Ministry of Energy, Mining, Water and Environment (MEMEE)
Agency of the Tensift Hydraulic Basin (ABHT)

No.

THE STUDY
ON
THE INTEGRATED WATER RESOURCES MANAGEMENT PLAN
IN
THE HAOUZ PLAIN
IN
KINGDOM OF MOROCCO

FINAL REPORT

SUPPORTING REPORTS

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A: SOCIAL AND ECONOMIC CONDITIONS

A.1 Social and Economic Conditions of the Country

A.1.1 Administration

(1) General

Morocco is divided into 16 regions, and subdivided into 62 prefectures/provinces, 162 districts and 1,497 communes. Central and local government administrations can be summarized as follows:

Central and Local Government Administrations

Level of Administration	Head of Administration		Congress
Central Government	Prime Minister, Ministers, Cabinet		National Assembel
Region	Wali		Regional Council
Province Prefecture	Governor		Provincial (Prefectura) Councile
Cercle	Super Caid	Bacha	
Municipality Commune	Caid		Municipality Council Rural Commune)
Douar, Ksar	Mqdem		Traditional Autonomy

(2) Central Level Administration

The Parliament consists of an upper house or Chamber of Counselors (270 seats; members elected indirectly by local councils, professional organizations, and labor syndicates for nine-year terms; 1/3 of the members are renewed every three years) and a lower house or Chamber of Representatives (325 seats; 295 by multi-seat constituencies and 30 from national lists of women; members elected by popular vote for five-year terms)

After the 2002 Parliamentary elections, reformation of the ministries was implemented at the central government level. At present, there are 21 ministries.

(3) Local Level Administration

In Morocco, the local government administrative subdivisions are prefectures and provinces, and they are supervised by the Ministry of Interior, also each chief of administration are appointed by the Minister of Interior. They are subdivisions of the Regions of Morocco. Each prefecture and province are subdivided into districts (*cercles*, *sing. cercle*), municipalities (*communes*, *sing. commune*) or urban municipalities (*communes urbaines*, *sing. commune urbaine*), and arrondissements in some metropolitan areas. The districts are subdivided into rural municipalities (*communes rurales*, *sing. commune rural*). The municipalities and arrondissements should probably be thought of as fourth-level subdivisions, on the same level as the rural municipalities.

A.1.2 Social Conditions

The Kingdom of Morocco is a country of constitutional monarchy, known as the Maghreb, and it is the most westerly of the North African countries. Strategically situated with both Atlantic and Mediterranean coastlines, Morocco is just 14 km from Europe, across the Strait of Gibraltar. Most

people live in the west of the Atlas Mountains, a range that insulates the country from the Sahara Desert. Casablanca is the center of commerce and industry, and the leading port; Rabat is the seat of government; Tangier is the gateway to Spain and also the major port; "Arab" Fes is the cultural and religious center; and "Berber" Marrakech is the major tourist center.

The total population of Morocco is 29,892 thousand in 2004 (Annuaire Statistique du Maroc 2005, HCP, 2006). Most Moroccans are Sunni Muslims of Arab, Berber, or mixed Arab-Berber stock. The Arabs invaded Morocco in the 7th and 11th centuries and established their culture there. Most of the 100 thousand foreign residents are French or Spanish. Annual growth rate of population is 1.4% in 2004 though the increase rate tends to decrease in recent years. An average of annual increase rate of these 10 years is 2.1% in the urban areas while the population in the rural areas is almost a level-off (an average of annual increase rate 0.6%), and the concentration of the population from the rural areas to the urban areas is remarkable. It is considered that the social infrastructures such as education, health, etc. and the economic infrastructures such as transportation, communication, etc. to concentrate on the urban areas, and to have expanded the socio-economic difference with the rural areas. Moreover, the population inflow from the rural areas to the urban areas becomes remarkable in year when the influence of drought is received, and social unrest has been brought. Therefore, the Moroccan government is working for correction of regional gap between rural areas and urban areas as one of the emphasis problems. On the other hand, the population of less than 20 years old accounts for 42% of the whole, and the problems of the education and employment will be worried about in the future.

Classical Arabic is Morocco's official language, but the country's distinctive Arabic dialect is the most widely spoken language in Morocco. In addition, about 10 million Moroccans, mostly in rural areas, speak Berber which is consisted of three different dialects (Tarifit, Tashelhit and Tamazight) either as a first language or bilingually with the spoken Arabic dialect. French, which remains Morocco's unofficial third language, is taught universally and still serves as Morocco's primary language of commerce and economics; it also is widely used in education and government. Many Moroccans in the northern part of the country speak Spanish. English is rapidly becoming the foreign language of choice among educated youth while still far behind French and Spanish in terms of number of speakers. English is taught in all public schools from the fourth year on.

A.1.3 Economic Conditions

Morocco has rich resources, including the world's largest phosphate reserves, a large tourist industry and growing manufacturing sector. However, agriculture remains as the backbone of the economy. Tourism revenues, depressed by post-9/11 fears of terrorism and the May 2003 Casablanca bombings, recovered by early 2004. King Mohammed VI has encouraged political and economic reform, the expansion of civil rights, and the elimination of corruption. The 2002 appointment of Prime Minister Driss Jettou bolstered prospects for free-market reforms, privatization, enhancement of the private sector, and liberalization of social laws. During 2004, the government also sold some of its shares in the state telecommunications company and the largest state-owned bank.

The various agreements of free trade that Morocco ratified with its principal economic partners like the Euro-Mediterranean free trade area agreement with the European Union with the objective of integrating the European Free Trade Association at the horizons of 2012; the Agadir Agreement, signed with Egypt, Jordan, and Tunisia, within the framework of the installation of the Arab Zone of Free Exchange; the US-Morocco Free Trade Agreement with USA which came into force in January 1,

2006 and lately the agreement of free exchange with Turkey.

The major industry of Morocco is phosphate rock mining and processing, food processing, leather goods, textiles, construction, tourism, etc. and GNI and GNI per capita in 2005 are US$ 52.3 billion and US$ 1,730 respectively (World Development Indicators Database, WB April 2006). GDP in 2005 is 51.7 billion, and the annual growth at same year is 1.6%. The proportions of each sector in GDP are 13% in agriculture, 31% in industry and 56% in services. Agriculture sector produces wheat, barley, citrus fruits, vegetables, olives, livestock, and fishing. The annual inflation rate (GDP deflator) is 1.8% in 2005.

Principal Economic Data

Year	2000	2004	2005
GNI, Atlas method (current US$)	34.0 billion	46.9 billion	52.3 billion
GNI per capita, Atlas method (current US$)	1,220	1,570	1,730
GDP (current US$)	33.3 billion	50.0 billion	51.7 billion
GDP growth (annual %)	1.0	4.2	1.6
Inflation, GDP deflator (annual %)	1.5	1.5	1.8
Agriculture, value added (% of GDP)	13.8	15.9	13.3
Industry, value added (% of GDP)	31.9	30.4	31.2
Services, etc., value added (% of GDP)	54.2	53.8	55.5
Exports of goods and services (% of GDP)	31.4	33.1	34.4
Imports of goods and services (% of GDP)	37.6	39.3	43.1
Gross capital formation (% of GDP)	23.6	25	25.6

Source: World Development Indicators Database, April 2006

The amount of the exports is US$ 9.78 billion and the imports is US$ 17.5 billion in 2004, and it is an excess of imports of US$ 7.7 billion. The principal export commodities are ready-to-wear-clothes, hosiery articles, phosphoric acid, phosphates, fertilizers, etc. and major partners are France 33%, Spain 17%, UK 7%, Italy 5% and USA 4%. On the other hand, the principal import commodities are crude petroleum oil, fabrics, machine and miscellaneous appliances, iron and steel blooms and pieces, wheat, etc. and major partners are France 18%, Spain 12%, Italy 7%, Germany 6% and Russia 6% (Morocco in Figures 2004, HCP, 2006). The remittance from overseas migrant workers is the principal foreign currency acquisition source.

The labor force in 2004 is 9.8 million peoples, and the labor force by occupation of sectors is agriculture 46%, industry 13% and services 41% in 2004. The unemployment rate shows about 11% (Morocco in Figures 2004, HCOP, 2006).

A.1.4 National Development Plan

(1) National Development Five-year Plan

The National Development 5-year Plan (2000-2004) which was agreed officially in the national assembly in August, 2000 is a social-economic development plan, and it established policy objectives, such as increase in the economic growth rate, improvement in the investment and saving rate, decrease of the unemployment rate, and increase of the literacy rate. Further, the reduction of poverty in the rural area was considered with importance.

As concrete measures to attain these goals, developments were proposed for 1) human resources and social development (education, vocational training, technology and investigation, culture, health, employment, social protection and social development), 2) production sectors development

(agriculture and forest, industry, handicraft, energy, mining and tourist) and 3) social-economic infrastructures development (land planning, urban planning, residence maintenance, environment preservation, transportation, communication, posts and information technology).

At present, the next National Development Five-year Plan (2007-2011 years) is said as the under preparation.

(2) National Initiative for Human Development

National Initiative for Human Development (NIHD; Initiative Nationale pour le Développement Humain: INDH) was addressed by His Majesty of Mohammed VI, and it faced the eradication of poverty and the correction of regional differential, and Government and privet sector were as one, and NIHD was started in May, 2005. NIHD was designed to reinforce the State's action and that of the local collectivities, without being a substitute for neither the sectorial programs nor the local socio-economic development plans. NIDH has four main benchmarks:

- Rural and urban poverty zones under difficult living conditions,
- Social upgrading and sustainable human development cannot rely on the specific assistance or charity action,
- The choice for the opening on the world can be only a collective endeavor, but not a returning in on oneself, and
- Lessons drawn from the past experiments attest of the relevance of the target demarche, and the integrated local development, as much as the participatory planning, the community ownership, and the integration of sectorial actions.

Four priority programs in the first phase are as follows:

- Poverty reduction program in rural areas
- Social exclusion program in urban areas
- Precarious livelihood reduction program
- Transversal program

Principles of action are as follows:

1) In terms of poverty and exclusion reduction:
   - Economic integration through revenues- generating activities
   - Widening access to proximity equipment and basic social services
   - Social, cultural and sports animation

2) In terms of precarious livelihood reduction:
   - Provision of direct assistance but in move towards social integration
   - Taking charge of welfare recipients in social reception centers

3) In terms of institutional instruments:
   - Strengthening of the human capital and local governance

- Strengthening the inter-ministerial coordination

The budgetary framing which means DH 10 billions over 5 years, as for the period 2006-2010 of NIHD priority programs are; 1) Rural program: DH 3.5 billions, 2) Urban program: DH 3.5 billions, 3) Precarious livelihood program: DH2.5 billions, 4) Transversal program: DH 0.5 billions.

(3) World Bank Country Assistance Strategy

The Country Assistance Strategy (CAS) is the World Bank's work plan that guides its operations in a country, usually for a period of three years. It describes the country's economic and social performance, its main development challenges, and a summary of the government's development strategy.

The CAS for the period 2005-09, is to help Morocco meet its key development challenges, notably:

- Accelerate employment-generation and sustainable economic growth, and
- Reduce poverty and marginalization.

To achieve and sustain these goals, a series of institutional reforms are needed to improve the transparency, accountability, and inclusiveness of the public sector. This CAS reflects differences from the past: the overarching objective of poverty reduction and the underpinning objective of governance are both more fully integrated in the country program, and in addition, the environment for reform has matured. The main difference between this CAS period and the previous one (2001-04), is the more favorable political, and bureaucratic environment within which to implement institutional reforms. A greater sense of urgency prevails, and this has generated political will at the top levels of leadership as well as within civil society. The CAS focuses on four objectives:

- Improve competitiveness and the investment climate,
- Increase access to basic services by poor and marginalized groups,
- Improve the efficiency of the education system; and
- Improve water management and access to water services and sanitation.

A.1.5 Privatization and Restructuring of Public Utilities

Morocco's economy is considered a liberal economy governed by the law of supply and demand although certain economic sectors still remain in the hands of the government. The decentralization/regionalization law passed by the legislature in March 1997, and 16 new regions and many new provinces were created although full details and scope of the reorganization are limited.

The current government has introduced a series of structural reforms in recent years. The most promising reforms have been in the liberalization of the telecommunications sector. This process started with the sale of a second GSM license in 1999. In 2001, the process continued with the privatization of 35% of the state operator Maroc Telecom. Morocco has announced plans to sell two fixed licenses in 2002. Morocco also has liberalized rules for oil and gas exploration and has granted concessions for many public services in major cities. The tender process in Morocco is becoming increasingly transparent. Many believe, however, that the process of economic reform must be accelerated in order to reduce urban unemployment below the current rates above 10%.

In Morocco, the water distribution system was developed by private enterprise around 1914, although after the country's independence, concessions held by French operators were not renewed. However, a

private company still provides Casablanca with a large part of its bulk water supply through a 50-year concession granted in 1949.

A.1.6 Environmental Policies

(1) Environmental Legislation

Current environmental legislation in the Kingdom of Morocco are largely based on three Laws of which were promulgated in 1993.

1) Law No. 11-03 on protection and the development of the environment

The law aims to enact the basic rules and the general principles of the national policy in the field of protection and the development of environment. These rules and principles aim to:

- protect the environment against all forms from pollution and degradation whatever is the origin;
- improve the framework and the living conditions of man;
- lay down the basic orientations of the legislative, technical framework and financier concerning the protection and the management of the environment; and
- set up particular responsibilities guaranteeing the compensation for the damages caused to the environment and the compensation for the victims.

The law, consisting of seven chapters and 80 articles, dictate the basic directionality to be taken for the protectetion of living environment, natural environment and resources, and for the prevention of pollution and harmful effects. Chapter 5 and 6 of the law dictates the process of environmental impact studies and legislative procedures for its evaluation, which is in relation to Law on Environmental Impact Studies

2) Law No. 12-03 on Environmental Impact Studies

In line with the Law on protection and the development of the environment, the Law on Environmental Impact Studies dictates the obligations of Environmental Impact Studies (EIE) to obtain authorization of projects listed in its Appendix. The law, comprising of four chapters and 20 articles largely refer the following issues:

- Definition of environment as well as EIE
- The obligation of EIE to obtain authorization of project subject to EIE under the Appendix of the Law
- Objectives of EIE, which are: a) to predict and evaluate in rational manner, the possible impact of the project to the environment, b) to avoid, reduce or substitute negative impacts, c) to enhance and improve the positive impacts, and e) to inform the concerned population of the negative impacts.
- The contents that should be incorporated in the EIE
- The mission of the National Committee and Regional Committees for EIE, which arelargely: a) to examine the EIE, b) to deliver opinions on the environmental acceptability of the projects, and c) to involve the public in the procedures of EIE

- The preparation of a decree specifying the procedures of the Law
- Define the period of validity of the EIE to five years for the realization of the project

At present, the decree for specifying the procedures for the law is still under preparation. The Regional Committees for Impact Studies are also at the stage of preparation. The National Committee is currently the only authority to provide the decision whether the project is environmentally acceptable or not. However, training of relevant government personnel for Regional Committees has been started in Marrakech and Casablanca as pilot cases. With the approval and issuance of the "Decree on the composition and the procedure of the national committee and the regional committees of the impact studies on environment (provisional title)", in the near future, these committees are expected to start performing its tasks.

3) Law No. 13-03 on the control of air pollution.

The law on control of air pollution aims at the prevention and the fight against the emissions of the atmospheric pollutants likely to attack the health of the man, to fauna, the ground, the climate, the cultural inheritance and the environment in general. The law dictates legal obligations for individuals and organizations who are to emit pollutants into the atmosphere.

(2) Environmental Policies

Within the framework of laws and regulations, the Ministry of Land Management, Water and Environment is in charge of elaborating and implementing the policy of the government.

The main strategic documents prepared by MATEE are as follows.

1) National Strategy for the Protection of Environment and Sustainable Development (SNPEDD)

The SNPEDD was elaborated in 1995 to integrate and strengthen environmental concerns and economic development activities, with the target year of 2020. The main principles of the plan are: a) strengthening of legal framework and institutional capacities, b) end-of pipe approach, and c) policy integration. Within the plan, analysis of cost/benefits for development activities are carried out and discussions are made on the mid-long term benefits which will be bared by protecting the environment.

Major activities elaborated in the plan include:

a) studies on the state of environment
b) preparation of an inventory of environmental projects
c) formulation of a National Action Plan for Environment
d) preparation of a database and information management system on environment
e) studies on biodiversity, green house gas emission and desertification
f) preparation of regional and local environmental monographies

2) National Action Plan for the Environment (PANE)

Based on the SNPEDD, the PANE has been prepared in 1998. The plan consists of 7 programmes / 165 activities, with the aim of implementing the strategies set under the SNPEDD. The programmes refer to conservation and sustainable management of natural environment and resources, as well as

prevention of hazards and improvement of living environment in urban and peri-urban areas. The strategic objectives of the PANE are:

a) to ensure rational management of natural resources, through implementation of a comprehensive solution;

b) integrate environmental concerns in the definition of the policies, programmes and projects set up in each principal sector of the development;

c) to support the implication, clarification of responsibility and participation of public as well as the investors in management of resources and securing of quality of living environment;

d) to support the development of an effective partnership between the actors concerned in environmental issues and sustainable development;

e) to develop human resources and the institutional capacity allowing a better knowledge of the state of the environment and its management.

A.2 Socio-Economic Conditions in the Study Area

A.2.1 Social and Economic Situations

(1) Population

The total population is 1,613,000 inhabitants and the Marrakech prefecture accounts for 63% of the whole population. Moreover, the urban population accounts 920,000 inhabitants which correspond to 57% of the whole population, and Marrakech prefecture occupies 89% of the total urban population.

On the other hand, the percentage of urban population for each prefecture/province are : 80% in the Marrakech prefecture, 12% in the Al Haouz province, 29% in the El Kelaâ des Sraghna province, and 18% in the Chichaoua province. The average of population density of the Study Area is 195 inhabitants/km2, and the population density of each prefecture/province is as follows: 620 inhabitants /km2 in the Marrakech prefecture, 124 inhabitants/km2 in the Al Haouz province, 124 inhabitants/km2 in the El Kelaâ des Sraghna province and 54 inhabitants/km2 in the Chichaoua province. (Table A.2.1)

(2) Regional Economy

Regional economy of the Marrakech - Tensift - Al Haouz region depends mainly on agriculture and agro-industry, tourism, processing industry, handicrafts and in a small measure on fishing. The central place of the regional economy is Marrakech city which has approximately 795,000 inhabitants.

The useful agricultural area is 1.4 million ha which represents a quarter of the useful agricultural area of the country. The main agricultural products are cereals, legumes and vegetables. Fruit-culture depends on the olives that cover 126,000 ha and they play an important role in regional economy ; the region is the top producer of olives on a national level. The forest covers the area of 491,000 ha and provides an indispensable income complement on the regional level (Le Maroc des Régions 2005, HCP 2006).

The tourism plays an important role in regional economy. This sector has some secondary effects on other sectors as handicraft, construction and transportation. The region possesses major assets for the development of the tourism such as: accommodation that represents 25% of the capacity of hotel beds of the country, transportation, and a varied cultural heritage consisting of tourist sites and the historic monuments essentially localized in Marrakech city.

The most important industrial units operate in the sectors of agro-processing, chemistry, and textiles and leather. With 387 companies, representing 5% of the total number of the industrial establishments, the region contributes up to 4% for national permanent employees and 3% for national production. The production value in 2003 reached more 5.7 billion DH, and grew 4% in relation to 2002. The agro-food industry has the biggest weight in the region, with 60% of the regional production. The unemployment rate of the region is 6.5% which is lower than the average of the country (10.8%). (Table A.2.2)

(3) Traditional Communal System

The traditional communal system has a tribal origin, and its geographical boundaries are based on blood relations. Traditional rural councils were run in a democratic manner by the co-opted collegial group (Jemaa) and the executive powers (Amghar) are vested with general competencies for collective matters, such as internal order, water management, road organization, as well as judicial practices. The traditional system seems to had some informal or mental validity, especially at grass-root level in the rural areas.

A.2.2 Agriculture

(1) Land Use

The Study Area is divided into three areas based on the administration organization of irrigation and agriculture (i.e., DPA Marrakech, DPA Chichaoua and ORMVAH), and the Study Area consists of a part of their jurisdictions. The management area of DPA Marrakech consists of 32 rural communes, of which 10 rural communes are in the Study Area. 29% of the DPA Marrakech Area is occupied by arable land, of which 32% is irrigable land. In the area of the DPA Chichoua, 13 rural communes are in the Study Area an also the DPA covers 35 rural communes. the arable land occupies 23% of total and 42% of that is irrigable area. The grazing land and fallow land occupies 61%, which is comparatively higher than other areas. ORMVAH manages 69 rural communes and 32 of them are in the Study Area. Arable land occupies 73% of the total and irrigable area is 66% of the arable land. The ORMVAH area is a highly developed agricultural area in the Plain. (Table A.2.3)

(2) Status of Land Resources

The Government of Morocco classifies the land into five categories as follows: the Melk, the Collective, the Habous, the Guich and the State Domain. Each is discussed below.

The Melk corresponds to the private lands, having a collateral value relating to their property, that the farmers can use for investment. This status facilitates the loans at the bank because the owner mortgages his lands to guarantee loans. The collective lands are managed by the assembly of the sages. The distributed lands do not have value-added by their owner. The Habous is the land under the supervision of the Minister for Habous and Islamic Affaires. The Guich is one of land forms of domanial origin, whose title was given, formerly, with certain communities and tribes, as the reward of their military services. These lands, placed under the supervision of the Ministry of the Interior, are classified as private domains of the State and are often small parcels. It is remarkable that Guich is more common in the province of Marrakech, since this status does not make it possible for farmers to access Agricultural credit because the bank does not accept the mortgage of the lands as a loan guarantee. The State Domain is a public domain managed by the government.

In addition, the agricultural farms are characterized by the dominance of small parcels and the spatial

dispersion of the parcels. In the zone of action of the ORMVAH, on 26,825 ha which are in the study area, farms of less than 5 ha account for 36% of the surface and 86% of the total number of exploitation. On the other hand, the farms of more than 20 ha present 2% of the total farms and cover 24% of the total surfaces. That does not favor good land utilization with limited infrastructures and insufficiency of public and private investment. (Figure A.2.1 and Table A.2.4)

(3) Agricultural Production

The agriculture sector plays a very important part in the economy of the Marrakech-Tensift-Al Haouz region. The useful agricultural surface (SAU) estimated in the study area is 469,279 ha. The irrigated surface accounts for 53.5% (251,034 ha) of the SAU, of which 56,970 ha of the Large Scale Irrigation Systems (GH) improved and headed by the ORMVAH, and 194,073 ha of the surface irrigated in the Small and Medium Irrigation Systems (PMH).

The principal agricultural productions mainly consist of cereal cultivations (wheat, barley) and of arboriculture. The surfaces of the cereal cultivation and arboriculture in the study area are respectively 244,608 ha and 92,517 ha which are 4.3% and 11.1% respectively compared to the total national surface. Arboriculture, in particular olive cultivation which widely covers 67,000 ha in the study area, plays an important part in the economy of the region. (Table A.2.5)

(4) Livestock Production

Livestock breeding constitutes one of the most important income sources of the population of the region; it plays a considerable part in the economic development of the region. Total number of livestock in the study area is about 1,161,513 heads. The ovine is most dominant, then the bovine and the goats ; these are respectively, 73%, 14% and 12% of the livestock number in the study area. (Table A.2.6)

Thus, this area has a pastoral vocation based on extensive livestock breeding, in particular ovine. Known degradation continues due of the severe climatic conditions, overgrazing and deregulated cultivation.

(5) Agriculture Extension and Supporting System

The ORMVAH; DPA of Marrakech and Chichaoua are the principal structures for leading and of support to the farmers in the study area.

The ORMVAH is a responsible for the whole of the irrigation development areas, in particular in Large Scale Irrigation Systems (GH)) of the Haouz Plain. On the other hand, the intervention zone of DPA extends over their provinces except the zone of action of the ORMVAH.

Principal attributions of the ORMVAH and DPA are as follows:

- Development and the management of irrigation development areas and water resources for agriculture use
- Agricultural techniques spreading and the vocational training
- Organization and the leading of the farmers and stockbreeders
- Development of vegetal and animal production
- Development of allied industry in agricultural sector.

The Center of Technique of Irrigation, Experimentation and Spreading (CTIEV) at Saâda created by

the ORMVAH in 1990, in the Central Haouz irrigation development areas (N'Fis), has two principal objectives:

- Experimental work and the demonstration of irrigation techniques in order to make the new irrigation methods used in the Center known to farmers
- Technical assistance to farmers who are interested to try new irrigation systems.

(6) Rural and Farmers Organization

1) Associations of irrigation (Agricultural Water Users Associations, AUEA)

Law No2/84 of December 21, 1990 lays down the objectives as well as the constitution and function of Agricultural Water Users Associations (AUEA), who are represented in the Haouz Plain, as the more widespread form of farmer's organization. Before the promulgation of this law, the irrigation associations had been created by the initiative of users in the study area. After the promulgation of the law of 1990, the ORMVAH and DPA carried out the conversion from existed associations to AUEA, also with the creation of new AUEA, in the GH and the PMH. They have the objective to manage and to preserve the agricultural water infrastructure. In the irrigation development areas of the ORMVAH, part of the responsibilities and obligations of farming and maintenance for the infrastructures (secondary infrastructures and distribution networks) has been transferred to the AUEA. (Table A.2.7)

2) Agricultural cooperatives

Various existing agricultural cooperatives in the study area play an important part for the agricultural development of the region. The major agricultural cooperatives in the study area are: the dairy cooperatives, the producer's cooperatives in particular the olive products and the pastoral products, the apiculture cooperatives, and the cooperatives of the Land Reform.

(7) Agro-industry

Agro-industry plays a major role from an economic as well as social stand point by providing regional production value and employment. Although the agro-food industry has the biggest weight in the region economy, most facilities of agro-industry are medium and small scale. There is total of 129 agro-industry establishments in the service area of ORMVAH. (Table A.2.8)

A.2.3 Tourism

(1) Accommodations

Marrakech city constitutes the first tourist destination of Morocco thanks to the wealth of its historic and cultural heritage. Marrakech-Medina was registered to the World Cultural Heritage of UNESCO in 1985. Tourist facilities are concentrated in Marrakech city.

One million tourists per year visited to the Marrakech - Tensift - Al Haouz region and spent 4.3 million nights in 2004 in hotels which corresponds to 33% of the country total. There are 397 accommodations in total in 2004 which corresponds to 41% of the country total, and the capacity of beds of the accommodations is 30,000 which correspond to 25% of the country total. Moreover, the occupancy rate of in hotels is from 50% to 60% in these years. (Table A.2.9 to 12)

(2) Park lands

The park lands of the Royal domain occupy 580 ha of which 500 ha are the Agdal gardens and 80 ha

of the Ménara gardens. The park lands inside Marrakech city total 935 ha of which 510 ha are hotel gardens and 30 ha are INRA gardens (Alimentation en Eau Potable et Industrielle de la Ville de Marrakech, ABHT, 2006).

(3) Golf Course

The existing golf courses (Royal, Amelkis and Palmeraie) are situated in the southeast of Marrakech city. The golf course projects are allowed withdrawals of water. These golf courses are:

- ASSOUFID project with 220 ha
- PALM Golf project with 170 ha
- ATLAS GOLF AND RESORT “GROUP ALAIN CRENN” project with 282 ha.

Other golf course projects under validation (agreement in principle is given by the ad hoc commission) for withdrawal authorizations of water are:

- LATSIS GROUP project with 140 ha
- “JARDINS DE L’ATLAS” project with more than 148 ha
- DOMAIN ROYAL PALM project with 250 ha
- The TRITEL project with 220 ha
- STRATEGIC PARTNERS project

A.2.4 Other Industries

The Wilaya of Marrakech monopolizes the essential industrial activities: it intervenes 80% in industrial employment and 70% in industrial production. The region includes an important industrial unit known as the Cement factory of Marrakech (CIMAR) that has a capacity of production of 450,000 tons (Le Maroc des Régions 2005, HCA 2006). In the Marrakech - Tensift - Al Haouz region 9 industrial zones are located as follows:

- Marrakech: Azli, Sidi Ghanem, Al Mssar, Harbil, Sidi Ghanem III
- El Kelâa des Sraghna: Sidi Bouathman, Ennakhil
- Chichaoua: Ennasr
- Essaouira: Industrial district of Essaouira

The region contains a substantial mining potential of phosphates with reserves estimated at 48 billion m^3 of barite, zinc, lead, salt and copper. (Table A.2.13)

Table A.2.1 Population of the Study Area

Province	Commune	Population	% of the whole S. A.	Number of Urban	% of the whole Urban	Urban Rate in Province	Population Density (per km2)
Marrakech	16	1,023,514	63%	816,293	89%	80%	620
Al Haouz	20	277,377	17%	32,086	3%	12%	124
E.K. Sraghna	10	132,993	8%	38,765	4%	29%	124
Chichaoua	16	179,032	11%	32,694	4%	18%	54
Total	62	1,612,916	100%	919,838	100%	57%	195

Source: Recensement Général de la Population et de l'Habitat 2004, Haut Commissariat au Plan, 2005

Table A.2.2 Industrial Production by Sector

(Unit: million DH)

Sector	2002	2003	
Agro-food industry	3,410	3,436	60%
Textile and leather industry	500	604	11%
Chemical and parachimique industry	1,452	1,571	27%
Mechanical and metallic industry	122	110	2%
Electric and electronic industry	20	17	0%
Total	5,504	5,738	100%

Source: Le Maroc des Régions 2005, HCP, 2006

Table A.2.3 Land Use of ORMVAH and DPA Managed Area

Items	DPA Marrakech		DPA Chichaoua		ORMVAH			
					Whole area		Concerned communs	
Number of Communes Rurals	32		35		69		32	
Surface Area (ha)	600,000		687,200		648,394		372,565	
Land Use								
-SAU (ha)	173,016	29%	160,000	23%	489,564	76%	272,948	73%
-Forest (ha)	216,092	36%	110,000	16%	22,656	3%	20,946	6%
-Pastures and uncultivated (ha)	210,892	35%	417,200	61%	136,174	21%	78,671	21%
Total (ha)	600,000	100%	687,200	100%	648,394	100%	372,565	100%
Irrigation								
-Non-Irrigation (ha)	117,916	68%	92,012	58%	211,819	43%	92,779	34%
-Irrigation (ha)	55,100	32%	67,988	42%	277,745	57%	180,169	66%

Remarks : Data includes outside of the Study Area.
Sources:
Monographie de la Zone DPA de Marrakech, 2005
Monographie Agricole de la Province de Chichaoua, 2006
Monographie Commune Rural, 2003-2004, ORMVAH

Table A.2.4 Legal status of Lands in the Study Area (SAU in ha)

Province	Melk		Collective		Habous		Guich		State Domain		Total
	ha	%	ha	%	ha	%	ha	%	ha	%	ha
Al Haouz	129,622	87.4	6,877	4.6	893	0.6	5,651	3.8	5,191	3.5	148,234
Chichaoua	74,881	31.7	111,473	47.3	3,581	1.5	17,649	7.5	28,317	12.0	235,901
El Kelâa Sraghna	234,482	39.8	341,956	58.1	616	0.1	7,099	1.2	4,676	0.8	588,829
Marrakech	46,213	38.4	2,826	2.4	3,788	3.2	64,211	53.4	3,176	2.6	120,214
Total	485,198	44.4	463,132	42.4	8,878	0.8	94,610	8.7	41,360	3.8	1,093,178

Source: Ministry of Agriculture, Rural Development and Fishery Maritime (2000) : General Agricultural Census, Results by communes

Table A.2.5 Agricultural Surface and Production in the Study Area

Province	Marrakech *1		Al Haouz *1, 2		El Kélâa Sraghna *1		Chichaoua	
	Area (ha)	Production (QX)	Area (ha)	Production (QX)	Area (ha)	Production (QX)	Area (ha)	Production (QX)
Cereals	44,410	347,652	65,926	567,928	59,627	1,153,007	74,645	473,299
whistle-berry	1,280	44,770	132	2,201	84	7,694	571	93,213
Forages	6,185	2,954,560	3,219	717,840	2,313	2,065,360	749	495,540
Vegetables	3,570	609,255	2,116	437,460	2,589	660,430	1,140	205,125
Arboriculture	43,296	2,344,109	20,046	553,020	15,239	243,397	13,936	409,425

Sources: *1: Data by ORMVAH (Monograph of rural commune, Data of 2003/2004)
*2: Data by DPA Marrakech *3: Data DPA Chichaoua

Table A.2.6 Number of Livestock and Traction Animals in the Study Area

Province	Number of livestock				Number of traction animals		
	Bovine	Ovine	Goats	Camels	Horses	Mules	Asses
Al Haouz	47,429	210,033	42,096	103	951	3,202	22,138
Chichaoua	22,892	263,946	65,975	244	552	2,756	15,916
El Kelâa Sraghna	60,268	253,441	29,697	60	1,879	4,360	22,881
Marrakech	35,084	125,458	4,765	22	380	668	9,415
Total	165,673	852,878	142,533	429	3,762	10,986	70,350

Source: Ministry of Agriculture, Rural Development and Fishery Maritime (2000): General Agricultural Census, Results by communes

Table A.2.7 Number of AUEA in the Zone of Action of the ORMVAH, the DPA Marrakech and Chichaoua

	ORMVAH*1		DPA*2 /Marrakech	DPA*3 /Chichaoua
	GM	PMH		
Number of AUEA	145	75	58	42
Number of members	70,609	6,179	2,504	6,535

Sources: *1: Data by ORMVAH (Monograph of rural commune, Data of 2003/2004)
*2: Data by DPA Marrakech *3: Data DPA Chichaoua

Table A.2.8 Agro-industry Establishments

Activity	Unit Number
Canning factories	45
Oil mills	33
Flour mills	14
Citrus fruits packing stations	05
Dairies	02
Vegetable horsehair processing	02
Manufacturing units of livestock products	05
Alimentary pates	05
Freezing chamber / Cold stores	18
Total	129

Source: Office Régional de mise en valeur agricole du Haouz,

Table A.2.9 Tourist Nights Spent in Hotels

Year	2000	2001	2002	2003	2004
Marrakech-Tensift-Al Haouz	3,889,365	3,721,996	3,464,098	3,447,104	4,332,904
The whole country	13,539,567	12,695,227	11,320,882	11,173,119	13,164,870
Rate	29%	29%	31%	31%	33%

Source: Annuaire Statistique du Maroc 2005, Haut Commissariat au Plan, 2006

Table A.2.10 Accommodations by Class

Year	5 Stars	4 Stars	3 Stars	2 Stars	1 Star	Host House	Truism Resid.	V.V.T.	Total
Marrakech-Tensift-Al Haouz	15	23	23	20	6	295	7	8	397
The whole country	39	128	147	155	116	320	41	33	979
Rate	38%	18%	16%	13%	5%	92%	17%	24%	41%

Note: V.V.T.: Villages de vacances touristiques

Source: Annuaire Statistique du Maroc 2005, Haut Commissariat au Plan, 2006

Table A.2.11 Bed Capacity by Accommodation Class

Year	5 Stars	4 Stars	3 Stars	2 Stars	1 Star	Host House	Truism Resid.	V.V.T.	Total
Marrakech-Tensift-Al Haouz	7,430	7,354	3,485	1,812	303	4,227	794	4,565	29,970
The whole country	17,758	33,991	20,352	12,038	6,410	4,714	6,108	17,693	119,064
Rate	42%	22%	17%	15%	5%	90%	13%	26%	25%

Note: V.V.T.: Villages de vacances touristiques

Source: Annuaire Statistique du Maroc 2005, Haut Commissariat au Plan, 2006

Table A.2.12 Occupancy Rate of Hotels

(Unit: Percent)

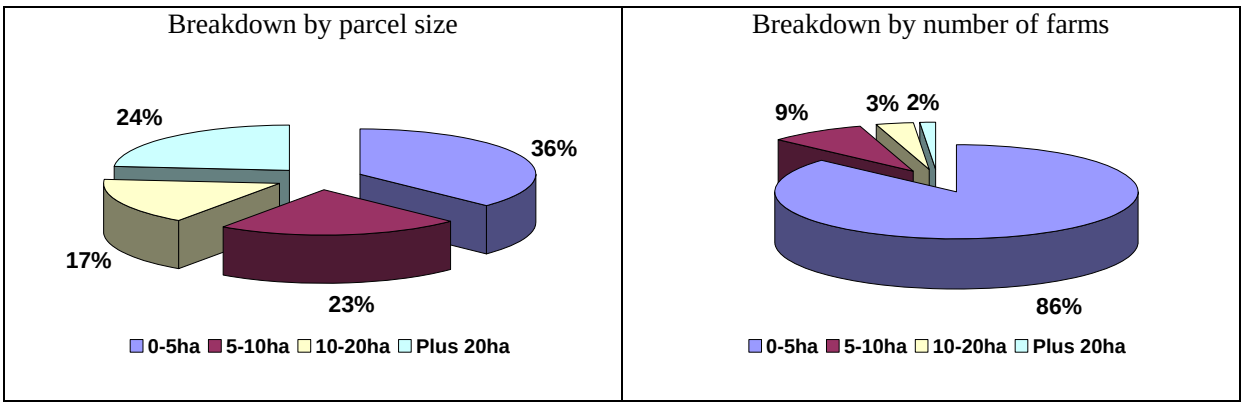
Year	2000	2001	2002	2003	2004
Marrakech-Tensift-Al Haouz		62	54	50	56
The whole country	52	48	42	39	43

Source: Annuaire Statistique du Maroc 2005, Haut Commissariat au Plan, 2006

Table A.2.13 Mining Production

Sector	2003	2004
Phosphates (thousand tons)	2,536	2,989
Lead (tons)	22,982	26,821
Zinc (tons)	131,340	130,957
Copper (tons)	17,539	10,308
Barite (tons)	90,434	52,525
Salt (tons)	695	1,073

Source: Le Maroc des Régions 2005, HCP, 2006



Source: Data from SGRID, ORMVAH

Figure A.2.1 Farm Scale by Area and Number of Farms in the Study Area (ORMVAH Zone)

B: WATER LEVEL FLUCTUATION AND GEOLOGICAL CROSS SECTION IN THE HAOUZ PLAIN

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B: WATER LEVEL FLUCTUATION AND GEOLOGICAL CROSS SECTION IN THE HAOUZ PLAIN

B.1 Water Level Fluctuation in the Haouz Plain

Figure B.1.1 shows the water level fluctuation in the monitoring wells installed an automatic water level recorder by the Study team. And the rainfall records in the Haouz Plain are graphed in Figure B.1.2.

The recorders were installed in the middle of February 2007. The water levels had been recorded once a day for the first four months, from February to the middle of June, and, after that, the interval of record was set at every five days following the standard of ABHT.

The record of 4403/44 shows clearly an artificial effect by pumping of nearby well(s). The irregular fluctuations in other wells, such as 4151/44 and 2826/53, also indicate pumping effect probably. Generally the water levels have been falling in the wells after the rainy season that is usually from October to April. Particularly the water level of 3664/53, 4403/44 and 4151/44 reveals considerable decline compared with other wells, (-0.97m in 3664/53 and -1.07m in 4403/44 during about 3.7months). These three wells are located in the downstream area of the N'Fis River where the irrigation farming has been developed widely.

The effect of recharge by rainfall is not clear during the term. The level of 2700/53, however, looks to be recovering after the rain on 21 May, though it cannot be said for sure whether this phenomenon means direct recharge by rainfall or not. The result of measure of 4403/44 shows the water level of the well have been stable since the middle of June, and the measure of 3664 indicates the level has been falling. A water level fluctuation can be caused by various factors. Therefore it is important to conduct a continuous monitoring of water level, rainfall, pumping discharge and so on, in order to clarify the relationship of them and the hydrogeological mechanism in the Haouz Plain.

B.2 Geological Cross Section in the Haouz Plain

The Haouz Plain consists of Pliocene-Quaternary Sediments. Some geological columns of boreholes show the stratigraphic features of these sediments in Figure B.2.1. In addition, geological cross sections in the Haouz Plain, Figure B.2.2, were provided based on the existing data, such as the results of geophysical prospecting carried out in 1980s and 90s, the inventory of boreholes and the topographic digital elevation data (SRTM90). These data have been used for constructing the updated model of groundwater flow in the Haouz Plain for the Study.

ABHT has stored many borehole data in their filing cabinet, but these data have not been processed for GIS or other computerized utilization yet.

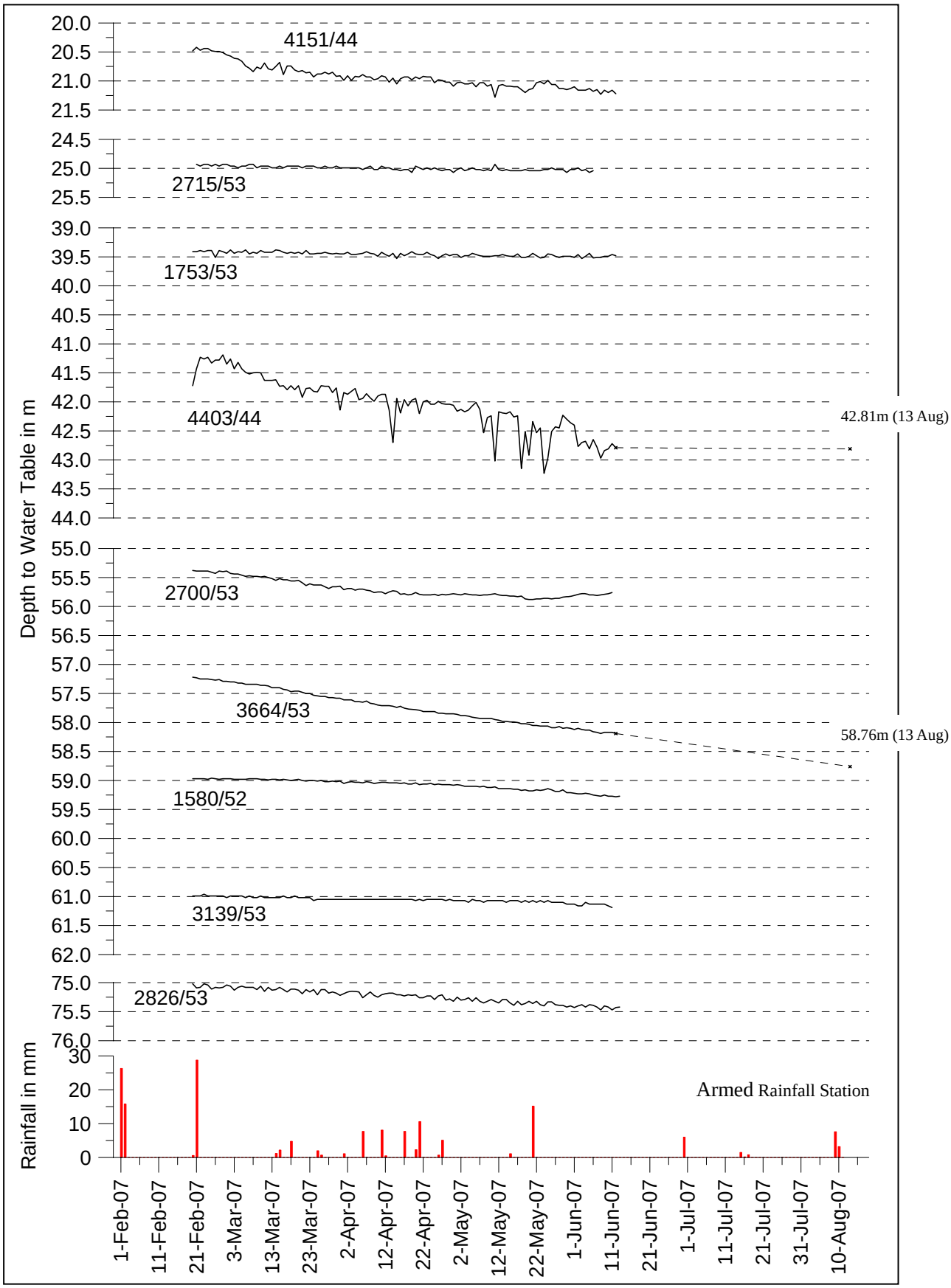
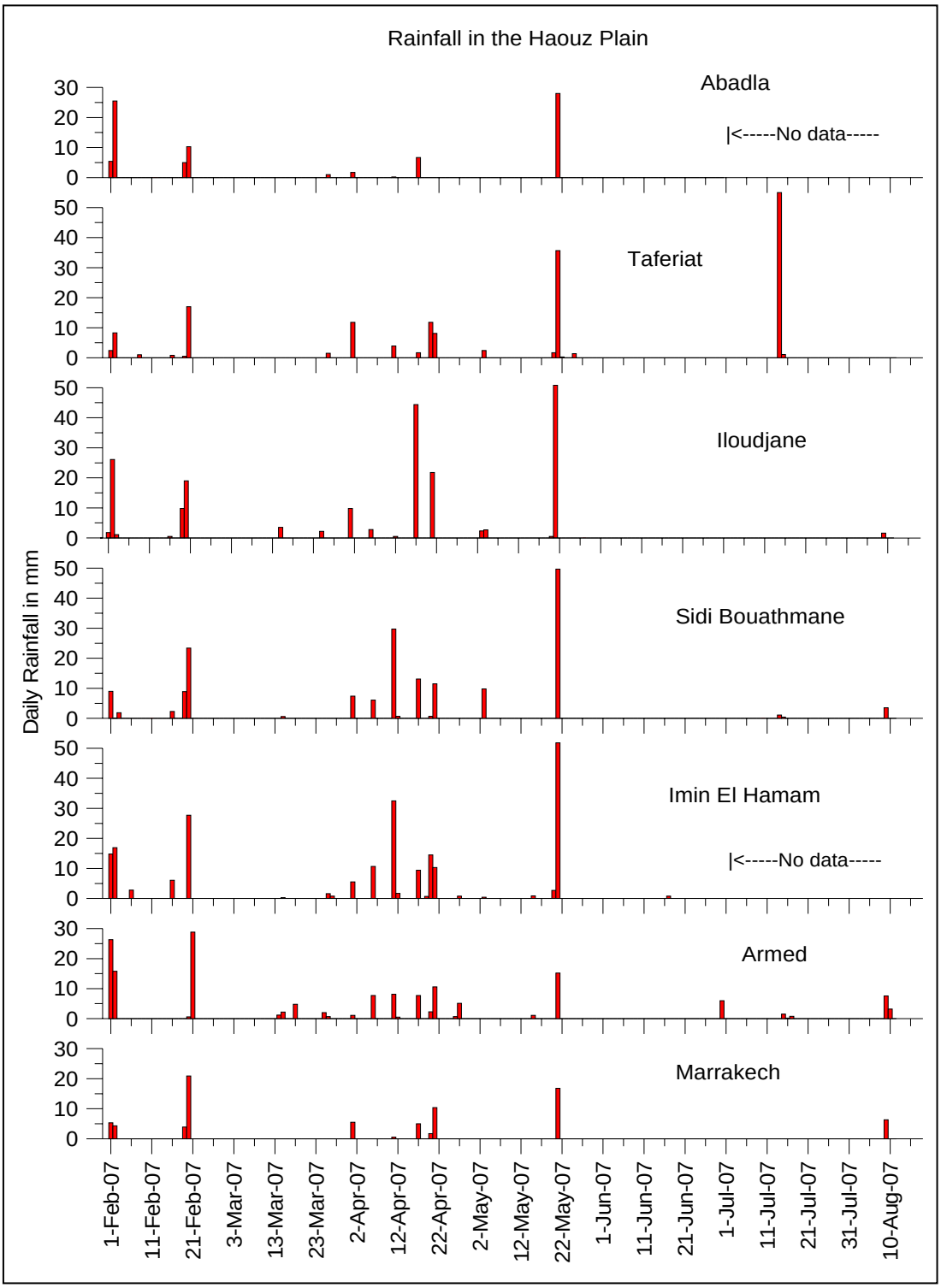
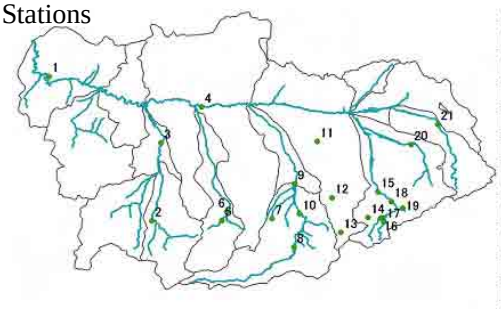


Figure B.1.1 Hydrograph of Monitoring Wells in the Haouz Plain



Locations of Rainfall Stations



No.	観測所名
1	TALMEST
2	ILOUDJANE
3	CHICHAOUA
4	ABADLA
5	TASKOURT
6	SIDI BOUATHMANE
7	SIDI HSAIN
8	IGUIR NKOURIS
9	L'TAKERKOUST
10	IMIN EL HAMAM
11	MARRAKECH
12	TAHANAOUT
13	AREMD
14	AGOUNS
15	AGHBALOU
16	TIOURDIOU
17	AMENZAL
18	TAZITOUNT
19	TOURCHT
20	TAFERIAT
21	SIDI RAHAL

Figure B.1.2 Rainfall in the Haouz Plain

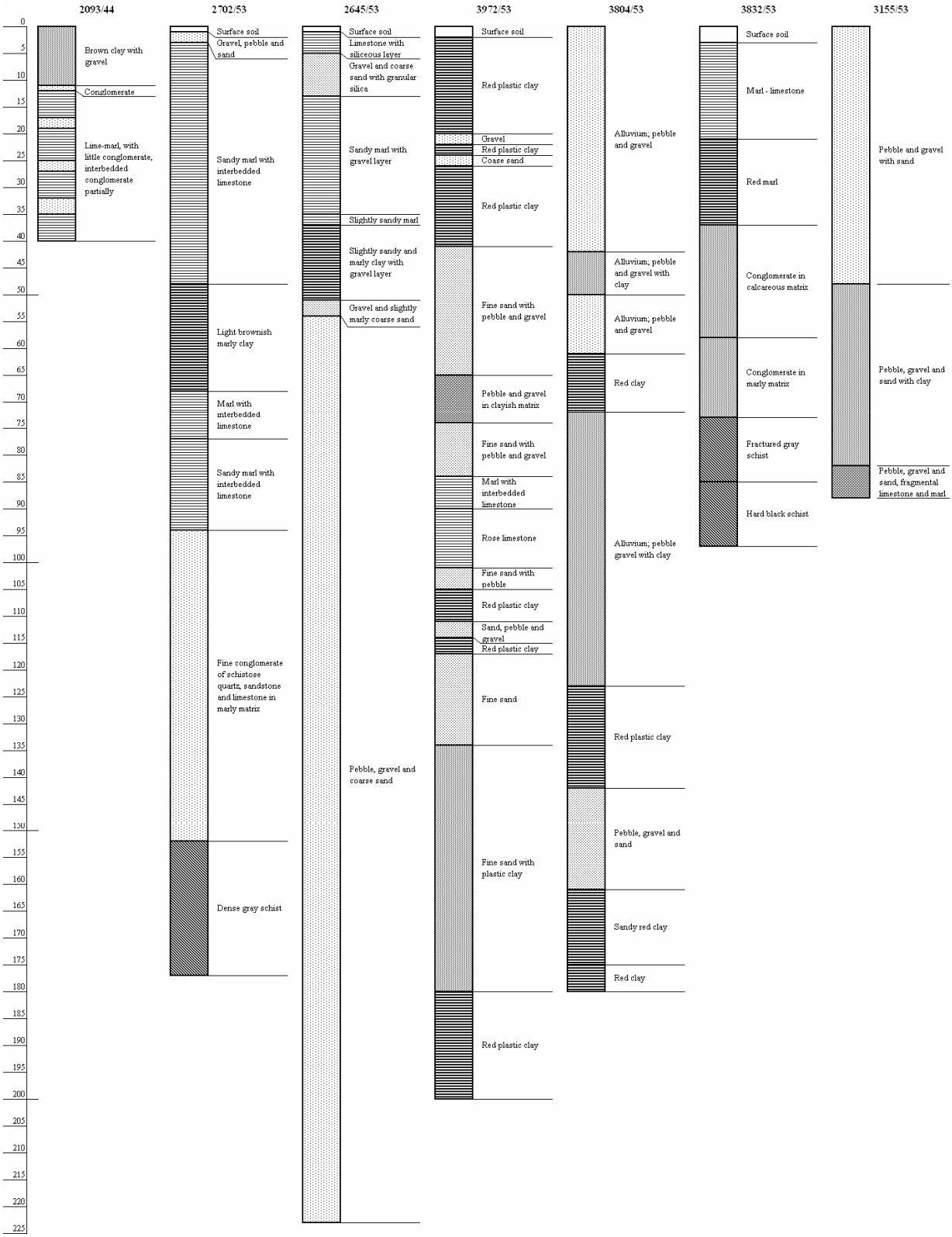


Figure B.2.1 Geological Columns of Selected Boreholes in the Haouz Plain

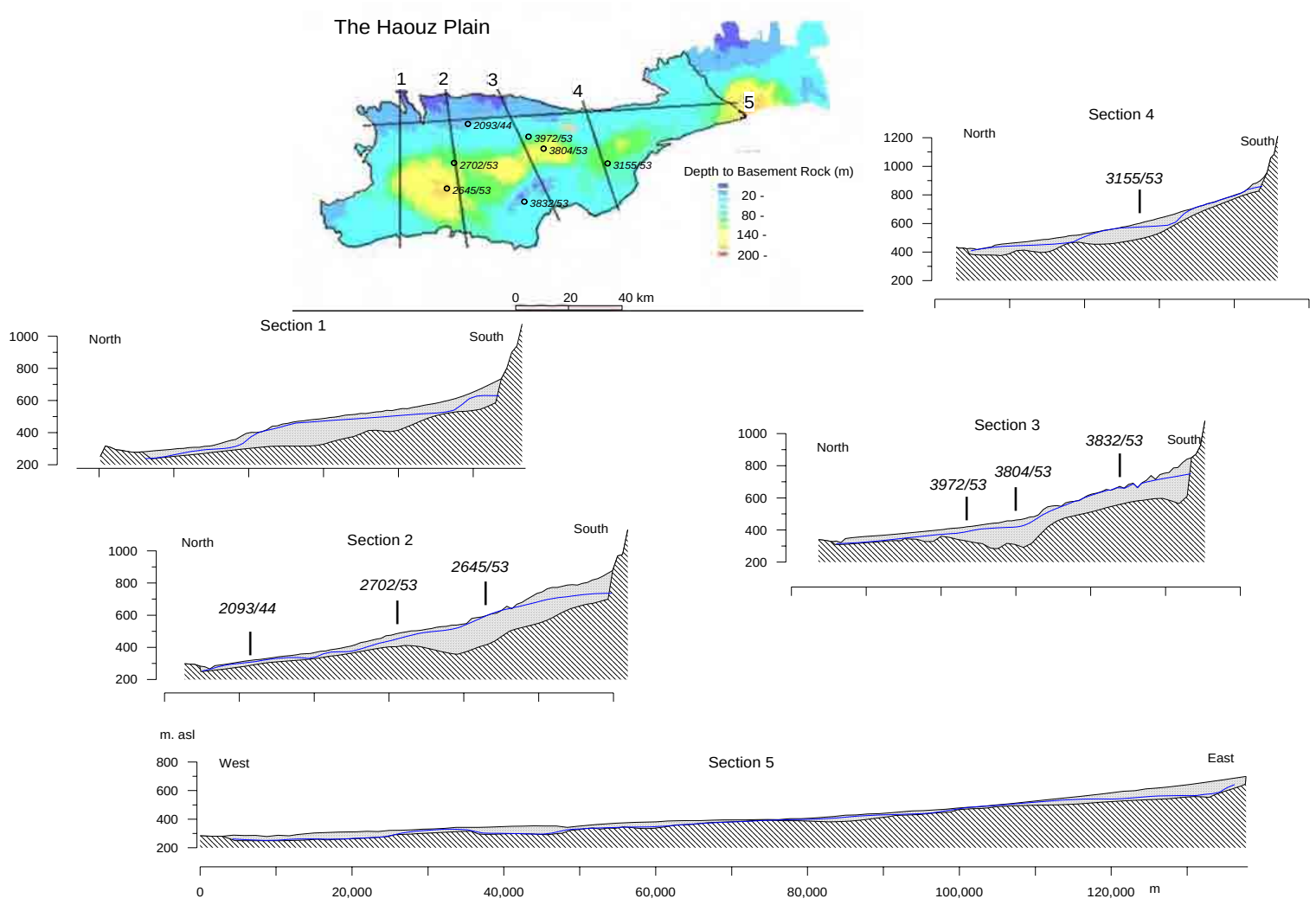


Figure B.2.2 Geological Cross Sections in the Haouz Plain

C: CLIMATE, HYDROLOGY AND SURFACE WATER RESOURCES

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C： CLIMATE, HYDROLOGY AND SURFACE WATER RESOURCES

C.1 Climate and Hydrology

C.1.1 Meteo-hydrological Network and their Data

ABHT has a rain gauging network composed of 20 stations within the Haouz Plain (Figure C.1.1). The stations and their data availability are listed in Table C.1.1. In addition to the ABHT network, there are meteorological observation networks managed by ORMVAH and the National Meteorological Direction in and around the Haouz Plain. The flow gauging stations of several rivers are operated by ABHT too (Figure C.1.2). The stations and the data availability are shown in Table C.1.2.

C.1.2 Rainfall

The climate of the Haouz Plain Area is arid continental type based on the Mediterranean climate. The annual mean temperature at Marrakech, which is located at the center of the Plain, is 19.9℃, and the monthly mean temperature varies from 11.9℃ in January to 28.7℃ in July. At Lalla Takerkoust, which is located at the foot of the Atlas Mountain, the annual mean temperature is 18.0℃, the monthly mean of January is 11.4℃ and of July is 26.6℃. At Sidi Rahal, which is the east end of the Central Haouz, the annual mean temperature is 18.8℃, the monthly mean of January is 12.0℃ and of July is 27.7℃. Comparatively high precipitation is observed along Atlas Mountain, which is located in the south and south-east part of the Plain, where average annual precipitation is 259mm at Lalla Takerkoust and 535mm at Aghbalou. In the plain area, the average annual precipitation observed is comparatively low: 176mm at Abadla and 216mm at Marrakech (Figure C.1.3). The rainy season starts on October and regularly continues to March or April. 86% of annual precipitation (equivalent to 216mm) is observed during the period of October to March in Marrakech, and in other areas too. The annual evaporation is 1,830mm at Lalla Takerkoust and 2,640mm at the center part of the Haouz Plain.

Table C.1.3 shows the record of rainfall of each station from 1970/71 and Table C.1.4 shows the change of annual rainfall of major stations.

Figure C.1.4 shows the possible rainfall of major station evaluated based on the data from 1970. The result of drought assessment from 1996/97 to 2005/06 is shown in Table C.1.5. According to the assessment, years of 1996/97~1997/98, 2003/04 and 2005/06 are considered as a humid year and years of 2001/02 and 2004/05 are considered as a drought year.

The basin average rainfall was calculated for the Haouz plain area and the Mid-upper Tensift Basin (upper from Chichaoua conjunction), which concern to inflow to the Haouz aquifer directly. Rainfalls in 13 observation stations in the Tensift baisn which have data in long period were applied and the basin average rainfall was evaluated by the Thessen method (Figure C.1.5 and Table C.1.6). As a result, the average basin rainfall of the Haouz aquifer area, of which area is 6,124 km^2, is estimated 281 mm and the Mid-upper Tensift Basin, of which area is 16,178 km^2, is 296 mm. Figure C.1.6 shows the possible basin average rainfall of both areas, which shows 209 mm for the Haouz aquifer area and 227 mm for the Mid-upper Tensift Basin in 5-year probability.

C.1.3 River Flow

The Tensift River Basin, where the Haouz Plain is located, has its south boundary along Atlas Mountain, and the Tensift River that is a major river of the Basin runs through the Plain from the east

to the west, and discharges to the Atlantic Ocean. The total length of the Tensift River is 260km and the area of basin is 19,800km^2. The Study Area is locatedoin the left bank of the Tensift River upstream from the conjunction of the Chichaoua River. The major tributaries of the Tensift River concerning the Study Area are Chichaoua River, Assif El Mal River, N'Fis River, Rheraya River, Rhmat River, and Ghdat River from west to east. The upstream of the Tensift River is called the Lagr River (Figures C.1.7).

Table C.1.7 shows the observed river flow of the Tensift river and and its major tributaries from 1970/71 to 2005/06. The monthly distribution of river discharge is shown in Table C.1.8. The discharge of the Tensift River and its tributaries starts to increase in November, following the start of rain ; the peak of discharge is observed in March to April, and generally a large amount of discharge continues to May. The discharge of these rivers area significantly fluctuates during year. More than 80% of total discharge is observed from November to May and the rivers are dried up from July to September during the dry season in the plain area including the Tensift River.

C.1.4 Long-term Climate Change

The rainfall in the Study Area shows a gradual decrease when examined in a long span, where the rainfall in Marrakech has decreased 0.18%/year in average. Sidi Rahal, which is located in the eastern part of the area also shows an average decrease of 0.21%/year (Figure C.1.8). Serious droughts have hit the area in the past decade. This can be seen in the average rainfall in Marrakech and Sidi Rahal, where the long term average since 1970 was 220mm and 349mm respectively, has shown a significant drop to an average of 204mm and 319mm in the past 10 years (Table C.1.4)

A long-term change of climate is difficult to prospect the future trend accurately. According to the "A Review of Climate Change Scenarios and Preliminary Rainfall Trend Analysis in the Oum Er Rbia Basin (International Water Management Institute)" applied the scenario prepared by Bennani et al. (2001) that the average temperature will increase 0.6 to 1.1 ^{o}C and the annual rainfall will decrease 4% from 2000 to 2020 in the country average. In the scenario, the average temperature in Marrakech, which is representative of the Tensift-Oum Er Rbia Basin, is expected to increase 0.8 to 1.1 ^{o}C (0.9 ^{o}C in average) and the annual rainfall is expected to decrease 7 to 0.2% (4.3% in the average) (Table C.1.9).

C.1.5 Design Rainfall

The basin average rainfalls in the Haouz aquifer area, which is the Study Area, and the Mid-upper Tensift Basin, which is directly affect to the water balance of the aquifer, are shown in Table C.1.6. The Study on Actualization of Surface Water Resources in ABHT Area conducted by CID Consultant examined the long term analysis of the rainfall in the Study area based on the record from 1935 to 2002. The report analyzed the historical climate trend of the Tensift Basin and concluded that long cycle of wet period and dry period continuing for 10 to 15 years had occur red alternately during these years, and that short cycle of wet/dry period continuing around 3 years had occurs twice or three times in each long dry/wet period. According to the analysis, 13 years from 1961 to 1973 was recognized as continuous wet period, the following 13 years (1974~1986) was a continuous dry period, and the following 11 years (1987~1997) was a continuous wet period with short dry period of 1990-1994.

According to the observed rainfall record, the characteristics of rainfall in the Haouz plain and surrounding area is considered similar with the conclusion of CID report, that alternate long wet/dry

period for 10 to 15 years is a base of climate cycle in the area and that short-mid cycle of wet/dry period around for 5 years became distinguished after 1980's.

- A long cycle of wet period started in 1960's continued to 1973/74.
- A long cycle of dry period continued from 1984/75 to 1986/87, while short cycles of wet period occurred in 1977/78 and 1981/82.
- A short cycle of wet period for 2 years occurred in 1987/88~1988/89.
- A significant dry period for 5 years occurred in 1989/90~1993/94.
- A significant wet period for 4 years occurred in 1994/95~19997/98.
- A continuous dry period from 1998/99 to 2002/2003. During this period, there was a significant dry period was observed from 1999/2000 to 2001/02
- After 2003/04, there were alternate dry year (2003/04, 2005/06) and wet year (2004/05).

Based on above assessment, it is desired to analyze rainfall conditions in the study area based on at least 30 years observed data which will include both of long cycles of wet and dry period. However, it is also pointed that analysis based on too long period data has a risk to bring over evaluation of rain due to long term climate change. In this study, the 15 years average of 1991/92 ~ 2005/06 was applied to the design rainfall, which covers a part of long cycles of wet and dry period and consists of short-midterm cycles around for 5 years of wet/ dry period in the period.

C.2 Surface Water Resources

C.2.1 Surface Runoffs

According to the Tensift River Water Resources Development Master Plan 2001, the Tensift basin had 1,124.5 Mm^3 of effective inflow including the transfer from Oum El Rbia River based on the historical data of 1935-1997. The inflow was re-evaluated in the *Actualisation de l'Etat de Connaissance des Ressources en Eau dans les Bassins Hydrauliques du Tensift 2004* as 1,067.8 Mm^3 with transfer based on the data 1970-2002 as shown below. The effective inflow into the Haouz Plain is estimated as 967.7 Mm^3 including transfer on average in the estimation. (Figure C.2.1) The surface runoff of the Tensift River and its major tributaries flowing into the Haouz plain from 1970/71 to 2005/06 is summarized in Table C.2.1.

Discharge Evaluated in *Actualisation de l'Etat de Connaissance des Ressources en Eau dans les Bassins Hydrauliques du Tensift 2004*

River	Effecitve catchment area	Annual runoffs in Mm^3 (Data 1970-2002)		
		Min.	Average	Max.
Discharge into the Haouz Plain				
N'Fis (at Lalla Takerkoust)	1,692	12.7	174.8	504.5
R'dat (at Sidi Rahal)	569	3.5	72.8	264.0
Zat (at tafriat)	516	16.8	103.9	278.7
Ourika (at Aghbalou)	503	14.5	155.8	618.5
Rheraya (at Tahanaout)	225	2.6	47.8	117.1
Lahr (at Herrisane)	65	0.3	9.9	25.8
Assif El Mal (at Sidi Bou Othman)	517	0.8	35.9	113.0
Chichaoua	1,317	10.9	66.8	230.6
Transfert du Oum Er Rbia	-	160.0	300.0	300.0
Sub-total of Haouz plain without transfer	5,404	62.1	667.7	2,152.2
Sub-total of Haouz plain with transfer	-	222.1	967.7	2,452.2
El Hallouf	185	0.0	1.4	4.6
Mramer	150	0.0	1.8	4.6
autrebassins effective	2,241	9.2	84.2	269.1
Autre bassin semi-effective	1,396	0.9	12.8	36.6
Without transfer	9,376	72.2	767.8	2,467.0
With transfer	-	232.2	1,067.8	2,767.0

Source: Actualisation de l'Etat de Connaissance des Ressources en Eau dans les Bassins Hydrauliques du Tensift, ABHT, 2004 , Les données sont observées dans les 10 dernières années. : l'ABHT

C.2.2 Dams

(1) Lalla Takerkoust Dam and Wirgane Dam

The Lalla Takerkoust Dam wa constructed on 1935 and it was expanded by raising the dam height to cope with the increase of water demand, as a multipurpose dam for irrigation, power supply, drinking and industrial water. The dam supplies irrigation water to the N'Fis Irrigation Sectors of 24,200 ha in total in combination with the Rocade Canal, as well as to the improved seguia system area of approximately 10,000 ha. The water of the dam is also used for the drinking water supply to the Marrakech town area in combination with the Rocade Canal.

The actual water distribution of Lalla Takerkoust Dam is shown in Table C.2.2 and Figure C.2.2. The average distribution of the last 10 years (1996/97 ~ 2005/06) excluding mining industry water is 72.8 Mm3, which is equivalent to 89% of the planned volume (82 Mm3). In consideration of the severe drought in 2000/2001 and 2001/2002, the average value is comparatively verified. However, the Lalla Takerkoust Dam is affected by the sedimentation and it has lost more than 20% of the storage capacity in the past 20 years. The decrease of storage capacity affects the effective outflow of the dam and it is expected to become unable to bypass in near future.

The construction of the Wirgane Dam started at the beginning of 2005 and is scheduled to start its service in March 2008. The dam is located 20km upstream of the Lalla Takerkoust Dam in the N'Fis River, and it is expected to be operated in combination with it in order to reinforce the drinking and industrial water supply to the Marrakech town area and to improve the regulation capacity of the Lalla Takerkoust Dam. The major parameters of the dam are:

A 82 Mm^3 is set as projected amount of water distribution by the Lalla Takerkoust Dam, which is design amount of the Dam. The distribution plan of dam water is set based on the proportion of average distribution from 2001/02 to 2005/06. After starting the operation of the Wirgane Dam, which is scheduled in 2008, a 17 Mm^3/year of the additional water resources regulated by the Dam is

expected to be supplied, which is planned to supply to the Marrakech water supply.

(2) Taskourt Dam

The Taskourt Dam has been started its construction from 2007 and it is scheduled to be competed in 2010. The design regulation water amount is 24Mm^3/year and it is planned to be used for irrigation. In the Study, the water distribution by the Taskourt Dam will be considered to be utilized from the year 2010/2011.

Even the beneficiary area of the Taskout Dam was set as 4,500 ha according to the Feasibility Study on Water Resources Development in Rural Area conducted by JICA, the detail of the irrigation development plan of the beneficiary area has not yet decided and the DPA Chichaoua is conducting the study at present. In the irrigation development plan has a basis that the project is improvement of existing seguia irrigation area by changing the water resources and development of new irrigation area dose not planned in the project.

(3) Moulay Youssef Dam

The Moulay Youseff Dam is located in the Oum Er Rbia basin, which supplies water to Upper Tessouat Irrigation Sector. A part of the Upper Tessouat Sector located within the Haouz Plain (Skhirat and Bouidda Sector) is also supplied water by the Dam. In the Study, it is assumed that the Moulay Youseff Dam supplies 46.2 Mm^3/year to the area within the Haouz Plain, which is 30% of the total amount supplied to the whole Upper Teesout Sector of 154 Mm^3/year (average in 1990/91 to 2004/05) corresponding to the ratio of the area.

C.2.3 Water Transferred from Oum Er Rbia Basin

The Rocade Canal is a hydraulic facility for the water transfer from the Oum Er Rbia basin to the Tensif Basin ; the transferred amount is designed as 300 million m^3/year. The water source of the Canal is the Moulay Hassan I Dam and Sidi Driss Dam in the Lakdar River of the El Rbia Basin, with total active capacity of 246.3 million m^3 (245 million m^3 for the Maoulay Hassan I and 1.3 for the Sidi Driss).The total length of the canal is approximately 120km and the flow capacity is 20m^3/s. In the design, the Canal takes 350 million m^3 of water from the dam complex and 296 million m^3 of water is to be transferred to the Tensift Basin to be supplied to the irrigation sectors in the Haouz Central and drinking water to Marrakech town area, as well as supplying irrigation water in the Oum Er Rbia Basin, with 33 million m^3 to the small and medium irrigation sectors of the Ladar basin of 4,000 ha and 21 million m^3 to a part of the Lower Tessaout Irrigation Sectors though B1 and B2 canal systems.

The actual distribution of water after starting operation is summarized in Table C.2.3 and Figure C.2.3. The total discharge of the Canal varied from 77.6 Mm^3 to 191.8 Mm^3 and the average was 150.1 Mm^3, which is equal to 43% of the designed discharge of 350 Mm^3. The deficit of the discharge is considered to be partly affected by the reduction of dam capacity by sedimentation; however, the main reason is considered to be the lack of precipitation in the catchment area of dam system. The lack of precipitation has been fixed in recent years and it has become a regular condition of the dam. It is necessary to take into account of this climatic change and deficit of dam discharge. It is also necessary to set a reasonable design discharge of the Canal during examining the water balance of the Haouz Plain Area. This will be examined in successive work in the Study.

The possible amount of water supplied to the Haouz Plain by the Rocade Canal was examined. Because the Hassan 1 Dam has constructed in 1988/89 and actual record exists after the operation

started, the possible amount of water supplied was estimated by the trial calculation that is simplified dam water balance analysis for long period based on the inflow of dam site observed. The major assumption and conditions of the calculation are:

- Calculation period: 1970/71~2005/06
- Time step of calculation: a month
- Estimated runoff at the dam site provided by ABHT was adopted.
- Average evaporation and leakage loss at the dam of 1991/92~2005/06, which was considered as a period that the operation of the dam become stable, was adopted. Monthly profile of evaporation was generated by the same data. A constant value of leakage was adopted through a year.
- Discharge for dam management such as blow-off was considered in the calculation. The average of 1991/92~2005/06 was adopted.
- An upper limit of 300 Mm^3/year was applied for the discharge to the Rocade canal. An assumption was applied in order to simplify the calculation, that all of the collected water in the dam is used within the campaign year and no carry-over of storage is considered.
- Monthly profile of distribution of Rocade canal was generated based on the average of 1991/92 ~ 2004/05.
- The storage capacity of the Hassan-I dam was set to be 245 Mm^3.

As a result of the analysis, possible water amount of the Rocade Canal was estimated as 186Mm^3/year in average 1970/71 to 2005/06, 146 Mm^3/year in average 1981/82 to 2005/06 and 152 Mm^3/year in average 1991/92 to 2005/06. The inflow of the dam site shows significant decrease after the rich period of 1970's, especially in the second half of 1970's. It is considered that there is a risk that the possible outflow might be overestimated based on the record including 1970's and before. Thus, the possible outflow to the Rocade Canal was set as 146 Mm^3/year in the Study, which is based on the average of the actual outflow from 1991/92 to 2005/06. The design distribution to the Rocade Canal, which excludes amount supplied to the Lower Tessout IrrigationSector and El Kelaa des Sraghna Water Supply, was set as 120 Mm^3/year.

C.2.4 Seguia Water

The seguia systems taking water from natural rivers are important water sources for irrigation in the Study Area. Because the traditional seguia systems connected to rivers do not have any water regulation system, the amount of water intake by them is highly fluctuating every year. In accordance with the inventory survey in Etude hydrologique des prélèvements au fil de l'eau dans le basin Tensift, the average amount of water intake by traditional seguia system excluding the N'Fis sub-basin is 257.7 Mm^3 on average in 1985-2001, and the ratio of water intake to river discharge was from 50% to 63%, where the overall average is 54.3% (Table C.2.4).

Even the amount of the water taken by seguias are reported based on the observation, it should be considered that whole sguias are not always observed and there is a gap between the observation and actual amount of water taken by seguias. In the Study, the average amount of water taken by seguias from 1985 to 2001 in each river is considered as an available water resources for sguias, based on "Etude hydrologique des prélèvements au fil de l'eau dans le basin du Tensift, ABHT, 2003". As for

the Chichoua river and Assif El mal river which do not have actual record, the available water for seguias are estimated based on the ratio of withdrawing in other rivers. After completion and starting operation of the Taskourt Dam, the seguias in the Assif El Mal river are considered that they receive water from the Taskourt Dam directly. Consequently, the available water taken by seguia sustems are set as 252 Mm^3 before starting the operation of the Taskourt Dam and 233 Mm^3 after that. 24 Mm^3 is counted as a supply by the Taskourt Dam when the Dam starts to operate. (Table C.2.5)

C.2.5 Available Surface Water Resrouces

The available surface water resources in the Haouz Plain is summarized below:

Available Surface Water Resources in Haouz Plain

C.2.6 Examination on Artificial Groundwater Recharge

(1) Assumption of Scale of facility and Infiltration Volume

It is assumed to build a channel storage facility to enhance infiltration in the river course, which composes a sill with 1.5m height and revetment dikes 8Figure C.2.6). This facility will have a capacity of 0.75 Mm3, which is calculated by 50 m width of river course X 1.5 m of average depth of water X 10km length. In the estimation of infiltration, this volume was applied for the maximum of daily infiltration.

(2) Conditions on Site Selection of Artificial Recharge

The site for the artificial recharge facilities are to be selected with following considerations:

- The site of the proposed/planned pilot project by ABHT for collecting basin data, information on construction method, etc.
- Expected volume of available storage/infiltration (Flow conditions, frequency of flood, topographic conditions, etc.)
- Water quality (Volume of suspended sedimentation affects the maintenance frequency to maintain infiltration capacity and durable life of facility.)
- Dam equipment in the upper reach of the river (Most of water will be taken by the dam and available flow is very limited in the river with dam equipment in the Haouz plain.)
- Expected direct contribution to the groundwater conditions in the conservation area or special risk area.

(3) Priority of Major Tributaries for Artificial Recharge

The seven major tributaries area examined as possible sites for the artificial recharge; Rerhaya river, Ourika river, Zat river, R'Dat river, Chichoua river, Assif El Mal river and N'Fis river. Assif El Mal river and N'Fis river are considered to be un suitable because they have very limited discharge flow even in the flood season due to the dam equipment in the upper reach. Chichoua river has low priory to develop artificial recharge because it located in the lower reach of the aquifer and the expected contribution to improving the groundwater condition of the whole plain is limited, and there are no sever constraints in the lower reach of the river where the impact of the recharge is expected. Consequently, the four rivers, i.e., R'Dat river, Rehraya river, Ourila river and Zat river, were considered as possible sites of the artificial recharge facilitirs. (Figure C.2.6)

Priority of Installation of Artificial Recharge Facilities

River	Evaluation of Priority	
Rerhaya river	Significant contribution to recovery of Marrakech water supply well field capture zone	2
Ourika river	Contribution to Z7 pump sector and risk area along Ourika river	3
Zat river	Contribution to Z7 pump sector and risk area along Ourika river	4
R'Dat river	Abundant river flow: located upstream thus contributing to large area. (However presence of sedimentation)	1
Chichaoua river	Located in downstream area where the decline of groundwater table is not a major issue. Low priority	-
Assif El Mal river	Not suitable because there will be only scarce flow after the completion of Taskourt dam	-
N'Fis river	Not suitable because there will be only scarce flow after the completion of Wirgane dam	-

(4) Expected Infiltration Volume

The expected infiltration volume by the proposed artificial recharge facilities is estimated by the following procedure based on the river flow data of 1991/92~2003/04.

- The infiltration volume was estimated by the daily calculation.
- The daily river flow is assumed that seguias take water firstly by their maximum capacity and the surplus volume flows in the course of the lower reach.
- The capacity of seguia intake in each sub-basin was set by the actual record of intake from 1991/92 to 2001/02.

Assumed Maximum Intake of Seguias in Each Sub-basin

River	Assumed maximum intake of seguias (m^3/s)
Ourika	7.6
Zat	3.4
Rerhaya	2.0
R'Dat	6.0

- The natural infiltration in the river course was assumed as 25 % of daily flow volume, which is calculated by [daily river flow] minus [daily intake of seguia].
- The maximum daily infiltration by the artificial recharge was set to be 0.75 Mm^3 and it was applied to the remaining flow in the river course which is [daily river flow] minus [Seguia intake]

and [natural infiltration].

The estimated infiltration by the artificial recharge in each site is shown in C.2.6 and summarized below:

Expected Infiltration of Each Site

River	Expected Infiltration
Rerhaya	2.9Mm^3/year
Ourika	3.8Mm^3/ year
Zat	5.5Mm^3/ year
R'Dat	2.1Mm^3/ year

Table A1.1 Availability of Rainfall Data of ABHT Observation Network

Nom de la Station	Code de la Station	Du	Au	Remarques
ABADLA	N° 008	1969/1970	2005/2006	
AGHBALOU	N° 6193	1968/1969	2005/2006	
AGOUNS	N°902	1996/1970	2005/2006	
AMENZAL	N°1004	1997 April	2005/2006	
AREMD	N°1182	1999 April	2005/2006	
CHICHAOUA	N°2601	1995/1996	2005/2006	
IGUIR N'KOURIS	N° 4299	1973/1974	2005/2006	
ILOUDJANE	N° 4222	1989/1990	2005/2006	
IMINE EL HAMMAM	N° 4432	1969 March	2005/2006	
Bge. LALLA TAKERKOUST	N° 8969	1962/1963	2005/2006	
MARRAKECH	N° 5229	1970/1971	2005/2006	1972/1973 Manque des Données
SIDI BOUOTHMANE	N° 6770	1989/1990	2005/2006	
SIDI HSSAIN	N°6826	1998 Jan	2005/2006	
SIDI RAHAL	N° 6976	1967/1968	2005/2006	
TAFERIAT	N° 7352	1983 Jan	2005/2006	1986 April -1987 Oct Manque des Données La location de l'indication de la pluie a changé en 8/10/1997
TAHANAOUT	N° 7512	1971 April	2005/2006	
TALMEST	N° 7660	1985 April	2005/2006	
TAZITOUNT	N°7994	1999 May	2005/2006	
TIOURDIOU	N°8411	1996/1997	2005/2006	
TOURCHT	N°8804	1997 March	2005/2006	

Source: ABHT

Table A1.2 Availability of Discharge Data of ABHT Observation Network

Rivier	Station	Code	Du	Au	Remarques
R'DAT	SIDI RAHAL	44/54	1963 Dec	2005-2006	
N ' FIS	IMINE EL HAMMAM	1566/53	1966 -1967	2003-2004	
N ' FIS	IGUIR N'KOURIS	510/62	1974 -1975	2004-2005	
AMEZMIZ	SIDI HSSAIN (R'HA D 'AZILAL)	2431/53	1988 Feb	2003-2004	
OURIKA	AGHBALOU	2089/53	1969 -1970	2005-2006	
ZAT	TAFERIAT	1562/53	1962 Mar	2005-2006	
KSOB	ADAMNA	111/51	1970 -1971	2005-2006	
IGROUNZAR	IGROUNZAR	400/52	1965 -1966	2003-2004	72 Feb - '75 Jan Manque des données
ZELTEN	ZELTEN	401/52	1975 May	2003-2004	
TENSIFT	ABADLA	1675/44	1969 Apr	2005-2006	
TENSIFT	TALMEST	189/43	1970 -1971	2003-2004	
RHERHAYA	TAHANAOUT	1565/53	1962 Apr	2005-2006	
EL MAL	SIDI BOUOTHMANE	1976/53	1984 Dec	2005/2006	
SEKSAOUA	ILOUDJANE	628/52	1975 -1976	2005-2006	
CHICHAOUA	CHICHAOUA	451/52	1971 Feb	2004-2005	
IGOUZOULEN	IGOUZOULEN	404/51	1997 -1998	2003-2004	
IMLIL	AREMD	3604/53	1999 Mar	2003-2004	
OURIKA	TAZITOUNT	3603/53	1999 Mar	2003-2004	
R'DAT	SEGUIA : AFIAD	832/45	1970 -1971	2003-2004	

Source: ABHT

Table C.1.3 Rainfall Data of Tensift Basin

Name of station	Abadla	Chichaoua	Iloudjane (Imintanaout)	Sidi Bouothmane	Iguir N'Kouris	Takerkoust	Imine El Hammam	Tahanaout	Aghbalou	Taferiat	Sidi Rahal	Marrakech	Talmest
Code	N° 008	N°2601	N° 4222	N° 6770	N° 4299	N° 8969	N° 4432	N° 7512	N° 6193	N° 7352	N° 6976	N° 5229	N° 7660
1970 /71	329.6	300.6	247.0	641.8	492.3	424.0	651.6	549.9	469.7	688.9	577.6	630.3	482.8
1971 /72	197.4	204.9	496.0	551.0	408.4	298.8	306.3	443.7	1053.5	548.4	466.2	212.4	318.8
1972 /73	130.8	143.9	275.0	418.2	285.9	277.6	396.3	398.9	802.0	367.0	322.3	189.2	270.3
1973 /74	234.6	273.7	179.0	597.0	450.9	415.4	694.0	605.2	563.3	673.5	565.4	345.0	296.6
1974 /75	89.4	112.7	499.0	291.8	98.6	223.7	328.6	369.4	921.4	279.4	252.9	150.0	163
1975 /76	173.5	199.0	297.6	390.6	143.7	245.4	458.4	478.6	499.1	624.9	382.3	236.9	288.5
1976 /77	121.1	114.5	122.3	293.7	218.8	219.3	359.7	221.3	583.8	496.0	270.4	123.3	248.7
1977 /78	278.2	292.6	422.1	515.5	239.3	278.1	396.5	452.5	489.0	563.1	412.1	273.2	382.3
1978 /79	145.9	223.8	244.2	238.9	192.3	144.8	205.2	227.0	647.9	281.3	277.7	199.1	281.7
1979 /80	196.3	201.0	304.0	428.3	231.1	251.5	471.5	401.0	334.4	558.4	449.9	224.3	262.2
1980 /81	77.2	91.4	115.5	252.5	173.8	210.3	254.4	296.7	646.5	344.8	328.4	109.8	190.7
1981 /82	263.5	298.7	318.1	487.6	189.0	292.9	500.6	412.3	407.7	539.6	394.4	245.1	239.2
1982 /83	88.9	78.3	145.5	180.5	114.9	105.9	239.1	221.8	567.7	208.9	176.4	78.7	173.8
1983 /84	125.2	131.4	174.7	301.8	156.5	146.7	287.5	311.6	314.9	274.3	241.4	156.8	273.6
1984 /85	184.8	199.3	297.0	397.8	281.0	235.1	405.7	395.5	376.3	388.2	319.9	242.9	302.3
1985 /86	129.5	164.9	205.8	332.1	122.9	191.1	202.2	327.0	551.8	360.6	349.2	238.5	178.6
1986 /87	110.7	112.1	108.2	228.6	140.2	209.5	230.3	280.1	467.5	229.5	220.6	154.6	101.4
1987 /88	233.9	260.7	513.5	447.1	304.4	298.3	487.4	365.0	313.8	376.9	351.4	272.2	487.3
1988 /89	244.8	249.7	614.6	508.2	443.5	323.8	485.6	544.6	596.1	497.2	437.6	273.2	385.2
1989 /90	174.3	210.3	371.4	236.5	424.4	177.3	309.2	327.8	680.9	320.0	319.6	143.7	411.1
1990 /91	197.7	207.2	244.4	359.3	177.4	295.8	393.0	462.0	421.1	474.4	467.5	261.4	326.8
1991 /92	98.0	105.6	401.5	358.4	339.6	196.3	397.6	360.6	617.1	291.5	247.9	141.3	149.1
1992 /93	60.0	56.8	221.2	199.5	83.7	118.8	225.9	192.2	487.2	237.6	167.7	140.9	173.5
1993 /94	202.6	228.9	146.1	386.5	270.3	231.1	374.9	416.0	276.9	468.1	359.9	214.8	344
1994 /95	195.4	213.8	389.4	415.3	207.9	334.7	309.8	329.6	647.8	396.4	346.3	287.1	149.7
1995 /96	311.3	295.1	350.5	559.1	442.5	389.4	553.3	539.0	359.4	913.4	648.2	350.3	604.7
1996 /97	296.1	294.5	390.0	394.1	290.3	462.4	522.0	469.4	725.1	420.9	429.6	337.5	514.4
1997 /98	185.9	217.1	518.1	397.9	237.1	286.7	401.8	354.8	515.2	415.9	388.5	270.0	400.7
1998 /99	129.2	136.0	380.8	392.9	147.9	226.1	393.6	372.9	560.3	395.0	349.0	191.5	196.3
1999 /00	148.9	159.0	355.4	327.6	256.0	187.5	319.7	280.2	552.4	308.3	265.8	158.7	212
2000 /01	87.7	89.8	394.6	209.8	46.1	165.3	161.6	212.1	449.4	234.6	195.8	102.8	200.2
2001 /02	134.3	139.4	229.0	291.6	168.5	217.2	379.9	296.2	379.6	299.1	241.3	181.8	263.1
2002 /03	215.8	162.6	268.6	277.4	154.9	335.5	221.1	289.7	481.9	274.4	347.3	207.4	237.6
2003 /04	201.7	196.1	508.3	440.5	201.7	248.9	482.6	466.9	704.7	338.3	389.7	227.4	358.1
2004 /05	97.3	99.8	231.6	241.8	189.0	122.8	261.1	212.7	324.0	215.2	197.0	107.9	173.8
2005 /06	238.1	293.7	403.9	369.2	203.6	295.6	362.4	606.7	542.6	334.6	389.8	252.8	337.6

Table C.1.4 Change of Annual Rainfall of Major Stations

Station	Chichaoua	Takerkoust	Tahanaout	Taferiat	Sidi Rahal	Marrakech
Average 1935-1970 (1)	199	282	502	464	400	257
Average 1970-2005	188	252	375	407	349	220
Ratio to (1)	*94%*	*89%*	*75%*	*88%*	*87%*	*86%*
Average 1976/77-1985/8	180	208	327	402	322	189
Ratio to (1)	*96%*	*82%*	*87%*	*99%*	*92%*	*86%*
Average 1986/87-1995/9	194	258	382	421	357	224
Ratio to (1)	*103%*	*102%*	*102%*	*103%*	*102%*	*102%*
Average 1996/97-2005/0	179	255	356	324	319	204
Ratio to (1)	*95%*	*101%*	*95%*	*80%*	*92%*	*92%*
Average 1993/94-2003/0	194	280	366	406	360	230
Ratio to (1)	*103%*	*111%*	*98%*	*100%*	*103%*	*104%*

Table C.1.5 Drought Condition of Major Stations

Station	Chichaoua			Lalla Takerkoust			Tahanaout		
Year	*1	*2	*3	*1	*2	*3	*1	*2	*3
96 /97	295	>average	> 50%	462	>average	> 50%	469	>average	> 50%
97 /98	217	>average	> 50%	287	>average	> 50%	355	2.6	0.4
98 /99	136	4.3	23%	226	3.1	33%	373	2.1	49%
99 /00	159	3.3	30%	188	4.5	22%	280	4.7	21%
00 /01	90	9.4	11%	165	6.0	17%	212	11.0	9%
01 /02	139	4.2	24%	217	3.4	30%	296	4.3	23%
02 /03	163	3.1	32%	336	>average	> 50%	290	4.5	22%
03 /04	196	>average	> 50%	249	2.2	45%	467	>average	> 50%
04 /05	100	8.0	13%	123	12.5	8%	213	10.9	9%
05 /06	294	>average	> 50%	296	>average	> 50%	607	>average	> 50%
Average 70/71-05/06	188			252			375		
Station	Taferiat			Sidi Rahal			Marrakech		
Year	*1	*2	*3	*1	*2	*3	*1	*2	*3
96 /97	421	>average	> 50%	430	>average	> 50%	338	>average	> 50%
97 /98	416	>average	> 50%	389	>average	> 50%	270	>average	> 50%
98 /99	395	2.2	45%	349	2.0	50%	192	2.8	36%
99 /00	308	4.0	25%	266	4.3	23%	159	4.4	23%
00 /01	235	6.5	16%	196	9.2	11%	103	13.3	8%
01 /02	299	4.2	24%	241	5.1	20%	182	3.3	31%
02 /03	274	4.7	21%	347	2.0	49%	207	2.1	49%
03 /04	338	3.4	0.3	390	>average	> 50%	227	>average	> 50%
04 /05	215	7.7	13%	197	9.1	11%	108	11.4	9%
05 /06	335	3.4	0.3	390	>average	> 50%	253	>average	> 50%
Average 70/71-05/06	407			349			220		

Remarks: *1: Annual Rainfall (mm) *2: Probable year *3: Non-exceedance Probability (%

Table C.1.6 Basin Average Rainfall of Haouz Aquifer and Mid-upper Tensift Basin

(mm)

Basin	Haouz Aquifer			Mid-upper Tensift Basin		
Area (km2)	6,124			16,178		
Type of Rainfall	Annual Rainfall	3-years Rainfall	5-years Rainfall	Annual Rainfall	3-years Rainfall	5-years Rainfall
1970 /71	493.0			474.3		
1971 /72	360.8			410.3		
1972 /73	271.6	1125.4		298.5	1183.1	
1973 /74	410.2	1042.6		410.7	1119.5	
1974 /75	240.6	922.4	1776.2	277.9	987.1	1871.7
1975 /76	306.8	957.6	1590.0	313.7	1002.3	1711.1
1976 /77	214.0	761.4	1443.2	231.6	823.2	1532.4
1977 /78	362.1	882.9	1533.7	373.8	919.2	1607.8
1978 /79	225.2	801.3	1348.7	242.5	847.9	1439.5
1979 /80	308.7	896.0	1416.8	314.3	930.6	1476.0
1980 /81	193.6	727.5	1303.6	210.1	766.9	1372.4
1981 /82	341.1	843.4	1430.7	341.9	866.4	1482.6
1982 /83	139.7	674.4	1208.3	163.7	715.7	1272.5
1983 /84	193.3	674.1	1176.4	201.0	706.6	1231.0
1984 /85	279.2	612.2	1146.9	289.5	654.2	1206.2
1985 /86	248.8	721.3	1202.1	251.4	741.9	1247.5
1986 /87	180.5	708.5	1041.5	185.9	726.8	1091.5
1987 /88	330.1	759.4	1231.9	341.2	778.5	1269.0
1988 /89	377.5	888.1	1416.0	413.9	940.9	1481.9
1989 /90	241.6	949.2	1378.5	287.7	1042.7	1480.0
1990 /91	308.5	927.6	1438.2	305.3	1006.8	1533.9
1991 /92	227.6	777.7	1485.3	267.6	860.6	1615.6
1992 /93	153.7	689.9	1309.0	168.9	741.8	1443.4
1993 /94	272.2	653.5	1203.6	273.1	709.6	1302.5
1994 /95	320.4	746.3	1282.5	327.8	769.7	1342.6
1995 /96	445.4	1038.0	1419.3	449.1	1049.9	1486.4
1996 /97	385.7	1151.5	1577.4	392.1	1168.9	1610.9
1997 /98	323.0	1154.1	1746.7	337.7	1178.9	1779.7
1998 /99	267.5	976.3	1742.0	284.4	1014.2	1791.1
1999 /00	233.9	824.5	1655.5	261.7	883.9	1725.0
2000 /01	174.1	675.6	1384.3	192.6	738.7	1468.5
2001 /02	217.3	625.3	1215.9	224.2	678.5	1300.7
2002 /03	260.1	651.5	1153.0	262.6	679.4	1225.6
2003 /04	317.3	794.7	1202.7	346.2	833.1	1287.4
2004 /05	160.2	737.6	1129.0	178.3	787.1	1203.9
2005 /06	323.4	800.9	1278.3	334.8	859.3	1346.2
Average 70/71-05/06	280.8			295.6		
Probable Rainfall - Non exceedence (Data: 70/71-05/06)						
1%	83.1	459.8	909.5	105.5	500.5	978.6
2%	106.3	503.0	963.6	127.8	544.2	1033.3
5%	141.1	567.8	1044.7	161.2	609.9	1115.2
10%	171.9	625.4	1116.7	190.9	668.2	1188.0
20%	209.3	695.2	1204.0	226.8	738.8	1276.2
50%	280.8	828.6	1370.8	295.6	873.9	1444.9
Average of various 15 years period						
1971/72-1985/86	273.0	$\Delta P/P_{(70/71\text{-}05/06)}$	-2.8%	288.7	$\Delta P/P_{(70/71\text{-}05/06)}$	-2.3%
1976/77-1990/91	262.9	$\Delta P/P_{(70/71\text{-}05/06)}$	-6.4%	276.9	$\Delta P/P_{(70/71\text{-}05/06)}$	-6.3%
1981/82-1995/96	270.6	$\Delta P/P_{(70/71\text{-}05/06)}$	-3.6%	284.5	$\Delta P/P_{(70/71\text{-}05/06)}$	-3.7%
1986/87-2000/01	282.8	$\Delta P/P_{(70/71\text{-}05/06)}$	0.7%	299.3	$\Delta P/P_{(70/71\text{-}05/06)}$	1.2%
1991/92-2005/06	272.1	$\Delta P/P_{(70/71\text{-}05/06)}$	-3.1%	286.7	$\Delta P/P_{(70/71\text{-}05/06)}$	-3.0%

Table C.1.7 River Flow of Tensift River and Major Tributaries

(Unité : Mm^3/year)

River	Tensift	Tensift	R'Dat	Ourika	Rherhaya	N'Fis	Assif El mal	Chichoua
Station	Talmest	Abadla	Sidi Rahal	Aghbalou	Tahanaout	Lalla Takerkoust	Sidi Bouotone	Chichoua
Code	189/43	1675/44	44/54	2089/53	1565/53	1935/36-	1976/53	451/52
1970 -1971	873.5	810.5	264.0	328.0	93.0	386.3		
1971 -1972	394.2	476.2	185.1	311.6	77.3	159.4		5.0
1972 -1973	50.5	92.4	47.0	111.6	32.2	85.8		0.9
1973 -1974	533.0	473.0	164.0	215.4	64.3	198.3		31.9
1974 -1975	74.4	86.1	23.4	72.5	17.1	38.3		12.0
1975 -1976	145.7	135.3	72.5	105.0	39.7	95.0		3.5
1976 -1977	71.0	80.7	59.9	84.5	34.7	64.2		1.6
1977 -1978	153.9	123.9	90.8	112.9	45.4	195.0		18.9
1978 -1979	152.0	177.2	71.9	72.8	44.2	279.8		32.8
1979 -1980	208.5	191.7	84.5	671.7	63.1	167.0		22.1
1980 -1981	47.6	38.8	25.7	68.7	37.2	112.5		14.2
1981 -1982	201.8	151.4	39.4	108.2	39.1	65.1		16.7
1982 -1983	4.8	4.4	3.4	18.8	12.7	26.1		0.3
1983 -1984	47.3	28.4	15.6	40.1	20.2	84.4		0.6
1984 -1985	148.5	83.6	37.5	120.5	52.3	111.8	-	12.6
1985 -1986	30.8	23.5	41.3	46.7	24.4	63.7	19.0	1.6
1986 -1987	124.9	71.3	45.4	65.3	40.4	54.6	7.8	1.9
1987 -1988	466.7	287.9	98.7	133.1	71.3	491.7	92.7	115.1
1988 -1989	457.3	400.5	114.2	145.7	88.3	381.2	94.3	155.2
1989 -1990	218.5	271.2	113.8	387.9	90.2	432.2	49.8	19.2
1990 -1991	291.1	246.6	90.2	482.5	61.2	129.6	14.6	12.6
1991 -1992	128.4	84.2	64.3	618.1	117.0	325.7	45.4	10.7
1992 -1993	5.2	2.8	9.1	86.4	28.2	59.7	20.9	0.3
1993 -1994	196.5	128.4	106.3	287.0	64.3	182.8	50.1	6.9
1994 -1995	143.5	49.2	32.8	100.6	30.6	97.6	9.8	14.8
1995 -1996	570.8	526.7	234.0	211.9	101.5	504.5	75.7	115.1
1996-1997	267.7	180.4	72.2	86.7	27.8	262.6	46.4	84.5
1997-1998	162.7	148.5	46.0	74.7	40.4	221.7	13.7	23.0
1998-1999	31.4	44.8	77.6	76.3	16.6	37.5	8.9	0.3
1999-2000	181.0	58.3	44.2	102.2	34.4	186.2	50.8	36.9
2000-2001	26.1	5.8	8.1	14.5	2.6	12.7	0.8	3.2
2001-2002	35.3	24.5	12.6	95.6	18.1	81.9	11.3	4.7
2002-2003	106.3	59.9	27.4	65.9	14.9	88.3	11.5	4.4
2003-2004	106.3	59.9	127.7	124.9	21.4	130.0	7.1	3.9
2004-2005		159.3	65.4	84.8	21.4		7.2	0.5
2005-2006		14.9	72.7	65.8	21.0		24.2	
min	4.8	2.8	3.4	14.5	2.6	12.7	0.8	0.3
average	195.8	161.2	74.7	161.1	44.7	171.0	31.5	23.2
max	873.5	810.5	264.0	671.7	117.0	504.5	94.3	155.2

Source: l'ABHT

Table C.1.8 Monthly and Annual Mean Discharge of Tensift River and Its Major Tributaries

Unit : Mm^3

Station	River	Data	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Annual	Runoff during Nov-May
Talmest	Tensift	*1	1.13	12.99	15.65	18.68	21.08	19.93	31.74	36.61	24.75	5.18	0.17	0.16	188.1	90%
Abadla	Tensift	*2	1.10	7.03	10.56	12.24	16.82	16.52	27.91	32.77	23.08	5.08	0.47	0.48	154.1	91%
Sidi Rahal	R'Dat	*2	1.06	4.14	5.76	5.48	8.68	9.16	15.58	12.31	7.98	2.12	0.66	0.74	73.7	88%
Aghbalou	Ourika	*2	3.87	6.12	6.43	8.63	9.53	12.09	30.42	36.73	31.15	11.70	3.13	2.89	162.7	83%
Tahanaout	Rherhaya	*2	0.89	2.06	2.35	2.25	2.71	3.49	5.78	7.89	8.69	4.94	1.67	1.08	43.8	76%
Lalla Takerkoust	N'Fis	*1	1.90	8.97	12.52	20.32	18.36	20.12	29.29	26.30	15.74	7.12	2.19	1.78	164.6	87%
Sidi Bouothmane	Assif El Mal	*3	0.54	3.50	1.57	3.17	2.31	3.09	5.12	5.23	2.83	1.49	0.36	0.65	29.9	78%
Chichaoua	Chichaoua	*4	0.40	2.01	1.19	2.18	3.27	2.46	3.08	2.22	1.61	0.93	0.23	0.09	19.7	81%

*1: Average from 1970/71-2003/04, *2: Average from 1970/71-2005/06, *3: Average 1985/86-2005/06, *4:Average from 1970/71-2004/05
Data of 1989/90 was rejected due to its peculiarity.

Table C.1.9 Distributed Changes on Temperature and Precipitation in Morocco

Climatic zones	Representative statio	ΔT		ΔP/P	
		range	mean	range	mean
		°C	°C	%	%
North-West Tanger	Tetouan	0.6~0.8	0.7	-2.8~-5.4	-3.3
Oriental Oujda	Bouarfa	0.6~0.9	0.7	-1.8~-5.5	-2.3
		0.8~1.1	0.9	-7~0	-4.2
West	Kenitra	0.6~1	0.8	-7~0.1	-3.8
Oum er Rbia/Tensift	Marrakech	0.8~1	0.9	-7~0.1	-4.3
Middle and High Atl	Ifrane, Beni Mellal	0.8~1.1	0.9	-7~0	-4.3
Tensift Draa	Agadir	0.8~1.1	0.9	-7~0.1	-4.3
				-11.7~+2.8	-10
South-East	Ouarzazate/Errachid	0.8~1.1	1	-7.5~0	-4.3
				-11.7~+2.8	-11
South	Laayoune/Dakhla	0.8~1 0.9		North: -8 ~-1	
				South: +1~+4	

Source: Bennani et al. 2001

Table C.2.1 Surface Water Resources of Tensift Basin 1970/71- 2005/06

Unit: Mm^3/year

Discharge into Haouz Plain	N'Fis River at Lalla Takerkoust	R'Dat River at Sidi Rahal	Zat River at Taheriat	Ourika River at Aghbalou	Rherhaya River at Tahanaout	Lahr River at Herrisane	Assif El Mal River at Sidi	Chichoua River at Chishoua
Active catchment area (km^2)	1,692	569	516	503	225	65	517	1,317
1970 -1971	386.3	264.0	278.5	328.0	93.0			
1971 -1972	159.4	185.1	229.0	311.6	77.3			5.0
1972 -1973	85.8	47.0	93.7	111.6	32.2			0.9
1973 -1974	198.3	164.0	205.3	215.4	64.3			31.9
1974 -1975	38.3	23.4	53.0	72.5	17.1			12.0
1975 -1976	95.0	72.5	122.7	105.0	39.7			3.5
1976 -1977	64.2	59.9	66.2	84.5	34.7			1.6
1977 -1978	195.0	90.8	96.5	112.9	45.4			18.9
1978 -1979	279.8	71.9	71.9	72.8	44.2			32.8
1979 -1980	167.0	84.5	134.0	671.7	63.1			22.1
1980 -1981	112.5	25.7	76.3	68.7	37.2			14.2
1981 -1982	65.1	39.4	89.9	108.2	39.1			16.7
1982 -1983	26.1	3.4	17.6	18.8	12.7			0.3
1983 -1984	84.4	15.6	49.5	40.1	20.2			0.6
1984 -1985	111.8	37.5	84.2	120.5	52.3		-	12.6
1985 -1986	63.7	41.3	65.0	46.7	24.4		19.0	1.6
1986 -1987	54.6	45.4	-	65.3	40.4		7.8	1.9
1987 -1988	491.7	98.7	130.9	133.1	71.3	N/A	92.7	115.1
1988 -1989	381.2	114.2	182.0	145.7	88.3		94.3	155.2
1989 -1990	432.2	113.8	151.4	387.9	90.2		49.8	19.2
1990 -1991	129.6	90.2	92.4	482.5	61.2		14.6	12.6
1991 -1992	325.7	64.3	97.1	618.1	117.0		45.4	10.7
1992 -1993	59.7	9.1	38.8	86.4	28.2		20.9	0.3
1993 -1994	182.8	106.3	135.3	287.0	64.3		50.1	6.9
1994 -1995	97.6	32.8	61.5	100.6	30.6		9.8	14.8
1995 -1996	504.5	234.0	199.0	211.9	101.5		75.7	115.1
1996-1997	262.6	72.2	60.9	86.7	27.8		46.4	84.5
1997-1998	221.7	46.0	108.2	74.7	40.4		13.7	23.0
1998-1999	37.5	77.6	41.3	76.3	16.6		8.9	0.3
1999-2000	186.2	44.2	183.2	102.2	34.4		50.8	36.9
2000-2001	12.7	8.1	20.5	14.5	2.6		0.8	3.2
2001-2002	81.9	12.6	16.8	95.6	18.1		11.3	4.7
2002-2003	88.3	27.4	46.4	65.9	14.9		11.5	4.4
2003-2004	130.0	127.7	79.2	124.9	21.4		7.1	3.9
2004-2005		65.4	41.9	84.8	21.4		7.2	0.5
2005-2006		72.7	11.2	65.8	21.0		24.2	
Average Whole Year								
Minimum	12.7	3.4	11.2	14.5	2.6		0.8	0.3
Average	171.0	74.7	98.0	161.1	44.7	N/A	31.5	23.2
Maximum	504.5	264.0	278.5	671.7	117.0		94.3	155.2
Average of 1970-2002								
Minimum	12.7	3.5	16.8	14.5	2.6	0.3	0.8	10.9
Average	174.8	72.8	103.9	155.8	47.8	9.9	35.9	66.8
Maximum	504.5	264.0	278.7	618.5	117.1	25.8	113.0	230.6

Source: ABHT

Table C.2.2 Actual Water Distribution of Lalla Takerkoust Dam 1985/86-2005/06

Unit : Mm^3

Year	Seguias de l'hyp. Constante	Seguias in N'Fis Left Bank	Seguias in N'Fis Right Bank	Secteur N1-1 (P2)	Secteur N4 (P1)	Portable Water Marrakech (ONEP)	Outflow at Lalla Takerkoust Dam
85/86	32.078	31.177	5.186	-	-	1.215	69.655
86/87	24.259	21.981	3.776	-	-	0.000	50.015
87/88	31.477	156.804	32.077	-	-	0.856	221.214
88/89	35.849	146.105	24.582	-	-	0.000	206.536
89/90	22.761	162.769	31.337	7.109	-	0.477	224.453
90/91	14.577	65.056	12.115	14.978	-	0.322	107.048
91/92	13.134	122.510	23.299	17.092	-	0.026	176.062
92/93	17.016	27.611	0.778	19.866	-	0.095	65.365
93/94	16.469	83.100	11.953	14.593	-	0.000	126.115
94/95	12.292	39.890	0.898	24.981	-	0.000	78.061
95/96	12.885	151.534	26.581	18.228	-	0.000	209.228
96/97	12.856	117.217	13.292	16.479	-	0.000	159.845
97/98	13.050	74.138	10.913	22.725	-	0.040	120.865
98/99	10.081	18.133	0.000	22.365	-	0.500	51.078
99/00	12.653	36.762	6.973	19.995	0.959	4.519	81.861
00/01	7.176	3.559	0.000	11.048	0.508	0.822	23.113
01/02	4.959	13.256	0.726	7.360	2.739	4.354	33.393
02/03	8.893	27.125	6.155	13.578	9.468	3.243	68.462
03/04	9.057	21.181	5.651	14.302	11.542	2.726	64.460
04/05	9.253	21.080	2.467	15.751	11.805	4.118	64.476
05/06	8.400	19.462	3.415	12.860	10.413	6.406	60.955

Source: ABHT

Table C.2.3 Actual Water Distribution of Transfer by Rocade Canal 1988/89-2005/06

Unit: Mm^3

Year	Use within Lakhdar River Basin					
	PMH Lakhdar	Seguia Tagharghourt	B1 Canal - Upper Tessaout (Yagoubia)	B2 Canal - Upper Tessaout (Sud El Kelaa)	Portable Water El Kelaa (ONEP)	Sub-total
1988 -1989	-	4.100	-	-	-	4.100
1989 -1990	-	4.066	2.644	-	-	6.710
1990 -1991	-	3.954	8.976	0.861	-	13.790
1991 -1992	-	4.111	9.487	0.000	-	13.598
1992 -1993	-	2.893	6.537	0.000	-	9.430
1993 -1994	-	2.863	7.956	0.000	-	10.819
1994 -1995	-	3.327	6.905	8.205	-	18.437
1995 -1996	-	2.607	8.680	4.782	-	16.069
1996-1997	-	4.100	1.352	9.461	1.892	16.805
1997-1998	-	4.066	16.506	11.095	1.892	33.560
1998-1999	-	3.163	15.815	10.846	1.734	31.558
1999-2000	-	2.830	15.263	3.079	1.581	22.753
2000-2001	-	1.170	7.584	1.536	1.852	12.142
2001-2002	-	0.817	5.644	1.027	2.012	9.500
2002-2003	-	1.057	11.282	2.511	2.682	17.532
2003-2004	-	1.674	13.363	0.829	2.405	18.271
2004-2005	3.885	2.348	19.335	8.825	2.472	36.865
2005-2006	5.072	1.430	19.717	7.113	2.519	35.851

Year	Use after Transferred to Tensift River Basin					
	Central Haouz Sectors	Portable Water Marrakech (ONEP)	Golf Course	Lower N'Fis River Right Bank Sectors	Seguia Targua & Aslejour	Sub-total
1988 -1989	-	19.577	1.892	0.000	-	21.469
1989 -1990	-	21.408	1.877	0.000	19.787	43.073
1990 -1991	-	22.654	1.892	29.890	19.919	74.354
1991 -1992	-	24.814	1.897	84.407	12.693	123.812
1992 -1993	-	24.752	1.851	78.381	5.791	110.775
1993 -1994	-	28.984	1.751	74.780	6.562	112.077
1994 -1995	-	29.630	1.892	76.812	7.232	115.565
1995 -1996	-	31.197	1.897	58.381	6.679	98.153
1996-1997	-	34.586	1.892	62.907	6.936	106.322
1997-1998	4.631	32.281	1.871	68.540	8.482	115.806
1998-1999	15.928	30.512	1.892	60.487	7.090	115.910
1999-2000	35.533	32.373	1.887	49.238	7.328	126.360
2000-2001	19.326	30.516	1.262	19.373	4.056	74.533
2001-2002	7.831	29.774	1.026	15.326	2.727	56.685
2002-2003	20.377	37.243	1.291	18.756	4.411	82.078
2003-2004	27.493	38.916	1.158	37.041	4.007	108.614
2004-2005	33.455	43.551	1.233	59.927	4.675	142.840
2005-2006	26.242	46.182	1.258	52.897	3.661	130.239

Year	Loss	Total	Outflow at Sidi Driss Dam
1988 -1989	14.618	25.569	40.188
1989 -1990	31.226	49.782	81.008
1990 -1991	8.785	88.144	96.929
1991 -1992	22.982	137.409	160.391
1992 -1993	4.468	120.205	124.673
1993 -1994	11.755	122.896	134.651
1994 -1995	10.653	134.002	144.656
1995 -1996	15.701	114.222	129.923
1996-1997	43.144	123.126	166.271
1997-1998	42.473	149.366	191.840
1998-1999	39.367	147.468	186.835
1999-2000	37.403	149.113	186.516
2000-2001	14.087	86.675	100.762
2001-2002	11.452	66.184	77.636
2002-2003	7.148	99.610	106.758
2003-2004	4.190	126.885	131.075
2004-2005	0.515	179.705	180.220
2005-2006	6.554	167.970	172.644

Source: ABHT

Table C.2.4 Water Intake from Rivers by Seguia Systems 1985/86-2000/01

Unit: Mm^3

	Sub-basin			
	R'Dat River	Zat River	Ourika River	Rheraya River
Active Catchment Area (km^2)	569	516	503	225
Number of Seguias	20	30	24	11
1985 -1986	34.55	40.56	64.95	20.72
1986 -1987	17.39	43.19	51.67	23.66
1987 -1988	31.20	87.93	101.30	31.71
1988 -1989	29.95	85.28	132.66	36.10
1989 -1990	39.74	62.84	130.81	24.08
1990 -1991	36.48	36.01	95.81	36.22
1991 -1992	39.39	64.73	124.21	48.01
1992 -1993	34.81	41.45	80.57	18.35
1993 -1994	64.46	84.16	119.49	34.24
1994 -1995	42.05	37.96	72.66	17.49
1995 -1996	52.60	54.07	110.12	37.77
1996-1997	61.53	36.91	79.83	24.30
1997-1998	62.65	38.41	88.12	24.49
1998-1999	77.69	33.23	66.82	17.59
1999-2000	22.59	38.82	65.26	20.19
2000-2001	36.52	11.67	-	2.85
Average Seguia Intake (1)	44.8	49.5	93.1	26.0
Average Annual River Flow Amount (2	71.2	99.0	177.4	93.1
Average Ratio of Seguia Intake (1)/(2)	62.9%	50.0%	52.5%	51.7%
Average	54.3%			

Source : Etude hydrologique des prelevements au fil de l'eau dans le bassin du Tensift, 2003

Table C.2.5 Estimation of Water Resources Supplied by Seguias

Sub-basin	Effective area of basin (km^2)	Design annual discharge* (Mm^3)	Ratio of water take to discharge	Available water in Seguias (Mm^3)
R'dat	569	71	62.9%	45
Zat	516	99	50.0%	49
Ourika	503	177	52.5%	93
Rheraya	225	50	51.7%	26
El Mal	517	36	54.3%**	20
Chichaoua	1,317	36		19
Total	5,404	470	54.3%	252

Remarks: Seguia systems in N'Fis river is counted in the table of Dam supply.

*: Design annual discharge of rivers are estimated as average of 1985-2001.

**: Estimation from sub-basins other than El Mal and Chichoua.

Table C.2.6 Estimation of Possible Artificial Recharge Amount (1/2)

(Mm^3) (Days)

River	Annual Discharge	Seguia Withdrawal	River Course	Infiltration in River Course	Flow Remaining	Art. Recharge	Days Flow Remaining
Ourika	150.0	80.8	69.2	17.3	51.9	3.8	47
Zat	83.7	41.7	42.0	10.5	31.5	5.5	74
Rerhaya	39.9	22.7	17.2	4.3	12.9	2.9	52
R'Dat	66.4	39.3	27.1	6.8	20.3	2.1	27
Sum	340.1	184.6	155.5	38.9	116.6	14.3	

OURIKA 1991/92-2003/04

(Mm^3)

	Annual Discharge	Seguia Withdrawal	River Course	Infiltration in River Course	Flow Remaining	Art. Recharge	Days Flow Remaining
91/92-03/04	149.97	80.81	69.16	17.29	51.87	3.81	47
	100.0%	53.9%	46.1%	11.5%	34.6%	2.5%	
			100.0%	25.0%	75.0%	5.5%	
1991/92	621.01	143.57	477.45	119.36	358.09	12.18	145
1992/93	86.44	64.88	21.57	5.39	16.18	2.77	33
1993/94	287.04	134.33	152.71	38.18	114.53	10.53	123
1994/95	100.75	68.58	32.17	8.04	24.13	3.57	44
1995/96	212.45	126.89	85.56	21.39	64.17	8.61	104
1996/97	86.86	67.13	19.73	4.93	14.80	2.42	34
1997/98	74.81	73.51	1.30	0.33	0.98	0.28	4
1998/99	76.41	69.02	7.39	1.85	5.54	2.26	32
1999/00	102.46	52.46	49.99	12.50	37.50	1.24	15
2000/01	14.55	14.34	0.21	0.05	0.15	0.09	1
2001/02	95.53	52.57	42.96	10.74	32.22	3.38	41
2002/03	65.99	65.71	0.28	0.07	0.21	0.10	2
2003/04	125.33	117.57	7.75	1.94	5.81	2.10	35

ZAT 1991/92-2003/04

(Mm^3)

	Annual Discharge	Seguia Withdrawal	River Course	Infiltration in River Course	Flow Remaining	Art. Recharge	Days Flow Remaining
91/92-03/04	83.74	41.70	42.04	10.51	31.53	5.50	74
	100.0%	49.8%	50.2%	12.6%	37.7%	6.6%	
			100.0%	25.0%	75.0%	13.1%	
1991/92	97.46	52.63	44.83	11.21	33.62	7.82	102
1992/93	38.74	33.91	4.83	1.21	3.63	1.66	27
1993/94	135.14	63.87	71.27	17.82	53.45	10.63	140
1994/95	61.47	36.31	25.16	6.29	18.87	4.50	57
1995/96	199.56	69.34	130.21	32.55	97.66	15.91	201
1996/97	60.91	40.85	20.06	5.01	15.04	4.94	61
1997/98	108.26	68.77	39.49	9.87	29.62	8.82	124
1998/99	41.21	36.67	4.54	1.14	3.41	2.12	35
1999/00	183.64	28.86	154.79	38.70	116.09	3.12	43
2000/01	19.66	10.21	9.46	2.36	7.09	0.78	11
2001/02	16.75	12.77	3.98	1.00	2.99	1.25	18
2002/03	46.32	36.33	9.99	2.50	7.49	3.12	44
2003/04	79.45	51.55	27.90	6.97	20.92	6.89	96

Table C.2.6 Estimation of Possible Artificial Recharge Amount (2/2)

RERHAYA 1991/92-2003/04 (Mm^3)

	Annual Discharge	Seguia Withdrawal	River Course	Infiltration in River Course	Flow Remaining	Art. Recharge	Days Flow Remaining
91/92-03/04	39.90	22.73	17.17	4.29	12.88	2.88	52
	100.0%	57.0%	43.0%	10.8%	32.3%	7.2%	
			100.0%	25.0%	75.0%	16.8%	
1991/92	117.39	30.13	87.26	21.81	65.44	7.67	100
1992/93	28.24	26.42	1.81	0.45	1.36	1.36	52
1993/94	64.45	30.35	34.10	8.53	25.58	8.22	110
1994/95	30.57	19.63	10.94	2.73	8.20	3.24	55
1995/96	101.96	40.37	61.59	15.40	46.19	9.49	148
1996/97	27.81	24.19	3.62	0.90	2.71	2.35	60
1997/98	40.24	38.04	2.20	0.55	1.65	1.28	67
1998/99	16.55	15.60	0.94	0.24	0.71	0.61	15
1999/00	34.48	17.95	16.53	4.13	12.40	0.69	8
2000/01	2.60	2.60	0.00	0.00	0.00	0.00	0
2001/02	18.10	14.01	4.09	1.02	3.06	2.41	58
2002/03	14.93	14.93	0.00	0.00	0.00	0.00	0
2003/04	21.41	21.27	0.14	0.04	0.11	0.11	6

R'DAT 1991/92-2003/04 (Mm^3)

	Annual Discharge	Seguia Withdrawal	River Course	Infiltration in River Course	Flow Remaining	Art. Recharge	Days Flow Remaining
91/92-03/04	66.44	39.33	27.11	6.78	20.33	2.08	27
	100.0%	59.2%	40.8%	10.2%	30.6%	3.1%	
			100.0%	25.0%	75.0%	7.7%	
1991/92	64.56	33.69	30.87	7.72	23.15	2.35	28
1992/93	9.16	8.30	0.86	0.21	0.64	0.26	4
1993/94	106.40	61.39	45.01	11.25	33.76	6.05	73
1994/95	32.85	22.19	10.67	2.67	8.00	1.14	15
1995/96	234.53	76.71	157.82	39.46	118.37	6.94	89
1996/97	72.13	44.94	27.20	6.80	20.40	2.42	33
1997/98	45.96	22.26	23.70	5.92	17.77	1.64	19
1998/99	77.48	72.62	4.86	1.22	3.65	1.24	18
1999/00	44.58	38.67	5.92	1.48	4.44	0.43	6
2000/01	8.08	7.71	0.37	0.09	0.28	0.11	2
2001/02	12.62	12.23	0.38	0.10	0.29	0.26	4
2002/03	27.42	24.94	2.47	0.62	1.85	0.26	4
2003/04	127.97	85.66	42.31	10.58	31.73	3.98	54

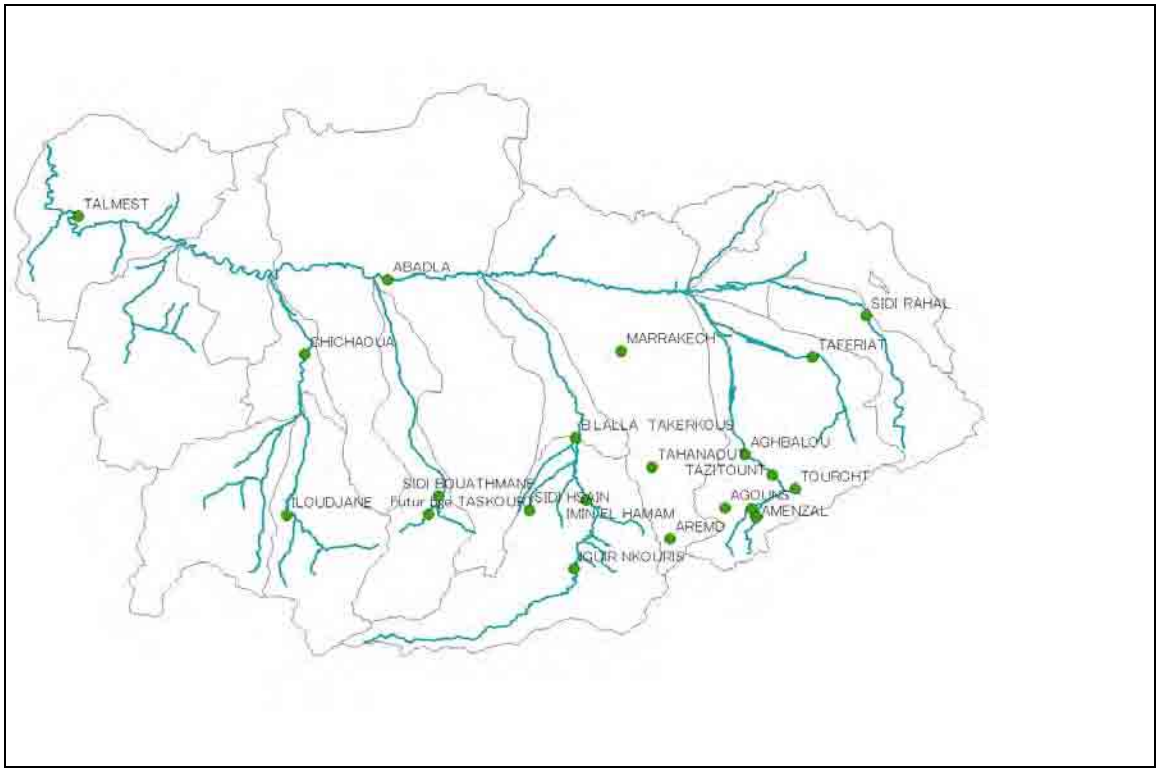


Figure C.1.1 Meteorological Observation Network of ABHT

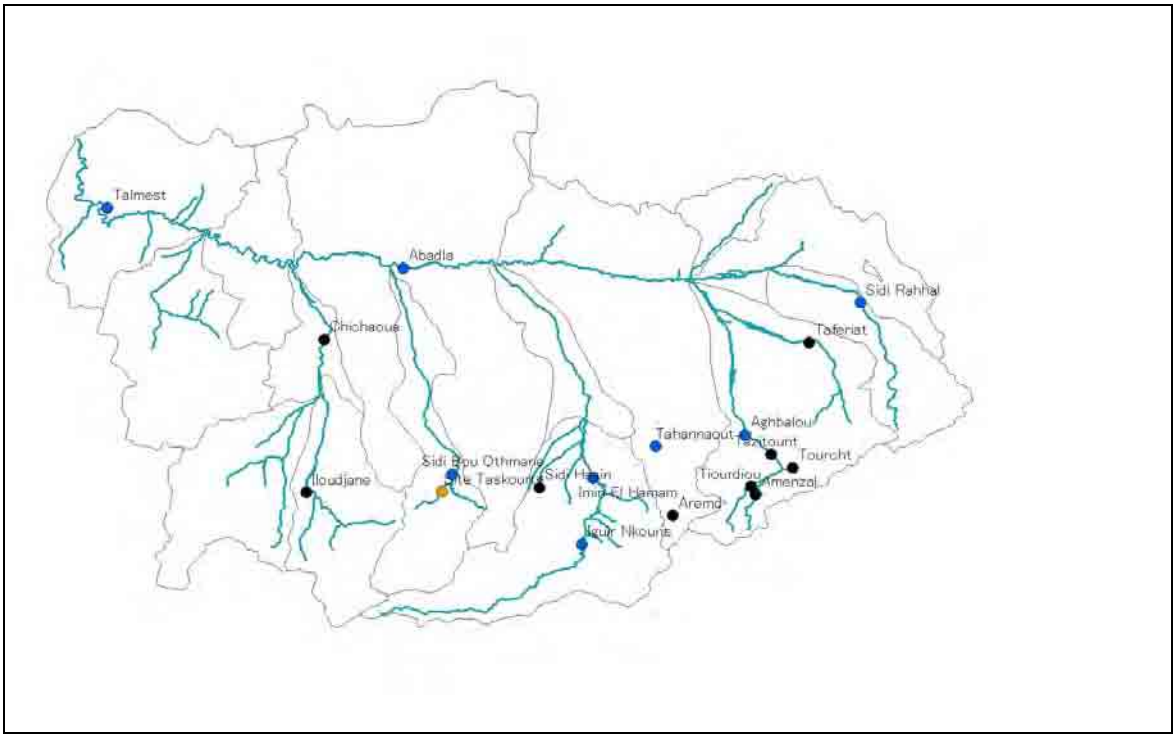
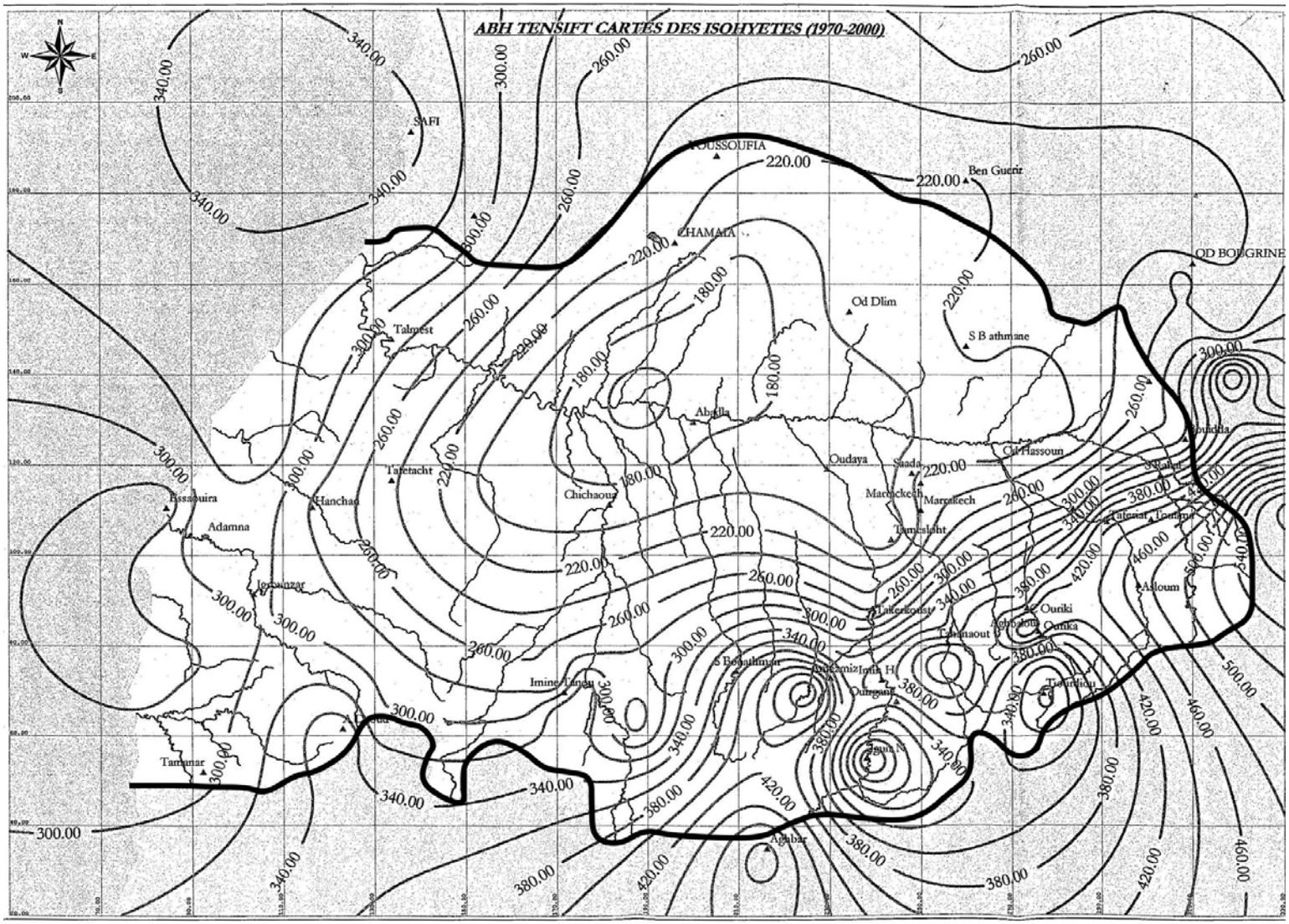
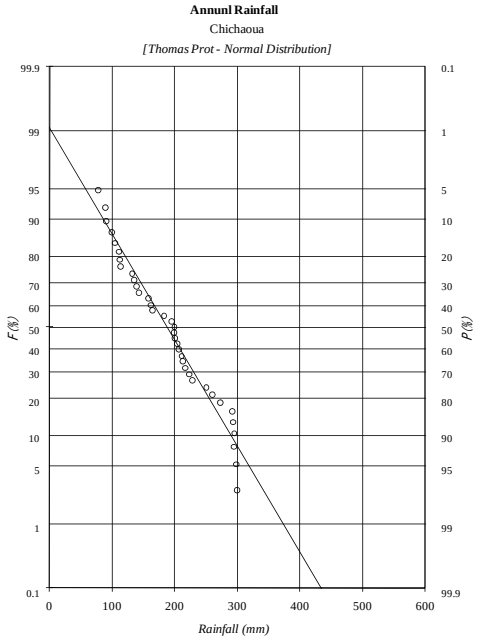


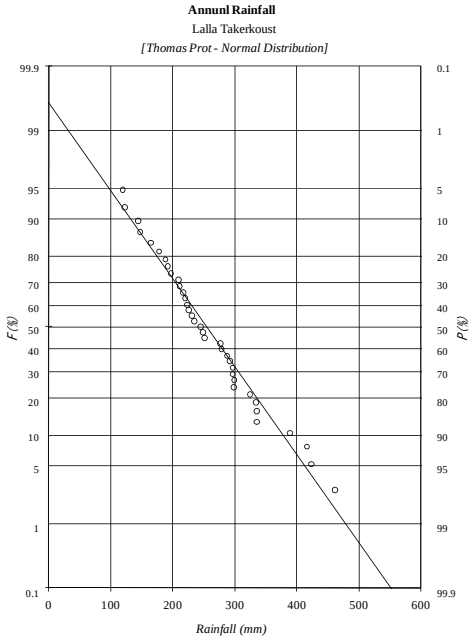
Figure C.1.2 Hydrological Observation Network of ABHT

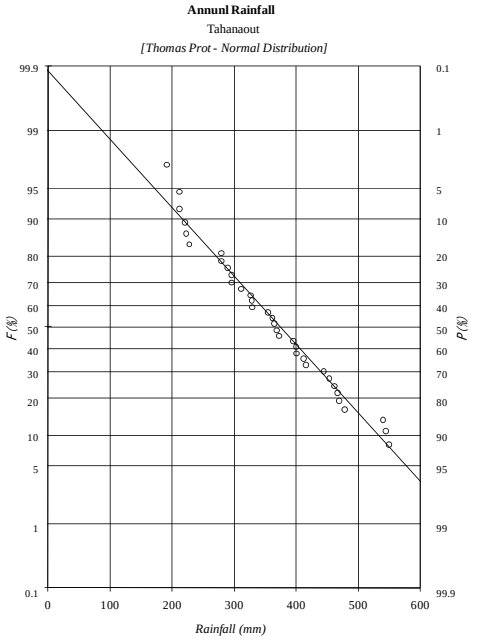


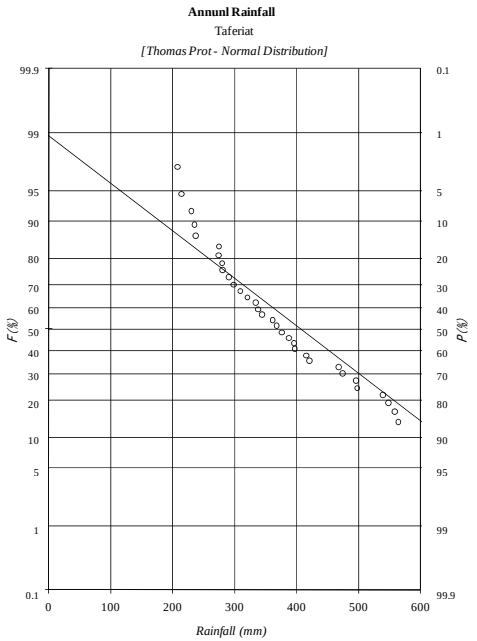
Source : Etude d'Actualization des Ressources en Eau de Surface de la Zone d'Action l'Agence du Basiin, ABHT

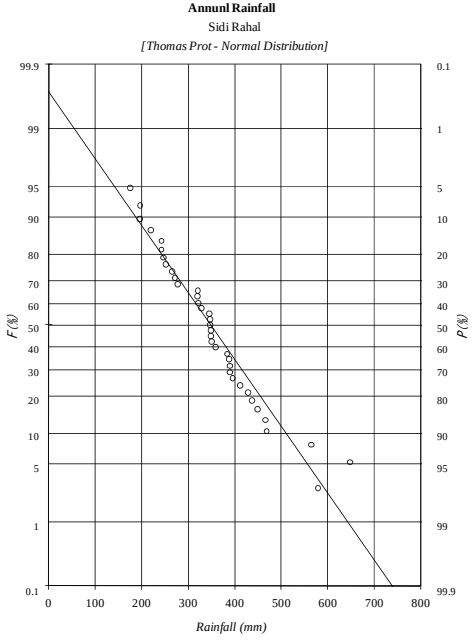
Figure C.1.3 Iso-hyeto Map of Tensift Basin (Average of 1970-2000)











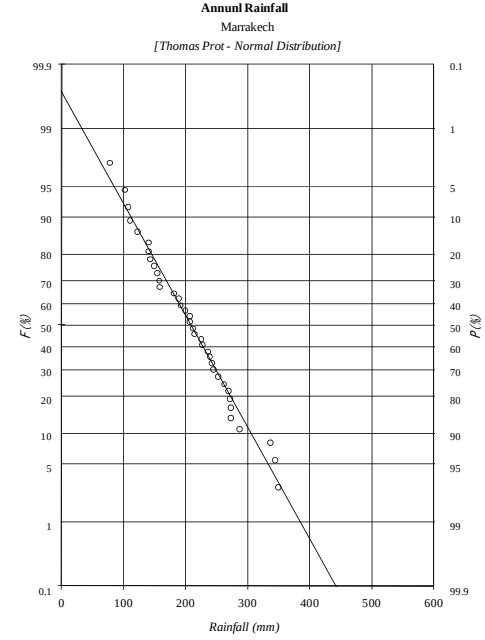


Figure C.1.4 Non-exceedence Probable Rainfall of Major Stations

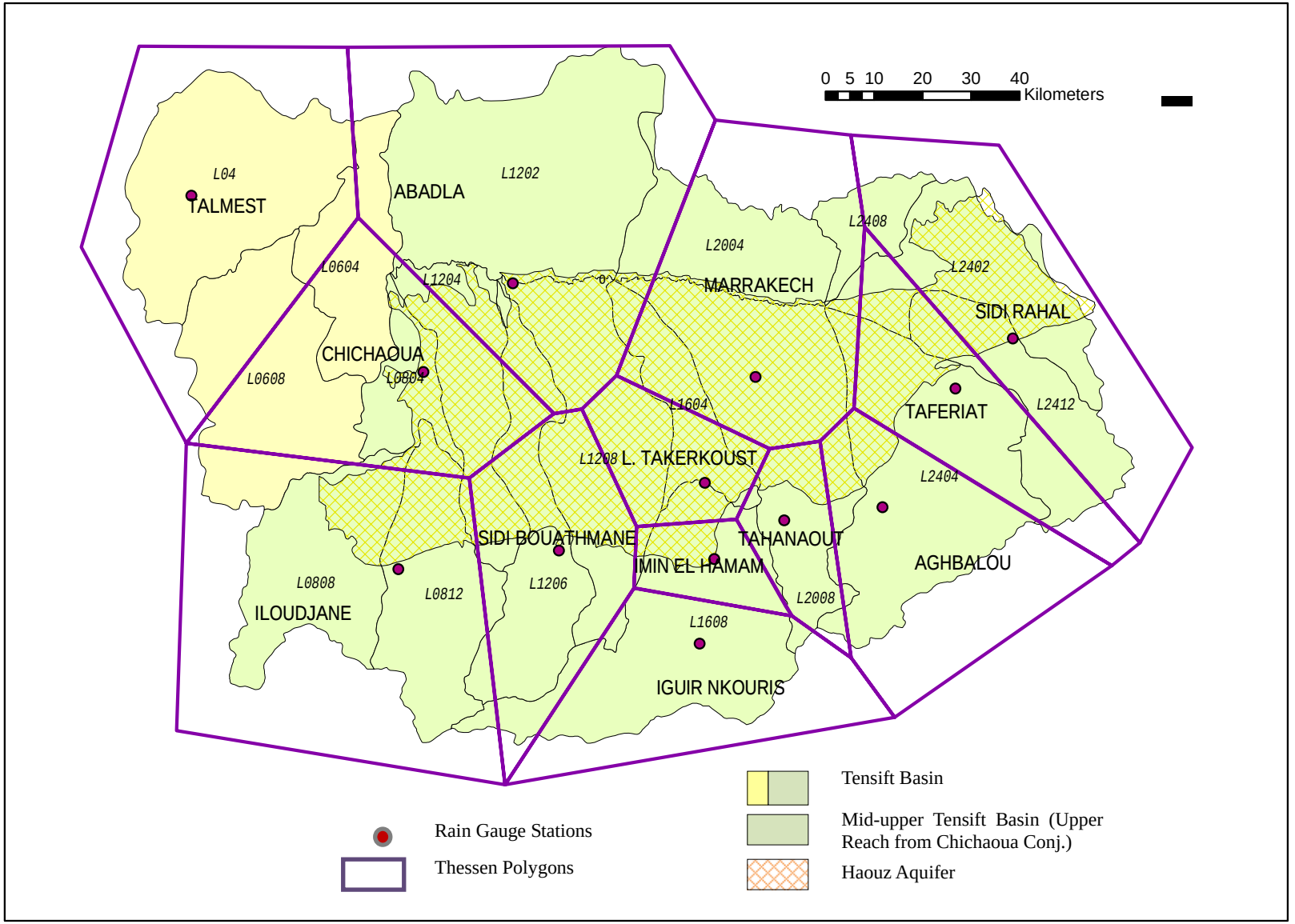
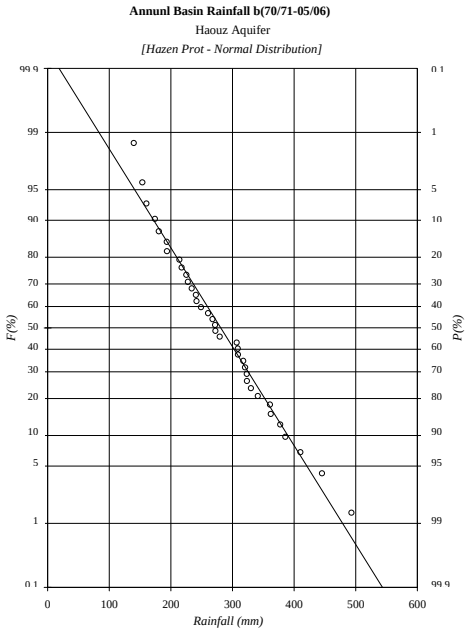
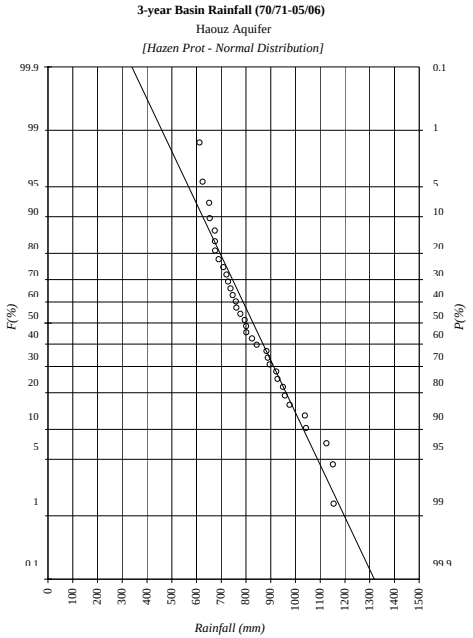
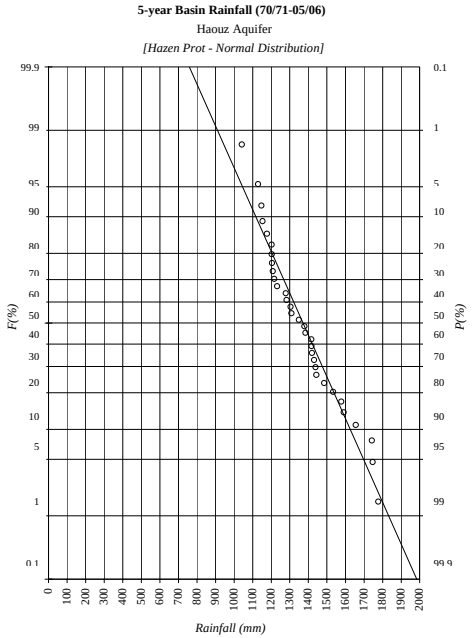
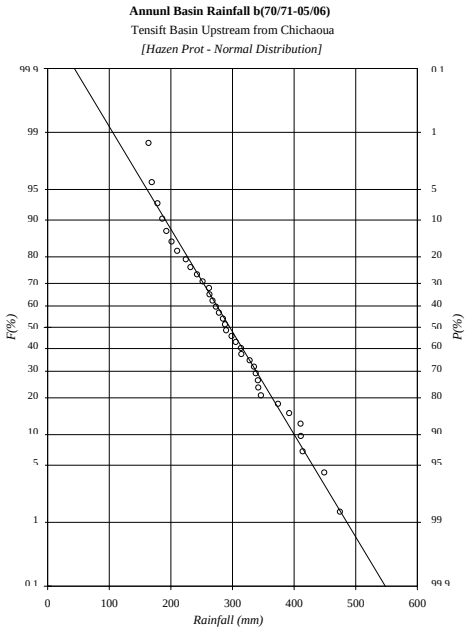


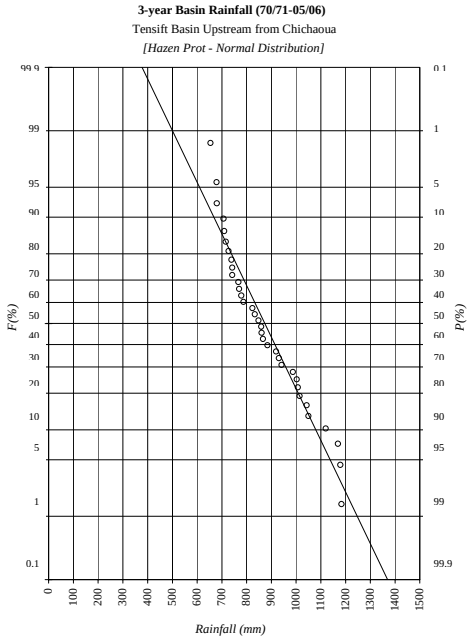
Figure C.2.5 Rain Gauge Stations and Thessen Polygones











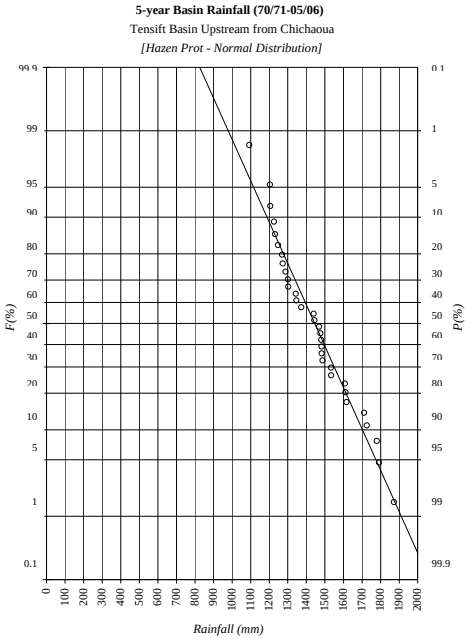
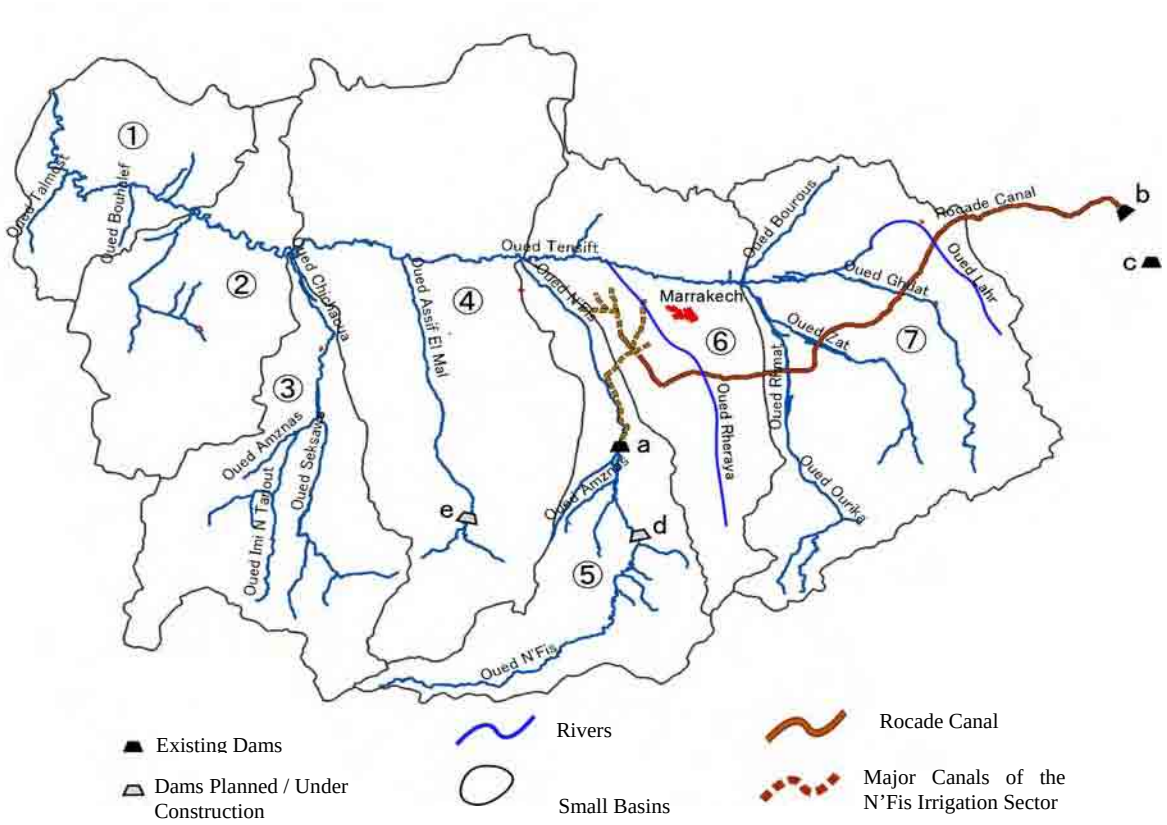
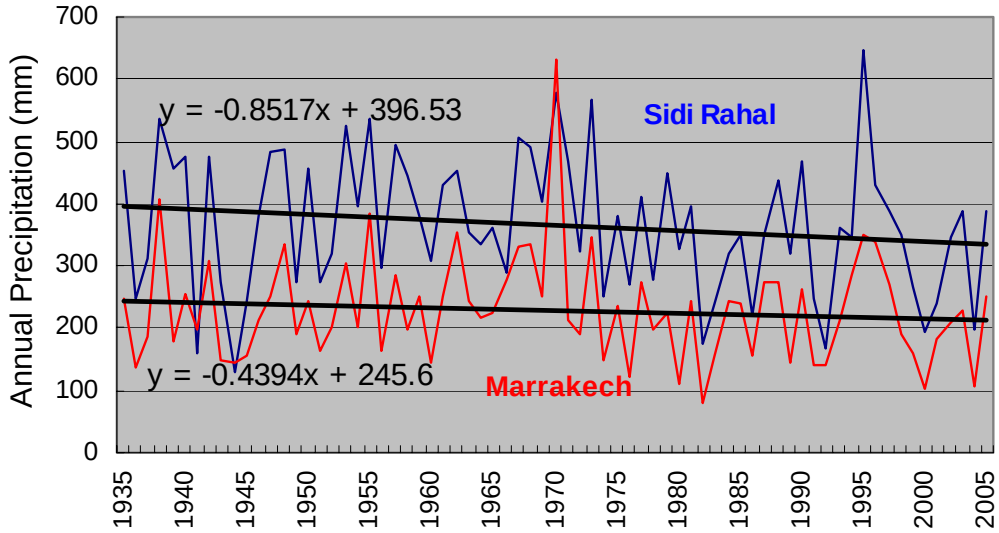


Figure C.1.6 Basin Average Probable Rainfall (Non-exceedence)



Small Basins		Dam Sites	
①	Down Stream Side of Tiroula River	a	Lalla Takerkoust Dam
②	Between Tiroul and Chichaoua Rivers	b	Sidi Driss Dam
③	Basin of Chichaoua River	c	Moulay Hassan I Dam
④	Between Chichaoua and N'fis Rivers	d	Wirgane Dam
⑤	Basin of N'fis River	e	Taskourt Dam
⑥	Between N'fis and Rhmat Rivers		
⑦	Upstream Side of Rhmat River		Source : ABHT

Figure C.1.7 River System of Tensift Basin



Source : l'ABHT

Figure C.1.8 Long Term Change of Precipitation in the Study Area

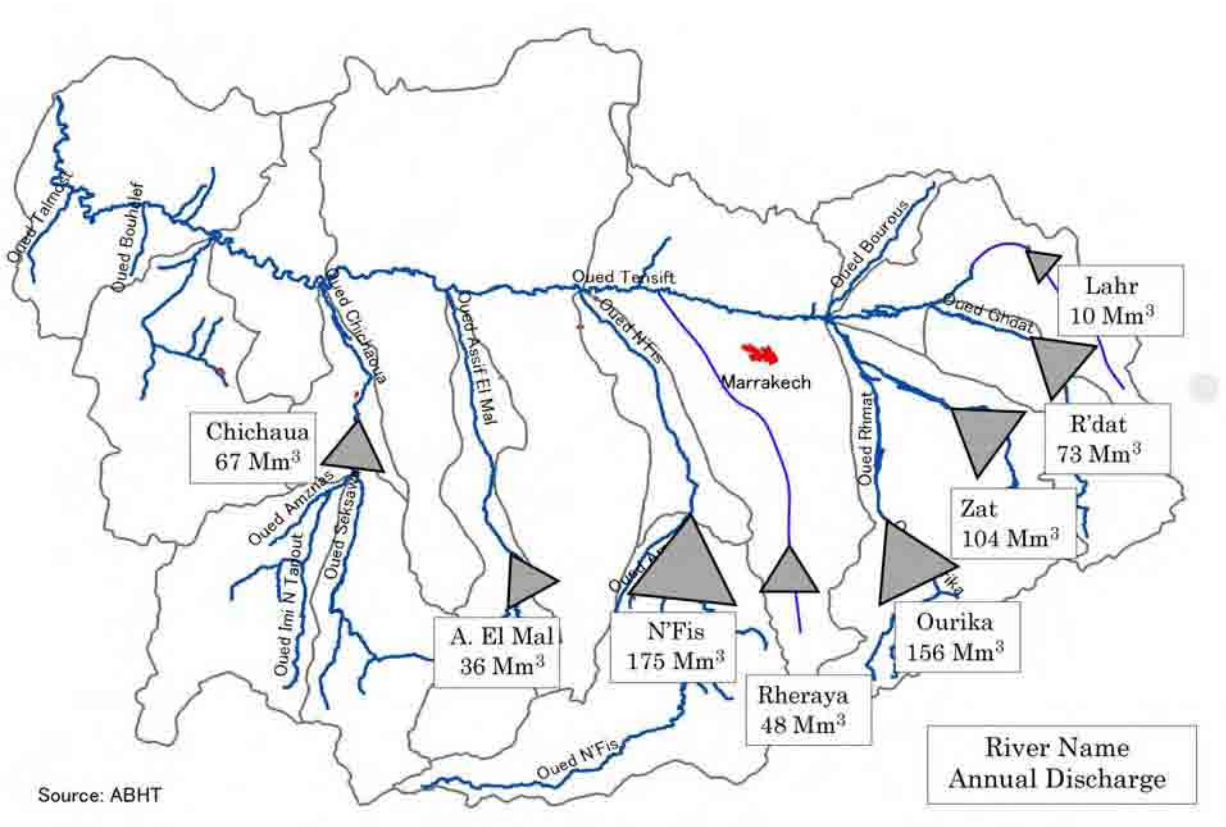


Figure C.2.1 Outflow from Major Rivers (Average of 1970-2002)

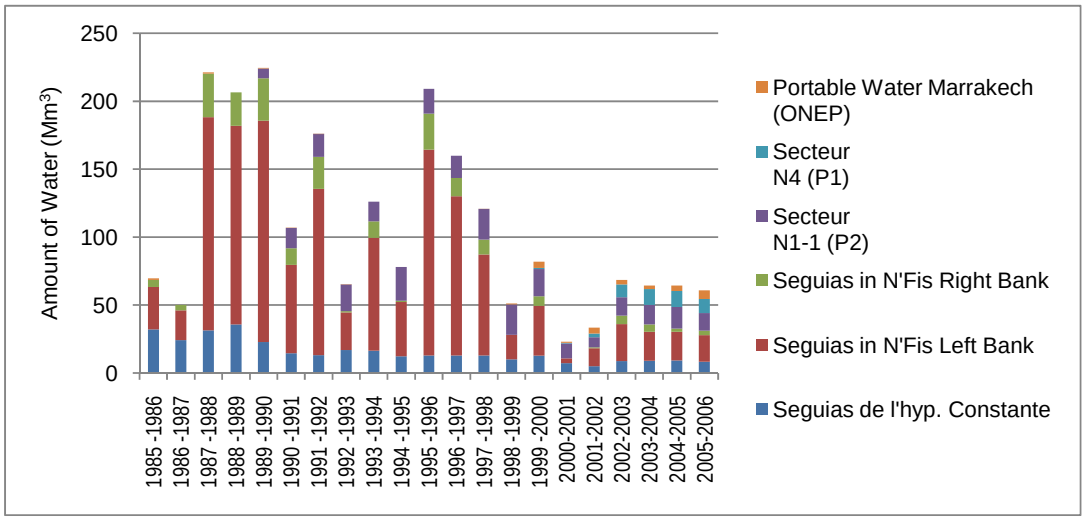


Figure C.2.2 Actual Water Distribution of Lalla Takerkoust Dam

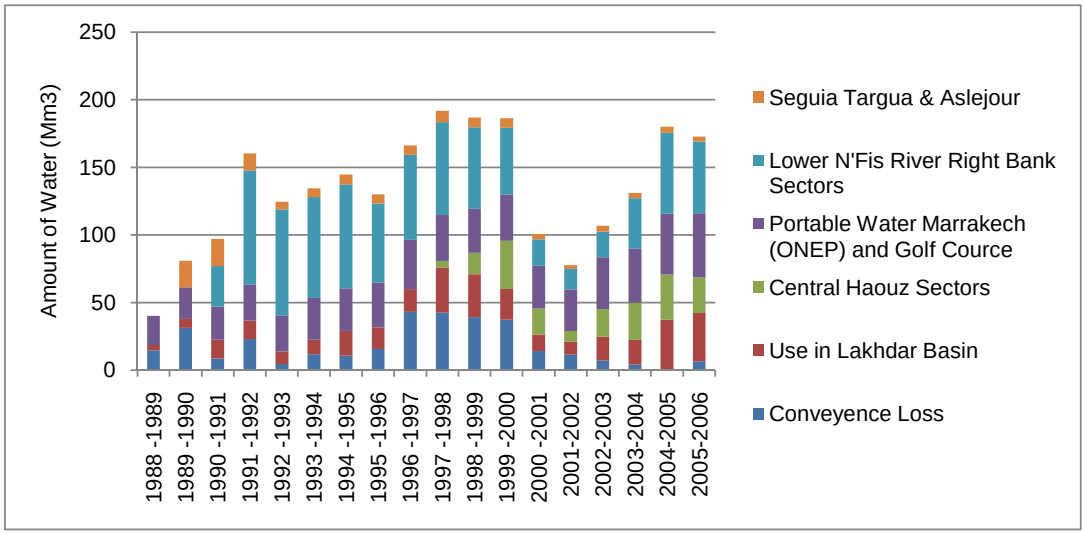


Figure C.2.3 Actual Water Distribution of Transfer by Rocade Canal

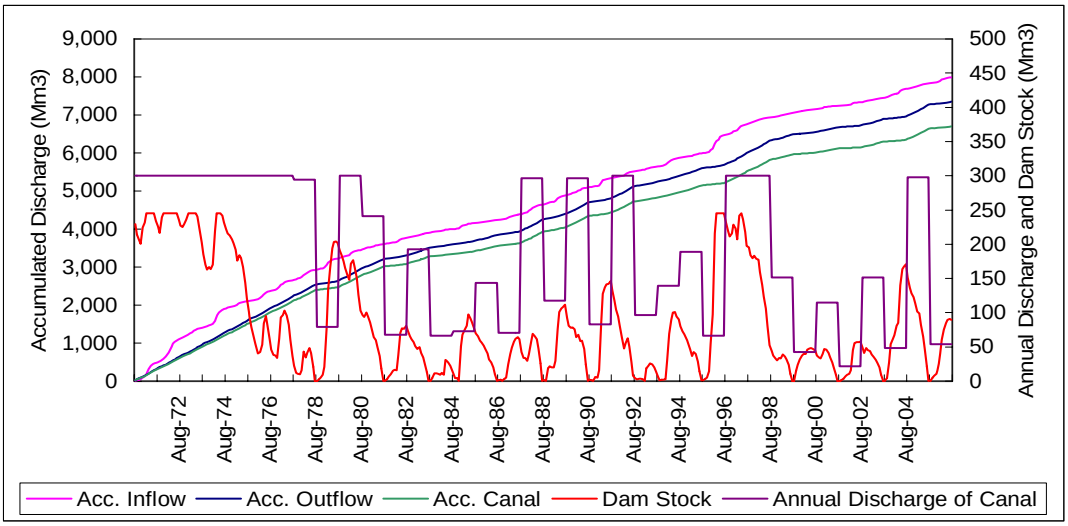


Figure C.2.4 Simplified Dam Water Balance Analysis of Hassan 1st Dam

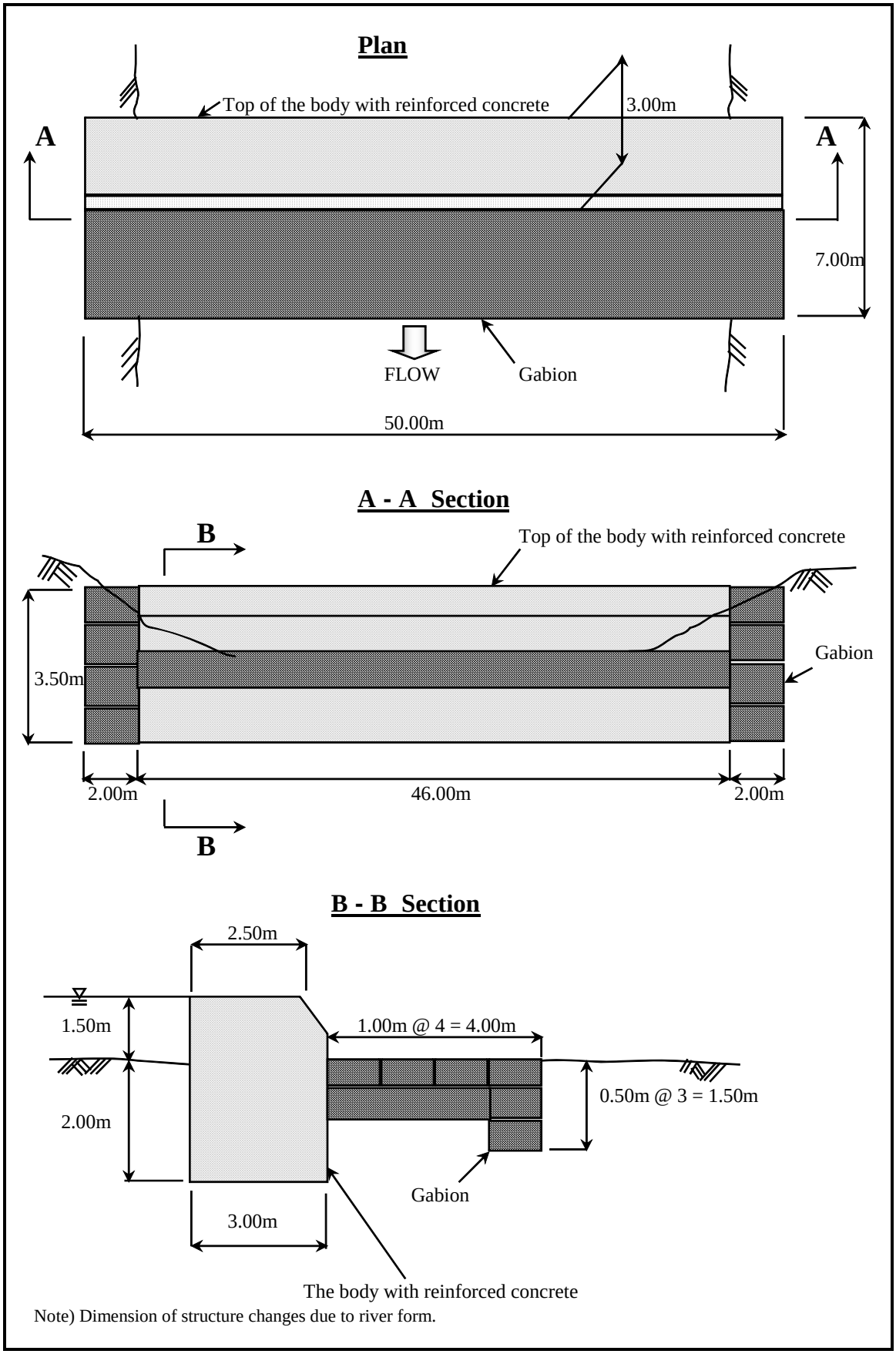


Figure C.2.5 General Plan of Artificial Groundwater Recharge Facility

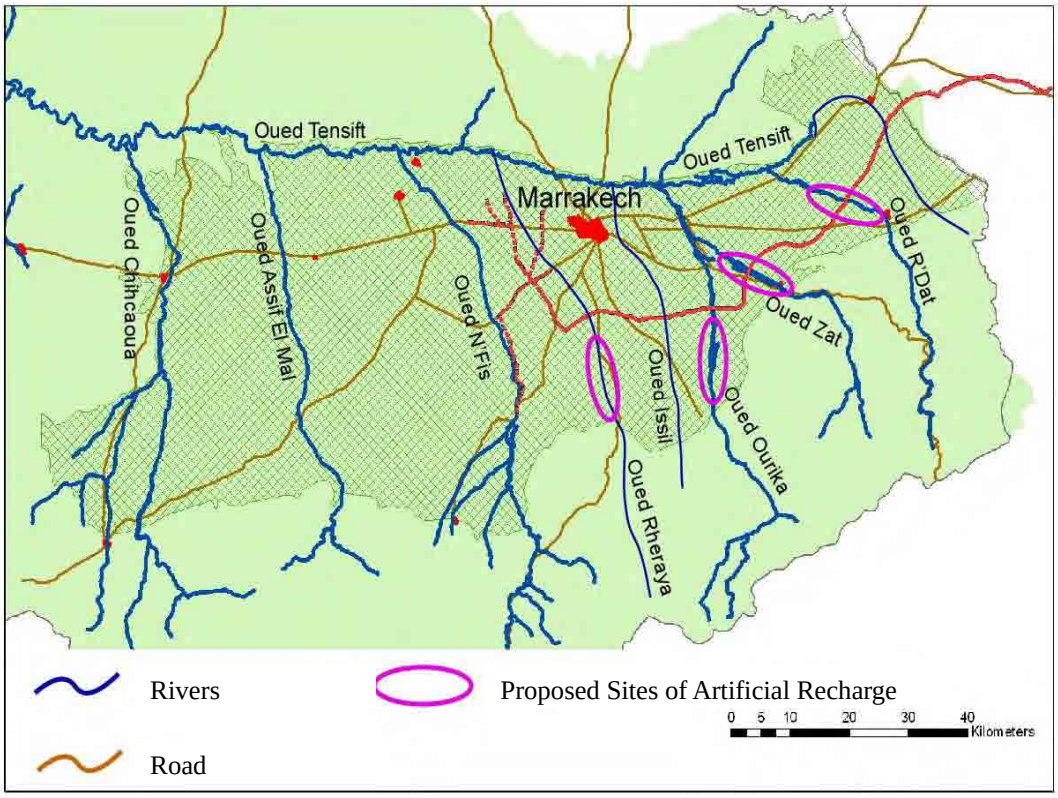


Figure C.2.6 Artificail Groundwater Recharge Facility Site Map

D: IRRIGATION

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D: IRRIGATION

D.1 Estimation of Irrigation Water Demand

D.1.1 Irrigated Area and Cultivated Crop

The statistic information on actual irrigated area and cultivated area by crops are not prepared as an uniformed database in the Study Area. Thus, the following information were collected and analyzed in order to estimate irrigation water demand in the Haouz Plain.

- Information prepared by ORMVAH, which shows record of 2003/04 by communes for ORMVAH Area.
- Information prepared by DPA Marrakech, which shows average cultivating area of the last 5 years for DPA Marrakech Area.
- Information prepared by DPA Chichoua, which shows record of 2005/06 by communes for DPA Chichoua Area.

According to above information, there are 176 thousand ha of irrigated area, of which 80 thousand ha (46%) is for cereal crops occupies, 13 thousand ha (1%) for beans, 10 thousand ha (6%) for forage crops, 7 thousand ha (4%) for vegetables, and 77 thousand ha (44%9 for orchard crops. The year of data is different for each organization; however, it could be used for estimation of proportion of crops in order to calculate the water demand of the areas. The proportion of cultivation area by crops shown in Table D.1.2 was applied for estimating present irrigation water demand in the Study.

D.1.2 Crop Water Requirement

In order to estimate water demand for irrigation, the crop water requirement shown below (RAZOKI, 2001), which is used in ORMVAH was applied. The requirement in the table shows the NET crop water requirement, which dose not consider effective rainfall and application efficiency in the field yet.

Crop Water Requirement in the Haouz Plain (RAZOKI, 2001)

Type of crops	Crop	Crop Water Requirement (m^3/ha)
Orchard	Olive	6,750
	Citrus fruits	10,500
	Apple	6,000
	Apricot	5,250
	Almond	5,250
	Grape	3,000
Annual Crops	Wheat	5,250
	Barley	4,500
	Maize	7,200
	Alfalfa	12,800

D.1.3 Water Requirement in the Field

The water requirement of corps in the field was calculated based on the information mentioned in the section D.1.1 and D.1.2. In order to estimated the water demand at the inlet of the field, which is recognized as a gross water demand considering the application efficiency of irrigation in the field, the assumption of the application efficiency of 0.75 was applied tentatively. The total gross irrigation

water demand in the field was estimated 1,544 Mm^3 for the Haouz Plain (Table D.1.3), which is equivalent to 8,790 m^3/ha of unit water demand.

D.1.4 Conveyance Efficiency of Irrigation Systems

According to the Study by ABHT, the average conveyance efficiency of the GH irrigation system in the Haouz Central is assessed to be 0.88.

Conveyance Efficiency of GH Irrigation System in the Haouz Central

CMV	Sector	Year			
		01/02	02/03	03/04	04/05
407	R1	0.93	0.89	0.92	0.90
422	R3	0.92	0.88	0.94	0.92
425	Z1	NA	NA	NA	NA
427	H2	0.93	0.92	0.93	0.95
430	N1-1, N1-4 Partiel	0.83	0.82	0.86	0.87
432 + 434	CV	0.87	0.85	0.86	0.90
	N1-2, N1-3, N2, N3	0.74	0.78	0.81	0.82
	N1-4 Partiel	NA	NA	NA	NA
431	N4	NA	0.92	0.93	0.86

Source: Ressources en Eau pour L'Irrigation des Perimetres de la Grande Hydraulique du haouz de Marrakech, ABHT

Among several assumptions that were proposed for the conveyance loss in the seguia systems in several studies, the assumption that takes account of 10% loss per 1km of canal length, proposed in *"Spatialisation de variables hydrologiques pour le bilan hydrique annuel et l'estimation des pompages dans la plaine du Haouz de Marrakech, Abdelhamid Fadil, 2006 "* was applied in the study. ABHT, in its study in 2003, estimates the average length of seguia canal is 6.3 km with the conveyance efficiency of 0.90^6.3=0.51.

As for groundwater irrigation, it is not necessary to consider the conveyance loss because the producers use well within or close to the field in general. (That means conveyance efficiency is 1.0.)

D.1.5 Water Deficit for Crops in the Field

Due to the limited available water resources, some water stress (water deficit) is given to crops in the field during cultivation in the Study Area, instead supplying 100% of water demand estimated in the section (3). In order to evaluate the actual water sufficiency of crops in the field, the actual volume of water supplied at the inlet of the field in the period of 1993/94~2003/04 was examined in comparison with theoretical water demand by the following procedure:

- Evaluation of supplied water volume at the main canal / well used for irrigation by sources (A = 879 Mm^3)
- Evaluation of water amount supplied to the inlet of the field, which considers conveyance efficiency of the irrigation system (B = Σ[A x Conveyance Efficiency $^{(4)}$] = 757 Mm^3)
- Evaluation of effective rainfall (C = 90% of the basin average rainfall of the Haouz Aquifer = 285 mm = 501 Mm^3)
- Evaluation of water volume supplied to crops in the field (D = B + C = 1,258 Mm^3)

The estimated water consumption of crops in the field is equivalent to 7,169 m^3/ha, which is evaluated that crops suffer approximately 18% of water stress (water deficit) in the field in comparison with the

theoretical water demand of 8,790 m^3/ha. This level of the water stress (water deficit) is similar with the result of Sudmed Project, which assessed it by the real evapo-transpiration (ETR).

D.1.6 Irrigation Water Demand

The present water demand for irrigation was examined by 2 types of estimation, i.e., the present water demand and the potential water demand, in consideration of the present situation of cultivation that crops are given some water stress (water deficit) and that the cultivation area is limited due to lack of water resources.

Present Water Demand for Irrigation:

- Present Water Demand for irrigation is estimated for the present irrigation area.
- The present water stress (water deficit) of crops (18%) is considered in calculation.
- The present water demand for irrigation based on the actual water sufficient level of crops in the field is estimated 1,061 Mm^3/year for 175,704 ha of irrigated area.

Potential Water Demand:

- No irrigation area is newly developed in the GH areas. The fallowing area due to lack of irrigation water, which is approximately 6,300 ha, is taken account of area to be irrigated for estimating water demand. For the PMH area, the area actually irrigated at present is taken into account as irrigation area for estimating water demand.
- It is understood that the water demand of crops is not satisfied at present due to lack of irrigation water. Thus, increase of water demand by increasing water application to crops is forecast instead of expanding the irrigation area.
- Under these conditions, the potential water demand for irrigation is estimated 1,459 Mm^3/year for 182,023 ha of irrigated area.

Water Demand Forecasting for Irrigation:

The following conditions were applied for forecasting water demand for irrigation:

- No irrigation area is newly developed in the GH areas. As for he fallowing area due to lack of irrigation water which is approximately 6,300 ha, two cases are set for forecasting water demand, that is including this area into the irrigated area and not included.
- Increasing the trend of borehole installations for irrigation is considered in the water demand forecasting, which is estimated 4% in each year of which 2% is replacement of existing well and others are considered as new development. That is to say, the irrigated area by groundwater in the PMH areas is assumed to increase 2% in each year.
- In consideration of the limited available water resources, the water demand for irrigation is estimated in two cases that is the present water stress will continue and another is considering increase of water demand for satisfying water requirement of crop in the field.

Under these conditions, the water demand for irrigation is set as 1,260 Mm^3, of which irrigated area is increasing to 203,377 ha in 2020 from 175,704 ha at present. In addition to above forecasting, the maximum water demand for irrigation, that is whole irrigation developed area of GH areas are under irrigation and whole irrigation area receive full water which satisfy the water sufficient of crop is also

set as 1,720 Mm^3, of which irrigated area is increasing to 209,696 ha in 2020 from 182,023 ha of the potential water demand.

The estimated water demand for irrigation is shown in Table D.1.7.

D.2 Water Demand for Irrigation in the Scenarios of IWRM

The following 4 scenarios are examined in the groundwater simulation in the study on the Integrated Water Resources Management.

Continuation Scenario: It is the scenario that acts as basis of the exam. It is assumed that the situation where the present water use will continue and the preventive measures won't be taken. (For the water supply, the measures to take, as the prevention of the water leakage, etc. are already considerations in the forecasting of the water demand.)

Maximum Demand Scenario: For the critical situation, it is assumed that the situation where 100% of the quantity of necessary water will be used by every sector. (For the water supply, the measures to take, as the prevention of the water leakage, etc. are already considerations in the forecasting of the demand in water.)

Basic Action Scenario: maintaining the water sufficiency for crop production at the current level, introduction and dissemination of drip irrigation, development and utilization of treated wastewater, artificial groundwater recharge, and regionalized allocation of surface water resources are included in the basic actions.

Major Action Scenario: in addition to the measure included in the basic actions, the control of increased groundwater usage by PMH sectors is included.

The water demand in Continuous Scenario and Maximum Demand Scenario is estimated in Section D.1.6. In forecasting the future water demand in Basin and Major Action Scenarios, the control of expansion of groundwater irrigation in PMH sector as well as increase of irrigation application efficiency by introduction and extension of drip irrigation. The water demand in 2020 was set 1,106 Mm^3 for 203 thousand ha of irrigation area in Basin Action Scenario and 931 Mm^3 for 175 thousand ha of irrigation area in Major Action Scenario. The estimation of the water demand for Basic and Major Action Scenarios are shown in Table D.2.1 and Table D.2.2.

D.3 Study on Expansion of Drip Irrigation

D.3.1 Concept of Expansion of Drip Irrigation

Drip irrigation is possible to save 20~30% of irrigation water by minimizing evaporation loss and percolation loss in the field. At the same time, it is possible to manage crop growth adequately by precise control of irrigation water and by introducing liquid manure technique. To reduce irrigation water will contribute to reducing irrigation cost as well as to improving regional water balance by reducing water demand for irrigation. Drip irrigation shall be promoted actively as a measure of reducing irrigation water demand in the Haouz plain.

Drip irrigation shall be introduced by users by themselves while the administration has a role to develop the circumstance that users can introduce easily. The expected intervention of administration is that: a) subsidy to equipment of drip irrigation and support for procedure of application, b) expansion of pipelines to grouped parcels, c) technical extension and enlightening of water saving

irrigation and farming practice, d) administrative guidance through licensing for well construction. It is necessary to apply the approach to expand drip irrigation to GH sectors where surface water is dominant source and PMH sectors where groundwater is dominant source.

D.3.2 Expansion of Drip Irrigation in GH Irrigation Sectors

Even though it is required to introduce drip irrigation over the GH sectors from the aspect of effective use of surface water, the following priorities are proposed in consideration of user's adoptability of drip irrigation and contribution to the significant groundwater depleting area:

- Priority area: GH irrigation sectors in the right bank of N'Fis river where pressurized irrigation system has been equipped. In this area, users can introduce drip irrigation using pressurized system easily while they are not necessary to invest pump equipment. It is proposed to introduce drip irrigation in whole of this area (100%) until 2012.
- Other area: Other area than the priority area, users are necessary to equip farm pond and pump equipment to introduce drip irrigation. It is proposed to introduce drip irrigation in the half of the area sequentially from 2013 to 2017.

In the priority area that is the GH irrigation sectors in the right bank of N'Fis river, users will install drip irrigation by themselves using subsidy by the government in irrigated field equipped peculiar outlet of pipeline. In the small parcels which are not equipped peculiar outlet of the pipeline, the administration will organize group of parcels and develop the extension of pipelines and prepare outlet to the grouped parcels while users will install drip irrigation by themselves using subsidy by the government. The GH irrigation sectors proposed to install drip irrigation are shown in Figure D.3.1.

D.3.3 Extension of Secondary Canal in GH Sector for Introducing Drip Irrigation

In order to proceed to install drip irrigation in the priority area mentioned above, some area requires improving or developing secondary canals. Even though the canal system is modernized in the GH sector under ORMVAH, the loss after the division work of the main canal is significant due to the unimproved secondary canals. Thus, it is necessary to improve canals in the distance of secondary and tertiary canals from the division work to the inlet of the field. Especially for the N'Fis Right Bank Sectors (N1, N2 and N3 Sectors) which are equipped by the pressurized pipeline network, the advantage of the pressurized system, that is pressure of water and small loss, is not fully utilized because the distance after the division work is generally equipped by open channel. The undeveloped secondary and tertiary canal is cause by the facts that the development of this distance is owned by users and it is difficult foe them to invest, and that one outlet of the main canal is equipped for numbers of individual and scattered parcels and the coordination between users who share a outlet is rather difficult. Because the improvement of the secondary and tertiary canal by extension of pipelines in the beneficiary area of pressurized system is considered as a precondition of expansion of drip irrigation in those area, it is necessary to be carried out in combination with the program of spread of drip irrigation in order to maximize the effect of reduction of irrigation demand.

- Land consolidation by grouping the small parcels in the beneficiary area of pressurized system
- Extension of pipeline for the distance of secondary and tertiary canal

Target area: N'Fis Right Bank Sectors where pressurized system is equip med. (N1-1, N1-2, N2 and N3 Sectors, approximately 16,000 ha in the total area of 21,100ha.) The work amount and cost of

extension of secondary canals estimated by ORMVAH are shown in Table D.3.1.

D.3.4 Expansion of Drip Irrigation in PMH Irrigation Sectors

In the groundwater irrigation area, drip irrigation will be promoted at the newly development or replacement of well. Especially at the new construction of wells, installation of drip irrigation is to be set as a condition of licensing. Users will install drip irrigation by themselves using subsidy by the government. As for the existing wells, it is necessary to be consider to set drip irrigation as a condition of licensing for groundwater irrigation as well as promoting registration of wells.

On the assumption that irrigation well increase at 4% per annum in PMH secotrs, of which 2% is newly construction and remaining 2% is replacement due to malfunctioning or dry-up of well, it is expected to develop wells in approximately 70,000 ha of irrigated area until 2020 in the Basin Action Scenario which allows some new development of wells for irrigation (Table D.3.2). On the other hand, the expectation of development of wells is approximately 41,000 ha in the Major Action Scenario which does not allow new development of wells. If the rules on the development wells mentioned above will be introduced, it is expected that 5,000 ha of drip irrigation will be expanded every year in the Basin Action Scenario and 3,000 ha in the Major Action Scenario. As a result of examination of scenarios, the Major Action Scenario was adopted in the Master Plan.

D.3.5 Cost and Budget of Program for Expansion of Drip Irrigation

The work amount and cost of Program for Expansion of Drip Irrigation are summarized in Table D.3.3.

D.3.6 Impact of Program for Expansion of Drip Irrigation to Improving Groundwater Balance

The drip irrigation will save irrigation water in the field by 20~30% in gross value. However, it must be mentioned that drip irrigation will reduce the groundwater recharge by infiltration of surplus irrigation water, and that approximately only 10% of water saving impact can be considered on improving water balance in net value. On the assumption that the gross water saving ratio of drip irrigation is 20% and that crop water requirement is 7,000~10,000 m^3/ha, it is expected to save 98~140 Mm^3 in gross value in the projected area of 70,000 ha. In addition, the extension of pipelines will save 11~16 Mm^3 (gross value) in the projected area 16,000 ha on the assumption that extension of pipeline will decrease the delivery loss by 10% (average length is 1 km). Above those water saving impact in gross values, 49~70 Mm^3 is considered as a net contribution to improving water balance.

Table D.1.1 Assumed Irrigated Area in the Study Area

Unit : ha

Jurisdiction	Total	Total Irrigation	Cereal		Legume	Forage	Vegetable	Orchard	
			Rainfed	Irrigation				Olive	Other orchard
ORMVA (2003/04)	179,430	137,689	41,742	56,769	794	9,140	5,793	47,046	18,148
Haouz Central Sub-total	166,785	127,941	38,844	51,839	749	8,298	5,256	43,857	17,943
	GH HC (excl.	34,766	0	12,957	0	1,613	1,623	11,886	6,687
	PMH HC	93,175	38,844	38,882	749	6,685	3,633	31,971	11,256
Upper Tessaout Sub-total	12,646	9,748	2,898	4,930	45	842	537	3,189	205
	GH TA	5,748							
	PMH TA	4,000							
DPA Marrakech (Average of last 5 years)	19,053	8,896	10,157	5,892	93	264	432	1,108	1,108
		8,896			3%	9%	14%	37%	37%
	Regular	2,250		0	69	198	323	829	829
	Seasonal+Flood	6,647		5,892	23	66	108	278	278
DPA Chichaoua (2005/06)	65,263	29,118	36,145	17,353	446	563	828	5,998	3,931
		29,118			4%	5%	7%	51%	33%
	Regular	6,627		0	251	317	466	3,378	2,214
	Seasonal+Flood	22,492		17,353	195	246	362	2,620	1,717
Total	263,746	175,704	88,043	80,015	1,332	9,967	7,053	54,151	23,187

Source: ORMVAH, DPA Marrakech, DPA Chicaoua

Table D.1.2 Distribution of Irrigated Area by Crop

	Area (ha)	Cereals	Legume	Forage	Vegetable	Olive	Other orchard
ORMVAH	137,689	41%	1%	7%	4%	34%	13%
GH in Nf-HC	34,766	37%	0%	5%	5%	34%	19%
PMH in Nf-HC	93,175	42%	1%	7%	4%	34%	12%
GH&PMH in TA	9,748	51%	0%	9%	6%	33%	2%
DPA MA	8,896	66%	1%	3%	5%	12%	12%
Regular	2,250	0%	3%	9%	14%	37%	37%
Seasonal+Flood	6,647	89%	0%	1%	2%	4%	4%
DPA CH	29,118	60%	2%	2%	3%	21%	13%
Regular	6,627	0%	4%	5%	7%	51%	33%
Seasonal+Flood	22,492	77%	1%	1%	2%	12%	8%

Table D.1.3 Estimation of Irrigation Water Requirement in the Study Area

Area	Irrigation Area (ha)	Crop						Water Requirement (Mm^3/year)
		Cereals	Legume	Forage	Vegetable	Olive	Other Orchard	
Net Crop Water Requirement (m^3/ha/year)		5,250	3,000	7,200	7,500	6,750	10,500	
Gross Crop Water Requirement (m^3/ha/year)		7,000	4,000	9,600	10,000	9,000	14,000	
ORMVA	137,689	41%	1%	7%	4%	34%	13%	1,224
Large Scale (GH) in N'Fis & Haouz Central Sectors	34,766	37%	0%	5%	5%	34%	19%	323
Small and Medium (PMH) in N'Fis & Haouz Central Sectors	93,175	42%	1%	7%	4%	34%	12%	821
GH & PMH in Lower Tessaout Sector	9,748	51%	0%	9%	6%	33%	2%	80
DPA Marrakech	8,896	66%	1%	3%	5%	12%	12%	74
Regular Water	2,250	0%	3%	9%	14%	37%	37%	24
Seasonal Water + Flood Water Supply	6,647	89%	0%	1%	2%	4%	4%	49
DPA Chichaoua	29,118	60%	2%	2%	3%	21%	13%	246
Regular Water	6,627	0%	4%	5%	7%	51%	33%	70
Seasonal Water + Flood Water Supply	22,492	77%	1%	1%	2%	12%	8%	176
Total	**175,704**							**1,544**
							Water Requirement in m3/ha/year	**8,790**

Table D.1.4 Assessment of Irrigation Water Supply in the Study Area

Items	Unit	Value	Conveyance Efficiency	Value at the head of parcel
Amount of Irrigation Water Supply	Mm^3/year	879		757
Dam water	Mm^3/year	133	0.88	117
River water taken by Seguias	Mm^3/year	201	0.51	103
Supplied by Rocade Canal	Mm^3/year	67	0.88	59
Groundwater GH	Mm^3/year	118	1.0	118
Groundwater PMH	Mm^3/year	360	1.0	360
Water Supply by Rain	Mm^3/year			501
Basin Average Rainfall of Haouz Plain (average of 1993/94~2003/04)	mm/year	317		
Effective Rainfall	mm/year			285
Total Water Supply to Crops	Mm^3/year			1,258
Irrigation Water Supply per hector	m^3/ha/year			7,160
Estimated Irrigation Water Demand	m^3/ha/year			8,790
Deficit Ratio				18.4%

Table D.1.5 Assumed Crop Area and Estimation of Unit Water Requirement

(1) Estimation of Irrigation Water Demand of Present Condition

Area	Irrigation Area (ha)	Cereals	Legume	Forage	Vegetable	Olive	Other Orchard	Net Unit Water Requirement (Mm3/ha/yea
Net Crop Water Requirement (m^3/ha/year)		5,250	3,000	7,200	7,500	6,750	10,500	
ORMVA	**137,689**	**41%**	**1%**	**7%**	**4%**	**34%**	**13%**	
N'Fis and Haouz Central Sectors								
Large Scale (GH)	**34,766**	37%	0%	5%	5%	34%	19%	6,968
Small and Medium (PMH)	**93,175**	42%	1%	7%	4%	34%	12%	6,609
Tessaout Amont Sectors								
Large Scale (GH)	**5,748**	51%	0%	9%	5%	33%	2%	6,130
Small and Medium (PMH)	**4,000**	51%	0%	9%	5%	33%	2%	6,130
GH Total	**40,514**	**88%**	**0%**	**13%**	**10%**	**67%**	**21%**	
PMH Total	**97,175**	**92%**	**1%**	**16%**	**9%**	**67%**	**14%**	
DPA Marrakech	**8,896**	**66%**	**1%**	**3%**	**5%**	**12%**	**12%**	**6,234**
DPA Chichaoua	**29,118**	**60%**	**2%**	**2%**	**3%**	**21%**	**13%**	**6,335**
Total	**175,704**							

(2) Estimation of Potential Irrigation Water Demand of Present Condition

Area	Irrigation Area (ha)	Cereals	Legume	Forage	Vegetable	Olive	Other Orchard	Net Unit Water Requirement (Mm3/ha/yea
Net Crop Water Requirement (m^3/ha/year)		5,250	3,000	7,200	7,500	6,750	10,500	
ORMVA	**144,008**	**41%**	**1%**	**7%**	**4%**	**34%**	**13%**	
N'Fis and Haouz Central Sectors								
Large Scale (GH)	**41,085**	37%	0%	5%	5%	34%	19%	6,968
Small and Medium (PMH)	**93,175**	42%	1%	7%	4%	34%	12%	6,609
Tessaout Amont Sectors								
Large Scale (GH)	**5,748**	51%	0%	9%	5%	33%	2%	6,130
Small and Medium (PMH)	**4,000**	51%	0%	9%	5%	33%	2%	6,130
GH Total	**46,833**	**88%**	**0%**	**13%**	**10%**	**67%**	**21%**	
PMH Total	**97,175**	**92%**	**1%**	**16%**	**9%**	**67%**	**14%**	
DPA Marrakech	**8,896**	**66%**	**1%**	**3%**	**5%**	**12%**	**12%**	**6,234**
DPA Chichaoua	**29,118**	**60%**	**2%**	**2%**	**3%**	**21%**	**13%**	**6,335**
Total	**182,023**							

(3) Estimation of Future Irrigation Water Demand on 2020

Area	Irrigation Area (ha)	Cereals	Legume	Forage	Vegetable	Olive	Other Orchard	Net Unit Water Requirement (Mm3/ha/yea
Net Crop Water Requirement (m^3/ha/year)		5,250	3,000	7,200	7,500	6,750	10,500	
ORMVA	**156,568**	**41%**	**1%**	**7%**	**4%**	**34%**	**13%**	
N'Fis and Haouz Central Sectors								
Large Scale (GH)	**34,766**	37%	0%	5%	5%	34%	19%	6,968
Small and Medium (PMH)	**112,054**	42%	1%	7%	4%	34%	12%	6,609
Tessaout Amont Sectors								
Large Scale (GH)	**5,748**	51%	0%	9%	5%	33%	2%	6,130
Small and Medium (PMH)	**4,000**	51%	0%	9%	5%	33%	2%	6,130
GH Total	**40,514**	**88%**	**0%**	**13%**	**10%**	**67%**	**21%**	
PMH Total	**116,054**	**92%**	**1%**	**16%**	**9%**	**67%**	**14%**	
DPA Marrakech	**10,954**	**66%**	**1%**	**3%**	**5%**	**12%**	**12%**	**6,234**
DPA Chichaoua	**35,855**	**60%**	**2%**	**2%**	**3%**	**21%**	**13%**	**6,335**
Total	**203,377**							

(4) Estimation of Maximum Future Irrigation Water Demand on 2020

Area	Irrigation Area (ha)	Cereals	Legume	Forage	Vegetable	Olive	Other Orchard	Net Unit Water Requirement (Mm3/ha/yea
Net Crop Water Requirement (m^3/ha/year)		5,250	3,000	7,200	7,500	6,750	10,500	
ORMVA	**162,887**	**41%**	**1%**	**7%**	**4%**	**34%**	**13%**	
N'Fis and Haouz Central Sectors								
Large Scale (GH)	**41,085**	37%	0%	5%	5%	34%	19%	6,968
Small and Medium (PMH)	**112,054**	42%	1%	7%	4%	34%	12%	6,609
Tessaout Amont Sectors								
Large Scale (GH)	**5,748**	51%	0%	9%	5%	33%	2%	6,130
Small and Medium (PMH)	**4,000**	51%	0%	9%	5%	33%	2%	6,130
GH Total	**46,833**	**88%**	**0%**	**13%**	**10%**	**67%**	**21%**	
PMH Total	**116,054**	**92%**	**1%**	**16%**	**9%**	**67%**	**14%**	
DPA Marrakech	**10,954**	**66%**	**1%**	**3%**	**5%**	**12%**	**12%**	**6,234**
DPA Chichaoua	**35,855**	**60%**	**2%**	**2%**	**3%**	**21%**	**13%**	**6,335**
Total	**209,696**							

Table D.1.6 Estimation of Irrigation Water Demand (1/2)

(1) Estimation of Irrigation Water Demand of Present Condition

Area	Irrigation Area (ha)	Net Unit Water Requirement (Mm3/ha/year)	Application efficiency	Gross Unit Water Requirement (Mm3/ha/year)	Deficit Ratio of Water Requirement	Unit Water Requirement Applied (Mm3/ha/year)	Water Requirement (Mm3/year)	Effective Rainfall (Mm3/year)	Water Demand at head of parcels (Mm3year)	Average Conveyance Efficiency	Conveyance Loss (Mm3/ha/year)	Water Demand at Main Canal / Well (Mm3/ha/year)
Net Crop Water Requirement (m^3/ha/year)								253				
ORMVA	**137,689**						**1,075**	**348**	**727**		**109**	**836**
N'Fis and Haouz Central Sectors							1,005	324	681		103	785
Large Scale (GH)	**34,766**	6,968	0.70	9,954	18%	8,163	284	88	196	0.92	17	213
Small and Medium (PMH)	**93,175**	6,609	0.70	9,441	18%	7,741	721	236	486	0.85	86	572
Tessaout Amont Sectors							70	25	45		5	51
Large Scale (GH)	**5,748**	6,130	0.70	8,757	18%	7,181	41	15	27	0.91	3	29
Small and Medium (PMH)	**4,000**	6,130	0.70	8,757	18%	7,181	29	10	19	0.88	3	21
GH Total	**40,514**						**325**	**103**	**223**		**20**	**242**
PMH Total	**97,175**						**750**	**246**	**504**		**89**	**593**
DPA Marrakech	**8,896**	**6,234**	**0.70**	**8,906**	**18%**	**7,303**	**65**	**23**	**42**	0.82	**9**	**52**
DPA Chichaoua	**29,118**	**6,335**	**0.70**	**9,050**	**18%**	**7,421**	**216**	**74**	**142**	0.82	**31**	**174**
Total	**175,704**						**1,356**	**445**	**912**		**149**	**1,061**

(2) Estimation of Potential Irrigation Water Demand of Present Condition

Area	Irrigation Area (ha)	Net Unit Water Requirement (Mm3/ha/year)	Application efficiency	Gross Unit Water Requirement (Mm3/ha/year)	Deficit Ratio of Water Requirement	Unit Water Requirement Applied (Mm3/ha/year)	Water Requirement (Mm3/year)	Effective Rainfall (Mm3/year)	Water Demand at head of parcels (Mm3year)	Average Conveyance Efficiency	Conveyance Loss (Mm3/ha/year)	Water Demand at Main Canal / Well (Mm3/ha/year)
Net Crop Water Requirement (m^3/ha/year)								253				
ORMVA	**144,008**						**1,374**	**364**	**1,010**		**148**	**1,158**
N'Fis and Haouz Central Sectors							1,289	340	949		141	1,090
Large Scale (GH)	**41,085**	6,968	0.70	9,954	0%	9,954	409	104	305	0.92	27	332
Small and Medium (PMH)	**93,175**	6,609	0.70	9,441	0%	9,441	880	236	644	0.85	115	759
Tessaout Amont Sectors							85	25	61		7	68
Large Scale (GH)	**5,748**	6,130	0.70	8,757	0%	8,757	50	15	36	0.91	4	39
Small and Medium (PMH)	**4,000**	6,130	0.70	8,757	0%	8,757	35	10	25	0.88	4	29
GH Total	**46,833**						**459**	**118**	**341**		**30**	**371**
PMH Total	**97,175**						**915**	**246**	**669**		**118**	**787**
DPA Marrakech	**8,896**	**6,234**	**0.70**	**8,906**	**0%**	**8,906**	**79**	**23**	**57**	0.82	**12**	**69**
DPA Chichaoua	**29,118**	**6,335**	**0.70**	**9,050**	**0%**	**9,050**	**264**	**74**	**190**	0.82	**42**	**232**
Total	**182,023**						**1,717**	**461**	**1,256**		**203**	**1,459**

Table D.1.6 Estimation of Irrigation Water Demand (2/2)

(3) Estimation of Future Irrigation Water Demand on 2020

Area	Irrigation Area (ha)	Net Unit Water Requirement (Mm3/ha/year)	Application efficiency	Gross Unit Water Requirement (Mm3/ha/year)	Deficit Ratio of Water Requirement	Unit Water Requirement Applied (Mm3/ha/year)	Water Requirement (Mm3/year)	Effective Rainfall (Mm3/year)	Water Demand at head of parcels (Mm3year)	Average Conveyance Efficiency	Conveyance Loss (Mm3/ha/year)	Water Demand at Main Canal / Well (Mm3/ha/year)
Net Crop Water Requirement (m^3/ha/year)								253				
ORMVA	**156,568**						**1,228**	**398**	**829**		**131**	**961**
N'Fis and Haouz Central Sectors							1,151	371	780		125	905
Large Scale (GH)	**34,766**	6,968	0.70	9,954	18%	8,163	284	88	196	0.92	17	213
Small and Medium (PMH)	**112,054**	6,609	0.70	9,441	18%	7,741	867	283	584	0.85	108	692
Tessaout Amont Sectors							77	27	50		6	56
Large Scale (GH)	**5,748**	6,130	0.70	8,757	18%	7,181	41	15	27	0.91	3	29
Small and Medium (PMH)	**4,000**	6,130	0.70	8,757	18%	7,181	35	12	23	0.86	4	27
GH Total	**40,514**						**325**	**103**	**223**		**20**	**242**
PMH Total	**116,054**						**903**	**296**	**607**		**112**	**719**
DPA Marrakech	**10,954**	**6,234**	**0.70**	**8,906**	**18%**	**7,303**	**85**	**28**	**57**	0.82	**12**	**69**
DPA Chichaoua	**35,855**	**6,335**	**0.70**	**9,050**	**18%**	**7,421**	**279**	**91**	**188**	0.82	**41**	**229**
Total	**203,377**						**1,591**	**517**	**1,074**		**185**	**1,260**

(4) Estimation of Maximum Future Irrigation Water Demand on 2020

Area	Irrigation Area (ha)	Net Unit Water Requirement (Mm3/ha/year)	Application efficiency	Gross Unit Water Requirement (Mm3/ha/year)	Deficit Ratio of Water Requirement	Unit Water Requirement Applied (Mm3/ha/year)	Water Requirement (Mm3/year)	Effective Rainfall (Mm3/year)	Water Demand at head of parcels (Mm3year)	Average Conveyance Efficiency	Conveyance Loss (Mm3/ha/year)	Water Demand at Main Canal / Well (Mm3/ha/year)
Net Crop Water Requirement (m^3/ha/year)								253				
ORMVA	**162,887**						**1,560**	**414**	**1,146**		**178**	**1,324**
N'Fis and Haouz Central Sectors							1,467	387	1,079		170	1,249
Large Scale (GH)	**41,085**	6,968	0.70	9,954	0%	9,954	409	104	305	0.92	27	332
Small and Medium (PMH)	**112,054**	6,609	0.70	9,441	0%	9,441	1,058	283	774	0.85	143	918
Tessaout Amont Sectors							93	27	66		8	75
Large Scale (GH)	**5,748**	6,130	0.70	8,757	0%	8,757	50	15	36	0.91	4	39
Small and Medium (PMH)	**4,000**	6,130	0.70	8,757	0%	8,757	43	12	31	0.86	5	36
GH Total	**46,833**						**459**	**118**	**341**		**30**	**371**
PMH Total	**116,054**						**1,101**	**296**	**805**		**148**	**953**
DPA Marrakech	**10,954**	**6,234**	**0.70**	**8,906**	**0%**	**8,906**	**103**	**28**	**76**	0.82	**17**	**92**
DPA Chichaoua	**35,855**	**6,335**	**0.70**	**9,050**	**0%**	**9,050**	**340**	**91**	**249**	0.82	**55**	**304**
Total	**209,696**						**2,003**	**533**	**1,471**		**250**	**1,720**

Table D.1.7 Summary of Estimation of Irrigation Water Demand

(1) Summary of Present Irrigation Water Demand

Area	Present Water Demand		Potential Water Demand	
	Irrigation Area (ha)	Water Demand at Main Canal / Well (Mm^3/year)	Irrigation Area (ha)	Water Demand at Main Canal / Well (Mm^3/year)
ORMVA	137,689	836	144,008	1,158
-GH	40,514	242	46,833	371
-PMH	97,175	593	97,175	787
DPA Marrakech	8,896	52	8,896	69
DPA Chichaoua	29,118	174	29,118	232
Total	175,704	1,061	182,023	1,459

82) Summary of Future Irrigation Water Demand in 2020

Area	Water Demand in 2020		Maximum Water Demand in 2020	
	Irrigation Area (ha)	Water Demand at Main Canal / Well (Mm^3/year)	Irrigation Area (ha)	Water Demand at Main Canal / Well (Mm^3/year)
ORMVA	156,568	961	162,887	1,324
-GH	40,514	242	46,833	371
-PMH	116,054	719	116,054	953
DPA Marrakech	10,954	69	10,954	92
DPA Chichaoua	35,855	229	35,855	304
Total	203,377	1,260	209,696	1,720

Table D.2.1 Estimation of Irrigation Water Demand of Basic Action Scenario

(1) Estimation of Potential Irrigation Water Demand of **Basic Action** in 2010

Area	Irrigation Area (ha)	Net Unit Water Requirement (Mm3/ha/year)	Application efficiency	Gross Unit Water Requirement (Mm3/ha/year)	Deficit Ratio of Water Requirement	Unit Water Requirement Applied (Mm3/ha/year)	Water Requirement (Mm3/year)	Effective Rainfall (Mm3/year)	Water Demand at head of parcels (Mm3year)	Average Conveyance Efficiency	Conveyance Loss (Mm3/ha/year)	Water Demand at Main Canal / Well (Mm3/ha/year)
ORMVA	**142,775**						**1,083**	**362**	**721**		**110**	**832**
N'Fis and Haouz Central Sectors							1,012	337	676		105	781
Large Scale (GH)	**34,766**	6,968	0.74	9,389	18%	7,699	268	88	180	0.92	16	195
Small and Medium (PMH)	**98,261**	6,609	0.72	9,239	18%	7,576	744	249	496	0.85	89	585
Tessaout Amont Sectors							71	25	46		5	51
Large Scale (GH)	**5,748**	6,130	0.70	8,757	18%	7,181	41	15	27	0.91	3	29
Small and Medium (PMH)	**4,000**	6,130	0.72	8,570	18%	7,028	30	11	19	0.87	3	22
GH Total	**40,514**						**309**	**103**	**206**		**18**	**225**
PMH Total	**102,261**						**774**	**259**	**515**		**92**	**607**
DPA Marrakech	**9,382**	**6,234**	**0.70**	**8,850**	**18%**	**7,257**	**69**	**24**	**45**	0.82	**10**	**55**
DPA Chichaoua	**30,708**	**6,335**	**0.70**	**8,997**	**18%**	**7,378**	**229**	**78**	**152**	0.82	**33**	**185**
Total	**182,864**						**1,381**	**463**	**918**		**154**	**1,072**
							7,554					5,861

(2) Estimation of Potential Irrigation Water Demand of **Basic Action** in 2020

Area	Irrigation Area (ha)	Net Unit Water Requirement (Mm3/ha/year)	Application efficiency	Gross Unit Water Requirement (Mm3/ha/year)	Deficit Ratio of Water Requirement	Unit Water Requirement Applied (Mm3/ha/year)	Water Requirement (Mm3/year)	Effective Rainfall (Mm3/year)	Water Demand at head of parcels (Mm3year)	Average Conveyance Efficiency	Conveyance Loss (Mm3/ha/year)	Water Demand at Main Canal / Well (Mm3/ha/year)
ORMVA	**156,568**						**1,109**	**398**	**710**		**114**	**824**
N'Fis and Haouz Central Sectors							1,039	371	667		108	776
Large Scale (GH)	**34,766**	6,968	0.82	8,503	18%	6,973	242	88	154	0.92	13	168
Small and Medium (PMH)	**112,054**	6,609	0.76	8,668	18%	7,108	796	283	513	0.85	95	608
Tessaout Amont Sectors							70	27	43		5	48
Large Scale (GH)	**5,748**	6,130	0.78	7,910	18%	6,486	37	15	23	0.91	2	25
Small and Medium (PMH)	**4,000**	6,130	0.76	8,040	18%	6,593	32	12	20	0.86	3	23
GH Total	**40,514**						**280**	**103**	**177**		**16**	**193**
PMH Total	**116,054**						**829**	**296**	**533**		**98**	**631**
DPA Marrakech	**10,954**	**6,234**	**0.72**	**8,604**	**18%**	**7,056**	**81**	**28**	**54**	0.82	**12**	**65**
DPA Chichaoua	**35,855**	**6,335**	**0.72**	**8,759**	**18%**	**7,182**	**269**	**91**	**178**	0.82	**39**	**217**
Total	**203,377**						**1,458**	**517**	**942**		**165**	**1,106**

Table D.2.2 Estimation of Irrigation Water Demand of Major Action Scenario

Estimation of Potential Irrigation Water Demand of **Major Action** in 2010

Area	Irrigation Area (ha)	Net Unit Water Requirement (Mm3/ha/year)	Application efficiency	Gross Unit Water Requirement (Mm3/ha/year)	Deficit Ratio of Water Requirement	Unit Water Requirement Applied (Mm3/ha/year)	Water Requirement (Mm3/year)	Effective Rainfall (Mm3/year)	Water Demand at head of parcels (Mm3year)	Average Conveyance Efficiency	Conveyance Loss (Mm3/ha/year)	Water Demand at Main Canal / Well (Mm3/ha/year)
ORMVA	**137,689**						**1,043**	**348**	**695**		**105**	**799**
N'Fis and Haouz Central Sectors							974	324	650		99	749
Large Scale (GH)	**34,766**	6,968	0.74	9,389	18%	7,699	268	88	180	0.92	16	195
Small and Medium (PMH)	**93,175**	6,609	0.72	9,239	18%	7,576	706	236	470	0.85	84	554
Tessaout Amont Sectors							69	25	45		5	50
Large Scale (GH)	**5,748**	6,130	0.70	8,757	18%	7,181	41	15	27	0.91	3	29
Small and Medium (PMH)	**4,000**	6,130	0.72	8,570	18%	7,028	28	10	18	0.88	3	21
GH Total	**40,514**						**309**	**103**	**206**		**18**	**225**
PMH Total	**97,175**						**734**	**246**	**488**		**86**	**575**
DPA Marrakech	**8,896**	**6,234**	**0.70**	**8,857**	**18%**	**7,263**	**65**	**23**	**42**	0.82	**9**	**51**
DPA Chichaoua	**29,118**	**6,335**	**0.70**	**9,005**	**18%**	**7,384**	**215**	**74**	**141**	0.82	**31**	**172**
Total	**175,704**						**1,322**	**445**	**878**		**145**	**1,023**
							7,525					5,820

Estimation of Potential Irrigation Water Demand of **Major Action** in 2020

Area	Irrigation Area (ha)	Net Unit Water Requirement (Mm3/ha/year)	Application efficiency	Gross Unit Water Requirement (Mm3/ha/year)	Deficit Ratio of Water Requirement	Unit Water Requirement Applied (Mm3/ha/year)	Water Requirement (Mm3/year)	Effective Rainfall (Mm3/year)	Water Demand at head of parcels (Mm3year)	Average Conveyance Efficiency	Conveyance Loss (Mm3/ha/year)	Water Demand at Main Canal / Well (Mm3/ha/year)
ORMVA	**137,689**						**968**	**348**	**620**		**94**	**714**
N'Fis and Haouz Central Sectors							905	324	581		89	670
Large Scale (GH)	**34,766**	6,968	0.82	8,503	18%	6,973	242	88	154	0.92	13	168
Small and Medium (PMH)	**93,175**	6,609	0.76	8,668	18%	7,108	662	236	427	0.85	76	502
Tessaout Amont Sectors							64	25	39		5	44
Large Scale (GH)	**5,748**	6,130	0.78	7,910	18%	6,486	37	15	23	0.91	2	25
Small and Medium (PMH)	**4,000**	6,130	0.76	8,040	18%	6,593	26	10	16	0.88	2	19
GH Total	**40,514**						**280**	**103**	**177**		**16**	**193**
PMH Total	**97,175**						**689**	**246**	**443**		**78**	**521**
DPA Marrakech	**8,896**	**6,234**	**0.72**	**8,710**	**18%**	**7,142**	**63**	**23**	**41**	0.82	**9**	**50**
DPA Chichaoua	**29,118**	**6,335**	**0.71**	**8,870**	**18%**	**7,273**	**211**	**74**	**137**	0.82	**30**	**168**
Total	**175,704**						**1,243**	**445**	**798**		**133**	**931**

Table D.3.1 Construction Cost of Extension of Pipelines for Introducing Drip Irrigation in GH Sector

Sector	Sub-sector	WUA	Irrigation Area (ha)	Length to be constructed (m	Cost incl. tax (DH)	Unit price (DH/ha)
N1	N1-1	Tizmit	283	10,619	27,893,728	-
		Sarrau	989	20,681	38,751,937	-
		Essalam	846	7,086	13,930,954	-
		Dar El Hamra	1,037	27,213	41,400,004	-
	Sub-total		3,155	65,599	121,976,623	38,661
	N1-2	Tarra	693	678	655,117	-
		Ben Toumi	722	22,924	33,661,062	-
		Aspersion	-	-	-	-
		Gravitaire	1,508	2,331	4,115,017	-
	Sub-total		2,923	25,933	38,431,196	13,148
Total of N1 Sector			6,078	91,532	160,407,819	26,392
N2	-	Beni Arich	1,481	27,842	32,149,965	-
	-	Ain Bitar	1,668	21,413	27,332,286	-
Total of N2 Sector			3,149	49,255	59,482,251	18,889
N3	Ennamaa	Ennama	970	30,968	29,922,970	-
		Sidi Arich	1,195	25,010	29,694,819	-
		N3-2	3,321	70,151	99,348,059	-
		Lamrija	1,040	28,619	35,287,300	-
		El Amal	349	14,309	20,759,660	-
		Tazakourt	-	-	-	-
	Intake (766A)		-	10	41,760	-
Total of N3 Sector			6,875	169,067	215,054,568	31,281
Total			16,102	309,854	434,944,638	27,012

(Source: ORMVAH)

Table D.3.2 Expected Area to Introduce Drip Irrigation in PMH Sector

Unit : ha

Year	Basin Action Scenario				Major Action Scenario			
	PMH Area	Area expected well construction			PMH Area	Area expected well construction		
		Newly constructed wells	Replacement of existing wells	Total		Newly constructed wells	Replacement of existing wells	Total
2006/07	135,190				135,190			
2010/11	142,350	7,160	11,144	18,304	135,190	0	11,144	11,144
2020/21	162,863	27,673	42,318	69,991	135,190	0	40,750	40,750

Table D.3.3 Work Amount and Cost of Program for Introduction and Extension of Drip Irrigation

No.	Location	Extension of pipelines		Install of drip irrigation		Total cost (MDH)	Remarks (Subsidy for drip irrigation)
		Area (ha)	Cost (MDH)	Area (ha)	Cost (MDH)		
1	GH sectors in the right bank of N'Fis river	16,000	435	19,000	532	967	(319)
2	PMH Sectors			41,000	1,148	1,148	(689)
3	Other GH sectors			10,000	600	600	(360)
		16,000	435	70,000	2,280	2,715	(1,368)

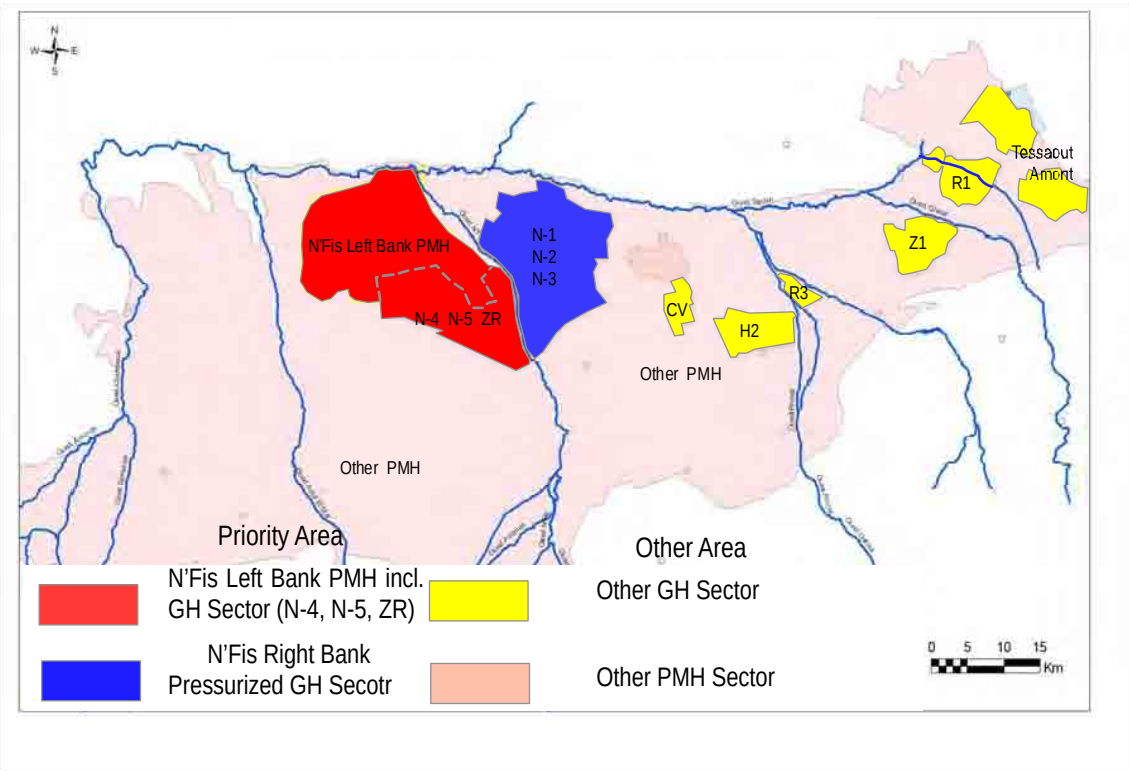

Figure D.1.1 Priority Area of Installing Drip Irrigation

E: SEWERAGE AND WATER QUALITY

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E: SEWERAGE AND WATER QUALITY

E.1 Water Supply System

E.1.1 Office of National Potable Water in Marrakech (ONEP)

ONEP was established as an autonomous administrative body under the Ministry of Equipment and Transport in 1972. After a series of structural reforms of the government organizations, it is now under the jurisdiction of the Ministry of Land Management, Water and Environment. After the restructuring of the government agencies in January 2004, ONEP became the sole authority to supply water to urbanized communes in the rural areas. The main roles and the functions of ONEP at present are summarized as follows.

1) Plan and Study for assuring to supply drinking water in the country.
2) Operation and Management for production of water and distribution of drinking water for access and consumption of the people.
3) Control of water quality for production and distribution of drinking water, and water pollution control in addition to assistance for monitoring of water quality.
4) Participation in studies and projects in cooperation with the agencies/departments of the interested ministries.

In addition to the main roles and functions mentioned above, ONEP conducts activities summarized as follows.

1) Supply water to the remote rural areas adjoining to the existing water service areas.
2) Appropriate water tariff system to extend and develop the service of water in the small urban centers.
3) Training and cooperation for participants in the fields of technical and financial matters in cooperation with international organizations.
4) Raising awareness of the people for water economy through schools, audiovisual media, holiday camps, sporting and cultural events.
5) Development of new technology such as desalination and demineralization conducted especially in the south provinces.
6) Wastewater treatment to avoid negative impacts of domestic and industrial wastewater on water sources.
7) Improvement of water quality using the decentralized laboratories managed by the central laboratory to achieve regular and sustainable water quality testing to assure the required water quality for water supply.

ONEP operates 9 Regional Offices scattered all over the country. In the Haouz Plain, Region-2 Office is set up in Marrakech for management of the services to Safi, Essaouira, El. Kalaa des Saraghna, Ouarzazate, Chichaoua, Zagora and Marrakech Prefecture. Currently, Region-2 Office operates the water supply system in 55 communes with approximately 750 staff members and about 70 staffs are working at the Marrakech office. Figure E.1.1 indicates the organization chart of ONEP.

E.1.2 RADEEMA

RADEEMA is an independent public company responsible for supply of water and electricity and wastewater management in Marrakech in commercial base. The organization was established by the City Council in 1971 under jurisdiction of the Ministry of Home Office and the Ministry of Economy to provide water and electricity service.

In 2005, RADEEMA supplied water to 87 % or 748,000 of the population in Marrakech after providing purified water from ONEP. Also, RADEEMA launched an environmental conservation project since 1998 and the development project of sewerage facilities has just started in August 2006 for the works to renovate the existing sewers, install intercept sewers and construct primary sewage treatment system at the river basin of the Tensift in the north-west suburbs of the city. To perform public services for water, electricity and sewage, RADEEMA employs about 1000 staff, of which some 300 are assigned to provide water related service. Figure E.1.2 indicates the organization chart of RADEEMA.

E.1.3 Water Supply in Marrakech

Water supply in Marrakech is produced by the water treatment facilities of ONEP and provided through the water distribution network of RADEEMA.

At 17 km away from the city, the water treatment plant started operation in 1983. Present rated capacity is 1,600 L/s. Construction work is in progress at the adjacent area of the existing plant to construct 1,400 L/s water treatment processes. Half of the water treatment facilities are expected to start operation in July 2007 and the other half is scheduled to complete in 2010. After completion of the expansion project, the rated water treatment capacity will reach 3,000 L/s.

Three water intake facilities convey raw water to the water treatment plant. Most of the raw water is conveyed from Rocade Canal by 2km gravity flow pipeline. Moulay Brahim Stream that runs in Bouzougharo about 25 km away from the water treatment plant to the South is the water source of subsurface water. Subsurface water is collected by under-drain facilities that convey the flow of approximately 200 L/s to the water treatment plant as long as the water is available especially in wet season. Standby water intake facilities are located at Station-9 about 25 km away from the water treatment plant to the South-West. The water intake facilities of Station-9 divert irrigation water of ORMVAH and convey 200 to 250 L/s raw water to the water treatment plant especially in summer season on request. The intake facilities suspended operation at the end of October for about 10 days due to work to remove sediments in the canal. In addition to the water intake facilities mentioned above, groundwater is pumped from 38 wells in 12 group well fields in Issil, Agudal and Ourika. The well water is conveyed to the distribution reservoir in the South of Marrakech in addition to the direct distribution of a portion of water feeding to the water distribution network.

There are two distribution reservoirs operated by RADEEMA. The first reservoir is located nearby the water treatment plant with the capacity of 37,500 m^3 and another reservoir of 12,500 m^3 is under construction in the adjacent site. The second distribution reservoir having the storage capacity of 55,000 m^3 is located in the South suburbs of Marrakech. Water is supplied to the consumers in Marrakech through gravity flow system. Water consumption, water production and water intake volumes are 34.6 M. m^3/year, 56.1 M. m^3/year and 58.9 M. m^3/year respectively in 2005. (Table E.1.1)

E.1.4 Rural Water Supply Systems

ONEP manages the water supply systems in 55 communes in the administration area of Region-2 Office. Out of 55 communes, the following 11 communes are located within the groundwater simulation boundary in the Study Area: (1) Sid Zouine, (2)Loudaya, (3) Tahannaout, (4) Ait Ourir, (5) Tameslohte, (6) Ghmate, (7) Abdallah Ghiat, (8) Lalla Takarkoust, (9) Chichaoua, (10) Tamallalt, and (11) Sidi Rahhal

All 11 communes use only groundwater sources and supply water to the communes after disinfection.

Table E.1.2 shows the water consumption of 11 communes estimated by ONEP. In 2005, the total of water consumption of 11 communes was 2.1Mm^3/year and the largest portion of water, 1.7Mm^3/year, was used for the domestic water.

E.1.5 Community Water Supply

Localized piped water supply systems are installed in the rural areas under the assistance programs of the Ministry of Equipment and the Ministry of Agriculture, or by self-help of the communities. Also, the people without the piped water supply system obtain water from the wells dug by themselves or from the half-underground water storage tank supplied water from the nearby well. Population of those localized rural communities is estimated approximately at 620,000 and the water consumption at 12 Million m3 in 2005.

ONEP, in collaboration with DGH has been promoting the PAGER project, which has been started in 1995 to supply water in the remote areas to achieve the water supply coverage ratio of 92% by 2007; however, the development is delayed due to budget constraints. Since 2004, ONEP has been authorized the sole responsibility for implementing the PAGER project

E.1.6 Water Quality of Domestic Water Supply

RADEEMA measures distribution water quality regularly at the inlet to the distribution network and the tap water in the network. Table E.1.3 shows the water quality test results only for the major water quality parameters shown in comparison with the drinking water standard determined by ONEP for purified water quality. The test result shows that the water quality passed well within the Recommended Maximum Level of ONEP's Drinking Water Standard.

E.1.7 Water Consumption by the Type of Water User

As for the water consumption ratio by the water user groups estimated from the water consumption record in 2005, the water amount of domestic water use accounts for the majority and the domestic water users of Marrakech consume 85.6 % while ONEP's 11 communes consume 81 % of water to the total water consumption. Water consumption ratio by the institutional buildings including government offices, municipality offices, schools, etc. is more or less 12 % and the second largest consumer in Marrakech and the ONEP's 11 water works respectively. Water consumption ratio by the industrial group is 2.7 % in Marrakech and 5.0 % in 11 communes in 2005. (Table E.1.4) However, the survey data in 2003 shows that the water consumption ratio of industrial water users including hotels account for about 8 %. The latest record of RADEEMA in 2006 modified and the water consumption ratio of industries including hotels account for 6.9 % which is almost the same level with the data in 2003. (Table E.1.5）

E.1.8 Future Water Demand Prediction of Water Supply Systems

The future water demand prediction of the water supply systems of ONEP and RADEEMA was studied and concluded that the predicted water demand is appropriate to adopt it for the Study. The village out of service areas of ONEP, the water demand of 30 liter per capita per day is adopted in the initial stage. As the village will be supplied with piped water supply system by public taps or by house connection, the water demand of 65 liter per capita per day is used, which is the same level of water demand adopted for the future water demand prediction by ONEP for 2020. Moreover, the water access ratio of 60 % was adopted for the rural residents in 2004 with reference to the World Bank appraisal report (November 2005) of ONEP. Also, the water access ratio of 2020 is assumed at 95 % in consideration of the on-going PAGER project to develop the water supply systems in the rural areas to supply water through public taps and house connection.

Table E.1.6 shows the result of prediction of present and future demand of water supply systems in Marrakech, the 11 communes by ONEP and other 41 communes locate within the groundwater simulation area. Total water demand in terms of required water intake quantity from surface water and groundwater sources. The required water intake quantity will be broken down into surface water and ground water sources in the course of the Study. However, the total required water intake quantity for water supply systems will increase from 76.5 Mm^3/year in 2005, and to 100.3 Mm^3/day in 2020.

E.1.9 Water Demand of Golf Course & Resort Areas

There are currently three (3) golf courses in the Study Area (Marrakech Royal Golf Club, Amelkis Golf Club and Palmeraie Golf Club) using water with the volume of 2.5M.m^3/year. Another three (3) golf course & resort projects have already obtained permission from ORMVAH/ABHT to withdraw water from Rocade Canal and groundwater. The total approved amount of water intake of these three golf course & resort projects reach at 3.92M.m^3/year. Furthermore, there are five (5) golf course & resort projects are currently applying for approval of the development project. These projects have requested to withdraw water from the Rocade Canal and from groundwater and the total water intake quantity requested by the projects reach at 7.85 Mm^3/year. Accordingly, the total water intake quantity in the future will become 14.27 Mm^3/year once the requests of these new projects will be permitted. In addition to the prescribed projects, there are eight (8) other projects of which status are unknown are listed up currently to prepare for the development of the golf course & resort business. Altogether nineteen (19) golf course & resort projects exist in the suburbs of Marrakech and the total water demand is estimated to exceed a little more than 30 Mm^3/year. The name of those golf courses and the water demand is summarized in Table E.1.7.

E.1.10 Future Water Source for Marrakech Water Supply System

ONEP has started for preparation on the study for future water sources of Marrakech water supply system. The study will be completed in 2008. The framework of the study in connection with the future water demand and the objective water sources are as summarized in Figure E.1.4. According to the graph in the Figure E.1.4, water sources until 2015 is secured at 2,900 L/s to meet with the water demand and the water treatment plant capacity including the existing and the on-going water treatment plants. And the required water intake demand in 2030 is estimated at 3,900 L/s increased by 1,000 L/s from the secured water intake capacity at present. The study of ONEP will be focused on the shortage of water intake capacity to fill up from the Rocade Canal and/or Massira Dam locates in the neighboring river basin of the Tensift on the north. Under the Master Plan Study, the existing water

sources have sufficient capacity up to meet with the target year of the master plan in 2020 and the study of new water sources for Marrakech is excluded from the Master Plan Study accordingly.

E.1.11 Reduction of Water Demand through Water Leakage Control Measures

Water leakage control measures practice currently is not efficient and it will be very difficult to reduce the unaccounted water amount toward future. Study was made for the future water intake amount for two cases. The first case estimated the future water intake amount assuming the unaccounted water ration of RADEEMA and ONEP remained the same level at present as 38 % and 36% respectively. The second case estimated the future water intake amount with the strengthening measures water leakage control to achieve the target level of unaccounted water ratio approximately at 30%-2010, 25%-2015 and 23%-2020 for RADEEMA and ONEP water supply systems. Table E.1.8 and Figure E.1.5 indicate the result of the study. In case of effective strengthening measures are taken for the water leakage control, the water intake amount for supplying water to the entire study area including the service areas of RADEEMA, ONEP and other rural area in 2020 is estimated at 100M.m3 per year and the water intake amount of 120M.m3 per year is estimated in the present circumstances of water leakage control measures. The balance of water intake amount of 20M.m3 per year between the two cases is a quite large amount and it will reach almost equivalent amount to the annual water consumption of 400,000 water users. There is necessity to review the unaccounted water ration (water leakage ratio) mentioned above determined for estimation of the future water demand and it is recommendable to set the target level at 20 % in 2020 with the final target level at 15% thereafter.

E.1.12 Study on Desalination for Water Resource

(1) State of Salinity in the Water Quality Test Result

As described in the section of Water Quality, it was identified that there is an existence of higher salinity and hardness groundwater from the water quality test result (1991-2004) of 400 water samples of 72 existing wells in the Study Area and at least 30 to 40% of water samples are necessary to reduce the concentration of salinity by desalination for drinking water use.

(2) Accumulation of Water Quality Database

It is conjectured that there are many villages in the Haouz Plain, where are not available to secure good quality of groundwater. Particularly, high salinity concentration groundwater can not be used for domestic water. Salinity is not measured directly but estimated from the conversion of electric conductivity. ABHT conducted groundwater quality analysis for about 400 water samples in the period from 1991 to 2004 in the Study Area of the Haouz Plain. But these water samples were taken from 72 wells and the groundwater quality analysis is not always conducted sufficient numbers of wells for the groundwater quality monitoring. Although it is essential to complete the groundwater quality monitoring system immediately, for the provisional measures for the time being, the ABHT shall carry out the investigation of the actual conditions of the groundwater quality analysis and the relevant activities based on the followings items.

- Conduct the investigation for the actual conditions of the method for obtaining domestic water, water quality, access time to water, etc. (well owners, water associations, ONEP, health office, others),
- Establishment of the system to conduct water quality analysis by the request of the owner of wells,

- Start direct analysis of the concentration of salinity,
- Structuring the groundwater quality database and analysis,
- Preparation and publicizing of groundwater contamination maps including the parameters of salinity, hardness, etc., and
- Closedown of contaminated wells, advice and support for water purification

(3) Important Matter of Desalination Project for Rural Villages

There is no village to supply water from the desalination plant in the study area at present. Because of a factor of expensive construction cost compared to the purification amount, construction of desalination facilities is not promoted. However, it is a fact that there are not a few villages suffering inconvenient access to good quality of water and the service of water to those villages is urgent. If the extension of service pipes from the existing water supply system is not feasible in technical and economic point of view, desalination of brackish water is considered for the alternative. The following procedures are recommended to implement the desalination project for rural villages.

- Pick out the villages suffering to secure water for domestic use and preparation of database of the basic conditions of water use,
- Preparation of selection standard for implementing the desalination project and selection of the villages (water quality, access time to water, population scale, water demand and other items)
- Prioritization of the village groups for implementation of the desalination project,
- Preliminary estimation of construction cost implementation time schedule, budgeting plan (by ONEP),
- Basic design of desalination facilities for the villages of high priority group (include the alternative to supply water by extension of the service pipes from the existing water supply facilities),
- Estimation of construction cost and operation & maintenance cost of the desalination facilities of the objective villages,
- Budgeting, cost sharing by the resident and confirmation for shouldering the shared cost, and
- Implementation of the project.

(4) Implementation of Desalination Project in the Villages

There revealed an existence of higher salinity and hardness groundwater from the water quality analysis of wells in the Study Area. The concentration value exceeds the drinking water standards but it is still within the irrigation water quality standards for most of the cases. In the remote settlements where good quality water source is not available, desalination/demineralization will be the only alternative and the construction work will be implemented. Even in this case, it is assumed that the treatment water amount might not be more than $50m^3$/day and it does not mean that the water source is an alternative for the development of new water resources since the desalination/demineralization water is abstracted from the existing groundwater.

(5) Seawater Desalination for Water Resource Development

There is a discussion of sea water desalination for the new water resources. In the oil-producing

countries where low price fuel is available, seawater desalination is an advantageous and the only alternative. Recent years, the large scale plants such as 100 Million m3/day class plants have been constructed. Looking for seawater desalination for the new water resources of Marrakech located inland is very disadvantageous conditions in technical and economical point of views. In the Study Area, there still have such several alternatives as effective use of water resources, saving water, and inter basin water conveyance. The mega-project like seawater desalination must be studied under the development strategies of integrated national development plan. Accordingly, it will be an appropriate disposition to exclude the seawater desalination for new water resources development from the study objective item of the Master Plan targeted up to the year 2020.

E.2 Re-use of Treated Sewage of Marrakech

E.2.1 Present Conditions of Sewage and Drainage of Marrakech

(1) Sewage and Drainage System in Marrakech

Sewer system in Marrakech is the so-called combined sewer system to collect both storm water and wastewater from the houses and buildings by reinforced concrete pipes. Collected sewage is discharged at 3 outfalls (Azib Ayadi, El Azzouzia and Issil) on the shore of the Tensift river and it causes of water pollution. The total length of the combined sewer system reaches approximately 1,400 km and is connected at about 106,000 points to cover 82 % of the city area.

No sewage treatment facilities are operated in Marrakech at present except for the sewage treatment plant managed by the community in the private housing development housing area of ERAC[1] (Etaolissement Regionale o Arrenagement et de Construction) located about 25km away from the city center to the West.

The project for sewerage system development started in 1998 with the objective to construct a sewage treatment plant, and installation and rehabilitation of existing sewers and intercept sewer system to collect and convey sewage to the sewage treatment plant. The project is financed by EU Bank for Reconstruction and Development and the construction work started in August 2006. The outline of the sewerage system development is discussed in the following section.

(2) Estimation of Sewage Generation Amount

No flow survey data was available. Assuming 80 % of the quantity of water consumption is discharged as sewage and the coverage area of sewers is 82% (RADEEMA data in 2005), the average sewage flow discharged to the Tensift River is estimated at 62,000 m^3/day.

Daily Average Water Consumption in 2005	:	94,800 m^3/day
Sewage Generation Amount	:	76,000 m^3/day
Sewage Collected and Discharged to the Tensift	:	62,000 m^3/day

(3) Construction Plan of Sewage System in Marrakech Town

Development project of sewerage system is being implemented by RADEEMA to construct sewage treatment plant at Azib Ayadi on the Tensift riverside including the rehabilitation of existing sewers, intercept facilities and interceptor pipelines. The project was awarded to the joint venture of

[1] Etaolissement Regionale o Arrenagement et de Construction

DEGEAMONTE, France and SOGEA, Morocco in 2004. Construction work started in August 2006. The construction project is outlined in the following.

Outline of Construction Project of Sewerage System in Marrakech

Planned Capacity of Sewerage System	
Daily Average Treatment Flow (Dry Weather Flow)	90,720 m^3/day
Treatment Flow in Summer (Max. Daily Treatment Flow)	117,936 m^3/day
Peak Treatment Flow	184,896 m^3/day
Wet Weather Flow	9,828 m^3/hr or 2.73 m^3/s
Sewage Treatment Sequence	
Phase 1 (2007)	Grit Removal－Primary Sedimentation -Disinfection - Discharge
Phase 2 (2010)	Grit Removal－Primary Sedimentation – Biological Treatment (Aeration) – Final Sedimentation - Disinfection - Discharge
Construction Cost (Phase 1)	
Construction Work (18 months)	190 Million Dhs
O & M Work (5 years)	20 Million Dhs
Funding Agency :	EU Bank for Reconstruction and Development RADEEMA (50%) and BEI (50%)

According to the sewerage development plan of Marrakech, sewage being discharged to the Tensift River from three (3) outfalls is intercepted by the overflow structures and be conveyed to the sewage treatment plant by gravity flow interceptor pipelines. Meanwhile, the excess storm water is conveyed and discharged to the Tensift River by the storm water discharge pipelines. The locations of these interceptor facilities, interceptor pipelines and sewage treatment plant under construction are indicated in Figure E.2.1. The sewerage facilities under construction at present include the overflow structures, interceptor pipelines and primary sewage treatment plant. Construction work is scheduled to complete in December 2007 and start primary treatment of sewage from January 2008. The primary sewage treatment plant including sludge treatment facilities is scheduled to complete in March 2008 and the regular sewage treatment is scheduled to start in June 2008 after three (3) months commissioning and adjustment period. Immediately after start of operation of the primary sewage plant, the construction of secondary treatment facilities will be started. Panning and the design of the secondary treatment facilities are under preparation by the Consultant. Completion of the secondary treatment plant is scheduled in 2010 and the design work including the system for reuse of reclaimed water of treated sewage together with the secondary sewage treatment processes are now in progress. Overall swage treatment flow sheet including the treated sewage reclamation facilities are indicated in Figure E.2.2. The sludge treatment process of characterizes the sewage treatment system of Marrakech. The sludge treatment process is comprised of anaerobic process to recover digestion gas and generation of electricity for supply to the equipment of sewage treatment plant, what is called the Clean Development Mechanism (CDM) project.

E.2.2 Construction Plan of Sewage System in Rural Communes in the Study Area

ONEP is implementing the development project of sewerage system in communes, 10 of which are communes within the Study Area. Currently, ONEP sublet the study and engineering design to the private consulting firms, and the implementation plan of the project will be started when the sharing of 30% of the construction cost is agreed by the commune. The following are the names of the 10 communes under preparation of the sewerage system development plan.

(1) Ait Ouir (Al Haouz), (2) Amiz Miz (Al Haouz), (3) Ghmate (Al Haouz), (4) Tahanaoute (Al Haouz), (5) Tamesloht (Al Haouz), (6) Chichaoua-center (Chichaoua), (7)Imintanout (Chichaoua), (8) Tammelalt (El Kelaa Des), (9) Sidi Zouine (Marrakech), (10) Tnine Laudaya (Marrakech)

E.2.3 Re-use of Treated Sewage of Marrakech Sewage Treatment Plant

(1) Possibility of Re-use of Treated Sewage

The sewage treatment plant of Marrakech will be completed in two phases. In Phase-1, the facilities of primary sewage treatment processes is constructed mainly aiming at reducing suspended solids by 66% or less than 200 mg/L in concentration. Biological treatment process and final settling tank is added in Phase-2 construction work to decompose organic matter in sewage and reduce BOD5 and SS concentration less than 30 mg/L respectively.

The concentration level of SS and BOD5 of the treated sewage of Phase 1 treatment process is rather high and water is still aggressive in nature to consider about wastewater reclamation. Treated sewage from the Phase-2 treatment process will reach at the permissible for the limited use for irrigation and similar level water use.

RADEEMA is implementing the plan to treat the secondary treatment sewage by rapid sand filtration to reduce BOD5 and SS less than 15mg/L and 10mg/L respectively and distribute to the Tensift river side palm garden and golf course and resort areas for irrigation use. RADEEMA's plan is made appropriate level in terms of the water quality for irrigation water use. However, it is preferable to install the chemical sedimentation process in the front of rapid sand filtration in consideration of operation and maintenance of the facilities, particularly the high loading of suspended solids to the filtration process and frequent wash out of distribution pipelines. It is expected to have more opportunity for utilization of reclaimed water, for example washing water, through the proposed tertiary treatment processes, chemical sedimentation, rapid sand filtration and disinfection, and the result of water clearness obtained the same level with that of general water supply system and BOD5 and SS decreased less than 5mg/L and 2 NTU respectively.

Mixture of industrial wastewater to the public sewers may cause contamination by hazardous material and sewage will be become unfavorable condition for re-use. Pre-treatment measures shall be regulated by the responsible agency(s) to force the polluters to remove the hazardous matter to meet with the acceptable level before connecting to the public sewer.

(2) Economic Feasibility of Reclaimed Water of Treated Sewage

The method for conveying reclaimed water to the re-use sites will be a key element to consider the economy to materialize the reuse of reclaimed water of treated sewage. RADEEMA is studying to use reclaimed water at the Tensift river side palm garden and eight (8) places of gold course & resort areas. There are several alternative routes of reclaimed water conveyance & distribution. In general, the shortest pipeline route connected between the tertiary treatment plant site and the water demand sites will have an advantage in energy for pumping and minimizing the cost for pumping operation. One of the advantageous pipeline rote was selected for reference and indicated in Figure E.2.3. The unit price of water is important factor for discussion of economy of reclaimed water. Trial calculation was carried out for the unit price of reclaimed water based on the RADEEMA's provisional construction cost, the alternative pipeline route in Figure E.2.3 and 25 years operation and maintenance period as shown in the following table.

Trial Calculation of Unit Price for Utilization of Reclaimed Water of Marrakech

Item	Cost (M.DH)
Construction Cost of Tertiary Treatment Plant (Capacity: 52,600m3/d), Chemical Sedimentation and Rapid Sand Filtration)	120
Construction Cost of Reclaimed Water Conveyance & Distribution Facilities (4 Pump Stations, 40 km pipelines)	140
Operation & Maintenance Cost (25 years, Chemical Cost, Electricity Cost, Maintenance Cost and Operators)	871
Total Cost	1,131
Unit Price of Reclaimed Water (DH/m3) (Not include the interest)	2.36

According to the trial calculation, the unit price of reclaimed water is estimated at 2.36 DH/m^3. This unit price is cheaper than the average water users of Marrakech residents paying at 6 to 8 DH/m3 though the estimated unit price exceed the unit price of 1.87 DH/m^3 agreed with ORMVAH. The golf course & resort owners having engaged in business with the vested right of water intake would not be acceptable to utilize reclaimed water due to increase of the cost. The issue in the difference of unit water price shall be solved in consideration of subsidy or other means.

E.3 Water Quality

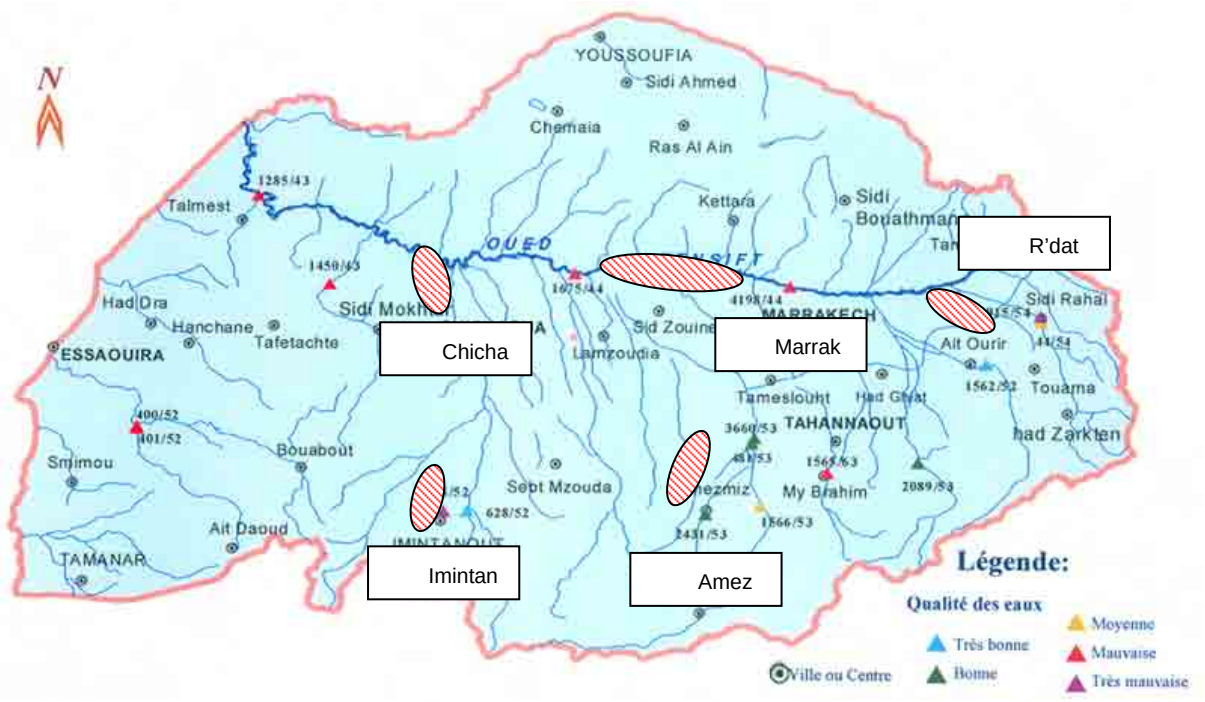
E.3.1 River Water Quality

Water quality standards for surface water are defined under Decree No. 1275-01, promulgated in December 2002. Under these standards, water quality of surface water is categorized into 5 levels based on a variety of parameters: Excellent, Good, Average, Bad and Very bad. Water quality survey by ABHT in 2004-2005 indicates “average” to “good” for the majority of surveyed points (Table E.3.1). However, the sections of rivers nearby the major cities and towns tend to show worse water quality. These include:

- Tensift river areas with discharges of waste water of the city of Marrakech.
- Imintanout river: downstream of the center of Imintanout
- R' dat river: downstream of the center of Sidi Rahal
- Amezmiz river: downstream of the rejections of the center of Amezmiz;
- Chichaoua river: downstream of the center of Chichaoua;

Table E.3.1 indicates water quality of selected survey sites. The classification of water quality (River water) is done based on 6 items. For sites categorized into “bad” and “very bad”, majority of the reason was the amount of Chemical Oxygen Demand (COD) and Total Phosphate (T-P). Other items showed rather good results for most of the water samples.

On the other hand, the water quality of major rivers including that of Rocade Canal contain higher concentration of turbid and sands and it makes difficult for water purification for drinking water and settlement of sands in dams.



Data Source: ABHT

Figure E.3.1 Surface Water Quality in the Haouz Plain (2004-2005)

E.3.2 Water Quality of Reservoir and Canal

ABHT conducted water quality test of 117 water samples of four (4) reservoirs and three (3) canals in the period from 1991 to 2002. The water quality test results do not indicate the time-wise water quality difference. Table E.3.2 shows the water test quality result of four (4) dams, Barrage Hassan 1 er, Barrage Mouley Youssef, Barrage Side Dris and arrage Takerkoust, and Rocade Canla. The values in the table show the average value of representative water quality parameters in the period of 2000-2002 together with the surface water quality standard (environmental water quality standard). As a result of the water quality test, average value of every water quality parameters is covered in the range of "good – excellent" though the values of Ammonia and Total Phosphate are a little higher than that of the water sources, the reservoirs, showing a sign of probable water contamination. (Table E.3.2)

On June 14, 2007, Study Team conducted water quality test of surface water and combined sewer at four (4) points in the Isil River and the Tensift River. Water sample from the river bed stagnant water is taken for the water quality test since no water ran in the rivers. Portable water test kit prepared for groundwater quality test was used for the water quality analysis and the test result in Table E.3.3 was shown only for information. (Table E.3.3)

E.3.3 Groundwater Quality

Table E.3.4 shows the groundwater quality standard prepared by ABHT and proposed to the Ministry for final approval.

Groundwater quality tests have been carried out regularly by ABHT for the production wells and monitoring wells. The groundwater quality test data analyzed for the period from 1991 to 2004 is

summarized in Table E.3.5 in comparison with the provisional groundwater quality standard. Findings of the groundwater quality tests for about 400 samples from 72 wells are summarized as follows:

- Conductivity ranges in the level of “good-medium” except for the remarkable numbers of samples shows the concentration in the level of “very bad”.
- Oxidizable matter is rather low for most of the samples.
- Chloride ranges in the level of “excellent – medium” except of the remarkable numbers of samples shows the level of “very bad”.
- Nitrogen in the form of Ammonia and Nitrates shows the tendency in the level of “excellent – medium”. Decomposition of nitrogen is in progress in most of the wells.
- Faecal coliform ranges in the level of “excellent – good”
- More than 90 % of the test samples grouped in the level of “excellent – medium” and the status of groundwater quality in Haouz Plain is acceptable level. However, it shall be noted that some of the wells about 8% are contaminated and appropriate mitigation measures shall be taken.

This time, the above groundwater quality test result of about 400 samples were reviewed in comparison with the recommendable level purified water (distribution water) quality standard of ONEP for major water quality parameters and tabulated in Table E.3.6. The facts learned from the review are summarized as follows. (Table E.3.6)

- Electric Conductivity; More than a half, fifty three (53) %, of water samples exceeded the recommendable level purified water quality standard value of 1,300μs/cm,
- KMnO4 Consumption; Twenty four (24) % of water samples exceeded the recommendable level purified water quality standard value of 2mg/L,
- Ammonium Nitrogen; Twenty four (24) % of water samples exceeded the recommendable level purified water quality standard value of 0.05mg/L,
- Sodium; Thirty four (34) % of water samples exceeded the Japanese Drinking Water Quality Standard of 200mg/L,
- Calcium; Only two (2) % of water samples exceeded the Japanese Drinking Water Quality Standard value of 300 mg/L (conversion to $CaCO_3$) prescribed for hardness,
- Magnesium; Eighteen (18) % of water samples exceeded the recommendable level purified water quality standard of 100mg/L,
- Chloride; Thirty nine (39) % of water samples exceeded the recommendable level purified water quality standard value of 300 mg/L,
- Nitrate Nitrogen; Seventy two (72) % of water samples exceeded the Japanese Drinking Water Quality Standard value at 10 mg/L, but the thirteen (13) % of water samples exceeded the maximum allowable level purified water quality standard value of 50mg/L,
- Bicarbonate; Cause of temporary hardness. Fifty six (56) % of water samples exceeded the Japanese Drinking Water Quality Standard value of 300mg/L for hardness,
- Sulfate; Cause of permanent hardness. Twenty eight (28) % of water samples exceeded the

recommendable level purified water quality standard value of 200mg/L.

- Coliform Bacteria; Sixty eight (68) % of water samples detected Coliform bacteria,
- Thirty six (36) % of overall average value of respective water quality parameters exceeded the water quality standard value.

Followings are the evaluation of the prescribed groundwater quality test results compared with the purified water quality standard.

- Dissolved salt and minerals caused of high Electric Conductivity and more that fifty three (53) % of water samples are not suitable for drinking water,
- The ratio exceeding the water quality standard is high in the water quality parameters of KMnO4 consumption, Ammonium Nitrogen, Nitrate Nitrogen and Coliform Bacteria Count. Particularly, sixty eight (68) % of water samples detected Coliform Bacteria which is a sign of artificial contamination of groundwater. It suggests that even though the water supply systems use groundwater source need disinfection equipment.
- Salinity became high caused of high concentration of Sodium Ion and Chloride Ion and 30 to 40 % of water samples are not suitable for drinking water without treatment,
- In the range from 18 % to 56% of water samples exceed the water quality parameters related with hardness, Electric Conductivity, Magnesium, Bicarbonate, and Sulfate. Groundwater in the Study Area is deemed hard water and not suitable for drinking water without treatment.
- Water quality problem of Coliform Bacteria and temporary hardness will be improved by boiling. However, 30 to 40 % of water samples are brought up for the problems of permanent hardness and salinity. Those groundwater are not suitable for drinking water without treatment by softening, desalination and/or demineralization.

E.3.4 Groundwater Quality Test in the Surrounding Area of Water Level Monitoring Wells

Study Team conducted groundwater quality test of twelve (12) wells based on the following conditions.

- Survey Period: June 12 and June 13, 2007
- Sampling Wells: 10 wells (locate adjacent to the auto water level monitoring wells installed by JICA) and 2 wells of ONEP
- Water Quality Parameters: Water Temperature, pH, Dissolved Oxygen, Electric Conductivity, Salinity and Turbidity,
- Water Quality Test Kit: Water Quality Checker (Model WQC-22A), made by TOA DKK

The result is tabulated in Table E.3.7 and summarized as follows. (Table E.3.7）

- Water Temperature is almost constant in the range of 20.8～24.9 ^{o}C,
- pH value is also almost constant in the range of 6.56～7.40,
- Dissolved Oxygen changes in the range of 5.61～8.48. The values are genrally lower than that of the surface water and there are 6 wells showing the sign of deoxidization,

- Electric Conductivity changes in the range of 53.5～373mS/m(535～3,730μS/cm). There are seven (7) wells exceed the recommendable level purified water quality standard of ONEP of 1,300μS/cm, which is caused of high dissolved minerals in water.
- Salinity converted from Electric Conductivity changes in the range of 0.027～0.2%. Taste of well water exceeded the salinity concentration of 0.2% was obviously salty.
- Turbidity changes in the range of 0～2NTU and good condition.

From the finding s of the groundwater quality test described above, it shall be noted that there are seven (7) wells out of twelve (12) wells exceeded the recommended level purified water quality standard for Electric Conductivity. Meanwhile, all the water quality test results meet with the irrigation water quality standard. Finally, the water quality test was conducted by portable water test kit and the test result shall be considered as the information only.

E.4 Water Quality Standards

E.4.1 Surface Water Quality Standards

Table-1 Water Quality Standard for Evaluation of Surfacewater Quality
Decree No. 1275-01, Bulletin No.5062 (5 December 2002)

Parameters		unit	Class 1	Class 2	Class 3	Class 4	Class 5
Organic Substance							
1	Color	mg pt/L	<20	20 - 50	50 - 100	100-200	>200
2	Odor (at 25℃)	-	<3	3 - 10	10 - 20	>20	-
Physical-Chemical Substance							
3	Temperature	℃	<20	20 - 25	25 - 30	30 - 35	>35
4	pH	-	6.5-8.5	6.5-8.5	6.5-9.2	>6.5 or >9.2	>6.5 or >9.2
5	Conductivity (at 20℃)	μs/cm	<750	750 - 1300	1300 - 2700	2700 - 3000	>3000
6	Chloride (Cl^-)	mg/L	<200	200 - 300	300 - 750	750 - 1000	>1000
7	Sulfate (SO_4^-)	mg/L	<100	100 - 200	200 - 250	250 - 400	>400
8	Suspended Solids (MES)	mg/L	<50	50 - 200	200 - 1000	11000 - 2000	>2000
9	Dissolved Oxygen (DO)	mg/L	>7	7 - 5	5 - 3	3 - 1	<1
10	BOD^5	mg/L	<3	3 - 5	5 - 10	10 - 25	>25
11	COD	mg/L	<30	30 - 35	35 - 40	40 - 80	>80
12	$KMnO_4$ Consumption	mg/L	<2	2 - 5	5 - 10	>10	-
Undesirable Substance							
13	Nitrate Nitrogen (NO_3^-)	mg/L	<10	10 - 25	25 - 50	>50	-
14	Kjerdahl Nitrogen (NTK)	mg/L	<1	1- 2	2 - 3	>3	-
15	Ammonium Nitrogen (NH_4^-)	mg/L	<0.1	0.1 - 0.5	0.5 -2	2 - 8	>8
16	Barium	mg/L	<0.1	0.1- 0.7	0.7 - 1	>1	
17	Phosphate (PO_4^{3-})	mg/L	<0.2	0.2 - 0.5	0.5 - 1	1 - 5	>5
18	Total Phosphorus (T-P)	mg/L	<0.1	0.1 -0.3	0.3-0.5	0.5 -3	>3
19	Total Iron （T-Fe)	mg/L	<0.5	0.5 - 1	1 - 2	2 - 5	>5
20	Cupper (Cu)	mg/L	<0.02	0.02 - 0.05	0.05 - 1	>1	-
21	Zinc (Zn)	mg/L	<0.5	0.5 - 1	1 - 5	>5	-
22	Manganese （Mn)	mg/L	<0.1	0.1- 0.5	0.5 - 1	>1	-
23	Fluoride (F)	mg/L	<0.7	0.7 - 1	1- 1.7	>1.7	-
24	Hydrocarbon	mg/L	<0.05	0.05 - 0.2	0.2 - 1	>1	-
25	Phenol	mg/L	<0.001	0.001-0.005	0.005-0.01	>0.01	-
26	Detergent-Anion	mg/L	<0.2	<0.2	0.2 - 0.5	0.5 - 5	>5
Toxic Substance							
27	Arsenic (As)	μg/L	<10	<10	10 - 50	>50	-
28	Cadmium (Cd)	μg/L	<3	<3	3 - 5	>5	-
29	Cyanide (CN-)	μg/L	<10	<10	10 - 50	0.5 - 5	-
30	Total Chrome (Cr)	μg/L	<50	<50	<50	>50	-
31	Lead (Pb)	μg/L	<10	<10	10 - 50	0.5 - 5	-
32	Mercury (Hg)	μg/L	<1	<1	<1	>1	-
33	Nickel (Ni)	μg/L	<20	<20	20 - 50	>50	-
34	Selenium (Se)	μg/L	<10	<10	<10	>50	-
35	Pesticides per substance	μg/L	<0.1	<0.1	<0.1	>0.1	-
36	Total Pesticide	μg/L	<0.5	<0.5	<0.5	>0.5	-
37	HPA	μg/L	<0.2	<0.2	<0.2	>0.2	-
Bacteriological Substance							
38	Coliform Bacteria (Faecal)	no./100ml	20		2,000		20,000
39	Coliform Bacteria (Total)	no./100ml	50		5,000		50,000
40	Streptcocus	no./100ml	20		1,000		10,000
Biologic Substance							
41	Chlorophyll a	μg/L	<2.5	2.5 - 10	10 - 30	30 - 110	>110

Table-2 Major Water Quality Parameters for Evaluation of Surfacewater

for River	DO	BOD^5	COD	NH_4^-	T-P	Coli. Count
	mg/L	mg/L	mg/L	mg/L	mg/L	no./100mL
Excellent	>7	<3	<20	<0.1	<0.1	<20
Good	7 - 5	3 - 5	20 - 25	0.1 - 0.5	0.1- 0.3	20 - 2000
Medium	5 - 3	5 - 10	25 - 40	0.5 - 2	0.3 - 0.5	2000-20000
Bad	3- 1	10 - 25	40 - 80	2 - 8	0.5 - 3	>20000
Very Bad	<1	>25	>80	>8	>3	-

for Lake	DO	T-P	PO_4^{2-}	NO_3^-	Chl.a
	mg/L	mg/L	mg/L	mg Pt/L	µg/L
Excellent	>7	<0.1	<0.2	<10	<2.5
Good	7 - 5	0.1- 0.3	0.2 - 0.5	10 - 25	2.5 - 10
Medium	5 - 3	0.3 - 0.5	0.5 -1	25 - 50	10 - 30
Bad	3- 1	0.5 - 3	1 - 5	>50	30 - 110
Very Bad	<1	>3	>5	-	>110

E.4.2 Groundwater Quality Standards

(ABHT Provisional Value)

Water Quality Grade	Conductivity	Oxidizable Matter (KMnO4)	Chloride (Cl-)	Anmonium Nitrogen (NH4+)	Nitrate Nitrogen (NO3-)	Faecal Coliform Count (nos./100mL)
	(µs/cm)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	
Excellent	<400	<3	<200	<0.1	<5	<20
Good	400 - 1300	3 - 5	200 - 300	0.1-0.5	5 - 25	20-2000
Medium	1300 -2700	5 - 8	300 -750	0.5-2	25-50	2000-20000
Bad	2700-3000	>8	750 - 1000	2 - 8	50-100	>20000
Very Bad	>3000	-	> 1000	>8	>100	-

E.4.3 Irrigation Water Quality Standard

Irrigation Water Quality Standard (fecal coliform bacteria)
Decree No. 1276-01, Bulletin No.5062 (5 December 2002)

Categories	Conditions of Use	Exposed Groupe	"NEMATHODES INESTINAUX" (name of a parasite) (a) {Arithmetic average of eggs (of parasite) number per	FAECAL COLIFORMS {geometric average of the number per 100 ml (b)}	Wastewater Treatment technology likely to assure the required microbiologic quality
A	Irrigation of crops intended to use raw, sport grounds, public gardens (c)	Labor, consummers, public people	Absence (Zero)	< 1 000 (d)	A series of stabilization pond installed to remove the required level of microbiological quality or any equivalent treatment (method)
B	Irrigation of cereal, agricultural industry, fodder, pasture and planting trees (d)	Labor	Absence (Zero)	No standard is specified	Retention time of stabilization pond is for 8 to 10 days or any other treatment methods that perform equivalent removal
C	Localized irrigation for culturing B category if labor and people are not exposed	No exposure	Absence (Zero)	No standard is specified	Preliminary treatment required for functioning of irrigation technology, but at least a primary

Remarks

(a) Roundworm, trichuris, ankylostom.

(b) During the irrigation period.

(c) A strict rule (< 200 "faecal coliforme" per 100 mL) shall be applied for the fields such as the hotel garden where people can have a direct access.

(d) In the case of fruit plants, the irrigation must be stopped two weeks before the harvest and no fruit on ground have to be picked up, irrigation by spraying is not allowed.

Irrigation Water Quality Standard
Decree No. 1276-01, Bulletin No.5062 (5 December 2002)

	Parameters	unit	Limit Value
Bacterioogical Parameters			
1	Coliform Bacteria (Faecal)	no./100ml	1000
2	Salmonelle	-	Absence in 5L
3	Vibrion	-	Absense in 450mL
Parasitological Paramaters			
4	Pasogenic Parasite		Absence
5	Oeufs		Absence
6	Larves		Absence
7	Fluococercaires		Absence
Toxic Substance Parameters (1)			
8	Mercury (Hg)	mg/L	0.001
9	Cadmium (Cd)	mg/L	0.01
10	Arsenic (As)	mg/L	0.1
11	Total Chrome (Cr)	mg/L	0.1
12	Lead (Pb)	mg/L	5
13	Cupper (Cu)	mg/L	0.2
14	Zinc (Zn)	mg/L	2
15	Selenium (Se)	mg/L	0.02
16	Fluoride (F)	mg/L	1
17	Cyanide (CN-)	mg/L	1
18	Phenol	mg/L	3
19	Alminium (Al)	mg/L	5
20	Beryllium (Be)	mg/L	0.1
21	Cobalt (Co)	mg/L	0.05
22	Total Iron （Fe)	mg/L	5
23	Lithium (Li)	mg/L	2.5
24	Manganese （Mn)	mg/L	0.2
25	Molybdene (Mo)	mg/L	0.01
26	Nickel (Ni)	mg/L	0.2
27	Vanadium (V)	mg/L	0.1

Remarks

* 1,000 CF/100mL is applied for the cultures used raw.

(1) Controlled only when water may be affected by wastewater

Irrigation Water Quality Standards (continued)

Irrigation Water Quality Standard

Decree No. 1276-01, Bulletin No.5062 (5 December 2002)

Phisical-Chemical Parameters		unit	Limit Value
Salinity			
28	Total Salinity (STD)*	mg/L	7680
	Electric Conductivity (CE) at 25℃	mS/cm	12
29	Infiltration SAR **	 0 - 3 and CE= 3 - 6 and CE= 6- 12 and CE= 12-20 and CE= 20-40 and CE=	 <0.2 <0.3 <0.5 <1.3 <3
Toxic (Hazardous) Ions (Sensible affectants for farming)			
30	Sodium (Na)		
	- Surface Irrigation (SAR)**		9
	- Spraying Irrigation	mg/L	69
31	Chloride (Cl^-)		
	- Surface Irrigation	mg/L	350
	- Spray Irrigation	mg/L	105
32	Boron B)	mg/L	3
Other Parameters (Sensible affectants for farming)			
33	Temperature	℃	35
34	pH	-	6.5 - 8.4
35	Suspended Matter		
	- Gravity Irrigation	mg/L	2000
	- Spray and Drip Irrigation	mg/L	100
36	Nitrate Nitrogen (N-NO3)	mg/L	30
37	Bicarbonate (HCO3-)	mg/L	518
38	Sulfate Ion (SO_4^{2-})	mg/L	250

Remarks

* Strict restriction is required for water from the electric conductivity of 3mS/cm, but 50% output of the potential output capacity (may) be realized with water of 8.7 mS/cm (in case of barley)

** SAR : Sodium Absorption Ratio
CE : Electric Conductivity

E.4.4 Raw Water Quality Standard for Production of Drinking Water (surface water)

Surface Water Quality (Raw Water Quality) Standard for Production of Dringking Water
Decree No. 1277-01, Bulletin No.5062 (5 December 2002)

Category		unit	A1		A2		A3	
			G	I	G	I	G	I
Organic Papameters								
1	Color	mg pt/L	<10	20	50	100	50	200
2	Odor (at 25℃)	-	<3	-	10	-	20	-
Physical-Chemical Parameters								
3	Temperature	℃	20	30	20	30	20	30
4	pH	-	6.5-8.5	-	6.5-9.2	-	6.5-9.2	-
5	Conductivity (at 20℃)	µS/cm	1300	2700	1300	2700	1300	2700
6	Chloride (Cl^-)	mg/L	300	750	300	750	300	750
7	Sulfate (SO_4)	mg/L	200	-	200	-	200	-
8	Suspended Solids (MES)	mg/L	50	-	1000	-	2000	-
9	Dissolved Oxygen (DO)	mg/L	7(90%)	-	5(70%)	-	3(50%)	-
10	BOD5	mg/L	3	-	7	-	10	-
11	COD	mg/L	-	-	25	-	40	-
12	$KMnO_4$ Consumption	mg/L	2	-	5	-	10	-
Undesirable Substance		mg/L						
13	Boron	mg/L	-	1	-	1	-	1
14	Ammonium Nitrogen	mg/L	0.05	0.5	1	1.5	2	4
15	Kjerdahl Nitrogen (NTK)	mg/L	1	-	2	-	3	-
16	Nitrate Nitrogen (NO_3)	mg/L	-	50	-	50	-	50
17	Total Phosphorus	mg/L	0.4	-	0.7	-	0.7	-
18	Barium	mg/L	-	1	-	1	-	1
19	Cupper (Cu)	mg/L	-	1	-	2	-	2
20	Zinc (Zn)	mg/L	-	5	-	5	-	5
21	Manganese （Mn)	mg/L	-	0.1	0.1	0.1	1	-
22	Dissolved Iron （Fe)	mg/L	-	0.3	1	2	1	3
23	Fluoride (F)	mg/L	0.7	1.5	0.7	1.5	0.7	1.5
24	Dissolved Hydrocarbon	mg/L	-	0.05	-	0.2	0.5	1
25	Phenol	mg/L	-	0.001	-	0.005	-	0.01
26	Detergent-Anion	mg/L	-	0.5	-	0.5	-	0.5
Toxic Substance								
27	Arsenic (As)	µg/L	-	50	-	50	-	100
28	Cadmium (Cd)	µg/L	1	5	1	5	1	5
29	Total Chrome (Cr)	µg/L	-	50	-	50	-	50
30	Lead (Pb)	µg/L	-	50	-	50	-	50
31	Mercury (Hg)	µg/L	-	1	-	1	-	1
32	Selenium (Se)	µg/L	-	10	-	10	-	10
33	Nickel (Ni)	µg/L	-	50	-	50	-	50
34	Cyanide (CN-)	µg/L	-	50	-	50	-	50
35	Pesticides per substance	µg/L	-	0.1	-	0.1	-	0.1
36	Total Pesticide	µg/L	-	0.5	-	0.5	-	0.5
37	HPA	µg/L	-	0.2	-	0.2	-	0.2
Bacteriological Substance								
38	Coliform Bacteria (Faecal)	no./100ml	20		2,000		20,000	
39	Coliform Bacteria (Total)	no./100ml	50		5,000		50,000	
40	Streptcocus	no./100ml	20		1,000		10,000	

Remarks
G : Guideline Value
I : Allowable Value
A1 : Simple Physical Treatment and Disinfection
A2 : Normal Physical-Chemical Treatment and Disinfection
A3 : Physical-Chemical-Special Treatment and Disinfection

E.4.5 Purified Water Quality Standard

Purified Water Quality Standard
ONEP Standard since January 1993

Category	unit	VMR	VMA	VmR
Organic Papameters				
Odor (at 25°C)	-	0	3	
Taste (at 25°C)	-	0	3	
Color	mg pt/L	5	20	
Turbidity	NTU	1	5	
Physical-Chemical Parameters				
pH	-	6.5-8.5	9.2	6
Conductivity	µs/cm at 20°C	1300	2700	110
Total Residues	mg/L (at 105°C)	1000	2000	100
Total Hardness	meq./L	6		2
Magnesium	Mg: mg/L	100		
Alminium	Al: mg/L	0.05		
Ammonium	$NH4^+$: mg/L	0.05	0.5	
Nitrites	$NO2^-$: mg/L		0.1	
Nitrates	$NO3^-$: mg/L		50	
Chloride	Cl^- : mg/L	300	750	
Dissolved Oxygen (DO	O2 : mg/L	5 - 8		
Sulfate (3)	$SO4^{2-}$: mg/L	200		
Undesirable Toxic Parameters				
Arsenic	As : mg/L		0.05	
Barium	Ba : mg/L		1	
Cadmium	Cd : mg/L		0.005	
Cyanide	CN^- : mg/L		0.1	
Total Chrome	Cr : mg/L		du	
Cupper	Cu : mg/L		1	
Total Iron	Fe : mg/L	0.7	0.3	
Fluoride	F : mg/L		1.5	
Manganese	Mn : mg/L		0.1	
Mercury	Hg : mg/L		0.01	
Lead	Pb : mg/L		0.05	
Hydrogen Suifide	H_2S : mg/L	Not detactable by sense		
Selenium	Se : mg/L		0.01	
Zinc	Zn : mg/L		5	
Biological Parameters				
KMnO4 Consumption	O2 : mg/L	2		

VMA: Maximum Admissible Value
VMR: Recommendable Maximum Value
VmR: Requuired Minimum Value

Maximum Admissible Bacteorogical Factor

unit	Faecal Coliform	Total Coliform Bacteria	Observation
nos./100mL	0	0	Water supplied by piped water system. a-1: water disinfected at the entrance of the distribution system 0.1mg/L (Residual Chlorine (1 mg/L))
	0	0 in 98% of analyzed samples in the 3rd year (ocassionally but not in 2 consecutive	a-2 : non-disinfected water at the entrance of the pipe system
	0	0 in 95% of analyzed samples in the 3rd year (ocassionally but not in 2 consecutive	a-3 : water in the distribution network : disinfected water 0.1mg (C.H. Res (1.0 mg/l)) (4)
	0	10	Water not supplied by piped water system
	0	0	Bottled water
unit	0	0	Water supplied in case of disasters
nos./mL	Total Germs : Must not exceed 20 times of the ratio obtained between the beginning and the end of the network in 90% of the analysis throgh out the year.		

Remarks

(1) -0.3 <Saturation Index < 0.3, =Langelier Index?
6.2 < stability index < 7 =Ryzner Stability Index?

(2) Choose the recommended concentration based on the matter of taste

(3) It must not higher than 30 mg/L if the concentration of Sulfate is more than 250 mg/L. If the Sulfate is lower, the tolerance of Mg shall be 150 mg/L.

(4) C. H. Res=Residual Chlorine

E.4.6 Effluent Quality Standard for Urban Area

Effluent Water Standard for Urban Area
Decree No. 2-04-553, Bulletin No. 5448, 17 August 2006

Table No.1
Applicable for wastewater discharge in new urban area

Parameters	Limit Value Specifically for Domestic Wastewater Discharge
BOD5 - mg O2/L	120
COD - mg O2/L	250
MES - mg/L	150

Table No.2
Applicable for domestic wastewater discharge from the existing area after the next 7 to 10 years from the date of announcement

Parameters	Limit Value Specifically for Domestic Wastewater Discharge
BOD5 - mg O2/L	300
COD - mg O2/L	600
MES - mg/L	250

BOD : Biochemical Oxygen Demand
COD : Chemical Oxygen Demand
MES : Suspended Matter (Suspended Solids : SS)

E.4.7 Effluent Quality Standard of Pulp, Paper and Cardboard Factory

Effluent Water Standard of Pulp, Paper and Cardboard Insustries
Decree No. 2-04-553, Bulletin No. 5448, 17 August 2006

Table is applicable specifically for wastewater discharge from the industries of Pulp, Paper and Carboard

Parameters	Limit Value of Wastewater Discharge	
	Pulp Industry	Paper and Cardbord Industries
Flow	50 m3/ton per finished product	40 m3/ton per finished product
Temperature	30 ℃	Not exceed more than 10 ℃ from the temperature of receiving water body
pH	5.5 - 8.5	5.5 - 8.5
MES - mg/L	200	400
COD - mg O2/L	1000	900
BOD5 - mg O2/L	200	200
Sulfide Ion (S^{2-}) - mg/L	2	-
Arsenic (As) - mg/L	0.1	0.1
Total Zinc (Zn) - mg/L	2	2
Total Iron (Fe) - mg/L	3	3
Alminum (Al) - mg/L	10	-

BOD : Biochemical Oxygen Demand
COD : Chemical Oxygen Demand
MES : Suspended Matter (Suspended Solids : SS)

E.4.8 Effluent Quality Standard of Sugar Factory

Standard Limit Value of Effluent of Sugar Industry
Bulletin No. 5448, 17 July 2006 Decree No.2-04-553, 24 January 2005

Parameters	Standard Limit Value of Effluent
Water Quantity	0.9 m3 per ton for beets and 0.7 m3 per ton for sugar cane
Suspended Matter, mg/L.	300
Biochemical Oxygen Demand (BOD^5) , mg /L.	400

Table E.1.1 Status of Water Supply Service (Marrakech-2005)

Population (x 1,000)	859.5
Served Population (x 1,000)	747.8
Annual Water Consumption (M.m^3/year)	34.59
Domestic : House Connection	29.16
Domestic : Public Taps	0.45
Institutional buildings including Govt. Office, Schools, etc.	4.09
Industries including hotels	0.89
Annual Average Water Production (M. m^3/year)	56.12
Annual Average Water Intake (M. m^3/year)	58.93
Estimated Water Loss Ratio (%)	38

Data Source : RADEEMA modified by the Study Team

Table E.1.2 Status of Water Supply Service (11 Communes of ONEP-2005)

Population (x 1,000)	97.6
Annual Water Consumption (M.m^3/year)	2.10
Domestic : House Connection	1.64
Domestic : Public Taps	0.06
Institutional buildings including Govt. Office, Schools, etc.	0.26
Industries including hotels	0.10
Others	0.04
Annual Average Water Production (M. m^3/year)	3.30
Annual Average Water Intake (M. m^3/year)	3.46
Estimated Water Loss Ratio (%)	36

Data Source : ONEP modified by the Study Team

Table E.1.3 Distribution Water Quality in Marrakech (2006)

Parameters	unit	RADEEMA Test Results for the Major Water Quality Parameters		ONEP Standard Recommended Max. Value (VMA)
		Minimum	Maximum	
Turbidity	NTU	0.35	1.20	5
pH	-	7.35	7.90	9.2
Nitrate	mg/L	5.52	9.10	50
KMnO4 consumption	mg/L	0.25	0.80	-
Iron	mg/L	0.28	0.3	0.3
Arsenic	mg/L	< 0.003		0.05
Cadmium	mg/L	< 0.001		0.005
Lead	mg/L	< 0.005		0.05
Conductivity	µS/cm	600	900	2,700
Chloride	mg/L	44	150	750
Calcium	mg/L	74	115	-

Data Source: RADEEMA

Table E.1.4 Water Consumption by User Types (2005)

Annual Water Consumption by the Type of User (M. m3/year)	Water Consumption (M.m3/year)	Ratio by User Groups (%)	
Marrakech (RADEEMA) and 11 Communes (ONEP)	36.69	100	
Domestic : House Connection	30.80	84.0	-
Domestic : Public Taps	0.51	1.4	-
Govt. Office, Institutional Bldgs., Office Bldgs., etc.	4.34	11.8	-
Industries including hotels	1.00	2.7	-
Others	0.04	0.1	-
Marrakech (RADEEMA)	34.59	100	94.3
Domestic : House Connection	29.16	84.3	79.5
Domestic : Public Taps	0.45	1.3	1.2
Govt. Office, Institutional Bldgs., Office Bldgs., etc.	4.09	11.8	11.1
Industries including hotels	0.89	2.6	2.4
Others	0.00	0.00	0.0
11 Communes (ONEP)	2.10	100	5.7
Domestic : House Connection	1.64	78.2	4.5
Domestic : Public Taps	0.06	2.7	0.2
Govt. Office, Institutional Bldgs., Office Bldgs., etc.	0.26	12.4	0.7
Industries including hotels	0.10	5.0	0.3
Others	0.04	1.7	0.1

Data Source : ONEP and RADEEMA

Table E.1.5 Water Consumption by Water User Group of Marrakech (2006)

Water User Group	Water Consumption ($M.m^3$/year)	Ratio of Water Users (%)
Domestic use	28.35	79.2
Industrial use	0.51	1.4
Institutions incl. govt. office, public facilities, school, etc.	4.47	12.5
Hotel use	2.09	5.8
Others	0.40	1.1
Total	35.82	100

Data Source: RADEEMA (modified by Study Team)

Table E.1.6 Estimation of Future Water Intake Demand: Water Supply

Communes/Items Year	2003	2004	2005	2010	2015	2020
Marrakech : RADEEMA						
Population (x 1,000)	821.69	840.18	859.51	963.00	1,071.58	1,160.09
Annual Water Consumption (M. m3/year)						
Domestic : House Connection	26.23	28.23	29.16	33.59	39.84	43.69
Domestic : Public Taps	0.48	0.38	0.45	0.47	0.18	0.13
Govt. Office, Institutional Bldgs, Schools, Office Bldgs	4.97	4.01	4.09	7.03	7.82	8.49
Industries	1.01	1.54	0.89	3.51	3.91	4.25
Others	-	-	-	-	-	-
Total	32.70	34.17	34.59	44.60	51.75	56.56
Annual Average Water Production (M. m3/year)	49.47	52.01	56.12	61.95	69.11	73.64
Annual Average Water Intake (M. m3/year)	51.94	54.61	58.93	65.05	72.56	77.32
Estimated Leakage Ratio (%)	34%	34%	38%	28%	25%	23%
11 Communes : ONEP						
Population (x 1,000)	91.5	94.9	97.6	112.4	127.4	144.4
Annual Water Consumption (M. m3/year)						
Domestic : House Connection	1.24	1.35	1.64	1.99	2.36	2.78
Domestic : Public Taps	0.03	0.03	0.06	0.04	0.03	0.01
Govt. Office, Institutional Bldgs, Schools, Office Bldgs	0.23	0.20	0.26	0.30	0.34	0.38
Industries	0.07	0.06	0.10	0.12	0.14	0.16
Others	0.04	0.03	0.04	0.04	0.04	0.05
Total	1.62	1.68	2.10	2.49	2.91	3.38
Annual Average Water Production (M. m3/year)	2.60	2.71	3.30	3.59	3.89	4.45
Annual Average Water Intake (M. m3/year)	2.73	2.85	3.46	3.77	4.09	4.67
Estimated Leakage Ratio (%)	38%	38%	36%	31%	25%	24%
Rural Area : Communes without ONEP Water Supply at Present						
Population (x 1,000)	612.2	615.9	619.6	638.4	657.8	677.8
Annual Water Consumption (M. m3/year)						
Domestic : House Connection						
Domestic : Public Taps						
Govt. Office, Institutional Bldgs, Schools, Office Bldgs	10.96	11.50	12.04	14.37	14.97	15.69
Industries						
Others						
Total	10.96	11.50	12.04	14.37	14.97	15.69
Annual Average Water Production (M. m3/year)	12.17	12.77	13.38	15.97	16.64	17.43
Annual Average Water Intake (M. m3/year)	12.82	13.45	14.08	16.81	17.51	18.35
Estimated Leakage Ratio (%)	10%	10%	10%	10%	10%	10%
Grand Total : Study Area (Groundwater Simulation Area)						
Population (x 1,000)	1,525.4	1,551.0	1,576.7	1,713.8	1,856.7	1,982.3
Annual Water Consumption (M. m3/year)						
Domestic : House Connection	38.43	41.08	42.85	49.95	57.17	62.16
Domestic : Public Taps	0.51	0.41	0.51	0.52	0.20	0.14
Govt. Office, Institutional Bldgs, Schools, Office Bldgs	5.20	4.21	4.34	7.33	8.16	8.87
Industries	1.09	1.61	1.00	3.64	4.05	4.40
Others	0.04	0.03	0.04	0.04	0.04	0.05
Total	45.27	47.35	48.73	61.47	69.63	75.62
Annual Average Water Production (M. m3/year)	64.24	67.49	72.80	81.51	89.64	95.52
Annual Average Water Intake (M. m3/year)	67.49	70.90	76.47	85.62	94.16	100.34
Estimated Leakage Ratio (%)	30%	30%	33%	25%	22%	21%
Summary of Annual Water Intake Amount (M. m3/year)						
Marrakech : RADEEMA	51.94	54.61	58.93	65.05	72.56	77.32
11 Communes : ONEP	2.73	2.85	3.46	3.77	4.09	4.67
Rural Area : Communes without ONEP Water Supply at Present	12.82	13.45	14.08	16.81	17.51	18.35
Grand Total : Study Area (Groundwater Simulation Area)	67.49	70.90	76.47	85.62	94.16	100.34
Ratio of Annual Water Intake Amount (%)						
Marrakech : RADEEMA	77.0%	77.0%	77.1%	76.0%	77.1%	77.1%
11 Communes : ONEP	4.1%	4.0%	4.5%	4.4%	4.3%	4.7%
Rural Area : Communes without ONEP Water Supply at Present	19.0%	19.0%	18.4%	19.6%	18.6%	18.3%
Grand Total : Study Area (Groundwater Simulation Area)	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Data Source: ONEP and RDEEMA（Modified by the Study Team）

Table E.1. 7 Water Demand of Golf Course & Resort Projects

Name of Golf Course & Resort, Investors, etc.		Area (ha)	Water Intake Quantity (Mm3/year)			Remarks
			Rocade Canal	Ground - water	Total	
1.	Existing Golf Course & Resort					
	Golf Royal					Existing,Groundwater & Rocade Canal
	Amelkis (Amelkis 1, 2 et 3)				2.50	5 tube wells & 3 dug wells, pumping application has not yet submitted
	Palmeraie Golf Palace					8 dug well constructed & approved for pumping 16L/s in total
2.	Golf Course Project : Taking water have authorized.					
	Assoufid	220	1.00	0.22	1.22	Under construction. Construction & pumping of 4 tube wells approved, 220,000 m3/year
	Palm Golf sur (Golf Resort Palace?)	170	1.00	0.20	1.20	
	Atlas Golf Resort (SAMAWAH)	282	1.00	0.50	1.50	Under construction
3.	Golf Course Project : Authorizarion of taking water is under validation					
	LATSIS GROUP	140			1.50	
	JARDINS DE L' ATLAS	148			1.65	
	DOMAINE ROYAL PALM	250			1.50	
	STRATEGIC PARTNERS	NA	1.00	0.20	1.20	
	TRITEL	220	1.50	0.50	2.00	
4.	Golf Course & Resort Project status unknown					
	Fadesa	258				
	La Fruittere	253			6.782	
	TF 497 (Tr 497?)	537				54 holes
	Club Tamesloht Partners	312	1.00	0.20	1.20	
	Riads De La Palmeraie	148			N.A	
	MEDZ				N.A	Under construction
	EMAAR				1.50	
	GULF FINANCE HOUSE				1.50	
	EXTENSION AMELKIS				1.50	
	EXTENSION DU GOLF PALACE				1.50	
5.	Palmeraie (Tensift River Side Palm Garden)				2.92	
Golf & Resort Total (Group-1: Existing)					2.50	
Golf & Resort Total (Group-1&2: Existing and water intake approved)					6.42	
Golf & Resort Total (Group-1 to 3 : Existing, water intake approved & in validation)					14.27	
Golf & Resort Total (Group 1 to 4: All golf and resort projects listed as of July 2007)					31.17	
Grand Total (Group 1 to 5: All golf & resort plus Tensift Riverside Palm Garden)					34.09	

Data Sources :

Data Source -1: ALIMENTATION EN EAU POTABLE ET INDUSTRIELLE DE LA VILLE DE MARRAKECH AVRIL 2006 (ABHT Report)

Data Source -2 : Le Traitement Des Eaux Usees Et Leur Reutilisation Pour L'irrigation (SGI INGENIERIE S.A.:SUISSE)

Data Source -3: Localisation Des Golfs Et Des Points De Rejets Des Eaux Usees De La Ville De Marrakech (ABHT????)

Data Source -4: Localisation des Golf (Map of Investment Center)

Table E.1.8 Planned Water Intake Amount with/without Effective Water Leakage Control Measures

With Effective Water Leakage Protection Program				
Communes/Items **Year**	**2005**	**2010**	**2015**	**2020**
Marrakech : RADEEMA				
Population (x 1,000)	859.5	963.0	1,071.6	1,160.1
Annual Water Consumption (M. m3/year)	34.59	44.60	51.75	56.56
Annual Average Water Production (M. m3/year)	56.12	61.95	69.11	73.64
Annual Average Water Intake (M. m3/year)	58.93	65.05	72.56	77.32
Estimated Leakage Ratio (%)	38.4%	28.0%	25.1%	23.2%
11 Communes : ONEP				
Population (x 1,000)	97.6	112.4	127.4	144.4
Annual Water Consumption (M. m3/year)	2.10	2.49	2.91	3.38
Annual Average Water Production (M. m3/year)	3.30	3.59	3.89	4.45
Annual Average Water Intake (M. m3/year)	3.46	3.77	4.09	4.67
Estimated Leakage Ratio (%)	36.4%	30.6%	25.4%	24.0%
Rural Area : Communes without ONEP Water Supply at Present				
Population (x 1,000)	619.6	638.4	657.8	677.8
Annual Water Consumption (M. m3/year)	12.04	14.37	14.97	15.69
Annual Average Water Production (M. m3/year)	13.38	15.97	16.64	17.43
Annual Average Water Intake (M. m3/year)	14.08	16.81	17.51	18.35
Estimated Leakage Ratio (%)	10%	10%	10%	10%
Total :Whole Study Area				
Population (x 1,000)	1,576.7	1,713.8	1,856.7	1,982.3
Annual Water Consumption (M. m3/year)	48.7	61.5	69.6	75.6
Annual Average Water Production (M. m3/year)	72.8	81.5	89.6	95.5
Annual Average Water Intake (M. m3/year)	76.5	85.6	94.2	100.3
Estimated Leakage Ratio (%)	33.1%	24.6%	22.3%	20.8%
Without Effective Water Leakage Protection Program				
Communes/Items **Year**	**2005**	**2010**	**2015**	**2020**
Marrakech : RADEEMA				
Population (x 1,000)	859.5	963.0	1,071.6	1,160.1
Annual Water Consumption (M. m3/year)	34.59	44.60	51.75	56.56
Annual Average Water Production (M. m3/year)	56.12	71.94	83.46	91.22
Annual Average Water Intake (M. m3/year)	58.93	75.54	87.63	95.78
Estimated Leakage Ratio (%)	38.4%	38.0%	38.0%	38.0%
11 Communes : ONEP				
Population (x 1,000)	97.6	112.4	127.4	144.4
Annual Water Consumption (M. m3/year)	2.10	2.49	2.91	3.38
Annual Average Water Production (M. m3/year)	3.30	3.89	4.54	5.28
Annual Average Water Intake (M. m3/year)	3.46	4.09	4.77	5.54
Estimated Leakage Ratio (%)	36.4%	36.0%	36.0%	36.0%
Rural Area : Communes without ONEP Water Supply at Present				
Population (x 1,000)	619.6	638.4	657.8	677.8
Annual Water Consumption (M. m3/year)	12.0	14.4	15.0	15.7
Annual Average Water Production (M. m3/year)	13.4	16.0	16.6	17.4
Annual Average Water Intake (M. m3/year)	14.1	16.8	17.5	18.4
Estimated Leakage Ratio (%)	10%	10%	10%	10%
Total :Whole Study Area				
Population (x 1,000)	1,576.7	1,713.8	1,856.7	1,982.3
Annual Water Consumption (M. m3/year)	48.7	61.5	69.6	75.6
Annual Average Water Production (M. m3/year)	72.8	91.8	104.6	113.9
Annual Average Water Intake (M. m3/year)	76.5	96.4	109.9	119.7
Estimated Leakage Ratio (%)	33.1%	33.0%	33.5%	33.6%

Data Source: Study Team

Table E.3.1 River Water Quality of Major Monitoring Points of ABHT (for major WQ parameters)

River Name	Sampling Point Name	Date	Class	BOD_5 mg/l	COD mg/l	DO mg/l	T-P mg/l	NH^+_4 mg /l	Coliform Count per 100ml
Tensift	Station Abadla	2005/10/11	Bad	7.2	66	10	0.2	1.01	0
	Amont Marrakech	2004/7/8	Very Bad	161	558	0	8.65	68.4	8,000,000
	Aval Marrakech	2005/10/7	Very Bad	83	227	0	3.41	46.6	13,000
	Aval décharge Markech	1996/4/1	Bad	3.7	30	9.7	1.69	0.26	4,800
Chichaoua	Aval Chichaoua	2004/7/15	Good	0.51	11.5	5.4	0.098	0.02	280
	Station Chichaoua	1998/2/6	Bad	2	9.6	8.4	0.76	0.007	950
Seksaoua	Station Iloudjane	2004/7/15	Bad	0.61	50	7.36	1.108	0.01	660
Zat	Station Taferiat	2005/10/6	Average	2.5	38	13.5	0.09	0.01	640
	Aval Ait Ourir	2004/7/13	Very Bad	125	322	0	5.71	39.6	18,000,000
Imintanout	Aval Imintanout	2004/7/15	Very Bad	281	825	0	19.62	93.6	20,000,000
Reraya	Station Tahanaout	1995/2/24	Bad	6.1	53	8.65	0.5	0.13	25
	Station Tahanout	2004/7/14	Average	0.91	8	8.48	0.014	0.005	4,200
N'Fis	Station Imlil Hmam	2005/10/10	Bad	1.8	69	8.3	0.51	0.07	38,000
	Aval mine Guemassa	2004/7/13	Good	2.74	8	8.2	0.13	0.032	10
Ourika	Station Aghbalou	2005/10/7	Average	0.38	30	8.25	0.084	0.04	850
Amizmiz	Station Sidi Hssain	2004/7/14	Good	0.57	8	6.88	0.07	0.005	120
	Aval Amizmiz	2005/10/10	Bad	0.8	27	5.6	0.1	0.13	42,000
Rdat	Station Sidi Rahal	2005/10/6	Bad	2.4	42	10.32	0.09	0.08	240
	Aval Sidi Rahal	2004/7/9	Very Bad	133	365	0	12.85	54	5,300,000
Canal de Rocade		1993/6/23	Good	2	6	6.6	0.13	0.04	20

Data Source : ABHT

Table E.3.2 Evaluation of Dam and Canal Water Quality by Surface Water Quality Standard

Water Quality Test Data of Dams and Canal (2000-2002)											
Sampling Sites (Dams & Canal)	No. of Sample	pH	Cond. (µ s/cm)	O2D (mg/L)	P_Tot (mg/L)	NH+4	Fe	Mn	NO3-	SO42-	PO43-
Barrage Hassan 1èr	7	8.2	762	7	0.12	0.11	0.15	0.05	2	180	0.02
Barr. Moulay Youssef	7	7.8	1,285	8	0.09	0.15	0.36	0.08	5	110	0.02
Barrage Sidi Driss	5	7.7	864	8	0.16	0.05	0.17	0.05	11	171	0.08
Barrage Takerkoust	9	7.8	1,051	7	0.20	0.13	0.92	0.35	7	86	0.08
Canal de Rocade	3	7.8	863	8	0.27	0.35	0.26	0.24	2	181	0.17
Surface Water Quality Standards by Grade											
Excellent	Class 1	8.5	750	7	0.1	0.1	0.5	0.1	10	100	0.2
Good	Class 2	8.5	1,300	5	0.3	0.5	1	0.5	25	200	0.5
Average	Class 3	9.2	2,700	3	0.5	2	2	1	50	250	1
Bad	Class 4	9.2	3,000	1	3	8	5	1	50	400	5
Very Bad	Class 5	9.2	3,000	1	3	8	5	1	50	400	5

Data Source: ABHT

Table E.3.3 Surface Water Quality Test Result in the Surrounding Area of Marrakech

Sampling Point	No.	S-1	S-2	S-3	S-4
	unit	El Fakhara-Downstream of bridge, Isil River	STAM Industrial zone (under construction), Isil River upstream	Marrakech N. East outfall to the Tensift	Upstrem of Old Bridge, Tensift River
Date		14-Jun-07	14-Jun-07	14-Jun-07	14-Jun-07
Time		9:40	10:20	10:50	11:30
Weather		fine	fine	fine	fine
Temperature	℃	25.1	27.7	25.1	29.7
pH	-	8.09	8.11	7.91	7.86
Dissolved Oxygen	mg/L	0.07	7.28	2.90	6.73
Electric Conductivity	mS/m	890.0	90.2	375.0	640.0
Salinity	%	0.480	0.045	0.195	0.340
Turbidity	NTU	581	3	623	13
Turbidity	mg/L	471	2	500	11
Remarks		No water flow, Bad smell	No water flow	Outfall downstream, Bad smell	No water flow

Data Source: Study Team

Table E.3.4 Provicional Groundwater Quality Standard by ABHT

Class	Conductivity	KMnO4 Consumption	Chloride (Cl-)	Ammonium Nitrogen (NH4+)	Nitrate Nitrogen (NO3-)	Fecal Coliform Count
	(μs/cm)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(nos/100ml)
Excellent	<400	<3	<200	<0.1	<5	<20
Good	400 – 1,300	3 – 5	200 – 300	0.1 – 0.5	5 – 25	20 – 2,000
Average	1,200 – 2,700	5 – 8	300 – 750	0.5 – 2	25 – 50	2,000 – 20,000
Bad	2,700 – 3,000	>8	750 – 1,000	2 – 8	50 – 100	>20,000
Very Bad	>3,000	-	>1,000	>8	>100	-

Data Source：ABHT

Table E.3.5 Evaluation of Groundwater Test Result (1991-2004) by the Provisional Groundwater Quality Standard

Item	Conductivity	Oxidizable Matter ($KMnO_4$)	Chloride (Cl^-)	Anmonium Nitrogen (NH4+)	Nitrate Nitrogen (NO_3-N)	Faecal Coliform Count
unit	(μs/cm)	mg/L	mg/L	mg/L	mg/L	nos./100mL
Maximum Value	14,071	2,485	5,530	50.4	251	8,600,000
Average Value	1,839	13	378	0.5	28	24,829
Minimum Value	290	0	11	0.0	0	0

Groundwater Quality Grade	Conductivity	Oxidizable Matter ($KMnO_4$)	Chloride (Cl^-)	Ammonium Nitrogen (NH4+)	Nitrate Nitrogen (NO_3-N)	Faecal Coliform Count	Total Number of Samples	Ratio in each Grade
Excellent	4	314	174	351	37	202	1082	46%
Good	183	28	67	32	226	147	683	29%
Medium	145	15	111	4	82	33	390	17%
Bad	14	0	6	5	31	0	56	2%
Very Bad	50	11	39	5	21	12	138	6%
Number of Samples	396	368	397	397	397	394	2349	100%

Data Source: ABHT

Table E.3.6 Evaluation of Groundwater Quality Test Result (1991-2004) by Purified Water Quality Standard

Water Quality Parameters	Conductivity (µS/cm)	Oxidizable Matter (KMnO4) (mg/L)	Anmonium (NH_4^{+})	Sodium (Na^+)	Calcium ($Ca2^+$)	Magnesium ($Mg2^+$)	Chloride (Cl-)	Nitrates (NO_3^-)	Bicarbonate (HCO_3^-)	Sulfate ($SO4^-$)	Coliform Count (MPN/100cc)
Water Quality Grade	Water Quality Concentration Range of Respective Water Quality Parameter Determined for Evaluation of Water Quality Grade										
Excellent	325	0.5	0.01	50	75	25	75	2.5	75	50	0
Good	650	1	0.025	100	150	50	150	5	150	100	0
VMR	1300	2	0.05	200	300	100	300	10	300	200	0
VMA	2700	4	0.5	400	600	200	600	50	600	400	0
Very Bad	2700	4	0.5	400	600	200	600	50	600	400	0
Note	1) VMR stand for the recommendable level water quality standard of ONEP										
	2) VMA stand for the allowwable maximum level water quality standard of ONEP										
	3) Japanese drinking water quality standards were applied for the water quality parameters not specified by ONEP										
	4) This water quality grade was determined for the evaluation purpose only and not specified in ONEP's purified water quality standard.										

Result of Evaluation of Groungwater Quality Test Data compared with the Purified Water Quality Standard (Number of sample in each water quality grade range)

Evaluation Items	Conductivity (µS/cm)	Oxidizable Matter (KMnO4) (mg/L)	Anmonium (NH_4^{+})	Sodium (Na^+)	Calcium ($Ca2^+$)	Magnesium ($Mg2^+$)	Chloride (Cl-)	Nitrates (NO_3^-)	Bicarbonate (HCO_3^-)	Sulfate ($SO4^-$)	Coliform Count (MPN/100cc)	Total No. of Samples	Avg. Ratio of each Grade (%)
Excellent	1	66	182	76	61	83	64	13	1	95	127	769	17.8%
Good	52	92	53	94	230	117	73	24	1	74	0	810	18.7%
VMR	134	121	65	92	97	127	104	74	171	115	0	1,100	25.4%
VMA	145	53	83	81	6	60	99	234	194	69	0	1,024	23.6%
Very Bad	64	36	14	54	3	10	57	52	28	44	267	629	14.5%
No. of Samples	396	368	397	397	397	397	397	397	395	397	394	4,332	100.0%
Exceeded Ratio (VMR)	52.8%	24.2%	24.4%	34.0%	2.3%	17.6%	39.3%	72.0%	56.2%	28.5%	67.8%	38.2%	38.2%
Exceeded Ratio (VMA)	16.2%		3.5%					13.1%					

Data Source: ABHT

Table E.3.7 Groundwater Test Result in the Surrounding Area

Item		G-1	G-2	G-3	G-4	G-5	G-6
Monitoring Well No.		1580/52	2826/53	1753/53	3664/53	4405/44	4403/44
Water Level : Piezometer (G.L.-)		59.28	75.45	39.48	58.19	21.22	42.79
Sampling Well-Depth-WL(GL-)	unit	Dar El Ghali-101m-?	ONEP Majat	El Batma-50m-24m	Mohamed Ben Chekroune-160m	Ouled Hamid-35m-?	Lahlou Ahmed-53.5m-40m
Date		13-Jun	13-Jun	13-Jun	13-Jun	13-Jun	13-Jun
Time		17:00	18:00	13:30	11:40	12:40	10:30
Weather		fine	fine	fine	fine	fine	fine
Water Temperature	℃	23.1	20.8	23.2	24.9	23.6	23.4
pH	-	6.96	7.28	6.9	7.24	7.4	7.2
Dissolved Oxygen	mg/L	7.24	8.48	5.61	6.42	7.01	6.8
Electric Conductivity	mS/m	94.9	53.5	232.4	126.9	256.2	139.8
Salinity	%	0.048	0.027	0.116	0.061	0.128	0.070
Turbidity	NTU	0	0	1	2	0	1
Turbidity	mg/L	0	0	1	1	1	1
Remarks		Yellow Melon 5.5ha	Chlorinated Water			Water Melon	Olive-9ha,
Item		G-7	G-8	G-9	G-10	G-11	G-12
Monitoring Well No.		2715/53	2700/53	4402/44	4004/53	1388/45	N. A.
Water Level : Piezometer (G.L.-)		25.04	55.76	31.8	61.19	50 (No Piezometer)	N.A. (No piezometer)
Sampling Well-Depth-WL(GL-)	unit	Tameslot, Jnan Lakbir (40m-30m)	Abdel Ali Douar Tadurt Roatim	Benlarbi Inheritors (60m)	Ben Chem Lorbi, Laghoiuba (130m-50m)	ONEP ZEMRANE West P.S.	ONEP Chichaoua P.S.
Date		12-Jun	12-Jun	12-Jun	12-Jun	12-Jun	13-Jun
Time		15:00	14:00	10:30	11:30	12:15	16:00
Weather		fine	fine	fine	fine	fine	fine
Temperature	℃	24.0	21.1	22.8	23.4	24.4	23.0
pH	-	6.76	7.24	7.4	6.98	7.0	6.56
Dissolved Oxygen	mg/L	5.85	7.02	7.2	6.6	7.9	6.80
Electric Conductivity	mS/m	200.2	61.7	72.3	373	235.8	225.9
Salinity	%	0.11	0.03	0.036	0.200	0.133	0.113
Turbidity	NTU	1	1	2	0	2	2
Turbidity	mg/L	1	1	2	0	2	2
Remarks				Olieve	Salty	2 Wells:2.5 lit/s & 12 lit/s	

Data Source: Study Team

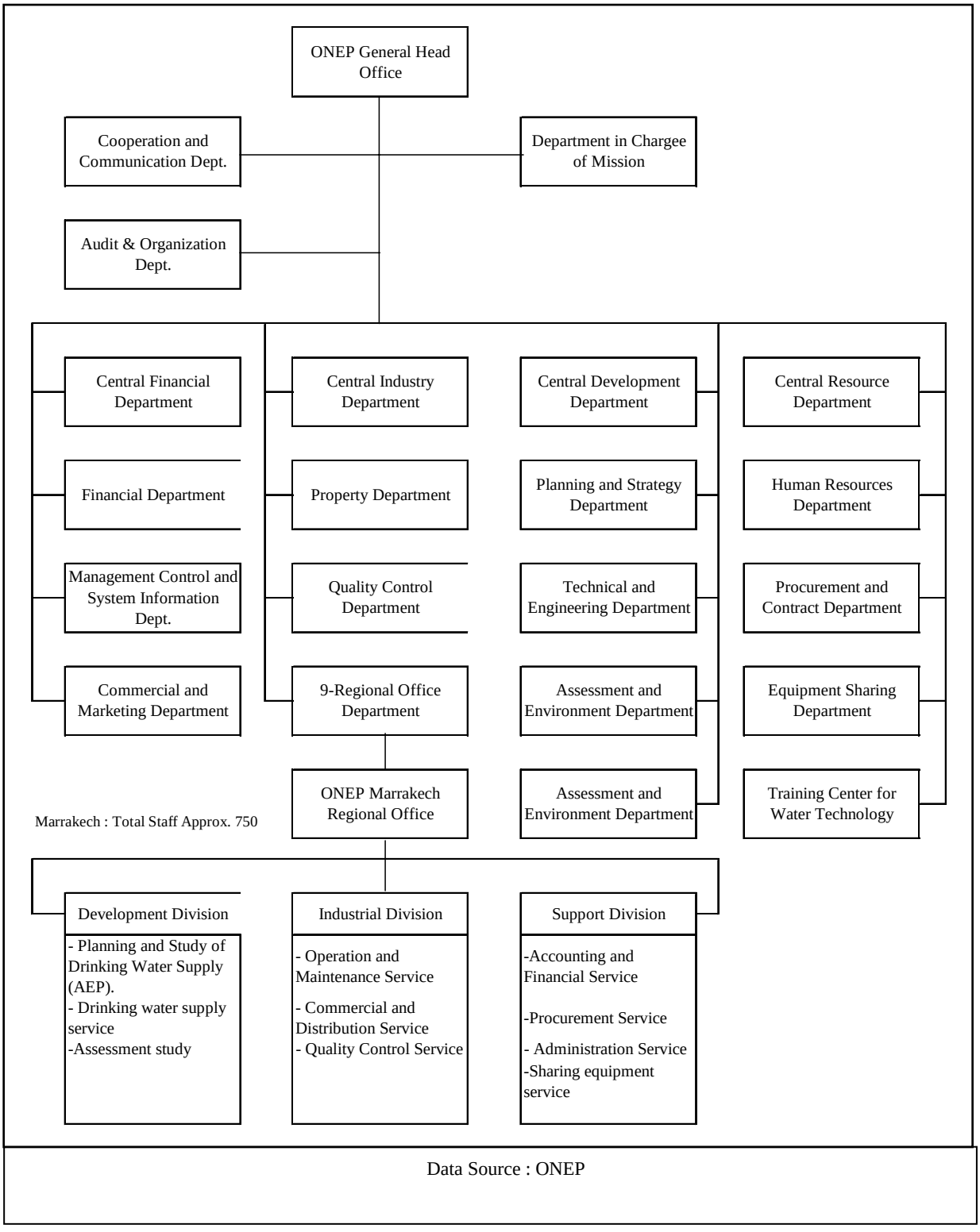
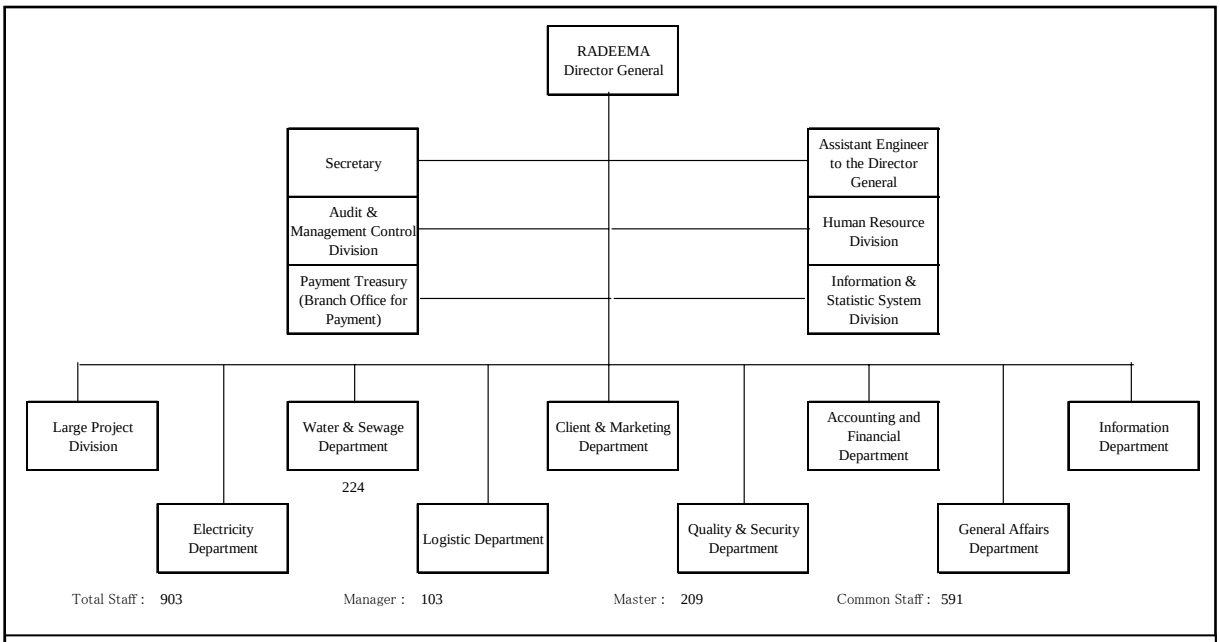
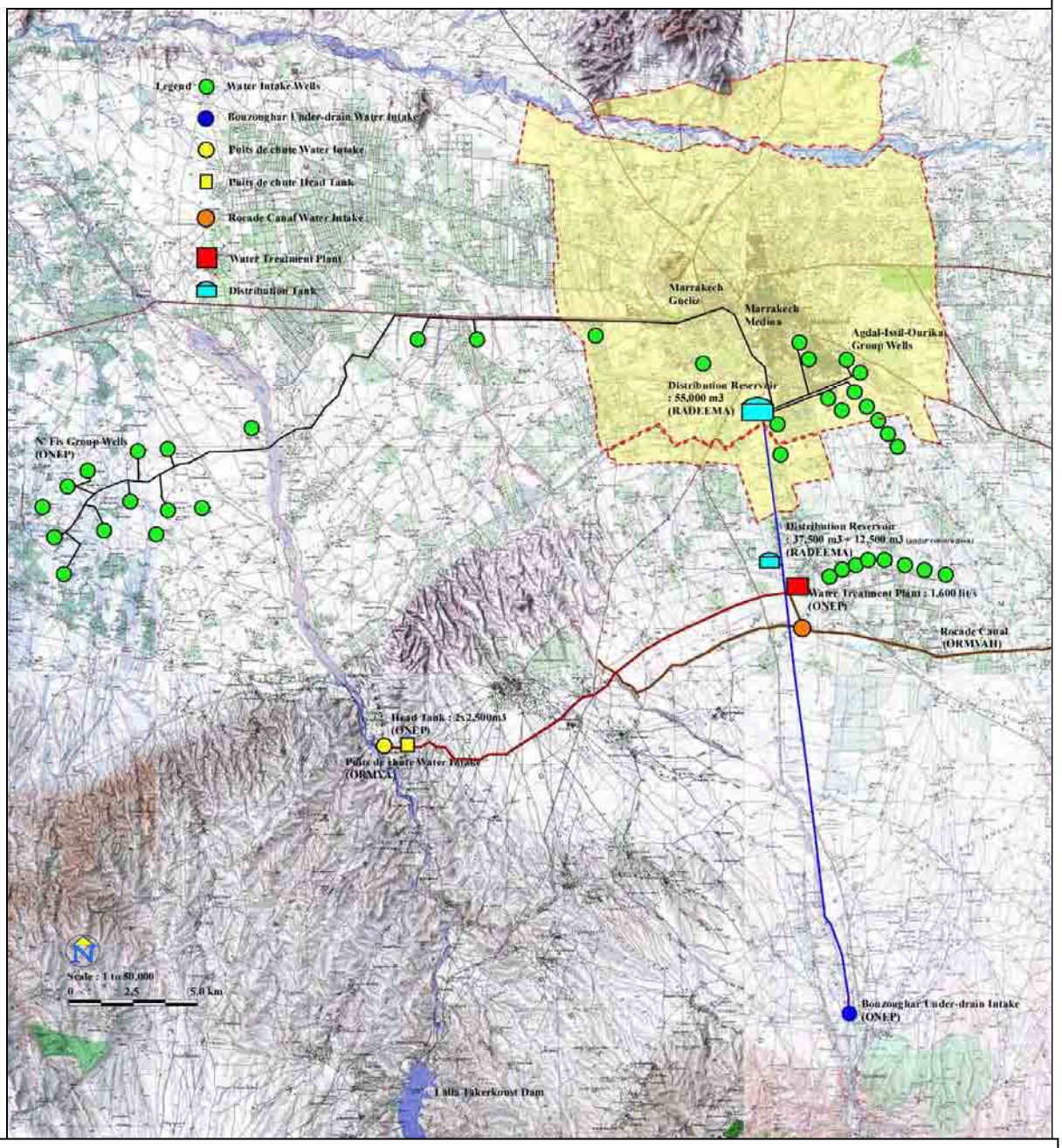


Figure E.1.1 Organization Chart of ONEP



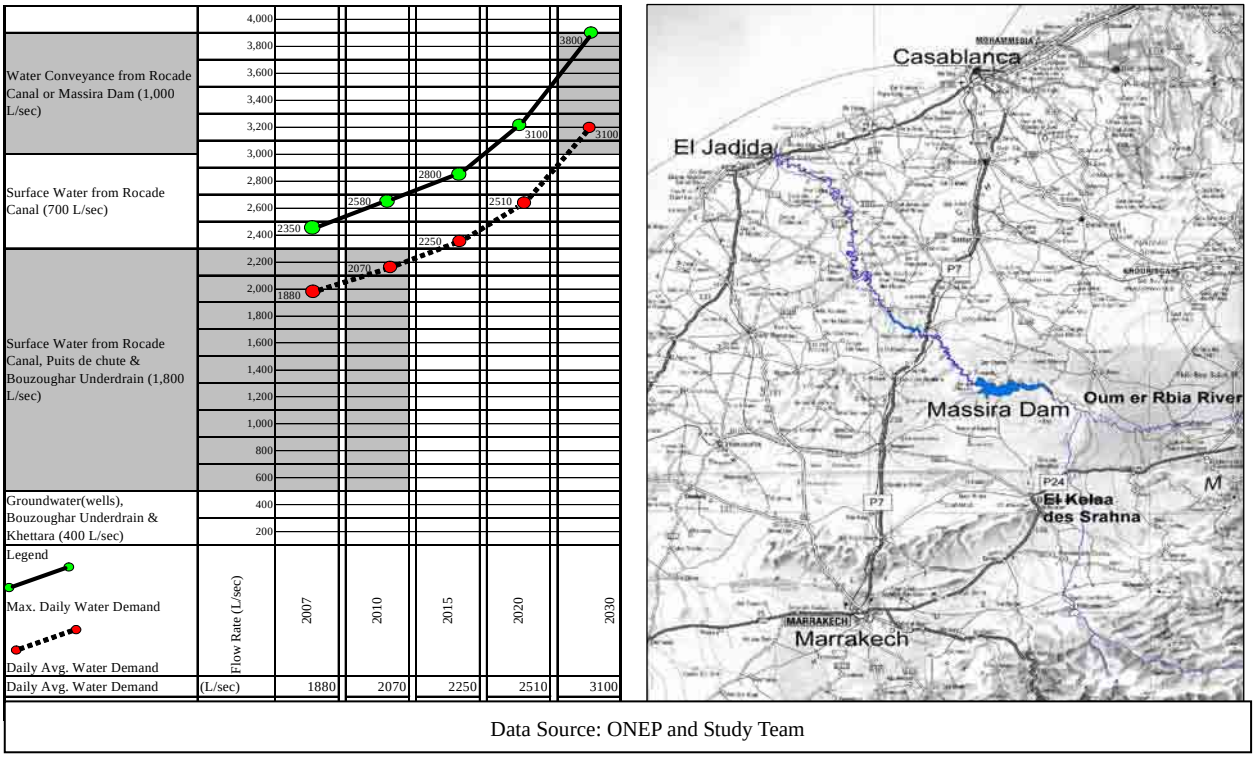
Data Source: RADEEMA

Figure E.1.2 Organization Chart of RADEEMA



Data Source: Study Team

Figure E.1.3 Layout of Marrakech Water Supply System



Data Source: ONEP and Study Team

Figure E.1.4 Prospective of Future Water Source of Marrakech Water Supply System

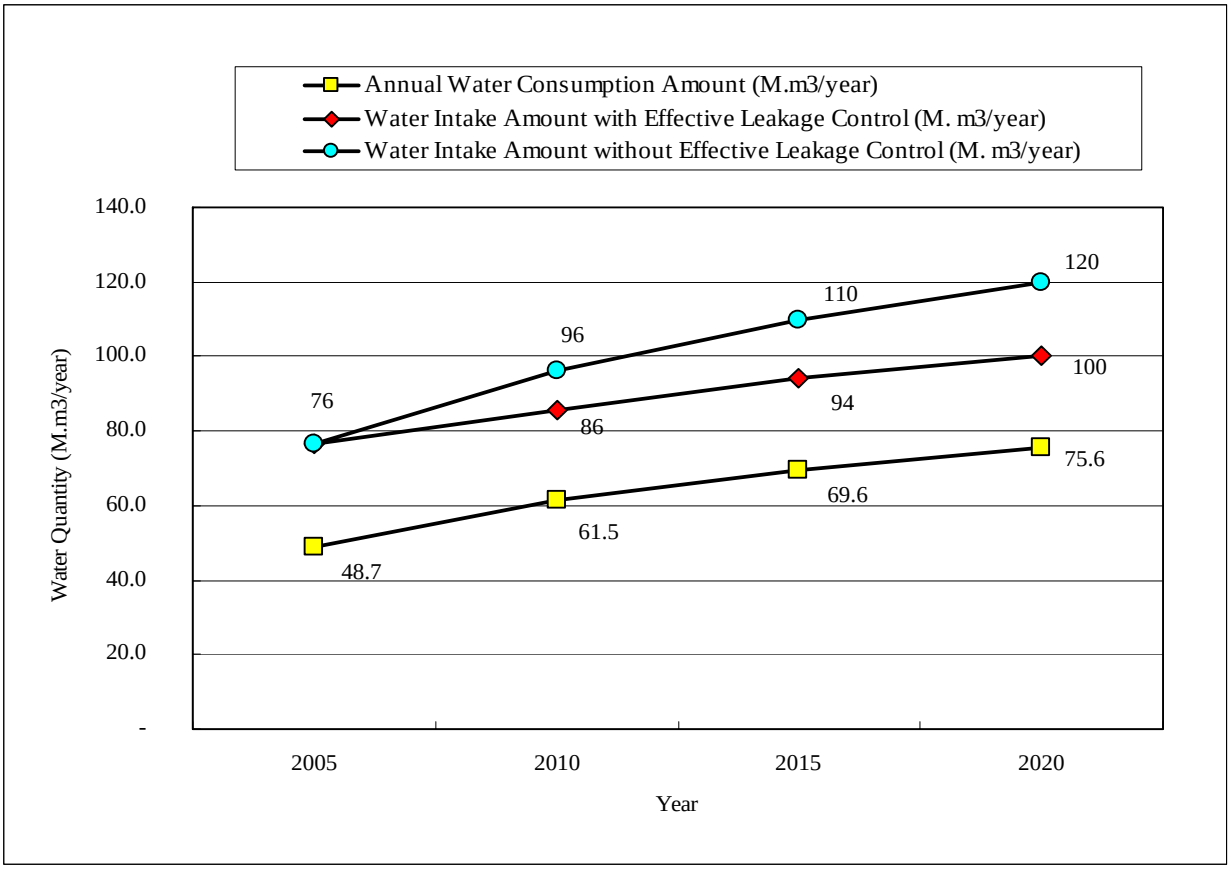
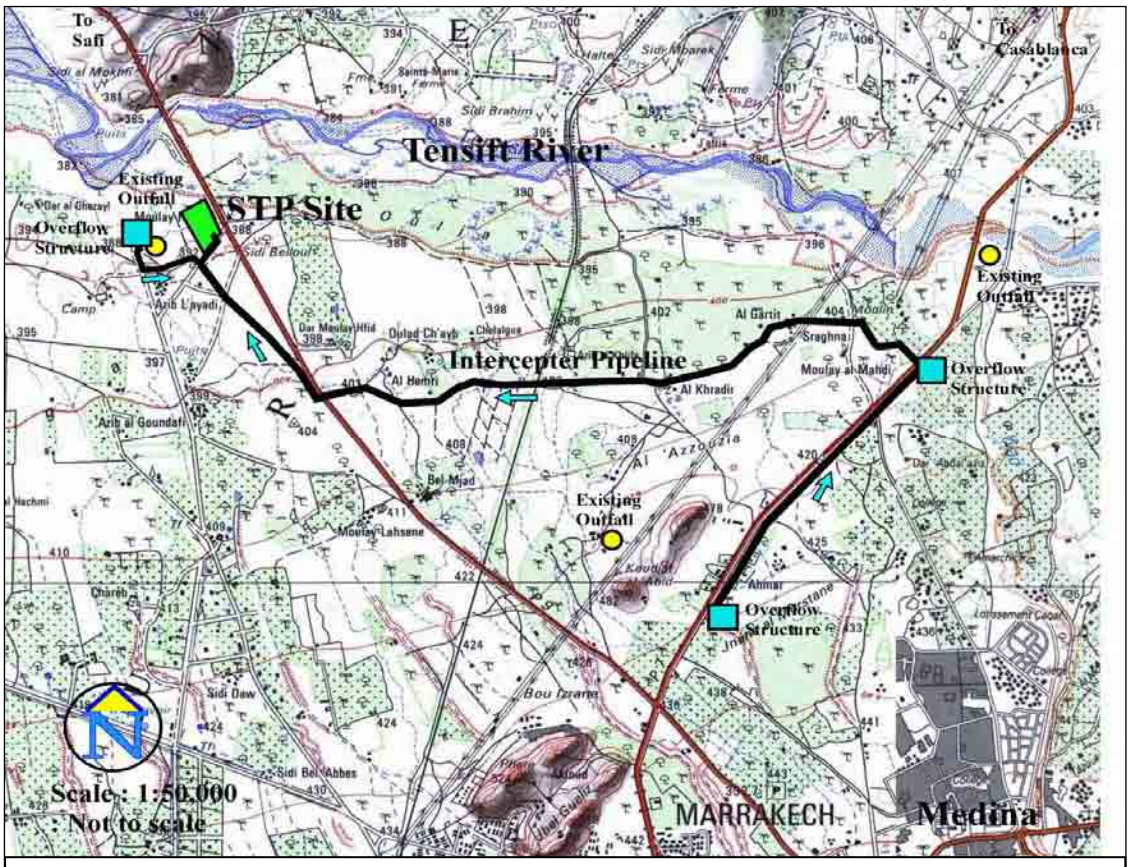
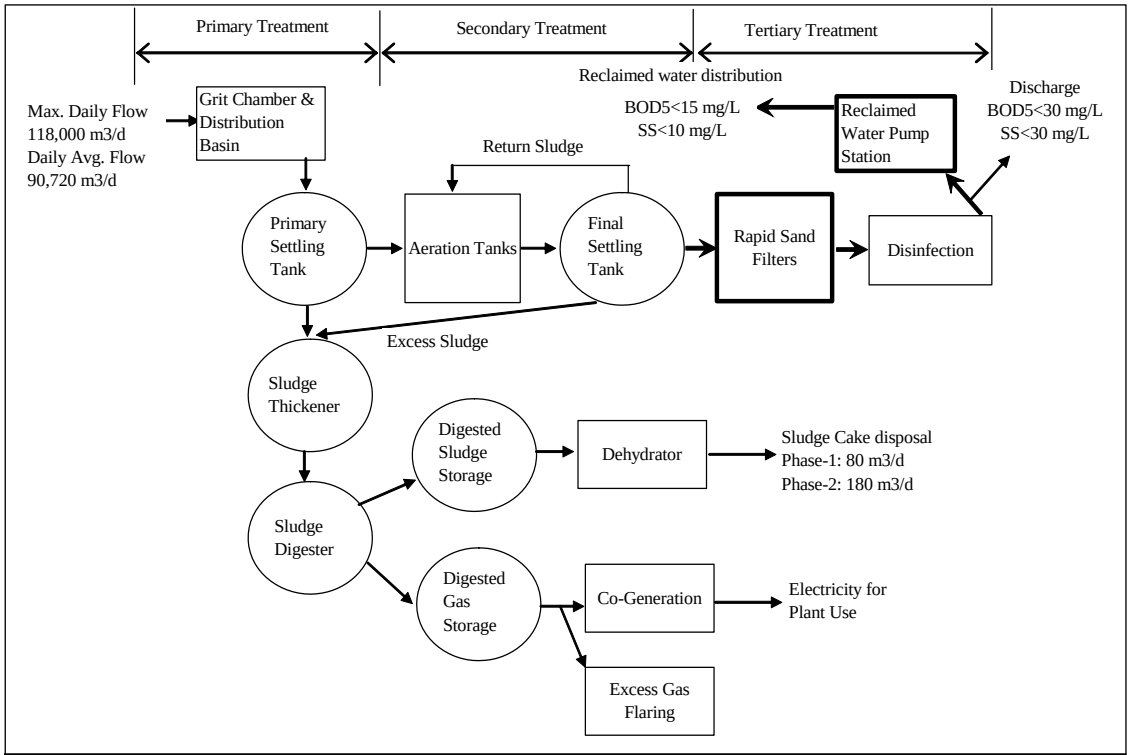


Figure E.1.5 Water Leakage Control : Present Measures VS Strengthened Measures



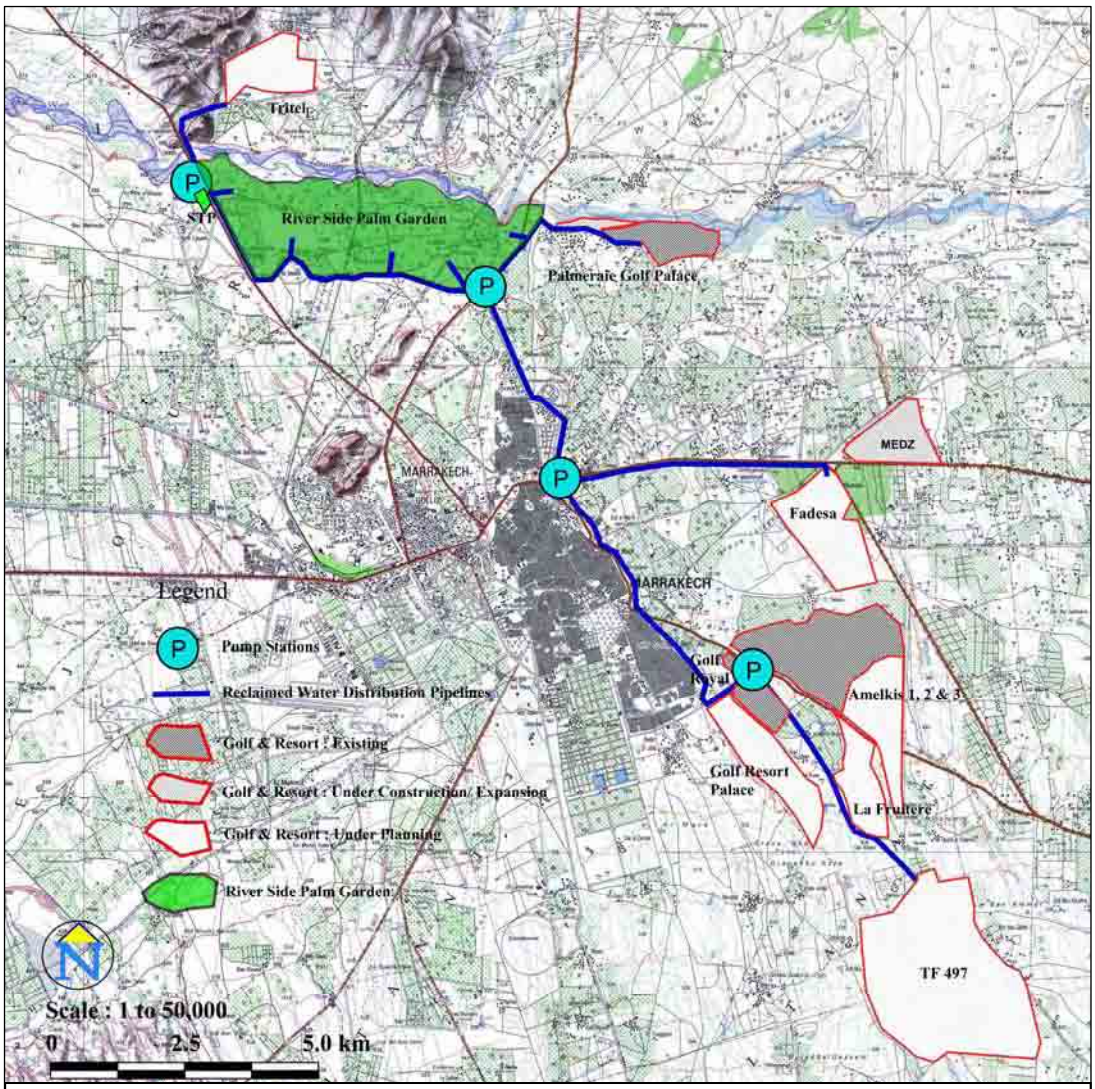
Data Source: RADEEMA, prepared by Study Team

Figure E.2.1 Layout of Marrakech Sewerage System(under construction)



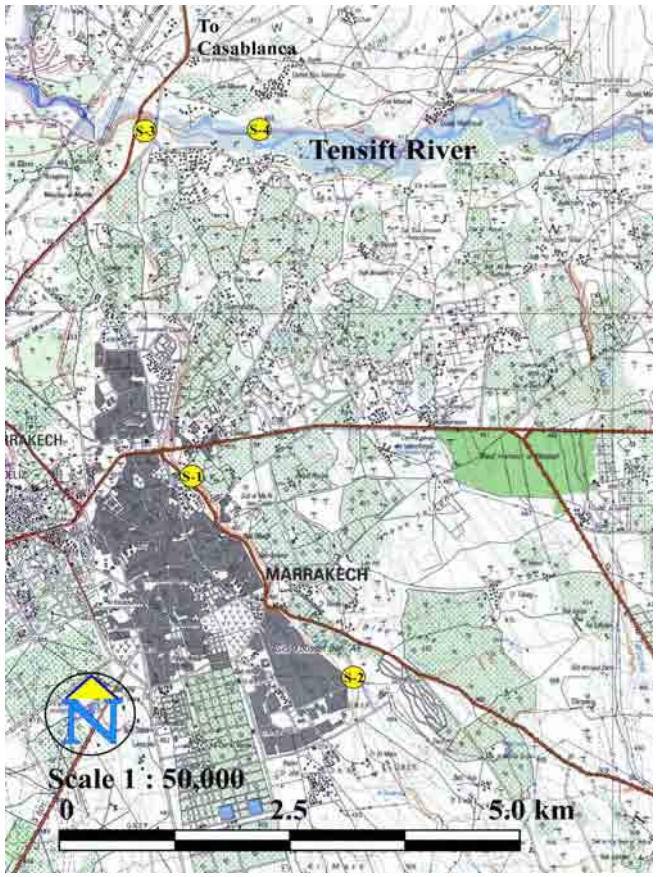
Data Source: RADEEMA, prepared by Study Team

Figure E.2.2 Marrakech (RADEEMA) Sewage Treatment Flow Sheet



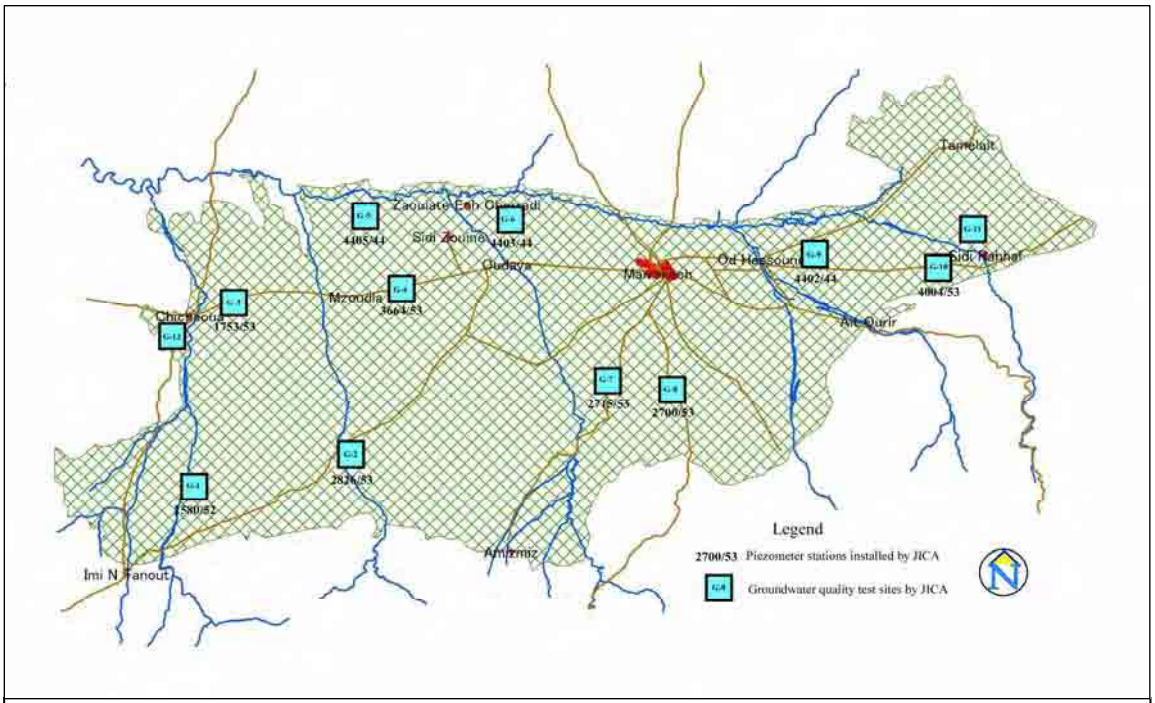
Data Source: Study Team

Figure E.2.3 Alternative Route of Reclaimed Water Conveyance & Distribution Pipeline



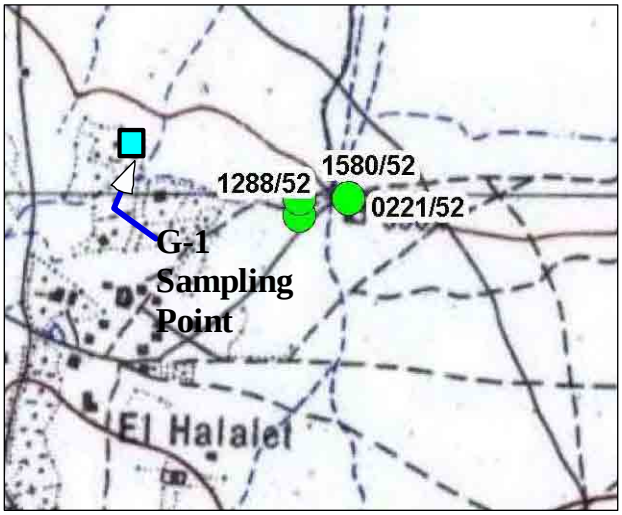
Data Source: Study Team

Figure E.3.2 Location of Surface Water Quality Test

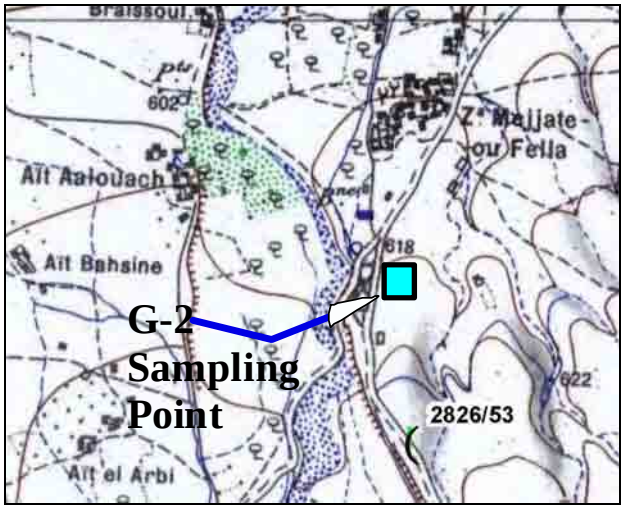


Data Source: Study Team

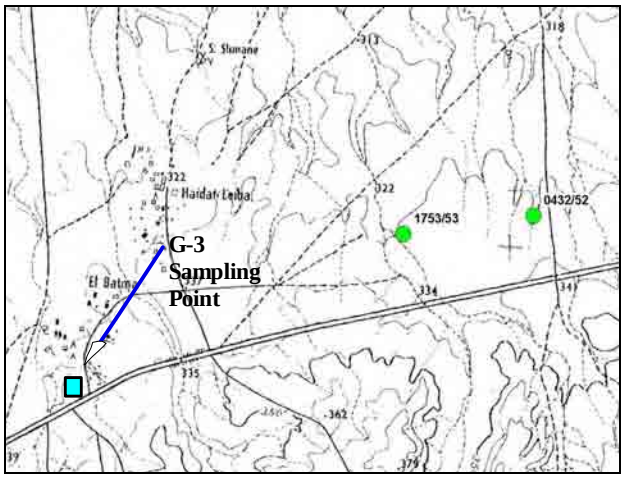
Figure E.3.3 Location of Monitoring Wells and Groundwater Quality Test Wells



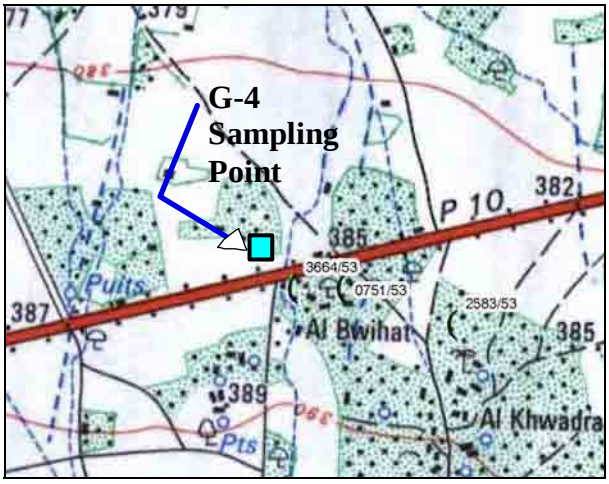
G-1: Location of Groundwater Test Well



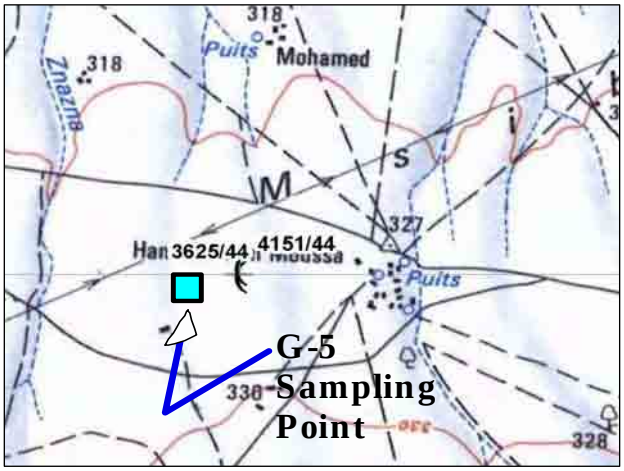
G-2: Location of Groundwater Test Well



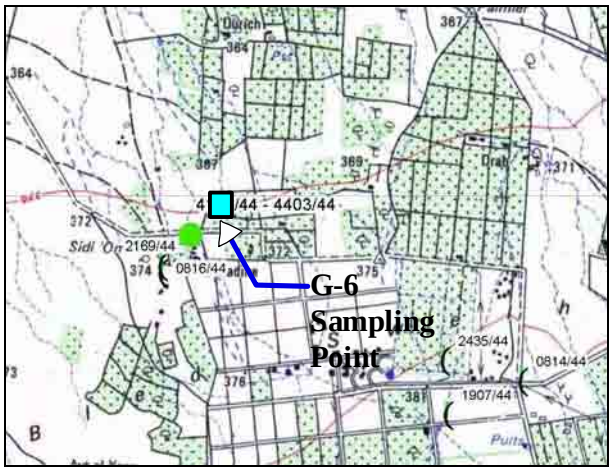
G-3: Location of Groundwater Test Well



G-4: Location of Groundwater Test Well

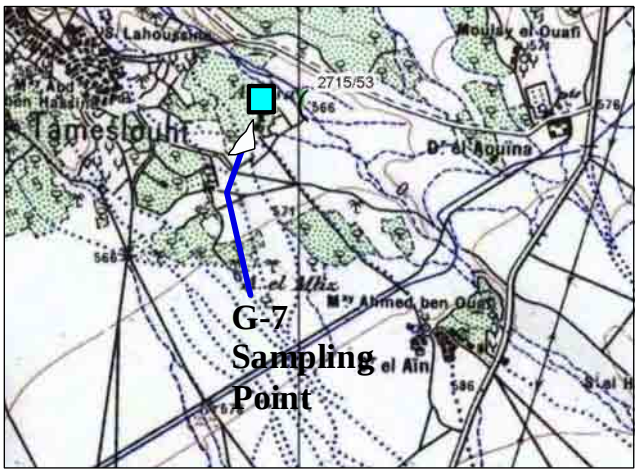


G-5: Location of Groundwater Test Well

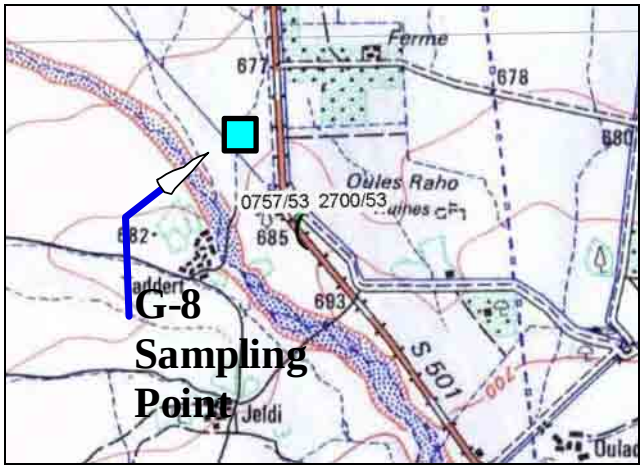


G-6: Location of Groundwater Test Well

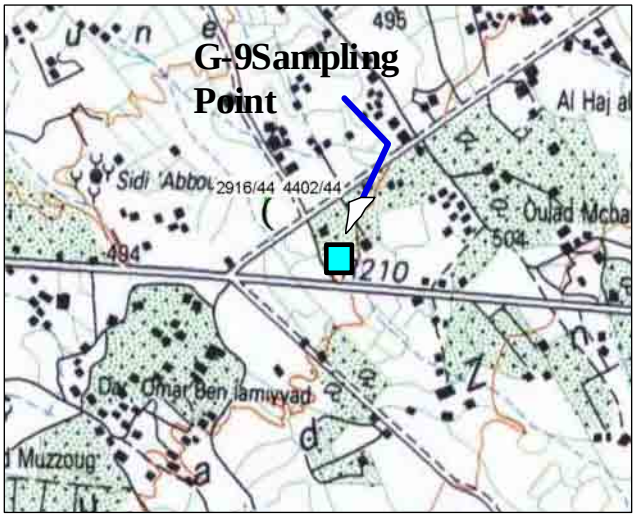
Figure E.3.4 Detail Location of Groundwater Quality Test Wells (1/2)



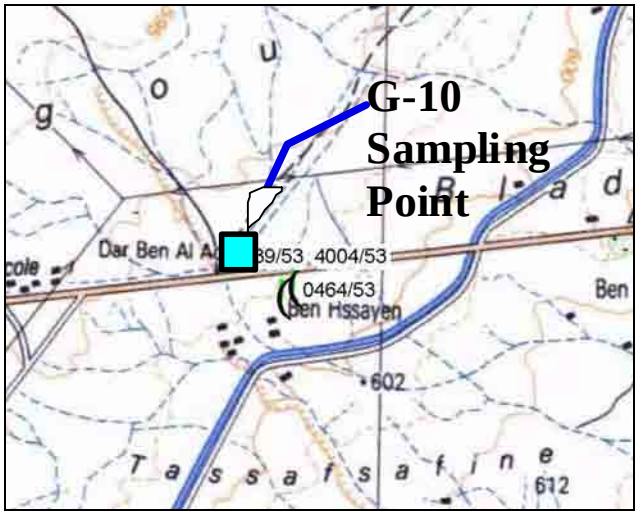
G-7: Location of Groundwater Test Well



G-8: Location of Groundwater Test Well



G-9: Location of Groundwater Test Well



G-10: Location of Groundwater Test Well

Figure E.3.4 Detail Location of Groundwater Quality Test Wells (2/2)