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PREFACE

This overview of the water resources availability and utilisation in the Upper Vaal 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 Vaal 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 VAAL
WATER MANAGEMENT AREA

OVERVIEW OF WATER RESOURCES AVAILABILITY AND UTILISATION

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UPPER VAAL WATER MANAGEMENT AREA

OVERVIEW OF WATER RESOURCES AVAILABILITY AND UTILISATION

1. GENERAL DESCRIPTION OF WATER MANAGEMENT AREA

1.1 Natural characteristics

The Upper Vaal water management area is located towards the centre of the country. It covers part of four provinces. The southern half of the water management area extends over the Free State, the north-east mainly falls within Mpumulanga, and the northern and western parts in Gauteng and North West respectively. Major rivers in the water management area are the Vaal and its tributary the Wilge River. Other tributaries of note are the Klip, Liebenbergsvlei, Waterval, Suikderbosrand and Mooi Rivers. The Upper Vaal is the uppermost water management area in the Vaal River catchment and one of five water management areas in the Orange River Basin, of which the Vaal River catchment forms a major component. It is surrounded by the Crocodile (West) and Marico, Olifants, Inkomati, Usutu to Mhlatuze, Thukela, Upper Orange and Middle Vaal water management areas, and adjoins Lesotho in the southern extreme. Refer to **Figure 1** for the location and general layout of the water management area.

Climate over the water management area is temperate and fairly uniform. Rainfall is strongly seasonal, with most rain occurring as thunderstorms during the summer period. Mean annual rainfall ranges between 600 mm and 800 mm per year over most of the water management area, with potential evaporation between 1 300 and 1 700 mm per year as shown in **Figure 2**. Frost occurs in winter, and occasional light snow on high lying areas. Vegetation is mostly savannah grassland, with sparse bushveld where conditions are favourable. The water management area is located on the central South African plateau, with a general roling topography. Main topographic features are the foothills of the Maluti Mountains in the South, the Drakensberg escarpment in the east and the Witwatersrand in the north. The geology is varied, and is particularly complex in the west and north-west where most of the mineral deposits are found, including some of the richest gold bearing ore in the world. Extensive dolomitic formations also occur in this part. Soils are arable over much of the water management area.

The Golden Gate National Park is located in the southern extreme of the water management area, while several other conservation areas are scattered throughout the water management area.

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1.2 Development

The discovery of gold by George Harrison on the farm Langlaagte near Johannesburg in 1886, was the single most influential event which impacted on the economic development of the region. Over time this reef yielded 48 000 tons: more than half of all the gold ever mined on earth. Further impetus was added through the occurrence of coal, which supported the development of six thermal power stations and later also petro-chemical industries at Sasolburg. From its early beginnings as a mining town, Johannesburg developed to the largest metropolitan area in South Africa, and the northern region of the Upper Vaal water management area together with the southern region of the Crocodile (West) and Marico water management area is regarded as the economic hub of South Africa.

Land use in the water management area is characterised by the sprawling urban and industrial areas, in the northern and western parts, together with mining of which much is now inactive, and the large areas under dry land cultivation occurring mainly in the central and south-western parts where maize, wheat and other annual crops are grown. No afforestation occurs in the water management area, which mostly remain under natural vegetation for livestock farming, as reflected in **Figure 3**. There are several large towns in the water management area, mainly to serve mining and agricultural development.

1.3 International

The Upper Vaal water management area does not directly share any rivers with neighbouring countries. Large quantities of water are, however, transferred into the water management area from Lesotho, in accordance with the Treaty between South Africa and Lesotho on the Lesotho Highlands Water Project. Through intercatchment transfers to and from neighbouring water management areas as well as the control of releases along the Vaal River, water management in the Upper Vaal water management area eventually also impacts on all the neighbouring countries to South Africa (Lesotho, Namibia, Botswana, Zimbabwe, Mozambique and Swaziland).

1.4 Sub-areas

Large spatial variation in climate, water availability, levels and nature of economic development, population density as well as potential for development and growth are typical of South Africa. Whilst the climate is relatively uniform over the Upper Vaal water management area, variation in other characteristics are evident, some of which manifest over relatively short distances.

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 :

- Wilge sub-area, which corresponds to the catchment of the Wilge River to its confluence with the Vaal River.
- The sub-area “upstream of Vaal Dam”, which corresponds to the portion of the Vaal River catchment upstream of Vaal Dam.
- The sub-area “Downstream of Vaal Dam”, which comprises the portion of the Vaal River catchment between Vaal Dam and the confluence of the Mooi River with the Vaal River, at the downstream border of the water management area.

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2. NATIONAL PERSPECTIVE

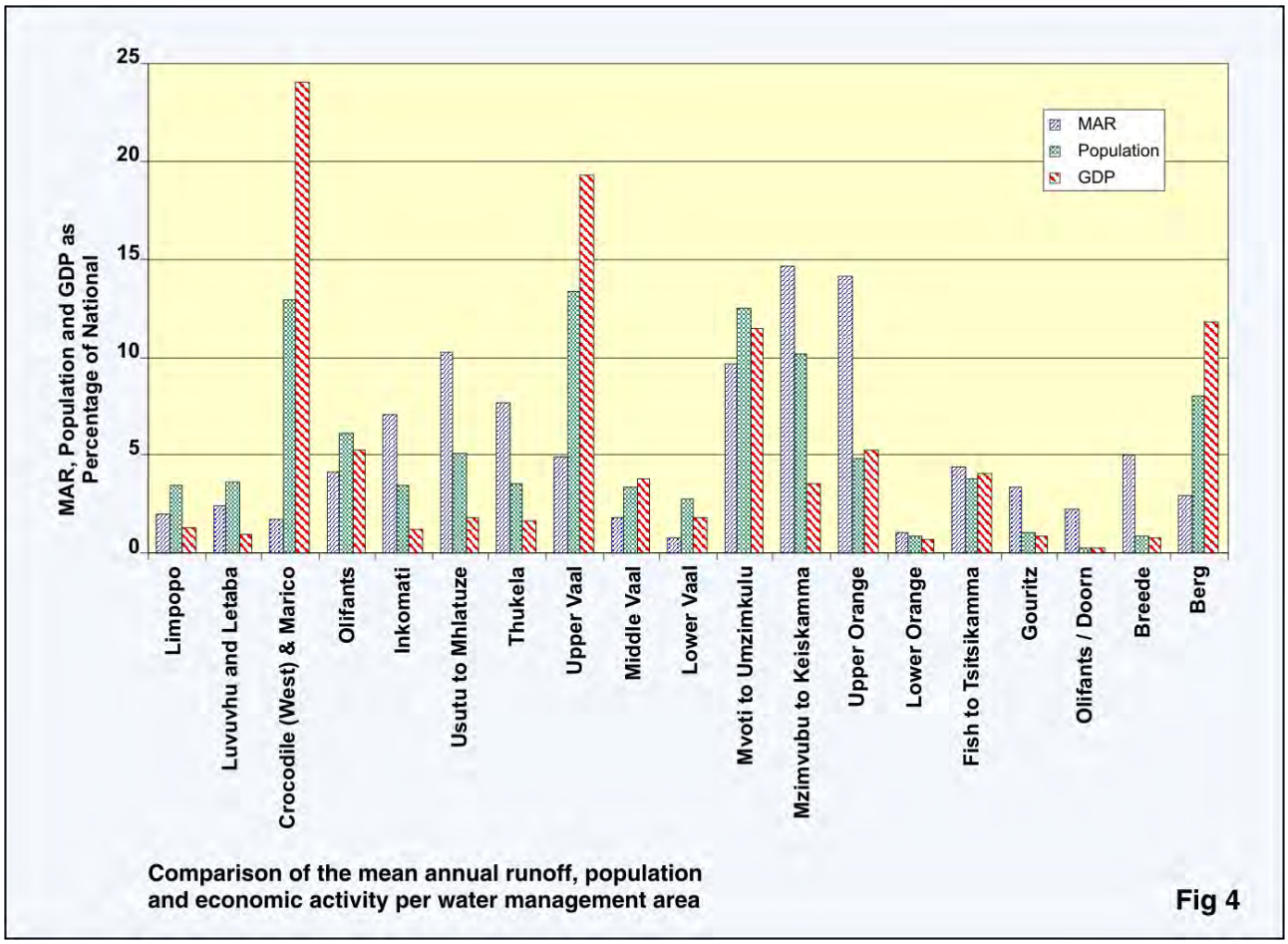
South Africa is located in a predominantly semi-arid part of the world. The climate varies from desert and semi-desert in the west to sub-humid along the eastern coastal area, with an average rainfall for the country of about 450 mm per year, well below the world average of about 860 mm per year, while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

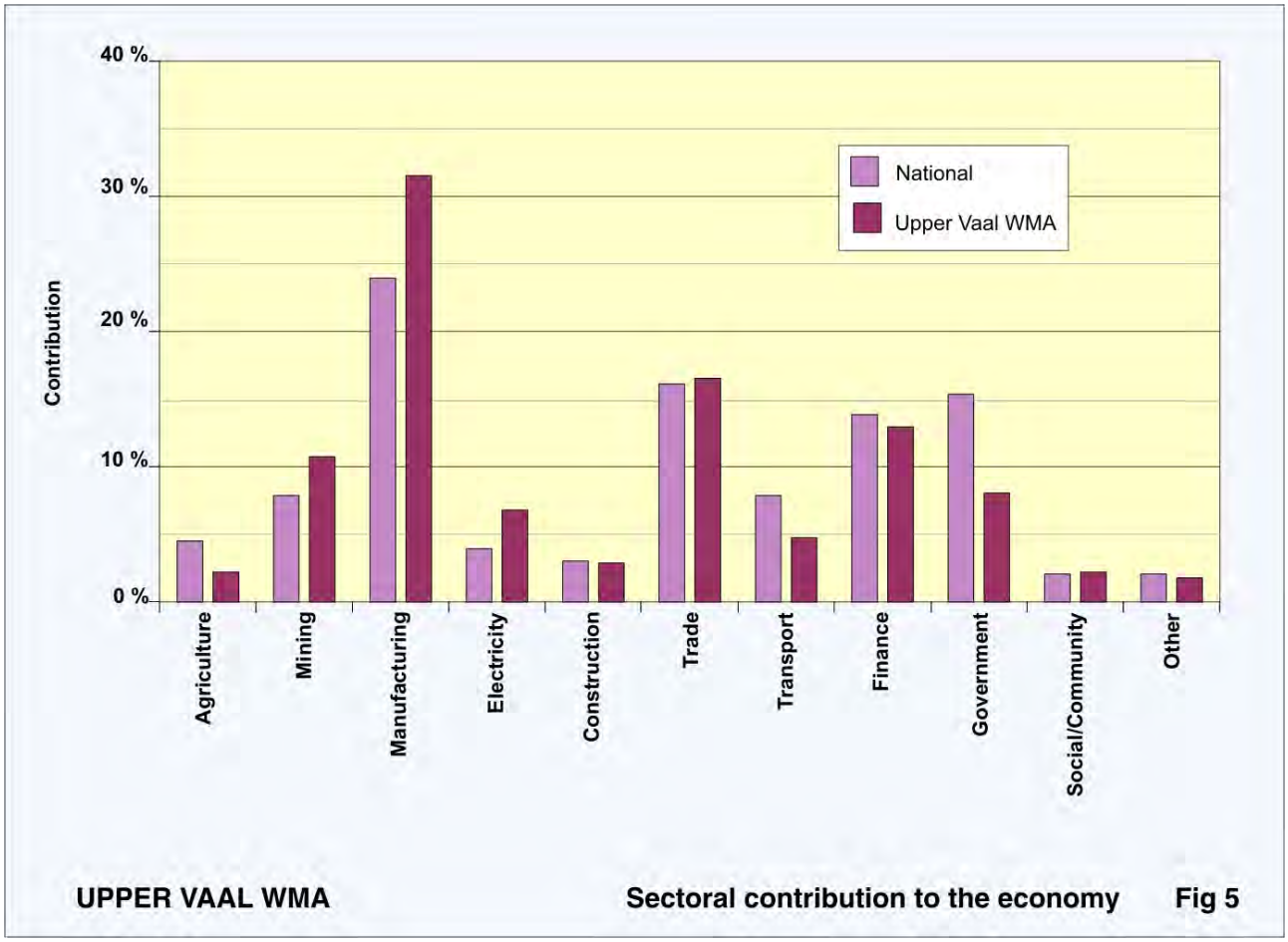
Whereas attention in the past was mainly focussed on the development of new resources as the requirements for water increased, partly as large unused potential was still available, the efficiency of water use has not developed to the same level of sophistication as resource management. With the current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

Nearly 20% of the Gross Domestic Product (GDP) of South Africa originates from the Upper Vaal water management area, which is the second largest contribution to the national wealth amongst all the water management areas. The composition of the economy in the Upper 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. This reflects a well diversified economy with a strong industrial and financial base. The largest economic sectors (in 1997) in the water management area, in terms of GGP, were:

- Manufacturing 31,6%
- Trade 16,6%
- Financial services 12,9%
- Mining 10,8%



The manufacturing sector in the water management area shows strong linkages with primary sector activities such as mining and agriculture. In the northern Free State and southern Mpumalanga, manufacturing is largely concentrated on petro-chemical products, much of which are related to the coal deposits in the region, with the SASOL fuel from coal plants at Sasolburg and Secunda of specific importance. The most dominant manufacturing activities in the southern Gauteng area relate to basic metal industries and the manufacturing of chemical, plastic and pharmaceutical products. The importance of these products can be attributed to the presence of large key industries such as AECI and Iscor.

The importance of the trade sector can be attributed to the fact the Gauteng is the major trade centre in South Africa and forms the core for numerous new trade related developments. Due to the presence of large numbers of financial and business service institutions and head offices in Gauteng, this sector plays an important role in the Upper Vaal Region.

The continued importance of the mining sector can be attributed to the coalfields in the northern parts and gold mining in the north-west of the water management area. Although the gold ore has been depleted in parts of the water management area, the largest un-mined gold reserve in South Africa occurs near Westonaria, with significant deposits also found at Carltonville and Randfontein. The increasing depth of gold mining, however, limits the economic viability of mining lower grade ore.

Despite the large areas under cultivation, agriculture only contributes about 2% of the GGP generated in the water management area. It has important linkages to other sectors, however, and provides livelihood to a large proportion of the rural population.

Of the total work force of 2,2 million people in the water management area in 1994, 56% were active in the formal economy, 31% were unemployed, with the remaining 13% in the informal economy. Of those formally employed, 28% were in the government sector, 23% in manufacturing and 14% in trade.

Attributed to an existing strong, and well integrated diversified economy together with its linkages and favourable with respect to economic activities in the broader region, potential for future economic growth in the Upper Vaal water management area remains strong. In particular, the economy in the water management area is relatively more competitive than the remainder of South Africa in the mining, manufacturing and electricity sectors. Growth will therefore largely be attracted to the already strong urban and industrial areas in the Johannesburg-Vereeniging-Vanderbijlpark complex. Potential for growth also exists at the petro-chemical developments, with little change expected elsewhere. New mining developments will mainly replace worked out mines, with a long term decline expected in this sector.

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 Vaal water management area is captured below.

The Upper Vaal is the most populous water management area in the country, which closely relates to the large proportionate contribution to the national economy. More than 80% of the population in the water management area reside in the sub-area downstream of Vaal Dam, nearly 97% of whom live in an urban environment. Of the total population in the water management area, 90% are classified as urban and 10% as rural, which mirrors the dominance of the urbanised sectors in the economy. Population density in the rural parts of the water management area is moderate to sparse.

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 (as shown in **Figure 6**) therefore are for continued strong growth in urban population in the sub-area downstream of Vaal Dam where most of the economic activity in the water management area is centred. A small growth in population is foreseen in the sub-area upstream of Vaal Dam, which is expected to stabilise by 2010. In contrast, a sharp decline in population is projected for the Wilge sub-area. This is mainly attributable to the expected migration of people out of Phuthaditjaba and the former Qwa Qwa area in the southern extreme of the water management area, as a result of the decentralisation policy and supporting incentives of the previous government not being in effect any longer.

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4. WATER REQUIREMENTS

4.1 Current requirements (year 2000)

Reflecting the predominantly industrialised nature of the economy in the water management area, 80% of the requirements for water is by the urban, industrial and mining sectors; with 9% for irrigation, 7% for power generation and the remainder for rural water supplies. Geographically, over 75% of the total requirements for water is in the sub-area downstream of Vaal Dam and nearly 20% in the sub-area upstream of Vaal Dam, which again corresponds to the concentration of development and economic activity in these regions. Most of the irrigation in the water management area is in the sub-area downstream of Vaal Dam, with a large proportion of the irrigation water supplied from urban return flows and from dolomitic aquifers (as groundwater or surface flow). 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.

Evident from Figure 7 are the large quantities of water transferred out of the water management area, and which are largely destined for urban, industrial and mining use as well as for power generation in neighbouring water management areas. (Described in more detail in 6.1.)

In the Wilge sub-area, more than half of the water requirements is for urban use (mainly at Bethlehem, Harrismith and Phuthaditjhaba), with the remainder split between rural use (domestic and livestock) and irrigation. Most of the water requirements in the sub-area upstream of Vaal Dam is for mining and bulk industrial use (coal mines and the Sasol petro-chemical complex), with substantial portions also for urban use and power generation. Downstream of Vaal Dam the urban requirements for water are dominant and, although proportionately small, large quantities are also used for mining and large industries as well as irrigation and power generation.

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. Nearly 50% of the urban water use in the sub-area downstream of Vaal Dam is re-used in this way, much of which via the Barrage. Effluent from smaller towns typically evaporates from maturation ponds, or may be absorbed by irrigation and infiltration.

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 urban distribution systems. Similar information with respect to irrigation is contained in Appendix 3.

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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
Wilge	18	27	15	0	0	0	60	0	60
Upstream of Vaal Dam	29	32	17	99	39	0	216	67	283
Downstream of Vaal Dam	67	576	11	74	41	0	769	1 343	2 112
Total	114	635	43	173	80	0	1 045	1 379	2 424

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 generally is available for other uses as well.)
4) Quantities given refer to impact on yield only.

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 Vaal water management area are for continued concentration of economic development in the Johannesburg-Vereeniging-Vanderbijlpark area and increasing urbanisation of the population. A strong growth in water requirements can therefore be expected in the sub-area downstream of Vaal Dam. As a result of similar growth in the urban and industrial requirements for water in the Crocodile (West) and Marico water management area, which is to a large extent dependent on water from the Upper Vaal water management area, large quantities of additional water will in future have to be transferred to the Crocodile (West) and Marico water management area. Additional water will also be required in the sub-area upstream of Vaal Dam, related to growth at the petro-chemical industries and increasing generation of power in the region.

Apart from some decline at Phuthaditjhaba, no meaningful change in the requirements for water is foreseen in Wilge sub-area and the rural parts in the other sub-areas.

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
Wilge	18	25	13	0	0	0	56	0	56
Upstream of Vaal Dam	29	36	17	99	75	0	256	74	330
Downstream of Vaal Dam	67	763	10	74	43	0	957	1 561	2 518
Total	114	824	40	173	118	0	1 269	1 634	2 903

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 generally is 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
Wilge	18	47	13	0	0	0	78	0	78
Upstream of Vaal Dam	29	52	17	99	75	0	272	74	346
Downstream of Vaal Dam	67	1,197	10	74	43	0	1 391	2 067	3 458
Total	114	1 296	40	173	118	0	1 741	2 140	3 881

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 generally is available for other uses as well.)
4) Quantities given refer to impact on yield only.

5. WATER RESOURCES

5.1 Surface Water

The largest proportion (46%) of the surface flow in the water management area is contributed by the Vaal River upstream of Vaal Dam, together with its main tributary the Klip River. The Wilge River and the Liebenbergsvlei River contribute 36%, with the remaining 18% originating from the tributaries downstream of Vaal Dam. About 83% of the surface water yield is realised at Vaal Dam, which closely corresponds to the proportionate runoff to this point. There are no natural lakes in the water management area. (One of the largest natural lakes in South Africa, Chrissiesmeer, lies in an endoreic area in the Usutu to Mhlatuze water management area, on the divide between the Komati, Usutu and Vaal Rivers.) Important wetlands occur along the Klip River, with several vlei areas elsewhere in the water management area. The main land use impacts are relatively large increases in runoff due to impermeable surfaces in urbanised areas, as well as reductions in runoff due to infestations by alien vegetation. No significant afforestation occurs in the water management area. Numerous farm dams have also been built in the catchment of Vaal Dam, which negatively impact on the inflow to Vaal Dam. A summary of the natural mean annual runoff (MAR), together with 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.

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.

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

Sub-area	Natural MAR (1)	Ecological Reserve (1, 2)
Wilge	868	116
Upstream of Vaal Dam	1 109	126
Downstream of Vaal Dam	446	57
Total	2 423	299

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.

Naturally the quality of surface water in the water management area is good, particularly in those streams in the north-western parts which receive outflow from the dolomitic aquifers in the region. However, the large quantities of urban and industrial effluent, together with urban wash-off and mine pumpage, have a major impact on the water quality in some tributary rivers in the north western part of the water management area (e.g. Waterval, Blesbokspruit, Natalspruit, Klip) and particularly on the Vaal River downstream of Vaal Dam. The Waterval River, for example, contributes 2% of the water reaching the Vaal Dam, but that 2% carries 12% of the pollution that reaches the dam. Similar situations also apply to some of the other tributaries. The built-up of salinity in the Barrage is of particular importance and salinity concentrations in the water body need to be carefully managed to ensure that usability of the water is maintained. Atmospheric pollution is also prevalent over parts of the water management area and contributes to the pollution of surface water resources.

The surface water naturally occurring in the water management area has been well developed through the construction of several large dams, and only limited potential for further development remains. The main storage dams, for which more detail sare given in Appendix 5, are:

- Grootdraai Dam on the Vaal River upstream of Vaal Dam.

- Sterkfontein and Fika Patso Dams in the Wilge River catchment and Saulspoort on the Liebenbergvlei River, in the Wilge sub-area. Sterkfontein Dam is one of the largest dams in the country, and serves as a holding dam for water transferred from the Thukela water management area to the Vaal River System.

- The Vaal Barrage as well as Klerkskraal, Boskop and Klipdrif Dams in the sub-area downstream of Vaal Dam.

In addition, large quantities of water are transferred into the water management area to augment the local resources. The total yield transferred into the Upper Vaal water management area amounts to the equivalent of more than 120% of the yield from local surface resources, while virtually the same quantity is again transferred (or released) out of the water management area. Transfers into the Upper Vaal water management area are from the Usutu to Mhlatuze and Thukela water management areas as well as from the Senqu (Orange) River in Lesotho. The water transferred from other water management areas is generally of good quality and lowers the salinity and turbidly of water in Vaal Dam. Transfers out of the water management area are to the Crocodile (West) and Marico, and Olifants water management areas, and through releases along the Vaal River to the Middle Vaal and Lower Vaal water management areas. More details on the existing transfers are given in Appendix 6.

From a water management perspective, the Upper Vaal water management area is in a pivotal position in the country. Through the extensive transfers of water into and out of the

water management area, water management in the Upper Vaal water management area impacts on flow volume, flow regime and water quality in all the surrounding water management areas and Lesotho, with secondary impacts on other water management areas as well as the other neighbouring countries to South Africa.

Several options for the possible further development of surface resources have been investigated, with a dam on the Klip River to augment supplies to users from Grootdraai Dam regarded as the only option feasible for development.

5.2 Groundwater

An important feature with regard to the groundwater resources of the Upper Vaal water management area, is the large dolomitic aquifers which extend across the north-western part of the water management area. Much of the water in the Mooi River, which is known for its strong base flow, originates as springflow from these aquifers. Large quantities of water are also abstracted through pumping for urban use (such as by Rand Water) and for irrigation. As a result of the direct connections between the dolomitic aquifers and surface streams, the resources are in balance and increases in groundwater abstraction will result in corresponding decreases in surface flow. Lowering of spring flow can also result in the formation of sink holes.

Extensive de-watering of dolomitic compartments for mining purposes, has taken place in the north-west of the water management area where gold ore underlies dolomitic formations. This resulted in temporary increases in surface flow while water tables were being lowered. Reductions in surface flow which may last several years, will be experienced when mine pumping is stopped and the compartments are allowed to fill again.

The remainder of the water management area are mainly underlain by fractured rock aquifers, which are well utilised for rural domestic water supplies and stock watering, with little undeveloped potential remaining. Although of specific importance in some areas, only 3% of the total water requirements in the water management area are supplied from groundwater.

The quality of groundwater is generally of a very high standard. Due to chemical reaction when groundwater infiltrates into mine caverns, poor quality water often results which can cause serious pollution when water spills or leaks from such mines.

5.3 Summary

The total water available for use in the Upper Vaal 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 water transfers into the water management area. In total, over 45% of the current available water in the water management area is supplied through transfers from other water management areas and Lesotho (refer to Section 6 for more detail). Also noticeable is the re-use of return flows which constitute 16% of the available water, with the remainder being supplied from surface and groundwater resources naturally occurring in the water management area.

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			
Wilge	46	4	2	7	0	59	0	59
Upstream of Vaal Dam	154	8	3	11	8	184	118	302
Downstream of Vaal Dam	399	20	7	325	138	889	1 224	2 113
Total	599	32	12	343	146	1 132	1 310	2 442

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

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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)
Wilge	59	0	59	60	0	60	(1)
Upstream of Vaal Dam	184	118	302	216	67	283	19
Downstream of Vaal Dam	889	1 224	2 113	769	1 343	2 112	1
Total	1 132	1 311	2 443	1 045	1 379	2 424	19

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 surplus shown for the sub-area upstream of Vaal Dam is attributable to the assumption that all transfers into the water management are operated at their full capacity, and that any surplus is shown at the most upstream point where the water could be made available (in this case at Grootdraai Dam). In practice, however, only the quantities of water actually required, are transferred. (For simplicity, the transfers from Lesotho and from the Upper Thukela River are shown to be received in the sub-area downstream of Vaal Dam, where the water is actually used, or again transferred from.) The sub-area downstream of Vaal Dam is therefore approximately in balance.

The marginal deficit shown with respect the Wilge sub-area is attributable to the provision made for the Reserve, which is still to be implemented. Without the provisions for the Reserve, a small surplus exists in this sub-area.

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

management area have been increased to reflect the additional yield available from the commissioning of Mohale Dam in Lesotho. The increased need for transfers out of the sub-area upstream of Vaal Dam is to meet the growing water requirements for power generation in the Olifants water management area, while increased transfers are required from the sub-area downstream of Vaal Dam to augment supplies to the Pretoria-Johannesburg metropolitan area, in the Crocodile (West) to Marico water management area. (Reference may also be made to the corresponding reports on the Crocodile (West) and Marico, and Olifants water management areas.)

In concert with the economic and demographic scenarios, most of the growth in the water management area is expected to be in the urban and industrial parts of the water management area, mainly in the Johannesburg-Vereeniging-Vanderbijlpark area. Growth is also foreseen in the sub-area upstream of Vaal Dam, mainly with respect to industrial development and power generation.

No dramatic change in water requirements is foreseen in the Wilge sub-area. Growth in this part of the water management area is likely to be concentrated around the main towns of Bethlehem and Harrismith, with a decline expected at Phuthaditjhaba.

Compared to the natural mean annual runoff of 2 423 million m^3 per year which originates from the Upper Vaal water management area, an estimated 2 216 million m^3 per year still flows out of the water management area towards the Middle Vaal water management area.

CLICK TO VIEW GRAPHIC

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)
Wilge	58	0	58	56	0	56	2	0
Upstream of Vaal Dam	184	118	302	256	74	330	(28)	50
Downstream of Vaal Dam	987	1 513	2 500	957	1 561	2 518	(18)	0
Total	1 229	1 630	2 859	1 269	1 634	2 903	(44)	50

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.
4) Based on the construction of Klip River Dam.

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)
Wilge	64	0	64	78	0	78	(14)	0
Upstream of Vaal Dam	190	118	308	272	74	346	(38)	50
Downstream of Vaal Dam	1 232	1 513	2 745	1 391	2 067	3 458	(713)	0
Total	1 486	1 630	3 116	1 741	2 140	3 881	(765)	50

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 highgrowth 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.
4) Based on the construction of Klip River Dam.

6.2 Key issues

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

- The high degree to which the water resources naturally occurring in the water management area has been developed, and the already full utilisation of these resources. Only limited potential for further water resource development exists.

- Continued strong growth expected in the Greater Johannesburg area and surrounds, which is one of the key growth areas in the country, with accompanying increases in water requirements.

- Increasing requirements for water for industrial purposes and power generation in the sub-area upstream of Vaal Dam, where the yield available from Grootdraai Dam will shortly be fully taken up.

- The strong dependence of the Upper Vaal water management area on water transfers from other water management areas as well as from Lesotho. Surplus capacity currently exists, which will be increased with the commissioning of Mohale Dam. It may also be necessary for some transfer capacities to be reduced as a result of implementation of the Reserve in the source catchments (eg. Upper Usutu).

- Large dependence of other water management areas on transfers and releases from the Upper Vaal water management area.

- The re-use of return flows, together with the management of water quality in the Barrage and lower reaches of the Vaal River.
- Impacts of mine closure on water quality and possibly on surface flows.

- The highly regulated nature of the Vaal River from Grootdraai Dam downstream, and the relevance thereof to the ecological requirements for water.

6.3 Strategic perspectives

The Upper Vaal water management area is highly developed and impacted upon by man. From a water resource perspective, it is probably the most strategic and pivotal water management area in the country. Through the extensive transfers of water into and out of the water management area, water resource management in the Upper Vaal water management area impacts on water balances in 12 water management areas and at all the neighbouring countries. It is evident that water resource management in the Upper Vaal water management should be well co-ordinated with other inter-dependent water management areas, and be viewed in an integrated systems context. Impacts on water resources in other water management areas as well as with respect to neighbouring

countries (mostly indirectly) as a result of inter-catchment transfers, should be of primary consideration. Management of water resources in the water management area should also be within the framework of the recently founded Orange-Senqu River Commission (ORASECOM) by South Africa, Lesotho, Botswana and Namibia.

Strategic perspectives on the main interventions and options with respect to the future availability and optimal utilisation of water in the Upper 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.

Sub-area downstream of Vaal Dam

The effective implementation of water demand management is a standard prerequisite, before resorting to further resource development and transfers. Good progress has already been made in this respect, and further implementation should receive continued priority, irrespective of the current surplus supply capacity. Given the high growth rates projected for the area, and the already high degree of development and utilisation of resources in the water management area together with the extensive re-use of effluent, additional water will have to be transferred in the Upper Vaal water management area in future. Surplus transfer capacities are to be reserved for high benefit uses such as urban and industrial use and for power generation, and should not be used for irrigation. Options for further large scale transfers of water into the water management area are from the Thukela water management area as well as from the Orange River (through further development of the Lesotho Highlands Water Project or direct transfers from the Upper Orange water management area).

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, using the latest assessments of the system yield and without accounting for transfers from the Lesotho Highlands Water project. This would then form the basis for future allocation of water. A programme should be set up for monitoring growth in water requirements as well as to better assess the factors influencing water requirements by different user sectors. Particular attention need to be given to the consumptiveness of use, to enable better assessment of the impacts of growth and of demand management on the future quantities of return flows.

Water quality is of specific importance in several rivers and streams in the water management area, and needs to be carefully managed. Options to increase the re-use of effluent should also be investigated which, in addition to blending of waters, may require some degree of desalination. Particular attention is also to be given to the impacts that closure of mines may have on both surface and groundwater.

Sub-area upstream of Vaal Dam

As a result of growth in the water requirements by Eskom for power generation, for which water also need to be transferred to the Olifants water management area, together with further growth surrounding the petro-chemical industries, it is expected that water requirements in this sub-area will exceed the available resources within the near future. Recent investigations showed the construction of a new dam on the Klip River as possibly the best option for additional supplies to this sub-area.

Implementation of the Reserve in the Upper Usutu River catchment and the Thukela River catchment, may also impact on the water available for transfer from these catchments to the Grootdraai Dam. Remedial measures may therefore be required, such as the re-allocation (or purchase) of water from existing uses, also in the neighbouring water management areas. (Refer to the Usustu to Mhlatuze and Thukela reports, references 12.6 and 12.7.)

Wilge sub-area

No meaningful change is foreseen with respect to water requirements in the rural areas. Growth in urban and industrial requirements for water, such as at Bethlehem and Harrismith should be supplied through water demand management and from local resources. Re-allocation of water may have to be considered. As a further option, some of the water transferred into the Upper Vaal water management area in the proximity of these towns, may be resorted to.

The expected migration of people out of the former QwaQwa area needs to be addressed in the catchment management strategy and options be investigated to provide alternative opportunities for people in the area.

6.4 Transfers and reservation of water

The transfer of water between water management areas and arrangements with neighbouring countries resort under national control. The following reservations need to be made with respect to water for transfer into and out of the Upper Vaal water management area, including provisions for future growth:

- The existing transfer of 491 million m³ per year from Lesotho, which is to be increased to 835 million m³ per year after the commissioning of Mohale Dam in Lesotho – Reserved by international agreement for use in and transfer from the Upper Vaal water management area.

  (After allowance for transfer losses of 7% en route, the volumes received in the Upper Vaal water management area are 457 million m^3 per year and 777 million m^3 per year respectively.)

- Existing transfers from the Thukela water management area up to the installed capacity of 630 million m³ per year. (Yield benefit in Vaal System is 736 million m³ per year.) – Reserved in the Thukela water management area.

- Future large scale water resources development on the Thukela River also reserved inter alia for transfer to the Upper Vaal water management area. Current planning is for an additional transfer of 475 million m^3 per year. – Reserved in the Thukela water management area.

- Existing transfer of 55 million m^3 per year from the Buffalo River in the Thukela water management area to the Upper Vaal water management area – Reserved in the Thukela water management area.

- Transfers from the Usutu to Mhlatuze water management area at the current capacity of 63 million m³ per year – Reserved in the Usustu to Mhlatuze water management area.

- Existing transfers from the Upper Vaal water management area to the Olifants water management area of 36 million m³ per year for power generation, plus an allowance of 38 million m^3 per year for future growth. (The latter included in Tables 7 and 8.)

- Transfers from the Upper Vaal water management area through the Rand Water distribution system to meet requirements in the Crocodile (West) and Marico water management area which are in excess of the capacity of the local resources in the Crocodile (West) and Marico water management area. This currently this amounts to 514 million m³ per year and is projected to increase to 723 million m³ per year. As an upper high growth scenario, the transfers may need to increase to 1 125 million m³ per year. (Included in Tables 7 and 8.) – Reserved in the Upper Vaal water management area.

- Releases from the Upper Vaal water management area along the Vaal River to users in the Middle Vaal and Lower Vaal water management areas, to meet their realistic needs which cannot be supplied from own resources. Little change is expected from the current transfer of 828 million m³ per year, although it may increase to about 910 million m^3 per year in 2025 under the high growth scenario – Reserved in the Upper Vaal water management area.

- Current surplus transfer capacity into the Upper Vaal water management area is to be reserved for growth in urban, industrial and mining water requirements in the Upper Vaal and Crocodile (West) and Marico water management areas, and is not to be used for commercial irrigation.

- The allocation of surplus yield in the Upper Vaal water management area will be subject to national authorisation as it can be allocated to users in the Upper, Middle, Lower Vaal as well as Crocodile (West) and Marico water management areas.

- The Upper Vaal water management area forms the central component of the Vaal River System, which extends over several water management areas. As water resources management in the Vaal River System impacts to some degree on the water quantity

and quality in all the interlinked water management areas, management of the Vaal River System is to be controlled at a national level.

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Report No. P WMA03000/00/0203

12.4 Olifants Water Management Area
Report No. P WMA04000/00/0203

12.5 Inkomati Water Management Area
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12.6 Usutu to Mhlatuze Water Management Area
Report No. P WMA06000/00/0203

12.7 Thukela Water Management Area
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12.8 Upper Vaal Water Management Area
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12.18 Breede Water Management Area
Report No. P WMA18000/00/0203

12.19 Berg Water Management Area
Report No. P WMA19000/00/0203

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)

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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

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