NAMIBIA WATER RESOURCES MANAGEMENT REVIEW

WATER USE AND CONSERVATION

THEME REPORT

AUGUST 2000

Engineers involved in water planning will often avoid situations where public debate and participation is necessary, preferring to see planning as a design process for which mathematical formulae provide acceptable answers. Consultation therefore often follows after the scheme is 'perfected', according to traditional engineering designs, instead of embracing political debate about scheme aims or policy goals. Any 'subjective' data are eliminated leaving the planning process comfortably neutral but, unfortunately incomplete.

Ward C , 1997

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ACKNOWLEDGMENTS

The progress made during the researching and writing up of this report could not have been achieved without the co-operation and assistance of many organisations. Altogether, the Task Force of 36 stakeholders were involved in discussions and some sent comments on this report. Their contributions during all workshops and meetings have been invaluable and this is gratefully acknowledged.

I would like to acknowledge the support that I have received from the Ministry of Agriculture and Rural Development, and especially the Department of Water Affairs in making data and information available. Some information and data used in this report were collected by several consultants: Windhoek Consulting Engineers, Environmental Engineering Services and Africon Namibia. Windhoek Consulting Engineers provided a few table and maps. Their contributions are hereby acknowledged.I appreciate the advice and encouragement of Mr Samuel Goagoseb.

Finally, I would like to give a special thanks to the World Bank for providing funds for hiring consultants, holding workshops and meetings that contributed to this report.

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1. INTRODUCTION

1.1 Background information

Scarcity of water means that there are limited sources of fresh water. About 97 per cent of the planet's water is seawater, another 2 per cent is locked in icecaps and glaciers. Vast reserves of fresh water underlie earth's surface, but much of it is too deep to economically tap. If all earth's water were to fit in a gallon (3,785l) jug, the available fresh water would equal just more than a tablespoon - less than half of one per cent of the total (Parfit, 1993). Humans use fresh water for much of their activities and so, when discussing, analysing, developing, negotiating or managing water resources, we must consider both the quantity and the quality aspects.

Namibia is a water scarce country. Actually, it is the most arid country in Southern Africa. The Country's water resources are limited owing to the low and highly variable rainfall and the high evaporation loss. Country-wide average rainfall is approximately 272mm (WCE, *et al*, 1999). It varies from less than 50mm at the Atlantic coast to more than 700mm in the Caprivi region. Evaporation rates are significantly greater and vary considerably throughout the year. Mean annual gross evaporation varies from less than 2500mm at the coast and north-east (Katima Mulilo) to as high as more than 3800mm in south-east of the country (WCE, *et al*., 1999).

22 per cent of Namibia can be classified as desert, with a mean annual rainfall of less than 100 mm, 33 per cent as arid, with a mean annual rainfall of between 100 and 300 mm, 37 per cent as semi-arid, with a mean annual rainfall of between 301 and 500 mm, and 8 per cent as sub-humid, with an annual rainfall of between 501 and 700 mm (National Drought Task Force, 1997).

Being scarce, water is considered to be one of the most important limiting factors to social, economic, industrial and agricultural development. Therefore, it is of paramount importance that the role of sustainable water utilisation and conservation is appreciated by each and every water consumer.

1.2 Definitions

From the hydrologic perspective, water use can be defined as follows:

Water use is all water flows that are a result of human intervention within the hydrologic cycle (Mays, 1996).

Generally, water use can be classified as off-stream use or in-stream use depending on whether water is withdrawn or diverted from a water source and used, or it is used, but not withdrawn from a water source for such purposes as hydroelectric power generation, navigation, fish propagation or recreation. There are a number of categories of off-stream use such as domestic, commercial, irrigation, industrial, livestock, mining, public, rural and thermoelectric power uses.

Sustainable water utilisation means that the available resources are not diminished in the long term.
For the purpose of this report, water conservation is defined as follows:

Water conservation is any beneficial strategy designed to manage water resources with a view to preserving them by reduction of water withdrawals, water use, or water waste, or protecting them from destruction or neglect and ensuring the wise and sustainable utilisation of water resources and guarding future use of water resources that have been depleted, carried out through care and supervision by a governmental authority, by a private association or business, or an individual.

(Adapted from Encyclopaedia Britannica)

Consequently, this report addresses water conservation issues whilst water is utilised, *i.e*. abstracted from a river, aquifer or some unconventional source, it is subject to the day-to-day use and it is returned to the place from which the water was abstracted, or any other suitable place. The report does not analyse water conservation in general and therefore it does not address issues of water conservation with a view to ensuring the healthy functioning of the whole ecosystem as the main objective. Source protection, as far as water quality and quantity are concerned, is included but limited to human intervention, *e.g*. regulating and controlling withdrawals from groundwater and surface water, providing facilities for pollution control, establishing water quality standards. Water conservation is, therefore, regarded here as a wise and beneficial utilisation of water resources with due respect to the environment. However, environmental considerations such as the interrelationship of organisms and their environments or impacts of human activities on ecological processes, are beyond the scope of this report.

1.3 The purpose of the report

The purpose of the water conservation theme paper can be summarised as follows:

- demonstrate that there is a need for water conservation in Namibia and that all the initiatives that are being undertaken to conserve water and protect water resources against over-abstraction and pollution are fully justified and highly beneficial;
- analyse issues relevant to sustainable water use and conservation as defined above, including reduction of water abstraction and eliminating wastage by practising water demand management, pollution prevention and control, efficient use of water, effective water pricing practices and water quality aspects;
- identify gaps in and shortcomings of the presently applicable relevant legislation that does not provide sufficient support to a water resource manager in carrying out his functions and achieving his objectives because of a fictitious institutional framework, distorted allocation principles and inadequate water resources protection regulations that were proven ineffective when tested in court;
- propose steps that could be taken to improve the state of water conservation in Namibia;
- recommend regulations that would enable the water resource manager to carry out his duty to conserve water more effectively.

2. CURRENT SITUATION ANALYSIS

2.1 Availability of water in Namibia

The low rainfall, high evaporation and high temperatures of Namibia result in most of the rainfall being "lost" to evaporation and transpiration by growing plants. Little ends as surface runoff. The flow in rivers in the interior of the country is thus intermittent and unreliable so the development potential of the surface water sources (ephemeral rivers) is limited. The perennial rivers that form the northern (Kunene, Kavango, Kwando, Linyanti, Chobe and Zambezi Rivers) and southern borders (Orange River) of Namibia are shared with neighbouring countries.

Some of rain seeps into the ground by a process called infiltration. Part of it remains as soil moisture and some reaches the zone of saturation becoming groundwater. Quantifying these processes is rather complex and the existing knowledge of potential recharge of our aquifers is very limited. The amount of precipitation available for recharge is one of the factors affecting the amount of water that recharges an aquifer but there are other factors such as the properties of surface deposits and the aquifer itself, especially their hydraulic conductivity, which are relevant.

Surface water

A number of ephemeral rivers have been tapped by building dams. The major dams are: Hardap, Naute, Swakopport, Von Bach, Omatako, Olushandja, Omaruru Delta, Oanob, Dreihuk, Otjivero Main Dam, Otjivero Silt Dam, Friedenau, Omatjenne, Goreangab, Avis, Tilda Vijoen, Bondels, and Daan Vijoen Dams. Their 95 per cent assured combined yield is **95.83Mm^3/a**, based on a single reservoir analysis. There is surplus water in some of those dams, *e.g.* in the Oanob, Hardap, Naute and Friedanau Dams in the amount of 1.6Mm^3/a, 19.1Mm^3/a, 7.0Mm^3/a and 0.82Mm^3/a respectively (WCE, *et al*., 1999). 65.445Mm^3/a (22 per cent) of the total demand of 296.882Mm^3/a in 1999 was supplied from the dams on the ephemeral rivers. Therefore, there was surplus water of 30.385Mm^3/a in all the existing dams, based on their 95 per cent assured yield.

At present, only two agreements concerning our water allocation from the perennial rivers have been concluded, *viz*. from the Kunene River with Angola and from the Orange River with South Africa. The amounts agreed on are 180Mm^3/a and 9Mm^3/a respectively. As far as our allocation or, as it is now called, entitlement is concerned, it was proposed that the Namibia’s basic share of the Orange River System would be 50 million m^3 per annum (including 9Mm^3/a which has been agreed on already). South Africa offered that this quantity of water would be available, for the use by Namibia, free of capital charge but 0.56c per m^3 should be paid to cover operation and maintenance costs. If agreed, this would be a very unfavourable scenario for Namibia. The natural water resources of the Orange River basin are estimated to be in the order of 12 000 million m^3/annum (BKS and Ninham Shand, 1996). The Namibia's contribution from the Fish and Nossob Rivers is in the order of 480 million m^3/a. It was estimated that 50 million m^3/a could be considered to be our share of the Orange River water based on the natural flow at the Orange - Vaal confluence, before damming took place (Van Langenhove, personal communication). It was also estimated that the Namibian future water demand would be 220Mm^3/a in 2020 (Biggs, personal communication). Furthermore, there are serious quality concerns, which are discussed later in this report. Be that as it may, our present water allocation from the perennial rivers is **189Mm³/a**. In addition to 50Mm³/a, 20Mm³/a from the Orange River might become available till 2007 at a cost still to be determined and agreed on with South Africa. Although not subject to agreements at present, it was estimated that Namibia utilised 21.481Mm³ and 6.432Mm³ from the Kavango and Zambezi Rivers respectively in 1999. Total abstraction from the perennial rivers in 1999 was estimated at 99.719Mm³ which is about 33.6 per cent of the total water demand. For the purpose of estimating potential sustainable resource, it was assumed that the resource potential is half utilised, i.e. Namibia would be entitled to abstract 42.962Mm³/a and 12.864Mm³/a from the Kavango and Zambezi Rivers respectively in the future (WCE, 2000) as shown in **Table 1**.

Table 1: Perennial Rivers as Water Sources

River	Present allocation Mm³/a	Present utilisation Mm³/a	Assumed future allocation Mm³/a
Orange	9	48.812	50
Kunene	180	22.992	180
Kavango		21.483	43
Zambezi		6.432	13
Total	**189**	**99.719**	**286**

From the above table, it can be seen that what is now allocated to Namibia from the Kunene River is not fully utilised. Figures under "assumed future allocation" are subject to further negotiations except 180Mm³/a from the Kunene River and 9Mm³/a allocated to the Noordoewer/Viooldrift Irrigation Authority as Namibia's share.

Groundwater

The availability of groundwater depends on a combination of sufficient rainfall and appropriate geohydrological conditions. Groundwater resources can be utilised on a sustainable basis provided that extraction does not exceed the long-term recharge potential. Aquifers occurring in Namibia are classified as alluvial, Kalahari, fracture, karst or artesian aquifers (WCE, *et al*., 1999). There are some estimates of stored water reserves in those aquifers but only some parts of the Grootfontein-Otavi-Tsumeb Karstland aquifer have been subject to thorough investigations and modelling. For the Otavi Mountain area, so-called Area I and small parts of Area II, the model gives the following recharge conditions:

- "The recharge rate amounts to 2 % of the long-term mean annual rainfall after a sequence of rainy seasons in each of which the long-term annual rainfall is exceeded.
- The recharge rate amounts to 1 % of the long-term mean annual rainfall after a single rainy season in which the long-term mean annual rainfall is exceeded.
- The recharge rate amounts to 0 % if the rainfall does not exceed the long-term mean annual rainfall.

The current drought situation, which has continued since 1979 (more than a decade), means that no sustainable long-term recharge rate can be worked out. As a short-term mean recharge rate, which was roughly valid during the last decade (including the single season 1988/1989), a value close to zero must be accepted" (Schmidt, 1996).

A second model was developed for Area II (Grootfontein Karts Area). A study of the model leads to the conclusion that: "the regional long-term sustainable recharge rate equals zero during the current drought conditions" and that "by assuming the current zero-recharge conditions (general drought situation), any additional groundwater abstraction in fact means groundwater mining" (Schmidt, 1996).

The above results clearly imply that the Karstland should not be used for the long-term continuous abstractions of excessive amounts of water. The report also concludes that the abstraction for farming purposes has negligible impact on the regional decline of the water table.

In 1999, a large-scale hydrocensus and aquifer modelling programme was initiated with the human resources and financial assistance provided by the Japanese government with a view to evaluating the resources of the Stampriet Artesian Basin. It is believed that at present this aquifer is being overutilised. The aim of the study is to determine the long-term potential of the Stampriet aquifer in terms of recharge, abstraction and natural losses. This is, therefore, the second Namibian aquifer to be investigated.

Our present knowledge of the available groundwater resources is extremely limited. Recommendations concerning abstraction levels are based on pumping tests carried out to determine, so called, safe yields. How safe is safe yield is difficult to judge. No figure is currently available on the sustainable yield of our aquifers. Nevertheless, 44.4 per cent of the present demand is supplied from groundwater sources and it amounts to 131.718Mm^3/a.

As far as the availability of water in Namibia is concerned, it was recommended that the total potential ephemeral water resources and the total potential groundwater resources be integrated into total available resource with **414.095Mm^3** of fresh water available per annum (WCE, 2000). It is not possible to split this total into surface water and groundwater because there are different possible options for the future development of the water resources and developing one will affect the development of others.

Wastewater

Reclaimed water is now valued as a resource and more and more often it is used for those applications that do not require drinking water quality, *e.g*. landscape irrigation in cities or agricultural irrigation. Estimates were made for Windhoek and urban centres having annual consumption greater than 1Mm^3. It was assumed that the return flow in these towns equals 40 per cent of fresh water consumption and can be reused after treatment. The following quantities of water could potentially become available from wastewater utilised as an unconventional water source (EES, 1999):

- Semi-purified wastewater from Windhoek 7Mm^3/a
- Semi-purified wastewater from other centres 10Mm^3/a.

Available resources

Accepting the above assumptions and estimates, it can be concluded that our potential water resources are as follows:

- Surface water from the ephemeral rivers and groundwater **414.095Mm^3/a**
- Perennial Rivers **286.000Mm^3/a**
- Wastewater **17.000Mm^3/a**

Total 717Mm^3/a.

2.2 Current water allocation system and licensing policy

The Namibian Constitution stipulates sovereign ownership of natural resources. Article 100 stipulates that:
"Land, water and natural resources below and above the surface of the land and in the continental shelf and within the territorial water and the exclusive economic zone of Namibia shall belong to the State if they are not otherwise lawfully owned".

Lawful ownership of water is defined in the Water Act, 54 (Act 54 of 1956). No one owns so-called public water but there are certain rights to use it, including rights to use by riparian owners.
Every riparian owner can use water from a public stream for domestic purposes and the watering of stock. If water is to be used for irrigation, a water court should determine "a riparian owner's share" (Section 52 of the Act). Presumably, this should result in entitlement or a license to use the quantity of water so determined.
If more than 300m^3 on any one-day or 250m^3 on an average day during any month will be used for industrial purposes, a permit authorising such use is required. A local authority also requires a permit to use public water.

However, groundwater if not derived from the bed of a public stream, is regarded as the property of the owner of the land, provided the land is not within any area declared by the Minister as a water control area. In Namibia, a number of areas have been declared as "water control areas". These are as follows: Municipality of Windhoek, Stampriet Artesian Basin, Gobabis, Maltahöhe, Grootfontein, Windhoek-Gobabis, Tsumeb-Otavi-Grootfontein, Otjiwarongo-Otavi, Otjiwarongo-Omaruru. In those areas no permits are needed to use water for household and watering animals but it is not allowed to abstract water for the irrigation of an area of more than one hectare without permission.

From a water conservation point of view, the above regulations do not ensure that data are collected of how much water is used and for what purpose. There is no control, whatsoever, over commercial land where farmers can use groundwater as much as they please. Water courts have never been established in this country. Therefore, no entitlements were given to use water from public streams for irrigation outside the water control areas. It is not certain why only industrial use of water above certain limit requires a permit. Some commercial establishments use on average, probably, more than 250m^3/d, and produce domestic/agricultural waste. There appears to be no good reason for not respecting the integrity of the hydrologic cycle; groundwater cannot be separated form surface water (*i.e.* public water). Additionally, the Act stipulates obligations of water users to apply for a license or a permit but does not clearly assign responsibilities for establishing all the required institutions that would carry out all the necessary functions. This might be one of the reasons why a register and control over the use of water, irrespective of whether in water control areas or not, is practically non-existent in Namibia at present. This situation is unacceptable for two reasons: firstly, it is difficult to manage and conserve water if it is not measured, secondly, it is impossible to comply fully with our international obligations in respect of water sharing and use as stipulated by agreements with the neighbouring countries unless we can prove our sincere commitment to sound water use strategies.

Other issues arise because of the recent establishment of the Namibia Water Corporation (NamWater). It is the biggest water "consumer" that uses water for commercial purposes. As such it has to apply for permits and submit information on the quantity of water abstracted from the rivers and aquifers. Questions which arise in this connection: does the company have exclusive rights to use water stored in the dams? Will there be a provision to establish other bulk water supply companies?

2.3 Present and future water demand

For the purpose of this report, water consumption in Namibia has been divided into the following categories:

- Domestic (urban and rural)
- Agriculture (livestock and irrigation)
- Mining
- Industry
- Tourism

"Domestic" in the above list means rural domestic consumption and all urban consumption except industry. Usually municipal water is used for domestic, commercial/institutional and industrial uses. Obviously, there are also some losses and unaccounted-for-water. Domestic consumption can be further subdivided into drinking/cooking, laundry, bathing/personal, toilet-flushing and lawn watering. An example of municipal water use in Canada is presented in **Table 2**.

Table 2: **Municipal Water Use by Major End Uses in Canada (Tate, 1990)**

Use	Percentage of total pumpage
Total	
Domestic	40
Commercial/institutional	16
Industrial	18
Losses/unaccounted	26
Domestic	
Drinking/cooking	5
Laundry	10
Bathing/personal	15
Toilets flushing	40
Lawn watering	30

The above table is presented to highlight the importance of research and data collection. Following traditional approach to water management, best described as supply management, usually only total quantities of water supplied are available. In order to know how much is needed to meet demands this is sufficient. However, it is not sufficient for managing the demands and detailed information is invaluable when analysing the most appropriate measures to be taken to reduce water consumption. Limited time and resources available for this project did not allow producing a similar table for municipal water use in Namibia and investigation into the present and future water demand had to be based on the available information which is inadequate.

One interesting fact has to be pointed out concerning domestic use of water. Only 30 per cent of the highest quality water is required. Toilet flushing and lawn watering do not need water of drinking quality. Although such studies have not been carried out in Namibia, it is expected that similar results would be obtained.

The analysis of the present use and future water demand has been carried out using the 23 hydrological basins of Namibia as the key units in water resources management. Parts of the desert and a few areas in the west, outside the boundaries of the 23 hydrological basins, have been grouped in a 24th basin which is referred to as "other". River basins of Namibia are presented in **Figure 1**. It must be pointed out that they do not coincide with the 13 administrative regions of Namibia.

2.3.1 Present water consumption

Water consumption in Namibia in 1999 by category is presented in **Table 3** (WCE, 2000). The single biggest user of water was agriculture that "consumed" 71.7 per cent of the total water used in Namibia in 1999; close to 46 per cent was used for irrigation.

Table 3: Water Consumption in Namibia By Category for 1999 in Mm^3

Sector	Rural[1] Urban[2]	Agriculture Irrigation Stock	Mining	Tourism	Industr y	Total
Water consumptio n Mm^3/a	5.7 57.0	135.9 77.1	13.4	2.3	5.6	297. 0
Percentage of Total %	21.1 1.9 19.2	71.7 45.7 26.0	4.5	0.8	1.9	100. 0

1 Rural = domestic
2 Urban = domestic + institutional + commercial

Rural and Urban

Rural and urban includes 56.981Mm^3/a (91 per cent) utilised in urban centres (= domestic + commercial + institutional + losses) and 5.669Mm^3/a (9 per cent) utilised for domestic purposes in rural areas. These two figures must be looked at from a proper perspective. The latter one was estimated based on the following norms:

- inhabitants living < 2.5km from a water point - 15 litres per capita per day
- inhabitants living > 2.5km from a water point - 7 litres per capita per day
- system losses - 40 %.

Some of the above figures come from a study conducted by SIAPAC for the Directorate of Rural Water Supply (DRWS) at the Ministry of Agriculture, Water and Rural Development (SIAPAC, 1997). Others are assumptions as no statistics are available from DRWS. Actually many rural water supply schemes are not equipped with water meters. It might very well be that this is an underestimated figure. Water consumption in urban centres, on the other hand, is based on measured quantities and includes exorbitant quantities used in some institutions, and excessive losses in a number of towns with poorly maintained distribution systems. The highest water consumption in urban centres is in the Swakop basin which includes Arandis, Karibib, Okahandja, Otjimbingwe, Swakopmund, Usakos and Windhoek. In this one basin urban water consumption was 21.2Mm^3 in 1999 which was about 37 per cent of the total used for urban supplies (for domestic, institutional and commercial purposes).

Urban and rural (domestic) water demand in the Swakop basin was 21.3Mm^3 in 1999. This basin is home to approximately 297807 persons. However, the most populous one is the Cuvelai basin with approximately 699020 persons. This basin has the highest rural domestic demand of about 3.6Mm^3/a which is about 63 per cent of the total water use for rural domestic purposes in Namibia.

Urban and rural (domestic) water consumption in this basin was about 10.9Mm^3 in 1999 (**Table 8**).
Based on urban and rural (domestic) use, which is the best available approximation of the quantity of water used for human consumption and domestic purposes, 196l/c/day and 43l/c/day were used in the Swakop and Cuvelai basins respectively.

Agriculture

Agricultural use includes 135.930Mm^3/a utilised for irrigation and 77.054Mm^3/a utilised for stock watering (WCE, 2000). Consuming 71.7 per cent of the total water supplied, the agricultural sector is the biggest water consumer in Namibia. Similar figures were found for South Africa. They are as follows:

1983 - 73% for irrigation and stock-watering

1997 - 69% for irrigation and stock-watering (Davies and Day, 1998)

Of the 42,962ha of irrigable land in our country, 7,573ha (~18%) are currently irrigated as presented in **Table 4**. It is remarkable that only for 34 (~18%) of the 189 irrigators, water consumption figures were available; they are shown in bold. For many established schemes this information was not available, for others, where obvious data errors were found, they were replaced by estimates based on the type and composition of crops that are grown and the irrigation method which is in use. From **Table 4**, it can be seen that surface irrigation (flooding) is still dominant in Namibia and more advanced irrigation techniques have not yet been applied very widely. Additionally, irrigation of lucerne, maize and wheat, all low value crops, is commonplace. Surface irrigation is characterised by low efficiency caused mainly by high evaporation. For comparison the efficiency of different irrigation systems is shown in **Table 5** (van der Merwe, 1999).

Table 5: Efficiency of Irrigation Systems

Irrigation system	Efficiency in %
Surface system (flood)	55
Conventional sprinkler	75
Centre pivot	80
Micro Jet	85
Drip	90

The highest consumption of irrigation water was in the Fish and Orange River basins with 41.5Mm^3 and 41.0Mm^3 respectively in 1999.

The amount of water required to produce a number of items is as follows (Davis and Day, 1998):

Produce	*m^3 of water required to produce 1 kg*
Lettuce	0,2
Tomatoes	0,2
Melon	0,3
Broccoli	0,4
Orange juice	0,8
Corn	1,0
Oats	1,6
Barley	1,8
Dry timber	2,0
Brown rice	2,1
Sugar	2,2
White rice	3,3
Eggs	4,0
Soya beans	4,0
Chicken	5,5
Almonds	10,7
Butter	17,2
Beef	24 - 110

Last year, the highest consumption of water for stock watering was in the Cuvelai basin (18.706Mm^3) followed by the Omatako (8.687Mm^3), Nossob (8.301Mm^3) and Okavango Delta (6.271Mm^3) basins.

Livestock water demand in Namibia is depicted in **Table 6** (WCE, 2000). By far the biggest number of livestock is kept in the Cuvelai Basin: about 627544 cattle, 53236 sheep, 330784 goats, 3286 pigs, 111677 donkeys, 14317 horses and 489 ostriches, see **Table 6** (WCE, 2000) . The Cuvelai Basin is followed by the Omatako, Nossob and Okavango Delta basins. These four basins alone, support close to 55 per cent of the Namibia's livestock as far as water and grazing are concerned. Some of the water used for stock-watering in the Cuvelai

Basin is transferred from the Kunene Basin. In fact the eastern and northern parts of the country carry the most of the livestock in Namibia.

Mining

The highest consumption of water for mining purposes was estimated for the Orange, Swakop and Ugab basins with 7.5Mm^3, 5.1Mm^3 and 0.4Mm^3 respectively in 1999. According to the Chamber of Mines, there were 51 operating mines in Namibia in 1999 and another 7 might be established or re-opened in future (WCE, 2000). One of the mines that might be re-opened is the Tsumeb Copper Mine in the north of the country. Haib Mine, in the south of Namibia, is one of the mines that can be established. If this happens, the Haib Mine will use about 20 Mm^3/a of water from the Orange River when in full production (WCE, 2000).

Tourism

It was assumed that establishments such as bed and breakfast, game farms, lodges, hotels, tourist resorts and camping facilities cater exclusively for tourists. In contrast to the mining sector present only in a few basins, tourist facilities are more evenly distributed throughout the country as depicted in **Figure 2**. However, the most popular destinations are in the Swakop, Cuvelai and Fish River basins, where water demand by tourism sector was 0.8Mm^3, 0.5Mm^3 and 0.4Mm^3 respectively in 1999 (WCE, 2000).

Industry

A list of 638 industrial establishments was obtained from the Ministry of Trade and Industry. Their water demand is presented in **Table 7** (WCE, 2000).

Table 7: **Present and Future Industrial Water Demand by Category**

Category	Water demand in m^3/a		
	1999	2005	2015
Baking	42596	46576	54053
Brewing and Beverages	760186	831220	964664
Cement	340691	372526	432332
Dairy	239805	262213	304309
Fish	2296033	2510581	2913632
General	165628	181105	210179
Manufacture	1175811	1285683	1492087
Meat processing	553322	605026	702157
Milling	33726	36877	42798
Total	5607796	6131807	7116212

The highest industrial water demand is in the Swakop, Kuiseb and Zambezi basins where it was 1.9Mm^3, 1.6Mm^3 and 1.1Mm^3 respectively in 1999. Values for the expected growth in

GDP as received from the Ministry of Trade and Industry have been used for projecting future water demand. These are as follows:

- 1.5% between 1999 and 2005
- 1.5% between 2005 and 2015.

2.3.2 Future water demand

A summary of the water consumption for 1999 and water demands for 2005 and 2015 by sector and basin are presented in **Table 8**. Total consumption in 1999 was 297Mm^3.

Estimated water demands will be approximately 418Mm^3 in 2005 and 555Mm^3 in 2015. Therefore the water demand will increase by 41 per cent and 87 per cent in comparison to 1999, respectively (WCE, 2000). When calculating future water demand the following factors were considered:

- Historical water consumption figures;
- Natural increase in population;
- Increase in population due to urbanisation;
- Expected increase in economic activity and general development;
- Water demand management;

It was assumed that system losses would decrease owing to the implementing of water demand management; in many cases this would mean leakage management only. The following decreases were assumed:

- Rural water supply - from 40 per cent in 1999 to 30 per cent in 2005 and to 20 per cent in 2015;
- Smaller urban centres - from 30 per cent in 1999 to 15 per cent in 2005;
- Larger urban centres - from present levels of between 7 per cent (Omaruru) and 58 per cent (Khorixas) to 10 per cent in 2005.

Owing to the envisaged much-improved water demand management and the expected lower population growth from 1999 to 2015, relatively low increases are foreseen for domestic, commercial, institutional and industrial water demands.

The major part of the anticipated increase in water demand is due to a large increase in irrigation demand from approximately 135Mm^3 in 1999 to 239Mm^3 in 2005 and 342Mm^3 in 2015. The Government has promoted irrigated crop production after independence as a possible means of poverty reduction, and it is assumed that this trend will continue and projects such as the proposed sugar project in the Caprivi will be carried out. More water will have to be abstracted from the perennial rivers.
More details concerning all the assumptions and calculations are to be found in a report "Analysis of Present and Future Water Demand in Namibia" prepared by the Windhoek Consulting Engineers in 1999.

2.4 Present level of water resources utilisation

A summary of 1999 water demand by source is depicted in **Table 9**.
In **Table 9**, the 1999 demand met from the ephemeral rivers was reduced by 5Mm^3 owing to some semi-purified effluent reused by a number of municipalities in Namibia. In Windhoek,

1.2Mm^3 was reused for irrigation (landscape and sports fields), 1.5Mm^3 was recycled as reclaimed water and 2.3Mm^3 of treated effluent was released to the river some of which was used downstream for agricultural irrigation. 1.5Mm^3 that was recycled back to the system can definitely be seen as a replacement of fresh water. How much landscape irrigation would be practised in Windhoek and other towns if done with fresh water, remains a question. 5Mm^3/a was taken as a reduction in fresh water consumption due to wastewater reuse.

Table 9: Water Resources Utilisation

Source	1999 demand Mm^3	Potential availability Mm^3	Source utilisation %
Perennial rivers	99.719	286.000	34.9
Ephemeral rivers	60.445		
Groundwater	131.718	414.095	45.9
Wastewater	5.000	17.000	29.4
Total	296.882	717.095	41.4

From **Table 9** it can be seen that, at present, 41.4 per cent of the total available resources is utilised in Namibia. It must be underlined that 717Mm^3/a is an estimated potential yield of all the resources, including perennial rivers, ephemeral rivers, groundwater and wastewater, developed and undeveloped resources, water that can be lawfully abstracted from the shared rivers and what Namibia will, hopefully, be able to abstract in future.

Provided all the assumptions in calculating future water demand are valid, Namibia will be able to meet her water needs of 555Mm^3 in 2015 as far as water resources are concerned. These resources, however, are not evenly distributed throughout the country. Two extreme examples are the Cuvelai and Kunene basins. Water demand within the Cuvelai basin is nearly double the estimated available resources of the basin and it is satisfied through transfer of water from the Kunene basin where only about 3Mm^3/a of the total potential sustainable resource of 190Mm^3/a is utilised. The latter includes 180Mm^3/a that, according to the agreement with Angola, is Namibia's allocation of water from the Kunene River. Other basins with practically fully utilised resources are the Swakop, Koichab, Tsondab and Tsauchab basins. In the Koichab basin, Luderitz is supplied with water from the Koichab Pan where the majority of the resource is considered to be fossil water, so duration of the sustainability is in fact questionable (WCE, 2000). The Swakop basin has been experiencing shortages of water for quite some time and its water supply is augmented by transfers from the Omatako, Kuiseb and Omaruru basins to meet the present water demand. Therefore, despite having sufficient potential sustainable water resources for the near future in Namibia, some basins rely, and others will have to rely, on water transfers, because of the unfavourable distribution of these resources.

2.5 Existing water supply infrastructure

Owing to limited resources and time constraints, the study into the infrastructure sufficiency was limited to bulk water supply through the Cuvelai drainage basin network, the Eastern

National Water Carrier and the West Coast supply system. The following were not included as information is not readily available (WCE, 2000):

- Municipalities that supply their own water;
- Water supply to mines that do not form part of a regional or national water supply scheme;
- Irrigation;
- Commercial farms;
- Borehole schemes for rural water supply not supplied by Namwater.

Cuvelai drainage basin network

The raw water system, including the pumps at Calueque and the raw water canals, has sufficient capacity to supply the water demand of the Cuvelai drainage basin. Generally speaking, this network can supply the water demand in the basin well into the future, e.g. the Oshakati - Ondangwa transfer infrastructure can meet the present demand downstream of Oshakati and can cope with approximately 150 per cent increase in that demand. Similarly, the bulk infrastructure feeding the Ombalantu area has capacity of 150 per cent of the present demand. The same can be said about the Oshakati - Omapale pumps and pipeline (WCE, 2000). Obviously, there are some constraints, e.g. the Ogongo - Okahau pump station is running at its limit; the Ondangwa town pumps are operating at the limit of their capacity; storage capacity on some components is inadequate; some rural off-takes experience low pressure. Evaluation of the Cuvelai water supply system was carried out in 1997 by NamWater. This system appears to be in a fairly good shape; generally, it has sufficient capacity and it has more than sufficient water resources from the neighbouring basin. Transfer of water from the Kunene to the Cuvelai basin is unquestionable; the resources of the Kunene basin cannot be fully utilised.

Eastern National Water Carrier (ENWC)

Most of the infrastructural components in this system have sufficient capacity to supply the future water demand of centres they serve, including the Otjozondjupa region, Okahandja, Karibib and the Navachab Gold Mine. However, there is insufficient pipeline capacity to supply Gross Barmen at its peak-projected demand in 2015. Also, there is insufficient pumping capacity to supply Windhoek at its peak-projected demand in 2005 (WCE, 2000). Apart from these infrastructure shortcomings, there is insufficient water to be supplied by the system. It was calculated that about 17.28Mm^3/a would need to be transferred from some additional source or sources to meet the water requirements in the central areas of Namibia (Water Transfer Consultants, 1997). It was estimated that the cost of the proposed Rundu to Grootfontein link to the ENWC with a design capacity of 17.28Mm^3/a would be N$ 603 million. Excluding groundwater sources because of their questionable sustainability, the estimated capital costs of other supply alternatives are as follows:

- From Calueque on the Kunene River to Grootfontein - N$ 1234 million;
- From the canal at Oshakati to Grootfontein - N$ 875 million;
- Desalinated water from the cost - N$ 1895 million, N$ 1920 million or N$ 2134 million, depending on where it ends (Windhoek or Okahandja) and the type of pipes to be used (Water Transfer Consultants, 1997);
- From the Orange River - N$ 2418 million.

The above are, presumably, 1997 constant prices. Further on in this report, it will be advocated that water demand management (WDM) can postpone new infrastructure development. It must, however, be stressed that WDM complements the more traditional supply management techniques but it does not replace them; recycling of reclaimed water has a limit and additional supplies will be required in Windhoek though later than if WDM were not instituted.

West Coast supply system

Some infrastructure components of the system have sufficient capacity to meet future water demand of their supply centres at the West Cost. However, pipeline capacities to supply peak-projected demand at Walvis Bay and Henties Bay in 2015 are insufficient. There is also concern about the negative environmental impacts of the high water abstraction from the Omaruru and Kuiseb Rivers, resulting in the notion of a shortage of water at the coast if the water abstraction is reduced to more sustainable levels. Recently, it was recommended that the desalination of seawater be considered for augmenting water supplies at the coast. Estimated cost of a reverse osmosis plant is N$ 227.2 million, at 1995 constant prices (GKW, et al., 1996). Ultimately it is for the communities concerned to decide on their preferences. It just appears that not all the aspects were fully explored in considering different options for water augmentation. This approach would result in very expensive water for all the consumers. Considering an enhanced recharge scheme for the Kuiseb aquifers, a willingness to pay study and a price elasticity of demand study would have been very informative. Price elasticity of demand measures the impact of changing prices on water demand by taking the ratio of the percentage change in the quantity of water to the percentage change in price. At least one big water consumer envisages that if such an increase in water tariffs is introduced, it will be beneficial for them to import water (as acid) to Namibia from the RSA: the Rössing Uranium Mine would like to increase the annual quantity of sulphuric acid imported through the Walvis Bay harbour to 210,000 tons per year as this will be cheaper than running their own acid plant producing sulphuric acid from local raw materials. The acid plant will be shut down. The CSIR has been appointed by the mine to carry out an Environmental Impact Assessment. Most probably, other big consumers will also look for alternative options or simply implement drastic water saving measures. Hopefully, impacts such as this one have been accounted for in the planning of the desalination plant so that the rest of the country will not be expected to participate in financing this project, in terms of the recent Cabinet approval of the cross-subsidisation policy, allowing Namwater to shift funds between different schemes (Cabinet Decision No: 9^{th}/20.04.99/006).

2.6 Water use efficiency

On average, about 30 per cent (van der Merwe, ed., 1999) of water supplied to towns and villages is wasted due to leakage, poor maintenance of the distribution systems, excessive and inefficient use by consumers, lack of efficient water fixtures and fittings, and especially relatively low water tariffs. This figure is based on water savings realised in Windhoek as a result of implementing water demand management. In 1995 and 1997 savings of 31,5 per cent and 33,3 per cent, were achieved in comparison to the calculated unrestricted water demand (van der Merwe, ed., 1999). It is assumed that similar savings could be realised by other local authorities. As far as municipal water demand management is concerned, in a number of places an initial decline in water usage of 25 per cent was achieved, with a rebound, as users adjusted their water use habits, to a long -term decrease of 15 - 20 per cent in response to the introduction of water demand management (Tate, 1990). The latter figure, most probably, is based on relatively well-maintained water networks, which is generally not the case in Namibia. Conservation efforts during severe water shortages such as droughts may result in as high a reduction of water use as 50 per cent. It is worth noting that in such cases per-capita consumption remains well below what it was before drought, even if water once again becomes abundant, provided increased water rates remain in place (Lynn Anderson-Rodriguez, 1996). Taking into account high unaccounted-for-water in many towns, it appears that 30 per cent reduction in water use could be achieved as a result of implementing water demand management in our towns. This justifies a statement that about 30 per cent of water used in urban centres is wasted.

In 1998 Directorate of Resource Management of the Ministry of Agriculture, Water and Rural Development and the City Engineer (Water Services) of the City of Windhoek carried out a study on water demand management in Namibia sponsored by the World Conservation Union (IUCN). The aim was to establish and assess the degree to which water demand management is practised in Namibia in different sectors, such as urban water supply, rural water supply, agriculture, mining and tourism sectors. This information is presented below.

2.6.1 Urban Water Supply Sector

There are a few towns in Namibia that practise water demand management and have implemented some water demand management measures. Metering of supplied water is usually done but it is not compulsory. Khorixas and Opuwo do not have metering. In Rundu and Rehoboth most connections are metered but not all of them. In smaller towns there is no metering of standpipes in informal settlements.
Water wastage due to leaks, pipe-breaks and, often, poor maintenance of the water reticulation networks result in high unaccounted-for-water. In municipal areas it varies from 7.5 per cent in Otjiwarongo and 7.7 per cent in Outjo to 31.1 per cent in Usakos. In towns, the unaccounted-for-water is as high as 38 per cent in Rundu and 58 per cent in Khorixas. More than 35 per cent of water supplied to Katima Mulilo, Ondangwa, Ongwediva, Opuwo, Oshakati and Rehoboth is unaccounted for (van der Merwe, ed., 1999). Taking into account only the municipalities and towns in Namibia, it was estimated that approximately 1.9 Mm^3 could be saved per year if the unaccounted-for-water were lowered to 15 per cent. One of the reasons for a lack of maintenance of water reticulation networks is generally limited information available about these networks; only in Windhoek is the total reticulation length known.

At present good quality water-saving devices such as low flush toilets, low flow rate showers and water efficient fittings are not available in our shops because they are not available in the Southern African region; there is no point in installing a low flush toilet if it has to be flushed twice. It is considered that the lack of durable and reliable water efficient fixtures and fittings is the main reason why any retrofitting programme is destined to fail. Apparently, Botswana imports good quality low flush toilets from Sweden. In 1996 the City of Windhoek promulgated Water Supply Regulations and the use of low flush toilets, low flow showerheads and water efficient equipment in new buildings was made mandatory. However, the lack on the market of good quality (durable and reliable) plumbing fixtures and fittings that could be classified as water conservation equipment makes it difficult to enforce these regulations (van der Merwe, ed., 1999).

Rising block water tariffs are considered to be one of the most effective water demand measures in Namibia. The principle is that rates increase for progressively larger volumes of water used, *i.e*. large-volume consumers pay a progressively higher average rate for increased water consumption. Typically, the higher rates include uses such as watering gardens, car washing or filling swimming pools. A few towns in Namibia use rising block tariffs to discourage such uses. They are as follows: Henties Bay, Okahandja, Swakopmund, Tsumeb, Walvis Bay and Windhoek. Other towns apply, so-called, flat rate or uniform volume rate. It is a single rate per unit irrespective of the amount consumed. The main advantage of this system is its simplicity and acceptability by the consumers. It does not however encourage water saving.

There are huge differences in the water tariffs charged in different urban centres; in Oranjemund water is free, in Walvis Bay those using more than 86m^3 pay as much as N$ 8.54/m^3. Free water at Oranjemund results in the highest total per capita per day consumption of water in Namibia. At 2667l/c/d, it compares very unfavourably with 322l/c/d in Walvis Bay. Additionally, these figures are based on total consumption in relation to water production and estimated population, and they include industrial water consumption (van der Merwe, ed., 1999). However, industrial use of water is minimal at Oranjemund where seawater is used at the diamond mine, and it is high in Walvis Bay because of the fishing industry. Residential water consumption at Oranjemund would be out of proportion in comparison to residential water consumption in Walvis Bay, if it could be separated. Extreme examples of undercharging for water are Kamanjab and Leonardville where the selling price of water is 17 and 12.6 per cent lower respectively than charged by Namwater (van der Merwe, ed., 1999). These are, probably, the most obvious examples of towns not concerned with cost recovery principles which is surprising because both Kamanjab and Leonardville are Namwater's customers; they receive their water bills from and pay directly to Namwater. This is one of the institutional arrangements for water supply to Local Authorities. Another is that water bills are sent by Namwater to the Ministry of Regional and Local Government and Housing which sends them to the respective Local Authority for verification and pays directly to Namwater. Opuwo, Khorixas and Rundu, with very high unaccounted-for-water, do not pay their bills. Revenues collected for water are sent into the state fund from which the Ministry pays these bills. It would be wise to find out the difference between the collected revenue and the bills paid by the Ministry. This appears like one way of subsidising water supply and accepting wastage of water.

Implementation of water demand management measures is in the discretion of local authorities. The Model Water Supply Regulations, 1996 (Notice No.72 of 1996), are not automatically applicable to all towns and villages. They have to be promulgated. This has happened in a number of towns but enforcing these regulations leaves much to be desired. The regulations attempt to prevent undue water consumption and prohibit the purposeless or wasteful discharge of water. They require that water is used efficiently. The regulations do not specify what is undue water consumption or when water is used inefficiently. There are no regulations concerning leak detection and repair programmes, water tariffs calculation or making practising water demand management by local authorities compulsory.

Public awareness, co-operation and commitment to conserving water by water providers, distributors and all consumers, are of fundamental importance in promoting the efficient use of water. Ongoing campaigns, information programmes or customer advisory services are carried out in Gobabis, Okahandja, Swakopmund, Tsumeb and Windhoek. Other local authorities participate to some extent in the National Water Awareness Campaign to which the water demand management advocacy component was linked. These programmes must be intensified.

An interesting fact was observed in the smaller towns. The water used by governmental institutions is higher than any other use. Wastage of water occurs due to poor maintenance of government institutions, extensive lawns at schools and hostel, and poor quality of fittings and fixtures.

2.6.2 Rural Water Supply Sector

Water consumption in rural areas in not as well documented as in urban areas. At present there are about 5419 water points but only some have been equipped with water meters. According to a recent study, per capita consumption is below 10 l which is less than the recommended consumption of 15 l/c/day for Namibia (SIAPAC, 1997). This in turn is less than the WHO guideline of 25 to 30 l/c/day. Therefore, human water consumption needs rather encouragement than reduction to be on a par with health related and hygienic guidelines.

Much more water is used for stock watering than for human consumption. It was estimated that livestock consumption is on average 6.4 times that of humans (SIAPAC, 1997). A lot of water is wasted in traditional drinking troughs, especially when the taps are left open overnight in order to create water pools for animals to drink from (Angula, 1999). The Ministry of Agriculture, Water and Rural Development pays for the water supplied to rural communities. Therefore, those rural communities that do not pay for water at all, receive fully subsidised water. In the majority of cases rural water supply is not metered, which makes it difficult to calculate unaccounted-for- water. The current system losses on rural water supply are assumed to be 40 per cent due to the lack of trained personnel to maintain the water supply infrastructure in rural areas. This figure was estimated from statistics of pipe breaks in the Northern Regions and the reaction time to repair pipe breakages and leaks.

Another example of water being wasted in rural areas are the illegal connections which are usually made in a very amateurish manner and with inferior quality materials. Such connections result in water leaking into the soil, probably, for as long as they remain undiscovered by the maintenance teams. Problems with pirate connections have been experienced at most of the schemes, especially at the 4 'O' Regions which are supplied with water through the Cuvelai Drainage Basin Network. Additionally to water wastage, in cases where there are many pirate connections, the pipelines cannot deliver the water to the legal end consumers, so depriving them of the access to safe drinking water.

The Department of Works supplies water to some remote schools and clinics in rural areas as well as communities living in the vicinity. All the costs of supplying water to those places are covered from the Department's budget. Therefore, this can, also, be considered as fully subsidised water. No information on how many institutions are supplied by the Department and how much water is supplied in this manner could be obtained from the Department in Windhoek.

2.6.3 Agriculture Sector

According to a recent study, the area under irrigation has risen by approximately 25 per cent from 6000 hectares in 1990 to 7500 hectares in 1999 (WCE, 2000). It was estimated that 107.1 Mm^3 of water was used for crop production in 1993; 32.6 Mm^3 originating from groundwater, 46.3 Mm^3 from perennial rivers and 28.3 Mm^3 from ephemeral rivers, *i.e*. 30.4, 43.2, 26.4 per cent, respectively (Lange, 1997).
Major sources of water wastage in irrigated crop production are open canals, trough leakage and evaporation, as well as the use of inefficient irrigation systems. Surface irrigation, also called flood irrigation, is still a dominant irrigation technique in Namibia. Various studies have found that the efficiency of water use in irrigation (*i.e*. water reaching the crop divided by total water supplied) is only about 35 per cent. No particulars of irrigation systems were given (Tate, 1990). Be that as it may, the prevalent irrigation system in Namibia, *viz*. flood irrigation is the most inefficient one resulting in excessive water wastage.

Commercial irrigation farmers, obtaining water from public streams, pay to the Department of Water Affairs a levy per hectare irrespective of how much water they use. Some schemes are state owned and are operated by the Department of Agriculture or by the NDC on behalf of the Department. There, the government covers all the costs. Department of Agriculture, also subsidises, to some extent, water supplied to commercial schemes, *e.g*. at Hardap Dam.

Another aspect of the water used for irrigation is its low value-added per m^3 of water input. $1m^3$ of water used for crop production generates N$ 0.2 as opposed to N$ 26.2 for livestock, N$ 86.6 for mining, N$ 403.6 for manufacturing and N$ 1018.6 for services (Lange, 1997). Therefore, as far as beneficial use of water is concerned, irrigating crops is the least beneficial water use of all and, therefore, from the economic point of view, it can be considered as a wasteful use of water, provided there are other opportunities to use it more beneficially. Agriculture and forestry products contributed N$ 513 million to the Gross Domestic Product in 1990. In 1998, this contribution was N$ 479 million despite substantial amounts of public money spent on developing new irrigation schemes such as Etunda or a portion of Aussenkehr, and on subsidising irrigation water. Both figures are 1990 prices. Using constant 1990 prices, the contribution of commercial agriculture decreased by about 12.5 per cent and subsistence agriculture increased by 5.6 per cent between 1990 and 1999 (NPC, 1998).

2.6.4 Mining Sector

There are 56 registered mines in Namibia, including Tsumeb Copper Mine that has been closed since 1998, and the Scorpion and Haib mines that are possible new mining developments. Only a few mines were surveyed for the IUCN study but it was found that generally water demand management, in one form or another, was practised at those mines. This includes recycling process water from slimes dams at Auchas mine, Navachab mine and Rössing mine. Such recycling does not happen at Rosh Pinah mine. Diamond mines at Oranjemund and Elizabeth Bay use seawater for processing. As far as mining and processing operations are concerned, it appears that the mines use water efficiently, especially fresh water. However, this cannot be said about some mining towns such as Oranjemund or Rosh Pinah. They are supplied with free water for residents. Consequently, water consumption is 16 m^3 per household per day at Oranjemund and 12 m^3 per household per day at Rosh Pinah (van der Merwe, ed., 1999). By comparison to the rest of the country, these are very high consumption rates. Excessive use of water at these towns is considered to be wasteful use.

2.6.5 Industrial Sector

Industrial use includes canning, dairy, fish and meat processing and packaging, chicken industry, tanning, breweries and manufacturing. During the IUCN study it was found that water scarcity had not been a major factor in the business decisions of most industries and that practising water conservation is unique to Windhoek (van der Merwe, ed., 1999).

Fish processing

Fish factories in Walvis Bay use not more than 5 to 15 per cent of fresh water in their production process. The rest is seawater. In Lüderitz, NovaNam uses approximately 86 per cent of seawater.
Other factories also plan to move towards greater use of seawater in fish processing. Implementing water conservation measures in the fishing industry is particularly important because fossil water is used in Lüderitz and the Kuiseb River aquifer supplying water to Walvis Bay has been over-utilised. Replacing fresh water with seawater was triggered by higher water prices.

Meat processing

The industry norm is 1.6 to 2.2m^3 per cattle head. This was met by Meatco in Windhoek and Okahandja, and by Namibia Meats in Otjiwarongo. At Metco in Oshakati, specific water consumption was 4m^3/unit and in Katima Mulilo it was 7.2m^3/unit. Therefore, there is room for improvement. One of the reasons could be cost saving because water cost as per cent of total production costs varies between 2.5 per cent in Windhoek and 15 per cent in Katima Mulilo. This is more than the "1 per cent rule" often used for industries - water costs average less than 1 per cent of a factory's costs. Personnel, raw materials, and the energy involved in running a factory normally take far greater priority resulting in placing water costs low on the priority list for industries (Ploeser, 1996).

Breweries and bottling plants

Integrated water management at the Windhoek Brewery was one of the cases studied recently. An integrated water management approach and considering water use efficiency as a design parameter resulted in the initial specific water intake of about 4 litres per litre of beer manufactured in 1998. Although Namibia Breweries do not have any malting facilities in Namibia and import malted barley from Germany for all their production, they still have low water consumption. Malting accounts for approximately 2 litres of water per litre of

beer. Therefore, Namibia Breweries compare favourably to other South African and European breweries that consume 7 - 12 litres of water per litre of beer produced.
At present there is insufficient information available to make a general statement about this industry countrywide.

2.6.6 Tourism sector

Only hotels and restaurants increased their contribution to the GDP from 78 million in 1990 to 171 million in 1998, both as constant 1990 prices (NPC, 1998). The tourism industry is the fastest growing industry in Namibia at a growth rate of 15 per cent per annum since 1993. In 1998, approximately 560 000 tourists visited Namibia. Hotels and restaurants contributed 2.5 per cent to the 1998 GDP. Hotels and restaurants generate N$112.7 of value-added per m3 of water input (Lange, 1997) which is high in comparison with agriculture, mining or manufacturing other than fish processing. At present there is insufficient data to come to a general conclusion about the water use efficiency and water wastage. It is also difficult to define what should be the daily per capita usage. For a few lodges surveyed, it varies from 35 litres per person per day at Etendeka Mountain Camp to 6210 litres per person per day at the Zambezi Lodge (van der Merwe, ed., 1999). It appears that water availability is a decisive factor rather than the cost of water. Many lodges have their own supply of water; they do not pay for water at all. Often, water used is not measured and some of the lodges are not even registered.

2.7 Water tariffs

The National Water and Sanitation Sector Policy, approved by the cabinet, recommends that:

- "Essential water supply and sanitation services should become available to all Namibians and should be accessible at a cost which is affordable to the country as a whole.
- An environmentally sustainable development and utilisation of the water resources of the country should be pursued in addressing the various needs."

It was accepted that the overall sustainability of the sector would depend on its ability to become self-sufficient. Certain considerations should be taken into account in deciding on a tariff policy for different sectors. The following was recommended (Department of Water Affairs, 1993):

- Urban water supply
  - A low price for a defined minimum lifeline volume of water and progressively increasing rates for increased consumption should be considered;
  - Rates for commercial enterprises and industries should, as far as possible, recover the full financial cost of water supply;
  - Direct and immediate recovery of costs for the supply of water to erven (i.e. local distribution investment) should be considered as erven related-costs;
  - Tariffs should be the subject of administrative approval by the Minister in charge of Water Affairs in order to ensure that they will comply with government policy and that any adjustments in tariffs or tariff structure are warranted and reasonable;
  - It would be appropriate to enforce payment for water. For the few who still cannot afford to pay, assistance should be given from a social security vote, to be provided

for by the authority responsible for these social services in any specific urban area rather than to circumvent the water revenue collection system.

- Rural water supply
  - An agreement between the community and the authorities setting out the respective responsibilities and commitments should be a prerequisite for government support;
  - Payment by the community should as a general rule cover operation and maintenance costs although there may be cases where a subsidy may apply;
  - Because of the great variations in conditions in general throughout Namibia a system should be worked out whereby the ability of each community to pay for services rendered can be assessed and evaluated and the need for subsidisation, if it exists, quantified;
  - Government support should be reconsidered if stipulated conditions of agreement are not complied with.
- Irrigation water supply
  - In all cases where irrigation water is supplied by the state it is to be charged for at an economic rate which may be reduced through a special subsidy determined by the value of the produce relative to its socio-economic benefits;
  - No irrigation scheme should be embarked upon without a comprehensive study confirming its overall viability, including the socio-economic benefits and an appropriate environmental assessment.

The above policy clearly recognises that water tariffs can play a significant role in securing equitable access to water services to all Namibians, stipulating environmentally sustainable development, ensuring sustainable utilisation of water resources and allowing the water sector to become financially self-sufficient.

Agenda 21 and the Dublin Principles advocate the concept of water as an economic good. Agenda 21 recommends "Introduction of water tariffs, taking into account the circumstances in each country and where affordable, that reflect the marginal cost and opportunity cost of water, especially for productive activities", with a view to achieving efficient and equitable allocation of water resources (Agenda 21, 1992).

The most fundamental purpose of water tariffs is to provide funds for operation and maintenance as well as development of the supply systems. However, cannot be considered to be the only role. At present, Namibia does not have any national water tariffs' policy, other than the recommendations included in the National Water Supply and Sanitation Sector Policy (see the above) and in the Water Act 1956 (Act 54 of 1956). The Act recommended already in 1956 that a water board recovers full financial cost (Section 117). It was to include the following costs:

- The cost of operation and maintenance (including costs of distribution and administration);
- The amount required for interest on loans and redemption of such loans; establishing of a sinking fund can be considered and "any surplus remaining after the redemption of the whole of the moneys for the repayment of which it was formed, shall be applied to such capital purpose as the water board concerned may, with the consent of the Minister, determine" (Section 121(2)(f)).
- The amounts to be set aside for renewing existing assets. This should be done by creating renewals and reserve funds.

The Act stipulates that when the prices to be charged are assessed or adjusted, each scheme should be taken into account separately. Separate accounts should be kept for each scheme of the actual expenditure, including overhead and administration charges, the amount of interest and redemption charges and other expenditure provided for in Section 118. However, the Minister may decide this to be undesirable or impracticable and authorise the board to take into account all or any of the water supply schemes, Section 118(2). In practice this means that the Minister may allow for cross-subsidisation between some water supply schemes or all of them.
As far as irrigation tariffs are concerned, the Act recommends that water rates shall be assessed at uniform amount per hectare of land, Section 120(3)(a). However, such a rate should be payable in addition to any charges for water supply. It was also recommended that it should be a general principle of a board to operate neither at a profit nor at a loss Section 120(4).
Unfortunately, these stipulations have never been implemented. Consequently, different approaches are followed by different institutions supplying and distributing water to different customers. Some of them are described in the following paragraphs.

Bulk water

According to the Namibia Water Corporation Act 1997 (Act No.12 of 1997), the Corporation can: "determine and levy, in consultation with the Minister, tariffs on a full cost-recovery basis for water supplied" (7(1)(a)). The Corporation's understanding of full cost recovery is to allocate all costs of an organisation to the product. The following costs have been identified (Tjituka, 1999):
Cash Flow Items

- Primary costs
  - salaries;
  - travel and subsistence;
  - material and supplies.
- Secondary costs
  - internal charge maintenance;
  - internal charge IT (information technology, e.g. computer maintenance and all the support and development services)
  - admin overheads

Non Cash Flow Items

- Depreciation
- Imputed costs

Depreciation of the assets transferred by the State to the Corporation is done using "straight line depreciation" at the following rates (Tjituka, 1999):

buildings	2%
water schemes	2 - 10%
construction equipment	20%
operational equipment	10%
vehicles	25%

furniture	10%
computer equipment	33,33%
office equipment	20%

Depreciation to recover the capital value of the transferred infrastructure and other assets is not a straightforward cost though it is, commonly, accounted for as a fixed percentage of the original cost of the asset that is charged off to expense or against revenue in order to compensate for the depreciation (loss of value) of the asset, over its estimated useful life. This useful lifetime cannot, always, be determined realistically. Just to compare with the above, the following used to be applied by the Department of Water Affairs as lifetime for different assets:

Civil structures such as dams - 45 years
Pipelines - 30 years
Mechanical/electrical equipment - 15 years

The above two sets of figures are both arbitrary and different. It is obvious that regular maintenance can extend the useful lifetime of all assets. If secondary costs are high, depreciation costs should be low because the assets service potential remains high. It would be useful if the Corporation could develop a water tariff policy with clear explanation of all the costs and their relationship, especially between depreciation, maintenance and replacement of assets. Also, the above information is limited to the existing assets only and there is no provision for capital costs of new investments being included somehow in a tariff calculation. Details of the tariff calculation for different consumers and schemes could not be obtained from Namwater. The main reason given as explanation was Cabinet Decision No. 9th/20.04.99/006 that allows unconditionally an area based cross-subsidisation of bulk water supply tariffs for the 1999/2000 financial year, changing Cabinet Decision No.5th/21.02.95/001 that the tariffs for water supply should be based on full recovery of the cost of water supply for individual schemes. The latter was consistent with the Water Supply and Sanitation Policy approved by Cabinet in 1993. In its decision taken in 1999, the Cabinet repealed this clause to allow for the cross-subsidisation of water tariffs. The Corporation interprets it as a permission to cross-subsidise nation-wide and has finalised its "improved" cross-subsidisation programme for the future tariff determinations (Tjituka, personal communication).

From the above it can be said that Namwater aims at full financial cost recovery. To achieve this the Corporation is allowed the unconditional cross-subsidisation between schemes in setting bulk water supply tariffs. This is an open invitation to waste water on highly subsidised (costly) schemes.

Urban water

Most of the towns and villages are supplied with water by Namwater. Grootfontein, Tsumeb, Omaruru, Outjo, Usakos and Oranjemund are responsible for supplying their own water. Windhoek has limited quantities of groundwater and uses it as well as treated wastewater as an additional source to augment water supplied by Namwater. There is no other cost recovery policy for Local Authorities than recommendations included in the Water Supply and Sanitation Policy (listed under "Urban water supply" above) and Model Water Supply Regulations. The latter stipulates that (Government Gazette of the Republic of Namibia, 1999):

- "Water supplied by the Council to a customer shall be paid for by the consumer at the rate of or charges determined in the water tariff for the particular category of use for which the supply was granted (14(1));
- The Council may, in addition to the charges determined in the water tariff for water actually supplied, levy an availability charge or a monthly minimum charge for the rendering of the service of water supply to residents in the local authority area (16(1));
- Where an availability charge is levied in terms of subregulation (1), it shall be payable
  - (a) subject to subregulation (4), by the owner of premises, with or without improvements, which are not connected to a water main but which can reasonably be provided with such a connection; and (16(2)(a))
  - (b) by every consumer in respect of each water connection provided by the Council to serve the premises occupied by the consumer, whether or not water is consumed on the premises (16(2)(b))
- Where a minimum monthly charge is levied in terms of subregulation (1), it shall be payable by every consumer in respect of a specified minimum quantity of water, whether or not such quantity has actually been consumed by the consumer. Provided that where the amount of water consumed exceeds the minimum quantity specified, the normal rate, except where otherwise provided shall be charged and be payable in respect of the quantity exceeding such minimum" (16(3)).

Therefore, clearly specified water tariff structures that can be used by the Local Authorities to recover their costs of water supply are as follows:

- A low price for a defined minimum lifeline volume of water + progressively increasing rates for increased consumption;
- Availability charge + volumetric charge;
- Monthly minimum charge in respect of a specified minimum quantity of water + volumetric charge.

Windhoek, Swakopmund, Walvis Bay, Tsumeb, Okahandja and Henties Bay have introduced rising block tariffs. They are different in different towns but based on the same principle that the unit charge increases with increasing consumption. This rate structure requires a multiple blocking structure with the rate per unit of consumption increasing with each successive block. If properly determined, this rate alternative can result in water conservation by reducing water use by larger-volume consumers. Another variation of rising block tariffs is, the so called, ratchet variation in which all usage, not just that falling within one block, is charged at the rate applicable to the highest block of consumption reached by a customer.

A number of towns levy the availability charges monthly. They are as follow: Ketmanshoop - N$12.40, Mariental - N$16.00, Usakos - N$6.50, Omaruru - N$9.85, Karibib - N$20.00, Okahandja - N$12.00, Lüderitz - N$11.00, Gobabis - N$12.65, Karasburg - N$23.00, Outjo - N$12.00 and Otjiwarongo - N$7.50 (van der Merwe, ed., 1999). These charges do not include any volume allocation.

Other towns apply minimum charge. They include Windhoek, Swakopmund, Tsumeb, Grootfontein and Otavi. At present, in Windhoek it is N$33.77 per month for a 20mm water meter. This charge, however, is deducted from the amount paid for water consumption. In Otavi, the minimum charge is N$28.00 and it includes consumption of $20m^3$.

The tariffs for different towns vary considerably, see **Table 10** (Africon, 2000). This is to be expected, first of all because of different Namwater tariffs for different schemes or having water sources independent of Namwater. Only a few towns introduced increasing block tariffs. The majority use uniform volume rates in which all water used is charged at the same rate. The uniform rate can be used to encourage water conservation by eliminating the lower priced water rates. This is, probably, the case at Gobabis (N$5.05/m^3) or Karibib (N$3.80/m^3). Other towns applying uniform volume rates do not seem to be concerned with water conservation.

The very low tariff at Omaruru (N$1.41/m^3), Grootfontein (N$1.71/m^3) or Outjo (N$1.60/m^3) does not provide any incentive for water conservation. The tariff of Outjo, surely, does not include any environmental costs of mining the underground aquifer; the water table has dropped by 30m over the last few years (van der Merwe, ed., 1999). Mining of water takes place, also, at the Koichab Pan supplying water to Lüderitz. It is questionable whether the tariff of Lüderitz of N$3.30/m^3 includes any environmental costs if the Namwater tariff is N$2.90/m^3.

Also, it rises some concern that in Bethanie, Kalkrand, Leonardville and Maltahöhe the water tariffs are lower than the Namwater tariffs. It can not be sustainable not to recover operation and maintenance costs of the distribution systems.

The Model Water Supply Regulations are concerned with the financial sustainability of the Local Authorities. Environmental sustainability and water conservation, including water demand management, are not addressed. Similarly, the recommendation of the Water Supply and Sanitation Policy that "a low price for a defined minimum lifeline volume of water and progressively increasing rates for increased consumption should be considered" is not reflected in these regulations and, consequently, it is not reflected in the water tariffs. This obviously is the case at Gobabis with the availability charge of N$12.65/month and the tariff of N$5.05/m^3 or Karibib with the availability charge of N$20.00/month and the tariff of N$3.80/m^3.

It is acceptable that increasing rates have not been introduced in many places yet. These rates are relatively complex to calculate and generate some additional administrative costs. However, lifeline rates are considered a must. First National Development Plan (NDP1) states that: "Water is a basic human need”.

The Government is committed to providing safe drinking water to the whole population" (First National Development Plan, 1995). As far as the Local Authorities are concerned, this has not happened yet; lifeline rates should be introduced and reflected in the water rates recognising that there are also urban poor. In Windhoek, water for standpipes is charged at the bulk water supply price levied by Namwater. On average, consumption is about 20 litres per person per day. First block (0 - 6m^3/month) tariff is calculated at the bulk supply price plus 10 per cent. Water use of up to 6m^3/month/household is for basic health purposes; for a family of 6. This equates to about 33 litres per person per day.

As a matter of principle, water for industrial purposes should be sold at a price ensuring full financial cost recovery. The same principle is used for the mining sector.

Rural water supply

In case of rural water supply, it is more appropriate to consider costs than tariffs. Rural population, involved in farming activities, can be divided into commercial and communal farmers. Commercial farmers are responsible for supplying their own water and they cover all the costs of developing water sources and infrastructure required on their farms to supply water for human consumption, stock watering and irrigation, if any. The Ministry of Agriculture, Water and Rural Development is responsible for paying all water bills for the rural water supply to communities (Angula, 1999). Rural water supply tariffs depend on who supplies water to the communities in communal areas. Where Namwater supplies drinking water, bulk water supply tariffs apply and invoices are sent to the Ministry. Different tariffs are used for irrigation water.

If water is supplied by the Rural Water Supply Divisions (North and South) of the Department of Water Affairs at the Ministry of Agriculture, Water and Rural Development, the Ministry covers all the costs of developing water sources, capital costs of infrastructure and operation and maintenance costs of supplying water. In 1996 total subsidies to bulk, urban and rural water supply amounted to N$70 million. This was 0.6 per cent of GDP (van der Merwe, ed., 1999). According to NDP1, as far as water supply is concerned, priority is to be given to provision of water to rural areas. The Government is committed to work towards rural development. The main objectives are as follows:

- "Reduce levels of rural poverty;
- Achieve more equitable distribution of the country's wealth;
- Achieve more equitable access to productive resources;
- Slow down the current high rate of rural/urban migration through increased development and service delivery in rural areas;
- Improve the provision of health, education, water and sanitation services in rural areas;
- Promote employment-generating opportunities, including informal activities" (First National Development Plan, 1995).

In an attempt to achieve these social objectives, the recommendations of a National Water and Sanitation Policy (WASP) concerning rural water supply (see above) have been sidelined temporarily. However, Cabinet in Decision No: 14th/10.06.97/003 reverted to the WASP principles and approved the implementation of the community management and cost recovery aspects as recommended by this policy. According to the approved principles, communities will manage and control their own individual water points and accept the related responsibilities as stipulated by "Principle 1: The communities undertake to accept full responsibility for, and eventually, full ownership of their own rural water supply service" (The Ministry of Agriculture, Water and Rural Development, 1997). In terms of the same document, Cabinet approved that revenues from the provision of water should cover operation and maintenance costs within 5 years and full cost within 10 years. It is up to the people using a water point to decide how these revenues are collected. Consequently, they decide on rural "water supply tariffs" that will, most probably, differ from one water point to another. As far as water conservation measures are concerned, a disincentive tariff will be applied to control what the community decides as excessive use of water. Rural water supply provides water for domestic use, stock watering and, sometimes, wildlife.

Another supplier of water in rural areas is the Ministry of Works, Transport and Communication. The Ministry supplies water and covers all the associated costs involved in supplying water to some schools and clinics as well as the communities living around them. There are a number of such places, such as Okongwe and Otjiperongo in the Khorixas area.

Irrigation

In Namibia water for irrigation purposes is supplied by individual farmers, from irrigation schemes, the co-operatives or by Namwater. In 1999, 135.9Mm^3 of water was used for irrigation which was 45.7 per cent of the total water consumed in Namibia. There is no other national irrigation water tariff policy than the recommendation by WASP that in all cases where irrigation water is supplied by the state it is to be charged for at an economic rate which may be reduced through a special subsidy determined by the value of the produce relative to its socio-economic benefits.

Commercial farmers use as much water as they need and can get from farm dams and groundwater sources available on their farms. Only in the water control areas are permits to abstract groundwater required and, apparently, even in those areas not all the farmers have abstraction permits (van der Merwe, ed., 1999). There is simply no control. There are no charges for abstraction and use of groundwater for irrigation purposes. The main irrigation areas include those supplied with water from the Omaruru River alluvial aquifer and the Gobabis-Stampriet aquifer. A permit for constructing a farm dam is only required if its capacity will be more than 20,000m^3 as stipulated by the amended Water Act, 1956 (Act No.54 of 1956). There are, also, no charges for using water stored in this manner for irrigation purposes. Individual commercial farmers cover all the costs involved in water storage/abstraction themselves and, mostly, do not pay any additional charges. There is, also, a private farm of about 90ha abstracting irrigation water from the Zambezi River. The only farmers who have to pay for irrigation water are those along the Orange River; the per hectare levy is N$2.27/a for the first 30 hectares and N$37.34/a for additional hectares. Not all the commercial farmers have their own farms and water sources. Some of them farm in irrigation areas supplied with water by Namwater.

Namwater supplies water to a number of irrigation schemes. Water for irrigation purposes accounts for close to 40 per cent of the total water supplied by Namwater annually (van der Merwe, ed., 1999). On average, it was 36.5 per cent between 1976/1977 and 1996/1997. There are two irrigation schemes supplied with water from the Naute and Hardap Dams. Volumetric tariffs are charged at N\$0.12/m^3 at both these schemes. Full cost tariffs, as calculated by Namwater, are N\$0.38/m^3 and N\$0.46/m^3 for the Hardap and Naute schemes, respectively (van der Merwe, ed., 1999). It appears that these tariffs are calculated to make irrigation water available but do not include all the operation and maintenance costs. In the Hardap area, the Ministry of Agriculture, Water and Rural Development has to pay a private contractor approximately N$480,000/a to maintain a network of concrete lined canals. The annual cost of water is approximately N$2.16 million and is payable by the Ministry to Namwater. The arrangements are such that this commercial irrigation scheme is subsidised at present (Environmental Engineering Services, 1999); farmers pay only N$333.00/ha/a to the Government. At the Naute irrigation scheme, the consumption is billed at N\$0.12/m^3 and paid by the National Development Corporation directly to Namwater.

Another scheme supplied by Namwater is Etunda irrigation scheme where water is supplied from the Kunene River via a concrete lined canal. The full cost recovery tariff of N\$1.00/m^3 was calculated by Namwater for off-takes from the canal. At present, N\$0.12/m^3 is applicable. The scheme is run by the National Development Corporation on behalf of the

Ministry of Agriculture, Water and Rural Development (van der Merwe, ed., 1999). The farmers pay the MAWRD and the Ministry pays Namwater. It was estimated that the losses at this scheme amounted to N$22.4 million in 1995/1996 constant prices.

There are a few schemes run by the NDC. They supply irrigation water themselves. The Aussenkehr irrigation scheme has to pay to the Government the same water tariff as the non-government farms along the Orange River (van der Merwe, ed., 1999). Other farms, such as Shadikongoro or Salem, do not have to pay any levy for water abstracted from the Kavango River.

The Vioolsdrift - Noordoewer Joint Irrigation Authority, a co-operative of Namibian and South African farmers uses water from the Orange River, according to the agreement between the two countries stipulating that $9Mm^3/a$ can be used by the Namibian and $11Mm^3/a$ by the South African farmers. Irrigation fees are paid and the system is well maintained. The Authority is required to submit its budget to the Permanent Water Commission of the Republic of South Africa and the Republic of Namibia. The farmers have to pay irrigation fees of N$315/ha/a to the Authority for the maintenance of the system and other expenditure. No payment is made to the Government by the individual farmers or by the Authority.

2.8 Reuse and recycling of wastewater

Reuse and recycling of water are options for conserving and extending available supplies from the best quality fresh water sources for drinking purposes by using lower quality water for other purposes such as landscape irrigation. Water reuse can also be practised for pollution abatement; instead of discharging treated effluents to surface water sources or potentially polluting groundwater, reclaimed water is reused for beneficial purposes such as agricultural irrigation. An additional reason for reusing wastewater arises from the fact that substantial savings on wastewater treatment when stringent discharge requirements regarding the removal of nutrients from wastewater before discharges can take place; water and wastewater treatment facilities are generally capital intensive. Yet another reason might limited available supplies.

For the purpose of clarity, these two terms, namely, wastewater recycling and wastewater reuse are defined.
Wastewater recycling is the use of wastewater that is captured and redirected back into the same water use. Predominantly, it is practised in industry such as manufacturing, and it usually involves only one industrial plant.

Wastewater reuse is the use of treated wastewater, for a beneficial use such as agricultural irrigation, industrial cooling, groundwater recharge or landscape irrigation. Reuse of water in Namibia is practised in many urban areas. Wastewater recycling is practised by a number of mines. The main reason cited for being "backward in fully developing recycling techniques" in South Africa is, probably, also valid for Namibia: "because there has always been another river to dam" (Davies and Day, 1998). There are still rivers in Namibia that can be dammed. However, there are no such rivers close to where water is needed most. It was estimated that there is potential for utilising another 1 - 2 Mm^3/a from the Swakop River in its lower reaches and no significant potential for the development of further resources in the upper part of the catchment which was home to more than 14 per cent of the country's population in 1991 (WCE, 2000). On the other hand, it was estimated that there is significant potential for development in the Fish Basin up to 125Mm^3/a from 62Mm^3/a which is the current yield of the Hardap (50 Mm^3/a) and Naute Dams (12Mm^3/a). This, however, looks unlikely because the present utilisation of water from these dams is 30Mm^3/a for the Hardap Dam and 5Mm^3/a for the Naute Dam. The Fish Basin had only about 4 per cent of the Namibia's population in 1991 (WCE, 2000). Owing to the unfavourable distribution of the potential water resources, the reuse and recycling of water might become more attractive as an alternative source of water because this source is at a place where wastewater is generated. Advanced treatment of wastewater to a high quality effluent might be cheaper than long-distance transport of fresh water, especially if distances of hundreds of kilometres are involved. Also, in view of the present policies concerning water tariffs and consequently their inevitable increases in the near future, it will become more viable to treat wastewater and reuse it instead of evaporating it in the process of the cheapest disposal of wastewater. Then, water reuse will become an integral component of water resources management. There are a number of options; many of the currently practised types of water reuse are listed in **Table 11** (Mays, 1996).

Table 11: Uses of Reclaimed Water

Landscape irrigation	*Non-potable urban (other than irrigation)*
Parks	Toilet and urinal flushing
Cemeteries	Fire protection
Golf courses	Air conditioner cooling water
School grounds	Vehicle washing
Greenbelts	Street cleaning
Residential lawns	Decorative fountains
Agricultural irrigation	*Impoundments*
Food crops	Ornamental
Fodder, fibre, and seed crops	Recreational
Nurseries	
	Environmental
Industrial	Stream augmentation
Cooling	Marshes
Boiler feed	Wetlands
Process water	Fisheries
Groundwater recharge	*Miscellaneous*
Recharge aquifers	Aquaculture
Salt-intrusion control	Soil compaction
	Dust control
	Livestock watering

Non-potable reuse of wastewater

The use of reclaimed water for non-potable purposes is practised in Swakopmund, Walvis Bay, Tsumeb, Otjiwarongo, Okahandja, Mariental, Oranjemund and Windhoek. These towns use it to irrigate sports fields, cemeteries, parks and gardens. In Windhoek 1.14Mm^3 of treated effluent was used for irrigation in 1997 (van der Merwe, ed., 1999). In Walvis Bay a dual distribution system is planed to supply treated effluent for watering private gardens. In Oranjemund treated wastewater is used for the golf course and a row of palm trees along the outskirts of the town. A wastewater treatment facility in Oranjemund treats only about 10 per cent of the total volume extracted from the boreholes.

It is becoming more popular to reuse water in private homes and saving water by watering gardens with, so called, "grey" water that is discharged from baths, shower and washing machines. It can be used for watering gardens and for flushing toilets. The latter application requires that a roof tank be installed. Jackpot 2000, a local company, markets such a system in Windhoek. Only 6 units have been installed in Windhoek which is not many taking into account that 40 - 50 per cent of the total residential water consumption is used for watering gardens (van der Merwe, ed., 1999) and much of drinking quality water used for watering gardens could be replaced with "grey" water. Both low water tariffs and relatively high cost of the system contribute to its modest popularity despite very good performance.

Potable reuse

In Windhoek the reclamation of water for potable reuse has been practised since 1968. At present the plant can supply 8000m^3/day which was about 19 per cent the average daily water demand in Windhoek in 1997. The production cost of N$2,40/m^3 was the same as charged by Namwater for the bulk supply. The capacity of the plant is to be increased to 21000m^3/day (van der Merwe, ed., 1999) and owing to external financing (100 per cent soft loans) the estimated production cost inclusive of capital charges is calculated at N$2,80/m^3. The Windhoek reclamation plant is "world-famous" (Davies and Day, 1998) and information concerning this installation can be found in practically any water treatment, water reuse or water conservation publication. The following are some examples:

"Currently, the only full-scale potable reuse of facilities in the world are at Windhoek and Stander, South Africa. Effluent from both these plants is blended with existing freshwater resources so that the reclaimed wastewater constitutes less than 15 per cent of the total water supply" (Montgomery, 1985).
"Pipe-to-pipe water reclamation and direct potable reuse is currently practised in only one city in the world, Windhoek, Namibia, and there only intermittently" (EPA, 1992).
"Wastewater reclamation to augment the potable water supply to the city was pioneered in Windhoek during 1968. Reclaimed wastewater provides approximately 12 per cent of the total production from all potable water sources" (Beavers and Gibson, eds., 1998).

However, the first documented case of direct potable reuse of wastewater occurred in Chanute, Kansas, USA. This happened when during a severe drought from 1952 - 1957 the city's normal water source ceased to flow in the summer of 1956. Secondary chlorinated effluent was then used for 5 months as intake water for the city's water treatment plant.

Windhoek is the only place where reuse of water for potable purposes is practised and, most probably, it will remain to be such a unique place not only in Namibia but also in the whole world because public acceptance of this practice is rather poor though no obvious adverse health effects were detected during both animal testing and epidemiological studies with indirect potable reuse (Crook, et al., 1999); direct potable reuse is not practised anywhere in the United States. Indirect potable reuse is practised when reclaimed water is used for to augment a potable water source before treatment. Toxicological studies of the product water from the treatment plant at Denver, Colorado, USA, also did not reveal any adverse health effects. However, it must be clarified that the treatment process at Denver used undisinfected secondary effluent and included high pH lime clarification, recarbonation, multimedia filtration, ultraviolet-radiation disinfection, granular activated carbon adsorption, reverse osmosis, air stripping, ozonation, and chloramination. This process is far superior to the one used in Windhoek. A report released by the National Research Council in 1998 concluded that indirect potable reuse of reclaimed water is viable and that direct potable reuse is not viable because health data are sparse and the results cannot be extrapolated to potable reuse in general (Crook, *et al*., 1999).

Mining reuse and recycling

There are also a few mines where water reuse and recycling are practised. Of the six biggest mines included in the IUCN study, Auchas Mine recycled about 54 and 36 per cent of water abstracted from the Orange River in 1997 and 1998 respectively. In 1998 it was 630 000 m^3. Navachab Gold Mine reused about 39 per cent of water (surface and groundwater) in 1997. Assuming similar level of reuse in 1998, the volume involved was 2 033 551m^3. The water was reused in the industrial processes and for the dust control at the mine. Rössing Mine recycled about 69 per cent of the water in 1997, which amounted to 6.5Mm^3. Recycling of water saved the mine approximately N$67 million in 1994 (van der Merwe, ed., 1999).

Industrial reuse

Comprehensive reuse of water for industrial purposes is not available at present. According to a list of registered industries obtained from the Ministry of Trade and Industry there are 638 establishments (WCE, 2000). Only a few examples are given below.

As far as industrial reuse of water is concerned, integrated water management at the Windhoek Brewery was one of the cases studied recently and was discussed in paragraph 2.6.5. Additionally, they practice water reuse for washing vehicles and garden irrigation; sand filter backwash water is used for these purposes.

Vicar Service Station (service station and car-wash) in Northern Industrial Area in Windhoek currently reuses 70 per cent of the water used for car washing (Van Harmelen, 1999).Meatco at Oshakati reuses heated water for cleaning purposes. They, also, practice leak detection. Meatco at Katima Mulilo uses boiler water for cleaning purposes.

The Tunweni Brewery follows, so called, Zero Emission Research Initiative (ZERI). Waste water from the brewery, returned produce and cleaning water are treated by means of a bio-digester and reused together with spent grain to support pig and fish farming and mushroom growth.

State of water reuse in Namibia

A number of examples was mentioned above. However, this information is insufficient to come to a conclusive figure for treated wastewater reuse for the whole country. According to information received from the Department of Water Affairs on effluent disposal in Namibia, the total volume of effluent amounts to 127 760m^3/day or about 46 Mm^3/a. Once again, according to the permits issued, close to 34 per cent is reused or recycled (Africon, 2000) which amounts to 15,6Mm^3/a. Permits, however, stipulate that effluents may be reused but it does not have to happen. It has not been verified to what extend reuse is really practised in Namibia. The above figures are based on 165 permits of which 15 are valid and 150 expired (Africon, 2000). There are, probably, only a handful of facilities where the amount of influent to a treatment facility is measured. In the majority of cases it was once estimated by a consultant when designing that facility and is repeated over and over again when reapplying for a permit, if at all. Therefore, the obtained information is of very limited value. A quick survey of the biggest towns including Swakopmund, Walvis Bay, Tsumeb, Keetmanshoep, Otjiwarongo, Gobabis, Oranjemund, Karibib, Mariental, Okahandja and Windhoek resulted in a reuse figure of about 4.34Mm^3/a. Keetmanshoep, Gobabis and Karibib do not reuse water at all. There are, however, some examples form other countries. 12 per cent of the total wastewater produced in California was reused in 1987: 63 per cent for agricultural irrigation, 14 per cent for groundwater recharge and 13 per cent for landscape irrigation. In Florida, 30 per cent of the state's municipal wastewater was reused in 1992: 30 per cent for agricultural irrigation, 14 per cent for groundwater recharge and 38 per cent for landscape irrigation (Mays, 1996). In Israel, nearly 70 per cent of the wastewater was reused for irrigation and groundwater recharge in 1987 (U.S.EPA, 1992).

2.9 Water quality issues

Water quality is determined by the solutes and gases dissolved in water, as well as the matter suspended in and floating on the water. They all have an impact on water quality characteristics based on physical, chemical (inorganic and organic) and microbiological determinants that can further be classified as health related or aesthetic. The usefulness of water depends on its quality. Major inorganic constituents include cations such as calcium, magnesium, sodium and potassium, and anions such as chloride, sulphate, carbonate and bicarbonate. Silica can also be a major constituent. Depending on the origin of the water, there may be some minor solutes such as iron, manganese, fluoride, nitrate, strontium and boron as well as trace elements including heavy metals, *e.g.* arsenic, chromium, lead, cadmium, copper. The major gases dissolved in water are oxygen and carbon dioxide. They both impact significantly on the quality of water. The baseline natural quality of water varies significantly from place to place. From the perspective of the usefulness of water, total dissolved solids (TDS) is traditionally, one of the most important determinants and it is a basis for classification of water as fresh, brackish, saline and brine. Fresh water with TDS between 0 – 1,000 mg/litre is of particular interest because of its suitability for drinking purposes. Characteristics of various water sources is presented in **Table 12** depicting typical concentrations of only a few determinants. It can be seen that infiltration and percolation of rainwater into groundwater aquifers changes the quality of water significantly due to weathering and leaching of minerals, soil and sediment leaching and possibly some biochemical processes in top soils. Weathering and soil ion exchange reactions are the main sources of calcium in natural waters. The quality of water deteriorates dramatically as a consequence of human activities and the use of water for household purposes.

Table 12: Characteristics of Various Water Sources (Mays, 1996)

	Water source		
wastewater	Typical surface water	Typical	Domestic groundwater
Solids			
Suspended, mg/ℓ	>50		200
Dissolved, mg/ℓ	<100	>100	500
Temperature, ^oC	0.5 – 30	2.7 – 25	10 – 25
Alkalinity, mg/ℓ as $CaCO_3$	<100	>100	>100
Hardness, mg/ℓ as CaCO3	<100	>100	
Chlorides, mg/ℓ	50	200	<100
Nitrogen, mg/ℓ	<10	<10	40
Phosphorus, total, mg/ℓ			12
pH	-	6.5 – 8	6.5 – 8.5
Total organic carbon, mg/ℓ	<5		150
Oxygen, mg/ℓ	7.5	7.5	<1.0
Bacteria, MPN/100mℓ	<2000	<100	10^8 – 10^9
Viruses, plaque forming units	<10	<1	10^2 – 10^4

Surface water

As far as the water quality of the Kavango, Kwando and Kunene rivers is concerned, it is generally very good (with the exception for seasonal high turbidity) because of very limited development in their catchments in Angola (WCE, et al., 1999). Also the water quality from the Zambezi River, based on concentrations of major ions, is good with the pH between 6,6 and 8,0 and TDS between 24 and 121mg/l (Schlettwein, 1985).

The Orange River, however, is of greater concern because of the Vaal River receives industrial and mine effluents (usually acidic) from many industries in Gauteng and the contamination caused by widespread use of agrochemicals for irrigated agriculture along the river as well as discharges of purified sewage. All these result in increased salinisation, nutrient enrichment of water, increased concentration of heavy metals (mercury, aluminium, cadmium, lead, nickel, copper, chromium, selenium, zinc), trace elements (antimony, arsenic) and organic compounds, including synthetic organic chemicals from industrial and agricultural effluents. In the Vaal Dam, the concentration of TDS is rising at a rate of 2.5 mg/l every year (Davis and Day, 1998). In 1984 it was estimated that an increase in TDS of 100 mg/l in the Vaal River would cost R78 000 000 per year to combat (Davis and Day, 1998). Such water might need treatment to make it suitable for domestic and industrial use. If used for irrigation it might cause salinisation of the soil and render it unsuitable for further agricultural activities due to the accumulation of salts. The danger of this happening is higher in dry-land environments such as along our border with South Africa. Orange River water is slightly alkaline (pH 7,6 - 7,9) with a concentration of total dissolved solids of 140 - 217mg/l, mainly calcium carbonate. From a water quality point of view, nitrate and nitrite

(NO_3 + NO_2) concentration is low with median values lower than 0,1mg/l along the river downstream of Vioolsdrift as it is rapidly taken up by plants (Jattiem, 1998). Therefore, salinity remains the main concern as it may have a negative impact on irrigated agriculture. According to the salinity model, median salt concentration will increase from 311mg/l at Vioolsdrift and 326mg/l at the Orange River mouth in 1995 to 410mg/l and 514mg/l in 2030 respectively. At Vioolsdrift, variations in salt concentration between 400mg/l and 1500mg/l were observed (Jattiem, 1998). Such high concentrations, even if they occur for short periods of time may be damaging to many plants. Salinity problem will be aggravated when next phases of the Lesotho Highlands Water Project are implemented resulting in not only decreasing the flow of low salinity water downstream but also increasing the flow of higher salinity polluted water from the Vaal River. In summary, general water quality deterioration is inevitable.

In addition, dams built on the Orange River affect the quality of water downstream. They act as silt traps.
It is considered that transport of silt is indispensable for the functioning of coastal ecosystems. The mean annual sediment discharge has been estimated at $60,4 \times 10^6$ t (Davis and Day, 1998). Silt is transported up the coast by the Benguela Current where tonnes of nutrient-rich sediments provide feeding for marine organisms. These are essential for commercially important species such as fish. Therefore, in the long term, reduced quantities of silt may negatively impact the productivity of our coastal waters.

Physical and chemical quality of water in Namibia's major dams is very good for most of the year (Bethune, 1992). Seasonal high turbidity is caused by river inflows during the rainy season. This can easily be removed from water in the purification process. Another quality problem originates from periodic algal blooms resulting in the presence of taste- and odour-producing compounds. Geosmin and 2-methylisoborneol are major causative determinants of such odours and need to be removed from drinking water by adsorption on activated carbon beds. Adsorption of these compounds is, however, significantly reduced in the presence of other naturally occurring organic matter such as humic acids. Algal blooms occur when nutrients released from decaying organic matter, accumulated in the deep layer of dam water, surface due to overturn of dam water as a result of breakdown of thermal stratification. This phenomenon may take place after heavy summer inflows of turbid, denser runoff from rivers or in autumn when temperatures of the warm surface layer decrease; gravity and wind combine to mix a water column with nutrient-rich deep water surfacing and supplying abundant nutrients for algae (Bethune, 1992).

The major ion chemistry is known for the rivers and dams. This, however, might be insufficient for water quality monitoring in general and pollution control in particular. The latter requires that the levels of detection be adjusted to usually low concentration of pollutants (Taylor, 1999). Additionally, appropriate pollution indicators must be decided on depending on the origin of the pollutants; they will be different for pollution by agrochemicals, by poorly treated sewage or mine effluents. It is unknown whether the Orange River is polluted with synthetic organic chemicals of industrial or agricultural origin or whether Zambia's copper mines have any impact on the Zambezi River. General water quality monitoring is insufficient for these purposes.

Similarly, it is unknown how much of naturally occurring organic matter is present in our water resource or what is the prevalence rate of waterborne pathogens such as *Giardia* or *Cryptosporidium*. Disinfection by-products, formed during chlorination of waters containing natural organic matter and protozoa are the major challenges as far as drinking water is concerned. Precursors of disinfection by-products or waterborne pathogenes are not monitored in our water sources. Farms were found to be major sources of contamination of water with protozoa with calves and lambs being primary sources of *Cryptosporidium* oocysts (Crockett and Haas, 1997). Actually, no systematic monitoring of the quality of our water resources is carried out by the resource manager, *i.e.* the Directorate: Resource Management.

Groundwater

Groundwater is used to supply 51 per cent of Namibia's current water consumption (van der Merwe, ed., 1999). It is used for human consumption, stock watering and irrigation. It is, also, supplied to mines and industries. Groundwater quality varies significantly from one aquifer to another depending mainly on residence time and the material that the groundwater passes through during infiltration and through-flow (WCE, *et al*., 1999). Owing to geochemical reactions of water and the material through which it passes, groundwater may contain naturally relatively high concentration of undesirable chemical determinants such as fluoride, sulphate, nitrate, hardness, iron, manganese or excessive dissolved solids. High concentrations of dissolved solids in groundwater are found Northwest of the Etosha Pan extending to the Cuvelai where high salinity renders it unusable for drinking purposes.

There is a danger of saltwater intrusion into the coastal alluvial aquifers such as the Omdel, Kuiseb and Orange Rivers aquifers. High salinity water is also found in parts of the Stampriet artesian basin in the shale layers where it has been retained for a long time. According to the available information there are numerous boreholes all over the country containing high concentration of dissolved solids, fluoride, sulphate, nitrate or hardness. They are of concern because groundwater is usually utilised untreated. Also, these determinants are not easily removable from water. Warmbad is the only place in Namibia where fluoride is removed from groundwater before pumping the treated water into the public water supply system. Owing to the above, drinking water standards are especially important and useful for evaluating groundwater quality.

It is believed that under conditions of water scarcity, on the one hand, and intensive development, on the other, the degradation of water quality might become a problem. Also, reuse of water requires that special attention is paid to the water quality and that quality requirements are in place to protect humans, animals, soil and, in general, the environment.

At present there are no drinking water standards in Namibia. There are guidelines for drinking water quality, stock watering and irrigation. They were developed for using fresh water sources. We do not have guidelines for water quality requirements concerning water reuse. These guidelines are needed for a variety of reasons. In order to conserve quality of our water sources, it is necessary to have a benchmark. Except for water conservation, these requirements are essential because of health considerations and the Namibian Government’s desire to ensure the supply of safe drinking water to all the people and obligations concerning "maintenance of ecosystems, essential ecological processes and biological diversity of Namibia and utilisation of living natural resources on a sustainable basis for the benefit of all Namibians", the latter specified in the Namibian Constitution.

Recently, it was recommended and approved that the South African Scoring System (SASS) technique be used in Namibia to make water quality assessments for management purposes. It uses biological indicators such as the macroinvertebrate fauna for assessing changes in water quality due to chemical or biological pollution as well as physical changes such as reduced flows. The system relies on the differing physiological response of different invertebrate taxa to changes in water quality and requires sampling, identification of organisms and allocation of scores to each scoring taxonomic group. Use of biological indicators gives a picture of the long-term prevailing water quality in any water-course (Taylor, 1999). Ideally, chemical and biological monitoring should be complementary because chemical analyses give accurate amounts of individual substances in the water and biological monitoring reflects general conditions in the river.

2.10 Pollution of water resources

According to the Water Act, 1956 (Act 54 of 1956), pollution is any act whereby any public or private water, including sea water, becomes less fit for the purpose for which it is or could be ordinarily used by other persons (including the Government and any local administration), or for the propagation of fish or other aquatic life or for recreational or other legitimate purposes. In other words, pollution of water is any change of its qualities that adversely affects subsequent beneficial use. The Department of Water Affairs, on behalf of the Minister, is responsible for protecting water resources. Contamination of surface and groundwater may have very diverse origins. There can be a single source or multiple sources, point sources or non-point sources. The major sources of pollution are as follows:

- Sewage effluent disposal sites
- Mines
- Industrial effluent
- Landfills
- Underground storage tanks for chemicals and petroleum products
- Gardening
- Agriculture

According to the Water Act, 1956 (Act 54 of 1956) water which has been used for domestic or industrial purposes shall be purified and returned to the place from which the water was abstracted. Effluent returned to the place of origin must conform to the requirements prescribed by effluent standards. If achieving acceptable quality is not practicable, a water user must obtain an exemption permit for disposal of substandard, *i.e.* semi-purified or untreated effluent from the Department of Water Affairs. The first permit was issued by the Department to the town of Koës in 1978. The procedure of issuing a permit is as follows:

- Information that an exemption permit is required for disposal of effluent or a reminder that the present permit expires is sent to a potential permit holder or a permit holder with a questionnaire;
- The permit seeker completes and submits the application to the Department of Water Affairs;
- A technical report is drafted wherein conditions for issuing a permit are proposed;

- The technical report together with the application is sent for comments and recommendations to the Ministry of Health and Social Services, Ministry of Environment and Tourism and to other Ministries such as Mine and Energy, Trade and Industry, Fisheries and Marine Resources, depending on the type of effluent to be disposed of.
- After receipt and incorporation of recommendations from the consulted Ministries, the law Administration Division of the Department of Water Affairs is requested to issue a permit.

Septic tanks

Of the 320 permit holders, the type of process used is unknown for 81 exemption permits. 53 permits were issued for septic tanks (Africon, 2000). In those tanks, sewage undergoes anaerobic decomposition and the liquid waste is carried to a drain, where it seeps away, often to the water table. Septic tank effluent is usually of relatively low quality. It contains bacteria and viruses. They are of greater concern that salts and organic compounds because potentially they can cause waterborne diseases such as viral hepatitis or typhoid when contaminated groundwater is used for drinking. Septic tanks are likely to contaminate groundwater where there is a high density of homes with septic tanks, the soil layer over permeable bedrock is thin, the soil is extremely permeable, such as gravel or sand, or the water table is high, *i.e.* not far below the land surface. Pit latrines and land burial are equally ineffective treatment methods. Septic tanks treat about 16 900 m^3/d of sewage which is 13.2 per cent of the total volume of effluent for the country. The latter is 127 760 m^3/d (Africon, 2000).

Stabilisation ponds

There are 120 stabilisation ponds in Namibia into which about 31.6 per cent (40 300 m^3/d) of the total volume of effluent for the country is disposed of. They are simple and inexpensive to build and operate. They can be aerobic, anaerobic, or aerobic-anaerobic. Sometimes they are designed to function as evaporation ponds, sometimes they produce effluent of varying quality depending on organic loading rates, hydraulic retention time and climatic conditions. A high degree of coliform removal is assured even with a 30 days detention (Metcalf & Eddy, 1991). Potential for groundwater contamination exists due to seepage if the bottom of such ponds are not properly compacted. A pond sealer or liner is advantageous in sandy places with minimal quantity or no clay at all. Examples of ponds where seepage resulted in groundwater contamination are Ujams in Windhoek or Okapuka Tannery. Leaking concrete-lined ponds contaminated groundwater at the Namibia Tannery. It was possible to detect pollution at these places because they have monitoring boreholes. This is an exception rather than a rule in Namibia. High concentrations of nitrates in groundwater used as a source of drinking water at Maltahöhe is thought to originate not only from the quartzite sediments but also from the seepage from the town's stabilisation ponds and it exceeds 20 mg/l (as N). It is estimated that 90 per cent of all stabilisation ponds under control of line ministries are neglected. They include the Ministry of Environment and Tourism, the Ministry of Regional and Local Government and Housing, the Ministry of Works, Transport and Communication (WCE, *et al.*, 1999).

Tailings dams

Mine tailings are disposed of into the tailings dams. They can cause contamination of groundwater by substances used in milling and extraction processes. Often, they are acidic. None of the tailings dams in Namibia has been lined. Some of them (Tsumeb, Rössing) were conveniently situated on geological faults. The tailings dam at TCL is of particular concern because the Tsumeb aquifer is used as a source of drinking water. One of the production boreholes at Kombat was considered to be contaminated by seepage from the tailings dam; it had exceptionally high concentration of sulphates. The tailings dam at the Otjihase mine, also was thought to cause groundwater contamination. At the Navachab gold mine, the tailings dam was sited after a thorough geological and geophysical investigation. However, seepage (containing cyanide) was detected after a few years of operation in a totally unexpected place. Seepage from the tailings dam at the Rössing Uranium Mine is believed to reach the Khan River. This is based on high concentrations of salts in water samples taken from the last cut-off trench close to the river. No uranium activity could be measured at the then Department's laboratory. Unlined uranium tailings dams caused formation of the plume with increased levels of uranium activity in one tailing dam investigated at a uranium mine (Fetter, 1994).
Information on volume of effluent disposed of into the tailings dams is incomplete. 1095 m^3/d (Africon, 2000) seems little in comparison with 51 411 m^3/d in 1994.

Industrial effluent

Industrial effluent is often disposed of into the sewage system and thereafter it is treated together with domestic effluent. However, this is not a rule. Effluent from fish factories in Walvis Bay and Lüderitz is disposed of into the sea. Walvis Bay is especially controversial because the disposal takes place at the harbour that turned anaerobic due to a very high organic load in the effluent from fish factories. Chemical organic demand (COD) was 2460 mg/l in similar waste discharged into the sea at Lüderitz (Africon, 2000).

Landfills

Landfills are the most common way of disposing of municipal waste such as garbage, garden refuse, demolition debris, industrial solid waste, sludges from municipal and industrial wastewater treatment facilities. Water infiltrating the waste can form leachate that in turn can move downward and reach groundwater. Landfill leachate can contain very high concentrations of organic and inorganic contaminants depending on the composition of the disposed waste and the amount of water percolating through the refuse. Solid waste disposal is less likely to result in groundwater contamination in places with little rainfall. There are no examples of groundwater contamination due to landfills in Namibia. It might be because of a lack of control and monitoring at the solid waste disposal facilities. Municipal waste does not generally contain massive quantities of toxic compounds, but it does contain the small amounts found in the wastes from normal household activities. Examples are bleach, cleaning fluids, insecticides, and gasoline (Tchobanoglous *et al*, 1993). The small amounts of these hazardous products, however, do not justify the present situation characterised by a lack of regulations concerning solid waste disposal. This might be even more of concern in Namibia where industrial hazardous wastes are disposed of at the municipal waste disposal sites together with wastes from homes, businesses and institutions.

Underground tanks

Leaking underground tanks can cause long lasting groundwater contamination. One such example is Aroab where three production boreholes were taken out of operation in the early 1980's, due to the pollution from a petrol storage tank. These boreholes supplied about 31 per cent of the water demand of the town. They were sampled again in 1989 and were found polluted. It is assumed that the contamination problem persists (WCE, *et al.*, 1999). Substances such as petrol with a specific gravity less than that of water tend to float on the water table and some soluble compounds such as benzene dissolve in the water below the water table resulting in a plume of groundwater with dissolved products.

Gardening and agriculture

Gardening and agriculture can result in contamination of surface and groundwater with nutrients originating from fertilisers and other agricultural chemicals. The following agrochemicals are commonly used in Namibia:
Herbicides for weed control: Harness, Atrazine, Lasso, Treffer, Duran, Roundup, Gramozone, Focus Ultra, Galleon, Wenner, Butril, Terbo;
Herbicides for bush encroachment control: Ustilan, Grasslan, Reclaim, Tordon;
Herbicides for reed control: Muster, Arsenal;
Pesticides: Bulldock, Decis, Karati, Gautho, Curaterr, Matazystox, Lebaycid, Nemacur, Thiodan;
Fungicides: Follicure, Bravo, Dithane M 45, Effekto Funginex.

Use of agrochemicals is widespread. The above are just a few of 264 agrochemicals approved for use in Namibia. The world market for pesticides was US$25 billion in 1992 (Rosen, *et al*. (eds), 1997). They are used to minimise losses in food production. Pests destroy about one-third of the world food supply during growth, harvesting and storage, even with the use of pesticides and other control methods. However, a number of problems can be created by the extensive use of pesticides. The first is negative health effects in humans, especially of insecticides that are inherently more toxic because of common site of action in insects and mammals. Pesticides account for more than 20 000 fatalities yearly, with most occurring in developing countries despite the fact that 85 per cent of the world agrochemical production is used in industrialised countries (Rosen, *et al*. (eds), 1997). The second is the potential for environmental pollution as a result of contaminated return flows and run-off water carrying fertilisers and synthetic organic agrochemicals to rivers and the potential for contaminating groundwater. The third is selection of resistant strains with enhanced detoxification capabilities resulting in the development of new varieties of agrochemicals with enhanced potency. The fourth is the potential for impoverishment of local flora and fauna with possible impacts on biological diversity and, consequently, ecosystems.

Fertilisers are equally essential in food production. The potential demand for grains closely follows the projected population growth and it was estimated that nutrients from soils and manure sources would not be enough to support the world's growing population who past the 6 billion mark on 12 October 1999. Increased production requires nitrogen (N) and phosphorus (P) fertilisation even if new cultivars use nutrients more efficiently. Irrigation and general N management are blamed for transport of large quantities of N to groundwater sources (Rosen, *et al*. (eds), 1997). Transport of nutrients to natural waters is controlled by the volume and rate of water movement through the soil and across the soil surface. These movements of water are caused by precipitation, infiltration, interception and evapotranspiration. As far as transport of nutrients is concerned, precipitation and infiltration are the most important processes. Infiltration controls the distribution between surface runoff and subsurface flow processes. The latter results in downward water movement with dissolved fertilisers, potentially to the water table. Surface runoff, *i.e*. the part of rainwater that flows over the land surface, may cause detachment and transport of soil particles. Leaching takes place when precipitation less the fraction of water flowing through surface runoff overcomes the sum of soil holding capacity plus evapotranspiration water.

Phosphorous is strongly adsorbed on soil particles; its contribution to pollution of ground waters is usually negligible. Nitrogen, however, supplied in the nitrate form is repulsed by negatively charged soil surfaces (clay) and can readily leach with percolating water. Nitrogen supplied as ammonium may resist leaching because of sorption of ammonium ions by the soil surface. The amount of leached nitrate depends mainly on climate, soil type, amount of nitrate in the soil, cropping system and irrigation practices. In semi-arid climates with high evapotranspiration no leaching processes take place in many areas. On the other hand, leaching from sandy soils, with the highest hydraulic conductivity and the smallest water-holding capacity, is usually higher than from clay soils. Also, nitrate leaching is generally seen to decrease with increasing efficiency of water distribution. Unfortunately, flood irrigation which is the most prevalent irrigation system in Namibia is the least efficient one.

No incidents of pollution of groundwater due to the use of agrochemicals and fertilisers were reported in Namibia. Also, there are no reports of the boarder rivers being polluted by pesticides, herbicides or having excessively high nitrate and nitrite concentrations. However, reeds growing in the Fish River below the Hardap irrigation scheme are thought to thrive owing to leaching of nutrients from the scheme. They increase the risk of flooding. Also, colonisation and encroachment of reeds were observed along the Orange River in the water and on the river banks. This is due to the stable flow conditions created by the dams built upstream but, most probably, irrigation farming and nutrients in the return flow contribute to this increase. The flow patterns of the middle Orange River changed from a strong seasonal to an almost equal summer-winter flow distribution that is favourable for agriculture. It must, however, be stated that no proper water quality monitoring is carried out in Namibia.

2.11 Water sector information system

Comprehensive research and data collection programmes are fundamental for any major field of resource management, including water conservation. Separate databases exist for:

- Surface water at the Division: Hydrology
- Groundwater at the Division: Geohydrology
- Water quality at the Division: Water Environment

Also, the Directorate: Rural Water Supply maintains its own database that can be accessed at headquarters and regions.

Hydrology

Hydrology database contains:

- River and dam levels, and from those calculated river flows and inflows;
- Rain intensities, from Weather Bureau and DWA Hydrology Stations;
- Daily rainfalls copied from Weather Bureau and from private observer;
- Weekly and monthly A-pan evaporation data;
- Various related information.

The Division: Hydrology has also calculated tabular information, in particular:

- Synthesised monthly flow records for sites with hydrological importance such as existing or studied dams, and for alluvial aquifers;
- Yield/reliability results for these sites;
- Flood frequency results for these and other sites;
- For the purpose of flood control, DWA also collects in real time:
  - cloud and cloud temperature images from Meteosat;
  - reports from DWA Hydrology and other observers in catchment regarding rainfall and river flow.

The Division: Hydrology has implemented a new database system, called HYDSYS. It was installed in April 1999. HYDSYS is well suited for the processing of the hydrological data in Namibia. There is a variety of data input procedures such as digitising of charts, reading of files generated by loggers, spreadsheets, text files and direct typing of data. Good reports for daily, monthly and annual totals also include basic statistics. There is also a powerful graphical interface (NWRMR, 2000).

On the regional level, there is good co-operation and exchange of information between Zambia, RSA and Botswana. Namibia also participates in the SADC Hydrological Cycle Observation System project (HYCOS).

Geohydrology

The Division: Geohydrology used to maintain a groundwater database. At present, as a result of a joint project between the Department of Water Affairs and NamWater, Ground Water Information System (GROWAS) is being implemented. It is a joint database. It consists of 14 major modules which contain the major sets and sub-sets of data. They are as follows:

- System administration module;
- Data conservation module;
- Borehole administration module;
- Borehole task module;
- Water quality module;
- Borehole production module;
- Groundwater monitoring module;
- Hydraulic testing module;
- Borehole geology module;
- Borehole siting module;
- Aquifer study module;
- Surface hydrology module;
- Ground water permit module;
- Additional add-on components.

GROWAS stores records of more than 60,000 boreholes as well as information on rest water levels, production data and water quality data. It is designed for the storage, retrieval and manipulation of all Geohydrological data. Brief description of some of these modules that most probably will be of interest to other users not only the Division: Geohydrology, is given below.

All borehole information will be managed by the Borehole Administration Module. Boreholes are identified with unique numbers and geographical co-ordinates. Information about boreholes includes borehole location, status, borehole owner, farm name, usage, equipment, geology, diameters, water strikes and yield. WW numbers issued by NamWater will come from a different set than those allocated by Water Affairs.

Water Quality Module manages the results received from the laboratory on water quality. The ion balance is included in the water sample table. Also, there is provision for keeping data about external water samples, i.e. samples brought by the public and not linked to a borehole. Analytical analysis report is one of the outputs. Except chemical data, microbiology and biochemical data will be stored in this module and these types of analysis will be listed as 'sample type'. Samples which do originate from ground water sources will be stored in the *External Water Sample* table. Different samples have different types of unique numbers starting with 'DS' for chemical analysis, 'MB' for biochemical samples and 'EW' for microbiology samples. They will be automatically generated by GROWAS for samples entered by NamWater users. Samples that are analysed on an ad hoc basis will not be included in GROWAS. There will be a clause indicating that the data as presented in any report could be used and published by NamWater.

The Borehole Production Module will contain water production data for NamWater boreholes as well as water levels for the production boreholes. The data will be entered by the various operations divisions and certified correct by the area manager.

The Groundwater Monitoring Module contains water levels for the monitoring boreholes, piezometers readings and water sample analyses. It has a number of reporting functions, including ground water level analyses report, ground water level graph, water level exception report (indicates boreholes where ground water levels are below given value).

The Hydraulic Testing Module manages the entry and the interpretation of hydraulic testing data from pump testing, slug-bail testing and other hydraulic testing, used to determine borehole yield.

The Aquifer Study Module groups boreholes per aquifer. It allows for aquifers to be defined and to be cross-referenced to boreholes.

The Hydrology Module stores applicable dam data, rainfall and runoff data, all used in groundwater modelling.

The Ground Water Permit Module will handle all permit applications to drill boreholes or to use ground water. There is provision to register permit application, to evaluate permit application, to complete permit application and maintain issued permits, including notification of permits about to expire. Permit numbers will be assigned automatically. The following procedure will be followed:

- Choose whom to e-mail permit application, cc is sent to the Divisional Head;
- Follow up after 2 working days if person who permit was allocated to evaluated it.

Evaluation is the responsibility of the Department of Water Affairs that also issues a permit if application is successful. This module allows for the following reports to be printed:

- List of applications not yet evaluated;
- Totals of boreholes permits issued per permit type and permit status;
- Permit form;
- List of permits for new boreholes that have not submitted borehole completion forms;
- List of permits due to expire;
- List of outstanding permit returns;
- Permits grouped per permit area.

The System Administration Module handles user information and user access. All users have to have a system allocated ID. Every module will also have its own ID. These will be assigned by the system administrator.

Water Environment

The Division: Water Environment is responsible for water quality data. Its database contains all the water quality data that were stored in the water quality database of the Department of Water Affairs. Since April 1997 the Department of Water Affairs does not have its own laboratory. The Division: Water Environment handles water samples collected by other Divisions and the Directorate: Rural Water Supply. The water samples are handed in for analyses at the laboratory that won the annual tender for that particular type of analyses. Results are entered into the existing database. Water quality database will be available in MS-Access in future. Water quality analyses usually do not have co-ordinates.

This Division is also involved in a process of issuing permits for disposal of effluent. Information concerning these permits is stored in Excel. No co-ordinates are provided for most of the places.

Rural Water Supply

The Directorate: Rural water Supply has developed a database (RUWIS), in Access, where major information on the water point is stored. This includes:

- General information;
- Extension information (community, water point committee);
- Maintenance and inspections (water levels and yields measured, tanker services, water meter reading);
- Extension history event;
- Applications and inspections for new and rehabilitated schemes.

Numbering of water points is done according to a region name and grouping of water points followed by a number. This is linked to the WW number used by the Geohydrology Division.

3. CURRENT INSTITUTIONAL AND LEGAL FRAMEWORK

3.1 Existing institutions

3.1.1 Water Resources Management

Department of Water Affairs

Cabinet, at its 32nd meeting on 21 September 1993, approved the following WASP recommendation:
"The Department of Water Affairs in the Ministry of Agriculture, Water and Rural Development will remain responsible for the overall management of water resources in the country with the prime objective of ensuring that they will be properly investigated and utilised on a sustainable basis to cater for the needs of both man and his environment" (Department of Water Affairs, 1993).
The following issues were identified for further consideration:

- Sustainable use of both surface and groundwater sources;
- Impact of water abstraction on the environment;
- Full utilisation of water sources in the interior;
- Need for long-distance water transfers from the border rivers;
- Use of the desalination of seawater as a water source at the coast;
- Improved and stricter control over usage of water, including its legality;

- Need to investigate the potential for expanding groundwater utilisation in the north and north- eastern parts of the country as well as in all other communal areas;
- Need to guard against the possible pollution of water resources by applying a pre-emptive approach.

As far as water resources management is concerned, the Department was made responsible for water resources inventory, control and management issues (Department of Water Affairs, 1993). The above functions are to be performed by the Directorate: Resource Management through its five Divisions: Planning, Hydrology, Geohydrology, Water Environment and Law Administration.

Namibia Water Corporation Ltd

Concerning water resources management, the Corporation has the following statutory functions:

- explore, develop and manage water resources for the purpose of water supply;
- investigate, research and study matters relating to water resources, waterworks and the environment;
- take such action as the Corporation may consider necessary or as the Minister may direct, for the purposes of conserving or augmenting water resources in Namibia.

Statutory duties of the Corporation include:

- duty to conserve and protect water resources:
  - utilise the water resources available to it on a long-term sustainable basis;
  - take appropriate steps to ensure that those water resources are protected from pollution caused by its operations.

Ministry of Environment and Tourism

Integrated Environmental Management is one of this Ministry's functions. The Ministry has a responsibility for the overall management of the natural environment with a view to ensuring "maintenance of ecosystems, essential ecological processes and biological diversity of Namibia and utilisation of living natural resources on a sustainable basis for the benefit of all Namibians, both present and future" as stipulated by the Constitution of the Republic of Namibia (Article 95 (l)). In order to achieve this, the Ministry developed an Environmental Impact Assessment (EIA) policy for the country and is in the process of implementing it. Practically all the water related development projects need an EIA study followed by a report to be submitted to the Ministry for their consideration and approval.

3.1.2 Water Supply

Namibia Water Corporation Ltd

Namibia Water Corporation Ltd is a public company incorporated under the Companies Act. Its main object is to supply bulk water to customers in sufficient quantities and of a quality suitable for the customers' purposes, and by cost-effective, environmentally sound and sustainable means.

Local Authorities

Concerning water supply, Local Authorities are, generally, responsible for distributing drinking water to customers. In most cases water is purchased from the bulk supplier. However, there are a few municipalities that supply their own water such as Grootfontein and Tsumeb. Some of the municipalities reuse treated sewage effluent for landscape irrigation, watering golf courses and trees. In those places, wastewater is an alternative water source. Reuse of treated sewage effluent is practised in Swakopmund, Walvis Bay, Tsumeb, Otjiwarongo, Mariental, Okahandja and Windhoek.

Department of Water Affairs

The Directorate of Rural Water Supply is responsible for planning, developing, and supporting operation and maintenance of rural water supply schemes. At present, its main objective is to implement a system of community based management with a view to transferring full responsibility for, and eventually, full ownership of their own rural water supply services to the communities. Providing extensive training to the members of Water Point Committees as well as training of the Directorate of Rural Water Supply staff was identified as one of the key issues in successful implementation of community based management policies.

Department of Works

The Department of Works provides water supply services to some schools, clinics, police stations and border posts in remote areas. Usually, also communities living in the vicinity of such places receive water from the same scheme. Water consumers in these places do not contribute to the cost of operation and maintenance of the water supply infrastructure.

3.1.3 Pollution Control

Department of Water Affairs

The Department has overall responsibility for water resources protection, including pollution control. This function involves managing the system of exemption permits for disposal of sub-standard effluents. These exemption permits are issued when it is considered that impacts of disposing of poorly treated effluents into the environment are negligible, which is not always the case.

Department of Works

The Department is responsible for all the arrangements concerning wastewater disposal at Government institutions where they are not connected to a sewerage system, e.g. a school or a hospital outside urban areas. This responsibility includes maintaining the effluent disposal systems under its supervision and applying for the renewal of an exemption permit for each such system before the existing one expires.

Ministry of Regional and Local Government and Housing

The Ministry is responsible for all the arrangements concerning wastewater disposal in smaller towns, villages and settlements. The Ministry is, also, responsible for ensuring that these places have valid exemption permits for disposal of sub-standard effluents. Municipalities and bigger towns are in a position to take care of their wastewater disposal and deal with the Department of Water Affairs directly. In these cases, Local Authorities carry out their functions as stipulated in the Model Sewerage and Drainage Regulations promulgated in terms of section 94(2)(a) of the Local Authorities Act, 1992 (Act 23 of 1992).

Ministry of Mines and Energy

Individual mines are responsible for managing their wastewater and industrial effluents as well as for applying for exemption permits, if required. Such applications are processed by the Department of Water Affairs and drafts of the exemption permits are sent to the Ministry of Mines and Energy for comments and suggestions.

Ministry of Health and Social Services (MHSS)

According to NDP1, the MOHSS “has a significant role to play in the areas of using safe, clean water, hygiene education and sanitation, as well as checking the quality of water for human consumption throughout the country". The Ministry is responsible for developing drinking water quality guidelines/standards. Additionally, this Ministry has been given responsibility for sanitation in rural areas and those urban settlements that are not equipped with proper sanitation facilities. The Ministry of Health and Social Services is consulted before any effluent disposal exemption permit is granted.

Ministry of Fisheries and Marine Resources

This Ministry is consulted in connection with exemption permits for fish factories disposing of their untreated effluents into the sea. They are requested to comment on the conditions of such permits and make recommendations.

3.2 Existing policies

3.2.1 Water Supply and Sanitation Policy

According to the Water Supply and Sanitation Policy (WASP), approved on 21 September 1993 by Cabinet, the Department of Water Affairs in the Ministry of Agriculture, Water and Rural Development is responsible for the overall management of the water resources. The prime objective is to ensure that the water resources are properly investigated and utilized on a sustainable basis to meet human and environmental needs. Improved water supply and improved sanitation are the overall sector objectives. Specifically, improved sanitation should protect water resources from pollution and promote the conservation of water. It is recommended that, due to the scarcity of water and supply costs, improved and stricter control over the judicious and appropriate usage of water should be investigated and exercised. It is further recommended that the possible pollution of water should be guarded against and should form part of all planning and decision making processes. The WASP stipulates that if feasibility studies are carried out for scheme development, environmental assessment should be part of it and source monitoring should be practiced to afford utilization of water resources on a long-term sustainable basis.

3.2.2 Environmental Assessment Policy

Namibia's Environmental Assessment Policy was approved in 1994 by Cabinet Resolution 16.8.94/002. It lists policies, programmes and projects requiring an EA that should be carried out according to the established EA procedure. As far as water resources are concerned, there are very few activities on the list that do not involve water in one way or another, directly, e.g. major groundwater abstraction schemes, major canals, major dams, or indirectly, e.g. water intensive industries, waste disposal sites, pest control programmes. The policy aims at promoting sustainable development by creating a mechanism for having to select for implementation that option that has less negative environmental impact and affords biggest benefits. It strives to achieve Integrated Environmental Management (IEM). The policy does not explicitly address water conservation or conservation of other natural resources, except all species of fauna and flora. However, implicitly, the policy advocates it by placing a high priority on maintaining ecosystems and related ecological processes, promotes sustainable development in Namibia and talks of the need to achieve "reduction-at-source" in the areas of pollution control and waste management.

3.2.3 The Implementation of the Community Based Management and Cost Recovery

Aspects of the Water Supply and Sanitation Sector Policy (WASP)

The policy on implementation of the community management and cost recovery was approved in 1997 by Cabinet resolution 10.06.97/003. In this resolution the Cabinet endorsed principles of community responsibility for rural water supply, in partnership with the government and support by Regional Councils, subject to the capacity of both the community and government. According to the approved principles, communities will manage and control their own individual water points and accept the related responsibilities. Subject to resource availability, minimum acceptable water supply to all Namibians is defined as follows:

Maximum walking distance of 2.5 km;

A minimum of 15 litre per person per day which may be adjusted regionally;

A maximum of 30 min waiting time at the water collecting point.

As far as cost recovery is concerned, revenues from the provision of water supply services shall cover operation and maintenance costs within 5 years, starting in year 2, and it is anticipated that full cost recovery would be feasible within 10 years. Regional and Central Government will provide subsidies, if required.

As far as water supply is concerned, the first priority is water for human consumption and subsistence livestock watering is allocated second priority.

As far as water conservation is concerned, it is suggested that disincentive tariffs would be applied if the community decides that water is used excessively.

3.2.4 Drinking Water Quality Guidelines

Drinking water quality guidelines were introduced in 1988 by the Department of Water Affairs. They list aesthetic, inorganic and bacteriological determinates of concern and limits for classifying water as group A, B, C or D. These guidelines were very much internal guidelines for the use by the Department involved in water supply as its main activity at that time. They were submitted for approval to the Cabinet of the Transitional Government in order to establish national guidelines for drinking water quality. However, such approval has never been granted. Decision 461/85 stipulates that the recommendations on water and sanitation services that were submitted to the Cabinet should be forwarded to all the State Departments for their comments via the Department of Local Government. It does not say anything about drinking water quality guidelines. This means that the guidelines in question remain a departmental recommendation and it is left to water suppliers to decide what quality water they want to supply. There are no obligations on their part, which means that there is no consumer protection by the Government.

3.3 Existing regulations

3.3.1 Water Act

The Water Act, 1956 (Act 54 of 1956) is the principal legal document according to which the Department of Water Affairs currently operates.

Water Use

The Act specifies two types of water: private water and public water.
"Private water - means all water which rises or falls naturally on any land or naturally drains or is lead on to one or more pieces of land which are subject of separate original grants, but is not capable of common use for irrigation purposes".
"Public water - means any water flowing or found in or derived from the bed of a public stream, whether visible or not". Water from such a stream is capable of common use for irrigation.

Private water can exclusively be used by the owner of the land and cannot be sold, given or disposed of to any other person, without a permit from the Minister (Section 5. (2) of the Act).

As far as public water is concerned, riparian owners can use water for the immediate purpose of watering stock, drinking, washing or cooking, or in a vehicle at that place. They shall not use such water wastefully. No person is allowed to impound more than two hundred and fifty thousand cubic meters of public water or abstract and divert more than one hundred and ten litre of water per second (Section 9B (1) of the Act), except when granted a permit issued by the Minister. The Minister may, however, prohibit, limit or regulate the impounding, storage, abstraction, supply or use of water by notice in the Government Gazette. This regulation has been amended and Section 4 of Act 22 of 1985 stipulates that impounding more than 20,000m^3 requires a permit. Riparian rights are protected to such an extent that even in the event of change of course of a public stream, they remain and are regarded as if nothing changed.

If any quantity of water, including seawater, is to be used for industrial purposes, the Secretary shall be advised of the nature and the method of purification of the waste water, effluent or waste generated by the operation of such establishment. Additionally, if a quantity of water required exceeds three hundred of cubic meter on any one day or two hundred and fifty cubic meter on an average per day during any month, such use shall be authorized by a permit issued by the Minister.

A local authority requires a permit if more than one hundred and twenty-five thousand cubic meter of public water is to be impounded or stored or more than five thousand cubic meter of water per day is to be abstracted or diverted from a public stream.

A Government water work can be constructed in any catchment. However, if such construction affects any lower riparian owner, whoever constructs such works or the Minister shall pay compensation to that lower riparian owner or supply such a quantity of water as may be agreed (Section18 (3) of the Act).
The Minister may take any necessary steps for the development, control and utilisation of water. A wasteful use of water is prohibited (Sections 6 (3) and 9 (1)(a) of the Act). The use of water is to some extent prioritised and upper riparian owners may not use it for irrigation if such use deprives others of water for domestic purposes or the watering of stock.

Pollution

The relevant Sections of the Water Act are 21-24, 26 and 170. Section 21 promotes water conservation. It stipulates that water which has been used for industrial purposes shall, after purification, be returned at the nearest convenient point to the place from which the water was abstracted and shall not be diminished in quantity more than is justified by its use. Exemption can be made if this is impracticable and water or effluent may be returned to some other place determined by the water court. It should be noted, however, that such an institution never existed in SWA/Namibia. The Minister may prescribe requirements for the purification of any wastewater or effluent by notice in the Government Gazette. These requirements can be general or specific for any industrial purpose, public stream, the sea or any prescribed area. A permit exempting from compliance with the prescribed requirements for effluent quality can be granted by the Minister and, consequently, unpurified or semi-purified effluent can be discharged into any public stream or the sea. This should not, however, result in the pollution of public or other water as well as seawater. Also, it should not detrimentally affect aquatic life (Section 21(5)(a)).

Specific requirements can be spell out concerning mining or other industrial operations, during as well as after the abandonment of such operations with a view to preventing the pollution of any water, i.e. public, private, groundwater or the sea.

A local authority carrying out purification or disposal of wastewater is considered to use it for industrial purposes and, therefore, it requires a permit and it can be subject to specific requirements. Local authorities can use purified effluent as authorized by the Minister (Section 22(1)).

Pollution of water is an offence when done willfully or negligently. It is considered to be such until the contrary is proved. Any costs accrued from the prevention of pollution carried out by the Minister can be fully or partially recovered from the polluter such as any person entitled to carry out mining, industrial or farming operations (Section 23).

As far as permits and control of pollution of water are concerned, the Minister may make regulations relating to the form of application for permits and the particulars to be furnished (Section 26).
Wastage of public water is punishable, in the case of a first conviction, by a fine not exceeding five hundred rand (Namibia dollars) or by imprisonment for a period not exceeding three months or by both such fine and such imprisonment. In the case of a second and subsequent conviction, the fine is one thousand rand (Namibia dollars), six months imprisonment or both (Section 170 (1)(e)).

An offence under section 21, 22 or 23 carries, in the case of a first conviction, a fine not exceeding two thousand rand (Namibia dollars) or imprisonment for a period not exceeding six months or both such fine and such imprisonment. In the case of a second and subsequent, it is not less than one thousand rand (Namibia dollars) or not less than six months or both (Section 170(2)).

Groundwater

Only in so called water control areas, to be proclaimed by the State President in the Government Gazette (Section 28), can the drilling of boreholes, the sinking of wells, the abstraction, protection against pollution and preservation of water be regulated by the Minister. An owner of land who is entitled to abstract groundwater for his own use shall not, without a permit, sell, give or dispose of groundwater to any person for use on any other land. Also, it cannot be conveyed beyond the boundaries of his land for his own use (Section 30(3)). Clearly, groundwater belongs to land. However, it can be conveyed and supplied by the Minister to any person for use on any land, subject to an obligation to pay compensation to the owner of land on which it has been found (Section 30A and Section 60).

In water control areas, it is required that comprehensive information about searching for or abstracting groundwater is gathered, kept and made available. Such information must include the rate of flow and duration of any tests as well as the water levels during the test and until the water has returned to its natural level (Section 32). In these areas, abstracting, impounding and storing of water requires a permit to be issued by the Minister after the applicant has furnished particulars concerning the nature, size and the value of the water works as well as the extent of land to be irrigated. If a permit is not required, such particulars should nevertheless be communicated to the Secretary and a register of such particulars should be kept. After it has been established for what total quantity of water permits are to be issued in relation to any public stream or natural channel within the water control area, the total quantity of water to be made available should be determined considering the area which can be beneficially irrigated (Section 62).
A similar register or schedule should be kept for areas to be irrigated from Government water works (Section 63).

Rates and charges can be levied on irrigated land when water is abstracted, supplied or distributed from or by a Government water work, or from a public stream or natural channel in a Government water control area, or into which water from a Government water work is released (Section 66).

Irrigation boards

The Act stipulates that an irrigation board could be established for every irrigation district with a view to protecting the sources of water, preventing the waste of water, preventing any unlawful abstraction or storage of water, investigating and recording the quantity of water utilized by every authorized person, and supervising and regulating the distribution and use of water in the irrigation district (Section 89). Such irrigation boards have never been established in Namibia, except for the irrigation authority in Noordoewer.

Water boards

The Act also stipulates that water boards could be established for supplying water for urban, industrial or agricultural purposes. There is a long list of functions of such a board including constructing, maintaining and controlling schemes to provide and supply water as well as to make and recover charges for water supplied (Section 110(1)), and search for and develop water resources (Section 110(3)). Water boards have never been established in Namibia.

Water tariffs

The Act provides details on how a water board should calculate water tariffs. Owing to the present debate on appropriate water tariffs, it is interesting to note that it was recommended already in 1956 that a water board recovers full financial cost, Section 117. It was to include the following:
The cost of operation and maintenance (including costs of distribution and administration);
The amount required for interest on loans and redemption of such loans;
The amounts to be set aside for renewing existing assets.
The Act stipulates that when the prices to be charged are assessed or adjusted, each scheme should be taken into account separately. Separate accounts should be kept for each scheme of the actual expenditure, including overhead and administration charges, the amount of interest and redemption charges and other expenditure provided for in Section 118. However, the Minister may decide this to be undesirable or impracticable and authorise the board to take into account all or any of the water supply schemes, Section 118(2).
The Act recommends that water rates shall be assessed at uniform amount per hectare of land, Section 120(3)(a). However, such a rate should be payable in addition to any charges for water supply. It was also recommended that it should be a general principle of a board to operate neither at a profit nor at a loss Section 120(4).

3.3.2 Namibia Water Corporation Act, 1997 (Act 12 of 1997)

The main object of the corporation is to supply bulk water to customers, "in sufficient quantities, of a quality suitable for the customers' purposes". The Act does not give any details about what a suitable quality means. It does not make any reference as to who and how decides about specific requirements. The corporation has a duty to consider each application for bulk water supply. Its decision, however, is subject to the availability of water of the required quantity and quality. This implies that if poor quality water is available, the corporation can reject an application.

A number of functions of the Corporation relate to water resources and their management. They are as follows:
"explore, develop and manage water resources for the purpose of water supply;
investigate, research and study matters relating to water resources, waterworks and the environment;
take such action as the Corporation may consider necessary or as the Minister may direct, for the purposes of conserving or augmenting water resources in Namibia", (Section 6(1)).
As far as water tariffs are concerned, the Corporation can determine and levy, in consultation with the Minister, tariffs on a full cost-recovery basis for water supplied. These tariffs shall be published by notice in the *Gazette* (Section 7(a)). It must be noted that no public consultation is obligatory. It appears that it is not even required that the Board of directors is consulted in this regard before an application for increased tariffs is sent to the Minister.

The Corporation has the duty to: utilise the water resources available to it on a long-term sustainable basis and take appropriate steps that those water resources are protected from pollution caused by its operations. The Minister may by notice in the *Gazette* authorise the corporation to utilise a particular water resource on a non-sustainable basis for a specified limited period of time (Section 11).

The Corporation is obliged to protect from pollution not only the water resources it utilises but also to protect the environment from damage, destruction or degradation that might result from its operations, *i.e.* it has the duty to conserve and protect the environment (Section 12). Additionally, the Corporation shall have regard to "the most cost-effective and commercially viable means of achieving the service standards and of attaining the optimum use of resources available to the corporation (Section 14(2)(c)).
Section 13 of the Act stipulates that the Corporation has the duty to maintain records and to supply information to the Department on water resources such as rainfall measurements, river flows, groundwater levels, water abstraction from water sources and water quality.
The Act makes provision for subsidised services (Section 15). This is in agreement with the Water Supply and Sanitation Policy. However, this policy does not specify when subsidies may be applied. Any subsidies or full cost are to be paid to the corporation by the Minister "out of funds appropriated by Parliament for such purposes". This can be interpreted as no cross subsidisation regulation, *i.e.* customers like the City of Windhoek should not pay for a desalination plant at the coast or a pipeline to supply water to the Uuvudhiya Constituency in the Oshana region. This particular clause is important when calculating water tariffs for each scheme.

The State is the only shareholder and owns all the shares issued by the corporation. Section 35(2) stipulates that "For the purpose of the Income Tax Act, 1981 (Act 24 of 1981) or any other law, the corporation shall be deemed to have actually incurred expenses in the acquisition of assets and rights under section 34 and such expenses including the cost of these assets shall be deemed to be equivalent to the value of the assets determined by the Minister under subsection (5) of Section 34". It does not stipulate that these expenses, equal to the value of the acquired assets, equal to the value of the issued shares, could be recovered by depreciating the cost of the assets, *i.e.* this particular arrangement does not have any bearing on the way in which water tariffs are to be calculated.

Subsection (3) of section 42 of the Act stipulates that the Corporation is not exempted from complying with any law that requires that a permit be obtained for the purpose of impounding or utilising water from water resources. This Section reafirms that the corporation is subject to the Water Act, except as otherwise provided in the Namibia Water Corporation Act, 1997 (Section 42(1)).

3.3.3 Nature Conservation Ordinance, 1975 (Ord. No. 4 of 1975)

The Ordinance addresses the conservation of nature, the establishment of game parks and nature reserves, the control of problem animals and a variety of hunting issues and the sale and transport of game. It specifies huntable game, protected game and specially protected game. It regulates keeping of fish and angling permits. It elaborates on indigenous plants, picking and transport of protected plants as well as their export.
It does not address issues of non-living natural resources.

3.3.4 Minerals (Prospecting and Mining) Act, 1992 (Act 33 of 1992)

As far as pollution of water resources is concerned, the Act stipulates that it shall be a term and condition of any mineral licence that the holder of such mineral licence shall:

"(f) prepare in such form as may be determined by the Commissioner for the approval of the Commissioner:

- an environmental impact assessment indicating the extent of any pollution of the environment before any prospecting operations or mining operations are being carried out and an estimate of any pollution, if any, likely to be caused by such prospecting operations or mining operations;
- if any pollution is likely to be caused, an environment management plan indicating the proposed steps to be taken in order to minimise or prevent to the satisfaction of the Commissioner any pollution of the environment in consequence of any prospecting operations or mining operations carried on by virtue of such mineral licence;

(g) from time to time as circumstances change to revise such environmental management plan either out of his or her own motion or if required by the Commissioner" (Section 50).

The Commissioner means the Mining Commissioner appointed under the Act. The above is a prerequisite to prevent pollution of water resources by mining industry. Hopefully, this requirement prevents placing tailings dams on geological faults as has happened in the past. These dams are the major source of pollution caused by mining operations.

If a prospecting area or mining area is abandoned, any damage caused "to the surface of, and the environment on, the land in the area in question" should be remedied, including demolition of any constructed works and removal of all debris and objects brought to such areas unless the owner of the land wants to retain them (Section 54).

Directions can be given to the permit holder as to carrying out of reconnaissance, prospecting and mining operations, including the erection and construction of any accessory works with a view to protecting the environment, to conserving any natural resources, including mineral resources and to preventing the waste of such resources (Section 57).

An application for a mining licence shall contain particulars of the condition of, and any existing damage to, the environment, an estimate of the further impact of carrying on with mining operations as well as "the manner in which it is intended to prevent pollution, to deal with any waste, to safeguard the mineral resources, to reclaim and rehabilitate land distributed by way of the prospecting operations and mining operations and to minimise the effect of such operations on land adjoining the mining area" (Section 91).
Such licence should not be granted if the Minister is not satisfied that adequate protection of the environment will be ensured (Section 92(2)(c)(ii)(bb)).

If it is necessary to obtain a supply of water or to dispose of water or any other substance originating from mining operations, a right to do it must be applied for in writing to the Commissioner (Section 109(1)(c) and (d)).

In case of concerns for the protection of the environment, the prevention of pollution or damage to the natural resources, any area can be declared to require the special permission of the Minister (Section 122(2)(b)).

The Act makes provision for the Minister to direct the holder of a prospecting or mining licence to remedy any damage to the environment, including demolition of any constructed buildings and removal of debris when such licence has been cancelled or has expired or if the mining area has been abandoned. Failure to do it can be punished by a fine not exceeding R100,000 or to imprisonment for a period not exceeding five years or to both such fine and such imprisonment (Section 128).

Pollution of the environment or other damages or losses caused by holders of licences or mining claims shall be reported to the Minister and the necessary steps shall be taken by the licence holders to remedy such pollution, loss or damage (Section 130).

3.3.5 Local Authorities Act, 1992 (Act No.23 of 1992)

According to the Local Authorities Act, a local authority shall have the power to:
- "supply water to the residents in its area for household, business or industrial purposes;
- provide, maintain and carry on a system of sewerage and drainage for the benefit of the residents in its area;
- provide for the removal of solid waste, slop water and “all other kinds of refuse or otherwise offensive or unhealthy matter”.

A local authority council shall exercise the above powers. A local authority shall include all municipalities, town councils and, with the prior approval of the Minister, village councils. According to the Local Authorities Act, 1992 there were fifteen municipalities, eight towns and twenty-two villages in Namibia in 1992.

A local authority may provide water meters for the purpose of determining the quantity of water supplied to residents in its area. Presumably, the intention is that the residents pay for what they consume.
A local authority may, subject to the provision of the Water Act, 1956 (Act 54 of 1956), discharge from any waterworks or water main water into any public watercourse. The Local Authorities Act, 1992 (Act 23 of 1992) does not, however, stipulate any quality requirements for such a discharge. Storm-water can, also, be discharged into any public watercourse.

As far as sewerage is concerned, the act stipulates that the local authority council shall pay the cost of construction of a private sewer/combined private sewer from the boundary of privately owned property to the point of connection with a public sewer. However, the costs of construction to the boundary of the property are to be covered by the owner. A local authority may render assistance to the owner by way of an advance or loan or by constructing sewerage itself and have these costs noted in respect of the property by the registrar of deeds. What a local authority may do with effluent form sewage works is not explicitly stated, unless sewage works are considered to be another type of waterworks. Assuming that this is correct, discharge into any public stream is subject to the provisions of the Water Act, 1956 (Act 54 of 1996).

It is further stipulated that prior approval is required in order to dispose into any sewer of industrial, trade or manufacturing waste, any chemical waste, petrol or oil or any hot waste. None-compliance with this requirement carries a fine of maximum N$ 2,000 or imprisonment for a period not exceeding six months.

3.3.6 Model Water Supply Regulations, 1996 (Notice No.72 of 1996)

Supply of water to any premises in the local authority area is done by the council on request of the owner/occupier and should not be refused unless there is no supply main within the close proximity. The fee determined in the water tariff for an initial connection or for a reconnection of the supply of water must be paid when submitting an application for the supply of water to the council. Additionally, payment of a deposit, equal to the estimated charge for an average month’s supply, is required before the council provides the supply of water. The consumer pays for materials (water connection pipe, water meter and isolating valve), labour and transport for providing the water connection plus 15 per cent of the amount of such costs to cover additional indirect costs. This connection, however, remains at all times the exclusive property of the council.
The consumer is charged for the quantity of water registered by the water meter installed on the premises at the rate or charges determined in the water tariff.

The council may suspend water supply in case of wastage, unauthorized use of water or in order to prevent pollution of water. The supply of water to any premises may be interrupted without prior notice. The council may, also, prohibit or restrict the use of water, or impose limits on the quantity of water that may be consumed over a specified period.

The council undertakes to maintain at all times a specific standard or quality of water supplied.

Chapter 2 of the regulations addresses prevention of undue water consumption and prohibits the purposeless or wasteful discharge of water and requires that water is used efficiently. It, also, stipulates requirements in relation to hot water distribution systems, flushing devices, metering devices for taps and showers and water fittings outside buildings.

Chapter 3 addresses thoroughly prevention of surface and subterranean water pollution. To some extent, it attempts source water protection. It also specifies the obligations of owners to prevent pollution of water by the entry of any substance that may be a danger to health or adversely affect the potability of water.
Chapter 7 stipulates that the council may enter into a special agreement with any consumer and grant, on application, the supply of non-potable water to such consumer. However, there is no warranty as to the quality of non-potable water supplied. The consumer is obliged to adhere at all times to any conditions and regulations concerning the use of non-potable water for irrigation purposes as laid down by the Ministry of Health and Social Services.

Any private boreholes are allowed only with the approval of the council under certain conditions.

3.3.7 Model Sewerage and Drainage Regulations, 1996 (Notice No. 99 of 1996)

Local authority councils are obliged to supply a sewerage service after signing a contract for the provision of such a service by the owner of the premises or his/her representative and paying fees for a connecting sewer. These are prerequisites for the provision of a sewerage service by the council. Model Sewerage and Drainage Regulations stipulate that the council is not obliged to accept an application for a connecting sewer if a public sewer is not available at a point within the close proximity of premises. The drainage installation on the premises is the responsibility of the owner. No other discharge except unpolluted water for the purpose of testing of the drainage installation is allowed until a drainage installation has been connected to the public sewer. In case there is no connection to a public sewer, the owner of such premises shall, before the occupation, make provision for a conservancy tank or a septic tank/absorption field or other means of sewage disposal, as agreed by the council. The emptying of such tanks may be carried out by the council at a cost to be paid by the owner. If no water-borne system is available, other means of sanitary disposal can be accepted by the council, e.g. pit latrines. As far as “other means” are concerned, the only requirement is that they should not cause any nuisance or any unhygienic or offensive conditions.

The regulations stipulate that in order to discharge an industrial effluent into the public sewer, the written permission of the council is required. Such permission can be withdrawn when there is a change in the method of sewage treatment or a revision of standards under the Water Act, 1956 (Act 54 of 1956) and then new conditions can be imposed for the acceptance of any industrial effluent into the public sewer. This type of discharge is subject to the payment of charges according to the sewerage tariff. According to section 43. (1)(b), before the industrial effluent is discharged into the public sewer, it shall be pre-treated to achieve quality objectives as specified in the regulations. The aim is that the final treated effluent from any water works conforms to the requirements prescribed under the Water Act, 1956 (Act 54 of 1956) for purified effluent.

As far as reuse of wastewater is concerned, permission can be granted to the occupier to use wastewater originating from showers, baths or laundry for irrigating gardens. However, no reduction in the sewerage tariff will be considered if this is done.

3.3.8 Public Health Amendment Ordinance, 1971 (Ordinance No. 2 of 1971)

The Act makes provisions for preventing and suppression of infectious diseases. It does not specifically mention water-borne diseases. As far as public water supplies are concerned, the Act stipulates that it is the duty of every local authority to prevent the pollution of water resources used as a source of drinking water and to purify any polluted supplies as well as to take action against polluters of such supplies. Action can also be taken against those who pollute streams resulting in those streams becoming a nuisance or danger to health (Section 111).

Local authorities and magistrates can be empowered by the Administrator to enforce regulations concerning protection of water resources, including prohibiting the erection of dwellings or disposal of waste that could endanger health of any supply of water (Section 112). The Act, however, does not specify what is a healthy water supply. The Administrator may make regulations concerning standards of cleanliness of milk but not drinking water.

3.3.9 Sea Fisheries Act, 1992 (Act No. 29 of 1992)

The Act provides for the conservation of the marine ecology and the orderly exploitation, conservation, protection and promotion of certain marine resources. The Minister may determine policies regarding the protection of the marine ecology and the promotion, protection and sustainable utilisation of the sea and its resources (Section 2), including research and development (Section 24). A licence is required if any person desires to use a vessel as a fishing vessel or any premises, vessel or vehicle as a factory (Section 26).

In the case of a licence in respect of a fishing vessel, such licence may determine conditions regulating or prohibiting the discard, landing or disposal of fish caught by or from the fishing vessel (Section 26(5)(b)(ix)).

The Minister may make regulations in relation to the control and management of fishing harbours as well as prohibiting the discarding, dumping or littering on the sea-shore or any place to which public has access. Also, regulations may be made regulating or prohibiting the dumping in the sea of substances and materials not complying with specified requirements or having specified properties (Section 32).

Dumping or discharging substances injurious to fish or aquatic plants or affecting the ecological balance in any area of the sea is an offence. Discharges or deposits of waste or any other polluting matter in a marine reserve requires a permit. To do so without a permit is an offence. These offences can be punished by a fine not exceeding R1,000,000 or to imprisonment not exceeding fifteen years or to both such fine and such imprisonment (Section 33).

However, the Act does not explicitly list discharging of a high organic content waste from fish factories situated on shore into the sea as requiring a permit, nor does it make any conditions for doing so.

3.3.10 Standards for Industrial Effluents

Regional Standards for Industrial Effluents were laid down in Government Gazette R553 of 5 April 1962. Provision was made for a Special Standard and a General Standard. The Special Standard was applied only to the selected catchment areas within the territory of the RSA. No catchment area or river in Namibia was included in this schedule. Therefore the General Standard is the only one applicable in Namibia. It stipulates quality standards for any wastewater or effluent produced by or resulting from the use of water for industrial purposes including water used by a local authority for purification or disposal of sewage or any effluent or waste. These standards were set with a view to preventing pollution of water that would render such water less fit for the purposes for which it is ordinarily used by other persons (including the Government and Local Authorities) entitled to the use thereof, or for the propagation of fish or other aquatic life, or for recreation or other legitimate purposes. The General Standard is considered to be adequate for protection of surface and groundwater. It is important to note that the Minister may prescribe requirements to which an effluent from any industry must conform on an individual basis. This will depend on the usage of water from that particular stream, i.e. as a source of drinking water, for industrial purposes, or for agriculture.

4. KEY ISSUES

4.1 The need for water resources assessment focussing on sources protection

Uncertainty concerning the availability of surface water preveils owing to low and erratic rainfall, high evaporation rates of impounded water and the obligation to share water from all our perennial rivers with the neighbouring countries. The variability of climatic conditions, coupled with unknown environmental requirements, makes the determination of potentially available quantities of surface water difficult and problematic. As far as groundwater is concerned there is very limited information available concerning its vulnerability, environmental risks involved in abstracting groundwater and long-term sustainability of the aquifers as sources of good quality water. The so-called, safe yield concept as applied when the use of an aquifer is planned and managed, cannot replace evaluation of the hydrologic and environmental impacts of groundwater abstraction. The big difference between these two approaches is that the former is easier and cheaper and the latter is very complex and can be horrendously expensive. Some type of trade-off between the two would be a wise compromise with a view to ensuring sustainable utilisation of our vulnerable aquifers with the limited knowledge on hand. A conservative approach is required in utilising the available groundwater resources, until such time that Namibia's groundwater resource base is better understood, more reliably quantified and the limits of sustainable abstraction from individual aquifers determined. This approach is warranted only if a water resource manager is prepared to accept the results of such surface water/groundwater research projects and apply them when deciding on water resources to be allocated. Recently, as a result of the course offered by the Desert Research Foundation of Namibia, a number of suggestions was offered by the students concerning the water reserve of the Kuiseb catchment. They suggested: "an in-depth study of the water reserve as the research proposes a 40 per cent reduction in abstraction to allow aquifers to recharge and the water level to recover to the reference level" (Nguaiko, 2000) Also, they were interested in the impact of the 750 dams in the catchment upstream of the Kuiseb River. This example is quoted to illustrate the point that this group of people evaluated the situation with a view to "maintaining a balance between abstraction, recharge and meeting the water needs of people, the environment and economy" (Nguaiko, 2000). Their findings differ a great deal from the assessment of the same aquifers by the bulk water supplier who explores, develops and manages water resources for the purpose of water supply. Consequently, there is a need for the water resource manager with a full responsibility for this and other water sources in Namibia. This responsibility can not be diluted between various interest groups.

The same example can be used to illustrate that it is impossible to separate water resources into groundwater and surface water when evaluating potential sustainable resources. Those 750 dams were constructed to catch some surface water at the expense of the groundwater resources in the lower catchment.

Groundwater investigations are expensive and require specialised skills. From a water resource manager point of view, these investigations should be focused on the availability of groundwater and protection of groundwater sources against depletion and pollution. The water resource manager (DWA at present) is responsible for allowing the depletion of the Kuiseb aquifers to happen, for over-abstraction of the Stampriet aquifer or for the continuous mining of the Koichab Pan aquifer. It is not a function of the resource manager to site and drill boreholes for the rural water supply. However, it is seen as one of the important functions to advise on how much groundwater can be abstracted on a sustainable basis and assume full responsibility for setting permit conditions.

Additional difficulty arises from the distribution of the Namibia's water resources in relation to our population distribution and the population migration patterns in the last decade; migration patterns that are expected to continue. There will be more and more people living in towns and, more or less, constant number of people living in rural areas. Already, Windhoek and coastal towns fully utilise their water resources. Sooner or later Windhoek will need to tap additional water source(s) and the coastal towns will have to finance the desalination of seawater. How much later depends on whether and to what extend these towns implement water conservation measures resulting in reduced utilisation of water resources. The distribution of our water resources results in a number of choices:

- to develop areas where water is available; or
- to embark on expensive long-distance water transfers to supply demands in the biggest urban centres; or
- to consider new water sources such as the sea requiring application of new and expensive technologies in Namibia, testing of such technologies produced questionable results in the past.

Water conservation, including water demand management should be seen as a complementary measure and not as a way to supplant the supply management techniques, such as developing new water sources. Before such a development is carried out and permits granted for using these resources, it is necessary to assess them, focussing on their protection with a view to maintaining a balance between abstraction, recharge and meeting the water needs of people, and the environment and ensuring the most efficient allocation of these resources.

4.2 Inadequate knowledge and control over water abstractions

According to the Water Act, 1956 (Act 54 of 1956), the owner of the land above owns groundwater and can use it at will, provided it is used beneficially. Outside of the declared water control areas, such water users do not need a permit to abstract groundwater on their properties/farms, do not pay any water use charges, do not have to do any monitoring of water levels and do not need to inform the water resource manager about the quantity of water they abstract. Consequently, except for the Karst and Stampriet areas and the Omaruru alluvial aquifer, it is not known how much groundwater is used for commercial farming purposes. As far as control over water use in these two areas is concerned, it must be said that it is very limited. There are 34 irrigation permit holders in the Karst area. 14 of them have never sent any information about the quantity of water that they were using for irrigation purposes on their farms. Do they irrigate? The farmer with the highest allocation of water of 1.5Mm^3/a has a 200hectare of irrigable land but irrigates only 2hectare. He has never sent any return to the Department of Water Affairs. This should be followed up by those responsible for issuing permits. If there is water to be utilised for irrigation, not to use it, is a waste. Some of the returns received from farmers are questionable. Is it really possible that one of them uses 2,158m^3/month exactly, from January to December? All the permits issued for the abstraction of water for irrigation in the Karst area amount to 7.294Mm^3/a. Is this sustainable? There are also other water users in the area, including NamWater, Tsumeb and Grootfontein Municipalities as well as tourist facilities. The situation concerning control over issued irrigation licenses in other groundwater control areas is similar.

Practically, there is no control over water abstraction from the Kavango River with four permit holders. One of them has never sent any return, and the Department of Agriculture stopped sending information concerning water consumption at Mashare in September 1994. The only permit holder fulfilling its obligation is the Rössing Foundation sending returns for Shankara. Assuming that all the permit holders use water allocated to them, it would amount to 12.775Mm^3/a. The present estimated water abstraction from the Kavango River is 21.481Mm^3/a (WCE, 2000). In view of the fact that this is an international river, this total lack of control over the utilisation of water abstracted from the Kavango River must be disturbing to the water resource manager. If all the other users use on average less than 250m^3/d, there must be many of them. The situation is a little better in the south with the abstractions of water from the Orange River. It might be because of the international obligations; "RSA mentioned that something has to be established to check and monitor when Namibia has reached the 50Mm^3/a. Namibia agreed to this" (Permanent Water Commission of the Republic of South Africa and the Republic of Namibia, 1998). Therefore, it must be stated that the knowledge of how much water is used in Namibia is very limited, fragmented, based on estimated consumption, and inadequate for proper water resources management. Also, no control *per se* over water usage in the water control areas is exercised.

4.3 Lack of a register of water users and uses

The lack of a register of all water consumers and the continuous long-term monitoring of water consumption of at least samples of different classes of users is an obvious defect in the water management system. Collecting data is usually time consuming and expensive. The past if at all possible, is difficult to uncover. On the other hand historical data are useful in water demand analysis. Having good quality water use data is a prerequisite of good estimates of future water demands. This becomes even more complex when integrating conservation into water resources and water supply planning. The latter is of particular importance for water suppliers and their revenues. Having good quality water use data is indispensable when planning and implementing water demand management measures. They will differ depending on the type of user and usage of water. Therefore, it is desirable to know not only how much water is consumed but also who consumes it and for what purpose. Similarly to the given example, municipal water use should be broken down to the following categories: domestic, commercial, institutional, industrial and losses. For the purpose of water demand management, it would also be useful to know how domestic water is used whether it be for watering gardens, flushing toilets, bathing, laundry, or drinking and cooking. Water demand management decisions should be based on costs and benefits analysis and, therefore, must be based on specific and detailed information. Our water use data is fragmented, incomplete, too general (urban consumption lumps together residential, commercial, institutional and industrial users) and often based on the recommended consumption figures and not on measurements. Also, it does not take into account the needs of different users of information, *e.g.* those who compile national accounts. Setting a national inventory of water consumers and water consumption figures is considered necessary in order to facilitate functioning of the water resources manager as well as to help the Local Authorities to identify areas where implementing water demand management measures would be beneficial.

4.4 High degree of the utilisation of the potential water resources

At present, 41.4 per cent of the total available resources, estimated at 717Mm^3/a, is utilised in Namibia. The latter figure includes perennial rivers, ephemeral rivers, groundwater and wastewater. It accounts for developed and undeveloped resources, including what can be lawfully abstracted from the shared rivers and what Namibia will, hopefully, be able to abstract in future.

Namibia will be able to meet her water needs of 555Mm^3 in 2015 as far as water resources are concerned. Water demand of 555Mm^3 for 2015 was estimated assuming that all the water consumers would implement water demand management measures to some extent and water losses in rural water supply schemes, small towns and the municipalities would be reduced substantially. Owing to the uneven distribution of these resources throughout the country, it will be necessary to transfer water between basins. There are basins with their potential resources already fully utilised, see **Table 13** and **Figure 3** (WCE, 2000). They are as follows: the Cuvelai, Swakop, Koichab, Tsondab and Tsauchab basins. In the Koichab basin, Luderitz is supplied with water from the Koichab Pan where the majority of the resource is considered to be fossil water, so duration of the sustainability is in fact questionable (WCE, 2000). The Swakop basin is the one with the most obvious shortages of water despite transfers from the Omatako and Kuiseb basins to meet its present water demand. Unlike the Cuvelai basin, the Swakop basin does not have a neighbour with abundant under-utilised water sources. Therefore, despite having sufficient potential sustainable water resources for the near future in Namibia, some basins rely and others will have to rely on water transfers because of unfavourable distribution of these resources. It must, also, be stressed that when estimating the future water demand, one of the components was omitted. Environmental water demand or environmental reserve is still to be determined and it may reduce our potentially available water when included in the above calculation.

At present no charges are levied for water abstraction. This is considered to be additional mechanism for influencing demand and controlling water abstraction and use. Regulation and water use charges practised together can also be seen as a water conservation mechanism.

4.5 Insufficient infrastructure to supply the future water demand

There are many water suppliers and water supply schemes in Namibia. Only the three biggest and most extensive systems operated by the bulk water supplier were analysed concerning their infrastructure sufficiency. These are the Cuvelai drainage basin network, Eastern National Water Carrier (ENWC) and the West Coast supply system.

The Cuvelai drainage basin network can supply water demand of the basin well into the future with some major components, *e.g.* Oshakati - Ondangwa, Oshakati - Omapale, the bulk infrastructure feeding the Ombalantu area, that can supply approximately 150 per cent of the present demand. Upgrading some pump stations and increasing storage capacity will, probably, be sufficient to supply the future demand in this basin.

The Eastern National Water Carrier has a number of components. Most of them have sufficient capacity to meet the future demand of their respective centres. There are, however, exceptions. Pipeline capacity is insufficient to meet water demand of Gross Barmen at its peak-projected demand in 2015. Also, there is insufficient pumping capacity to supply Windhoek at its peak-projected demand in 2005 (WCE, 2000). However, the main issue is to tap a new source of about 17.28 Mm^3/a that will be needed additionally in the central areas of Namibia, and provide infrastructure required to connect this source to the ENWC, most probably at Grootfontein where the ENWC ends.

The cheapest option is to link Rundu to Grootfontein at a cost of N$ 603 million in 1997 constant prices which is an exorbitant amount of money. The second cheapest solution is to link Oshakati to Grootfontein at a cost of N$ 875 million. Exploring all the possibilities to save water that can be created by implementing water demand management measures is, therefore, well worth trying because it can postpone new infrastructure requirements and development.

Generally, the West Coast supply system has sufficient capacity to meet future water demand of their supply centres at the West Coast. However, pipeline capacities to supply peak-projected demand at Walvis Bay and Henties Bay in 2015 are insufficient. Similarly to the ENWC, there is a question of additional sources of supply. Recently, it was recommended that the desalination of seawater be considered for augmenting water supplies at the cost. Estimated cost of a reverse osmosis plant is N$ 227.2 million, in 1995 constant prices (GKW, *et al.*, 1996).

Rural water supply infrastructure requirements have not been evaluated yet. At present, the Directorate: Rural Water Supply is involved in having the Kavango and Caprivi regions assessed and rural water supply development plans prepared. It is difficult to answer how much money is needed to secure that 90 per cent of the rural population has access to potable water by 2010, as targeted by the Directorate. Access is defined as being within 2.5km of the home, whilst users should not have to wait longer than 30 minutes to collect water. There will be estimates available when such plans for all the regions requiring rural water supply schemes are finalised (Zelma, personal communication).

4.6 Wastage of water

Wastage of water occurs because of the following reasons:

- leaks, pipe-breaks and generally poor maintenance due to limited information available about reticulation systems and the lack of trained personnel to maintain the water supply infrastructure;
- low water tariffs and wide-spread subsidies by the government as well as institutional arrangement resulting in water bills being paid by the Ministry of Local Government and Housing and not Local Authorities themselves;
- lack of durable and reliable water efficient fixtures and fittings in the Southern African region;
- lack of regulations pertaining to service metering, leak detection and rate structures; our regulations are written in such a way that Local Authorities may do quite a number of things but they can as well do very little - shall is not often used in those regulations;
- water - inefficient landscaping and inefficient agricultural irrigation methods and practices are commonplace;
- lack of attractive, properly designed and continuous public awareness campaigns and education, including education of school children, with a view to changing water-use practices.

The above points form a fairly exhaustive list of the elements of water demand management practice which, in conjunction with the supply side, could realise a number of benefits. The main one is considered to be water conservation by reduction of water withdrawals and forestalled future supply capacity needs. Water demand management is practised by a few local authorities, mines, industries and other establishments in Namibia with satisfying results. However, a national policy and strategy, with the development of detailed guidelines to follow and capacity building, would result in water demand management becoming a way to handle water resources and water supply issues by local authorities. It could have impact on individual consumers by changing their water-use practices and eliminating wasteful uses of water. Finally, it would, most probably, affect water suppliers who want to maintain their revenue stability.

Of the number of benefits of practising water demand management some seem more important than others by being more fundamental. Reducing water demand by 30 - 50 per cent with no deterioration in life style, significantly reducing capital requirements (Forde, 1999) for developing new water resources, transfer schemes, water treatment and wastewater treatment works and reducing potential for pollution, are the major benefits.

Unfortunately, only a few towns in Namibia seem to realise this, with Windhoek being a very lonely leader.

It was estimated that 17,28m^3/a is most likely to be needed additionally in the central area of Namibia in 2012/2013 (BICON NAMIBIA, *et al.*, 1997). This figure includes the following estimated savings through water demand management: Windhoek - 1,9 per cent, Okahandja - 2.1 per cent, Otjiwarongo - 5,5 per cent, Grootfontein - 16,1 per cent and Tsumeb - 10,4 per cent. Relatively high potential savings in water consumption in Grootfontein were due to excessive water consumption in government and semi-government institutions. Possible saving at the Army Camp in Grootfontein was estimated to be 90 per cent which means that 90 per cent of water used at the camp is wasted.

4.7 Lack of water tariff policy and transparency in setting water tariffs at present

In the absence of a national policy on water tariffs or any guidelines concerning these issues, the institutions concerned decide on how they calculate their water tariffs. Many Local Authorities and NamWater were approached by the consultant with a request for information. Very limited information was obtained from NamWater after a request, signed by the Minister, had been sent to the Corporation. Two reasons were given for this reluctance: area based cross-subsidisation and that their annual report was subject to the approval by Cabinet; no information was to be revealed before this happened. Actually, according to the Act, the Minister is to table the annual report of the Corporation to the National Assembly, presumably for information.

The Local Authorities have found it equally difficult to provide the requested information. **Table 14** (Africon Namibia, 1999) illustrates it better than any discussion could do it. It is likely that some Municipalities or Town Councils do not keep detailed records and found it too cumbersome to extract the information. It is, however, surprising that the Windhoek Municipality was not in a position to provide any information whatsoever. In this case and others, it is, most probably, not inability to do it but lack of transparency for one or another reason.

Obviously, all the above-mentioned institutions have to recover financial costs of supplying or reticulating water in order to provide water supply services on a sustainable basis. Villages of Bethanie, Kalkrand, Leonardville and Maltahöhe where water tariffs are lower than the Namwater tariffs must subsidise this service with money coming from charges for other services or fees. These villages receive their water bills from NamWater and pay their water bills directly to NamWater. Therefore, provision to cover their expenses is not made in the budget of the Ministry of Regional and Local Government and Housing.

Except for a few towns with increasing block tariffs and some with a high flat rate, the water retailers do not seem to be concerned with conservation-oriented pricing. There are a number of criteria that have to be considered when evaluating water tariffs. They include the following (AWWA, 1992):

- Financial sufficiency;
- Ease of implementation;
- Impact on customer groups or individual customers;
- Equity;

- Water conservation;
- Simplicity and understandability by customers;
- Legality.

Some of these principles are recommended in WASP, but it is not clear whether all Local Authorities know about this policy. Clearly, there is a need for detailed guidelines or a policy concerning water tariffs that could help Local Authorities to decide on their objectives in accordance with the objectives set for the whole country by the Government. WASP gives fundamental principles and could be a good starting point. Priorities on the above list will be different for different towns but all of these elements should be considered by each Local Authority. An appropriate oversight institution would be needed to facilitate this process, *e.g.* Independent Pricing Regulator.

Also, from a conservation point of view, it is imperative that the procedure for setting tariffs and tariff structures are transparent and the public is allowed appropriate input before decisions are taken. This does not happen at present. Therefore, it is difficult to judge if any of the above institutions takes into account costs of implementing water demand management measures or at least a leak detection programme in order to reduce unaccounted-for-water.

Clearly, there is a need to improve transparency of all the suppliers and distributors by detailing the services they provide.
Projected costs of the Department of Land and Water Conservation in Australia (operator + water resource manager + regulator) include the following costs:

- Surface water database,
- Groundwater database,
- Other water databases,
- Water information products,
- Surface water allocation strategy,
- Surface water licences,
- Groundwater allocation strategies,
- Groundwater licences,
- Rural water supply strategies,
- Rural water operations,
- Flood operations,
- Rural water infrastructure,
- River quality/flow reforms,
- Blue green algae strategies,
- Groundwater strategies,
- Water industry strategies,
- Environmental planning controls,
- Integrated natural resource management framework,
- Catchment strategies, and
- Community education campaigns.

The above costs form a structure of water tariff (NSW Department of Land and Water Conservation, 1998). The above list is presented to illustrate what 'detailing the services' means.

As far as tariff systems are concerned there are only two in Namibia, namely:
- uniform volume rates with a single rate (flat rate) for all metered or estimated units of consumption;
- inverted-block rates or increasing blocks with the rate per unit of consumption increasing with each successive step.

Setting a flat rate sufficiently high could be considered as a conservation oriented rate. However, for some customers it might be difficult to afford water services at the resulting high rates. Also, such practices are "illegal" if WASP is considered to be an official policy of the Government.

Inverted block rates can contribute to water conservation, depending on the level of rates and how rate blocks are set. This system offers an opportunity to set the rate for the final block at the marginal cost of the new water supplies. Also, the initial block rate can be set at a level that provides for "a defined minimum lifeline volume of water" as recommended by WASP.
There is another rate structure with quite unique characteristics. Conditions in which it is likely to be adopted are as follows:
- water resources are scarce in the area served; or
- water use reduction is a major objective of the utility or community.

A marginal-cost rate structure is developed to set rates equal to the cost of providing the next increment, or marginal unit(s), of service to the customers. True marginal cost rates are difficult to define, develop, and implement. One of the solutions is to adopt modified marginal cost rates. Under this concept, the utility sets rates based on long-term marginal costs associated with new supply, treatment, distribution, and customer facilities, which are typically more expensive. In this situation, a utility is signalling to the customer what it would potentially cost to construct more expensive facilities for service. The customers respond to the pricing increase through their consumption and indicate whether the utility should go to the more expensive service facilities. If properly designed, a marginal cost rate can ensure efficient use of the utility's facilities and water resources. Also, it can generate surplus revenue that could be set aside for future capital projects. This could help to avoid large "jumps" in water tariffs when an expansion is unavoidable. Additionally, this rate structure provides to utilities information similar to that obtained from a willingness to pay study. The coast and the central area of the country face water supply problems and these could be used for testing this rate structure. It has been shown in Windhoek that higher tariffs resulted in reduced demand. It is likely that marginal cost rate would result in significantly reduced demands in both these areas. The communities would realise that owing to the supply limitations, it is imperative to use the resources more efficiently and it is necessary to adopt a rate structure that takes into account the cost of the proposed expansion. This approach is very much in tune with the following WASP recommendation:
"In determining priorities the real value and cost to provide water should be carefully calculated and considered, in consultation with consumers, to decide on the real need and viability of any prospect to be developed".

4.8 Limited reuse and recycling of reclaimed water

Reclaimed water is not used as an alternative water source in many places in Namibia. To start with, it is not seriously considered as such in planning new supplies. However, reuse of water is practised in a few urban areas. Wastewater recycling is practised by a number of mines. To encourage more reuse and recycling of water, higher water tariffs would be a good incentive; it would become more viable to treat wastewater and reuse or recycle industrial effluent. The biggest towns including Swakopmund, Walvis Bay, Tsumeb, Otjiwarongo, Mariental, Okahandja and Windhoek used about 31.73Mm^3 in 1999 (WCE, 2000). They reused about 4.09Mm^3 (town engineers, personal communication) of their treated wastewater. Assuming that 50 per cent of fresh water consumed becomes wastewater, wastewater utilisation was about 26 per cent. Oranjemund was excluded from this calculation because it is an exceptional town where only about 10 per cent of the total volume of water extracted from the boreholes arrives at the wastewater treatment facility. Of that amount about 50 per cent is reused. If calculated nation-wide, the figure of 26 per cent mentioned above would be much lower because except for the above towns, reuse of treated wastewater is negligible. Individual reuse of wastewater in a form of "grey" water is also negligible with only six installations completed in Windhoek. Both low water tariffs and relatively high cost of the system (about N$8,000) contribute to its modest popularity despite very good performance.

Concerning water reclamation and reuse for drinking purposes, the capacity of the plant in Windhoek will be increased from 8,000m^3/d to 21,000m^3/d in the near future.

A few mines using fresh water as process water practise reuse and recycling. However, owing to lack of information about most of the mines one cannot make a general statement. Water demand for mines in Namibia was estimated at 13.38Mm^3 in 1999. Assuming a similar level of reuse and recycling at Auchas Mine, Navachab Gold Mine and Rössing Mine as in previous years, about 3.51Mm^3 (about 26%) was reused and recycled in 1999. It would be informative to collect more information including smaller mines. Additionally, sometimes when mines reuse and recycle industrial effluents, their associated towns use water in excess owing to free water available to the employees. Arandis and Oranjemund are such examples.

Comprehensive reuse of water for industrial purposes is not practised at present. Industrial establishments are usually in towns and their water consumption is included in urban consumption. For the purpose of water conservation they should be registered and monitored separately, including reuse practices.

From information on hand, it is concluded that there is additional potential to increase reuse of treated municipal wastewater as well as reuse and recycling of mine/industrial effluents. The fact that the practice of water conservation is only limited to a few towns, three mines and a few industrial establishments is considered to be a serious issue in the country with limited water resources and a very unfavourable distribution of these resources.

4.9 Lack of policies concerning water quality issues

Namibia does not have a national water quality policy. However, there are some recommendations regarding water quality in other policies/documents.

- One element of the overall long-term sector policy as recommended by WASP stipulates that: "an environmentally sustainable development and utilisation of the water resources of the country should be pursued in addressing the various needs".
- WASP lists sector objectives, including:
  - to protect water resources from pollution;
  - to promote the conservation of water;
  - to promote economic development.
- WASP also stipulates that: "The possible pollution of water should be guarded against. A pre-emptive management approach rather than trying to counteract eventual negative effects should form part of all planning and decision making processes" (Department of Water Affairs, 1999);
- NDP1 says that: "Water is a basic human need. The Government is committed to providing safe drinking water to the whole population" (NDP1, 1995);
- The Constitution of the Republic of Namibia in Article 100 underlines "maintenance of ecosystems, essential ecological processes and biological diversity…"

Based on the above, the water quality policy objective could be formulated as follows: *to ensure sustainable utilisation of the water resources of the country by protecting their quality through pollution control and water conservation with a view to securing the well-being of the whole community, at present and in the future, while continuing with social and economic development*.

This could be considered as **what** the Government wants to achieve. A strategy to achieve the policy objective is not in place and should be developed, which means to set out precisely **how** the policy should be implemented and by **whom**. There is a need for a detailed plan of action for developing and implementing strategies concerning water quality issues.

4.10 Ineffective and inadequate water pollution control

The Department of Water Affairs has a statutory duty to control the disposal of "industrial water and effluents" generated by the use of water for industrial purposes, including urban water supplies, to ensure that no pollution takes place. It is recommended that industrial effluents and wastewater be sufficiently treated before being returned to where the water was abstracted. Sufficiently means that it complies with the requirements of the General Standard as stipulated in regulation No. R. 553 of 5 April 1962. However, achieving this compliance necessitates an advanced wastewater treatment. As none of the plants that were installed were able to comply with these requirements, exemption permits were issued instead. It must be admitted that it is costly to treat sewage. Typical capital expenditure for activated sludge treatment is N$ 496,000, N$ 113,6000, N$ 222,4000 and N$ 6,050,000 for treating 50m^3/d, 150m^3/d, 500m^3/d and 2,000m^3/d of sewage respectively (Africon, 2000). It might be cheaper to contain raw sewage in stabilisation/evaporation ponds than to treat it and reuse it, or to provide additional supplies of fresh water, when the water is plentiful and pollution regulations are lenient. When they are not, it might be beneficial to reuse treated wastewater and conserve good quality water sources.

Therefore, from water a conservation point of view, exemption permits should be granted only after thorough evaluation of the applicant’s water demand and supply situation. If proper treatment and reuse of wastewater proves to be beneficial using benefit-cost analyses, the proper treatment should be carried out. At present, it is too easy to get an exemption permit.

No regulations have been made concerning procedures to be followed during the processing of applications and issuing permits. Proper functioning of the present procedure depends on good will and understanding of the Department's statutory obligation by other Government institutions. Generally, these are lacking if only 15 out of 165 exemption permits are currently valid. The procedure is all-inclusive and a few Ministries may be involved during a process of issuing one permit. Delays of a few years in issuing permits are commonplace.

Lack of suitably qualified and dedicated staff in the Department and other involved institutions is one of the reasons for those delays. There are difficulties right from the beginning. According to the policy of decentralisation questionnaires with a request for information are forwarded, via relevant Ministry, to the Regional Councils. Unfortunately, these institutions lack suitably qualified staff. Often the questionnaires return to the Department incomplete or erroneously completed. The Ministry of Health and Social Services might recommend that a permit be not issued because of lack of a fence around the stabilisation ponds. However, it is a common knowledge that fences in Namibia disappear in no time.
Additionally, the requirements as stipulated in regulation No.R. 553 of 5 April 1962 are unrealistic. They must have been developed for disposal of treated effluent into perennial rivers. That high degree of treatment is not needed if effluent is to be used for irrigation of lucern. There is a need to have a number of guidelines for the required quality of effluent, depending on its designated use. Ideally, the Department of Environment could determine limits for pollutants in each site individually and based on this information it would not be too difficult to decide on the effluent quality.

4.11 Fragmented information with restricted access

Data collected for hydrological, geohydrological and water quality purposes are kept separately in different databases. As a matter of principle this is undesirable. First of all it flouts the concept of the hydrologic cycle. Secondly, it is against the principle that the hydrologic cycle must be defined in terms of both the water quality and the water quantity. Thirdly, it does not serve its main purpose of facilitating and supporting decisions concerning water resources management by offering one 'piece' of information at a time.
How those different databases could be linked is being investigated at present. However, it does not appear that the need for data integration has been accepted; linking does not mean integration.

Concerning GROWAS that is being developed at a huge expense to the Government and NamWater there are a number of issues that need to be pointed out. It is obvious that it does not recognise integration as its fundamental principle. For NamWater at least it integrates surface water, ground water and water quality information as well as ground water extraction permits. Presumably there is another database for infrastructure and operation and maintenance. Soon there will be a need for surface water abstraction permits. A register of all customers appears to be a logical component of such a database that would facilitate water demand projections and control.

However, the integration of data within the Department is more urgent than the above. Also, GROWAS reflects the present situation only. It is to be seen whether it will be useful for a register of all ground water users including those who drill their own boreholes. Some of them will not need to send returns on water extraction and others will have to do it. Where will surface water abstraction permits be accommodated? Also it is difficult to see how the Geohydrology Division will fulfil its obligation to "monitor and investigate pollution of water resources" (DWA File No: 12/1/2/15, folio 46). Location of wastewater disposal facilities in relation to water sources would greatly facilitate such monitoring programmes and investigations. Also, it would be useful when evaluating applications for effluent disposal. Why not include wastewater disposal permits in the same database? From the available information it is difficult to see how the Department will use the Water Quality and Borehole Production Modules for its own monitoring boreholes and for returns from users other than NamWater.

To call an information system the 'water sector information system' would require that needs of other users of data are considered. There is an urgent need for such a system to be developed owing to the increasing costs of collecting and processing data.

At present access to information is restricted. As a general rule, hydrologists have access to HYDSYS, geohydrologist have access to GROWAS and Water Environment staff have access to water quality database. Permits are processed manually.

4.12 Grouping in one ministry the water resources manager with the biggest water consumer

At present, water resources management is carried out by the Directorate: Resource Management of the Department of Water Affairs at the Ministry of Agriculture, Water and Rural Development. At the Department of Water Affairs there is also the Directorate: Rural Water Supply. This means that the resource manager who is to protect water resources and allocate them for the most efficient use is in the same organisation with by far the biggest and the least efficient water consumer, *i.e.* agriculture and with the Directorate where water is treated as a public good. Objectives of the water resource manager are very different from those of the other Directorate and the Department of Agriculture. It appears that there is more commitment to developing agricultural sector that produces goods than to water resources management. Also, the Ministry is committed to ensuring that safe drinking water reaches the whole population. Consequently, the water resources manager receives less attention and less money. Hydrological monitoring stations are rather closed than opened owing to the lack of financial resources, aquifer studies are only carried out when outside financing and expertise becomes available, source water quality is not monitored any more, of the 165 pollution permits only 15 are valid, there are no checks for compliance with conditions set in the water abstraction permits. The Department of Agriculture does not fulfil its obligation to adhere to the permits' conditions and does not send returns on how much water is used for irrigation. It proves to be impossible for the resource manger to carry out his statutory obligation even within the same Ministry. This situation has continued for the last few years and it deteriorates rather than improves with time. Failure to ensure that a Water Supply and Sanitation Co-ordination Committee works is additional prove of this deteriorating situation. It is unfortunate that the creation of NamWater happened in isolation and not as a part of integrated plan for the whole sector. It also appears that it was created prematurely. The commercialised bulk water supplier treats water as a commodity. This is a fine and popular concept and works well in the United Kingdom where water supply has been privatised and resources are relatively ample and consistent. The fundamental difference between the United Kingdom and Namibia in this regard is that most people can afford to pay the full costs of water supplied to them.

A tiny minority of those who can not afford to pay is helped by a charity funded by the association of the water suppliers. It was an outcry when Hepatitis B cases were reported as a result of water disconnection. At present, in Namibia there are probably relatively many more people who can not afford to pay for piped safe drinking water and owing to the policy of Government this type of water should be treated as a common good. It appears that it is becoming more and more difficult for the Government to subsidise more and more expensive water supplies, hence the cross-subsidisation policy. In practice it means abandoning some important aspects of WASP that, besides other uniquely valuable elements, was water conservation oriented. This also means that those who can pay will have to help the Government to subsidise water supplies in the whole country. It is a form of indirect taxation.

There is scope for conflict of interests and duplication of functions between the bulk supplier, Local Authorities, rural water suppliers and the resource manager. Namibia can ill afford this. A few examples are presented to illustrate this point.

- Flood warning in general and flood control at gated dams are both functions of the Division: Hydrology at the Department of Water Affairs. However, these dams belong to NamWater. Who is really responsible? This particular question should be answered as soon as possible. It is a question of safety and co-operation with the Emergency Management Unit at the Office of the Prime Minister.
- The Division: Hydrology is responsible for investigations and assessment of surface water resources including yield studies for dams on the ephemeral rivers. However, these studies are carried out by NamWater.
- The Division: Geohydrology (DWA) is responsible for monitoring and investigating pollution of water resources (DWA, File No: 12/1/2/15),
  The Division: Water Environment (DWA) is responsible for monitoring pollution of surface and groundwater resources in general (NWRMR, 1999).
- Some objectives and functions of the Division: Geohydrology are set out in the table hereunder together with corresponding functions of Namwater. The duplications and potential conflict are obvious.

Department of Water Affairs	**NamWater**
Investigating the occurrence of groundwater	Investigating the occurrence of groundwater
Plan and establish a monitoring system	Collect and collate monitoring data from dedicated observation boreholes
Assembling existing groundwater information	Collecting and collate existing groundwater information
	Routine updating of production borehole monitoring data on the National Groundwater Database of DWA
	Routine updating of the National Groundwater Database of DWA
Making recommendations regarding the utilisation of groundwater in the subterranean water control areas Advise on the utilisation of aquifers and boreholes	Presenting recommendations regarding the utilisation, monitoring and management of the groundwater resources in terms of an appropriate abstraction strategy to be implemented

Assuming that a full cost recovery policy is implemented, who is going to charge for what? Is it NamWater's function to update the National Groundwater Database of DWA? Actually, the question is who is responsible? If NamWater does not keep it up to date, the Division Geohydrology at DWA is responsible because it renders the service of a national geohydrological centre to the country.

Also, it proves difficult to find sufficient human resources locally for disintegrated: water resources management, bulk water supply, rural water supply and the regulator (to be created). Each of these institutions will also have its own human resources development programme, finance departments, administration, databases. For the time being more and more employment opportunities are created only for expatriates.

5. CURRENT INITIATIVES

5.1 Environment Management Act

According to the Act all people and government Institutions have a duty to protect and conserve Namibia's environment, including water. As a renewable resource, water shall be utilised on a sustainable basis. The Act stipulates that the polluter pays principle shall be applied and that reduction, re-use and recycling shall be promoted. It, also, stipulates that there shall be no importation of nuclear, hazardous or toxic waste into Namibia (Part 2, Section 6). Compliance with these and other listed principles of environmental management, *viz*. community involvement, public participation, equitable access, are to be monitored by the Sustainable Development Commission with the assistance of the Environmental Commissioner. One of the Commission's functions is to co-ordinate pollution control and waste management.

It does not list, as one of its functions, formulation of national strategies, plans, programmes and guidelines for the development and utilisation of water resources. It does not explicitly address water demand management. It does, however, stipulate that environmental assessment is required before carrying out such activities as:

- the construction of canals and channels including the diversion of the normal flow of water in a river bed and water transfer schemes between water catchments and impoundments;
- the drilling of boreholes and the construction of dams, reservoirs, levees and weirs;
- the erection and construction of sewage treatment plants and associated infrastructure;
- the erection and construction of waste sites, including any facility for the final disposal or treatment of waste;
- the abstraction of ground or surface water.

The Act establishes general principles for the management of natural resources, therefore including water resources, in so far as to give guidelines to the Environmental Commissioner with a view to determining whether an environmental assessment is required or not. To give statutory effect to the Namibia's Environmental Assessment Policy is the main objective of the Environment Management Act.

5.2 Pollution Control and Waste Management Bill; first draft

Only two aspects of this proposed legislation will be discussed, namely: water quality monitoring and pollution licensing. The Bill stipulates establishment of the Pollution Control and Waste Management Agency that would, as some of its functions, undertake and co-ordinate the monitoring of water quality in Namibia as well as make regulations setting standards, objectives or requirements in relation to water quality. It is not specified what water quality. As far as water resources quality is concerned, it is part and parcel of the hydrologic cycle that must be defined in terms of both the water quantity and the water quality. When discussing water resources, both the quantity and the quality aspects must be considered (Mays, 1996). Therefore, a water resources manager should do water quality monitoring.

The Bill stipulates that setting limits for the discharge of pollutants, specifying water quality objectives, specifying standards for the pretreatment or purification of effluents as well as specifying the procedures for determining compliance with any such standards would be done by the Pollution Control and Waste Management Agency. The Agency would also do pollution licensing, *i.e.* regulate application procedures, process applications for a licence and maintain a licence register.

5.3 National Drought Policy and Strategy

The objectives of the proposed drought policy are to:

- "ensure that household food security is not compromised by drought;
- encourage and support farmers to adopt self-reliant approaches to drought risk;
- preserve adequate reproductive capacity in livestock herds in affected areas during drought periods;
- ensure the continuous supply of potable water to communities, and particularly to their livestock, their schools and their clinics;
- minimise the degradation of the natural resource base during droughts;
- enable rural communities and the agricultural sector to recover quickly following drought;
- finance drought relief programmes efficiently and effectively by establishing an independent permanent National Drought Fund".

The policy attempts to introduce measures that support the on-farm management of risk that should be taken into account by farmers in Namibia, instead of regular financial assistance to commercial and communal farmers. It advocates that short-term financial assistance and drought relief programmes should be limited to exceptional years of "disaster drought". A list of measures that could be taken to reduce vulnerability to drought includes water supply and demand management and water pricing. Equity, efficiency and sustainability are basic principles on which the proposed policy is founded. The policy advocates the conjunctive use of different water sources, conservative aquifer management and the use of non-conventional water sources. Water awareness campaigns, punitive water tariffs for large water consumers and specific regulations to promote the responsible use of water resources by farmers, are seen as important elements of the strategy to reduce long-term vulnerability to drought.

The policy recommends that a disaster drought is declared only when exceptionally low rainfall conditions prevail, *i.e*. seasonal rainfall is lower than that prevailing in the lowest 7 per cent of growing seasons in a particular area.

The proposed policy and strategy have not yet been approved.

5.4 Sanitation Policy

The Ministry of Health and Social Services (MOHSS), acting on recommendations made by the Water Supply and Sanitation Co-Ordination Committee (WASCO, 1996), accepted the national responsibility for sanitation and initiated the development of a National Strategy on Sanitation. At present, the so called, zero draft is available and is having circulated for comments. Sanitation was defined as “the process whereby people demand, effect and sustain a hygienic and healthy environment for themselves by erecting barriers to prevent the transmission of disease agents”.

Rural sanitation, largely ignored in the past, is given most attention in the document owing to the results of 1991 census showing that only 12 per cent of rural households have access to sanitation facilities. From a mid – decade goals survey carried out in 1996, it was estimated that about 145 000 households would require sanitation facilities. This is approximately 80 per cent of all rural households. At present, the favoured option for rural sanitation is a VIP latrine. According to the MOHSS, N$ 50.8 million (at N$ 350 per unit) would be needed for construction material only. Achieving 50 per cent of NDP 1 target by 2006 would mean building about 10 000 latrines a year for next 7 years at N$ 3.63 million per year. In the financial year 1998-1999, the MOHSS provided N$ 1.3 million for sanitation projects. It is obvious that financing household sanitation is a difficult issue. The initial proposal by the MOHSS is that the Ministry should consider providing approximately 50 per cent subsidy on materials. To assist communities with additional financing a revolving fund/credit scheme could be developed. However, present concerns are long term sustainability and availability of sufficient funds to cover such an option. Financing institutional sanitation at schools, health facilities and public places, is yet another challenge for the MOHSS. It is, also, planned to explore issues of urban sanitation in informal settlements, as local authorities in many areas neglect this, often due to a shortage of funds and skills.

Additionally, some technical problems were identified such as the need for pit lining, a lack of naturally occurring clay and hard rock in many parts of Northern Namibia or seasonal water-logging of pits. All these are likely to add to the basic cost of the provision of sanitation.

According to the zero draft document on sanitation, “environmental aspects, such as the potential pollution of water sources, may also be problematic in some areas and should also be considered”. Though, the MOHSS’s main concern is the promotion of sanitation and hygiene education with a view to reducing the burden of poor sanitation resulting in unnecessary loss of life, they are conscious of negative environmental impacts which the widespread construction of pit latrines may have if not done properly. The ministry contemplates conducting environmental impact assessments and consulting other ministries in this regard. Such an approach, from a water conservation point of view, is commendable.

5.5 Water Demand Management Country Study

The Water Demand Management Country Study was carried by the Directorate of Resource Management of the Department of Water Affairs and Water Services of the City of Windhoek according to the proposal based on the terms of reference supplied by the World Conservation Union (IUCN). The final report was submitted to the IUCN in 1999. Most of the recommendations are listed below. They are as follows:

" The creation of a distinct National or even Regional Water Demand Management Policy, to raise awareness of the scarcity of water and to focus the players in the water sector on the issue of water conservation and efficiency of supply, will yield net benefits comparable to those seen in Windhoek. Evidence from around the country suggests that there is considerable potential to be exploited.

From a WDM point of view it is important that NamWater be monitored/regulated in order that the financial pricing technique reflects the long-term cost of water supply and that environmental costs are taken into consideration and managed. If this is not the case, consumers will be given the wrong signal with respect to the scarcity of water and although NamWater may achieve financial cost recovery, the social costs of water may not be reflected.

Local Authorities share the responsibility for providing water. Tariff setting in Local Authorities has been shown to be inadequate for WDM. It is important that Local Authorities pass on the rue costs of water supply to the consumers. Training to improve in this area is urgently required.

The extend of non-payment and unaccounted for water should be addressed in order to establish the sustainability of supply in certain areas. Unaccounted for water, non-payment and tariff setting should be monitored over time to indicate the effectiveness of the new management regimes.

The extent to which savings in water could be achieved cost effectively in the Government institutions should be investigated.

The accountability of different water users needs to be established at each supply node, e.g. NamWater, Local Government/municipality, and consumer (residents, businesses and government institutions). It seems evident that a firm grip on water accounts in each of the institutions is required for water to be effectively managed.

The establishment of a regional network and website on Water Demand Management practices to promote the exchange of information will be worthwhile.

An interest group in the region to further the objectives of integrated Water Demand Management policies and practices should be created.

Establishment of specific water intakes for different types of mining and industrial operations in the region is recommended.

A series of guideline booklets specific to each sector should be developed for the region" (van der Merwe, ed., 1999).

5.6 Zero emissions research initiative (ZERI)

The ZERI integrated biosystem concept is based on the premise of zero waste and zero pollution. This implies more than wastewater treatment. It is wastewater and solid waste utilisation. A pilot plant will be constructed at the Ujams Treatment Works that receives wastewater from the Windhoek northern industrial area. More than 97 per cent (900m^3/d) of the influent to the Ujams Treatment Works comes from Hartlief, Meatco and Namibia Breweries Ltd., with high concentrations of organic material. According to the Ujams integrated biosystem process design, organic waste will be utilised for animal (pigs, ducks, crocodiles) production, cultivation of mushrooms and crop production (fruit trees, shrubs, vegetables and fodder). Funding for the construction of the pilot plant has been secured based on the economic viability and sustainability of the project (Van Harmelen, 1999).

6. OPTIONS

6.1 Improved water resources assessment focussing on sources protection

The water resource manager, e.g. Water Resources Management Agency, should be responsible for overall management of the water resources. This responsibility must be clearly assigned to the Agency in contrast to systematic monitoring that should be done by water users. Monitoring of water resources and reporting to the Agency should be a condition for the issue of an abstraction permit. The Agency should be in a position to authorise any suitable staff member or any other person, e.g. a consultant to verify the received information submitted in the application by means of investigations, taking readings, collecting samples, or any other accepted method.

From a water conservation point of view, water resources assessment should be carried out on a basin basis with a view to determining the potential sustainable resource. The analysis should be based on integrated water resources management approach with full recognition that groundwater and surface water belong to the same hydrologic cycle and that the hydrologic cycle must be defined in terms of both the water quantity and the water quality. If hydrological mapping of the country is considered worthwhile, the same must be said about a rainfall/runoff map and a groundwater quality map of Namibia. The quality aspect should, also, be considered in any hydrological investigation and assessment. From a potential user point of view, flow of a river has more meaning when complemented by water quality information. If this is accepted, a surface water quality map of Namibia appears as a possibility, although not in the near future.

Considering that water resources assessment data can be of interest to many other institutions and individuals, collecting, processing and storing of information should be done in such a way that the needs of potential users are recognised. Apart from a water resources management point of view this information will be of prime importance when regional development plans are prepared and catchment management committees are established. Also, it will be useful to support negotiations concerning shared rivers.

6.2 Implement water allocation system and appropriate controls

In order to further our knowledge concerning water abstraction from the rivers and withdrawal from the aquifers, it would be useful to declare the whole of Namibia a water control area, with a different degree of control for different areas depending on their vulnerability. A priority status must be afforded to those areas that have been declared water control areas already. Kuiseb alluvial aquifers and the Koichab Pan should be added to this list of the most sensitive areas in Namibia. Less sensitive areas would require lower degree of control. Those different degrees of control could be as follows:

- A - for boreholes with extraction of >10m^3/d: registration with the water resource manager;
- B - for boreholes with extraction of >25m^3/d: registration of the boreholes, metering and making this information available on request;
- C - for boreholes with extraction of >50m^3/d: registration of the boreholes, source metering, recording and reporting to the water resource manager. A permit would be required to abstract more than 50m^3/d.

The above figures were only given for illustration purposes. Obviously, they could be different for different areas and the Geohydrology Division is best equipped to advise on proper numbers.

Owing to the fact that all of Namibia's perennial rivers are shared rivers, they should be given a C status with an exemption to send returns for those who use less than, say, 25m^3/d. Still they would have to register. Water stored in the dams owned by NamWater belongs to the State and therefore the Corporation will have to obtain permits for abstraction of surface water from these dams, measure it, record it and send the data to the water resource manager. A register of farm dams should be compiled to complement evaluation of potential sustainable resources.

This register will require source metering by individual users and an indication on how they use their water.

6.3 Establish and maintain a register of water users and uses

The above register of individuals and institutions drawing water from the aquifers and abstracting it from the rivers will not provide sufficient information on how water is used in Namibia. Bulk suppliers should be required to meter at the service end of the pipe and indicate their clients, *e.g.* a local authority, irrigation scheme, rural water supply, a mine, or other user.

Local authorities distributing drinking water to individual customers should improve their customer register and reporting capabilities in order to indicate the following categories of users:

- Residential (single family: low income, medium income, high income, apartment, hotel, motel, camps, resorts);
- Commercial (country clubs, restaurants, cafeterias, bars, coffee shops, stores, office buildings, barber shops, beauty salons, laundries, service stations, theatres, airports, car wash);
- Institutional (hospitals, rest homes, prisons, schools);
- Industrial (canning, milk and dairy, meat packaging, cattle, dairy, chicken, tanning);
- Losses;

These uses should be based on measurements and it is relatively simple to produce this type of statistics. It might be more difficult to establish how individual households use water. Nevertheless, such studies could be conducted at a number of representative households and thereafter estimates could be made for the rest of the town consumers. This information could be used by the local authorities for their water conservation programmes. In those cases where it is difficult to persuade a local authority to put a little extra work into maintaining such a detailed register, it should be made clear that accepting any request for more water supplies will be subject to submitting a water conservation plan, preparation of which could prove very difficult, if not impossible, without good quality information on hand. Also, integrating conservation with water supply planning should become a prerequisite for any Government support, including the supply of subsidised water. There is a need for legislation that would make keeping a good record of water users and uses, including metering, compulsory. This information should be passed on to the water resource manager by NamWater, Local Authorities, Department of Works, or other users. Supplying this information should be made a permit condition. One year is considered sufficient for suppliers and distributors to organise their information collection and processing system so as to provide this information.

6.4 Introducing the requirement for water conservation programmes and water use charges

At present 41.4 per cent of the resources of 717Mm^3/a are utilised. There are a few basins where the available resources are fully utilised. In such cases transfers from other basins will have to be made. As a matter of principle, it should be required that before the water resource manager approves such transfers, an applicant must submit his water conservation programme. Some performance standards will have to be set, *e.g.* unaccounted-for-water or water consumption per capita per day or water consumption per household per day. Other standards can be developed for industrial purposes. Developing these standards will be facilitated by detailed information on water usage in that particular town or establishment. When developing demand forecasts for future water demand in Namibia, it was assumed that unaccounted-for-water will be reduced to 10 per cent in municipal areas and towns, to 15 per cent in villages and settlements, and to 30 per cent in 2005 and to 20 per cent in 2015 for rural water supply. These figures could be adopted as a standard; they do not look unrealistic. In South Africa, "good" means less than 5 per cent unaccounted-for-water. For the bulk water supplier, 5 per cent unaccounted-for-water could be recommended as a target.

The Rand Water Board, in South Africa, reports 3 per cent unaccounted-for-water in a supply environment similar to the one in Namibia.

In places where there is abundant water, there must be another mechanism to enforce that water conservation is practised. Rundu could be used to illustrate this situation. Any Government support for building new purification plant could be made subject to reducing unaccounted-for-water from 38 per cent to 15 per cent. Also, Rundu does not reuse any effluent. There are at least two good reasons for reusing it. Treated effluent is a source of nutrients that are badly needed for poor Kavango soils to succeed in any agricultural activity. Secondly, it would be to Namibia's advantage to be able to show that water conservation is practised in the central area of the country, including Rundu, when negotiating with Angola and Botswana for a water allocation from the Kavango River. These negotiations will have to take place sooner rather than later.

The above examples shows that objectives for protecting water resources are site specific and that integrated resource planning should be practised as a matter of policy because it facilitates an assessment of demand-side as well as supply-side options. It is also necessary to include water reuse and other water conservation measures in cost-benefit analyses before deciding on the preferred option because all these issues are interrelated. Additionally, as a matter of policy, a well co-ordinated process to inform and involve the public must accompany this process. It should be required that the public be consulted from the very beginning of the integrated resource planning process. Public acceptability must become one of the major issues included in integrated water resources planing with a view to protecting water resources against depletion. The objective is to limit the increasing utilisation of Namibia's potential water resources as far as possible, without compromising the quality of life of the people.

Owing to the high degree of the utilisation of the Namibia's water resources, consideration should be given to the introduction of charges for water abstraction, similar to the present system used for charging for irrigation water, except that volumetric charges rather than per hectare charge would be a more effective incentive to reduce water abstraction from a river or a borehole. Regulation and charges for using water are practised in many countries. In Belgium charges are levied for the extraction of groundwater for purposes other than drinking. In France, groundwater extraction charges are 2 to 3.5 times higher than charges for surface water abstraction. Both Germany and the Netherlands have introduced water use charges. In England and Wales, no charges are levied on groundwater extraction of $20m^3$ or less per day for agricultural purposes (Burchi, 1999). All other groundwater extractions are charged. The rates and rate structures vary between countries but the revenue is used for the protection of groundwater, to fund research into developing groundwater policy plans, to cover the costs to Government of performing its function of water custodian. Part of the income can be paid to the Finance Ministry as general taxation, as is done in the Netherlands (Burchi, 1999).

6.5 Integrate conservation with water supply planning

Information on infrastructure requirements for rural water supply is not available at present. As far as urban water supply is concerned, the central areas of Namibia and the west cost do not have more available water sources and they will need additional infrastructure in order to obtain more water by a long distance transfer from the Kavango River to the central areas and by desalination of sea water at the cost. The relevant costs of the necessary infrastructure are N$603million (1997 constant prices) for the Kavango River link and N$227 million, in 1995 constant prices for the desalination option

It was estimated that about 46.2Mm^3 (15.6%) could have been saved on the total estimated demand of 296.9Mm^3 for 1999 if water demand management were implemented in Namibia. The estimated savings, by deferring capital costs on urban bulk water infrastructure, were calculated as N$490 million. If the initiative of Windhoek with water demand management succeeds, the estimated deferred capital cost is N$1.15 billion, owing to the postponement of the Kavango-Grootfontein link to the ENWC (ENVES, 1999). Additionally, the estimated annual savings in bulk supply cost amount to N$18 million per annum if the losses can be lowered. To lower unaccounted-for-water to less than 15 per cent would cost approximately N$5.2 million/annum for an implementation period of approximately 5 years (ENVES, 1999). It must be clearly stated that saving water has benefits but that it also costs money. However, the estimated cost of implementing water demand management in urban areas is usually below 1 per cent of the selling price of water.
This example was used to illustrate how much can be saved if water demand management is implemented and how to account for such initiatives during water supply planning. It is not sufficient to discuss alternatives in general terms; they have to be part of the planning process, as shown below (Maddaus, *et al*., 1996).

How to integrate conservation with water supply planning

- Forecast water demand
- Identify non-structural alternatives
  - Conservation
  - Reclamation
  - Exchange-transfer
- Compare costs with new supply cost
- Seek a balanced solution

In order to protect our limited resources and defer or downsize capital facilities, it is necessary to regulate water supply planning with a view to achieving an appropriate balance between capacity expansion and conservation. Once again, public participation is imperative to make this a success. "To regulate" does not mean that the communities cannot choose the option they prefer. They would, however, have to follow the above procedure if they want to receive **any** subsidy. If they can afford to pay for new supplies they should be required to do so. This can be illustrated by the following examples:
"…If one considers that a reasonable and comfortable subsistence level of consumption by middle and high income groups should be in the order of 30m^3 per household per month, and given the fact that over 37% of all water demand in Swakopmund and over 25% of all water demand in Walvis Bay occurs from private consumers using between 30 and 120m^3/month, then there is obviously great scope for water demand management in this sector.

It was noted that the municipal toilets by the jetty use some 600m^3/month of water.

It is suspected that the DWA bulk water transfer system infrastructure is currently losing some 20%.

Both Walvis Bay and Swakopmund are at present apparently over-irrigating their park- and garden areas by some 200% to 300%" (GKW, *et al.*, 1996).

In 1995 total effluent produced was 3,990m^3/d and 3,120m^3/d was reused (GKW, *et al.*, 1996). In 2000 total effluent produced is 4,300m^3/d of which 2,100m^3/d is used for landscape irrigation and 2,200m^3/d is disposed of into the sea. Most probably irrigation efficiency has been improved but effluent utilisation is now about 49 per cent and used to be 78 per cent.
As far as water conservation is concerned, there is a big room for improvement in Swakopmund; the same was said in 1996. The coastal towns should not be prevented from having a desalination plant but they have to pay for it themselves. In the present situation, it might be difficult to control that this will happen. Cabinet approved an area-based cross-subsidisation of water tariffs for the 1999/2000 financial year because of the equity principle and provision of water to rural areas. In the same decision Cabinet repealed the clause in para.2, Decision No.5th/21.02.95/001 stipulating that:
"The tariffs for water supply to each specific water supply point will be adjusted to that level which enables full recovery of the cost, inclusive of the overhead cost, associated with the supply of water to the specific point consistent with the Water Supply and Sanitation Policy, adopted by the Government of the Republic on Namibia".
Consequently, the bulk water supplier can build a subsidised desalination plant because it was allowed to subsidise in general; **area-based** cross-subsidisation was only for the 1999/2000 financial year. In the meantime wastage of water in Swakopmund will continue unabated. Coincidently, NamWater made it public that the Co-operation will press ahead with building a desalination plant at the coast (Moyo, 2000).
There is a need for legislation that could prevent cross-subsidisation between "specific places" in order to prevent the construction of new infrastructure where the financial consequences are not accepted by the communities, except when such cross-subsidisation is justified, *e.g.* providing safe drinking water to those who can not afford it. This is a logical consequence of the Government's policy that water is a commodity.

Keeping in mind community based management and taking over water points by the communities, it is worthwhile to pay attention to new developments that could be useful in rural areas. A cheap and remarkably effective solar still was invented in the United States. The McCracken solar still is a rectangular structure that can be raised off the ground on bricks or oil drums. The still produces 8 - 10 ℓ of solar-distilled water per day, sufficient to supply a small family with safe, potable water. The polymer is resistant to both heat and ultraviolet radiation and requires no power source other than the sun. It is reputed to have a life of 20 years, is virtually maintenance-free and, because of heat it has stored, continues to work even after darkness has fallen. It could be a major boon for rural women whose duty it is to provide water for their families. The WRC and the Foundation for Research Development have already commenced small-scale test projects in the Oudtshoorn and Brandvlei districts of South Africa. The unit costs about R1,500 per unit (Davis and Day, 1998). It would be ideal, in those places where there is saline ground water for producing good quality drinking water for people.

6.6 Water demand management

It cannot be said that implementing water demand management eliminates the need for augmenting water supplies. It has a complementary function and can result in deferral or downsizing of infrastructure for future supplies. Using the above example, another option to building a desalination plant at present is to implement water demand management measures, and consider reusing treated wastewater as a replacement for fresh water in some applications. At present, the municipalities of Walvis Bay, Swakopmund and Arandis utilise the majority of their treated wastewater for the watering of municipal parks, sports fields, and vegetable gardens. Unfortunately, the GKW Consult report does not give a breakdown of the residential consumption to domestic and outdoor uses. Surely, some or all water used for landscape irrigation could be replaced with treated effluent, provided dual distribution system is in place. In 1998, unaccounted-for-water was 14.4 per cent in Walvis Bay, 12 per cent in Swakopmund and more than 35 per cent in Arandis (van der Merwe, ed., 1999). This could be reduced. Water demand measures such as water-efficient landscaping and public awareness and education would be worth trying. Conservation-oriented pricing seems not to be in place. Bulk water supply to Walvis Bay and Swakopmund is at N$2.00/m^3 and to Henties Bay at N$2.40/m. Assuming calculations made in 1996 are still applicable, and accepting that the marginal cost equals the cost of providing additional supplies, the bulk water supply tariff should be N$2.96/m^3. Actually to send the right signal to the public, this tariff should have been introduced in 1996. Also, the latter tariff does not consider environmental costs at all and there are signs of over-utilisation of the aquifers. This has a negative impact not only on the environment but also on the communities living in the Kuiseb area. Additionally, higher tariffs encourage the public to consider investing in water saving devices at homes.

Realistic water pricing is one of the most fundamental measures of water demand management. The increasing block tariff system in itself does not guarantee achieving water savings; Tsumeb, where it resulted in increased water consumption, is a good example. It does not really matter much if a handful of big water users pays a very high price. In this category, price elasticity of demand is very low. How, so called, average consumers respond to water tariffs is more important.

The need for water demand management policy and strategy

One option for tackling water shortages is to supply so much of additional water as to meet the demand. Another option is to implement effective water demand management and, more generally, water conservation. It usually results in water savings of about 30 per cent. If after exploring all the conservation measures, there is still shortage of water, augmenting water supplies with desalinated water will be inevitable at the coast. However, it is quite likely that a smaller plant will suffice. This approach requires that a cost-benefit analysis be carried out. This type of analysis can be done in a very imaginative way depending on the desired result. Here, it is advocated that such analysis be done based on water conservation as the most fundamental principle.

Two options were discussed above:

Supply management by providing additional water supplies; Demand and supply management by exploring all the conservation measures first and next, providing the shortfall of what is required according to the water demand analysis. The former should be a prerequisite for the latter.

The second option is preferred. For this type of integrated water demand and supply management to become a commonplace in Namibia, there is a need for a national water demand management policy and strategy to be approved by the Government. This should be followed by a number of regulations to create an enabling environment for implementing the preferred option. Water demand management should be practised as a matter of principle. However, there are areas in our country, such as Cuvelai, Koichab, Swakop and Tsondab Basin where this is becoming imperative because the present demand exceeds their potential sustainable resources (WCE, 2000).

A national water demand management strategy is foreseen as a step by step guideline that could be followed by water suppliers and distributors in deciding what to do and how to do it. Regulations are, also, required in order that responsibilities are assigned and sensible water allocation policies are followed. The Municipality of Grootfontein cannot pump more and more free water to supply their customers who waste 90 per cent of it. Namwater cannot pump more and more free water from the Kavango River at Rundu if 38 per cent of what is supplied is wasted because of leakages in the distribution system. Water abstraction from the rivers and the extraction of groundwater should be charged.

6.7 The need for improved water-pricing practices and transparency

WASP recommended that: "Tariffs should be the subject of administrative approval by the Minister in charge of Water Affairs in order to ensure that they will comply with government policy and that any adjustments in tariffs or tariff structures are warranted and reasonable".

Another option is that there is a process of setting tariffs "guided" by the Independent Pricing Regulator who ensures that the public is allowed appropriate input, that the government policy is adhered to and that the tariff increases are not used to cover inadequate performance and very low operational efficiencies of applicants. The Regulator should prepare guidelines concerning different tariff structures to be applied in different circumstances, namely: bulk water pricing, municipal water tariffs and rural bulk water pricing, including irrigation water. A clear division of responsibilities between the resource manger, the bulk supplier and the retailers would greatly facilitate this process. Preferably, charges for water resources management should appear only once. This is why detailing the water services should become a fundamental requirement. In the 1996/97 financial year, the City of Windhoek set their tariff blocks in such a way that block tariff for consumption above $45m^3$ was based on the long run marginal cost, i.e. on the cost of bringing water from the Kavango River. However, it is unlikely that the Municipality will ever be involved in doing this. The bulk water supplier should base its tariffs on the marginal cost related to the cost of new infrastructure and developing new resources. The same can be said about Local Authorities that supply their own water. The surplus revenue should be paid into a fund or a separate account for the replacement of the existing infrastructure.

Considering cross-subsidisation policy, it is interesting to note two most fundamental principles adopted by the Council of Australian Governments relating directly to bulk water pricing for rural water supplies:

- "adopt pricing regimes based on the principles of consumption-based pricing, full cost recovery and removal of cross-subsidies. Where cross subsidies continue to exist, they should be made transparent
- disclose the costs whenever service deliverers are required to provide water services to classes of customers at less than full cost" (Independent Pricing and Regulatory Tribunal of New South Wales, 1996)

Full cost recovery means the full economic costs of bulk water services provided by the Department of Land and Water Conservation that is a resource manager (administers and formulates plans), operator and regulator (enforces). All the costs were listed in paragraph **4.7**.

Current country costs of providing water in Namibia are as follows:

Operators

- the bulk supplier's costs: head office and the regional offices and schemes - NamWater
- rural water supply costs: head office, the regional offices, extension officers - DWA: Rural Water Supply
- Local Authorities: supply and distribution or distribution - municipalities, towns, villages
- Water supply for remote schools, clinics, and other centres - Department of Works

Resource Managers

- resource management: surface water allocation, groundwater allocation, hydrological and geohydrologiacl monitoring, hydrological and geohydrological investigations, geohydrological modelling, surface water database, groundwater database, surface water licences, groundwater licences, pollution control, effluent disposal licences, reuse permits, water demand management, public awareness campaigns, source water quality and monitoring, aquatic weeds control and strategies - DWA: Resource Management
- sustainable utilisation of water resources, investigation and research related to water resources - NamWater

Resource regulator

- enforcement of agreed conditions for abstraction of water and for disposal of effluents, setting guidelines and standards, liaison with the Department of Works, Ministry of Regional and Local Government and Housing, Ministry of Health and Social Services, Local Authorities, Ministry of Fisheries and Marine Resources, Ministry of

Environment and Tourism, Ministry of Mines and Energy, Ministry of Trade and Industry - DWA: Resource Management

The above costs were listed to show that "full cost" is different for different institutions. If all these costs were added, the full financial cost or accounting cost of water could be calculated. Additionally, there are environmental costs associated with water abstraction and water use, especially for irrigation and industry (pollution, increased salinity of groundwater). These costs are not recovered in existing charges. Consequently, the full economic costs of using resources are not considered in Namibia. It must be noted that infrastructure, and operation and maintenance costs can be as low as 30 per cent of the full financial cost of water, *i.e.* water supply costs are only one third of the costs that also include proper water resources management, regulation and enforcement (NSW Department of Land and Water Conservation, 1998). It is therefore obvious that if 99 per cent of the financial resources of the country for the water sector are devoted to water supply in Namibia, water resources management, regulation and enforcement cannot function well as is the case at present. From a water conservation point of view, this is a very distorted proportion that should be changed. The country as a whole can hardly afford that its bulk water supplier replaces its computer equipment every three years, cars every four years, office equipment every five years, and water schemes every ten years (see 2.7). The last one is simply ludicrous. "The Tribunal accepts that proper maintenance of some infrastructure assets will extend their useful lives indefinitely. No depreciation charge should be levied against them" (IPART, 1996). In Australia, as a matter of policy all the dams and weirs (existing assets), except those parts of the structure with a known life of five years or less, are treated as sunk costs. This is additional argument for establishing the Independent Pricing Regulator; monopolies have tendency to overcharging and overspending. A lack of transparency is unacceptable and the transparency should become a statutory obligation, for the bulk supplier and all the Local Authorities. Transparency and public acceptability can eliminate any potential conflicts, see **ANNEX 2**.

Those Local Authorities that buy water from the bulk supplier should consider replacement costs of their infrastructure, costs of implementing water demand management (retrofitting, metering, detecting infrastructure leaks, public awareness campaigns), costs of building dual distribution systems, and water treatment or wastewater treatment plants, or other works. There are a few different tariff systems considered to be conservation-oriented tariffs. The Local Authorities should be free to decide on the one of their choice, provided it meets with public acceptance.

6.8 Encourage reuse and recycling of reclaimed water

It should be subject to further investigation but for the purpose of this report it is assumed that municipalities and towns can potentially reuse their effluent and that 50 per cent of water they consume becomes wastewater. They used 48.49Mm^3 in 1999 (based on WCE, 1999) and generated approximately 24.25Mm^3 of effluent. Only 4.09Mm^3 (~17%) was reused in 1999. There is no question that this potential should be tapped. Most probably some villages and settlements could also reuse their effluent but because of lower quantities this is not considered as a priority. Local Authorities must be made aware of this water source and be helped in tapping it. This could be done by the water resource manager. It is a prerequisite for the successful implementation of water conservation programmes that the

Local Authorities accept more responsibility for managing their water affairs. At present when short of water they simply approach the bulk supplier with a request for more water and leave it to Namwater to make decisions for them. This is far from ideal and it would be wise to enforce water conservation programmes by amending the Model Water Supply Regulations and the Local Authorities Act accordingly. To consult the communities involved should be the Local Authorities' first obligation. Owing to this situation, it would also be wise not to allow unconditional cross-subsidisation to be applied by the bulk supplier.

All the Local Authorities should examine reuse of treated wastewater but some towns need it more urgently than others do. Lüderitz, because of mining groundwater, Okahandja, because of using water from ENWC and Rundu, because of using water from the Kavango River (shared river), should explore this possibility. The best way of doing it is to prepare integrated water plans.

These towns could be seen as pilot studies based on which a manual could be prepared to help other Local Authorities.

6.9 Develop water quality policy and strategy

Assuming that the policy objective *to ensure sustainable utilisation of the water resources of the country by protecting their quality through pollution control and water conservation with a view to securing well-being of the whole community, at present and in the future, while continuing with social and economic development*, is accepted, there are some elements that could be identified already as part of the water quality strategy. They are as follows:

- To review drinking water guidelines with a view to revising the existing ones set in 1988 by the Department of Water Affairs. These guidelines need to be updated by considering progress made in the last decade and more information being available on health effects of consuming water containing elevated concentrations of certain chemicals. Probably even more important is to legalise these guidelines. The Water Act, 1956 (Act 54 of 1956) does not make provision for the Minister to introduce drinking water quality guidelines. It is not surprising that the eighty years old Public Health Act, 1919 (Act 36 of 1919) also does not recognise a need for such guidelines. Guidelines for drinking water quality are essential as the point of reference when evaluating quality of water resources and making recommendations on their use;
- To review the existing stock watering and irrigation water quality requirements in order to revise them, if required;
- To review the existing standard for disposal of domestic effluent because its requirements are unrealistic in general and unachievable in Namibia. There is not one wastewater treatment plant in the country that can produce effluent of the required quality. The accepted practise is to exempt the water user from compliance with these requirements. Actually, these permits are permits to pollute;
- To develop environmental water quality guidelines in order to facilitate achieving this, constitutionally required, maintenance of ecosystems, essential ecological processes and biological diversity;

- To develop guidelines for water resources protection. None of the previous points includes solid waste management and disposal, and pollution from diffuse sources, *e.g.* drainage from large agricultural irrigation projects or "rivers" of treated sewage effluent.

In order to be effective the above guidelines and the water quality strategy in general should be based on both regulatory and market-based measures. The latter means that, *e.g.* a tannery includes all the costs of treating and disposing of liquid and solid wastes in the costs of production. Managing the waste can not be seen as a burden, it is a part of the production process. Consequently, if it is too costly the production process should not be initiated. Competitiveness of the product should be increased by higher efficiency, not by artificially reducing production costs by savings on the waste treatment and disposal.

Additionally, developing and implementing the water quality strategy will necessitate close co-operation of a number of Government institutions such as Department of Water Affairs, the Ministry of Health and Social Services, the Department of Agriculture, the Ministry of Mines and Energy, the Ministry of Trade and Industry, the Department of Works, the Ministry of Environment and Tourism, and the Ministry of Fisheries and Marine Resources.

There is no other option that could be considered. Maintaining *status quo* would inevitably lead to the deterioration of the quality of water resources, contrary to the principle of sustainable development.

6.10 Introducing effective and adequate water pollution control

To use the existing legislation for prosecuting water pollution offenders is not an option any more. The Water Act, 1956 (Act 54 of 1956) has been tested in court twice and both attempts were unsuccessful. The Act is ineffective because it does not form a basis for enforcing protection of water resources. A new act should introduce "polluters pay" and "precautionary measures" principles into our legislation. This would have two consequences. Firstly, it would ensure, at least, that the cost of sewage and effluent treatment will be taken into account in the benefit-cost analysis. It is difficult to prove that the pollution of water was caused wilfully or negligently, it is easier to prove that no adequate precautions were taken to prevent it. Costs of cleaning and restoration of environmental damages are usually very high. In order to avoid risks of polluting the environment and be faced with cleaning charges, it might be wiser to embark on proper treatment of sewage right from the beginning. Secondly, it would enable successful prosecutions of polluters. One such prosecution would have a great impact on the rest of the sector. For the time being no one thinks that we have any water protection law. Therefore, it is obvious that there is inadequate pollution legislation in Namibia at present and it has to be changed. Any establishment generating industrial effluent or sewage and disposing of it in any other way than into a sewer must have a valid permit. Conditions of such permits will vary depending on type of effluent generated and the designated use of treated effluent or its disposal. There is no need to exempt an applicant for disposal of raw sewage into stabilisation ponds from compliance with the requirements specified for disposal of effluents into the perennial rivers. Therefore, there will be permits for disposal of effluents. Ideally, granting an exemption from the requirements will be an exception rather than a rule.

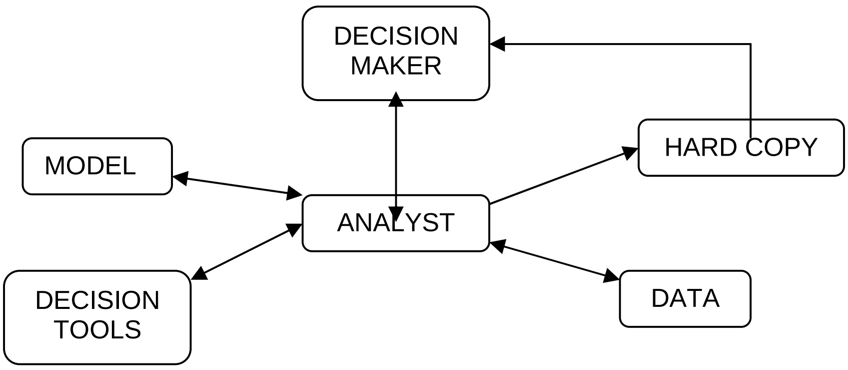
Concerning procedures for issuing permits, the procedure to be followed when issuing permits for disposal of effluents should be prescribed and the responsibilities assigned to different institutions should be clearly set out. The Permanent Secretaries could delegate this task to their staff but should retain the responsibility for timely contribution of their institutions to the process. Also, there should be a provision for enforcing this particular responsibility, including referring the problem to the Ombudsman if no action is taken. It is essential that duration of those tasks is regulated as well with a view to reducing a period of time required to process an application.

Adequate regulatory measures are necessary for the system to work but having them is insufficient. An institution responsible for handling these issues needs trained personnel. The same must be said about all the other institutions involved. Training personnel does not solve the problem; the Water Environment Division has done that a number of times. Unfortunately, these well-trained people did not have a big problem to find more attractive and better-paid jobs. Therefore, it is necessary to train people and to create incentives for them to stay in the same organisation and continue working; often better employment conditions would be all what is required.

This mix of regulatory, organisational and educational approaches should result in effective and adequate pollution control of our water resources. An up-to-date computerised information system is considered to be a necessary tool in handling administration of the permit system.

6.11 Integration of a water sector information system functioning as a decision support system

Flows of information in traditional water resources management are depicted below (Mays, 1996).



However, as a result of the development of electronic systems the Decision-Maker often interacts more directly with the system and the role of the different elements in the information flow model depicted above changes. Data and data management become the main focus. Decision Tools facilitate this process. Plan-evaluation tools can be defined as facilities that present data in a form which accommodates the assessment or appraisal of a policy or a plan. They allow to filter, modify and present parts of the system's data in a form suited for alternative evaluation and decision making, thereby transforming a system's data into information (Mays, 1996).
Models commonly used in water resources management are depicted in **Table 15**.

Table 15: Taxonomy of Models in Water Resources Management (Mays, 1996)

Model type	Description
Watershed models	Relate meteorological phenomena to the runoff quantity and/or quality from a land area. They vary from simple empirical relationships like the rational formula to complex physically deterministic models that take into account land and vegetation types, antecedent moisture, evapotranspiration, infiltration, solar radiation, and other details.
Surface water Quantity models	Describe the movement of water on the earth's surface, including rivers, lakes and artificial channels. They include representations of structures such as dams, power plants, and control structures, as well as laws and policies such as operating procedures and water rights. They may also include boundary conditions with the atmosphere and/or the ground water. In addition, some address the problem of sediment transport.
Surface water Quality models	These include quantity as required, but focus on the fate of constituents carried by water. Modelled variables include temperature, dissolved oxygen, plant biomass, metals, toxic organics, suspended and dissolved solids. Water quality models have grown in importance over the past two decades in managing water resources within environmental regulations.
Ground water models	Simulate quantity and/or quality of water below the surface of the ground. They may include infiltration, pumping, movement through geological formations, aquifer management, contaminant plume tracking, and conjunctive management of surface and ground water.
Economic models	These do not explicitly model physical processes, but consider the economic aspects of water resources development and management. These aspects include cost-benefit analysis of projects or policies, regional economic impacts of water resources projects, costs of pollution control, and risk-benefit analysis.
Social models	Consider the social impacts of water resources projects and policies, including migration, displacement, farming practices, and the uneven distribution of benefits among various population groups.

The above table was presented to underline the fact that decisions concerning water resources must take socio-economic aspects into account. Availability of water is not the only criteria when considering the allocation of water for different uses. One of the water conservation principles is that water is used efficiently for the benefit of the current and future population of the country. It is likely that even if groundwater is available such cost-benefit analysis would conclude that is more cost-effective to keep water in an aquifer then to irrigate many hectares of lucern fields.

Also it is an attempt to point out that as far as water resources management is concerned, a water sector information system should be seen as a decision support system. It is defined as follows:
"Decision support systems provide information on the historic, current, and future states of an environmental resource where future states are computed by one or more simulation and/or optimisation models. This information is communicated in forms which are directly useful for operational decision making and/or long-term planning" (Mays, 1996).

The BGR model for the Karstland aquifer is a good example: it concludes with certain recharge rates under specific rainfall conditions and states that the abstraction of water for farming purposes has negligible impact on the regional decline of the water table. Also, it recommends that the Karstland should not be used for the long-term continuous abstraction of excessive amounts of water. In this case, huge amount of data and extensive modelling resulted in very useful planning **information**.

Created database could be managed by a geographic information system (GIS) that is a tool for the storage, retrieval, and management of spatial data.

6.12 Proposed restructuring

In the long-term water conservation would be better taken care off in any other company than with agriculture. However, owing to the similarity of interests in protecting water resources and exploiting them on a sustainable basis without causing any serious environmental damage, it would best fit in the present Ministry of Environment and Tourism. Recently, a commercialised Namibia Wildlife Resorts Company was established. The tourism industry is also one of the water consumers, though an efficient one. It would be wise to transfer it from the Ministry of Environment and Tourism to the Ministry of Trade and Industry. Water, Environment and Forestry could be placed in the Ministry of Natural Resources. The Namibia Water Resources Management Agency would be under the umbrella of this Ministry. Doing this would result in separation of water consumers from water resources management. Environment and Forestry are legitimate or natural "consumers" of water and it is in their interest to reduce abstraction of water and the large-scale extraction of groundwater. Together, these three Departments would stand for protecting natural resources of Namibia and united they could succeed. Additionally, there will have to be close co-operation between the resource manager and the Department of Environment as pollution control issues are of common interest, the allocation of water to the environment (water reserve) and Environmental Impact Assessment studies are of mutual concern. Large-scale water abstraction and groundwater extraction projects are also important to both institutions. Theoretically, within one Ministry these Departments (or agencies in the future) could work together better and achieve more than when isolated.

7. RECOMMENDATIONS

It is recommended that:

- Water Resource Management Agency be solely responsible for overall management of water resources in Namibia, including water resources assessment that should be done on a basin basis with full recognition of the integrity of the hydrological cycle and the principle that the hydrologic cycle must be defined in terms of both the water quality and the water quantity. When carrying out water resources assessment, consideration should be given to the needs of potential users of raw and processed data as well as information on the potential sustainable resource.

- Namibia is considered as a water control country with different degrees of control depending on vulnerability and strategic importance of water sources in specific areas.
- As a matter of principle all surface water abstractions and groundwater extractions should be registered. For practical reasons smaller water withdrawals should be exempted from metering, recording and reporting.

- The Divisions: Hydrology and Geohydrology make proposals for appropriate figures concerning different degrees of control. If this is regarded as premature because of very limited knowledge of the resource base at present, provision should be made for regulating this in a future.

- A register of water users is established by obtaining information from the bulk water supplier concerning their customers. They include local authorities, irrigation schemes, rural water supply, schools, hospitals, mines, and other users. Local authorities should improve their customer register in order to be able to indicate the following categories of water use: residential, commercial, institutional and industrial. Also, more detailed information on residential water use should be collected. This register should be based on measured quantities and make provision for updating it by collecting data annually on a basin basis. Such a register could create a basis for estimating future water demand and indicate uses that should be targeted by water demand management.

- It should be a requirement to attach a water conservation programme to any request for inter-basin water transfer. Efficient use of water can be made a prerequisite for approval of such a request. Some performance standards should be developed to measure this efficiency.
- Integrated resource planning should be adopted in order to assess demand-side as well as supply-side options before embarking on tapping new water resources. Detailed evaluation of reuse options and other conservation measures should form part of such a plan and should be based not only on cost-benefit analysis but also take into account public acceptance of the proposal.
- Consideration should be given to introducing water use charges for using surface and groundwater with a view to achieving full cost recovery on a national basis by covering not only costs to the bulk water supplier but also the costs to the Government of performing its function of water custodian.

- In order to protect Namibia's limited water resources and defer or downsize capital facilities, water conservation should be integrated with water supply planning with a view to achieving an appropriate balance between capacity expansion and conservation. This should be a condition whenever Government support is requested for financing new infrastructure.

- National policy and strategy for water conservation, including water demand management should be adopted and get full recognition in new water regulations. A proposal presented in **ANNEX 1** should form a basis for such a policy and strategy to be formulated and approved.

- An Independent Pricing Regulator should be established in order to formulate a tariff policy and provide guidelines for the bulk water supplier, local authorities and bulk rural water supply institutions for calculating water tariffs. As a matter of policy, cross-subsidies should be eliminated and where they continue to exist, they should be made transparent and be presented when new tariffs are published in the *Government Gazette*. Stipulations of WASP should be a starting point for the formulation of such a policy.
- The full cost recovery principle should be adopted, meaning that the full economic cost of water supply, which is different than full financial cost of the bulk water provision in a situation when there are different institutions acting as regulator, resource manager, and operator and provider of technical services, should be recovered from the consumer.

- Reuse and recycling of reclaimed water should be encouraged because of growing demand for new water supplies and new regulatory constraints associated with discharging treated wastewater into the environment that will hopefully be introduced in Namibia. Where treated wastewater can not replace drinking water supplies, it should become environmental water used for preserving existing environmental resources, *e.g*. wetlands.

- A water quality policy and strategy should be developed and adopted with the main objective to ensure sustainable utilisation of the water resources of Namibia by protecting their quality through pollution control and water conservation, with a view to securing the well-being of the whole community, at present and in the future, while continuing with social and economic development.
- Emerging water quality issues associated with protecting public health and aquatic resources necessitate that water quality guidelines and/or standards are developed for a variety of uses by the responsible institutions in co-operation with all interested parties.

- Water pollution control should be reinforced in new legislation, as the existing one is inadequate. Streamlined procedures for issuing permits and disposal of effluent should be adopted, implemented and be enforceable. The processing of applications for permits should be expedited.

- The integrated water sector information system is established as a decision support system for water resources management. Only with complete restructuring of the database structures and in full consultation with all organisations involved can this be achieved. It requires involvement of all those currently involved in the collection, processing and even analysis of data. The role of GIS will be fundamental in this process of integration (NWRMR, 2000).

- In case a restructuring of the present Ministries is considered in the near future, the Ministry of Natural Resources be created under umbrella of which the Namibia Water Resource Management Agency could find a more conducive environment to ensure sustainable and efficient utilisation of the Namibia's water resources.

- New water legislation concerning water resources should propose amendments to the existing legislation relevant to water resources management with a view to achieving consistency.

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