Appendix E

Potable Water Supply and Demand Projections

CURRENCY EQUIVALENTS

Main Currency US$ = United States Dollar

Exchange rates (source: http://www.xe.com/ucc/)

Currency	October 2008	May 2009	June 2010
US Dollar (US$)			
Euro (€)	€ 0.778	€ 0.733	€ 0.8069
Jordanian Dinar (JD)	JD 0.708	JD 0.709	JD 7095
Israeli Shekel (ISL)	ISL 3.82	ISL 4.113	ISL 3.8827
Euro (€)			
US Dollar (US$)	US$ 1.285	US$ 1.364	US$ 1.2384
Jordanian Dinar (JD)	JD 0.909	JD 0.967	JD 0.8791
Israeli Shekel (ISL)	ISL 4.914	ISL 5.610	ISL 4.812
Jordanian Dinar (JD)			
US Dollar (US$)	US$ 1.412	US$ 1.410	US$ 1.4094
Euro (€)	€ 1.100	€ 1.1034	€ 1.1375
Israeli Shekel (ISL)	ISL 5.394	ISL 5.794	ISL 5.471
Israeli Shekel (ISL)			
US Dollar (US$)	US$ 0.2618	US$ 0.243	US$ 0.2576
Euro (€)	€ 0.2035	€ 0.179	€ 0.2078
Jordanian Dinar (JD)	JD 0.1854	JD 0.172	JD 0.1828

ABBREVIATIONS AND ACRONYMS

AIEC	Average Incremental Economic Cost
AIFC	Average Incremental Financial Cost
ASEZ	Aqaba Special Economic Zone
BCR	Benefit Cost Ratio
CAPEX	Capital Expenditure
CBJ	Central Bank of Jordan
C&B	Coyne et Bellier
CBA	Cost Benefit Analysis
DOS	Department of Statistics (Jordan)
EC	European Commission
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
FCR	Full Cost Recovery
FIRR	Financial Internal Rate of Return
GAM	Greater Amman Municipality
GDP	Gross Domestic Product
GEF	Global Environment Fund
GTZ	German Agency for Technical Cooperation
HKJ	The Hashemite Kingdom of Jordan
IBRD	International Bank for Reconstruction and Development (World Bank)
IMF	International Monetary Fund
IWRM	Integrated Water Resources Management
JVA	Jordan Valley Authority
JWC	Jordan Water Company – Miyahuna
MIT	Ministry of Industry and Trade - Jordan
MOA	Ministry of Agriculture - Jordan
MOP	Ministry of Planning and International Cooperation - Jordan
MOTA	Ministry of Tourism and Antiquities - Jordan
MWI	Ministry of Water and Irrigation - Jordan
NPV	Net Present Value
NRW	Non Revenue Water
NWMP	National Water Master Plan
NWMPD	National Water Master Plan Directorate
OCC	Opportunity Cost of Capital
PNA	Palestinian National Authority
PWA	Palestinian Water Authority
SCF	Standard Conversion Factor
SIA	Social Impact Assessment
STPR	Social Time Preference Rate
SW	Switching Values
SWOT	Strengths, Weaknesses, Opportunities and Threats
SWR	Shadow Wage Rate
TOR	Terms of Reference
UN	United Nations
WAJ	Water Authority of Jordan

FINANCIAL YEAR

1st January – 31st December

CONTENTS

1. INTRODUCTION

1.1 General

This appendix presents the water demand and supply forecasts for the Greater Amman Region (GAR) of Jordan (including the governorates of Amman, Madaba, Karak and Zarqa) from 2010 to 2060. The projections have been prepared in the wider context of Jordan's national water demands and the long-term availability of sustainable water resources.

1.2 Acknowledgements

Meetings and discussions were held with a wide range of ministries, departments, and agencies in the water sector – especially, senior representatives in the Ministry of Water and Irrigation (MWI), Water Authority of Jordan (WAJ), Jordan Valley Authority (JVA), Jordan Water Company (JWC – Miyahuna), plus in country representatives of USAID and GTZ.

Annex A presents a list of those consulted and provided information. The main documents and references that were collected and reviewed are listed in Annex C.

1.3 Appendix Outline

The Appendix is divided into ten section:

Section 2	Method of Approach
Section 3	Economic Background
Section 4	Future Development and Projections
Section 5	Water Sector
Section 6	Previous Studies
Section 7	Water Demands and Projections
Section 8	Water Resources
Section 9	Water Balances
Section 10	Potable Water Requirements from RSDS Project

Annex B presents basic data on Jordan, the water sector and water demand projections.

2. METHOD OF APPROACH

2.1 Introduction

This section outlines the general method of approach in assessing future water requirements in the designated demand zones over the 50-year period from 2010 to 2060, which equates to a reasonable economic life for the proposed main conveyor from the Red Sea to the Dead Sea. In relation to the resources allocated to this component of the project, the Study Team have relied heavily on effective updating of existing studies, coupled with analysis of the most recent data and discussions with relevant government specialists in the water sector in Jordan. At the outset, it must be emphasised that the projections are indicative and should be subject to regular review and updating both during and after project implementation. This will ensure that the forecasts are treated as a dynamic and not static function; and reduce the risk of over-estimation that could lead to over-investment and much higher water charges in the medium to long term. In this context, it is important not to focus excessively on supply-side management, but to allow demand management initiatives to encourage and promote much higher water-use efficiency in all sectors (e.g. through: consumer awareness and education programmes; water saving and conservation; realistic and effective water pricing; etc.).

The assessment framework covers: (i) concepts and parameters; (ii) data collection; (iii) data processing; and (iv) projection parameters.

2.2 Concepts and Parameters

The following general guidelines have been adopted:

- Unit of measurement – metric system
- Calendar year – January to December
- Base year – 2007 adopted as the base year. However, data for previous years have been included in the analysis, which is important in providing trend indicators
- Demand zones – these were defined by the Project Team in consultation with the Ministry of Water and Irrigation (MWI), namely: (i) main demand area – Greater Amman Region (including the governorates of Amman, Madaba, Karak and Zarqa; and (ii) broad estimates for the north western Governorates, comprising Amman, Zarqa, Madaba, Karak, Balqa, Irbid, Marfaq and Jarash, and (iii) broad estimates for all other governorates in Jordan.
- Water sources – surface water, groundwater, and treated wastewater

2.3 Data Collection

Information and data were collected from a range of sources, including: (i) regular and periodic statistical publications; (ii) relevant reports and documents produced by national and international agencies; (iii) internal reports prepared by ministries, departments and agencies in the public sector; (iv) data prepared at the specific request of the Study Team; and (v) meetings and discussions with relevant ministries, departments and agencies in the public sector.

The main sources of information are:

- Ministry of Water and Irrigation (MWI)
- Water Authority of Jordan (WAJ)
- Jordan Valley Authority (JVA)
- Jordan Water Company – Miyahuna (JWC)
- National Water Master Plan Directorate (NWMPD)
- USAID
- GTZ

2.4 Data Review and Processing

The data review and processing are summarised as follows:

- Data Review – a wide range of reports and data were reviewed, including: (i) national and regional development plans; (ii) specific reports on the water sector; and (iii) latest statistical data. Important water sector reports and documents are the following:

    - General: Red Sea – Dead Sea Canal Project, Pre-Feasibility Study Report, Harza JRV Group, February 1998

    - Jordan:
        1. National Water Master Plan, MWI and GTZ, May 2004
        2. Jordan's Water Strategy & Policies, MWI, October 2008
        3. Water for Life: Jordan's Water Strategy 2008-2022, September 2008

- Data Processing – substantial volume of recent data on water demand and water resources for the period 2004 to 2007. Most of the data have been processed for the purposes of this report (see: Annex B).

2.5 Projection Parameters

The following projection parameters were adopted:

- Base year – 2007
- Projection period – 50 years at five-year intervals from 2010 to 2020, and 10 year intervals from 2020 to 2060
- Population and socio-economic projections – official plans and indicative study estimates for Low, Medium and High forecasts
- Water demand projections – based on available reports, official projections and study estimates
- Water resource projections – based on available reports, official projections and study estimates

The basic geographical framework is based on the country's 12 governorates. These were used as the basic unit in the NWMP (May 2004). The focus governorates for the study are: Amman, Zarqa, Madaba and Karak. The locations are illustrated in Figure 2.1.

3. ECONOMIC BACKGROUND

Jordan's population is about 6 million (2009) and growing at 2.4% per year (2000-2009), with 83% living in urban areas and 70% of the population below the age of 30. Official records indicate that only 28% (Population and Housing Census 2004) of the population are economically active, which is low by international standards and largely due to low female participation rates, high proportion of the population under 16 years of age, and high number of Jordanians working abroad mainly in the Gulf states. The country also suffers high unemployment rates (13% in 2008, with some governorates much higher) and significant levels of poverty (13% in 2006, with pockets of poverty that are much higher). These issues present considerable challenges to the Government, both now and in the future.

Despite the challenging social welfare situation, the economy has performed well over the last 10 years with average GDP growth of 5.9% p.a. in real terms (2000-2009), despite the regional uncertainties, poor resource base and the serious international financial crisis over the last two to three years. Per capita GDP reached JD 2,720 (US$ 3,840) in 2009, with real growth of 3.7% p.a. Income is also bolstered by significant remittances from Jordanians working abroad, increasing from JD 1.3 billion in 2000 to JD 1.77 billion in 2005.

Table 3.1: Jordan – General Economic Indicators

Year	Population (000)	GDP (JD millions)		Per Capita (JD)	
		Current Prices	1994 Constant Prices	Current Prices	1994 Constant Prices
1995	4,264		4,628		1,085
2000	4,857	5,999	5,419	1,235	1,116
2001	4,978	6,364	5,704	1,278	1,146
2002	5,098	6,794	6,034	1,333	1,184
2003	5,230	7,229	6,286	1,382	1,202
2004	5,350	8,091	6,816	1,512	1,274
2005	5,473	8,925	7,368	1,631	1,346
2006	5,600	10,379	7,965	1,853	1,422
2007	5,723	12,057	8,666	2,107	1,514
2008	5,850	15,056	9,342	2,574	1,597
2009	5,980	16,266	9,603	2,720	1,606
Growth (% p.a.)					
1995-2000	2.6%		3.2%		0.6%
2000-2005	2.4%	8.3%	6.3%	5.8%	3.8%
2005-2009	2.4%	12.8%	5.5%	10.7%	3.6%
2000-2009	2.4%	10.5%	5.9%	8.2%	3.7%

Sources: (i) Department of Statistics; and (ii) Central Bank of Jordan.

In recent years, the best performing sectors have been: construction; financial and real estate; wholesale and retail trade (including tourism); telecommunications and transport; electricity and water; and manufacturing – with sector growth rates of 5% to 8% p.a. On the other hand, agricultural performance has been variable and accounts for less than 3% of GDP, but accounts for more than 60% of total annual water use (see: Table 5.2).

Inflationary pressures have been increasing in recent years, from 2% to 3% p.a. in the early part of the decade to 6.3% in 2006, 4.7% in 2007 and 13.9% in 2008; but, declined by 0.7% in 2009. The IMF predicts that inflation will range between 2% and 4% p.a. over the next five years (2010 to 2014).

Amman, the capital city and administrative, cultural and religious centre of the country, has witnessed substantial economic growth over the last 5 to 10 years, especially in the construction, service, tourism and public sectors. The Amman Governorate has an official resident population of about 2.3 million (39% of national total) and growing at about 2.5% per year (DOS estimates). However, Amman is faced with other population pressures that are placing considerable strain on the capital's infrastructure and water supply services. Since the beginning of the Iraq conflict in 2003, many Iraqi families moved to Jordan (especially from Baghdad) - most reside in Amman (estimated 80%). A survey carried out in 2007 estimated that 450,000 to 500,000 had moved to Jordan (source: Iraqis in Jordan – Their Number and Characteristics, Norwegian Research Institute FAFO and DOS, 2007), but other sources estimate 750,000 (UNHCR). In addition, many Jordanians working abroad return for summer vacations. Hence, the actual numbers in Amman could peak at between 2.6 and 3.3 million.

4. FUTURE DEVELOPMENT AND PROJECTIONS

Over recent decades, Jordan has implemented a number of development programmes and plans designed to sustain macro-economic and monetary stability. However, despite some solid progress, the economy is still faced with a range of critical challenges. Most notable are: (i) high poverty and unemployment rates; (ii) high debt burden and high budgetary deficits; (iii) infrastructure weaknesses in the water and energy sectors; and (iv) potential impact of the current uncertainty in the global economy.

In terms of future development, the Ministry of Planning and International Cooperation (MOP) has published several documents that provide important guidelines and indicators:

- National Agenda 2006 – 2015: The Jordan We Strive For
- Executive Programme 2007 – 2009
- The National Social and Economic Development Plan (2004 – 2006)

The National Agenda 2006 – 2015 sets ambitious targets to be achieved over the next 10 years – as set out in Table 4.1. The target average growth rate for GDP is 7% to 8% per year and halving the unemployment rate. These targets will be difficult to achieve without substantial overseas investment in the private and public sectors, plus sustained recovery in the global economy. On the other hand, the World Bank (2010) and the IMF (2009) predict more modest GDP growth rates of 4% to 5.5% per year, but with declining inflation rates and continuing difficulties in the global economy.

Table 4.1: Jordan – Main National Agenda Socio-Economic Targets

National Agenda Indicators	2004	Targets	
		2012	2017
Average Annual Real GDP Growth Rate	5%	8%	7%
Public Debt as % of GDP	91%	63%	36%
Budget (Deficit)/Surplus as % of GDP	(11.8%)	(3.6%)	1.8%
Capital Investments as % of GDP	21%	21%	24%
National Savings as % of GDP	13%	23%	27%
Net Exports/Imports (US$ billion)	(2.4)	(1.7)	(0.9)
Unemployment as % of Active Population	12.5%	9.3%	6.8%

Source: National Agenda 2006 – 2015: The Jordan We Strive For, MOP.

The National Agenda 2006 – 2015 is divided into three phases with specific themes:

- Phase I (2007 – 2012): employment opportunities for all – focuses on socio-economic development through the growth of labour-intensive and export-oriented industries and traded services, plus investment in key infrastructure.

- Phase II (2013 – 2017): upgrade and strengthen the industrial base through the promotion of capital-intensive industries and induce the newly educated workforce into value-added jobs.

- Phase III (2018 – onwards): world-class competitor in the knowledge economy, focusing on selected economic sectors in the knowledge economy.

The document is expressed in very general terms and will need a detailed action plan, plus a clear statement of the financial & human resources required to achieve the ambitious targets.

With regard to the RSDS Project, there are two themes in the document that have a direct bearing, namely Investment Development and Infrastructure Upgrade:

- Investment Development – envisages the investment of JD 1.5 billion (US$ 2.1 billion) over a 10 year period and creation of 270,000 new jobs. Key sectors include: apparel; tourism; food & beverages; pharmaceuticals; IT services; healthcare; minerals; iron and steel; furniture; and agriculture (improvements based on transition to high-yield revenue crops that optimise water-use efficiency). Many of these initiatives will require important water inputs, but there is no indication of the potential incremental requirements.

- Infrastructure Upgrade – water sector is clearly first priority, the document states: "*Water sector is of strategic importance as water scarcity can significantly impede socio-economic growth. In addition to the scarcity of renewable resources and depletion of underground water, the water sector suffers from distribution inefficiencies, inadequate tariffs, limited wastewater treatment capabilities, & restricted private sector involvement*."

The main initiatives proposed for the water sector include:

1. Develop water supply and new resources, exploit unconventional resources and enforce the Kingdom's water rights according to international agreements.
2. Improve efficiency of water distribution networks to decrease operational costs and non-revenue water.
3. Restructure tariffs and progressively reduce subsidies.
4. Develop and upgrade wastewater treatment facilities and re-use treated water for agriculture and industry.
5. Encourage involvement of the private sector in developing the water sector and creating an investment friendly environment.

These and other initiatives could have a significant impact in the water sector if they are implemented in a timely and sustained manner with active political support.

The National Agenda also sets out ambitious service targets for the water and sanitation sectors – see Table 4.2 – but, there is no clear indication as to how they might be achieved.

Table 4.2: Jordan – Water and Sanitation Performance Targets 2006 - 2017

Key Performance Indicators	Unit	Current	2012	2017
Water Supply – Service Coverage	%	97%	98%	98%
Sewerage – Service Coverage	%	58%	70%	80%
Municipal NRW	%	46%	30%	20%
Water Consumption per Capita	lcd	150	160	170
Water Supply - Average Cost Recovery	%	70%	75%	80%
Irrigation in Jordan Valley – O&M Cost Recovery	%	45%	100%	120%

Source: National Agenda 2006 – 2015: The Jordan We Strive For, MOP.

Finally, the Greater Amman Municipality (GAM) has prepared an urban master plan for the next 20 years to 2025, which plans for a substantial increase in the city's population that will have a dramatic impact on the future development of Jordan and put increasing pressure on the nation's available water resources. The population estimates are presented in the following documents:

- Amman Vision Document – A Discussion Paper, May 2006
- The Amman Plan – Metropolitan Growth, Summary Report, May 2008

The Amman Vision Document recognises that adequate water supplies will be the major constraint, but does not state how the issue might be resolved:

"Amman's major impediment to growth is the water and sewerage system. Our total water supply is at about 130 million m^3 annually – with a current deficit of about 35% - which has resulted in water rationing."

The figures in Table 4.3 highlight the issue:

- Population – projected to more than double in 20 years to 6.5 million by 2025. Two comments are appropriate: (i) the base figure for 2005 seems to assume that all Iraqi immigrants (500,000 to 750,000 – see: Section 3 above) will become permanent residents; and (ii) the city's population in 2025 is 8% higher than the reported national population in 2009 (see: Table 3.1), which implies substantial migration from all other governorates in Jordan.

- Potable water supply – based on average consumption of 100 to 150 litres/capita/day, the incremental water requirement would amount to between 152 and 271 million m^3 per year by 2025. The Amman-Disi Conveyor is expected to supply 100 million m^3 per year, with the RSDS

Project as the only other large potential water source (note: these estimates exclude the requirement for non-residential water).

Table 4.3: Greater Amman – Population Projections & Potential Water Requirements

Year	Population (million)	Water Requirement (m3 million)		Incremental Requirement (m3 million) (1)	
		100 lcd	150 lcd	100 lcd	150 lcd
2004	2.7	99	148	14	63
2005	2.9	106	159	21	74
2010	3.9	142	214	57	129
2015	4.9	179	268	94	183
2020	6.0	219	329	134	244
2025	6.5	237	356	152	271

Note: (1) Based on estimated residential consumption of 85 million m^3 in 2007.
Sources: (i) The Amman Plan – Metropolitan Growth, Summary Report, May 2008; and (ii) Study estimates.

In recent years, Jordan has also experienced a construction boom in the main urban areas – initiated by Government and private property development companies that are largely supported by investment funds from the Gulf States and Saudi Arabia. These investments have been an important source of economic growth, and demand centres for water and sewerage services. However, these developments are exposed to significant risks associated with the recent substantial downturn in the local and regional property market, and continuing uncertainties in the global economy and international financial markets.

Major current developments include the following:

1. Amman
   - Abdali Urban Regeneration Project – major development of 38 hectares in central Amman, with commercial, residential, retail and hotel components. The developers project 40,000 residents and 50,000 daily commuters. The project is in two phases (Phase 1 by 2010) with a reported total investment of US$ 3 billion.
   - Other property developments throughout the central & upper income areas of the city.

2. Zarqa – King Abdullah Bin Abdul Aziz City to accommodate a population of 500,000 (mainly families relocating from Amman and Zarqa City) over the next 10 to 20 years.

3. Dead Sea tourism and residential developments:
   - Tourism - recent and ongoing development of major hotel and resort complexes (e.g. Movenpick, Marriott, Kempinski and Crown Plaza) with a total of about 1,400 rooms and investment of more than US$ 580 million.
   - Emaar Dead Sea Project to develop residential, commercial and leisure facilities with a reported investment of US$ 500 million.

4. Irbid and Ma'an Special Development Zones.

5. Mafraq Economic Development Zone launched in 2006 with proposals to invest up to US$ 750 million over a 20 year period.

6. Aqaba:
   - Aqaba Special Economic Zone (ASEZ) has continuing development plans, including: (i) Kempinski Hotel (216 rooms); (ii) Al Yemenya Heights residential development; (iii) residential development by International Investment Arabian Group (reported US$ 140 million); and (iv) proposed sugar refinery.
   - Ayla Oasis Development Co. – residential, hotel, tourism & leisure development on 430 hectares, over a nine-year period with 3,000 residential units, 1,700 rooms in five luxury hotels, etc. with a reported total investment of US$ 1.4 billion.

Finally, two other potential developments were identified and relate directly to the RSDS Project.

These are:

- Dead Sea Development Plan, November 2007
- Valley of Opportunity – A Concept Master Plan for Jordan Rift Valley, Foster and Partners (UK), September 2008

Both documents were not made available to the Study Team and their potential development prospects remain unknown. The second document is probably the most significant because it proposes substantial modern urban development on either side of the proposed canal from Aqaba to the Dead Sea (i.e. along the length of Wadi Araba).

5. WATER SECTOR

Jordan is one of the 10 most water-deprived countries in the world. At present, renewable fresh water sources average 140 m^3 per person/year (and still declining), compared to the international average of 1,000 m3 per person/year. The sector also faces a number of severe challenges, including: (i) over exploitation of groundwater resources; (ii) no readily accessible new resources, except at very high cost and long implementation schedules (e.g. Disi bulk water will be pumped over a distance of 300 km and is expected to cost about JD 1 per m^3 on a take-or-pay basis from 2013); (iii) inadequate pricing policies and tariff structures; (iv) inefficient irrigation sector that uses more than 60% of annual resources, while the agriculture sector accounts for less than 3% of GDP; (v) high cost of water distribution systems with high levels of non revenue water (national average 46% in 2007); and (vi) limited development of wastewater re-use, especially for irrigated agriculture. Addressing the water infrastructure issues is now the Government's top investment priority.

General service coverage for drinking water and wastewater in 2008 is illustrated in Table 5.1. For drinking water, the public systems serve about 74% of households (note: WAJ states that 95% to 98% are actually connected); while a high proportion (19%), mainly in Amman and Zarqa, rely on bottled water. Water tankers generally account for between 1% and 7% of requirements. These percentages are important in terms of the comparative prices of water and what households are prepared to pay. In Amman, for example, the indicative prices in late-2008 were as follows: (i) public supply: JD 0.26 to 0.47 per m^3; (ii) bottled water: JD 0.7 per litre (JD 700 per m^3); and (iii) water tankers: JD 2.5 per m^3. For wastewater discharge, service coverage in urban areas ranges from 70% to 80%.

Table 5.1: Jordan – Households by Main Source of Drinking Water & Wastewater Discharge 2008 (%)

Component	Amman Governorate	Main Demand Area Governorates (1)	National		
			Urban	Rural	Total
Water for Drinking					
Public Network	71%	73%	73%	78%	74%
Bottled Water	27%	26%	22%	4%	19%
Water Tankers	1%	1%	1%	7%	2%
Others (2)	1%	…	4%	11%	5%
Total	100%	100%	100%	100%	100%
Wastewater					
Public Network	78%	74%	71%	3%	60%
Cesspool	22%	26%	29%	97%	40%
Total	100%	100%	100%	100%	100%

Notes: (1) Governorates of Amman, Zarqa, Madaba and Karak; and (2) Wells, springs and rainwater
Source: Household Expenditure and Income Survey 2008, DOS.

Most households have an intermittent service from the public water supply network. In Amman, for example (2007-08), 66% of registered customers received water for less 5 hours per day and only 11% had a continuous supply. In these circumstances, families have adopted coping strategies that include: (i) roof tanks (1 m^3 to 6 m^3 capacity); (ii) individual pumps to extract more water from the system; (iii) purchases from water tankers that pump water from private and public wells in the outskirts of the city (reported to be about 600 water tankers in Amman, varying in size from 6 m^3 to 10 m^3 capacity); and (iv) bottled water for drinking and cooking.

The pricing and tariffs for public water supplies and irrigation water continue to be controversial issues in both economic and financial terms, because of the Government's reluctance to price water at a value that reflects both its scarcity and the real costs of service provision. Table 5.2 illustrates domestic water and sewerage tariffs for Amman and other urban centres for a range of quarterly consumption levels in 2006. For example, for 50 m^3 per quarter (equivalent to 100 lcd for a household of 5.5 persons) the average tariff is JD 0.39 (US$ 0.55) per m^3 in Amman and JD 0.27 (US$ 0.38) per m^3 in other urban centres.

Non-residential customers are charged a flat rate of JD 1 (US$ 1.41) per m^3 for water and JD 0.56 (US$ 0.79) per m^3 for sewerage.

Irrigation water is charged at JD 0.012 (US$ 0.017) per m^3.

Table 5.2: Jordan – Domestic Water and Sewerage Tariffs 2006 (JD)

Consumption (m3 per quarter)	Lcd (1)	Water	Sewerage	Additional Charge	Meter Rent	Total	Av. Tariff per m3	
							JD	US$
Amman								
20 m3	40	2.000	0.672	2.150	0.300	5.122	0.256	0.36
40 m3	80	4.800	1.568	4.150	0.300	10.818	0.270	0.38
50 m3	100	10.278	3.858	5.150	0.300	19.586	0.392	0.55
60 m3	120	12.267	6.571	5.150	0.300	28.288	0.471	0.67
Other Urban Centres								
20 m3	40	1.300	0.600	2.150	0.300	4.350	0.218	0.31
40 m3	80	2.800	1.300	3.650	0.300	8.050	0.201	0.28
50 m3	100	6.009	2.664	4.650	0.300	13.623	0.272	0.38
60 m3	120	9.920	4.293	4.650	0.300	19.164	0.319	0.45

Note: (1) Based on average household size of 5.5 persons.
Source: Jordan Water Company – Miyahuna.

In the context of household expenditure patterns in 2008, it is worth noting that average annual costs of water and sanitation services ranged from JD 43 to JD 97 amounting to 1% of average household expenditure (see: Annex B, Table 4). This percentage is low by international standards for developing countries. Benchmark values of 3% to 5% are generally considered more appropriate.

For the future, the illustration of these values is important for several reasons:

- New sources of supply (e.g. Disi fossil water and RSDS desalinated water) will be much more expensive and the Jordanian authorities need to address this fact now, rather than wait for prospective supplies to come on-stream.

- Irrigation water tariffs should, as a minimum, cover direct and indirect recurrent costs, coupled with incentives to promote water-use efficiency and transition to higher value crops.

- Finally, prospective international donors who are interested in supporting the RSDS Project may not be willing to contribute unless there is a positive commitment on the issue of realistic water pricing.

The latter point also highlights another issue that continues to draw national and international attention, namely the high levels of non-revenue water [NRW – generally defined as: physical losses (leakages); commercial losses (meter reading and data handling errors + unauthorised consumption, illegal connections); and unbilled authorised consumption]. Official records indicate that NRW levels are still high despite some improvement over the last 10 years. At the national level, average NRW declined from 54% in 1999 to 49% in 2002 and 45% in 2007. For Amman, the figures were 50%, 47% and 40% respectively. To put the issue in perspective, the reported total annual quantity of NRW water for Jordan (120 to 140 million m^3 per year) would have been sufficient to cover Amman's annual supplies (see: Appendix B, Table 9) and have an indicative sales value of JD 47 to 55 million (US$ 66 to 77 million) per year.

Table 5.3 summarises the reported water supplies to the main consumption sectors from 1985 to 2007. The figures indicate the following:

- Total – available supplies increased by only 8% over the last 17 years, from 870 million m^3 in 1990 to 940 million m^3 in 2007.

- Municipal (domestic, commercial and institutional) – supplies increased by 67% over the same period, but available resources of potable water were severely constrained while the total population continued to increase at 2.3% per year. Jordan has the added strain of more than 500,000 immigrants from Iraq. Nevertheless, the proportion allocated to the municipal sector has increased from 20% in 1990 to 31% in 2007, but the percentage remained static since 2000.

- Industry (mainly large industries that draw water from individual wells) – reported water usage by large industries increased by 32% from 37 million m^3 in 1990 to 49 million m^3 in 2007. The percentage allocation has been modest at between 3.5% and 5% of total supplies.

- Agriculture – irrigated agriculture is the largest water user, accounting for between 540 and 650 million m^3 per year (depending on annual rainfall and some minor improvements in water-use efficiency). The percentage allocation has declined from 75% in 1990 to about 63% in 2007, which is high given agriculture's small GDP contribution of less than 3%.

- Livestock – estimated usage has generally amounted to less than 1% of total annual supply.

Table 5.3: Jordan – Water Supplies for Municipal, Industry & Agriculture 1985-2007

Year	Municipal	Industrial	Agriculture	Livestock	Total
Quantity (m3 million)					
1985	116	22	497	4	639
1990	176	37	652	5	870
1995	240	33	596	9	878
2000	239	37	534	7	817
2001	246	33	488	8	774
2002	249	37	511	7	804
2004	281	38	540	7	866
2005	291	38	604	8	941
2006	291	38	588	8	925
2007	294	49	589	8	940
Distribution (%)					
1985	18.2%	3.4%	77.8%	0.6%	100%
1990	20.2%	4.3%	74.9%	0.6%	100%
1995	27.3%	3.8%	67.9%	1.0%	100%
2000	29.3%	4.5%	65.4%	0.8%	100%
2001	31.8%	4.3%	63.0%	1.0%	100%
2002	31.0%	4.6%	63.6%	0.9%	100%
2004	32.4%	4.4%	62.4%	0.8%	100%
2005	31.0%	4.0%	64.1%	0.9%	100%
2006	31.4%	4.2%	63.6%	0.8%	100%
2007	31.2%	5.2%	62.7%	0.8%	100%

Sources: (i) MWI; and (ii) NWMP 2004

The general performance of Jordan's water sector has experienced some improvements in the operational efficiency in both water supply and irrigation sub-sectors. However, severe water scarcity requires sustained and comprehensive action to address the full range of efficiency and demand management reforms. Nevertheless, major investments will still be required in order to sustain socio-economic development over the next 10 to 20 years to: (i) reduce the high levels of non-revenue water; (ii) increase bulk water supplies (e.g. Disi-Amman transfer project and possibly the RSDS Project); and (iii) expand wastewater treatment capacity and promote re-use of treated effluent. Increases in bulk water supplies and wastewater treatment will be expensive investments and result in substantial increases in delivered service costs. Therefore, more effective demand management of existing resources should be a prerequisite, in terms of realistic water pricing and more water-efficient irrigation methods that encourage transition to higher value crops per unit of water.

The Government is well aware of all the issues and has published two important documents:

- Jordan's Water Strategy & Policies 2008, MWI, October 2008
- Water for Life: Jordan's Water Strategy 2008 – 2022, MWI, September 2008

The first document addresses the full range of issues in terms of general strategy and management of groundwater, water utilities, irrigation and wastewater. The *"Water for Life"* document makes explicit statements on the future development of the water sector, many of which have a direct bearing on the present study. The most important are cited below:

The Minister's introduction includes the following statements:

"We intend to reduce demand by raising awareness of the general public on the water condition in Jordan. We all agree that we need to value water more, use it more wisely and have every stakeholder to take his share of responsibility for protecting this vital resource."

"We are taking on board serious important plans. By 2022, the Disi water conveyance and Red-Dead Canal would be operational. By 2022, non-revenue water (NRW) would not exceed 25%. By 2022, we should have cost reflective tariffs. The Ministry shall introduce a new Water Law, Water Regulatory body and a Water Council. We shall dispose of all non-water functions from JVA. The Ministry shall have a streamlined structure by operating "wholesale" operations (National Infrastructure) and "retail" operations (Service Delivery). This will enhance and improve how the private sector could participate effectively."

Vision by 2022 includes:

Water Demand:

1. Water demand for agriculture not to exceed that of Municipal, Tourism and Industrial combined.
2. Water tariff to cover the O&M costs plus part of the capital investment.
3. Revise WAJ/JVA bulk tariff setting mechanism to reflect the real value of water, based on the high cost of developing and providing water from new sources.

Water Supply:

4. Water supply from Desalination of the Red Sea is a major source.
5. Wastewater treated effluent is fully utilised for irrigation.
6. Non-revenue water to be 25% by 2022.
7. First priority to basic human needs, and as such, first priority is given to the allocation of a modest share of 100 litres per capita per day to domestic water supplies.
8. Set municipal water and wastewater charges at a level which will cover at least the cost of operation and maintenance.
9. Revise tariffs on the basis of the cost of utilities and the provision of services.
10. Population will continue to grow from about 5.87 million today (2008) to over 7.92 million by 2022.

Irrigation:

11. Recovery of Operation and Maintenance cost of irrigation is achieved.
12. Annual water demand for irrigation is reduced from 68% today to 58% of the total water demand by 2022 and to 50% of the water supply.

Wastewater:

13. Adequate wastewater collection and treatment facilities for all major cities and towns in Jordan.
14. Wastewater treated effluent a source of irrigation.

Alternative Water Resources:

15. Sufficient infrastructure for desalination of the Red Sea Water.
16. Red Sea – Dead Sea Canal is operational.
17. Take all necessary actions to expedite the financing, design, construction and operation of the Red Dead Canal.
18. The Red-Dead Canal will add 570 MCM/year if operational by 2022.

Many of the targets are very ambitious and will require the framework of a comprehensive action plan that sets clear priorities with the full support of the necessary institutional, legal and financial resources. Indeed, it is worth re-emphasising that the Government's actions and achievements over the next 3 to 5 years may well influence the reaction and willingness of potential international donors to pledge support and financial resources for the RSDS Project.

6. PREVIOUS STUDIES

6.1 Introduction

There are three main documents that relate directly to the present study, and their water forecasts are worth summarising as background information. The reports are:

- Red Sea – Dead Sea Canal Project, Prefeasibility Report, Harza JRV Group, Feb. 1998
- National Water Master Plan, MWI and German Technical Cooperation – GTZ, May 2004
- NWMP Update, MWI, 2008

6.2 Harza Report 1998

The water forecasts presented in the Harza Report are summarised in Table 6.1. The figures indicate the projected national water deficit rising from 405 million m^3 in 2010 to 439 million m^3 in 2020 and 645 million m^3 by 2040. The main factors are as follows:

- Water demand – municipal demand (domestic, commercial and institutional consumers) was projected to more than double over the 30 years, from 477 million m^3 in 2010 to 1,263 million m^3 by 2040. However, it is important to note that the original projections were based on: (i) high population projections: 7.1 million in 2010 (cf. 6 million in 2009) rising to 16.1 million by 2040 at an average growth rate of 2.8% per year; and (ii) high per capita demand, rising from 157 litres/capita/day (lcd) in 2010 to 187 lcd by 2040 (see: Appendix B, Table 7). In addition, irrigation demand was projected to stabilise at 786 million m3 per year (cf. 589 million m^3 in 2007).

- Water resources – total available resources were projected to increase by more than 60%, from 968 million m^3 in 2010 (cf. 940 million m^3 in 2007) to 1,573 million m^3 by 2040, mainly due to the substantial increase in wastewater reuse. The groundwater estimates include adjustments to safe yields of 277 million m^3 per year from existing sources plus 170 million m^3 per year from the Disi aquifer.

The general conclusions from the Harza projections are: (i) water demand – the municipal forecasts may be optimistic, but the irrigation figures were considerable under-estimates; and (ii) water resources – the forecasts appear to be reasonable.

Table 6.1: Jordan – Harza Study 1998: Forecasts of Water Demand, Water Resources and Deficits

Component	Unit	1990	2000	2010	2020	2040
Water Demand						
Municipal	m3 million	240	340	477	670	1,263
Industrial	m3 million	43	78	110	130	170
Irrigation	m3 million	692	742	786	786	786
Total	m3 million	975	1,160	1,373	1,586	2,219
Annual Growth Rate	% p.a.		1.7%	1.7%	1.4%	1.7%
Water Resources						
Treaty Allocations	m3 million	130	220	245	245	245
JRV Wadis	m3 million	120	153	175	175	175
Groundwater	m3 million	476	429	405	492	522
Wastewater Reuse	m3 million	48	85	143	234	631
Total	m3 million	774	887	968	1,146	1,573
Annual Growth Rate	% p.a.		1.4%	0.9%	1.7%	1.6%
Water Deficit	**m3 million**	**-201**	**-273**	**-405**	**-439**	**-645**
Annual Growth Rate	**% p.a.**		**3.1%**	**4.0%**	**0.8%**	**1.9%**

Source: Appendix B, Table 7.

6.3 NWMP 2004

The NWMP presents a comprehensive planning framework based on digital planning tools supported by an extensive statistical database and GIS mapping. The system provides an interface between demand and resources, plus the ability to produce a water balance and analyse the impact of alternative development options in the future. This implies that the NWMP should be regularly updated and tested with the latest information.

Table 6.2 summarises the water balance prepared by the NWMP for 15 years from 2005 to 2020. The results indicate that future deficits should stabilise at 306 to 379 million m^3 per year, which are 15% to 25% lower than the Harza estimates for 2010 and 2020:

- Water demand - municipal demand was projected to increase by 20% over the next 10 years, from 405 million m^3 in 2010 to 493 million m^3 by 2020. The latter is more than 25% below the Harza forecast. The main parameters underlying the NWMP forecasts are: (i) modest population projections: 6.5 million in 2010 (cf. 6 million in 2009) rising to 8.1 million by 2020 at an average growth rate of 2.2% per year; and (ii) average per capita consumption, rising from 131 lcd in 2010 to 142 lcd by 2020. On the other hand, irrigation demands are forecast to stabilise at about 1,100 million m^3 per year (cf. 589 million m^3 in 2007), with no improvement in water-use efficiency.

- Water resources - total available resources were projected to remain stable at about 1,200 million m^3 per year; although this includes increased importance of treated wastewater and additional resources.

Table 6.2: Jordan – NWMP 2004: Forecasts of Water Demand, Water Resources and Deficits

Component	Unit	1998	2005	2010	2015	2020
Water Demand						
Municipal	m3 million	297	367	405	444	493
Tourism	m3 million	2	6	10	16	20
Industrial	m3 million	38	59	77	100	120
Irrigation	m3 million	901	1,114	1,120	1,101	1,052
Total	m3 million %	1,237	1,545	1,612	1,661	1,685
Annual Growth Rate	p.a.			0.8%	0.6%	0.3%
Water Resources						
Renewable Groundwater	m3 million		259	259	245	245
Surface Water	m3 million		382	404	175	175
Treated Wastewater	m3 million		34	69	492	522
Additional Resources	m3 million		344	511	234	631
Total	m3 million		1,019	1,243	1,220	1,248
Annual Growth Rate	% p.a.			4.1%	-0.4%	0.5%
Groundwater Return Flows	m3 million		66	63	62	63
Water Deficit	**m3 million**		**-460**	**-306**	**-379**	**-374**
Annual Growth Rate	**% p.a.**			**-7.9%**	**4.4%**	**-0.3%**

Source: Appendix B, Table 8.

6.4 NWMP Update 2008

Finally, Table 6.3 presents MWI's latest update using the NWMP planning tools. The results indicate a potential surplus of 243 million m^3 by 2022, which is presumably based on a significant increase in treated wastewater and additional resources (e.g. Disi water and possibly desalinated water from the Red Sea):

- Water demand – total demand was projected to increase by 10% over the next 14 years, from 1,462 million m^3 in 2008 to 1,604 million m^3 by 2022. In terms of the main sectors: (i) municipal – increase of 31% from 371 million m3 to 486 million m^3; (ii) tourism – tripling from 10 million m^3 to 29 million m^3; (iii) industry – doubling from 81 million m^3 to 163 million m^3; and (iv) irrigation – indicates a modest reduction of 7% from 1,000 million m^3 to 926 million m^3, which implies a very minor no improvement in water-use efficiency.

- Water resources – expected to double from 966 million m^3 to 1,847 million m^3, but no breakdown was given.

Table 6.3: Jordan – NWMP Update 2008: Forecasts of Water Demand, Water Resources and Deficits

Component	Unit	Quantity (million m3)		Distribution (%)		Growth Rate (% p.a.)
		2008	2022	2008	2022	
Water Demand						
Municipal	m3 million	371	486	25.4%	30.3%	+1.9%
Tourism	m3 million	10	29	0.7%	1.8%	+7.9%
Industrial	m3 million	81	163	5.5%	10.2%	+5.1%
Irrigation	m3 million	1,000	926	68.4%	57.7%	-0.5%
Total	m3 million	1,462	1,604	100.0%	100.0%	+0.7%
Water Resources						
Renewable Groundwater	m3 million	n.a.	n.a.	n.a.	n.a.	n.a.
Surface Water	m3 million	n.a.	n.a.	n.a.	n.a.	n.a.
Treated Wastewater	m3 million	n.a.	n.a.	n.a.	n.a.	n.a.
Additional Resources	m3 million	n.a.	n.a.	n.a.	n.a.	n.a.
Total	m3 million	966	1,847	100.0%	100.0%	+4.7%
Water Surplus (Deficit)	m3 million	**-496**	**+243**			

Source: Water For Life: Jordan's Water Strategy 2008 – 2022, September 2008.

6.5 Conclusions

The forecast results of previous studies highlight the importance of several specific issues:

- Municipal forecasts – critical importance of reasonable municipal demand projections for domestic, commercial & institutional consumers. Key factors are: population projections, per capita consumption targets, and non-revenue water targets.

- Irrigation forecasts – need for radical measures to improve water-use efficiency and focus on high value crops.

- Demand management – need for sustained use of demand management techniques to promote increased water use efficiency in all sectors, including the implementation of an effective water pricing policy.

- Water resources – the extent and speed with which treated wastewater and additional resources can be introduced.

7. RSDS UPDATES AND FORECASTS

7.1 Introduction

This sub-section presents updates and forecasts at 5 year intervals from 2010 to 2020 and 10 year intervals from 2020 to 2060. The projections are based on the following sources:

- NWMP 2004 and the update prepared in 2008
- Data and information collected by the Study Team from MWI, WAJ, JVA, JWC, DOS and others
- Latest views and information on future water demands and water resources

The presentation is divided into six sub-sections:

1. Population forecasts
2. Historical water consumption by main user categories
3. Indicative water demand forecasts by main user categories
4. Water resources
5. Indicative water balance
6. Indicative water deficits 2020 to 2060

Detailed statistical information is presented in Appendix B.

7.2 Population Forecasts

Population forecasts are addressed first because they are crucial in appreciating the current position and assessing future water demand, plus the socio-economic challenges facing Jordan.

The national population is estimated at 6 million in 2009 with an average growth rate of 2.3% per year, which has fallen from about 3% per year in the 1990s. In addition, since 2003, Jordan has been accommodating between 500,000 and 750,000 Iraqi immigrants, of whom the majority live in the Greater Amman region and have put increased pressure on the capital's infrastructure and public utilities.

The designated Project Area (governorates of Amman, Zarqa, Madaba and Karak) had a reported permanent population of nearly 3.6 million, accounting for 60% of the national population.

Table 7.1: Jordan – Population by Governorate

Governorate	Population (000)			Growth Rates (% p.a.)		
	2000	2005	2009	2000-03	2005-09	2000-09
Main Demand Area						
Amman	1,885	2,125	2,316	2.4%	2.2%	2.3%
Zarqa	724	811	891	2.3%	2.4%	2.3%
Madaba	121	137	150	2.5%	2.2%	2.3%
Karak	189	214	233	2.5%	2.2%	2.3%
Total	2,919	3,287	3,589	2.4%	2.2%	2.3%
Other Governorates	1,938	2,186	2,391	2.4%	2.3%	2.4%
National Total	4,857	5,473	5,980	2.4%	2.2%	2.3%

Source: Department of Statistics (Appendix B, Table 1).

Recent estimates published by the Government indicate that the total population is expected to reach nearly 8 million by 2020 at an average growth rate of 2.3% per year (source: DOS 2008 and Water for Life: Jordan's Water Strategy 2008-2022). However, there is still some uncertainty over future growth rates, because of: (i) historically high birth rates, although the Government has active strategies for birth control awareness and family planning; and (ii) the number of immigrants who have begun to make a home in Jordan. Therefore, it is prudent for study purposes to develop Low, Medium and High projection scenarios. In addition, the projections need to reflect the increasing dominance and attraction of the Greater Amman region for internal and external migrants.

Table 7.2 presents the population growth rates for the three scenarios at the national level and the project area. All three scenarios assume continuing high growth rates for the next 5 to 10 years, followed by a general decline in the average growth rates over the following 40 years from 2020 to 2060.

Table 7.2: Jordan – Population Growth Rates: National and Project Area

Period	Low	Medium	High
National			
2000-2007	2.4%	2.4%	2.4%
2007-2010	2.4%	2.9%	3.5%
2010-2015	2.3%	2.8%	3.4%
2015-2020	2.1%	2.5%	3.0%
2020-2030	1.9%	2.3%	2.7%
2030-2040	1.7%	2.0%	2.4%
2040-2050	1.2%	1.5%	1.8%
2050-2060	0.8%	1.0%	1.2%
Main Demand Area			
2000-2007	2.4%	2.4%	2.4%
2007-2010	2.6%	2.9%	3.3%
2010-2015	2.5%	2.8%	3.2%
2015-2020	2.3%	2.7%	3.2%
2020-2030	2.3%	2.4%	2.8%
2030-2040	1.6%	2.1%	2.5%
2040-2050	1.3%	1.7%	2.1%
2050-2060	1.0%	1.3%	1.7%

Source: Appendix B, Table 11.

Table 7.3 summarises the resulting population projections for both the project area and the national total:

- Low – national population is forecast to double over the next 50 years from 6.1 million in 2010 to 7.4 million by 2020 and 12 million by 2060. In the Main Demand Area, the projected increase is 135% from 3.7 million in 2010 (61% of national total) to 4.7 million by 2020 (63%) and 8.8 million by 2060 (73%).

- Medium – national population is forecast to increase by 125% from 6.2 million in 2010 to 7.7 million by 2020 and 13.8 million by 2060. In the Main Demand Area, the projected increase is 175% from 3.8 million in 2010 (61%) to 4.9 million by 2020 (64%) and 10.3 million by 2060 (75%).

- High – national population is forecast to increase by 170% from 6.2 million in 2010 to 8 million by 2020 and 16.6 million by 2060. In the Main Demand Area, the projected increase is 240% from 3.8 million in 2010 (61%) to 5.2 million by 2020 (65%) and 12.9 million by 2060 (78%).

Table 7.3: Jordan - Population Projections 2010 – 2060 (million)

Governorate	Base Year 2007	Projections			
		2010	2020	2040	2060
Low					
Main Demand Area					
Amman	2.22	2.43	3.36	5.34	7.02
Zarqa	0.85	0.90	1.01	1.13	1.21
Madaba	0.14	0.15	0.17	0.19	0.20
Karak	0.22	0.24	0.27	0.30	0.32
Total	3.44	3.71	4.71	6.96	8.75
Other Governorates	2.28	2.42	2.73	3.06	3.29
National Total	5.72	6.13	7.44	10.02	12.04
Medium					
Main Demand Area					
Amman	2.22	2.46	3.47	5.97	8.45
Zarqa	0.85	0.90	1.03	1.19	1.28
Madaba	0.14	0.15	0.17	0.20	0.22
Karak	0.22	0.24	0.27	0.31	0.34
Total	3.44	3.75	4.94	7.67	10.29
Other Governorates	2.28	2.42	2.77	3.22	3.50
National Total	5.72	6.17	7.71	10.89	13.79
High					
Main Demand Area					
Amman	2.22	2.50	3.70	7.01	10.94
Zarqa	0.85	0.90	1.05	1.25	1.37
Madaba	0.14	0.15	0.18	0.21	0.23
Karak	0.22	0.24	0.28	0.33	0.36
Total	3.44	3.79	5.19	8.80	12.90
Other Governorates	2.28	2.43	2.83	3.40	3.74
National Total	5.72	6.22	8.02	12.20	16.64

Source: Appendix B, Tables 12 to 14.

7.3 Historical Water Consumption

7.3.1 Municipal

Municipal water consumption, for the purposes of this study, covers domestic, commercial, institutional consumers, plus tourism facilities and light industries. WAJ supplied data on municipal total potable water supplies by governorate for the period from 1999 to 2007. However, it should be noted that the Water Information System was not able to provide a breakdown of water consumption by customer category. Additional data were provided by: (i) Jordan Water Company (Miyahuna) on water services in Amman; and (ii) PMU/Al-Meyyeh Project (MWI) on the records of non-revenue water (NRW) by governorate from 1999 to 2007.

Table 7.4 summarises reported municipal potable water supplies by governorate. In the Main Demand Area, total supplies increased by 40% over the eight-year period from 135 million m^3 in 2000 to 189 million m^3 in 2007, implying an average growth rate of 4.9% per year. A similar rate of increase was experienced in Amman, with supplies increasing from 89 million m^3 in 2000 to nearly 125 million m^3 in 2007. For the country as a whole, the rate of increase was lower at 3.7% per year from 234 million m^3 in 2000 to 301 million m^3 in 2007.

Table 7.4: Jordan – Municipal Potable Water Supplies Delivered by Governorate 2000-2007 (m3 million)

Governorate	2000	2001	2002	2005	2006	2007
Main demand Area						
Amman	89.0	94.4	94.1	119.9	122.0	124.8
Zarqa	31.8	32.7	34.4	38.4	40.3	44.6
Madaba	5.6	5.9	6.1	6.2	6.4	6.9
Karak	9.0	9.4	11.2	11.0	11.5	12.9
Total	135.3	142.5	145.7	175.5	180.1	189.2
Other Governorates	98.5	97.3	99.8	106.5	106.2	111.7
National Total	233.8	239.7	245.6	282.0	286.3	300.9

Source: Appendix B, Table 9.

The figures in Table 7.4 include high levels of NRW (defined as: (i) physical losses (i.e. leakages); and (ii) administrative losses (i.e. illegal connections, faulty meters, unmetered connections, poor meter reading and billing, etc.). Table 7.5 illustrates the consistently high levels of NRW over the last decade; although there has been some improvement in recent years in addressing the problem with assistance from international donors. Average NRW declined from 51% in 2000 to 46% in 2007. The level is still high by international standards.

Table 7.5: Jordan – NRW as % of Municipal Water Supplies by Governorate 2000-2007 (%)

Governorate	2000	2001	2002	2005	2006	2007
Main Demand Area						
Amman	48%	49%	47%	43%	40%	40%
Zarqa	55%	55%	56%	52%	51%	65%
Madaba	58%	58%	50%	45%	40%	46%
Karak	55%	56%	52%	45%	54%	61%
Total	51%	51%	50%	45%	43%	48%
Other Governorates	52%	49%	48%	44%	43%	44%
National Total	51%	50%	49%	45%	43%	46%

Source: Appendix B, Table 9.

Table 7.6 provides an estimate of effective water consumption by governorate, assuming that administrative losses account for half of NRW (note: estimate by PMU/Al-Meyyeh Project, MWI). The results indicate that effective consumption in the project area rose from 101 million m^3 in 2000 to 144 million m^3 at an average of 5.2% per year; and, at the national level, from 174 million m^3 in 2000 to 231 million m^3 in 2007 at an average of 4.2% per year.

Table 7.6: Jordan – Estimated Municipal Water Consumption by Governorate 2000-2007 (m3 million)

Governorate	2000	2001	2002	2005	2006	2007
Main Demand Area						
Amman	67.5	71.2	71.8	94.4	97.8	99.9
Zarqa	23.1	23.8	24.8	28.4	30.1	30.1
Madaba	4.0	4.2	4.5	4.8	5.1	5.3
Karak	6.5	6.8	8.3	8.6	8.4	9.0
Total	101.0	105.9	109.4	136.1	141.4	144.2
Other Governorates	72.7	73.4	75.8	83.0	83.6	86.9
National Total	173.7	179.3	185.2	219.2	225.0	231.1

Source: Appendix B, Table 9.

Further processing of the data provides an estimate of per capita water consumption for domestic purposes and total consumption (i.e. domestic plus commercial/institutional use). The results are presented in Table 7.7:

- Domestic – in the project area, the figures indicate that per capita consumption has increased from 81 lcd in 2000 to 98 lcd in 2007. However, the higher figures for Amman are somewhat misleading because of the influx of Iraqi immigrants since 2003. At the national level, the average rose from 80 lcd in 2000 to 91 lcd in 2007. (note: these figures represent actual effective consumption, excluding NRW).

- Total unit consumption – the figures are about 18% higher than domestic per capita consumption, because they include water usage by hotels, restaurants, shops, small industrial enterprises, etc.

Table 7.7: Jordan – Estimated Per Capita Water Consumption by Governorate 2000-2007 (litres per capita/day) (1)

Governorate	2000	2001	2002	2005	2006	2007
Domestic Consumption						
Main Demand Area						
Amman	83	86	85	103	105	105
Zarqa	74	75	76	82	84	82
Madaba	76	79	83	81	85	86
Karak	80	81	97	93	89	94
Total	81	83	83	97	98	98
Other Governorates	78	78	78	81	79	80
National Average	80	81	81	90	90	91
Total Unit Consumption						
Main Demand Area						
Amman	98	101	99	122	123	123
Zarqa	87	88	90	96	99	97
Madaba	89	93	98	98	99	101
Karak	94	95	114	109	105	110
Total	95	97	98	113	115	115
Other Governorates	103	101	102	104	103	104
National Average	98	99	100	110	110	111

Note: (1) Figures represent actual effective consumption, excluding NRW.
Source: Appendix B, Table 10.

7.3.2 Industry

Industry (manufacturing) is an important economic sector that accounts for an increasing proportion of GDP, rising from 13% in 2000 to 17% in 2007. It also accounts for about 90% of exports and employs about 16% of the national labour force.

Most of the industrial enterprises in Jordan are small to medium in size catering for the local market, and consuming small quantities of water that are drawn from municipal water supply systems. The most recent Statistical Bulletin of the Ministry of Industry and Trade (MIT) reports that there are 16,364 registered industrial companies with a capital value of JD 1,671 million (June 2007). On the other hand, DOS reported a total of 20,662 industrial companies in 2006, of which 50% were in Amman Governorate (see: Governorates Indicators 2003-2006).

Within the context of the present study (and the NWMP), industrial water consumption focuses on the large industries that generally consume/use water as an integral part of the production process and mainly draw water from their own licensed wells. The NWMP divided industries into three water consumption categories:

1. Public water supplies – in Aqaba, the Thermal Power Station and Jordan Fertilizer in the Aqaba Special Economic Zone (ASEZ).

2. Groundwater wells – most of the large industries in Jordan.

3. Surface water sources – two companies: (i) Tomato Paste Factory in Deir Alla; and (ii) Jordan Potash Company (JPC) on the Dead Sea (note: JPC uses surface and groundwater).

According to WAJ/MWI statistics, reported industrial water usage has doubled over the last 20 years, from 22 million m^3 in 1985 to 37 million m^3 in 2000 and 49 million m^3 in 2007. However, these volumes only account for 3.5% to 5% of total national water supplies. In the past, some annual variations have occurred due movements in the international market for the end products (e.g. phosphate rock and fertilizer) and the increase in mining costs.

Table 7.8: Jordan – Industrial Water Consumption/Use: Large Enterprises

Year	Quantity (m3 million)	% of Total Water Supplies
1985	22	3.4%
1990	37	4.3%
1995	33	3.8%
2000	37	4.5%
2001	33	4.3%
2002	37	4.6%
2004	38	4.4%
2005	38	4.0%
2006	38	4.2%
2007	49	5.2%

Source: Table 5.3.

MWI's water information system (WIS) database records water consumption/use for the large industrial enterprises. The nine largest companies account for about 86% (NWMP 2004) of total water usage by industry. Table 7.9 presents the available records of water consumption by the nine companies for a number of representative years. The figures for 2001 indicate that about 37% of consumption is in the governorate of Karak, followed by Ma'an 19%, Aqaba 12%, Zarqa 9% and Tafiela 8%.

Table 7.9: Jordan – Industrial Water Consumption/Use by Large Enterprises

Industry	Governorate	Quantity (m3 million)				Distribution (%)	
		1998	2001	2005	2007	2001	2007
1. Aqaba Thermal Power Station	Aqaba	0.9	0.7	n.a.	n.a.	2.2%	n.a.
2. Jordan Phosphate Mines (fertilizer)	Aqaba	3.6	3.2	n.a.	n.a.	10.1%	n.a.
3. Arab Potash Company	Karak	9.8	10.6	n.a.	n.a.	33.5%	n.a.
4. Phosphate Mines – Wadi Al-Abyad	Karak	3.2	1.1	n.a.	n.a.	3.5%	n.a.
5. Jordan Cement Company	Mafraq, Balqa & Ma'an	0.5	0.4	n.a.	n.a.	1.3%	n.a.
6. Jordan Phosphate Mines (Shediya)	Ma'an	6.6	6.0	n.a.	n.a.	19.0%	n.a.
7. Jordan Phosphate Mines (Hassa)	Tafiela	5.1	2.5	n.a.	n.a.	7.9%	n.a.
8. Jordan Petroleum Refinery Co.	Zarqa	2.0	2.3	n.a.	n.a.	7.3%	n.a.
9. Al Hussein Power Station	Zarqa	0.8	0.5	n.a.	n.a.	1.6%	n.a.
Total		37.5	31.6	n.a.	n.a.	100%	100%

Sources: (i) NWMP, May 2004; and (ii) WAJ.

7.3.3 Irrigation

Agriculture accounts for less than 3% of GDP (note: there has been a small increase in recent years: 2% in 2000; 2.5% in 2003; and 2.8% in 2007). The sector also accounts for 9% to 10% of exports (mainly vegetables) and employs about 11% of the national labour force. At the national level, the total cultivated area has ranged from 240,000 to 305,000 hectares in recent years, of which about 30% is irrigated (71,000 to 83,000 hectares) – Table 7.10 presents the figures.

Table 7.10: Jordan – Total Cultivated Area: Irrigated and Non-Irrigated

Year	Area (Dunums 000)			Area (hectares 000) (1)			Irrigated (%)
	Irrigated	Non-Irrig.	Total	Irrigated	Non-Irrig.	Total	
1999	787.5	2,267.0	3,054.5	78.8	226.7	305.5	26%
2000	769.1	1,584.9	2,354.1	76.9	158.5	235.4	33%
2001	734.5	1,829.9	2,564.4	73.4	183.0	256.4	29%
2002	749.3	1,856.6	2605.9	74.9	185.7	260.6	29%
2003	713.2	1,673.2	2,386.4	71.3	167.3	238.6	30%
2004	761.2	1,947.5	2,708.8	76.1	194.8	270.9	28%
2005	800.5	1,673.4	2,473.9	80.1	167.3	247.4	32%
2006	834.5	1,687.8	2,522.4	83.4	168.8	252.2	33%
2006 – areas by main crop type							
Fruit Trees	337.3	526.0	863.3	33.7	52.6	86.3	39%
Field Crops	88.6	1,147.3	1,235.9	8.9	114.7	123.6	7%
Vegetables	408.6	14.5	423.1	40.8	1.5	42.3	97%
Total	834.5	1,687.8	2,522.4	83.4	168.8	252.2	33%

Note: (1) 1 hectare = 10 dunums.
Source: DOS.

Table 7.11 illustrates the official estimates of water consumption by irrigated agriculture since 1985. The figures indicate that water usage over the last decade has ranged from 488 million m^3 in 2001 to

604 million m^3 in 2005, accounting for 62% to 65% of total water supplies. Usage levels have declined from the peak of 725 million m^3 in 1993, but in recent years there has been no discernible downward trend to indicate effective improvements in water use efficiency that Jordan's water-stressed environment demands.

Table 7.11: Jordan – Irrigation Water Consumption

Year	Quantity (m3 million)	% of Total Water Supplies
1985	497	78%
1990	652	75%
1995	596	68%
2000	534	65%
2001	488	63%
2002	511	64%
2004	540	62%
2005	604	64%
2006	588	64%
2007	589	63%

Source: Table 5.3.

The use of irrigation water in the Jordan Rift Valley (JRV) and the Uplands shows marked differences and trends, as indicated by the figures in Table 7.12:

- Jordan Rift Valley (JRV) – reported water use declined significantly from 294 million m^3 in 1996 to 194 million m^3 in 2002, largely due to persistent water shortages from 1998-2002 which resulted in reductions in the irrigated area. In addition, the decline was entirely confined to reduced surface water abstractions, while the use of groundwater and treated wastewater remained relatively stable.

- Uplands – water use ranged between 286 and 317 million m^3 per year. The distribution between surface, groundwater and treated wastewater sources remained more or less stable, with about 70% being extracted from renewable and non-renewable groundwater sources.

- Total – total water use declined from 598 million m^3 in 1996 to 511 million m^3 in 2002 (due to the drought in the JRV), before returning to the levels of the mid-1990s of 590 to 600 million m^3 per year. In terms of the figures for 2006, the important factors are: (i) surface water abstractions have returned to the mid-1990 levels at 263 million m^3 (45%); (ii) groundwater abstractions have remained high at 245 million m^3 (42%), which has resulted in continuing over-abstraction, declining groundwater levels and declining water quality in some aquifers; and (iii) treated wastewater, which has increased from 59 million m^3 (10%) in 1996, to 70 million m^3 (14%) in 2002 and 80 million m^3 (13%) in 2006.

Table 7.12: Jordan – Irrigation Water by Main Sources in JRV & Uplands (m^3 million)

Component	1996	2000	2001	2002	2003	2004	2005	2006	2007
Quantity									
JRV									
Surface	182	121	94	70					
Groundwater	60	54	47	64					
Treated WW	52	61	60	59					
Total – JRV	294	236	201	194					
Uplands									
Surface	67	89	87	87					
Groundwater	230	199	186	219					
Treated WW	7	11	13	11					
Total – JRV	304	298	286	317					
Total									
Surface	249	210	181	157				263	
Groundwater	290	253	233	283				245	
Treated WW	59	72	73	70				80	
Total	598	534	487	511		540	604	588	589
Distribution									
JRV									
Surface	62%	51%	47%	36%					
Groundwater	20%	23%	23%	33%					
Treated WW	18%	26%	30%	30%					
Total – JRV	100%	100%	100%	100%	100%	100%	100%	100%	100%
Uplands									
Surface	22%	30%	30%	27%					
Groundwater	76%	67%	65%	69%					
Treated WW	2%	3%	5%	4%					
Total – JRV	100%	100%	100%	100%	100%	100%	100%	100%	100%
Total									
Surface	42%	39%	37%	31%				45%	
Groundwater	48%	47%	48%	55%				42%	
Treated WW	10%	14%	15%	14%				13%	
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%

Sources: (i) MWI; and (ii) NWMP 2004.

7.3.4 Livestock

Livestock is a small water-consuming sector, but is nonetheless important in pastoral communities and the provision of meat and dairy products to the local market. DOS records livestock numbers on an annual basis for cattle, goats and sheep. The available figures are presented in Table 7.13. Total numbers have increased from nearly 2 million head in 2001 to 2.5 million in 2006, of which sheep account for 74%, goats 23% and cattle 3%.

Table 7.13: Jordan – Livestock Numbers by Type (000)

Year	Cattle	Goats	Sheep	Total
2001	65	426	1,458	1,949
2002	68	557	1,433	2,058
2003	66	548	1,476	2,090
2004	69	501	1,529	2,099
2005	68	516	1,890	2,474
2006	69	474	1,971	2,514
Annual Average	68	504	1,626	2,198
Distribution (%)	3%	23%	74%	100%

Source: Statistical Yearbook 2006, DOS.

Table 7.14 summarises livestock distribution by governorate in 2006. The project area had 961,000 head (38%), with a fairly even distribution between the four governorates. Mafraq supports the largest concentration of livestock with 963,000 (38%), followed by Balqa (10%) and Irbid (6%).

Table 7.14: Jordan – Livestock Numbers by Governorate 2006 (000)

Year	Cattle	Goats	Sheep	Total
Main Demand Area				
Amman	5	78	294	377
Zarqa	29	41	133	203
Madaba	1	34	108	143
Karak	…	87	151	238
Total – Project Area	35	240	686	961
Other Governorates				
Balqa	5	74	175	254
Irbid	17	39	103	159
Mafraq	10	61	892	963
Jarash	2	19	4	25
Ajlun	…	7	3	10
Tafiela		7	49	56
Ma'an		19	54	73
Aqaba		8	5	13
Total – Other Governorates	34	234	1,285	1,553
National Total	69	474	1,971	2,514

Source: Statistical Yearbook 2006, DOS.

Livestock rely heavily on local water sources (wells, canals, local water courses and other sources). Unit water requirements will vary by type, size, age, condition and sex of the animal, plus reasonable access to water sources in a water-stressed environment. Daily consumption requirements are likely to be in the following ranges: cattle 40 to 65 litres per day; and goats and sheep 5 to 15 litres.

MWI estimates indicate that the livestock sector consumes between 7 and 9 million m^3 per year, which represents less than 1% of total water supplies (see: Table 7.15).

Table 7.15: Jordan – Livestock Estimated Water Consumption

Year	Quantity (m3 million)	% of Total Water Supplies
1985	4	0.6%
1990	5	0.6%
1995	9	1.0%
2000	7	0.8%
2001	8	1.0%
2002	7	0.9%
2004	7	0.8%
2005	8	0.9%
2006	8	0.8%
2007	8	0.8%

Source: Table 5.3

8. INDICATIVE WATER DEMAND FORECASTS TO 2060

8.1 Introduction

This section presents indicative water demand forecasts to 2060, based on the framework and results of NWMP 2004 plus recent data and information provided by MWI, WAJ, JVA and JWC.

Water shortages are a critical issue in Jordan and effective resolution of the problem is a key factor affecting stable and sustained socio-economic development throughout the Kingdom. At present, Jordan has limited and finite water resources that are fully exploited and in the case of renewable groundwater over-exploited by an average of 154% (see: Section 9.3) – with the exception of: (i) Disi fossil water that will be pumped to the Greater Amman area from 2013 (100 million m^3 per year); (ii) increasing use of treated wastewater for irrigation, thereby releasing some freshwater sources; and (iii) desalinated water from the Red Sea. Against this background, Jordan's population is expected to increase by at least 35% in the next 10 years and to double in the next 30 years (see: Section 7.2). The country is also facing increased urbanization and plans for development in the industrial, tourism and service sectors in order to reduce unemployment and create new job opportunities. The situation is further complicated by the uncertain situation in the Middle East, which has placed considerable strains on the country's infrastructure public utility services, especially municipal water supplies.

In the water sector, the Government's declared priorities are: 1st potable water for human consumption; 2nd industry; and 3rd irrigated agriculture. In terms of policy and action, these priorities increase the pressure to: (i) reduce waste and conserve water (e.g. significant reductions in NRW); (ii) substantial improvements in water-use efficiency in the irrigation sector, including transition to higher value crops; (iii) sustained investment in wastewater treatment facilities for effluent re-use; (iv) more realistic pricing that reflects real costs and encourages the consumer/user to value water as a scarce resource; and (v) education through sustained public awareness and information campaigns. These factors imply that more attention should be given to Demand Management.

8.2 Municipal

Jordan continues to struggle in its efforts to satisfy municipal water demand (residential and non-residential). Average domestic consumption has remained low at 80 to 90 lcd for the last decade. The government has been striving to boost supplies, but the options are limited. In the short to medium term, the options are: (i) the Disi-Amman water conveyor should be commissioned in 2013 (100 million m^3 per year; (ii) continuing efforts to reduce the high level of NRW; and (iii) water transfer from irrigation through improvements in water-use efficiency and increasing use of treated wastewater. In the longer term, desalinated seawater or bulk transfer of fresh water from outside the immediate region are probably the only options that can satisfy continuing population growth and the Government's drive to raise living standards.

The population projections for Low, Medium and High scenarios are presented in Section 7.2. Similar indicators have been prepared for domestic per capita consumption in order to derive the demand projections for potable water. Table 8.1 presents the unit projection parameters, based on the following statements and initiatives:

- The Government is committed to the minimum target of 100 lcd for domestic water consumption (see: (i) Water for Life: Jordan's Water Strategy 2008-2022; and (ii) Jordan's Water Strategy & Policies 2008).

- Municipal water and wastewater tariffs will be set at levels that cover the cost of operation and maintenance as a minimum; and move towards recovery of all or part of the capital costs of water infrastructure. They will also be subject to regular adjustments that reflect the increasing marginal cost of water supply (ibid). This will be an important factor to promote water use efficiency in the home.

- Public awareness and education programmes will be developed and implemented to inform the population on the key issues facing the water sector, and the need to conserve water through modest investments in water efficient facilities and effective plumbing in the home.

By 2020, it is projected that average consumption will cover the following ranges:

- Low - 105 to 120 lcd
- Medium – 110 to 130 lcd
- High – 115 to 140 lcd

From 2020 to 2060, it is assumed that unit consumption will continue to grow: Low at 0.25% per year; Medium at 0.5% per year; and High at 0.75% per year.

Table 8.1: Jordan – Municipal: Forecast of Domestic Per Capita Consumption

Governorate	Per Capita Consumption (lcd)				Av. Growth Rate (% p.a.)	
	2007	2010	2015	2020	2020-40	2040-60
LOW						
Main Demand Area						
Amman	105	110	110	120	0.25%	0.25%
Zarqa	82	110	110	120	0.25%	0.25%
Madaba	86	100	100	105	0.25%	0.25%
Karak	94	100	100	105	0.25%	0.25%
Main Demand Area Average	**98**	**109**	**109**	**119**	**0.25%**	**0.25%**
Other Governorates	80	104	104	114	0.25%	0.25%
National Average	**91**	**107**	**107**	**117**	**0.25%**	**0.25%**
MEDIUM						
Main Demand Area						
Amman	105	120	120	130	0.5%	0.5%
Zarqa	82	120	120	130	0.5%	0.5%
Madaba	86	100	100	110	0.5%	0.5%
Karak	94	100	100	110	0.5%	0.5%
Main Demand Area Average	**98**	**118**	**118**	**128**	**0.5%**	**0.5%**
Other Governorates	80	107	107	117	0.5%	0.5%
National Average	**91**	**113**	**114**	**124**	**0.5%**	**0.5%**
HIGH						
Main Demand Area						
Amman	105	125	130	140	0.75%	0.75%
Zarqa	82	125	130	140	0.75%	0.75%
Madaba	86	100	100	115	0.75%	0.75%
Karak	94	100	100	115	0.75%	0.75%
Main Demand Area Average	**98**	**122**	**127**	**137**	**0.75%**	**0.75%**
Other Governorates	80	111	111	123	0.75%	0.75%
National Average	**91**	**118**	**121**	**132**	**0.75%**	**0.75%**

Sources: (i) Appendix B, Table 11; and (ii) Study estimates.

The gross municipal demand projections are also crucially affected by the assumptions about future NRW levels and physical losses in the public water distribution systems. The Government, MWI, WAJ and JWC have been making continuing efforts to reduce the losses with the assistance of international donors. Historical figures indicate that high NRW levels are a continuing problem (see: Table 7.5). Nevertheless, it must be assumed that the authorities will be successful in their drive to address and reduce the problem. Indeed, the Government has made a policy commitment that average NRW will be reduced to 25% by 2022 (see: Water for Life: Jordan's Water Strategy 2008 – 2022). Therefore, this commitment has been incorporated into the projections in order to derive the gross municipal demand. It is further assumed that NRW will be further reduced to 20% by 2040. It should be noted that the NWMP 2004 optimistically assumed that NRW would be reduced to 15% by 2020.

Table 8.2 summarises the gross municipal water demand projections from 2010 to 2060 (note: includes residential and non-residential demand):

- Low – total national demand is projected to more than double over the projection period from 376 million m3 in 2010 to 512 million m^3 in 2020 and 857 million m^3 by 2060. In the project area, the increase would be 270% from 229 million m^3 in 2010 to 321 million in 2020 and 619 million m^3

by 2060. Amman will be the major demand centre, increasing by 350% from 143 million m^3 in 2010 (38% of national total) to 224 million m^3 in 2020 (44%) and 499 million m^3 by 2060 (58%).

- Medium – total national demand is projected to nearly triple from 401 million m^3 in 2010 to 561 million m^3 in 2020 and 1,156 million m^3 by 2060. In the project area, the increase would be 350% from 250 million m^3 in 2010 to 362 million in 2020 and 869 million m^3 by 2060. Amman would increase by 450% from 158 million m^3 in 2010 (39%) to 258 million m^3 in 2020 (46%) and 720 million m^3 by 2060 (62%).

- High – total national demand is projected to increase four-fold from 420 million m^3 in 2010 to 622 million m^3 in 2020 and 1,651 million m^3 by 2060. In the project area, the increase would be nearly five-fold from 263 million m^3 in 2010 to 408 million in 2020 and 1,293 million m^3 by 2060. Amman would increase more than six-fold from 158 million m^3 in 2010 (40%) to 296 million m^3 in 2020 (48%) and 1,108 million m^3 by 2060 (67%).

Table 8.2: Jordan – Gross Municipal Water Demand Projections 2010 – 2060 (m^3 million)

Governorate	Estimate 2007	Forecasts					
		2010	2020	2030	2040	2050	2060
LOW							
Main Demand Area							
Amman	125	143	224	309	362	430	499
Zarqa	45	63	70	76	76	82	86
Madaba	7	8	11	12	12	13	13
Karak	13	15	17	18	18	20	21
Total – Main Demand Area	189	229	321	414	468	544	619
Other Governorates	112	146	191	208	211	226	238
National Total	301	376	512	622	679	770	857
MEDIUM							
Main Demand Area							
Amman	125	158	258	365	460	590	720
Zarqa	45	69	76	87	91	101	109
Madaba	7	8	11	12	13	14	16
Karak	13	15	17	19	20	22	24
Total – Main Demand Area	189	250	362	483	585	727	869
Other Governorates	112	151	199	227	239	265	288
National Total	301	401	561	711	824	992	1,156
HIGH							
Main Demand Area							
Amman	125	167	296	450	611	843	1,108
Zarqa	45	72	84	100	109	124	139
Madaba	7	8	11	13	14	16	18
Karak	13	15	17	21	22	26	29
Total – Main Demand Area	189	263	408	584	757	1,010	1,293
Other Governorates	112	158	214	255	280	320	358
National Total	301	420	622	839	1,037	1,330	1,651

Source: Appendix B, Tables 12 to 14.

8.3 Industry

Jordan's large industrial enterprises are mainly in mining, quarrying and manufacturing, related to the production and export of phosphate rock, potash, fertilizer, cement, petroleum products and power generation. The large companies account for about 86% of water usage by industry, with reported consumption of 49 million m^3 in 2007. For the future, industrial development is one of the government's pillars to promote economic growth and sustained expansion of employment opportunities.

In preparing the NWMP 2004, MWI issued an industrial water demand questionnaire to all of Jordan's main industrial enterprises. The results of the questionnaire formed the basis for the NWMP projections. All companies provided details of the plans and expectations for the period from 2005 to

2020. NWMP also reported the further expansion of production by Jordan Bromine Company and Jordan Magnesia Company. Reference should also be made to the following plans and initiatives in the industrial sector: (i) Aqaba Special Economic Zone (ASEZ) – continuing development of industrial outlets; (ii) Lajoun oil shale mining project in Karak Governorate (note: it is reported that the National Resources Authority is negotiating a concession contract with Shell); (iii) Cyber City Industrial Park in Irbid; and (v) others. For example, the ASEZ Master Plan (2001) predicted that industrial water demand would reach 17.9 million m^3 by 2020; and the Lajoun oil shale project is expected to need 20 to 40 million m^3 per year.

Table 8.3 presents the indicative industrial demand projections from 2010 to 2060:

- 2010 to 2020 – reflect the demand projections prepared by NWMP 2004.
- 2020 to 2060 – industrial demand is conservatively predicted to increase at 2% per year from 2020 to 2040, and 1% per year thereafter.

Table 8.3: Jordan – Industrial Water Demand Forecasts: Large Enterprises 2010 -2060 (m^3 million)

Governorate	Estimate 2007	Forecasts					
		2010	2020	2030	2040	2050	2060
Main Demand Area							
Amman	1.0	1.5	2.3	2.8	3.5	3.8	4.2
Zarqa	6.5	10.2	13.0	15.8	19.3	21.3	23.6
Madaba	0.2	0.3	0.5	0.6	0.7	0.8	0.8
Karak	18.5	29.0	56.0	68.3	83.3	92.0	101.6
Total – Main Demand Area	26.1	41.0	71.8	87.6	106.7	117.9	130.2
Other Governorates	23.1	36.4	48.1	58.6	71.5	79.0	87.2
National Total	49.2	77.4	119.9	146.2	178.2	196.9	217.5

Sources: (i) NWMP 2004; and (ii) Appendix B, Table 15.

8.4 Irrigation

The National Strategy for Agricultural Development 2002 – 2010 sets out the Government's development objectives and future outlook for the agricultural sector, which remains an integral part of the national economy and an important source of employment and income in rural areas. Nevertheless, the document recognises the pressure on the agricultural sector in two specific areas: (i) continuing decrease in arable farmland due to the encroachment of urban development and population growth; and (ii) increasing pressure on available water resources for irrigation. Indeed, the document makes the following statements on the water issue:

"Maintaining the current rates of groundwater extraction, which exceed double the safe yield, will result in an accelerated drop in water table levels of groundwater basins, increased cost of pumping, and increasing water salinity (to the point that it may not be suitable for domestic use or unrestricted agricultural use). Continuing extraction at this level will ultimately cause groundwater depletion, loss of investment made in the irrigated agriculture in the highlands, and of other related agribusinesses."

"Increasing the quantities of fresh water pumped from the King Abdullah Canal for municipal and industrial use outside the JV area and replacing it with treated wastewater of high salinity, will lead to increased soil salinity, deterioration of soil productivity and quality of produce, and a decreasing consumer confidence in Jordanian products."

"The increased ratio of treated wastewater in irrigation water will lead to limiting its use to restricted agriculture. This will result in loosing an important agricultural area in the JV, important for its productive capacity and comparative advantage in the regional and international markets and of investment already made or planned these areas especially for enhancing agricultural exports."

More recent policy statements clearly indicate the Government's aim to improve efficiency in the irrigation sector.

For example:

- "*Vision for Irrigation Water by 2022:*

    1. *Efficient on-farm distribution systems are in place.*
    2. *Recovery of operation and maintenance cost of irrigation water is achieved.*
    3. *All treated wastewater effluent is used for irrigation.*
    4. *Annual water demand for irrigation water is reduced from 68% today to 58% of the total water demand by 2022 and to 50% of the water supply.*
    5. *Retail irrigation water is handled by farmers association."*

Source: Water For Life – Jordan's Water Strategy 2008-2022

- *Irrigation Water Policy:*

    "Existing areas of irrigated agriculture shall be accorded the chances for sustainability. No diversion of its waters to other uses shall be allowed without providing a replacement source fit for agricultural use unrestricted by health and public health considerations."

    "Sustainability of agriculture shall be compromised only if it threatened the sustainability of use of ground water resources. Potential pollution of underlying aquifers or the depletion thereof are among the reasons that can prompt such compromise".

    "Close co-ordination with the Ministry of Agriculture and other related institutions with the aim of enhancing on-farm irrigation efficiency and maximising the agricultural output of a unit of land area per unit flow of irrigation water."

Source: Jordan's Water Strategy & Policies 2008

In preparing the forecasts for irrigation water requirements, the NWMP 2004 carried out a detailed investigation of the net irrigation water requirements for irrigation centres identified by the Ministry of Agriculture. The modelling took account of: (i) rainfall and climatic data; (ii) hydrological conditions; (iii) crops, cropping patterns and calendars by zone; (iv) alternative cultivation and water application methods; and (v) use of a GIS-based digital model. The model calculates historical demands for a reference year and demands for future scenarios based on the assessment of six (6) key input parameters:

1. Changes in irrigated areas with respect to the reference year
2. Changes in cropping patterns
3. Changes in distribution of irrigation methods
4. Projected gains in distribution and application efficiency
5. Projected irrigation water salinity class
6. Climatic conditions

The relevant values for each of these parameters are set out in NWMP – Volume 3 Water Uses and Demands (Section 2.6.4 in that report). It should be noted that the NWMP consultants make the important assumption that all irrigable areas in the JRV and Uplands will be fully developed between 2010 and 2020.

The RSDS Project does not have the resources to update the NWMP's irrigation calculations. Therefore, the Master Plan estimates have been adopted as a reasonable projection of future gross irrigation requirements in an unstressed water environment. Table 8.4 illustrates the indicative forecasts. The following factors should be noted:

- 2007 figures – indicative estimate of reported irrigation water use by governorate.
- 2010 and 2020 – NWMP forecasts based on the inputs, efficiency assumptions and modelling computations developed by the GTZ consultants.
- 2030 to 2060 – assumes that water-use efficiency in the irrigation sector will continue to improve in the same ratio as predicted by the NWMP consultants between 2010 and 2020.

In the Main Demand Area, the gross irrigation water requirements are predicted to fall from 279 million m^3 in 2010 to 264 million m^3 by 2020, followed by 236 million m^3 by 2030 and

212 million m^3 by 2060. At the national level, the NWMP model predicts gross requirements at about 1,000 million m3 per year in the period from 2010 to 2020, followed by further efficiency improvements to 827 million m^3 by 2040 and 703 million m^3 by 2060.

Table 8.4: Jordan – Gross Irrigation Water Requirements 2010 - 2060 (m^3 million)

Governorate	Estimate 2007	Forecasts - Gross Requirements in Unstressed Water Environment					
		2010	2020	2030	2040	2050	2060
Main Demand Area							
Amman	40	74	72	70	69	67	66
Zarqa	71	130	122	115	107	101	95
Madaba	3	6	6	5	5	5	5
Karak	38	69	64	59	55	51	47
Total – Main Demand Area	152	279	264	249	236	224	212
Other Governorates	437	797	719	651	591	538	491
National Total	589	1,076	983	900	827	762	703

Sources: (i) NWMP 2004; and (ii) Appendix B, Table 16.

8.5 Livestock

Livestock is an important part of rural life in Jordan, and a key source of meat and dairy products. The water demand projections presented in Table 8.5 are based on the following assumptions:

- Livestock numbers will increase in line with the medium population forecast (see: Table 7.2). This assumes adequate pasture and fodder crops will be available in the future.
- In the past, livestock has been constrained by lack of water and access to local water sources. With future improvements in irrigation efficiency and increased availability of treated wastewater, this should allow livestock numbers to increase.
- Unit water consumption per head is assumed to increase to 65 litres per head/day for cattle and 15 litres per head/day for goats and sheep.

The projections indicate livestock water demand doubling over the projection period from 15 million m^3 in 2010 to nearly 19 million m^3 in 2020 and 34 million m^3 by 2060.

Table 8.5: Jordan – Livestock: Indicative Water Demand Forecasts 2010 - 2060 (m^3 million)

Governorate	Estimate 2006	Forecasts					
		2010	2020	2030	2040	2050	2060
Main Demand Area							
Amman	1.1	2.2	2.7	3.2	3.8	4.4	4.8
Zarqa	1.0	1.6	2.0	2.4	2.9	3.3	3.6
Madaba	0.4	0.8	1.0	1.2	1.4	1.6	1.8
Karak	0.7	1.3	1.6	2.0	2.3	2.6	2.9
Total – Main Demand Area	3.2	5.9	7.4	8.8	10.4	11.9	13.2
Other Governorates	4.8	9.1	11.4	13.7	16.1	18.4	20.4
National Total	8.0	15.0	18.8	22.6	26.5	30.3	33.6

Sources: (i) Appendix B, Table 17; and (ii) Study estimates.

8.6 Total Demand Projections

The gross water demand projections for the municipal, industrial, irrigation and livestock sectors are summarised in Table 8.6 by governorate and Table 8.7 by sector:

- Low – total national demand is projected to double over the projection period from 947 million m^3 in the present water-stressed conditions of 2007 to 1,633 million m^3 in 2020 and 1,812 million m^3 by 2060. In the project area, demand is projected to increase by 260% from 371 million m^3 in 2007 to 664 million m^3 in 2020 and 975 million m^3 by 2060. Amman's share of total demand is projected to increase from 18% (167 million m^3) in 2007 to 19% (301 million m^3) in 2020 and 32% (574 million m^3) by 2060.

- Medium – total national demand is forecast to increase by 220% from 947 million m^3 in 2007 to 1,683 million m^3 in 2020 and 2,111 million m^3 by 2060. In the project area, demand is projected to increase by 330% from 371 million m^3 in 2007 to 705 million m^3 in 2020 and 1,224 million m^3 by 2060. Amman's projected share would be 20% (335 million m3) in 2020 rising to 38% (794 million m^3) by 2060.

- High – total national demand is forecast to increase by 275% from 947 million m^3 in 2007 to 1,744 million m^3 in 2020 and 2,605 million m^3 by 2060. In the project area, demand is projected to increase by 440% from 371 million m^3 in 2007 to 751 million m^3 in 2020 and 1,649 million m^3 by 2060. Amman's projected share would be 21% (373 million m^3) in 2020 rising to 45% (1,182 million m^3) by 2060.

Table 8.6: Jordan – Total: Indicative Water Demand Forecasts by Governorate 2010 - 2060 (m^3 million)

Governorate	Estimate 2007	Forecasts					
		2010	2020	2030	2040	2050	2060
LOW							
Main Demand Area							
Amman	167	221	301	385	438	506	574
Zarqa	123	205	207	209	206	207	208
Madaba	11	15	18	19	19	20	21
Karak	70	114	138	148	159	165	172
Total – Main Demand Area	371	555	664	760	821	898	975
Other Governorates	576	989	970	932	890	861	837
National Total	947	1,543	1,633	1,692	1,711	1,759	1,812
MEDIUM							
Main Demand Area							
Amman	167	236	335	441	536	665	794
Zarqa	123	211	213	220	221	226	231
Madaba	11	15	18	19	20	22	23
Karak	70	114	138	149	161	168	176
Total – Main Demand Area	371	576	705	829	938	1,081	1,224
Other Governorates	576	993	978	951	918	900	887
National Total	947	1,569	1,683	1,780	1,856	1,981	2,111
HIGH							
Main Demand Area							
Amman	167	245	373	527	687	919	1,182
Zarqa	123	214	221	233	239	250	261
Madaba	11	15	18	20	21	24	26
Karak	70	114	139	150	163	171	180
Total – Main Demand Area	371	588	751	929	1,110	1,363	1,649
Other Governorates	576	1,000	993	979	959	956	957
National Total	947	1,588	1,744	1,908	2,069	2,319	2,605

Source: Appendix B, Table 18.

Table 8.7 summarises the water demand forecasts by sector for the Medium Projection. The figures clearly illustrate the increasing importance of the municipal sector and the decline in the irrigation sector as its water-use efficiency steadily improves. Thus, the municipal sector's share increases

from 32% in 2007 to 40% by 2030 and 55% by 2060; whereas irrigation's share falls from 62% in 2007 to 51% in 2030 and 33% by 2060. In the Main Demand Area, the dominance of the municipal sector is even more marked because of the presence of Amman and its increasing population.

Table 8.7: Jordan – Total: Medium Water Demand Forecasts by Sector 2010 - 2060 (m^3 million)

Sector	Est. 2007	Forecasts					
		2010	2020	2030	2040	2050	2060
Quantity (m3 million)							
Main Demand Area							
Municipal	189	250	362	483	585	727	869
Industry	26	41	72	88	107	118	130
Irrigation	153	279	264	249	236	224	212
Livestock	3	6	7	9	10	12	13
Total – Main Demand Area	371	576	705	829	938	1,081	1,224
Other Governorates							
Municipal	112	151	199	227	239	265	288
Industry	23	36	48	59	71	79	87
Irrigation	436	797	719	651	591	538	491
Livestock	5	9	11	14	16	18	20
Total: Other Governorates	576	993	978	951	918	900	887
National Total							
Municipal	301	401	561	711	824	992	1,156
Industry	49	77	120	146	178	197	217
Irrigation	589	1,076	983	901	827	762	703
Livestock	8	15	19	23	27	30	34
National Total	947	1,569	1,683	1,780	1,856	1,981	2,111
Distribution (%)							
Main Demand Area							
Municipal	51%	43%	51%	58%	62%	67%	71%
Industry	7%	7%	10%	11%	11%	11%	11%
Irrigation	41%	48%	37%	30%	25%	21%	17%
Livestock	1%	1%	1%	1%	1%	1%	1%
Total – Main Demand Area	100%	100%	100%	100%	100%	100%	100%
Other Governorates							
Municipal	19%	15%	20%	24%	26%	29%	32%
Industry	4%	4%	5%	6%	8%	9%	10%
Irrigation	76%	80%	74%	68%	64%	60%	55%
Livestock	1%	1%	1%	1%	2%	2%	2%
Total: Other Governorates	100%	100%	100%	100%	100%	100%	100%
National Total							
Municipal	32%	26%	33%	40%	44%	50%	55%
Industry	5%	5%	7%	8%	10%	10%	10%
Irrigation	62%	69%	58%	51%	45%	38%	33%
Livestock	1%	1%	1%	1%	1%	2%	2%
National Total	100%	100%	100%	100%	100%	100%	100%

Source: Appendix B, Tables 20 and 21.

9. WATER RESOURCES

9.1 Introduction

Water scarcity is Jordan's most important natural constraint. Rapid population growth and lack of water-use efficiency in the irrigation sector have placed unprecedented demands on the Kingdom's water resources. Total demand is about 1 billion m^3 per year, which is approximately equal to Jordan's renewable and economically developable water resources. Current water demands are not being met satisfactorily throughout the country (both spatially and temporally), and the costs of developing new water sources are rising rapidly. Hence, the pressure to improve efficiency, conserve water and develop expensive alternative sources (i.e. RSDS Project) so as not to inhibit long-term socio-economic development and improvements in the living standards of Jordanians.

This section provides a brief overview of the latest available information on water resources, against the background of the NWMP 2004. The sub-sections cover: (i) surface water; (ii) groundwater; and (iii) treated wastewater.

Table 9.1 summarises Jordan's water resource use by main source and consumption sector for 2004 and 2007. The figures illustrate the following factors:

- Main sources – groundwater continues to be the main water source, accounting for 53% of total supplies in 2007, despite the fact that there is significant over-pumping of all the main aquifers (see: Section 9.3); followed by surface water with 37% and treated wastewater with 10%. The general distribution between the main sources of supply has remained more or less stable in recent years. It is noticeable that treated wastewater is still only a modest source of supply (see: Section 9.4).

- Consumption sectors – the figures highlight the discussion in Section 8, namely: (i) the dominance of irrigated agriculture in abstractions from both surface and groundwater sources; and (ii) the importance of groundwater supplies in satisfying municipal demands, with surface water less important.

Table 9.1: Jordan – Water Resource Use by Main Source and Consumption Sector in 2004 and 2007

Source	Municipal	Industry	Irrigation	Livestock	Total
Quantity (million m3)					
2007					
Surface Water	80	4	254	7	345
Groundwater	214	45	245	1	504
Treated Wastewater			91		91
Total	294	49	590	8	940
2004					
Surface Water	66	4	203	6	279
Groundwater	215	34	251	1	501
Treated Wastewater			86		86
Total	281	38	541	7	866
Distribution (%)					
2007					
Surface Water	9%	…	27%	1%	37%
Groundwater	23%	5%	26%	…	53%
Treated Wastewater			10%		10%
Total	31%	5%	63%	1%	100%
2004					
Surface Water	8%	…	23%	1%	32%
Groundwater	25%	4%	29%	…	58%
Treated Wastewater			10%		10%
Total	33%	4%	62%	1%	100%

Source: Appendix B, Table 22.

9.2 Surface Water

Jordan is divided into 15 surface water catchments. The Dead Sea drainage area (consisting of nine basins) in the north-west and the eastern bank of the Dead Sea account for 90% of available surface water. Most of the rivers and wadis are perennial, although some smaller wadis lose their base flow because of over-exploitation of local aquifers.

Data on surface water by main sources and consumption sector are summarised in Table 9.2 for 2004 and 2007. Extractions increased from 279 million m^3 in 2004 to 345 million m^3 in 2007 following the completion of the Al Wehda Dam on the Yarmook River in 2005, and a modest increase in water volumes from springs. Renewable water (i.e. from dams, reservoirs, etc.) accounts for more than 64% of the reported volume, followed by springs with about 20% and about 16% from floods and other discharges. In terms of usage, irrigated agriculture uses 74% of the reported volume and municipal 23%.

Table 9.2: Jordan – Surface Water Use by Main Source & Consumption Sector in 2004 and 2007

Source	Municipal	Industry	Irrigation	Livestock	Total
Quantity (million m^3)					
2007					
Renewable Water	41	4	176		221
Springs	39	1	37		77
Floods & Other Discharges			41	7	48
Total	80	4	254	7	345
2004					
Renewable Water	49	3	125		178
Springs	17	…	37		54
Floods & Other Discharges			40	6	46
Total	66	4	203	6	279
Distribution (%)					
2007					
Renewable Water	12%	1%	51%		64%
Springs	11%	…	11%		22%
Floods & Other Discharges			12%	2%	14%
Total	23%	1%	74%	…	100%
2004					
Renewable Water	18%	1%	45%		64%
Springs	6%	…	13%		19%
Floods & Other Discharges			15%	2%	17%
Total	24%	1%	73%	2%	100%

Source: Appendix B, Table 22.

For the future availability of Jordan's surface water resources, the NWMP 2004 carried out detailed calculations based on: (i) rainfall statistics and run-off estimates; (ii) baseflows leaking from groundwater sources; (iii) discharges from wastewater treatment plants; and (iv) construction and completion of reservoirs and dams. The results are summarised in Table 9.3. The NWMP report emphasised that: *"great care was taken that neither any baseflow nor any wastewater released from the treatment plants had been double-counted."* The projections indicate that total surface water resources could reach 569 million m^3 in 2010 and 598 million m^3 by 2020. The latter is 73% higher than the reported extractions in 2007.

The calculations in the NWMP (Volume 4 – Surface Water Resources) include treated wastewater discharges, which mask estimates of future surface freshwater sources. Therefore, until the issue has been resolved, it has been assumed that future average surface water resources will be between 350 and 400 million m^3 per year. This average reflects the availability in recent years and allows for annual variations in yields from springs, floods and other discharges.

Table 9.3: Jordan – NWMP Projections of Surface Water Availability 2005 to 2020

Source	2005	2010	2015	2020
Base inflow into reservoirs (contributing to safe yield)	48	63	63	75
Baseflow use upstream from gauging stations	55	55	55	55
Baseflow observed downstream from reservoirs	48	48	48	48
Base flow in wadis without reservoirs	54	39	39	27
Total baseflow excluding reservoir inflow	157	142	142	130
Reservoir safe yield (considering flood flow, base flow and wastewater) 50% reliability	225	260	274	301
Yarmook water diversion to King Abdullah Canal	166	167	167	167
Total Surface Water Resource	**548**	**569**	**583**	**598**
Total wastewater not flowing into reservoirs	34	70	89	101

Source: NWMP 2004, Volume 4 – Surface Water Resources.

9.3 Groundwater

Groundwater is the major water source in Jordan. There are 12 identified groundwater basins that contain several aquifer systems. Current official estimates state that total annual renewable recharge to the aquifers is approximately 275 million m^3 per year. However, most renewable groundwater sources have been over-pumped for many years, with abstractions ranging from 126% to 276% above the safe yield estimates (see: Table 9.5). In the short to medium term, over-exploitation will contribute significantly to the degradation of groundwater quality and seriously endanger resource sustainability for future use.

Table 9.4 illustrates reported groundwater use by main source and consumption sector in 2004 and 2007. The figures indicate sustained abstraction of about 500 million m3 per year. Irrigated agriculture accounts for 49% of total abstractions, followed by municipal with 42%, and industry 9%. In addition, 83% of abstractions are from renewable groundwater sources and 15% from non-renewable sources (i.e. fossil water from the Disi aquifer). From these figures, it is reasonable to conclude that concerted action is needed to reduce abstractions to self-sustaining levels by: (i) phased reduction in irrigation abstractions and substitution with treated wastewater as far as possible (see: Section 9.4); (ii) sustained improvements in water-use efficiency in irrigation; and (iii) construction of alternative water sources (i.e. RSDS Project) to relieve the pressure on groundwater sources.

Table 9.4: Jordan – Groundwater Use by Main Source and Consumption Sector in 2004 and 2007

Source	Municipal	Industry	Irrigation	Livestock	Total
Quantity (million m^3)					
2007					
Renewable Water	186	30	203	1	419
Non-Renewable Water	17	15	42		74
Brackish/Saline	11				11
Total	214	45	245	1	504
2004					
Renewable Water	192	29	199	1	422
Non-Renewable Water	22	5	52		79
Brackish/Saline					
Total	215	34	251	1	501
Distribution (%)					
2007					
Renewable Water	37%	6%	40%	…	83%
Non-Renewable Water	3%	3%	8%		15%
Brackish/Saline	2%				2%
Total	42%	9%	49%	…	100%
2004					
Renewable Water	38%	6%	40%	…	84%
Non-Renewable Water	5%	1%	10%		16%
Brackish/Saline					
Total	43%	7%	50%	…	100%

Source: Appendix B, Table 22.

Groundwater abstractions by basin are illustrated in Table 9.5 for 2007. For renewable groundwater sources, abstractions exceeded the safe yield estimates by an average of 154%, ranging from 128% in the Yarmook Basin to 276% in the Azraq Basin. The other striking feature is the level of over-abstraction in the north west of Jordan where most of the population and irrigated agriculture are located. In terms of non-renewable groundwater, the Disi-Madawarra Basin is the main source in the south of the country bordering Saudi Arabia. At present, the Disi aquifer (fossil water i.e. it is being mined) is only partially exploited. It is expected that the aquifer will be fully exploited when the Disi-Amman Conveyor is completed in 2013 for the transfer of 100 million m^3 per year.

For the future, the figures in Table 9.5 clearly imply the following:

- Renewable groundwater sources – abstractions will need to be reduced by at least 150 million m^3 per year (from 423 million m^3 to 275 million m3 per year) if these aquifers are to be sustainable sources of good quality water in the medium to long term. This applies especially to the aquifers in the north west of Jordan.

- Non-renewable groundwater sources – Disi-Madawarra Basin and part of the Jafar Basin will be exploited to their full safe yields within the next five years. The expected life of these aquifers is 50 years (NWMP 2004).

- Total safe annual yield – according to MWI's estimates, the safe annual yield from groundwater sources is 418.5 million m^3 per year, of which 275.5 million m^3 per year (66%) are from renewable sources and 143 million m^3 (34%) from non-renewable sources.

The NWMP 2004 also states that opportunities exist for the exploitation of non-renewable brackish groundwater up to a potential capacity of 80 million m^3 per year. However, the NWMP does not state where these resources are or whether they can be exploited economically.

Table 9.5: Jordan – Groundwater Abstractions by Basin and Safe Yields 2007

Basin	R. or Non-R. (1)	Safe Yield (m3 million)	Quantity Abstracted (m^3 million)					% of Safe Yield
			Private + Gov't	Industry	Irrigation	Other	Total	
Main Demand Area								
Amman-Zarqa	R	87.5	80.1	6.9	62.9		149.8	171%
Azraq	R	24.0	23.3	8.6	33.9	0.2	66.1	276%
Dead Sea	R	57.0	40.0	12.3	38.1	0.2	80.5	141%
Total – Main Demand Area		168.5	143.4	27.8	124.9	0.4	296.5	176%
Other Basins								
Yarmook	R	40.0	9.3	0.2	41.0		50.4	128%
Side Wadis	R	15.0	25.8		1.4		27.2	181%
Jordan Valley	R	21.0	8.8	0.4	18.2		27.5	131%
Wadi Arabia – North	R	3.5	0.4	0.9	3.4	0.1	4.8	138%
RS/Wadi Arabia–S	R	5.5	1.3	0.3	6.1		7.7	139%
Disi-Madawarra	Non-R	125.0	16.4	8.3	41.5		66.3	53%
Jafar	R	9.0	2.6	2.3	2.4		7.4	82%
	Non-R	18.0	5.3	4.7	4.8		14.8	82%
Sarhan	R	5.0			1.0	0.1	1.1	23%
Hammad	R	8.0	0.6			0.2	0.7	9%
Total – Other Basins		250.0	70.6	17.1	119.9	0.4	208.0	83%
National Total		**418.5**	**214.0**	**44.9**	**244.8**	**0.7**	**504.4**	**121%**
Renewable	**R**	**275.5**	**192.2**	**31.9**	**198.4**	**0.7**	**423.3**	**154%**
Non-Renewable	**Non-R**	**143.0**	**21.8**	**13.0**	**46.4**		**81.1**	**57%**

Notes: (1) Renewable or Non-Renewable.
Source: Appendix B, Table 24.

For the future, all water agencies in Jordan agree that groundwater abstractions must be reduced to the "safe yield" levels for all renewable sources. Unfortunately, this challenge will continue to confront the authorities until there are significant advances in water-use efficiency, reductions in water losses, sustained exploitation of treated wastewater and the introduction of a major new supply source. The NWMP 2004 proposed a strategy to reduce groundwater abstraction by 2020.

The main components were:

- Phased reduction in abstractions from the main groundwater sources (basins: Amman-Zarqa, Azraq, Dead Sea and Yarmook) in order to reach the safe yield level of 275 million m3 by 2020.

- Large and sustained increase in the availability of treated wastewater for irrigation, especially for the Jordan Valley. On the other hand, Uplands irrigation with groundwater would have to be significantly lowered, which probably implies a cut-back in the irrigated area.

It is evident from the data in Table 9.5 that this proposed strategy is not being implemented.

9.4 Treated Wastewater

The growth of water demand in Jordan has led to the full utilisation of surface water and the over-extraction of groundwater – as outlined in Sections 9.2 and 9.3. By overdrawing groundwater resources, Jordan has and is creating serious negative environmental impacts, increasing water costs, lowering water quality and compromising future socio-economic development. Therefore, the country has been developing non-conventional water resources e.g. treated wastewater and desalinated water.

This section reviews the potential for future development of treated wastewater, which will be particularly important in providing a viable water substitute for irrigated agriculture. Indeed, recent policy statements make it clear that the government intends to pursue this strategy:

Water for Life – Jordan's Water Strategy 2008 – 2022:

1. *Adequate wastewater collection and treatment facilities for all major cities and town in Jordan.*
2. *The environment and public health in the areas affected by the proposed systems, especially, surface waters and ground waters are protected.*
3. *Wastewater treated effluent a source of irrigation*
4. *All industries have wastewater treatment plants.*
5. *Grey water is used.*

In 2007, Jordan had 24 wastewater treatment plants (WWTP) located in or near most urban centres throughout the country. The treatment processes range from waste stabilisation ponds (WSP) to trickling filters (TF), extended aeration (EA) and activated sludge (AS). The total design capacity of the plants is 184,000 m^3 per day, of which the As Samra WWTP serving Greater Amman accounts for 37% (68,000 m^3/day capacity). The available details for each plant, including the influent and effluent discharges from 2004 to 2007, are presented in Appendix B, Table 25. The figures indicate that 13 of the plants are under-utilized (31% to 78% capacity utilisation in 2007). However, seven (7) of the plants are overloaded with utilisation ranging from 111% to 250% of design capacity, which would imply that the plants are not achieving their design treatment standards and/or the excess is being diverted into by-pass channels without receiving any treatment. This is most evident in the figures relating to the As Samra WWTP, which exceeded its design capacity by more than 300% in the three years from 2004 to 2006 (see: Appendix B, Table 25).

Table 9.6 summarises the wastewater volumes of the last four years in terms of the influent and the effluent. The influent volume has ranged between 122 and 134 million m^3; while the effluent discharges have ranged between 94 and 107 million m^3. These figures imply average losses due to seepage and evaporation of 23%, which is high by international standards but is probably explained by the fact that a large percentage (70%) of the treatment capacity is in waste stabilisation ponds and maturation ponds, and that 20 million m^3 per year are reused at the As Samra WWTP prior to its discharge into the Wadi Dhuleil and thence to the Zarqa River and the King Talal Reservoir. The NWMP 2004 raises some concerns about the general quality of the treated effluent from the As Samra WWTP and the potential impact on sensitive annual and tree crops – in terms of high concentrations of total nitrogen, chloride, sodium and in some cases high faecal coliform. The NWMP also estimates 8% losses in the transmission and storage of treated wastewater.

Table 9.6: Jordan – Municipal Treated Wastewater Volumes 2004 to 2007 (m^3 million)

Year	Main Demand Area	Other Governorates	National Total
Wastewater Influent			
2004	100.5	21.3	121.8
2005	105.2	22.1	127.4
2006	106.1	24.8	130.9
2007	107.7	26.1	133.8
Treated Effluent			
2004	74.7	19.4	94.2
2005	78.5	20.5	99.0
2006	82.7	24.0	106.8
2007	73.9	24.0	97.9

Source: Appendix B, Table 25.

MWI's reported use of treated wastewater by irrigation is presented in Table 9.7. The figures are between 8 and 27 million m^3 lower than the recorded effluent discharges in Table 9.6, which implies that not all wastewater discharges are used in the irrigation sector.

Table 9.7: Jordan – Treated Wastewater Use by Irrigation 2004 to 2007

Year	Quantity (m^3 million)	% of Total Irrigation Use	% of Total Water Resource Use
2004	86	16%	10%
2005	84	14%	9%
2006	80	14%	9%
2007	91	15%	10%

Source: Appendix B, Table 22.

Based on the available information at this stage in the study, indicative treated wastewater projections were prepared on the following assumptions:

- Jordan will continue to invest in the construction, expansion and upgrading of existing and new wastewater treatment plants as outlined in the Government's recent policy statement (see: Water for Life – Jordan's Water Strategy 2008 – 2022). This policy has three primary aims: (i) reclaim treated wastewater for reuse by irrigated agriculture, industry and landscape greening; (ii) promote environmental protection and conservation; and (iii) enhance living standards in all urban areas.

- Service coverage by public sewerage systems is assumed to increase throughout the projection period. Table 9.8 summarises the assumptions, which also reflect the fact that the urban population will continue to grow as a proportion of the national population.

Table 9.8/ Jordan – Sewerage Service Coverage Projections 2010 – 2060 (%)

Year	Main Demand Area		Other Governorates	National Total
	Amman	Total		
2007	80%	75%	41%	61%
2010	85%	80%	46%	67%
2015	90%	85%	51%	72%
2020	95%	90%	56%	78%
2030	95%	91%	61%	81%
2040	95%	92%	65%	84%
2050	95%	92%	70%	86%
2060	95%	93%	75%	88%

Source: Appendix B, Tables 26 to 28.

- Wastewater influent - percentage of municipal water consumption discharged to public sewerage systems 85%

- Wastewater effluent for irrigation and industrial use - percentage of losses through seepage, evaporation, transmission and conveyance 27%

The resulting projections are summarised in Table 9.9 for the Low, Medium and High scenarios:

- Low – total national wastewater effluent is projected to triple from 122 million m^3 in 2010 to 186 million m^3 in 2020 and 375 million m^3 by 2060. In the project area, the forecasts increase by 330% from 87 million m^3 in 2010 to 134 million m^3 in 2020 and 285 million m^3 by 2060. Amman's share of the total increases from 49% in 2010 to 53% in 2020 and 62% by 2060.

- Medium - total national wastewater effluent is projected to increase four-fold from 132 million m^3 in 2010 to 207 million m^3 in 2020 and 510 million m^3 by 2060. In the project area, the forecasts increase by 420% from 95 million m^3 in 2010 to 152 million m^3 in 2020 and 401 million m^3 by 2060. Amman's share total increases from 50% in 2010 to 55% in 2020 and 66% by 2060.

- High - total national wastewater effluent is projected to increase by 530% from 138 million m^3 in 2010 to 231 million m^3 in 2020 and 734 million m3 by 2060. In the project area, the forecasts increase six-fold from 100 million m^3 in 2010 to 173 million m^3 in 2020 and 599 million m^3 by 2060. Amman's share total increases from 51% in 2010 to 56% in 2020 and 71% by 2060.

Table 9.9/ Jordan – Indicative Treated Wastewater Projections by Governorate 2010 – 2060 (m^3 million)

Governorate	Estimate 2007	Forecasts					
		2010	2020	2030	2040	2050	2060
LOW							
Main Demand Area							
Amman	49	60	98	136	170	202	234
Zarqa	16	24	31	33	36	38	40
Madaba	1	2	3	4	4	5	5
Karak	1	1	2	3	4	4	5
Total – Main Demand Area	67	87	134	175	213	249	285
Other Governorates	24	35	52	61	71	81	90
National Total	91	122	186	237	284	330	375
MEDIUM							
Main Demand Area							
Amman	49	66	114	160	216	277	338
Zarqa	16	26	34	38	43	47	51
Madaba	1	2	3	4	4	5	6
Karak	1	1	2	3	4	5	6
Total – Main Demand Area	67	95	152	206	267	334	401
Other Governorates	24	36	54	67	81	95	109
National Total	91	132	207	273	348	429	510
HIGH							
Main Demand Area							
Amman	49	70	130	198	287	396	520
Zarqa	16	27	37	44	51	58	65
Madaba	1	2	3	4	5	6	7
Karak	1	1	2	3	4	6	7
Total – Main Demand Area	67	100	173	249	347	466	599
Other Governorates	24	38	58	75	94	114	135
National Total	91	138	231	324	441	580	734

Source: Appendix B, Tables 26 to 28.

10. INDICATIVE WATER BALANCES

10.1 Introduction

This section illustrates the indicative water balance forecasts for Jordan, the Main Demand Area and all North West Governorates, based on the water demand and water resource forecasts in Sections 8 & 9 and Appendix B.

10.2 All Jordan

Table 10.1 presents the indicative water balances for Jordan from 2010 to 2060 for the Low, Medium and High scenarios. The results indicate the following deficits that will need to be addressed if Jordan is to achieve sustained socio-economic development in line with objectives set out in the national plans (see: Sections 4 and 5):

- Low – the deficit is projected to remain relatively stable at between 560 and 590 million m^3 per year.
- Medium – the deficit is forecast to increase from 611 million m^3 in 2020 to 643 million m^3 in 2040 and 735 million m^3 by 2060 – an increase of 20%.
- High – the deficit is forecast to increase by 55% over the projection period from 648 million m^3 in 2020 to 763 million m^3 in 2040 and 1,006 million m^3 by 2060 – this is entirely due to the much higher level of municipal water demand.

Table 10.1/ Jordan – Indicative National Water Balances: Water Demands, Water Resources and Deficits 2010 - 2060 (m^3 million)

Sector and Source	Estimate 2007	Forecasts					
		2010	2020	2030	2040	2050	2060
LOW							
Water Demand							
Municipal	294	376	512	622	679	770	857
Industrial	49	77	120	146	178	197	217
Irrigation	590	1,076	983	901	827	762	703
Livestock	8	15	19	23	27	30	34
Total	940	1,543	1,633	1,692	1,711	1,759	1,812
Water Resources							
Surface Water	345	400	400	400	400	400	400
Groundwater							
Renewable	419	380	276	276	276	276	276
Non-Renewable	74	77	143	143	143	143	143
Brackish/Saline	11	37	47	47	47	47	47
Treated Wastewater	91	122	186	237	284	330	375
Total	940	1,015	1,052	1,102	1,149	1,195	1,241
Surplus (Deficit)	0	-528	-582	-590	-562	-564	-571
MEDIUM							
Water Demand							
Municipal	294	401	561	711	824	992	1,156
Industrial	49	77	120	146	178	197	217
Irrigation	590	1,076	983	901	827	762	703
Livestock	8	15	19	23	27	30	34
Total	940	1,569	1,683	1,780	1,856	1,981	2,111
Water Resources							
Surface Water	345	400	400	400	400	400	400
Groundwater							
Renewable	419	380	276	276	276	276	276
Non-Renewable	74	77	143	143	143	143	143
Brackish/Saline	11	37	47	47	47	47	47
Treated Wastewater	91	132	207	273	348	429	510
Total	940	1,025	1,072	1,138	1,213	1,294	1,375
Surplus (Deficit)	0	-544	-611	-642	-643	-687	-735
HIGH							
Water Demand							
Municipal	294	420	622	839	1,037	1,330	1,651
Industrial	49	77	120	146	178	197	217
Irrigation	590	1,076	983	901	827	762	703
Livestock	8	15	19	23	27	30	34
Total	940	1,588	1,744	1,908	2,069	2,319	2,605
Water Resources							
Surface Water	345	400	400	400	400	400	400
Groundwater							
Renewable	419	380	276	276	276	276	276
Non-Renewable	74	77	143	143	143	143	143
Brackish/Saline	11	37	47	47	47	47	47
Treated Wastewater	91	138	231	324	441	580	734
Total	940	1,032	1,096	1,189	1,306	1,445	1,599
Surplus (Deficit)	0	-556	-648	-719	-763	-874	-1,006

Source: Appendix B, Table 29.

10.3 Main Demand Area

The Main Demand Area is defined as the four (4) Governorates of Amman, Zarqa, Madaba and Karak. Table 10.2 summarises the indicative water balances for the Low, Medium and High scenarios:

- Low – the deficit is forecast to double from 152 million m^3 in 2020 to 231 million m^3 in 2004 and 313 million m^3 by 2060.
- Medium – the deficit is forecast to increase by 250% from 176 million m^3 in 2020 to 294 million m^3 in 2040 and 446 million m^3 by 2060.
- High – the forecast deficits are much higher, rising from 201 million m^3 in 2020 to 386 million m^3 in 2040 and 673 million m^3 by 2060 – an overall increase of 335%.

The forecast deficits represent the minimum requirements for desalinated water from the RSDS Project, especially if the rising demand for potable water in the Greater Amman Region (GAR) is to be satisfied. Other key factors in the projections are as follows:

- Disi fossil water – the pipeline from Disi to Amman is expected to be commissioned in 2013 and will convey 100 million m^3 per year to the GAR.

- Other groundwater sources – by 2020, pumping is assumed to reflect MWI's estimates of safe yield.

- Treated wastewater – the projected expansion of wastewater treatment capacity will be essential if irrigation and all (or a proportion) industrial demands are to be satisfied.

Table 10.2: Project Area – Indicative Water Balances: Water Demands, Water Resources and Deficits 2010 - 2060 (m^3 million)

Sector and Sources	Estimate 2007	Forecasts					
		2010	2020	2030	2040	2050	2060
LOW							
Water Demand							
Municipal	189	229	321	414	468	544	619
Industrial	26	41	72	88	107	118	130
Irrigation	153	279	264	249	236	224	212
Livestock	3	6	7	9	10	12	13
Total	371	555	664	760	821	898	975
Water Resources							
Surface Water	105	122	122	122	122	122	122
Groundwater	199	187	255	255	255	255	255
Treated Wastewater	67	87	134	175	213	249	285
Total	371	395	511	552	590	626	662
Surplus (Deficit)	0	-160	-152	-207	-231	-271	-313
MEDIUM							
Water Demand							
Municipal	189	250	362	483	585	727	869
Industrial	26	41	72	88	107	118	130
Irrigation	153	279	264	249	236	224	212
Livestock	3	6	7	9	10	12	13
Total	371	576	705	829	938	1,081	1,224
Water Resources							
Surface Water	105	122	122	122	122	122	122
Groundwater	199	187	255	255	255	255	255
Treated Wastewater	67	95	152	206	267	334	401
Total	371	404	530	583	644	711	778
Surplus (Deficit)	0	-172	-176	-247	-294	-370	-446
HIGH							
Water Demand							
Municipal	189	263	408	584	757	1,010	1,293
Industrial	26	41	72	88	107	118	130
Irrigation	153	279	264	249	236	224	212
Livestock	3	6	7	9	10	12	13
Total	371	588	751	929	1,110	1,363	1,649
Water Resources							
Surface Water	105	122	122	122	122	122	122
Groundwater	199	187	255	255	255	255	255
Treated Wastewater	67	100	173	249	347	466	599
Total	371	409	550	626	724	843	976
Surplus (Deficit)	0	-179	-201	-303	-386	-520	-673

Source: Appendix B, Tables 30 to 32.

10.4 All North West Governorates

This sub-section illustrates the indicative water balances for all Governorates in the north west of Jordan. The nine (9) Governorates (Amman, Zarqa, Madaba, Karak, Balqa, Irbid, Marfaq, Jarash and Ajlun) account for 95% of the national population and more than 85% of annual water demand.

Table 10.3 summarises the indicative water balances for the Low, Medium & High scenarios:

- Low – the deficit is projected to remain relatively stable at between 515 and 540 million m^3 per year.
- Medium – the deficit is forecast to increase by about 20% from 560 million m^3 in 2020 to 593 million m^3 in 2040 and 686 million m^3 by 2060.
- High – the deficit is forecast to increase by nearly 60% from 597 million m^3 in 2020 to 709 million m^3 in 2040 and 950 million m^3 by 2060 – this is driven by the much higher level of municipal water demand.

The forecast deficits represent the maximum requirements for desalinated water from the RSDS Project if the projected demand for potable water in the North West Governorates is to be satisfied. In addition, the provision of desalinated potable water to the main cities and towns in the North West Governorates may also require the construction of a pipeline network from Amman to Zarqa, Salt, Jarash, Ajlun, Irbid, Ramtha and Mafraq. This would require a separate optimisation study to determine the least-cost routing for the distribution and conveyance of existing resources and the desalinated water.

Table 10.3: North West Jordan – Indicative Water Balances: Water Demands, Water Resources and Deficits 2010 - 2060 (m^3 million)

Sector and Sources	Estimate 2007	Forecasts					
		2010	2020	2030	2040	2050	2060
LOW							
Water Demand							
Municipal	273	347	473	580	636	724	809
Industrial	32	51	83	101	123	136	150
Irrigation	501	914	834	763	700	644	594
Livestock	8	14	18	21	25	29	32
Total	814	1,326	1,407	1,465	1,484	1,532	1,585
Water Resources							
Surface Water	255	296	296	296	296	296	296
Groundwater	475	395	407	407	407	407	407
Treated Wastewater	83	112	173	221	267	311	355
Total	814	803	875	923	969	1,013	1,057
Surplus (Deficit)	0	-523	-532	-542	-515	-519	-528
MEDIUM							
Water Demand							
Municipal	273	371	520	664	775	937	1,097
Industrial	32	51	83	101	123	136	150
Irrigation	501	914	834	763	700	644	594
Livestock	8	14	18	21	25	29	32
Total	814	1,350	1,454	1,549	1,622	1,745	1,873
Water Resources							
Surface Water	255	296	296	296	296	296	296
Groundwater	475	395	407	407	407	407	407
Treated Wastewater	83	121	192	255	327	406	485
Total	814	812	894	957	1,030	1,108	1,187
Surplus (Deficit)	0	-538	-560	-591	-593	-637	-686
HIGH							
Water Demand							
Municipal	273	389	580	789	982	1,267	1,581
Industrial	32	51	83	101	123	136	150
Irrigation	501	914	834	763	700	644	594
Livestock	8	14	18	21	25	29	32
Total	814	1,369	1,515	1,674	1,830	2,075	2,357
Water Resources							
Surface Water	255	296	296	296	296	296	296
Groundwater	475	395	407	407	407	407	407
Treated Wastewater	83	127	216	305	418	553	704
Total	814	818	918	1,008	1,121	1,256	1,407
Surplus (Deficit)	0	-550	-597	-666	-709	-819	-950

Source: Appendix B, Tables 30 to 32.

10.5 Indicative Water Deficits 2020 to 2060

The indicative water deficits for Jordan, the Project Area and all North West Governorates are summarised in Table 10.4 in terms of the annual requirements and daily average requirements for the Low, Medium and High Scenarios:

- Jordan – average daily deficits range from 1.6 million m^3 in the Low Scenario to 1.7 to 2 million m^3 in the Medium Scenario, and 1.8 to 2.8 million m^3 in the High Scenario.

- Main Demand Area (Amman, Zarqa, Madaba and Karak) - average daily deficits range from 0.5 to 0.9 million m^3 in the Low Scenario, to 0.5 to 1.2 million m^3 in the Medium Scenario, and 0.6 to 1.8 million m^3 in the High Scenario.

- North West Governorates (Amman, Zarqa, Madaba, Karak, Balqa, Irbid, Marfaq, Jarash and Ajlun) – average daily deficits range from 1.5 million m^3 in the Low Scenario to 1.5 to 1.9 million m^3 in the Medium Scenario, and 1.6 to 2.6 million m^3 in the High Scenario.

Table 10.4: Indicative Water Deficits for Jordan, Main Demand Area and North West Governorates 2020 – 2060 (m^3 million)

Year	Annual (m^3 million)			Daily Average (m^3 million)		
	Low	Medium	High	Low	Medium	High
Jordan						
2020	582	611	648	1.59	1.67	1.77
2030	590	642	719	1.62	1.76	1.97
2040	562	643	763	1.54	1.76	2.09
2050	564	687	874	1.55	1.88	2.09
2060	571	735	1,006	1.56	2.01	2.75
Main Project Area						
2020	152	176	201	0.42	0.48	0.55
2030	207	247	303	0.57	0.68	0.83
2040	231	294	386	0.63	0.81	1.06
2050	271	370	520	0.74	1.01	1.42
2060	313	446	673	0.86	1.22	1.84
North West Governorates						
2020	532	560	597	1.46	1.53	1.64
2030	542	591	666	1.48	1.62	1.82
2040	515	593	709	1.41	1.62	1.94
2050	519	637	819	1.42	1.75	2.24
2060	528	686	950	1.45	1.88	2.60

Source: Tables 10.1, 10.2 and 10.3.

ANNEXES

ANNEX A PERSONS MET AND CONSULTED

A.1 Project Team

1. Jean-Pierre Chabal, Project Director
2. Francois Halgand, Principal Project Engineer
3. David Meehan, Team Leader
4. Peter Darley, Interim Team Leader
5. Jeremy Berkoff, Economic Strategist and Regional Economist
6. Dr Ramon Ortiz, Environmental and Industry Economist
7. Jaques Schittekat, Manager of Projects, Engineering Geology and Hydrogeology (Geologist and Hydrogeologist)
8. Alain Van Cotthem, Manager of Projects, Civil and Engineering Technologies (Tunnel Expert)
9. Jawdat J Yaghmour, General Manager, Associated Consulting Engineers (ACE)
10. Abdullatif Abu-Keer, Senior Engineer Water and Wastewater, ACE
11. Yousef Al-Soudani, Senior Design Engineer, ACE

JORDAN

A.2 Ministry of Water and Irrigation (MWI)

12. Eng Fayez Bataineh, Project Manager RSDSP
13. Dr Issa Al-Nsour, Director, Water Resources and Planning
14. Eng. Ali Subah, Project Coordinator and Senior Hydrologist, Jordanian-German Technical Cooperation Project
15. Eng. Muawia Samarah, Director of Water Resource Studies
16. Eng. Louis Qaqish, NRW, Performance Monitoring and Benchmarking Officer (PMU/Al-Meyyah Project)

A.3 Water Authority of Jordan (WAJ)

17. Dr Khair Al-Hadidi, Director of Groundwater Basins Directorate
18. Ahmad Al Rashadia, Director Wastewater Operations and Maintenance
19. Majid Joudeh, Operations Manager, Wastewater Treatment
20. Majid Ibrahim, Chief Statistician – Water Supply

A.4 Jordan Valley Authority (JVA)

21. Eng. Yousef Hasan Ayadi, Planning Director
22. Ikram Daghistani, Director, Investment Unit
23. Zaid Halsa, Director of Lands

A.5 Jordan Water Company – Miyahuna (JWC)

24. Eng Kamal Zoubi, Chief Executive Officer

A.6 Ministry of Planning and International Cooperation (MOP)

25. Maha Al-Zu'Bi, Deputy Director, Projects Department and Head of Water and Agriculture Division

A.7 Others

26. Eng. Nashwa Subah, Managing Director, Urban Workshop & General Manager, King Abdullah Bin Abdul Aziz City

27. Ross Hagan, Deputy Director, Office of Water Resources and Environment, USAID, Jordan

28. Dr Andreas H Lűck, Program Manager, Improvement of Steering Competence in the Water Sector (SCWS), GTZ – German Technical Cooperation

29. Dr Mohamed Chebaane, Chief of Party, USAID-Funded IDARA Project (Instituting Water Demand Management in Jordan)

30. Tony Gregg, Senior Technical Adviser, USAID-Funded IDARA Project (Instituting Water Demand Management in Jordan)

ANNEX B JORDAN – STATISTICS, WATER DEMAND & PROJECTIONS, AND WATER BALANCES

B.1 Introduction

This annex presents: (i) basic statistics on Jordan's population, household water supply and wastewater, and average income & expenditure; and (ii) main assumptions and calculations for the water demand projections from 2010 to 2060. The tables and calculations are presented in a separate Excel File.

B.2 Jordan – Basic Statistics

The tables are as follows:

Table 1 Jordan – Population by Governorate 1999 – 2007
Table 2 Jordan – Households by Governorate & Main Source of Water Supply 2008
Table 3 Jordan – Households by Governorate and Type of Sewage System 2008
Table 4 Jordan – Households by Governorate & Average Income & Expenditure 2008
Table 5 Jordan – Households by Governorate and Main Source of Drinking Water: Census 2004
Table 6 Jordan – Households by Governorate and Main Type of Sewage System: Census 2004

B.3 Jordan – Previous Studies

The tables are as follows:

Table 7 Jordan – Harza Study 1998: Forecasts of Water Demand, Water Resources and Deficits
Table 8 Jordan – NWMP 2004: Forecasts of Water Demand, Water Resources and Deficits

B.4 Jordan – Water Demand Projections

B.4.1 Tables

Table 9 Jordan – Municipal Water Supply, Billed Sales and Non Revenue Water by Governorate 1999-2007
Table 10 Jordan – Municipal Unit Consumption: Billed Sales and Estimated Effective Consumption by Governorate 1999-2007
Table 11 Jordan – Municipal Projection Parameters and Assumptions: Low, Medium and High Projections by Governorate 2007–2060
Table 12 Jordan – Medium Gross Municipal Demand Projections by Governorate 2007-2060
Table 13 Jordan - Low Gross Municipal Demand Projections by Governorate 2007-2060
Table 14 Jordan – High Gross Municipal Demand Projections by Governorate 2007-2060
Table 15 Jordan - Industrial Water Demand Projections by Governorate 2007-2060
Table 16 Jordan – Irrigation Water Requirement Projections By Governorate 2007-2060
Table 17 Jordan – Livestock Water Requirement Projections by Governorate 2007-2060
Table 18 Jordan – Total Gross Water Demand Projections by Governorate 2007-2060
Table 19 Jordan – Total Gross Water Demand Projections by Governorate: Distribution
Table 20 Jordan – Total Gross Water Demand Projections by Main Sector 2007-2060
Table 21 Jordan – Total Gross Water Demand Projections by Main Sector: Distribution

B.4.2 Parameters and Assumptions

1. Table 9 – Municipal Water Supply, Billed Sales and Non Revenue Water (NRW)
   - Residential (domestic) and non-residential (commercial, small industry & institutional) sales – split based on estimates provided by WAJ, JWC and various reports.
   - Estimated effective total consumption – assumes that 50% of NRW are "administrative losses" (source: PMU Al-Meyyeh Project, MWI; and NWMP 2004).

2. Table 10 – Unit Consumption: Billed Water Sales and Estimated Effective Consumption
   - Derived from Tables 1 and 9.

3. Table 11 – Municipal Projection Parameters: Low, Medium and High Projections
   - Population growth rates – (i) DOS national projections to 2020; & (ii) Study estimates.
   - Residential unit consumption – (i) based on parameters and assumptions specified in Section 3.6.4 of the main text; and (ii) growth rates from 2020 to 2060, based on study estimates for the low, medium and high growth scenarios in a high cost water environment.
   - NRW – assumed reduction to: (i) government target of 25% by 2020 (source: Water For Life: Jordan's Water Strategy 2008-2022; and (ii) 20% by 2040.

4. Tables 12 to 14 – Low, Medium and High Demand Projections
   - Derived from Tables 1, 9, 10 and 11

5. Table 15 – Industrial Water Demand Projections
   - Based on: (i) 2010 to 2020 - demand projections prepared by NWMP 2004; and (ii) study estimates: 2% per year from 2020 to 2040, and 1% per year from 2040 to 2060

6. Table 16 – Irrigation Water Requirement Projections
   - Based on: (i) 2010 to 2020 - demand projections prepared by NWMP 2004; and (ii) 2020 to 2060 – sustained improvements in water-use efficiency based on the gains estimated by NWMP between 2010 and 2020.

7. Table 17 – Livestock Water Requirement Projections
   - 2006: (i) DOS reported livestock numbers by governorate; and (ii) assumed water requirement per head
   - Projections based on: (i) livestock numbers increase in line with medium population projections (Table 12); and (ii) high water consumption per head/day.

8. Tables 18 and 20 – combined results of Tables 12 to 17

B.5 Jordan – Water Resources and Projections

B.5.1 Tables

B.5.2 Treated Wastewater – Parameters and Assumptions

1. Tables 26 to 28 – Treated Wastewater Projections:
   - Sewerage service coverage: (i) 2007 – estimates based on 2006 figures in Table 3; (ii) coverage projection – increase in coverage of 5% for each time period interval up to a maximum of 95% (e.g. for Amman, Zarqa and Aqaba).
   - Wastewater influent - percentage of municipal water consumption discharged to sewer – 85%
   - Wastewater effluent for irrigation or industrial use – percentage of wastewater losses through seepage, evaporation, transmission and conveyance – 27%

B.6 Jordan – Indicative Water Balances

B.6.1 Tables

ANNEX C DOCUMENTS AND REFERENCES

C.1 Project Documents and Reports

1. Terms of Reference – Feasibility Study - Environmental, Technical and Economic, and Environmental and Social Assessment, IBRD, April 2005
2. Red Sea – Dead Sea Water Conveyance Study Program – Feasibility Study: Technical Proposal, Coyne et Bellier, 31st January 2008
3. Draft Report on Sub-Studies B and D – Main Report, May 2010
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   - Main Report
   - Appendices – Volumes 1 and 2
6. Water Demands and Water Supply Evaluation, Draft Report, M T Summerfield, November 2008
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8. Water Demands from Project – Internal Project Paper, P Darley and J Berkoff, July 2008
9. Treatment of Return Flows from the RSDSP in the Water Balance, Draft, J Berkoff, July 2008
10. Economic Analysis – Methodological Note, A Markandya, July 2008
11. The Project Context, Internal Working Paper, J Berkoff, August 2008
12. Red Sea Dead Sea Study Program – A Project Overview, P Darley, June and August 2008
13. Mission Report, Draft, R A Ortiz, Environmental and Industry Economist, Metroeconomica Limited, September 2008
14. Feasibility Study Proposal – Visit to Region, Trip Report 2-13 September 2007, P Darley

C.2 Previous Studies and Reports

15. Jordan Rift Valley Integrated Development Study:

    Red Sea-Dead Sea Canal Project, Prefeasibility Report, Harza JRV Group, Feb. 1998:

• Volume I	Main Report	
• Volume II	Appendix 1	Interim Environmental Assessment
• Volume III	Appendix 2	Cost Estimates
	Appendix 3	Alternative Studies
	Appendix 4	Desalination
	Appendix 5	Water Resources
	Appendix 6	Economic Analysis
	Appendix 7	Financial Analysis
	Appendix 8	Cross Drainage
• Volume IV	Appendix 9	Geology
	Appendix 10	Hydrogeology

C.3 National Water Master Plan (NWMP)

16. Summary Brochures, National Water Master Plan Directorate, reprinted 2008:
    1. National Water Master plan
    2. Water Resources in Jordan
    3. Water Uses and Demands
    4. Water and Environment

17. National Water Master Plan 2004, MWI and German Technical Cooperation – GTZ, May 2004:
    - Volume 1 Main Report
    - Volume 2 Planning Framework
    - Volume 3 Water Uses and Demands
    - Volume 4 Surface Water Resources
    - Volume 5 Groundwater Resources
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