Feasibility Study on Water Resources Development in Rural Area in the Kingdom of Morocco
Final Report
Volume IV Supporting Report (2.A)
Feasibility Study

Supporting Report XI Hydro-Meteorology and Hydro-Geology

FEASIBILITY STUDY
ON
WATER RESOURCES DEVELOPMENT
IN
RURAL AREA
IN
THE KINGDOM OF MOROCCO

FINAL REPORT

VOLUME IV
SUPPORTING REPORT (2.A)
FEASIBILITY STUDY

SUPPORTING REPORT XI
HYDRO-METEOROLOGY
AND
HYDRO-GEOLOGY

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SUPPORTING REPORT XI

HYDRO-METEOROLOGY AND HYDRO-GEOLOGY

XI1 Introduction to Feasibility Study

XI1.1 General

The hydrological study presented in Supporting Report II covers 25 candidate dams located over the country and focuses mainly on clarification of general hydrological features to select priority projects.

As a result of the study, following four (4) dams have been selected as priority projects subject to the feasibility study. They are N'Fifikh dam, Taskourt dam, Timkit dam, and Azghar dam.

In this Supporting Report, more intensive hydrological studies are carried out for the selected four dams to provide necessary data for the feasibility studies. The study primarily aims to fix following hydrological design values:

(1) Monthly rainfall and inflow to dam,

(2) Probable flood discharge,

(3) Reservoir sedimentation, and

(4) Ground water.

XI1.2 Previous Hydrological Studies

XI1.2.1 Water Resources Development Master Plan

Master plans for the water resources development are available for the river basins under study as listed below.

- Study on Integrated Master Plan for Water Resources Development of the Sebou, Bou Regreg, Oum Er Rbia and Tensift River Basins (ETUDE DU PLAN DIRECTEUR INTEGRE D'AMENAGEMENT DES EAUX DES BASSINS SEBOU, BOU REGREG, OUM ER RBIA ET TENSIFT)
- Study on Master Plan for Water Resources Development of the Guir, Ziz, Rheris and Draa river basins (ETUDE DU PLAN DIRECTEUR DE L'AMENAGEMENT DES EAUX DES BASSINS DU GUIR, ZIZ, RHERIS ET DRAA).

The former study includes the basins related to N'Fifikh (No.5), Taskourt (No.9) and Azghar (No.17) dams and the latter related to Timkit dam (No.10). These master plan studies were carried out for MOE by foreign and local consulting firms (MOTOR COLUMBUS, Swiss; COYNE ET BELLIER, France; C.I.D, Morocco and INGEMA, Morocco). The study includes basic hydrological studies on rainfall, river flow and sedimentation. The study results have been reflected to the studies for specific dam schemes presented below.

XI1.2.2 Hydrological Study for N'Fifikh Dam

Hydrological study was made by DGH in 1990 for the N'Fifikh dam initially at Skhrat Ben Rouane (ETUDE HYDROLOGIQUES AU NIVEAU DES SITES DES BARRAGES: N'FIFIKH SUR L'OUED N'FIFIKH, August 1990). The local association of the N'Fifikh River, however, did not accept the site, because wide agricultural land would be submerged by the reservoir.

Additional study was carried out by DGH in 1998 to study potential dam sites along the N'Fifikh River (ETUDE D'UN BARRAGE MOYEN DANS LE BASSIN DE L'OUED N'FIFIKH; Mission Ia: Potential Site Survey and Comparative Study; Prepared by Al Khibra for DGH in July 1998). In the study, five (5) potential sites along the N'Fifikh River were studied. They are, from the lower site, Skhrat Ben Rouane, Ziaida, Oulad Ouhab, Ain Ksob and Oulad Zid. As a result of study, Ain Ksob site was recommended due to its higher potential of irrigation development and less compensation problems than the other sites.

In July 2000, DGH carried out a hydrological study for Ain Ksob dam (ETUDE HYDROLOGIQUE DU BARRAGE AIN KSOB SUR L'OUED DALYA, Province de Benslimane). The study, incorporating the previous study results, covers all the hydrological aspects necessary for the planning dam; namely, physical characteristics of river basin, climatic features, monthly inflow, flood runoff, and reservoir sedimentation.

XI1.2.3 Hydrological Study for Taskourt Dam

A hydrological study report is available (ETUDE HYDROLOGIQUE DU BARRAGE TASKOURT SUR ASSIF EL MAL, prepared by DGH in April 1996).

The report covers study results of dam site, precipitation, monthly inflow, flood runoff, and reservoir sedimentation.

XI1.2.4 Hydrological Study for Timkit Dam

Study on Dam Construction Project in the Rheris Basin (ETUDE DU PROJET DE CONSTRUCTION DES BARRAGES DANS LE BASSIN VERSANT DU RHERIS) was carried out from December 1988 to March 1990 by JICA (The JICA Study). Timkit dam was studied in the JICA Study as one of 32 candidate dam sites and as one of 3 first-priority dam sites.

DGH recently carried out a hydrological study (ETUDE HYDROLOGIQUE DU BARRAGE TIMKIT DANS LA PROVINCE D'ERRACHIDIA), and the results were incorporated in AVANT-PROJET DEFINITIF: BARRAGE TIMKIT, September 1997. The study covers hydrological data necessary for planning dam such as climatic features, annual inflow, flood runoff, and reservoir sedimentation.

XI1.2.5 Hydrological Study for Azghar Dam

A hydrological study is available (ETUDES HYDROLOGIQUES DES BARRAGES ADAROUCH, AZGHAR, SIDI ABBOU; prepared by DGH in June 1996). The study covers monthly inflow, flood runoff, and reservoir sedimentation.

XI1.3 Methodology

In this section, methods employed for the hydrological study are described in general, and those commonly used by DGH are introduced.

DGH has conducted so far various hydrological studies for dam projects over the country. These study results were incorporated into the present study as far as they were verified.

XI1.3.1 Monthly Rainfall and Inflow to Dam

Monthly rainfall and inflow to dam were estimated for water balance analyses. The water balance analysis aims to determine reservoir capacity and dam height, examining the inflow to dam and outflow to meet water demand in the downstream basin. The analysis is performed on monthly data basis.

The monthly rainfall and inflow to dam were estimated as long period as data are available, primarily based on monthly flow records at the reference stations supplementing lack of data with rainfall and flow records of nearby stations after examining the correlation between relevant stations.

Correlation analyses are generally used to estimate the monthly rainfall. A regression curve, generally assumed as a linear curve, is derived as a result of the correlation analysis between stations under similar hydrological conditions.

The correlation analyses are also applicable to estimate the monthly discharges from monthly rainfalls and discharges at the stations under similar hydrological conditions. In case the point of interest is close to the reference station, monthly discharges can be estimated assuming the same specific discharge (or unit area runoff rate) at the station.

XI1.3.2 Probable Flood Discharge

Probable flood discharges at the proposed dam site were estimated for various return periods from 2 years to 10,000 years. The 2-year flood discharge was assumed as an average value of annual maximum flood discharges.

For other return periods of flood discharges, probable flood discharges proposed by DGH were adopted after verification with the latest flood records and probable discharges of other dams in the similar hydraulic conditions.

The probable discharges were estimated by DGH after examining probable discharges estimated by several methods presented below.

(1) Francou-Rodier Method

This method is applicable to estimate probable discharge from that already known at a reference station or a site of similar hydrological conditions.

$$Q_p = \left(\frac{S}{S_0}\right)^k Q_0, \; k = \frac{\log(Q_0/10^6)}{\log(S_0/10^8)}$$

where

Q_p, Q_0: Probable peak discharges at an interest point and the reference station (m^3/s)

S, S_0: Basin areas upstream of the interest point and the reference station (km^2)

(2) Rational Method

This method is applicable to estimate peak discharge from rainfall intensity and basin area.

$Q_p = (C/3.6) \cdot R_i \cdot S$

where

Q_p: Probable peak discharges (m^3/s)

R_i: Probable rainfall intensity during the time of concentration (mm/hr)

S: Basin areas (km^2)

C: Coefficient of runoff

In case the rainfall intensity data are not available, the intensity (R_i) may be estimated from daily data as follows:

$$R_i = P_{24} \left(\frac{T_c}{24} \right)^n \cdot \frac{1}{t_c}$$

Where

P_{24}: 24 hour rainfall (mm/24hr)

T_c: Time of concentration (hr)

n: Index depending on the rainfall characteristics, generally ranges from 0.3 to 0.5.

The coefficient of runoff (C) is assumed, in the DGH study reports, as variable which increases as the return period becomes larger.

The time of concentration (T_c) is estimated by various formulas as follows:

a) Ventura Formula:

$$T_c = 1.27 \left(\frac{S}{I} \right)^{1/2}$$

b) Passini Formula:

$$T_c = 1.08 \frac{(L \cdot S)^{1/3}}{I^{1/2}}$$

c) Kirpich Formula:

$$T_c = 0.667 \frac{L^{0.77}}{I^{0.385}} = 0.667 \left(\frac{L}{I^{0.5}} \right)^{0.77}$$

d) Giandotti Formula:

$$T_c = \frac{4S^{0.5} + 1.5L}{0.8(H_m - H_{\min})^{0.5}}$$

where

T_c: Time of concentration (hr)

L: Length of main river course (km)

I: Gradient (%)

S: Basin area (km^2)

H_m: Mean basin elevation (m, MSL)

H_{min}: Elevation at basin outlet (m,MSL)

(3) Gradex Method:

$Q_{pT} = Q_{p10} + G_{qtc} (U_T – U_{10})$

where

Q_{pT}: T-year peak discharge (m^3/s)

Q_{p10}: 10-year peak discharge estimated by Gumbel method (m^3/s)

G_{qtc}: Discharge increase rate

U_T, U_{10}: Gumbel's variables for T- and 10-year return periods defined as follows:

$U_T = -l_n\{-l_n (1-1/T)\}$, $U_{10} = 2.25$

The discharge increase rate (G_{qtc}) is estimated from rainfall data as follows:

$$G_{qtc} = \frac{G_{ptc} \cdot S}{3.6t_c} \cdot C_p \,,\; G_{ptc} = a\sqrt{t_c} + b$$

where

S: Basin area (km^2)

t_c: Time of concentration (hr)

C_p: Ratio of peak discharge to daily discharge

b: Coefficient depending on topography, ranging from zero (0) for plain to 3 for mountain

a: Coefficient defined as follows:

$a = (G_{p24} - b) / \sqrt{24}$, $G_{p24} = 1.15Gp$

Gp Gumbel's parameter depending on characteristics of daily discharge

XI1.3.3 Reservoir Sedimentation

Reservoir sedimentation rates applied to the design of 25 dams are shown in Table XI1.3.1. These values have been estimated based on the past reservoir sedimentation data in Morocco. According to the data, the specific annual sediment yield rate (Ds) shows similar rates by regions. These rates are considered as standard rates for the region.

An intensive study on reservoir sedimentation was made for the Water Resources Master Plan (ETUDE DU PLAN DIRECTEUR INTEGRE D'AMENAGEMENT DES EAUX DES BASSINS SEBOU, BOU REGREG ET OUM ER RBIA; SOUS MISSION 1B2, HYDROLOGIE: DEBITS LIQUIDES ET TRANSPORTS SOLIDES, July 1985). According to the study result, an empirical relationship for the estimation of specific annual reservoir sedimentation is introduced below.

$$Ds = K \cdot L \cdot S^{-0.25}$$

where

Ds: Specific annual reservoir sedimentation in weight (t/km^2/yr))

L: Annual runoff height (mm/yr)

S: Basin area (km^2)

K: Coefficient for intensity of erosion

The coefficient K was proposed for various zones of Morocco as follows:

- K = 50 for north-western Morocco (Sebou and Oum Er Rbia river basins)
- K = 100 for Moulouya and Tensift river basins
- K = 200 for southern Morocco (Ziz and Draa river basins)

The coefficient K was estimated for reference based on the reservoir sedimentation rates shown in the Table XI1.3.1. The estimated K-values are about 10 for the N'Fifikh, Taskourt and Azghar dams, and 30 for the Timkit dam. The coefficient K proposed in the above seems too large comparing with the estimated values.

XI2 N'Fifikh Dam

XI2.1 River Basin

The N'Fifikh River, originating near El Khatouet about 88 km south of Rabat, flows almost straight towards northwest joining small tributaries on both sides. The river finally empties into Atlantic Ocean near Mohammedia. The upper portion of the N'Fifikh River is named as the Daliya River. General location map of the N'Fifikh river basin is shown in Figure XI2.1.1.

N'Fifikh dam is proposed on the Daliya River at about 10 km east from the center of Mellila. The N'Fifikh River has a total basin area of 737 km^2 as shown below.

Basin Area: Daliya/N'Fifikh River

Location	Basin area (km^2)	
	Sub-basin	Total
Dam site	323	323
Ziaida bridge	127	450
Feddane Taba	156	606
S. Mok El Abri	112	718
River mouth	19	737

The basin is mountainous in the upstream of the proposed dam. In the lower reaches of the dam, the river flows through the bottom of hilly lands gradually developing valley along the river. In the downstream reaches of Feddane Taba, the river forms deep valley of about 100 m depth. For the stretch of about 12 km from the river mouth, the river crosses undulating coastal lands probably formed by sea movements. In these reaches subsurface ground contains saline soil layers.

XI2.2 Climate

The site is located in the North-Central Atlantic Region. Wet and dry seasons are distinct and annual changes in temperature and humidity are moderate.

According to the data at Sidi Jaber, the annual average temperature is 19.8℃ with the maximum monthly average of 28℃ in July/August and the minimum of 12℃ in January.

The relative humidity shows opposite tendency with the temperature, i.e., the maximum monthly humidity (63.2%) in January and the minimum (45.5%) in July with the annual average of 55.2% according to the data at Marrakech.

XI2.3 Rainfall

Monthly rainfall at Feddane Taba station is shown in Table XI2.1.1 for 24 years from 1976/77 to 1999/2000. The rainfall can be assumed as that of N'Fifikh dam site.

Lack of data at Feddane Taba station was supplemented with records at nearby stations after examining the correlations (Figure XI2.3.1) as follows:

- The lack of data was primarily supplemented by correlation with Cheikhreguig records (correlation coefficient R = 0.87).

- The lack of data from September 1976 to January 1977 was supplemented by correlation with Skhirat records (R = 0.79).

Lack of whole month records is found in June, July and August of most years. They are probably due to suspension of measurement during dry months.

According to records at Feddane Taba, the average annual rainfall is 323 mm/yr with relatively wet months (>20 mm/mon) from October to April. Rainfall rarely occurs in July and August. From the yearly data, it is seen that the monthly rainfall is below 20 mm in 7 months of a year and below 5mm in 5 months on average.

XI2.4 River Flow

XI2.4.1 Inflow to Dam

The inflow to N'Fifikh dam was estimated on the monthly basis for 58 years from 1939/40 to 1996/97, primarily based on records at Feddane Taba as shown in Table XI2.4.1. Discharge records at Feddane Taba are available from 1975/76 to 1996/97. For the estimation of monthly discharges from 1939/40 to 1974/75, following procedures were taken:

(1) Annual average discharges were first estimated based on correlation with the "rainfall index for the Atlantic coastal region" presented in the Master Plan-SBOT (Plan Directeur-SBOT).

(2) Then, the annual average discharge was distributed in accordance with recorded monthly runoff patterns at Mellah dam.

In the above estimate, discharges in July and August coincide strangely. This comes from the coincidence of Mellah dam records, though the reason is not known yet. Monthly discharge in 1944/45, 1949/50, 1956/58 and 1974/75 were estimated based on correlation with Mellah dam records, since the annual average discharge could not be estimated in the above procedures because of too small rainfall indices.

According to the estimate, average annual inflow is 13.32 Mm^3 ranging from 0.15 Mm^3 to 41.57 Mm^3 depending on the year. Figure XI2.4.1 shows historical changes of annual runoff. The annual runoff was below the average in 60% of the record years and 31% of the years did not reach half of the average value. It is noted that the annual runoff was low continuously for 16 years from 1979 to 1994.

XI2.4.2 Flood Discharge

Discharges data recorded at shorter intervals during floods are available at Feddane Taba station as well as daily and monthly records. According to the correlation analysis based on these flow data, relationships of monthly discharge (Qmon) vs. monthly maximum daily discharge (Qdayx) and instantaneous flood peak discharge (Qpeak) vs. daily discharge (Qday) are on the average as follows (Figure XI2.4.2):

Qdayx = 10 x Qmon (R = 0.76)

Qpeak = 2.3 x Qday (R = 0.94)

Probable flood discharge proposed for N'Fifikh dam by DGH was verified to be acceptable by the latest flood records and probable discharges of other dams in the similar hydraulic conditions. The flood peak discharges of various return periods are shown in Table XI2.4.2.

Based on the instantaneous annual maximum discharges at Feddane Taba station for 22 years (Table XI2.4.3), probability analysis was attempted by Gumbel method as shown in Figure XI2.4.3. From the Figure, the plotted data seems to be grouped into two below and above 60 m^3/s. The lower data group causes the probable discharge too low.

XI2.5 Reservoir Sedimentation

Annual reservoir sedimentation proposed by DGH was verified to be acceptable in comparison with sediment yield rates for other dams in the similar hydraulic conditions. The annual sediment yield rate (Ds) and annual reservoir sedimentation (Vs) of N'Fifikh dam are as follows:

Ds = 93 $m^3/km^2/yr$, Vs = 30,000 m^3/yr

XI2.6 Flood and Sediment Disasters

XI2.6.1 Existing Flood Problems

Data and information on flood conditions and damages were investigated in the basin related to the dam. Flood inundation and bank erosion are the main problem of this basin. The flood inundations cause damages to riverine farmlands and road along the river. However, the damages are not so serious. The inundated depth is not much and the duration is short in general.

The basin experienced big floods in 1996. Result of flood damage survey for the 1996-flood is shown in Table XI2.6.1. These are only part of damages gathered by interview survey to the farmers.

XI2.6.2 Effects of Dam

Flood mitigation functions of the dam are primarily runoff regulation. The runoff regulation by the dam reservoir will bring about remarkable effects to lowering flood peaks and channel stabilization in the lower reaches. The effects of dam may be extended to about 24 km of river stretch from the dam to Feddane Taba.

XI2.6.3 Flood Mitigation

Dam reservoir plays substantial roles for flood mitigation. In addition to the dam, flood mitigation activities should be executed within a framework of operation and maintenance program for the project, at the sections where severe bank erosions and inundations still remain.

XI2.7 Groundwater Study

The barrage N'Fifikh is located along the Atlantic Ocean Coastal zone. Approximately 25km southeast of Ben Slimene town in linear distance, and 45 km upstream from the estuary of the Oued Daliya near Mohammadia town. The elevation of the river floor in the barrage site is around 240m. In the vicinity of the site, quartzite and alternation of silicious sandstone and schistosed shale are developed. These basement rocks are categorized into "Socle Orogenique Caledono-Hercynien" in Triassic, Mesozoic period.

While, the downstream area of the Oued Daliya is widely developed the alternation of sandstone and shale in "Zone Caledono-Hercynian Cratonique". It strikes N25°E and dips 30° to the east (the upstream side).

Both areas of the barrage site and the downstream area are geotechnically judged to be good water tightness.

XI2.7.1 Groundwater Quality

The total 6 existing wells along the Oued Daliya are observed and analyzed the water quality for temperature, pH, Electrical Conductivity (EC), and Cations (Ca and Fe) at the date of 31 October 2,000 by using the portable aparatus brought from Japan by JICA team. The result is shown in the table on the next page from the upstream to the middle reaches in descending order.

Water Quality Test Result (by JICA team)

Location (coordinated by GPS)		Elevation	GWL/Quality		T	pH	EC	Ca	Fe
X	Y	(m)	GWL	Depth	℃		mS/cm	mg/l	mg/l
1 km downstream of barrage		**240**	3.25	3.35	**22.6**	**6.8**	**135.1**	50	0.2
W 7- 4--35.8	N33-25-32.7	**230**	10.5	10.80	**19.8**	**7.0**	**256.0**	50	0.1
W 7-5- 4.2	N33-27-48.0	**215**	7.75	7.90	**19.0**	**7.3**	**115.5**	50	0.2
Zaida village (under const.)		**210**	8.00	10.25	**20.7**	**7.8**	**1480.0**	50	0.1
W 7- 7- 1.7	N33-29-48.0	**185**	3.65	5.40	**19.1**	**7.2**	**253.0**	50	0.1
W 7- 8-44.7	N33-31-49.8	**165**	7.20	8.40	**20.2**	**7.0**	**233.0**	50	0.1
W 7-11- 9.5	N33-33-39.1	**140**	4.20	4.80	**19.1**	**7.3**	**170.9**	50	0.2

It is a tendency that the groundwater temperature and EC are decreasing, and pH is increasing toward to the downstream area with exception the well of Zaida village (under construction). There is no clear tendency for the Cations contents (Ca and Fe).

XI2.7.2 Groundwater Circumstance

The groundwater level (GWL) is not concordant with the river water level. The 7 GWL measurements were carried out at the same time just one week after the flood at 20-21 October 2,000. GWL is very low, though the river floor is still remaining the water on its floor. It means that the alluvial deposits composed of silty to clayey material are impervious (permeability coefficient is less than 1 x 10^{-5} cm/sec). According to the field reconnaissance, well depth is 10 m or less and aquifers of these wells is in the weathered cracks zone (fissures). Therefore, the thickness of the alluvial deposits is generally very thin of 5 – 10m only. It is judged that the groundwater potential in this area along the Oued Daliya is poor, the recharge from the river water is nearly negligible, and the irrigation water loss by infiltration to the underground is quite small after release from the N'Fifikh reservoir.

XI2.7.3 Transportation Method of the Water from Barrage N'Fifikh

By the above mentioned groundwater circumstance, bulk water transportation method from the reservoir to the irrigation area is the most practical to mitigate the evaporation loss from the river course. The bulk transportation shall be timely carried out by the irrigation requirement. The quantity of evaporation loss (E) can be estimated as followings:

$E = Ep \times Hrs \times L \times D$ = 1,500 to 1,800 m^3 / one time transportation

where,

E : quantity of evaporation loss (m^3 per one time transportation

Ep : average evaporation per day (= 5-6 mm/ 12 hrs)

Hrs : total duration hours for water transportation (= total 5 hrs for total 20 km distance to the downstream-most irrigation area)

L : distance (=20 km)

D : average width of the river channel (=30m)

XI2.7.4 Recommendation of Sub-Barrage Plan Near the Downstream Irrigation Area

The right bank side near the estuary of the Oued Daliya is planned to irrigate. It is said that the area is faced the intrusion of saline groundwater due to past over abstraction. Therefore, anther source is required for irrigation in the area. Considering the limited reservoir volume in barrage N'Fifikh by the catchment of 300 km^2 and long transportation distance more than 30 km, it is recommended to plan a small sub-barrage near the area to supply. It is conceivable to pumping up timely the water from the rest catchment of approximately 500 km^2 after barrage N'Fifikh.

A probable barrage site is found approximately 500 m upstream from the bridge of the National Highway "R106"connecting from Rabat to Casablanca. The site in the immediately upstream of the bridge forms narrow gorge of some 250m width at the 10m upper location from the river floor (conceivable maximum crest length), and 200m width at the river floor. Steady, hard bedrock of alternation of sandstone and shale is outcropped at the both banks. The thickness of alluvial deposits seems very thin of 5 – 10m only. Good water tightness can be expected from the geological condition and structure of simple-dipping of strike N25 ° E and dip 30 ° to east (the upstream side), When the foundation is rest on the bedrock in the river floor after excavation of the alluvial deposits.

XI2.7.5 Hydrogeology

It is a tendency of the groundwater quality that the water has decreasing temperature and EC, and increasing pH toward to the downstream area.

GWL is not concordant with the river floor level. It means that the alluvial deposits composed of silty to clayey material are impervious. The thickness of deposits is generally very thin of 5 – 10m. The existing well depth is 10 m or less. Aquifers are in the weathered cracks zone (fissures). It is judged that the groundwater potential is very poor, because that the recharge from the river is almost negligible.

Bulk water transportation from the reservoir to the irrigation area is the most practical one to mitigate the evaporation through the channel. The quantity of evaporation loss can be estimated from 1,500 to 1,800 m^3.

The right bank area near the estuary of the Oued Daliya is planned to irrigate. Considering the limited reservoir volume in barrage N'Fifikh and long transportation distance more than 30 km, it shall be planned a small sub-barrage to use the rest water by pump up timely. The site is found approximately 500 m upstream from the bridge of the National Highway "R106". The site forms narrow gorge of some 200m width at the river floor. Steady, hard bedrock of alternation of sandstone and shale is out cropped.

XI3 Taskourt Dam

XI3.1 River Basin

The Al Mal River is a left tributary of the Tensift River. The Al Mal River originates in the High Atlas Mountains and flows down toward north joining small tributaries in the mountainous basin that ends at about 2.5 km downstream of the Bouathmane station. The river flows down further on the plain land toward north without joining major tributaries and finally flows into the Tensift River at about 60 km west of Marrakech. General location map of the Al Mal river basin is shown in Figure XI3.1.1.

Taskourt dam is proposed on the Al Mal River at about 8 km upstream of Sidi Bouathmane station. The Al Mal River has a total basin area of 513 km^2 at the end of the mountainous basin as shown below.

Basin Area: Al Mal River

Location	Basin area (km^2)	
	Sub-basin	Total
Dam site	419	419
Sidi Bouathmane sta.	91	510
End of mountainous basin	3	513

In the mountainous basin, the Al Mal River takes its course in the narrow valley on the northern slope of the High Atlas, meandering severely forced by the topography. From the outlet of the mountainous basin, the river flows on the alluvial fan with deep and wide riverbed, which gradually decreases toward downstream. The Al Mal River becomes deeper again in the lower reaches of Had Mejjat until it flows into the Tensift River.

XI3.2 Climate

The site is located in the North-Central Atlantic Region. Wet and dry seasons are distinct and annual changes in temperature and humidity are moderate.

According to the data at Marrakech, the annual average temperature is 20.0℃ with the maximum monthly average of 28.7℃ in July and the minimum of 12.1℃ in January.

The average annual humidity at Marrakech is 55.2% with the maximum monthly humidity (63.2%) in January and the minimum (45.5%) in July.

XI3.3 Rainfall

Monthly rainfall at Sidi Bouathmane station is shown in Table XI3.3.1 for 11 years from 1989/90 to 1999/2000. The rainfall can be assumed as that of Taskourt dam site.

Lack of data at Sidi Bouathmane was supplemented with data obtained from Regional Office of MOA in Amezmiz. Reliability of the monthly rainfall at Sidi Bouathmane was verified with strong correlations with nearby stations such as Sidi Hssain station (correlation coefficient R = 0.92) and Amezmiz station (R = 0.89) as shown in Figure XI3.3.1.

According to records at Sidi Bouathmane, the average annual rainfall is 366 mm/yr with relatively wet months (>20 mm/mon) from October to April. Rainfall is scarce in July and August. From the yearly data, it is seen that the monthly rainfall is below 20mm in 6 months of a year and below 5 mm in 4 months on average.

XI3.4 River Flow

XI3.4.1 Inflow to Dam

The inflow to Taskourt dam was estimated on the monthly basis for 62 years from 1935/35 to 1996/97, primarily based on records at Sidi Bouathmane as shown in Table XI3.4.1. Discharge records at Sidi Bouathmane are available from November 1984 to July 1997. The monthly discharges from September 1935 to October 1984 were estimated based on the study results of Master Plan-SBOT (Plan Directeur-SBOT). Lack of data in August 1997 was supplemented based on the average runoff pattern (1985-1995) at Sidi Bouathmane station.

According to the estimate, average annual inflow is 44.65 Mm^3 ranging from 6.41 Mm^3 to 125.37 Mm^3 depending on the year. Historical changes of annual runoff are shown in Figure 3.4.1. The annual runoff was below the average in 60% of the record years and 29% of the years did not reach half of the average value. It seems that the runoff was relatively high continuously from 1961 to 1971, while the higher runoffs took place sporadically in other period.

XI3.4.2 Flood Discharge

Discharge data recorded at shorter intervals during floods are available at Sidi Bouathmane station as well as daily and monthly records. According to the correlation analysis based on these flow data, relationships of monthly discharge (Qmon) vs. monthly maximum daily discharge (Qdayx) and instantaneous flood peak discharge (Qpeak) vs. daily discharge (Qday) are on the average as follows (Figure XI3.4.2):

Qdayx = 5.5 x Qmon (R = 0.72)

Qpeak = 2.0 x Qday (R = 0.82)

Probable flood discharge proposed for Taskourt dam by DGH was verified to be acceptable by the latest flood records and probable discharges of other dams in the similar hydraulic conditions. The flood peak discharges of various return periods are shown in Table XI3.4.2.

Based on the instantaneous annual maximum discharges at Sidi Bouathmane Station for 13 years (Table XI3.4.3), probability analysis was attempted by Gumbel method as shown in Figure XI3.4.3. From the Figure, a group of data below 20 m^3/s shows different trend from other group. The estimated probable discharges are by far smaller than the design discharges mentioned above affected by the smaller data group.

XI3.5 Reservoir Sedimentation

Annual reservoir sedimentation proposed by DGH was verified to be acceptable in comparison with sediment yield rates for other dams in the similar hydraulic conditions. The annual sediment yield rate (Ds) and annual reservoir sedimentation (Vs) of Taskourt dam are as follows:

Ds = 280 $m^3/km^2/yr$, Vs = 120,000 m^3/yr

XI3.6 Flood and Sediment Disasters

XI3.6.1 Existing Flood Problems

Data and information on flood conditions and damages were investigated in the basin related to the dam. Flood inundation and bank erosion are the major types of flood problems in the basin. As far as the damages are concerned, bank erosion is more serious. The inundated areas are limited to the riverine lands.

Result of flood damage survey for 1999-flood is shown in Table XI3.4.4. These are only part of damages gathered by interview survey to the farmers. The 1999-flood is one of the biggest floods in recent years. During the flood irrigation canal to Tafroukht area and traditional intake facilities were seriously damaged mainly due to bank erosion. Riverbed farmlands in the mountainous reaches have also suffered from flood inundations. Damages were not informed except for the mountainous basin and alluvial fan area, probably since in the plain area riverbanks are high from the riverbed.

XI3.6.2 Effects of Dam

Flood mitigation functions of the dam are primarily runoff regulation. The runoff regulation by dam reservoir will bring about remarkable effects to lowering flood peaks and channel stabilization in the lower reaches. The effects of dam may be extended to about 27 km of river stretch from the dam to Souq al Had Mejjat including 14 km long mountainous river reaches.

XI3.6.3 Flood Mitigation

Dam reservoir plays substantial roles for flood mitigation. In addition to the dam, flood mitigation activities should be executed within a framework of operation and maintenance program for the project, at the sections where severe bank erosions and inundations still remain.

XI4 Timkit Dam

XI4.1 River Basin

The Iffer River is a left tributary of the Ferkla River which is further a tributary of the Rheris River. The Iffer River originates in the Tikajouine Mountains on the southeastern slope of the High Atlas Mountains. The river flows southwestward and changes its course to the south near Arhbalou N'Kerdous. At Timkit the Iffer River goes out from the mountainous basin and flows toward southeast until it joins to the Ferkla River near Tinejdad.

Timkit dam is proposed on the Iffer River at the outlet from mountainous basin at about 30 km northwest of Tinejdad. General basin map of the Iffer river basin is shown in Figure XI4.1.1 with the related river basins such as the Todra and Ferkla rivers.

The total basin area upstream of Merroutch station on the Ferkla River is 4,500 km^2 including the Iffer river basin as shown in the next page.

Basin Area: Iffer/Ferkla River

River	Location	Basin area (km^2)	
		Sub-basin	Total
Iffer/Tanguerfa R.	Dam Site	572	572
	Ait Labzem weir	382	954
	Chtam weir ①	172	1,126
Todra/Ferkla R.	At Bouijane sta.	702	702
	Assif Imiter R. jct.	367	1,069
	Ras-Sdad weir	1,254	2,323
	Chitam weir ②	19	2,342
Ferkla R.	Chitam weir ①+②	3,468	3,468
	Merroutcha sta./Right basin	830	4,298
	Merroutcha sta./Left basin	202	4,500

Most of these river basins have no vegetation and rivers are dried up most of the time except for flood times. Water and vegetation are found only in oases which are dotted about the low-lying riverine lands.

XI4.2 Climate

The site is located in the South Atlantic and Sahara Region. The climate is dry and wet season is not clear.

According to the data at Rachidia, the annual average temperature is 19.4℃ with the maximum monthly average of 31.3℃ in July and the minimum of 8.3℃ in January.

The average annual humidity at Rachidia is 41.0% with the maximum monthly humidity (58.2%) in December and the minimum (23.2%) in July.

XI4.3 Rainfall

Monthly rainfall at Iffer station located near proposed Timkit dam is shown in Table XI4.3.1 for 35 years from 1964/65 to 1998/1999. Lack of data for 1964/65 through 1969/70 was supplemented based on records at Tadighoust by correlation and for 1970/71 through 1998/99 based on Ait Bouijane records.

Since the basins related to Timkit dam are located in the arid region, the rainfalls are irregular by months/years and changeable by places. The correlations of monthly rainfalls were studied, in order to grasp the basin's rainfall characteristics (Figure XI4.3.1).

As to Iffer station, the correlation is rather strong with Ait Bouijane and Tadighoust stations which are located commonly at the outlet from the mountainous basins, while the correlation is weak with Tinejdad, Goulmima and Merroutcha stations, which are located in plain areas. The correlation among the plain stations is rather strong.

According to records at Iffer station, the average annual rainfall is only 186 mm/yr with irregular monthly and yearly distributions. Relatively much rainfall (>20 mm/mon) is observed in October, November and February, and rainfall seldom occurs in July. From the yearly data, it is seen that the monthly rainfall is below 20 mm in 9 months of a year and below 5 mm in 6 months on average.

XI4.4 River Flow

XI4.4.1 Reference Station

Iffer station exists at the proposed Timkit dam site. The station, however, is a simplified station only for rainfall and water level gauging. In and around the basin related to the Timkit dam, three (3) principal stations are available. They are Ait Bouijane, Tadighoust and Merroutcha stations. According to the study on runoff characteristics of these stations, Tadighoust was selected as a reference station of Timkit dam. Correlation analyses were made based on annual data, since the correlation between monthly data is weak (Figure XI4.4.1). The major findings are as follows:

(1) Annual rainfalls at Ait Bouijane and Tadighoust stations are similar, while those of Iffer station are slightly high comparing to those of Merroutcha station in general (Figure XI4.4.2).

(2) Annual runoffs at Ait Bouijane station are high by around 20 mm/yr in comparison with those of Tadighoust, though their rainfalls are similar (Figure XI4.4.2). This is probably due to the abundant spring water at Ait Bouijane station.

(3) On the other hand, annual runoffs of Merroutcha station are low comparing with other two stations. Merroutcha station is located in the plain area, and maybe affected by water intake and loss due to infiltration and evaporation.

(4) Correlation between annual runoff heights at Ait Bouijane (Q_{AB}) and Tadighoust (Q_T) stations suggests the same results mentioned in item-2). According to the correlation (Figure XI4.4.1), the relationship is expressed as:

$$Q_{AB} = 0.99 \times Q_T + 19.4$$

The above relationship indicates that the runoff heights at Ait Bouijane are almost equal to those at Tadighoust with a difference of about 20 mm/yr, which probably be the annual height of spring water at Ait Bouijane.

(5) Correlation between annual rainfalls and runoffs was also examined (Fiure XI.4.4) and the results are summarized below.

- $Q_{ann} = 0.15 \times R_{ann} - 9.2$ for Merroutcha (R = 0.73)
- $Q_{ann} = 0.22 \times R_{ann} - 15$ for Tadighoust (R = 0.69)
- $Q_{ann} = 0.23 \times R_{ann} + 4.0$ for Ait Bouijane (R = 0.70)

These indicate that (1) the annual rainfall up to about 70 mm may not contribute for surface runoff, (2) above the rainfall height about 20% (15 to 23%) of rainfall contributes for surface runoff.

XI4.4.2 Inflow to Dam

The inflow to Timkit dam was estimated on the monthly basis for 36 years from 1961/62 to 1996/97, primarily based on records at Tadighoust as shown in Table XI4.4.1.

Average annual inflow was worked out to 10.11 Mm^3 ranging from 0.22 Mm^3 to 86.71 Mm^3 depending on the year. The annual runoff varies with wide range, and the average value is raised by some extraordinary flood years as shown in Figure XI4.4.3. The annual runoff was below the average in 70% of the record years and 56% of the years did not reach half of the average value. The extraordinary flood years are 1965/66 and 1989/90.

XI4.4.3 Flood Discharge

Discharges data recorded at shorter intervals during floods are available at Merroutcha and Tadighoust stations as well as daily and monthly records. According to the correlation analysis based on these data, relationships of monthly discharge (Qmon) vs. monthly maximum daily discharge (Qdayx) and instantaneous flood peak discharge (Qpeak) vs. daily discharge (Qday) are on the average as follows (Figure XI4.4.4):

Merroutcha station:

$Qdayx = 15 \times Qmon$ (R = 0.97)

$Qpeak = 2.8 \times Qday$ (R = 0.89)

Tadighoust station:

$Qdayx = 9.7 \times Qmon$ (R = 0.87)

$Qpeak = 3.8 \times Qday$ (R = 0.89)

Probable flood discharge proposed for Timkit dam by DGH was verified to be acceptable by the latest flood records and probable discharges of other dams in the similar hydraulic conditions. The flood peak discharges of various return periods are shown in Table XI4.4.2.

Based on the instantaneous annual maximum discharges at Tadighoust station for 35 years (Table XI4.4.3), probability analysis was attempted by Gumbel method as shown in Figure XI4.4.5. From the Figure, a group of data below 240 m^3/s shows apparently different trend from other group. The group of smaller data that shares about 75% of the whole data size may be that of non-flood years.

XI4.5 Reservoir Sedimentation

Annual reservoir sedimentation proposed by DGH was verified to be acceptable in comparison with sediment yield rates for other dams in the similar hydraulic conditions. The annual sediment yield rate (Ds) and annual reservoir sedimentation (Vs) of Timkit dam are as follows:

Ds = 350 $m^3/km^2/yr$, Vs = 200,000 m^3/yr

XI4.6 Flood and Sediment Disasters

XI4.6.1 Existing Flood Problems

Data and information on flood conditions and damages were investigated in the basin related to the dam. Flood inundation and bank erosion in oases are the major types of flood problems in the basin. The oasis develops in low-lying lands near springs, which is vulnerable to flood inundations. Furthermore, the area is arid and floods are rare events that cause the residents defenseless against floods. Flood once in a long while causes the serious damages in the area.

Flood in 1979 is said the biggest flood in the basin. Result of flood damage survey for the flood is shown in Table XI4.6.1. These are only part of damages gathered by interview survey to the farmers. It is noted many farmer houses were suffered from inundation.

XI4.6.2 Effects of Dam

Flood mitigation functions of the dam are primarily runoff regulation. The runoff regulation by dam reservoir will bring about remarkable effects to lowering flood peaks and channel stabilization in the lower reaches. The effect may contribute much to alleviation of damages in oases in the lower reaches. River reaches passing through the oases are about 7 km in total.

XI4.6.3 Flood Mitigation

Dam reservoir plays substantial roles for flood mitigation. In addition to the dam, flood mitigation activities should be executed within a framework of operation and maintenance program for the project, at the sections where severe bank erosions and inundations still remain.

XI4.7 Groundwater Study

XI4.7.1 Scope the Study

The area in the vicinity of Tinejdad had serious groundwater lowering by drought in the several years and increase of demands. The surface flow is not reliable and/or not available except with several floods per year. For this reason, groundwater recharge is important. The agriculture for dates and cattle had damaged by un-controlled groundwater exhaust. Hydrogeological study for groundwater potential is important.

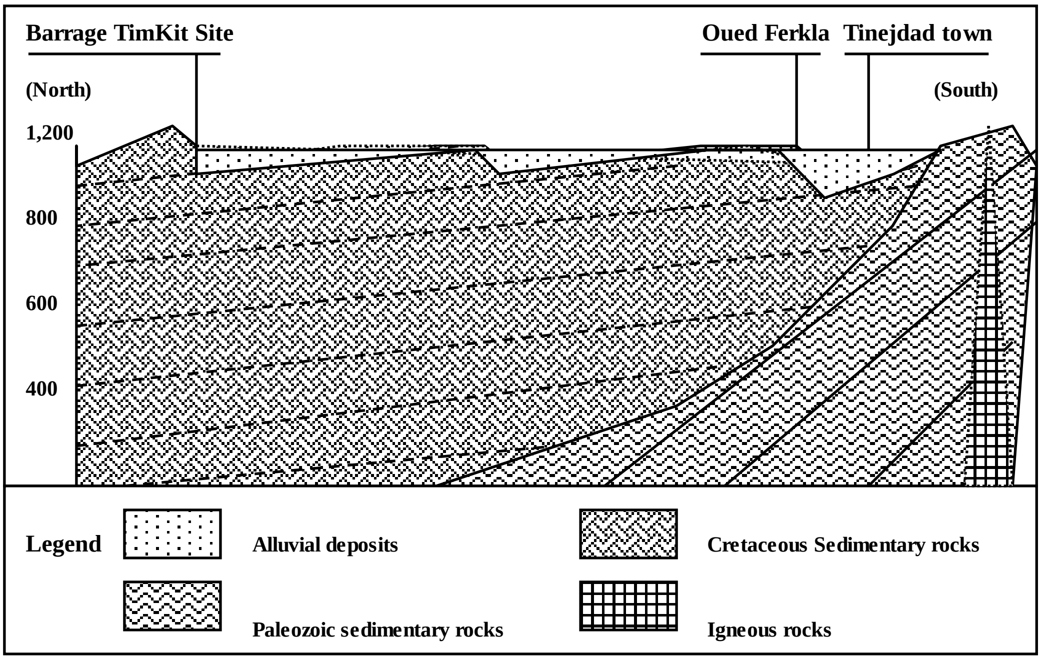
Unique Khettaras and open dug wells are developed for groundwater exploitation. In order to interpret a groundwater flow system and its mechanism, approximately 25 groundwater samples were tested for the planning of future sustainable development. These samples are including Khettara water, Oued Timkit water, Todhra gorge water and the monitoring wells. A huge numbers of wells are distributed in the area. Among them, the groundwater level (GWL) of approximately 16 wells in and around Tinejdad are periodically monitored under Direction de la Region Hydraulique in Errachidia (DRH) since 1973. In this study, GWL records and precipitation records of Tinejdad, Ait Bouijane and Tadighoust are used for the calibration of groundwater basin model to decide the hydrogeological parameters. Then, the simulation of the groundwater development with recharge is conducted by using the hydrological data of floods to the underground infiltration from the Oued Ifegh (downstream of barrage Timkit) and Tinejdad.

The 3 drilling investigation was conducted at the designated production well fields, i.e., 20m upstream and right bank of barrage Ait Labzem (GS-1), confluence of Oued Tanguerfa and Oued Todrha (GS-2) and 440m downstream and right bank of barrage Chitam (GS-3) in the Oued Ferkla, respectively.

(1) Hydrogeological Structure in the Downstream Area of Barrage Timkit

Topographically, the area forms rather flat land with the elevation from 1,230m at the barrage Timkit to 990m at the barrage Chtam. It has the width of some 35km in N-S direction. The latitude of the area ranges from S 8 ° 30’ to S 7 ° 80’, and the longitude ranges from N 35 ° 00’ to N 35 ° 20’.

Basement rocks in the flat land is composed of hard sandstone, shale and conglomerate in Cretaceous. The formation of this rocks dips very slightly to the north (the barrage Timkit side) with 5 ° or less. Due to high groundwater potential in Cretaceous sandstone and conglomerate formations, several deep tubewells are scattered. Basement in the south area of Tinejdad and right side of the barrage Chitam is composed of igneous and sedimentary rocks in Paleozoic. They are nearly impervious. The formation of Paleozoic sedimentary rocks dips rather steep angle of 20 ° to 30 ° to the north in the east and south area of Tinejdad. The alluvial deposits are developed in the flat land as shown in the figure below:



Schematic Profile from Timkit to Tinejdad

The groundwater exists mostly in the alluvial deposits of boulders, gravel, pebbles and coarse sand along the main river courses such as Oued Ferkla (Oued Todrha, Oued Ifegh and Oued Tanguerfa), Oued Rheris and Oued Izilf. Due to its high permeablility of average 1 x 10^{-1} cm/s in the deposits, most of the existing wells are in the depth varying from 10 - 12 m (the north area) to 20 - 30m (the south area : Tinejdad). The depth is depending on the thickness of the alluvial deposits.

Because of unknown hydrogeological condition in the confined aquifers of the basement, groundwater analysis for Cretaceous basement rocks is excluded in this study. It is considered that the groundwater exploitation is more reliable and easier for the phreatic groundwater of the alluvial deposits than the confined groundwater of the basement. Therefore, this study interprets the groundwater in the alluvial deposits.

(2) Groundwater Quality

Temperature, pH, Electrical Conductivity (EC) and Cations (Ca and Fe) were tested at site as well as GWL measurement. Well was surveyed by Global Positioning System (GPS) and barometer. The result is shown in Table XI4.7.1. The groundwater flow system and its direction are interpreted as below;

i. Temperature

The temperature contour is prepared by computer. The result is in Figure XI4.7.1. It is a result from the 25 sites including Khettara and river-bed water of the barrage Timkit. The temperature is lower in the north and higher in the south. Because that the temperature of the groundwater in the alluvial deposits is directly influenced by recharge amount from river system, it is judged that the recharge is dominant in the north of the Oued Ifegh and Oued Rheris. On the contrary, the recharge from the west of the Oued Todrha may not be much.

ii. pH

The pH contour is shown in Figure XI4.7.2. The highest pH value of 7.8 is obtained from the well under construction near Goulmima along the National road from Errachidia. It is a tendency that the water in higher pH value comes from the north area “Haut Atlas Mountain”, which is well known as the zone dominantly outcropped limestone. While, the south area is in the lower pH. It is composed of Paleozoic rocks outcropped dominantly without limestone.

The pH in the water along the Oued Todrha course is not so high, though its upstream area is composed of limestone. It means that the recharge from Oued Todrha may be not much.

- Electrical Conductivity (EC)**:** EC contour is shown in Figure XI4.7.3. EC value ranges from 80 mS/m (the northeast) to 600 mS/m (the east). It is inferred that high EC value is mostly by pollution or contamination from various social activities. The EC contour map indicates that highly contaminated groundwater is diluting by the recharge of clean water from the northeast and the west. It is also inferred that the water in the downstream area is by the recharge from contaminated water in the towns such as Goulmima, Tinerhir and Tinejdad.

- Cations (Calcium and Ferrite): Ferrite (Fe) and Calcium (Ca) contents were tested in site by the portable apparatus brought by the team. The Fe and Ca maps are shown in Figure XI4.7.1 -B and -C.

- The Fe and Ca have the inverse values mutually. The higher Fe content area is coincided with the lower Ca. It is clear that high Fe and low Ca water is located in the area of Paleozoic rocks. The water of low Fe and high Ca is recharged from the zone of “Haut Atlas Mountain”.

(3) Groundwater Flowing Mechanism Inferred from the Water Quality Results

Data of temperature, pH, EC and cations (Fe, Ca) have a good relation. It conducts the following conclusion for the groundwater flow system and its flow directions;

- The main recharge is from the rivers flowing from the north to the south such as the Oued Ifegh (Timkit) and Rheris (Goulmima),
- the recharge from the west of the Oued Todrha is not much,
- the recharge from the south is also small. Because the area is outcropped the impervious Paleozoic rocks,
- groundwater in the downstream area is contaminating gradually. The recharge from the east is not much, possibly by the reason of over abstraction in the upstream of Tinerhir.

XI4.7.2 Groundwater Level Fluctuation

The records of approximately 16 existing wells have been taking under the DRH by monthly base since 1973, though it has some discontinuity. Also, Office Regional de Mise en Valeur Agricole du Tafilalet, Goulmima sub-divisional office (ORMVA) carefully monitored GWL by their registered irrigation wells. In this study, GWL observation is conducted for total 25 existing wells including the above wells in the date of 20-22 October and 2-6 November 2000.

The collected GWL records by the DRH were compiled with the observation result in this time. The data is listed in Table XI4.7.2 and Table XI4.7.3. The precipitation records were combined with it as shown in Figure XI4.7.4. The relation between GWL and precipitation is clear. That is, after large or small amount of rainfall gain, immediate infiltration to the ground might be within one cycle of year. It can be understood that recharge is quickly started by flood and rainfall to the phreatic aquifers in the alluvial deposits. Further interpretation of the chronological history regarding agricultural activity and demands increase are described in the next Section B1.3 “Calibration for Groundwater Basin Model”.

Figure XI4.7.5 is drawn the 5 GWL contour maps of 1973 August, 1989 January, 1991 October, 1995 March and 2,000 October in descending order. The first map of 1973 March is the 8 well records only. The next 3 contour maps are by using the 16 well records. The last map of 2,000 October is adding all well records in this study (total 25 well). The following Clauses is described the GWL chronology since 1973.

(1) 1973August - 1977 January

The map of 1973 August is prepared by the 8 well data only. However, it has a good relation for GWL chronology with the map of 1977 January. Conspicuous GWL lowering is traced in the north. GWL ranges from 2 m to 18 m. The both maps of 1973 August and 1977 January, and Figure XI4.7.4 and XI4.7.5, indicate that a large quantity of abstraction had not yet started in the whole area. The abstraction in the whole areas was an allowable range for its potential and recharge. The main abstraction might be concentrated near Goulmima and its vicinity until the year around 1982.

(2) 1982 – 1989 January

The map of 1989 January shows that GWL in Tinejdad had drastically lowered. However, Goulmima was not much. It means that the recharge from the Oued Rheris and the Oued Ifegh was enough in the vicinity of Goulmima, though the demand was high level as well as Tinejdad. The rainfall in Goulmima station shown in Fig. B1.2.1 supports a good recharge by infiltration of surface water. On the contrary, GWL in Tinejdad had been seriously lowered below 25m in some places. The rainfall records in Tinejdad had not enough for recharge in the area. A large abstraction might be made, and serious GWL lowering was occurred in the south of Tinejdad where the impervious Paleozoic rocks of poor recharge are outcropped.

(3) 1989 February – 1992 March

Serious GWL in the year 1989 had been gradually recovered in the whole areas, especially in Tinejdad. GWL had been risen from 24m to 16m (max. 8m up) in the east of Tinejdad. The reasons are inferred that a) considerable rainfall and floods might be contributed, and b) groundwater development had been reached to limit (GWL was lowered to the well bottom). However, the most serious area is in Tinejdad.

(4) 1992 April – 1995 March

GWL lowering had occurred again in the whole areas as the results of the demand increase, though considerable amount of rainfall and floods had contributed to recharge in the Tinejdad area.

(5) 1995 April – 2,000 October

GWL in the whole areas is lowering with high ratio. It reaches more than 5m in the west. An average 2m lowering per year is reported by the ORMVA. It seems that the recharge from the Oued Todrha is not functioned because of high demands in the upstream area (Tinerhir). However, GWL in Goulmima is not much comparing with Tinejdad due to high infiltration from the Oued Rheris and Ifegh.

Based on the above findings and interpretation, rainfall records and other information, the groundwater study was carried out.

XI4.7.3 Calibration for Groundwater Simulation

The calibration of groundwater basin models was conducted to decide its size and hydrogeological parameters. The 2 models are considered from the site reconnaissance. Table XI4.7.4 is made for the past history of social activity ;

Considering the accuracy of available hydrogeological and hydrological data, the social data was simplified from the existing report "Rheris Basin Dam Study, JICA 1990". Main domestic and cattle water use were simplified as 50 liters/day/capita. The irrigation water of 7,500 m^3/ha/year was equally input for the both models. Figure XI4.7.6 shows the concept of groundwater analysis in this study.

The inflow was calculated by the following formula between annual rainfall (1), runoff and groundwater infiltration (2);

(1) Annual river runoff (Q) is estimated from rainfall (R) by the formula. The detail is discussed in the previous hydrological study section.

Rainfall Data	Year	Relation between annual rainfall (R) and annual runoff (Q)
Tinejdad station	1978-1997	Q = 0.1493 x R
Ait Bouijane station	1971-1999	Q = 0.2348 x R + 3.9614
Tadighoust station	1971-1999	Q = 0.2179 x R

Groundwater inflow is estimated as 30% of the runoff. It is inferred from a) the ground between the surface and GWL is under unsaturated condition (aeration zone), then, b) infiltration of surface water to the underground might be occurred by flood only, and c) flood with limited frequency is very quickly runoff to the outside of the area.

(2) Runoff from the models was calculated based on the hydraulic gradient by the actual average GWL records at the outlet of the model of W = 2,000 m and thickness of aquifer.

(3) GWL was reflected the actual average GWL in the former year for each calculation cycle.

(4) GWL was calculated by quantities of inflow, consumption and runoff, by using various parameters such as permeability and porosity, and modification of basin model size.

(5) Simple model (1 cell) was adopted from the reason that the actual GWL records and hydrological data are by monthly base, and the inflow will come mostly by floods in a few days along the river courses.

(6) Size of Todrha Basin and Timkit Basin models were decided by trial calculations under the consideration of hydrogeological structures.

(7) Formula of inflow calculation was fixed for the both models.

(8) Permeability coefficient and porosity were set by the same figures for the both models from the reason that they are the same hydrogeological condition of the alluvial deposits. Hydraulic gradient in the outlet of the models was set as 1:300 (V:H) for the Todrha model and 1:150 for the Timkit model, respectively.

Figure XI4.7.7 and XI4.7.8 are drawn for the 2 GWL curves of actual records (upper) and the calculation result (down). Table XI4.7.6 is the summary of the result.

The model of the Todrha has approximately 90km linear distance from Tinehir to Tinejdad. The model demonstrates that the 1/3 of distance (=30 km) with 2,000 m width and 18.0 m deep. The result shows that GWL is almost continuously and constantly lowering. It has the same result of some 9m lowering as the actual GWL since 1973. The inflow to the basin had been consumed (100%) by the demands. The calculation was controlled by the condition that it should be allowable range for a probable basin size, not so as to minus values for runoff, and not shallower than the actual lowest GWL.

The model along the Oued Ifegh (Timkit) has approximately 30km linear distance from the barrage Timkit to Tinejdad. The model demonstrates that the 1/3 of distance (=10 km) with 2,000 m width and 8.5 m deep. The result shows that GWL curve is slightly lowering by 2 m as well as the actual GWL.

Based on the obtained hydrogeological parameters and findings by these calibrations, the recharge/pumping method is simulated by the manner to catch floods, to transport it through canals to the command area, and to infiltrate to the underground at the irrigation fields.

XI4.7.4. Groundwater Recharge/Pumping in the Irrigation Fields

The infiltration capacity test was carried out by “Rheris Basin Dam Study, JICA 1990”. It is ranging from 40 to 70 mm/hour per unit area. It is judged to be an enough infiltration capacity for recharge quantity in the both fields.

The well alignment shall be taking into account the following concepts;

- GWL shall be kept not so as to lower than 10 m for the sustainable development, when it is possible. The shallower GWL than 10m will keep in good condition for the cultivation soil and dates trees.
- All existing wells in the fields should be surveyed their locations, dimension, capacity and operation to select new well construction site. For a selection of well construction site, electrical sounding investigation shall be carried out.
- The design for main production well is shown in Figure XI4.7.9, Figure XI4.7.10, and Figure XI4.7.11.
- As shown in Figure XI4.7.12, the well intervals shall be more than 300 m in case of the yield 30 l/s/well. The location shall be near the existing canals.

XI5 Azghar Dam

XI5.1 River Basin

The Zloul River is a right tributary of the Sebou River. The river, originating in the Nerkiba Mountains of about 2000 m,MSL, takes route toward south-west as a whole, and flows into the Sebou River at about 29 km north-west of Ribat Al Khayr.

Azghar dam is proposed on the Zloul River at the outlet from the mountainous basin, located at about 7 km east of Ribat Al Khayr. General location map of the Zloul river basin are shown in Figure XI5.1.1.

The Zloul river basin has a total area of 794 km^2 at the confluence with the Sebou River as shown below.

Basin Area: Zloul River

Location	Basin area (km^2)	
	Sub-basin	Total
Dam site	263	263
Karia River basin	335	598
Dar Hamra sta.	72	670
Confluence with Sebou R.	124	794

The Karia River that has similar basin size to that of the main Zloul River joins at about 6 km downstream of the proposed dam site (or about 2.5 km upsteam of Dar Hamra station). Vegetation of the mountainous basins of the main Zloul and the Karia rivers is relatively good covered with natural and planted forests. Plain land sloping toward the river extends in the downstream reaches of the dam. Before joining the Sebou River, the Zloul River passes through narrow valley at the foot of Beni Hamda Mountains.

XI5.2 Climate

The site is located in the North-Central Atlantic Region. Wet season lasts long and annual changes in temperature and humidity are moderate.

According to the data at Fes, the annual average temperature is 16.8℃ with the maximum monthly average of 25.8℃ in July and the minimum of 9.0℃ in January.

The average annual humidity at Fes is 61.4% with the maximum monthly humidity (70.8%) in December and the minimum (46.3%) in July.

XI5.3 Rainfall

Monthly rainfall at Dar Hamra station is shown in Table XI5.3.1 for 18 years from 1982/83 to 1999/2000. The rainfall can be assumed as that at Azghar site.

Correlations were studied for monthly rainfalls between Dar Hamra and nearby stations as shown in Figure XI5.3.1. The study result shows that Dar Hamra station has strong correlation with nearby stations, namely, correlation coefficient R = 0.92 for Ain Timedrine station, R = 0.88 for Azzaba station, and R = 0.83 for Pont due Mdez station.

According to records at Dar Hamra, the average annual rainfall is 447 mm/yr with relatively wet months (>20 mm/mon) from September to May. Rainfall is scarce in July and August. From the yearly data, it is seen that the monthly rainfall is below 20 mm in 5 months of a year and below 5 mm in 3 months on average.

XI5.4 River Flow

XI5.4.1 Inflow to Dam

The inflow to Azghar dam was estimated on the monthly basis for 44 years from 1955/56 to 1998/99, primarily based on records at Dar Hamra as shown in Table XI5.4.1. Discharge records at Dar Hamra are available from September 1984 to April 1999. The monthly discharges from September 1955 to August 1984 were estimated based on records at Ain Timedrine, which is located on the Sebou River near the confluence with the Zloul River after examining the correlation (Figure XI5.4.1).

According to the estimate, average annual inflow is 53.21 Mm^3 ranging from 9.06 Mm^3 to 125.96 Mm^3 depending on the year. Figure XI5.4.2 shows historical changes of annual runoff. The annual runoff was below the average in 54% of the record years and 27% of the years did not reach half of the average value.

XI5.4.2 Flood Discharge

Discharges data recorded at shorter intervals during floods are available at Dar Hamra station as well as daily and monthly records. According to the correlation analysis based on these data, relationships of monthly discharge (Qmon) vs. monthly maximum daily discharge (Qdayx) and instantaneous flood peak discharge (Qpeak) vs. daily discharge (Qday) are on the average as follows (Figure XI5.4.1):

Qdayx = 4.1 x Qmon (R = 0.60)

Qpeak = 2.3 x Qday (R = 0.80)

Probable flood discharge proposed for Azghar dam by DGH was verified to be acceptable by the latest flood records and probable discharges of other dams in the similar hydraulic conditions. The flood peak discharges of various return periods are shown in Table XI5.4.2.

Based on the instantaneous annual maximum discharges at Dar Hamra station for 13 years (Table XI5.4.3), probability analysis was attempted by Gumbel method as shown in Figure XI5.4.3. The plots show relatively linear distribution.

According to Table XI5.4.2, the ratio Q_n/Q_{10} of Azghar dam is lower comparing with other probable discharges in the same region. But the distribution of the Q_n/Q_{10} shows similar trend to that of probability analysis, and discharge values are larger than the estimated probable discharges at Dar Hamra adjusted by the ratio of basin sizes. Therefore, the probable flood discharged proposed by DGH are judged reasonable, though their specific discharges are low.

XI5.5 Reservoir Sedimentation

Annual reservoir sedimentation proposed by DGH was verified to be acceptable in comparison with sediment yield rates for other dams in the similar hydraulic conditions. The annual sediment yield rate (Ds) and annual reservoir sedimentation (Vs) of Azghar dam are as follows:

$$Ds = 490\ m^3/km^2/yr, \quad Vs = 130,000\ m^3/yr$$

XI5.6 Flood and Sediment Disasters

XI5.6.1 Existing Flood Problems

Data and information on flood conditions and damages were investigated in the basin related to the dam. The damages due to flood and sediment disasters are not so serious in the basin, since the riverine lands are high sloping toward the river. Big runoffs were recorded in 1996 and 1997. Result of flood damage survey is shown in Table XI5.6.1. Information on serious damages was not gathered by the interview to the farmers.

XI5.6.2 Effects of Dam

Flood mitigation functions of the dam are primarily runoff regulation by dam. The runoff regulation by dam reservoir will bring about remarkable effects to lowering flood peaks and channel stabilization in the lower reaches. However, contribution of the dam is not so expected in this basin, since no serious flood problem was identified. River length affected by the Zloul River is only 5 km from the dam site to the confluence of the Karia River.

XI5.6.3 Flood Mitigation

Flood mitigation activities should be executed within a framework of operation and maintenance program for the project, at the sections where severe bank erosions take place.

XI6 Installation of Gauges

In order to supplement basic hydrological data necessary for promoting and mobilizing the priority dam projects, flow and rainfall gauges were installed at the proposed dam sites.

The procurement of equipment and its installation were carried out under sublet contract with Moroccan contractor, COFAS (Companie de Founiture d'Apparellarge Scientifique, Casablanca). The gauges installed are automatic water level gauge (pressure type) with recording rain gauge manufactured by SEBA, Germany.

Four (4) sets of gauges were procured by the end of October 2000 and they were installed during the month of November 2000 at the proposed sites of N'Fifikh, Taskourt, Timkit and Azghar dams.

Inspection of the procured equipment, selection of final installation sites, inspection of completed gauges and operation tests at sites were carried out taking proper steps in collaboration with DGH/DRH officers and the Study Team.

Operation manuals and other appurtenant materials were handed over to the DGH/DRH officers in charge with full explanation and operation practices. These gauges are operational from the beginning of December 2000 under the management of DGH/DRH.

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Tables

Table XI1.3.1: Design Values of Reservoir Sedimentation Volume

River system	Candidate dam	BA	Ds	Vs	L	K
1. MOROCCO NORTH BASINS						
Neckor R.	No.01: Neckor	710	3 333	3.800	16	717
2. SEBOU RIVER BASIN						
Sebou R.						
- Ouerrha R.						
- Aoudour R.	No.06: Tazarane	30	(3,800)	0.114	397	14.9
- Aoulai R.	No.19: Aoulai	490	863	0.430	363	7.5
- Amezetz R.	No.21: Sidi El Mokhf	378	(101)	0.038	480	0.6
- Mengou R.	No.02: Tizimellal	170	(2,876)	0.489	226	30.6
- Lebene R.	No.20: Sidi Abbou	363	(2,755)	1.000	96	83.5
- Zloul R.	No.17: Azghar	263	(490)	0.130	133	9.9
- Beht R.(Tigriga R.)	No.14: Adarouch	630	(317)	0.200	102	10.4
3. BOU REGREG RIVER BASIN AND ATLANTIC COASTAL AREA OF CASABLANCA						
Bou Regreg R.(Tabahart R.)	No.15: Sidi Omar	350	649	0.230	79	23.7
Iqem R.(Khellata R.)	No.04: Ain Kwachiya	162	(105)	0.017	41	6.1
Nefifikh R.	No.05: Lower N'fifikl	606	(100)	0.061	29	11.4
	No.05: Upper N'fifikl	323	(93)	0.030	29	9.1
Mellah R.(Zamrine R.)	No.18: Boukarkour	1 120	(100)	0.112	29	13.3
4. OUM ER RBIA RIVER BASIN						
Oum Er Rbia R.						
- El Abid R.	No.22: N'ouantz	204	(392)	0.080	87	11.4
- Tessaout R.(Lakhdar R.)	No.03: Ait Baddou	194	1 200	0.250	144	20.7
5. TENSIFT RIVER AND ESSAOUIRA COASTAL BASINS						
Tensift R.						
- N'fiss R.	No.07: Amezmiz	80	280	0.025	194	2.9
- Assif el Ma R.	No.09: Taskourt	419	280	0.120	84	10.1
- El Rhira R.	No.08: Boulaouane	565	(283)	0.160	74	12.4
6. SOUSS, MASSA RIVER BASINS						
Souss R.						
- Issen R.	No.24: Amont Abdel.	938	(161)	0.152	64	9.3
- L'ouaar R.	No.25: Sidi Abdellah	233	430	0.103	52	21.5
- Aguerd R.	No.23: Igui N'ouaqa	161	460	0.075	52	21.0
7. GUIR, ZIZ, RHERIS AND DRAA RIVER BASINS						
Guir R.	No.12: Tiouzaguine	258	(543)	0.140	16	90.7
- Bouanane R.	No.13: Kheng Grou	4 900	333	1.500	13	143.0
Rheris R.	No.11: Tadighoust	2 239	(335)	0.750	16	96.0
- Ferklo R.	No.10: Timkit	572	(350)	0.200	18	64.5
Draa R.	No.16: Tiouine	1 540	700	1.000	63	46.4

(Notes)

BA: Basin area (km^2)

Ds: Specific annual reservoir sedimentation ($m^3/km^2/yr$);

Ds in ( ) were calculated from Vs and BA.

Vs: Annual sedimentation volume (Mm^3/yr)

L : Annual runoff height (mm/yr

K : Coefficient for intensity of erosion, assuming unit weight of sediment to be 1.5 t/m3;

$K = Ds \cdot BA^{-0.25}/(1.5L)$, assuming unit weight of sediment to be 1.5 t/m^3

Table XI2.1.1: Monthly Rainfall

Station: FEDDANE TABA (unit: mm)

Year	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Rann	R>20	R<5
7677	14.1	90.1	6.7	98.9	58.2	14.1	15.7	1.7	4.6	2.7	0.4	0.0	307.3	3	5
7778	0.6	42.2	52.8	41.3	88.3	77.1	10.8	57.1	0.2	0.3	0.0	0.2	370.9	6	5
7879	0.0	22.0	14.2	156.2	155.1	97.1	130.5	21.4	3.8	0.2	0.0	0.0	600.5	6	5
7980	0.1	126.6	13.2	20.0	75.5	13.6	89.7	23.9	11.1	0.1	0.0	0.8	374.6	4	4
8081	2.8	28.4	41.1	7.1	14.3	4.3	21.1	21.1	9.0	6.4	0.0	0.0	155.6	4	4
8182	0.2	0.8	0.2	53.9	34.8	5.8	34.9	63.5	1.6	0.0	0.2	0.0	195.9	4	7
8283	2.2	14.7	43.6	47.3	0.3	88.5	54.4	27.6	2.3	0.0	0.0	0.0	280.9	5	6
8384	2.8	1.5	58.0	63.4	12.0	7.0	98.4	43.8	105.8	1.2	0.0	0.0	393.8	5	5
8485	0.0	2.5	81.3	26.7	84.5	31.6	2.2	17.7	18.2	0.9	0.0	0.0	265.6	4	6
8586	0.3	0.0	61.2	54.4	55.4	156.0	30.2	36.8	1.1	16.8	0.0	0.0	412.2	6	5
8687	0.8	4.9	59.9	17.6	86.4	81.0	12.5	13.6	6.4	0.5	1.4	0.1	285.1	3	5
8788	3.3	31.9	83.3	110.0	81.9	78.7	7.6	20.3	15.3	7.4	0.0	0.0	439.7	6	3
8889	0.2	20.5	79.2	8.9	27.7	30.1	55.4	76.4	1.6	0.7	0.0	1.4	302.1	6	5
8990	0.0	8.0	80.3	138.8	67.9	0.0	47.5	59.0	2.9	0.9	0.0	0.0	405.3	5	6
9091	0.9	34.3	42.0	78.6	45.9	125.8	93.0	19.7	0.4	0.5	0.2	0.0	441.3	6	5
9192	55.0	111.9	7.2	21.9	0.0	33.4	31.2	89.5	3.6	24.3	0.0	0.2	378.2	7	4
9293	1.1	23.6	9.7	14.0	14.8	21.3	45.4	34.8	12.5	0.0	0.0	0.0	177.2	4	4
9394	4.5	25.9	109.6	14.6	36.8	44.1	7.8	3.2	1.0	0.0	0.0	0.0	247.5	4	6
9495	1.0	7.2	17.4	0.2	6.4	30.5	11.0	22.7	0.1	8.9	0.0	0.4	105.8	2	5
9596	1.0	5.1	45.7	59.7	172.5	34.6	63.3	20.0	39.1	0.1	0.0	0.1	441.3	6	4
9697	5.1	18.0	29.0	253.9	64.5	0.4	2.4	36.9	0.0	0.3	6.0	0.0	416.5	4	5
9798	6.2	21.1	60.6	32.8	20.5	32.8	6.8	8.8	1.2	6.1	0.0	0.7	197.6	5	3
9899	4.2	3.8	0.0	77.5	67.6	61.4	7.7	8.0	14.0	0.0	0.0	0.0	244.2	3	6
9900	0.0	46.7	39.7	11.3	20.2	0.0	0.0	--	--	--	--	--	--	--	--
Average	4.6	28.0	43.3	60.8	55.3	46.5	38.2	31.6	11.1	3.4	0.4	0.2	323.4	5	5
%	1.4	8.7	13.4	18.8	17.1	14.4	11.8	9.8	3.4	1.1	0.1	0.1	100.0	39	41

NOTES: 1) Sep.1976-Jan.1977: Estimated based on Skhirat records by correlation. (yellow)

2) Other lack of data was estimated based on Cheikhreguig records by correlation. (green)

3) Year 7677 denotes the hydrological year from Sept.1976 to Aug.1977.

4) R>20 mm: Number of rainy months of which monthly rainfall is more than 20 mm.

5) R<5 mm: Number of dry months of which monthly rainfall is less than 5 mm.

Table XI2.4.1: Monthly Discharge

Site: N'FIFIKH DAM SITE (323 km2) (unit: m3/s)

Year	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apl	May	Jun	Jul	Aug	Mean	Total Mm3
1939 / 40	0.139	0.134	0.598	0.577	2.363	2.618	1.197	1.237	0.415	0.429	0.134	0.134	0.819	25.83
1940 / 41	0.145	0.141	0.623	0.603	2.464	2.730	1.247	1.288	0.431	0.447	0.141	0.141	0.854	26.93
1941 / 42	0.100	0.100	0.266	0.504	0.685	1.118	0.776	0.671	0.338	0.181	0.100	0.100	0.407	12.83
1942 / 43	0.167	0.161	0.429	0.809	1.103	1.797	1.244	1.077	0.547	0.294	0.161	0.161	0.655	20.66
1943 / 44	0.066	0.065	0.067	0.065	0.181	0.058	0.052	0.054	0.052	0.054	0.007	0.007	0.061	1.92
1944 / 45	0.126	0.124	0.126	0.124	0.191	0.121	0.119	0.119	0.119	0.351	0.091	0.091	0.142	4.46
1945 / 46	0.097	0.092	0.253	0.477	0.652	1.065	0.735	0.637	0.321	0.175	0.092	0.092	0.386	12.18
1946 / 47	0.345	0.339	0.345	0.339	0.941	0.307	0.276	0.282	0.276	0.282	0.038	0.038	0.317	10.01
1947 / 48	0.105	0.101	0.271	0.514	0.702	1.142	0.789	0.683	0.349	0.183	0.101	0.101	0.415	13.10
1948 / 49	0.099	0.094	0.257	0.484	0.662	1.082	0.746	0.647	0.326	0.178	0.094	0.094	0.393	12.38
1949 / 50	0.163	0.161	0.163	0.161	0.293	0.154	0.149	0.152	0.149	0.152	0.096	0.096	0.157	4.96
1950 / 51	0.125	0.121	0.326	0.610	0.834	1.356	0.940	0.815	0.413	0.220	0.121	0.121	0.494	15.59
1951 / 52	0.349	0.343	0.349	0.343	0.953	0.311	0.280	0.286	0.280	0.286	0.038	0.038	0.321	10.14
1952 / 53	0.379	0.367	0.379	0.367	1.021	0.330	0.300	0.312	0.300	0.312	0.037	0.037	0.345	10.88
1953 / 54	0.157	0.150	0.402	0.758	1.032	1.679	1.164	1.007	0.513	0.276	0.150	0.150	0.613	19.33
1954 / 55	0.143	0.140	0.374	0.704	0.957	1.561	1.081	0.934	0.474	0.254	0.140	0.140	0.569	17.93
1955 / 56	0.212	0.041	0.909	0.880	3.598	3.984	1.820	1.881	0.630	0.652	0.205	0.205	1.233	38.87
1956 / 57	0.177	0.175	0.177	0.175	0.328	0.165	0.158	0.161	0.158	0.161	0.098	0.098	0.169	5.34
1957 / 58	0.106	0.101	0.278	0.524	0.718	1.168	0.806	0.701	0.357	0.190	0.101	0.101	0.424	13.39
1958 / 59	0.387	0.376	0.387	0.376	1.053	0.342	0.307	0.319	0.307	0.319	0.040	0.040	0.354	11.18
1959 / 60	0.124	0.120	0.318	0.602	0.823	1.335	0.924	0.799	0.407	0.217	0.120	0.120	0.487	15.36
1960 / 61	0.099	0.094	0.256	0.483	0.661	1.080	0.744	0.646	0.325	0.177	0.094	0.094	0.392	12.35
1961 / 62	0.173	0.167	0.444	0.837	1.143	1.859	1.284	1.115	0.566	0.306	0.167	0.167	0.678	21.38
1962 / 63	0.148	0.144	0.639	0.619	2.531	2.801	1.280	1.323	0.443	0.459	0.144	0.121	0.875	27.58
1963 / 64	0.191	0.185	0.495	0.932	1.270	2.065	1.430	1.237	0.630	0.338	0.185	0.185	0.754	23.76
1964 / 65	0.331	0.318	0.331	0.318	0.894	0.291	0.265	0.271	0.265	0.271	0.033	0.033	0.302	9.52
1965 / 66	0.343	0.336	0.343	0.336	0.935	0.305	0.274	0.280	0.274	0.280	0.037	0.037	0.315	9.94
1966 / 67	0.235	0.235	0.235	0.235	0.652	0.209	0.183	0.196	0.183	0.196	0.026	0.026	0.217	6.86
1967 / 68	0.155	0.152	0.406	0.765	1.041	1.695	1.174	1.016	0.517	0.279	0.152	0.152	0.618	19.50
1968 / 69	0.154	0.147	0.658	0.636	2.601	2.880	1.316	1.361	0.457	0.472	0.147	0.147	0.901	28.42
1969 / 70	0.125	0.121	0.327	0.611	0.835	1.359	0.942	0.816	0.414	0.220	0.121	0.121	0.496	15.63
1970 / 71	0.187	0.182	0.807	0.780	3.193	3.535	1.616	1.670	0.559	0.579	0.182	0.182	1.106	34.89
1971 / 72	0.164	0.160	0.427	0.093	1.096	1.779	1.231	1.068	0.541	0.292	0.160	0.160	0.589	18.58
1972 / 73	0.186	0.186	0.186	0.186	0.466	0.093	0.093	0.093	0.093	0.093	0.000	0.000	0.140	4.42
1973 / 74	0.191	0.186	0.496	0.933	1.271	2.067	1.431	1.238	0.630	0.338	0.186	0.186	0.754	23.78
1974 / 75	0.177	0.175	0.177	0.175	0.328	0.165	0.158	0.161	0.158	0.161	0.098	0.098	0.169	5.34
1975 / 76	0.016	0.021	0.034	0.084	0.042	0.207	0.449	0.530	0.203	0.029	0.016	0.009	0.136	4.29
1976 / 77	0.012	0.490	0.037	0.813	1.657	2.071	0.157	0.072	0.056	0.062	0.038	0.032	0.449	14.18
1977 / 78	0.019	0.051	0.088	0.225	0.954	3.593	0.063	0.222	0.107	0.023	0.006	0.004	0.424	13.38
1978 / 79	0.041	0.098	0.078	1.478	3.799	8.603	1.066	0.393	0.257	0.238	0.201	0.125	1.318	41.57
1979 / 80	0.097	0.677	0.178	0.147	0.454	0.173	1.972	0.183	0.138	0.055	0.016	0.002	0.345	10.87
1980 / 81	0.045	0.085	0.388	0.070	0.065	0.042	0.184	0.051	0.036	0.018	0.015	0.015	0.084	2.66
1981 / 82	0.017	0.020	0.019	0.158	0.398	0.349	0.093	0.711	0.029	0.020	0.017	0.015	0.152	4.79
1982 / 83	0.017	0.023	0.084	0.099	0.041	0.418	0.073	0.058	0.047	0.031	0.028	0.022	0.076	2.40
1983 / 84	0.017	0.021	0.226	0.290	0.029	0.019	0.311	0.220	0.416	0.023	0.009	0.008	0.134	4.21
1984 / 85	0.009	0.009	1.310	0.090	0.471	0.107	0.023	0.012	0.031	0.009	0.007	0.008	0.173	5.45
1985 / 86	0.024	0.007	0.370	0.075	0.261	1.321	0.101	0.171	0.009	0.004	0.001	0.001	0.187	5.89
1986 / 87	0.001	0.003	1.407	0.026	0.129	1.042	0.025	0.018	0.004	0.001	0.001	0.002	0.213	6.72
1987 / 88	0.012	0.078	0.323	0.798	0.787	1.745	0.319	0.034	0.029	0.024	0.009	0.002	0.338	10.65
1988 / 89	0.006	0.027	0.197	0.021	0.181	0.259	0.494	0.708	0.008	0.005	0.002	0.001	0.157	4.97
1989 / 90	0.002	0.010	0.755	1.380	0.628	0.034	0.102	0.026	0.016	0.008	0.002	0.001	0.249	7.86
1990 / 91	0.001	0.041	0.070	0.641	0.042	0.833	1.090	0.803	0.048	0.033	0.019	0.015	0.299	9.44
1991 / 92	0.113	0.204	0.046	0.113	0.042	0.092	0.085	0.684	0.109	0.087	0.008	0.008	0.132	4.16
1992 / 93	0.008	0.081	0.080	0.046	0.040	0.012	0.258	0.040	0.012	0.012	0.012	0.012	0.052	1.63
1993 / 94	0.016	0.021	0.034	0.084	0.042	0.207	0.449	0.530	0.203	0.029	0.016	0.009	0.136	4.29
1994 / 95	0.003	0.004	0.040	0.001	0.001	0.001	0.001	0.006	0.001	0.001	0.001	0.001	0.005	0.15
1995 / 96	0.002	0.006	0.350	0.737	4.265	1.022	2.050	0.090	0.127	0.042	0.012	0.004	0.730	23.01
1996 / 97	0.006	0.012	0.042	4.541	3.970	0.160	0.117	0.387	0.043	0.028	0.017	0.011	0.790	24.92
Mean	0.122	0.142	0.339	0.515	1.013	1.188	0.655	0.560	0.261	0.187	0.074	0.071	0.422	13.32
(%)	2.4	2.8	6.6	10.0	19.8	23.2	12.8	10.9	5.1	3.6	1.4	1.4	100.0	

Note: Monthly dischages at N'fifikh dam site were estimated based on monthly discharge data at Feddane Taba station.
The discharge data at Feddane Taba station were estimated as follows:
1) Discharge records at Feddane Taba are available from 1975/76 to 1996/9
2) Monthly discharges from 1939/40 to 1974/75 were estimated in the following procedures:
(1) Annual average discharges were estimared based on correlation with Rainfall Index for the Atlantic coastal regi
presented in Master Plan - SBO (Plan Directeur -SBO).
(2) The annual average discharge was distributed in accordance with monthly runoff patterns at Mellah dam site
3) Monthly discharges in 1944/45, 1949/50, 1956/58 and 1974/75 were estimated based on correlation with Mellah dam records,
since annual average discharges could not be estimated in procedure (2) of 2) due to small rainfall indeces for these year

Table XI2.4.2: Probable Flood Discharges

Probable Design Floods

Desctiptions		Return period (year) 2	10	20	50	100	1000	10000
N'FIFIKH (NO.5)								
Basin area (km^2)	323							
Time of consentration (hr)	7.5							
Base length of hydrograph (hr)	18							
Probable discharge (m^3/s)		45.8	140	250	380	490	820	1800
Specific discharge ($m^3/s/km^2$)		0.14	0.43	0.77	1.18	1.52	2.54	5.57
Ratio to Q10yr		0.33	1.00	1.79	2.71	3.50	5.86	12.86
Runoff volume (Mm^3)		1.48	4.54	8.10	12.31	15.88	26.57	58.32

Probable Dischcarges of Proposed Dams by DGH in Same Hydrologic Region

Dam	BA (km^2)	Return period (year) 2	10	20	50	100	1 000	10 000
N'Fifikh (5)	323							
Probable discharge(m^3/s)		46	140	250	380	490	820	1 800
Specific discharge($m^3/s/km^2$)		0.14	0.43	0.77	1.18	1.52	2.54	5.57
Ratio to Q10		0.33	1.00	1.79	2.71	3.50	5.86	12.86
Sidi Omar (15)	350							
Probable discharge(m^3/s)		-	290	400	550	700	1 470	2 360
Specific discharge($m^3/s/km^2$)		-	0.83	1.14	1.57	2.00	4.20	6.74
Ratio to Q10		-	1.00	1.38	1.90	2.41	5.07	8.14
Ain Kwachiya (4)	162							
Probable discharge(m^3/s)		-	160	-	-	260	450	-
Specific discharge($m^3/s/km^2$)		-	0.99	-	-	1.60	2.78	-
Ratio to Q10		-	1.00	-	-	1.63	2.81	-
Boukerkour (18)	1 120							
Probable discharge(m^3/s)		-	400	610	810	1 100	1 900	2 800
Specific discharge($m^3/s/km^2$)		-	0.36	0.54	0.72	0.98	1.70	2.50
Ratio to Q10		-	1.00	1.53	2.03	2.75	4.75	7.00

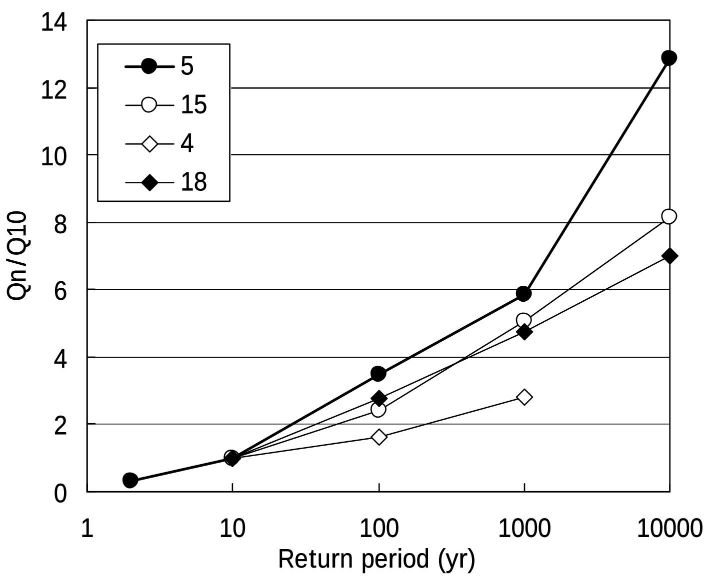

Table XI2.4.3: Monthly Maximum Peak Discharge: Feddane Taba

STATION: FEDDANE TABA

Year	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Ann.max
1974/75									23.20	0.07	0.04	0.03	
1975/76	0.05	0.07	0.16	1.20	0.18	17.30	56.90	36.00	10.70	0.13	0.05	0.03	56.90
1976/77	0.06	33.50	0.41	22.60	30.60	45.10	0.73	0.20	0.13	0.15	0.12	0.07	45.10
1977/78	0.06	0.22	0.73	20.90	105.00	285.00	0.39	11.50	3.10	0.07	0.03	0.01	285.00
1978/79	0.09	6.00	0.18	54.40	143.00	151.00	19.80	1.24	0.52	0.49	0.46	0.28	151.00
1979/80	0.23	33.50	0.54	0.44	10.40	1.33	48.80	0.58	0.61	0.17	0.10	0.08	48.80
1980/81	0.11	6.67	28.30	0.14	0.16	0.11	22.10	0.55	0.21	0.04	0.04	0.04	28.30
1981/82	0.04	0.05	0.05	21.70	19.90	25.60	13.00	41.40	0.16	0.05	0.04	0.03	41.40
1982/83	0.04	0.08	8.32	5.02	0.08	14.70	0.69	0.21	0.12	0.07	0.06	0.06	14.70
1983/84	0.08	0.05	19.40	20.70	0.06	0.06	26.70	19.90	21.20	0.07	0.03	0.02	26.70
1984/85	0.02	0.02	205.00	9.40	15.80	4.26	0.07	0.18	3.04	0.03	0.02	0.02	205.00
1985/86	3.30	0.02	58.70	6.09	23.10	36.70	4.98	12.10	0.04	0.01	0.00	0.00	58.70
1986/87	0.00	0.01	81.90	0.05	8.53	104.00	0.08	0.04	0.02	0.00	0.00	0.01	104.00
1987/88	1.28	10.40	38.70	45.80	24.10	135.00	12.40	0.07	0.06	0.05	0.04	0.02	135.00
1988/89	0.02	3.36	20.30	0.09	24.60	19.90	37.40	52.90	0.04	0.01	0.01	0.00	52.90
1989/90	0.00	1.61	67.00	79.00	17.70	0.16	6.09	0.16	0.06	0.04	0.01	0.00	79.00
1990/91	0.00	5.31	10.40	64.10	0.08	38.80	26.10	53.70	0.12	0.08	0.05	0.03	64.10
1991/92	6.78	9.17	0.10	6.78	0.09	4.62	5.38	31.20	13.70	13.30	0.02	0.02	31.20
1992/93	0.02	14.30	8.74	6.54	5.31	0.09	12.70	4.35	0.03	0.02	0.02	0.02	14.30
1993/94	0.03	15.80	83.30	6.55	52.90	57.10	26.20	0.02	0.01	0.01	0.00	0.00	83.30
1994/95	0.02	0.02	3.36	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	3.36
1995/96	0.01	0.02	28.90	117.00	138.00	6.11	107.00	0.36	5.89	1.06	0.04	0.02	138.00
1996/97	0.06	0.91	3.07	223.00	80.70	0.51	16.90	34.90	0.11	0.07	0.06	1.06	223.00
1997/98													
Max.	6.78	33.50	205.00	223.00	143.00	285.00	107.00	53.70	23.20	13.30	0.46	1.06	285.00

Table XI.2.6.1 Result of Flood Damage Survey

Area: N'Fifikh (1996-flood)

CR	Douar	Farmer No.	Inondated depth: House (cm)	Inondated depth: Road (cm)	Damages to agricultural crops due to inundation: Types of crops	Area (ha)	Damage (qintal)	Damages to agricultural crops due to bank erosion: Types of crops	Area (ha)	Damage (qintal)
Oued Yayia Louta	Beni Karzaz : 3 of 11 interviewee farmers were damaged.									
		5	100	100	Hard wheat	1.00	10	BD	0.10	2
		10	10	20	PC	0.40	0	PC	0.12	2
		11	50	50	PC	0.20	0	PC	0.10	2
	Lamsaada : 7 of 10 interviewee farmers were damaged.									
		12	0	30	Soft wheat	1.00	15	-	0.00	0
		13	0	50	Soft wheat	0.70	5	-	0.00	0
		15	0	20	Bean	1.00	10	-	0.00	0
		16	0	5	Soft wheat	1.00	10	-	0.00	0
		17	0	10	Bean	1.50	25	-	0.00	0
		20	0	0	-	0.00	0	Luzerne	0.14	0
		21	0	50	Soft wheat	0.80	15	Jachère	0.12	0
Mouline El Ghaba	Oued Tarfia : 12 of 19 interviewee farmers were damaged.									
		28	0	20	Hard wheat	0.40	0	BD	0.08	8
		29	0	20	Soft wheat	0.50	0	BT	0.18	10
		30	0	70	Hard wheat	1.20	20	Jachère	0.20	0
		31	0	20	-	0.00	0	Luzerne	0.30	0
		32	0	30	PC	0.60	9	CUMAR	0.10	50
		33	300	40	CUMAR	1.00	300	Jachère	0.30	0
		34	0	20	Hard wheat	1.00	25	CUMAR	0.10	40
		35	0	20	-	0.00	0	-	0.00	0
		36	0	60	PC	0.80	20	Jachère	0.08	0
		37	0	20	Bean	1.00	20	-	0.00	0
		38	0	0	Bean	0.50	14	-	0.00	0
		39	0	50	Bean	0.60	10	-	0.00	0
T'lat Ziaïda	Lamsaada : 6 of 13 interviewee farmers were damaged.									
		41	0	50	Hard wheat	0.20	5	Jachère	0.12	0
		45	0	20	CUMAR	0.50	40	-	0.00	0
		46	0	20	CUMAR	0.20	25	-	0.00	0
		47	0	20	CUMAR	0.10	15	-	0.00	0
		49	0	100	Bean	0.50	15	Jachère	0.18	0
		53	0	10	Bean	0.40	15	BD	0.20	5
El Mansouria	Beni Rach : None of 6 interviewee farmers were damaged.									
	Beni Makraz : None of 4 interviewee farmers were damaged.									
Whole survey area	: 28 of 63 interviewee farmers were damaged.									

Table XI3.3.1: Monthly Rainfall

Station: SIDI BOUATHMANE (unit: mm)

Year	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Rann	R>20	R<5
8990	2.3	37.2	24.2	30.2	35.6	0.0	31.3	20.9	12.7	7.4	34.4	0.3	236.5	7	3
9091	1.2	2.5	4.8	53.3	8.9	140.3	120.7	6.2	6.2	5.1	4.0	6.1	359.3	3	4
9192	44.7	23.1	13.0	27.6	0.0	47.9	79.9	59.7	7.4	49.8	3.5	1.4	358.0	7	3
9293	0.2	61.2	14.2	8.6	35.3	29.2	18.7	24.9	7.2	0.0	0.0	0.0	199.5	4	4
9394	0.1	27.4	103.5	44.4	67.1	80.1	36.8	8.1	0.0	0.0	0.0	18.8	386.3	6	4
9495	0.0	91.5	0.0	0.1	0.0	77.2	58.2	187.5	0.0	0.2	0.6	0.0	415.3	4	8
9596	8.0	40.8	12.6	77.1	92.4	105.4	125.4	7.6	26.4	63.4	0.0	0.0	559.1	7	2
9697	6.2	0.9	58.7	84.6	62.5	5.2	42.9	97.2	32.1	3.6	0.0	0.2	394.1	6	4
9798	79.7	40.6	33.7	91.6	25.8	34.8	18.9	52.0	20.7	0.1	0.0	0.0	397.9	8	3
9899	13.2	46.1	0.1	38.1	77.9	88.7	96.7	4.6	9.0	14.3	0.2	4.0	392.9	5	4
9900	4.3	154.8	45.2	70.6	5.5	0.5	0.3	24.8	21.0	0.1	0.0	0.5	327.6	5	6
Ave-1.	21.0	43.7	11.2	42.3	34.3	74.8	74.1	48.9	11.0	19.0	1.2	1.6	383.1		
Ave-all	14.5	47.8	28.2	47.8	37.4	55.4	57.3	44.9	13.0	13.1	3.9	2.8	366.0	6	4
(%)	4.0	13.1	7.7	13.1	10.2	15.1	15.6	12.3	3.5	3.6	1.1	0.8	100.0	47	34

NOTES: 1) Ave-1: Average value of 7 years of complete records (9091-9293, 9495-9596, and 9798-9899).
2) Ave-all: Average value of all data including estimated/supplemented ones.
3) Lack of data was supplemented with data obtained from Regional Office of MOA in Amizmiz.
4) Year 8990 denotes the hydrological year from Sept.1989 to Aug.1990.
5) R>20 mm: Number of rainy months of which monthly rainfall is more than 20 mm.
6) R<5 mm: Number of dry months of which monthly rainfall is less than 5 mm.

Table XI3.4.1: Monthly Discharge

Site: TASKOURT DAM SITE (419 km2) (unit: m3/s)

Year	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Mean	Total Mm3
1935 / 36	0.012	0.879	0.133	0.063	0.127	1.528	3.212	1.084	0.510	0.205	0.078	0.028	0.651	20.53
1936 / 37	0.008	0.090	0.854	0.887	0.252	0.108	0.036	0.014	1.175	0.177	0.068	0.022	0.310	9.78
1937 / 38	0.003	4.880	1.290	1.224	0.513	0.242	0.109	3.278	0.784	0.320	0.122	0.049	1.073	33.84
1938 / 39	0.016	0.719	0.134	6.400	2.547	4.601	1.545	1.668	0.458	0.193	0.074	0.029	1.518	47.87
1939 / 40	0.007	0.555	0.920	1.224	2.785	4.642	2.473	0.969	0.394	0.159	0.062	0.025	1.163	36.69
1940 / 41	0.195	1.799	1.117	0.430	3.442	1.996	2.005	2.637	0.662	0.272	0.100	0.039	1.220	38.48
1941 / 42	0.137	0.225	3.442	1.060	2.120	4.223	2.678	1.093	0.423	0.173	0.067	0.026	1.283	40.45
1942 / 43	0.237	1.799	7.254	4.132	1.758	0.821	3.664	4.215	3.327	0.994	0.386	0.154	2.400	75.67
1943 / 44	0.086	0.036	0.044	1.117	0.229	1.857	0.480	0.195	0.071	0.522	0.064	0.020	0.383	12.09
1944 / 45	2.703	0.359	1.569	0.728	1.758	0.565	0.203	0.081	0.031	0.008	0.002	0.000	0.664	20.92
1945 / 46	0.000	0.027	0.230	0.077	1.199	0.333	0.546	1.224	0.320	0.129	0.049	0.019	0.346	10.90
1946 / 47	0.937	0.090	1.577	1.331	3.385	4.428	2.070	0.794	1.742	0.343	0.132	0.052	1.387	43.75
1947 / 48	0.016	0.006	0.945	0.196	1.035	1.372	2.506	6.753	4.297	1.446	0.559	0.223	1.607	50.69
1948 / 49	0.092	0.061	0.025	0.787	1.257	2.613	6.145	13.967	6.178	2.604	1.002	0.398	2.916	91.97
1949 / 50	0.163	0.064	0.711	5.496	3.845	1.569	0.566	0.237	0.278	0.074	0.028	0.019	1.092	34.44
1950 / 51	0.986	2.374	0.501	2.350	2.958	2.843	2.514	0.830	0.369	0.151	0.058	0.019	1.325	41.78
1951 / 52	0.348	0.081	2.366	1.972	3.237	1.150	0.446	0.379	0.122	0.048	0.015	0.002	0.845	26.66
1952 / 53	1.996	0.484	0.228	0.377	2.506	1.947	3.927	1.356	0.520	0.213	0.078	0.025	1.134	35.75
1953 / 54	0.005	2.489	1.224	3.319	3.648	2.563	5.496	7.337	2.300	0.945	0.366	0.146	2.487	78.43
1954 / 55	0.060	0.023	2.185	2.383	2.103	3.245	2.440	2.021	0.591	0.245	0.094	0.035	1.271	40.08
1955 / 56	0.014	2.111	0.555	3.122	7.115	10.845	9.366	5.217	3.311	1.134	0.438	0.175	3.578	112.84
1956 / 57	0.069	0.022	0.059	0.053	0.484	0.144	0.158	1.364	0.776	0.207	0.080	0.028	0.287	9.04
1957 / 58	0.008	3.713	3.237	9.941	5.463	3.344	1.208	1.290	1.101	0.640	0.158	0.058	2.520	79.47
1958 / 59	0.021	0.120	0.953	0.681	0.336	1.208	2.317	0.863	1.101	0.261	0.101	0.035	0.663	20.92
1959 / 60	0.529	0.068	1.265	0.485	4.404	1.413	1.668	1.734	0.461	0.772	0.137	0.051	1.080	34.05
1960 / 61	0.021	0.467	0.382	2.843	0.759	0.334	0.334	0.130	0.072	0.026	0.010	0.000	0.453	14.27
1961 / 62	0.010	0.002	0.384	1.109	3.294	1.126	6.762	5.710	3.467	1.191	0.459	0.177	1.983	62.53
1962 / 63	0.664	2.029	4.765	3.927	6.646	12.734	5.036	3.426	4.067	1.076	0.415	0.164	3.686	116.24
1963 / 64	0.067	0.022	0.068	7.682	5.866	2.974	1.388	5.726	1.421	0.587	0.226	0.090	2.176	68.63
1964 / 65	0.033	0.012	0.150	5.118	5.488	9.037	3.886	3.631	1.093	0.449	0.173	0.064	2.389	75.33
1965 / 66	0.021	4.330	8.084	4.888	1.955	0.871	1.282	0.317	0.140	0.058	0.022	0.007	1.836	57.90
1966 / 67	0.016	0.101	5.135	1.323	0.586	3.385	2.539	2.637	0.978	0.384	0.149	0.058	1.418	44.72
1967 / 68	0.030	1.955	15.199	8.544	4.124	4.067	6.195	5.102	1.635	0.675	0.256	0.096	3.975	125.37
1968 / 69	0.036	0.010	2.802	3.664	2.391	7.369	3.360	5.841	2.120	0.863	0.326	0.128	2.369	74.70
1969 / 70	0.049	0.475	4.486	1.692	6.564	3.344	3.015	1.462	0.522	0.215	0.083	0.033	1.819	57.36
1970 / 71	0.007	1.142	0.753	6.260	7.008	4.535	6.039	8.216	5.398	1.931	0.744	0.295	3.528	111.25
1971 / 72	0.117	0.096	4.379	1.282	1.224	6.293	3.442	1.651	0.732	0.302	0.116	0.046	1.602	50.52
1972 / 73	0.205	0.170	1.668	0.994	0.375	0.335	0.904	1.060	0.249	0.100	0.039	0.014	0.508	16.02
1973 / 74	0.006	0.035	1.183	5.069	1.635	4.198	7.468	8.544	3.097	1.298	0.500	0.200	2.758	86.97
1974 / 75	0.077	0.026	0.007	0.007	0.371	0.152	0.082	4.108	1.840	0.610	0.236	0.090	0.632	19.92
1975 / 76	0.031	0.010	0.010	0.254	0.099	1.692	1.865	4.157	4.248	1.183	0.456	0.182	1.176	37.09
1976 / 77	0.429	1.208	0.197	0.994	3.270	1.594	0.633	0.258	0.097	0.039	0.015	0.006	0.727	22.91
1977 / 78	0.662	1.175	2.128	3.368	7.024	3.787	1.454	2.415	0.687	0.288	0.111	0.039	1.919	60.52
1978 / 79	0.012	0.376	0.056	1.865	5.455	3.410	1.199	0.494	0.187	0.073	0.028	0.012	1.089	34.33
1979 / 80	0.000	3.623	0.738	0.283	0.383	3.188	5.800	2.621	0.994	0.409	0.158	0.061	1.514	47.75
1980 / 81	0.026	0.012	2.473	0.493	0.252	0.838	0.629	0.196	0.073	0.029	0.011	0.004	0.413	13.04
1981 / 82	0.000	0.092	0.025	0.037	3.787	1.684	1.068	5.077	4.420	1.290	0.495	0.196	1.512	47.68
1982 / 83	0.080	0.029	1.002	0.349	0.139	1.495	0.394	0.176	0.080	0.032	0.012	0.003	0.306	9.65
1983 / 84	0.002	0.000	2.415	0.532	0.210	0.093	1.446	0.778	0.331	0.136	0.053	0.021	0.501	15.80
1984 / 85	0.006	0.000	0.065	0.015	1.399	1.603	1.316	2.120	2.071	0.516	0.043	0.019	0.759	23.92
1985 / 86	0.018	0.024	0.021	0.036	0.165	0.132	1.263	2.045	1.931	0.244	0.017	0.016	0.495	15.60
1986 / 87	0.015	0.156	0.035	0.012	0.411	0.884	0.255	0.191	0.127	0.397	0.009	0.008	0.203	6.41
1987 / 88	0.016	1.814	2.652	5.411	1.342	4.951	6.441	3.323	2.158	0.960	0.123	0.020	2.421	76.36
1988 / 89	0.015	0.904	12.054	3.250	1.899	1.812	2.278	3.788	2.324	0.808	0.309	0.186	2.456	77.44
1989 / 90	0.052	3.045	2.389	1.232	1.032	0.443	2.567	1.746	1.902	0.612	0.418	0.077	1.301	41.02
1990 / 91	0.017	0.018	0.124	0.144	0.055	0.412	1.298	0.901	0.527	0.091	0.059	0.913	0.381	12.00
1991 / 92	0.157	0.139	0.110	3.566	0.676	1.394	1.647	3.305	2.339	0.574	0.198	0.122	1.186	37.39
1992 / 93	0.196	0.276	0.286	0.875	0.547	1.261	0.790	1.494	0.573	0.287	0.015	0.007	0.545	17.17
1993 / 94	0.009	0.204	0.878	0.729	1.008	1.122	4.927	4.922	1.457	0.348	0.020	0.017	1.302	41.07
1994 / 95	0.019	0.297	0.108	0.040	0.011	0.015	0.039	1.470	0.696	0.193	0.029	0.164	0.257	8.09
1995 / 96	0.063	0.167	0.268	1.237	2.368	2.316	4.166	5.424	2.522	2.153	0.337	0.193	1.761	55.54
1996 / 97	0.086	0.069	0.520	0.627	1.112	1.309	1.127	4.468	3.585	0.822	0.857	0.172	1.226	38.66
Mean	0.192	0.768	1.787	2.090	2.249	2.513	2.453	2.734	1.475	0.540	0.191	0.090	1.416	44.65
(%)	1.1	4.5	10.5	12.2	13.2	14.7	14.4	16.0	8.6	3.2	1.1	0.5	100.0	

Note: 1) From Sep.1935 to Oct.1984: Estimated based on Plan Directeur and basin area ratio.
2) From Nov.1984 to Jul.1997: Estimated based on actual records at Sidi Bouathmane by basin area ratio.
3) Aug.1997: Estimated based on average runoff pattern (1985-95) at Sidi Bouthamane.

Table XI3.4.2: Probable Flood Discharges

Probable Design Floods

Desctiptions		Return period (year) 2	10	20	50	100	1000	10000
TASKOURT (NO.9)								
Basin area (km^2)	419							
Time of consentration (hr)	5							
Base length of hydrograph (hr)	15							
Probable discharge (m^3/s)		89.2	400	600	800	900	1700	2300
Specific discharge ($m^3/s/km^2$)		0.21	0.95	1.43	1.91	2.15	4.06	5.49
Ratio to Q10yr		0.22	1.00	1.50	2.00	2.25	4.25	5.75
Runoff volume (Mm^3)		2.41	10.80	16.20	21.60	24.30	45.90	62.10

Probable Dischcarges of Proposed Dams by DGH in Same Hydrologic Region

Dam	BA (km^2)	Return period (yr) 2	10	20	50	100	1 000	10 000
Taskourt (9)	419							
Probable discharge(m^3/s)		89	400	600	800	900	1 700	2 300
Specific discharge($m^3/s/km^2$)		0.21	0.95	1.43	1.91	2.15	4.06	5.49
Ratio to Q10		0.22	1.00	1.50	2.00	2.25	4.25	5.75
Amezmiz (7)	80							
Probable discharge(m^3/s)		-	210	280	360	455	670	900
Specific discharge($m^3/s/km^2$)		-	2.63	3.50	4.50	5.69	8.38	11.25
Ratio to Q10		-	1.00	1.33	1.71	2.17	3.19	4.29
Boulaouane (8)	565							
Probable discharge(m^3/s)		-	-	620	-	1 050	1 740	2 400
Specific discharge($m^3/s/km^2$)		-	-	1.10	-	1.86	3.08	4.25
Ratio to Q10		-	-	-	-	-	-	-

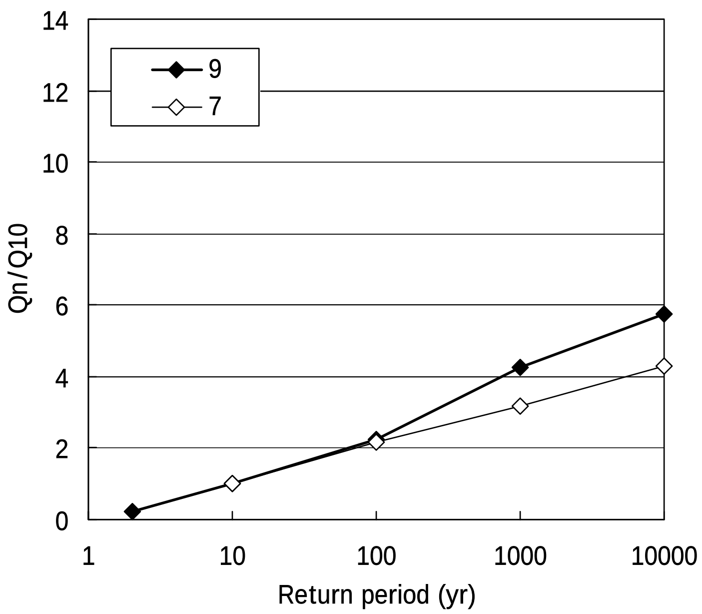

Table XI3.4.3: Monthly Maximum Peak Discharge: Sidi Bouathmane

STATION: SIDI BOUATHMAN

Year	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Ann.max.
1983/84													
1984/85				0.05	72.50	21.10	2.10	7.04	7.04	1.14	0.21	0.07	72.50
1985/86	0.04	0.56	0.04	0.56	0.80	0.21	4.39	3.32	100.00	5.86	0.02	0.02	100.00
1986/87	0.02	50.40	2.85	0.02	14.80	22.10	0.90	0.78	1.04	137.00	0.01	0.01	137.00
1987/88	0.34	100.00	160.00	50.70	2.69	33.60	33.60	7.68	3.29	2.05	0.49	0.05	160.00
1988/89	0.04	33.40	305.00	4.88	5.27	2.49	4.09	7.84	5.90	1.38	0.95	8.10	305.00
1989/90	0.54	137.00	6.70	11.40	2.41	0.99	19.40	3.77	4.63	1.57	6.21	0.49	137.00
1990/91	0.03	0.05	0.25	0.22	0.11	1.02	4.12	2.01	1.13	0.29	0.40	241.00	241.00
1991/92	6.70	0.29	0.29	47.30	1.61	2.62	4.97	8.28	4.99	1.66	1.15	0.46	47.30
1992/93	0.91	5.23	4.27	1.84	1.66	10.90	2.23	2.23	1.66	1.25	0.23	0.21	10.90
1993/94	0.06	16.60	4.03	9.05	6.82	2.05	16.60	13.40	3.52	1.70	0.04	0.09	16.60
1994/95	0.04	19.00	1.17	0.07	0.03	0.88	2.15	20.40	2.30	0.62	0.08	10.80	20.40
1995/96	0.12	19.50	3.91	5.87	8.50	5.87	10.50	15.50	3.91	9.17	2.79	0.32	19.50
1996/97	0.20	0.11	1.59	2.99	5.29	1.71	4.17	15.40	7.50	1.49	1.34		15.40
1997/98													
Max.	6.70	137.00	305.00	50.70	72.50	33.60	33.60	20.40	100.00	137.00	6.21	241.00	305.00

Table XI.3.4.4 Result of Flood Damage Survey

Area: Taskourt (1999-flood)

CR	Douar	Farmer No.	Inundated Depth House (cm)	Inundated Depth Farmlan (cm)	Damages to agricultural crops due to inundation: Type of crops	Area (ha)	Damage	Damages to agricultural crops due to bank erosion: Type of crops	Area (ha)	Damage
Assif El Mal	Tafroukht : 7 of 8 interviewee farmers were damaged.									
		1	0	0	Olivier	1.00	15	Olivier	1.00	15
		2	0	200	Bersim,luzerne	0.03	3	Bersim,luzerne	0.03	3
		3	0	200	Orge,cult.mar.	2.00	40	Orge,cult.mar.	0.20	10
		5	0	150	Orge	0.50	6	Orge	0.20	0.6
		6	0	100	Oranger,olivier	1.00	440	Oranger,olivier	1.00	440
		7	0	100	Oliviers	1.00	56	Olivier	1.00	56
		8	0	200	Cult.mar.,BD	0.02	1.5	Cult.mar.,BD	0.02	1.5
	Dar Nams : 4 of 12 interviewee farmers were damaged.									
		9	0	200	Orge,olivier,luz.	0.40	10qx+10	Orge,olivier,luz.	0.10	0.5qx+1
		11	0	200	Orge,olivier	0.10	30	Orge,olivier	0.10	30
		13	0	100	Orge	0.50	0.6	Orge	0.10	0.6
		15	0	300	Orge	0.75	0.9	Orge	0.00	0.9
	Dar Akimekh : 6 of 10 interviewee farmers were damaged.									
		21	0	100	Orge,luzerne	0.25		Orge,luzerne	0.20	0.4
		22	0	100	Orge	0.03	0	Orge	0.03	0
		23	0	100	Luzerne,maïs	2.00	0.8	Luzerne,maïs	0.05	0.8
		25	0	150	Orge	0.30	0.5	Orge	0.00	0.5
		26	0	200	BD,Maïs	1.50	3	BD,Maïs	0.05	3
		27	0	100	Orge	1.00	2	Orge	1.00	2
	Ajmâni : 2 of 3 interviewee farmers were damaged.									
		31	0	150	Luz,maïs,olivier	1.00	0.0225	Luz.maïs,olivier	1.00	0.0225
		32	0	300	Orge,olivier	1.30	2	Orge,olivier	1.30	2qx et
Guammas	Azib Miloud : None of 6 interviewee farmers were damaged.									
Mejjat	Ait Si Brahim : None of 9 interviewee farmers were damaged.									
	Lahraracha : None of 5 interviewee farmers were damaged.									
Mzouda	Azrabouk : None of 3 interviewee farmers were damaged.									
	Tiguami Oumghar : None of 7 interviewee farmers were damaged.									
	Ait M'hamed : None of 6 interviewee farmers were damaged.									
	Ait Hssaine : None of 6 interviewee farmers were damaged.									
Whole survey area	: 19 of 75 interviewee farmers were damaged.									

Table XI4.3.1: Monthly Rainfall

Station: IFFER (unit: mm)

Year	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Rann	R>20	R<5
6465	30.3	0.0	0.4	12.7	36.1	147.0	0.0	43.0	0.0	8.7	0.0	13.9	292.0	4	5
6566	22.3	87.4	64.0	0.6	0.0	0.0	34.0	0.0	23.0	4.5	0.0	0.6	236.3	5	7
6667	13.2	0.0	41.7	0.0	7.4	37.7	5.2	13.1	99.6	1.5	0.0	1.5	220.9	3	5
6768	39.5	25.7	182.4	2.5	0.0	24.2	17.2	17.0	13.0	4.2	5.2	0.0	330.9	4	4
6869	12.0	1.8	15.2	23.8	38.3	68.5	0.0	4.6	2.0	0.0	0.0	16.1	182.3	3	6
6970	9.4	7.2	49.9	3.7	45.7	1.3	19.2	0.0	9.1	4.0	0.0	2.4	151.9	2	6
7071	10.0	78.6	44.5	32.0	0.8	3.0	10.8	12.5	8.1	2.3	0.4	0.0	203.0	3	5
7172	36.3	38.9	20.1	1.5	11.8	13.2	13.0	44.0	2.7	0.2	0.0	0.0	181.7	4	5
7273	2.5	23.2	73.3	7.2	4.0	0.0	16.3	0.0	0.4	5.5	0.0	9.2	141.5	2	6
7374	0.0	0.0	58.6	7.3	0.0	0.0	21.2	13.2	3.2	1.0	6.0	2.3	112.8	2	7
7475	5.6	0.0	27.3	8.6	0.0	0.0	0.0	63.6	33.9	5.0	4.3	3.0	151.3	3	6
7576	3.0	4.6	1.3	20.7	0.0	19.6	25.3	10.8	38.3	6.2	2.9	3.0	135.7	3	6
7677	88.0	5.0	0.0	8.2	26.0	2.0	0.0	17.9	7.8	0.0	0.0	6.2	161.1	2	5
7778	21.0	26.4	0.0	98.0	91.2	0.0	0.0	0.0	3.0	0.0	0.0	19.8	259.4	4	7
7879	4.0	19.0	6.8	0.0	113.3	21.4	0.1	5.3	7.2	0.9	0.0	11.9	190.0	2	5
7980	5.7	119.2	16.1	0.0	19.4	39.3	40.1	4.8	0.2	0.5	0.0	0.0	245.3	3	6
8081	9.9	0.0	25.2	14.8	1.6	37.7	0.0	1.1	3.0	0.0	2.1	0.0	95.4	2	8
8182	4.1	1.8	11.5	0.0	5.0	2.7	4.2	13.2	52.7	2.8	0.7	14.6	113.3	1	7
8283	1.6	0.0	14.2	0.0	0.0	0.0	14.0	14.0	21.6	0.8	0.6	3.0	69.8	1	8
8384	10.4	6.0	12.3	3.9	1.5	0.2	0.8	1.5	23.0	9.2	0.0	1.0	69.9	1	7
8485	10.2	0.0	65.1	7.0	26.2	15.0	1.0	51.5	18.8	0.0	0.0	0.6	195.4	3	5
8586	8.1	10.5	38.8	11.3	1.1	2.4	0.0	0.8	5.0	0.8	0.0	0.9	79.7	1	7
8687	11.0	40.9	4.2	0.0	10.3	7.3	11.2	1.2	27.5	6.0	0.1	4.5	124.2	2	5
8788	35.0	33.4	19.2	51.3	33.6	103.4	38.1	2.2	4.9	0.0	0.0	1.9	323.0	6	5
8889	4.0	36.0	128.4	0.0	12.9	49.1	16.6	19.0	1.2	34.3	19.9	18.3	339.6	4	3
8990	16.5	86.2	47.2	161.0	6.4	0.0	79.3	5.2	12.0	0.0	3.2	7.8	424.8	4	3
9091	33.8	0.0	3.2	22.5	1.8	19.2	32.3	7.2	6.0	16.2	9.6	14.4	166.1	3	3
9192	6.2	4.0	4.0	61.2	0.0	61.4	9.3	0.4	12.0	8.7	0.0	15.8	182.9	2	5
9293	2.6	7.6	3.8	18.1	17.2	24.9	10.8	0.0	5.7	0.0	1.8	1.6	94.1	1	6
9394	2.7	29.2	81.4	3.0	11.0	1.8	4.2	9.7	0.0	0.0	11.5	3.7	158.2	2	7
9495	5.5	71.5	0.0	0.0	0.0	0.0	55.5	21.2	0.5	4.7	1.8	2.3	162.9	3	8
9596	12.5	48.2	7.2	23.4	59.2	28.2	58.4	3.5	4.0	51.6	16.0	1.4	313.6	6	3
9697	1.8	1.6	0.0	55.0	8.0	15.0	11.5	10.6	4.7	0.0	0.2	24.5	132.9	2	6
9798	18.6	3.8	1.2	0.0	32.3	97.1	53.0	9.5	0.0	9.6	0.0	10.0	235.0	3	5
9899	4.9	0.0	0.0	2.8	21.0	0.1	5.4	0.0	2.0	0.0	0.0	9.6	45.8	1	9
Ave	14.3	23.4	30.5	18.9	18.4	24.1	17.4	12.0	13.0	5.4	2.5	6.5	186.4	3	6
(%)	7.7	12.5	16.4	10.1	9.9	12.9	9.3	6.5	7.0	2.9	1.3	3.5	100.0	23	48

NOTES: 1) Lack of data for years 1964/65 through 1969/70 was supplemented based on records at Tadighoust by correlation.
2) Lack of data for years 1970/71 through 1998/99 was supplemented based on records at Ait Bouijane by correlation.
3) Year 6465 denotes the hydrological year from Sept.1964 to Aug.1965.
4) R>20 mm: Number of rainy months of which monthly rainfall is more than 20 mm.
5) R<5 mm: Number of dry months of which monthly rainfall is less than 5 mm.

Table XI4.4.1: Monthly Discharge

Site: TIMKIT DAM SITE (572 km2) (unit: m3/s)

Year	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apl	May	Jun	Jul	Aug	Mean	Total Mm3
1961 / 62	0.037	0.008	0.717	0.009	0.000	0.000	0.000	0.077	0.154	0.000	0.000	0.000	0.083	2.61
1962 / 63	0.745	0.478	0.109	0.052	0.029	0.016	0.016	0.064	3.779	0.467	0.000	0.000	0.485	15.29
1963 / 64	0.232	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.013	0.000	0.000	0.020	0.63
1964 / 65	1.137	0.000	0.000	0.000	0.000	1.985	0.130	0.228	0.053	0.153	0.101	0.322	0.328	10.36
1965 / 66	0.557	4.591	17.525	4.882	1.045	0.650	0.920	0.906	0.722	0.656	0.361	0.254	2.749	86.71
1966 / 67	0.448	0.275	0.328	0.243	0.212	0.294	0.295	0.210	0.258	0.011	0.001	0.001	0.214	6.74
1967 / 68	0.109	0.448	2.882	0.445	0.372	0.404	0.393	0.593	0.283	0.255	0.211	0.173	0.544	17.15
1968 / 69	0.201	0.204	0.171	0.214	0.149	0.150	0.074	0.053	0.040	0.044	0.096	1.342	0.230	7.25
1969 / 70	0.315	0.063	0.173	0.009	0.025	0.014	0.013	0.016	0.198	0.120	0.015	0.019	0.082	2.57
1970 / 71	0.038	0.019	0.112	0.014	0.013	0.013	0.013	0.347	0.005	0.002	0.002	0.002	0.048	1.51
1971 / 72	0.021	0.184	0.036	0.000	0.000	0.000	0.000	0.782	0.018	0.021	0.017	0.017	0.091	2.86
1972 / 73	0.017	0.020	2.255	0.143	0.115	0.111	0.088	0.097	0.060	0.141	0.122	0.060	0.266	8.40
1973 / 74	0.060	0.060	0.240	0.086	0.044	0.023	0.018	0.080	0.035	0.039	0.044	0.026	0.063	1.98
1974 / 75	0.269	0.019	0.004	0.002	0.001	0.001	0.001	0.772	0.706	0.045	0.009	0.020	0.154	4.86
1975 / 76	0.023	0.026	0.040	0.087	0.061	0.022	0.015	0.051	0.450	0.212	0.156	0.031	0.099	3.11
1976 / 77	0.604	0.191	0.130	0.158	0.254	0.056	0.019	0.023	0.022	0.020	0.009	0.005	0.124	3.91
1977 / 78	0.117	0.045	0.009	0.314	0.016	0.001	0.001	0.001	0.002	0.002	0.002	0.001	0.043	1.35
1978 / 79	0.000	0.061	0.000	0.000	0.203	0.000	0.000	0.000	0.164	0.002	0.000	0.000	0.036	1.15
1979 / 80	0.296	1.828	0.001	0.000	0.044	0.330	0.975	0.582	0.201	0.113	0.122	0.082	0.383	12.08
1980 / 81	0.148	0.180	0.116	0.164	0.088	0.126	0.035	0.023	0.055	0.052	0.052	0.043	0.090	2.84
1981 / 82	0.009	0.009	0.043	0.042	0.036	0.000	0.000	0.032	0.293	0.146	0.000	0.000	0.051	1.61
1982 / 83	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.109	0.000	0.000	0.056	0.014	0.44
1983 / 84	0.039	0.041	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.22
1984 / 85	0.000	0.000	0.098	0.000	0.000	0.000	0.000	0.002	0.153	0.000	0.000	0.000	0.021	0.67
1985 / 86	0.331	0.358	1.508	0.694	0.000	0.000	0.000	0.000	0.000	0.428	0.000	0.279	0.299	9.44
1986 / 87	0.589	1.849	0.000	0.000	0.000	0.000	0.234	0.000	0.228	0.000	0.000	0.000	0.245	7.72
1987 / 88	0.199	0.527	0.474	0.565	0.000	0.000	0.000	0.000	0.074	0.000	0.000	0.000	0.154	4.87
1988 / 89	0.001	1.604	0.356	0.000	0.000	0.829	0.618	0.036	0.005	0.970	0.227	0.787	0.451	14.22
1989 / 90	0.355	0.490	3.453	4.527	1.469	1.138	0.722	0.558	2.637	0.532	0.484	0.534	1.412	44.54
1990 / 91	1.171	0.304	0.184	0.376	0.480	0.504	0.200	0.152	0.217	2.612	0.671	0.711	0.629	19.82
1991 / 92	0.465	0.172	0.071	0.334	0.099	0.112	0.075	0.016	0.014	0.126	0.003	0.000	0.124	3.89
1992 / 93	0.610	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.050	1.58
1993 / 94	0.046	0.088	6.285	0.107	0.378	0.430	0.429	0.512	0.500	0.414	0.360	0.133	0.799	25.19
1994 / 95	0.133	1.043	0.207	0.126	0.088	0.107	0.212	1.967	0.128	0.165	0.081	0.077	0.360	11.37
1995 / 96	0.074	5.583	0.695	0.088	0.080	0.287	0.470	0.154	0.145	0.138	0.131	0.124	0.672	21.18
1996 / 97	0.117	0.111	0.105	0.100	0.095	0.090	0.084	0.076	0.069	0.062	0.056	0.468	0.120	3.78
Mean	0.264	0.580	1.065	0.383	0.150	0.214	0.168	0.234	0.327	0.221	0.093	0.155	0.321	10.11
(%)	6.9	15.1	27.6	9.9	3.9	5.5	4.4	6.1	8.5	5.7	2.4	4.0	100.0	

Note: 1) Inflows to Timkit dam were estimated based on flow records at Tadighoust station by basin area ratio.

Table XI4.4.2: Probable Flood Discharges

Probable Design Floods

Desctiptions		Return period (year)						
		2	10	20	50	100	1000	10000
TIMKIT (NO.10)								
Basin area (km^2)	572							
Time of consentration (hr)	3							
Base length of hydrograph (hr)	9							
Probable discharge (m^3/s)		84.0	300	500	750	1000	2000	2800
Specific discharge ($m^3/s/km^2$)		0.15	0.52	0.87	1.31	1.75	3.50	4.90
Ratio to Q10yr		0.28	1.00	1.67	2.50	3.33	6.67	9.33
Runoff volume (Mm^3)		1.36	4.86	8.10	12.15	16.20	32.40	45.36

Probable Dischcarges of Proposed Dams by DGH in Same Hydrologic Region

Dam	BA	Return period (yr)						
	(km^2)	2	10	20	50	100	1 000	10 000
Timkit (10)	572							
Probable discharge(m^3/s)		84	300	500	750	1 000	2 000	2 800
Specific discharge($m^3/s/km^2$)		0.15	0.52	0.87	1.31	1.75	3.50	4.90
Ratio to Q10		0.28	1.00	1.67	2.50	3.33	6.67	9.33
Tadighoust (11)	2 239							
Probable discharge(m^3/s)		-	1 080	-	-	6 300	8 090	11 000
Specific discharge($m^3/s/km^2$)		-	0.48	-	-	2.81	3.61	4.91
Ratio to Q10		-	1.00	-	-	5.83	7.49	10.19
Tiouzaguine (12)	258							
Probable discharge(m^3/s)		-	400	700	1 000	1 200	2 200	3 300
Specific discharge($m^3/s/km^2$)		-	1.55	2.71	3.88	4.65	8.53	12.79
Ratio to Q10		-	1.00	1.75	2.50	3.00	5.50	8.25
Kheng Grou (13)	4 900							
Probable discharge(m^3/s)		-	2 450	3 200	4 500	5 800	9 300	13 000
Specific discharge($m^3/s/km^2$)		-	0.50	0.65	0.92	1.18	1.90	2.65
Ratio to Q10		-	1.00	1.31	1.84	2.37	3.80	5.31
Tiouine (16)	1 540							
Probable discharge(m^3/s)		-	1 000	1 500	2 000	2 600	4 400	6 000
Specific discharge($m^3/s/km^2$)		-	0.65	0.97	1.30	1.69	2.86	3.90
Ratio to Q10		-	1.00	1.50	2.00	2.60	4.40	6.00

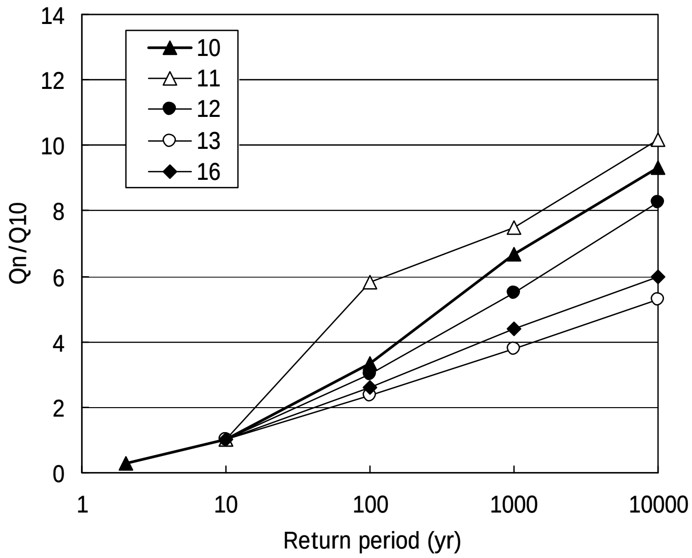

Table XI4.4.3: Monthly Maximum Peak Discharge: Tadighoust

STATION: TADIGHOUST

Year	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Ann.max.
1960/61	0.37	0.37	0.37	43.60	0.03	0.02	-	-	-	-	-	-	
1961/62	0.08	0.08	79.00	2.10	-	-	37.20	31.80	-	0.07	-	-	79.00
1962/63	43.40	43.40	143.00	31.80	4.35	4.59	4.35	14.20	1 170.00	194.00	-	-	1 170.00
1963/64	108.00	108.00	0.34	-	-	-	-	-	-	-	-	-	108.00
1964/65	463.00	463.00	-	-	-	-	681.00	3.98	84.00	14.10	3.41	3.60	681.00
1965/66	48.20	48.20	866.00	2 950.00	10.90	6.51	17.80	21.50	5.98	17.30	66.80	2.59	2 950.00
1966/67	4.66	4.66	21.50	19.60	0.91	0.79	1.37	2.50	2.66	4.44	4.22	1.05	21.50
1967/68	33.20	33.20	62.10	202.00	3.24	1.96	2.92	1.96	24.50	2.60	0.88	0.82	202.00
1968/69	1.32	1.32	0.94	0.88	1.00	0.82	0.88	0.64	0.52	0.40	0.46	6.00	6.00
1969/70	4.82	4.82	2.20	32.30	0.03	1.88	0.05	0.05	0.01	66.80	41.80	0.03	66.80
1970/71	3.34	3.34	0.31	30.80	0.03	0.01	0.01	0.01	66.80	1.11	0.02	0.02	66.80
1971/72	2.45	2.45	34.80	14.20	-	-	0.37	-	103.00	6.05	7.05	0.23	103.00
1972/73	0.95	0.95	7.05	233.00	2.07	0.70	0.60	0.33	1.45	0.33	6.00	0.43	233.00
1973/74	0.24	0.24	0.24	20.20	0.47	0.38	0.05	0.13	22.20	0.29	0.21	0.29	22.20
1974/75	18.40	18.40	0.19	0.05	0.04	0.04	0.01	0.00	242.00	108.00	0.88	0.10	242.00
1975/76	1.74	1.74	0.09	0.15	0.79	0.53	0.09	0.15	23.80	59.20	9.30	41.50	59.20
1976/77	86.10	86.10	23.10	0.65	0.93	17.60	0.35	0.15	0.06	0.45	0.06	0.04	86.10
1977/78	17.60	17.60	17.00	0.03	97.80	0.02	0.02	0.02	0.02	0.01	0.01	0.00	97.80
1978/79	-	-	18.10	-	-	51.50	-	-	-	140.00	-	-	140.00
1979/80	84.50	84.50	292.00	-	25.90	66.50	66.50	26.50	1.56	0.69	0.98	0.46	292.00
1980/81	19.60	19.60	3.63	0.80	4.23	0.62	2.77	0.46	0.09	0.06	0.06	0.06	19.60
1981/82	0.03	0.03	0.03	0.02	0.01	0.01	-	-	22.40	74.90	-	-	74.90
1984/85	-	-	-	43.50	-	-	-	-	0.28	121.00	-	0.02	121.00
1985/86	97.50	97.50	39.10	88.60	92.40	0.00	-	-	-	0.01	60.20	-	97.50
1986/87	40.30	40.30	253.00	-	-	-	-	25.70	0.00	29.10	-	-	253.00
1987/88	20.80	20.80	137.00	110.00	94.80	-	0.01	-	-	17.40	0.13	-	137.00
1988/89	0.70	0.70	129.00	66.90	-	-	35.70	7.33	5.45	0.66	109.00	5.78	129.00
1989/90	3.17	3.17	51.80	1 990.00	331.00	6.86	5.48	36.60	185.00	180.00	3.76	5.75	1 990.00
1990/91	225.00	225.00	11.90	1.32	10.70	2.62	3.42	2.26	11.30	10.70	230.00	19.60	230.00
1991/92	118.00	118.00	1.77	0.49	49.20	0.60	1.42	2.93	0.07	0.17	13.50	0.07	118.00
1992/93	138.00	138.00	-	-	-	-	-	-	-	-	-	-	138.00
1993/94	31.00	31.00	21.40	1 400.00	1.27	2.10	2.10	1.92	2.93	2.10	2.10	1.75	1 400.00
1994/95	17.70	17.70	154.00	24.20	0.54	0.42	0.54	49.20	394.00	0.70	10.00	0.70	394.00
1995/96	5.17	5.17	480.00	8.66	0.49	0.34	87.00	57.60	0.64	0.61	0.58	0.55	480.00
1996/97	0.49	0.49	0.47	0.44	0.42	0.40	0.38	0.36	0.33	0.30	0.27	0.24	0.49
1997/98	139.00	139.00	0.38	-	-	-	-	-	-	-	-	-	139.00
Max.	463.00	463.00	866.00	2 950.00	331.00	66.50	681.00	57.60	1 170.00	194.00	230.00	41.50	2 950.00

Table XI.4.6.1 Result of Flood Damage Survey

Area: Timkit (1979-flood)

CR	Douar	Farmer No.	Inundated deoth House (cm)	Farmland (cm)	Damages to agricultural crops due to inundation: Type of crops	Area (ha)	Damage (qintal)	Damages to agricultural crops due to bank erosion: Type of crops	Area (ha)	Damage (qintal)
Farkla Haut	Aït Aissa	1	100	100		0.0	0.0		0.0	0.0
	Aït Bouhddou	2	100	0		0.0	0.0		0.0	0.0
	Aït Boutakhsayine	4	30	100		*	10.0		0.0	0.0
	Aït Labzim	5	50	100	PD, CM, Orge	*	5.0		*	100.0
		6	0	80		0.0	0.0	PD,CM	*	80.0
		7	0	0		0.0	0.0		*	100.0
		10	50	100		0.0	0.0		0.0	0.0
		11	80	100	PD	0.0	0.0		0.0	0.0
	Aït Hammou	12	200	50		0.0	0.0		0.0	0.0
		13	130	200	BD, Orge	1.0	30.0		0.0	0.0
		14	50	100	PD, CM, Orge	0.1	10.0		0.0	0.0
		15	200	200	BD	0.0	0.0		0.0	0.0
		16	150	150		0.0	0.0		0.0	0.0
	Tamrdoult	17	0	50		0.0	0.0	BD	*	0.5
		18	0	20		0.0	0.0		0.0	0.0
		19	75	100		0.0	0.0		0.0	0.0
		20	40	40	DB	0.3	9.0		0.0	0.0
		21	200	400	Orge	*	0.4		0.0	0.0
		22	0	20		0.0	0.0		0.0	0.0
		23	20	50		0.0	0.0		0.0	0.0
		24	15	150	BD, Orge	0.1	4.5	BD, luzerne	0.5	10.0
	Gardmit	26	0	20		0.0	0.0	Luzerne	0.0	0.0
		28	0	10		0.0	0.0		0.0	0.0
		31	0	5		0.0	0.0		0.0	0.0
Farkla Bas	Aït Maamer Lakdim	33	0	20	PD	0.0	0.0		0.0	0.0
		34	0	10		0.0	0.0		0.0	0.0
		35	0	15		0.0	0.0	Orge	*	0.2
	Talalt	38	50	60	BD, Luzerne	0.1	1.0	PD	0.0	0.0
		40	0	10		0.0	0.0		0.0	0.0
	Taïrza	41	0	50		0.0	0.0		0.0	0.0
		42	0	100	PD, Orge	0.1	1.0		0.0	0.0
		43	0	100	BD	*	1.0	PD	0.0	0.0
	Tighfart	45	5	150	Luzerne	0.0	0.0	PD, Luzerne	0.0	0.0
		46	0	100	PD,Luzerne	0.0	0.0		0.0	0.0
		47	0	20	PD,BD	*	5.0	PD,BD	0.1	10.0
		48	50	150	PD, BD	*	1.0	PD	0.0	0.0
		50	10	50	PD,BD	0.1	2.0	PD	0.0	0.0
	Zaouia	51	0	10		0.0	0.0	PD	0.0	0.0
		52	0	20		0.0	0.0	PD,BD,Orge	0.1	0.5
		56	0	100	PD,Luzerne,CM	0.1	100.0	PD,Luzerne	0.1	*
		57	0	200	PD,BD,Luzerne	0.5	20.0		0.0	0.0
		59	0	10	PD,Orge,Luzerne	0.0	0.0		0.0	0.0
		60	0	50	PD	0.0	0.0		0.0	0.0
Aghbalou N'Kardous		61	200	400	Luz, Maïs	*	6.0	Luz,Maïs,Amandier,Olivie	*	6.0
	Taghya	62	20	200	Luz	*	2.0		0.0	0.0
		64	0	500		*	0.5	Maîs	*	0.5
		65	0	10	BD,orge,fève,PT	0.7	6.2		0.0	0.0
		66	0	50	BD,orge	1.4	4.0		0.0	0.0
	Irbiben	67	0	20	Maïs	1.0	4.0	Carrottes,palmier figuiers	0.1	15.0
	Izkal	69	0	400		0.0	0.0	Amandier,olivie	0.0	0.0
		70	0	300		0.0	0.0	Amandier,palmie	0.2	*
		71	0	50	BD,Maïs	1.0	5.1		0.0	0.0
		72	0	50	BD,orge	0.5	5.1	Maïs	*	6.0
		73	0	120	Luz,PT	0.4	5.5		0.0	0.0
	Timkit	74	0	100	Luz	*	1.0		0.0	0.0
		75	0	200	Luz	*	2.0		0.0	0.0
		76	0	150	Potiron,poivrons	0.0	0.0	Carrottes,navets	*	4.5
		77	0	200	BD,orge	2.4	13.0		0.0	0.0

Wlole survey area : 58 of 77 interviewee farmers were damaged.

(Note) *: Area or damages is not known.

Table XI4.7.1: Results of Water Quality Analysis

No	Date (Year) 2000	Coordination X °	X ′	X ″	Y °	Y ′	Y ″	Altitude (m)	Location/Well Nos	W/L (well depth) (m)	T ℃	pH	EC (mS/m)	Ca (mg/l)	Fe (mg/l)
1	20-Oct	-5	9	54.3	31	34	16.7	1080	Abandoned well along the road to TimKit	11.20(11.50)	21.8		44.0	50	0.1
	20-Oct	-4	59	58.7	31	32	14.2	990	Barrage Chtam Well	(14.05) Dry at 20 Oct					
2	20-Oct	-5	0	8.1	31	32	20.7	990	Barrage Chtam Well	11.65(14.05)	20.0	7.3	47.4	50	0.2
3	20-Oct								Spring at Todrha Gorge		20.0		77.5	100	0
	21-Oct	-5	0	53.6	31	35	46.2	1030	Khettara, Litama						
	21-Oct	-5	1	17.2	31	36	5.9	1000	Khettara tunnel	11.00					
4	21-Oct	-5	5	6.5	31	34	58.0	1010	Khettara, Daroumtra		18.1		118.7	50	0.1
5	21-Oct	-5	18	58.3	31	41	4.3	1270	Tafrarout Village	21.00	19.6		132.2	100	0.1
6	21-Oct	-5	20	42.8	31	40	19.3	1330	TimKit Reservoir, Korsi Igourgite	10.00	20.1		81.2	100	0.1
7	21-Oct	-5	19	4.2	31	38	17.8	1215	Barrage Tim Kit site		22.5	7.2	199.8	100	0
	21-Oct	-5	5	30.3	31	31	52.9	1040	500m downstream of Barrage Ait Labzem						
8	22-Oct	-4	40	10.7	31	48	56.1	1035	Well of under construction by Derrami Co., Ltd	7.05	16.6	8.8	93.8	100	0.1
	22-Oct	-4	56	33.1	31	41	24.7	1030	Ksar Goulmima Public Oubir		21.2		129.7		
9	22-Oct	-4	56	33.1	31	41	24.7	1030	Well near Goulmima	19.95(25.00)	18.5		395.0	100	0.2
10	22-Oct	-4	59	54.3	31	32	6.1	1020	Chtam village, irrigation well		13.8		151.0	50	0.1
11	22-Oct	-4	56	17.7	31	41	10.4	1030	Chtam village, canal water		13.6		278.0	100	0.2
12	31-Oct								N'fifikh area, Zaida, Diameter:170cm	8.00(10.25)	20.7	7.8	1480.0	50	0.1
13	31-Oct								Downstream of Barrage N'fifikh, Diameter:335	3.25(3.35)	22.6	6.8	135.1	50	0.2
14	31-Oct	-7	4	35.8	33	25	32.7	230	N'fifikh area	10.50(10.80)	19.8	7.0	256.0	50	0.1
15	31-Oct	-7	5	4.2	33	27	48.0	215	N'fifikh area	7.75(7.90)	19.0	7.3	115.5	50	0.2
16	31-Oct	-7	7	1.7	33	29	48.0	185	N'fifikh area, ID:180, OD:245cm	3.65(5.40)	19.1	7.2	253.0	50	0.1
17	31-Oct	-7	8	44.7	33	31	49.8	165	N'fifikh area, L:135, W:180cm	7.20(8.40)	20.2	7.0	233.0	50	0.1
18	31-Oct	-7	11	9.5	33	33	39.1	140	N'fifikh area	4.20(4.80)	19.1	7.3	170.9	50	0.2
19	02-Nov	-4	42	44.5	31	33	36.2	965	Well No. 1372/56, ID:58, OD:84, H:93cm	15.57(17.75)	21.7	6.4	629.0	20	0.2
20	02-Nov	-4	50	55.4	31	32	54.0	975	Well No. 1361/56, ID:118, OD:142, H:115cm	13.57(14.90)	20.6	7.1	551.0	20	0.1
	02-Nov	-4	53	12.1	31	33	17.6	990	Well No. 1517/56, ID:60, OD:70, H:80cm	(14.70) Dry at 2 Nov					
21	02-Nov	-4	54	14.5	31	33	17.5	995	Well No. 1358, Igri, (Ferme, re-visit at 6 Nov)	16.10(17.97)	20.6	6.4	356.0	50	0.3
22	02-Nov	-4	58	11.3	31	31	47.0	1000	Well No. 1360/65, ID:63, OD:106, H:53cm	9.40(11.21)	21.1	6.8	235.0	50	0.1
23	02-Nov	-5	4	2.2	31	29	33.3	1010	Well No. 1438/56, L:114, W:112, H:103cm	26.34(26.54)	22.2	7.4	101.5	50	0.4
24	02-Nov	-5	4	2.2	31	29	33.4	1050	Well No. 1445/56, ID:93, OD:110, H:79cm	19.71(21.45)	20.8	7.0	214.0	50	0.1
25	02-Nov	-5	4	28.2	31	30	33.0	1040	Well No. 1449/56, ID:50, OD:82, H:75cm	18.42(20.05)	19.1	7.0	308.0	50	0.1
26	02-Nov	-5	1	58.6	31	30	55.7	1020	Well No. 1476/56, ID:88, OD:107, H:27cm	19.33(23.67)	20.5	6.8	238.0	75	0
27	02-Nov	-5	1	11.7	31	31	41.3	1000	Well No. 1357/56, L=W=87, H:60cm	15.24(19.53)	20.4	7.8	139.7	75	0.2
28	03-Nov	-5	3	8.1	31	29	55.6	1050	Irrigation well with motor pump	24.95(30.60)	19.2	6.7	292.0	50	0.1
29	03-Nov	-5	2	53.8	31	29	40.6	1055	Irrigation well with motor pump	29.31(32.52)	22.0	6.2	241.0	75	2.0
30	05-Nov								Ain El Atti, artisan well		21.2	7.1	$1156X10^{-3}$	50	5.0
31	06-Nov	-4	54	27.4	31	40	39.5	1025	Well near No. 659	24.67(25.44)	19.9	7.0	515.0	50	0.1
32	06-Nov	-4	47	45.2	31	38	36.8	990	Well near No. 1525, Donar Bouchiha Tilouine	6.08(6.95)	19.4	7.3	149.2	100	0.2
	06-Nov	-4	54	56.7	31	36	50.5	1040	Irrigation well with motor pump, near Tigida	20.58(32.60)					
33	06-Nov	-4	53	15.4	31	33	53.0	1025	Irrigation well, Boul Mercha under construction	12.40(12.95)	18.9	8.0	556.0	50	0.1
34	06-Nov	-4	58	21.1	31	36	25.5	1020	Well near No. 1493, Merroacha	12.10(13.46)	(15.2)	7.2	151.3	100	0.2
35	06-Nov	-4	57	34.1	31	36	32.8	1020	Well near No. 1500	9.68(10.00)	20.9	7.6	850.0	100	0.1

Note: Total 35 samples were tested for Calcium and Ferrite by Pack Test in this study

Table XI4.7.2(1/2): Groundwater Level Records in the Outside of Tinejdad

Well No. 659/47

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1973								18.79	18.84	18.79	18.75	18.05
1974	17.13	17.17	17.61	17.17	17.77	17.80	19.10	18.50	18.35	18.52	18.20	18.36
1975		18.76	18.83	18.80	16.75	17.17		18.52	18.00	18.15	18.80	18.88
1976	17.65	17.58	17.16	17.70	18.15	17.20	17.28		18.48	17.12	17.23	17.27
1977	17.13	17.25	17.23	17.55		18.40	18.70	18.67	18.40	17.45	18.20	17.41
1978	17.16	17.24	17.64	17.80	18.76	19.46	19.54	18.78	18.52	18.25	18.78	
1979	18.30	18.50									17.20	17.30
1980		17.25	16.62	16.50	16.67	17.13	17.24	18.77	18.74		17.83	17.88
1981	16.95	17.22	17.28	17.10	17.30	17.45	17.60	18.75	18.55	18.85	18.65	17.78
1982	17.35	17.25	17.27	17.70	17.85	18.30						17.87
1983	17.57	17.53	17.95	17.43	17.51			18.85	19.02		18.97	
1984	18.12		18.12	18.84	18.97	19.06	18.92			18.65	17.97	17.54
1985	17.43	17.48	17.48	17.60	17.47	19.05	19.08	19.00		17.59	17.39	
1986	17.27	17.29										
1987				17.35	17.35	17.27	17.30	17.95	17.23	17.13	17.25	17.25
1988	17.25	17.25	17.18	17.20	17.17	17.37	17.49	17.40	17.50	17.29	17.85	17.30
1989	17.27	17.20	16.45	17.20	17.29	17.26	17.30	17.20	17.25	17.18		
1990				14.90	15.05	13.05	15.40	16.49	15.90	15.73		
1991	15.70		16.67	16.90	16.89		17.49	17.81	17.19	17.15	17.15	17.16
1992	17.10	17.00	17.13	17.15		17.19				17.30	17.27	17.27
1993	17.23		17.25	17.73	17.30	17.36			17.45		17.12	16.15
1994					17.43						16.54	17.21
1995			17.31									
1996		17.18										
1997												
1998												
1999												
2000										24.67		

Well No. 663/47

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1973								19.47	19.37	18.45	18.20	18.06
1974	18.10	18.36	18.28	18.51	18.65	18.90	18.90	18.80	18.71	18.65	18.70	18.60
1975		18.75	18.73	18.74	17.80	18.44	18.60	18.66	18.73	18.75	18.76	18.60
1976	18.58	18.70	18.60	18.69	18.40	18.40	18.53		18.65	18.54	18.47	18.57
1977	18.45	18.50	18.58	18.68		18.70	18.71	18.80	18.67	18.72	18.73	18.70
1978	18.65	18.64	18.73	18.77	18.85	19.36	18.95	18.87	19.17	18.95	18.92	
1979	18.95	17.80									18.45	18.36
1980		18.60	17.85	17.38	17.55	18.05	18.35	18.50	18.54		18.49	18.20
1981	17.95	18.20	18.35	18.25	18.42	17.57	18.55	18.60	18.65	18.60		18.65
1982	18.65	18.40	18.40	18.20	18.50	18.58						18.86
1983	18.80	18.89	18.84	18.90	18.74			19.00	18.78		18.86	
1984	18.92		19.00	19.05	19.09	19.21	19.21	20.33		19.22	19.82	19.10
1985	19.10	19.00	18.98	19.01	19.06	18.85	19.17	19.12	19.50	19.50	19.08	19.84
1986		18.73	18.94									
1987				19.02	19.00	19.10	19.21	19.30	19.00	19.01	18.85	18.71
1988	18.85	18.92	18.72	18.90	18.85	19.00	19.10	19.53	19.45	19.22	18.72	18.90
1989	18.93	18.94	18.40	18.70	18.65	18.79	18.91	18.83	18.65	18.44		
1990				16.37	16.08	15.95	16.40	16.98	16.90	16.64		
1991	16.50		16.98	17.30	17.60		17.78	17.90	18.55	17.92	17.95	17.93
1992	17.90	17.78	17.80	17.87		18.05				18.18	18.16	
1993	18.11		18.10	18.85	18.31	18.77			18.52		17.73	17.50
1994					18.30						17.44	17.98
1995			18.21									
1996		17.35										
1997												
1998												
1999												
2000												

Well No. 1360/56

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1973								8.00	7.48	7.66	7.66	6.81
1974	7.52	7.88	8.12	8.22	8.24	8.54	9.08	9.01	8.36	7.94	8.08	8.23
1975		8.70	8.85	8.87	3.11	3.10	3.06	3.45	3.94	4.31	4.41	4.61
1976	4.70	5.01	5.54	6.20	6.41	6.42	6.84		7.33	5.41	4.58	4.66
1977	4.66	5.00	5.57	6.41		6.67	7.13	7.71	8.06	8.76	8.81	8.47
1978	8.95	9.35	9.11	8.52	8.64	9.87	9.86	9.71	9.68	9.86	7.93	
1979	7.93	7.76									3.23	3.43
1980		10.02	3.90	4.11	4.33	4.77	5.12	6.15	6.18		6.52	6.67
1981	6.41	6.50	6.89	7.10	7.43	7.65	7.95	8.25	8.80	8.35	8.35	8.55
1982	8.33	8.15	8.22	8.50	4.57	5.70		7.45				8.15
1983	8.53	9.13	8.63	8.70	8.28			8.90	8.58		9.20	
1984	8.88	9.45	9.51	9.41	9.37	10.29	9.49		10.43	10.43	9.64	10.13
1985	9.55	10.11	9.85	10.21	10.00	10.10		10.25	10.25	7.71	6.92	
1986	6.08	6.56										
1987				7.30	7.65		8.17	8.34	7.95	7.87	7.62	7.66
1988	7.74	8.14	8.03	8.12	8.14	8.30		8.86		8.34	7.77	7.60
1989	7.62	7.43	7.42	7.57	7.92	7.59	7.60	7.72	7.85	7.74		
1990				4.28	4.37	4.67	5.01	5.36	6.00	5.87		
1991	6.14		6.52	6.67	7.01		7.24	7.52	7.75	7.36	7.32	7.33
1992	7.30	7.28	7.35	7.18		7.80				7.62	7.84	
1993	7.82		7.42	6.47	7.66	7.85			8.09		6.37	5.93
1994					7.78						6.57	6.84
1995			6.84									
1996		5.15										
1997												
1998												

Well No. 1370/56

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1973								15.34	15.37	15.64	15.00	14.95
1974	15.28	15.38	15.30	15.27	15.25	15.28	15.50	15.50	15.45	15.38	15.53	15.36
1975		15.65	15.67	15.50	15.54	14.80	15.25	15.35	15.33	15.35	15.36	15.35
1976	15.50	15.36	15.15	15.50	14.92	15.76	15.40		15.38	14.62	15.05	15.22
1977	14.58	14.99	15.09	15.08		15.25	15.33	15.40	15.30	15.45	15.50	15.24
1978	14.96	15.19	15.52	15.46	15.60	16.46	15.75	15.92	15.79	15.90	15.92	
1979	15.92	15.20									15.15	15.16
1980		15.61	13.72	14.17	14.33	14.55	15.22	15.10	15.08		14.94	14.77
1981	14.85	15.08	15.00	14.87	15.08	15.05	15.05	15.20	15.15	15.25	15.35	16.00
1982	15.35	15.25	15.25	15.75	14.95	14.95		15.70				15.86
1983	15.89	16.02	15.95	16.03	15.91			16.13	16.36		16.65	
1984	16.18	16.55	16.66	16.76	16.77	16.78	16.70		16.63	16.50	16.19	16.46
1985	16.57	16.48	16.48	16.63	16.03	16.68	16.53	16.79	16.79	16.54	16.80	
1986	16.37	16.55										
1987				16.75	16.85	16.85	16.76	16.95	16.56	16.78	16.65	16.65
1988	16.76	16.65	16.71	16.59	16.58	16.69	16.89	16.95	15.80	15.48	14.25	16.75
1989	16.74	16.61	16.60	16.68	16.70	16.29	16.78	16.45	16.60	16.50		
1990				13.55		12.40	13.80	14.25	13.32	12.75		
1991	12.85		13.45	13.60	13.74		13.79	13.86	14.42	13.93	14.15	14.14
1992	13.96	14.18	14.35	14.47		14.83				15.19	15.33	
1993	15.43		15.37	15.06	15.07	15.90			16.03		13.92	13.64
1994					15.88						15.07	15.85
1995			16.08									
1996		14.28										
1997												
1998												

Table XI4.7.2(2/2): Groundwater Level Records in the Outside of Tinejdad

Well No. 1372/56

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1973								6.10	6.12	6.13	6.00	5.96
1974	5.99	6.02	6.00	6.05	6.10	6.10	6.10	6.10	6.10	6.10	6.10	6.05
1975		6.00	5.95	6.00	5.90	5.95	6.05	7.10	7.15	7.19	7.30	7.32
1976	7.05	6.20	7.05	6.03	6.56	6.64	6.65		6.65	6.55	6.26	6.27
1977	6.05	5.68	5.98	6.40		6.75	7.39	7.16	6.62	6.32	6.32	6.20
1978	6.29	6.44	6.24	6.51	7.00	8.26	8.55	7.82	7.44	7.15	5.92	
1979	6.17	6.10									5.65	6.23
1980		13.45	13.19	13.29	13.37	13.58	13.90	14.09	14.13		13.78	13.69
1981		13.84	13.79	13.69	13.95	14.04	14.33	14.29	14.34	14.29	14.14	14.14
1982	14.04	13.85	13.84	14.11	13.47	13.58		14.04				14.05
1983	14.09	14.09	14.29	14.27	14.06			14.26	14.23		14.27	
1984	14.16	14.24	14.27	14.40	14.32	14.63	14.77		15.11	14.77	14.75	14.95
1985	14.43	15.04	14.95		14.42	14.89	15.19	15.70	15.70	14.98	15.33	
1986	14.56	15.23										
1987				15.40	15.75	15.30	15.55	15.75	15.38	15.17	15.50	15.10
1988	15.35	15.80	15.80	16.10	16.18	15.51	15.96	16.11	16.00	15.75	14.75	15.16
1989	15.41	15.15	15.48	15.82	15.54	14.94	15.25	14.60	14.94	14.94		
1990				14.00	13.68	14.00	14.31	14.39	14.22	14.06		
1991	13.70		13.94	14.18	14.21		14.52	14.52	15.00	14.20	14.32	14.25
1992	14.39	14.48	14.43	14.65		15.16				15.22	15.60	
1993	14.75		15.10	15.18	15.32	15.76					14.24	13.47
1994					15.29						14.25	14.53
1995			15.18									
1996		13.53										
1997												
1998												
1999												
2000										15.57		

Well No. 1493/56

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1973												
1974												
1975												
1976	6.47	6.19	7.30	6.70	6.75	6.80	6.96		7.05	6.75	6.73	6.75
1977	6.80	6.97	7.00	7.65			7.85	7.91	7.85	7.93	7.89	7.86
1978	7.49	7.52	7.64	7.81	7.85	8.71	8.05	8.17	8.17	8.05	7.95	
1979	7.95	7.80									7.12	7.09
1980		7.00	6.92	7.04	7.07	7.30	7.44	7.82	7.84		7.79	7.36
1981	6.37	7.29	6.29	7.35	7.52	7.65	7.97	7.97	7.82	7.77	7.77	7.62
1982		7.12	7.11	7.54	7.47	7.49		7.96				7.93
1983	7.60	7.54	7.63	7.80	7.72			8.04	8.27		8.42	
1984	7.82	7.77	7.79	8.46	8.57	9.01	9.06		9.06	9.04	9.07	8.77
1985	8.45	8.30	8.34	8.50	8.60	9.10	9.10	9.61	9.61	9.60	9.70	
1986	8.78	8.61										
1987				9.25	9.59	9.80	9.88	9.80	9.93	9.99	9.85	9.58
1988	9.30	9.30	9.25	9.65	9.70	10.03	10.05	9.42	9.42	9.45	9.11	8.95
1989	8.85	8.60	8.69	8.75	8.91	9.21	9.35	9.39	9.40	9.39		
1990				8.43	8.16	8.85	9.17	9.21	9.45	9.36		
1991	8.38		8.45	8.65	8.69	0.00	8.92	9.51	9.41	9.15	9.09	8.55
1992	8.42	8.38	8.47	8.77		9.21				9.69	9.65	
1993	9.32		8.87	9.04	9.37	9.72			9.80		9.54	8.75
1994					10.00						10.10	10.00
1995			9.82									
1996		9.81										
1997												
1998												
1999												
2000										12.10		

Well No. 1500/56

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1973												
1974												
1975												
1976												
1977												
1978												
1979												
1980		4.65	4.62	4.60	4.60	4.66	4.67	4.77	4.76		4.65	4.60
1981	4.71	4.65	4.70	4.55	4.70	4.42	4.80	4.70	4.67	4.65	4.60	4.65
1982		4.40	4.41	4.75	4.65	4.70		4.69				5.10
1983	4.65	4.57	4.69	4.66	4.68			4.80	4.70		4.90	
1984	4.65	4.63	4.65	4.74	4.73	4.95	4.83		4.98	4.95	4.95	4.89
1985	4.69	4.77	4.88	5.06	5.16	5.38	5.44	5.58	5.58	5.38	5.05	
1986	4.90	5.00										
1987				5.05	5.15	5.40	5.40	5.60	5.23	5.22	5.00	5.12
1988	5.21	5.15	5.33	5.31	5.30	5.55	5.78	5.90	5.68	5.38	5.17	5.25
1989	5.20	5.10	5.23	5.29	5.30	5.34	5.55	5.50	5.35	5.25		
1990				5.18	5.15	5.35	5.34	5.29	5.23	5.18		
1991	5.10		5.08	5.17	5.28		5.48	5.35	5.30	5.20	5.25	5.18
1992	5.05	5.07	5.09	5.22		5.29				5.18	5.13	
1993	5.15		5.09	5.12	5.36	5.44					5.19	4.73
1994					5.27						5.27	5.20
1995			5.17									
1996		4.95										
1997												
1998												
1999												
2000										9.68		

Well No. 1525/56

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1973												
1974												
1975												
1976	2.57	2.44	2.46	2.56	2.51	2.62	2.90		2.96	2.66	2.69	2.60
1977	2.21	2.40	2.58	2.71		3.01	3.16	3.26	3.09	3.01	2.91	2.80
1978	2.17	2.50	2.86	2.90	3.21	4.32	3.65	3.48	3.40	3.31	3.08	
1979	3.08	2.88									2.09	2.10
1980		2.13	2.05	2.20	2.06	2.23	2.56	2.90	2.90		2.56	2.24
1981	2.55	2.35	2.30	2.60	2.84	3.00	3.40	3.50	3.36	3.30	3.25	2.24
1982	2.55	2.35	2.30	2.60	2.84	2.03		3.15				3.08
1983	2.65	2.54	2.94									
1984												
1985	2.24	2.66										
1986												
1987												
1988												
1989						4.02	4.24	4.30	4.15	4.05		
1990				2.35		3.05	3.72	3.91	3.75	3.70		
1991	2.30		2.30	3.10	3.53		3.77	4.21	4.11	4.00	4.10	4.06
1992	3.30	3.26	3.18	3.25	4.25					4.66	4.60	
1993	4.52		3.63	3.87	3.98	4.04			4.13		3.97	3.60
1994					4.41						4.35	4.23
1995			4.04									
1996		2.52										
1997												
1998												
1999												
2000										6.08		

Table XI4.7.3(1/2): Groundwater Level Records in the Vicinity of Tinejdad

Well No. 1357/56

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1973								9.97	10.23	10.29	10.22	9.89
1974	10.10	10.23	10.46	10.79	10.84	10.42	11.80	11.62	11.17	11.19	11.64	11.77
1975		11.89	11.82	11.84	9.19	9.52	10.32	11.52	11.55	11.72	11.99	12.05
1976	12.19	12.52	12.39	12.29	12.37	11.67	12.12		10.61	10.31	11.66	12.11
1977	12.14	13.26	12.72	13.17		13.07	13.27	13.44	13.34	13.42	13.49	13.33
1978	13.91	13.27	13.51	13.61	13.82	14.73	14.10	13.99	13.94	14.22	13.89	
1979	13.97	11.73									10.91	11.07
1980		13.52	11.70	12.13	12.32	12.72	12.83	13.25	13.34		13.83	13.50
1981	13.37	14.52	13.40	13.55	13.85	14.10	14.25	14.20	14.35	14.50		14.49
1982	14.50	14.35	14.40		14.36	13.41		14.00				14.43
1983	14.40	14.37	14.66	15.09	15.18			14.58	14.89		15.08	
1984	15.05	15.15	15.29	15.15	16.03	16.43	16.44		16.31	16.38	16.12	15.45
1985	15.02	15.35	14.46	16.00	14.20	14.19	14.59	14.76	14.76	15.00	15.13	
1986	14.82	14.90										
1987				14.30	14.15	14.90	15.41	15.83	14.70	14.46	14.30	14.20
1988	14.24	14.62	15.32	15.10	15.15	14.66	16.31	16.26	16.28	15.00	14.23	14.10
1989	14.06	13.90	14.07	13.44	13.80	13.53	13.18	13.30	13.35	13.30		
1990				12.06	11.85	12.30	12.63	12.81	13.00	13.07		
1991	13.40		13.13	13.94	14.10	14.10	14.28	14.36	14.90	14.16	14.30	14.30
1992	14.25	14.44	14.48	14.84		15.65				16.00	15.93	
1993	15.60		16.22	16.30	16.36						13.18	13.03
1994					14.45						16.06	13.06
1995			14.15									
1996		12.92										
1997												
1998												
1999												
2000										15.24		

Well No. 1358/56

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1973								5.22	5.22	5.24	5.07	4.94
1974	4.92	4.94	5.01	5.07	5.12	5.40	5.44	5.52	5.22	5.34	5.07	5.02
1975		5.02	5.02	5.26	4.77	4.94	5.22	5.32	5.37		5.21	5.10
1976	5.11	5.10	5.16	5.32	5.32		5.77		5.49		5.21	5.20
1977	5.19	5.31	5.39	5.40		5.59		5.62			5.76	5.50
1978	5.59	5.86	5.68		4.87			6.14				
1979		4.32									4.47	5.98
1980		6.07	5.99		6.18	6.41	6.45	6.58	6.55		6.19	6.08
1981	5.96	6.01	5.50	6.21		6.57	6.83	7.03	6.76	6.63	6.58	
1982	6.58	6.02	6.39		6.89	7.00		7.53				7.28
1983	7.23	7.41	7.60	8.01	7.98			8.41	8.70		8.50	
1984	8.47	8.66	8.81	9.09	9.02		9.80		10.33	9.87	9.94	10.04
1985	9.78	10.26	10.40	10.64	10.73	12.05	11.35	11.37	11.37	11.95	11.92	
1986	10.72	11.27										
1987				12.05	13.20	12.70	13.17	13.65	13.14		12.50	
1988	12.64	12.85	13.11	13.05	13.01	13.35	14.60		14.51	14.38	13.45	13.65
1989	13.67	13.49	13.52	14.70	14.60	12.41	13.50	12.85	14.55	11.95		
1990				9.59	9.25	9.36	9.77	9.70	8.95	8.69		
1991	8.15		7.75	8.05	8.10	8.10	8.55	8.39	8.78	7.98	7.95	7.93
1992	7.66	7.55	7.93	7.98		8.80				8.88	9.27	
1993	9.03		9.45	9.87	10.32	10.55			11.58		11.46	10.75
1994					11.65						11.97	12.12
1995			12.54									
1996		9.62										
1997												
1998												
1999												
2000										16.10		

Well No. 1361/56

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1973								10.81	10.58	10.95	10.03	8.80
1974	8.71	8.70	8.84	8.86	9.06	9.15	9.86	10.13	10.08	9.73	9.58	9.23
1975		9.36	8.96	8.98	7.68	7.93	8.45	8.88	9.21	9.28	9.38	8.68
1976	8.10	8.24	8.15	8.46	8.56		8.60		9.58	9.32	9.13	8.98
1977	8.83	8.40	8.80	8.80		9.48	9.81	10.83	10.43	10.45	10.71	10.63
1978	10.28	9.62	10.54	10.57	10.90	11.84	11.23	11.55	11.38	11.36	11.20	
1979	11.30	10.83									9.80	9.74
1980		9.82	9.72	9.15	9.15	10.37	9.76	10.37	10.57		10.99	11.04
1981	11.20	11.20	11.07	10.99	11.20	10.45	11.45	11.60	11.65	11.70	11.50	11.95
1982	11.80	11.60	11.63	11.80	11.48	10.32		10.92				11.63
1983	11.85	11.82	11.91	11.97	11.84			11.85	12.47		12.29	
1984	12.62	12.72	12.73	12.81	12.86	13.25	13.09		13.19	12.93	12.71	12.45
1985	12.30	12.11	12.03	12.00	11.90	11.60	11.38	11.37	11.37	11.30	11.15	
1986	10.78	10.79										
1987				11.05	11.15	11.40	12.25	12.65	12.56	12.33	12.00	11.51
1988	11.65	11.75	11.70	11.75	11.80	11.85	12.47	12.10	12.07	11.90	11.67	11.50
1989	11.53	11.60	11.30	11.30	11.43	11.41	11.05	10.85	10.80	10.80		
1990				10.52	10.41	10.35	10.46	10.49	10.59	10.55		
1991	10.75		10.95	10.85	11.00		10.77	10.75	10.93	10.79	10.30	10.25
1992	10.43	10.44	10.49		10.59					10.65	10.79	10.82
1993		10.75	10.85	11.18	11.29			11.32		11.07	10.55	
1994					10.69						10.37	10.30
1995			10.39									
1996		9.87										
1997												
1998												
1999												
2000										13.57		

Well No. 1438/56

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1973												
1974												
1975												
1976	10.31	10.59	10.72	10.72	9.99	11.07	11.04		10.69	10.22	10.72	10.80
1977	10.45	10.97	11.00	11.75		11.94	11.53	12.59	12.49	11.90	11.65	11.44
1978	9.93	11.84	12.36	12.83	13.13	13.15	13.77	14.50	14.67	13.67	14.09	
1979	14.09	13.25									14.09	13.25
1980												
1981	11.37	11.81	12.07	12.87	12.93	13.07	12.97	13.32	12.79	12.67	12.37	11.92
1982	11.77	11.52	11.48	13.92	11.54	12.15		12.91				11.68
1983	11.96	11.76	12.57	12.74	13.30			13.32	13.20		12.87	
1984	13.08	13.29	13.63	14.99	15.09	15.36	16.28		15.62	15.30	15.69	15.35
1985	15.13	15.80	16.17		16.71	17.15	16.90	18.20	18.20	18.45	18.52	
1986	17.65	16.00										
1987				19.20	19.45	19.98	20.07	20.80	21.18	20.63	19.82	19.41
1988	19.18	19.26	19.32	19.40	19.38	21.10	21.40	22.01	22.10	21.88	22.00	22.00
1989	20.85	19.10	19.48	19.35	19.45	20.21	21.53	19.80	18.95	18.60		
1990	20.85	19.10	19.48	19.35	19.45	20.21	21.53	19.80	18.95	18.60		
1991	11.50		12.21	12.50	12.05		12.30	12.33	13.55	12.52	11.82	11.71
1992	11.22	10.78	11.52	11.69		11.96				11.40	11.46	
1993	10.82		11.80	12.22	13.12	13.70			13.98		13.65	13.09
1994					17.09						19.03	
1995												
1996		19.00										
1997												
1998												
1999												
2000										26.34		

Table XI4.7.3(2/2): Groundwater Level Records in the Vicinity of Tinejdad

Well No. 1445/56

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1973												
1974												
1975												
1976	10.05	10.19	10.20	10.41	10.45	10.37	10.54		10.47	8.45	10.27	10.25
1977	10.10	10.29	10.64	10.55		10.75	11.29	11.15	11.07	11.10	10.97	11.49
1978	10.74	11.04	11.35	11.64	12.07	12.71	12.61	12.82	13.34			
1979	13.55										13.88	13.27
1980		11.79	11.02	10.91	10.72	10.79	10.72	10.67	10.55		10.34	10.00
1981	9.95	12.00	10.07	12.14	10.41	10.43	10.47	10.57	10.47	10.32	10.17	10.12
1982	9.82	9.82	9.87	10.22	19.67	9.81		10.01				9.95
1983	9.71	9.81	10.01	10.35	10.43			10.70	11.20		11.21	
1984	11.46	11.86	12.24	13.02	14.04	14.62	15.02		15.03	17.05	17.57	17.67
1985	17.33	17.27	17.74	18.15	17.60	17.86	17.90	18.05	18.05	18.85	18.50	
1986	18.20											
1987				17.66	18.25	18.40	18.55	18.92	17.60	17.80	17.54	18.00
1988	18.15	18.45	18.60	18.80	18.85	19.22	19.54	19.18	19.13	18.36	16.56	17.84
1989	17.93	15.28	16.65	17.77	18.90	16.39	17.00	16.50	17.25	17.60		
1990				14.00	13.46	12.90	12.69	12.52	12.00	11.81		
1991	11.14		11.04	11.30	11.54		11.66	11.76	12.43	11.42	11.20	11.00
1992	10.66	10.30	10.51	11.13		10.92				11.15	11.10	
1993	10.60		11.08	11.21	11.77	12.22			13.00		12.80	12.70
1994					18.75						16.23	17.17
1995			17.50									
1996		16.82										
1997												
1998												
1999												
2000										19.71		

Well No. 1449/56

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1973												
1974												
1975												
1976	8.58	8.94	9.60	8.80	9.00	8.56	8.70		8.55	7.76	9.10	8.56
1977	8.52	9.04	10.70	11.50		12.54						
1978												
1979											11.97	12.02
1980		12.84	11.84	12.62	13.89	12.68	12.82	13.34	13.27		12.86	12.00
1981	11.92	11.75	11.45	12.18	12.05	12.25	12.38	12.60	12.65	12.20	12.02	11.85
1982	11.12	10.62	10.60	11.77	10.34	10.31		11.52				10.84
1983	10.06	10.08	10.88	11.84	12.02			11.40	13.79		13.54	
1984	12.99	13.40	13.46									
1985								16.33	16.34	16.55	16.40	
1986	15.20	14.70										
1987				15.76	16.10	17.28		19.35	20.02	17.84	14.05	13.85
1988	14.15	14.68	14.66	15.15	15.10	15.90	19.25	19.60	19.45	19.15	15.46	14.77
1989	14.72	13.96	13.93	14.52	14.92	15.32	15.22	15.68	15.82	15.08		
1990				13.97	13.62	13.97	14.29	14.45	14.27	14.17		
1991	14.05		14.04	14.12	14.27		14.02	14.00	14.25	13.42	13.37	13.24
1992	13.05	12.84	13.14	13.87		13.50				13.80	13.82	
1993	13.68		13.62	13.89	19.98	14.06			15.35		14.70	13.92
1994					15.16						16.12	15.07
1995			15.62									
1996		13.73										
1997												
1998												
1999												
2000										18.42		

Well No. 1476/56

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1973												
1974												
1975												
1976	9.32	8.67	9.82	9.82	9.75	10.21	10.26		10.22		9.75	9.73
1977	10.22	10.18	11.58	11.55		11.80	11.60	11.27	11.75	11.75	11.66	11.67
1978	11.70	11.35	11.47	12.09	12.40	12.45	12.90		12.86	12.70	12.47	
1979	12.35	11.90									12.26	12.08
1980		11.86	11.79	12.24	12.41	12.82	12.96	13.24	13.47		12.96	12.72
1981	12.44	12.43	12.54	12.82	13.23	13.34	13.54	13.59	13.54	13.44	13.39	13.54
1982	13.44	12.84	12.80	13.84	13.39	13.45		13.87				13.74
1983	13.39	13.48	13.94	14.41	14.55			14.37	14.38			
1984	13.64	13.67	13.94	14.41	14.55	14.76	14.91		13.98	14.96	14.89	13.82
1985	14.43	14.88	15.03		16.06	16.10	16.20			17.00	16.55	
1986	15.51	16.86										
1987				20.45	21.40	22.94	22.92	22.91	22.84	22.92	22.78	22.86
1988		22.92	23.01	23.04	22.06	22.86	23.06			24.01	23.66	23.66
1989	19.31	21.78	20.76	21.26	24.11	21.12	23.44	24.01	22.26	20.31		
1990				16.26	16.21	17.06	17.33	17.19	17.07	16.74		
1991			16.26	16.44	16.81		17.14	17.06	16.71	16.41	16.16	15.68
1992	15.66	15.26	15.51	16.46		16.49				16.82	16.61	
1993	15.72		16.15	16.37	17.16	17.46			18.67		16.76	15.97
1994					23.00						17.97	18.22
1995			19.25									
1996		19.37										
1997												
1998												
1999												
2000										19.33		

Well No. 1517/56

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1973												
1974												
1975												
1976	8.69	8.85	8.97	8.97	9.20	8.85	9.23		9.58	9.37	9.15	9.35
1977	9.13	9.22	9.14	9.40		9.60	9.75	10.17	9.75	9.93	10.12	9.79
1978	9.29	9.65	9.92	10.03	10.22	10.51	10.98		10.55	10.55	10.37	
1979	10.37	10.32									8.72	8.58
1980		8.61	8.75	8.62	9.23	9.68	9.96	10.30	10.40		10.35	10.33
1981	10.11	10.25	10.05	10.28								
1982						10.47						
1983												
1984												
1985												
1986	13.26	13.04										
1987				13.72	13.95	13.95	13.98	13.90	13.91	13.87	13.60	13.70
1988	13.55	13.90	13.90	13.90	13.37					13.90	13.42	
1989	13.41	13.31	13.05	13.52	14.10	14.13	13.94	14.12	13.80	13.60		
1990				11.65	11.90	12.50	13.16	12.70	13.30	12.60		
1991	13.05		12.45	13.20	13.73		13.57	13.54	13.20	12.90	12.32	12.30
1992	12.40	12.35	12.44	12.57		13.54				13.68	13.41	
1993	13.36		13.15	13.50	13.94	14.36			14.35		13.80	12.40
1994					13.73						13.20	12.93
1995			12.54									
1996												
1997												
1998												
1999												
2000										14.70		

Table XI4.7.4: Assumption of Population, Irrigation Area, Cattle and Domestic Use

Models	Assumption	1973-1981	1982-1989	1990-1991	1992-2000
Ifegh (downstream of barrage TimKit)	Population (ratio)	22,086 (1971) 27,784 (1981) (2.6%/year)	27,114(1982) 31,900(1989) (2.5%/year)	32,418(1990) 32,936(1991) (1.6%/year)	33,454(1992) 37,080(1999) (1.5%/year)
	Irrigation Area in ha	300(1971) 400(1981) (3%/year)	410(1982) 470(1989) (2 %/year)	480(1990) 490(1991) (2%/year)	490(1992) 520(1999) (1%/year)
Todrha (along Oued Todrha course)	PopulationTinejdadA	22,086(1971) 27,784(1981) (2.6%/year)	27,114(1982) 31,900(1989) (2.5%/year)	32,418(1990) 32,936(1991) (1.6%/year)	33,454(1992) 37,080(1999) (1.5%/year)
	PopulationTinerhirB	25,229(1971) 34,689(1981) (3.7%/year)	35,627(1982) 41,850(1989) (2.5%/year)	42,472(1990) 43,094(1991) (1.5%/year)	43,716(1992) 48,070(1999) (1.5%/year)
	Population (=A + B)	47,315(1971) 62,473(1981) (3%/year)	62,741(1982) 73,750(1989) (2.5%/year)	75,512(1990) 76,652(1991) (1.5%/year)	77,170(1992) 85,150(1999) (1.5%/year)
	Irrigation Area in ha	4,000(1971) 4,000(1981) (0%/year)	4,250(1982) 6,000(1989) (5 %/year)	5,000(1990) 5,000(1991) (0 %/year)	5,250(1992) 7,250(1999) (5%/year)

Table XI4.7.5(1/2): Calibration Result for Groundwater Basin Model (Todrha)

Year	Rainfall			In-flow			Population		Agriculture	Abstraction	Out-Flow	Balance				
	Tinjudad	Ait Bouijane	Tadighoust	Tinjudad	Ait Bouijane	Tadighoust	Thineril	Tinjudad	(ha)	Pumping		GWL	Simulated GWL			
							Water use of 50 lit/person is estimated including cattle					Actual	Tinjudad	Ait Bouijane	Tadighoust	Average
1971		91	112		1.8E+07	1.7E+07	**25 299**	**22 086**	4000	3.1E+07	0.0E+00	**8.8**		**8.77**	**8.77**	**8.77**
1972		92	192		1.8E+07	2.9E+07	939	419	4000	3.0E+07	0.0E+00	**8.9**		**8.78**	**8.79**	**8.78**
1973		120	176		2.3E+07	2.7E+07	1 878	838	4000	3.0E+07	0.0E+00	**9.0**		**8.88**	**8.89**	**8.89**
1974		109	130		2.1E+07	2.0E+07	2 817	1 257	4000	3.0E+07	0.0E+00	**9.0**		**8.98**	**8.98**	**8.98**
1975		129	188		2.4E+07	2.9E+07	3 756	1 676	4000	3.0E+07	0.0E+00	**9.3**		**8.99**	**8.99**	**8.99**
1976		137	177		2.5E+07	2.7E+07	4 695	2 095	4000	3.0E+07	0.0E+00	**9.5**		**9.29**	**9.29**	**9.29**
1977		79	115		1.6E+07	1.8E+07	5 634	2 514	4000	3.0E+07	0.0E+00	**10.0**		**9.47**	**9.47**	**9.47**
1978	215	136	105	2.3E+07	2.5E+07	1.6E+07	6 573	2 933	4000	3.0E+07	0.0E+00	**10.2**		**9.99**	**9.97**	**9.98**
1979	31	106	96	3.3E+06	2.0E+07	1.5E+07	7 512	3 771	4000	3.0E+07	0.0E+00	**10.4**	**10.35**	**10.18**	**10.17**	**10.23**
1980	114	248	239	1.2E+07	4.4E+07	3.7E+07	8 451	4 190	4000	3.0E+07	0.0E+00	**10.6**	**10.57**	**10.42**	**10.41**	**10.46**
1981	31	96	78	3.2E+06	1.9E+07	1.2E+07	9 390	4 609	4000	3.0E+07	0.0E+00	**11.0**	**10.95**	**10.58**	**10.57**	**10.70**
1982	5	63	115	4.7E+05	1.3E+07	1.8E+07	**35 627**	**27 114**	4250	3.3E+07	0.0E+00	**11.5**	**11.44**	**10.96**	**10.97**	**11.13**
1983	50	39	96	5.3E+06	9.2E+06	1.5E+07	622	6 734	4500	3.4E+07	0.0E+00	**12.0**	**11.95**	**11.45**	**11.46**	**11.62**
1984	103	49	35	1.1E+07	1.1E+07	5.3E+06	1 244	7 252	4750	3.6E+07	0.0E+00	**13.0**	**12.95**	**11.96**	**11.95**	**12.29**
1985	85	136	112	8.9E+06	2.5E+07	1.7E+07	1 866	7 770	5000	3.8E+07	0.0E+00	**14.0**	**13.95**	**12.98**	**12.96**	**13.30**
1986	119	63	119	1.3E+07	1.3E+07	1.8E+07	2 488	8 288	5250	4.0E+07	0.0E+00	**15.0**	**14.95**	**13.95**	**13.96**	**14.29**
1987	164	106	91	1.7E+07	2.0E+07	1.4E+07	3 110	8 806	5500	4.1E+07	0.0E+00	**16.0**	**15.96**	**14.96**	**14.95**	**15.29**
1988	192	159	161	2.0E+07	2.9E+07	2.5E+07	4 354	9 324	5750	4.3E+07	0.0E+00	**16.5**	**16.46**	**15.97**	**15.97**	**16.13**
1989	124	242	142	1.3E+07	4.3E+07	2.2E+07	**41 850**	**31 900**	6000	4.6E+07	0.0E+00	**16.5**	**16.44**	**16.49**	**16.46**	**16.47**
1990	95	240	300	1.0E+07	4.2E+07	4.6E+07	622	518	5000	3.8E+07	0.0E+00	**15.5**	**15.45**	**16.51**	**16.51**	**16.16**
1991	64	116	114	6.8E+06	2.2E+07	1.7E+07	1 244	1 036	5000	3.8E+07	0.0E+00	**14.5**	**14.45**	**15.47**	**15.46**	**15.13**
1992	195	137	145	2.0E+07	2.5E+07	2.2E+07	1 866	1 554	5250	3.9E+07	0.0E+00	**14.0**	**13.96**	**14.47**	**14.47**	**14.30**
1993	144	71	62	1.5E+07	1.4E+07	9.6E+06	2 488	2 072	5500	4.1E+07	0.0E+00	**14.0**	**13.95**	**13.95**	**13.94**	**13.95**
1994	271	124	187	2.8E+07	2.3E+07	2.9E+07	3 110	2 590	5750	4.3E+07	0.0E+00	**15.0**	**14.97**	**13.96**	**13.97**	**14.30**
1995	103	158	137	1.1E+07	2.9E+07	2.1E+07	3 732	3 108	6000	4.5E+07	0.0E+00	**15.5**	**15.44**	**14.97**	**14.96**	**15.12**
1996	112	292	211	1.2E+07	5.1E+07	3.2E+07	4 354	3 626	6250	4.7E+07	0.0E+00	**16.3**	**16.24**	**15.50**	**15.47**	**15.74**
1997	85	87	96	9.0E+06	1.7E+07	1.5E+07	4 976	4 144	6500	4.9E+07	0.0E+00	**17.0**	**16.93**	**16.24**	**16.24**	**16.47**
1998		153	153		2.8E+07	2.3E+07	5 598	4 662	6750	5.1E+07	0.0E+00	**17.7**		**16.96**	**16.95**	**16.96**
1999		83	29		1.7E+07	4.5E+06	6 220	5 180	7250	5.5E+07	0.0E+00	**18.0**		**17.63**	**17.61**	**17.62**

Model	Width	Length	Thickness	Porosity	Permeability		(Gradient V : H)
Todrha Area	2000 m	30000 m	18.0 m	0.1	0.1 (cm/sec)	= 3 m/day	"= 1: 150"

Infiltration ratio of Groundwater is estimated as 30 % (=0.3) from the surface flow

Irrigation area was subjected to change to meet this balance study

Model size of Out flow valley for groundwater was estimated as W=2000m, Depth=18m in maximum

Source:Tableau 4.3.1"Rheris Basin Dam Study, JICA 1990"

Groundwater flow speed is estimated as 1 x 10-1cm/sec (=3m/day)

Catchment area of 2346 km2 was adopted

Table XI4.7.5(2/2): Calibration Result for Groundwater Basin Model (Timkit)

Year	Rainfall			Inflow			Population	Agriculture	Abstraction	Out-Flow	Balance				
	Tinjudad	Ait Bouijane	Tadighoust	Tinjudad	Ait Bouijane	Tadighoust	Tinjudad	(ha)	Pumping	Asril	GWL	Simulated GWL			
							Water use of 50l/person is estimated including cattle				Actual	Tinjudad	Ait Bouijane	Tadighoust	Average
1971		91	112		1.0E+07	9.7E+06	**22 086**	300	2.7E+06	0.0E+00	**6.5**		**6.52**	**6.52**	**6.5**
1972		92	192		1.0E+07	1.7E+07	517	310	2.3E+06	0.0E+00	**6.6**		**6.57**	**6.59**	**6.6**
1973		120	176		1.3E+07	1.5E+07	1 036	320	2.4E+06	0.0E+00	**6.6**		**6.63**	**6.64**	**6.6**
1974		109	130		1.2E+07	1.1E+07	1 554	330	2.5E+06	0.0E+00	**6.7**		**6.68**	**6.68**	**6.7**
1975		129	188		1.4E+07	1.6E+07	2 072	340	2.6E+06	0.0E+00	**6.7**		**6.73**	**6.74**	**6.7**
1976		137	177		1.4E+07	1.5E+07	2 590	350	2.7E+06	0.0E+00	**6.8**		**6.79**	**6.79**	**6.8**
1977		79	115		9.0E+06	1.0E+07	3 108	360	2.8E+06	0.0E+00	**6.9**		**6.92**	**6.92**	**6.9**
1978	215	136	105	1.3E+07	1.4E+07	9.1E+06	3 626	370	2.8E+06	0.0E+00	**7.2**		**7.18**	**7.17**	**7.2**
1979	31	106	96	1.8E+06	1.1E+07	8.3E+06	4 662	380	2.9E+06	0.0E+00	**7.3**	**7.24**	**7.28**	**7.26**	**7.3**
1980	114	248	239	6.8E+06	2.5E+07	2.1E+07	5 180	390	3.0E+06	0.0E+00	**6.9**	**6.91**	**6.97**	**6.96**	**6.9**
1981	31	96	78	1.8E+06	1.1E+07	6.8E+06	5 698	400	3.1E+06	0.0E+00	**7.2**	**7.14**	**7.17**	**7.16**	**7.2**
1982	5	63	115	3.0E+05	7.5E+06	1.0E+07	**27 114**	410	3.6E+06	0.0E+00	**7.2**	**7.19**	**7.21**	**7.22**	**7.2**
1983	50	39	96	3.0E+06	5.2E+06	8.3E+06	6 734	420	3.3E+06	0.0E+00	**7.3**	**7.30**	**7.30**	**7.31**	**7.3**
1984	103	49	35	6.1E+06	6.2E+06	3.0E+06	7 252	430	3.4E+06	0.0E+00	**7.4**	**7.41**	**7.41**	**7.40**	**7.4**
1985	85	136	112	5.1E+06	1.4E+07	9.7E+06	7 770	440	3.4E+06	0.0E+00	**7.5**	**7.45**	**7.48**	**7.47**	**7.5**
1986	119	63	119	7.1E+06	7.5E+06	1.0E+07	8 288	450	3.5E+06	0.0E+00	**7.6**	**7.56**	**7.56**	**7.57**	**7.6**
1987	164	106	91	9.8E+06	1.1E+07	7.9E+06	8 806	460	3.6E+06	0.0E+00	**7.6**	**7.62**	**7.62**	**7.61**	**7.6**
1988	192	159	161	1.1E+07	1.6E+07	1.4E+07	9 324	470	3.7E+06	0.0E+00	**7.9**	**7.92**	**7.94**	**7.93**	**7.9**
1989	124	242	142	7.4E+06	2.4E+07	1.2E+07	**31 900**	470	4.1E+06	0.0E+00	**8.0**	**8.01**	**8.07**	**8.03**	**8.0**
1990	95	240	300	5.7E+06	2.4E+07	2.6E+07	518	480	3.6E+06	0.0E+00	**7.5**	**7.50**	**7.56**	**7.57**	**7.5**
1991	64	116	114	3.8E+06	1.2E+07	9.9E+06	1 036	480	3.6E+06	0.0E+00	**7.2**	**7.15**	**7.18**	**7.17**	**7.2**
1992	195	137	145	1.2E+07	1.4E+07	1.3E+07	1 554	490	3.7E+06	0.0E+00	**7.5**	**7.52**	**7.53**	**7.53**	**7.5**
1993	144	71	62	8.6E+06	8.2E+06	5.4E+06	2 072	490	3.7E+06	0.0E+00	**8.1**	**8.06**	**8.06**	**8.05**	**8.1**
1994	271	124	187	1.6E+07	1.3E+07	1.6E+07	2 590	500	3.8E+06	0.0E+00	**8.2**	**8.19**	**8.18**	**8.19**	**8.2**
1995	103	158	137	6.1E+06	1.6E+07	1.2E+07	3 108	500	3.8E+06	0.0E+00	**8.2**	**8.21**	**8.24**	**8.22**	**8.2**
1996	112	292	211	6.7E+06	2.9E+07	1.8E+07	3 626	510	3.9E+06	0.0E+00	**8.1**	**8.11**	**8.18**	**8.15**	**8.1**
1997	85	87	96	5.1E+06	9.8E+06	8.3E+06	4 144	510	3.9E+06	0.0E+00	**8.4**	**8.35**	**8.37**	**8.36**	**8.4**
1998		153	153		1.6E+07	1.3E+07	4 662	520	4.0E+06	0.0E+00	**8.5**		**8.49**	**8.48**	**8.5**
1999		83	29		9.4E+06	2.6E+06	5 180	520	4.0E+06	0.0E+00	**8.5**		**8.52**	**8.49**	**8.5**

Model	Width	Length	Thickness	Porosity	Permeability		(Gradient V : H)
	2000 m	15000 m	8.5 m	0.1	0.1 (cm/sec)	= 6 m/day	"= 1: 300"

Infiltration ratio of Groundwater is estimated as 30 % (=0.3) from the surface flow

Source:Tableau 4.3.1"Rheris Basin Dam Study, JICA 1990"

Irrigation area was changed to meet the balance study

Groundwater flow speed is estimated as 1 x 10-1cm/sec (=6m/day)

Model size of Out flow valley for groundwater was estimated as W=2000m, Depth=8.5m in maximum

Catchment area of 1328 km2 was adopted

Table XI4.7.6: Calibration Result of the Todrha Basin and Timkit Basin

Models	Model Dimension				
	Width (m)	Length (km)	Thickness (m)	Porosity	Permeability (=1 x 10-1 cm/s)
Todrha	2 000	30	18	0.1	3m/day
TimKit	2 000	10	8.5		6m/day

Table XI5.3.1: Monthly Rainfall

Station: DAR HAMRA (unit: mm)

Year	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Rann	R>20	R<5
8283					--	36.7	46.6	11.6	27.7	0	0	3.3	--	--	--
8384	1.6	8.8	82.5	48.2	27.4	9.1	48.6	50.1	111.4	3.3	1.6	0.8	393.4	6	4
8485	8.9	0	102.7	9.5	70.8	30	42.8	36.6	81.5	0	4.1	0	386.9	6	4
8586	3	15.8	42.2	55.2	89.8	96.7	85.9	57.4	5.2	44.3	0	3.8	499.3	7	3
8687	8.1	20.1	34.4	34.1	79	139.3	1.7	8.3	14	0.7	39.7	0.8	380.2	6	3
8788	39.9	28.9	74.9	48.5	79.9	80.2	44.4	25.3	42.1	7.2	1.7	0.5	473.5	9	2
8889	0	41.3	56.8	13.6	21.7	44.6	68.6	78.7	20.4	18.7	11	15.4	390.8	7	1
8990	41.1	61.5	80.6	82.8	44.3	0.0	39.2	72.9	9.3	4.3	34.1	2.8	472.9	8	3
9091	45.6	9.9	40.1	121.4	12.4	105.5	159.6	49.4	14.6	9.5	8.9	23.1	600.0	7	0
9192	52.3	39.6	26.4	36.4	4.3	34.5	85.2	66.2	78.9	69.5	0.6	17.1	511.0	9	2
9293	12.8	40.3	13.2	20.3	18	49.6	94.9	38.8	23.1	9	0	2.6	322.6	6	2
9394	6.2	15.2	97.5	23.4	55	122.2	81.6	18.8	24.4	0.5	0	1	445.8	6	3
9495	35.6	21.8	9.4	2.4	7.4	78.1	75.2	57.1	8.4	24.9	0.1	8.7	329.1	6	2
9596	14.2	13.2	27.8	111.3	183.9	64.2	79.2	83.8	64.4	35.4	1.3	1.9	680.6	8	2
9697	42.3	18.5	15.2	154.6	114.5	0.0	18.4	78	39.9	11.6	0	3.9	496.9	5	3
9798	95.2	18.9	72.7	88.3	11.7	26.8	42.1	12.9	47.9	6.2	0	26.2	448.9	7	1
9899	16	0.8	3.3	45.9	75.1	51.8	80	3.8	32.2	5.5	0.0	2.4	316.8	5	5
9900	14.1	16.4	--	--	--	0	0	34.3	--	--	--	--	--	--	--
Ave-1	19.0	21.2	50.7	43.7	54.1	71.2	72.3	47.5	40.7	18.6	5.8	6.3	451.1		
Ave-all	26.4	22.2	48.7	56.0	56.0	58.3	65.5	46.1	38.6	15.7	6.4	6.9	446.8	7	3
(%)	5.9	5.0	10.9	12.5	12.5	13.0	14.7	10.3	8.6	3.5	1.4	1.6	100.0	56	21

NOTES: 1) Ave-1: Average value of 12 years (8384-8889 and 9091-9596).

2) Ave-all: Average value of all data including estimated/supplemented ones (1983/84-1998/99).

3) Lack of data was supplemented based on Ain Timedrine records by correlation.

4) Year 8283 denotes the hydrological year from Sept.1982 to Aug.1983.

5) R>20 mm: Number of rainy months of which monthly rainfall is more than 20 mm.

6) R<5 mm: Number of dry months of which monthly rainfall is less than 5 mm.

Table XI5.4.1: Monthly Discharge

Site: AZGHAR DAM SITE (263 km2) (unit: m3/s)

Year	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Mean	Total Mm3
1955 / 56	0.120	0.358	0.464	2.814	1.731	5.983	9.470	11.662	7.066	3.303	1.679	0.913	3.778	119.14
1956 / 57	0.543	0.728	0.596	0.767	1.481	0.728	2.207	4.016	3.593	1.084	0.437	0.371	1.383	43.60
1957 / 58	0.054	0.675	1.996	2.431	4.887	4.927	2.497	2.999	2.194	1.084	0.332	0.054	1.992	62.83
1958 / 59	0.002	0.002	0.266	3.276	3.171	2.128	4.108	2.458	2.048	1.256	0.503	0.134	1.615	50.93
1959 / 60	0.054	0.107	0.239	6.710	10.539	6.683	6.683	4.214	2.445	3.065	1.137	0.543	3.527	111.23
1960 / 61	0.279	0.477	0.728	4.676	5.508	5.363	3.646	3.739	1.533	1.150	0.385	0.068	2.280	71.89
1961 / 62	0.041	0.147	1.164	0.873	0.715	0.583	5.653	4.755	1.863	1.164	0.385	0.094	1.457	45.94
1962 / 63	0.000	0.279	2.643	2.141	7.211	10.618	5.468	3.197	8.572	5.231	1.771	1.282	3.994	125.96
1963 / 64	0.900	0.767	0.662	3.937	1.784	1.692	2.841	6.868	2.088	1.230	0.701	0.490	1.995	62.90
1964 / 65	0.517	0.358	0.913	0.966	4.082	4.346	5.891	5.812	2.471	1.626	1.111	0.688	2.384	75.19
1965 / 66	0.754	0.741	0.649	0.490	0.662	0.517	0.649	0.754	0.437	0.094	0.000	0.000	0.478	15.06
1966 / 67	0.028	3.831	1.124	0.371	0.015	0.147	0.371	1.071	0.992	0.596	0.000	0.000	0.717	22.61
1967 / 68	0.000	0.239	0.398	0.952	1.441	3.844	8.479	6.129	4.544	1.996	0.913	0.503	2.445	77.11
1968 / 69	0.252	0.107	1.467	3.831	5.561	8.268	6.525	5.706	3.646	2.629	1.322	0.649	3.299	104.03
1969 / 70	0.517	0.583	1.190	2.167	10.209	3.290	3.290	3.210	1.652	1.005	0.411	0.213	2.312	72.92
1970 / 71	0.213	0.173	0.094	0.186	2.471	2.893	4.069	8.109	7.951	4.346	1.943	1.124	2.793	88.07
1971 / 72	0.794	0.662	1.599	1.547	2.682	5.218	8.875	6.591	4.808	2.722	1.375	0.728	3.118	98.34
1972 / 73	0.767	1.309	0.807	0.860	1.520	3.580	5.746	5.534	2.907	1.441	0.662	0.490	2.123	66.96
1973 / 74	0.120	0.186	0.186	0.371	0.543	1.137	3.739	6.406	5.085	2.180	1.111	0.503	1.798	56.71
1974 / 75	0.385	0.437	0.252	0.081	0.028	1.111	3.092	6.142	4.306	2.326	0.926	0.503	1.630	51.39
1975 / 76	0.239	0.173	0.200	0.385	0.266	2.048	2.775	5.191	7.832	2.577	1.362	0.569	1.966	62.01
1976 / 77	0.464	0.913	1.124	2.709	6.393	7.476	4.650	3.514	1.771	1.071	0.490	0.173	2.533	79.88
1977 / 78	0.292	0.530	0.345	1.018	1.190	3.739	2.973	3.739	2.497	1.269	0.530	0.279	1.517	47.83
1978 / 79	0.015	0.002	0.000	0.200	0.754	5.600	5.772	3.752	1.903	1.045	0.451	0.094	1.604	50.59
1979 / 80	1.560	1.877	2.788	1.626	1.243	1.335	3.039	2.009	2.312	0.662	0.134	0.000	1.548	48.82
1980 / 81	0.000	0.266	0.860	0.451	0.609	1.045	1.481	2.563	1.877	0.715	0.200	0.002	0.835	26.33
1981 / 82	0.000	0.266	0.000	0.000	0.292	0.952	1.599	3.224	2.352	0.926	0.226	0.000	0.816	25.74
1982 / 83	0.000	1.863	0.952	1.481	1.269	1.296	1.494	1.230	0.437	0.015	0.000	0.000	0.836	26.36
1983 / 84	0.000	0.000	0.292	0.490	0.279	0.000	0.622	1.401	1.969	0.913	0.000	0.027	0.502	15.83
1984 / 85	0.030	0.033	0.892	0.385	1.231	0.586	0.728	0.377	1.654	0.223	0.054	0.025	0.519	16.37
1985 / 86	0.024	0.056	0.225	0.301	2.099	7.610	6.828	2.959	0.504	1.440	0.073	0.034	1.806	56.97
1986 / 87	0.070	0.213	0.460	0.147	1.477	8.271	1.199	0.313	0.147	0.105	0.157	0.065	1.002	31.58
1987 / 88	1.234	1.482	1.265	0.383	2.427	2.144	3.745	0.476	0.868	0.163	0.050	0.032	1.186	37.39
1988 / 89	0.028	0.032	0.165	0.128	0.044	0.479	1.315	4.845	0.573	0.291	0.050	0.100	0.665	20.98
1989 / 90	0.588	1.141	1.115	4.407	3.379	0.463	0.186	1.550	0.339	0.038	0.274	0.089	1.140	35.94
1990 / 91	0.400	0.044	0.556	2.390	0.280	2.343	10.318	3.355	0.718	0.253	0.207	0.131	1.751	55.23
1991 / 92	0.555	0.256	0.210	0.167	0.198	0.278	0.902	3.400	0.452	1.191	0.212	0.163	0.661	20.85
1992 / 93	0.069	0.162	0.136	0.523	0.140	0.175	1.365	1.187	1.604	0.099	0.029	0.018	0.462	14.58
1993 / 94	0.012	0.099	2.199	0.404	1.603	5.365	1.880	0.428	0.201	0.053	0.015	0.008	0.990	31.23
1994 / 95	0.171	0.119	0.217	0.047	0.047	0.042	1.600	0.855	0.178	0.101	0.025	0.026	0.287	9.06
1995 / 96	0.045	0.063	0.100	1.704	10.861	5.608	6.249	5.197	2.761	0.863	0.220	0.045	2.800	88.32
1996 / 97	1.051	0.726	0.228	7.695	10.455	1.825	0.797	1.967	0.738	0.217	0.064	0.034	2.166	68.32
1997 / 98	0.769	1.370	2.194	2.728	1.609	3.030	0.557	0.518	0.530	0.225	0.162	0.222	1.147	36.17
1998 / 99	0.242	0.231	0.226	0.258	1.240	0.754	0.993	0.189	0.257	0.120	0.036	0.023	0.380	11.97
Average	0.323	0.547	0.777	1.579	2.628	3.080	3.554	3.491	2.379	1.230	0.503	0.262	1.687	53.21
(%)	1.6	2.7	3.8	7.8	12.9	15.1	17.5	17.2	11.7	6.0	2.5	1.3	100.0	

Note:
1) Sep.1955-Aug.1984: Estimated based on correlation between Ain Timedrine and Dar Harma stations and basin area ratio.
2) Sep.1984-Apr.1999: Estimated from Dar Hamra records by basin area ratio.
3) May-Aug.1999: Estimated based on average runoff pattern at Dar Hamra from 1984/85 to 1997/98.

Table XI5.4.2: Probable Flood Discharges

Probable Design Floods

Desctiptions		Return period (year) 2	10	20	50	100	1000	10000
AZGHAR (NO.17)								
Basin area (km^2)	263							
Time of consentration (hr)	5							
Base length of hydrograph (hr)	15							
Probable discharge (m^3/s)		88.5	200	250	300	400	500	700
Specific discharge ($m^3/s/km^2$)		0.34	0.76	0.95	1.14	1.52	1.90	2.66
Ratio to Q10yr		0.44	1.00	1.25	1.50	2.00	2.50	3.50
Runoff volume (Mm^3)		2.39	5.40	6.75	8.10	10.80	13.50	18.90

Probable Dischcarges of Proposed Dams by DGH in Same Hydrologic Region

Dam	BA (km^2)	Return period (yr) 2	10	20	50	100	1 000	10 000
Azghar (17)	263							
Probable discharge(m^3/s)		89	200	250	300	400	500	700
Specific discharge($m^3/s/km^2$)		0.34	0.76	0.95	1.14	1.52	1.90	2.66
Ratio to Q10		0.44	1.00	1.25	1.50	2.00	2.50	3.50
Tazarane (6)	30							
Probable discharge(m^3/s)		-	215	-	350	400	550	950
Specific discharge($m^3/s/km^2$)		-	7.17	-	11.67	13.33	18.33	31.67
Ratio to Q10		-	1.00	-	1.63	1.86	2.56	4.42
Aoulai (19)	490							
Probable discharge(m^3/s)		-	650	800	1 000	1 200	1 700	2 500
Specific discharge($m^3/s/km^2$)		-	1.33	1.63	2.04	2.45	3.47	5.10
Ratio to Q10		-	1.00	1.23	1.54	1.85	2.62	3.85
Tizmellal (2)	170							
Probable discharge(m^3/s)		-	400	-	700	900	1 700	2 500
Specific discharge($m^3/s/km^2$)		-	2.35	-	4.12	5.29	10.00	14.71
Ratio to Q10		-	1.00	-	1.75	2.25	4.25	6.25
Adarouch (14)	630							
Probable discharge(m^3/s)		-	180	240	300	400	700	1 100
Specific discharge($m^3/s/km^2$)		-	0.29	0.38	0.48	0.63	1.11	1.75
Ratio to Q10		-	1.00	1.33	1.67	2.22	3.89	6.11

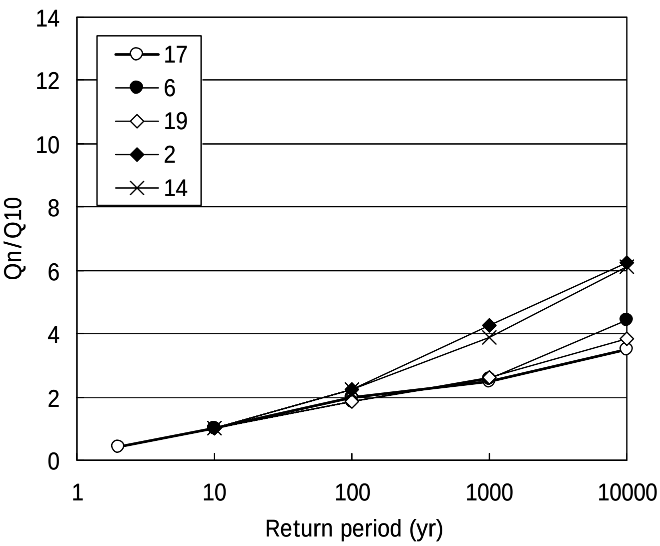

Table XI5.4.3: Monthly Maximum Peak Discharge: Dar Hamra

STATION: DAR HAMRA

Year	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Ann.max.
1983/84													
1984/85	0.10	0.10	68.00	12.00	29.90	14.20	15.50	9.41	28.30	1.31	0.25	0.09	68.00
1985/86	0.49	6.74	41.00	31.20	68.10	99.80	190.00	31.90	2.94	331.00	0.31	0.25	331.00
1986/87	14.30	45.80	36.70	22.20	127.00	173.00	7.29	2.75	0.50	0.32	15.70	8.65	173.00
1987/88	442.00	461.00	86.20	36.10	68.10	68.10	72.80	14.00	32.30	0.74	0.25	1.35	461.00
1988/89	0.08	0.10	13.20	24.00	1.25	44.10	51.50	81.20	4.53	58.00	2.29	31.30	81.20
1989/90	125.00	154.00	71.60	265.00	135.00	2.75	2.47	141.00	45.20	0.30	44.10	36.10	265.00
1990/91	112.00	8.62	65.80	131.00	2.01	39.00	170.00	39.20	8.97	4.12	21.50	62.50	170.00
1991/92	118.00	25.20	25.00	3.67	14.00	32.00	91.40	97.40	67.40	154.00	3.52	57.80	154.00
1992/93	13.60	29.90	23.60	8.35	19.30	29.00	19.30	42.50	83.40	0.39	0.34	0.88	83.40
1993/94	0.05	17.00	237.00	22.70	35.20	126.00	75.20	20.30	11.20	0.24	0.16	0.42	237.00
1994/95	40.20	11.20	46.70	0.16	0.16	3.83	28.00	241.00	0.89	17.60	2.06	2.74	241.00
1995/96	1.77	21.10	8.00	23.00	456.00	121.00	81.60	138.00	74.50	84.00	6.22	0.21	456.00
1996/97	195.00	135.00	2.90	201.00	212.00	11.30	5.30	128.00	56.10	0.63	0.48	0.57	212.00
1997/98													
Max.	442.00	461.00	237.00	265.00	456.00	173.00	190.00	241.00	83.40	331.00	44.10	62.50	461.00

Table XI.5.6.1 Result of Flood Damage Survey

Area: Azghar (Not specific flood)

CR /CU	Douar	Farmer	Inondated depth		Damages to agricultural crops due to inundation			Damages to agricultural crops due to bank erosion		
			House (cm)	Road (cm)	Type of production	Area (ha)	Damage (qintal)	type	Area (m2)	Damage (qintal)
Ighzrane	Bni Lchaâ : None of 6 interviewee farmers were damaged.									
	Taghza : 1 of 8 interviewee farmers were damaged.									
		13		50	Blé dur	0.5		Blé dur	6000	
	Nass Daoud :2 of 7 interviewee farmers were damaged.									
		15						Orge	7500	0.3
		16						Blé dur	20000	0.6
	Nass Saïd : None of 6 interviewee farmers were damaged.									
	Tichout Tamallalt : None of 5 interviewee farmers were damaged.									
Ribat Al Kheïr	Zitouna : None of 6 interviewee farmers were damaged.									
Od M'Koudou	Mghila : 2 of 6 interviewee farmers were damaged.									
		42	50	20	Blé dur	3		Orge	7500	1
		43		80	Orge	3				
Whole survey area	: 5 of 44 interviewee farmers were damaged.									