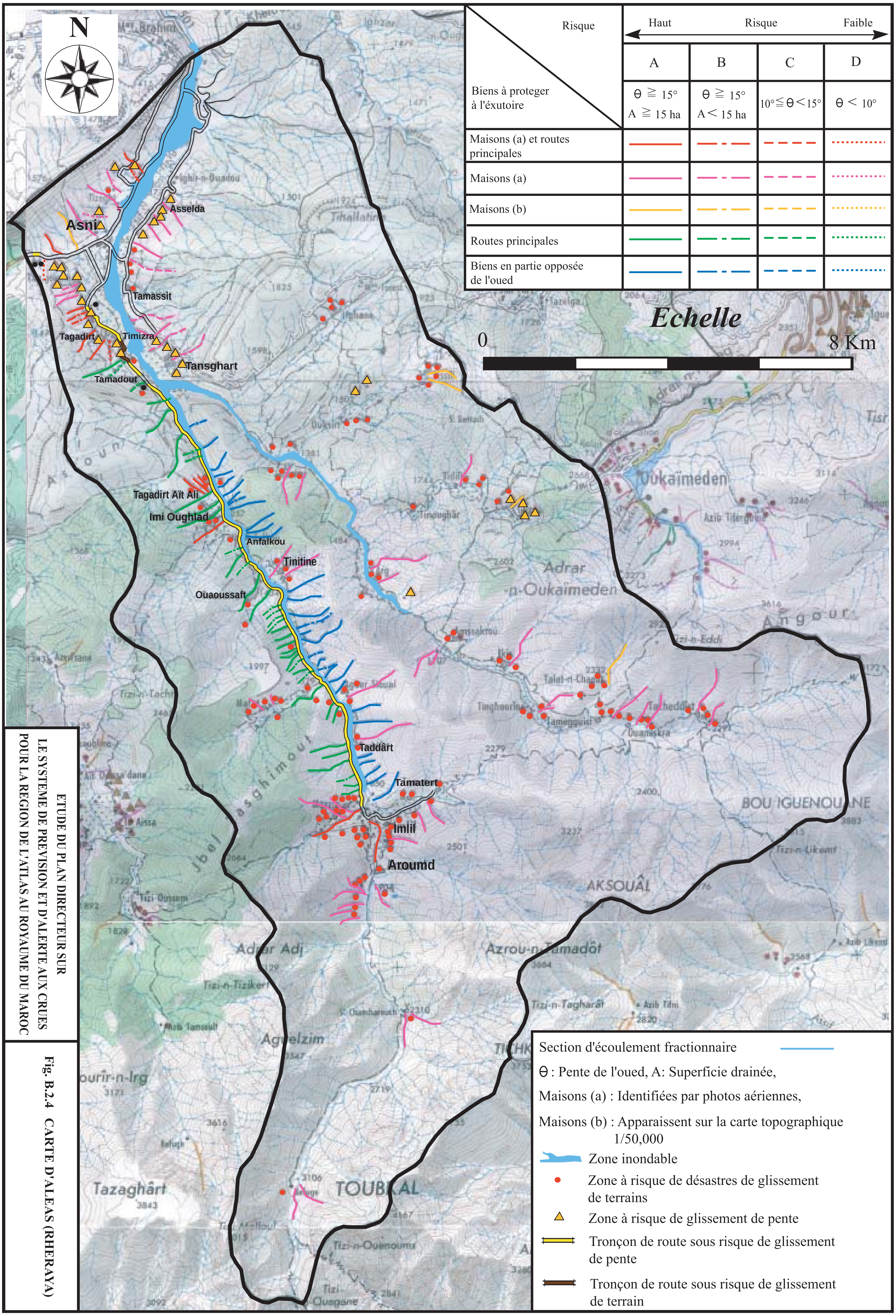
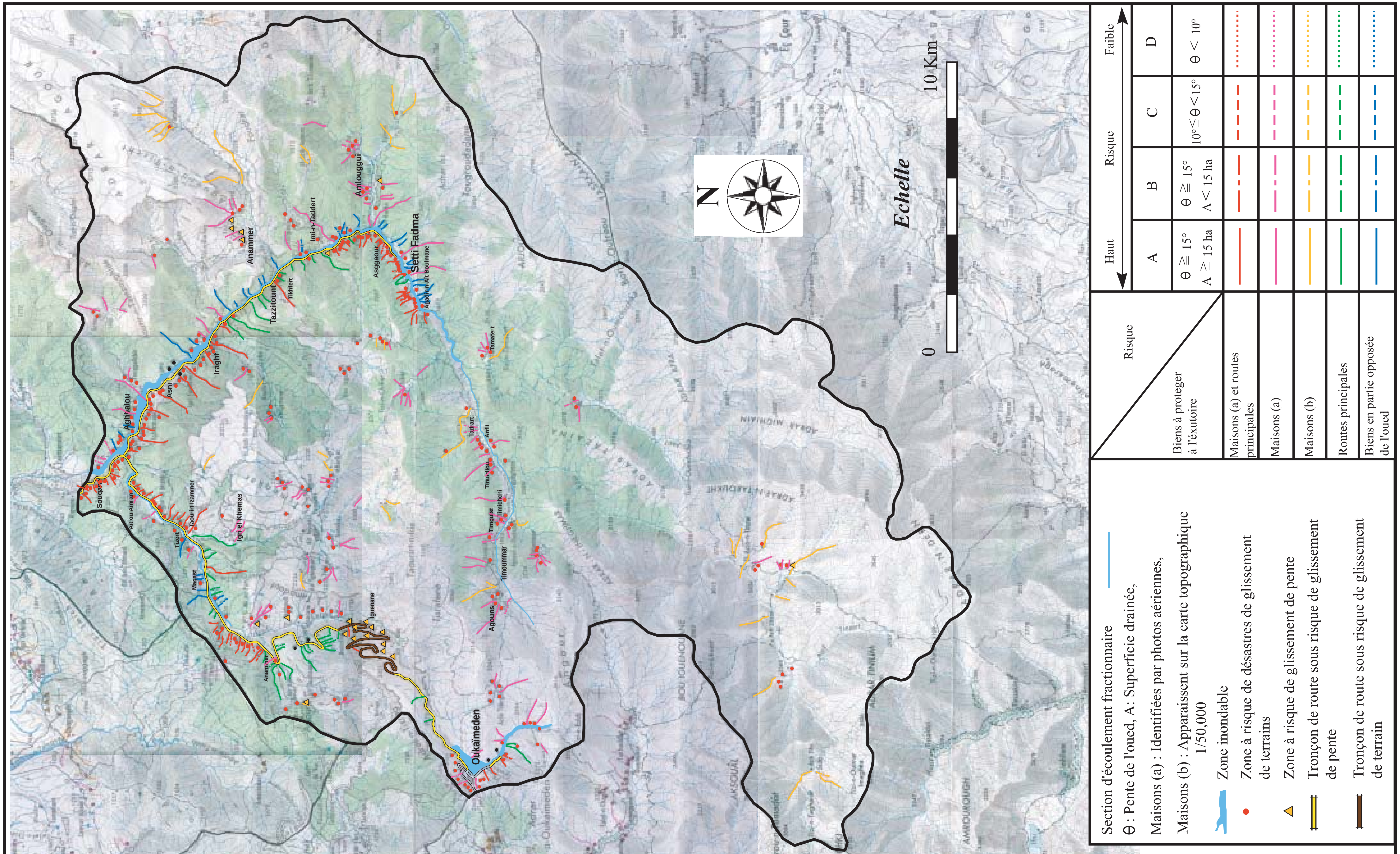


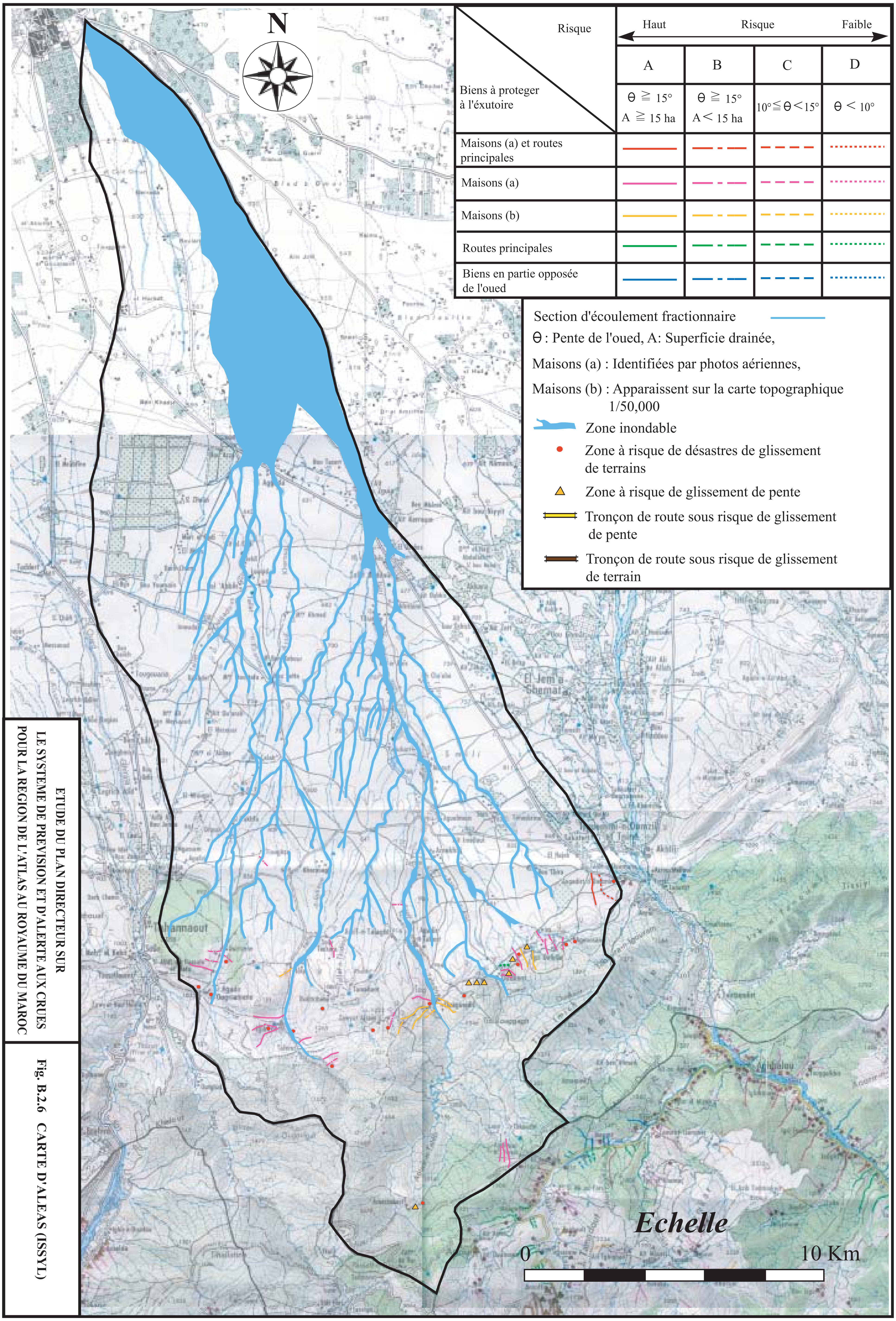
ETUDE DU PLAN DIRECTEUR SUR
LE SYSTEME DE PREVISION ET D'ALERTE AUX CRUES
POUR LA REGION DE L'ATLAS AU ROYAUME DU MAROC

Fig. B.2.4 CARTE D'ALEAS (RHERAYA)



ETUDE DU PLAN DIRECTEUR SUR
LE SYSTEME DE PREVISION ET D'ALERTE AUX CRUES
POUR LA REGION DE L'ATLAS AU ROYAUME DU MAROC

Fig. B.2.5 CARTE D'ALEAS (OURIKA)



Biens à protéger à l'éxutoire \ Risque	A (Haut)	B	C	D (Faible)
	θ ≧ 15° A ≧ 15 ha	θ ≧ 15° A < 15 ha	10° ≦ θ < 15°	θ < 10°
Maisons (a) et routes principales	———	—·—	– – –	········
Maisons (a)	———	—·—	– – –	········
Maisons (b)	———	—·—	– – –	········
Routes principales	———	—·—	– – –	········
Biens en partie opposée de l'oued	———	—·—	– – –	········

Section d'écoulement fractionnaire

θ : Pente de l'oued, A: Superficie drainée,

Maisons (a) : Identifiées par photos aériennes,

Maisons (b) : Apparaissent sur la carte topographique 1/50,000

Zone inondable

Zone à risque de désastres de glissement de terrains

Zone à risque de glissement de pente

Tronçon de route sous risque de glissement de pente

Tronçon de route sous risque de glissement de terrain

ETUDE DU PLAN DIRECTEUR SUR
LE SYSTEME DE PREVISION ET D'ALERTE AUX CRUES
POUR LA REGION DE L'ATLAS AU ROYAUME DU MAROC

Fig. B.2.6 CARTE D'ALEAS (ISSYL)

APPENDIX C

HYDROLOGICAL AND HYDRAULICS ANALYSIS

**THE MASTER PLAN STUDY ON
FLOOD FORECASTING AND WARNING SYSTEM
FOR ATLAS REGION IN THE KINGDOM OF MOROCCO**

APPENDIX C HYDROLOGICAL AND HYDRAULICS ANALYSIS

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APPENDIX C HYDROLOGICAL AND HYDRAULICS ANALYSIS

CHAPTER 1. GENERAL CONDITION

1.1 River Condition

1.1.1 River Basin

The Study Area is composed of the High Atlas and the Haouz Plain. The High Atlas rises to more than 4,000 m, and embraces several torrential watercourses that are perpendicular to the general direction of the High Atlas (East-West). On the other hand, the Haouz Plain situated between 600 m and 1,500 m in altitude is an alluvial plain formed by fluvial detritus from the above watercourses in the Neocene and Quaternary Periods.

(1) Basin Division and Rivers

In this Study, the location of the hydrological observation stations and the basin boundaries were closely checked, and drainage areas of the objective rivers were measured as shown in Fig. C.1.1 and Table C.1.1. The Study Area is estimated at 3,453 km^2 in total. The Area of each objective river is 532 km^2 for the R'dat River, 528 km^2 for the Zat River, 495 km^2 for the Ourika River, 221 km^2 for the Rheraya River, 1,256 km^2 for the N'fis River and 421 km^2 for the Issyl River.

(2) Hypsographical Matter

Fig. C.1.2 shows the relation between the accumulated area and elevation for each river basin in the Study Area. This curve is called hypsographic curve. According these curves, the ratio of higher mountain areas (over the elevation of 2500 m) to the whole river basin is about 20 % at the N'fis, Zat, and R'dat River Basin. On the other hand, the ratio is 30 % and 55 % in the Rheraya and Ourika River Basin. Therefore, N'fis, Zat, and R'dat River Basin have larger area with gently slopes in comparison with the Ourika and Rheraya River Basins. Especially the Ourika, Zat, and R'dat River Basins are almost equal in area, but the Ourika River Basin holds higher mountains than the Zat and R'dat River Basins. The curve of Issyl River Basin is separated into two parts at a bend point of about 900 m in elevation because the Issyl River has two different areas, which are mountain areas and flat alluvial plains.

(3) Water Resources

The N'fis, Rheraya, Ourika, Zat, and R'dat Rivers other than the Issyl River that are originated in the High Atlas generate the average water resources of 590 Mm^3/year and have 50% of the surface water resources of the Tensift River Basin (7,854 km^2). Additionally, the Rocade Canal from the Sidi Driss Barrage (at the Lakhdar River east of the Study Area) supplies 300 Mm^3/year to the drinking water for Marrakech and irrigation water for the Haouz Plain. Hence, the potential in surface water reaches 890 Mm^3/year on an average year in the Study Area.

Regarding groundwater, actually, 400 Mm^3/year is extracted from groundwater at the foot of the High Atlas, and complement to irrigation water supply for 78,000 ha.

(4) Floods

The Study Area is characterized with floods in autumn, winter and spring, provoked by rain and melting snow. Flash floods also take place in summer, generating a sudden large discharge. Some villages along the rivers are exposed to floods of the rivers or debris disasters mainly from the tributaries.

1.1.2 River Morphology

The N'fis, Rheraya, Ourika, Zat and R'dat rivers are originated in the mountains of the High Atlas that have elevations of between 2,400 and 4,000 m. The Issyl River, normally dried up, originates in the mountain with approximately 2,000 m situated northeast of the Ourika River Basin. These rivers join the Tensift River through the alluvial plains after passing the valleys. The profile and dimensions of these rivers are given in Fig. C.1.3 and Table C.1.2. The followings are descriptions of the morphology of these rivers.

(1) R'dat River

The R'dat River drains an area of 532 km^2 at the Sidi Rahal Hydrological Observation Station. This river presents the slope of 1/10-1/100 between the station and its origin with a distance of 57 km. Debris flow is not expected to occur in this river because of its gentle slope. The annual average discharge is of 2.5 m^3/s at the Sidi Rahal Station. This river has five principal tributaries: Tichka, Iswal, Ifraden, Imzer, and Tissert Rivers. Based on the basin gradient of these tributaries of R'dat River shown in Fig. C.1.4, it is recognized that basin gradient of the tributaries is relatively gentler than the others.

(2) Zat River

The Zat River drains an area of 528 km^2 at the Taferiat Hydrological Observation Station. This river shows the slope of 1/5-1/70 between the station and its origin with a distance of 94 km. In the downstream of this river between the Taferiat Station and Tighedouine village, no debris flow is expected to happen. However, debris flow was generated from a tributary, Tighedouine River, and the debris flow brought damage to the Tighedouine village in the 1995 flood. The annual average discharge is of 3.9 m^3/s at the Taferiat Station. This river has seven major tributaries: Ikiys, Yagoun, Tarat, Wasna, Tiqqui, Ansa, and Tighedouine Rivers.

(3) Ourika River

The Ourika River, originating in the mountain situated in the southwestern part of the Ourika River Basin, flows down 16 km in the northeast to Setti Fadma. Then the river changes its flow direction to the north and flow down 12km to the Aghbalau Hydrological Observation Station. This river has a catchment area of 495 km^2 at the Aghbalau Station and presents the steepest slope of 1/5-1/32 among the six rivers. The annual average discharge is of 6.2 m^3/s at the Aghbalau Station. This river has three major tributaries: Tifni, Noufra and Tarzara Rivers. The former two tributaries, originating at the altitude of 3,800 m, are confluent on the right side at 8km upstream, and 6.5km from Setti Fadma respectively. The last one (Assif Tarzara) joins at the upstream of the Aghbalau Station and is a sloppy river whose violent floods has caused considerable damage, for example, interruption of the road P2017 along the Ourika River.

(4) Rheraya River

The Tahanaout Hydrological Observation Station with a catchment area of 221 km^2 controls the Rheraya River whose basin possesses the culminating point of Mt. Toubkal, 4,167 m. This river shows the slope of 1/5-1/45 between the station and its origin with a distance of 32 km. The annual average discharge is of 1.8m^3/s at the Tahanaout Station. The Rheraya River consists of two major tributaries (Tachedirt and Imlil river) that are confluent at the upstream 3.5 km from Asni. According to the observer of the Aremd Hydrological Observation Station located upstream of the Imlil River, the cross-section near the station always varies and has not regularized.

(5) N'fis River

The N'fis River drains the river basin of 1,256 km^2 at the Imin el Hammam Hydrological Observation Station. The river length between its origin and the station is of 100 km. Compared to the other rivers, this river has a gentler slope of 1/50-1/110. The annual average discharge is estimated at 6.5 m^3/s at the station. This river has five major tributaries: Ourigane, Imigdal, and Ougrandis Rivers. In the 1995 flood, debris flow caused destruction of infrastructure, and road interruption happened at two tributaries, the Ourigane and Imigdal Rivers.

(6) Issyl River

The Issyl River flows down 48 km through the Haouz Plain from its origin to the Tensift River, crossing the Rocade Canal. The river has the gradient of between 1/20 and 1/160 with an average of 1/60. The 4 km lowest stretch runs on the east site of Marrakech. However, water flow occurs only after a heavy rainfall and lasts for only a few hours. A majority of the floodwater comes from the mountain areas that are active (effective) catchment with an area of 175 km^2. In the 1997 flood, the discharge was estimated at 90 m^3/s. The river crosses a bridge of Road 31 at Sidi Yossef Ben Ali that does not have enough capacity to evacuate floods. Near the city wall there is another old bridge causing the overflow of floods.

1.2 Climate

The Mediterranean Sea, the Atlantic Ocean and the Atlas Mountains influence the climate of the Study Area. Climate in the study area is of the arid continental type based on the Mediterranean climate, because the area is located comparatively inland.

The Study Area is characterized by the dry and rainy seasons that alternately occur. The rainy period is October-April and the dry period is May-September. The average annual rainfall at the High Atlas ranges from 600 to 800 mm. On the other hand, from the foot of the High Atlas to the Haouz Plain the range is between 300 and 400 mm. Approximately 80 to 90% occur during the rainy season. Thunderstorms often generate serious damage to the valleys in the Atlas Mountain between July and October. The variations of monthly mean rainfall at the principal stations are shown in Fig. C.1.5.

The temperature generally gets hotter from the Atlas Mountain Region to the Haouz Plain. According to the data measured at the Marrakech Meteorological Station (DMN) from 1984 to 1991 as shown Table C.1.3, monthly mean temperatures vary between 11.8°C and 29.2°C. The hottest months are generally July and August (Mean max: from 37.2°C to 37.7°C) and the coldest month is January (about Mean min: 5.3°C). The extreme maximum and minimum temperatures recorded are 1.4°C and 43.9°C. Records of temperature at the other stations are shown in Table C.1.4.

The yearly average pan evaporation varies between 1,800 mm on the High Atlas and 2,600 mm in the Haouz Plain, according to the report issued by DRHT (Entitled Memory). Table C.1.4 shows the monthly total of evaporation at the Lalla Takerkoust and Sidi Rahal Hydrological Observation Stations (DRHT).

It snows somewhere in the medium-elevation areas from November to May. In the High Atlas, snow cover can be seen as long as between January and April at the areas of between 2,500 and 3,000 m in elevation, and it can snow all over the year above 3,000 m.

Regarding wind, the prevailing winds are from west-northwest and the average wind velocity in Marrakech is about 1.5 m/s, 2.5 m/s and 3.4 m/s representatively at 0600, 1200 and 1800 hours according to the report issued by DRHT entitled Memory.

Sunshine hours in Marrakech are about 200 hours in February and 325 hours in June (See Table C.1.3).

1.3 Hydrology

River discharge varies seasonally, corresponding to the seasonal change of rainfall. The variations of monthly mean discharge at the principal hydrological observation stations (Sidi Rahal, Taferiat, Aghbalau, Tahanaout, and Imin el Hamam) are shown in Fig. C.1.6. River flow normally starts to increase in October, and peaks between March and May when intensive precipitation is caused by frontal rainfall or melting snow. Thunderstorm rainfall often results in a torrential flood in the valley in summer.

Annual maximum discharge data at the principal observation stations are shown in Table C.1.5. According to the record at the Aghbalau Hydrological Station in the Ourika River, the maximum discharge was 1,060 m^3/s in 1967, followed by that of 1,030 m^3/s in 1995. According to the statistic analysis by DRHT, the return periods of the peak discharges in these floods are about 30 years at Aghbalau. As for the other stations, no discharge of over the 30-year return period has been recorded except at the Tahanaout Hydrological Observation Station in the Rheraya River, which recorded a maximum discharge of over the 100-year return period in August 1995. The probable discharges at the principal stations estimated by DRHT are shown in Table C.1.6.

It is noted that the Issyl River that is located in the alluvial fan is a so-called *Wadi*. It is usually dry and river flow is observed only during a flood. The other rivers also become wadis in the alluvial fans after they pass the valleys. River water infiltrate into the riverbeds covered by sand

CHAPTER 2 PAST FLOOD AND DEBRIS FLOW DISASTER

2.1 Past Major Disaster

2.1.1 High Atlas

DRHT in its report entitled “MEMORY” has stated that major floods occurred in 1925, 1949, 1967 and 1980. However, no detailed information on these floods is available. Two other big floods occurred in 1995 and 1999 in the High Atlas including the five river basins except the Issyl River Basin. The flood in 1995 was more serious in terms of flood damages. Over two hundred people were reported to be either dead or missing, and agricultural areas, houses and infrastructures were also damaged heavily. On the other hand, in the 1999 flood roads, irrigation channels and agricultural areas received much damage in the Ourika, Rheraya, and N‘fis Rivers, although no casualties were reported.

2.1.2 Alluvial Plain (Issyl River Basin)

The overflow of floodwaters from the Issyl River and the Chaabas Channel has resulted in considerable damages to the neighborhood of Menara, Sidi Yossef Ben Ali and to the road along the city wall. According to the DRHT, human casualties and material losses during floods had occurred many times in the past. Except the 1997 flood, however, detailed information on the other floods is not available.

Past Major Floods

River Basin	Year/ Month	Major Flooded Area	Flood Damage
Issyl	1956/-	Sidi Youssef Ben Ali and along the river course (Most severe flood in the past)	Many lives were lost.
	1963/12	Marrakech city area	2 people died and 97 houses were washed away.
	1971/-	No data	Flood damage was less severe than the 1956 flood.
	1982/-	Sidi Youssef Ben Ali area	Many houses were washed away.
	1984/-	Mainly Bab Rob area	Not specified
	1986/-	Sidi Youssef Ben Ali	10 houses were washed away
	1990/1	No data	4 people died, 20 people were injured, 530 ha of agricultural area were inundated.
	1994/10	Sidi Youssef Ben Ali	8 houses were damaged
	1995/4	No data	36 houses were damaged
	1997/3	23 villages and Sidi Youssef Ben Ali	40 houses were damaged
Other Basins (R‘dat, Zat, Ourika, Rheraya and N’fiss)	1949/-	No data	No data
	1967/-	- do -	- do -
	1980	- do -	- do -
	1995/8	Ourika and other areas (55 villages)	More than 200 people were killed or missing and total damage amount was 70 mil. DH
	1999/10	N‘fiss, Ourika and Rheraya	Infrastructure and agricultural areas were damaged.

2.2 Features of Flood and Debris Damage

Among the floods mentioned above, those in 1995, 1997 and 1999 are described as follows. The flood map about these floods is shown in Fig.C.2.1. As a conclusion of this section, the flood features in each river basin is summarized in Table C.2.1.

2.2.1 17 August 1995 Flood

(1) Hydrological Condition

In the 1995 flood event, local heavy rainfall caused by a thunderstorm occurred in a very limited area. The violent storm hit the high mountain area from about 5 p.m. to 8 p.m. on August 17. It peaked at between 6 and 7h20mn p.m. The rainfall intensity was presumed to be 100 mm/hr in the area of 228 km^2 upstream of Setti Fadma in the Ourika River Basin and 200 mm/hr in the Imlil area of the Rheraya river basin. However, there was no rain or almost no rain at the areas downstream of Setti Fadma.

Fig. C.2.2 shows hydrographs of the representative stations in the 1995 flood. Immediately after the heavy rainfall, flood emerged in the downstream. The flood travel time was very short and it was assumed to be between 30 minutes and 1 hour. The Aghbalau Station recorded 1000 m^3/s, and the Tahanaout Station 680 m^3/s. These peak discharges correspond to the annual maximum discharges with the return periods of 30 years and 100 years respectively.

The hydrographs at Aghbalau was especially very sharp. In the past hydrological analysis of the Ourika Basin by DRHT, rainfall of 130 mm in three hours is necessary to generate the same runoff volume as that of the 1995 flood (3.8Mm^3/s). However, the peak discharge of 1,000 m^3/s could be never reached by the 130 mm rainfall at all. This result means that the 1995 flood cannot be interpreted by the normal hydraulic condition.

The following is an interpretation of the flood phenomenon made in *"Amenagements Hydrauliques pour la Protection de la Vallee de l'Ourika Contre les Crues, Mission I, Mars 1996 INGEMA"*. The violent flood happened with sediment flow including pebbles, sand, silt, blocks, and tree trunks. Such materials formed a "natural dam", behind which water accumulated until the dam collapsed. After the dam was breached, the flow including sediment made a sharp hydrograph downstream at Aghbalau. This phenomenon was repeated every time the topography and lithology permit it and occurred in particular in the two bridges that disturbed the flow and at the two villages of Anfli and Tiourdiou, where alluvial cones flow into the Ourika River. Inhabitants were aware of this phenomenon.

Besides the places mentioned above, the gravels generated from the riverbank of the Ourika River disturbed the river flow at Tazzitount, where the river is narrow and the debris from Tighazrit tributary caused the same phenomenon, according to a staff of DRHT.

(2) Flood Damage

In this flood, the area most severely damaged was the area along the Ourika River where many tourists usually make a visit. In the area, 210 were reported as lost or missing, and many houses, agricultural areas and roads were damaged. The total damage amount was 70 million DH. The following description is about the flood damage in each basin.

(a) Ourika River Basin:

According to Royal Mounted Police (Gendarmerie Royale) and DPA, 210 human lives were lost or missing, 142 buildings were completely or partly destroyed, and 300 ha of agricultural land were inundated (62 ha were lost).

The following is additional information obtained through the field reconnaissance:

- A few hundred meters of the road P2017 upstream of the Aghbalau Station were damaged.
- Debris flow from the Tighazrit tributary in Iraghf destroyed bridges and roads.
- Most of causalities are Moroccan tourists who were killed in tourist places of Iraghf and Setti Fadma. Causalities of local Inhabitants were as few as 16.

(b) Rheraya River Basin:

A torrential flow caused the death of 5 persons in R‘ha Moulay Brahim and 7 others were injured (transferred to Tahanaout Hospital). According to the DPA, 983 ha of agricultural land were inundated. An interview survey shows that flood flow washed away 40 cars parked at Imlil and the weir near the town of Tahanaout was destroyed. Several houses were partly damaged in Asni town.

(c) N‘fis River Basin:

Debris flow happened in the two tributaries, the Imigdal and Ourigane Rivers. Although 20 mm of rain was recorded in Iguir N’kouris, no flood was noted at the station. According to the Royal Mounted Police and the DPA, the Ourigane Bridge was destroyed by debris flow, and a total 900 ha of agricultural land was inundated in the river basin.

(d) Zat River Basin:

Royal Mounted Police reported gave the number of human casualties as 11, the number of destroyed buildings as 22 and the number of dead livestock as 2,982. DPA reported the inundated agricultural area as 3,700 ha (148 ha were lost). According to the field reconnaissance, debris flow from the Tighedouine tributary washed out many houses and killed 11 inhabitants.

(e) R‘dat River Basin:

The damaged zone is located in the Zerkten commune rural that is crossed by the Tazlida tributary. The Royal Mounted Police reported the following losses caused by debris from the Tazilida River: the number of casualties was 3, buildings destroyed were 27, and dead livestock were 190 heads. The road at 2 Km near the Zerkten was washed out partly. In addition, DPA reported that agricultural land inundated was 1,350 ha.

2.2.2 1997 Flood (Issyl River Basin)

In the Issyl River basin, besides the inundation area devoid of any drainage system or those having ones but not operating correctly, floods essentially inundate and inflict damage on the urban perimeter and threaten the inhabitants' safety. The overflow of floodwaters from the Issyl River results in a considerable damage to the neighborhood of Sidi Yossef Ben Ali and to the road along the city wall. Human casualties and material losses during floods had occurred many times in the past.

(1) Hydrological Condition

In the 1997 flood, heavy rainfall occurred several days in a wide part of the Study Area. The total monthly rainfall of March and April occupied more than 30% of the total annual rainfall and at the B. L. Takerkoust point in the N'fis river basin it was 238 mm, which corresponds to 90% of the total annual rainfall.

On April 6, 1997, the discharge from the Issyl River was estimated at 90 m^3/s at the P 31-bridge level.

(2) Flood Damage

Intense streaming on March 27, 1997 and April 8, 1997 essentially caused the flood damage. All rural and urban communes of the Sidi Yossef Ben Ali Prefecture were generally flooded.

Flood damage was observed mainly in the Issyl river basin. In the basin, 358 houses in 26 villages were damaged and, at 16 points, the road was washed away. The damaged agricultural area was 113 ha in the M-Menara area.

2.2.3 October 11-13, 1999 Flood

(1) Hydrological Condition

Abundant rain fell at high intensity from October 11 to 13, 1999 in the whole sub-basins of the Ourika, Rheraya and N'fis Rivers. According to the rainfall recorded at the respective stations, this rainfall was interrupted on the 12th and started again on the 13th. At Tourcht Hydrological Station in the Ourika basin, the maximum daily rainfall was recorded at 62.4 mm/day on the 11th of October.

The peak discharge at the Aghbalau Station was 561 m^3/s at 22h30mn on the 11th. This discharge exceeds the 10-year discharge, according to DRHT. On the other hand, the peak discharges at the other basins were not so large, less than the 5-year return period.

(2) Flood Damage

According to the DRHT, the provincial road P2017 along the Ourika River was damaged (erosion of the edges of the road).

2.2.4 28 October 1999 Flood

(1) Hydrological Condition

Around the noon of October 28th, heavy rainfall hit the High Atlas. At the Tourcht and Amenzal Hydrological Stations in the Ourika basin, heavy rainfall was recorded at 108.3 and 103.8 mm/day on October 28. On the same day, heavy rainfall was recorded at 112.0 mm/day at the Aremd Observation Station in the Rheraya River, too.

Fig. C.2.3 presents hydrographs at the Aghbalau Station. Compared to the flood on August 17, 1995, this flood had a gentler rise time and hydrographic base time.

Runoff discharge was also quite large in the Ourika river basin. The maximum flood discharge was estimated at 762 m^3/s (17h30mn), corresponding to the 20-year return period, while those in the Rheraya and N'fis river basins correspond to 50 years (476m3/s) and 25 years (970 m^3/s), respectively.

(2) Flood Damage

In these floods, the direct flood damage to inhabitants has been minimal, but infrastructures such as roads and irrigation system, as well as agricultural areas, were severely damaged. The following description is about the flood damage in each basin.

(a) Ourika River Basin

According to the report by Royal Mounted Police, the flood caused the interruption of P 2017 (Marrakech-Setti Fadma Route) between KP 47 (Lgharmane) and KP 59+750 (Setti Fadma) with very significant damage. In addition to the electricity interruption in the center of Aghbalau and telephone disturbances in the whole Ourika valley, two secondary houses in the center of Aghbalau that were already damaged by the flood in 1995 were completely washed away by the flood. On the other hand, the agricultural area of 69 ha was inundated along the Ourika River.

(b) Rheraya and N'fis River Basin:

According to the report from Royal Mounted Police, the regional road R 203 along the N'fis and Rheraya Rivers was damaged at six points by flood and debris from the tributaries. P 2015 (Asni-Imlil) was also damaged. In addition, the agricultural area of 56 ha in the Rheraya river basin was lost. Furthermore, according to the census performed by the DPA, the agricultural area of 2,160 ha was damaged in the N'fis river basin.

(c) Zat River Basin

At Tighedouine, about one-third of the agricultural area in the river was washed away and flood damage amount was about one million DH.

CHAPTER 3. RAINFALL ANALYSIS AND DISCHARGE

3.1 Rainfall Analysis

3.1.1 Data Availability

Four agencies, DRHT, DMN, MCEF, and MOI mainly observe rainfall in and around the Study Area. Besides, some rainfall gauging stations are operated by the other agencies such as ORMVHA. Their locations are shown in Fig. C.3.1.

Among the total 48 rainfall gauging stations in and around the Study Area, representative 29 stations have been selected as shown in Fig. C.3.2 for the following hydrological analysis, considering data availability and spatial distribution of the stations. The stations are listed in Table C.3.1.

An automatic rain recorder has been installed at the Aghbalau Station (DRHT) and the Oukaimeden Station (DMN) in the Ourika River Basin, and the Marrakech Stations (DRHT and DMN) beside the Issyl River Basin. Among these automatic gauging stations, the Aghbalau (DRHT) Stations have continuous records over some 20 years, while records of the other stations are not continuous and of shorter observation period.

3.1.2 Annual Rainfall

(1) Altitude and Annual Rainfall

The Study Area extends in altitude from 500m at Marrakech to 4,167m at Mt. Toubkal, while the locations of the rainfall stations are biased to lower areas with the Amenzal Station at 2,230m as the highest station. In this connection, the relationship between altitude and rainfall is examined to estimate rainfalls at high altitudes (See Fig. C.3.3).

(2) Spatial Distribution of Annual Rainfall

Fig. C.3.3 shows that relationship between altitude and annual rainfall. A clear trend can be seen. The higher the altitude is, the more it rains. This relationship will be very useful to analyze the spatial variation of rainfall and to draw an isohyetal map as shown in Fig C.3.4. The annual rainfall depth in the Study Area increases from north to south, ranging from 250 mm in Marrakech to 700 mm in the High Atlas Region.

3.1.3 Seasonal Rainfall

A year is divided into three seasons in terms of rainfall patterns: dry summer and two rainy seasons (winter and spring). Summer can be defined as four months from June to September, winter from October to January, and spring from February to May respectively, as defined by *"Amenagements Hydrauliques pour la Protection de la Vallee de l'Ourika Contre les Crues, Mission I, Mars 1996 INGEMA"*.

Fig. C.3.5 indicates the seasonal variation of rainfall by basin. Except the N'fis River Basin, the seasonal depth of rainfall is recorded higher in spring than in other seasons. In the upper N'fis River Basin including the Arhbar, Talal Nous, Idni, Ijoukak and Iguir N'kouris Stations, rainfall is more in winter. On the other hand, spring rainfall is dominant with an amount of over 200mm in the Rheraya, Ourika and the R'dat River Basins.

3.1.4 Correlation of Rainfalls

It is very important to know the relation of rainfall between stations for flood forecasting study. In this section, the correlation coefficient between rainfalls in different intervals is conducted to recognize if the rainfall have a homogeneous or local characteristics.

(1) Correlation Coefficient of Yearly Rainfall

Table C.3.4 show the correlation coefficient of yearly rainfall between the stations on the basis of collected data summarized in Table C.3.3. Fig. C.3.6 show the line that expresses the classification of the correlation coefficient of rainfall between the stations. This classification line presents the characteristics of thinly relation between the mountain area and the flood plain. Additionally, the rainy area in the mountain area is narrower than that of the flood plain. It explains the different feature between the mountain area and the flood plain in this study area in view of yearly rainfall.

(2) Correlation Coefficient of Daily Rainfall

Fig. C.3.7 and Table C.3.5 show the correlation of daily rainfall between the stations in the Ourika river basin and principal stations in another basin. According to this table and figure, the rainfall in the Aghbalau station which locate in the top of alluvial fan evidence the strong relation to the rainfall in the alluvial fan (flood plain) and to the Tazzitount station in the 8km upstream from the Aghbalau station. But the correlation coefficient of rainfall between in the Aghbalau and in the station at further upstream is obviously low. Actually the rainfall in the Aghbalau station is 3mm of the daily rainfall on 1995 flood (30-years flood) but the rainfall around the mountain area is estimated over 100mm/hour by *"Amenagements Hydrauliques pour la Protection de la Vallee de l'Ourika Contre les Crues, Mission I, Mars 1996 INGEMA"*.

3.1.5 Rainfall Intensity

Rainfall intensity is one of the most important factors of such a flash flood in the Study Area. An insensitive rain causes a flash flood in a short time. It rapidly saturates the soil, and generates surface torrents that erode the riverbank.

The annual maximum rainfall intensities observed at the Aghbalau Station were collected for storm durations of 15, 30, 60, 120, 180, 360,720 and 1440 minutes, tabulated in Table 3-6. Based on the collected rainfall data above mentioned, an intensity-duration analysis has been carried out for different frequency of 2, 5, 10, 30, 50, 100 years return period . The process of this analysis is described below.

(1) Probable rainfall intensities in different duration is estimated such next table (The Gumbel method is applied as a result of trial by several method)

Intensity-Duration-Frequency Relationship at Aghbalau

(mm)

Return Period		Duration of Rainfall							
		15 min.	30 min.	60 min.	120 min.	180 min.	360 min.	720 min.	1440 min.
2 years	mm	6.0	10.0	15.6	22.1	26.2	33.2	39.9	46.5
	mm/h	24.0	20.1	15.6	11.1	8.7	5.5	3.3	1.9
5 years	mm	8.2	14.5	23.3	33.6	39.4	47.5	53.1	56.3
	mm/h	32.9	29.0	23.3	16.8	13.1	7.9	4.4	2.3
10 years	mm	9.6	16.8	26.7	37.9	44.0	52.5	58.2	61.5
	mm/h	38.6	33.6	26.7	18.9	14.7	8.8	4.8	2.6
30 years	mm	13.6	23.3	36.1	49.7	56.9	66.6	72.7	76.2
	mm/h	54.5	46.5	36.1	24.9	19.0	11.1	6.1	3.2
50 years	mm	15.2	25.8	39.7	54.2	61.8	71.8	78.2	81.8
	mm/h	60.7	51.6	39.7	27.1	20.6	12.0	6.5	3.4
100 years	mm	17.5	29.4	44.6	60.1	68.0	78.2	84.6	88.2
	mm/h	69.9	58.8	44.6	30.0	22.7	13.0	7.1	3.7

(2) Rainfall intensity-duration curve is illustrated as can be seen in figure below. This curve is used for supplementing probable rainfall at any duration and generally, the following formulas are applied to express the relationship between rainfall intensity and storm duration.

(a) Talbot Type :$R = a / (T + b)$

(b) Sherman Type :$R = a / T^n$

(c) Kuno Type :$R = a / (T^{0.5} + b)$

(d) Horner Type :$R = a / (T + b)^n$

(e) Kimijima Type :$R = a / (T^n + b)$

where ; R: Rainfall Intensity (mm/hr)

T: Storm Duration (minutes), a, b, n : Constants

Talbot, Sherman and Kuno types can be integrated into Kimijima type. And Kimijima type is superior to Horner type in many cases, judging from the standard deviation between original data and estimated data. Therefore, Kimijima type was employed in this analysis. The constants in the rainfall intensity formula are determined by the method of least squares.

Rainfall intensity-duration curve is illustlated in next figure.

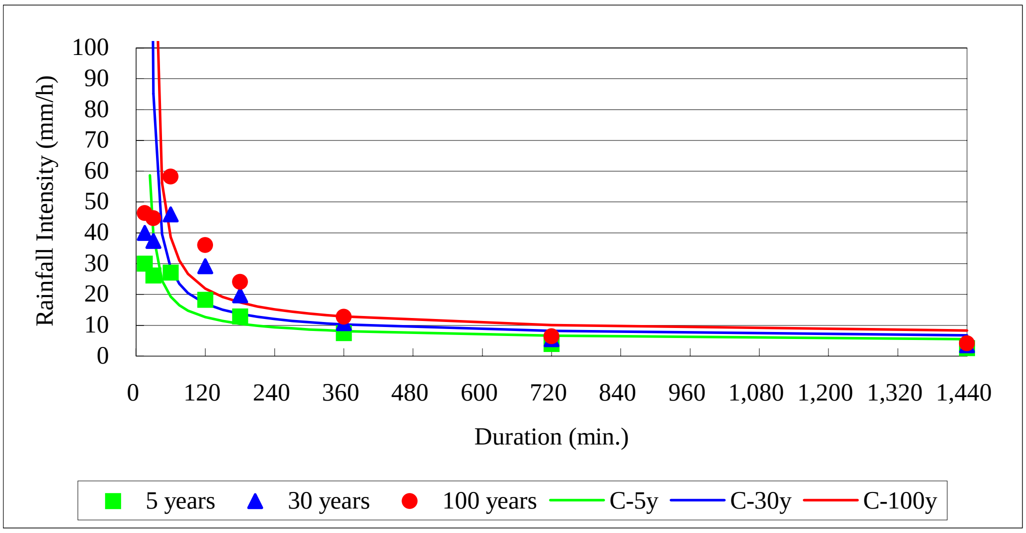


Figure. Rainfall Intensity Curve at Aghbalau (1)

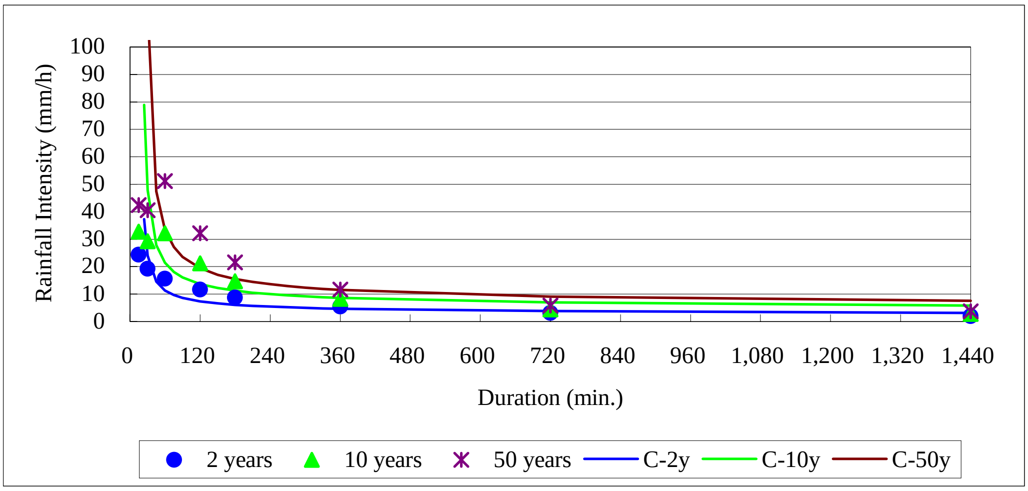


Figure. Rainfall Intensity Curve at Aghbalau (2)

3.1.6 Probability of Daily Rainfall

A statistical analysis was carried out to estimate probable daily rainfall (based on the data of annual maximum daily rainfall in a year summarized in Table C.3.6) of principal hydrological station by DRHT. The result is given as below:

Probability of Daily Rainfall

(mm)

Station Name	Return Period					
	2-years	5-years	10-years	20-years	50-years	100-years
Sidi Rahal	40.0	54.4	63.9	73.0	84.8	93.6
Taferiat	35.9	61.0	86.2	119.0	177.5	-
Aghbalau	47.9	61.9	71.2	80.1	91.6	100.3
Tahanaout	36.1	44.5	49.7	54.4	60.2	64.4
Imin El Hammam	36.0	49.5	59.5	70.0	85.1	97.5
Iguir Nkouris	33.2	46.5	54.7	62.3	71.9	78.8
Marrakech	33.3	47.9	57.9	67.6	80.4	90.3

3.2 Discharge

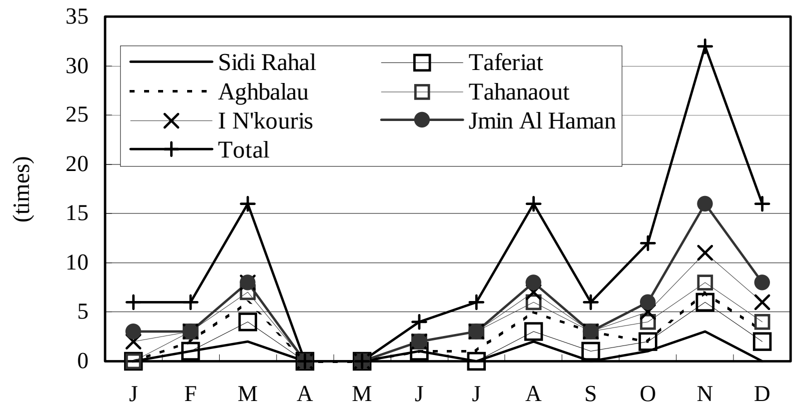
3.2.1 Data Availability

Water level is measured by DRHT in the Study Area at the stations presented in Fig. C.3.2 and Table C.3.2. Among these stations, the Sidi Rahal, Taferiat, Aghbalau, Tahanaout, Imin el Hammam, and Iguir N'kouris Stations are principal stations. In these principal stations, discharge measurement is made once a month for making rating curves for conversion from water level to discharge.

The other stations are simple stations that were newly installed for the flood watch purpose after the 1995 disaster. At these simple stations discharge measurement is rarely made but river cross section survey is made once a year.

3.2.2 Flood Season in Maximum Discharge Point of View

In the study area, the winter season has the highest frequency of floods followed by summer and spring. However, most floods occur in the summer season. The 10 large floods at each principal station are given in Table C.3.7 and the frequency is shown in the figure below.



Frequency of 10 Large Floods by Month

3.2.3 Statistical Analysis

A statistical analysis was carried out to estimate probable discharge of principal hydrological station by DRHT. The several method was used to carried out this statistical analysis (see Fig. C.3.8) and the most adequate method was applied. The result is given as below:

Probability of Maximum Discharge

(m^3/s)

Station Name	Return Period					
	2-years	5-years	10-years	20-years	50-years	100-years
Sidi Rahal	150	300	420	550	740	900
Taferiat	110	250	390	560	840	1,110
Aghbalau	115	300	490	750	1,200	1,650
Tahanaout	40	90	150	230	390	560
Imin El Hammam	150	440	770	1,220	2,040	2,880
Iguir Nkouris	100	280	520	850	1,500	2,200

TABLES

Table C.1.1 CATCHMENT AREAS OF SUB-BASIN

No.	Basin	Catchment Area (km^2)	Remarks
1	N'fis River Basin	1,256	Upstream from Sta. Imin El Hammam
2	Rheraya River Basin	221	Upstream from Sta. Tahanaout
3	Ourika River Basin	495	Upstream from Sta. Aghbalau
4	Zat River Basin	528	Upstream from Sta. Taferiat
5	R'dat River Basin	532	Upstream from Sta. Sidi Rahal
6	Issyl River Basin	421	Upstream from Root N8
Total		3,453	

Table C.1.2 DIMENSION OF MAJOR RIVERS

No.	River	Length (Km)*1	Origin EL. (m)	End EL. (m)	Slope
1	N'fis River	133.1	3,000	300 (780)	1/50-1/200 (1/110)
2	Rheraya River	87.2	3,800	350 (925)	1/5 -1/140 (1/45)
3	Ourika River	76.1	3,000	430 (1,011)	1/5 -1/160 (1/32)
4	Zat River	93.8	3,700	430 (760)	1/10-1/160 (1/70)
5	R'dat River	76.6	2,400	500 (700)	1/10-1/155 (1/100)
6	Issyl River	47.0	1,900	400 -	1/20-1/160

*1 : From confluence with Tensift river to Origin
( )···Value at edge of downstream of each river in the study area)

Table C.1.3 CLIMATE IN MARRAKECH

Month	Temperature (℃)					Humidity (%)	Sunshine (hour)	Precipitation	
	Maximum		Minimum		Mean			(mm)	Number of Days
	Mean max	Extreme	Mean max	Extreme					
Jan	18.4	23.4	5.3	1.4	11.8	58.5	228.8	32.3	5.8
Feb	20.1	27.7	7.7	3.4	13.9	57.9	197.8	33.8	6.4
Mar	22.6	30.0	9.6	5.7	16.1	52.5	254.6	52.7	5.6
Apr	24.5	32.2	11.3	7.2	17.9	51.6	275.7	15.5	5.3
May	27.4	36.0	13.8	10.2	20.6	48.4	297.6	9.5	3.1
Jun	32.2	38.8	16.4	13.3	24.3	48.0	324.6	6.0	0.9
Jul	37.7	43.9	20.8	16.3	29.2	40.9	318.5	1.8	1.6
Aug	37.2	43.9	21.0	16.7	29.1	40.9	308.3	3.8	1.3
Sep	33.7	41.5	19.3	15.2	26.5	43.1	253.6	5.6	1.9
Oct	27.3	33.4	14.9	11.1	21.1	50.9	250.6	14.0	3.8
Nov	22.6	29.7	11.2	5.6	16.9	55.5	229.4	37.3	6.8
Dec	19.7	25.7	7.4	2.5	13.6	57.0	223.1	16.9	4.8
Total	323.4	406.2	158.7	108.6	241.0	605.2	3,162.6	229.2	47.3
Average	27.0	33.9	13.2	9.1	20.1	50.4	263.6	19.1	3.9
Maximum	37.7	43.9	21.0	16.7	29.2	58.5	324.6	52.7	6.8
Minimum	18.4	23.4	5.3	1.4	11.8	40.9	197.8	1.8	0.9

Data Source: DRHT

Table C.1.4 TEMPERATURE AT SIDI RAHAL STATION AND LALLA TAKERKOUST STATION

Sidi Rahal

Month	Temperature(℃)			Average Evaporation (mm)
	Average	Extreme Max	Extreme Min	
Jan	12.3	28.2	-0.6	119.3
Feb	13.3	29.0	-5.6	115.6
Mar	14.9	32.6	1.8	138.1
Apr	16.1	36.0	3.0	138.9
May	19.1	40.0	5.0	197.5
Jun	23.2	43.4	8.4	246.2
Jul	28.2	45.0	11.4	365.7
Aug	27.8	43.6	12.2	340.7
Sep	24.9	41.4	9.4	263.5
Oct	20.1	37.4	5.0	190.0
Nov	16.3	31.2	2.0	150.6
Dec	13.0	28.0	-0.8	117.6
Total	-	-	-	2,383.7
Average	19.1	435.8	51.2	198.6
Maximum	28.2	45.0	12.2	365.7
Minimum	12.3	28.0	-5.6	115.6

Data Source: DRHT

Lalla Takerkoust

Month	Temperature(℃)			Average Evaporation (mm)
	Average	Extreme Max	Extreme Min	
Jan	10.9	28.8	-7.4	90.3
Feb	12.8	29.4	-4.8	88.8
Mar	14.8	32.0	-2.6	120.6
Apr	15.4	39.4	-4.2	123.1
May	18.7	41.2	1.0	155.6
Jun	22.2	42.0	3.8	175.3
Jul	27.0	45.8	6.4	244.1
Aug	26.4	46.0	8.6	239.5
Sep	23.2	42.2	3.6	178.4
Oct	18.6	36.6	2.2	134.3
Nov	14.9	31.8	-2.2	105.0
Dec	12.2	28.4	-6.4	96.6
Total	-	-	-	1,751.6
Average	18.1	443.6	-2.0	146.0
Maximum	27.0	46.0	8.6	244.1
Minimum	10.9	28.4	-7.4	88.8

Data Source: DRHT

Table C.1.5 ANNUAL MAXIMUM DISCHARGE

(m^3/s)

River	N'FIS	N'FIS	RHERAYA	OURIKA	ZAT	R'DAT
Station	I.E.HAMMAM	N'KOURIS	TAHANAOUT	AGHBALAU	TAFERIAT	S.RAHAL
1880					730.0	
1937/38			145.0			
1938/39			130.0			
1939/40			75.0			
1940/41				155.0		
1941/42				135.0		
1942/43				130.0		
1944/45			100.0			
1945/49					490.0	
1949						380.0
1948/49				350.0		
1950/51					100.0	
1952/53					120.0	
1954/55					150.0	
1962/63			34.5		145.0	
1963/64			13.0		285.0	
1964/65			35.7		209.0	70.3
1965/66			37.3		600.0	200.0
1966/67	335.0	272.0	54.3		225.0	183.0
1967/68	1,400.0	620.0	290.0	1,060.0	230.0	202.0
1968/69	89.6	74.0	9.3		46.4	66.5
1969/70	720.0	584.0	8.7	96.7	50.2	149.0
1970/71	110.0	90.0	24.2	117.0	96.9	202.0
1971/72	38.5	32.0	15.6	55.2	108.0	125.0
1972/73	40.7	34.0	42.3	72.0	47.0	60.4
1973/74	47.6	40.0	47.6	77.5	109.0	103.0
1974/75	50.1	42.0	12.0	23.4	63.2	35.7
1975/76	36.1	24.0	16.2	101.0	48.7	87.2
1976/77	111.0	119.0	9.4	52.6	108.0	49.3
1977/78	301.0	263.0	21.6	95.6	32.0	160.0
1978/79	400.0	403.0	9.9	18.4	108.0	87.8
1979/80	132.0	127.0	39.0	350.0	138.0	210.0
1980/81	44.8	44.1	36.7	8.1	108.0	210.0
1981/82	58.5	25.8	33.7	91.3	680.0	685.0
1982/83	51.4	33.8	22.5	24.4	14.7	5.5
1983/84	482.0	393.0	30.9	37.4	106.0	77.0
1984/85	86.5	45.9	23.4	40.1	106.0	110.0
1985/86	57.0	20.3	54.0	50.5	85.0	49.8
1986/87	508.0	135.0	155.0	250.0		351.2
1987/88	810.0	1,120.0	146.0	651.0	467.0	397.0
1988/89	1,220.0	585.0	58.9	823.0	73.8	325.0
1989/90	455.0	229.0	103.0	265.0	270.0	345.0
1990/91	63.9	92.5	26.2	207.0	72.6	146.0
1991/92	446.0	319.0	71.2	290.0	99.5	125.0
1992/93	9.0	13.7	27.6	74.5	26.9	27.6
1993/94	283.0	146.2	86.4	226.0	237.0	144.0
1994/95	501.0	42.8	680.0	1,030.0	400.0	533.0
1995/96	501.0	212.0	63.0	165.0	72,8	407.0
1996/97	54.4	124.0	15.6	65.0	37.0	212.0
1997/98	155.0	62.5	44.0	61.3	17.8	536.0
1998/1999	970.0	158.0	762.0	561.0	104.0	252.0
Maximum	1,400.0	1,120.0	762.0	1,060.0	730.0	685.0
Minimum	9.0	13.7	8.7	8.1	14.7	5.5
Average	320.2	197.8	88.1	223.1	178.6	203.0

Source : Ajustements statistic de valeurs extremes de pluies et de debits dans le bassin de Tensift-Qsob par le logiciel "EXTREM" issued by DRHT/SHL, dec 1999

Table C.1.6 PROBABILITY OF ANNUAL PEAK DISCHARGE AT PRINCIPAL STATION

(m^3/s)

No.	Station	Catchment Area (km^2)	Probability						
			1/2	1/5	1/10	1/20	1/50	1/100	1/200
1	Sidi Rahal	532	150	300	420	550	740	900	1,070
2	Taferiat	528	110	250	390	560	840	1,110	1,440
3	Aghbalau	495	115	300	490	750	1,200	1,650	2,200
4	Tahanaout	221	40	90	150	230	390	560	800
5	Iguir N'kouris	848	100	280	520	850	1,500	2,200	3,090
6	Imin El Hammam	1,256	150	440	770	1,220	2,040	2,880	3,950
Total		3,880							

Source : Ajustements statistic de valeurs extremes de pluies et de debits dans le bassin de Tensift-Qsob par le logiciel "EXTREM" issued by DRHT/SHL, dec 1999

Table C.2.1 (1/2) FEATURE OF FLOOD AND SEDIMENT FLOW DAMAGE (1995 FLOOD)

River Basin	Damage Site	Contents of Damage								Scale of Damage		Cause of Damage		Remarks
		House	People: Loss of Lives	People: Injured	Household Effects	Live Stocks	Agricul-tural Area	Infra structure	Others	Wide Area	Localized	Flood	debris	
R'dat	Sidi Rahal						Yes		Yes		Yes	Yes		Generally debris damage occurred by tributary, Flood damage occurred by main river
	Zerqten	Yes	Yes		Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes	
Zat	Tighedouine	Yes	Yes		Yes	Yes	Yes	Yes	Yes	Yes			Yes	
Ourika	Aghbalau							Yes			Yes	Yes		
	Iraghf	Yes	Yes	Yes	Yes			Yes		Yes		Yes	Yes	
	Setti Fadma	Yes	Yes	Yes	Yes		Yes	Yes		Yes		Yes	Yes	
Issyl	—	Yes										Yes		
Rheraya	Asni	Yes					Yes	Yes			Yes	Yes		
	Tahanaout								Yes		Yes	Yes		
	my. Brahim		Yes	Yes					Yes		Yes	Yes		
	Imlil								Yes		Yes	Yes		
N'fis	Wirgane						Yes	Yes			Yes	Yes	Yes	
	Imigdal						Yes	Yes			Yes	Yes	Yes	

Table C.2.1 (2/2) FEATURE OF FLOOD AND SEDIMENT FLOW DAMAGE (1999 FLOOD)

River Basin	Damage Site	Contents of Damage								Scale of Damage		Cause of Damage		Remarks
		House	People: Loss of Lives	People: Injured	Household Effects	Live Stocks	Agricultural Area	Infra structure	Others	Wide Area	Localized	Flood	debris flow	
R'dat	Sidi Rahal													Generally, debris damage occurred by tributary, Flood damage occurred by main river
	Zerqten													
Zat	Tighedouine													
Ourika	Aghbalau	Yes						Yes			Yes	Yes		
	Lgharmane～Setti Fadma							Yes		Yes		Yes		
	Setti Fadma						Yes	Yes			Yes	Yes	Yes	
Issyl	—													
Rheraya	Asni～Imlil							Yes		Yes		Yes		
N'fis	Imigdal						Yes				Yes	Yes		
	Ijoukak						Yes				Yes	Yes		
	Talat N'Yacob						Yes				Yes	Yes		
	Wirgane～Mzouzite						Yes	Yes		Yes		Yes	Yes	

Table C.3.1 RAINFALL GAUGING STATION FOR HYDROLOGICAL STUDY

Basin	No.	Station Name	Organization	Location		Installation	Altitude (m)	Period of Collected Data
				Latitude	Longitude			
R'dat	1	Sidi Rahal	DRHT	31° 38.34'	7° 28.52'	03/10/63	690	1967-1999
	2	Azrif	WAF	31° 32'	7° 16'	01/01/51	1760	1951-1997
	3	Taddart	WAF	31° 21'	7° 25'	01/01/35	1650	1936-1997
	4	Toufliht	WAF	31° 28'	7° 26'	01/12/38	1465	1970-1997
Zat	5	Taferiat	DRHT	31° 32.80'	7° 35.99'	09/02/62	760	1980-1999
	6	Asloune	WAF	31° 24'	7° 32'	01/01/38	1115	1937-1997
Ourika	7	Aghbalau	DRHT	31° 19.02'	7° 44.75'	04/04/69	1070	1969-1999
	8	Agouns	DRHT	31° 11.98'	7° 48.17'	26/06/96	2200	1996-1999
	9	Tazzitount	DRHT	31° 16.443	7° 41.30'	21/02/99	1270	1999
	10	Tourcht	DRHT	31.14.08	7.37.91	04/12/97	1650	1997-1999
	11	Amenzal	DRHT	31° 11.28'	7° 45.02'	10/04/97	2230	1997-1999
	12	Tiourdiou	DRHT	31° 12.02'	7° 44.78'	20/06/96	1850	1996-1999
Rheraya	13	Tahanaout	DRHT	31° 17.66'	7° 57.85'	08/03/62	925	1962-1999
	14	Armed	DRHT	31° 07'	7° 55'	12/02/99	1950	1999
	15	Ifghane	WAF	31° 14'	7° 55'	01/09/73	1920	1977-1999
	16	Asni	MOF	31° 15'	8° 00'	01/01/37	1200	1937-1997
N'fis	17	Imin El Hammam	DRHT	31° 12.87'	8° 06.72'	01/07/66	770	1969-1999
	18	Iguir N'kouris	DRHT	31° 03.54'	8° 08.38'	20/03/74	1100	1974-1999
	19	Arhbar	WAF	30° 52'	8° 24'	01/04/37	1900	1938-1997
	20	Idni	WAF	30° 55'	8° 17'	24/04/53	1700	1953-1997
	21	Ijoukak	WAF	31° 01'	8° 09'	01/02/42	1440	1941-1997
	22	Wirgane	WAF	31° 09'	8° 07'	02/27/89	1045	1927-1998
	23	Talat Nos	WAF	31° 03'	8° 08'	01/04/37	1300	1937-1997
Other	24	B.L.Takerkoust	DRHT	31° 21.47'	8° 08.38'	1962	630	1953-1999
	25	Agaiouar	WAF	31° 17'	7° 49'	04/25/89	1805	1930-1997
	26	Dar Ouriki	WAF	31° 22'	7° 47'	01/06/37	800	1937-1997
	27	Tizi Ghourane	WAF	31° 13'	8° 14'	01/01/36	1150	1970-1997
	28	Amizmiz	WAF	31° 13'	8° 14'	06/01/23	1005	1923-1995
	29	Marrakech	DMN	31° 36'	8° 01'	01/01/84	460	1913-1999

Table C.3.2 WATER LEVEL OBSERVATION STATION

Basin	No.	Station Name	Organization	Location		Installation	Altitude (m)	Period of Collected Water Level Data
				Latitude	Longitude			
R'dat	1	Sidi Rahal	DRHT	31° 38.34'	7° 28.52'	03/10/63	690	1963-1999
Zat	2	Taferiat	DRHT	31° 32.80'	7° 35.99'	09/02/62	760	1962-1999
Ourika	3	Aghbalau	DRHT	31° 19.02'	7° 44.75'	04/04/69	1070	1969-1999
	4	Tazzitount	DRHT	31° 16.443	7° 41.30'	21/02/99	1270	1999
	5	Tourcht	DRHT	31.14.08	7.37.91	04/12/97	1650	1997-1999
	6	Amenzal	DRHT	31° 11.28'	7° 45.02'	10/04/97	2230	1997-1999
	7	Tiourdiou	DRHT	31° 12.02'	7° 44.78'	20/06/96	1850	1996-1999
Rheraya	8	Tahanaout	DRHT	31° 17.66'	7° 57.85'	08/03/62	925	1962-1999
	9	Armed	DRHT	31° 07'	7° 55'	12/02/99	1950	1999
N'fis	10	Imin El Hammam	DRHT	31° 12.87'	8° 06.72'	01/07/66	770	1966-1999
	11	Iguir N'kouris	DRHT	31° 03.54'	8° 08.38'	20/03/74	1100	1974-1999

Table C.3.3(1) YEARLY RAINFALL

(mm)

No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	No.
Year	Sidi Rahal	Azrif	Taddart	Toufliht	Taferiat	Asloune	Aghbalou	Agouns	Tazitount	Tourcht	Amenzal	Tiourdiou	Tahanaout	Aremd	Ifgane	Year
1913-14																1913-14
1914-15																1914-15
1915-16																1915-16
1916-17																1916-17
1917-18																1917-18
1918-19																1918-19
1919-20																1919-20
1920-21																1920-21
1921-22																1921-22
1922-23																1922-23
1923-24																1923-24
1924-25																1924-25
1925-26																1925-26
1926-27																1926-27
1927-28																1927-28
1928-29																1928-29
1929-30																1929-30
1930-31																1930-31
1931-32																1931-32
1932-33																1932-33
1933-34																1933-34
1934-35																1934-35
1935-36																1935-36
1936-37																1936-37
1937-38			-			188.9										1937-38
1938-39			-			109.3										1938-39
1939-40			-			-										1939-40
1940-41			-			713.9										1940-41
1941-42			-			415.9										1941-42
1942-43			-			298.4										1942-43
1943-44			-			76.0										1943-44
1944-45			-			-										1944-45
1945-46			-			191.8										1945-46
1946-47			-			172.4										1946-47
1947-48			-			513.2										1947-48
1948-49			580.4			695.1										1948-49
1949-50			258.5			395.1										1949-50
1950-51			496.3			452.4										1950-51
1951-52		232.5	335.6			337.4										1951-52
1952-53		528.5	328.9			415.8										1952-53
1953-54		720.5	441.0			602.6										1953-54
1954-55		497.0	472.7			485.9										1954-55
1955-56		214.0	662.4			198.5										1955-56
1956-57		-				-										1956-57
1957-58		-	443.6			505.3										1957-58
1958-59		-	-			196.1										1958-59
1959-60		-	-			-										1959-60
1960-61		-	-			-										1960-61
1961-62		-	-			-										1961-62
1962-63		928.5	-			-							-			1962-63
1963-64		748.5	-			516.8							-			1963-64
1964-65		600.0	-			396.9							-			1964-65
1965-66		429.3	-			296.2							-			1965-66
1966-67	117.9	682.8	-			574.4							-			1966-67
1967-68	505.5	-	-			495.9							-			1967-68
1968-69	490.5	551.0	-			672.8							-			1968-69
1969-70	397.9	834.0	-			490.1	570.6						-			1969-70
1970-71	-	122.5	-	1125.1		848.9	931.7						-			1970-71
1971-72	463.6	819.5	708.6	645.2		752.3	1061.9						772.2			1971-72
1972-73	302.5	482.8	112.1	730.4		435.9	796.4						574.7			1972-73
1973-74	561.8	1018.0	464.9	996.1		693.0	959.2						747.5			1973-74
1974-75	262.9	-	350.7	628.0		452.4	590.9						387.2			1974-75
1975-76	379.7	-	371.4	661.7		330.1	742.2						485.8			1975-76
1976-77	270.4	-	381.2	677.5		377.6	489.0						318.9			1976-77
1977-78	412.1	-	536.9	779.4		595.3	651.5						393.6		241.2	1977-78
1978-79	277.7		502.5	572.7		403.4	347.9						294.1		226.0	1978-79
1979-80	449.9	-	449.0	762.9		-	689.7						418.7		317.0	1979-80
1980-81	327.4	-	487.6	589.3	272.6	321.0	407.7						395.0		201.5	1980-81
1981-82	394.4	128.4	509.4	893.5	404.6	450.2	582.1						410.7		-	1981-82
1982-83	172.7	130.4	249.4	359.8	150.9	220.0	314.9						240.1		87.0	1982-83
1983-84	236.9	250.3	501.3	670.7	277.0	298.6	376.3						311.6		228.1	1983-84
1984-85	319.9	361.6	573.0	704.4	388.2	376.4	551.8						395.5		289.3	1984-85
1985-86	302.2	317.5	538.6	780.3	300.3	316.2	467.5						311.5		442.1	1985-86
1986-87	220.6	334.0	387.9	-	-	368.4	313.8						280.1		-	1986-87
1987-88	351.4	518.1	633.8	-	331.6	554.7	594.5						365.1		-	1987-88
1988-89	437.6	634.7	719.3	-	453.5	644.1	680.9						544.6		507.1	1988-89
1989-90	313.6	497.9	518.2	699.0	285.8	502.0	438.3						309.8		400.6	1989-90
1990-91	467.5	513.0	637.4	866.5	474.4	632.4	829.1						462.0		415.8	1990-91
1991-92	247.9	500.8	265.5	780.0	291.5	416.6	487.2						360.6		463.2	1991-92
1992-93	167.7	47.4	140.6	-	237.6	228.0	276.9						192.2		210.5	1992-93
1993-94	359.9	260.5	242.3	758.1	468.3	668.1	647.8						416.2		340.9	1993-94
1994-95	346.3	282.0	192.5	-	396.4	343.6	359.4						329.6		261.3	1994-95
1995-96	531.2	775.0	600.2	1213.0	912.6	866.2	725.1						539.0		545.0	1995-96
1996-97	429.6	233.4	134.3	475.7	420.9	320.5	515.2	112.0				314.5	469.4		247.3	1996-97
1997-98	388.5	-	-	-	415.9	-	560.3	15.6		347.0	401.4	240.5	354.8		-	1997-98
1998-99	349.0	-	-	-	395.0	-	552.4	302.5	-	362.3	337.6	251.3	372.9	-	303.5	1998-99
Average	**351.8**	**474.8**	**435.1**	**744.1**	**382.1**	**438.9**	**583.7**	**143.4**	**-**	**354.7**	**369.5**	**268.8**	**409.1**	**-**	**318.2**	**Average**

Table C.3.3(2) YEARLY RAINFALL

(mm)

No.	16	17	18	19	20	21	22	23	24	25	26	27	28	29	No.
Year	Asni	Imin El Ham.	Iguir N'kouris	Arhbar	Idni	Ijoukak	Wirgane	Talat nous	B.L. Takerkous	Agaiouar	Dar Ouriki	Tizi Ghourane	Amizmiz	Marrakech	Year
1913-14														255.4	1913-14
1914-15														362.2	1914-15
1915-16														378.3	1915-16
1916-17														310.5	1916-17
1917-18														205.2	1917-18
1918-19														197.3	1918-19
1919-20														286.4	1919-20
1920-21														399.3	1920-21
1921-22														501.2	1921-22
1922-23														311.1	1922-23
1923-24													483.7	111.1	1923-24
1924-25													446.6	299.5	1924-25
1925-26													510.5	183.1	1925-26
1926-27													672.6	-	1926-27
1927-28							658.5						669.5	-	1927-28
1928-29							392.2						672.9	-	1928-29
1929-30							337.0						528.2	-	1929-30
1930-31							432.2			423.2			136.6	198.2	1930-31
1931-32							269.8			412.7			421.5	169.0	1931-32
1932-33							477.2			447.5			403.1	-	1932-33
1933-34							504.2			589.3			717.5	-	1933-34
1934-35							381.3			493.5			583.6	-	1934-35
1935-36							434.2			591.4			326.8	-	1935-36
1936-37							266.0			457.0			257.3	132.5	1936-37
1937-38	295.3						414.8	216.7		768.1	369.0		461.2	225.6	1937-38
1938-39	785.7			129.9			623.6	372.9		742.4	-		447.2	469.3	1938-39
1939-40	588.1						381.9	390.2		665.3	139.9		436.8	242.3	1939-40
1940-41	451.0			746.7			513.4	328.1		878.3	583.2		514.0	-	1940-41
1941-42	431.0			106.6			570.2	333.5		794.4	441.0		538.1	-	1941-42
1942-43	434.5			614.6		626.3	523.3	580.1		959.2	716.2		646.3	-	1942-43
1943-44	233.5			-		-	305.3	151.0		490.7	412.2		349.1	-	1943-44
1944-45	147.5			-		273.0	213.6	233.5		148.9	169.8		263.8	-	1944-45
1945-46	369.0			-		147.5	340.1	200.5		620.9	387.4		279.0	-	1945-46
1946-47	394.0			-		325.2	462.6	330.8		585.9	636.7		458.0	-	1946-47
1947-48	456.0			361.3		293.3	411.9	450.3		509.6	479.8		478.3	-	1947-48
1948-49	759.0			567.8		423.5	599.0	632.2		1078.3	-		678.1	-	1948-49
1949-50	284.0			638.8		282.6	359.6	365.3		452.0	313.6		289.2	-	1949-50
1950-51	490.0			460.9		381.2	524.2	544.3		794.5	578.7		545.3	-	1950-51
1951-52	343.0			634.3		220.8	343.4	382.3		483.2	397.5		506.5	-	1951-52
1952-53	442.0			614.5		330.6	387.0	447.3		665.1	462.1		217.3	-	1952-53
1953-54	569.5			651.1	696.5	469.2	616.6	496.2	324.2	741.4	666.0		649.7	-	1953-54
1954-55	496.0			654.9	511.3	372.0	459.9	314.0	293.6	574.4	526.5		318.6	-	1954-55
1955-56	548.5			589.3	962.1	512.7	541.7	291.1	381.9	528.4	542.3		686.8	-	1955-56
1956-57	264.9			-	181.8	161.4	-	149.0	-	310.5	60.5		302.1	-	1956-57
1957-58	588.0			920.2	347.8	230.1	585.1	288.0	-	581.4	-		629.9	-	1957-58
1958-59	415.5			365.5	-	132.0	421.4	-	-	274.0	-		351.4	-	1958-59
1959-60	457.2			437.8	-	285.9	346.0	-	-	849.8	-		581.2	-	1959-60
1960-61	328.5			157.2	-	141.2	353.2	-	-	770.7	-		438.3	141.5	1960-61
1961-62	598.5			342.2	-	464.6	668.6	110.5	-	553.9	-		565.4	238.1	1961-62
1962-63	709.6			1269.5	-	619.4	669.8	501.7	380.6	980.9	-		726.2	359.0	1962-63
1963-64	455.0			823.0	186.3	259.2	415.7	330.4	154.0	594.2	463.6		427.3	199.6	1963-64
1964-65	397.5			793.8	756.2	460.0	653.9	352.7	224.4	532.9	709.6		435.3	230.7	1964-65
1965-66	367.4			578.2	565.6	279.4	401.1	261.3	266.2	546.0	527.5		339.0	195.2	1965-66
1966-67	395.5			491.1	453.5	322.8	547.1	319.6	262.5	742.9	584.7		511.5	252.1	1966-67
1967-68	490.8			1172.5	975.8	565.7	637.7	444.8	417.9	755.9	638.5		643.0	348.6	1967-68
1968-69	504.0			790.7	566.9	283.1	589.1	324.7	355.1	984.8	702.5		616.2	316.6	1968-69
1969-70	359.5	468.2		952.7	726.4	288.3	455.6	255.3	276.7	741.5	469.7		488.2	295.7	1969-70
1970-71	682.5	598.9		1120.9	818.1	383.7	904.9	346.8	424.0	1033.4	892.1	774.9	614.9	461.0	1970-71
1971-72	361.5	321.4		337.0	276.9	268.5	1153.3	390.8	298.8	783.1	-	562.1	529.2	244.9	1971-72
1972-73	395.5	368.3		429.7	360.2	226.6	349.0	259.9	271.5	633.0	342.3	451.5	282.0	211.1	1972-73
1973-74	559.9	439.3		443.7	394.9	301.0	541.8	437.4	361.4	797.0	668.2	631.1	298.2	371.9	1973-74
1974-75	-	237.7	98.6	131.9	92.8	91.4	283.0	201.8	223.7	668.9	-	507.8	323.6	168.1	1974-75
1975-76	-	466.7	141.2	436.7	362.3	238.6	355.5	229.7	235.4	630.0	421.0	442.6	377.2	233.7	1975-76
1976-77	106.9	344.7	187.2	318.9	275.2	239.8	234.9	90.7	216.4	509.2	289.8	346.5	285.5	153.4	1976-77
1977-78	496.5	365.3	239.3	820.8	695.8	254.4	431.0	309.1	281.6	639.4	576.4	554.8	495.4	314.2	1977-78
1978-79	210.4	199.0	192.5	916.2	165.5	-	281.6	241.0	142.3	280.8	-	270.4	232.9	207.7	1978-79
1979-80	462.8	420.2	231.1	505.2	-	-	353.2	197.0	251.6	630.3		451.7	410.9	266.2	1979-80
1980-81	269.6	271.2	190.6	477.9	267.4	193.9	246.2	172.0	217.0	350.5	299.7	316.9	246.5	107.9	1980-81
1981-82	382.1	487.1	189.0	536.0	266.8	380.2	360.9	139.0	292.9	454.0	475.7	690.6	468.9	306.8	1981-82
1982-83	189.5	213.9	114.9	373.7	-	-	130.9	58.5	105.9	132.1	253.2	308.8	178.3	101.0	1982-83
1983-84	-	287.5	156.5	440.0	76.4	-	284.1	116.5	146.7	439.1	266.9	405.2	293.7	197.4	1983-84
1984-85	449.1	378.7	281.0	516.3	484.9	-	325.6	222.5	235.1	763.0	444.6	537.3	385.1	233.1	1984-85
1985-86	132.5	202.5	122.9	388.0	338.0	142.4	283.0	115.5	159.6	487.6	358.9	451.9	321.8	216.6	1985-86
1986-87	350.8	230.3	140.2	387.0	380.0	182.1	276.8	152.7	209.5	460.6	265.9	300.5	222.9	149.8	1986-87
1987-88	-	470.3	304.4	1213.6	1103.0	425.0	299.4	289.4	298.3	536.7	614.4	622.0	464.8	267.4	1987-88
1988-89	-	365.0	412.5	736.0	786.7	454.8	516.6	352.3	323.8	952.4	479.6	543.0	488.5	276.5	1988-89
1989-90	341.3	295.7	-	698.1	1152.6	573.7	308.0	377.3	-	508.0	303.1	395.0	263.9	176.1	1989-90
1990-91	492.6	373.2	177.4	372.6	268.3	231.5	428.8	222.5	295.8	534.7	494.3	446.0	355.1	310.6	1990-91
1991-92	369.1	397.6	339.6	461.8	837.4	119.4	310.4	231.7	196.3	595.9	428.6	483.0	338.5	177.6	1991-92
1992-93	208.3	225.9	83.7	158.5	175.2	107.2	-	114.0	118.8	255.4	155.8	279.0	215.7	99.9	1992-93
1993-94	416.4	364.9	270.3	478.8	445.0	372.2	364.3	357.4	228.8	696.0	603.0	525.0	353.0	224.8	1993-94
1994-95	361.0	309.8	207.9	273.3	263.7	211.6	189.0	187.5	334.7	316.4	250.3	329.6	308.5	259.1	1994-95
1995-96	477.8	553.3	442.5	1221.3	488.1	1026.9	520.1	501.4	389.4	787.8	633.5	567.8	-	364.2	1995-96
1996-97	448.2	522.0	290.3	498.0	571.8	472.7	237.5	164,3	462.4	383.9	328.5	319.5	-	316.3	1996-97
1997-98	-	401.8	237.1	-	-	-	-	-	286.7	-	-	-	-	266.9	1997-98
1998-99	-	393.6	147.9	-	-	-	327.2	-	220.1	-	-	-	-	217.3	1998-99
Average	**418.4**	**365.8**	**216.6**	**576.5**	**494.0**	**327.5**	**431.7**	**298.4**	**270.9**	**602.6**	**454.7**	**463.5**	**436.2**	**253.7**	**Average**

Table C.3.4 MATRIX OF CORRELATION OF YEARLY RAINFALL

No		Sidi Rahal	Azrif	Taddart	Toufliht	Taferiat	Asloune	Aghbalou	Tahanaout	Ifghane	Asni	Imin ElHam	Iguir N' kouris	Arhbar	Idni	Ijoukak	Wirgane	Talat Nos	B.L. Takerkoust	Agaiouar	Dar Ouriki	Tizi Ghourane	Marrakech
1	Sidi Rahal		0.55	0.46	0.65	0.84	0.66	0.78	0.78	0.56	0.68	0.70	0.62	0.45	0.26	0.51	0.51	0.65	0.77	0.56	0.65	0.60	0.82
2	Azrif			0.44	0.35	0.63	0.56	0.58	0.82	0.88	0.39	0.25	0.79	0.40	0.10	0.30	0.46	0.67	0.26	0.59	0.41	0.32	0.35
3	Taddart				0.61	0.32	0.55	0.38	0.32	0.49	0.32	0.11	0.36	0.49	0.28	0.38	0.53	0.28	0.21	0.47	0.50	0.50	0.37
4	Toufliht					0.81	0.78	0.57	0.41	0.85	0.62	0.64	0.57	0.57	0.25	0.51	0.47	0.61	0.54	0.72	0.81	0.77	0.76
5	Taferiat						0.83	0.71	0.76	0.64	0.68	0.70	0.67	0.58	0.00	0.81	0.74	0.75	0.68	0.62	0.67	0.46	0.79
6	Asloune							0.79	0.70	0.71	0.41	0.57	0.70	0.49	0.19	0.40	0.50	0.48	0.49	0.57	0.58	0.74	0.45
7	Aghbalou								0.92	0.63	0.68	0.58	0.45	0.21	0.13	0.22	0.82	0.67	0.61	0.78	0.82	0.73	0.68
13	Tahanaout									0.61	0.61	0.50	0.66	0.10	0.02	0.26	0.81	0.70	0.65	0.72	0.67	0.59	0.62
15	Ifghane										0.35	0.46	0.67	0.42	0.50	0.50	0.73	0.66	0.41	0.75	0.59	0.67	0.52
16	Asni											0.76	0.62	0.29	0.43	0.45	0.60	0.60	0.73	0.65	0.65	0.70	0.79
17	Imin El Hammam												0.64	0.56	0.45	0.59	0.38	0.53	0.79	0.58	0.75	0.67	0.80
18	Iguir N' Kouris													0.69	0.71	0.76	0.60	0.81	0.64	0.63	0.67	0.48	0.61
19	Arhbar														0.60	0.65	0.26	0.39	0.46	0.36	0.61	0.47	0.62
20	Idni															0.52	0.22	0.52	0.55	0.38	0.51	0.37	0.36
21	Ijoukak																0.34	0.61	0.65	0.40	0.50	0.32	0.55
22	Ouirgane																	0.53	0.50	0.63	0.83	0.57	0.59
23	Talat Nos																		0.70	0.66	0.60	0.63	0.63
24	B.L. Takerkoust																			0.57	0.58	0.53	0.85
25	Agaiouar																				0.73	0.78	0.63
26	Dar Ouriki																					0.90	0.73
27	Tizi Ghourane																						0.73
29	Marrakech																						

* The Station that have a insufficient statistic for this analysis is ommited from this table

R>0.9

0.8<R<0.9

0.7<R<0.8

Table C.3.5 MATRIX OF CORRELATION OF DAILY RAINFALL

(Ourika River Basin)

	Aghbalou	Tazzitount	Amenzal	Agouns	Tiourdiou	Tourcht
Aghbalou		0.87	0.44	0.27	0.48	0.47
Tazzitount			0.72	0.4	0.73	0.89
Amenzal				0.26	0.79	0.66
Agouns					0.37	0.41
Tiourdiou						0.64
Tourcht						

(Alluvial Fan)

	Aghbalou
Tahanaout	0.80
Taferiat	0.73

Table C.3.6 ANNUAL MAXIMUM DAILY RAINFALL

(mm/day)

Year	Sidi Rahal	Taferiat	Aghbalau	Tahanaout	Imin El Hammam	Iguir Nkouris	Marrakech
1969 /70	41.5	-	-	-	-	-	-
1970 /71	52.0	-	63.0	37.4	38.1	-	60.0
1971 /72	41.3	-	59.5	28.6	23.0	-	61.0
1972 /73	38.0	-	35.1	32.1	40.5	-	defect
1973 /74	56.2	-	48.6	39.9	41.1	-	66.0
1974 /75	52.1	-	46.7	49.4	49.6	15.6	36.2
1975 /76	26.6	-	32.0	39.4	26.8	15.4	30.9
1976 /77	25.0	-	48.9	25.0	23.2	31.9	20.0
1977 /78	36.0	-	56.7	38.6	35.1	36.8	30.0
1978 /79	29.0	-	37.8	31.3	18.5	39.9	28.0
1979 /80	55.7	-	65.2	22.5	36.8	27.9	27.7
1980 /81	46.2	-	39.8	35.0	28.4	32.1	16.2
1981 /82	33.2	-	66.7	37.7	65.6	24.5	44.1
1982 /83	18.0	23.0	32.2	27.2	32.5	24.0	9.6
1983 /84	31.0	38.7	46.4	33.1	32.3	38.2	38.9
1984 /85	35.6	28.3	55.4	37.3	28.0	24.8	30.0
1985 /86	48.9	33.8	36.0	37.3	35.8	30.2	38.6
1986 /87	42.6	defect	57.1	45.5	26.7	35.9	39.9
1987 /88	34.2	25.7	42.5	23.7	50.0	35.5	34.0
1988 /89	36.3	59.3	67.2	64.8	53.5	76.8	42.1
1989 /90	37.0	38.0	38.3	36.2	44.6	59.0	23.4
1990 /91	48.5	69.3	71.6	56.7	32.9	16.0	66.9
1991 /92	25.0	21.8	41.5	39.6	31.0	49.1	26.7
1992 /93	19.0	31.3	22.7	29.6	26.0	17.2	22.2
1993 /94	63.5	93.1	64.9	46.6	46.4	42.1	25.8
1994 /95	64.5	44.2	67.8	36.8	51.0	38.6	78.9
1995 /96	130.0	174.6	41.4	42.4	35.4	51.0	32.8
1996 /97	38.0	48.8	39.3	42.5	66.5	46.6	46.9
1997 /98	42.0	24.6	58.4	28.0	36.6	48.9	32.3
1998 /99	45.0	41.1	67.9	36.4	93.2	19.5	29.8

Table C.3.7 MAXIMUM 10 FLOODS FOR EACH RIVER

Serial	Sidi Rahal (R'dat)				Taferiat (Zat)				Aghbalau (Ourika)			
	Data Period : Nov. 1963 to Aug. 1997				Data Period : Feb. 1962 to Aug. 1997				Data Period : Aug. 1969 to Jul. 1997			
	Flood Period		Peak Discharge (m^3/s)	Time of Peak Discharge	Flood Period		Peak Discharge (m^3/s)	Time of Peak Discharge	Flood Period		Peak Discharge (m^3/s)	Time of Peak Discharge
1	Mar. 16 to 17,	1980	210	24:00 Mar. 16	Dec. 20,	1963	285	5:00 Dec. 20	Sep. 8 to 19,	1979	350	19:00 Sep. 10
2	Nov. 13,	1980	210	12:30 Nov. 13	Sep. 23,	1965	530	15:15 Sep. 23	Feb. 11,	1987	250	17:30 Feb. 11
3	Aug. 13,	1982	685	21:30 Aug. 13	Oct. 27,	1965	600	21:00 Oct. 27	Nov. 1 to 2,	1987	651	10:00 Nov. 2
4	Feb. 11 to 12,	1987	351	13:30 Feb. 11	Nov. 3,	1966	225	9:30 Nov. 3	Jul. 14 to 15,	1989	823	23:00 Jul. 14
5	Nov. 2 to 3,	1987	397	11:00 Nov. 2	Nov. 12 to 13,	1967	230	12:00 Nov. 12	Mar. 10 to 11,	1990	265	18:00 Mar. 10
6	Nov. 10,	1988	325	10:00 Nov. 10	Aug. 13 to 14,	1982	680	2:00 Aug. 14	Sep. 14,	1990	207	17:15 Sep. 14
7	Oct. 27 to 28,	1989	277	22:30 Oct. 27	Nov. 2,	1987	467	10:00 Nov. 2	Dec. 5 to 9,	1991	200	2:00 Dec. 7
8	Mar. 10 to 11,	1990	345	13:00 Mar. 10	Dec. 3 to 4,	1988	305	0:00 Dec. 4	Aug. 1,	1992	290	19:00 Aug. 1
9	Aug. 17,	1995	534	22:30 Aug. 17	Mar. 10 to 11,	1990	270	17:00 Mar. 10	Mar. 7 to 8,	1994	226	3:00 Sep. 10
10	Jun. 9,	1996	293	20:15 Aug. 17	Mar. 7,	1994	237	3:00 Mar. 7	Aug. 17,	1995	1,030	20:15 Aug. 17

Serial	Tahanaout (Rheraya)				Iguir N'kouris (N'fis)				Jmin Al Haman (N'fis)			
	Data Period : Mar. 1962 to Jul. 1997				Data Period : Aug. 1974 to Jul. 1997				Data Period : July. 1966 to Aug. 1997			
	Flood Period		Peak Discharge (m^3/s)	Time of Peak Discharge	Flood Period		Peak Discharge (m^3/s)	Time of Peak Discharge	Flood Period		Peak Discharge (m^3/s)	Time of Peak Discharge
1	Feb. 11,	1987	155	14:00 Feb. 11	Jan. 7,	1978	263	14:00 Jan. 7	Nov. 13,	1967	1,400	16:00 Nov. 13
2	Jun. 24,	1987	66	20:00 Jun.24	Jan. 18 to 19,	1979	403	12:00 Jan. 18	Jan. 4 to 7	1970	720	12:00 Jan. 4
3	Oct. 25,	1987	60	12:00 Oct. 25	Nov. 16,	1983	393	7:30 Nov. 16	Nov. 16,	1983	482	10:00 Nov. 16
4	Nov. 1 to 2,	1987	146	14:00 Nov. 2	Nov. 2 to 3,	1987	1,120	13:00 Nov. 2	Nov. 2,	1986	508	23:00 Nov. 2
5	Jul. 16,	1989	59	17:00 Jul. 16	Dec. 3 to 4,	1987	536	9:00 Dec. 4	Nov. 2 to 3,	1987	810	14:00 Nov. 2
6	Oct. 23 to 24,	1989	103	10:00 Oct. 24	Nov. 9 to 11,	1988	585	22:00 Nov. 9	Dec. 3 to 5,	1987	773	9:00 Dec. 4
7	Dec. 5 to 9,	1991	71	7:00 Dec. 7	Mar. 9 to 10	1990	229	14:00 Mar. 9	Nov. 9 to 11,	1988	1,220	6:00 Nov. 10
8	Jul. 28,	1992	62	20:00 Jul. 28	Dec. 7 to 8,	1991	319	13:00 Dec. 7	Oct. 24 to 25,	1989	455	22:00 Oct. 24
9	Aug. 17,	1995	680	19:30 Aug. 17	Oct. 31,	1993	229	4:00 Oct. 31	Dec. 7 to 9,	1991	446	7:00 Dec. 8
10	Mar. 25,	1996	68	13:00 Mar. 25	Aug. 7,	1994	239	22:00 Aug. 7	Aug. 17,	1995	501	19:00 Aug. 17

Representative Floods