

OCCASIONAL PAPER NO. 1

**WATER USAGE PATTERNS IN THE KUISEB CATCHMENT AREA  
(with emphasis on sustainable use)**

January 1994

Authors:-

**F. Dausab; G. Francis; G. Jöhr; J.R. Kambatuku; M. Molapo;  
S.E. Shanyengana; S. Swartz**



Desert Research Foundation of Namibia  
P O Box 20232, Windhoek  
Tel: + 264 61 229855  
Fax: +264 61 230172  
email: drfn@drfn.org.na

The Gobabeb Training and Research Centre  
P O Box 953, Walvis Bay  
Tel: + 264 64 202613  
Fax: + 264 64 205197  
email: gobabeb@iafrica.com.na

## TABLE OF CONTENTS

Table of Contents .....	i
FOREWORD .....	iii
EXECUTIVE SUMMARY .....	iv
ACKNOWLEDGEMENTS .....	vi
Chapter 1 - GENERAL INTRODUCTION .....	1
WATER PROBLEM AND RELEVANCE .....	1
THE PROJECT .....	2
GEOGRAPHIC DESCRIPTION OF THE KCA .....	2
HISTORICAL PERSPECTIVE .....	3
OVERVIEW OF WATER INPUT IN THE KCA .....	5
OVERVIEW OF WATER OUTPUT FROM THE KCA .....	7
Chapter 2 - COMMERCIAL FARMERS .....	15
ABSTRACT .....	15
INTRODUCTION .....	15
MATERIALS AND METHODS .....	15
RESULTS .....	16
DISCUSSION .....	18
CONCLUSION .....	22
RECOMMENDATIONS .....	22
Chapter 3 - WATER USE BY THE TOPNAARS .....	31
ABSTRACT .....	31
INTRODUCTION .....	31
MATERIALS AND METHODS .....	33
RESULTS .....	33
DISCUSSION .....	34
CONCLUSION .....	36
RECOMMENDATIONS .....	36
Chapter 4 - WATER USE AT GOBABEB .....	44
ABSTRACT .....	44
INTRODUCTION .....	44
MATERIALS AND METHODS .....	45
RESULTS .....	47
DISCUSSION .....	49
CONCLUSIONS .....	51
RECOMMENDATIONS .....	51
Chapter 5 - WALVIS BAY .....	54
ABSTRACT .....	54
INTRODUCTION .....	54
MATERIALS AND METHODS .....	55
RESULTS AND DISCUSSION .....	55
CONCLUSION .....	65

RECOMMENDATIONS .....	65
Chapter 6 - SWAKOPMUND .....	79
ABSTRACT .....	79
INTRODUCTION .....	79
MATERIALS AND METHODS .....	80
RESULTS .....	80
DISCUSSION .....	82
CONCLUSION .....	83
RECOMMENDATIONS .....	83
Chapter 7 - WATER USE AT RÖSSING URANIUM MINE .....	89
ABSTRACT .....	89
INTRODUCTION .....	89
MATERIALS AND METHODS .....	90
RESULTS .....	90
DISCUSSION .....	93
RECOMMENDATIONS .....	94
Chapter 8 - FUTURE DEVELOPMENT .....	103
ABSTRACT .....	103
INTRODUCTION .....	103
THE POPULATION GROWTH - WATER DEMAND LINK .....	104
SOCIO-ECONOMIC LEVELS .....	104
EFFECTS OF INDUSTRY .....	106
EXPECTED EFFECTS OF DEVELOPMENT .....	106
POSSIBLE ALTERNATIVES .....	107
CONSERVATION CAMPAIGNS .....	108
CIVIL PARTICIPATION .....	109
CONCLUSION .....	109
RECOMMENDATIONS .....	109
GENERAL RECOMMENDATIONS .....	113
LIST OF REFERENCES .....	116

## FOREWORD

The Kuiseb River in central and western Namibia is one of the most heavily used rivers in the country. It is well known for providing all the water used in Walvis Bay and part of that used in Swakopmund and by Rössing Mine and Arandis. In addition, it supports the farming activities and production of the Topnaars along the lower water course, the activities of researchers and educators working with the Namib Research Institute at Gobabeb and animals living in the Namib-Naukluft Park. Last but not least, it supports the production from 109 commercial farms in the upper reaches of its catchment area.

Water limits production and development throughout Namibia, and the Kuiseb Catchment Area is no exception. Nevertheless, plans for further water abstraction from the catchment are afoot and the search for alternative water sources such as desalination is being pursued more seriously than ever before. How much is really understood about the inter-related processes that take place throughout the catchment and how they affect the activities of everyone else sharing this single water source?

During December 1993 and January 1994 a group of students from the University of Namibia agreed to work with Desert Research Foundation of Namibia staff at Gobabeb in an attempt to address some of the unanswered questions about water use in the Kuiseb Catchment Area. Their time was limited, many of their potential sources of information were away on summer holiday and a number of important questions emerged only late in their investigation. Nevertheless, they interviewed a variety of people, worked through the available literature, evaluated what they heard and read, and attempted to synthesise this information into a coherent and readily understandable overview.

This report has deficiencies and should not be expected to provide definitive answers to the many pressing questions about water use in the Kuiseb Catchment. What this report does is highlight the integrated and interactive nature of water availability for diverse communities dependant on the Kuiseb Catchment for all or some of their water needs. By illustrating a holistic approach and providing simple examples of how water use can be assessed, we hope that this report will prove useful to people living not only in the Kuiseb Catchment but elsewhere in our dry country, the driest in southern Africa.

[Note: Computer programmes used to produce this document use the USA standard notation for indicating decimal points (.) and for separation of multiples of  $10^3$  (,).]

## EXECUTIVE SUMMARY

1. A study of the entire Kuiseb Catchment Area (KCA) was undertaken to identify the major water uses and to estimate the total and the proportional amount of water used by the various consumer groups.
2. Information was gathered by conducting interviews with identified users and studying existing literature.
3. The Kuiseb Catchment Area (KCA) provides water to a number of different user categories ranging from individual farmers to towns to a large mine.
4. The Kuiseb is an ephemeral river that originates about 30 km west of Windhoek and runs westwards to the coast at Walvis Bay. The catchment occupies an area of 14 700 km<sup>2</sup>.
5. Of the total water entering the KCA annually as rain, 83% evaporates immediately and 17% runs off or percolates into the ground. Of the latter amount, 14% is used by vegetation while only 3% is potentially available for consumption.
6. On a hypothetical average year, 660 Mm<sup>3</sup> of water would fall as rain in the upper catchment and 21 Mm<sup>3</sup> would pass the Kuiseb-Gaub confluence. In the lower catchment where over 5 Mm<sup>3</sup> of water are extracted for the west coast annually, 2 Mm<sup>3</sup> of water would be measured at Swartbank Wier and 0.6 Mm<sup>3</sup> would be measured at Rooibank Wier.
7. The runoff from the upper catchment is highly variable, with a high of 105.9 Mm<sup>3</sup>/a and a low of 0.0065 Mm<sup>3</sup>/a recorded at the Schlesien Wier.
8. In the upper catchment, commercial farmers on 109 farms use 0.6 Mm<sup>3</sup>, from ground dams and boreholes, for livestock (90%) and domestic purposes (10%).
9. In the middle catchment, about 400 Topnaar communal farmers in 10 villages use about 0.006 Mm<sup>3</sup> per year, from Kuiseb groundwater, for livestock (58%) and domestic (42%) purposes. The groundwater also supports the vegetation upon which the livestock browse and the Inara plants which provide a cash income and a source of food.
10. Also in the middle catchment, about 30 researchers and educators living at the Namib Research Institute at Gobabeb in the Namib-Naukluft Park use about 0.007 Mm<sup>3</sup> per year, from Kuiseb groundwater, for domestic purposes. Of this amount, 86% is currently used for gardens.
11. In the lower catchment, the town of Walvis Bay with a population of 38 000 people uses 4.3 Mm<sup>3</sup> per year, from the Rooibank aquifer, for domestic (72%) and industrial purposes (28%). Ornamental home gardens use 36% of the town's entire water consumption, which is approximately 10% more than industry.
12. The town of Swakopmund with a population of 24 000 people uses 2.9 Mm<sup>3</sup> per year, one third of which is KCA water from the Swartbank aquifer, for domestic purposes (96%) and light industry (4%).
13. Rössing Uranium Mine and the town of Arandis use 3.0 Mm<sup>3</sup> per year from the DWA reservoir in Swakopmund, supplied from the Kuiseb and Omaruru aquifers.
14. Evaporation, from open water storage surfaces on farm dams and reservoirs, was identified as a large avenue for water loss in the upper and middle catchment.
15. Use of ornamental plants for gardening was identified as a major source of water use and loss at Gobabeb (86%) and the west coast towns (over 50%).

16. A large state dam has been proposed for the upper catchment at Donkersan as an additional supply of water for Windhoek. This is expected to reduce runoff to the lower catchment by 70% and to have major environmental impacts.
17. Supplementation of the bulk water supply to the west coast by desalination is being seriously considered by Walvis Bay, Swakopmund and Rössing. This alternative water source is not expected to have major environmental impacts and appears to be cost effective.
18. Conservation of existing water resources, particularly by domestic users, is presently limited, but offers potential for extending current supplies.
19. People in Namibia are not generally aware of the overall shortage of water in this arid environment. It is important not only to increase awareness but to change peoples' behaviour in terms of water conservation and use.
20. This study found that many people dependent on the KCA are aware of the developing water shortage. Their responses are different, however, with town people mainly concerned about the economic implications whereas farmers in the upper and lower catchment view it as a matter influencing their livelihoods.
21. Recommendations developed during the course of this study focused on conservation of existing sources, increasing awareness and action amongst all user groups of the resource, the interdependence of people using a single catchment, and the importance of a holistic view of water development in Namibia.
22. Scarcity of water in Namibia is poised to undermine the prospects of economic progress and development.

## ACKNOWLEDGEMENTS

The authors would like to express their heartfelt gratitude to the Swedish International Development Authority (SIDA), in particular Ambassador S. Rylander and Mr. L. Karlsson, for their generous contribution toward making this project and the subsequent report possible and for their overall commitment to the betterment of Namibian youth through education. The contribution from Rotary Club Windhoek towards publication of a poster associated with this report is equally appreciated.

Our thanks also extend to the following groups, companies and individuals for their co-operation in providing answers and relevant information to our queries during the course of our field survey: Deputy Town Engineer of Walvis Bay Mr. A. Brümmer, Desert Research Foundation of Namibia (DRFN) trustee Mr. J. A. Brückner, Research-assistant Mrs. C. Berry and staff of the Ministry of Environment and Tourism at Gobabeb, Town Clerk and Town Engineer Messrs. E. Demasius and K. Lester of Swakopmund, Hansa Brewery Ltd., Swakopmund Tannery, Ms. H. Rapmund of the Hotel Association in Swakopmund, Port Engineer A. J. Raw of Portnet, Deputy Managing Director Mr. G. Le Roux of Tunacor, Public Relations Officer Nikki Wood, Tailings/Water Management staff Messrs. B. Kloot, J. Bierberg, B. Morwe and G. von Oppen of Rössing Uranium Mine Ltd., Mr. K. Ahlert of Niedersachsen Guest Farm, Water Affairs officer and member of the Topnaar Chief Council Mr. R. Dausab of Oswater, Mr. D. Damaseb and Ouma J. Fischer of Soutrivier, Mr. A. Huber of Donkersan Farm, Oupa E. Kooitjie of Oswater, Chief S. Kooitjie of Homeb, A. Kuriseb from Soutrivier, Mr. H. Lombard of Weissenfels Guest Farm, Mr. F. Malan of Hornkranz, and former Town Engineer of Walvis Bay Mr. E. Tworeck.

The advice and guidance given by the Director Dr. M. K. Seely, researchers Dr. K. M. Jacobson and P. J. Jacobson as well as the staff of the Desert Research Foundation of Namibia (DRFN) throughout the planning and execution of the research to its final conclusion deserve special words of thanks. Without their presence, understanding the biological and cultural interactions of the KCA would have been a difficult and complicated task for us indeed.

The Permanent Secretary in the Ministry of Environment and Tourism Mr. H. Rumpf is acknowledged for having arranged accommodation for the authors at Gobabeb. Mr. P. Heyns from the Ministry of Agriculture, Water and Rural Development's Department of Water Affairs is thanked for having cleared contradictory information unearthed by this research.

We sincerely acknowledge Dr. M. M. Abrams and D. du Toit for having read and commented on this manuscript and A. Karita for his assistance with map lay-outs. Last but not least, we thank Peace Corps Volunteers C. Michaud (media and awareness) and E. Rosenberg (organisation, logistics and report layout) for their respective contributions which were essential in realising our objectives. A final word of appreciation goes to all those who participated, rendered help or took keen interest in the research and compilation of the report but whom we may not have mentioned.

## Chapter 1 - GENERAL INTRODUCTION by Jack Kambatuku

### WATER PROBLEM AND RELEVANCE

The first ever state of emergency to be declared in Namibia was in 1992 in response to one of the most severe droughts in the history of the country. Government attention shifted from developmental activities to ensuring the immediate survival of the people. Practically speaking the drought and the emergency situation were due to lack of sufficient rainwater for the agricultural sector; crops had insufficient water and there was no forage for livestock. This once more highlighted the central role water plays in determining human development activities. Water is and always has been the principal controlling factor of life and hence the pace of development should be set by the availability thereof. Namibia does not only struggle with insufficient rainwater, however, but faces depletion of drinking water as well as soil water from her diminishing ground water resources.

Already the capacity of some major towns, including the capital city of Windhoek, to meet the ever increasing demand for water is questionable. A dark cloud of doubt hangs over the continued existence of such cities, not to mention future developments within them. It is true for all Namibian urban centres that settlement, planning, investments and development have often been done without consideration of whether or not water was available for long term sustainable use. In spite of these facts, water continues to be extracted from some underground sources at a rate faster than it is being recharged, making this precious commodity even more scarce. Hence a pressing need for alternative means of providing water and managing the demand thereof exists in Namibia.

Of many proposed projects, three: the Donkersan dam to supply Windhoek, the Kuiseb-Gaub confluence dam and the desalination plant to supply the coastal towns (SLW JVC 1993f) are bound to have an impact (both positive and negative), on the Kuiseb Catchment Area (**KCA**) if implemented.

The water from this area supplies a wide range of users, including inland commercial farmers, communal Topnaar farmers along the course of the river, the entire Namib-Naukluft Park, Rössing Uranium Mine and the coastal towns of Swakopmund and Walvis Bay, making it representative of all major forms of water utilization in Namibia. Moreover, the **KCA** is included in the recently proposed Central Area Water Master Plan (SLW JVC 1993e). This plan proposes the continued taking of water from the **KCA** to supply areas outside the catchment. This is in addition to the fact that serious problems are encountered in the **KCA** itself with regard to water availability for people and the environment. Boreholes on many farms and some Topnaar villages have dried up while trees have been dying ever since the 1979/80 through 1983/84 droughts in the lower Kuiseb (Ward & Breen 1985).

With brighter prospects of European markets most farmers in the **KCA** want to expand their beef production, while Topnaars are eager to benefit from increased tourism within the Namib-Naukluft Park in addition to their own agricultural enterprises. The coastal towns are envisaged to have a tremendous growth potential due to the anticipated discovery of oil, growth in fishing industry and linkage to neighbouring landlocked countries. Finally, Rössing mine is expected to return to full capacity production when world prices of uranium stabilize.

Therefore the **KCA** provides a perfect case study that might typify problems generally experienced with extraction, storage, consumption, wastage, conservation and future projections for water management and sustainable development in Namibia. Nevertheless, no accurate documentation of the total amount of water used, proportions used by different consumers and the purpose for which it is used has been made within the **KCA**.



## THE PROJECT

As a step in this direction, the **KCA** became the subject of study for a group of environmentally concerned students from the University of Namibia associated with Desert Research Foundation of Namibia and sponsored by the Swedish International Development Authority.

In search of a complete picture of the water budget within the **KCA**, the group conducted interviews with representatives from each major water user group within the catchment. The sites visited were the Donkersan, Hornkranz, Niedersachsen and Weissenfels commercial farms; Homeb, Oswater and Soutrivier Topnaar villages; Rooibank - site of the South African Department of Water Affairs (DWAR) pumping centres; the municipality, Portnet and Tunacor - major industries from Walvis Bay; the municipality and the brewery in Swakopmund and the Rössing Uranium Mine (Figure 1).

Interviews covered subjects such as input (source) of water, output (consumption), and wastage (loss) as well as perceptions of concerned parties pertaining to water conservation and its essential and non-essential use. Where possible, figures depicting the input, output and losses were obtained from interviewees and the Namibian Department of Water Affairs (DWAN). In addition, contact was made with resourceful individuals who had good background of the water issue through their local or national involvement in dealing with the problem, such as retired former town engineers and elderly village dwellers.

Basic practical measurements of average water consumption per individual were carried out over a period of two months to give an indication of actual water usage at Gobabeb. Existing data and literature on total consumption throughout the **KCA** were also consulted. Distances, areas and rainfall amounts were determined using a computerised digitiser on topographic (1:50 000) and isohyet maps respectively.

The primary project objective was to sensitize people to the water issue, promote awareness and provide information to aid future policy development on water management schemes. The project further aims to identify the socio-economic and environmental components that are central to sustainable utilization of Kuiseb water.

## GEOGRAPHIC DESCRIPTION OF THE KCA

The Kuiseb River originates in the Khomas Hochland about 24 km west of Windhoek (Figure 1). The main ephemeral stream and its numerous tributaries make deep incisions in the mountains and through the escarpment. From its origin the 503 km long river follows a south-westerly course that changes to north-westerly as it emerges from the deep Kuiseb Canyon into the Namib desert. Here the river forms the boundary between the sand dunes on the southern bank and the gravel plains on the northern bank. The river becomes flanked by dunes on both sides as it approaches the sea.

From the Gorob River all the way down, the river bed is filled with alluvial sands that get deeper with distance downstream from Gobabeb. Along the course of the river prominent bedrock outcrops are found on both sides and in the river bed for much of the river course. About 5 km downstream from Rooibank the river splits into two channels, a western and northern arm, to form a delta. Sandwiched between these arms is a dune area dissected by numerous watercourses.

The northern arm which used to be the main flood channel was cut off in 1961 at Mile 16 to prevent flooding of Walvis Bay (Huntley 1985).

The Kuiseb River descends from a height of about 2,000 metres above sea level down to the sea forming a catchment area of approximately 14,700 km<sup>2</sup> (digitised from Huntley 1985) over mountains, plains and sand dunes. Its main catchment, which is responsible for its flooding frequency of one out of three years (Heyns 1992), has an average altitude of more than 1500 m above mean sea level.

## HISTORICAL PERSPECTIVE

Utilization of water from the Kuiseb River and its aquifers can be traced back to the stone age. Archaeological evidence exists of humans dwelling in the desert and along the coast for several hundred thousand years. Most evidence, in the form of shell middens, was found in areas around extinct springs (Kinahan 1991).

The indigenous people of Nama descent, known as the Topnaars, have long been deriving a living from the river bed of the Kuiseb. Their ancient methods of obtaining water (some of which are still in use today in some villages) included a simple pit locally known as gorras which was dug in the river bed and lined with tree trunks. The average depth of such wells is said to have been 1 m to 4 m only. Rooibank is said to have been a natural fountain with semi-permanent springs and pools of water forming on the surface (Kooitjie pers. comm. 1993). This fact is well illustrated in Galton's (1890) description of Rooibank or Scheppmansdorf as it was known then, when he said "a small streamlet rises from the ground, and runs through the place, watering about three acres of gardens and field, and losing itself half a mile off in a reedy pond full of wild fowl." This indicates that the water table was much higher then, and could therefore sustain large Inara fields and riverine plant communities that supported game and the livestock of the Topnaar nomadic herders.

Despite the apparent abundance of water in the Kuiseb aquifers in those days, the establishment of coastal diamond towns like Conception Harbour and Meob Bay, and especially the harbour of Walvis Bay was hampered by a severe lack of drinking water. Fresh water had to be shipped in barrels from Cape Town in 1874 (Wilken & Fox 1978). Early attempts to exploit underground water resources at places like Sandwich Harbour, Sandfontein near Walvis Bay and the Swakop River produced brackish water which was mainly used for washing.

The battle against water shortage resulted in small scale desalination plants at Luderitz (1897) and Walvis Bay (1899) (Heyns 1992). The plant at Walvis Bay yielded the most expensive water in the world in those days at £ 1 / m<sup>3</sup>. At an average inflation rate of 3 % per annum between the years 1900 and 1995, the cost of that water would be N\$ 80 / m<sup>3</sup>. In time, with expansion and population growth the water requirements of the town exceeded the supplying capacity of the plant. As a major consumer of water, the S.A. Railways & Harbours took the lead in the search for a local water supply. They started to test and develop water supply schemes in 1923 at Rooibank (Wilken & Fox 1978).

This was also the time when the state started to allow the establishment of farms in the former state owned land of the Khomas Hochland within the **KCA**. Initially the state would not approve such a step as this area was known to have too little water to sustain farming activities. The first farm here was Niedersachen, now a guest farm, whose establishment was favourably considered merely because it could boast seven springs on its premises (Ahlert pers. comm. 1993).

This is indicative of how long the availability of water in the KCA for farms as well as towns has been a major problem. However, both the towns and farms continued to grow and expand unhindered in the face of water scarcity in the area. The studies at Rooibank exposed a "phenomenal source" of water according to Wilken and Fox (1978). The Rooibank water scheme administered by the Railways was completed in 1927 and the Walvis Bay headache over fresh water supply seemed to be over. However, after World War II the demand for water paralleled the rapid growth of the towns to an extent where the Rooibank scheme could not continue to meet the demand. As a result water had to be rationed for certain hours (18h00 to 21h00) in Walvis Bay in 1951. To allow for possible expansion of the scheme into Namibia, it was handed over to the then South West Africa Administration in 1952.

In 1954 the Union of South Africa set up a Water Affairs Division for South West Africa within the Works Department. This Division grew and became a branch of the DWAR in 1969 (Stern & Lau 1990). This organisational adjustment in RSA Government Departments resulted in the Rooibank water scheme being taken over by the DWAF from the Railways when SA embarked on administering South West Africa as part of the Republic of South Africa.

By this time the number of farms in the **KCA** had increased to more than 100 and a proliferation of dam construction in major flood channels and tributaries of the Kuiseb commenced. This had resulted from views held by farmers that run off in this area was not able to sufficiently recharge boreholes, but rather displaces the water from the upper reaches of the **KCA** to the lower catchment, out of their reach. Hence the feasible way to retain water on their farmland was dam construction. By 1974 four hundred dams were estimated to have been constructed in the commercial farmland of the upper **KCA** (Anon 1974). This is the area where rain falls significantly enough to generate floods that eventually recharge the alluvial aquifers downstream at Rooibank, Swartbank and Topnaar communal land.

The water from Swakop River groundwater resources had shown increased salinization due to runoff over gravel plains dissolving salts and carrying them into the groundwater. The problem of salinization made it impossible for Swakopmund to continue using water supplied from this river and therefore its supply was linked to the Rooibank scheme in 1963. The Swartbank aquifer, which is also in the Kuiseb upstream from Rooibank, was added to the scheme in the late sixties as demand skyrocketed in both towns.

In 1976 the giant mining operation of Rössing Uranium Ltd started off and the small company town of Arandis was born. This prompted the upgrading of the Swartbank pipeline to a capacity of 4 million m<sup>3</sup> of water a year (Heyns 1992) to meet the demand by the mine. This upgrading marked the first phase of the Central Namib Scheme (CNS). Rössing consumed such a vast volume of water that its possible impact on the aquifers and environment became a bone of contention amongst other consumers and environmentalists within only a few months. In its early years of existence (1976/77) Rössing used twice the total amount of water used in Walvis Bay and Swakopmund combined (see Chapter 7).

In 1979 the SWA branch of the DWAR was turned into a South West Africa/Namibia Department of Water Affairs (Stern & Lau 1990). Having realized their heavy impact on the water table and the possible complications this might pose to the environment, Rössing in 1981 started to cut down on their water consumption through reclamation and reduction in evaporative losses from tailing dams. The well propagated success story of the remarkable drop in water usage by Rössing has, however, been partly due to a drop in production that resulted from decline in uranium prices (see Chapter 7).

The Central Namib Scheme was split into two in 1985 with one part (DWAR) extracting water within the Walvis Bay enclave while the CNS was handled by the DWA in South West Africa/Namibia.

The common source of water and existing infrastructure and the overall importance of water necessitated the close contact and cooperation in water management maintained by the two authorities (Van Niekerk 1992).

Apart from the natural growth of population from births in the towns of Swakopmund and Walvis Bay, many immigrants entered the area in search of employment opportunities. The establishment of farms, along with the development of Rössing and the town of Arandis, in addition to established settlements within the **KCA**, resulted in a tremendous growth in the number of people depending on the Kuiseb for their water supply. Both Rössing and the farmers employed workers who were mainly from outside the areas supplied by the **KCA**. This resulted in an explosive increase in water demand which continues today.

Parallel to these developments in the **KCA** were the technological advancements in water extraction methods. Drilling machines could reach much deeper than hand dug wells while, simultaneously, automatic water pumps could withdraw water at a much faster rate. Consequently, the rate of extraction outpaced the rates of natural recharge from surface runoff or underground flow of water.

The situation was complicated by the fact that water attained multiple uses apart from basic human and animal consumption. Water was used for brewing processes, mining operations and industrial activities. This added dimension to the increase in water demand, coupled with the increased efficiency of extraction methods, the underground water sources were subjected to an unrestricted over-exploitation.

Namibia attained independence in 1990, though South Africa retained control over Walvis Bay. The latter authority was forced to give up the Swartbank aquifer as it was in Namibian national territory. More pressure was now placed on the Rooibank aquifer (operated and maintained by the Walvis Bay municipality on an agency basis for the DWAR) to supply Walvis Bay, resulting in an extraction rate double the estimated sustainable yield of 2 million m<sup>3</sup> per annum from this area. Alternate sources had to be sought and extensive studies were carried out on the feasibility of a desalination plant for Walvis Bay. Though preliminary findings indicated that high cost will be involved, the plant remains the only feasible option.

Though everything possible was done to ensure ample water supply to towns, the people of the Kuiseb valley were forgotten in all endeavours. This is despite the fact that they were the most vulnerable to a drop in the water table of the **KCA** as they had no water pumps. In response to their plight, the DWAN within the Ministry of Agriculture, Water and Rural Development constructed water installations including reservoirs and pipelines in five Topnaar villages, sinking new boreholes and installing diesel-driven pumps in 1993.

## OVERVIEW OF WATER INPUT IN THE **KCA**

The only means of water input into the **KCA** is rain. Though fog is utilized by some desert organisms and might reduce their dependency on other forms of water in the **KCA**, it has not been harvested for human use in this area and is therefore not considered as a means of water input for the purpose of this report. Rain provides the water that collects in the Kuiseb River and its tributaries to form run off. It is this run off that is trapped and held up in farm dams and seeps through sand and permeable rock formations to recharge the underground water resources and form temporal pools from which game drinks.

All along its course the Kuiseb River and its catchment area can be demarcated into at least six different rainfall regions (See Figure 2 on page 23). The upper Kuiseb on the plateau, from Wasservallei upwards, receives 300-350 mm annual rainfall; the escarpment to about 29 km from Wasservallei, receives 250-300 mm; 200-250 mm from Niedersachsen up to about 32 km up river; 150-200 mm from Niedersachsen up to about 15 km before Schlesien; 50-150 mm from Hudaob up to Schlesien up river and less than 50 mm from Hudaob to Walvis Bay (See Figure 2 on page 23). Less than 50 mm annual rainfall is experienced in the desert and is highly variable, unpredictable and unreliable. The desert area of the catchment can go for years without rain, though 3 to 4 years of consecutive rains may be experienced as occurred in the mid- 70's. At Gobabeb the average rainfall per year is 23 mm dropping to only 14 mm for Swakopmund.

The volume of water contained in the total average rainfall for the entire **KCA**, digitised from the Huntley (1985) map, is 2,347,025,000 cubic meters of which 1, 525,400,00 falls above the Schlesien Weir. These are of course hypothetical amounts, as rain is never evenly distributed in Namibia and less so for the **KCA**. Patchiness is a distinct characteristic of rainfall in Namibia (Dealy et. al 1993) and it is therefore normal for rain to fall as isolated storms over small areas of the **KCA**.

It is clear that the upper Kuiseb, through the plateau and the escarpment with their well defined drainage systems, is the only part of the catchment that contributes significantly to run off formation. The lower desert Kuiseb reaches are therefore mainly dependent on the run off originating in the Khomas Hochland for the recharge of its alluvial aquifers.

Since run off rarely makes it to the lower Kuiseb below Swartbank the recharge of this aquifer is almost entirely through subsurface flow. It is estimated that it takes 70 years for water to reach the sea through seepage and underground flow after rain has fallen in the Khomas Hochland (Wilken & Fox 1978). Hence the recharging of the lower Kuiseb, where surface run off is uncommon, is a slow process.

The total mean annual runoff of the Kuiseb before it joins the Gaub, (Figure 3 on page 25), amounts to 16.665 Mm<sup>3</sup>. The Gaub itself contributes a mean annual runoff of 4.273 Mm<sup>3</sup> to the total annual average runoff of 20.938 Mm<sup>3</sup> at the Kuiseb-Gaub confluence. It is logical that runoff volume will vary greatly with normal variation in rainfall. The wet season of 1962/63, followed immediately by a dry one in 1963/64, clearly illustrates this variability. Approximately 105.9 Mm<sup>3</sup> of water passed at the Schlesion Weir in 1962/3 compared to only 0.0065 Mm<sup>3</sup> in 1963/64 with many intervening years of zero flow.

In the upper reaches of the Kuiseb the alluvial material in the river bed is very thin with bare bedrock exposure found in some areas. Characteristic of this area are the deep and narrow flow channels causing high flow velocity. These factors result in minimal infiltration and the apparent consistency in increase of flood volumes up to the Kuiseb-Gaub confluence (Figure 3 on page 25). Furthermore, the numerous tributaries in this part of the catchment continually add to the flood as it progresses over distance. This will bring a steady increase in flood volume, even though running water may be lost to evaporation, in the upper reaches of the Kuiseb (Figure 3).

From the Gorob River downstream, the alluvial deposits get thicker and the river bed filled with more sand, which enhances infiltration and increases the groundwater storage volume. The total runoff volume is systematically reduced due to infiltration and evaporation, however, as the tributaries over the gravel plains do not contribute significantly to runoff. Total average annual runoff is reduced to 4.472 Mm<sup>3</sup> at Gobabeb, 1.935 Mm<sup>3</sup> at Swartbank and 0.570 Mm<sup>3</sup> at Rooibank (Figure 3). The Kuiseb river rarely reaches the sea; during 150 years, 1830 to 1980, the river reached the sea in only 14 years (Braune 1992).

Not much is known about the recharge of the aquifers in the upper KCA. Interviews and field studies showed a substantial number of boreholes in the area regularly running dry. It has not been confirmed whether this can be attributed to the rate of recharge or simply to the fact that most of the boreholes are sunk into very steep geological structures that decline at an angle of more or less 45 degrees, as suggested by some farmers. Farmers are of the opinion that aquifers in these structures are not suited to hold much water as it is lost to lower areas. As recharge is very low in this area, the aquifers never built up large reserves to support the boreholes. Boreholes tap the little water that manages to collect in the aquifers and consequently run dry.

Whatever the cause, the unreliability of boreholes had prompted farmers to build farm dams to simultaneously supplement boreholes and recharge the water table. The dams can support livestock for at least a year if they fill to full capacity. On all the farms visited, boreholes were found to be located adjacent to dams. However the dams tend to accumulate silts, which makes infiltration difficult and consequently exposes water to evaporation.

Another rather interesting alternative method of enhancing the recharge of underground resources or simply storing water found on one farm is through construction of "sand dams." This entails a sand filled dam that traps and "stores" water underground (Stengel 1968), greatly reducing evaporative losses.

Although data on the recharge rate of the aquifers in the upper catchment as well as Topnaar villages are sketchy, extensive data exist for the Swartbank and Rooibank aquifers. If it is supposed that all other factors, such as evaporation and seepage, were equal over the 33 km section from Swartbank to Rooibank, then this section would be recharged at a rate of 8,9 Mm<sup>3</sup> a year (DWA-SWA-BRANCH 1978). The actual annual rate of recharge at Rooibank based on 1960-1976 records is 2,1 Mm<sup>3</sup> and 3.0 Mm<sup>3</sup> for Swartbank based on 1985-88 records (Braune 1992).

## OVERVIEW OF WATER OUTPUT FROM THE KCA

Water collected in the Kuiseb river system can be taken out of the catchment through various methods. Water can either get lost, pass through the river system without being used within the system or be tapped for human use. Human use of water refers to any use water is put to by humans including consumption (drinking and cooking), washing, industrial processes, recreation, irrigation and watering animals.

The major cause of water loss from the catchment, and in Namibia as a whole, is evaporation. Water evaporates from standing pools, dams, soil surfaces and swimming pools due to heat from the sun. The arid climatic conditions prevailing in Namibia result in 83% of rainfall evaporating immediately leaving only 17% as remaining surface water. From this 17 percent, 15% seeps through soil and remains as soil water while 2 % is trapped in dams. Only one percent from the 15% seepage recharges aquifers and the remaining 14 % is used by plants (Heyns 1992) (Figure 4).

It is important to note that the percentage of rainfall water trapped in dams as well as that recharging aquifers, amounting to a total of 3 % , can not be considered to be safe from evaporation. Water continues to evaporate from dams every day after being trapped, while daily extractions retrieve it from aquifers, often storing it in open reservoirs from where it evaporates. Farmers in the upper catchment, and the same can be assumed for the Topnaars, see evaporation as their major hurdle and enemy number one in their efforts to conserve and retain water in dams and reservoirs. Evaporative losses in towns can mainly be attributed to irrigation of gardens and uncovered swimming pools.

The overall picture shows that in essence only less than three percent of total rainfall is available for human use while the rest is virtually lost. The Namib, being a desert, is expected to have higher rates of evaporation than the rest of the country. Apart from temperatures being extremely high, winds are very common and both are factors which increase the rate of evaporation. However, evaporation is reduced at the coast due to humid climatic conditions prevailing near the sea.

Another factor causing loss of water from a catchment is runoff into the sea. Though runoff facilitates infiltration and recharge of aquifers, it occasionally has the negative effect of spilling fresh water into the sea. Such water is lost for human consumption but, as mentioned before, events where the Kuiseb River reaches the sea are exceptional. In most events runoff within the **KCA** is simply a process of redistribution of water from one area to another. It should be added, however, that it is critical for the environment and the continued existence of the Kuiseb vegetative communities within the river bed, that floods reach the sea. Most of the water that reaches the sea does so through subsurface flow although this fact is often disputed (Brummer pers. comm. 1993).

Most probably due to massive extraction of water from the lower Kuiseb at Rooibank and Swartbank, subsurface flow no longer reaches the sea. Instead, sea water may move inland posing another threat to the supply to towns. The advancing "saline wedge" is believed by a number of interviewees to act as a barrier to fresh water, thus preventing it from moving into the sea. Fresh water is less dense than sea water and floats on top of sea water where they occur together. Consequently the sea water occupies space previously occupied by fresh water in the aquifer. Boreholes tap the floating fresh water and open up space for sea water to move inland. Some interviewees expressed fears for what might happen if this saline water reaches major extraction centres like Rooibank. Their fears are not unfounded if it is considered that this saline water has already been detected at Dorop, more than four kilometres inland.

Not only are fresh water reserves being depleted, but the quality of the little remaining water is deteriorating due to salinization by advancing sea water. More worrisome is the fact that this dangerous situation is irreversible. Once the storage space within an aquifer is lost to sea water, it is lost forever.

Different water usage patterns are found in the Kuiseb catchment area, depending on the user. Water for human use is mainly drawn from boreholes sunk all along the river. The boreholes vary in depth from place to place in the KCA, but any average depth calculated for the entire catchment area will be a far cry from the 4m Topnaars used to dig to get to the water table within the lower Kuiseb River. The seriousness of the shrinking water table is demonstrated by the fact that the springs at both Rooibank and Niedersachen have vanished in less than 70 years.

Commercial farmers, Topnaar villages, the Gobabeb Research Station, the Rössing Uranium Mine, Swakopmund and Walvis Bay were identified as major categories of users of KCA water. Rössing claims to have shifted their dependency from the Kuiseb basin to the Omaruru Delta (Omdel) but their historical exploitation of the Kuiseb compels any researcher to examine the mine's water usage patterns. As water from both the Omdel and the Kuiseb is mixed in one big reservoir before it is distributed by the DWA to various consumers, including Rössing and Swakopmund, the claim by Rössing is unsubstantiated.

Usage patterns and user habits within these major user groups are discussed in depth in the specific chapters. Rough estimations of proportional total annual water use by six user groups from the upper KCA westward produced the following results: Commercial farmers ( $0.6 \text{ Mm}^3$ ), Communal farmers ( $0.006 \text{ Mm}^3$ ), Gobabeb ( $0.007 \text{ Mm}^3$ ), Walvis Bay ( $4.3 \text{ Mm}^3$ ), Swakopmund ( $2.9 \text{ Mm}^3$ ), and Rössing and Arandis ( $3.0 \text{ Mm}^3$ ). The mean percentage used by each group per year is portrayed in Figure 5. Water installations in Walvis Bay, Swakopmund, Rössing, Arandis and at Gobabeb are metered and actual measurements (readings) were available, whereas commercial farmers have no measurements at all. Measurements of water use on the communal farms of the Topnaars has only been initiated recently (1993) in some villages. Hence Figure 5 depicts approximate amounts used by the several groups and not exact measures.

The amount of water used annually is relatively constant in contrast to the high variability of rain and the amount of water entering and passing through the KCA and the Omaruru Catchment annually. As mentioned before, the years 1962/63 and 1963/64 illustrate this variability. Water consumed by users downstream (Figure 5 on page 29) represents only 9.6% of the  $105.9 \text{ Mm}^3$  that passed the Schlesien Weir confluence in the wet year of 1962/63. The same use represents more than 1500 times the  $0.0065 \text{ Mm}^3$  estimated for the 1963/64 dry season. The rough estimations given here must be used with great caution as the data are taken from different years and sources and because some of the water used comes from the Omaruru catchment, not the KCA. Moreover, there are many other losses of water from runoff before it infiltrates into aquifers where extraction for use takes place. Nevertheless, these calculations give an idea of the relationships between input and use in wet and dry years.

The categories of users, as it is with the whole KCA, are not entities in isolation. As components of an integrated water supply system, interactions amongst the groups are inevitable. Typical of social interactions wherever problems are encountered, there was a great tendency amongst the interviewees to blame someone else for the current water shortages in the KCA. Though most interviewees pointed fingers at Rössing for having taken so much out of the aquifers, some were cautious because Rössing has cut its uses and losses. They brought up the question of farm dams occasionally. Many influential people, scientist and politician alike, have nurtured the idea that farm dams hold up floods and hence interrupt the recharge of aquifers in the lower Kuiseb River. This view seems to have been adopted by most urban dwellers of the KCA. However, there were those who hold the view that farm dams being small in size and mainly built in tributaries, will have a minor effect, especially on big floods. This group blames the drop in rainfall for forming small floods that can easily be stopped by dams. They suggest that an increase in rainfall will alleviate the situation.

Statistics show that rainfall is normally low for Namibia and especially so for the central-western region in which the KCA is situated. It is therefore inappropriate to talk of a "drop" in rainfall. The blame should rather be placed on extensive over-exploitation of the aquifers which was brought about by population growth, livestock production, industrial development and "improved" living standards, all factors contributing to the increased demand.

Towns have been blamed by farmers for having massive gardens and no control over water use within them. Both Swakopmund and Walvis Bay project their future rate of increase in water demand to increase with 0,5 % for every five years. This means that if the current yearly increase in water demand is 3,5 % then it will be 4 % after 5 years. It is such trends that lead to desperate non-sustainable over extractions at Rooibank and other extraction points in the KCA.

The KCA is not a closed system in respect to water output as it supplies water to Swakopmund and Rössing which are outside its boundaries. The possibility of aquifers within the KCA being connected to other catchments can not be excluded. Depletion of such aquifers might result in a broader problem rather than a localized one.

Interactions due to a dependence on a common source of water are not restricted to human-to-human relations only, but extend to human-to-environment relations too. Should the water levels drop to a point where no plant species, or at least no preferential plant species, can reach it, then the support base of life will be destroyed. No forage for livestock will be available. The consequences are more far-reaching for the desert, where lack of vegetation cover and big floods allow dune encroachment. Dunes are estimated to move approximately 8 m into the river bed per year at Rooibank, where extraction has been too heavy for too long (Huntley 1985). Severe water extraction in this area is manifested in the mortality of shallow rooted palm trees planted by missionaries as well as total failure of the Inara plant to bare melons. The issues raised herein are the core concerns of the chapters contained in this report.



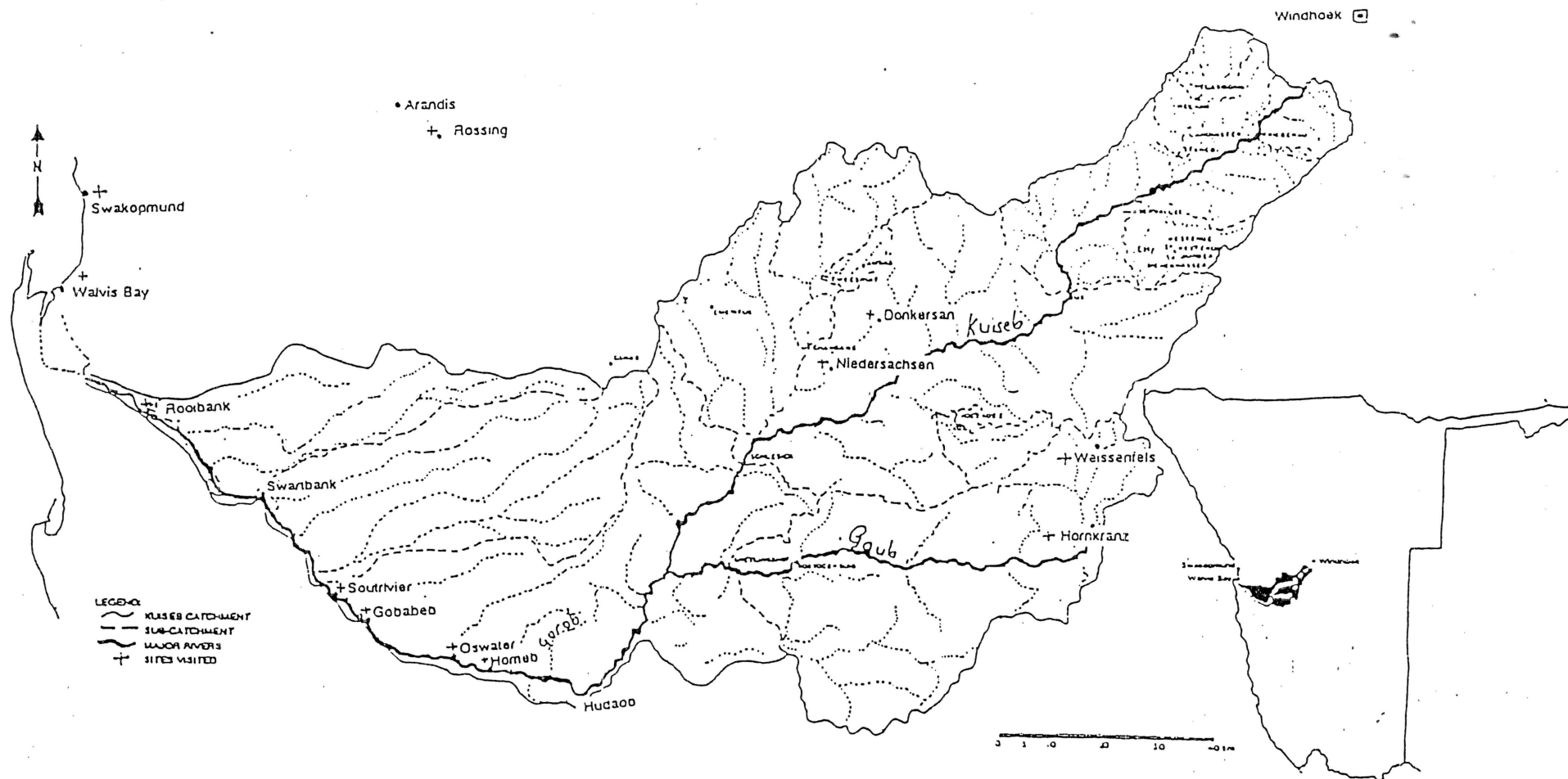


Figure 1: The Kuiseb Catchment Area (KCA);  
Orientation map

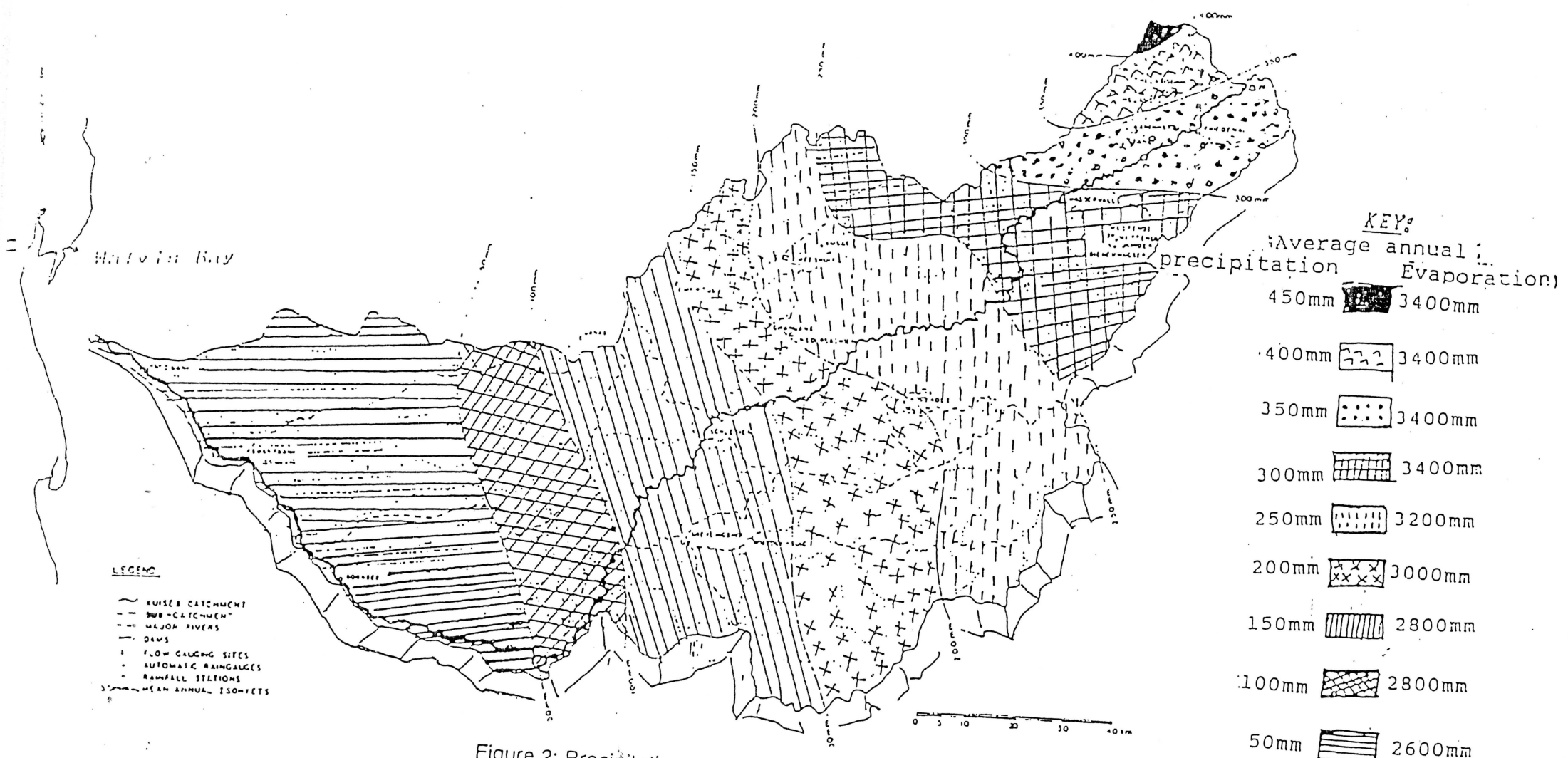


Figure 2: Precipitation vs Evaporation over the KCA

Fig.3. Kuiseb flood volume decreases along length of river

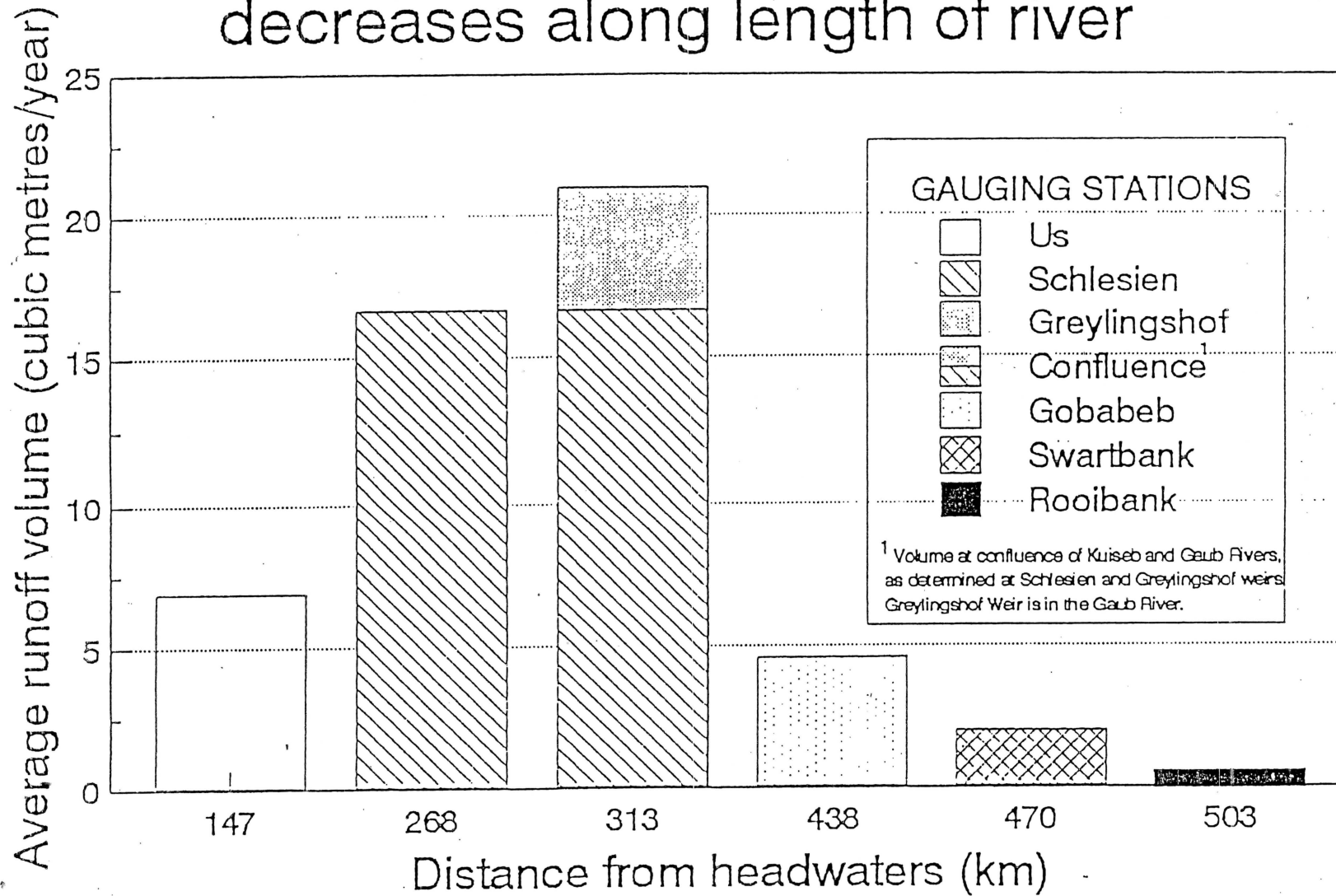


Fig.5. Percentage Water Usage  
In the Kuiseb Catchment

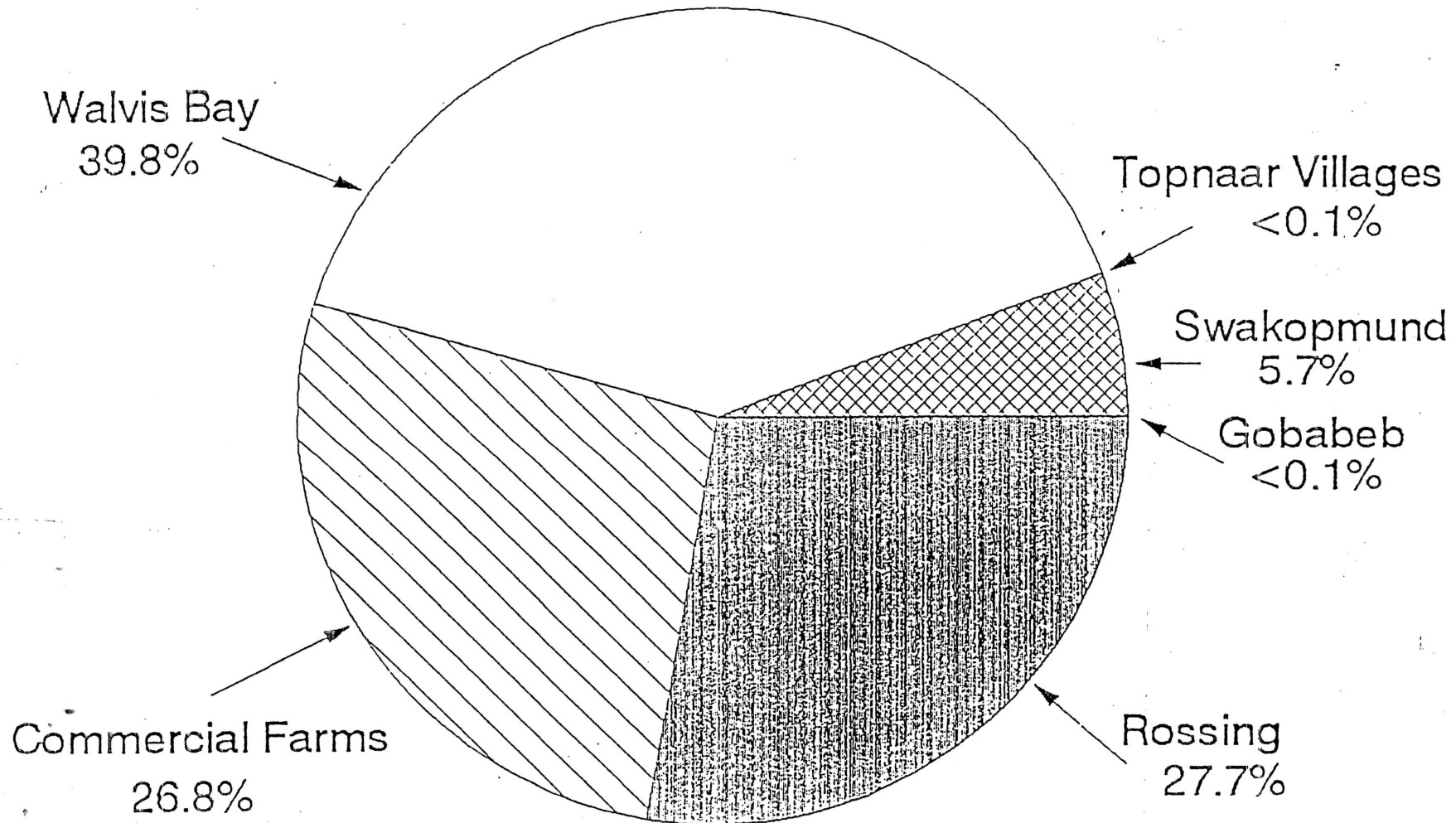
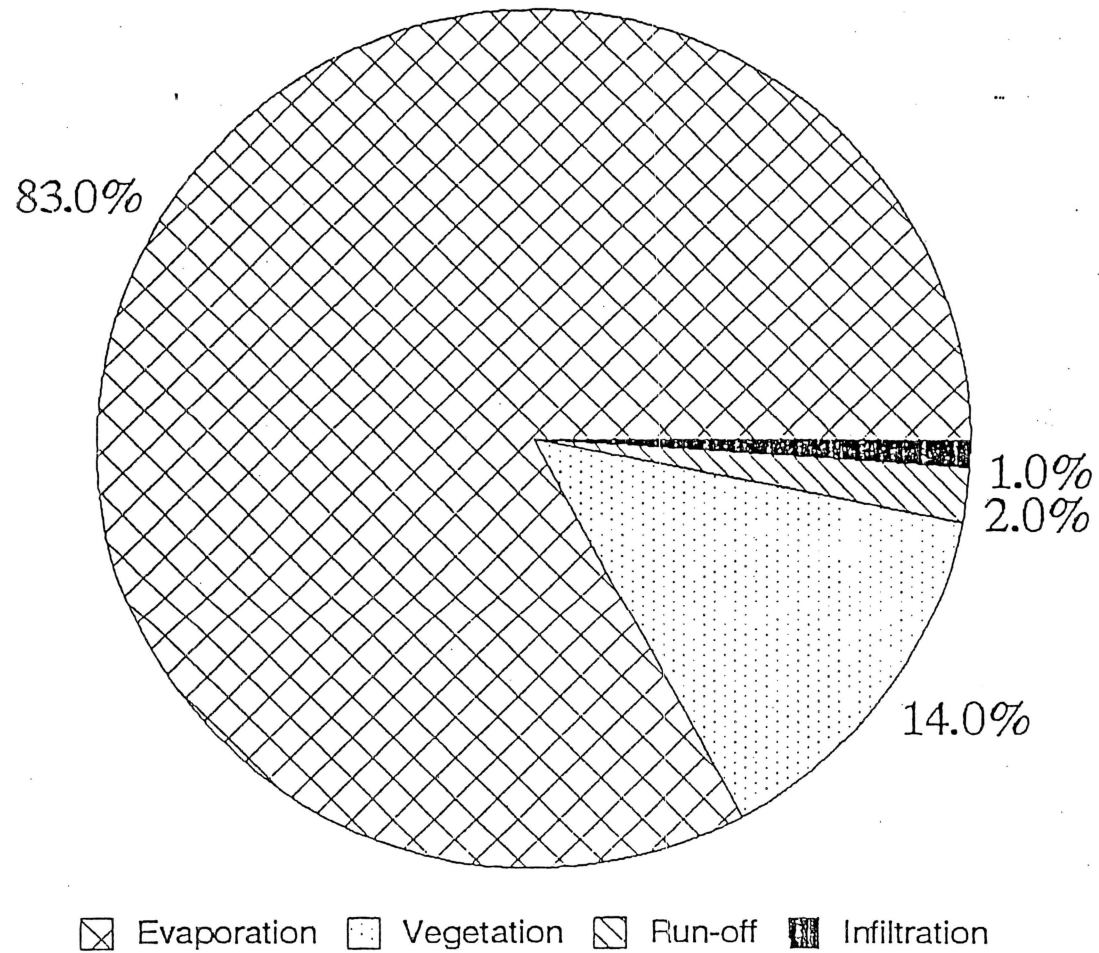


Fig. 1. Precipitation Partitioning on the Farm Niedersachsen



## Chapter 2 - COMMERCIAL FARMERS OF THE KUISEB CATCHMENT AREA by Samuel Swartz

### ABSTRACT

The aim of this chapter was to determine the influence of the water related activities of the commercial farmers in the upper Kuiseb Catchment Area (KCA) on the lower catchment and to come up with possible ways to reduce any negative impact. Information was gathered through personal interviews and a review of the available literature. It was difficult to determine exact figures of consumption, due to the lack of meters on pumping installations. A series of actual and hypothetical calculations were made, allowing estimates of gross consumption patterns to be developed. These are discussed herein, with recommendations for future studies and conservation of the water resources of the upper KCA.

### INTRODUCTION

Farmers, and more specifically commercial farmers, form an integral part of the economy of any country. Namibia is increasingly dependent on the agricultural sector to supply its growing food demands. Farming can therefore be expected to play a more important role in the future. Since water is a primary need for the existence of any form of agriculture, the means by which farmers obtain and use their water is of great importance.

Seen in this light, and given the suggested negative influence of farm dams on aquifers lower down in the catchment, the means by which the commercial farmers obtain and use their water forms an integral part of the Kuiseb River Catchment study. An attempt has therefore been made to define the sources and uses of water on the farms, and also to determine any losses or wastage of water, in addition to any conservation methods being employed to counteract these losses.

A total of 109 commercial farms are located in the KCA (Huyser 1979) with a total area estimated at 9500 km<sup>2</sup>. Commercial farms occupy the entire headwaters area of the Kuiseb catchment. Their sources of water, means of transporting the water and the ways they are using water would therefore give an idea of the water distribution patterns in the upper catchment area, for comparison to urban consumption patterns in the lower catchment.

### MATERIALS AND METHODS

Four farmers in the upper catchment were selected for interviews, during which data was gathered. This was the chief method used to gather information. A questionnaire was developed for use in these interviews (Appendix A). The farmers interviewed were:

- Mr. H. Lombard from the farm Weissenfels;
- Mr. F. Malan from the farm Hornkranz;
- Mr. K. Ahlert from the farm Niedersachsen, and
- Mr. A. Huber from the farm Donkersan.

While conducting the interviews, observations about water usage patterns were made in order to confirm the information supplied by the farmers. Literature was also consulted to help evaluate available data. Rainfall data, as supplied by farmers and other sources, was analyzed to calculate the average rainfall inputs to the farms.

### RESULTS

The sizes of the farms from which interview data was gathered are given in Table 1. It should be realized, however, that some of the farmers bought additional land, thereby increasing the size of their farms (Lombard pers. comm. 1993). Figures of the average numbers of boreholes should therefore not be taken as precise counts for all the farms in the catchment area.

Table 1 - LOCATION AND SIZE OF FARMS

FARM	RIVER/TRIBUTARY	SIZE OF FARM (ha)
DONKERSAN	KUISEB	14,700 ha
HORNKRANZ	GAUB	15,000 ha
NIEDERSACHSEN	KUISEB	18,500 ha
WEISSENFELS	GAUB	12,000 ha

## SOURCES

The main sources of water on farms are boreholes and dams, which are supplied via rainfall. On the farm Niedersachsen seven springs existed in the 1920's, but these areas could not even supplement one borehole today, due to the drop in groundwater levels drying up all seven springs (Ahlert pers. comm. 1993).

### Boreholes

The farms are divided into camps to prevent overgrazing by permitting rotational grazing. Boreholes are usually located at the intersection of four camps to minimize the number of boreholes needed. The total figure varies; some farmers have drilled up to 60 boreholes, but due to bad location sites and lowering watertables, on average only 5 to 12 boreholes are used. Water from boreholes is pumped into small reservoirs - one located at or near each borehole. The water from these reservoirs is used to water livestock by means of troughs. Refilling rates of reservoirs depends on demand (use by the livestock).

No information was available concerning pumping rates of boreholes. According to farmers, water is pumped from some boreholes every second day for up to twelve hours, providing livestock with drinking water. In the rainy season, the amount decreases to only 6 hours due to the availability of other sources (i.e. dams and waterholes in the river). Boreholes providing water for domestic use are pumped at an average of up to 20 hours/day; the amount pumped is unknown (Lombard pers. comm. 1993).

No significant changes in water levels have been noticed recently. Boreholes that did run dry during the last three years are related to fluctuating rainfall figures of the past ten years (Malan pers. comm. 1993). Water levels of these boreholes have been noticed to rise slightly after usage is stopped, probably due to a recovery of the local water table associated with later movements of groundwater. Changes in water quality are described as insignificant.

The cost given by the farmers to drill a borehole is up to N\$ 65/metre, with the average depth of the boreholes reaching down to about 100 metres, depending on the area and aquifer, as well as geological structures. This can add up to figures of over N\$ 6 500, depending on the depth of the borehole.

### Dams

Ground dams are important as a source of water. The size of ground dams is mainly dependant on their location in the river or stream bed. The mean height of the dam wall is about 5 metres, with a maximum depth of 10 metres.

Volumetric capacities vary according to sizes with estimated figures given by farmers as 10-15,000 m<sup>3</sup>. No exact figures could be obtained about the surface areas of the dams. The total potential storage of the dams in the catchment area was approximated at 19,9 Mm<sup>3</sup>, which has been reduced to approximately 15,8 Mm<sup>3</sup> due to siltation (Anon 1974).

At a rate of N\$ 325/h to hire earth-moving equipment, constructing a dam is very expensive: working about 12 hours/day for up to five days, costs can amount to over N\$ 20,000 per dam.

## RAINFALL

The farmers interviewed had a varying number of rain gauges distributed on the farm. These are for personal use only as they have no interaction with the Weather Bureau in Namibia.

The average rainfall in this area (upper catchment area) is as high as 350 mm per year (Weather Bureau). Rainfall data as supplied by farmers and the Weather Bureau were used to calculate the total amount of water input per year on the farms where interviews were conducted (see Appendix D for calculations).

## USERS AND USES

Livestock on the farm are the main priority in water use. Animals are - as stated by farmers - on average responsible for 90% of the total water consumption on farms; domestic use accounts for the remainder. The majority of farms have gardens; averaging approximately 50 square metres in size with an unknown consumption of water. Consumption figures for domestic use (showers, toilets, cooking, etc.) are also unknown. This is again due to a lack of meters on the water installations.

The amount of water used by livestock on farms - supplied by farmers - adds up to an average of 50 l/day/individual for cattle and 5 l/day/individual for sheep. In theory the carrying capacity of these areas can be up to 1:12 (one livestock unit per twelve hectares). Farmers claim to maintain a figure of 1:20.

Even though guest farms and farmschools are uncommon amongst the 109 farms in the KCA, their influence on water consumption cannot be neglected. The school on the farm Weissenfels consists of an average of 40 students with 3 teachers (Lombard pers. comm. 1993). Facilities like showers(6), toilets(6) and basins(4) are in use; the consumption figures however, are unknown, as are those for the guest farm on the same farm. Again, the complete absence of meters prevents exact assessment of water usage rates.

## STORAGE

Dams are an important way of storing water. The current number of dams in the K.C.A, their average volume and surface areas are unknown. The farm dams are claimed to have a storage capacity to fulfil one year's need (Lombard, Malan, Ahlert, Huber pers. comm. 1993). Insufficient rainfall in some areas has caused dams to be only 60% full in the past three years. The most commonly used method for storing water is in small uncovered reservoirs - one for each borehole. The average size of these reservoirs is 1.8 m (height) with a radius of 2.5 m. This gives an average volume of 35.35 m<sup>3</sup> and a surface area of 19.64 m<sup>2</sup>.

## TRANSPORT

The only known means of transporting water on the farms is via plastic pipeline.

## LOSSES AND WASTAGE

Farmers admitted to water losses but refute the existence of any water wastage. Considerable losses occur through evaporation, however, given an evaporation rate of up to 3 500 mm/a. Water loss may occur through human error as well with valves and taps being left open and because of faulty water equipment, with pipes leaking or bursting. Wild animals, for example baboons, damage pipelines and other equipment, causing an unknown amount of water to be spilled. Accidental cases of animals drowning in reservoirs occur, whereupon farmers are forced to empty the reservoirs due to the unsanitary conditions created.



## CONSERVATION

According to farmers the building of dams to store excess runoff is a means of conserving water. The resulting rise in the recharge rate of the groundwater levels relieves the pressure on the water stored underground. Other conservation methods being taken, include the regular maintenance of water supply infrastructure. In the case of guest farms and schools, general awareness to save water is encouraged by small campaigns using stickers and other means. No extra costs are involved with these campaigns.

## DISCUSSION

### INPUT

The major sources of water on a farm are boreholes and dams, with rainfall being the only contributor towards the sustainability of these sources. With the rainfall being very variable, ground dams are an unreliable source that normally only supply water for 8-10 months. Rivers and streams on the farms normally flow every year for a few days, but flow can last for a few weeks depending on rainfall. This runoff water recharges the underground aquifers as well as the ground dams (if any) in the rivers or stream beds. Groundwater levels will rise after rains, the level depending on the amount of rain and infiltration.

An important factor influencing run-off figures and infiltration capacity of an area is the vegetation. Thus the less vegetation in an area, the less infiltration will occur. A few low rainfall years can cause the vegetation of the area to decrease, leading to an increase in percentage of run-off in the next high rainfall season. In such a case, valuable soil and nutrients are lost, inhibiting the recovering of vegetation.

Overgrazing of farmland can have the same effects as low rainfall. Poor management of livestock grazing patterns can lead to the livestock trampling vegetation and soil. This causes the soil to be washed away due to the increased run-off of the area associated with the decreased vegetation coverage.

### OUTPUT

The main users of water on farms can be partitioned into two groups (according to the farmers); livestock, using 90% of the water, and domestic users consuming the remaining 10%.

No strict priorities for the use of water on the farms exist, although during drought periods, according to the farmers, livestock will be the first priority with gardens receiving a lower priority. No crop farming takes place on these farms but there are relatively small vegetable gardens on some farms. Farmers state that it is easier to buy vegetables in town when water is scarce.

Water consumption is not metered on any of the farms. We were not able to obtain any measured values for borehole pumps on any farm, including the guest farms and the farm school on Weissenfels.

### LIVESTOCK

According to the farmers, their livestock consists mainly of cattle and sheep. The cattle are bred for export purposes to the central areas of Namibia, from where some are further exported to neighbouring countries. The sheep are only used for providing meat on the farm. Some poultry are also raised.

The upper Kuiseb catchment was estimated to carry a total of 35 567 cattle, 71,075 sheep and 3,025 goats in the mid 1970's (Huyser 1979). A more recent estimate, based on the carrying capacity of the area (between 8 and 30 ha per large livestock unit), indicates that the areas potential stock carrying capacity would be in the order of 76,230 cattle and 102,244 small stock - sheep and goats (Huntley 1985).

With livestock using most of the water, one would expect the carrying capacity of the farms to be of great importance. Farmers state that even though the carrying capacity of their farms is 1:12 (one large livestock unit per 12 hectares), they are maintaining a stocking rate of only 1:20. This is an attempt to sustainably use the available pasture. Using these given figures, an attempt has been made to estimate the livestock numbers owned by the farmers interviewed, according to each farm's carrying capacity (Table 2).

**Table 2 - CARRYING CAPACITY OF FARMS**  
(large livestock units per hectare)

FARMS	C.C 1:12	C.C 1:20	ACTUAL FIG.
DONKERSAN	1225	735	234
HORNKRANZ	1250	750	---
NIEDERSACHSEN	1542	925	584
WEISSENFELS	1000	600	---

These figures have been calculated using a 1:6 ratio to convert all small livestock numbers into large livestock units. Figures listed under 'actual' were those given by farmers. Refer to Appendix B for examples of the calculations made.

Although water consumption of the cattle and sheep can be estimated, no information about the total number of livestock on some of the farms was available. Water consumption of livestock was therefore estimated by using the figures calculated in Table 2 (see Table 3).

**TABLE 3 - Calculated Livestock Consumption per Day (m<sup>3</sup>)**

FARM	C.C 1:12	C.C 1:20	ACTUAL
DONKERSAN	61.25	36.75	11.7
HORNKRANZ	62.50	37.50	---
NIEDERSACHSEN	77.10	46.30	29.2
WEISSENFELS	50.00	30.00	---

Problems are currently experienced by farmers with wild zebras that move into their land seeking water and pasture. The zebras use the same watering points as the cattle, causing the water demand to rise significantly. In order to control this problem, farmers have obtained permits to shoot some of the animals. This number is limited to a minimum, however, to prevent future ecological imbalance.

#### TOTAL WATER USE ON FARMS

##### Input

An effort has been made to define the relationship between the actual input of water on the farm (rainfall) and the usage thereof. A hypothetical analysis of the water usage patterns on the farms surveyed has been made to try to determine the actual amount of available water on the farms. The calculation is based on the hydrological cycle of Namibia as adopted from Heyns (1992).

Yearly input figures for the farms have been calculated using average rainfall figures supplied by the farmers. We also used the lowest and highest figures from rainfall records for the past 40-50 years, providing an example of the variability that is typical in arid-land rainfall. For the farms Weissenfels and Donkersan, average rainfall figures for the area were used because exact figures were unavailable. Rainfall figures used can be found in Table 4.

**TABLE 4 - Rainfall figures on the Farms (mm/year)**

FARMS	LOWEST	AVERAGE	HIGHEST
DONKERSAN	----	105.0	250.0
HORNKRANZ	97.0	235.5	391.5
NIEDERSACHSEN	45.7	105.0	459.9
WEISSENFELS	163.3	225.0	704.5

Using the figures in Table 4 the yearly input figures on the farms were calculated (Table 5). As can be seen in Figure 1 (Appendix C), the majority of rain falling in the upper KCA rapidly evaporates or is used by the vegetation, leaving only a small fraction available to recharge groundwater supplies or fill dams. Figure 2 (Appendix C) shows the wide range of rainfall possible at a site, with the average typically much closer to the lowest value than the highest. In addition, it emphasises the high evaporation rate characteristic of Namibia's arid climate. Finally, it depicts the very low amounts of surface runoff and infiltration in any given year.

**TABLE 5 - Yearly Rainfall Input For Farms (Mm<sup>3</sup>)**

FARMS	LOWEST	AVERAGE	HIGHEST
DONKERSAN	----	15.435	36.750
HORNKRANZ	14.550	35.330	58.725
NIEDERSACHSEN	8.455	19.425	85.082
WEISSENFELS	19.596	27.000	84.540

With the water consumption of livestock taken as 90% of the total on most farms (Lombard, Malan pers. comm. 1993) and 95% on others (Huber pers. comm. 1993), an approximate figure for the yearly water consumption on the farms can be calculated, as shown in Table 6. Examples of calculation methods can be found in Appendix B.

**TABLE 6 : Yearly Water Consumption For The Farms (m<sup>3</sup>)**

FARMS	WITH LIVESTOCK USE = 90% OF TOTAL	WITH LIVESTOCK USE = 95% OF TOTAL
DONKERSAN	4,745	4,495
HORNKRANZ <sup>1</sup>	15,208	14,408
NIEDERSACHSEN	11,842	11,219
WEISSENFELS <sup>1</sup>	12,167	11,526

<sup>1</sup>Calculated assuming stocking rate of 1:20-

## INFLUENCE OF FARM DAMS

Increasing development in the Kuiseb catchment area has the direct consequence of increasing water demands. Development is taking place in the whole of the catchment area, including among the commercial farmers. In the case of the farmers it normally means increasing the number of boreholes or dams on the farm. Due to a lack of control, the current number of farm dams is unknown, though the last known number cited was approximately 407 dams in 1974 (Anon 1974).

Presently, according to the farmers, no authorization is needed to build farm dams with a volume less than 20,000 m<sup>3</sup>. Farmers only have to reach an agreement with neighbours who might also be dependent on water from the same river or stream. Larger dams must, however, be authorized by the Department of Water Affairs. As a result of this, no exact figures exist of the number of small farm dams in the KCA.

These dams may have a tremendous effect on the flood characteristics of the Kuiseb river. It was estimated - with this number of dams - that the reduction in the average downstream flow amounts to up to 21% (Anon 1974). However, some farmers claim many of their dams to be more than 30 years old. This claim is being used to refute the allegations that their dams are having a negative influence on the runoff reaching the lower Kuiseb River. With the total volumetric capacity of these dams estimated to be 16 million cubic meters (Anon 1974), they may have a major impact on the flooding frequency of the Kuiseb. The effect would be less significant during big floods such as the one recorded in 1962/3 with a runoff volume of 105 million cubic metres recorded at the Schleisien weir (DWA Records). It will however have a more profound effect during the 'drier' seasons, when the runoff volumes are at or below average condition (Workshop DWAF 1991).

Since the lower catchment (coastal area of Walvis Bay and Swakopmund) is largely dependent on Kuiseb aquifers, such as Rooibank and Swartbank, for their water supply, reduction in the flow of the Kuiseb could influence them directly. These aquifers rely on the floodwater of the Kuiseb for their recharge. It is therefore a threatening fact that the last major flood reaching these areas and contributing significantly to aquifer recharge was recorded in 1973/4, twenty years back.

This shortage is putting the coastal towns in a precarious position as recharge of the aquifers is needed. This is particularly so because sustainable yield from the aquifers is being exceeded (Brümmer, pers. comm.). It is clear that something will have to be done - if it is not too late already. Given that the aquifers in the lower Kuiseb have been overused for too long, seawater seepage may preclude chances of a complete recovery of the aquifer to its original potential (Kooijie, pers comm)

It is worth noting that the Department of Water Affairs is currently assisting in an investigation conducted by the Desert Research Foundation of Namibia to quantify the current influence of the smaller dams in the upper Kuiseb catchment on downstream runoff (Jacobson pers. comm. 1993). If an effect is found, restrictions on the building of farm dams should be set up and enforced in order to maintain aquifer recharge in the lower Kuiseb.

As pointed out in a workshop held in Walvis Bay by the Department Of Water Affairs and Forestry (S.A.) in February 1991 however: "Farm dams can offer some explanation for the long period of, largely, below average runoff since 1962/63, but not for the longest waiting time in living memory of an event that breaks through to the sea." The persisting trend of a lower frequency of floods cannot be blamed entirely on the alleged building of more and more farm dams. Future studies of the hydrology of the Kuiseb catchment, including rainfall and runoff analyses, will therefore be of the utmost importance.

In contrast to their effects on the lower catchment aquifers, farm dams are beneficial to groundwater in the upper catchment. They indirectly supplement boreholes on the farms by recharging local groundwater levels. The water can then be pumped into reservoirs for use by people and livestock. This benefit should not be discounted.

## EVAPORATION

Farmers described water losses due to evaporation out of ground dams to total one foot per month. Exact losses from ground dams could not be calculated due to the unknown surface areas. Figures for evaporative losses were calculated using estimated surface areas (Figure 3 - Appendix C). The calculations indicate that such losses are extremely high, relative to actual amounts of consumption.

Losses from uncovered reservoirs also contribute to the total evaporative losses. For example, from a borehole reservoir with a surface area of 19,64 m<sup>2</sup>, the annual water can be calculated as 68,74 m<sup>3</sup> (based upon an evaporation rate of 3500 mm/a.). Using an average figure of 10 reservoirs in use per farm, an estimated amount of 74,927 m<sup>3</sup> is lost per year through evaporation out of reservoirs on the 109 farms in the upper KCA.

## DONKERSAN DAM

A major dam on the farm Donkersan has been proposed as a way to supply Windhoek with water. This would greatly reduce runoff from the upper catchment. The dam is estimated to reduce the total run-off of the Kuiseb up to 70% (Jacobson, pers. comm. 1993). This would likely cause major problems for farmers living downstream and dependent on the Kuiseb for most of their water needs. However, farmers living along the Gaub tributary have no complaints against such a project, since it is unlikely to influence them in any direct way.

It was an astonishing fact that the owner of the Donkersan farm (Mr. Huber) - when interviewed - did not have any knowledge of the proposed building of the dam. The owner of the neighbouring farm (Mr. Ahlert, Farm Niedersachsen), however, knew about the proposed construction of the dam and approves of it because of the possible benefits to his farm.

## WASTE

The general perception among the farmers interviewed is that, although they admit some forms of water losses, no water wastage exists on the farms. Water usage patterns on the farms, even though known, could not be accurately measured due to the lack of any meters on water abstraction points on the farm. This makes it difficult to estimate total amounts of water used or lost.

## CONCLUSION

### FUTURE PROSPECTS

Future expansions of commercial agriculture in the upper KCA are dependent on water, more specifically rainfall. The major future source of water is, or will be, boreholes. This includes both drilling new ones and increasing the depth of those already in existence. Some farmers also see the building of more dams as a means of capturing runoff and increasing the available water supply on their farms.

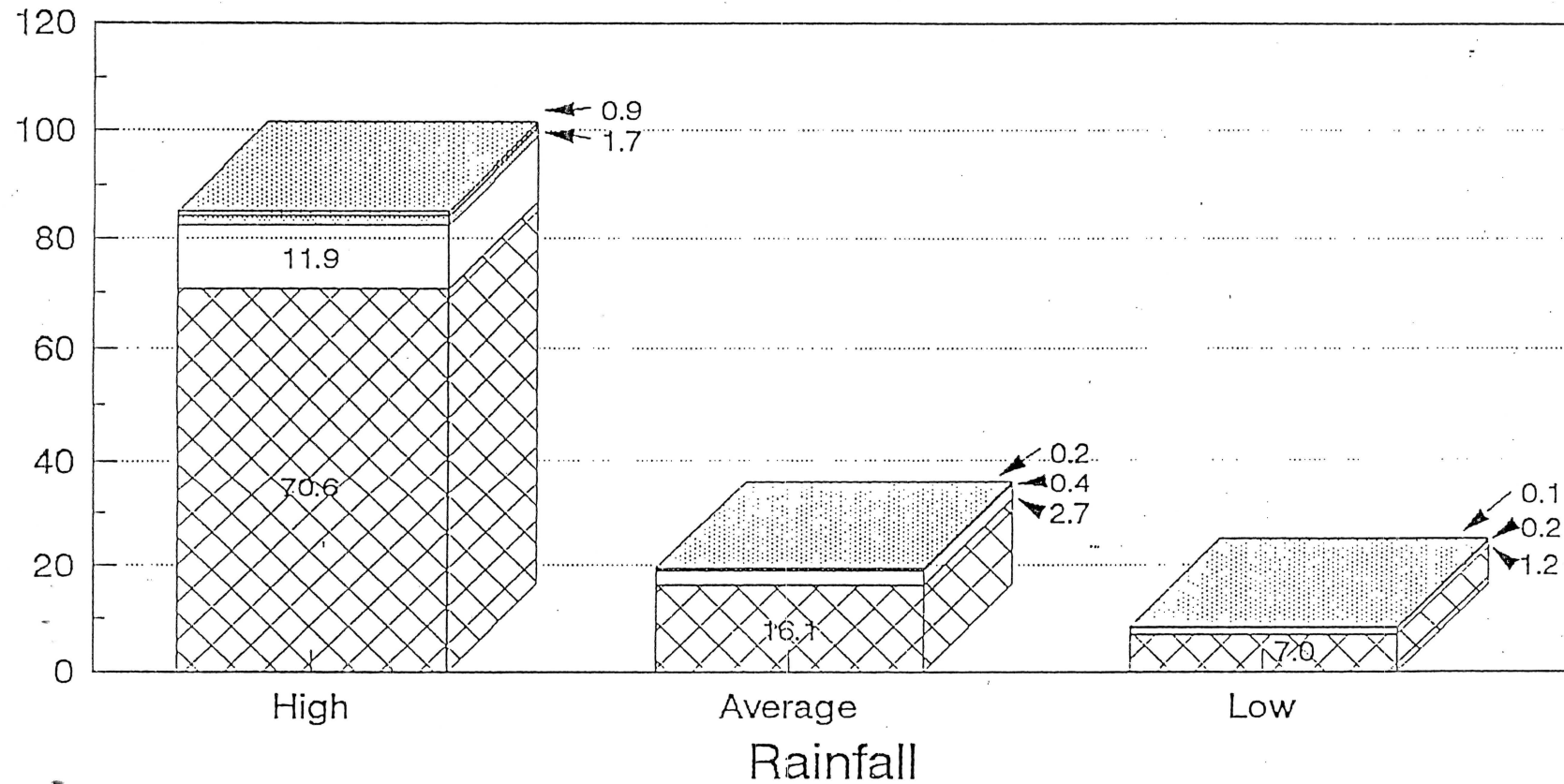
## RECOMMENDATIONS

- 1.) Farmers should investigate the feasibility of sand dams where possible. This would reduce water losses due to evaporation and would have less effect on downstream runoff patterns than ground dams.
- 2.) Future drilling of boreholes should only be done after a thorough investigation has been conducted to ensure the sustainable usage of underground water.
- 3.) The Department of Water Affairs should continue its investigations to quantify the influence of farm dams on the total catchment run-off.

- 4.) Restrictions should be set on the building of farm dams if an effect is found.
- 5.) Feasibility studies about the covering of water surfaces exposed to excessive sunlight should be conducted. Subsidizing possible means of covering should be considered if the savings are of advantage to the farmer and indirectly to the rest of the catchment.
- 6.) Water consumption patterns on farms should be measured and thus better controlled.

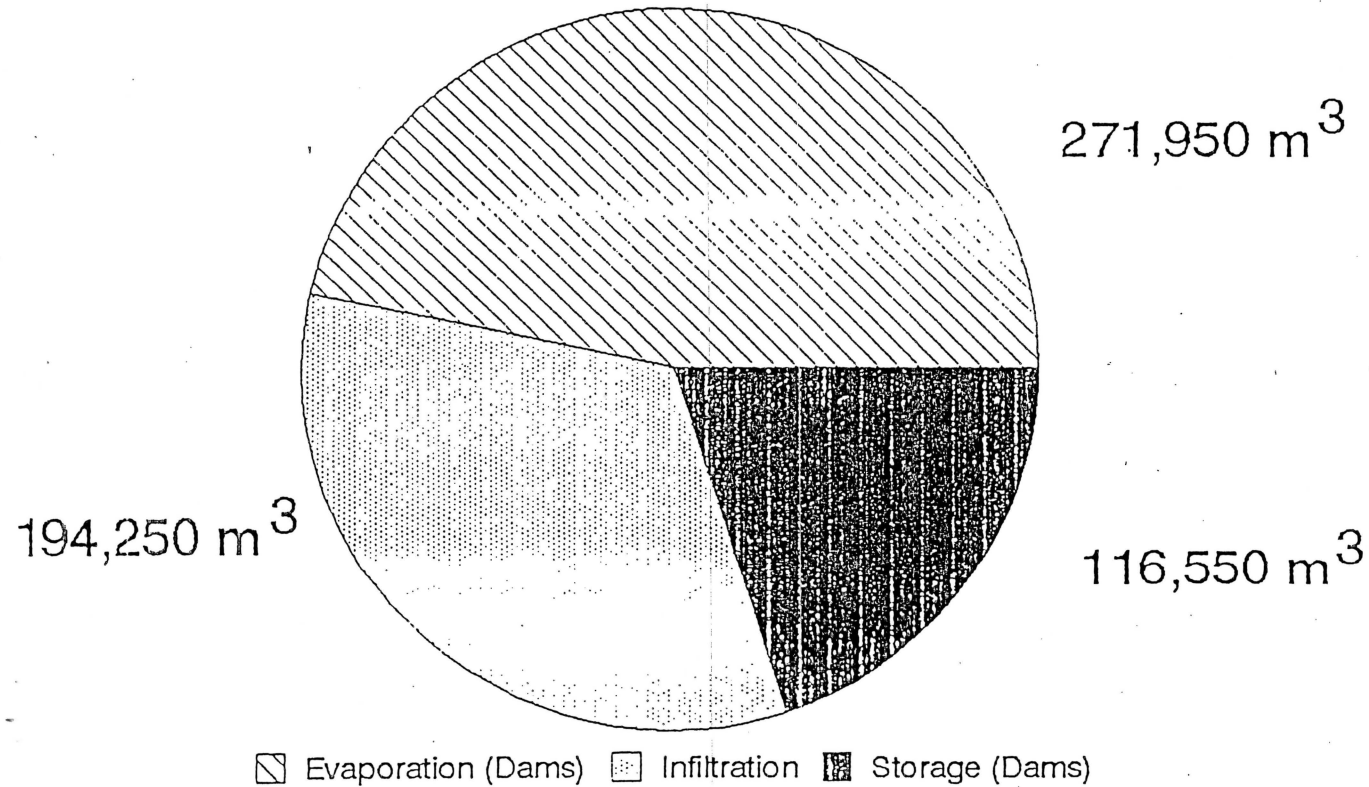
# Fig.2. Fate of precipitation for varying rainfall amounts

Volume of water (million cubic metres)



Evaporation
  Vegetation
  Surface Run-off
  Infiltration

Fig.3. Distribution of Surface Water Runoff on the Farm Niedersachsen



Annual consumption by stock: 10,658 m<sup>3</sup>



## APPENDIX A

### QUESTIONNAIRE FOR INTERVIEWING FARMERS

#### INTRODUCTION

To determine the source(s), the amount and ways water is used.

#### INPUT

What is the approximate total size of your farm?

What is the source of your water?

Do you treat this water?

What source do you prefer?

What is the cost of drilling a borehole, building a dam and the construction network(s)

Does rainfall contribute toward your water input?

If so, what percentage does this contribution constitute?

Do you have any interaction with the Weather Bureau concerning the collection of rainfall data?

If so, what period does this collection of data entail?

Is it possible to forward such data?

Do you need any authorization (eg. in the form of building permits) to extract water and are there any restrictions in terms of depth, amount, etc

Do you have to do any reporting to the DWA on the amount level of the boreholes, dams, etc?

Were there any markable changes in the rainfall patterns?

Do you do any monitoring of the water table?

Has the water quality changed significantly, if at all?

How often do the rivers on the farm flow?

What is your relationship with the DWA?

If requested, will you allow for water from your dam to flow downstream?

#### TRANSPORT

What means of transport is used to carry water from the source to where it is needed/used?

#### STORAGE

Are there any storage facilities on this farm?

What is the surface area & volume of these storage facilities?

Are the sites/location of these dams dependent on the distribution of camps?

How often are these dams/tanks filled?

What is the influence of the dams on the watertable and surrounding boreholes?

#### OUTPUT

##### USERS/USES

Who are the major consumers of water on the farm and how much does each use?

What is the water used for?

Are there any priorities in the usage of water?

##### SCHOOL

Are there any means of regulating the amount of water used here?

Are you using an additional source of water solely for the school?

Was there a noticeable increase in the TWC of the farm since the building of the school?

Is this water specially treated?

## LIVESTOCK

What types of livestock do you keep on the farm?  
What methods are you using to supply water to the livestock?  
How much water do they consume?  
Which sources are used to water the livestock?

## IRRIGATION

Do you practise any crop farming?  
If so, which crops do you cultivate?  
Do you have any form of irrigation on the farm?  
If so,:  
    How much water does it use?  
    How often do you water the fields?  
    How is this water transported to the fields?  
    What are the costs involved?

## CONSERVATION

Has DWA made any contributions in terms of suggestions or support on methods of conserving water?  
Are there any steps being taken to conserve water?  
Do you consider the building of dams as a means of conserving water?  
How effective have these steps proven to be and how have the employees reacted to it?  
What influenced your decision to launch such a conservation effort?  
What are the costs involved in running this campaign?  
What do you think is the main reason for waterlosses or -wastage on a farm?

## FUTURE PLANS

Do you intend any expansion of livestock/ increasing size of farm?  
Do you depend on the Kuseb for all of your water needs?  
Do you have any idea of how many farmers are staying along the Kuseb?  
Are you aware of the proposed building of a dam on the Donkersan farm?  
How do you think this dam is going to influence you?  
What impact will possible pipelines across the farm have?  
What steps will you take to find alternative sources in the future?  
    Increase depth  
    Increase number of boreholes  
    Explore alternative sources  
    Increase number of dams

## CONCLUSION

How do you see the future for water management in the Kuseb Catchment Area in general, and the farming community in specific?  
How do you think we should go about disseminating the outcome of the research, especially among the farmers?

**THANK YOU VERY MUCH!!!**



**Table 5: YEARLY RAINFALL INPUT FIGURES**

*(Donkersan figures used for example)*

Average rainfall on farm	: 105 mm/year	
Size of farm		: 14 700 ha
Yearly Input	: 105mm/year /1000	= 0,105m/year
		14 700 ha = 147 Mm <sup>2</sup>
Total Input		: 147 Mm <sup>2</sup> * .105 m/a
		= <u>15.435 Mm<sup>3</sup>/year</u>

**Table 6: YEARLY WATER CONSUMPTION**

*(Donkersan figures used for example)*

Yearly Livestock usage (90% of total)	: 4 270.5 m <sup>3</sup> /a
Yearly Total Consumption On Farm	: <u>4 745.0 m<sup>3</sup>/a</u>

**Figure 2: DISTRIBUTION OF SURFACE WATER RUNOFF ON THE FARM NIEDERSACHSEN**

Yearly Rainfall Input (Table 5)	: 19.425 Mm <sup>3</sup>	:
Assume 3% Surface Runoff		: 0.582750 Mm <sup>3</sup>
Assume one-third (1% of total) infiltrates into groundwater		: 0.194250 Mm <sup>3</sup>
Assume two-thirds (2% of total) flows into Farm Dams		: 0.38850 Mm <sup>3</sup>
Assume dams 5 m deep, yielding surface area of		: 0.07770 Mm <sup>3</sup>
with average annual evaporation of	: 3.500 mm/year	
Evaporative losses from farm dams equal		
	0.07770 Mm <sup>3</sup> * 3.5 m/year = 0.27195 Mm <sup>3</sup>	
Annual Stock consumption equals losses.		: 10,658 m <sup>3</sup> or 3.9% of evaporation losses.

### Chapter 3 - WATER USE BY THE TOPNAARS by Friedel Dausab

#### ABSTRACT

Along the Kuiseb River are a group of users so dependent on the waters of the river that they may have to leave what was their home for centuries if its resources are depleted. This is the primary reason the Topnaars were included in the research project. This research project was done over a period of two months and looked into the ways the Topnaars use their water. The overall consumption of water was determined through borehole readings and the distribution of water was calculated from the data generated from interviews with members of the Topnaar community.

The interviews, observations and measurements revealed that the Topnaars' water usage is similar to the water usage patterns in Walvis Bay. The Topnaars at Soutrivier use as much water as the low income group in Walvis Bay, Oswater uses amounts similar to the middle income group, and Homeb uses amounts equivalent to the high income group in Walvis Bay. The number of goats owned per person was also much higher at the villages where water consumption was higher and therefore goats may be compared to the gardens of the high income groups in Walvis Bay.

Goats were found to exert too much pressure on the vegetation around water holes, potentially harming the ecosystem in the long run. The depletion of ground water sources already reaching alarming levels, also exerts another pressure on the vegetation. Another finding was that water abstraction by the DWA and the DWAF and the blocking of water by the farm dams in the upper catchment area, apparently has already reduced water availability to the Topnaars dramatically. The proposed Donkersan Dam will only aggravate the water shortages.

I therefore reached the conclusion that although the Topnaars use a negligible amount of water compared to the other user groups, they will be most affected by water shortages if the Kuiseb water flow is interrupted or if the water table is lowered to an extent that water becomes too saline and is unpotable both for humans and for other organisms that depend on the Kuiseb River ecosystem.

Based on this, I recommended that further studies be carried out to determine the impact the Topnaars have on the Kuiseb River and to what extent they will be affected by the implementation of the proposed Donkersan dam. I also recommended that the impact of both the Topnaars and the unavailability of water be investigated so that more precise evaluations of the proposed developments can be made.

#### INTRODUCTION

The Topnaars are understood to be the most ancient people to have lived along the Kuiseb River. It is recorded that they dwelled along the river as far back as the 14th century (Van den Eynden, 1992).

Their traditional area, which included "Walvis Bay to Swakopmund to where the Rössing mine is today," was reduced by the German Government and later on again by the proclamation of the British territory in 1878 (Kooitjie 1992). This might have been because the Topnaars did not live permanently in the whole area but rather led a nomadic lifestyle, moving from the red dune area up to the Kuiseb Canyon (Kooitjie 1992).

The Topnaars originate from the Khoi-san and are said to have been hunter-gatherers, moving up and down the Kuiseb River according to the changes in the flood periods and the availability of food and water. They fished in the Walvis Bay lagoon and harvested the Inara melon to supplement their diet. They have, however, followed the present day trend of modernization and this, to an extent, has detached them from the natural environment on which they depend. Permanent villages have since been established, partly due to the fact that their nomadic behaviour was discouraged when the lower Kuiseb valley was declared a national park, and partly because of provision of permanent water.

Today there are 10 settlements and a school cum settlement along the lower Kuiseb. The Topnaars make a living through livestock rearing, small scale gardening and the harvesting of Inara melons (*Acanthosicyos horridus*). The Topnaars still depend greatly on the ecosystem supported by the Kuiseb River. Vegetation types like *Acacia erioloba* and *Faidherbia albida* are the primary food source for the Topnaars' livestock. They forage on the leaves and the pods of these trees, although other vegetation types in the Kuiseb ecosystem also contribute to the livestock diet.

The Inara melon is one of the most historically and eminently important vegetation types in the Topnaar culture. Every family had their own field when these were still abundant.

Today however, because the Inara fields have lowered their productivity, individuals harvest from any field to sell the Inara pips for income (S. Kooitjie pers. comm. 1993). This melon grants the Topnaars one of their scarce means of income, because it can be sold in Walvis Bay for the export market to Cape Town or even Europe, where the Inara pips are perceived as a delicacy (Van den Eynden, 1991). The rest of the fruit is dried in the sun for later use until the next harvesting season. The other main source of income, which the Topnaars are utilizing now that the productivity of the Inara fields has been reduced is goat farming. This has become a predominant practice in the villages situated east of Swartbank, because it brings more income than the Inara fields located in the west. This however does not solve the problem of the poor living conditions of the Topnaars. There are still no adequate income generating systems and most of the Topnaar youth migrates to Walvis Bay to find employment, returning only to visit the villages on weekends, holidays and during the festive season.

Not only has the culture of the Topnaar people started to fade, but they have started to experience serious water shortages. Traditionally the Topnaars used hand dug wells as the source of their water. In the 1970's they only had to dig 2 to 3 metres to come into contact with ground water. Their traditional wells or "gorras" were then reinforced with tree trunks of *Faidherbia albida*, by lining the wells with them. Sometimes galvanised steel tanks or oil barrels were used (DWA South West Africa, 1978).

The lowering of the water table, however, has led to the installation of boreholes by the Department of Water Affairs (DWA). The lowering of the water table is influenced by the abstraction of water by the DWA and the less frequent flooding, possibly associated with farm dams in the catchment area. A lack of water would affect the Topnaars more directly than any other user group of the Kuiseb River aquifers. This is the reason the Topnaars were included in the study.

The Donkersan Dam, which is proposed for construction in 2006 (SLW JVC, 1993e) and is estimated to catch 70% of the total run-off volume of the Kuiseb River (P. Jacobson pers. comm. 1993), is also another threat to the Topnaars. If this plan proceeds, they will have to be resettled or suffer further poverty and malnutrition. The damage this dam would have on the environment is not known, but is likely to be irreversible.

With these considerations, the objective of this research was to estimate the overall water budget of the Topnaar villages. In this chapter, comparisons between essential and non-essential uses of water in the Topnaar villages are made in order to determine water usage patterns. Water wastage areas and the resulting loss of water is examined as a part of the overall water budget. The consequences of the river drying up (as would happen if proposed dam installations were built upstream) are also examined and recommendations for possible solutions or alternatives are proposed. The document also assesses the impact of the water crisis on the Topnaars and the environment and makes recommendations for conserving water within the Topnaar villages.

## **MATERIALS AND METHODS**

Information was gathered for this paper primarily through interviews with water users in the area. Questionnaires (Appendix A) were prepared beforehand and administered in the form of interviews. Some interviews were conducted in Nama for those who were not comfortable with Afrikaans or English. Any questions prompted by observations during the interview were asked in addition to those on the questionnaire. Borehole readings were also taken at three newly installed lister engines with submersible pumps.

One household at each of three villages upstream of Swartbank was visited and interviewed (Appendix B). The households to be visited were not selected before arrival at the villages. Two of the three households interviewed came from a higher socio-economic status group than average for each location. The captain/chief (Seth Kooitjie) was interviewed, as well as the "Water Affairs Officer" within the Topnaar council (Rudolph Dausab).

To supplement the data gathered, literature which examines how the Topnaars live and use the Kuiseb water was reviewed. These documents also provided figures for the amount of water usage in the Topnaar villages over time.

## RESULTS

The following responses were generated from Chief Kooitjie at Homeb:

- 1.) In 1965, one only had to dig about 3 meters to get water from a traditional well. Today a borehole has to be sunk 18 meters to come into contact with moisture and 25 meters to reach the water table.
- 2.) The borehole pump is switched on once every week at Homeb, for a few hours.
- 3.) More than two thirds of the total number of Topnaars live in cities, the majority are in Walvis Bay. These people only come to the settlement at certain times of the year.
- 4.) Due to over abstraction of water, plants do not survive. The Inara has reduced productivity by 50%.

The following responses were generated from Ouma Johanna Fischer at Soutrivier:

- 1.) When large water containers (20 litre each) are available they are filled twice a day, for the household of five people.
- 2.) This water is used for washing, cooking, and bathing.
- 3.) Farm dams block water and more dams built upstream will mean that less water will flow down.
- 4.) There is overpopulation of people and overstocking at Soutrivier
- 5.) There has been a decrease in productivity of *Faidherbia albida* and *Acacia erioloba*.

The following responses were generated from Rudolph Dausab at Oswater:

- 1.) The digging of traditional pits became impossible about 1985, the people having to dig 10-12 meters to reach the water. The DWA thus installed boreholes at the villages.
- 2.) The only areas which have municipal water are the villages below Swartbank. These are supplied with water from the DWA pipeline. The other areas made use of traditional pits which were mainly reinforced with trunks from *Faidherbia albida*.
- 3.) The people stopped growing their own vegetable gardens due to water limitations. The livestock consume approximately 70% of the total water pumped into the reservoirs, although the human and animal (livestock) supplies are separated. The remaining 30% is used by the people.
- 4.) Installation of the new boreholes has led to the perception that people can expand their agricultural activities, especially the cultivation of small vegetable gardens.
- 5.) There are 200 goats at Homeb and 195 goats at Oswater.
- 6.) The borehole at Homeb is 20 meters deep and the water table is at 9 meters. This is because water levels are dropping due to low rainfall, which in turn affects the flooding of the river.

Oswater:

The borehole is 33 meters deep. It's the deepest borehole. The water table is at 11 meters below the soil surface.

Natab 1: The borehole is 28-30 meters deep. Its yield is not very high at 2,5 m<sup>3</sup> an hour. It has a connecting pipeline of 3 km to support the people at Natab 2.

Natab 2: The borehole is 15 meters deep. The borehole could not be sunk very deep because the deeper the borehole was, the more brackish (saline) the water became.

Soutrivier: This village has a strong borehole which is 20 meters deep. From 25 meters the water starts to become saline. The water, however, is of the best quality. Before November 23, 1993 Soutrivier had the worst water situation in the lower Kuiseb Valley, receiving water from Gobabeb in drums.

- 7.) The lowering water table also affects the vegetation along the river. The production of the !nara plant (*Acanthosicyos horridus*) has dramatically decreased. It is the only natural resource the Topnaars have which is income generating.
- 8.) The Walvis Bay diversion wall cuts the river off from the biggest !nara fields. This has resulted in a dramatic decrease in the !nara. The prohibition by Nature Conservation on burning down the !nara fields has also led to a reduced rate of productivity. Traditionally this was done to make way for new plants.

The number of people and livestock and water consumption metered at the study villages differed (Fig. 1). Evaporation from the open reservoirs was assumed to be constant, but the amounts used by people and livestock varied with the different population at the three sites. The amount of water used by livestock was assumed to be 50/goat/day and that used by people, 300/person/day. As the usage at Soutrivier was so low, it was assumed that half the goats were watered at Gobabeb, and that people used less than elsewhere.

## DISCUSSION

After two months of information gathering a lot still remains unanswered about the water usage pattern at the Topnaar villages. This can be attributed to the fact that the time allocated for information sampling was limited, and the number of villages visited was not enough. When looking at the information in the chapter, it should thus be kept in mind that the data on water consumption are purely an estimation based on the figures that were collected in this short time span.

The data were collected over the festive season and the holidays. This could have distorted the information, because an influx of Topnaars residing in Walvis Bay and of children from the school at Utuseb, is experienced at this time of the year.

Figure 2 and Figure 3 show that different groups of the Topnaar villages can be assigned to different water use categories that are similar to those found in Walvis Bay. The consumption at Homeb is similar to that of the high income group in Walvis Bay. Gardens are the major consumers of water in Walvis Bay, whereas goats consume most of the water at Homeb. It should be kept in mind, however, that Homeb water might also supply the nearby tourist camping site. The extremely high usage of water at Homeb may thus be affected by this.

Water use at Oswater is similar to that of the middle income group in Walvis Bay. This may be due to the fact that their number of goats per person is higher than at Soutrivier but lower than at Homeb. Soutrivier, unlike the other Topnaar villages, has had serious water problems, because until recently they had no water-hole. The goats obtained water from Gobabeb until the borehole for Soutrivier was installed in October 1993. At the moment the goats of Soutrivier use two sources of water (Gobabeb and Soutrivier), although the goats are currently being moved over to the source at Soutrivier. The fact that there are still goats watered at Gobabeb may have influenced the data gathered for Soutrivier, making their water usage appear to be very low and similar to that of the lower income group in Walvis Bay.



However, the people at Soutrivier are more conservative with water than the Topnaars at other settlements, because water has not been freely available for them in the last twenty years (R. Dausab pers. comm. 1993). This is supported by the fact that a household of five people uses forty litres per day, only eight litres per day per individual!

In the past, the Topnaars, with no modern machinery, abstracted little water. But as the new technological advances became available they started to abstract more water, which has enabled them to enlarge their livestock numbers. Although the dry period experienced recently in 1992 and those before, forced the Topnaars to sell off some of their livestock (R. Dausab pers. comm. 1993), the livestock numbers at the settlements are still larger than the natural vegetation can support. The goat numbers may be beyond the carrying capacity at the Topnaar villages and this may eventually have an environmental impact that can harm the Kuiseb ecosystem.

The Kuiseb ecosystem which supports vegetation is like a long thread along the Kuiseb River banks. The area is not able to support large numbers of stock because it is too small and stretched out. The pressure that the goats exert on this small area as they move up and down the river is great. Near the water-holes, the vegetation is heavily grazed and all the new seedlings and pods that enter the ecosystem are foraged upon. No new trees can grow and the ecosystem may be disturbed beyond its threshold and may not return to its previous equilibrium. A "browse-line" can be seen on the vegetation along the river bank and, due to the dropping water table, these trees and shrubs might not be able to regenerate because they are pressured from both directions. According to Captain Kooitjie, small trees can send out their roots to search for water, but those which have already matured cannot adjust to the dropping water table and thus die out. Can so many goats then be sustained by the ecosystem along the Kuiseb River or more specifically at the Topnaar settlements?

Can one call this a case of over-utilization of the natural resources along the riverbanks of the Kuiseb River? The answer to that question might be yes. As one drives along the river banks, the farther you are from the settlements where the goats are held, the lower the "browse-line" becomes. A reduction in the herd size may thus be the best option to solve the overgrazing problem.

This, however, does not mean that the vegetation along the river banks will regenerate, because reducing the herd size will only remove the pressure that the goats exert on the vegetation. The primary problem that the ecosystem faces at the moment is a lack of water, claimed by two powerful users at both ends of the river.

Farm dams upstream block water from running through to the delta and the coastal towns downstream demand more and more water, which is abstracted by the DWAF and DWA at Rooibank, Swartbank, Dorob South and Dorob North.

Water has thus become a scarce commodity for the Topnaars, which limits all the activities that they plan. Ground water provides the Topnaars with both food and water. The trees and other vegetation depend on ground water to grow. The same ground water source supplies drinking water to the people and their livestock. No other user group of the Kuiseb water is so dependent on a single natural resource.

Wastage of water by Topnaar villagers is minimal, but a significant waste derives from overflowing troughs when taps are left open for the goats to drink. Conservation of water is widespread within the Topnaar settlements and, according to Rudolph Dausab, the Topnaars try to save every bit of water. Bathing water is sometimes re-used twice or thrice, and is thereafter used to water plants or for any other activity that does not require clean water. The main loss of water at the villages is due to evaporation from the open reservoirs used for their livestock's drinking water. The rate of evaporation from such uncovered reservoirs at the villages is 0.181 cubic meters per day.

Although the Topnaars use a negligible amount of water compared to the coastal towns and the commercial farmers upstream, they face a water shortage. Water may not be available to them anymore if there is no recharge and the water is too brackish for human and animal consumption or if the Donkersan Dam is constructed. If this happens, it could mean the collapse of the whole ecosystem downstream of the dam.

The effect this would have on the Topnaars is tremendous. It will mean that the Topnaars will have to move to another environment with which they are not familiar, losing their substantial cultural heritage and history.

## CONCLUSION

From this study we concluded that water usage by the Topnaar community is negligible when compared to their neighbours - the farmers, the coastal towns and the mine. Water usage within the Topnaar settlements has remained stable, although this may change with the installation of modern boreholes, which will allow more livestock to be supported and the people to cultivate vegetable gardens.

It can also clearly be seen that a lack of water will lead to the collapse of the Kuiseb ecosystem, which will, in turn, lead to the Topnaars losing their traditional land. Tremendous harm will also be done to the environment which will never recover. Water usage patterns within the Topnaar communities are however unclear and therefore further research will need to be conducted to determine precisely how the Topnaars use their water.

## RECOMMENDATIONS

- 1.) Smaller numbers of livestock will relieve the ecosystem from overgrazing and over-browsing. This would give the plants a chance to regrow and possibly adjust to the dropping water table. It will minimize water use now when some boreholes have already run dry and every drop of water has become precious. New seedlings will have a chance to enter the system to add new plant growth, thus giving the system "demographic equilibrium." The Ministry of Agriculture, Water and Rural Development should therefore carry out studies to ascertain the carrying capacity of the area and to implement policies that prevent numbers of livestock increasing beyond a given amount.
- 2.) If the water table drops and water is not available or becomes unpotable for humans, livestock and the trees, an expensive alternative might be looked into. This could be a pipeline with desalinated water from either Walvis Bay or Swakopmund. Fodder would also have to be transported for the Topnaars' livestock. Not much could then be done for the ecosystem, as it would be impossible to give water to all the organisms that depend on the river's ecosystem. The construction of the proposed Donkersan Dam should therefore be considered carefully before implementation, as it would aggravate water shortages which already create many problems without this additional stress.
- 3.) The abstraction of water by the DWA and the DWAF should be minimized and possible solutions, as given by the chapters on Swakopmund, Rössing and Walvis Bay, should be implemented to relieve the pressure on the ground water table. This would allow the water table to rise so that the Topnaars could continue to utilize the Kuiseb River waters.
- 4.) The Topnaars should monitor their borehole readings in order to know how much water is pumped into the village and how it is used. This would also enable the Topnaars to implement water conservative measures and reduce any water loss.
- 5.) The Topnaars should receive general education about their ecosystem and how best to manage it. This would lead to better management of the ecosystem without over-utilizing its resources and damaging it. The Desert Ecological Unit of Namibia, the DWA, the Ministry of Agriculture, Water, and Rural Development and other relevant institutions should contribute to this process.
- 6.) The monitoring of meters at all boreholes and the installation of metered boreholes where they do not yet occur, would help the Topnaars to determine how important their impact is. It would also give them a tool to defend themselves in case dams like the Donkersan Dam are proposed.

- 7.) The last and most important recommendation that can be made is that further research be carried out so that precise evaluations could be made about the river ecosystem which influences the Topnaars as a people. Research could be done to verify the decreasing production of the !nara plants, which is attributed to a wide variety of reasons, including a lack of water, parent bushes not being burned down and the flowers being eaten by the goats and donkeys. Research could also be done to find out why the trees along the riverbank are dying, regardless of the water situation.

# Fig.1 Water usage in Topnaar villages.

Water consumption (cubic metres/day)

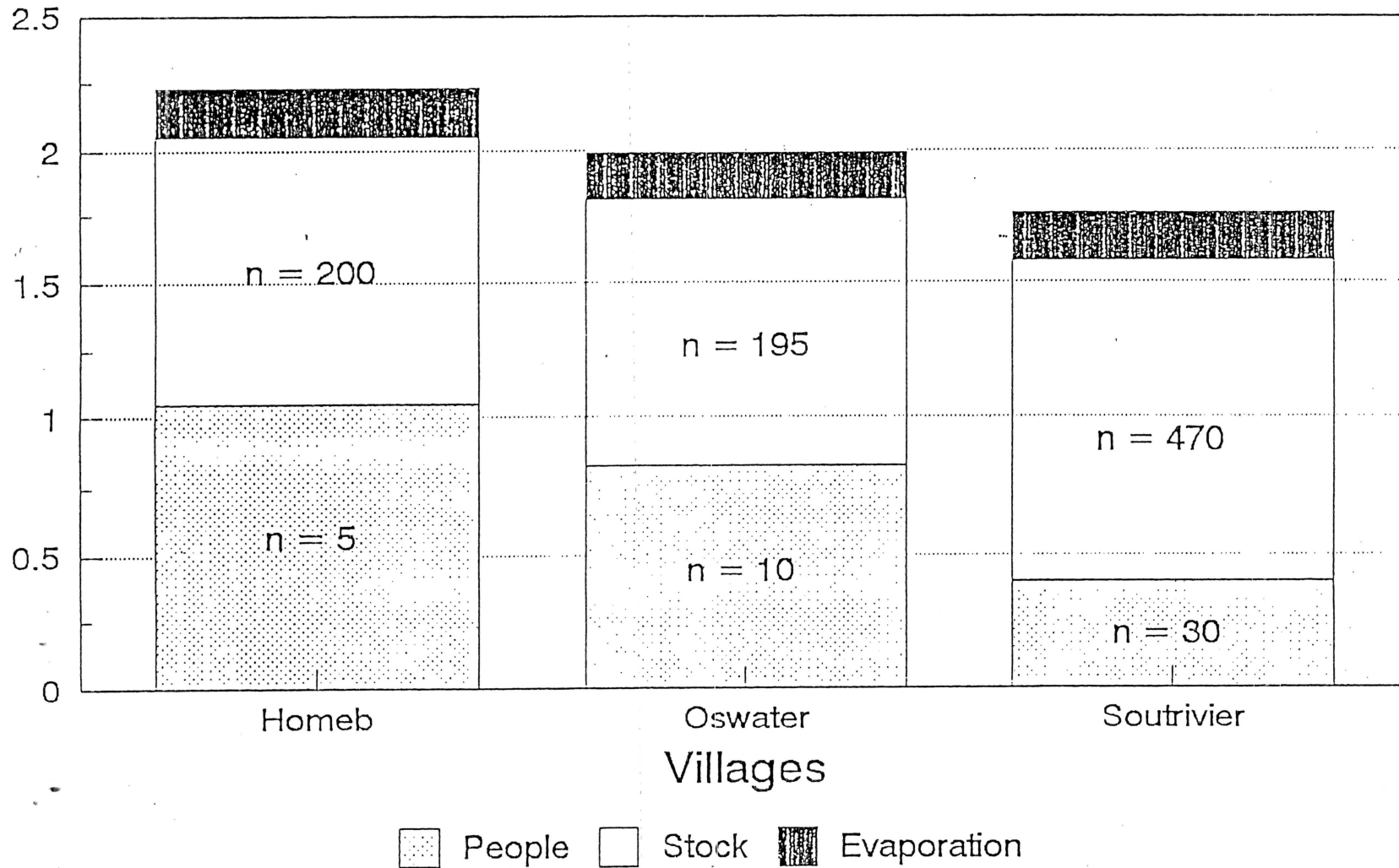


Fig.2. Water usage at Topnaar villages

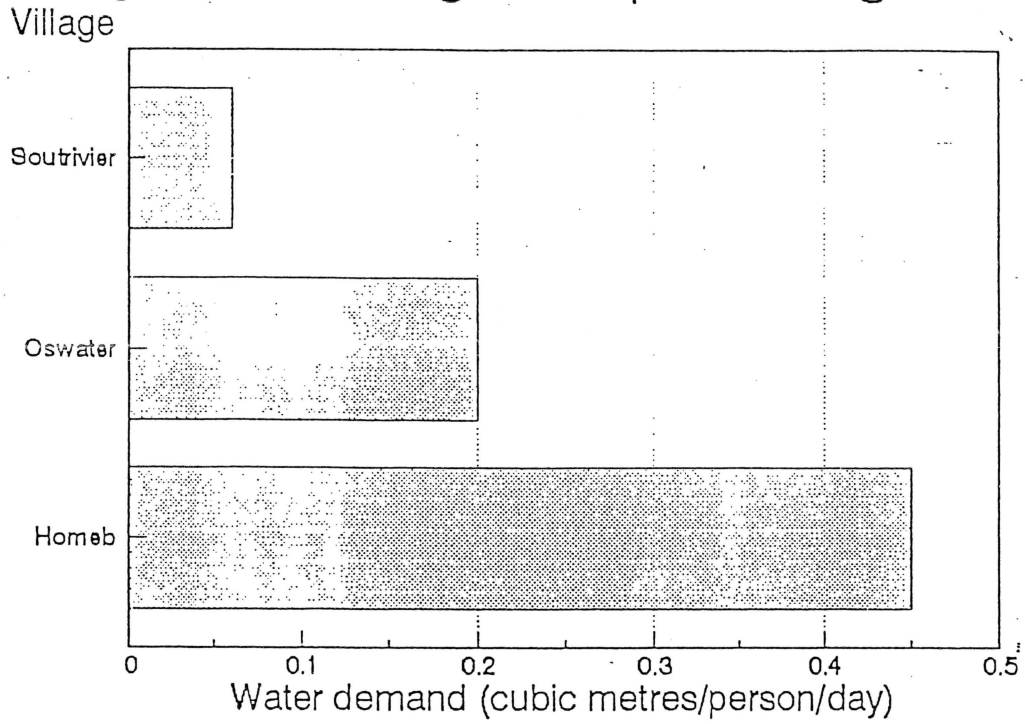
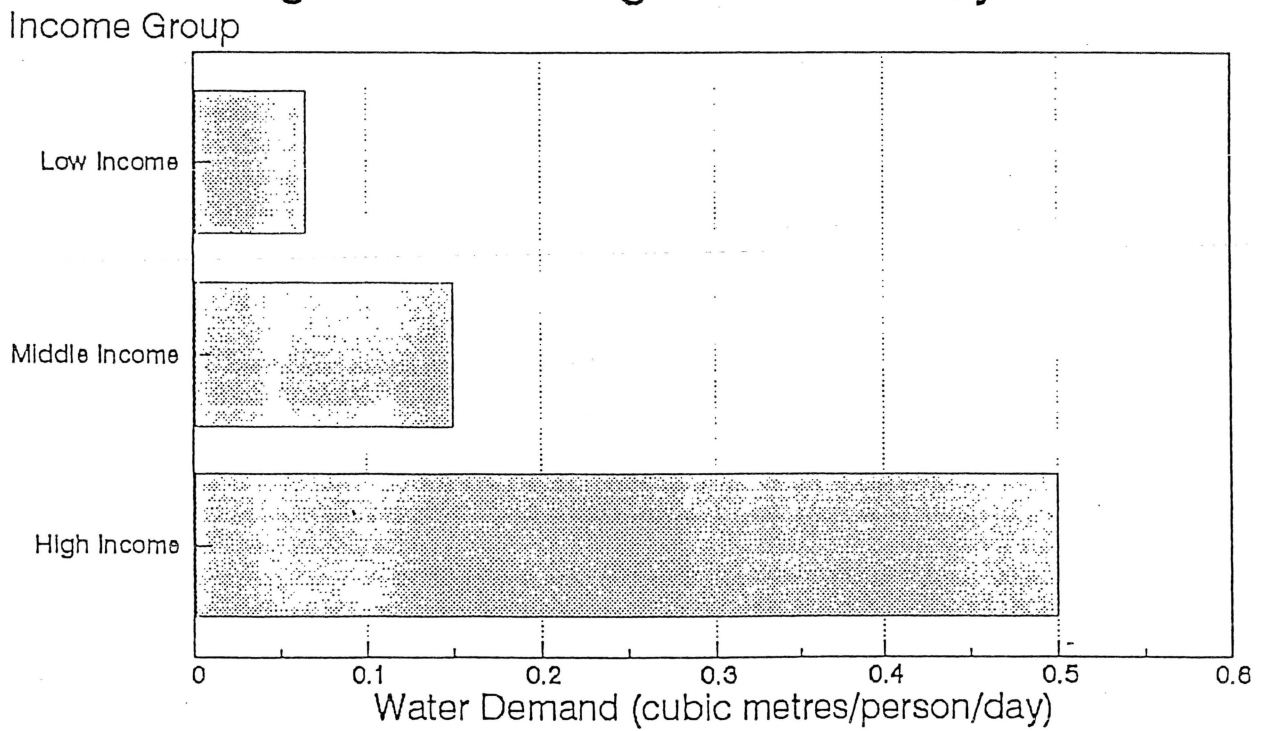


Fig. 3 Water usage in Walvis Bay



## APPENDIX A

### THE TOPNAAR QUESTIONNAIRE

#### INTRODUCTION

TO DETERMINE AND EVALUATE THE AMOUNT OF WATER AND ITS USAGES IN ORDER TO MAKE RECOMMENDATIONS THERE-UPON

#### INPUT

- a) WHAT ARE YOUR PRINCIPAL SOURCES OF WATER?  
BOREHOLES  
WELLS  
WINDMILLS  
OTHER
- b) IT IS SAID THAT THE WATER TABLE WAS SO HIGH THAT WATER WAS SEEN ON THE SURFACE EARLIER ON. ARE SUCH STATEMENTS TRUE?
- c) HAS THE QUALITY OF WATER CHANGED ?  
HOW?
- d) HOW OFTEN DOES THE RIVER FLOW PAST?  
HAS THERE BEEN ANY SIGN THAT RAINFALL OCCURS IN A CERTAIN CYCLE, AND TO WHAT EXTENT IS THE RIVER FLOW AFFECTED BY THIS ?
- e) HOW DEEP DOES ONE HAVE TO DIG TO COME INTO CONTACT WITH SOME WATER?

#### TRANSPORT

- a) WHAT MEANS OF TRANSPORT DO YOU USE TO TRANSFER WATER FROM THE SOURCE TO WHERE IT IS USED?

#### STORAGE

- a) WHAT HAPPENS TO THE WATER AFTER IT IS PUMPED? IS IT STORED IN THOSE BIG TANKS ?
- b) WHAT TYPES OF STORAGE FACILITIES ARE THESE?
- c) HOW BIG ARE THEY i.e. THE SURFACE AREA?
- d) HOW OFTEN ARE THE TANKS FILLED?

## OUTPUT

### USES/USERS

- a) WHO ARE THE MAJOR CONSUMERS?  
PEOPLE  
CATTLE  
SHEEP  
GOATS  
OTHER
- b) HOW MUCH DO THEY USE (EACH OF THE ABOVE MENTIONED) ?  
DO YOU HAVE ANY PRIORITIES IN THE USAGE OF WATER?
- c) WHAT ARE THE FLUCTUATIONS IN YOUR CONSUMPTION ON AN ANNUAL BASIS?
- d) DO YOU SELL OFF STOCK AT CERTAIN TIMES OF THE YEAR?  
- AT WHAT PROPORTION?
- e) DO YOU HAVE A SCHOOL HERE?  
IS IT A BOARDING SCHOOL?  
HOW MANY PUPILS DO YOU HOUSE?  
HOW MANY TEACHERS ARE THERE?  
DOES THE SCHOOL RECEIVE ITS WATER FROM YOUR BOREHOLE?  
IS THERE A MEANS OF REGULATING THE AMOUNT OF WATER USED AT THE SCHOOL?  
HAS THE WATER DEMAND INCREASED AT THE SETTLEMENT SINCE THE SCHOOL WAS BUILT?  
IS THE WATER FOR THE SCHOOL SPECIALLY TREATED?  
HOW MANY OF THE FOLLOWING ARE THERE AT THE SCHOOL:
  - BATHTUBS
  - SHOWERS
  - BASINS
  - TAPS
  - CISTERNS (INCLUSIVE OF THE TEACHERS' HOUSES)
- f) WHAT METHODS DO YOU USE TO SUPPLY YOUR LIVESTOCK WITH WATER?
- g) DO YOU HAVE ANY GARDEN HERE?
  - HOW OFTEN DO YOU IRRIGATE THE GARDEN?
  - HOW LONG DO YOU IRRIGATE YOUR CROPS?
  - DO YOU HAVE PLANTS THAT ARE ADAPTED TO THE ENVIRONMENT?
  - DO THE OTHER PLANTS, IF ANY, NEED A LOT MORE WATER THAN THE INDIGENOUS PLANTS?
  - ARE THE GARDENS FOR OWN USE OR DO THE OWNERS ALSO SELL THEIR CROPS TO THE OTHER SETTLERS?

### WASTAGE AND LOSSES

- a) WHAT ARE THE MAIN SOURCES OF WASTAGE AT THE SETTLEMENT?  
- WHEN DO YOU DEFINE WATER AS WASTED?

### ENVIRONMENTAL IMPACT

- a) HAS THE VEGETATION CHANGED DUE TO THE DECREASE IN THE GROUND WATER TABLE? HOW?  
- HAS THE ANIMAL DIVERSITY BEEN AFFECTED BY THIS?  
- HAS THE NUMBERS OF THE NARRA BEEN AFFECTED?  
- HOW HAVE ALL THESE CHANGES AFFECTED YOU?

### FUTURE PLANS

- a) DO YOU INTEND TO EXPAND YOUR FARMING NOW THAT MORE WATER IS AVAILABLE?  
- DO YOU INTEND TO INCREASE THE NUMBER OF CATTLE?  
- GOATS?  
- SHEEP?
- b) DO YOU INTEND TO BUILD A BIGGER VEGETABLE GARDEN?
- c) WHAT ALTERNATIVE SOURCES OF WATER WOULD YOU USE IF THE KUISEB CANNOT SUPPLY WATER ANY MORE?
- d) PLANS ARE UNDERWAY TO BUILD THE DONKERSAN DAM WHICH WILL SUPPLY WINDHOEK WITH WATER. THIS DAM WILL ALSO TAKE AN APPROXIMATED 70% OF THE TOTAL RUNOFF. WHAT DO YOU THINK ABOUT THIS AND WHAT WILL YOU DO IF YOU DON'T AGREE?
- e) HOW DO YOU THINK WE SHOULD RUN THE CAMPAIGN TO SUCCESSFULLY PUT ACROSS THE MESSAGE TO THE TOPNAAR PEOPLE?



On the question of sustainability, sources at DRFN claim that the water supply in terms of quantity will not be much of a problem, at least for the time being. This claim is probably substantiated by the vast number of floral species found in the riverbed which serve as indicators of the underlying water table.

## TRANSPORTATION AND MANAGEMENT

Transportation of water from the boreholes at Gobabeb occurs via metered pipelines which feed water into a 100m<sup>3</sup> capacity storage reservoir. The reservoir uses gravity to supply water to various points and also has an automatic triggering system which activates the electric pump at the boreholes whenever a certain level below full reservoir capacity is reached. During storage in the reservoir, the water is chlorinated on a weekly basis. Loss of water during transportation and storage was thought to have been a problem in the past and was investigated as a part of this survey.

The Department of Water Affairs (DWA) carries the responsibility of maintaining the boreholes and pipelines at Gobabeb. DWA also takes water samples quarterly for chemical analysis to determine the group status and the salt content. Interestingly, DWA charges no tariffs whatsoever for the cost incurred in providing and maintaining the facilities that provide water to Gobabeb.

Despite its low quality, water still continues to be utilized domestically for cooking, washing, drinking, watering gardens and plants, filling the swimming pool, flushing toilets and cleaning. The station also has a modern technology laboratory which requires de-ionized water for some of its operations. Workers employed by the Ministry of Wildlife, Conservation and Tourism keep livestock such as donkeys and goats, drawing their water supply from the same source as that of the station.

The purpose of this chapter is to look at one user group living along the Kuiseb river, Gobabeb, a research station that has been in existence since 1963, then manned by only three people. The basic philosophy behind drawing attention to Gobabeb is to determine

- (i) various uses of water
- (ii) the amount used for different purposes, and
- (iii) the approximate amount used per individual

in a small community where detailed measurements are possible. Gobabeb typifies a modern, urban domestic set up in terms of housing and improved water installations, including geysers and a swimming pool. This study strives to integrate the results obtained and to develop sensible and clear recommendations relating to water consumption for station staff and visitors.

---

## MATERIALS AND METHODS

Measurements were started on 11 December 1993 and continued until 14 January 1994. Initially, all possible sites of water use, including stock watering and plant watering, were identified. These observations facilitated subsequent measurements. Having identified all sites of water use, the next step was to determine the total amount of water used around each site. This was achieved by devising spread sheets to facilitate recording of water use and subsequent calculations based on the data obtained from the sheets. The following data sheets were developed:

- a log in the toilet required the "visitor" to tick off after flushing the cistern. The amount of water that drained off at every flush was determined by emptying the cistern using calibrated Elenmeyer flasks.
- the time used in activities, including showers, watering of plants and gardens with both hose-pipes and sprinklers and washing vehicles, was recorded in minutes and, using additional appropriate measurements, was converted to water volume.
- for cooking and drinking purposes, a standard cup (250 ml) was used to either fill the pots or quench the thirst. Users recorded the number of cups used for each activity.

- basins used for washing dishes or hands were marked below full capacity on the inside of the basin. The plug was kept in position and opened only when the water mark had been reached. Users recorded the number of times the basin was filled to the mark.
- evaporative loss of water from large scale open water surfaces, such as the swimming pool, was determined by incorporating the meteorological data available at the station with measurements of surface area.
- distilled water used in the laboratory is produced every second week and stored in two 25 litre containers. Cooling water used in the distillation process was collected for 1 minute in a 1000 ml measuring cylinder. The still was run over an eight hour period and the amount of cooling water calculated.

Examples of calculations are provided using data from the first week of measurement for the different water use activities.

#### Basins

Conversion factor: 1 basin (marked) = 6 l/fill-up  
 Total number of fill-ups = 129 fill-ups/week  
 Volume (l)/week: 129 fill-ups/week x 6 l/fill-up  
 = 774 l/week

#### Cooking

Conversion factor: 4 cups (250 ml each) = 1 l  
 Total number of cups = 673.6 cups/week  
 Volume (l)/week: 673.6 cups/week ÷ 4 cups/l  
 = 168.4 l/week

#### Drinking

Conversion factor: 4 cups (250 ml) = 1 l  
 Total number of cups = 1,524 cups/week  
 Volume (l)/week: 1,524 cups/week ÷ 4 cups/l  
 = 381 l/week

#### Garden and Plant watering

##### Plant watering around main station

Number of days watered per week = 3 days/week  
 Total average time per day = 495 min/day  
 Total number of sprinklers = 135  
 Average discharge rate per sprinkler per min  
 = 0.620 l/min  
 Discharge rate for total number of sprinklers per min  
 0.620 l/min x 135 sprinklers = 83.7 l/min  
 Therefore, Volume (l) watered per day:  
 83.7 l/min x 495 min/day = 41,431.5 l/day  
 Thus, for 3 days per week  
 3 days/week x 41,431.5 l/day  
 = 124,294.5 l/week

Three houses without sprinklers: using hose pipes  
Volume (ℓ)/min (tap twisted mid way) = 21 ℓ/min  
Average time of watering per day: 53 min/day  
Therefore, Volume (ℓ) used per day:  
 $21 \text{ ℓ/min} \times 53 \text{ min/day} = 1,113 \text{ ℓ/day}$   
Thus, for 3 days per week:  
 $3 \text{ days/week} \times 1,113 \text{ ℓ/day}$   
 $= 3,339 \text{ ℓ/week}$

#### Vegetable gardens

Volume (ℓ) used per min (tap twisted mid way): 16 ℓ/min  
Average time of watering per day: 45 min/day  
Number of days watering per week: 2 days/week  
Therefore, Volume (ℓ) used per week:  
 $16 \text{ ℓ/min} \times 45 \text{ min/day} \times 2 \text{ days/week}$   
 $= 1,440 \text{ ℓ/week}$

#### Showers

Total number showers: 72 showers/week  
Average time per shower: 6.4 min/shower  
Conversion factor: 1 min = 8 ℓ/min  
Volume (ℓ) per shower:  
 $8 \text{ ℓ/min} \times 6.4 \text{ min/shower} = 51.2 \text{ ℓ/shower}$   
Volume (ℓ) of total showers:  
 $72 \text{ showers/week} \times 51.2 \text{ ℓ/shower} =$   
 $3,686.4 \text{ ℓ/week}$

#### Toilet flushes

Conversion factor: 1 flush = 10 ℓ/flush  
Number of flushes: 118 flushes/week  
Volume (ℓ) flushed per week:  
 $10 \text{ ℓ/flush} \times 118 \text{ flushes/week} =$   
 $1,180 \text{ ℓ/week}$

#### Baths

Although several residences have baths at Gobabeb, they are rarely used and were thus not included in this survey. Nevertheless, it was determined that the amount of water to half fill one bath tub is the equivalent of 15-30 minutes of showering, depending on water pressure, shower head and other variables.

## **RESULTS**

Water at Gobabeb is mainly used for the following activities; domestic uses, garden and plant irrigation, laboratory uses, stock watering and filling the swimming pool. Under domestic uses, the following featured high on the list: cooking, drinking, cleaning, dish-washing, laundry, showering and toilet flushing. Though the main research station doesn't have a vegetable garden, there are two small scale, private vegetable gardens manned by the workers at the Ministry of Environment and Tourism for their own use. Crops such as cabbages, pumpkins, water-melons and maize predominate in these gardens. At the station itself, xerophytic plants and trees are grown and watered a minimum of three times a week. De-ionization of water for use in the laboratory constitutes the major portion of the water used in the laboratory itself. Livestock, mainly donkeys and goats kept by the workers, also use the water resource and thus constitutes a category on its own.

A swimming pool is regularly used by staff and visitors for recreation and cooling off on warm days. With a surface area of 40.5 m<sup>2</sup>, it represents the main source of evaporative water loss after gardening.

Water was measured for five weeks at Gobabeb from 11 December 1993 to 14 January 1994. The water use during that period is summarised in Table 1.

**Table 1 - WATER USE AT GOBABEB (m<sup>3</sup>)**  
**This table presents estimates of water use over five weeks at Gobabeb.**  
**Methods and calculations are explained in the test.**

	USE	DATES					Mean Monthly	Annual Total
		11-17 Dec.	18-24 Dec.	25-31 Dec.	1-7 Jan.	8-14 Jan.		
1	Drinking	0.38	0.52	0.50	0.30	0.62	??	??
2	Cooking	0.17	0.28	0.26	0.32	0.34	??	??
3	Basins	0.77	0.80	0.78	0.72	0.74	??	??
4	Showers	3.69	4.90	5.66	3.92	7.02	??	??
5	Toilet	1.18	3.55	4.74	3.23	3.43	??	??
6	Laundry	0.13	1.30	0.78	2.73	1.17	??	??
7	Stock	7.90	7.24	7.40	4.61	1.61	??	??
8	Lab Uses	0	0.63	0	0.63	0	??	??
9	Car Wash	0	0.07	0	0.20	0.12	??	??
10	Pool	3.54	3.71	3.52	2.69	3.15	??	??
11	Irrigation	129.07	128.83	ND	120.44	105.35	??	??
	Total 1-3	??	??	??	??	??	??	??
	Total 1-10	??	??	??	??	??	??	??
	Total 1-11	??	??	ND	??	??	??	??

Essential uses, considered to be drinking, cooking and washing dishes and hands, consume a calculated monthly mean of 6.5 m<sup>3</sup>. A mean of 88.6 m<sup>3</sup> water per month is used for all activities at Gobabeb, with the exception of watering gardens and ornamental plants. The latter use consumes 86% of all water used at Gobabeb with a monthly mean of 525.4 m<sup>3</sup>. Because of the summer school holidays, the number of people at Gobabeb during the measurement period varied from day to day. Assuming an average of 30 people present during the month, the per capita water use, was about 3 m<sup>3</sup> per month, for all domestic, recreational and research consumption, inclusive of water for Topnaar stock but excluding gardens.

Gardens constitute the overwhelming use of water, when compared to other use categories (Figure 1). The percentage distribution of water into all identified categories, except watering plants and gardens, is illustrated in Figure 2.

Because the methods used to measure amounts of water used for different purposes were neither orthodox nor standard, there was a possibility that large inaccuracies could arise. To verify the accuracy of the measurements, those derived from the detailed measuring of this study were compared with the only three metered values of water use at Gobabeb (DWA reports, courtesy of C Berry, MET, Gobabeb). These results are displayed in Table 2.

The population turnover at Gobabeb is very variable. During 1993, the population consisted of 20 permanent staff members with scientific visitors fluctuating between 26 and 243 per month (MET records, Gobabeb). As a consequence, the applicability of the short term mean values derived in this survey requires further measurement.

**TABLE 2 - ESTIMATES OF DAILY WATER USE AT GOBABEB**

Derived from hours of pumping time <sup>1</sup>	25.2 m <sup>3</sup> /day
Derived from volume pumped at borehole <sup>1</sup>	24.3 m <sup>3</sup> /day
Derived from volume of water distributed from water tower <sup>2</sup>	19.3 m <sup>3</sup> /day
Derived from this study	20.1 m <sup>3</sup> /day

<sup>1</sup> Daily rates based upon pumping time and upon volume pumped were calculated for two pumps for the period 15-01-93 to 17-01-94.

<sup>2</sup> Daily rate based upon volume of water distributed from the water tower was calculated from seven months' data recorded during 1993.

## DISCUSSION

Detailed measurements of water use in the various categories were collected for only five weeks during this survey. A variety of innovative but unorthodox methods were used. Although the results obtained were unexpectedly close to the amounts distributed from the single source of water at Gobabeb, the water tower, the estimates should be considered very provisional and additional measurements of this kind should be undertaken.

The discrepancy between the measurements taken from the pumps at the boreholes on the bank of the Kuiseb River and the amount distributed from the water tower at Gobabeb is cause for note (Table 2). It is not known if this can be attributed to faulty metering or to an actual daily loss of over 4 m<sup>3</sup> to leaks, evaporation or other unidentified causes. As the water tower, the only storage facility, is covered, losses to evaporation do not present a plausible explanation.

The measurements at Gobabeb were taken during the summer vacation period. This summer vacation is a time when some residents leave for holiday elsewhere, while others remain on the station where they are joined by their children home from school and visitors of all ages to share the festive season. A number of scientists take the opportunity of visiting at this time and short term staff are numerous. Thus the data taken during this period do not necessarily reflect normal usage patterns.

Another factor confounding measurement, is the regular movement of people between Gobabeb and Soutrivier, less than 5 km distant. Particularly during weekends, the population of Gobabeb decreases and that of Soutrivier increases. This complicates both measurement of water usage at the two sites and estimates of the number of people using that water.

The data in Table 1 show great variation for which explanations are not easily provided. The very low figure for irrigation during the third week, indicated as ND (no data), is attributable to the absence of the workers over the holidays who are usually responsible for all garden watering. The steady decrease in stock watering at Gobabeb could be attributed to the installation of a new pumping system at Soutrivier. Many of the stock, present at Soutrivier but previously drinking at Gobabeb, may have been shifted to the new source. The low value for the swimming pool during the first week in January relates to the cool weather and the relatively low evaporation rates measured at the Weather Bureau's A-pan, recorded thrice daily at Gobabeb (e.g. Lancaster, Lancaster and Seely 1984). The increase in water use for laundry relates to the acquisition of a new communal washing machine after the previous one broke down in December. Longer term measurements would be necessary to provide a more accurate picture of water use patterns.

Some of the water uses will continue no matter what conservation measures are invoked. These would include drinking, cooking and basins. Other domestic use could also be considered essential. Stock drinking is shifting naturally to Soutrivier but can not be eliminated entirely. Only the swimming pool, water for ornamental gardens and possibly laboratory use and car washes could be considered strictly non-essential. Water use for the swimming pool could be reduced by covering the pool and water used for ornamental gardening could be greatly reduced by establishing appropriate gardens. These might incorporate more rock gardens and desert-adapted plants. The scope for creativity in this direction is enormous.

Per capita usage of water at Gobabeb as measured in this survey, inclusive of all uses, is about 0.68 m<sup>3</sup> per person per day. This falls within the range of high income users in Walvis Bay with a mean of about 0.5 m<sup>3</sup> per person per day (see Chapter 5). This value is higher than the highest value obtained by Topnaar farmers on the Kuiseb (0.45 m<sup>3</sup> per person per day, see Chapter 3) and much higher than middle income users (0.15 m<sup>3</sup> /c /d) and low income users (0.06 m<sup>3</sup> /c /d) in Walvis Bay. The Gobabeb results are surprising, as the population incorporates what appear to be both high and low income life styles. The ready availability of free water and the extensive use of water for gardens may provide part of the explanation.

Water is provided free from the Department of Water Affairs to the Ministry of Environment and Tourism at Gobabeb. It is, in turn, distributed to residents at no cost other than that included in their overall rental. The majority of water is used directly by Ministry staff in maintaining ornamental and vegetable gardens. On the other hand, the staff and visitors to Gobabeb are acutely aware of the water scarcity in Namibia. The contrasting influences on water use at Gobabeb - of the presence of free water, high use of water for gardens and awareness of water's extreme scarcity in the desert and throughout Namibia - requires further study.

Using a large proportion of water for gardens is not unique to Gobabeb, for the chapters on Walvis Bay (Chapter 5) and Swakopmund (Chapter 6) highlight similar patterns. A re-evaluation of this pattern should be carried out by all towns in Namibia with similar high water use for gardens, in the presence of current and potential water shortages in these same towns.

Most of the infrastructure at Gobabeb was constructed or upgraded in 1974. At that time there was little thought of potential water shortages and the infrastructure available was not designed for water use efficiency. While some alterations could be instituted, including smaller toilet cisterns or reduced-flow shower heads, it is possible that the sewage system would not operate on reduced water flow. A holistic assessment of potential water savings must be undertaken to establish the range of possibilities available.

On the other hand, the reduction of water use could have both negative and positive effects on residents and visitors. For those residents extensively involved in gardening, whether it be vegetable or ornamental gardens, water restrictions could constitute a negative impact. Many trees have been planted close to buildings to provide shade, as none of the residences and only two small laboratories are air conditioned. Their absence could mean discomfort and reduced productivity during warmer periods of the year. These potentially negative impacts should be weighed against the positive effects of heightened water awareness and reduced water use.

Reduced water use and establishment of a visible water conservation campaign would improve the image of the desert research station, provide information about water reduction that could be shared with other communities living in the arid parts of Namibia, have educational value for those resident at and visiting Gobabeb and would provide examples for environmental education materials. The establishment of a working model of a water-conserving organisation would have national value.

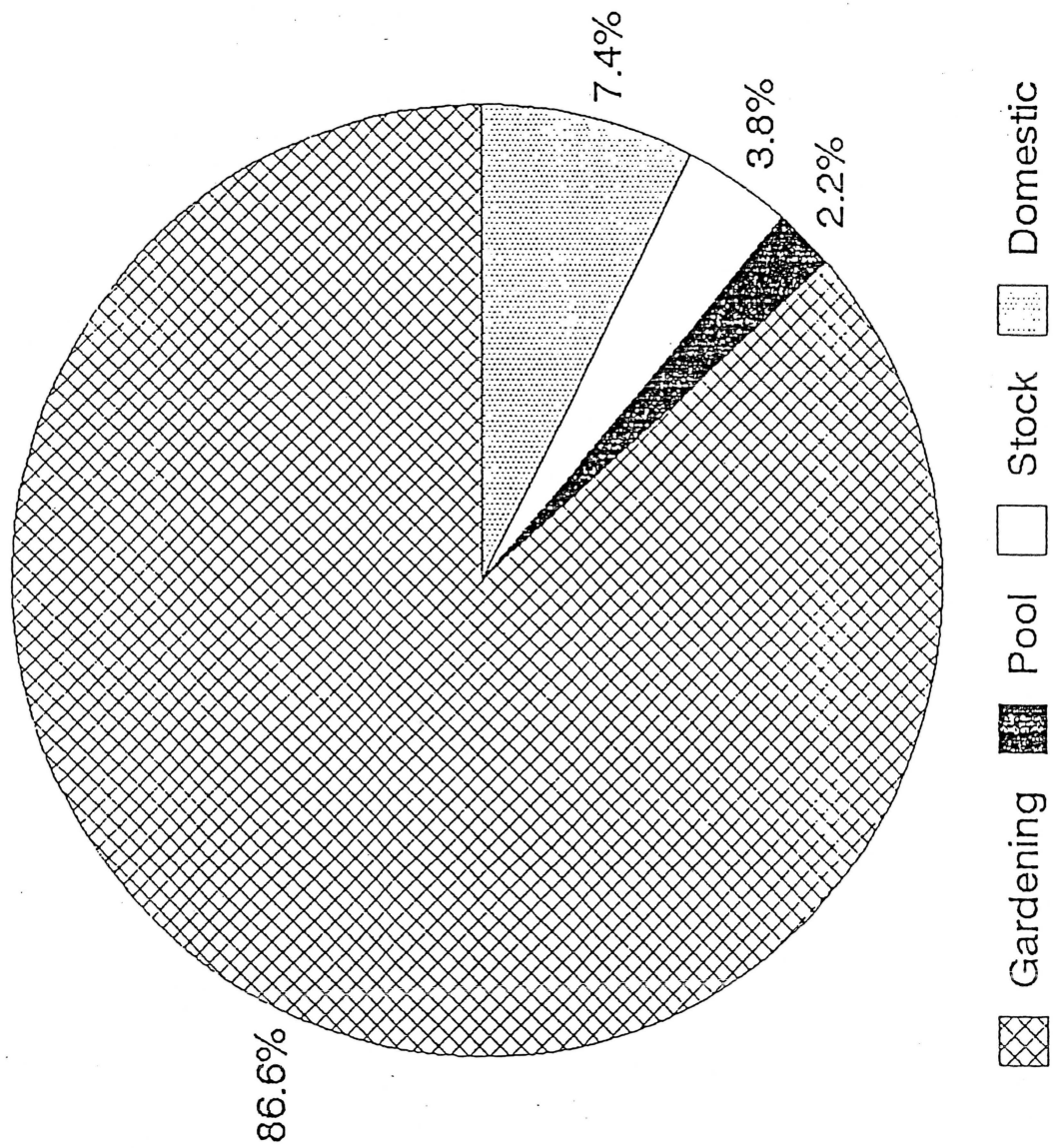
## **CONCLUSIONS**

Water use at Gobabeb was found to be very high, with more than 80% of this use going to watering ornamental gardens containing mainly exotic plants. Water use should be evaluated and alterations made in water use patterns where deemed necessary. Gobabeb should attempt to establish itself as an example of water conservation in arid lands.

## **RECOMMENDATIONS**

- 1.) Individual dwellings and other buildings at Gobabeb should be fitted with water meters and records should be kept on a long term basis. The results of these observations should be made available, on a continuous basis, to all residents and visitors in the form of graphs and charts.
- 2.) A strategy to save water should be drawn up by the residents of Gobabeb and its implementation be effected through the Joint Management Committee.
- 3.) An awareness campaign, specific to Gobabeb and directed at all residents and visitors, should be established and made an integral part of the visitors programme.
- 4.) Use of water saving devices, e.g. smaller toilet cisterns and shower heads, should be investigated and adopted where possible. As the home of the Namib Research Institute, Gobabeb should aim to become a model of low water use.
- 5.) Use of exotic plants and gardening outside of the building courtyards should be investigated and evaluated for their contribution to both water use, life style, comfort (shade) and pleasure of the residents and visitors. Use of desert-adapted plants, rock gardens and other water saving strategies should be investigated and adopted where possible.
- 6.) Watering of gardens should be done at night rather than at mid-day when evaporative losses are greater. This could be considered an interim measure for water use reduction until the gardening policy has been reviewed.
- 7.) The swimming pool should be covered when not in use.
- 8.) Gobabeb should seek to establish itself as an example of water saving possibilities in Namibia.

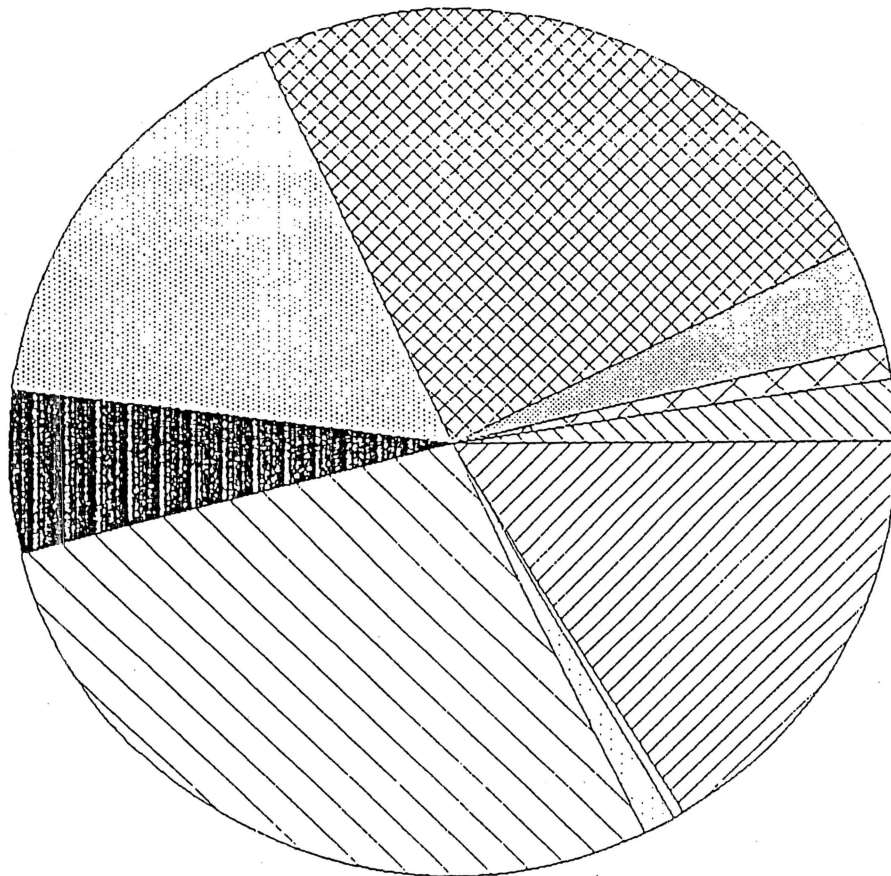
Fig. 1: Percentage Water Use At Gobabeb





# Fig.2: Percentage Water Use At Gobabeb

(EXCLUDING GARDENING)



- |          |         |        |          |        |
|----------|---------|--------|----------|--------|
| Drinking | Cooking | Basins | Showers  | Toilet |
| Laundry  | Stock   | Lab    | Car Wash | Pool   |

## Chapter 5 - WALVIS BAY

by Elias "Charlie" Shanyengana

### ABSTRACT

Namibia, being 97% arid or semi-arid, lives with a natural water scarcity. This problem has been aggravated as a result of an ever increasing water demand that has led to over-extraction of the country's inland water resources, especially at the coast.

This document looks at water consumption patterns and identifies loopholes for water wastage within the Walvis Bay enclave. The study unveiled the total absence of water conservation efforts among the residents and industry, despite the fact that these sections account for more than 60% and 30% respectively of total water consumption.

The urgent need to relax pressure on the over-extracted internal water sources and the possibility and pressing need for sea water desalination were identified. Finally, this report provides recommendations on water resource management aimed at governmental, municipal, industrial and residential bodies, making it a resource for planning, future research and water resource management.

### INTRODUCTION

The Walvis Bay settlement dates back to the turn of the 13<sup>th</sup> century with the Arabian traders and expeditions of the Portuguese navigators, followed by the appearance of British settlers in 1793 and its annexation by Britain in 1878. In 1884 the town was incorporated into the Cape colony and mandated to South Africa in 1922 as part of the mandate area of Namibia. Ever since its establishment, Walvis Bay has had a dramatic history of water acquisition. This dates back as far as the 1850's when water was imported in barrels from the Cape (Wilken & Fox 1978).

From 1923, the South African railways and the harbour authorities supplied 80,000 m<sup>3</sup>/a (230 m<sup>3</sup>/day) from two wells at Rooibank into Walvis Bay (Heyns 1992, Wilken & Fox 1978). However, due to an increased water demand at the towns of Walvis Bay and Swakopmund, the water scheme was taken over by the South West African administration in 1950. This transfer resulted in the expansion of the Rooibank and Swartbank schemes, development of the Omaruru delta scheme and thus the establishment of the "Central Namib Regional State Water Scheme" as known to date.

Today, Walvis Bay, with a total area of 1124 km<sup>2</sup>, a population of roughly 38,000 and a growth rate estimated at 2.7%, is faced with the challenge of meeting the rapidly growing water demand of its residents and ever expanding industry. This increasing demand has resulted in the over-extraction of the available water source, a severe drop in the ground water level and consequent negative ecological and socio-economic impacts on the Kuiseb Catchment Area (KCA) (Walvis Bay workshop, 1991).

With current abstraction estimated at roughly 200% of the yearly recharge rate, a marked decrease in the average rainfall over the catchment area in the past decade and an aggressively approaching saline-wedge, the entire west coast, and Walvis Bay in particular, is today threatened by a water crisis of a magnitude that has never before been faced in its history of water development.

It is in the light of these concerns and the fact that water is a scarce and limiting resource throughout Namibia, that this project was undertaken at the Desert Ecological Research Unit of Namibia, situated roughly a hundred kilometres away from Walvis Bay, in the Namib Desert. The objective of the study was to identify water consumption patterns within the KCA and review alternative water sources and conservation plans for the west coast. This chapter concentrates on the Walvis Bay enclave and aims at creating awareness, highlighting means of minimizing water waste and/or loss and forwarding viable recommendations for consideration by policy making bodies and the public in general.

## Consumers and Consumption Patterns

Today, the Walvis Bay enclave consumes roughly 10 - 11,000 m<sup>3</sup> of water per day during the normal season, and in the region of 12,000 m<sup>3</sup>/day, during peak season. This compares with about 230 m<sup>3</sup>/day, i.e. roughly 80,000 m<sup>3</sup>/annum, in the early 1920's (DWA report No. 12/7/G10 1989). Current use totals ~4.3 Mm<sup>3</sup> of water per annum, about 38 % of total water consumption at the coast, making it the first major consumer at the coast. Industry, residents (residential) and the port (Portnet) consume about 60%, 30% and 8% respectively, of the total water supplied to Walvis Bay during the fishing season (March - August). However, during the non-fishing season the situation is said to be reversed (Municipality pers. comm. 1993).

However, 1991 statistics show an overall 72% consumption for residential and only 24% going into industry (combined) throughout the year (see Appendix B, Fig. 4). This phenomenon alone stresses the need to concentrate water conservation measures equally on the two main consumers, domestic and industrial users.

## Industrial Water Consumption

Industry (the port included) gave birth to the town of Walvis Bay, sustains it today and will continue to do so in the future. However, uncontrolled industry is also posing a threat to the future existence of the town and this makes every attempt to monitor industry in the town, a step towards a brighter future for Walvis Bay.

At present, industry (Portnet included) has approximately 373 water connections (Municipality pers. comm. 1993) and uses between 25 - 30% of total water supplied to the town (see Appendix B, Fig. 5). The industrial water-uses comprise fishing operations such as canning, steaming, cleaning of fish, vicinity and machinery, as well as ice-making. The harbour operations include domestic and industrial activities on off- and onshore vessels, washing of trailers (e.g. Trans-Namib), coal watering, operation of fire hydrants and some other small scale industrial operations e.g. the abattoir, Namibia Wine & Sprits and several sea food industries.

In the period 1986/87, water consumption in the fishing industry increased by 80% per annum. Today, the fishing industry alone is said to utilise up to 15% of the town's total water consumption (SLW JVC 1993b). Even though this water might be essential (for cleaning fish and machinery), this figure is of note if one thinks of the industry's expansion potential of 1% per annum. It is common to find, upon visiting a fish factory, the floor river wet (ankle deep) and the hose pipe still flowing unattended.

The port services on average 150 ships per month. Due to their awareness of the water problems the coast faces, the port authorities discourage water-refill (bulk supply) by foreign vessels at the port and only provide 30 - 40% of the amount demanded, after approval of an application.

With the expansion potential estimated at about 1% per annum for the fishing industry, 10% (in general) for other industries and 6% (general) for tourism, the uses of fresh-water by the fishing industry, other industries and vessels still need to be investigated and classified into essential and non essential uses. The industrial carrying capacity (based on water availability) of the town should be determined and industrial policy on water-use should then be implemented as a matter of urgency. It is essential to regulate water demand, supply, use, waste and even industrial pollution of our offshore waters (Tworeck pers. comm. 1993). Fresh water being a precious and scarce resource in our arid region, sea water should be used where fresh water is not a necessity. This could then be enforced by policy.

The possibility of fog-water collection (e.g. for watering imported coal) and/or erection of a seawater supply network for industry should also be investigated by either private, municipal and/or governmental bodies. This water could then be treated to the least requirements (tds etc.) of all industries concerned and then sold at a production cost that will be much less than the cost of desalinated sea-water, the inevitable alternative. The actual cost of erecting such a pipeline is minimal compared to installation of an individual pipeline by each industry.

Without consideration of all the above-mentioned factors, future industrial development within Walvis Bay and along the coast will impair sustainable use of the town and the environment and, in general, represent a far worse slap in nature's face than it is today.

#### Residential Water Consumption

Ninety percent of our body fluid is water and it is for this reason that water drives basically all our domestic activities in life. It is also because of this everyday contact that it is considered a right. As a result, the true value of water is so often forgotten.

Walvis Bay residential water consumption has increased drastically over the years. This increase can be attributed to population growth and the increase in water-usage with increasing living standards. Residential water consumption amounts to more than 60% of the town's total water consumption, with about 55% used by the high income group alone (see Appendix B, Fig. 4 and 5). This therefore implies that about 36% of the town's water ends up in house gardens (about 10% more than industrial consumption). A normal household in Walvis Bay consumes on average 23 m<sup>3</sup>/month (Kusebmond), 21 m<sup>3</sup>/month (Narrawille) and 40 - 48 m<sup>3</sup>/month (Walvis Bay town itself). This huge discrepancy between different user groups, can be partially attributed to:

- house gardens, (<85 kl for small & >85 kl for bigger gardens).
- wider range of water-dependent domestic facilities, e.g. washing machines, etc.
- wider range of water-dependent activities, e.g. more car washings, wall washing (e.g. after sandstorms), etc.

The Walvis Bay population, though 85% "aware", has a high income group that is reluctant to conserve water because of the financial ability to pay. The low income's reluctance to conserve can be attributed to the lack of knowledge on how to act and, in most cases, total negligence.

Apart from purely domestic activities such as cooking, drinking and washing, people have lost their respect for water as the driving force for life, such that many of water's domestic uses today can be described as wasteful.

With current water consumption figures at 4.3 Mm<sup>3</sup>/annum and its demand steadily increasing at roughly 3.5% per annum, the town of Walvis Bay urgently needs to re-evaluate its present fresh water uses in order to accommodate its population and industry. The high potential for expansion is expected to increase water demand in the future to about 5.9 Mm<sup>3</sup>/annum by the year 2005 and consequently ca. 12.3 Mm<sup>3</sup>/annum by 2020, which is more than the current total demand for the coast (SLW JVC 1993b).

This estimate becomes unrealistic if one considers the fact that the predicted 3.0%/annum increase in demand for 1995 is significantly less than the actual increase of 3.5% for 1993. This implies higher water demand figures than predicted (above) for the years ahead (e.g. 2005 & 2020 planning horizons). However, our present resources will not be capable of covering these demands and this leads us to look into alternative sources and proper water management for the future (See future plans and conservation in this chapter).

The domestic use of fresh water by people in Walvis Bay at the expense of the other consumers in the KCA for such purposes as car washing (weekly), wall washing, watering of gardens (big gardens and those with alien plants) etc. is wasteful, and an abuse to nature and its resources, humans included. In view of the functional domestic role played by water, its wastage can be considered a sin and people should therefore be encouraged to rediscover its aesthetic value to nature and humans in particular.

It is also worth taking note that water is not a right but a privilege, and this privilege is running out fast because of our arid land. Our survival and that of other species is drastically threatened, if not already shattered (e.g. vegetation in the lower Kuseb). It is therefore our responsibility to see to it that water, though scarce and running out, remains available for our daily domestic activities as well as our natural environment.

## COSTING AND PRICING

The price of water in Namibia, and Walvis Bay in particular, has had a history of fluctuation over the years. Increases have become even more prominent in recent years as a result of the increased cost of extracting from rapidly depleting sources. Walvis Bay experienced a price hike of 18c/m<sup>3</sup> within a year (i.e. from 1992 to 1993, 40c to 58c/m<sup>3</sup>), compared to only 9c/m<sup>3</sup> in three years (i.e. from 1979 to 1992, 31c to 40c/m<sup>3</sup>) on its residential water pricing. However, even though the price has increased, water still is priced only at its production cost and subsidized for domestic use, therefore remaining priced at less than its replacement cost.

The present cost of water in Walvis Bay is 58c/m<sup>3</sup> for every 0 - 15m<sup>3</sup> of water supplied per month (domestic) and 132c/m<sup>3</sup> for industry. This price (domestic) increases with the amount of water used per month due to the implementation of the scaled water tariff system (a conservation measure). For every 15 - 25m<sup>3</sup> consumed, the consumer pays 77c/m<sup>3</sup>; from 25 - 85m<sup>3</sup>, 104c/m<sup>3</sup> is paid; and 220c/m<sup>3</sup> is paid for consumption greater than 85m<sup>3</sup>/month (Municipality pers. comm. 1993). This pricing system, though illustrative of the water limitations, still remains far too cheap to cause a change in user attitudes and has been found to affect only the lower income groups that contribute the least to the water problem. This system has had almost no success in reducing water use.

The term replacement cost, in this context, refers to the cost of reclaiming the water consumed and should therefore be expected to increase with each consumer's quantity and with quality and amount of impurities in the discharge (effluent). This system allows the consumer (esp. industry) to make a contribution (equal to their pollution) to the reclamation of water from their effluent (Tworeck pers. comm. 1993).

The fact that water is so cheap and still subsidized, makes it lose its true value to the consumers, thus creating loopholes for its wastage and strangling any reasons for conservation.

However, consensus seemed to be reached by most of our interviewees, that water is a life supporting resource and should therefore remain priced at prices affordable to the individual consumer. People acknowledged, however, that water is Namibia's least abundant resource and that pricing it at production cost, with no thought towards replacement, is not a sustainable use of water.

The general trend of agreement seems to be that water should rather be priced at its replacement cost in order to stress its true value and reflect the scarcity of water in a desert town like Walvis Bay. This price will, therefore, serve to initiate and enforce proper use of water as well as its conservation.

## CONSERVATION

Water conservation is a concept hardly understood by the consumer as yet, partly because of the present low price of water, the lack of interest and, in most cases technical know how. Similar to other Namibian urban areas (e.g. Windhoek), about 85% of Walvis Bay's population is said to be aware of the current water problem and the need to conserve. However true this might be, it is not evident in actions and one wonders if the town's residents do not feel threatened enough yet, to consider conservation efforts.

What's more illogical, though, is the fact that voluntary awareness alone, without any positive measures by the consumer, is thought to have a potential for saving 15% of normal water consumption. With measures such as putting bricks into cisterns included, up to 25% could be saved. It is also believed that with implementation of policies, mandatory measures and even regulators (e.g. water saving devices), Walvis Bay's yearly increased water demand could decrease to only 2.5% /annum as compared to the current 3.5%. Up to 40% of total water consumption could be conserved in a specific area. In view of these statistics, one wonders if 85% of the Walvis Bay population is really aware and, if so, when positive conservation actions should be expected.

Water conservation in the context of this report refers to the proper use of fresh water (i.e. only where other resources can't be used e.g. sea-water) and any efforts to reduce the loss of fresh water, thus water demand management. These losses and mis-use should therefore be targeted by water conservation through public awareness campaigns, water pricing, regulation and educational programmes for schools.

The town's Municipality has tried to encourage water conservation through awareness campaigns and the implementation of the tariff system. These awareness campaigns were said to have been too technical and were therefore received with an irresponsive attitude by the residents. The water tariff system's success is also thought to be lower than was expected, because it ended up affecting mainly the low income groups which already use a relatively low amount of water.

Programmes carried out in 1992, to reduce water usage by 25% through conservation measures (e.g. tariffs and awareness campaigns) in order to support collapsing aquifers, followed the same trend and the water usage increased by roughly 6.5% (Municipality pers. comm. 1993).

With enough evidence of no measurable success (insignificant) with all conservation attempts, it is more advisable to couple measures presently being carried out by the municipality, with more water demand management plans.

Water demand management looks at the water losses and mis-use, the potential for conservation, possible measures, their targets and means of implementation. Even though water demand management cannot create water, it does decrease the demand through conservation measures, thus consequently decreasing the need for supplementary sources for future water supply.

The investigation of the industrial and human carrying capacity of the town will also place the town in a better position to make plans for the future. This point emphasizes the need to put or transfer industry to areas that can better sustain it rather than having it where its existence is a continuous threat to itself, nature and the town in particular.

Populations should therefore be limited, (according to available resources esp. water) and residents' innovations should be encouraged for saving water in their homes, e.g. by insulation of their hot water pipelines, putting bricks in their cisterns and even only buying water saving devices, e.g. shower heads (70% savers), washing machines, dish washers, vacuum toilets, etc.

Another interesting means of water conservation and supplementation of the already existing supply is collection of fog water. In Chile and Peru individuals collect enough fog water for their own consumption. Could fog water therefore be used by Walvis Bay residents, for purposes such as gardening and others (Schemenauer 1990)?

The municipality and other bodies involved in water distribution should re-evaluate their pricing system, meter all consumers (from government to private) and improve leak detection and preventive measures. Investigations should be carried out on the possibility of sewage reclamation, the reduction of water pressure and residents should also be encouraged to re-use and/or recycle their water (hygienically) before discharging it into the main sewage system (Tworeck pers. comm. 1993).

Considering the number and size of gardens, their value to the town, present effects on water consumption and their future coexistence with sewage reclamation (if it is ever effected), alternative gardening becomes a recommendable approach for homes and even the municipality. This gardening involves decorative schemes with desert plants that consume less water and could be even better if fog collecting plants are used instead. The rest of the garden is then decorated with beautiful sea pebbles and/or stones etc. (e.g. in southern California). Nurseries at the west coast should also be encouraged to promote these ideas (through demonstration gardens) and, if possible, restrictions in terms of size, type of plants, etc. should be considered and passed as policy, by policy making bodies e.g. the Municipality.

The town's industry should also be responsible for treating their sewerage to an acceptable standard, before discharging it into the town's sewage system. In addition, regular inspection of industry's water uses should be carried out by an appointed independent environmental body and punitive measures (e.g tariffs and/or withdrawal of permits) be considered if any deviations from policy are detected.

With so much said, it remains our opinion that water conservation remains part and parcel of the solution to the water problem in Namibia. The effect of conservation remains profound, be it during times of water shortage or abundance, today or in the future. Thus, conservation must always play a big role in solving the biggest of all Namibian puzzles, "WATER & HUMAN DEVELOPMENT".

#### FUTURE PLANS

Walvis Bay, with a water consumption of about 4.3 Mm<sup>3</sup>/annum, a yearly increase in water demand estimated at 3.5% and a population figure expected to double in 25 years, still retains great potential for expansion, if exhausted water sources are not considered. Moreover, with re-integration of the enclave, it should be assumed that the population and economic expansion potential will be even higher than previously estimated. This higher estimate is based on an expected increase in harbour activities, industry (esp. fishing) and population growth rate. In addition, because of the perceived great work potential, a higher immigration rate from inland Namibia should be expected.

Today the town already has a lot of development plans in the pipeline, such as:

- 112 erven for holiday homes at Langstrand,
- optimal development of fishing industry,
- additional residential erven at Langstrand,
- caravan park at the same area,
- harbour rezoning with a hotel & small craft harbour,
- sixty bed hotel at Meersig,
- Dolfynstrand holiday resort extensions and
- additional erven at Meersig and Time Share Homes (SLW JVC 1993b)

Other future plans include economic expansion to accommodate trade links with land locked neighbouring states, as well as possible oil mining, depending on the outcome of current oil explorations.

However, with current sources of water already exhausted and a sky-rocketing water demand estimated for this coastal town in the future, development plans such as the above become a threat to the town's existence. Sustainable alternatives such as the use of different water sources, re-evaluation of current water use to minimize misuse and most probably consideration of such development outside Walvis Bay will have to be considered.

Among these possible alternatives, several have been considered for Walvis Bay:

1. Underground water sources,
2. Other inland alternative sources,
3. Reclamation,
4. Desalination.

#### Other Underground Water Sources

These alternatives include the development (expansion) of present sources, as well as the exploration for other underground sources, such as:

- The future development and/or better management of present aquifers at the Rooibank A and B-areas, Kuiseb channel, as well as the Dorop South and North areas (Bush 1992).
- Development of Walvis Bay dune area and other dune areas south of the Kuiseb.

Three categories of options are suggested for underground water source development. These are: aquifer options, technical development options and cost, as well as aquifer management options (Bush 1992). Aquifer options refer to the available aquifers, while the second option (above) refers to the technicality of their development. These technical options involve: mining of the aquifers (currently done in B-area and the most feasible and cheapest of all), simultaneous abstraction and injection of fresh water along the saline wedge, and finally simultaneous abstraction of both saline and fresh water from the aquifer (Bush 1992).

The possibility of further extraction of groundwater from the Rooibank A and B-areas, Kuiseb channel as well as the Dorop South and North still exists. However, their development, though advantageous due to the considerable volume of water available, the potential to draw water from a much more extensive area and the delay of capital costly alternatives, has negative economic and environmental impacts. The limited small volume of water obtainable (e.g. Kuiseb channel), reduced source sustainability, the necessity for saline wedge monitoring and the potential effects of shifting dunes (esp. in B-area and Dorop North), make aquifer development in these areas cost ineffective. Considering present over-extraction (e.g. Rooibank A-area) and possible contamination by saline water, the environmental impacts accompanying these developments will be enormous. These impacts are expected to be more severe at Rooibank A-area as well as Dorop South, where saline wedge monitoring will be difficult because of high aquifer diversity (Bush 1992).

Current exploration in the dune areas (Walvis Bay and south of the Kuiseb river), though promising, still has a lot of unanswered questions concerning the sources of the water, its sustainability (possibly fossil water), its quality, as well as the environmental impacts associated with its exploitation.

#### Other Inland Alternative Sources

Other alternatives include construction of surface water storage dams on ephemeral rivers (proposed Kuiseb/Gaub dam or Otjompaue dam on the Kuiseb and Omaruru rivers, respectively) and connection of the coastal water schemes to the Eastern National Water Carrier (E.N.W.C.) (SLW JVC 1993e).

None of these alternative sources could meet the increasing water demand independently and have thus only been considered in conjunction with seawater desalination. Thus, either the Kuiseb/Gaub or the Otjompaue dam would be constructed. The third alternative (E.N.W.C.) would also be implemented only if it proves more feasible than sea water desalination.

The first two alternatives (Kuisseb/Gaub and Otjompaue) are primarily aimed at supplementing and delaying implementation of "more expensive" alternatives such as sea water desalination and linking the coast to E.N.W.C. (SLW JVC 1993e). However, the effects of dams and the linking of the west coast to the E.N.W.C. are equally high in terms of construction, maintenance, and distribution costs, as well as the consequent environmental impact.

#### Reclamation

A fourth alternative for Walvis Bay is water reclamation. Even though an expensive alternative due to a higher salt content of the water (compared to e.g. Windhoek), this remains a cheaper and comparatively environmental friendly solution.

At present Walvis Bay has a septic tank with a capacity of 5000 m<sup>3</sup>/day and treats 100% of its 3500 m<sup>3</sup>/day sewerage through bio-filters. The resultant water is however not potable and thus is used for watering municipal gardens, school gardens, church gardens, parks and sports fields. This reclamation plant has a potential to expand its capacity by 1500 m<sup>3</sup>/day, with the addition of one more bio-filter to its present infrastructure (SLW JVC 1993). A reclamation plant at Walvis Bay could further treat the water to drinkable qualities and possibly process Swakopmund's sewage as well, in order to reclaim a significant amount of water.



## Desalination

The presence of underground brackish water and unlimited sea water initiated the idea of desalination, as our final and most sustainable alternative water source.

### Brackish Water Desalination

The desalination of brackish water has been identified as a possible alternative that can consequently delay the implementation of sea water desalination to a later stage (e.g. A and B areas of Kuiseb aquifer). This process might include such procedures as reverse osmosis desalination, 'low lime' softening and even 'high lime' softening if dolomite lime is used. A typical example of proposed brackish water desalination for Walvis Bay, is the 5,000 m<sup>3</sup>/d (i.e. 1,83 Mm<sup>3</sup>/a) RO plant at the B-area of the Kuiseb delta (Botha 1992). Even though the water might not be desalinated to a highly desirable quality (tds), blending it with marginally poor quality water will result in larger quantities of better quality water. This would reduce the price of the water even if desalinated water is as expensive as expected.

With labour costs associated with this desalination contributing about N\$ 0,50 to the water cost, automation of the desalination plant needs to be considered (Bush 1992). However, the brackish water's low salinity and comparably low labour costs makes it much cheaper than sea water to desalinate and is a good delaying alternative.

Brackish water desalination also has its disadvantages, however. The presence of unusually high concentrations of SiO<sub>2</sub>, that can lower recovery potential by 25% (Botha 1992), is a particular consideration.

### Sea Water Desalination

The sea water desalination alternative involves the treatment of sea water to a low salinity that would make it good enough (quality) for human consumption. The resultant water would then be mixed with water from sustainable underground sources, decreasing over-utilisation of desalinated water, and consequently moderating the cost of the undertaking and its product to the users.

The implementation of desalination for the west coast has been proposed to run concurrently with either the Kuiseb/Gaub or Otjompaue dam (SLW JVC 1993e). This development was proposed to start as early as the year 1996, with the installation of two desalination units with a total capacity of about 1.1 Mm<sup>3</sup>/annum. The year 2008 (i.e. after every 3 yrs.) would then again see the implementation of two additional plants with the same overall capacity of 1.1 Mm<sup>3</sup>/a. This three year implementation programme is said to be the most advantageous for cost recovery. For economic and environmental reasons, all alternatives have been re-evaluated and the immediate implementation of seawater desalination was recommended (SLW JVC executive summary July 1993).

However new sea water desalination may sound, it's not a new concept to the Namibian water platform. A test "Single Stage Reverse Osmosis" plant (RO-plant), run by the D.W.A. from 1979 to 1981, provided insight into the future of sea water desalination in Namibia (SLW JVC 1993e). This plant, located 40m from the beach at Mile 4 near Swakopmund (in the surf zone), had a capacity of 100 m<sup>3</sup>/day but a recovery rate of only about 40% which steadily dropped to about 25%.

The decreased productivity of the plant was as a result of:

- unacceptable pump vibrations due to aggressive sea waves,
- pipe breakages,
- high load of suspended sediments in the sea water,
- plugging of the membrane by plankton and organic matter, as well as
- the very high membrane replacement cost.

This experiment came with recommendations such as the use of a proper pretreatment system for sea water desalination in the future.

At present, the unit capital cost of the sea water desalination plant that has been studied is significantly higher than that quoted recently for substantially larger plants of up to 500,000 m<sup>3</sup>/d (Bush 1992). However, feasibility studies carried out on sea water desalination for Walvis Bay considered the possibility of using Reverse Osmosis or mechanical evaporation mechanisms.

The cost of a mechanical evaporation desalination plant in Walvis Bay (both construction and maintenance) is estimated at about N\$ 80m (Municipality pers. comm. 1993).

Such a plant is, however, also said to be much better off at Swakopmund due to the lower counts of suspended sediments in comparison to Walvis Bay. Such a plant with a 10,000 m<sup>3</sup>/d capacity could be installed within three years (i.e. from planning to implementation). A plant also lends itself to expansion in portions of 5,000 m<sup>3</sup>/d and is expected to yield up to 3.5 Mm<sup>3</sup>/a (Municipality pers. comm. 1993).

The cost of sea water desalination is currently estimated at about N\$ 6,58/m<sup>3</sup> i.e about 498% of present groundwater production. However, the mixing of desalinated water with water from other sources (e.g. underground) is estimated to lower the cost of water to about N\$ 3,00 to N\$ 4,00 for the consumer, thus a 300% increase overall (Municipality pers. comm. 1993).

Even though sea water desalination is considered to provide an unlimited water source, the high nutrient and organic matter levels in our sea threaten our ability to tap this resource. It is for this reason that the possibility of developing sea-wells along the coast should be studied to determine whether good quality seawater suitable for direct RO feed could be obtained consistently (Botha 1992).

Another threatening factor is the continually increasing discharge of industrial effluent into our sea waters, thus destroying the fishing industry's primary resource on one hand and polluting our infinite water alternative, the sea, on the other.

The high nutrient and organic matter levels in the sea, as well as industrial pollution, increases the cost of installing and maintaining any desalination plant. This is mostly due to continuous damage of the membrane (RO plant) or the need to erect a very efficient pretreatment plant.

Considering all proposed future alternative plans (esp. internal water source developments), emphasis should be laid on their sustainability, their contribution to the water supply as well as on the severity of their environmental impacts. Such emphasis is necessary to avoid a crisis of another dimension. The development of water sources on ephemeral rivers adds stress to our fragile ecosystems, and should therefore be well screened for all possible impacts before implementation. Moreover, Namibia being 97% arid and thus the driest country south of the Sahara, already lives within a water shortage posed by its natural environment. It is thus our responsibility to live within this natural limit as do other species. With this in mind, one would therefore not expect current over-extraction to cease as a result of supplementation with other inland water schemes, but rather just a transfer and/or expansion of the water-crisis and its consequent detrimental ecological and socio-economic impacts to another part of the country.

Possible examples of the above are the proposed development of the Donkersan dam (SLW JVC 1993e) that will impound an estimated 70% of the Kuiseb's annual runoff (Jacobson pers. comm. 1993). Also, the exploration for water south of the Kuiseb (BGR) and Walvis Bay dune areas deserves a high degree of concern due to their uninvestigated sustainability and the possibility of the water being fossil underground water and thus unsustainable as a source for future developmental activities. The effects of the proposed developments on the Kuiseb river, which is an essential part of the functioning and fragile Namibian desert ecosystem, should therefore be given special consideration.

Walvis Bay, being a desert town, has the responsibility of developing its one and only infinite source of water, the sea. With low rainfall recorded over the past century, over-exploited water sources, as well as a tremendously high potential for growth, Walvis Bay has reached the crossroads between development and collapse. The road towards a sustainable future can only be travelled via sea water desalination.

However expensive desalination is thought to be, it works out that the cost of meeting the 30 Mm<sup>3</sup>/annum water demand (projected demand for 2020) through desalination (N\$ 464 million) is lower than the other alternative sources combined (N\$ 460 - 500 million). This cost is much reduced (N\$ 386 million) if one considers the fact that about 15% of the demand could be met through sustainable utilization of current sources, namely the Kuiseb aquifers (sustainable yield of 5 Mm<sup>3</sup>/annum). The environmental cost of the dam alternatives makes these alternatives comparatively even more expensive.

Sea water desalination also makes a better alternative because it takes the pressure off the over-exploited, underground, exhausted environment and also has the potential to expand with demand. It is for this reason and many more that desalination should be seen rather as a sustainable and relatively cheap, long term alternative which implementation deserves urgent attention (see Appendix B, Table 1 for the above cost comparisons).

## CONCLUSION

The water problem surrounding our country, and the coast in particular, results from natural scarcity of inland sources as a result of a poor hydrological cycle, the ongoing abuse of water and the excessive water demand. In view of the wave of water shortages encircling our country, it is appropriate for government to determine and plan future development within the encompassed water limit. Water investment should also be done in much more sustainable and expandable sources, such as sea water desalination. The next wars to be fought in arid lands will be over water and not oil (Holder 1992, Homer-Dixon et al. 1993).

With such a high economic and industrial growth potential, a population expected to double in twenty five years and the negligent abuse of water by the residents, the future water demand of Walvis Bay is expected to have a devastating effect on the town. However, even though the town's natural environment has already experienced a fair share of these effects, the town still stands a chance of averting this catastrophe. It therefore remains up to the authorities and the Walvis Bay residents to scrutinize the available recommendations in order to restore dignity and certainty of the town's future existence.

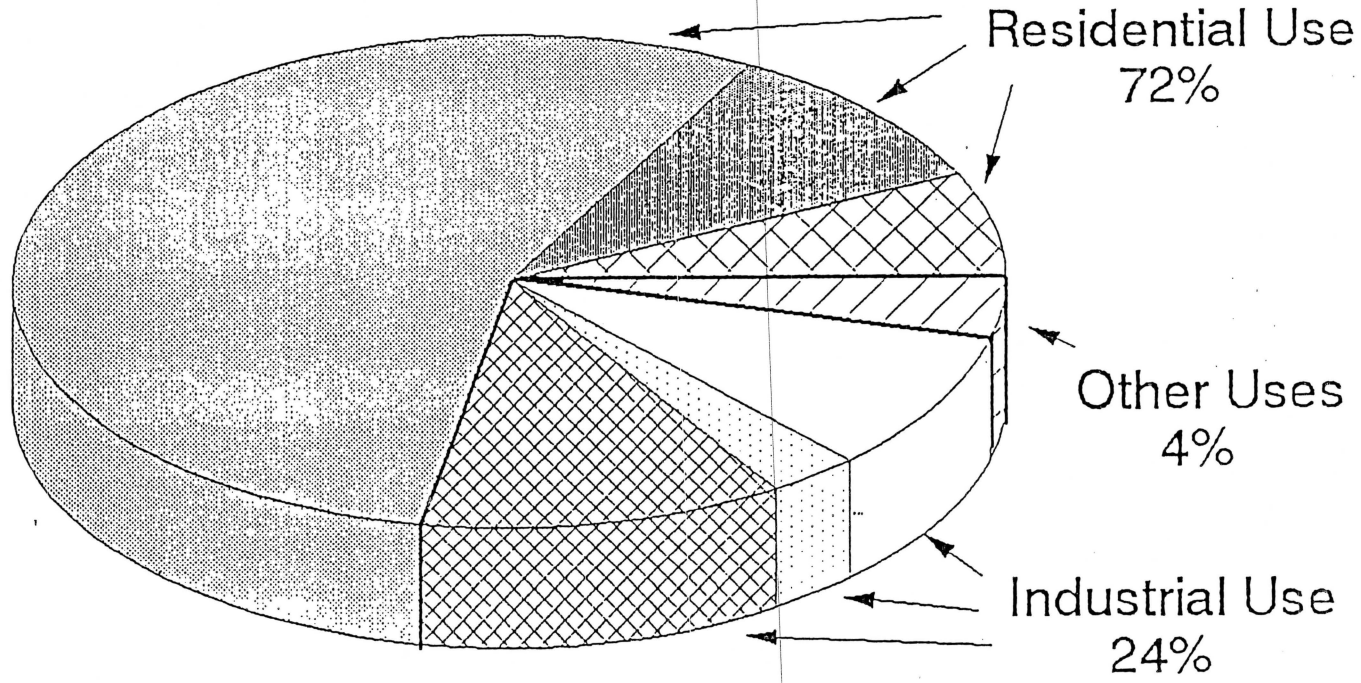
## RECOMMENDATIONS

Several loopholes encouraging water wastage were revealed in this study. They are primarily the result of a lack of control over the use of water by industry and residents. We therefore propose the following recommendations to governmental, municipal, industrial and residential bodies, on water management.








### GOVERNMENT

- 1.) Namibia, having no internal perennial rivers, should strive to develop to full capacity its only infinite water source, the sea. This should start with developing high potential regional water sources thus reducing regional interdependency, i.e. desalination for the coast.
- 2.) The industrial and population carrying capacity of the towns should be investigated and further development planned only within the limits of the water resources. Thus, development should only go where the principal resources are, in this case water.
- 3.) There should be policy on industrial water use. For example, water use should be restricted for identified non-essential uses and a maximum amount available for industry should be determined.
- 4.) There should be a body of inspectors to monitor industrial water use, waste and pollution of our waters.
- 5.) The possibility of erecting a seawater pipeline network for industrial use should be explored. Industry could then be attracted to this with some incentives (e.g. cheaper water).

# Fig.4 Water Consumption for 1991 in Walvis Bay



70

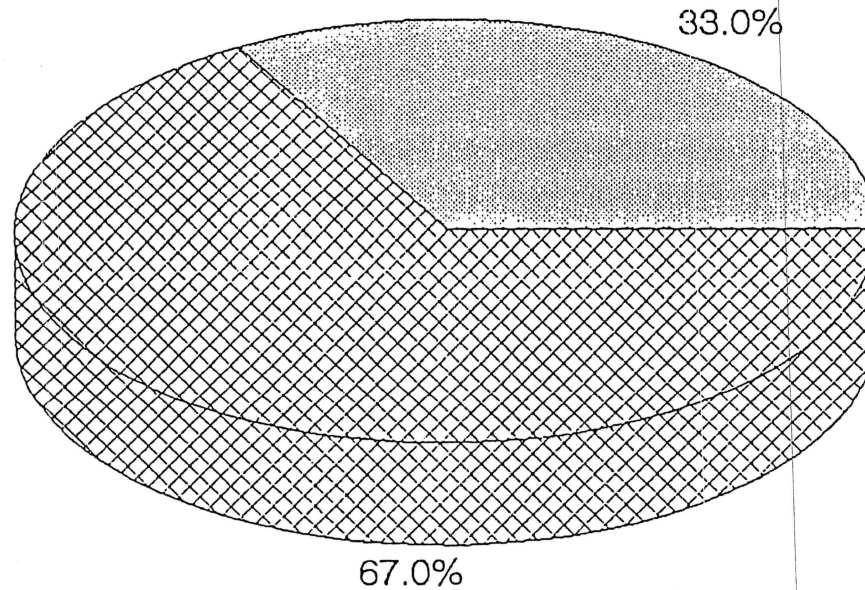
-  Low Income
-  Middle Income
-  High Income
-  Fish Factories
-  Portnet
-  Industrial
-  Others

Total volume of water consumed was 3.817Mm<sup>3</sup>/a

Adapted from Walvis Bay Workshop, 1991.

# Fig.5. Water usage by high income group

High income group consumes 55% of total  
Walvis Bay consumption

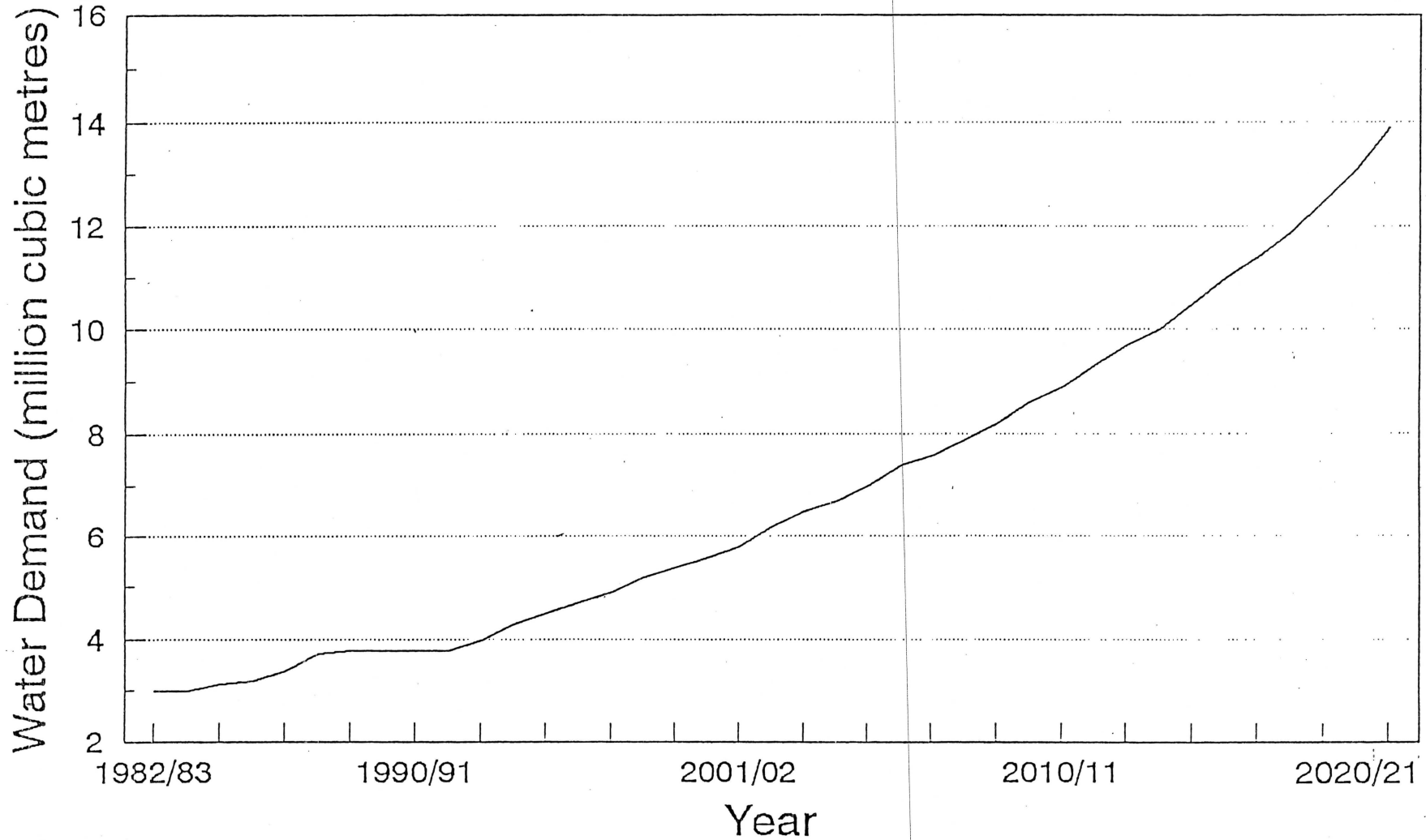


□ Domestic Activities    ▣ Gardens

Home gardens consume 36% of total town consumption

Calculated from Fig.4.

# Fig.6 Water Demand Predictions for Walvis Bay



1982-1991 values are based on consumption data  
1992-2020 values are high demand predictions (see text)

Adapted from SLW JVC 1990b

Table 1: Comparison of yield and costs of potential water supply schemes for West Coast.<sup>1</sup>

	95% assured yield (x10 <sup>6</sup> m <sup>3</sup> /a)	Cost <sup>2</sup> (N\$x10 <sup>6</sup> )
Kuiseb/Gaub Dam	7.80	170.48
Walvis Bay Dune Area	Undetermined	Undetermined
Otjompau Dam	10.22	130.21
ENWC	Sufficient to supplement dam options	330.31
Desalination	30.00	463.60

<sup>1</sup> Cost of meeting water demands in 2020 (estimated at 30 Mm<sup>3</sup>/a) (N\$x10<sup>6</sup>)

By desalination: 463.60

By ENWC + Kuiseb/Gaub Dam: 500.79

By ENWC + Otjompau Dam: 460.52

<sup>1</sup> Calculated from values obtained from SLW JVC 1993e

<sup>2</sup> The cost includes construction, annual maintenance and distribution.

## APPENDIX A

### INTERVIEW OUTLINE (WALVIS BAY)

#### 1 Input

##### 1.1 Sources

**"Where does Walvis Bay get its water?"**

##### 1.1.1 Proportion

**"What proportion comes from each source?"**

##### 1.1.1.1 Kept separate or mixed

**"Is the water from different sources kept separate or mixed?"**

##### 1.1.1.2 Any recycled

**"Is any of Walvis Bay's water recycled or reclaimed?"**

##### 1.1.2 Location

**"Where does the water originate from?"**

##### 1.1.2.1 Boreholes

##### 1.1.2.2 Dams

##### 1.1.3 Transportation from source location

**"How is the water transported from source to Walvis Bay?"**

##### 1.1.3.1 Losses during transportation

**"Are there any losses associated with the water's transportation from its source to Walvis Bay?"**

##### 1.1.4 Sustainability of individual sources

**"How sustainable are the sources tapped by the municipality?"**

##### 1.2 Quality of water (dependent on source?)

**"What is the quality of the water before any treatment and is this dependent on its source?"**

##### 1.2.1 Treatment

**"Is the water used in Walvis Bay treated?"**

##### 1.2.1.1 If yes, method of treatment

**"What is the method of treatment?"**

##### 1.2.1.2 If yes, is all water treated the same

**"Is all the water put through the same treatment process?"**

##### 1.2.2 Is any water recycled or reclaimed (distinguish between 'recycled' and 'reclaimed')

**"How do you treat any water that is recycled or reclaimed?"**

##### 1.3 Storage

**"Is there any storage of water?"**

##### 1.3.1 How is the water stored

**"What storage methods are used?"**

##### 1.3.2 How much is stored at any one time

##### 1.3.2.1 Quantity

**"What is the quantity of water stored?"**

##### 1.3.2.2 How many days supply

**"How many days supply is this?"**

##### 1.3.3 Any losses associated with storage

**"Are there any losses associated with storage?"**

##### 1.3.4 What is the purpose of storage

**"What is the purpose of storing the water?"**



## 2 Output

### 2.1 What are the major users that are being supplied

**"Who and what are the major users being supplied with water?" (offshore ships)**

#### 2.1.1 Partitioning of user groups

**"How does the municipality partition the users into different groups?"**

2.1.1.1 Area or location?

2.1.1.2 Industrial/residential/agricultural

2.1.1.3 Essential/Non-essential

2.1.1.4 Tourism (hotels etc.)

#### 2.1.2 How is the water distributed to these users

**"Is the water distributed to each of these user groups in the same manner?"**

#### 2.1.3 What are the quantities to each of these users?

**"How much water is supplied to each of these groups?"**

#### 2.1.4 How is the water being used?

**"Do you have any idea to what uses each of these groups is putting the water they use?"**

##### 2.1.4.1 Household usage

**"Have there been any studies investigating how a typical household utilises their water?"**

### 2.2 Loss and wastage

#### 2.2.1 How is wastage technically defined

**"What does the municipality consider waste water?"**

#### 2.2.2 Losses due to distribution within Walvis Bay

**"How much water is lost due to the distribution system within Walvis Bay?"**

#### 2.2.3 Losses due to improper or inefficient use by user

**"Do you have a measure of the amount of loss attributable to leakage at the user's end?"**

##### 2.2.3.1 How many swimming pools in Walvis Bay

**"How many swimming pools are there in Walvis Bay?"**

2.2.3.1.1 Municipal

2.2.3.1.2 Residential

2.2.3.1.3 Total surface area

2.2.3.1.4 Mean surface area of each pool

## 3 Management

### 3.1 Policy and distribution of water

#### 3.1.1 Infrastructure

##### 3.1.1.1 Satisfying increased demand by individual users

**"What is your policy for providing additional water infrastructure due to the increased demands of individual users?"**

### 3.2 Conservation

#### 3.2.1 What methods are being used to conserve water within Walvis Bay

**"What methods are being used to conserve water within Walvis Bay?"**

#### 3.2.2 Is there a media campaign to encourage conservation

**"Is there a media campaign to encourage conservation within Walvis Bay?"**

##### 3.2.2.1 Involvement of the municipality

**"Is the municipality involved?"**

- 3.2.2.2 What does it entail
  - "What does it entail?"**
- 3.2.2.3 When was it implemented
  - "When was it implemented?"**
- 3.2.2.4 Who actually controls it
  - "Who actually controls it?"**
  - 3.2.2.4.1 Funding and budget
    - "Who funds it?"**
    - "What is the budget?"**
- 3.2.2.5 Has there been any measurable decrease in water usage as a result of the campaign
  - "Has there been any measurable decrease in water usage and/or loss as a result of the campaign?"**
- 3.2.2.6 Potential for additional conservation
  - "How do you assess the potential for additional water savings through conservation measures?"**
  - 3.2.2.6.1 Using same media program
  - 3.2.2.6.2 Total potential if all users were perfect
- 3.2.3 Any studies conducted on water conservation in Walvis Bay
  - "Have there been any studies conducted on water conservation in Walvis Bay?"**

### 3.3 Costing and pricing

- 3.3.1 What is the cost to the municipality of securing the water it supplies to its users
  - "What is the cost to the municipality of securing the water it supplies to its users?"**
  - 3.3.1.1 Import duties
    - "Do you pay a premium because your water must cross national boundaries?"**
  - 3.3.1.2 How is this determined
    - "How is this cost determined?"**
- 3.3.2 Pricing
  - 3.3.2.1 What are users charged
    - "What is the price you charge your customers for the water?"**
    - 3.3.2.1.1 Is it the same for all users
      - "Is it the same for all users?"**
    - 3.3.2.1.2 How is this price determined
      - "How is this price determined?"**
  - 3.3.2.2 Any subsidies policy
    - "Is there any policy for providing subsidies for certain users?"**
    - 3.3.2.2.1 Offshore ships
      - "Do offshore ships receive subsidized water to encourage them to stop at Walvis Bay?"**
    - 3.3.2.2.2 How does this relate to conservation efforts
      - "How does this subsidy policy relate to any conservation efforts you have?"**
- 3.3.3 Budget
  - "Now I would like to ask you some questions about the overall budget of the water department."**
  - 3.3.3.1 Income to water department
    - "What are all your sources of income?"**
    - 3.3.3.1.1 Taxes
    - 3.3.3.1.2 User fees

Measurements of water consumption in Swakopmund for the month of February 1991, showed a typical distribution among the user groups. The total consumption was 253 210 m<sup>3</sup> and this was distributed amongst six categories of users: (Table 1, SLW JVC 1993).

**Table 1. Total Water Consumption Pattern of Swakopmund**

Type of Consumption	Consumption: Feb. 1991 m <sup>3</sup> /month	Percentage
Public Institutions	14,408	5.7%
Hotels, Old AgeHomes, Flats	24,790	9.8%
Educational Institutions	9,257	3.7%
Industries	9,552	3.8%
Irrigation of Parks	390	0.15%
Domestic Consumption	194,813	76.85%
<b>Total Consumption Feb. 1991</b>	<b>253,210</b>	<b>100%</b>

These data clearly reveal that the main water consumers of Swakopmund are the domestic users. The Swakopmund Municipality estimates the recommended amount of water that can be used in the average Swakopmund home to be 20 m<sup>3</sup> per month for a house with no garden and 60 m<sup>3</sup> for a house with a large garden (e.g 600 m<sup>2</sup> site). This is based upon the assumption that the requirement for an ornamental garden in the desert coastal area is about the equivalent of 2 mm of precipitation per day (Demasius pers. comm. 1993).

Details of the distribution supply between sections of the town (in 1991) were that 11.8% of the total water supplied was consumed by Mondesa, 9.1% by Tamariskia, and the balance of 79.1% by Swakopmund, including the town's industry (SLW JVC 1993).

Figures of the water sales by the Finance Division of the DWA only date back to 1984. Swakopmund has experienced a steady increase in water consumption since 1984/85. During the eight year period, 1984/85 to 1991/92, the average increase in consumption rate was 3.3% per annum (p.a.) whilst the rate of increase for the last year was 2.7% p.a. (SLW JVC 1993).

Water cost is determined by how much it costs to distribute the bulk water (presently N\$ 0.79) and how much it costs the Municipality to purchase the water from the DWA (presently N\$ 0.70). The water consumption bill for a household is then determined by applying staggered rates:

1 m<sup>3</sup> - 30 m<sup>3</sup> at N\$ 1.49/m<sup>3</sup>  
 31 m<sup>3</sup> - 60 m<sup>3</sup> at N\$ 1.67/m<sup>3</sup>  
 61 m<sup>3</sup> - more at N\$ 2.22/m<sup>3</sup>

The management of water distribution in the town is regulated by the Municipality. This is done by metering all water coming into the town and all water going to the different residential areas and water used in households or industries. The semi-recycled effluent water directed to the Municipal gardens is also metered. This semi-recycled effluent is approximately 80% of the water used in Swakopmund.

The total amount of water used per month at the Brewery is 7000 m<sup>3</sup> (Demasius pers. comm. 1993). The water comes directly from the Swartbank Scheme, and is not treated by DWA. This is necessary as chlorides affect the quality of the beer and they quickly erode the stainless steel tanks.

Using a multi million dollar computerized system, the Brewery was able to reduce the amount of water needed to make a litre of beer from the normal international standard of between 6 - 8 litres of water per litre of beer to 5.56 litres of water per litre of beer (Brewery pers. comm. 1993). Seventy percent of the waste water from the brewing process is reused for cleaning the bottles and the pipes transporting the beer in the factory. The beer itself is 97% water.

The Brewery pays the same water tariff rates as Swakopmund residents, which is N\$ 1.49/ℓ of water for the first 30 m<sup>3</sup> of water, N\$ 1.67/ℓ between 31 and 60 m<sup>3</sup>, and N\$ 2.22/ℓ for 61 or more cubic meters.

The Tannery receive its water from the normal Municipal pipes transporting water within the town. The factory uses approximately 800 m<sup>3</sup> of water per month for the cleaning and tanning of hides. All of the water used in the tanning process goes directly into the Municipal sewage system. The factory could save 10% of the total water used through proper management (Tannery pers. comm. 1993).

The Municipality does not have any policies directed towards water conservation, but conservation measures in Swakopmund are carried out by the Wildlife Society of Swakopmund. This includes the water conservation campaign which included water conservation posters and pamphlets. Unfortunately this was unsuccessful, as the projected high increase rate did not decrease (Demasius pers. comm. 1993). The Municipality also suggests that the size of new erven be reduced, so as to reduce the possibility of large gardens being installed. The projected increase in water demand per annum is 3 - 5%, while the projected increase in population of Swakopmund is 4.26% (Demasius pers. comm. 1993).

To have a 3, 4 or 5 star rating, a hotel must provide baths, not showers, for its guests. Baths require more water than showers under normal use. A change in the rating system was recommended as one way to eliminate the need for baths and possibly to save water (H. Rapmund pers. comm. 1993).

## DISCUSSION

Swakopmund faces serious problems in meeting its ever increasing demand for water. Because the KCA could not meet the total demand for Swakopmund and other coastal users, the OSR was introduced to help satisfy this demand. This was meant to be a long term solution with a sustainable yield of 10 Mm<sup>3</sup> p.a. over 20 years or 8 Mm<sup>3</sup> over 25 years. Now the yield averages 4 Mm<sup>3</sup> p.a. (SLW JVC 1993). Due to the possibility of saline water coming into the aquifer brought about by over extraction, the sustainable yield of the aquifer may become drastically reduced. The problem of water shortage now includes the OSR aquifer. More research into the threat of the saline wedge advancing inland via the paleochannels adjacent to the main fresh water bearing channels is needed, before another miscalculation of a similar magnitude is repeated.

Several alternative sources that could supply water to Swakopmund have been proposed. These alternatives include the proposed desalination plant that would supply the Central Namib Region (CNR) and the linking up of Swakopmund to the Swakoppoort Dam (SLW JVC 1993). However cheap the proposed inland water sources might seem, the environmental impact has the potential of being very detrimental. This therefore leaves us with only one feasible alternative; sea water desalination for the CNR.

The allocation time for water to be stored before distribution in Swakopmund is not what it should be at 4 - 5 hours, as the water supply may run low if a reservoir pipe bursts. The possibility of such a disaster does exist and should therefore be addressed by the water distributors.

With the annual water demand fluctuating at 3 - 5% p.a, it has been noted that the increase in water consuming household appliances also increases the water demand. This increase could be due to the increase in living standards, enabling citizens to purchase modern appliances. This has resulted in more and more people using water-consuming appliances such as dish washers and washing machines.

The lack of success of the awareness campaigns shows an inadequate level of public participation in matters that affect the citizens directly, even though it may be a matter of life or death to the town. If people say they are proud of being citizens of Swakopmund, let them show it through their sustainable use of their town's lifeline, water.

Tourism, Swakopmund's local revenue provider, wastes a large volume of water, as a three star quality hotel has to offer a bath, an accessory that uses too much water. It is therefore necessary to re-evaluate the grading system to accommodate water conservation conscious hotels.

## **CONCLUSION**

However serious the water problem proves to be at the coastal towns, especially Swakopmund, the study being conducted on the KCA revealed that water conservation still remains a stale rumour and it is therefore logical to conclude that the water shortage remains a threat to the town's present and future development.

## **RECOMMENDATIONS**

With the potential water shortage crisis becoming more of a reality in the coastal town of Swakopmund, sustainable water usage, including reliable conservation measures, should be carried out. The main users of water in Swakopmund can be divided into domestic and industrial users. They should both be involved in implementing effective conservation measures. There are also recommendations that apply to the local policy makers in the Swakopmund Municipality.

### **RECOMMENDATIONS FOR DOMESTIC USERS:**

- 1.) Buy washing machines that use less water
- 2.) Use indigenous plants with low water demand for gardening.

### **RECOMMENDATIONS FOR INDUSTRIAL USERS:**

- 1.) Try to automate systems using water, so as to cut down on water wastage at the factory.
- 2.) A positive example that could help other factories searching for good examples for water management, is that of the brewery. Here, the reduction of water used to make one litre of beer does not affect the quality of the product, showing that water conservation is possible.

### **RECOMMENDATIONS FOR MUNICIPALITY**

- 1.) Water is still too cheap, therefore tariffs should be raised to help conserve this precious commodity.
- 2.) Water conservation awareness at schools should be increased to promote the importance of water for the sustainability of life.
- 3.) An adequate emergency water supply should be established.
- 4.) The size of new erven should be reduced to avoid the possibility of large gardens being established.
- 5.) Information should be provided to consumers with their accounts, about how much water each uses and what would be an appropriate amount.

### **RECOMMENDATION FOR THE HOTEL ASSOCIATION**

- 1.) The hotel grading system needs to be changed to eliminate the need for baths.
- 2.) A water awareness campaign for hotel guests should be initiated.

## Interview Outline (Swakopmund)

### 1 Input

#### 1.1 Sources

**"Where does Swakopmund get its water?"**

##### 1.1.1 Proportion

**"What proportion comes from each source?"**

1.1.1.1 Kept separate or mixed

**"Is the water from different sources kept separate or mixed?"**

1.1.1.2 Any recycled

**"Is any of Swakopmund's water recycled or reclaimed?"**

##### 1.1.2 Location

**"Where does the water originate from?"**

1.1.2.1 Boreholes

1.1.2.2 Dams

##### 1.1.3 Transportation from source location

**"How is the water transported from source to Swakopmund?"**

1.1.3.1 Losses during transportation

**"Are there any losses associated with the water's transportation from its source to Swakopmund?"**

##### 1.1.4 Sustainability of individual sources

**"How sustainable are the sources tapped by the municipality?"**

#### 1.2 Quality of water (dependent on source?)

**"What is the quality of the water before any treatment and is this dependent on its source?"**

##### 1.2.1 Treatment

**"Is the water used in Swakopmund treated?"**

1.2.1.1 If yes, method of treatment

**"What is the method of treatment?"**

1.2.1.2 If yes, is all water treated the same

**"Is all the water put through the same treatment process?"**

1.2.2 Is any water recycled or reclaimed (distinguish between 'recycled' and 'reclaimed')

**"How do you treat any water that is recycled or reclaimed?"**

#### 1.3 Storage

**"Is there any storage of water?"**

##### 1.3.1 How is the water stored

**"What storage methods are used?"**

##### 1.3.2 How much is stored at any one time

1.3.2.1 Quantity

**"What is the quantity of water stored?"**

- 1.3.2.2 How many days supply  
**"How many days supply is this?"**
- 1.3.3 Any losses associated with storage  
**"Are there any losses associated with storage?"**
- 1.3.4 What is the purpose of storage  
**"What is the purpose of storing the water?"**

## 2 Output

- 2.1 What are the major users that are being supplied  
**"Who and what are the major users being supplied with water?" (Arandis, Rossing, Tannery, Brewery, Hotel Association)**
  - 2.1.1 Partitioning of user groups  
**"How does the municipality partition the users into different groups?"**
    - 2.1.1.1 Area or location
    - 2.1.1.2 Industrial/residential/agricultural
    - 2.1.1.3 Essential/Non-essential
    - 2.1.1.4 Tourism (hotels, etc.)
  - 2.1.2 How is the water distributed to these users  
**"Is the water distributed to each of these user groups in the same manner?"**
  - 2.1.3 What are the quantities to each of these users  
**"How much water is supplied to each of these groups?"**
  - 2.1.4 How is the water being used  
**"Do you have any idea to what uses each of these groups is putting the water they use?"**
    - 2.1.4.1 Household usage  
**"Have there been any studies investigating how a typical household utilizes their water?"**
- 2.2 Loss and wastage
  - 2.2.1 How is wastage technically defined  
**"What does the municipality consider waste water?"**
  - 2.2.2 Losses due to distribution within Swakopmund  
**"How much water is lost due to the distribution system within Swakopmund?"**
  - 2.2.3 Losses due to improper or inefficient use by user  
**"Do you have a measure of the amount of loss attributable to leakage at the user's end?"**
    - 2.2.3.1 How many swimming pools in Swakopmund  
**"How many swimming pools are there in Swakopmund?"**
    - 2.2.3.1 Municipal
    - 2.2.3.1 Residential
    - 2.2.3.1 Total surface area
    - 2.2.3.1 Mean surface area of each pool

## 3 Management

- 3.1 Policy and distribution of water
  - 3.1.1 Infrastructure
    - 3.1.1.1 Satisfying increased demand by individual users  
**"What is your policy for providing additional water infrastructure due to the increased demands of individual users?"**

### 3.2 Conservation

- 3.2.1 What methods are being used to conserve water within Swakopmund
  - "What methods are being used to conserve water within Swakopmund?"**
- 3.2.2 Is there a media campaign to encourage conservation
  - "Is there a media campaign to encourage conservation within Swakopmund?"**
  - 3.2.2.1 Involvement of the municipality
    - "Is the municipality involved?"**
  - 3.2.2.2 What does it entail
    - "What does it entail?"**
  - 3.2.2.3 When was it implemented
    - "When was it implemented?"**
  - 3.2.2.4 Who actually controls it
    - "Who actually controls it?"**
      - 3.2.2.4.1 Funding and budget
        - "Who funds it?"**
        - "What is the budget?"**
  - 3.2.2.5 Has there been any measurable decrease in water usage as a result of the campaign
    - "Has there been any measurable decrease in water usage and/or loss as a result of the campaign?"**
  - 3.2.2.6 Potential for additional conservation
    - "How do you assess the potential for additional water savings through conservation measures?"**
      - 3.2.2.6.1 Using same media program
      - 3.2.2.6.2 Total potential if all users were perfect
- 3.2.3 Any studies conducted on water conservation in Swakopmund
  - "Have there been any studies conducted on water conservation in Swakopmund?"**

### 3.3 Costing and pricing

- 3.3.1 What is the cost to the municipality of securing the water it supplies to its users
  - "What is the cost to the municipality of securing the water it supplies to its users?"**
  - 3.3.1.1 How is this determined
    - "How is this cost determined?"**
- 3.3.2 Pricing
  - 3.3.2.1 What are users charged
    - "What is the price you charge your customers for the water?"**
      - 3.3.2.1.1 Is it the same for all users
        - "Is it the same for all users?"**
      - 3.3.2.1.2 How is this price determined
        - "How is this price determined?"**
  - 3.3.2.2 Any subsidies policy
    - "Is there any policy for providing subsidies for certain users?"**
      - 3.3.2.2.1 How does this relate to conservation efforts
        - "How does this subsidy policy relate to any conservation efforts you have?"**
- 3.3.3 Budget
  - "Now I would like to ask you some questions about the overall budget of the water department."**
  - 3.3.3.1 Income to water department
    - "What are all your sources of income?"**
      - 3.3.3.1.1 Taxes



- 3.3.3.1.2 User fees
- 3.3.3.1.3 Foreign government and NGO donations

If so, "In what?"

3.3.3.2 Expenditures

"What are your total expenditures and what are they spent on exactly?"

"Do you run at a deficit?"

4 Municipality and its relationship with the DWA

4.1 What is the relationship

"What is the relationship between the municipality and the DWA?"

4.1.1 Relative responsibilities

"What are the relative responsibilities of the municipality and the DWA?"

4.2 How do DWA policies influence municipality water policies

"How do DWA policies influence municipality water policies?"

4.2.1 Do they put any constraints

"Do DWA policies ever place constraints on the municipality?"

4.3 Interaction of town council and water department

"How does the mayor and town council influence water development decisions?"

5 Future Plans

5.1 Demographics

5.1.1 Area serviced

"What is the exact area serviced by the Swakopmund water department?"

5.1.2 Current population

"What is the population of the area serviced by the municipality?"

5.1.3 Rate of growth

"What is the projected rate of population growth?"

5.2 Projected change in water demand

"What is the projected change in future water demand

5.2.1 Proposed water development schemes to satisfy this demand

"Proposed water development schemes to satisfy this demand?"

5.2.1.1 Desalination

5.2.1.2 Reclamation

5.2.1.3 Recycling

5.2.1.4 Use of Antarctic icebergs

5.2.1.5 Proposed sources from other catchments

6 Opinions

6.1 Who does he think should receive the information we are compiling (awareness campaign)

"Who do you think should receive the information we are compiling?" (schools, tourists, residents, farmers, local, regional or national government)

6.1.1 How should this information be disseminated

"Do you have any ideas on how this information can be disseminated?"

6.2 Off the record - What efforts should the municipality make to best meet the growing demands of the city's water users

"Off the record - What efforts do you think the municipality should make to best meet the growing demands of the city's water users?"



## Chapter 7 - WATER USE AT ROSSING URANIUM MINE by Graham Jöhr

### ABSTRACT

Water use by the largest mine to have utilized water from the Kuiseb Catchment Area, Rössing Uranium Limited, is the object of this study. In this chapter, emphasis is placed on the mine's primary sources of water and the ways water partitioning is prioritized. With the increasing awareness of the area's inability to supply adequate amounts of water indefinitely, Rössing has launched a conservation effort aimed at reducing its use of fresh water. The risks involved, such as seepage of radioactively contaminated water and the threat this may hold for the Namibian environment, is contrasted with the effectiveness of this mode of water conservation.

### INTRODUCTION

Mining is the most important foreign exchange earner in Namibia, and contributes the largest percentage (29.4 %) to the Gross Domestic Product (GDP) (SLW JVC 1993a). It follows that this industry will have the most impact on the economy in terms of the investments made in such a venture by either shareholders or clients, and also, possibly, on the environment - due to the size of such an operation.

Namibia has several mines within its borders, but the most controversial is that of Rössing Uranium Limited. The mine is situated about 70 km east-north-east of Swakopmund, in the heartland of the Namib Desert.

This site features the largest known ore deposit of its kind in the world (RUL 1993). The deposit is found in its unrefined form as  $\beta$ -uranophane crystals.

### ROSSING URANIUM LIMITED - THE MINE

The discovery of the ore deposit by Captain Peter Louw, a mineral prospector working in the Namib Desert, dates back to the early 1920's. He attempted to draw the interest of several mining companies until, in the 1960's, a subsidiary of the Rio Tinto Zinc (RTZ) Corporation took up the task of geological and geo-physical prospecting by drilling, surveys and evaluation. Planning and design of the mine was started in 1973 and in early 1978 the plant was in full production.

Modern mines, such as the one at Rössing, demand sophisticated technology and therefore a huge capital investment. Due to the enormous costs involved in establishing such a mine, the RTZ corporation holds 41.35 % of Rössing's equity, and the remainder is invested in private holdings.

The town of Arandis was built as an industrial housing project for the employees, migratory and resident, of Rössing. Although officially under the then Damara Government as the controlling body, Rössing provided all the finance to run the town and the mine and therefore had great influence in the administration. The town has, since independence, been handed over to the Namibian Government, although Rössing still pays for most of the amenities used by the citizens.

This chapter addresses several aspects of water use by Rössing: the fundamental water use patterns of the mine, how water usage is partitioned among the primary users and, most importantly, the water conservation efforts being undertaken and the actions to ensure the effectiveness of these conservation attempts.

## MATERIALS AND METHODS

Interviews with the mine's chief tailing metallurgist, Mr Buzzy Kloot and other water management executives provided much of the information gathered (Appendix A for questionnaire).

An on-site visit to explore the various stage of the mining process was also part of observational data gathering. A literature survey was made to supplement and substantiate data from the interviews. This literature came from the libraries of the Desert Ecological Research Unit and the Department of Water Affairs within the Ministry of Agriculture, Water and Rural Development as well as from the mine's public relations division.

## RESULTS

### WATER

The water to the mine is supplied at standard commercial rates. This means that the DWA charges Rössing the full cost of basic transportation and distribution.

In terms of the DWA-Rössing agreement, Rössing receives a monthly allocation of 22,000 m<sup>3</sup> per day (7.92 Mm<sup>3</sup> per annum) (SLW JVC 1993b). Rössing has, in the past, contravened this agreement, but no persecutive steps have been taken against the mine (Kloot pers. comm. 1994).

Today, the mine consumes an average volume of 8,200 m<sup>3</sup> per day. This is divided into 1,200 m<sup>3</sup> for dust suppression within the open pit and 7,000 m<sup>3</sup> for in-plant operations. The latter figure includes 3,000 m<sup>3</sup> for entrainment. Entrainment refers to the entrapment of water within waste products produced by any process in the mining operation. The main losses are by means of evaporation, 2,700 m<sup>3</sup> and road spraying, 1,300 m<sup>3</sup>.

In its effort to reduce water usage, the company identified evaporative losses in their water usage balance (Fig. 1) as the most efficient area on which to focus their conservation program.

They reduced the evaporative rate from 28,000 m<sup>3</sup>/day to 5,900 m<sup>3</sup>/d by 1993; this represents a cut of 25 % of the total losses within a 2 year period. Recycling proved successful as well, leading to a decrease in fresh water usage of 70 % during the period 1983 - 1993 (Fig. 2).

### ROLE OF WATER

The mine is supplied with water from the Department of Water Affairs' Swakopmund Terminal Reservoir (STR), about 5 km outside Swakopmund. The set-up is illustrated in Figs. 3.1 to 3.3.

The correlation between the production capacity and water usage on the mine is given as a doubling in the production output and will demand a 50 % increase in water usage within the whole process (Fig. 2). The drop in water usage after 1991, may be attributed to the decline in the production output of the plant. This decline was the consequence of the negative change in the uranium market with the large scale dumping of low grade uranium from the former Eastern Block (CIS) countries on the world market, and the company's difficulty in securing contracts during this period.

Rössing does not, according to the mine's tailings metallurgist, make use of any fresh water from the Kuiseb River. This statement is, however, contrary to information provided by the DWA.

According to operators at the STR, confirmed by the Department of Water Affairs' Director of Research and Investigations, Mr Piet Heyns, water from the Kuiseb and the Omdel scheme is mixed at the Swakopmund Terminal Reservoir, chlorinated and transported via pipeline to Rössing's three 20,000 m<sup>3</sup>-Terminal Reservoirs.

According to the mine's representative (Kloot pers. comm. 1994), their only source of water is from the Omdel Storage Reservoir (OSR) and the Omaruru delta dam. It was claimed that during the last two years water from the Kuiseb Scheme was used only once, at the request of the DWA, while the Omdel pipeline was under maintenance.

The Swakopmund- Rössing pipeline - about 75 cm diameter x 90 km - ferries the water at a rate of 467 litres/second to the three 20,000 m<sup>3</sup> Rössing Terminal Reservoirs (RTR). There are 1,800 m<sup>3</sup> balancing reservoirs at each of the three booster stations on the pipeline between the STR and the RTR's, with individual capacities as indicated in Fig. 3.3. Arandis town also withdraws from one of these reservoirs.

#### PRO-ACTIVE PROBLEM SOLVING

The mine is committed to a pro-active approach to problem solving, i.e trying to find a solution to a problem that may pose a danger to the whole operation, or any part thereof, in the future. This prompted the mine to cut back on its fresh water usage in the late 1970's and early 1980's (Fig. 2). The reason for this was the realization that at the previous water consumption rates the DWA would eventually be forced to mandate cuts in usage.

In addition, large savings could be realized through reducing fresh water usage.

In terms of the usage of water in the various processes, water is partitioned as follows:

- Recycled water is used in conjunction with a road binding agent (Calcium Lignosulfonate, a by-product of the paper industry) for road-spraying.
- Water from the Khan River is drawn from a fountain within the open pit and is used in dust suppression in the area.
- Fresh water is used in the mining process itself, mainly for washing and transportation of the ore.

#### TAILINGS DAMS

The tailings are the slurry left over after the clear uranium 'pregnant' solution has been decanted. This remainder is transported, via pipeline, to the tailings dam just above the plant.

Initially, the present dams, with a surface area of 700 ha ( $\pm 7$  km<sup>2</sup>), were designed as a single circular pond. The company, in 1980, took up the initiative to reduce the wetted surface area, presently 350 ha ( $\pm 3.5$  km<sup>2</sup>), thereby reducing the area exposed to solar radiation and consequently, evaporation.

The volume of the tailings, as reported in October 1979 in the Rössing Magazine (Dropkin 1992), amounted to about 80,000 m<sup>3</sup> liquid waste and 40,000 tonnes of solid waste per day. This amounts to approximately 13 million tonnes/annum.

To reduce this, Rössing also acquired a N\$ 500,000 digger used to reduce the total exposed area of the decantation channels by increasing the depth. They also redesigned and restructured the single circular pond into smaller paddies, thereby reducing the overall exposed wetted surface. The tailings are now pumped into these paddies, the sludge settles to the bottom and the water decants via the decantation channels into a final pond, where it is allowed to percolate into an underground aquifer. Here the water is stored and, when needed, pumped back to the plant for re-use.

The dams are located on a tributary of the Khan River, Pinnacle Gorge. Although a seepage dam, with affirmed capture of 99 % of seepage, has been built just below the confluence of the two branches of the Gorge, the threat of seepage nevertheless remains a consideration. Any seepage not only poses a threat to the long-term health of the workers, but also to the safety and quality of the underground water of the nearby Khan River, a tributary of the Swakop River. According to the DWA (Heyns pers. comm. 1994), the Khan River's water is regularly monitored and, to date, no levels of pollution have been found.

Rössing acknowledges the present threat of a spillage, yet vehemently denies the occurrence of a spillage in the past. This is, however, contrary to a report published in 1992 (Dropkin 1992) which, based on confidential company documents, alleges the occurrence of a big leak in 1980. According to this report, the radioactive liquid that leaked from the tailings dam had an estimated volume eight times that of the Church Rock, New Mexico leak, with a volume of  $95 \times 10^6$  gallons of liquid ( $\pm 359,614.045 \text{ m}^3$  liquid waste). This mass has not been recovered and "...remains as a permanent threat to the Namibian environment" (Dropkin 1992).

The mine also has plans to "...upgrade the existing tailings dam infrastructure..." (Kloot pers. comm. 1994) by a lump sum investment of N\$ 3 million. The purpose being to "... reduce the risk of seepage into Pinnacle Gorge" (Kloot pers. comm. 1994).

#### ARANDIS

The town of Arandis also draws its water from one of the Rössing Terminal Reservoirs. The volume used, when last recorded in 1993, amounted to  $0.623 \text{ Mm}^3/\text{a}$  (SLW JVC 1993b).

The Arandis to Rössing water demand ratio amounts to 0.21 : 1 This means for every  $1 \text{ m}^3$  of water that Rössing consumes, Arandis uses only  $0.21 \text{ m}^3$ .

#### CONSERVATION

Water conservation has been the primary consideration in prompting the company to launch its environmental protection and preservation campaign.

As part of these efforts, the mine has contracted a consulting firm from South Africa to assist in the assessment of conservation potential. A meeting involving the delegation of engineers from the consulting firm and the mine's water management team is convened every two months. Based on figures supplied by Rössing, they are able to make recommendations on where cut-backs in fresh water usage may be possible.

Conservation directed at the employees is partially contained within every employment contract. The mine allows a monthly amount of  $\pm 100 \text{ m}^3$  of water depending on the employee's grade. Some of the employees, especially those in executive posts, are subsidized with cash rather than free water.

Water savings are not a priority with those employees who receive the water, as they would be disadvantaged if they do not use all - or at least as much of this water as possible.

Rössing has recently attempted to switch to the same cash allowance provided to upper level management for all its employees. However, the majority of the employees are members of the Namibian Mine Worker's Union, and negotiations on every aspect of the employment contract have to be successful before any changes can be made. Rössing maintains that this is the reason for the delay in bringing about this change.

Lack of awareness was given as the major reason for high fresh water consumption rates, especially in the initial stages of production: 1978 - 81.

From data made available during an audiovisual presentation, Rössing, in 1976, used 14 Mm<sup>3</sup> per annum compared to Swakopmund's 1 Mm<sup>3</sup> per annum. One can also attribute this high consumption to the construction of both the mine's infrastructure and the town of Arandis. Misuse of water may have been attributable to the ignorance of sustainable water use and the frontier mentality - the endless resource irrespective of consequence - approach to support this development.

#### FUTURE PLANS

The company relies on long-term contracts to determine its production. This demand-supply equilibrium is the factor determining the rate of production and ultimately the rate of water consumption within the process. Due to the absence of a suitable market, Rössing reduced its work week to production rate relation from a 50 % capacity 7-day week to a 70 % capacity 5-day week.

They secured a drop in the water use as fewer employees were on call over the weekends and therefore less water was being used in the bathrooms and other staff facilities. Any increase in demand for uranium will result in increased production at Rössing and, consequently, increased use of water. However, no significant increase is expected by Rössing in the near future.

#### DESALINATION

"Planning and constructing our own desalination plant may not be as remote a possibility as may be perceived." (Kloot pers. comm. 1994) The estimated capital investment in the project amounts to N\$ 4 million. The feasibility of the desalination project is still under investigation, but that the plant will have to pay for itself in the long-term, is inevitable. Considering the immediate threat of exhaustion of the sub-terranean aquifer system that the mine is drawing on at present, this may be an unavoidable expense.

#### ALTERNATIVE TECHNOLOGY

On the question of whether the mine has explored the opportunity of employing technology that might either reduce water consumption or fulfil the same function as water in the entire absence of water, Mr Kloot said that, judging by the numerous enquiries and visits by other desert mining companies, it can be said that Rössing is a leader in the field of Desert Mining Technology

We were informed that the mine has had a recent visit from a delegation of top executives from an Australian Diamond Mining company - seated in the vast Australian midland desert - in search of technology and methods to make the desert mining operation efficient and to minimize environmental impact when mining ceases.

#### DISCUSSION

The main point of controversy surrounding water and Rössing Mine, in our point of view, is that of the company's source of water. According to the operators at the DWA's reservoir outside Swakopmund, the water they channel to the destinations of Swakopmund and Rössing, originates from two sources, the Swartbank Abstraction Scheme in the Kuiseb River and the Omdel Storage Reservoirs. The latter is the storage site of the extracted water from the Omaruru delta boreholes. Contrariwise, the water engineer at the mine stated that no water from the Kuiseb River has been used at Rössing for the past two years. Whether this was a quantitative denial, or merely a comparative reply, necessitates further investigation.

The other controversy, that surrounding the tailings dams, needs yet to be resolved. The existence of seepage into the underground tributaries and sub-tributaries of the ephemeral river must not be overlooked.

The report by Dropkin & Clark (1992) is adamant that the leakage from the mine back in 1980 is very suspicious. According to the authors, Rössing claimed that they are sure no water from the tailings dam flows off the mine property to pollute the water systems of the Khan River. According to July 1985 documents that the authors had researched, no evidence could be found of monitoring the Thorium ( $^{230}\text{Th}$ ) levels, one of the key radionuclides in the tailings.

Protection of groundwater quality is another major concern. In 1980 the total dissolved solid (tds) levels of the drinking water were measured at 642 mg/l, Canadian standard: 500 mg/l. In July 1985, tds levels were measured at the boreholes and typically found to be between 10,000 mg/l and 15,000 mg/l. Rössing claims, however, that the tds levels of the underground water of the Khan river has always been this high.

Rössing did make an attempt to redress their overuse of the fresh water in the past by launching a recycling effort. This has been successful, to some extent, but additional measures should be investigated.

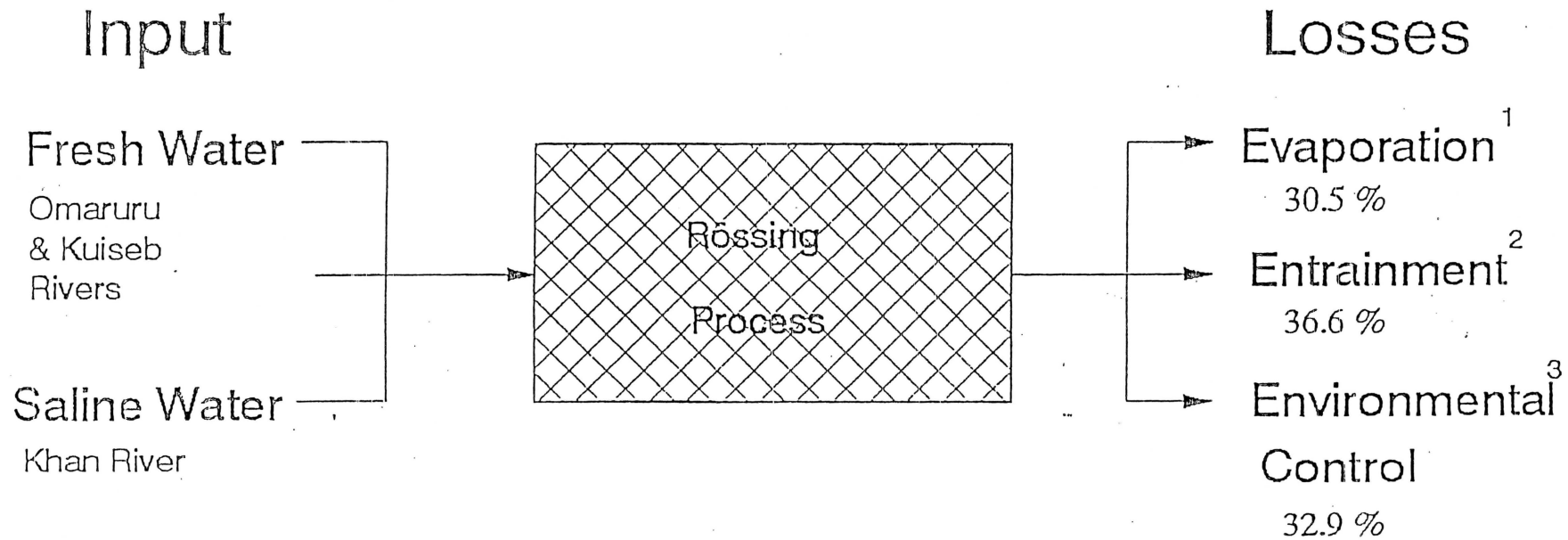
## RECOMMENDATIONS

Several department-specific recommendations can be made. They are:

- 1.) Intensified and on-going monitoring of the radioactive levels of the tailings, by the metallurgical division of the mine, especially in the post-leaching stage of the process.
- 2.) Water quality control, by the Environmental Control officers, of water withdrawn from the Khan aquifer, especially where abstraction within the open pit is taking place.
- 3.) Stricter control by the Department of Water Affairs of water volumes used on the mine, to ensure compliance with agreement(s). If necessary, Rössing should negotiate with the DWA on increasing the water quota, with detailed demands outlined and the purposes for which the water is to be used.
- 4.) Attempts should be made to speed up negotiations between the NMWU and the company to secure the transition from the water subsidy to the allowance scheme. Such allowances should be separate and in addition to the employee's contract.
- 6.) The desalination option for the entire process should be vigorously explored by the mine's water engineers.



# Fig. 1: Rössing Water Balance



<sup>1</sup> from road spraying, dust suppression, and exposed surfaces of tailings dams

<sup>2</sup> waste disposal of tailings

<sup>3</sup> dust suppression and road spraying

Source: Modified from Kloot B, pers comm. - audio visual material

# Rössing Uranium Limited

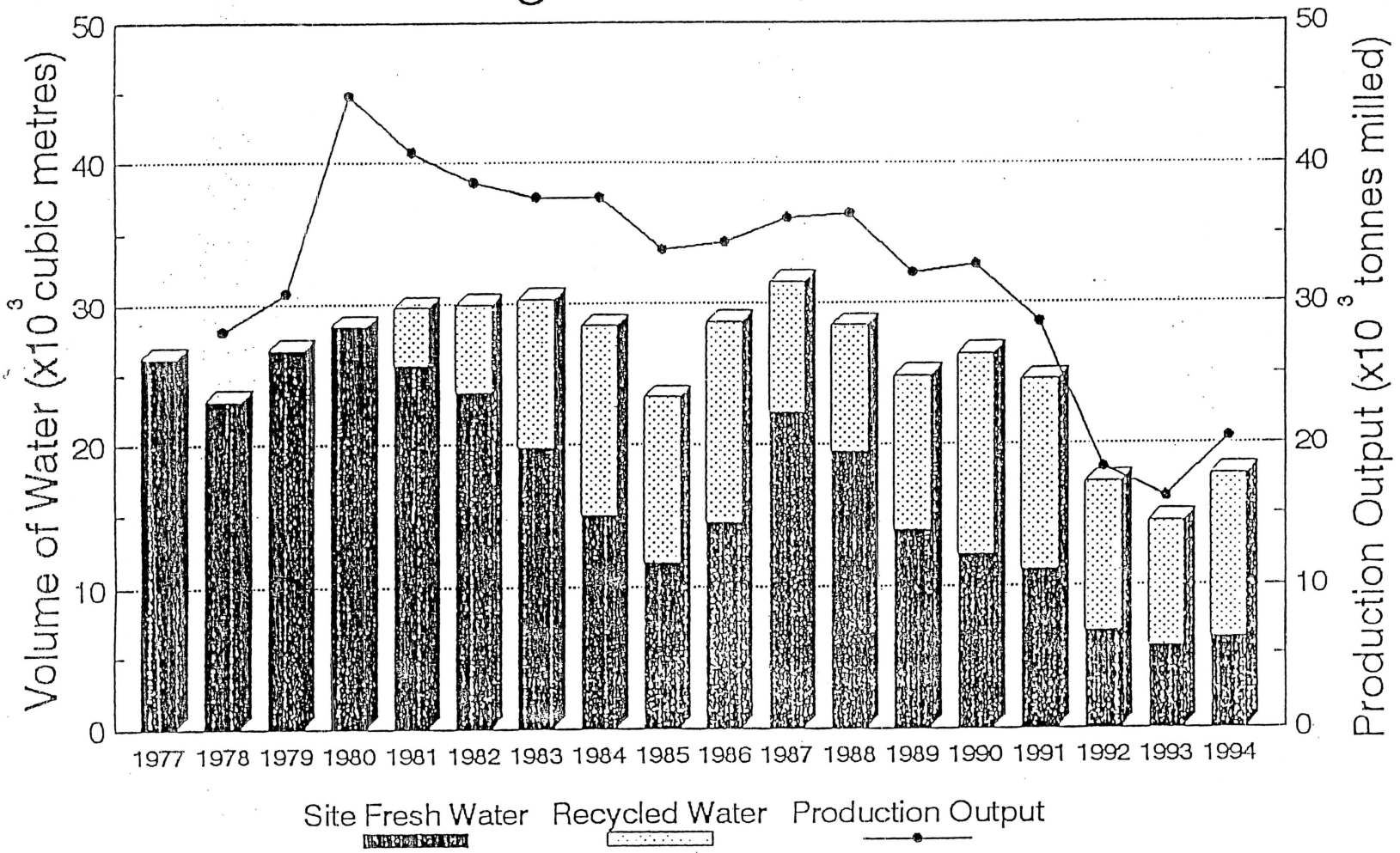


Fig. 2: Fresh and Recycled Water Use compared to Production Output

Source: Klot B, pers. comm (Audio-visual material)

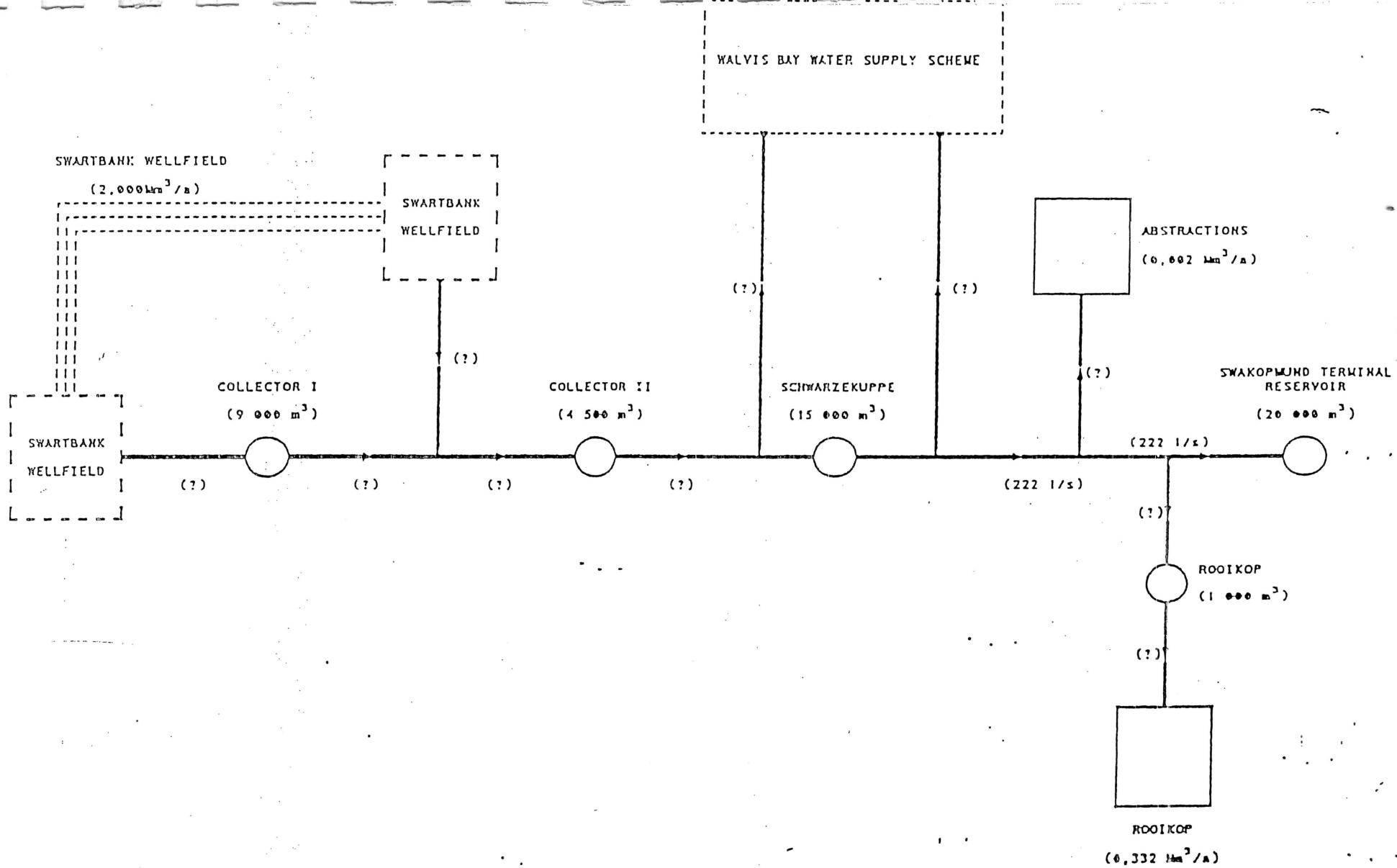


Fig. 3.1: SWARTBANK - SWAKOPMUND...  
REGIONAL WATER SUPPLY  
INFRASTRUCTURE

Source: SLW JVC, 1993b. Vol 6: R11

97

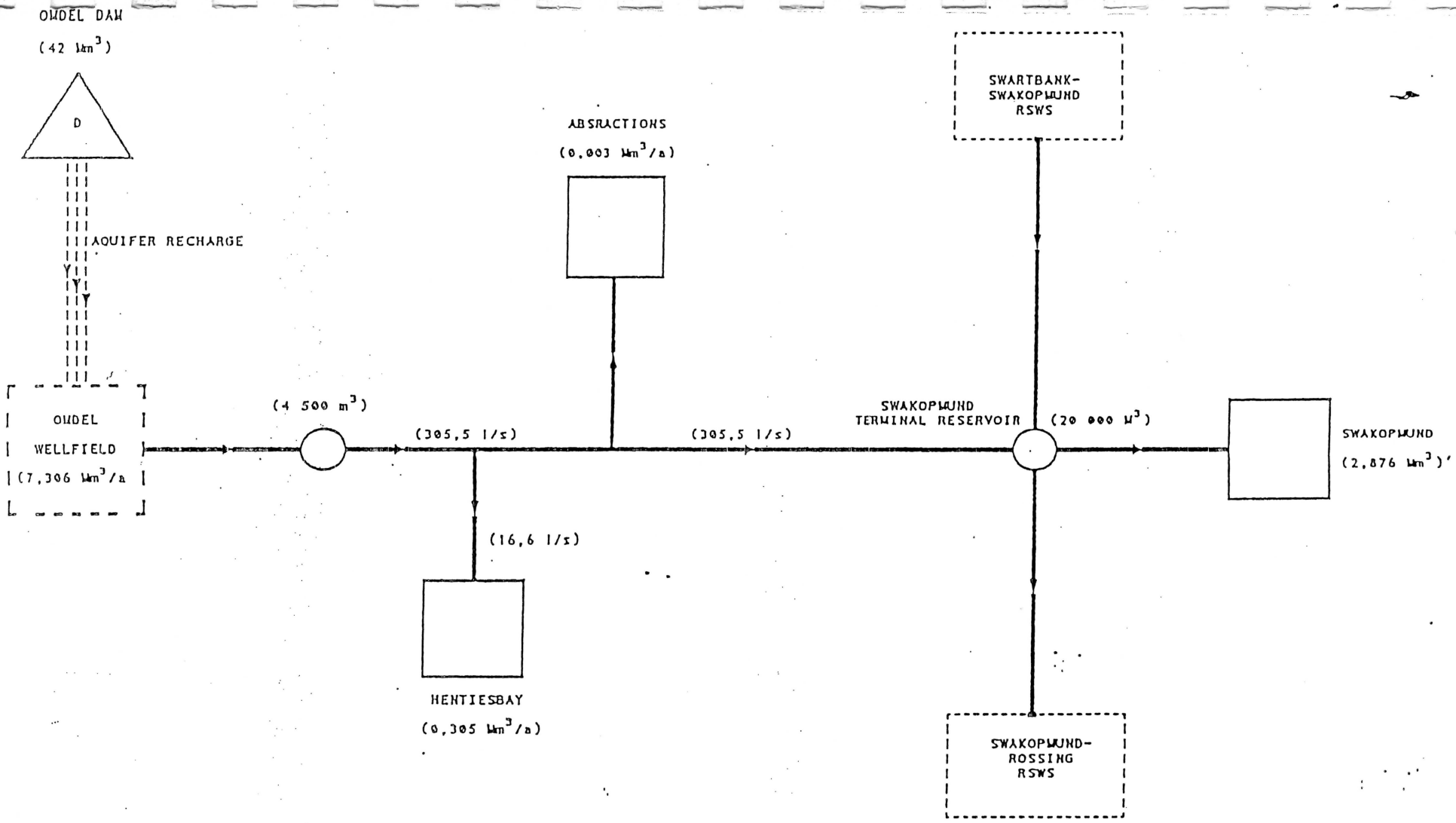


FIG. 3.2: Omdel - Swakopmund  
 Regional Water Supply  
 Infrastructure

Source: SLW JVC. 1993b. Vol 6: R12

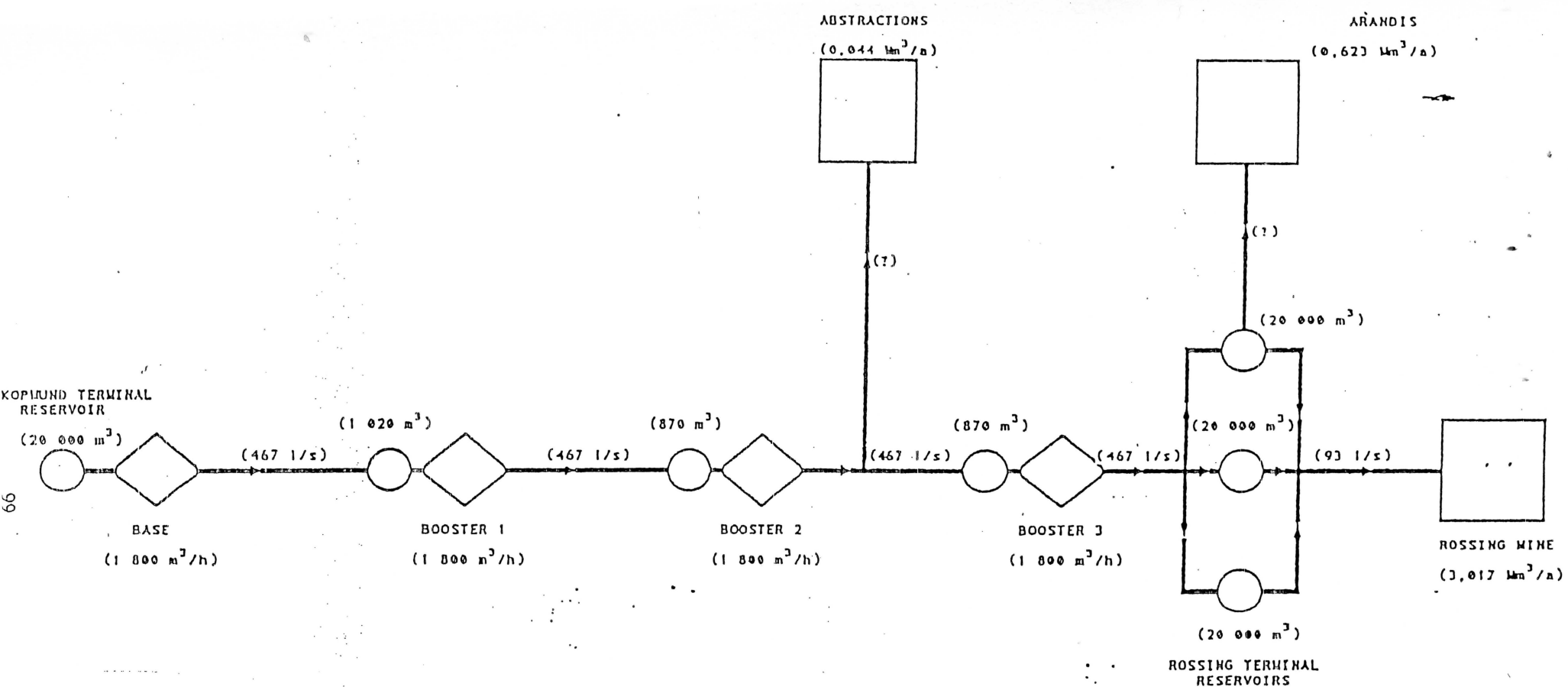


Fig. 3.3: SWAKOPMUND - ROSSING REGIONAL WATER SUPPLY INFRASTRUCTURE

Source: SLW/JVC. 1993b. Vol 6: R13

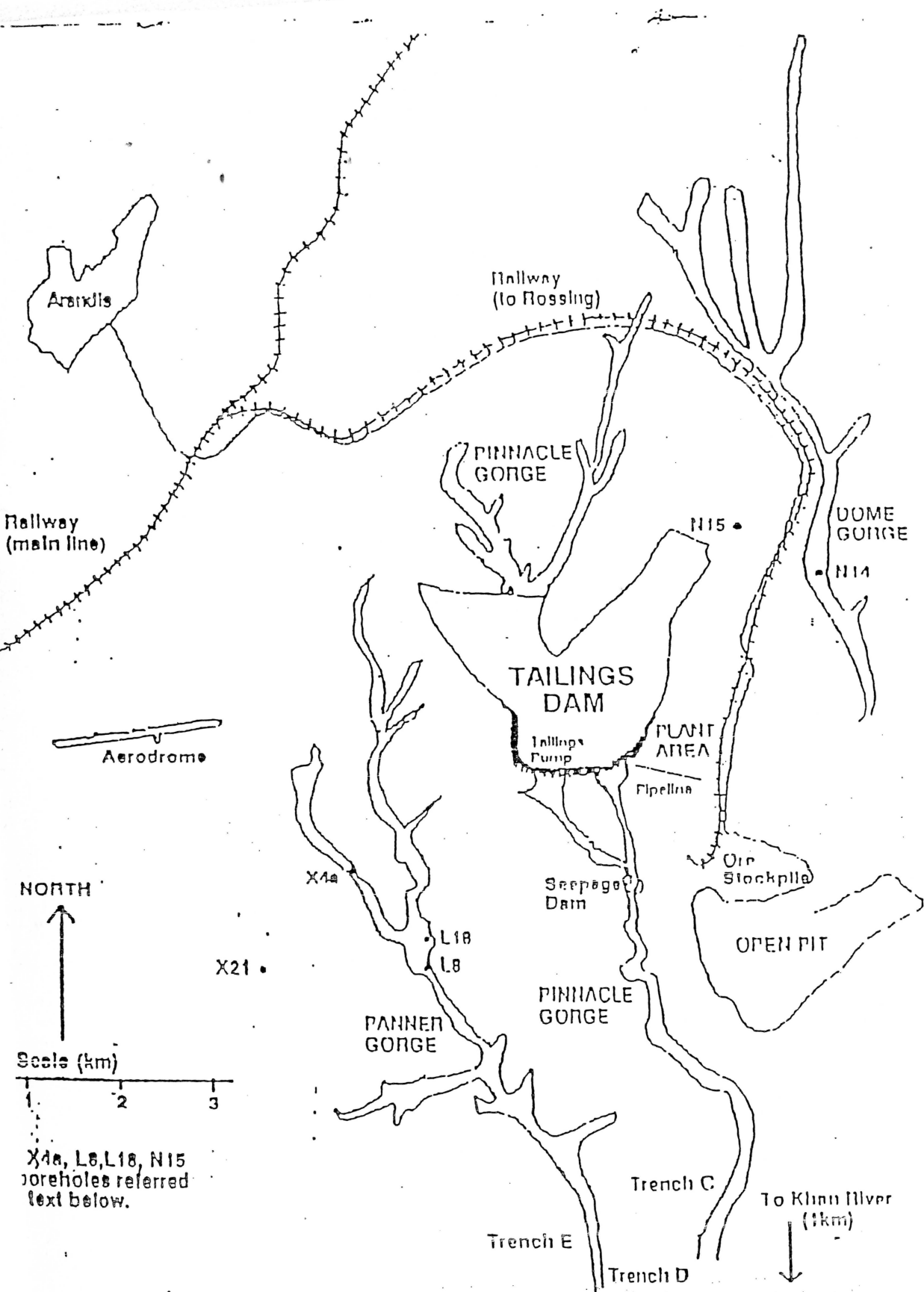


Fig. 4: SITE LAYOUT OF THE TAILINGS DISPOSAL DAMS AT ROSSING URANIUM MINE

Source: Drophin & Clark, 1992: 109

## APPENDIX A

### RÖSSING URANIUM LTD QUESTIONNAIRE

#### INPUT - What constitutes Rössing's principal water source?

- Is this one source or the combination of water from several?
- If more than one source, what are the proportional contributions of each source?
- How does the water quality compare i.t.o salinity?
- Is any part of the water treated; as may be required by a specific part of the process?
- If so, what is the volume/percentage treated?
- Are there any specific treatment process demands water in itself?; chemicals that need to be diluted prior to addition to the water to be treated.
- Do you consider recycling or re-use of all or part of the water?
- Is the company subsidized i.t.o. water use?

#### TRANSPORT

- Transport mainly by gravitation feed-pipeline?

#### LOSSES

&

#### WASTAGE

- Technically, how would you define wastage?
- Are there any losses during either the transportation to or storage at the site where water is needed?
- What measures are being taken to reduce the risk of loss through pipe breakages? e.g. strict control at beginning- and end-metering points

#### STORAGE

- What type of storage facilities do you have?
- Are the design(s) for these storage facilities solely based on projected demand or strictly according to DWA specifications?
- What are their capacities?
- How often are these refilled?
- How does the discharge rate from and the recharge rate to these facilities compare?
- For what period of time is the water stored?
- Do you provide for a buffer quantity; e.g. in time of pipe breakages or water supply malfunctions, to keep the process going?
- Do you have a particular system of partitioning of water into the different processes where it may be needed?

#### CONSERVATION & POLICY

- Policy measures for conservation? What are these?
- How do you go about assessing the potential for water conservation?
- What efforts have been made to see where water conservation measures can be increased?

(Ref. consultants contracted to investigate conservation potential during any stage of the process, suggestion boxes to make the middle and top management aware of root level accidental losses, etc.)

- Elaborate on  $\pm 100 \text{ m}^3/\text{month}$  free water volume allowance to executive grade employees.
- Subsidies to employees; How is the system operated?
- Comment on mere allowance payable to employees and them being responsible for their own account, payable to the Municipality of Swakopmund?

FUTURE  
PROSPECTS

- Feasibility of constructing an own desalination plant?
- Will this be cost effective in the long run?
- Comment on water conservation in view of subsidies to employees? (Ref. "Don't pay - Don't save" attitude)
- Water consumption rate since establishment of plant?
- Increased water consumption; esp. during initial stages of establishment. Only for construction period or what other reasons may be provided?
- In light of present increased water extraction rate, what has Rössing, for its part, considered doing to ensure sustainable use of water?
- Has Rössing considered making use of water from the Khan river? If so, to what uses is this water being applied?  
If not, why is this not possible?
- Contribution to GNP & GDP of country?
- Do you have data available?
- How has the change in the world market affected production, in general, and water consumption, in particular?
- Does the DWA place any constraints on the amount and way water is used?
- What does your gross expenditure for water per month/per annum amount to?
- Whom do you pay it to?
- What happens to the water that is used in, for instance the washing of the ore, etc
- What are the possibility for water from this facility to reach the underground sources in a polluted form?
- Does the company have any short-, medium- or long-term prospects i.t.o. expanding the mining operation or any part thereof?



## Chapter 8 - FUTURE DEVELOPMENT

By Graham Jöhr

### ABSTRACT

In this paper the discussion is based on the envisaged effects of proposed future development plans on water demand within the Kuiseb Catchment Area (KCA). I look at the short- and long-term benefits and adversities of progress in the form of the discovery of oil and the building of the Donkersan Dam. Suggestions are made which aim to highlight the identification of alternative solutions to the water shortage such as effluent recycling, reclamation and desalination. I also outline the importance of civil participation in planning and decision making. This may ensure success of any conservation strategies or awareness campaigns.

### INTRODUCTION

Development can either be positive or negative in terms of the impact it may have on the environment where this development is planned. This is certainly no different in the case of the Kuiseb Catchment Area (KCA) where several new developments may transpire (SLW JVC 1993d). Among these are the proposed building of a dam in the upper KCA, the expansion of Walvis Bay and the construction work accompanying the eventual discovery of oil, which is still in its exploration phases. Therefore, in view of the lack of awareness of water conservation in an already overexploited environment, in both the KCA and the rest of the country, the expected repercussions could certainly be alarming if not managed properly.

The water shortage that the country as a whole is experiencing now, is related to the rapidly increasing demand (SLW JVC 1993b) and the efforts to meet these demands - of both growing rural and urban communities. Yet, the explosion in the population across Namibia poses a further challenge as overuse and lack of consideration of long-term effects are aggravating the problem. Pondering on the future effects - as is attempted in this chapter - will lay the groundwork for productive and safe development.

In this chapter, which seeks to explore the foreseeable aftermaths of many of the proposed developments in the area, the following issues will be discussed:

- The consequences of reintegration of Walvis Bay into Namibia on February 28th, 1994;
- The building of dams in the area in the near future; and
- The oil exploration along the coast and the impact that its eventual discovery will have on the two coastal towns of Walvis Bay and Swakopmund.

Emphasis will be placed on the expected growth in population and industry and how this will affect the water situation in the entire KCA, in general, and the areas of development in particular. Suggestions will focus on how to find alternative sources of water to supply the increasing demand. Consideration will be given to specific solutions proposed, including expansion of existing infrastructure, desalination, water reclamation and recycling, the control of evaporation and role of community participation (especially in conservation efforts).

## THE POPULATION GROWTH - WATER DEMAND LINK

Water is the most important consideration where settlement of people and/or animals is envisaged. Thus, where there is a growth in population, one would expect the water demand to increase at least proportionally. Looking towards the growth of the entire country, figures - both projected and past - show population growth of 5.50 % for urban and 1.97 % for rural areas (SLW JVC 1993b).

Two of the four major towns on the coast of Namibia, Swakopmund and Walvis Bay, are significant in the way they consume the water of the Kuiseb. Not only does Walvis Bay have the lowest population growth rate - about 2.7 % - in comparison to Swakopmund (4.26 %), but also the lowest projected figure for water demand, 4.0 % (2005 - 2020) (SLW JVC 1993b) on the coast. This figure also provides for the increasing trend of urbanization to and the emigration from the town. This low growth rate is attributable to the political situation of Walvis Bay's past administrator, South-Africa. The sanctions imposed against the country triggered a severe recession which has been one of the reasons for reluctance of investors and people who manage these investments to settle there.

This fact should, however, not mask the low rates Walvis Bay citizens pay for their water: only N\$ 0,48 for the first 30 m<sup>3</sup>, whereas Swakopmund residents (growth rate: 4.26 %) pay about N\$ 1.43 for the same initial volume (Demasius 1991, Demasius 1992). It is worth noting, however, that these tariffs are still below the actual cost of supplying the water, at N\$ 1,32 (Walvis Bay) and N\$ 1,49 (Swakopmund) (Demasius pers. comm. 1993, Brümmer pers. comm. 1993).

### SOCIO-ECONOMIC LEVELS

Mean figures on water demand from the DWA report (SLW JVC 1993b) revealed the following:

- The water demands of Walvis Bay, Swakopmund and Windhoek are of particular interest in that they clearly outline the usage patterns among the economic classes of the urban centres (Fig. 1).
- From these figures it can be seen that the water consumption of the high income group of Windhoek exceeds the water consumption of the high income groups of Walvis Bay-Swakopmund by an amount just below 110 litres/capita/day. This raises the question as to what this water is being used for.
- The DWA demand criteria for planning purposes (indicated by figures in parentheses) is being greatly exceeded by actual usage of the different groups, especially among the high and middle income individuals (Table 1). A correlation between socio-economic levels and water use is clearly distinguishable.

Table 1 - COMPARATIVE WATER DEMAND AND POPULATION STATISTICS FOR THE TOWNS AS INDICATED

	Walvis Bay		Swakopmund		Windhoek	
	Pop'n	Water Demand (l/c/d)	Pop'n	Water Demand (l/c/d)	Pop'n	Water Demand (l/c/d)
Squatters	-	-	4,100	25	12,600	25
Low Income (60)	10,600	65	12,420	85	92,600	70
Middle Income (150)	6,797	150	4,285	207	18,200	200
High Income (400)	11,598	500	8,195	508	33,600	615
Total	??		??		??	

Source: SLW JVC, 1993b. Vol 3: pp 3/10 - 3/17  
l/c/d = litres per capita per day

In these usage patterns, it is apparent that socio-economic status is the determinant in the rate of consumption and especially high rates of consumption are noticeable among the affluent part(s) of the community. These people can afford to have big gardens and large entertainment areas for the aesthetic enhancement of their erven and are willing to use large amounts of water to sustain these. The lower income groups, however, are at a disadvantage in that they cannot afford the water rates or other amenities of the more affluent.

Expectations, in terms of water demand, are also based on the increased socio-economic level of the entire population. With increased population affluence, the demand for the addition of especially water demanding technology will increase in many households. Among these are household appliances such as dishwashers, washing machines, and other large consumers of fresh water. Other luxuries may include swimming pools and large gardens. These two in particular may be the root of the increase - or present high usage levels - among these high income groups.

In Windhoek, 21.4 % of the population is contained in the high income group (earnings exceeding N\$ 2'500 per month) and 58.98 % in the low-income group (earnings of less than N\$ 100 per month) (SLW JVC 1993a). Comparing the water usage of these two groups the following phenomena is noted: the low income group usage makes up only about 4 % of the entire high income consumption.

If used even out of the water consumption rates, increased tariffs will, in the long run, have the following effects:

- Cutting the consumption of the high income group, will mean a loss of income for the Department of Water Affairs, which relies - at least in part - on the funds generated by these groups, to subsidize - to a certain extent - the low/no-income groups' water consumption.
- Cutting the subsidies to the latter groups will have far-reaching effects, such as the creation of unhealthy conditions due to lack of sanitation, sufficient nutrition and clean drinking water. These conditions will, in turn, adversely affect the entire community and even the country's economy. The government will be forced to increase the budget for upgrading community health programmes to stabilize health conditions. However, maintaining subsidies to those low income groups unable to pay the rates charged by the DWA has a cut-off limit where this may be more disadvantageous than beneficial to either party. For example, subsidies may promote the squatter problem and create a discontentment, especially among the rate payers within the middle and high income groups.
- The urbanization figure (SLW JVC 1993b) was approximately 4 % per annum with an expected increase of 6 % during 1990 and recent trends draw the figure closer to 8 % per annum.
- The high income group is reported, depending on the state of the economy, to be increasing by an estimated rate of 4 % per annum. It is projected that in 1995 the increase of this group will begin to decline, reaching 3.25 % per annum by 2020 (SLW JVC 1993b). One explanation for this pattern is the post-independence influx of investors into the country and the establishment of foreign liaison offices, especially in the capital city of Windhoek.
- At the other end of the scale, the low-income group has also grown considerably with the migration of rural people, especially from the north, into the capital in search of job opportunities. The migratory groups are usually accompanied by large families, resulting in an increase in per capita water consumption. The present trend, 12 % per annum, is expected to continue until 1995, after which the period 2005 -2020 is expected to display a growth rate of 6.5 % (SLW JVC 1993b).

## EFFECTS OF INDUSTRY

The establishment of industry in already water-deficient areas is another major concern. Many industries tend to settle in the major urban centres. There, existing infrastructure favours production, including the presence of a distribution network for the completed product. Consumer market(s) may, however, be centred in the outlying areas of the country, whereas other industries may even have markets. The decentralisation of industries, encouraged through incentives granted to water-intensive users, can be considered a means of relieving the strain on these critical water areas.

Water-use related to the contribution of the user to the country's Gross National Product (GNP), is another issue that demands attention. The argument considered is that an industry using vast amounts of water to run its operations, yet making a minimal contribution to the country's economic development, does not justify its existence in the country. On the other hand, an industry that contributes a considerable amount to the country's GNP, using a considerable quantity of water to run its operations, might be justified, although its operation might not be sustainable. Thus, avenues to reduce water-use and maintain production (if possible with increased efficiency) should be explored.

## EXPECTED EFFECTS OF DEVELOPMENT

Several development proposals have surfaced in the past few months. The impact that these developments may have on the environment and the Kuiseb Catchment's water base is of grave concern to this study and the country in general. Among the proposed developments are the oil exploration operations, at present under way along the west coast of the country off Walvis Bay, the reintegration of Walvis Bay into Namibia and a dam being planned in the upper Kuiseb River to provide water to Windhoek.

### OIL EXPLORATION

The effects of this development is still unknown as it is still in the exploration phases. However, the short and long term effects of the eventual discovery of oil off the coast of Namibia on the water resources of the KCA, may be beneficial in some respects, but there could be negative impacts. At present, the construction of a desalination plant on the oil rig is the most feasible option. This will reduce cost and the operation will have water immediately available for use in the operations.

### REINTEGRATION OF WALVIS BAY INTO NAMIBIA

The expected influx of both people and industry to the enclave is inevitable with the handing back of Walvis Bay to Namibia. Not only will this mean economic prosperity for the town in the form of possible foreign investments, but also in the establishment of new industries. These industries will, however, place greater demands on an already over-utilized water resource. The handing over of the Rooibank scheme - at present under the control of the South African Department of Water Affairs - to supplement the supply from the Swartbank operations, is a consideration.

Joining these two schemes may, however, have more negative impacts than positive. The increased conveyance of water from an already exhausted source (Rooibank) to a scheme in a similar dilemma can only exacerbate existing problems.

## FUTURE DAMS

It had been proposed to build a dam on the farm of Donkersan, catching a large part of the run-off of the Kuiseb River. This water will be relayed to the existing Friedenau dam, from where it will be piped eastward, providing water to the capital, Windhoek. The reduction in flow on the main stream of the Kuiseb will amount to approximately 70 % of its total run-off into the lower Kuiseb River, the Gaub River only contributing approximately 20 % to the river's total run-off into the lower reaches (Jacobson pers. comm. 1993). Both the vegetation downstream, the towns at the coast, and the people depending on the river for their livelihood, will probably be adversely affected if such a dam is built.

The lower Kuiseb River supports a rich and diverse stand of trees along its banks. With the reduced flow of the river and the resulting drop in the water table, these trees will eventually die back or be completely eliminated.

The construction of the dam will also destroy the viability of the coastal aquifers. The already low water levels in the lower Kuiseb, where extraction for supply to the coastal towns is in progress, will drop further if extraction is continued at the present rate. This will further increase the stresses placed on the scheme by the increasing demand, with obvious negative effects on the local environment.

Any decline in the vegetation resources and the water level in the lower Kuiseb River will affect the Topnaar communities which make a living by livestock farming on the river. A decrease in the availability of browsing for the animals will be translated into a drop in the yield of milk and meat - the principle staple food for many of the communities.

This will expedite the process of poverty and famine, which will ultimately displace these communities to urban centres, such as Walvis Bay.

## POSSIBLE ALTERNATIVES

### EXPANSION OF EXISTING INFRASTRUCTURE

A possible solution to alleviate the supply problem is to expand the existing bulk water infrastructure. Among the suggestions made is the possibility of linking the coast with the Eastern National Water Carrier (ENWC) and the Okavango River (Van Schalkwyk 1992, SLW JVC 1993d).

This in itself poses various problems, including the conveyance of water-borne diseases such as schistosomiasis and bilharziasis to outlying areas such as Walvis Bay and Swakopmund. Treatment of the water to eliminate this risk will increase costs of this already capital intensive venture. In addition, the environmental and political consequences of withdrawing water from the Okavango River may be large and far-reaching.

### DESALINATION

Another of the solutions cited is that of desalination. However, among the challenges faced by the entrepreneurs are:

- \* Siting,
- \* Feasibility in terms of capital and operation cost and
- \* Overall environmental impact.

A preliminary feasibility study (Steward Scott Inc. 1993) concluded that:

Siting

due to the high plankton and pollution levels in the Bay area, alternative siting will have to be found; e.g. Swakopmund, Paaltjies - 10-12 km south of Walvis Bay, or at Bird Island.

## Costing

At an initial capital investment of N\$ 80 x 10<sup>6</sup>, this is quite an expensive undertaking. The added problems of finding a suitable fuel to power the desalination process, the pre-treatment necessary to purify the polluted Bay area water and the eventual unit cost (± N\$ 6-8/m<sup>3</sup>), only suffice to compound the ultimate decision.

## WATER RECLAMATION AND RECYCLING

At present, Namibia has one of the best facilities in the world to reclaim potable water via effluent recycling. In 1991, this facility, situated in Windhoek, was able to reclaim 15 % of the city's effluent. Due to the high cost of operating this installation, however, it is only fully utilized in times of drought, when other sources reach dangerously low levels.

## EVAPORATION CONTROL

In a country as arid as Namibia, the temperatures reach very high levels, combined with low levels of humidity. This threatens its surface water supplies with excessive rates of evaporation. The country as a whole derives 40 % of its water supply from surface water (43 % for the KCA) (SLW JVC 1993c) and it is therefore critical to manage this resource as carefully as possible.

The farmers in the upper KCA are especially dependent on surface dams to supplement their borehole supply. Yet, with the risk of evaporation, this can be a costly "conservation effort" - as some described it. Proposals to counteract this phenomenon are of utmost importance to the farmers who depend so heavily on dams as a means of catching as much run-off as possible. Open reservoirs used to store the water pumped from the boreholes are also subject to evaporation.

## CONSERVATION CAMPAIGNS

The spreading of awareness among the dependents of the KCA, as well as all those concerned at all levels of decision making, including policy makers, donor agencies, non-governmental agencies and daily users of water, will inevitably determine the success of this study. Aiming to increase awareness of not only the water shortage in the KCA, but all over the country, is a formidable task facing Namibia today.

Past awareness campaigns, such as the one in Walvis Bay in 1992/3, have had little success. This has been ascribed to the high technical content of the campaign (Müller pers. comm. 1993). Seeing that this campaign - as many others - was designed by technicians and engineers, the viewpoint and level of comprehension of the laymen was seriously overlooked. Designing an awareness campaign, often in the form of a poster or booklet, overlooks the high level of illiteracy in a large part of the population. Printed material containing text may only reach a minority within the country. Graphics, which take advantage of the associative capabilities of every man in the street, are a better way to get the message across to those not able to fully comprehend written text. Electronic media such as radio may also be effective in the Namibian context.

Tariffs may, as a short-term measure to regulate the water usage, be implemented and in so doing, reduce the demand in the long-term. Higher tariffs should, however, be kept in place irrespective of the improved conditions to avert the reoccurrence of the present crisis situation.

## CIVIL PARTICIPATION

Lastly, the most important factor neglected by especially the policy makers, is the community. Making the community part of any campaign or development planning, should be a priority, since this planning and development will ultimately affect the people who have to live with it. It should be stressed that for any strategy, plan or campaign to be successful, consultation at every level within the affected community should be ensured.

## CONCLUSION

The conclusions that can be drawn from the study of future development, with particular reference to the Kuiseb Catchment Area, emphasize the fragility of the environment we inhabit.

It is futile to attempt development with the hope that this will not harm the environment. One may, however, try to reduce the impact on the environment to as low a level as possible. It is therefore crucial in any development project to examine both the short- and long-term benefits and impacts. We must essentially ask how the proposed development will affect the environment. The crucial role of environmental impact assessments and feasibility studies in all steps of development, should be accentuated to identify the ways which the situation can be managed and monitored.

Careful consideration of water resources within an area contemplating development is essential to prolong the life of the people as benefactors of the development and the environment upon which the people depend. The establishment of a desalination plant on the coast of Namibia will be a substantial capital expense to the country, but as the groundwater resources are on the brink of exhaustion, this will probably prove the only option. The prominence of conservation efforts in development is the core issue that should be touched. Conservation of water is especially of importance as this is the principal resource upon which industry and life depend.

## RECOMMENDATIONS

Recommendations for future water development are directed at the most important body within the catchment, the people. This includes everyone, from the Topnaars, among the oldest residents of the KCA, to the policy makers whose decisions shape the future of human activity within the catchment.

- 1.) Development must be preceded by both an environmental impact and an economic feasibility study.
- 2.) The implementation of development proposals on only the highest levels of local and national government - as was the case in the past - should be reversed. This new order should start with consultation with the people who will be most directly affected. Only then should the design be laid on municipal and regional executive tables for approval. There must be a shift from a top-down to a bottom-up approach to developmental approval.
- 3.) Where the natural habitat of any wildlife is threatened, the developers should work in close collaboration with the relevant policy-making bodies such as the Ministry of Environment and Tourism, and the Department of Water Affairs. Together they must assess the possibility of finding either an alternative siting for the development, or to reach an agreement on how to reduce any negative impacts on the environment.
- 4.) Establishment of industry must be based on the available resources found in the area. This is especially relevant for water if the industry is expected to feature (a) water-intensive operation(s).

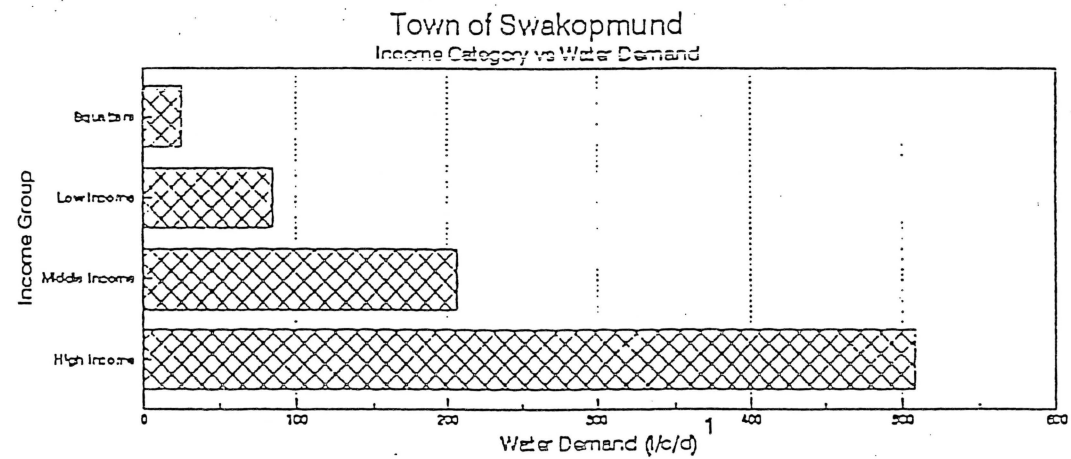
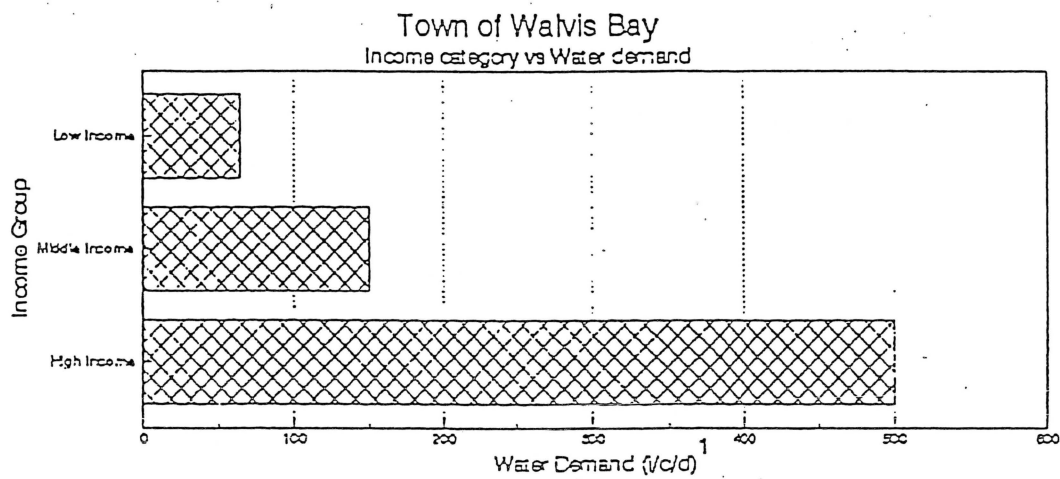
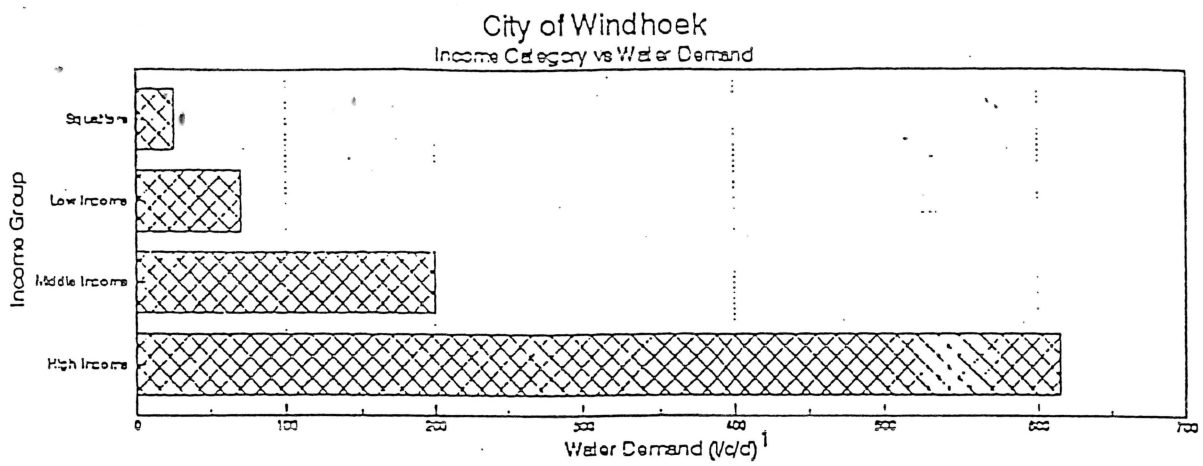


Fig.1 Influence of Socio-economic Distribution on Water Demand

Source: SLW JVC, 1993b. pp 3/10 - 3/17

¹ litres/capita/day





## GENERAL RECOMMENDATIONS

by Jack Kambatuku

Availability of water in any form for both humans and animals as well as environment has become increasingly unreliable, not only for the Kuiseb Catchment Area (KCA) but for Namibia and the world at large. Over the years technology has allowed us to penetrate deeper below the earth's surface to tap reserves built up over millions of years. As is evident in the KCA, these reserves have shrunk and their capacity to supply the needs of mankind has diminished. That this is a problem which is destined to grow worse in the face of the rapid rate of population growth in Namibia, is a hard reality to accept.

Water flows over long distances both on the surface and underground, making it unrestricted by cultural, regional or national boundaries. Any impact resulting from non-sustainable and thus unconstitutional utilization of this resource will similarly not be restricted to certain areas or regions only.

Although "sustainability" and "environmentally friendly" have been the recent keywords in the conditions laid down by donors for Governments and NGO's to qualify for aid, this seems not to have implied the long term sustainability of water resources in the many schemes developed so far.

### We therefore recommend:

#### Planning:

- \* All planning that in any way touches on water should be multi-sectoral, involving all relevant authorities, governmental bodies, NGO'S, organisations and interest groups.
- \* A holistic bottom-up approach involving a two-way-traffic of information should be the attitude towards consultations and cooperation with communities which should be applied to such planning.
- \* In depth research and assessment of sustainability, environmental and socio-economic implications should precede such planning.
- \* Unbiased evaluation of all risks involved should precede implementation of any plan.

#### Thus:

- \* Government should spell out a well calculated and carefully constructed national development plan that clearly demarcates development centres. Such a plan should clearly state which kind of development, industries and economic activities should go to which area, region or town. In Namibia, these distinctions should be primarily based on assessed long-term (for generations) sustainability of water supply to a given area, region or town. Government ministries should make an integrated effort toward planning and development and do away with separate sectoral planning.
- \* Government should install meters at all extraction and major discharge points in the country and ensure consistent reading and recording of extraction and discharge as well as the difference between the two (losses). This would provide the broad data base which is critical for extensive research, assessment and proper planning. Industries and companies should also study their own water uses and consider ways to minimise wastage.
- \* Government should provide the framework for donor aid so that donor contribution conforms to the limitations the country faces with regard to water.
- \* Donors should screen project proposals for funding on the basis of availability of water for the proposed sites of schemes. Considerations should be given to the impact of proposed schemes, especially when they are water consuming, like gardens, and affect the water supply of the area in which projects are planned. Primary funding should be dedicated to studies or projects which are aimed at solving problems with water supply.

Appropriate technology (alternative sources):

- \* All inventions and development should apply technologies that maximise the harvest of forms of water other than water in aquifers.
  - \* Economic incentives should be introduced for efforts aimed at applying such technologies to find alternative sources of water.
    - Large scale projects such as:
      - Reclamation of water for more than one use
      - Desalination of brackish and seawater
      - Recycling and treatment to drinkable standards
    - and small scale:
      - Sand dams
      - Fog and rainwater harvesting
- should be high on priority lists of government, donor agencies, NGO'S, municipalities, industries and individuals.
- \* How best architecture can guarantee rain water collection should be the predominant criteria for evaluating tender applications for providing housing. All new houses should be fitted with efficient designs to collect rain water.

Management and monitoring:

- \* Strict management and monitoring should be exercised over consumption, wastage and unnecessary losses of water.
- \* Strict management and monitoring measures to curb non-essential water use and wastage should be instituted.
- \* Water subsidies by government to institutions and industries which are huge water consumers should cease. Companies should also cease water subsidies to employees.
- \* Government should apply pressure to those industries not influenced by international conservation ideas, e.g. agriculture and fisheries, to use water more efficiently.
- \* Water quotas to industries and mining companies should be managed on a fixed rate determined on an annual basis. Heavy penalty tariffs should be applied to companies and industries exceeding their quotas. Proper pricing of water at replacement cost rather than production cost should be strongly considered.
- \* Government should enact a law that will make water use beyond allocated quotas or blatant wastage punishable, in court. Efforts should be made to establish and train a body of Water Inspectors in major urban centres to carry out regular inspections and monitoring of major industries as well as domestic users.
- \* Standing taps in large settlements where no one has a responsibility for them should be done away with. An alternative would be to charge a single individual for water used in such an area and allow him/her to charge others for the water use.
- \* Covering of swimming pools and open reservoirs as well as constructions of sand dams instead of open ground dams is recommended, to minimise loss due to evaporation.

Appropriate gardening:

- \* All measures to reduce water use and losses by gardens should be exercised.
- \* Sizes of new erven to be allocated in towns should be reduced to decrease the available space for gardens, thus avoiding high water consumption to maintain huge gardens.
- \* People should rather make colourful rocks (rock gardens) the focus of their gardens.
- \* Local plant species adapted to climatic conditions in the area should be used, to eliminate excessive evapotranspiration. Namibia is known around the world for its beautiful and unique indigenous plants.
- \* Gardens should be watered at night to reduce evaporative losses.

Education and training:

- \* People need to be educated about the water problem facing the entire country and the implications it holds for the environment and their own existence.
- \* NGO's should concentrate their programmes and activities around cultivating a culture of sustainable use and water conservation amongst the general public.
- \* NGO'S and pressure groups should force the water issue into the political arena and election campaigns, and all other public platforms.
- \* People should also be educated about existing and possible alternatives for water use and conservation and be trained to explore such alternatives.

## LIST OF REFERENCES

- ON 1974. Verslag betreffende die plaasdamme in die Kuisebopvanggebied. Ongepubliseerde verslag, Afdeling Navorsing en Hidrologie, Departement Waterwese. Windhoek. 11 pp.
- THAGR 1992. Walvis Bay water supply: Desalination of sea water. pp 117-125. In: Slabbert A (ed), Water resource development for Walvis Bay. Proceedings of the Workshop held in Walvis Bay, February 1991. Department of Water Affairs and Forestry, Pretoria.
- CHRA 1992. Groundwater abstraction options. pp 107-116. In: Slabbert A (ed), Water resource development for Walvis Bay. Proceedings of the Workshop held in Walvis Bay, February 1991. Department of Water Affairs and Forestry, Pretoria.
- UNE E 1992. Hydrology. pp 30-56. In: Slabbert A (ed), Water resource development for Walvis Bay. Proceedings of the Workshop held in Walvis Bay, February 1991. Department of Water Affairs and Forestry, Pretoria.
- LIEFF, SAHAMATA, JR KAMBATUKU, M MOLAPO, LG PARENZEE & FW SOROSSES 1993. Rainfall in Namibia: What is normal?. Desert Research Foundation of Namibia.
- MASIUS E 1991. Memorandum on water savings to the town clerk, Municipality of Walvis Bay. Walvis Bay. Unpublished report.
- MASIUS E 1992. The water demand and supply situation at the West Coast. Unpublished speech of the Town Engineer, Municipality of Swakopmund.
- ROPKING & D CLARK 1992. Past Exposure: Revealing health and environmental risk at Rössing Uranium Mine. Britain, London: Aldgate Press. 134 pp.
- V. A., SWA-BRANCH 1978. Geohydrological Report. A report on the groundwater investigation of the lower Kuiseb River. (2990/1).
- W 1989. Report on the Rooibank aquifers of the lower Kuiseb River: A summary of current situation and suggestions for further investigations. Department of Water Affairs and Forestry. Windhoek. (12/7/610)
- ONFRS 1890. s.a. Narrative of an explorer in Tropical South Africa: visit to Damaraland in 1851. 320 pp.
- WIKINS HAWKINS & OSBORN 1991. Rössing Uranium Limited: Dam on the Khan River. Technical Pre-feasibility study. RSA, Cape Town.
- YNS P 1992. Water in the Desert sands. In: Namibia Review. pp 8 - 16.
- WEN C 1992. Technology not enough for a thirsty planet. Science 258: 1435
- WYER-DIXON T F, J H BOUTWELL & G W RATHJENS 1993. Environmental change and violent conflict: growing scarcities of renewable resources can contribute to social instability and civil strife. Scientific American, February, pp 16-23.
- WLEY B J (ed) 1985. The Kuiseb environment: the developing of a monitoring baseline. SA National Scientific Programmes Report No 106. CSIR, FRD, Pretoria. 136 pp.
- WYER D J 1979. In Intensiewe opname van waterbronne in die Kuiseb opvanggebied. Ongepubliseerde verslag. SWA-Streeklaboratorium, Nasionale Instituut vir Waternavorsing. Windhoek.



