ISLAMIC REPUBLIC OF IRAN

FINAL REPORT
FOR
THE MASTER PLAN
ON
THE CASPIAN SEA COASTAL AREA
AGRICULTURAL DEVELOPMENT PROJECT

APPENDIX

FEBRUARY 1987

JAPAN INTERNATIONAL COOPERATION AGENCY

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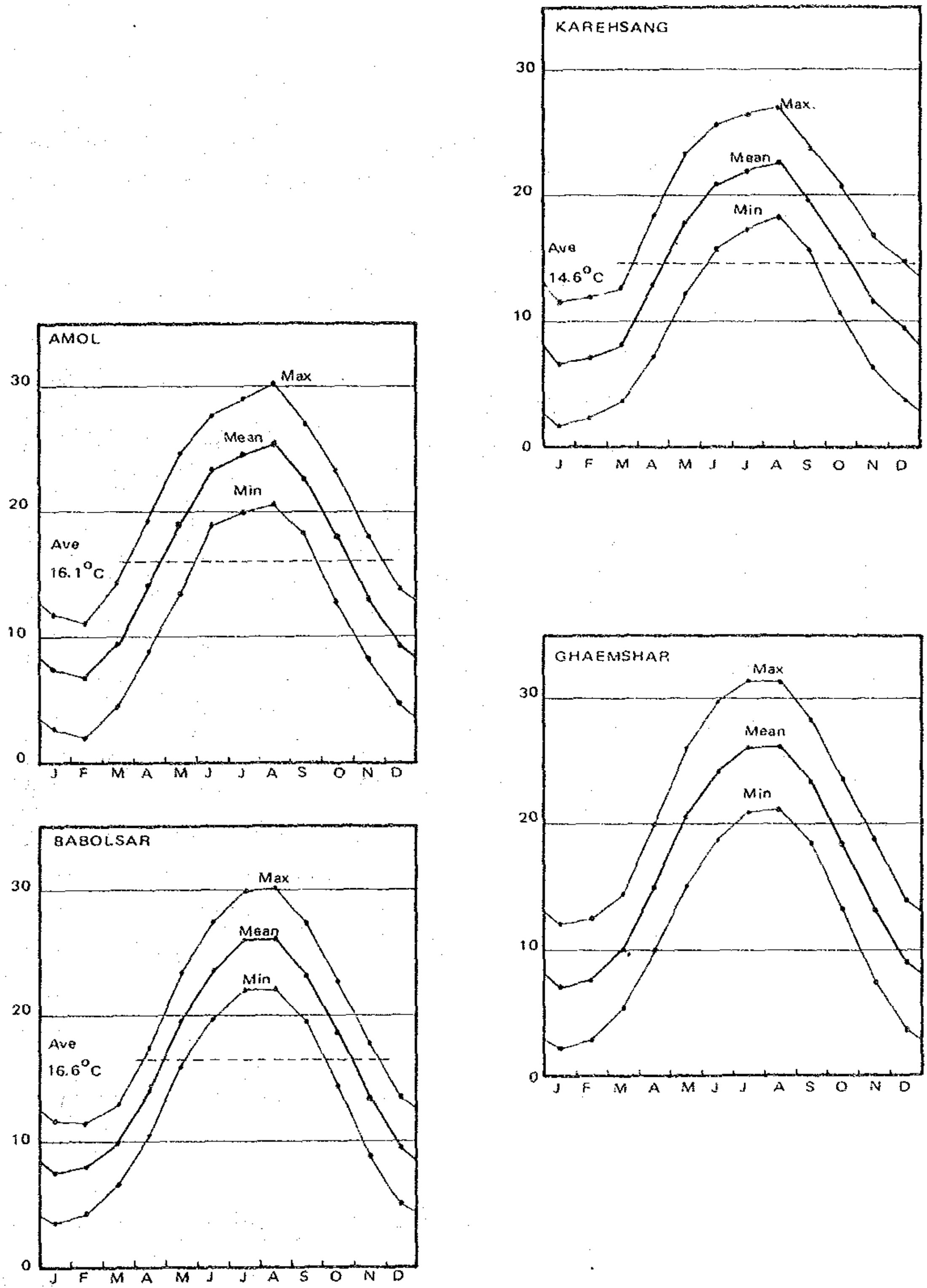
Station	Location		Altitude	Start of	Collected Data						Remarks
	Location Latitude	Altitude Longitude	(PGD, m)	Obser-vation	P	T	R.H.	W.S.	S.H.	C.N.	
Babolsar	36°43'	52°39'	-21	1951-	51-84	51-76	51-76	51-75	59-76	51-75	
Babol	36°33'	52°41'	2	1958-	58-76	58-76	58-76				
Ghaemshahr	36°29'	52°53'	50	1956-	56-76 81-85	56-76	57-76				
Amol Rice Station	36°28'	52°23'	29	1964-	64-84 1/	64-84 1/	64-84				
Karehsang	36°19'	52°22'	500	1951-79	51-76	56-76	57-76				Closed in 1979
Shirgah	36°17'	52°54'	223	1964-	64-76	63-76 2/	63-76 2/				
Qarantalar	36°20'	52°47'	90	1951-							
Mahmud Abad	36°37'	52°16'	-23	1966-	66-82						
Sorkh Rud	36°40'	52°27'	-23	1976-	76-84						
Charmestan				1971-	71-82						
Miandasht Babolsar	36°42'	52°39'	-21	1966-	66-82						

Note: P : Precipitation T : Temperature, P.H.: Relative Humidity,
W.S.: Wind Speed S.H.: Sunshine Hours C.N.: Cloudiness

1/ : 1977-81 not informed 2/ : Observed from December in 1963

Table A.1.2. Monthly Mean Temperature, Relative Humidity, Wind Speed and Sunshine Hours

	Monthly Mean Maximum Temperature (°C)			Monthly Mean Temperature (°C)			Monthly Mean Minimum Temperature (°C)			Monthly Mean Relative Humidity (%)			Monthly Mean (Babolsar)	
Month	Babolsar	Amol	Karehsang	Babolsar	Amol	Karehsang	Babolsar	Amol	Karehsang	Babolsar	Amol	Karehsang	Wind Speed (Knot)	Sunshine Hour (hr/day)
Jan.	11.6	11.8	11.6	7.6	7.3	6.7	3.7	2.7	1.7	86	83	74	2.1	4.29
Feb.	11.4	11.1	11.9	7.9	6.6	7.1	4.2	2.1	2.3	85	84	75	2.6	4.35
Mar.	12.9	14.3	12.6	9.8	9.4	8.1	6.6	4.5	3.6	84	85	79	3.0	4.19
Apr.	17.3	19.2	18.5	13.9	14.1	12.9	10.5	8.9	7.2	83	82	74	2.9	5.21
May	23.3	24.6	23.4	19.5	19.0	17.8	15.8	13.4	12.2	80	82	75	3.0	7.30
Jun.	27.3	27.6	25.7	23.5	23.3	20.8	19.7	18.9	15.8	77	79	77	2.9	8.30
Jul.	29.8	28.9	26.6	25.9	24.5	22.0	22.0	20.0	17.3	78	81	82	2.8	7.87
Aug.	30.2	30.2	27.0	26.1	25.4	22.7	22.0	20.5	18.3	80	83	82	2.7	6.76
Sep.	27.2	26.9	23.7	23.2	22.6	19.7	19.3	18.2	15.6	82	83	84	2.5	5.59
Oct.	22.7	23.2	20.8	18.6	18.0	15.8	14.3	12.8	10.7	84	82	79	2.3	5.45
Nov.	17.7	18.0	16.8	13.4	13.1	11.5	8.9	8.2	6.2	86	82	78	2.1	4.90
Dec.	13.5	13.8	14.8	9.3	9.3	9.3	5.1	4.7	3.7	87	83	75	2.0	4.34
Annual	20.9	20.9	19.5	16.6	16.1	14.6	12.7	11.3	9.6	82	82	78	2.6	5.72



(Unit: °C)

ISLAMIC REPUBLIC OF IRAN MINISTRY OF AGRICULTURE
CASPIAN SEA COASTAL AREA AGRICULTURAL DEVELOPMENT PROJECT
MONTHLY MEAN TEMPERATURE

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	FIGURE A.1.1.

A.1.1. Monthly Rainfall

Monthly rainfall in the area has been estimated by the records at Babolsar and Amol. Record at Babol has not been used due to low reliability.

Table A.1.3. Probable Annual and Monthly Precipitation

(Unit: mm)

Month	Mean Precipitation			Probability of Exceedance 2/				
	Babolsar	Amol	Project Area 1/	10%	20%	50%	80%	90%
Jan.	81.8	82.5	82.2	98	90	79	69	65
Feb.	66.9	77.9	73.1	87	81	70	61	57
Mar.	64.2	66.8	65.7	79	73	63	55	51
Apr.	33.4	56.3	46.3	55	51	44	39	36
May	18.7	31.2	25.7	41	35	25	17	13
Jun.	24.7	30.1	27.7	45	38	28	18	14
Jul.	40.5	22.0	30.1	49	42	30	20	16
Aug.	52.8	42.7	47.1	76	65	46	31	24
Sep.	107.4	53.2	76.9	83	80	75	70	68
Oct.	135.5	94.4	112.4	121	117	109	103	100
Nov.	116.3	78.0	94.8	103	99	92	87	85
Dec.	116.6	107.2	111.3	120	115	108	102	99
Total	858.8	742.2	793.3	957	886	769	672	628

Note: 1/ ... Weight: Babolsar; 0.438, Amol; 0.562
2/ ... Monthly allocation follows a distribution of mean precipitation of the Project Area.

A.1.2. Rainy Days

Annual rainy days are 106 days at Babolsar and rainy days by intensity are as follows;

Table A.1.4. Monthly and Annual Mean Rainy Day

(Unit: days)

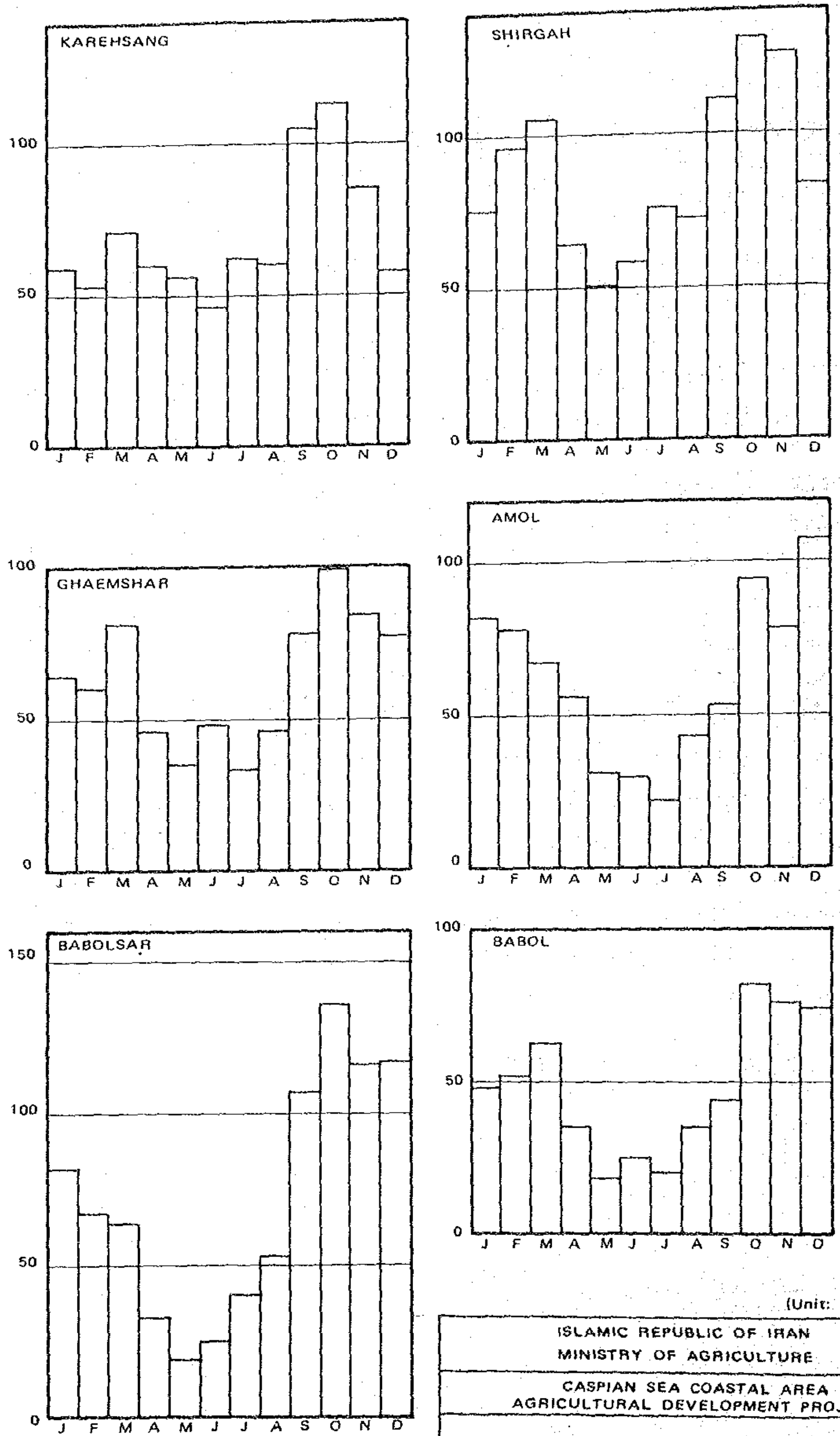
Rainfall Intensity	Rainy Day												
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
≥ 0 mm/day	10.8	9.3	12.5	9.6	6.4	5.4	5.6	7.0	9.6	9.3	9.8	10.2	105.5
≥ 1 mm/day	8.8	7.3	9.3	5.6	2.9	3.1	3.5	4.6	7.2	7.4	8.3	8.5	76.5
≥ 5 mm/day	5.3	4.5	4.8	2.2	1.0	1.3	1.8	2.2	4.3	5.3	5.2	6.4	44.3
≥ 10 mm/day	3.2	2.5	2.9	1.2	0.5	0.8	1.2	1.0	3.0	3.6	3.7	4.6	28.2

Note: Babolsar ... 1951 ~ 75

Table A.1.5. Monthly Mean precipitation

(Unit: mm)

Month	Babolsar	Babol	Ghaemshahr	Amol Rice Station	Karehsang	Shirgah
Jan.	81.8	47.8	64.1	82.5	59.1	75.2
Feb.	66.9	52.4	60.2	77.9	52.7	96.4
Mar.	64.2	63.1	81.8	66.8	71.3	104.7
Apr.	33.4	35.2	45.7	56.3	59.7	63.7
May	18.7	18.5	35.2	31.2	55.9	50.1
Jun.	24.7	24.5	48.4	30.1	45.6	57.5
Jul.	40.5	20.6	33.3	22.0	62.5	75.8
Aug.	52.8	34.8	46.0	42.7	59.7	72.1
Sep.	107.4	44.1	78.7	53.2	105.3	111.1
Oct.	135.5	82.4	98.8	94.4	113.5	130.9
Nov.	116.3	76.4	84.0	78.0	85.3	126.4
Dec.	116.6	74.0	77.4	107.2	57.3	83.5
Annual	858.8	573.8	753.5	742.2	827.8	1,047.3
Max.	1,210.8	911.8	998.4	1,101.1	1,172.5	1,326.2
Min.	641.8	267.5	435.0	343.4	550.9	840.1



(Unit: mm)

ISLAMIC REPUBLIC OF IRAN MINISTRY OF AGRICULTURE
CASPIAN SEA COASTAL AREA AGRICULTURAL DEVELOPMENT PROJECT
MONTHLY MEAN PRECIPITATION

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	FIGURE A.1.2.

A.1.3. Daily Rainfall

Annual maximum daily rainfall happens generally in non-irrigation period especially in autumn from September to December. For estimating probable daily rainfall in the area, daily rainfalls are studied at four stations (Babolsar, Miandasht Babolsar, Sorkh Rud and Mahmud Abad) in the area. The results are as follows;

Table A.1.6. Probable Daily Rainfall

(Unit: mm)

Year / Days	Annual				Irrigation Period (Sep. - Mar.)				Non-Irrigation Period (Apr. - Aug.)			
	1/2	1/5	1/10	1/25	1/2	1/5	1/10	1/25	1/2	1/5	1/10	1/25
1	70	103	130	170	33	48	57	66	70	103	130	170
2	-	-	-	-	-	-	-	-	-	-	166	-
3	-	-	-	-	-	-	-	-	-	-	179	-
4	-	-	-	-	-	-	-	-	-	-	195	-
5	-	-	-	-	-	-	-	-	-	-	204	-

Note: 1) One day rainfall has been estimated only by the records at Babolsar considering reliability.
2) Consecutive rainfalls for 2 to 5 days are average value of above 4 stations due to insufficient number of records at Babolsar.

Since above probable daily rainfall means spot rainfall, it is necessary to reduce the value for estimating areal rainfall in the basin bigger than 100 sq.km.

A.1.4. Hourly Rainfall

When estimating hourly rainfall from daily rainfall, Mononobe equation is well in accord with the study result of Reference 13.

$$r_t = \frac{Rd}{24} \left(\frac{24}{t}\right)^C \qquad C = 0.57$$

where;

Rd = daily rainfall (mm/day)

r_t = hourly rainfall intensity (mm/hr)

t = duration (hours)

It is recommended to use this equation for estimating hourly rainfall intensity.

A.1.5. Areal Rainfall

Areal rainfall is generally smaller than recorded maximum spot rainfall in the area. For clarifying this phenomenon, seven rainfalls are selected as shown in the Table A.1.7. Areal rainfall has been estimated for each rainfall using Thessen Polygon. The results are summarized as shown in the Figure below. It is recommended to use this figure for estimating areal rainfall in the basin more than 100 sq.km. When the basin is smaller than 100 sq.km, spot rainfall shall be applied.

Figure A.1.3. Areal Reduction of Daily Rainfall

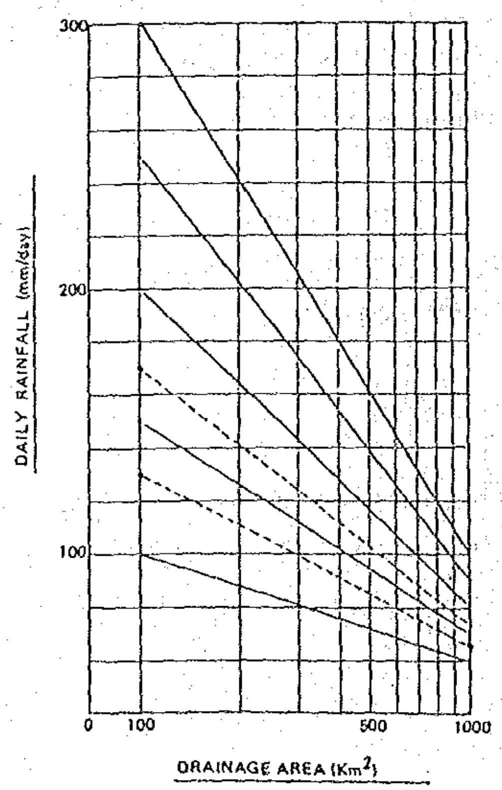


Table A.1.7. Rainfalls Used for Estimating Areal Rainfall

No.	Date	Rainfall Stations							
		Babolsar	Babolsar Miandasht	Sorkh Rud	Mahmud Abad	Chamestan	Ghaemshar	Amol	Babol
1	1 Oct'71 (9 Meh'50)	219	118	80	262	-	-	-	-
2	21 Sep'81 (31 Sha'60)	200	143	160	127	12	0	-	-
3	17 Oct'81 (25 Meh'60)	164	151	85	47	8	67	-	-
4	16 Sep'81 (25 Sha'60)	1.6	0	191	5	0	0	-	-
5	4 Oct'76 (12 Meh'55)	74	77	36	54	80	32	115	59
6	Dec'68 (Aza'47)	34	33	40	32	-	40	200	37
7	Nov'75 (Aba'54)	49	45	61	41	42	85	61	84

Note: 1) - no records

A.1.6. Modified Penman Method

The original Penman equation (1948) predicted losses from an open water surface (Eo). Experimentally determined crop coefficients ranging from 0.6 in winter months to 0.8 in summer months related Eo to grass evapotranspiration for the climate in England. The Penman equation consisted to two terms: the energy (radiation) term and the aerodynamic (wind and humidity) term. The relative importance of each term varies with climatic conditions. Under calm weather conditions the aerodynamic term is usually less important than the energy term. In such conditions the original Penman Eo equation using a crop coefficient of 0.8 has been shown to predict ETo closely, not only in cool, humid regions but also in very hot, and semi-arid regions. It is under windy conditions and particularly in the more arid regions that the aerodynamic term becomes relatively more important and thus errors can result in predicting ETo when using 0.8 Eo.

A modified Penman equation is suggested to determine ETo, involving a revised wind function term and an adjustment on day and night time weather conditions.

$$ETo = C\,[\underbrace{W \cdot Rn}_{\text{radiation term}} + \underbrace{(1 - W) \cdot f(u) \cdot (es - ea)}_{\text{aerodynamic term}}]$$

where;

ETo = reference crop evapotranspiration in mm/day.

W = temperature-related weighting factor.

Rn = net radiation in equivalent evaporation in mm/day.

f(u)= wind-related function.

(es - ea)= difference between the saturation vapour pressure at mean air temperature and the mean actual vapour pressure of the air in mbar.

C = adjusted factor to compensate for the effect of day and night weather conditions.

Wind function f(u)

$$f(u) = 0.27\ (1 + u/100)$$

where;

u = wind run in km/day at 2 meters height

when wind (Uz) at different height at Z meters, wind at 2 meters (U_2) is;

$$U_2 = U_Z\ \left(\frac{2}{z}\right)^{0.2}$$

Weighting factor (1 - W)

(1 - W) is a weighting factor for the effect of wind and humidity on ETo.

$$W = \Delta/(\Delta + \gamma)$$

where;

Δ = slope of saturation vapour pressure-temperature curve in mbar/°C = 33.86 $[0.05904(0.00738T + 0.8072)^7 - 0.0000342]$

γ = psychrometric constant = $cp \cdot p/(0.622\lambda)$

cp = 0.240

P = atmospheric pressure in mbar = 1013 - 0.1055EL

EL = elevation from sea level in meters

λ = latent heat of water in cal/g = 595.9 - 0.55T

T = air temperature in °C

Vapour pressure (es - ea)

(es - ea) is the difference between the mean saturated vapour pressure (es) and the mean actual vapour pressure (ea) in mbar. es can be obtained by temperature (T°C) in Table A.1.9, and ea is calculated by relative humidity (RH) thus ea = es*RH.

Net radiation (Rn)

Net radiation (Rn) is the difference between all incoming and outgoing radiation in mm/day. Rn can be calculated from solar radiation or sunshine hours (or degree of cloud cover), temperature and humidity data.

$$Rn = Rns - Rn\ell$$

where;

Rns = net shortwave solar radiation in mm/day

$Rn\ell$ = net longwave solar radiation in mm/day

$$Rns = (1 - \alpha)\ Rs$$

where;

α = reflection depending on the nature of the surface cover and being approximately 0.25.

Rs = Solar radiation being dependent on Ra (amount of radiation received at top of the atmosphere) and transmission through the atmosphere, which is largely dependent on cloud cover.

$$Rs = (a + b\ n/N)\ Ra$$

where;

n = actual sunshine hours per day

N = maximum possible sunshine hours per day, N for a given month and latitude is given in Table A.1.10.

a,b = constant by regions, 0.25 and 0.50 can be used respectively for practical purposes.

Ra = Extra-terrestrial radiation, Ra for a given month and latitude is given Table A.1.11.

$$Rn\ell = f(T)(ea)f(n/N)$$

where;

$Rn\ell$ represents net energy loss, since outgoing is greater than incoming.

$f(T)$ = effect of temperature = σTk^4

$= 1.98 \times 10^{-9} (T + 273)^4$

$f(ea)$ = effect of vapour pressure = $0.34 - 0.044 \cdot ea^{0.5}$

$f(n/N)$ = effect of the ratio actual and maximum bright sunshine hours = $0.1 + 0.9\ n/N$

Adjustment factor (c)

Adjustment factor (c) is given in Table A.1.12, to adjust calculated ETo to weather conditions by relative humidity, U day/U night, U day and Rs.

Table A.1.8 is showing the evapotranspiration by the modified Penman equation, and sample calculation is presented in Table A.1.13.

Table A.1.8 Evapotranspiration by Modified Penman Method

		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.*	Aug.	Sep.	Oct.	Nov.	Dec.	Annual	
T mean	(°C) 1/	7.4	7.2	9.6	14.0	19.2	23.4	25.1	25.7	22.9	18.3	13.2	9.3	16.3	(Table A.1.2)
RH mean	(%) 1/	84	84	85	82	81	78	80	82	83	83	84	85	82.6	- ditto-
U_2	(knot)	2.1	2.6	3.0	2.9	3.0	2.9	2.8	2.7	2.5	2.3	2.1	2.0	2.6	- ditto -
n	(hours/day)	4.29	4.35	4.19	5.21	7.30	8.30	7.87	6.76	5.59	5.45	4.90	4.34	5.72	- ditto -
Ra	(mm/day)	7.3	9.3	12.0	14.7	16.4	17.2	16.7	15.4	13.0	10.5	7.9	6.5		(Table A.1.11)
N	(hours/day)	10.0	10.9	11.9	13.2	14.1	14.7	14.4	13.6	12.4	11.3	10.2	9.7		(Table A.1.10)
U day	(m/sec)	1.1	1.3	1.55	1.49	1.55	1.49	1.44	1.39	1.29	1.18	1.08	1.03		
Rs	(mm/day)	3.39	4.2	5.11	6.58	8.35	9.16	8.74	7.68	6.18	5.16	3.87	3.08		
(1) (1 - W) f(u) (es - ea)		0.42	0.46	0.51	0.70	0.87	1.09	1.01	0.90	0.77	0.66	0.51	0.41		
(2) W·Rn		0.67	1.00	1.53	2.33	3.38	4.07	4.03	3.57	2.61	1.78	0.97	0.57		
(3) = (1) + (2)		1.09	1.46	2.04	3.03	4.25	5.16	5.04	4.47	3.38	2.44	1.48	0.98		
C		0.96	0.97	0.975	1.02	1.04	1.06	1.06	1.04	1.02	1.00	0.975	0.96		
ETo = C*(3)	(mm/day)	1.0	1.4	2.0	3.1	4.4	5.5	5.3	4.7	3.5	2.4	1.4	0.9		
ETo	(mm/month)	31	40	62	93	136	165	164	146	105	74	42	28	1.086	

Note:
1) Location 36°30'N, Altitude 10m PGD at the center of the Project Area.
2) For estimating adjustment factor (c), assuming RH max = 90% and U day/U night = 1.0
3) 1/ weighted average by Babolsar (0.438) and Amol (0.562) by area ratio.
4) * sample computation is presented.
5) 1 knot = 0.515 m/sec.

Table A.1.9 Saturation Vapour Pressure (es) in mbar as Function of Mean Air Temperature (T) in °C

T (°C)	es (mbar)	T (°C)	es (mbar)	T (°C)	es (mbar)	T (°C)	es (mbar)
0	6.1	10	12.3	20	23.4	30	42.4
1	6.6	11	13.1	21	24.9	31	44.9
2	7.1	12	14.0	22	26.4	32	47.6
3	7.6	13	15.0	23	28.1	33	50.3
4	8.1	14	16.1	24	29.8	34	53.2
5	8.7	15	17.0	25	31.7	35	56.2
6	9.3	16	18.2	26	33.6	36	59.4
7	10.0	17	19.4	27	35.7	37	62.8
8	10.7	18	20.6	28	37.8	38	66.3
9	11.5	19	22.0	29	40.1	39	69.9

Table A.1.10 Mean Daily Duration of Maximum Possible Sunshine Hours (N) for Different Months and Latitudes

Northern Lats	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
50°	8.5	10.1	11.8	13.8	15.4	16.3	15.9	14.5	12.7	10.8	9.1	8.1
48	8.8	10.2	11.8	13.6	15.2	16.0	15.6	14.3	12.6	10.9	9.3	8.3
46	9.1	10.4	11.9	13.5	14.9	15.7	15.4	14.2	12.6	10.9	9.5	8.7
44	9.3	10.5	11.9	13.4	14.7	15.4	15.2	14.0	12.6	11.0	9.7	8.9
42	9.4	10.6	11.9	13.4	14.6	15.2	14.9	13.9	12.6	11.1	9.8	9.1
40	9.6	10.7	11.9	13.3	14.4	15.0	14.7	13.7	12.5	11.2	10.0	9.3
35	10.1	11.0	11.9	13.1	14.0	14.5	14.3	13.5	12.4	11.3	10.3	9.8
30	10.4	11.1	12.0	12.9	13.6	14.0	13.9	13.2	12.4	11.5	10.6	10.2
25	10.7	11.3	12.0	12.7	13.3	13.7	13.5	13.0	12.3	11.6	10.9	10.6
20	11.0	11.5	12.0	12.6	13.1	13.3	13.2	12.8	12.3	11.7	11.2	10.9
15	11.3	11.6	12.0	12.5	12.8	13.0	12.9	12.6	12.2	11.8	11.4	11.2
10	11.6	11.8	12.0	12.3	12.6	12.7	12.6	12.4	12.1	11.8	11.6	11.5
5	11.8	11.9	12.0	12.2	12.3	12.4	12.3	12.3	12.1	12.0	11.9	11.8
0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0

Table A.1.11. Extra-terrestrial Radiation (Ra) Expressed in Equivalent Evaporation in mm/day

	Northern Hemisphere											
Lat	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
50°	3.8	6.1	9.4	12.7	15.8	17.1	16.4	14.1	10.9	7.4	4.5	3.2
48	4.3	6.6	9.8	13.0	15.9	17.2	16.5	14.3	11.2	7.8	5.0	3.7
46	4.9	7.1	10.2	13.3	16.0	17.2	16.6	14.5	11.5	8.3	5.5	4.3
44	5.3	7.6	10.6	13.7	16.1	17.2	16.6	14.7	11.9	8.7	6.0	4.7
42	5.9	8.1	11.0	14.0	16.2	17.3	16.7	15.0	12.2	9.1	6.5	5.2
40	6.4	8.6	11.4	14.3	16.4	17.3	16.7	15.2	12.5	9.6	7.0	5.7
38	6.9	9.0	11.8	14.5	16.4	17.2	16.7	15.3	12.8	10.0	7.5	6.1
36	7.4	9.4	12.1	14.7	16.4	17.2	16.7	15.4	13.1	10.6	8.0	6.6
34	7.9	9.8	12.4	14.8	16.5	17.1	16.8	15.5	13.4	10.8	8.5	7.2
32	8.3	10.2	12.8	15.0	16.5	17.0	16.8	15.6	13.6	11.2	9.0	7.8
30	8.8	10.7	13.1	15.2	16.5	17.0	16.8	15.7	13.9	11.6	9.5	8.3
28	9.3	11.1	13.4	15.3	16.5	16.8	16.7	15.7	14.1	12.0	9.9	8.8
26	9.8	11.5	13.7	15.3	16.4	16.7	16.6	15.7	14.3	12.3	10.3	9.3
24	10.2	11.9	13.9	15.4	16.4	16.6	16.5	15.8	14.5	12.6	10.7	9.7
22	10.7	12.3	14.2	15.5	16.3	16.4	16.4	15.8	14.6	13.0	11.1	10.2
20	11.2	12.7	14.4	15.6	16.3	16.4	16.3	15.9	14.8	13.3	11.6	10.7
18	11.6	13.0	14.6	15.6	16.1	16.1	16.1	15.8	14.9	13.6	12.0	11.1
16	12.0	13.3	14.7	15.6	16.0	15.9	15.9	15.7	15.0	13.9	12.4	11.6
14	12.4	13.6	14.9	15.7	15.8	15.7	15.7	15.7	15.1	14.1	12.8	12.0
12	12.8	13.9	15.1	15.7	15.7	15.5	15.5	15.6	15.2	14.4	13.3	12.5
10	13.2	14.2	15.3	15.7	15.5	15.3	15.3	15.5	15.3	14.7	13.6	12.9
8	13.6	14.5	15.3	15.6	15.3	15.0	15.1	15.4	15.3	14.8	13.9	13.3
6	13.9	14.8	15.4	15.4	15.1	14.7	14.9	15.2	15.3	15.0	14.2	13.7
4	14.3	15.0	15.5	15.5	14.9	14.4	14.6	15.1	15.3	15.1	14.5	14.1
2	14.7	15.3	15.6	15.3	14.6	14.2	14.3	14.9	15.3	15.3	14.8	14.4
0	15.0	15.5	15.7	15.3	14.4	13.9	14.1	14.8	15.3	15.4	15.1	14.8

Table A.1.12 Adjustment Factor (c) in Presented Penman Equation

	RHmax = 30%				RHmax = 60%				RHmax = 90%			
Rs mm/day	3	6	9	12	3	6	9	12	3	6	9	12
Uday m/sec	Uday/Unight = 4.0											
0	.86	.90	1.00	1.00	.96	.98	1.05	1.05	1.02	1.06	1.10	1.10
3	.79	.84	.92	.97	.92	1.00	1.11	1.19	.99	1.10	1.27	1.32
6	.68	.77	.87	.93	.85	.96	1.11	1.19	.94	1.10	1.25	1.33
9	.55	.65	.78	.90	.76	.88	1.02	1.14	.88	1.01	1.16	1.27
	Uday/Unight = 3.0											
0	.86	.90	1.00	1.00	.96	.98	1.05	1.05	1.02	1.05	1.10	1.10
3	.76	.81	.88	.94	.87	.96	1.06	1.12	.94	1.04	1.18	1.28
6	.61	.68	.81	.88	.77	.88	1.02	1.10	.86	1.01	1.15	1.22
9	.46	.56	.72	.82	.67	.79	.88	1.05	.78	.92	1.06	1.18
	Uday/Unight = 2.0											
0	.86	.90	1.00	1.00	.96	.98	1.05	1.05	1.02	1.06	1.10	1.10
3	.69	.76	.85	.92	.83	.91	.99	1.05	.89	.98	1.10	1.14
6	.53	.61	.74	.84	.70	.80	.94	1.02	.79	.92	1.05	1.12
9	.37	.48	.65	.76	.59	.70	.84	.95	.71	.81	.96	1.06
	Uday/Unight = 1.0 (Adapted)											
0	.86	.90	1.00	1.00	.96	.98	1.05	1.05	1.02	1.06	1.10	1.10
3	.64	.71	.82	.89	.78	.86	.94	.99	.85	.92	1.01	1.05
6	.43	.53	.66	.79	.62	.70	.84	.93	.72	.82	.95	1.00
9	.27	.41	.59	.70	.50	.50	.75	.87	.62	.72	.87	.96

Table A.1.13 Sample Calculation by Modified Penman

Latitude	:	36°30'N (Center of Project Area)
Altitude	:	EL 10m PGD (Center of Project Area)
Wind Measurement	:	2 meters in height
Period	:	July
U day/U night	:	1.0

Data		Calculation
T mean	25.1 °C	es = 31.89 mbar (Table A.1.9)
RH mean	80 %	ea = es x 0.80 = 25.51 mbar (es - ea) = 31.89 - 25.51 = 6.38 mbar
U_2	2.8 knot	u = 1.44 m/s = 124.6 km/day f(u) = 0.27(1 + u/100) = 0.27(1 + 124.6/100) = 0.606
T mean Altitude	25.1 °C, EL 10 m	Δ = 33.86[0.05904(0.00738* T mean + 0.8072)^7 - 0.0000342] = 1.894 mbar/°C λ = 595.9 - 0.55 T mean = 582 °C γ = 0.24(1013 - 0.1055EL)/(0.622λ) = 0.671 W = $\Delta/(\Delta + \gamma)$ = 0.738 (1 - W) = 0.262 (1 - W)f(u)(es - ea) = 1.01 mm/day
Ra		Ra = 16.7mm/day(July at latitude 36°30'N) (Table A.1.11)
n		n = 7.87 hr/day (data)
N		N = 14.4 hr/day (July at Latitude 36°30'N) (Table A.1.10) n/N = 0.547 Rs = (0.25 + 0.50 n/N)Ra = 8.74 mm/day
α = 0.25		Rns = (1 - α) Rs = 6.55 mm/day
σ = 1.98 x 10^{-9}		f(T) = σ(T mean + 273)^4 = 15.6
ea = 25.51 mbar		f(ea) = 0.34 - 0.044 ea$^{0.5}$ = 0.118
n/N = 0.547		f(n/N) = 0.1 + 0.9 n/N = 0.592 Rnℓ = f(T)f(ea)f(n/N) = 1.09 mm/day Rn = Rns - Rnℓ = 6.55 - 1.09 = 5.46 mm/day
W = 0.738		W·Rn = 4.03 mm/day W·Rn + (1 - W)f(u)(es - ea) = 4.03 + 1.01 = 5.04
U day/U night = 1.0 RH max = 90% Rs = 8.74 mm/day U day = 1.44 m/s		C = 1.06 (Table A.1.12) ETo = C [W·Rn + (1 - W)f(u)(es - ea] = 1.06 x 5.04 = 5.3 mm/day

A.1.7. Jensen-Haise Method

Jensen and Haise used observations of consumptive use from the Western United States to develop a linear relationship for estimating reference crop potential evapotranspiration Etp (well watered alfalfa in langleys/day (cal/cm^2 per day).

$$Etp = Ct\ (T - Tx)\ Rs$$

Where;

- Ct = a temperature coefficient
- T = mean temperature in °C
- Tx = the intercept on the temperature axis
- Rs = incident solar radiation in langleys/day

Ct and Tx are determined for the warmest month of the year in a given area.

$$Ct = 1/(C_1 + C_2 C_H)$$

$$Tx = -2.5 - 0.14\ (e_2 - e_1)°C/mbar - EL/550$$

Where;

- C_H = 50 mbar/$(e_2 - e_1)$
- C_1 = 38 - (2°C x EL/305)
- C_2 = 7.6°C
- e_2, e_1 = saturation vapour pressures at the mean maximum and mean minimum temperatures, respectively, for the warmest month of the year in a given area.
- EL = Elevation in meters

1) Application of Jensen-Haise Method

For applying this method, observed Rs is necessary. However, there is no observed Rs in the area for this method. As a result, we need to estimate Rs in the area. For estimating Rs, Hargreaves suggested that where measured Rs values are not available, a fair estimate is

$$Rs = 0.10\ Rso\ (S)^{0.5}$$

Where;

S = percent of possible sunshine

For the values of S, we apply n/N values as mentioned in the modified Penman method.

Ct and Tx can be determined in August as the warmest month in the area. The mean maximum and mean minimum temperatures are 30.2°C and 21.2°C, respectively in August.

e_1 = 42.9 mbar (Tmax = 30.2°C in Table A.1.15)
e_2 = 2.52 mbar (Tmin = 21.2°C in Table A.1.15)

Therefore,

$$C_H = 50\ \text{mbar}/(e_2 - e_1) = 50/(42.9 - 25.2) = 2.82$$
$$C_1 = 38 - (2°C \times EL/305) = 38 - (2 \times 10/305) = 37.93°C$$
$$C_2 = 7.6°C$$
$$Ct = 1/(C_1 + C_2C_H) = 1/(37.93 + 7.6 \times 2.82) = 0.0168$$
$$Tx = -2.5 - 0.14\ (e_2 - e_1)°C/\text{mbar} - EL/550$$
$$= -2.5 - 0.14\ (42.9 - 25.2) - 10/550 = -5.0$$

2) Evapotranspiration by Jensen-Haise Method

Table A.1.14 shows the result of calculation by this method.

Table A.1.14. Evapotranspiration by Jensen-Haise Method

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual	
T mean (°C)	7.4	7.2	9.6	14.0	19.2	23.4	25.1	25.7	22.9	18.3	13.2	9.3	16.3	given data
n (hours/day)	4.29	4.35	4.19	5.21	7.30	8.30	7.87	6.76	5.59	5.45	4.90	4.34	5.72	given data
N (hours/day)	10.0	10.9	11.9	13.2	14.1	14.7	14.4	13.6	12.4	11.3	10.2	9.7		(Table A.1.10)
S = n/N x 100 (%)	42.9	39.9	35.2	39.5	51.8	56.5	54.7	49.7	45.1	48.2	48.0	44.7		
Rso (lang/eys/day)	327	477	556	693	742	800	759	690	592	460	363	294		(Table A.1.15)
Rs = 0.1 Rso $(S)^{0.5}$	214	301	330	436	534	601	561	486	398	319	251	197		
T mean - Tx (°C)	12.4	12.2	14.6	19.0	24.2	28.4	30.1	30.7	27.9	23.3	18.2	14.3		
Etp = Ct (T-Tx)Rs (lang/eys/day)	44.6	61.7	80.9	139.2	217.1	286.7	283.7	250.7	186.6	124.9	76.7	47.3		
λ=595.9 - 0.55 T mean	592	592	591	588	585	583	582	582	583	586	589	591		
Etp = Etp (10λ) (mm/day)	0.8	1.0	1.4	2.4	3.7	4.9	4.9	4.3	3.2	2.1	1.3	0.8		
(mm/month)	25	28	43	72	115	147	152	133	96	65	39	25	940	

Note: 1) Location 36°30'N, Altitude 10 m PGD at the center of the Project Area.

Table A. 1. 15. Mean Daily Solar Radiation for Cloudless Skies, Longleys (Rso)

Latitude °N	Month											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
60	58	152	319	533	671	763	690	539	377	197	87	35
55	100	219	377	558	690	780	706	577	430	252	133	74
50	155	290	429	617	716	790	729	616	480	313	193	126
45	216	365	477	650	729	797	748	648	527	371	260	190
40	284	432	529	677	742	800	755	674	567	426	323	248
35	345	496	568	700	742	800	761	697	603	474	390	313
30	403	549	600	713	742	793	755	703	637	519	437	371
25	455	595	629	720	742	780	745	703	660	561	486	423
20	500	634	652	720	726	760	729	697	680	597	537	474
15	545	673	671	713	706	733	706	684	697	623	580	519
10	584	701	681	707	684	700	681	665	707	648	617	565
5	623	722	690	700	652	663	645	645	710	665	650	606
0	652	740	694	680	623	627	616	623	707	684	680	619
-5	648	758	690	663	590	587	577	590	693	690	727	677
-10	710	772	691	640	571	543	526	558	680	690	727	710
-15	729	779	665	610	516	497	497	519	657	697	747	739
-20	748	779	645	573	474	447	445	481	630	677	753	761
-25	761	779	626	533	419	400	406	439	600	665	767	777
-30	771	772	600	497	384	353	358	390	567	648	767	793
-35	774	754	568	453	335	300	310	342	530	629	767	806
-40	774	729	529	407	281	243	261	290	477	603	760	813
-45	774	704	490	357	229	183	203	235	447	571	747	813
-50	761	669	445	307	174	127	148	177	400	535	727	806
-55	748	630	397	250	123	77	97	123	343	497	707	794
-60	729	588	348	187	77	33	52	74	283	455	700	787

Source: From Table 3-1, Consumptive Use of Water and Irrigation Water Requirements, M. E. Jensen, ed. A.S.C.E., 1974.

APPENDIX A. 2.

HYDROLOGY

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A.2.1. Runoff

Runoff of the concerned rivers is observed at the stations shown in Table A.2.1, and summarized in monthly basis in the Table A.2.2. In this table, runoffs are not in virgin flow at Sork Rud, Babol and Miandasht Babolsar due to intake of irrigation water.

Table A.2.1 List of River Gaging Stations

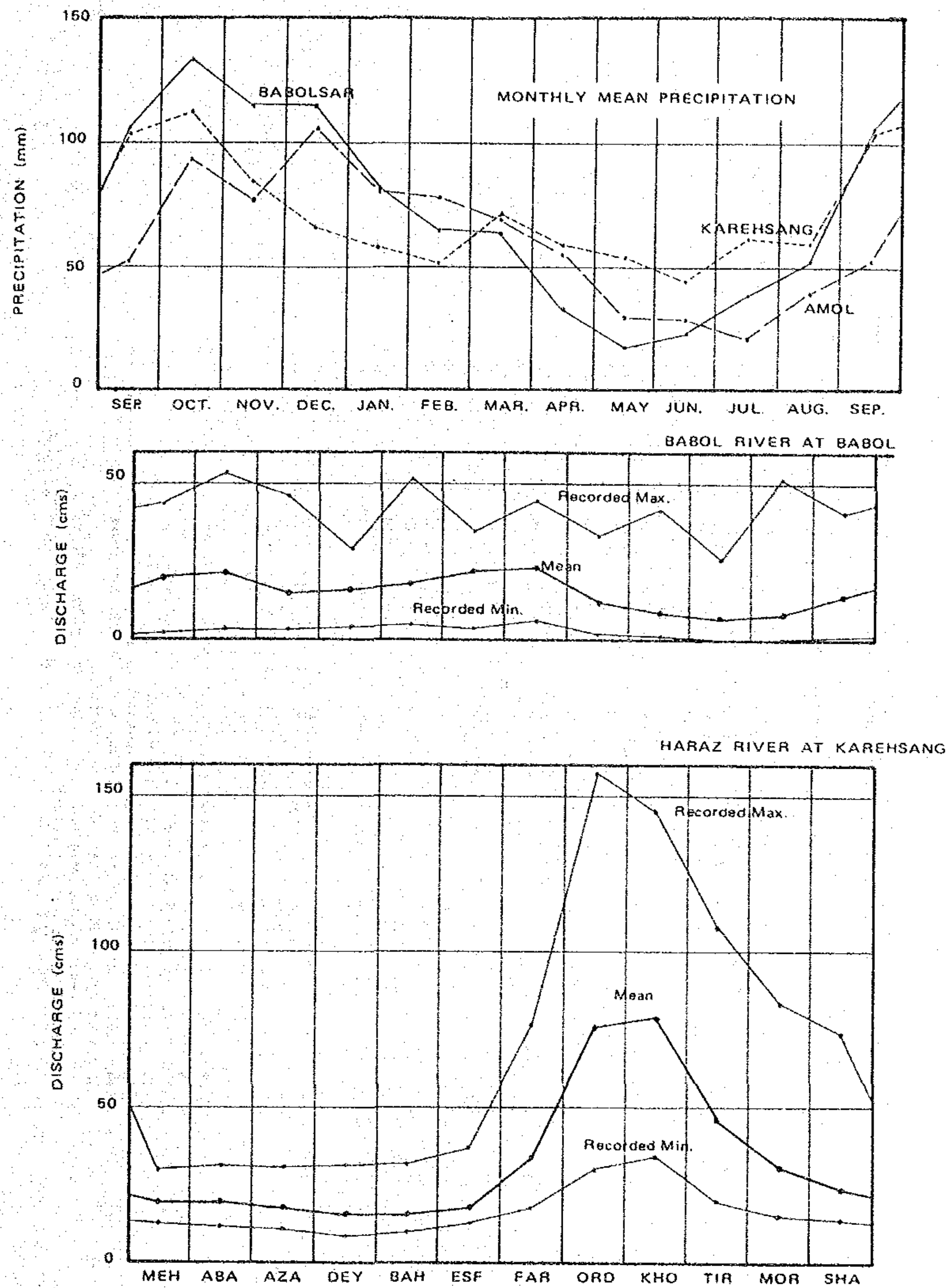
River	Station		Drainage Area (sq.km)	Collected Discharge Records Monthly	Collected Discharge Records Daily
Haraz River					
Lar River	Polour	(H_1)	1,250	1946-83	1946-83
Nur River	Razan	(H_2)	1,270	1969-82	-
Haraz River	Karehsang	(H_3)	4,086	1950-83	1950-83
Haraz River	Ring Road Bridge	(H_5)	(Proposed by JICA Survey Team)		
Haraz River	Sorkh Rud	(H_4)	4,194	1969-82	1975-81
Babol River	Gharan Talar	(B_1)	515	1949-82	1955-82
	Babol	(B_2)	1,430	1949-82	1955-82
	Miandasht Babolsar	(B_3)	-	1970-80	1975-80
Kari Rud	Kom Kola	(K_1)	-	-	-
Mahmudabad River	Mahmudabad	(M_1)	-	-	-
Feredun Kenar River	Feredun Kenar	(F_1)	(Proposed by JICA Survey Team)		

Table A.2.2 Mean Monthly Discharge and Annual Runoff

(Unit : m^3/sec)

	Mehr	Ahan	Azar	Dey	Bahm	Esfa	Farv	Ordi	Khor	Tir	Mord	Shah	Annual m^3/sec	Annual MCM	Annual MCM/km^2
Haraz River															
Lar River at Poloor (1,250 sq.km)	4.9	4.4	3.9	4.7	3.7	3.6	12.9	40.4	38.5	18.1	9.1	5.9	12.7	400	0.320
Nur River at Razan (1,270 sq.km)	2.8	2.6	2.3	2.1	2.1	2.7	6.2	13.3	14.4	7.8	4.2	2.6	5.3	167	0.131
Haraz River at Karehsang (4,086 sq.km)	19.7	20.2	17.9	16.2	15.9	18.2	34.3	78.4	79.3	45.9	51.3	24.4	33.6	1,062	0.260
Haraz River at Sorkh Rud (4,194 sq.km)	3.3	4.3	4.4	4.8	3.9	4.6	5.1	11.3	8.6	1.7	1.5	2.8	4.7	148	0.0353
Babol River															
Gharan Talr (515 sq.km)	8.7	8.0	6.0	5.7	6.7	9.0	11.2	7.1	5.7	4.7	5.2	8.1	7.2	227	0.441
Babol (1,430 sq.km)	19.9	21.5	15.1	15.9	17.9	21.7	23.2	11.8	8.5	6.3	8.3	13.5	15.2	479	0.335
Miandasht Babolsar (-)	14.5	14.4	13.8	15.5	16.8	24.5	20.9	10.2	5.3	6.5	6.0	11.7	13.3	419	-
Garma Rud (84 sq.km)	1.4	1.3	1.0	0.9	1.1	1.5	1.8	1.2	0.9	0.8	0.8	1.3	1.2	37	0.441
Alesh Rud (144 sq.km)	2.4	2.2	1.7	1.6	1.9	2.5	3.1	2.0	1.6	1.3	1.5	2.3	2.0	63	0.441

Note: 1) Garma Rud and Alesh Rud are estimated from the data of Babol river at Gharan Talr where basin characteristic is similar.



ISLAMIC REPUBLIC OF IRAN MINISTRY OF AGRICULTURE	
CASPIAN SEA COASTAL AREA AGRICULTURAL DEVELOPMENT PROJECT	
MONTHLY MEAN DISCHARGE	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	FIGURE A.2.1

Table A.2.3 Monthly Discharge of the Haraz River at Karehsang (MCM) 1329 - 1360

	MEHR	ABAN	AZAR	DEY	BAHM	ESFA	FARV	ORDI	KHOR	TIR	MORO	SHAH	ANNUAL
1329	40.95	36.21	33.69	31.54	30.85	32.39	47.19	80.88	101.00	56.31	40.79	40.18	571.98
1330	35.77	44.67	37.08	34.82	35.94	43.55	115.61	217.49	231.91	167.19	98.32	73.53	1135.88
1331	53.48	53.05	46.23	32.05	35.34	43.46	99.27	203.73	222.82	179.72	137.81	69.98	1176.94
1332	51.94	77.19	57.57	47.59	40.85	32.27	97.87	265.03	280.11	216.47	83.83	65.35	1316.07
1333	51.06	52.36	46.40	41.99	41.47	40.74	62.46	116.03	157.49	83.35	62.54	61.60	817.49
1334	45.88	45.79	48.82	48.04	48.64	52.53	96.94	267.16	265.25	157.59	222.48	198.21	1497.33
1335	54.00	41.46	41.99	33.69	31.19	31.97	56.76	170.64	308.53	289.44	210.13	132.63	1402.43
1336	78.11	82.07	63.33	57.19	47.08	49.94	129.86	191.80	140.14	97.28	66.69	51.06	1054.55
1337	47.69	45.01	44.50	39.83	38.70	37.24	105.58	294.20	262.31	143.77	89.78	66.18	1214.79
1338	54.86	58.15	56.77	57.28	54.87	57.20	88.82	157.43	122.78	77.42	66.69	65.06	917.33
1339	57.11	54.34	48.73	48.74	47.69	43.98	59.53	154.48	114.92	68.86	60.22	56.76	815.36
1340	42.16	42.07	38.19	36.04	39.49	34.30	54.60	155.96	202.43	94.70	56.94	51.98	848.46
1341	45.27	43.21	35.51	33.35	33.18	34.91	74.82	166.07	236.74	121.04	75.87	59.01	958.98
1342	44.23	48.55	45.19	39.40	40.43	41.99	106.19	235.49	150.67	80.70	57.46	53.48	943.78
1343	38.19	38.71	34.82	32.22	33.44	40.87	84.06	281.66	227.76	115.09	68.69	50.89	1046.40
1344	48.82	52.28	45.09	38.88	39.84	41.04	93.83	238.56	206.93	107.31	67.82	45.62	1026.02
1345	46.91	43.12	36.28	35.60	33.69	35.94	51.23	185.94	164.33	81.22	52.35	40.36	806.97
1346	41.90	36.98	34.99	29.03	29.29	48.04	110.68	256.00	360.55	179.97	92.19	62.29	1281.91
1347	46.06	49.85	46.65	43.11	43.54	91.92	204.94	430.01	388.11	250.82	136.85	86.14	1818.00
1348	73.32	83.48	63.44	53.21	46.44	45.12	93.14	116.53	90.45	54.70	45.66	41.82	807.31
1349	46.79	44.92	41.64	41.22	39.92	50.74	103.62	251.95	201.57	100.50	74.10	64.32	1061.29
1350	50.13	52.29	46.07	43.88	42.38	47.42	88.12	264.39	350.60	212.86	155.91	126.55	1480.60
1351	51.64	52.02	53.70	48.59	50.34	60.59	114.26	376.86	382.74	115.16	83.17	54.35	1443.42
1352	51.64	46.17	41.53	31.68	34.98	51.86	95.38	148.08	132.97	104.61	53.38	48.04	840.32
1353	35.42	32.56	28.42	23.34	25.96	35.11	90.69	261.48	352.03	86.79	47.66	37.15	1056.61
1354	37.72	50.31	50.79	46.92	37.72	41.04	71.27	232.88	271.53	163.44	89.44	76.18	1169.24
1355	68.20	68.81	71.50	54.69	59.83	59.31	63.29	164.25	202.63	116.19	94.44	67.68	1090.82
1356	61.21	78.66	46.58	38.70	31.59	46.20	132.43	158.50	149.43	102.87	50.53	36.28	932.98
1357	71.06	79.20	80.74	82.40	83.68	81.17	94.98	155.18	177.16	92.41	66.57	61.21	1125.76
1358	57.80	54.63	45.05	45.65	43.89	45.61	108.75	141.81	115.24	80.19	65.96	56.07	860.65
1359	44.34	45.13	42.47	40.76	40.54	37.83	88.03	139.15	103.15	76.93	54.37	49.18	761.88
1360	57.21	44.82	34.62	33.15	33.71	34.65	54.97	108.89	121.32	61.84	55.45	44.45	685.08
MEAN	50.96	52.44	46.51	42.02	41.14	45.97	91.85	205.89	212.36	123.02	83.88	65.41	1061.45
MAX	78.11	83.48	80.74	82.40	83.68	91.92	204.94	430.01	388.11	289.44	222.48	198.21	1818.00
MIN	35.42	32.56	28.42	23.34	25.96	31.97	47.19	80.88	90.45	54.70	40.79	36.28	571.98
SD	10.61	13.97	11.44	11.21	10.83	13.25	30.81	77.18	88.91	58.15	44.05	32.39	271.84

Note:
1) Above data are complied in monthly basis from daily records supplied from MAHAB GHOTZ.
2) Year is in hydrological year. (e.g. 1329 means 1329 - 30)
3) Daily records have been missed for two years 1332 and 33.
4) For the years 1332 and 33, monthly records have been applied for Meh to Tir in 1332 and for Bah to Shah in 1333, and long term averages have been applied for other months.
5) Observed records have been modified in 3rd 10 day Ord 1330 in connection with runoff at Polour.

Table A.2.4 Monthly Discharge of the Lar River at Polour (MCM) 1329 - 1360

	MEHR	ABAN	AZAR	DEY	BAHM	ESFA	FARV	ORDI	KHOR	TIR	MORD	SHAH	ANNUAL
1329	13.64	10.77	8.93	10.60	10.87	8.80	17.44	50.47	64.98	23.33	17.84	15.11	252.78
1330	14.35	15.10	12.33	21.98	12.47	9.63	87.56	143.86	165.98	92.36	34.12	25.29	635.03
1331	19.34	15.96	14.50	15.26	14.00	12.04	20.51	118.98	116.29	67.56	27.66	19.18	461.28
1332	17.49	17.10	16.51	18.54	15.31	13.67	26.16	179.55	168.65	89.16	51.84	24.20	638.18
1333	12.73	11.32	10.04	16.65	10.84	9.21	30.97	107.61	108.53	50.20	24.55	16.35	409.00
1334	10.39	9.36	10.65	16.36	6.32	6.80	21.83	148.60	116.11	59.09	33.00	20.28	458.79
1335	17.46	15.53	13.77	22.83	14.87	12.64	42.49	147.64	148.90	68.88	33.67	22.41	561.09
1336	15.62	13.16	13.31	13.94	16.04	13.07	62.90	91.15	58.84	33.73	17.88	12.85	362.49
1337	10.07	8.80	9.67	19.65	5.37	9.08	56.36	107.31	94.43	47.44	24.13	16.57	409.38
1338	12.78	9.96	9.74	13.48	6.87	10.17	13.37	58.49	46.66	21.73	15.69	12.38	231.32
1339	10.77	9.69	10.00	10.63	9.01	7.12	10.99	66.00	49.33	28.69	16.69	13.32	242.74
1340	11.18	9.89	9.64	10.44	8.99	10.32	22.18	79.40	87.00	40.17	23.63	17.03	329.87
1341	13.36	11.25	8.69	9.54	8.00	7.08	35.28	96.85	133.31	57.11	31.88	19.77	432.12
1342	13.98	10.82	12.15	18.12	9.48	10.44	48.15	110.34	59.79	22.65	14.58	14.24	344.74
1343	10.24	8.68	8.55	7.52	7.52	8.31	23.11	127.26	85.71	34.31	18.92	13.77	353.90
1344	11.45	11.29	9.85	9.61	8.79	11.35	29.80	94.26	86.48	37.32	20.44	13.10	343.74
1345	12.36	12.20	10.31	8.94	7.87	7.13	12.55	82.77	70.25	27.99	16.76	12.01	281.14
1346	10.48	8.60	8.48	8.30	12.04	7.81	22.51	129.00	184.72	68.34	29.32	23.27	512.87
1347	15.67	14.97	11.35	18.04	15.62	21.13	72.53	231.90	211.08	92.54	47.18	26.84	778.85
1348	18.93	23.44	16.37	14.15	12.33	11.17	39.84	52.83	43.53	23.31	16.42	12.51	284.83
1349	10.03	8.61	8.02	6.83	7.19	8.13	28.97	140.10	120.73	41.07	20.91	14.43	415.02
1350	11.94	10.54	9.00	26.14	23.21	11.23	18.50	139.22	155.97	87.99	36.88	20.08	550.70
1351	18.53	13.58	11.16	11.10	9.50	13.00	43.97	135.94	108.99	41.99	21.25	15.16	444.17
1352	12.30	10.49	10.30	9.04	8.16	7.98	29.44	82.60	68.13	40.72	23.74	18.50	321.40
1353	14.44	9.90	8.01	7.21	5.68	5.39	50.33	102.66	102.56	35.94	18.45	13.37	373.94
1354	10.12	9.19	7.15	7.31	6.06	5.69	14.52	145.52	136.89	62.72	29.48	17.31	451.96
1355	12.42	11.38	8.86	7.59	7.46	9.83	26.46	72.91	87.99	35.65	19.79	15.21	315.55
1356	15.42	14.52	13.11	9.81	8.30	10.39	71.44	106.96	87.61	48.91	25.84	16.37	428.68
1357	11.38	10.96	8.79	7.21	7.65	7.19	58.87	125.48	114.42	58.44	28.61	17.76	456.76
1358	12.25	10.72	7.84	7.60	6.62	6.88	58.35	78.33	75.13	26.80	11.16	2.18	303.86
1359	1.23	2.45	2.13	1.08	0.91	0.77	1.92	87.31	80.25	42.55	10.15	5.40	236.15
1360	4.57	3.15	2.04	1.72	1.56	1.17	1.53	24.08	59.96	44.80	15.26	2.42	162.26
MEAN	12.72	11.36	10.04	12.10	9.53	9.21	34.42	108.29	103.10	48.55	24.30	15.91	399.52
MAX	19.34	23.44	16.51	26.14	23.21	21.13	87.56	231.90	211.08	92.54	51.84	26.84	778.85
MIN	1.23	2.45	2.04	1.08	0.91	0.77	1.53	24.08	43.53	21.73	10.15	2.18	162.26
SD	3.77	3.85	3.16	5.92	4.43	3.71	21.48	41.46	42.55	21.11	9.58	5.70	134.13

Note:
1) Above data are complied in monthly basis from daily records supplied from MAHAB GHOTZ.
2) Year is in hydrological year. (e.g. 1329 means 1329 - 30)
3) Daily records are missed for six years 1333,34,35,53,55 and 57.
4) Monthly records have been applied for four years 1334,53,55 and 57.
5) For the years 1333 and 35, monthly data are derived from annual runoff estimated in Reference 4.
6) Observed records have been modified in 3rd 10 day Ord. 1332, 1st 10 day Bah. 1342, 2nd 10 day Bah. 1346 and 1st Bah. 1350 in connection with Runoff at Karehsang.

Table A.2.5 Monthly Discharge of Residual Area at Karehsang (MCM) 1329 - 1360

	MEHR	ABAN	AZAR	DEY	BAHM	ESFA	FARV	ORDI	KHOR	TIR	MORD	SHAH	ANNUAL
1329	27.31	25.44	24.76	20.94	19.98	23.59	29.75	30.41	36.02	32.98	22.95	25.07	319.20
1330	21.42	29.57	24.75	12.84	23.47	33.92	28.05	73.63	65.93	74.83	64.20	48.24	500.85
1331	34.14	37.09	31.73	16.79	21.34	31.42	78.76	84.75	106.53	112.16	110.15	50.80	715.66
1332	34.45	60.09	41.06	29.05	25.54	18.60	71.71	85.48	111.46	127.31	31.99	41.15	677.89
1333	38.33	41.04	36.36	25.34	30.63	31.53	31.49	8.42	48.96	33.15	37.99	45.25	408.49
1334	35.49	36.43	38.17	31.68	42.32	45.73	75.11	118.56	149.14	98.50	189.48	177.93	1038.54
1335	36.54	25.93	28.22	10.86	16.32	19.33	14.27	23.00	159.63	220.56	176.46	110.22	841.34
1336	62.49	68.91	50.02	43.25	31.04	36.87	66.96	100.65	81.30	63.55	48.81	38.21	692.06
1337	37.62	36.21	34.83	20.18	33.33	28.16	48.72	186.89	167.88	96.33	65.65	49.61	805.41
1338	42.08	48.19	47.03	43.80	48.00	47.03	75.45	98.94	76.12	55.69	51.00	52.68	686.01
1339	46.34	44.65	38.73	38.11	38.68	36.86	48.54	88.48	65.59	40.17	43.53	42.94	572.62
1340	30.98	32.18	28.55	25.60	30.50	23.98	32.42	76.56	115.43	54.53	33.31	34.55	518.59
1341	31.91	31.96	26.82	23.81	25.18	27.83	39.54	69.22	103.43	63.93	43.99	39.24	526.86
1342	30.25	37.73	33.04	21.28	30.95	31.55	58.04	125.15	90.88	58.05	42.88	39.24	599.04
1343	27.95	30.03	26.27	24.70	25.92	32.56	60.95	154.40	142.05	80.78	49.77	37.12	692.50
1344	37.37	40.99	35.24	29.27	31.05	29.69	64.03	144.30	120.45	69.99	47.38	32.52	682.28
1345	34.55	30.92	25.97	26.66	25.82	28.81	38.68	103.17	94.08	53.23	35.59	28.35	525.83
1346	31.42	28.38	26.51	20.73	17.25	40.23	88.17	127.00	175.83	111.63	62.87	39.02	769.04
1347	30.39	34.88	35.30	25.07	27.92	70.79	132.41	198.11	177.03	158.28	89.67	59.30	1039.15
1348	54.39	60.04	47.07	39.06	34.11	33.95	53.30	63.70	46.92	31.39	29.24	29.31	522.48
1349	36.76	36.31	33.62	34.39	32.73	42.61	74.65	111.85	80.84	59.43	53.19	49.89	646.27
1350	38.19	41.75	37.07	17.74	19.17	36.19	69.62	125.17	194.63	124.87	119.03	106.47	929.90
1351	33.11	38.44	42.54	37.49	40.84	47.59	70.29	240.92	273.75	73.17	61.92	39.19	999.25
1352	39.34	35.68	31.23	22.64	26.82	43.88	65.94	65.48	64.84	63.89	29.64	29.54	518.92
1353	20.98	22.66	20.41	16.13	20.28	29.72	40.36	158.82	249.47	50.85	29.21	23.78	682.67
1354	27.60	41.12	43.54	39.61	31.66	35.35	56.75	87.36	134.64	100.72	59.96	58.87	717.28
1355	55.78	57.43	62.64	47.10	52.37	49.48	36.83	91.34	114.64	80.54	74.65	52.47	775.27
1356	45.79	64.14	33.47	28.89	23.29	35.81	60.99	51.54	61.82	53.96	24.69	19.91	504.30
1357	59.68	68.24	71.95	75.19	76.03	73.98	36.11	29.70	62.74	33.97	37.96	43.45	669.00
1358	45.55	43.91	37.21	38.05	37.27	38.73	50.40	65.48	40.11	53.39	54.80	53.89	556.79
1359	43.11	42.68	40.34	39.68	39.63	37.06	86.11	51.84	22.90	34.38	44.22	43.78	525.73
1360	52.64	41.67	32.58	31.43	32.15	33.48	53.44	84.81	61.36	17.04	40.19	42.03	522.82
MEAN	38.25	41.08	36.47	29.92	31.61	36.76	57.43	97.60	109.26	74.48	59.57	49.50	661.94
MAX	62.49	68.91	71.95	75.19	76.03	73.98	132.41	240.92	273.75	220.56	189.48	177.93	1039.15
MIN	20.98	22.66	20.41	10.86	16.32	18.60	14.27	8.42	22.90	17.04	22.95	19.91	319.20
SD	10.33	12.41	10.86	12.57	11.80	12.08	23.00	51.92	60.48	42.05	39.34	30.33	174.80

Note: 1) Year is in hydrological year. (e.g. 1329 means 1329 - 30)
2) Residual discharge = Karehsang discharge - Polour discharge.

Table A.2.6 Monthly Discharge of the Nur River at Razan (cms)

DISCHARGE (NOR R.) RAZAN

YEAR	MEHR	ABAN	AZAR	DEY	BAHM	ESFA	FARV	ORDI	KHOR	TIR	MORD	SHAH	ANNUAL	
1348	5.1	6.0	4.5	3.5	3.2	2.7	5.4	7.6	7.2	3.5	1.9	1.3	4.3	
1349	1.3	1.4	1.3	1.2	1.2	3.0	8.4	16.4	15.6	7.6	3.6	1.4	5.3	
1350	2.1	3.0	2.8	2.4	2.3	2.5	6.8	14.5	18.6	15.7	10.1	6.7	7.4	
1351	3.5	3.2	2.8	2.5	2.8	3.3	5.9	13.3	13.4	6.1	2.3	1.5	5.1	
1352	1.6	1.4	1.1	1.4	1.6	2.8	5.6	8.2	8.7	7.4	4.7	3.2	4.0	
1353	2.0	1.5	1.3	1.4	1.3	1.3	5.1	13.6	17.4	7.6	1.8	1.5	4.7	
1354	1.8	1.9	1.7	1.7	1.6	1.7	6.1	17.0	15.7	10.3	4.3	3.1	5.7	
1355	4.9	2.9	2.9	3.0	2.9	3.9	6.0	15.6	18.9	4.5	4.5	2.2	6.1	
AVER	2.8	2.6	2.3	2.1	2.1	2.7	6.2	13.3	14.4	7.8	4.2	2.6	5.3	5.3
SD	1.4	1.4	1.1	0.8	0.7	0.8	1.0	3.3	4.1	3.6	2.5	1.7		1.0
MAX	5.1	6.0	4.5	3.5	3.2	3.9	8.4	17.0	18.9	15.7	10.1	6.7		7.4
MIN	1.3	1.4	1.1	1.2	1.2	1.3	5.1	7.6	7.2	3.5	1.8	1.3		4.0

Table A.2.7 Monthly Discharge of the Haraz River at Sorkh Rud (cms)

DISCHARGE(HARAZ R.) SORK RUD

YEAR	MEHR	ABAN	AZAR	DEY	BAHM	ESFA	FARV	ORDI	KHOR	TIR	MORD	SHAH	ANNUAL	
1344	2.1	2.8	1.7	2.4	2.0	2.1	1.0	7.1	6.1	0.2	0.3	1.4	2.4	
1345	3.8	4.2	1.6	2.3	2.3	2.2	0.7	7.8	2.0	0.1	0.2	0.2	2.3	
1346	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	******	
1347	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	******	
1348	1.7	*****	*****	*****	*****	6.6	4.3	0.3	0.1	0.0	0.5	0.8	******	
1349	1.0	0.7	0.9	1.0	1.0	0.8	0.7	8.4	6.2	0.5	0.6	0.8	1.9	
1350	1.1	2.5	2.7	3.1	3.3	3.3	1.5	8.5	20.4	9.0	5.8	7.2	5.8	
1351	13.3	10.9	11.2	11.5	11.1	11.2	8.2	19.2	7.9	0.0	0.0	4.0	9.0	
1352	3.6	3.1	3.7	3.9	4.6	5.6	7.0	0.8	0.1	2.9	1.0	2.7	3.2	
1353	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	******	
1354	0.2	0.0	1.4	2.9	0.1	0.1	3.7	38.6	40.8	0.8	0.7	0.1	7.6	
1355	2.5	5.1	3.0	4.2	3.2	3.1	2.1	0.1	0.1	0.0	1.8	4.1	2.4	
1356	3.8	8.8	16.5	7.4	5.5	11.8	9.1	17.2	2.2	0.1	0.1	0.3	6.9	
1357	2.1	7.2	5.4	6.6	7.1	8.9	3.7	18.6	13.0	1.4	4.4	3.7	6.8	
1358	3.4	2.0	1.0	1.9	1.6	1.2	22.0	*****	*****	*****	0.1	1.5	******	
1359	1.1	4.7	3.7	3.4	0.9	3.3	4.9	19.1	11.9	6.1	2.6	7.7	5.8	
1360	6.7	4.6	4.8	11.2	7.8	4.7	2.1	0.6	0.6	0.8	3.4	4.5	4.3	
AVER	3.3	4.3	4.4	4.8	3.9	4.6	5.1	11.3	8.6	1.7	1.5	2.8	4.7	4.9
SD	3.2	3.0	4.4	3.3	3.1	3.6	5.4	10.6	11.0	2.7	1.8	2.4		2.3
MAX	13.3	10.9	16.5	11.5	11.1	11.8	22.0	38.6	40.8	9.0	5.8	7.7		9.0
MIN	0.2	0.0	0.9	1.0	0.1	0.1	0.7	0.1	0.1	0.0	0.0	0.1		1.9

Table A.2.8 Monthly Discharge of the Babol River at Gharan Talar (cms)

DISCHARGE(BABOL R.) GHARAN TALAR

YEAR	MEHR	ABAN	AZAR	DEY	BAHM	ESFA	FARV	ORDI	KHOR	TIR	MORD	SHAH	ANNUAL	
1328	*****	*****	*****	7.4	2.4	3.9	4.9	4.1	9.2	4.9	6.2	5.6	******	
1329	4.4	7.1	7.0	5.3	7.0	11.1	6.7	5.5	1.8	2.1	1.2	3.7	5.2	
1330	15.6	14.0	6.7	4.4	7.0	11.9	8.6	13.2	5.1	9.7	1.0	6.8	8.6	
1331	3.1	4.8	3.6	4.4	5.1	8.3	16.7	4.8	5.0	2.9	16.6	10.8	7.2	
1332	8.1	8.0	5.4	7.3	4.4	8.3	13.7	5.4	1.7	3.5	12.3	7.2	7.1	
1333	5.0	4.6	5.0	3.9	2.7	7.0	7.8	5.5	5.9	2.5	2.4	6.3	4.9	
1334	7.4	3.9	3.9	3.9	6.1	8.9	13.6	4.7	5.5	1.4	3.7	4.6	5.6	
1335	11.9	4.4	5.9	4.9	7.6	8.3	11.6	3.2	17.6	8.5	7.4	3.7	7.9	
1336	12.1	15.9	9.0	7.0	3.9	4.4	9.6	4.0	6.1	7.5	5.9	5.6	7.6	
1337	8.6	10.8	8.7	4.9	14.9	13.3	16.6	14.3	5.9	3.7	4.3	10.6	9.7	
1338	10.8	20.5	12.2	5.2	3.7	7.7	18.3	7.1	5.0	9.4	4.1	12.0	9.7	
1339	5.3	11.0	6.7	8.4	7.2	9.0	13.2	4.3	5.8	1.1	3.5	14.2	7.5	
1340	11.9	11.1	6.5	5.1	10.9	5.8	10.9	7.8	13.4	2.5	2.5	10.1	8.2	
1341	7.1	9.8	3.8	3.1	3.9	7.2	6.6	20.0	4.9	4.3	5.6	10.5	7.2	
1342	32.9	8.3	7.1	7.7	9.9	12.6	16.0	6.2	1.3	2.3	8.5	21.9	11.2	
1343	6.5	6.9	3.8	5.1	5.6	8.6	7.4	5.6	1.1	4.5	7.1	7.7	5.8	
1344	6.0	6.3	3.8	8.0	4.1	12.3	10.6	11.6	2.2	2.1	2.2	4.5	6.1	
1345	28.8	3.6	1.3	1.7	5.5	7.4	16.6	6.0	4.4	1.2	4.1	3.7	7.0	
1346	12.5	4.6	4.2	9.5	9.8	12.5	13.7	8.7	14.1	8.9	4.0	7.1	9.1	
1347	1.7	12.3	9.4	3.2	7.4	8.3	10.8	2.6	2.1	6.2	8.7	14.6	7.3	
1348	10.2	13.9	10.4	9.8	7.8	10.5	7.8	4.8	5.0	2.4	8.3	18.5	9.1	
1349	4.9	7.2	4.9	5.6	9.5	10.0	8.9	3.5	1.9	1.9	0.9	1.8	5.1	
1350	1.1	3.4	2.6	4.2	4.7	10.2	14.0	15.8	9.0	3.9	4.5	2.7	6.4	
1351	1.5	1.7	5.4	5.3	7.3	6.7	9.4	6.9	4.1	5.8	1.6	18.9	6.2	
1352	6.6	5.4	5.0	4.5	8.1	13.7	15.4	6.4	3.1	9.3	5.5	7.8	7.5	
1353	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	******	
1354	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	******	
1355	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	******	
1356	8.8	7.5	4.6	3.9	8.1	8.1	6.3	5.7	8.2	6.8	4.3	5.6	6.5	
1357	4.1	7.0	6.5	6.4	7.7	8.1	9.3	10.1	7.9	5.0	6.3	4.4	6.9	
1358	3.4	5.5	6.4	5.6	6.6	10.0	10.3	4.6	3.7	3.4	3.9	6.9	5.8	
1359	5.6	8.6	5.5	6.8	4.5	6.8	13.9	6.5	6.2	8.5	4.9	4.3	6.8	
1360	6.5	4.9	8.5	8.6	6.5	8.2	7.9	4.1	4.3	4.2	3.4	1.8	5.7	
AVER	8.7	8.0	6.0	5.7	6.7	9.0	11.2	7.1	5.7	4.7	5.2	8.1	7.2	7.2
SD	7.0	4.2	2.4	1.9	2.6	2.4	3.6	4.0	3.8	2.7	3.3	5.1		1.5
MAX	32.9	20.5	12.2	9.8	14.9	13.7	18.3	20.0	17.6	9.7	16.6	21.9		11.2
MIN	1.1	1.7	1.3	1.7	2.4	3.9	4.9	2.6	1.1	1.1	0.9	1.8		4.9

Table A.2.9 Monthly Discharge of the Babol River at Babol (cms)

DISCHARGE(BABOL R.) BABOL

YEAR	MEHR	ABAN	AZAR	DEY	BAHM	ESFA	FARV	ORDI	KHOR	TIR	MORD	SHAH	ANNUAL	
1328	32.9	20.9	11.7	27.3	22.0	24.3	19.2	11.5	20.0	6.4	9.1	16.8	18.4	
1329	7.4	11.7	14.5	15.0	18.3	24.4	11.9	5.6	1.1	1.6	0.4	4.3	9.6	
1330	32.5	36.9	19.6	12.8	21.7	27.4	17.9	34.3	7.1	20.6	1.7	8.7	20.0	
1331	9.0	19.7	8.8	17.7	11.7	22.8	43.4	10.9	15.6	3.1	52.0	22.8	19.9	
1332	21.1	17.5	12.6	14.6	12.3	21.2	24.7	13.3	6.0	5.5	13.1	18.1	15.0	
1333	27.0	24.8	17.6	10.3	7.9	18.1	21.1	10.6	14.9	5.8	5.4	11.7	14.5	
1334	20.5	15.6	14.4	13.8	23.4	28.3	38.1	9.8	13.7	2.1	6.4	10.7	16.3	
1335	24.5	9.5	13.6	12.1	17.8	15.2	19.0	6.1	41.7	26.3	32.1	9.0	19.0	
1336	34.8	53.2	27.8	25.0	13.3	8.9	17.9	9.1	5.7	14.6	10.2	11.4	19.2	
1337	19.7	15.6	23.7	15.7	51.8	34.7	35.8	19.5	8.4	3.9	4.4	20.2	21.0	
1338	24.5	64.0	47.0	20.9	11.2	23.8	44.7	11.7	6.5	13.6	7.6	24.6	24.9	
1339	15.4	32.6	15.2	26.1	18.2	19.6	20.6	8.6	9.6	0.7	5.9	34.3	17.2	
1340	34.2	27.8	18.6	16.7	23.3	14.7	17.6	16.2	18.6	3.5	2.0	14.1	17.2	
1341	18.5	21.3	12.8	8.3	9.5	21.5	21.4	25.3	10.8	6.4	10.4	21.9	15.7	
1342	45.5	25.4	28.1	30.4	27.6	34.0	38.4	10.1	1.3	2.3	10.7	40.8	24.4	
1343	17.7	17.8	9.8	18.5	14.7	21.6	17.4	19.8	2.3	4.7	10.8	11.1	13.8	
1344	12.7	14.4	6.9	20.9	7.3	21.4	13.7	22.1	2.8	1.5	9.0	7.7	11.6	
1345	38.6	9.9	4.4	5.8	19.0	21.9	42.2	9.5	6.1	0.8	1.8	10.4	14.1	
1346	33.5	24.2	11.6	26.1	26.9	30.5	37.0	19.9	17.9	10.6	6.5	8.7	21.0	
1347	4.2	30.3	20.7	8.9	23.5	29.2	35.1	6.4	4.1	8.6	15.3	25.1	17.5	
1348	21.2	46.0	29.4	28.3	23.2	22.8	15.5	4.8	3.4	0.0	8.0	32.7	19.5	
1349	8.8	11.8	6.6	11.2	21.5	15.1	17.1	4.2	1.3	0.2	0.1	1.4	8.2	
1350	3.5	9.0	3.4	7.7	10.8	28.0	29.4	22.3	7.9	2.4	8.9	3.8	11.4	
1351	2.7	3.6	14.7	19.3	20.9	13.4	16.3	6.9	3.1	5.9	1.0	3.4	9.2	
1352	17.3	15.5	20.1	16.3	29.1	35.3	33.0	12.9	2.8	19.2	7.6	15.8	18.6	
1353	11.5	4.6	5.4	9.3	13.6	25.7	8.9	5.2	1.5	0.1	0.9	4.6	7.5	
1354	14.6	14.7	16.3	10.1	9.8	34.4	29.9	18.4	11.6	10.0	5.6	11.9	15.5	
1355	27.7	33.9	18.2	24.4	19.5	14.4	7.6	2.0	1.1	6.6	11.3	16.7	15.2	
1356	23.2	26.6	12.1	13.6	14.1	17.6	6.0	5.0	16.5	7.6	0.8	1.7	12.0	
1357	2.1	7.2	5.9	13.5	15.6	12.1	7.0	8.1	0.9	0.2	2.3	1.2	6.3	
1358	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	******	
1359	13.3	12.4	6.8	4.1	4.5	9.5	22.5	4.7	1.8	2.5	2.9	4.1	7.4	
1360	16.4	8.3	5.1	4.5	8.5	3.6	10.8	4.1	4.7	3.1	2.3	2.9	6.2	
AVER	19.9	21.5	15.1	15.9	17.9	21.7	23.2	11.8	8.5	6.3	8.3	13.5	15.2	15.2
SD	11.0	13.7	9.0	7.2	8.8	7.9	11.2	7.4	8.3	6.4	9.9	10.0		5.1
MAX	45.5	64.0	47.0	30.4	51.8	35.3	44.7	34.3	41.7	26.3	52.0	40.8		24.9
MIN	2.1	3.6	3.4	4.1	4.5	3.6	6.0	2.0	0.9	0.0	0.1	1.2		6.2

Table A.2.10 Monthly Discharge of the Babol River at Miandasht Babolsar (cms)

DISCHARGE(BABOL R.) MIANDASHT

YEAR	MEHR	ABAN	AZAR	DEY	BAHM	ESFA	FARV	ORDI	KHOR	TIR	MORD	SHAH	ANNUAL	
1349	10.7	15.3	10.7	12.6	18.0	16.1	16.5	8.2	4.2	0.8	1.9	2.7	9.7	
1350	4.8	7.8	5.0	8.4	11.3	17.7	16.2	18.4	*****	*****	*****	*****	******	
1351	4.1	5.1	19.2	19.4	16.7	9.8	13.9	6.3	3.6	4.9	0.8	35.5	11.6	
1352	17.5	12.8	16.4	15.1	27.1	43.4	60.6	11.0	2.9	24.8	19.4	15.4	22.2	
1353	7.9	4.7	4.4	7.6	9.8	16.4	6.1	5.3	2.9	0.0	1.5	1.9	5.6	
1354	22.9	23.2	26.2	25.6	16.9	51.1	45.1	26.6	14.4	10.9	7.3	15.6	23.7	
1355	28.5	22.8	20.0	23.5	17.7	15.9	9.1	1.0	5.1	8.0	14.8	22.5	15.7	
1356	31.5	27.1	15.2	10.4	16.3	17.0	6.0	6.9	14.5	9.1	2.1	2.4	13.1	
1357	2.8	9.9	8.4	18.5	15.3	19.7	11.7	12.8	0.2	0.1	6.1	2.1	8.9	
1358	14.5	15.4	12.1	13.5	18.6	38.2	24.1	5.7	0.0	0.0	0.0	6.9	12.2	
AVER	14.5	14.4	13.8	15.5	16.8	24.5	20.9	10.2	5.3	6.5	6.0	11.7	13.3	13.6
SD	9.8	7.5	6.6	5.9	4.4	13.4	17.1	7.1	5.1	7.6	6.5	11.0		5.6
MAX	31.5	27.1	26.2	25.6	27.1	51.1	60.6	26.6	14.5	24.8	19.4	35.5		23.7
MIN	2.8	4.7	4.4	7.6	9.8	9.8	6.0	1.0	0.0	0.0	0.0	1.9		5.6

A.2.2. Water Temperature of Haraz River

Rice growing may suffer from cool water damage, because runoff water depends on snowmelt during irrigation period. However, cool water damage is not reported by the Ministry of Agriculture. For clarifying water temperature, MOA started the observation of water temperature in the Haraz river.

Table A.2.11. Water Temperature of the Haraz River

Date	Weather	Water Temperature (°C) Kari Diversion	Water Temperature (°C) Ring Road Bridge	Difference Between Two Points
17 Apr'85 (64.1.28)	Semi-cloudy	10.1	12.5	2.4
25 Apr'85 (64.2. 5)	Clear	13.8	15.9	2.1
3 May'85 (64.2.13)	Rainy	13.0	13.9	0.9
12 May'85 (64.2.23)	Clear	14.8	16.4	1.6
23 May'85 (64.3. 2)	Semi-clear	15.1	17.6	2.5
2 Jun'85 (64.3.12)	Clear	17.5	19.9	2.4
12 Jun'85 (64.3.22)	Clear	17.7	19.1	1.4
22 Jun'85 (64.4. 1)	Clear	19.4	22.0	2.6
2 Jul'85 (64.4.11)	Clear	19.1	20.8	1.7
15 Jul'85 (64.4.24)	Cloudy	20.1	21.4	1.3
25 Jul'85 (64.5. 3)	Cloudy	19.9	21.6	1.7
4 Aug'85 (64.5.13)	Clear	22.0	24.6	2.6
14 Aug'85 (64.5.23)	Clear	20.5	23.0	2.5
24 Aug'85 (64.6. 2)	Cloudy	20.4	21.8	1.4
3 Sep'85 (64.6.12)	Semi-clear	21.1	21.8	0.7
14 Sep'85 (64.6.23)	Clear	21.6	21.8	0.2
24 Sep'85 (64.7. 2)	Semi-clear	21.2	22.0	0.8
10 Oct'85 (64.7.18)	Semi-cloudy	16.8	17.7	0.9
19 Oct'85 (64.7.27)	Cloudy	14.0	14.6	0.6
28 Oct'85 (64.8. 6)	Rainy	13.8	14.5	0.7
10 Nov'85 (64.8.19)	Cloudy	13.7	14.2	0.5
19 Nov'85 (64.8.28)	Rainy	12.2	12.6	0.4
27 Nov'85 (64.9. 6)	Cloudy	11.4	12.0	0.6
8 Dec'85 (64.9.17)	Clear	8.4	9.0	0.6
19 Dec'85 (64.9.28)	Semi-cloudy	10.8	11.2	0.4
28 Dec'85 (64.10.7)	Clear	8.6	9.6	1.0
9 Jan'86 (64.10.19)	Clear	10.2	11.2	1.0
19 Jan'86 (64.10.29)	Clear	6.7	7.4	0.7
29 Jan'86 (64.11. 9)	Clear	6.4	7.0	0.6
? Feb'86 (64.11. ?)	Semi-cloudy	7.5	8.3	0.8
? Feb'86 (64.11. ?)	Clear	6.5	6.9	0.4
27 Feb'86 (64.12. 8)	Clear	11.0	11.5	0.5
11 Mar'86 (64.12.20)	Cloudy	8.5	9.5	1.0
? Mar'86 (64.12. ?)	Clear	6.0	6.8	0.8

- to be continued -

Date	Weather	Water Temperature (°C) Kari Diversion	Ring Road Bridge	Difference Between Two Points
26 Mar'86 (65.1. 6)	-	-	-	-
5 Apr'86 (65.1.16)	Rainy	11.0	11.8	0.8
15 Apr'86 (65.1.26)	Clear	14.8	17.0	2.2
24 Apr'86 (65.2. 4)	Semi-cloudy	12.5	14.0	1.5
3 May'86 (65.2.13)	Cloudy	14.5	15.5	1.0
12 May'86 (65.2.22)	Cloudy	13.8	14.3	0.5
22 May'86 (65.3. 1)	Semi-cloudy	16.4	17.0	0.6
1 Jun'86 (65.3.11)	Clear	16.0	17.4	1.4
11 Jun'86 (65.3.21)	Cloudy	18.0	19.2	1.2
22 Jun'86 (65.4. 1)	Cloudy	19.5	17.1	-2.4
1 Jul'86 (65.4.10)	Cloudy	20.0	21.0	1.0
13 Jul'86 (65.4.22)	Cloudy	20.0	22.0	2.0

Data Source: Amol Agricultural Office

A.2.3. Water Quality

The Haraz river has not any particular harm on its water quality as irrigation water as see in Table A.2.12. There is no harm on salinity, because a electrical conductivity is only 550 micro mhos/cm in average. However, it increases to more than 750 micro mhos/cm sometimes, when river discharge decreases less than 20 cms. It does not cause any harm, because such high concentration occurs during the non-irrigation period.

As see in Figure A.2.3 showing a relation between river discharge and electrical conductivity, electrical conductivity increases sharply when river discharge becomes less than 30 cms. Higher electrical conductivity is caused by prominent mineral water when low discharge stage. Major springs are shown in Table A.2.12 (2). This phenomenon is remarkable especially in the Garma Rud which has mineral springs in its river basin. This causes a severe problem on irrigation in the Garma Rud command area.

Figure A. 2. 2. Water Temperature of the Haraz River

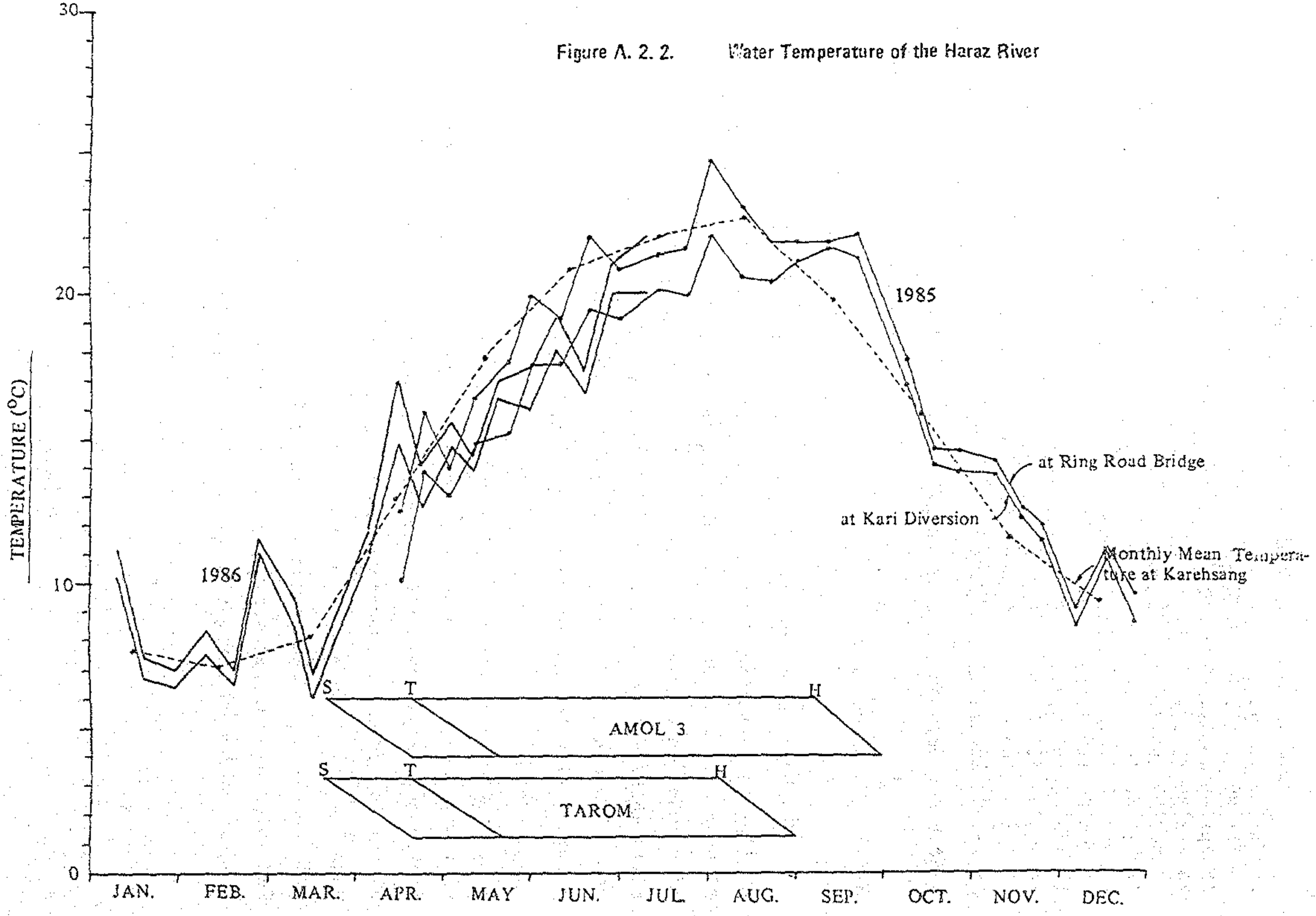


Table A.2.12 (1). Water Quality of the Haraz River

	SAR	Ion (meq/ℓ) Sum Cation	K^+	Na^+	Mg^{++}	Ca^{++}	Sum Anion	SO_4^-	Cl^-	HCO_3^-	CO_3^-	PH	$EC\times10^6$ 25°C	TDS (mg/ℓ)	Dis-charge (cms)
Mean	0.52	5.47	0.01	0.81	1.71	2.94	5.32	2.21	0.56	2.28	0.27	8.2	546	349	56.25
SD	0.13	1.57	0.03	0.29	0.71	0.77	1.53	0.95	0.15	0.61	0.17	0.1	179	111	49.28
Max.	0.94	7.80	0.10	1.44	3.60	4.40	8.25	4.45	0.85	3.80	0.60	8.7	900	570	151
Min.	0.32	3.15	0	0.40	0.50	1.90	3.25	1.11	0.30	1.30	0	8.0	300	200	8.306

Note : recorded from Oct. 1967 to Feb. 1969 at Karehsang.

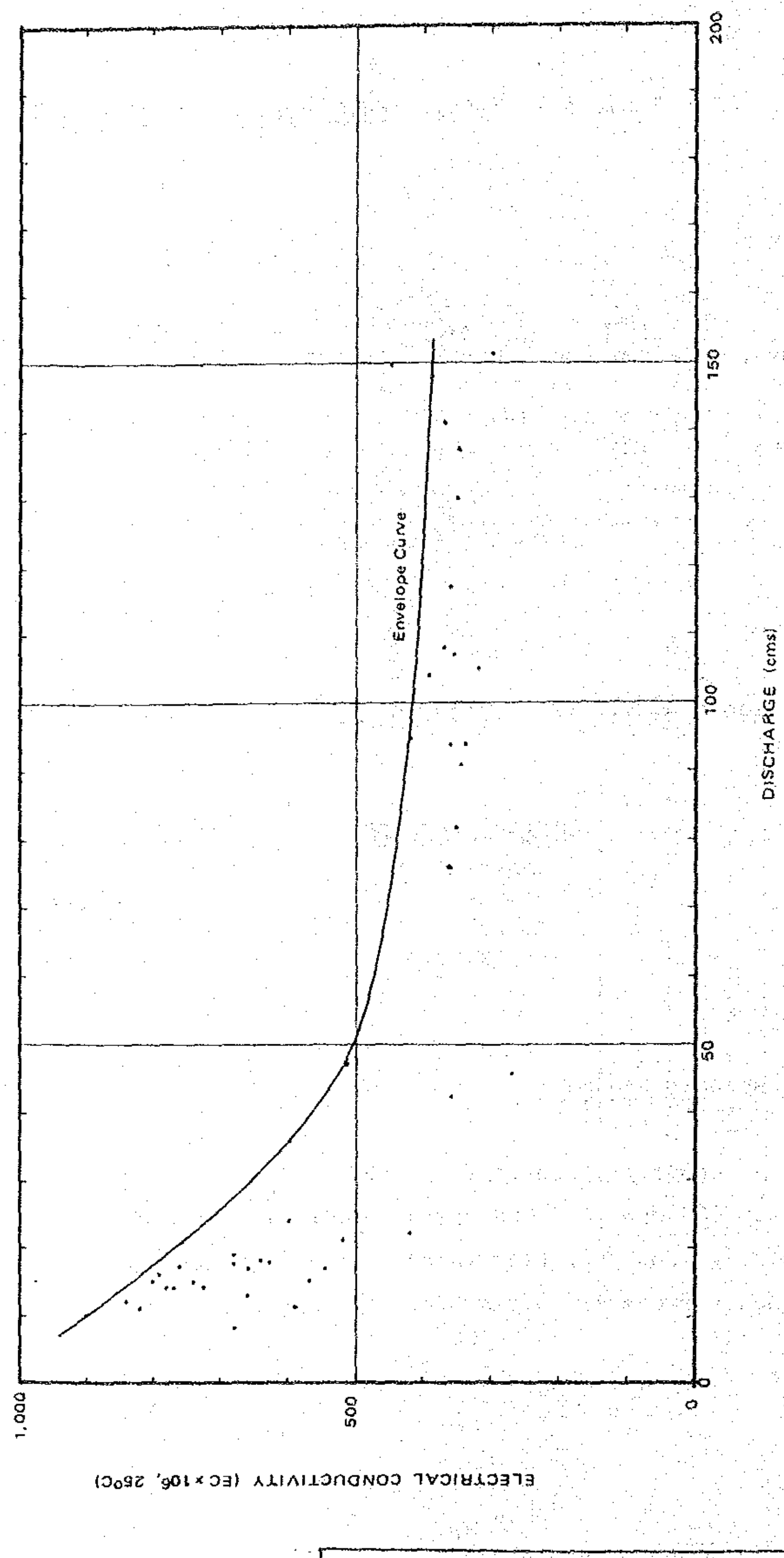
Data Source: Quality of Surface Water of Iran, Vol. I, No.17
Ministry of Water and Power

Table A.2.12 (2). Major Mineral Springs in the Haraz River Basin

Mineral Springs	Electrical Conductivity (EC x 10^6 at 25°C)
Abgarm	880
Amolo	1,500
Abask	3,700
Estrabako	2,600

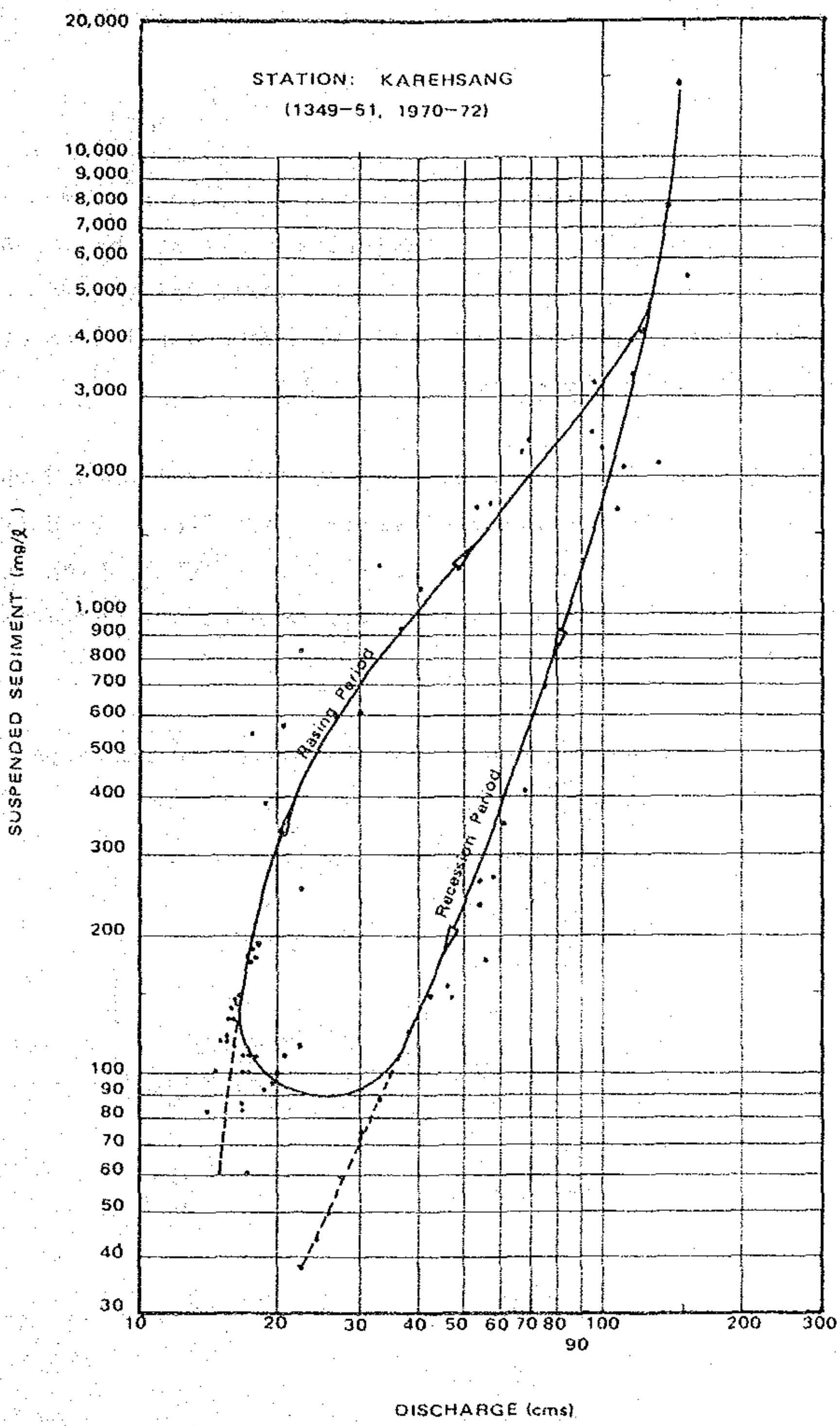
Suspended Sediment

Concentration of suspended sediment of the Haraz river differs from 100 ppm to 5,000 ppm by river discharge as shown in Figure A.2.4. Concentration is considerably higher during a raising period than a recession period even at same discharge.



ISLAMIC REPUBLIC OF IRAN MINISTRY OF AGRICULTURE
CASPIAN SEA COASTAL AREA AGRICULTURAL DEVELOPMENT PROJECT
DISCHARGE VS EC OF HARAZ RIVER AT KAREHSANG

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	FIGURE A.2.3



ISLAMIC REPUBLIC OF IRAN MINISTRY OF AGRICULTURE	
CASPIAN SEA COASTAL AREA AGRICULTURAL DEVELOPMENT PROJECT	
RATING CURVE OF SUSPENDED SEDIMENT OF HARAZ RIVER	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	FIGURE A.2.4

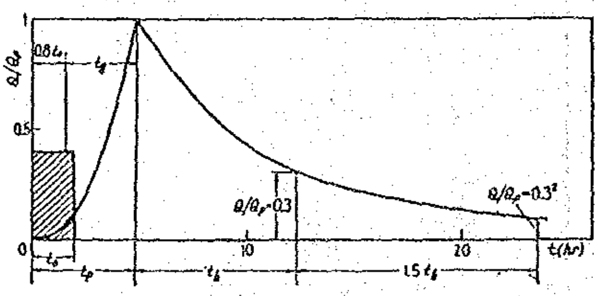
A.2.4. Flood Analysis

1) Flood Discharge

Floods have been analysed in the concerned four rivers of Haraz, Babol, Alesh and Garma. Statistical analysis has been applied to the Haraz and the Babol rivers using daily maximum records, and synthetic unit hydrograph has been applied to other two rivers due to no observed data.

Statistical analysis has been done by the Iwai method which is based on the logarithmic-normal distribution. Synthetic unit hydrograph has been developed by the Nakayasu method which is recommended to the basins in Japan. The results are summarized in Table A.2.17.

Synthetic unit hydrograph is developed in the following manner by the Nakayasu method.



$$Q_p = \frac{0.2778\ A\ Ro}{0.3t_p + t_k}$$

Where;

Q_p = peak discharge (m^3/sec)

A = drainage area (km^2)

R_o = effective unit rainfall (mm)

t_p = time to peak discharge from beginning of unit rainfall (hr)

t_k = $0.47(AL)^{0.25}$

L = Maximum length of water course of the basin (km)

Time to peak discharge (t_p) is;

$$t_p = 0.8\ to + t_g$$

Where;

t_o = unit time = (0.5 - 1.0) t_g (hr)

$t_g = 0.21\ L^{0.7}$ for L < 15 km (hr)

$0.4 + 0.058L$ for L > 15 km

Unit hydrograph is developed in following equations using above data;

Rising limb $$\frac{Q}{Q_p} = (\frac{t}{t_p})^{2.4}$$

Recession limb $$\frac{Q}{Q_p} = 0.3^{\frac{t-t_p}{t_k}} \quad \text{----- for } 1 \geqq \frac{Q}{Q_p} \geqq 0.3$$

$$\frac{Q}{0.3Q_p} = 0.3^{\frac{t-(t_p+t_k)}{1.5t_k}} \quad \text{----- for } 0.3 \geqq \frac{Q}{Q_p} \geqq 0.3^2$$

$$\frac{Q}{0.3^2Q_p} = 0.3^{\frac{t-(t_p+t_k+15t_k)}{2.0t_k}} \quad \text{-- for } 0.3^2 \geqq \frac{Q}{Q_p}$$

i) Garma Rud

The Garma Rud has been analysed at the confluence of the Kari Rud. For estimating flood in the Kari Rud, side flow basin to the Kari Rud has been taken in the drainage basin of the Garma Rud as shown in the drainage basin map. (Garma Rud 84 km^2 + side flow basin 30 + 11 km^2)

- Unit Hydrograph

  Drainage area $A = 125\ km^2$

  Water course $L = 27.4\ km$

  $t_g = 2.0$ hrs ($L > 15$ km)

  $t_k = 0.47\ (AL)^{0.25} = 3.6$ hrs

  $t_o = 2.0$ hrs ($1.0 \times t_g$)

  $t_p = t_g + 0.8\ to = 3.6$ hrs

  $R_o = 10$ mm (effective unit rainfall)

  $$Qp = \frac{0.2778\ A\ Ro}{0.3\ tp + tk} = 74.2\ m^3/sec$$

Table A.2.13. Unit Hydrograph of the Garma Rud

(Ro = 10 mm, to = 2 hrs)

Time (t hr)	0.5	1.0	1.5	2.0	2.5	3.0	3.6
Discharge (m^3/sec)	0.7	3.4	9.1	18.1	30.9	47.9	74.2
Time (t hr)	4.0	4.5	5.0	6	7	8	9
Discharge (m^3/sec)	64.9	54.9	46.4	33.2	23.8	18.6	14.9
Time (t hr)	10	11	12	13	14	15	16
Discharge (m^3/sec)	11.9	9.6	7.6	6.2	5.3	4.5	3.8
Time (t hr)	17	18	19	20	21	22	24
Discharge (m^3/sec)	3.2	2.7	2.3	1.9	1.6	1.4	1.0

- Rainfall

Flood has been analysed in three cases of rainfall as below;

1) 1/25 years rainfall 170 mm/day
2) 1/10 years rainfall 130 mm/day
3) 1/10 years rainfall 78 mm/day

Rainfall 3) is areal rainfall of 759 km^2 (Garma Rud basin 114 km^2 + Kari command 453 km^2 Haraz Right Bank Command 192 km^2) reduced by size of area.

- Flood Discharge

Distributing daily discharge to each 2 hours, flood discharges are estimated as follows;

Table A.2.14 Flood Discharge of the Garma Rud

Rainfall	Time (hrs) 2	4	6	8	10	12	14	16	18	20	22	24
1/25 years rainfall(mm)	5.3	6.0	7.1	9.2	15.2	43.8	11.3	8.0	6.5	5.6	5.0	4.7
Discharge (m^3/sec)	9.6	45	69	93	128	233	388	283	215	174	144	124
1/10 years rainfall(mm)	4.0	4.6	5.5	7.1	11.6	33.5	8.6	6.1	5.0	4.3	3.8	3.6
Discharge (m^3/sec)	7.2	34	53	71	99	178	297	212	165	134	110	95
1/10 years rainfall(mm) ..... areal reduction	2.4	2.7	3.3	4.2	7.0	20.1	5.2	3.7	3.0	2.6	2.3	2.2
Discharge (m^3/sec)	4.3	21	32	43	59	107	178	130	98	77	62	50

Runoff coefficient (f) is estimated at 0.75 considering the characteristics of the basin which is formed by the Tertiary and covered with thin deposit.

ii) Alesh Rud

The Alesh Rud has been analysed at the confluence of the Nafara Rud where drainage area is 312 km^2 including the side flow basin of the Valekan Rud. (side flow basin 22 km^2 + Angta Rud and Nafara Rud 144 km^2)

- Unit Hydrograph

Drainage area A = 312 km^2

Water course L = 32 km

t_g = 2.3 hrs (L > 15 km)

$t_R = 0.47\ (312 \times 32)^{0.25} = 4.7$ hrs

t_o = 2 hrs ($\doteqdot 1.0 \times t_g$)

$t_p = t_g$ = 0.7 to = 3.9 hrs

R_o = 10 mm (effective unit rainfall)

$$Q_p = \frac{0.2778\ A\ Ro}{0.3\ t_p + t_k} = 147.7\ m^3/sec$$

Table A.2.15 Unit Hydrograph of the Alesh Rud

(Ro = 10 mm, to = 2 hrs)

Time (t hrs)	0.5	1.0	1.5	2.0	2.5	3.0	3.5
Discharge (m^3/sec)	1.0	5.6	14.9	29.7	50.8	78.8	105.3

Time (t hrs)	3.9	4.0	4.5	5	6	7	8
Discharge (m^3/sec)	147.7	144.0	126.7	111.4	86.3	66.8	51.7

Time (t hrs)	9	10	11	12	13	14	15
Discharge (m^3/sec)	41.4	35.0	29.5	25.0	21.0	17.7	14.9

Time (t hrs)	16	17	18	20	22	24
Discharge (m^3/sec)	12.8	11.2	9.9	7.7	5.9	4.6

- Rainfall

Flood has been analysed in following two cases;

1) 1/25 years rainfall 122 mm/day (reduced from 170 mm by area)
2) 1/10 years rainfall 98 mm/day (reduced from 130 mm by area)

- Flood Discharge

By the same manner of the Garma Rud, flood discharges are estimated as follows;

Table A.2.16 Flood Discharge of the Alesh Rud

	Time (hrs)											
Rainfall	2	4	6	8	10	12	14	16	18	20	22	24
1/25 years rainfall(mm)	3.8	4.3	5.2	6.7	11.0	31.4	8.0	5.7	4.7	4.0	3.5	3.4
Discharge (m^3/sec)	11	68	110	152	210	361	641	509	401	333	283	244
1/10 years rainfall(mm)	3.0	3.5	4.1	5.3	8.8	25.3	6.5	4.7	3.8	3.2	2.9	2.7
Discharge (m^3/sec)	8.9	54	89	120	166	288	515	410	325	269	229	198

Table A.2.17 Probable Floods

	Haraz River						Babol River						Garma Rud	Alesh Rud
Drainage Area	Karchsang 4,086 km^2						Babol 1,430 km^2						125km^2 1/	312km^2 1/
	Annual		Irrigation Period		Non-irrigation Period		Annual		Irrigation Period		Non-irrigation Period			
Recorded Max.	cms	Date	cms	Date	cms	Date	cms	Date	cms	Date	cms	Date		
1	311	Ord'48	311	Ord'48	77	Esf'48	700	Meh'42	376	Mor'36	700	Meh'42	-	-
2	244	Ord'52	244	Ord'52	67	Meh'36	394	Aba'38	315	Ord'44	394	Aba'38	-	-
3	212	Ord'54	212	Ord'54	63	Sha'36	376	Mor'36	237	Far'43	335	Sha'48	-	-
4	192	Kho'47	192	Kho'47	57	Sha'51	335	Sha'48	202	Ord'42	257	Aba'55	-	-
5	185	Kho'35	185	Kho'35	50	Meh'55	315	Ord'44	198	Far'48	256	Meh'46	-	-
Probable Flood Return Period														
1/50 year	293 cms		293 cms		79 cms		553 cms		398 cms		553 cms		-	-
1/30	265		265		71		495		350		495		-	-
1/25	255		255		69		475		335		475		388 cms	641 cms
1/20	245		245		65		448		314		448		-	-
1/10	208		208		56		370		255		350		297	515
1/5	171		171		46		294		197		228		-	-
1/2	117		117		33		186		119		115		-	-

Note: 1) Irrigation Period; Far-Mor, Non-Irrigation Period; Sha-Esf

2) 1/ Locations are indicated in Exhibit 1.2.3 in the Main Report.

3) Flood discharges are shown in maximum daily basis for the Haraz and the Babol rivers, and in momentary peak for the Garma rud and the Alesh rud.

Table A.2.18 Daily Maximum Discharge of the Haraz River

Station: Karehsang

(Unit: cms)

Year	Meh	Aba	Aza	Dey	Bah	Esf	Far	Ord	Kho	Tir	Mor	Sha	Annual
1329-30	19	15	13	13	12	16	21	54	54	24	16	18	54
1330-31	19	19	18	16	15	19	68	120	122	87	45	33	122
1331-32	23	22	20	15	16	20	50	88	94	86	100	31	100
1332-33	-	-	-	-	-	-	-	-	-	-	-	-	-
1333-34	-	-	-	-	-	-	-	-	-	-	-	-	-
1334-35	19	18	20	19	20	21	156	176	185	125	66	22	185
1335-36	29	16	17	13	13	13	41	105	170	175	95	63	175
1336-37	67	45	33	24	19	24	99	98	66	44	29	21	99
1337-38	22	23	24	19	19	18	68	150	120	87	39	28	150
1338-39	27	24	24	24	22	23	65	93	62	34	34	27	93
1339-40	23	22	20	19	19	18	33	76	63	30	26	25	76
1340-41	25	33	16	14	26	17	32	123	100	48	23	34	123
1341-42	23	26	15	13	15	16	62	89	141	65	55	39	141
1342-43	44	22	20	24	22	29	60	124	89	37	25	44	124
1343-44	17	17	17	14	15	26	64	143	140	57	37	23	143
1344-45	28	23	22	16	29	49	97	145	110	53	39	*	145
1345-46	31	18	15	15	14	17	34	130	90	38	22	17	130
1346-47	22	16	15	13	13	40	110	128	192	94	44	26	192
1347-48	19	25	20	19	20	77	198	311	206	103	73	56	311
1348-49	35	45	28	22	21	34	48	60	48	24	24	22	60
1349-50	20	19	18	17	17	30	55	129	118	53	31	26	129
1350-51	21	22	19	18	18	21	58	146	177	111	74	57	177
1351-52	24	28	24	21	23	35	87	244	219	72	37	*	244
1352-53	15	19	19	15	14	33	80	75	71	99	32	25	99
1353-54	20	16	13	11	11	21	69	212	194	58	19	18	212
1354-55	18	27	22	31	17	18	90	129	142	78	67	30	142
1355-56	50	31	34	23	24	27	32	94	91	58	43	31	94
1356-57	38	47	21	18	18	41	87	76	67	56	27	18	87
1357-58	30	31	32	32	32	32	50	75	77	65	26	23	77
1358-59	24	22	20	19	18	19	68	70	50	36	30	23	70
1359-60	23	18	17	16	16	15	58	59	46	36	22	21	59
1360-61	24	21	15	13	13	14	31	53	56	38	23	19	56
Max.	67	47	34	32	32	77	198	311	219	175	100	63	311

* : Record not readable.

Table A.2.19 Daily Maximum Discharge of the Babol River

Station: Babol

(Unit: cms)

Year	Meh	Aba	Aza	Dey	Bah	Esf	Far	Ord	Kho	Tir	Mor	Sha	Annual
1328-29													160
1329-30													82
1330-31													300
1331-32													305
1332-33													123
1333-34													292
1334-35	70	58	28	50	65	41	68	28	58	20	28	50	70
1335-36	151	23	28	14	47	33	51	14	286	179	376	13	376
1336-37	215	240	93	44	21	15	55	20	50	140	64	99	240
1337-38	58	208	83	59	238	71	112	137	40	21	21	60	238
1338-39	80	394	111	35	21	65	87	52	22	63	50	70	394
1339-40	39	190	44	106	40	37	94	18	161	1.9	82	156	190
1340-41	246	248	90	58	90	45	83	55	109	29	15	56	248
1341-42	101	150	71	13	22	67	81	202	45	31	76	140	202
1342-43	700	100	112	100	66	208	237	54	2.5	12	99	253	700
1343-44	68	69	38	53	28	58	41	315	5.1	30	91	67	315
1344-45	48	80	57	88	19	106	50	164	10	4.3	51	*	164
1345-46	170	21	6.0	19	69	73	149	32	67	83	6.0	81	170
1346-47	256	242	44	65	80	97	134	157	53	91	28	77	256
1347-48	8.0	301	123	19	61	74	198	18	11	45	90	335	335
1348-49	89	177	119	89	78	117	104	35	75	0	57	132	177
1349-50	23	41	50	45	71	38	47	18	6.9	2.1	0.9	2.9	71
1350-51	38	85	8.8	32	31	71	65	123	61	18	102	13	123
1351-52	11	18	83	44	44	26	70	32	23	25	3.4	97	97
1352-53	77	49	42	34	45	71	86	45	20	81	29	38	86
1353-54	77	16	20	26	49	68	26	56	10	0.7	5.7	23	77
1354-55	83	49	64	34	31	61	70	135	48	65	14	34	135
1355-56	156	257	53	78	33	31	38	25	6.8	57	45	121	257
1356-57	104	180	33	18	53	37	15	34	159	48	11	8.5	180
1357-58	10	35	30	53	110	21	92	52	4.8	5.5	33	16	110
1358-59	-	-	-	-	-	-	-	-	-	-	-	-	-
1359-60	55	19	9.2	6.7	5.1	31	141	102	2.5	3.7	3.8	2.4	141
1360-61	235	18	5.6	8.1	16	13	17	7.3	6.1	14	4.0	4.1	235
Max.	700	394	123	106	238	208	237	315	286	179	376	335	700

* : Record not readable.

2) Flood Flows in the Area

As see in Figure A.2.5, major floods are caused in the project area by the Babol river, Kari Rud and Alesh Rud. These floods happen mostly in autumn by heavy rainfall and in early spring by snow melt. Since the flood of the Haraz river happens in May to June, its flood period is different from above three rivers.

i) Flood of Haraz River

Maximum flood was recorded at 311 cms in Ordibehest 1348 (May 1969). This maximum flood is assumed to be more than 1/50 years flood. Overtopping was not caused even in this flood, because half of flood was spreaded in the project area through irrigation canals and another half of flood was drained to the Caspian Sea through the lower reach of the Haraz river. However it caused large inundation in the project area due to poor drainage system.

In case of 1/10 years flood, flood discharge is estimated at 208 cms. In such flood, mirabs try to prevent flood not to flow into the area and to drain it through the Haraz river. However, there is no permanent gates at the heads of irrigation canals, flood intrudes into the area and causes inundation. Flood of the Haraz river has been mitigated by completion of the Lar dam. Once permanent gates are provided at the heads of irrigation canals, it is expected to be able to control floods completely in the Haraz river.

ii) Flood of the Babol River

Maximum flood was recorded at 700 cms in Mehr 1342 (Oct. 1963). The maximum flood is assumed to be exceptional and caused large scale of overtopping to the project area due to small flow capacity of the river only at 300 cms in the lower reach.

Probable floods are estimated at 475 cms, 370 cms and 294 cms for once in 25 years, 10 years and 5 years respectively. Since flow capacity is assumed at 300 cms, overtopping may happen almost once in 5 years. However, overtopping did not last more than 24 hours even at the recorded maximum flood. From the records, six overtoppings were recorded for 33 years since 1328 (1949), and only two out of six were caused in rice growing period.

For preventing flood damage by the Babol river, it is recommended to study the possible flood mitigation scheme for this river.

iii) Flood of the Kari Rud

Flood of the Kari Rud is caused mainly by the Garma Rud which flows into from the southern hilly basin. Duration of the flood is generally short assumed within one day. Flow capacity of the Kari Rud is extremely large (assumed at 400 cms or more) from the confluence of the Garma Rud to Zahed Kola and becomes considerably smaller (assumed at only 50 cms) at its downstream. Therefore, almost all amount of flood overflows to the flood-way at the right bank at this point and some amount overflows into the project area. Overflow is assumed at 7 to the flood-way and 3 to the project area in this study. For preventing flood of the Kari Rud, it is recommended to provide a flood control dam in the Garma Rud basin or to improve the flood-way by the further study. Flood-way needs to have an capacity of about 350 cm to pass flood of once in 25 years when no possible flood control dam in the Garma Rud.

For considering inundation in the area, amount of overflow is assumed at about 800,000 m^3 to the project area when areal rainfall of once in 10 years happens.

iv) Flood of the Alesh Rud

Flood of the Alesh Rud is caused due to extreme small flow capacity of the river at the downstream of the confluence with the Angta Rud. Flood overflows and causes large scale of inundation at both banks in the middle and low lands. Although MOE has completed river improvement in the lower reach providing the by-pass to the Waz Rud, it is not sufficient to mitigate the flood in this area. Since floods happen frequently in this area, there remains large forestry in this area. For developing this area along the Alesh Rud, river training is the most important measure.

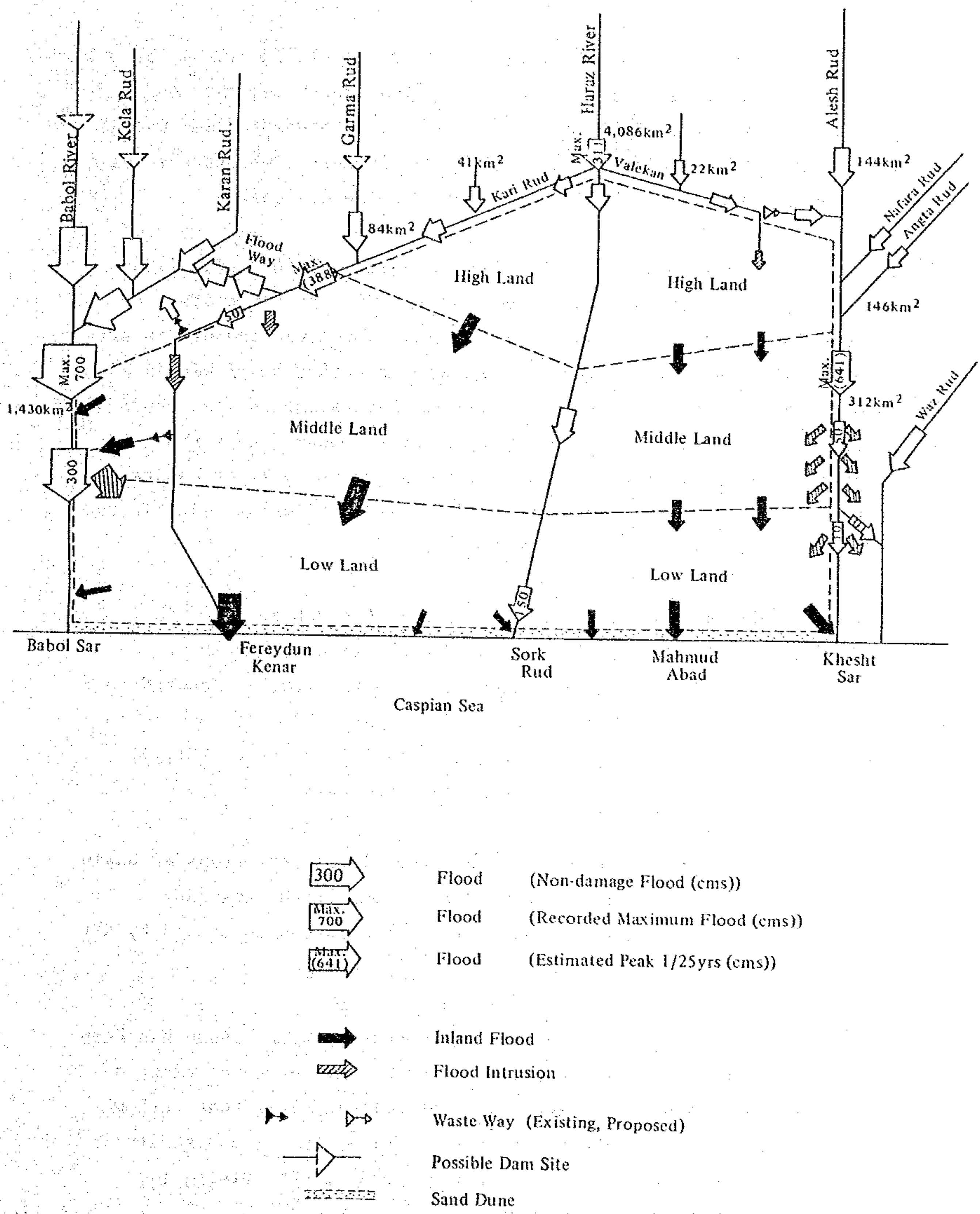


Figure A. 2. 5. Flood Flows in the Project Area

A.2.5. Caspian Sea

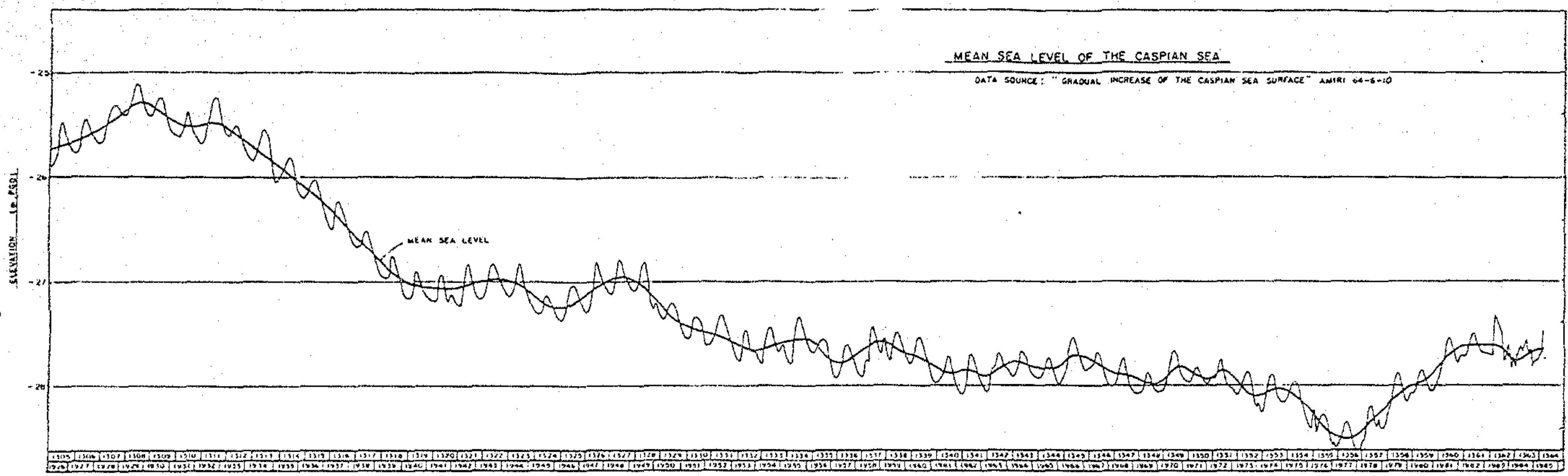
The Caspian Sea is the largest inland lake in the world, of which surface area is 371,000 sq.km, maximum depth is 995 m and salinity concentration is about 20,000 ppm. The Caspian Sea has no outflow forming closed basin itself. The largest river is the Volga having a basin of 1,420,000 km^2 in the Caspian sea basin.

From the record of the Caspian sea level for 60 years (1926 - 1985), it has remarkable different three cycles of fluctuation as shown in Figure A.2.6. One is a ordinary tide cycle and others are annual and long term cycles. Tide range is rather small within 30 cm by observation. The range of annual fluctuation is also about 30 cm, low in winter and high in summer. It is assumed that the seasonal fluctuation of inflow from the surrounding river basins have some influence to such annual fluctuation of water level in the Caspian Sea.

Though the sea level remains at EL-27.6 m PGD in 1984, it fluctuated greatly since 1926 as see in the figure. After it reached to the highest level at EL-25.3 PGD in 1929, it lowered to EL-28.5 m PGD by 3.2 meters until 1977. Since 1978, it changed to rise again and reached to EL-27.6 m PGD in 1981. After 1981, it remains at almost same level for recent few years.

As the reason of recent rising of sea level, the transfer basin (12 rivers) to the Volga is assumed to be one of the reasons. However, it is not clear whether this rising have been caused by the transfer basin or by the long term fluctuation.

Although it is reported that the transfer basin scheme has been postponed since August 1986 from a point of environmental view, a part of that has been completed already. It is clear that inflow has been increased by that part of transfer basin which was already completed, therefore it is necessary to predict this rising by further observations and studies.



Data Source: "General Increase of the Caspian Sea Surface" by Amiri 64/6/10

Figure A. 2, 6. Long Term Fluctuation of the Caspian Sea Level

APPENDIX A. 3.

GROUNDWATER

CONTENTS

LIST OF TABLES

LIST OF EXHIBITS

A.3.1. General

The geological formation in the project area are all composed of Quarternary unconsolidated deposits, without outcrops of bedrock. The geological features of the bedrock are described in Reference 5 and Geological Map of Iran (1:2,500,000), and is outlined below.

The Alborz Mountains stretch nearly east-west along the southern shore of the Caspian Sea, their uplift took place in the Alpine orogeny from the Miocene to the Pliocene Neogene Tertiary era, where they went from the most active to the last stages of formation.

The deep erosion accompanied by the most active upheavals produces the clastic deposits (molasse, conglomerate facies) in the Mio-Pliocene.

The southern hills are formed by conglomerate facies from the Mio-Pliocene, and the bedrock of the area is considered to be composed of this member. The bedrock descends at an inclination of about 10% from the hills to a level of -100 to -300 m PGD with large undulations (Exhibit A.3.1). The bedrock is overlaid with late Quarternary unconsolidated deposits, at the bottom these are marine deposits from the Ancient Caspian Sea with fluvial deposits from the Haraz river on top, but without a clear boundary.

The surface geology relates closely to the topography. According to the observation of outcrops and Reference 5, the piedmont fan is mainly formed by conglomeratic soil with a few impermeable layers and silt layers in the middle. There is a 2 - 3 m thick surface soil and the depth of the basement gradually increases from upstream to downstream.

The alluvial plain is made on an alternation of sand or silt. However, the range of each stratum is still unknown. A continuation of the conglomeratic soil forming the piedmont fan presumably exists under the alluvial deposits. The wells reaching the conglomeratic layer occasionally form artestian wells and these wells are found even at -10 m PGD.

A.3.2. References on Groundwater

A groundwater survey of the Mazandaran Province has been conducted on a large scale over almost 10 years, and has provided a substantial contribution to the development of groundwater resources. The following survey reports and data have been furnished to the survey team:

(1) Report on the Lar-Mazandaran Pole Project by Booker & Takshab-1357 (Reference 1)

(2) Report on the Geo-electric Prospecting Study for the Amol, Babol, and Shahi Plains in Mazandaran Province by Abkav-1352 (Reference 5)

(3) Report on the Reconnaissance Study of Groundwater compiled by the Ministry of Energy-1362 (Reference 6)

(4) Data of Springs, Artesian Wells, Wells by the Ministry of Energy 1364 (Reference 7)

Reference 1 is a hydrologic analysis in the watershed of the three major rivers in Mazandaran Province (the Haraz, Babol, and Talar rivers), and it contains some data on groundwater.

Reference 5 is a hydrogeological study based on electrical prospecting by dividing the project area into 4 km squares (Exhibit A.3.2.)

Reference 6 is data of the following research conducted in the Project Area:

- Data on the change in hydrostatic head of approximately 40 observation wells in the irrigation and non-irrigation periods

- Results on water quality analysis

- Results on pumping tests conducted at 4 points

Reference 7 is data of the scale and water quality of all springs and wells in the Project Area.

It is considered that there are two kinds of water sources for the artesian wells, one is seepage water from the piedmont fan, and the other is fossil water due to transgression and regression of the Caspian Sea.

The former has good quality but the latter has salinity.

Springs are sometimes found in gullies at around 25 m PGD and they are usually formed in groups on a gully.

A.3.3. Groundwater Use at Present

It is reported that there are 70 springs in the project area in Reference 7 and they are in a group.

Exhibit A.3.2. shows the sites of the springs. Discharge of the springs is as follows:

	-	less than 10 lit/sec ...	44 springs
more than 10 lit/sec	-	less than 20 lit/sec ...	10
more than 20 lit/sec	-	less than 50 lit/sec ...	8
more than 50 lit/sec	-	less than 100 lit/sec ..	4
above 100 lit/sec	-	..	4

The total discharge is 1.5×10^5 m^3/day and increases in the irrigation period.

Thirty Seven artestian wells are reported and the total discharge from them is 74 lit/sec according to the Reference 7, but it is considered that total discharge from the artesian wells including the unreported ones amounts to 55,000 m^3/day (Reference 1).

Number of 9,400 wells is reported in Reference 7. Exhibit A.3.2 shows the distribution of them. 4,145 wells of them are in the Project Area. The number in the parenteses with "D" and "AR" stands for "Deep well" and "Artesian well" respectively.

As Exhibit A.3.2 shows, the greater part of wells in the Project Area are shallow wells under 15 meter deep and deep wells (over 30 meter deep) are mostly located in the westside of the piedmont.

Average water quantity from the wells is 5.32 lit/sec and average operating hours amount to 1,342 hours. Both figures are estimated from 10% samples drawn from total wells.

Therefore, the total irrigation water supplied from the wells is obtained as follows:

$$5.32 \text{ lit/sec} \times 3{,}600 \text{ sec} \times 1{,}342 \text{ hr} \times 4{,}145 \text{ wells}$$
$$= 1{,}065 \times 10^5 \text{ m}^3$$

A.3.4. An Estimate of Groundwater Discharge by Flow Net Analysis

Exhibits A.3.3 show the groundwater equipotential lines in the wet season in April 1982 (1361 Farvardin) and in the dry season in September 1982 (1361 Ordibehest), which is a partial modification of the old data.

Exhibits A.3.4 and A.3.5 also show the flow nets in April 1982 and September 1982 respectively. The flow nets are drawn so that the flow lines cross at right angles to the equipotential lines drawn at 5 m intervals and form squares[1/]. By flow net analysis, the groundwater discharge Q_g can be obtained from the following formula:

$$Q_g = T \cdot \Delta h \cdot \frac{n_f}{n_d} \left[= k\ (h - h_o) \cdot \Delta h \cdot \frac{n_f}{n_d} \right] \quad \ldots\ldots\ldots \quad (1)$$

Where, T: transmissibility

k: coefficient of permeability

h: hydrostatic head

h_o: elevation of impermeable base

Δh: total potential drop along a flow line

n_f: number of flow channels in a flow net

n_d: number of equipotential drops in a flow net

At present, an accurate aquifer constant has not been found, therefore it is assumed in the following way.

In Reference 1, 5 m/day is used for "k" 200 meter for aquifer thickness (h-ho) and 0.1 for "S" in the alluvial plain, and 12 m/day is used for "k" and 0.15 for "S" in the piedmont fan.

Therefore, $T = k\ (h - ho)$

$= (5 \sim 12) \times 200 \fallingdotseq 1{,}000 \sim 2{,}400\ m^2/day$

On the other hand, $T = 3{,}000\ m^3/day$ is adopted in Reference 6. In Reference 1, the total discharge of groundwater is considered as $Q_g = 6.3 \times 10^7\ m^3/year$.

Note: 1/ In the Haraz Fan, not forming squares but rectangules stretched east-west, this suggests that the inner part of the fan has a larger number of flow lines than the alluvial plain.

Substituting $h = 95$ m, $nf = 15$ and $nd = 19$ (obtained from Exhibits A.3.4 and A.3.5 for the formula (1), $T = 2{,}300\ m^2/day$ can be obtained.

This figure accords with $T = 1{,}000 \sim 3{,}000\ m^2/day$ above mentioned.

$T = 2{,}300\ m^2/day$ is adopted in this study.

As a result, the groundwater discharge in 1982 can be assumed as follows:

$1.73 \times 10^5\ m^3/day$: in April, 1982
$1.71 \times 10^5\ m^3/day$: in September, 1982

The result means that the average discharge of groundwater from the project area to the Caspian Sea is: $Q_g = 1.72 \times 10^5\ m^3/day$.

A.3.5. Groundwater Balance

The groundwater balance is studied in the project area.

There are two inflow sources from the outside area. One is the Haraz river bed and the other is hills. Inflow from the Haraz river bed can be calculated at $5{,}000\ m^3/day$, applying the formula $Q = B.D.i.k$ - based on the assumptions that width of the river $B = 1{,}000$ m, the thickness of the aquifer $D = 50$ m, the hydraulic gradient $i = 0.01$ and the coefficient of permeability $k = 10$ m/day -

The inflow from the river bed $5{,}000\ m^3/day$ is negligible small compared to the total discharge.

The inflow from the hills is considered to be balanced with the discharge to the Babol river.

The survey area was divided into 4 km squares and the average potential drop of the groundwater (Δh) was calculated at the intersections for the five months between April and September 1982. The average potential drop (Δh) was found to be 0.65 m, which is very close to the average potential drop of the 40 observation wells (0.61 m) with a difference of only 4 cm. Also, h between September 1981 and April 1982 was found to be -0.71 m.

The water balance of the groundwater aquifer per unit time is obtained from the following formula:

$$\bar{Q}_g = A \left(S.\frac{\Delta h}{\Delta t} + w - qw - q_s\right) \; \ldots\ldots\ldots \; (2)$$

where, $\bar{Q}_g$: average groundwater discharge (1.72×10^5 m^3/day from ii))

A : total survey area (9.56×10^8 m^2)

S : storage coefficient (0.12 for piedmont fan and alluvial plain)

Δh: average potential drop of groundwater (-0.71 m in a non-irrigation period, 0.65 m in an irrigation period)

Δt: time increment

w: infiltration recharge per unit area

q_w: well discharge (0.54×10^5 m^3/day in a non-irrigation period, (0.54 x 105 x 1065) x $10^5 m^3$/105 days in an irrigation period from i))

q_s: spring and qanat discharge (1.58×10^5 m^3/day in a non-irrigation period, 2.34×10^5 m^3/day in a irrigation period obtained from Reference 1)

By using the above values in formula (2), the water balance results as shown in Table A.3.1 and A.3.2.

Table A.3.1. Groundwater Balance in Non-irrigation Period

Item		Amount (10^5 m^3)
Change in Groundwater Storage	$A \cdot S \cdot \Delta h \cdot t$	$9.56 \times 10^8 \times 0.12 \times (0.71) =$ -815
Groundwater Discharge	$Q_g \cdot t$	447
Spring and Qanat Discharge	$q_s \cdot t$	411
Well Discharge	$q_w \cdot t$	140
Infiltration Recharge	$A \cdot W \cdot t$	-1,813
(Infiltration Recharge W = -0.73 mm/day)		

Note:
1) Water balance for t = 260 days
2) Water balance basing on data Aug.'81 - Apr.'82 (Sha.'60 - Esf.'61)
3) Area (A) = 9.56×10^8 m^2, Storage coefficient (S) assumed at 0.12, and Average potential drop (Δh) assumed at -0.71 m for non-irrigation period.
4) "+" indicating discharge, "-" indicating recharge.

Table A.3.2. Groundwater Balance in Irrigation Period

Item		Amount (10^5 m^3)
Change in Groundwater Storage	$A \cdot S \cdot \Delta h \cdot t$	$9.56 \times 10^8 \times 0.12 \times (0.65) =$ 746
Groundwater Discharge	$Q_g \cdot t$	181
Spring and Qanat Discharge	$q_s \cdot t$	246
Well Discharge	$q_w \cdot t$	1,122
Infiltration Recharge	$A \cdot W \cdot t$	-803
(Infiltration Recharge W = -0.80 mm/day)		

Note:
1) Water balance for t = 105 days
2) Water balance basing on data Apr.'82 - Aug.'82 (Far.'61 - Mor.'61)
3) Average potential drop (Δh) assumed at 0.65 m in irrigation period
4) Others are same as in Table A.4.1.

A.3.6. Groundwater Quality

A survey of electical conductivity (EC) was conducted to analyze water quality and the results are shown in Exhibit A.3.6. As illustrated in the figure, values of 3000 micromhos/cm are found in the north-eastern part and also along the Babol river. However, the average electrical conductivity in the whole project area is below 1000 micromhos/cm and there is no indication of saline-water intrusions to the coastal wells as shown in Table A.3.4. It is assument that the high electrical conductivity is caused by the fossil water mentioned in A.3.1.

The Exhibit A.3.6 also shows the groundwater quality and temperatures of wells and springs located at 13 points in the survey area. According to these measurements, an area with high electrical conductivity is located in the southern hilly range. Further, deep wells in Kamongar Kola (No.10) show high electrical conductivity and the temperature is rather high at 24°C.

Table A.3.3. Water Quality of Mineral Springs

Q: 150 - 200 lit./sec	Hardness: 1400	E.C. (25°C): 11299 micromhos/cm
PH: 6.8	Co_3: 0 mg/lit.	HCo_3: 543 mg/lit.
Cl^-: 3617 mg/lit.	So_4: 136 mg/lit.	Ca^{++}: 300 mg/lit.
Mg^{++}: 158 mg/lit.	Na^+: 2010 mg/lit.	

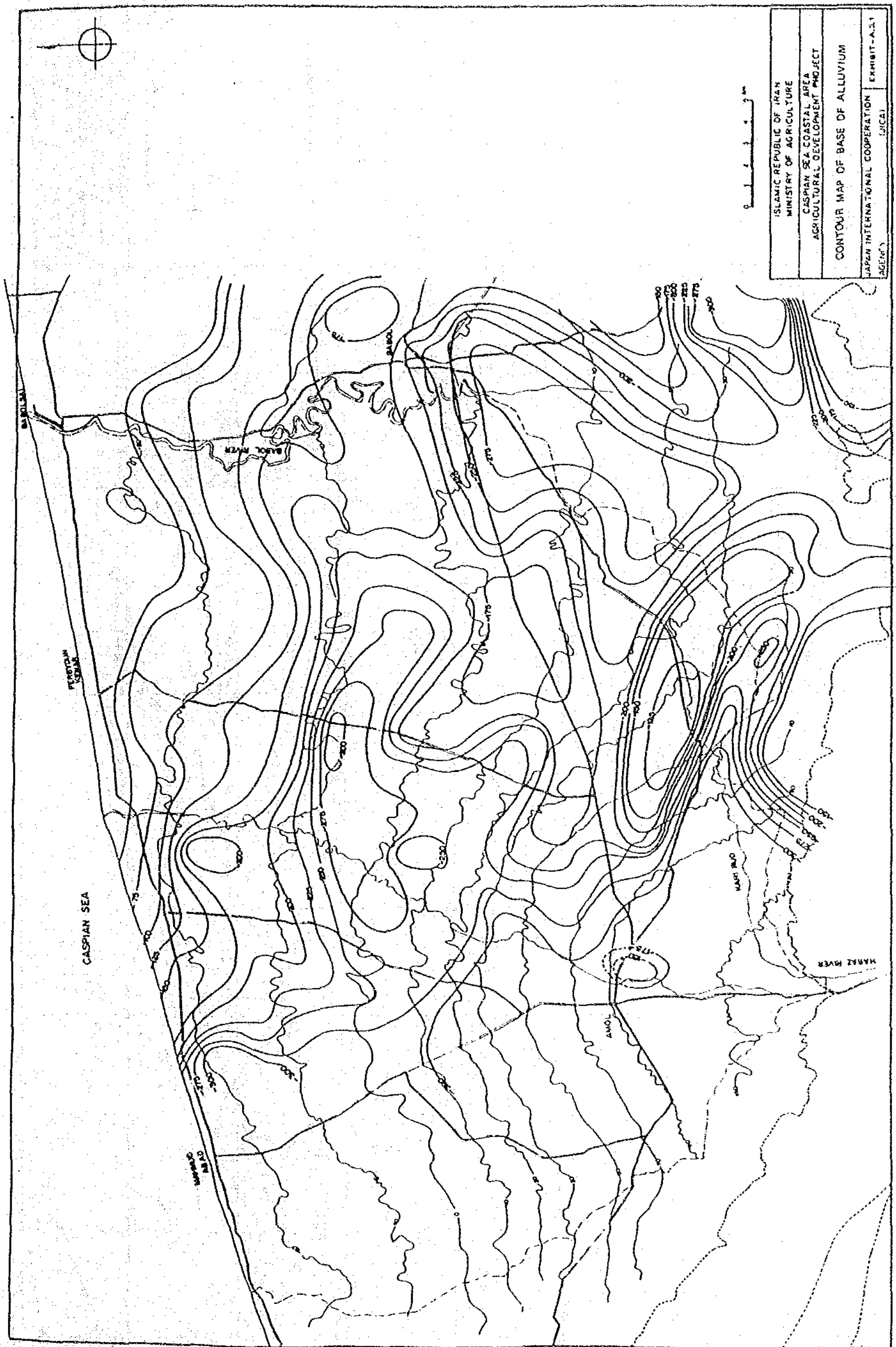
Data Source: The Ministry of Energy
The North Department of Power Experiments for Surface Water

Note: A group of mineral springs are located about 6 km upstream of the Garma Rud piedmont. Water sample was obtained from the Lalehzar Spring which is the largest in a group of springs.

Table A.3.4. Groundwater Table and Water Quality of the Coastal Wells

Well No.	1		2		3		4		5		6		7		8	
Well Network No.	-		-		5E33D		-		-		9D2S		-		8D5S	
Owner of Well	MOE		Motel (Private)		Air Force		Beach House		Farmer		School		MOE		Farmer	
Location	Kheshtsar		Wester of Abu Mahalleh		Bisheh Kola		Bisheh Kola		Siah Kola		Ahmad Abad		Feridon Kenar		Kazarshar	
Purpose of Well	Observation		Drinking & Agriculture		Drinking		Drinking & Agriculture		Agriculture		Agriculture		Observation		Agriculture	
Digging Year	1361		-		1352		1342		1359		1356		1361		1348	
Depth of Well	12m		12m		40m		8m		60m		13m		12m		13m	
Diameter of Well	6in		-		4in		3m		6in		12in		6in		-	
Observation Date	Depth (m)	$ECx10^6$ 25°C	Depth (m)	$ECx10^6$ 25°C	Depth (m)	$ECx10^6$ 25°C	Depth (m)	$ECx10^6$ 25°C	Depth (m)	$ECx10^6$ 25°C	Depth (m)	$ECx10^6$ 25°C	Depth (m)	$ECx10^6$ 25°C	Depth (m)	$ECx10^6$ 25°C
III Jan.'86(64.11.I)	0.57	570	5.24	610	-	840	1.14	550	-	750	0.93	520	1.29	390	0.95	560
I Feb. (II)	0.965	510	5.29	700	-	860	1.285	560	-	800	0.98	550	1.305	425	0.95	595
II (III)	0.89	562	5.42	710	-	970	1.29	590	-	770	0.97	580	1.275	420	0.94	560
III (12.I)	1.04	760	5.16	840	-	990	1.30	610	-	780	0.93	600	1.36	460	0.90	540
I Mar. (II)	0.85	530	5.07	680	-	820	1.34	460	-	850	0.96	600	1.20	430	0.87	600
II (III)	0.97	530	5.42	640	-	770	1.33	510	-	710	0.95	500	1.21	390	0.95	450
III (65. 1.I)	1.09	560	5.92	710	-	800	1.77	560	-	710	0.945	510	1.265	420	0.95	490
I Apr. (II)	1.195	620	5.70	680	-	760	1.56	540	-	730	1.00	500	1.20	430	1.00	470
II (III)	1.275	520	5.42	720	-	900	1.67	520	-	750	1.03	530	1.12	470	1.06	480
III (2.I)	1.25	530	5.51	700	-	880	1.86	530	-	720	1.01	530	1.10	480	1.26	470
I May (II)	1.31	530	5.52	690	-	850	1.81	520	-	760	0.645	780	1.55	470	1.16	470
II (III)	1.37	520	5.62	670	-	840	1.93	530	-	780	0.92	700	1.57	480	1.44	480
III (3.I)	1.43	520	5.61	670	-	875	1.88	537	-	740	0.94	700	1.56	420	1.50	480
I Jun. (II)	1.50	560	5.95	720	-	970	1.88	590	-	830	0.94	680	1.73	470	1.58	570
II (III)	1.62	540	6.00	700	-	900	2.10	590	-	780	0.95	690	2.00	430	1.58	470
III (4.I)	1.70	520	6.82	700	-	900	1.91	570	-	750	0.95	670	1.73	390	0.60	462
I Jul. (II)	1.77	505	7.02	725	-	895	1.88	560	-	800	0.96	655	1.85	400	1.50	475
II (III)	1.85	480	6.94	710	-	920	1.91	550	-	760	1.03	530	1.09	410	1.77	490
Average	1.26	548	5.76	699	-	874	1.66	549	-	765	0.95	601	1.41	433	1.16	506
S.D.	0.35	61	0.60	46	-	65	0.30	36	-	39	0.08	86	0.28	32	0.32	49
Max.	1.85	760	7.02	840	-	990	2.10	610	-	850	1.03	780	2.00	480	1.77	600
Min.	0.57	480	5.07	610	-	760	1.14	460	-	710	0.645	500	1.09	390	0.60	450

Note) Depth: depth to water table from the top edge of the well.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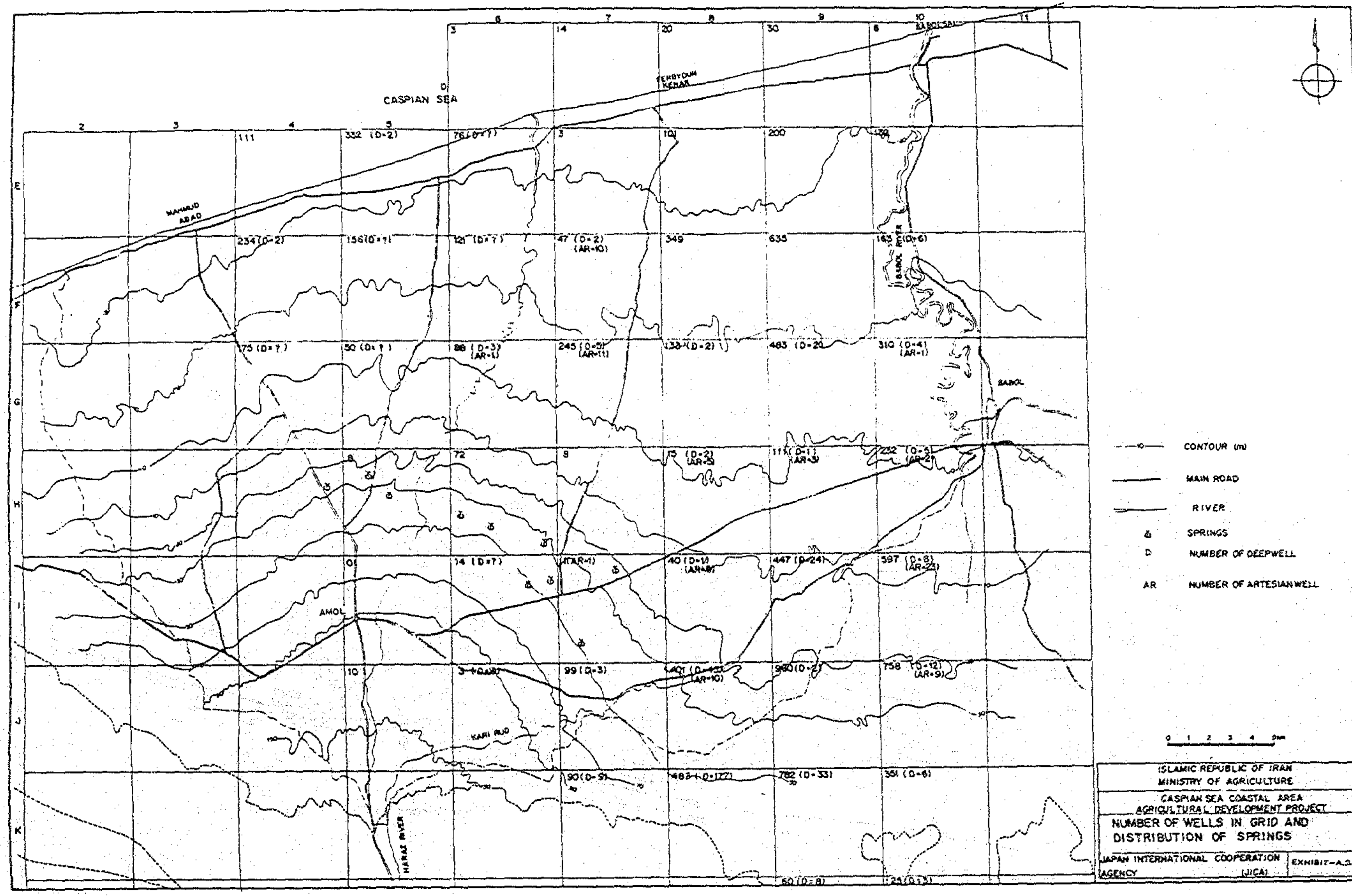
MINISTRY OF AGRICULTURE
CASPIAN SEA COASTAL AREA
AGRICULTURAL DEVELOPMENT PROJECT
CONTOUR MAP OF BASE OF ALLUVIUM
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
EXHIBIT-A3.1
CASPIAN SEA
BABOLSAR
BABOL RIVER
BABOL
AMOL
HARAZ RIVER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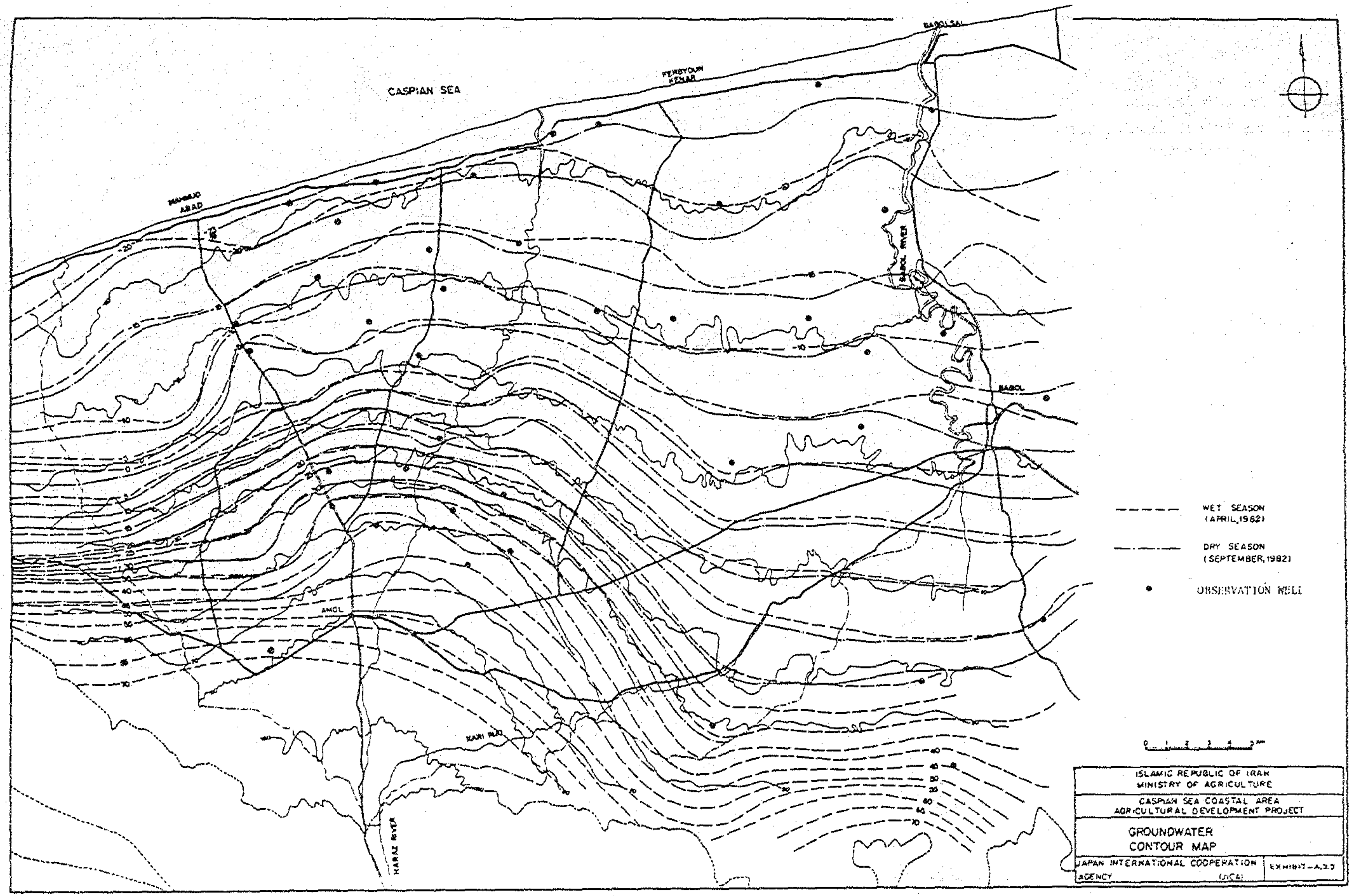
MAHMUD ABAD
FERDYDUN KENAR
BABOLSAR
BABOL RIVER
BABOL
AMOL
KARI RUD
HARAZ RIVER
CONTOUR (m)
MAIN ROAD
RIVER
SPRINGS
D NUMBER OF DEEPWELL
AR NUMBER OF ARTESIAN WELL
0 1 2 3 4 5km
ISLAMIC REPUBLIC OF IRAN
MINISTRY OF AGRICULTURE
CASPIAN SEA COASTAL AREA
AGRICULTURAL DEVELOPMENT PROJECT
NUMBER OF WELLS IN GRID AND
DISTRIBUTION OF SPRINGS
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
EXHIBIT-A.3.2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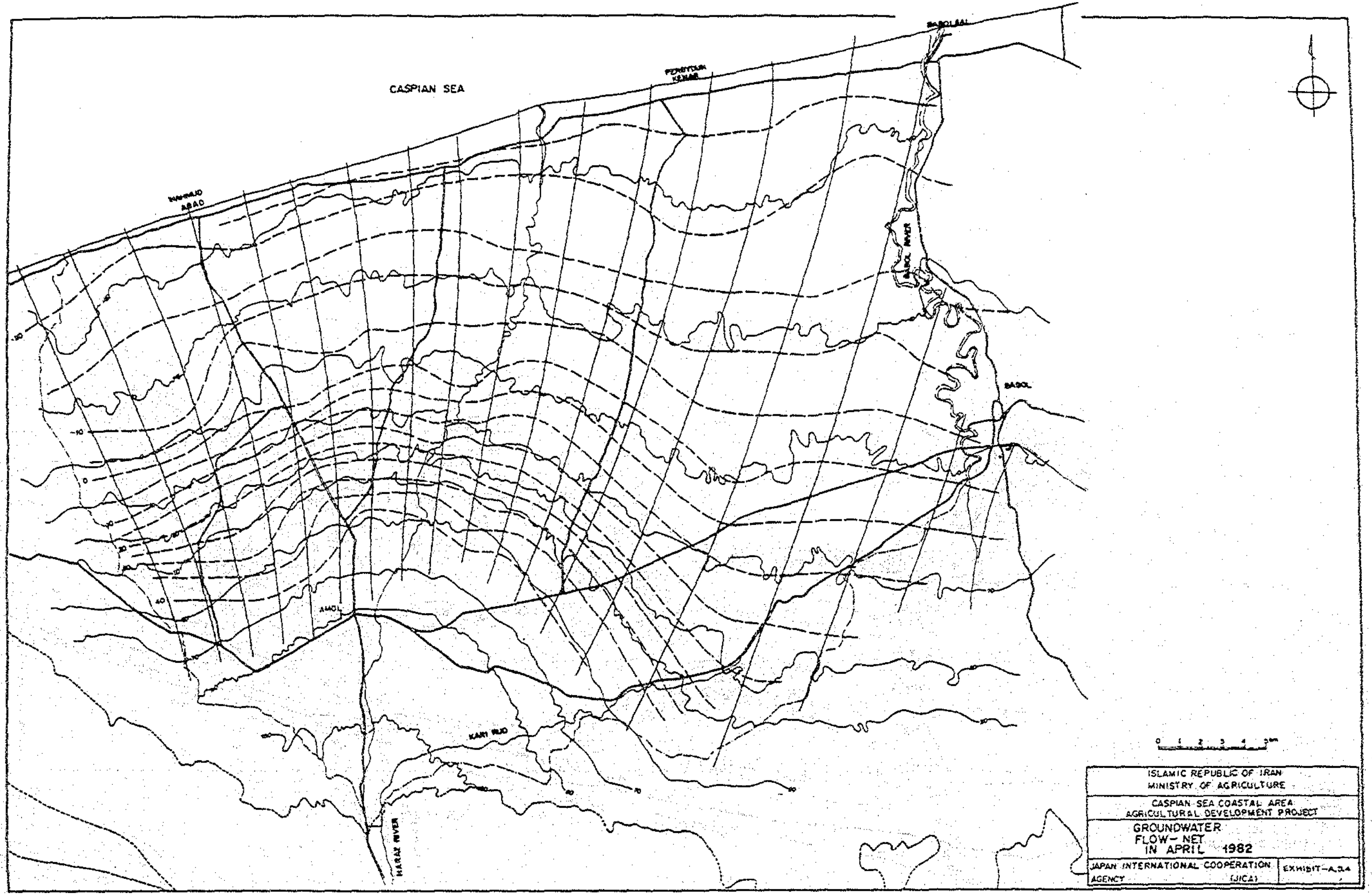
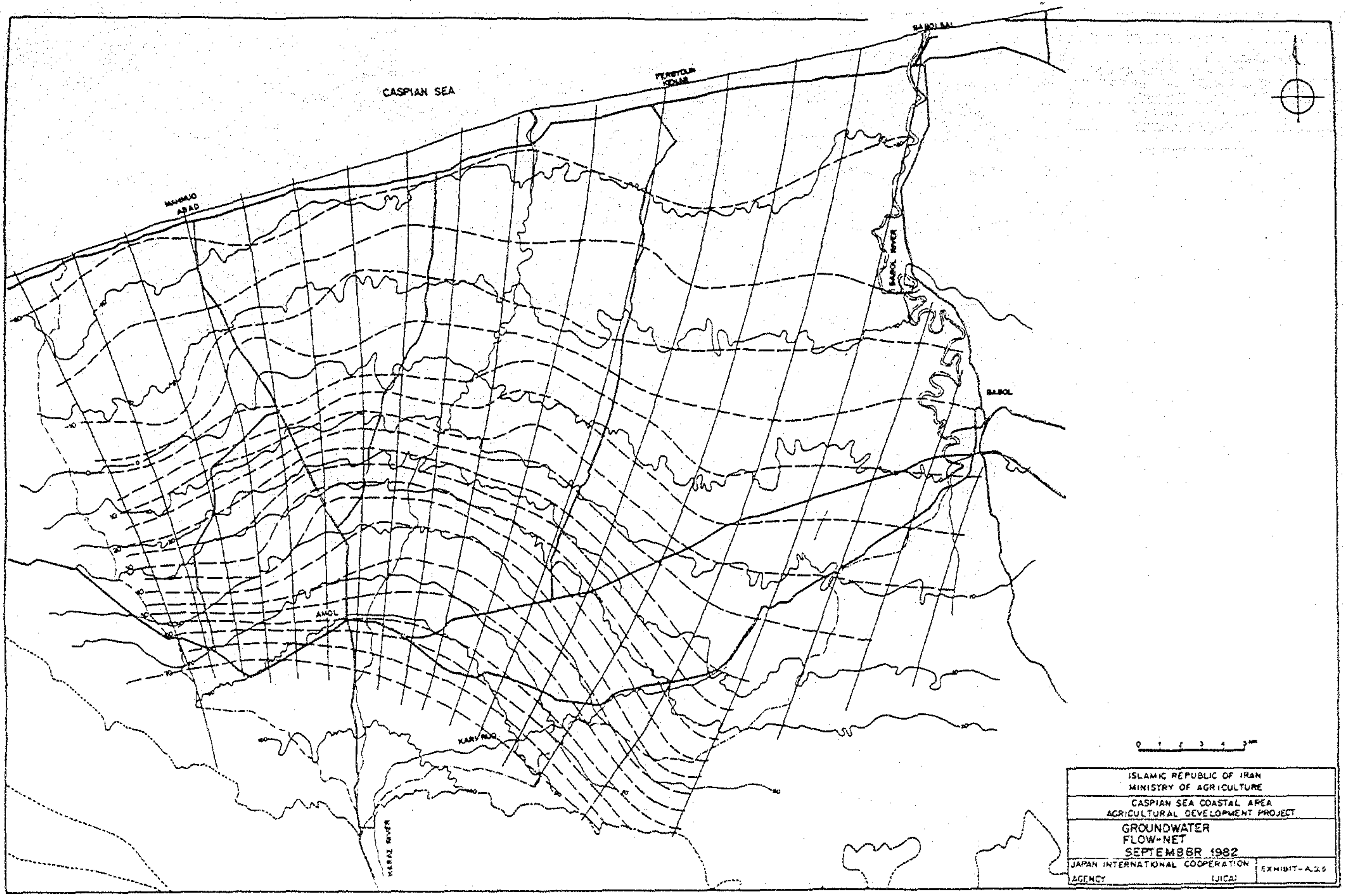
BABOLSAR
FERIDOUN KENAR
MAHMUD ABAD
BABOL RIVER
BABOL
AMOL
HARAZ RIVER
KARI RUD
WET SEASON (APRIL, 1982)
DRY SEASON (SEPTEMBER, 1982)
OBSERVATION WELL
0 1 2 3 4 5km
ISLAMIC REPUBLIC OF IRAN
MINISTRY OF AGRICULTURE
CASPIAN SEA COASTAL AREA
AGRICULTURAL DEVELOPMENT PROJECT
GROUNDWATER
CONTOUR MAP
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
EXHIBIT-A.3.3


CASPIAN SEA
BABOL RIVER
BABOL
AMOL
KARI RUD
HARAZ RIVER
0 1 2 3 4 5km
ISLAMIC REPUBLIC OF IRAN
MINISTRY OF AGRICULTURE
CASPIAN SEA COASTAL AREA
AGRICULTURAL DEVELOPMENT PROJECT
GROUNDWATER
FLOW-NET
IN APRIL 1982
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
EXHIBIT-A3.4


CASPIAN SEA
BABOL SAR
FEREYDUN KONAR
MAHMUD ABAD
BABOL RIVER
BABOL
AMOL
KARI RUD
HERAZ RIVER
ISLAMIC REPUBLIC OF IRAN
MINISTRY OF AGRICULTURE
CASPIAN SEA COASTAL AREA
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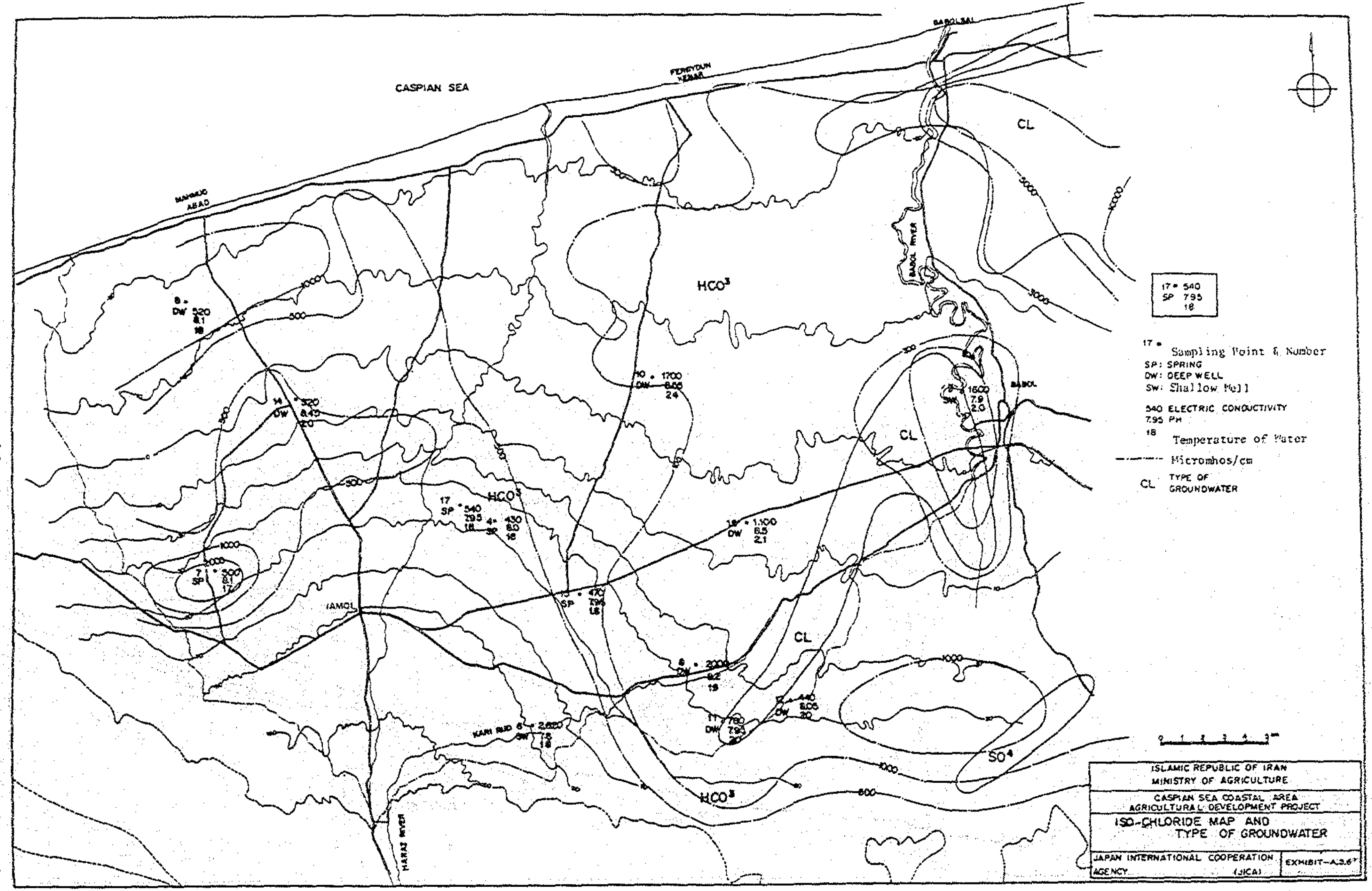
GROUNDWATER
FLOW-NET
SEPTEMBBR 1982
JAPAN INTERNATIONAL COOPERATION
AGENCY (JICA)


CASPIAN SEA
MAHMUD ABAD
FEREYDUN KENAR
BABOLSAR
BABOL RIVER
BABOL
AMOL
HARAZ RIVER
KARI RUD
CL
HCO3
SO4
17 • 540
SP 795
18
17 • Sampling Point & Number
SP: SPRING
DW: DEEP WELL
SW: Shallow Well
540 ELECTRIC CONDUCTIVITY
7.95 PH
18 Temperature of Water
Micromhos/cm
CL TYPE OF GROUNDWATER
ISLAMIC REPUBLIC OF IRAN
MINISTRY OF AGRICULTURE
CASPIAN SEA COASTAL AREA
AGRICULTURAL DEVELOPMENT PROJECT
ISO-CHLORIDE MAP AND
TYPE OF GROUNDWATER
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
EXHIBIT-A3.67

APPENDIX A. 4.

SOIL

LIST OF TABLES

LIST OF FIGURES

Table A.4.1. Soil Classification and Correlation [1/]

Soil Series & Mapping Symbol	USDA Soil Taxonomy			FAO 1974	Iranian
	Family	Sub Group	Order		
Nur (Nu)	Fine Mixed Thermic	Mollic Ochraqualfs	Alfisols	Humic Gleysols	Humic Gley Soils
Darzikola (Da)	Fine Loamy Mixed Calcareous Thermic	Mollic Fluvaquents	Entisols	Mollic Gleysols	Humic Gley Soils
Babol (Ba)	Fine Mixed Non-acid Thermic	Mollic Fluvaquents	Entisols	Mollic Gleysols	Humic Gley Soils
Form (Fo)	Fine Mixed Calcareous Thermic	Typic Fluvaquents	Entisols	Calcaric Gleysols	Low Humic Gley Soils
Kelayban (Ke)	Fine Loamy Mixed Non-acid Thermic	Mollic Udifluvents	Entisols	Calcaric Fluvisols	Alluvial Soils
Borj (Bo)	Fine Loamy Mixed Calcareous Thermic	Typic Xerofluvents	Entisols	Calcaric Fluvisols	Alluvial Soils
Khazar (Kz)	Mixed Calcareous Thermic	Typic Xeropsamments	Entisols	Calcaric Regosols	Regosoils
Ganjafruz (Ga)	Fine Mixed Thermic	Typic Calciaquolls	Mollisols	Mollic Gleysols	Humic Gley Soils
Sufimahaleh (Su)	Fine Mixed Non-acid Thermic	Fluventic Haplaquolls	Mollisols	Mollic Gleysols	Humic Gley Soils
Afratakht (Af)	Coarse Loamy Mixed Calcareous Thermic	Fluventic Haplaquolls	Mollisols	Mollic Gleysols	Humic Gley Soils
Miantalar (Mt)	Fine Mixed Thermic	Typic Argiudolls	Mollisols	Luvic Phaeozems	Prairi Soils
Gavlangar (Gl)	Fine Mixed Thermic	Calcic Agrixerolls	Mollisols	Calcic Kastanezems	Chestnut Soils
Banikola (Bn)	Fine Mixed Thermic	Typic Argixerolls	Mollisols	Calcic Kastanezems	Chestnut Soils

1/ According to Semi-Detailed & Reconnaissance Studies of West Mazandaran (1984)

Table A.4.2 General Characteristics of Soil Series

Soil Series & Mapping Symbol	Soil Depth	Drainage	Texture	Relief	Related Land-form
Nur (Nu)	Very deep	Poorly drained	Clay	Very gently to gently sloping	Piedmont plain & fans, flood plain
Darzikola (Da)	Very deep	Poorly drained	Loam	Very gently sloping	Flood plains, river alluvial plains, and interfluvial basins
Babol (Ba)	Very deep	Poorly drained	Silty clay	Very gently sloping	River alluvial plains & inter-fluvial basins
Form (Fo)	Very deep	Poorly drained	Silty clay	Very gently sloping	River alluvial plain
Kelayban (Ke)	Very deep	Moderately well drained	Loam	Very gently to gently sloping	Flood plains & Piedmont plains
Borj (Bo)	Very deep	Well drained	Loam	Very gently sloping	River alluvial plains (levee)
Khazar (Kz)	Very deep	Moderately well drained 1/	Loamy sand to sand	Very gently sloping	Coastal bank and sand bar
Ganjafruz (Ga)	Very deep	Poorly drained	Silty clay	Very gently sloping	Piedmont plains, river alluvial plain and interfluvial basin
Sufimahaleh (Su)	Very deep	Poorly drained	Loam to clay loam	Very gently to gently sloping	Flood plains & piedmont alluvial plains
Afratakht (Af)	Very deep	Poorly drained	Silt loam	Gently sloping	River alluvial plains & inter-fluvial basins
Miantalar (Mt)	Very deep	Imperfectly drained	Silt loam to silty clay loam	Gently sloping	Piedmont plains & fans
Gavlangar (Gl)	Very deep	Imperfectly drained	Clay loam	Very gently sloping	River alluvial plain & inter-fluvial basins
Banikola (Bn)	Very deep	Imperfectly drained	Silty clay loam	Very gently to gently sloping	Piedmont plains

1/ Very rapid permeability