ANNEXES

Table A-1 Principal Features of Dams without Power Facilities

	Name of Dam	V_E/Q_Y	Catchment Area	Ann. Rainfall	Ann. Inflow	Reservoir										Dam used for Water Supply & Flood Control				Dam Exclusively Used for Water Supply			
						F.W.L. EL.	H.W.L. EL.	L.W.L. EL.	Deposit Surface EL.	Drow-down	Area	Gross Storage Capacity	Effective Capacity	Firm Discharge	Flood Control Capacity	Type	Dam Crest EL.	Height x Crest Length	Design Flood Discharge	Type	Dam Crest EL.	Height x Crest Length
	(up)		km^2	mm	10^6m^3	m	m	m	m	m	km^2	10^6m^3	10^6m^3	$m^3/sec.$	10^6m^3		m	m x m	m^3/sec		m	m x m
1-32	Bamseonggol	58%	582.7	1,350	525.5	299.5	297.5	258.0	251.0	39.5	11.3	372	303.0	12.66	18	R.F.	302.5	85.5 x 299	5,400	R.F.	300.5	83.5 x 295
2-23	Hupyeong*	100	576.2	1,360	519.7	459.0	457.0	393.5	386.0	63.5	14.4	581	519.7	14.54	29	R.F.	462.0	149 x 451	5,370	R.F.	460.0	147 x 446
3-22	Inje (up)	100	1,043.3	1,340	941.0	338.0	336.0	279.0	269.0	57.0	27.3	1,062	941.0	26.31	48	R.F.	341.0	117 x 341	7,200	R.F.	339.0	115 x 336
4-30	Weolhak	31	563.4	1,280	497.5	298.0	296.0	269.0	263.0	27.0	9.0	212	154.7	9.02	20	R.F.	301.0	77 x 326	5,310	R.F.	299.0	75 x 319
5-A3	Hongcheon	60	1,473	1,430	1,333.2	115.0	112.0	84.0	76.0	28.0	40.5	970	799.3	30.40	110	C.G.	117.0	78 x 319	8,460	C.G.	114.0	75 x 310
6-3	Gujeol (up) *	80	100.8	1,210	83.9	748.1	746.1	717.9	717.9	28.2	5.2	76	67.1	2.21	12	R.F.	751.1	60.1 x 202	1,870	R.F.	749.1	58.1 x 196
7-9	Pyeongchang*	80	485.3	1,330	408.5	408.5	406.5	365.5	359.0	41.0	14.8	381	326.9	10.83	24	R.F.	411.5	98.5 x 385	4,570	R.F.	409.5	96.5 x 381
8-10	Panun	5	652	1,320	548.9	281.5	279.5	273.9	273.9	5.6	5.6	71	27.5	5.09	10	R.F.	284.5	47.5 x 273	5,310	R.F.	282.5	45.5 x 267
9-13	Suju*	80	328.9	1,440	287.3	425.0	423.0	386.5	381.0	36.5	11.3	263	229.8	7.64	23	R.F.	428.0	98 x 463	3,720	R.F.	426.0	96 x 456
10-12	Dogog	33	492.6	1,420	430.3	323.5	321.5	291.0	285.0	30.5	8.0	185	141.5	9.16	15	R.F.	326.5	66.5 x 407	4,610	R.F.	324.5	64.5 x 394
11-A1	Dalcheon	40	1,348	1,220	1,054.2	115.5	112.5	96.5	91.0	16.0	40.5	550	421.7	14.39	140	C.G.	117.5	53.5 x 296	6,980	C.G.	114.5	50.5 x 285
12-A2	Ganhyeon	35	1,180	1,420	1,068.0	108.5	105.5	88.5	83.0	17.0	32.0	475	374.0	14.45	106	C.G.	110.5	39.4 x 231	7,670	C.G.	107.5	36.4 x 223
13-35	Bonghwa	100	1,105	1,020	655.1	294.5	292.5	236.5	228.0	56.0	22.2	755	655.1	17.74	45	R.F.	297.5	117.5 x 277	6,360	R.F.	295.5	115.5 x 272
14-43	Imha	100	1,230	1,040	729.2	190.0	188.0	156.0	147.0	32.0	42.3	845	729.2	19.60	155	R.F.	193.0	79 x 357	6,700	R.F.	191.0	77 x 348
15-36	Chibo (down)	32	4,550	1,040	2,439.0	90.7	87.7	77.0	71.0	10.7	84.3	1,305	776.0	58.68	316	C.G.	92.7	45.7 x 666	11,780	C.G.	89.7	42.7 x 649
16-51	Hamyang (up)	80	264	1,400	251.4	382.5	380.5	328.2	328.2	52.3	6.9	279	201.1	6.83	15	R.F.	385.5	95.5 x 402	3,290	R.F.	383.5	93.5 x 394
17-53	Dogsan*	100	231	1,550	230.9	162.0	160.0	121.0	116.0	39.0	9.5	261	230.9	6.82	21	R.F.	165.0	81 x 382	3,280	R.F.	163.0	79 x 378
18-62	Yongdam*	60	949	1,340	766.1	255.5	253.5	229.0	221.0	24.5	30.5	580	460.0	17.09	65	R.F.	258.5	63.5 x 382	5,920	R.F.	256.5	61.5 x 372
19-63	Sutong	20	1,526	1,310	1,174.2	202.0	200.0	185.0	177.0	15.0	20.9	383	232.3	18.73	39	R.F.	205.0	62 x 246	7,390	R.F.	203.0	60 x 241
20-64	Myeongcheon	34	2,003	1,260	1,503.4	152.0	150.0	136.5	127.0	13.5	49.5	821	507.0	28.42	109	R.F.	155.0	61 x 314	8,350	R.F.	153.0	59 x 303
21-69	Simcheon*	60	640.3	1,160	462.4	158.0	156.0	130.5	124.0	25.5	18.6	331	277.4	12.42	34	R.F.	161.0	62 x 293	4,870	R.F.	159.0	60 x 287
22-77	Jeokseong	80	1,004	1,390	187.0	128.0	126.0	96.5	92.0	29.5	9.5	163	149.6	5.01	19	R.F.	131.0	59 x 353	6,580	R.F.	129.0	57 x 345
23-82	Juam*	80	1,010	1,410	709.3	117.5	115.5	86.5	78.0	29.0	35.0	650	567.4	19.79	80	R.F.	120.5	67.5 x 388	6,590	R.F.	118.5	65.5 x 381
24-A4	Boseonggang* (up)	100	457	1,410	175.6	127.0	125.0	110.5	106.0	14.5	20.8	200	175.6	3.68	45	R.F.	130.0	31 x 266	4,430	R.F.	128.0	29 x 257

Remark: Location of dam and development scale with asterisk differs from those of multipurpose dam, based on the comparative study.

Table A-2 Construction Cost of Water Supply and Flood Control Dams

Unit : 10^6Won

Name of Dam		V_E/Q_Y	Reservoir					Dam Construction						Total	Annual Cost		
			Compensation	General Expense	Contingency	Interest during Const.	Sub-Total	Dam	Preparatory Works	Metal & Valve	General Expense	Contingency	Interest during Const.	Sub-Total		Capital Cost	OMR	Total
1-32	Bamseonggol(up)	58%	3,900				5,913	7,530		356				12,184	18,096	1,479	61	1,540
2-23	Hupyeong	100	4,400				6,860	20,350		689				33,435	40,295	3,294	167	3,461
3-22	Inje(up)	100	8,200				12,784	12,130		880				20,661	33,445	2,734	103	2,837
4-30	Weolhak	31	5,640				8,308	7,610		231				11,774	20,082	1,642	59	1,700
5-A3	Hongcheon	60	12,150				17,897	12,500		303				19,227	37,125	3,035	96	3,131
6-3	Gujeol	80	3,250				4,787	2,740		101				4,266	9,053	740	21	761
7-9	Pyeongchang	80	7,150				10,840	9,670		297				15,403	26,243	2,145	77	2,222
8-10	Panun	5	3,870				5,701	3,870		155				6,043	11,744	960	30	990
9-13	Suju	80	3,840				5,822	11,400		272				18,041	23,862	1,951	90	2,041
10-12	Dogog	33	2,480				3,706	7,050		241				11,107	14,814	1,211	56	1,266
11-A1	Dalcheon	40	11,900				17,785	6,500		210				10,223	28,007	2,289	51	2,340
12-A2	Ganhyeon	35	8,900				13,110	2,810		210				4,531	17,641	1,442	23	1,465
13-35	Donghwa	100	3,390				5,285	12,270		649				20,524	25,809	2,110	103	2,212
14-43	Imha	100	13,170				19,966	7,940		434				12,936	32,902	2,689	65	2,754
15-36	Chibo (down)	32	33,860				49,877	8,450		777				13,841	63,717	5,208	69	5,277
16-51	Hamyang(up)	80	4,500				6,822	8,920		264				14,194	21,016	1,718	71	1,789
17-53	Dogsan	100	5,750				8,717	7,340		222				11,687	20,404	1,668	58	1,726
18-62	Yongdam	60	15,850				24,029	6,180		363				10,107	34,136	2,790	51	2,841
19-63	Sutong	20	8,050				11,858	5,700		355				9,087	20,945	1,712	45	1,757
20-64	Myeongcheon	34	20,700				30,492	6,330		458				10,185	40,677	3,325	51	3,376
21-69	Simcheon	60	15,500				23,498	5,340		253				8,641	32,140	2,627	43	2,670
22-77	Jeokseong	80	5,950				9,020	5,850		165				9,296	18,317	1,497	46	1,544
23-82	Juam	80	29,600				44,875	6,990		367				11,365	56,240	4,597	57	4,654
24-A4	No. 2 Boseonggang (up)	100	5,910				8,706	2,170		163				3,500	12,206	998	18	1,015

Remarks: Sub-total in reservoir is calculated as follows; compensation x 1.12 x 1.20 x (1+0.4 iT) i=8%, T=construction period, 3-4 years
Sub-total in dam construction is calculated as follows; (dam x 1.02 + metal & valve) x 1.12 x 1.20 x (1+0.4 iT)

Table A-3 Construction Cost of Water Supply Dams

Unit : 10^6Won

Name of Dam	V_E/Q_Y	Reservoir					Dam Construction							Total	Annual Cost		
		Compensation	General Expense	Contingency	Interest during Const.	Sub-Total	Dam	Preparatory Works	Metal & Valve	General Expense	Contingency	Interest during Const.	Sub-Total		Capital Cost	OMR	Total
1-32 Bamseonggol(up)	58%	3,850				5,837	7,280		356				11,797	17,634	1,441	59	1,500
2-23 Hupyeong	100	4,320				6,735	19,750		689				32,481	39,216	3,206	162	3,368
3-22 Inje(up)	100	8,020				12,504	11,700		880				19,978	32,481	2,655	100	2,755
4-30 Weolhak	31	5,540				8,160	7,140		231				11,068	19,228	1,572	55	1,627
5-A3 Hongcheon	60	12,010				17,691	11,700		303				18,025	35,716	2,919	90	3,010
6-3 Gujeol(up)	80	3,200				4,714	2,680		101				4,175	8,889	726	21	747
7-9 Pyeongchang	80	7,090				10,749	9,330		297				14,878	25,626	2,095	74	2,169
8-10 Panun	5	3,780				5,568	3,700		155				5,788	11,356	928	29	957
9-13 Suju	80	3,760				5,700	10,950		272				17,345	23,045	1,884	87	1,970
10-12 Dogog	33	2,380				3,557	6,750		241				10,650	14,207	1,161	53	1,214
11-A1 Dalcheon	40	11,450				17,112	5,500		210				8,698	25,810	2,110	43	2,153
12-A2 Ganhyeon	35	8,470				12,476	2,600		210				4,216	16,692	1,364	21	1,386
13-35 Bonghwa	100	3,350				5,223	11,850		649				19,856	25,079	2,050	99	2,149
14-43 Imha	100	13,070				19,814	7,580		434				12,379	32,194	2,632	62	2,693
15-36 Chibo (down)	32	33,800				49,788	8,130		777				13,360	63,148	5,162	67	5,228
16-51 Hamyang(up)	80	4,450				6,746	8,600		264				13,699	20,445	1,671	68	1,740
17-53 Dogsan	100	5,640				8,550	7,000		222				11,161	19,711	1,611	56	1,667
18-62 Yongdam	60	15,720				23,832	5,870		363				9,627	33,459	2,735	48	2,783
19-63 Sutong	20	8,000				11,784	5,530		355				8,832	20,616	1,685	44	1,729
20-64 Myeongcheon	34	20,700				30,492	5,740		458				9,299	39,790	3,252	46	3,299
21-69 Simcheon	60	15,000				22,740	5,080		253				8,239	30,980	2,532	41	2,573
22-77 Jeokseong	80	5,840				8,854	5,560		165				8,848	17,701	1,447	44	1,491
23-82 Juam	80	28,370				43,010	6,660		367				10,855	53,865	4,403	54	4,457
24-A4 No. 2 Boseonggang (up)	100	5,880				8,661	2,040		163				3,305	11,966	978	16	995

Remarks: Sub-total in reservoir is calculated as follows; compensation x 1.12 x 1.20 x (1+0.4 iT) i=8%, T=construction period, 3-4 years
Sub-total in dam construction is calculated as follows; (dam x 1.02 + metal & valve) x 1.12 x 1.20 x (1+0.4 iT)

Table A-4 Benefit Cost Analysis for Water Supply and Flood Control Dams

		Catchment Area	VE/Qy	Annual Cost	Water Supply Benefit					Water Supply & Flood Control Benefit			
					Increase of Firm Discharge	Unit Benefit	W.S. Benefit	Bw/C	Bw-C	F.C. Benefit	Total Benefit	$\frac{Bw+Bf}{C}$	(Bw+Bf) -C
		(km^2)	(%)	($10^6W/y$) (C)	(10^6m^3)	(W/m^3)	($10^6W/y$) (Bw)			($10^6W/y$) (Bf)	($10^6W/y$) (Bw+Bf)		
1-32	Bamseonggol(up)	593	58	1,540	322.6	8.56	2,761	1.80	1,221	88	2,849	1.85	1,309
2-23	Hupyeong	576	100	3,461	87.8	8.56	752	0.22	-2,709	97	854	0.25	-2,607
3-22	Inje(up)	1,043	100	2,837	159.5	8.56	1,365	0.48	-1,472	66	1,431	0.50	-1,406
4-30	Weolhak	563	31	1,700	26.3	8.56	225	0.13	-1,475	74	299	0.18	-1,401
5-A3	Hongcheon	1,473	60	3,131	798.5	8.56	6,835	2.18	3,704	131 2,158	6,966 8,993	2.22 2.87	3,835 5,862
6-3	Gujeol(up)	101	80	761	39.0	8.56	334	0.44	-427	66	400	0.53	-361
7-9	Pyeongchang	485	80	2,222	132.0	8.56	1,123	0.51	-1,099	98	1,221	0.55	-1,001
8-10	Panun	652	5	990	14.7	8.56	126	0.13	-864	29	155	0.16	-835
9-13	Suju	329	80	2,041	135.6	8.56	1,161	0.57	-880	49	1,210	0.59	-831
10-12	Dogog	493	33	1,266	82.9	8.56	710	0.56	-556	45	755	0.60	-511
11-A1	Dalcheon	1,348	40	2,340	403.5	8.56	3,453	1.48	1,113	107 1,868	3,560 5,321	1.52 2.27	1,220 2,981
12-A2	Ganhyeon	1,180	35	1,465	405.7	8.56	3,473	2.37	2,008	34 1,260	3,507 4,733	2.39 3.23	2,042 3,268
13-35	Bonghwa	1,105	100	2,212	139.3	6.52	908	0.41	-1,304	35	943	0.43	-1,269
14-43	Imha	1,230	100	2,754	590.9	6.52	3,851	1.40	1,097	61 1,915	3,912 5,766	1.42 2.09	1,158 3,012
15-36	Chibo (down)	4,550	32	5,277	965.7	6.52	6,296	1.19	1,019	141 4,527	6,437 10,823	1.22 2.05	1,160 5,546
16-51	Hamyang(up)	264	80	1,789	184.4	6.52	1,202	0.67	-587	36	1,238	0.69	-551
17-53	Dogsan	231	100	1,726	186.8	6.52	1,218	0.70	-508	55	1,273	0.74	-453
18-62	Yongdam	949	60	2,841	499.0	5.85	2,919	1.03	78	47	2,966	1.04	125
19-63	Sutong	1,526	20	1,757	307.0	5.85	1,796	1.02	39	28	1,824	1.04	67
20-64	Myeongcheon	2,003	34	3,376	670.0	5.85	3,920	1.16	544	46	3,966	1.17	590
21-69	Simcheon	640	60	2,670	298.5	5.85	1,746	0.65	-924	88	1,834	0.69	-836
22-77	Jeokseong	1,004	80	1,544	134.4	9.03	1,214	0.79	-330	55	1,269	0.82	-275
23-82	Juam	1,010	80	4,654	504.9	9.03	4,559	0.98	-95	127	4,686	1.01	32
24-A4	No. 2 Boseonggang(up)	457	100	1,015	129.5	9.03	1,169	1.15	154	38	1,323	1.30	308

Table A-5 List of Completed Dams
(including under construction & preparation)

			Hwachon	Chunchon	Soyang (*)	Uiam	Chongpyong	Chongpyong (Pump up) (**)	Kwesan	Chungju (***)	Paldang	Andong (*)	Hapchon (***)	Namgang	Daechong (**)	Sumjin	Bosung
	Owner		KECO	KECO	ISWACO	KECO	KECO	KECO	KECO		KECO	ISWACO		MOC	MOC	KECO	KECO
	River		N. Han	N. Han	Soyang	N. Han	N. Han	N. Han	S. Han	S. Han	Han	Nakdong	Nakdong	Nakdong	Geum	Sumjin	Sumjin
	Catchment	(km^2)	4,145	4,736	2,703	7,666	10,138		671	6,648	23,800	1,588	925	2,285	4,134	763	275
	Annual rain	(mm)			1,100					1,070			1,100	1,263			
Reservoir	Mean run-off	(m^3/S)	84.6	97.2	55.6	148.1	242.7		14.5	154.8	545	29.8	27.5	50	102.1	15.77	
	NHWL	(m)	181.2	103.0	192.0	71.5	51.0	535	135.7	140.5	25.5	160	176	37.5	76.5	196.5	127.3
	Drawdown	(m)	24.2	5.0	42.0	5.2	5.0	21.0	4.0	30.5	0.5	30	36	6.5	16.5	21.5	6.8
	Area	(km^2)			70.0					87		51.5	24	30.1	72.8		
	Gross storage	(10^6m^3)	1,018	150	2,476	80	186		15.3	2,280	244	1,248	793	136	1,240	466	5.7
	Effective storage	(10^6m^3)	658	61	1,772	39	83	2.3	5.7	1,749	18	1,000	542	108	790 (WS) 250 (FC)	370	4.7
	Design flood	(m^3/S)	9,500	12,600	10,500		19,000		2,711	26,680	28,500	2,600	5,100	2,000	11,400	3,268	
	Purpose		P	P	Multi	P	P		P	Multi	P	Multi	Multi	Multi	Multi	P	P
Dam	Type		CG	CG	F		CG	F	CG	CG	CG	F	F	F	CG & F	CG	CG
	H x L		81.5 x		125x447	3 x	19 x	58 x	28 x	100 x	5.5 x	83x532	93x532	21x974	72x495	64 x	11.9x
	Volume	(m^3)						975,000		928,000		4,046,000	4,000,000		Con. 490,000 Em. 880,000		
	Spillway									11.0x15		14x9.7x4	25x4.0		13x16x6		
Power station	Type		Dam & Conduit	Dam	Dam	Dam	Dam		Dam	Dam	Dam	Dam, Pump	Dam & Conduit	Dam	Dam	Diver-sion	Diver-sion
	Conduit							3.6-2.4 x 733 Under-grand									
	P.S.									Indoor					Indoor		
	Max. discharge	(m^3/S)	184.8	228.4	251.0	340.0	372.6		11.5	460	800	116	87	100	270	21.9	5
	Effective head	(m)	74.5	28.8	110.5	15.9	26.0		23.7	72.5	11.8	67	102	10.1	48	151.7	83.6
	Inst. capacity	(kW)	108,000	57,600	200,000	45,000	79,600	400,000	2,600	210,000	80,000	80,000	72,500	11,000	90,000	28,800	3,120
	Annual energy	(10^6kWh)	326	145	353	161	271.5		10.8	316.7	338	162	182	37	250	160	16
	Turbine									70MW x 3		40,000KW x2	36,250KW x2	5,800KW x2			
	Generator									82.35KVA x3		45,000KVA x2	41,000KVA x2				
After bay pondage	HWL	(m)										98					
	Drawdown	(m)										3					
	Capacity	(10^6m^3)										3					
	Weir											Concrete					
	H x L											20mx238m					
	Gate											12x6x10m					
Transmission line								154kVx45km				154kVx66km		66kVx8.8km	154kVx25km		
Completion			1944.5/ 1968.6	1965.2	1973/10	1967.11	1943.12/ 1967.12		1957.4			1976.10			1976	1939/ 1965.10	1937.2

Note: * Completed
** Under construction
*** Scheduled to be developed

Annex 1 Cost Items of Dam and Reservoir

1. Construction Cost of Dam

1-1 Dam (Fill type)

1)	Dam	Excavation	(cu.m)	
		Embankment	(cu.m)	
		Other	(L.S)	(20% of above subtotal)
2)	Spillway	Excavation	(cu.m)	
		Concrete works	(cu.m)	
		Reinforcement bar	(t)	
		Gate	(t)	
		Others	(L.S)	(20% of above subtotal)
3)	Miscellaneous works		(L.S)	(3% of subtotal of dam & spillway)

1-1' Dam (Concrete gravity)

1)	Dam and spillway			
		Excavation	(cu.m)	
		Concrete works	(cu.m)	
		Reinforcement bar	(t)	
		Gate	(t)	
		Others	(L.S)	(20% of above subtotal)
2)	Miscellaneous works		(L.S)	(3% of dam & spillway)

1-2	Preparatory works	(1% of Dam cost)
1-3	Compensation	
1-4	General expenses	(12% of sum 1-1 thru 1-3)
1-5	Contingency	(20% of sum 1-1 thru 1-4)
1-6	Interest during construction	0.4 iT x sum 1-1 thru 1-5 i = interest rate = 8% per annum T = construction period, year

Total

Annex 2 Formulae for Rough Estimate of Work Quantity

Dam and Spillway

Work Items	Unit	Formulae
1. Rockfill dam		
1-1 Dam		
Excavation	cu.m	$V_E = 10 \cdot H \cdot L$
Embankment	"	$V_D = 1/6\,[\,2a + H(m+n)\,](L+2\ell) + 1/6\,[\,3a + (3H+h)\cdot(m+n)\,]\ell h$
1-2 Spillway		
Excavation	cu.m	$V_E = 84\sqrt{Q_F}\cdot H$
Concrete works	"	$V_C = 13\sqrt{Q_F}\cdot H$
Reinforcement bar	t	$W_R = 0.02\cdot V_C$
Gate	"	$W_G = 0.22\cdot Q_F$
2. Concrete gravity dam		
Excavation	cu.m	same as in rockfill dam
Concrete works	"	as per shown in Annex Fig. 1
Spillway gate	t	$W_G = 0.13\cdot Q_F$

H : dam height (m)

L : dam crest length (m)

a : crest width (m)

m : slope of upstream surface of dam

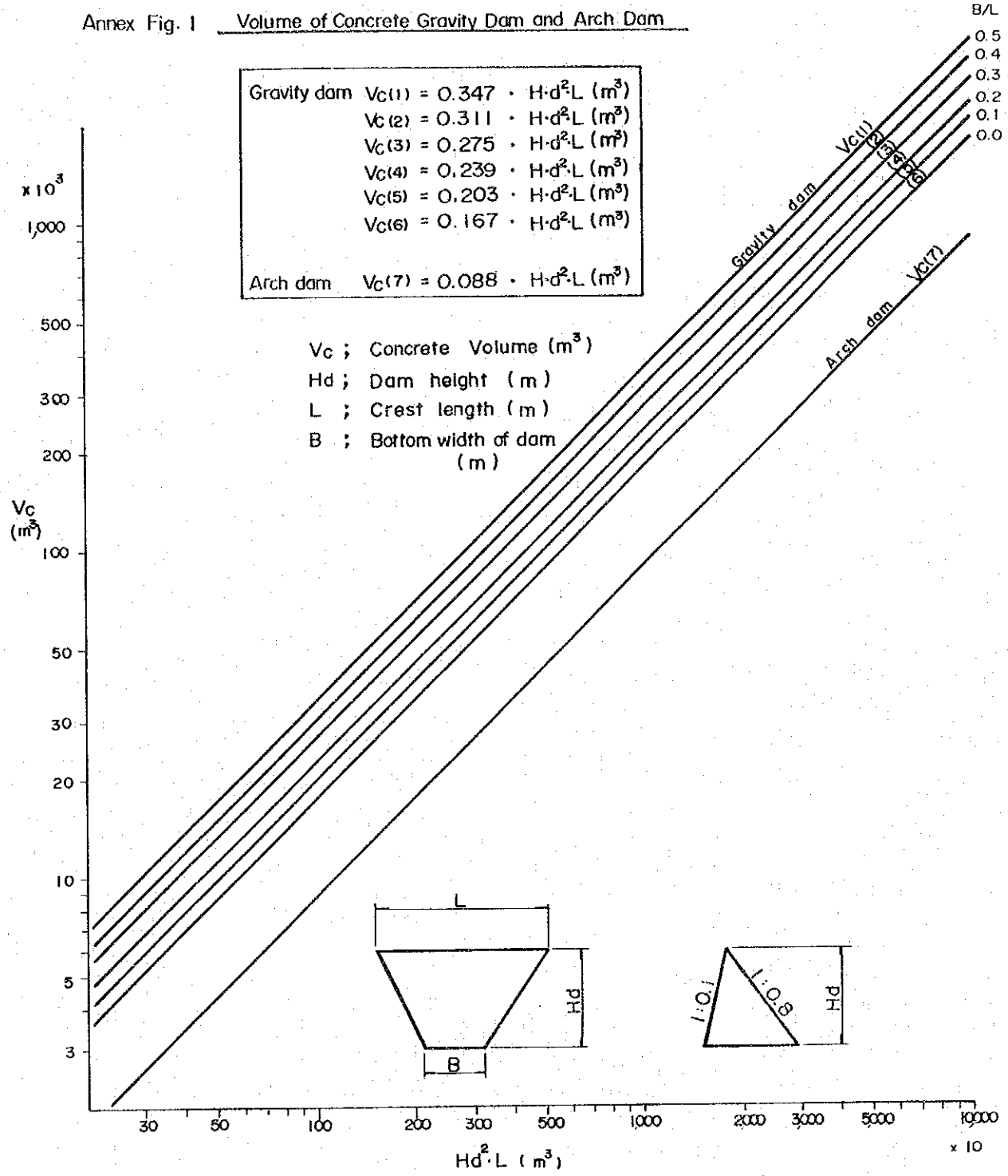
n : slope of downstream surface of dam

l : width of river channel (m)

h : excavation depth for dam foundation (m)

Q_F : design flood (cms)

Annex Fig. 1 Volume of Concrete Gravity Dam and Arch Dam



Gravity dam

$Vc(1) = 0.347 \cdot H \cdot d^2 \cdot L \ (m^3)$

$Vc(2) = 0.311 \cdot H \cdot d^2 \cdot L \ (m^3)$

$Vc(3) = 0.275 \cdot H \cdot d^2 \cdot L \ (m^3)$

$Vc(4) = 0.239 \cdot H \cdot d^2 \cdot L \ (m^3)$

$Vc(5) = 0.203 \cdot H \cdot d^2 \cdot L \ (m^3)$

$Vc(6) = 0.167 \cdot H \cdot d^2 \cdot L \ (m^3)$

Arch dam

$Vc(7) = 0.088 \cdot H \cdot d^2 \cdot L \ (m^3)$

Vc ; Concrete Volume (m^3)

Hd ; Dam height (m)

L ; Crest length (m)

B ; Bottom width of dam (m)

Annex 3 Cost Items of Power Facilities

1. Conduit

1-1	Intake	Excavation	(cu.m)	
		Concrete	(cu.m)	
		Reinforcement bar	(t)	
		Gate	(t)	
		Screen	(t)	
		Others	(L.S)	(20% of above subtotal)
1-2	Tunnel	Excavation	(cu.m)	
		Lining concrete	(cu.m)	
		Reinforcement bar	(t)	
		Others	(L.S)	(22% of above subtotal)
1-3	Surgetank	Excavation	(cu.m)	
		Concrete	(cu.m)	
		Reinforcement bar	(t)	
		Others	(L.S)	(20% of above subtotal)
1-4	Penstock	Excavation	(cu.m)	
		Concrete	(cu.m)	
		Reinforcement bar	(t)	
		Steel pipe	(t)	
		Others	(L.S)	(20% of above subtotal)
1-5	Tailrace	Gate	(t)	
		Others	(L.S)	
1-6	Miscellaneous works		4% of sum 1-1 thru 1-5	

2. Power Station

2-1	Substructure	Excavation	(cu.m)	
		Concrete	(cu.m)	
		Reinforcement bar	(t)	
		Others	(L.S)	(20% of above subtotal)
2-2	Miscellaneous works		(L.S)	
2-3	Superstructure	Building volume	(cu.m)	

3. Generating equipment, transmission line, substation and flood forecasting system

4.	Preparatory Works	1% of sum 1 and 2
5.	General Expenses	12% of sum 1 thru 4
6.	Contingency	20% of sum 1 thru 5
7.	Interest during Construction	0.4 iT x sum 1 thru 6

i = interest rate = 8% per annum
T = construction period, year

Total

Annex 4 Formulae for Rough Estimate of Work Quantity

Conduit and Power Station

Work Items		Unit	Formulae
Intake	Excavation	cu.m	$\nabla_E = 200\{(hd+2r_o)Q\}^{1/2} \cdot n^{1/3}$
	Concrete works	"	$\nabla_C = 90\{(hd+2r_o)Q\}^{1/2} \cdot n^{1/3}$
	Reinforcement bar	t	$W_R = 0.03\ \nabla_C$
	Gate	"	$W_G = 0.7(hd+2r_o)^{1/3} \cdot Q_o$
	Screen	"	$W_S = 0.5(hd+2r_o)^{1/3} \cdot Q_o$
Tunnel	Excavation	cu.m	$\nabla_E = 3.2(r_o+t_o)^2$
	Lining concrete	"	$\nabla_C = V_E - \pi r_o^2$
	Reinforcement bar	t	$W_R = 0.04\nabla_C$
Surge tank	Excavation	cu.m	$\nabla_E = 38Q(hd+Lt)^{1/4}$
	Concrete	"	$\nabla_C = 11Q(hd+Lt)^{1/4}$
	Reinforcement bar	t	$W_R = 0.05\nabla_C$
Penstock	Excavation	cu.m	$\nabla_E = 2\{(2r_m+15)\{n(r_m+1)+1\}+0.021\nabla\} \cdot Lp$
	Concrete	"	$\nabla_C = 0.024(\nabla+143) \cdot Lp$
	Reinforcement bar	t	$W_R = 0.01\nabla_C$
	Steel pipe	"	$W_P = 0.0529\ r_m \cdot t_m \cdot Lp$
Power house, substructure	Excavation	cu.m	$\nabla_E = 14Q_o H_e^{2/3} \cdot n^{1/2}$
	Concrete	"	$\nabla_C = 5Q_o H_e^{2/3} \cdot n^{1/2}$
	Reinforcement bar	t	$W_R = 0.052\ \nabla_C$
Power house, superstructure	Building volume	cu.m	$\nabla_B = 20\left(\frac{P}{\sqrt{He}}\right)^{0.7}$
Tail race	Gate	t	$W_G = 0.5\ Qo$

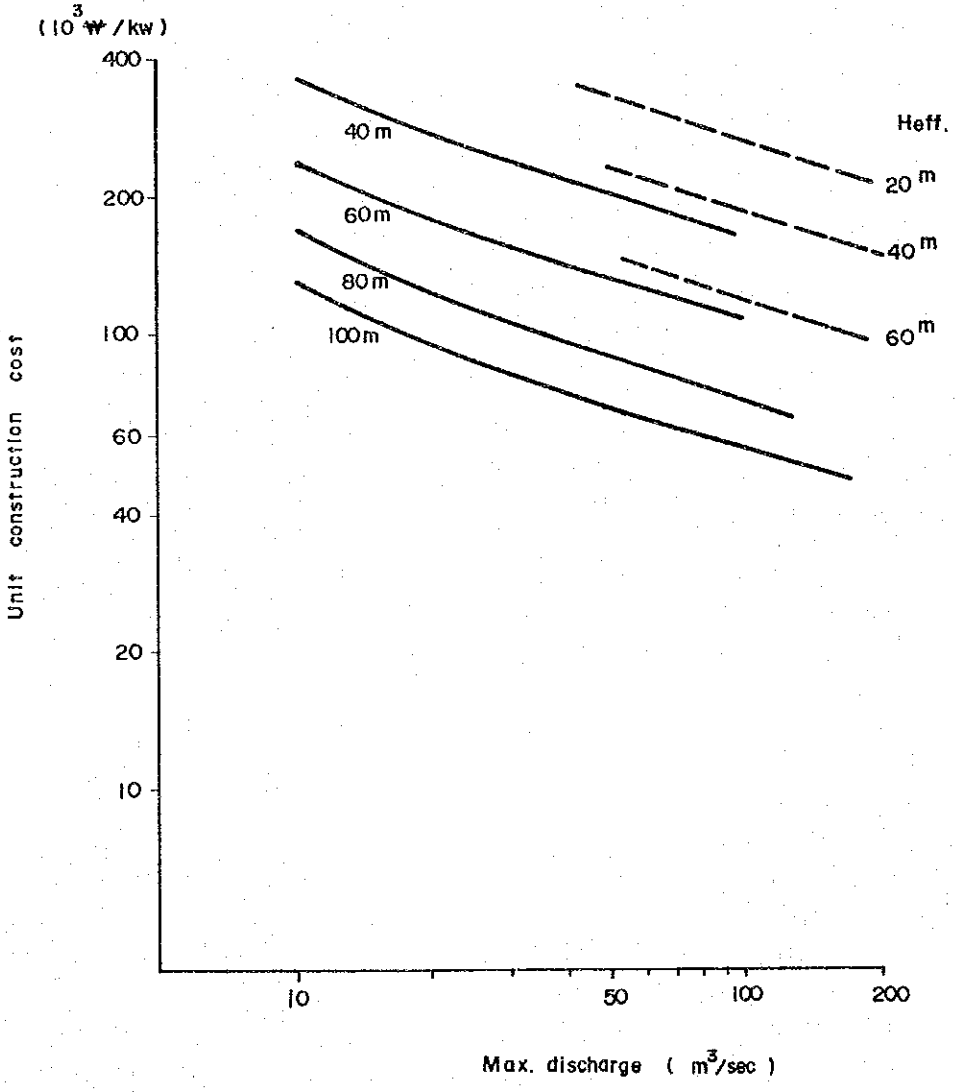
hd : drawdown (m)
ro : radius of tunnel (m)
Qo : max. discharge (cms)
n : number of conduit
to : thickness of tunnel lining (m)
Lt : tunnel length (m)
rm : mean radius of penstock pipe (m)

V : volume of a anchor block (cu.m)
$= 6r_m\{n(r_m+2)(5r_m+2)+2(2r_m+1)\}$
n : number of penstock pipe
LP : length of penstock pipe (m)
tm : mean thickness of pipe shell (mm)
He : effective head (m)
n : number of generating facilities
P : installed capacity (kW)

Annex 5 Unit Construction Cost for Major Civil Works

Items	Application	Unit	Unit Cost
Excavation (earth & rock)			
Open exc.	intake, tailrace	W/cu.m	1,450
"	surge tank	"	1,600
"	penstock line	"	2,000
"	power house	"	2,300
"	dam	"	1,350
Tunnel exc.	tunnel	"	9,000
Concrete works			
Open conc.	intake, tailrace	W/cu.m	16,000
"	surge tank	"	15,000
"	penstock line	"	12,500
"	power house	"	14,000
Mass conc.	dam, more than 10,000 cu.m	"	12,000
Lining conc.	Tunnel	"	16,000
Fill conc.	penstock line (under ground)	"	16,500
Reinforcement bar	common	W/ton	136,000
Gate	"	"	500,000
Screen	"	"	420,000
Penstock pipe	" (incld. SM, MT)	"	325,000
Dam embankment	fill dam	W/cu.m	1,250
Powerhouse, superstructure		W/cu.m	20,000

Annex Fig. 2 Construction Cost of Power Generating Facilities



(Refer to note on next page)

Note to Fig. 2

The weights of turbine and generator are estimated from the rated output of turbine (kw), effective head (m), rated capacity of generator (KVA) and rated speed (n). 1/ Recent prevailing unit prices 2/ are applied. Costs of transformer 3/, appurtenant equipment and materials 4/ and costs of transportation and installation 5/ are included. And these all costs per kw versus maximum discharge are illustrated for types of turbine with a parameter of effective head.

1/ Weight of turbine $W_T = 0.025 \left(\frac{kw}{\sqrt{H}} \right)^{1.1} \pm 15\%$

Weight of generator $W_G = 10 \left(\frac{KVA}{n} \right)^{\frac{5}{7}} \pm 15\%$

2/ $8,000/ton for turbine & $7,000/ton for generator

3/ $12/KVA

4/ $30/kw

5/ 20% of FOB prices

(1 US$ = W 485)

Annex 6 Costs of Transmission Line and Substation

(1) Transmission line

The unit cost of transmission line is as follows;

The cost includes the compensation of land on the route.

66 kv single circuit	W 6,000,000/km
66 kv double circuit	W12,000,000/km
154 kv single circuit	W15,000,000/km
154 kv double circuit	W20,000,000/km

(2) Substation

Switchgear only is added to the nearest existing power station and/or substation to receive the power and energy of the power plant investigated.

The cost is as follows;

66 kv single circuit	W50,000,000
66 kv double circuit	W80,000,000
154 kv single circuit	W120,000,000
154 kv double circuit	W200,000,000

Annex 7 Power and Energy Benefits

(1) Alternative thermal power plant

Installed capacity	300 MW
Unit const. cost	$450/kw = W218,250/kw 1/
Life time	30 years
Fuel	Bunker C
Thermal energy of fuel	9,850 kcal/lit.
Thermal efficiency	38.5%
Equivalent energy	2,234 kcal/kwh
Fuel consumption	0.2268 lit./kwh
Cost of fuel	W40.21/lit.

(2) Unit kw benefit

Annual cost rate	14.52%
(interest rate	10.3%)

Adjustment	Hydro	Thermal
Transmission loss	4.0%	2.0%
Forced outage	-	5.0%
Auxiliary power use	0.3%	6.0%
Overhaul	2.0%	12.5%

$$\text{Adjustment factor} = \frac{(1-0.04)(1-0.003)(1-0.02)}{(1-0.02)(1-0.05)(1-0.06)(1-0.125)} = 1.2249$$

Unit kw benefit = W218,250 x 0.1452 x 1.2249

= W38,820/kw

(3) Unit kwh benefit

Adjustment	Hydro	Thermal
Transmission loss	4.0%	2.0%
Auxiliary power use	0.3%	6.0%

$$\text{Adjustment factor} = \frac{(1-0.04)(1-0.003)}{(1-0.02)(1-0.06)} = 1.0390$$

Unit kwh benefit = 0.2268 lit./kwh x W40.2/lit. x 1.0390 = W9.475/kwh

---

/1 1US$ = W485

Annex 8 Unit Benefit of Water Supply

Basin	Dam	Annual Cost	Net Increment of Water	Unit Cost (Unit Benefit)
		10^6W/year	$10^6 m^3$/year	W/m^3
Han river	Bamseonggol	1,500	322.6	4.65
	Hupyeong	3,368	88.4	38.10
	Inje	2,758	159.5	17.29
	Weolhak	1,627	26.3	61.90
	Hongcheon	3,010	798.5	3.77
	Gujeol	747	39.0	19.15
	Pyeongchang	2,169	112.0	19.37
	Panun	957	14.7	65.10
	Suju	1,970	135.6	14.53
	Dogog	1,214	82.9	14.64
	Dalcheon	2,153	403.5	5.34
	Ganhyeon	1,386	405.7	3.42
	Total:	22,859	2,668.7	8.56
Nagdong river	Bonghwa	2,149	139.3	15.43
	Imha	2,693	590.9	4.56
	Chibo	5,228	965.7	5.41
	Hamyang	1,740	184.4	9.44
	Dogsan	1,667	186.8	8.92
	Total:	13,477	2,067.1	6.52
Geum river	Yongdam	2,783	499.0	5.58
	Sutong	1,729	307.0	5.63
	Myeongcheon	3,299	670.0	4.92
	Simcheon	2,573	298.5	8.62
	Total:	10,384	1,774.5	5.85
Seumjin river	Jeokseong	1,491	134.4	11.09
	Juam	4,457	504.9	8.83
	Boseonggang	995	129.5	7.68
	Total:	6,943	768.8	9.03

Annex 9 Scope of Work for the Second Stage Survey

Quote

III. Scope of Work

1. Study work will be carried out according to the following two stages:

1-1 1st Stage:

In 1974, Korean Government conducted nation-wide potential hydro power resources study in Korea and selected 22 sites as suitable sites to be developed.

In this stage reviewing work on the development plan for these selected sites and selection of the project sites (8 or 10 sites) to be developed in future, with consideration of the multiple water resources utilization for the selected sites, shall be made.

(1) Review and study on all data available in connection with sites proposed by the Government in 1974.

(2) Field reconnaissance survey including topographical and geological reconnaissance at the proposed sites with map of 1/50,000 and or 1/25,000.

(3) Study on meteoro-hydrological data mainly for river run-off and design flood.

(4) Preliminary study on the flood control effect and water supply effect in order to prepare a multipurpose development plan (including selection of possible water supply area.)

(5) Preliminary study on the optimum development scale of the hydro power project.

(6) Estimate of land and right compensation cost in the reservoir area with the decision elevation based on the 1/25,000 map.

(7) Estimate of preliminary construction cost for each projects.

(8) Preliminary technical and economic study on the projects.

(9) Selection of a priority project.

... to be cont'd

1-2 2nd Stage:

Preliminary feasibility study on the optimum development scale of the selected sites (8 - 10 sites) shall be made.

(1) Surveying work of the proposed dam sites and establishment of the bench-mark at the sites.

(2) Study on the flood control effect and water supply effect in order to prepare a multipurpose development plan. (including selection of possible water supply area.)

(3) Basic plan of general layout of major structures including preliminary design.

(4) Study on the optimum development scale of the project as the multipurpose dam project for the selected sites.

(5) Estimate of preliminary construction cost for each project.

(6) Estimate of various benefits by the project.

Unquote

ANNEX 10 Outline of Each Multipurpose Dam Scheme

The outline of the 24 each dam scheme is described hereinafter.

1-32 Bamseonggol

The Pamseonggol Dam site is located approximately 4 km upstream from the conjunction of the Suib River which merges at the right bank of the upstream part of the Hwacheon Reservoir.

The river gradient downstream from the dam site to the Hwacheon Reservoir averages approximately 1/110.

The original dam site examined in the Report of Potential Hydro-Electricity had been selected approximately 1 km upstream from the end of the Hwacheon Reservoir.

The geology in this vicinity is comprised of granitic gneiss and it is thought there will be no problem in particular at either site for a dam foundation.

As a result of examinations of the upstream and downstream plans based on the field reconnaissance, the upstream alternative site compared with the downstream original site will have better water storage efficiency, and utilizing the head by a relatively short tunnel, it is thought possible for an advantageous development to be carried out economically.

Although a rockfill type was considered as the dam type in this study, further examinations will be necessary for the type by carrying out investigations of dam materials and other studies.

1-32 Bamseonggol

Location of dam Gangweon-do Yanggu-gun

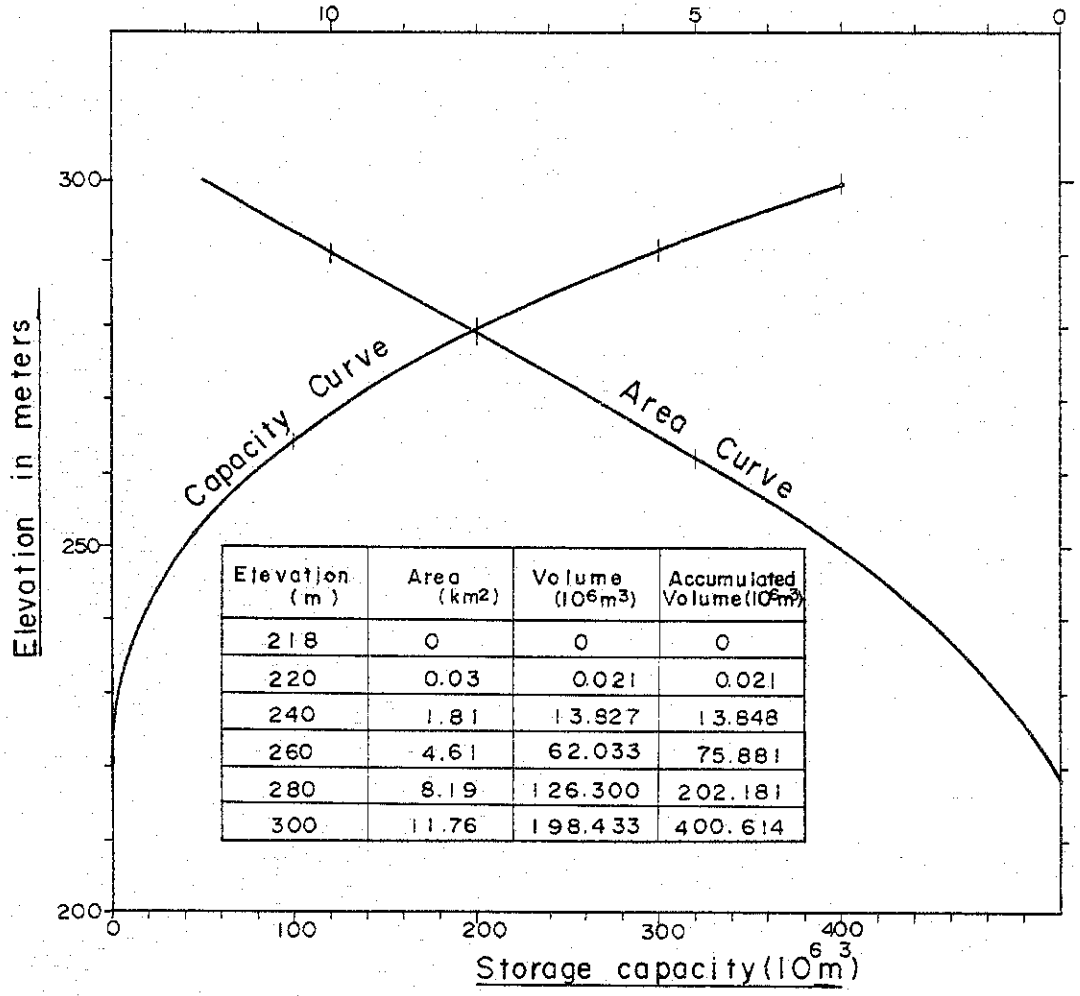
Name of river	Suib R., North Han R.	
Basin		
Catchment area	km^2	582.7
Annual precipitation	mm	1,350 /1
Annual mean discharge	m^3/s	16.7
Reservoir		
F.W.L.	EL.m	302
N.H.W.L.	"	300
L.W.L.	"	264
Gross storage capacity (N.H.W.L)	$10^6 m^3$	400.6
Effective capacity	"	303
Dead capacity	"	97.6
Reservoir area (N.H.W.L)	km^2	11.8
Firm discharge	m^3/sec	12.66
Flood control capacity	$10^6/m^3$	19.8
Dam		
Type		Rock-Fill
Dam height	m	88
Crest length	"	303
Volume of dam	$10^3 m^3$	2,775
Spillway design flood	m^3/s	5,400
Geology		Granitic gneiss
Power station		
Type		Dam & conduit
Max.discharge	m^3/sec	61.26
Rated head (effective)	m	103.6
Installed capacity	kW	54,900
Annual energy output	10^3kWh	116,300

Construction cost	10^6Won	
Compensation	"	5,745
Dam	"	11,758
Sub total	"	17,503
Power facilities	"	11,067
Total	"	28,570
Annual cost of dam and power station	10^6Won	2,671
Power & energy benefit	10^6Won	3,014
kW benefit	"	1,870
kWh benefit	"	1,144
B/C of power		1.13
(B-C) of power	10^6Won	343
Increase of annual available discharge	10^6Won	322.6
Benefit of water supply	10^6Won	2,761
Benefit of flood control	"	88
Total benefit	"	5,863
Total B/C		2.20
B-C	10^6Won	3,192

/1 Average in 1963 through 1972

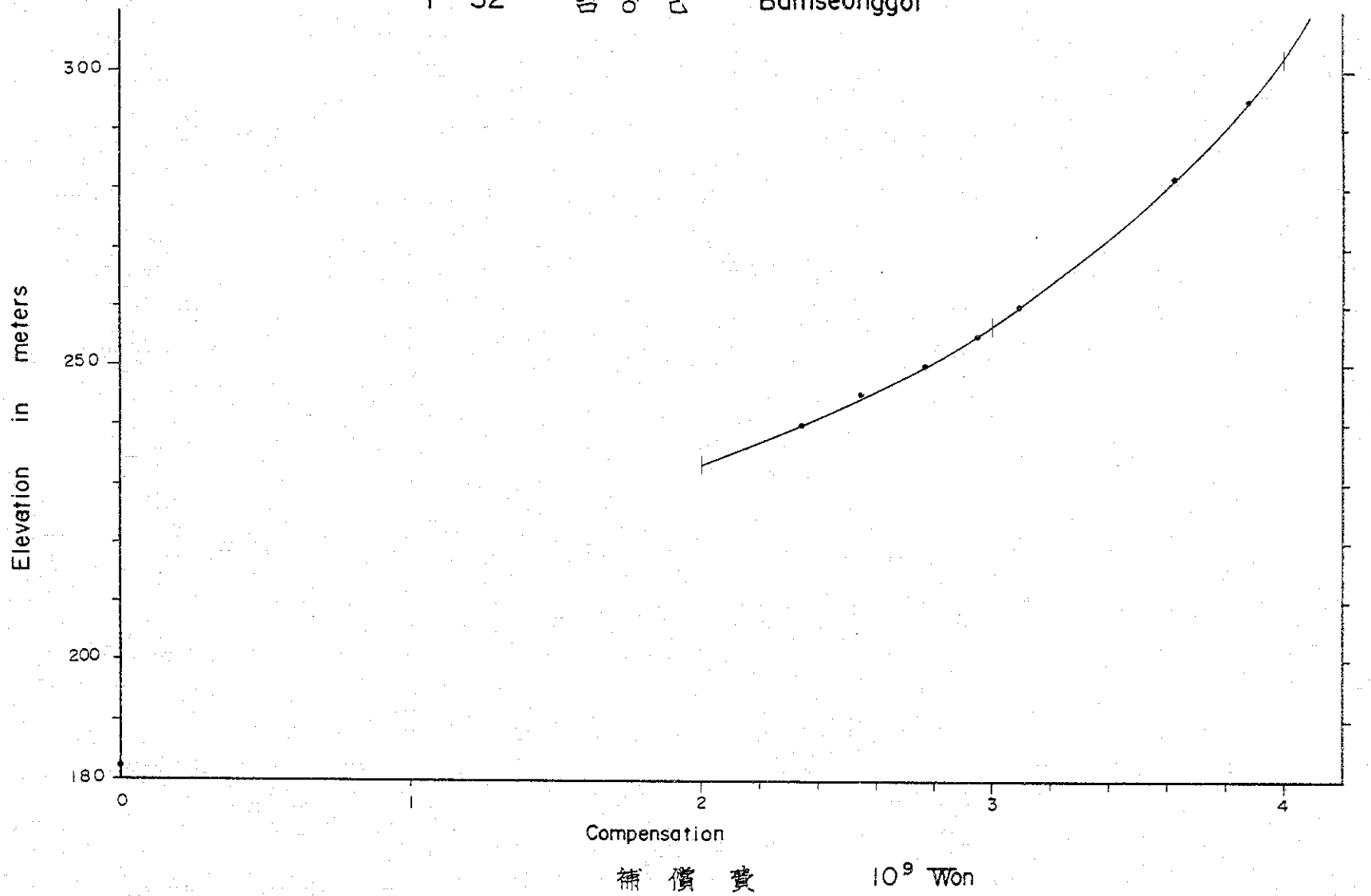
1 - 32 밤성 골 Bamseonggol

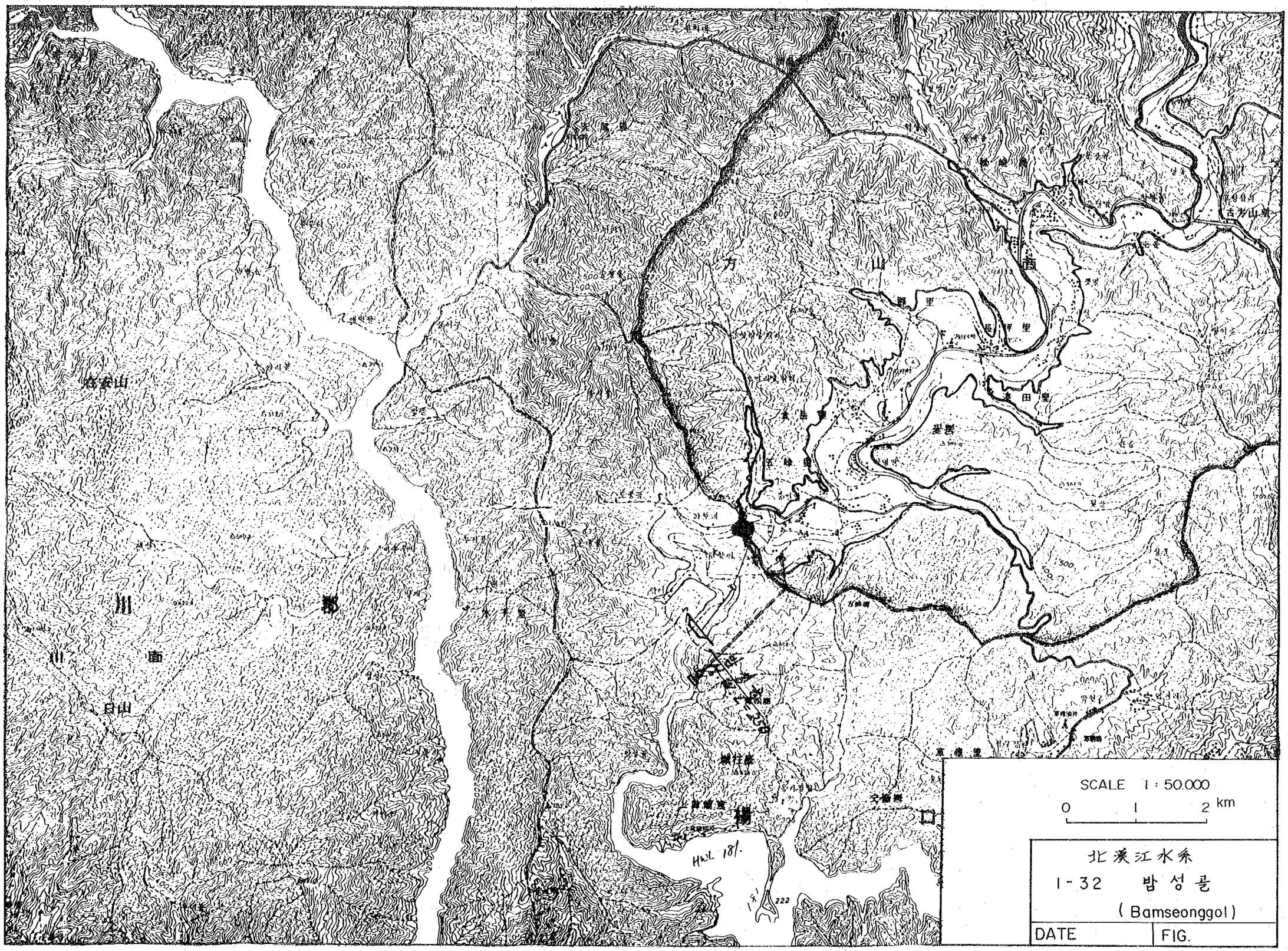
Catchment area : 582.7 Km^2



Elevation (m)	Area (km^2)	Volume ($10^6 m^3$)	Accumulated Volume ($10^6 m^3$)
218	0	0	0
220	0.03	0.021	0.021
240	1.81	13.827	13.848
260	4.61	62.033	75.881
280	8.19	126.300	202.181
300	11.76	198.433	400.614

1-32 삼성곡 Bamseonggol

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2-23 Hupyeong

The Hupyeong Dam site is located at the upstream reach of the Soyang River approximately 40 km above the end of the Soyanggang Reservoir.

The river gradient in this vicinity is a steep slope of approximately 1/150 downstream of the dam site, while topographically, the left and right banks are relatively close together.

Dam sites were considered at 3 locations including the originally proposed dam site.

Since faults were recognized in the north-south direction at both banks of the original dam site, an alternative dam site was selected at a point approximately 300 m downstream the original site. Dam sites for midstream and upstream alternatives approximately 10 km and 15 km upstream the original dam site were also selected and development plans for combined use of a dam and tunnel utilizing the steep gradient of the river were formulated.

The basal rock of all of the dam sites is comprised of granitic gneiss, and it is thought there will be no special problems as dam foundation rock.

As a result of rough comparisons of the 3 alternatives, a development plan based on the upstream one was considered to be economically advantageous, but it will be necessary for further detailed investigations for comparison of the upstream and midstream alternatives.

2-23 Hupyeong

Location of dam Gangweon-do Inje-gun

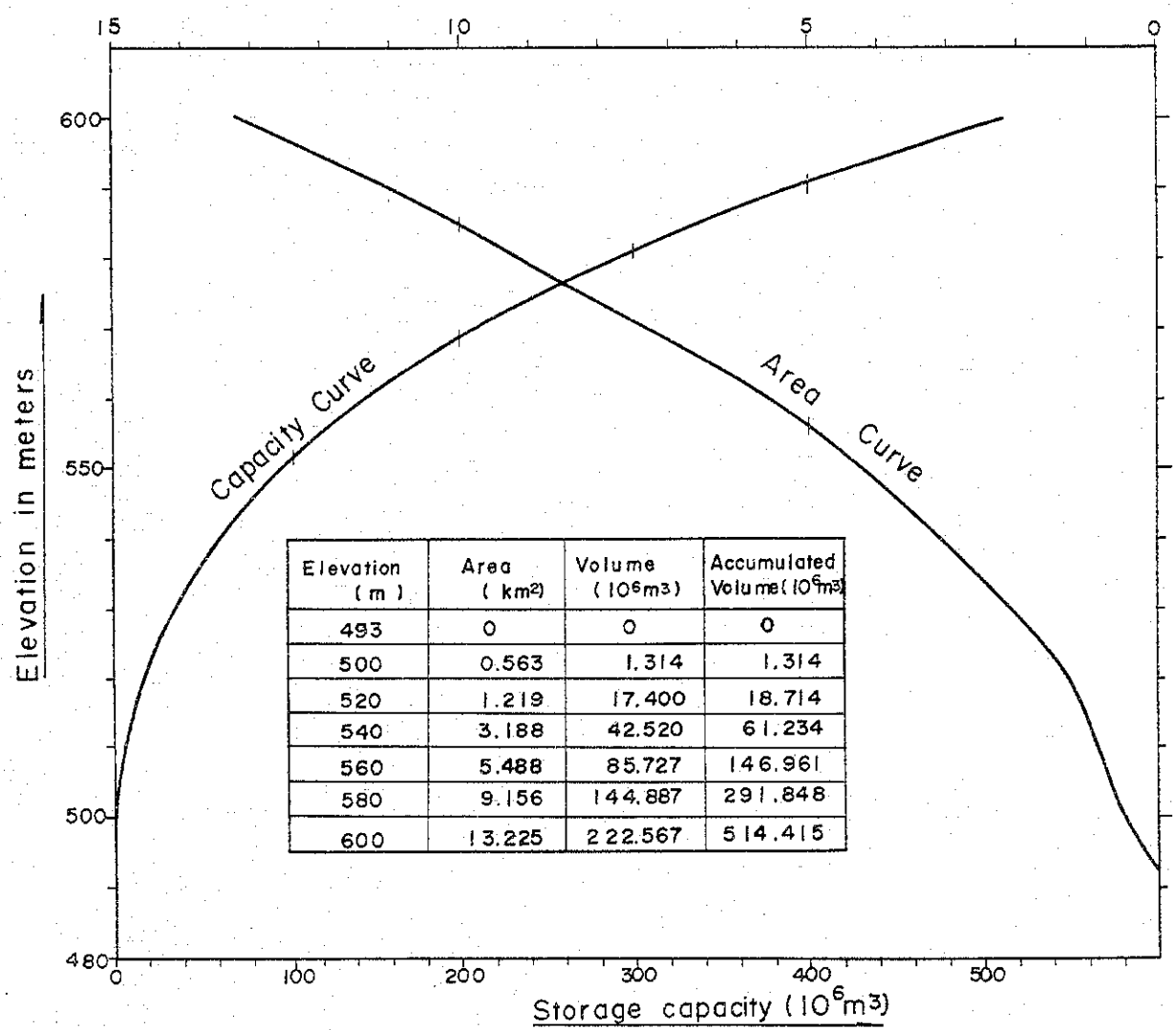
Name of river Soyang R., North Han R.

Basin		
Catchment area	km^2	305
Annual precipitation	mm	1,360
Annual mean discharge	m^3/s	8.72
Reservoir		
F.W.L.	El.m	568.4
N.H.W.L.	"	566.4
L.W.L.	"	521.6
Gross storage capacity (N.H.W.L)	$10^6 m^3$	180.4
Effective capacity	"	165.1
Dead capacity	"	15.3
Reservoir area (N.H.W.L)	km^2	6.7
Firm discharge	m^3/sec	6.7
Flood control capacity	$10^6 m^3$	14.0
Dam		
Type		Rock-Fill
Dam height	m	88.4
Crest length	"	327
Volume of dam	$10^3 m^3$	2,960
Spillway design flood	m^3/s	3,830
Geology		Granitic gneiss
Power station		
Type		Dam & conduit
Max. discharge	m^3/sec	32.4
Rated head (effective)	m	195.2
Installed capacity	kW	54,700
Annual energy output	10^3kWh	118,500

Construction cost	10^6Won	
Compensation	"	2,651
Dam	"	11,493
Sub total	"	14,144
Power facilities	"	16,637
Total	"	30,781
Annual cost of dam and power station	10^6Won	2,989
Power & energy benefit	10^6Won	3,083
kW benefit	"	1,945
kWh benefit	"	1,138
B/C of power		1.03
(B-C) of power	10^6Won	94
Increase of annual available discharge	$10^6 m^3$	28.7
Benefit of water supply	10^6Won	246
Benefit of flood control	"	45
Total benefit	"	3,374
Total B/C		1.13
B-C	10^6Won	385

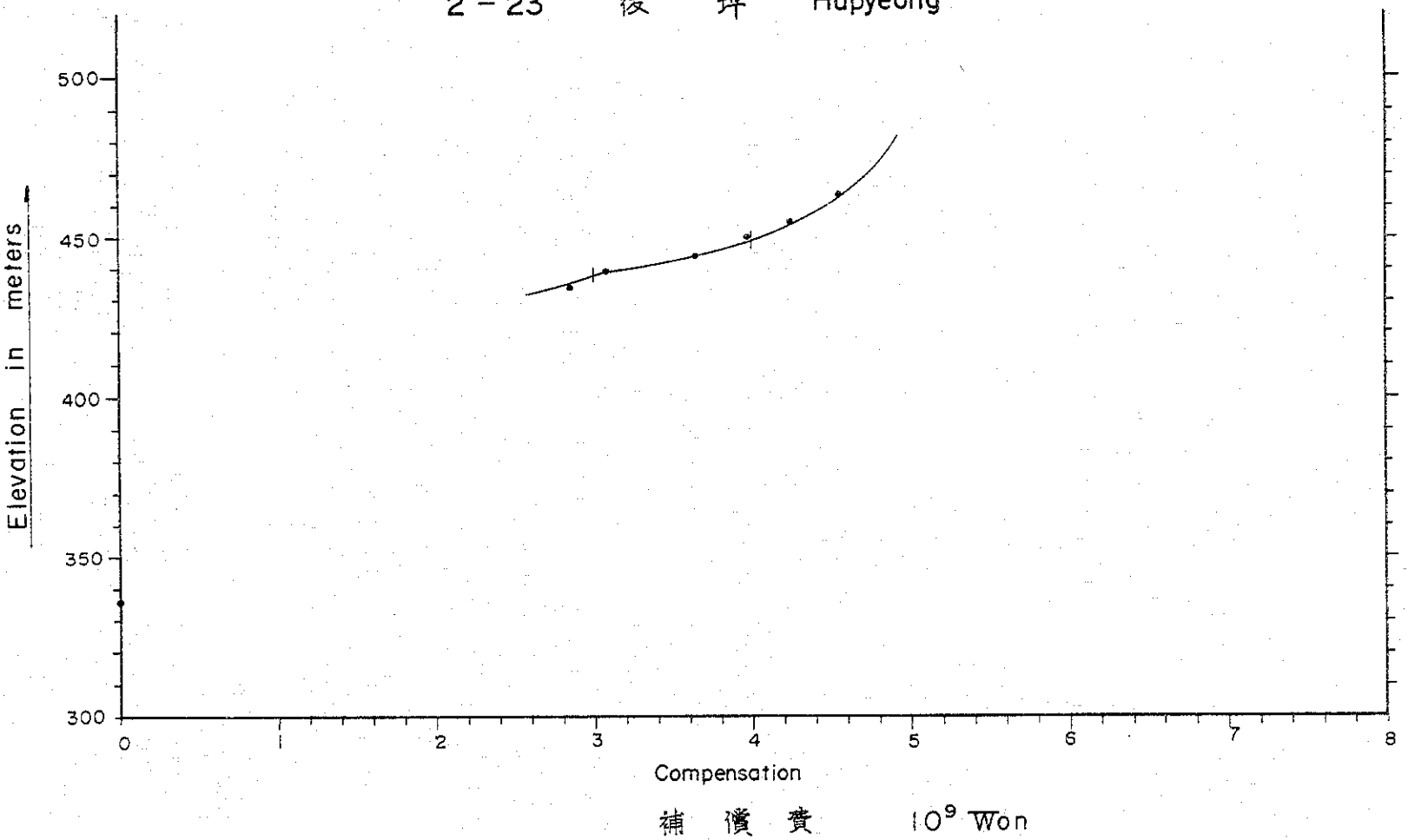
2-23 後 坪 (上流案) Hupyeong

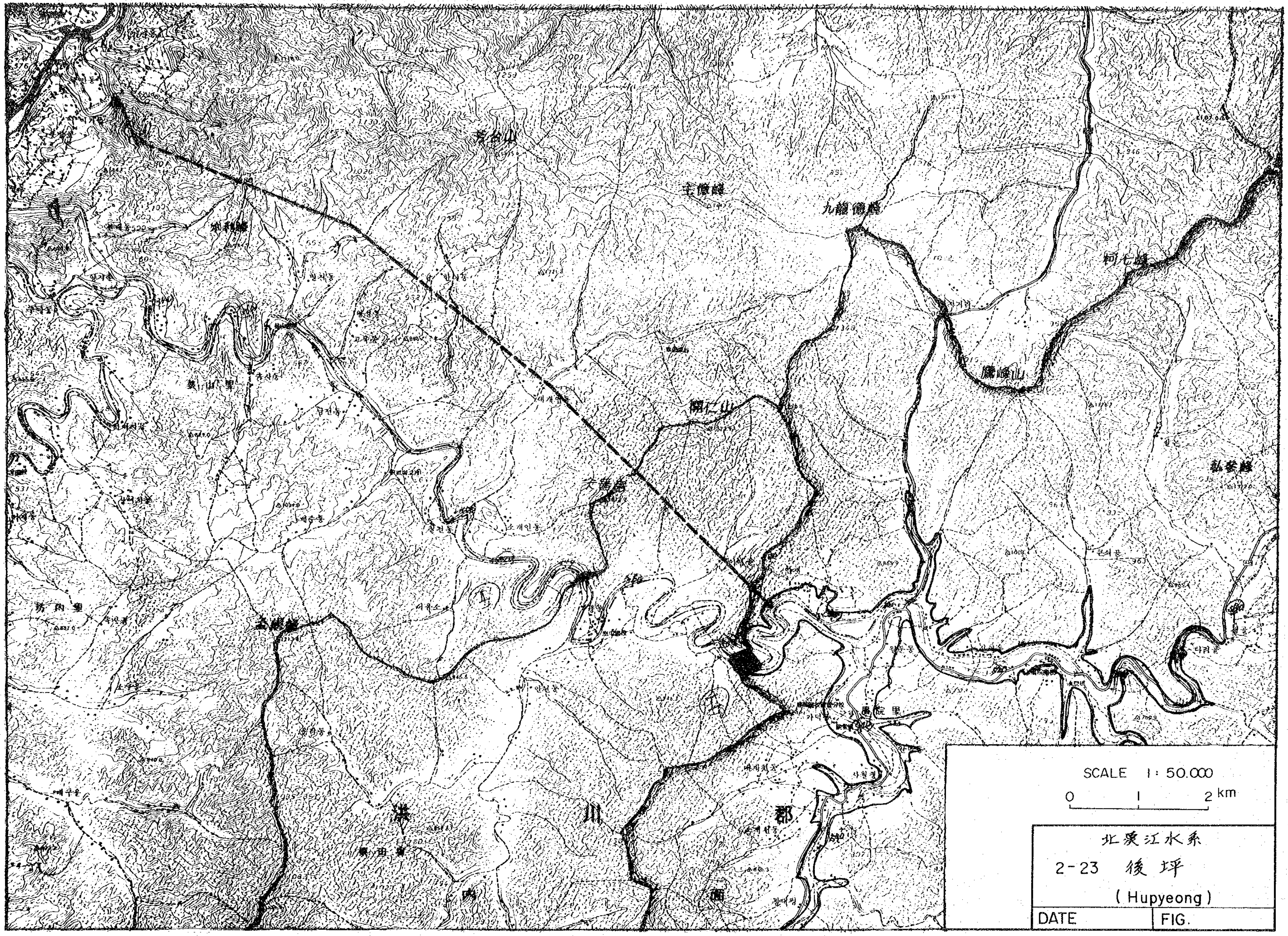
Catchment area : 305 Km²



Elevation (m)	Area (km²)	Volume (10⁶m³)	Accumulated Volume (10⁶m³)
493	0	0	0
500	0.563	1.314	1.314
520	1.219	17.400	18.714
540	3.188	42.520	61.234
560	5.488	85.727	146.961
580	9.156	144.887	291.848
600	13.225	222.567	514.415

2 - 23 後 坪 Hupyeong





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SCALE 1 : 50.000
0 1 2 km
北漢江水系
2-23 後坪
(Hupyeong)
DATE
FIG.

3-22 Inje

The Inje Dam site is planned on the Soyang River mainstream and is located approximately 10 km upstream from the end of the Soyanggang Reservoir.

At first, 3 locations had been considered as the dam site for this project. The site for the original proposal finally selected by the Government of Korea involves no problems in particular either topographically or geologically. However, since the river gradient at the proposed site is considerably steep, an alternative development scheme was formulated for a site selected approximately 4 km upstream from the original site, where the storage efficiency of the dam would be good and a tunnel taking advantage of the head obtained could be utilized, and a comparison study was made.

The dam site of the upstream alternative has topographically a somewhat broader valley compared with the original site and the abutments at the left and right banks are indented irregularly, then it is thought dam volume will be increased.

Geologically, granite makes up the basal rock at both sites and it is thought there will be no special problems in construction of a dam.

The results of the comparison study of the alternatives show that the upstream development scheme is slightly more advantageous, but since it is thought either alternative can be developed economically, it will be necessary for examinations to be made of the two alternatives on carrying out further detailed investigations.

3-22 Inje

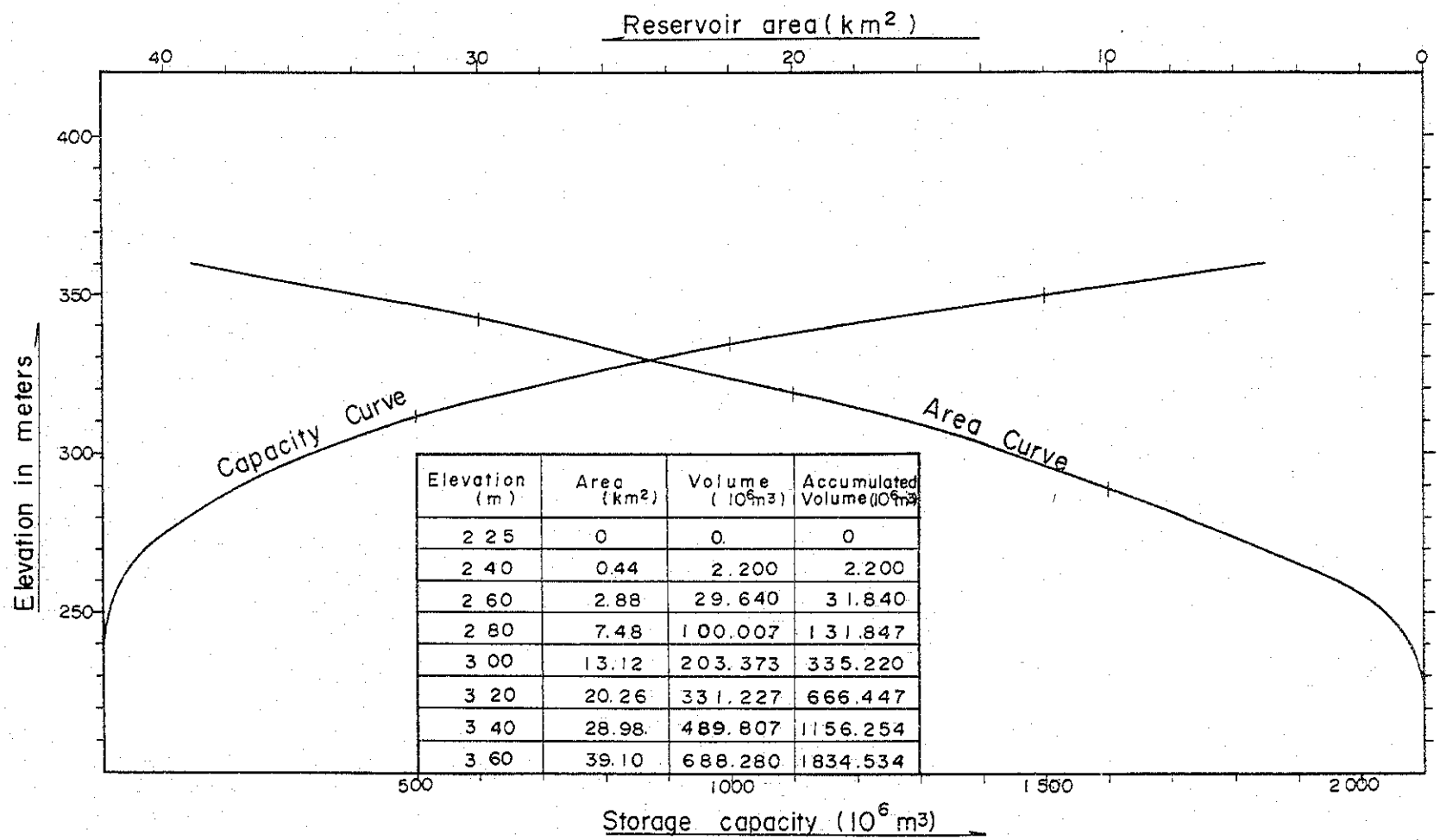
Location of dam Gangweon-do Inje-gun

Name of river Soyang R., North Han R.		
Basin		
Catchment area	km^2	1,043.3
Annual precipitation	mm	1,340
Annual mean discharge	m^3/s	29.84
Reservoir		
F.W.L.	EL.m	346
N.H.W.L.	"	344
L.W.L.	"	300.6
Gross storage capacity (N.H.W.L)	$10^6 m^3$	1,300
Effective capacity	"	941
Dead capacity	"	359
Reservoir area (N.H.W.L)	km^2	31
Firm discharge	m^3/sec	26.31
Flood control capacity	$10^6 m^3$	67.8
Dam		
Type		Rock-Fill
Dam height	m	125
Crest length	"	362
Volume of dam	$10^3 m^3$	5,206
Spillway design flood	m^3/s	7,200
Geology		Granite
Power station		
Type		Dam & conduit
Max.discharge	m^3/sec	127.73
Rated head (effective)	m	130.6
Installed capacity	kW	144,300
Annual energy output	10^3kWh	277,600

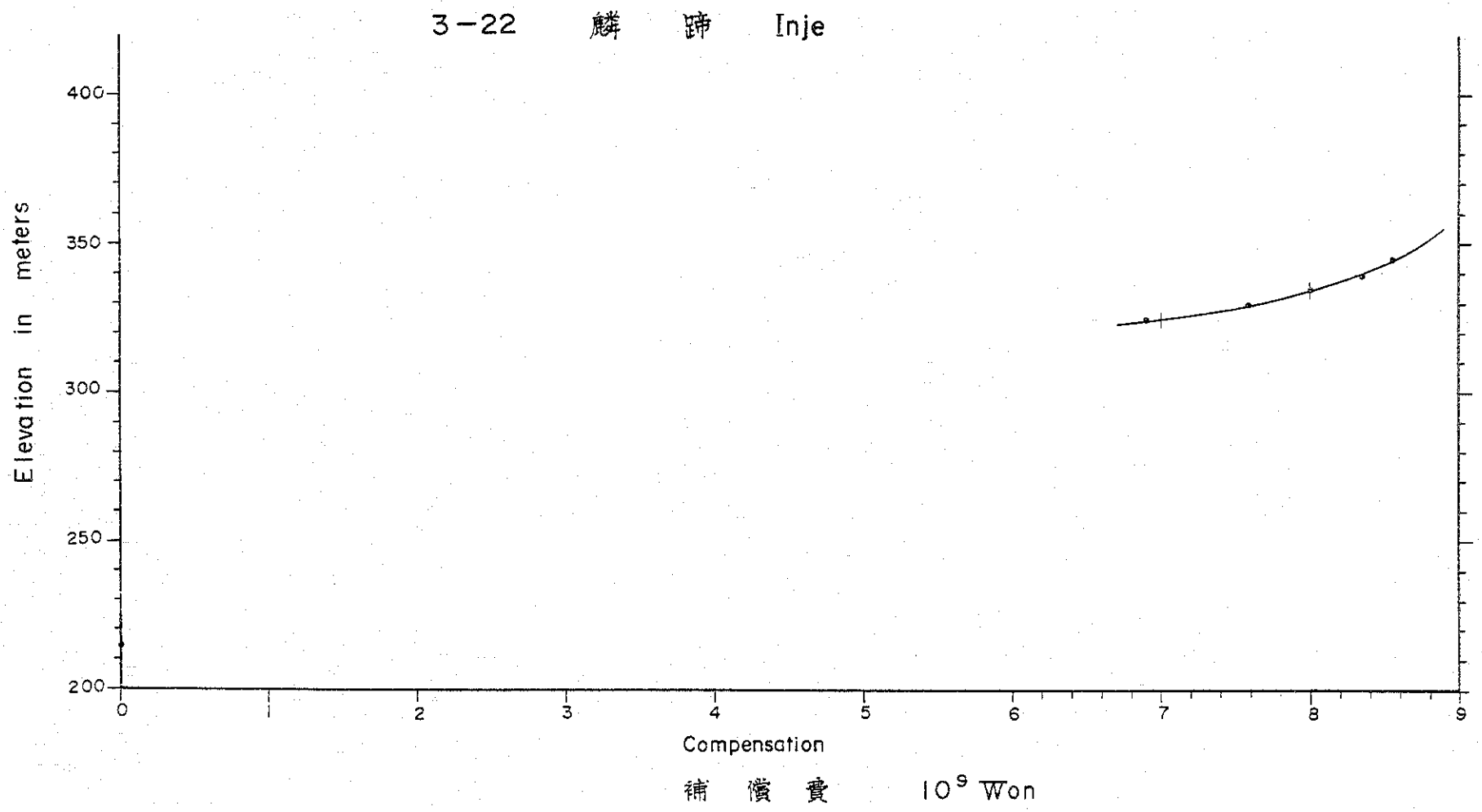
Construction cost	10^6Won	
Compensation	"	12,537
Dam	"	21,094
Sub total	"	33,631
Power facilities	"	26,887
Total	"	60,518
Annual cost of dam and power station	10^6Won	5,724
Power & energy benefit	10^6Won	7,753
kW benefit	"	4,944
kWh benefit	"	2,809
B/C of power		1.35
(B-C) of power	10^6Won	2,030
Increase of annual available discharge	$10^6 m^3$	159.5
Benefit of water supply	10^6Won	1,365
Benefit of flood control	"	66
Total benefit	"	9,184
Total B/C		1.60
B-C	10^6Won	3,461

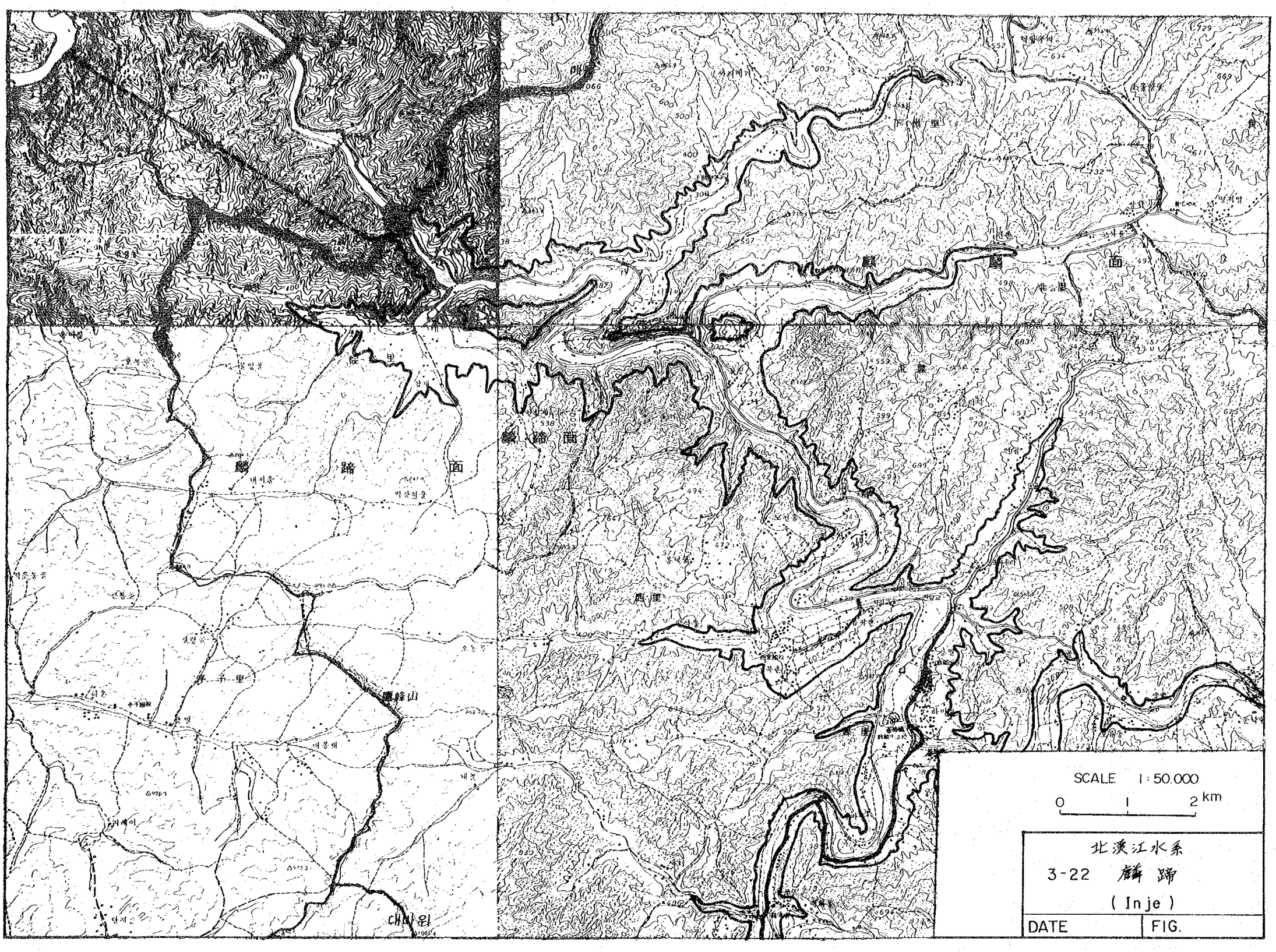
3 -22 麟 蹄 (上流案) Inje

Catchment area : 1,043.3 Km²



Elevation (m)	Area (km²)	Volume (10⁶m³)	Accumulated Volume(10⁶m³)
225	0	0.	0
240	0.44	2.200	2.200
260	2.88	29.640	31.840
280	7.48	100.007	131.847
300	13.12	203.373	335.220
320	20.26	331.227	666.447
340	28.98	489.807	1156.254
360	39.10	688.280	1834.534


3-22 麟 蹄 Inje
Elevation in meters
400
350
300
250
200
0
1
2
3
4
5
6
7
8
9
Compensation
補 償 費 10^9 Won


麟蹄面
麟蹄面
SCALE 1:50.000
0 1 2 km
北漢江水系
3-22 麟 蹄
(Inje)
DATE
FIG.

4-30 Weolhak

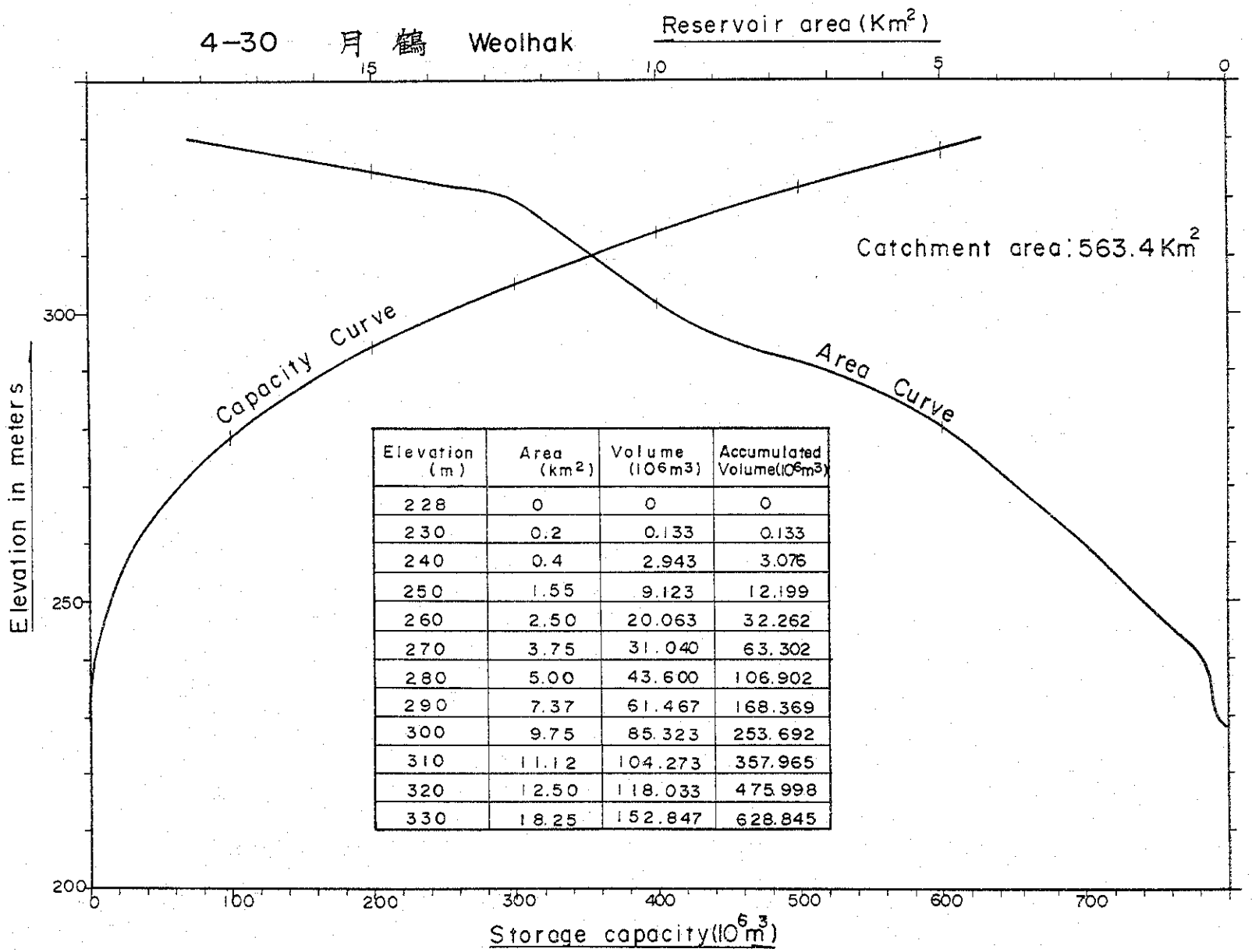
The Weolhak Dam site is located on the Inbuk river approximately 4 km upstream from the confluence with the Soyang river, which flows from the right side at the end of Soyanggang Reservoir.

At this site, the dam crest length will be comparatively long in comparison with the dam height. Although geologically there are outcrops of granitic gneiss and it is thought there will be no special problems as a dam site, the left bank of the site is in the form of a low saddle parallel to the Soyang river. A road from Wontong-Ri to Weolhak Ri runs north passing this saddle. When the reservoir as presently planned reaches high water level of El. 300 m, this saddle will be only about 150 to 200 m to the Wontong-Ri side, while moreover, the Wontong-Ri side is a steep cliff and the fault-fractured zone can be seen, so there will be problems of leakage from this vicinity. Consequently, detailed geological investigations will be necessary for the planned reservoir area upstream of the dam.

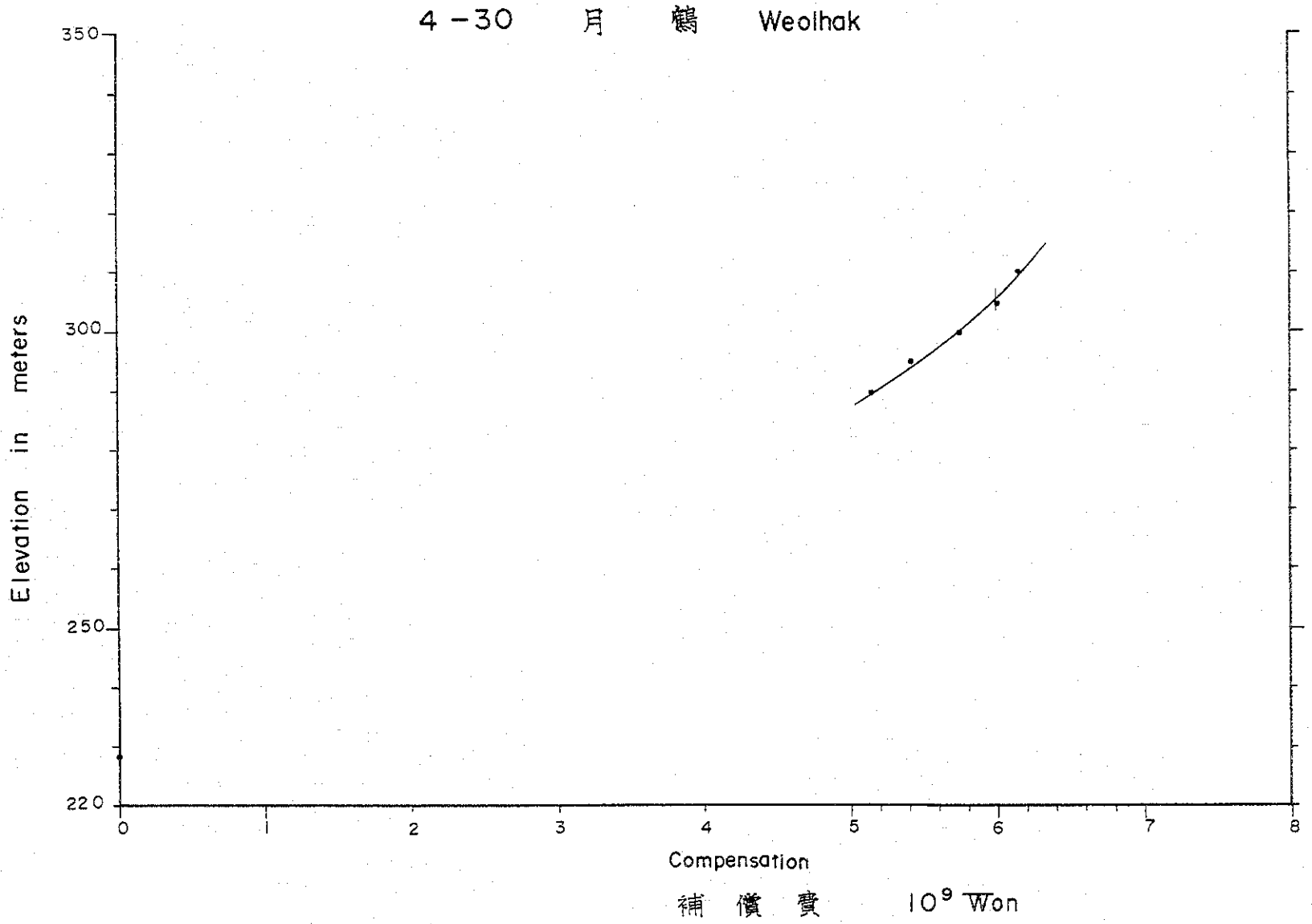
Location of dam Gangweon-do Inje-gun

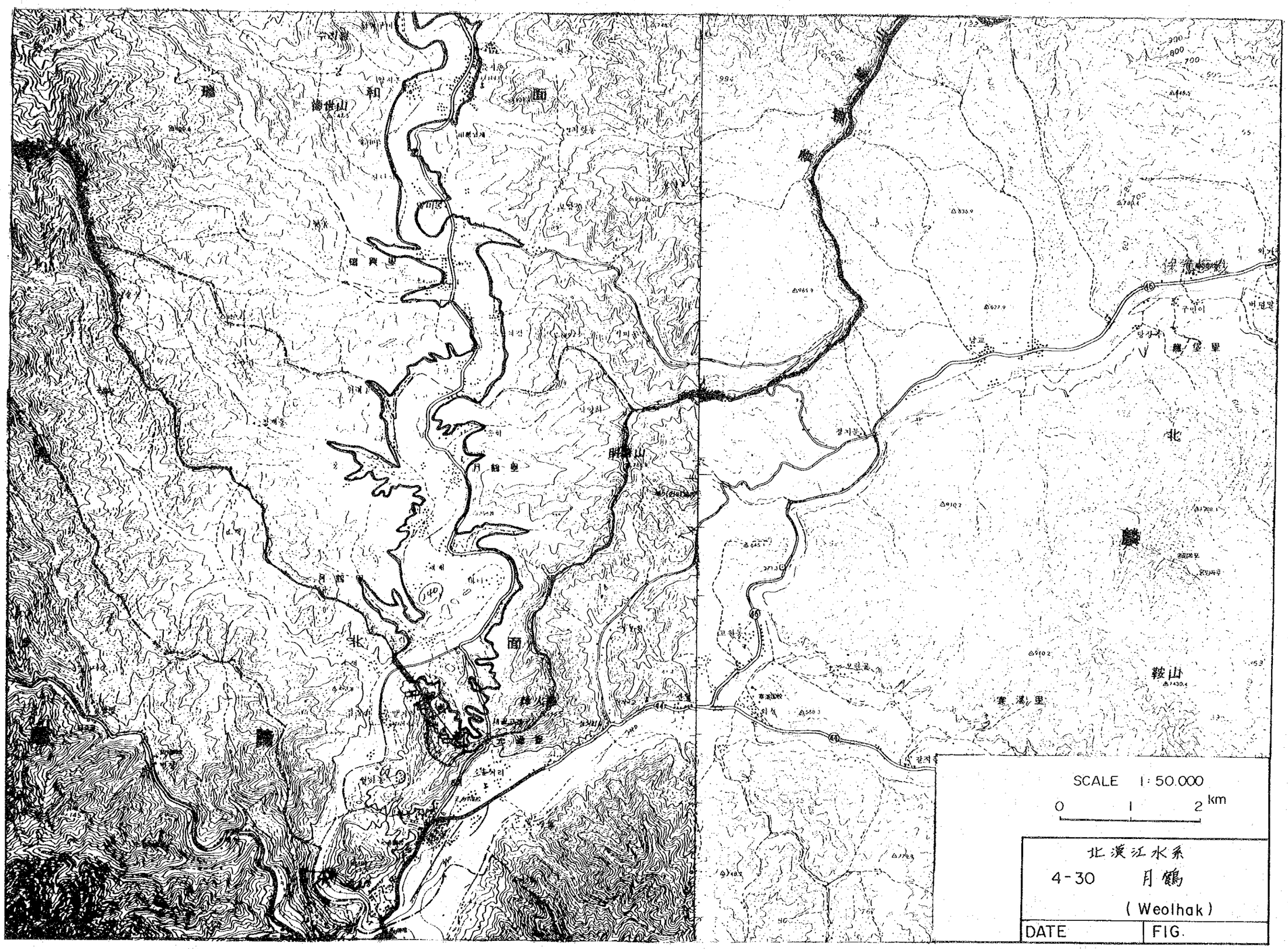
Name of river	Inbuk R. , North Han R.	
Basin		
Catchment area	km^2	563.4
Annual precipitation	mm	1,280
Annual mean discharge	m^3/s	15.78
Reservoir		
F.W.L.	EL.m	302
N.H.W.L.	"	300
L.W.L.	"	278.4
Gross storage capacity (N.H.W.L)	$10^6 m^3$	254
Effective capacity	"	154.7
Dead capacity	"	99.3
Reservoir area (N.H.W.L)	km^2	9.8
Firm discharge	m^3/sec	9.05
Flood control capacity	$10^6 m^3$	20.9
Dam		
Type		Rock-Fill
Dam height	m	81
Crest length	"	357
Volume of dam	$10^3 m^3$	3,330
Spillway design flood	m^3/s	5,310
Geology		Granitic gneiss
Power station		
Type		Dam
Max.discharge	m^3/sec	43.95
Rated head (effective)	m	63.4
Installed capacity	kW	24,100
Annual energy output	10^3kWh	64,800

Construction cost	10^6Won	
Compensation	"	8,470
Dam	"	12,782
Sub total	"	21,252
Power facilities	"	7,318
Total	"	28,570
Annual cost of dam and power station	10^6Won	2,582
Power & energy benefit	10^6Won	1,458
kW benefit	"	823
kWh benefit	"	635
B/C of power		0.56
(B-C) of power	10^6Won	-1,124
Increase of annual available discharge	$10^6 m^3$	26.3
Benefit of water supply	10^6Won	225
Benefit of flood control	"	74
Total benefit	"	1,757
Total B/C		0.68
B-C	10^6Won	-825



Elevation (m)	Area (km²)	Volume (10⁶m³)	Accumulated Volume (10⁶m³)
228	0	0	0
230	0.2	0.133	0.133
240	0.4	2.943	3.076
250	1.55	9.123	12.199
260	2.50	20.063	32.262
270	3.75	31.040	63.302
280	5.00	43.600	106.902
290	7.37	61.467	168.369
300	9.75	85.323	253.692
310	11.12	104.273	357.965
320	12.50	118.033	475.998
330	18.25	152.847	628.845


4 -30 月 鶴 Weolhak
Elevation in meters
350
300
250
220
0
1
2
3
4
5
6
7
8
Compensation
補 償 費 10^9 Won


SCALE 1:50.000
0 1 2 km
北漢江水系
4-30 月鶴
(Weolhak)
DATE
FIG.

5-A3 Hongcheon

The Hongcheon Dam site is located at the lower reach of the Hong River, approximately 14 km upstream from the confluence with the North Han River.

The river gradient in this vicinity is comparatively gentle of approximately 1/600. The dam site has slopes of about 45° at both left and right banks. The right bank is a granitic gneiss ridge and the upper part of the left bank is a relatively soft biotitic gneiss, while from mid-slope to the river bed is quartzite. The river bed is about 200 m wide and a deposited sand layer is relatively thick, the depth being estimated at around 10 m. It is estimated a fault exists at the river bed and it will be necessary to study foundation treatment grasping the scale of the fault in future investigations.

Hongcheon Town is situated at the end of the backwater of the proposed reservoir and it will be necessary to examine the dam height carrying out detailed longitudinal profile surveys of the river and investigations of the reservoir area for relocation and compensation purposes.

5-A3 Hongcheon

Location of dam: left bank : Gangweon-do Hongcheon-gun
right bank : Gangweon-do Chunseong-gun

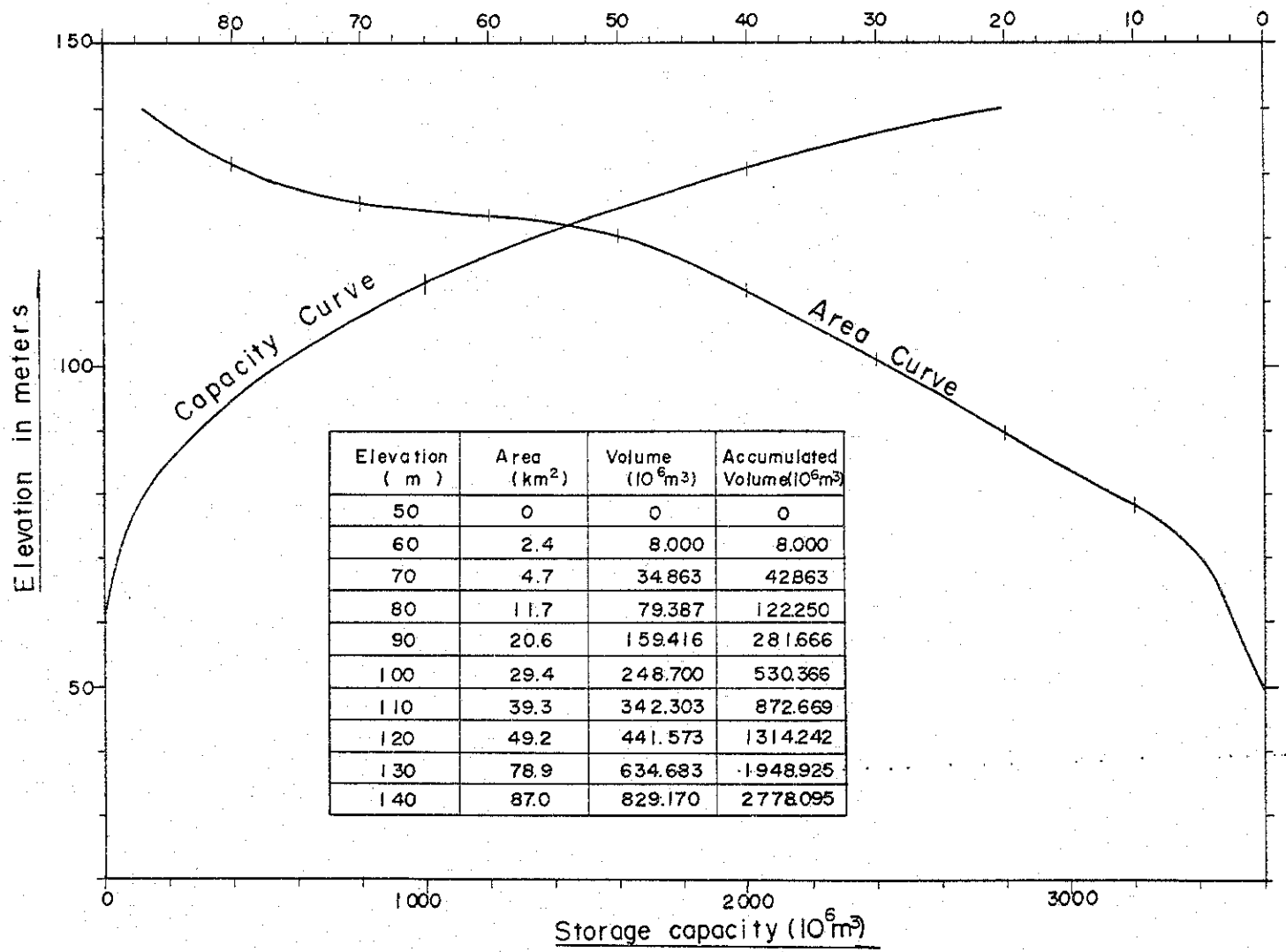
Name of river: Hong R., North Han R.

Basin		
Catchment area	km^2	1,473
Annual precipitation	mm	1,430
Annual mean discharge	m^3/s	42.24
Reservoir		
F.W.L.	EL.m	123.5
N.H.W.L.	"	120
L.W.L.	"	99.3
Gross storage capacity (N.H.W.L)	$10^6 m^3$	1,314
Effective capacity	"	799.3
Dead capacity	"	
Reservoir area (N.H.W.L)	km^2	49
Firm discharge	m^3/sec	30.4
Flood control capacity	$10^6 m^3$	202.5
Dam		
Type		Concrete-Gravity
Dam height	m	85
Crest length	"	351
Volume of dam	$10^3 m^3$	700
Spillway design flood	m^3/s	8,460
Geology		Quartzite & gneiss
Power station		
Type		Dam
Max.discharge	m^3/sec	147.85
Rated head (effective)	m	60.6
Installed capacity	kW	77,500
Annual energy output	10^3kWh	182,000

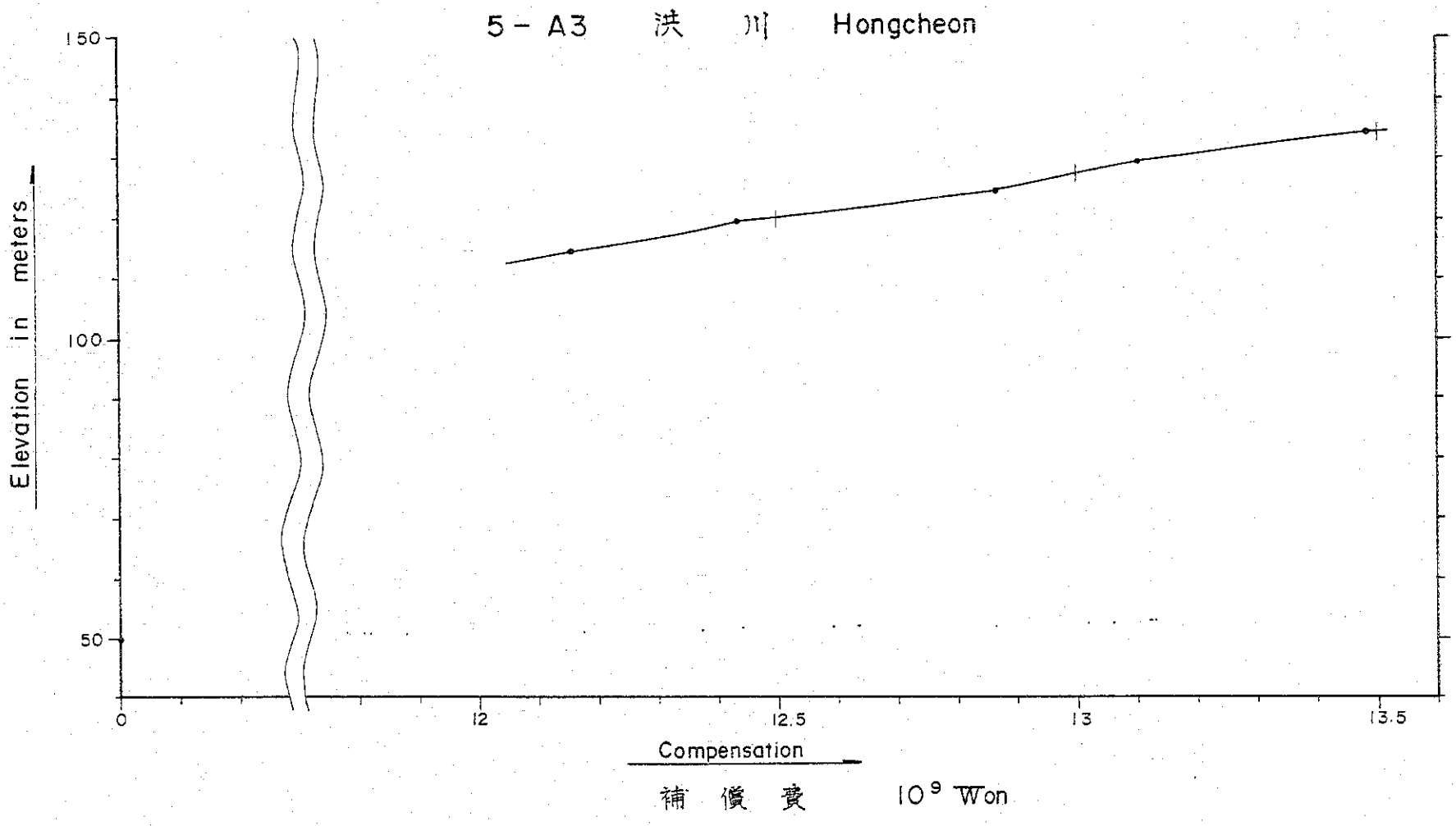
Construction cost	10^6Won	
Compensation	"	18,736
Dam	"	23,580
Sub total	"	42,316
Power facilities	"	16,248
Total	"	58,564
Annual cost of dam and power station	10^6Won	5,311
Power & energy benefit	10^6Won	4,742
kW benefit	"	2,646
kWh benefit	"	2,096
B/C of power		0.89
(B-C) of power	10^6Won	-569
Increase of annual available discharge	$10^6 m^3$	798.5
Benefit of water supply	10^6Won	6,835 (131)
Benefit of flood control	"	2,158 (11,708)
Total benefit	"	13,735
Total B/C		(2.20) 2.59
B-C	10^6Won	(6,397) 8,424

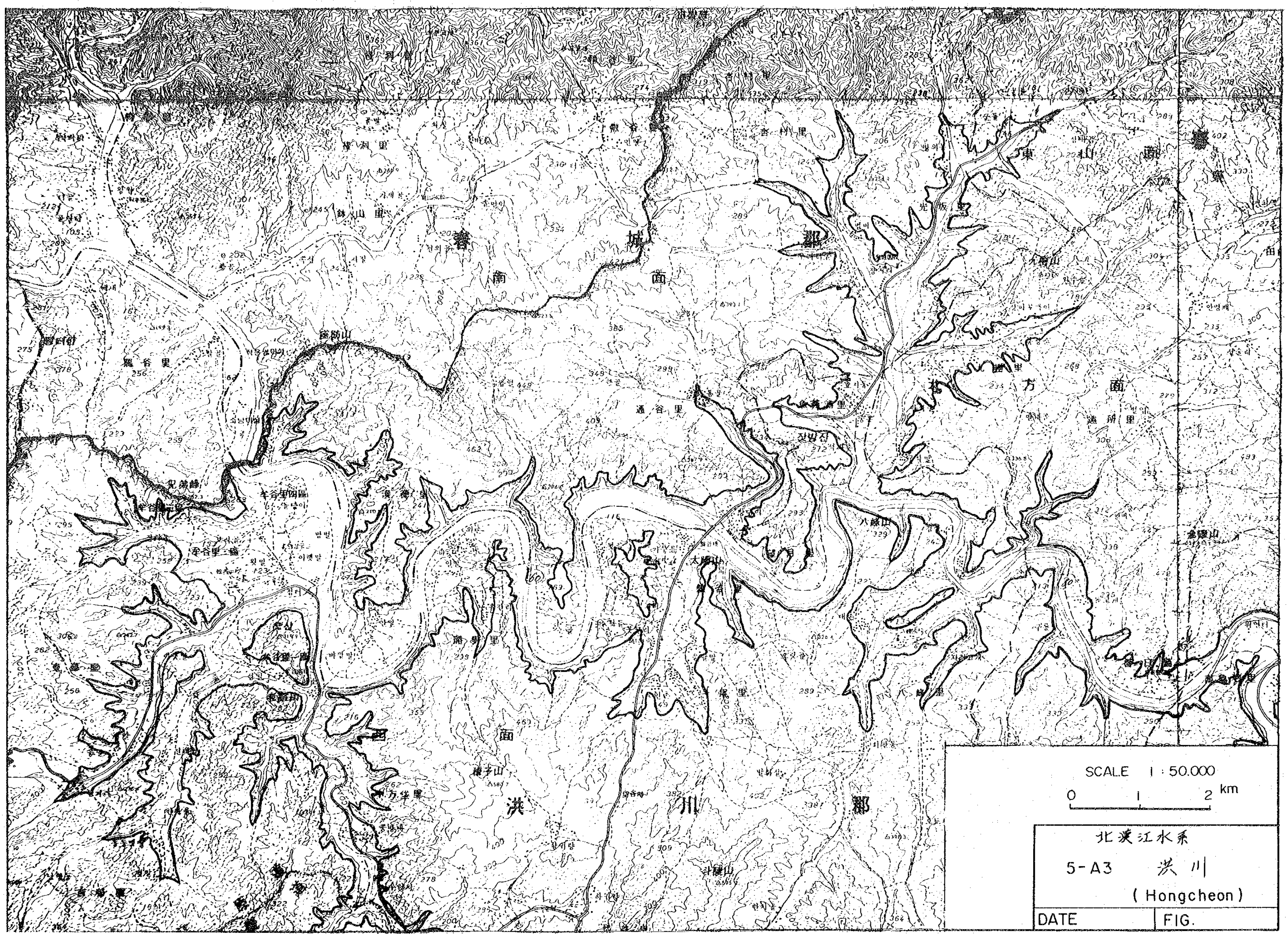
5 - A3 洪川 Hongcheon

Catchment area : 1,473 Km²



Elevation (m)	Area (km^2)	Volume (10^6m^3)	Accumulated Volume(10^6m^3)
50	0	0	0
60	2.4	8.000	8.000
70	4.7	34.863	42.863
80	11.7	79.387	122.250
90	20.6	159.416	281.666
100	29.4	248.700	530.366
110	39.3	342.303	872.669
120	49.2	441.573	1314.242
130	78.9	634.683	1948.925
140	87.0	829.170	2778.095


5 - A3 洪 川 Hongcheon
150
100
50
Elevation in meters
0
12
12.5
13
13.5
Compensation
補 償 費
10⁹ Won


SCALE 1:50.000
0 1 2 km
北漢江水系
5-A3 洪川
(Hongcheon)
DATE
FIG.
洪
川
郡

6-3 Gujeol

The Gujeol Dam was originally planned at the north side of Gujeol-ri approximately 10 km upstream from the confluence of the South Han River and the So River.

This Gujeol dam site is situated where there are numerous state-owned and privately-owned coal mines, and at the left bank of the original dam site there is a coal mine presently in operation where a few adits have been excavated.

The river gradient upstream of this vicinity is relatively steep at around 1/100 while large boulders and outcrops of sandstone are seen at the river bed. Upstream, there are proposed dam sites such as Wangsan, Daeki and Doam, but the river gradient is steep from Doam to Gujeol, and it cannot be said to be advantageous to build dams along this stretch where the storage efficiency will be low. Accordingly, a scheme for utilizing the head from Doam to Gujeol by a tunnel was formulated.

The dam site selected at Doam is located approximately 10 km by a local road branching to the south from the highway connecting Seoul and Gangnung.

The bed rock of the dam site is comprised of good-quality sandstone and there is no problem as a foundation for the dam.

However, the surroundings of the planned reservoir area is a gently terraced area, and there are many objects which would require compensation such as shops and hamlets. On the other hand, by constructing a dam taking advantage of the topography and utilizing the surrounding terraces, it is conceivable for a recreation center to be developed, and in fact there are recreation facilities of the mining companies now existing. Accordingly, it will be necessary for detailed investigations by elevation to be made of properties for compensation.

6-3 Gujeol

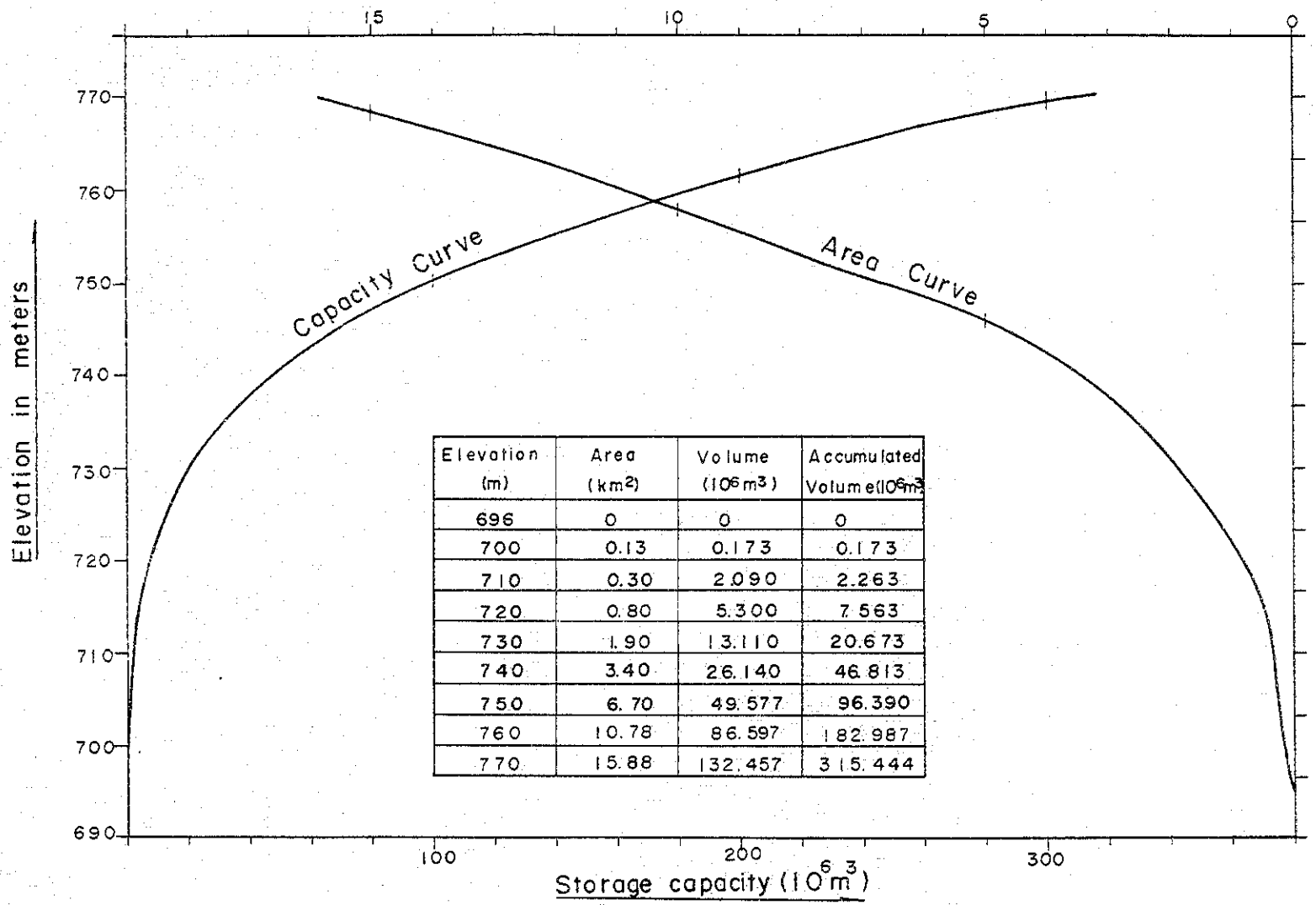
Location of dam Gangweon-do Pyongcheng-gun

Name of river	So R., South Han R.	
Basin		
Catchment area	km^2	100.8
Annual precipitation	mm	1,210
Annual mean discharge	m^3/s	2.66
Reservoir		
F.W.L.	EL.m	744.5
N.H.W.L.	"	742.5
L.W.L.	"	717.9
Gross storage capacity (N.H.W.L)	$10^6 m^3$	57
Effective capacity	"	50.3
Dead capacity	"	6.7
Reservoir area (N.H.W.L)	km^2	4.0
Firm discharge	m^3/sec	2.03
Flood control capacity	$10^6 m^3$	9.0
Dam		
Type		Rock-Fill
Dam height	m	54.5
Crest length	"	193
Volume of dam	$10^3 m^3$	790
Spillway design flood	m^3/s	1,870
Geology		Sandstone
Power station		
Type		Dam & conduit
Max.discharge	m^3/sec	9.9
Rated head (effective)	m	315.4
Installed capacity	kW	27,000
Annual energy output	10^3kWh	60,200

Construction cost	10^6Won	
Compensation	"	4,805
Dam	"	3,955
Sub total	"	8,760
Power facilities	"	9,344
Total	"	18,104
Annual cost of dam and power station	10^6Won	1,733
Power & energy benefit	10^6Won	1,583
kW benefit	"	1,012
kWh benefit	"	571
B/C of power		0.91
(B-C) of power	10^6Won	-150
Increase of annual available discharge	$10^6 m^3$	29.1
Benefit of water supply	10^6Won	249
Benefit of flood control	"	78
Total benefit	"	1,910
Total B/C		1.10
B-C	10^6Won	177

6-3 九 切 Gujeol

Catchment area : 100.8Km^2



Elevation (m)	Area (km^2)	Volume (10^{6}m^3)	Accumulated Volume(10^{6}m^3)
696	0	0	0
700	0.13	0.173	0.173
710	0.30	2.090	2.263
720	0.80	5.300	7.563
730	1.90	13.110	20.673
740	3.40	26.140	46.813
750	6.70	49.577	96.390
760	10.78	86.597	182.987
770	15.88	132.457	315.444

SCALE 1 : 50.000

0 1 2 km

南漢江水系

6-3 九 切

(Gujeol)

DATE	FIG.

7-9 Pyeongchang

The Pyeongchang Dam site is located approximately 100 km upstream on the Pyeongchang River from its conjunction with the South Han River. The river meanders widely for about 5 km both upstream and downstream from the dam site and the river gradient is relatively gentle at around 1/350, but by making a shortcut of the meandering part of the river by tunnel (ℓ = 2,000 m), it will be possible to utilize a head of approximately 20 m, so that a development scheme involving a tunnel was contemplated.

The bed rock of both banks at the dam site is comprised of hard gneiss with partial outcropping at the river bed, but since there is terrace with height difference of about 10 m on the left bank, the cross section will become slightly large, but it is not thought there will be any special problem as a foundation.

The greater part of the area scheduled for reservoir is of limestone, but this limestone is silicic and gneissose so that it is thought there is little possibility of large caves existing. Observations of surface conditions reveal small-scale cavities, but large caves cannot be recognized.

The problem is that the valley where the road from Pyeongchang to Pangrim-Ri runs is thought to be a tectonic line (fault) and there are many talus deposits along the road, so it will be necessary for further investigations of this vicinity. According to the presently planned high water level of El. 420 m, the width of the valley will be approximately 800 m so that it is thought there will be no leakage from the reservoir, but since the reservoir area also consists of similar limestone, it is considered necessary for examinations to be made preparing geologic maps of this planned reservoir area.

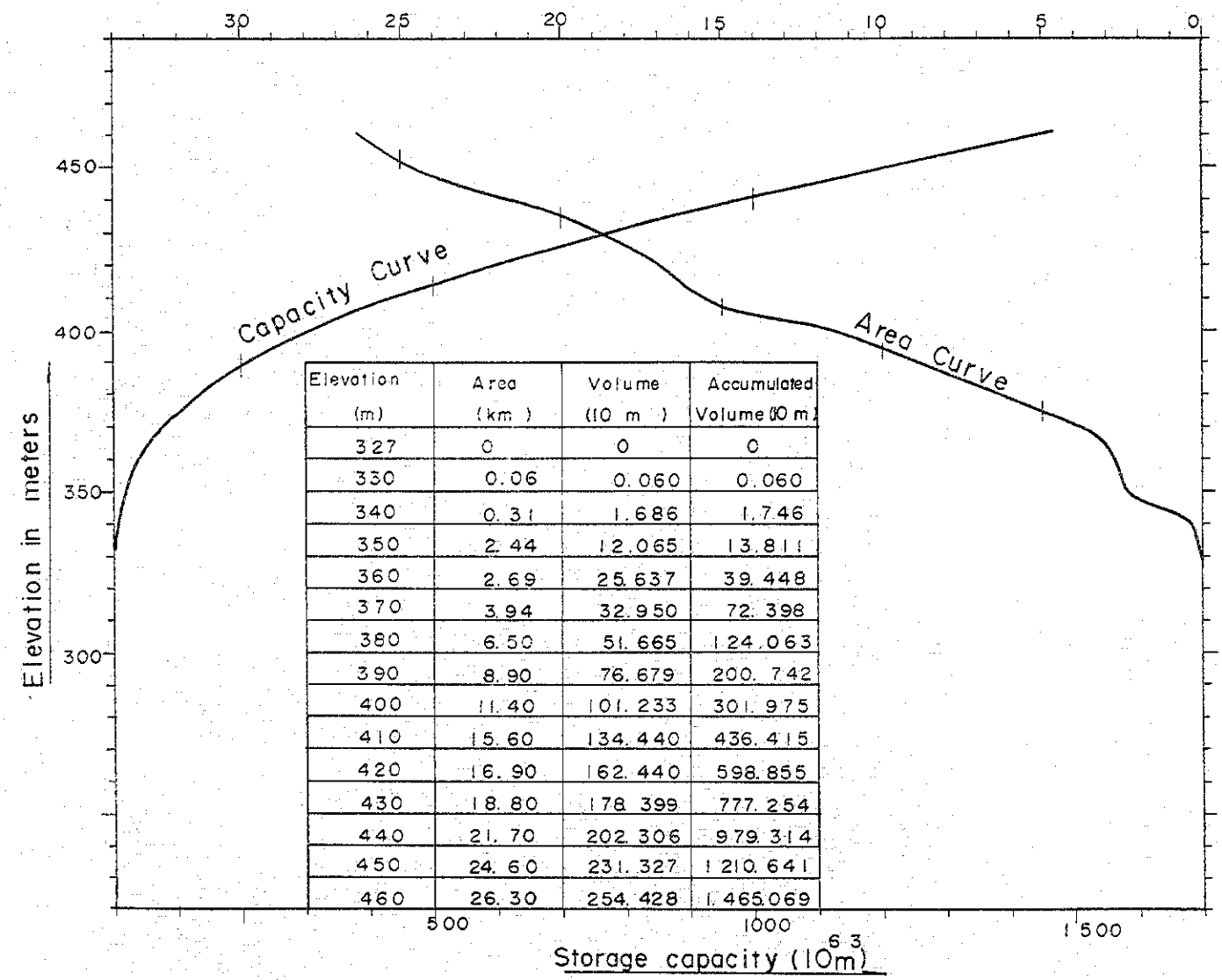
7-9 Pyeongchang

Location of dam Gangweon-do Pyongchang-gun

Name of river	Pyeongchang R., S. Han R.	
Basin		
Catchment area	km^2	485.3
Annual precipitation	mm	1,330
Annual mean discharge	m^3/s	12.96
Reservoir		
F.W.L.	EL.m	422
N.H.W.L.	"	420
L.W.L.	"	388.6
Gross storage capacity (N.H.W.L)	$10^6 m^3$	598.8
Effective capacity	"	408.6
Dead capacity	"	190.2
Reservoir area (N.H.W.L)	km^2	16.9
Firm discharge	m^3/sec	11.71
Flood control capacity	$10^6 m^3$	35.6
Dam		
Type		Rock-Fill
Dam height	m	102
Crest length	"	424
Volume of dam	$10^3 m^3$	5,570
Spillway design flood	m^3/s	4,570
Geology		Gneiss
Power station		
Type		Dam & conduit
Max.discharge	m^3/sec	56.99
Rated head (effective)	m	95.1
Installed capacity	kW	46,900
Annual energy output	10^3kWh	88,500

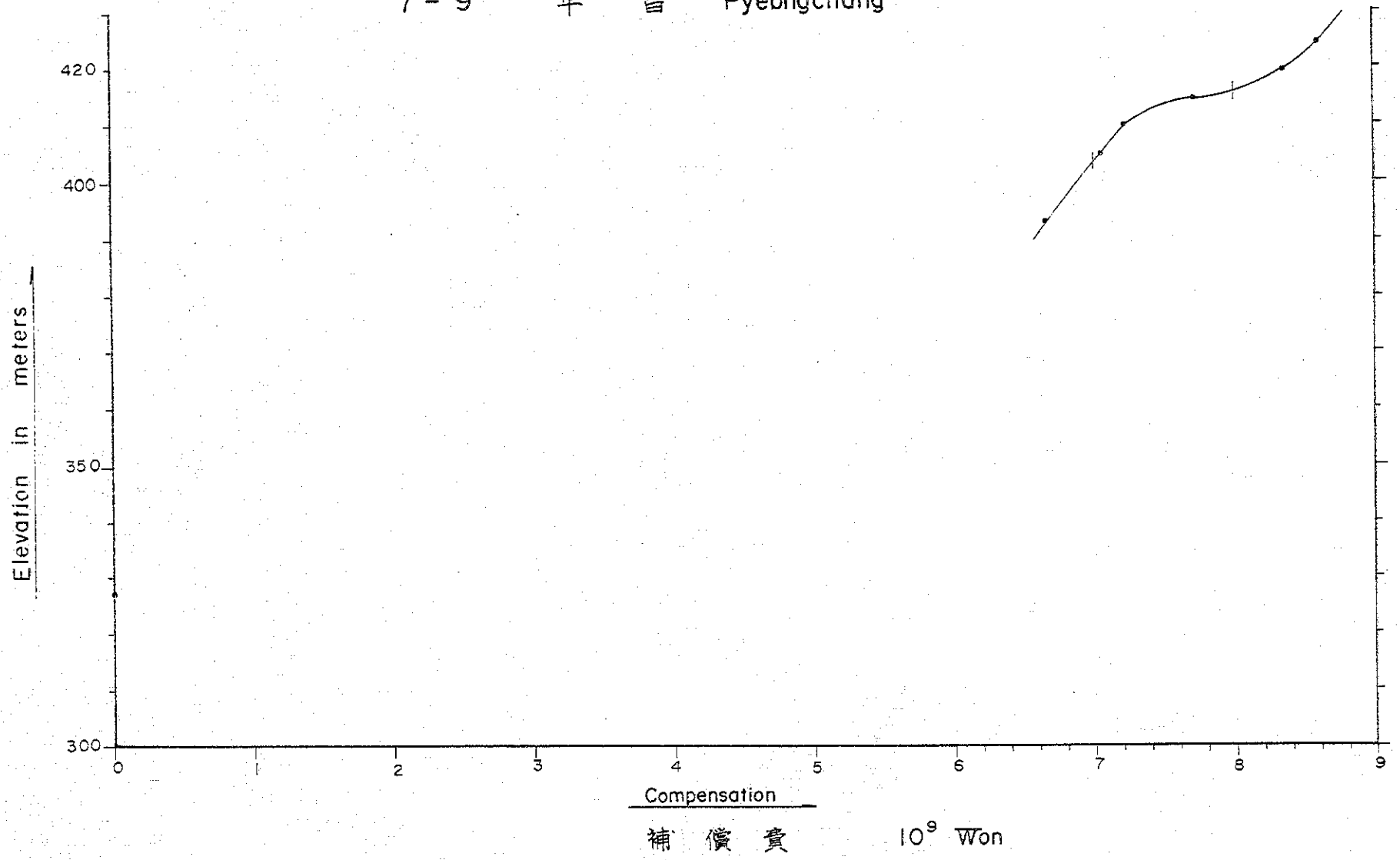
Construction cost	10^6Won	
Compensation	"	12,299
Dam	"	18,675
Sub total	"	30,974
Power facilities	"	10,719
Total	"	41,693
Annual cost of dam and power station	10^6Won	3,769
Power & energy benefit	10^6Won	2,498
kW benefit	"	1,608
kWh benefit	"	890
B/C of power		0.66
(B-C) of power	10^6Won	-1,271
Increase of annual available discharge	$10^6 m^3$	201.9
Benefit of water supply	10^6Won	1,728
Benefit of flood control	"	84
Total benefit	"	4,310
Total B/C		1.14
B-C	10^6Won	541

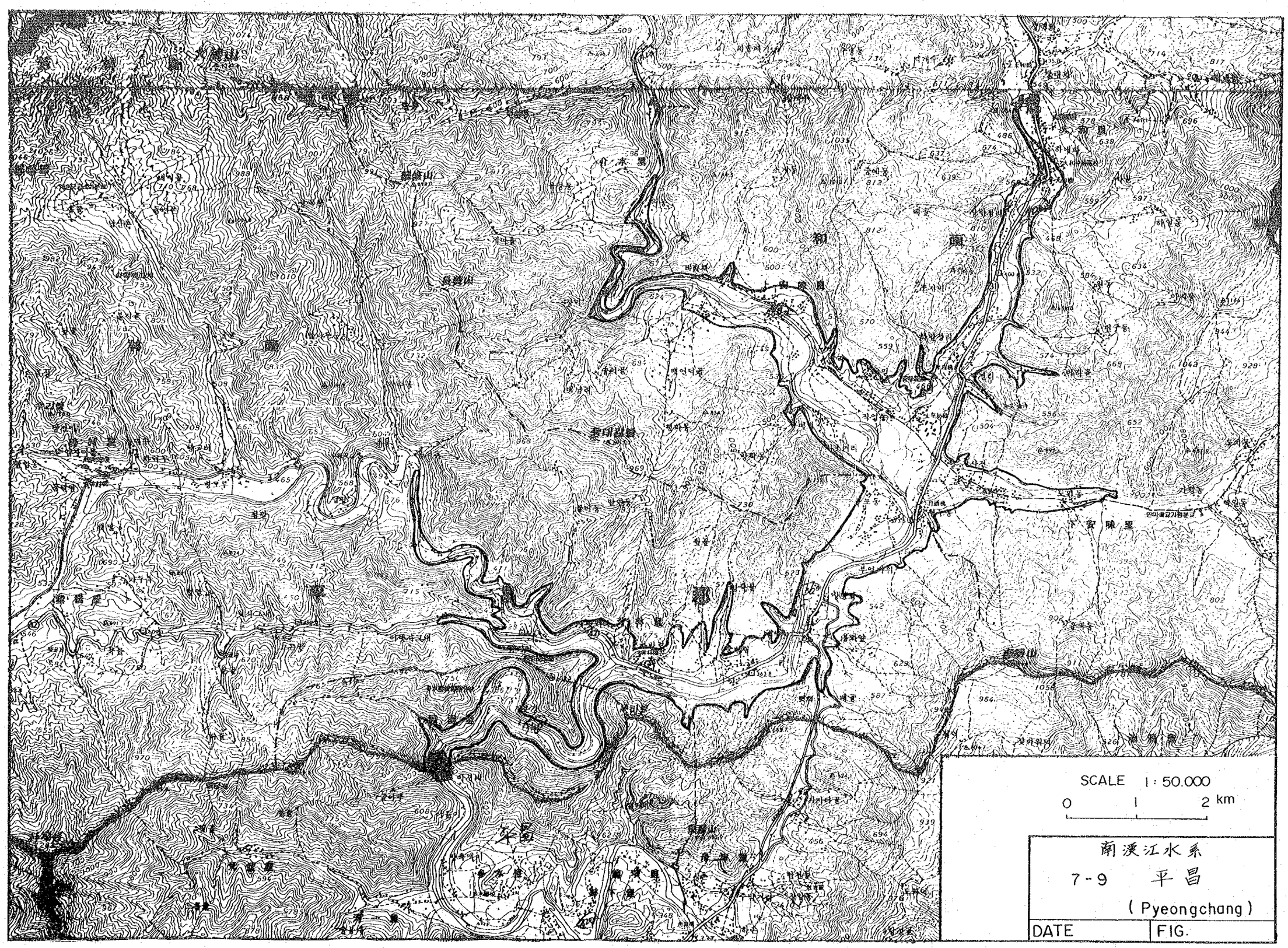
7 - 9 平昌 Pyeongchang Reservoir area (Km^2) Catchment area 485.3 Km^2



Elevation (m)	Area (km)	Volume (10 m)	Accumulated Volume (10 m)
327	0	0	0
330	0.06	0.060	0.060
340	0.31	1.686	1.746
350	2.44	12.065	13.811
360	2.69	25.637	39.448
370	3.94	32.950	72.398
380	6.50	51.665	124.063
390	8.90	76.679	200.742
400	11.40	101.233	301.975
410	15.60	134.440	436.415
420	16.90	162.440	598.855
430	18.80	178.399	777.254
440	21.70	202.306	979.314
450	24.60	231.327	1210.641
460	26.30	254.428	1.465.069

7 - 9 平 昌 Pyeongchang




SCALE 1 : 50.000
0 1 2 km
南溪江水系
7-9 平昌
(Pyeongchang)
DATE
FIG.

8-10 Panun

The dam site is located at a point approximately 10 km southwest of Pyeongchang Ri and approximately 80 km upstream on the Pyeongchang River from its confluence with the South Han River.

The river in this area meanders widely from the vicinity of Pyeongchang Ri and flows toward southwest. The river gradient is relatively gentle and the river bed is wide.

There are fairly wide distributions of sand-gravel deposits at the river bed, the depths being estimated to be about 2 to 5 m.

There is no alternative site other than the presently planned site which is suitable for a dam.

National Highway No.31 from Yeongweol to Gangnung via Pyeongchang Ri runs along the river and relocation of the road will be required when the dam be constructed. The dam site is located on green sandstone which forms steep cliffs at the left and right banks. This green sandstone is very hard and presents no problem as a dam foundation.

The reservoir area is mainly comprised of limestone, this limestone also being very hard, and large caves cannot be seen in the areas where the limestone is outcropped at the both sides of the river. Since there is non-calcareous bedrock distributed to surround the limestone, it is thought there will be no leakage, but though the scale of the reservoir is small as in the case of Pyeongchang, it is thought necessary for studies to be made upon preparation of a geologic map for the area where water is planned to be impounded.

8-10 Panun

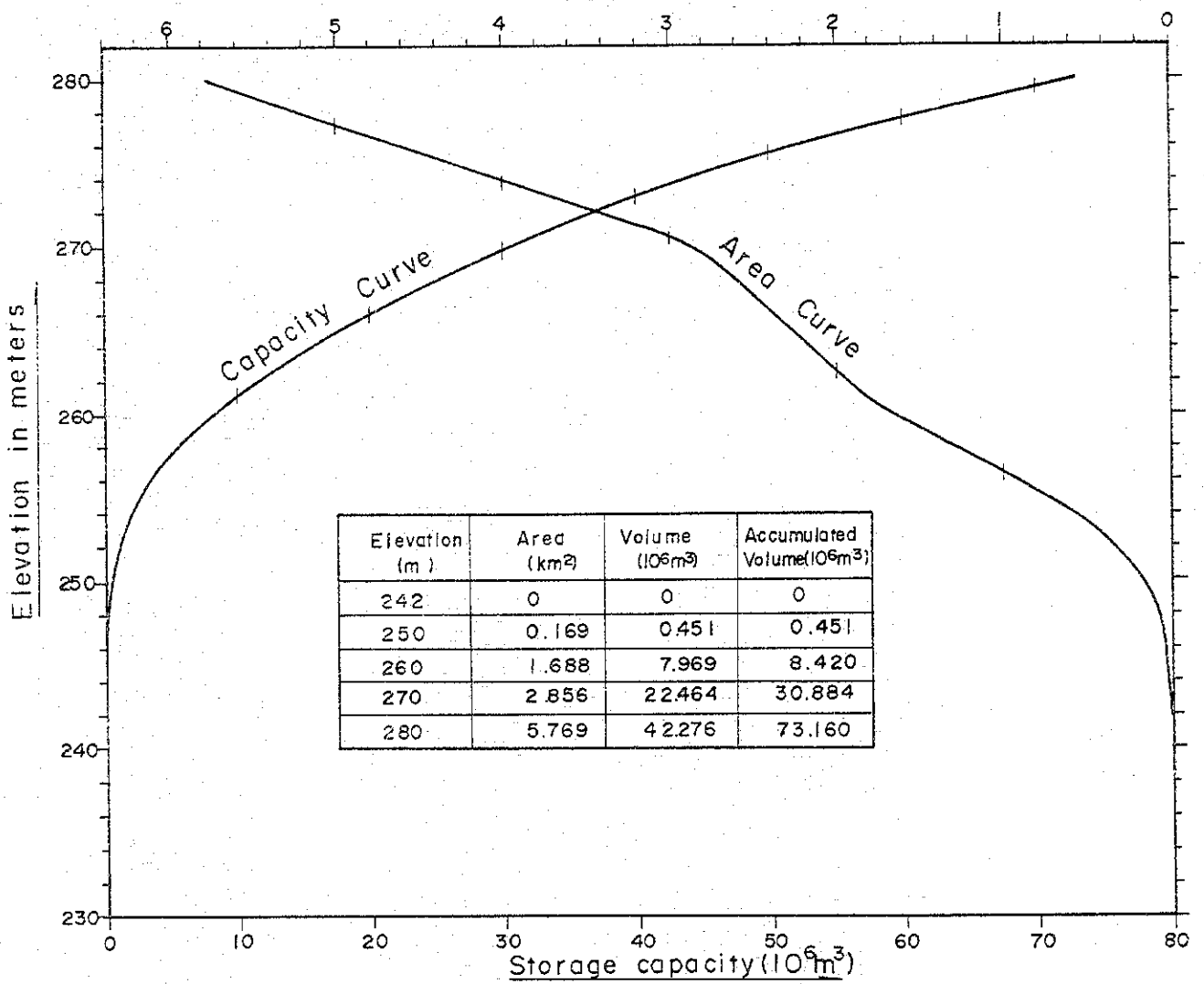
Location of dam Gangweon-do Yeongweol-gun

Name of river	Pyeongchang R., S. Han R.	
Basin		
Catchment area	km^2	651.9
Annual precipitation	mm	1,320
Annual mean discharge	m^3/s	17.41
Reservoir		
F.W.L.	EL.m	282
N.H.W.L.	"	280
L.W.L.	"	273.9
Gross storage capacity (N.H.W.L)	$10^6 m^3$	78.1
Effective capacity	"	27.5
Dead capacity	"	50.6
Reservoir area (N.H.W.L)	km^2	5.8
Firm discharge	m^3/sec	5.09
Flood control capacity	$10^6 m^3$	8.5
Dam		
Type		Rock-Fill
Dam height	m	48
Crest length	"	285
Volume of dam	$10^3 m^3$	1,090
Spillway design flood	m^3/s	5,300
Geology		Green sand-stone
Power station		
Type		Dam & conduit
Max.discharge	m^3/sec	24.73
Rated head (effective)	m	45.1
Installed capacity	kW	9,650
Annual energy output	10^3kWh	40.2

Construction cost	10^6Won	
Compensation	"	5,583
Dam	"	5,802
Sub total	"	11,385
Power facilities	"	5,196
Total	"	16,581
Annual cost of dam and power station	10^6Won	1,515
Power & energy benefit	10^6Won	744
kW benefit	"	355
kWh benefit	"	389
B/C of power		0.49
(B-C) of power	10^6Won	-771
Increase of annual available discharge	$10^6 m^3$	14.7
Benefit of water supply	10^6Won	126
Benefit of flood control	"	29
Total benefit	"	899
Total B/C		0.59
B-C	10^6Won	-616

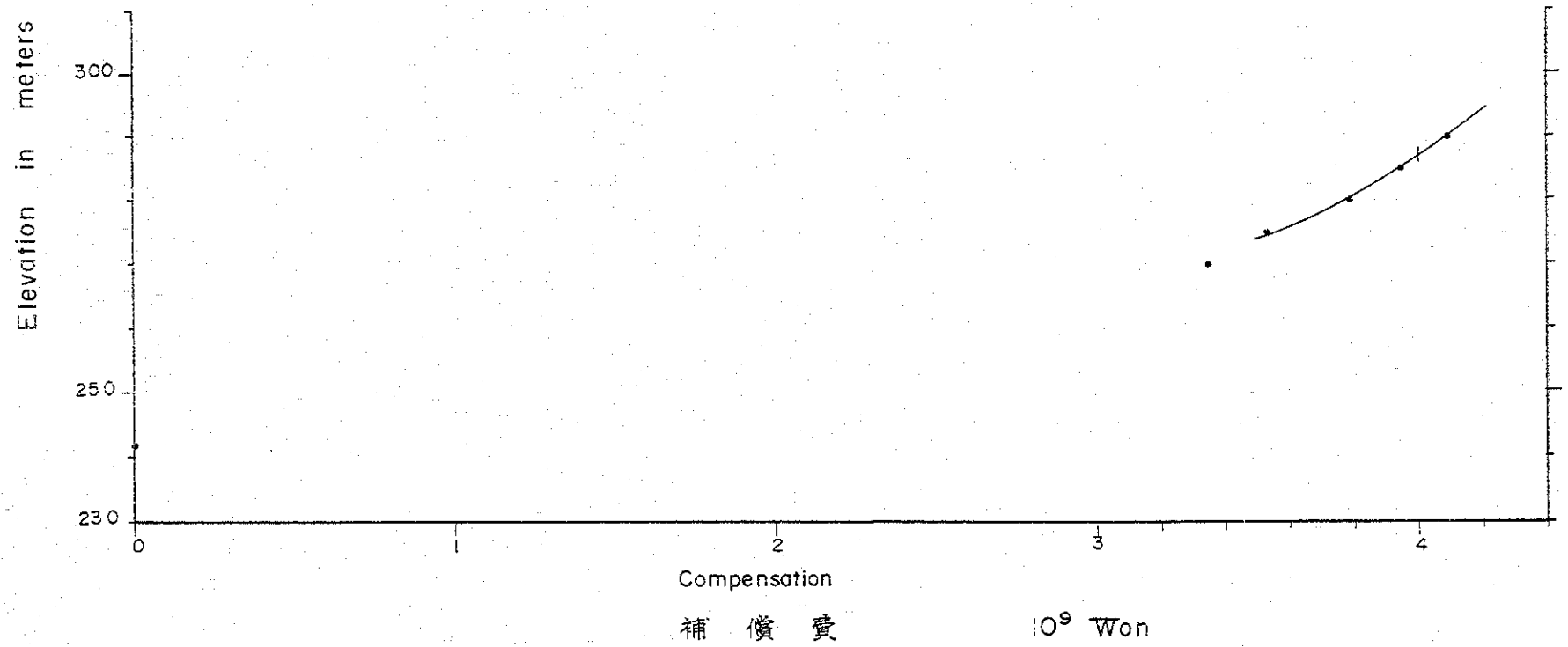
8 - 10 板 雲 Panun

Catchment area : 651.9 Km^2



Elevation (m)	Area (km^2)	Volume ($10^6 m^3$)	Accumulated Volume ($10^6 m^3$)
242	0	0	0
250	0.169	0.451	0.451
260	1.688	7.969	8.420
270	2.856	22.464	30.884
280	5.769	42.276	73.160

8－10　板　雲　Panun


Elevation in meters
300
250
230
0
1
2
3
4
Compensation
補　償　費
10⁹ Won

SCALE 1 : 50.000

0 1 2 km

南漢江水系

8 - 10 板雲

(Panun)

DATE | FIG.

9-13 Suju

The Suju Dam site is located on the Karim River approximately 60 km upstream from the confluence with the Pyeongchang River. The river gradient in this vicinity for about 2 km to the end of Dogog Reservoir is relatively steep at approximately 1/100.

The geology of the dam site is comprised of gneiss and the right bank is a gentle slope covered by 1 to 3 m of talus. Gneiss is exposed at the left bank and although there is no big problem as a dam foundation, the existence of a fault may be presumed on the right bank as seen from the topography.

All of the area inside the reservoir is of gneiss and there will be no problem of leakage from the reservoir, but there are several places at the opposite bank (right bank) of Tongchachi-ri approximately 2 km upstream of the dam site where old collapses of land may be seen. This is thought to be a collapse deposit and not the result of landsliding. Although it is not thought there will be landslides caused by storage of water, it will be necessary for further investigations to be made in the field.

Road conditions to the dam site are extremely poor, and although there is a road coming from the upper reaches, the only means for reaching the site for about 3 km is on foot.

9-13 Suju

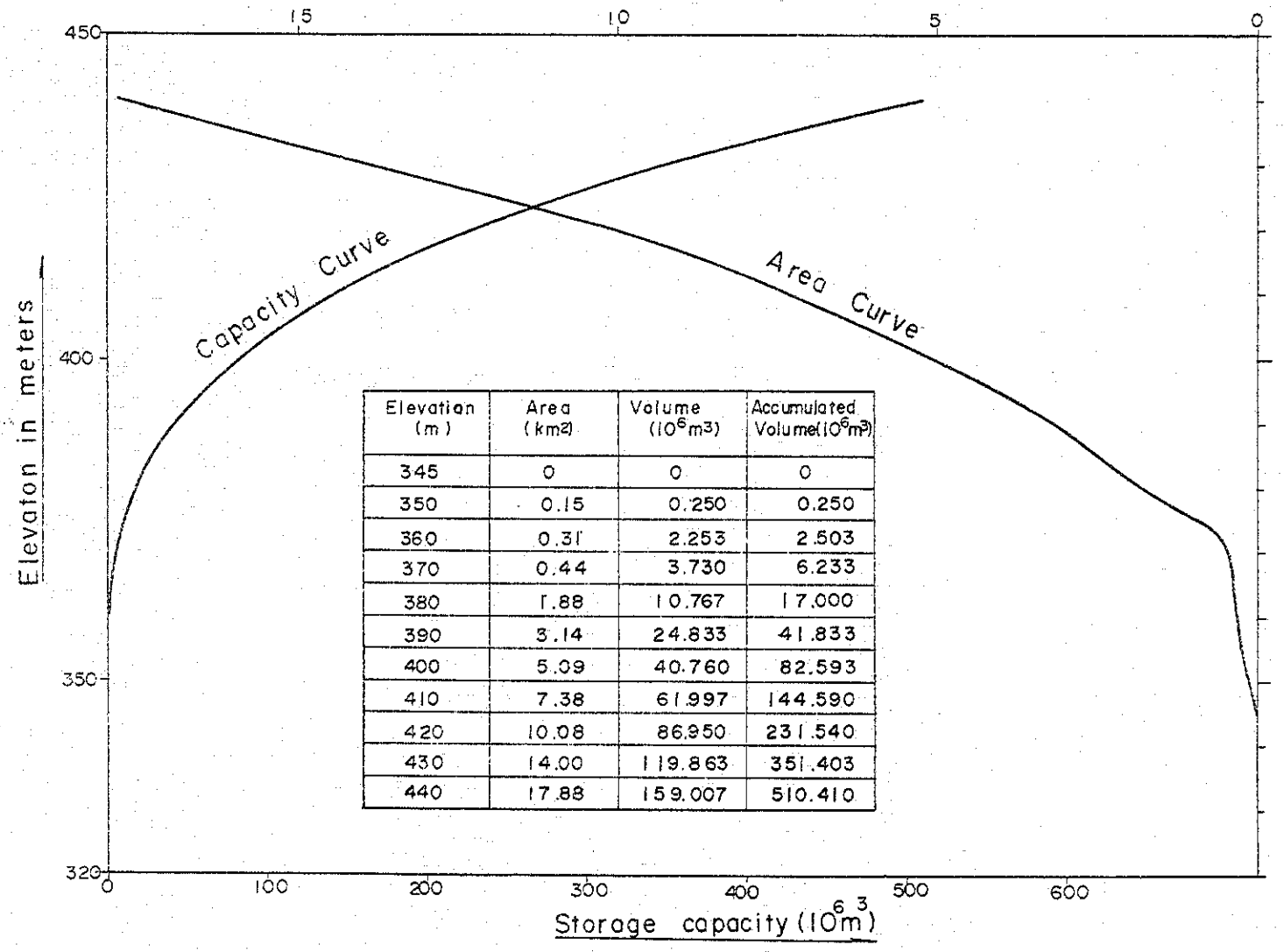
Location of dam Gangweon-do Yeongweol-gun

Name of river	Karim R., South Han R.	
Basin		
Catchment area	km^2	328.9
Annual precipitation	mm	1,440
Annual mean discharge	m^3/s	9.11
Reservoir		
F.W.L.	EL.m	434
N.H.W.L.	"	432
L.W.L.	"	399
Gross storage capacity (N.H.W.L)	$10^6 m^3$	380
Effective capacity	"	287.3
Dead capacity	"	92.7
Reservoir area (N.H.W.L)	km^2	14.8
Firm discharge	m^3/sec	8.28
Flood control capacity	$10^6 m^3$	31.8
Dam		
Type		Rock-Fill
Dam height	m	107
Crest length	"	483
Volume of dam	$10^3 m^3$	6,300
Spillway design flood	m^3/s	3,720
Geology		Gneiss
Power station		
Type		Dam & conduit
Max.discharge	m^3/sec	40.14
Rated head (effective)	m	91.9
Installed capacity	kW	31,900
Annual energy output	10^3kWh	60,300

Construction cost	10^6Won	
Compensation	"	6,064
Dam	"	20,757
Sub total	"	26,821
Power facilities	"	8,343
Total	"	35,164
Annual cost of dam and power station	10^6Won	3,187
Power & energy benefit	10^6Won	1,662
kW benefit	"	1,082
kWh benefit	"	580
B/C of power		0.52
(B-C) of power	10^6Won	-1,525
Increase of annual available discharge	$10^6 m^3$	142.9
Benefit of water supply	10^6Won	1,223
Benefit of flood control	"	35
Total benefit	"	2,920
Total B/C		0.92
B-C	10^6Won	-267

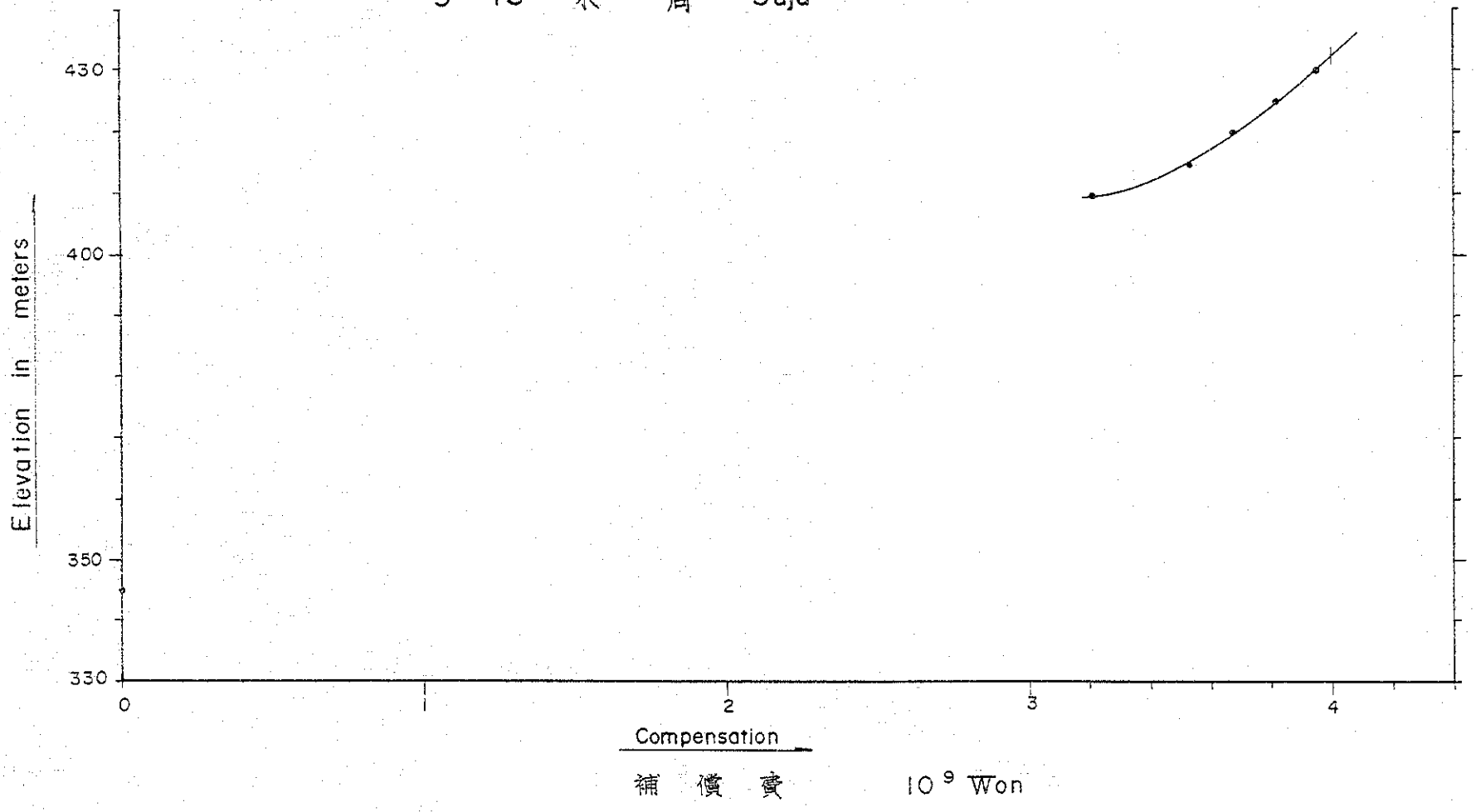
9－13　水　周　　Suju

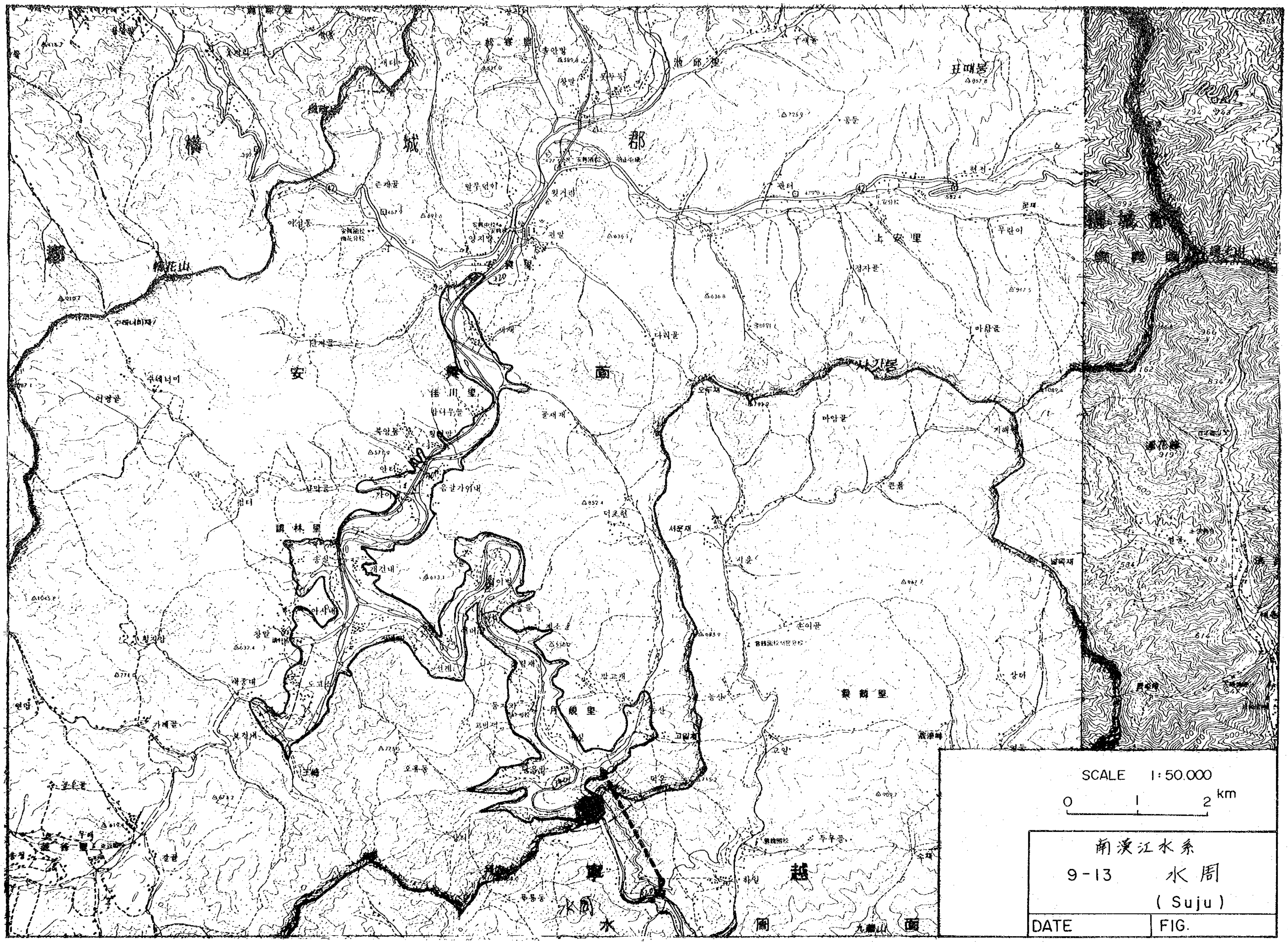
Reservoir area (Km^2)　　Catchment area : 328.9 Km^2



Elevation (m)	Area (km^2)	Volume ($10^6 m^3$)	Accumulated Volume ($10^6 m^3$)
345	0	0	0
350	0.15	0.250	0.250
360	0.31	2.253	2.503
370	0.44	3.730	6.233
380	1.88	10.767	17.000
390	3.14	24.833	41.833
400	5.09	40.760	82.593
410	7.38	61.997	144.590
420	10.08	86.950	231.540
430	14.00	119.863	351.403
440	17.88	159.007	510.410

9-13 水 周 Suju


Elevation in meters
430
400
350
330
0
1
2
3
4
Compensation
補 償 費
10⁹ Won


SCALE 1:50.000
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南漢江水系
9-13 水周
(Suju)
DATE
FIG.

10-12 Dogog

The Dogog site is located on the Kachon River approximately 20 km upstream from the conjunction with the Pyeongchang River. The river in this vicinity meanders widely flowing in the southeast direction to merge to the Pyeongchang River, and the river gradient is about 1/250.

The geology of the dam site is comprised of gneiss with intrusions of granite on the right bank and granitic gneiss on the left bank.

The left bank rises from the river in a steep slope, and the geological conditions being good, there will be no problems. The right bank consists of granite, but the abutment is covered by talus, while the river bed is a broad terrace area of relative height of 10 to 20 m. The problems are the degree of weathering of the granite underlying the talus and the complexity of the topography of the abutment at the dam crest, and detailed surveys are necessary regarding the topography of the surroundings. Depending on the results of these surveys and the condition of weathering of rock, there will be a possibility of a saddle at the right bank.

There is no special problem as a dam site, but an investigation of the right bank abutment including the terrace deposits will be required. It is estimated that a fault exists immediately downstream of the dam so that it may be considered that the present site is suitable for the dam.

Since there are thin saddles at two places upstream of the dam it will be necessary for further detailed investigations to be made of these parts.

10-12 Dogog

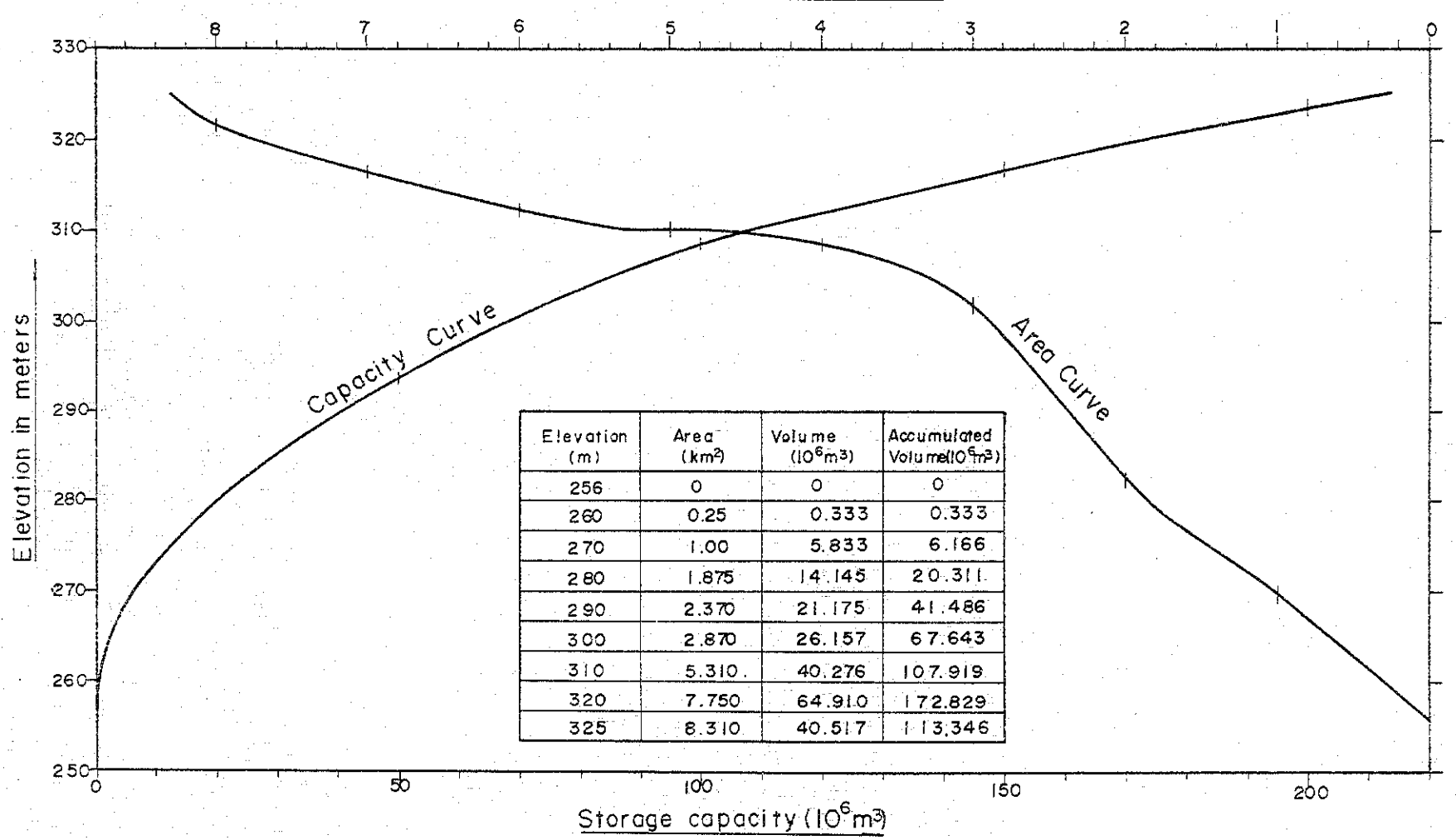
Location of dam Gangweon-do Yeongweol-gun

Name of river	Kachon R., South Han R.	
Basin		
Catchment area	km^2	492.6
Annual precipitation	mm	1,420
Annual mean discharge	m^3/s	13.64
Reservoir		
F.W.L.	EL.m	327
N.H.W.L.	"	325
L.W.L.	"	301.5
Gross storage capacity (N.H.W.L)	$10^6 m^3$	213.3
Effective capacity	"	141.5
Dead capacity	"	71.8
Reservoir area (N.H.W.L)	km^2	8.3
Firm discharge	m^3/sec	9.16
Flood control capacity	$10^6 m^3$	16.2
Dam		
Type		Rock-Fill
Dam height	m	70
Crest length	"	415
Volume of dam	$10^3 m^3$	3,000
Spillway design flood	m^3/s	4,610
Geology		Gneiss
Power station		
Type		Dam
Max.discharge	m^3/sec	44.26
Rated head (effective)	m	59.8
Installed capacity	kW	22,900
Annual energy output	10^3kWh	58,400

Construction cost	10^6Won	
Compensation	"	3,683
Dam	"	11,203
Sub total	"	14,886
Power facilities	"	7,453
Total	"	22,339
Annual cost of dam and power station	10^6Won	2,069
Power & energy benefit	10^6Won	1,329
kW benefit	"	767
kWh benefit	"	562
B/C of power		0.64
(B-C) of power	10^6Won	-740
Increase of annual available discharge	$10^6 m^3$	82.9
Benefit of water supply	10^6Won	710
Benefit of flood control	"	45
Total benefit	"	2,084
Total B/C		1.01
B-C	10^6Won	15

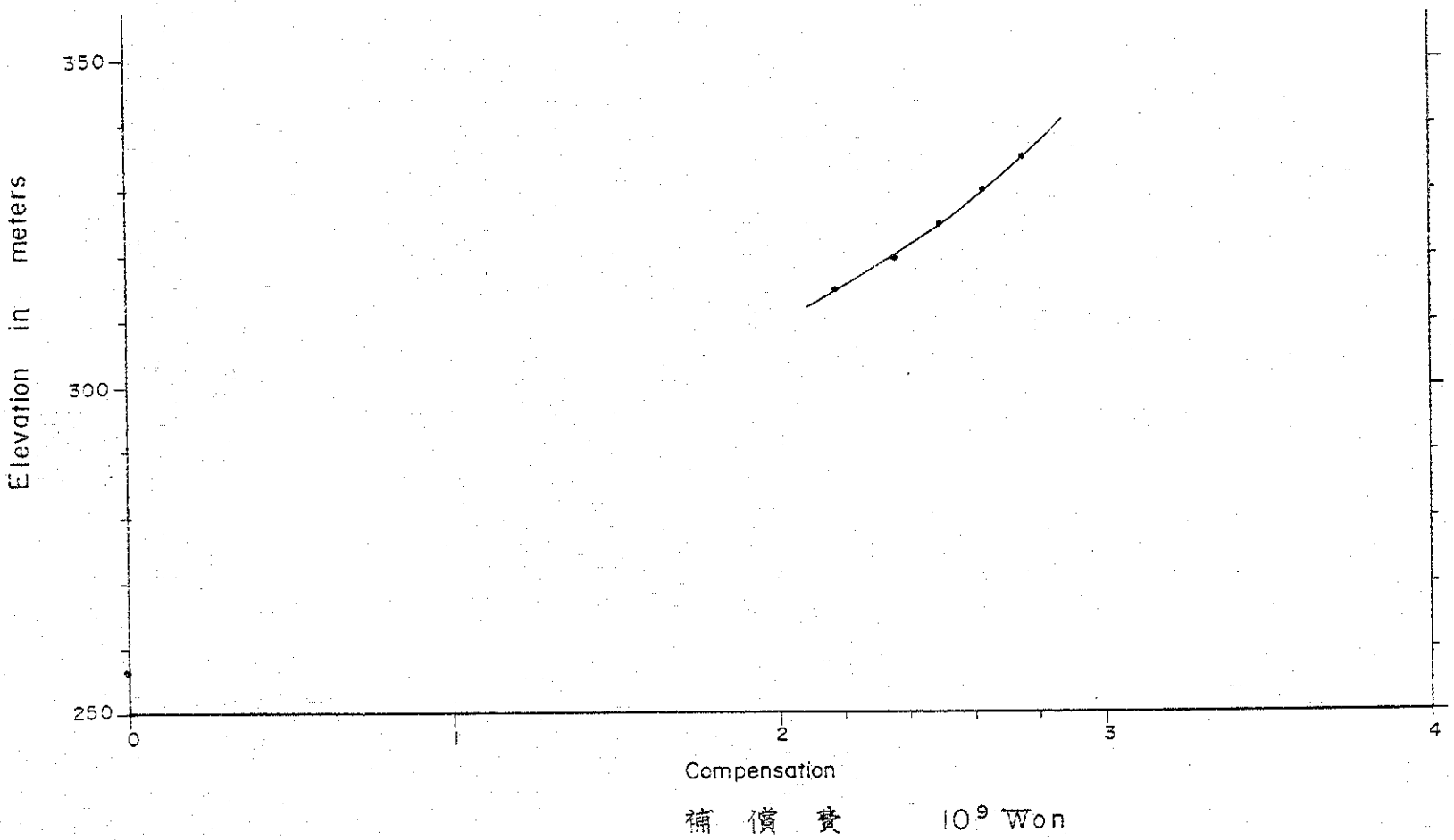
10-12 道谷 Dogog

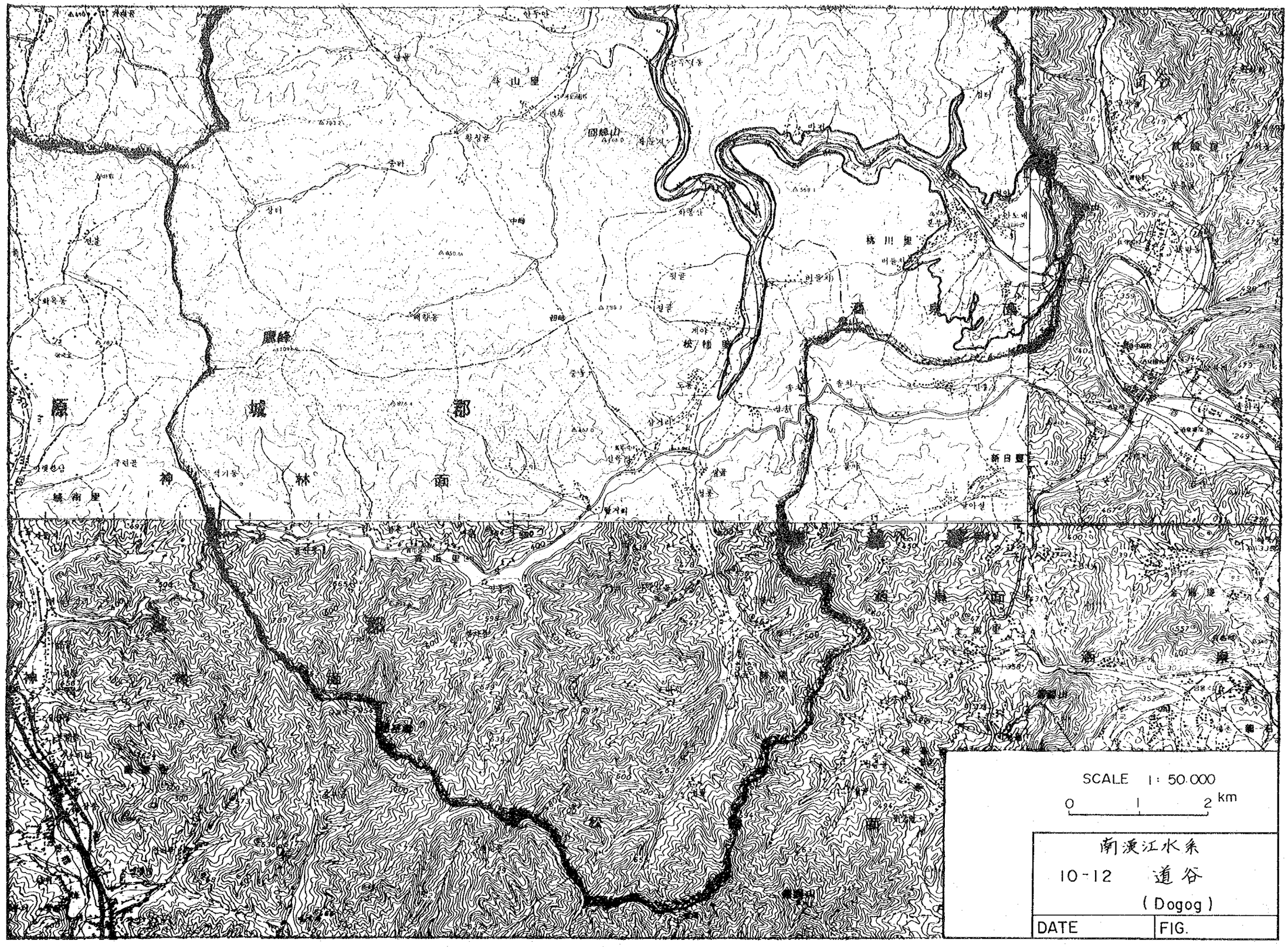
Catchment area : 492.6 Km²



Elevation (m)	Area (km²)	Volume ($10^6 m^3$)	Accumulated Volume ($10^6 m^3$)
256	0	0	0
260	0.25	0.333	0.333
270	1.00	5.833	6.166
280	1.875	14.145	20.311
290	2.370	21.175	41.486
300	2.870	26.157	67.643
310	5.310	40.276	107.919
320	7.750	64.910	172.829
325	8.310	40.517	113.346

10-12 道 谷 Dogog




SCALE 1 : 50.000
0 1 2 km
南漫江水系
10-12 道谷
(Dogog)
DATE
FIG.