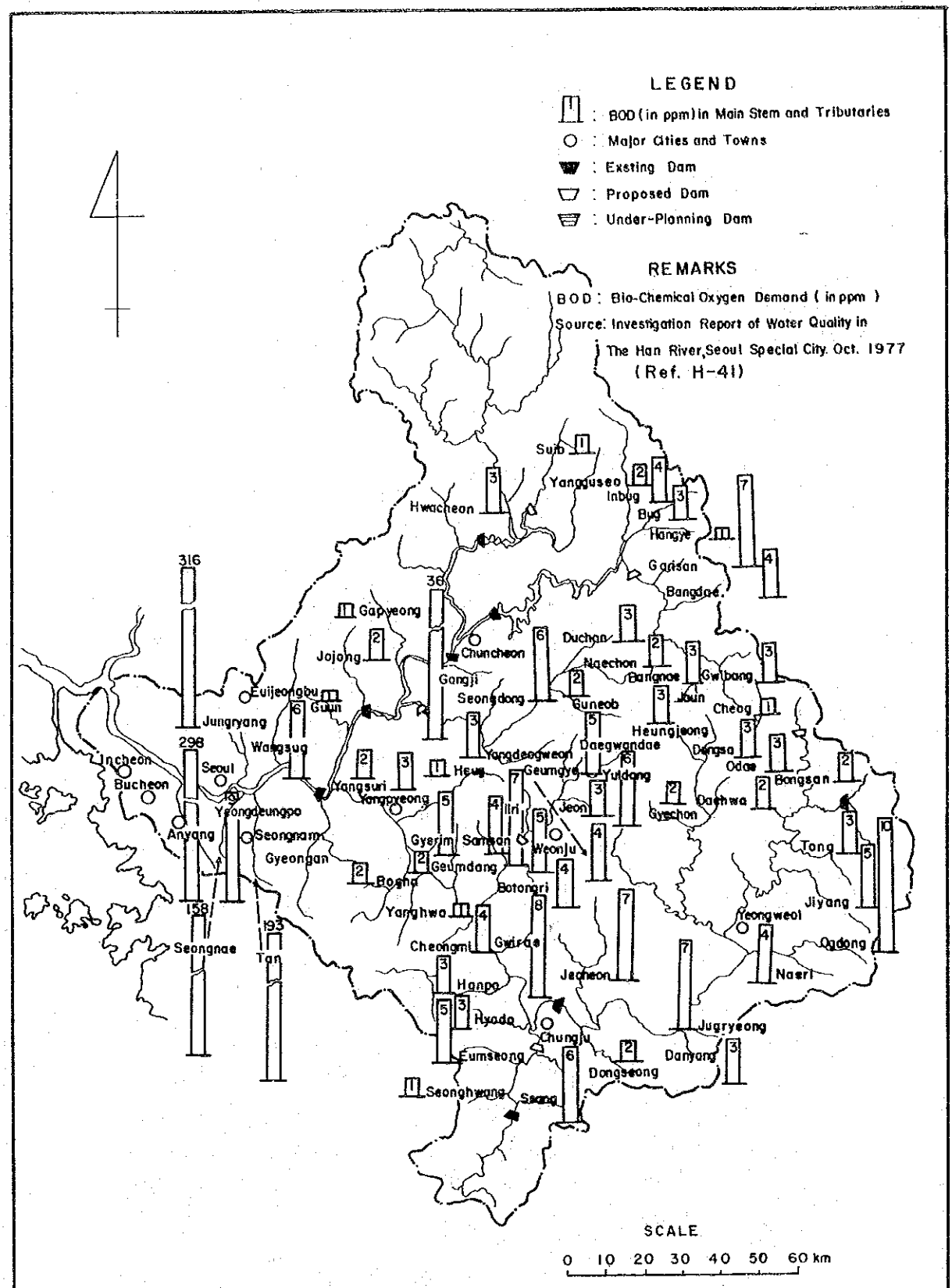

Fig. H 2 BOD in The Han River (1977)

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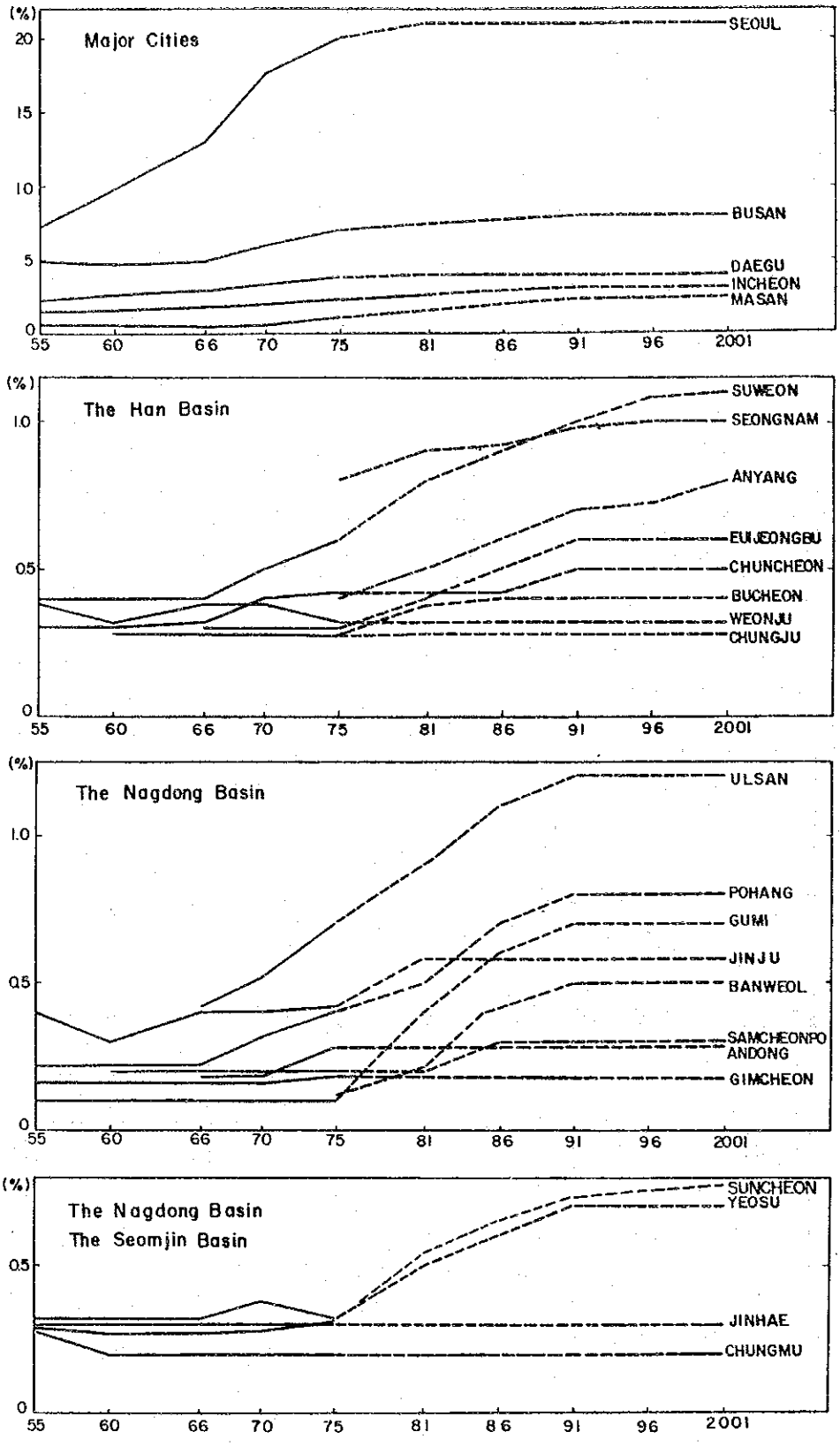

Fig. H3 Population of Cities as Percent of National Population

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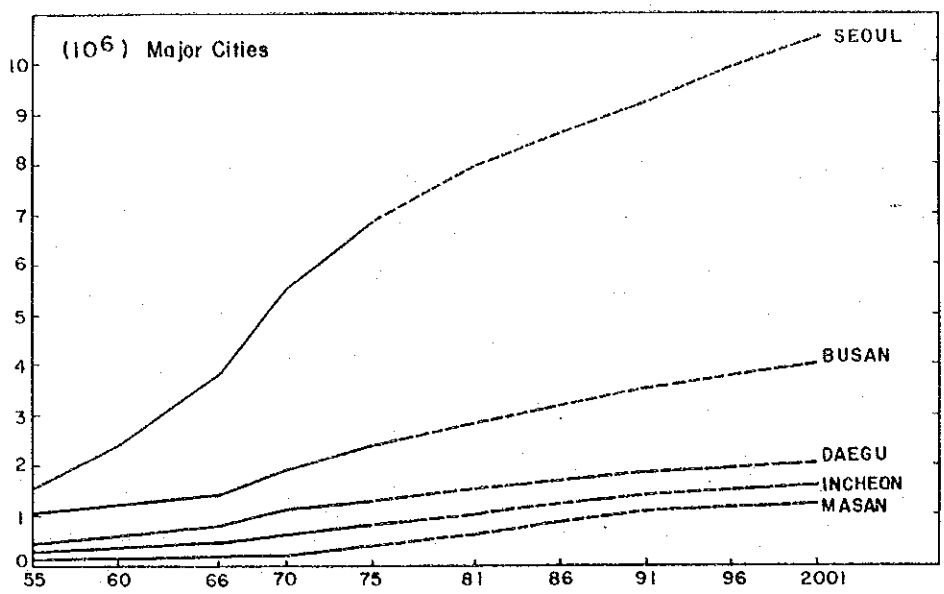

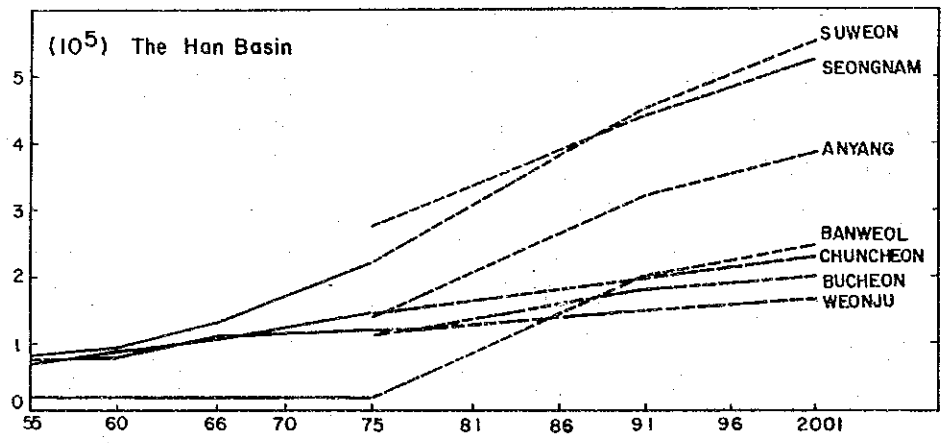

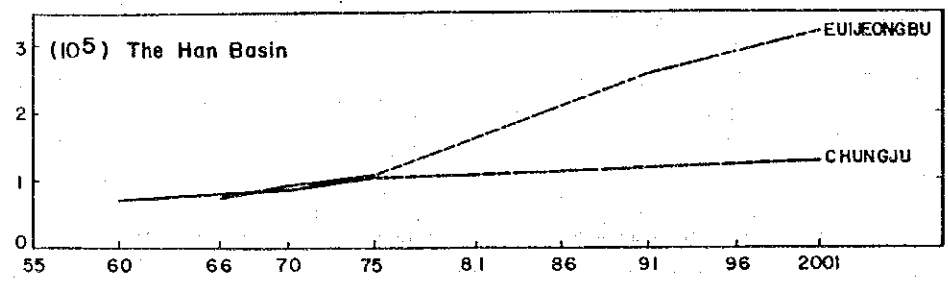

Fig. H 4 (1) Historical and Projected Population of Cities in the Three Basins

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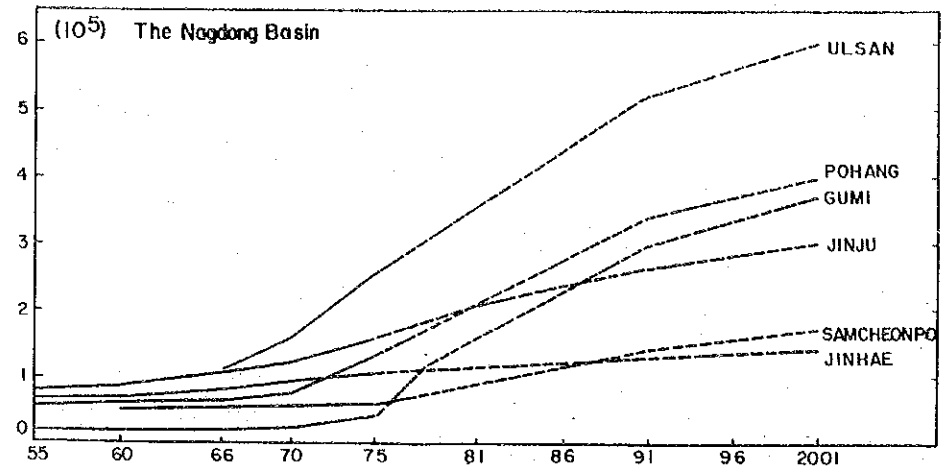

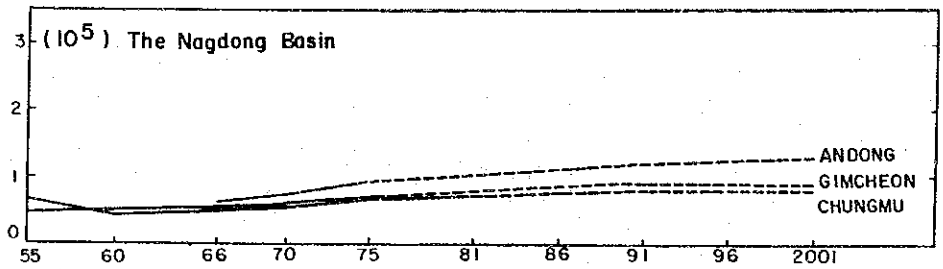

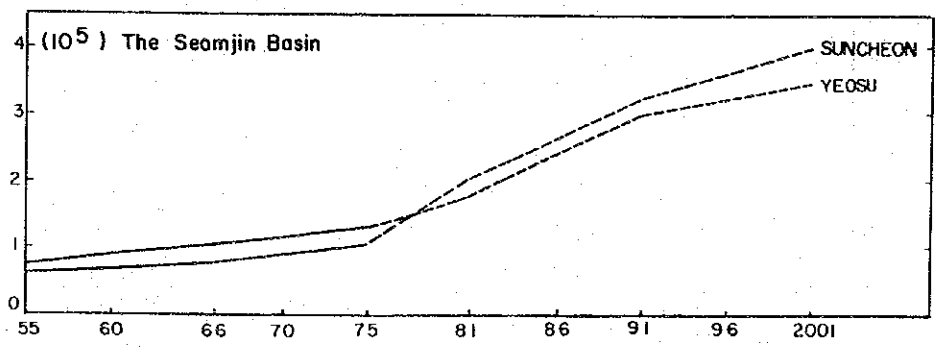

Fig. H 4 (2) Historical and Projected Population of Cities in the Three Basins

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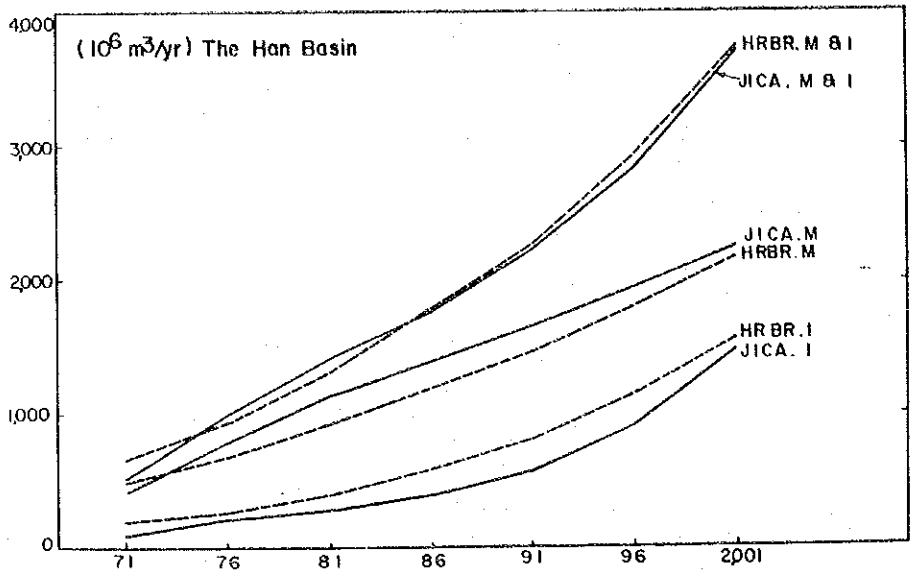

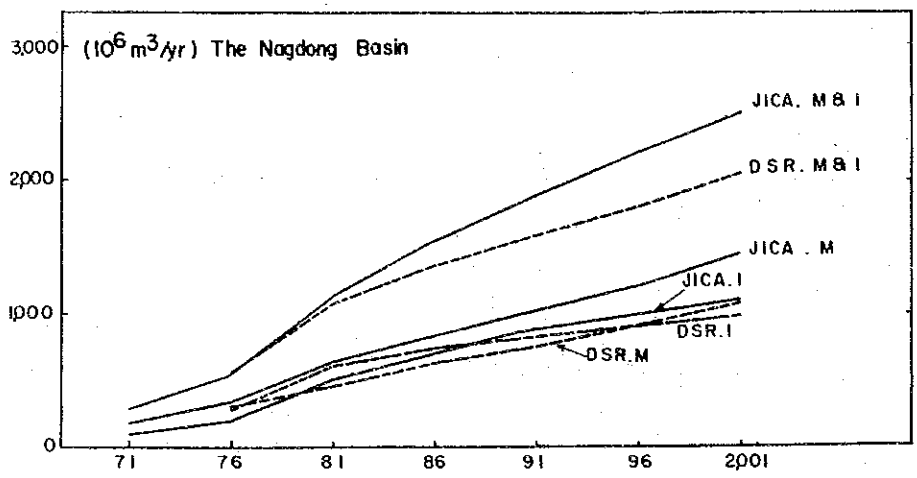

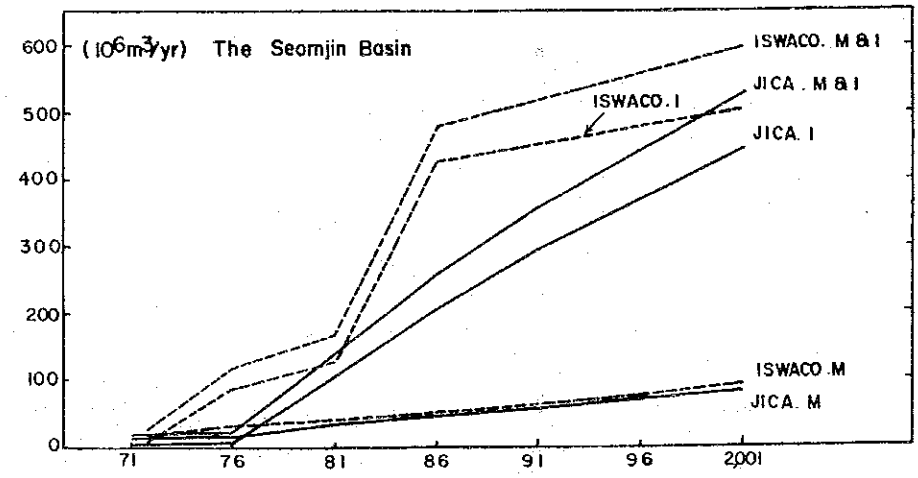

LEGEND

ISWACO : Seomjin River Basin Investigation, ISWACO, 1973
HRBR : Han River Basin Report, USBR, 1971
D S R : Nagdong River Basin Delta Study, UNDP/FAO, 1976

Fig. H 5 M & I Water Requirement in Three Basins

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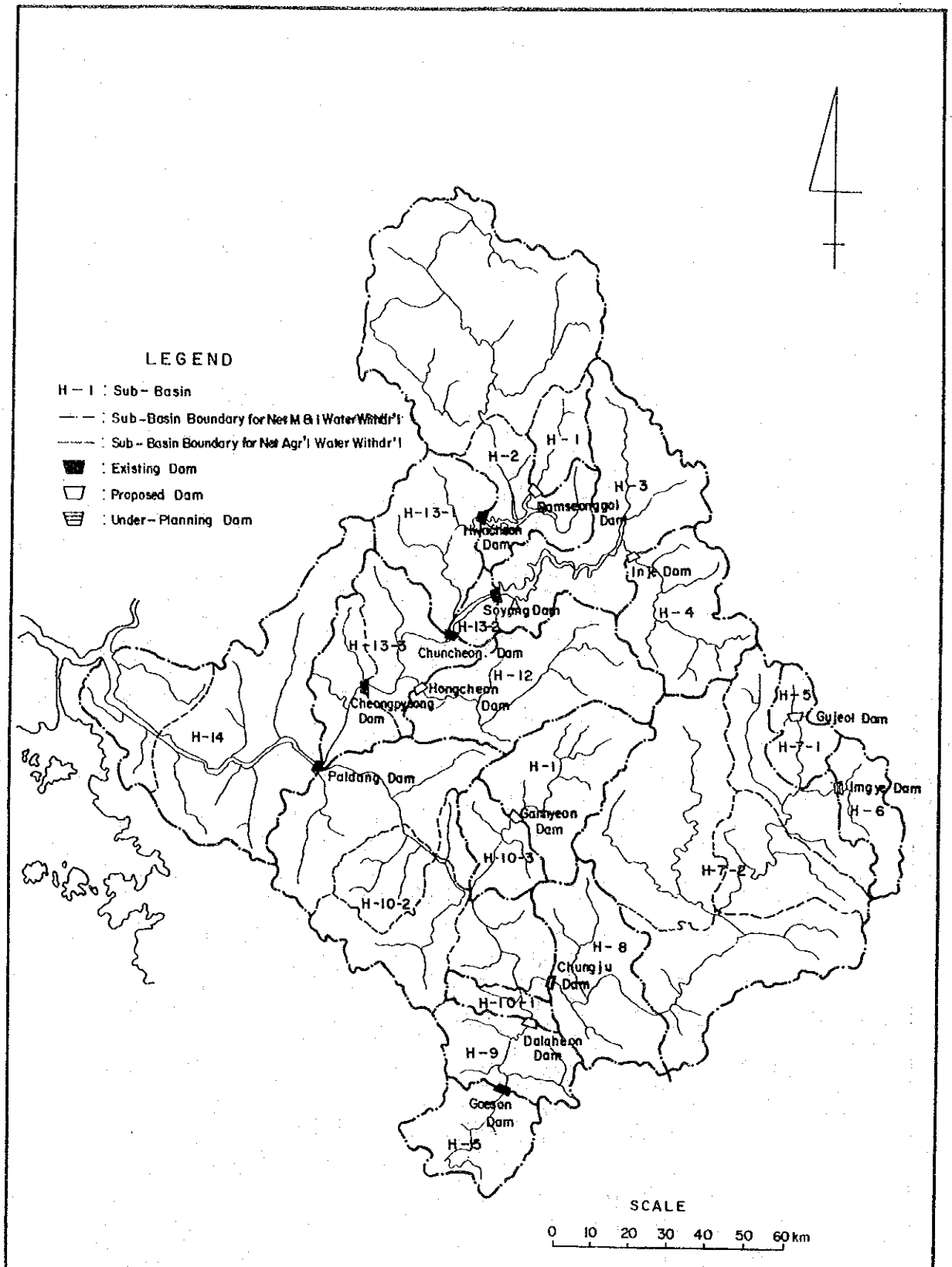

Fig. H 6 (1) Basin-Divisions of The Han River for Water Budget

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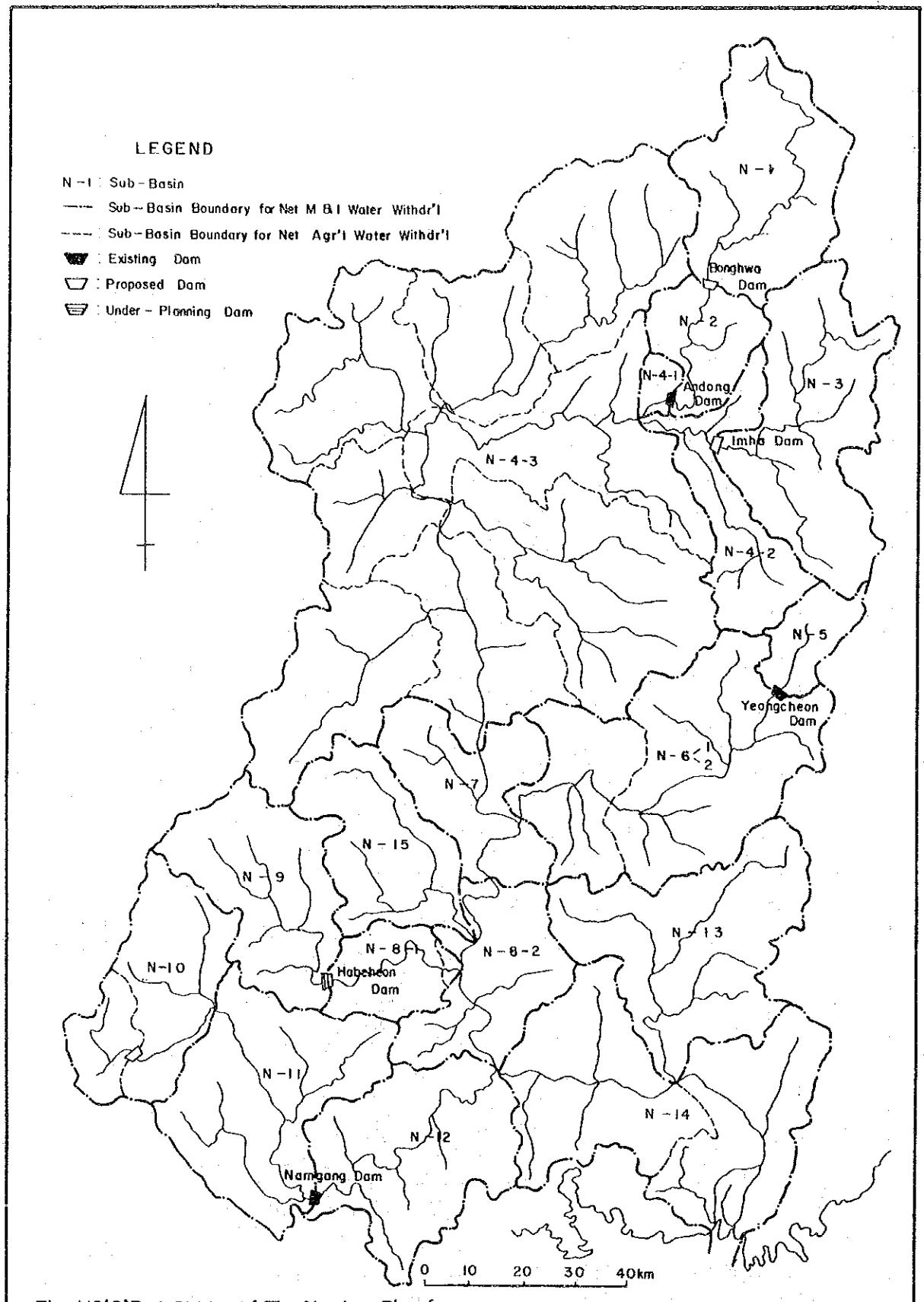

Fig. H6(2) Basin Divisions of The Nagdong River for Water Budget

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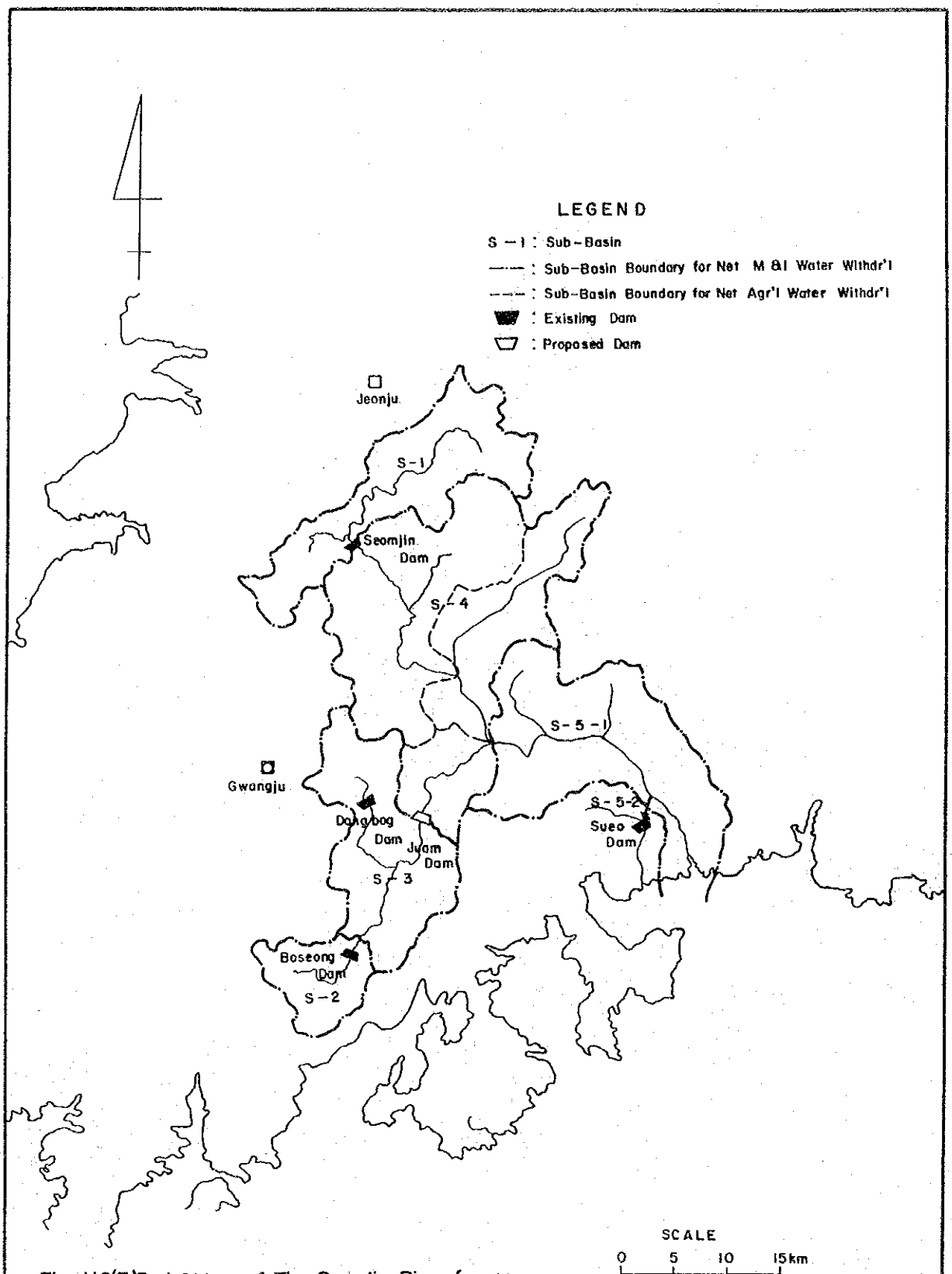

Fig. H6(3) Basin Divisions of The Seomjin River for Water Budget

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A N N E X I

ALTERNATIVE SOURCES

FOR M & I WATER SUPPLY

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I 1 INTRODUCTION

This ANNEX presents the results of study on the alternative dams for M&I water supply. Consisting of search of possible damsites, study on their development scales, construction cost estimate and cost of water. The Yeonggye dam on the Isa river and its associated pipeline to the Gwangyang area of the Honan Industrial Estates was studied as the M&I alternative scheme of the Juam dam.

Data involved in this ANNEX were utilized to estimate M&I water supply benefit of the proposed dam schemes in ANNEX Q.

I 2 ALTERNATIVE DAMS

Through investigation on the maps in scale of 1:50,000 covering the Han, Nagdong, Seomjin river basins and neighboring basin of the Seomjin river basin, six alternative damsites in the Han river basin and 12 damsites in the Nagdong river basin were selected as the alternative dams for M&I water supply. No appropriate alternative damsite was found within the Seomjin river basin. The Yeonggye dam in the Isa river basin was selected as the alternative dam of M&I water supply of the Juam dam. Location of the selected 19 alternative dams is shown in Fig. I 1.

The inflow into each alternative damsite was estimated referring to the annual rainfall and specific run-off of the basin. Scale of the alternative dam was selected so that the draft from the reservoir was 80 % or so of the annual inflow, unless the scale of dam was restricted by the topographical and/or social constraints. The net water supply capacity was calculated on the basis of variable draft operation.

I 3 CONSTRUCTION COST AND O & M COST

All the dimensions of the alternative dams for M&I water supply were measured on the maps of 1:25,000.

Dam volume was calculated from the following formula, which was derived from the precedents of many dams.

$$V = \frac{1}{2}aH^2 \left\{ B + \frac{1}{3}(L - B) \right\} \quad \text{for concrete gravity dam}$$

$$V = 2.5aH^2 \left\{ B + \frac{1}{3}(L - B) \right\} \quad \text{for rockfill dam}$$

where, V = dam volume (m^3)

a = coefficient varying between 0.9 and 1.3 depending on location of dam and dam height. For a dam locating in the lower reach of the main stream with a large catchment area and a large design flood, the higher value of a was applied.

H = dam height (m)

B = bottom width of the river at damsite (m), and

L = dam crest length (m).

Weight of spillway gates was assumed to be 0.16 times the design flood, which was estimated from the following formula.

$$Q = qA$$

$$q = CA^{(A^{-0.05} - 1)}$$

where, Q = design flood (m^3/sec),

q = historical maximum specific flood run-off ($m^3/sec \cdot km^2$),

A = catchment area (km^2) and

C = regional coefficient

The regional coefficient was assumed to be 55 in the Han river basin and at 44 in the Nagdong and Isa river

basins, based on the study of ANNEX C and the analysis of the existing dams in Korea.

Direct construction cost was divided into cost of civil works and cost of metalworks. The cost of civil works of the alternative dam was estimated applying a unit price per dam volume which was derived from the estimated costs of the ten proposed dams, ranging between $ 55/m^3 and $ 70/m^3 of dam volume for the concrete gravity dam and $ 14/m^3 of dam embankment volume for the rockfill dam. For concrete gravity dams locating on the main stream with the catchment area of more than 1,000 km^2 and a relatively low dam height, a unit price of $ 70/m^3 was applied. For the concrete gravity dams locating on the tributaries with the catchment area less than 1,000 km^2 and having a relatively high dam height, a unit price of $ 55/m^3 was applied.

The cost of metalworks was estimated applying the unit cost per weight of spillway gate; $ 7,500/ton, including costs of river outlet facilities and flood forecasting system.

The relocation cost of road, railway and other ground facilities in the reservoir area was estimated through investigation on the maps of 1:25,000.

The engineering and administration cost was assumed to be 10 % of the direct construction cost. The contingency was assumed to be 20 % of all the construction costs.

The costs estimated above were the financial costs. The economic cost, which was used in the project evaluation, was obtained by deducting 5 % which was regarded as the transfer payment from the financial cost.

Operation and maintenance cost of the alternative dams were assumed to be 0.5 % of the investment cost.

I 4 PRINCIPAL FEATURE OF M&I ALTERNATIVE DAMS

The principal feature of M&I alternative dams is summarized in Table I 1. The cost of water in the table was indicatively calculated as the annual equivalent of costs including the investment cost, replacement cost, O & M cost and production foregone divided by a product of the net water supply capacity and the number of second in the year.

I 5 YEONGGYE M&I ALTERNATIVE DAM AND M&I PIPELINE SYSTEM

It was assumed that the outflow from the Yeonggye dam in the Isa river will be totally supplied to Gwangyang, becuase the projected M&I water demand is quite little with in the Seomjin river basin and Gwangyang will be the largest demand center out of the basin in the future. Water will be conveyed by gravity through a 36 km long pipeline from the Yeonggye dam to Gwangju (Yeonggye-Gwangyang pipeline).

If the Yeonggye dam is operated for the constant draft, the net water supply capacity of the Yeonggye dam will be 2.1 m^3/s and Yeonggye-Gwangyang pipeline will be one line with 1,500 mm dia. pipe.

If the Yeonggye dam is operated only in the periods in which water deficit occurs in the Seomjin river and water is taken from nearby the existing intake of the Yeoncheon/Gwangyang Water Supply System in the non-deficit period (variable draft operation), the net water supply capacity of the Yeonggye dam will be 6.2 m^3/s. The Yeonggye-Gwangyang pipeline will consist of two lines of 1,760 mm dia. pipe. Furthermore, a pipeline will be needed between the intake in the Seomjin river and Gwangyang (Hadong-Gwangyang pipeline) for the water supply in the non-deficit period.

The outline of the Yeonggye-Gwangyang pipeline and Hadong-Gwangyang pipeline is shown in Tables I 2 and I 4. Note that the nominal discharge capacity of the Yeonggye-Gwangyang pipeline is equal to the net M&I water supply capacity of the Yeonggye dam, but the nominal capacity of the Hadong-Gwangyang pipeline is different in the table. This is because the latter was determined for some stages of construction assuming that a number of M&I alternative dams of variable draft operation are constructed in stages each having the same capacity as the Yeonggye dam.

The financial investment cost, replacement cost and O & M cost are summarized in Table I 3 for the Yeonggye dam and Yeonggye-Gwangyang pipeline and in Table I 5 for the Hadong-Gwangyang pipeline, respectively.

An economic comparison of the costs of the Yeongge M&I alternative dam including the associated pipeline facilities for the constant draft operation and variable draft operation is shown in Table I 6. The Yeonggye dam and its associated facilities based on the variable draft operation was taken up as the M&I alternative facilities for the proposed Juam dam, because of lower annual equivalent of cost per net M&I water supply capacity compared with that based on the constant draft operation at a discount rate of 8 %.

A layout of the Yeonggye dam and its associated pipeline systems was prepared based on the constant draft operation as shown in Fig. I 2.

I 6 CASH FLOW OF ALTERNATIVE DAMS

Nine alternative dams were used for evaluation of M&I water supply benefit of the proposed dams among the 19 studied alternative dams. Their cash flow is shown in Table I 7.

Table I 1 PRINCIPAL FEATURE OF ALTERNATIVE DAMS FOR M&I WATER SUPPLY

Han River Basin

Name of dam		Weonseong A	Weonseong B	Janghoweon	Yeoju	Gwangju I	Gwangju II
Catchment area	km^2	8,848 (2,200)	10,487 (3,839) /1	399	11,926 (5,278) /1	284	154
Annual run-off	10^6 m^3	971 /2	2,160 /2	290	3,678 /2	221	120
High water surface	El. m	62	62	81	40	65	76
Drawdown	m	7	4	7	2	18	16
Active storage	10^6 m^3	220	235	223	61	232	97
Surface area	km^2	50	73	38	40	21	10
Dam type	-	CG	CG	CG + R	CG	CG	CG
Dam height	m	35	35	31	29	45	48
Dam crest length	m	570	550	460 + 1,700	620	370	480
Dam volume	10^3 m^3	385	365	115 + 687	306	238	287
Economic investment cost							
Civil works	\$ 10^6	33.79	32.04	16.55	26.86	16.42	19.80
Metal works	\$ 10^6	28.11	30.25	8.15	32.45	7.02	5.23
Relocation of ground facilities	\$ 10^6	4.39	10.45	1.88	3.76	4.86	7.79
Total	\$ 10^6	66.29	72.74	26.58	63.07	28.30	32.82
Economic O & M cost	\$ 10^3/y	310	312	124	296	117	125
Production foregone	\$ 10^3/y	1,551	5,031	3,303	3,474	1,779	847
Net supply capacity	m^3/s	34.7	44.4	17.1	8.2	14.4	7.4
Cost of water	mill/m^3	7.7	9.0	11.2	39.0	10.3	17.8

Remarks; /1: Deducting Chungju dam catchment area
/2: Deducting inflow to Chungju dam
Weonseong A and Weonseong B are mutually exclusive alternative.

Table I 1 Continued (2)

Nagdong River Basin (i)

Name of dam		Pyeongeun	Bomun	Gilan	Nagdong	Mungyeong	Gunwi
Catchment area	km^2	455	1,111	372	5,773	523	563
Annual run-off	10^6 m^3	271	665	224	2,600	312	337
High water surface	El. m	180	135	245	80	150	95
Drawdown	m	17	23	45	18	25	15
Active storage	10^6 m^3	244	674	198	1,335	290	260
Surface area	km^2	22	50	8	129	22	25
Dam type	-	CG	CG	R	CG	CG	CG
Dam height	m	46	58	85	46	72	52
Dam crest length	m	450	500	330	480	270	400
Dam volume	10^3 m^3	436	606	3,070	495	428	487
Economic investment cost							
Civil works	$ 10^6	32.80	53.19	53.89	43.45	32.20	36.64
Metal works	$ 10^6	6.62	9.89	7.11	21.00	7.85	7.28
Relocation of ground facilities	$ 10^6	18.86	43.57	2.51	25.34	2.51	13.58
Total	$ 10^6	58.28	106.65	63.51	89.79	42.56	57.49
Economic O & M cost	$ 10^3/y	198	315	305	322	200	219
Production foregone	$ 10^3/y	447	839	113	5,052	511	767
Net supply capacity	m^3/s	7.8	22.5	7.3	43.6	10.2	10.4
Cost of water	mill/m^3	25.6	16.1	28.5	10.3	15.1	20.0

Table I 1 Continued (3)

Nagdong River Basin (ii)

Name of dam		Gimcheon	Gaya	Goryeong	Daecheon	Dajang	Sancheong
Catchment area	km^2	295	126	763	300	310	422
Annual run-off	10^6 m^3	177	91	549	183	186	296
High water surface	El. m	145	255	55	160	85	80
Drawdown	m	22	45	20	30	29	20
Active storage	10^6 m^3	106	66	750	183	154	360
Surface area	km^2	8	2	51	10	8	30
Dam type	-	CG	CG	CG	CG	CG	CG & R
Dam height	m	56	100	50	60	62	47
Dam crest length	m	400	620	390	480	670	650
Dam volume	10^3 m^3	494	1,467	455	662	1,361	502 + 41
Economic investment cost							
Civil works	\$ 10^6	37.16	110.38	39.94	53.96	102.40	38.28
Metal works	\$ 10^6	5.92	3.72	8.81	4.73	4.83	6.83
Relocation of ground facilities	\$ 10^6	2.51	1.25	7.52	3.76	2.51	3.76
Total	\$ 10^6	45.59	115.36	56.27	62.45	109.73	48.88
Economic O & M cost	\$ 10^3/y	216	570	243	294	536	225
Production foregone	\$ 10^3/y	78	14	1,979	138	128	1,099
Net supply capacity	m^3/s	4.3	2.4	19.2	5.6	5.4	9.0
Cost of water	$mill/m^3$	34.7	153.4	12.7	36.4	66.0	21.4

Table I 1 Continued (4)

Alternative dam for M&I water supply of Juam dam

Name of dam		Yeonggye
River system		1 sa
Catchment area	km^2	133
Annual run-off	10^6 m^3	120
High water surface	El. m	90
Drawdown	m	30
Active storage	10^6 m^3	93.8
Surface area	km^2	4.7
Dam type	-	CG
Dam height	m	70
Dam crest length	m	365
Dam volume	10^3 m^3	445
Economic investment cost		
Civil works	\$ 10^6	33.48
Metal works	\$ 10^6	3.04
Relocation of ground facilities	\$ 10^6	1.44
Total	\$ 10^6	37.96
Economic O & M cost	\$ 10^3/y	182
Production foregone	\$ 10^3/y	70
Net supply capacity	m^3/s	6.2
Cost of water	mill/m^3	20.0

Table I 2 OUTLINE OF M&I PIPELINE SYSTEM ASSOCIATED WITH THE YEONGGYE DAM

Operation Method		Constant draft	Variable draft
1. Net Water Supply Capacity	(m^3/s)	2.1	6.2
2. Yeonggye-Gwangyang Pipeline			
2.1 Nominal capacity	(10^3 m^3/d)	177	268
2.2 Dimensions	(D mm x L km)	1,500 x 36	1,760 x 36
2.3 Number of lines	(nos)	1	2
2.4 Primary treatment plant	(10^3 m^3/d)	212	322

Table I 3 FINANCIAL COSTS OF YEONGGYE DAM AND YEONGGYE-GWANGYANG PIPELINE

Unit: $ 10^6

Operation Method	Constant draft	Variable draft
1. Investment Cost		
1.1 Yeonggye dam		
Civil work	26.70	26.70
Metalwork	2.42	2.42
Compensation on ground facilities	1.26	1.26
Compensation on land	5.00	5.00
Engineering	2.91	2.91
Contingency	7.66	7.66
Sub-total	45.95	45.95
1.2 Yeonggye-Gwangyang Pipeline		
Trunk main	11.44	27.04
Primary treatment plant	1.52	4.62
Regulating pond	0.97	2.94
Distribution main	1.93	5.87
Land compensation	0.40	0.90
Engineering	0.79	2.02
Contingency	3.41	8.68
Sub-total	20.46	52.07
Total	66.41	98.02
2. Replacement Cost		
2.1 Yeonggye dam	2.88	2.88
2.2 Yeonggye-Gwangyang Pipeline	16.35	40.59
3. O & M Cost		
3.1 Yeonggye dam		
Fixed cost	0.19	0.19
3.2 Yeonggye-Gwangyang Pipeline	Full supply	155 days supply
Fixed cost	0.22	0.70
Material cost	0.10	0.13
Energy cost	-	-
Total	0.32	0.83

Table I 4 OUTLINE OF HADONG-GWANGYANG PIPELINE SYSTEM ASSOCIATED WITH ALTERNATIVE YEONGGYE DAM

1.	Order of Construction		1	2	3
2.	Scope		Extension of existing system	New pipeline	Extension of new pipeline
3.	Discharge Capacity (10^3 m^3/d)		300	320	320
4.	Intake Pump				
	4.1 Capacity	(ps)	8,100	7,000	7,000
	4.2 Water head	(m)	68	56	56
5.	Tunnel				
	5.1 Discharge capacity (10^3 m^3/d)		-	768	-
	5.2 Dimensions	(D m x L km)	-	2.5 x 1.5	-
6.	Pipeline				
	6.1 Route		Sueo dam -Gwangyang	Hadong -Gwangyang	Hadong -Gwangyang
	6.2 Trunk main	(D mm x L km)	1,750 x 15.4	1,800 x 17.5	1,800 x 17.5
	6.3 Primary treatment plant	(10^3 m^3/d)	360	384	384
	6.4 Distribution main	(D mm x L km)	1,200 x 10	1,200 x 10	1,200 x 10

Table I 5 FINANCIAL COST OF HADONG-GWANGYANG PIPELINE SYSTEM ASSOCIATED WITH ALTERNATIVE YEONGGE DAM

Unit: $ 10^6

Order of Construction	1	2	3
1. Investment Cost			
Intake weir	0.65	-	-
Intake & pump	4.62	3.62	3.62
Tunnel	7.93	9.28	9.28
Trunk main	-	1.17	-
Primary treatment plant	2.60	2.75	2.75
Regulating pond	1.64	1.76	1.76
Distribution main	3.50	3.50	3.50
Transmission line & substation	0.50	0.87	0.38
Land compensation	0.40	0.50	0.40
Engineering	1.07	1.14	1.06
Contingency	4.59	4.92	4.55
Total	27.50	29.51	27.30
2. Replacement Cost	17.60	19.20	18.50
3. O & M Cost (210 days operation)			
Fixed cost	0.48	0.48	0.44
Material cost	0.09	0.11	0.11
Energy cost	0.60	0.53	0.53
Total	1.17	1.12	1.08

4. O & M Cost of Yeocheon/Gwangyang existing M&I Water Supply Pipeline System with assumed deficit period of 52 days where withdrawal at Hadong intake limited to 1.8 m^3/s.

Fixed cost	0.74
Material cost	0.14
Energy cost	2.02
Total	2.90

Table I 6 ECONOMIC COMPARISON OF YEONGGYE DAM BY OPERATION METHOD

Operation Method		Constant draft	Variable draft
1. Net Water Supply Capacity	(m^3/s)	2.1	6.2
2. Economic Cost			
2.1 Investment cost			
Yeonggye dam	($\$ 10^6$)	38.0	38.0
Yeonggye-Gwangyang pipeline	($\$ 10^6$)	19.4	49.5
Hadong-Gwangyang pipeline	($\$ 10^6$)	-	45.2
Total	($\$ 10^6$)	57.4	132.7
2.2 Replacement Cost			
Yeonggy dam	($\$ 10^6$)	2.7	2.7
Yeonggye-Gwangyang pipeline	($\$ 10^6$)	15.5	38.6
Hadong-Gwangyang pipeline	($\$ 10^6$)	-	30.0
Total	($\$ 10^6$)	18.2	71.3
2.3 O & M Cost			
Yeonggye dam			
Fixed cost	($\$ 10^6$)	0.18	0.18
Yeonggye-Gwangyang pipeline		Full supply	15 days supply
Fixed cost	($\$ 10^6$)	0.22	0.70
Material cost	($\$ 10^6$)	0.10	0.13
Energy cost	($\$ 10^6$)	-	-
Sub-total	($\$ 10^6$)	0.32	0.83
Hadong-Gwangyang pipeline			210 days operation
Fixed cost	($\$ 10^6$)	-	0.77
Material cost	($\$ 10^6$)	-	0.18
Energy cost	($\$ 10^6$)	-	0.89
Sub-total	($\$ 10^6$)	-	1.84
Total	($\$ 10^6$)	0.50	2.85
2.4 Production foregone			
Yeonggye dam	($\$ 10^6$)	0.07	0.07
3. Annual Equipment of Economic Cost			
Capital cost	($\$ 10^6$)	5.46	12.33
O & M cost	($\$ 10^6$)	0.50	2.85
Production foregone	($\$ 10^6$)	0.07	0.07
Total	($\$ 10^6$)	6.03	15.25
4. Unit Cost/Capacity	(mill/m^3)	91.0	78.0

Remarks: Cost of the Hadong-Gwangyang pipeline (sum of 2 and 3 in order of construction in Table I 5) reduced by the ratio of 0.838 (= net water supply capacity/nominal capacity, see Tables I 2 and I 4).

Table I 7 CASH FLOW OF ALTERNATIVE DAMS FOR M&I WATER SUPPLY

Unit: $ 10^6

Weonseong - B (Han Basin)

No. of Year	Investment Cost	O & M Cost	Production Foregone
1	9.10	-	-
2	18.18	-	-
3	18.18	-	-
4	18.18	-	-
5	9.09	-	-
6 - 30	-	0.31	5.03
31	3.40	0.31	5.03
32	6.81	.	.
33	6.81	.	.
34	6.81	.	.
35	3.40	0.31	5.03
36 - 50	-	0.31	5.03

Janghaweon (Han Basin)

No. of Year	Investment Cost	O & M Cost	Production Foregone
1	3.32	-	-
2	6.65	-	-
3	6.65	-	-
4	6.65	-	-
5	3.31	-	-
6 - 30	-	0.12	3.30
31	0.93	0.12	3.30
32	1.83	.	.
33	1.83	.	.
34	1.83	.	.
35	0.92	0.12	3.30
36 - 50	-	0.12	3.30

Table I 7 Continued (2)

Unit: $ 10^6

Yeoju (Han Basin)

No. of Year	Investment Cost	O & M Cost	Production Foregone
1	7.88	-	-
2	15.77	-	-
3	15.77	-	-
4	15.77	-	-
5	7.88	-	-
6 - 30	-	0.30	3.47
31	3.66	0.30	3.47
32	7.30	.	.
33	7.30	.	.
34	7.30	.	.
35	3.65	0.30	3.47
36 - 50	-	0.30	3.47

Gwangju (Han Basin)

No. of Year	Investment Cost	O & M Cost	Production Foregone
1	3.53	-	-
2	7.08	-	-
3	7.08	-	-
4	7.08	-	-
5	3.53	-	-
6 - 30	-	0.12	1.78
31	0.79	0.12	1.78
32	1.58	.	.
33	1.58	.	.
34	1.58	.	.
35	0.79	0.12	1.78
36 - 50	-	0.12	1.78

Table I 7 Continued (3)

Unit: $ 10^6

Gwangju II (Han Basin)

No. of Year	Investment Cost	O & M Cost	Production Foregone
1	4.10	-	-
2	8.21	-	-
3	8.21	-	-
4	8.21	-	-
5	4.10	-	-
6 - 30	-	0.13	0.85
31	0.59	0.13	0.85
32	1.18	.	.
33	1.18	.	.
34	1.18	.	.
35	0.59	0.13	0.85
36 - 50	-	0.13	0.85

Mungyeong (Nagdong Basin)

No. of Year	Investment Cost	O & M Cost	Production Foregone
1	5.32	-	-
2	10.65	-	-
3	10.64	-	-
4	10.64	-	-
5	5.32	-	-
6 - 30	-	0.20	0.51
31	0.88	0.20	0.51
32	1.77	.	.
33	1.77	.	.
34	1.77	.	.
35	0.88	0.20	0.51
36 - 50	-	0.20	0.51

Table I 7 Continued (4)

Unit: $ 10^6

Gimcheon (Nagdong Basin)

No. of Year	Investment Cost	O & M Cost	Production Foregone
1	5.70	-	-
2	11.40	-	-
3	11.40	-	-
4	11.40	-	-
5	5.70	-	-
6 - 30	-	0.22	0.08
31	0.67	0.22	0.08
32	1.33	.	.
33	1.33	.	.
34	1.33	.	.
35	0.67	0.22	0.08
36 - 50	-	0.22	0.08

Goryeong (Nagdong Basin)

No. of Year	Investment Cost	O & M Cost	Production Foregone
1	7.03	-	-
2	14.07	-	-
3	14.07	-	-
4	14.07	-	-
5	7.03	-	-
6 - 30	-	0.24	1.98
31	1.00	0.24	1.98
32	1.98	.	.
33	1.98	.	.
34	1.98	.	.
35	0.99	0.24	1.98
36 - 50	-	0.24	1.98

Table I 7 Continued (5)

Unit: $ 10^6

Hypothetical Yeonggye (Seomjin Basin)

No. of Year	Investment Cost	O & M Cost	Production Foregone
1	4.74	-	-
2	9.49	-	-
3	9.49	-	-
4	9.49	-	-
5	4.75	-	-
6 - 30	-	0.18	0.07
31	0.35	0.18	0.07
32	0.68	.	.
33	0.68	.	.
34	0.68	.	.
35	0.35	0.18	0.07
36 - 50	-	0.18	0.07

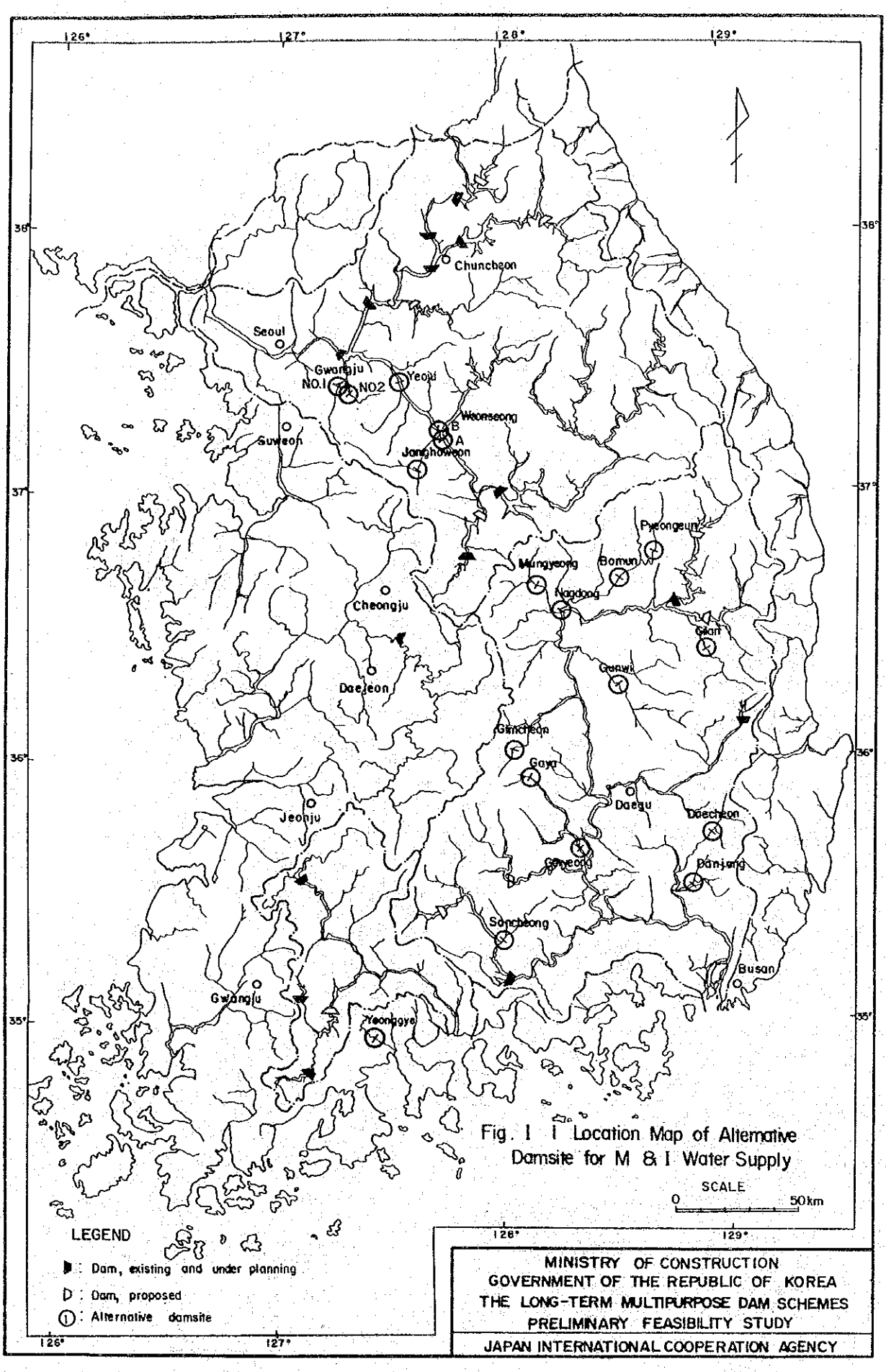

Fig. I 1 Location Map of Alternative Damsite for M & I Water Supply

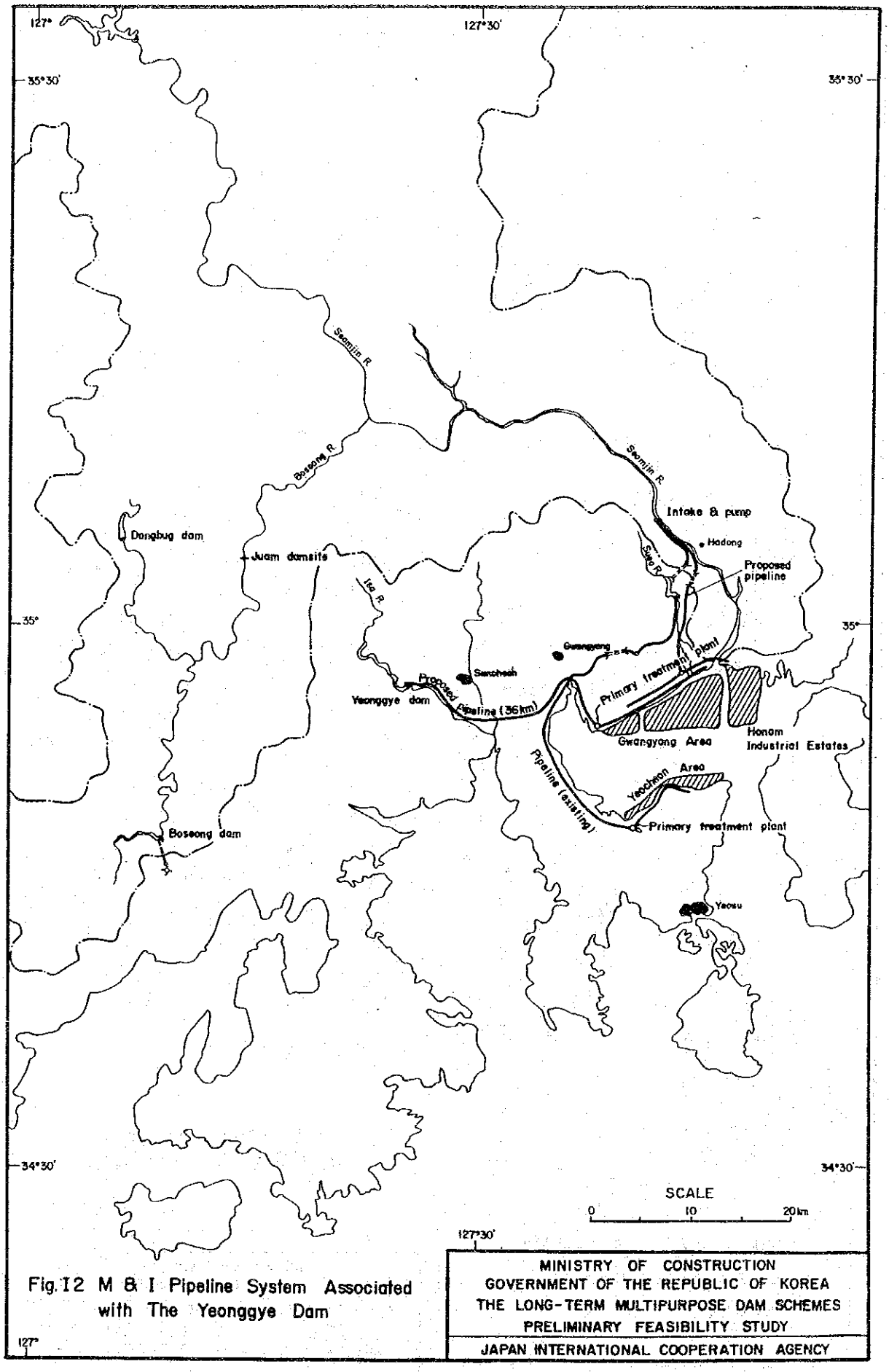

Fig. I2 M & I Pipeline System Associated with The Yeonggye Dam

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GOVERNMENT OF THE REPUBLIC OF KOREA
THE LONG-TERM MULTIPURPOSE DAM SCHEMES
PRELIMINARY FEASIBILITY STUDY
JAPAN INTERNATIONAL COOPERATION AGENCY

A N N E X J

POWER MARKET

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J 1 INTRODUCTION

This ANNEX presents the results of power market survey including the studies on the present power situation, prospective power demand, power development plan and cost of alternative power.

J 2 PRESENT POWER SYSTEM

J 2.1 Existing Power System

Korea Electric Company (KECO) supplies electric power covering the whole country including some isolated system (Fig. J 1). Some power plants are operated by ISWACO and private owners.

J 2.2 Generating Facilities in KECO System

Power generation facilities of KECO system at the end of 1977 are shown in Table J 1. The installed capacities are summarized by type in Table J 2. Out of the total installed capacity of 5,781 MW, thermal power stands for 87.9 %. The majority is oil fired units of 100 to 300 MW. They are operated at a high efficiency, having been installed recently. Old generating facilities of 210 MW including some of coal-fired units, gas turbine units and diesel units are planned to be scrapped by 1983.

The Gori power station of 587 MW started commercial operation in July, 1978 as the first nuclear power plant in Korea.

J 2.3 Transmission Facilities in KECO System

KECO transmission line network is detailed in Table J 3. Transmission lines of 154 kV connect major cities. KECO constructed 345 kV lines connecting Seo Seoul, Sinokucheon, Sinulsan, Gori and Yeosu. The network of 345 kV line is planned to be extended over the country as shown in Fig. J 1.

The distribution line voltage in Korea has been 110 V, but it is 220/380 V in recently constructed lines.

J 2.4 Transforming Facilities in KECO System

The present (1977) capacities of KECO transformers by voltage are shown in Table J 4. In accordance with the expansion of 345 kV transmission lines, new substations of 500 MV such as Bug Busan, Dong Seoul, Deogso and Seo Daegu are planned to be constructed in the near future.

J 2.5 Private Power Facilities

The present (1977) power generating facilities owned by self-producers are summarized in Table J 5. Most of the facilities are diesel generators and the majority in number are for emergency use. The generation record is as shown in Table J 6.

J 3 KECO POWER GENERATION RECORD

The power generation record in KECO power system is summarized in Table J 7. In 1977, the gross generation was 26,587 GWh with the maximum output of 4,187 MW. The auxiliary use factor was 5.2 % and the transmission and distribution loss was 9.3 %. Energy sold was 22,833 GWh at an average rate of W 21.81/kWh. The annual load factor was 72.5 % and the plant factor was 52.4 %.

Historically, the transmission and distribution loss factor has been reduced. The annual growth rate has been declined, but it is still as high as 16 % to 18 %. The load factor ranged between 63.5 % and 72.5 %.

The composition of total energy sold in KECO system in 1977 was as shown below:

Lighting	13.1 %
Power under 99 kW	8.8 %
Power over 100 kW	77.5 %
Agriculture	0.6 %

The development of monthly maximum demand in KECO system is as illustrated in Fig. J 4. The peak demand has usually occured in December, while the demand in July and August is increasing rapidly.

Weekly load curves in March, June, September and December, 1977 were as shown in Fig. J 2. Based on the load curve for December, a typical load duration curve was derived as shown in Fig. J 3 and the load factor was calculated to be 78 %. Composition of load duration curve by type of generating facilities in December, 1977 was as shown in Fig. J 5.

J 4 HYDRO POWER SITUATION

J 4.1 Existing Hydro Power Station

Details of existing hydropower stations are listed in Table J 8.

Among 13 existing hydropower stations (with the total installed capacity of 701 MW), 6 stations (530 MW) are located in the North Han river. The Hwacheon (108.8 MW), Chuncheon (57.6 MW), Uiam (45.0 MW), Cheongpyeong (79.6 MW) and Paldang (80.0 MW) power stations develop a water head of 157 m between Els. 181 m and 10.6 m. The Hwacheon power station has a regulation reservoir of 658 x 10^6 m^3 in active storage capacity, while the storage capacity at the other stations are insignificant. The Soyanggang multipurpose dam (200 MW) of 1,772 x 10^6 m^3 in active storage is located in the Soyang river, a tributary between the Chuncheon and Uiam power stations. The Goesan power station (2.6 MW) is located in the Dal river, a tributary of the South Han river.

The Andong multipurpose dam reservoir in the Nagdong river has an active storage capacity of 1,000 x 10^6 m^3. It was designed to meet the downstream water requirement which fluctuates highly by season. The Andong power station (80 MW) is therefore installed with reversible turbine units. The Namgang power station (12.6 MW) is a running power station as a part of the Namgang multipurpose dam.

The Chilbo (28.8 MW) and Unam (2.6 MW) power stations are supplied with diverted water from the Seomjingang dam reservoir of 370 x 10^6 m^3 in active storage. Their tailrace water are served for irrigation. The Boseong power station (3.1 MW) also serve for the power generation and irrigation with water diverted from the Boseong dam.

The Chusan power station (1.2 MW) is located in the Jeju island.

J 4.2 Hydro Power Generation

The monthly energy production at the hydro-electric power station in 1977 was as shown in Table J 9. The annual energy production by 701.1 MW of hydropower stations was 1,393 GWh and the annual plant

factor was 22.7 %. Seasonal plant factors are calculated to be 19 % for January to March, 32 % for April to May, 29 % for July to September and 10.6 % for October to December. An illustration showing the seasonal change in the energy production at each power station in Fig. J 6 was prepared based on the data in Table J 9. The Hwacheon, Chuncheon, Soyanggang and Andong power stations show little seasonal variation in the operation hours owing to large amount of storage supplement by reservoirs. The Uiam, Cheongpyeong and Paldang power stations follow them showing the influence of the Soyanggang dam. The operation condition of the Paldang power station will be largely improved after the completion of the Chungju dam. The Chilbo and Unam power stations show long operation hours in the irrigation period. The other stations are largely affected by the seasonal fluctuation of natural flow.

The annual plant factor of the Hwacheon, Chuncheon, Soyanggang and Andong power stations are calculated to be 19 %.

J 5 POWER DEMAND PROJECTION

The future power demand in the whole country was projected in this study by applying the "Macroscopic Method" (Ref. J 5).

The "Macroscopic Method" was developed based on the correlation between per capita power generation and GNP. On the basis of IBRD's world-wide statistics in 1968, the relationship between per capita power generation and GNP could be expressed by four curves according to the extent of power generation: low, average, high and maximum. These curves are presented in Fig. J 7.

In projecting the future power generation in Korea, first, the per capita power generation (779 kWh including that of both KECO system and self-producers) and per capita GNP ($ 864 at current price or $ 233 at 1968 constant price) in 1977 were plotted in Fig. J 7. That fell between the curves of "high" and "maximum". Secondly, starting from this point, a regression curve for Korea was established as shown in the above figure. Thirdly, by applying the future per capita GNP estimated in ANNEX A, the future per capita power generation in Korea was derived. Finally, by multiplying the future population which was also estimated in ANNEX A, the future power generation in the whole country was derived and presented in Table J 11.

Deducting the power generation by self-producers, the power generation in KECO system was obtained as shown in Table J 12. The results show that the annual growth rate of energy generation will be maintained at 13.5 % level until 1986, the end of the fifth 5-year plan period, and thereafter it will fall down.

The self-producers' generation will increase for the time being but will decrease by the development of KECO system. Therefore, the self-producers' generation was assumed to be constant after 1981. The load factor was assumed to decrease from 70 % in 1978 to 67 % in 1996.

A long-term power projection was presented by KECO in August, 1978 as shown in Table J 10. The maximum power projected in the present study is close to the KECO projection. Table J 12 may supplement the gross generation of KECO projection for 1987-1996.

J 6 POWER DEVELOPMENT PLAN

The Government of Korea established the long-term power development scheme (1977-2000) in January, 1978. According to this development scheme, total installed capacity in KECO's power system will amount to 80,142 MW in 2000, as shown in Table J 13. Principal power generating facilities of the scheme consist of 41 nuclear units and 21 thermal units (coal and oil-fired plants). The total investment in the plan period will amount to $ 47.400 x 10^9.

The requirement of fossil fuel and uranium in the plan period are as shown in Table J 14.

It is noted that the potentiality of hydropower development in Korea is not high and the share of hydropower in the total power generation will decrease in the future. The share of nuclear and coal-fired power will increase at the large size units for base load supply will be installed. Simultaneously, pumped-storage power plants will be required for peaking load supply.

Based on the Government's long-term power development scheme, a long-term power facilities expansion program was established by KECO on August 1, 1978 as shown in Table J 15.