



# DEVELOPMENT OF AN INTEGRATED WATER RESOURCES MANAGEMENT PLAN FOR NAMIBIA

## Theme Report 3

### FORMULATION OF WATER DEMAND MANAGEMENT STRATEGY



AUGUST 2010

PREPARED FOR:

MINISTRY OF AGRICULTURE, WATER  
AND FORESTRY

FUNDED BY:

AFRICAN WATER FACILITY







**GOVERNMENT OF THE REPUBLIC OF NAMIBIA**

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IWRM Plan Joint Venture Namibia



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## **FORMULATION OF WATER DEMAND MANAGEMENT STRATEGY**

### **EXECUTIVE SUMMARY**

#### **E1 ASSESSMENT OF THE STATUS AND POTENTIAL FOR WATER DEMAND MANAGEMENT**

##### **E1.1 INTRODUCTION**

Water Demand Management (WDM) is a fundamental part of an integrated approach to sustainable management of the water sector, particularly important in an arid country such as Namibia. "WDM involves measures that improve efficiency by reducing water use or altering patterns of water use after abstraction" (Beecher, 1995). Within the Namibian context the WDM strategy attempts to improve cost recovery, the management and maintenance of infrastructure and the reduction of inefficient consumer demand to reduce the pressure and reliance on conventional water resources and infrastructure. By reducing demand, through a variety of approaches, Water Demand Management (WDM) provides an equivalent outcome to supply augmentation. This, in turn, results in a net financial benefit to the supplier as well as its customers and benefits to the environment.

The GINI coefficient for Namibia is 0.604 according to the results of the Namibia Household Income and Expenditure Survey for 2003/2004 (NHIES, 2003/2004). Although the inequality in the distribution in income decreased from 0.701 in 1993/94 to 0.604 in 2003/2004 it is still among the highest in the world. Implementation of equitable tariffs and improved maintenance of infrastructure to prevent wastage will contribute to skills development, more employment opportunities and poverty alleviation.

##### **E1.2 LEGAL AND POLICY FRAMEWORK**

- The previous South African Water Act, applicable in Namibia, supported the provision of cheap access to water leading to the perception that it is the government's duty to provide water as a cheap and abundant commodity. Lack of recognition of the true value of water in an arid country such as Namibia resulted in an inefficient and unsustainable water demand.
- Water Demand Management (WDM) was included in the Namibian Water Policy in August 2000 for the first time. Although included in the revised Draft Water Resource Management Bill there are no legal mechanisms yet in place to apply WDM within the water sector. Most of the results reflected in this report are based on individual efforts by service providers and/or water users.
- The Draft Water Resource Management Bill makes provision, inter alia, for a Water Regulator to harmonize and integrate the expectations of consumers and decision makers regarding the price of water supply and wastewater discharge services without compromising the financial viability of the service providers. The regulator will also address the development of water service plans and water conservation and water demand management strategies.



### **E1.3 TARIFF SETTING AND SUBSIDIES**

- Nine principles were determined by NamWater (LCE 2008) underpinning fundamental requirements of tariff structures, affordability and service delivery. It is suggested that these principles be accepted as interim measures for tariffs to be set by local authorities. Experience in Namibia has shown that as soon as local authorities start addressing their billing and payment systems and increase the efficiency of these systems, and start addressing the integrity of their reticulation networks, water consumption drops dramatically.
- As stated in the WSASP (2008): “Mechanisms for transparent subsidies and/or cross-subsidization by means of rebates for those who are unable to pay for water supply and sanitation services should be pursued.” In the situation assessment for the determination of NamWater tariffs it was recommended that the following guideline be used as an interim measure: Cross subsidies within a region can handle a poverty component up to 15% and rural subsidies are required between 15% and 30% poverty index. Where the total poverty index is above 30%, subsidies for both urban and rural areas may be required. Blanket subsidies are not recommended as they mainly benefit the rich. To conserve water it is important to apply the same tariff principles to all end consumers linked to the same water supply scheme.
- In a study made in Rehoboth in 2003 (ref Water Management Assistance for MRLGHRD funded by SIDA) the relation between income level and water demand (income elasticity - family income versus water consumption) was used as an indicator of the number of poor families. It was established that approximately 27% of the consumers (mostly concentrated in the low income areas) consumed approximately 8% of the water. By introducing appropriate tariffs (rising block tariffs, which include an element of cross-subsidization) the cost of water to the low income group can be reduced by more than 50% without industry, business, government and middle and high income households having to pay significantly more (5%) for their water. This had a significant effect on the availability of money for poor households in Rehoboth.

### **E1.4 GENDER RELATED ISSUES**

- In the review and assessment of the existing situation report, a detailed analysis of the regulations in the draft revised Water Act was made with respect to opportunities for gender initiatives. The review shows that many of these regulations are gender neutral but some of them provide opportunities for gender initiatives to ensure that women and youth are involved on an equitable basis. Out of the five WDM instruments described in this report, there is potential to mainstream gender and youth issues in two of these instruments; namely in education and information as well as in training.

## **E1.5 NATURAL RESOURCE ACCOUNTING**

- Natural resource accounting for the water sector was identified as an important tool in prioritising the allocation of water with competing uses and to measure economic and social efficiency in the use of water within the different sectors.

## **E1.6 RESOURCE PROTECTION**

- Bush encroachment influences surface runoff and groundwater recharge in Namibia. According to studies by the Department of Agriculture approximately 27 million ha of grazing in Namibia are affected by bush encroachment. In a pilot study on the Platveld Aquifer (near Otjiwarongo) it was estimated that the groundwater recharge at the de-bushed location was approximately 8%, while it was less than 1% at the bush-invaded locations. Such information for surface run-off is not available but there is consensus amongst scientists that bush encroachment reduces both run-off and groundwater recharge. Service providers such as NamWater and local authorities which abstract water for urban use can play an important role as facilitators to identify areas with water stress where bush encroachment influences surface runoff and groundwater recharge. Pilot projects such as in the Von Bach Catchment and the Otjiwarongo Marble Aquifer may be beneficial to quantify benefits over time and to improve security of supply.

## **E1.7 STATUS OF WATER DEMAND MANAGEMENT IN BULK WATER SUPPLY**

- The main challenges for NamWater are recovery of debt amounting to N\$ 270 million, reduction of production losses on some schemes, maintenance improvement, accessing secure funding for much needed capital replacement as well as funding for new bulk infrastructure projects. Security of bulk supply linked to the condition of infrastructure and resources for the Central Coast (Walvis Bay, Swakopmund and uranium mines) and the Central Area of Namibia are major concerns. The cost of breakdowns in water supply to the economy of Namibia amounts to approximately \$ 17.1 million/day and N\$ 22.5 million/day for the Central Coast and the Central Area of Namibia respectively.

## **E1.7 STATUS OF WATER DEMAND MANAGEMENT THE DIFFERENT SECTORS**

### **Urban Water Sector**

- The biggest long-term benefit from WDM is keeping the annual growth in water consumption within acceptable limits (lower than 3% per annum) despite high economic growth rates. The ability of Windhoek residents to improve water efficiency is well evidenced by their responses during drought periods. WDM can be a highly cost-effective means of extending water supplies. In most urban areas the water demand has dropped over the past few years despite increased population and economic activities.

- During 2006 an investigation was completed at Arandis to reduce the non-revenue water which exceeded 50%. In a project including the replacement of a main pipeline and pressure reduction, non-revenue was reduced to approximately 15%. A consumer survey confirmed that 5% of the consumers were not recorded on the costing system. At least 4 major leakages were identified and repaired which reduced the night flow by 2.5 m<sup>3</sup>/hour resulting in an estimated annual saving of N\$ 130 000 in bulk water supply costs. A pressure reduction system was installed in December 2008. The cost of the installation was N\$ 250 000 while the estimated savings in the bulk water supply cost (based on night-flow measurement) amounted to N\$ 400 000/annum with a payback period of 8 only months. The bulk water supply decreased by 24% between 2006 and 2009 while sales increased by approximately 29%. The net effect of reduced bulk supply cost and increased sales amounts to N\$ 1.24 million /annum based on 2010 tariffs. In the case of Gibeon where pipelines were replaced and system leakages were fixed, the reduction in bulk supply between 2002 (379 438m<sup>3</sup>) and 2007 (123.507m<sup>3</sup>) was 255 931m<sup>3</sup> (67.5% reduction) with a money value of N\$ 1.45 million based on 2010 NamWater tariffs.
- The inability of local authorities to recover costs through inappropriate tariffs, poor credit control, high non-revenue water and the lack in management skills, makes the delivery of proper services, and the proper maintenance of infrastructure impossible in certain urban areas. The high cost of non-revenue water makes it almost impossible for local authorities to improve their financial position to improve service delivery.
- In most villages high water consumption can be attributed to one or more of the following factors: high losses at government buildings and institutions, inappropriate water tariffs, inefficient administration (infrequent meter reading, poor billing and credit control), poor infrastructure maintenance and inaccurate metering.
- The potential saving through water demand management interventions in urban centres varies from 4% to 85% while non-revenue water varies from 5% to 50% in urban areas which indicate a major scope for improvement.

### **Rural Domestic Water Sector**

- The main challenges for the water point committees/associations are to improve the financial and technical management. Recovery of costs by Water Point Committees to pay NamWater for the operation and maintenance of the water points is not adequate. Persons leaving rural areas create problems with continuity of committees while there is no subsidy scheme in place to assist the rural poor. There is a need to devise a mechanism for billing water lost from pipe bursts in branch lines. Improved reliability of water supply schemes with fewer interruptions and proper maintenance of water infrastructure and in some cases replacement or upgrading of existing infrastructure, are major challenges. More frequent monitoring of water quality in schemes not supplied by NamWater is required. Rural consumers and water point committees need to be sensitised to prevent the pollution of water sources. During discussions with stakeholders more regular visits and assistance from DWSSC were requested.



## **Irrigation Water Sector**

The current status of WDM within the irrigation sector can be summarised as follows:

- Only a few irrigation farmers complete the annual returns to DWAF and the actual volume of water used is unknown.
- Because returns are not completed the over- or under-utilisation of resources cannot be assessed.
- The extent of pollution resulting from irrigation practices is unknown.
- Metering for proper scheduling as well the determination of volumes abstracted is inadequate.
- The tariffs applied for irrigation does not provide incentives for water use efficiency;
- Information to farmers for proper scheduling is inadequate.
- Inadequate information is provided to farmers regarding improved crop yields which are linked to improved irrigation efficiency.
- Maintenance of both canals and on-farm irrigation systems is inadequate.
- The irrigation sector accounts for a relatively large percentage (41%) of the water used in Namibia in 2008 and offers potential savings of between 15 and 25% through the implementation of WDM initiatives.

## **Livestock Water Sector**

The following challenges were identified in the livestock sector:

- Payment for water as determined by the Water Point Committees are inconsistent with some charging a fee per head of livestock while others pay a flat rate irrespective of the number of livestock.
- Groundwater depletion and or pollution and the wider social effects that might result are highly relevant to rural water supply, most of which comes from boreholes.
- Wastage at cattle troughs occurs mainly as a result of poor maintenance while the maintenance of water infrastructure on resettlement farms was neglected by beneficiaries to such extent that it affected the production on the farms.
- Bush encroachment has a negative effect on the availability of fodder and influences both surface run-off and groundwater recharge negatively. Controlled de-bushing is a proven method of increasing the availability of groundwater and surface run-off and thereby enhancing economic growth. It is suggested that service providers and farmers (both commercial and communal) combine efforts to address bush encroachment on a national basis.
- The extent of pollution of groundwater in both communal and commercial farming areas as a result of livestock farming is unknown.

## **Mining Sector**

The mining industry is fairly diligent when it comes to the management of water used for processing. The main challenges for the implementation of WDM within the mining sector are:

- Development of water management plans for each mine based on the principles as practiced by Rössing Uranium.
- Most of the mines recycle water which realises significant savings in water demand.
- Prevention of ground and surface water pollution was indentified as one of the major concerns.

## **Tourism Sector**

Very little information is available on the potential for water savings in the tourism sector. The following challenges were indentified within the tourism sector:

- Lack of maintenance at resorts operated by Namibia Wildlife Resorts is documented and at some resorts savings from 30 to 50% may be realized through improved maintenance.
- Most of lodges which supply their own water may over-abstract water from the resource and regular monitoring is required.
- Disposal of both solid and liquid waste may pollute water resources.

The situation assessment demonstrated that there are major opportunities in most of the sectors to implement WDM through better management of financial resources, revenue collection, infrastructure maintenance and replacement to reduce the water demand. Prevention of pollution and monitoring of groundwater and surface water sources must be addressed by all sectors.

## **E2 WATER DEMAND MANAGEMENT SECTOR STRATEGIES**

The strategies for the different sectors to implement WDM measures and performance indicators were developed in consultation with service providers and users in rural areas, in the fields of irrigation, livestock farming, tourism and mining in all 13 regions, through discussions in focus groups. The WDM strategies include legal, institutional, capacity building, financial and technical requirements as well as customer care where applicable. Greater emphasis should be placed on ensuring broad participation and engagement in water related activities.

The following steps were identified for the implementation of a WDM strategy in all water use sectors in Namibia:

1. Carry out a situation assessment which covers:
  - Water use and conservation planning goals, historic water requirements, water use efficiency, infrastructure characteristics, non-revenue water, customer profile if applicable, management practices and the pollution potential of the activity/entity;

- A demand forecast without water savings to estimate the extent of supply augmentation required to satisfy the water demand including the estimated capital and operational costs;
  - Identification of WDM initiatives, expected water savings and costs based on Unit Reference Values (URV);
  - Determination of the required capital and human resources for implementation;
  - Evaluation of the effect of savings on both the service provider and consumer; and
  - Determination of the effect of sanitation provision in area of jurisdiction if applicable.
2. Develop an implementation and monitoring programme for the performance indicators to measure the improved efficiency over time in relation to the target set in the implementation programme.

### **Bulk Water Supply:**

- During 2008 the NamWater supplied approximately 66.9 Mm<sup>3</sup> (treated surface water and groundwater) to the urban water sector, mining sector, tourism facilities, rural water supply schemes that were taken over from DWSSC as well as a large number of end-users. NamWater also supplies water to many of the government institutions such as border posts, police stations, schools, hostels and clinics. These use excessive amounts of water mainly a result of non-maintenance of plumbing systems in buildings.
- The overall objective for the bulk water supplier (NamWater) is to improve service delivery by ensuring efficient and effective bulk supply services at a high level of security of supply, with the necessary capacity (legislative, human and financial) to provide socially accepted services, provided that the environment and the ability of NamWater to become financial self-sustaining are not compromised.

### **Urban Sector:**

- During 2008 the urban water sector, including industries in urban areas, consumed approximately 69.1 Mm<sup>3</sup> which represents 20.2% of the total water supplied. In Vision 2030 the urban sector is earmarked for the accommodation of the majority of the population (75%) and significant industrialization and the expected water demand will increase to 117.2 Mm<sup>3</sup>. This represents 15.2% of the total expected water requirements in 2030.
- The overall objective for the urban water sector is to improve service delivery by ensuring that the service providers are efficient and effective and have the necessary capacity (legislative, human and financial) to provide socially accepted services provided that the environment and the ability of the Service Providers to become financial self-sustaining are not compromised.

### **Rural Domestic Sector**

- During 2008 the rural domestic water sector consumed approximately 10.3 Mm<sup>3</sup> which represented 3.1% of the total water requirement. In Vision 2030 it is not expected that the rural domestic sector will grow significantly. The expected water demand will increase to only 11.4 Mm<sup>3</sup> and will comprise only 1.5% of the total

expected water requirements in 2030. The median per capita daily water consumption is 9.9 litre/capita/day which is well below the acceptable minimum water consumption of 25 litre/ capita/day required for good health.

- The overall objective for the rural domestic water sector is to improve service delivery by ensuring that the water point committees and water point associations are efficient and effective and have the necessary capacity (legislative, human and financial) to deliver affordable services with a high level of supply security provided that the environment and the long-term target of the committees/associations to become financially self-sustaining are not compromised.

### **Irrigation Sector**

- During 2008 the irrigation water sector consumed approximately 135.3 Mm<sup>3</sup> which represents 41.0% of the total water requirement. In Vision 2030 the irrigation sector is earmarked for major development and the expected water demand will increase threefold to 497.2 Mm<sup>3</sup> which represents 64.6% of the total expected water requirements in 2030.
- The overall objective for the irrigation sector is to improve water use efficiency, crop production (more crop per drop) and value addition to enhance economic growth, increase food security and exports from Namibia provided that the environment and water resources are not compromised.

### **Livestock Sector**

- During 2008 the livestock water sector consumed approximately 86.9 Mm<sup>3</sup> which represents 26.6% of the total water requirement both in commercial and rural areas. The figure includes an allowance of 50% for wastage which may be high. No significant growth is expected in the livestock sector and the expected water demand will stay the same and will only comprise 11.3% of the total expected water demand in 2030.
- The overall objective in the livestock sector is to improve water use efficiency and protein production to enhance economic growth in Namibia through increased exports and food security, provided that the range land environment and water resources are not compromised.

### **Mining Sector**

- During 2008 the mining sector used approximately 16.1 Mm<sup>3</sup> which represents 4.9% of the total water requirement. The expected water requirement will increase to 20.3 Mm<sup>3</sup> which represents only 2.6% of the total expected water requirements in 2030. The figure of 20.3 Mm<sup>3</sup> excludes water provided from unconventional water sources such as brackish water, sea-water and desalination.
- The overall objective for the mining sector is to improve water use efficiency and to enhance economic growth in Namibia through local processing and exports provided that the environment and water resources are not compromised.

## **Tourism Sector**

- During 2008 the tourism sector used approximately 19.6 Mm<sup>3</sup> which represents 6.0% of the total water consumption. The tourism sector was identified as a high growth sector in Vision 2030 and the expected water requirement is expected to increase to 38.9 Mm<sup>3</sup> representing 5.0% of the total expected water requirements by 2030.
- The overall objective for the tourism sector is to improve water use efficiency and to enhance economic growth in Namibia through increased tourism, provided that the integrity of the ecosystems on which tourism depends are protected and that water resources are not compromised.

In conclusion, the development of end use water tariffs, subsidy or cross subsidy policies and appropriate credit control policies are overdue, and no water demand management policy or strategy will succeed without it. Moreover, to implement WDM successfully it is important that the revisions of the Water Resource Management Act and the Regulations should be finalised as soon as possible to enable the promotion of water use efficiency, the prevention of water pollution and the controlling of water quality. The water use efficiency regulations must include the performance indicators required in the different water use sectors.





## TABLE OF CONTENTS

1.	ASSESSMENT OF THE STATUS AND POTENTIAL FOR WATER DEMAND MANAGEMENT .....	1
1.1	INTRODUCTION .....	1
1.2	LEGAL FRAMEWORK.....	1
1.3	TARIFF SETTING AND SUBSIDIES .....	3
1.3.1	Tariff Setting.....	3
1.3.2	Subsidies.....	4
1.4	GENDER RELATED ISSUES.....	6
1.5	RESULTS OF THE NATIONAL RESOURCE ACCOUNTING.....	7
1.6	RESOURCE PROTECTION.....	9
1.7	STATUS OF WATER DEMAND MANAGEMENT IN BULK WATER SUPPLY.....	9
1.8	STATUS OF WATER DEMAND MANAGEMENT THE DIFFERENT SECTORS .....	12
1.8.1	Urban Water Sector.....	12
1.8.2	Rural Domestic Water Sector .....	22
1.8.3	Irrigation Water Sector.....	23
1.8.4	Livestock Water Sector.....	28
1.8.5	Mining Sector .....	30
1.8.6	Tourism Sector.....	32
1.9	CONCLUSIONS .....	33
2.	WATER DEMAND MANAGEMENT SECTOR STRATEGIES.....	34
2.1	INTRODUCTION .....	34
2.2	BULK WATER SUPPLY .....	34
2.2.1	Objective for Bulk water supply is to Improve Water Efficiency and Service Delivery through the Implementation of WDM .....	35
2.2.2	Strategies to Implement Improved Water Efficiency and Service Delivery through the Implementation of Water Demand Management.....	35
2.2.3	Performance Indicators .....	38
2.3	URBAN WATER SECTOR .....	39
2.3.1	Objective to Improve Water Efficiency and Service Delivery in Urban Sector through Implementation of WDM.....	40
2.3.2	Strategies to Implement Improved Water Efficiency and Service Delivery through the Implementation of Water Demand Management.....	40
2.3.3	Prioritizing of the Water Demand Management Measures.....	43
2.3.4	Performance Indicators .....	44
2.4	RURAL DOMESTIC WATER SECTOR .....	45
2.4.1	Objective to Improve Water Efficiency and Service Delivery in the Rural Domestic Sector through Implementation of WDM.....	46
2.4.2	Strategies to Implement Improved Water Efficiency and Service Delivery in the Rural Domestic Sector .....	46
2.4.3	Performance Indicators .....	48

2.5	IRRIGATION SECTOR.....	49
2.5.1	Objective to Improve Water Efficiency and Crop Production through Implementation of WDM.....	49
2.5.2	Strategies to Implement Improved Water Efficiency and Crop Production through the Implementation of Water Demand Management.....	49
2.5.3	Summary of identified Water Demand Management Measures in the Irrigation Sector.....	51
2.5.4	Performance Indicators .....	53
2.6	LIVESTOCK SECTOR.....	54
2.6.1	Objective to Improve Water Efficiency in the Livestock Sector through Implementation of WDM.....	54
2.6.2	Strategies to Implement Improved Water Efficiency through the Implementation of Water Demand Management .....	55
2.6.3	Performance Indicators .....	57
2.7	MINING SECTOR.....	58
2.7.1	Objective to Improve Water Efficiency Mining through Implementation of WDM.....	58
2.7.2	Strategies to Implement Improved Water Efficiency and Service Delivery through the Implementation of Water Demand Management.....	59
2.7.3	Performance Indicators .....	60
2.8	TOURISM SECTOR.....	61
2.8.1	Objective to Improve Water Efficiency in the Tourism Sector through Implementation of WDM.....	61
2.8.2	Strategies to Implement Improved Water Efficiency through the Implementation of Water Demand Management .....	62
2.8.3	Performance Indicators .....	64
3.	CONCLUSIONS AND RECOMMENDATIONS.....	66
3.1	CONCLUSIONS .....	66
3.2	RECOMMENDATIONS .....	67
4.	APPENDIX A: BALANCED SCORE CARD FOR IRRIGATION FARMING.....	68
5.	APPENDIX B: GENERAL BACKGROUND TO WATER DEMAND MANAGEMENT.....	70
5.1	INTRODUCTION .....	69
5.2	EDUCATION AND INFORMATION .....	70
5.2.1	General Campaigns .....	70
5.2.2	Industrial, Commercial and Mining.....	71
5.3	TRAINING.....	72
5.4	ECONOMIC AND FINANCIAL PRINCIPLES.....	72
5.4.1	Economic Aspects and Sustainable Economic Development .....	72
5.4.2	Integrated Resource Planning (IRP).....	73
5.4.3	Price Elasticity of Demand.....	74
5.4.4	Income Elasticity of Demand .....	77
5.4.5	The Role of Subsidies .....	78

5.5	WATER COSTING AND WATER TARIFF POLICIES.....	78
5.5.1	Water Tariff Principles .....	78
5.5.2	Rising Block Tariffs.....	79
5.5.3	Water Conservation Tariffs.....	80
5.5.4	Wastewater Tariffs .....	81
5.5.5	Cleaner Production and Waste Minimisation .....	82
5.6	TECHNICAL ISSUES .....	84
5.6.1	Leakage Management.....	84
5.6.2	Retrofitting plumbing fixtures .....	85
5.6.3	Water Efficient Household Appliances.....	87
5.6.4	Xeriscaping .....	88
5.7	WATER DEMAND MANAGEMENT IN THE IRRIGATION SECTOR.....	88
5.7.1	Introduction .....	88
5.7.2	Measurement of Improved Water Use Efficiency and Higher Crop Yields .....	89
5.7.3	Support Structures .....	89
5.7.4	Establishing of Irrigation Management Institutions.....	89
5.7.5	Establishing a Water Use Efficiency Unit.....	90
5.7.6	Fostering Private-sector Involvement .....	90
5.7.7	Training of Farmers.....	91
5.7.8	Institutional Policies and Control.....	92
5.7.9	Metering of Irrigation Water .....	92
5.7.10	Irrigation Tariffs .....	93
5.7.11	Technical and Planning requirements.....	94
5.7.12	Leaching Requirements and Proper Drainage Systems .....	94
5.7.13	Improved Management on Farms.....	95
5.7.14	Better Matching of Crops.....	101
5.7.15	Covering of Soil to Stop Evaporation .....	102
6.	APPENDIX C: WATER DEMAND MANAGEMENT IN THE IRRIGATION SECTOR.....	103
6.1	POLICIES IN INDIA.....	103
6.2	FEEDBACK AND IRRIGATION EFFICIENCY: ROCKY MOUNTAIN INSTITUTE.....	103
6.3	IRRIGATION EFFICIENCY TECHNIQUES OF FEEDBACK: ROCKY MOUNTAIN INSTITUTE ...	104
6.4	EFFICIENT WATER MANAGEMENT PRACTICES FOR AGRICULTURAL WATER SUPPLIERS IN CALIFORNIA .....	104
6.5	BLYDE RIVER SCHEME IN SOUTH AFRICA .....	105
6.6	HIGH PLAINS UNDERGROUND WATER CONSERVATION DISTRICT IRRIGATION EFFICIENCY .....	106
6.7	BENEFITS OF IRRIGATION WATER MEASUREMENT. ....	106
6.8	BROADVIEW WATER DISTRICT IN CALIFORNIA: WATER PRICING.....	107
6.9	AUSTRALIAN GUIDELINES FOR SPECIFIC CROPS.....	107
7.	REFERENCES.....	109

## LIST OF FIGURES

Figure 5.1: Relationship between Water Price and Volume Consumed.....	75
Figure 5.2: Reduction in Toilet Water Use.....	87

## LIST OF TABLES

Table 1.1: List of Regions with Percentage Poor and Preliminary Subsidy Intervention .....	6
Table 1.2: Water Use and Value Added by Detailed Economic Sectors 2001/02 .....	8
Table 1.3: Summary of Urban Areas with a Reduction in Water Requirements .....	14
Table 1.4: Summary of Urban Areas with an Increase in Water Demand .....	15
Table 1.5: Urban Areas with Potential for Water Savings .....	16
Table 1.6: Summary of Non-revenue Water .....	19
Table 1.7: Summary of Returns to the Department of Water Affairs and Forestry .....	24
Table 1.8: Economic Indicators and Employment for Orange River Irrigation Farms .....	26
Table 1.9: Rössing Example for Water Recycling.....	31
Table 2.1 Category of Local Authority for WDM Classification and Required Measures .....	43
Table 2.2: Proposed Institutional Actions to Improve Irrigation Water Use Efficiency .....	52
Table 2.3: Proposed Farming Management Actions to Improve Irrigation Water Use Efficiency.....	53
Table 5.1: Price Elasticity of Demand.....	76
Table 5.2: Improvements in Industrial Water Use Efficiency in California .....	81
Table 5.3: Scope of Savings in the Textile Industry .....	83
Table 5.4: Specific Crop Water Requirements in South and Western Parts .....	97
Table 5.5: Specific Crop Water Requirements in the North and North East.....	98
Table 5.6: Efficiency of Irrigation Systems.....	99



## LIST OF ABBREVIATIONS

AWWA	American Water Works Association
CAN	Central Area of Namibia
CBM	Community Based Management
CoW	City of Windhoek
CSJV	Central South Joint Venture Consultants
DWAF	Department of Water Affairs and Forestry
DWSSC	Directorate of Water Supply and Sanitation Coordination
EPT	End-of-Pipe Technology
HAN	Hospitality Association of Namibia
IRP	Integrated Resource Planning
IUCN	The World Conservation Union
IWA	International Water Association
IWRM	Integrated Water Resource Management
IWRP	Integrated Water Resource Planning
LCE	Lund Consulting Engineers
LORMS	Lower Orange River Management Study
MRLGHRD	Ministry of Regional, Local Government and Housing and Rural Development
NDI	Net Disposable Income
NACOBTA	Namibia Community Based Tourism Assistance Trust
NHIES	Namibia Household Income and Expenditure Survey
NWJV	North West Joint Venture Consultants
PIT	Processed Integrated Technology
RPL	Recognition of Prior Learning
SABS	South African Bureau of Standards
SCADA	System Control and Data Acquisition
SIDA	Swedish International Development Agency
USEPA	United States Environmental Protection Agency
WDM	Water Demand Management
WEAP	Water Efficient Appliance and Plumbing Group
WHO	World Health Organisation
WPC	Water Point Committee

WRMA Water Resources Management Act  
WSASP Water Supply and Sanitation Sector Policy

### **LIST OF APPENDICES**

Appendix A: Balanced Scorecard for Irrigation Farming  
Appendix B: General Background to Water Demand Management  
Appendix C: Water Demand Management in the Irrigation Sector

## **FORMULATION OF WATER DEMAND MANAGEMENT STRATEGY**

### **1. ASSESSMENT OF THE STATUS AND POTENTIAL FOR WATER DEMAND MANAGEMENT**

#### **1.1 INTRODUCTION**

In the past arid, developing countries such as Namibia have followed the traditional path of providing a water supply through technical and engineering solutions, which generally exceeded the water demand. The previous South African Water Act which was applicable in Namibia supported the provision of cheap access to water for most citizens. This led to a general perception among the public, especially outside Local Authority boundaries, that it is the government's duty to provide water as a cheap and abundant commodity.

This lack of recognition of the true value of water in an arid country such as Namibia resulted in an inefficient and unsustainable water demand, especially when development needs and population growth created a constant, additional increasing water demand. Opportunities to develop new supply-oriented solutions, such as dams in ephemeral rivers in Namibia, and water transfers are limited and extremely expensive. By reducing demand, WDM provides an equivalent alternative to supply augmentation. The sustained decrease in water demand is the same as adding the same amount of water through an additional reliable supply source. Implementation of WDM results in a net financial benefit to the supplier as well as its customers. The environment also benefits from the abstraction of less water, reduced consumption of energy to transfer and heat water, and lower pollution load through decreased discharge of wastewater to the environment.

The independence of Namibia provided an opportunity to rewrite the Water Policy and the Water Act and Water Demand Management (WDM) has found its way into a Water Policy in August 2000 for the first time. This marks an important change that water planners no longer resort only to supply-oriented solutions, but accept new ways to reduce the actual demand for water in Namibia. Although included in the revised Draft Water Resource Management Bill there are no legal mechanisms yet in place to advance the cause of WDM within the water sector. Most of the results reflected in this report are based on individual efforts by service providers and or water users.

#### **1.2 LEGAL FRAMEWORK**

The Water Resources Management Act, 2004 (Act No. 24 of 2004), (WRMA) hereinafter called the Act, makes provision under Section 111 to 113 (revised Draft Act) that the Minister of Agriculture Water and Forestry must determine a water and effluent pricing policy after consultation with interested persons at a meeting invited by the Minister by notice in the Gazette. Subsection (2) of the same section, refers to the approval of tariffs by the Water Regulator in accordance with the approved policy for maximum charges, fees and tariffs relating to the supply of water by water utilities and suppliers to any water user for domestic, commercial, industrial or agricultural use. The status of the WRMA overrules any other law in Namibia with respect to water matters including the setting of tariffs. Although gazetted,

certain amendments were required before the law could be implemented. As a result of the large number of amendments required it was decided in 2008 to rewrite the Act and to repeal Act 24 of 2004.

The role of the Water Regulator is to harmonise and integrate the expectations of consumers and decision makers regarding the price of water supply and wastewater discharge services without compromising the financial viability of the service providers;

The functions of the Water Regulator are:

- to evaluate charges, fees and tariffs for compliance with the water, wastewater and effluent pricing policy;
- to set targets in consultation with service providers and evaluate the efficiency (financial and technical) of water service providers in accordance with performance indicators as required in section 97; and
- to evaluate performance of service providers to increase access and coverage of water related services (water and sanitation) as required in Section 97.

Sections 96 and 97 cover the development of water service plans and water conservation and water demand management strategies. The Minister may prescribe (by regulation) to water service providers and bulk water users such as irrigation schemes, wet industry and mining to develop and adopt water services plans including water conservation and water demand management strategies. In the compilation of regulations required for implementation of conservation and water demand management measures, the Minister must consult with the water service providers, the water industry and the water users having interest.

The Minister may direct:

- a water service provider to supply the information prescribed in the regulations, or any additional information which may be required, when the Water Regulator considers an application for the approval of tariffs or when water users apply for a licence to abstract water;
- any water user to implement more efficient water use practices as prescribed in the regulations.

To implement efficient water management practices the Minister may:

- prescribe and determine performance indicators for water service providers and identified water users to undertake periodic inspections to determine compliance with a water services plan and conservation and demand management strategies;
- advise water service providers regarding the implementation of efficient water management practices within a certain agreed time frame.

The Draft Water Resources Management Bill also provides for remedial action in cases of non-performance or compliance with the regulations and licence conditions. If a water service provider or water user fails to comply with the directives of the Minister, the Minister may issue a notice to the water service provider or water user to take the required corrective

measures to comply with the directive of the Minister within a period of time specified in the notice, but not more than sixty days from the date of receipt of the notice. The ultimate remedy to the Minister is to advertise and ask for tenders to appoint another service provider to render efficient services to communities or to terminate the licence issued to water user.

### **1.3 TARIFF SETTING AND SUBSIDIES**

The implementation of a conservation tariff for all sectors including the irrigation sector to regulate over-abstraction may be easier to administrate than the cumbersome penalty system as contemplated in Section 132 (1) of the Draft Water Resources Management Bill. There is a need for a national policy for water tariffs including irrigation water tariffs in compliance with Sections 106, 107 and 108 of the Bill which give the mandate to the Minister to determine both a water and effluent pricing policy.

#### **1.3.1 Tariff Setting**

In the report on the principles and methodology to calculate costs and tariffs for water supply by Namwater (LCE, 2008) the following fundamental requirements of tariff structures, affordability and service were determined:

1. For any tariff structure to succeed, it is essential that the water users accept the tariff policy as fair.
2. The tariff structure should avoid unnecessary complexity and be readily understandable to water users and others who are expected to make decisions based on water prices.
3. Tariffs need to send out to users the correct economic signal which will further the water supplier's aspirations in the directions of demand management and conservation. (The tariff should be sufficiently high to influence behaviour and reduce wasteful use).
4. Tariffs should ensure revenue stability for the service provider, taking variations in water demand into account.
5. Costs relevant to mining, industrial and commercial enterprises, including irrigation, should be recovered in full from the tariffs.
6. When large increases in tariffs are necessary, they should be introduced in smaller steps over time, so that the increase can be integrated smoothly into production and consumption decisions by all consumers.
7. Social equity in the context of water resources implies that all user groups have fair and reasonable access to the scarce water resources of Namibia. Equitable tariffs also mean that all customers within the same customer group, in a particular water supply area linked to the same infrastructure, should pay the same price. An example of this principle would be that all rural consumers obtaining potable water from the pipeline network in the Central North of Namibia should be charged the same tariff.



8. Water service providers should be accountable to the people within their area of supply. The cost of providing services should be open to the public for scrutiny if required. The way in which tariffs are calculated and levied should be transparent and explainable to consumers.
9. Water service providers should provide accurate and user-friendly monthly invoices at a specific date each month.

It is suggested that the above principles be accepted as interim measures for tariffs to be set by local authorities. For the successful implementation it is important that end-use tariff subsidy and cross-subsidy policy be determined as soon as possible as required in the Draft Water Resources Management Bill.

### 1.3.2 Subsidies

There are only two ways to handle subsidies, namely through:

- Cross sub-subsiding in the water tariff between users; or
- A subsidy from the fiscus.

As stated in the WSASP (2008): “Mechanisms for transparent subsidies and/or cross-subsidisation by means of rebates for those who are unable to pay for water supply and sanitation services should be pursued. It is important that the consumer should know the amount of the subsidy, why the consumer is subsidised and by whom.”

The GINI coefficient for Namibia is 0.604 according to the results of the NHIES 2003/2004. The inequality in the distribution in income decreased from 0.701 in 1993/94, but is amongst the highest in the world. The poorest 30% of the households represent 40.7% of the population earning 8% of the income, whilst the richest 10% of the households represent 5.7% of the population earning 43.5% of the income. In Namibia approximately 3.9% of the households spending more than 80% of their income on food are classified as severely poor and 23.9% are classified as poor spending 60% to 79% of household income on food, (NHIES, 2003/2004). The regions with the highest percentage poor (including severely poor) households are Kavango, Oshikoto, Omusati and Caprivi with 50%, 47%, 47% and 44% respectively. In the Khomas region, only 4% of the households can be classified as poor according to this definition – refer to Table 1.1 below. With the relatively recent (2008), high cost increases for basic foods, it should be accepted that the number of poor households spending more than 60% of their income on food may increase above 28% in Namibia.

Affordability of water is generally a problem for low income households. This group is found in both the urban and rural environments. Considering a norm for water consumption of 40 l/c/day and a household size of 4.5 people per household (National Census 2001), the monthly cost of water @ N\$10.00/m<sup>3</sup> (typical Local Authority water tariff) is N\$ 54.00. The minimum water consumption to ensure adequate health and hygiene standards can be assumed to be 15 l/c/d (NamWater norms for water use at a communal standpipe). At this consumption level, the monthly cost of water to the average household will be N\$ 20.25/month. If the 5% rule as suggested for water use is applied, a minimum annual family income of N\$ 4 860 is required, which is well below the average household income for

many regions. The NHIES (2003/2004) survey determined that the national average income was N\$ 6 139/household.

In urban areas the total cost of land and services is made up of occupational rent (or mortgage repayments), property taxes, water and sewer basic charges, sewer user charges, water consumption, refuse removal and electricity or alternative energy costs such as wood or paraffin. Smaller settlements and rural inhabitants generally receive lower levels of services compared to those provided in larger towns and therefore these costs are particularly low or non-existent in the smaller and rural settlements. In many cases the service costs consist of only the direct cost of services (water and electricity) consumed, thus making them more affordable.

In a study conducted in Rehoboth in 2003, the relation between income level and water demand (income elasticity – family income versus water consumption) was used as an indicator of the number of poor families. It was established that approximately 27% of the consumers (mostly concentrated in the low income areas) consumed approximately 8% of the water. By introducing appropriate tariffs (rising block tariffs, which include an element of cross-subsidisation through a rebate), the cost of water to the low income group was reduced by more than 50% without the middle and high income groups having to pay significantly more (5%) for their water.

The cost of water, in general, is affordable to commercial and industrial undertakings and for domestic consumption to the middle and high income groups. The cost of water to commerce, industry and mining is normally small in comparison to their overall cost structure and is therefore affordable. Cost recovery from these groups is generally not problematic as they can afford to pay for water.

If it is accepted that cross subsidies within a region can handle a poverty component up to 15% and rural subsidies are required between 15% up to 30% poverty index, then the regions requiring subsidy intervention are as listed in Table 1.1. Where the total poverty limit is above 30%, subsidies for both urban and rural areas may be required. Subsidies in urban areas should be restricted to informal areas and depend to a very large extent on the economic activity of the town. Places such as Gobabis in the Omaheke Region may be able to provide baseline water through a cross subsidy (subject to a more detailed assessment of the customer profile), whilst other settlements in the region may require more assistance if they pay for water. If end-users do not pay for water, as in Aminius, the subsidy to all is not defensible because rich consumers which may consume large quantities of water, and do not require a subsidy, benefit the most from such a blanket subsidy.

**Table 1.1: List of Regions with Percentage Poor and Preliminary Subsidy Intervention**

Region	Population National (%)	Severely Poor in Region (%)	Poor in Region (%)	Total Percentage Poor in Region	Subsidy Intervention
Caprivi	4.7	7.1	36.5	43.6	Subsidy
Erongo	5.4	0.4	5.3	5.9	Cross Subsidy
Hardap	3.7	4.9	22.7	27.6	Subsidy Rural
Karas	3.4	3.1	15.4	18.5	Subsidy Rural
Kavango	11.4	8.0	42.4	50.4	Subsidy
Khomas	14.1	0.6	3.0	3.6	Cross Subsidy
Kunene	3.4	11.2	25.7	36.9	Subsidy
Ohangwena	12.9	0.2	22.5	22.7	Subsidy Rural
Omaheke	3.1	12.4	28.0	40.4	Subsidy
Omusati	12.3	1.8	44.9	46.7	Subsidy
Oshana	9.3	6.0	25.3	31.3	Subsidy
Oshikoto	9.4	6.1	40.9	47.0	Subsidy
Otjozondjupa	6.8	3.4	15.3	18.7	Subsidy Rural

Key: Subsidy: A government subsidy to both urban and rural areas may be needed;

Cross Subsidy: Due to the income profile of this Region, it can provide a subsidy to other Regions;

Subsidy Rural: A Government subsidy to only rural areas (Rural Water Supply) may be needed.

#### 1.4 GENDER RELATED ISSUES

Issues of gender and youth are not given prominence in any of the water related legislation currently in force in Namibia. In the National Water Policy, reference to gender is only made in terms of equitable allocation of water and with respect to human resources development. The Draft Water Resources Management Bill makes provision for gender considerations in terms of granting water permits and in the establishment of a Water Advisory Council. However, the National Water Policy and subsequent Water Act are based on Integrated Water Resources Management (IWRM) principles. IWRM approach calls for the involvement of women in the provision, management and safeguarding of water. The constitution of the Republic of Namibia, Namibia's Vision 2030 and the Millennium Development Goals all stress gender equity and equality throughout their texts. These elements undoubtedly provide opportunities for gender mainstreaming in the water sector.

In the review and assessment of the existing situation report, a detailed analysis of the regulations in the Draft Water Resources Management Bill was made with respect to opportunities for gender initiatives. The review shows that many of these regulations are gender neutral but some of them provide opportunities for gender initiatives to ensure that women and youth are involved on an equitable basis. Out of the five WDM instruments described in Appendix A of this report, there is potential to mainstream gender and youth issues in two of these instruments; namely education and information as well as training.

WDM information should be tailor-made to all audiences that is; men, women and youth and should be communicated in media that are reachable to all, such as radio, TV, posters, pamphlets, meetings and workshops. Greater emphasis should be placed on ensuring broad participation and engagement in water-related events, taking into consideration gender and youth representation.

Training and employment in the water sector is still gender-imbalanced. This disadvantages women in terms of technical, financial and managerial tasks thought to be male prerogatives based on perceived advantages. Women should be assured of equal access to finance and training in appropriate water related fields.

## **1.5 RESULTS OF THE NATIONAL RESOURCE ACCOUNTING**

The National Resource Accounts for the water sector were completed in January 2006 for the year 2001/2002. These accounts calculate the water use per sector as well as the value added for each m<sup>3</sup> of water consumed. Agriculture is the major user of water in most countries and Namibia is no exception to this global trend: 73.6% of water use in 2001/02 was for agriculture, about 24.4% in the communal sector and 49.1% in commercial agriculture (Table 1.2). Water for crop irrigation dominated, accounting for 52.5% (commercial & communal) of total water use, while livestock watering accounted for 21.1%. Within the commercial sector, irrigation used much more water than livestock, but in communal areas, water use was roughly the same for crop and livestock farming. In communal areas, irrigation water is used mainly for commercially oriented farming, not subsistence farming.

Over 7 years (1995/96 to 2002/2003), land under irrigation grew by 48% from 6 673 hectares to 9 847 hectares in 2002. Water used for irrigation increased by 44.5%, from 110 million m<sup>3</sup> to 159 million m<sup>3</sup> in 2002. The lower increase in consumption may be a combination of more water efficient irrigation systems, planting of more water efficient crops and development of irrigation in areas with more favourable climatic conditions.

The contribution (N\$) of each economic sector to Gross Domestic Product of Namibia, as published by the National Planning Commission, divided by actual water consumption/use during the same report period is used to calculate the value added per m<sup>3</sup> for the National Water Accounts. (DWAF, 2005)

**Table 1.2: Water Use and Value Added by Detailed Economic Sectors 2001/02**

Economic Sector	Water use Mm <sup>3</sup>	% of Water Use	Economic Indicators		
			% of Employ- ment	% of GDP	Value (NS/m <sup>3</sup> )
<b>AGRICULTURE</b>	202.03	73.6%	24%	6%	4.54
Commercial agriculture	134.95	49.1%	7%	4%	4.61
Commercial Crop Irrigation	108.63	39.6%			0.55
Commercial Livestock	26.32	9.6%			18.44
Communal agriculture	67.08	24.4%	17%	2%	4.41
Communal Crop Irrigation	35.56	12.9%			-0.49
Communal Livestock	31.52	11.5%			9.92
<b>FISHING</b>	0.69	0.3	2%	4%	939.04
<b>MINING</b>	9.13	3.3%	1%	7%	127.20
Diamond mining	0.94	0.3%			891.14
Other mining & quarrying	8.19	3.0%			39.58
<b>MANUFACTURING</b>	6.64	2.4%	5%	11%	260.62
<b>Total for Food Processing</b>	3.61	1.3%	2%	7%	314.31
Meat processing	1.38	0.5%			77.70
Fish processing	0.91	0.3%			218.38
Beverages	1.12	0.4%			451.48
Other food processing	0.20	0.1%			1 645.87
<b>Textiles</b>	0.13	0.1%			194.67
<b>Other Manufacturing</b>	2.91	1.1%	4%	4%	153.19
<b>UTILITIES &amp; CONSTRUCTION</b>	0.51	0.2%	7%	5%	1 170.60
<b>SERVICES</b>	7.92	2.9%	45%	27%	551.92
Trade, Hotels & Restaurants	3.76	1.4%	13%	11%	775.70
Transportation & Communication	0.49	0.2%	4%	8%	2 510.20
Financial & Business services	0.71	0.3%	11%	8%	1 681.43
Social services	2.97	1.1%	17%	1%	45.19
<b>GOVERNMENT</b>	14.15	5.2%	15%	21%	234.16
<b>HOUSEHOLDS</b>	33.6	12.2%	-	-	-
<b>AVERAGE FOR ALL USES</b>	<b>274.67</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>	<b>57.23</b>
<b>Value added without Agriculture</b>					<b>203.76</b>

Notes: All calculations are based on 1995 constant prices. Employment figures for all sub-sectors are not available.

The value added by each sector is important from a national perspective on the efficient use of water. If the volume of water used for an activity such as irrigation and the value of the



crop increase, the water productivity increases. The same principle is applicable to all sectors. Water productivity can be identified as one of the performance indicators for some of the economic activities such as mining and industry.

## 1.6 RESOURCE PROTECTION

Bush encroachment influences surface runoff and groundwater recharge in Namibia. According to studies by the Department of Agriculture approximately 27 million ha of grazing in Namibia are affected by bush encroachment. No scientific studies on the effect of bush encroachment on the recharge of aquifers are available in Namibia but similar studies in South Africa have proved that it is worthwhile to remove invasive plants from catchments to improve groundwater recharge and surface run-off.

During the recent Platveld Aquifer Study<sup>1</sup> conducted by DWAF, a thunderstorm ranging between 60mm and 130mm occurred in the Otjiwarongo area. Observations and water level measurements were made at 4 comparable locations in the study area following the thunderstorm. Three of the locations were covered with dense *Acacia Millefera*, while one was de-bushed. The bush-invaded locations received the higher rainfall of about 130mm, while the latter received about 60mm of rainfall. Sufficient monitoring boreholes were available to estimate aquifer characteristics; hence fairly accurate estimations of groundwater recharge could be made.

At the bush-invaded locations, water levels rose by about 0.2 m. The water level reaction was delayed and observed 2 days after the rain storm occurred, while water levels at the de-bushed location rose by about 2.7 m within 12 hours after the rain storm occurred.

Based on the aquifer characteristics, it was estimated that the groundwater recharge at the de-bushed location was approximately 8%, while it was less than 1% at the bush-invaded locations. Such information for surface run-off is not available but there is consensus amongst scientists that bush encroachment reduces both run-off and groundwater recharge.

Service providers such as NamWater and local authorities which abstract from own boreholes for urban use ( Grootfontein, Tsumeb, Outjo and Omaruru) can play an important role as facilitators to identify areas with water stress where bush encroachment influences surface runoff and groundwater recharge. Pilot projects such as in the Von Bach Catchment and the Platveld Aquifer or the Otjiwarongo Marble Aquifer may be beneficial to quantify benefits over time and to improve security of supply.

## 1.7 STATUS OF WATER DEMAND MANAGEMENT IN BULK WATER SUPPLY

Experience by NamWater has shown that as soon as local authorities start addressing their billing and payment systems and increase the efficiency of these systems, and start addressing the integrity of their reticulation networks, water consumption drops dramatically. A good example of this is Rehoboth, where following such programmes, the annual demand almost halved from more than 2 Mm<sup>3</sup>/a to about 1.2 Mm<sup>3</sup>/a. Another example is Khorixas,

<sup>1</sup> F. Böckmuhl personal communication

where once the local authority had fixed their reticulation system, the consumption dropped by so much that the old supply scheme had sufficient capacity and NamWater had to mothball a newly constructed scheme. In order to avoid investing in additional schemes or infrastructure to supply wastage and losses, it is NamWater's policy to supply bulk water to local authorities at realistic consumption rates (normally based on the calculated theoretical water demand with a provision for losses) and not to increase the capacity of supply schemes until unrealistically high consumption rates have been addressed by the local authority.

There are several NamWater supply schemes with significant losses between the production and sales from the scheme. In a recent study by LCE (2009) on the water supply schemes in the Central North Water Supply Area it was found that non-revenue water in the water supply system is a major concern. In the Central North the difference between the inflow into the scheme and the billed consumption from the scheme (including sales of irrigation water at Etunda) is water for which NamWater receives no payment, and is thus termed non-revenue water and amounts to approximately 46.885 Mm<sup>3</sup>/a, or 74% of the volume pumped at Calueque. The historic billed consumption of 16.205 Mm<sup>3</sup>/a between 1997/98 and 2006/07 was only 26% of the water abstracted at Calueque. For every four units of water pumped at Calueque therefore, NamWater sells only one unit of water. The main cause of the losses is seepage losses, illegal off-takes, unbilled consumption, leakage from pipes and evaporation losses. The greatest portion (over 64%) of this non-revenue water is lost to evaporation mostly at Olushandja Dam.

On some other schemes (North West) major production losses occur such as at Terrace Bay where the production was 45 209m<sup>3</sup> and the sales amounted to 27 086 m<sup>3</sup> for the period from April 2008 to the end of March 2009. NamWater's non-revenue water for the period was 17 370 m<sup>3</sup> (39%). The losses of 39% are attributed to inefficient manual control of the production boreholes which causes regular reservoir overflow. The abstraction from the boreholes is well above the recommended abstraction rate, (NWJV Consultant 2009).

The maintenance of NamWater infrastructure is hampered to a certain extent by the outstanding debt of their clients. The current budgetary allocation (2009 financial year) of approximately 13% of the total NamWater operational budget for maintenance is insufficient to maintain their vast infrastructure at an acceptable level. It is also important that NamWater solve their institutional constraints to achieve the required level of maintenance. For the long term security of water supply in Namibia, it is imperative, and less costly, if funds are directed towards properly maintaining and eventually replacing infrastructure, as opposed to being accumulated as cash reserves, since in a high inflationary environment, the interest earned on capital is much lower than the escalation of costs, (LCE 2008).

A large percentage of the bulk infrastructure requires replacement because it is beyond the economic lifetime of the asset. In many towns in Namibia frequent water interruptions are experienced with accompanied major economic losses. A good example is the bulk infrastructure supplying water to coastal areas which experiences interruptions on a regular base. The daily financial losses to the economy amount to an estimated N\$ 17 million if industry and mining have to stop production in the Erongo Region.

There are some examples where bulk supply water meters were out of order in places such as Fransfontein, Braunfels, Rehoboth and Arandis for extended periods of time. Besides financial losses to NamWater or the local authority, accurate information of bulk water supply is important to calculate water balances on local authority networks. The maintenance/replacement of NamWater meters requires improvement.

On some water supply systems especially in the Caprivi Region, the accuracy of water accounts is a major concern. This creates problems at the water points and leads to consumer dissatisfaction with the payment of accounts.

In some rural areas illegal connections are a concern. It is suggested that illegal connection be registered during a grace period determined by NamWater. To control illegal connections in future it is necessary to address this matter in the National Regulations which need to be compiled for water use efficiency, or alternatively NamWater should promulgate regulations for the regulation of their consumers, especially end users which are supplied directly from NamWater supply schemes..

In many cases NamWater supplies water to end consumers in places such as Herbotsblick which are linked to the same supply system as Windhoek. It is known that high growth in the Central Area of Namibia will require major capital investment. In many cases consumers on the supply system pay different tariffs. Windhoek has a punitive tariff system while consumers in Herbotsblick pay the bulk supply price which is approximately 50% of the cost recovery price in Windhoek. The same applies to Okahandja and Karibib which are also linked to the CAN supply system. To conserve water it is important to apply the same tariff principles to all end consumers linked to the same water supply scheme. This should be included in NamWater contracts with their clients.

The outstanding operational debt to NamWater during July 2008 was approximately N\$ 69.4 million, whilst doubtful debtors amounted to approximately N\$ 160.7 million – NamWater has apparently not adjusted these values and they may not be entirely accurate. According to the Financial Statements for the 2007/08 Financial Year, a provision of N\$ 220 million was made for bad debt. It is of paramount importance that NamWater establish accurate figures of the outstanding debt and finalise these values before the preparation of their next financial statements, (LCE 2008)

The NamWater credit control measures are cumbersome and very difficult to implement. The existing credit control policy is also not in accordance with the Water Supply and Sanitation Policy (2008). NamWater's inefficient credit control measures should be replaced by more appropriate measures in accordance with the requirements of the Water Supply and Sanitation Policy, (LCE 2008).

NamWater is losing personnel and capacity mostly to the private sector and seems to be unable to retain the necessary technical staff to operate and maintain the bulk water supply systems adequately.

Section 6(3) of the Namibia Water Corporation Act, 12 of 1997 allows the Minister to negotiate and conclude, on behalf of the State as the sole shareholder in the Corporation, "the expectations of the Government in respect of the Corporation's scope of business, efficiency and financial performance", as well as "the financial targets which the Corporation

is expected to achieve over periods of at least five years at a time". It should be noted, that even after NamWater has been in existence for more than 10 years, the agreement between NamWater and the Government, regarding NamWater's scope of business, efficiency and financial performance, has still not been concluded. It is important that performance agreement between NamWater and the Government should be concluded as soon as possible. Such agreement should cover not only financial performance but also technical performance with respect to service delivery and proper maintenance of infrastructure.

## **1.8 STATUS OF WATER DEMAND MANAGEMENT THE DIFFERENT SECTORS**

### **1.8.1 Urban Water Sector**

During 2008 the urban water sector including industries in urban areas consumed approximately 69.1 Mm<sup>3</sup> which represents 20.2% of the total water requirement. In Vision 2030 the urban sector is earmarked for the accommodation of the majority of the population (75%) and significant industrialisation and the expected water demand will increase to 117.2 Mm<sup>3</sup>. This represents only 15.2% of the total expected water requirements in 2030.

The general financial and technical management expertise, especially in smaller towns, is limited. Even Municipalities such as Windhoek are losing personnel and capacity mostly to the private sector. In the case of the City of Windhoek they have been unable to fill critical vacancies at operation level for more than one year. This will influence future capacity for the proper management and operation of the Windhoek Artificial Recharge Scheme which is important for water security in the Central Area of Namibia.

The total outstanding debt for services in urban areas is unknown. The total outstanding debt to local authorities amounts to approximately N\$ 450 million excluding Windhoek, Gobabis, Mariental, Swakopmund and Walvis Bay. If these 5 municipalities are included it may be in excess N\$ 900 million. The estimated debt on water accounts may be in excess of N\$ 225 million if only 25% of the total debt is allocated to water. Most local authorities with a few exceptions are not in the position to fulfil their obligations with respect to new capital projects, capital maintenance (replacement of old assets beyond their economic lifetime) or even normal maintenance requirements.

Of all the urban centres in Namibia, only Windhoek Municipality and Rehoboth have water demand management policies and strategies which were approved in 1994 and 2003 respectively. A wide range of WDM measures have been classified in Windhoek as issues involving policy, legislation, technical issues as well as public education and awareness.

The success of the implementation of the WDM Strategy in Windhoek was evaluated by Water Transfer Consultants (2001) and Bulk Water Master Plan Consultants (2004) and the following conclusions were drawn:

- The biggest long term benefit from WDM is keeping the annual growth in water consumption within acceptable limits (lower than 3% per annum) despite high economic growth rates.

- In the Central Area System Update<sup>2</sup> (2001) the reduced consumption was attributed to the following factors: “Firstly, most of the new residential development has taken place in the middle to low income sectors of the community. These sectors of the community use less water than the middle to high and high-income sectors. Secondly, even in the middle and middle to high-income sectors, the new developments have smaller plot sizes, resulting in smaller gardens and therefore less water consumption. After the 1995/96 drought Windhoek residents generally reduced the size of their gardens, and changed the garden types, layout and irrigation methods, all of which combine to reduce water consumption. Also, new appliances such as washing machines, dish washers, toilet cisterns and shower heads are becoming more water efficient.”
- It was also determined that in new developments such as Cimbebasia and Kleine Kuppe the water consumption rates are lower for similarly sized erven than in the rest of the City. This is as a direct result of the City of Windhoek’s WDM policy of developing smaller erven, even for higher income groups. Smaller erven force residents to have smaller gardens, and as a result the water consumption per property is lower.
- The ability of Windhoek residents to improve water efficiency is well evidenced by drought period responses. Unfortunately the City’s Water Demand Management policy has generally been actively pursued only during times of water shortage. The continuous implementation of the integrated approved policy needs to be strengthened. This is by far the cheapest option to stretch the available water sources.
- Recent research shows that there are still some technical aspects that could be addressed such as leakage on private and government properties, pressure reduction and introduction of water efficient showerheads, dual flush toilets and other technical innovations.
- WDM can be a highly cost-effective means of extending water supplies. This is particularly true when one of the water resources utilized is groundwater, since this source has higher value due to its availability during droughts. While CoW is pursuing groundwater banking with artificial recharge, it should also realise that replacing production from groundwater by other means of meeting demand, including WDM, is another form of groundwater banking for use during periods of water shortages in the Central Area of Namibia.
- WDM is unlikely to be effective in the long term if it does not receive consistent attention from the CoW and is constantly monitored. It is strongly recommended that CoW pursues WDM in non-shortage years in order to maximize use of the groundwater bank. If artificial recharge is to be made cost-effective, the storage of excess, lower value water, which is available in high-rainfall years, must be maximized for use as high-value water during drought years.

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<sup>2</sup> Water Transfer Consultants, 2001

The water requirements in some urban centres have declined since 2000. This may be attributed to one or more of the following factors at a specific Local Authority:

- the real increase of bulk water tariffs based on cost recovery since the creation of NamWater in 1996 (price elasticity of demand);
- rising block tariffs applied by some local authorities;
- improved accounting practices and timely delivery of accurate water accounts;
- enforcement of payment for water;
- improvement of metering and water distribution systems by some local authorities; and
- probably as a result of national and local awareness campaigns which have been undertaken since 1992 in tandem with the annual world water day.

The main urban areas are listed in Table 1.3 with an indication of the reduction in water requirements in recent years.

**Table 1.3: Summary of Urban Areas with a Reduction in Water Requirements**

Local Authority	Maximum Water Requirement (m <sup>3</sup> )	Year	Water Requirement 2008 (m <sup>3</sup> )	Percentage Reduction
Arandis	468 808	2004	343 601	26.7%
Aranos	248 435	1999	183 292	26.2%
Aroab	62 357	2000	56 691	9.1%
Gibeon	370 160	2000	133 260	64.0%
Gobabis	750 222	2004	742 847	1.0%
Gochas	69 202	2003	50 621	26.9%
Karibib	289 093	2000	283 092	2.1%
Katima Mulilo	2 578 224	2000	1 348 828	47.7%
Keetmanshoop	1 802 615	2000	1 604 370	11.0%
Khorixas	1 282 328	1999	591 912	53.8%
Maltahöhe	134 678	1999	102 265	24.1%
Okahandja	1 311 450	2001	1 277 615	2.6%
Okakarara	430 979	1999	207 882	51.8%
Omaruru	656 251	1999	526 347	19.8%
Ongwediva	993 255	1999	970 281	2.3%
Opuwo	888 533	2000	357 159	59.8%
Oranjemund	6 450 000	2003	5 479 875	20.0%
Otavi	419 071	2000	311 525	25.7%
Otjiwarongo	1 495 618	1999	1 373 512	8.2%

Local Authority	Maximum Water Requirement (m <sup>3</sup> )	Year	Water Requirement 2008 (m <sup>3</sup> )	Percentage Reduction
Rehoboth	1 945 876	2000	1 112 544	42.8%
Rundu	3 421 390	2002	2 346 184	31.4%
Stampriet	67 717	2001	51 178	24.4%
Tsumeb	2 637 034	1999	997 468	62.2%
Uis	417 351	2001	140 543	66.3%

The above figures include distribution losses.

In most urban areas the water demand has dropped over the past few years despite an increase in population and economic activities. A few exceptions may be towns such as Tsumeb where the closing of the mine affected the economic growth in the town negatively. Despite the reduction in water demand there is still room for improvement. In the “Bulk Water Supply Infrastructure Development and Capital Replacement Master Plans” conducted by NamWater (Most studies are not finalised yet) for the various NamWater supply areas it was determined that in places such as Arandis, Opuwo, Khorixas, Otavi, Otjiwarongo, Aranos, Mariental, Maltahöhe and Ongwediva savings from 20 to 50% may be realised through the implementation WDM initiatives. In most villages high water consumption can be attributed to one or more of the following factors: high losses at government buildings and institutions, inappropriate water tariffs, inefficient administration (infrequent meter reading, poor billing and credit control), low levels of infrastructure maintenance and inaccurate metering.

Water losses including non-payment of accounts are even more critical in proclaimed settlements regulated by Regional Councils. It seems that lack of administrative capacity, unmetered and illegal water connections as well as old infrastructure all contributes to the high water losses. In places such as Aminuis the measured night-flow on 22 April 2007 was 97% of the average flow for 2007, (CSJV Consultants, 2007). Similar exceptionally high water consumption figures were measured in places such as Schlip and Fransfontein.

Table 1.4 is a summary of urban areas with an increased water requirement in recent years. Although the water demand has increased there still could be an improvement in efficiency in water use if the economic development and increase in population is taken into account. The growth rates in most urban areas were moderate except for Oshikango where the water demand increased rapidly at a very high rate.

**Table 1.4: Summary of Urban Areas with an Increase in Water Demand**

Local Authority	Maximum Water Requirement (m <sup>3</sup> )	Year	Water Requirement 2008 (m <sup>3</sup> )	Percentage Increase per Annum
Eenhana	144 407	2002	175 446	3.3%
Grootfontein	2 883 269	1999	3 176 543	1.1%



Local Authority	Maximum Water Requirement (m <sup>3</sup> )	Year	Water Requirement 2008 (m <sup>3</sup> )	Percentage Increase per Annum
Hentiesbaai	379 188	2002	398 944	0.8%
Karasburg	246 288	2003	261 654	1.2%
Lüderitz	1 121 606	2003	1 143 721	0.4%
Mariental	779 357	2001	839 086	1.1%
Ondangwa	731 344	2000	765 449	0.6%
Oshakati	1 289 758	2002	1 406 248	1.4%
Oshikango (Helao Nafidi)	187 500	2001	491 695	14.8%
Swakopmund	2 893 904	2002	3 706 417	4.2%
Usakos	168 283	2003	169 390	0.1%
Walvis Bay	4 684 797	2003	4 861 823	0.7%
Windhoek*	18 967 480	1994	22 372 348	1.2%

\*Consumption in 1994 before WDM was implemented

The average annual growth rate between the two dates (In Table 1.4) varied from 0.1 % to 1.5% except for Swakopmund with a 4.7% growth rate and Oshikango with an average growth rate of 23%. In most places the growth rate over the past 5 years was well below 3% which is acceptable taking the high urban population growth of more than 4%/+annum into account.

A first order assessment was made based on per capita water consumption in 2008 versus a realistic per capita water use in order to identify places with potential water savings. The results are summarised in Table 1.5. It was not possible to determine realistic demand figures for Walvis Bay or Lüderitz because actual water consumption by the fishing industry was not available.

**Table 1.5: Urban Areas with Potential for Water Savings**

Basin/Local Authority	2008 Water Requirement (m <sup>3</sup> )	Per capita use (ℓ/c/d)	Realistic use (ℓ/c/d)	Revised Water Requirement (m <sup>3</sup> )	Percentage Saving
<b>CUVELAI-ETOSHA</b>					
Ogongo	102 513	787	120	15 638	85%
Okahao	280 768	883	120	38 163	86%
Omungwelumbe	36 500	164	120	26 787	27%
Onayena	57 921	204	120	34 021	41%
Onesi	36 500	241	120	18 138	50%
Ongwediva	970 281	175	140	776 442	20%
Oniipa	305 198	402	120	91 108	70%

Basin/Local Authority	2008 Water Requirement (m <sup>3</sup> )	Per capita use (ℓ/c/d)	Realistic use (ℓ/c/d)	Revised Water Requirement (m <sup>3</sup> )	Percentage Saving
Oshigambo	42 241	166	120	30 561	28%
Oshikango (Helao Nafidi)	491 695	246	140	279 967	43%
Oshikuku	188 188	515v	120	43 876	77%
Oshivelo	124 156	267	120	55 881	55%
Outapi	187 889	163	120	138 392	26%
Ruacana-Oshifo	139 334	429	120	38 949	72%
Tsandi	142 790	740	120	23 170	84%
Tsumeb	1 338 884	200	120	803 330	40%
<b>EISEB-EPUKIRO</b>					
Otjinene	96 067	144	120	80 232	16%
Talismanus	31 701	169	120	22 562	29%
<b>KUNENE</b>					
Opuwo	366 311	158	120	278 398	24%
<b>NOSSOB-AUOB</b>					
Aminuis	76 821	295	120	31 201	59%
Aranos	183 292	163	130	145 945	20%
Dordabis	39 231	250	130	20 400	48%
Groot Aub	87 521	150	120	70 017	20%
Kappsfarm	24 129	250	200	19 303	20%
Koes	47 744	137	120	41 766	13%
Leonardville	61 811	171	120	43 329	30%
Onderombapa	29 334	138	120	25 587	13%
<b>OKAVANGO-OMATAKO</b>					
Grootfontein	1 997 826	300	200	1 331 884	33%
Kapako	71 527	406	120	21 121	70%
Kayengona	108 040	272	120	47 666	56%
Mukwe	136 469	432	120	37 914	72%
Muroro-Mashari	94 535	308	120	36 875	61%
Mururani-Gate	26 080	140	120	22 391	14%
Okakarara	207 882	135	120	184 850	11%
Okamatapati	120 705	616	120	23 497	81%
Tsumkwe	72 270	197	120	44 107	39%

Basin/Local Authority	2008 Water Requirement (m <sup>3</sup> )	Per capita use (ℓ/c/d)	Realistic use (ℓ/c/d)	Revised Water Requirement (m <sup>3</sup> )	Percentage Saving
<b>OMARURU-SWAKOP</b>					
Arandis	343 601	213	120	194 000	44%
Aris	31 893	250	200	25 515	20%
Hentiesbaai	398 944	298	150	200 658	50%
Karibib	283 092	187	120	182 076	36%
Okahandja	1 277 615	188	180	1 221 513	4%
Okombahe	94 963	160	120	71 403	25%
Omaruru	581 633	300	120	232 653	60%
Otjimbingwe	76 388	197	120	46 508	39%
Ovitoto	42 397	162	120	31 498	26%
Swakopmund	3 706 417	345	200	2 148 560	42%
Uis	140 543	326	120	51 751	63%
Usakos	169 390	152	120	133 413	21%
Windhoek	22 372 348	199	180	20 190 151	10%
Wlotzkasbaken	7 038	154	120	5 471	22%
<b>ORANGE-FISH</b>					
Ariamsvlei	57 839	356	120	19 515	66%
Berseba	41 955	207	120	24 303	42%
Bethanie	126 308	327	120	46 371	63%
Karasburg	261 654	163	120	192 376	26%
Keetmanshoop	1 746 615	263	180	1 197 005	31%
Maltahöhe	102 265	156	120	78 502	23%
Mariental	839 086	196	150	643 429	23%
Oranjemund	845 612	500	150	253 684	70%
Rosh Pinah, Scorpion	1 180 265	1 761	200	134 070	89%
Schlip	79 145	259	120	36 631	54%
Tses	94 106	274	120	41 219	56%
Warmbad	25 181	409	120	7 387	71%
<b>UGAB-HUAB</b>					
Fransfontein	153 757	733	120	25 175	84%
Kamanjab	77 142	173	150	66 798	13%
Khorixas	591 912	221	150	401 824	32%
Otavi	311 525	139	120	269 844	13%
Outjo	683 692	250	200	546 954	20%

Basin/Local Authority	2008 Water Requirement (m <sup>3</sup> )	Per capita use (ℓ/c/d)	Realistic use (ℓ/c/d)	Revised Water Requirement (m <sup>3</sup> )	Percentage Saving
<b>ZAMBESI-KWANDO-LINYATI</b>					
Bukalo	44 895	387	120	13 930	69%
Chinchimani	73 000	385	120	22 776	69%
Katima Mulilo	1 572 420	157	120	1 198 822	24%
Linyanti	73 000	367	120	23 885	67%
Mafuta	222 285	555	120	48 042	78%

The data to calculate non-revenue water in urban areas are not yet available. According to the various master plan studies conducted by NamWater and other investigations by others, non-revenue water varies from a very low 5% up to 50% in urban areas. Available results are summarised in Table 1.6.

**Table 1.6: Summary of Non-revenue Water**

Town Village or Municipality	Bulk Supply (m <sup>3</sup> )	Water Sold (m <sup>3</sup> )	Non- revenue Water (m <sup>3</sup> )	Percentage
Arandis (2006)	426 285	213 413	212 872	50%
Arandis (2008)	343 601	228 733	114 868	33%
Gochas (2006)	48 170	35 192	12 978	27%
Kalkrand (2006)	37 102	30 072	8 030	22%
Kamanjab (2007)	72 454	48 995	23 499	32%
Khorixas (2007)	504 389	551 103	-46 714	-9%
Maltahöhe (2006)	94 550	58 045	36 505	43%
Mariental (2006)	793 425	698 519	94 906	12%
Opuwo (2007)	366 311	255 340	110 971	30%
Otavi (2007)	276 677	164 162	112 515	41%
Otjwarongo (2007)	1 046 638	983 840	62 798	6%
Rehoboth (2006)	1 285 712	973 270	312 442	26%
Stampriet (2006)	50 429	29 761	17 337	34%

\* Khorixas has intermittent supply and air in the system causes higher sales than bulk supply

The inability of local authorities to recover costs, high non-revenue water and the lack in management skills, make delivery of proper services and proper maintenance of infrastructure impossible in certain urban areas. Proper maintenance of water reticulation, pump stations and reservoirs are reasons for concern. In many urban areas the infrastructure has deteriorated to such an extent that water can only be supplied for a few hours a day as is the case in Khorixas and Kamanjab. LA's are unable to raise funding for infrastructure replacement.

The high cost of non-revenue water makes it almost impossible for local authorities to improve their financial position. If NamWater has a leakage on their system they lose only production and pumping cost which amounts to say N\$ 1 /m<sup>3</sup> (treatment costs and pumping cost) while they expect the local authority to pay N\$ 6/m<sup>3</sup> based on the metered delivery. In the case of Usakos their water network is collapsing, (no money to replace it or do pressure reduction). Their demand went up from 161 560 m<sup>3</sup> in the 2009 NamWater Financial Year to 162 304 m<sup>3</sup> for the 12 months ending March 2010 without any increase in customer sales. Financial cost to Namwater is less than N\$ 100 000, but Usakos must try and recover N\$ 600 000 from consumers to pay NamWater.

The inability of local authorities to pay NamWater accounts has a negative effect on NamWater's income, making it difficult for them to expand and maintain infrastructure properly.

During 2006 an investigation was completed at Arandis to reduce the non-revenue water which was in excess of 50%. In a project including the replacement of a main pipeline and pressure reduction, the non-revenue was reduced to approximately 15%. A consumer survey confirmed that 5% of the consumers were not recorded on the costing system. At least 4 major leakages were indentified and repaired which reduced the night flow by 2.5 m<sup>3</sup>/hour resulting in an estimated annual saving of N\$ 130 000 in bulk water supply costs. A pressure reduction system was installed in December 2008. The cost of the installation was N\$ 250 000 while the estimated savings (based on night-flow measurement) in bulk water supply amounted to N\$ 400 000/annum with a payback period of 8 months. The bulk water supply decreased by 24% between 2006 and 2009 while sales increased by approximately 29%. The net effect of reduced bulk supply cost and increased sales amounts to N\$ 1.24 million based on 2010 tariffs. In the case of Gibeon where pipelines was replaced and system leakages was fixed the reduction in bulk supply from 2002 (379 438m<sup>3</sup>) to 2007 (123.507m<sup>3</sup>) was 255 931m<sup>3</sup> (67.5% reduction) with a money value of N\$ 1.45 million based on 2010 NamWater tariffs.

The present system of assisting local authorities (especially villages) by paying outstanding NamWater accounts does not solve the problem, as the problem will resurface within a few months. It would be a better investment to provide funds to solve the problems to provide a long-term benefit, instead of a quick fix solution by paying the outstanding NamWater accounts. Implementation of Water Demand Management with improved maintenance of infrastructure, and capital replacement can contribute too much needed development of skills and the creation of more employment. Most of the capital replacement schemes such as replacement of water pipelines in urban areas are labour intensive due to the presence of other services on sidewalks which may be damaged.

The migration from rural to urban areas creates a major burden on local authorities to try and deliver services to new residents that are generally unable to pay the full cost of services rendered. There are insufficient funds available to provide water and sanitation services to address the rural urban migration. In the case of Windhoek there are approximately 16 100 households (64 500 residents) which are supplied from standpipes both in legal and illegal settlements around the City.

Maintenance of plumbing systems of government building throughout Namibia is a major concern. In a study conducted by Fourie (2004) night flow measurements were taken at few government buildings in Windhoek. The night flow at the Windhoek Prison is 24 m<sup>3</sup>/h which represents 62% of the average water flow rate for 2002. Similar high night flow rates were recorded at the Augustinium and Centaurus Secondary Schools. In smaller towns such as Leonardville and Maltahöhe the water consumption by government institutions is sometimes more than 50% of the total water consumption for the town.

According to the IUCN Study <sup>3</sup>(1999) the best case examples of water demand management techniques implemented by the urban commercial and industrial sectors were in Windhoek. For example Namibia Breweries has one of the lowest specific water consumption levels (i.e. litres of water used to produce one litre of beer) in the world, at 5 to 6 litres. This is as a result of the integrated approach to water used in the design of the brewery, the incentives to save water that arise from the tariffs structure in Windhoek and the high level of water awareness in Windhoek. In smaller industries, such as meat processing and small scale bottling plants, there are often no financial incentives for water saving investments. Water costs make up a small percentage of total costs, and the amounts of water used are small in comparison. Therefore, any innovation to the existing plant will often be costly and achieve only relatively small cost savings in water. In the other urban centres of Namibia few WDM practices were noted in the industries questioned, although the move towards full financial cost pricing has made most private organisations more aware of the need to use water more efficiently.

There are concerns in areas where LA's are responsible for own supplies such as Omaruru, Outjo, Tsumeb and Grootfontein that abstraction, water quality and protection of boreholes may not be well managed.

The status of WDM with the urban sector can be summarised as follows:

- Except for Windhoek and Rehoboth no other local authority has a WDM policy or implementation strategy;
- There are no legal instruments to enforce WDM within the urban sector;
- There is a lack of information to consumers to reduce their water consumption;
- There is an absence of appropriate water tariffs to curb excessive water use in most urban areas;
- Most local authorities do not compile regular water balances to calculate their non-revenue water;
- Inaccurate metering (only a few LA's with water meter replacement programs) as well as dysfunctional pre-payment water meters contribute to high non-revenue water;
- Government properties in most urban areas or settlements are poorly maintained which contributes to very high wastage and water consumption figures;

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<sup>3</sup> Van der Merwe Editor, 1999

- Most tariff systems are based on a basic charge and a fixed unit rate which does not enhance water use efficiency and in many cases leads to overcharging of low-income households; and
- There is a lack of financial and technical skills for the proper administration and management of water systems in most local authorities.

### 1.8.2 Rural Domestic Water Sector

During 2008 the rural domestic water sector consumed approximately 10.3 Mm<sup>3</sup> which represented 3.1% of the total water requirement. In Vision 2030 it is not expected that the rural domestic sector will grow significantly. The expected water demand will increase to only 11.4 Mm<sup>3</sup> and will comprise only 1.5% of the total expected water requirements in 2030.

During stakeholder meetings there were complaints that the reliability of water supply of many rural water supply schemes is unacceptable due to frequent interruptions as a result of old infrastructure including water pumps and infrequent maintenance. The policy of DWSSC is to try and keep systems operational, but in many cases it is difficult due to old infrastructure.

Government Institutions such as schools, clinics and police stations providing services to rural communities have very high consumption mainly as a result of a total lack of proper maintenance. Although not part of the rural domestic sector, proper maintenance at these institutions as well as maintenance of water schemes or water points seems to be problematic.

Concerns were expressed by stakeholders in the Central North area where water point associations are responsible for branch lines where pipe bursts result in very high accounts from NamWater. If there is a pipe burst on a branch-line which is not detected, NamWater loses N\$ 1 /m<sup>3</sup> (treatment costs and pumping cost) while they expect the water point association to pay N\$ 6/m<sup>3</sup> based on the metered loss. It is important to develop a mechanism to handle such losses.

Historically, supply of water to rural areas has been undertaken through a sense of social justice and as such the government did not recover the costs of water supply. The movement towards Community Based Management (CBM) of rural water points has been instigated to encourage water users to become responsible for their water supply by taking responsibility for recovering the water supply operation, and maintenance costs as well as the management of the system. This was achieved through the creation of Water Point Committee's (WPC's). The collection of money for water consumption and fair tariffs are some of the major obstacles of WPC's and associations. The subsidy policy for water if developed and implemented may help to improve payment.

The establishment of committees, handing over of water points, maintenance tools and books to the treasurers seems to be well handled, but a need was identified for follow-up and continued support from DWSSC. The mobility of people leaving rural areas to reside in urban areas contributes to the inability of many committees to function properly. There is a

need for regular follow-up visits by DWSSC but it is hampered by available transport, and the attitude of officers and others.

Except for NamWater schemes, water quality in rural areas is not monitored regularly. Pollution of boreholes may occur as a result of human activity which may include pit latrines, septic tanks, disposal of solid waste and the position of kraals in livestock farming areas. .

The issue of Water Demand Management in Rural Water Supply has not been specifically addressed in any policy for very good reasons. Recent studies have shown that in rural areas the national mean per capita daily water consumption is 9.9 litre/capita/day. The median for urban areas is approximately 83 litre/capita/day. In Namibia the acceptable minimum water consumption required for good health is stated to be 25 litre/ capita/day (WHO). The capacity of boreholes is planned by Directorate of Rural Water Supply and Sanitation Coordination (DWSSC) using 15 litre/capita/day as a rule of thumb, 45 litre/day per large stock unit and 6 litre/day for small livestock units. It can be seen that the average daily consumption is less than that recommended for good health, thus to look towards rural domestic consumption as a potential area for water demand management policy, seems illogical and any measures can be restricted to improved management and maintenance.

The type of sanitation system selected in rural areas may influence water requirements significantly. It is important that with the implementation of the National Sanitation Strategy availability of water should be considered.

The biggest challenges in rural areas are:

- Recovery of costs by Water Point Committees to pay NamWater or for the operation and maintenance of the water points;
- Persons leaving rural areas create problems with continuity of committees;
- Implementation of a subsidy scheme to assist the poor;
- Devising a mechanism of how to bill water resulting from pipe bursts in branch lines;
- Improved reliability of supply with fewer interruptions ;
- Proper maintenance of water infrastructure and in some cases replacement or upgrading of existing infrastructure;
- More frequent monitoring of water quality in schemes not supplied by NamWater;
- Prevention of pollution of water sources; and
- The need for more regular visits and assistance from DWSSC.

### **1.8.3 Irrigation Water Sector**

During 2008 the irrigation water sector consumed approximately 135.3 Mm<sup>3</sup> which represents 41.4% of the total water requirement. In Vision 2030 the irrigation sector is earmarked for major development and the expected water demand will increase to 497.2 Mm<sup>3</sup> which represent 64.4% of the total expected water requirements in 2030.



From previous inspections, Bäumle (2004) reported the most common violations of the licence conditions to abstract water for irrigation were the following:

- The allocated water quota is not used or not used to its full extent;
- Water is used inefficiently;
- The actual abstraction exceeds the permitted quota;
- No water meters are installed;
- No returns of the abstracted volumes of water are submitted.

To address the above malpractices by licence holders it is suggested that all suspect properties be inspected and that permits be changed to temporary licences, which places the onus on the farmer to come forward with motivation why the permit/licence should be extended.

The returns, which are required from irrigation farmers, are not taken seriously as is shown in Table 1.7.

**Table 1.7: Summary of Returns to the Department of Water Affairs and Forestry**

Year	Number of Licences	Returns Received	% Returns	Returns Complete	% Complete	Irrigation Areas <1ha	% 1 < ha
2003	78	24	30.8%	4	5.1%	37	47.4%
2004	83	30	36.1%	11	13.3%	37	44.6%
2005	78	44	56.4%	12	15.4%	37	47.4%
2006	86	50	58.1%	13	15.1%	37	43.0%

It is clear from the information in Table 1.7 that most of the farmers do not comply with the licence conditions as stipulated.

Karst Aquifers are very susceptible to pollution. Strict licence conditions should be specified for point pollution sources such as mines and wastewater treatment plants as well as diffused sources of pollution such as irrigation farms. Effluent from wastewater treatment plants is covered in Part XIII of the WRMA. Mines will also require effluent licences for discharges into the environment.

According to the draft regulations for artificial recharge of aquifers under the heading "Unintended Recharge of Aquifers" the following is required.

"The Minister may request any person that may cause pollution of an aquifer (or receiving water that may recharge an aquifer) through diffused sources or point sources by discharging of wastewater (domestic, process or industrial), run-off or infiltration of any water originating from any human activity such as from mine dumps, irrigation drainage water, leaching of refuse dumps, or any other activity including the use of underground storage tanks, to do a proper investigation to:

- determine the effect of such an activity on the quality of sub-surface water;

- determine the type and extent of such pollution;
- propose methods to prevent pollution from occurring, or mitigating effects, or remedial measures once pollution has occurred.

A person shall do remedial action to stop such pollution within a time frame prescribed by the Minister provided that if such remedial work is not completed within the prescribed timeframe, the Minister may appoint another contractor to do the remedial work for the account of the polluter”.

Although not yet promulgated, such conditions can be included in new abstraction licences with the proviso that the licence for abstraction will be cancelled Section 93 of the Act until the pollution problem has been resolved. This approach will address the main cause of the pollution. This is in accordance with the Licence issued for effluent disposal in the environment as described in Part XIII regulating “Water Pollution Control. In Section 88 (1) provision is made that the Minister may cancel the licence to discharge effluent.

In terms of Section 136 (2) (b) of the draft Water Resource Management Bill, a person may be fined N\$ 25 000 or imprisonment of 5 years or both for pollution of a water source. With a second conviction the penalties are N\$ 500 000 fine or imprisonment of 10 years.

Farmers need to be sensitised about the high risk of pollution in Karst Aquifers. Irresponsible irrigation where plants are over irrigated resulting in higher demands for fertiliser and pesticide, will increase nitrate and pesticide concentrations in the Karst Aquifer. Measures should be put in place to prevent such pollution. In order to monitor pollution by diffused sources such as irrigation schemes it is suggested that registers be kept by the farmers showing the type, quantities and frequency of application of fertiliser, pesticides and any other chemicals utilised in crop production.

In any irrigation scheme there is an accumulation of chemicals in the soil over time. The normal practice to remove such an accumulation is by periodic flushing of the chemicals through over-irrigation, possibly once a year as practiced along the Orange River at Aussenkher. The water accumulates in drainage channels, which may eventually end up in the river.

Accumulation of chemicals in a Karst area which may be “washed out” into the aquifer by periodic flushing or high intensity rain cannot be disregarded and requires special attention by both the irrigation farmers and DWAF. It is suggested that this matter be investigated further by DWAF to protect the aquifer from pollution. The minimum requirement is to monitor boreholes in the vicinity of irrigation schemes for nitrates and known pesticides/chemicals applied to the crop at least on an annual basis.

Protection of boreholes through proper stand pipes and concrete aprons of at least 5 x 5 m should be a requirement to prevent direct pollution of boreholes. The Ramotswa Karst aquifer south of Gaborone was polluted by nitrates from pit latrines to such an extent that the water is no longer suitable for human or animal consumption. Once a Karst Aquifer has been polluted, rehabilitation is almost impossible.

Commercial irrigation water for schemes such as Hardap, Naute and Etunda accounts for some 40% of the water supplied by NamWater each year. The water provided to farmers

from the Hardap Dam is sold at a price which is lower than the price charged by NamWater to the Ministry. This can be regarded as a subsidy. Water sold to irrigation farmers is not metered and the quantities billed are based on the allocated quota for each farm.

In areas such as Stampriet and in the Karst Area, commercial farmers abstract groundwater for irrigation subject to a permit issued by DWAF. They are responsible for their own infrastructure including the energy required to abstract water except in the Stampriet artesian areas. It is a requirement that abstraction must be metered and reported to DWAF. Reporting by irrigation farmers is mostly not done in accordance with the permit conditions.

It is known that certain crops add very little value or job opportunities. In a recent study done in South Africa on the development potential along the Orange River, the following information was collected along six river stretches in a survey of 168 selected farms with a variety of cash crops (predominantly maize and wheat) and perennial crops (predominantly table wine, dry and juice grapes).

Table 1.8 represents some economic parameters for the various regions and indicates the Gross Income (GI), Net Disposable Income (NDI) and number of direct job opportunities, (Van der Merwe, 2004).

**Table 1.8: Economic Indicators and Employment for Orange River Irrigation Farms**

Item	VDKL-HT	PD	Boegoe	Upkeim	Kakamas	AugBlou
Gross income (R/ha)	12 255	11 978	17 002	38 168	41 657	91 034
Total gross margin (R/ha)	4 976	5 589	7 097	14 124	17 104	46 834
NDI (R/ ha)	2 030	2 259	3 310	7 491	9 703	22 042
Water use (m <sup>3</sup> ha)	11 000	10 000	15 000	15 000	15 000	15 000
NDI (R/m <sup>3</sup> )	0.18	0.23	0.22	0.50	0.65	1.47
Labourers per ha irrigated	0.07	0.03	0.50	1.45	1.20	2.10

VDKLHT= Vanderkloof/Hopetown

PD= Prieska/De Aar

Boegoe=Boegoeberg Dam

Upkeim= Upington /Keimoes

AugBlou= Augrabies/Blouputs

NDI = Net Disposable Income.

It is clear from Table 1.8 that there are major differences in the contribution to the economy if the gross margins, net disposable income and number of job opportunities are compared for the different areas. In evaluating water use in primary economic activities such as Agriculture, it is useful to consider the entire 'value-chain,' ie. the 'upstream' and 'downstream' activities, which are linked as suppliers of inputs to, or users/processors of output from the primary activity. This is an important area for future research.

If ground water is utilised for irrigation it is imperative that the water should be used on crops that add the maximum value as well as the number of job opportunities. Detailed information of value added per m<sup>3</sup> water used for different crop types is not readily available within Namibia. It is suggested that value added through the use of water, including the number of job opportunities created by such irrigation activity be included in the assessment of

irrigation schemes. One of the irrigation farmers near Tsumeb indicated that they add value of approximately N\$5 /m<sup>3</sup> of water utilised on that specific farm (2006 figure).

The potential saving of water in the Hardap Irrigation Scheme is limited to an estimated saving of 10% through scheduling and a further 10% saving on the reduced consumption through tariffs and metering. Approximately 85% of all the irrigation fields are levelled using laser levelling which limits future savings that could result from the installation of improved high technology irrigation systems. Over-irrigation by farmers at Hardap cannot be measured and it may be a problem which enhances the excessive growth of reeds in the Fish River.

Estimated saving along the common border area with the RSA was estimated at 5% through scheduling, 10% through proper metering and conservation tariffs for over-abstraction and 9% through the installation of improved irrigation systems. The general management of irrigation systems as well as crop water requirements seems to be well managed at most of the farms at the Aussenkehr.

No information is available for irrigation efficiency for the Naute and Etunda schemes. Information on irrigation efficiency is not available for the Karst and Stampriet irrigation areas. Where farmers are responsible for their own infrastructure and associated energy cost to abstract water, it can be expected that the efficiency will be higher.

Farmers normally tend to over-irrigate. The return flow and the excessive drainage water normally flows back into the river by overland flow and return seepage. In certain areas, this return water can be nutrient enriched and polluted with fertilizers, herbicides, pesticides and other pollutants that could affect the water quality of rivers, streams and groundwater.

Very little information is supplied by the DWAF Agriculture Division to irrigation farmers, but some is provided by the Agronomic Producer Association and sharing of knowledge at Aussenkehr. Meeting, but not exceeding the actual crop water requirements increases production. This information is often not available to irrigation farmers.

The current status of WDM within the irrigation sector can be summarised as follows:

- Only a few irrigation farmers complete the annual returns to DWAF and the actual volumes of water used is unknown;
- Because returns are not completed the over- or under-utilisation cannot be assessed;
- The extent of pollution resulting from irrigation areas is unknown;
- Metering and tariffs for irrigation water are inadequate;
- Information for proper scheduling is inadequate;
- Inadequate information is provided to farmers regarding improved crop yields which are linked to improved irrigation efficiency; and
- Maintenance of both canals and on-farm irrigation systems is inadequate.

#### 1.8.4 Livestock Water Sector

During 2008 the livestock water sector consumed approximately 86.9 Mm<sup>3</sup> which represents 26.6% of the total water requirement both in commercial and rural areas. The figure includes an allowance of 50% for wastage which may be high. No significant growth is expected in the livestock sector and the expected water demand will stay the same and will only comprise 11.3% of the total expected water requirements in 2030. Growth in the livestock sector can only occur if bush encroachment is controlled. If de-bushing is actively promoted the carrying capacity will increase and the additional water required can be obtained from water savings from enhanced groundwater recharge.

Since livestock are larger users of water, DWSSC designed systems based on the carrying capacity for a specific area to try and manage land degradation and overgrazing. The capacity of boreholes is planned by DWSSC using 45 litre/day per large stock unit and 6 litre/day for small livestock units. Payment for water is determined by the Water Point Committees. Some charge a fee per head of livestock while others pay a flat rate irrespective of the number of livestock. The issue of groundwater depletion and or pollution and the wider social effects that might result are highly relevant to rural water supply, most of which comes from boreholes. Wastage at cattle troughs occurs mainly as a result of poor maintenance.

In communal areas where NamWater supplies water they charge cost recovery prices to the consumers. With rural water supply, technical and management services are provided to the different water point committees free of charge. The aim is to gradually introduce cost recovery prices that cover the operational and maintenance costs of such infrastructure.

The maintenance of water infrastructure on resettlement farms was neglected by beneficiaries to such an extent that it affected the production on the farms.

Commercial farmers use water mainly for stock watering. The farmers are largely responsible for developing and maintaining their own water supplies from groundwater and farm dams and there are no accurate consumption figures available. The scope for implementation of water demand management on commercial livestock farms is limited and most farmers try to lower their input costs (pumping cost) as they do not have any control on the price that they get for their product.

There are a large number of small farm dams in the commercial farming areas. Most of the dams were constructed to provide water for stock farming and to enhance recharge of boreholes. The evaporation from these dams is very high. Some of the dams act as evaporation ponds due to siltation. It is considered that the large number of dams in the catchment of the Von Bach Dam may influence the run-off into the dam.

Bush encroachment is influenced by farm management practices, overgrazing, prevention of veld fires which control the growth of bush and the absence of animals such as rhino and elephant which control the growth of bush. The ever increasing global levels of carbon dioxide (CO<sub>2</sub>) in the atmosphere contribute significantly to the growth rate of bushes in the country. The biomass of bush is much higher than grass and there are major declines in surface water run-off and lowering of rest water levels which may be attributed to bush encroachment. No scientific studies on the effect of bush encroachment on the recharge of

aquifers are available in Namibia but similar studies in South Africa have proved that it is worthwhile to remove invasive plants from catchments to improve groundwater recharge and surface run-off. An integrated approach to land management practices in sensitive areas such as the Von Bach Catchment and important aquifers such as the Karst and Platveld or the Otjiwarongo Marble Aquifer is required to address bush encroachment especially in areas supplying water to urban areas.

A case study in the Otjiwarongo area confirmed that evapo-transpiration is very high in areas with high levels of bush encroachment (mostly swarthaak). The water consumption by these plants as a result of bush encroachment over large areas, prevents recharge of aquifers and far exceeds the water consumed by the stock farming. It was demonstrated that on farms where de-bushing has been implemented there was a rapid recovery of water levels when compared to farms with high swarthaak density.

The type of bush encroachment (sekelbos) in the Karst Area differs from that in the Otjiwarongo Area and the magnitude of losses through evapo-transpiration that prevents recharge of aquifers is unknown. It will require major studies over many years to get accurate figures on the benefits resulting from a reduction of the bush densities. It is not clear if the same advantages as observed in the Otjiwarongo Area will manifest in the Karst Area as a result of de-bushing. It may be worthwhile to start monitoring farms where de-bushing is in process to get tangible information for decision-making.

Theoretically the water demand of a plant is related to the bio-mass, provided that it is from the same main species. The water requirement of grass will be lower than shrubs but the exact savings in the Karst environment is unknown. It is known that in some areas the livestock carrying capacity has been reduced by up to 50% as a result of overgrazing and the resulting bush encroachment.

Controlled de-bushing is a proven method of increasing the availability of groundwater and surface run-off and thereby enhancing economic growth. It is suggested that service providers and farmers (both commercial and communal) combine efforts to address bush encroachment on a national basis.

The extent of pollution of groundwater in both communal and commercial farming areas as a result of livestock farming is unknown. It is important to sensitize all farmers about the dangers of pollution (mostly nitrate) from concentration of livestock in kraals, near boreholes or even around surface dams. Regular monitoring of water quality of rural and farm boreholes can contribute towards awareness.

In order to reach the targets as set for the Agricultural Sector and other sectors such as Urban in Vision 2030 it is important to implement a national strategy with targets to address bush encroachment. This will contribute to the growth of the GDP through increased production of meat (resulting from higher fodder availability) as well as the benefit of increasing groundwater recharge and surface runoff.

### 1.8.5 Mining Sector

During 2008 the mining sector used approximately 16.1 Mm<sup>3</sup> which represents 4.9% of the total water requirement. The expected water requirement will increase to 20.3 Mm<sup>3</sup> which represents only 2.6% of the total expected water requirements in 2030. The figure of 20.3 Mm<sup>3</sup> excludes water provided from unconventional water sources such as brackish water, sea-water and desalination.

Mines which are provided with water by NamWater are supposed to get their water at a cost recovery price. The full cost recovery to supply water has not been calculated for a few years. During an assessment of the cost allocation and calculation of full cost recovery prices on Namwater schemes (LCE, 2008) it was found that for the 5 mines Otjihase, Rosh Pinah, Skorpion, Navachab and Rössing the full cost recovery to provide water to the mines was N\$ 11.2 million more than the income derived from tariffs for the 2009 financial year. The full cost recovery price for the two mines Rosh Pinah and Langer Heinrich was slightly lower than the tariff charged.

When operating mines such as Kombat and Tsumeb dewater their underground workings some of the water is utilised for their processes. In the case of Kombat the surplus mine water was sold to NamWater for distribution via the Eastern National Water Carrier mostly in the Kambazembi Area.

Mines normally apply the principles of Best Affordable Techniques Not Exceeding Economic Cost (BATNEEC) for decision making to maximise the profit of the mine during its lifetime. This implies that if water is cheap or subsidised there is no incentive for the mine to invest in infrastructure or process optimisation to save water as this will influence the profit margin of the mine. Hidden environmental cost such as groundwater pollution as a result of high infiltration is normally not reflected on the income statement of mines. If the mine closes because of market trends or exhaustion of ore reserves, the cost to clean up the environmental pollution is normally carried by the Fiscus and not the mine.

On the whole, the mining industry is fairly diligent when it comes to the management of water for industrial purposes. This diligence arises for a number of reasons including:

- The large amount of water used;
- The high expenditure on fresh water supply although the proportion of the cost of water in comparison with total cost of mining may be low;
- The need for precise inputs of water in the mining processes;
- The proximity of certain mines to alternative inputs such as seawater;
- The proven financial benefits of alternatives like recycling from the slimes dams; and
- Environmental obligations (e.g. voluntary compliance with ISO 14001 and other requirements such as water and mining laws, International Council of Mines, charter ethics of the Chamber of Mines and safety fundamentals).

It appears that mines are confronted by economies of scale when it comes to water saving strategies due to the large quantities of water they use. It has become viable for some mines to take unilateral action to save water. Examples include Rössing and Navachab mines, both

of which are fairly large and sophisticated and can seemingly exploit economies of scale in water saving techniques, such as large scale recycling.

Since 1977, the amount of fresh water used by Rössing Mine has decreased dramatically from 26 000m<sup>3</sup>/day (9.5Mm<sup>3</sup>/a) to 7 500m<sup>3</sup>/day (2.7Mm<sup>3</sup>/a) in 1997, this in spite of higher production by the mine. However, the total amount of water used by Rössing has returned to 1977 levels, the fresh water being largely made up by the use of recycled water. The comparison is made in Table 1.9.

**Table 1.9: Rössing Example for Water Recycling**

Source	1977 (Mm <sup>3</sup> /a)	1977 (%)	1997 (Mm <sup>3</sup> /a)	1997 (%)
NamWater	9.5	100	2.6	27.66%
Recycled	0.0	0.0	6.5	69.15%
Brackish	0.0	0.0	0.3	3.19%
TOTAL	9.5		9.4	

These figures are based on information contained a booklet called “the Story of Water at Rössing Uranium Mine” and are estimate from a graph in the booklet.

It is evident that Rössing Mine finds the water management strategy less costly than obtaining all its water from NamWater. A brief financial cost benefit analysis by Rössing themselves shows that the benefits outweigh the costs by approximately N\$67 million per annum (1994) and as such, there are obvious incentives for them to undertake these measures.

However, there are considerable savings possible in many of the mines addressed. An obvious example include Oranjemund mine where, although certain water management practices are undertaken in the mining process the practices undertaken in the town associated with the mine leave much to be desired. Namdeb provides water to the citizens of Oranjemund at no charge. Water is paid for through the general taxation in the town and as such the marginal costs of water usage to the residents are zero. This leads to huge figures of water consumption of up to 16m<sup>3</sup> per household per day. In Windhoek it is found that the consumption averages about 200 litres per person per day. If the average household has 6 persons, this leads to a consumption of 1.2m<sup>3</sup> per household per day, which 14.8m<sup>3</sup> (13 times) lower than in Oranjemund.

Indeed, if the per household consumption in Oranjemund was reduced to the levels attained on average in Windhoek, approximately 8% of the water would be required. This would mean savings in the order of 6 Mm<sup>3</sup>/a, for Oranjemund. This quantity of water represents a significant proportion of the 40-50 Mm<sup>3</sup>/a initial entitlement of water from the Orange River for Namibia. (Oranjemund water comes from a groundwater scheme which derives its recharge from the river – so the comes only indirectly from the river.)

The cost of WDM in the mining sector is normally included in their operations cost. In most cases, major cost savings can be realised by mines by recycling water. Further water saving options by the current mines is limited, except for mining towns.



### 1.8.6 Tourism Sector

During 2008 the tourism sector used approximately 19.6 Mm<sup>3</sup> which represents 6.0% of the total water requirement. The tourism sector was identified as a high growth sector in Vision 2030 and the expected water requirement will increase to 38.9 Mm<sup>3</sup> which represents 5.0% of the total expected water requirements in 2030.

Schachtschneider and Nashipili, (2002) carried out an assessment at 6 tourism facilities in Namibia. The water use patterns showed that visitors used between 4% and 20% of all water supplied. Staff consumption, leakage and watering gardens were independent of visitor numbers and made up the bulk of the water used.

The following observations were made:

- Water use was influenced by a number of variables. Water use within an enterprise varied over time and was influenced by temperature, rainfall and visitor numbers. Water use varied significantly and depended on the scale and design of the facility, as well as the approach to water management. Where water saving had been included in the design and construction of a facility and followed up during operation, maximum efficiency was achieved. Due to these many variables, it was difficult to quantitatively determine water use efficiency for any single study site and it was thus impossible to compare water use efficiency between sites.
- Facility managers are the major decision makers who decide on how water resources are managed. The willingness of facility managers to adopt WDM in their approach to water management depended on water availability, the cost of water, controls by external institutions and the commitment of the company towards the protection of the environment.
- No single “best” or “easiest” WDM approach was identified during the study. However, the results suggest that sound maintenance and efficient irrigation of landscape areas resulted in substantial water savings at several study sites. Best results were obtained through a combination of site-specific WDM approaches.
- The water audit, as a data gathering tool, had a direct influence on resort managers, making them consider and implement an increasing number of WDM approaches during the study period. Each facility had at least doubled the number of WDM approaches adopted during the year of the audit. It suggests that regular contact, ongoing monitoring and constant reinforcement of WDM by an outside water audit team can in itself act as a promotional WDM tool.

More recent studies at Okaukuejo and Namutoni concluded that major wastage results from infrequent or no maintenance of plumbing systems especially at the staff facilities (NWJV Consultants 2009). Night-flow measurements were not available but it was estimated that savings up to 40% are possible at both camps.

Very few tourism facilities sensitise their own personnel and visitors to improve water use efficiency. Previous campaigns to sensitise tourism operators on water use efficiency seemed to fade away, as very few tourism establishments display signs to improve water use efficiency.

## 1.9 CONCLUSIONS

It is clear from the information supplied in this chapter that there were reductions in water supply in most of the listed urban areas. Despite relatively high reduction in water use, further savings from 20 to 50% may be realised in places such as Arandis, Opuwo, Khorixas, Otavi, Otjiwarongo, Aranos, Mariental, Maltahöhe and Ongwediva through the implementation WDM initiatives, as reported in some of the recent studies by NamWater (Central South Joint Venture Consultants, 2007 and LCE 2009). Water savings in settlements seems to have major potential as indicated in places such as Schlip and Aminuis. Target figures for potential saving (based on per capita water consumption figures) through WDM strategies in urban areas varies from 4% to 85% while non-revenue water varies from 5% to 50% in urban areas.

Due to the relatively low demand requirement in rural areas, varying from 15 l/c/d to 40 l/c/d, the potential for saving from water demand management is limited except for government institutions providing community services (schools, hostels, clinics). Leakages at water cattle troughs may present the only opportunity to save water. Along rural pipelines, government buildings in settlements should be targeted to reduce water wastage through improved maintenance.

Very little information is available on water use efficiency at mines, except for Rössing and Navachab where water is recycled. In a place such as Oranjemund where the mine supplies free water to inhabitants the water consumption is exorbitant, reaching more than 10 times the average water use in Windhoek.

The potential for the reduction of the water requirement for livestock farming is limited. De-bushing should be addressed through an integrated approach by service providers and farmers as it influences not only the availability of fodder but also groundwater recharge and surface run-off.

The irrigation sector accounts for a large percentage (41%) of the water used in Namibia and offers potential savings of between 15 and 25% through the implementation of WDM initiatives.

Very little information is available on the potential for water savings in the tourism sector. Lack of maintenance at resorts operated by Namibia Wildlife Resorts is documented and at some resorts savings from 30 to 50% may be realised through improved maintenance.

It can be seen from the discussion above that there exists considerable potential for Water Demand Management to be implemented in the different water use sectors to improve general efficiency within the sectors.

Prevention of pollution and monitoring of groundwater and surface water sources must be addressed by all sectors.

## 2. WATER DEMAND MANAGEMENT SECTOR STRATEGIES

### 2.1 INTRODUCTION

The proposed strategies are designed to keep the process as simple as possible.

The following steps were identified for the implementation of a WDM strategy in all water use sectors in Namibia:

3. Carry out a situation assessment which covers:
  - Water use and conservation planning goals, historic water requirements, water use efficiency, infrastructure characteristics, non-revenue water, customers profile if applicable, management practices and pollution potential of the activity/entity;
  - The preparation of a demand forecast without water savings to estimate the extent of supply augmentation required to satisfy the water demand including the estimated capital and operational costs;
  - The identification of WDM initiatives, expected water savings and price them based on Unit Reference Values (URV);
  - The determination of required capital & human resources for implementation;
  - The evaluation of the effect of savings on both the service provider & consumer; and
  - The effect of sanitation provision in area of jurisdiction if applicable.
4. Develop an implementation and monitoring programme for the performance indicators to measure the improved efficiency over time in relation to the target set in the implementation programme.

The strategies for the different sectors to implement WDM measures and performance indicators were developed in consultation with service providers in all 13 regions through discussions in focus groups. The WDM strategies include legal, institutional, capacity building, financial and technical requirements as well as customer care where applicable.

### 2.2 BULK WATER SUPPLY

During 2008 NamWater supplied approximately 66.9 Mm<sup>3</sup> of treated surface water and groundwater to the urban water sector, mining sector, tourism facilities and rural water supply schemes (taken over from DWSSC) as well as to a large number of end-users. NamWater also supplies water to many of the government institutions such as border posts, police stations, schools, hostels and clinics which use excessive amounts of water mainly a result of non-maintenance of plumbing systems in buildings.

Irrigation water (50 Mm<sup>3</sup>/a) was supplied at Hardap and Naute Dam and in the central north to Etunda and Mahenene.

The main challenges for NamWater are the reduction of production losses, improved maintenance of infrastructure including capital replacement, security of supply in areas with high economic growth, outstanding debt to which local authorities contribute significantly, a cumbersome credit control policy, high capital investment for additional supply (Erongo Region), poor metering and accounting (mostly in rural areas), branch-line losses as result of pipe breakages, illegal connections, loss of professional personnel to the private sector and the cumbersome process of getting approval for tariff increases from the Cabinet.

From a national perspective, security of supply and the condition of supply infrastructure in high growth areas such as the Erongo and Khomas Regions are of concern due to the high economic losses in case of interruption of bulk water supply. It is important that a performance agreement between NamWater and the Government as required in the NamWater Act should be concluded as soon as possible. Such agreement should not only cover financial performance but also technical performance with respect to service delivery and proper maintenance of infrastructure.

### **2.2.1 Objective for Bulk water supply is to Improve Water Efficiency and Service Delivery through the Implementation of WDM**

The overall objective for the bulk water supplier (NamWater) is to improve service delivery by ensuring efficient and effective bulk supply services at a high level of security of supply, with the necessary capacity (legislative, human and financial) to provide socially accepted services provided that the environment and the ability of NamWater to become financial self-sustaining are not compromised.

### **2.2.2 Strategies to Implement Improved Water Efficiency and Service Delivery through the Implementation of Water Demand Management**

#### **LEGAL AND POLICY REQUIREMENTS**

**Strategy: Establish and implement legal instruments to support WDM in bulk water supply sector**

The following measures should be taken to implement WDM successfully:

- The Water Resource Management Act and the Regulations which control the activities of Service Providers such as NamWater, and also control licensing, compliance with the implementation of WDM and Water Conservation strategies, should be finalized and implemented.
- Appointment of the Water Regulator to streamline the approval of bulk water tariffs when required.
- The national policies and principles for equitable and conservation orientated end-use water tariffs and for the subsidy or cross subsidy should be finalized.
- Compilation of a National Water Supply Regulation to assist NamWater and other suppliers to enhance WDM practices and to make provision for a penalty tariff for

unauthorized use of water to curb illegal connections and water use.

### **INSTITUTIONAL DEVELOPMENT AND CAPACITY BUILDING**

**Strategy: Enhance institutional development and capacity building at all levels to implement WDM**

The following measures should be taken to enhance institutional development and capacity building:

- Participation of NamWater in the Performance Support Teams to assess the performance of LA's where required and to develop operational management plans with Objectives, Actions, Resources Required, Responsible Agents, Performance Indicators, Target Dates, Milestones and Outcomes to implement WDM;
- Provide on-the-job, hands-on training and capacity for technical infrastructure management, maintenance and financial management;
- Establish mentoring programmes for institutions and individuals;
- Develop technical skills programmes for water;
- Create performance based incentives to retain expertise, provide mentors to assist employees and promote sharing of expertise between authorities;
- Foster public private partnerships or outsource specific functions to the private sector.

### **FINANCIAL REQUIREMENTS/CAPACITY**

**Strategy: Improvement of the financial performance of NamWater including funding for implementing WDM initiatives and capital replacement**

The following measures should be taken in order to improve NamWater's financial performance and provide funding to implement WDM successfully:

- Develop end use tariffs (including conservation tariff) for recovering costs from end users which get water directly from NamWater schemes especially in areas with water scarcity;
- Develop and implement a strategy on how to handle and recover costs for water losses on branch lines as a result of pipe breakages and urban areas with high non-revenue water;
- Develop and implement a practical credit control policy including late fees and restriction of flow if required;
- Record information on outstanding debt for water in accordance with the customer classification or water use sector and strive to recover 95% of the monthly invoiced amount;
- Calculate monthly water balances on schemes to determine non-revenue water over the previous past 12 months;

- Provide accurate and informative accounts to consumers on specific dates;
- Provide adequate annual budget allocations for the proper maintenance of the water infrastructure including meter replacement; and
- Establish a relationship with the Development Bank (facilitated by the Central Government) for long term loans to fund infrastructure replacement to improve security of supply and minimize bulk supply interruptions.

### **TECHNICAL REQUIREMENTS/CAPACITY**

#### **Strategy: Improvement of the infrastructure to reduce non-revenue water and reduce water supply interruptions to customers**

The following measures should be taken to enhance the technical performance of NamWater:

- Develop and implement maintenance and replacement programs and action plans to replace water meters and old infrastructure to improve service delivery to customers;
- Implement a meter management program to record meter numbers and date of installation and replacement;
- Provide regular night-flow measurements to customers in cases where supply meters are linked to the NamWater SCADA system;
- Develop a program to record pipe breakages, duration of supply interruptions to determine weak spots in the bulk supply system for replacement;
- Develop standard operation manuals for each scheme including water treatment plants;
- Determine the benefits of reduced scaling and corrosion on the lifetime of NamWater and local authority infrastructure and identify basic treatment options with cost in consultation with beneficiaries;
- Determine life cycle costs with respect to technical options such as sophisticated water treatment options including capital, maintenance and operational costs before any decision is taken in consultation with the customer; and
- Provide support for the 5 yearly external technical audits through the collection of the required information.

## **CUSTOMER CARE, EDUCATION AND AWARENESS RAISING**

**Strategy: Sensitizing customers to use water efficiently and to curb unnecessary wastage**

The following measures should be taken to sensitize customers to use water efficiently and reduce wastage.

- Provide informative billing to consumers with information how to read their water meters;
- Handle customer account queries professionally;
- Educate customers on how to detect a leakage on their premises;
- Promote water savings;
- Provide information on annual water audits in places where water is supplied mainly to government agencies as the main consumer including the inspection of such government institutions to curb leakage and wastage.

Other aspects not directly related to WDM which influence the quality of services to customers may include the following:

- Compliance with water quality standards (95% percentile values) including parameters which influence the potential lifetime of infrastructure.

### **2.2.3 Performance Indicators**

Performance indicators for NamWater must include at least the following:

- Reduction of outstanding debt to 5% of the annual operation budget within 5 years;
- Breakdown of debt per sector (local authorities, rural water supply, private users, mines etc) with summary of debt not older than 3 months and debt older than 3 months including accounts rendered per sector;
- Development and implementation of improved credit control policies before the end of 2010;
- Compliance with tariff setting principles as described in section 1.3.1 for all tariff setting after approval of the LCE Report (2008) on the “Principles and Methodology to Calculate the Costs and Tariffs for Water Supplied by NamWater”;
- Development and implementation of a meter maintenance/replacement program with a monitoring system with specific targets and monitoring methods to improve infrastructure and meter maintenance for completion before the end of 2010;
- Calculation of annual water balances for each scheme to determine production losses for each scheme to reduce non-revenue water;
- Reduction of production losses to less than 10% for groundwater supply schemes and 15% (including treatment losses) for surface water schemes except for systems

such as the Central North where seepage and evaporation losses on transfer schemes are high;

- Reduction and better control of illegal connections;
- Use of unconventional water resources such as desalination and managed aquifer recharge;
- Participation in initiatives to improve catchment management (de-bushing) in identified sensitive catchments such as the Von Bach Dam and the Otjiwarongo Marble or Platveld Aquifers to enhance run-off and groundwater recharge.
- Inclusion of WDM requirements in all customer contracts;
- Compliance with water quality standards (95% values) for both surface and groundwater;
- Availability of standard operation procedures for each scheme including water treatment plants;
- Recording of downtime with explanations for unscheduled water supply interruptions of more than 8 hours on any scheme during a period of one year, excluding scheduled interruptions agreed with the Client;
- A record of pipe bursts per kilometer of pipeline per scheme per year; and
- Results of the 5 year external technical audit of supply schemes providing more than 200 000 m<sup>3</sup>/annum.

### **2.3 URBAN WATER SECTOR**

During 2008 the urban water sector including industries in urban areas consumed approximately 69.1 Mm<sup>3</sup> which represents 20.2% of the total water requirement. In Vision 2030 the urban sector is earmarked for the accommodation of the majority of the population (75%) and significant industrialization and the expected water demand will increase to 117.2 Mm<sup>3</sup>. This represents only 15.2% of the total expected water requirements in 2030.

Critical issues identified for the successful implementation of WDM in the urban sector include the drafting of legal instruments, capacity building, improvement of financial and technical management, implementation of equitable conservation orientated tariffs, reduction on non-revenue water, improved revenue collection, improved infrastructure maintenance and replacement and improved customer services. Other factors not directly related to WDM which influence the quality of services to customers include the level of service provided, coverage of service delivery for both water and sanitation services and compliance with water quality standards.

Mining towns where the mines supply water to local consumers are included in the category of urban water sector; therefore they need to comply with the strategies proposed for this sector.



### 2.3.1 Objective to Improve Water Efficiency and Service Delivery in Urban Sector through Implementation of WDM.

The overall objective for the urban water sector is to improve service delivery by ensuring that the service providers are efficient and effective and have the necessary capacity (legislative, human and financial) to provide socially accepted services provided that the environment and the ability of the Service Providers to become financial self-sustaining are not compromised.

### 2.3.2 Strategies to Implement Improved Water Efficiency and Service Delivery through the Implementation of Water Demand Management

#### LEGAL AND POLICY REQUIREMENTS

##### Strategy: Establish and implement legal instruments to support WDM in urban sector

The following measures should be taken to implement WDM successfully:

- The Water Resource Management Act and the Regulations that control the activities of Service Providers and prescribe the implementation of WDM and Water Conservation should be finalized and implemented.
- Water and industrial effluent regulations (Both the Model and Individual) applicable in urban areas should be revised and standardized by local authorities.
- The national policies and principles for equitable and conservation orientated end-use water tariffs and for subsidies or cross subsidies should be finalized.
- The national industrial effluent requirements to control pollution from wet industries including mining should be compiled.
- The existing Water Supply Regulations in urban areas should be amended to enhance WDM practices and to make provision for a penalty tariff for unauthorized use of water to curb illegal water use.
- Local Authorities and Regional Councils should be licensed as service providers in accordance with the revised WRMA

#### INSTITUTIONAL DEVELOPMENT AND CAPACITY BUILDING

##### Strategy: Enhance institutional development and capacity building at all levels to implement WDM

The following measures should be taken to enhance institutional development and capacity building:

- Establish Performance Support Teams to assess the performance of LA's where required and to develop operational management plans with Objectives, Actions, Resources Required, Responsible Agents, Performance Indicators, Target Dates, Milestones and Outcomes to implement WDM;
- Provide on-the-job, hands-on training and capacity building for technical

infrastructure management, maintenance and financial management;

- Establish mentoring programmes for institutions and individuals;
- Develop technical skills programmes for water and sanitation;
- Create performance based incentives to retain expertise, provide mentors to assist employees and promote sharing of expertise with more than one authority;
- Foster public private partnerships or outsource specific functions to the private sector;
- Enhance capacity to manage and operate unconventional water resources; and
- Develop awareness and training campaigns for end users (public) on water saving measures such as how to read their water meters and carry out water audits, how to detect leakages on properties, and how to save water inside and outside the house.

### **FINANCIAL REQUIREMENTS/CAPACITY**

#### **Strategy: Improvement of the financial performance of Local Authorities including funding for implementing WDM initiatives and capital replacement**

The following measures should be taken in order to improve financial performance and provide funding to implement WDM successfully:

- Establish tariff advisory committees to determine equitable and conservation orientated tariffs including subsidies or cross subsidies according to the national policy principles;
- Develop credit control policies including late fees and restriction of flow if required;
- Implement industrial effluent charges to curb pollution by industries;
- Record information on outstanding debt on water and sanitation accounts separately and strive to recover 95% of the monthly invoiced amount;
- Calculate monthly water balances to determine non-revenue water over the previous 12 months;
- Provide accurate and informative accounts to consumers on specific dates;
- Provide adequate annual budget allocations for the proper maintenance of the water infrastructure including meter replacement; and
- Establish a national fund at the Development Bank (facilitated by the Central Government) for short and long term loans to implement WDM initiatives such as pressure reduction, meter and infrastructure replacement.

### TECHNICAL REQUIREMENTS/CAPACITY

#### Strategy: Improvement of the infrastructure to reduce non-revenue water and reduce water supply interruptions to end consumers

The following measures should be taken to enhance the technical performance of local authorities:

- Develop and implement maintenance and replacement programs and action plans to replace water meters and old infrastructure to improve service delivery to consumers and reduce non revenue water;
- Implement a meter management program to record meter numbers and date of installation and replacement;
- Implement regular night-flow measurements to detect increased leakage on networks and properties;
- Develop a program to record pipe breakages to determine weak spots in the reticulation for replacement;
- Keep a record of time and areas affected by pipe breakages and time from reporting until the problem was rectified;
- Determine life cycle costs with respect to technical options such as pre-paid meters including capital, maintenance and operational costs before any decision is taken; and
- Provide support for the 5 yearly technical audits through the collection of the required information.

### CUSTOMER CARE, EDUCATION AND AWARENESS RAISING

#### Strategy: Sensitizing customers to use water efficiently and to curb unnecessary wastage

The following measures should be taken to sensitise customers to use water efficiently and reduce wastage.

- Provide informative billing to consumers with information how to read their water meters;
- Handle customer account queries professionally;
- Educate customers on how to detect a leakage on their premises;
- Promote water savings inside and outside the house;
- Provide information on annual water audits for large consumers; and
- Inspect government institutions to curb leakage and wastage.

Other aspects not directly related to WDM which influence the quality of services to customers may include the following:

- The level of service provided and the coverage of service delivery for both water and sanitation services; and
- Compliance with water quality standards (95% percentile values) in water reservoirs/networks with special emphasis on monitoring of free chlorine;

### 2.3.3 Prioritizing of the Water Demand Management Measures

The capacity of local authorities in Namibia varies to a very large extent and measures as listed in Table 2.1 were determined based on the classification of the local authority, population served, water consumption and water scarcity.

**Table 2.1 Category of Local Authority for WDM Classification and Required Measures**

Group/Measures	Required Water Demand Management Measures
<b>Group 1a</b> <b>Settlements administrated Regional Councils, Total Water Production/Bulk supply <math>\leq 150\ 000\ m^3/a</math>, no water scarcity.</b>	
<b>Settlements</b>	Proper maintenance programs for infrastructure including water meters; Programmes for replacement of infrastructure beyond their economic lifetime (capital replacement); Proper and regular meter reading; Determination of non-revenue water over a period of 12 months on an ongoing basis; Proper financial accounting and costing of water provision Develop and implement equitable water tariffs with incentives to conserve water
<b>Group 1b</b> <b>Village, Population up <math>\leq 5\ 000</math>, Total Water Production/Bulk Water Supply <math>\leq 200\ 000\ m^3/a</math>, no water scarcity.</b>	
<b>Required measures</b>	As listed for Group 1a Proper water metering with meter replacement programs related to the expected economic lifetime of meters; Inspections at schools and government offices to identify, quantify and report water losses; Education to consumers: How to read water meter; How to detect and fix leakages on premises; Information to consumers: Water saving in gardens Water saving in the house.
<b>Group 2</b> <b>Village or Town, Population 5000 to <math>\leq 10\ 000</math>, Total Water Production/Bulk Water Supply <math>200\ 000 \leq 400\ 000\ m^3/a</math>, no water scarcity</b>	
<b>Required measures</b>	As listed for Group 1a and 1b Pressure management where water pressure is above 40 m head;

Group/Measures	Required Water Demand Management Measures
<b>Group 3</b> <b>Town or Municipality, Population 10 000 to ≤50 000, Total Water Production/Bulk Water Supply 400 000 to ≤ 2 million m<sup>3</sup>/a, no water scarcity</b>	
<b>Required measures</b>	As listed for Group 2 Consumer audits including water management plans for large consumers using more than 10 000 m <sup>3</sup> /month including government institutions and offices Notification to consumers of the results of the audit Promotions to save water Reuse of water and other unconventional sources Regulation to control excessive use of water
<b>Group 4</b> <b>Any place with water scarcity, Population ≥50 000, Total Water Production/Bulk Water Supply ≥2 million m<sup>3</sup>/a</b>	
<b>Required measures</b>	Any of the required measures as applicable in groups 2 and 3 Local district metering to determine areas with high losses if non-revenue water is above 10%. Rain water harvesting and other unconventional sources if applicable Practice integrated water resource management within its area of jurisdiction

### 2.3.4 Performance Indicators

Targets for the performance indicators will be determined and reviewed regularly by the Water Regulator in consultation with the relevant service provider in accordance with the revised WRMA. The specific service provider performance indicators will be determined by DWAF and included in the licence conditions.

The following performance indicators are fundamental for the successful implementation of WDM in the urban water sector:

- Total water supplied (bulk supply) versus number of residents in ℓ/person/day based on census figures should be recorded;
- Volume of water produced versus water of volume sold (non-revenue water) with a target figure of not more than 10% discrepancy subject to system characteristics such as number of connections and water pressure;
- Actual recovery of debt on the water and sanitation account (water and sanitation debtors) versus the total annual amount billed and actual amounts paid by consumers for each financial year with a target of 95%;
- Breakdown of debt per sector (government, business, industry and households) on the water and sanitation accounts (water and sanitation debtors) with summary of

debt amounts not older than 3 months and debt older than 3 months including accounts rendered per sector;

- Average age of debt;
- The annual expenditure on the water account versus income;
- Reduction of outstanding debt to a target figure of 5% on the water and sanitation accounts of the annual operation budget for each service within 5 years;
- Total non-revenue water divided by the number of water connections in litre/connection/day;
- Night-flow (minimum normalised night-flow figure over 15 minutes measured over 3 to 5 days) as percentage of the average daily consumption with a target figure of not more than 5% based on system characteristics;
- Number of pipe bursts per year in comparison with the total length of water pipelines in the water network;
- Number of unscheduled water supply interruptions per pressure zone/township with a duration of more than 6 hours;
- Number of inaccurate water meters replaced in comparison the total number of water meters;
- Volume of water provided from unconventional sources (reuse, managed aquifer recharge etc) in comparison with the total water supplied (bulk supply or bulk water purchased);
- Number of employees in the water section per 1000 connections;
- Results of the 5 year external technical audit for supply schemes selling more than 200 000 m<sup>3</sup>/annum;
- Informative billing to consumers to enhance water use efficiency;
- Information supplied to customers to save water, curb wastage and water audits for large consumers
- Other indicators not directly linked to WDM are:
  - the level of service and the coverage of service delivery for both water and sanitation services;
  - Compliance with water quality standards (95% percentile values) in water reservoirs/networks with special emphasis on monitoring of free chlorine;

## 2.4 RURAL DOMESTIC WATER SECTOR

During 2008 the rural domestic water sector consumed approximately 10.3 Mm<sup>3</sup> which represented 3.1% of the total water requirement. In Vision 2030 it is not expected that the rural domestic sector will grow significantly. The expected water demand will increase to only 11.4 Mm<sup>3</sup> and will comprise only 1.5% of the total expected water requirements in 2030. The

median per capita daily water consumption is 9.9 litre/capita/day which is well below the acceptable minimum water consumption required for good health of 25 litre/capita/day, (WHO).

The biggest challenges in rural areas are the recovery of costs by Water Point Committees to pay NamWater for the operation and maintenance of the water points, flat rates for water use (irrespective of size of household and number of livestock), illegal connections on pipeline systems, continuity of committees affected by rural urban migration, lack of subsidies, system reliability with frequent breakdowns, improved maintenance and capital replacement, water quality monitoring on schemes not supplied by NamWater and prevention of pollution of water sources.

#### **2.4.1 Objective to Improve Water Efficiency and Service Delivery in the Rural Domestic Sector through Implementation of WDM.**

The overall objective for the rural domestic water sector is to improve service delivery by ensuring that the water point committees and water point associations are efficient and effective and have the necessary capacity (legislative, human and financial) to deliver affordable services with a high level of supply security provided that the environment and the long-term target of the committees/associations to become financially self-sustaining are not compromised.

#### **2.4.2 Strategies to Implement Improved Water Efficiency and Service Delivery in the Rural Domestic Sector**

##### **LEGAL AND POLICY REQUIREMENTS**

##### **Strategy: Establish and implement legal instruments to support WDM in rural domestic sector**

The following measures should be taken to implement WDM successfully:

- The Water Resource Management Act and the Regulations which are responsible for the implementation of WDM should be finalized and enforced.
- The national policies and principles for equitable rural water tariffs including credit control for domestic and livestock consumption (to substitute flat rates) determination of subsidies or cross subsidies should be finalized and implemented to assist rural areas if required.
- Develop and implement in co-ordination with Traditional Authorities, a system or regulations to address non-payment for water and other issues such as handling of illegal connections, legalizing connections and curbing illegal water use.

### INSTITUTIONAL DEVELOPMENT AND CAPACITY BUILDING

#### Strategy: Enhance institutional development and capacity building at all levels

The following measures should be taken to enhance institutional development and capacity building:

- Provide training to extension officers on financial management and maintenance to support and strengthen the institutional capacity of WPC's;
- Provide on-the-job, hands-on training and capacity for financial management, technical infrastructure management and maintenance to WPC's;
- Provide guidelines to WPC's to remunerate treasurers and technical maintenance staff;
- Develop concise financial guidelines for implementation to enhance proper financial control including mandatory external checking/auditing;
- Establish mentoring programmes for institutions and individuals through DWSSC;
- Develop technical skills programmes with basic training courses for water and sanitation through DWSSC;
- Foster public private partnerships or outsource to the private sector within the regions specific functions that cannot be handled by the WPC provided that such functions can be controlled by the extension officers.

### FINANCIAL AND TECHNICAL REQUIREMENTS/CAPACITY

#### Strategy: Improvement of the financial performance and service delivery

The following measures should be taken to improve financial performance and service delivery:

- Develop a system in consultation with NamWater to handle payment for losses resulting from pipe breakages on branch-lines to recover only operational costs;
- Provide sufficient funding from the Fiscus to assist DWSSC to rehabilitate rural water supply water points before the community takes full responsibility for such water points;
- Provide funding from the Fiscus to install water meters to measure domestic and livestock consumption separately;
- Implement fair tariffs with credit control measures supported by Traditional Authorities;
- Record supply interruptions with reasons for such interruptions to address the causes of unforeseen interruptions.



## POLLUTION AND WATER QUALITY CONCERNS

### Strategy: Prevention of Pollution of water sources though human activities

The following measures should be taken to prevent water pollution and monitor potable water supply quality:

- Provide sufficient information to WPC's and residents in rural communal farming areas about the danger of pollution to groundwater around water points as well as the legal requirements with respect to such pollution;
- Implement a system where WPC's may forward drinking water samples to DWSSC for analysis by DWAF at least once a year to determine the water quality.

### 2.4.3 Performance Indicators

In accordance with the decentralisation policy, rural water supply is in the process of decentralisation to Regional Councils. It is suggested that the degree of compliance with the performance indicators be monitored by Regional Councils in collaboration with DWAF.

The following performance indicators are relevant in the rural domestic sector to measure water use efficiency:

- Payment of NamWater accounts by water point committees or water point associations, and comparison of amount correctly billed versus amount paid;
- Checking actual recovery of cost by water point committees/associations by comparing the amount billed against actual amounts paid by consumers for each financial year;
- Instituting equitable tariffs based on equivalent households (say 6 family members) and stock numbers instead of monthly flat rates to improve payment of water bills;
- Administration of a subsidy or cross subsidy policy after finalization by DWAF.
- Ensuring proper maintenance of infrastructure in areas where communities are responsible for maintenance;
- Reporting on the number of supply interruptions per year with more detailed information on reasons for any interruptions of longer than 8 hours;
- Instituting a program for replacement of old infrastructure in close consultation with DWSSC for implementation and funding.
- Prevention of water pollution around boreholes and water points by controlling the location of livestock kraals, pit latrines and waste dumps; and
- Water quality testing of boreholes in communal areas (excluding schemes supplied by NamWater) by ensuring that Water Point Committees/Water Point Associations provide samples to DWSSC for analyses by DWAF at least once a year.

## 2.5 IRRIGATION SECTOR

During 2008 the irrigation water sector consumed approximately 135.3 Mm<sup>3</sup> which represents 41.0% of the total water requirement. In Vision 2030 the irrigation sector is earmarked for major development and the expected water demand will increase threefold to 497.2 Mm<sup>3</sup> which represents 64.6% of the total expected water requirements in 2030.

Farmers normally tend to over-irrigate. The return flow and the excessive drainage water normally flows back into the river or aquifer by overland flow and return seepage. In certain areas, this return water can be nutrient enriched and polluted with fertilizers, herbicides, pesticides and other pollutants that could affect the water quality of rivers, streams and groundwater.

### 2.5.1 Objective to Improve Water Efficiency and Crop Production through Implementation of WDM

The overall objective for the irrigation sector is to improve water use efficiency, crop production (more crop per drop) and value addition to enhance economic growth, increase food security and exports from Namibia provided that the environment and water resources are not compromised.

### 2.5.2 Strategies to Implement Improved Water Efficiency and Crop Production through the Implementation of Water Demand Management

#### LEGAL AND POLICY REQUIREMENTS

##### Strategy: Establish and implement legal instruments to support WDM in the irrigation sector

The following measures should be taken to implement WDM successfully in the irrigation sector:

- The Water Resource Management Act and the Regulations which control the activities of irrigators and prescribe the implementation of WDM and Water Conservation should be finalized and implemented:
- The Water Pollution Regulations which require mandatory water quality testing including monitoring of drainage or seepage with regular reporting of results to DWAF in accordance with license conditions should be compiled and implemented
- A policy for irrigation water tariffs with rebates/incentives to improve water use efficiency in the irrigation sector should be developed.

### INSTITUTIONAL DEVELOPMENT AND CAPACITY BUILDING

#### Strategy: Enhance institutional development and capacity building at all levels to implement WDM

The following measures should be taken to improve institutional capacity to implement WDM successfully in the irrigation sector:

- Establish an Irrigation Efficiency Committee under control of the Water Regulator through a private-public partnership with farmers and agricultural cooperatives within one year after approval of the IWRM Plan;
- Establish water management institutions for the proper management of irrigation schemes with a mandate from the Minister to:
  - Scrutinise and make recommendations on all new applications for water allocation via the Water Basin Management Committee to DWAF;
  - Collect required information from irrigation farmers for reporting to the Water Use Efficiency Group and DWAF;
  - Collect water use levies for abstraction of groundwater;
  - Monitor compliance with licence conditions; and
  - Evaluate the information supplied by farmers in accordance with the balanced scorecard and share results from the collected information amongst the farmers to enable the farmer to compare his own performance with other farmers producing similar crops.
- Foster private sector involvement for dissemination of efficient technologies, information etc;

### FINANCIAL REQUIREMENTS/CAPACITY

#### Strategy: Provision of financial Resources to implement critical WDM initiatives in the Irrigation Sector

The following financial support mechanisms were identified to implement WDM successfully in the irrigation sector:

- Provide an operational subsidy from the Fiscus for the establishment and operation of the Irrigation Efficiency Committee;
- Provided a once off subsidy from the Fiscus for the implementation of metering for all irrigation water based on 1 ha irrigation from groundwater and 5 ha for surface water irrigation systems;
- Provide money from the Fiscus to install automatic weather stations at larger concentrated irrigation schemes (larger than 200 ha) such as Etunda, Hardap and Orange River locations.

### IMPROVEMENT IN FARMER SKILLS

#### Strategy: Training of farmers to improve crop yields, water use efficiency and prevention of water pollution

The following support mechanisms were identified to assist farmers in the successful implementation of WDM in the irrigation sector within the next three years:

- Short modules and training courses for irrigation farmers are required for:
  - Scheduling and plant water requirements;
  - Growing of specific crop types;
  - Selection of the best irrigation system taking climatic and type of crop into account;
  - Correct application of fertilizer and pesticides;
  - Assessing the benefits of organic farming methods;
  - Prevention of water pollution;
  - Others to be identified by farmers water management institutions and the Irrigation Efficiency Group.
- Control of bush encroachment in areas such as the Karst where groundwater recharge can be enhanced. (Incentives from Central Government may be required);
- Implementation of a balanced score card system to sensitize farmers on their efficiency in comparison with their colleagues through information collected and distributed by the local water management institution which is responsible for training of farmers, financial and economic parameters and WDM indicators.

### POLLUTION AND WATER QUALITY CONCERNS

#### Strategy: Prevention of Pollution of water sources through irrigation activities

The following measures should be taken to prevent water pollution:

- Provide sufficient information to irrigation farmers about the pollution potential of irrigation schemes as a result of the use of fertilizer and pesticides and the effect of over-irrigation which exacerbates such pollution.
- Identify critical areas for sampling of water quality in areas such as the Karst, and downstream of Hardap and Naute irrigation schemes for sampling and testing of water quality to determine baseline data on pollution.

#### 2.5.3 Summary of identified Water Demand Management Measures in the Irrigation Sector

Tables 2.2 and 2.3 provide a summary and a time framework for the different initiatives identified in the report. The time indicates when the initiative should start. Most of the actions should be continuous and should not be stopped after the expected time indication.

**Table 2.2: Proposed Institutional Actions to Improve Irrigation Water Use Efficiency**

<b>Department of Agriculture</b>		
<b>Timing</b>	<b>WDM Measure</b>	<b>Expected Results</b>
<b>Short-term</b> Immediate to five years	<b>Support structures</b> Establish irrigation management institutions Establish the Irrigation Efficiency Committee Foster private sector involvement Support the training of farmers Install automatic weather stations at all major irrigation schemes larger than 200 ha Incentives for de-bushing in areas such as the Karst using groundwater for irrigation. <b>Policies and control</b> Volumetric allocation of water Proper scheduling and abstraction through the metering of irrigation water Develop and implement tariffs/rebates which include an incentive to conserve water and to improve water use efficiency. Equal allocation for the irrigation farmers based on the type of crop should rather be used during periods of shortfall. In cases of water shortage water can then be traded amongst farmers with cash crops to protect perennial crops. Monitor and regulate water pollution <b>Technical &amp; Planning</b> Allocate licences based on certified proper irrigation system planning on new schemes Allocate licences based on proper drainage systems on all schemes	Improved farm management, crop yields and water productivity  Estimated savings of 10% in water consumption.  Higher water use efficiency and higher crop yields through efficient water application and proper drainage
<b>Medium term</b> Five to ten years	<b>Operational</b> Reduce conveyance losses on canal systems where applicable	Higher scheme water use efficiency
<b>Long term</b> Ten to fifteen years	<b>Operational</b> Introduce demand-driven supply to canal based irrigation schemes	Higher crop yields

**Table 2.3: Proposed Farming Management Actions to Improve Irrigation Water Use Efficiency**

<b>Management of Farms</b>		
<b>Timing</b>	<b>WDM Measure</b>	<b>Expected Results</b>
<b>Short-term</b> Immediate to five years	Acquire scheduling system or assistance to establish plant water requirements Improve maintenance of application systems, canals and storage facilities Proper drainage systems should be a major component of the irrigation scheme management which must be included as part of the initial development cost of any irrigation scheme. Grow higher value crops where possible Control pollution potential (correct fertiliser & pesticides application)	10% water saving Higher value crops and higher crop yields /m <sup>3</sup> water used. Reduced water pollution
<b>Medium term</b> Five to ten years	Re-engineer existing irrigation systems Install more efficient irrigation systems Better matching of crops to climate, soil and water quality	Water savings up to 20% and increased crop yields.
<b>Long term</b> Ten to fifteen years	Install more efficient irrigation systems Cover soil to lower evaporation	Improve water use efficiency.

#### 2.5.4 Performance Indicators

The performance indicators are very site specific and can only be compared for similar crops in similar irrigation areas with similar soil and climatic conditions. Regular reporting of the performance indicators as stipulated in the licence conditions will be through the local water management institutions to the Water Efficiency Group, the Department of Agriculture and DWAF.

The following performance indicators are relevant for the irrigation sector.

- Improvement of crop yields using water efficiently by comparing water usage per ha for similar crops in the different irrigation areas with similar soil and climatic conditions, (more crop per drop);
- Attendance at specialised training sessions by farmers, foremen and workers and creation of study groups in the different irrigation areas (Such as Hardap, Orange River, Karst and Etunda) to share information and to train farmers to bench mark themselves and to get resilience in the system;
- Area of de-bushing in ha, (based on reduction in canopy cover) versus the area under irrigation (ha) where groundwater is abstracted such as the Karst and Stampriet;

- Addition of value in N\$ per m<sup>3</sup> of water consumption for specific crops in a specific region;
- The net disposable income (profit) in N\$ per m<sup>3</sup> of water consumption per crop/region;
- Number of permanent and seasonal job opportunities per ha of irrigation area including improved labour productivity;
- Selection of the correct irrigation systems taking soil and climatic conditions into account including proper management and maintenance of such systems;
- Record keeping on the use of fertiliser, pesticides and water to determine risk of surface and groundwater pollution;
- Accurate metering; and
- Prevention of water pollution through careful application of fertilisers, pesticides and water and regular monitoring of groundwater quality.

## 2.6 LIVESTOCK SECTOR

During 2008 the livestock water sector consumed approximately 86.9 Mm<sup>3</sup> which represents 23.6% of the total water requirement both in commercial and rural areas. The figure includes an allowance of 50% for wastage which may be high. No significant growth is expected in the livestock sector and the expected water demand will stay the same and is expected to use only 11.3% of the total expected water requirements in 2030.

Livestock farming can be divided in three categories commercial farming (including game and trophy hunting), resettlement farms and communal farming which may include conservancies for game.

The challenges to implement WDM in the livestock sector are control of bush encroachment which affects surface runoff, groundwater and fodder availability, reduction of leakages at water troughs and water points especially at windpumps and the prevention of water pollution, especially groundwater near livestock pens. On communal land and resettlement farms vandalism and poor maintenance of water infrastructure are major concerns. Capital replacement is required in some rural water supply schemes mainly as a result of old infrastructure past its economic lifetime.

### 2.6.1 Objective to Improve Water Efficiency in the Livestock Sector through Implementation of WDM

The overall objective in the livestock sector is to improve water use efficiency and protein production to enhance economic growth in Namibia through increased exports and food security, provided that the range land environment and water resources are not compromised.

## 2.6.2 Strategies to Implement Improved Water Efficiency through the Implementation of Water Demand Management

### LEGAL AND POLICY REQUIREMENTS

#### Strategy: Establish and implement legal instruments to support WDM in the livestock sector

The following measures should be taken to implement WDM successfully in the livestock sector:

- Finalize and implement the Water Resource Management Act and the Regulations which control the activities of the livestock sector and prescribe the implementation of WDM and Water Conservation.
- Compile and implement Water Pollution Regulations to prevent water pollution as a result of livestock farming, feedlot kraals near boreholes. Regulations are needed to control associated industrial activities such as abattoirs and tanneries and sampling and water quality testing should be mandatory.
- Register all dams and impoundments and control construction of new dams through licensing by DWAF.
- Register all existing boreholes used by stock farmers (both commercial and other) in the DWAF data base within one year of promulgation of the Act.
- Finalize and implement the Draft National Range Land Management Policy and Strategy (2009) and the Draft Control of Bush Encroachment Policy and Strategy (2007) to increase productivity in the livestock sector and to enhance groundwater recharge and surface run-off through the reduction in bush canopy cover.

### INSTITUTIONAL DEVELOPMENT AND CAPACITY BUILDING

#### Strategy: Enhance institutional development and capacity building at all levels to improve efficiency in the livestock sector

The following water demand management measures were identified for the livestock sector:

- Promote international cooperation and exchange of information on best land and water management practices to enhance fodder availability and surface and ground water recharge;
- Support farmers' cooperatives and unions to train and provide information to farmers in the implementation of better land management practices and the control of bush encroachment and alien vegetation to improve fodder availability and increase meat production;
- Promote the participation of farmers or farmer interest groups in water basin management committees;
- Support farmers' cooperatives, unions and farmers with the implementation of the Range Land Strategy and Control of Bush Encroachment based on the outcome of the final strategies.



### IMPROVEMENT IN FARMER SKILLS

#### Strategy: Training of farmers to improve fodder availability, water use efficiency and prevention of water pollution

The following support mechanisms were identified to assist farmers in the successful implementation of WDM in the livestock sector:

- Short modules and training courses for livestock farmers are required for:
  - Rangeland management including control of bush encroachment;
  - Groundwater recharge enhancement through rainwater harvesting, managed aquifer recharge and construction of sand dams in vulnerable areas;
  - Prevention of water pollution resulting from livestock farming activities;
  - Basic maintenance of water supply infrastructure especially in areas with high scaling and corrosion potential.
- Control of bush encroachment based on the finalised national strategy;
- Provide information to farmers on how to monitor groundwater levels and to calculate water abstraction volumes based on stock numbers.

### POLLUTION AND WATER QUALITY CONCERNS

#### Strategy: Prevention of Pollution of water sources through farming and human activities

The following measures should be taken to prevent water pollution and ensure safe drinking water for livestock and human consumption:

- Provide sufficient information to farmers regarding the pollution potential from livestock farming activities.
- Provide a service where farmers and water point committees (only on schemes not supplied by NamWater) should collect samples for DWAF to analyze water quality to determine baseline data for groundwater pollution in Namibia.
- Identify critical areas for sampling of water quality in areas such as the Karst and other identified areas for sampling and testing of water quality to determine baseline data on pollution.

### FINANCIAL REQUIREMENTS/CAPACITY

#### Strategy: Improvement of the performance of the livestock farming sector

- Support the implementation of the national range land and control of bush encroachment strategies in accordance with recommendations;
- Capital should be provided for replacement of infrastructure past its economic lifetime by the relevant ministry in communal areas, while commercial farmers should carry their own costs except in cases where projects are identified for National interest.

### 2.6.3 Performance Indicators

Performance indicators should be reported regularly to the water basin management institutions or DWAF. The following performance indicators are relevant for the stock farming sector.

- Registration of all existing boreholes by commercial stock farmers and DWSSC on the DWAF data base within the period as determined by regulation;
- The number of hectares where selective de-bushing has been done on a farm or in a communal area as part of a national initiative;
- Voluntary measurement of rest water levels in boreholes by commercial stock farmers and water point committees in collaboration with DWSSC and forwarding of the information for inclusion in the DWAF data base;
- Improved sustainable animal production per hectare without the loss of bio-diversity;
- Keep records of livestock and game numbers on commercial farms and communal farms (water point committees) to determine annual water use;
- Prevention of water losses at water points, mainly at drinking troughs, by commercial farmers, resettled farmers and water point committees in communal areas;
- Submission of samples for testing ground water quality by DWAF by indentified water point committees and commercial farmers; and
- Prevention of surface and ground water pollution by controlling positions of kraals, sub-soil drains, pit latrines and solid waste sites in relation to groundwater recharge areas and boreholes.

## 2.7 MINING SECTOR

During 2008 the mining sector used approximately 16.1 Mm<sup>3</sup> which represents 4.9% of the total water requirement. The expected water requirement will increase to 20.3 Mm<sup>3</sup> which represents only 2.6% of the total expected water requirements in 2030. The figure of 20.3 Mm<sup>3</sup> excludes water provided from unconventional water sources such as brackish water, sea-water and desalination.

Water demand management measures for mines are very site specific and depend on the type of mining process and operation. The water management plan which is required in accordance with the Draft Water Resource Management Bill will determine the most important measures to improve water use efficiency. Such plans must include mine de-watering policies and abstraction rules if applicable as well as strategies to prevent water and environmental pollution.

On the whole, the mining industry is fairly diligent when it comes to the management of water for industrial purposes which results mainly from the large amount of water used, high expenditure on fresh water supply, precise inputs of water in the mining processes, proximity of certain mines to alternative inputs such as brackish or seawater and the proven financial benefits of alternatives such as recycling from the slimes dams. Other requirements such as compliance with water and mining laws, the International Council of Mines, charter ethics of the Chamber of Mines and safety fundamentals also contribute to efficient water use of mines.

In cases where mines act as self providers to supply water to urban areas such as Oranjemund and Kombat (when in operation) the requirements for WDM in urban areas are applicable.

### 2.7.1 Objective to Improve Water Efficiency Mining through Implementation of WDM

The overall objective for the mining sector is to improve water use efficiency and to enhance economic growth in Namibia through local processing and exports provided that the environment and water resources are not compromised.

## 2.7.2 Strategies to Implement Improved Water Efficiency and Service Delivery through the Implementation of Water Demand Management

### LEGAL AND POLICY REQUIREMENTS

#### Strategy: Establish and implement legal instruments to support WDM in the mining sector

The following measures should be taken to implement WDM successfully in the mining sector:

- Finalize the revisions of the Water Resource Management Act and the Regulations to control water use efficiency including regulations requiring water management plans by mines within 12 months after promulgation of the act, performance indicators required in the mining sector as well as the reporting periods to the basin management committees and DWAF.
- Compile and implement Water Pollution Regulations to prevent water pollution as a result of mining activities which include mandatory water quality testing of seepage from slimes dams and elsewhere such as treatment plant areas, ore stockpiles, oil spillage from workshop areas and other contaminants. Mandatory measuring and regular reporting of water quality information should also be included the licence conditions.

#### Strategy: Development of Water Management Plans for Mines enhance water use efficiency and to prevent pollution

The detailed requirements of water management plans will be determined in the relevant regulations which will be promulgated in accordance with the Water Resource Management Act. (It is contemplated that other mines should develop water management plans similar to that of Rössing Uranium) It is recommended that such plans should not be restricted to, but should comply with at least the following guidelines or requirements:

- Appointment of a person that will be responsible for collecting and processing data concerning water consumption and water use efficiency. Depending on the size of the mine (suggest water use of more than 3 Mm<sup>3</sup>/annum) and the water intensity of most operations on large mines, the appointment of a specialist for proper total water cycle management on the mine may be required (Rössing example).
- On-site management committees composed of mine employees should contribute to the creation of site-specific WDM strategies;
- Training of mine personnel in water use efficiency and prevention of pollution in cases of accidental spillage of harmful chemicals should be part of the normal training of the relevant employees and should be included in the water management plan;
- Funding required for the implementation of the water use plan should be provided by the mine as part of the capital and operational costs;
- Funds to cover the cost of remediation must be reserved while the mine is still in

production to prevent a situation where the owners of an abandoned mine cannot be traced for restoration after closing;

- Address longer term environmental pollution and cost for remedial action including the decline in groundwater quality. (Tsumeb is a good example of the effects of environmental pollution over a long period.)
- Water resources providing water to mining towns including other places downstream of the basin receiving waters which may be affected by the mining activity should be properly managed and protected against pollution;
- Financial and technical measures will form part of the specific water management plan of a mine.

### 2.7.3 Performance Indicators

Performance indicators should be included in the licence conditions for mines including mandatory reporting to the basin management committees and DWAF in accordance with the licence conditions. The following performance indicators were identified for the mining sector:

- The volume of water used (abstracted or bulk supply) to treat one ton of ore as a mine specific indicator to measure the relevant mine's performance over time;
- Value added per m<sup>3</sup> of water consumed in the process (total turnover in N\$ per financial year/total water use in m<sup>3</sup> for the financial year) as a sector specific indicator for various types of mines such as for uranium, diamonds or copper;
- Water use for residential water use based on per capita consumption including the number of households where the mine provides free water;
- Number of days of lost production as a result of the non-availability of water and average turnover per production day for the specific mine;
- Volume of water pumped for mine dewatering and made available for use by other sectors in the economy except in cases such as the uranium mines where water is unsuitable for use by others;
- Process related parameters such as the volume of recycled water from the slimes dams relative to fresh water intake;
- Development and implementation of a water management plan<sup>4</sup> (WDM) for the mine including residential households provided with water by the mine, within one year after promulgation of the Water Use Efficiency Regulations;
- A plan to prevent the mining activities causing water pollution during operation and after closure of the mine. An environmental impact assessment should be required within one year after promulgation of the water pollution regulations;

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<sup>4</sup> Rössing Uranium water management plan may serve as template to other mines.

- Voluntary compliance with the relevant ISO 9001 and ISO 14 001 requirements if implemented by the mine.

## **2.8 TOURISM SECTOR**

During 2008 the tourism sector used approximately 19.6 Mm<sup>3</sup> which represents 6.0% of the total water consumption. The tourism sector was identified as a high growth sector in Vision 2030 and the expected water requirement is expected to increase to 38.9 Mm<sup>3</sup> which represents 5.0% of the total expected water requirements by 2030.

Staff consumption, leakage from water networks and watering gardens were independent of visitor numbers and made up the bulk (80 to 90%) of the water used. Water use varied significantly and depended on the scale and design of the facility, as well as the approach of facility managers on how water resources are managed. Sound maintenance and efficient irrigation of landscape areas resulted in substantial water savings at several study sites. Information collected from water audits as part of case studies had direct influence on the management of water at resorts. Best results were obtained through a combination of site-specific WDM approaches. More recent studies at Okaukuejo and Namutoni concluded that major wastage results from infrequent or lack of maintenance of plumbing systems especially at the staff facilities and estimated that savings up to 40% are possible at both camps. Very few tourism facilities sensitize their own personnel and visitors to improve water use efficiency. Previous campaigns to sensitize tourism operators about water use efficiency seemed to fade away, as very few tourism establishments display signs to improve water use efficiency.

Water demand measures for the tourism sector are very site specific and depend on the type of operation. The water management plan will determine the most important measures to improve water use efficiency such as the use water efficient shower heads and toilets and landscaping adapted to reduce water requirements. The disposal of wastewater and solid waste to prevent pollution of water sources should be included in such a plan. The general strategy determined as part of the IWRM needs to be internalised or adapted for their own use.

### **2.8.1 Objective to Improve Water Efficiency in the Tourism Sector through Implementation of WDM.**

The overall objective for the tourism sector is to improve water use efficiency and to enhance economic growth in Namibia through increased tourism, provided that the integrity of the ecosystems on which tourism depends are protected and that water resources are not compromised.

## 2.8.2 Strategies to Implement Improved Water Efficiency through the Implementation of Water Demand Management

### LEGAL AND POLICY REQUIREMENTS

#### Strategy: Establish and implement legal instruments to support WDM in tourism sector

The following measures should be taken to implement WDM successfully in the tourism sector:

- Finalize the revisions of the Water Resource Management Act and the Regulations to control water use efficiency including regulations requiring water management plans by tourism facilities (20 beds) located outside municipal areas within 12 months after promulgation of the act. Performance indicators required in the tourism sector should be defined and the reporting periods to the basin water management institutions and DWAF should be laid down.
- Compile and implement Water Pollution Regulations to prevent water pollution as a result of tourism activities, which should include mandatory water quality testing of potable water and effluent as well as regulations covering the disposal of solid and other waste for all enterprises irrespective of location. Mandatory measuring and regular reporting of water quality information should also be included in the licence conditions of all self providers in the tourism sector.
- Recognize that the high value added by the tourist industry must be balanced against the need to conserve the integrity of the ecosystems on which tourism depends through appropriate, efficient and environmentally sustainable means including education, awareness and research.
- Harmonize relevant policies and Acts (MET and DWAF) which regulate tourism. It is important that with the registration of tourism facilities outside municipal areas, proof must be provided that an abstraction and sewage treatment licence has been issued by DWAF. It is recommended that water and energy use, as well as environmental accountability (over abstraction, pollutions of resources etc) should be included in the grading system of tourism enterprises.
- Tourism facilities located outside proclaimed townships must be subjected to the same regulations with respect to water use efficiency as those located inside urban areas.
- The tourism sector should participate in basin management committees.

### INSTITUTIONAL DEVELOPMENT AND CAPACITY BUILDING

#### Strategy: Enhance institutional development and capacity building at all levels to implement WDM

The following measures should be taken to enhance institutional development in the tourism sector

- Appointment of a specific person that should be responsible to collect and process data with respect to water consumption, water use efficiency and liquid and solid waste disposal in the case of self providers.
- Tourism coordinating organisations such as the Hospitality Association of Namibia (HAN) and Namibia Community Based Tourism Assistance Trust (NACOBTA) or even the Tourism Board should be encouraged to award a prize for “green” hotels, lodges and camps (i.e. a green rating system).
- Training of the tourism enterprise personnel in water use efficiency and prevention of pollution should be included in the water management plan for the tourism facility.
- Foster partnerships with Vocational Training Centres and others during practical training periods to repair plumbing and water supply systems at larger enterprises which will contribute to capacity building and reduction of water wastage and maintenance costs.
- Outsource specific functions to the private sector to improve operation and maintenance water and sanitation infrastructure;
- Provide sufficient funding for proper maintenance of water infrastructure including replacement if required.

### TECHNICAL REQUIREMENTS/CAPACITY

#### Strategy: Selection of appropriate technologies, infrastructure maintenance and the reduction of wastage

The following measures should be taken to enhance the performance of tourism facilities:

- Incorporate both water and energy efficiency in the design of new facilities;
- Incorporate disposal of solid and liquid waste in planning of facilities and in water management plans to prevent pollution of water resources and the environment;
- Vest the responsibility for regular maintenance inspections and for the maintenance in a specific person.
- Implement separate metering of water for landscaping, water holes, permanent staff consumption, onsite washing facilities and use by guests;
- Develop and implement maintenance and replacement programs to reduce leakage and wastage;
- Measure night flows regularly to determine leakage rates;



- Investigate and implement recharge enhancement to improve sustainability of the water resource;
- Measure abstraction and rest water levels to determine sustainable levels of abstraction. (licence requirement for self providers,)

### **CUSTOMER CARE, EDUCATION AND AWARENESS RAISING**

#### **Strategy: Sensitizing employees and visitors to use water efficiently**

The following measures should be taken to sensitise customers to use water efficiently and reduce wastage.

- Provide information to employees and visitors to conserve water;
- Implement a system where visitors can report leakages.

Other aspects not directly related to WDM which influence the level of services to visitors:

- Compliance with potable water quality standards.

### **2.8.3 Performance Indicators**

The performance indicators should be included in the licence conditions for tourism enterprises providing their own water supply. The mandatory reporting of self providers to the basin management committees and DWAF should be included in the Water Efficiency Regulations as well as in the licence conditions of such enterprises.

The following performance indicators are suggested for the Tourism Sector

- Development of a water management plan to manage the water system including the prevention of water pollution for facilities with more than 20 beds;
- Average water consumption per occupied bed night over one year;
- Measurement of night-flows with a target figure of less than 10% on facilities with more than 20 beds;
- Separate metering of worker quarters, onsite washing facilities, and water consumption for landscaping, water holes etc to determine segregated water consumption patterns for facilities with an annual consumption above 15 000 m<sup>3</sup>;
- Value added (total annual turnover/annual water consumption) by the enterprise for annual reporting to DWAF;
- Mandatory reporting of metered abstraction and borehole rest water levels by tourism facilities supplying their own water;

- Mandatory monitoring of potable water quality by self suppliers to determine suitability for human use at least twice a year or as specified in the licence conditions;
- A system of solid waste disposal which does not create a threat to water pollution;
- Use of unconventional sources such as recharge enhancement and possible reuse of water for irrigation or landscaping, provided that such water complies with the required standards and such a system is properly designed and monitored in accordance with the reuse and recharge Regulations; and
- Mandatory self monitoring by tourism enterprises and reporting of results to the relevant authority which may be a local authority, management committees or DWAF in cases of self provision of water.

### **3. CONCLUSIONS AND RECOMMENDATIONS**

#### **3.1 CONCLUSIONS**

As stated in the report, the development of end use water tariffs, subsidy or cross subsidy policies and appropriate credit control policies are overdue, and no water demand management policy or strategy will succeed without it.

To implement WDM successfully it is important that the revisions of the Water Resource Management Act and the Regulations should be finalised as soon as possible in order to enable the promotion of water use efficiency, the prevention of water pollution and the controlling of water quality. The water use efficiency regulations must include the performance indicators required in the different water use sectors.

The urban water supply sector (including industry) and irrigation sector offer the biggest opportunity for the implementation of WDM to provide significant savings in money and water. During 2008 the urban water sector, including industries in urban areas, consumed approximately 69.1 Mm<sup>3</sup>/annum which represents 20.9% of the total water consumption. In Vision 2030 the urban sector is earmarked for the accommodation of the majority of the population (75%) with significant industrialisation taking place. It is expected that the urban water demand will increase to 117.2 Mm<sup>3</sup>/annum which is 15.2% of the total expected water requirements in 2030.

During 2008 the irrigation water sector consumed approximately 135.3 Mm<sup>3</sup>/annum which represents 41.4% of the total water demand. In Vision 2030 the irrigation sector is earmarked for major development and the expected water demand for irrigation will increase to 497.2 Mm<sup>3</sup>/annum which represents 64.6% of the total expected water requirements in 2030.

To improve water management in urban areas, including the implementation of WDM, it is suggested that a special team be created to assess the water management and the condition of water infrastructure at local authorities and make recommendations for improvement. Such a team should be appointed by DWAF in consultation with the Ministry of Regional, Local Government and Housing and Rural Development within one year after acceptance of the IWRM Plan.

To improve irrigation efficiency and to increase crop productivity it is suggested that Government assists in the establishment of an Irrigation Efficiency Committee through a private-public partnership with agricultural cooperatives within one year of the approval of the IWRM Plan.

The livestock sector was identified as a candidate for increased production provided that bush encroachment and de-bushing is actively pursued to increase the fodder availability of rangelands. During 2008 the livestock water sector consumed approximately 86.9 Mm<sup>3</sup>/annum which represents 26.6% of the total water demand. No significant growth is expected in the livestock sector and the expected water demand will stay the same and will use only 11.3% of the total expected water requirements in 2030.

According to Vision 2030 the tourism sector may grow significantly. During 2008 the tourism sector used approximately 19.6 Mm<sup>3</sup> which represents 6.0% of the total water use. The tourism sector was identified as a high growth sector in Vision 2030 and the water demand is expected to increase to 38.9 Mm<sup>3</sup> which represents 5.0% of the total expected water demand in 2030. The known potential for WDM saving in the Tourism Sector is limited except for some resorts under the control of Namibia Wildlife Resorts where maintenance seems to be inadequate. The biggest threats to private lodges that provide their own water from boreholes, are over abstraction and pollution of groundwater which were identified as focus areas.

The potential to implement WDM in the rural domestic sector and the mining industry is limited except for mining towns. Mining towns were included in the urban sector. During 2008 the rural domestic water sector consumed approximately 10.3 Mm<sup>3</sup>/annum which represents 3.1% of the total water demand. In Vision 2030 it is the rural domestic sector is not expected to grow significantly. The expected water demand will increase to only 11.4 Mm<sup>3</sup>/annum and it will use only 1.5% of the total expected water demand in 2030.

During 2008 the mining sector used approximately 16.1 Mm<sup>3</sup>/annum which represents 4.9% of the total water demand. The expected water requirement will increase to 20.3 Mm<sup>3</sup> which represents only 2.6% of the total expected water requirements in 2030 which excludes use from unconventional sources such as, recycling, sea water and desalination.

The consultant promoted the WDM strategy with water management institutions and service providers and opinions and expectations were included in the strategies. Successful examples implemented in Rehoboth, Windhoek and other towns in Namibia were shared with stakeholders during workshops and meetings. WDM was also be integrated into the capacity building and awareness programmes.

### **3.2 RECOMMENDATIONS**

It is recommended that the Water Demand Management Strategy for each sector as discussed in Chapter 2 be accepted for implementation.



**APPENDIX A**

**BALANCED SCORECARD FOR IRRIGATION  
FARMING**



#### 4. APPENDIX A: BALANCED SCORE CARD FOR IRRIGATION FARMING

Knowledge of farmer (40%)		Maximum	Scored
Participation by farmer/ foreman in training sessions and study groups	1=5 2=10	10	
Keeping of records (planting periods, pesticides, water application, crop yield/ha etc) to reduce risk of water pollution	No record=0 Partial=5 Complete=10	10	
Groundwater and surface water pollution verification on an annual basis (Nitrate only)*	No pollution =10 N ≤3 =5 ≥3 = 0	10	
Management (metering, wastage, maintenance of equipment etc) including water use for a specific crop in a specific area with similar soil and climatic conditions such as Hardap, Etunda etc.	Excellent =10 Good = 6 Average =4 Bad = 0	10	
<b>Financial Economic (30%)</b>			
Value added (N\$/m <sup>3</sup> )	N\$ 5+/m <sup>3</sup> =15 N\$ 3-5/m <sup>3</sup> =10 N\$ 2-3/m <sup>3</sup> =5 N\$ 1-2/m <sup>3</sup> =3 ≤N\$ 1= 1	15	
Jobs/ha on irrigation scheme including improved labour productivity over time. (convert temporary job to equivalent fulltime jobs; 4 X 3 month= 1 year)	≥ 2=15 1-2=10 0.5-1=5 ≤0.5 =2	15	
<b>Water Demand Management (30%)</b>			
Irrigation system	≥85% efficiency=15 ≥75% efficiency=10 ≥60% efficiency=5	15	
Scheduling (keep records of irrigation water, rainfall, plant growth cycle, plant water requirements)	Excellent =15 Good = 10 Medium = 5 No information = 0	15	

\* Note rising levels of nitrate may influence water allocations





**APPENDIX B**

**GENERAL BACKGROUND TO WATER DEMAND  
MANAGEMENT**



## **5. APPENDIX B: GENERAL BACKGROUND TO WATER DEMAND MANAGEMENT**

The background information summarised in the Appendices B and C was summarised and updated from several reports such as the “Development of the National Strategy for Water Demand Management” (Namibia), November 1999 which formed part of the Namibia Water Resources Management Review and the “Water Conservation Report” which in turn was part of the “Prefeasibility Study into Measures to Improve the Management of the Lower Orange River and to Provide for Future Developments along the Border Between Namibia and South Africa”, June 2004.

New concepts such as cleaner production, waste minimisation, segregation of waste which were included in the Draft Water Resource Management Bill were also included in the appendices.

### **5.1 INTRODUCTION**

There are many definitions of Water Demand Management, but for the purpose of this project the following definition is accepted: “Water Demand Management involves measures that improve efficiency by reducing water use or altering patterns of water use after abstraction”, Beecher, (1995).

WDM attempts to reduce the consumption of water through the reduction of inefficient consumer demand in order to reduce the pressure and reliance on conventional water resources and infrastructure. The demand for water impacts directly on conventional water sources such as perennial rivers, ephemeral rivers and groundwater.

“Well planned and implemented Water Demand Management measures can reduce a water authority’s cost significantly, primarily through avoiding or deferring the need for new capital works and also by reducing operating costs associated with pumping and water treatment” (White Editor, 1998). The main purpose of WDM is to reduce wastage and to enhance the efficient use of water. This entails a reduction of losses and volume of water used to perform a particular task, without sacrificing the level of customer service. For example, the use of a low flush toilet and an efficient shower head does not influence the level of service to the user.

Water Demand Management is a fundamental part of an integrated approach to sustainable management of the water sector in an arid country such as Namibia. WDM is an alternative method of increasing the available supply of water instead of traditional supply augmentation strategies. Supply is effectively increased through increasing the services to end users from a given quantity of water. In light of the growing demands in Namibia, due to growth and change in the structure of population which results in water shortages in major growth centres remote from potential new water resources, and the high capital cost of supply augmentation, more attention is now focused on WDM to ensure that the greatest benefits are derived from limited available water resources.

WDM can be implemented in a variety of ways with different policy tools being successful in a variety of contexts. These policy tools include market mechanisms such as rising block

tariffs (conservation tariffs), non-market mechanisms such as the application of quotas for water allocation or fines for water wastage, as well as direct intervention such as pressure reduction, repairs to leaks, reduction of non-revenue water, promotion of water efficient technologies, public education and changes in legislation.

Instruments have been identified from the literature for practising water demand management. In most countries all the efforts are concentrated on initiatives of the water authority to improve their own efficiency and change the behaviour of their customers. Most of these instruments and principles are described in detail in the Water Demand Management Manual (White 1998) and in the USEPA Guidelines for Water Conservation (1998).

The most important instruments that could have a major impact in the short and long term water demand, if applied within Namibia are classified for discussion purposes under the following main headings:

- Education and Information
- Training
- Economic and Financial Principles
- Water Pricing and Tariff Policies (form part of economic and financial principles)
- Technical Issues

## **5.2 EDUCATION AND INFORMATION**

### **5.2.1 General Campaigns**

Community involvement in decision-making is crucial for the success of any WDM planning or development of a WDM strategy. This is important to establish 'ownership' of the final product. The best way to achieve such input is to liaise with stakeholders within the specific sector. If residential consumption is targeted for reduced consumption, workshops with consumer groups and the horticulture industry may be a good avenue to explore. Suggested measures are spreading of information, transparency, establishment of a customer advisory committee and customer services that help customers participate in the process as was implemented in Windhoek during 1996.

Education forms a cornerstone for changing people's behaviour. In the case of water use in the Rand Water Service Area in Gauteng, RSA, guidance towards improved water use efficiency and perhaps even some practical training in maintenance of basic water infrastructure, such as taps and cisterns, were important components of a WDM strategy.

The exchange of information, the improvement of public understanding of complex water resources issues and discussions on tariff issues will foster trust and goodwill. Both education and information are crucial for the successful implementation of any WDM programme. For example, in Tucson Arizona, school programmes have been developed for sensitising school children and teachers to water efficiency. Children are also required to

pass a skills-training programme prescribed by the Arizona Education Department (Personal communication Dotson, 1999).

In Windhoek, the 1996 education and information programme of the Municipality included the following:

- Lectures in schools and other institutions of learning on the subject of water management;
- Radio and television appearances and advertisements in the print media;
- Pamphlets on saving water in and outside the home, compiled and distributed with accounts;
- Advice on all water related issues, including reduction of water losses and pressure reduction;
- Information on how to detect water leaks on premises; and
- Advice on efficient garden watering practices, as well as advice on suitable shrubs and trees. (Van der Merwe et al, 1999).

It is not possible to establish the actual value of public campaigns in the long-term. It may change the behaviour of people over time. In many cases changes do not seem to be permanent. The only known experience was with the drought of 1992 in Windhoek, where a public campaign yielded a saving of only 5% on the projected unrestricted water demand over a period of 6 months. Permanent change of behaviour needs to be achieved over a long period to establish a new generation that has a different ethic towards the real value of water.

According to the literature, focused public campaigns linked to a specific activity such as the installation of low flow shower heads, introduction of conservation water tariffs and changing of gardening methods are more successful.

### **5.2.2 Industrial, Commercial and Mining**

Marketing of good WDM approaches in industry needs a totally different approach to that used for domestic supply. Ploeser (1996) summarised it as follows:

- Saving of water and money needs to be the main approach;
- WDM should be advocated on different levels to be successful (management and workers);
- Conservation technologies are more complex and expensive;
- The human variables in water use are more diverse;
- Water costs are normally a low priority (less than 1% of the total operational cost) for business and industry;
- Credibility, reliability and confidentiality form the foundation for results.

To be successful the following six elements are important:

- Target market identification;
- Whole programme outreach approach;
- Individual customer contact;
- Proper information;
- Political promotion; and
- Programme monitoring and customer follow up are required.

No other references could be found concerning the influence of public campaigns on the water consumption of users such as business, mining and government departments. Technical measures to change actual water demand for commercial, industrial and institutional facilities are described in great detail in the “Water Efficiency Manual for Commercial, Industrial, and Institutional Facilities” (North Carolina Department of Environment and Natural Resources, August 1998).

### **5.3 TRAINING**

There is a major need for training water professionals in integrated resource planning. The biggest challenge will be to bring about a change of mindset, away from the “business as usual approach”. The benefits of an integrated approach will far outweigh the cost.

Operational training of employees within the water service providers will quickly yield benefits. Water institutions (service providers) should set an example of water use efficiency. The development of skills of people employed by local authorities and NamWater is a prerequisite for the successful implementation of any WDM programme within Namibia. Particular individuals should be identified, trained and given responsibility and financial rewards for improving WDM within the different institutions.

Training of new entrepreneurs in high density townships and rural areas in basic plumbing skills for proper maintenance of taps, cisterns and even basic skills in new installations can make a major contribution by providing employment and improving water use efficiency in the townships.

### **5.4 ECONOMIC AND FINANCIAL PRINCIPLES**

#### **5.4.1 Economic Aspects and Sustainable Economic Development**

The term scarcity is well understood in secular society to refer to a current or potential shortage of a particular good or service, or a set of goods and services. Used in the context of resources deemed essential to society's well-being such as oil, gas, water, etc. predictions of scarcity may cause widespread consternation on the part of the public, and trigger wide-ranging public policy studies. In economics the concept of scarcity is more tightly defined than in common usage, and carries with it a set of economic conditions and dynamics. Since economics itself has been defined as the science of scarcity, the economic framework is an appropriate one within which to place this discussion.

The basic reason why the economic system works well in allocating marketed resources and in providing incentives for technological change is that it tends to produce efficient solutions to problems concerning the production and consumption of resources. Suppliers have an incentive to maximise their profits by producing goods and services of acceptable quality at lowest costs. Consumers have incentives to satisfy their needs, again as cheaply as possible.

When these two basic forces meet in the market, there is a tendency towards efficient resource allocations - that is, resource allocations at the lowest possible prices. The challenge for water managers is to apply as many of the efficiency-generating properties of economics as soon as possible. The past failure to do so is currently causing enormous harm to the water resources of the planet. It is also the motivation for the massive move to privatisation of water providers around the world to improve efficiency in distribution and end-use consumption through better credit control.

#### **5.4.2 Integrated Resource Planning (IRP)**

Demand-side management practices started in the early 1970s in the energy sector to lower the spiralling cost of energy resulting from the oil crisis. IRP includes a wide range of traditional and innovative supply and demand-side planning principles. It is a non-traditional response to long-term water resource issues and goes beyond the "business as usual" approach of supply augmentation. IRP evolved as a result of this change in planning and was defined by the New Jersey Regulatory Commission as follows:

"Integrated resource planning is a process for determining the appropriate mix of demand-side and supply-side resources, which are expected to provide long-term, reliable service to utility customers at the lowest reasonable cost and which maximises benefits to the state. This will require considerations of the impacts of various resource options on electricity prices, system reliability, financial stability of the electric utility, environmental quality, economic development, fuel efficiency and diversity, and other social goals deemed important by state policy makers. The IRP process should identify and assess the various demand- and supply-side options available to the utility and outline a flexible plan for fulfilling energy and capacity needs", (American Water Works Association, (AWWA) 1996).

IRP is still in its infancy among water utilities, which presently lack the widely used planning tools to support it. Water utilities lack information on such critical variables as customer demand, conservation programme impacts, customer sensitivity to pricing changes, public preferences and institutional constraints. IRP includes many of the planning components that characterise a well performed traditional planning effort, as well as extensive analysis of conservation programmes, consideration of uncertainty and co-ordinated efforts to involve and inform the public that are not found in traditional water supply planning. IRP should consider the impact on wastewater systems, urban growth, and land use etc. There are definitely wrong ways to practise IRP, but no single "correct" approach.

In South Africa, IRP within the water sector is defined as: "A way of analysing the change in demand and operation of water institutions that evaluates a variety of supply and demand factors to determine the optimal way of providing water services for the customers. This



path must include economic efficiency and stability, a reasonable return on investment for the utility, environmental protection and equity among ratepayers”, (DWAf 1999).

It is suggested that the following definition be accepted in Namibia for IWRP. Integrated Water Resource Planning (IWRP) is a process for determining the appropriate mix of demand-side and supply-side resources, which is expected to provide long-term, reliable service to utility customers at the lowest reasonable cost and which maximises benefits to the society. This will require considerations of the impacts of various resource management options on water prices, system reliability, financial stability of the water service provider, environmental quality, security of sources, economic development, water use efficiency, social equity and other social goals deemed important by government policy makers. The IWRP process should identify and assess the various demand- and supply-side options available to utilities and outline a flexible plan for fulfilling the water needs in Namibia, (Adapted from AWWA, 1996)

The fact that IWRP was not used to in the past, led to inefficient allocation of financial resources. The Oanob Dam near Rehoboth is a typical example of an investment that was done without reassessing the water demand pattern in the service area supplied by the new dam. After implementation of water demand management in Rehoboth in 2004 the water requirements decreased from 2 Mm<sup>3</sup> (in 2000) to 1.1 Mm<sup>3</sup>/a (in 2008) which is well within the safe yield of the Rehoboth Aquifer of 1.7 Mm<sup>3</sup>/a.

The principle of Total Least Cost Planning entails that the water supply authorities and distribution authorities determine the options that, at the lowest cost, will provide their customers with the water related services they need, rather than with the water itself. Integrated least cost planning recognises that customers do not actually want more water, but rather the services that water provides, such as clean homes, dishes and clothes, sanitation and pleasing landscapes. A good example of the cross-sectoral benefits of total least cost planning is the installation of low flow showerheads. The consumer also saves money by heating less water (lower peak demand on electricity supply), while the reduction in wastewater flow also contributes to savings in wastewater treatment costs, (White, 1998).

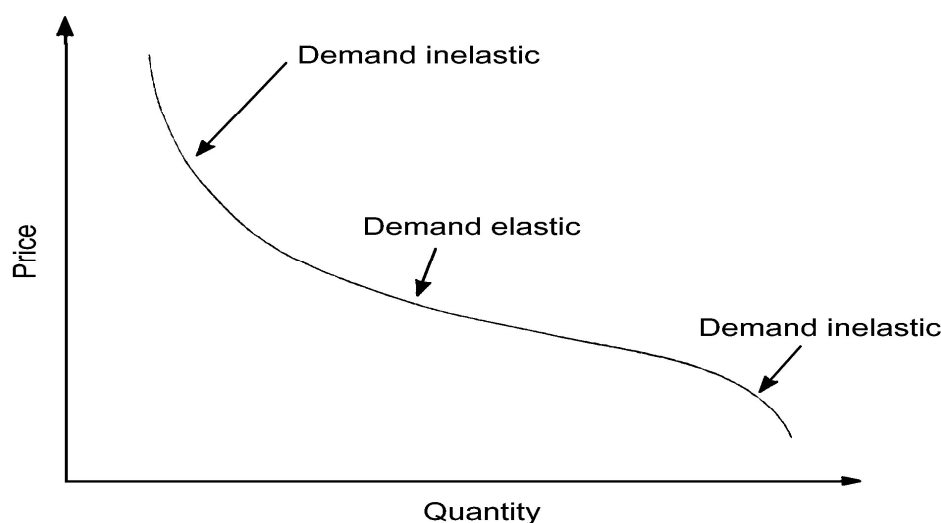
The calculations of total least cost are done on present worth values of the various supply and demand management options. Total least cost planning principles can be used to prioritise the actions needed for the implementation of WDM. It can also be used as an instrument to evaluate WDM options with resource augmentation.

### **5.4.3 Price Elasticity of Demand**

The price of water is an important determinant for those who use it and affects how they use it. Demand for water, in economic terms, follows a price/quantity relationship. It has been found that this relationship is an inverse one, thus as price increases water demand decreases.

The percentage change in demand for any given percentage change in price is known as the “price elasticity of demand”. The price elasticity of demand is a measure of the sensitivity of the consumer to changes in water prices. Demand is said to be elastic when it decreases as price increases and inelastic when price increases have little influence on

demand. The relationship between price and water consumption is illustrated in Figure 5.1. (Stephensen, 1999)



**Figure 5.1: Relationship between Water Price and Volume Consumed**

The threshold price defines the unit cost of water at which small increases in the price begin to significantly reduce demand. In 1991 water tariffs in Windhoek were changed from a single basic charge plus a low unit tariff per  $\text{m}^3$  to a minimum charge that includes a certain volume of water and a relatively high unit charge. This change in the tariff system reduced the bills for lower income consumers by 25%. For consumers who used more than  $50 \text{ m}^3/\text{month}$ , the cost of water increased by 25 to 40%. Despite major increases in some customers' accounts, there was no discernible change in the water consumption pattern. Thus, demand by high-income users continued to be inelastic after a large increase in water tariffs. The unit tariff for water increased from  $\text{N}\$ 1.12/\text{m}^3$  to  $\text{N}\$ 1.55/\text{m}^3$  with the change to a new tariff system in 1991. (If an inflation rate of 10% is accepted over the 7 years the equivalent prices for 1998 would be  $\text{N}\$ 2.18/\text{m}^3$  and  $\text{N}\$ 3.00/\text{m}^3$  respectively). It is estimated that the "threshold price", where medium and high-income customers will start to use less water, was approximately  $\text{N}\$ 5.00$  to  $\text{N}\$ 8.00/\text{m}^3$  in Windhoek in 1998. Water in Windhoek is regarded as expensive in comparison to other towns in the region (Van der Merwe Ed, 1999).

The report to the Water Research Commission on the estimation of the residential price elasticity by Veck and Bill (2001) that was done for Alberton and Thokoza in South Africa during 1998 provided the results as summarised in Table 5.1. Price elasticities were derived using the Contingent Valuation Methodology.

**Table 5.1: Price Elasticity of Demand**

Description of group	No. of Respond.	Price Elasticity of Demand		
		Indoors	Outdoors	Total
Upper, middle and lower income groups	161	-0.13	-0.38	-0.17
Upper income group	52	-0.14	-0.47	-0.19
Middle income group	59	-0.12	-0.46	-0.17
Lower income group	50	-0.14	-0.19	-0.14
Upper and middle income groups	111	-0.13	-0.47	-0.18

During the survey it was determined that people were not aware of how they use water. As a result an educational programme was implemented to provide meaningful results. These price elasticity values should be regarded as short-run price elasticities. An econometric model yielded a price elasticity of  $-0.73$ . This figure for the long-run price elasticity cannot be regarded as reliable because of the fact that all the statistical indicators were not within the required limits. These elasticities are specific for an income and social group and cannot be applied generally without taking these factors into account. No detailed information is available but it is estimated that the effect of a 10% increase in the bulk water supply tariff of NamWater will decrease the water demand by at least 3%.

A failure to consider water demand elasticity can have an impact on generating necessary revenues of service providers. The reduction in water use in urban areas as listed in Table 2.3 as well as the general decline in water sales by NamWater indicates that the threshold price has been reached where water demand may become highly elastic as prices increase. With the envisaged massive investments required to augment supply and treat increased wastewater volumes, the unit cost of water will need to be increased. The increase in costs could conceivably reduce water demand (price elasticity of demand) and thereby reduce anticipated revenues required to recover the capital cost of augmentation.

According to the literature there is ample proof that increasing the cost of water and wastewater treatment in countries such as Germany, Sweden and in some states within the USA (mainly in Arizona and California) leads to major reductions in water consumption in all sectors including domestic water demand. The driving force in most countries is the high cost of supply augmentation, high cost of wastewater treatment as well as strict environmental legislation to prevent water pollution. The high cost of rehabilitation of areas that were damaged as a result of over abstraction of water or excessive water pollution contributed to the spiralling cost of water.

Residential water demand is flexible, especially in the long term. Increased water cost makes residential users pay more attention to wastage and is thus effective in eliminating domestic wastage. Consequently, wastage is also flexible. The price of luxury residential demand is even more flexible, increased prices can more easily reduce less essential water-use such as car washing, garden watering and private swimming pools. Studies show that the flexibility depends on the marginal price of water and not on the average price.

A review of the impact of price changes on water demand and of the "Best Practices in Improving Economic Efficiency and Environmental Quality" through water conservation and reallocation has been presented in a study by Bhatia, Cestti and Winpenny (1993). The study covers both developed and developing countries and gives examples of successful practices which have resulted in water demand management in Brazil, China, Indonesia, India, Israel, USA (mostly in California and Arizona), and Australia. The main conclusions of the study can be summarised as follows:

- There is scattered but compelling evidence that improved policies can have major impacts: at least 20-30 per cent of water currently used by households and industries in developing countries can be saved by adopting appropriate policy instruments such as water tariffs, quantitative allocations, effluent charges, fiscal incentives and technology policies;
- Higher prices reduce demand: In the household sector, for example, the price elasticity varies between -0.23 and -0.70. This means that a 100 per cent increase in price will produce a 23 to 70 per cent decline in water demand. Similarly in the industrial sector, the majority of estimates of price elasticity are in the range of -0.49 to -1.00. (The coefficient of 1.00 is with respect to cooling water where treated effluent is used for cooling with a 100% reduction in potable water intake);
- Prices alone are not enough: The reviewed cases show that prices work best in combination with supportive regulatory mechanisms, other economic incentives, public education and persuasion including increased options for reallocation of water among water users; and
- Pollution control charges and taxes encourage reduction in water use.

#### **5.4.4 Income Elasticity of Demand**

The income elasticity of demand describes the relationship between earned income and water demand among consumers. This is similar to price elasticity of demand but looks at the relationship from the opposite side, where money comes in instead of going out. Logically, customers tend to use more water if their income is higher. This is normally related to more appliances using water in the house as well as larger houses and gardens in general.

According to Baumann et al (1998) income elasticity of demand in the USA as determined in various studies, varied between 0.2 and 1.03. Income elasticity of demand is an important factor to be taken into account within the long term planning horizon. If the average income in the urban areas in Namibia reduces over a period of time as a result of economic circumstances or demographic changes, the per capita water consumption will go down.

Experience in most developing countries indicates that both average income and per capita water consumption decrease as a result of the influx of poor people from the rural areas. No reliable information could be found on income elasticity of demand within the Southern African region.

### **5.4.5 The Role of Subsidies**

The water sector is heavily subsidised worldwide. Subsidies are not inherently bad as they can provide social benefits to the poor and promote desirable patterns of use across all sectors. They should not, however, be allowed to become a hidden advantage to rich consumers, farmers, and industrial users. The effects of subsidies should be monitored and the policies should be openly analysed and debated in terms of costs and benefits (Lundquist and Sandström, 1997).

Subsidised water is often directed towards sectors where the economic benefit is low since the water is not implicitly valued. The fact that water has historically been supplied at low cost has led to a general feeling that water should be supplied at low cost. The implementation of water pricing has been met with resistance in some regions, manifesting itself in non-payment of water bills and illegal connections. Subsidised water has shaped the pattern of development in Southern Africa towards water intensive activities such as irrigation, and within these activities inefficient practices such as flood irrigation.

In the past, incentives to use water more efficiently or productively have been low mainly as a result of very low water tariffs. Subsidies to improve water efficiency or to install pollution prevention devices have been shown to be ineffectual in a large variety of cases. Subsidisation can reduce the operating costs of particular industries and thereby either increase entry into the industry or increase the amount of outputs. Adverse effects have been witnessed, including an increase in water use and pollution as a result of subsidisation. As subsidised resource-intensive products become relatively cheaper, the wrong market signals are sent to consumers of water-intensive goods. The World Bank has stated that “subsidies may encourage a long-term increase in environmental damage and their use should be well targeted, time-bound and carefully monitored.”

## **5.5 WATER COSTING AND WATER TARIFF POLICIES**

Water costing and tariff policy form part of economic and financial instruments but are discussed separately for the purpose of this report.

The setting of water tariffs is one of the most powerful and versatile tools in WDM. Water tariffs, if correctly structured, can be used to change the behaviour of consumers and prevent the wasteful use of water. An understanding of the price elasticity is essential before considering pricing and tariffs.

### **5.5.1 Water Tariff Principles**

Tariffs play a very important role in the implementation of water conservation and WDM though they should not be seen in isolation from other WDM programmes. The application of an efficient water tariff policy is one of the most important instruments for the successful implementation of a WDM policy. All the evidence suggests that water is constantly overused in parts of Southern Africa because it is consistently under priced. Tariffs can be used to remind consumers to promote appropriate and efficient use of water.

Several methods of tariff application exist and are covered in the text below. It is important to liaise with service providers and users before the adoption of a specific tariff system. Failure to do so could lead to conflicting and cost compounding rates for the consumers or retailers. For example, if NamWater charges a high fixed charge and a low unit cost, the local authorities can experience major revenue instability if they do not adopt a similar tariff system.

With respect to WDM and influencing of water consumption patterns, it is important that the tariff charged to end consumers should give a clear signal to the consumer to conserve water. Public relations measures need to be initiated long ahead of the tariff system as well as programmes to help people identify ways of reducing their demand. An impoverished household that receives a massive water bill in the first month of the new tariff system due to an unknown leaking pipe leads to bad publicity - and history shows there will be a lot of such cases.

From the literature and experience in other countries it is clear that an integrated approach to WDM in combination with an effective water pricing policy can influence the long-term water consumption. In Windhoek, savings of up to 30% were realised in 1996 and 1997 in residential water consumption as a result of implementing rising block tariffs and adopting an integrated approach to WDM including public campaigns. Through an integrated approach and the commitment of all the players, it is estimated that similar or even higher savings can be achieved in the commercial, industrial and especially the public sector. Towards the end of 1997 the lower limit of the block tariff, in which long run marginal cost pricing was applied, was increased from 30 to 36m<sup>3</sup>/month. A survey of water consumption in 1998 by households showed that almost all middle and high-income households made use of the extra allowance of 200 litres/household/day (6m<sup>3</sup>/month).

Experience in Windhoek confirms the existence of a threshold price, where water demand is only reduced significantly in the higher and middle household income groups when the price to the end user is in excess of R 12 to R 15/m<sup>3</sup> (estimated price for 2009) depending on the income of the specific household.

Hanemann (1999) suggests that the higher tier tariff to curb excessive consumption should be much higher (at least 60 to 100%) to effectively reduce water consumption. A gradual increase does not realise substantial savings at all. Simply put, for the tariff to work, the customer needs to feel it when he or she is using too much water.

### **5.5.2 Rising Block Tariffs**

It is often felt that the pricing of water based on economic principles may achieve efficiency at the expense of equity. Since water demand and willingness to pay for water are influenced heavily by incomes, basing the price of water on demand and supply principles may leave some people unable to afford water. In many developing countries this has been addressed by the use of increasing block tariffs i.e. progressively higher tariffs for progressively higher consumption. Clearly, equitable and affordable water supply is an issue when using pricing as a WDM tool. However, scant regard was given to some of the

detailed implications of such methods. The design of the tariff system is critical in achieving the required effects of equity and economic efficiency while still achieving cost recovery.

Hanemann (1999) suggests groups based on erf size. There should be two separate blocks within each erf size category. The first block is for social, i.e. necessary, use. The second block is the price elastic block for surplus (gardening, car washing, etc.) use. The switching point was set at 125% of the median use within each block. The high-end consumers are most likely to have the most options for conservation available to them.

There are practical problems in setting and implementing rising block tariffs. Detailed information is needed on the user patterns to be able to calculate revenues as accurately as possible. Rising block tariffs are not simple and during community meetings in Windhoek, members of the public expressed their difficulties in understanding the principles. In the case of the Windhoek Municipality, revenue instability (expenditure to supply service much higher than the income) was caused by the drought of 1996. The accumulated loss of income (due to changed water use patterns) was never recovered from income from water sales and was transferred to a stabilisation fund created from surpluses on the wastewater and the refuse removal account.

Boland and Whittington (1998) proposed a simple two tier system for recovering marginal costs for the variable cost element, namely a fixed availability charge and a fixed credit (or rebate) to accommodate low income consumers. This alternative is much simpler to implement and understand than increasing block tariffs. The problem with revenue stability is solved through the availability charge that covers the fixed cost of the system.

A study of the effectiveness of billing to conserve water in major urban centres in the USA done by Cuthbert (1996) concluded that billing is an effective method of demand reduction. In cases where conservation tariffs were applied, coupled to an active water conservation programme, the results were even better.

### **5.5.3 Water Conservation Tariffs**

Given the theoretical goal of economic efficiency, Beecher and Chesnutt (1998) define conservation oriented water tariff structures as follows:

"A conservation-oriented rate structure encourages efficient water use and discourages waste by ensuring that customer bills communicate the full cost of providing water services, including the cost of new supplies. From a more technical perspective, conservation-oriented rates reflect marginal-cost pricing principles and resource efficiency goals."

Prices based on historic costs create the illusion that future water resources will cost the same as resources developed in the past. This provides the wrong price signal to consumers and leads to over-consumption. In the past, water agencies have largely ignored the three possibilities to influence water demand, i.e. demand can be lowered and influenced, prices alter demand and prices can be used intentionally to alter the water demand.

If this definition of conservation tariffs is accepted, then it is clear that supply of water without measurement (mainly irrigation) and rising block tariffs not linked to marginal cost (or the cost of future schemes) do not qualify as conservation tariffs.

A large percentage of water users in the urban, industrial and mining sector can afford to pay marginal cost. Detailed information about income, family sizes and water usage within the service areas is needed to design a tariff system that will be acceptable to consumers. It is critical that consumers perceive that the water tariff is fair.

#### 5.5.4 Wastewater Tariffs

Wastewater tariffs promote the efficient use of water by creating incentives for industries to decrease their effluent volume. Reductions in effluent volume can be realised by adopting more water efficient manufacturing processes, water reuse, and water recycling. The effect of wastewater tariffs on industrial water-use in California has been summarised by Gleick (1995); Table 5.2 gives an indication of the savings realised.

**Table 5.2: Improvements in Industrial Water Use Efficiency in California**

Industry Group	1989 Water-Use as Percent of 1985 Water-Use
Paint	46%
Computers	50%
Vehicles	57%
Electronic Components	56%
Fruits and Vegetables	61%
Aircraft	63%

The savings were mainly realised as a result of more efficient manufacturing machines, introduction of higher charges for pollutants and strict enforcement of legislation to prevent excessive water pollution.

Wet industries are normally more sensitive to industrial effluent charges, than to the cost of water. The cost of industrial wastewater treatment can be two to three times higher than the cost of water. In Windhoek even wet industries except abattoirs spend less than 1% of their expenditure on water and wastewater treatment (this figure corresponds with figures from the USA where they talk about the 1% rule). The money value of large volumes of water and wastewater forces wet industries to try and lower effluent volumes as well as water intake.

According to Achttienribbe (1998) water price increases in Industry and the introduction of a purification tax led to long-term decline in industrial consumption in the Netherlands. It is doubtful whether industry will be price sensitive until water and waste treatment costs represent more of the operational cost for industry. In Windhoek, successful results were only obtained in some wet industries where the amount of savings, although a small percentage of total cost, warranted optimisation. Through discussions and commitments by some industries (mainly wet industries) to save water, good results were obtained.



In most countries the water price includes the cost of sewage treatment. Price sensitivities quoted with respect to water should be seen within this context. In countries such as Sweden and Germany with strict pollution and environmental legislation, the cost of sewage treatment contributed more than 66% of the total cost of water services, (water supply and sewage/industrial effluent disposal).

### **5.5.5 Cleaner Production and Waste Minimisation**

There are two fundamental approaches to waste management in the in wet industries: Processed Integrated Technology (PIT, cleaner technology) and End-of-Pipe Technology. Processed Integrated Technology is the more effective as not only does it reduce the generation of waste, but it also results in savings to a company, provided that the equipment utilised in the wet process lends itself to optimisation.

The impact of End-of-Pipe Technologies (EPT's) on the whole production process is limited compared with that of cleaner technologies. This implies that firms will face less uncertainty and irreversibility when they make a decision on investment in EPT. Therefore, most of the firms would prefer to adopt end-of-pipe technologies, which include additions to existing facilities, rather than altering the whole production process. There are limits in the extent to which the adoption of EPT is appropriate in dealing with environmental problems in the long run. It is normally very costly to reduce pollution with low concentration levels, to levels that are safe for the environment. In order to achieve drastic reductions in micro pollutants fundamental changes will be necessary in the production process and/or even in the composition of the product itself. With the application of end-of-pipe technologies the benefits of raw material and energy savings will not occur, and technological spill-overs to the main production process will be limited.

In order to understand the shift from treatment-oriented EPT towards prevention-oriented cleaner technologies, (Process Integrated Technology, PIT) it is necessary to identify the factors that would influence the introduction of cleaner technologies. Researchers of the economics of technological change have come to understand the innovation process by focusing on three explanatory variables: market demand (including environmental regulation), technological opportunity and local conditions. When cleaner technologies are introduced they are mainly measures for reuse and recycling and they are selected on the basis of the rate of return on the investment calculations. That is, the extent to which cleaner technologies are adopted is limited mostly to cases where reuse and recycling of energy, water, and raw materials can contribute to a reduction in production costs.

In obnoxious industries such as the textile and tannery industries, implementation of cleaner technologies has been considered mainly for economic reasons. Therefore, when the input costs of water, energy, and chemicals can be reduced, there is a strong incentive for the textile industry to implement the practice of saving, reuse and recycling. As environmental problems in the textile industry are typically associated with wastewater, the reduction, reuse, and recycling of water is particularly emphasised in the industry. As the stringency of environmental regulations is increasing, cleaner technologies, such as input changes for a reduction or elimination of the use of chemicals, are being developed in the industry.

## Process Integrated Technologies

Most of introduction of cleaner technologies is driven by costs. Based on the costs and savings identified, areas for improvement can be identified and ranked according to priority. This will give some indication of the starting point of the waste minimization audit. This general trend is for raw materials to be the area where the greatest savings can be achieved, followed by water and effluent combined and energy. Table 5.3 gives an indication of the magnitude of such savings in the textile industry.

**Table 5.3: Scope of Savings in the Textile Industry**

Utility	Scope of Saving
Raw materials	1 to 5%
Packaging	10 to 90%
Ancillary materials	5 to 20%
Consumables	10 to 30%
Electricity	5 to 20%
Heat for process and space heating	10 to 30%
Water	20 to 80%
Effluent	20 to 80%
Solid Waste	10 to 50%

## Waste minimisation

Cleaner technologies include waste minimisation programmes to:

- Effect source control by changing raw materials, i.e. change to non-toxic or purer materials, use renewable raw materials or materials with a long service lifetime.
- Change production technology and equipment, e.g. improved process automation, process optimization, equipment re-design and process substitution. This creates less hazardous wastes and emissions.
- Improve housekeeping by making changes to procedures and management in order to eliminate waste, e.g. spill prevention, improved worker education and training.
- On site-recycling: i.e. useful application of waste material produced by the company, e.g. reuse as raw material, recovery etc.

The benefits of waste minimisation include:

- environmental improvement as there is less impact on the environment due to a reduction in waste;

- Cost savings due to increased operating efficiency and reduced production costs;
- Risk reduction due to a better understanding, control and management of present risks and future liabilities;
- A competitive advantage through an improvement in the company image;
- Improved communication within the company as waste minimization requires team effort

### **Effluent Segregation**

Segregation of the various effluent streams is important for the optimization of opportunities because:

- specific treatment such as oxidation, neutralization, reduction or decolourization are best achieved prior to mixing of streams;
- recovery or recycling will be more effective if the waste stream is as concentrated as possible, and
- mixing of waste streams with different characteristics leads to a high volume of waste that still requires treatment.

### **Reuse and Recycling**

Re-using and recycling is accomplished either by using the waste generated directly or after treatment. It helps in eliminating disposal costs, reducing raw material costs, and may provide income from the sale of recovered goods. Either on-site or off-site recovery can be carried out.

### **Treatment and Disposal of Wastes**

Even after effective waste minimization programmes have been implemented, there will still be waste that must be treated and disposed. The treatment route chosen must be one that is suitable for the particular effluents produced. Examples include separation, neutralization, chemical treatment and biodegradation.

## **5.6 TECHNICAL ISSUES**

A WDM strategy will also involve the implementation of a variety of technical measures for the water service providers. The selection of particular technical measures must be made on a case by case basis, taking into account the financial and technical capacity of the authority and a cost/benefit analysis of each technical measure under consideration.

### **5.6.1 Leakage Management**

Non-revenue water is the difference in the volume of water purchased and the volume of water sold. The difference is due to factors such as administrative losses, unmetered connections, physical leaks, inaccurate metering, unauthorised use and illegal connections.

A focussed and comprehensive programme including meter replacement, leak detection and repair, and review of accounting and bill collection systems is required to reduce the level of non-revenue water.

Two methods of leakage control can be practised:

- Passive control, the traditional method used by most water authorities where leaks are measured in a systematic way but are only repaired during normal maintenance
- Active control usually performed by a dedicated team through sounding of leaks (detection of underground leaks through sensitive sounding systems), district metering, measurement of night-flow and pressure reduction. Very few Local Authorities in Southern Africa practice active leakage control.

Pressure reduction in the water network can play a major role in the lowering of leakage within the water networks of the utility as well as the consumers. Due to low consumption during the night the pressure in the water network is higher, which leads to increased leakage losses. Thus the pressure in the network is normally reduced during the night to reduce night-flow.

The South African Water Research Commission launched several projects concerned with reducing of non-revenue water, water balances, measurement of night-flow and pressure reduction. These projects incorporate the recommendations of International Water Association (IWA) and were adapted and augmented by various computer programmes for practical implementation.

With new water legislation in Namibia, reduction of non-revenue water and leakage are seen as a major priority that needs to be addressed in the near future. The breakdown of non-revenue water into its different components needs to be done to be able to determine a realistic figure for actual leakage reduction.

### **5.6.2 Retrofitting plumbing fixtures**

Water providers around the globe pursue a variety of retrofitting programmes whereby utilities provide cash rebates or even free water-efficient plumbing fixtures. The cost effectiveness of these programmes depends on legislation of plumbing fixtures and immediacy of reduced demand.

In the United States, legislation passed in 1992 prevented the sale of inefficient plumbing devices, effective as of January 1994. The slow but eventual replacement of old, inefficient fixtures with new, efficient fixtures is referred to as natural conservation, the reduction of demand realised through no effort of the customers. A case study in California involving 45,000 single-family homes built before 1994, comprised of customers that did not participate in any WDM programmes, found a 7% reduction in demand over four years, which was attributed to natural conservation. The same phenomena occur with respect to washing machines and dishwashers where newer models are normally more water efficient than older models, (Niesar, 1998).

Investments in water saving toilets by utilities have generally been found to be economical in certain places. However, the programmes create hidden challenges of assuring that toilets

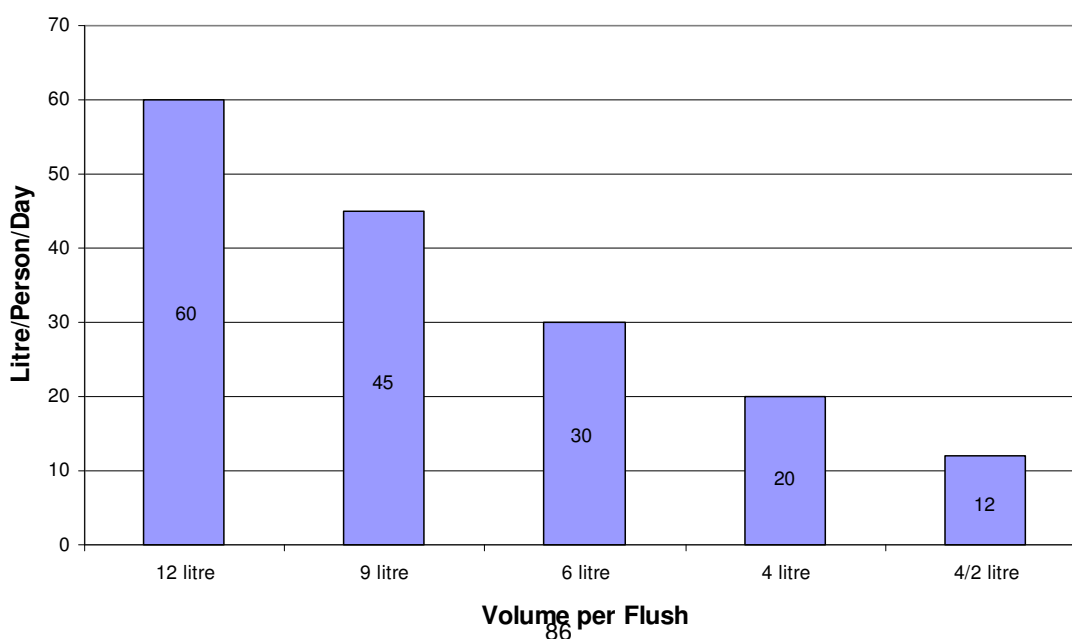
and valves are of adequate quality and that spare parts are available to make repairs, as toilets are likely to fail within 2-3 years (Brittsan, 1999). In the Metropolitan Water District of Southern California, where 1.2 million toilets with 19 litre flush volumes have been replaced with 6 litre units since 1994, a survey revealed that the actual consumption as a result of leakage was approximately 16 litres three years after installation. (The leakage rates from the 19 litre flush units before replacement were unknown.) In some countries only the reliable siphon type toilets are allowed. In Britain, national requirements will be a maintenance-free lifetime of 20 years for a family of 5, (Brittsan, 1999).

Cistern replacement programmes normally are not so efficient as a result of the hydraulic design parameters of the toilet bowl. Most of the water efficient toilets are designed to create a suction effect during flushing.

Planners should proceed very cautiously when promoting the use of water efficient devices, particularly toilets. According to various distributors, some low cost toilets (water saving toilets) tend to have sticking flush valves and leaks. In the long run, a low cost toilet designed to save water may actually waste water because of leaks. Twenty years of retrofitting programmes in the United States provides one inarguable lesson: low cost and high quality are essential. In many cases low flush toilets were not efficient and have to be flushed more than once, negating the benefits of water conservation.

The graph in Figure 5.2 gives an indication of the potential savings through the installation of more water efficient toilets based on 5 flushes/person/day. Most of the models in use in Southern Africa use 9 to 12 litre/flush. In some Scandinavian countries, toilets using 4 and 2 litre flushes have been mandatory since 1996. In Australia dual flush units using 6 and 3 litre flush are installed. Since 1994 toilets using more than 7.3 litres/flush are not allowed in the USA.

Namibia relies mostly on South Africa to supply toilets and other housing appliances. There is no law in South Africa regulating the flush volumes of toilets. Due to higher prices (price of toilets from other countries is more than twice the RSA price) it will be very difficult to implement such policies before South Africa implements regulations to control water use efficiency of toilets.



### **Figure 5.2: Reduction in Toilet Water Use**

In a data logging exercise done on private households in Windhoek and Swakopmund it was determined that low income households use up to 30% of their water for flushing toilets.

If conventional showerheads are replaced with water saving showerheads, the investment can normally be recovered within one year if the cost saving on water is calculated. If the cost of electricity for heating water is also taken into account, the cost can be recovered within three months. In countries such as Australia and USA (Arizona and California) retrofitting of showerheads is often jointly spearheaded by water and energy utilities because of the reduction of the energy demand. Research in the USA indicates, however, that people normally shower a little longer with low flow showerheads. It is therefore important to take these factors into account when savings through retrofitting programmes are calculated.

In Southern Africa plumbing installations (especially with respect to low flow toilets, heat insulation, pipe sizing etc) are lagging behind the rest of the world. SABS 0252 (1996) started to address some of these deficiencies with respect to "Water Supply and Drainage for Buildings".

#### **5.6.3 Water Efficient Household Appliances**

There are many water efficient appliances and plumbing fixtures available on the world market. Many water supply authorities have successfully employed incentives such as vouchers, tax breaks, and subsidies to promote the use of water saving devices. Incentives to promote the use of water efficient showerheads, washing machines and dishwashers are often co-financed by the electricity utility because they also benefit from the reduction in demand on their systems. The psychological effect on consumers of receiving multiple cash incentives from water and power agencies proved very effective in the United States. There have been large improvements in the water use efficiency of washing machines in recent years. Even the large machines use less than 100 litre/load compared to an average of 150 litre/load in the 1980s. Comparing the water efficiency of washing machines is a complex subject because machines vary in load size, and the water requirement can vary according to up to 10 different washing conditions (fabric type, water temperature, load size, cycle duration). For a meaningful comparison washing machines should be compared in terms of litres of water used/kg of fabric for the same fabric type.

Consumers should be advised to select a washing machine using water efficiency criteria. The option of matching the cycle to the load requirements appears to promote water use efficiency.

The example of Australia where water efficient appliances, domestic irrigation systems and plumbing fittings are rated, may be beneficial to this country to ensure that water efficient equipment is imported or manufactured in the future. The Water Efficient Appliance and Plumbing (WEAP) Group in Australia and New Zealand have developed a system to label categories of water efficient appliances. The system is being implemented on a national basis and customers are advised to buy water efficient appliances. (Sydney Water 1994)

An investigation in Windhoek demonstrated that replacing a washing machine, which uses water inefficiently, with one that uses water efficiently will yield more water annually than the collection of roof water using a tank and the cost will be much lower.

#### **5.6.4 Xeriscaping**

In high-income areas, water consumption in gardens can comprise more than 50% of a household's water demand. Garden use is regarded as a luxury use and the price elasticity of demand for garden water is higher than for other household uses.

The xeriscape garden (landscaping for dry conditions) and the use of mulch is a relatively new concept in Southern Africa. Xeriscaping combines creative landscaping and conservation principles with efficient irrigation practices in a manner whereby energy, time and money, and especially water, is conserved. According to the literature the water needed for gardening can be reduced by 50% through the application of these principles, or as much as 25% of total household consumption.

White (1998) summarised the principles as follows: proper planning and design, soil analyses, appropriate plant selection, efficient irrigation, use of mulches and appropriate maintenance. The establishment of demonstration gardens by local authorities, nurseries and Non-Governmental Organisations (NGO's) based on the xeriscape principles can help to propagate the concept in Namibia.

### **5.7 WATER DEMAND MANAGEMENT IN THE IRRIGATION SECTOR**

#### **5.7.1 Introduction**

The irrigation sector is different to other sectors in that it consumes large volumes of untreated water. This section of the report concentrates mainly on improvements to water use efficiency in the irrigation sector. Many of the key issues that have been identified are universal and applicable to the irrigation sector irrespective of the location of the activity.

In the Pre-Feasibility Study into Measures to Improve the Management of the Lower Orange River: Water Conservation (Van der Merwe, 2005) the following remarks were made. The performance of the irrigation sector with respect to water management and conservation is not highly regarded in water management circles. Perceptions exist that:

- the majority of farmers do not "schedule" correctly to fulfil the needed crop water requirements;
- water supplies are not well managed;
- distribution losses are high;
- existing systems, both on scheme and on farm, are not well maintained;
- few farmers are concerned about actual crop irrigation requirements;
- water wastage is excessive; and
- water management on farms has a low priority.

In most developing countries, very little support is given by Central Governments to improve irrigation farming practices and water use efficiency.

### **5.7.2 Measurement of Improved Water Use Efficiency and Higher Crop Yields**

To improve productivity in irrigation and to measure such improvement can be a daunting task due to the large number of variables such as average temperatures, wind, rainfall, proper scheduling, application of fertiliser (alternatively organic farming), presence of pests etc. which influence the actual water consumption. Crop water requirements can be calculated accurately through available methods, but the biggest challenge is to apply the water effectively and efficiently. The efficiency improvements are normally measured over a period of time through trends. There are methods to normalise the effect of weather changes through time series analyses. Accurate data over a period of at least 5 years is needed with exact water uses. To develop reliable figures over a period of time would be a major task.

The following indicators can be useful in such an evaluation:

#### **Water Productivity (more crop/drop)**

It is suggested that the change in water productivity be assessed on a regular basis to measure the success of WDM initiatives. Water productivity can be calculated by comparison of the percentage crop yield improvement/ha/a versus the percentage the total water consumption/ha/a. This will provide the farmer with a benchmark to measure his own performance.

#### **Other Productivity Indexes**

Other indexes include net disposable income (NDI) per m<sup>3</sup> of water applied, job opportunities and other economic indexes. These factors should preferably be calculated for each crop for specific regions with similar climatic conditions.

### **5.7.3 Support Structures**

Support structures are needed to create an enabling environment for farmers to increase water use efficiency and increase crop yields, (water productivity) as well as economic efficiency.

### **5.7.4 Establishing of Irrigation Management Institutions**

In Namibia the White Paper for the proposed new Water Act makes provision for the management of water supply schemes at the lowest possible level as well as for the establishment of water basin management institutions. The Act makes provision for a Water Advisory Council that will advise the Minister of Water Affairs on the allocation of quotas etc. It also states that Irrigation Boards (Act 56) will not exist after the Water Advisory Council is formed. It is assumed that the water basin management institutions will indirectly control irrigation licences. It is not clear how the water basin management institutions would handle the local management of irrigation schemes.



The Act makes provision for the establishment of irrigation management institutions for specific irrigation schemes.

#### **5.7.5 Establishing a Water Use Efficiency Unit.**

Neither the Department of Agriculture nor the Department of Water Affairs has the mandate, funding or trained personnel to assist the irrigation farmers in achieving the goals for water use efficiency, higher crop production and the growing of higher value crops. Their only recourse is to use consultants, but these are few in number and tend to have specialised expertise in particular fields.

The spatial distribution and small size of irrigation schemes make the establishment of local water efficiency groups almost impossible. In places such as Aussenkehr there is a critical mass to provide such services because of the concentration and growing of a specific crop. Within the Namibian context it may be possible to request the Agronomic Board to coordinate the functions of a Water Use Efficiency group. Specific functions may then be outsourced to farmer cooperatives which may be active in certain areas.

A Water Use Efficiency Unit, established in 1999 in Dubbo (New South Wales), is unique in many respects and may be worth studying. It is a joint initiative of the New South Wales equivalent of the Department of Agriculture and the Department of Water Affairs and Forestry in South Africa. It is administered by the Department of Agriculture but has personnel from both departments and is jointly funded. It plays a key role in the delivery of the agricultural components of the New South Wales water conservation strategy. The Unit is accepted as being a well-informed neutral source of unbiased information and advice. The value of a neutral professional group of this nature to both departmental management and to the stakeholders involved in difficult negotiations, cannot be over estimated. The Unit is assisting irrigators to identify and move towards higher water use efficiency, and increase the value of irrigated agricultural production to the State, (Crosby, 2001).

The Water Use Efficiency Unit should play an important role in the collection and processing of data from irrigators on crop yields, actual water use as well as detailed weather data. This is required to measure efficiency improvement over time. The collection of more detailed information to quantify and calculate economic indicators may be added to the list of required data.

The Water Use Efficiency Unit should also help to identify tasks in consultation with farmers for greater private sector involvement and co-ordinate the training of farmers. One of the main tasks of the Water Use Efficiency Unit in cooperation with cooperatives and irrigation management institutions is to assist irrigators to identify and move towards higher water use efficiency and to increase the value of irrigated agricultural production.

#### **5.7.6 Fostering Private-sector Involvement**

Effective management of land and water resources requires growers to be familiar with the resources on the farm, and to plan for the use of these resources. The core best management practice for land and water management is to develop a plan that describes

the resources of the farm, and how these are to be used sustainably. This type of plan is often called an irrigation and drainage management plan.

A good example of this can be taken from a guidelines booklet developed in Australia for the growing of cotton. Essentially, what is provided is a comprehensive guide to cotton production including irrigation and water management. These guidelines were compiled by people with scientific knowledge and a wealth of practical experience. (Appendix A, Section A.9).

It is recommended that the possibility of developing similar manuals for Namibia covering the main commodities should be investigated and such manuals should include in-depth irrigation guidelines for specific crop types,

### **5.7.7 Training of Farmers**

In New South Wales the transfer of knowledge and training of farmers is actively pursued. This training is part of the “Water Wise on the Farm” programme, an education and awareness programme that promotes the adoption of best irrigation management practices and technologies. Water Wise on the Farm aims to provide farmers with basic irrigation skills. The course program consists of four workshops:

- Assessing your soil and water resources;
- Evaluating your irrigation system;
- Scheduling and benchmarking; and
- Irrigation and drainage management planning.

The complete program should require about 18 hours of attendance spread over four workshop sessions and about 8 hours of the farmer’s time assessing the soils and irrigation system on his own property.

The training follows the modern pattern of competency-based training and the courses are aligned to National Competency Standards. Those successfully completing the course can seek “Recognition of Prior Learning” towards formal qualifications in Agriculture or Horticulture.

Each of the nine regions in New South Wales has a technical irrigation specialist and a training specialist who run the courses in the districts. The course material is outstanding and includes training manuals, detailed course notes and related practical exercises, as well as complete competency specifications and evaluation procedures. All the usual irrigation methods are catered for but only one irrigation method is dealt with in a course. The courses are aimed at farmers and the instructor has ample opportunity to pass on his own field experience.

Nothing like this exists in Southern Africa. The courses are generic in that they are as applicable to Southern Africa as they are to NSW. There would probably be no objection to using the information that obviously represents many months of preparation, but this will only be effective in conjunction with appropriate infrastructure and manpower. It is possible that this could become a private sector initiative, (Crosby, 2001).

If water use efficiency in the irrigation sector is pursued, training and transfer of knowledge will be an important component. This is especially applicable to new farmers that may enter the market. At least some of the expense for training will have to come from government. It is unlikely that the local communities will be able to absorb the full cost. The implementation of tax rebates for training or even a subsidy based on a 50% contribution to the cost of training would create an enabling environment.

### **5.7.8 Institutional Policies and Control**

Without clear policies with proper regulating and control structures over the execution of these policies/guidelines it would be difficult to improve water use efficiency in the irrigation sector. Many of these policies or guidelines (mandatory metering, cost recovery tariffs) are covered in the legislation or draft legislation in Namibia.

### **5.7.9 Metering of Irrigation Water**

Measurement of water is important for linking of a price to a volume of water consumed. Measurement is also an important management instrument on the farm for proper scheduling. Measurement of irrigation water seems to be problematic. In most of the irrigation schemes such as Hardap, farmers are not charged according to actual consumption based on metered water. The quota system (area x volume) or indirect methods of measurement are used. In canal systems volumes are determined based on a certain flow rate over a pre-determined allocated number of hours. Implementation of WDM, including conservation orientated tariffs, without accurate measurement would be difficult as it would be impossible to measure efficiency improvements.

The following problems are experienced with irrigation water meters

- high initial capital costs;
- high maintenance costs;
- vandalism and meter tampering;
- high cost of reading water meters regularly in remote locations; and
- meters are not robust enough.

In 2001 the South African Water Research Commission initiated a three year study to develop guidelines for the choice, installation and maintenance of water measurement devices by the irrigation authorities for canal, pipeline and river distribution systems. The guidelines may be valuable for the implementation of metering within the irrigation sector.

Measurement at remote locations in Namibia may be problematic due to relatively small irrigation areas in remote areas with access problems in some areas. Ideally flow should be measured, because payment per m<sup>3</sup> of water used enhances water use efficiency, especially when water conservation tariffs are applied.

In the Lower Orange River where mostly high value crops are grown, the cost of water itself is minimal compared to total operational costs, excluding labour. The cost of water

represents only 1.5% of the operational costs in some cases, whilst the cost of electricity used for pumping, fertiliser, pest control, labour, marketing and transport to international markets are the biggest cost components. An informed farmer will not over-irrigate and pay more for electricity, wash fertiliser from the soil, create a good micro-environment for pests and create high water tables with drainage problems. Despite the high costs there are uninformed farmers with sophisticated irrigation systems who over-irrigate.

To implement metering the following guidelines are suggested:

- Approved water meters should be installed on all new schemes as part of the development cost of the irrigation scheme (The outcome of the WRC study may provide useful information);
- The Irrigation Water Management Institution (with a subsidy from DWAF) should pay for the installation of meters on existing irrigation schemes after the guidelines of the WRC study are available;
- The replacement and maintenance cost of meters should be included in the water tariff as a fixed monthly fee payable to the Irrigation Management Institution or the distribution authority;
- Maintenance should perhaps be privatized to a contractor;
- Farmers could read water meters themselves and phone, fax or e-mail the reading to the irrigation water management institution while the institution could do spot checks on a regular basis during the year; and
- Farmers should be responsible for protecting water meters against vandalism and meter tampering.

#### **5.7.10 Irrigation Tariffs**

The principle of cost recovery of irrigation water supply is accepted in the WSASP 2008. If this definition of conservation tariffs is accepted, then it is clear that the supply of water without measurement (i.e. irrigation water) and rising block tariffs not linked to marginal cost (or the financial cost of future schemes) do not qualify as conservation tariffs.

Introduction of two-step tariffs in irrigation water, can lead to major savings in overall water demand and improved water use efficiency. Despite the fact that the price of irrigation water is very low, major savings can be realised if irrigators are sensitized about their water use as they will not want to pay a punitive tariff that could be as much as 2.5 times higher than the normal tariff, (Hanemann, 1999).

Water should be priced and managed as a volume. The present system does provide a volume estimate (area x quota) but expressing water allocation in terms of volume and managing it as such could "fix" the idea of a volume of water. This implies the measuring of water, which is a problem at present due to the high cost of measuring devices and problems of reliability and lack of ruggedness of some meters.

Selling water at a higher price will result in the farmer feeling/seeing the effect of inefficiency in his bank balance, but one must be careful how it is applied. The cost of water for farmers

who pump water is higher than for those that receive "gravity" water from a canal. For each and every farmer the total cost of water must still be affordable. This approach could impact negatively on newly settled farmers or farmers that invest to improve irrigation efficiency, unless special arrangements are made for them through a rebate system.

If the development of high value perennial crops along the Lower Orange River and at Hardap (where development costs are high and may exceed R 500 000 per ha) is actively promoted, the issue of linking a tariff to the level of security of supply needs to be resolved.

There are two ways to recover this cost:

- A higher tariff linked to the higher security of supply; or
- A higher tariff that will be payable during periods of water shortages.

The latter method, where the prices are higher during scarcity, is more linked to market forces where the price is higher in times of a shortage. It may also help to stabilise the income of the supply authority during periods of shortage.

### **5.7.11 Technical and Planning requirements**

#### **Selection of the Correct Irrigation Systems**

The selection of the correct irrigation system is influenced by various factors that include capital costs, operation costs, crop type, soil type, topography, climatic conditions, water quality and availability of labour. During the site visit to the Lower Orange River (Aussenkher and other schemes) various irrigation systems were observed on new schemes. It was obvious that some of the newly installed systems may not be the optimum solution for the prevailing circumstances along the Lower Orange River. It was also mentioned by some farmers that they had to change from one system to another at very high costs. Variations in design efficiency also contribute significantly to the ranges experienced in irrigation efficiency.

There is no system in Namibia to register irrigation system designers. It is suggested that new irrigation schemes, and old schemes being up-graded or renovated, be designed and developed professionally by trained and experienced personnel. Designers should be SAIL approved members or registered by the Engineering Council in Namibia. This will not guarantee that the system will be of the best design but it may help to set standards and if planned incorrectly there is recourse through the indemnity insurance of the Consultant.

DWAF could help to set a certain standard. The above suggestion could be enforced in the licence conditions. Collection of information and distribution of such information on the performance and problems experienced with different irrigation systems could form part of the guidelines as recommended in Section 1.7.5 for different crop types along the Common Border Area.

#### **5.7.12 Leaching Requirements and Proper Drainage Systems**

Soil quality, irrigation systems, water quality as well as the salt tolerance of the plants influence leaching requirements. All irrigation water contains salts, which accumulate in the

soil over a period of time. Their removal, before harmful effects set in, is important. The extra water required for this purpose becomes drainage water and is not considered wasteful as it is performing a vital function and re-enters the system as return flow, with the likelihood of further downstream utilisation. Over-irrigation is much in evidence with flood irrigation - in most cases sufficient to obviate additional leaching.

There are various places in the Lower Orange River, especially in the floodplain areas where high water tables are present, mainly as a result of over irrigation or inadequate drainage systems. With more advanced irrigation systems like drip irrigation or micro irrigation systems, and with proper scheduling, an allowance should be made to flush the salts from the soil once or twice a year depending on local circumstances. It is estimated that 10 to 15% additional water requirements will be needed for leaching in the Lower Orange River area. With saline soils in new developments in the area it can be anticipated that the initial water requirement will be higher in order to condition the soil by leaching out excessive salts.

It was clear at several sites visited along the Lower Orange River Area, that even new developments do not have proper drainage systems. It was also clear that irrigation fields irrigated at higher elevations cause drainage problems for lower lying farmers. This was evident at Aussenkehr.

Leaching requirements and proper drainage systems need to be taken into account with quota allocations and approval of new developments in Namibia. These irrigation areas should be identified and if the problems are not rectified within a stipulated period, abstraction permits should be withdrawn.

### **5.7.13 Improved Management on Farms**

#### **Better irrigation scheduling**

Irrigation scheduling should ensure that crops are supplied with just sufficient water to obtain optimum yield and, where applicable, the desired quality. In Southern Africa the number of farmers that actually use "scheduling" is confined to the limited group producing high value crops and applying intensive irrigation methods. Generally speaking, however, the indications are that scheduling is the exception rather than the rule in the Orange River system. Evidence of this is the widespread high water-table problem in many of the areas within the Orange River system. Atmospheric evaporative demand fluctuates violently from day to day, and is quite impossible to map or follow, but over a week or a month this smooths out and, unless there are exceptional weather systems, seasonal variations are not so great.

It has been found in South Africa that it is possible to irrigate according to a pre-season programme that can even go as far as justifying equal applications weekly, right throughout the growing season. The empirical computer model BEWAB enables pre-season programmes to be drawn up and has produced exceptional results in the extensive area where it was developed. All that is required of the farmer is to keep a record of the depth of irrigation water applied on a weekly basis and to correct if the depth applied is not in line with the programme. In the case of sprinkler and centre pivot systems a rain gauge is placed in

the field and read weekly. In addition the soil profile water content should be checked periodically for major deviations, using an appropriate method.

The 'Dipstick Method' that was developed and implemented in the Kimberley/Douglas area is ideal for duplication in other areas. It was established that cost savings on water, fertiliser and pesticides is much higher than the cost of implementing and maintaining the system. Unfortunately no detailed studies have been done to date to quantify actual water savings.

Haarhoff (2001) summarised the benefits of scheduling as follows:

- Better absorption of fertiliser by plants;
- Prevent saturation of soil and high water tables;
- Save water costs and pumping costs;
- Prevent soil becoming more dense;
- Improved product quality;
- Improved yield; and
- Prevention certain crop diseases.

The SAPWAT program was used extensively to develop crop coefficients that are well suited to specific cropping circumstances. The so-called "Dipstick Method" used in the area can serve as a good example for duplication in other major irrigation areas and in areas where high value crops are cultivated.

### **Scheduling through the "Dipstick Method"**

Rain can present a problem but in the more arid areas the pre-season programme is set-up in terms of "water in the rain gauge", irrigation or rainwater. A methodology, nick-named "dipstick", has been developed to a fine art in the semi-arid area along the Orange river by the Griekwaland West Co-operative and this year is mandatory over an area of some 30 000 hectare of centre pivot wheat cultivation. The Cooperative develops the crop factors for a range of crop varieties and planting dates, a task simplified by the application of the Food and Agriculture Organisation four-stage crop factor curve as built into SAPWAT. The pre-season programmes can also be set up in accordance with various irrigation methods and application strategies by running these scenarios on SAPWAT. Each week during the season the Cooperative calculates the water use for each cultivar, variety and planting date utilising the Penman Monteith reference evaporation calculated from an automatic weather station and the matching crop factor. This is sent to farmers by e-mail, fax or telephone. The farmer can see immediately if the demand during the past week was as targeted or above or below and can make minor adjustments to irrigation application depths during the coming week to compensate. Nobody tells the farmer to add so many mm of water. That decision is left to him.

It is important that the water content of the profile be checked periodically, just as one needs to check the oil level of an engine, and hence the name of the neutron probe service provided by the Cooperative viz. "dip stick". Before commencing this service the technicians of the Cooperative determine the water release curve of the soil and the farmer

is regularly provided with a table and graph indicating the progressive “oil level” throughout the season.

In a study done by the University of California (1996) it was determined that through scientific scheduling net savings of 13% were realised in California. The average crop yield increase was 8%.

### Estimating of Crop and Irrigation Water Requirements

A large percentage of the irrigation water used in Namibia is not metered. For the compilation of the “Water Accounts for Namibia” (2005) the water requirement was estimated based on irrigation areas and the type of crop on a farm. The Division of Agricultural Engineering<sup>5</sup> was consulted to provide estimates for the consumption per hectare per annum. The factors that are taken into consideration are the location of the irrigation scheme, the crops grown and the irrigation technology employed. As evaporation, wind and soil types further influence the irrigation water requirements, the country was divided into two typical regions with evaporation rates of 2500 to 2900 mm/a (Tsumeb, Okavango Area) and from 3 400 to 3 800mm/a (Hardap, Stampriet and north western areas). Specific crop water requirements were calculated with the CROPWAT programme (Windows) with the modified Penman-Monthief Formula for the different types of crops as summarised in Tables 5.4 and 5.5.

**Table 5.4: Specific Crop Water Requirements in South and Western Parts**

Crop Type	Net Water Requirement (mm/season)	Irrigation System Water Requirement (m <sup>3</sup> /a per hectare)			
		Flood (65%)	Centre Pivot (85%)	Sprinkler (75%)	Drip & Micro (95%)
Citrus	1 060	16 300	12 460	14.120	11 150
Cotton	1 240	19 100	14 600	16 500	13 100
Lucerne	2 145	33 000	25 200	28 600	22 600
Maize	706	10 900	8 300	9 400	7 400
Sorghum	702	10 800	8 300	9 400	7 400
Vegetables	633	9 700	7 400	8 400	6 700
Wheat	751	11 600	8 800	10 000	7 900

Evaporation zone: 3400 to 3800 mm/a

The accepted irrigation efficiencies for the different types of irrigation system were accepted as listed in brackets as the percentage below each irrigation application system.

The crop water requirements/hectare for the following crops listed below were accepted after consultation with the Division for Agricultural Engineering:

<sup>5</sup> Information provided for the Water Account for Namibia



- Grapes 15 000 m<sup>3</sup>/a for micro/drip
- Dates 12 000 m<sup>3</sup>/a for micro/drip
- Olives 10 000 m<sup>3</sup>/a for micro drip

**Table 5.5: Specific Crop Water Requirements in the North and North East**

Crop Type	Net Water Requirement (mm/season)	Irrigation System Water Requirement (m <sup>3</sup> /a per hectare)			
		Flood (65%)	Centre Pivot (85%)	Sprinkler (75%)	Drip & Micro (95%)
Citrus	836	12 880	9 840	11 150	8 820
Cotton	887	13 100	10 440	11 830	9 340
Lucerne	1 630	25 100	19 180	21 730	17 160
Maize	506	7 800	5 950	6 750	5 330
Potato	448	6 900	5 270	5 970	4 720
Sorghum	492	7 600	5 790	6 560	5 180
Vegetables	507	7 800	5 970	6 760	5 340
Wheat	659	10 100	7 750	8 790	6 940

Evaporation zone: 2 500 to 2 900 mm/a

It is suggested that water consumption in the irrigation sector be estimated based on the water requirements as summarised in Tables 5.4 and 5.5 for the two zones until universal metering is implemented.

### Improved Irrigation Efficiency

There is much scope within Namibia to improve the efficiency of the prevailing irrigation application systems, with a considerable associated water saving. Inefficiency stems largely from irrigation systems not being appropriate for the local conditions, or not being managed to accommodate specific local constraints.

Table 5.6 shows different types of irrigation systems for the South African Irrigation Institute's suggested efficiencies, as well as the typical cost of the systems per hectare. These costs are based on 35 hectare units. These costs are average costs and without detailed investigations on individual farms more accurate figures cannot be determined. The installation or upgrading will depend entirely on cost benefit analyses. It will not pay at all to upgrade irrigation systems to the best technology without training of farmers, proper scheduling, proper maintenance and increasing the value of crops grown.

**Table 5.6: Efficiency of Irrigation Systems**

<b>Irrigation System</b>	<b>Design Efficiency</b>	<b>Capital Costs (R/ha)</b>
Flood: Furrow	65	13 000
Flood: Border	60	17 600
Flood: Basin	75	18 800
Sprinkler: Dragline	75	24 800
Sprinkler: Quick-coupling	75	22 500
Sprinkler: Permanent	85	34 500
Sprinkler: Hop-along	75	27 100
Sprinkler: Big gun	70	20 200
Sprinkler: side-roll	75	26 600
Sprinkler: Boom	75	20 200
Sprinkler: Travelling gun	75	21 800
Sprinkler: Travelling boom	80	23 200
Sprinkler: Centre pivot	85	43 300
Sprinkler: Linear	85	69 400
Sprinkler: Micro sprinkler	85	36 300
Micro: Spray	90	53 200
Micro: Drip	95	46 300

It should be kept in mind that the irrigation efficiencies are further influenced by the following factors:

- A Distribution Uniformity Factor is applied (normally 0.85) to minimise the adverse effects of poor irrigation distribution when aiming for high production/yield targets.
- Conveyance losses will also influence the final efficiency of application.

Flood irrigation is notoriously inefficient, mostly due to the lack of management opportunity for fine-tuning. The application problems associated with surface irrigation are inadequate flow-rates, excessively long beds, uneven beds, soils with low water-holding capacity and layered soils associated with riverine deposits. Management of flood irrigation schemes must be of high quality. Some current systems operate at less than 40% efficiency. Where conditions are correct (soil type, bed shape, slope, flow rate) and levelling has been undertaken accurately (using laser-controlled equipment), flood irrigation systems have been measured to be more than 90% efficient with proper management.

Usually, one or two factors would be dominant. For example, soils may be too light or the terrain too broken for surface systems or insufficient labour may have been available for conventional sprinkler irrigation. In some circumstances, potential crop returns may have been sufficiently high to warrant drip irrigation, where water could be saved and plant

diseases and weed problems minimised. In other circumstances, economic pressures may have made the most suitable irrigation system unaffordable. There are many situations in Namibia where change from one system to another is desirable, but for various reasons, often linked to the prevailing growing of low-value crops or very low irrigation water tariffs, such change cannot be economically justified.

Vineyards planted within the flood plain of the Orange River remain on flood basin irrigation systems whereas plantings away from the flood-plain are predominantly irrigated by drip and micro-jet, as these expensive micro-systems are vulnerable to flood damage. Planting vineyards under micro-irrigation on slopes away from the river can only be justified by the high value of the table-grape crop. Other crops have not been grown there in the past because of the high pumping costs.

It is foreseen that drip or micro-systems will be used predominantly with new developments in the Lower Orange River area for the cultivation of high value crops because of the high cost of pumping water to higher elevations.

According to studies done in the USA, Israel, Spain, India and other countries a change from flood irrigation to drip irrigation reduced the water requirement by 30 to 70% with crop yield increases of 20 to 90% for different types of crop. Unfortunately, for the higher figures quoted for water savings (India), the reduction in seepage and tail water was not quantified. In Israel, irrigation efficiency improvement (drip systems) over a period of 15 years resulted in a reduction of 37% in water use (8 200 to 5 200 m<sup>3</sup>/ha/a) while the yield increase was threefold and the crop values increased tenfold. (Postel, 1999).

Experience elsewhere in the world has demonstrated that Water Demand Management (WDM) in the irrigation sector has been successful if the farmers benefited through the implementation. A good example is the "Water for Profit" scheme in Queensland (Australia) where farmers are supported by the Government to improve irrigation systems and farm management to save water and to increase crop production. With an investment of 41 million Australian dollars by the Queensland Government, 180 Mm<sup>3</sup>/a of water was saved and the value of crop yield increased by AU\$ 280 million/a. There are no similar examples documented in Southern Africa and the benefit to the farmers needs to be demonstrated before they will participate actively in WDM initiatives.

Most of these figures are average figures and may differ significantly on different farms depending on soil and climatic conditions. The improvement in crop yield is mostly realised by applying the required water needs of a plant at specific times to get the best absorption by the plant. Most of the advanced systems like drip or micro irrigation can apply water and fertiliser daily or even several times a day if required (sandy soils). With flood irrigation and other less advanced irrigation systems this is practically impossible.

It was not possible to get figures on crop yield increases based on research in Southern Africa, though the general feeling among practitioners is that significant yield increases are experienced when converting to a more sophisticated irrigation system. For the purpose of LORMS the SAPWAT program was used to calculate yield losses due to increased irrigation application intervals. For maize on a light soil for example, it was shown that when compared to a 2 day irrigation cycle (center pivot), the estimated yield reduced by 11 % for a

7 day cycle (floor irrigation), or 18 % for a 10 day cycle (flood irrigation). These calculations were done for a number of crops and locations and it is suggested that estimated yield increases be limited to a maximum of 7.5%.

### **Better Maintenance of Equipment**

In-field systems for water distribution can contribute significantly to losses, with unlined furrows/canals and storage dams being the worst culprits. Unlined furrows are mostly associated with flood irrigation. Such furrows may lead directly from the bulk distribution turnout, or may only occur as tertiary canals or header lines. The length of the on-farm earthen furrows is important with regard to seepage losses, as this is directly related to the overall water/soil contact area. Many systems comprise a short canal leading to an on-farm 'night storage' dam. From the night storage dam, water is gravitated out to the irrigation lands through furrows, or piped under pressure where a sprinkler system is installed. Evaporation from on-farm canals and dams is considered to be small compared to the water losses from the more extensive bulk water distribution systems along the Orange River.

Replacement of unlined tertiary and header canals and night storage dams must be seen as an important strategy for water saving in the Orange River system. Cost will be an important factor as lining is expensive. There are, however, a number of less costly seepage reduction methods available. These include replacing header furrows with gated pipes or lay-flat tube and partial sealing of earthen furrows with cement stabilised soil mixes or bentonite. Special low-pressure pipelines designed for sewage/drainage may be used as the principal tertiary distribution system. Whilst more expensive than 'partial lining' techniques, such pipes have the added advantage of better control of water, and they obviate tail-end losses.

In the Lower Orange River it is expected that most of the water used for high value crops will be through pumping systems and pressure irrigation. In this case pump efficiency and wear and tear on the moving parts need to be closely monitored to ensure efficiency over time. Maintenance of micro and drip irrigation systems will also require special attention, because it will influence the potential of the crop yields. There is a tendency to develop new schemes without proper preventative maintenance. Farmers need to be sensitised to the importance of proper maintenance. This may be another opportunity for private sector involvement.

#### **5.7.14 Better Matching of Crops**

There is a concern in the common border area that every farmer wants to get his/her fair share of the lucrative export market. Farmers need to be aware of changing water quality over time that may damage crops. Crops should be selected to get the best benefit from climatic conditions, soil conditions and the quality of water available. The awareness of new cultivars with higher production rates, higher water use efficiency (more crop per drop) and higher value per m<sup>3</sup> water used should be propagated in all irrigation areas.

### 5.7.15 Covering of Soil to Stop Evaporation

The average rainfall varies from approximately 100mm/a at 20° East longitude to less than 50 mm/a west of Aussenkehr. The evaporation decreases from 3 400 mm/a in the east (20° East longitude) to approximately 2 500 mm/a along the coast. At Aussenkehr the evaporation loss is approximately 2 900mm/a. The common border area falls in a region where evaporation losses are more than 30 times the average annual rainfall.

In the north eastern areas of Namibia such as the Okavango and Tsumeb area the evaporation rates 2 500 to 2 900 mm/a are approximately 5 times the average rainfall. In the south and western parts of the country evaporation rates of 3400 to 3800 mm/a are 12 to 20 times the annual average rainfall.

Mulch is normally a layer of inert material covering the soil surface around plants to reduce evaporation losses. Mulches can be organic materials such as pine bark, compost or woodchips; or inorganic materials, such as lava rock, limestone or permeable plastic (not sheet plastic). Good mulch conserves water by reducing moisture evaporation from the soil. Mulch also reduces weed populations, prevents soil compaction and keeps soil temperatures more moderate.

The use of mulch is a widely applied practice in Southern Africa. In countries with low rainfall and high evaporation, mulch is used intensively to protect the surface areas of soil from evaporation. In Israel, where crops are grown in desert conditions similar to Namibia, soil is covered with plastic strips manufactured to reduce evaporation losses from the surface area. The use of underground drip irrigation also reduces evaporation losses.

**APPENDIX C**

**WATER DEMAND MANAGEMENT IN THE  
IRRIGATION SECTOR**



## 6. APPENDIX C: WATER DEMAND MANAGEMENT IN THE IRRIGATION SECTOR

### 6.1 POLICIES IN INDIA

The main strategic adjustments to India's irrigation management policy are:

- Participatory management of irrigation schemes by farmers;
- A programme of training and action/applied research;
- Revision of water rates;
- Technological improvements such as drip and sprinkler irrigation, data storage systems and canal automation;
- Involvement of NGOs, social research institutions, water and land management institutes etc. in motivating farmers;
- Increased human resources development through water and land management institutes and action research programmes;
- Rationalisation of water rates to reflect the scarcity and value of water;
- Subsidies to encourage the adoption of drip and sprinkler systems. (Suryanarayanan, 1996).

### 6.2 FEEDBACK AND IRRIGATION EFFICIENCY: ROCKY MOUNTAIN INSTITUTE

Case studies have shown the following types of information to be the most effective:

- Information about the real cost of water use – this includes the cost of the water plus energy, materials, maintenance, labour, and the cost of drainage water;
- Information about how much water is actually being used – including diversions, evaporation, leakage and seepage before reaching the crop;
- Information about how much irrigation water a given crop actually needs and when does the crop need additional moisture from irrigation (Scheduling);
- Programmes to improve flow of information and the provision of incentives for an appropriate response to feedback signals;
- Water and energy pricing – pricing methods that provide a comparison of actual water use to real crop needs and show farmers the real cost of water use;
- Technical assistance for monitoring water use and needs;
- Financial assistance for improvements in monitoring - water and energy providers benefit by postponement of expensive supply augmentation schemes by offering rebates, grants, give always, or low-cost loans to irrigators for the improvement of monitoring capabilities;



- Rebates for saving water and energy – water and energy providers can give rebates to irrigators who install water and energy saving equipment;
- Educational programmes – workshops, videos and printed material can provide general information to farmers.

### **6.3 IRRIGATION EFFICIENCY TECHNIQUES OF FEEDBACK: ROCKY MOUNTAIN INSTITUTE**

The following techniques of providing feedback to the water use decision maker have been found to be effective:

- Simplify - large and complex programmes discourage farmer participation and co-operation. Once initiated, a programme can be expanded as the capacity of farmers to use new information and techniques increases.
- Specify – farmers find programmes that take their specific needs into account more useful.
- Demonstrate – field-testing, presentation and demonstration are crucial in order to convince farmers to adopt new technologies.
- Use economic arguments – the effectiveness an efficient technology, must also be shown on the farmer's bottom line to ensure involvement and implementation.

Contact leading farmers – getting the leading farmers in a community to adopt a new technology or practice may help to persuade other local farmers to follow.

Build trust in the field – farmers are more likely to implement changes when they trust the field representative. Training a trusted local community member may lead to increased adoption of new practices.

Create a positive attitude – the success of a programme may rely on how it is presented to the farmers. Rather than telling farmers that they are wrong, it may be more effective to propose the programme as a way to improve productivity and provide the reasons why it may work, (Laird and Dyer, 1992).

### **6.4 EFFICIENT WATER MANAGEMENT PRACTICES FOR AGRICULTURAL WATER SUPPLIERS IN CALIFORNIA**

#### **List A- Generally applicable Efficient Water Management Practices**

- Prepare and adopt a water management plan.
- Designate a water conservation co-ordinator.
- Support the availability of water management services to water users.
- Improve communication and cooperation among water suppliers, water users, and other agencies.

### List B- Conditionally Applicable Efficient Water Management Practices

- Facilitate alternative land use.
- Facilitate financing capital improvements for on-farm irrigation systems.
- Facilitate voluntary water transfers that do not unreasonably affect the water user, water supplier, the environment, or third parties.
- Line ditches and canals or insert pipes.
- Increase flexibility in water ordering by, and delivery to, water users within operational limits.
- Automate canal structures.

### List C- Other Efficient Water Management Practices

- Water measurement and water use reporting
- Pricing and other incentives (Hanemann, 1999)

## 6.5 BLYDE RIVER SCHEME IN SOUTH AFRICA

The scheme to install a pipeline (cost R 105 million) was implemented to upgrade a very poorly maintained channel distribution system. The same allocation from the river was allowed for the new scheme. One of the objectives was also to make irrigation land available for the subsistence farmers in the region.

- The effective transmission of water improved from less than 40% to more than 95%;
- water was supplied under sufficient pressure to operate micro-irrigation schemes;
- water was supplied to 7 025 ha according to seasonal crop demand to.
- 800 ha was made available to new upcoming farmers from deprived communities.
- electricity cost for farmers was reduced by between R 200 and R 2000 per farmer/month as a result of the pressure line connection. The fixed irrigation charge is R 1 450/ha/year to pay for the scheme.
- quotas of 9 990 m<sup>3</sup>/ha/year were allocated and all water is metered.

Not only did the pipe network reduce the risk to crop production from loss or unavailability of water (except in extreme conditions of drought), it also enabled optimal and equitable water distribution amongst users. Water savings effected through improved efficiency of use were applied to increase the area served by present water quotas. After the change to high value perennial crops such as mangoes and oranges is complete the number of job opportunities will increase from 1 800 fulltime and 2 100 seasonal workers to 9 300 workers, (Van der Merwe ed, 1999)

## **6.6 HIGH PLAINS UNDERGROUND WATER CONSERVATION DISTRICT IRRIGATION EFFICIENCY**

The High Plains Underground Water Conservation District in West Texas achieved a 25-40% reduction in regional irrigation water use. The self-financed effort employed techniques such as replacing unlined ditches with pipelines, shortening furrows and watering in short surges, recirculating tail water at a faster rate to reduce evaporation, using soil moisture monitoring devices, and switching from high to low pressure drop-line sprinkler systems. The programme was voluntary and respect of farmers for the irrigation district employees contributed significantly to the success of the programme, (Postel, 1999).

## **6.7 BENEFITS OF IRRIGATION WATER MEASUREMENT.**

Apart from the legislative reasons for measuring irrigation water, many other benefits related to practical water management are derived from upgrading water measurement programs and systems, some of which are the following:

- Accurate accounting and good records help allocate equitable shares of water between competitive uses both on and off the farm;
- Good water measurement practices facilitate accurate and equitable distribution of water within district or farm, resulting in fewer problems and easier operation;
- Accurate water measurement provides the decision-maker on the farm with the necessary information to achieve the best use of the irrigation water available while minimising negative environmental impacts;
- Installing canal flow measurement structures reduces the need for time consuming current metering, which is frequently needed after making changes of delivery and also reduces the need to make seasonal corrections for changes of boundary resistance caused by weed growth, sectional bank slumping or sediment deposits;
- Instituting accurate and convenient water measurement methods improves the evaluation of seepage losses in unlined channels. Thus, better determinations of the cost benefits of proposed canal and ditch improvements are possible;
- Permanent water measurement devices can also form the basis for future improvements, such as remote flow measurement and canal operation automation;
- Good water measurement and management practice prevents excess run-off and deep percolation, which can damage crops, pollute ground water with chemicals and pesticides, and result in drainage flows containing contaminants;
- Accounting for individual water use combined with pricing policies that penalise excessive use, can be implemented, (Water Measurement Manual, 1997)

## 6.8 BROADVIEW WATER DISTRICT IN CALIFORNIA: WATER PRICING

In an effort to slow infiltration of salts and selenium into ground water, the Broadview Water District in California developed incentives to encourage efficient irrigation. Crop-specific tiers of water use were set at 10% below the required amount. The price difference between the tiers was more than 150%. The successes of the programme were:

- Involvement of the District Board in designing and updating the pricing programme;
- Establishment of prices and tiering levels that represented realistic goals and were relevant to local conditions
- Collection of field-specific data describing water deliveries, irrigation events, and other cultural practices; and
- The timely exchange of information among district farmers, (Hanemann, 1999)

## 6.9 AUSTRALIAN GUIDELINES FOR SPECIFIC CROPS

The guidelines are not confined to irrigation and water management but deal with all aspects of cotton production. It is an authoritative “how to do it” regional guide for the irrigation farmer. There was a time when similar publications were developed in South Africa, although few focused on irrigation. In earlier days experienced senior staff would produce manuals of this nature for the farming community but times and priorities have changed and few now have the necessary scientific knowledge combined with practical on-the-ground experience that is required to produce publications of this type..

The introduction to this draft best management practice manual is worth quoting in detail because it indicates the direction in which technology transfer is moving in Australia. Successful cotton production relies on the sustainable use of land and water resources. Soils, water, and crops need to be managed so that the farm is profitable well into the future and the risk of any adverse environmental impacts is minimised.

Effective management of land and water resources requires growers to be familiar with the resources on the farm, and to plan for the use of these resources. For example, the types of soil found on the farm, and their condition will affect how those soils are managed. Similarly, the quality of water available for irrigation can affect how that water is best used. The core best management practice for land and water management is to develop a plan that describes the resources of the farm, and how these are to be used sustainably. This type of plan is often called a land and water management plan or an irrigation and drainage management plan. Both the New South Wales and Queensland governments have developed guidelines for the development of these plans. Plans consist of a farm map and overlays, and written information on land, water and crop management.

The planning guidelines and practices outlined in this module are consistent with these government guidelines. Growers who have addressed the issues outlined in this book will have gone a long way to meeting any legal requirements for land and water management established under state government legislation.

Many growers will have already adopted the practice as recommended in this booklet. Recording these practices and a plan provides evidence of good practice, and can be used to make changes and improvements in the future, (Crosby, 2001).

## 7. REFERENCES

- Achtienribbe G.E., (1998) *Water Price, Price Elasticity and Demand for Drinking Water*, Aqua, Vol.47 No. 4.
- American Water Works Association, (1996). *Integrated Resource Planning: A Balanced Approach to Water Resources Decision Making*. ISBN 0-89 867-756-4.
- Baumann, D.D., Boland, J.J. and Hanemann, W.M., *Urban Water Demand Management and Planning*, McGraw-Hill 1998.
- Bäumle, R, (2004), (Report Compiled by the Geohydrology Division), *Revised Criteria to be Considered when Allocating Licences for the Abstraction Of Groundwater for Irrigation Purposes in The Tsumeb-Grootfontein-Otavi Subterranean Water Control Area*, Department of Water Affairs and Forestry.
- Beecher, J. A., (June 1995), *Integrated Resource Planning Fundamentals*, Journal. AWWA, Volume 87 Issue 6.
- Beecher, J.A., Chesnut, T.W., (1998). *Conservation Rates in the Real World*. Journal, AWWA, Volume 90, Issue 2.
- Bathia, R., Cestti, R., and Winpenny, J., (1993). *Water Conservation and Reallocation "Best Practice", Cases Improving Economic Efficiency and Environmental Quality*. International Bank for Reconstruction and Development/The World Bank.
- Boland, J.J., Whittington, D. *The Political Economy of Increasing Block Tariffs in Developing Countries*. International Development Research Centre, Ottawa, Canada.
- Brittsan, B. (1999), *Fixing the Leak in Demand Management Programmes*, *Demand Management Bulletin*, External Newsletter of the National Water Demand Management Centre, Issue 36.
- Bulk Water Master Plan Consultants,(2004), *Windhoek Bulk Water Master Plan*, Client: City of Windhoek.
- Central South JV Consultants, (2007), *Bulk Water Supply Infrastructure Development and Capital Replacement Master Plan for the Central South of Namibia*, Client NamWater.
- Crosby, C.P.), (2001) Study Tour Dr. Nick Austin, *Water Use Efficiency Advisory Unit, NSW Agriculture, Australia, WRC, A Water Use Efficiency Unit, established in 1999 in Dubbo* (New South Wales)
- Crosby C.T. and Crosby C.P. (1999). *SAPWAT: A computer programme for establishing irrigation requirements and scheduling strategies in South Africa*. A Water Research Commission Project, Pretoria
- Cuthbert, R.W., Lemoine, P, (1996) *Conservation Oriented Water Rates*, Journal AWWA, November 1996.
- Department of Water Affairs and Forestry, (May 1999), RSA. *Draft Water Conservation and Water Demand Management National Strategy Framework*.
- Department of Water Affairs and Forestry, (2006), *Water Accounts for Namibia*.

- Dotson, K., (1999). Personal Communication. Project Manager, Reclaimed Water System. Tucson Water, Arizona.
- Fourie, G., (2004) *Leakage Management on Plumbing Systems in Households and on Government Properties, Sida Leakage Management Project.*
- Gleick, P.H., Loh, P., Gomez, S.V., Morrison, J., (1996). *California Water 2020 - A Sustainable Vision. Pacific Institute for Studies in Development, Environment and Security.*
- Haarhoff, D. (2001), Skedulering met 'n neutron vogmeter in die GWK Gebied. Interne verslag, Griekwaland Wes Koöporasie.
- Hanemann, M. *The Role of Pricing in Water Resources Management.* Paper delivered at the Global Water Partnership meeting on 12 August 1999, Stockholm (Department of Agricultural and Resources Economics, University of California, Berkeley).
- Laird, C., Dyer, J. (1992), *Feedback on Irrigation Efficiency. Water Efficiency Implementation Report No 4,* Rocky Mountain Institute Agricultural and Water Programmes
- Lower Orange River Consultants, (2005), *Prefeasibility Study into Measures to Improve the Management of the Lower Orange River and to Provide for Future Developments along the Border Between Namibia and South Africa. Water Conservation and Demand Management.*
- Lund Consulting Engineers, (2009), *Bulk Water Supply Infrastructure Development and Capital Replacement Master Plan for the Central North of Namibia,* Client: NamWater.
- Lund Consulting Engineers, (2008), Report on the Principles and Methodology to Calculate Costs and Tariffs for Water Supply by Namwater, Client: Department of Water Affairs and Forestry.
- Lundqvist, J., Sandström, K., (1997). *Most Worthwhile Use of Water Efficiency, Equity and Ecologically Sound Use; Pre-requisites for the 21st Century Management.* Publications on Water Resources: No 7, Department for Natural Resources and the Environment, Swedish International Development Cooperation Agency, Stockholm, Sweden.
- Niesar, T., (1998), *Development of a Time Series Analysis to Determine the Effect of Water Demand Management and for Demand Forecasting,* Internal Report, Alameda County Water District, Fremont California, USA
- NAPCOD, (1998). *Booklet on Namibia's National Programme to Combat Desertification.* A Partnership Programme of the Ministry of Environment and Tourism, Ministry of Agriculture, Water and Rural Development and the Desert Research Foundation of Namibia.
- National Planning Commission, Central Bureau of Statistics, 2003, *2001 Population and Housing Census,* "Republic of Namibia".
- National Planning Commission, (2006). *The 2003/04 Namibia Household Income and Expenditure Survey, Living Conditions in Namibia.* Central Statistics Office. (NHIES, 2003/2004)
- North Carolina Department of Environment and Natural Resources, (1998), *Water Efficiency Manual for Commercial, Industrial, and Institutional Facilities.*

- North West JV Consultants, (2009), *Bulk Water Supply Infrastructure Development and Capital Replacement Master Plan for the North West of Namibia*, Client: NamWater.
- Postel, S., (1999). *Pillar of Sand*. World Watch Institute, W.W. Norton & Company, New York, London.
- Ploeser, J.H., (1996). *Conservation and the Industrial Customer*. AWWA Journal.
- Rössing Mine. *The Story of Water at Rössing Mine*.
- SABS 0252, (1996), *Water Supply and Drainage for Buildings*.
- Schachtschneider, K. and Nashipili, N., (2002), *Water Demand Management Study of Namibian Tourist Facilities*, Ministry of Agriculture, Water and Forestry.
- Suryanarayanan, N., (1996). *Irrigation and Drainage in India*. New World Water, Sterling Publications Limited.
- Stephenson, D., (1999). *Demand Management Theory*. *Water SA*, Volume 25, No 2.
- Sydney Water, (1994). *Demand Management in the Water Board*. Sydney Water Board, Australia.
- United States Environmental Protection Agency, (1999). *Water Conservation Plan Guidelines*, Available online <http://www.epa.gov/owmitnet/wave0319/index.htm>
- Van der Merwe, B. (Editor), (1999). *IUCN Water Demand Management Country Study - Namibia*. Directorate Resource Management DWA, MWARD and the City Engineer (Water Services) City of Windhoek.
- Van der Merwe, B, (2004), Task Leader, *Pre-feasibility Study into Measures to Improve the Management of the Lower Orange River and to Provide for Future Developments along the Border between Namibia and South Africa*, Report Title: *Water Conservation*, Client: Department of Water Affairs Namibia, Department of Water Affairs South Africa.
- Veck, G.A., Bill, M. R. (2001), *Estimation of the Residential Price Elasticity of Demand for Water by Means of a Contingent Valuation Approach*, Report to the Water Research Commission. WRC Report No. 790/1/2001
- Water Efficiency Manual for Commercial, Industrial, and Institutional Facilities* (North Carolina Department of Environment and Natural Resources, August 1998).
- "Water for Profit" scheme in Queensland (Australia)
- White, S. (Editor), (1998). *Wise Water Management, A Demand Management Manual for Water Authorities*. Report for the Urban Water Research Association of Australia by the NSW Department of Land and Water Conservation.
- WSASP (2008), *Water Sector and Sanitation Sector Policy*, Department of Water Affairs and Forestry, Minister of Agriculture, Water and Forestry.
- Water Research Commission, RSA, 2004, *"Waste Minimisation Guide for the Textile Industry"*



Water Transfer Consultants, (2001), *Central Area System Update: Determination of the Current and Forecasted Water Demands for The Central Area of Namibia*. Client: NamWater.