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DEPARTMENT OF WATER AFFAIRS
AND FORESTRY

UPPER ORANGE WATER MANAGEMENT AREA

Overview of Water Resources Availability and Utilisation

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PREFACE

This overview of the water resources availability and utilisation in the Upper Orange water management area, is one of a series of similar reports covering all 19 water management areas in the country, and results directly from work performed in preparation of the First Edition National Water Resource Strategy, which is to be published in its final form during 2003. It is further complemented by a report giving a national perspective on the water resources of the country.

The information contained in this series of reports, reflects the combined efforts and contributions by a wide spectrum of people. Most of the data follow from water resource situation assessments with respect to each of the water management areas as well as from demographic, economic, environmental and other related studies, which were performed under assignment of the Department of Water Affairs and Forestry. The reports also summarise the knowledge and insights gained through a series of workshops (several per water management area) conducted during the years 2000 and 2001, in which strategic perspectives were developed with respect to the reconciliation of requirements for and availability of water, then and into the future.

It is the objective of the report to, in a non-technical style, provide an overview of the current and expected future water resources situation in the Upper Orange water management area, highlight the key issues of relevance and provide broad strategies with regards to the management of water resources in the water management area. Although an internal document by the Department of Water Affairs and Forestry, it should also serve as valuable background to officials from other government departments and institutions, members of catchment management agencies and water user associations, regional and local authorities, consultants and others.

It is important to note that the information, strategies and priorities given are not static. All relate to a certain point in time, and should be regularly reviewed in future as improved information becomes available and to adjust to changing circumstances. Greater technical detail can be obtained from the documentation referenced.

ACKNOWLEDGEMENTS

Invaluable contributions to the contents of the water management area reports were made by several individuals and through the combined knowledge and wisdom of many others. Only a few can be named here, and this note serves as a rather incomplete recognition to them and our other professional colleagues for what they have done and for what the authors have learned from them.

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UPPER ORANGE
WATER MANAGEMENT AREA

OVERVIEW OF WATER RESOURCES AVAILABILITY AND UTILISATION

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OVERVIEW OF WATER RESOURCES AVAILABILITY AND UTILISATION

1. GENERAL DESCRIPTION OF WATER MANAGEMENT AREA

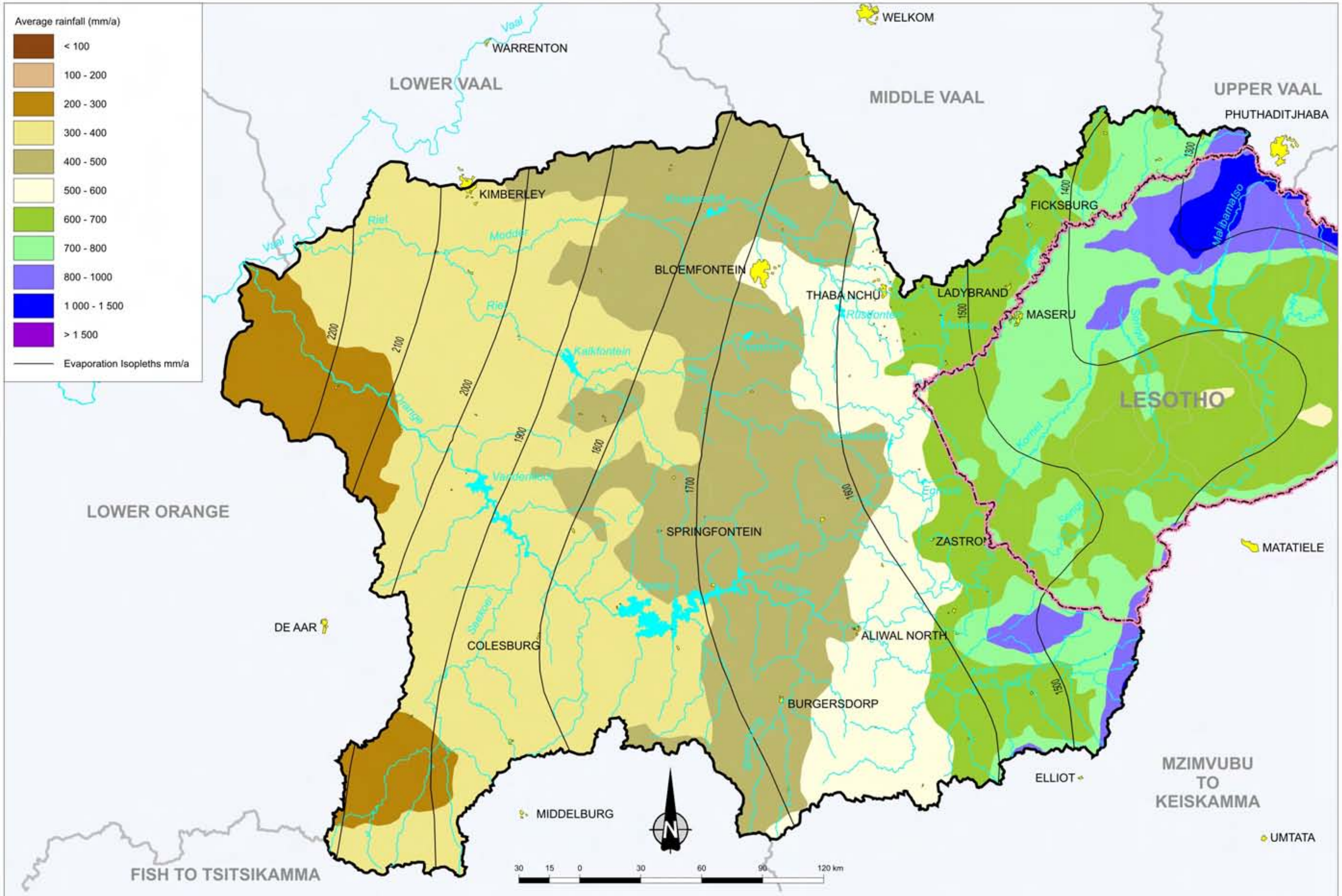
1.1 Natural characteristics

The Upper Orange water management area lies predominantly within the Free State, but also occupies portions of the Eastern and Northern Cape provinces. It borders on Lesotho in the east as well as on six other water management areas. The Orange River, which rises in the eastern highlands of Lesotho where it is known as the Senqu River, is the main river in the water management area and is also the largest and longest river in South Africa. From the Upper Orange water management area, the river flows through the Lower Orange water management area where it discharges into the Atlantic Ocean some 2 300 km from its origin in Lesotho. The Caledon River, which forms the border between South Africa and Lesotho over most of its length, is the largest tributary to the Orange River within the Upper Orange water management area. Other sizeable tributaries are the Kraai and Riet Rivers. The Riet River, however, first flows into the Vaal River, which then joins the Orange River a short distance further downstream. Refer to **Figure 1** for the location and general layout of the water management area.

Climate over the water management area is cool to temperate and ranges from semi-arid to arid. Rainfall mainly occurs as summer thunder showers, and reduces dramatically from as high as 1 000 mm per year in South Africa at locations in the east to about 200 mm per year in the west. In Lesotho, which is the source of most of the water in the Upper Orange water management area, rainfall varies between 600 mm per year to about 1 500 mm per year. Potential evaporation is well in excess of the rainfall as shown on **Figure 2**. Savannah grassland covers the eastern part of the water management area, making way to Karoo shrubbery towards the south and west. From the foothills of the Maluti Mountains at the border with Lesotho, the topography opens into wide plains in the west, with characteristic flat-topped hills. The geology mainly consists of sedimentary rocks of the Karoo Supergroup, with relatively little water bearing capacity. Soils are generally shallow with arable soils mostly found in the north-eastern areas.

Several small game reserves and conservation areas are found in the water management area, one of the best known being the Golden Gate National Park.

UPPER ORANGE WMA **Base Map** **Fig 1**



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Rainfall and Evaporation

Fig 2

1.2 Development

The history of human presence in the water management area can be traced back to at least 40 000 years through the Florisbad skull which was discovered near Dealesville in the 1930’s. Major impetus to modern economic development was given by the discovery of the first diamond in June 1870 near a fountain frequented by early transport riders. This prompted the usual diamond rush (about 3 years before Kimberley) and lead to the establishment of the towns Koffiefontein and Jagersfontein. Bloemfontein, the capital of one of the former boer republics, later developed into the only city in the water management area. (Kimberley, which is situated on the divide with the Lower Vaal water management area, is administratively regarded as within the latter water management area.) Irrigation development was stimulated by the construction of several dams in the water management area, the most recent and notable being the Gariep and Vanderkloof Dams on the Orange River.

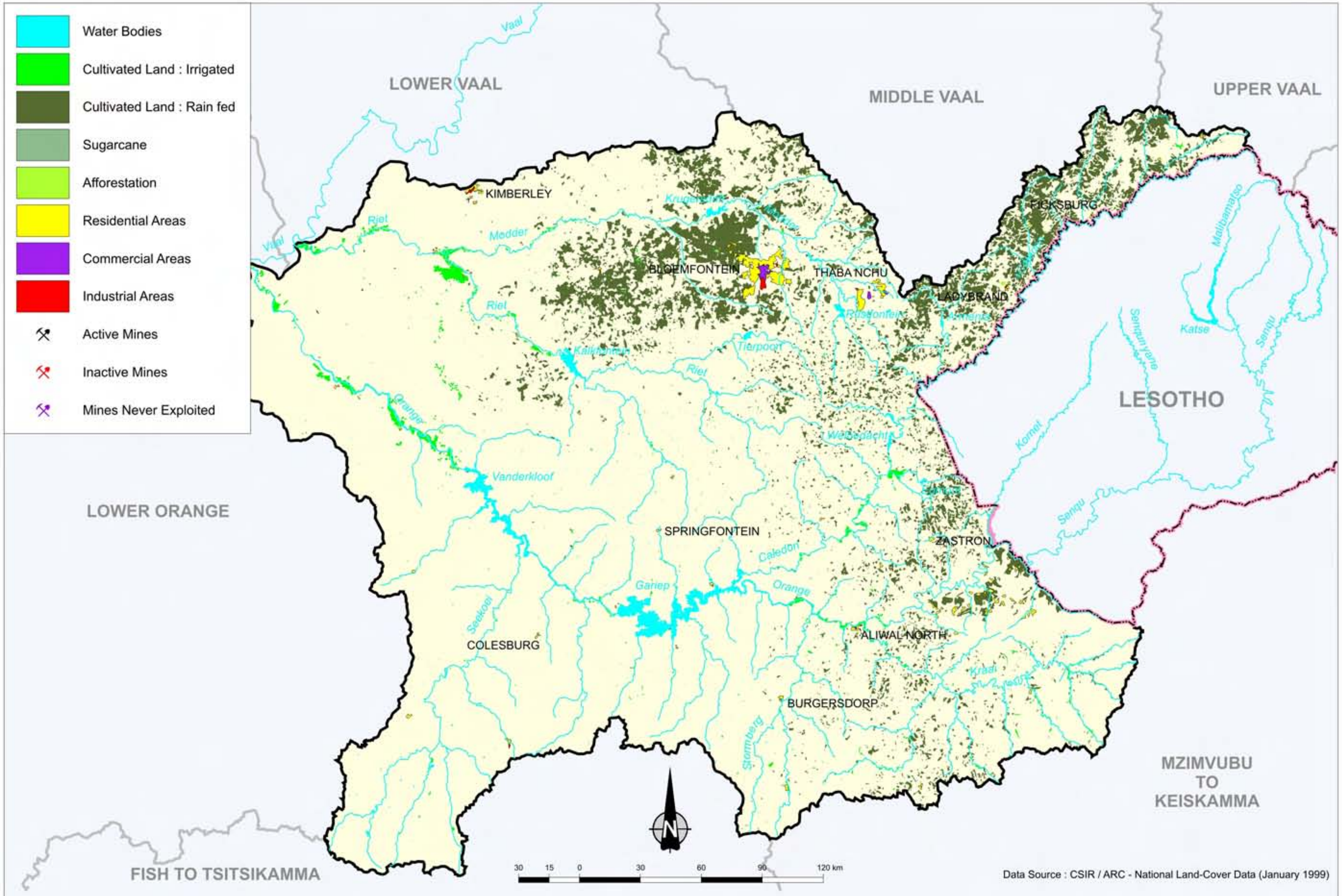
Present land use in the water management area as presented in **Figure 3**, shows most of the water management area remaining under natural vegetation with livestock farming (sheep, cattle and some game) as main economic activity. Extensive areas under dry land cultivation, mostly for the production of grains, are found in the north-eastern parts of the water management area. Ficksburg is famous for the cherry orchards in the region. Large areas under irrigation for the growing of grain and fodder crops have been developed along the main rivers, mostly downstream of irrigation dams. There is no afforestation in the water management area.

Bloemontein and Thaba ‘Nchu represent the main urban and industrial development in the water management area. Two large hydropower stations were constructed at Gariep and Vanderkloof Dams. Mining activities have significantly declined and currently mainly relate to salt works and small diamond mining operations.

1.3 International

The Upper Orange water management area shares the Orange (Senqu) and Caledon Rivers with Lesotho. It also is part of the Orange River Basin with South Africa, Lesotho, Botswana and Namibia as co-basin countries.

Bilateral arrangements on water issues by South Africa and Lesotho are addressed through the Lesotho Highlands Water Commission and in terms of the Treaty between the countries on the Lesotho Highlands Water Project. Co-operation amongst the Orange River Basin countries is facilitated through the Orange-Senqu River Commission (ORASECOM), with membership by the basin countries.



UPPER ORANGE WMA

Land use

Fig 3

1.4 Sub-areas

Significant spatial variations in climate, water availability, level and nature of economic development and growth are typical of South Africa, and are also evident in the Upper Orange water management area. To enable improved representation of the water resource situation in the water management area under such varied conditions, and to facilitate the applicability and better use of information for strategic management purposes, the water management area was divided into sub-areas. Delineation of the sub-areas was judgementally based on practical considerations such as size and location of sub-catchments, homogeneity of natural characteristics, location of pertinent water infrastructure (e.g. dams), and economic development. The catchment management agency may later introduce smaller or alternative subdivisions.

Consequently, four sub-areas were identified to facilitate the presentation and management of key issues in the water management area. These sub-areas as shown on Figure 1, are :

- The Caledon RSA sub-area, corresponding to the catchment of the Caledon River in South Africa.
- The Kraai sub-area, wich includes the catchment of the Kraai River together with that of the Orange River between the Lesotho border and the Caledon River confluence.
- The Riet/Modder sub-area, comprising the catchment of the Riet River together with the Modder tributary.
- The Vanderkloof sub-area, comprising the Orange River catchment between the Caledon River confluence and the Vaal River confluence.

Due to the inextricable dependence of the water situation in the Upper Orange water management area on water resource management in Lesotho, primary statistics are also provided with respect to the Senqu and Caledon catchments in Lesotho. These are presented as the Senqu Lesotho and Caledon Lesotho sub-areas in the tables.

2. NATIONAL PERSPECTIVE

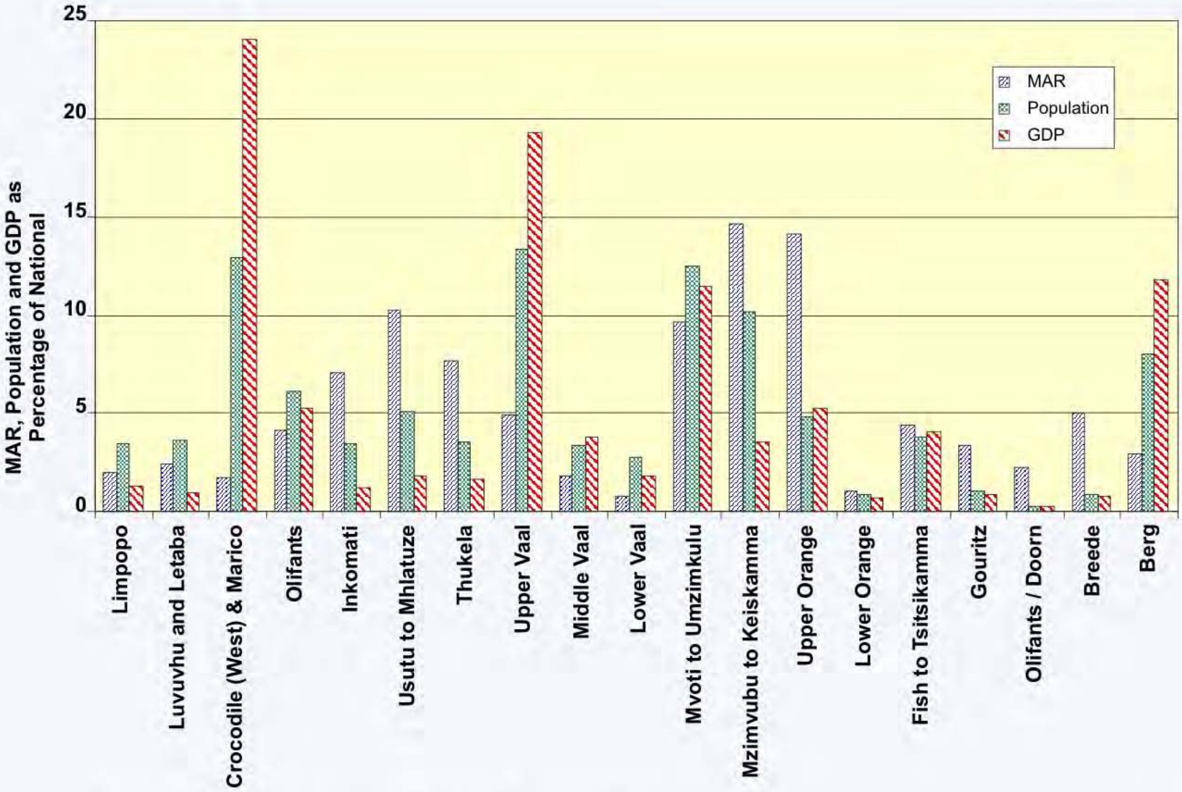
South Africa is located in a predominantly semi-arid part of the world. The climate varies from desert and semi-desert in the west to sub-humid along the eastern coastal area, with an average rainfall for the country of about 450 mm per year, well below the world average of about 860 mm per year, while evaporation is comparatively high. As a result, South Africa's water resources are, in global terms, scarce and extremely limited in extent. More than 90% of the water use in the country is supplied from surface resources, whereas groundwater plays a pivotal role in especially rural water supplies. Due to the predominantly hard rock nature of the South African geology, few major groundwater aquifers exist that could be utilised on a large scale.

Attributable to poor spatial distribution of rainfall over South Africa, the natural availability of water across the country is also highly uneven. This is compounded by the strong seasonality of rainfall over virtually the entire country as well as the high within-season variability of rainfall and consequently of runoff. As a result, streamflow in South African rivers is at relatively low levels for most of the time, with sporadic high flows occurring; characteristics which limit the proportion of streamflow that can be relied upon to be available for use. To aggravate the situation, most urban and industrial development, as well as some dense rural settlements, have been established in locations remote from large watercourses; dictated by the occurrence of mineral riches and influenced by the political dispensation of the past, rather than by the plentiful availability of water. As a consequence, the requirements for water already far exceed the natural availability of water in several river basins. Widely spread and often large-scale transfers of water across catchments have, therefore, been implemented in South Africa in the past.

Of the 19 water management areas in the country, only the Mzimvubu to Keiskamma water management area is currently not linked to another water management area through inter-catchment transfers, giving effect to one of the main principles of the National Water Act which designates water as a national resource. Eleven water management areas share international rivers.

A graphical comparison of the natural occurrence of water, the population and the economic activity per water management area is given in **Figure 4**, clearly demonstrating the exceedingly varied conditions among the water management areas.

Water, which is naturally of poor quality, also occurs in some areas, which limits its utilisation. This applies to both surface and groundwater. Where feasible, special management techniques may be applied to improve water quality to appropriate standards for particular uses.



Comparison of the mean annual runoff, population and economic activity per water management area **Fig 4**

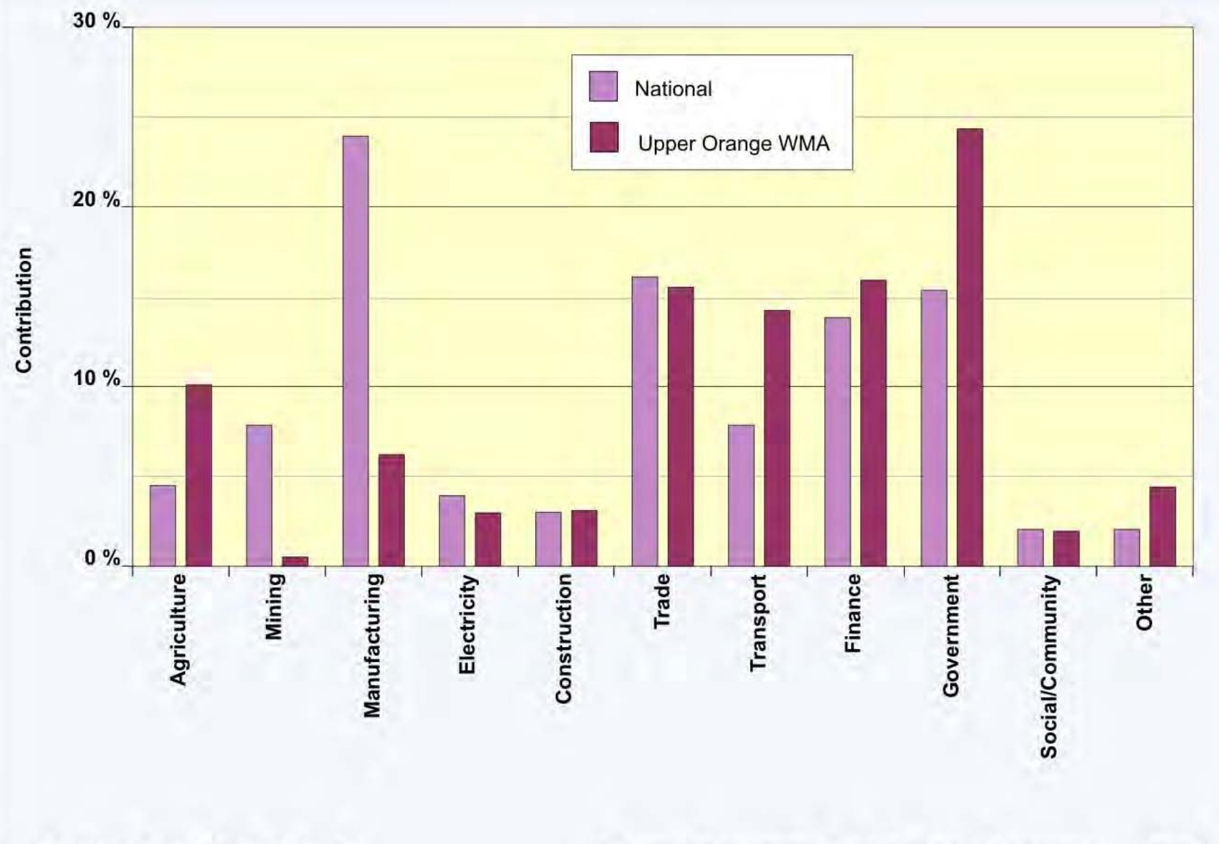
Whereas attention in the past was mainly focussed on the development of new resources as the requirements for water increased, partly as large unused potential was still available, the efficiency of water use has not developed to the same level of sophistication as resource management. With the current high degree of water resource utilisation in the country, the efficiency of water use must be substantially improved. The Department of Water Affairs and Forestry is developing an extensive programme for water conservation and water demand management which forms an important element of the National Water Resource Strategy. In addition, measures are being introduced to ensure the most beneficial utilisation of water in the country, both from a social and economic perspective. This will include the re-allocation of some water from low benefit uses to higher benefit uses over time.

3. ECONOMIC ACTIVITY AND POPULATION

3.1 Regional Economy

Approximately 5% of the Gross Domestic Product (GDP) of South Africa originates from the Upper Orange water management area. The composition of the economy in the water management area in terms of contribution to the Gross Geographic Product (GGP) and in comparison to the national averages, is shown in **Figure 5**. Explanation of the sectors is given in Addendum 2. The largest economic sectors (in 1997) in the water management area terms of GGP, were:

- Government 24,6%
- Finance 16,0%
- Trade 15,7%
- Transport 14,4%



UPPER ORANGE WMA Sectoral contribution to the economy Fig 5

Geographically, nearly 64% of the GGP is produced at Bloemfontein. The second largest district contribution being 4,2% from Thaba 'Nchu.

Bloemfontein as the capital of the Free State fulfils an important government function with many provincial government departments located in this area. The activities of the University of the Free State, the Free State Technikon, the Appeal Court and the major hospitals further enhance the role of this sector. Bloemfontein also serves as a regional centre with close linkages to economic activities in the surrounding rural areas, such as generated by the agricultural sector.

The importance of the transport sector is attributable to transport companies taking advantage of the fact that Bloemfontein is a major model interchange and stopover for cargo travelling on the routes from Gauteng or Durban to Cape Town or Port Elizabeth. It is also supported by the Bloemfontein airport and the importance of the railway station in context of the national rail network.

The strength of the finance and trade sectors is largely as a result of the other economic activities in the region.

Manufacturing occurs mainly in Bloemfontein, while manufacturing activities at Thaba 'Nchu have seriously declined since the cancellation of the previous government's decentralisation policy. This may be reversed through establishment of the Thaba 'Nchu Industrial Development Zone.

Of the work force of 376 000 people in the water management area in 1994, 59% were active in the formal economy, 31% were unemployed, which is higher than the national average of 29%. The remaining 10% participated in the informal economy. Of those formally employed, 33% were in the government sector, 17% in agriculture and 12% in trade.

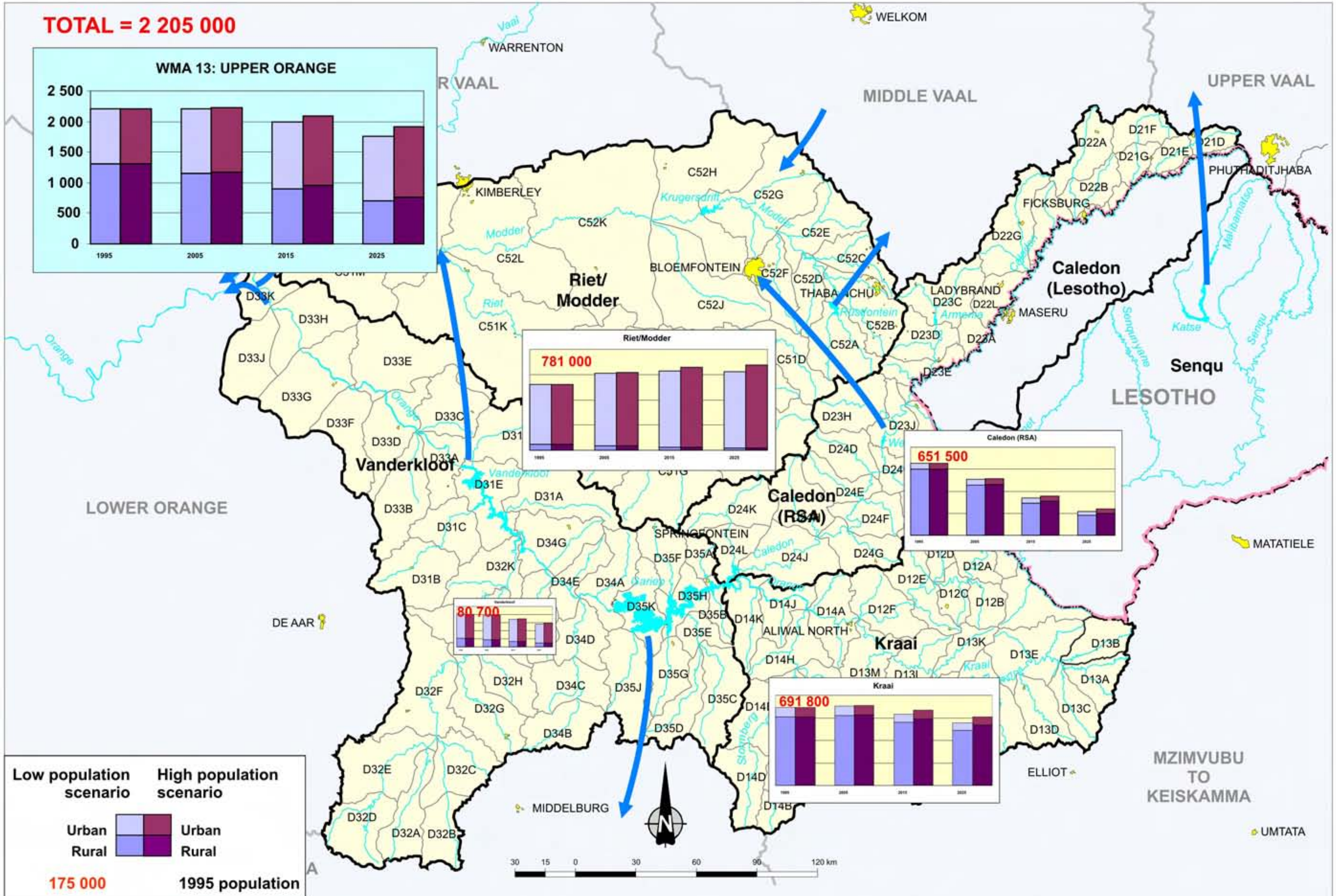
There are no distinct strong primary drivers to stimulate strong economic growth in the water management area. Potential for economic growth can be found in the agricultural sector converting to higher value products, such as from grains to orchard crops and cut flowers, and through further processing and packaging. Growth in the transport sector, given the strategic central location of Bloemfontein, is likely to be stimulated by increasing economic activity elsewhere in the country.

3.2 Demography

A detailed study of the population distribution in the country and of the expected future demographic and economic changes was conducted to serve as background to the estimation of future water requirements. Different scenarios were developed as described in Addendum 1. Demographic information pertinent to the Upper Orange water management area is captured below.

Close to 5% of the population of South Africa resides in the Upper Orange water management area, which is approximately the same as the proportionate contribution to the national economy from this water management area. Nearly 80% of the urban population in the water management area is concentrated in Bloemfontein and Thaba ‘Nchu, mainly attracted by the economic opportunities in Bloemfontein as well as by previous initiatives to stimulate development at Thaba ‘Nchu and Botshabelo. Most of the rural population live in the higher rainfall eastern areas with the population density sparse in the drier parts.

As applies to the current population distribution, the future demography of the water management area will also largely be influenced by economic opportunities and potential. Projections therefore are for continued growth in urban population in the Riet/Modder sub-area as shown in **Figure 6**, and which virtually exclusively relate to economic growth in the Bloemfontein area. Attributable to the lack of economic stimulants in the remainder of the water management area together with the impacts of HIV/AIDS, a significant decrease in rural population can be expected, which could be particularly pronounced in the Caledon (RSA) sub-area. This corresponds to similar trends elsewhere in the country.



UPPER ORANGE WMA **Population Scenarios** **Fig 6**

4. WATER REQUIREMENTS

4.1 Current requirements (year 2000)

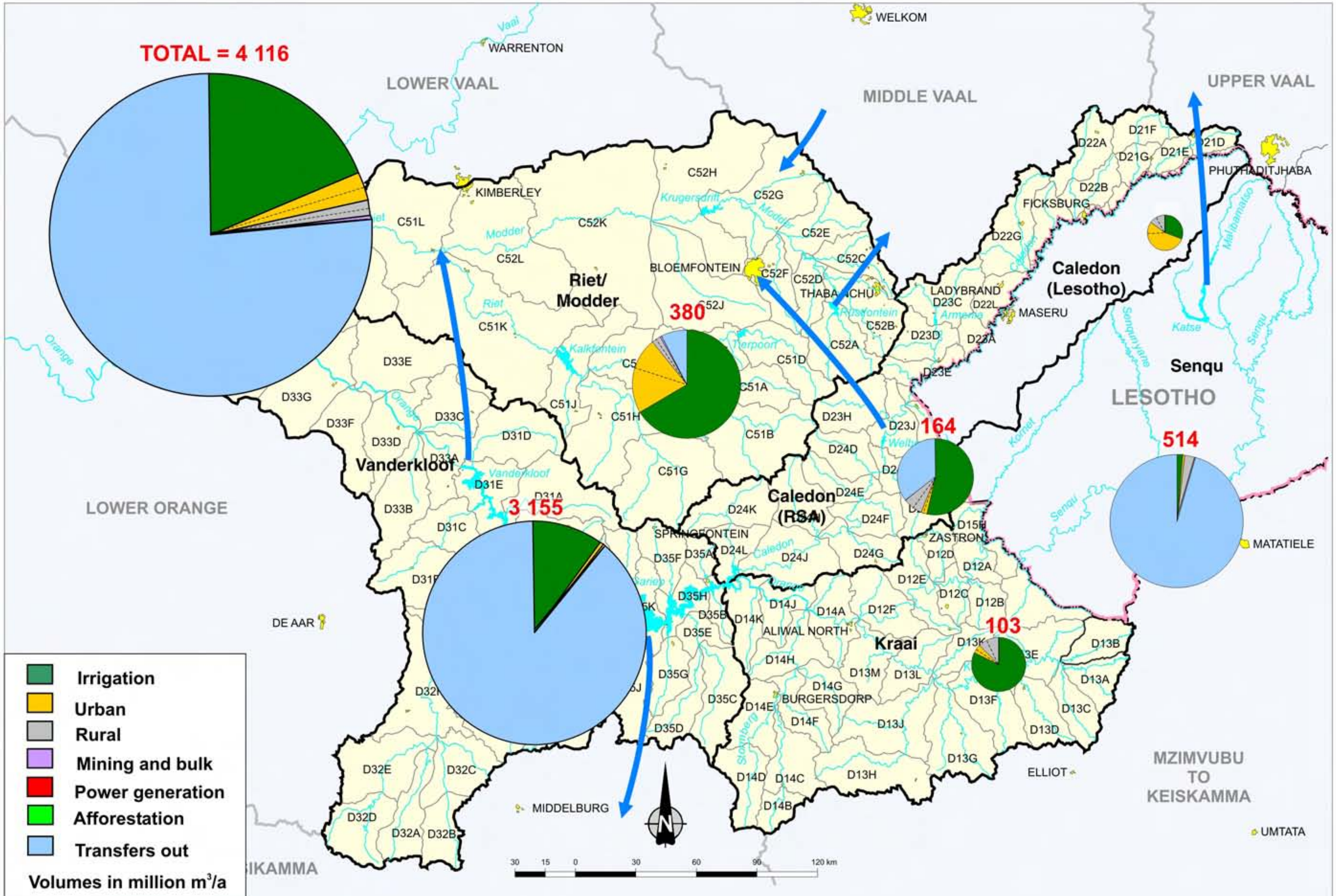
Water requirements within the water management area are dominated by irrigation water use, which represents 80% of the local requirements for water. As would be expected, most of the urban and industrial requirements for water are in the Riet/Modder sub-area, where Bloemfontein and Thaba 'Nchu are located. Water requirements for rural domestic supplies and for stock watering are relatively small. A summary of the sectoral water requirements in each of the sub-areas is given in **Table 1** and is diagrammatically shown in **Figure 7**. There are no large industries with own bulk water supplies in the water management area, while the water requirements for mining are insignificant. Although large quantities of water are passed through turbines at Gariep and Vanderkloof Dams for power generation, the water is primarily released to meet other downstream requirements, with hydropower as a secondary and non-consumptive use and therefore not reflected in the tables. (Surplus water may at times be released for the express purpose of power generation, but does not constitute a basic requirement for water.)

Table 1: Year 2000 Water Requirements (million m³/a)

Sub-area	Irrigation	Urban (1)	Rural (1)	Mining and bulk industrial (2)	Power generation (3)	Afforestation (4)	Total local requirements	Transfers out	Grand Total
Senqu Lesotho	8	2	13	0	0	0	23	491	514
Caledon Lesotho	12	22	6	0	0	0	40	0	40
Caledon RSA	88	4	13	0	0	0	105	59	164
Kraai	84	6	13	0	0	0	103	0	103
Riet / Modder	252	87	10	2	0	0	351	29	380
Vanderkloof	336	5	5	0	0	0	346	2 809	3 155
Total	780	126	60	2	0	0	968	3 148	4 116

1) Includes component of Reserve for basic human needs at 25 ℓ/c/d.
2) Mining and bulk industrial water uses which are not part of urban systems.
3) Includes water for thermal power generation only. (Water for hydropower, which represents a small portion of power generation in South Africa, is generally available for other uses as well.)
4) Quantities given refer to impact on yield only.

All the requirements are given at a standard 98% assurance of supply, as explained in Addendum 3. The run-of-river abstraction of water for irrigation such as in the Kraai and Caledon RSA sub-areas, is normally at a much lower assurance of supply, although large quantities may be abstracted when there is sufficient flow in the rivers.



UPPER ORANGE WMA

Sectoral water requirements

Fig 7

Also shown in Figure 7 (and described in more detail in 6.1) are the large quantities of water which are transferred out of the Upper Orange water management area for use in other water management areas. For the purpose of continuity in the water balance and to facilitate the understanding thereof, transfers of water out of Lesotho (to the Upper Vaal water management area) as well as estimates of the water requirements in Lesotho, are also included in the diagram.

A substantial proportion of water used in the urban and industrial sectors is used non-consumptively and again becomes available as effluent. At the larger centres, most or all of the effluent is discharged back to the rivers after appropriate treatment, from where it can potentially be re-used. Effluent from smaller towns typically evaporates from maturation ponds, or may be absorbed by irrigation and infiltration. (Although discharged into a tributary of the Modder River, effluent from Bloemfontein only occasionally reaches the river or Krugersdrift Dam, and not during the dry season.)

Estimates of return flows for the urban sector are given in Appendix 1, which also shows the quantities of water estimated to be lost through the urban distribution systems. Similar information with respect to irrigation is contained in Appendix 3.

4.2 Future requirements

There are many factors which influence the requirements for water. These include climate, nature of the economy (i.e. irrigated agriculture, industrialised) and standards of living. Of these, climate is relatively stable, while in most cases control can be exercised over the growth in irrigation water requirements. Population and economic activity, however, have their own inherent growth rates which are dependent on a wide spectrum of extraneous influences. Population growth and economic growth, which also relates to socio-economic standards, are therefore regarded as the primary determinants with respect to future water requirements.

Based on the scenarios for population and economic growth, initial estimates of possible future water requirements were made for the period until 2025. In addition, provision was made for known and probable future developments with respect to power generation, irrigation, mining and bulk users as described under the respective sub-areas where applicable. (Specific quantities, rather than a general annual growth rate, were allowed for in these sectors.)

Within the spectrum of population and economic growth scenarios, a base scenario was selected for estimating the most likely future water requirements. This is built on the high scenario of population growth and more equitable distribution of wealth leading in time to higher average levels of water services. The ratio of domestic to public and business (commercial, communal, industrial) water use for urban centres in the year 2000, for the respective centres, is maintained. A possible upper scenario of future water requirements, is also given, based on the assumption that there will be high population growth and a high standard of services (socio-economic development); together with a strong increase in the economic requirements for water, where the public and business use of water would increase in direct proportion to the gross domestic product. The purpose of the upper scenario is to provide a conservative indicator in order to prevent the occurrence of possible unexpected water shortages. No adjustments have been made for reflecting the impacts of increased water use efficiency.

General trends in the Upper Orange water management area are the continued concentration of economic development and population in the Bloemfontein region, and a decline in rural population. In addition, water has been allocated for 12 000 ha new irrigation development for poverty relief to be sourced from the Upper Orange water management area, which will result in an approximate balance situation once implemented. (3 000 ha for Free State Province, 4 000 ha for Northern Cape Province and 5 000 ha for Eastern Cape Province; to be developed in the Upper Orange, Lower Orange and Fish to Tsitsikamma water management areas.) A growth in urban/industrial water requirements can therefore be expected in the Riet/Modder sub-area, and a possible decrease in domestic requirements elsewhere. Strong needs for the transfer of additional water to other water management areas have also been identified.

Quantification of the projected future requirements for water is presented in **Tables 2** and **3** for the base and high scenarios respectively, and is further discussed in Section 6.

Table 2: Year 2025 base scenario water requirements (million m³/a)

Sub-area	Irrigation	Urban (1)	Rural (1)	Mining and bulk industrial (2)	Power generation (3)	Affore-station (4)	Total local require-ments	Transfers out	Grand Total
Senqu Lesotho	8	2	13	0	0	0	23	835	858
Caledon Lesotho	12	22	6	0	0	0	40	0	40
Caledon RSA	88	6	10	0	0	0	104	118	222
Kraai	119	7	12	0	0	0	138	0	138
Riet / Modder	252	146	10	2	0	0	410	52	462
Vanderkloof	336	6	5	0	0	0	347	2 878	3 931
Total	815	189	56	2	0	0	1 062	3 584	4 646

1) Includes component of Reserve for basic human needs at 25 ℓ/c/d.
2) Mining and bulk industrial water uses which are not part of urban systems.
3) Includes water for thermal power generation only. (Water for hydropower, which represents a small portion of power generation in South Africa, is generally available for other uses as well.)
4) Quantities given refer to impact on yield only.

Table 3: Year 2025 high scenario water requirements (million m³/a)

Sub-area	Irrigation	Urban (1)	Rural (1)	Mining and bulk industrial (2)	Power generation (3)	Affore-station (4)	Total local require-ments	Transfers out	Grand Total
Senqu Lesotho	8	2	13	0	0	0	23	835	858
Caledon Lesotho	12	22	6	0	0	0	40	0	40
Caledon RSA	88	8	10	0	0	0	106	171	277
Kraai	119	10	12	0	0	0	141	0	141
Riet / Modder	252	199	10	2	0	0	463	72	535
Vanderkloof	336	10	5	0	0	0	351	2 946	3 297
Total	815	251	56	2	0	0	1 124	3 672	4 796

1) Includes component of Reserve for basic human needs at 25 ℓ/c/d.
2) Mining and bulk industrial water uses which are not part of urban systems.
3) Includes water for thermal power generation only. (Water for hydropower, which represents a small portion of power generation in South Africa, is generally available for other uses as well.)
4) Quantities given refer to impact on yield only.

5. WATER RESOURCES

5.1 Surface water

Nearly 70% of the total surface runoff, which would under natural conditions flow through the water management area, originates from Lesotho territory and just more than 30% from within the water management area. As a result of the topography and climate, there are no natural lakes or wetlands of note in the water management area.

Land use impacts relate to cultivation and some overgrazing, mainly in the north eastern parts of the water management area and western Lesotho, causing increased erosion of the naturally highly erodable soils which occur in these areas. There is little impact from urbanisation in the water management area, apart from some bacteriological pollution from areas with insufficient sanitation services. No commercial forests and no serious infestations by alien vegetation occur in the water management area. A summary of the natural mean annual runoff (MAR), together with the estimated requirements for the ecological component of the Reserve, are given in **Table 4**. More detail on the estimation of the Reserve is given in Addendum 4.

Table 4: Natural Mean Annual Runoff and Ecological Reserve (million m³/a)

Sub-area	Natural MAR (1)	Ecological Reserve (1, 2)
Senqu Lesotho	4 012	933
Caledon Lesotho	753	92
Caledon RSA	650	90
Kraai	956	158
Riet / Modder	407	45
Vanderkloof	203	31
Total	6 981	1 349

1) Quantities given are incremental, and refer to the sub-area under consideration only.
2) Total volume given, based on preliminary estimates. Impact on yield being a portion of this. Refer to Appendix 4

It is important to note that the data with respect to the mean annual runoff as well as the ecological component of the Reserve have been taken from national data sources, for the purpose of compatibility of the water management area information in the National Water Resource Strategy. In many instances more detailed studies have been conducted or are under way, from which improved information may be obtained (also on items other than the MAR and Reserve), and which should also be referred to with respect to detail planning and design work.

In the natural state the quality of surface water in the water management area is good, particularly water which flows from the Highlands of Lesotho in the Senqu River. Water in the Caledon River is naturally of high turbidity and carries a concerning high sediment load.

Irrigation return flows has a major impact on salinity in the lower Riet River and water is transferred to the Riet River from Vanderkloof Dam, partly for blending and water quality management purposes. A natural pan below Krugersdrift Dam also adds salinity to the Modder River.

The surface water resources, which naturally occur in the water management area (together with inflows from Lesotho), are already well developed, and with a high degree of utilisation. The main storage dams, for which more details are given in Appendix 5, are:

- Katse Dam in the Senqu sub-area in Lesotho, for transfer of water to the Upper Vaal water management area. Mohale Dam, which is under construction in the same sub-area, is destined to start impounding water in 2003, also for transfer to the Upper Vaal water management area.

- Gariep and Vanderkloof Dams on the Orange River (Vanderkloof sub-area), which command the two largest reservoirs in South Africa. Hydropower for peaking purposes is generated at both sites.

- Armenia and Egmont Dams on tributaries in the Caledon sub-area. Welbedacht Dam lies on the main stem of the Caledon River, with Knellpoort Dam an off-channel storage dam that supplements the water supply to Bloemfontein.

- Rustfontein, Mockes and Krugersdrift Dams are situated on the Modder River, and the Tierpoort and Kalkfontein Dams on the Riet River.

There are no large dams in the Kraai sub-area, or in the Caledon River catchment in Lesotho. However, extensive inter-catchment transfer schemes have also been developed for the transfer of water within the water management area as well as to other water management areas. The most significant transfers being from Katse Dam via the Lesotho Highlands Water Project to the Upper Vaal water management area and from Gariep Dam via the Orange-Fish tunnel to the Fish to Tsitsikamma water management area. Transfer capacities for both schemes are of the order of 491 million m^3 per year, with the Lesotho Highlands Water Project transfer to be increased to about 835 million m^3 per year when Mohale Dam is commissioned. Water is also transferred to Douglas Weir in the Lower Vaal water management area, and a small quantity is transferred into the Riet/Modder sub-area from the Middle Vaal water management area for rural village water supplies. In addition, a substantial part of the yield from the Upper Orange water management area is transferred to the Lower Orange water management area by means of releases from Vanderkloof Dam (about 2 035 million m^3 per year in 2000). Main transfers within the water management area are from Welbedacht and Knellpoort Dams via the Novo transfer scheme to Bloemfontein and Thaba 'Nchu and from Vanderkloof dam via the Sarel Hayward canal to the Riet/Modder sub-area for irrigation and water quality management. More details on the main inter-catchment transfers are given in Appendix 6.

A substantial proportion of the still undeveloped water resource potential in South Africa lies in the Upper Orange water management area (and Lesotho). A site for harnessing this potential through the construction of a large dam exists at the confluence of the Orange and Kraai Rivers (at the farm Bosberg) provisionally referred to as Boskraai Dam.

5.2 Groundwater

Underlain by hard formations, no large porous aquifers are found in the water management area. Although relatively large quantities of groundwater are abstractable from fracture zones at dolorite intrusions, recharge rates and therefore the sustainable yields are low over most of the water management area. Higher recharge occur in localised areas, such as where lime bogs are found. In the drier parts of the water management area, groundwater constitutes the main, and in many cases the only, source of water for rural domestic supplies and stock watering, as well as for towns such as Colesberg. Severe over-exploitation of groundwater is experienced in some peri-urban areas, notably at the Bainesvlei smallholdings near Bloemfontein. Over-exploitation of groundwater also occurs at Petrusburg in the Riet/Modder sub-area, due to increasing irrigation from groundwater in the area.

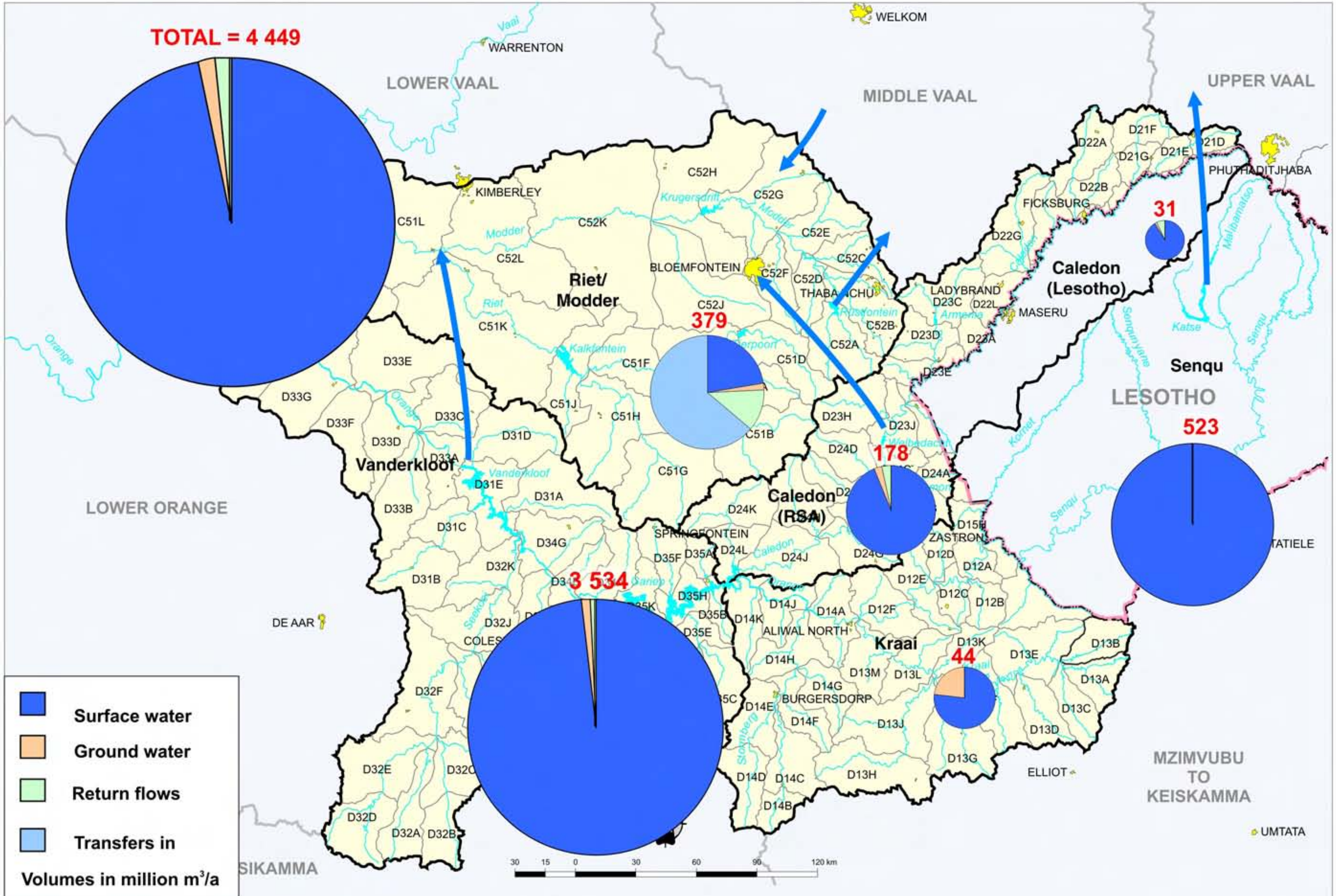
The quality of groundwater is naturally good in the eastern high rainfall parts of the water management area, becoming more mineralised and brackish in the drier areas and in the vicinity of salt pans.

5.3 Summary

The total water available for use in the Upper Orange water management area at the year 2000 development levels, is schematically presented in **Figure 8** and summarised in **Table 5**. Details on factors which influence the yield such as the impacts of the Reserve, invasive alien vegetation, river losses and urban runoff are contained in Appendix 4.

Particularly evident from Figure 8, is the overriding importance of surface water in the water management area, predominantly as a result of the high runoff from Lesotho and from the catchments immediately adjoining to Lesotho. It is important to note that Figure 8 shows the yield of water resources at the locations where the yield is realised (available) rather than the mean annual runoff. Therefore the large quantities available where the Orange River is regulated by the Gariep and Vanderkloop Dams, although very little runoff is generated in this sub-area. The Upper Orange water management area also serves a pivotal role with respect to water transfers to other water management areas, with 70% of the surface water yield which is realised within the water management area (including Lesotho) being transferred to other water management areas.

Although groundwater proportionately is a small component of the water available in the water management area, it constitutes the main source of water in much of the rural areas.



UPPER ORANGE WMA **Water availability (expressed as yield)** **Fig 8**

Table 5: Available water in year 2000 (million m³/a)

Sub-area	Natural resource		Usable return flow			Total local yield (1)	Transfers in	Grand Total
	Surface water	Ground-water	Irrigation	Urban	Mining and bulk			
Senqu Lesotho	523	0	0	0	0	523	0	523
Caledon Lesotho	28	1	0	2	0	31	0	31
Caledon RSA	167	5	4	2	0	178	0	178
Kraai	34	10	0	0	0	44	0	44
Riet / Modder	85	6	13	33	0	137	242	379
Vanderkloof	3 474	43	17	0	0	3 534	0	3 534
Total	4 311	65	34	37	0	4 447	2	4 449

1) After allowance for the impacts on yield of: ecological component of Reserve, river losses, alien vegetation, rain-fed agriculture and urban runoff.

6. RECONCILIATION OF REQUIREMENTS AND AVAILABILITY

6.1 Water balance

A reconciliation of the available water and total requirements for the year 2000 (and 2025), including transfers between water management areas, is graphically presented in **Figure 9** with quantifications given in **Table 6**. As before and due to the pronounced impacts of water resource management in Lesotho on the same in the Upper Orange water management area, information with respect to Lesotho is also included. The main transfers with associated quantities are shown on Figure 1 and are summarised in Appendix 6.

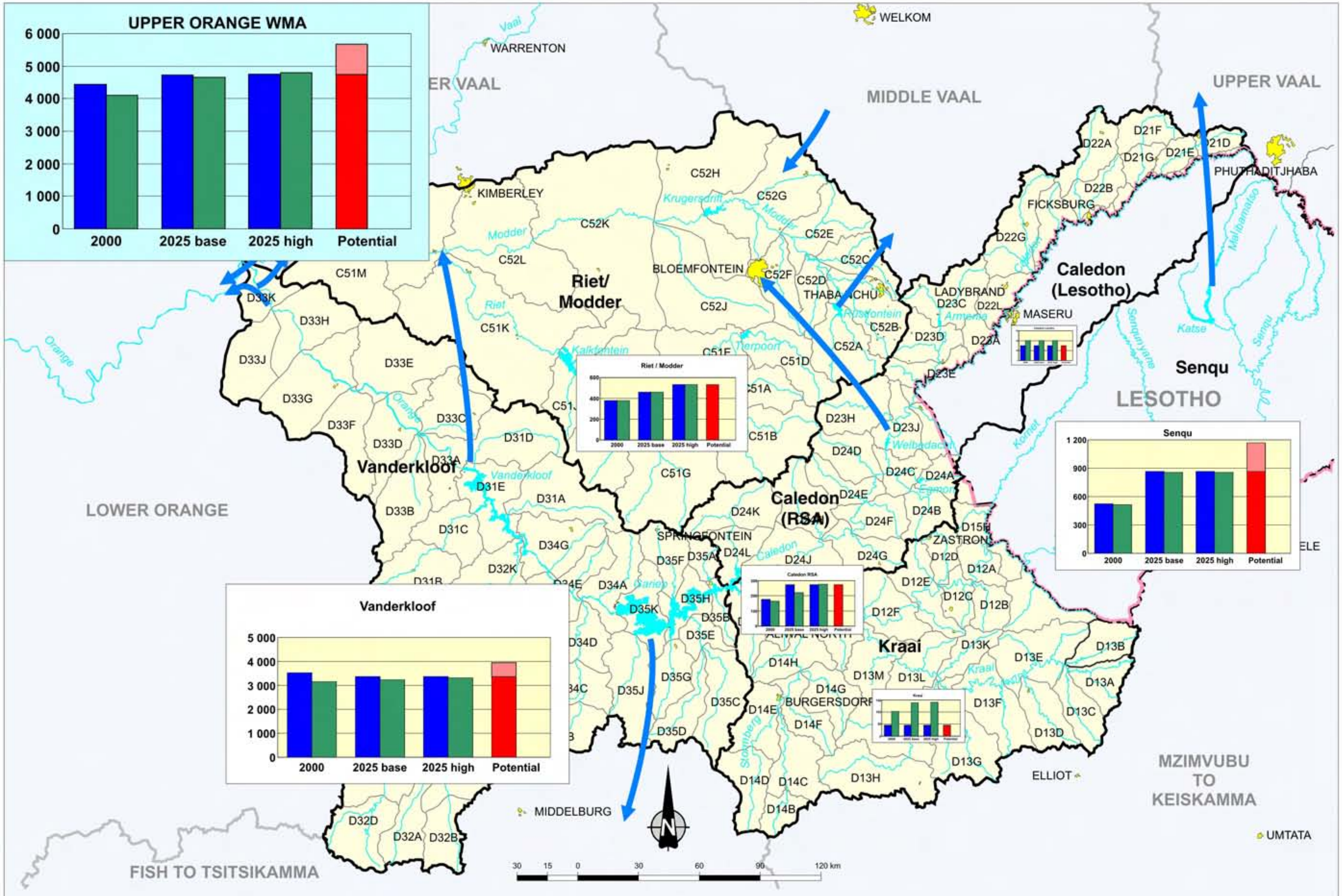
Table 6: Reconciliation of requirements and available water for year 2000 (million m³/a)

Sub-area	Available water			Water requirements			Balance
	Local yield	Transfers in (2)	Total	Local require-ments	Transfers out (2)	Total	(1)
Senqu Lesotho	523	0	523	23	491	514	9
Caledon Lesotho	31	0	31	40	0	40	(9)
Caledon RSA	178	0	178	105	59	164	14
Kraai	44	0	44	103	0	103	(59)
Riet / Modder	137	242	379	351	29	380	(1)
Vanderkloof	3 534	0	3 534	346	2 809	3 155	379
Total	4 447	2	4 449	968	3 148	4 116	333

1) Brackets around numbers indicate negative balance. Surpluses are shown in the most upstream sub-area where they first become available.

2) Transfers into and out of sub-areas may include transfers between sub-areas as well as transfers between WMAs. Addition of the transfers per sub-area therefore does not necessarily correspond to the total transfers into and out of the WMA. The same applies to Tables 7 and 8.

A small surplus is shown in Table 6 with respect to the Senqu catchment, which is associated with the run-of-river yield estimated to be in excess of the local requirements for water in the area. The total yield available from Katse Dam is transferred to the Upper Vaal water management area. The deficit for the Caledon sub-area in Lesotho, is partly attributable to a provision made for implementation of the ecological component of the Reserve, and partly due to the requirements for water estimated to be in excess of what can reliably be supplied from existing infrastructure. It is important to note that the situation as given for Lesotho (Senqu and Caledon) is based on a combination of estimates and known information, and does not reflect official data from Lesotho or imply agreement by Lesotho with the estimates.



UPPER ORANGE WMA Water reconciliation **Fig 9**

The deficit for the Kraai sub-area is as a result of the provision for the ecological component of the Reserve, which is still to be implemented. A small surplus currently exists in the Caledon RSA sub-area, which is attributable to irrigation return flows and some spare capacity in the existing transfer scheme to Bloemfontein. Although localised shortages of water are experienced in the Riet/Modder sub-area, such as with respect to irrigation below Krugersdrift Dam, the overall requirements for and availability of water are approximately in balance. The balance being mainly attributable to the large transfers of water into the area.

A notable surplus still exists (at year 2000) with respect to the yield from the Vanderkloof sub-area (Gariep and Vanderkloof Dams) which is not yet fully utilised. However, most of this surplus will be taken up with the commissioning of Mohale Dam and by the 12 000 ha new irrigation envisaged. No additional water can therefore be allocated from the existing infrastructure.

A perspective on the possible future situation is given by **Table 7** for the base scenario, and **Table 8** as a representative of a possible high water use scenario. (Refer to Addendum 1.) There are also graphically presented in Figure 9. Additional yield will become available in the Senqu Lesotho sub-area with the commissioning of Mohale Dam from year 2003, all of which is destined for transfer to the Upper Vaal water management area. The yield from the Caledon RSA sub-area will also increase with the phased implementation of the Novo transfer scheme, for the augmentation of supplies to Bloemfontein. These additional transfers of water from the upper reaches and tributaries of the Orange River will induce a substantial decrease in the yield from Gariep and Vanderkloof Dams.

Table 7: Reconciliation of water requirements and availability for the year 2025 base scenario (million m³/a)

Sub-area	Available water			Water requirements			Balance	Potential for develop-ment
	Local yield (1)	Transfers in	Total	Local require-ments (2)	Transfers out	Total	(3)	(4)
Senqu Lesotho	867	0	867	23	835	858	9	300
Caledon Lesotho	30	0	30	40	0	40	(10)	0
Caledon RSA	273	0	273	104	118	222	51	0
Kraai	45	0	45	138	0	138	(93)	0
Riet / Modder	160	301	461	410	52	462	(1)	0
Vanderkloof	3 359	0	3 359	347	2 878	3 225	134	600
Total	4 734	2	4 736	1 062	3 584	4 646	90	900

1) Based on existing infrastructure and infrastructure under construction in the year 2000. Also includes return flows resulting from growth in requirements.
2) Based on growth in water requirements as a result of population growth and general economic development. Irrigation expansions of 4 000 ha in the Upper Orange WMA and 4 000 ha in the Lower Orange WMA, to be sourced from Upper Orange WMA, have been allowed for (44 million m^3 /a and 46 million m^3/a respectively).
3) Brackets around numbers indicate negative balance.
4) The potential of 900 million m^3 per year could be realised through construction of Mashai Dam in Lesotho together with Boskraai Dam (confluence of Orange and Kraai), or through a large Boskraai Dam alone.

Sufficient water can be made available through the Novo transfer scheme to meet the projected future requirements at Bloemfontein, also in the event of the high growth scenario. (The increases in yield with respect to the Riet/Modder sub-area are attributable to growth in urban return flows, assumed to be available for other uses.) Due to a lack of information with respect to future water requirements in Lesotho, no specific allowances are included in the above tables. Appropriate provisions, however, need to be made.

Compared to the natural mean annual runoff of 6 981 million m^3 per year which originates from the water management area and Lesotho, an estimated 4 490 million m^3 per year (64%) still flows out of the area towards the Lower Orange water management area.

Table 8: Reconciliation of water requirements and availability for the year 2025 high scenario (million m³/a)

Sub-area	Available water			Water requirements			Balance	Potential for develop-ment
	Local yield (1)	Transfers in	Total	Local require-ments (2)	Transfers out	Total	(3)	(4)
Senqu Lesotho	867	0	867	23	835	858	9	300
Caledon Lesotho	30	0	30	40	0	40	(10)	0
Caledon RSA	274	0	274	106	171	277	(3)	0
Kraai	45	0	45	141	0	141	(96)	0
Riet / Modder	180	354	534	463	72	535	(1)	0
Vanderkloof	3 359	0	3 359	351	2 946	3 297	62	600
Total	4 755	2	4 757	1 124	3 672	4 796	(39)	900

1) Based on existing infrastructure and infrastructure under construction in the year 2000. Also includes return flows resulting from growth in requirements.
2) Based on growth in water requirements as a result of population growth and general economic development. Irrigation expansions of 4 000 ha in the Upper Orange WMA and 4 000 ha in the Lower Orange WMA, to be sourced from Upper Orange WMA, have been allowed for (44 million m^3 /a and 46 million m^3/a respectively).
3) Brackets around numbers indicate negative balance.
4) The potential of 900 million m^3 per year could be realised through construction of Mashai Dam in Lesotho together with Boskraai Dam (confluence of Orange and Kraai), or through a large Boskraai Dam.

6.2 Key issues

Key considerations with respect to the Upper Orange water management area are:

- The yield from the Upper Orange water management area is by far the largest of all water management areas in the country, while significant potential for further water resource development still exists.

- It is the main source of water for the Lower Orange water management area (including some uses by Namibia), and for the Fish to Tsitsikamma water management area. The Lesotho Highlands Water Project, which is an integral and crucial component of the Vaal River System, also relies on water which under natural conditions would flow into the Upper Orange water management area, and therefore has a major impact on water availability in the Upper Orange water management area.

- No surplus water will be available from the Orange River after completion of Mohale Dam, and given the allocations already made with respect to the 12 000 ha new irrigation. A deficit situation may therefore occur before 2025.

- Hydropower generation at Gariep and Vanderkloof Dams forms an important component of Eskom's peak generation capability. Fluctuating releases from hydropower turbines impact negatively on some users. In turn, upstream transfers of water negatively impact on the water availability for power generation.

- Water quality in the Lower Riet River is of concern, and also impacts on water quality in the Lower Vaal River and at the Douglas Weir.
- Over-exploitation of groundwater is experienced in localised areas.
- Needs exist for increased future transfers of water to the Upper Vaal water management area and to Port Elizabeth in the Fish to Tsitsikamma water management areas.
- Flood management at Gariep and Vanderkloof Dams, in concert with flood management along the Vaal River, is of major importance with respect to the protection of developments along the Lower Orange River.
- Developments in Lesotho and increased transfers of water out of the water management area can have a major impact on water availability in the Upper Orange water management area.

6.3 Strategic perspectives

The Upper Orange water management area is a major source of water, and of pivotal importance for several other water management areas which receive large quantities of water either directly or indirectly from the Upper Orange water management area through inter-catchment transfers or via the Orange River. With close to 60% of the water resources generally associated with the Upper Orange water management area originating from Lesotho, developments in Lesotho can have a major impact on the Upper Orange water management area. Through its inter-dependence with other water management areas, it is essential that water resource management in the Upper Orange water management area should be well co-ordinated with these water management areas, particularly in the Orange/Vaal Basin, and that it be viewed in a integrated systems context. Management of water resources in the basin should also be within the framework of the recently founded Orange-Senqu River Commission by South Africa, Lesotho, Botswana and Mozambique.

Strategic perspectives on the main interventions and options with respect to the future availability and optimal utilisation of water in the Upper Orange water management area are concisely described below. A general description of options for the reconciliation of the requirement for and availability of water is given in Addendum 5.

Senqu Lesotho sub-area

The Treaty between South Africa and Lesotho on the Lesotho Highlands Water Project, signed in 1986, provides for further phases (after Phase 1) of the Lesotho Highlands Water Project to be constructed. However, the present needs for augmentation of the Vaal River System are fundamentally different than given in the Treaty, with current projections of future water requirements dramatically lower than before. Whilst the development of Phase 2 (Mashai Dam) of the Lesotho Highlands Water Project remains a possibility, options such as the Thukela Water Project and transfer from within the Upper Orange water management area (Boskraai Dam) to the Upper Vaal water management area have also been considered. A final decision on Mashai Dam will only be taken (at national level) after further investigation and due consultation with the co-basin countries.

As a future scenario, consideration should be given to the possibility that a dam could be built at Mashai to yield in the order of 300 million m^3 per year, for transfer to the Upper Vaal water management area. Little other growth in water requirements is foreseen in this area.

Caledon Lesotho

Further growth in the water requirements for Maseru can be expected while the possibility also exists of greater water resource utilisation in the Lowlands of Lesotho (Caledon River catchment). Provision for these should be made in consultation with Lesotho, through the appropriate channels.

Caledon RSA

No significant change in the water requirements within this sub-area is foreseen, although a small decrease in rural water requirements may be experienced as a result of the projected future decline in population. The expected strong decline in population as shown in Figure 6 should be further investigated and accounted for during the development of the catchment management strategy.

The projections are that significant quantities of water will have to be sourced from the Caledon River for additional transfers to Bloemfontein, via the Novo transfer scheme. (These are already provided for in Tables 7 and 8.) Management of the sediment load from the catchment will require continued attention.

Kraai sub-area

Potential exists for the possible establishment of commercial forests in the upper reaches of the Kraai River catchment. Small scale irrigation development for the settlement of emerging farmers in the Herschel area, could also be considered.

A site for the construction of a large dam on the Orange River has been identified on the farm Bosberg, just upstream of the confluence of the Kraai River (Bosberg Dam). A larger dam could also be constructed to span both rivers at the same site (provisionally referred to as Boskraai Dam). Initial investigations showed that such a dam would only be feasible should most of the water be designated to a large anchor user group, such as for transfer to the Vaal River System.

Riet/Modder sub-area

Growth in the urban and industrial requirements for water in Bloemfontein and at Botshabelo should first be contained through appropriate water demand management measures, after which the water supply to the area can best be augmented from the Caledon River by means of the Novo transfer scheme.

Water quality in the lower Riet River, as well as downstream of dense settlements with inappropriate sanitation services, needs to be carefully monitored and managed. Proper controls need to be instituted with respect to the utilisation of groundwater, and compulsory licensing may be required in some instances to curb over-exploitation.

Vanderkloof sub-area

Additional requirements for water are likely to be in the Fish to Tsitsikamma and Lower Orange water management areas, and possibly by Namibia. The impacts of using the low level storage (below the Vanderkloof canal and the turbine intakes) at Vanderkloof Dam on Eskom’s power generation for peak clipping and irrigation from the canal need to be carefully assessed and appropriate measures be introduced to manage the situation.

Further large-scale development of water resources upstream of Gariep Dam, particularly for transfer to the Vaal River System, will have a major impact on the yield available from Gariep and Vanderkloof Dams. It will also impact on the water quality (increase in salinity) in these reservoirs and could significantly decrease the capacity for power generation at the dams.

The operation of Gariep and Vanderkloof Dams for the purposes of flood control, should continue to be in unison with the dams on the Vaal River.

6.4 Transfers and reservation of water

The development of 12 000 ha new irrigation for the purposes of rural development, poverty relief and settlement of emerging farmers have in principle been sanctioned by the Minister and water was allocated for this purpose. While these developments are likely to be located in the Upper Orange, Lower Orange and Fish to Tsitiskamma water management areas, the water will have to be sourced from the Upper Orange water management area. Other priorities are for urban and industrial use in Bloemfontein/Botshabelo and for augmenting supplies to the Port Elizabeth area (Fish to Tsitsikamma water management area). Additional water for use by Namibia may also have to be released from the Upper Orange water management area, via the Lower Orange water management area.

The transfer of water between water management areas, water for strategic use and arrangements with neighbouring countries resort under national control. The following reservations are made in the National Water Resources Strategy with regard to the Upper Orange water management area:

- The transfer of the current 491 million m³ per year from the Senqu River in Lesotho to the Upper Vaal water management area, which is to be increased to 835 million m³ per year when Mohale Dam in Lesotho comes into operation by the year 2004 – Reserved in the Upper Orange water management area.

  In view of the reduced projections of water requirements from the Lesotho Highlands Water Project, it is imperative that the minimum quantity for water delivery as specified in Annexure 2 of the Treaty on the Lesotho Highlands Water Project, be revised.

- The transfer of water to the Fish to Tsitsikamma water management area up to the current allocations of approximately 600 million m^3 per year, including the allowances for new irrigation and some growth in the Port Elizabeth area – Reserved in the Upper Orange water management area.

- Transfer of 18 million m³ per year from Marksdrift to Douglas Weir in the Lower Vaal water management area, for water quality purposes – Reserved in the Upper Orange water management area.

- Release of water to meet needs in the Lower Orange water management area and for use by Namibia (currently about 2 035 million m³ per year). Also to allow for possible 4 000 ha new irrigation (at 46,4 million m^3 per year) – Reserved in the Upper Orange water management area.

- The agreement with Eskom with respect to the use of water for hydropower generation is to be honoured. Revisions to the agreement are, however, are required to address the impact of hydropower generation on the flow regime in the river, as well as the impacts of further resource developments on power generation more adequately – Agreement at national level with Eskom imposes reservation on Upper Orange water management area.

- Large scale water resource developments on the Orange River as well as on the Caledon and Kraai tributaries, that may impact on the above or on neighbouring countries (including the Senqu in Lesotho), will be subject to authorisation at national level – Reservation applies to the Upper Orange water management area.

- Existing transfers of about 0,1 million m^3 per year from the Bloem Water system in the Upper Orange water management area to domestic users in the Middle Vaal water management area – Reserved in the Upper Orange water management area.

- The allocation of all surplus water in the Upper Orange water management area will resort under national control as this water may be allocated to users in the Upper Orange or other water management areas. (All surplus water has since 2 000 been allocated.)

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APPENDICES

APPENDIX 1

Urban Water Requirements (year 2000) - WMA 13: Upper Orange

Sub-area	Urban population	Domestic (direct)	Indirect	Urban losses	Total	Proportion indirect: direct	Urban per capita (domestic)	Urban return flow
		million m^3/a					ℓ/c/d	%
Senqu	0	1.6	0.0	0.5	2.1	0.00	n/a	0
Caledon Lesotho	0	15.1	0.8	5.9	21.8	0.05	n/a	10
Caledon RSA	50 235	2.3	0.9	1.1	4.3	0.38	125	38
Kraai	81 360	2.9	1.5	1.2	5.6	0.51	98	0
Riet/Modder	786 434	37.7	20.4	28.5	86.6	0.54	131	38
Vanderkloof	60 050	2.7	1.2	1.5	5.4	0.46	125	0
Total	**978 079**	**62.3**	**24.8**	**38.7**	**125.8**	**0.40**	**175**	**29**

APPENDIX 2

Rural Water Requirements (year 2000) - WMA 13: Upper Orange

Sub-area	Rural population	Domestic	Stock watering	Total	Rural human per capita
		million m^3/a			ℓ/c/d
Senqu	0	0.8	12.0	12.8	23
Caledon Lesotho	0	2.4	3.6	6.0	33
Caledon RSA	532 155	5.2	8.2	13.4	27
Kraai	619 413	5.7	7.0	12.7	25
Riet/Modder	65 876	0.6	9.7	10.3	25
Vanderkloof	19 468	0.2	4.8	5.0	26
Total	**1 236 912**	**14.9**	**45.3**	**60.2**	**33**

APPENDIX 3

Irrigation water requirements (year 2000) - WMA 13: Upper Orange

Sub-area	Irrigation area		Unit requirement	Irrigation requirement	Convey-ance losses	Total irrigation requirement		Irrigation return flows
	Green cover	Harvested	Green cover			No assurance	1:50 assurance	
	ha		m^3/ha/a	million m^3/a	%	million m^3/a		%
Senqu	2 570	2 570	3 360	8.6	10.0	9.5	8.0	0.0
Caledon Lesotho	1 300	1 300	10 150	13.2	10.0	14.5	12.3	0.0
Caledon RSA	11 179	13 680	8 600	96.1	10.0	105.8	87.8	5.0
Kraai	16 930	9 830	5 550	94.0	10.0	103.4	83.7	0.0
Riet/Modder	21 034	39 790	13 000	273.4	15.0	314.5	251.6	5.0
Vanderkloof	28 684	38 822	13 000	372.9	9.0	406.5	333.3	5.0
Total	**81 697**	**105 992**	**10 505**	**858.2**	**11.2**	**954.2**	**776.7**	**4.3**

APPENDIX 4

Factors influencing runoff and yield (year 2000) - WMA 13: Upper Orange

Sub-area	MAR (naturalised, incremental)	Reserve		Alien vegetation			Afforestation			Sugar cane			River losses	Urban runoff
		Reduction in runoff	Reduction in yield	Area	Reduction in runoff	Reduction in yield	Area	Reduction in runoff	Reduction in yield	Area	Reduction in runoff	Reduction in yield	Reduction in yield	Increase in yield
	million m³/a	million m³/a		ha	million m³/a		ha	million m³/a		ha	million m³/a		million m³/a	
Senqu Lesotho	4 012	933	167	498	1	0	0	0	0	0	0	0	0	0
Caledon Lesotho	753	92	4	0	0	0	403	0	0	0	0	0	0	1
Caledon RSA	650	90	1	0	0	0	958	0	0	0	0	0	0	1
Kraai	956	158	56	34	0	0	0	0	0	0	0	0	0	0
Riet / Modder	407	45	11	5 346	1	0	0	0	0	0	0	0	0	18
Vanderkloof	203	31	0	1 139	0	0	0	0	0	0	0	0	0	0
Total	6 981	1 349	239	7 017	2	0	1 361	0	0	0	0	0	0	20

APPENDIX 5

Major dams data - WMA 13: Upper Orange

Dam name	Quaternary catchment	River	Year completed	Purpose	Natural MAR million m³/a	FSC million m³
Armenia	D23D	Leeu	1951	Irrigation	64.3	14.2
Egmont	D12E	Wit Spruit	1938	Irrigation	4 155.0	9.3
Gariep	D35K	Orange	1971	Irrigation	6 435.0	5 343.0
Groothoek	C52B			Domestic	59.0	13.2
JL de Bruin	D14F	Stormberg Spruit	1961	Domestic	53.0	2.2
Kalkfontein	C51J	Riet	1938	Irrigation	239.6	318.8
Kopfontein	D24L	Buitendagspruit	1941		1 402.0	1.4
Krugersdrif	C52G	Modder	1970	Irrigation	145.1	73.2
Meulspruit	D22B	Meul Spruit	1976	Domestic	69.2	2.6
Mockes	C52E	Modder	1948	Domestic	98.8	6.0
Molteno	D14C	Stormberg Spruit	1935	Domestic	22.4	3.0
Montagu	D12D	Kingna	1969	Domestic	14.2	4.1
Newburry	D23C	Leeu	1896	Irrigation	41.8	5.6
Poortjie	C51B	Blaasbalkspruit	1925		49.7	5.4
Rietwater	C52F	Fouriespruit	1961		12.5	2.0
Rustfontein	C52A	Modder	1955	Domestic	30.7	72.2
Smithfield	D24H	Groen Spruit	1955	Domestic	16.0	4.6
Sterkspruit	D12B	Sterkspruit		Irrigation	52.0	11.4
Tierpoort	C51D	Kaffir	1922	Irrigation	23.8	34.0
Vanderkloof	D31E	Orange	1976	Hydro Power	3 554.0	3 187.1
Welbedacht	D23J	Caledon	1973	Domestic	1 244.0	15.0

APPENDIX 6

Details of main inter-WMA transfers (year 2000) - WMA 13: Upper Orange

From quaternary	To quaternary	User group	Volume (million m^3/a)	Description
Transfers In				
C41G	C52G	Urban	2.3	Erfenis Dam (Middle Vaal WMA) to Brandfort TLC
Total in			**2.3**	
Transfers Out				
D11J*	C22F*	Urban	600.0	Lesotho Highlands Project to Upper Vaal WMA
D35K	Q12B	Urban	68.2	Orange-Fish transfer to Port Elizabeth region
D35K	Q12B	Irrigation	503.0	Orange-Fish transfer
D33K	C92B		18.0	Orange-Vaal transfer from Marksdrift (Upper Orange WMA)
Total out			**1 189.2**	

ADDENDA

ADDENDUM 1 : BACKGROUND ON DEMOGRAPHIC AND ECONOMIC STUDIES

ADDENDUM 2 : ECONOMIC SECTOR DESCRIPTION (for GGP and Labour Distribution)

ADDENDUM 3 : YIELD, RELIABILITY, AVAILABLE WATER AND ASSURANCE OF SUPPLY

ADDENDUM 4 : ECOLOGICAL COMPONENT OF RESERVE

ADDENDUM 5 : RECONCILIATION INTERVENTIONS

ADDENDUM 6 : PRIORITIES FOR ALLOCATING WATER

ADDENDUM 7 : INTER CATCHMENT TRANSFER OF WATER

ADDENDUM 1 : BACKGROUND ON DEMOGRAPHIC AND ECONOMIC STUDIES

A detailed study of the expected demographic and socio-economic changes in the country, and the associated impacts on water requirements, was conducted to serve as background to the NWRS. The main outcome was the expectation of lower population growth rates than previous, mainly due to the impact of HIV/AIDS, as well as reduced reproduction rates linked to urbanisation and economic growth. High and low population scenarios were developed as reflected in Fig. 6.

Estimates of the future population were initially made for the country as a whole, and then subdivided into smaller geographic units to facilitate the estimation of future water requirements on a regional basis. Because of the trend towards urbanisation as well as the expected stronger economic growth in the major urban and industrial centres, the greatest long-term uncertainty about future water requirements exists with respect to these user sectors. Greater attention was consequently given to the main urban centres in the subdivision of population, with possible lesser substantiation of the population projections for smaller centres and some rural areas. The representatives of population projections for the latter areas should therefore be reconsidered during the development of catchment management strategies

Scenarios were also developed for economic growth, and of the influence of economic growth on future water requirements, in an attempt to cautiously narrow the uncertainties which the future holds. Multi-variate analyses were performed in order to develop scenarios of possible low and high economic growth for different geographic regions in the country. Gross Geographic Product (GGP) was considered the most relevant economic indicator for the purposes of the National Water Resource Strategy because of relationships which can be established to water usage. In general, economic growth is expected to be substantially higher in the larger urban and industrialised areas and which are favourably located with respect to resources and transportation routes than in the rural areas. Consideration was given to the trend towards growth in service and manufacturing industries, and the expected impact of changing trade patterns on manufacturing, transport infrastructure and export facilities.

Within the spectrum of population and economic growth scenarios, a base scenario was selected for estimating the most likely future water requirements. This comprises the high scenario of population growth and higher average levels of urban domestic water requirements resulting from a more equitable distribution of wealth. The ratio of domestic to commercial, communal and industrial water use for urban centres in the year 2000 is maintained. A possible upper limit scenario is also proposed. This scenario is based on the same assumption of high population growth and a high standard of service provision flowing from rapid socio-economic development, with the distinction that these be combined with strong economic growth in which commercial, communal and industrial water use increases in direct proportion to growth in GDP. The upper scenario is intended to serve as a conservative indicator to prevent the occurrence of possible unexpected water shortages. No adjustments have been made to reflect the impact increased water use efficiency would have.

Caution should be exercised that possible temporary migration from rural areas to towns, which may be an interim step towards migration to cities, not wrongly be interpreted as a long term sustainable growth.

ADDENDUM 2 : ECONOMIC SECTOR DESCRIPTION (for GGP and Labour Distribution)

From Urban Econ – Reference 5

- **Agriculture :** This sector includes agriculture, fishing, forestry, hunting and related services. It comprises activities such as growing of crops, market gardening, horticulture, mixed farming, production of organic fertiliser, forestry, logging and related services and fishing, operation of fish hatcheries and fish farms.
- **Mining :** This section entails the mining and quarrying of metallic minerals (coal, lignite, gold, cranium ore, iron ore, etc); extraction of crude petroleum and natural gas, service activities incidental to oil and gas extraction; stone quarrying; clay and sand pits; and the mining of diamonds and other minerals.
- **Manufacturing :** Manufacturing includes, inter alia, the manufacturing of food products, beverages and tobacco products; production, processing and preserving of meat, fish, fruit, vegetables, oils and fats, dairy products and grain mill products; textile and clothing; spinning and weaving; tanning and dressing of leather, footwear, wood and wood products; paper and paper products; printing and publishing; petroleum products; nuclear fuel; and other chemical substances.
- **Electricity & Water :** Utilities comprise mainly three elements, namely electricity, water and gas. The services rendered to the economy include the supply of electricity, gas and hot water, the production, collection and distribution of electricity, the manufacture of gas and distribution of gaseous fuels through mains, supply of steam and hot water, and the collection, purification and distribution of water.
- **Construction :** This sector includes construction; site preparation and building of complete constructions or parts thereof; civil engineering; building installation; building completion; and the renting of construction or demolition equipment with operators all form part of the construction sector.
- **Trade :** Trade entails wholesale and commission trade; retail trade; repair of personal household goods; sale; maintenance and repair of motor vehicles and motor cycles; hotels; restaurants; bars canteens, camping sites and other provision of short-stay accommodation.
- **Transport & Comms :** The transportation and communication sector comprises land transport; railway transport; water transport; transport via pipelines; air transport; activities of travel agencies; post and telecommunications; courier activities; and storage.
- **Finance :** The economic activities under this category include, inter alia, financial intermediation; insurance and pension funding; real estate activities; renting of transport equipment; computer and related activities; research and development; legal; accounting, book-keeping and auditing activities; architectural, engineering and other technical activities; and business activities not classified elsewhere.
- **Government :** This sector includes public administration, defence and other government services at central, provincial and local level. (Note: for Labour figures this sector is included under Community Services below)
- **Community Services :** This sector includes social and related community services (education, medical, welfare and religious organisations), recreational and cultural services and personal and household services.
- **Other :** Private households, extraterritorial organisations, representatives of foreign governments and other activities not adequately defined. (Note: for Labour figures there is no “Other” category)

The labour distribution provides information on the sectoral distribution of formal economic activities, as do the GGP figures, but in addition, information is provided on the extent of informal activities, as well as dependency. Dependency may be assessed from unemployment figures, as well as by determining the proportion of the total population that is economically active.

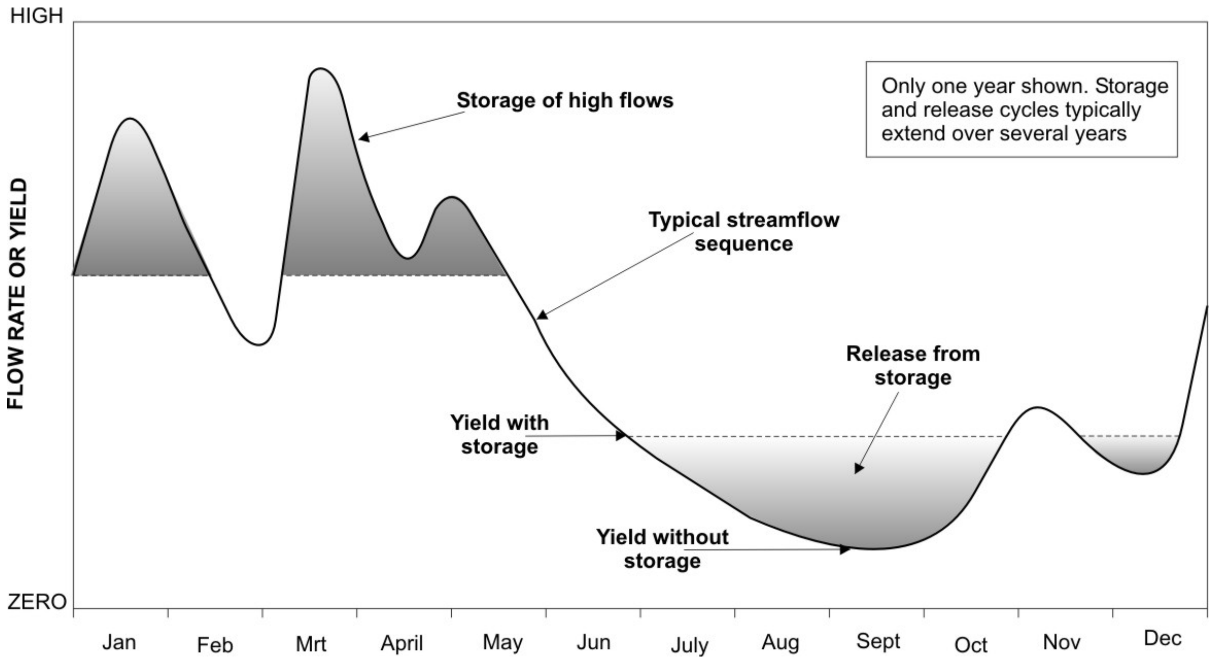
- **Total :** The total economically active population consists of those employed in the formal and informal sectors, and the unemployed.
- **Formal sector :** Includes employers, employees and self-employed who are registered taxpayers.
- **Informal sector :** Includes people who are employers, employees or self-employed in unregistered economic activities, i.e. businesses not registered as such.

  Unemployed : Includes people who are actively looking for work, but are not in any type of paid employment, either formal or informal.

ADDENDUM 3 : YIELD, RELIABILITY, AVAILABLE WATER AND ASSURANCE OF SUPPLY

The yield from a water resource system is the volume of water that can be abstracted at a certain rate over a specified period of time (expressed in million m³/a for the purposes of the NWRS). For domestic, industrial and mining use water is required at a relatively constant rate throughout the year, whereas strong seasonality occurs with respect to irrigation. Because of the typically large fluctuations in stream flow in South Africa, as demonstrated over a 12-month period in the diagram below, the highest yield that can be abstracted at a constant rate from an unregulated river is equal to the lowest flow in the river. By regulating stream flow by means of dams, water can be stored during periods of high flow for release during periods of low flow, as shown by the dotted lines on the diagram, This increases the rate at which water can be abstracted on a constant basis and, consequently, the yield. The greater the storage, the greater the yield that can be abstracted, within certain limits.

Diagrammatic presentation of stream flow and storage



Because rainfall, runoff and thus stream flow vary from year to year, low flows (and floods) are not always of the same duration and severity. The amount of water that can be abstracted without failure (the yield) therefore also varies from year to year. A yield that can be abstracted for 98 out of 100 years on average is referred to as a yield at a 98 per cent assurance of supply. Implicit in this is the acceptance that some degree of failure with respect to supplying the full yield will on average occur two years out of every 100 years. For a specific river and water resource infrastructure, the higher the assurance of supply required (or the smaller the risk of failure that can be tolerated), the smaller the yield that can be abstracted, and vice versa. For the purposes of the NWRS all quantities have been adjusted to a 98 per cent assurance, where applicable, to facilitate the legitimate numerical comparison and processing thereof. (Yields or water requirements are not directly comparable when at different assurances of supply, but first need to be normalised to a common standard.)

Available water refers to all water that could be available for practical application to desired uses. The total yield locally available includes the yield from both local surface water and groundwater resources, as well as contributions to the yield by usable return flows from the non-consumptive component of upstream water use in the area under consideration. Total water available includes the total local yield plus water transferred from elsewhere.

ADDENDUM 4 : ECOLOGICAL COMPONENT OF RESERVE

The ecological component of the Reserve refers to that portion of streamflow which needs to remain in the rivers to ensure the sustainable healthy functioning of aquatic ecosystems, while only part of the remainder can practically and economically be harnessed as usable yield. (Refer Addendum 2)

A summary of the mean annual runoff and the estimated average annual requirements for the ecological component of the Reserve per sub-area is given in Table 4. In the determination of water available for abstraction, allowance was made for maintaining the ecological flow requirements as pertain to drought conditions, which closely relates to the impact of the ecological component of the Reserve on the yield. All quantities relate to a particular sub-area only, that is, quantities reflect water that originates or is required in that particular sub-area. Where more than one sub-area or water management area is located along the same river, such as along the Vaal and Orange Rivers, the quantities from upstream have to be added to those of the area under consideration to reflect the actual, cumulative situation for the area under consideration.

Quantification of the water requirements for the ecological component of the Reserve, is based on the currently still incomplete understanding of the functioning of ecosystems and their habitat requirements. These figures are therefore subject to improvement as better insights are gained through monitoring, studies and improved assessment methodologies. Current provisional assessments indicate that, as a national average, about 20 per cent of the total river flow is required as ecological Reserve which needs to remain in the rivers to maintain a healthy biophysical environment. This proportion, however, varies greatly across the country, from about 12 per cent in the drier parts to 30 per cent in the wetter areas. Owing to a lack of better factual data, it has provisionally been assumed that provision of the ecological water requirements in the lowest reach of a river will be sufficient to meet estuarine freshwater requirements as well.

The component of the Reserve required for basic human needs has to be abstracted from the water resource and is therefore catered for under water requirements in Section 4.

ADDENDUM 5 : RECONCILIATION INTERVENTIONS

In line with the objectives of equitable and sustainable social and economic development, government has progressively adopted a more comprehensive and holistic approach to the planning of interventions to resolve problems of inadequate water availability. This approach accords with the requirements of national policies and legislation relating to the environment, and is informed by internationally accepted best practice.

Whenever there is a water shortage, all possible solutions will be investigated, taking account of the availability of surface and groundwater and the interactions between them, and the integration of water quality and water quantity issues. Options will include the following:

- Demand-side measures to increase water availability and improve the efficiency of water use, considered from the start of the planning process in parallel with other solutions.
- Re-allocations of water, including the possibility of moving water from lower to higher benefit uses by trading water use authorisations.
- The construction of new dams and related infrastructure, including inter-catchment transfers. Where infrastructure construction is indicated as an optimal solution, a range of alternative developments, including the implications of no development, will be presented.

The significant impacts of all development options and other interventions will be assessed and social and environmental considerations will be accorded the same attention as those of a technical, financial and economic nature. The social, environmental and economic impacts of all development options will be evaluated to ensure that the benefits arising from such actions will exceed the costs, that the benefits will be distributed equitably and that the negative impacts will be minimised or mitigated so that no-one is disadvantaged to any unreasonable extent.

In terms of the NWA comprehensive impact assessments may be required to determine the effect of proposed water uses on the water resource, and will be mandatory before a major government water work is constructed. Impact assessments will be undertaken in accordance with the regulations to the Environment Conservation Act, 1989, which are still in force under the National Environmental Management Act, 1998, until replaced by new regulations.

Water users, other stakeholders and the public a need to be involved at all stages of a development project or a scheme.

The main reconciliation interventions as given in the National Water Resource Strategy are :

- Demand management
- Improved water resource management
- Managing groundwater resources
- Re-use of water
- Control of invasive alien vegetation
- Re-allocation of water
- Development of surface water resources
- Inter-catchment transfers

Water quality considerations

ADDENDUM 6 : PRIORITIES FOR ALLOCATING WATER

Water is one of the most fundamental natural resources and it is one of the primary principles of the National Water Act that the nation's water resources are managed in such a manner that their use will achieve optimum long-term social and economic benefits for all people. Water is also a finite resource, and it is recognised that water allocations may have to change over time to meet this objective on an ongoing basis.

The NWA gives highest priority to water for the Reserve, which includes water for basic human needs and for the natural environment. Thereafter international obligations as agreed with neighbouring countries must be respected and honoured.

Beyond this, water should be allocated to ensure that the greatest overall social and economic benefits are achieved. But consideration must not only be given to this primary aim, but also to potential disbenefits to society where water is made available to competing optional uses. This applies both to long-term allocations for water use as well as to short-term curtailments in supply during periods of drought and temporary shortage. Where surplus or unused water exists, prioritisation need not apply, provided that the water is not used wastefully.

To facilitate the most beneficial utilisation of water, a general guide on priorities for water use is given below. The priorities are listed in descending order of importance, although the order may vary under particular circumstances.

- Provision for the Reserve.
- International agreements and obligations.
- Water for social needs, such as poverty eradication, primary domestic needs and uses that will contribute to maintaining social stability.
- Water for Strategic use.
- Water for general economic use, which includes commercial irrigation and forestry. In this category, allocation is best dictated by the economic efficiency of use. With the introduction of water trading, demand will automatically adjust over time to reflect the value of water in particular uses.
- Uses of water not measurable in economic terms. This may include convenience uses and some private water uses for recreational purposes, which are likely to be of low priority.

Additional factors to be considered in assessing priorities for the allocation of water are the level of assurance of supply required, the consumptiveness of use and the quality of return flows.

It is important to realise that all water use by a particular sector or user is unlikely to be of the same priority. Water to maintain primary production functions, for example, would be of higher value and priority than the additional water required for other uses in the same enterprise. This also relates to the efficiency of water use, with greater efficiency leading to a higher value of water. The same principle applies to a greater or lesser extent to all uses of water.

ADDENDUM 7 : INTER-CATCHMENT TRANSFER OF WATER

The National Water Act recognises both the relative scarcity of water in South Africa and the uneven and often unfavourable distribution of water resources in both space and time. The national government is therefore entrusted with the responsibility to effect the equitable allocation of water for beneficial use and to ensure that sufficient water is available to support the continued growth and wellbeing of the country. This includes the preparation of guidelines for the spatial redistribution of water as well as the actual implementation of inter-catchment transfer projects, where applicable.

An inherent benefit of linking the country's water resources over a large geographic area is that it can, in certain circumstances, help to manage the consequences of climatic variability through the transfer of water supplies to areas that may be suffering from severe drought conditions, from areas where the prevailing conditions are less critical. This not only helps to prevent disasters, but also provides the opportunity of operating the available resources in a systems context, thereby achieving an overall yield that is greater than the sum of the component parts.

The same technical, environmental, social and economic considerations as are applicable to any water resource development and use of water are applicable to inter-catchment transfers of water. Key considerations and items of specific relevance to inter-catchment transfers can be summarised as follows:

- Priorities for water use are stipulated in the NWA and are also contained in the NWRS. The highest priority in a catchment is to be afforded to the provision of water for the Reserve and to honouring international rights and obligations. Thereafter, consideration is to be given to the most beneficial use of water (actual and potential), both within the source and the (potential) recipient basins.
- The allocation of water away from a catchment can only be justified if it results in an overall benefit from a national perspective. Any negative impacts, or the loss of opportunity as a result of the transfer, must be outweighed by the advantages that are created. Full consideration must be given to any possible negative impacts in the source basin and all reasonable measures must be taken to mitigate such impacts in the interest of those affected.
- The maintenance of environmental integrity is of particular importance in all water resource developments. The inter-catchment transfer of water may have unique impacts on natural ecosystems that extend beyond those associated with in-catchment developments, and these need to be considered and provided for. In addition to comprehensive environmental impact assessments being undertaken in both the source and receiving areas, specific consideration must be given to the possible transfer of organisms and changes in habitat conditions.
- Interbasin transfers will only be permitted subject to water conservation and demand management by the relevant authorities and user organisation in the receiving region, conforming to the applicable criteria in this regard. Similarly, inefficient or non-beneficial use of water in a source basin cannot serve as reason for not transferring water.
- The transfer of water for the express purpose of meeting the requirements of the ecological component of the Reserve in the receiving catchment will not be considered.
- Water should not unduly be reserved over long periods of time for possible future use within or outside a catchment, in this way foregoing opportunities for the interim beneficial use of such water. Where appropriate, water use licences of short duration may be issued.
- In determining the volumes of water to be transferred from one catchment to another, water that is not already gainfully utilised and water resource potential still to be developed will be considered first. The re-allocation and inter-sectoral redistribution of water from existing to more beneficial uses should only be effected where merit can be demonstrated clearly on an economic and social basis.
- Conforming to the principle in the NWA that water is a national resource that belongs to all people, no payment is to be made to a source catchment for the actual water transferred. A portion of the water resource management charge raised in the recipient catchment will, however, revert to the source catchment and opportunities will be sought to mitigate any negative impact that may result.
- All costs associated with the transfer of water will be borne by the users of the transferred water. These include normal water use charges in terms of the prevailing pricing policy together with project and operational costs, as well as the cost of possible mitigatory measures.
- The national government will normally initiate, plan and authorise inter-water management area transfers.