COVER PAGE

PROJECT NAME	**:**	PREFEASIBILITY STUDY INTO MEASURES TO IMPROVE THE MANAGEMENT OF THE LOWER ORANGE RIVER AND TO PROVIDE FOR FUTURE DEVELOPMENTS ALONG THE BORDER BETWEEN NAMIBIA AND SOUTH AFRICA
REPORT TITLE	**:**	Water Requirements
AUTHORS	**:**	Chris Muir; Manie Maré; Francois du Plessis; Ben van der Merwe; Charles Crosby
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Submitted on behalf of the Project Team by Lower Orange River Consultants:

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PERMANENT WATER COMMISSION

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LIST OF REPORTS

TITLE	REPORT NUMBER		
	DWAF RSA	DWA Namibia	LORC (NS)
Main Report	PB D000/00/4703	400/8/1/P-13	3749/97331
Synopsis	PB D000/00/4703	400/8/1/P-13	3749/97331
Legal, Institutional, Water Sharing, Cost Sharing, Management and Dam Operation	PB D000/00/4603	400/8/1/P-10	3692/97331
Specialist Report on the Environmental Flow Requirements - Riverine	PB D000/00/4503	400/8/1/P-07	3519/97331
Specialist Report on the Determination of the Preliminary Ecological Reserve on a Rapid Level for Orange River Estuary	PB D000/00/4503	400/8/1/P-08	3663/97331
Water Requirements	**PB D000/00/4202**	**400/8/1/P-02**	**3486/97331**
Hydrology, Water Quality and Systems Analysis (Volume A)	PB D000/00/4303	400/8/1/P04	3736/97331
Hydrology, Water Quality and Systems Analysis (Volume B)	PB D000/00/4303	400/8/1/P-03	3485/97331
Water Conservation and Demand Management	PB D000/00/4903	400/8/1/P-12	3487/97331
Dam Development Options and Economic Analysis – Volume 1	PB D000/00/4403	400/8/1/P-05	3484/97331
Dam Development Options and Economic Analysis – Volume 2 (Appendices)	PB D000/00/4403	400/8/1/P-05	3484/97331
Environmental Assessment of the Proposed Dam Sites on the Orange River	PB D000/00/4503	400/8/1/P-06	3873/97331
Vioolsdrift/Noordoewer Joint Irrigation Scheme: Assessment of Viability	PB D000/00/4803	400/8/1/P-11	3525/97331
Public Consultation	PB D000/00/4503	400/8/1/P-09	3869/97331
Inception Report	PB D000/00/4102	400/8/1/P-01	3365/97331

PRE-FEASIBILITY STUDY INTO MEASURES TO IMPROVE THE MANAGEMENT OF THE LOWER ORANGE RIVER

WATER REQUIREMENTS

EXECUTIVE SUMMARY

INTRODUCTION

The Orange River has the largest river basin south of the Zambezi. It rises in the Drakensberg Mountains in Lesotho at an altitude of some 3 300 m, from where it flows to the west for approximately 2 200 km to the sea. It has a total catchment area in excess of 1 million km², 600 000 km² of which is located in South Africa and the rest in the three neighbouring states of Lesotho, Namibia and Botswana. From 20°E Longitude westwards it forms the nearly 600 km-long international border between Namibia and South Africa. This Common Border Area (CBA) has an arid climate. Here the Orange River passes through some of the most rugged and isolated terrain, but with fertile soils in narrow corridors along its banks. A map of the river catchment is included as ***Figure 1****.*

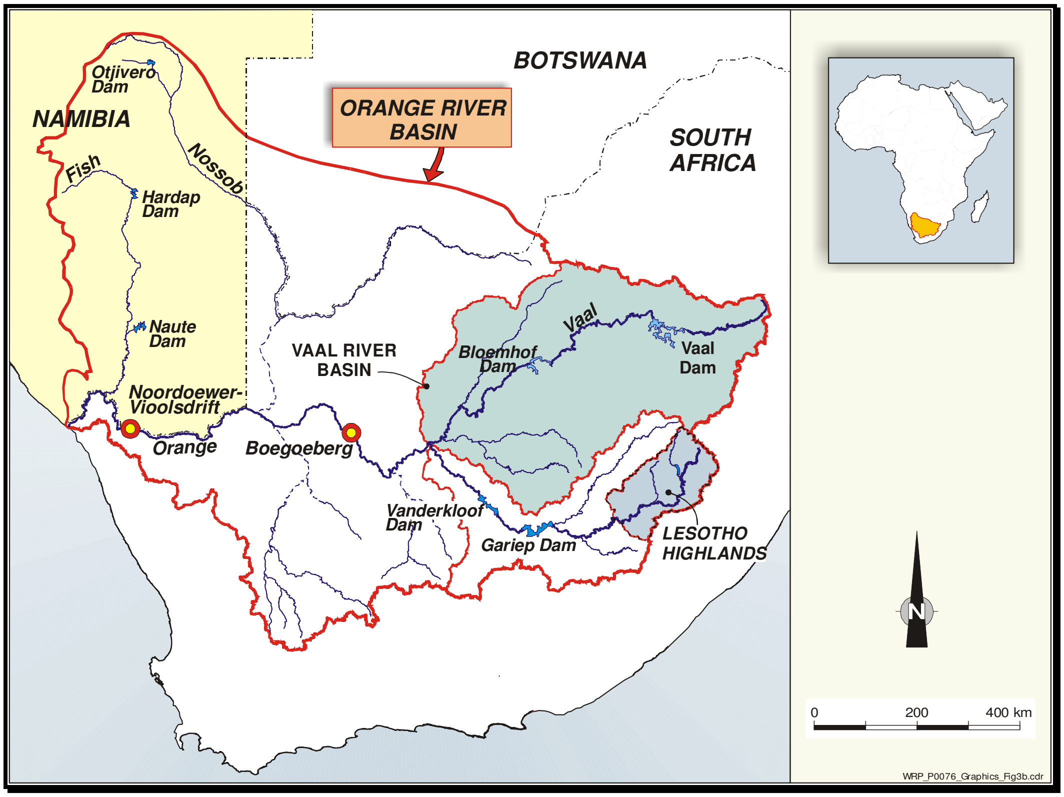

Figure 1: Orange River Basin

The natural runoff of the Orange River basin is in the order of 11 300 million m^3/a of which only 800 million m^3/a is contributed by the catchment downstream of the Orange/Vaal confluence. The runoff originating from the Orange River downstream of the Orange Vaal confluence is highly erratic and cannot be relied upon to support the various downstream demands unless further storage is provided in the Lower Orange River (LOR).

Major Demand Centres of the Orange River

The major demand centres supplied from the Orange River system are defined as:

1. *Vaal River System.*
2. *Upper Orange River (as far as the Vanderkloof Dam upstream of the Orange/Vaal confluence).*
3. *Eastern Cape (transfers through the Orange/Fish Tunnel).*
4. *Lower Orange River (Orange/Vaal confluence to the river mouth), which includes the Common Border Area – (Namibia/RSA border to the river mouth).*

PURPOSE OF THIS REPORT

The purpose of this report is to:

- *estimate the total water requirement of the Lower Orange River, including water demand projections to the year 2025.*
- *provide an agreed basis for water allocations between South Africa and Namibia.*
- *provide the basis for the Orange River systems analysis.*
- *make recommendations for the development of a "curtailment model" for implementation during times of drought and water shortage.*

The following consumer groups were analysed:

- *Irrigation;*
- *Urban/domestic and industrial/mining;*
- *Social and environmental; and*
- *Riverine requirements and operating losses.*

Irrigation

In addition to the detailed analysis of the Common Border Area, which included a visit to site, the study included a brief review of the water demands from the Upper Orange, the Vaal River Catchment and the Eastern Cape that receives water from the Orange River via the Orange-Fish Transfer System.

Urban and Mining Water Requirements

The information on water consumption in the urban and mining sectors was collected through questionnaires and directly from bulk suppliers of water, both in South Africa and Namibia.

WATER DEMAND ON THE ORANGE RIVER SYSTEM

Total Water Demand on the Orange River System

Table 1 *below presents the current demand on the Orange River System.*

Table 1: 2002 Consumer Demand on the Orange River System (Mm³/a)

Demand Area	Irrigation	Urban/Ind/ Mining	Total
Vaal River System	908	1 756	2 664
Eastern Cape	607	18	625
Upstream of Vanderkloof	111	82	193
Vanderkloof – 20°E Long.	1 273	20	1 293
Diffuse Irrigation	397		397
Common Border Area	102	24	126
TOTAL	**3 398**	**1 900**	**5 298**

The largest consumers on the system are the Vaal urban demands and Irrigation. The urban, industrial and mining demand from the Orange River (excluding the Vaal) represents only 3% of the total demand. Irrigation demand is 64% of the total demand.

Return Flows

Substantial volumes of water from irrigation, urban and industrial developments are returned to streams and become available for re-use in the system. However, part of the return flow generated from the Rand Water (RW) supply area is returned to the Crocodile River Catchment and is lost to the Orange River System.

Transfers from Gariep Dam through the Orange/Fish tunnel are mainly used to support irrigation developments in the Eastern Cape. The Port Elizabeth supply area is the main urban supply area supported with water from the Orange River.

DEVELOPMENT POTENTIAL ALONG THE LOWER ORANGE RIVER

Introduction

The Common Border Area of the Lower Orange River falls in the Northern Cape Region in South Africa and in the Karas Region in Namibia. The economy of both regions is based on mining and agriculture, which is estimated to contribute between 80 and 90% of the study area's economic activity. The economy is seen as underdeveloped and unsophisticated.

The production of high value crops along the common border will bring great opportunities to the underdeveloped regions of both countries. The hot, dry climatic conditions contribute to the success of irrigation in the area.

Historic Development

If the older norms to determine the irrigability of land are applied to the Common Border Area the outcome will be unfavourable for development

The establishment of the table grape vineyards and date palms in the area has changed the traditional outlook and approach to irrigation along the Lower Orange River. The climatic advantages of the area only started to show as time and development progressed. Currently these advantages are well known and there is a rapid growth in the development of irrigable land.

Current Situation

Currently there is a rapid growth in irrigation development on the Namibian side of the river. Land that was earlier considered as unsuitable for irrigation is now being developed. Approximately 60 000 ha has been identified, on both sides of the border that are suitable for the development of high value crops.

The Namibian Government is encouraging irrigation developments and is thus seeking as much water as possible from the river. There are a number of irrigation projects that are in an advanced stage of capital investment and many new vineyards are being developed.

Table grapes are the dominant high value crop at this stage. Dates are, however, starting to make inroads.

In South African no new water quotas will be allocated over and above the water that will be required to irrigate the 4000 ha that has been promised to developing farmers. This policy may be revised if additional water can be made available.

Future Scenarios

There are a number of other crops that can be considered as alternatives, but none of these have proved to be as profitable as table grapes. In the long-term the role that table grapes are playing now can be taken over by dates. Dates are already *being produced successfully along the Lower Orange River. The production of dates has one major setback and that is the time that it takes to come into production. Dates start to produce at an age of five years and only come into full production after ten years.*

The market for dates is unlimited at this point in time. The fruit can be stored for longer periods of time and the marketing is not subject to a window period that is determined by global climatic conditions. In terms of profitability dates can compete with grapes marketed in the peak period.

Availability of Water

The availability of water for large scale development may be a constraint to develop the full potential in the Lower Orange River. The following measures may affect this availability:

- *Savings through water demand management initiatives (Report under separate cover, Lower Orange River Management Study (LORMS).*
- *Reduction of losses due to peak hydro power releases that do not coincide with peak irrigation demands.*
- *Reduction of operational losses in the river.*
- *The environmental requirements of the river.*

Water savings through improved water use efficiency and Water Demand Management (WDM) initiatives upstream of the Common Border will not necessarily be available for use in the Common Border Area. These savings may possibly be used to support further development in the Upper Orange River Region.

Economic Aspects

Irrigation systems play an important role in the efficient use of irrigation water. The amount of water needed for flood and drip irrigation differs considerably due to evaporation. The efficiency gains of more sophisticated (but also more expensive) irrigation systems are clear. The drip system is the most efficient followed by micro. Flood irrigation is highly inefficient.

Although the growing of high value crops can result in substantially greater profits, this is also coupled to far greater capital investments, higher management inputs and higher risks.

Employment and Labour

Good labour management is a key to profitability. Because of the perishable nature of products, hand picking is often the only alternative. Understanding the labour market and planning for adequate and experienced labour is critical to having a high-quality crop ready to market. Growers must understand the laws which apply to the use of agricultural labour. These laws include those relating to migrant and seasonal workers, child labour, wages and hours, unemployment compensation, family and medical leave, worker's compensation, worker protection (pesticide exposure, safe workplace, field sanitation), and migrant housing.

New Farmers

The Lower Orange River area offers an ideal opportunity for settlement of new farmers.

Social and Socio-economic Benefits

Appropriate development and expansion can be highly significant for the economy and the accompanying upliftment of the communities in the area along the Lower Orange River, on both sides of the border. Indications are strong that expansion will be to the advantage of the region and both countries.

Possible Development Models

The South African programme for Land Redistribution for Agricultural Development is designed to provide grants to previously disadvantage South African citizens to access land specifically for agricultural purposes.

In Namibia a model was developed where commercial development is done in combination with the settlement of small farmers. The main problem area that persistently and clearly emerges when studying the history of irrigation schemes in developing countries, and more specifically where settlement of small farmers was involved, is the inability to ensure continuous, reliable and proper management and support.

Benefits of Development

The benefits of the development of the Lower Orange River Region are obvious.

- *It is the area where water can be used to the biggest economic advantage in agriculture in Southern Africa.*
- *It will bring economic upliftment to an impoverished area.*
- *It will stimulate regional infrastructure development.*
- *It will earn foreign currency for both countries involved.*
- *It will create job opportunities in an area where there is currently very little other potential for development.*
- *It will warrant the establishment of social infrastructure such as schools and medical services.*

Constraints in Development

The topography of the Lower Orange River Region is one of its biggest constraints. As a result of the topography, access and the construction of infrastructure are expensive.

The provision of bulk infrastructure in certain areas may be a major task and very costly. The joint development of infrastructure such as roads, electricity and telephone services warrants further investigation to realise the benefit of scale.

Water Quality

Water quality affects both the soils and the plants that are irrigated. Irrigation upstream of the Common Border may lead to an increase in salt concentrations over time. Changes in salt concentration will not significantly affect the fitness for use of the water for irrigation as long as salt sensitive crops are not planted. The main crops in this area, namely table grapes and dates, are not likely to be affected.

Proposed Further Investigations

Use of a Social Accounting Matrix

It is suggested that for the full Feasibility Study a general economic equilibrium analysis should be used to quantify the direct and indirect effects relating to the backward and forward linkages of each scheme. Social Accounting Matrices (SAM) are available for both Namibia and South Africa.

Input/Output (IO) tables will provide additional insights into the impacts of the various water-augmentation schemes on the economies of both countries, as well as providing additional benchmarks for the comparison of alternatives.

RIVERINE AND OPERATIONAL DEMANDS

Losses from the Orange River System represent important "demands" that must be taken into account. The main losses are river requirements, operating losses and normal transmission or conveyance losses.

River requirements *are a natural phenomenon to both regulated and unregulated rivers. As a result of the long conveyance distance and extreme dry and hot conditions, large river requirements are bound to occur. These requirements are mainly due to evaporation from the river surface area, but also include seepage and evapo-transpiration from the riparian vegetation. The river requirement proposed for the Lower Orange River is estimated to be 615 Mm³/a at a river flow of 70 m³/s.*

Gariep and Vanderkloof Dams are used to support the demands along the Lower Orange River from Vanderkloof Dam to the Orange River mouth. These demand centres are located along a river length of approximately 1 380 km which, together with river requirements and inflows from the Vaal and Fish (Namibia) Rivers, contribute to the complexity of operating the system and determining how much water to release from Vanderkloof Dam. The large controlling structures (sluice gates, hydropower turbines, etc.), at Vanderkloof Dam make it very difficult to release the required flow with accuracy. It is thus clear that some ***operating loss*** *should be expected, which in this study, is currently estimated to be 270 Mm³/a.*

In the case of normal ***transmission or conveyance losses****, the loss is expressed as a percentage of the upstream inflow to a specific system node and is generally used for canal losses and transfer losses. The percentages used in this study vary* *from 4 to 12% depending on the conveyance systems used and the condition of canals.*

NAMIBIAN WATER REQUIREMENTS

Orange River

The expansion of commercial irrigation land on the Namibian side of the river is currently progressing at a rate that results in substantial seasonal increases in the areas under irrigation. While commercial farms, and in particular table grape vineyards, are expanding, the planting of cash crops has decreased.

2 700 ha is currently under irrigation of which some 606 ha is under flood irrigation while the rest is irrigated by pressurized systems. The major urban consumers are the towns of Oranjemund, Rosh Pinah (including the Skorpion Mine) and Noordoewer.

*The projections of future water demand in the Common Border Area depend to a large extent on the development of further irrigation projects. The forecast for the total Namibian demand from the Orange River is presented in **Table 2.***

Table 2 : Total Water Demand Projections of the Lower Orange River Basin – Namibia (Most Probable)

CONSUMER	2002 (Mm^3/a)	2005 M(m^3/a)	2010 (Mm^3/a)	2015 (Mm^3/a)	2020 M(m^3/a)	2025 (Mm^3/a)
Irrigation	40.55	59.70	102.75	150.00	196.50	226.73
Urban/Industrial	7.12	8.54	8.65	8.94	9.38	9.47
Mining	2.01	7.35	22.54	37.74	37.97	38.22
TOTAL	**49.68**	**75.59**	**133.94**	**196.68**	**243.85**	**274.42**

Fish River (Namibia)

There are no mines that abstract water from the Fish River. Thus only the irrigation and domestic/industrial demands were considered. There are currently 2 490 ha under irrigation at the two main irrigation projects in the Fish River Basin – 2 200 ha at Hardap Dam and 290 ha at Naute Dam. The major towns on the Fish River are Keetmanshoop and Mariental.

Table 3 : Water Demand Projections for the Fish River (Most Probable)

CONSUMER CATEGORY	2002 (Mm³/a)	2005 (Mm³/a)	2010 (Mm³/a)	2015 (Mm³/a)	2020 (Mm³/a)	2025 (Mm³/a)
Irrigation	46.4	48.0	48.0	48.0	48.0	48.0
Small scale abstraction	1.7	1.7	1.7	1.7	1.7	1.7
Urban / Industrial	2,7	2,9	3,0	3,1	3,2	3,3
TOTAL	**50.8**	**52.6**	**52.7**	**52.8**	**52.9**	**53.0**

SOUTH AFRICAN WATER REQUIREMENTS

There are currently 4 115 ha under irrigation along the common border on the South African side of the Orange River. This is expected to increase for two main reasons; the South African Government has allocated 4 000 ha of irrigable land for the establishment of small farmers from previously disadvantaged groups, and there is likely to be further demand from commercial farmers for irrigation of high value crops in the area.

Table 4: Total Water Demand Projections for South Africa in the CBA (Most Probable)

CONSUMER	2002 (Mm³/a)	2005 (Mm³/a)	2010 (Mm³/a)	2015 (Mm³/a)	2020 (Mm³/a)	2025 (Mm³/a)
Irrigation	61.7	76.7	91.7	106.7	121.7	121.7
Urban/Mining	14.8	16.6	23.0	23.7	21.9	22.7
TOTAL	**76.5**	**93.3**	**114.7**	**130.4**	**143.6**	**144.4**

COMBINED WATER REQUIREMENTS – NAMIBIA AND SOUTH AFRICA

*The combined current demand and future demand projections within the Common Border Area are presented in **Tables 5 and 6.***

Table 5: 2002 Combined Demands in the CBA

USER CATEGORY	NAMIBIA		SOUTH AFRICA		TOTAL	
	Mm³/a	% NAM	Mm³/a	% RSA	Mm³/a	% TOT
Irrigation	40.55	79	61.72	78	102.27	15.4
Urban/Domestic	7.12	13	14.80	18	23.93	3.6
Mining/Industrial	2.01	4				
River Requirements					264.60	39.7
Operational losses					270.00	40.6
Conveyance losses	2.03	4	3.09	4	5.12	0.8
TOTAL	**51.71**		**79.61**		**665.92**	

Table 6: The Combined Water Demand Projection of Both Countries

CONSUMER CATEGORY	2002		2005		2010		2015		2020		2025	
	NAM	RSA	NAM	RSA	NAM	RSA	NAM	RSA	NAM	RSA	NAM	RSA
Irrigation	40.6	61.7	59.7	76.7	102.8	91.7	150.0	106.7	196.5	121.7	226.7	121.7
Urban/Domestic	7.1	14.8	8.5	16.6	8.7	23.0	9.0	23.7	9.4	21.9	9.5	22.7
Mining/Industrial	2.0		7.3		22.5		37.7		38.0		38.2	
TOTAL	**49.7**	**76.5**	**75.5**	**93.3**	**134.0**	**114.7**	**196.7**	**130.4**	**243.9**	**143.6**	**274.4**	**144.4**

ASSURANCE OF SUPPLY

Reliability Classifications

*In times of water shortage it will be necessary to have a set of guidelines on how to implement water restrictions in the catchment, when necessary. Different water users are grouped into user categories and these categories are classified according to priorities for water supply. **Tables 7 and 8** present the priority classifications used in the Orange River Re-planning Study (ORRS).*

Table 7: User Category and Priority Classifications Used in the ORRS Study

System and User Category	Priority Classification (%)			
	Low (90% assurance) (1:10 year)	Medium (95% assurance) (1:20 year)	Intermediate (99% assurance) (1:100 year)	High (99,5% assurance) (1:200 Year)
Irrigation	Percentage split varies from crop to crop (see Table 8 below)			
Urban and mining	0	20	30	50
River losses (evaporation)	0	0	0	100
Environmental	0	36	66	0
Conveyance losses	0	0	0	100
Curtailment level	**0** **1**	**1** **2**	**2** **3**	**3** **4**

Table 8: ORRS Priority Classifications for Different Crops

System and User Category	Priority Classification (%)			
	Low (90% assurance) (1:10 year)	Intermediate (95% assurance) (1:20 year)	Medium (99% assurance) (1:100 year)	High (99,5% assurance) (1:200 year)
Annual crops				
Maize	100	0	0	0
Wheat	100	0	0	0
Cotton	100	0	0	0
Beans / Peas	100	0	0	0
Groundnuts	100	0	0	0
Fodder	100	0	0	0

System and User Category	**Priority Classification (%)**			
	Low (90% assurance) (1:10 year)	**Intermediate (95% assurance) (1:20 year)**	**Medium (99% assurance) (1:100 year)**	**High (99,5% assurance) (1:200 year)**
Vegetables	50	50	0	0
Perennial fodder Lucerne	100	0	0	0
Perennial fruits / nuts				
Dates	30	50	20	0
Citrus	30	30	40	0
Grapes	30	40	30	0
Curtailment level **0**	**1**	**2**	**3**	**4**

Proposed Reliability Classification for This Study

*Questionnaires were sent to various users and their input and suggestions regarding the required reliability classifications were obtained. For this purpose four user categories were used, (Urban; Industrial; Mining and Irrigation) and three reliability classes (Low, Medium and High). The results obtained from this survey are summarised in **Table 9**.*

Table 9: User Categories and Priority Classifications Obtained from Questionnaires

System and User Category	**Priority Classification (%)**		
	Low (95% assurance)	**Medium (99% assurance)**	**High (99,5% assurance)**
Urban	19	31	50
Industrial	45	35	20
Mining	10	23	68
Irrigation	63	27	10

It is difficult, at this stage, to propose a final priority classification for this study. Two or three scenarios will be selected and the effect of these on the system yield will be analysed.

The priority classifications will be discussed in more detail in the Yield Analysis Report, which will contain the final recommended classifications for this study.

Curtailment Model

The Planning Model is used to analyse the system and allocate water in such a way as to maintain the assigned assurance of supply for all the users in the four proposed different user categories, subject to any physical constraints that may exist. Restrictions in water supply are applied first to the water use allocated to the low assurance level. The model will only start to impose curtailments on the water use allocated to the 95% assurance level, when 100% of the water use that is allocated to the low assurance level has been curtailed (curtailment level 1). In a similar way curtailments will each time only be imposed on the higher assurance level if all the water allocated to the lower assurance level has been curtailed in full.

CONCLUSIONS

Operational Losses downstream of Vanderkloof Dam are estimated at 270 Mm³/a. This is a significant loss that can be substantially reduced by establishing further storage in the Lower Orange River.

Urban and industry consume 67% of the water consumption in the Vaal River System. Some of the return flows generated from the Rand Water supply area are returned to the Crocodile River Catchment and are lost to the Orange River System.

Along the Common Border irrigation constitutes 81% of total water consumption. This percentage will increase in the long-term.

Inefficient irrigation, high return flows and seepage contribute to the quality deterioration in the Vaal River. The water quality in the lower Vaal River is of concern because of the high total dissolved solids (TDS) values. This may in turn influence the water quality downstream of the confluence with the Orange River.

Most of the crops grown in the Upper Orange River are cash crops that are normally regarded as low value crops. A significant quantity of water is lost through inefficient irrigation and could contribute to significant savings, if reduced.

In the CBA the hot, dry climate contributes to the success of the high value grape growing industry that has established there. Irrigation along the Common Border generally uses high technology systems and the potential for improved water use efficiency is limited.

From available information, the gross margin of high value crops along the Lower Orange River is in excess of R 100 000/ha/annum. The direct job opportunities vary from 15 to 23 jobs per 1000m³ of water consumed. This is much higher than for *other crops grown in the Orange River System.*

The long-term water quality in the Lower Orange River is a cause for concern. The selection of crops for the CBA west of Vioolsdrift/Noordoewer should be done in a way that water quality does not affect the long-term future production prospects.

The provision of bulk infrastructure in remote areas that have potential for irrigation development is a major task and very costly. The joint development of infrastructure such as roads, electricity and telephone services warrants further investigation to realise the benefit of scale.

Due to various problems that have been experienced over time with the development of small scale irrigation schemes, models should be investigated where commercial development is done in combination with the settlement of small farmers.

RECOMMENDATIONS

It is recommended that:

1. *the water demand projections for the Lower Orange River as proposed in the report be accepted.*
2. *the proposed water demand projections be used as a basis for discussion in the allocation of the available water in the Lower Orange River between Namibia and South Africa.*
3. *the proposed curtailment model be accepted as the basis for modelling the operation of the system in times of water shortage.*
4. *water allocations and the issuing of permits on both sides of border should follow the same principles and conditions.*
5. *measurement of river flow be improved to facilitate a more accurate water balance.*
6. *transfer of water rights be further investigated where feasible to get a higher return on water use.*
7. *the joint development of bulk infrastructure such as access roads, electricity and telephone services should be pursued to realise the benefits of scale.*
8. *furthering of cross border co-operation takes place.*
9. *a proper data base be developed.*

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LIST OF ABBREVIATIONS

a	annum
ARC	Agricultural Research Council
CBA	Common Border Area
CBOT	Chicago Board of Trade
DAC	Direct Allocatable Cost
d/s	downstream
DWA	Department of Water Affairs (Namibia)
DWAF	Department of Water Affairs and Forestry (South Africa)
FAO	Food and Agriculture Organisation
GDP	Gross Domestic Product
GI	Gross Income
GM	Gross Margin
GWS	Government Water Scheme
ha	hectare
ICAC	International Cotton Advisory Committee
IO	Input/Output
IRP	Integrated Resource Planning
LHWP	Lesotho Highlands Water Project
LOR	Lower Orange River
LORMS	Lower Orange River Management Study
MAWRD	Ministry of Agriculture, Water and Rural Development
Mm^3	million cubic metres
NamWater	Namibia Water Corporation Ltd
NDC	National Development Corporation
NDI	Net Disposable Income
NWA	National Water Act
NWRS	National Water Resources Strategy
ORDPRS	Orange River Development Project Re-planning Study
ORP	Orange River Project
ORRS	The Orange River Replanning Study
PDG	Previously Disadvantaged Group
RSA	Republic of South Africa
RW	Rand Water
SAM	Social Accounting Matrix

TDS	Total Dissolved Solids
u/s	upstream
VRSAU	Vaal River System Analysis Update
WCE	Windhoek Consulting Engineers
WMA	Water Management Area
WRC	Water Research Commission
WRPM	Water Resources Planning Model
WRYM	Water Resources Yield Model
WUA	Water User Associations

LIST OF TABLES

MAIN REPORT

LIST OF FIGURES

1. INTRODUCTION

1.1 General

The Orange River has the largest river basin south of the Zambezi. It rises in the Drakensberg Mountains in Lesotho at an altitude of about 3 300 m, from where it flows to the west for 2 200 km to the sea. It has a total catchment area in excess of 1 million km², 600 000 of which is located in South Africa and the rest in the three neighbouring states of Lesotho, Namibia and Botswana. From 20°E Longitude westwards it forms the nearly 600 km long international border between Namibia and South Africa. This Common Border Area (CBA) has an arid climate. Here the Orange River passes through some of the most rugged and isolated terrain, but with fertile soils in narrow corridors along its banks. A map of the river catchment is included as **Figure 1.1**.

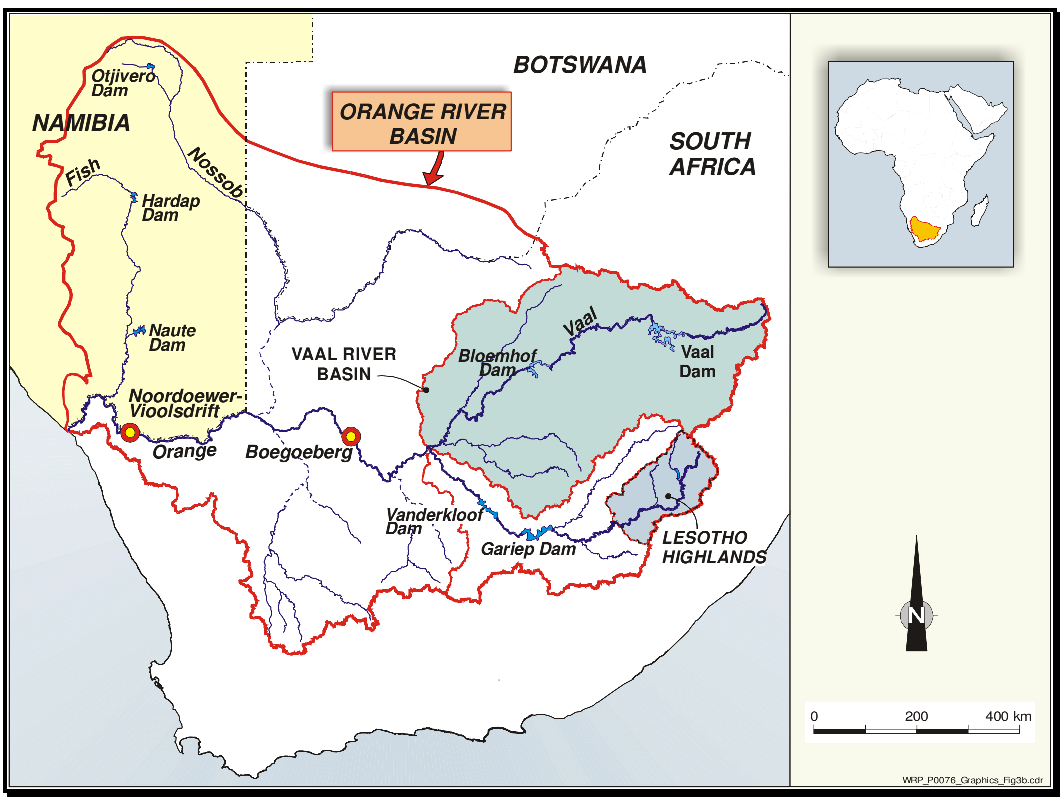


Figure 1.1: Orange River Basin

1.1.1 Runoff

It has been estimated that the natural runoff of the Orange River Basin is in the order of 11 300 million m^3/a, of which approximately 4 000 million originate in the Lesotho Highlands and approximately 800 million from the contributing catchment downstream of the Orange/Vaal confluence. The remaining 6 500 million m^3/a originate from the areas contributing to the Vaal, Caledon, Kraai and Middle Orange Rivers (See **Figure 1.2**). Much of the runoff originating from the Orange River downstream of the Orange Vaal confluence is highly erratic and cannot be relied upon to support the various downstream demands unless further storage is provided.

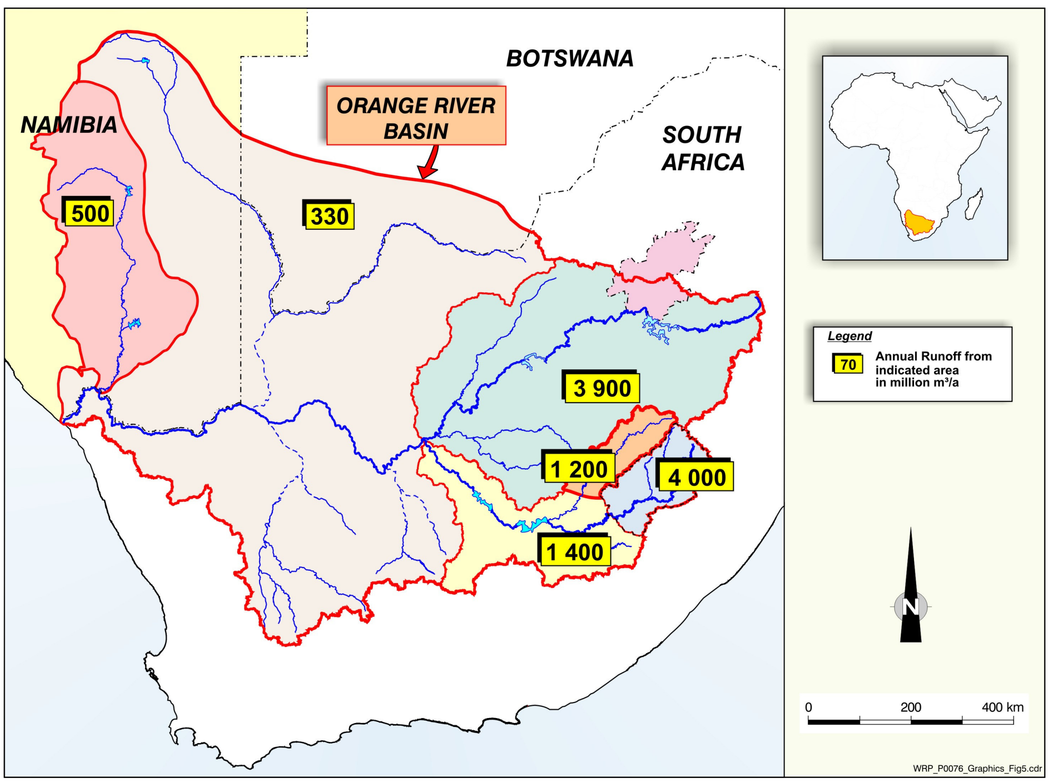


Figure 1.2: Sub-division of Areas of Natural Run-off in the Orange River Basin

Two important factors that will increase the water use efficiency of the system through storage in the Lower Orange will be the capturing of some of the 800 Mm^3 contributed by the catchment downstream of the Orange/Vaal confluence and by reducing the operating losses from the releases made at the Vanderkloof Dam.

1.1.2 Major Demand Centres of the Orange River

In this report the major demand centres supplied from the Orange River System are defined as:

1. Vaal River System.
2. Upper Orange River (upstream of the Orange/Vaal confluence).
3. Eastern Cape (transfers through the Orange/Fish Tunnel).
4. Lower Orange River (LOR) (Orange/Vaal confluence to the river mouth).
   In this report, the LOR is sub-divided into the following main sections:
   4(i) Lower Orange River – upstream area (Orange/Vaal confluence to the Namibia/RSA border).
   4(ii) Common Border Area – (Namibia/RSA border to the river mouth).

The Lower Orange is further sub-divided into irrigation areas and main urban/mining water use centres as indicated in **Figure 1.3**.

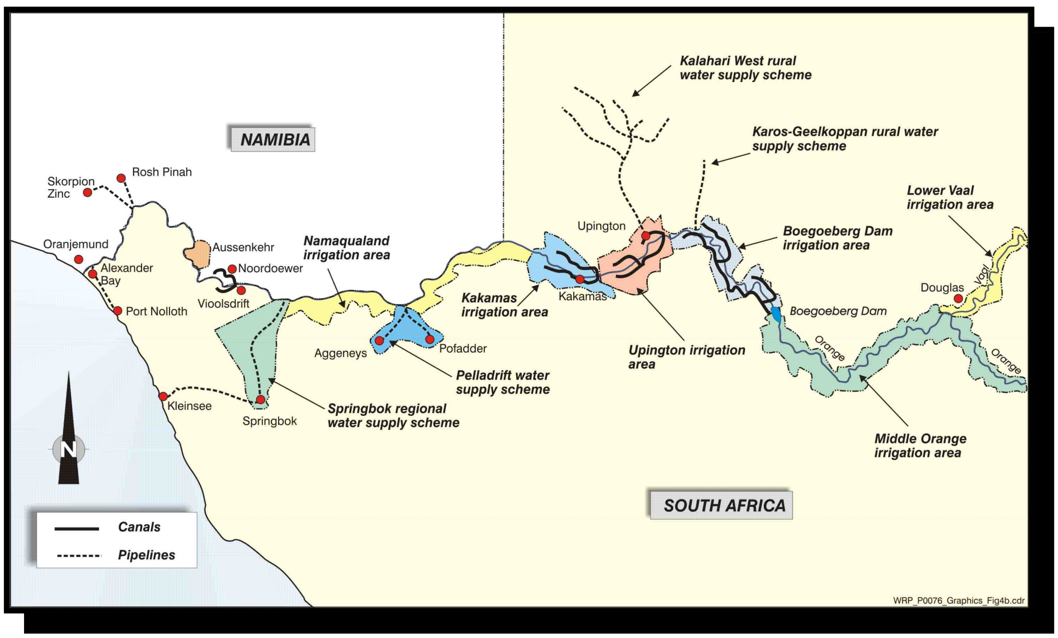


Figure 1.3: Water Supply Schemes along the Lower Orange River

Whereas a review and updating of available data was made to determine the water demands upstream of the 20°E Longitude, a detailed analysis of water demands in the CBA, which included a site visit to the area, was made.

The region is sparsely populated and is not well served by infrastructure or supporting services.

The intensive dissection of the landscape by the Orange River has resulted in the areas in the vicinity of the river being very mountainous and hilly. Combined with the arid climatic conditions, this dissection has resulted in a restricted flood plain. The potential useable soils are generally scarce and limited to strips of alluvium and terrace gravel alongside the river.

From Augrabies in the Republic of South Africa (RSA) to Vioolsdrift/Noordoewer the geology consists mainly of gneisses and schists, as well as granite and pegmatite. In the region of Noordoewer and Kotzéshoop shale, limestone, arcose and phillites of the Nama system are found. West of Kotzéshoop the Orange River flows through the Richtersveld igneous complex. A variety of rocks varying from the Swaziland system to the young tertiary river terrace-gravel can be found in this area.

The study area has an arid climate with an annual rainfall, which varies from about 100 mm in the east to less than 50 mm in the west. Mean maximum temperatures for the hottest month vary from 31°C at Oranjemund to more than 40°C at Goodhouse. The mean minimum daily temperature for the coldest month varies from 6.4°C at Goodhouse to 7.9°C at Oranjemund. The area has a very low frost risk. The average annual evaporation is estimated to be approximately 2 800 mm.

1.2 Objective of the Study

The objective of this study is to investigate measures to improve the availability of water along the LOR.

The options investigated include both demand and supply measures. In particular, the study investigated the potential of water demand management along the LOR together with ways to improve the beneficial use of water. It also investigated the need for, and feasibility of, constructing new storage reservoirs in the Lower Orange. Social and environmental issues were assessed, accompanied by full public involvement in the process.

The practical and financial viability of all the options to improve the water availability along the LOR were assessed and the options prioritised. A framework was developed for the allocation of costs of the proposed developments.

1.3 Scope of this Report

This report presents the results of the water requirements study whose objectives are to:

- estimate the total water requirement of the Orange River System, including water demand projections to the year 2025.
- provide an agreed basis for water allocations between South Africa and Namibia.
- provide the basis for the Orange River systems analysis.
- to make recommendations for the development of a "curtailment model" for implementation during times of drought and water shortage.

The environmental water requirements were assessed and the following water use categories were analysed:

- Irrigation;
- Urban/domestic and industrial/mining;
- Rural domestic;
- Riverine, evaporation/transpiration; and
- Operating losses.

Water demand forecasts were produced for low, medium and high scenarios. In addition, the assurance of supply requirements of the different user groups have been defined in several reliability classifications.

The study considered water requirements from the Orange River System in three distinct geographic areas. The first is the demand upstream of 20°East Longitude where the border between South Africa and Namibia commences. This area falls within Botswana, South Africa and Lesotho. The second part is the area west of 20°East Longitude, where the Orange River is shared between South Africa and Namibia and the river forms the boundary between the two countries. The third, which was considered separately from the demand on the Orange River System, is the Fish River catchment in Namibia. The resource from the Fish River, after deducting the demands, was used in the modelling of the entire system. The effect that a dam on the Fish River may have on the system as a whole was also assessed.

Upstream of 20°East Longitude, the demand figures used in the Orange River Replanning Study (ORRS) were used as a basis. These figures were updated as far as possible using recent data obtained through the new consumer registration procedures implemented in South Africa. Irrigation is the largest consumer and particular emphasis was placed on obtaining the latest available data for this sector.

An assessment was made, at a Desktop level of detail, with respect to the following water consumption aspects:

- Accuracy of available data;
- Existing irrigation areas;
- Potential for new irrigation areas in the CBA;
- Potential for development of the urban, industrial and mining sectors;
- Plant water requirements;
- Water allocations; and
- Flow measurement.

The Vaal River catchment has been the subject of recent detailed studies, the results of which were reviewed and used in this Study. The existing information on the areas in the Eastern Cape that receive a fixed allocation of water from the Orange River via the Orange-Fish Transfer System was also reviewed and used.

Recommendations have been made with respect to the possible improvement of the information under each of the topics listed.

Water demand for the area downstream of 20°East Longitude was evaluated in detail. This included a site visit to the Orange River to obtain information on the extent of the current irrigation areas and present irrigation practices. Projections for future demand have taken the following into account:

- historic trends;
- current consumption;
- improvements in irrigation technology;
- crop types;
- possible market influences;
- the economic situation influencing the development of the area; and
- potential irrigable soils.

Projections of future water demands in the CBA were done in 5-year increments. The year 2000 was used as the base year and the projections extend to the year 2025.

2. METHODOLOGY

2.1 Upstream of the Common Border Area

The area east of the common border between the RSA and Namibia was, for the purpose of this study, sub-divided into two main areas, the Vaal River System and the remaining Orange River Catchment.

For the Vaal River System, fairly recent data regarding the various demands were available from the latest reports. A detailed study on the Vaal River System, Vaal River System Analysis Update (VRSAU) was completed in 2001. As part of this study the hydrology and demands were updated for the total Vaal River System and supporting sub-systems. The VRSAU Study indicated that more detail was required regarding the irrigation and related demands and was followed by a detailed study, the Vaal River Irrigation Study, which focussed on the irrigation and improved the accuracy of the irrigation demands used in the system models.

Operating analyses are carried out for the Integrated Vaal River System on an annual basis. As part of this analysis, the main system demands and demand projections are updated. For this study the Vaal River System demands were not updated, but were obtained from the 2002/2003 operating analysis database.

The Orange River Development Project Re-planning Study (ORDPRS) completed in 1998 was the last detailed (hydrology and system analysis) study, which covered the total Orange River. The demands from this study were used as the initial base set for the current study. These demands were compared with more recent data that became available from the RSA water use registration process, as well as from the Northern Cape Provincial Water Resources Situation Assessments, Water Services Development Plans, Integrated Development Plans and localised studies within the catchment area. The Hydropower Operating Analysis is performed for the Orange River System on an annual basis. As part of these analyses, the demands (mainly irrigation) imposed on Gariep and Vanderkloof Dams are also updated. The irrigation and urban/industrial/mining data from the 2002 hydropower operating analysis were used to improve the initial base data set used for this study. Data were also confirmed and adjusted in liaison with the Department of Water Affairs and Forestry (DWAF) and with the Department of Agriculture where required.

Questionnaires were sent to selected urban/Industrial users (main demand centres) along the Orange River to update demands and demand projections.

2.2 Downstream of 20°E Longitude (CBA)

2.2.1 Irrigation Water Requirements

Water use pertaining to irrigation water was determined through the registered quotas allocated to irrigation schemes, Irrigation Boards (Vioolsdrift/Noordoewer) and individual irrigation farmers. Historic consumption was sourced from previous reports, 1992 air photos and consultation with responsible officials in the area. Information was also collected from detailed plans on the larger schemes like Aussenkehr and Komsberg on the Namibian side of the border. The whole CBA was visited with a light aircraft and a helicopter. Major irrigation areas, in the vicinity of Vioolsdrift/Noordoewer and Aussenkehr, were also visited by car. Valuable information was collected through direct interviews with farmers in the area.

The Consultants arranged a meeting in Kimberley where officials of the DWAF (Head Office, Northern Cape, Eastern Cape and Free State Regional Offices), Water User Associations (WUAs) and other key role players like the Douglas Cooperative shared their views and knowledge. An official of the Ministry of Agriculture, Water and Rural Development (MAWRD) of Namibia also attended the meeting.

The main purpose of the meeting can be summarised as follows:

- Provide the Regional Offices with background to the study, and to share the perspectives of the Study Team with the DWAF representatives.
- Enable the Project Team (RSA and Namibian members) to understand the current situation in the Lower and Upper Orange River water supply areas better. These discussions also brought the RSA and Namibian team members to similar levels of understanding of the various aspects of the Orange River Water Supply system.
- Discuss and clarify the available data from the most recent reports regarding developments supplied from the Orange River, upstream and downstream of the Namibian Border.
- Discuss and clarify the increases in irrigation area and demand since the completion of the ORRS, the current available databases and possible future growth.

- Discuss and understand a typical water allocation rule to be implemented during drought periods, when insufficient water is available to supply the full demand imposed on the system.
- Discuss water conservation and demand management options.
- Identify future actions that should be undertaken as part of this study.

2.2.2 Urban and Mining Water Requirements

The information on current water consumption and projected future demands for urban and mining consumers was collected through questionnaires and directly from bulk suppliers of water, both in South Africa and Namibia. The information was processed and validated by comparison with information in previous reports.

3. CURRENT WATER ALLOCATIONS AND ABSTRACTIONS

3.1 Namibia

3.1.1 General

The Government of Namibia is currently entitled to allocate up to 110 Mm^3/a of water from the Orange River for domestic, industrial, mining and irrigation purposes.

These allocations are made by issuing permits in accordance with Government principles and procedures. One of the most important principles is that the country must obtain the maximum benefit from the water it allocates for specific uses. Fundamentally, the water must be fully and efficiently utilised. It may not be misappropriated for speculative objectives.

Permit holders are expected to fully utilise the water allocated to them. Regular inspections are carried out to establish if permit conditions are adhered to and to check on any unauthorised abstraction. Permits are reviewed from time to time and allocation amounts can be revised if the permit conditions and water utilisation requirements are not met.

It is understood that, at the time of writing, the permits for the abstraction of water from the Namibian side of the Orange River for irrigation purposes have been withdrawn. This was a regulatory measure since the abstraction in many instances does not correspond with the information on the permits. A new permit system is in the process of implementation.

3.1.2 Applications for Water Abstraction Permits

Applications for Water Abstraction Permits are made to the Department of Water Affairs (DWA). Currently water allocations exist for urban, mining and irrigation purposes. For urban and mining applications, the volumes are based on the predicted water demands of each development and the permits are issued accordingly.

The permit allocations for irrigation are based on the area to be irrigated. Water volumes were calculated on a crop water requirement of 18 000 m^3/a per hectare. For the purposes of this study, however, a crop water requirement, as determined by the SAPWAT analyses, of 15 000 $m^3/ha/a$ has been used in estimating the water demand projections. Additional information to be supplied by the applicant includes:

- Total area and crops to be cultivated by area.
- Soil analysis.
- A Feasibility Study indicating the economic feasibility of the project.
- For irrigation schemes greater than 10 ha an environmental assessment of the project showing how the impact of the development on the environment will be managed. It has to be carried out in terms of a DWA policy document titled "*Guidelines for Environmental Assessments of Large Irrigation Projects*".

3.1.3 Monitoring of Water Abstraction

Where the water is abstracted and supplied by the Namibia Water Corporation Ltd (NamWater), the monthly sales figures are available. Where abstraction is done privately the permit holder submits monthly abstraction figures to the DWA.

In the case of irrigation, regular inspection trips are made to site to verify the actual abstractions. Metering of water is currently not a requirement for irrigation, except on large schemes.

Table 3-1 presents a list of the current allocations for the different consumers in Namibia. The "Present" column is the current allocation given to each landowner. However, not all landowners utilize their full allocation. The DWA has thus decided to revise the allocations in line with the areas currently irrigated. These revised allocations are given in the "Proposed" column.

Table 3-1: Current Permit Allocations (Source: DWA Namibia)

Name of Property	Area Under Irrigation (ha)	Allocation Mm^3/a	
		Present	Proposed
IRRIGATION			
Remainder, Komsberg 156	13	8.0	0.208
Portion 1, Komsberg 156	32	10.0	0.512
Remainder, Stolzenfels 74	80	9.0	2.56
Portion 1, Stolzenfels 74	3.5	1.0	0.856
Portion 2, Stolzenfels 74	0	0	0
Portion 3 and 4, Stolzenfels 74	15	0	0.24
Portion 5, Stolzenfels 74	0	0	0
Portion 1, Ondermatje 75	-	-	-
Portion 2, Ondermatje 75	-	-	-

Name of Property	Area Under Irrigation (ha)	Allocation Mm³/a	
		Present	Proposed
Remainder Naros 76	-	-	-
Hlala 411	25	0.56	0.4
Portion 2, Beenbreek 152	25	0.34	0.4
Beenbreek 152	15	0.24	0.24
Remainder Khaais 153	-	-	-
Portion 1 to 4, Khaais 153	-	-	-
Remainder, Velloorsdrift 93	400	6.4	6.4
Portion 1 Velloorsdrift	200	3.2	3.2
Kleimasmund 98	-	-	-
Orange Fall 101	-	-	-
Consolidated Farm 449	250	0	4.0
Kambreek 104	100	0	1.6
Kumkum 413	-	-	-
Hartbeesmund 108	-	-	-
Girtis 109	-	-	-
Houmsrivier	15	0	0.24
Portion 1, Houmsrivier 133	-	-	-
Gaidip 146	50	6.4	6.4
Remainder, Ramansdrift 135	-	-	-
Portion 1, Ramansdrift 135	-	-	-
Portion 2, Ramansdrift 135	-	-	-
Portion 3, Ramansdrift 135	-	-	-
Portion 4, Ramansdrift 135	-	-	-
Remainder, Hakiesdoorn 137	250	4.0	4.0
Portion 2, Hakiesdoorn 137	-	-	-
Noordoewer	-	9.0	9.0
Tsams 360	-	-	-
Aussenkehr 147	300	13.2	4.8
Portion 1, Aussenkehr 147	-	-	-
Portion 2, Aussenkehr 147	-	-	-
Portion 3, Aussenkehr 147	95	-	1.52
Portion 4, Aussenkehr 147	68	-	1.088
Portion 5, Aussenkehr 147	92	-	1.875
Portion 6, Aussenkehr 147	44	-	0.705
Portion 7, Aussenkehr 147	360	5.76	5.76
Portion 8, Aussenkehr 147	244	-	3.904
Portion 9 and 10, Aussenhehr 147	220	-	3.52
Veralex Industries (Pty) Ltd Aussenkehr 147	-	-	0.05
Boplaas	14	-	0.224
TOTAL IRRIGATION	**2 910.5**	**77.1**	**63.7**

Name of Property	Area Under Irrigation (ha)	Allocation Mm³/a	
		Present	Proposed
URBAN (Mm³/a)			
Noordoewer		0.07	0.07
Oranjemund		6.50	6.50
Rosh Pinah Town		0.60	0.60
TOTAL URBAN		**7.17**	**7.17**
MINING (Mm³/a)			
Rosh Pinah	-	7.5	7.5
Skorpion	-	Included in Rosh Pinah	Included in Rosh Pinah
Mining Daberas	-	0.95	0.95
Mining Augas	-	1.26	1.26
TOTAL MINING		**9.71**	**9.71**
TOTAL ALLOCATIONS		**93.98**	**80.58**

3.2 South Africa

3.2.1 General

The present status in South Africa is defined in the National Water Act, 1998 (NWA) and is described in Chapter 3 of the National Water Resource Strategy (NWRS), 2004.

The regulation of water use will be achieved through formal water use authorization that will impose limits and restrictions on water use.

There are three types of authorizations:

- Schedule 1 uses, which are relatively small quantities of water, mainly for domestic and stock watering purposes;
- General Authorizations, by which limited water use is conditionally allowed without a license; and
- Water use licenses, which are used to control water use that exceeds the limits imposed by Schedule 1 and General Authorizations.

Licenses give existing or prospective water users formal authorization to use water for beneficial purposes. A license to use water may only be issued by a responsible authority, to which a prospective user must apply. Sections 28 and 29 of the Act describe respectively the essential information that must be included in a license, and the conditions under which the water use is authorized. As far as possible, conditions of use will be determined by negotiation and agreement with users, and every case will be decided on its individual merits. A license:

- will replace all previous entitlements, if any, to use water for the purpose specified in the license;
- will be specific to the user to whom it is issued, and to a particular property or area;
- will be specific to the use or uses for which it is issued;
- will be valid for a specified time period, which may not exceed 40 years;
- may have a range of conditions attached to it; and
- must be reviewed by the responsible authority at least every five years.

As a transitional measure the Act permits water use that was lawfully exercised under any law which preceded the NWA, to continue under the same conditions until such time as it is formally licensed.

In addition to the licensing period that needs to be determined for each license application, water use may be subject to a range of other conditions, which are jointly intended to ensure that the total use from a particular water resource does not unreasonably prejudice the integrity of the resource, that individual users do not unreasonably prejudice other users, and that water resources are effectively managed.

Conditions attached to licenses will not necessarily remain unchanged throughout the life of the license. Any condition, except for the license period, may be amended on review (at least every five years) if such amendments are necessary to maintain the integrity of the water resource, to achieve a balance between available water and water requirements, or to accommodate changes in water use priorities. License conditions for similar uses from the same water resource must be reviewed together, and amended in an equitable manner. At each general review the license period may be extended, but only by the length of a single review period.

All users are required to adhere to the conditions of use attached to permitted water uses and responsible authorities are required to ensure they do so. A responsible authority may issue a notice directing the user to rectify the contravention. If the user fails to comply with the notice, the responsible authority may suspend or withdraw the entitlement to use water. Failure to comply with any condition of use is an offence under the Act, and the responsible authority may choose to prosecute an offending user.

Water use authorizations may be transferred, on application to the relevant authority, through a temporary or permanent transfer. Both types of transfers will only be permitted where both the original and transferred water use are from the same water resource.

3.2.2 Irrigation Water Allocation - South Africa

The water allocations for irrigation in the Upper and Lower Orange, as well as the Eastern Cape, were derived from the DWAF water registration records, as confirmed by the regional DWAF offices. There are differences in terms of both areas and quotas when compared with the ORRS, and the reasons for these were identified.

The current allocations are given in **Table 3-2**.

Table 3-2: Present Allocations of the Irrigation Sector in the Upper and Lower Orange, as well as the Eastern Cape (u/s = upstream, d/s = downstream)

River	River Reach	Scheduled Irrigation (ha)	Water Quota Farm Gate ($m^3/ha/a$)	Water Allocations (Mm^3/a)
Caledon	**u/s Welbedacht Dam**			
	Lesotho	*1 150.0*	*7 620*	*8.76*
1a	Welbedacht/Armenia and Caledon	1 440.0	7 620	10.97
	Sub-Total	**1 440.0**		**10.97**
Caledon	**u/s Gariep, d/s Welbedacht**			
2	River abstraction	4 775.1	7 620	36.39
	Sub-Total	**4 775.1**		**36.39**
Orange	**u/s Aliwal North, d/s Oranjedraai**			
3a	River abstraction, u/s Bosberg (15%)	236.2	8 000	1.89
3b	River abstraction, d/s Bosberg (85%)	1 338.4	8 000	10.71
	Sub-Total	**1 574.6**		**12.60**

River	River Reach	Scheduled Irrigation (ha)	Water Quota Farm Gate (m^3/ha/a)	Water Allocations (Mm^3/a)
Orange	**u/s Gariep Dam, d/s Aliwal North**			
4	River abstraction	2 559.7	8 000	20.48
	Sub-Total	**2 559.7**		**20.48**
Kraai	**u/s Aliwal North**			
5	Diffuse only	0.0	0	0.00
	Sub-Total	**0.0**		**0.00**
Orange	**u/s Vanderkloof, d/s Gariep Dam**			
	River abstraction from Orange River	1 990.5	11 000	21.90
	Sub-Total	**1 990.5**		**21.90**
6a	Orange/Fish transfer (Eastern Cape) Irrigation	19 329.9	13 500	260.95
6b	Orange/Fish transfer (Eastern Cape) Irrigation	14 732.6	12 500	184.16
6c	Orange/Fish transfer (Eastern Cape) Irrigation	15 980.5	9 000	143.82
6d	Orange/Fish transfer (Ciskei) Irrigation	1 470.0	12 500	18.38
	Sub-Total	**51 513.0**		**607.31**
Orange	**Canals from Vanderkloof Dam**			
7a	Vanderkloof/Ramah and right bank	5 682.0	11 000	62.50
7b	Orange/Riet canal	3 980.0	11 000	43.78
7c	Riet River Settlement	8 045.0	11 000	88.50
7d	Ritchie Irrigation Board	96.8	11 000	1.06
	Sub-Total	**17 803.8**		**195.84**
Orange	**Vanderkloof Dam and Riet River**			
8a	Scholtzburg Irrigation Board	645.7	11 000	7.10
8b	Lower Riet River Irrigation Board	3 937.9	11 000	43.32
	Sub-Total	**4 583.6**		**50.42**
Orange	**Vanderkloof to Marksdrift**			
9a	Vanderkloof to Torquay	11 532.0	11 000	126.85
9b	Torquay to Marksdrift	3 922.0	10 000	39.22
	Sub-Total	**15 454.0**		**166.07**
Modder	**u/s Tweerivier, d/s Krugersdrift**			
10	Modder River GWS	1 697.1	8 130	13.80
10	Modder River GWS	1 802.2	8 640	15.57
	Sub-Total	**3 499.3**		**29.37**
Riet	**u/s Kalkfontein, d/s Tierpoort**			
11	Tierpoort Irrigation Board	708.0	9 000	6.37
	Sub-Total	**708.0**		**6.37**
Riet	**u/s Riet River Settlement, d/s Kalkfontein**			
12	Kalkfontein Scheme (canal)	3 046.3	11 000	33.51
	Sub-Total	**3 046.3**		**33.51**

River	River Reach	Scheduled Irrigation (ha)	Water Quota Farm Gate (m³/ha/a)	Water Allocations (Mm³/a)
Vaal	**Harts-Vaal Confl. To Douglas weir (above)**			
13	River abstraction (Vaal water)	0.0	0	0.00
	Sub-Total	**0.0**		**0.00**
Vaal	**Douglas weir to Orange-Vaal confluence,**			
14a	River abstraction	5 343.7	9 140	48.84
14b	Weir canal abstraction	1 681.2	9 140	15.37
14c	Orange-Vaal canal abstraction	1 583.1	9 140	14.47
	Sub-Total	**8 608.0**		**78.68**
Orange	**Marksdrift to Boegoeberg**			
15	River abstraction	15 434.0	10 000	154.34
	Sub-Total	**15 434.0**		**154.34**
Orange	**Boegoeberg to Gifkloof weir**			
16a	Boegoeberg IA / N Oranje IB (canal)	7 733.4	15 000	116.00
16b	River abstraction	2 070.6	15 000	31.06
	Sub-Total	**9 804.0**		**147.06**
Orange	**Gifkloof weir to Neusberg**			
17a	Upington Main Board (canal)	6 955.0	15 000	104.33
	Upington Main Board	1 707.0	15 000	25.61
17b	Upington IB (canal)	747.2	15 000	11.21
	Upington IB (R/A)	45.5	15 000	0.68
17c	Keimoes IBs (own diversions - canal)	5 052.5	15 000	75.79
	Keimoes IBs (own diversions - R/A)	1 056.4	15 000	15.85
17d	River abstraction	0.0	15 000	0.00
	Sub-Total	**15 563.6**		**233.45**
Orange	**Neusberg - Namibian border (20° E)**			
18a+b	Kakamas N&S and Augrabies (canal)	8 336.0	15 000	125.04
18c	River abstraction, Neusberg to Augrabies	2 469.0	15 000	37.04
18d	River abstraction: Augrabies to border	766.9	15 000	11.50
	Sub-Total	**11 571.9**		**173.58**
Orange	**Namibian border to Onseepkans**			
	Namaqwaland - Vioolsdrift Namibia	*1 437.0*	*15 000*	*21.56*
19a	River abstraction	1 603.7	15 000	24.06
19b	Onseepkans (canal)	313.6	15 000	4.70
	Sub-Total	**1 917.3**		**28.76**
Orange	**Onseepkans Weir to Vioolsdrift Weir**			
20a	River abstraction, Onseepkans to Kambreek		15 000	
20b	River abstraction, Kambreek to Vioolsdrift	835.3	15 000	12.53
	Sub-Total	**835.3**		**12.53**

River	River Reach	Scheduled Irrigation (ha)	Water Quota Farm Gate (m³/ha/a)	Water Allocations (Mm³/a)
Orange	**Vioolsdrift to Orange-Fish confluence**			
21a	Vioolsdrift South (canal)	600.5	15 000	9.01
21b	*Vioolsdrift North, Aussenkjer, others Namibia*	*1 437.0*	*15 000*	*21.56*
	Sub-Total	**600.5**		**9.01**
Orange	**Orange-Fish confluence to mouth**			
22	River abstraction	761.1	15 000	11.42
	Sub-Total	**761.1**		**11.42**
	TOTAL	**174 043.6**		**2 040.0**

Note: Above totals do not include Namibia and Lesotho

Based on DWAF's estimates from bulk water supplied to irrigation authorities, the current abstraction appears to correspond well with the allocation, except in the Eastern Cape, where less water is abstracted than allocated. These figures will be difficult to verify on farm level, due to the general lack of water meters.

The abstractions differ every year, depending on the climate and the crops irrigated.

Table 3-3 is a summary of the figures presented in detail in **Table 3.2** above.

Table 3-3: Summary of Irrigation Allocations in the Orange River

Area	Scheduled Irrigation (Ha)	Water Allocation Mm³/a
Lesotho	1 150	8.8
Eastern Cape	51 513	607.3
Upper Orange	118 416	1 371
Lower Orange (20° E Long. – Vioolsdrift) (Vioolsdrift – Alexander Bay)	4 114 (2 753) (1 361)	61.7 (41.3) (20.4)

3.2.3 Allocations for the Urban/Mining Sectors

The current allocations for the Lower Orange shown in **Table 3-4** are based on a combination of the old permits and registered water use. The registered water use is in most cases based on the old permits. Before licenses are issued, the registered volumes must first be verified, followed by a reserve determination and then licences will be issued, depending on the availability of water. New water use applications must, however, apply for an interim license.

Table 3-4: Present Allocations and Abstractions of the Urban/Mining/Industrial Sectors

Description	Allocation (Mm^3/a)	Abstraction (Mm^3/a)	% of Allocation Utilised
Orange Vaal confluence to Nam/RSA border			
Prieska urban requirement	1.40	1.77	126.4
Groblershoop	0.42	0.39	92.9
Boegoeberg Small users	0.59	0.59	100.0
Karos Geelkoppan	0.04	0.04	100.0
Upington	25.45	12.92	50.8
Upington Small Users	0.56	0.56	100.0
Keimoes Urban	11.04	0.97	8.8
Keimoes Small users	0.18	0.18	100.0
Kakamas Urban	1.50	0.83	55.3
Kakamas Small Users	0.20	0.20	100.0
Sub-total	**41.38**	**18.45**	**44.6**
Common Border Area RSA			
Pelladrift Water Board (Pofadder, Aggeneys, Pella,	4.48	4.70	104.9
Black Mountain Mine and farmers)			
Springbok or Namakwa Water Board (Springbok,	4.00	4.15	103.8
Kleinzee, Steinkopf, O' Kiep, Nababeep, Carolusberg			
Concardia, O'Kiep Copper Mine, De Beers Mine)			
Namakwa Small users	0.04	0.04	100.0
Trans Hex Mine	2.40	1.50	62.5
Trans Hex other mines	2.45	0.96	39.2
Alexander Bay	2.00	3.18	159.0
Small mines	0.24	0.24	100.0
Sub-total	**15.61**	**14.77**	**94.6**
Total	**56.99**	**33.22**	**58.3**

From **Table 3-4** it can be seen that within Area 4 only 45% of the allocation is currently utilised. This is mainly as a result of the allocations for Upington and Keimoes, which are significantly higher than their current water use. Upington has, however, already indicated that they are planning to apply for a reduction in their allocation. The high allocation for Keimoes apparently originates from a decision taken long ago and no one really knows why the allocation is so high. The Local Kai Garib Municipality, which includes Keimoes is, however, expecting that this allocation will be reduced as part of the licensing process.

Within the CBA most of the current abstractions slightly exceed the allocation. Alexander Bay exceeds their allocation by almost 60%, but is currently in the process of applying for an increase in their current allocation. Overall, the abstractions represent 95% of the allocation.

4. ESTIMATED FUTURE WATER REQUIREMENTS UPSTREAM OF THE NAMIBIA/RSA BORDER

4.1 Orange River System

4.1.1 Future Urban, Industrial and Mining Water Requirements

The Orange River System east of the common border was sub-divided into four smaller areas to tie in with the work previously done in the ORRS. These areas are:

- Area 1 – Upstream of Gariep Dam;
- Area 2 – Gariep Dam to the Orange / Vaal confluence;
- Area 3 – Riet and Modder River catchments; and
- Area 4 - Orange / Vaal confluence to Namibian Border (20°E Longitude).

The urban, industrial and mining demand on the Orange River System represents approximately 3% of the total demand imposed on the system (losses included). Verification and updating of the projected demands, therefore, focussed mainly on the larger users such as Bloemfontein, Botshabelo, Upington, Eastern Cape, etc. Several of the smaller users' projections were also updated, particularly in Area 4, close to the CBA, the focus area of this study. The current (2000-development level) total urban, industrial, mining demand for the Upper Orange River System is 123 mm^3/a, excluding losses associated with the main transfer systems. The current total volume of these losses is estimated to be in the order of 10 mm^3/a. Improved estimates will, however, be obtained from the system analysis results. A summary of the current and projected urban/industrial and mining demands, using the future demand projections from the ORRS, is given in **Table 4-1**.

The transfer from the Lesotho Highlands Water Project (LHWP) to the Vaal System is also included in **Table 4-1** as it is utilised for the urban/industrial requirements of the Vaal System. This transfer by far exceeds the total urban/industrial/mining demand imposed on the remaining Orange River System. Mohale Dam was not operational in the year 2000, which explains the lower transfer indicated for 2000 in **Table 4-1**. Mohale Dam will start to impound water late in 2002 and the maximum transfer rate will only come into effect in the year 2004. This transfer volume from the LHWP is not added to the total demand, as it is already included in the Vaal River System demand.

Although Bloemfontein and Botshabelo are physically located in Area 3, they are mainly supplied with water from the Caledon River in Area 1. For this reason, the demands for these two urban centres were included in Area 1.

The ORRS only provides a projection for the most probable demand and therefore in general, only the one demand projection is provided for the Upper Orange River System. However, additional demand projections are shown in **Table 4-2** for the demand centres where updated demands and demand projections were available.

Table 4-1: Updated Urban, Industrial and Mining Demands for Upper Orange River

Description	Demand (Mm³/a)					
	2000	2005	2010	2015	2020	2025
Area 1 Upstream of Gariep						
RSA						
Caledon abstractions	4.0	4.2	4.5	4.7	5.0	5.2
Orange River Upstream of Gariep	9.7	10.7	11.7	12.8	14.0	15.3
Botshabelo Urban (partly) from Caledon	11.4	15.2	19.1	23.0	26.7	30.4
Bloemfontein Urban partly from Caledon	41.9	47.4	51.3	55.1	57.8	60.4
Sub-total	**67.0**	**77.5**	**86.6**	**95.6**	**103.5**	**111.3**
Lesotho						
Lesotho from Caledon	9.8	11.0	12.3	13.7	15.2	17.0
Sub-total	**9.8**	**11.0**	**12.3**	**13.7**	**15.2**	**17.0**
Total	**76.8**	**88.5**	**98.9**	**109.3**	**118.7**	**128.3**
Area 2 Gariep to Orange -Vaal confluence						
Hopetown, Vanderkloof & Orania	2.0	2.0	2.0	2.1	2.1	2.1
Douglas	1.1	1.2	1.3	1.4	1.6	1.7
Orange/Fish Transfer Urban requirements	18.2	20.0	20.0	20.0	20.0	41.3
Richie	0.3	0.3	0.4	0.4	0.4	0.5
Urban demand between Gariep & Vanderkloof	2.0	2.1	2.2	2.3	2.4	2.5
Sub-total	**23.5**	**25.6**	**25.9**	**26.2**	**26.5**	**48.1**
Area 3 Riet / Modder catchment						
Thaba Nchu	3.0	3.2	3.3	3.3	3.3	3.3
Koffiefontein, Jacobsdal, Koffiefontein Mine supplied	1.6	1.7	1.8	1.9	2.0	2.1
from Kalkfontein Dam						
Sub-total	**4.5**	**4.9**	**5.1**	**5.2**	**5.3**	**5.4**
Area 4 Orange Vaal confluence to Nam/RSA border						
Prieska urban requirement	1.8	2.0	2.3	2.7	3.1	3.6
Groblershoop	0.4	0.5	0.6	0.7	0.8	0.9
Boegoeberg Small users	0.6	0.6	0.6	0.6	0.6	0.6
Karos Geelkoppan	0.04	0.04	0.04	0.04	0.04	0.04
Upington	12.9	16.0	17.7	19.5	20.1	21.0
Upington Small Users	0.6	0.6	0.6	0.6	0.6	0.6

Description	Demand (Mm³/a)					
	2000	2005	2010	2015	2020	2025
Keimoes Urban	1.0	1.1	1.2	1.4	1.5	1.6
Keimoes Small users	0.2	0.2	0.2	0.2	0.2	0.2
Kakamas Urban	0.8	0.9	1.0	1.1	1.2	1.3
Kakamas Small Users	0.2	0.2	0.2	0.2	0.2	0.2
Sub-total	**18.5**	**22.1**	**24.4**	**27.0**	**28.3**	**29.9**
Total	**123.2**	**141.1**	**154.2**	**167.7**	**178.7**	**211.7**
Senqu/Vaal transfer (LHWP)	492.4	804	804	804	804	804

As part of this study, high and low demand projections were, however, obtained for the urban/industrial requirements within Area 4 (Orange / Vaal confluence to 20°E Longitude). These projections are shown in **Table 4-2**.

Table 4-2: Urban, Industrial and Mining Demands for Upper Orange River (High, Most Probable and Low Projections)

Description	Demand (Mm³/a)					
	2000	2005	2010	2015	2020	2025
Area 4 Orange Vaal confluence to Nam/RSA border						
Prieska - High Projection	1.8	2.2	2.8	3.5	4.3	5.4
Prieska - Most Probable Projection	1.8	2.0	2.3	2.7	3.1	3.6
Prieska - Low Projection	1.8	1.9	2.0	2.1	2.2	2.3
Karos Geelkoppan - High Projection	0.04	0.04	0.04	0.04	0.04	0.04
Karos Geelkoppan - Most Probable Projection	0.04	0.04	0.04	0.04	0.04	0.04
Karos Geelkoppan - Low Projection	0.04	0.04	0.04	0.04	0.04	0.04
Upington - High Projection	12.9	16.4	19.0	22.0	24.0	26.0
Upington - Most Probable Projection	12.9	16.0	17.7	19.5	20.1	21.0
Upington - Low Projection	12.9	14.0	15.5	17.0	18.5	20.0
Keimoes Urban – High Projection	1.0	1.2	1.3	1.6	1.8	2.1
Keimoes Urban - Most Probable Projection	1.0	1.1	1.2	1.4	1.5	1.6
Keimoes Urban – Low Projection	1.0	1.1	1.1	1.2	1.2	1.3
Kakamas Urban - High Projection	0.8	0.9	1.1	1.3	1.4	1.7
Kakamas Urban - Most Probable Projection	0.8	0.9	1.0	1.1	1.2	1.3
Kakamas Urban - Low Projection	0.8	0.8	0.9	0.9	1.0	1.0

4.1.2 Future Irrigation Water Requirements

In terms of the NWA, the registered areas will form the basis for the licenses to be issued. The allocation, which appears in

Table 3-2 for the different river reaches, should therefore be used as the present irrigation requirement. An analysis was done on the variation of irrigation requirement along the river for specific crops. The results of this analysis are given in **Chapter 8.**

There are also small private irrigation developments, referred to as diffuse irrigation, upstream of major dams. No specific allocation was given to these users from the dams, because these irrigators obtain the water directly from the river (mainly tributaries) as well as from farm dams in the tributaries. These irrigation developments are usually referred to as diffuse irrigation and a summary of the current development is given in **Table 4-3**.

Table 4-3: Diffuse Irrigation Developments in the Upper Orange River

River	River Reach	Water Use (Mm³/a)
Caledon	RSA Upstream of Welbedacht Dam	23.0
Orange	u/s of Gariep d/s Aliwal North & Welbedacht Dam	145.9
Orange	u/s of Vanderkloof Dam d/s of Gariep Dam	81.0
Orange	u/s of Aliwal d/s of Oranjedraai	17.8
Kraai	Kraai River catchment	44.2
Modder	u/s of Krugersdrift Dam d/s of Rustfontein Dam Krugersdrift tributaries Krugersdrift main stream Mockes farm dams Mockes main stream	 4.8 7.5 1.4 4.2
	Sub-total	**17.9**
Modder	u/s of Rustfontein Dam Rustfontein farm dams Rustfontein main stream	 0.9 2.6
	Sub-total	**3.5**
Modder	u/s of Tweerivier d/s Krugersdrift Dam Tweerivier farm dams	 17.8
Riet	u/s of Tierpoort Dam Tierpoort farm dams Tierpoort main stream	 1.3 0.4
	Sub-total	**1.7**
Riet	u/s of Kalkfontein Dam d/s of Tierpoort Dam Kalkfontein farm dams Kalkfontein main stream	 37.4 7.1
	Sub-total	**44.5**
	Total	**397.3**

Note: * - The diffuse irrigation requirements were obtained from the ORRS reports. No irrigated areas were provided. To obtain an indication of the irrigated area an average irrigation water requirement of 10 000 m³/ha/a was assumed.

4.1.3 Urban, Industrial and Mining Return Flows

Urban and industrial return flows in the Orange River System are minimal compared to the irrigation return flows. Only the return flows from the major consumers in the catchment were therefore included in the water balance model. The return flows from most of the smaller users are generally directed to evaporation ponds or pan areas with the result that they do not return to the river network. Estimated return flows for the major consumers (most probable projection) in the Upper Orange are given in **Table 4-4**.

Table 4-4: Urban/Industrial Return Flows from the Upper Orange River

Description	Return Flow (Mm^3/a)					
	2000	2005	2010	2015	2020	2025
Botshabelo Urban	4.9	6.5	8.2	9.9	11.5	13.1
Bloemfontein Urban	21.5	24.3	26.3	28.2	29.6	31.0
Thaba Nchu	1.5	1.6	1.6	1.7	1.7	1.6
Upington	4.5	5.6	6.2	6.9	7.1	7.4

The bulk of the return flows from Bloemfontein are used for irrigation purposes. The volume of the Bloemfontein return flow, which enters the main river system, is unknown.

4.1.4 Irrigation Return Flows

Substantial volumes of water from irrigation, urban and industrial developments are returned to rivers and are then available for re-use. In the NWRS, DWAF, 2002, figures of the total useable return flows are given for the Upper and Lower Orange. These available yields appear in **Table 4-5**. The boundary between the Lower and Upper Orange in this document is located at the Orange / Vaal confluence.

Table 4-5: Usable Return Flows in 2000 (Mm^3 per annum)

Water Management Area	Natural Resource		Usable Return Flow			Total Local Yield
	Surface Water	Ground Water	Irrigation	Urban	Mining & Industrial	
Upper Orange	4 420	65	34	38	0	4 557
Lower Orange	(1 108)	24	76	1	0	(1 007)

The negative yield from surface water in the Lower Orange Water Management Area (WMA) (in brackets) reflects the fact that river losses due to evaporation and seepage are greater than the additional yield contributed by local run-off in these areas.

The updated LORMS demands and the return flows calculated on the same basis as in the ORRS will be used in the Lower Orange River Management Study (LORMS). **Table 4-6** shows the return flows proposed for use in the LORMS.

Further detailed work is needed on return flows in order to get a clearer picture of the volume of water, as well as the quality thereof, in order to establish to what extent water from this source is available for re-use.

4.2 Vaal River System

The most up to date water demand and return flow data as obtained from the 2002/2003 Annual Operating Analysis for the Integrated Vaal River System were used as the base data set for the purpose of this study. As explained in **Section 2.1**, this data is based on the demand data obtained from the VRSAU Study, but also include several updates for some of the demand components. A summary of the 2002 demands imposed on the Vaal River System is given in **Table** 4-7. The demands in **Table 4-7** include the total Vaal System down to the confluence of the Vaal and the Riet Rivers. Demands within the Riet/Modder catchment are for the purpose of this study included as part of the Orange River System as water from the Orange River is used to support demands in the Riet/Modder Catchment. The total demand at the 2002 development level is 3 065 Mm^3/a with a total of 664 Mm^3/a return flows flowing back to the Vaal System.

Insert

Table 4-6: Return Flows Proposed for use in the LORMS

Table 4-7: Summary of Water Demands and Return Flows for the Integrated Vaal River System – 2002 Development Level

Demands & Return Flow Description		Demand in Mm³/a
DEMANDS:	Rand Water	1,172.40
	ISCOR	26.00
	ESCOM	268.87
	SASOL I	28.18
	SASOL II & III	97.50
	Midvaal Water Company	41.70
	Sedibeng Water (Balkfontein only)	40.67
	Other towns and industries (Vaal)	163.66
	Sub-total Urban	**1,839.98**
	Vaalharts/Lower Vaal irrigation	523.88
	Diffuse irrigation and afforestation (Sub-systems)	72.05
	Other irrigation in Vaal	303.18
	Other irrigation in sub-systems	25.10
	Sub-total Irrigation	**907.77**
	Wetland losses	42.57
	Bed losses	267.20
	Mooi River (net losses)	8.40
	Sub-total Losses	**318.68**
	Total Demand	**3,065.43**
RETURN FLOWS:	Southern Gauteng (Rand Water)	331.56
To Vaal Catchment	Midvaal Water Company	1.00
	Sedibeng Water	1.63
	Other towns and industries	61.55
	Irrigation *	42.02
	Mine dewatering	128.37
	Increased urban runoff	97.45
	Sub-total Vaal Return Flows	**663.58**
RETURN FLOWS:		
To Crocodile	Part of Rand Water demand return to	230.37
Catchment	the Crocodile River Catchment	
OVERALL GROSS SYSTEM DEMAND:		**3,065.43**
OVERALL NET SYSTEM DEMAND:		**2,401.85**

Notes: * Includes distribution losses within the Vaal/Harts canal system

These return flows include irrigation, urban and industrial return flows, as well as mine dewatering and increased urban runoff. The net system demand at the 2002-development level is therefore 2 401.85 Mm³/a and includes urban, industrial, mining and irrigation demands, as well as system losses.

Part of the return flows generated from the Rand Water (RW) supply area is returned to the Crocodile River Catchment where it is currently fully utilised, mainly for irrigation, but also for urban, industrial and mining purposes. At the 2000-development level these return flows already reached a total of 230 Mm³/a.

A distribution of the Integrated Vaal River System Demand into various user groups is shown in **Figure 4.1**. From this figure, it can be seen that the urban/industrial user group represents 45% of the total demand and increases to almost 60% of the total demand if the large industries such as SASOL, ISCOR and ESCOM are included.

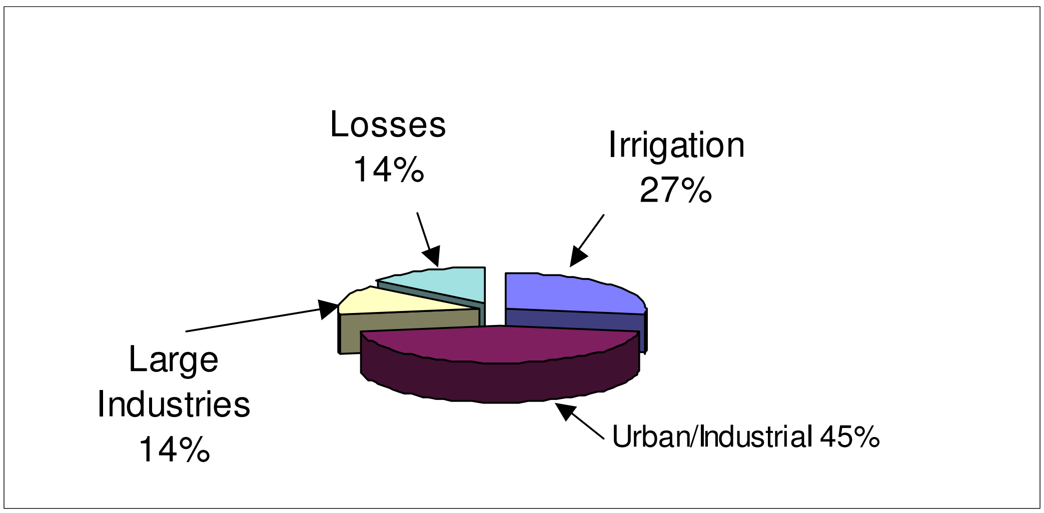


Figure 4.1: Distribution of the Integrated Vaal River System Demand

After discussions with the South African DWAF, it was decided to use two different demand projections for the Vaal River System, referred to as Scenario A and Scenario B, as described below. Both of these scenarios were used in the 2002/2003 Annual Operating Analysis of the Integrated Vaal River System.

Scenario A: This scenario can be referred to as the high projection scenario for the purpose of this study. Scenario A includes the proposed RW November 2001-water requirement projection, which was used in the 2002/2003 Annual Operating Analysis. Revised water requirements from Sedibeng Water, Midvaal Water and Eskom were obtained and are included in this projection.

Scenario B: It is recommended that this scenario be used as the reference scenario for the Vaal River System, as DWAF regard the RW Projection used in Scenario A as too high. The only difference between scenario A and Scenario B is that different projections are used for the RW demand. Scenario B used the 2000 actual (RW) water use of 1 114 Mm^3 as starting point for the RW Projection. The demand projection is then based on a combination of the RW Scenario 2 (RW SC2) and the Ratio Method projection as obtained from the NWRS. The RW SC2 is a demand projection that was provided by RW in August 2002 and includes the effect of HIV/AIDS, as well as demand management initiatives. From 2000 to 2005, this demand projection is almost identical to the RW November 2001 water requirement projection and from 2015, it follows the NWRS Ratio Method demand projection.

The demand projections for Scenario A and Scenario B are graphically compared in **Figure 4.2**.

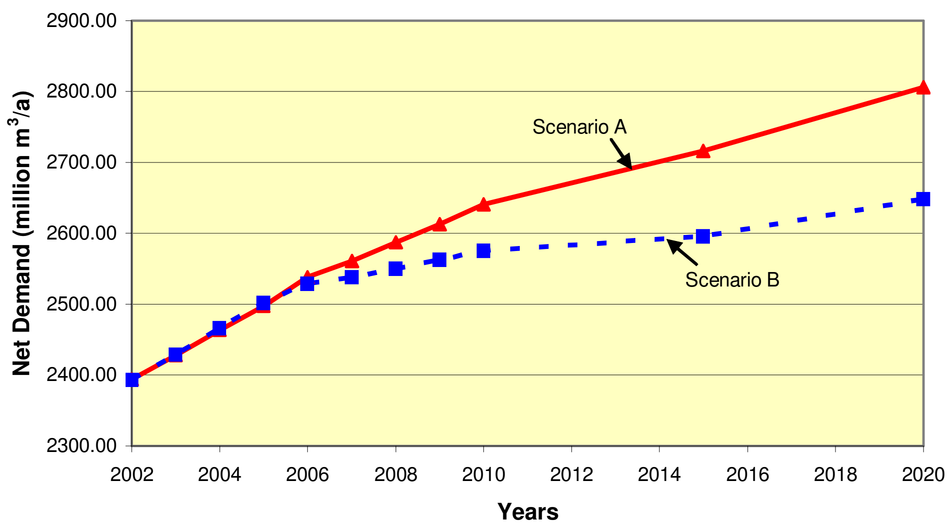


Figure 4.2: Integrated Vaal River System Demand Projections

Details of the two water requirement projections are summarised in **Table 4-8** and **Table 4-9.**

Table 4-8: Scenario A Demand Projections for the Integrated Vaal River System

DESCRIPTION		Actual Water Usage		Projected Demands										
		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2015	2020
DEMANDS:	Rand Water [1]	1113.99	1115.56	1172.40	1200.22	1228.70	1257.86	1279.89	1302.30	1325.11	1348.31	1371.92	1466.83	1579.26
	ISCOR	20.20	17.90	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00
	ESKOM	272.24	276.62	268.87	279.76	293.16	307.33	316.91	322.80	330.59	338.46	347.92	369.25	379.92
	SASOL I	21.72	24.17	28.18	29.22	32.14	23.01	24.84	25.57	26.66	28.49	29.22	33.00	33.00
	SASOL II & III	91.00	92.44	97.50	98.00	98.00	98.00	98.00	98.00	98.00	98.00	98.00	98.00	98.00
	Midvaal Water Company	44.25	42.20	41.70	41.08	40.17	39.92	39.90	39.90	39.93	40.00	40.00	40.00	40.00
	Sedibeng Water (Balkfontein only)	40.23	36.85	40.67	40.42	39.49	39.31	39.07	38.77	38.47	38.18	37.89	36.41	34.97
	Other towns and industries (Vaal)	152.38	139.94	163.66	166.17	168.64	171.16	172.33	173.49	174.67	175.84	176.97	183.47	187.44
	Other towns and industries(Zaai)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Vaalharts/Lower Vaal irrigation [2]	523.88	412.15	507.44	507.44	507.44	507.44	507.44	507.44	507.44	507.44	507.44	507.44	507.44
	Diffuse irrig and affor (Vaal)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Diffuse irrig and affor (Sup systems)	72.05	72.05	72.05	72.05	72.05	72.05	72.05	72.05	72.05	72.05	72.05	72.05	72.05
	Other irrigation in Vaal [3]	303.18	303.18	303.18	303.18	303.18	303.18	303.18	303.18	303.18	303.18	303.18	303.18	303.18
	Other irrigation in sup subsystems -[3]	25.10	25.10	25.10	25.10	25.10	25.10	25.10	25.10	25.10	25.10	25.10	25.10	25.10
	Wetland losses -[4]	42.57	42.82	43.08	43.34	43.60	43.86	44.11	44.35	44.60	44.86	45.11	46.40	47.70
	Bed losses -[5]	267.20	267.20	267.20	267.20	267.20	267.20	267.20	267.20	267.20	267.20	267.20	267.20	267.20
	Mooi River (net losses) -[6]	8.40	8.40	8.40	8.40	8.40	8.40	8.40	8.40	8.40	8.40	8.40	8.40	8.40
RETURN FLOWS:	Southern Gauteng (Rand Water)	-312.52	-311.53	-331.56	-339.05	-346.72	-354.57	-360.50	-366.53	-372.67	-378.92	-385.27	-410.83	-441.10
	Midvaal Water Company	-1.05	-1.01	-1.00	-0.99	-0.97	-0.96	-0.96	-0.96	-0.96	-0.97	-0.97	-0.97	-0.97
	Sedibeng Water	-1.61	-1.47	-1.63	-1.62	-1.58	-1.57	-1.56	-1.55	-1.54	-1.53	-1.52	-1.46	-1.40
	Other towns and industries	-52.92	-49.33	-61.55	-62.86	-65.49	-60.09	-61.61	-62.33	-63.40	-64.84	-65.68	-69.21	-69.33
	Irrigation [7]	-42.02	-42.02	-42.02	-42.02	-42.02	-42.02	-42.02	-42.02	-42.02	-42.02	-42.02	-42.02	-42.02
	Mine dewatering	-126.36	-124.62	-128.37	-126.63	-124.90	-124.44	-110.47	-110.01	-109.56	-109.10	-108.64	-126.72	-126.72
	Increased urban runoff	-95.56	-96.49	-97.45	-98.41	-99.40	-100.40	-100.94	-101.49	-102.06	-102.64	-103.24	-106.51	-113.32
OVERALL GROSS SYSTEM DEMAND:		2998.38	2876.58	3065.42	3107.58	3153.28	3189.82	3224.42	3254.56	3287.41	3321.51	3356.40	3482.73	3609..65
OVERALL NET SYSTEM DEMAND:		2366.34	2250.09	2401.86	2436.00	2472.21	2505.77	2546.36	2569.66	2595.21	2621.49	2649.06	2725.02	2814.79

Table 4-9: Scenario B Demand Projections for the Integrated Vaal River System

DESCRIPTION		Actual Water Use		Projected Demands										
		2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2015**	**2020**
DEMANDS:	Rand Water [1]	1113.99	1115.56	1171.55	1201.43	1232.08	1263.50	1267.30	1271.11	1274.93	1278.76	1282.60	1302.00	1363.30
	ISCOR	20.20	17.90	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00	26.00
	ESKOM	272.24	276.62	268.87	279.76	293.16	307.33	316.91	322.80	330.59	338.46	347.92	369.25	379.92
	SASOL I	21.72	24.17	28.18	29.22	32.14	23.01	24.84	25.57	26.66	28.49	29.22	33.00	33.00
	SASOL II & III	91.00	92.44	97.50	98.00	98.00	98.00	98.00	98.00	98.00	98.00	98.00	98.00	98.00
	Midvaal Water Company	44.25	42.20	41.70	41.08	40.17	39.92	39.90	39.90	39.93	40.00	40.00	40.00	40.00
	Sedibeng Water (Balkfontein only)	40.23	36.85	40.67	40.42	39.49	39.31	39.07	38.77	38.47	38.18	37.89	36.41	34.97
	Other towns and industries (Vaal)	152.38	139.94	163.66	166.17	168.64	171.16	172.33	173.49	174.67	175.84	176.97	183.47	187.44
	Other towns and industries(Zaai)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Vaalharts/Lower Vaal irrigation [2]	523.88	412.15	507.44	507.44	507.44	507.44	507.44	507.44	507.44	507.44	507.44	507.44	507.44
	Diffuse irrig and affor (Vaal)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Diffuse irrig and affor (Sup systems)	72.05	72.05	72.05	72.05	72.05	72.05	72.05	72.05	72.05	72.05	72.05	72.05	72.05
	Other irrigation in Vaal -[3]	303.18	303.18	303.18	303.18	303.18	303.18	303.18	303.18	303.18	303.18	303.18	303.18	303.18
	Other irrigation in sup subsystems -[3]	25.10	25.10	25.10	25.10	25.10	25.10	25.10	25.10	25.10	25.10	25.10	25.10	25.10
	Wetland losses [4]	42.57	42.82	43.08	43.34	43.60	43.86	44.11	44.35	44.60	44.86	45.11	46.40	47.70
	Bed losses -[5]	267.20	267.20	267.20	267.20	267.20	267.20	267.20	267.20	267.20	267.20	267.20	267.20	267.20
	Mooi River (net losses) -[6]	8.40	8.40	8.40	8.40	8.40	8.40	8.40	8.40	8.40	8.40	8.40	8.40	8.40
RETURN FLOWS:	Southern Gauteng (Rand Water)	-312.52	-311.53	-331.33	-339.37	-347.62	-356.08	-357.11	-358.13	-359.16	-360.19	-361.23	-366.45	-382.95
	Midvaal Water Company	-1.05	-1.01	-1.00	-0.99	-0.97	-0.96	-0.96	-0.96	-0.96	-0.97	-0.97	-0.97	-0.97
	Sedibeng Water	-1.61	-1.47	-1.63	-1.62	-1.58	-1.57	-1.56	-1.55	-1.54	-1.53	-1.52	-1.46	-1.40
	Other towns and industries	-52.92	-49.33	-61.55	-62.86	-65.49	-60.09	-61.61	-62.33	-63.40	-64.84	-65.68	-69.21	-69.33
	Irrigation [7]	-42.02	-42.02	-42.02	-42.02	-42.02	-42.02	-42.02	-42.02	-42.02	-42.02	-42.02	-42.02	-42.02
	Mine dewatering	-126.36	-124.62	-128.37	-126.63	-124.90	-124.44	-110.47	-110.01	-109.56	-109.10	-108.64	-126.72	-126.72
	Increased urban runoff	-95.56	-96.49	-97.45	-98.41	-99.40	-100.40	-100.94	-101.49	-102.06	-102.64	-103.24	-106.51	-113.32
OVERALL GROSS SYSTEM DEMAND:		2998.38	2876.58	3064.58	3108.79	3156.65	3195.46	3211.82	3223.36	3237.23	3251.95	3267.08	3317.90	3393.69
OVERALL NET SYSTEM DEMAND:		2366.34	2250.09	2401.24	2436.89	2474.67	2509.89	2537.16	2546.86	2558.54	2570.66	2583.78	2604.56	2656.97

4.3 Eastern Cape (via Orange Fish Tunnel)

4.3.1 Urban, Industrial and Mining

The Port Elizabeth supply area is the main urban supply area supported with water from the Orange River. The supply infrastructure to Port Elizabeth (Algoa Sub-system) from the Orange River Project (ORP) currently has a capacity of 25 Mm^3/a if operated continuously at peak capacity. Taking into account the seasonal demand patterns, a more realistic maximum average demand is 20 Mm^3/a. In the ORRS, it was assumed that the growth in the Algoa Sub-system demand will be supplied from the ORP until the capacity of 20 Mm^3/a from the ORP is reached. The growth in demand will then be supplied from the development of local resources until 2020, where after further growth will be supplied from the ORP. The Algoa Pre-feasibility Study, which was recently completed, showed that with demand management and the re-use of return flows, Port Elizabeth will only require augmentation by approximately 2017/18. This includes the effect of the Coega development, but excludes the development of local resources in the Algoa System. It will therefore be conservative to assume that the Algoa Sub-system will only need additional support from the ORP from 2020 onwards as indicated in **Table 4-1**.

Return flows from the urban/industrial areas in the Eastern Cape sub-system will not contribute to any flow in the Orange River System and are therefore not included in this report.

4.3.2 Irrigation Water Requirements and Return Flows

Transfers from Gariep Dam through the Orange Fish Tunnel are mainly utilised to support irrigation developments in the Eastern Cape.

As described for the Upper and Lower Orange, the registered allocations, which appear in **Table 3.2** for the Eastern Cape should be used as the irrigation requirement. Reliable information about return flows is not available. However, if the same conditions as for the Orange River are also applicable here, 10 to 15% of the irrigation applied will be return flow.

5. DEVELOPMENT POTENTIAL ALONG THE LOWER ORANGE RIVER

5.1 Introduction

The CBA of the LOR falls in the Northern Cape Region in South Africa and in the Karas Region in Namibia. The economy of both regions is based on mining and agriculture, which is estimated to contribute between 80 and 90% of the study area's economic activity. This means that the economy is based on the primary sector and little secondary or tertiary sector development has taken place. The economy is thus seen as underdeveloped and unsophisticated. There is no detailed economic information available for the CBA, but in 1990, the whole Northern Cape Region contributed only 1.9% to the Gross Domestic Project (GDP) of South Africa. The contribution of the CBA in South Africa may be less than 1% of the GDP of South Africa. Northern Cape's contribution to the total GDP might be low, but it should be kept in mind that, whatever income is generated in that area, is of crucial importance to the local people who rely on that income. It is easy to compare GDPs of areas and then make assumptions on a macro scale, but local effects of proposed or potential actions must be considered and pointed out.

The area on the Namibian side of the river, while perhaps contributing a bigger percentage to the Namibian GDP, is not a hive of activity. However, there has been a high growth rate in irrigation development in recent years on the Namibian side.

The following was stated in the ORRS[1] Study: "Although the agricultural sector in the Eastern Cape study area contributes only five percent to the total GDP, it is important, as a large number of manufacturing industries are reliant on the local products of the agricultural sector. These industries include the manufacture of frozen vegetables, fruit juice, wool, textiles, leather and shoes". This statement applies equally to the CBA.

The production of high value crops along the common border will bring great opportunities to the underdeveloped regions of both countries. It is common knowledge the even high value crops cannot normally compete with value added through mining or full-scale manufacturing of goods. However, mining activities

[1] Orange River Development Project Replanning Study, Regional Economic Assessment FINAL, 0710h.wpd (iii) May 1997

normally have a limited life span and cannot be regarded as a permanent production source. Both in South Africa and Namibia, manufacturing activities are normally concentrated in larger cities and towns.

It is ironical that along the LOR the hot, dry climate contributes to the success of the high value grape growing industry that has established there. Some of the benefits are:

- Early harvesting of crops. This earlier harvest of approximately two to six weeks means that the grapes reach the overseas markets before the competitors and in this period very favourable prices are fetched.
- Reduction in disease, which is related to untimely rainfall.
- Cost of disease control is less than in competing areas.
- Risk of hail damage is small.

In manufacturing, the cost of water is normally less than **1% of the total expenditure** to manufacture the goods. With the high prices of high value crops obtained in foreign markets and the weak exchange rate of the South African Rand, growing of high value crops in the LOR competes well with industry, as the cost of water, including pumping costs, is less than **1% of the total income** received for the products.

If it is possible to establish a strong agricultural based industry with the production of high value crops the total product cycle will be very competitive with industry elsewhere. The growth of crops based on organic principles can create further major opportunities in the international market if it is marketed correctly. It is doubted if the growing of low value crops will be viable at all, except for small scale production for own consumption due to distances to markets, high pumping costs, low value of products and other negative factors.

The effect of forward and backward multiplication factors may also be significant, although no accurate figures are readily available. This will be discussed in more detail in **Section 5.4**. With the little information available, it seems that one of the most viable options will be the production of high value crops with associated industries to stimulate economic growth in the CBA.

If this principle is accepted, and provided that it is economically viable, the following opportunities are created:

- Reduction or eradication of poverty and creation of wealth.
- Accommodation of affected groups displaced by dams in the upper catchment.
- Betterment and upliftment of formerly disadvantaged communities.
- Transfer of water rights from low value crops elsewhere to get a higher return on

water use.

- Creation of opportunities for secondary and tertiary sector development in an underdeveloped region in both countries.
- It is known that some farmers in the upper catchment grow mostly low value crops and struggle to make ends meet because of factors beyond their control (limited irrigation areas, development below the floodline, bad soils, etc). This may create an opportunity for farmers to escape from this vicious circle.

5.2 Historic Development

If the land along the Orange River, where the river forms the border between South Africa and Namibia, is considered using the older norms for irrigable land, the outcome will be unfavourable for development. This evaluation is confirmed by the limited irrigation development that took place in this area until about 10 years ago.

The production of table grapes for the export market started about 20 years ago in the Upington area. The early development was slow and the complexity and risks of the production process that was followed in those days did not generate much enthusiasm. The then existing sultana vineyards were used for the production of table grapes. The production process included the spraying of the vineyards during flowering phase with hormones that caused bunches to wean a percentage of the kernels. If the hormones were applied too early or too late, the vineyards would either wean too many or too few kernels, resulting in bunches that were not acceptable in the market. The window period within which the spraying had to take place was literally only a couple of hours. It occurred anytime during the day or night and it varied from row to row. A second application of hormones caused the kernels to grow to about three to four times the size of the kernels that were used for the productions of raisins. Only a small percentage of the crop eventually qualified for the export market.

The expansion of the table grape vineyards was a logical progression. It started with existing sultana vineyards. Then cash crops were replaced with table grapes. The next stage was the development of land above the canals in the immediate vicinity of existing infrastructure. It was only once these options were no longer readily available, that the entrepreneurs started to venture into virgin land and it was once again a case of areas in the vicinity of good and existing infrastructure enjoying preference. The climatic advantages of the areas further west along the river only started to show as time progressed. Currently,0 these advantages are well known and there is a rapid growth in the development of irrigable land.

5.3 Current Situation

Currently there is a rapid growth in irrigation development on the Namibian side of the river. Land that was earlier considered as unsuitable for irrigation is now being developed.

Due to the fact that some of the water quotas that had been allocated had no relevance to the land under irrigation, all quotas have been withdrawn. New quotas are in the process of being issued. The Namibian Government is encouraging irrigation developments rather than restricting them and is thus seeking as much water as possible from the river.

There are at this stage a number of irrigation projects that are in an advanced stage of capital investment even though production might not yet be at the same level.

Cash crops under flood irrigation are mainly produced on low-lying flood plains where the water is supplied from a canal. The production of cash crops is on the decline for a number of reasons.

- Abstraction facilities and conveyance systems have been damaged during floods.
- Farmers do not have the resources to repair the facilities.
- The lack of infrastructure has limited the financial viability.
- The land is being used for more profitable perennial crops.
- The gradual reduction in the gross margin of these crops no longer warrants production.

In an area such as Noordoewer and Vioolsdrift, the repair cost of infrastructure is spread over a wider spectrum and the basic water supply infrastructure is of a higher standard than some of the small schemes elsewhere.

The high value crops such as table grapes are virtually without exception irrigated by pressurised irrigation systems. The pressurised systems allow a far more efficient use of water, but there is still room for improvement in the efficiencies in the area, particularly if the latest scheduling techniques are introduced.

Table grapes are the dominant high value crop at this stage. Dates are, however, starting to come onto the scene.

The South African Government on the other hand, maintains that no new water quotas will be allocated over and above the water that will be required to irrigate the 4000 ha that has been promised to developing farmers. This policy can only be due to the limited quantities of water available and not as a matter of principle. If water is available this policy is likely to be revised. If the transfer of water rights is allowed from areas in the Upper Orange to the CBA there are still significant areas that can potentially be developed.

This “capping” of the water quotas does not necessarily mean that no further development will take place on the South African side of the Common Border. The option to transfer water rights from low value crop schemes further upstream in the river to the CBA for the development of more lucrative high value crop projects remains an attractive one.

5.4 Future Development Potential

5.4.1 South African Perspective

History has shown that the economic future of irrigation is difficult to predict due to its complexity. Technology development and changes in the world situation have a major impact on this industry. Experience has shown that the projections, on which financial analyses, irrigation quotas, etc., are based, are seldom correct.

Ten years ago the Loskop Irrigation Scheme in South Africa was on its knees but today centre pivot irrigation systems, shade nets, open hydroponics and computer controlled fertigation via high frequency drip irrigation are the order of the day and the valley blooms. Douglas is an example of unanticipated efficiency and development. The Green Valley Nuts project at Prieska is another example.

Innovative farmers have revitalised the table grape industry by exploiting modern methods and the potential of the desert along the LOR. It is also possible that new initiatives like sugar beet and chicory production in the Eastern Cape could start a major change in irrigation patterns and value of crops grown.

The main task of the State is to create an enabling environment in which the implementation of irrigation projects can be carried out by the farming, business and financial leaders. The big dams on the Orange River are enabling, so are the infrastructure facilities such as the roads and airfreight facilities. Any development that results from the LORMS is also an enabling action. These are aspects that could and will have a major impact on development in both Namibia and the Northern Cape. The possibilities of new plant breeding and irrigation technologies, and the viability of pumping water to where it can be utilised have been proven in the LOR.

There is obviously a risk involved, but this risk stems from progressing into the unknown. There is every possibility that meaningful reductions in water requirements can be achieved as the techniques of scheduling according to crop physiology rather than atmospheric demand or profile water content develop.

5.4.2 Namibian Perspective

General

There are three obvious areas with potential for development, namely mining, tourism and irrigated agriculture. The consumptive water demand of the first two is small relative to that of irrigation. Tourism in this region is likely to be dependent on streamflow in the river. The flow that is required for environmental purposes and in particular for the protection of the estuary is likely to satisfy the demands that tourism may have on streamflow in the river.

History has shown that the success of irrigation projects is unpredictable. Very few irrigation projects in the world would have been viable without some or other form of subsidy. Even the currently lucrative table grape farming practices along the LOR would be unlikely to be able to carry the present day costs of the dams and the other water supply infrastructure on which they are dependent. Add to this scenario the complexity of the markets and the influence of climatic conditions then it is clear that the irrigation potential is volatile.

Irrigable Land

The irrigability of land is no longer determined by a fixed set of parameters:

- Some crops will flourish in soils that are completely unsuitable for others.
- The type of irrigation system to be used determines the suitability of a land from a topographical perspective.
- The availability of water can influence the viability of irrigation on some soils.

Future Scenarios

There are two crops that are known to flourish in the LOR Region that render previously unsuitable land suitable for irrigation farming. These are table grapes and dates. In future other crops may emerge that will equal or exceed the potential of dates and grapes.

Table grapes have been tried and tested in this region and is a viable crop for the immediate future. The current success is, however, dependent on a very narrow market window, which makes it vulnerable. The profitability of the grapes that are marketed at the right time slot is such that competition is likely to develop. There is even a risk that the increase in production along the Orange River can saturate the market. New markets are however being investigated and developed. The period of time during which the grapes fetch phenomenally high prices is so brief that it is virtually impossible to determine the extent of the demand during this period. It occurs during the first week or two that grapes become available from the LOR. Within one week, the price drops to 50% of its highest level.

There are a number of other crops that can be considered as alternatives for the short-term scenario, but none of these are known to be as profitable as table grapes. This may, however, be due to the fact that the market for the grapes is known and that the transport routes and procedures are known entities.

In the long-term, the role that table grapes are playing now can be taken over by dates. Dates are already being produced successfully along the LOR. The production of dates has one major setback and that is the time that it takes for them to come into production. Dates start to produce at an age of five years and only come into full production after ten years.

The market for dates is unlimited at this point in time. The fruit can be stored for longer periods of time and the marketing is not subject to a window period that is determined by global climatic conditions. In terms of profitability, dates compete with grapes marketed in the peak period.

The switch over to the production of dates will be a slow process. Producers need to be convinced of the advantages. Lands are unlikely to be switched over within a short period and the input costs, capitalised interest, and operating costs will have to be carried for long periods of time. The long-term potential for dates is there and ways will be found to develop this potential.

5.4.3 Potentially Irrigable Soils

As described in **Chapters 7** and **8**, a total area of 60 366 ha has been identified, mainly for the development of high value crops in the LOR. In **Table 5-1** and **Table** 5-2 are summaries of the developable areas in both countries. The presumed development of high value crops is related to high pumping cost, market advantages for certain crops, water quality, soil conditions and climatic factors.

Table 5-1: Height above River of Irrigable Land – South Africa

Location / River Reach	Irrigable Land , including Present Development (ha) Height above River			
	0 - 60 m	60 - 140 m	140 - 240 m	Total Area
Nam/RSA border – Vioolsdrift Dam site	1 786	2 701	5 739	10 226
Vioolsdrift Dam site to Fish River	2 651	937	639	4 227
Fish River to Oranjemund	4 964	6 031	14 668	25 663
Total Area Irrigable Land	9 401	9 669	21 046	40 116

Table 5-2: Height above River of Irrigable Land - Namibia

Location / River Reach	Irrigable Land , including Present Development (ha) Height above River			
	10 - 60 m	60 - 140 m	140 - 240 m	Total area
Nam/RSA border – Vioolsdrift Dam site	2 605	2 155	485	5 245
Vioolsdrift Dam site to Fish River	2 065	3 505	5 080	10 650
Fish River to Oranjemund	1 555	1 295	1 405	4 255
Total Area Irrigable Land	6 225	6 955	6 970	20 150

Figure 5.1 gives a breakdown of the elevations of suitable soil above the river level for both South Africa and Namibia.

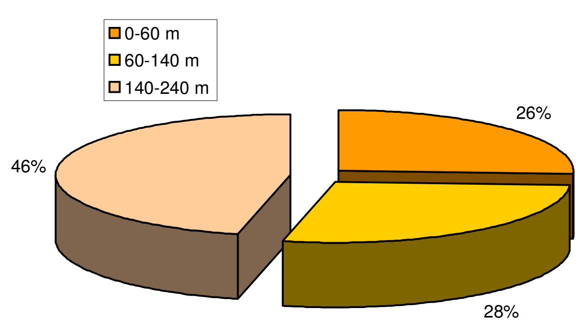


Figure 5.1: Total Irrigable Land Area Available at Different Elevations in LOR

More than 74% of the identified area in the LOR is located from 60 to 240 metres above the river. This implies high pumping cost and high cost of irrigation water. The only way that these areas can be developed, will be through the cultivation of high value crops.

5.5 Availability of Water

The availability of water for large scale development may be a constraint to develop the full potential in the LOR. The following measures may affect this availability:

- Reduction of losses due to peak hydropower releases that do not coincide with peak irrigation demands.
- Reduction of operational losses in the river.
- Improved irrigation efficiency.
- Environmental requirements of the river.
- Adequate flow measurement.

One possible way to enhance water use efficiency up to the Common Border may be through appropriate pricing and ‘capping’ of the quota through an appropriate reduction when the licenses are approved on a volumetric basis.

The volumes that will be available downstream can only be quantified after the yield analysis modelling and the optimisation of positions and sizing of a dam and/or river flow control structures downstream of the Vanderkloof Dam have been completed.

5.6 Economic Aspects

This section illustrates the differences between regions along the Orange River that produce lower value crops compared to regions producing high value crops. Secondly, the development potential along the LOR is explored.

This section gives the reader a background to the present crop production, current markets and potential, and the financial potential and risk of irrigation in the Lower Orange Region. Survey results from a 2002 farm survey in the Boegoeberg and Kakamas Regions are used as representative of the present situation along the LOR and can be extrapolated to the CBA.

Survey results[2] from a 2002 farm survey along the Orange River are used for purposes of illustration. In this document, the river is divided into 5 irrigation regions:

- Vanderkloof/Hopetown;
- Douglas/Prieska
- Boegoeberg (the area from Boegoeberg Dam to Upington);
- Upington – Keimoes;
- Kakamas (from halfway between Keimoes and Kakamas to Marchand); and
- Augrabies – Blouputs.

The following acronyms are used for discussion purposes:

- VDKL-HT = Vanderkloof/Hopetown
- PD = Douglas/Prieska
- Boegoe = Boegoeberg
- Upkeim = Upington - Keimoes
- AugBlou = Augrabies – Blouputs.

The total irrigated area is represented in **Table 5-3**. The total irrigated area for each of the regions is an approximation since the regions do not correspond exactly to the DWAF data on scheduled irrigation areas.

Table 5-3: Percentage of Area covered by Survey

ITEM	VDKL-HT	PD	Boegoe	Upkeim	Kakamas	AugBlou
Total irrigation entitlement	14174	9972	7558	7989	6457	3512
Irrigated area surveyed (double cropping excluded)	6989	8991	1824	1121	2105	1054
Percentage of entitlement covered	49%	90%	24%	14%	33%	30%

The area covered (with the exception of Upington-Keimoes) is adequate to represent irrigation farming in this region. For the purpose of this study, it will be assumed that the Upington-Keimoes Region is also representative.

[2] The data were collected for a current Water Research Commission (WRC) project. Financial support from the WRC to enable the research is hereby acknowledged.

5.6.1 Existing Crops

Figure 5.2 presents the distribution of crops in the LOR during 1996 and **Figure 5.3** the 2002 survey results (approximately 8% of the total irrigated area was covered during the survey). It is clear that dry grapes still dominate production in the region.

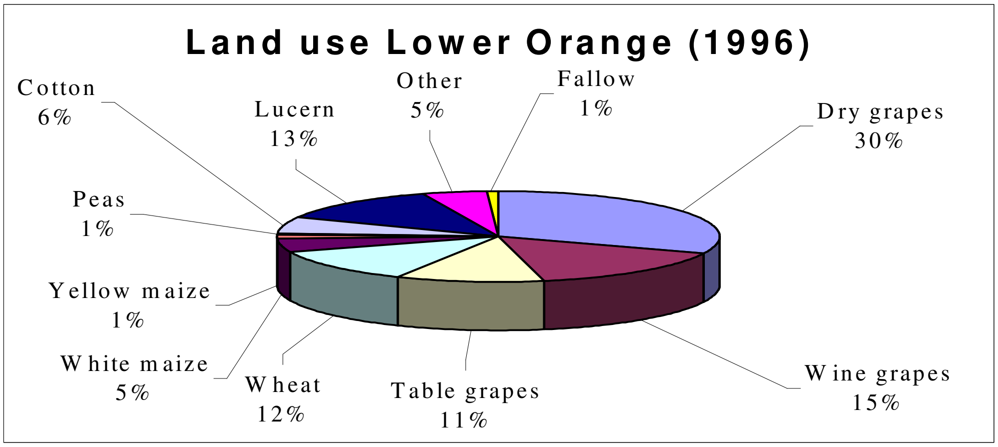


Figure 5.2: Land-use in 1996

Source: Department of Agriculture Northern Cape, 1996.

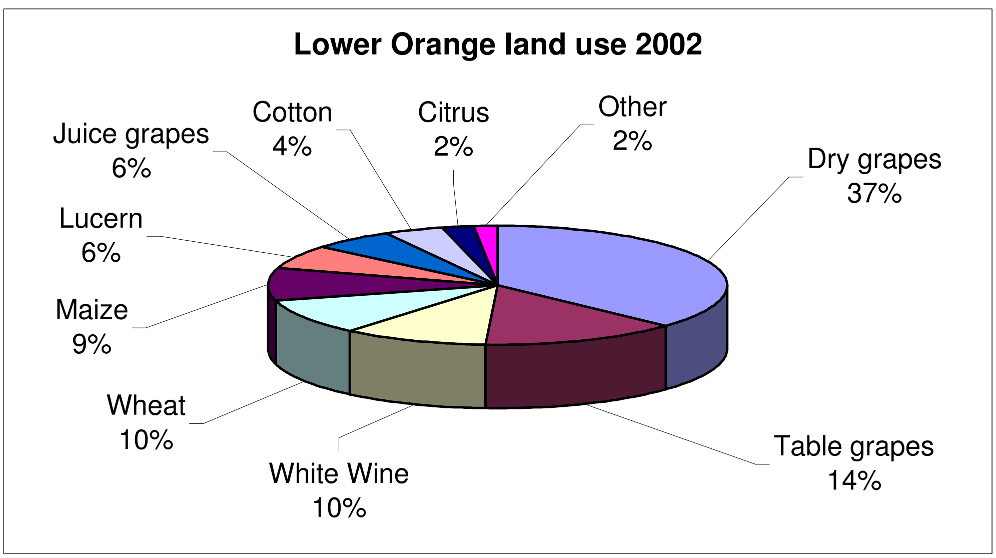


Figure 5.3: Land-use in 2002

Source: Survey results 2002

Interviews with farmers during 1996 (Department of Agriculture: Northern Cape, 1996) confirmed that a significant change towards export grapes was planned for the next 5 to 10 years. Soil with a high risk of cold and fluid damage is not suitable for this change. It is desirable that farmers reserve a part of their irrigated area for cultivation of seasonal crops. The advantage of this is that it makes water management easier during periods of irrigation water shortages when available water can be diverted to long-term crops with a higher income. The development of the "outside land", further away from the river, and new areas downstream of Kakamas with the emphasis on export grapes and other export crops, due to the use of micro and drip irrigation, have huge implications. Although the survey results of 2002 are not sufficiently representative since the Boegoeberg and Kakamas Regions only represent approximately 40 percent of the total irrigated area, there seems to be a trend, which favours the production of table grapes as predicted in the 1996 survey.

During the 1996 interviews with farmers, it was found that generally, in South Africa, as in most other countries, the main objective is to protect yields, ensure product quality and maintains a reasonable income. Irrigation is one of the inputs that must be managed well to be able to reach this objective.

Water restrictions, a series of official investigations and the new Water Act of 1998 (RSA) highlighted the need for improved water management and farmers now have a new understanding of water management and water saving practices. During interviews with farmers, it was also found that there is uncertainty around the meaning of the concepts of crop water demand, irrigation demand and irrigation efficiency, and how this relates to the water quota. It is important that irrigation farmers understand the relationship between farming practices on the one hand and profitability, water availability and water quality on the other hand.

Irrigation systems play an important role in the efficient use of irrigation water. The amount of water needed for flood and drip irrigation differs considerably due to evaporation. **Figure 5.4** presents the gross crop water requirements for a combination of crops in the LOR under different irrigation technologies. The efficiency gains of more sophisticated (but also more expensive) irrigation systems are clear. The drip system is the most efficient followed by the micro jet system. Flood irrigation is very inefficient. However, this is purely from a water use point of view and does not consider the costs of the systems.

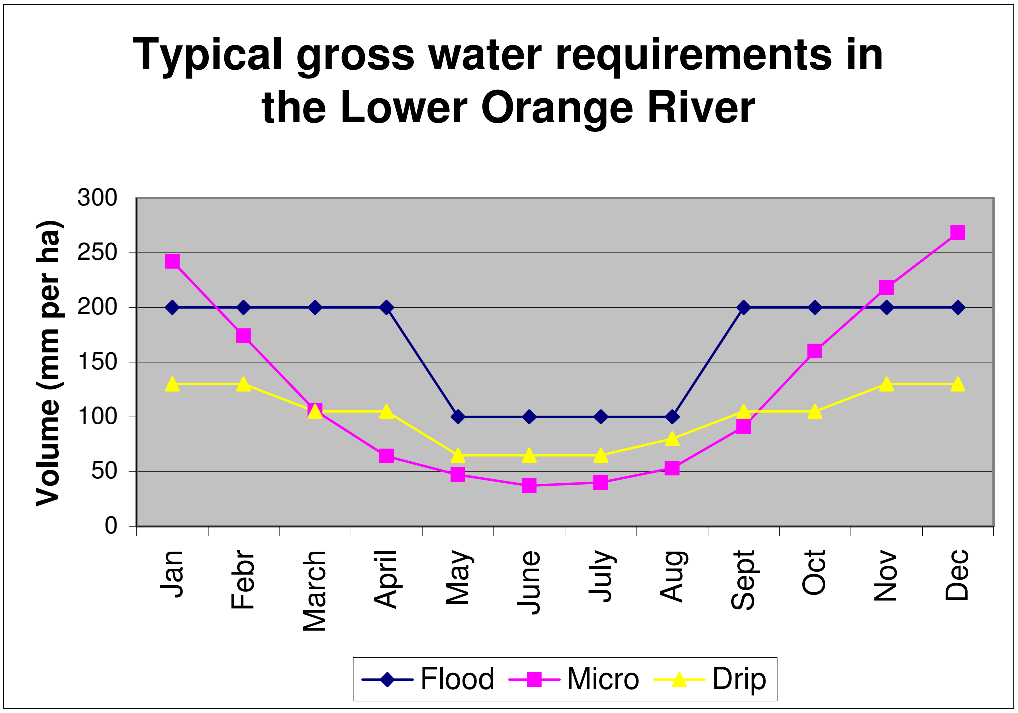


Figure 5.4: Gross Crop Water Requirements for Different Irrigation Systems

Source: Department of Agriculture Northern Cape, 1996.

5.6.2 Market Conditions for Existing and Alternative Crops

The following general aspects are important regarding the marketing of crops:

- The exchange rate of the Rand against the Dollar is expected to stabilise around the level of R8.50 to R9.50. Local farmers can therefore expect that they will not be protected from imports since most of our crops are already close to the import parity price. It is therefore not expected that local prices will rise because of a declining exchange rate.
- On the positive side, it can be expected that the tremendous input cost increases that were experienced during the 2002 season will also be halted for the time being.

This section gives the reader background information relating to market prospects for the most important crops. The reader must be aware, however, that market analysis is part and parcel of the farming activity since market conditions for most crops can change overnight. Most of the information in this section was obtained from Agri Mark Trends, specialists in market information and provides background to the potential of alternative high value crop cultivation.

Maize and Wheat

Stock levels for these crops are at their lowest in many decades. Stock levels in the USA are at their lowest since 1995/1996. Unfavourable climatic circumstances in Australia and Canada contributed to the current and expected low stock levels. Also, the economic problems in Argentina create uncertainty about the contribution to production from this source. It is expected that the Chicago Board of Trade (CBOT) prices will rise to their highest levels since 1997. The short to medium prospects for these crops are therefore favourable. However, it can be expected that prices will drop to more realistic levels due to the strengthening of the Rand during the last few months.

Cotton

It is expected that the international price of cotton in the 2002/2003 season will increase by 27%. The local price per kg will therefore reach approximately R3.80 and it is expected to increase to R4.00 in the 2003/2004 season. China is the most important importer of cotton. A 17% reduction in China's production is expected for 2002 due to flood damage. In general it is expected that world production will be lower. According to the International Cotton Advisory Committee (ICAC), demand will increase by 3% on the previous year. The South African crop forecast is 46% lower than the previous year mainly due to substitution in production to maize and wheat. The short- to medium-term prospects are considered to be good.

Vegetables

Due to the considerable fluctuations in the market for vegetables, it is not possible to make medium or long-term predictions. However, vegetables have an inherent strong demand in the local market as part of a staple diet. At present, most vegetables are highly profitable due to shortages caused by inclement weather conditions. Because of the difficulty in market projections, as well as the relatively high management requirement, vegetables are considered to be high-risk crops. The three main vegetables grown in South Africa in terms of value of production are potatoes (R1 078 million), tomatoes (R 459 million) and onions (R 286 million).

The 2002 potato harvest was approximately 7% lower than in 2001, because of frost damage in the Western Free State and the Northern Cape, as well as late plantings in Limpopo. The per capita consumption of potatoes is very low compared to other countries. This creates an enormous potential for market development. However, producers should be aware of market circumstances for 2003 since the current high price will induce large plantings in 2003 with a consequent drop in prices.

At present, tomato prices are under pressure due to very high prices in the previous season and an increase in local production. Onion farmers had a very bad season last year due to a low quality harvest and low prices. This signals an increase in prices for this season.

It is a fact that farmers react to current market conditions when they make their planting decisions. However, wise farmers will plant more when present conditions are bad and less when conditions are good because they know that the chances are good that the next season will probably be just the opposite from the present conditions.

Table Grapes

During 1996, it was estimated that one hectare of export grapes provides an income equal to the Northern Cape per capita income for 2.96 persons. It was estimated that an additional 31 380 hectares can be put under irrigation if enough water is available. It is clear that not only can enormous foreign exchange be earned, but employment opportunities could double with expansion.

The 2002/2003 Table Grape season started during week 44 in the Northern Province where the first grapes are being exported. A disastrous hailstorm hit Blouputs (Orange River) during the first week of November. It has been estimated that 1.2 million cartons were lost from an initial crop estimate of 16.6 million cartons. **Figure 5.5** represents the 2002/2003 crop estimate compared with the 2001/2002 actual exports.

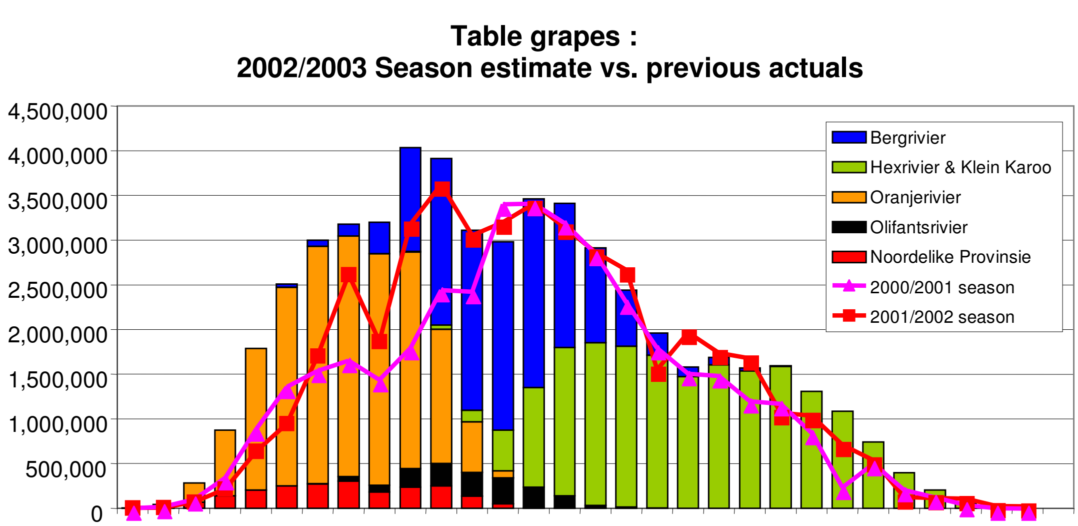


Figure 5.5: 2002/2003 Crop Estimate Compared with the 2001/2002 Actual Exports

Total exports have the potential to increase to 50 million cartons, up 6 million from the 2001/2002 season. The Orange and the Berg Rivers (which had a disastrous season in 2001/2002) will contribute to most of the growth in exports. Exports from the Hex River will be approximately 17-18 million cartons. Production in the Hex River has stabilised and only limited growth is expected in years to come because of the limited water resources.

Namibia contributes only about 2.5% to the Southern African table grape production. However, it is expected that this contribution will double in the next four years. Also, the LOR traditionally produced a relatively small volume of table grapes early in the season. This relatively small volume soared from approximately 8 million cartons during 1999/2000 to over 14 million cartons in the 2001/2002 season. With a growth of between 8-10% expected for the next three years, it can be expected that the comparative advantage with regard to a relatively "small" volume early in the season will gradually be eroded. Production costs in the Orange River (due to its distant location) are relatively higher compared to other production regions. If table grape prices come under pressure, the profitability and return on capital investment will decline substantially. The author is of the opinion that the table grape industry will remain a high value industry in this region for the foreseeable future. However, individual farmers should be very careful not to indulge in excessive loan capital to finance expansions since they can be sure that relative price levels and profitability are going to come under pressure in the years to come.

Wine and Dry Grape Industry

During recent years the profit margins of dry and wine grapes decreased substantially. The breakeven price per tonne of wine grapes during 2002 was approximately R 734/ton (estimated by Vinpro). However, during 2002, farmers only received an average net price of R 631.69/ton, more than a R 100 below the breakeven price. The main reason for the pressure on the price of wine grapes is the pressure to produce higher quality wines for the export market. During the past year, and still ongoing, the local industry made substantial investments to improve the quality of their wine products. However, this will take time to yield dividends and it is not foreseen that the situation will change overnight.

Conditions in the dry grape industry were also very depressed. The nominal price of Orange River sultanas per kg (which represents the largest contribution to total production) decreased from R4.20 for standard grade in 1999 to R3.50. At the same time, the inflation rate averaged approximately 8% over these years. The real price is therefore 24% lower than R3.50 i.e., R2.82. Also, most of the input costs increased by between 30 and 50% during 2002 after the horrific events on 11 September 2001. Innovative marketing strategies in the years to come should be able to increase profit margins again. However, for at least the short-term, depressed market conditions are expected.

Pecanuts (Alternative Crop)

Accurate production data for pecanuts in South Africa does not exist. It is estimated that the total area under production is approximately 2 000 to 2 500 ha. The problem in South Africa is not necessarily a lack of demand but rather to introduce the product to the general public through generic marketing. The industry is not properly organised, highly fragmentised with very little coordination. Also, on most farms the crop is just a sideline with production probably far under the potential of the trees due to a relatively low management input.

The Middle East and European nations, with the Netherlands leading, has a very high per capita consumption. Most of the nuts from South Africa are shipped directly to Rotterdam from where they are re-packed and distributed. A substantial potential therefore exists to add value in South Africa before shipment. A prerequisite for such an operation is a better organised local industry.

South Africa's main competitors are the USA, Mexico, Australia and Argentina. In spite of the present economic problems in Argentina, it is expected that they will become South Africa’s main competition. Recent research proved that Pecanut oil is the healthiest plant oil. The use of this oil reduces cholesterol and could play a major role in controlling this disease. Efficient marketing is the key for a profitable future for pecanut farmers. The medium to long-term prospects are relatively good.

Olives (Alternative Crop)

The almost 75-year old olive industry in South Africa was, until recently, relatively small and closed, but is expanding at a rapid rate and has become more open. New plantings are visible from Paarl in the Western Cape up to Prieska and Vaalharts in the Northern Cape, as well as the Little Karoo. South Africa's production is estimated to be approximately 4 000 to 5 000 ton produced on 1 500 ha. However, the area under production doubled during the last five years. These trees are now slowly but surely starting to bear and it is expected that production will more than double in the near future. It is estimated that approximately 70 farmers farm with olives, but that there are only six farms where it is produced as the main crop.

Between 20 and 30% of the total table, olive crop is being exported. In Southern Europe, the production of table olives has decreased over time because of the expensive labour in these countries. South Africa is very competitive with table olives, but not with oil olives because of the high level of subsidies in other countries. A major advantage of olive production is that the trees are productive for centuries. The establishment costs of trees are therefore insignificant. Also, olive production is fairly easy compared to deciduous fruit and wine and their water requirement is much lower. The current average price for olives is about R5.00 per kg and the yield on full bearing trees approximately 6 ton per ha.

The first planting of olives in the Vaalharts Region was in 1987 and commercial plantings commenced in 1992. It has been reported that the trees have adapted well and came into production earlier than expected. There should be no reason why olives cannot be produced successfully in the LOR. Marketing prospects look relatively good, especially for the export of table olives. However, there is a surplus of oil production (internationally) and European olive producing countries are highly subsidised, which makes it difficult to compete.

Pistachio (Alternative Crop)

The growth in this industry has been curbed by the relatively long period of time required for a pistachio tree to reach full production, typically ranging from eight to ten years and resulting in excessive development costs. These significant costs, combined with the long time horizon for payback of initial investment, serve to limit the number of new plantings that typically occur as commodity prices rise. As a result, the overall average earnings have remained fairly consistent as the tendency for growers to quickly respond to anticipated profitability by over planting has been limited.

The initial planting of choice was the Kerman variety on the *Pistacia Atlantica* rootstock, commonly known as the Atlantica rootstock. However, Atlantica rootstock has since proved susceptible to the *Verticillium Dahliae* wilt organism, a disease most commonly associated with land that was once planted to cotton. Many orchards planted on such cotton land have suffered significantly and will require eventual replanting. The pistachio industry recently responded with the development of the *Pistacia Integerrima* rootstock (commonly known as Pioneer Gold), which has proven resistant, but not immune, to the wilt organism. An additional benefit of the Pioneer Gold rootstock is increased vigour and production compared to Atlantica rootstock.

Mature pistachio orchards exhibit a pronounced alternate bearing cycle similar to avocados, with the entire industry generally rotating between a large crop one year and smaller crop the next. This tendency does appear more severe in orchards planted on the Atlantica rootstock than those planted on Pioneer Gold rootstock, especially in marginal orchards or those lacking in cultural care.

An extensive industry study of this alternate bearing phenomenon has yet to discover a “cure”. However, certain cultural practices, such as summer pruning, have shown promise in reducing the variability in production. In order to compensate for increasing crop sizes and the alternate bearing characteristic of the pistachio tree, the pistachio industry was faced with the challenge of effectively marketing the nuts to result in attractive grower returns. In general, commodity prices share an inverse relationship with the size of the crop, resulting in prices over $1.25 per pound in the off-production year, and lower prices, ranging from $0.92 to $1.10 per pound, in heavy crop years. While nut prices have trended downward as production has increased, the net resultant revenues, on a per acre basis, have continued to climb.

As noted, however, revenues per acre are much more a function of yield per acre, than of price per pound. Clearly, the economics of pistachio production are based on high yields per acre. Orchards, which produce at the higher yield rates, are relatively insulated from swings in nut prices.

Export markets continue to show promise for additional sales, especially in the Far East and in particular, Japan, Hong Kong and Taiwan. The majority of product sold is for the retail or consumer market, with relatively small amounts being sold for industrial or processing uses. Given the strong domestic market, per-capita consumption showed a steady upward climb during the early eighties as prices declined from historical levels. However, consumption slowed in the latter part of the decade as prices rose in response to declining production. Trend analysis indicates that general market equilibrium is achieved as prices stabilize near $1.10 per pound. This appears to illustrate the industry's need for a steady, consistent supply and the ability to accurately forecast future crop sizes. Supply may stabilize as the popularity of the Pioneer Gold rootstock increases and slowly replaces the older Atlantica rootstock. The average yield in California for the period from 1988 through 1999 is approximately 2,126 pounds per acre, although average yields have clearly been increasing in recent years.

The total world production remains dominated by Iran and the United States. Iran has historically produced over 65% of the total crop, with the United States, (California), following closely with 20 to 30% of the total crop. Iran's production appears to be heavily impacted by the alternate bearing characteristic, and the product is generally considered lower in quality, due to less sophisticated growing, harvesting, and processing techniques. However, little information is available on

Iranian production, and many question the accuracy of what is available.

Overall, the key to continuing profitability for pistachios is contingent upon the growers' ability to maintain high levels of production and quality standards, as well as the industry's ability to effectively educate the consuming public as to the superior quality of local pistachios. Obviously, the impact of the changing global economy and the lifting of the trade embargo with Iran may impact the industry in coming years. Given this background, the industry could become a viable component of agri-business in the LOR.

However, very little information is available on the production of pistachio under South African climatic conditions and until the crop has been tested in the LOR, it should be regarded as a high-risk crop.

Other Alternative Crops

Other alternatives, which were identified in the ORDPRS (1998) for the G5 (Boegoeberg) to G9 (Alexander Bay) regions are:

- Lemon;
- Grapefruit;
- Figs;
- Special export vegetables;
- Paprika;
- Grape (juice);
- Granadilla;
- Papaya; and
- Avocado.

Unfortunately, very little is known of the successful production and marketing of these crops in the Orange River Region since they are not proven products in this region. Recently, an opportunity to produce 400 ha paprika arose because of the situation in Zimbabwe. However, this market is much closed, and only accessible to a few individuals.

5.6.3 Financial Potential and Risks

After deregulation in 1997, the marketing environment in South Africa changed forever. Farmers operate in a globalized economy where they not only compete with their fellow farmers, but also with other governments. In this environment, competition is strong and only the best survive. There is no place in the market for farmers who cannot produce a quality product at a competitive price. Prices are not determined in South Africa - they are determined by global market forces. Potential investors in the LOR must realise this before they make large investments in irrigation agriculture. In considering any investment in this region, farmers must ensure that they can produce a product competitively. They must first do the right things (effective) and then do the right things right (efficiency).

Financial Potential

The opening up of new markets within the globalized economy creates enormous financial potential. The development of the table grape industry in the LOR proved that if it is possible to produce a high quality product within a market window where it is difficult for competitors to produce, the financial rewards are substantial, not only for individuals but for economic growth in the whole region.

The author is of the opinion that more market research is necessary to draw the attention and interest from potential investors. Also, local agri-business and government should invest in more research on alternative crops for the region. The pressure from international retailers to supply healthy food is increasing. If the Lower Orange Region can succeed in being branded as a preferred supply region for many different crops because of the relatively healthy production environment, the rewards will be substantial.

Horticultural crop production has excellent profit potential and the ability to generate significant income on small areas and limited resource farms. This profit potential, however, comes with a fair amount of risk. Producers must be prepared to not only produce a high quality crop, but also be an active and aggressive marketer. Initial investment is high and the substantial annual cost of production requires growers to be able to financially weather annual cash flow demands (and the costs associated with pre-productive years in fruit crops). For those who can balance the demands of production and marketing, the future of fresh market horticultural crop production, in particular, appears very favourable. Per capita fresh consumption of most fruits and vegetables is rising, which bodes well for the continued strength of fresh market prices.

Risks in Irrigation Agriculture

When considering profitability, people are often seduced by the potential of fruit and vegetable production. Compared to most agronomic crops, these horticultural crops offer the opportunity to produce a fair amount of income per ha. With this income potential, however, come sizable risks. These risks can be categorized as either those impacting receipts, or those relating to the cost of production.

Yield and Price Risk

Receipts are the gross returns (price times yield) from production. For perennial horticultural crops (tree fruits and nuts, small fruits), receipts may be zero for several years, while the planting is in the pre-productive stage. Variability in both yield and price will affect receipts. The ability of the producer to deal with both types of variability will impact on the profitability of the enterprise. Large yields are not the important yardstick; having sufficient sales of high quality product is what is important to profitability.

Every year, horticultural producers face yield risk in the form of adverse weather and pest damage. In a perennial crop, yield risk can take the form of year-to-year variability, or more serious damage, which reduces the long-term production potential of the planting. Although yield risk is important, it usually has readily identifiable causes and remedies.

Producers can reduce the effects of yield risk through irrigation (see Cuykendall and White, 1998, Cuykendall, *et al*. 1999, and Jarrett *et al*. 1995), pest management practices, and site and cultivar selection. In addition, multi-peril crop insurance is available for many fruit and vegetable crops grown in the LOR. While it is important to minimize the effect of yield risks and their impact on profitability, producers are usually much better equipped to deal with this type of risk than those associated with marketing.

Marketing Risk

Marketing plays a crucial role in horticultural crop production and should be planned well in advance of harvest. In fact, fruit and vegetable growers really should be thinking of marketing prior to planting. This is particularly important for perennial crops where decisions about which varieties to plant are made several years prior to the first crop.

Knowledge of ***what*** the market requires (in terms of form and quality) and ***when*** to market is the key to success. Why do "good" growers go out of business, while others in less ideal production circumstances thrive? Often the difference is marketing acumen. Developing a marketing strategy requires careful evaluation of the supply and demand for your product and investigation of market alternatives. The successful marketer must strive to produce products, which satisfy basic customer needs and wants, rather than simply selling the products, he/she produces. Strategic marketing planning requires specification of target markets, or the individuals or businesses identified as the most desirable customers. The selection of target markets in turn drives decisions about products (including varieties and packaging), promotion, pricing, location, and distribution strategies.

Seven traditional (distribution) alternatives are generally available to the horticultural crop growers: wholesale market, marketing cooperatives, local retail, roadside stands, farmers markets, pick-your-own, and processing. Other options such as rent-a-row/tree, community supported agriculture, and internet and/or mail order may be worth investigating depending on the nature and location of the farm operation and the crops grown.

Price and quality are synonymous in horticultural crop production. Unfortunately, it is not always easy to know what is meant by "high quality" and quality judgement often varies from year to year. Grade standards do not exist for all horticultural crops and those that have them are often not very specific. Often, there is only one recognized quality grade, which means produce of "good average quality". Buyers, however, often have additional criteria by which they judge produce quality, including flavour, ripeness, aroma, cleanliness, and the absence of pest damage and foreign material.

Proper disease management, harvest practices (including picker instruction and supervision), and post-harvest handling are critical to marketing success. Cooling produce to remove field heat and improve shelf life is especially important in the LOR. Treatments to reduce decay may be another important consideration. Sorting and washing of some fruits and vegetables can also be done to help maintain quality and improve appearance.

Cost of Production

Horticultural crop production is not for the financially faint of heart. For certain vegetable crops, pre-harvest costs may amount to several thousand Rand per ha. For perennial crops, substantial initial investments are required and many years may go by before the crop breaks even. For most perennial crops, the pre-productive costs for land preparation and establishment are often many times the cost of annual horticultural crops. This is the period where growers are most exposed to financial risk. Growers must realistically assess their ability to absorb losses during this period and not rely on single enterprises for current and future income.

Naturally, growers complain when the costs of fertilizers and pesticides increase and they are often tempted to reduce these costs by cutting applications. In the whole scheme of things, however, these costs are minor. It makes little economic sense to jeopardize profitability by trying to save a few Rand here and there. Once the crop is established, the major cost by far in horticultural crops is for harvesting and marketing the crop. Labour management and costs are the primary concern given the new labour laws in both South Africa and Namibia. Investing in production practices, which reduce variability in yield and quality, are rarely a waste of money.

Good labour management is a key to horticultural crop profitability. Because of the perishable nature of these products, hand picking is often the only alternative. Understanding the labour market and planning for adequate and experienced labour is critical to having a high-quality crop ready to market. Growers must understand the laws, which apply to the use of agricultural labour. These laws include those relating to migrant and seasonal workers, child labour, wages and hours, unemployment compensation, family and medical leave, worker's compensation, worker protection (pesticide exposure, safe workplace, field sanitation), and migrant housing. Communicating the firm's personnel policies is a key element in effective human resource management.

Horticultural Crop Budgeting

Understanding the magnitude of the financial risks and the nature of cash flows in horticultural crop production requires the preparation of enterprise budgets. Enterprise budgets represent estimates of the receipts (income), costs, and profitability associated with the production of agricultural products. Budgets are used to:

- enumerate the receipts (income received) for an enterprise;

- enumerate the inputs and production practices required by an enterprise;
- evaluate the efficiency of farm enterprises;
- estimate benefits and costs for major changes in production practices;
- provide the basis for a total farm plan;
- estimate break-even price and/or yield for market planning purposes; and
- support applications for credit.

Enterprise budgets should contain receipts (income) for every product and by-product of the enterprise. Prices should be used, which reflect the markets faced and the productivity of the enterprise, given the specific resource situation (land, labour, equipment, etc.).

Total costs are the sum of variable and fixed costs. Although a grower's aim is to earn a profit above total costs, this is not always possible. Because of yield or marketing conditions beyond the grower's control, income received is sometimes less than the total costs of production. Should a grower continue to produce under these circumstances? The answer may be yes if:

(1) returns are above variable costs; and

(2) it is a short-term condition.

If fixed costs are not covered in the long run, however, re-investment in capital items (like tractors, implements, buildings, and equipment) cannot be made and the result is a depletion of the existing capital stock.

5.6.4 Comparison between the Upper and Lower Orange River Regions

The Boegoeberg and Kakamas regions are used to illustrate the vast difference between regions in the river where relatively high valued crops and in comparison relatively low valued crops are produced. Although the Boegoeberg region is per definition part of the LOR, the crop combination in this region, for the purpose of illustration, differs substantially from the Kakamas region. Also, survey data is not yet available for the Upper Orange River to make the kind of comparison needed to illustrate the financial differences in farming operations. Therefore, for the purpose of comparison only, the Boegoeberg region are regarded as representative for the upper reaches of the river and Kakamas for the lower reaches of the river.

The data used is from a farm survey[3] in Boegoeberg was conducted on 29 farms, which represent approximately 20% (1500 ha) of the total water rights allocated to the Boegoeberg irrigation region. The farm survey in the Kakamas region covered approximately 14% (1143 ha) of the total irrigated area on the irrigation scheme. Because crop combinations in both regions are relatively homogeneous, the sample can be accepted as representative for the purpose of this report. The results presented for Kakamas are those of 32 farmers. The intension of this section is not to compare all the survey results. Only the results, which are relevant to this report, are discussed. The detailed survey results are available from the author.

The reader should be aware that the results presented here are average figures. Substantial differences exist between individual farms. To capture these differences, representative farms were constructed by using the mean instead of average figures.

Land-use

The main difference between the two regions is in the farm structure.

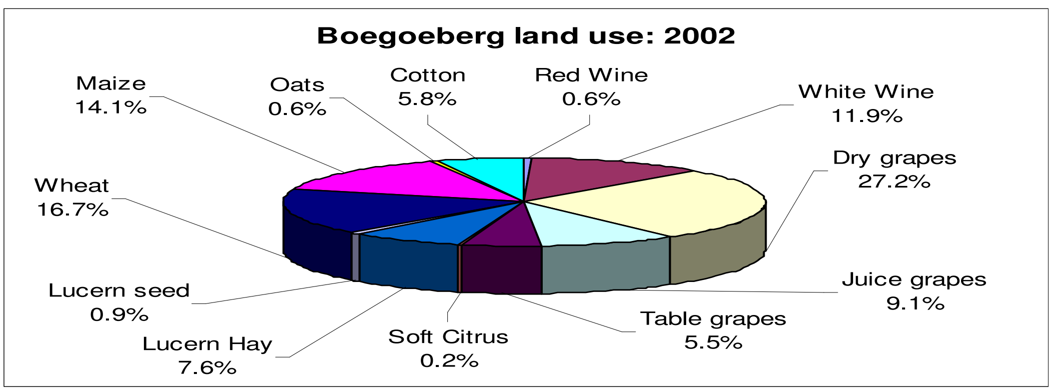


Figure 5.6: Boegoeberg Land-use

It is clear from **Figure 5.6** and **Figure 5.7** that the main difference in farm structure is the percentage area cultivated with long-term crops. The Boegoeberg region produces more short-term (lower value) crops than the Kakamas region. Also, the percentage contribution of table grapes (at present the highest value crop) in the Kakamas region is approximately 28% compared to only 5.5% in the Boegoeberg region.

This section is based on data, which were collected for a current Water Research Commission (WRC) project. Financial support from the WRC to enable the research is hereby acknowledged.

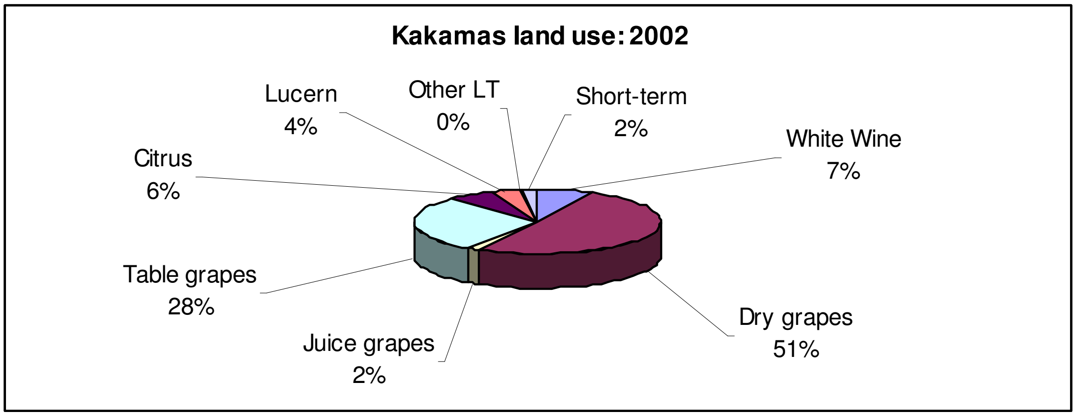


Figure 5.7: Kakamas Land-use

The reader must be aware that the model used in this report to calculate the relative profitability of farms does not account for risks. A present study funded by the Water Research Commission (WRC) will address the impact of these and other risk factors and the results should be available by the end of 2003.

Labour Use

Table 5-4 represents the difference in labour use and costs between the two regions. It is clear that the agricultural practices in the Kakamas region are more labour intensive.

Table 5-4: Labour Use and Cost Comparison

Labour	Begoeberg	Kakamas
Permanent labour (labourers)	9	15
Casual labour (man days)	3 178	5 978
Total labour costs	160 578	280 546
Casual permanent labour equivalent (240 days)	13	25
Total labour (casual plus permanent)	23	40
Labourers per ha irrigated	0.54	0.96
Labour cost per ha irrigated	5 386	6 328
Average labour cost per month per labourer	516	527

This can be explained because of the higher percentage table grapes in the region. It is clear that the number of labourers (permanent equivalent) is almost double, compared to Boegoeberg. Also, the remuneration per permanent equivalent labourer is slightly higher in Kakamas compared to Boegoeberg.

Figure 5.8 indicates that there are substantial differences in seasonal labour requirements between the two regions. These differences can also be explained because of the difference in farm structure. The table grape season commences in September and normally finishes by the end of February.

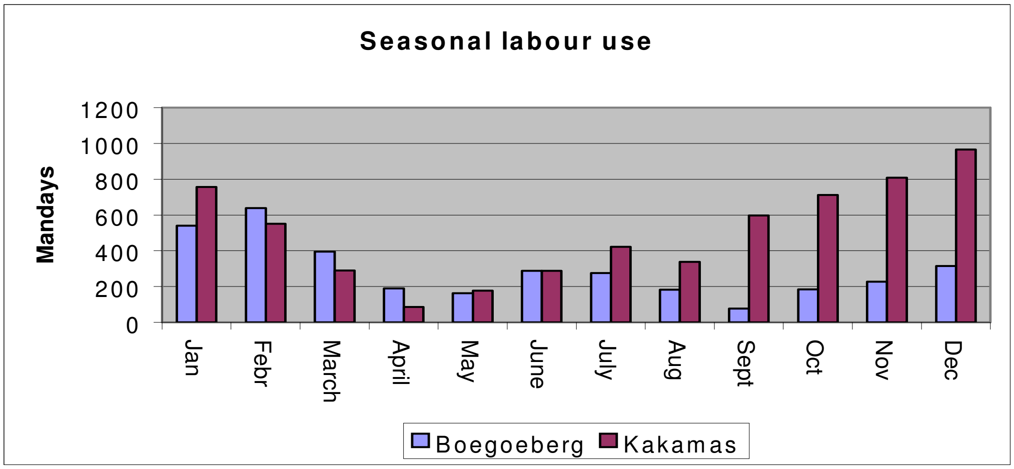


Figure 5.8: Seasonal Labour Use - Boegoeberg vs. Kakamas

Farm Valuation

It is clear from **Table 5-5** that there are substantial differences between the two regions with regard to capital investment. The difference is not surprising and can also be explained by the higher percentage of table grape cultivation in Kakamas compared to Boegoeberg.

Table 5-5: Valuation of Farm Assets

Valuation of farm per ha farm	Boegoeberg	Kakamas
Fixed improvements	10 294	41 496
Vehicles, machinery, implements, livestock	7 500	14 113
Land	35 861	83 478
Total	**54 809**	**137 387**

Liabilities

Table 5-6 represents the liabilities on farms for the two regions. It is important to note that in order to produce high value crops (such as table grapes in Kakamas) fairly high loan capital is required. The reader must be aware that high liabilities are also associated with high risks.

Table 5-6: Farm Liabilities

Liabilities	Boegoeberg	Kakamas
Short-term	256 516	837 258
Medium term	68 665	72 067
Long-term	285 225	640 348
Total liabilities	482 148	1 131 044
Liabilities per ha irrigated	9 888	33 541

Overhead Expenses

The overhead expenses (expenses such as accounting, maintenance, labour, etc., that are not easy to allocate to a specific crop or livestock enterprise) in the Kakamas region are almost 50% higher compared to Boegoeberg. The difference is not surprising since farming practices in Kakamas are much more capital intensive. These differences are illustrated in **Table 5-7**.

Table 5-7: Overhead Expenses - Boegoeberg vs. Kakamas

Overhead expenses	Boegoeberg	Kakamas	% Difference
Overheads per ha irrigated	4 053	7 776	48%

Water Cost as Percentage of Total Production Costs

Table 5-8 represent the total average production costs of farms in the Kakamas region. Water tariffs represent 3.4% of the total production costs.

Table 5-8: Kakamas Average Production Costs

Cost Items	Per ha	% of Total
- Direct allocateable	21721	78.3%
- Maintenance of fixed improvements	1010	3.6%
- Water cost	950	3.4%
- Electricity	942	3.4%
- Income tax	312	1.1%
- Administration fees	253	0.9%
- Consultation fees	247	0.9%
- Land rent	245	0.9%
- Insurance	239	0.9%
- Telephone and post office	232	0.8%
- Hired management	229	0.8%
- Bank costs	136	0.5%
- Other costs	1214	4.4%
Total production costs	**27730**	**100.0%**

Table 5-9 represents the average production costs in the Boegoeberg region. Water costs represent approximately 5.4% of the total cost of production in this region.

Table 5-9: Boegoeberg Average Production Costs

Costs Items	Per ha	% of Total
Direct allocateable	12629	75.2%
- Water cost	850	5.4%
- Insurance	542	3.5%
- Land rent	350	2.2%
- Electricity	276	1.8%
- Maintenance of fixed improvements	261	1.7%
- Hired management	174	1.1%
- Telephone and post office	145	0.9%
- Bank costs	105	0.7%
- Cellphone	92	0.6%
- Accountancy	87	0.6%
- Administration fees	76	0.5%
- Other costs	87	0.6%
Total production costs	**15674**	**100.0%**

Crop Budgets and Gross Margin per m³ Water Requirement

Table 5-10 represents the gross margins of existing crops in the region. For the purpose of analysis, it was assumed that the gross margins for the two regions are the same and that other factors (e.g., farms size, economies of scale) are responsible for differences in financial results. It is clear that the gross margin per m^3 water requirement is substantially higher for table grapes followed by red wine and dry grapes.

However, the reader should be aware that the author are of the opinion that from a water allocation policy (for regional economic planning) point of view this is the wrong criteria to be used since gross margin analysis only tells half of the story with regard to the economic contribution of crops in a irrigation region. It is of paramount importance that the forward and backward economic linkages of irrigation crops to the rest of the economy should also be considered. Unfortunately, these linkages have not been established in the Northern Cape Province. However, the author is of the opinion that they are substantial.

Table 5-10: Gross Margin per ha per m Estimates

Crop	Yield	Price/Unit	Gross Income	Production Costs	Gross Margin	Water Requirement (m^3/ha)	GM per m^3
Red wine	15	1200	18000	8254	9745	1472	6.6
White wine	25	600	15000	8453	6546	1472	4.4
Juice grapes	24	460	11040	7653	3386	1472	2.3
Dry grapes	25	850	21250	12221	9028	1472	6.1
Table grapes	15	8300	124500	79901	44598	1350	33.0
Lucern	18	500	9000	5652	3347	1477	2.3
Wheat	5	1400	7000	4363	2636	527	5.0
Maize	7	1300	9100	5380	3720	880	4.2
Oats	5	1300	6500	4062	2437	880	2.8
Cotton	3	2800	8400	5674	2725	1125	2.4

GM= Gross margin

Representative Farms

Three representative farms were constructed for Boegoeberg and four for Kakamas. The reason for an additional representative farm in Kakamas is to include a representative farm, which is similar to the large farm with a smaller veldt area and large irrigation area. The main criteria to construct these farms were farms size in order to capture the effect of economies of scale. **Table 5-11** shows the land classification of the representative farms.

Table 5-11: Land Classification of Representative Farms

Item	Boegoeberg			Kakamas			
	Small	Medium	Large	Small	Medium	Large	Extra large
Irrigable	22	42	95	9	24	35	54
Actual irrigated	22	41	90	9	23	35	54
Dryland	0	0	0	1	1	0	0
Veldt	5	30	24	0	440	292	58
Odd	4	15	37	4	2	6	60
Total farm size	**31**	**87**	**156**	**13**	**466**	**333**	**173**

Table 5-12 clearly shows the relatively smaller importance of short-term crops in the Kakamas area, as well as the larger contribution of table grapes on representative farms.

Table 5-12: Land-use on Representative Farms

Long-term crops	Boegoeberg			Kakamas			
	Small	Medium	Large	Small	Medium	Large	Xlarge
Red Wine	0	0.3	0.9	0.0	0.0	0.2	0.2
White Wine	3	4.7	13.2	1.4	1.9	2.3	4.9
Dry grapes	4	12.1	32.6	5.3	17.3	19.8	20.4
Juice grapes	3	7.3	4.0	0.2	0.5	0.7	1.0
Table grapes	4	3.4	1.8	0.0	2.7	9.3	13.4
Soft Citrus	0	0.1	0.1	0.0	0.0	1.2	9.6
Lucern seed	0		0.0	0.2	0.8	1.3	3.8
Dates	0	0.0	0.1	0.6	0.0	0.0	0.0
Total area	**19**	**32.4**	**58.5**	**7.7**	**23.1**	**34.7**	**53.3**
Short-term crops							
Wheat	1	8.3	20.9	0.0	0.0	0.0	0.0
Maize	0	5.0	21.3	0.0	0.2	0.0	0.0
Oats	0	0.8	0.0	0.0	0.0	0.0	0.0
Cotton	2	0.9	8.2	1.4	0.5	0.6	0.0
Total area	**2**	**15.0**	**50.5**	**1.4**	**0.6**	**0.6**	**0.0**
Total short + long-term	**22**	**47.3**	**108.9**	**9.1**	**23.7**	**35.3**	**53.3**

Table 5-13 represents the contribution of grapes to total area for each of the regions and representative farms.

Table 5-13: Grape Contribution to Total Area Cultivated

Crop	Boegoeberg			Kakamas			
	Small	Medium	Large	Small	Medium	Large	Xlarge
% Table grapes	18%	7%	2%	0%	12%	26%	25%
% Dry grapes	19%	26%	30%	58%	73%	56%	38%
% Wine grapes	16%	10%	12%	15%	8%	6%	9%
% Total grapes	67%	59%	48%	76%	94%	91%	75%

Figure 5.9 represents the contribution of representative farms to the total irrigated area in the Boegoeberg region. The combined area of large and medium farms is approximately 86% of the total irrigation area with small farms representing only 14%.

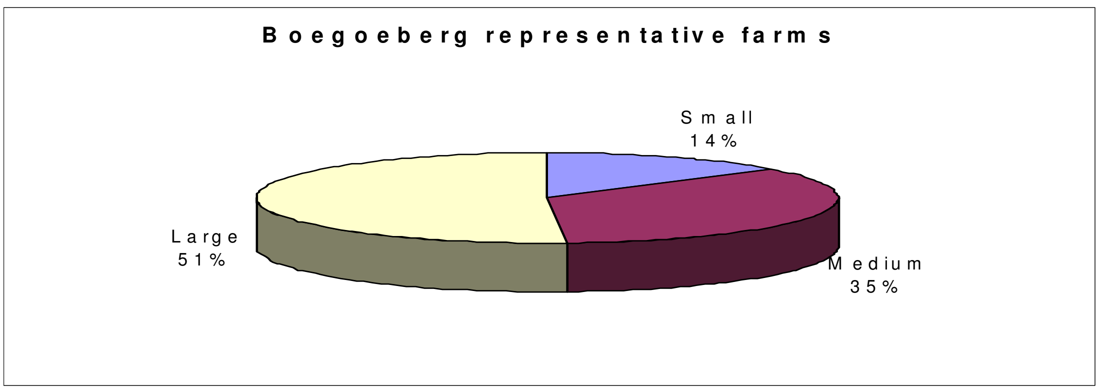


Figure 5.9: Contribution of Representative Farms – Boegoeberg

Figure 5.10 represent the contribution of representative farms to the total irrigated area in the Kakamas region. The combined area of Xlarge, large and medium farms is approximately 95% of the total irrigation area with small farms representing only 5%.

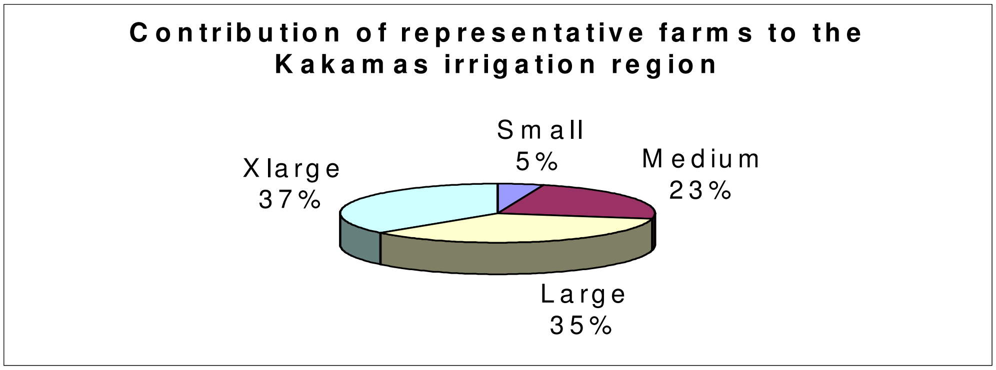


Figure 5.10: Contribution of Representative Farms - Kakamas

Farm size and structure plays an important role in the financial feasibility of farms. In the following section, the results of an analysis to compare the differences will be discussed and the reader can refer back to this section to explain the results.

Economic Comparison between Regions

Table 5.14 represents some economic parameters for the various regions and indicates the Gross Income (GI), Direct Allocatable Costs (DAC) and Net Disposable Income (NDI). The reader should note that depreciation is not accounted for in the calculations below since the survey did not collect adequate information for accurate depreciation calculations.

Table 5-14: Economic Parameters

ITEM	VDKL-HT	PD	Boegoe	Upkeim	Kakamas	AugBlou
Long term crops	546	430	1 324	994	2 003	1 046
Short term crops	10 252	15 907	669	20	49	0
Total Irrigated	**10 798**	**16 337**	**1 993**	**1 014**	**2 051**	**1 046**
Capital Investment per ha irrigated	**47 782**	**48 475**	**55 395**	**143 772**	**161 549**	**205 605**
Gross income per ha	12 225	11 978	17 002	38 168	41 657	91 034
DAC per ha	7 279	6 389	9 905	24 044	24 553	44 199
Total gross margin per ha	4 976	5 589	7 097	14 124	17 104	46 834
Overheads per ha	2 946	3 330	3 787	6 633	7 400	24 793
NDI per ha	**2 030**	**2 259**	**3 310**	**7 491**	**9 703**	**22 042**
Water use per ha	11 000	10 000	15 000	15 000	15 000	15 000
NDI per m^3	**0.18**	**0.23**	**0.22**	**0.50**	**0.65**	**1.47**

Results of Comparison

The financial results of a comparison between the two regions and between different farms sizes and farm structures is shown in **Table 5-15**. It is clear that in the Boegoeberg region, where relatively lower valued crops are produced, the return on capital investment, NDI per m^3 and per labour hour used, are substantially lower than that for the Kakamas region. Also, the large farm in Kakamas with the highest percentage table grapes (26%) scores the highest for all the comparison criteria.

Table 5-15: Financial Results of Comparison

Criteria	Boegoeberg		Kakamas			
	Medium	Large	Small	Medium	Large	Xlarge
Return on capital investment	3.6%	4.5%	1.2%	8.1%	14.6%	10.1%
Net Disposable Income per m^3 water	0.10	0.10	0.04	0.14	0.26	0.21
Net Disposable Income per labour hour	3.76	4.05	1.77	4.26	8.27	6.54

Development Implications for the Lower Orange River

The results of the analysis in this section clearly indicate that the financial results are substantially higher in a region where higher valued crops are produced. From a development point of view it is therefore important to only consider high yield potential, high value, medium to low risk crops.

5.6.5 Other Benefits and Potential

Employment

The potential for increase in employment with a 25% shift to high value crops is presented in **Table 5-16**. It was assumed that the large farm in Kakamas is a representative high value crops farm using 1.15 labourer per ha irrigated. Therefore, if present employment rise as a result of the establishment of higher value crops up to a level of 1.15 labourers per ha irrigated, average employment for the whole region (Kakamas plus Boegoeberg) will rise with 13%. However, in some cases the increase can be up to 38% depending on the current farm structure and level of employment.

Table 5-16: Potential Increase in Employment

Item	Boegoeberg: 7558ha		Kakamas: 6463 ha				
Farm size	Medium	Large	Small	Medium	Large	Xlarge	Total
Base employment per ha	0.53	0.33	0.46	0.83	1.15	1.13	
Number of ha of total scheme	2651	3867	297	1513	2279	2374	12981
Base number of labourers	1397	1265	136	1260	2623	2677	9359
25% increase in high value crops	1810	2060	187	1380	2623	2690	10751
% increase in number of labourers	22.8%	38.6%	27.4%	8.7%	0.0%	0.5%	13.0%

It should be noted that a major threat to employment is the new labour legislation. Louw (2003) estimated that approximately 19% of the present job opportunities would be lost at a minimum wage of R 650 and more than 60% at a minimum wage of R 800. The loss will be higher on labour intensive farms that produce high value crops.

Another threat to employment is the introduction of a property tax in agriculture. Louw (2003) estimated that if a property tax of 2% are introduced on the market value of land and fixed improvement and the tax is not deductible from other taxes the results will be similar (19% job losses) as with the introduction of a R 650 minimum wage. When a property tax of 2% and a minimum wage of R 650 are introduced simultaneously, job losses will be in excess of 60%.

It is important that regional planners and policymakers take cognisance of these policies when they consider development projects. The introduction of these agricultural policies will without doubt impact negatively on irrigation development in the LOR.

Possibilities for Development of Small Farmers

Garden Farmers

Several towns on the banks of the Orange River such as Groblershoop, Upington, Keimoes and Kakamas offers the possibility for home garden development to ensure food security to the inhabitants. Apart from these municipal areas, the informal town settlements also offer the possibility of home garden development. The potential has not been developed to the fullest, but offers the opportunity for future farmers to get the knowledge and experience of vegetable growing under irrigation.

New Farmers

Almost all the opportunities for development projects along the Orange River are connected to irrigation. Established small farmers in the LOR irrigation area were involved in the agricultural development projects (Eerstekuil, Congregational Church Ground). These farmers are relatively well organised and anxious for development, compared to small farmers in the rest of the country. Some of these farmers have up to thirty years experience in small-scale irrigation farming.

Small farmers struggle to exist because their land is usually very small (1 hectare) and is situated on the flood plain of the Orange River and thus exposed to flood damage. A minimum unit of 5 hectares is perceived as a feasible unit. The literacy level of the small farmers is regarded as the highest in the country. The population is concentrated in centres along the river, which make the accessibility of schools, clinics and other services easier and more effective. Training opportunities improved through the attempts of irrigation farmers to uplift labourers through literacy and management training.

The LOR area offers the best opportunity for settlement of new farmers in the Northern Cape Province. Around 160 000 seasonal farm labourers obtain new skills and training every year when they do seasonal work on commercial farms. The potential for small farmer support and development includes the following:

- Support to existing farmers to be more effective and profitable. Although the high-risk approach of intensive farming is not necessarily applicable to small farmers, they can learn the principles risks and agricultural production management by attending training periods at present successful farmers.

- Extension services from the Department of Agriculture, farmers and private organisations should be co-ordinated to prevent confusion under small farmers. The Department of Agriculture should strengthen its extension services with highly trained officers.

- The Congregational Church Grounds (Curries Camp and Soverby) have "outside land" available for potential irrigation development, but water will have to be pumped and only high-income crops can be considered. A potential extension of 450 to 500 hectares will provide an additional 1000 employment opportunities (4 500 to 5 000 dependants at 3 to 5 individuals per family will benefit from this). The establishment of a vineyard in the Eerstekuil rural area can create an additional 1 400 farm labourer jobs. At Riemvasmaak, a potential 133 permanent farm jobs can be created if 400 hectares of dry grapes are established or a 1 600 farm jobs if 400 hectares of export grapes are established.

The Agricultural Research Council (ARC) is also involved with extension services in the region.

Economic Empowerment of Previously Disadvantaged Groups (PDGs)

Many people think that land ownership is a prerequisite to empower PDGs in agriculture. However, the supply chain of many agricultural products is long and there exists many opportunities to empower people by creating opportunities within the supply chain. There is also a strong link between the tourism industry in the Northern Cape and the irrigation agricultural sector. This link creates enormous potential to empower PDGs also in agri-tourism.

Social and Socio-economic Benefits

Appropriate development and expansion can be highly significant for the economy and the accompanying upliftment of the communities in the province. Indications are strong that expansion will be to the advantage of the province and the country.

Almost 35% of agricultural production in the Northern Cape contributes 32% of foreign earnings. 25 Percent of these earnings go directly to labour. The area has a healthy, self-sustaining economy, due to the fact that more than 90% of the earnings in the rural area are spent in the local economy, which make improved services possible.

The availability of water and the favourable climate enable the area to react on world market opportunities. The local business sector is supported by these developments in the form of soil preparation services, transport services, nursery and plant material supplies, pipes and irrigation equipment, trellising material supply, etc.

The towns in the regions' infrastructure are almost exclusively developed and maintained by the irrigation farming industry. However, the whole region reaps the benefits. According to local authorities in the region, towns are totally dependant on agriculture for their existence. More than 70% of the secondary industry activities in the LOR are connected through forward and backward linkages to agriculture with little connection to the mining industry.

Towns like Groblershoop, Upington, Keimoes and Kakamas alone have a population of more than 100 000 people. These towns do not have an alternative water source and is totally dependent on the availability of water from the Orange River. Also towns like Pofadder, Seinkopf, Springbok, Concordia and Port Nolloth are supplied with water directly from the Orange River.

There is a strong interaction with the livestock industry as well. The local feedlot industry, which is mainly supplied from lucern and grains grown from the Orange River water, has a stabilising effect on the livestock industry. The 600 000 hectares extensive livestock production area of Western Kalahari is dependant on the Municipality of Upington for their domestic water, as well as for stock watering. The rural areas have no alternative water source. The Geelkoppan stock farming area is also dependent on water from the Orange River. The Mier area would also like to get water from the Kalahari pipeline, but due to the bad economic position of the community, it is not possible.

The optimal usage of national assets like the airport, roads, railway line and irrigation infrastructure, as well as the extended specialised infrastructure like cold stores, wine cellars and grape juice plants, are of benefit to the economy of the whole country. A mine like Aggeneys is served by water from the Orange River and so will the possible future mine developments at Renosterkop (Augrabies and Keimoes).

Regional Development

The Northern Cape is the largest of the nine provinces, making up 30% of the land surface of South Africa. Its borders touch four other provinces, the Atlantic Ocean, and the countries of Namibia and Botswana, making the Northern Cape ideally situated as a gateway to West African markets.

The economy of the province is dominated by the primary sector. The Province offers unique and profitable investment opportunities in the areas of mineral-processing, agro-processing, fishing, marine culture and tourism.

Four Investment Corridors have been developed:

- Namaqua Corridor;
- Karoo Corridor;
- Diamond Field – Kalahari Corridor; and
- Orange River Basin.

The major infrastructure to support developments includes:

- Buchu Bay / Doring Bay deep water harbour servicing mining and agricultural sector.
- Upington Airport – perishable and international cargo hub.
- Gamsberg to Loop 10 railway Line – facilitating regional development opportunities.

The Northern Cape produces some of the highest-quality agricultural products in South Africa. Produce ranges from grapes, lucerne, cotton, wheat, corn, carrots, potatoes, groundnuts and Soya beans. The province is fast becoming a significant exporter of table grapes, raisins and meat.

Opportunities exist for the production and processing of dates, olives, rooibos tea and citrus products. The establishment of fruit and vegetable processing operations would add value to the province's agriculture products. Growth in agro-related industries would also create a market for the establishment of related businesses such as fibre sack and cardboard carton manufacturing. The Northern Cape is a large producer of sheep and goats, with specialist products such as ostrich meat on the rise. The livestock industry is to a large extent supported by fodder production from irrigation in the Orange River.

The Northern Cape is richly endowed with natural beauty and resources that appeal to tourists who appreciate the vast open spaces and serenity it provides. The long sun-drenched days, the silence of the veld, the extremes that range from rolling sand dunes to stark and craggy lunar landscapes are features that are attracting increasing numbers of tourists. The tourism industry exhibits significant growth potential.

The province has four National Parks, five Provincial Parks and over 300 registered game farms – all providing huge opportunities for potential investors. The province has an engaging mix of historic and archaeological sites. Investment is required to upgrade accommodation facilities, develop new attractions and entertainment centres -like theme parks -and upgrade air transportation networks.

For those who want to export to Southern Africa, Northern Cape borders on the important markets of Botswana and Namibia and is the closest South African province to Angola, earmarked by many as a vital future market.

The specific opportunities for companies that want to make locally sourced products are numerous. These include carrot and fruit juice processing, vegetable canning, groundnut and wheat processing, meat and leather processing, cotton and wool-based textiles, wine-making, sunflower oil production and Soya-based products.

The development plans for Port Nolloth will help facilitate exports of both processed minerals and processed fish. The R 905 million project (which is inviting foreign investors) will provide the province with its own deep-water port serving key export destinations in Europe and the Americans. This would prevent the need for exported products to leave Northern Cape via another South African province or Namibia.

Access to raw materials, cheap energy, and upgraded communications infrastructure, the conditions for competitive value-added processing in Northern Cape are already in place. The only key criterion missing from this list is labour. Here again, the province scores highly. Labour is among the cheapest in South Africa.

While there are clearly a wide range of sectorally defined opportunities to promote economic growth and development, it is important to take into account where such opportunities are to be found geographically. It is true that there is a need to "back the winners" and exploit every opportunity that arises, especially bearing in mind the poverty and unemployment that challenges us. However, the fact is that some regions are better endowed with economic potential than others and the geographic distribution of socio-economic needs does not always mirror that of economic opportunity. The Lower Orange is one of these regions; there is a huge opportunity to develop this region and reduce or eliminate poverty. The Northern Cape Department of Agriculture will specifically target areas such as Riemvasmaak, Schmidtsdrift, Goodhouse and Witbank for development.

5.7 Rate of Development

Over the last three years, the growth rate in land under irrigation in Namibia was more than 25% per year. If this growth rate is maintained for nine more years, all the land that has been identified on the Namibian side of the river, will have been developed. It is, however, unlikely that this growth rate will continue. Some of the areas that have been identified, will require high development costs and are therefore likely to slow down the development.

The rate of development is subject to a number of criterias:

- The available markets will have a major influence on the rate of development. If the market for export table grapes remains as lucrative as it has been in recent years, the current growth rate will remain steady.
- The producers have only recently started to investigate the potential market of the Far East and other areas.
- The development of internal infrastructure such as roads, power lines, communications systems and social facilities will influence the future development.
- The availability of water will not only influence the development, but may under unfavourable circumstances, restrict development.
- The nett income per cubic metre of water, used for table grapes, is five times more than that of the next crop and up to eight times more than that of crops such as maize. This margin is sufficiently high to warrant the development of the LOR area at the expense of existing development in areas with a less favourable climate.

5.8 Possible Development Models

5.8.1 Guidelines in South Africa for Small Scale Farming Development

The South African programme for Land Redistribution for Agricultural Development is designed to provide grants to previously disadvantaged South African citizens to access land specifically for agricultural purposes. The objectives of the programme are:

- To increase access to agricultural land by black people (African, Indian and Coloured) and to contribute to the redistribution of approximately 30% of the country's commercial agricultural land over the duration of the programme.
- To improve the nutrition and incomes of the rural poor who want to farm on any scale.
- To overcome the legacy of past racial discrimination in ownership of farm land.
- To facilitate structural change in the long run by assisting formerly disadvantage people who want to establish small and medium-sized farms.
- To stimulate growth from agriculture.
- To create stronger linkages between on-farm and off-farm income generating activities.
- To expand opportunities for women and young people who stay in rural areas.
- To empower participants to improve their economic and social well-being.

- To contribute to relieving the congestion in overcrowded former homeland areas.
- To enable those accessing land in communal areas at present, to make better productive use of their land.
- To promote environmental sustainability of land and other natural resources.

Every participant to the program must make a contribution of at least R 5 000. This contribution can be in the form of labour inputs. For this minimum contribution the participant will receive a grant of R 20 000. For higher own contributions, higher grants will be applicable. The largest grant is at present R 100 000 per participant, with an own contribution of R 400 000.

It is against this background that future development of small-scale farmers will take place along the LOR. Discussions with the Department of Agriculture for the Northern Cape indicate that no specific, or detailed, short and medium term programs currently exist for the Lower Orange.

5.8.2 Experience in Namibia

Any development model for new or small farmers will require subsidization of the initial capital costs in one form or another. As security for these inputs a form of control, which is not always appreciated, is essential.

Potential farmers have to qualify for placement. Basic qualifications would include knowledge of the crops to be planted, a financial understanding, and knowledge of irrigated agriculture and perhaps, most important of all, a capital input that he or she stands to lose if they are not successful.

The form of contract for these farmers must make provision for successful farmers to advance. By the same token, such a contract must allow for non-performers to be replaced.

It is further necessary to provide ongoing training to the farmers. The most effective form of training is to embroider on the farmers' own experience. Budgets should allow for experts in all the specialist fields involved to visit the farms and lecture the farmers, but also for specialists to visit farmers if there are particular problems.

The manager of a model comprising a commercial farm and a number of associated small farmers, as proposed here below, should have specific managerial skills rather than farming skills and should be assisted by a number of specialists that must be available on contract.

Due to various problems that have been experienced over time with the development of small-scale irrigation schemes, a model was developed where commercial development is done in combination with the settlement of small farmers. The main problem area that persistently and clearly emerges when studying the history of irrigation schemes in developing countries, and more specifically, where settlement of small farmers was involved, is the inability to ensure continuous, reliable and proper management and support.

This fact mainly prompted the idea of a "Farming Model" where the development of a settlement component directly alongside the commercial component service provider was chosen. The objective is to create a strong basis whereby the commercial component takes the initiative to experiment with new crops, develop markets and thereby create a modern and business orientated environment for settlement farmers to operate in. This arrangement further offers the very important opportunity to achieve proper management.

The primary function of the Service Provider is to render services to the settler farmers and surrounding community at cost. This means that beneficiaries will not be subsidised by government, but have to pay the full cost of inputs. The Service Provider will not make any profit out of the settlement component, but will only recover actual costs, inclusive of operational and replacement costs, plus handling charges.

The second function is to farm the Commercial Unit of the Project at optimum level in order to create funds to cover operational expenditure, including replacement, and to generate funds for capital investment on the project. The Project Manager will also share in the profits of this unit (all income and expenses being taken into account).

The tasks of the service provider will include the following:

- Administer the credit scheme for the settler farmers for crop production;
- Provide water and electricity up to the boundary at cost;
- Provide mechanisation services at cost;
- Provide agricultural inputs such as fertiliser, seeds and chemicals;
- Provide processing facilities and marketing;
- Provide practical training to new farmers; and
- Help to train new project leaders.

The National Development Corporation (NDC) Scheme at Aussenkehr is based on this principle. The idea can be exploited further through leasehold agreements and private sector involvement. The model may need further development, but it provides a good framework to help new farmers to gain the necessary skills to develop as future commercial farmers.

5.9 Benefits of Development

The benefits of development in the LOR are obvious.

- It is the area where water can be used to the biggest economic advantage in agriculture in Southern Africa.
- It will bring economic upliftment to an impoverished area.
- It will stimulate regional infrastructure development.
- It will earn foreign currency for both countries involved.
- It will create job opportunities in an area where there is currently very little other potential for development.
- It will warrant the establishment of social infrastructure such as schools and medical services.

5.10 Constraints in Development

5.10.1 Topography

The topography along the LOR is one of its biggest constraints to development. As a result of the topography, access and the construction of infrastructure is expensive.

5.10.2 Provision of Bulk Infrastructure

The provision of bulk infrastructure in certain areas may be a major task and very costly. In the selection of development options, areas with difficult access for roads and other infrastructure were identified. These areas will be marked where appropriate for later development. The joint development of infrastructure like electricity, remote telephone services and other related services by both countries warrants further investigation to realise the benefit of scale.

Agricultural development in particular has suffered because of the expensive infrastructure. Irrigable land is spread along a 400 km long rugged river valley, which requires extended infrastructure. The income from cash crops did not warrant the establishment of proper infrastructure to isolated pieces of land and in many instances, even the high value crops that are now under consideration do not warrant the high investment cost of infrastructure.

Powerlines can be constructed over a rugged terrain, but the roughness has an adverse effect on the cost. The long length of line per hectare of irrigation that is required in this area remains unattractive.

Road access is more problematical. In general, road access to the river is from main roads running in an east-west direction quite a distance away from the river. The access roads to the river are generally not of a high standard and have to negotiate rough terrain and often only serve a single farm or patch of irrigable land.

These constraints have been taken into account in the evaluation of the available potential irrigable soils.

5.10.3 Water Quality[4]

The problems relating to irrigation can be divided into two categories, namely effects on the soil and on the plants. The effect on soils is mainly concerned with clayey soils, where the colluvial structure can be destroyed due to ion exchange (mainly sodium). This affects the infiltration capacity of the soil, which again affects the availability of water to the plant. The soil structure can be improved by means of ameliorative measures such as the application of gypsum, albeit at a cost.

Plants are mainly affected in two ways. Firstly, higher salt concentrations in the root zone means that the osmotic potential is increased, which may lead to a situation called physiological drought in the plant. This means that the roots cannot absorb sufficient water, even though the soil may be saturated. Secondly, some constituents have a toxic effect on plants. The sensitivity to these constituents varies from plant to plant. In both cases, the resultant effect is a reduction in the yield. Salt concentrations in the root zone can be controlled to some extent by means of over-irrigation or leaching. The excess water applied (expressed as a fraction of the net demand) is normally referred to as the leaching fraction.

Water quality affects both the soils and the plants that are irrigated. The effect is that crop yield is reduced and/or management inputs are increased. The effects of water quality are therefore dependent on a complex relationship between soil type, crop type and management options. In general, it can be said that the cost of production increases as the quality of the water deteriorates, and that the yield decreases.

The norm to ensure fitness of use for irrigation is therefore that the water can be

[4] Abstracted from: Orange River Development Project Replanning Study, Water Quality Aspects : Orange River Basin : Volume 1 : Expected Water Quality Changes FINAL, 3157h.wpd 6 - 2 April *1998*

used for even the most sensitive crops and soils without any reduction in the yield or the need for special management practices. However, these standards should be site-specific as certain areas may not have sensitive crops and the water quality guidelines may be slightly reduced.

Whilst climatic influences are often ignored in salinity studies - owing to lack of sufficient experimental data to quantify differences - the effects of climate are known to be significant. The arbitrary factors chosen above are indicative only, but due to the extremes of climate involved and the nature of the study where broad patterns only are being considered, the assumptions are considered justified.

Irrigation systems employed, with respect to frequency of application of water, will have an influence on the salinity effects experienced by a crop. However, not all crops can be grown under the different system types (e.g., wheat under micro-jet is not practical). In other cases, the possibility exists of growing a certain crop under high and low frequency irrigation types. High frequency irrigation is practical for the growing of high value crops on the LOR.

The increase in the median salt load between the current scenario and the future scenario at the Orange/Vaal confluence is due to the increased salt concentration of the water in the Vanderkloof Dam. The variability of the salt load decreased, with the result that the total salt load over the modelled period decreased. The reduction in the variability of the salt load is a result of the increased flow regulation in the river. Once the modelled transfers from the upper reaches of the river are in operation, the Gariep and Vanderkloof Dams will spill less often.

It is interesting to note that the median salt load at Vioolsdrift remained the same (for all practical purposes), while it reduced at the Orange River mouth. This is mainly due to a drastic reduction in the flow in this part of the river. The marked decrease in the variability of the salt load at Kakamas can be ascribed to the fact that this represents the salt load just downstream of the diversion weir. As the irrigation demand at Kakamas represents a substantial portion of the flow in the river upstream of the diversion weir, the flow becomes highly regulated. This effect disappears further downstream as natural contributions have a more pronounced effect on the flow in the river.

A somewhat disturbing result from the model output is the decrease in salt load down the river. This means that salt is retained in the system, a situation, which cannot continue indefinitely. Further investigations into salt retention on irrigated lands should be conducted as a matter of priority in order to validate this effect.

As was expected, the salt concentrations increased substantially. This effect was more pronounced further downstream. A noticeable change in concentration occurs between Boegoeberg and Kakamas in both scenarios. This is due to the effect of the irrigation return flow from the Boegoeberg area on the reduced flow in the river.

The change in salt concentration will not significantly affect the fitness for use of the water for irrigation, except for the area below Vioolsdrift. In this area, it will not be possible to grow salt sensitive crops such as onions economically. However, the main crops in this area, namely table grapes and dates, will not be affected.

The increase in salt concentration, although substantial in absolute terms, is therefore not significant in terms of fitness for use. This should, however, be confirmed as soon as the question of salt retention in the catchment has been resolved, as the salt concentrations may be much higher in the long run than the model predicts.

In the river below the Vanderkloof Dam, there is more variability in the concentrations, with regular sharp increases. These increases are associated with periods of low flow, and are to some extent due to the way in which the model performs the calculations. The real increases will be less pronounced, but they will still occur.

The impoundment at Boegoeberg serves to dampen the peaks, and this is probably a fairly close approximation of what will occur in the river itself. The concentration here never exceeded 500 mg/ℓ and therefore, remains fit for use for the irrigation of any crop.

At Kakamas, the concentrations exceeded 500 mg/ℓ regularly, but remained below 750 mg/ℓ on all but a few isolated occasions. These short duration exclusions beyond 750 mg/ℓ should have no long-term effect on permanent crops, although the yield of sensitive cash crops such as onions may be significantly reduced during such episodes of high salt concentration. The same applies to Vioolsdrift, where the same pattern occurs as at Kakamas.

The situation downstream of Vioolsdrift is, however, cause for concern. There is a marked annual cycle in the salt concentration of the water, with variations between 400 and 1 500 mg/ℓ. Under these circumstances, only salt-tolerant crops such as dates and wheat can be grown. It should be possible to mitigate the situation by providing a balancing dam at Vioolsdrift, which would not only serve to reduce operational losses, but will also buffer the fluctuations in salt concentration. A median salt concentration of between 500 and 750 mg/ℓ can then be expected. This will render the water fit for use for irrigation of most crops.

The results of the model have shown that the predicted change in salt concentration is not significant in terms of fitness for use, except in the Orange River downstream of Vioolsdrift. This conclusion should, however, be seen against the background of the following facts:

1. The difficulty of calibrating the salinity model due to problems with the available Data; and
2. The question of salt retention in the system (which is what the available data suggests) and which cannot continue indefinitely.

The information in **Table 5-17** gives an indication of the salt/chloride tolerance of the main crops envisaged to be developed along the LOR. The figure quoted for grapes is for low frequency irrigation. With high frequency, well controlled irrigation (micro or drip) possible negative effects can be controlled better although at a higher risk.

Table 5-17: Crop Salinity Effects and Leaching Control

CROP DATA		Expected percentage crop yield (relative to normal) according to salinity and chloride level of irrigation water											
		GRAPES Using low frequency irrigation methods (Flood, sprinkler)						DATES Using high frequency irrigation systems (Drip, micro-jet, short-cycle sprinkler)					
Salinity Class	TDS Mg/l	**Total salts**			**Chloride**			**Total salts**			**Chloride**		
A	**@ Leaching %**	10	15	20	10	15	20	10	15	20	10	15	20
B	250-500	100	100	100	NDA	NDA	NDA	100	100	100	NDA	NDA	NDA
C	500-750	95	100	100				100	100	100			
D	750-1000	90	95-90	95				100	100	100			
E	1000-1250	80	90	90				100	100	100			
F	1250-1500		80	90				100	100	100			
G	1500-1750			80				100	100	100			
H	1750-2000							100	100	100			
								95-100	95	100			

The selection of crops for the LOR west of Vioolsdrift/Noordoewer should be done in a way that water quality does not affect the long-term future production prospects. It can be short-sighted to invest heavily in infrastructure and high value crops with associated industries and to lose return on the investment over time as a result of salinity or other water quality related problems.

5.10.4 Development of New Cultivars

The most lucrative market is when grapes of good quality can be marketed before the other global producers can produce table grapes. There are already a few new cultivars on the market that produce good quality grapes earlier in the season. In the western part of the United States there are attempts to develop new grape varieties that will produce grapes later in the season. If these two seasons coincide, it can be expected that market prices will drop.

5.11 Proposed Further Investigations

5.11.1 Use of a Social Accounting Matrix

It is suggested, that for the full Feasibility Study, a general economic equilibrium analysis should be used to quantify the direct and indirect effects with regard to the backward and forward linkages of each scheme. Social Accounting Matrixes (SAM) are available for both Namibia and South Africa.

The SAM differs from the traditional Input-Output Table (IO Table) in one important aspect. Apart from information on the interdependence among the different sectors taken up in the IO Table, the SAM also includes detailed information on the income and spending patterns of households.

By making use of SAM, the direct, indirect and induced effects of each scheme can be calculated. For example, the “direct effect” emanating from a particular scheme, refers to the effect occurring within the water sector, while the “indirect effects” refer to those effects occurring in the different economic sectors (those that link backwards to the water sector due to the supply of intermediate inputs). The “induced effect” on the other hand, refers to the chain reaction triggered by the salaries and profits (less retained earnings) that are ploughed back into the economy in the form of private consumer spending.

The analysis should be done for the standard economic aggregates, namely:

- Capital utilisation;
- Employment impact in different sectors;
- Impact on the GDP;
- Impact on the poor (Income distribution); and
- Fiscal impact.

This approach will provide additional insights into the impacts of the various water-augmentation schemes on the economies of both countries, as well as providing additional benchmarks for the comparison of alternatives.

With the use of a SAM, the proposals contained in this report such as the transfer of water rights from upper catchments to the LOR, growing of high value crops versus low value crops, different augmentation options at different costs can be evaluated in more detail. These models are not perfect, but as more information becomes available, they will become more accurate. It will contribute to attempts to quantify the economic multiplier effect of irrigation within a larger context.

5.11.2 Market Research

Existing information indicates that table grapes have the highest potential for the LOR. Total exports from RSA and Namibia are expected to increase to 50 million cartons - an increase of 6 million from the 2001/2002 season. The Orange and Berg Rivers (which had a disastrous season in 2001/2002) will contribute to most of the growth in exports. Exports from the Hex River will be approximately 17-18 million cartons. Production in the Hex River has stabilised and only limited growth is expected in years to come because of the limited water resources.

The advantage of the Orange River table grape industry has traditionally been the relatively low volumes early in the market when there is a shortage in supply. However, the expected increases in production are slowly but surely eroding away the "relatively small volumes" advantage of this region. It is expected that export volumes from the Orange River region will increase from 14.35 million cartons in the 2001/2002 season to 22.6 million in 2006. The major challenge for the region is to increase demand, by exploring new markets to coincide with the growth in supply. If this cannot be achieved, the region will produce itself out of the market and the current price advantage of this region will be eroded. With an estimated establishment cost of between R 250 000 and R 300 000 per ha (much higher than other production regions) the region is vulnerable to price cuts.

It is therefore necessary to consider other alternative crops for sustainable development. It is not possible to make a relatively accurate assessment with the current information available on the crop potential of the LOR. It will be necessary to identify irrigation crops, which are physically and biologically adapted to the region and secondly, to conduct a market potential study. Only then, will it be possible to make a proper assessment of the development potential of the LOR.

6. RIVERINE AND OPERATIONAL DEMANDS

6.1 General

Losses from the Orange River System represent important "demands" that must be taken into account. The main losses modelled in the ORRS analysis are normal transmission or conveyance losses, river losses from the Orange River and operating losses. Details of these demands are given in the following sections.

6.2 Riverine Requirements

6.2.1 Background

River requirements are a natural phenomenon to both regulated and unregulated rivers. In the case of unregulated rivers, the actual volume of the requirements is seldom quantified, as it is included in the hydrology or natural runoff. In the event of the Orange River, where water is released from Vanderkloof Dam and conveyed by means of the river to users as far as 1 380 km downstream from the point of release, it is of utmost importance to obtain a good estimation of the actual volume of the requirements, as they have to be included in the Vanderkloof Dam releases. Only approximately 6% (4% from the Namibia Fish River and 2% from the Orange River) of the total natural flow generated in the Orange River catchment (Vaal River included), is generated downstream of the Orange\Vaal confluence. The runoff generated in the Lower Orange (downstream of the Vaal confluence) therefore contributes an almost negligible amount to the downstream demands in the LOR. As a result of the long conveyance distance and extreme dry and hot conditions, large river requirements are bound to occur. These requirements are mainly due to evaporation from the river surface area, but also include seepage and evapo-transpiration from the riparian vegetation.

6.2.2 Evaluation of River Requirements

Separate studies funded by the WRC were undertaken by BKS (Pty) Ltd in order to evaluate the river requirements along the Orange River, with greater accuracy. The first or phase one study on the river requirements, “The Evaluation of River Losses from the Orange River Downstream of the PK le Roux Dam” (Vanderkloof Dam was previously PK le Roux Dam), was completed in 1994, and the results were available for use in the ORRS. For the purpose of the requirements study the Orange River was split into seven reaches as shown in **Figure 6.1**. A summary of the requirements estimated for each reach is given in **Table 6.1.**

For the purpose of Phase I of the requirements study, the evaporation from the Orange River was assumed to remain constant irrespective of the river flow. This assumption is considered realistic for all flows above 100 m^3/s. The assumption is based on the fact that the river cross-section is generally rectangular with the result that the surface area is relatively constant throughout a wide range of flows. When sand banks do appear, they are quickly overgrown with vegetation, particularly reeds, with the result that evaporation occurs through the vegetation in place of direct evaporation from the water surface. At very low flows, however, the above assumption is likely to over-estimate the evaporation from the water surface.

During the analysis phase of the ORRS, no further information was available, with the result that the figures given in **Table 6-1**, as obtained from the Phase I Losses Study, were used in the ORRS System Analysis.

Table 6-1: River Requirements Study Phase I - Summary of Net Evaporation from the Orange River

Reach	From	To	Length (km)	Areas of Evaporation (km^2)			Rainfall (mm/a)	Gross Evap (mm/a) (Symons Pan)	River Requirements	
				Water * Surface	Vegetation	Total			Mm^3/a	m^3/s
1	Vander-kloof	Orange/ Vaal	186	24.9	8.7	33.6	300	2 200	63.8	2.02
2	Orange/ Vaal	Boegoe-berg	283	59.9	19.4	79.3	230	2 340	167.3	5.30
3	Boegoe-Berg	Kakamas	236	74.3	24.4	98.7	150	2 590	240.8	7.63
4	Kakamas	20° E	77	12.6	5.4	18.0	100	2 700	46.8	1.48
5	20° E	Vioolsdrift	315	78.9	13.6	92.5	100	2 600	231.2	7.33
6	Vioolsdrift	Fish	135	32.9	3.8	36.7	50	2 400	86.2	2.73
7	Fish	Mouth	145	52.8	7.7	60.5	50	2 100	124.0	3.93
Total			**1 377**	**336.3**	**83.0**	**419.3**	**-**	**-**	**960.1**	**30.4**

Note: * - The water surface areas are based on river flows of between 400 and 1 000 m^3/s.

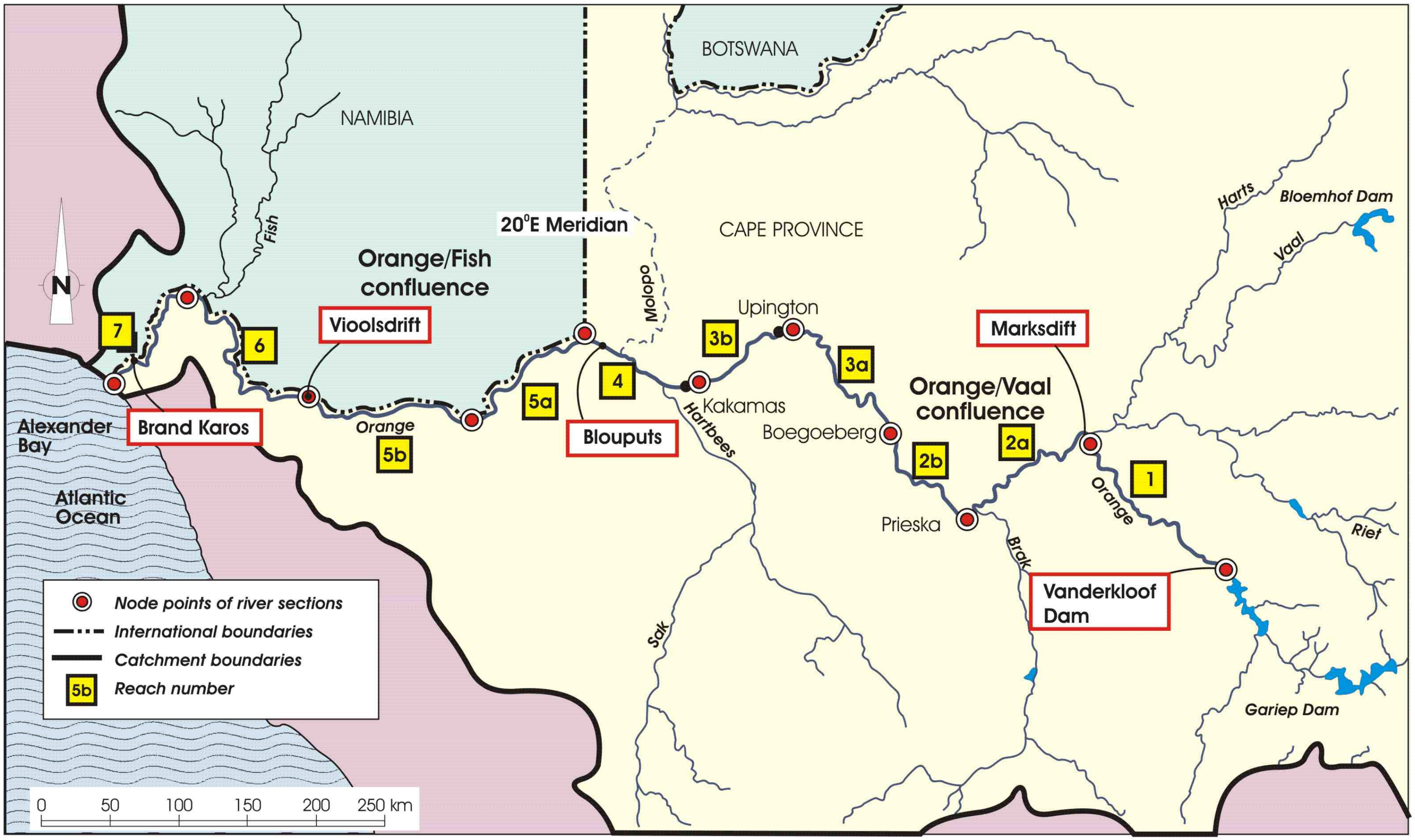


Figure 6.1: Orange River Basin – River Loss Reaches

The purpose of Phase II of the River Losses Study was to refine estimates of evaporation from the Orange River between Vanderkloof Dam and the river mouth, and to derive a general methodology for calculating requirements from other rivers in South Africa. Refining the estimation of the Orange River requirements included:

- Determining the areas of the water surface and riparian vegetation at different flows for each reach using aerial photographs, satellite images and hydraulic modelling.
- Environmentek derived information on evaporation rates from flowing water by using a Bowen Ratio Energy Balance Study. Results from this study were utilised for the Phase II Losses Study.
- Further evaluation of evaporation results indicated that the best estimate of river evaporation is given by the A-pan equivalent evaporation. This was obtained from work done by Schultze and Maharaj (1991, 1997).
- Evapo-transpiration rates for reeds and trees were based on research into riparian water consumption in the Kruger National Park (Birjhead, *et al*, 1996).
- Manual flow gaugings were carried out on the Orange River to assist in the verification of the requirements methodology.
- Validation of results was obtained by using a hydraulic model.

The calculated evaporation from the Orange River, derived from the Phase II Study, ranges from 575 Mm^3/a at an annual low flow release of 50 m^3/s to 989 Mm^3/a at an annual release of 400 m^3/s. The variation in evaporation is due to the change in surface area with flow. Although the river evaporation has been estimated in Phase II to be higher than the S-pan values, the reduction in surface area produced a net reduction in the total estimate of approximately 380 Mm^3/a. The river requirements as obtained from the Phase II Study are summarised in **Table 6-2** for each of the selected river reaches.

Table 6-2: River Losses Study Phase II - Summary of Net Evaporation from the Orange River

Reach	From	To	Gross Evap (mm/a)	Rainfall (mm/a)	Areas of Water (km²)		Area of River Vegetation (km²)		River Requirements (Mm³/a)	
					50 m³/s	400 m³/s	Reeds	Trees	50 m³/s	400m³/s
1	Vanderkloof	Marksdrift	2 665	301	17.8	31.3	0.5	7.7	52.4	83.1
2a	Marksdrift	Prieska	2 761	257	23.8	38.7	1.2	8.4	73.1	107.4
2b	Prieska	Boegoeberg	2 795	216	14.8	23.8	1.0	3.5	45.2	65.9
3a	Boegoeberg	Gifkloof	2 865	178	23.2	40.0	1.3	9.9	79.3	120.8
3b	Gifkloof	Neusberg	2 885	146	11.0	26.0	1.7	6.0	43.1	79.5
4	Neusberg	20° E	2 920	109	8.3	17.0	1.5	5.1	34.7	54.9
5a	20° E	Pella	2 938	75	16.8	36.0	1.4	6.0	60.8	111.6
5b	Pella	Vioolsdrift	2 921	42	19.5	46.0	2.4	7.4	73.8	143.1
6	Vioolsdrift	Fish	2 942	31	12.0	32.0	3.1	4.7	50.7	100.0
7a	Fish	BrandKaros	2 925	29	9.4	24.5	2.7	2.0	38.1	73.9
7b	BrandKaros	Mouth	2 765	39	4.1	14.2	1.0	7.5	24.1	48.9
Total	**Vanderkloof**	**Mouth**	**2 849**	**145**	**160.7**	**329.5**	**17.9**	**68.2**	**575.2**	**989.0**

The preliminary results from Phase II of the River Requirements Study became available towards the end of the ORRS. These preliminary results were therefore only included in the water balances given in the ORRS Main Report.

6.2.3 River Requirements Proposed for Use in this Study

During periods of high flows, the accuracy of the river requirements is not that critical, as there is sufficient water available under these conditions to satisfy the water requirements of the users along the Orange River, as well as to cover the river requirements. During low flow conditions when the river flow is mainly regulated by releases from Vanderkloof Dam, the accurate estimation of the river requirements becomes increasingly critical. Underestimating the river requirements will result in shortages in supply along the Orange River, which, depending on the time of occurrence, can have a significant effect on crop yields. Overestimating the river requirements will result in a total loss of the excess releases, as there is no significant storage available downstream of Vanderkloof Dam, to capture these releases.

The best and most reliable estimation of the Orange River Requirements currently available is the results from Phase ll of the Orange River Losses Study, as published in the WRC Report No 638/1/99, dated December 1998. Results from this report clearly show that the average annual flow rate in the Orange River has a noticeable effect on the river requirements. Estimations of the annual river requirements are given for three typical average annual river flows, 50, 120 and 400 m^3/s. The river requirements associated with the average river flows are 575, 706 and 989 Mm^3/a, respectively. It is therefore proposed that the most recent updated water demands to be released from Vanderkloof Dam should be used to determine the initial estimate of the Orange River requirements for use in the LORMS. An updated estimation of the river requirements can be made as soon as the water demands have been reviewed and updated as part of the LORMS. The most recent estimate of the releases required from Vanderkloof Dam can be obtained from the draft report "Orange River System: 2002 Hydro-Power Operating Analysis" dated May 2002. BKS (PTY) Ltd carries out these analyses on an annual basis on behalf of the DWAF to determine the surplus available in the Orange River System. These surpluses can be used for hydropower generation over and above the normal releases from Vanderkloof, which are used to supply the downstream requirements. The results from this report showed that the required annual release from Vanderkloof Dam for the 2002/2003 planning year is 70.65 m^3/s (2 230 Mm^3/a). Based on the river requirements versus annual river flow as published in the WRC Report, the representative river requirements for an average annual river flow of 70.65 m^3/s, is 615 Mm^3/a. The proposed river requirements based on the 70.65 m^3/s average annual river flow, is summarised for each river reach in **Table** 6-3.

The monthly distribution of the river requirements is given in **Table 6-4**. The distribution takes into account both the variation in evaporation, as well as the variation in the river flow over the year.

Table 6-3: River Requirements Proposed as the Initial Estimation for the LORMS Analysis

Reach	From	To	Gross Evap (mm/a)	Rainfall (mm/a)	River Requirements (Mm^3/a)		
					At 50 m^3/s River Flow	Proposed at 70 m^3/s River Flow	At 400m^3/s River Flow
1	Vanderkloof	Marksdrift	2 665	301	52.4	56.0	83.1
2a	Marksdrift	Prieska	2 761	257	73.1	78.1	107.4
2b	Prieska	Boegoeberg	2 795	216	45.2	48.3	65.9
3a	Boegoeberg	Gifkloof	2 865	178	79.3	84.8	120.8
3b	Gifkloof	Neusberg	2 885	146	43.1	46.1	79.5
4	Neusberg	20° E	2 920	109	34.7	37.1	54.9
5a	20° E	Pella	2 938	75	60.8	65.0	111.6
5b	Pella	Vioolsdrift	2 921	42	73.8	78.9	143.1
6	Vioolsdrift	Fish	2 942	31	50.7	54.2	100.0
7a	Fish	BrandKaros	2 925	29	38.1	40.7	73.9
7b	BrandKaros	Mouth	2 765	39	24.1	25.8	48.9
Total	**Vanderkloof**	**Mouth**	**2 849**	**145**	**575.2**	**615.0**	**989.0**

Table 6-4: Monthly Distribution of the Proposed River Requirements

Reach	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1	7.83	5.86	4.69	3.18	2.41	1.73	2.00	2.95	4.44	5.86	7.22	7.85	56.0
2a	10.92	8.17	6.54	4.44	3.36	2.41	2.78	4.12	6.19	8.17	10.08	10.95	78.1
2b	6.75	5.05	4.05	2.75	2.08	1.49	1.72	2.55	3.83	5.05	6.23	6.77	48.3
3a	11.84	8.86	7.10	4.82	3.65	2.62	3.02	4.47	6.72	8.86	10.93	11.88	84.8
3b	6.44	4.82	3.86	2.62	1.98	1.42	1.64	2.43	3.65	4.82	5.94	6.46	46.1
4	5.18	3.88	3.11	2.11	1.60	1.15	1.32	1.96	2.94	3.88	4.78	5.20	37.1
5a	9.08	6.80	5.44	3.70	2.80	2.01	2.32	3.43	5.15	6.80	8.38	9.11	65.0
5b	11.02	8.25	6.61	4.49	3.39	2.44	2.81	4.16	6.25	8.25	10.17	11.06	78.9
6	7.57	5.67	4.54	3.08	2.33	1.67	1.93	2.86	4.29	5.67	6.99	7.60	54.2
7a	5.69	4.26	3.41	2.32	1.75	1.26	1.45	2.15	3.23	4.26	5.25	5.71	40.7
7b	3.60	2.69	2.16	1.46	1.11	0.80	0.92	1.36	2.04	2.69	3.32	3.61	25.8
Total	**85.92**	**64.30**	**51.49**	**34.97**	**26.46**	**19.00**	**21.91**	**32.43**	**48.73**	**64.30**	**79.29**	**86.20**	**615.0**

6.3 Operating Losses

6.3.1 Background

Gariep and Vanderkloof Dams are used to support the demands along the LOR from Vanderkloof Dam to the Orange River mouth. These demand centres are located along a river length of approximately 1 380 km, which, together with river losses, and inflows from the Vaal and Fish Rivers, contributes to the complexity of operating the system and determining how much water to release from Vanderkloof Dam. A further complication concerns releases from Vanderkloof Dam to generate hydropower, which are sometimes in excess of the downstream demands. The large controlling structures (sluice gates, hydropower turbines, etc.) at Vanderkloof Dam make it very difficult to release the required flow with accuracy.

As a result of the problems mentioned above, it is clear that some operational loss should be expected. In view of the fact that in the past there has been excess water in the Orange River System, the whole question of such operational losses has been of little importance. Had excess water not been released from Vanderkloof Dam through the turbines, it would eventually have spilled or evaporated. It was therefore of greater benefit to the country to use such water for power generation. The whole situation has, however, changed and it has become necessary to release only as much as is needed to supply the various downstream users, including the needs of the environment.

6.3.2 Historic Operating Losses

The historic operating losses were quantified for the first time as part of the ORRS. From the data available at that time, it was very difficult to determine the historic operational losses, since it is only in more recent years that it has become necessary to reduce the releases to match the downstream demands. Preliminary estimates of the historic operational losses as experienced in practice were, however, made during the ORRS, which at least provided some indication of the extent of the operational losses.

Two estimations for the operational losses were made as part of the ORRS. The first estimation was based on the dry period 1982/83 to 1984/85, during which the water level in Vanderkloof Dam was below the storage control curve levels. This implies that the hydropower releases should not have exceeded the downstream demands. During this period, it was estimated that an average flow of 17m^3/s reached the river mouth and was therefore lost from the system. This estimate of 17m^3/s was obtained by means of a monthly water balance from Vanderkloof Dam to the river mouth. Flows estimated in this water balance were crosschecked at the various existing flow gauges. Inflows from the Fish River (Namibia) were subtracted from the Orange River mouth flows, for the purpose of this calculation. Based on this value and the total annual demand of ± 60 m^3/s supplied from Vanderkloof Dam by means of releases directly into the river, the operational losses were estimated to be in excess of 20%.

The second estimation was based on the period February 1993 to January 1994. During this period, the water level in Vanderkloof Dam was below the minimum operating level for hydropower generation. It was thus not possible to release water through the turbines during that period. Restrictions for downstream users were also imposed during this time, and an average flow of 55m^3/s was released over this period. The average demand over this period was estimated to be 45m^3/s (the effect of the restrictions included), indicating an operational loss of 10m^3/s, which represents 20% of the reduced demand and 17% of the full demand as determined in the ORRS.

These figures have been discussed with the operations staff at DWAF, and it was agreed that the operational losses from Vanderkloof Dam of between 15 and 20% of the downstream demand is realistic. For the purpose of the system analysis, it was proposed from the ORRS to use 280 Mm^3/a as a typical operational loss, which is almost equal to 9m^3/s.

6.3.3 *Operating Losses as Adjusted by Recent Studies*

The operational loss of 280 Mm^3/a, as determined from the ORRS, was the best estimate that could be made at the time with the available data. It should, however, only be seen as a first order estimate, as the extent of the operational losses that are experienced in the Orange River System is difficult to determine from the historic data before 1996. During the earlier period, surplus water was available for most of the time and large volumes were therefore released for hydropower generation. Significantly, more water than the downstream requirement was therefore released, making it almost impossible to determine the operational losses with the very limited data available on the actual requirements and surplus releases, for that period.

As part of the annual hydropower operating analysis carried out by BKS on behalf of DWAF, the water demand data, including the operational losses are updated each year in consultation with the DWAF Regional Offices. On request of the DWAF

Regional Office, the operational losses were increased in May 1999 by 76,3 Mm^3/a to 356,3 Mm^3/a. This adjustment was based on their practical experience in the day-to-day operation of the system.

In the year 2000, an additional task was carried out for DWAF over and above the normal annual hydropower operating analysis. The use of the Annual Operating Analyses since May 1997 resulted in tighter control measures for river releases and increased the availability, as well as improved the reliability of data regarding the water requirements and surplus releases. One of the purposes of the additional task was therefore to update the operational losses, based on observed releases from the Vanderkloof Dam and the observed flow, as gauged at various points along the Orange River downstream of Vanderkloof Dam. During the execution of this task, it was discovered that part of the increased operational losses was as a result of the fact that 38,6 Mm^3 of the annual Middle Orange Government Water Scheme (GWS) irrigation requirement was never included in the ORRS data set. The operational losses were therefore reduced by the 38,6 to 317,7 Mm^3/a and the irrigation requirement subsequently increased. The task description, the methodology and results of the additional task are given in a report titled "Orange River System: 1999/2000 Operating Analysis", dated August 2000.

One of the main difficulties that was experienced with the calculation of the operational losses during the execution of the additional task, was the inaccuracy of the gauging of flows at low flow conditions, specifically at Vioolsdrift, which is the most downstream flow gauging station. Taking into account the accuracy of the available flow data, the effect of spills, incorrect releases from Vanderkloof Dam and the time lag for flow between Vanderkloof Dam and Vioolsdrift weir, it was found that an accurate calculation could at that time, still not be obtained for the operational losses. The water balance results, however, did confirm that the current estimation of operational losses is fairly close to the actual losses and it appears that, currently, the operational losses tend to be slightly over estimated rather than under estimated. Results from the ORRS indicate that operational losses occur mainly during the months March to September. No evidence of this distribution pattern could be found from the updated evaluation and it was therefore recommended that an equal distribution be used throughout the year until better information becomes available. The ORRS, as well as the updated proposed operational losses, are given in **Table 6-5**.

During the 2000/2001 planning year, the suggested equal monthly distribution of the 317.7 Mm^3/a operational losses was used in practice for the first time. Based on their practical experience during that year, DWAF Regional Office found that the equal distribution required some adjustment. As part of the May 2001 annual hydropower operating analysis, DWAF Regional Office suggested that the releases from Vanderkloof Dam should be increased to at least 65 and 50 m^3/s in March and April, respectively. To obtain this, the operational losses were adjusted as shown in **Table 6-5**. The operational losses were not updated again for the 2002/2003 planning year, as large volumes of spills occurred during the 2001/2002 planning year, so that it was not possible to observe the effect of the operational losses, as suggested in May 2001. The May 2002 operating analysis therefore used the same operational losses and distribution as suggested in May 2001.

Table 6-5: Orange River System Operational Losses (Mm^3)

DESCRIPTION	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
ORRS distribution	0.0	0.0	23.0	52.4	55.4	59.4	61.4	47.6	18.4	0.0	0.0	0.0	317.7
Proposed operational losses (Additional Task year 2000)	26.5	26.5	26.5	26.5	26.5	26.5	26.5	26.5	26.5	26.5	26.5	26.5	317.7
May 2001 proposed distribution	18.7	17.1	40.2	59.6	40.2	25.5	23.8	18.7	18.1	18.7	18.1	18.7	317.7

6.3.4 Conclusion

Operational losses not only include the effect of inaccurate releases, but also the differences between the actual abstractions and those used in the model. The irrigators do not necessarily abstract exactly their allocated quota and sometimes use less and sometimes more, due to various factors such as weather, market, physical water supply system conditions, etc. Data on actual return flows are almost non-existent and the data in the models are mostly based on assumptions. The effect of all these inaccuracies is therefore included in the operational losses.

The updated irrigation demand, as received from the DWAF Regional offices for the 2002-annual hydropower operating analysis, increased by almost 70 Mm^3/a in comparison with that used for the 2001-analysis. The main reason for this is the updated data that became available from the registration process. It is therefore possible that the operational losses can be reduced again by a similar volume, depending on when the additional irrigation developments take place.

From discussions with DWAF (RSA), it seems that, most of the increase in the irrigation area due to the registration process is the result of allocated permits that were previously not included in the list of scheduled areas. For the purpose of this study, it was therefore assumed that 50 of the 70 Mm^3/a "increase" was previously included as part of the operational losses. It is therefore suggested that the operational losses be reduced by 50 to 270 Mm^3/a.

6.4 Conveyance Losses

In the case of normal transmission losses, the loss is expressed as a percentage of the upstream inflow to a specific system node and is generally used for canal losses and transfer losses. The percentages, for the net losses (effect of return flows taken into account) as used in the ORRS, and accepted for this study, are given in **Table** 6-6. River losses are normally considered to be part of the transmission losses in most studies. In the case of the ORRS, however, the evaporation losses from the Orange River are particularly high with the result that they are modelled separately (detail is given in **Section 6.2**).

Table 6-6: Normal Transmission Losses Expressed as a Percentage of the Inflow

Channel No.	Description	Percentage for Net Loss
68	Transfer losses Knellpoort to Welbedacht Dam	10%
73	Transfer losses Welbedacht Dam to Bloemfontein	10%
74	Orange/Riet transfer losses	12%
151	Orange/Vaal transfer losses	10.7%
79	Transfer losses Mockes Dam to Bloemfontein	5%
81	Transfer losses Rustfontein to Mockes Dam	5%
158	Boegoeberg canal losses	6%
167	Upington canal losses	6%
168	Keimoes canal losses	6%
199	Kakamas canal losses	4%

A second component of the transmission losses is the operational losses, which are also particularly high in Orange River System. This loss component is discussed in detail in **Section 6.3**.

The net transmission loss percentage as given in **Table 6-6** refers to the net effect of the transmission loss. If any portion of the gross transmission loss returns to the river as a return flow or as tail water from canals, it was taken into account in determining the net effect of the transmission loss on the system. The net effect of the losses is used in the Water Resources Yield Model (WRYM) and Water Resources Planning Model (WRPM) for modelling purposes.

7. NAMIBIAN WATER REQUIREMENTS

7.1 Current Consumption

7.1.1 Irrigation

The expansion of commercial farms on the Namibian side of the river is currently progressing at a rate that results in substantial seasonal increases in the areas under irrigation. While commercial farms, and in particular table grape vineyards, are expanding, the planting of cash crops has decreased.

The areas in **Table 7-1** below indicate the extent of the irrigation operations in September 2002.

Some 606 ha of the total area under irrigation of 2 700 ha is under flood irrigation, while the rest is irrigated by pressurized systems. The pressurized systems include centre pivots, micro sprays and drip irrigation.

A quota of 18 000m³ per ha per year was allocated in the water permits which have now been cancelled as discussed under **Section 3**. This volume per hectare is likely to be reduced in future allocations. Although many irrigated areas in the Upper Orange have much lower allocations per hectare, these have been determined by the type of crop under irrigation and the number of months per year that they are irrigated. Along the CBA, irrigation is mainly for high value perennial crops that require irrigation throughout the year. The volume assumed for the CBA is thus 15 000 m³/ha/a. This may be on the low side for irrigation in this area due to the hot climate and the need to cool the vineyards down. Water is also required to backwash filters used with micro-jet spraying and for dust suppression to maintain the high fruit quality required for export. These "losses" have been included in the water consumption figures as conveyance losses and have been estimated at 5% of the irrigation requirement.

There are no metered records of the actual quantities of water that are currently abstracted for irrigation purposes.

Table 7-1: Current Irrigation Water Consumption along the LOR @ 15 000 m³/ha/a

River Reach	Area Under Irrigation (Ha)	Water Demand (Mm³/a)
20°E Long. - Vioolsdrift Dam Site	1,060	15.90
Vioolsdrift Dam Site - Fish River	1,629	24.44
Fish River - Oranjemund	14	0.21
Total	**2,703**	**40.55**

7.1.2 Urban / Domestic and Industrial

Industrial activity along the LOR is virtually non-existent. Therefore, industrial water consumption has been included in the urban demand figures.

Although the irrigation water demand along the Orange River far outweighs the urban, mining and industrial water demand, it is important to study these demands to identify mismanagement of a valuable resource. In general, effective water management is not practised along the Orange River for urban water consumption. There is a common perception that there are never water shortages along the Orange River. Often, this is because the domestic water is supplied without cost, as in the case of mining towns, where the water account is paid by the mine and not by the consumer.

The analysis of the urban water demand has been carried out, using the water consumption of the major towns in the Orange River and Fish River Basins. These two basins were considered separately in the study of current consumption and future demand projections. **Section 7.1.2** deals with urban and industrial water demand of the LOR and **Section 7.1.5** with the Fish River Basin.

A list of the towns that were considered in the study, and their populations according to the 1991 and 2001 Namibian Census, is shown in **Table 7-2**.

Table 7-2: Population Figures for Namibian Towns

Town	1991 Census	2001 Census
Ariamsvlei	350	428
Grunau	494	379
Karasburg	4,602	14,693
Noordoewer	1,069	1,211
Oranjemund	7,400	5,451
Rosh Pinah Town	855	1,537
Warmbad	558	162

Two town developments that were also included in the future water demand projection of the Orange River are Aussenkehr Town and Skorpion Village. The future domestic water use of the Kudu Gas Development was also included.

NamWater is responsible for the bulk water supply to all the towns under consideration, with the exception of Oranjemund. In obtaining the current water consumption of the towns, NamWater's records of water sales were used.

The coastal diamond mine, Namdeb Diamond Co. operates in Oranjemund. Namdeb Diamond Co. has a water abstraction permit issued by the DWA. Domestic water is abstracted from the alluvial aquifer, which forms part of the river mouth. Since abstraction takes place close to the river and the aquifer is recharged directly from the river, it has been treated as a direct abstraction from the river. The mining process in Oranjemund uses only seawater, thus the current water consumption shown in **Table 7-3** is for domestic consumption alone. This represents an extremely high consumption per capita. All the annual water consumption figures received from NamWater and Namdeb are given for a year from April to March.

NamWater is also responsible for the water supply to the Rosh Pinah Mine and Town, and to Skorpion Mine and Village. Consideration is being given to proclaiming Rosh Pinah as a Town, but to date the mine still owns the town and pays for the domestic water use of the town inhabitants. This has also given rise to the high domestic water consumption of the town. NamWater only started to differentiate between the water demand of the mine and the town in 1992, and thus the consumption record of Rosh Pinah Town only dates back 9 years. Although the population of Rosh Pinah Town has almost doubled in ten years, the water demand of the town has remained fairly constant.

With the development of the Skorpion Mine in 2001, the domestic water consumption of Rosh Pinah increased from an average of ±495 000 to 600 000m^3/a. Although Skorpion Village can almost be considered as a suburb of Rosh Pinah Town, its water is metered separately. According to the existing agreement, and until Rosh Pinah is proclaimed as a town, Rosh Pinah Mine will pay for the water consumption of Rosh Pinah Town and Skorpion Mine will pay for the water consumption of Skorpion Village.

Compared to mining and industrial water use, the urban consumption would not be expected to be significant. However, with the high water consumption of Oranjemund, the current domestic water consumption of the town is higher than the combined mining and industrial demand of all other consumers in Namibia.

Table 7-3: Current Urban Water Consumption for Namibia in 2001/02

Consumer	Population	Permit Allocation	Consumption (m³/a)	Unit Consumption ℓ/c/d
From Orange River				
Aussenkehr		n/a	0	
Kudu Gas (Domestic)		n/a	0	
Noordoewer	1,211	70,000	70,300	159
Oranjemund	5,451	6,500,000	6,445,762	3,239
Rosh Pinah Town	1,537	600,000	601,145	1,071
Skorpion Village		n/a	0	
Sub-total LOR	**8,199**		**7,117,207**	
From Boreholes				
Ariamsvlei	428	n/a	43,035	275
Grunau	379	n/a	9,501	68
Karasburg	14,693	n/a	237,992	44
Warmbad	162	n/a	37,126	628
Sub-total Boreholes	**15,662**		**327,654**	
TOTAL	**23,861**		**7,444,861**	

7.1.3 Mining

The water consumed by the mining industry is discussed below for each individual mine and presented in **Table 7-4**.

Namdeb Diamond Co. Mine, Oranjemund

Namdeb Diamond Co. Mine uses seawater for its process operations and is therefore not discussed further in the report.

Namdeb Auchas and Daberas Mines

Auchas and Daberas Mines are both diamond mines owned by Namdeb. Daberas Mine has a current permit for 950 000m^3/a. Auchas Mine had a DWA permit for an abstraction limit of 1,26 Mm^3/a from the Orange River. The permit expired in September 2002 and has not been renewed by Namdeb. Although Auchas Mine is still in operation, it is expected to be closed down in the near future. No distinction was made between water use for the mining process and domestic use, as the domestic use is an insignificant percentage of the total water use at these mines.

Rosh Pinah Mine

Rosh Pinah Mine and Rosh Pinah Town make use of the NamWater infrastructure for their water supply. Rosh Pinah and Skorpion have an abstraction permit from the Orange River for 7,5 Mm^3/a. The water supply records for the mine and town were supplied by NamWater.

Skorpion Mine

Skorpion Mine also makes use of the NamWater infrastructure, and has only been in operation since May 2002. Its present consumption is included with Rosh Pinah.

Small Mining Enterprises

An estimate was made for the water consumption for a number of smaller mining enterprises based on a recent report on an analysis of the present and future water demand in Namibia (WCE 1999).

Table 7-4: Current Water Consumption for Major Mines in the LOR

Mine	Permit Allocations	2002 (m³/a)
Haib Mine	0	0
Kudu Gas	0	0
Namdeb Auchas & Daberas Mines	2,210,000	930,828
Rosh Pinah Mine	7,500,000	832,000
Skorpion Mine	0	0
Small Mining Enterprises	n/a	250,000
TOTAL		**2,012,828**

7.1.4 Namibian Total for Lower Orange River

The estimated total Namibian water consumption (2002) along the LOR is presented in **Table 7-5** below.

Table 7-5: Total 2002 Namibian Water Consumption from the LOR

Consumer Category	Permit Allocation Mm³/a	Consumption (2002) Mm³/a
Irrigation	77.10	40.55
Urban / Industrial	7.17	7.12
Mining	9.71	2.01
Conveyance Losses		2.03
TOTAL	**93.98**	**51.71**

7.1.5 Fish River

There are no mines that abstract water from the Fish River. Thus, only the irrigation and domestic/ industrial demands will be considered.

Current Irrigation Consumption for the Fish River Basin

There are currently 2 490 ha under irrigation at the two main irrigation projects in the Fish River Basin – 2 200 ha at Hardap Dam and 290 ha at Naute Dam. There are, in addition, a number of riparian farmers along the river that are irrigating small pieces of land. Since the river is not perennial, these farmers can only periodically abstract surface water.

The water that is used for irrigation at Hardap is measured and monthly consumption figures are available. The average annual consumption over a three-year period was 41,7 Mm^3 with a minimum of 39,6 Mm^3 and a maximum of 43,7 Mm^3.

The consumption at the Naute Project, where all the irrigation is done with pressurized systems, is estimated at 4,64 Mm^3.

The total abstraction from the Fish River at the two major developments amount to 46,33 Mm^3 per annum. If the small scale abstraction of riparian farmers is added, it is unlikely that the total abstraction from the Fish River will exceed 48 Mm^3/a.

Table 7-6: Current Irrigation Consumption from the Fish River (measured)

Irrigation Scheme	Area under Irrigation (Ha)	Water Demand Mm^3/a
Hardap Dam	2 200	41.70
Naute Dam	290	4.64
Small scale abstraction		1.66
TOTAL	**2 490**	**48.0**

Current Urban / Domestic Consumption for the Fish River Basin

Only two urban centres were studied in the Fish River Basin, Mariental and Keetmanshoop. These are the only towns that abstract water directly from the Fish River (Hardap and Naute Dam). The other towns in the Fish River Basin abstract groundwater from boreholes.

Industrial activity in the area is not significant and the industrial demands have therefore been included in the urban demands.

Regarding populations, the results from the 1991 and 2001 Census are shown in **Table 7-7**.

Table 7-7: Current Population Figures – Fish River

Town	1991 Census	2001 Census
Keetmanshoop	15,032	14,945
Mariental	7,581	11,977

NamWater sales records provided the historic water use of Keetmanshoop and Mariental. The current water consumption can be seen in **Table 7-8**.

Table 7-8: Urban Water Consumption in the Fish River Basin in 2002

Consumer	Population	Consumption (m^3/a)	Unit Consumption ℓ/c/d
Keetmanshoop	14,945	1,790,000	328
Mariental	11,977	930,000	212
TOTAL		**2,720,000**	

Total Current Consumption for the Fish River

The total consumption for the Fish River in 2002 is shown in **Table 7-9**.

Table 7-9: Total Consumption from the Fish River in 2002

Consumer Category	Consumption Mm^3/a
Irrigation – Hardap and Naute	46.34
Small scale abstraction	1.66
Urban / Industrial	2.72
TOTAL	**50.72**

7.2 Water Demand Projections

7.2.1 Irrigation

The projections of future water demand in the CBA depend largely on the development of further irrigation projects. In considering the potential of these future developments, the following factors need to be considered:

- The available irrigable land;
- The financial viability of irrigation along the LOR;
- The availability of markets and the long-term prospects of the crops grown;
- Effective marketing of produce; and
- The economic and socio-economic benefits to the region and to the country.

Points 2 – 5 above have been discussed in detail in **Chapter 5** of the report, which assesses the potential of the LOR for further development. The conclusions, which can be drawn from **Chapter 5**, with respect to the above points, can be summarised as follows:

1. Large profits and valuable foreign exchange can be earned from well-managed irrigation projects that grow high value crops along the LOR.
2. The world markets currently being supplied by table grape growers in the region have the capacity to absorb substantial expansion. There exists a big potential of other hitherto untapped markets, particularly in the east.
3. The market for dates can be expanded, and it is believed that dates are more stable than table grapes in the long-term.
4. The market potential can be greatly strengthened and stabilised by cultivating further high value crop varieties.
5. Effective marketing is essential, particularly as high value produce grown in the area will have to compete with other global players competing for the same markets.
6. Irrigation farming, particularly for high value crops, is labour intensive and the expansion of irrigation will provide many employment opportunities.
7. Of particular significance is the opportunity afforded to establish and train farmers from previously disadvantaged groups.
8. Since the crops will chiefly be grown for the export market, this will provide a significant contribution to the country's foreign exchange earnings.
9. All the land identified as potential irrigable land can be developed over the long-term as the current and possible new markets have the capacity to absorb the harvests produced on these areas.

The estimate of the future water demand projections is therefore based on the areas of potentially irrigable land as discussed in the sections that follow. The rate of development assumed is based on the development that has taken place along the LOR in the recent past.

7.2.2 Available Irrigable Land

In considering the irrigation water demand projections, specific criteria for irrigable land were adopted. These are discussed below.

General

The criteria for irrigable land in general, and along the LOR in particular, has changed dramatically. The role of the soil in which the crops are planted, has been reduced to that of a structural medium to support the plant. Water and plant food are provided mechanically with the aid of sophisticated demand determinants. If water is available, the value of the crops that the climate will allow, dictates the criteria for irrigable land.

High-income crops make extensive land preparation, high pump heads and the establishment of basic infrastructure, such as roads and electrical power, more affordable. This phenomenon has manifested itself in practice. Land that was previously not even considered for irrigation is now in production. The farms Stolzenfells and Komsberg are a case in point.

In order to determine the extent of the irrigable land on the Namibian side of the Orange River, it was necessary to consider the economic viability of the various pieces of potentially irrigable land and not only the physical parameters, in the evaluation of the land.

The parameters, which were considered, included:

- Height that the water had to be pumped;
- Distance that the water had to be pumped and the geometry of the land;
- Quality of the soils – chemically and physically;
- Topography;
- Relief;
- Available infrastructure;
- Transport costs;
- Mineral rights; and
- Climate.

Given the number of variables under consideration, it was imperative that the influence of each parameter had to be quantified. A cost implication was used for this purpose. It was found that the preparation of the land and the provision of access roads had major capital implications. The height that the water is pumped has an ongoing cost implication. A lifespan of 20 years was used in the evaluation of the effect of the pump head.

Pump Head

Until recently, there was a general guideline that water should not be pumped higher than 60 metres for irrigation purposes. This was an arbitrary economic parameter and was used to determine the available irrigable soils along the Orange River. Practical considerations and commercially driven farming practices have started to develop land that required higher pump heads. Currently, soils up to 240 m above the river level are planned for irrigation at Aussenkehr. In a recent study, it was found that high-income crops warranted the irrigation of land up to 250 m above river level.

In the absence of specific guidelines for allowable pump heads, and given the number of variables that influence the economic viability of a pumped irrigation scheme, it was decided to split the potentially irrigable soils into a number of pump head categories and to list the available land in each category. Different pump costs were then attached to each category.

Given the depth of the gorge in which the river flows downstream of Augrabies Falls the potentially irrigable soils are generally in close proximity to the river.

There were, however, a number of areas where large pieces of land that were not in the immediate vicinity of the river, were considered. The northwestern area at Aussenkehr and Tandjieskoppe are the two most prominent ones in this category.

Pump Distance

The distance that the land is away from the river has an influence on the economic viability of the pump operation. Generally, the land that was identified starts from the bank of the river. There are, however, areas where commercial farmers have identified land that is divorced from the land in the immediate vicinity of the river. The land to the north-west of Aussenkehr is a case in point.

The distance that the land is away from the river, and the geometric layout of the land has an implication on the developmental costs, as well as on pump costs due to the variance in friction head.

Soil Quality

The Soil and Irrigation Research Institute of Pretoria did a soil survey of the area along the northern bank of the river in 1978. MBB verified this survey in a number of areas in 1993. Subsequent, surveys were done at Sendelingsdrift and Aussenkehr, and at commercial farm developments.

Given the constraints that were applicable in 1978 relative to the height above the river, and the cost of processing the soil, the early soil surveys reflect deficiencies in both extent and level of information. It was therefore necessary to assume percentages of irrigable soils in some areas. These percentages are conservative and were derived from actual soil surveys in comparable areas. Where recent detailed soil surveys were available, this information was used to determine the irrigable areas.

The suitability of soils can be improved by processing the soils. The costs of the processing operation become more tolerable with high-income crops. Soils that were previously considered marginal, or even unsuitable, may thus become suitable.

Topography

Pressurized irrigation systems have reduced the limitations that the topography has on the irrigability of the land. The determining criteria for topographical constraints are whether the machines that have to operate in the lands can do so. Different crops would have different requirements. It was assumed that a 10% slope would be the steepest that can be accommodated.

Relief

Some of the areas under consideration have a broken surface due to a delta of dry streams crossing it. These areas would require diversion berms, drainage canals and surface preparation that will result in a percentage of the available land being lost. These percentages would vary depending on the severity of the disturbance of the surface. Some high-income crops can be planted on berms or mounds that have been formed mechanically. Such an operation may affect the plant density, thus reducing the efficiency of land usage. A percentage of the available area was deducted to allow for the lower efficiencies.

Infrastructure

The availability of road access, electrical power and other infrastructure has a major impact on the viability of the development of some of the areas. Access in particular is critical. The costs of suitable access roads can make the development of small isolated patches of land impossible from an economic point of view.

The potential of the land that has been identified as irrigable in terms of other parameters have been weighted economically relative to the available infrastructure.

Mineral Rights

Downstream of the Noordoewer weir there are lands that are currently under irrigation, as well as lands that are in the planning stages that are affected by mineral rights. The land at Sendelingsdrift and further to the west falls in the "Sperrgebied", which is an area of restricted access.

For the purposes of this study, it was assumed that these lands will become available for agricultural development in the future. It was also anticipated that the mining operations in this area will be subject to the ruling environmental protection measures which would require the reinstatement of the area. If the re-instatement is done under certain guidelines, the land would become suitable for cultivation. A period of time has been allowed in the demand forecast calculations before these areas would come into consideration.

Crop Water Requirements

The annual crop water requirements for permanent crops vary considerably for the stretch of river downstream of Augrabies to the west. The water permits that have been withdrawn used a quota of 1800 mm per hectare per year. In an area along this stretch of river where irrigation scheduling is practised, it was indicated that table grapes have been irrigated using 1400 mm per year, but that provision should be made for 1600 mm for years when climatic conditions are not ideal.

Table grapes have the highest water requirement of the permanent crops that have been considered and it varies from 1160 mm per year to 1618 mm along the stretch of river under consideration. These requirements are based on the SAPWAT method of calculation. This method uses meteorological statistics and the projected irrigation requirements are thus subject to the accuracy and adequacy of this information. An average water requirement of 1 500 mm has been used in the demand forecasts. It would require judicious application and good management, but should be adequate as an average demand for the area.

Irrigation Water Demand Forecast

The criteria discussed in **Section 7.2.1** were applied to determine the areas that can economically be irrigated. Detailed calculations are attached in **Appendix C**. For the high growth rate scenario, it was assumed that all the available land that can economically be developed, will be developed by the year 2025. The low growth rate was taken as 50% of the high rate with an expected growth rate half way in between (medium scenario). The forecast for irrigation water demand is given in **Table 7-10** below. The information in the table is presented diagrammatically in **Figure 7.2** for the LOR.

The distribution of irrigable land relative to its height above river level is presented graphically in **Figure 7.1**.

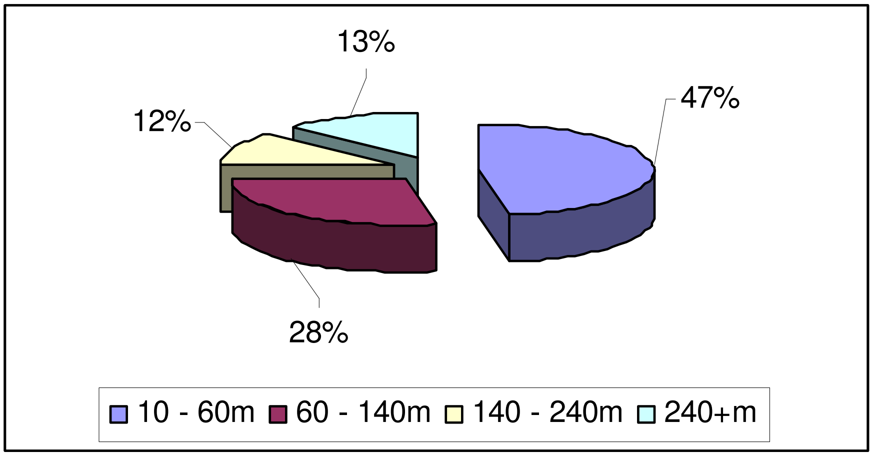


Figure 7.1: Distribution of Irrigable Land – Height above River Level

Fish River

No further irrigation development is expected at the existing schemes at Hardap and Naute. Several potential dam sites have been identified in the Fish River for possible future development. The two most notable are the Brukkaros and Neckertal sites. At this point in time, however, these developments are fairly unsure. For the purposes of this study, it has been assumed that these dams will not be developed in the immediate future.

Table 7-10: Namibian Irrigation Water Demand Forecast for the LOR: Low, Medium and High Projections– Mm^3/a

YEAR	2002	2005			2010			2015			2020			2025		
Demand Scenario		**Low**	**Med**	**High**	**Low**	**Med**	**High**	**Low**	**Med**	**High**	**Low**	**Med**	**High**	**Low**	**Med**	**High**
Irrigation Area - ha																
Fish River - Oranjemund	0	0	0	0	1,040	1,300	1,560	1,450	2,000	2,550	1,790	2,600	3,415	2,000	3,000	4,255
Vioolsdrift Dam Site - Fish River	1,724	2,410	2,600	2,790	2,755	3,445	4,135	3,570	4,915	6,265	4,390	6,390	8,390	5,240	7,860	10,650
20°E Long - Vioolsdrift Dam Site	979	1,290	1,380	1,600	1,685	2,105	2,530	2,240	3,085	3,930	2,825	4,115	5,400	2,835	4,255	5,245
Total Irrigation Area	**2,703**	**3,700**	**3,980**	**4,390**	**5,480**	**6,850**	**8,225**	**7,260**	**10,000**	**12,745**	**9,005**	**13,105**	**17,205**	**10,075**	**15,115**	**20,150**
Irrigation Demand – Mm^3/a																
Fish River - Oranjemund	0.00	0.00	0.00	0.00	15.60	19.50	23.40	21.78	30.00	38.22	26.79	39.00	51.21	30.00	45.00	63.83
Vioolsdrift Dam Site - Fish River	25.86	36.15	39.00	41.85	41.33	51.66	62.00	53.54	73.74	93.95	65.84	95.82	125.81	78.59	117.90	159.75
20°E Long - Vioolsdrift Dam Site	14.69	19.35	20.70	24.00	25.28	31.59	37.91	33.59	46.26	58.94	42.38	61.68	80.99	42.54	63.83	78.68
Total Irrigation Water Demand	**40.55**	**55.50**	**59.70**	**65.85**	**82.21**	**102.75**	**123.31**	**108.91**	**150.00**	**191.11**	**135.01**	**196.50**	**258.01**	**151.13**	**226.73**	**302.26**

Note: A Crop Water Requirement (as determined by SAPWAT) of 15 000 m^3/ha/a has been used in the above table.

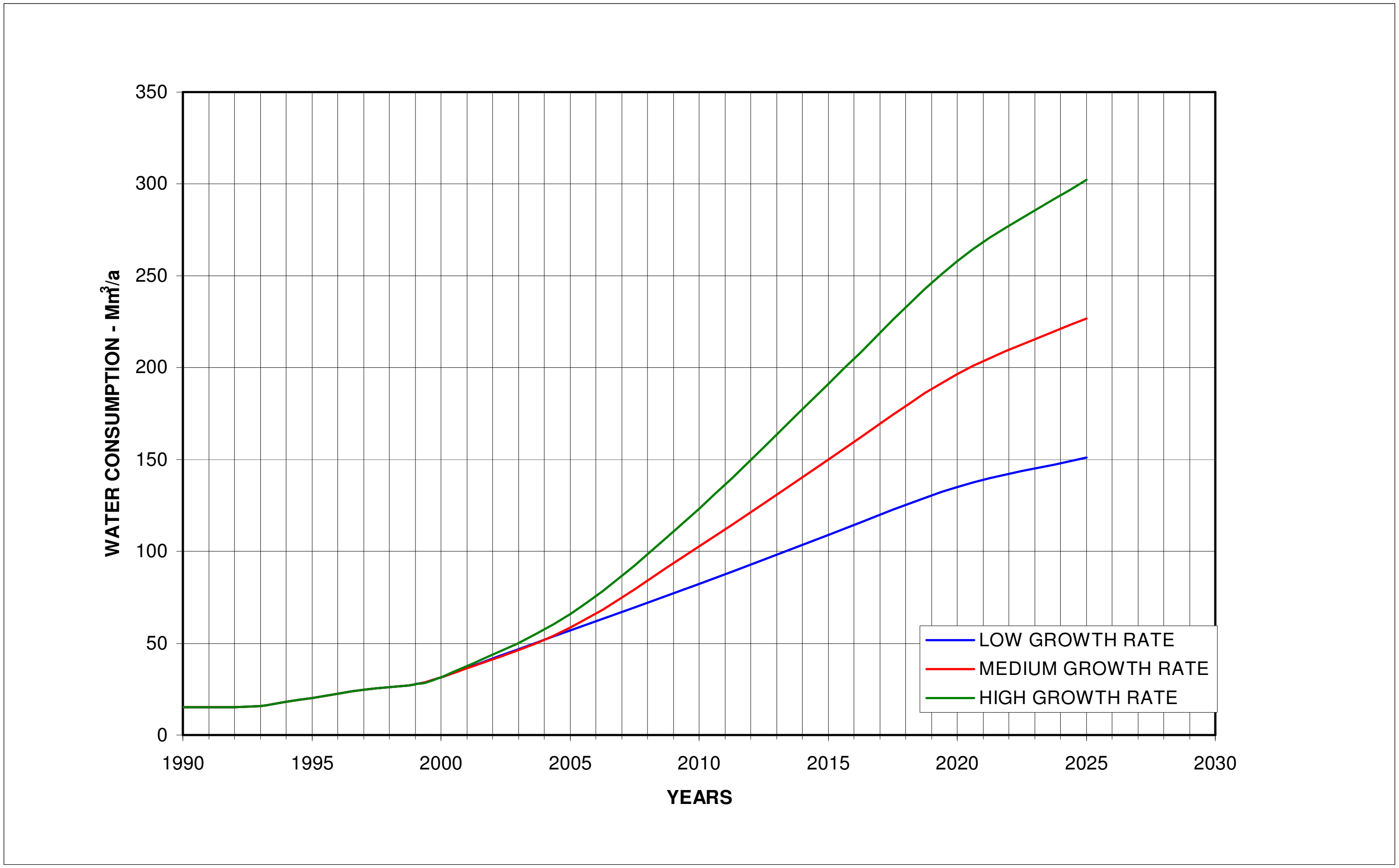


Figure 7.2: Namibian Irrigation Water Demand Projections for the LOR

7.2.3 Urban / Domestic and Industrial

The time extrapolation method was used for the water demand forecasting for the urban centres in the LOR Basin. Time extrapolation is based on past water use patterns by linearly extrapolating the available historic water use data. This method is not generally considered as accurate as multiple coefficient methods, which introduce a range of variables into the model such water tariffs, access to water, household data, etc., which can be used for more accurate forecasting. However, the current study does not require such an in-depth analysis of the urban water demands, especially when considering the small contribution of the urban water demand to the overall future water demand of Namibia from the Orange River. For this study, the time extrapolation method is considered adequate to estimate future urban water demands.

Although the historic trends were used as basis for the forecasting as mentioned above, the linear projections were adjusted to take into account other factors such as:

- Population and historic population increases. To use only population for water demand forecasting is considered insensitive to the realistic urban water use, but the per capita consumption gives a good idea of the water mismanagement in the urban centres.
- Possible effect of Aids.
- Future social upliftment of the inhabitants.
- Economic activity in the region and the potential for economic growth.
- Recent short-term activity, as in the case of Rosh Pinah Town.

Certain towns situated in the Orange River Basin currently obtain water from own sources, mainly boreholes. As these towns grow, it is possible that the local groundwater sources will not be able to sustain the growth of the towns and it has been assumed that these towns will eventually obtain water from the Orange River. **Table 7-11** lists these towns and provides their projected water demands.

Table 7-11: Towns Currently Dependent on Groundwater Sources

Town	2001 (m^3/a)	2005 (m^3/a)	2010 (m^3/a)	2015 (m^3/a)	2020 (m^3/a)	2025 (m^3/a)
Ariamsvlei	43,035	44,000	48,000	52,000	56,000	60,500
Grunau	9,501	9,550	9,850	10,300	10,700	11,100
Karasburg	237,992	249,000	257,000	265,000	273,500	281,500
Warmbad	37,126	40,000	47,000	54,500	62,000	69,000
TOTAL	**327,654**	**342,550**	**361,850**	**381,800**	**402,200**	**422,100**

In this study, the water demand is projected in intervals of 5 years up to the year 2025. Ariamsvlei, Grunau, Karasburg and Warmbad are currently being supplied by surrounding boreholes. However, at the growth rate of these four towns their current water sources will not be able to support further growth in the foreseeable future. The cheapest alternative water source that is available to these four towns is the Orange River. For the water demand projections carried out for the study, these towns have been included as demand centres on the Orange River for the medium and upper scenarios from 2010 onwards. Their demands have been gradually phased into the projected water demand of the LOR, commencing with 10% in the year 2010, and progressively increasing to 100% in 2020. The projected urban water demand of all towns is presented in **Table 7-12**.

Table 7-12: Namibian Urban Water Demand Projections in the LOR – Most Probable Projection

Consumer	2002 (m^3/a)	2005 (m^3/a)	2010 (m^3/a)	2015 (m^3/a)	2020 (m^3/a)	2025 (m^3/a)
Upstream of the Vioolsdrift Dam Site						
Ariamsvlei	0	0	4,800	26,000	56,000	60,500
Grunau	0	0	985	5,150	10,700	11,100
Karasburg	0	0	25,700	132,500	273,500	281,500
Warmbad	0	0	4,700	27,250	62,000	69,000
Sub-total Upstream	**0**	**0**	**36,185**	**190,900**	**402,200**	**422,100**
Downstream of Vioolsdrift dam Site						
Aussenkehr	0	103,989	156,038	259,150	464,609	516,658
Kudu Gas (Domestic)	0	90,000	90,000	90,000	90,000	90,000
Noordoewer	70,300	66,000	81,000	100,000	112,000	128,000
Oranjemund	6,445,762	6,445,762	6,445,762	6,445,762	6,445,762	6,445,762
Rosh Pinah Town	601,145	514,000	523,000	533,000	542,500	550,000
Skorpion Village	0	1,321,300	1,321,300	1,321,300	1,321,300	1,321,300
Sub-total Downstream	**7,117,207**	**8,541,051**	**8,617,100**	**8,749,212**	**8,976,171**	**9,051,720**
TOTAL	**7,117,207**	**8,541,051**	**8,653,285**	**8,940,112**	**9,378,371**	**9,473,820**

Aussenkehr Town

A maximum of 20 000 people are expected to settle in Aussenkehr Town when considering the optimum development and increase in migration resulting from the proposed 2000 ha irrigation project. For Aussenkehr Town, it was necessary to use a single co-efficient method in projecting future water demand. A preliminary estimate was proposed at a domestic water consumption rate of 140 ℓ/c/day. This figure is high for a low cost housing development, but it was decided on as this correlates with the water consumption rate of Noordoewer. A consumption rate of 20 ℓ/c/day was allowed for schools and 400 ℓ/100m^2/day for businesses. One health centre was included with a water usage rate of 500 ℓ/100m^2/day.

Kudu Gas (Domestic)

The domestic water consumption of the Kudu Gas Project has been based on the settlement of 60 households at Oranjemund.

Rosh Pinah Town

Rosh Pinah has been allocated a low increase in water demand for all three scenarios. This is to take into consideration the possible proclamation of Rosh Pinah Town. Residents will then have to pay for their water use.

Skorpion Village

The expected average daily consumption of Skorpion Village, when it is fully developed, is 3 620 m^3/day. This is based on the estimated projections of the mine management and included in the agreement for water supply between the mine and NamWater. For the water demand projection, this demand was included from the year 2005 as the mine is expected to be in full production by then.

Haib Mine Village

Since the future of the Haib Mine is still very uncertain, it has been decided not to include any urban water demand for the village. The urban water demand is deemed to be included in the total water demand of the mine.

The Upper, Medium and Low Demand projections for urban water supply are summarised in **Table 7-13**.

Table 7-13: Urban/Domestic Demands for Upper, Medium and Low Scenarios

Demand Scenario	Projected Urban Demand (Mm^3/a)					
	2002	2005	2010	2015	2020	2025
Upper	7.12	8.94	9.64	10.71	11.36	11.51
Medium	7.12	8.54	8.65	8.94	9.38	9.47
Low	7.12	8.40	8.48	8.56	8.63	8.70

7.2.4 Mining

A different approach was taken to the forecasting of demand by the mines than was used in the urban demand forecasting. Mostly as the demand for the mining industry stays constant, a growth percentage was estimated for the established mines to accommodate any possible change. For new mining developments, the maximum average daily demand was taken as a constant water demand over a 25 - year period. The results of the demand forecast are presented in **Table 7-14**.

Table 7-14: Mining Water Demand Projections of the Lower Orange River Basin - Most Probable Projection

Consumer	2002 (m^3/a)	2005 (m^3/a)	2010 (m^3/a)	2015 (m^3/a)	2020 (m^3/a)	2025 (m^3/a)
Upstream of Vioolsdrift Dam Site - None						
Downstream of Vioolsdrift Dam Site						
Haib Mine	0	0	15,000,000	30,000,000	30,000,000	30,000,000
Kudu Gas Power Station	0	500,000	500,000	500,000	500,000	500,000
Namdeb Auchas & Daberas Mines	930,828	987,947	1,064,299	1,146,553	1,235,163	1,330,621
Rosh Pinah Mine	832,000	883,054	951,300	1,024,821	1,104,023	1,189,346
Skorpion Mine	0	4,695,360	4,695,360	4,695,360	4,695,360	4,695,360
Small Mining Enterprises	250,000	281,377	326,193	378,147	438,377	508,199
TOTAL	**2,012,828**	**7,347,738**	**22,537,152**	**37,744,881**	**37,972,923**	**38,223,526**

Haib Mine

Whether Haib Mine will be realised is uncertain at this stage. Provision for the mine has to be made as the water demand of Haib Mine, if established, will overshadow any other mining enterprises along the Orange River on the Namibian side. According to initial studies a water demand of 30 Mm^3/a is expected in the first phase of the mine and 60 Mm^3/a when in full operation. This high water consumption rate is as a result of the water intensive processes that the mine intends to use. Although more expensive, there are other methods of extracting copper from the ores which are less water intensive. The water demand expected for Haib Mine is unrealistic and should the mine be realised, it is strongly recommended that a less water intensive method should be required. Provision was made in the Medium and Upper Demand Scenarios for 15 Mm^3/a in 2010 with the opening of the mine, increasing to 30 Mm^3/a in 2020 when the mine is in full production.

The Low Demand Scenario assumes that the development of the Haib Mine will not take place.

Kudu Gas Power Station

A number of studies relating to water demand were undertaken during the Feasibility Study of the Kudu Gas Power Station. For this study, it was assumed that seawater would be used for the cooling operations of the power station. The only fresh water required from the Orange River will be the demineralised water used in the boilers. The Medium and Upper Demand Scenarios assume full development of the Kudu Gas Project, commencing in 2005. The Low Demand Scenario assumes no development of Kudu Gas.

Namdeb Auchas and Daberas Mines

A growth percentage of 1.5% per annum was allowed for Auchas and Daberas Mines in all the Demand Scenarios.

Rosh Pinah Mine

The demand of the Rosh Pinah Mine was also estimated at a growth of 1.5% per annum for all Demand Scenarios.

Skorpion Mine

The expected average daily consumption for Skorpion Mine (including domestic water use of the mine) in full production is 12,864 m^3/day, as estimated by the Mine Management. The Skorpion Village demand was taken as constant over the next 25 years for all Demand Scenarios.

Small Mining Enterprises

An allowance was made for small mining enterprises in all the Demand Scenarios.

Table 7-15: Namibian Mining Demands for Upper, Medium and Low Scenarios

Demand Scenario	Projected Mining Demand (Mm^3/a)					
	2002	2005	2010	2015	2020	2025
Upper	2.01	7.35	22.54	37.74	37.97	38.22
Medium	2.01	7.35	22.54	37.74	37.97	38.22
Low	2.01	6.85	7.04	7.24	7.47	7.72

7.2.5 Namibian Total Projections for the LOR

The total water demand for Namibia is given below. The Upper, Medium and Low Scenarios are presented. These have been determined as follows:

Medium (most likely) Scenario

This scenario has taken the current urban and mining developments into account, using the method described above for estimating the future projected demands. The Medium Scenario is thus based on the following:

- The most likely irrigation development.
- Including the full development of the Haib Mine.
- Including the development of Kudu Gas Field and Power Station.
- Including the full development of Skorpion Mine and Village.
- Including 1.5% per annum growth of Rosh Pinah Mine.
- Including 1.5% per annum growth of Auchas and Daberas Mines.
- Including the development of Aussenkehr Town for 10 000 inhabitants.
- Assuming normal growth for Noordoewer and Rosh Pinah Town.
- Assuming no increase in consumption at Oranjemund.
- Including the phased-in demand of Ariamsvlei, Karasburg, Grunau and Warmbad.

Upper Scenario

The Upper Scenario is based on the following:

- The maximum likely irrigation development.
- Including the full development of the Haib Mine.
- Including the development of Kudu Gas Field and Power Station.
- Including 1.5% per annum growth of Rosh Pinah Mine.
- Including 1.5% per annum growth of Auchas and Daberas Mines.
- Including the accelerated development of Noordoewer due to the Haib Mine.
- Including the maximum development of Aussenkehr Town for 20 000 inhabitants.
- Including a projection of the historic growth for Oranjemund.
- Including the phased-in demand of Ariamsvlei, Karasburg, Grunau and Warmbad.
- Including the full development of Skorpion Mine and Village.
- Assuming normal growth for Rosh Pinah Town.

Lower Scenario

The Lower Scenario is based on the following:

- The lower likely irrigation development.
- Excluding the development of the Haib Mine.
- Excluding the development of Kudu Gas Power Station.
- Including 1.5% per annum growth of Rosh Pinah Mine.
- Including 1.5% per annum growth of Auchas and Daberas Mines.
- Including Aussenkehr Town for 5 000 inhabitants.
- Excluding water supply from the Orange River to Ariamsvlei, Karasburg, Grunau and Warmbad.
- Including the full development of Skorpion Mine and Village.
- Assuming no increase in consumption at Oranjemund.
- Assuming normal growth for Noordoewer and Rosh Pinah Town.

Table 7-16 presents the water demand projections of the three scenarios described above.

Table 7-16: Water Demand Projections for Namibia for the Medium, Upper and Low Demand Scenarios along the LOR – All Consumers

Demand Scenario	Projected Demand (Mm³/a)					
	2002	2005	2010	2015	2020	2025
Upper	**49.68**	**82.14**	**155.48**	**239.55**	**307.33**	**351.98**
Upstream	14.69	24.00	37.94	59.13	81.39	79.10
Downstream	34.99	58.13	117.54	180.43	225.94	272.88
Medium	**49.68**	**75.59**	**134.75**	**196.68**	**243.85**	**274.42**
Upstream	14.69	20.70	32.44	46.45	62.08	64.25
Downstream	34.99	54.89	102.31	150.23	181.77	210.18
Low	**49.68**	**70.75**	**97.72**	**124.70**	**151.10**	**167.55**
Upstream	14.69	19.35	25.28	33.59	42.38	42.54
Downstream	34.99	51.40	72.44	91.12	108.73	125.01

7.2.6 Fish River Basin

No major mining ventures are located in the Fish River Basin. The industrial sector is also not prominent. The industrial sector demand is included in the urban water demand.

Projected Water Demands for the Fish River

The same method was used for projecting urban / industrial water use over the next 25 years in the Fish River Basin, as for the LOR Basin. The results of the two consumer categories can be seen in **Table 7-17**.

Table 7-17: Water Demand Projections for the Fish River

Consumer Category	2002 (Mm^3/a)	2005 (Mm^3/a)	2010 (Mm^3/a)	2015 (Mm^3/a)	2020 (Mm^3/a)	2025 (Mm^3/a)
Irrigation	48.0	48.0	48.0	48.0	48.0	48.0
Urban / Industrial	2.7	2.9	3.0	3.1	3.2	3.3
Total	**50.70**	**50.90**	**51.00**	**51.10**	**51.20**	**51.30**

8. SOUTH AFRICAN WATER REQUIREMENTS

8.1 Current Consumption

8.1.1 Irrigation

Table 8-1 provides an estimate of the current irrigation on the South African side of the Common Border. The volume of water consumed is based on a crop requirement of 15 000 m^3/ha/a.

Table 8-1: Current irrigation – South Africa

River Reach	Area Irrigated (ha)	Water Consumption (Mm^3/a)
20°E Long – Vioolsdrift Dam Site	2,752.6	41.29
Vioolsdrift Dam Site to Orange / Fish Confluence	600.5	9.01
Orange / Fish Confluence to River Mouth	761.1	11.42
TOTAL	**4,114.20**	**61.72**

Crop Water Requirements

Although discussed under the chapter on South African water requirements, this paragraph is equally applicable to Namibia.

There are various methods to determine crop water requirements. The atmospheric demand concept has been accepted in South Africa as the standard, and the SAPWAT program was generally accepted as a 'tool' to use in this regard. The following description of the program is an extract from the WRC Report TT 163/01: "Using SAPWAT to estimate water requirements of crops in selected irrigation areas managed by the Orange-Vaal and Orange-Riet Water Users Association".

SAPWAT was developed to satisfy a need for a user-friendly and credible aid to planning of irrigation schemes and for water management by WUAs.

Within the South African context, it is a further development of, and improvement on, the Green Book of 1985, which has been the basis of irrigation requirement planning for many years, but which has been overtaken by developments in irrigation practice and management. On the international front, SAPWAT links to, and is also a further *development on, a Food and Agriculture Organisation (FAO) planning model, CROPWAT which, in turn, leans strongly on several FAO irrigation and drainage reports on irrigation management that have been published since 1977.*

SAPWAT is not a crop growth model. It is a planning and management aid that is supported by an extensive South African climate and crop database. Some of the biggest improvements that have been incorporated into SAPWAT are:

- *the replacement of the American Class A evaporation pan with reference evaporation from a short grass surface;*
- *the Penman-Monteith calculation methodology for reference evaporation which is acknowledged internationally;*
- *the use of a simple methodology whereby crop factors can be determined and adapted to provide for virtually any growing situation. The inclusion of an extensive climate and crop database enhances the user friendliness because the user does not have to look elsewhere for data.*

SAPWAT takes the user through a process from the selection of up to six weather stations out of 350, which are shown on a map; comparative reference evaporation graphs; crop factors for a selected crop; and a screen which shows the water requirement for that crop, effective rainfall and irrigation requirement. Several options are provided, enabling the user to replicate a specific situation. These include choice of growing periods, planting dates, geographic regions, basic irrigation management options, favourable, normal or severe climatic conditions, inclusion or exclusion of rain as a factor and changeable irrigation efficiency levels.

A management module is also provided that enables the user to evaluate different irrigation strategies in order to identify a "best" strategy for a specific situation.

In the Lower Orange, there are a limited number of weather stations to use for the estimation of irrigation requirement. To overcome this limitation, the Project Team decided to rather look at the trend of irrigation requirements at various locations along the river. Eleven weather stations between the Addo and the Richtersveld were used and six alternative crop water requirements were calculated for each of the locations. **Figure 8.1** shows the results of these calculations.

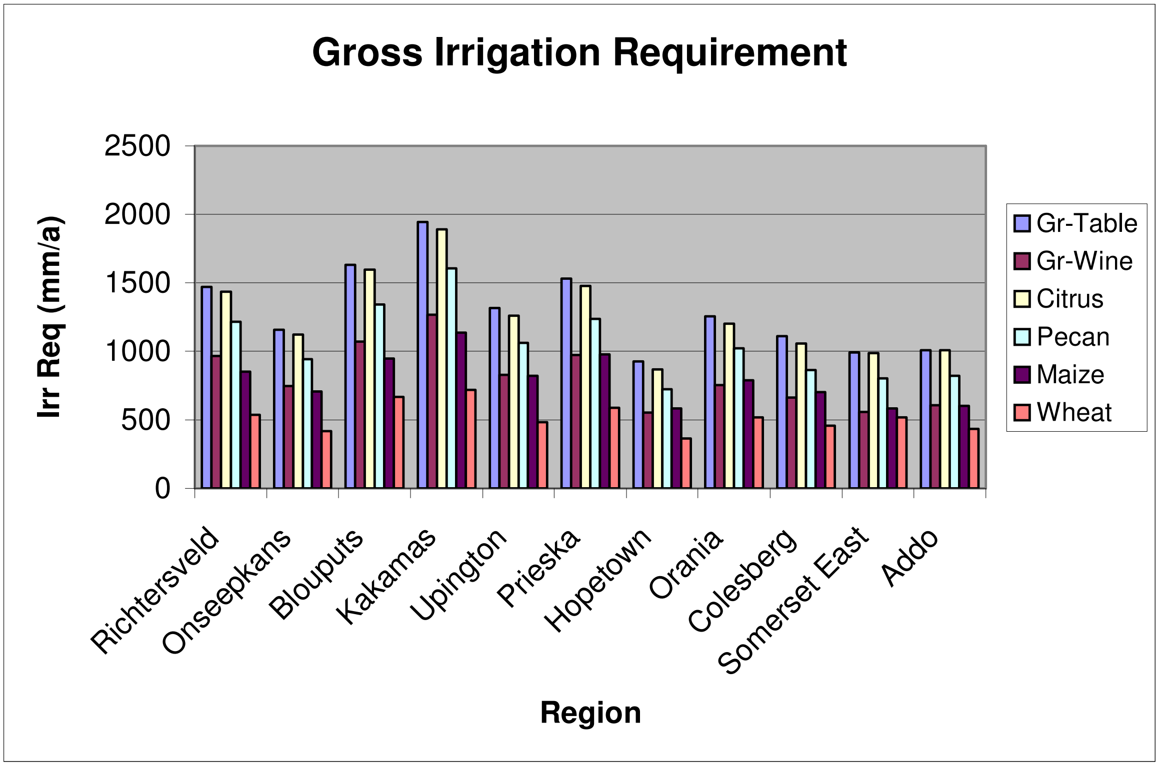


Figure 8.1: Gross Irrigation Requirements at Various Locations for Different Crops

There are some doubts about the correct positioning of the weather station at Onseepkans, which may result in a lower requirement than the actual situation.

From the graph, it is evident that the maximum irrigation requirement occurs in the Kakamas/Blouputs region. To either side, there is a gradual drop in the requirement. The suggested annual allocation per hectare of 15 000 m^3 appears to be realistic for the crops likely to be cultivated in the LOR.

Depending on the size of a development at a particular location, the future demand will be lower because of the humidity changes that will take place as a result of the irrigation and evapotranspiration.

8.1.2 Urban / Domestic and Mining / Industrial

The LOR is the focus area of this study and for this reason all the urban/industrial/mining demands supplied with water from the CBA, were updated. Updated demand projections were obtained for most of the users except for the very small users. The registered/permit volume was used for the small users.

The current urban, industrial and mining demands are summarised in **Table 8-2**. The water use for the major consumers was obtained from questionnaires sent to the following users:

- Pelladrift Water Board;
- Namakwa Water Board;
- Trans Hex Mine; and
- Alexander Bay.

The total demand of 14.8 Mm³/a in 2000 is just below the allocation of 15,6 Mm³/a. To put the total urban, industrial and mining demand into perspective it is important to note that this demand represents less than 0,4% of the total Orange River System demand (Vaal System excluded).

Table 8-2: Current Urban, Industrial and Mining demands for the LOR

Description	Demand (Mm³/a) Year 2000
Pelladrift Water Board (Pofadder, Aggeneys, Pella, Black Mountain Mine and farmers)	4,7
Namakwa Water Board (Springbok, Kleinzee, Steinkopf, O' Kiep, Nababeep, Carolusberg, Concardia, O'Kiep Copper Mine, De Beers Mine)	4,2
Namakwa Small users	0,04
Trans Hex Mine	1,5
Trans Hex other mines	1,0
Alexander Bay	3,2
Small mines	0,2
Total	**14,8**

8.1.3 Return Flows

The bulk of the urban requirements are supplied through the Pelladrift and Namakwa Water Supply Systems to towns located far from the Orange River. Return flows from these towns will not return to the Orange River due to the distance and the fact that the return flows from most of the smaller users are generally directed to evaporation ponds or pan areas. Wastewater from the mines is evaporated through evaporation ponds and is not returned directly to the river. The mines re-circulate their water to a large extent. Seepages do occur from some of the mines.

Unfortunately, no data is available on the magnitude of seepage flows. It is, however, expected to be negligible. Return flows from the mines are therefore regarded as zero as they are limited and do not feed back into the river system.

8.2 Water Demand Projections

8.2.1 Irrigation

A number of documents were used to determine the potential irrigable land in the Lower Orange. The most useful of these was the work done by Schloms, Oosthuizen, Ellis and Rudman in 1977, as per their report "Verkenningsopname van die Benede Oranjerivier." Their findings were included in the 1:250,000 Land Type map series compiled by the Institute for Soil, Water and Climate. These maps show a great deal of detail about soil types and the physical properties of the soils.

The potential irrigation areas were identified on these maps within the area between the river and a height of 240 m above the river. Two intermediate height lines were also considered, namely 60 m and 140 m above the river. Due to infrastructure to be established, only pockets of land larger than 150 ha were considered to have potential for development. From the Land Use maps, the soils could be categorised in different potential classes. The ratio between these classes could be calculated, and these were applied on the areas for the three height lines.

Table 8-3 and **Table 8-4** show the results of these calculations.

Table 8-3: Height above River of Irrigable Land - South Africa

Location / River Reach	Irrigable Land , Including Present Development (ha) Height Above River			
	0 - 60 m	60 m - 140 m	140 m - 240 m	Total area
20°E long - Goodhouse	1 786	2 701	5 739	10 226
Noordoewer / Vioolsdrif	1 058	406	0	1 464
Opposite Ausenkehr	1 593	531	639	2 763
Khubus	531	6 031	14 668	21 230
Sendelingsdrif - Alexanderbay	4 433	0	0	4 433
Total area irrigable land	9 401	9 669	21 046	40 116

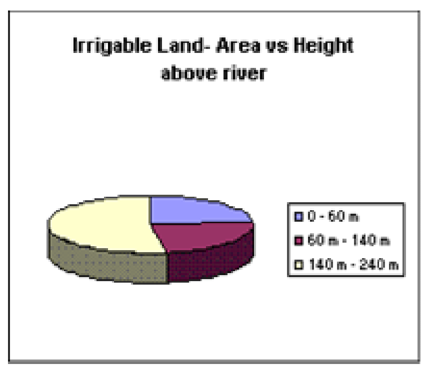
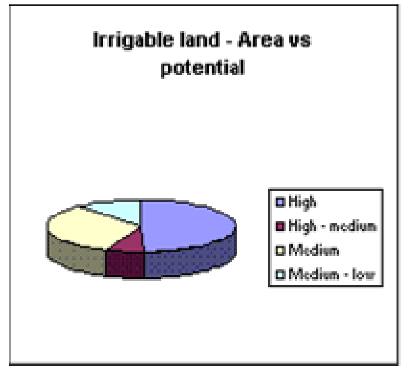


Table 8-4: Total Area of Irrigable Land – South Africa

Location / River Reach	Irrigable Land , Including Present Development (ha) Soils Potential Classification				
	High	High - Medium	Medium	Medium - Low	Total Area
20°E long – Goodhouse	760	2 572	5 423	1 471	10 226
Noordoewer / Vioolsdrif	1 269	195	0	0	1 464
Opposite Aussenkehr	1 719	0	768	276	2 763
Khubus	15 828	0	5 402	0	21 230
Sendelingsdrif – Alexanderbay	212	0	1 274	2 947	4 433
Total area irrigable land	**19 788**	**2 767**	**12 867**	**4 694**	**40 116**



Due to the "capping" of water rights in South Africa, historic information of the rate of irrigation development along the LOR is of little value.

At this stage, it appears that the only irrigation developments, for which new water rights will be released, will be for small-scale farming. In this regard, three allocations have been made. These are 4 000 hectare for the Lower Orange WMA, 4 000 hectare for the Upper Orange WMA and 4 000 hectares for the Fish to Tsitsikama WMA.

It is reasonable to believe that the full extent of 4 000 hectare in the Lower Orange WMA can easily be developed before 2025. For the purpose of future water demand projections, it was therefore assumed that it will take a maximum of 23 years to reach this limit (Low Scenario). On the other hand, it is unlikely that this limit will be reached by the year 2015 (Upper Scenario). The average of these two scenarios was used as the Medium Scenario. For all three scenarios, it is assumed that development will take place at a linear rate. The projection for the area of land to be developed, is illustrated in **Figure 8.2**. The projection for irrigation demand until 2025, appears in **Table 8-5**.

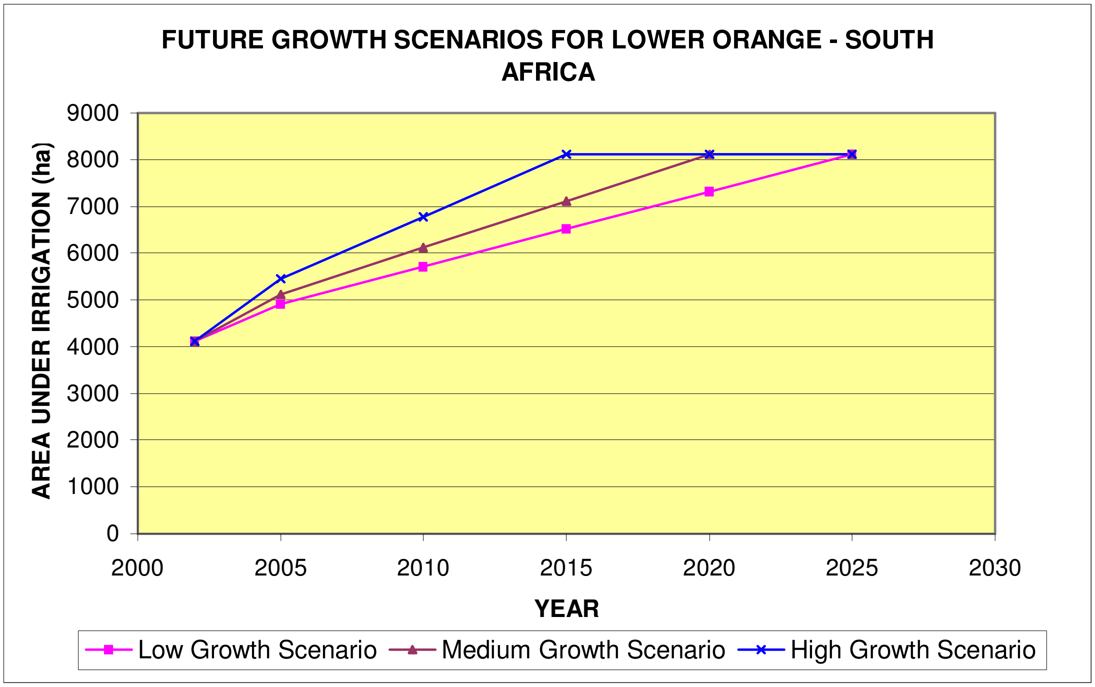


Figure 8.2: Future Irrigation Development Scenarios for Lower Orange - South Africa

Table 8-5: South African Irrigation Demand Projections

YEAR	2002	2005			2010			2015			2020			2025		
Growth Scenario		**Low**	**Med**	**High**	**Low**	**Med**	**High**	**Low**	**Med**	**High**	**Low**	**Med**	**High**	**Low**	**Med**	**High**
Upstream of Vioolsdrift Dam Site																
Area (ha)	2 752	3 152	3 252	3 418	3 552	3 752	4 085	3 952	4 252	4 752	4 352	4 752	4 752	4 752	4 752	4 752
Requirement Mm^3/a	41.3	47.3	48.8	51.3	53.3	56.3	61.3	59.3	63.8	71.3	65.3	71.3	71.3	71.3	71.3	71.3
Downstream of Vioolsdrift Dam Site																
Area (ha)	1 362	1 762	1 862	2 029	2 162	2 362	2 695	2 562	2 862	3 362	2 962	3 362	3 362	3 362	3 362	3 362
Requirement Mm^3/a	20.4	26.4	27.9	30.4	32.4	35.4	40.4	38.4	42.9	50.4	44.4	50.4	50.4	50.4	50.4	50.4
Total Area (ha)	4 114	4 915	5 114	5 447	5 714	6 114	6 780	6 514	7 114	8 114	7 314	8 114	8 114	8 114	8 114	8 114
Total Requirement (Mm^3/a)	61.7	73.7	76.7	81.7	85.7	91.7	101.7	97.7	106.7	121.7	109.7	121.7	121.7	121.7	121.7	121.7

8.2.2 Urban / Domestic and Mining / Industrial

The urban, industrial and mining demand projections are given in **Table 8-6**. The demand growth for the small users was accepted as zero as their impact on the system is negligible.

The significant increase in demand for Pelladrift Water Board between 2005 and 2010 is as a result of the possible Gamsberg Mine Project. When the Gamsberg Project materializes, the town Aggeneys is expected to increase with a further 500 houses. The Gamsberg Project is dependent on the "Zinc" price and related global markets. The earliest expected date for the Gamsberg development is 2006.

The decrease in demand for the Trans Hex Mine is as a result of the expected closure of the mine after 2015. Alexander Bay only provided demand projections up to 2010 as there are no plans for future expansion, and they are not sure when the closure of the mine will be. Indications are that it might not be for more than 10 years from now. For the purpose of the study, it was decided to keep the growth constant from 2015 to 2025.

Due to internal uncertainties regarding the future existence of the Namakwa Water Board or possible merging with one of the municipalities, the Board was not able to provide demand projections. They have, however, said that no new projects are currently planned. The Okiep Copper Mine has already scaled down to a minimum level and it is expected that the mine will still continue to operate at this level for another 5 to 8 years. No new mines are planned. The projection included in **Table** 8-6 is, however, in line with the previous ORRS projection and that of typical towns in the area.

Table 8-6: Urban, Industrial and Mining Demand Projections for the LOR – South Africa

Description		Demand (Mm³/a)					
		2000	2005	2010	2015	2020	2025
Area 5: 20°E Longitude to River Mouth							
Upstream of Vioolsdrift Dam Site							
Pelladrift Water Board -	High Projection	4.7	5.2	10.5	10.5	10.5	10.5
	Most Probable Projection	4.7	4.7	9.8	9.9	9.9	9.9
	Low Projection	4.7	4.7	8.0	8.0	8.0	8.0
Namakwa Water Board -	High Projection	4.2	4.9	5.6	6.5	7.6	8.8
	Most Probable Projection	4.2	4.6	5.1	5.6	6.2	6.9
	Low Projection	4.2	4.4	4.6	4.9	5.1	5.4
Namakwa Small users		0.04	0.04	0.04	0.04	0.04	0.04
Total for Upstream:	**High Projection**	**8.94**	**10.14**	**16.14**	**17.04**	**18.14**	**19.34**
	Most Probable Projection	**8.94**	**9.34**	**14.94**	**15.54**	**16.14**	**16.84**
	Low Projection	**8.94**	**9.14**	**12.64**	**12.94**	**13.14**	**13.44**
Downstream of Vioolsdrift Dam Site							
Trans Hex Mine -	High Projection	1.5	3.0	3.0	3.0	1.0	1.0
	Most Probable Projection	1.5	2.8	2.8	2.8	0.3	0.3
	Low Projection	1.5	2.0	2.0	2.0	0.2	0.2
Trans Hex other mines -	High Projection	1.0	1.2	1.3	1.6	1.8	2.1
	Most Probable Projection	1.0	1.1	1.2	1.4	1.5	1.6
	Low Projection	1.0	1.1	1.1	1.2	1.2	1.3
Alexander Bay -	High Projection	3.2	4.0	4.0	4.0	4.0	4.0
	Most Probable Projection	3.2	3.2	3.8	3.8	3.8	3.8
	Low Projection	3.2	3.2	3.2	3.2	3.2	3.2
Small mines		0.2	0.2	0.2	0.2	0.2	0.2
Total for Downstream:	**High Projection**	**5.9**	**8.4**	**8.5**	**8.8**	**7.0**	**7.3**
	Most Probable Projection	**5.9**	**7.3**	**8.0**	**8.2**	**5.8**	**5.9**
	Low Projection	**5.9**	**6.5**	**6.5**	**6.6**	**4.8**	**4.9**
Total	**(High Projection)**	**14.8**	**18.5**	**24.6**	**25.8**	**25.1**	**26.6**
	(Most Probable)	**14.8**	**16.6**	**23.0**	**23.7**	**21.9**	**22.7**
	(Low Projection)	**14.8**	**15.6**	**19.1**	**19.5**	**17.9**	**18.3**

8.2.3 South African Water Demand Projections – All Consumers

The total water demand projection for all consumers in the CBA is summarised in **Table 8-7** and **Figure 8.3** below.

Table 8-7: South African Water Demand Projections - All Consumers – Mm^3/a

YEAR	2002	2005			2010			2015			2020			2025		
Growth Scenario		Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
Upstream of Vioolsdrift Dam Site																
Urban/Mining	8.9	9.1	9.3	10.1	12.6	15.0	16.1	12.9	15.5	17.0	13.1	16.1	18.1	13.4	16.8	19.3
Irrigation	41.3	47.3	48.8	51.3	53.3	56.3	61.3	59.3	63.8	71.3	65.3	71.3	71.3	71.3	71.3	71.3
Sub-total Upstream	50.2	56.4	58.1	61.4	65.9	71.3	77.4	72.2	79.3	88.3	78.4	87.4	89.4	84.7	88.1	90.6
Downstream of Vioolsdrift Dam Site																
Urban/Mining	5.9	6.5	7.3	8.4	6.5	8.0	8.5	6.6	8.2	8.8	4.8	5.8	7.0	4.9	5.9	7.3
Irrigation	20.4	26.4	27.9	30.4	32.4	35.4	40.4	38.4	42.9	50.4	44.4	50.4	50.4	50.4	50.4	50.4
Sub-total Downstream	26.3	32.9	35.2	38.8	38.9	43.4	48.9	45.0	51.1	59.2	49.2	56.2	57.4	55.3	56.3	57.7
TOTAL RSA DEMAND	76.5	89.3	93.3	100.2	104.8	114.7	126.3	117.2	130.4	147.5	127.6	143.6	146.8	140.0	144.4	148.3

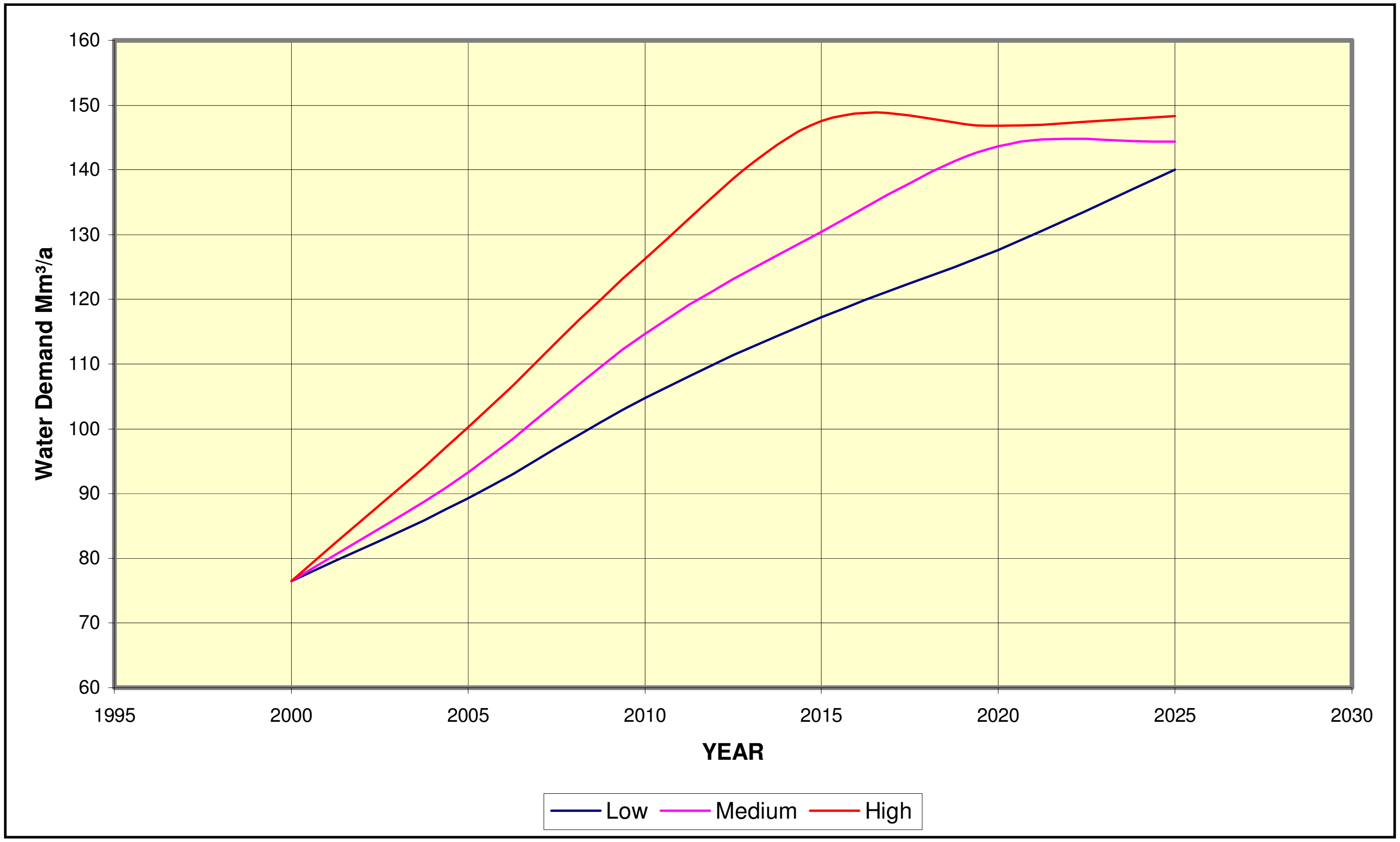


Figure 8.3: South African Water Demand Projections - All Consumers

9. COMBINED WATER REQUIREMENTS ALONG THE COMMON BORDER – NAMIBIA AND SOUTH AFRICA

This chapter is a brief summary of the results of the preceding two chapters and presents an overview of the combined current consumption and future demand projections of both countries.

9.1 Current Consumptive Demand

Table 9-1 presents an overview of the consumer demand on the Orange River System.

Table 9-1: 2002 Consumer Demand on the Orange River System (Mm³/a)

Demand Area	Irrigation	Urban/Ind/ Mining	Total
Vaal River System	908	1 756	2 664
Eastern Cape	607	18	625
Upstream of Vanderkloof	111	82	193
Vanderkloof – 20°E Long.	1 273	20	1 293
Diffuse Irrigation	397		397
Common Border Area	102	24	126
TOTAL	**3 398**	**1 900**	**5 298**

From **Table 9-1**, it is clear that irrigation is the largest consumer of water. If the Vaal River System is included, irrigation uses 64% of the total consumption. If the Vaal River System is excluded, this percentage increases to 94%.

In evaluating the estimated water consumed by irrigation, the following should be borne in mind:

- Estimated consumption figures are based on areas irrigated. Water for irrigation is not metered.
- There is an improved confidence in areas irrigated land in South Africa as earlier figures have been adjusted after the recently introduced registration process.

Table 9.2 presents the current demand in the CBA. The Human Reserve is included in the domestic demand.

Table 9-2: 2002 Combined Demands in the CBA

User Category	Namibia		South Africa		Total	
	Mm³/a	% Nam	Mm³/a	% RSA	Mm³/a	% Total
Irrigation	40.6	79	61.7	78	102.3	15.4
Urban/Domestic	7.1	13	14.8	18	23.9	3.6
Mining/Industrial	2.0	4				
River Requirements[1]					264.6	39.7
Operational losses[2]					270.0	40.6
Conveyance losses[3]	2.0	4	3.1	4	5.1	0.8
TOTAL	**51.7**		**79.6**		**665.9**	

Note 1. At a flow of 70m^3/s, excludes the environmental reserve and the environmental demand of the river mouth. This represents the total losses for reaches 5, 6 & 7 in the CBA

2. Operational losses apply to the river downstream of Vanderkloof Dam.

3. Assumed at 5% of irrigation use, includes possible canal losses, pipeline breaks, backwashing of filters, etc.

9.2 Water Demand Projections – Scenario Used in the Yield Model

It was decided, at a meeting held with the Client that for modelling purposes, the Medium Scenario demand projections would be used in the Yield Model with the exception that the following irrigation demand projections would be used in the CBA:

- The High Demand Scenario for South African irrigation.
- The Medium Demand Scenario for Namibian irrigation.

The combined water demand projection of both countries as used in the Yield Model is presented in **Table 9.3**.

Table 9-3: Combined Water Demand Projections used in the Yield Model

Category	Expected Water Demand (Mm³/a)											
	RSA						Namibia					
	2002	2005	2010	2015	2020	2025	2002	2005	2010	2015	2020	2025
Irrigation - Ha												
Vaal (VRSAU)	*(117 380)*	*(117 380)*	*(117 380)*	*(117 380)*	*(117 380)*	*(117 380)*						
Vaal (Loxten Venn)	91 300	91 300	91 300	91 300	91 300	91 300						
Upper & Middle Orange	118 416	120 416	122 416	122 416	122 416	122 416						
Eastern Cape	51 513	53 513	55 513	55 513	55 513	55 513						
LOR (Common Border Area)	4 114	5 447	6 780	8 114	8 114	8 114	2 703	3 980	6 850	10 000	13 105	15 115
20° Longitude - Vioolsdrift site	*2 752*	*3 418*	*4 085*	*4 752*	*4 752*	*4 752*	*979*	*1 380*	*2 105*	*3 085*	*4 115*	*4 255*
Vioolsdrift site - Mouth	*1 362*	*2 029*	*2 695*	*3 362*	*3 362*	*3 362*	*1 724*	*2 600*	*4 745*	*6 915*	*8 990*	*10 860*
Subtotal Irrigation (VRSAU figures)	**265 344**	**270 676**	**276 009**	**277 343**	**277 343**	**277 343**	**2 703**	**3 980**	**6 850**	**10 000**	**13 105**	**15 115**
Irrigation - Mm³/a												
Vaal (VRSAU)	*(908)*	*(908)*	*(908)*	*(908)*	*(908)*	*(908)*						
Vaal (Loxten Venn)	796	796	796	796	796	796						
Upper & Middle Orange	1 371.0	1 393.0	1 415.0	1 415.0	1 415.0	1 415.0						
Eastern Cape	607.3	629.3	651.3	651.3	651.3	651.3						
Diffuse Irrigation – Upper Orange	397.3	397.3	397.3	397.3	397.3	397.3						
Lower Orange	61.7	81.7	101.7	121.7	121.7	121.7	40.6	59.7	102.8	150.0	196.5	226.7
20° Longitude - Vioolsdrift site	*41.3*	*51.3*	*61.3*	*71.3*	*71.3*	*71.3*	*14.7*	*20.7*	*31.6*	*46.3*	*61.7*	*63.8*
Vioolsdrift site - Mouth	*20.4*	*30.4*	*40.4*	*50.4*	*50.4*	*50.4*	*25.9*	*39.0*	*71.2*	*103.7*	*134.8*	*162.9*
Subtotal Irrigation (VRSAU figures)	**3 233.3**	**3 297.3**	**3 361.3**	**3 381.3**	**3 381.3**	**3 381.3**	**40.6**	**59.7**	**102.8**	**150.0**	**196.5**	**226.7**
Urban, Industrial & Mining												
Vaal	1 840.0	1 968.2	2 038.6	2 088.1	2 162.6	2 270.0						
Upper & Middle Orange	101.3	110.1	121.9	134.0	143.5	153.4						
Eastern Cape	18.9	20	20	20	20	41.3						
Lower Orange	14.8	16.6	23.0	23.7	21.9	22.7	9.1	15.8	31.2	46.7	47.4	47.7
20° Longitude - Vioolsdrift site	*8.9*	*9.3*	*15.0*	*15.5*	*16.1*	*16.8*	*0.0*	*0.0*	*0.0*	*0.2*	*0.4*	*0.4*
Vioolsdrift site - Mouth	*5.9*	*7.3*	*8.0*	*8.2*	*5.8*	*5.9*	*9.1*	*15.8*	*31.2*	*46.5*	*47.0*	*47.3*
Subtotal Urban, Industrial, Mining	**1 975.0**	**2 114.9**	**2 203.5**	**2 265.8**	**2 348.0**	**2 487.4**	**9.1**	**15.8**	**31.2**	**46.7**	**47.4**	**47.7**
TOTAL	**5 208.4**	**5 412.2**	**5 564.8**	**5 647.2**	**5 729.4**	**5 868.8**	**49.7**	**75.5**	**134.0**	**196.7**	**243.9**	**274.4**

Note:

1. For Namibian irrigation the medium demand scenario has been used.
2. For South African irrigation the high demand scenario has been used.
3. All other projections are medium projections.
4. 2025 Urban, industrial, mining demand of Vaal is extrapolated figure.
5. Eastern Cape irrigation allows for 4000 ha development from present to 2010 @ 11 000m³/ha/a.
6. Upper & Middle Orange allows for 4000 ha development from present to 2010 @ 11 000m³/ha/a.
7. Lower Orange RSA allows for 4000 ha development, 2 000 ha downstream of dam site and 2 000 ha upstream of the dam site, from now to 2015 @ 15 000m³/ha/a.
8. Two irrigation figures for the Vaal have been quoted:
   (i) the latest VRSAU figures. (These have been used throughout the Water Requirements report as they were the latest figures available while compiling this component of the study. In the above Table they are presented in brackets and they are not included in the totals).
   (ii) recent figures estimated by Loxten Venn. (These figures are the latest figures available. The have been used in the Yield Model and are included in the Totals given in the Table.)
9. The Diffuse Irrigation refers to irrigation from farm dams and from tributaries of the Orange. There are no irrigation allocations for these irrigators. The hectares under irrigation vary annually and are not known. Only the irrigation consumption has been estimated.

10. ASSURANCE OF SUPPLY

10.1 General

The WRYM and WRPM will both be used in this study for the Water Resources Yield Analysis Task (Task 3). The WRYM is used to determine the system yield for various possible scenarios. By using stochastic yield analysis, it is possible to determine the system yield at different reliability levels. At low reliability levels, the system can typically provide a higher yield than would be available at a high reliability level. The WRPM uses the yield characteristics as obtained from the WRYM in planning and operational analyses to supply the system demands at the required level of assurance. Irrigation or urban garden watering will, for example, be supplied at a lower assurance than strategic industries. For the purpose of these analyses, it is therefore important to sub-divide the demand of the different user categories into three or four priority classes, which represent different assurance or reliability levels.

10.2 Reliability Classifications

10.2.1 Description of Existing Reliability Classifications

One of the inputs required by the WRPM when analysing the integrated system, is a set of guidelines on how to implement water restrictions in the catchment, when necessary. The method of allocating the supply of available water to users, based on current supply characteristics of the various components of a system, is built into the WRPM. This requires that the different water users should be grouped together into user categories and these categories should be classified according to priority for water supply. User categories that were considered for the ORDPRS were urban, industrial, strategic industries, mining, irrigation and environmental. The urban and industrial users were grouped together due to the fact that it was difficult to split the total water demand of a municipality into these two user categories.

The user categories were each split into different levels of assurance of supply. In the ORRS it was decided to split each of these user categories into three levels of assurance of supply, namely the low level (95% assurance of supply), medium level (99% assurance of supply), and the high level (99,5% assurance of supply). In this way a portion of the demand for a specific user category (say urban) can be supplied at a high level of assurance (e.g., domestic consumption), while the remaining portion of the demand can be supplied at a lower level of assurance (e.g., garden watering).

Examples of typical user categories and priority classifications as used in different studies are summarised in **Table 10-1**.

In the case of the priority classification for the Crocodile River (North-West) System, the Vaal River System was used as basis, with the only difference being the medium/high split for irrigation changing from 30/20 (Vaal River) to 40/10 (Crocodile River) due to more permanent crops in the Vaal River than in the Crocodile River.

The priority classification used in the ORRS study is given in **Table 10-2**.

The reason why river losses and conveyance losses are in the high assurance class is that these losses cannot be curtailed and will still exist during dry periods. The most realistic option is therefore to include them in the highest assurance class.

The priority classification for the ORRS was proposed at a meeting on 8 May 1996. The major difference between the proposed priority classification for the ORRS and the classification of other studies are, that a 1:10-year recurrence interval (90% assurance of supply) group was added. Most of the irrigation demand will be allocated to this group, especially annual crops. A relatively small portion of the demands for some crops were allocated to the 95% and 99% assurance of supply levels as can be seen in

Table 10-3.

Table 10-1: Examples of User Categories and Priority Classifications Used in Other Studies

System and User Category	**Priority Classification (%)**		
	Low (95% assurance)	**Medium (99% assurance)**	**High (99,5% assurance)**
Original Vaal River System			
Urban	40	30	30
Industrial	0	30	70
Strategic industries	0	0	100
Irrigation	50	30	20
Western Cape System			
Urban	40	30	30
Industrial	10	35	55
Irrigation	50	30	20
Crocodile River (North-West) System			
Urban/industrial	20	30	50
Mining	0	30	70
Strategic industries	0	20	80
Irrigation	50	40	10
Mgeni River System			
Urban	25	25	50
Industrial	10	20	70
Irrigation	70	25	5
Orange River System			
Urban	20	30	50
Irrigation	50	40	10
Updated Vaal River System			
Urban	22	24	54
Strategic industries	0	0	100
Irrigation	50	30	20
Curtailment Level	**0**	**1**	**2** **3**

Table 10-2: User Category and Priority Classifications Used in the ORRS Study

System and User Category	Priority Classification (%)			
	Low (90% assurance) (1:10 year)	Medium (95% assurance) (1:20 year)	Intermediate (99% assurance) (1:100 year)	High (99,5% assurance) (1:200 Year)
Irrigation	Percentage split varies from crop to crop (see Table 10-3 below)			
Urban and mining	0	20	30	50
River losses (evaporation)	0	0	0	100
Environmental	0	36	66	0
Conveyance losses	0	0	0	100

Curtailment level	**0**		**1**		**2**		**3**		**4**

Table 10-3: ORRS Priority Classifications for Different Crops

System and User Category	Priority Classification (%)			
	Low (90% assurance) (1:10 year)	Intermediate (95% assurance) (1:20 year)	Medium (99% assurance) (1:100 year)	High (99,5% assurance) (1:200 year)
Annual crops				
Maize	100	0	0	0
Wheat	100	0	0	0
Cotton	100	0	0	0
Beans / Peas	100	0	0	0
Groundnuts	100	0	0	0
Fodder	100	0	0	0
Vegetables	50	50	0	0
Perennial fodder				
Lucerne	100	0	0	0
Perennial fruits / nuts				
Dates	30	50	20	0
Citrus	30	30	40	0
Grapes	30	40	30	0

Curtailment level	**0**		**1**		**2**		**3**		**4**

10.2.2 Proposed Reliability Classification for This Study

Questionnaires were sent to various users and their input and suggestions regarding the required reliability classifications were obtained. For this purpose, four user categories were used, (Urban; Industrial; Mining and Irrigation) and three reliability classes (Low, Medium and High). The results obtained from this survey are summarised in **Table 10-4**.

Table 10-4: User Categories and Priority Classifications Obtained from Questionnaires

System and User Category	Priority Classification (%)		
	Low (95% assurance)	Medium (99% assurance)	High (99,5% assurance)
Urban	19	31	50
Industrial	45	35	20
Mining	10	23	68
Irrigation	63	27	10

It is extremely difficult, at this stage, to propose a final priority classification for this study. It is therefore proposed to select two or three scenarios and to analyse the effect of these on the system yield. Results from such analyses can provide valuable guidance to the users in the selection of a priority classification. The priority classifications will be discussed in more detail in the Yield Analysis Report, which will contain the final recommended classifications for this study.

10.3 Curtailment Model

The WRPM is used to analyse the system and allocate water to maintain the assigned assurance of supply for all the users in the four proposed different user categories, subject to any physical constraints that may exist. Restrictions in water supply are applied first to the water use allocated to the low assurance level, which in this case is the 90% assurance level (possibility of a shortage in the supply of an average, once in ten years). The WRPM will only start to impose curtailments on the water use allocated to the 95% assurance level, when 100% of the water use that is allocated to the low assurance level has been curtailed (curtailment level 1).

In a similar way, curtailments will each time only be imposed on the higher assurance level if all the water allocated to the lower assurance level has been curtailed in full. There are therefore 4 curtailment levels used in the ORRS in which curtailment level one represents the curtailments being imposed on the low assurance supply, curtailment level 2 for the intermediate (95%) assurance level, curtailment level 3 for the medium (99%) assurance level and curtailment level 4 for the high (99.5%) assurance level water use.

These curtailments are based on the short-term stochastic yield characteristic curves that were determined with the WRYM for various start storage levels and then included in the data input files of the WRPM. The short-term yield is very sensitive to the available storage in the dam at the beginning of a short-term planning period. When the dams are 100% full, the short-term available yield will typically be higher than the long-term stochastic yield at the same assurance level of supply. At the other extreme, when the dams are at a low level at the beginning of the short-term planning period, the short-term yield will again be significantly lower than the long-term yield at the same assurance level of supply. Under such conditions, it will then be required to curtail the demand to such a level that the water resources are protected and that the water supply will not exceed the predetermined risk of failure as defined for the different user categories.

11. CONCLUSIONS

11.1 General

Gariep and Vanderkloof Dams are used to support the demands along the LOR from Vanderkloof Dam to the Orange River mouth. These demand centres are located along a river length of approximately 1 380 km which, together with river losses, and inflows from the Vaal and Fish Rivers (Namibia), contributes to the complexity of operating the system and determining how much water to release from Vanderkloof Dam. A further complication concerns releases from Vanderkloof Dam to generate hydropower, which are sometimes in excess of the downstream demands. The large controlling structures (sluice gates, hydropower turbines, etc.) at Vanderkloof Dam make it very difficult to release the required flow with any accuracy.

Operational Losses downstream of Vanderkloof Dam are estimated to be 270 Mm^3/a. This is a significant loss that can be substantially reduced by establishing further storage in the LOR.

Some of the return flows generated from the Rand Water supply area are returned to the Crocodile River catchment and are lost to the Orange River System.

Most of the water consumed in the system is not accurately metered and more accurate measurement of water consumed is vitally important if the system is to be managed effectively.

Table 11.1 is a summary of the current combined water demand in the CBA.

Table 11-1: Combined Demand in the Common Border Area in 2002

User Category	Namibia		South Africa		TOTAL	
	Mm^3/a	%NAM	Mm^3/a	%RSA	Mm^3/a	%
Irrigation	40.6	79	61.7	78	102.3	15.4
Urban/Domestic	7.1	13	14.8	18	23.9	3.6
Mining/Industrial	2.0	4				
River Requirements					264.6	39.7
Operational losses [3]					270.0	40.6
Conveyance losses[2]	2.0	4	3.1	4	5.1	0.8
TOTAL	**51.7**		**79.6**		**665.9**	

Note 1: Operational loss applies to the total system from Vanderkloof Dam to the river mouth

Table 11-2 presents the combined demand projections for both countries in the CBA.

Table 11-2: Combined demand projections for Namibia and South Africa in the CBA – Medium Demand

User Category	2002		2005		2010		2015		2020		2025	
	NAM	RSA	NAM	RSA	NAM	RSA	NAM	RSA	NAM	RSA	NAM	RSA
Irrigation	40.6	61.7	59.7	76.7	102.8	91.7	150.0	106.7	196.5	121.7	226.7	121.7
Urban / Mining	9.1	14.8	15.8	16.6	31.2	23.0	46.7	23.7	47.4	21.9	47.7	22.7
River Requirements		264.6		264.6		264.6		264.6		264.6		264.6
Operational Losses		270.0		270.0		270.0		270.0		270.0		270.0
Conveyance	2.0	3.1	3.0	3.8	5.1	4.6	7.5	5.3	9.8	6.1	11.3	6.1
TOTAL		**665.9**		**710.2**		**793.0**		**874.5**		**938.0**		**970.8**

Note * - Operational Losses apply to the river reach from the Vanderkloof Dam to the river mouth

The River Requirements apply to the river reach from the border to the river mouth

The River Requirements for the total river reach from Vanderkloof Dam to the river mouth are estimated at 615 Mm^3/a

Table 11.3 above differs from Table 9.3 in that it presents the medium demand for all consumer categories in both South Africa and Namibia.

11.2 Upper Orange River

Urban and industry consume 66% of the water consumption in the Vaal River System.

Inefficient irrigation, high return flows and seepage contribute to the quality deterioration in the Vaal River. The water quality of the Lower Vaal River is of concern because of the high Total Dissolved Solids (TDS) values. This may influence the water quality downstream of the confluence with the Orange River.

Most of the crops grown in the Upper Orange are cash crops that are normally regarded as low value crops. A significant quantity of water is lost through inefficient irrigation. Improved efficiency could contribute to significant savings.

Transfers from Gariep Dam through the Orange/Fish tunnel are mainly utilised to support irrigation developments in the Eastern Cape. In the Upper Orange and Eastern Cape, more than 90% of water consumed is used for irrigation. Only 17 to 20% of the crops grown in these areas are perennial crops. Even after major price increases in certain commodities like maize, grain and potatoes, more than 60% of the crops grown can be classified as low value crops.

11.3 Irrigation

In the CBA, the hot, dry climate contributes to the success of the high value grape growing industry that has established there. Some of the benefits are:

- Early harvesting of crops.
- Reduction in disease, which is related to untimely rainfall.
- Reduced cost of disease control.
- Risk of hail damage is extremely small.

With the high prices of high value crops obtained on foreign markets and the weak exchange rate of the South African Rand, growing of high value crops in the LOR competes well with industry, as the cost of water, including pumping costs, is less than **1% of the total income** received for the products.

From available information, the gross margin of high value crops along the LOR is in excess of R 120 000/ha/annum. The direct job opportunities vary from 15 to 23 jobs per 1000m^3 of water consumed. This is much higher than for other crops grown in the Orange River System.

If the principle of growing high value crops is accepted, and provided that it is economically viable, the following opportunities are created:

- Eradication of poverty and creation of wealth.
- Accommodation of affected groups displaced by dams in the upper catchment.
- Settlement of formerly disadvantaged communities.
- Transfer of water rights, where feasible, to get a higher return on water use.
- Creation of opportunities for secondary and tertiary sector development in two underdeveloped regions of both countries.

The long-term water quality in the LOR is a cause for concern.

The selection of crops for the CBA west of Vioolsdrift/Noordoewer should be done in a way that water quality does not affect the long-term future production prospects.

The provision of bulk infrastructure in remote areas that have potential for irrigation development may be a major task and very costly. The joint development of infrastructure such as roads, electricity, remote telephone services and other related services by both countries warrants further investigation to realise the benefit of scale.

The importance of co-operation, a proper database, water allocation and valuation, control of salinity/drainage, technical support and the formulation of a proper implementation strategy must be emphasised.

Due to various problems that have been experienced with the development of small-scale irrigation schemes, models should be investigated where commercial development is done in combination with the settlement of small farmers.

11.4 Urban, Domestic and Mining

Along the LOR, the total consumption of the urban, industrial and mining sectors amounts to 19% of total consumptive use.

The domestic water consumption of mining towns in Namibia is unacceptably high. Potential for savings in these towns is significant.

12. RECOMMENDATIONS

It is important that Integrated Resource Planning (IRP) is implemented in the Orange River Basin. The goal should be to provide a long-term, reliable service to all consumers at the lowest reasonable cost and at the highest possible level of assurance. This will require considerations of the impacts of various resource management options on water use efficiency, water pricing, system reliability, environmental quality, economic development, and social equity.

In order to achieve these goals, it is recommended that:

1. The water demand projections for the LOR, as proposed in the report, be accepted.
2. The proposed water demand projections be used as a basis for discussion in the allocation of the available water in the LOR between Namibia and South Africa.
3. The proposed curtailment model be accepted as the basis for modelling the operation of the system in times of water shortage.
4. Water allocations and the issuing of permits on both sides of the border follow the same principles and conditions. These should include:
    - a requirement for efficient irrigation systems;
    - strict application of water pollution criteria to prevent water pollution in the LOR;
    - monitoring of water use and regular permit revision;
    - a Feasibility Study indicating the economic feasibility of proposed new irrigation projects;
    - an environmental assessment of the project showing how the impact of the development on the environment will be managed; and
    - determining quotas based on estimated crop use (SAPWAT), including firm, but fair application efficiencies.
5. Measurement of river flow be improved to facilitate a more accurate water balance.
6. Transfer of water rights be investigated, where feasible, to get a higher return on water use.

7. The joint development by both countries of bulk infrastructure such as access roads, electricity, telephone services and other related services to realise the benefits of scale.
8. Furthering of cross border co-operation.
9. Development of a proper database.

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APPENDIX A

THE SOCIAL ACCOUNTING MATRIX (SAM) AS A MODELLING TOOL

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THE SOCIAL ACCOUNTING MATRIX (SAM) AS A MODELLING TOOL

Background

There is an underlying inter-dependence in all economic activity. Inputs are bought in order to produce output, which is then sold. Stimulation of any given sector of the economy gives rise to the need for more inputs, which in turn stimulates the sector providing the inputs, and so on. These inter-sectoral linkages are fundamental to the operation of an economy, and need to be taken into account when any impact on the economy is being analysed.

General economic equilibrium analysis has been used to quantify the impact of these linkages (known as direct, indirect and induced effects). The "direct effect", emanating from activity in any specific sector, refers to the impact occurring in that sector, whilst the "indirect effects" refer to those impacts occurring in other economic sectors that link backwards with the specific sector due to the supply of intermediate inputs. The "induced effects" refer to the chain reaction triggered by the salaries and profits (less retained earnings) that are ploughed back into the economy in the form of private consumer spending.

An approach to dealing with this type of analysis, which has been found effective in the past, is to transform a system of input-output relationships into an economic model, as the basis for general economic equilibrium analysis. Systems normally used for this purpose are IO tables or SAMs for the region being studied.

In order to provide an overall macroeconomic impact, the analysis must recognise the inter-relation of the economic sectors through forward and backward linkages in the economy. Thus, both indirect and induced impacts will need to be evaluated. The first step in setting up a model is to analyse and to project the direct economic and socio-economic impacts of the present state (the base scenario) of water consumption in macro terms. A model derived from this base scenario is then to be established so that the economic impact of various alternative water use scenarios may be analysed.

The economic indicators, which can be generated in this process include:

- Capital utilisation;

- Employment impact;
- Impact on the GDP;
- Impact on the poor (Income distribution); and
- Fiscal impact.

The model developed to accomplish this analysis makes use of a SAM. This SAM will be used to convert the present day water use quantities to monetary values, and also to form the basis of an economic model to determine the impact on the economy of various future water use scenarios.

Theory of the SAM

An account of the Social Accounting Matrix, or SAM as it is more commonly called, cannot begin without some basic understanding of input-output and the economic analysis to which they give rise.

There is interdependence in economic activity, buying inputs and selling outputs: the relationship between inputs and outputs in the table underpins the philosophy of the table. In IO tables, the economy is aggregated into homogeneous industry groups (or sectors) and these buying and selling activities are recorded in matrix form in monetary terms. As a result, it is possible to track the flow of goods (represented by cash flows) in the economy through the various sectors of the economy in a systematic way, and in as much detail as can be handled. This facilitates focusing upon the impact of very specific activities in the economy on other areas of the economy and on the economy as a whole. This is important if it is necessary to investigate particular interests in very specific areas of the economy (such as changing water use patterns arising as a result of different reserve determination scenarios).

The entries in an IO table can be used to generate a consistent set of equations representing the economy. Simultaneous solution of these equations (usually by means of matrix algebra) enables any changes in the economy to be analysed, and the impact of these changes to be expressed in terms of any of the economic indicators such as GDP, employment, balance of payments, and so on.

As such, input-output tables form a sound basis for undertaking economic analysis. Although much more comprehensive, the SAM is based on the same principles as the IO table, and is a logical extension of it. The SAM, however, differs from the IO table in a few important respects. Besides information on the inter-dependence between the different sectors of the economy (which is also part of the IO table), the

SAM also includes detailed information on the income and spending patterns of households.

The SAM is a relatively recent development in the field of National Accounting. This development is of particular significance since the SAM provides a framework within the context of the national accounts in which the activities of households are prominently distinguished. The household is indeed the basic unit where significant decisions are taken on important economic variables such as, *inter alia*, expenditure and saving. By combining households into meaningful groups, the SAM makes it possible to clearly distinguish, and study the effect of, interactions between groups of similar households.

The development of the SAM, with the household as focus point, was indeed stimulated by the fact that conventional national accounts often do not provide sufficient information, and also no framework, to properly investigate and address important policy issues regarding aspects such as income distribution, personal saving, employment, etc.

The SAM therefore lends itself to economic analysis in the same way as the IO table, but it is much more useful in quantifying income distribution effects and income categories relating to a specific initiative such as changing water reserve determinations.

The SAM as a Modelling Tool

Since the SAM provided a detailed description of the economy under discussion in quantified terms, it can also serve as an effective economic model for planning and policy analysis purposes. The SAM's modelling attributes are based on the fact that its composition has an intrinsic matrix form. This allows the researcher to re-arrange its components into exogenous (independent) and endogenous (dependent) sections.

Its dynamic nature can be further enhanced through adding more equations to the core matrix. An example of the extension of the SAM-structure is the so-called semi-Input-Output Model by Wang and Mullins[5](1988) where labour and capital

[5] Wang, T.F. & Mullins, D (1988). The model of income distribution, employment and growth for South Africa: A semi-closed input-output approach. Studies in Economics and Econometrics, 12(3).

equations were added to the SAM-structure. A SAM normally forms the basis of a General Equilibrium Model.

Many economic impacts can be quantified using this SAM structure. For the purpose of evaluating the impact of various water use scenarios associated with water reserve analysis, the impacts investigated will be confined to the effects on economic value added and employment.

Interpretation of the SAM

Once a SAM has been developed, it becomes a powerful econometric tool that can be used to conduct various economic analyses.

Using the SAM, a Leontief inverse can be calculated in the same manner as for the IO Table. Isolating the endogenous variables within the SAM, sub-tracting them from an identity matrix and inverting the result provides a matrix that can be used to determine and interpret various impacts on the economy.

This inverted matrix contains all the direct as well as indirect and induced impacts that changes in any sector’s output will have on the economy as a whole. When stimulated (“kicked”) by changes in the exogenous part of the economy, it quantifies the various impacts of such changes on the economy.

Construction of the SAM

It can be seem from the above discussion that any SAM is peculiar to the focus area for which it is developed and its construction is an endeavour that requires patience, knowledge of the nature of relationships that exist in an economy in general, and that of the focus area in particular.

In order to develop a SAM it is necessary to determine all possible interactions/transactions (flows) between the different sectors and economic role players in the designated area.

The SAM to be used for this exercise has been specifically developed for use in Namibia and South Africa respectively.

APPENDIX B

FIGURES SHOWING IRRIGATED AREAS AND POTENTIAL

IRRIGABLE LAND ALONG THE COMMON BORDER

APPENDIX C

CRITERIA FOR DETERMINING IRRIGABLE LAND

ON THE NAMIBIAN SIDE OF THE ORANGE RIVER