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DEPARTMENT OF WATER AFFAIRS
AND FORESTRY

MIDDLE VAAL WATER MANAGEMENT AREA

Overview of Water Resources Availability and Utilisation

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MIDDLE VAAL
WATER MANAGEMENT AREA

OVERVIEW OF WATER RESOURCES AVAILABILITY AND UTILISATION

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MIDDLE VAAL WATER MANAGEMENT AREA

OVERVIEW OF WATER RESOURCES AVAILABILITY AND UTILISATION

1. GENERAL DESCRIPTION OF WATER MANAGEMENT AREA

1.1 Natural characteristics

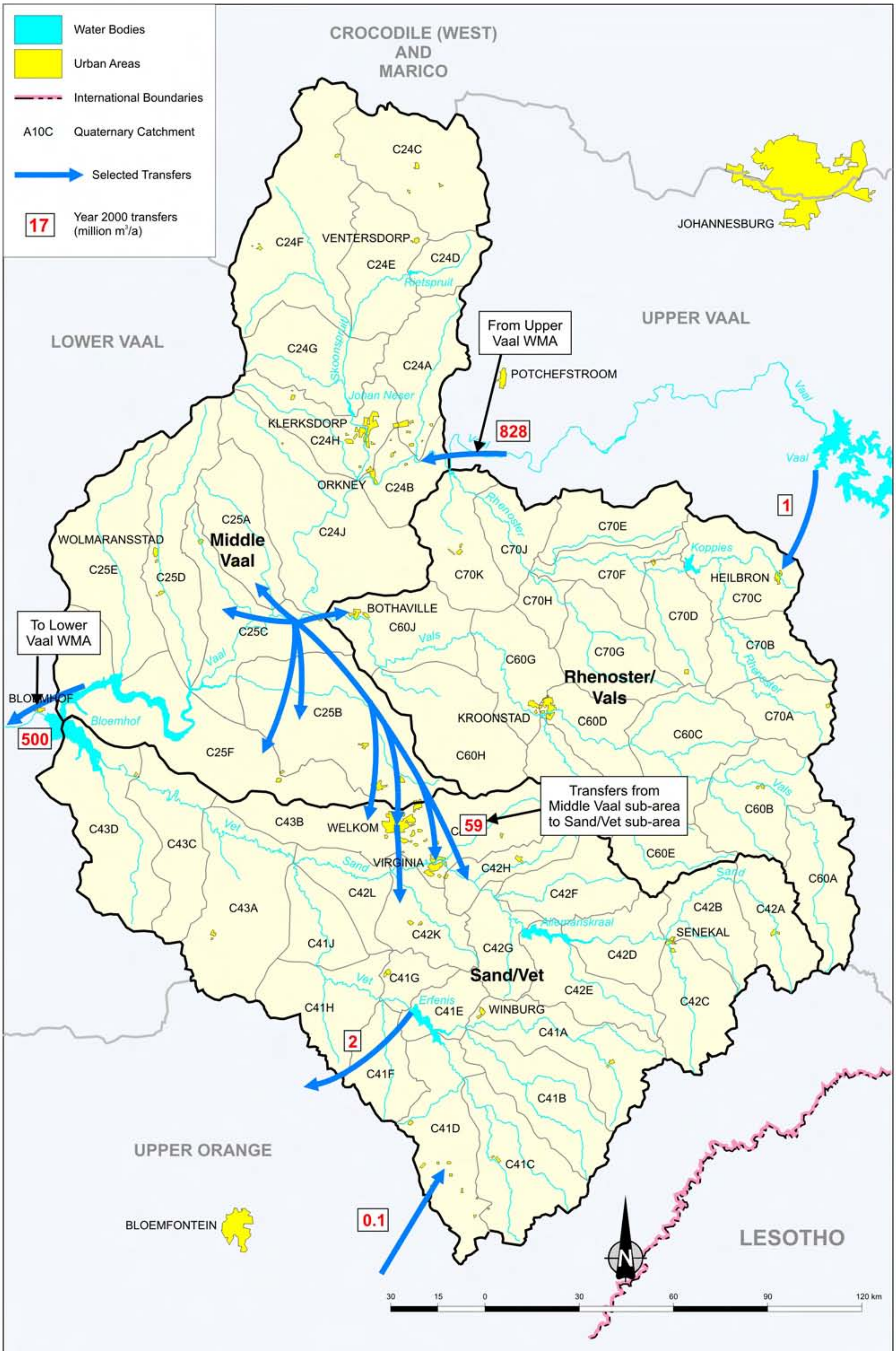
The Middle Vaal water management area is situated in the central part of South Africa, in the Free State and North West Provinces. It is situated between the Upper Vaal and Lower Vaal water management areas and also borders on the Crocodile (West) and Marico as well as the Upper Orange water management areas. The Vaal River is the only main river in the water management area. It flows in a westerly direction from the Upper Vaal water management area, to be joined by the Skoonspruit, Rhenoster, Vals and Vet Rivers as main tributaries from the Middle Vaal water management area, before flowing into the Lower Vaal water management area and then into the Orange River. Refer to **Figure 1** for the location and general layout of the water management area.

Climate over the water management area is temporate with frost occurring in winter, and is generally semi-arid. Mean annual rainfall ranges from 700 mm in the south-east to 400 mm in the west, and mainly occurs as summer thunder storms. The potential evaporation, which can be as high as 1 900 mm per year as shown in **Figure 2**, is well in excess of the rainfall. Vegetation is mainly grassland, with sparse bushveld in patches. The topography is relatively flat with no distinct features. Hilly terrain occurs to the south-east. The geology is varied, which also gave rise to different soil types. A large dolomitic formation occurs from Orkney and extends towards the northern part of the water management area. Diamonds are found in the north-west of the water management area, with rich gold ore in the vicinity of Klerksdorp and Welkom.

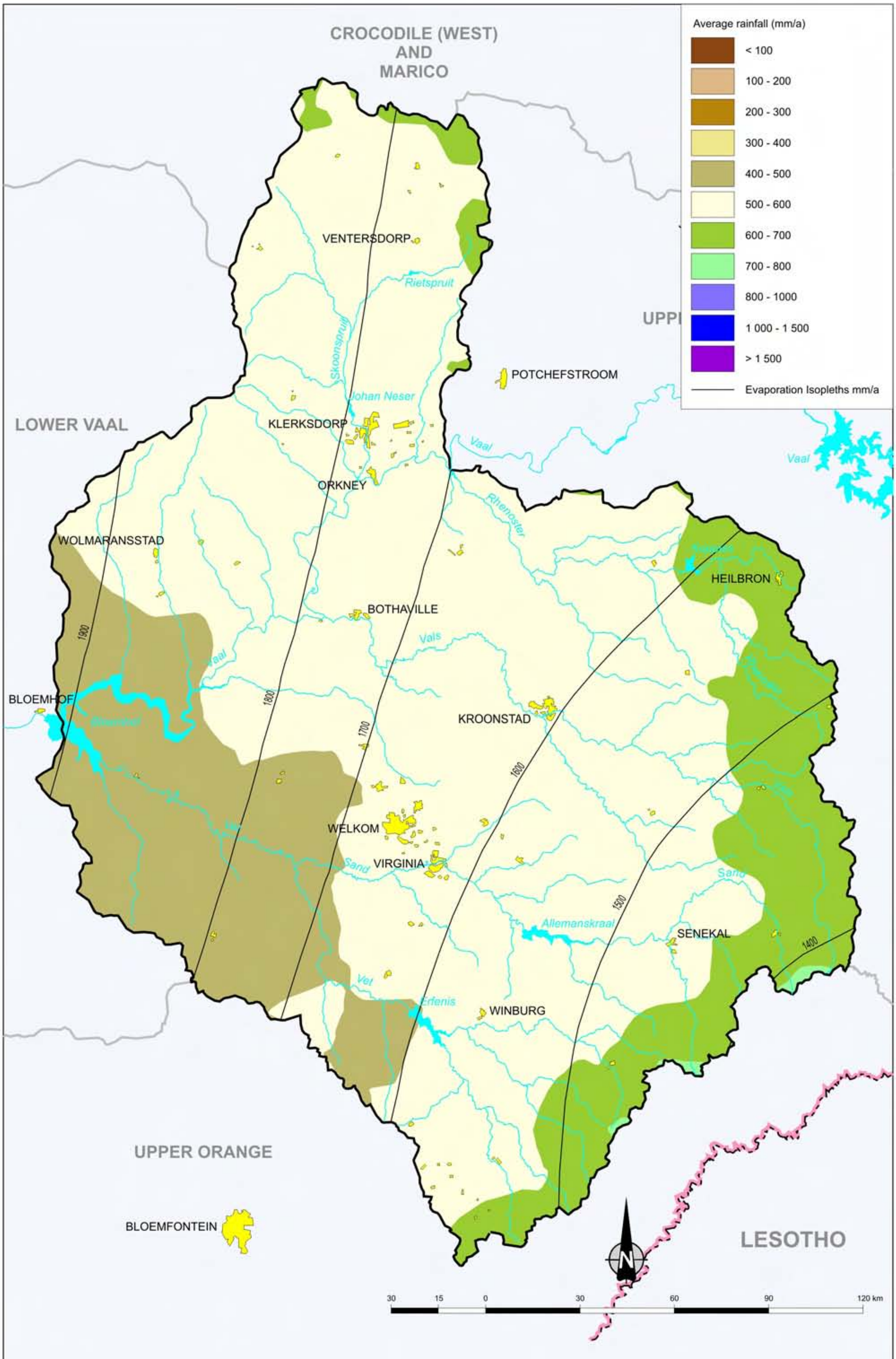
The Allemanskraal game reserve is the best know reserve in the water management area. Some smaller conservation areas are also to be found.

1.2 Development

Nomadic people first lived in the area, followed by livestock farmers in later years. Diamonds were discovered in the north-west of the water management area around 1870 and serious cultivation of land started around the 1930’s. Gold was first mined near Klerksdorp in 1886, with rich gold founds at Welkom and Virginia in 1896. All these events contributed to shaping the present character of development in the water management area.



MIDDLE VAAL WMA **Base Map** **Fig 1**



MIDDLE VAAL WMA **Rainfall and Evaporation** **Fig 2**

Present land use in the water management area is characterised by extensive dry land cultivation, particularly in the central parts as reflected in **Figure 3**. Irrigation is practised downstream of dams along the main tributaries as well as at locations along the Vaal River. The remainder being natural grassland under livestock farming. No afforestation occurs in the water management area. Infestations of alien vegetation are found along the Vaal River. The largest urban areas are at Klerksdorp, Welkom and Kroonstad. Numerous inactive mines are found in the north and west of the water management area, many of which were small diamond claims.

1.3 International

The Middle Vaal water management area does not directly share any rivers with or adjoins any neighbouring countries. Through its location which covers part of the Vaal River catchment, and which falls within the Orange River Basin, water resource management in the Middle Vaal water management area indirectly also impacts on neighbouring countries.

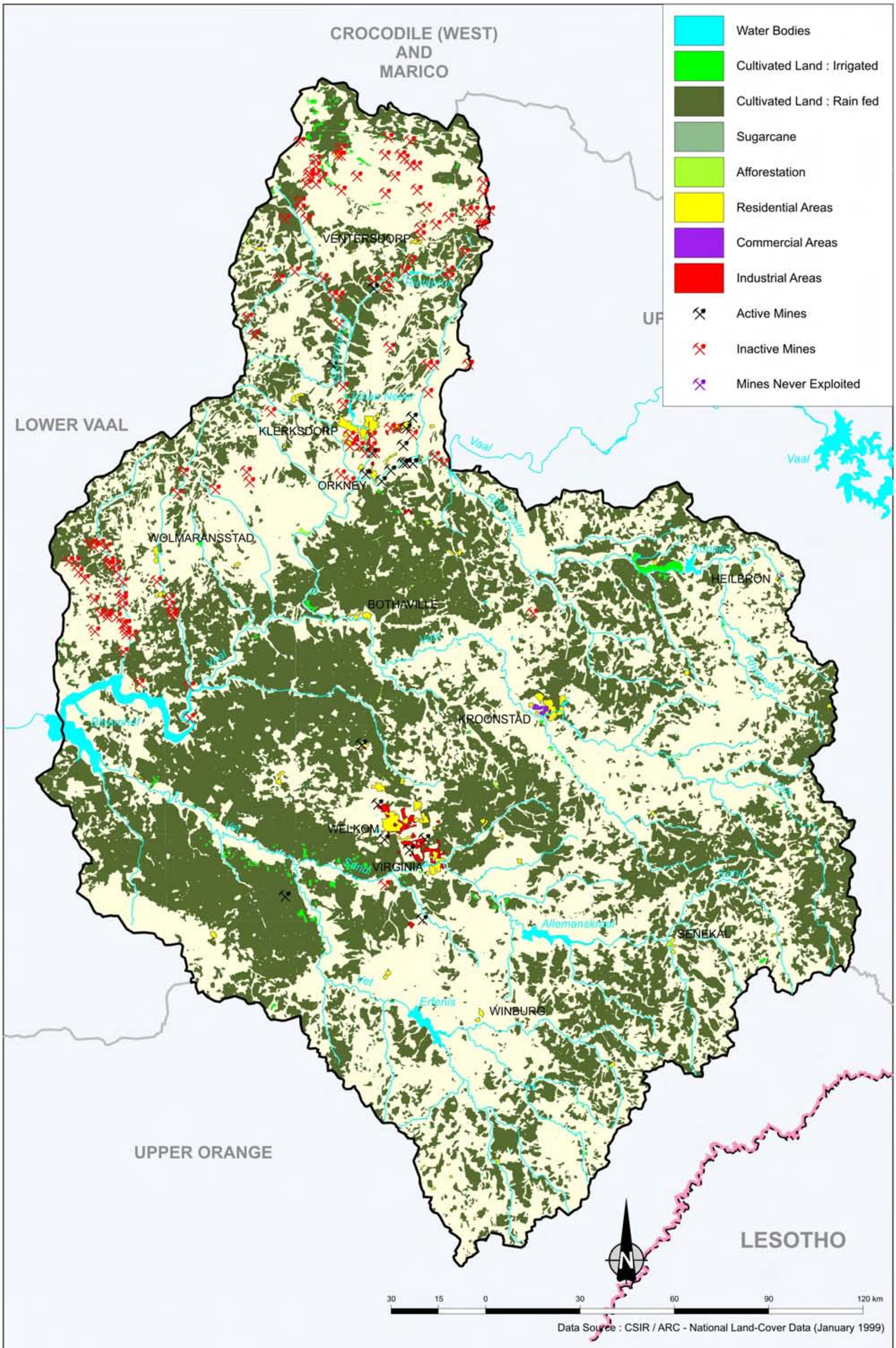
1.4 Sub-areas

Large spatial variations in climate, water availability, level and nature of economic development, population density as well as potential for development and growth are typical of South Africa, and also evident in the Middle Vaal water management area.

To enable improved representation of the water resources situation in the water management area, 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. Smaller or alternative subdivisions may later be introduced by the catchment management agency.

Consequently, three 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 Rhenoster-Vals sub-area, comprising the catchments of the Rhenoster and Vals Rivers.
- The Middle Vaal sub-area, which corresponds to the portion of the Vaal water management area between the confluence of the Rhenoster River down to the confluence of the Vet River in the Bloemhof Dam reservoir, together with the Skoonspruit catchment and some smaller tributaries.
- The Sand-Vet sub-area, which comprises the catchments of the Sand and Vet Rivers.



MIDDLE VAAL WMA **Land use** **Fig 3**

2. NATIONAL PERSPECTIVE

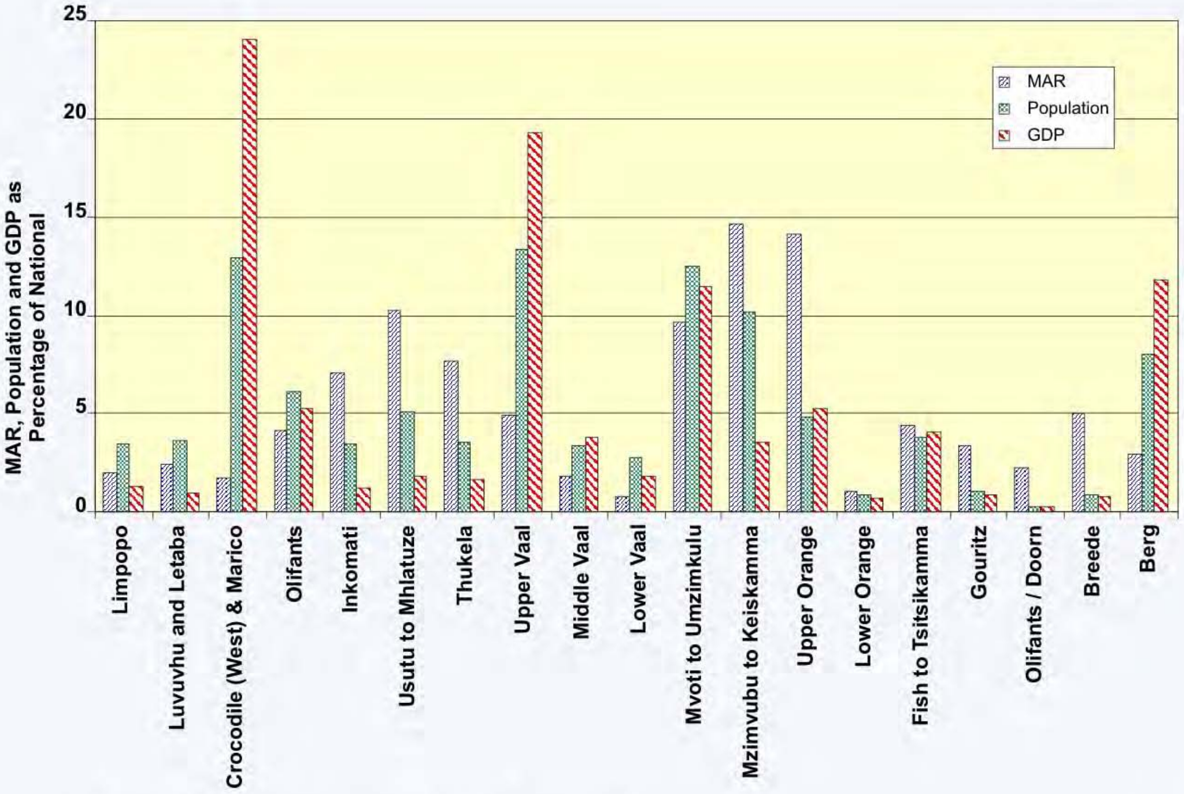
South Africa is located in a predominantly semi-arid part of the world. The climate varies from desert and semi-desert in the west to sub-humid along the eastern coastal area, with an average rainfall for the country of about 450 mm per year, well below the world average of about 860 mm per year, while 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**

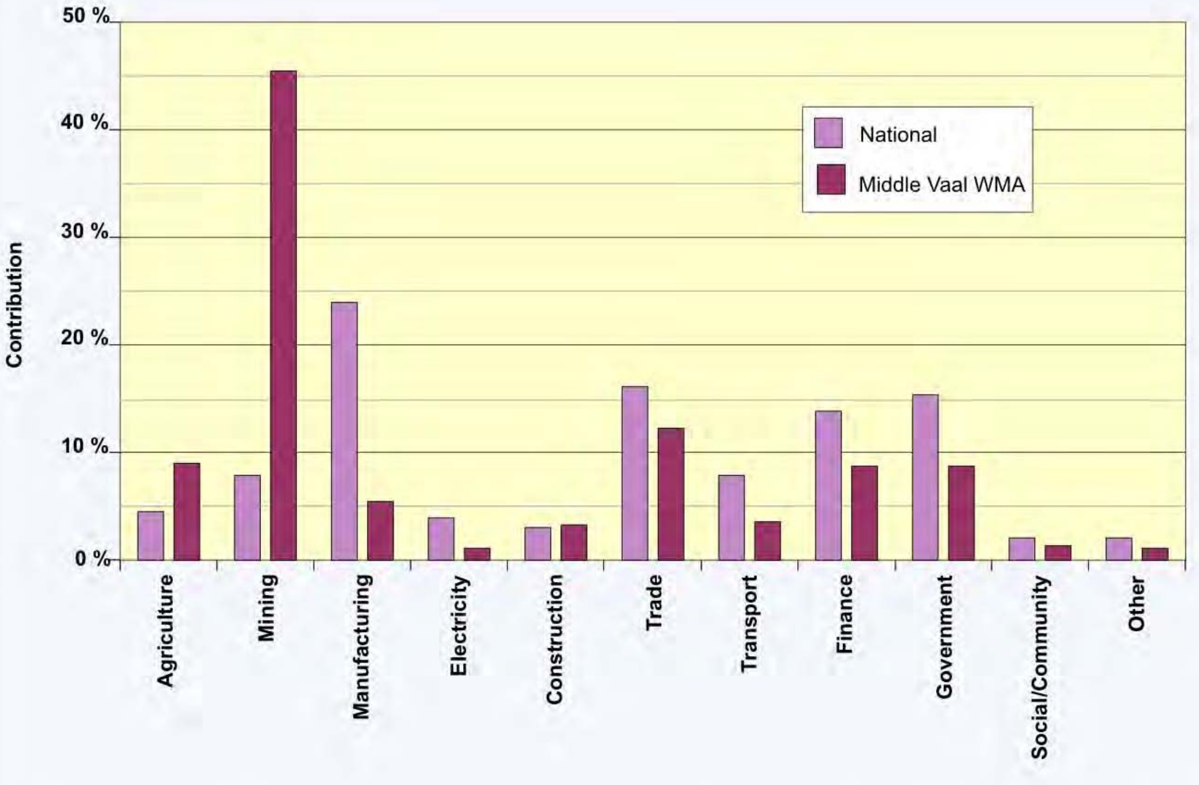
Whereas attention in the past was mainly focussed on the development of new resources as the requirements for water increased, partly as large unused potential was still available, the efficiency of water use has not developed to the same level of sophistication as resource management. With the current 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

The economy in the water management area is mainly based on mining and agriculture as primary production sectors. About 4% of the Gross Domestic Product (GDP) of South Africa originates from the Middle Vaal water management area, which reflects an average level of economic activity. The composition of the economy in the Middle Vaal 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, in terms of GGP, were:

- Mining 45,6%
- Trade 12.3%
- Agriculture 8,9%



MIDDLE VAAL WMA Sectoral contribution to the economy Fig 5

The economy in the Middle Vaal water management area is still dominated by mining, which in the past contributed nearly 60% to the GGP, but has shown a steady decline over the last decade. The main mining activity in the area is gold mining. Few of the gold mines have a secure life span beyond the year 2010, although the reserve base could support mining up to the year 2030. The future of gold mining will be strongly influenced by the gold price, the rand exchange rate, the industry's ability to contain operating costs, as well as the tax regime and environmental requirements. The general expectations, however, are for the declining trend to continue.

The trade sector is the second largest contributor to the GGP of the water management area. Trade is not a primary production sector and trade activities represent a derived demand. The levels of personal consumption expenditure and international trade (gold) largely drive the trade sector's performance.

Some of the main agricultural products being cultivated are maize, groundnuts, sorghum and sunflowers. Livestock farming consists mainly of beef, dairy and sheep farming enterprises.

Manufacturing activities in the water management area mainly relate to the mining and agriculture sectors as well as items for local consumption. Of the work force of 659 000 people in the water management area in 1994, 67% were active in the formal economy and 23% were unemployed, which is less than the national average of 29%. The remaining 10% participated in the informal economy. Of those formally employed, about 36% were in the mining sector, 24% in the government sector and 17% in agriculture.

No dramatic changes to the economy of the region are foreseen over the medium term. Although the mining sector in the water management area has a comparative advantage seen within a national context, which is attributable to the importance of gold mining in the region, production by this sector is set to decline. Considering that about half of the GGP in the water management area used to come from the mining sector, such decline will have a significant impact on the socio-economy of the region as well as on water requirements in the water management area. The construction sector will also be affected by the reducing activity in the mining sector.

Attributable to the diversity of products both in terms of crop and livestock production, the agricultural sector in the region is relatively stable and will continue to make an important contribution to the regional economy. In real terms, production by this sector will probably remain close to the current levels.

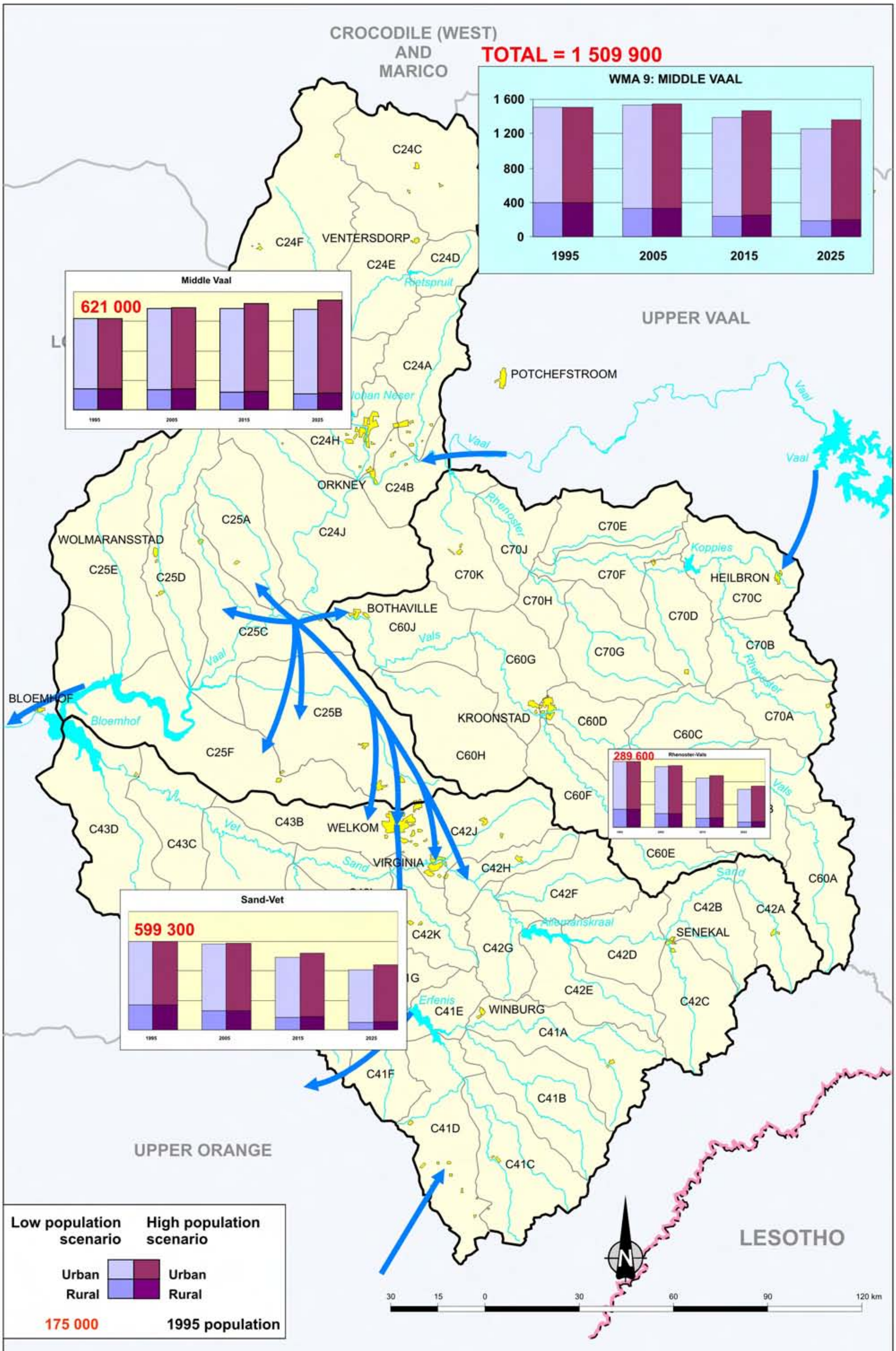
3.2 Demography

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 4. Demographic information pertinent to the Middle Vaal water management area is captured below.

The Middle Vaal water management area is relatively sparsely populated, with just over 3% of the national population, which is somewhat less than the proportionate contribution to the economy.

Over 75% of the population in the water management area are classified as living in urban areas, and about 25% as rural. Most of the population are concentrated in the main urban and mining centres of Klerksdorp, Orkney and Stilfontein in the Middle Vaal sub-area; Welkom and Virginia in the Sand-Vet sub-area, as well as Kroonstad (which is not a mining town) in the Rhenoster-Vals sub-area.

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. In concert with the general trend towards urbanisation in the country, a decline in rural population is expected throughout the water management area, as shown in Figure 6. Mainly as a result of the decline in mining activity as well as due to a lack of other economic stimulants in the region, urban populations are also expected to decline over much of the water management area. Moderate population growth is foreseen in the Middle Vaal sub-area, which is probably attributable to migration of people towards the more diversified economy in the Klerksdorp area, and which is expected to stabilise after 2005.



MIDDLE VAAL WMA **Population Scenarios** **Fig 6**

4. WATER REQUIREMENTS

4.1 Current requirements (year 2000)

About 40% of the total water requirements in the water management area is for irrigation, nearly 30% for urban and industrial use, and about 20% for mining. Water for rural domestic and stock water purposes represent less than 10% of the total requirements. Most of the irrigation (63%) is in the Sand-Vet area, where it is supplied from the Allemanskraal and Erfenis Dams, with the remainder about equally split between the other two sub-areas. Water from urban, industrial and mining use is mainly required in the Klerksdorp-Orkney-Stilfontein and Welkom-Virginia area, with urban water requirements at Kroonstad. 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**. All the requirements are given at a standard 98% assurance of supply, as explained in Addendum 3.

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

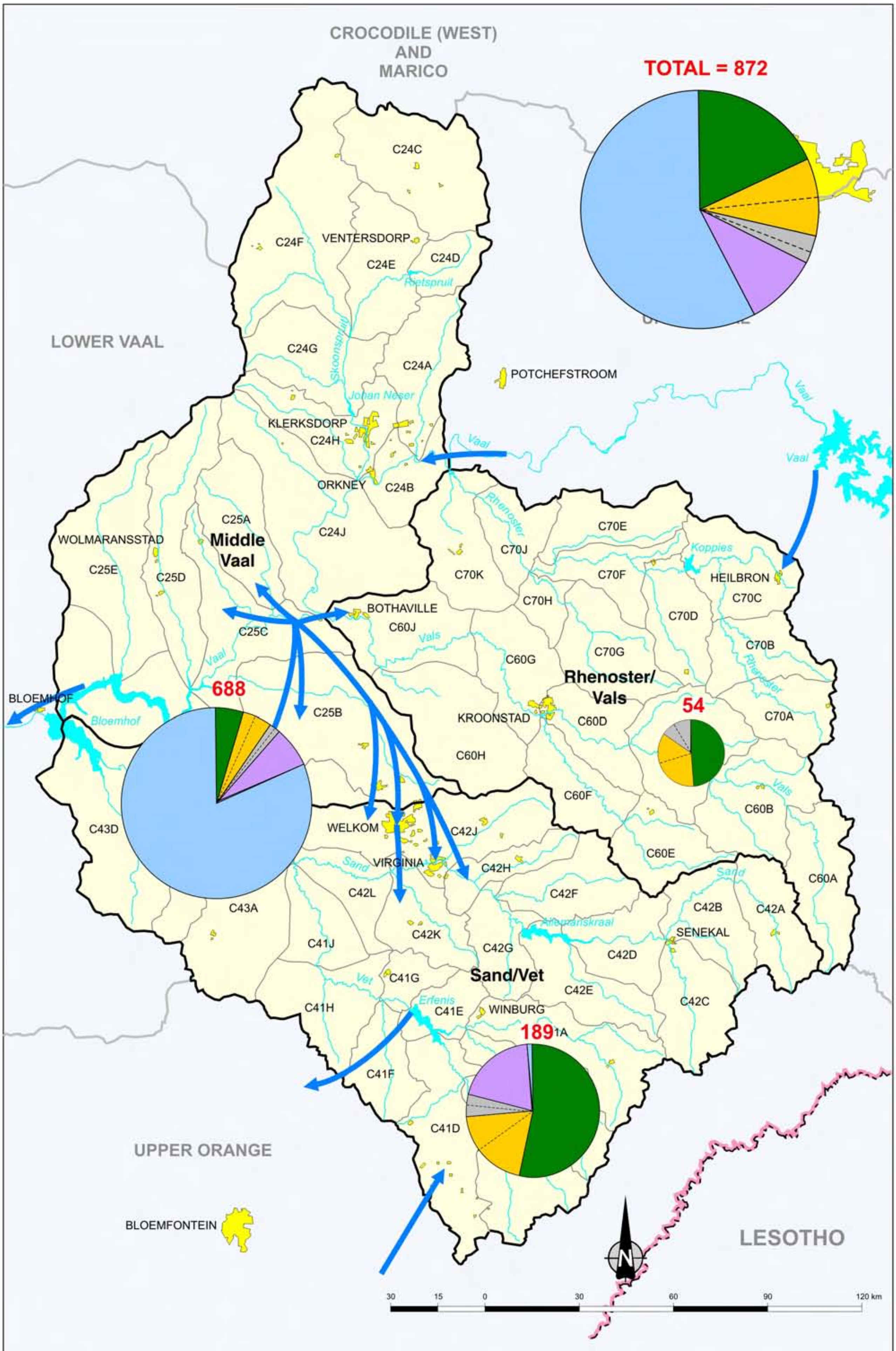
Sub-area	Irrigation	Urban (1)	Rural (1)	Mining and bulk industrial (2)	Power generation (3)	Affore-station (4)	Total local require-ments	Transfers out	Grand Total
Rhenoster-Vals	26	20	8	0	0	0	54	0	54
Middle Vaal	33	35	13	48	0	0	129	559	688
Sand-Vet	100	38	11	38	0	0	187	2	189
Total	159	93	32	86	0	0	370	502	872

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.

Figure 7 shows the bulk of the water requirements in the Middle Vaal sub-area as destined for transfer, which represents the water being transferred from the Upper Vaal to the Lower Vaal water management area via the Vaal River (as also described in 6.1). Water requirements within this sub-area are mainly for mining, urban and irrigation use, a substantial proportion of which again become available as usable return flows.

Although most of the water in the Sand-Vet sub-area is used for irrigation, large quantities are also required for urban and mining use.

Water use in the Rhenoster-Vals sub-area is mainly for irrigation and urban use, with a smaller component for rural domestic supplies and stock watering.



MIDDLE VAAL WMA **Sectoral water requirements Fig 7**

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 Middle Vaal water management area are the decline expected in water requirements by the mining sector, and associated declines in the urban requirements for water in the vicinity of mine closures. Indications are that the Welkom-Virgina area may be most affected.

No meaningful change is foreseen with respect to irrigation and rural water requirements. However, it has been recorded that fields have been taken out of irrigation in certain areas, due to poor financial viability.

In total for the water management area, the requirements for water are expected to remain at the current levels over most of the water management area.

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
Rhenoster-Vals	26	19	8	0	0	0	53	0	53
Middle Vaal	33	48	13	48	0	0	142	560	702
Sand-Vet	100	39	10	38	0	0	187	2	189
Total	159	106	31	86	0	0	382	503	885

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
Rhenoster-Vals	26	31	8	0	0	0	65	0	65
Middle Vaal	33	58	13	48	0	0	152	628	780
Sand-Vet	100	52	10	38	0	0	200	2	202
Total	159	141	31	86	0	0	417	557	974

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

Surface water flows which originate within the water management area are highly seasonal and variable, with flow in many of the tributaries intermittent. Base flow in the Skoonspruit is fed from dolomitic springs in the upper reaches (much of which is abstracted for use at Ventersdorp). The flow in the Vaal River, most of which originates in the Upper Vaal water management area, represent the bulk of the surface water in the water management area. There are no natural lakes or swamps in the water management area. Vlei areas occur along the lower Vet River and in the upper Skoonspruit catchment.

No significant land use impacts have been quantified in the water management area, although some influence on the water resources will result from the large areas under cultivation as well as from urban runoff. There are no commercial forests in the water management area, although significant quantities of water are estimated to be lost through infestations by alien vegetation, much of which occur on the banks of the Vaal River. A summary of the natural mean annual runoff (MAR), together with the estimated requirements of the ecological component of the Reserve, is 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 m^3/a)

Sub-area	Natural MAR (1)	Ecological Reserve (1, 2)
Rhenoster-Vals	295	35
Middle Vaal	170	29
Sand-Vet	423	45
Total	888	109

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.

Naturally the quality of surface water in the water management area is good, but can be of high turbidity. Wash-off and return flows from urban areas in the proximity of the Vaal River and main tributes, such as at Klerksdorp, also impact on water quality. Water which enters the Middle Vaal water management area along the Vaal River, contains a large proportion of urban and industrial return flows from the Johannesburg area with part of the water having been through more than one cycle of use. As a consequence, salinity levels can be very high and need to be managed through blending with fresh water in the Upper Vaal water management area, so as not to exceed certain target concentrations. High nutrient concentrations also occur as a result of the large domestic component of return flows which, together with the low turbidity of the return flows, stimulates excessive algal growth. Pollution of the Skoonspruit has also been experienced as a result of improper diamond mining operations on the banks of the river.

Development of surface water naturally occurring in the water management area has reached its potential and all the water is being fully utilised. The main storage dams, for which more detail are given in Appendix 5, are:

- Rietspruit and Johan Neser Dams on the Skoonspruit tributary in the Middle Vaal sub-area;

- Koppies Dam on the Rhenoster River, Serfontein Dam and a diversion weir on the Vals River together with the off-channel Bloemhoef Dam at Kroonstad, in the Rhenoster Vals sub-area; and

- Allemanskraal Dam on the Sand River and Erfenis Dam on the Vet River, in the Sand-Vet sub-area.

Bloemhof Dam is located on the Vaal River immediately below the confluence of the Vet River. The dam structure is in the Lower Vaal water management area, although most of the reservoir falls within the Middle Vaal water management area. The yield from the dam is available in the Lower Vaal water management area.

The dams on the tributaries are operated independently from the Vaal River, although flood spillage from the dams and flow from unregulated tributaries, are captured at Bloemhof Dam at the downstream end of the water management area. The full yield from the local surface runoff is used within the water management area, mostly for irrigation, but with a large proportion also for urban supplies to towns in the water management area.

In addition, large quantities of water are transferred into the water management area along the Vaal River, to augment the local resources. Most of this water is used for urban, industrial and mining purposes in the Klerksdorp-Orkney and Welkom-Virginia areas. Water is also abstracted from the Vaal River for supply to Bothaville and Wolmaranstad as well as for irrigation. A small quantity of water is transferred from Vaal Dam in the Upper Vaal water management area to Heilbron in the Middle Vaal water management area, and a small transfer also exists from Erfenis Dam in the Middle Vaal water management area to Brandfort in the Upper Orange water management area. More details on the existing transfers are given in Appendix 6.

Additional regulations of surface water have been considered for water quality management. However, further development of surface resources is not regarded as feasible.

5.2 Groundwater

Large dolomitic aquifers occur in the northern part of the water management area. These extend from Stilfontein in a northern direction and across the water management area in the vicinity of Ventersdorp. The aquifers, which occur in different compartments, also underlay large parts of the Upper Vaal, Lower Vaal, and Crocodile (West) and Marico water management areas. Water from the aquifers is abstracted for urban use at Ventersdorp, part of which is processed as bottled water, as well as for irrigation and rural water supplies.

The remainder of the water management area is mostly underlain by fractured rock aquifers, which are well utilised for rural water supplies and with little undeveloped potential remaining.

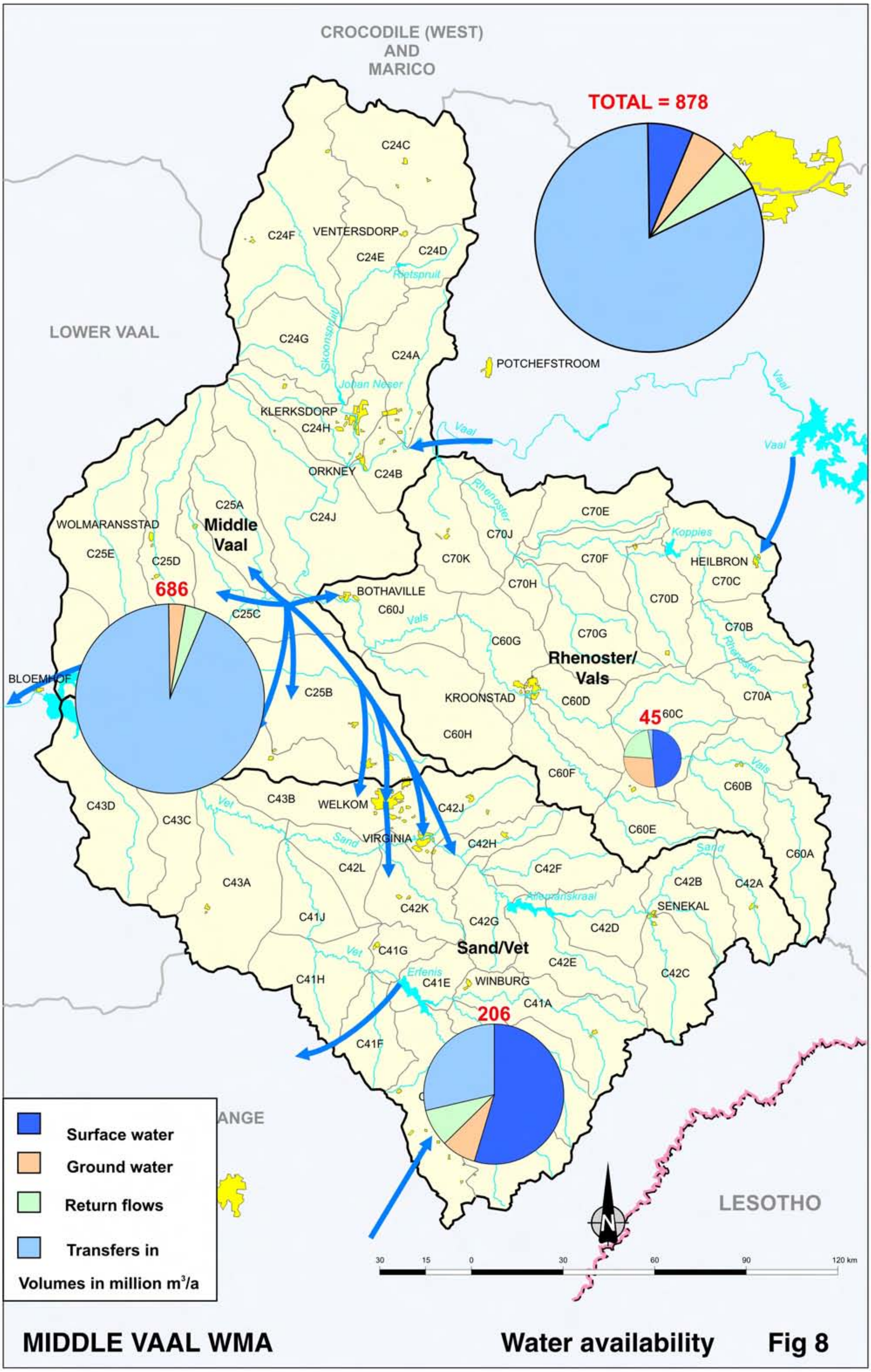
De-watering of dolomitic compartments for mining purposes occurred in the vicinity of Stilfontein, and pollution of groundwater due to chemical reaction, may result when mining operations are discontinued. Problems had also been experienced with seepage of groundwater containing manganese from mining areas, into the Vaal River, but were remedied. The quality of groundwater over the remainder of the water management area is generally of a very high standard.

About 11 million m^3 per year pumpage from the de-watering of mines in the Welkom-Virgina area, evaporates from pans.

5.3 Summary

The total water available for use in the Crocodile (West) and Marico 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 when viewing Figure 8 and Figure 6 together, is the overriding importance of water transfers through the Middle Vaal water management area, along the Vaal River. Of the total yield available in the water management area, 80% is attributable to inflows from the Upper Vaal water management area, 76% of which flows through the Middle Vaal water management area into the Lower Vaal water management area. Therefore, only 24% of the yield transferred into the Middle Vaal water management area is used locally, the bulk of which is in the Klerksdorp-Orkney and Welkom-Virginia areas.



MIDDLE VAAL WMA **Water availability** **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			
Rhenoster-Vals	22	12	3	7	0	44	1	45
Middle Vaal	(201)	25	3	15	16	(142)	828	686
Sand-Vet	112	17	10	7	1	147	59	206
Total	(67)	54	16	29	17	49	829	878

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

Particularly evident when viewing Figure 8 and Figure 6 together, is the overriding importance of water transfers through the Middle Vaal water management area along the Vaal River. The yield available in the water management area is dominated by inflows from the Upper Vaal water management area, most of which flows through the Middle Vaal water management area into the Lower Vaal water management area. Only about 40% of the yield transferred into the Middle Vaal water management area is used locally, the bulk of which is in the Klerksdorp-Orkney and Welkom-Virginia areas.

A significant quantity of water is also lost through evaporation and riparian vegetation along the Vaal River, which is in excess of the run-of-river yield contributed by local inflows, resulting in a negative yield for the Middle Vaal sub-area as shown in Table 5.

Due to the intermittent nature of the tributary rivers, provision for the ecological component of the Reserve has relatively little impact on the yield from these rivers.

6. RECONCILIATION OF REQUIREMENTS AND AVAILABILITY

6.1 Water Balance

A reconciliation of 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**. The main transfers with associated quantities are also shown on Figure 1 and are summarised in Appendix 6.

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

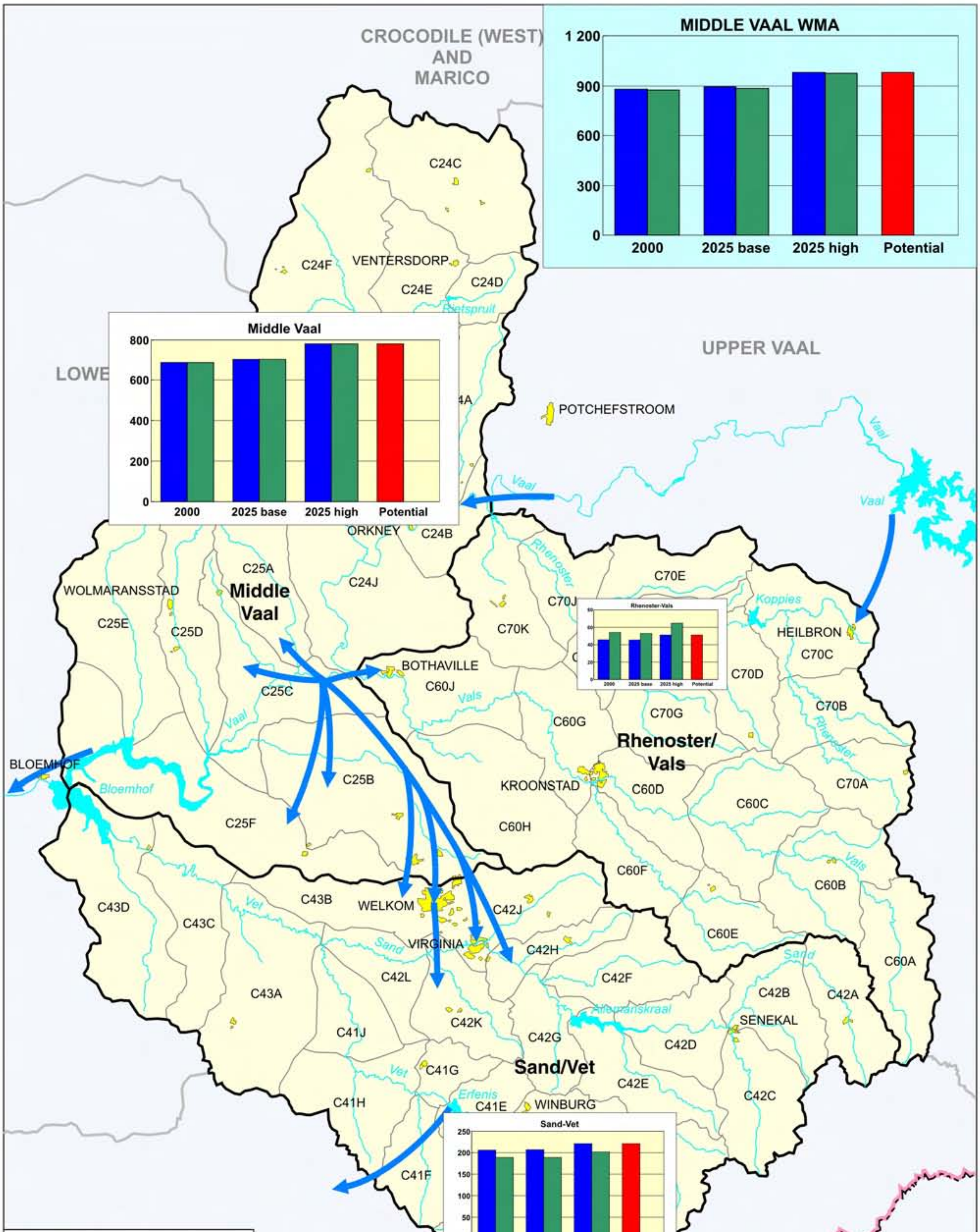
Sub-area	Available water			Water requirements			Balance
	Local yield	Transfers in (2)	Total	Local require-ments	Transfers out (2)	Total	(1)
Rhenoster-Vals	44	1	45	54	0	54	(9)
Middle Vaal	(142)	828	686	129	559	688	(2)
Sand-Vet	147	59	206	187	2	189	17
Total	49	829	878	370	502	872	6

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.

The approximate balance for the Middle Vaal sub-area is attributable to the fact that just enough water is released from the Upper Vaal water management area to ensure that the requirements in the Middle Vaal (and Lower Vaal) water management areas can be met. A deficit is shown for the Rhenoster-Vals sub-area, which is attributable to ideal irrigation water requirements in excess of what can reliably be supplied. Actual irrigation practices, however, have adjusted accordingly. The small surplus in the Sand-Vet sub-area is as a result of return flows from irrigation downstream of the points of use as well as due to some decline in irrigation.

Localised water shortages are experienced in the extreme upper tributaries of the Sand-Vet sub-area, such as at Marquard. Some settlements near the southern corner of the water management area are connected to the Bloem Water supply system, which mainly serve users in the Upper Orange water management area.

A perspective on the possible future water supply situation is given by **Table 7** for the base scenario, and **Table 8** as representative of a possible high water use scenario scenario. (Refer to Addendum 1.) These are also graphically presented in Figure 9. In both cases it



(blue)	Available water
(green)	Requirements

Resource potential:

(pink)	Undeveloped
(red)	Developed

Volumes in million m^3/a

MIDDLE VAAL WMA **Water reconciliation** **Fig 9**

was assumed that transfers from the Upper Vaal water management area would be equal to the requirements for augmentation of local resources, with a balance being maintained with respect to abstractions and the yield available from the Vaal River.

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)
Rhenoster-Vals	44	1	45	53	0	53	(8)	0
Middle Vaal	(136)	837	701	142	560	702	(1)	0
Sand-Vet	147	59	206	187	2	189	17	0
Total	55	838	893	382	503	885	8	0

1) Based on existing infrastructure and under construction in the year 2000. Also includes return flows resulting from growth in requirements.
2) Based on normal growth in water requirements as a result of population growth and general economic development. Assumed no general increase in irrigation.
3) Brackets around numbers indicate negative balance.

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)
Rhenoster-Vals	49	2	51	65	0	65	(14)	0
Middle Vaal	(131)	910	779	152	628	780	(1)	0
Sand-Vet	149	72	221	200	2	202	19	0
Total	67	911	978	417	557	974	4	0

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 high growth in water requirements as a result of population growth and high impact of economic development. Assumed no general increase in irrigation.
3) Brackets around numbers indicate negative balance.

Similarly, water will be transferred from the Vaal River to the Welkom-Virginia area as required for urban, industrial and mining purposes. Virtually no change in water requirements is foreseen with respect to the Rhenoster-Vals and Sand-Vet sub-areas for the base scenario, and with the assumption that mining use of water will remain approximately at the current levels. Should mining activities have significantly decreased by 2025 as the expectations are, a corresponding decrease in water requirements in the Middle-Vaal and Sand-Vet sub-areas will result. Growth in water requirements in the Rhenoster-Vals sub-area is mainly associated with growth at Kroonstad.

Compared to the MAR (888 million m^3/a) which originates from the Middle Vaal water management area together with the average annual inflow of 2 216 million m^3/a into the water management area as transfers and spillage from the Upper Vaal water management area, which constitute 3 104 million m^3 per year in total, an estimated 2 519 million m^3 per year or 81% flows out of the water management area into the Lower Vaal water management area.

6.2 Key issues

Key considerations with respect to the Middle Vaal water management area:

- Given its location between the Upper Vaal and Lower Vaal water management areas, water availability along the Vaal River is inextricably linked to these water management areas and to water resource management in the Vaal River System.

- The Middle Vaal water management area is dependant on releases from the Upper Vaal water management area for meeting the bulk of the requirements by the urban, mining and industrial sectors within its area of jurisdiction.

- Water quality in the Vaal River is of serious concern because of high salinity and nutrient content, which mainly results from urban and industrial return flows as well as mining activities in the Upper Vaal water management area. The closure of mines may have further water quality impacts.

- There are no large control structures with respect to the regulation of flow in the Vaal River within the Middle Vaal water management area, and both the quantity and quality of water in the Vaal River are largely influenced by management practices in the Upper Vaal water management area. (There are existing weirs on the Vaal River at Orkney and Balkfontein.)

- Water from tributaries as well as from groundwater in the water management area is fully utilised, mainly for irrigation and for towns remote from the Vaal River.

- The potential decline in population in parts of the water management area need to be addressed in the development of the catchment management strategy.

6.3 Strategic perspectives

Most of the economic production in the water management area is by the urbanised and mining sectors of the economy (refer to Figure 5), which are largely dependent on water supplies from the Vaal River. With water availability in the Vaal River being a function of the management of the Vaal River System which extends over several water management areas, it is evident that water resource management in the Middle Vaal water management area should be well co-ordinated with other inter-dependent water management areas, and be viewed in an integrated systems context. Management of water resources in the Middle Vaal water management area, should also be within the framework of the recently founded Orange-Sequ River Commission (ORASECOM) by South Africa, Lesotho, Botswana and Namibia.

As a result of the expected decline in mining activities as well as the projected negative population growth in some parts of the water management area, no significant change in the requirements for water are foreseen. The most likely locations for possible moderate growth are at Klerksdorp and Kroonstad. The main issue of concern will be the management of water quality within acceptable limits, as this could be severely impacted upon by further urban and industrial development in the Upper Vaal water management area.

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

<u>Rhenoster-Vals sub-area</u>

No meaningful change is foreseen with respect to water requirements in the rural areas. Growth in urban and industrial requirements, such as at Kroonstad, should be supplied through water demand management and the re-allocation of water (mainly from irrigation). Additional water may also be obtained through increased regulation on the Vals River or via the Goudvelde bulk distribution system, which supplies water from the Vaal River to the Welkom area.

<u>Middle Vaal sub-area</u>

Water quality management in the Vaal River is expected to become of increasing importance, while a moderate growth in water requirements may also occur. Both the quality and quantity aspects should be addressed in the context of the Vaal River System, where water resource management in the Upper Vaal water management area is of pivotal importance. A water quality management plan should be devised together with the upper Vaal and Lower Vaal water management areas.

It is important that national control be exercised over the management of the Vaal River System. In this respect, compulsory licensing is required to bring existing water use (in all the Vaal water management areas) in balance with the yield of the Vaal River System.

Sand-Vet sub-area

Little change in the transfer of water from the Vaal River to the Welkom-Virginia area is foreseen, and the transfers should be adjusted according to changes in the requirements for water. Because of economic considerations, it may be advantageous for more water to be obtained (purchased) from Allemanskraal Dam for supply to the Welkom-Virginia area, to replace a portion of the water supplied from the Vaal River.

Small towns such as Marquard, which experience growth due to the (temporary) migration of people and where local surface and groundwater resources are insufficient, may require the development of a small regional water supply scheme which could be sourced from the Caledon River in the Upper Orange water management area.

6.4 Transfers and reservation of water

The transfer of water between water management areas, as well as provisions for future growth, resort under national control. The following reservations need to be made with respect to the transfer of water in to and out of the Middle Vaal water management area:

- Transfers from the Upper Vaal water management area for use in the Middle Vaal and Lower Vaal water management areas. Currently this amounts to about 828 million m³ per year, and may under a high growth scenario increase to 910 million m³ per year – Reserved in the Upper Vaal water management area.
- Transfers from the Middle Vaal water management area to the Lower Vaal water management area. The current volume is 500 million m³ per year, which under a high growth scenario may increase to about 555 million m³ per year – Reserved in the Middle Vaal water management area.
- Small existing transfers for domestic use from Vaal Dam in the Upper Vaal water management area to Heilbron in the Middle Vaal water management area – Reserved in the Upper Vaal water management area.
- Small existing transfers for domestic use from Erfenis Dam in the Middle Vaal water management area to users in the Upper Orange water management area – Reserved in the Middle Vaal water management area.
- Existing transfers of about 0,1 million m³ 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.

REFERENCES

1. *First Edition National Water Resource Strategy*, DWAF, for publication in 2003.

2. *Reports on Water Resources Situation Assessment Studies:*
Water Resources Situation Assessment - Middle Vaal WMA: DWAF Main Report No 09000/00/0301. August 2001.

3. *The Distribution of South Africa's Population, Economy and Water Usage into the Long Term Future*: Schlemmer,L; and Markdata (Pty) Ltd for DWAF, 2001.

4. *Water Situation Assessment Model: Data Preparation and Processing*: Craig, AR and Taviv, I. DWAF Report P.RSA/00/2401, March 2001.

5. *Economic Information System 2000.* Urban Econ for DWAF, 2000.

6. *Alien Invading Plants and Water Resources in South Africa: A Preliminary Assessment*. Versveld, DB; Le Maitre, DC; and Chapman, RC. Water Research Commission, September 1998.

7. *The Impacts of Timber Plantations on Runoff in South Africa: A Handy Reference Manual*, Le Maitre, DC; Scott, DF; and Fairbanks, DHK. CSIR Stellenbosch, July 1, 1997.

8. *Preparation of Climate Data and Information for Application in Impact Studies of Climate Change over South Africa*: (Report to South African Country Studies for Climate Change Programme), School of Bioresources Engineering and Environmental Hydrology, University of Natal, Pietermartizburg, ACRUcons. Report 32 January 2000. Perks, LA; Schulze, RE; Kiker, GA; Horan, MJC; Maharaj, M.

9. *Assessment of the Impact of Climate Change on Hydrology and Water Resources in South Africa*: (Report to South African Country Studies for Climate Change Programme), School of Bioresources Engineering and Environmental Hydrology, University of Natal, Pietermartizburg, ACRUcons Report 33 January 2000. Schulze, RE; and Perks, LA.

10. *National Water Resource Quality Status Report: Inorganic Chemical Water Quality of Surface Water Resources in South Africa – The Big Picture;* Hohls, Silberbauer, Kühn, Kempster, van Ginkel; DWAF Report N/0000/REQ0801, April 2002.

11. *Assessment of the conservation priority status of South African estuaries for use in management and water allocation.* J K Turpie et al, Water SA Vol 28 No 2, April 2002.

12. **Reports on Overview of Water Resources Availability and Utilisation:**

12.1 Limpopo Water Management Area
Report No. P WMA 01/000/00/0203

12.2 Luvuvhu and Letaba Water Management Area
Report No. P WMA 02/000/00/0203

12.3 Crocodile (West) and Marico Water Management Area
Report No. P WMA 03/000/00/0203

12.4 Olifants Water Management Area
Report No. P WMA 04/000/00/0203

12.5 Inkomati Water Management Area
Report No. P WMA 05/000/00/0203

12.6 Usutu to Mhlatuze Water Management Area
Report No. P WMA 06/000/00/0203

12.7 Thukela Water Management Area
Report No. P WMA 07/000/00/0203

12.8 Upper Vaal Water Management Area
Report No. P WMA 08/000/00/0203

12.9 Middle Vaal Water Management Area
Report No. P WMA 09/000/00/0203

12.10 Lower Vaal Water Management Area
Report No. P WMA 10/000/00/0203

12.11 Mvoti and Umzimkulu Water Management Area
Report No. P WMA 11/000/00/0203

12.12 Mzimvubu to Keiskamma Water Management Area
Report No. P WMA 12/000/00/0203

12.13 Upper Orange Water Management Area
Report No. P WMA 13/000/00/0203

12.14 Lower Orange Water Management Area
Report No. P WMA 14/000/00/0203

12.15 Fish to Tsitsikamma Water Management Area
Report No. P WMA 15/000/00/0203

12.16 Gouritz Water Management Area
Report No. P WMA 16/000/00/0203

12.17 Olifants/Doorn Water Management Area
Report No. P WMA 17/000/00/0203

12.18 Breede Water Management Area
Report No. P WMA 18/000/00/0203

12.19 Berg Water Management Area
Report No. P WMA 19/000/00/0203

APPENDICES

APPENDIX 1 : URBAN WATER REQUIREMENTS (year 2000)

APPENDIX 2 : RURAL WATER REQUIREMENTS (year 2000)

APPENDIX 3 : IRRIGATION WATER REQUIREMENTS (year 2000)

APPENDIX 4 : FACTORS INFLUENCING RUNOFF AND YIELD (year 2000)

APPENDIX 5 : MAJOR DAMS DATA

APPENDIX 6 : DETAILS OF MAIN TRANSFERS (year 2000)

APPENDIX 1

Urban Water Requirements (year 2000) - WMA 9: Middle Vaal

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	%
Rhenoster-Vals	210 011	9.1	5.4	5.0	19.5	0.59	119	38
Middle Vaal	514 901	16.5	11.2	7.4	35.1	0.68	87	43
Sand-Vet	440 417	18.5	12.5	7.4	38.4	0.68	115	18
Total	**1 165 329**	**44.1**	**29.1**	**19.8**	**93.0**	**0.66**	**104**	**32**

APPENDIX 2

Rural Water Requirements (year 2000) - WMA 9: Middle Vaal

Sub-area	Rural population	Domestic	Stock watering	Total	Rural human per capita
		million m^3/a			ℓ/c/d
Rhenoster-Vals	69 990	0.6	7.6	8.2	25
Middle Vaal	141 872	1.3	11.8	13.1	25
Sand-Vet	151 852	1.4	9.3	10.7	25
Total	**363 714**	**3.3**	**28.7**	**32.0**	**25**

APPENDIX 3

Irrigation water requirements (year 2000) - WMA 9: Middle Vaal

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		%
Rhenoster-Vals	2 910	3 198	8 450	24.6	22.5	30.1	26.2	10.0
Middle Vaal	5 580	5 920	5 850	32.6	21.0	39.5	32.8	10.0
Sand-Vet	12 196	21 780	7 920	96.6	19.0	114.9	100.0	10.0
Total	**20 686**	**30 898**	**7 407**	**153.8**	**20.0**	**184.5**	**159.0**	**10.0**

APPENDIX 4

Factors influencing runoff and yield (year 2000) - WMA 9: Middle Vaal

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	
Rhenoster-Vals	295	35	0	162	0	0	0	0	0	0	0	0	0	2
Middle Vaal	170	29	144	6 753	1	0	0	0	0	0	0	0	80	5
Sand-Vet	423	45	0	154	0	0	0	0	0	0	0	0	0	7
Total	888	109	144	7 069	1	0	0	0	0	0	0	0	80	14

APPENDIX 5

Major dams data - WMA 9: Middle Vaal

Dam name	Quaternary catchment	River	Year completed	Purpose	Natural MAR million m^3/a	FSC million m^3
Allemanskraal	C42E	Sand	1960	Irrigation	96.1	179.3
Bloemhoek	C60D	Jordaan Spruit	1978	Domestic	104.2	19.6
Erfenis	C41E	Vet	1959	Irrigation	167.4	212.3
Johan Neser	C24G	Schoon	1915	Irrigation	87.7	5.7
Klipplaatdrift	C25A	Vaal	1972		4.2	5.7
Koppies	C70C	Renoster	1918	Irrigation	59.1	41.1
Marquard	C41A	Laai Spruit	1950	Domestic	42.4	2.3
Rietspruit	C24D	Schoonspruit	1955	Irrigation	36.0	7.3
Three Sisters	C42F	Sand	1967		18.9	1.2
Uniefees	C70C	Eland Spruit	1933	Domestic	59.1	1.4

APPENDIX 6

Details of main inter-WMA transfers (year 2000) - WMA 9: Middle Vaal

From quaternary	To quaternary	User group	Volume (million m^3/a)	Description
Transfers In				
C22F	C70C	Urban	0.9	Transfers from Vaal Dam to Heilbron
Total in			**0.9**	
Transfers Out				
C41G	C52G	Urban	2.3	Erfenis Dam to Brandfort TLC (Upper Orange WMA)
Total out			**2.3**	

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.

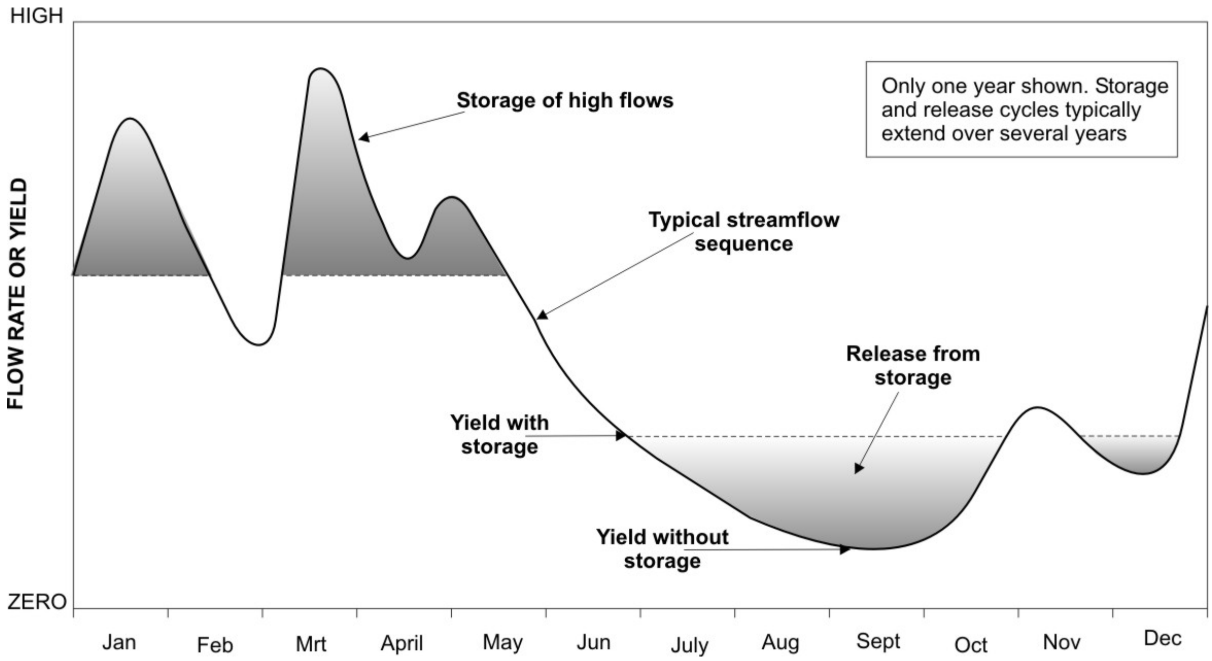
- **Total :** The total economically active population consists of those employed in the formal and informal sectors, and the unemployed.
- **Formal sector :** Includes employers, employees and self-employed who are registered taxpayers.
- **Informal sector :** Includes people who are employers, employees 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.