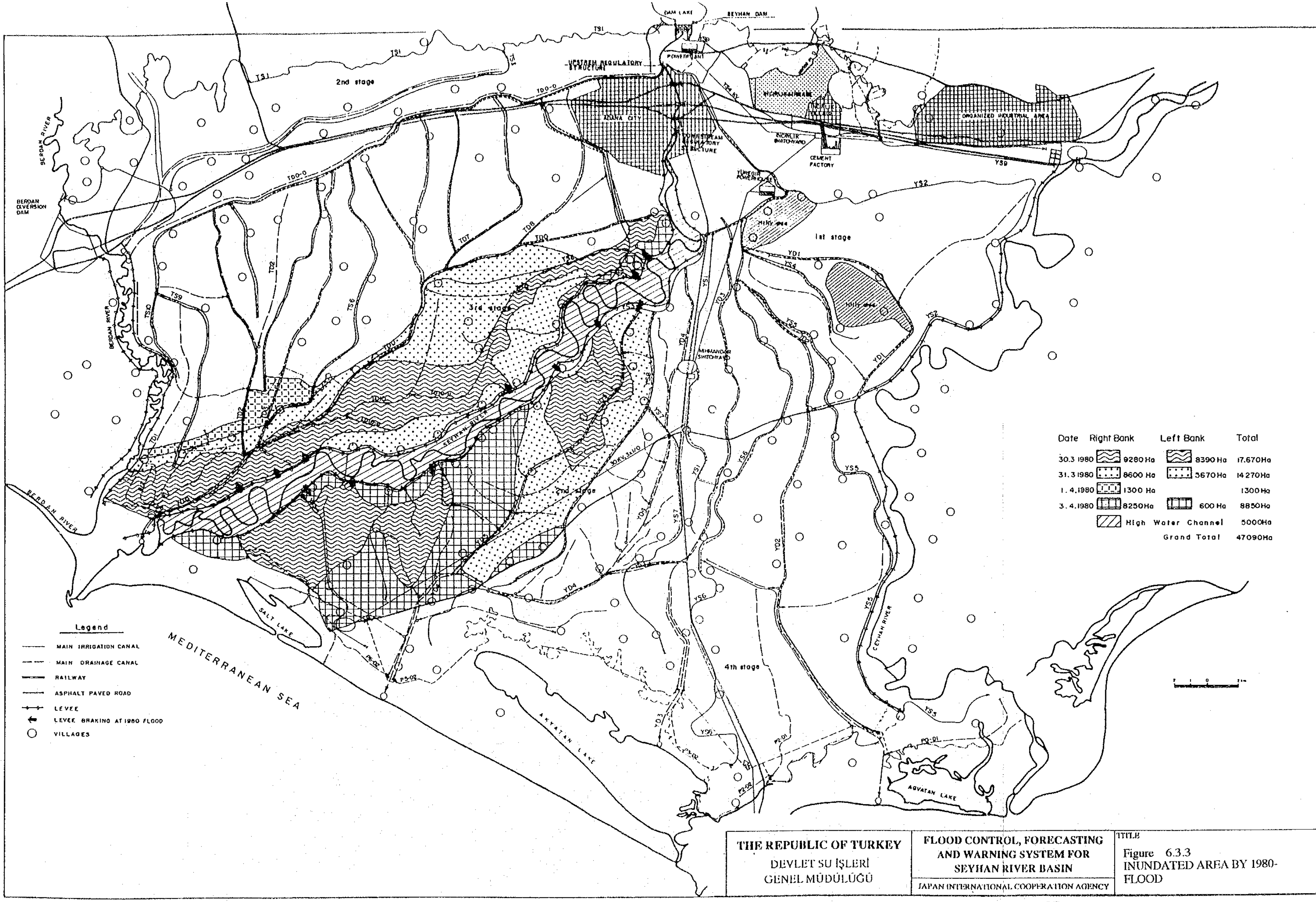
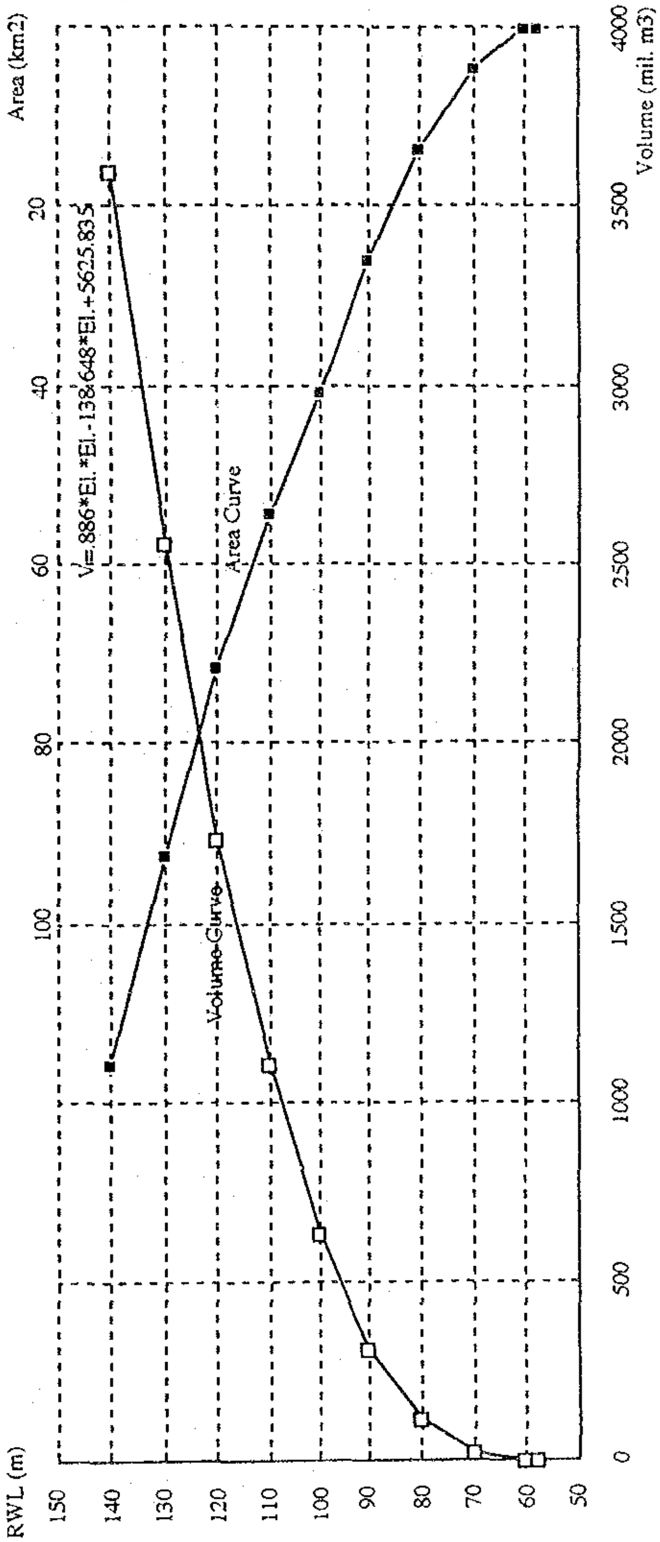
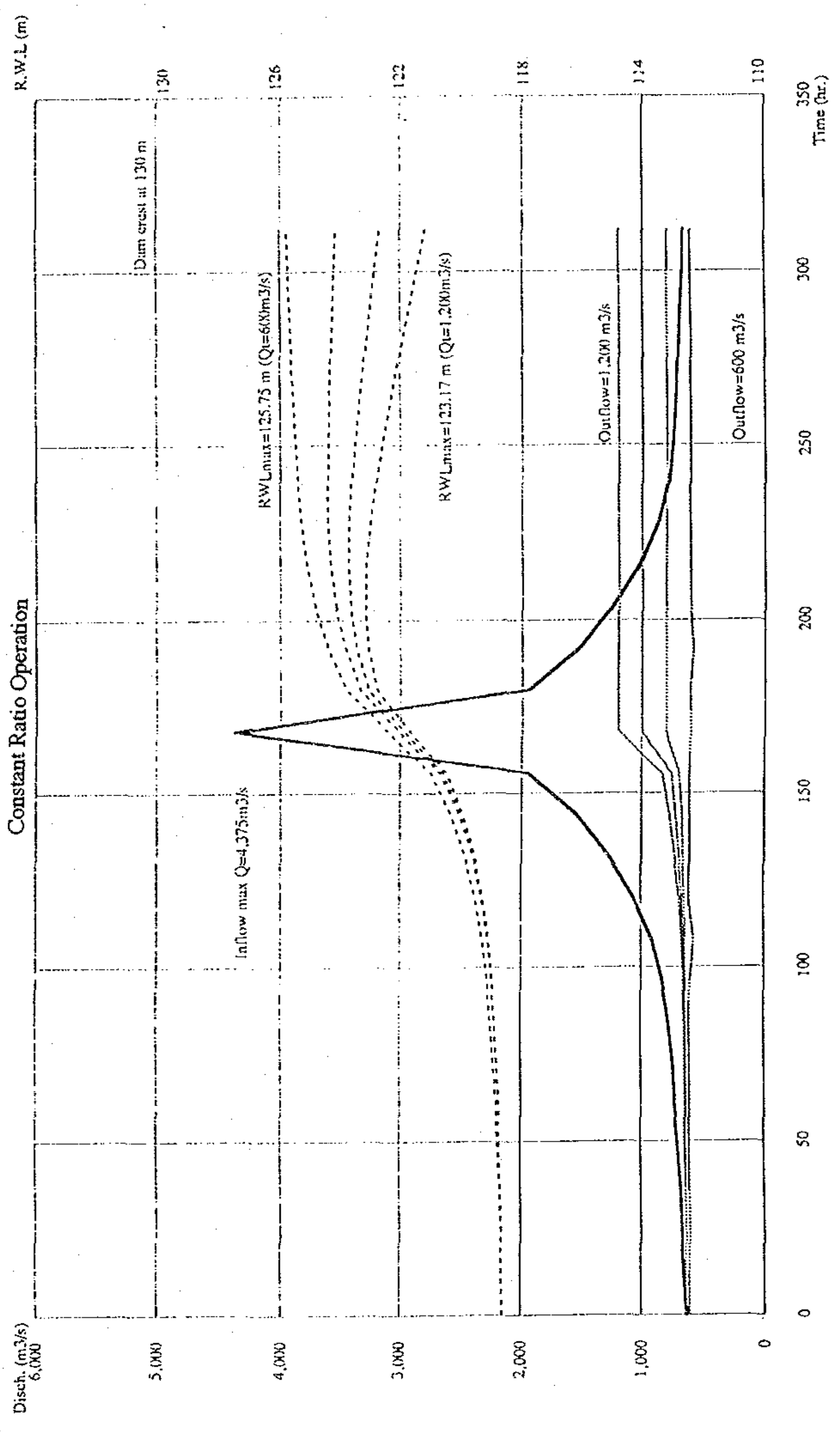


THE REPUBLIC OF TURKEY	FLOOD CONTROL, FORECASTING AND WARNING SYSTEM FOR SEYHAN RIVER BASIN	TITLE
DEVLET SU İŞLERİ GENEL MÜDÜLÜĞÜ	JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 6.3.3 INUNDATED AREA BY 1980-FLOOD

FIG. NO.

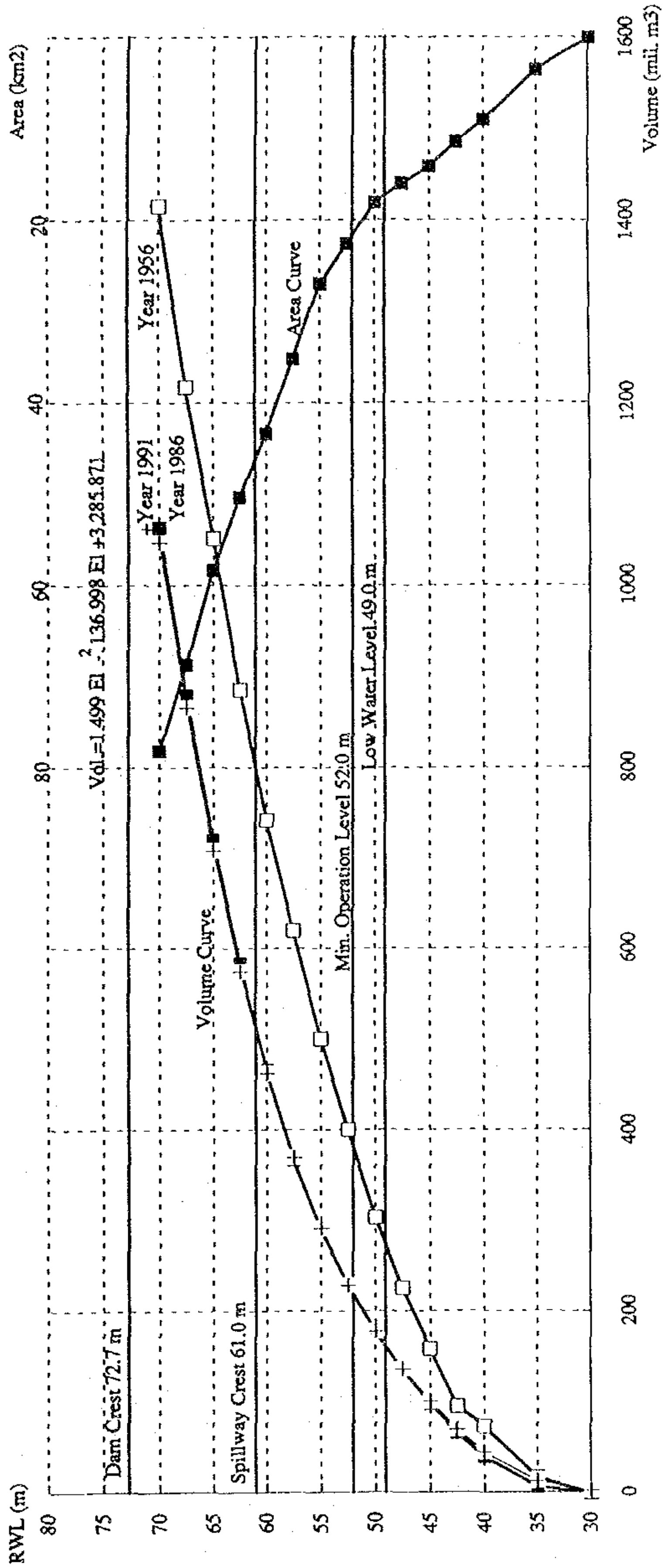


THE REPUBLIC OF TURKEY	FLOOD CONTROL, FORECASTING AND WARNING SYSTEM FOR SEYHAN RIVER BASIN	TITLE
DEVLET SU İŞLERİ GENEL MÜDÜLÜĞÜ	JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 7.1.1 ÇATALAN DAM AREA - VOLUME CURVE



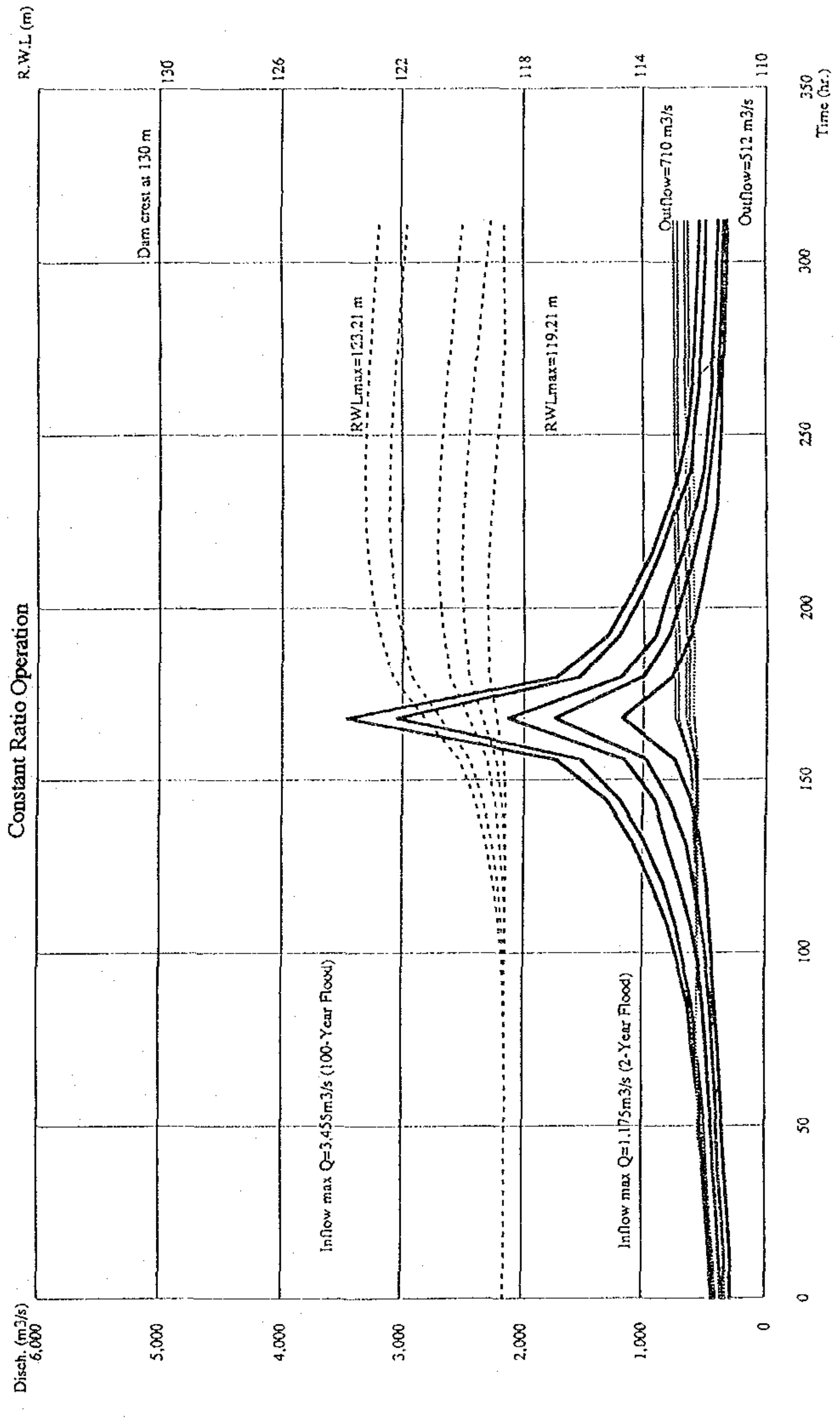
THE REPUBLIC OF TURKEY DEVLET SU İŞLERİ GENEL MÜDÜLÜĞÜ	*FLOOD CONTROL, FORECASTING* **AND WARNING SYSTEM FOR SEYHAN RIVER BASIN** JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Figure 7.1.2 ÇATALAN DAM FLOOD ROUTING FOR 500-YEAR FLOOD

FIG. NO.

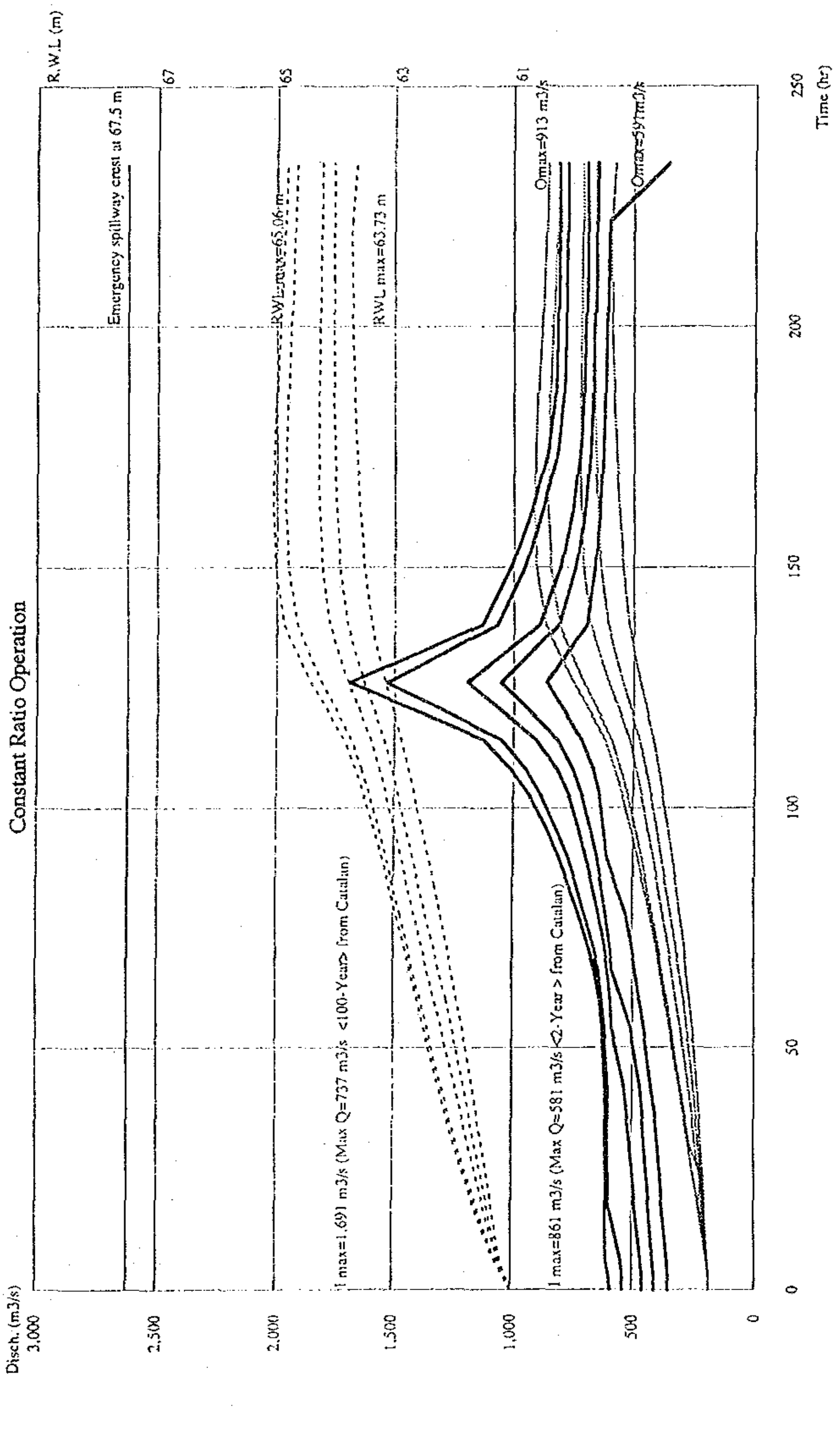


THE REPUBLIC OF TURKEY DEVLET SU İŞLERİ GENEL MÜDÜLÜĞÜ	*FLOOD CONTROL, FORECASTING AND WARNING SYSTEM FOR SEYHAN RIVER BASIN* *JAPAN INTERNATIONAL COOPERATION AGENCY*	TITLE Figure 7.1.3 SEYHAN DAM AREA - VOLUME CURVE

FIG. NO.

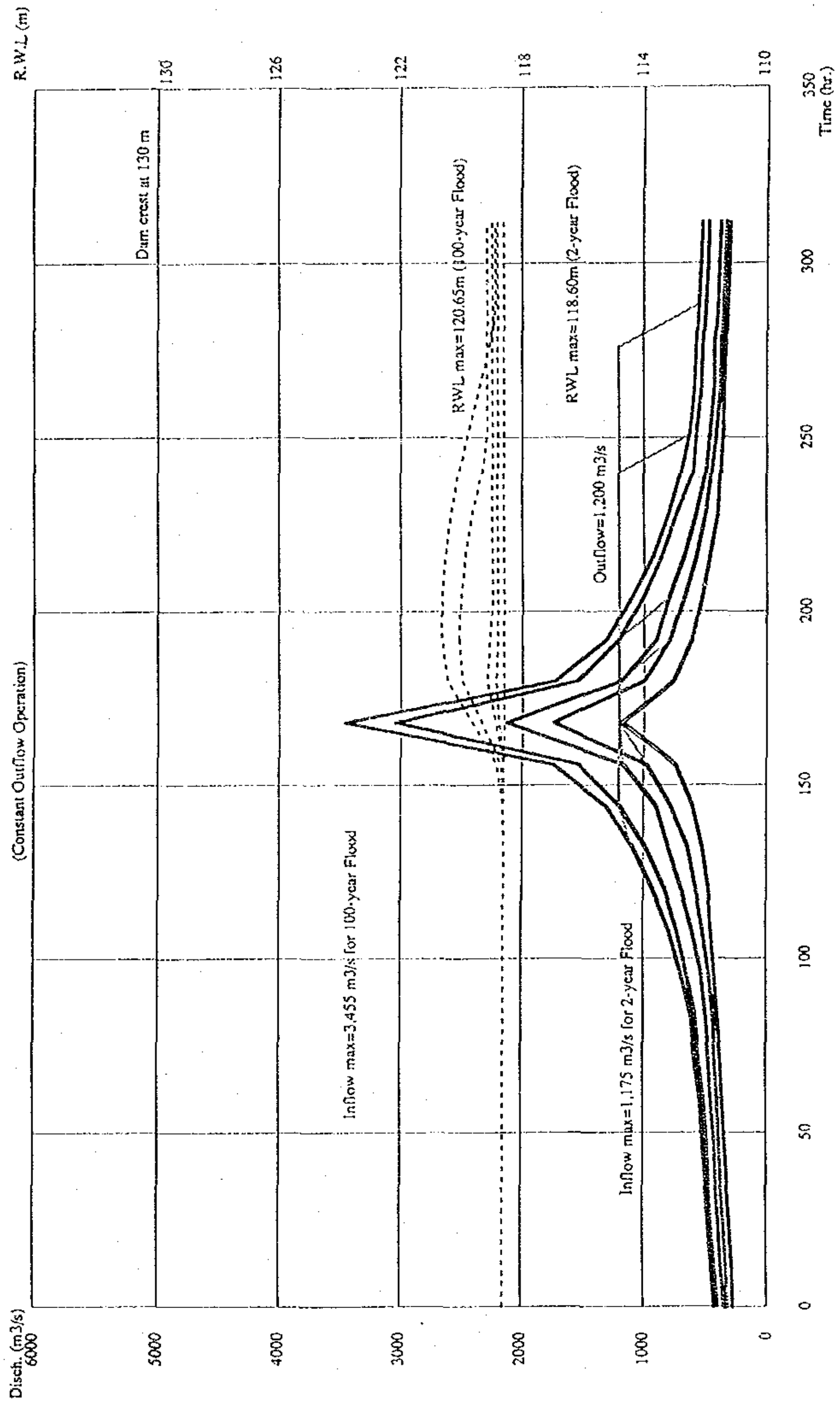


THE REPUBLIC OF TURKEY DEVLET SU İŞLERİ *GENEL MÜDÜLÜĞÜ*	**FLOOD CONTROL, FORECASTING AND WARNING SYSTEM FOR SEYHAN RIVER BASIN** JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Figure 7.1.4 ÇATALAN DAM FLOOD ROUTING (CONSTANT RATIO OPERATION)



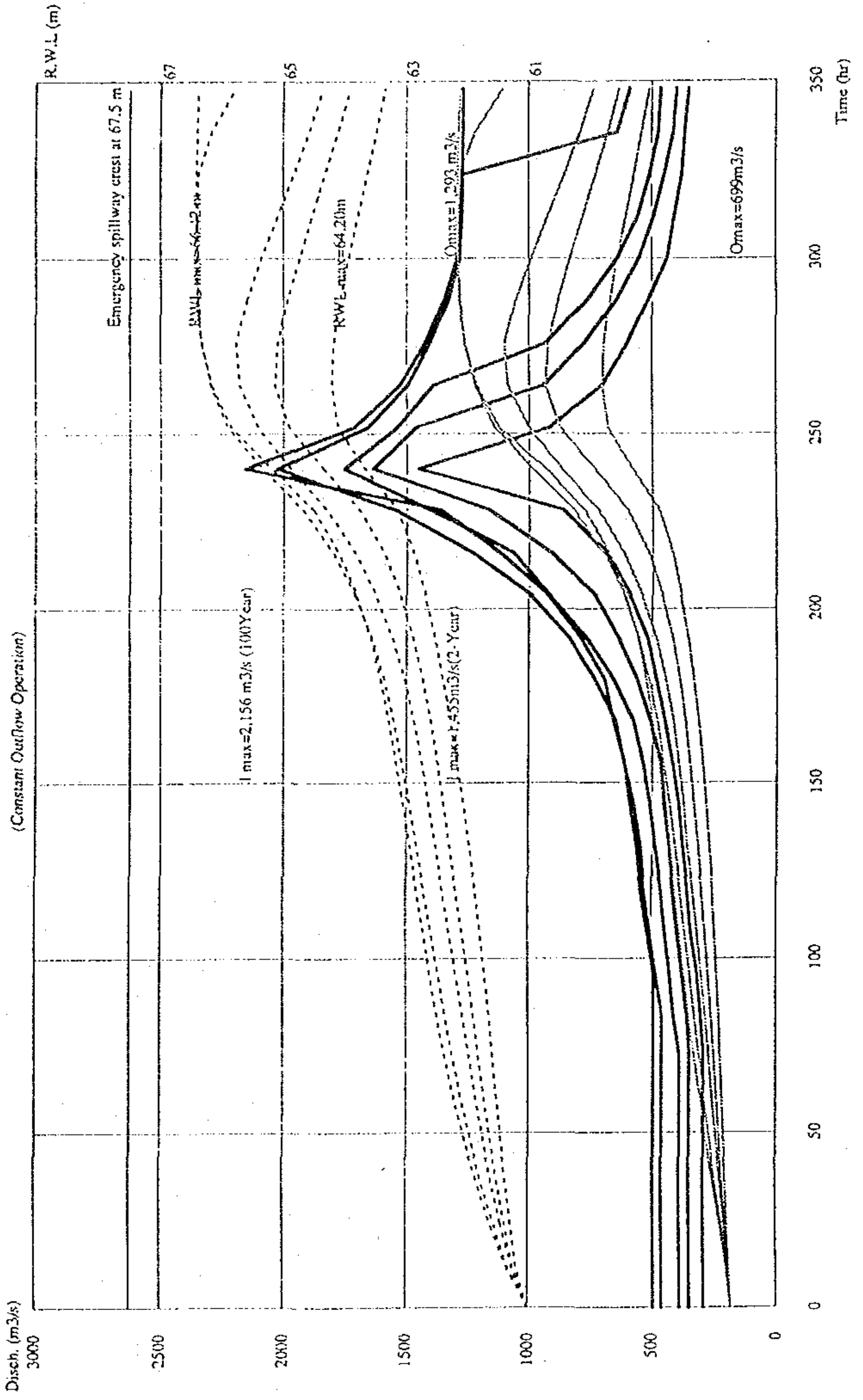
THE REPUBLIC OF TURKEY DEVLET SU İŞLERİ GENEL MÜDÜLÜĞÜ	FLOOD CONTROL, FORECASTING AND WARNING SYSTEM FOR SEYHAN RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Figure 7.1.5 SEYHAN DAM FLOOD ROUTING (CONSTANT RATIO OPERATION)

FIG. NO.



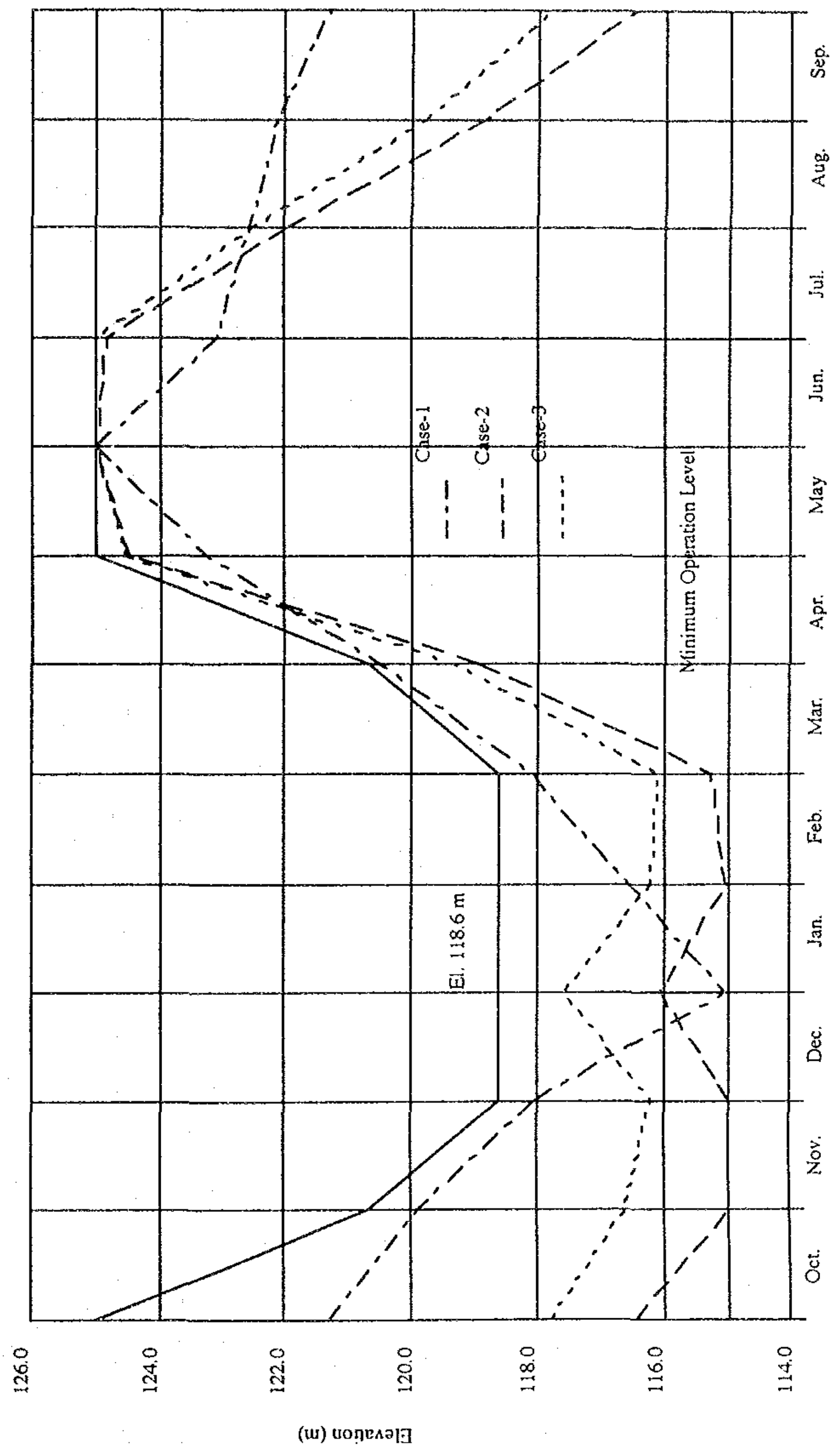
THE REPUBLIC OF TURKEY DEVLET SU İŞLERİ GENEL MÜDÜLÜĞÜ	FLOOD CONTROL, FORECASTING AND WARNING SYSTEM FOR SEYHAN RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Figure 7.1.6 ÇATALAN DAM FLOOD ROUTING (CONSTANTOUTFLOWOPERATION)

FIG. NO.



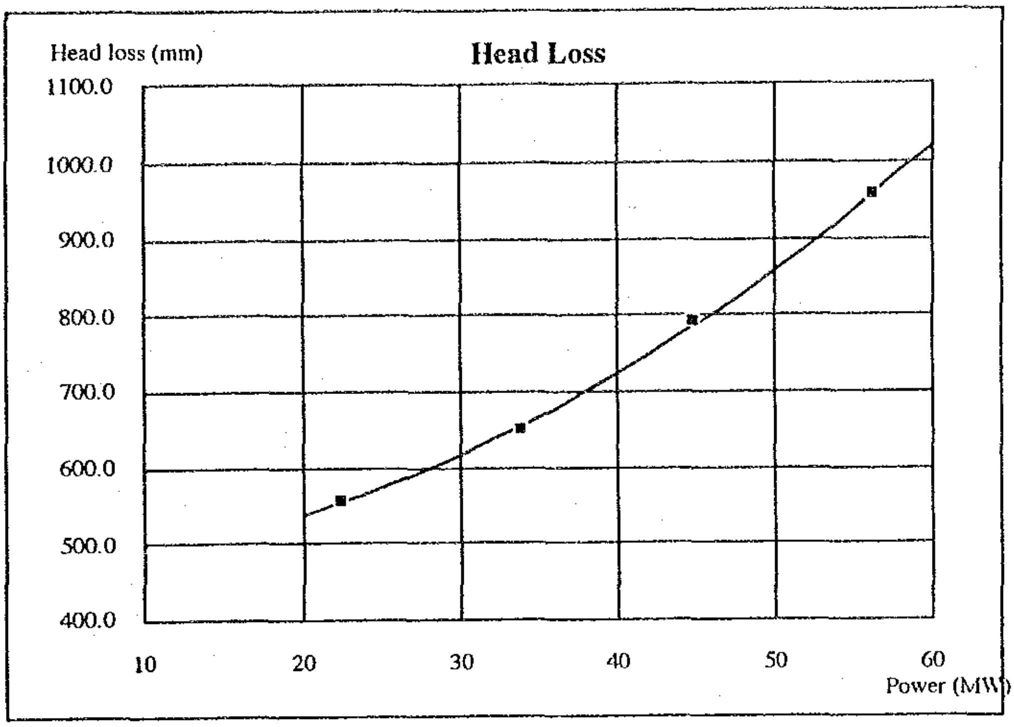
THE REPUBLIC OF TURKEY DEVLET SU İŞLERİ GENEL MÜDÜLÜĞÜ	FLOOD CONTROL, FORECASTING AND WARNING SYSTEM FOR SEYHAN RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Figure 7.1.7 SEYHAN DAM FLOOD ROUTING (CONSTANTOUTFLOWOPERATION)

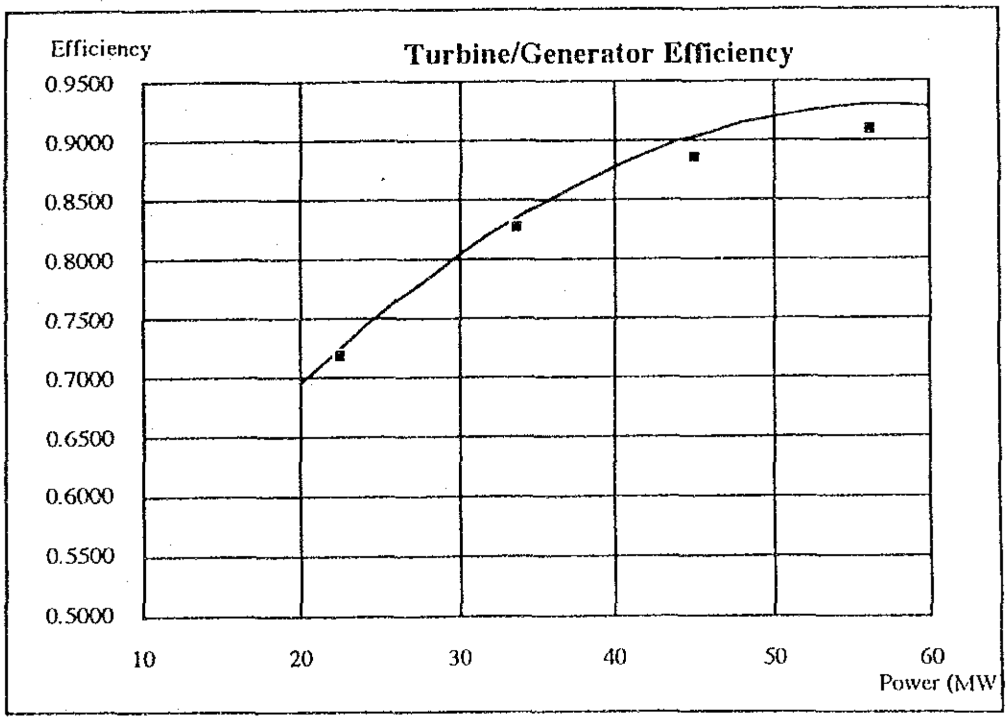
FIG. NO.



THE REPUBLIC OF TURKEY *DEVLET SU İŞLERİ* GENEL MÜDÜLÜĞÜ	**FLOOD CONTROL, FORECASTING AND WARNING SYSTEM FOR SEYHAN RIVER BASIN** JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Figure 7.2.1 ÇATALAN DAM OPERATION RULE CURVE

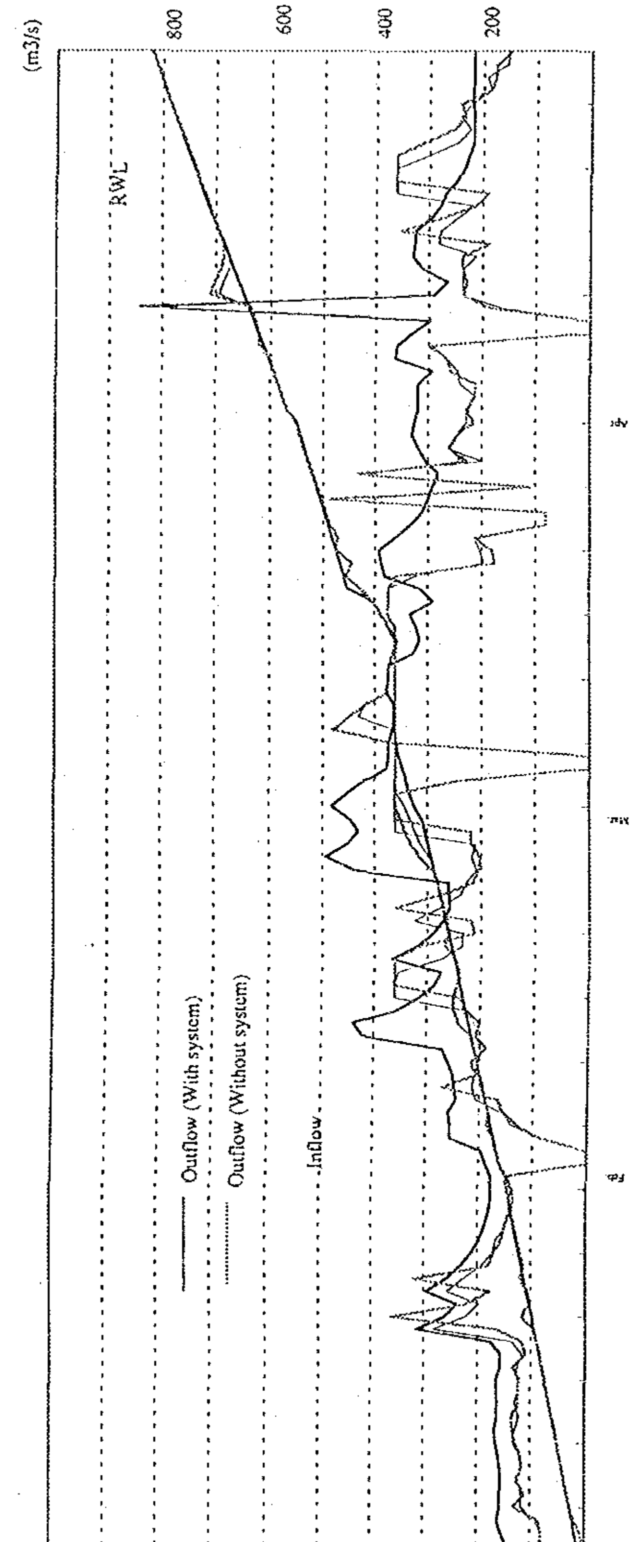
FIG. NO.





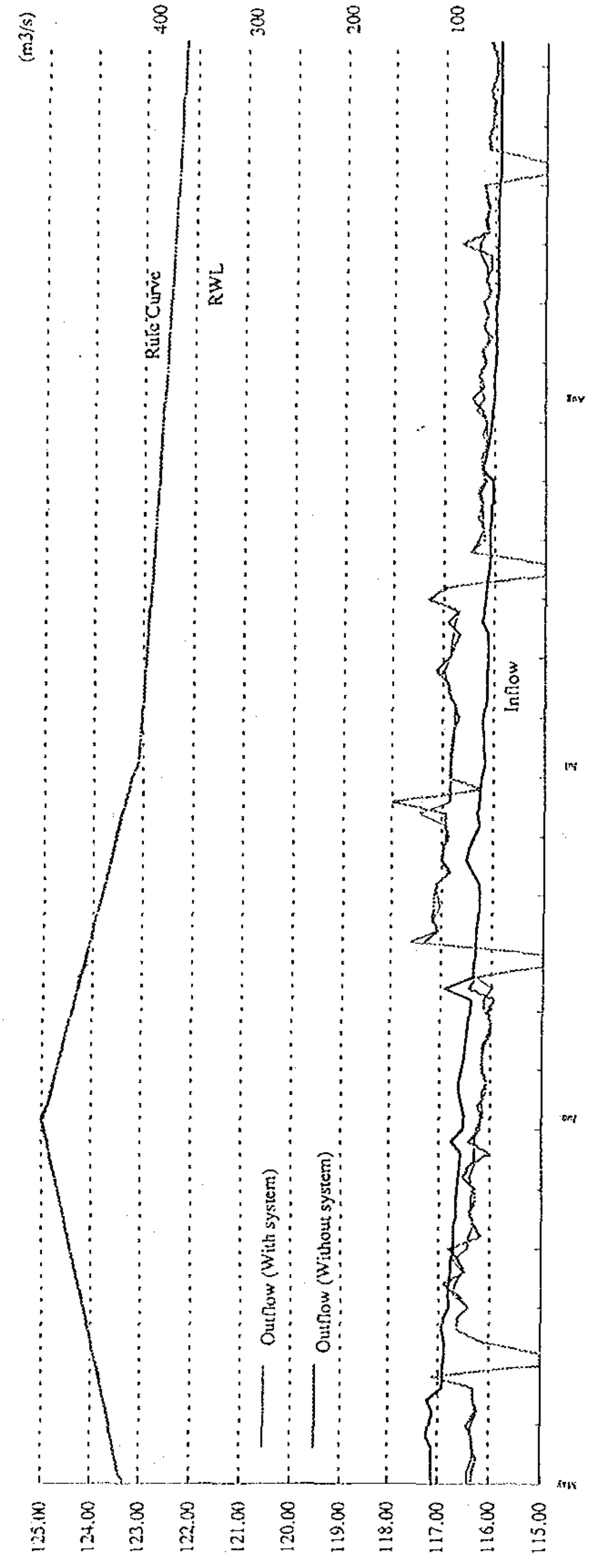
THE REPUBLIC OF TURKEY DEVLET SU İŞLERİ GENEL MÜDÜLÜĞÜ	FLOOD CONTROL, FORECASTING AND WARNING SYSTEM FOR SEYHAN RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Figure 7.2.2 HEAD LOSS AND TURBINE GENERATION EFFICIENCY

FIG. NO.



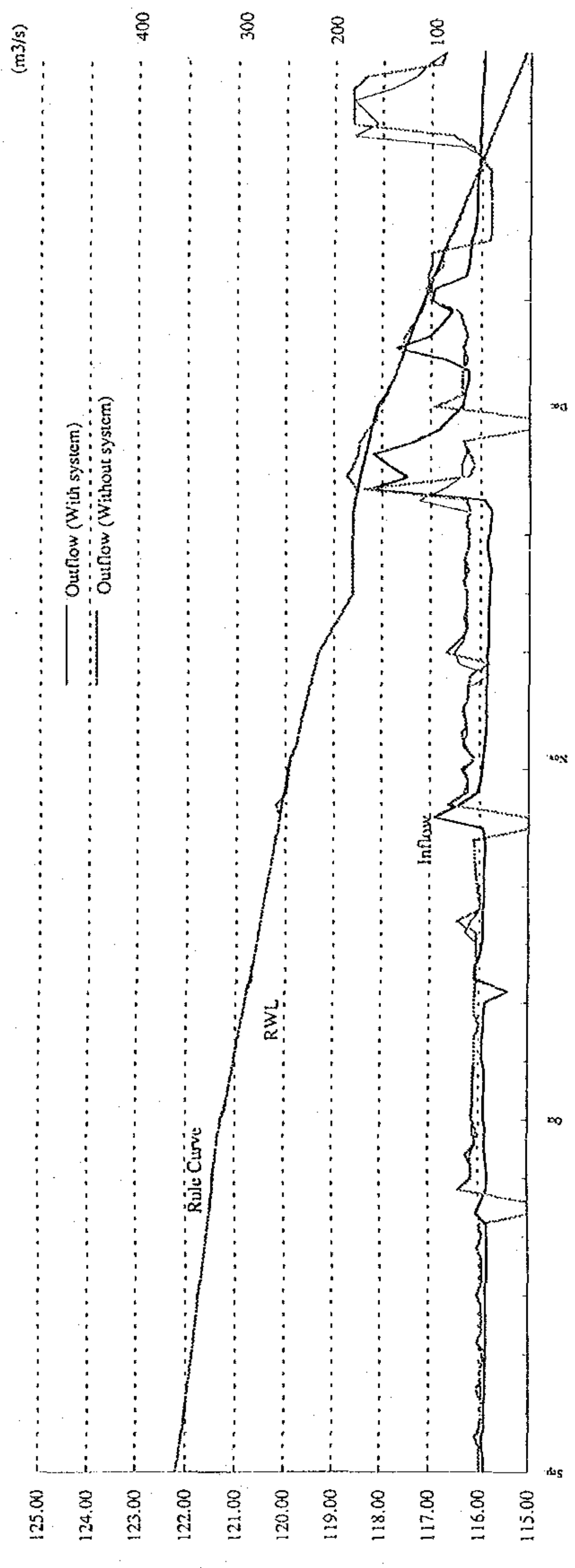
THE REPUBLIC OF TURKEY	FLOOD CONTROL, FORECASTING AND WARNING SYSTEM FOR SEYHAN RIVER BASIN	TITLE
DEVLET SU İŞLERİ GENEL MÜDÜLÜĞÜ	JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 7.2.3 (1/3) ÇATALAN DAM DAILY OPERATION (1970)

FIG. NO.



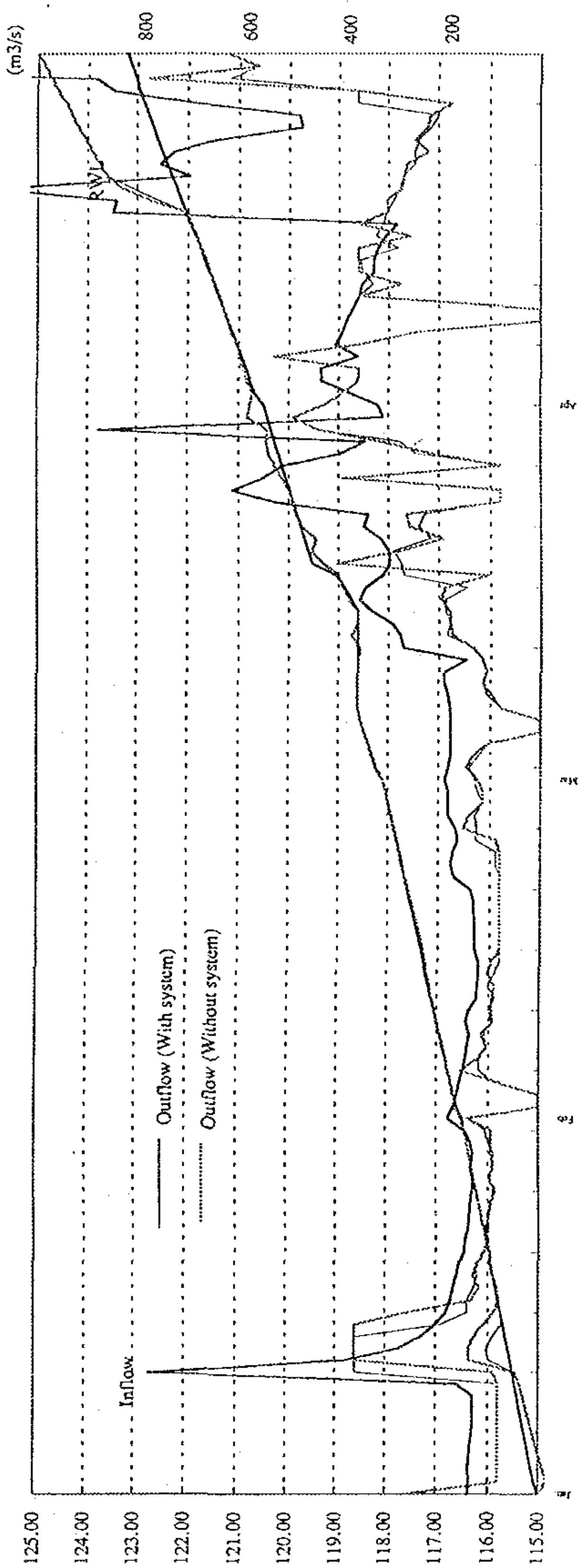
THE REPUBLIC OF TURKEY DEVLET SU İŞLERİ GENEL MÜDÜLÜĞÜ	FLOOD CONTROL, FORECASTING AND WARNING SYSTEM FOR SEYHAN RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Figure 7.2.3 (2/3) ÇATALAN DAM DAILY OPERATION (1970)

FIG. NO.



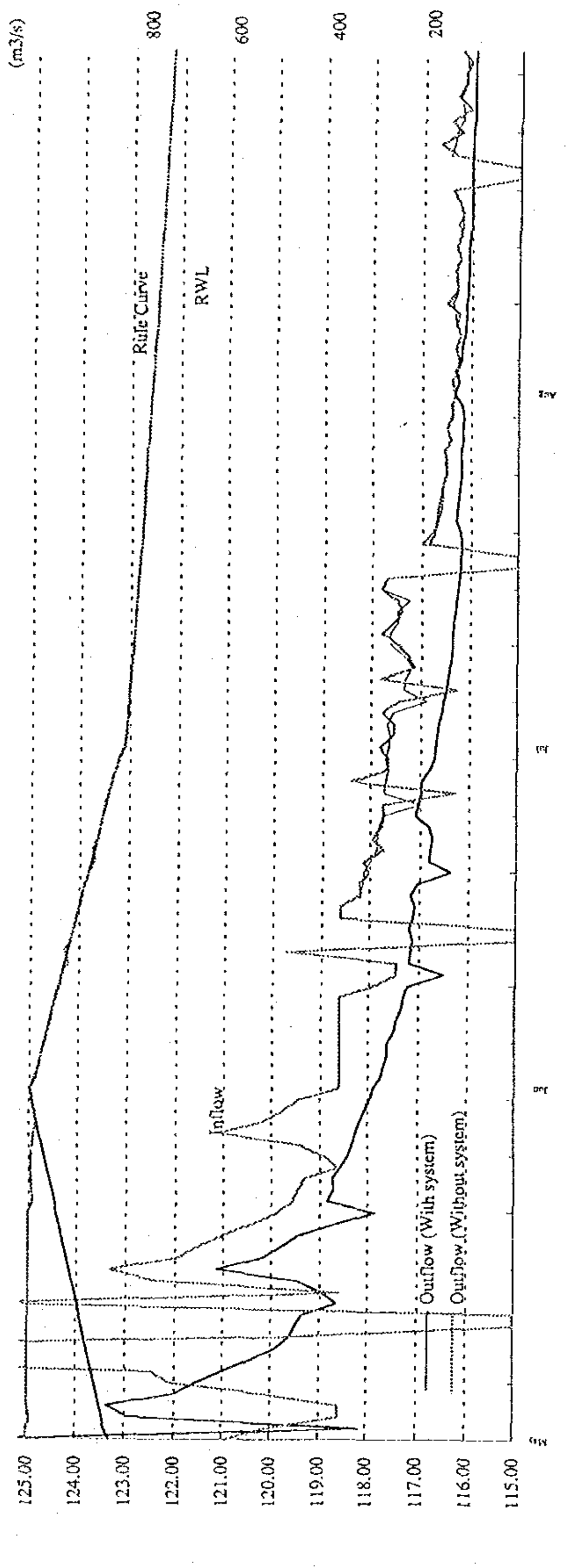
THE REPUBLIC OF TURKEY DEVLET SU İŞLERİ GENEL MÜDÜLÜĞÜ	FLOOD CONTROL, FORECASTING AND WARNING SYSTEM FOR SEYHAN RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Figure 7.2.3 (3/3) ÇATALAN DAM DAILY OPERATION (1970)

FIG. NO.



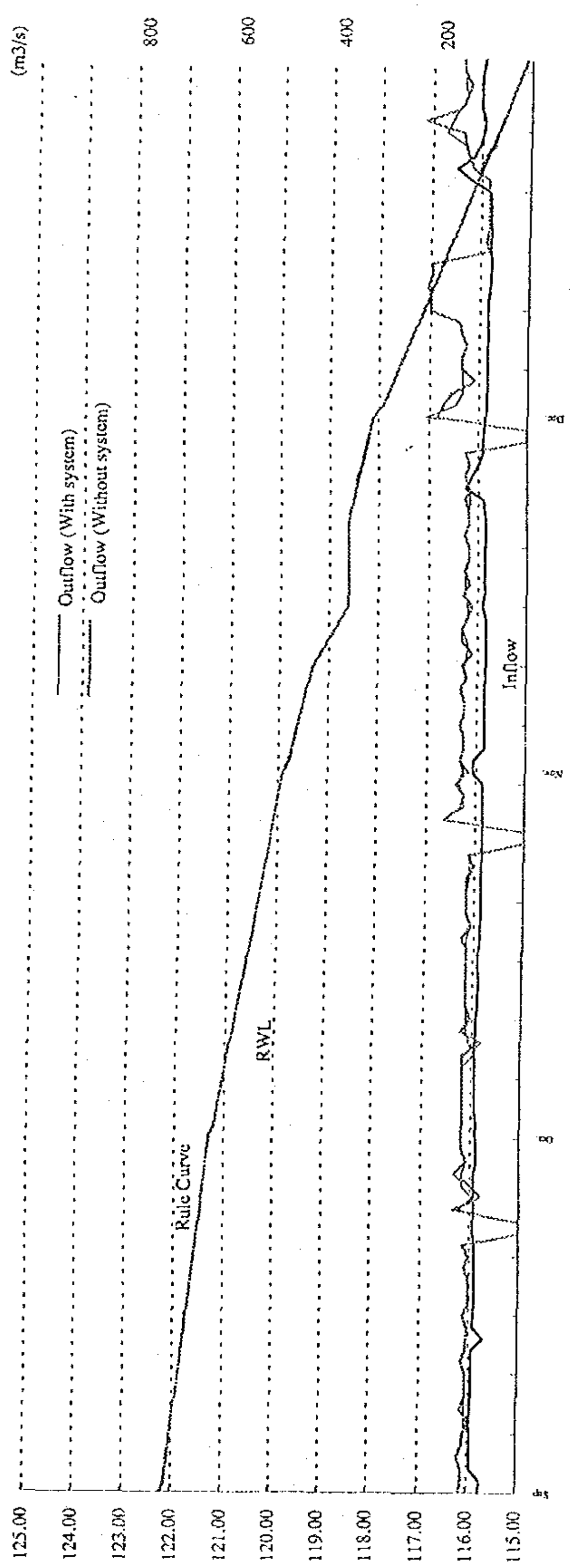
THE REPUBLIC OF TURKEY DEVLET SU İŞLERİ GENEL MÜDÜLÜĞÜ	FLOOD CONTROL, FORECASTING AND WARNING SYSTEM FOR SEYHAN RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Figure 7.2.4 (1/3) ÇATALAN DAM DAILY OPERATION (1975)

FIG. NO.



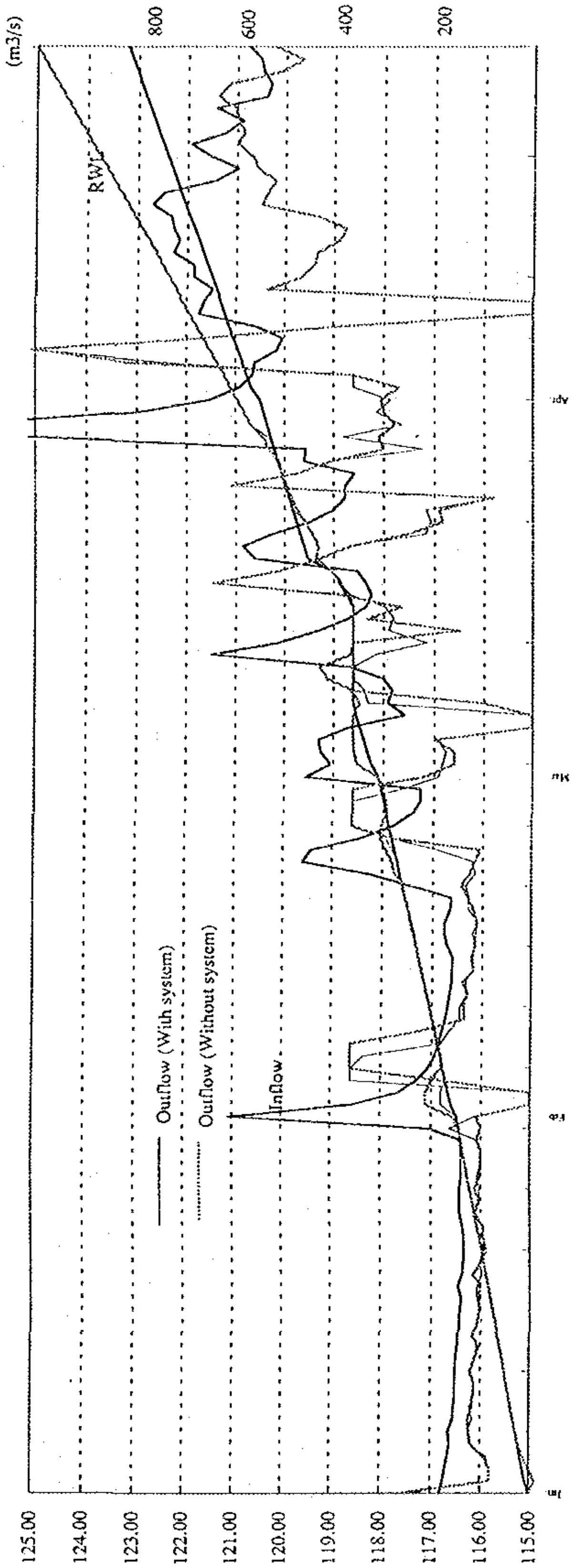
THE REPUBLIC OF TURKEY *DEVLET SU İŞLERİ* GENEL MÜDÜLÜĞÜ	FLOOD CONTROL, FORECASTING AND WARNING SYSTEM FOR SEYHAN RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Figure 7.2.4 (2/3) ÇATALAN DAM DAILY OPERATION (1975)

FIG. NO.



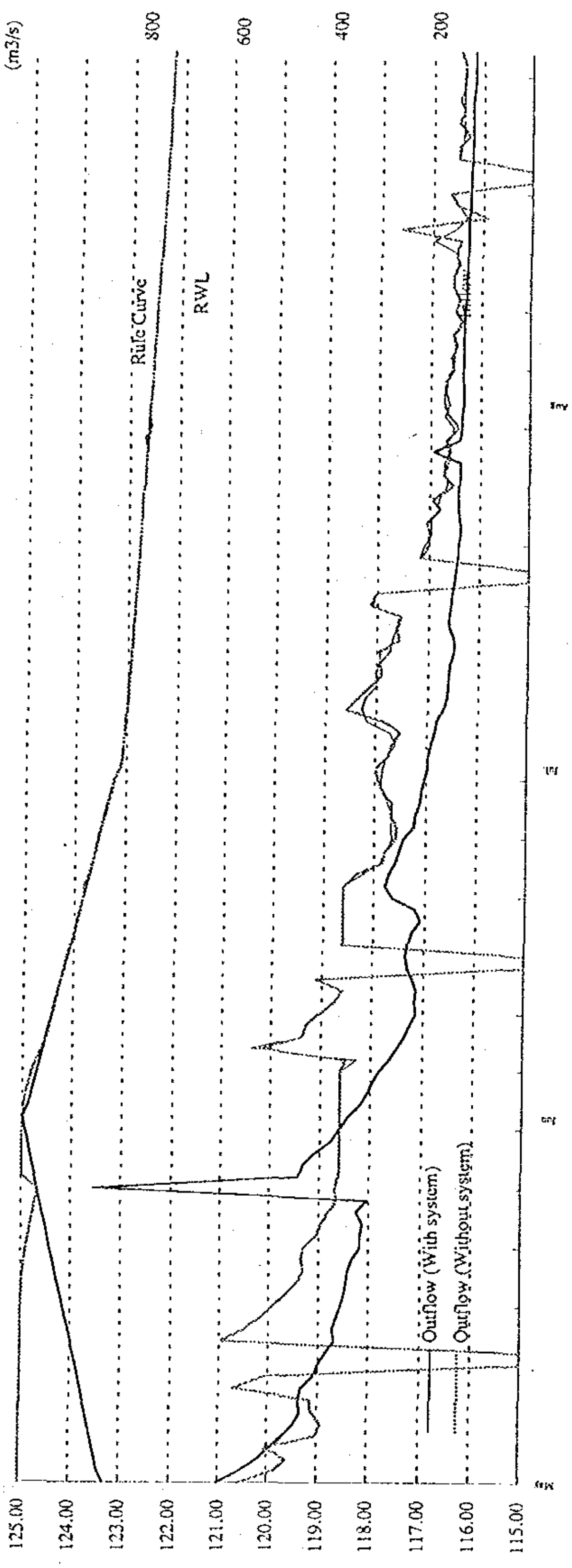
THE REPUBLIC OF TURKEY DEVLET SU İŞLERİ GENEL MÜDÜLÜĞÜ	**FLOOD CONTROL, FORECASTING AND WARNING SYSTEM FOR SEYHAN RIVER BASIN** JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Figure 7.2.4 (3/3) ÇATALAN DAM DAILY OPERATION (1975)

FIG. NO.



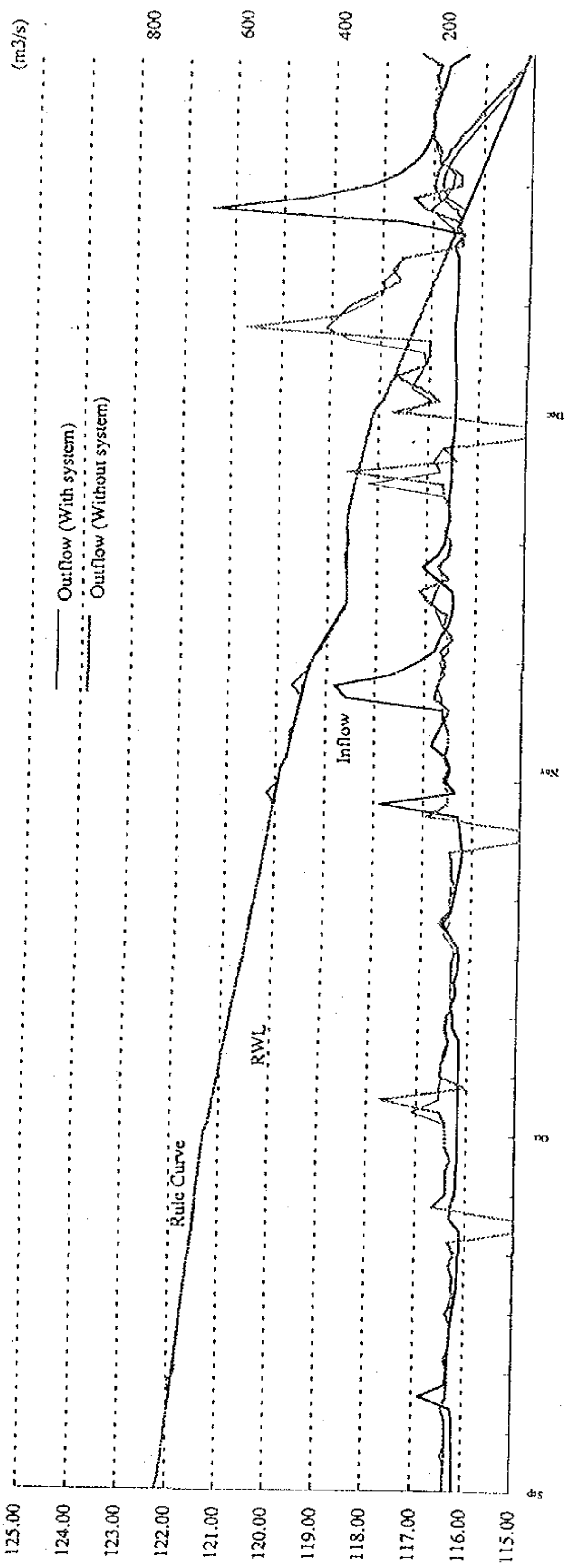
THE REPUBLIC OF TURKEY	FLOOD CONTROL, FORECASTING AND WARNING SYSTEM FOR SEYHAN RIVER BASIN	TITLE
DEVLET SU İŞLERİ GENEL MÜDÜLÜĞÜ	JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 7.2.5 (1/3) ÇATALAN DAM DAILY OPERATION (1988)

FIG. NO.



THE REPUBLIC OF TURKEY	FLOOD CONTROL, FORECASTING AND WARNING SYSTEM FOR SEYHAN RIVER BASIN	TITLE
DEVLET SU İŞLERİ GENEL MÜDÜLÜĞÜ	JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 7.2.5 (2/3) ÇATALAN DAM DAILY OPERATION (1988)

FIG. NO.



THE REPUBLIC OF TURKEY DEVLET SU İŞLERİ GENEL MÜDÜLÜĞÜ	**FLOOD CONTROL, FORECASTING AND WARNING SYSTEM FOR SEYHAN RIVER BASIN** JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Figure 7.2.5 (3/3) ÇATALAN DAM DAILY OPERATION (1988)

SUPPORTING REPORT D

ECONOMIC EVALUATION

THE FEASIBILITY STUDY
ON
FLOOD CONTROL, FORECASTING AND WARNING SYSTEM
FOR
SEYHAN RIVER BASIN

Supporting Report D Economic Evaluation

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1. INTRODUCTION

For the economic and social evaluation of the project, the Team conducted the field survey and interviews as well as document researches to obtain necessary data and information. These data and information include land use and socio-economic conditions of the target areas, and macro-economic conditions of Turkey.

The economic evaluation is initiate by the identification of the economic cost and benefit. The economic cost of this project is rather easy to identify, since the nature of the project does not create significant social cost other than investment, and operation and maintenance (O&M) costs. On the other hand the economic benefit identification involves complexity and difficulties especially for flood damage reduction.

The explanation of the process to identify the economic value of the flood damage reduction by the project is unnecessarily complicated to be included in the main report and deviates from the main discussion. Taking the above circumstances into account, this technical note is prepared for convenience.

2. FLOOD DAMAGE

2.1 Damage Risk Area

Damage risk area is limited to the cultivated land within the high water channel (HWC) on which wheat, corn, soy beans, water melon, and vegetable are planted. Residential areas on the HWC are located on the higher land of which flood damages are limited. Shallow inundation may cause negligible damages comparing to the agricultural land. Orchards and tree plantation areas are omitted from the damage risk land, too, since their expected damages are not significant.

2.2 Standardized Agricultural Damage

Table 2.2.1 shows the cropping pattern of vulnerable crops on the HWC agricultural land in 1993. Based on their cultivation expenses which are distributed to the expected time of occurrence and product prices, anticipated full damage amounts by time of incident for each crop per area (unit: da=1,000m^2) are calculated for the flood period. Flood incident period consists of November, December, January, March, April, and May. The amount is calculated by the following formula:

expenditures already spent + expected profit - actual profit by substituted crop (if possible).

Average of the each crop's expected full damage amounts for the months is used for the further steps. (Tables 2.2.2, 2.2.3, and 2.2.4)

2.3 Estimation of the Extent of Inundation

Based on the following information, expected extents of inundated vulnerable agricultural land corresponding to the discharge volume from the Seyhan Dam are estimated:

(a) Inundation information regarding the 1987 flood of which discharge volume was approximately 1,050 m^3/s,

(b) Inundation information regarding the 1993 flood of which discharge volume was approximately 550 m^3/s, and

(c) Location of the vulnerable crops' cultivation to the inundation. (Figure 2.3.1 and Table 2.2.1)

Presupposition used for the estimation is that the low water channel (LWC) has 500 m^3/s capacity and the HWC has 1,200 m^3/s level capacity. This means that up to 500 m^3/s

discharge the HWC agricultural land has no inundation and with 1,200 m^3/s discharge the HWC is fully inundated.

Assuming the extent of the inundation by the 1993 flood as the corresponding one to the 550 m^3/s and the inundated area by 1987 flood as the corresponding one to the 1,050 m^3/s, expected inundation extent corresponding to the discharge volume from the Seyhan Dam is determined incorporating the cropping pattern of the vulnerable crops. (Table 2.3.1)

2.4 Estimation of the Flood Damage

Expected flood damages corresponding to the discharge volume is basically calculated by the following formula crop by crop:

standardized damage amount per area x inundation area.

The following discharge volumes used for this calculation are estimated in 7.2.3 of the main report.

(unit: m^3/s)

Probability	1/2	1/5	1/10	1/50	1/100
Without Project	699	931	1,102	1,288	1,293
With Project	591	659	720	856	913

For the calculation of the wheat damage, discount rates are set for adjustment of the damage level from fully damaged to partly damaged to incorporate differences in terms of location and magnitude of discharge volume. Both factors affect the velocity, and depth and duration of inundation which are the main causes of damages. (Table 2.4.1)

The differences between the estimated damages without and with project are the base of the project benefit. The result is shown in Table 10.2.6 of the main report.

2.5 Conversion of the Flood Damage to the Project Benefit

To derive the project benefit, the amounts of the differences between the estimated flood damages corresponding to the respective flood probabilities are discounted by the probabilities of the occurrence of the flood. The following figure is used for the calculation.

Project benefit =

$$(D_0+D_1)/2 \times (P_0-P_1) + (D_1+D_2)/2 \times (P_1-P_2) + \cdots\cdots\cdots + (D_{n-1}+D_n)/2 \times (P_{n-1}-P_n)$$

where,

D_0	:	No damage
D_n	:	Differences of damages corresponding to the flood probability Pn
P_0	:	Probability of maximum flow without inundation
P_n	:	Probability of flood from 1/2 to 1/100.

Concept of the discount method is shown in Figure 2.5.1.

Tables

Table 2.2.1 Potential Damage Cultivation (Sequence from Upstream to Downstream)

(Unit: da)

Village Name	Cult. Land	Wheat	Corn	Cotton	Vegetable	Water-Melon	Risk Land	Only Wheat	Corn(2)	Soy Bean(2)
Right Side										
E.HADIRLI	2,500	100	0	0	100	0	200	5	95	0
B.YALMANLI	1,500	100	350	0	50	0	500	10	90	0
DIKOĞLU	2,356	1,039	450	0	0	0	1,489	309	730	0
KAYIŞLI	1,718	1,439	206	0	0	0	1,645	219	1,220	0
KARAYUSUFLU*	1,897	1,357	270	90	140	40	1,897	357	1,000	0
SALMANBEYLI *	1,407	1,271	0	105	31	0	1,407	310	961	0
DERVIŞLI*	1,838	831	200	110	67	50	1,258	349	482	0
MURSELOGLU	2,125	1,385	0	120	20	0	1,525	285	1,100	0
KEFELI*	878	765	45	68	0	0	878	305	460	0
COPLU *	3,005	355	2,550	100	0	0	3,005	105	250	0
YARAMIŞ	1,300	0	1,200	100	0	0	1,300	0	0	0
ÇATALCA	3,000	1,000	2,000	0	0	0	3,000	250	750	0
AGZIDELIK	1,830	500	1,330	0	0	0	1,830	100	400	0
Sub Total	25,354	10,142	8,601	693	408	90	19,934	2,604	7,538	0
Left Side										
HAVUTLU	1,868	431	116	0	20	0	567	40	391	0
TAŞÇI	244	93	71	0	0	0	164	0	93	0
AYDINCIK	1,660	705	200	0	0	75	980	75	630	0
DENIZKUYUSU	2,040	0	130	0	0	0	130	0	0	0
YERDELEN	1,736	1,636	0	0	0	0	1,636	136	1,500	0
TUZSUZOĞLU*	1,333	370	803	70	20	0	1,263	19	351	0
KUMURLU*	825	147	115	60	0	0	322	47	100	0
GUMUŞYAZI*	1,392	900	214	0	10	203	1,327	130	395	375
DAMLAPINAR*	7,502	4,947	1,020	1,495	0	40	7,502	647	4,300	0
YENIMURATLI*	1,984	1,000	580	200	0	0	1,780	140	860	0
TABAKLAR*	4,214	4,129	25	0	0	0	4,154	209	3,920	0
Sub Total	24,798	14,358	3,274	1,825	50	318	19,825	1,443	12,540	375
Total	50,152	24,500	11,875	2,518	458	408	39,759	4,047	20,078	375

*Lower land from ──── were inundated during the 1987 flood

*Land between ──── were under the river's nearly full capacity water height during 1987 flood.

*Land of village with * had damages by the 1993 flood.

Table 2.2.2 Cultivation Expenses Distribution

(Unit: TL)

Crops	Work Period		Month					
	From	To	Jan	Feb	Mar	Apr	May	Jun
Wheat	Oct	Jun	0	31,950	0	0	33,167	22,833
Corn	Mar	Sep	0	0	20,000	205,000	105,934	49,333
Cotton	Nov	Sep	0	10,000	117,175	144,425	90,000	44,967
Tomato	Feb	Jul	0	35,000	554,658	315,408	347,800	322,417
Water Melon	Sep	Jun	0	1,098,333	196,917	292,917	136,000	127,500
Corn (2nd)	Jun	Oct	0	0	0	0	0	292,500
Soybean (2nd)	Jun	Sep	0	0	0	0	0	221,925

Crops	Work Period		Month						Total
	From	To	Jul	Aug	Sep	Oct	Nov	Dec	
Wheat	Oct	Jun	0	0	0	30,000	211,300	0	329,250
Corn	Mar	Sep	64,200	79,333	75,000	0	0	0	598,800
Cotton	Nov	Sep	173,583	134,833	431,917	0	17,500	27,500	1,191,900
Tomato	Feb	Jul	322,417	0	0	0	0	0	1,897,700
Water Melon	Sep	Jun	0	0	35,000	35,000	50,000	63,333	2,035,000
Corn (2nd)	Jun	Oct	155,800	58,500	0	70,000	0	0	576,800
Soybean (2nd)	Jun	Sep	209,575	12,000	38,000	0	0	0	481,500

Table 2.2.3 Profit by Cultivation

Crops	Yield (kg/da) (1)	Price* (TL/kg) (2)	Product Value (1)*(2)	Cost (TL/da) (3)	Profit (TL/da) (1)*(2)-(3)
Wheat	550	1,550	852,500	329,250	523,250
Corn	1,100	1,400	1,540,000	598,800	941,200
Cotton	300	7,800	2,340,000	1,191,900	1,148,100
Tomato	3,500	1,850	6,475,000	1,897,700	4,577,300
Water Melon	3,700	1,400	5,180,000	2,035,000	3,145,000
Corn (2nd)	900	1,400	1,260,000	576,800	683,200
Soybean (2nd)	270	3,500	945,000	481,500	463,500

*1993 PRICES

Table 2.2.4 Standard Damage Value per Unit Land (da)

(Unit: TL)

	Av. Loss	Nov	Dec	Jan	Feb	Mar	Apr	May
Wheat								
(only Wheat no Substitute)	786,053	764,550	764,550	764,550	0	796,500	796,500	829,667
(w/2nd Corn to 1st Corn Only)	657,053	506,550	506,550	506,550	0	796,500	796,500	829,667
(w/2nd Soy to 1st Corn Only)	547,203	286,850	286,850	286,850	0	796,500	796,500	829,667
Corn	224,989	0	0	0	0	278,000	483,000	588,934
Cotton	399,596	17,500	45,000	45,000	0	637,075	781,500	871,500
Tomato	2,404,982	0	0	0	0	4,483,758	4,799,166	5,146,966
Water Melon	3,402,508	2,581,800	2,645,133	2,645,133	0	3,940,383	4,233,300	4,369,300

Table 2.3.1 Expected Inundation Cultivated Land by Discharge from the Seyhan (Crop by Crop)

(Unit: da)

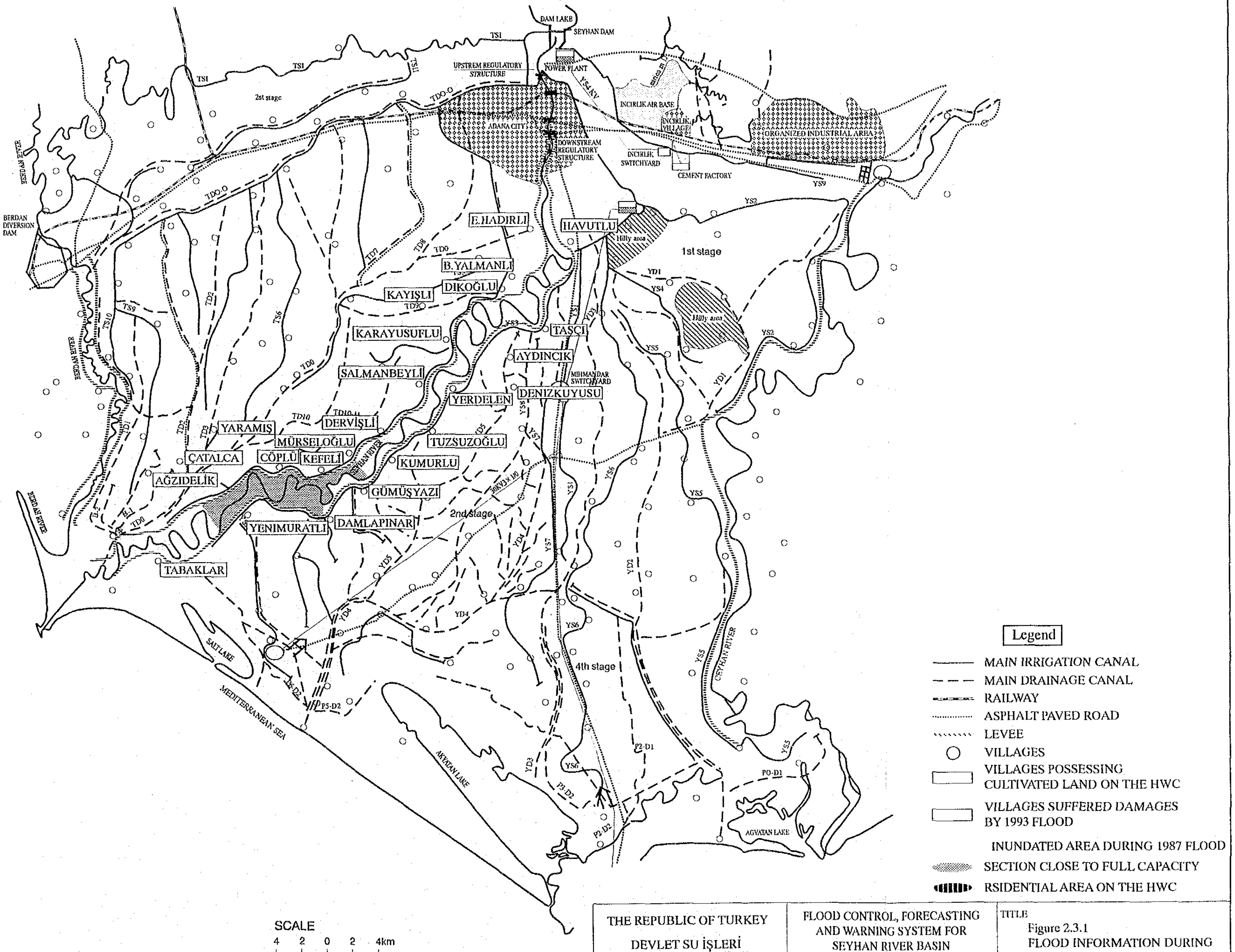
	500	550	600	650	700	750	800	850	900	950	1,000	1,050	1,100	1,150	1,200
Right Side															
Wheat	0	2,190	2,776	3,362	3,948	4,534	5,120	5,706	6,292	6,878	7,464	8,134	8,803	9,473	10,142
No 2nd	0	628	787	947	1,106	1,265	1,424	1,583	1,743	1,902	2,061	2,197	2,333	2,468	2,604
2nd Corn	0	1,562	1,989	2,415	2,842	3,269	3,696	4,123	4,549	4,976	5,403	5,937	6,471	7,004	7,538
2nd Soy	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Corn	0	0	844	1,688	2,532	3,376	4,219	5,063	5,907	6,751	7,595	7,847	8,098	8,350	8,601
Cotton	0	230	281	333	384	436	487	539	590	642	693	693	693	693	693
Vegetable	0	87	106	125	144	163	182	201	220	239	258	296	333	371	408
Water-Melon	0	50	54	59	63	68	72	77	81	86	90	90	90	90	90
Risk Land	0	2,557	4,062	5,567	7,071	8,576	10,081	11,586	13,090	14,595	16,100	17,059	18,017	18,976	19,934
Left Side															
Wheat	0	4,023	5,123	6,224	7,324	8,425	9,525	10,626	11,726	12,827	13,927	14,035	14,143	14,250	14,358
No 2nd	0	417	527	636	746	855	965	1,074	1,184	1,293	1,403	1,413	1,423	1,433	1,443
2nd Corn	0	3,474	4,438	5,402	6,366	7,330	8,294	9,257	10,221	11,185	12,149	12,247	12,345	12,442	12,540
2nd Soy	0	131	158	185	213	240	267	294	321	348	375	375	375	375	375
Corn	0	2,115	2,329	2,543	2,757	2,824	2,891	2,958	3,024	3,091	3,158	3,187	3,216	3,245	3,274
Cotton	0	1,223	1,424	1,624	1,825	1,825	1,825	1,825	1,825	1,825	1,825	1,825	1,825	1,825	1,825
Vegetable	0	0	10	20	30	30	30	30	30	30	30	35	40	45	50
Water-Melon	0	0	81	162	243	256	268	281	293	306	318	318	318	318	318
Risk Land	0	7,361	8,683	10,005	11,327	12,649	13,970	15,292	16,614	17,936	19,258	19,400	19,542	19,683	19,825
Total															
Wheat	0	6,213	7,899	9,586	11,272	12,959	14,645	16,332	18,018	19,705	21,391	22,168	22,946	23,723	24,500
Corn	0	2,115	3,173	4,231	5,289	6,199	7,110	8,021	8,932	9,842	10,753	11,034	11,314	11,595	11,875
Cotton	0	1,453	1,705	1,957	2,209	2,261	2,312	2,364	2,415	2,467	2,518	2,518	2,518	2,518	2,518
Vegetable	0	87	116	145	174	193	212	231	250	269	288	331	373	416	458
Water-Melon	0	50	135	221	306	323	340	357	374	391	408	408	408	408	408
Risk Land	0	9,918	12,745	15,571	18,398	21,225	24,051	26,878	29,705	32,531	35,358	36,458	37,559	38,659	39,759

Table 2.4.1 Expected Damages by Discharge from Seyhan Dam

(Unit: da for land & mill TL for Loss)

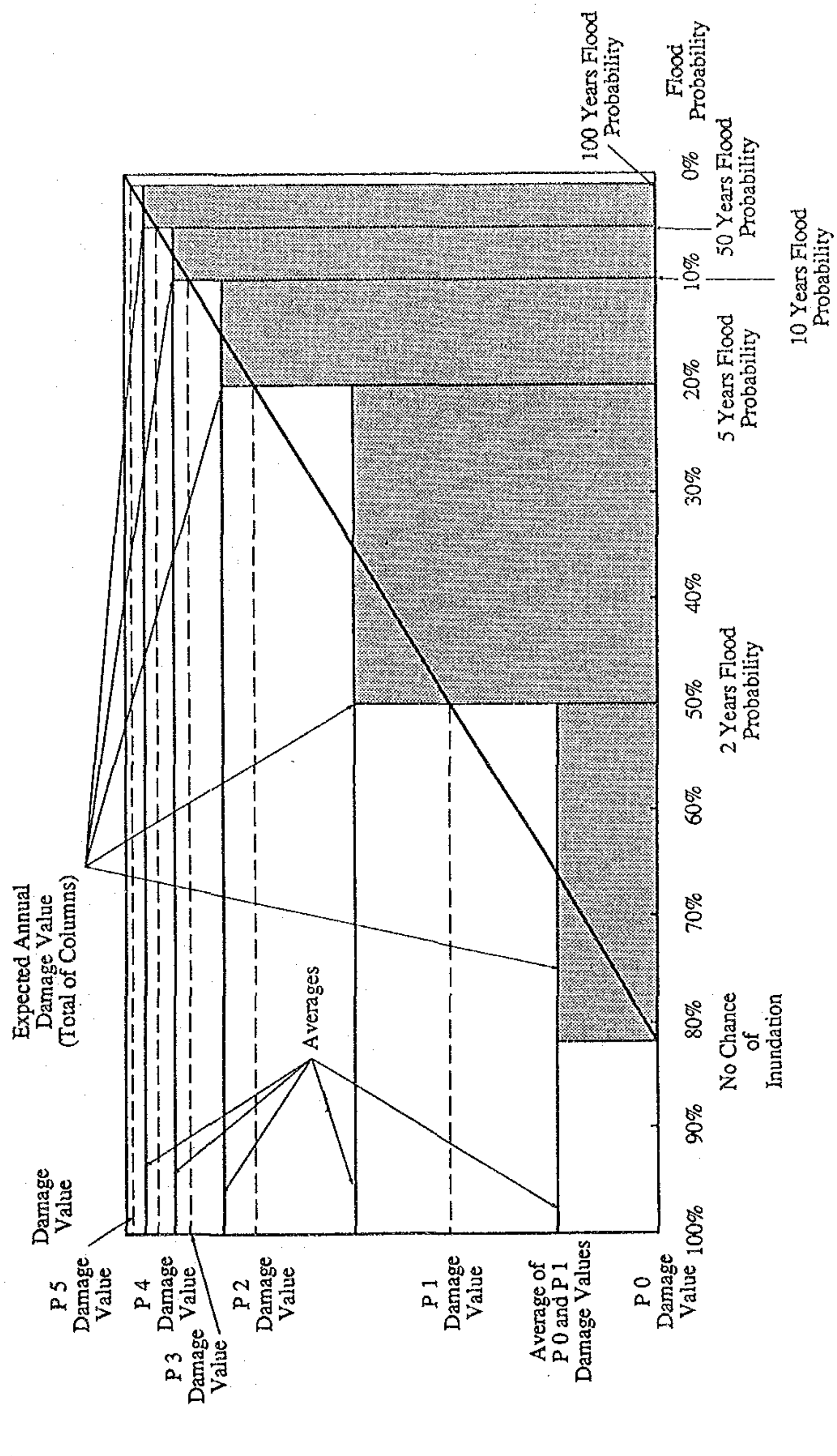
Item	Discharge Volume from the Seyhan Dam (cub. m/s)														
	500	550	600	650	700	750	800	850	900	950	1,000	1,050	1,100	1,150	1,200
Right Side															
Wheat (sum)	0	1,592	2,012	2,433	2,853	3,273	3,694	4,114	4,535	4,955	5,375	5,833	6,290	6,748	7,205
No 2nd	0	494	619	744	869	994	1,120	1,245	1,370	1,495	1,620	1,727	1,833	1,940	2,047
2nd Corn	0	1,026	1,307	1,587	1,867	2,148	2,428	2,709	2,989	3,270	3,550	3,901	4,251	4,602	4,953
2nd Soy	0	72	87	101	116	131	146	161	176	190	205	205	205	205	205
Left Side															
Wheat (sum)	0	2,659	3,394	4,129	4,864	5,594	6,324	7,054	7,783	8,513	9,243	9,338	9,434	9,529	9,624
No 2nd	0	328	414	500	586	672	758	845	931	1,017	1,103	1,111	1,119	1,126	1,134
2nd Corn	0	2,283	2,916	3,550	4,183	4,816	5,449	6,083	6,716	7,349	7,983	8,047	8,111	8,175	8,239
2nd Soy	0	48	63	79	95	106	116	126	137	147	158	181	204	227	251
Damage Ratio		20.0%	27.8%	35.6%	43.3%	51.1%	58.9%	66.7%	74.4%	82.2%	90.0%	92.5%	95.0%	97.5%	100%
Wheat (R)	0	318	559	865	1,236	1,673	2,175	2,743	3,376	4,074	4,838	5,395	5,976	6,579	7,205
Wheat (L)	0	532	943	1,468	2,108	2,859	3,724	4,702	5,794	7,000	8,319	8,638	8,962	9,291	9,624
Right Side															
Corn	0	0	190	380	570	759	949	1,139	1,329	1,519	1,709	1,765	1,822	1,879	1,935
Cotton	0	489	569	649	729	729	729	729	729	729	729	729	729	729	729
Vegetable	0	209	255	301	346	392	438	483	529	575	620	711	801	891	981
Water-Melon	0	0	276	551	827	869	912	954	997	1,039	1,082	1,082	1,082	1,082	1,082
Total		1,016	1,848	2,746	3,708	4,423	5,203	6,049	6,960	7,936	8,978	9,683	10,410	11,160	11,933
Left Side	0	476	524	572	620	635	650	665	680	695	711	717	724	730	737
Cotton	0	3,963	5,093	6,222	7,352	8,481	9,611	10,740	11,870	12,999	14,129	14,569	15,008	15,448	15,888
Vegetable	0	0	24	48	72	72	72	72	72	72	72	84	96	108	120
Water-Melon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	4,971	6,583	8,311	10,152	12,048	14,057	16,180	18,417	20,767	23,230	24,008	24,790	25,577	26,369
Total	0	5,987	8,432	11,056	13,860	16,471	19,261	22,229	25,377	28,703	32,209	33,690	35,200	36,737	38,301

Figures



THE REPUBLIC OF TURKEY DEVLET SU İŞLERİ GENEL MÜDÜRLÜGÜ	FLOOD CONTROL, FORECASTING AND WARNING SYSTEM FOR SEYHAN RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Figure 2.3.1 FLOOD INFORMATION DURING 1987 AND 1993 FLOODS

FIG. NO.



THE REPUBLIC OF TURKEY DEVLET SU İŞLERİ GENEL MÜDÜLÜĞÜ	FLOOD CONTROL, FORECASTING AND WARNING SYSTEM FOR SEYHAN RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Figure 2.5.1 CONCEPT OF EXPECTED ANNUAL FLOOD DAMAGE CALCULATION

SUPPORTING REPORT E

FORMULATION OF FLOOD FORECASTING AND WARNING SYSTEM

THE FEASIBILITY STUDY
ON
FLOOD CONTROL, FORECASTING AND WARNING SYSTEM
FOR
SEYHAN RIVER BASIN

Supporting Report E Formulation of Flood Forecasting and Warning System

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1. INTRODUCTION

The study on the formulation of flood forecasting and warning system presents the optimum flood forecasting and warning plan for the Seyhan River basin.

The study items are composed of the following;

(1) Formulation of hydrometeorological observation plan
(2) Formulation of optimum plan

The contents of the following chapters are briefly explained below.

(1) Chapter 2 : Formulation Of Hydrometeorological Observation Plan
(2) Chapter 3 : Basic Study of Alternative Plans
(3) Chapter 4 : Evaluation of Alternative Plans
(4) Chapter 5 : Formulation of Optimum Plan
(5) Chapter 6 : Configuration and Function of Optimum System
(6) Chapter 7 : Education and Training
(7) Chapter 8 : Maintenance and Management System

2. FORMULATION OF HYDROMETEOROLOGICAL OBSERVATION PLAN

2.1 Formulation of Water Level Gauging Station

(1) Basic approach

To formulate the water level gauging station which shall be telemetered for flood forecasting, the existing gauging stations are evaluated by several requirements for an ideal base station. The water level gauging station at flood control structures such as Seyhan Dam and Çatalan Dam is also considered to be a forecasting station for flood forecasting.

(2) Requirements for an ideal base station

The requirements for an ideal base station are outlined as below:

(a) It must be strategically located,
(b) It must be equipped with an automatic water level recorder,
(c) The gauge should be easily accessible,
(d) The gauge should be located in a straight reach of the river without the influence of back-water from downstream reservoir, and
(e) It must have sufficiently long-term flood records with continuous water level recording charts.

(3) Subdivision of Göksu and Zamantı River basins

The entire basins of Göksu and Zamantı River are subdivided into two subbasins at 1801 and 1822 water gauging stations since the upstream and downstream subbasins are regarded as independent and homogenous ones based on the geographical, geological, topographical, and hydrological observations. Also, the basin size of each subbasin is suitable for storage function basin model.

(4) Selection of base water level gauging station to be telemetered

The several water level gauging stations are selected, based on the above criteria mentioned in (2), as given below:

Base Water Level Gauging Stations to be Telemetered

No. of Gauge	Type of Gauge	Name of River	Catchment Area (km^2)	Operated by	Main Purpose of Estimate
1822	Automatic	Zamantı	6,990	EİE	Outflow from middle and upstream of Zamantı River
1806	Staff *1	Zamantı	1,833	EİE	Outflow from downstream of Zamantı River
1801	Automatic	Göksu	2,298	EİE	Outflow from middle and upstream of Göksu River
1805	Staff *1	Göksu	2,099	EİE	Outflow from Göksu River
1818	Automatic	Seyhan	858	EİE	Inflow into Çatalan Dam
1825	Automatic	Eğlence	506	EİE	Inflow into Çatalan Dam
1820	Automatic	Körkün	1,427	EİE	Inflow into Seyhan Dam
1828	Automatic	Çakıt	1,797	EİE	Inflow into Seyhan Dam

Note: *1 Type of gauge shall be changed to be automatic for flood forecasting system plan.

(5) Selection of forecasting water level gauging station

To forecast the flood runoff into the reservoir and to operate the dam, the water level gauging station shall be installed at Seyhan and Çatalan Dams.

2.2 Formulation of Rainfall Gauging Station

(1) Basic approach

To forecast the flood runoffs draining into the flood control structures such as Seyhan and Çatalan Dams from several sub-basins of the Seyhan River basin, it is of importance to estimate the mean basin rainfall when a rain storm occurs in the basin.

The rainfall gauging station to be telemetered is a group of the minimum rainfall gauging stations required to represent the mean basin rainfall amount within the acceptable range of estimate error, and it is defined to be representative rainfall gauging station. For the purpose of estimating the basin rainfall, the representative rainfall gauging station is selected among the existing rainfall gauging stations by the statistical method, namely, the multiple linear regression analysis on the observed rainfall records.

Since the Seyhan River basin is needed to be divided into several sub-basins for the flood runoff analysis, the representative rainfall gauging station shall be selected on the basis of the sub-basins.

(2) Evaluation of major rain storms

Following 24 storm rainfall records are picked up as the representative storm rainfall among the past observation records when the storm caused flood in the Seyhan River basin.

Month	Year	Month	Year
Dec.	1937	Dec.	1957
May	1946	Dec.	1961
Nov.	1947	Dec.	1969
Dec.	1947	Jan.	1970
Feb.	1948	Jun.	1972
May	1950	May	1973
Feb.	1952	Jun.	1973
Mar.	1952	Apr.	1975
Apr.	1952	May	1975
Apr.	1953	Mar.	1980
Jun.	1957	Apr.	1980
Jul.	1957	Dec.	1987

The above storm records are used for the evaluation of allocation plan of representative rainfall station.

(3) Interpolation of missing data

The missing data of daily and hourly rainfall are interpolated by the following method using the rainfall data of the nearby stations.

(a) The simple linear regression analysis is made among all the rainfall gauging stations in and around the Seyhan River basin on a daily basis. The correlation coefficient (r) between two stations is calculated and summarized in the correlation matrix as shown in Table 2.2.1.

The correlated stations having a correlation coefficient (r) greater than or equal to 0.8 are shown in Figure 2.2.1. Also, the uncorrelated stations having (r) less than or equal to 0.2 are shown in Figure 2.2.2. Two figures clearly suggest that the results of this analysis are in agreement with the topographical and climate conditions in the Seyhan River basin.

(b) The nearby station correlated with the station with missing data, having the highest value of correlation coefficient, is selected to interpolate the missing data.

The minimum requirement of correlation coefficient is set to be greater than or equal to 0.8.

The linear regression equation adopted as below:

$$Y = aX + b$$

where,

Y	=	Missing daily rainfall
X	=	Daily rainfall at correlated station
a	=	Simple regression coefficient
b	=	Constant

(c) In case that missing data cannot be interpolated by the simple linear regression analysis explained in (b), the multiple linear regression using the forward stepwise regression method is adopted. The multiple linear regression equation is described as below:

$$Y = a_1 X_1 + a_2 X_2 + \ldots\ldots + a_n X_n + b$$

where,

X_i	=	Daily rainfall at correlated stations
n	=	Number of station
a_i	=	Multiple regression coefficients (i = 1 to n)
b	=	Constant

For the purpose of illustration the sample computations are summarized only for Karsantı rainfall gauging station as below.

<u>The Results of Multiple Linear Regression</u>

	Selection of Stations		
	Step 1	Step 2	Step 3
Selected Station	• Sıhlı	• Sıhlı • Seyhan Brj.	• Şıhlı • Seyhan Brj. • Pozantı
a (for Sıhlı)	0.805	0.605	0.517
a (for Seyhan Brj.)		0.671	0.630
a (for Pozantı)			0.118
b (mm)	1.607	0.115	0.013
r	0.783	0.875	0.882

(4) Estimation of mean basin rainfall

The selection of representative rainfall gauging station requires knowledge of true value of mean basin rainfall. The hypothetical true value of mean basin rainfall is calculated by Thiessen Method which weights each existing station in direct proportion to the area it represents.

Polygons are constructed by drawing perpendicular bisectors to lines connecting the existing stations as shown in Figure 2.2.3.

(5) Selection of representative station

The representative rainfall gauging station is selected, using the daily rainfall data prepared by (2) and (3), based on the following procedure.

(a) Multiple linear regression using the backward stepwise regression method is adopted to determine the required number of representative station.

(b) The effective area for each station obtained by Polygons is allocated to sub-basins as shown in Table 2.2.2.

(c) Hypothetical true value of mean basin rainfall is calculated by total number of existing stations of which rainfall amount is effective to the sub-basin given in Table 2.2.2.

(d) Multiple linear regression equation is described below:

$$R_s = \sum_{i=1}^{n} (a_i \times R_i) + b$$

where,
R_s = Hypothetical true value of mean basin rainfall
R_i = Point rainfall of representative rainfall gauging station
n = Number of representative rainfall gauging stations
a_i = Multiple regression coefficient
b = Constant

(e) The accuracy of estimate of mean basin rainfall depends on the number of representative rainfall gauging station.

The degree of accuracy is indicated by the correlation coefficient given by multiple linear regression. Relationship between the degree of accuracy of estimate and the number of representative station for the plan of Alternative 2 is shown in Figure 2.2.4 and also Figure 2.2.5 as an example for the Göksu River basin.

(f) As indicated in Figure 2.2.4, there is a point from which the curve inclines drastically depending on the decrease of the number of station.

The point indicates the minimum number of representative rainfall gauging station required to estimate the mean basin rainfall within the acceptable range of accuracy.

(6) Alternative plan of representative rainfall gauging station to be telemetered.

(a) The alternative plan of representative rainfall gauging station to be telemetered is studied only for the Zamantı and Göksu River basins because of the following reasons.

- The Zamantı and Göksu River basins are composed of two sub-basins characterized by the noticeable different climate and topography as below:

Sub-basin	Basin Characteristics
(1) The upstream and middle-stream basins (Approximately up to 1822 and 1801 stream gauging stations)	- Flat river basin - Comparatively less storm rainfall
(2) Downstream basin (Approximately after 1822 and 1801 stream gauging stations)	- Steep river basin - Comparatively more storm rainfall

- The other small tributaries have no remarkable characteristics of different climate and topography within the basin.

(b) Therefore, the alternative plans are conceived as below:

- Alternative 1: The Zamantı and Göksu basins are divided into two sub-basins before and after 1822 and 1801 stream gauging stations.

- Alternative 2: The Zamantı and Göksu basins are treated as one whole basin.
  1822 and 1801 stream gauging stations are not installed as the result of the treatment.

(c) The results of the selection of representative rainfall gauging station for the above Alternative 1 and Alternative 2 are summarized in Figures 2.2.6 and 2.2.7 and Tables 2.2.3 and 2.2.4. The multiple regression coefficients of the representative rainfall gauging stations for Alternative 1 are shown in Table 2.2.5.

Considering the lesser influence of the rainfall in the middle and upstream basins of the Zamantı River basin observed by rainfall study in the case of flood events in the Seyhan River basin, the Alternative 3 is additionally conceived as below.

- Alternative 3: No telemetering rainfall gauging stations are installed above 1822 stream gauging station.

  1822 stream gauging station is only installed with telemetry to observe the secondary flood runoff.

2.3 Formulation of Temperature Gauging Station

(1) Representative meteorological gauging stations

To select the representative temperature gauging stations to be telemetered for the purpose of forecasting the snowmelt runoff in the subbasins, the representative meteorological gauging stations that were formulated for the hydrometeorological observation network to be telemetered for the Seyhan River basin are evaluated on the basis of hydrometeorological criteria. The locations of the representative stations are shown in Figure 2.2.6.

(2) Meteorological gauging stations with available daily mean temperature data

Among the representative meteorological gauging stations, daily mean temperature data are obtained at the following stations.

(a) Pozantı (778 El.m)
(b) Çamardı (1500 El.m)
(c) Feke (620 El.m)
(d) Tomarza (1400 El.m)
(e) Pınarbaşı (1470 El.m)

(3) Criteria to select the representative temperature gauging stations

To estimate the accurate and reliable temperature at the snow-covered area, the following criteria are considered.

(a) The gauging stations situated at relatively higher elevation are to be selected to minimize the estimate errors.

(b) The gauging stations are to be representatively situated in the subbasin.

(c) The selected gauging stations are recommended to possess the past records of daily temperature.

(d) The nearest gauging station is to be selected in case that no gauging stations are available within the subbasin.

(4) Selected representative temperature gauging stations

Based upon the above-defined criteria, the representative temperature gauging station is evaluated for each subbasin. Seven stations are selected and shown below.

Selected Representative Temperature Gauging Stations

Basin No.	Basin Name	Selected Station	Elevation (El.m)
1	Upper Zamantı (above 1822)	Tomarza	1,400
2	Lower Zamantı (1806 - 1822)	Şıhlı	1,400
3	Upper Göksu (above 1801)	Tufanbeyli	1,350
4	Lower Goksu (1805 - 1801)	Mansurlu	1,050
5	Seyhan (1818 - Confluence)	Karsantı	860
6	Eğlence (above 1825)	Kamışlı	1,225
7	Eğlence (below 1825)	Not necessary	
8	Seyhan (Çatalan - 1818)	Not necessary	
9	Körkün (above 1820)	Kamışlı	1,225
10	Körkün (below 1820)	Not necessary	
11	Üçürge	Pozantı	778
12	Seyhan (Seyhan - Çatalan)	Not necessary	
13	Çakıt (above 1828)	Pozantı	778

2.4 Formulation of Hydrometeorological Observation Network

Based on the above studies to formulate the representative water level and rainfall gauging stations to be telemetered, three alternative plans are conceived as summarized below:

Alternative Plans of Hydrometeorological Observation Network

Alternative	No. of water level gauging station		No. of rainfall gauging station	No. of temperature gauging station	Note
	Base station	Forecasting station*			
1	8	2	16	7	Zamantı and Göksu Rivers are divided into two subbasin at 1822 and 1801
2	6	2	13	7	Zamantı and Göksu Rivers are treated as one basin
3	7	2	10	7	Zamantı River is divided into two subbasins at 1822, but no rainfall stations are installed for sub-basin above 1822

Note *: Forecasting station is installed at Seyhan and Çatalan Dams.

Among three conceivable alternative plans studied by the statistical methods and hydraulic consideration, Alternative 1 is the most suitable plan for the Seyhan River basin taken into consideration the unpredictable natural phenomenon as below.

- The unilateral area of storm rainfall,
- The changeable distribution of storm rainfall, and
- The changeable magnitude of storm rainfall.

Optimum Plan of Hydrometeorological Observation Network

Base Water Level Gauging Station	Forecasting Water Level Gauging Station	Rainfall Gauging Station	Temperature Gauging Station
1822 (Zamantı upstream)	Seyhan dam	Çatalan Dam	Karsantı
1806 (Zamantı downstream)	Çatalan dam	Karsantı	Pozantı
1801 (Göksu upstream)		Çiftehan	Kamışlı
1805 (Göksu downstream)		Pozantı	Mansurlu
1818 (Seyhan River)		Karaisalı	Tufanbeyli
1825 (Eğlence River)		Kamışlı	Şıhlı (Şeyhli)
1820 (Körkün River)		Çamardı	Tomarza
1828 (Çakıt River)		Feke	
		Mansurlu	
		Saimbeyli	
		Tufanbeyli	
		Kazancık	
		Pınarbaşı	
		Şıhlı (Şeyhli)	
		Toklar	
		Tomarza	

3. BASIC STUDY OF ALTERNATIVE PLANS

This chapter describes the basic items of study as to the sub-systems of the flood forecasting and warning system that are common to the alternative plans presented below; the sub-systems referring to a data collection system, a data processing system and a data transmission system.

3.1 Basic Study of Data Collection System

Based on prior studies of a hydrometeorological observation network plan, basic studies are made for the hydrometeorological data collection system that covers the area from hydrometeorological gauging sites to the DSİ 6th regional directorate and related agencies. These basic studies relate to those basic items of the data collection system that are common to each alternative plan. More specifically, the following items are studied:

3.1.1 Basic study policies

During study of a data collection system for the flood forecasting and warning system in Seyhan River basin, further studies are made for the results of survey of the current data collection system, for the purpose and functions of the flood forecasting and warning system to be structured, and for the geographical conditions of the areas covered. The basic design concept for the new data collection system is established using those analyses.
The basic design concept for the new data collection system is to be set on the study policies described below.

(a) The data collection system is capable of collecting and hydrometeorological data both accurately and rapidly from hydrometeorological gauging sites into a flood forecasting and warning control center. The flood forecasting and warning control center is to act as the center of flood forecasting and warning control information that collects, processes, and distributes and hydrometeorological data. The Seyhan Dam office and the DSİ 6th regional directorate are selected as the promising setup locations for the control center. The flood forecasting and warning control center, however, is to be set up in the DSİ 6 th regional directorate since the flood control committee is organized in DSİ 6 th regional directorate for the following reasons:.

i) Concerning the construction in a Seyhan Dam office, several other dams, including a Yedrgöze dam and the Çatalan Dam (currently under construction,) are also scheduled to be contracted. One of the probable plans, therefore, is to structure an integrated dam management system that uses the Seyhan Dam office as the integrated dam management office in the future. Integrated dam management system structuring, although required in the future, is to be excluded from the feasibility study of flood forecasting and warning system planning, because all those additional dams (but except the Çatalan Dam whose construction is scheduled to be completed in 1994) will be constructed only after 10 years ahead, and because the main objectives of the system differ from those of the flood forecasting and warning system.

ii) The control center of the flood forecasting and warning system is to be set up in the DSİ 6th regional directorate for the reasons listed below, and using collected/processed information, the control center is to perform the appropriate judgments and supports on flood control activities and transmit information to related agencies. A supervisory station, which collects hydrometeorological data and dam reservoir water level data, should be established at the Seyhan Dam office to allow for future extendibility of the system.

- In the event of flooding, a flood control committee is organized in the DSİ 6th regional directorate. The control center therefore is set up in the DSİ 6th regional directorate to ensure that the flood control activities of the flood control committee are supported using previously collected data and processed information.
- If a flood is likely to occur, this is to be notified from the DSİ 6th regional directorate to the Governor.
- The existing organizations of the DSİ 6th regional directorate are used to support flood control activities and transmit necessary information. Thus, the command system does not become disturbed.

Collection of necessary data in related agencies is discussed in Section 3.3, Basic Study of The Data Transmission System.

(b) The types of data to be collected using the data collection system are rainfall, water level and air temperature. The maximum gauging stations for these three types of data are listed in Table 3.1.1, and alternative plans are to be set up from the listing.

(c) In principle, data collection intervals are as listed below.

Gauging item	Collection Intervals	Remarks
Rainfall	Every hour on the hour	Calculations of hourly rainfalls, every hour on the hour, become the minimum unit.
Waterlevel	Every hour on the hour	It is preferable that whenever necessary, collection of any data is possible.
Air temperature	Every hour on the hour	It is preferable that whenever necessary, collection of any data is possible.

(d) Use of radar rain gauge data, described in this section, is discussed as one alternative method for rainfall data collection.

(e) If terrestrial communications circuits are to be used to collect data, since continuous collection of hydrometeorological data is not required, those communications circuits are of the half-duplex type that uses VHF radio communications links of high circuit design efficiency. Also, the optimum link configuration is designed by combining those links with the multiplex radio communications links mainly intended for data and information transmission purposes. In addition, considering the topographical conditions of the Seyhan River basin, the VHF radio communications links use a frequency band of 70 MHz, which is ideal for mountainous propagation, while at the same time being high in circuit design efficiency and allowing its use in the Republic of Turkey to be licensed.

3.1.2 Study of circuits schemes

During study of the data collection methods, the available circuit schemes can be broadly divided into the terrestrial communications circuit scheme and the satellite communications circuit scheme. Comparative studies on these two schemes are listed in Table 3.1.2. The satellite communications circuit under the comparative study plan is the VSAT (Very Small Aperture Terminal) system that uses a Turkish satellite. The VSAT system, although not yet usable, is to be studied in comparison with the terrestrial communications circuit, on the assumption that the system will become usable in the near future. For the flood forecasting and warning system, further studies that assume use of the terrestrial communications circuit are to be performed for the following reasons:

(a) To use the VSAT system, users should install VSAT equipment. Also, considering circuit usage charges, the equipment costs are more expensive than the same as those of the terrestrial communications circuit

(b) In areas that suffer from snow fall, snow-melting equipment is required against the accumulation of snow on the antennas. In view of the electrical power supply situation in the Seyhan River basin areas, measures for stabilized supply of power should be undertaken since missing-data is likely to occur very frequently.

(c) In terms of maintenance and management, if failures occur in the satellite communications circuit, significant amounts of time will need to be spent in restoration.

(d) The frequency band used for the VSAT system is susceptible to attenuation due to rainfall, and thus missing-data is likely to occur.

3.1.3 Study of data collection methods

Either centralized collection or distributed collection is usually used to collect data. Centralized collection is a method intended to directly collect data at flood forecasting and warning centers, and distributed collection is a method intended to collect data at sub-supervisory stations and then transfer the data to the flood forecasting and warning centers. Comparative studies on these two methods are listed in Table 3.1.3. A distributed collection method approximate to the centralized collection method should be used for the system, mainly for the following reasons:

(a) In the Seyhan River basin, river management, dam management and flood control are centralized at the DSİ 6th regional directorate.

(b) For ideal centralized collection, a supervisory station is installed at the flood forecasting and warning center. To allow for the structuring of an integrated dam management system in the future, however, setup of a supervisory station at the Seyhan Dam office increases the extendibility of the system.

3.1.4 Study of telemetering methods

Rainfall, water levels and other river management data, including flood forecasting and warning information, are usually collected using one of the following two telemetering methods :

- Polling
- Event reporting

Comparative studies on three methods (the above mentioned two, and a combination of the two) are listed in Table 3.1.4 to Table 3.1.6.

Judging from the comparative studies listed in Table 3.1.4 to Table 3.1.6, it is preferable that the flood forecasting and warning system should use the polling method for the following four main reasons:

(a) It is necessary that radio waves are effectively used under appropriate circuit control of the radio waves, because the area to be covered is very wide and because the total number of intended stations is large.

(b) The system correctly performs the functions that become effective in the event of flooding, and thus high system reliability is demanded.

(c) Since the area to be covered is very wide, not only circuit configuration becomes sophisticated, but also is demanded a very wide span. A method advantageous for the prevention and reduction of noise, therefore, is required. In view of this, polling is effective since, if data cannot be collected because of noise, automatic recollection becomes possible with the polling method.

(d) The telemetering method demands one effective in terms of maintenance. Unlike event reporting, polling allows data to be checked and thus becomes effective in terms of maintenance.

3.1.5 Study of measurement method

This paragraph performs comparative studies on the methods of measuring various data and on the measuring instruments required for data collection then defines requirements for remote measurement, and presents the criteria for selection of the measuring instruments that are to be provided in gauging stations.

(1) General requirements of remote measuring instruments

General requirements that are to be satisfied prior to the use of remote measurement with telemetering methods, whether they be existing ones, are listed below.

(a) Those existing instruments should have special interface terminals for telemetering connection.
(b) Output data to telemetering interface checking for maintenance and data calibration purposes should be possible.
(c) The data output format should be a code checked one.
(d) The instruments should be of a power-saving design.
(e) The instruments should match to telemetering.
(f) No problems should occur in terms of both unattended remote gauging and environmental characteristics.
(g) The instruments should be highly reliable.
(h) Sufficient protection against lightning surges should have been provided.
(i) Maintenance should be easy.

(2) Study of water level gauges

Various types of water level gauges are available, including the float type, the pressure type, the non-contact type, etc. Table 3.1.7 and 3.1.8 compares the characteristics of various water level gauges. The applicability of existing water level gauges to the flood forecasting and warning system was surveyed to find that since they did not have an output function for a telemetering, those gauges couldn't be used for the system.
The water level gauges used for the flood forecasting and warning system, therefore, are to be selected on the following study policies:

(a) Float-type water level gauges is to be used as far as possible where they can be readily used.
(b) If use of other types of water level gauges is judged to be appropriate in terms of either topographical factors, such as the cross-sectional shapes of rivers, or economical factors, such as the construction costs for float-use wells, then using pressure type water level gauges, acoustic type water level gauges, sensing pole type water level gauges, etc. are to be considered. What type of water level gauge to be used for what place will be determined after further detailed design and from the results of further detailed survey of each place in future.

(3) Study of rain gauges

The applicability of existing rain gauges to the flood forecasting and warning system was surveyed to find that since they do not have an output function for a telemetering, those gauges couldn't be used for the system. At present, all the world over, the tipping-bucket type is most commonly used as the rain gauges for remote measurement such as telemetering. The flood forecasting and warning system therefore use rain gauges of the tipping-bucket type.

3.1.6 Study of radar rain gauges

Radar gauges is rainfall data collection system which emits radio waves, receives and amplifies reflected waves from rain drops and measures rainfall intensity indirectly by receiving power. This clause describes the roles, functions and location plan of radar gauges in the flood forecasting and warning plan.

(1) Roles of radar rain gauge

Roles of radar rain gauges are as follows:

(a) Checking the basin rainfall
Rainfall gauging with a ground rain gauge is point gauging, and to check the basin rainfall in an area, it becomes necessary to measure the amounts of rainfall in various positions of that area. Radar rain gauges were developed for this purpose, and they can be organically linked to ground rain gauges to check more accurate basin rainfall.

(b) Real-time monitoring of rain fall
One of the major features of a radar rain gauge is that the movement of a constantly changing, rainy area can be visually checked in real time on a color display unit. Thus, the very excellent pattern recognition capabilities of human beings allow the positions, directions-of-movement, and speeds of rainy areas to be qualitatively checked.

(c) Possibility of forecasting rainy area
With point gauging that uses a ground rain gauge, although the amount of rain fall at the particular time can be checked, it is very difficult to estimate the subsequent amounts of rainfall which may further continue. With a radar rain gauge, however, the constantly changing positions and intensity levels of a rainy area in the future can be estimated since the directions and speeds of movement of the rainy area can be quantitatively derived from the time-based observations of its distribution by gauging the aril amounts of rainfall within the corresponding gauging range.

(2) Functions of radar rain gauges

Functions of radar rain gauges are as follows:

(a) Gauging range

- Quantitative gauging within a radius of 120 km
- Qualitative gauging within a radius of 198 km

(b) Processing

Processing of the intensity of five-minute rainfall within a mesh of 3 km, five levels of qualitative display data, and ten levels of quantitative display data

(c) Display

Gauged rainfall, history replay of rainfall and rainfall forecast are displayed in four split patterns:

- Qualitative river chart
  km-meshed five-level display of the qualitative data that is measured within a radius of 198 km
- Quantitative river chart
  km-meshed ten-level display of the quantitative data that is measured within a radius of 120 km
- Quantitative basin chart
  Quantitative display for each river basin
- Basin-dependent rainfall depth chart
  Display of split river basin rainfall for each basin

(e) Transmission

Simultaneous transmission of data to multiple remote sites

(3) Location plan of radar rain gauge

The concept for the layout of radar rain gauges is described below.

(a) The Seyhan River basin and the downstream area of the Göksu River are the most important areas of all those which are to be monitored in terms of the basin rainfall. Also, the distributions of rainfall cover the area from a downstream section to an upstream section as far as possible.

(b) The Seyhan Dam and the Çatalan Dam are very important facilities for the prevention of flooding. To check the amounts of runoff into the dams, it becomes important to check the distributions of rainfall in areas upstream from the dams.

(c) Considering the topographical conditions of the Seyhan River basin, radar rain gauges must be laid out both efficiently and effectively.

(4) Study of prospective radar sites

Here, the radar sites where radar rain gauges for the system is located are studied. During study of prospective radar sites, it is necessary that the intended basin belongs to the area where data can be measured as accurately as possible. In these terms, judging from the topographical conditions of the Seyhan River basin, Ziyaret T. and Feke Daği can be selected as promising candidates. Comparative studies on these two places are listed in Table 3.1.9. Figure 3.1.1 shows the gauging ranges obtained by setting of a radar site in the two candidates, and Figure 3.1.2 shows the system configuration of radar rain gauges in that case.

3.2 Basic Study of Data Processing System

3.2.1 Basic study items

The data processing system is intended to support flood control activities both smoothly and efficiently by processing collected data and then rapidly supplying the appropriate and accurate data. To fulfill these objectives, the data processing system having various processing functions is required. This section describes the basic requirements of the data processing system that are common to each alternative plan. The functions of the data processing system in the flood forecasting and warning system are to process the input data from a telemetering system first, then perform analyses based on previously stored and processed data, and rapidly outputs the appropriate data at the request of the flood forecasting and warning system. During study of the data processing system, therefore, it becomes important to make the output functions of the system and its specifications clear.

For that purpose, it becomes necessary to study: the methods and items of display, including data transmission in places related to flood forecasting and warning; the methods and items of recording, and; the methods of data storage which considers the form of flood forecast and analysis.

The following lists study items that are likely to be required at control centers:

- Display processing
- Record processing
- Computing
- File processing and data storage

3.2.2 Display processing

Display processing provides the support information required for smooth and rapid execution of flood forecasting and warning operations. The information to be provided includes graphics, tables, numeric data, etc. The available hardware units for display-output include CRT display units, projectors, data display panels, warning panels, etc. While CRT display units and projectors can display graphics, tables, and numeric data, data display panels can only display numeric data and warning status. Warning display panels also can only display warning status. The optimum display-output units are to be selected only after thoroughly studying both the characteristics of the hardware units described above and the functions required in each section of the flood forecasting and warning organization.

The following lists display items that are usually required for a flood forecasting and warning system:

(a) Display items on graphics and tables
- River basin status charts
- Water level data lists
- Rainfall data lists
- Discharge data lists
- Air temperature data lists
- Water level data chronological graphs
- Rainfall data chronological graphs
- Water level and discharge data chronological graphs
- Air temperature data chronological graphs
- Simulation display of flood forecast
- Other necessary items

(b) Display items on numeric data and states
- Hourly rainfall data
- Cumulative rainfall data
- Average basin rainfall data

- Current water level data
- Current discharge data
- Water level warnings
- Rainfall warnings
- Other necessary items

3.2.3 Record processing

Printer units and hard copy units are available as recording/output units. Hard copy units can output the graphics and tables listed in Clause 3.2.2 (a) above. The following lists recording items that are usually required for a flood forecasting and warning system:

- Daily management reports
- Monthly management reports
- Operation/operating logs
- Warning logs
- Others required

3.2.4 Computing

The computing items required for the display and recording operations described in Clause 3.2.2 and 3.2.3 above are listed below.

- Hourly rainfall processing
- Daily rainfall processing
- Average basin rainfall processing
- Rainfall warning judgment processing
- Water level warning judgment processing
- Discharge processing
- Statistical processing
- Flood forecast processing

3.2.5 File processing and data storage

File processing and data storage refers to storing various types of data and files into hard disk drives or other storage units in the required formats after providing filtering, such as abnormal data detection and necessary computing to the input data from a telemetering facility Storage data forms databases in the flood forecasting and warning system. To store data that becomes the core of databases, files of a relatively large capacity are required since various types of data are to be filed in large amounts. The types of files that are likely to be required for the flood forecasting and warning system, and the approximate periods of filing are listed below.

(a) Hourly data and daily files
The amounts of data that consider file extendibility are estimated. In terms of the periods of filing, two months are usually good enough for monthly reporting. Although it may be necessary to prepare files of a larger capacity that allows annual reporting, two months are usually the maximum periods of filing in taking account of reliability and restoration against troubles.

(b) Data files for annual reporting
A capacity that allows one year of daily data to be stored is required.

(c) Supervisory information files
Alarm information on hydrometeorological data and information on any hardware unit abnormalities are to be stored as supervisory information files. These files will be created in the order that alarms or abnormalities have occurred. The number of such events likely to occur are to be registered beforehand, and the capacity is to be determined from this registered number of events.

(d) Data files for flood forecast simulation
Evaluation files for flood forecast simulation are to have their respective capacities and periods of storage reserved beforehand.

(e) Working data files for analysis
The amounts of data required for flood forecast and analysis are estimated and reserved. Any other necessary file capacities are also to be estimated and reserved.

3.3 Basic Study of Data Transmission System

3.3.1 Current situations of flood control and information transmission

The rivers in the Seyhan River basin are now managed by the DSİ 6th regional directorate. In the event of floods, the flood control committee and the ASO, shown in Figures 3.3.1 and 3.3.2, respectively, are organized in the DSİ 6th regional directorate and carry out flood control activities. Flood control activities against flooding of the relevant rivers are undertaken by flood teams, and if there are any signs of flooding, then evacuation information shown in

Figure 3.3.3 is given to the Adana provincial governor. Evacuation activities for the residents are undertaken by each head of official district under the directions of the Adana provincial governor. For large-scale floods, the Adana provincial governor convokes the Emergency Assistance and Rescue Committee shown in Figure 3.3.4 and takes the command of the Headquarters during evacuation activities. Figure 3.3.5 shows the current information transmission routes. Figure 3.3.6 shows the overall data and information transmission network in present condition.

3.3.2 Basic study conditions

The data transmission system is studied under the conditions described below.

(a) After collecting rainfall, water level, and air temperature data and then obtaining flood forecast information by processing the data, the data transmission system , in principle, creates dam operations, flood control, and evacuation information from analyses of the data, and transmits the information from the flood control committee of the DSİ 6th regional directorate to related agencies.

3.3.3 Selection of related agencies

Twenty-eight (28) agencies are involved in the flood control system of the Seyhan River basin: eight (8) Governmental, one (1) Provincial, seventeen (17) district-administrative, and two (2) municipalities.

The necessity for current and future tie-up between, and transmission of information to, those agencies during flood control activities, is examined. Table 3.3.1 lists obtained results of examination. Judging from the results, it is likely to be good enough just to transmit information to only 16 agencies among the 28 agencies. Table 3.3.1 is a listing of evaluations on the degree of importance of each such agency. The following describes the criteria for selection of related agencies:

(a) Since the flood control committee of the DSİ 6th regional directorate is an important information source for the flood control of the Seyhan River basin, all eight governmental agencies is ranked A in terms of the degree of importance.

(b) The provincial governor receives information and then transmits the information to its subsidiary agencies. The provincial governor, although originally likely to be ranked B in the degree of importance, also is ranked A since it is an agency that gives and transmits particularly important information.

(c) Since, during actual evacuation activities, they give direct directions based on received information, the administrative districts and municipalities are originally equivalent to rank B in the degree of importance. These administrative districts and municipalities, however, are either ranked C or excluded from selection, since, administratively, they are all placed under the control of the provincial governor.

3.3.4 Types and definitions of information

During information transmission planning towards the future, the types and transmission ranges of flood information are arranged and analyzed only after checks based on the current flood information shown in Table 3.3.2 are performed to scan the current situation for improvements or additions. The data transmission system handles the following data:

(1) Hydrometeorological information

Hydrometeorological information refers to the rainfall data, water level data, and air temperature data that are sent from rainfall gauging stations, water level gauging stations, and meteorological gauging stations, respectively, and to the rainfall distribution data obtained from radar rain gauges. Hydrometeorological information is continually transmitted, irrespective of whether a flood occurs.

(2) Flood control information

Flood control information is needed to judge whether the water level at the particular water level gauging station reaches a predetermined alert water level or estimated design water level, then estimate that state, and inform the state to related agencies. The information is transmitted only during flood periods.

(3) Evacuation information

Evacuation information is needed for related agencies to take evacuation activities for the people living in any areas that are likely to suffer from floods.

(4) Dam information

Dam information relates to dam operating commands.

3.3.5 Information transmission routes and media

Selection of transmission routes and media to each related agencies is studied as follows:

(1) General study of the transmission media

The data transmission media (methods) that are most commonly used in a flood forecasting and warning system include the following:

(a) Image information display (CRT, projector, etc.)
(b) Data display (CRT, projector, data display panel, etc.)
(c) Facsimile transmission (FAX)
(d) Recording (Printer, hard copy units, etc.)
(e) Telex
(f) Voice transmission (through the phone)
- Private phones
- Independent contact
- Group contact
- General contact phones
(g) Loudspeaker warning equipment (except sirens, which are only for air-raid warning use)
(h) Electronic display boards
(i) Warning lights

Table 3.3.3 and 3.3.4 lists outlines and characteristics of the information transmission media listed above, examples of forms of information supply, and typical related hardware units.

(2) The types of information to be transmitted, and transmission media

The types of information to be transmitted have been listed in Clause 3.3.5 (1) above. The optimum transmission media to be installed generally is selected for each information type.

(a) Prerequisites for study
Selection of the transmission media actually used for related agencies is based on the following prerequisites:
- Selection of related agencies is shown in Table 3.3.1.
- Transmission of information between the flood control committee of the DSİ 6th regional directorate and related agencies is studied.

- The degree of importance of data transmission media for each transmission route is set as follows from the purpose of this project and the scope of study:

Level in the degree of importance	Information transmission route
1	From the DSİ Flood control committee to the DSİ general directorate
2	From the DSİ Flood control committee to the Seyhan Dam office
3	From the DSİ Flood control committee to the Çatalan Dam office
4	From the DSİ Flood control committee to the EİE Adana regional directorate
5	From the DSİ Flood control committee to the DMİ Adana regional directorate
6	From the DSİ Flood control committee to the Doğankent office of ASO
7	From the DSİ Flood control committee to theYenice office of ASO
8	From the DSİ Flood control committee to the Adana Provincial Governor
9	From the DSİ Flood control committee to the offices of towns and villages' head downstream
10	From the DSİ Flood control committee to the Seyhan municipality
11	From the DSİ Flood control committee to the Yüreğir municipality
12	From the DSİ Flood control committee to Pozantı administrative district
13	From the DSİ Flood control committee to the Feke administrative district

(b) Criteria for selection of information transmission media

- Hydrometeorological information

Basically, hydrometeorological information is to be displayed as either image information or data. For levels of 6 or less in the degree of importance, however, voice communications are used as the media. Also, information transmission by facsimile is added to necessary agencies .

- Flood control information

Flood control information refers to forecast information on water levels, including an alert one, and on discharge. It is preferable that the information is transmittable as image information. In view of economical aspects, however, flood control information, in principle, is classified according to the degree of importance, as listed in the table below.

Level in the degree of importance	Image	Data display	Facsimile	Voice
Rank 3 or more	√	√	√	√
Rank 4 and 5		√		
Rank 6 to 9			√	√
Rank 10 or less				√

- Evacuation information

  Evacuation information is water level and discharge information that provides a basis for the time information that the residents will need to evacuation. As with flood control information, evacuation information is also to be ranked as listed in the table above, and this also applies for voice communications. For evacuation information that are to be informed from the flood control committee of the DSİ to the Adana provincial governor, a private telephone line is provided between them since those warnings become one of most important types of information. Group radio telephone contact to the heads of the towns and villages located in the downstream area of the Seyhan Dam, and loudspeaker broadcasting to the residents are effective for information transmission. Also, facsimile equipment should be connected to this radio communication links to ensure that commands are correctly and accurately received.

- Dam information

  Dam information is dam operating command information. Since dam information is exchanged between the DSİ flood control committee and the dam office, a private telephone line is provided between them. Also, facsimile equipment is connected to this telephone line to ensure that commands are correctly and accurately received.

(3) Study of the information transmission media for each information type

Those preferable methods of transmission for each information type that are judged from the studies described in Clause 3.3.5 (2) above, are summarized together with priority levels in Table 3.3.5. During planning for the routes and methods of information transmission to related agencies in the flood forecasting and warning system, the general study results discussed above are analyzed in further detail, and then the system that gives best results is structured.

(4) Selection of transmission media for each related agency

The information transmission media required for each related agency can be selected by arranging the study results shown in Tables 3.3.1 and 3.3.5. The media required for information transmission from the flood control committee of the DSİ to related agencies are listed in Table 3.3.6. Also, the basic plan for the data transmission system is shown in Figure 3.3.7.

3.3.6 Study of methods of information transmission

Those methods of information transmission that are common to each alternative plan are studied here.

(1) Study of the methods of information transmission in voice communication

Ideally, a multiplex radio communications network that covers all sections from the flood control committee of the DSİ to related agencies are structured to perform information transmission in voice communications. The feasibility study here, however, is performed from the viewpoint that UHF and other radio communications links are provided to transmit information from a nearby multiplex communications station to related agencies. Methods of information transmission in voice communication in that case are studied below.
The following lists typical methods of voice radio communication:

- (a) Voice call radio communication
- (b) Selective call radio communication
- (c) Single-channel dial radio communication
- (d) Frequency division multi-channel communication
- (e) Time division multi-channel communication

Functional comparisons on the methods listed above are shown in Table 3.3.7 and 3.3.8. Of all the methods above, selective call radio communication and single-channel radio communication are to be used for the three main reasons listed below.

- (a) A method is used that allows dial calling that matches to the exchange circuit network of multiplex communications links.
- (b) Selective call radio communication is possible for group contact that is useful to inform message of discharge from the dam.
- (c) Under the radio wave administration of the Republic of Turkey, it is possible to get a license to use a frequency band of 400 MHz, and for this frequency band, communication is possible with equipment that most commonly uses the frequency division multichannel communications method, and such communication is very economical.

(2) Items of data transmission to related agencies

The section that required data transmission in the system is between the DSİ Flood control committee and the agencies listed below.

(a) DSİ general directorate
(b) Seyhan Dam office
(c) Çatalan Dam office
(d) Adana EİE regional directorate
(e) Adana DMİ regional directorate

4 EVALUATION OF ALTERNATIVE PLANS

4.1 Basis For Setup of Alternative Plans

The following describes the philosophies for the planning of the Seyhan River basin flood forecasting and warning system:

(a) Floods in the entire basin of the Seyhan River should be managed under an unified, consistent concept.

(b) The flood control committee of the DSİ 6th regional directorate is to manage all floods of the entire Seyhan River basin by collecting and hydrometeorological data and processing flood forecasts.

(c) Hydrometeorological data should be collected both accurately and rapidly. The water levels and discharge that are required for the management of floods should be rapidly calculated from the collected data, and the processed data required for the management of floods should be accurately transmitted.

The flood forecasting and warning system consists of three subsystems: the data collection system, the data processing system, and the data transmission system.
During setup of alternative plans, combinations that allow these sub-systems to exist as alternative plans in terms of the relationship between the functions and processing capabilities of each sub-system, the scale of facilities, and costs, are studied. The following describes the results of study.

4.1.1 Alternative plans for data collection system

The data collection system collects rainfall, water level and air temperature data from hydrometeorological gauging stations into the flood control committee of DSİ 6th regional directorate, which is the control center that processes data both accurately and rapidly. The basic concepts for alternative plans are described below.

(1) Water level telemetering stations

Water level telemetering data is the most important data in flood forecast. The water level gauging stations required for the forecast of floods in the Seyhan River basin are located in a downstream section of the Zamantı River, a downstream section of the Göksu River, and along the river that leads to the Çatalan dam and the Seyhan dam. Although the gauging stations in upstream and middle sections of the Zamantı River do not directly affect flood forecast, these gauging stations are needed to monitor the indirect runoff due to the dividing of the Zamantı River basin. The number of water level telemetering gauging stations is therefore likely to become one object of alternative plan setting.

(2) Rainfall depth telemetering stations

The purpose of rainfall telemetering data is to calculate basin rainfall within range of allowable errors by typical rainfall gauging. The available alternative plans, therefore, depend on the manner of dividing of the intended river basin.

(3) Radar rain gauges

The main purposes of radar rain gauges are to understand the current rainfall situation in areal form and to estimate both the situation of the rainy area and its subsequent situation from those results. For the flood forecasting and warning system, it becomes important to correctly understand the basin rainfall and accurately estimate the subsequent situation of the rainfall. Alternative plans can therefore be set up in terms of functional improvement of the rainfall gauging. Also, considering the accuracy of radar rain gauges, rainfall gauging stations of the minimum level required are provided since calibration is required for operation.

4.1.2 Alternative plans for data processing system

The data processing system, after performing abnormal data checks, missing-data compensations, and other processing operations on the gauged data that is sent from the data collection system, arranges collected data for tabulation and display of data and performs flood forecast processing operations. Basically, data is to be processed on-line. The configuration of the processing system, however, is likely to depend on the size of the flood forecast program to be used, the particular scales and capabilities of the computers, and the configuration of peripheral hardware units. Thus, the available alternative plan is to use either centralized processing or distributed processing.

4.1.3 Alternative plans for data transmission system

The data transmission system transmits, from the flood control committee of the DSİ 6th regional directorate to related agencies, the dam operations information, flood control activities information, and evacuation information that are judged from collected hydrometeorological data and processed flood forecast information. First, constructing data transmission facilities that accommodate multiplex radio communications links, UHF radio communications links

PTT private lines, or any other appropriate lines, are considered as one alternative plan for the data transmission system. Next, to what subsidiary administrative units of each related agency the system is to transmit data are compared and studied from the necessity for information transmission.

4.2 Setup and Comparative Study of Alternative Plans for Data Collection System

This section, after setting up alternative plans based on the concepts of alternative planning for the sub-systems forming the flood forecasting and warning system, performs comparative studies on these alternative plans and formulates the optimum plan.

4.2.1 Comparative study of alternative plans for data collection system

The results of comparative study intended to set up alternative plans for the data collection system and then select the optimum plan are described below.

(1) Alternative plan setup

For the data collection system, three (3) alternative plans that use water level telemetering stations, rainfall telemetering stations, rainfall and temperature telemetering stations, and radar rain gauges. Table 4.2.1 lists the alternative plans of telemetering gauging stations.

(a) Alternative plan 1

Alternative plan 1 is to set up water level gauging stations and rainfall gauging stations in Seyhan River basin, the Göksu River basin, and the basin obtained by dividing the Zamantı River basin into two sub-basin at 1822 water level gauging site. The former gauging stations are intended to check runoff, and the latter gauging stations are intended to check basin rainfall. Kinds and number of gauging stations are as follows:

- Water level gauging stations : 8
- Dam reservoir water level gauging stations : 2
- Rainfall gauging stations : 9
- Rainfall and temperature gauging stations : 7

(b) Alternative plan 2

Alternative plan 2 is to set up water level gauging stations and rainfall gauging stations in idea that Zamantı River basin is one under the alternative plan 1. Kinds and number of gauging stations are as follows:

- Water level gauging stations : 7
- Dam reservoir water level gauging stations : 2
- Rainfall gauging stations : 8
- Rainfall and temperature gauging stations : 6

(c) Alternative plan 3

Alternative plan 3 is to gauge the derivative runoff from the water levels at 1822 water level gauging station. Rainfall gauging stations are not to be set up in upstream or middle areas of the Zamantı River basin since the amounts of rainfall in these areas do not almost influence flooding of the Seyhan River basin. Kinds and number of gauging stations are as follows:

- Water level gauging stations : 8
- Dam reservoir water level gauging stations : 2
- Rainfall gauging stations : 6
- Rainfall and temperature gauging stations : 5

(d) Alternative plan 4

Alternative plan 4 is the same as alternative plan 3 above in terms of the setup of water level gauging stations and air temperature gauging stations. Basin rainfall gauging is likely to become possible with radar rain gauges. Since, however, calibration relative to ground rainfall is required, the minimum necessary number of basin rainfall gauging stations are to be set up. Kinds and number of gauging stations are as follows:

- Water level gauging stations : 8
- Dam reservoir water level gauging stations : 2
- Rainfall gauging stations : 6
- Rainfall and temperature gauging stations : 5
- Radar rain gauge in Zıyaret T. : 1

4.2.2 Functional outline for each alternative plan

The components and functions of the data collection system under each alternative plan are listed in Table 4.2.2. An outline of each alternative plan is given below.

(a) Each alternative plan has been set up from two factors: the number of rainfall gauging stations to be provided for collecting rainfall data automatically, and whether radar rain gauges are to be provided. Functions, therefore, are to be evaluated by evaluating the reliability of flood forecast according to the particular number of gauging stations, and by evaluating added functions in case radar rain gauges are provided.

(b) Alternative plan 1 assumes dividing of the Zamantı River basin into two sub-basins. It therefore assumes selection of the rainfall gauging stations required for flood forecast analysis, and is excellent in the following respects:

- Any slight changes in regional runoff can be checked during the initial phase of flooding.
- Flooding can be forecasted very accurately over the entire flood continuation period.
- Forecast accuracy is not dependent on the scale of flooding.

(c) Alternative plan 2 assumes no dividing of the Zamantı River basin. Since a 1822 water level gauging station is not to be set up that monitors the runoff in the upstream or middle areas, this alternative plan is likely to lack the characteristics listed in Item b) above.

(d) Alternative plan 3 assumes that the rainfall gauging stations in upstream and middle areas of the Zamantı River basin are to be removed under alternative plan 1. This Alternative plan, therefore, is estimated not to give sufficient gauging accuracy in terms of the rainfall distributions obtained if the areas of heavy rain change according to the particular climate or topographical characteristics of the intended river basin.

(e) Alternative plan 4 is the same as alternative plan 3 in terms of the setup of rainfall gauging stations and temperature gauging stations. In addition, alternative plan 4 assumes that radar rain gauges are to be provided to complement the functions of the rainfall gauging stations. Two factors, therefore, become the criteria for selection: whether the sufficient accuracy of basin rainfall gauging under alternative plan 1 can be compensated for with the radar rain gauges, and evaluation of the facilities costs for the radar rain gauges. Comparative studies on the functions of radar rain gauges and ground rain gauges are listed in Table 4.2.3.

4.2.3 Evaluation and study of alternative plans

The items required for evaluation of each alternative plan are as studied above. Studying each alternative plan synthetically, alternative plans 2 and 3 do not need to be further studied for the three main reasons listed below and only alternative plans 1 and 4 need further comparative study towards the selection of the final alternative plan.

(a) Alternative plans 2 and 3 are not sufficient in flood forecast reliability.

(b) Radar rain gauges can act as a powerful means against the corresponding function of the flood forecasting and warning system. During further comparative study of the alternative plans, therefore, use of these gauges is to be studied because of the relationship to future planning.

(c) Considering the operational results of the current flood forecasting and warning system, data collection is the most important factor of all those conceivable, and the first priority is assigned to data collection. Introducing the radar rain gauges under alternative plan 4 requires complementing the accuracy of forecast under alternative plan 3 and synthetically studying the facilities costs and other factors of the gauges.

It is judged from the above studies that alternative plans 2 and 3 are not appropriate. Only alternative plans 1 and 4, therefore, are to be further studied as the alternative plans for the data collection system.

4.3 Setup and Comparative Study of The Alternative Plans for Data Processing System

Alternative plans for the data processing system are presented below, and then comparative studies are performed on these alternative plans to formulate the final alternative plan.

4.3.1 Setup of alternative plans for data processing system

Two alternative plans are available for the data processing system: centralized processing, which assumes use of minicomputers, and distributed processing, which assumes use of workstations.

(a) Alternative plan 1

Alternative plan 1 is to design a centralized processing system that uses mini computers to perform telemetering data input processing, primary processing, and flood forecast processing operations.

(b) Alternative plan 2

Alternative plan 2 is to design a distributed processing system that mainly uses workstations to perform similar operations to those mentioned for alternative plan 1 above. With alternative plan 2, future functional extension of the system is anticipated.

4.3.2 Hardware configurations under and hardware functional comparison between alternative plans

Another probable alternative plan for the data processing system in the flood forecasting and warning system is to split the data processing section into parts. Considering the purpose of the flood forecasting and warning system, however, such an alternative plan is not likely to be appropriate for the current operational form of the flood control committee of the DSİ 6th regional directorate. During alternative plan setup, therefore, any differences in the configuration method of the data processing equipment of control centers between alternative plans 1 and 2 are to be studied. Basically, alternative plans 1 and 2 are almost the same in function since both have the functions required for the flood forecasting and warning system.

4.3.3 Evaluation criteria for alternative plan selection

It is judged from the study results of Items (1) and (2) above that since there are no functional differences between alternative plans 1 and 2, operational convenience, reliability, extendibility, and maintainability, etc. become the criteria for evaluation of the two alternative plans.

4.3.4 Selection of final alternative plan

Table 4.3.1 lists comparative studies on the centralized processing method that uses minicomputers, and the distributed processing method that uses workstations with LAN. It is judged from the study results of Table 4.3.1 that distributed processing should be used for three main reasons:

(a) It is estimated that the data processing system undertakes overall status display, which is one feature of the flood forecasting and warning system, and that persons specializing in various tasks, such as flood forecast processing, carry out their respective analytical jobs. Also, it becomes absolutely necessary that image display is used very frequently in necessary sections for various purposes, such as status checking by the system administrator. The centralized processing method, if used for those purposes, imposes a significant load on the system, and in this respect, the distributed processing method is also excellent.

(b) System feedback by analysis of each flood is essential in the flood forecasting and warning system. While, in general, distributed processing allows separate tasking with each workstation, centralized processing significantly affects the operation of the entire system partly because this method stops the system during operation.

(c) The recent technological progress of both hardware and software is currently spreading the use of further sophisticated and higher-capacity workstations, and general-purpose software has also become usable in some cases. Also, distributed processing that covers a LAN has come to be most commonly used.

4.4 Comparative Sudy of Alternative Plans for Data Transmission System

Alternative plans for the data transmission system are presented below, and then comparative studies are performed on these alternative plans to formulate the final alternative plan.

4.4.1 Setup of alternative plans for data transmission system

Based on the evaluations listed previously in Clause 3.3.3 as to the degree of importance of related agencies, three alternative plans are to be set up as the range of data transmission. Evaluations on related agencies, and the three alternative plans are shown in Table 4.4.1.

(1) Alternative plan 1

Alternative plan 1 is to set a system that transmits information to not only the provincial governor and higher-level related agencies that require important data and information very frequently, but also offices of town and villages' head along the downstream area of the Seyhan dam. Information transmission, in principle, use radio communications links and the appropriate communications circuits for the particular types and amounts of information are considered. The information transmission range is as follows:

- Governmental agencies and related ones : 8
- Provincial Governor : 1
- Offices of towns and villages' head : 5

(2) Alternative plan 2

Alternative plan 2 is to set a system that transmits information to head of official districts and to agencies higher in the degree of importance. The basic concept for communications link is the same as that of alternative plan 1. The information transmission range is as follows:

- Governmental agencies and related ones : 8
- Provincial Governor : 1
- Offices of towns and villages' head : 5
- Head of official districts : 4

(3) Alternative plan 3

Alternative plan 3 is to set a system that transmits information to municipalities and all other related agencies. The basic concept for communications links is the same as that of alternative plan 1. The information transmission range is as follows:

- Governmental agencies and related ones : 8
- Provincial Governor : 1
- Offices of towns and villages' head : 5
- Head of official districts : 4
- Municipalities : 2

4.4.2 Configurations under and functional comparison between the alternative plans

As listed above, alternative plans 1 to 3 are to be established from the basic philosophies of flood forecasting and warning system planning for the Seyhan River basin, and from the data transmission system design concepts based on those basic philosophies. The configurations and functions of the data transmission system under the three alternative plans are summarized in Table 4.4.2. An outline of each alternative plan is given below.

(a) All three alternative plans are presented in terms of the information transmission range. Under each of the alternative plans, information is to be transmitted to the DSİ general directorate, the Seyhan dam office, the Çatalan dam office, the Adana EİE regional directorate, the Adana DMİ regional directorate, and the provincial governor of Adana, because all these agencies are the most important administrative units among all related agencies in the area that the flood forecasting and warning system is to cover. Similar common information is also to be transmitted to the offices of towns and villages' head along the downstream area of the Seyhan dam, because these offices of towns and villages' head are necessary ones in letting their respective residents know beforehand the discharge from the dam. Alternative plan 1 assumes transmission only to this administrative level, and it can be said that this administrative level is the minimum level that requires information transmission.

(b) Alternative plan 2 is plan under which information also is transmitted to heads of official districts as well as to the agencies of alternative plan 1.

(c) Alternative plan 3 is plan under which information also is transmitted to municipalities as well as to the agencies of alternative plan 2.

4.4.3 Criteria for evaluation of alternative plans

Since the three alternative plans for the data transmission system are identified by their respective ranges of information transmission, each alternative plan is to be evaluated by analyzing to which levels the individual ranges are improved after the current transmission method is checked against the purpose of the flood forecasting and warning system.

4.4.4 Selection of final alternative plan

Of course, it is preferable that the final alternative plan selected in terms of the information transmission range is that which allows accurate information to be transmitted over a wider range as possible. Such selection is performed considering the limitations on facilities costs and the effectiveness of the costs. For the moment, however, only alternative plan 1 is to be further studied for the reasons listed below.

(a) Alternative plan 1 assumes that information on flood control activities, dam operations, etc., is to be transmitted to the related agencies located in the territory of the DSİ 6th regional directorate and to the DSİ general directorate, and that evacuation information is to be transmitted to the provincial governor. Also, the agencies that require rapid transmission of information are selected under the alternative plan.

(b) Evacuation information to the heads of the towns and villages along the downstream section of the Seyhan dam are to be transmitted on the basis of dam operations information.

(c) Alternative plans 2 and 3 assume that transmission of evacuation and other information is to cover a range as far as heads of official districts and municipalities, and considering the current administrative organizations of the Republic of Turkey, such a transmission range is too wide. Also, compared with alternative plan 1, alternative plans 2 and 3 are both high in facilities costs.

5. FORMULATION OF OPTIMUM PLAN

5.1 Final Alternative Plans

Two alternative plans can be derived from the studies described in up to Chapter 3.. These two alternative plans are studied in comparison below.

(1) Alternative plan A

Alternative plan A is combinations of alternative plan 1 for the data collection system, alternative plan 2 for the data processing system and alternative plan 1 for the data transmission system.

(2) Alternative plan B

Alternative plan B is combination of alternative plan 4 for the data collection system, alternative plan 2 for the data processing system and alternative plan 1 for the data transmission system.

5.2 Comparative Study in Terms of Function

Alternative plans A and B are derived from the results of evaluation of the basin rainfall calculation accuracy of collected rainfall gauging stations and the support functions of calculation accuracy by radar rain gauges. These two factors are studied in Section 3.2.3. It is considered that alternative plans A and B differ in the functions of the corresponding facilities. The degree of application to various needs for system functions also is considered. If the information obtained from the flood forecasting and warning system is to be divided into direct information and indirect information, then although the former would usually become higher in the degree of needs, the latter would also be required. Overall judgements therefore are performed, including the comparison of facilities construction costs.

5.3 Comparison in Terms of Facilities Configurations

Under Alternative plans A and B that are set up for the formulation of the optimum plan facilities configurations are to differ according to the particular differences in the functions of the data collection systems. For this reason, comparison in terms of facilities configurations is limited to the data collection system, and thus only telemetering facilities are selected, station-by-station, and comparative studies are performed. The results are shown in the table below. The radio repeater stations here are only those related to VHF radio communications links and multiplex repeater stations in the middle of the corresponding transmission route are not included. For Alternative plan B, other facilities are also required in addition to radar rain gauges.

Comparison of Alternative plans A and B in terms of facilities configurations

Facilities	Alternative plan A	Alternative plan B
Telemetering supervisory station	1	1
V-V repeater station	5	5
V-V repeater station (Cross-repeater)	2	0
μ-V repeater station	4	3
Dam water level gauging station (Wired)	2	2
Dam rainfall gauging station (Wired)	1	1
Water level gauging station (Wireless)	8	8
Rainfall depth gauging station (Wireless)	8	5
Rainfall/air temperature gauging station(Wireless)	7	5
Radar rain gauging station	0	1

As can be seen from the above table, both alternative plan A and alternative plan B are exactly the same in the numbers of telemetering supervisory stations, water level gauging stations, dam water level gauging stations and dam rainfall gauging station, and the only difference between both alternative plans is in the number of rainfall gauging stations, rainfall/temperature gauging stations, repeater stations, and that of radar rain gauges.

5.4 Comparison in Terms of Maintainability

Maintainability depends on the number and the scale of the corresponding entire facilities. Compared to alternative plan A, alternative plan B may become less expensive since it assumes a smaller number of rainfall gauging stations. Since, however, alternative plan B assumes setup of one radar gauging station, economical burdens associated with maintenance are not likely to differ too significantly between both alternative plans.

5.5 Comparison in Terms of Cost Estimates

The studies described previously in Section 5.3. imply that the difference in facilities costs between alternative plans A and B becomes the differences in the numbers of rainfall gauging stations, rainfall/temperature gauging stations, repeater stations and a radar rain gauge. This makes it necessary that the approximate construction costs for the rainfall gauging stations, rainfall/temperature gauging stations, repeater stations and radar rain gauge facilities are calculated for comparison. These costs are to be estimated under the conditions shown below.

(1) Cost estimation conditions

Cost estimation conditions are listed below.

(a) Civil construction costs are not to be included.

(b) The repeater stations and the rainfall gauging stations are to be powered from a solar battery power supply equipment.

(2) Cost comparison

The table below lists cost comparisons between Alternative plans A and B. All costs are calculated at the foreign exchange rate of 1$ = ¥109.2 as of February 1, 1994.

Facilities	Unit cost ($)	Alternative plan A		Alternative plan B	
		Stations	Cost ($)	Stations	Cost ($)
1. Rainfall gauging station facilities					
(1) Telemetering equipment (W/radio)	17,400				
(2) Rain gauging equipment	6,770				
(3) Solar battery power unit	7,050				
(4) Antenna equipment	2,910				
Sub-total	34,130	8	273,040	5	170,650
2. Rainfall/temperature gauging stations					
(1) Telemetering equipment (W/radio)	17,400				
(2) Rain gauging equipment	6.770				
(3) Temperature sensor	16,500				
(4) Solar battery power unit	13,740				
(5) Antenna equipment	2,430				
Sub-total	54,640	7	382,480	5	273,200
3. Repeater station facilities (Cross type)					
(1) Repeater equipment (W/radio)	80,390				
(2) Solar battery power unit	18,320				
(3) Antenna equipment	8,150				
Sub-total	106,860	2	213,720	0	0
4 Repeater station facilities (μ-V type)					
(1) Repeater equipment (W/radio)	40,200				
(2) Antenna equipment	4,080				
Sub-total	44,280	4	177,120	3	132,840
5. Radar rain gauging facilities					
5.1 Radar site stations					
(1) Radar equipment	3,317,770				
(2) Power supply equipment	452,310				
5.2 Control center					
(1) Control equipment	2,990,940				
(2) Power supply equipment	369,970				
Sub-total	7,130,990	0	0	1	7,130,990
Total			1,046,360		7,707,680

5.6 Formulation of Optimum Plan

It is judged to be appropriate from the above studies that alternative plan A should be formulated for the intended system for the moment. As studied previously in the section on radar rain gauges, it can be said that for the flood forecasting and warning system, radar rain gauges also become powerful equipment that complements the functions of ground rain gauges. It is desirable, therefore, that use of radar rain gauges will be included in future plans and that the facilities costs for these rain gauges will be improved in steps. Alternative plan A should be formulated as the optimum plan for the reasons listed below.

(1) The studies discussed previously in Section 5.5 indicate that the difference in facilities costs between the two Alternative plans becomes about $6,661,320 under the cost estimation conditions, and compared with alternative plan A, alternative plan B brings about significant total system cost burdens.

(2) In actual forms of system operation, a majority of existing flood forecasting and warning systems use ground rain gauge data, not radar rain gauge data, as the basis for judgment. Since, however, radar rain gauges have the feature that they can analyse the areal and dynamic characteristics of rainy regions, many systems actually use them as one powerful component that complements such function of the systems.

(3) Although improvement of the accuracy of radar rain gauges is likely to become possible by carrying out analytical studies based on after-installation data storage, it is judged to be appropriate that for the moment, ground rain gauges should be used to perform flood forecasts and warnings, because the ground type surpasses the radar type very significantly in terms of the history of actual data storage.

6. CONFIGURATION AND FUNCTIONS OF OPTIMUM SYSTEM

6.1 System Configurations

6.1.1 Overall system configuration

The overall configuration and functional block diagram of the flood forecasting and warning system should be shown in Figure 6.1.1. The flow chart of data should be shown in Figure 6.1.2.

6.1.2 Circuit configuration

The overall circuit configuration of the flood forecasting and warning system should be shown in Figure 6.1.3.

6.1.3 Station configuration of facility

The station configuration of the flood forecasting and warning system facility should be shown in the table below.

Type of station	Number of stations
Control center (DSİ 6th regional directorate flood control committee)	1
Data monitoring stations (DSİ general directorate, Adana EİE and DMİ)	3
Seyhan Dam office facility	1
Çatalan Damoffice facility	1
Multiplex radio repeater stations	3
Multiplex radio repeater stations (Telemetering repeater station also provided)	4
Telemetering repeater stations (V-V and Cross type)	7
Water level gauging stations (Seyhan Dam and Çatalan Dam water level included)	10
Rainfall gauging stations (Çatalan Dam rainfall included)	9
Rainfall/temperature gauging stations	7
Adana Provincial Governor	1
UHF repeater station	1
ASO UHF radio liaison stations(Doğankent and Yenice)	2
Town/villages' head UHF radio liaison stations (downstream areas of Seyhan Dam)	5
Mobile station	1

6.1.4 System configuration

Figure 6.1.4 to Figure 6.1.9 should show the schematic configuration of flood forecasting and warning system for Seyhan River basin.

6.2 System Scheme and Function Outline

The flood forecasting and warning system should consist of three sub-systems:

- Data collection system
- Data processing system
- Data transmission system

The functions of the sub-systems are outlined in Sections 6.2.1 to 6.2.3 below.

6.2.1 Data collection system

The data collection system should consist of one (1) supervisory station at Seyhan Damoffice, eleven (11) telemetering repeater stations, ten (10) water level gauging stations, nine (9) rainfall gauging stations, and seven (7) rainfall and temperature gauging stations. The functions of the data collection system should outlined below.

(1) Data to be collected

The types of data to be collected should be listed in Table 6.2.1

(2) Collection intervals

In principle, the intervals of data collection should be based on the following table:

Gauging item	Collection conditions	Remarks
Rainfall	Every hour on the hour	Calculations of hourly rainfall, every hour on the hour, become the minimum unit.
Waterlevel	Every hour on the hour	It is preferable that whenever necessary, collection of any data should be possible.
Air temperature	Every hour on the hour	It is preferable that whenever necessary, collection of any data should be possible.

(3) Data collection circuits

Simplex radio links for data collection should be of the half duplex communications type based on VHF radio links of high circuits design efficiency. Since a VHF radio frequency band of 70 MHz can be used even during the implementation phase of the system, 70 MHz should be used that is high in circuits design efficiency and ideal for mountainous propagation.

(4) Telemetering method

Polling telemetering should be used as the method of telemetering for the data collection system.

(5) Frequency assignment planning for the telemetering radio links

An outline of frequency assignment planning for the telemetering radio links should be given in Figure 6.2.1.

6.2.2 Data processing system

The data processing system should use distributed processing configuration. The system configuration is shown in Figure 6.2.2, and its processing functions are outlined below.

(1) Computing items

The following lists computing items required for the flood forecasting and warning system:

- Hourly rainfall processing
- Daily rainfall processing
- Average basin rainfall processing
- Rainfall warning judgment processing
- Water level warning judgment processing
- Water level/discharge processing
- Statistical processing
- Outflow forecast processing

(2) Processing items list

A list of processing items in the control center should be given in Table 6.2.2 to Table 6.2.7.

6.2.3 Data transmission system

The data transmission system should transmit data and information for flood control activities from the flood control committee of the DSİ 6th regional directorate to related agencies. A total functional block diagram of the data transmission system should be given in Figure 6.2.3, and an outline of its related circuits and operating frequency planning should be given in Figure 6.2.4. The function of the data transmission system are outlined below.

(1) Data distribution

Data should be transmitted in image service from the control center. The service area and the types of services should be listed below.

(a) Image service destination stations and service types

The following lists stations to which image services should be provided:

Image data distribution source	Image data distribution destination	Service image type
• Control center	• DSİ general directorate	• River basin status chart
(Flood control committee of	• Seyhan Dam office	• Rainfall data table
DSİ 6th regional directorate)	• Çatalan Dam office	• Water level data table
	• Adana EİE regional directorate	• Discharge data table
	• Adana DMİ regional directorate	• Air temperature data table
		• Rainfall chronological graph
		• Water level chronological graph
		• Discharge chronological graph
		•Air temperature chronological graph

Distribution of image data to the Seyhan Dam office and the Çatalan Dam office should be performed via multiplex radio links and distribution of image data to the DSİ general directorate, the Adana EİE regional directorate, and the Adana DMİ regional directorate via PTT private lines provided with optical fiber cables.

(2) Information transmission through direct call lines

Private lines for interconnection between each of the following sections should be provided to allow direct telephone calls to be placed:

Section	Communications line type
• Between Control center and Seyhan Dam office	Multiplex radio links
• Between Control center and Çatalan Dam office	Multiplex radio links
• Between Control center and Adana Governor	PTT private lines

(3) Voice information transmission

Voice information should be transmitted via the exchange circuits of multiplex radio links. Information transmission circuits systems are classified as follows according to the combination of the multiplex radio links and UHF radio links to be structured:

- Liaison telephone system that uses multiplex radio links
  This system is made up of only multiplex radio links.
- Liaison radio telephone system
  This system is made up of a combination of multiplex radio links and UHF radio links.

Both two types of information transmission systems listed above should allow full duplex communication through the dial telephone. The functions of the two types of information transmission systems should be outlined below.

(a) Liaison telephone system that uses multiplex radio links
This system, which should be made up of only multiplex radio links, should be provided in the three places listed below. While the call channel remains unoccupied, this system can be used to intercommunicate between stations or with a liaison radio telephone system.

- Flood control committee of the DSİ 6th regional directorate
- Seyhan Dam office
- Çatalan Dam office

(b) Liaison radio telephone system
This system should be made up of a combination of multiplex radio links and UHF radio links. A single-channel radio communication should be provided in the two places and one patrol car listed below. This system should allow telephone contact between these two stations, patrol car and multiplex radio communication stations.

- Doğankent Flood Control Center
- Yenice Flood Control Center

- Patrol car (Downstream areas of Seyhan Dam)

(4) Voice liaison system

The voice liaison system should transmit in voice dam discharge information through UHF radio links. Voice information transmission should become possible by selective call communication between the control centers and the following stations since group contact is required for information of dam discharge.

- Taşci (Seyhan River Left Bank)
- Kuranşa (Seyhan River Left Bank)
- Karayusuflu (Seyhan River Left Bank)
- Baharli (Seyhan River Right Bank)
- Tabaklar (Seyhan River Right Bank)

7. EDUCATION AND TRAINING

7.1 Outline

It is demanded that the installed system and its components will be appropriately serviced over a long period of time to ensure their normal continued operation. Education and training of personnel takes up an important position in fulfillment of that. During establishment of curriculums on the methods, contents, and organizations of personnel education and training, sufficient studies should be performed in terms of various factors, such as the technical levels of the personnel to be educated and trained, the configuration and scale of the system, and the characteristics of the maintenance personnel system. The curriculums, after being established, should be studied in further detail during total system design, including cost estimation.

This section describes the items to be studied during establishment of education and training curriculums for the personnel who will get involved in maintenance services.

7.2 Objectives of Education and Training

The major objectives of personnel education and training for the flood forecasting and warning system include the following:

(1) Understanding a general concept concerning the flood forecasting and warning system
(2) Understanding the functions and operation of the system and its components
(3) Becoming familiar with operation and handling of the system and its components
(4) Becoming familiar with maintenance

7.3 Processes Up To Execution of Education and Training

Study during the following phases is required:

(a) Preliminary check
First, it is to be decided on whether training is required.

(b) Job analysis
It is to be first checked where and how the current maintenance jobs are analyzed and what is now used to perform these analyses. Based on the information that has thus been obtained, analyses are then be performed as to

what types of training and what types of working manuals are required. Further, maintenance personnel are to be selected and job execution targets are to be set. Thus, evaluation of the validity of training at the job execution levels becomes possible.

(c) Needs of training

The needs of training must be set by subtracting the acquired capabilities of the trainees from the skills, intelligence, and attitudes required for execution of training.

(d) Selection of the types of education and training

Education and training can be divided into various types according to the method of classification to be used. For the flood forecasting and warning system, the following three types are likely to be required:

- Factory training
- Site training
- Training in operation and maintenance

(e) Testing

It is effective to set attainment tests on defined training targets and carry out the tests.

(f) Establishment of curriculums and planning for preparation of manuals

Detailed curriculums are to be prepared. Also, preparation of manuals and educational materials are to be planned.

(g) Preparation of manuals and educational materials

Manuals and educational materials are prepared.

(h) Evaluation of validity and modification of the manuals and the educational materials

After evaluation of the validity of training and diagnosis for defects in the manuals and the educational materials, any necessary modifications are performed on the corresponding documentation.

(i) Execution of training

- Precautions on execution of training
- Operational planning for the training equipment
- Selecting training course administrators

- Letting trainees thoroughly know the programs and contents of training
- Selecting trainees and setting the needs of training