



water affairs

Department:
Water Affairs
REPUBLIC OF SOUTH AFRICA

REPORT NO: P RSA 000/00/12610



Assessment of the Ultimate Potential and Future Marginal Cost of Water Resources in South Africa

SEPTEMBER 2010

Title: *Assessment of the ultimate potential and future marginal cost of water resources in South Africa*

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DWA Report No: *P RSA 000/00/12610*

Status of Report: *Final*

PSP Report No: *J01330-12*

First Issue: *June 2010*

Final Issue: *September 2010*

PROFESSIONAL SERVICE PROVIDER

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ASSESSMENT OF THE ULTIMATE POTENTIAL AND FUTURE MARGINAL COST OF WATER RESOURCES IN SOUTH AFRICA

EXECUTIVE SUMMARY

South Africa is rapidly approaching the full utilisation of its fresh water resources and most of the remaining potential has already been committed to be developed. With the continued population and economic growth as well as industrialisation in South Africa, the requirements for water also keep on increasing, in many cases to well beyond the potential of the fresh water resources that could serve specific geographic areas. In particular, large quantities of water will in future be required for urban/industrial growth, power generation and mining developments, and mostly in locations distant from the large remaining fresh water resources.

This report assesses the remaining potential for water resource development in South Africa as well as means to extend the utility of the resources, all with associated costs and estimated energy requirements. Scenarios are developed on how the future requirements for water and the potential ability of water resources could be reconciled.

It is foreseen that the report should serve as background to spatial and sectoral development planning on a national scale to, amongst others, determine the most appropriate parameters and locations for large future developments. It should also serve as background towards achieving the most beneficial allocation and sectoral use of water.

The report is focussed on the key growth areas in the country, which comprise the main urban and metropolitan areas as well as areas of high potential for exploitation of mineral resources.

It is concluded that sufficient water can be made available to meet the future needs in all the major urban and industrial centres in South Africa, although at steeply increasing costs in most cases. The full utilisation of fresh water will also not be reached at a common date throughout the country, but at different dates over an extended period of time, depending on the situation pertaining to the respective areas. Water resources across the country will become even more inter-connected and inter-dependent in future.

Sufficient water can be made available to the Vaal River system supply area (Gauteng) at reasonable cost until about 2050, also to the KwaZulu-Natal coastal metropolitan areas to beyond 2050. Similar perspectives apply to the Amatole, Outeniqua and Mhlatuze areas. Most of the projected potential water requirements for the mining, energy and petrochemical developments in the Lephalale area can be supplied from the Crocodile West and Vaal river systems at reasonable cost. The greater Cape Town area, however, is likely to become totally dependent on the desalination of seawater and the re-use of water for any growth in water requirements from about 2030.

The most critical situation is with respect to the Olifants River system where a deficit already exists. This will be dramatically exacerbated with the implementation of releases for the Reserve, thus requiring the large scale augmentation of resources from the Vaal River System at substantial cost.

Comparisons of the indicative future costs of water to the economic value of water indicate that the unit cost of water from some new developments will substantially exceed the economic value of some existing water uses. Although the URVs and economic values are based on different financial and economic approaches and are not intended to be directly comparable, they at least provide a broad indication of the relative costs and economic values/benefits. The re-allocation of water could therefore offer a feasible alternative to some new resource developments and augmentation schemes.

It is also evident from the report that large financial investments will be required to secure the future water resource situation in South Africa.

Key recommendations that flow from the findings of the report are:

- *Long term financial planning should be conducted to provide for the large capital investments in water resource developments together with the relevant operating and maintenance costs that will be needed during the coming decades.*
- *The implementation of projects needs to be expedited and decision-making streamlined to prevent further backlogs from developing.*
- *The practical aspects relating to the implementation of the Reserve should be further investigated and clear guidelines – also on the application of Compulsory Licensing – should be developed as a priority.*
- *Continued monitoring and assessment of developments and of water requirements (as is being done).*
- *Specific attention needs to be given to remain abreast with technological developments and trends on climate change.*
- *Further studies need to be conducted into the value of water in different sectors and uses, to inform the possible re-allocation of resources. Social, political and strategic aspects should be considered together with the economic value of water, to ensure that all are properly accounted for.*
- *Following on the latter point above, a national strategy should be developed on the preferential utilisation of the country's water resources. This should also include guidelines on what products should preferably be produced/grown in South Africa, and what products could or should rather be imported and thereby saving large quantities of precious water in South Africa, without imposing any unwarranted risks.*

ASSESSMENT OF THE ULTIMATE POTENTIAL AND FUTURE MARGINAL COST OF WATER RESOURCES IN SOUTH AFRICA

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1 INTRODUCTION

1.1 Background

South Africa is rapidly approaching the full utilisation of its fresh water resources and most of the remaining potential has already been committed to be developed. With the continued population and economic growth as well as industrialisation in South Africa, the requirements for water also keep on increasing, in many cases to well beyond the potential of the fresh water resources that could serve specific geographic areas. In particular, large quantities of water will in future be required for urban/industrial growth, power generation and mining developments, and mostly in locations distant from the relatively large remaining fresh water resources.

It is imperative, therefore, that strategies be developed on how the future requirements for and availability of water could be reconciled at various locations in the country. Such strategies should be based on proper assessments of the remaining potential for water resource development as well as means to extend the utility of the resources, all with associated costs, together with sound estimates of the future requirements for water. These should then serve as background to spatial and sectoral development planning on the national scale to, amongst others, determine the most appropriate parameters and locations for large future developments. It would also serve as background towards achieving the most beneficial allocation and sectoral use of water.

1.2 Purpose of the report

The purpose of this report is to give a first order overview of the future water resources and water balance situation in South Africa, which should serve as input to national strategic spatial and sectoral development planning.

The report provides a clear perspective on the water resources and future water requirements, and scenarios on how these could be reconciled, for various key areas in the country. It specifically addresses the remaining options for water resources development together with an assessment of the ultimate water resources potential. It also addresses the time lines and costs associated with the various possible interventions. A concise perspective is given on the economic value of water in comparison to the cost of securing additional resources.

1.3 Study area

The report addresses the whole of South Africa. Due to the intent of providing a future perspective, however, the focus necessarily had to be on the key growth areas in the country, which comprise the main urban and metropolitan areas as well as areas of high potential for exploitation of mineral resources. The distinctive areas are as listed below:

- **Vaal River System** supply area which includes virtually all of the urban, industrial and mining developments in Gauteng as well as in parts of the Mpumalanga and the North-West Provinces. It also includes the water supplies to the Eskom power stations in Mpumalanga and the Free State.

- **Orange River System** which supplies water to the irrigation developments along the lower Orange River, including in Namibia, as well as the Fish-Sundays irrigation areas and to Port Elizabeth in the Algoa area. The Orange River System is integrally linked to the Vaal River System by means of the Lesotho Highlands Water Project as well as through the natural confluence of the two rivers.
- **Lephalale Area** in the north-west of the Limpopo Province, where several large new coal-fired power stations and petrochemical industries are planned to be located, together with the accompanying mining developments. (It was decided to focus on the Lephalale area rather than the Crocodile West system, as much of the pressure on the Crocodile West system is as a result of developments in the Lephalale area. Also, growth in water requirements in the Crocodile West catchment is essentially provided for by transfers from the Vaal River system via the Rand Water network.)
- **Olifants River System** that supplies water to the Witbank/Middelburg area as well as to irrigation and extensive mining developments of the platinum group metals. The river then flows through the Kruger National Park and into Mozambique.
- **Mhlatuze System** which is the main source of water for the Richards Bay area and for irrigation development in the catchment.
- **KwaZulu-Natal Coastal Metropolitan Areas** which comprise the Durban-Pietermaritzburg area and environs.
- **Amatole System** which supplies water to the East London area and environs.
- **Algoa Area** centred around Port Elizabeth that receives water from local resources as well as from the Orange River via the Orange-Fish-Sundays transfer.
- **Outeniqua Coastal Area**, which mainly comprise the rapidly developing Knysna, George and Mossel Bay urban areas.
- **Western Cape System** that comprise an integration of local (or regional) water resources to supply water to Cape Town as well as other urban users and to irrigation along the Berg and Sonderend rivers.
- **Remainder of South Africa.** The report also gives a concise perspective of the water resource situation in the predominantly rural parts of South Africa.

The locations of the above areas are schematically shown on **Figure 1.1**. A larger map is given in **Appendix A**.

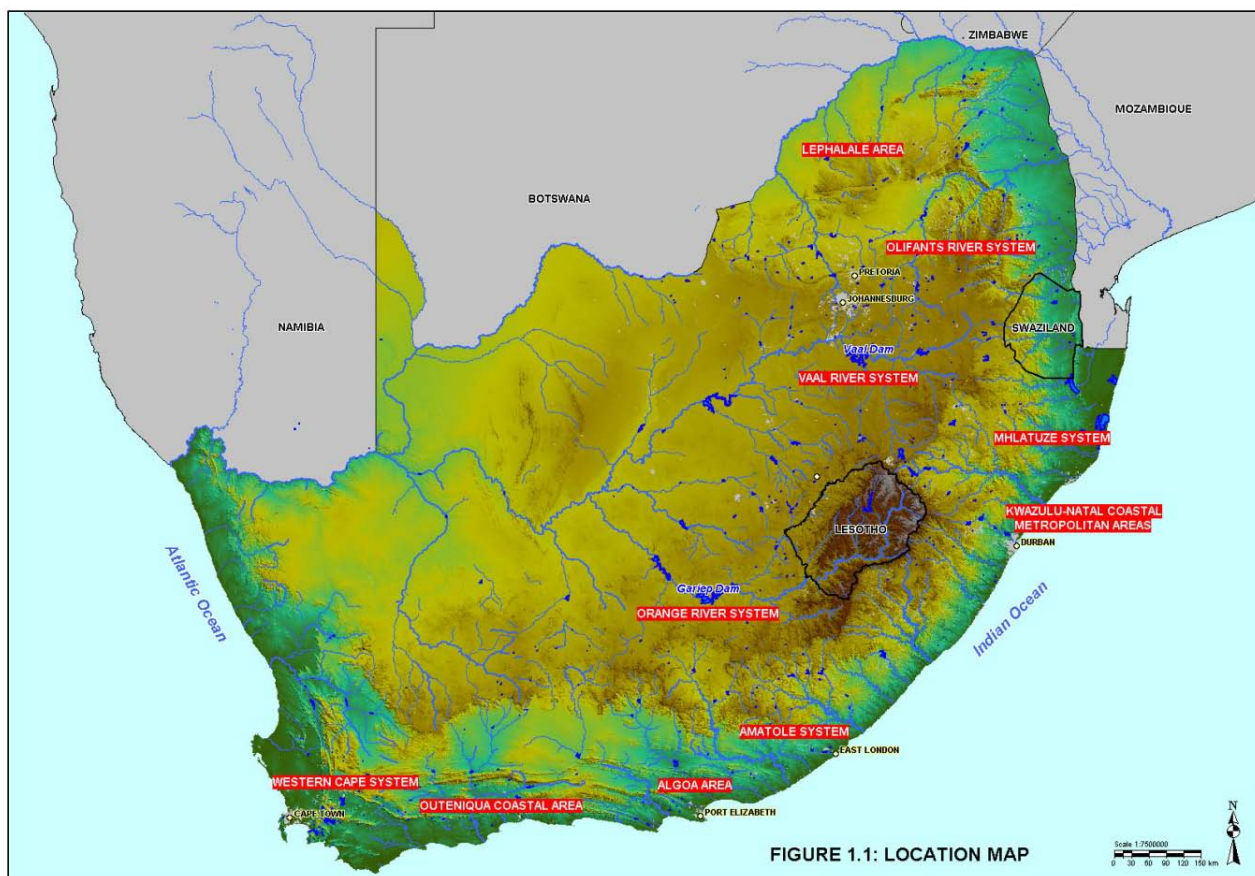


FIGURE 1.1: LOCATION MAP

Figure 1.1: Location Map

1.4 Sources of information

Where available, the Reconciliation Strategies prepared under the auspices of the Department of Water Affairs (DWA) for some key areas in the country were used as the primary source of information. In cases where the Reconciliation Strategies had not been completed or not commissioned yet, reference was made to the National Water Resource Strategy (NWRS). All the above information was supplemented with the latest findings from recently completed as well as ongoing studies, as referenced in the appendices.

As a result of the various sources of information used, some of which being recent outcomes from “work in progress”, a number of variances occurred with respect to the primary information from the Reconciliation Strategies. It is important that a procedure be implemented in future for the regular updating of primary information sources with the latest information, as relevant.

2 APPROACH

2.1 General

As a general approach, all potential sources of fresh water of significant size that could still be developed, were identified. In order to facilitate an initial and indicative ranking of developments and interventions, all the options had to be evaluated on a common basis. Assessments were also made of the quantities of water that could be made available through the various options and of the lead times for implementation, to facilitate the broad reconciliation of the potential resources with the expected future requirements for water. From this, estimates were made of the ultimate capacity of South Africa's water resources, and by when the resources are likely to reach full utilisation in the respective geographic areas.

Use was mainly made of existing information from previous studies and other sources, which were all processed to common denominators.

Reference to water resources should be taken as implying fresh water resources, unless otherwise specified (e.g. seawater, acid mine drainage).

2.2 Water resources and options for augmentation

The most recent assessments of the water availability, based on current infrastructure and levels of development, were obtained for each of the areas under consideration. Surface water, groundwater, the indirect re-use of water (return flows) that are discharged to rivers as well as the inter-basin transfers of water are all being properly accounted for. Estimates were also obtained of the potential impacts of the implementation of the Reserve on the availability of water for use (mainly surface resources).

Furthermore, information was obtained on all the potential options for future water resources development and augmentation of the water availability. These are described in more detail in Chapter 3.

Given the abundance of water available in the oceans, the desalination of seawater and pumping to where it may be needed, was regarded as the ultimate source of water in all cases, to be resorted to once all the other options have been fully exploited. Whilst it is well recognised that the cost of such water is likely to be prohibitive for inland locations, it nevertheless serves as a valuable and often sobering reference.

2.3 Future requirements for water

Estimates of the future requirements for water were obtained from the latest studies for each of the respective areas. Special care was taken where water is transferred from one catchment to another, to ensure that no duplications or omissions would occur. Similar precautions were taken with respect to provisions made for water supply to future power stations.

Projections of future requirements were typically available for the period until 2035, which were then extrapolated until 2050. Instead of a whole spectrum of high and low scenarios, a reference scenario was selected for each of the areas in consultation with the relevant officials or advisors. In

addition, estimates of the possible savings achievable through the implementation of water conservation and water demand management (WC/WDM) were also obtained.

The expected growth in water requirements is predominantly in the urban, industrial, mining and power generation sectors. With the exception of the provisions already made in the National Water Resources Strategy for irrigation developments, no other growth in water for irrigation has been provided for.

The projected future requirements for water for the respective areas are shown in the diagrams under Chapter 4.

2.4 Basis for comparison

2.4.1 Unit cost of water

The unit cost of water was selected as the primary basis for the comparison of options. In order to ensure that all options are compared on an equal basis, the marginal cost¹ of water was used in preference to the price of water, as the latter is often skewed by the blend of old and new infrastructure investments. For comparative purposes, the marginal cost was expressed in terms of unit reference value (URV) as a first order economic indicator. Refer to Appendix B for more detail on URV calculations.

With energy requirements as a major variable with respect to many of the options, standardised marginal costs for energy were also determined for use in the URV calculations.

Whilst the URV can be quite robust as an economic indicator for the comparison of appropriately sized options targeted at a specific solution and at a particular point in time, the use of URVs for the general comparison of options at various locations and to serve different needs can be strongly influenced by the growth in future water requirements as well as the sizing and scheduling of a development option. Of specific relevance with respect to this report, is the many generalised assumptions that had to be made as described in Section 2.5, and the fact that many of the options have not been attuned (sized, phased, timed, etc) to particular needs. The URVs are therefore intended to give a broad comparative indication of the cost only, and care should be taken when comparing URVs for different locations or different sizes of schemes with one another.

It should be noted, however, that it is not the purpose of this report to make recommendations on any schemes to be implemented, but rather to give an indication of differences in cost with respect to the main options, in order to give an indication of the relative merits of possible interventions. The relevant detailed assessments should be the topics of different assignments.

¹ *The marginal cost of an additional unit of output is the cost of the additional inputs needed to produce that output. As the sizing of water resource developments is largely dictated by physical needs and constraints, discrete new developments were considered in total for the purposes of this report, rather than attempting to add only one additional unit of water from a new scheme.*

2.4.2 Unit energy requirements

Similar to water, energy is also a scarce and costly resource that needs to be judiciously utilised. Given the high energy requirements of some of the options for augmenting the water availability in future, and which cannot be justly reflected by a URV alone, it is prudent that the unit energy requirements associated with the respective development options also be considered. Unit energy requirements have therefore been calculated for each of the development options, whilst marginal costs of energy were used in the URV calculations

2.4.3 Other considerations

The **quality of water** at the point of abstraction as well as the users' quality requirements at the point of delivery can have a significant influence on the cost of water. Other than for the desalination of seawater and special treatment of some effluent and decant mine water, this has not specifically been accounted for.

Consensus is growing amongst the scientific community of the world, that accelerated **climate change** is being experienced due to human induced impacts on the environment. There is also commonality in the results from global circulation (climate) models that rainfall over the south-western part of South Africa can be expected to significantly decline and become highly variable over the coming decades. Whilst the rainfall over the remainder of the country may on average not be much affected, expectations again are that it is likely to become much more variable.

The possibility of decreasing rainfall over the Western Cape area will have a pronounced negative impact on both surface water and groundwater resources, whilst at the same time the requirements for water may increase due to the higher temperatures that are predicted. In addition and as for the remainder of the country, the higher variability of rainfall (if manifesting) would likely cause more prolonged and severe droughts with resultant reductions of the yield from water resources systems.

Whilst the possible impacts of climate change are taken into account during the detailed planning of water resources developments, specific provisions for climate change have not been included at the broad overview level of this report. One exception being the Western Cape, which is the area expected to be first and most seriously impacted upon.

2.4.4 Acid mine drainage

Unit reference values for acid mine drainage were calculated, based on the collection and treatment costs to bring the water to an acceptable raw water standard. These URVs are then compared to the URVs of other development options. (Refer to Sections 3.1 and 3.4.)

It may be argued, however, that such treatment to allow the acid mine drainage to be discharged into receiving streams would in any case be required in terms of the relevant legislation. Similar to the indirect re-use of water through the discharge of treated urban and other effluent to streams, the acid mine drainage should then be available at no additional economic cost. This would also make the use of acid mine drainage one of the highest priority augmentation options.

2.5 Standardisation

2.5.1 Assumptions

Various assumptions had to be made to ensure the uniformity of assessments and compatibility of the results and findings, with respect to the different water resource development and augmentation options. Many of the assumptions were necessitated by the different levels of detail to which options have been investigated as well as the non-uniformity of some of the approaches used. Greater standardisation needs to be introduced in future.

Distinction is made between general assumptions that apply to all the options, and assumptions that are specific to particular options. A summary of the more important general assumptions is given below, whilst a comprehensive list of assumptions is given in the appendices.

Main general assumptions:

- All the URVs are representative of raw water. Where potable water would result from a process, such as the desalination of seawater, the normal raw water to potable water treatment cost was subtracted to reflect the raw water equivalent.
- All energy costs were priced at a representative marginal cost for electricity. It was assumed that all new generation until 2019 would be from coal-fired power stations at 60 cents per kWh. From 2020 onwards half of the new generating capacity would be from nuclear power at R1.20 per kWh, with a resultant average marginal rate of 90 cents per kWh. Provisions of between 2% and 15% were made for distribution costs, dependent on the location of the power station(s) relative to the point of supply (refer to **Appendix B2**).
- All costs (capital, energy, operation and maintenance) are in mid-2009 money values. VAT is excluded as it is not relevant from a national economic perspective.
- URVs are calculated for raw water to be delivered in bulk at representative locations, such as Vaal Dam for the Vaal River System. No clean water distribution costs are included.
- The URVs with respect to WC/WDM for all areas/systems were assumed to be the same as that of the Vaal River System, for which the most comprehensive information was available. This needs to be further investigated in future.
- Other assumptions pertaining to the URV calculations include:
 - construction of developments during 2009 to 2015, to finish in 2015;
 - water delivery (sales) to commence in 2016;
 - water volumes delivered based on growth in water requirements from 2016 onwards (i.e. no deficit or surpluses up to 2015 considered - see **Appendix B4** and **B5** for more information), and taking scheme capacity into account;
 - discount rate of 8% over 30 years of water delivery, with no residual value; and
 - where specific parameters were not given with respect to maintenance costs, standard parameters were assumed.
- All new water resource developments must fully comply to the release of ecological water requirements (EWR).

- The implementation of water releases for the EWR from existing dams is assumed to be phased in over a 5-year period, starting when new water resource developments on the same system are commissioned.
- Although unlimited quantities of seawater can theoretically be abstracted, assumptions were made with respect to practical sizes of schemes for the respective areas.

2.5.2 Price adjustments

Estimates of construction costs for the various development options were obtained from reports spanning nearly two decades. As a consequence, the estimates for construction costs are also pegged to widely varying base dates, and had to be adjusted to the mid-2009 common base.

Statistics were obtained with respect to movements in the Consumer Price Index (CPI) as well as the Construction Price Adjustment Factors (CPAF) for the period from January 1992 until June 2009, and the cumulative index/adjustment calculated. The results are graphically illustrated in **Figure 2.1**.

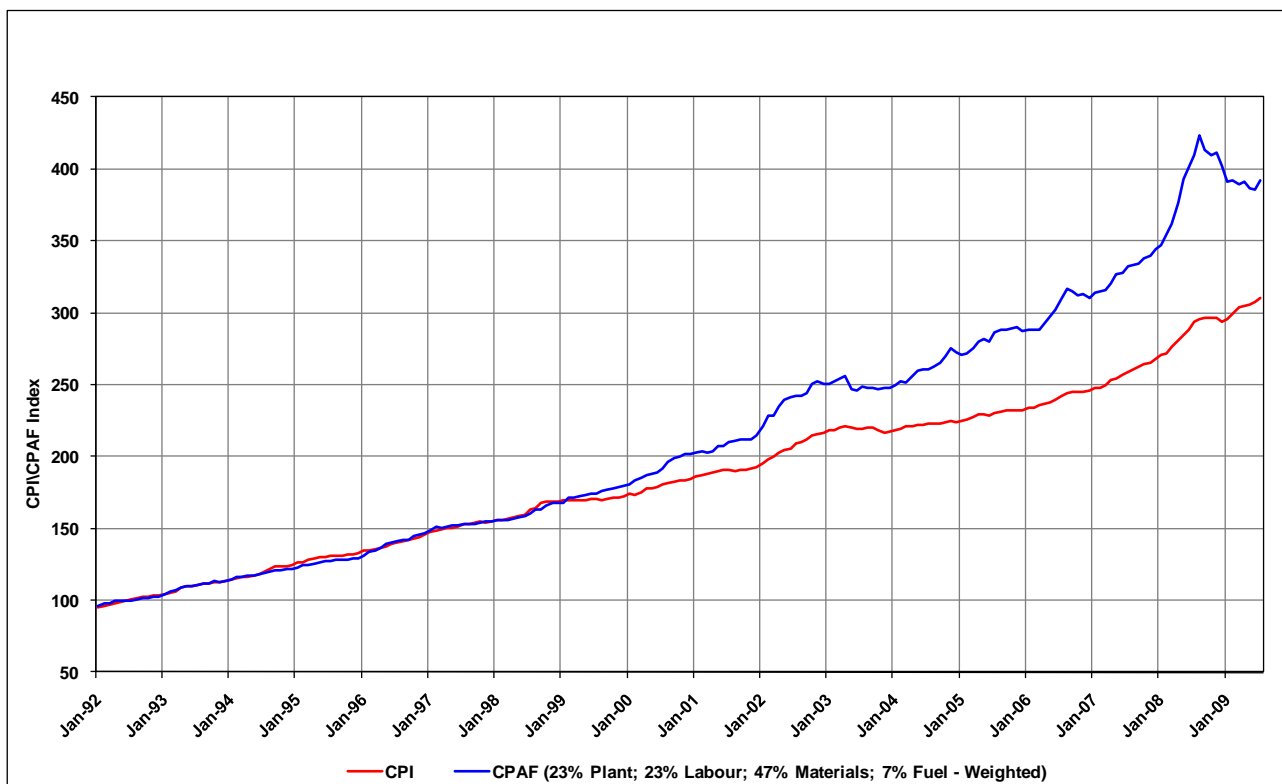


Figure 2.1: CPI and CPAF (Cumulative Index)

It is evident that the CPAF departed significantly from the CPI over the last ten years. This can be attributed in part to the construction boom during that period in South Africa and globally, and also to the greater scarcity and different weighting of some inherent key components of the CPAF in comparison to the CPI (i.e. fuel). The CPAF was judged to be more relevant to the construction industry than the CPI, and the CPAF was therefore applied for the adjustment of construction costs to the common base date.

A common approach was also followed with respect to the provision for professional costs and the pricing of components which may not have been covered in some of the reports. However, no adjustment was made to account for cost estimates that originate from different levels of detail (such as reconnaissance versus feasibility).

2.5.3 Typical development cycle

The development of new water resources infrastructure is a complex and time-consuming process that typically takes more than a decade from inception to commissioning. For larger and more complex projects with environmental and political sensitivities, the lead times may be more than two decades. It is essential therefore that development needs be identified and that preparatory work be undertaken well ahead of when water is actually needed from a project. Ample provision should also be made for possible unforeseen delays.

A diagrammatic presentation of the different phases of development is shown in **Figure 2.2**. It is important to note that many of the activities span over several phases with improving detail and confidence as they progress through the phases, rather than being restricted to one phase only as simplistically shown on the diagram.

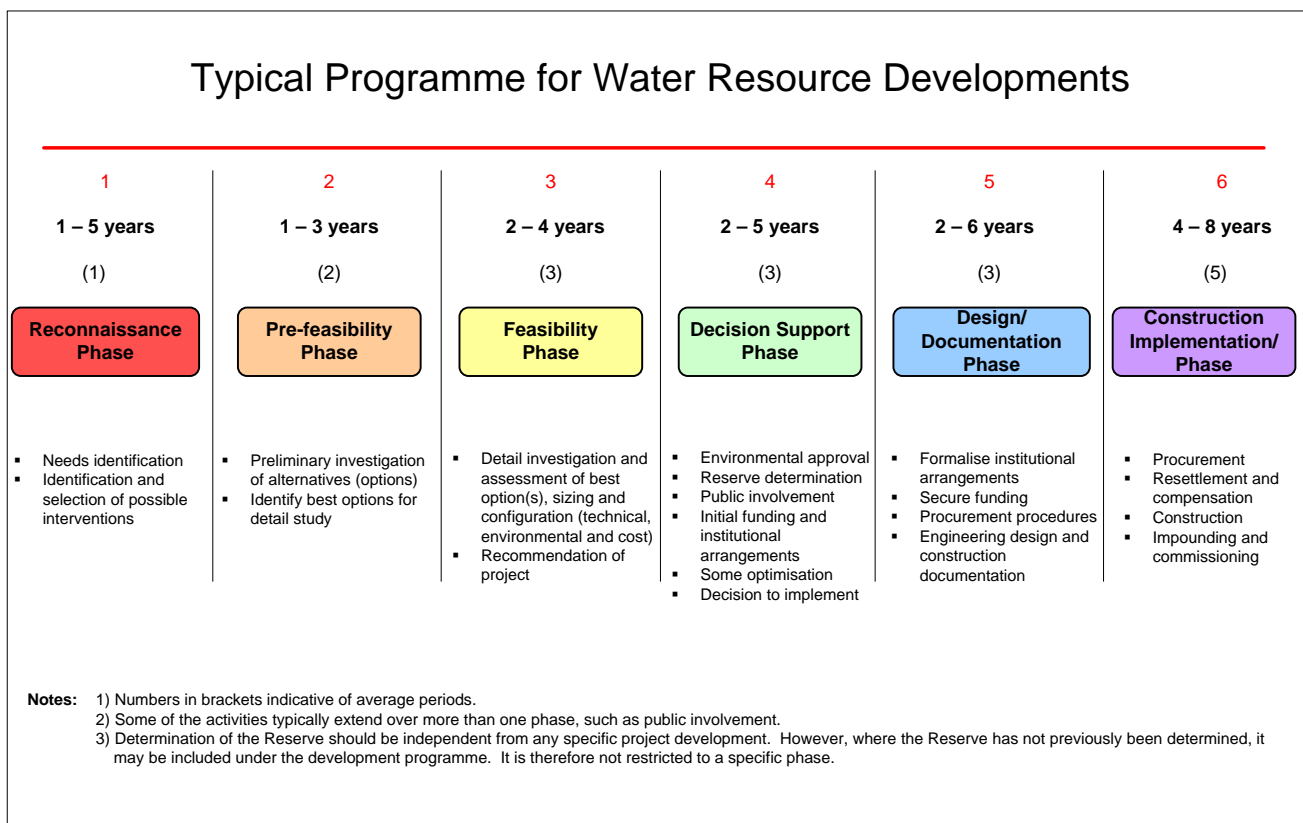


Figure 2.2: Typical Programme for Water Resource Developments

Assessments were made of the present stage of development for each of the various options considered, as background to the indicative phasing of developments.

2.6 Ultimate utilisation of water resources

Due to the strong spatial variation in the availability of water over South Africa, and the fact that economic development and growth in water requirements are mostly driven by factors other than abundance of water, large spatial variations occur with respect to the availability of and requirements for water. The full utilisation of fresh water will therefore not be reached at a common date for the whole country, but at different dates over an extended period of time, depending on the situation pertaining to the respective areas. It is perceivable that full utilisation of the water resource potential may never be reached in some areas due to a lack of economic viability (i.e. the Mzimvubu River).

In order to assess the future water balance situation, an indicative phasing in of development options was done for each of the areas under consideration. New schemes or interventions were introduced only when dictated by the growth in water requirements, and were prioritised and phased for each area according to the following criteria:

- Options were first ranked according to the unit cost of water, with the highest ranking afforded to the lowest URV.
- Should two options have the same URV, then one with the lowest unit energy requirement would receive priority.
- Options were then phased to meet the growth in water requirements by first using the highest ranked option, and then progressively lower rankings.
- Should the highest ranked scheme at any point during the phasing not be able to deliver water in time (due to its status in the development cycle), then the next-ranked scheme that could timely be implemented, were used. In some instances it was found that none of the options could be timely implemented and that interim deficit situations were unavoidable.

The projected water balances, based on assuming the above indicative phasing of options, are described in Chapter 4.

3 DEVELOPMENT OPTIONS

The various development options to increase the availability of water in the respective areas are described below. For each option, the quantity of water to be made available is given, together with the accompanying URV and unit energy requirement. Each option was assessed as if it would be the next option to be implemented (thus prior to ranking and phasing). As was mentioned in section 2.4.1, the proper sizing, phasing and timing of developments will likely have an influence on the resulting URVs.

Water Conservation and Water Demand Management (WC/WDM) would also reduce the demand and thereby extend the sufficiency of existing resources. Investments in WC/WDM should therefore be viewed similar to investments in water resource development projects. Due to a paucity of data, however, to determine URVs for WC/WDM in each of the areas, information on the costs and water savings associated with WC/WDM in the Vaal River System were used and also transposed to the other areas.

3.1 Vaal River System

Based on the extensive investigations and preceding studies by DWA, the following have been identified as the main options for increasing the availability of water in the Vaal River System:

- **Lesotho Highlands Water Project Phase II:** This comprises the proposed Polihali Dam and connecting tunnel to Phase I of the LHWP. In order to compensate for the reduction in yield downstream along the Orange River that would result from transferring the full yield of Polihali Dam to the Vaal River System, it would be necessary to also construct dams at Vioolsdrift as well as at the Bosberg site on the Orange River.
- **Use of acid mine drainage:** This will comprise the collection and processing of acidic water draining from defunct mines, for supply to urban users.
- **Orange-Vaal transfer:** Water could be made available from a larger dam near Bosberg on the Orange River (the proposed Boskraai Dam) for transfer via pipeline to the Vaal River System, after the LHWP Phase II.
- **Thukela-Vaal transfer (Phase II):** Planning has already been done for the construction of a dam at Mielietuin on the Bushmans River as well as a dam at Jana on the Thukela River, and the piping and pumping of water up the Drakensberg escarpment to the head waters of the Vaal River System.
- **Mzimvubu-Vaal transfer:** With the Mzimvubu River as the only major river in South Africa that is still largely undeveloped, the option exists for dams to be constructed on the main tributaries of the river and the water to be transferred to the upper Kraai River in the Orange River catchment, for further transfer to the Vaal River System via a pipeline from the proposed Boskraai Dam.
- **Zambezi-Vaal transfer:** A conceptual assessment was made of abstracting water from the Zambezi River upstream of the Victoria Falls, and pumping it via a pipeline to the Gauteng area on the border of the Vaal River System. The possibility of a shared scheme with

Botswana may also exist (as well as for water supply to the Lephalale area and further on to the Olifants River System).

Such a scheme will obviously be subject to agreement being reached with the Zambezi basin countries with respect to the abstraction of water as well as on royalties. A provisional allowance for royalties is included in the URV.

- **Desalination of seawater:** As the ultimate fall-back option and benchmark, seawater can be desalinated and pumped to locations where needed.

The above options, together with their key parameters (URV, unit energy requirement, and volume of water), are schematically presented in **Figure 3.1**. More detail can be found in **Appendix C**.

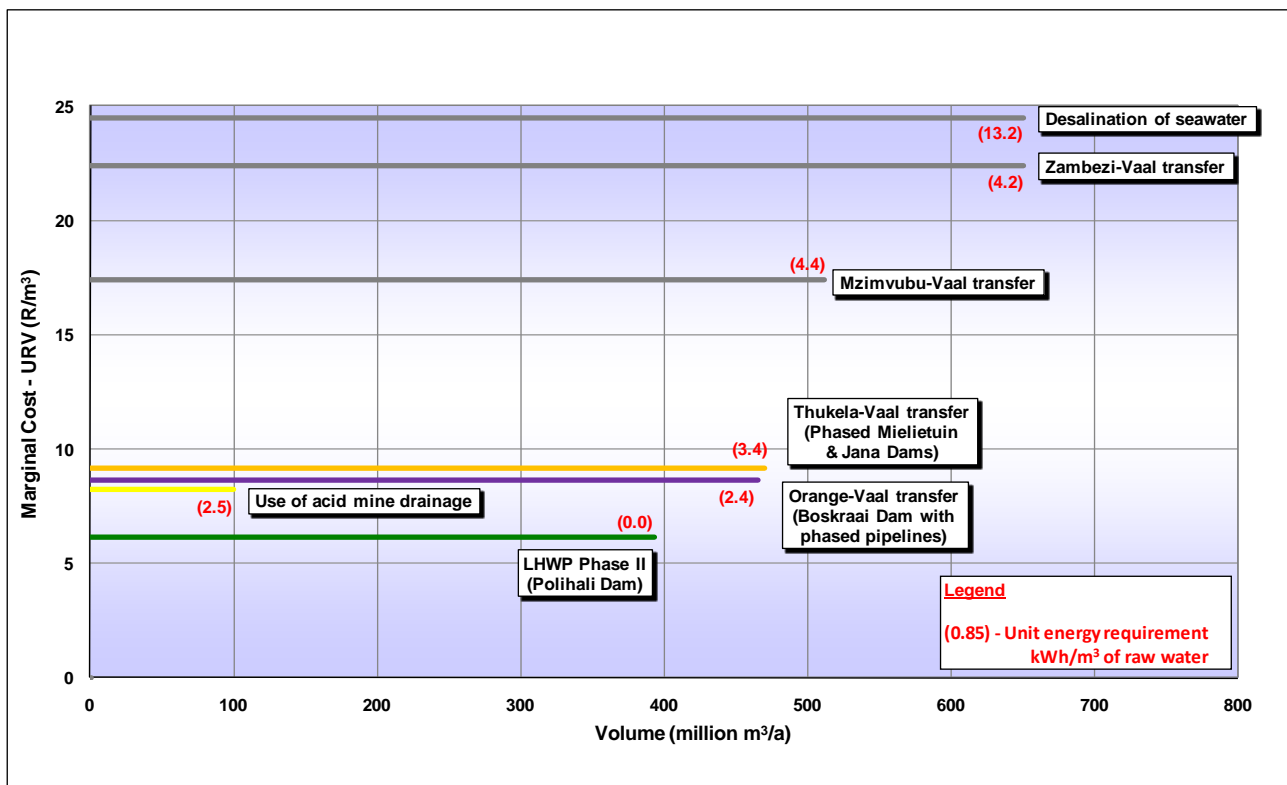


Figure 3.1: Vaal River Augmentation Options

3.2 Orange River System

The options considered under this section are targeted at the augmentation of water availability for users from the Orange River, and do not include options for the express purpose of water transfer to the Vaal River System. Phase II of the LHWP is assumed to be committed to, which would include a dam at Vioolsdrift as well as at Bosberg and, where applicable, these were accounted for in the assessment of the remaining options as listed below.

- **Boskraai Dam:** A larger dam than is required to only compensate for the impacts of the LHWP II, can be constructed at the confluence of the Orange River and Kraai River near Bosberg. The additional yield from such a dam would then be available downstream along the Orange River.

- **Mzimvubu-Kraai transfer:** The transfer of water from the Mzimvubu River to the upper reaches of the Kraai River, a main tributary of the Orange River, would correspond to the first section of a Mzimvubu-Vaal transfer. A portion of this water could be retained in the Orange River for local use. Alternatively, a scaled down version that would transfer water from the Ntabelanga Dam only, could be constructed to serve users from the Orange River. The latter option being further considered.
- **Desalination of seawater:** This option was only assessed as a reference benchmark, as it would not be logical to pump desalinated seawater to the Orange River, whilst water is being supplied from the Orange River to Port Elizabeth, via the Orange-Fish transfer.

A diagrammatic presentation of the above options is given in **Figure 3.2**. It should be noted that varying quantities of water can be transferred from the Mzimvubu River to the Orange River. The smaller and lowest cost option shown is based on construction of the Ntabelanga Dam only with transfer of water via a pipeline. The larger capacity and higher cost option is based on the construction of six dams in the Mzimvubu River catchment, and the transfer of water via pipelines and a tunnel to the Kraai River. Also refer to **Appendix D**.

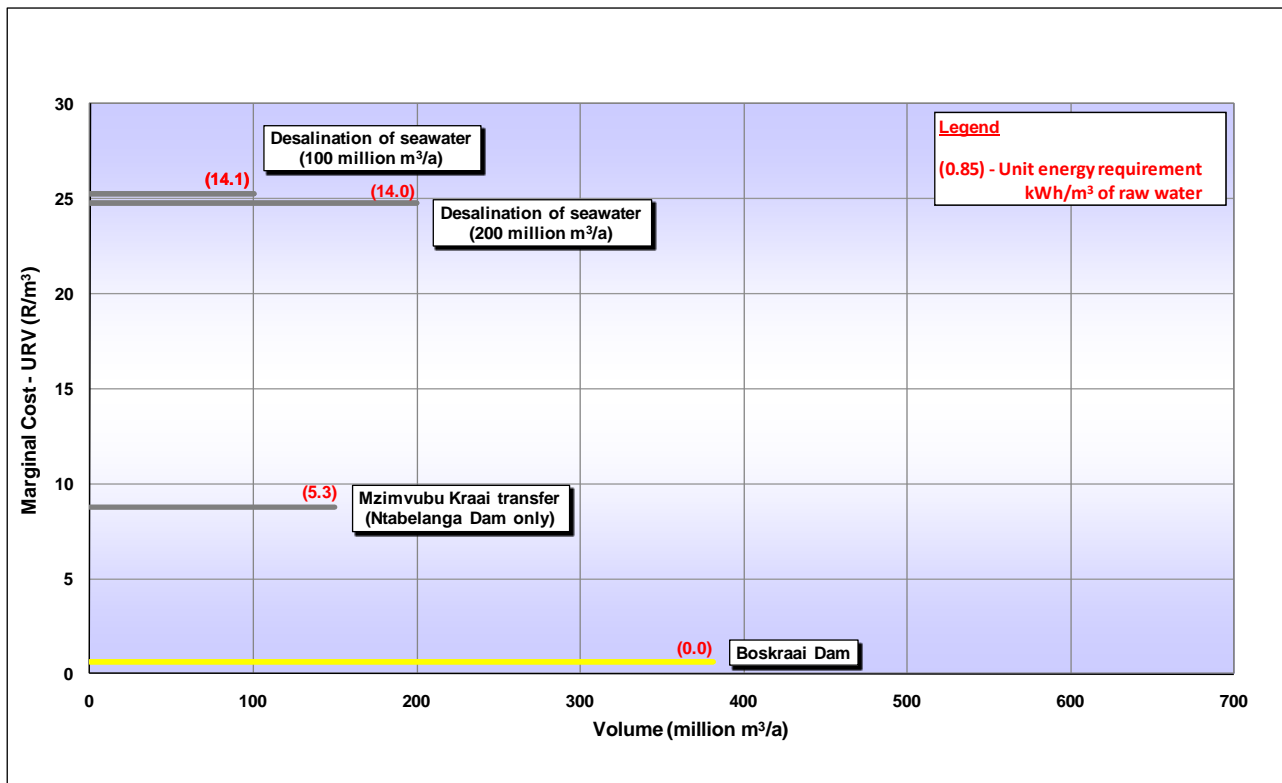


Figure 3.2: Orange River Augmentation Options

3.3 Lephale area

Only a small portion of the water needed to support the developments in the Lephale area can be secured from local resources, whilst the bulk of the water needs to be transferred from neighbouring catchments and further afield. The options for augmentation of the water availability in the Lephale area are summarised below.

- **Mokolo Dam:** The upgrading of bulk conveyance infrastructure from the Mokolo Dam to the Lephhalale area, to fully utilise the available yield, could bridge some short-term needs with respect to the new developments.
- **Mokolo-Crocodile Augmentation:** This option comprises a large pipeline and pumping stations for the transfer of surplus effluent from the Crocodile West River to the Lephhalale area in the Mokolo River catchment. The pipeline is being over-sized to provide for increased transfers in future, which adds to the URV for this option.
Whilst surplus water is on average available in the Crocodile River for transfer to the Lephhalale area (Mokolo-Crocodile Augmentation Project Phase II), some regulation of flows is likely to be required.
- **Re-use of effluent from the Vaal River catchment:** It is intended that surplus effluent that originates from large wastewater treatment works in the Vaal River catchment and close to the divide with the Crocodile West River catchment, be transferred to the Lephhalale area via the Crocodile West River and the *Mokolo-Crocodile Water Augmentation Project (MCWAP)*. The scheme will comprise pipelines and pumping stations as well as the tertiary treatment of effluent to the relevant standards.
- **Transfer from Vaal River:** Water could be transferred directly from the Vaal Dam to the Crocodile West River and then to the Lephhalale area via the *MCWAP*. This is likely to stimulate the need for additional transfers into the Vaal River system from other catchments.
- **Transfer of Zambezi water:** Similar to the possible Zambezi-Vaal transfer, a perspective was gained on the transfer of water from the Zambezi River to the Lephhalale area.
- **Desalination of seawater:** The benchmark parameters for the pumping of desalinated seawater directly to the Lephhalale area were determined for comparative purposes.

The key parameters for the respective options are presented in **Figure 3.3**. Also refer to **Appendix E**.

It should be noticed that the URV as given in Figure 3.3 for a Zambezi transfer was based on a Lephhalale-only scheme. Lower unit costs should result with respect to a scheme shared with the Vaal River system.

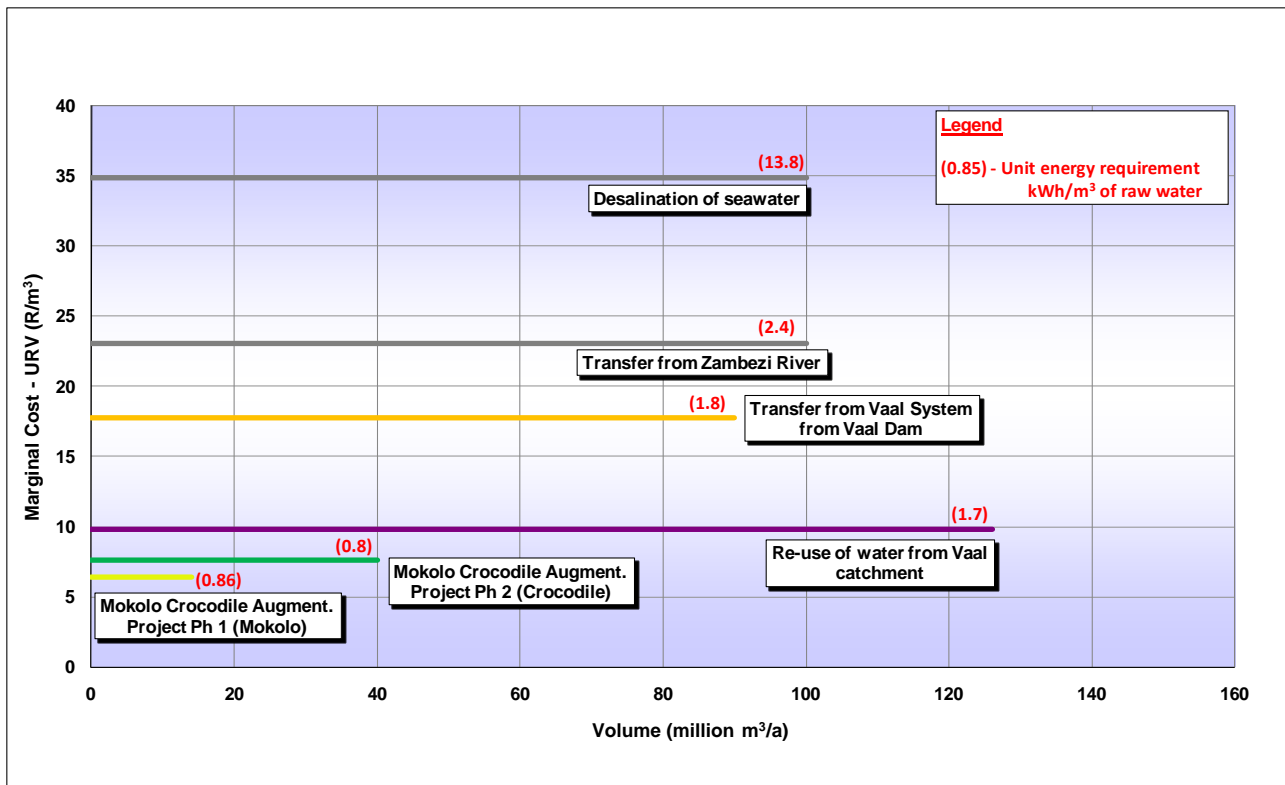


Figure 3.3: Lephale WMA Augmentation Options

3.4 Olifants River System

The water resources of the Olifants River System are already highly developed and nearly fully utilised. Only limited potential for further water resource development exists, after which water will need to be transferred from elsewhere, as reflected by the augmentation options below.

- **Olifants Dam:** Potential exists for the construction of a dam on the middle reaches of the Olifants River in the proximity of Rooipoort.
- **Acid mine drainage re-use:** Acidic water is being discharged from decommissioned coal mines in the upper reaches of the Olifants River. Much of this water can be treated for use in the municipal systems.
- **Transfer from the Vaal:** Water could be transferred via pipeline and pumping stations from the Vaal River System (Vaal Dam) to the upper reaches of the Olifants River, for use lower down. Such additional load on the Vaal River System would expedite the need for further augmentation of the Vaal River System.
- **Desalination of seawater:** The provision of desalinated seawater to the Olifants River System, although technically possible, is likely to be prohibitively expensive.
- **Transfer of Zambezi water:** The cost of supplying water from the Zambezi River via a dedicated scheme to the Olifants River System only, will be excessive. Lower costs would result from a possible scheme shared with the Vaal River system as mentioned under Section 3.1.

The key statistics with respect to the above options are given in **Figure 3.4**. Further detail can be found in **Appendix F**.

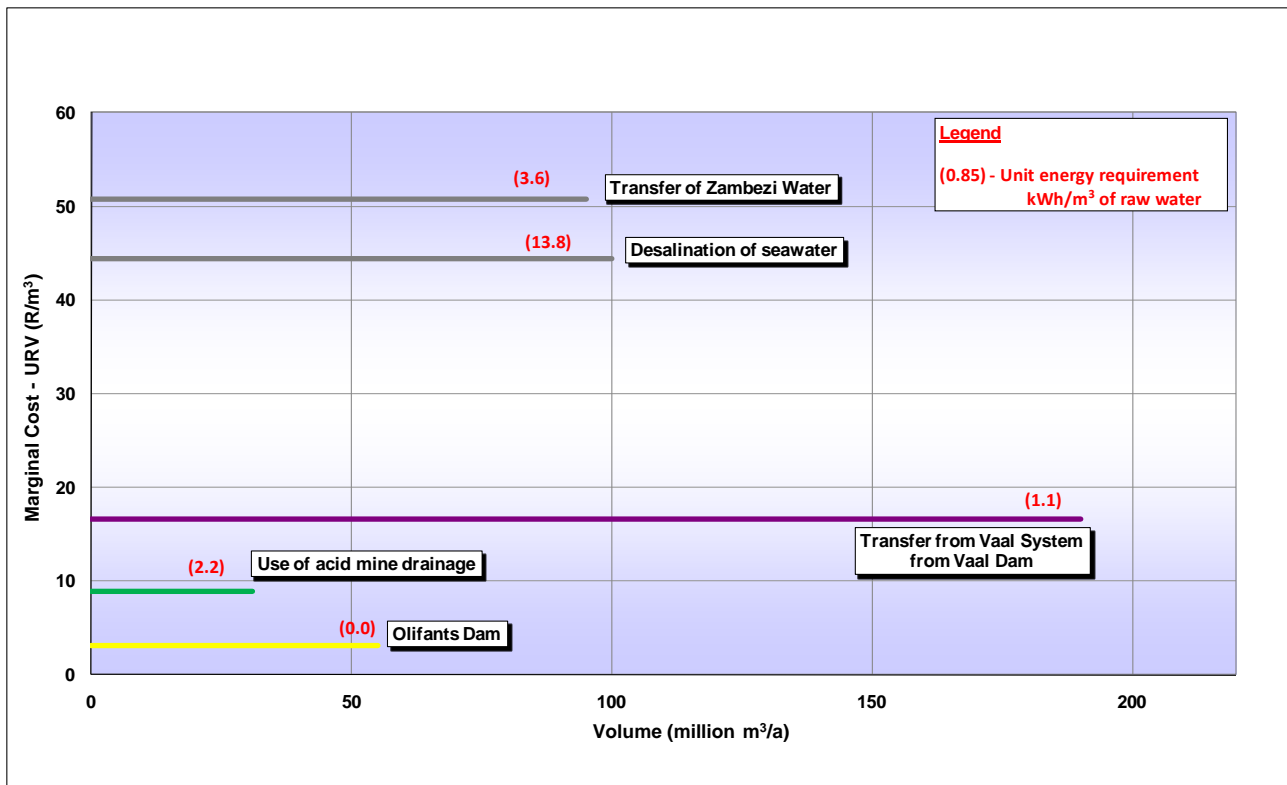


Figure 3.4: Olifants River Augmentation Options

3.5 Mhlatuze System

The requirements for and availability of water are approximately in balance for the Mhlatuze System. A small theoretical deficit pertains to a shortfall with respect to allocations for irrigation water, but which are not all being fully utilised.

No specific growth in water requirements is projected. It was therefore assumed for the purpose of URV calculations, that, should a large new industrial development(s) occur, the additional water required would be fully utilised within a period of ten years. The options for augmentation of the Mhlatuze System are given below.

- **Lower Thukela Scheme:** Provision was made in the National Water Resource Strategy (NWRS) for the abstraction of water from the lower Thukela River for transfer via pipeline and pumping station to the Richards Bay area. This would need to be co-ordinated with transfers to the Vaal River System and abstractions for the Stanger/Mdloti area.
- **Re-use of water:** Due to the complex composition of the industrial effluent which is discharged via an off-shore ocean outfall, it was assumed that the re-use of effluent would likely be restricted to normal municipal/domestic effluent.
- **Desalination of seawater:** The same unit cost as for the Durban area was assumed to apply (refer to Section 3.6).

A graphic comparison of the options is given in **Figure 3.5**. Refer to **Appendix G** for supporting information.

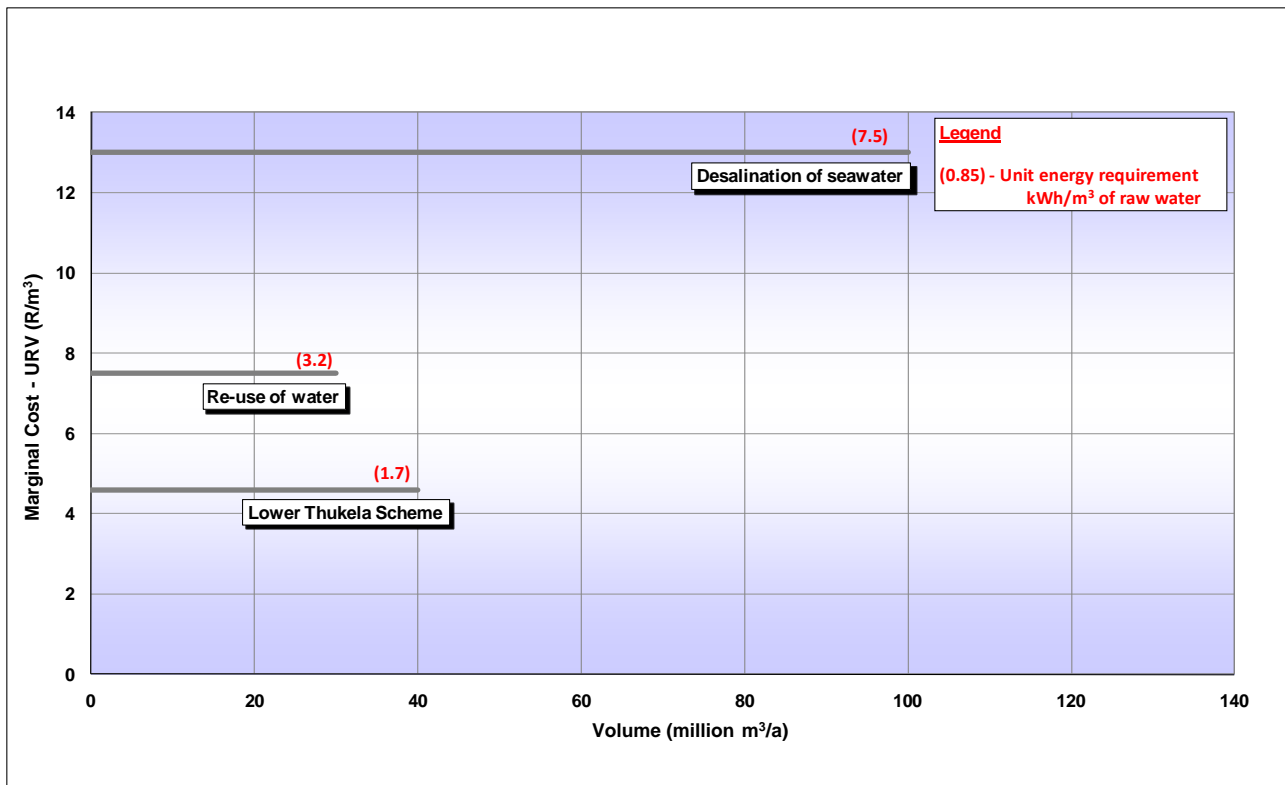


Figure 3.5: Mhlatuze System Augmentation Options

3.6 KwaZulu-Natal Coastal Metropolitan Areas

The KwaZulu-Natal Coastal Metropolitan areas represent one of the main growth areas in South Africa. Many studies have been conducted on the augmentation of water availability in the region and the main options that can still be resorted to are:

- **Mooi-Mgeni Transfer Phase II**, which comprises construction of the Spring Grove Dam on the Mooi River and a pipeline and pumping station for the transfer of water to the Mgeni River.
- **Re-use of water**: A first stage re-use opportunity exists whereby easily accessible effluent can be collected and pumped to the Inanda and Hazelmere dams for re-use. Further re-use of water will be more expensive and has not been investigated in detail yet. A representative URV determined for Cape Town, as another coastal city, was therefore provisionally assumed.
- **Lower Thukela Scheme**: Water can be abstracted from the lower Thukela River for supply to the northern coastal areas. Such abstraction would need to be co-ordinated with further developments on the Thukela River and transfers to other areas.
- **Mkomazi Transfer**: The scheme would consist of two dams on the Mkomazi River, one at Smithfield and the other further upstream at Impendle, together with a transfer tunnel from the Smithfield Dam to the Mgeni System. A phased development is foreseen whereby the downstream Smithfield Dam and transfer tunnel should first be constructed due to logistical considerations, to be followed by the dam at Impendle.

- **Umzimkulu Dam:** An option also exists for the construction of a dam on the Umzimkulu River and the transfer of water via the Smithfield Dam to the Mgeni System.

Due consideration should be given to this option at the time of final sizing of the Smithfield to Mgeni tunnel, as this could have a meaningful influence on the project economics.

- **Isuthundu Dam:** A dam at Isuthundu on the Mvoti River would serve to augment the water supplies to Stanger and the northern coastal areas. This could be in addition to, or as a future replacement of the lower Thukela transfer.
- **Desalination of seawater:** Given the coastal location of this area, the desalination of seawater is a realistic option for the future augmentation of the water resources.

The key parameters of these options are given in **Figure 3.6**. Further details are given in **Appendix H**.

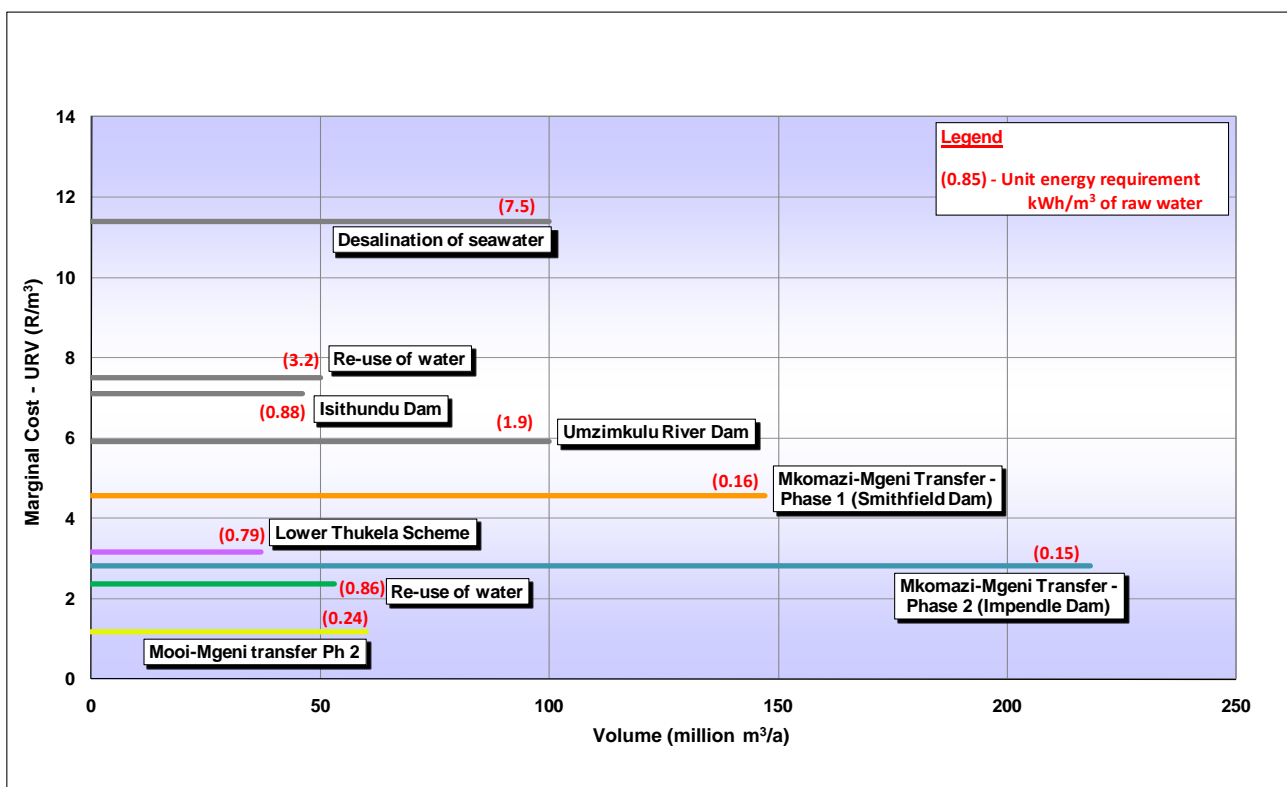


Figure 3.6: KZN Coastal Augmentation Options

3.7 Amatole System

There is still substantial uncertainty about the projections of future water requirements for the Amatole area. However, the provision of water for the ecological Reserve together with growth in urban water requirements will necessitate the need for additional water resources. The following options could remedy the situation.

- **Dam on Nahoon River:** A new dam could be built on the Nahoon River at Stone Island.
- **Transfer from Keiskamma River:** Surplus yield is available from the existing Sandile Dam on the Keiskamma River that could be transferred to the Amatole area (East London).

- **Dams on Qunube River:** Two dams could still be constructed on the Qunube River, one at Mhalla's Kop and the other at Groothoek.
- **Re-use of Water:** A substantial quantity of urban effluent from East London could be treated to appropriate standards for re-use.
- **Desalination:** A realistic option for coastal locations, although still relatively expensive.

The key statistics for the above options are presented in **Figure 3.7**. Also refer to **Appendix I**.

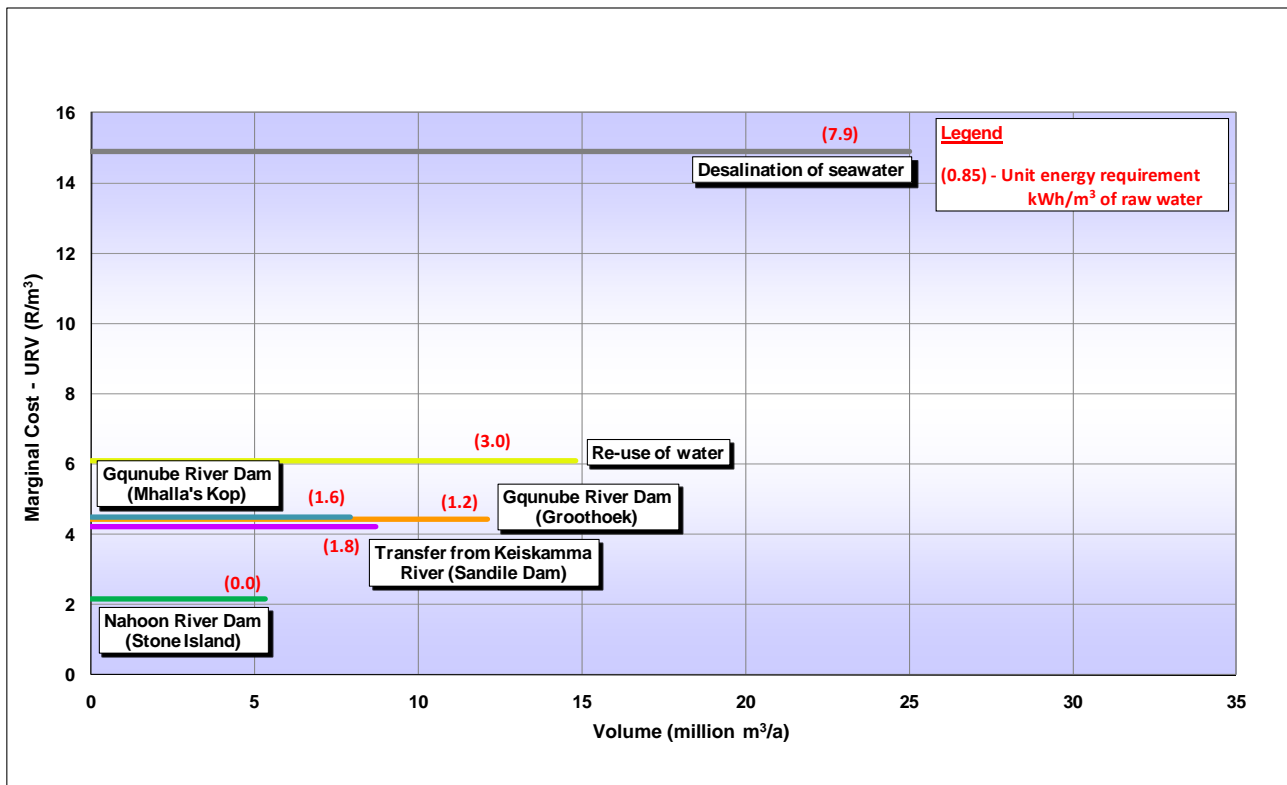


Figure 3.7: Amatole System Augmentation Options

3.8 Algoa Area

The augmentation of the water resources supporting the Algoa area has been the subject of various investigations during recent years. The more promising options in this regard are listed below.

- **Groundwater schemes:** A substantial quantity of water can be made available on a sustainable basis through development of groundwater resources.
- **Lower Sundays River return flows:** Return flows from upstream irrigation in excess of the environmental flow requirements at the Sundays River mouth, could be desalinated and processed for use in the Algoa water supply system.
- **Desalination (Straits Chemicals):** As a by-product of the abstraction of minerals (salt) from seawater by the possible Straits Chemicals scheme, potable water could also be produced at a competitive price.
- **Guernakop Dam/Kouga Dam:** Potential exists for more water to be made available from the Kouga River through construction of a new dam at Guernakop, or the raising of the existing Kouga Dam.

- **Re-use of water:** Most of the water used at Port Elizabeth (non-consumptively) is discharged to the ocean after one cycle of use. Much of this water could be captured and processed for re-use.
- **Desalination of seawater:** As also applies to the other coastal cities, the desalination of seawater offers a realistic option for the augmentation of resources.
- **Mzimvubu transfer:** Surplus resources in the Mzimvubu River catchment could still be developed for transfer to other areas where needed (such as the Vaal River System). The most feasible option for the transfer of such water to the Algoa area appears to be via the Orange River system.

Figure 3.8 gives a summary of the augmentation options for the Algoa area. See **Appendix J** for supporting information.

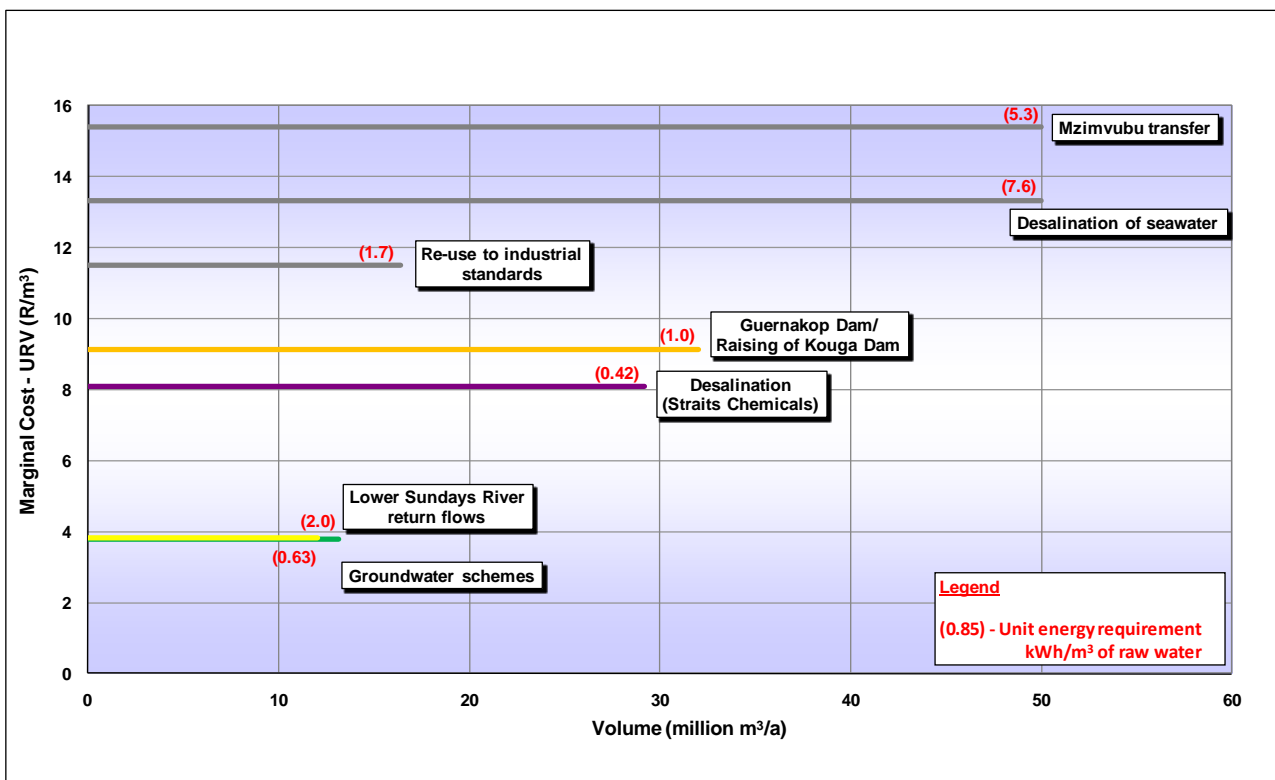


Figure 3.8: Algoa WSA Augmentation Options

3.9 Outeniqua Coastal Area

The Outeniqua Coastal Area experienced rapid development and a high growth in water requirements during recent years, although the total quantum of water used is the smallest of all the areas covered. Given its location between the Outeniqua mountains and the ocean, the region is characterised by several small rivers and aquifer systems. For simplicity, the George and Mossel Bay areas have been lumped together for the purposes of this study.

The following options have been identified for the augmentation of the water resources in the area:

- **Surface water:** These options include the raising of Klipheuwel Dam and a possible new dam on the Moordkuil River, to mainly serve the Mossel Bay Area. Augmentation options for George include the Malgas Dam, Upper Kaaimans Dam and the raising of Garden Route Dam.
- **Groundwater:** Moderate quantities of groundwater can be developed for abstraction on a sustainable basis.
- **Re-use of water:** The re-use of water at both George and Mossel Bay can add a substantial quantity of water back into the system.
- **Desalination of seawater:** The desalination of seawater is already practised at some of the more isolated coastal towns, and could be resorted to on a larger scale in future.

A graphic presentation of the above options is given in **Figure 3.9**. As sufficient information was not available on the individual surface water and groundwater schemes, averaged numbers are presented. A range of unit costs and energy requirements can be expected around these numbers. Also refer to **Appendix K**.

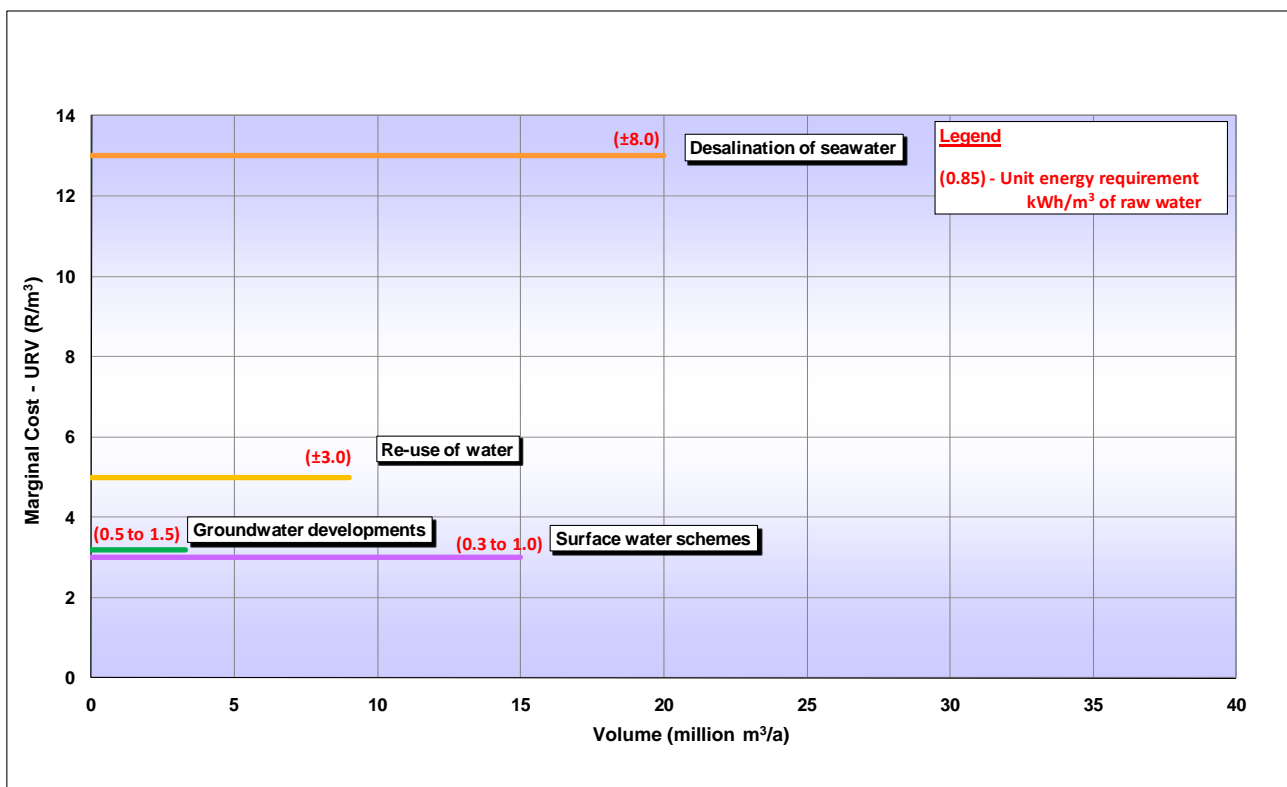


Figure 3.9: Outeniqua Coastal Area

3.10 Western Cape System

The Western Cape is one of the areas in greatest need of the augmentation of the water resources. The various options that have been identified and investigated in this regard are summarised below:

- **Voëlvlei Augmentation:** The capacity of the existing Voëlvlei Scheme can be significantly increased through abstractions from the Berg River and the raising of the Voëlvlei Dam

together with an additional pipeline to Cape Town. A first phase of the above works that would make use of some spare capacity of the existing water treatment works at Voëlvlei and the pipeline to Cape Town, could be relatively easily implemented.

- **Groundwater:** Potential exists for increasing the abstractions from the sandy aquifers currently in use, by means of artificial recharge. Substantial quantities of water may also be abstracted from the Table Mountain Group aquifers, although the feasibility and sustainability thereof still need to be confirmed.
- **Upper Molenaars Diversion:** A weir and tunnel could be constructed for diverting of water from the upper Molenaars River to augment the Western Cape System.
- **Upper Wit River Diversion:** Water could also be diverted from the Wit River to the Western Cape System by means of a regulation dam, diversion weir and tunnel.
- **Michell's Pass Diversion:** The head waters of the Upper Breede River could be diverted by means of a weir on the Dwars River and a canal, and then via the existing infrastructure into the Voëlvlei Dam. This option will form an integral part of the Voëlvlei Scheme and would be dependent on the additional pipeline capacity to Cape Town.
- **Re-use of water:** A large proportion of the water that is currently discharged to the sea after one cycle of use, could be treated to the required standards for re-use.
- **Desalination of seawater:** Given the coastal location and limited capacity of freshwater resources in the Western Cape, the desalination of seawater is a realistic option for the augmentation of water resources.

A comparison of the key parameters of the above options is given in **Figure 3.10**. Further supporting information is given in **Appendix L**.

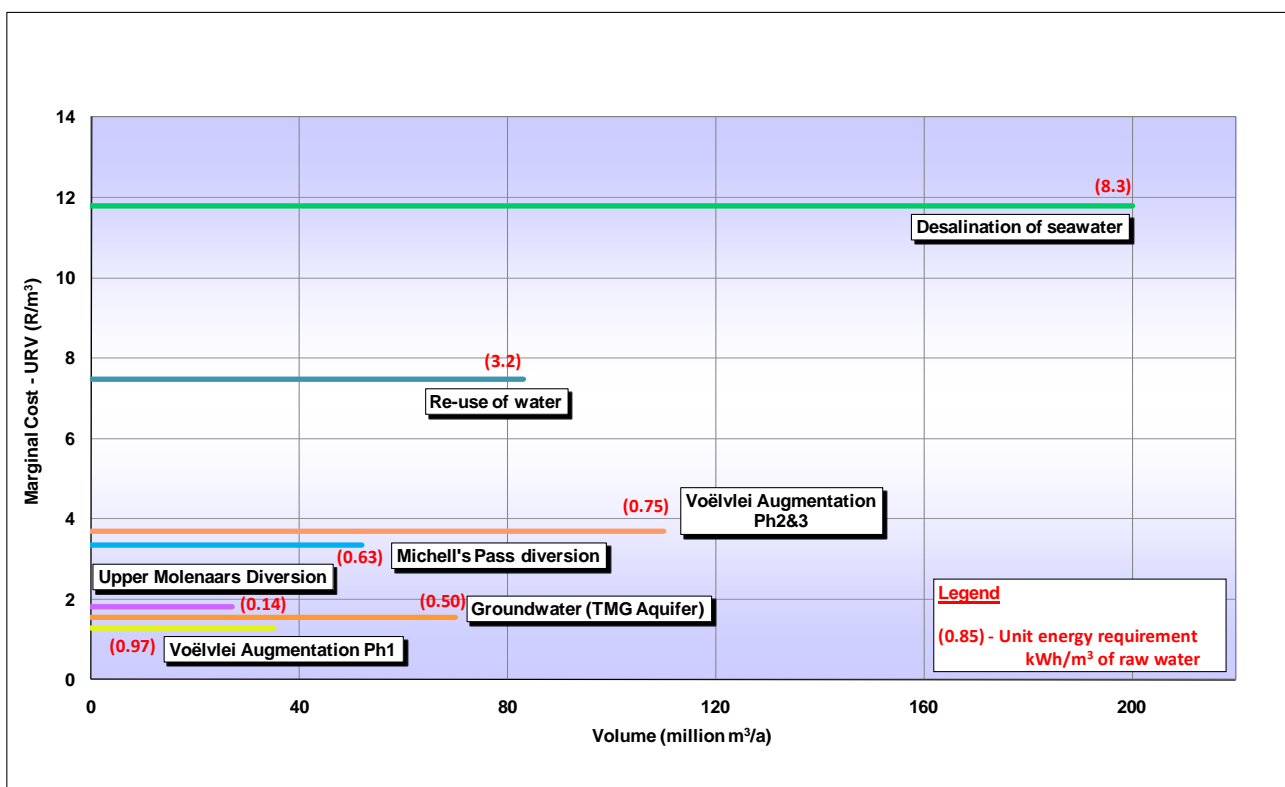


Figure 3.10: Western Cape Augmentation Options

3.11 Remainder of South Africa

The main urban complexes and areas of potential high economic growth in South Africa are covered in the preceding paragraphs. The remainder of the country is predominantly rural of nature and characterised by towns and settlements, where no specific growth stimulus currently exists. These areas, which are typically dependent on groundwater and smaller local surface resources for their water supply, resort under the *All Towns Studies* of the DWA and are therefore not specifically covered in this report. These studies are still in progress.

Some larger possible development options that have been identified for water supply to rural areas are:

- Nwamitwa Dam on the Letaba River in the Limpopo Province for the purposes of improved assurances for domestic and irrigation water supplied as well as for environmental water requirements in the Kruger National Park.
- Zalu Dam on the Lusikisiki River in the Eastern Cape Province for domestic use and possible irrigation.

3.12 Irrigation Development

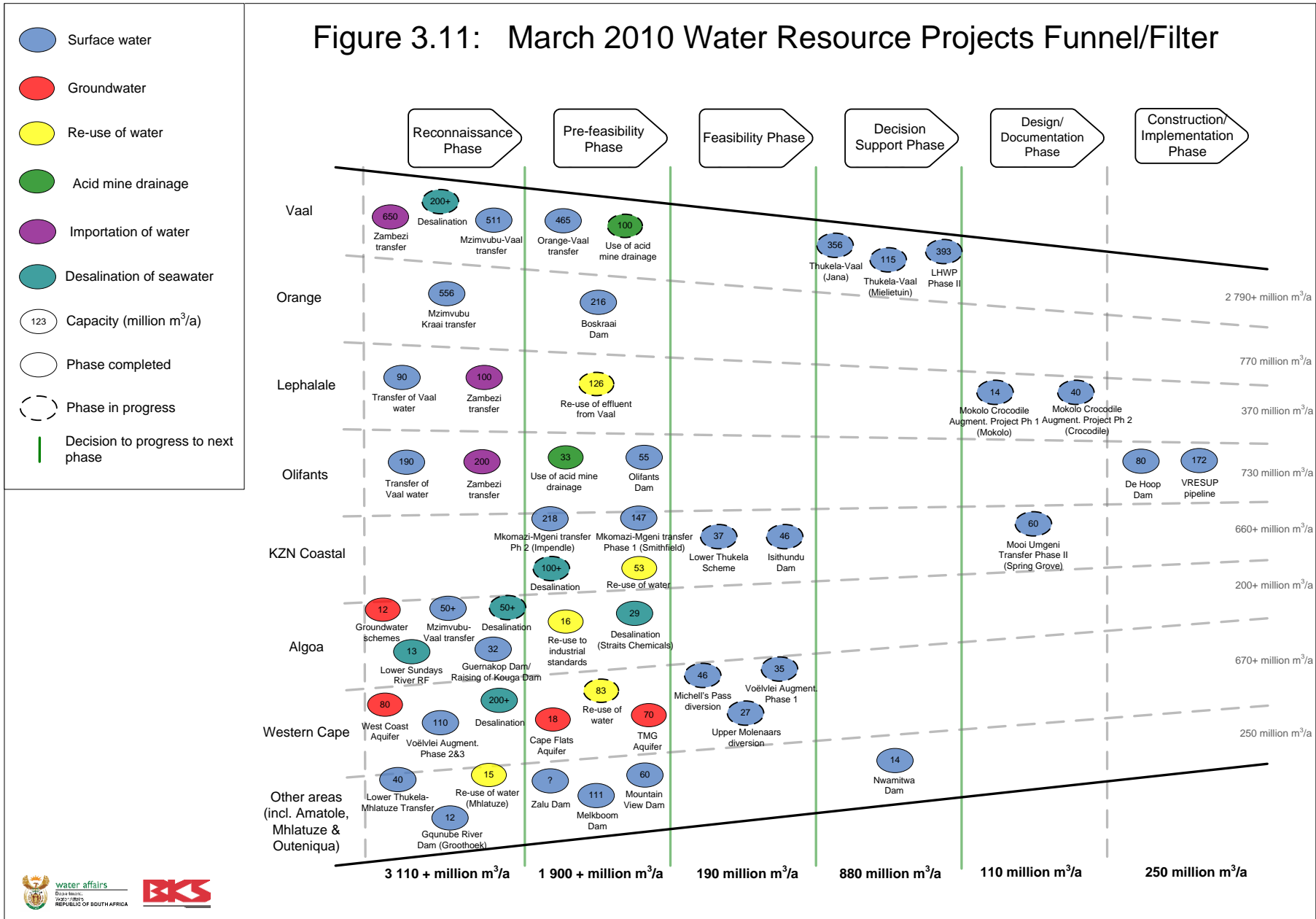
In accordance with the National Water Resource Strategy very little large scale development of water resources for irrigation purposes is foreseen. This is due to the relative scarcity of water and the already high level of water resource development and utilisation in South Africa, as well as the high cost of new water resource developments with respect to the economic and financial viability of irrigation enterprises. Also refer to Section 5.1 on the economic value of water.

The proposed Nwamitwa Dam as mentioned in the previous section would also serve to improve the assurance of supply to existing irrigation users, whilst the proposed Zalu Dam could also support some irrigation development. A possible dam mainly for irrigation purposes is considered in the Mzimvubu River catchment.

3.13 Summary of Development Options

A summary of the potential water resource development options is graphically presented in **Figure 3.11**. It shows the March 2010 development status of each project together with its location and an indication of size. Options mentioned in the preceding sections but which are unlikely to ever be developed, such as the supply of desalinated seawater to the Lephalale area, have been omitted.

Figure 3.11: March 2010 Water Resource Projects Funnel/Filter



4 RECONCILIATION SCENARIOS

This chapter presents the reconciliation of the requirements for and availability of water for each of the areas under consideration.

The ranking and scheduling of development options were based on the criteria as given in Section 2.6. The more stringent implementation of WC/WDM was regarded as non-negotiable. The implementation of development options were therefore scheduled according to the projected future water requirements, after provision was made for the best estimates of the savings that could be achieved through WC/WDM. (That is in addition to measures already taken.)

It needs to be emphasized that the projections made and scheduling of options are intended as indicative only of the possible future water balance situation for the respective areas. The main purpose is to give an indication of whether sufficient water could be made available in future, and also at what order of cost and energy requirements. Much uncertainty remains about what the actual future growth in water requirements will be, and about whatever trends there may be after 2050. Also, for many of the development options only scant details were available. The costs and sizes should therefore be viewed as indicative and for comparative purposes, rather than absolute.

For some of the areas it was found that all the possible development options may not be needed by 2050. These are then shown in shades of grey on the graphs, for information and reference only.

Supporting details on the URVs as well as the timelines for development options can be found in **Appendix M** and **Appendix N** respectively.

4.1 Vaal River System

The findings indicate that sufficient water could be made available to meet the needs from the Vaal River system until about 2050, and at reasonable cost. The cost for developing additional resources thereafter is likely to show a quantum increase. (In the price to the consumer, however, the high unit costs of new developments will largely be masked by the bulk of resources that were previously developed at lower cost.)

A summary of the reconciliation and scheduling of development options for the Vaal River System supply area is given in **Figure 4.1 (a)**.

The following should be noted:

- The diagram shows the use of processed acid mine drainage to be scheduled before the LHWP Phase II (which has a lower URV), as the former is the first option that will be ready for implementation.
- Given that some storage at Bosberg will be required to compensate for the impacts of the LHWP II on the Orange River System, the existence of such a dam may slightly favour an Orange-Vaal transfer over a Thukela-Vaal transfer. This scheme may be further optimised by also considering together the growth in water requirements from the Vaal and Orange River Systems.

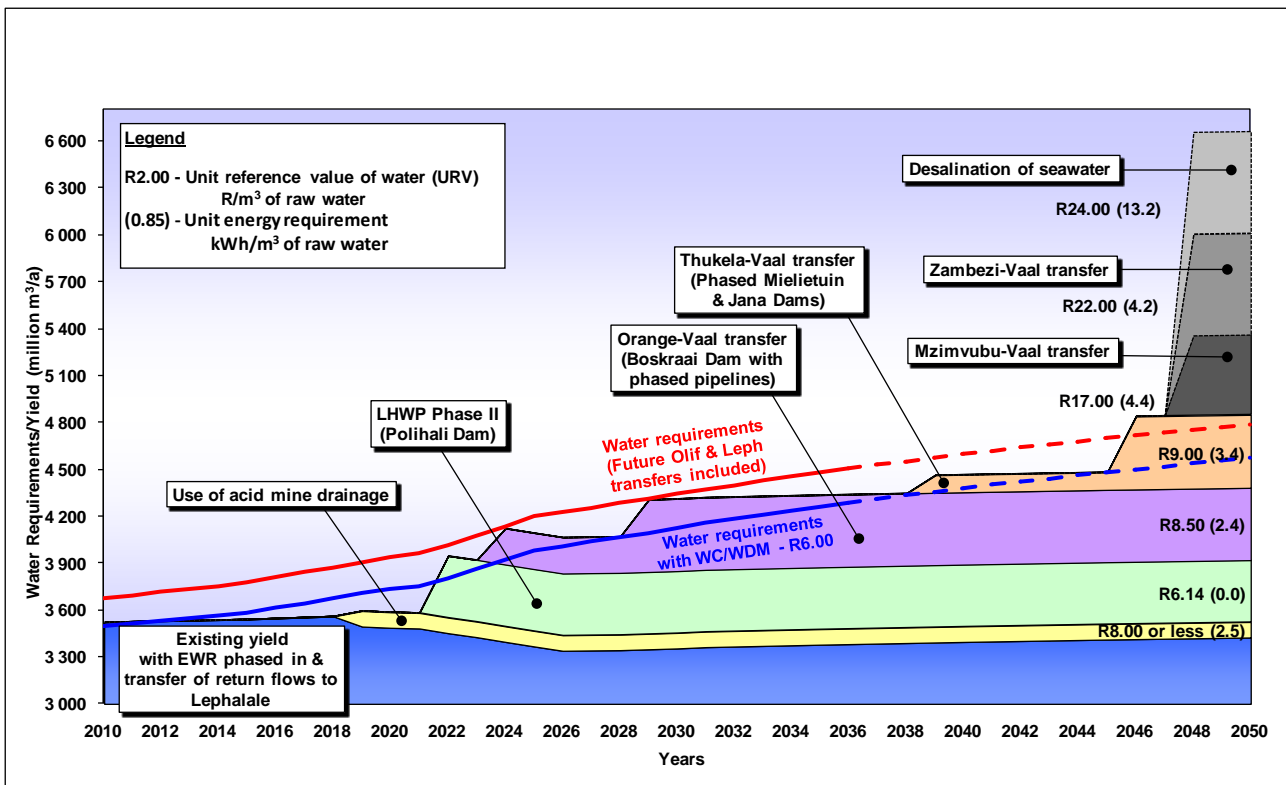


Figure 4.1(a) Vaal River Augmentation Options

- Indications are that the phased implementation of an Orange-Vaal transfer by using two parallel pipelines could be more favourable than a single pipeline. (The transfer of water by pipeline appears to be a better option than the use of canals as was previously proposed.)
- The Thukela-Vaal transfer lends itself to phased implementation, with the transfer from Mielietuin Dam first and then the transfer from Jana Dam.
- The transfer of water from the Mzimvubu River to the Vaal River system will be very expensive and measures such as the re-allocation of water (through trading) may be more advisable.
- It is doubtful whether the importation of water from the Zambezi River and the pumping of desalinated seawater to the Vaal River System will ever be needed and be justifiable.

The reductions in the yield available from the existing system are attributable to the transfer of return flows from the Vaal River catchment to the Lephahale area as well as provisions for the implementation of environmental water requirements (EWR). **Figure 4.1 (b)** provides a breakdown of how the available yield and water requirements, as shown on Figure 4.1(a), were derived. It illustrates the reduction of available yield as a result of the proposed transfer of return flows from the Vaal River catchment to the Lephahale area, together with the impact of an increased provision for ecological water requirements (EWR). It also illustrates the additional water requirements imposed on the Vaal River system through possible transfers of water to the Olifants River catchment and possibly also to the Lephahale area.

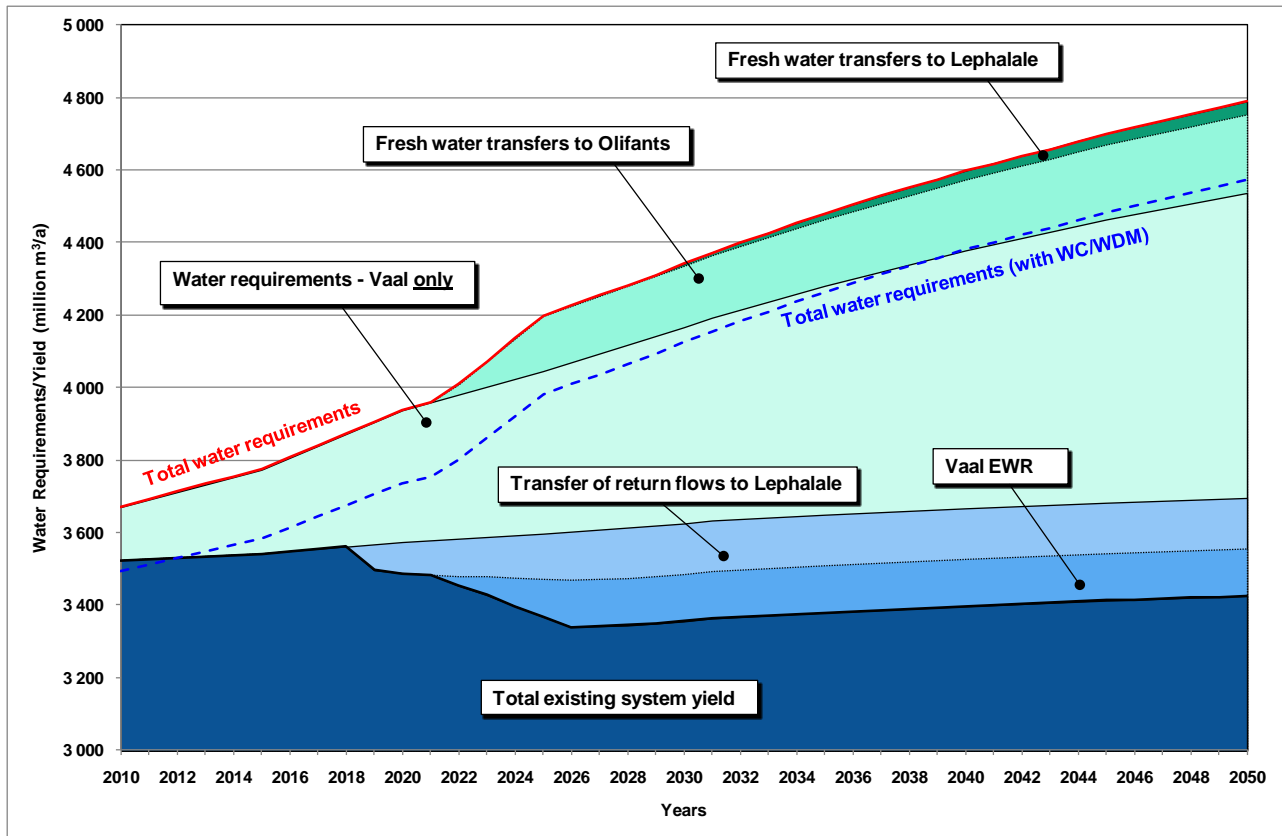


Figure 4.1(b) Integrated Vaal River water requirements and existing system yield (with transfers to the Olifants River catchment and the Lephale area)

Of specific concern is the projected deficiency in water availability over the period 2012 to 2022 (see Figure 4.1 (a)). The indications are that new developments may not be implemented in time to prevent a deficit situation occurring, even after the successful implementation of WC/WDM. Priority measures should be taken to expedite the implementation of the augmentation schemes, as any failure to meet the WC/WDM targets and the possible occurrence of a drought period during that time could seriously aggravate the situation.

4.2 Orange River System

In the context of this report, both Phases I and II of the Lesotho Highlands Water Project (LHWP) are assumed to be in place. Whilst the impacts of these developments on the yield from the Orange River Project (ORP) comprising the Gariep and Vanderkloof Dams are fully accounted for, only the yields downstream of the LHWP are further considered. New dams at Vioolsdrift and at Bosberg, to restore the yield of the ORP to that before the LHWP II, are to form part of the LHWP II development.

Given the above, the water balance for the Orange River System currently reflects a surplus situation, as shown on **Figure 4.2**. The deficit projected for the period 2012 to 2024 is mainly attributable to provisions made for the expansion of irrigation for emerging farmers, possible additional irrigation by Namibia and for the solar power installations by Eskom. Other growth in water requirements are mainly with respect to urban users in Port Elizabeth and Bloemfontein.

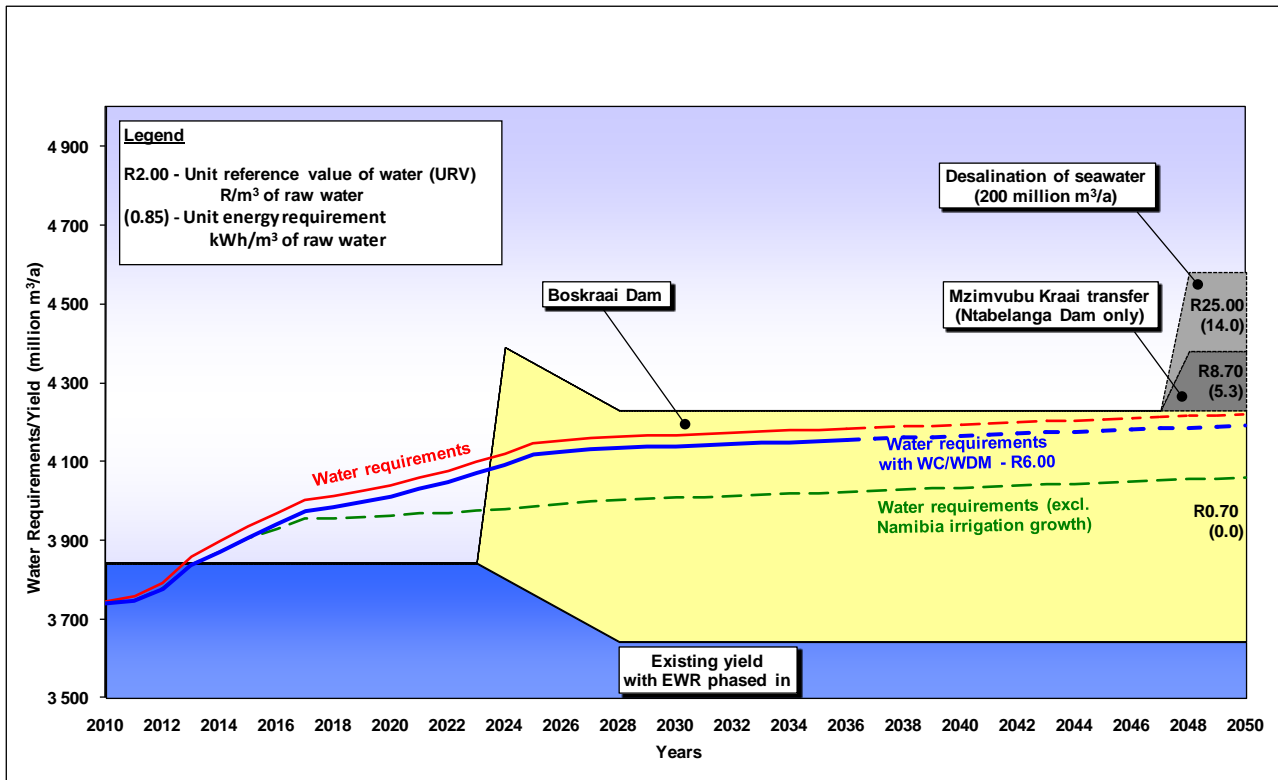


Figure 4.2 Orange River Augmentation Options

The deficit situation can largely be remedied by expediting the construction of the Boskraai Dam together with delaying the expansion of irrigation. Further optimisation can also be achieved through refined synchronisation with transfers to Port Elizabeth (Algoa area).

It is doubtful whether the transfer of water from the Mzimvubu catchment for the express purpose of augmenting supplies along the Orange River will ever be necessary and justifiable.

The transfer of desalinated seawater to the Orange River is purely shown for comparative purposes. It would not be logical to pump water from the ocean to the Orange River, whilst fresh water is supplied from the Orange River to Port Elizabeth on the coast and irrigation along the Fish and Sundays rivers.

4.3 Lephale Area

The yield available from local water resources in the Lephale area is very small, with the consequence that any new developments in the area will essentially be totally dependent on the transfer of water from other areas. A summary of how the expected strong and rapid growth in water requirements can be met, and which is reflective of the current planning, is given in **Figure 4.3**.

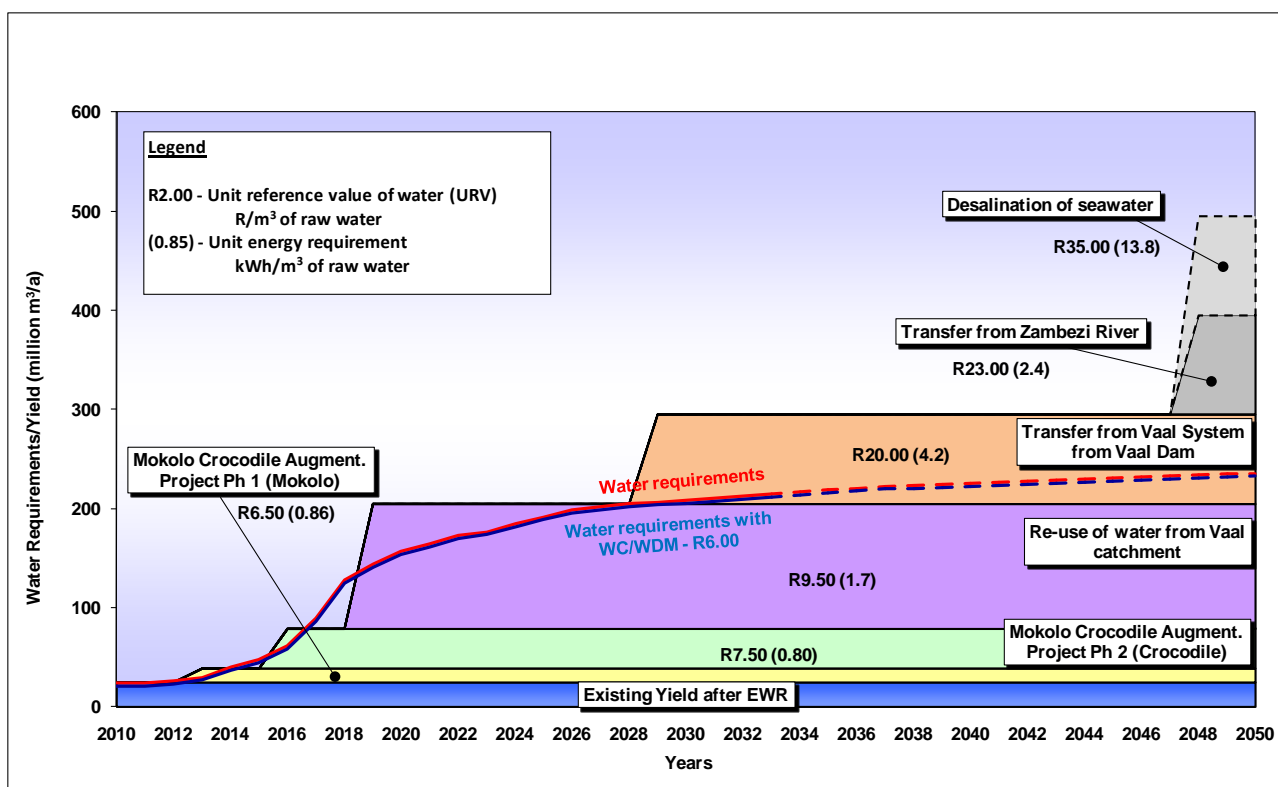


Figure 4.3 Lephallale WMA Augmentation Options

It is important to note that the growth in water requirements reflected in Figure 4.3 is totally as a result of the new power stations, and mining and petrochemical developments in the region with the bulk of the water for use in the production processes. Of importance also is that these processes have already been highly optimised with respect to the consumptive requirements for water. Little scope for WC/WDM therefore exists, whilst virtually all the water needs to be supplied at a very high assurance of supply.

The scheduling of schemes shows a logical progression from the priority use of local water resources (Mokolo Dam as the nearest and cheapest), to those options that would bring water from further afield.

A substantial increase in the unit cost of water as well as in the unit energy requirement is shown to occur once raw water needs to be sourced from the Vaal Dam to the Lephallale area. This is attributable to the fact that, although the water would be abstracted at Vaal Dam, it would actually be sourced via the Orange-Vaal (or Thukela-Vaal) transfer scheme at the time.

It should also be noted that the URV and the unit energy requirement for a Vaal Dam to Lephallale transfer as given in Figure 4.3 are both higher than the corresponding numbers in Figure 3.3. The reason for this being that for the comparisons in Figure 3.3 all optional developments were considered as being the “next best” scheme, whilst for Figure 4.3 the actual conceptual scheduling of options was used. Therefore, in the case of Figure 3.3 the water was to be sourced from the LHWP II, whilst the numbers in Figure 4.3 reflect the Orange River as source. This also explains the relatively small difference between the transfer of water from the Vaal River System to Lephallale and a possible transfer from the Zambezi River to Lephallale.

Whilst the importation of water from the Zambezi River as well as the pumping of desalinated seawater to the Lephalale area will probably be prohibitively expensive, it is very unlikely that these sources will have to be resorted to.

4.4 Olifants River System

The water balance for the Olifants River System is already in a deficit situation, as shown on **Figure 4.4**. This will partly be eased as the yield from the De Hoop Dam is phased in. Further augmentation of the resources will, however, still be required. A new dam on the middle Olifants River would be the lowest cost option, followed by the use of treated mine drainage.

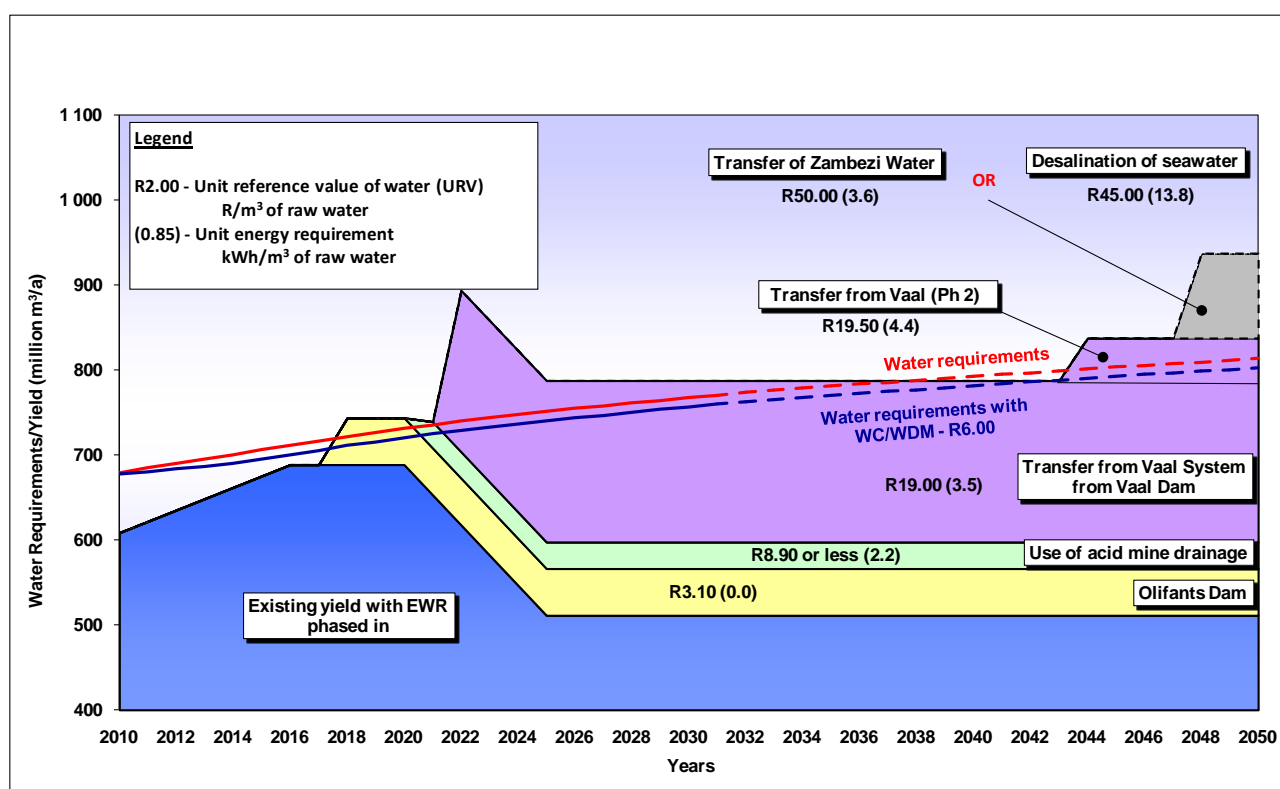


Figure 4.4: Olifants River augmentation options

Of major consideration with respect to the Olifants River System is the important conservation status of the Kruger National Park downstream, and the priority need for implementation of the Reserve (provisionally shown to be phased in during 2020 to 2025). This will reduce the water available for abstraction by about 180 million m³ per year, which will then have to be replaced by transfers from the Vaal River (and indirectly from augmentation schemes to the Vaal River System).

Apart from the high cost and energy requirements of such transfer, much further investigation and debate are needed to judge the merits of having water resource developments in remote catchments to compensate for environmental requirements in another river. Applying the principles and priorities from the National Water Resources Strategy to the Olifants River System would require that the re-apportionment/re-allocation of resources through compulsory licensing first be resorted to.

The financial and environmental costs to continue meeting future growth in water requirements in the Olifants River System appear to be unjustifiable and unsustainable.

4.5 Mhlatuze System

The requirements for and availability of water are approximately in balance for the Mhlatuze System. A small theoretical deficit pertains to a shortfall with respect to allocations for irrigation water, but which are not all being fully utilised.

Due to the dominance of the port and large industries in the economy of Richards Bay, the growth in water requirements is largely influenced by specific identifiable developments. With a temporary stagnation in such development, no growth in water requirements is currently foreseen, as also reflected on **Figure 4.5**. The options that could be resorted to for the augmentation of resources, should it become necessary, are:

- Transfer of water from the Lower Thukela River, should water be available at the time;
- Re-use of municipal/domestic effluent; and
- The desalination of seawater.

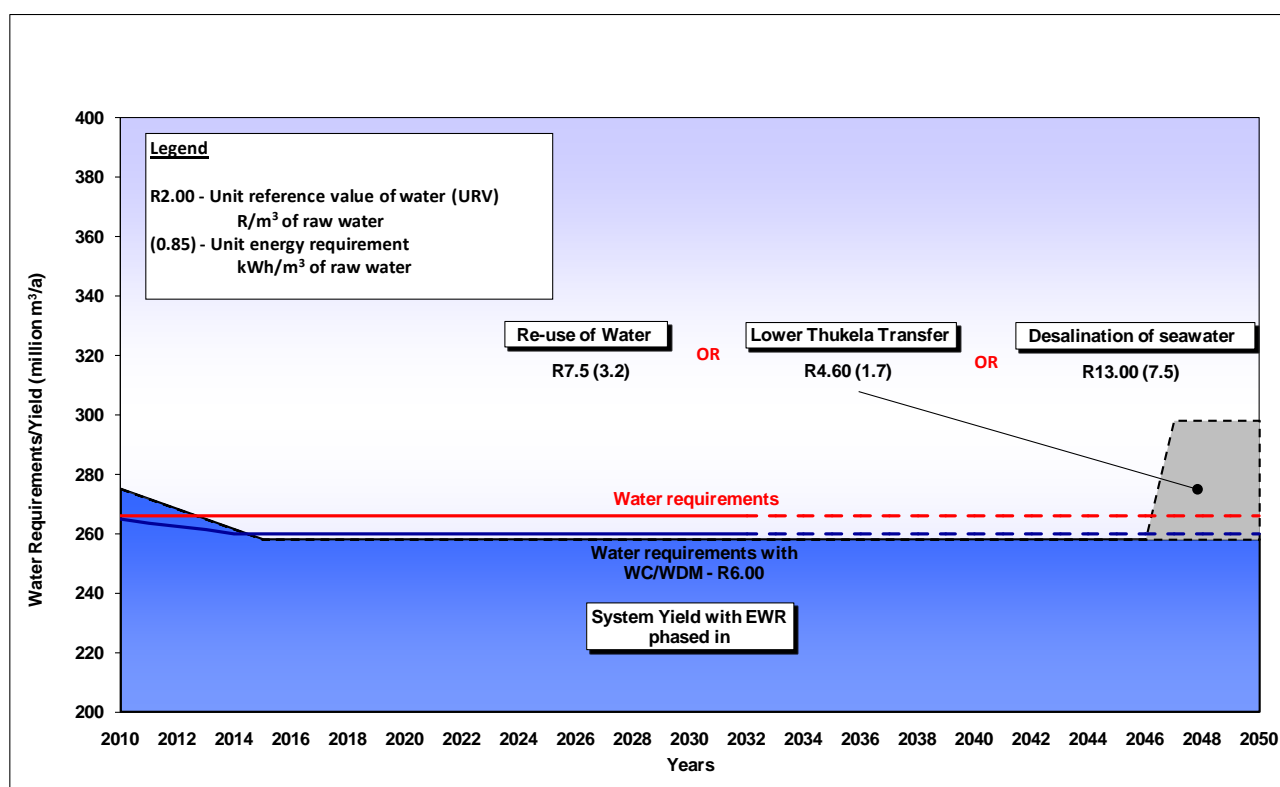


Figure 4.5 Mhlatuze System augmentation options

The small surplus that currently exists will change into a small deficit once releases for the Reserve are implemented. The deficit can mostly be attributed to an over-allocation of irrigation water. All the allocations are not being fully utilised, however, which still leaves some margin in practice.

4.6 KwaZulu-Natal Coastal Metropolitan Area

Water supply to the KZN Coastal Metropolitan Area has been under stress during recent years and several studies have been conducted on the augmentation of the water resources to meet the future growth in water requirements. The main options available are described in Section 3.6, with a provisional implementation scheduling shown on **Figure 4.6**. It is evident from the diagram that it would not be possible for any of the options to be implemented in time to overcome the current deficit situation, and that water supply to the area would remain vulnerable to severe curtailments at least until 2017.

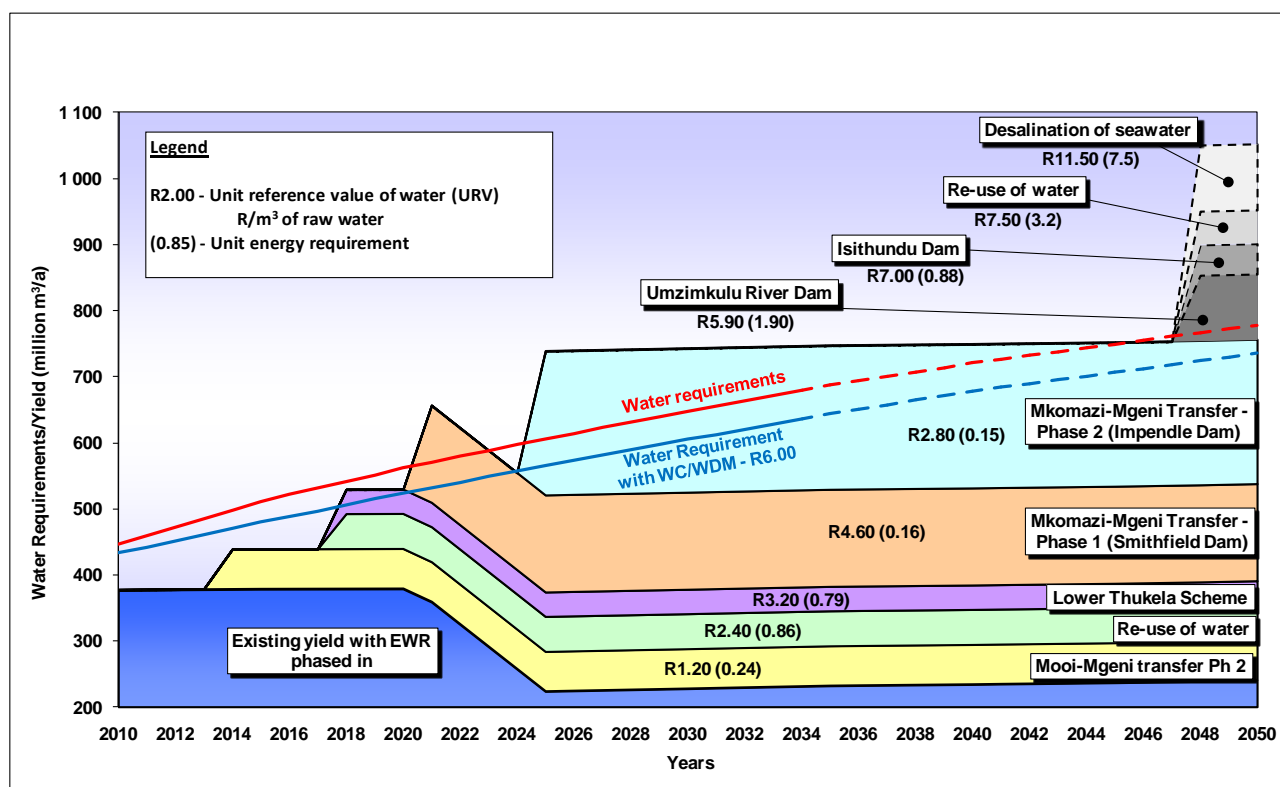


Figure 4.6 KZN Coastal Augmentation Options

A substantial reduction in the yield available for abstraction will result when releases for the Reserve are implemented, mainly relating to dams in the Mgeni River system. According to current estimates, the yield that will have to be replaced is more than the net yield (after provision for the Reserve) from the proposed Smithfield Dam. It is important therefore, that the quantities for the Reserve be verified also in the context of considering the impacts on both the Mgeni and Mkomazi rivers.

The growth in available yield from 2025 to 2050, as is noticeable on the graph, is as a result of return flows to the river system.

It appears unlikely that the desalination of seawater, which is substantially more expensive and more energy intensive than the other options, will need to be implemented in the foreseeable future.

4.7 Amatole System

A moderate growth in water requirements is foreseen for the Amatole system, although substantial uncertainty in this regard prevails. From a current balanced situation, a small deficit is expected to develop before a next augmentation option can be implemented, as reflected on **Figure 4.7**. As also applies to several other systems, the impact of the implementation of the Reserve according to current quantifications is substantial, and will have to be made good by the construction of new dams, which in turn may be questionable.

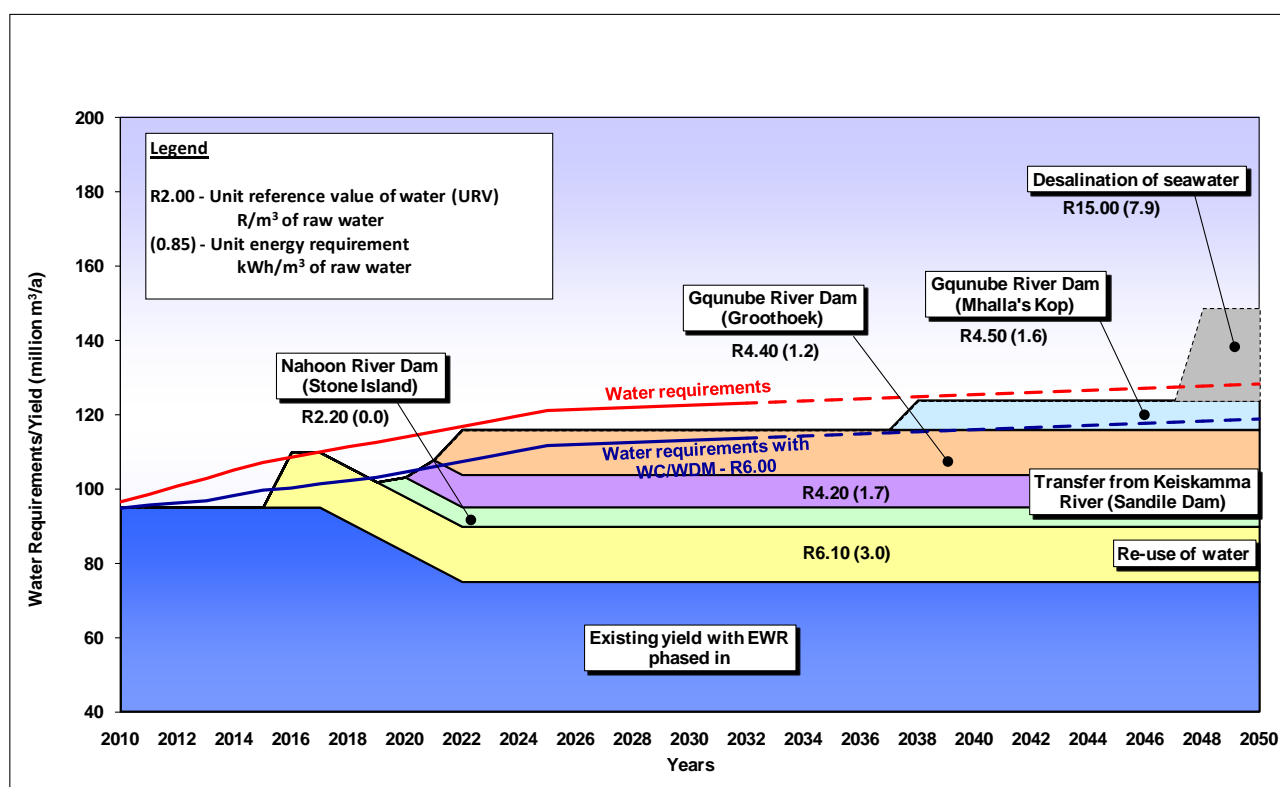


Figure 4.7: Amatole System Augmentation Options

The re-use of water, although not the cheapest option, was scheduled first for implementation due to the expected shorter time line compared to the construction of new dams. Following on the re-use and new dam options, further growth in water requirements will have to be met from the desalination of seawater the unit cost and energy requirements of which will be substantially higher than for the more traditional land-based options.

4.8 Algoa Area

Bolstered by a recent additional allocation from the Orange River System, sufficient water resources should be available to meet the requirements in the Algoa water supply area until about 2025. This provides sufficient time for the implementation of any of the future augmentation options. The implementation of options has therefore simply been scheduled according to unit costs and unit energy requirements as shown in **Figure 4.8**.

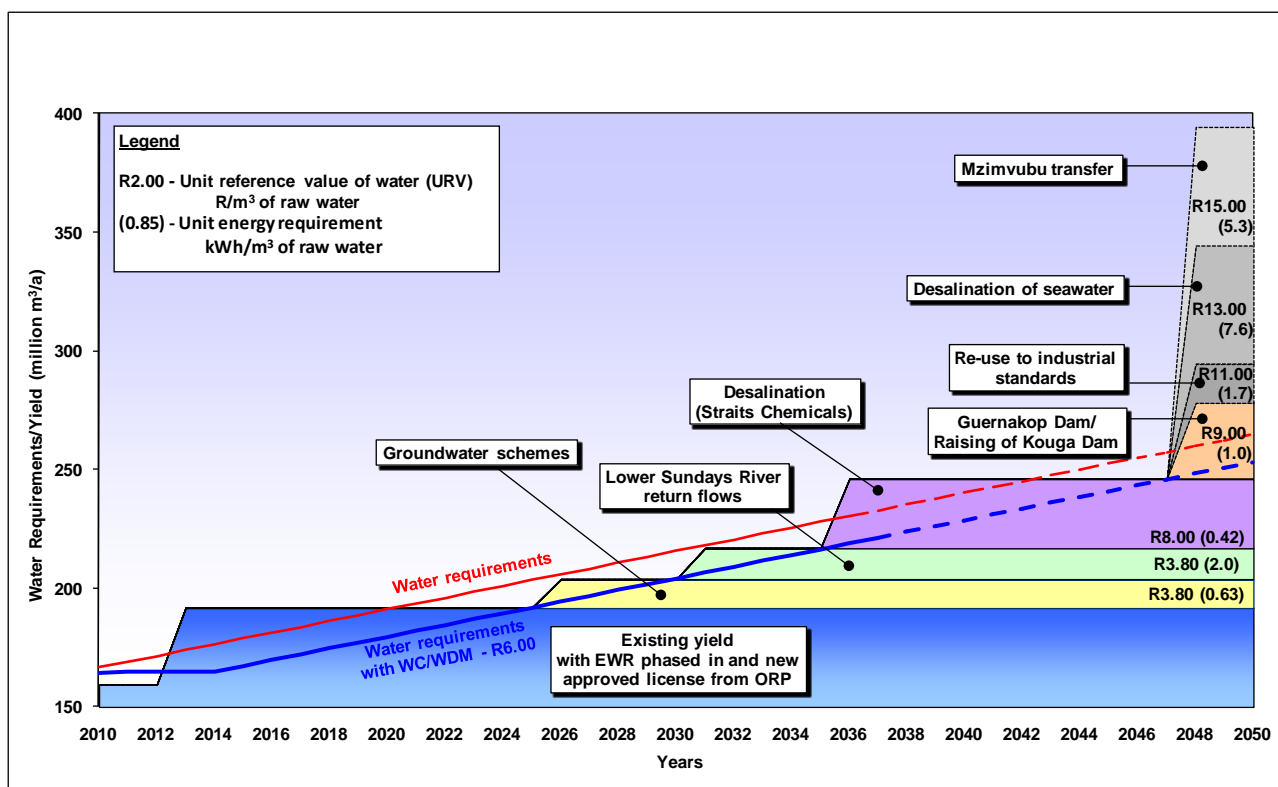


Figure 4.8 Algoa WSA Augmentation Options

The projections at this stage indicate that sufficient water can be made available to the Algoa area until well beyond 2050, although at steeply increasing cost of water from the later schemes. The impacts of climate change may, however, influence the situation and should regularly be assessed.

4.9 Outeniqua Coastal Area

Overall the requirements for and availability of water in the Outeniqua coastal area are approximately in balance (that is not accounting for the current drought situation). Given the relatively small size of the schemes for this region compared to most other regions, construction times can be expected to also be commensurately shorter, thus allowing for the incremental implementation of new schemes according to the growth in water requirements. However, it may still be necessary to first resort to the more expensive option of re-use of water before new surface water schemes can be implemented, as shown on **Figure 4.9**. Also evident from Figure 4.9 is the limited extent of the local freshwater resources, including the re-use of water. Should current water use patterns and growth trends persist, the larger scale use of desalinated seawater will need to be resorted to around 2040.

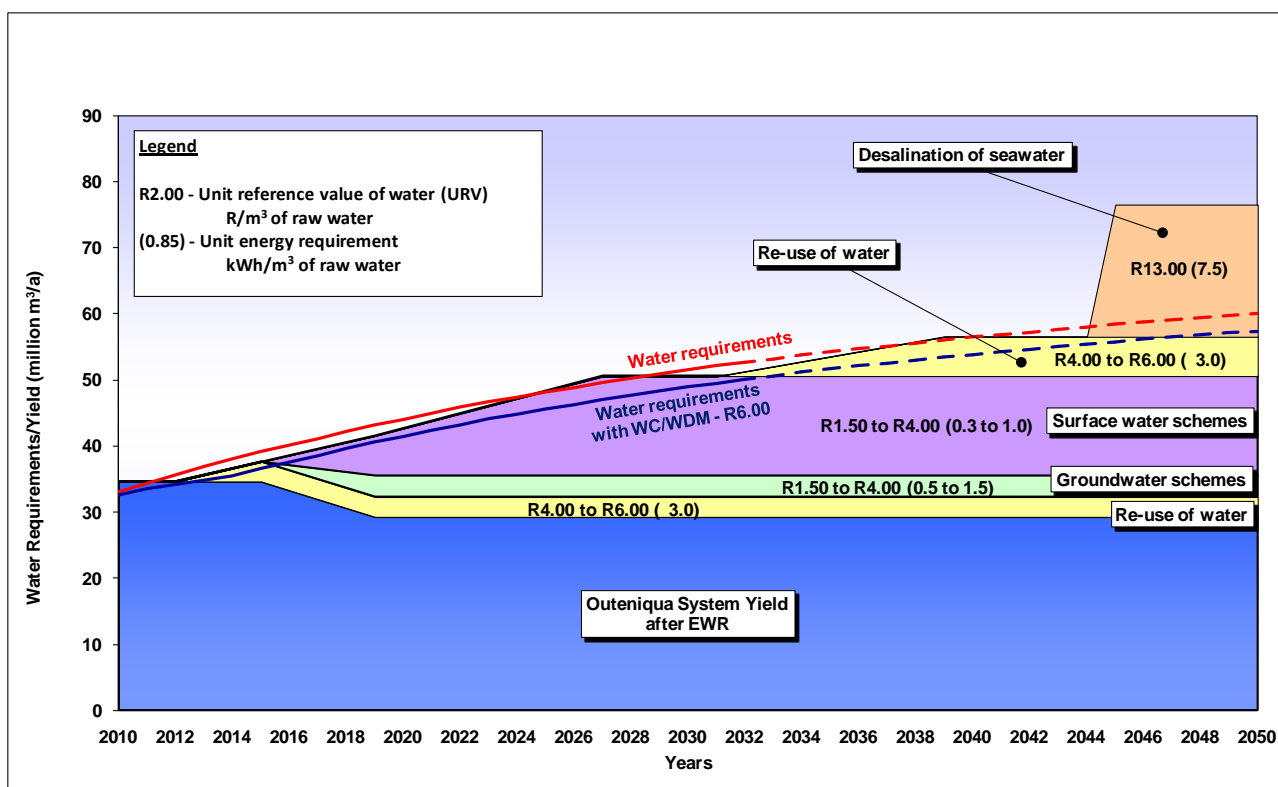


Figure 4.9 Outeniqua Coastal Area Augmentation Options

4.10 Western Cape System

The freshwater resources within practical and economic proximity of the Western Cape System have been nearly fully developed and utilised, with only options for some incremental developments still remaining. Combined, these options would yield sufficient water only to meet the growth in water requirements until approximately 2028, after which the re-use of water, followed by the desalination of seawater, would need to be resorted to. A provisional scheduling of resources is shown on **Figure 4.10 (a)**.

In the diagram, the scheduling of groundwater use from the TMG aquifer is shown to follow after the more expensive Michell's Pass diversion. This is because of further investigative work and feasibility assessments that still need to be conducted before the implementation of the TMG groundwater option in practice. There is also a paucity of costing information on the TMG option at this time, and the unit costs and unit energy requirements will likely have to be adjusted, following the outcome of the further studies.

The high water requirement projection suggest continuing rapid growth well beyond 2025, which is an anomaly when compared to growth projections in other metropolitan areas that tend to show a slowing in water requirement growth beyond 2025. It may therefore be prudent to re-assess the growth projections, based on primary driving elements.

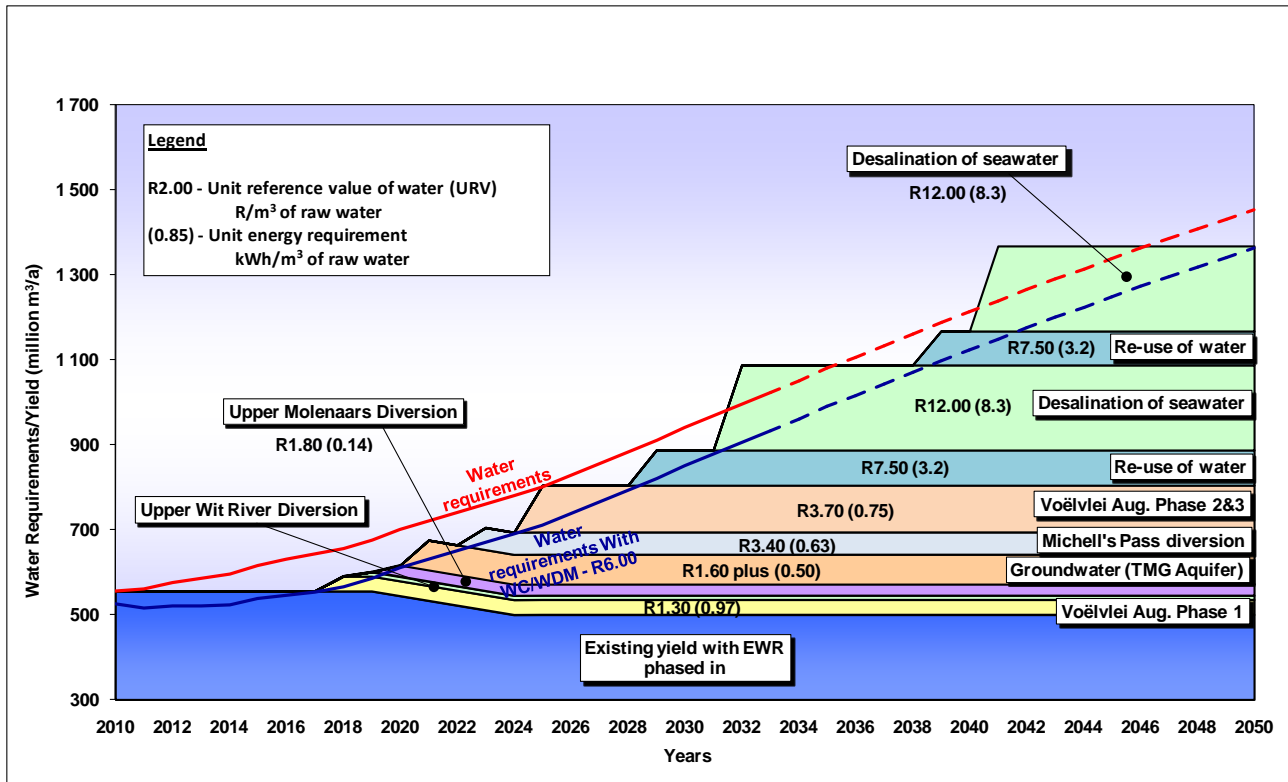


Figure 4.10 (a) Western Cape Augmentation Options (without climate change)

Given the growing consensus amongst the scientific community that rainfall over the south-western part of South Africa can be expected to significantly decline and become highly variable over the coming decades, assessments were also performed on the impacts of climate change on the yields obtainable from existing water resource developments. The results showed a significant decline in yield, as presented in **Figure 4.10 (b)**, with the obvious impact of accelerating the need for new augmentation schemes.

Not included in Figure 4.10 (b) is the effect that climate change may have on the requirements for water. The impacts of global warming and possible seasonal shifts in rainfall could in particular be pronounced for agricultural irrigation, which represent of the order of 30 percent of the current (2010) water use from the Western Cape System.

4.11 Remainder of South Africa

In general, water resource developments in the remainder of South Africa are of a less critical nature than those serving the main metropolitan and growth areas. These projects are also typically independent from one another, with no synchronisation of their scheduling needed, and are not further addressed.

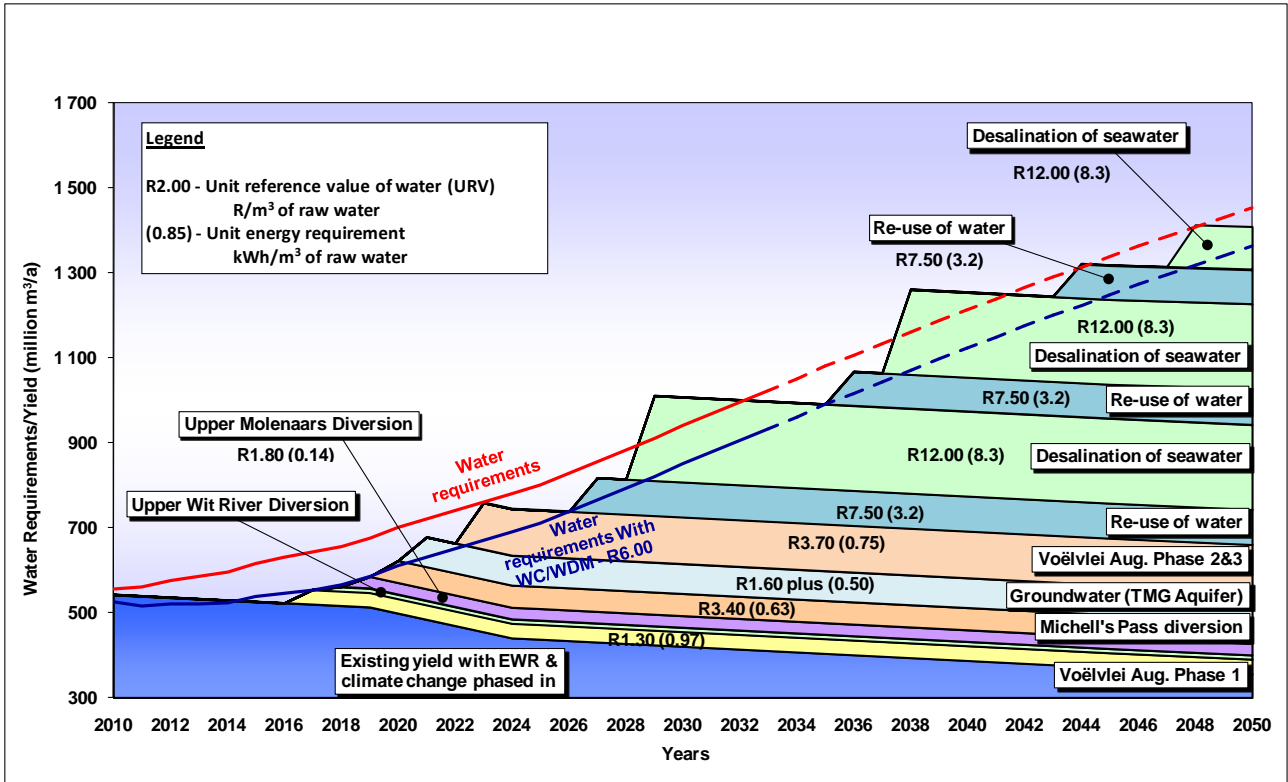


Figure 4.10 (b) Western Cape Augmentation Options (includes the negative effects of climate change in the Western Cape)

5 ECONOMIC AND FINANCIAL

5.1 Economic value of water

The economic value of water refers to the assessment of the economic benefits that are typically achieved through the use of water in different sectors of the economy. It is therefore not based on the cost of water in any way. From an economic perspective, however, it is important that the value of water to be derived from the application thereof for purposes of economic production be in excess of the cost of water supply for that particular use. Should this not be the case, it would imply that other sectors of the economy would indirectly be subsidising the relevant use.

The criteria as above, however, does not apply to the primary uses of water such as basic human needs and for environmental purposes, which are not measured in economic terms but where other norms apply.

Economic effects are conveniently expressed in terms of production and employment. A well-known production indicator is the Gross Domestic Product (GDP). Reference can also be made to Gross Value Add (GVA). Employment is expressed in jobs (person years) per unit of water. Issues such as social impacts as well as construction costs and transfer costs are excluded from the above.

5.1.1 Sectoral water utilisation efficiencies

In previous studies on the Orange River and Vaal River catchments, sectoral water utilisation efficiencies were determined by means of a “water multiplier” analysis, to obtain an indication of the relative importance of water in production by some of the water use sectors and sub-sectors of the economy.

The results of the analysis are in terms of national multipliers per million m³ of water used, expressed as employment opportunities and GDP supported. High-, mid- and low-level jobs are distinguished, based on the skills levels required to produce the output.

An abstract of the results is given in **Table 5.1**. These are based on 1995 statistics and incorporate both direct and indirect effects. The rand values were adjusted to June 2009, according to the CPI in Figure 2.1.

Table 5.1: Sectoral multipliers per million m³ water used

Sector	High-level jobs	Mid-level jobs	Low-level jobs	GDP supported (R million)
Agriculture (general) ⁽¹⁾	10	30	210	13
Gold mining	650	2 880	11 900	1 600
General manufacturing	6 800	27 000	28 000	6 700
Pulp and paper	25 000	79 000	81 000	23 000
Beverages	38 000	131 000	158 000	37 000
Glass products ⁽²⁾	233 000	716 000	836 000	250 000

⁽¹⁾ Least efficient (includes irrigation, rain-fed and livestock farming)

⁽²⁾ Most efficient

The results show agriculture as the most inefficient user of water. Gold mining and general manufacturing could serve as being representative of water use efficiencies in the mining and manufacturing sectors. It is important to note that the results are based on national statistics, and therefore reflect the average performance of the different sectors. Wide variations around these averages are bound to occur, but they are unlikely to change the essence of the results, considering the very large difference between agriculture and the following sector in the ranking.

Similar outcomes were also obtained in a study with respect to a new water resource development in the Olifants River catchment that was based on 2002 statistics. The findings in terms of water use, in this case expressed as GVA, are summarised in **Table 5.2**.

Table 5.2 Anticipated total impact per million m³ water used

Sector	GVA (R million)	Employment
Agriculture (irrigation)	20	200
Mining	370	3 300

5.1.2 Utilisation efficiencies of water in different geographic areas

In this case the economic benefits of allocating the water to the Orange and Fish/Sundays River region, where the economic activity is dominated by irrigated agriculture, were compared with the benefits achievable by applying the same volumes of water to the diversified and industrialised economy of Gauteng.

The results of the analysis, as summarised in **Table 5.3**, indicated that allocating water for use in the industrialised areas rather than for irrigated agriculture, will, from an economic point of view, render the highest returns.

Table 5.3 Comparative economic returns from water use in the Orange River and Gauteng areas

Factor	Orange River supported area	Gauteng area	Ratio
Production (R million/million m ³)	2.1	510	1:240
Employment (jobs/million m ³)	24	1 940	1:80

5.1.3 Summarised findings

The results obtained from the economic analyses indicate that agriculture as a general economic sector and irrigation as a specific sub sector, are relatively inefficient users of water. The agricultural sector utilises significantly more water to produce output and creates less employment per unit of water than any other sector in the economy.

This does not imply that water should be taken away from irrigation, but rather that industrial activity should not be impeded by a lack of water in favour of irrigated agriculture. Whereas the availability of water may stimulate growth in agricultural irrigation, water *per se* does not induce industrial development. The non-availability of water will, however, impose severe limitations on industrial activity and growth.

It also implies that, from an economic perspective, consideration should first be given to the possible re-allocation of water from irrigation to other sectors, before new water resources are developed at a higher unit cost of water than the value of production achievable from the continued irrigation use of existing resources.

5.2 Financial requirements

Based on the scheduling of projects as presented in Chapter 4, together with the cost estimates and construction times used in the URV calculations, projections were made of the capital investments as well as of the operation and maintenance costs required. A summary of these, for all the regions in the country, is presented in **Figure 5.1** for the period until 2050. All the costs are in constant June 2009 money values, with each bar representing the relevant annual expenditures.

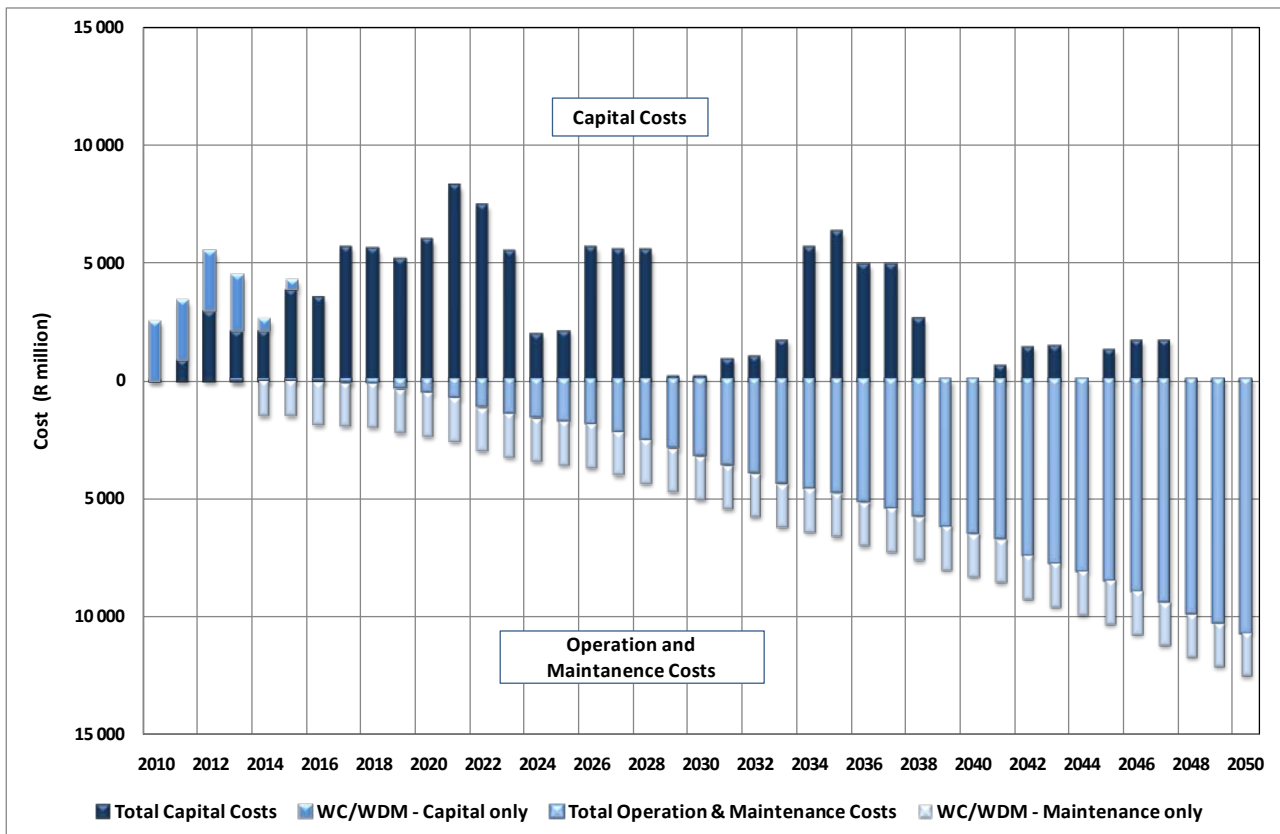


Figure 5.1 Water Resource Projects – Combined capital, operations and maintenance and WC/WDM costs stream

Figures 5.2 and 5.3 present break-downs per region, of the information given in Figure 5.1.

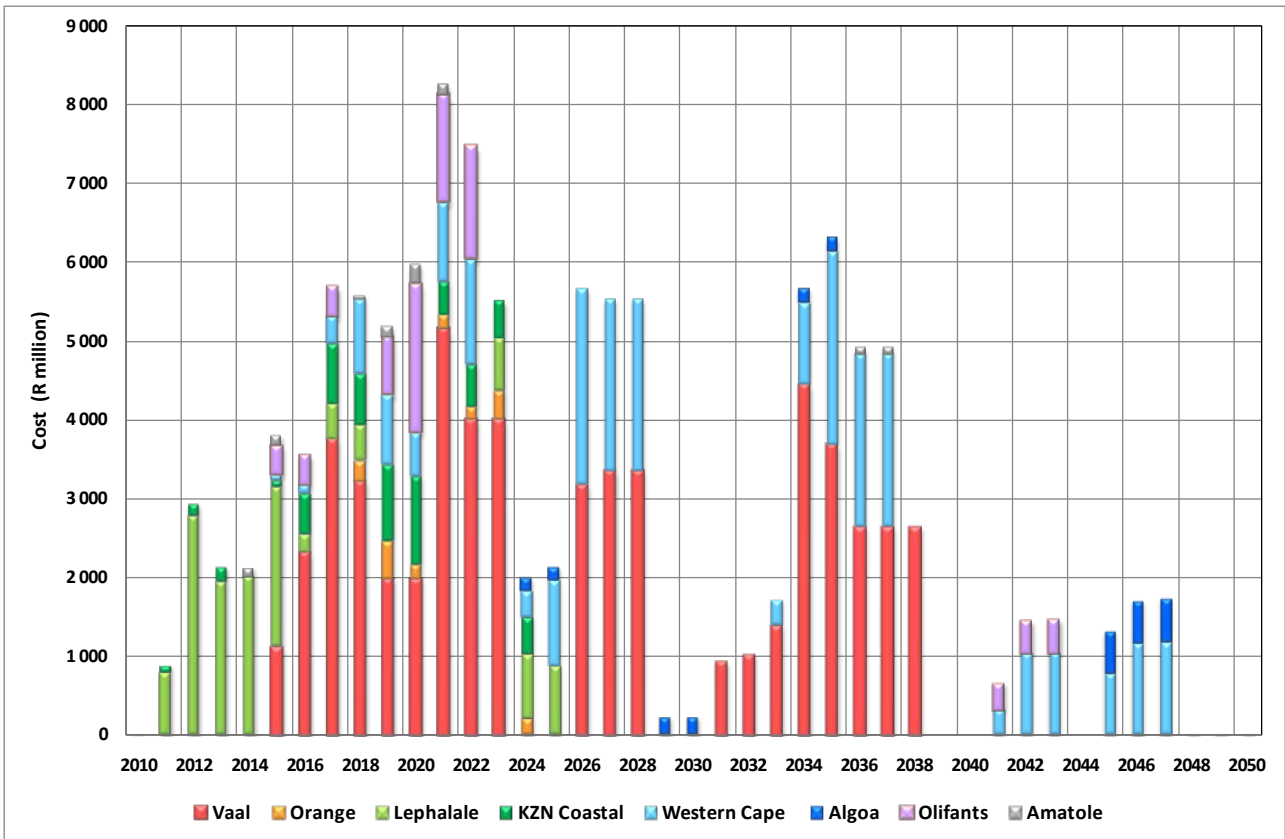


Figure 5.2 Water resource projects – Capital costs stream

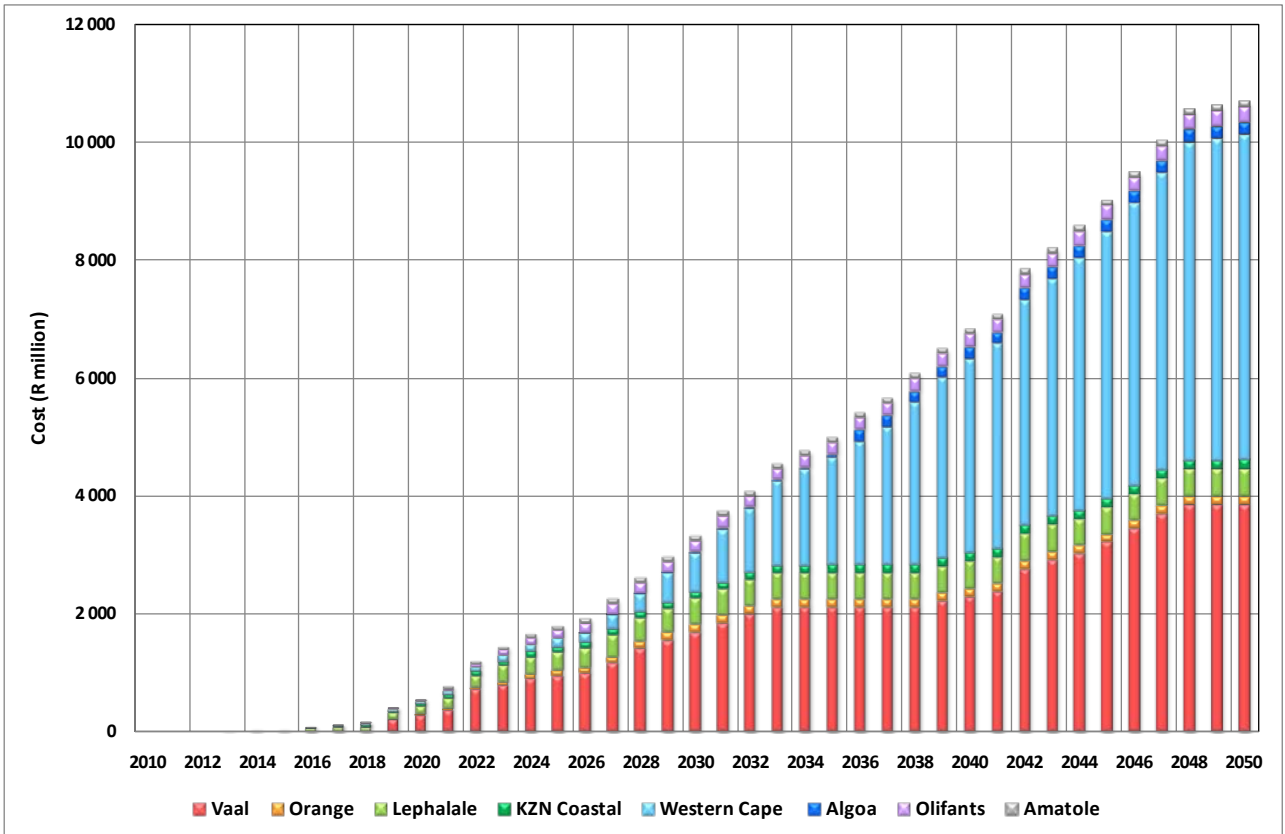


Figure 5.3 Water resource projects: Operations and maintenance costs stream

Particularly evident from Figure 5.1 is the high initial investments required with respect to WC/WDM. The successful implementation of WC/WDM is a necessary prerequisite to achieving the lower demand curves on which the scheduling of all the augmentation options has been based (refer to Chapter 4). Also evident is the high capital costs during the early years for the construction of new schemes, compared to lesser expenditures during later years. This is reflective of the backlog that has developed with respect to the implementation of new schemes, and where further delays are likely to put the water supply situation to several key economic and growth areas in the country severely at risk.

The strong growth in operation and maintenance costs in future (all in current money values) is largely attributable to the large energy requirements for future pumping of water and desalination of seawater, as covered in Section 5.3.

5.3 Energy Requirements

Similar to the financial requirements, estimates were also made of the future energy requirements associated with the various augmentation options to be implemented. Only the energy requirements of new developments were considered, and are summarized in **Figure 5.4**. This indicates a total of about 1000 MW additional electricity to be required for water resource projects, by year 2050. Also evident from figure 5.4 are the large energy requirements for the future pumping of water to the Vaal River System supply area and in particular also for the desalination of seawater in the Western Cape.

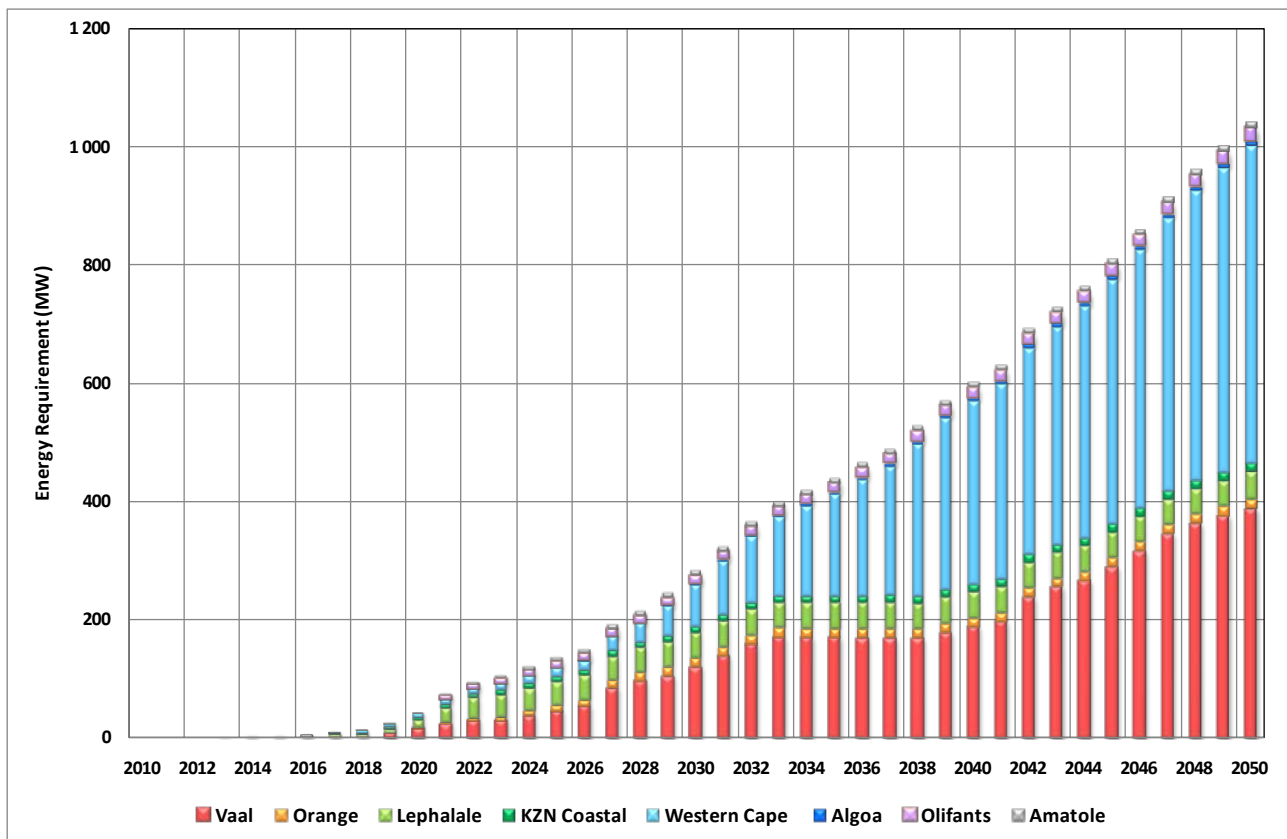


Figure 5.4 Water resource projects: Future energy requirements

6 SUMMARY AND CONCLUSIONS

Sufficient water can be made available to meet the future needs in all the major urban and industrial centres in South Africa, although at steeply increasing costs in most cases. The full utilisation of fresh water will also not be reached at a common date throughout the country, but at different dates over an extended period of time, depending on the situation pertaining to the respective areas. Water resources across the country will become even more inter-connected and inter-dependant in future.

The greater Cape Town area, in specific, is likely to become totally dependent on the desalination of seawater and the re-use of water for any growth in water requirements from about 2030. Sufficient water can be made available to the Vaal River System supply area (Gauteng) at reasonable cost until about 2050, whilst relatively low cost water can be made available to the KwaZulu-Natal coastal metropolitan areas to well beyond 2050. Various augmentation options can still be implemented to secure the future water supply to the other coastal areas, although in several areas the desalination of seawater will have to be resorted to in later years (Amatole \pm 2050, Outeniqua \pm 2045 (earlier for some parts), Mhlatuze beyond 2050, KZN Coastal beyond 2050 and Algoa beyond 2050).

Most of the projected water requirements for the mining, energy and petrochemical developments in the Lephalale area can be supplied from the Crocodile and Vaal River systems at reasonable cost. Depending on the ultimate size of the developments it may, however, be necessary to transfer water from as far away as the Orange River and at substantial cost.

The most critical situation is with respect to the Olifants River system where a deficit already exists. This will be dramatically exacerbated with the implementation of releases for the ecological Reserve, thus requiring the large-scale augmentation of resources from the Vaal River System at substantial cost.

In several cases the implementation of releases for the Reserve from existing water resource developments, is shown to be compensated for by new water resource developments – mostly in other areas with transfers to where needed. It may be possible that at least some of these could be offset or be partly compensated for by applying compulsory licensing.

Comparisons of the URVs to the economic value of water indicate that the unit cost of water from some new developments will substantially exceed the economic value of some existing water uses. (Although the URVs and economic values are based on different financial and economic approaches and are not intended to be directly comparable, they at least provide a broad indication of the relative costs and economic values/benefits.) The re-allocation of water could therefore offer a feasible alternative to some new resource developments and augmentation schemes.

It is also evident from the report that large financial investments will be required to secure the future water resource situation in South Africa.

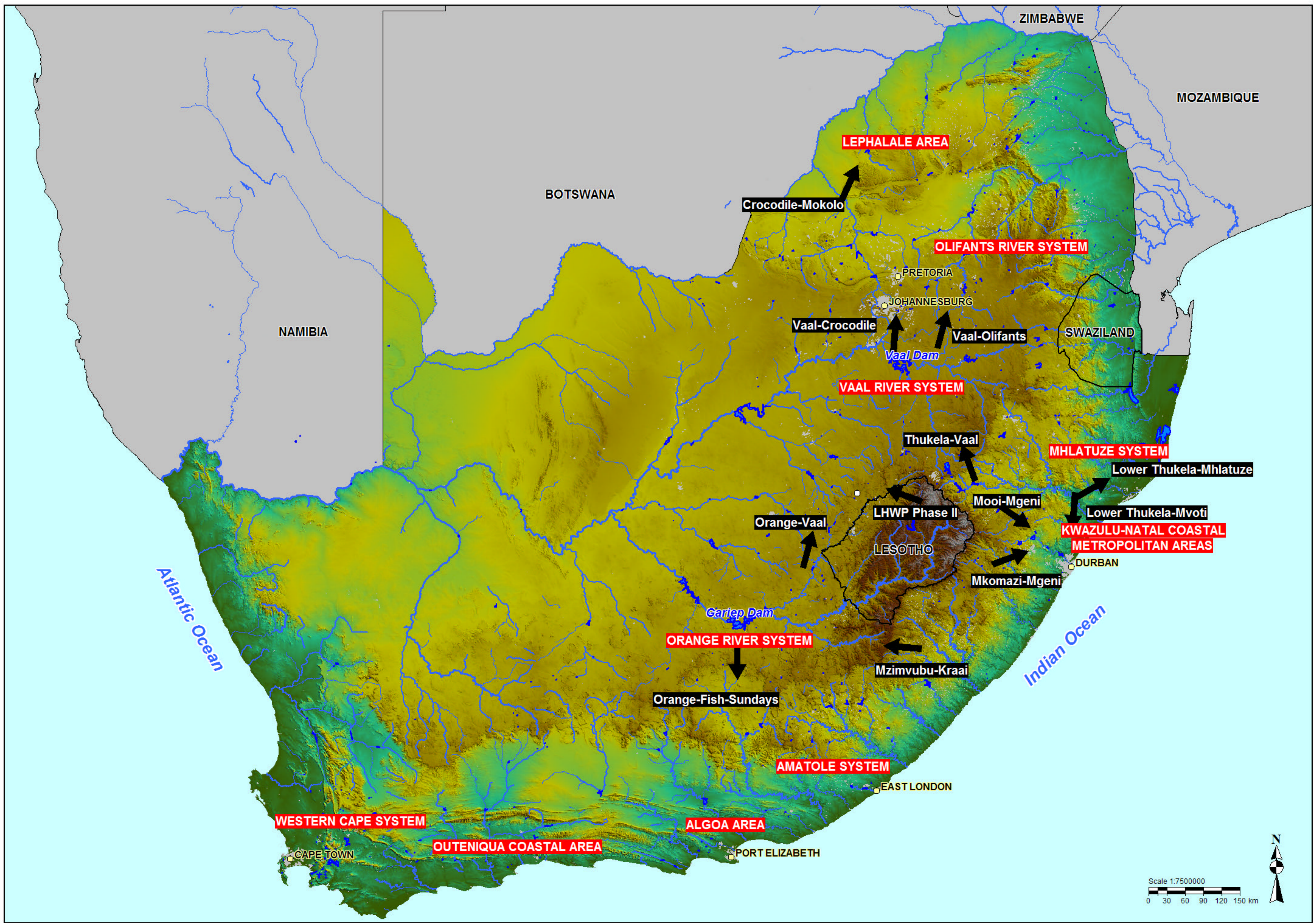
7 RECOMMENDATIONS

Key recommendations that flow from the findings of the report are concisely captured below:

- Long-term financial planning should be conducted to provide for the large capital investments in water resource developments together with the relevant operating and maintenance costs that will be needed during the coming decades.
- The implementation of projects needs to be expedited and decision-making streamlined to prevent further backlogs from developing.
- The practical aspects relating to the implementation of the ecological Reserve should be further investigated and clear guidelines, also on the application of compulsory licensing and should be developed as a priority.
- Continued monitoring and assessment of developments and of water requirements (as is being done). Specific attention needs to be given to remain abreast with technological developments and trends on climate change.
- Further studies need to be conducted into the value of water in different sectors and uses, to inform the possible re-allocation of resources. Social, political and strategic aspects should be considered together with the economic value of water, to ensure that all are properly accounted for.
- Following on the latter point above, a national strategy should be developed on the preferential utilisation of the country's water resources. This should also include guidelines on what products should preferably be produced/grown in South Africa, and what products could or should rather be imported, thereby saving large quantities of precious water in South Africa, without imposing any unwarranted risks.

APPENDIX A

LOCATION OF DEVELOPMENT OPTIONS (MAP)



ZIMBABWE

MOZAMBIQUE

BOTSWANA

NAMIBIA

SWAZILAND

LEPHALALE AREA

OLIFANTS RIVER SYSTEM

Crocodile-Mokolo

PRETORIA

JOHANNESBURG

Vaal-Crocodile

Vaal Dam

Vaal-Olifants

VAAL RIVER SYSTEM

Thukela-Vaal

MHLATUZE SYSTEM

Lower Thukela-Mhlatauze

Orange-Vaal

LHWP Phase II

Mooi-Mgeni

Lower Thukela-Mvoti

KWAZULU-NATAL COASTAL METROPOLITAN AREAS

LESOTHO

DURBAN

Mkomazi-Mgeni

Atlantic Ocean

Indian Ocean

ORANGE RIVER SYSTEM

Gariep Dam

Orange-Fish-Sundays

Mzimvubu-Kraai

AMATOLE SYSTEM

EAST LONDON

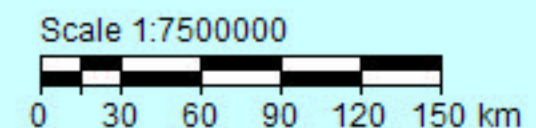
WESTERN CAPE SYSTEM

ALGOA AREA

OUTENIQUA COASTAL AREA

PORT ELIZABETH

CAPE TOWN



APPENDIX B

GENERAL ASSUMPTIONS FOR URV CALCULATIONS OF MARGINAL COST OF WATER

APPENDIX B

GENERAL ASSUMPTIONS FOR URV CALCULATIONS OF MARGINAL COST OF WATER

- B1 CAPITAL COST**
- B2 OPERATION AND MAINTENANCE**
- B3 WATER DELIVERY AND PROJECT TIMING**
- B4 URV CALCULATIONS**
- B5 DEMAND CURVES**
- B6 PUMPING AND PIPELINES**
- B7 YIELDS**
- B8 TREATMENT COSTS**
- B9 PHASING**
- B10 COST STREAM**
- B11 WATER CONSERVATION AND DEMAND MANAGEMENT (WC/WDM)**
- B12 ECOLOGICAL WATER REQUIREMENTS (EWR)**
- B13 ZAMBEZI RIVER ROYALTIES**

APPENDIX B – GENERAL ASSUMPTIONS FOR URV CALCULATIONS OF MARGINAL COST OF WATER**B1 CAPITAL COST**

- a) Prices escalated to July 2009 prices.
- b) Price escalation according to CPAF (contract price adjustment factor).
- c) Split/weighting of labour, plant, materials and fuel of 23, 23, 47 and 7% respectively (average civil project split).
- d) Where existing costs are at a low reconnaissance level of detail, and no allowance has been made for, 10% for engineering fees and 10% for environmental and social costs is added.
- e) VAT is excluded as the capital gain for governmental purposes is not included in the cost to the economy.

B2 OPERATION AND MAINTENANCE

- a) Maintenance costs included as determined in previous studies, unless major discrepancies from:
 - Civil: 0.25% of the capital cost as an annual maintenance cost
 - Pipelines: 0.5% of the capital cost as an annual maintenance cost
 - Mechanical & Electrical: 4.0% of the capital cost as an annual maintenance cost
 - Where no distinction was made between the Civil and Mechanical & Electrical costs of dams, 0.265% of the capital cost was taken as an annual maintenance cost
- b) Operation costs based on pumping requirements and the marginal cost of coal or nuclear power:
 - Coal: R0.60/kWh for coal fired power with the following transmission fees:
 - Western Cape 15%
 - Natal 10%
 - Port Elizabeth 12%
 - Gauteng 2%
 - RSA Average 5%
 - Nuclear: R1.20/kWh for nuclear power with the following transmission fees:
 - Western Cape 2%
 - Natal 2%
 - Port Elizabeth 2%
 - Gauteng 10%
 - RSA Average 5%
- c) Coal fired power assumed R0.60/kWh up to 2019, with a blend of coal and nuclear from 2020 onwards at R0.90/kWh. Transmission fees taken as 5% across the country for the coal/nuclear blend.

B3 WATER DELIVERY AND PROJECT TIMING

- a) All schemes to start delivery of water in 2016 for URV calculations to be consistent. This date was chosen as it is the earliest date the longest scheme (LHWP phase 2) can deliver water if construction starts mid 2009.
- b) Construction of all schemes to start such that construction ends 2015 and water delivery can start 2016.
- c) Water delivery assumed to be limited either by growth in demand, or growth in yield.
- d) Filling times either obtained from reports, or first water delivery assumed depending on the scheme size and capacity of dams included relative to runoff.

B4 URV CALCULATIONS

- a) URVs calculated for a discount rate of 8% and discounted back to 2009 prices (base year)
- b) URVs calculated over a 36 year discount period (30 years from date of first water delivery in 2016)
- c) No allowance made for residual values
- d) No financing costs are included
- e) URV (R/m³) is calculated as the sum of all annual net present costs (NPC) between 2009 and 2036, divided by the sum of the annual net present value (NPV) of water delivered between 2016 and 2036. The formula is given as:

$$\text{URV} = \sum \text{NPC}_i / \sum \text{NPV}_i$$

- f) The formulae used to calculate discounted the annual net present costs and value of water to the base date is:

$$\text{NPC}_i = (\text{cost in year}_i) / (1 + (D / 100)) ^ (\text{year}_i - \text{year}_{\text{base}})$$

- Where NPC_i = net present cost in year_i (Rands)
- i = base year too base year plus n
- n = number of years in URV calculation (discount period)
- D = discount rate (in percent)

$$\text{NPV}_i = (\text{Water delivered in year}_i) / (1 + (D / 100)) ^ (\text{year}_i - \text{year}_{\text{base}})$$

- Where NPV_i = net present value of water in year_i (million m³/a)

B5 DEMAND CURVES

- a) Water demands included in the URV calculations are only the growth in demand as of 2016 onwards. No short term deficits or surpluses leading up to 2016 are taken into account. This has been conducted so as to better determine the **next best scheme** for phasing.
- b) Demand curves used in URV calculations does not allow for decrease in water use due to water conservation and demand management (WC/WDM).
- c) Two demand curves are shown on graphs, one including WC/WDM and the other excluding WC/WDM.

B6 PUMPING AND PIPELINES

- a) Pipelines assumed to be straight line plus 20% where no detail is available.
- b) Pipeline velocity of about 1.5 m/s assumed.
- c) Pumping 22 hours out of 24 per day (this is 92% of the time which is slightly conservative, but compatible with the DWA standard of 95%).
- d) Friction calculated with the Hazen Williams equation and using $c=120$ (long term average).
- e) Maximum pumping head of 350m (preferable to not go over 300m).
- f) 33% of the capital cost for pump stations assumed to be civil costs and the remainder (67%) mechanical and electrical costs.

B7 YIELDS

- a) Yields for the different augmentation options were taken from previous studies. However, it may be that these yields need to be attended to further as the hydrology and ecological water requirements might have changed since (especially in the Orange River catchment).
- b) Yields obtained from previous studies for the different regions may not be at the same level of assurance of supply, but are applicable to the users in the different regions.

B8 TREATMENT COSTS

- a) Most schemes make raw water available. This water still needs to be treated to potable standards in most cases. To compare the “conventional” schemes with acid mine drainage re-use and the desalination of seawater, the cost of treating raw water needs to be known, and either added to the “conventional” scheme costs, or subtracted from the acid mine drainage and desalination of seawater costs.
- b) The URV cost of treatment was calculated with the same discount rate and first delivery (and thus treatment) assumptions as used for the augmentation schemes.
- c) An average operating and maintenance costs of treatment of R1/m³ was used, and the capital costs of the WTP was included with a sliding scale of R3.5 million per Mℓ/d for a 300 Mℓ/d plant, up to R9 million per Mℓ/d for a 10 Mℓ/d plant.
- d) The URV of treating water is approximately R2.20/m³ for a volume of 100 million m³/a and R2.00/m³ for a volume of 200 million m³/a. A value of R2.00/m³ was used for this study.

B9 PHASING

- a) Schemes are phased according to:
 - when the growth in demand (including WC/WDM) requires new augmentation
 - earliest practical scheme implementation dates
 - cost of water (lowest to highest URV)
- b) Due to the lengthy process inherent in implementing water resource schemes, and that some schemes are still in their infancy, short-term deficits may occur in some regions, and more expensive schemes may need to be implemented before cheaper schemes.

B10 COST STREAM

- a) The cost streams are calculated separately for the capital costs and the operation and maintenance costs.
- b) The cost stream will be based on the phasing of schemes and will be calculated both regionally and for a national total (Note: National total only includes major centres covered in this study).

B11 WATER CONSERVATION AND DEMAND MANAGEMENT (WC/WDM)

- a) Costs for WC/WDM are based on work conducted in the Vaal River system.
- b) WC/WDM is phased in according to the current status of WC/WDM in each region.
- c) Where little or no information exists, a 10% saving in urban water use due to WC/WDM was assumed and phased in over 5 years.

B12 ECOLOGICAL WATER REQUIREMENTS (EWR)

- a) All new developments take into account the EWR, and yields stated after allocating water to the downstream EWR.

- b) The implementation of water releases for the EWR from existing dams is assumed to be phased in over 5 years, starting when new schemes are able to come on-line to augment the loss in system yield as a result of the implementation of the Reserve.
- c) Although outlet capacities at existing dams may be limiting, it is suspected that most of previous studies assumed that the full range of EWR flows can be released. Further clarity on this may be required.

B13 ZAMBEZI RIVER ROYALTIES

- a) Royalties for water from the Zambezi River where not available from previous studies.
- b) Royalties are assumed to be based on the shared benefit between Zambezi schemes and the next best schemes in South Africa, which was desalination of seawater and pumping, and a scheme from the Mzimvubu River transferring water to the Olifants River.
- c) Depending on the scheme configurations and volumes of water, the benefit (cost difference) between Zambezi schemes and the next best scheme ranged between R7/m³ and R17/m³. This indicates a range for the possible royalties of between R3.50 and R8.50/m³.
- d) For the purpose of this study a Royalty of R5/m³ was assumed and added to the URVs of all the Zambezi River schemes.

APPENDIX C

ASSUMPTIONS AND OBSERVATIONS PERTAINING TO THE VAAL RIVER SYSTEM

APPENDIX C

ASSUMPTIONS AND OBSERVATIONS PERTAINING TO THE VAAL RIVER SYSTEM

- C1 WATER REQUIREMENTS AND WATER AVAILABILITY
- C2 WATER CONSERVATION AND WATER DEMAND MANAGEMENT (WC/WDM)
- C3 ECOLOGICAL WATER REQUIREMENTS (EWR)
- C4 DEVELOPMENT OPTIONS – ASSUMPTIONS FOR URV'S
 - C4.1 Lesotho Highlands Water Project Phase II*
 - C4.2 Thukela-Vaal Transfer Scheme (Southern Tributaries: Jana & Mielietuin dams)*
 - C4.3 Thukela-Vaal Transfer Scheme (Northern Tributaries)*
 - C4.4 Use of acid mine drainage*
 - C4.5 Direct re-use of treated water*
 - C4.6 Orange-Vaal Transfer Scheme (Boskraai/Bosberg Dam)*
 - C4.7 Mzimvubu Transfer Scheme (Kraai option)*
 - C4.8 Mzimvubu transfer scheme (Thukela option)*
 - C4.9 Zambezi-Vaal transfer*
 - C4.10 Desalination of seawater*
- C5 DEVELOPMENT OPTIONS – NOTES ON PHASING

APPENDIX C – ASSUMPTIONS AND OBSERVATIONS PERTAINING TO THE VAAL RIVER SYSTEM

C1 WATER REQUIREMENTS AND WATER AVAILABILITY

▪ Water requirements

Future water requirements for the Vaal River system were abstracted from the *Vaal River System: Large Bulk Water Supply Reconciliation Strategy: Second Stage Reconciliation Strategy (Report prepared by WRP, March 2009, updated figures November 2009)* and extrapolated beyond 2030.

These water requirements already included the future requirements of power stations in the Olifants River catchment relying on water from the Vaal River system (essentially from the Komati, Usutu, Assegaai and Buffels river catchments). However, the future requirements of power stations in the Lephalale area were excluded. Subsequently, additional future water requirements for the Olifants and Lephalale river catchments, as determined as part of this study, were included in the total water requirements for the Vaal River system.

An irrigation water requirement of 1 210 million m³/a was included in the total current water requirements of the Vaal River catchment. For future projections this number was decreased by ± 200 million m³/a as it is expected that unlawful irrigation in the catchment will be removed.

▪ Water availability

The existing yield of 2 877 million m³/a, as obtained from the *Vaal River System: Large Bulk Water Supply Reconciliation Strategy*, reflects the yield of the Vaal River system i.e. include transfers from the Komati, Usutu, Assegaai, Buffels, Thukela and Senqu river catchments.

This yield was reduced to compensate for the proposed future transfer of return flows from the Vaal River system to the Crocodile (West) River catchment as well as the implementation of the Reserve (*Item C3*).

C2 WATER CONSERVATION AND WATER DEMAND MANAGEMENT (WC/WDM)

According to Mr Pieter van Rooyen from WRP, municipalities within the Vaal River system are aiming for a saving of 15% as a result of WC/WDM. However, actual figures show that they are currently only achieving a 12% saving. These savings (as a result of WC/WDM) were taken from the *Vaal River System: Large Bulk Water Supply Reconciliation Strategy, 2009* and the figures for 2030 duplicated beyond 2030 assuming that the impact of WC/WDM will even out over time.

C3 ECOLOGICAL WATER REQUIREMENTS (EWR)

A recent study on the future ecological water requirements (EWR) in the Vaal River system showed that the Vaal River system's water availability will reduce by 130 million m³/a as a result of the implementation of the Reserve. This EWR was phased in over 5 years and was only implemented once the LHWP Phase II (Polihali Dam) came on line.

C4 DEVELOPMENT OPTIONS – ASSUMPTIONS FOR URV'S

C4.1 Lesotho Highlands Water Project Phase II

a) Description of development option

The LHWP Phase II comprises the construction of Polihali Dam and transfer of water through a gravity tunnel to Katse Dam from where the water will flow through the existing delivery tunnel to the Ash River outfall in South Africa. To make up for the loss in yield in the Orange River system, Vioolsdrift Dam needs to be constructed in the Lower Orange River as well as a portion of a Boskraai Dam.

b) Description of scenarios

- Only one scenario considered.

c) Source(s) of information on costs

- Polihali Dam: *Vaal River WRDP: Comparative Study between LHWP Phase II and Thukela Water Project, 2008*
- Vioolsdrift Dam: *Pre-feasibility study into the measures to improve the management of the Lower Orange River and to provide for future developments along the border between Namibia and South Africa (LORMS), 2005*
- Boskraai Dam: *Orange River Development Project Replanning Study, 1999*

d) Base date of costs

- Polihali Dam: Base date October 2007, therefore all costs escalated with a factor of 1.16
- Vioolsdrift Dam: Base date April 2004, therefore all costs escalated with a factor of 1.53
- Boskraai Dam: Base date April 1994, therefore all costs escalated with a factor of 3.36

e) Infrastructure

- **Polihali Dam**
 - Maximum yield: 437 million m³/a (provision made for EWR downstream of Polihali Dam)
 - Gross capacity: 2 322 million m³
- **Vioolsdrift Dam**
 - Maximum yield: Unknown
 - Gross capacity: 1 090 million m³
- **Bosberg Dam (28% of a large Boskraai Dam)**
 - Maximum yield: 290 million m³/a (provision made for EWR downstream of Boskraai Dam)
 - Gross capacity: 3 554 million m³ (NB: Half of a Boskraai Dam to be built, but only 56% of Bosberg's yield and cost assigned to the LHWP Phase II. Remaining 44% allocated to a development option to provide only for future growth in the Orange River system)

f) Programme

- Construction on Polihali Dam starts mid June 2009
- First delivery of water mid 2016
- 7 years from start of construction to impoundment up to minimum operating level at which the scheme can start to deliver 5.8 m³/s (183 million m³/a)
- Filling time for Polihali Dam taken as 4 years

g) Maintenance and operation

Maintenance and operation costs included as determined as part of the *Comparative Study between LHWP Phase II and Thukela Water*:

- Administration costs = 10% of construction cost of LHWP Phase II (Civil, Mechanical & Electrical)
- Engineering fees (pre-engineering) = 4.5% of construction cost of LHWP Phase II (Civil, Mechanical & Electrical)
- Engineering fees (supervision) = 10% of construction cost of LHWP Phase II (Civil, Mechanical & Electrical)
- Maintenance costs (Civil) = 0.25% of construction cost of LHWP Phase II (Civil)
- Maintenance costs for dam and tunnel (M&E) = 1% of construction cost of dam and tunnel (M&E)
- Maintenance costs for roads, bridges, power supply and camps (M&E) = 3% of construction cost of roads, bridges, power supply and camps (M&E)
- Useful life (Civil) = 50 years
- Useful life (M&E) = 30 years – replacement of M&E capital after 30 years

h) Losses

- 10% losses assumed for transfer of water from the Ash River Outfall to Vaal Dam (point of delivery).

i) Energy requirement

- No energy required for this development option.

j) Other

- An additional R262 million was included in the URV calculation for the Polihali/Katse tunnel as it was found in the *Comparative Study between LHWP Phase II and Thukela Water Project* that there might be a need for full lining of the tunnel to Katse Dam (as was found necessary for the existing tunnels).

k) Royalties

- Royalties paid to Lesotho from first year of construction (mid 2009) up to 2045
- Incremental Royalties (only Phase II, difference between Phase II and Phase I cancellation) were included as calculated by Mr Peter Ramsden for the *Comparative Study between LHWP Phase II and Thukela Water Project* and escalated, on his recommendation, by PPI (1.14)

4.2 Thukela-Vaal Transfer Scheme (Southern Tributaries: Jana & Mielietuin dams)**a) Description of development option**

This development option comprises a scheme on the Thukela River with the main aim of increasing the transfer of raw water to the Vaal River catchment, via the Drakensburg Pumped Storage Scheme. It includes two dams namely Jana Dam in the Thukela River and Mielietuin Dam in the Bushmans River. Conveyance will be through a 120 km pipeline linking the proposed dams to the existing Kilburn Dam at the foot of the Drakensburg Pumped Storage Scheme. From here water will be pumped through the existing scheme to Sterkfontein Dam in the Vaal River catchment.

b) Description of scenarios

The following 2 scenarios were considered in this regard:

- Mielietuin Dam only with pipeline to Kilburn Dam
- Jana Dam only with pipeline to Kilburn Dam

- Phased Mielietuin and Jana Dam with 2 separate parallel pipelines (and pump stations) to Kilburn Dam (as the phasing of the 2 dams is almost 5 years apart)

c) Source(s) of information on costs

- *Vaal River WRDP: Comparative Study between LHWP Phase II and Thukela Water Project, 2009*

d) Base date of costs

- Base date of all costs October 2007, therefore costs escalated with a factor of 1.16

e) Infrastructure

▪ **Mielietuin Dam**

- Maximum yield: 126 million m³/a (provision made for EWR downstream of Mielietuin Dam)
- Full supply level: 1 033 mamsl

▪ **Jana Dam**

- Maximum yield: 369 million m³/a (provision made for EWR downstream of Jana Dam)
- Full supply level: 890 mamsl

f) Programme

▪ **Mielietuin Dam:**

- Construction on Mielietuin Dam starts mid 2011
- 5 years from start of construction to first delivery of water - water can be delivered immediately after construction of the dam
- First delivery of water mid 2016

▪ **Jana Dam:**

- Construction on Jana Dam starts mid 2009
- 7 years from start of construction to first delivery of water - water can be delivered immediately after construction of the dam
- First delivery of water mid 2016

g) Maintenance and operation

Maintenance and operation costs included as determined as part of the *Comparative Study between LHWP Phase II and Thukela Water*:

- Administration costs = 8% of construction cost of Tugela Water Project (TWP) (Civil, Mechanical & Electrical)
- Engineering fees (pre-engineering) = 4.5% of construction cost of TWP (Civil, Mechanical & Electrical)
- Engineering fees (supervision) = 10% of construction cost of TWP (Civil, Mechanical & Electrical)
- Maintenance costs (Civil) = 0.25% of construction cost of TWP (Civil)
- Maintenance costs for dam and tunnel (M&E) = 1% of construction cost of dam and tunnel (M&E)
- Maintenance costs for roads, bridges, power supply and camps (M&E) = 3% of construction cost of roads, bridges, power supply and camps (M&E)
- Useful life (Civil) = 50 years
- Useful life (M&E) = 30 years - replacement of M&E capital after 30 years

h) Losses

- 10% losses assumed for transfer of water from Sterkfontein Dam to Vaal Dam (point of delivery).

i) Energy requirement

- Mielietuin Dam only: 367 776 MWh/a* (44 MW)
- Jana Dam only: 1 381 477 MWh/a* (166 MW)
- Combined Mielietuin and Jana Dam: 1 653 044 MWh/a* (198 MW)

*All costs include the additional Drakensburg electricity costs

C4.3 Thukela-Vaal Transfer Scheme (Northern Tributaries)

This development option comprises two dams (one at Uitkyk and the other at Rorkes Drift) on the northern tributaries of the Thukela River. However, on DWA's recommendation, this scheme was not included as it poses significant social impacts. Water quality problems in the northern tributaries of the Thukela River also make water from the southern tributaries (*see C4.2*) much more suitable. It is foreseen that this scheme will not be constructed in the near future.

C4.4 Use of acid mine drainage**a) Description of development option**

This development option comprises the direct use of acid mine drainage in the Vaal River i.e. water is treated at the mines to potable standards and pumped to Rand Water reservoirs.

b) Description of scenarios

Two different scenarios for the use of acid mine drainage in the Vaal River catchment were considered. One scenario was based on all mines in the Vaal River catchment (100 million m³/a of water available) and the other based on a few selected mines (38 million m³/a of water available) in the Vaal River catchment.

c) Source(s) of information on costs

- Capital costs: *Development of an Integrated Water Quality Management Plan for the Vaal River System: Task 6 – Evaluation of Water Quality Management Scenarios, 2008*
- Energy and maintenance costs: As no information could be obtained on energy and maintenance costs involved in the use of acid mine drainage, costs were based on figures included as part of the re-use of effluent-option obtained from the *Western Cape Reconciliation Strategy*. This, in turn, was based on a report from the WRC on *desalination for municipalities in the Western Cape, 2006*.
- Communication with Dr Trevor Coleman from Golder Associates

d) Base date of costs

- Base date of all costs July 2006, therefore costs escalated with a factor of 1.11

e) Infrastructure

Capital costs on infrastructure (treatment plants, pump stations and pipelines) taken directly from the report on the *Development of an Integrated Water Quality Management Plan for the Vaal River System: Task 6 – Evaluation of Water Quality Management Scenarios, 2008*

f) Programme

- Start of construction = 2013
- First delivery of water = 2016
- Construction time of various infrastructure vary between 2 and 3 years

g) Maintenance and operation

- An additional operating cost of R1.50/m³ of water was assumed at the treatment plants for treating the acidic water to potable standards (excluding energy). This figure is between the operating cost of desalinating seawater and treating effluent for re-use.

h) Losses

- 0% losses assumed for transfer of water, as water is delivered directly to Rand Water reservoirs

i) Energy requirement

Existing energy requirements (stated by Dr Trevor Coleman) are in the region of 2.4 kWh/m³ (of product water) to get water to potable standard, therefore the following were assumed:

- All Vaal mines: 245 000 MWh/a (29 MW)
- Select Vaal mines: 95 200 MWh/a (11 MW)

C4.5 Direct re-use of treated water

A decision was made that, for the sake of this project, no distinction will be made between direct and indirect re-use as it will have a negligible impact on the mass balance of the Vaal River system. One method of re-use may be financially more preferable than the other, however, as no information on that level of detail exists a decision was made not to further investigate this as an option.

C4.6 Orange-Vaal Transfer Scheme (Boskraai/Bosberg Dam)**a) Description of development option**

On request of the Client and as part of the *Vaal River WRDP: Comparative Study between LHWP Phase II and Thukela Water Project, an Assessment of Water Availability in the Orange River* was carried out by WRP. As part of this study a scenario was analysed to determine the yield of a Boskraai Dam with a capacity of 7 107 million m³ that will not inundate land in Lesotho. It was found that the surplus yield available at Boskraai Dam after allowing for support to the Orange River Project (ORP) (at 2008/09 development level) to prevent shortfalls at a 1:50 assurance level is 1 033 million m³/a. In the determination of this yield the following assumptions were made:

- LHWP Phase I included upstream;
- Polihali and Vioolsdrift dams in place;

- EWR for Orange River as currently released for the river mouth (287 million m³/a) included;
- The so-called 'Top-up' EWR (modelled as part of the *LORMS* as well as the *Comparative Study* and the additional work carried out by WRP) included;
- Future Namibia demands (± 160 million m³/a) included; and
- Future growth in the Orange River (± 300 million m³/a) excluded (future growth in the Orange River take account of the 120 million m³/a allocated to resource poor farmers in the Orange).

As there is currently surplus water available in the Orange River system (± 100 million m³/a) an assumption was therefore made that half a Boskraai Dam (Bosberg Dam) will be needed to make up for the loss in yield in the Orange River system as a result of LHWP Phase II (± 290 million m³/a) as well as to supply the future growth in the Orange River system (± 300 million m³/a).

As a result thereof it was assumed that the other half of Boskraai Dam's yield (± 517 million m³/a) will be available to be transferred to the Vaal River catchment. Therefore, for this development option, water will be abstracted at the Goedemoed Weir, utilising the Boskraai Dam as main storage. Conveyance will be either through a system of pumps (*6), rising mains, canals, syphons and tunnels (515 km) or through a pipeline to a tributary of the Liebenbergsvlei River.

b) Description of scenarios

Three different scenarios for the Orange-Vaal transfer were considered:

- Transfer with conveyance through a canal to the Vaal River catchment
- Transfer with conveyance through a pipeline to the Vaal River catchment
- Transfer with conveyance through a phased dual pipeline to the Vaal River catchment

c) Source(s) of information on yields & costs

- Yields: *Assessment of Water Availability in the Orange River, 2009*
- Dam: *Orange River Development Project Replanning Study, 1999*
- Conveyance infrastructure: *Vaal Augmentation Planning Study (VAPS), 1996*

d) Base date of costs

- **Transfer with conveyance through a canal to the Vaal River catchment;**
 - Dam and canal infrastructure (including pumps (*6), rising mains, canals, syphons and tunnels): Base date April 1994, therefore costs escalated with a factor of 3.36
- **Transfer with conveyance through a pipeline to the Vaal River catchment;**
 - Pipelines and balancing reservoirs: Base date 2009, therefore costs were not escalated
 - Pump stations: Base date 2008, therefore costs escalated with a factor of 1.1

e) Infrastructure

- **Boskraai Dam (50% of a large Boskraai Dam)**
 - Maximum yield: 517 million m³/a (provision made for EWR downstream of Boskraai Dam)
 - Gross capacity: 3 554 million m³
- **Transfer with conveyance through a canal to the Vaal River catchment:**
 - A system of pumps (*6), rising mains, canals, syphons and tunnels (515 km) were used to convey water to a tributary of the Liebenbergsvlei River

- **Transfer with conveyance through a pipeline to the Vaal River catchment:**

- Pipelines: A 360 km long pipeline (from Goedemoed weir to Liebenbergsvlei River) with diameters as follows were used:
 - 3.4 m for the single pipeline; and
 - 2 * 2.5 m for phased dual pipelines.
- Pump stations: 4 pump stations with a maximum head of 200m. Each pump station has a balancing reservoir to provide a couple of hour's storage.

f) Programme

- Based on the *VAPS* the construction period of Boskraai Dam was taken as 5 years and an assumption was made that the dam will take 3 years to deliver its full yield (2018).

g) Maintenance and operation

For the **transfer with conveyance through a canal to the Vaal River catchment-scenario** the following assumptions taken from the *VAPS* were made with regard to operation and maintenance (total costs exclude replacement of infrastructure and land acquisition as well as compensation costs):

- 0.5% of the total canal costs
- 0.25% of the total syphon cost
- 0.25% of the total tunnel costs
- 0.5% of the total rising main costs
- Pump stations: 4% of total electrical/mechanical cost + 0.25% of the total civil cost
- 0.25% of the total dam cost

h) Losses

- **Transfer with conveyance through a canal to the Vaal River catchment:**
 - 20% losses assumed (10% for conveyance losses within the canal i.e. evaporation, seepage etc. and 10% for transfer of water from the Liebenbergsvlei River to Vaal Dam).
- **Transfer with conveyance through a pipeline to the Vaal River catchment:**
 - 10% losses assumed (for transfer of water from the Liebenbergsvlei River to Vaal Dam (point of delivery)).

i) Energy requirement

- Transfer with conveyance through a canal to the Vaal River catchment:
1 026 480 MWh/a (123 MW)
- Transfer with conveyance through a pipeline to the Vaal River catchment:
1 101 067 MWh/a (132 MW)
- Transfer with conveyance through a phased dual pipeline to the Vaal River catchment:
1 216 761 MWh/a (146 MW)

*Pumping costs allowed for a downtime period of 5 weeks per year therefore pumps active 47 weeks per annum.

C4.7 Mzimvubu Transfer Scheme (Kraai option)

a) Description of development option

For this development option water is abstracted at 6 dams in the Mzimvubu River catchment (Siqingeni, Thabeng, Pitseng, Hlabakazi, Mpindweni and Ntabelanga dams). Conveyance is through a system of pump stations (*7), pipelines, canals, syphons and tunnels to the Bell River, a tributary of the Kraai River. From the Bell River water flows down to the Kraai River to the Boskraai Dam. Costs for the Boskraai Dam was, however, excluded from this option as it is assumed that the Mzimvubu Transfer Scheme will not realize without this dam in place. It was, however, assumed that the Orange-Vaal Canal System will be duplicated in the case when water will be transferred from the Mzimvubu River catchment, therefore these costs were included. Water will be abstracted at the Goedemoed Weir, from where it will be pumped through a system of pumps (*6), rising mains, canals, syphons and tunnels (515 km) to a tributary of the Liebenbergsvlei River.

b) Description of scenarios

The following 2 scenarios were considered in this regard:

- **Mzimvubu to Vaal - Vaal only**

For this scenario it was assumed that all water will be transferred to the Vaal.

- **Mzimvubu to Vaal - Vaal and Algoa**

For this scenario it was assumed that part of the water will be transferred to the Vaal River catchment whereas the remainder of the water (50 million m³/a) will be transferred to the Algoa Water Supply System. An assumption was made in this regard that the capacity of the Orange-Fish Tunnel will be sufficient to accommodate this additional quantity.

c) Source(s) of information on costs

- Dams: *DWAF Water Resource Study in support of the ASGISA-EC Mzimvubu Development Project, 2009*
- Conveyance infrastructure: *Vaal Augmentation Planning Study (VAPS), 1996*

d) Base date of costs

- Dams: Base date March 2008, therefore costs escalated with a factor of 1.08
- Conveyance infrastructure: Base date April 1994, therefore costs escalated with a factor of 3.36

e) Infrastructure

- Dams (Siqingeni, Thabeng, Pitseng, Hlabakazi, Mpindweni and Ntabelanga):
In the VAPS 2 scenarios (20 m³/s and 40 m³/s) were analysed for the Mzimvubu-Kraai Transfer. However, new yields from dams now had to be used as determined as part of the *Mzimvubu Development Project*. These dams are much smaller than those proposed in the VAPS. In the VAPS the suggested active storage requirement was approximately 2.5 MAR, whereas now the maximum capacities that were analysed was in the order of 1.5 MAR. A scenario was run with the WRYM set up as part of the *Mzimvubu Development Project* and the available yield from the same dam configuration as proposed in the VAPS determined as 22 m³/s (historic firm yield drawn from all 6 dams simultaneously). An assumption could thus be made that 20 m³/s (EWR included) are available in the Mzimvubu River for transfer to the Vaal River catchment and a URV was determined for the 20 m³/s scenario only.

f) Programme

- Start of construction = Mid 2009
- First delivery of water = 2016
- Construction times of the various elements, except for the dams, based on the original programme for this scheme from *VAPS*
- Construction time of dams taken between 3 and 4 years as determined as part of the *Mzimvubu Development Project* (start 2010)
- Filling time requirements for the 2.5 MAR dams in the VAPS was given as 10 years to fill up to 60% of active storage (as the dams are in series). However, as these dams are now much smaller (1.5 MAR) the filling times as shown in the **Table C1** were assumed (based on experience from the *Mzimvubu Development Project*). This entails 20% of the yield delivered in 2016 with full delivery in 2020 (100%).

Table C1 Filling times for dams in the Mzimvubu River catchment

Dam	Filling time (years)
Pitseng	2
Hlabakazi	3
Mpindweni	5
Thabeng	2
Siqingeni	3
Ntabelanga	2

g) Maintenance and operation

- General assumptions on maintenance and operation included.

h) Losses

- **Mzimvubu to Vaal - Vaal only**
20% conveyance losses were assumed (10% to the Orange River and another 10% through the Orange-Vaal Canal to the Vaal River). Therefore, it was assumed that 20 m³/s of water (yield of the series of dams) is pumped from the Mzimvubu River catchment to the Orange River, however, only 18 m³/s of water (10% less) is pumped from the Orange River to the Vaal River and only 16 m³/s reaches Vaal Dam at the end.
- **Mzimvubu to Vaal - Vaal and Algoa**
For this scenario losses were assumed as shown in **Figure C1**.

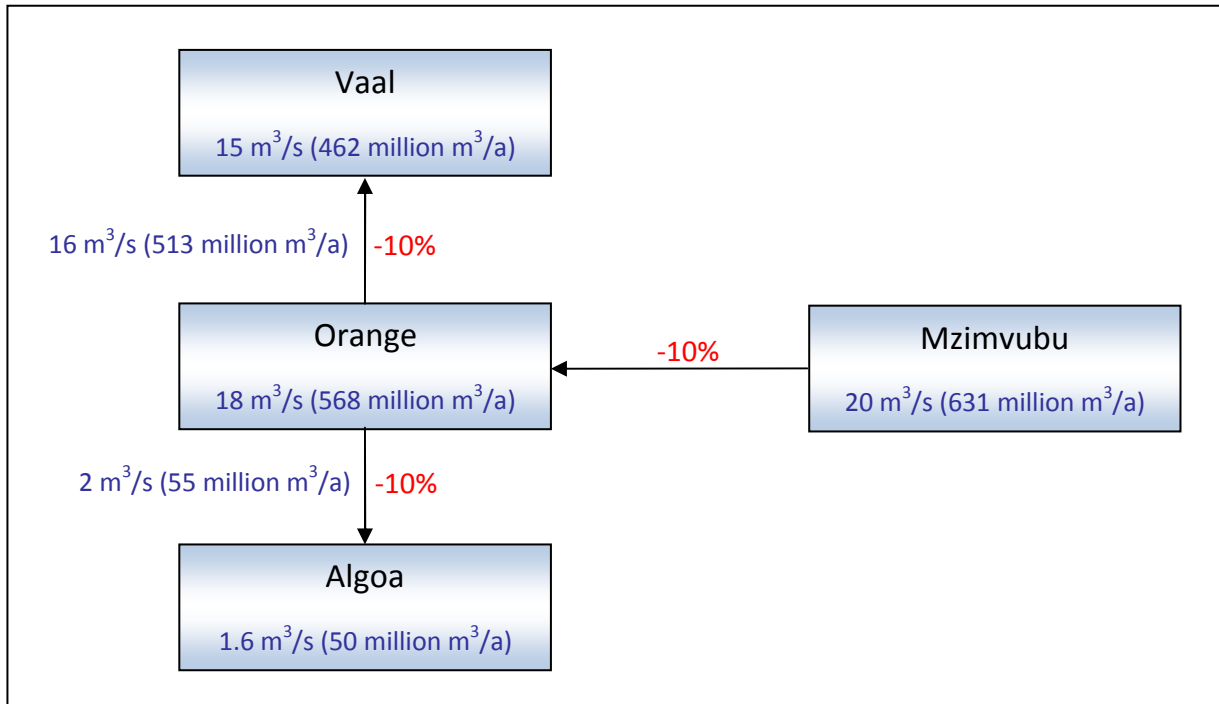


Figure C1 Schematic diagram of losses for the Mzimvubu-Vaal transfer (to Vaal and Algoa)

i) Ecological water requirements (EWR) in the Mzimvubu River catchment

As part of the *DWAF Water Resource Study in Support of the AsgiSA-EC Mzimvubu Development Project* the Desktop Reserve Model (DRM) was used to determine EWRs for each quaternary catchment of the Mzimvubu River and its main tributaries. These EWRs were included in the WRYM and therefore taken into account when the yields of future dams (as used in the *Marginal Cost of Water* task) were calculated. The EWRs that were used are summarised in **Table C2**.

Table C2 EWRs in the Mzimvubu River catchment

Quaternary catchment	MAR	Total MAR	EWR low flow requirement	Total EWR requirement	EWR (% of MAR)	Comments
	(million m ³ /a)		(million m ³ /a)			
T34F	39.5	55.1	7.5	14.0	25	D/s of Pitseng site
T34F_1		237.2	34.2	63.9	27	D/s of Hlabakazi site
T34H	91.2	331.4	47.3	88.1	27	D/s of Mpindweni site
T33D	61.0	304.2	14.5	41.2	14	D/s of Thabeng site
T33G	60.9	728.3	86.7	163.4	22	D/s of Siqingeni site
T35E	102.9	407.8	55.8	104.0	26	D/s of Ntabelanga site

j) Energy requirement

- As no information could be found on the electricity calculations of the Mzimvubu Kraai transfer, assumed (average) flows were calculated and used to determine the annual electricity costs of this scheme.
- As average flows were used no allowance was made for outages and maintenance (24 hours a day, 365 days per year).
- Mzimvubu to Vaal: 2 764 046 MWh/a (332 MW)

C4.8 Mzimvubu transfer scheme (Thukela option)

Since the *Vaal Augmentation Planning Study (VAPS)*, the demand in the KZN Coastal Area (Durban, Pietermaritzburg etc.) has increased considerably. Therefore, should water from the Mzimvubu River catchment be transferred (via the Mkomazi River) to the Thukela River catchment it will be a better option to use the water in the KZN Coastal Area rather than transferring it to the Vaal River catchment. Based on this, as well as the fact that the difference in costs between transferring water from the Mzimvubu River either via the Kraai River or the Thukela River proved to be very small (based on URVs taken from the *Vaal Augmentation Planning Study*), it was decided to only include the Mzimvubu-Kraai transfer in this study.

C4.9 Zambezi-Vaal transfer**a) Description of development option**

This development option comprises abstraction of water from a point on the Zambezi River upstream of the Victoria Falls where the borders of all three countries meet (near Kazangula). Conveyance will be through a pipeline to the centre of Pretoria (point of delivery).

b) Description of scenarios

Three different scenarios for the transfer of water from the Zambezi River to the Vaal River were considered:

- Pipe sized according to demand (2.8m diameter yielding 350 million m³/a)
- Largest single practical pipe size (3.5m diameter yielding 650 million m³/a)
- Pipe-sharing scheme between Vaal, Lephalale and the Olifants (3.5 diameter yielding 650 million m³/a: 350 million m³/a to the Vaal River; 200 million m³/a to the Lephalale area and 100 million m³/a to the Olifants River)

c) Source(s) of information on costs

Balancing dam, balancing reservoirs, pipelines, pump stations and other infrastructure: calculated based on latest information available on costs for these types of infrastructure.

d) Base date of costs

- Pipelines and balancing reservoirs: Base date 2009, therefore costs were not escalated
- Pump stations and balancing dam: Base date 2008, therefore costs escalated with a factor of 1.1

e) Infrastructure

- Pipelines: A 1 080km long pipeline (from the Zambezi River to Pretoria) with diameters as follows were used:
 - 2.8 m for the 350 million m³/a transfer
 - 3.5 m for the 650 million m³/a transfer
- Pump stations: 8 pump stations with a maximum head of 195 m. Each pump station has a balancing reservoir to provide a couple of hour's storage.

f) Programme

- Start of construction = 2012
- First delivery of water = 2016
- Construction time of various infrastructure vary between 2 and 4 years

g) Maintenance and operation

- General assumptions on maintenance and operation included.

h) Losses

- 0% losses assumed for transfer of water as water is assumed to be delivered to the centre of Pretoria.

i) Energy requirement

- 350 million m³/a scheme: 1 474 363 MWh/a (177 MW)
- 650 million m³/a scheme: 2 738 104 MWh/a (329 MW)
- Vaal River, Olifants River and Lephalale area shared scheme (Total: 650 million m³/a): 2 187 961 MWh/a (263 MW)

j) Royalties

- Royalties are assumed to be based on the shared benefit between Zambezi schemes and the next best schemes, which is desalination of seawater and pumping, and a scheme from the Mzimvubu River transferring water to the Olifants River.
- Depending on the scheme configurations and volumes of water, the benefit (cost difference) between Zambezi schemes and the next best scheme ranged between R7/m³ and R17/m³. This indicates a range for the possible royalties of between R3.50 and R8.50/m³.
- For this purpose of this study a royalty of R5/m³ was assumed and added to the URVs of all Zambezi schemes.

C4.10 Desalination of seawater**a) Description of development option**

This development option comprises abstraction and desalination of seawater at a site near Richards Bay. Conveyance will be through a pipeline to the Vaal River catchment.

b) Description of scenarios

Five different scenarios for desalination of water to the Vaal River were considered:

- 100 million m³/a into the headwaters of the Vaal River;
- 100 million m³/a into Vaal Dam WTW;
- 200 million m³/a into the headwaters of the Vaal River;
- 200 million m³/a into Vaal Dam WTW; and
- 650 million m³/a into Vaal Dam WTW (for comparison purposes with the largest Zambezi transfer scheme to the Vaal River).

c) Source(s) of information on costs

Balancing reservoirs, pipelines, pump stations and other infrastructure: Calculated based on latest information available on costs for these types of infrastructure (also based on work considered by WRC for desalination for municipalities, 2006).

d) Base date of costs

- Pipelines and balancing reservoirs: Base date 2009, therefore costs were not escalated
- Pump stations: Base date 2008, therefore costs escalated with a factor of 1.1
- Other infrastructure (Wastewater treatment works): Base date December 2007, therefore costs escalated with a factor of 1.14

e) Infrastructure

- Pipelines: A 575 km long pipeline would be needed to deliver water to Vaal Dam WTW whereas this could be reduced to a 345 km pipeline for water delivery to the headwaters of the Vaal River only. Diameters as follows:
 - 1.7 m for the 100 million m³/a transfer
 - 2.3 m for the 200 million m³/a transfer
 - 3.5 m for the 650 million m³/a transfer
- Pump stations: 7 pump stations with a maximum head of 300 m

f) Programme

- Start of construction = 2013
- First delivery of water = 2016
- Construction time of various infrastructure vary between 2 and 3 years

g) Maintenance and operation

- General assumptions on maintenance and operation included.

h) Losses

- 100, 200 and 650 million m³/a into the headwaters of the Vaal River: 10% losses assumed for transfer of water from the Vaal River to Vaal Dam (point of delivery).
- 100 and 200 million m³/a into Vaal Dam: 0% losses assumed for transfer of water as water is delivered to Vaal Dam (point of delivery).

i) Energy requirement to deliver full yield

- 100 million m³/a schemes: 1 316 182 MWh/a (158 MW)
- 200 million m³/a schemes: 2 624 933 MWh/a (315 MW)
- 650 million m³/a schemes: 8 623 382 MWh/a (1 035 MW)

C5 DEVELOPMENT OPTIONS – NOTES ON PHASING

- Although more expensive than other options, **use of acid mine drainage** is the 1st scheme that can be implemented in the Vaal River catchment.
- Following on this will be **LHWP Phase II** as a decision has already been taken that Polihali Dam will be the next scheme to be implemented for water to the Vaal River catchment. Polihali Dam is also the cheapest option for transfer of water to the Vaal River and can be implemented before other options.
- Both the **Orange-Vaal transfer (Boskraai Dam)** and the **Thukela-Vaal transfer (Mielietuin and Jana dams)** can be phased according to the demand in the Vaal River catchment.
- None of the **Mzimvubu-Vaal transfer**, the **Zambezi-Vaal transfer** and **desalination of seawater to the Vaal River catchment** development options will be needed until 2050.
- The Vaal River catchment could experience an interim deficit of ± 8 years (2013 – 2021) as a result of the required time to implement the different augmentation options.

APPENDIX D

ASSUMPTIONS AND OBSERVATIONS PERTAINING TO THE ORANGE RIVER SYSTEM

APPENDIX D

ASSUMPTIONS AND OBSERVATIONS PERTAINING TO THE ORANGE RIVER SYSTEM

- D1 WATER REQUIREMENTS AND WATER AVAILABILITY
- D2 WATER CONSERVATION AND WATER DEMAND MANAGEMENT (WC/WDM)
- D3 ECOLOGICAL WATER REQUIREMENTS (EWR)
- D4 DEVELOPMENT OPTIONS – ASSUMPTIONS FOR URV'S
 - D4.1 Dam at Vioolsdrift*
 - D4.2 Utilising low level storage at Vanderkloof Dam*
 - D4.3 Boskraai/Bosberg Dam*
 - D4.4 Mzimvubu-Kraai transfer*
 - D4.5 Desalination of seawater*
 - D4.6 Water supply to Bloemfontein*
- D5 DEVELOPMENT OPTIONS – NOTES ON PHASING

APPENDIX D – ASSUMPTIONS AND OBSERVATIONS PERTAINING TO THE ORANGE RIVER SYSTEM

D1 WATER REQUIREMENTS AND WATER AVAILABILITY

▪ Water requirements

Future water requirements for the Orange River system were abstracted from the *Annual Operations Analyses for the Orange River System, 2009 (report prepared by WRP)*. **Tables D1** and **D2** summarise the future water requirements between 2009 and 2045 (extrapolated from the 2009-2030 curve) in the Orange River system (all figures in million m³).

Table D1 Future water requirements in the Orange River system (volumes in million m³/a)

Water requirements	2009	2045	Growth
Urban: LHWP to Vaal River system <i>(From LHWP Phase I (Katse & Mohale dams) to the Vaal River System)</i>	780	780	0
Urban: Bloem Water <i>(Including Bloemfontein, Botshabelo and Mangaung LM)</i>	97	155	58
Urban: Upper Orange <i>(Smaller towns in the Upper Orange River)</i>	12	21	9
Urban: Gariep <i>(Smaller towns between Gariep and Vanderkloof dams)</i>	5	6	1
Urban: Vanderkloof – RSA <i>(Including Hopetown, Vanderkloof, Orania, Douglas, Prieska, Upington, Groblershoop, Keimoes, Kakamas, Namakwa, Pelladriift, Springbok, Alexander Bay, Industrial RSA and smaller users)</i>	58	82	24
Urban, mining and industrial: Vanderkloof – Namibia <i>(Including Haib Mine, Rosh Pinah, Auchas and Skorpion mines and urban and industrial use: Oranjemund & Rosh Pinah)</i>	22	49	27
Irrigation: Upper Orange <i>(Excluding expansion of irrigation due to developing farmers)</i>	256	256	0
Irrigation: Gariep to Vanderkloof <i>(Excluding expansion of irrigation due to developing farmers)</i>	20	20	0
Irrigation: From Vanderkloof (RSA) <i>(Excluding expansion of irrigation due to developing farmers)</i>	1 287	1 289	2
Irrigation: From Vanderkloof (Namibia) <i>(Growth in the order of ±160 million m³/a)</i>	40	201	161
Urban: Orange-Fish Tunnel <i>(Including additional allocation to NMBM)</i>	26	58	32
Irrigation: Orange-Fish Tunnel <i>(Excluding expansion of irrigation due to developing farmers)</i>	608	608	0
Operating requirements <i>(Only operating requirements. EWR of 287 million m³/a included as a reduction in yield)</i>	885	885	0
*Solar Power (5 000 MW total, 3 – 4 million m ³ /1 000 MW, worked on 4 million m ³ /1 000 MW) <i>(Assume starting in 2021, according to ESKOM's programme)</i>	0	20	20
*Expansion of irrigation (12 000ha to developing farmers) <i>(Assume starting in 2012, phasing in over 6 years)</i>	0	139	139
Total requirements	4096	4569	473

Table D2 Summarised water requirements of the Orange River system

Water requirements	2009	2045	Growth
LHWP transfers to the Vaal River system (only LHWP Phase 1)	780	780	0
Requirements between LHWP and Gariep-Vanderkloof system	365	432	67
Requirements to be supplied from Gariep-Vanderkloof system	2951	3357	406
Total requirements	4096	4569	473

The following regarding the water requirements are worth mentioning:

- The transfer from LHWP Phase I to the Vaal River system was kept constant on 780 million m³/a (1:50 year yield of this scheme) and not adjusted to 870 million m³/a in line with the updated agreement between Lesotho and RSA. In 2009 a volume of 743 million m³/a was transferred from Katse Dam to the Vaal River System.
- Without the future irrigation requirement from Vanderkloof Dam to Namibia (± 160 million m³/a) the future growth in the Orange River system from 2009 to 2045 is in the order of 300 million m³/a (Boskraai Dam sized according to this growth – see *Item D4.3a*).

- **Water availability**

The existing yield of the Orange River system of 3 843 million m³/a was obtained from WRP. This yield includes the reduction as a result of the existing EWR currently implemented in the Orange River system (287 million m³/a).

D2 WATER CONSERVATION AND WATER DEMAND MANAGEMENT (WC/WDM)

An assumption was made that a saving of 10% (phased in over 5 years) on the urban demand will be realistic in the Orange River catchment. DWA is currently conducting a study on this topic, however, the results of such a study is not yet available.

D3 ECOLOGICAL WATER REQUIREMENTS (EWR)

The future EWR to be implemented in the Orange River system was determined as part of the *LORMS Study*. This EWR (referred to as the 'Top-up' EWR) will only be a demand on Gariep and Vanderkloof dams and will comprise releases at the mentioned dams to compensate for the river mouth EWR. It is estimated that the implementation of the Reserve in this catchment will reduce the overall availability on average by 200 million m³/a.

An assumption was made that the 'Top-up' EWR will only be implemented once the next scheme comes into existence (mainly Boskraai/Bosberg and Vioolsdrift dams). However, as the yields of all future schemes in the Orange River system were calculated taking into account the 'Top-up' EWR, the effect of the Reserve is reflected as a reduction in the individual yields of these schemes rather than a decrease in the overall existing system yield of the Orange River system.

D4 DEVELOPMENT OPTIONS – ASSUMPTIONS FOR URV'S

D4.1 Dam at Vioolsdrift

On request of the Client and as part of the *Vaal River WRDP: Comparative Study between LHWP Phase II and Thukela Water Project*, an *Assessment of Water Availability in the Orange River* was carried out by WRP. From this assessment it was evident that a dam(s) need to be build In the Orange River to compensate for the loss in yield if LHWP Phase II is to be constructed. It was even found that an optimal sized Vioolsdrift Dam will not be able to compensate on its own for the loss in yield in the Orange River system and therefore a portion of Boskraai Dam will also need to be constructed. As a result Vioolsdrift Dam cannot be regarded any longer as an option to supply additional yield in the Orange River system.

D4.2 Utilising low level storage at Vanderkloof Dam

This remains an option but, as it will entail decreasing the amount of power supplied from the Vanderkloof Dam hydropower station, will not be realistic until the power problems have been solved in South Africa.

D4.3 Boskraai/Bosberg Dam

a) Description of development option

On request of the client and as part of the *Vaal River WRDP: Comparative Study between LHWP Phase II and Thukela Water Project*, an *Assessment of Water Availability in the Orange River* was carried out by WRP. As part of this study a scenario was analysed to determine the yield of a Boskraai Dam with a capacity of 7107 million m³ that will not inundate land in Lesotho. It was found that the surplus yield available at Boskraai Dam after allowing for support to the ORP (at 2008/09 development level) to prevent shortfalls at a 1:50 assurance level is 1 033 million m³/a. In the determination of this yield the following assumptions were made:

- LHWP Phase I included upstream
- Polihali and Vioolsdrift dams in place
- EWR for Orange River as currently released for the river mouth (287 million m³/a) included
- The so-called 'Top-up' EWR (modelled as part of the *LORMS* as well as the *Comparative Study* and the additional work carried out by WRP) included
- Future Namibia demands (± 160 million m³/a) included
- Future growth in the Orange River (± 300 million m³/a) excluded (future growth in the Orange River take account of the 120 million m³/a allocated to resource poor farmers in the Orange)

As there is currently surplus water available in the Orange River system (± 100 million m³/a) an assumption was made that half a Boskraai Dam (Bosberg Dam) will be sufficient to make up for the loss in yield in the Orange River system as a result of LHWP Phase II (± 290 million m³/a) as well as to supply the future growth in the Orange River system (± 300 million m³/a).

Therefore, this development option comprises the construction of a Bosberg Dam to supply the future growth in the Orange River system. No costs for conveyance infrastructure were included as it was assumed that water will only be released downstream for abstraction at Gariep Dam.

b) Description of scenarios

- Only one scenario considered.

c) Source(s) of information on costs

- Yield: *Assessment of Water Availability in the Orange River, 2009*
- Dam: *Orange River Development Project Replanning Study, 1999*

d) Base date of costs

- Dam: Base date April 1994, therefore all costs escalated with a factor of 3.36

e) Infrastructure**▪ Bosberg Dam (22% of a large Boskraai Dam)**

- Maximum yield: 227 million m³/a (provision made for EWR downstream of Boskraai Dam).
- Gross capacity: 3 554 million m³ (NB: Half of a Boskraai Dam to be built but only 44% of Bosberg's yield and cost assigned to this development option. Remaining 56% allocated to the LHWP Phase II).

f) Programme

- Based on the VAPS the construction period of Boskraai Dam was taken as 5 years and an assumption was made that the dam will take 3 years to deliver its full yield (2018).

g) Maintenance and operation

- General assumptions on maintenance and operation included.

h) Losses

- 10% losses were assumed to release water downstream for delivery to the Gariep Dam.

i) Energy requirement to deliver full yield

- No energy required for this development option.

D4.4 Mzimvubu-Kraai transfer**a) Description of development option**

For this development option water will be either abstracted at:

- 6 dams in the Mzimvubu River catchment (Siqingeni, Thabeng, Pitseng, Hlabakazi, Mpindweni and Ntabelanga dams) with conveyance through a system of pump stations (*7), pipelines, canals, syphons and tunnels to the Bell River, a tributary of the Kraai River; or
- Ntabelanga Dam only with conveyance through a pipeline to the Kraai River.

b) Description of scenarios

As set out above the following 2 scenarios were considered in this regard:

- Maximum transfer from the Mzimvubu catchment (20 m³/s or 631 million m³/a) from 6 dams in the Mzimvubu catchment; and
- Transfer of 150 million m³/a from Ntabelanga Dam only (to be comparable with desalination options).

c) Source(s) of information on costs

- Dams: *DWAF Water Resource Study in support of the ASGISA-EC Mzimvubu Development Project, 2009*
- Conveyance infrastructure for 631 million m³/a scheme: *Vaal Augmentation Planning Study (VAPS), 1996*
- Conveyance infrastructure for 150 million m³/a scheme: Calculated based on latest information available on costs for these types of infrastructure

d) Base date of costs

- Dams: Base date March 2008, therefore costs escalated with a factor of 1.08
- Conveyance infrastructure for 631 million m³/a scheme:
 - Base date April 1994, therefore costs escalated with a factor of 3.36
- Conveyance infrastructure for 150 million m³/a scheme:
 - Pipelines and balancing reservoirs: Base date 2009, therefore costs were not escalated.
 - Pump stations: Base date 2008, therefore costs escalated with a factor of 1.1

e) Infrastructure

- **Mzimvubu-Kraai transfer of 631 million m³/a:**
 In the VAPS 2 scenarios (20 m³/s and 40 m³/s) were analysed for the Mzimvubu-Kraai transfer. However, new yields from dams now had to be used as determined as part of the *Mzimvubu Development Project*. These dams are much smaller than those proposed in the VAPS. In the VAPS the suggested active storage requirement was approximately 2.5 MAR, whereas now the maximum capacities that were analysed was in the order of 1.5 MAR. A scenario was run with the WRYM set up as part of the *Mzimvubu Development Project* and the available yield from the same dam configuration as proposed in the VAPS determined on 22 m³/s (HFY drawn from all 6 dams simultaneously). An assumption could thus be made that 20 m³/s (EWR included) are available in the Mzimvubu River for transfer to the Orange River and a URV was determined for the 20 m³/s scenario.
- **Mzimvubu-Kraai transfer of 150 million m³/a:**
 - Taking account of the 10% loss from the Bell River to Gariep Dam, a 1.2 MAR Ntabelanga Dam that can deliver 165 million m³/a, was included in this scenario. As a result 150 million m³/a will reach Gariep Dam at the end.
 - Pipelines: A 90 km long pipeline with a diameter of 2.1 m was used.
 - Pump stations: 5 pump stations with a maximum head of 336 m. Each pump station has a balancing reservoir to provide a couple of hour's storage.

f) Programme

- **Mzimvubu-Kraai transfer of 631 million m³/a:**
 - Start of construction = Mid 2009
 - First delivery of water = 2016
 - Construction times of the various elements, except for the dams, based on the original programme for this scheme from VAPS
 - Construction time of dams taken between 3 and 4 years as determined as part of the Mzimvubu Development Project (start 2010)
 - Filling time requirements for the 2.5 MAR dams in the VAPS was given as 10 years to fill up to 60% of active storage (as the dams are in series). However, as these dams are now much smaller (1.5 MAR) the filling times as shown in **Table D3** were assumed (based on experience from the Mzimvubu Development Project). This entails 20% of the yield delivered in 2016 with full delivery in 2020 (100%).

Table D3 Filling times for dams in the Mzimvubu River catchment

Dam	Filling Time (years)
Pitseng	2
Hlabakazi	3
Mpindweni	5
Thabeng	2
Siqingeni	3
Ntabelanga	2

- **Mzimvubu-Kraai transfer of 150 million m³/a:**
 - A construction time of 3 years was assumed for Ntabelanga Dam as determined as part of the Mzimvubu Development Project (start 2013)
 - 2 years were allowed for filling of the dam

g) Maintenance and operation

- General assumptions on maintenance and operation included.

h) Losses

- 10% losses assumed for transfer of water from the Bell River to Gariep Dam (point of delivery).

i) Energy requirement

- Mzimvubu-Kraai transfer of 631 million m³/a:
 - As no information could be found on the electricity calculations of the Mzimvubu-Kraai transfer, assumed (average) flows were calculated and used to determine the annual electricity costs of this scheme
 - As average flows were used and no allowance was made for outages and maintenance (24 hours a day, 365 days per year)
 - Energy requirement: 1 778 329 MWh/a (214 MW)
- Mzimvubu-Kraai transfer of 150 million m³/a: 868 175 MWh/a (104 MW)

* Note that the unit energy requirement (kWh/m³ of raw water) for the 150 million m³/a Mzimvubu-Kraai transfer of 5.3 is much higher than that for the 631 million m³/a Mzimvubu-Kraai transfer of 2.9. This is as a result of the smaller transfer making use of a pipeline to pump water over the divide whereas conveyance to the Orange River for the bigger transfer is through a tunnel.

j) Ecological water requirements (EWR) in the Mzimvubu River catchment

As part of the *DWAF Water Resource Study in Support of the AsgiSA-EC Mzimvubu Development Project* the Desktop Reserve Model (DRM) was used to determine EWRs for each quaternary catchment of the Mzimvubu River and its main tributaries. These EWRs were included in the WRYM and therefore taken into account when the yields of future dams (as used in the *Marginal Cost of Water* task) were calculated. The EWRs that were used are summarised in **Table D4**.

Table D4 EWRs in the Mzimvubu River catchment

Quaternary catchment	MAR	Total MAR	EWR low flow requirement	Total EWR requirement	EWR (% of MAR)	Comments
	(million m ³ /a)		(million m ³ /a)			
T34F	39.5	55.1	7.5	14.0	25	D/s of Pitseng site
T34F_1		237.2	34.2	63.9	27	D/s of Hlabakazi site
T34H	91.2	331.4	47.3	88.1	27	D/s of Mpindweni site
T33D	61.0	304.2	14.5	41.2	14	D/s of Thabeng site
T33G	60.9	728.3	86.7	163.4	22	D/s of Siqingeni site
T35E	102.9	407.8	55.8	104.0	26	D/s of Ntabelanga site

D4.5 Desalination of seawater

a) Description of development option

This development option comprises abstraction and desalination of seawater at a site near Algoa Bay (about 50 km to the east of Port Elizabeth). Conveyance will be through a pipeline to the Orange River catchment.

b) Description of scenarios

Four different scenarios for desalination of water to the Orange River were considered:

- 100 million m³/a into the headwaters of the Orange River
- 100 million m³/a into Gariep Dam WTW
- 200 million m³/a into the headwaters of the Orange River
- 200 million m³/a into Gariep Dam WTW

c) Source(s) of information on costs

Balancing reservoirs, pipelines, pump stations and other infrastructure: Calculated based on latest information available on costs for these types of infrastructure (also based on work considered by WRC for desalination for municipalities, 2006).

d) Base date of costs

- Pipelines and balancing reservoirs: Base date 2009, therefore costs were not escalated
- Pump stations: Base date 2008, therefore costs escalated with a factor of 1.1
- Other infrastructure (WTW): Base date December 2007, therefore costs escalated with a factor of 1.14

e) Infrastructure

- Pipelines: A 430km long pipeline would be needed to deliver water to Gariep Dam WTW whereas this could be reduced to a 390km pipeline for water delivery to the headwaters of the Vaal River only. Diameters as follows:
 - 1.7 m for the 100 million m³/a transfer
 - 2.3 m for the 200 million m³/a transfer
- Pump stations: 8 pump stations with a maximum head of 300m

f) Programme

- Start of construction = 2013
- First delivery of water = 2016
- Construction time of various infrastructure vary between 2 and 3 years

g) Maintenance and operation

- General assumptions on maintenance and operation included.

h) Losses

- 100 and 200 million m³/a into the headwaters of the Orange River: 5% losses assumed for transfer of water from the Orange River to Gariep Dam (point of delivery) as it is a relatively short distance.
- 100 and 200 million m³/a into Gariep Dam WTW: 0% losses assumed for transfer of water as water is delivered to Gariep Dam (point of delivery).

i) Energy requirement to deliver full yield

- 100 million m³/a schemes: 1 410 140 MWh/a (169 MW)
- 200 million m³/a schemes: 2 812 850 MWh/a (337 MW)

D4.6 Water supply to Bloemfontein**a) Description of development option**

This development option comprises four different alternatives for augmenting the supply to Bloemfontein and includes the following:

- Bosberg/Boskraai Dam
- Water re-use from Krugersdrift Dam
- Additional pumping capacity at Tienfontein/Novo and new Novo/Modder pipeline
- Additional pumping capacity at Novo

b) Description of scenarios

- No unit reference values (URV's) calculated for the mentioned alternatives. However, total costs were reflected in the capital cost stream for the country.

c) Source(s) of information on costs

- Water demands and costs: *Bloemfontein Reconciliation Strategy, 2009*

d) Base date of costs

- Assumption made that the base date is 2009, therefore costs were not escalated.

e) Infrastructure

- No additional information available.

f) Programme

- All four mentioned alternatives need to be implemented to compensate for the current and future deficit in supply to Bloemfontein.
- Assumption made that all four mentioned alternatives can be implemented by 2020.
- Based on the demand, the Boskraai/Bosberg-option (being the most expensive option) only needs to be implemented 5 years after the other options.

g) Maintenance and operation

- As the available information from the *Bloemfontein Reconciliation Strategy* only included a fixed cost for 'maintenance and operation', an assumption was made that 1% of the capital cost could be attributed to maintenance cost and the remainder to energy. Based on the above the energy usage (MWh/a) was calculated for each alternative (assuming a cost of energy of 60c/kWh) and the general assumptions on energy applied to calculate the energy requirement for each.

h) Losses

- No unit reference values (URV's) calculated for the mentioned alternatives and therefore no assumptions need to be made on losses.

i) Energy requirement

- Bosberg/Boskraai Dam: 49 500 MWh/a (6 MW)
- Water re-use from Krugersdrift: 51 150 MWh/a (6 MW)
- Additional pumping capacity at Tienfontein/Novo and new Novo/Modder pipeline: 33 000 MWh/a (4 MW)
- Additional pumping capacity at Novo: 1 650 MWh/a (0.2 MW)

D5 DEVELOPMENT OPTIONS – NOTES ON PHASING

- **Bosberg Dam** will be sufficient to supply the future growth in the Orange River up to 2050 and should be seriously considered as the next development option to augment the Orange River's yield.
- However, the Orange River catchment could experience an interim deficit of ± 11 years as a result of the required time to implement **Bosberg Dam**.
- Although expensive, **the transfer of water from the Mzimvubu River catchment** remains an option for augmenting the Orange River's yield.

APPENDIX E

**ASSUMPTIONS AND OBSERVATIONS PERTAINING TO
THE LEPHALALE AREA**

APPENDIX E

ASSUMPTIONS AND OBSERVATIONS PERTAINING TO THE LEPHALALE AREA

- E1 WATER REQUIREMENTS AND WATER AVAILABILITY
- E2 WATER CONSERVATION AND WATER DEMAND MANAGEMENT (WC/WDM)
- E3 ECOLOGICAL WATER REQUIREMENTS (EWR)
- E4 DEVELOPMENT OPTIONS – ASSUMPTIONS FOR URV'S
 - E4.1 Crocodile River surplus (Mokolo Crocodile Augmentation Phase 1 & 2)*
 - E4.2 Re-use and transfer of water from Vaal*
 - E4.3 Transfers from Vaal River supply system*
 - E4.4 Transfers from the Zambezi River*
 - E4.5 Desalination of seawater*
- E5 DEVELOPMENT OPTIONS – NOTES ON PHASING

APPENDIX E – ASSUMPTIONS AND OBSERVATIONS PERTAINING TO THE LEPHALALE AREA

E1 WATER REQUIREMENTS AND WATER AVAILABILITY

The following reports and information were primarily used to obtain and abstract information about water requirements and water availability:

- *Mokolo-Crocodile Water Augmentation Project (MCWAP) feasibility study: Technical module (2009)*
- *Crocodile (West) River System: Large Bulk Water Supply Reconciliation Strategy, 2009*
- Updated water requirement projections for the Lephalale Area (received per e-mail from Aurecon, 23 October 2009)

Currently water is supplied to the Lephalale area from the Mokolo Dam. The yield of Mokolo Dam is 39 million m³/a, of which 10.4 million m³/a is allocated to irrigation. Return flows are minimal and are assumed not to contribute to additional water availability.

The current water requirement of about 15 million m³/a, excluding irrigation, is expected to grow rapidly as a result of expansions in power generation and petro-chemical developments. Projections of water requirement growth are currently volatile due to economic uncertainties. As a result, various scenarios have been developed to try and adapt to changing water requirement projections. A scenario was chosen that takes into account possible delays in development in the area but includes likely stakeholders. This is shown as the Delayed scenario 9 in **Figure E1**.

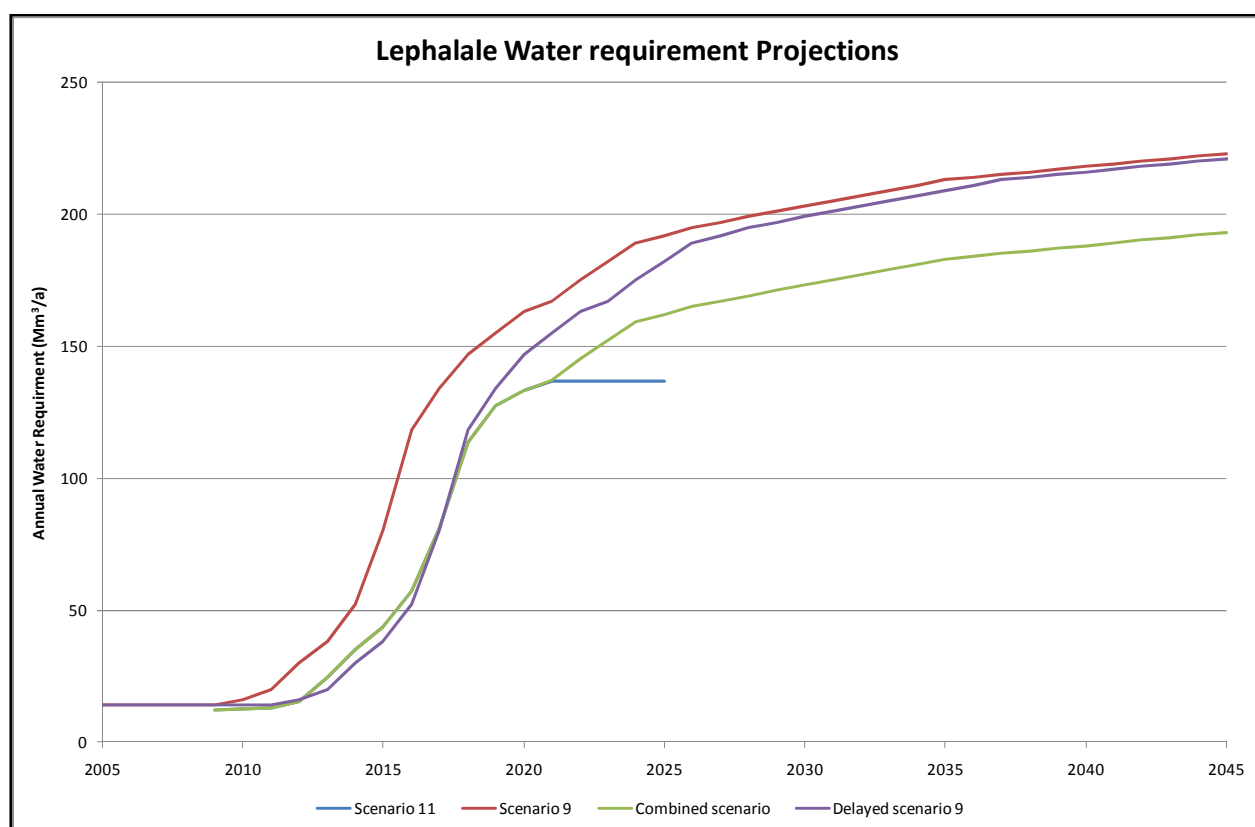


Figure E1 Water requirement projection scenarios for Lephalale

E2 WATER CONSERVATION AND WATER DEMAND MANAGEMENT (WC/WDM)

No information was available on possible WC/WDM interventions for Lephalale. The planned power generation and petro-chemical developments are likely to make very efficient use of water and the only limited scope for WC/WDM lies with the urban users. The generic assumption of 10% reduction/savings in Urban water requirements achieved over 5 years was applied, which resulted in a small possible saving of about 1 million m³/a by 2015.

E3 ECOLOGICAL WATER REQUIREMENTS (EWR)

The EWR was considered and the yield of Mokolo Dam provided for releases for the EWR. As the current use of Mokolo Dam is lower than the yield, implementing the EWR will not affect existing users.

E4 DEVELOPMENT OPTIONS – ASSUMPTIONS FOR URV'S

E4.1 Crocodile River surplus (Mokolo Crocodile Augmentation Phase 1 & 2)

a) Description of development option

The *Mokolo-Crocodile Water Augmentation Project* is to augment water supply to the Lephalale area by expanding the infrastructure from Mokolo Dam (Phase 1) and transferring water from the Crocodile River (Phase 2).

Phase 1 involves fully utilizing the available yield from Mokolo Dam. Although Phase 1 has a long term capacity of 28 million m³/a, it only adds 14 million m³/a additional yield to the existing 14.7 million m³/a of the existing Exxaro pipeline, which becomes a redundant back-up system. Phase 1 has a higher peak capacity to supply growing demands in the short term before Phase 2 comes online, after which the spare capacity becomes a redundancy. Phase 1 includes a new pump station and gravity line to the Zeeland reservoir, and a new gravity main to Lephalale and on to the users at Steenbokpan.

The transfer capacity of Phase 2 is not yet determined due to uncertainties in growth in the Lephalale region to economic variability. As such the volume of 169 million m³/a included in the Feasibility study has been used for this exercise. This volume also corresponds to the water requirements projections used in this study. Although Phase 2 will have a transfer capacity of around 169 million m³/a, only 40 million m³/a surplus is likely to be available in the Crocodile River for transfer. Additional water will need to be transferred into the Crocodile River. A possible identified source is the transfer of re-use water from the Klip River (a tributary of the Vaal River, west of Johannesburg CBD) to the Crocodile River.

b) Description of scenarios

Various scenarios of water requirement growth and associated augmentation transfer capacity have been investigated (see Figure E1):

- Scenario 9 – Water requirements growing to 165 million m³/a by 2020 and up to 200 million m³/a by 2030, with Medupi and 4 new coal fired power stations and other petro-chemical and mining developments
- Scenario 11 – a delayed growth in water requirements (predominantly due to economic climate) up to 135 million m³/a by 2020 and up to 140 million m³/a by 2025, with Medupi and 3 other new coal fired power stations and other petro-chemical and mining developments
- For this study a combined scenario was derived whereby the total growth of scenario 9 was used including more potential developments, but was delayed to match the delayed growth rate which is more likely as per Scenario 11. This has been referred to as Delayed Scenario 9.

c) Sources of information on costs

- *Mokolo and Crocodile River (West) Water Augmentation Project (MCWAP) Feasibility Study: Technical Module (2009).*
- Additional spreadsheets were obtained from the Regional Chief Engineer and the consultants (Africon) that worked on the feasibility study and the Consultants (Aurecon) that are conducting further work on the project.

d) Base date of costs

- The base date for costs on the *Mokolo-Crocodile Water Augmentation Project* Phases 1 and 2 is April 2008 and an escalation factor of 1.04 was used to update the cost of the schemes.

e) Infrastructure

- Mokolo Dam (Phase 1): Yield 39.1 million m³/a
- Weir at Vlieëpoort on Crocodile River (Phase 2) for run of river abstraction
- 84 km of rising and gravity mains ranging from 800 mm to 1 900 mm in diameter for Phase 1
- 120 km of rising and gravity mains ranging in diameter from 1 900 mm to 2 300 mm for Phase 2
- A new pump station at Mokolo Dam for Phase 1
- 2 new pump stations (1 low lift river abstraction and 1 high lift) at Vlieëpoort for Phase 2

f) Programme

- Implementation programs for the two phases were adopted as included in the feasibility reports, but were updated where necessary. **Table E1** is taken from the Feasibility Report conducted for Phase 2.

g) Maintenance and operation

- Included as per general assumptions.

h) Losses

- Conveyance losses of 2% were included as detailed in the feasibility study. No river transmission losses were included for the *Mokolo-Crocodile Water Augmentation Project* Phases 1 and 2.

i) Energy requirement

- The energy requirements of Phase 1 are 71 MWh/day (approximately 3 MW). Phase 2 requires 388 MWh/day or 16 MW to pump the full 169 million m³/a.

j) Other

- The URV of water supplied by these schemes may be higher than that supplied by a similar scheme but at a lower assurance of supply and with less back-up storage and redundancy (phase 1).

E4.2 Re-use and transfer of water from Vaal**a) Description of development option**

Water is collected from three large wastewater treatment works (WWTW) in the Klip River catchment, a tributary of the Vaal River lying in Western Johannesburg, treated further and transferred over the divide into the headwaters of the Crocodile River. The three WWTWs are Olifantsvlei, Goudkoppies and Bushkoppie.

**Table E1 Implementation program for Mokolo-Crocodile Water Augmentation Project
(Phase 1 and 2)**

Item No.	DESCRIPTION	Original Program dated 01 April 2008	Revised Program dated 12 June 2009	Revised Program dated 30 June 2009
1	Topographical Survey		14 Aug 2009	28 Sep 2009
2	Detail Geotechnical Investigations P1		28 Aug 2009	14 Aug 2009
3	Detail Geotechnical Investigations P2A		15 Jan 2010	7 Jun 2010
4	Environmental Module		20 Jul 2010	13 Sep 2010
5	User Supply Agreements P1		09 Dec 2009	09 Dec 2009
6	User Supply Agreements P2A			12 June 2011
7	Procure Engineering Services		08 Jun 2009	31 July 2009
8	Land Acquisition Phase 1		09 Jun 2010	6 Dec 2010
9	Land Acquisition Phase 2A		12 Oct 2010	28 Jun 2011
10	Award Contract Phase 1		08 Oct 2010	6 Dec 2010
11	Award Contract Phase 2A		30 May 2011	9 Aug 2011
12	Water Delivery Phase 1	Nov 2011	12 April 2012	3 Dec 2012
13	Water Delivery Phase 2A	Jun 2014	16 Dec 2014	12 Aug 2015

b) Description of scenarios

Various volumes of 30, 70 and 140 million m³/a were investigated for transfer, with equal contributions from the 3 WWTW:

- For this study the largest volume of 140 million m³/a was utilised
- Due to the lower capital cost, the scheme with a collection point at Goudkoppies was chosen.

c) Source(s) of information on costs

- Preliminary Engineering Design of the Water Distribution System for the Vaal Water Scheme: Technical Memorandum (Report prepared by Golder)

d) Base date of costs

- Capital, maintenance and operation costs, excluding energy, were escalated from an assumed Jan 2008 base date (report dated June 2008 – no date for capital costs given). The associated escalation factor is thus 1.129.

e) Infrastructure

- Three pipelines of diameter 1 100 mm to deliver water from WWTWs to collection point totalling 14.5 km in length. An additional 35.5 km of 2 000 mm diameter pipeline is required to then deliver water over the divide into the Crocodile River.

▪ Pump stations:	<u>Head</u>	<u>Energy</u>
○ Goudkoppies to Collection:	15 m	116 kW
○ Bushkoppie to Collection:	120 m	802 kW
○ Olifantsvlei to Collection:	110 m	1 146 kW
○ Collection to outfall:	164 m	1 670 kW

f) Programme

Implementation program adopted from generic timeline. The current status is that of a completed reconnaissance level study and by assuming the following, earliest water delivery can begin in 2019:

- 1 year pre-feasibility study
- 2 year feasibility study
- 2 year decision support phase
- 2 year design phase
- 2 year construction

This program does not assume any fast-tracking that may be needed.

g) Maintenance and operation

- Maintenance of infrastructure costs based on general assumptions. Additional operational costs of R7.7 million/a and treatment costs of R11.2 million/a were included (both costs stated for Jan 2008).

h) Losses

- 10% river losses are assumed for the stretch between delivery into the headwaters of the Crocodile River and abstraction at Vlieëpoort. The lower reach of the Crocodile River is known for losses as a result of sand aquifers.

i) Energy requirement

- Energy requirements for pumping and treatment together are 350 MWh/day or 14.5 MW.

j) Other

- No desalination of water is deemed necessary as the water being received by the WWTWs is still of sufficiently low salinity to be introduced into the Crocodile River, due to the high standards and low salinity of the original water being supplied to users by Rand Water.
- The cost of transferring the water in the Crocodile River to the Lephalale area (*Mokolo-Crocodile Water Augmentation Project* Phase 2 URV) needed to be added to the incremental cost of this augmentation of the surplus of water in the Crocodile River to provide the full marginal cost of this re-use of water to the Lephalale area.

E4.3 Transfers from Vaal River supply system

a) Description of development option

Water is assumed to be transferred from the Vaal Dam to a tributary of the Crocodile River along the shortest distance, but avoiding urban areas where possible

b) Description of scenarios

Two possible routes:

- To the west of the Johannesburg CBD to a tributary of the Bloubank Spruit
- To the east of Johannesburg CBD into the headwaters of the Hennops River

The route to the east has a 60 m lower pumping head and was the same length and thus chosen as preferable. Two reference scheme sizes were included for comparison, namely 100 and 200 million m³/a.

c) Source(s) of information on costs

The scheme was identified and a conceptual level design and cost estimate conducted based on:

- The pipeline, pump station costs gathered for this study
- 1:50 00 maps and Google Earth
- Additionally, any pipeline routes through urban areas were assumed to double the normal cost to account for the difficulties in routing, and any pipelines through peri-urban areas were assumed to be 50% more expensive
- Abstraction at Vaal Dam based on VRESUP scheme configuration

d) Base date of costs

- July 2009 (current/reference date prices obtained and utilised)

e) Infrastructure

- 110 km of pipeline was required
- 1 700 mm diameter pipe for the 100 million m³/a capacity scheme
- 2 250 mm diameter pipe for the 200 million m³/a capacity scheme
- One low lift pump station for abstraction from Vaal Dam and
- One high lift pump station was required. The pumping head and energy requirements are provided:

	<u>Low lift pump station</u>		<u>High lift pump station</u>	
○ 100 million m ³ /a scheme	38 m	1 MW	280 m	11 MW
○ 200 million m ³ /a scheme	38 m	3 MW	280 m	22 MW

f) Programme

- The generic timeline was adopted with the earliest delivery of water possible in 2020.

g) Maintenance and operation

- As per general assumptions.

h) Losses

- 10% river losses are assumed for the stretch between delivery into the headwaters of the Crocodile River and abstraction at Vlieëpoort. The lower reach of the Crocodile River is known for losses as a result of sand aquifers.

i) Other

- Additional to adding the cost (URV) of transfer from the Crocodile River to the Lephalale area to the incremental cost of water for this scheme (Vaal-Crocodile transfer), the cost of securing additional water for the Vaal River system also needs to be added to get the total cost of water in the Vaal to Lephalale. I.E. The water being transferred from the Vaal River to the Lephalale area via the Crocodile River will most likely come from another source e.g. LHWP Phase II (Polihali Dam).

E4.4 Transfers from the Zambezi River

a) Description of development option

The Zambezi River has been studied for water delivery to the Vaal River as part of the VAPS. The study suggested that water could either be taken from below the Victoria Falls or from above it. The flows in the Zambezi River at the Victoria Falls taken from the VAPS are included in **Figure E2** and **Figure E3**.

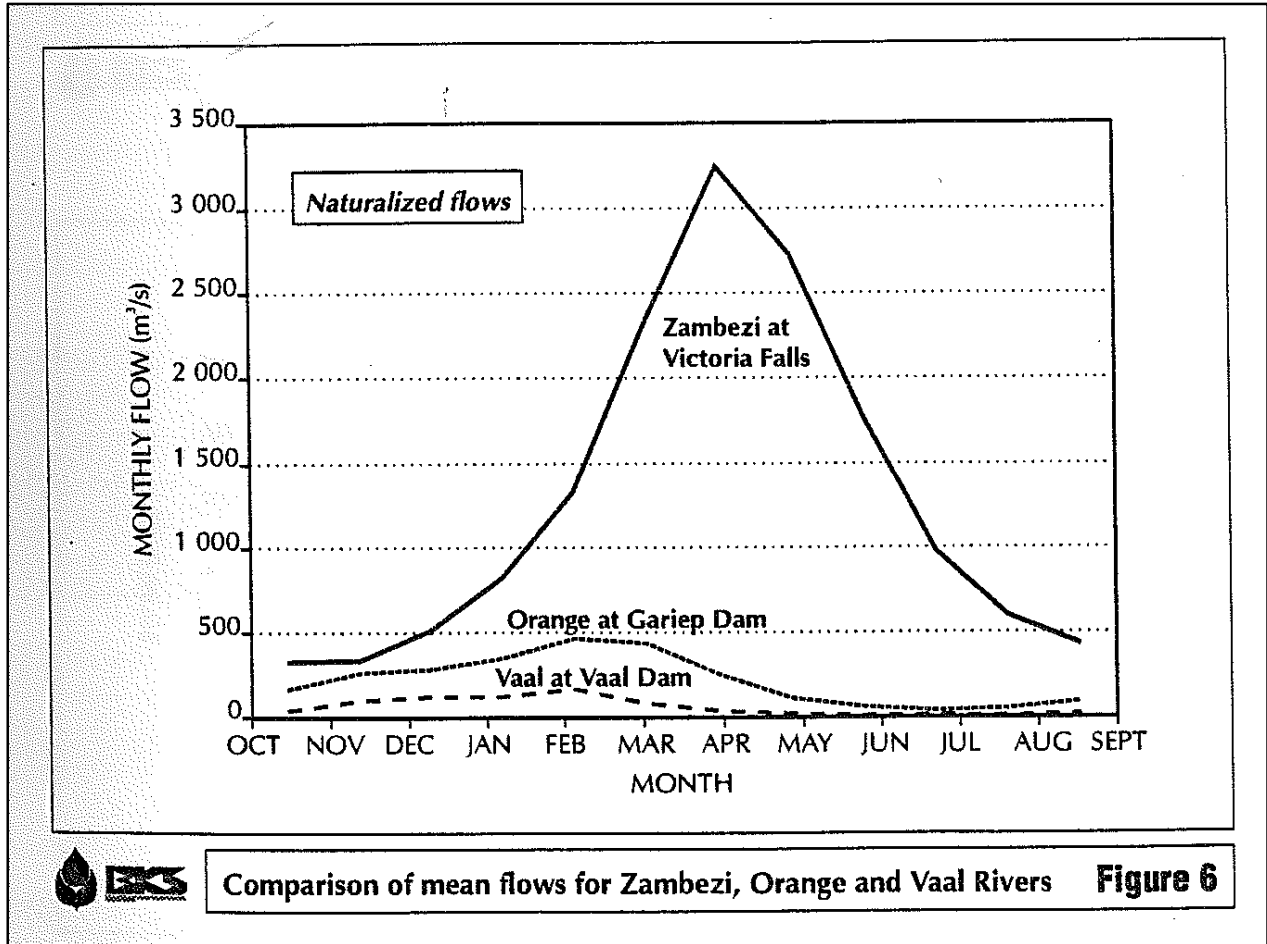
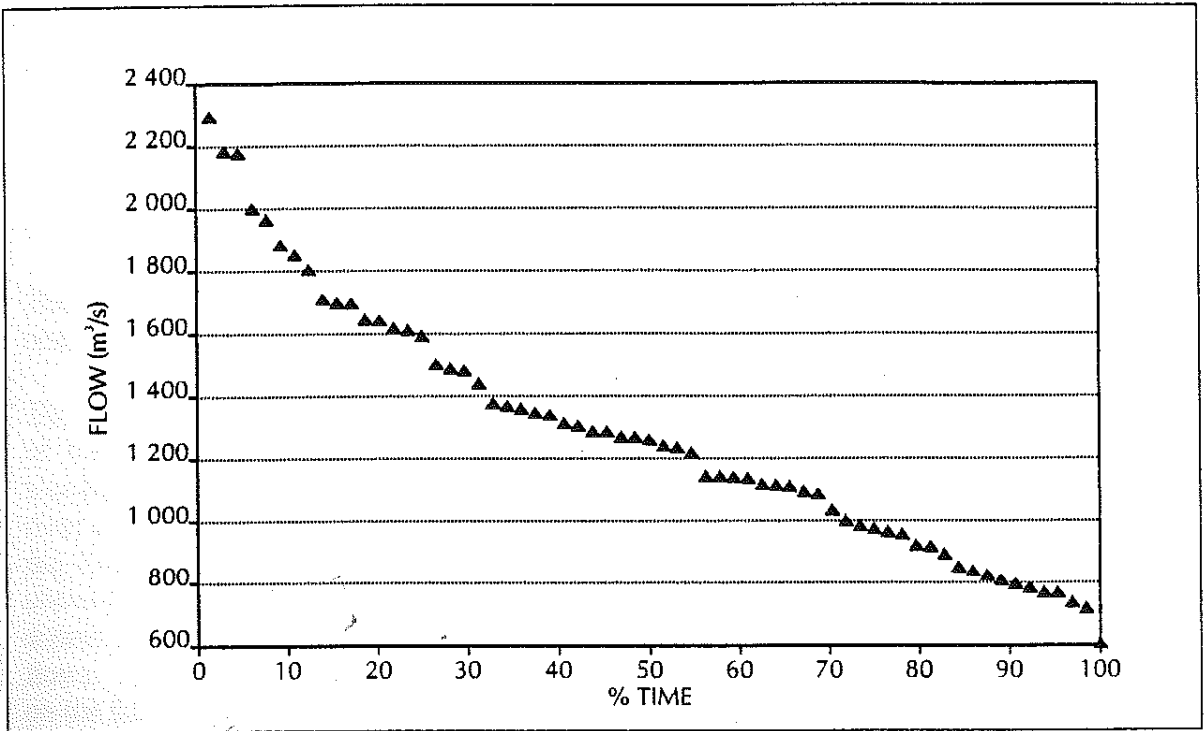


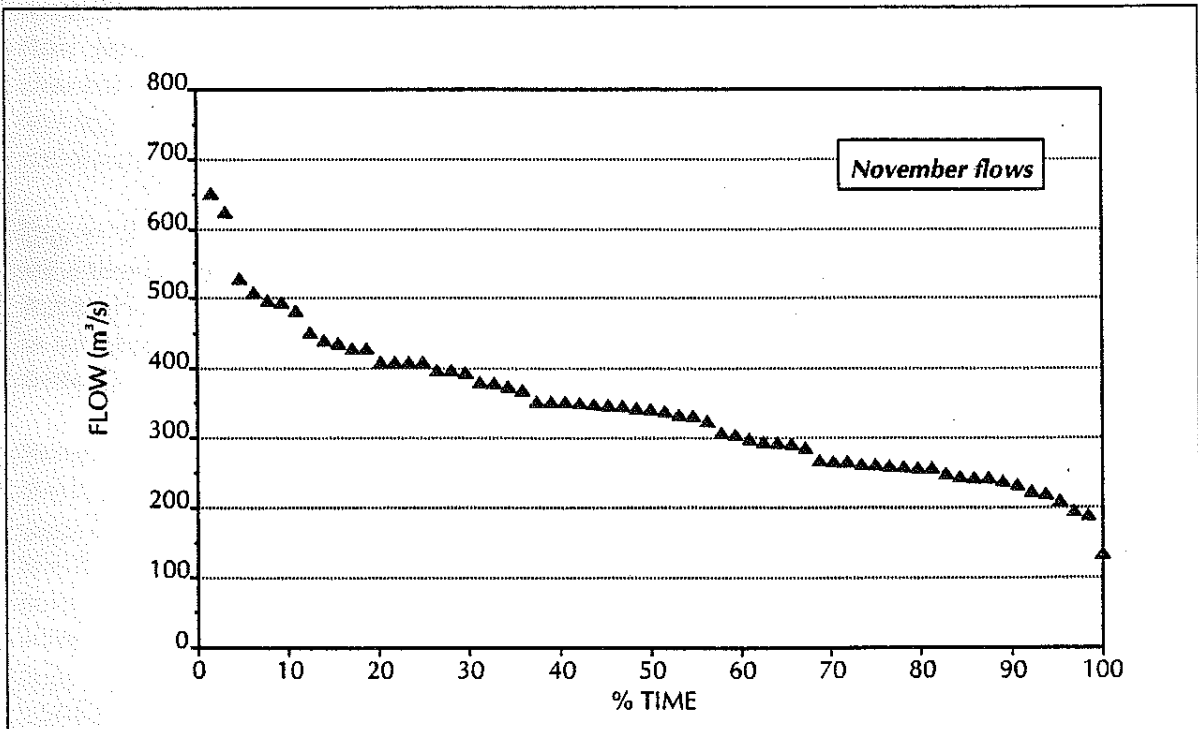
Figure E2 Mean monthly flows at Victoria Falls on the Zambezi River

Abstracting water upstream of the Victoria Falls has the benefit of a lower pumping head. According to the flows at Victoria Falls presented in the figures, an abstraction of 200 million m³/a is approximately only 3% of the low monthly flow at a 98 percentile assurance, and 1% of the 98 percentile of the average annual flow duration. These volumes being abstracted would thus be small relative to the flows recorded in the Zambezi it was assumed that abstraction above the falls is acceptable, with negligible impact on the river flow and flow over the falls. This assumption however has not been validated. The point of abstraction chosen on the Zambezi upstream of the Victoria Falls is where the three countries' borders meet near Kazangula.



Annual flow duration for Zambezi River at Victoria Falls

Figure 7



Monthly flow duration for Zambezi River at Victoria Falls

Figure 8

Figure E3 Flow duration curves for Victoria Falls on the Zambezi River

b) Description of scenarios

Three possible schemes have been investigated at a low level of detail.

- 100 million m³/a and
- 200 million m³/a schemes for Lephalale,
- A transfer option from the Zambezi River using the largest practical pipe size of 3.5 m in diameter (total transfer of 650 million m³/a), and sharing the delivered water between the Lephalale area (200 million m³/a), Pretoria (350 million m³/a) and the Olifants River catchment (100 million m³/a).

c) Source(s) of information on costs

- The scheme was identified and a conceptual level design and cost estimate conducted based on the pipeline, pump station costs gathered for this study, and 1:50 00 maps and Google Earth.

d) Base date of costs

- July 2009 (current/reference costs).

e) Infrastructure

- Dams
 - An off-channel balancing dam was included to provide a fortnight's storage for the 100 million m³/a scheme and a week's storage for the larger scheme. The off-channel storage is located on a gully to the south of the Zambezi River and has a wall height of about 15 m.
- Pipelines
 - 770 km of 1 700 mm diameter pipeline for the 100 million m³/a scheme,
 - 770 km of 2 250 mm diameter pipeline for the 200 million m³/a scheme
- Pump stations
 - 1 low lift abstraction works and
 - 5 high lift pump stations with a maximum pumping head of 200 m and a combined energy requirement of 30 MW.

f) Programme

- The timeline model was utilized to determine the implementation program. Considering the current low level of detail, and the size and complexity of the scheme, particularly the negotiations to determine royalties that would need to be paid to 5 or more riparian countries, the earliest delivery date was estimated to be 2028.

g) Maintenance and operation

- Costs derived as per the general assumptions
- Royalties were estimated for a Zambezi scheme on the assumption that the royalties paid will be equal to half the benefit between the cost of the Zambezi scheme and the next best scheme, which in almost all cases would be desalination of seawater. The cost benefit ranged from about R7 to R14/m³ and as such an average indicative royalty of R5/m³ was chosen.

h) Losses

- No Losses were included to Lephalale.

i) Energy requirement

- The energy required to pump the 100 million m³/a was 30 MW and 59 MW is required to deliver 200 million m³/a.

j) Other

- Although a large sharing scheme with water delivered to Pretoria, Lephalale and the Olifants appears to be possibly cheaper, the planning and implementation of a scheme to supply all three regions is likely to be difficult.

E4.5 Desalination of seawater**a) Description of development option**

Water is assumed to be abstracted and desalinated from the Indian Ocean at a plant on the KZN coastline at Richards Bay. The water is then pumped to Lephalale.

b) Description of scenarios

Four scenarios in total were investigated:

- 100 million m³/a directly to Lephalale via pipeline
- 100 million m³/a released into a tributary of the Crocodile River with a shorter pipeline and then transferred to the Lephalale area from the Crocodile River
- 200 million m³/a directly to Lephalale via pipeline
- 200 million m³/a released into a tributary of the Crocodile River with a shorter pipeline and then transferred to Lephalale from the Crocodile River

Both options to put water into the headwaters of the Crocodile River and then transfer the water to the Lephalale area from Vlieëpoort were not considered further as the URVs were greater and the addition of the good quality desalinated seawater to lesser water quality in the Crocodile River with its associated river losses would not be favourable.

c) Source(s) of information on costs

- Pipeline and pump station costs were calculated based on the current costs obtained for this study.
- Desalination costs were based on work conducted for the *Western Cape Reconciliation Strategy*, and the work conducted by WRC for desalination for Municipalities 2006.

d) Base date of costs

- Base dates of different infrastructure components varied between current (2009) costs and (2006) costs, but were all escalated to 2009 where necessary.

e) Infrastructure

- Pipelines
 - 900 km of pipeline was required. 1 700 mm diameter pipeline was used for a transfer capacity of 100 million m³/a, and a 2 250 mm pipeline for transferring 200 million m³/a.
- Pump stations
 - Seven pump stations (up to 300 m pumping head) were included to pump over the water divide, after which the water is gravity fed to Lephalale.
 - Balancing reservoirs were included at each pump station.

f) Programme

- The earliest implementation date was estimated from a program based on the generic timeline. The earliest date of water delivery was estimated at 2025.

g) Maintenance and operation

- Determined as per the standard assumptions, but with an additional R1.94/m³ of water for operation cost of the desalination plant (excl. energy).

h) Losses

- No losses were included as the water was delivered directly to Lephalale.

i) Energy requirement

- The energy required to desalinate the seawater is 7.5 kWh/m³, which equates to about 179 MW for a 200 million m³/a plant, and 90 MW for a 100 million m³/a plant.
- The energy required for the full transfer of water to Lephalale is 159 MW for the 200 million m³/a schemes and 80 MW for the 100 million m³/a schemes.

j) Other

- A reduction in the total URV of R2/m³ was made to bring the potable desalinated seawater to a raw water basis.

E5 DEVELOPMENT OPTIONS – NOTES ON PHASING

Although a surplus of 40 million m³/a is likely to be available in the Crocodile River for transfer as for Phase 2 of the *Mokolo-Crocodile Water Augmentation Project*, the additional water required to augment the surplus in the Crocodile River may not be available on time. The identified source for this additional water is the re-use of water from wastewater treatment works in the Klip River. The scheme to transfer this water, if following the generic timeline, will only be available in 2018, which could create a short term deficit if water requirements grow as projected.

APPENDIX F

ASSUMPTIONS AND OBSERVATIONS PERTAINING TO THE OLIFANTS RIVER SYSTEM

APPENDIX F

ASSUMPTIONS AND OBSERVATIONS PERTAINING TO THE OLIFANTS RIVER SYSTEM

- F1 WATER REQUIREMENTS AND WATER AVAILABILITY
- F2 WATER CONSERVATION AND WATER DEMAND MANAGEMENT (WC/WDM)
- F3 ECOLOGICAL WATER REQUIREMENTS (EWR)
- F4 DEVELOPMENT OPTIONS – ASSUMPTIONS FOR URV'S
 - F4.1 Olifants Dam (at Rooipoort)*
 - F4.2 Use of acid mine drainage*
 - F4.3 Direct re-use of treated water*
 - E4.4 Transfers from Vaal River supply system*
 - F4.5 Transfers from the Zambezi River*
 - F4.6 Desalination of seawater*
- F5 DEVELOPMENT OPTIONS – NOTES ON PHASING

APPENDIX F – ASSUMPTIONS AND OBSERVATIONS PERTAINING TO THE OLIFANTS RIVER SYSTEM

F1 WATER REQUIREMENTS AND WATER AVAILABILITY

The following reports and information were primarily used to obtain and abstract information about water requirements, and water availability:

- *Integrated Water Resources Management plan for the Upper and Middle Olifants Catchment* (Interim report May 2009)
- *Olifants River Water Resources Development Plan (2004/2005)*
- *National Water Resources strategy (2003)*
- Conversations with Mr T Coleman from Golder

The water requirements and availability for the Olifants River system were based on figures from the *National Water Resources Strategy (NWRS) Report entitled Olifants Water Management Area: Overview of Water Resources Availability and Utilisation*. Some adjustments were made based on results from follow-up studies, namely the *Olifants River Water Resources Development Plan (ORWRDP)*.

In the NWRS the projected mining requirements increased from 94 to 119 million m³/a between 2000 and 2025. This increase of 16 million m³/a in mining water requirements is projected in the Middle Olifants sub-catchment.

The ORWRDP projected an increase of 19 million m³/a in the Steelpoort sub-catchment and an increase of 8 million m³/a in the Middle Olifants, totalling 27 million m³/a between 2009 and 2025. This additional increase of 11 million m³/a (between 16 million m³/a of the NWRS and 27 million m³/a from the ORWRDP) was included in the updated water requirements for this project. It was assumed that no further growth in mining requirements will take place after 2025.

The NWRS projected an increase in water deficit from 194 million m³/a in 2000 to a deficit of 281 million m³/a by 2025 (increase of 87 million m³/a). Through linear interpolation this is an increase in water deficit of 56 million m³/a between 2009 and 2025. The ORWRDP projected an increase in water deficit of 50 million m³/a over the same period. Because of this small difference (between 56 and 50 million m³/a) seen in context with the total water requirement (over 1 000 million m³/a), no further refinements of the projected water requirements for the Olifants River system from the NWRS were made.

The deficits projected included the estimated impact of the implementation of the Reserve on the system yield for the Olifants River catchment of 177 million m³/a.

The Olifants River System is currently supplemented with transfers from the Inkomati (Nooitgedacht Dam to Eskom's Duvha, Hendrina and Arnot Power Stations), from the Usutu (Jericho Dam to Eskom's Kendal, Matla and Kriel Power Stations) as well as from the Upper Vaal (Grootdraai Dam to Eskom's Matla Power Station).

These water requirements for power stations situated in the Olifants River, but supplied from the Vaal River system which includes the Inkomati and the Usutu, were excluded from the Olifants River system and included in Vaal River System. These portion of the water requirements totalled 185 million m³/a in 2009 growing to 209 million m³/a in 2025. Correspondingly the water availability of 182 million m³/a currently available to supply these power stations was also excluded from the Olifants River system and included in the Vaal River system.

The total water requirement of 1 029 million m³/a, includes 557 million m³/a of irrigation water requirements. Irrigation is assumed to be kept constant in future projections.

F2 WATER CONSERVATION AND WATER DEMAND MANAGEMENT (WC/WDM)

Very little information was available on possible WC/WDM interventions for the Olifants catchment. As such the generic assumption of 10% reduction/savings in Urban water requirements achieved over 5 years was applied, which resulted in a small possible saving of about 11 million m³/a by 2015.

F3 ECOLOGICAL WATER REQUIREMENTS (EWR)

As mentioned in F1, the impact of implementing releases for the EWR on the existing system yield is on average 177 million m³/a. The current flow requirements of the EWR and will be focused on further as part of the Reconciliation strategy study that is currently commencing. The yields provided for additional possible developments (i.e. the Olifants Dam at Rooipoort) include releases for the EWR.

F4 DEVELOPMENT OPTIONS – ASSUMPTIONS FOR URV'S

F4.1 Olifants Dam (at Rooipoort)

a) Description of development option

The Olifants Dam site, also known as Rooipoort Dam from previous reports, lies in the middle Olifants River below Flag Boshielo Dam. Water releases from the Olifants Dam could be utilised at Havercroft Weir and pumped to various users.

b) Description of development option

- Only one scenario for the Olifants Dam was investigated

c) Source of information on costs

- Information was sourced from the *Olifants River Water Resources Development Plan*.

d) Base date of costs

- The base date of the costs for the information gathered on the Olifants Dam is March 2003 and an escalation factor of 1.54 was used to update the cost of the scheme.

e) Infrastructure

- Olifants Dam - capacity 365 million m³, Yield 55 million m³/a
- Abstraction at dam or Havercroft Weir downstream

f) Programme

- Implementation program for the Olifants Dam development was determined from the generic timeline with consideration of the project size and complexity. The earliest possible water delivery date is 2018 with construction to begin in 2015.

g) Maintenance and operation

- Included as per general assumptions.

h) Losses

- Losses of 5% were included for the river reach between the dam and Havercroft Weir.

i) Energy requirement

- Water can be gravitated to Havercroft Weir in the river. No further distribution of water was considered to final users as and as such no associated energy was included

j) Other

- Other possible sites near Rooipoort for an Olifants Dam have been investigated, but the yields are all similar, and the site at Rooipoort was chosen to be representative of a dam development in this stretch of the Olifants River.

F4.2 Use of acid mine drainage**a) Description of development option**

This development option comprises the in-direct use of acid mine drainage in the Upper and Middle Olifants i.e. water is treated at the mines to a standard that can be re-introduced to the river systems and utilised downstream.

b) Description of scenarios

- One scenario for use of acid mine drainage in the Olifants was investigated. The volume was based on the anticipated volume of acid mine drainage that is expected to decant by about 2016 based on an annual rainfall of 700 mm (33 million m³/a of water available).

c) Sources of information on costs

- Energy and maintenance costs: A report from the WRC on desalination for municipalities in the Western Cape, 2006
- *Integrated Water Resources Management plan for the Upper and Middle Olifants Catchment (Interim report May 2009)*
- *Development of an Integrated Water Quality Management Plan for the Vaal River System: Task 6 – Evaluation of Water Quality Management Scenarios, 2008*
- Communication with Trevor Coleman

d) Base date of costs

- Base date of all costs July 2006, therefore costs escalated with a factor of 1.11.

e) Infrastructure

Capital costs on infrastructure (treatment plants, pump stations and pipelines) taken from the report on the *Development of an Integrated Water Quality Management Plan for the Vaal River System: Task 6 – Evaluation of Water Quality Management Scenarios, 2008*.

f) Programme

- Based on generic timeline model
- Start of construction = 2016/2017
- First delivery of water = 2019
- Construction time of various infrastructure varies between 2 and 3 years

g) Maintenance and operation

- An additional operating cost of R1.00/m³ of water was assumed at the treatment plants for treating the acidic water to re-introduction to river system standards (excluding energy). This figure is similar to the treatment of effluent for re-use.

h) Losses

- 5% losses assumed for river losses to downstream dams and users.

i) Energy requirement

Existing energy requirements are in the region of 2.4 kWh/m³ (of product water) to desalinate the acid mine water to potable standard. 2.2 kWh/m³ was assumed to desalinate the water for in-direct re-use:

- Desalination requires about 9 MW for 33 million m³/a of water

F4.3 Direct re-use of treated water

The direct re-use of water does not increase the system yield, as it reduces return flows and the yields at downstream dams, particularly at Loskop Dam. As such, this option was not explored any further in this study.

E4.4 Transfers from Vaal River supply system**a) Description of development option**

Water is assumed to be transferred from the Vaal Dam to the headwaters of the Olifants River at Trichardsfontein Dam. A similar scheme layout and configuration is utilized to the current VRESUP Scheme, with a 10 km longer pipeline to reach Trichardsfontein Dam.

b) Description of scenarios

Two reference scheme sizes were included for comparison:

- 100 million m³/a
- 200 million m³/a

c) Source(s) of information on costs

- A conceptual level design and cost estimate calculated based on the pipeline, pump station costs gathered for this study and 1:50 00 maps and Google Earth. The abstraction works at Vaal Dam were based on estimates of the current abstraction being constructed for the VRESUP Scheme.

d) Base date of costs

- July 2009 (current/reference date prices obtained and utilised)

e) Infrastructure

- Pipelines
 - 125 km of Pipeline was required.
 - 1 700 mm diameter pipe for the 100 million m³/a capacity scheme
 - 2 250 mm diameter pipe for the 200 million m³/a capacity scheme
- Pump stations
 - One low lift pump station for abstraction from Vaal Dam and one high lift pump station were required. The pumping head and energy requirements are provided:

	<u>Low lift pump station</u>		<u>High lift pump station</u>	
○ 100 million m ³ /a scheme	38 m	1 MW	305 m	12 MW
○ 200 million m ³ /a scheme	38 m	3 MW	305 m	24 MW

f) Programme

- The generic timeline was adopted with construction to begin in 2017 and the earliest delivery of water possible in 2020.

g) Maintenance and operation

- As per general assumptions

h) Losses

- 5% river losses are assumed for the stretch between delivery into the headwaters of the Olifants River at Trichardsfontein Dam and Witbank Dam.

F4.5 Transfers from the Zambezi River**a) Description of development option**

The abstraction point and scheme layout is the same that described in Appendix E4.4. Additional pipeline is required from Lephalale to the delivery point in the headwaters of a tributary near Potgietersrus.

b) Description of scenarios

Three possible schemes have been investigated at a low level of detail:

- 100 million m³/a and
- 200 million m³/a reference capacity schemes for the Olifants, and

- A transfer option from the Zambezi River using the largest practical pipe size of 3.5 m in diameter (total transfer of 650 million m³/a), and sharing the delivered water between the Lephhalale area (200 million m³/a), Pretoria (350 million m³/a) and the Olifants River (100 million m³/a).

c) Source(s) of information on costs

- The scheme was identified and a conceptual level design and cost estimate conducted based on the pipeline, pump station costs gathered for this study, and 1:50 00 maps and Google Earth.

d) Base date of costs

- July 2009 (current/reference costs).

e) Infrastructure

- Dams
 - An off-channel balancing dam was included to provide a fortnight's storage for the 100 million m³/a scheme and a week's storage for the larger scheme. The dam is located on a gully to the south of the Zambezi River and has a wall height of about 15 m.
- Pipelines
 - 1 000 km of pipeline
 - 1 700 mm diameter for the 100 million m³/a scheme
 - 2 250 mm diameter pipeline for the 200 million m³/a scheme
 - For the larger sharing scheme a 3 500 mm pipeline utilised from the Zambezi River to Lephhalale.
- Pump stations
 - 1 low lift abstraction works and
 - 7 high lift pump stations with a maximum pumping head of 200m and a combined energy requirement of 45 MW for the 100 million m³/a transfer and 90 MW for the 200 million m³/a transfer.
 - Balancing reservoirs included at each of the pump stations

f) Programme

- The timeline model was utilized to determine the implementation program. Considering the current low level of detail, and the size and complexity of the scheme, particularly the negotiations to determine royalties that would need to be paid to 5 or more riparian countries, the earliest delivery date was estimated to be 2028 with construction beginning in 2024.

g) Maintenance and operation

- Operation and maintenance costs derived as per the general assumptions
- Royalties were estimated for a Zambezi scheme on the assumption that the royalties paid will be equal to half the benefit between the cost of the Zambezi scheme and the next best scheme, which in almost all cases would be desalination of seawater. The cost benefit ranged from about R7 to R14/m³ and as such an average indicative royalty of R5/m³ was chosen.

h) Losses

- 5% Losses were included to account for the river losses from the headwaters of the tributary to Havercroft Weir.

i) Energy requirement

- The energy required to pump the 100 million m³/a was 45 MW, and 90 MW is required to deliver 200 million m³/a.

F4.6 Desalination of seawater**a) Description of development option**

Water is assumed to be abstracted and desalinated from the Indian Ocean at a plant on the KZN coastline near Lake Sibaya. The water is then pumped to Witbank.

b) Description of scenarios

Four scenarios in total were investigated:

- 100 million m³/a directly to Witbank via pipeline
- 100 million m³/a released into a tributary of the Olifants with a shorter pipeline
- 200 million m³/a directly to Witbank via pipeline
- 200 million m³/a released into a tributary of the Olifants with a shorter pipeline

c) Source(s) of information on costs

- Pipeline and pump station costs were calculated based on the current costs obtained for this study.
- Desalination costs were based on work conducted for the *Western Cape Reconciliation Strategy*, and the work conducted by WRC for desalination for Municipalities (2006).

d) Base date of costs

- Base dates of different infrastructure components varied between current (2009) costs and (2006) costs, but were all escalated to 2009 where necessary.

e) Infrastructure

- Pipelines
 - For the options directly to Witbank 555 km of pipeline was required, and
 - For the options to the headwaters of a tributary, 490 km of pipeline was required.
 - 1 700 mm diameter pipeline was used for options with transfer capacities of 100 million m³/a, and
 - 2 250 mm pipeline for transferring 200 million m³/a.
- Pump stations
 - Seven pump stations (up to 300 m pumping head) were included to pump over the water divide, after which the water is gravity fed to Witbank.
 - Balancing reservoirs were included at each pump station.

f) Programme

- The earliest implementation date was estimated from a program based on the generic timeline. The earliest date of water delivery was estimated at 2025.

g) Maintenance and operation

- Determined as per the standard assumptions, but an additional R1.94/m³ of water for operation cost of the desalination plant (excl. energy) was included.

h) Losses

- 5% losses were included for the options that delivered water to the Olifants River.

i) Energy requirement

- The energy required to desalinate the seawater is 7.5 kWh/m³, which equates to about 90 MW for a 100 million m³/a, and 179 MW for a 200 million m³/a plant.
- The energy required for the full transfer of water to Witbank is 80 MW for the 100 million m³/a schemes and 159 MW for the 200 million m³/a schemes.

j) Other

- A reduction in the total URV of R2/m³ was made to bring the potable desalinated seawater to a raw water basis.

F5 DEVELOPMENT OPTIONS – NOTES ON PHASING

Removal of alien vegetation and illegal irrigation is included as possible strategies in the IWRMP and can increase yields in the Upper Olifants by 16.1 million m³/a. URV's have not been calculated for these potential interventions but they could.

APPENDIX G

ASSUMPTIONS AND OBSERVATIONS PERTAINING TO THE MHLATUZE RIVER SYSTEM

APPENDIX G

ASSUMPTIONS AND OBSERVATIONS PERTAINING TO THE MHLATUZE RIVER SYSTEM

- G1 WATER REQUIREMENTS AND WATER AVAILABILITY
- G2 WATER CONSERVATION AND WATER DEMAND MANAGEMENT (WC/WDM)
- G3 ECOLOGICAL WATER REQUIREMENTS (EWR)
- G4 DEVELOPMENT OPTIONS – ASSUMPTIONS FOR URV'S
 - G4.1 *Transfer from Lower Thukela*
 - G4.2 *Re-use of water*
 - G4.3 *Desalination of seawater*

APPENDIX G – ASSUMPTIONS AND OBSERVATIONS PERTAINING TO THE MHLATUZE RIVER SYSTEM

G1 WATER REQUIREMENTS AND WATER AVAILABILITY

The following reports and information were primarily used to obtain and abstract information about water requirements, and water availability

- *Mhlatuze Water Availability Assessment Study – Water Use, Water Requirements and Return flows (2007)*

There is a currently a small surplus in the Mhlatuze catchment. Once the reserve is implemented, apart for some small deficits as a result of assurances of supply, to irrigators in particular, the Mhlatuze River system will be in balance. Water requirements and water availability are about 266 million m³/a and 258 million m³/a respectively, once the reserve is implemented. Furthermore no significant growth is projected in water requirements for the region at present. Irrigation requirements of about 100 million m³/a are included.

G2 WATER CONSERVATION AND WATER DEMAND MANAGEMENT (WC/WDM)

Very little information was available on possible WC/WDM interventions for the Mhlatuze River system. As such the generic assumption of 10% reduction/savings in Urban water requirements achieved over 5 years was applied, which resulted in a small possible saving of about 6 million m³/a by 2015.

G3 ECOLOGICAL WATER REQUIREMENTS (EWR)

The yield of the Mhlatuze River system as provided in the WAAS, already takes releases of water from existing dams into account. The impact of implementing the reserve on yield is about 17 million m³/a.

G4 DEVELOPMENT OPTIONS – ASSUMPTIONS FOR URV'S

G4.1 *Transfer from Lower Thukela*

a) Description of development option

The scheme consists of run-of-river water abstraction from the Lower Thukela at Middledrift, and pumping over the water divide into a tributary of the Mhlatuze River, which runs into Goedertrouw Dam. The new scheme layout and capacity is the same as the existing transfer scheme from the Lower Thukela. The capacity is the same only by virtue that the additional yield available in the Lower Thukela (77 million m³/a) is assumed to be shared between Durban North (37 million m³/a) and the Mhlatuze (40 million m³/a).

Although no demand currently exists for the scheme, a hypothetical scenario of a large development in the region was derived, with the yield of the scheme fully utilized within 10 years.

b) Source(s) of information on costs

- *KwaZulu Natal Coast Metropolitan Areas Reconciliation Strategy (2008), and*
- *Mhlatuze Water Availability Assessment Study – System analysis report (2007).*

c) Base date of costs

- Although information on the yield of the Thukela and transfer capacity of the scheme was determined from the above-mentioned reports, the costs were based on a conceptual design using current (2009) pipeline and pump station costs gathered for this study.

d) Infrastructure

- Pipeline
 - 20 km pipeline of 1 100 mm diameter pipeline
- Pump stations
 - A low lift abstraction from a sump in the river
 - 2 high lift pump stations requiring 4 MW energy with 270 m pumping heads.

e) Programme

- No growth in water requirements is currently projected. If a large development were to occur in the Mhlatuze River System, however, the earliest date of water delivery would be approximately 2018.

f) Maintenance and operation

- Included as per general assumptions.

g) Losses

- Losses of 5% were included for the river reach between the outlet of the scheme in the headwaters of the tributary and Goedertrouw Dam.

h) Energy requirement

- Energy requirements for the full delivery of water are 8 MW.

G4.2 Re-use of water

a) Description of development option

Although not currently projected, if water demands were to grow, an estimated 30 million m³/a of re-use of water could be developed in Richards Bay and the surround areas, based on current domestic and industrial water use of approximately 112 million m³/a.

b) Sources of information on costs

- The likely cost for on re-use of water in the Mhlatuze River system is based on re-use of water in the Western Cape (as re-use in Durban is based on a few favorable WWTWs and may not be representative of re-use in general). Refer to Appendix K4.5 for more information.
- No more detail was included or investigated for this scheme

G4.3 Desalination of seawater

a) Description of development option

If further water requirement growth were to occur, desalination of seawater presents an ultimate solution. As a reference, the cost of desalination of seawater at Richards Bay is expected to be similar to that of desalination of seawater in Durban. Refer to Appendix H4.6 for more information.

APPENDIX H

**ASSUMPTIONS AND OBSERVATIONS PERTAINING TO
THE KWAZULU NATAL COASTAL METROPOLITAN
AREA**

APPENDIX H

ASSUMPTIONS AND OBSERVATIONS PERTAINING TO THE KWAZULU NATAL COASTAL METROPOLITAN AREA

- H1 WATER REQUIREMENTS AND WATER AVAILABILITY
- H2 WATER CONSERVATION AND WATER DEMAND MANAGEMENT (WC/WDM)
- H3 ECOLOGICAL WATER REQUIREMENTS (EWR)
- H4 DEVELOPMENT OPTIONS – ASSUMPTIONS FOR URV'S
 - H4.1 Mooi-Mgeni Transfer (Spring Grove Dam)*
 - H4.2 Re-use of water*
 - H4.3 Mkomazi-Mgeni Transfer (Phase 1 & 2)*
 - H4.4 Lower Thukela Transfer*
 - H4.5 Isithundu Dam*
 - H4.6 Desalination of seawater*
- H5 DEVELOPMENT OPTIONS – NOTES ON PHASING

APPENDIX H – ASSUMPTIONS AND OBSERVATIONS PERTAINING TO THE KWAZULU NATAL COASTAL METROPOLITAN AREA

H1 WATER REQUIREMENTS AND WATER AVAILABILITY

The following reports and information were primarily used to obtain and abstract information about water requirements, and water availability

- *Water Reconciliation Strategy Study for the KwaZulu Natal Coastal Metropolitan Areas (2008)*

The total water demand in the KZN coastal region includes the demands of 3 basins, namely the Mgeni, Mdloti and Mvoti river catchments. For the purpose of this study the three catchments were lumped together.

The schemes generally either augment supply in the Mgeni River catchment e.g. The Mooi-Mgeni Transfer Scheme, or the schemes augment the Mdloti and Mvoti river catchments. The Mdloti and Mvoti river catchments water requirements are lumped, as the new dual direction North Coast pipeline allows water to be supplied in either catchment.

Water requirements in the Mgeni catchment are currently 400 million m³/a and the Mdloti and Mvoti catchments combined water requirements are currently 47 million m³/a. Irrigation water requirements of approximately 88 million m³/a in the three catchments are a reduction in the water availability and not included in the water requirements. Irrigation requirements in neighbouring catchments were also considered when determining the volume of water that could be transferred into the Mgeni or Mdloti/Mvoti River catchments.

Water availability in the Mgeni River catchment is 350 million m³/a, and the combined availability in the Mdloti and Mvoti catchments is 28 million m³/a.

H2 WATER CONSERVATION AND WATER DEMAND MANAGEMENT (WC/WDM)

Mgeni Water has an established WC/WDM strategy in place. Further possible savings (with focus on Msinduzi (Pietermaritzburg), Ethekwini (Durban) and Ilembe (Stanger) municipalities) has been identified. Three scenarios were identified for this additional WC/WDM:

- 5 Year water loss programme (approximately a 9 % reduction in wastage achieved over 5 years)
- 5 year water loss and efficiency (most optimistic with up to 25 % saving by 2024)
- 10 year water loss programme (same as first scenario but reduction in wastage over 10 years)

The first scenario was chosen as it is similar to the generic WC/WDM scenario of 10 % reduction in water requirements over 5 years, and the lower savings are considered to be more realistic. The total net reduction in water requirements for this scenario is approximately 40 million m³/a by 2030.

H3 ECOLOGICAL WATER REQUIREMENTS (EWR)

The impact of implementing releases for the reserve (as currently determined) at existing dams is significant resulting in a total reduction in yield of the Mgeni system of 174 million m³/a. Return flows that are introduced below Inanda Dam could contribute towards satisfying the EWR. Some of these return flows have been identified for possible in-direct re-use. With the re-use of water being implemented, a volume of about 10 million m³/a growing to about 30 million m³/a is however still available to augment the EWR. The reduction in yield in the Mdloti River by implementing the EWR at Hazelmere Dam is assumed to be compensated for by the raising of Hazelmere Dam. Possible phasing in of the reserve is discussed in H5. It should also be noted that the reduction in yield is as a result of an interim EWR and that further work and stakeholder participation is still required.

All future possible developments of the three rivers make provision for EWR releases.

H4 DEVELOPMENT OPTIONS – ASSUMPTIONS FOR URV'S**H4.1 Mooi-Mgeni Transfer (Spring Grove Dam)****a) Description of development option**

The scheme includes a dam (Spring Grove) on the Mooi River with a transfer of 60 million m³/a of water over the divide to the Lions River, a tributary of the Mgeni that joins upstream of Mid Mar Dam.

b) Description of Scenarios

- Only one scenario was considered for this scheme

c) Source(s) of information on costs

- *Water Reconciliation Strategy Study for the KwaZulu Natal Coastal Metropolitan Areas (2008)*

d) Base date of costs

- The base date for costs on the Mooi-Mgeni is September 2007 and an escalation factor of 1.17 was used to update the cost of the schemes.

e) Infrastructure

- Dams
 - Spring Grove Dam - 1.2 MAR capacity; FSL 1 433.5 m mamsl; Yield 60 million m³/a
 - Fish barrier upstream of dam
- Pipelines
 - 7.9 km of new 600 mm diameter gravity pipeline
 - 6.2 km of new 1 400 mm diameter rising main
 - 21 km of existing gravity and rising mains
- Pump stations
 - New pump stations at Spring Grove Dam (capacity 4.5 m³/s)
 - Nottingham Road break pressure tank

f) Programme

- Construction to start in 2011 and the first delivery of water in 2014.

g) Maintenance and operation

- Included as per general assumptions.

h) Losses

- River conveyance losses of 5% were included for the reach of the Lions River between the outfall and Mid Mar Dam.

i) Energy requirement

- The energy requirements are 40 MWh/day with an installed pump station of 3.8 MW (pumping about 11 hours a day).

H4.2 Re-use of water

a) Description of development option

In-direct re-use of water linked to specific WWTWs, where their position and volume of water available are favorable, and constituent of industrial effluent was less than 10% of the return flows:

- KwaMashu WWTW water of 23 million m³/a available for re-use to be returned to both Hazelmere and Inanda Dams (14 and 9 million m³/a respectively)
- North coast WWTWs include Tongaat (2.9 million m³/a) and Verulam (2.4 million m³/a). Phoenix WWTW (5.1 million m³/a) will most likely not be available for re-use and as such was not included in this study. All water returned to Hazelmere Dam.
- The water from Northern WWTW of 19.7 million m³/a returned to Inanda Dam.

b) Description of scenarios

- Re-use of water Scenario 1 B from the Reconciliation Strategy Report
- Additional to the re-use of water from specific favorable WWTWs, an additional re-use of water from less favourable WWTWs could be an additional augmentation option. The cost of this re-use of water is likely to be higher than that at the favorable WWTWs and was assumed to be the same as the cost of re-use of water in the Western Cape (See Appendix K4.5). Focus will for now be on the re-use at favorable WWTWs and a volume of water of 53 million m³/a.

c) Source(s) of information on costs

- *Water Reconciliation Strategy Study for the KwaZulu Natal Coastal Metropolitan Areas (2008)*

d) Base date of costs

- The base date for costs on for re-use of water is Sep 2007 and an escalation factor of 1.17 was used to update the cost of the schemes.

e) Infrastructure

- KwaMashu WWTW
 - Upgrading of existing KwaMashu WWTW
 - 20 km long 700 mm diameter pipeline to Hazelmere Dam
 - 30 km long 600 mm diameter pipeline to Inanda Dam
 - Pump station for water to Hazelmere Dam (17 MWh/day)
 - Pump station for water to Inanda Dam (30 MWh/day)
- Northern WWTW
 - Upgrading of existing Northern WWTW
 - 22 km of 800 mm diameter pipeline to Inanda Dam
 - Pump station for water to Inanda Dam (66 MWh/day)
- North Coast WWTWs
 - Upgrade to Existing Tongaat, Verulam and Phoenix WWTWs
 - 6 km of 350 mm diameter pipeline from Tongaat WWTW to Hazelmere Dam
 - 8 km of 500 mm diameter pipeline from Verulam WWTW to Hazelmere Dam
 - 6 km of 400 mm diameter pipeline from Phoenix to Verulam
 - Pump station at Tongaat WWTW to Hazelmere Dam (4 MWh/day)
 - Pump station at Verulam WWTW to Hazelmere Dam (4 MWh/day)
 - Pump station at Phoenix WWTW (4 MWh/day)

f) Programme

- Implementation program adopted from generic timeline. Construction could start in 2016 with the earliest possible delivery of water in 2018.

g) Maintenance and operation

- Maintenance of infrastructure costs based on general assumptions. Additional operational costs of R0.13/m³ included for pre-treating the water to remove nutrients before returning to the river.

h) Losses

- No losses were included as water is returned directly to the dams.

i) Energy requirement

- Energy requirements for pumping and treatment together are 125 MWh/day (5.2 MW).

j) Other

- Treatment costs before returning the water to the dams appears to be low compared to other regions e.g. Western Cape. Results from updated work are expected, but were not available at the time of finalizing this report.

H4.3 Mkomazi-Mgeni Transfer (Phase 1 & 2)**a) Description of development option**

Two dam developments on the Mkomazi River with transfer via a tunnel to the Baynesfield Dam on the Mlazi River, a tributary of the Mgeni River.

- Phase 1 (Smithfield Dam)

Phase 1 would comprise of a new dam at Smithfield, with an abstraction tower on a steep bank on the northern shore, and a short gravity main leading to the tunnel intake. The tunnel would exit near the existing Baynesfield Dam, which could be raised and used as a raw water balancing storage. Due to the high turbidity often occurring in the Mlazi River that flows into Baynesfield Dam, the option of bypassing the dam and taking the water directly to the Umlaas Road Reservoir and distribution point via a pipeline is included. The minimum practical tunnel size that can be constructed is too large for the Phase 1 transfer only and has spare capacity to that can accommodate the water delivery from Phase 2.

- Phase 2 (Impendle Dam)

Phase 2 would consist of a new dam upstream of Smithfield on the Mkomazi River with releases of water to the downstream Smithfield Dam. Additional pumping capacity and pipelines included to deliver water to Umlaas Road reservoir.

b) Description of scenarios

- Although various configurations of the Mkomazi-Mgeni transfer were explored in the pre-feasibility study, the configuration as described in H4.3a above, and referred to as the Smithfield scheme in the Pre-feasibility Study, appeared to be the most favorable and was selected for this study.
- In the prefeasibility study, the development of the Impendle portion of the scheme was included as phase 2 and phase 3. In this report this has been lumped together as phase 2.

c) Source(s) of information on costs

Information on Phase 1 was obtained from:

- *Water Reconciliation Strategy Study for the KwaZulu Natal Coastal Metropolitan Areas (2008)*
- *Mkomazi-Mgeni Transfer Scheme Pre-feasibility Study (1999)*

Phase 2 was not considered in the Reconciliation Strategy Study and information was only available in:

- *Mkomazi-Mgeni Transfer Scheme Pre-feasibility Study (1999)*

d) Base date of costs

- The costs for Phase 1 were available with a base date of Sep 2007 and a factor of 1.17 was used to escalate to costs
- The base date for the costs available for phase 2 was March 1998 and an escalation factor of 2.52 was utilised.

e) Infrastructure

Phase 1 comprises the following:

- Smithfield Dam: Cap 137 million m³ (0.2 MAR dam) with yield of 147 million m³/a
- Intake tower situated approximately 1.8 km upstream of the dam wall
- Raising of Baynesfield Dam
- 33 km of 3.5m diameter tunnel
- 26 km in total of 1 800 to 1 900 mm diameter pipeline from tunnel to Baynesfield Dam and from Baynesfield Dam to the Umlaas Road reservoir
- Pump station in abstraction tower at Smithfield with a total energy requirement of 63 MWh/day (2.6 MW)

Phase 2 comprises of:

- Impendle Dam: 1.5 MAR capacity with a incremental yield (additional to phase 1) of 230 million m³/a
- Second 26 km of 1 800 to 1 900 mm pipeline from tunnel outlet to Baynesfield Dam and on to Umlaas Road reservoir.
- Additional Pumping capacity in pump station at Smithfield Dam with an additional 98 MWh/day energy requirement.

f) Programme

- The implementation program for Phase 1 was obtained from the Reconciliation Strategy study and updated slightly, with construction beginning in 2018 and the first delivery of water in 2021.
- The implementation program for Phase 2 was obtained by considering both the program for phase 1 and the implementation program from the pre-feasibility report. The resulting program indicates construction starting in 2019 and water delivery possible in 2023.

g) Maintenance and operation

- As per general assumptions

h) Losses

- No losses were included in Phase 1 as water is expected to normally bypass Baynesfield Dam
- 5% river losses are assumed for the stretch between Impendle and Smithfield dams for Phase 2

i) Other

- The cost of the WTP near Baynefield Dam and the Reservoir at Umlaas Road were excluded from the costs when determining the URV to provide a raw water cost.

H4.4 Lower Thukela Transfer**a) Description of development option**

An additional run of river yield of 45 million m³/a is available in the Lower Thukela with support from Wagendrift and Spioenkop dams, and taking the reserve into account. Add to this the existing unutilised allocation of 32 million m³/a to the Mhlatuze River catchment and 77 million m³/a is available in the Lower Thukela River for possible transfer.

A volume of 37 million m³/a was considered for transfer to The Mdloti and Mvoti river catchments (Durban North) in the Reconciliation Strategy. The balance of the possible yield of 40 million m³/a (of which 32 million m³/a is already allocated) is considered for possible transfer to the Mhlatuze should the need arise, as discussed in Appendix G4.1.

The transfer from the Lower Thukela River to the Mvoti River comprises of an abstraction at an existing weir on the Lower Thukela River at Mandini and pumping through a new pipeline to Fawsley WTP with the intention of supplying the Kwadukuza and surrounding areas.

b) Description of scenarios

- Only one scenario was considered.

c) Source(s) of information on costs

- *Water Reconciliation Strategy Study for the KwaZulu Natal Coastal Metropolitan Areas (2008)*

d) Base date of costs

- Sep 2007 with an escalation factor of 1.17 to bring the costs to a July 2009 level.

e) Infrastructure

- Pipelines
 - 27 km of 1 200 mm diameter pipeline
- Pump stations
 - Abstraction works at the existing gauging weir at Mandini
 - Pumping station at the weir requiring 80 MWh/day (3.3 MW)

f) Programme

- The implementation program taken from the Reconciliation Strategy and updated where necessary. Construction possible to begin in 2016 with the earliest delivery of water in 2018.

g) Maintenance and operation

- Costs derived as per the general assumptions

h) Losses

- No Losses were included.

i) Energy requirement

- The energy required to pump would be 80 MWh/day or 3.3 MW.

j) Other

- The cost of a new water treatment plant for the scheme was excluded to provide for the raw water cost.

H4.5 Isithundu Dam**a) Description of development option**

Previously also known as the Mvoti River Development, the scheme consists of Isithundu Dam on the Mvoti River, abstraction works at the existing Mvoti Weir and a short pipeline to an off-channel storage dam and a short pipeline from the off-channel storage to Fawsley WTP. The transfer volume of the possible scheme is 46 million m³/a.

b) Description of scenarios

- Only one scenario was considered.

c) Source(s) of information on costs

- *Water Reconciliation Strategy Study for the KwaZulu Natal Coastal Metropolitan Areas (2008)*

d) Base date of costs

- Base date of costs was Sep 2007 and an escalation factor of 1.17 was used to bring the prices to July 2009.

e) Infrastructure

- Dams
- Isithundu Dam: Capacity 102 million m³; yield 46 million m³/a
- Off-channel storage dam (no size available – cost R11 million)
- Pipelines
 - 1 375 m of 700 mm diameter pipeline
 - 1 600 m of 900 mm diameter pipeline
- Pump stations
 - River pump station of off channel storage (17 MWh/day)
 - Off-channel storage pump station to Fawsley WTP (99 MWh/day)

f) Programme

- The implementation program taken from the Reconciliation Strategy and updated where necessary. Construction possible to begin in 2018 with the earliest delivery of water in 2020.

g) Maintenance and operation

- Determined as per the standard assumptions.

h) Losses

- No losses were included.

i) Energy requirement

- The energy requirement to pump the full volume of water will be 116 MWh/day (4.8 MW).

j) Other

- Again the cost of a new WTP was not included to give an indication of the cost of raw water.

H4.6 Desalination of seawater**a) Description of development option**

Seawater assumed to be desalinated from the Indian Ocean at a plant on the KZN coastline near just north of Durban. The water will be delivered into local reticulation system.

b) Description of scenarios

Two reference scenarios were investigated:

- 100 million m³/a scheme
- 200 million m³/a scheme

c) Source(s) of information on costs

- *Water Reconciliation Strategy Study for the KwaZulu Natal Coastal Metropolitan Areas (2008), and*
- The work conducted by WRC for desalination for Municipalities 2006.

d) Base date of costs

- Dec 2007 and an escalation factor of 1.14 was used to bring the costs to July 2009.

e) Infrastructure

- Pipelines
 - A nominal amount of pipeline was assumed (R20 million) to deliver water from the desalination plant into the existing supply system.
- Pump stations
 - A new pump station was assumed (R50 million)
- Treatment plant
 - A desalination plant to desalinate 100 and 200 million m³/a for the two scenarios.
 - The intake and outlet works were assumed to be 30 % of the capital cost of the desalination plant.

f) Programme

- The earliest implementation date was estimated from a program based on the generic timeline. The earliest date construction to be 2017 with delivery of water in 2020.

g) Maintenance and operation

- This was determined as per the standard assumptions, but an additional R1.94/m³ of water for operation cost of the desalination plant (excl. energy) was included.

h) Losses

- No losses were included.

i) Energy requirement

- The energy required to desalinate the seawater is 7.5 kWh/m³, which equates to about 90 MW for a 100 million m³/a, and 179 MW for a 200 million m³/a plant
- An additional 28 MWh/day (9.2 MW) for pumping of water

j) Other

- A reduction in the total URV of R2/m³ was made to bring the potable desalinated seawater to a raw water basis.

H5 DEVELOPMENT OPTIONS – NOTES ON PHASING

The implementation of the reserve at existing dams is assumed to be phased in over 5 years beginning in 2020 when sufficient new schemes can come on line to resolve the short term deficit and reduce the impact of implementing the reserve.

APPENDIX I

ASSUMPTIONS AND OBSERVATIONS PERTAINING TO THE AMATOLE SYSTEM

APPENDIX I

ASSUMPTIONS AND OBSERVATIONS PERTAINING TO THE AMATOLE SYSTEM

- I1 WATER REQUIREMENTS AND WATER AVAILABILITY
- I2 WATER CONSERVATION AND WATER DEMAND MANAGEMENT (WC/WDM)
- I3 ECOLOGICAL WATER REQUIREMENTS (EWR)
- I4 DEVELOPMENT OPTIONS – ASSUMPTIONS FOR URV'S
 - I4.1 Re-use of water*
 - I4.2 Transfer from Keiskamma (Sandile Dam)*
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 - I4.4 Gqunube River Dam (Groothoek)*
 - I4.5 Gqunube River Dam (Mhalla's Kop)*
 - I4.6 Desalination of seawater*
- I5 DEVELOPMENT OPTIONS – NOTES ON PHASING

APPENDIX I – ASSUMPTIONS AND OBSERVATIONS PERTAINING TO THE AMATOLE SYSTEM

I1 WATER REQUIREMENTS AND WATER AVAILABILITY

The following reports and information were primarily used to obtain and abstract information about water requirements, and water availability:

- *Development of a Reconciliation Strategy for the Amatole Bulk Water supply system (2008)*
- Spreadsheets from UWP who are conducting follow up work on the Reconciliation Strategy

The total water requirement projections for the Amatole River system are somewhat uncertain. Two different census have been conducted which gave different population figures. These different population figures and different levels of projected impacts of HIV aids formed the basis for high and low water requirement projections.

Recent water requirements based on recorded water usage at water treatment plants (WTP) was obtained and the high water requirement growth projection scenario adjusted to match the recorded water usage for that year. This formed the basis for the water requirement projections used for this study. The total current (2010) water requirements of approximately 100 million m³/a, includes 12Mm³/a of irrigation water requirements.

Water availability in the catchment is approximately 95 million m³/a, which includes transfer of water from Wriggleswade Dam.

I2 WATER CONSERVATION AND WATER DEMAND MANAGEMENT (WC/WDM)

Two levels of WC/WDM were included in the Reconciliation Strategy, namely a fairly extensive series of WC/WDM interventions, and a more conservative and possible realistic scenario of the WC/WDM measures that the Buffalo City Municipality (BCM) has in hand.

The WC/WDM measures that the BCM has in hand of a reduction in water requirements of 9.5 million m³/a were considered for this study as they are more in line with possible WC/WDM savings in the other regions.

I3 ECOLOGICAL WATER REQUIREMENTS (EWR)

Implementing the Reserve at existing dams has a significant effect on the system yield. The reconciliation strategy study considered two different regimes of releases for the EWR, one with full flood releases and the other without full flood releases (based on outlet release capacity):

- Full flood releases for the EWR were considered for this study to be consistent with other regions, and would result in a reduction in the existing system yield of on average 25 million m³/a. The practicality of full flood releases above the outlet capacity at existing dams may however be questionable?
- Although re-use of water from WWTWs is considered as an option to augment supply, only 14 million m³/a of the total of about 25 million m³/a in return flows are considered for re-use. 15 million m³/a is returned directly to the sea and 6 million m³/a of return flows enters the river system below the existing dams. An amount of approximately 5 million m³/a is assumed to be available to augment the EWR and reduce the impact of releases on the yields of upstream dams.

All future possible developments of the three rivers make provision for EWR releases.

14 DEVELOPMENT OPTIONS – ASSUMPTIONS FOR URV'S

14.1 Re-use of water

a) Description of development option

Re-use of water was considered for a volume of 14.8 million m³/a. The re-use of water would be predominantly from the Eastern Bank Works, and return the treated water back to a Dam in the Lower Buffalo River for in-direct re-use. The desalination and associated costs for pre-treatment were based on an existing re-use scheme on the Cape Flats in the Western Cape.

b) Description of scenarios

- Only one scenario was considered for this scheme

c) Sources of information on costs

- Infrastructure cost were based on the *Amatole Water Resources System Analysis Phase II – Augmentation of Water Resources (1999)*
- Energy costs were based on the Re-use of water option from the *Western Cape Reconciliation Strategy* due to the rapid changes in desalination technology and associated energy usage.

d) Base date of costs

- The base date for costs was June 1997 and an escalation factor of 2.57 was used to update the cost of the scheme.

e) Infrastructure

- Dams
 - Balancing storage (60 Mℓ)
- Pipelines
 - 3.7 km of 500 mm diameter rising main
- Pump stations
 - New pump stations at WWTW (capacity 4.5 m³/s)

f) Programme

- BCM has indicated possible intention of progressing with more detailed work, and taking this into consideration and an implementation program based on generic project timeline, construction could possibly start in 2014 and the first delivery of water in 2016.

g) Maintenance and operation

- Included as per general assumptions, with an additional R1.00/m³ for treatment costs (excluding energy) before return it to the dam.

h) Losses

- No losses were included.

i) Energy requirement

- The energy requirement to desalinate the water before introducing it back to the river system is approximately 2.2 kWh/m³ or 33 000 MWh/a and the pumping energy requirement is estimated at an additional 7 000 MWh/a, working back from an energy cost with the energy tariff used.

14.2 Transfer from Keiskamma (Sandile Dam)**a) Description of development option**

This possible scheme entails the transfer of 8.7 million m³/a of water from the existing Sandile Dam on the Keiskamma River into the Buffalo River catchment at the possible new Beacon Hill WTP site near King Williams Town. This is scenario C in the Systems Analysis report.

b) Description of scenarios

- Only the one scenario described in E4.2a was considered.

c) Source(s) of information on costs

- *Amatole Water Resources System Analysis Phase II – Augmentation of Water Resources (1999)*

d) Base date of costs

- The base date for costs was June 1997 and an escalation factor of 2.57 was used to update the cost of the scheme.

e) Infrastructure

- Dams
 - Unutilised yield at the existing Sandile Dam of 8.7 million m³/a
 - Balancing dam (R2.3 million – June 1997)
- Pipelines
 - 30.8 km of gravity main (diameter not given but total cost of R23.38 million - June 1997)
- Pump stations
 - New pump station at Sandile Dam (R7.3 million – June 1997)

f) Programme

- Implementation program adopted from generic timeline. Construction could start in 2016 with the earliest possible delivery of water in 2018.

g) Maintenance and operation

- Maintenance of infrastructure costs based on general assumptions.

h) Losses

- No losses were included.

i) Energy requirement

- Energy requirements for pumping would be 15 800 MWh/a (1.9 MW).

14.3 Nahoon River Dam (Stone Island)

a) Description of development option

A new dam on the Nahoon River at Stone Island yielding 5.3 million m³/a and augmenting the existing yield from the downstream Nahoon River Dam.

b) Description of scenarios

- Only one scenario was considered.

c) Source(s) of information on costs

- *Amatole Water Resources System Analysis Phase II – Augmentation of Water Resources (1999)*

d) Base date of costs

- The base date for costs was June 1997 and an escalation factor of 2.57 was used to update the cost of the scheme.

e) Infrastructure

- Stone Island Dam: Capacity of 31.8 million m³, yield of 5.3 million m³/a
- Abstraction at existing Nahoon Dam

f) Programme

- The implementation program was determined from the general implementation program with construction possibly beginning in 2017 and water delivery in 2019.

g) Maintenance and operation

- As per general assumptions

h) Losses

- No losses were included.

14.4 Gqunube River Dam (Groothoek)

a) Description of development option

A new dam on the Gqunube River at Groothoek with 12.1 million m³/a of water being pumped over the water divide where it will be gravitated to the existing Nahoon River Dam

b) Description of scenarios

- Only one scenario was considered.

c) Source of information on costs

- *Water Reconciliation Strategy Study for the KwaZulu Natal Coastal Metropolitan Areas (2008)*

d) Base date of costs

- Sep 2007 with an escalation factor of 1.17 to bring the costs to a July 2009 level.

e) Infrastructure

- Dams
 - Groothoek Dam: Capacity 76.7 million m³, yield for transfer of 12.1 million m³/a
 - Balancing dam 490 000 m³ storage
- Pipelines
 - 2.8 km of 700 mm diameter rising main,
 - 4.7 km of 650 mm diameter gravity main
- Pump stations
 - Pumping station at the dam requiring (1.2 MW)

f) Programme

- The implementation program was determined from the general implementation program with construction possibly beginning in 2017 and water delivery in 2019.

g) Maintenance and operation

- Costs derived as per the general assumptions

h) Losses

- No Losses were included.

i) Energy requirement

- The energy required to pump would be 1.2 MW.

j) Other

- The cost of a new water treatment plant for the scheme was excluded to provide for the raw water cost.

14.5 Gqunube River Dam (Mhalla's Kop)**a) Description of development option**

The scheme includes new dam on the Gqunube River at a site near Mhalla's Kop upstream of the possible Groothoek site yielding 7.9 million m³/a, for possible transfer to the Nahoon WTP in the Nahoon River catchment.

b) Description of scenarios

- Only one scenario was considered.

c) Sources of information on costs

- *Water Reconciliation Strategy Study for the KwaZulu Natal Coastal Metropolitan Areas (2008)*

d) Base date of costs

- Base date of costs was Sep 2007 and an escalation factor of 1.17 was used to bring the prices to July 2009.

e) Infrastructure

- Dams
 - Mhalla's Kop Dam: Capacity 57.8 million m³, yield for transfer of 7.9 million m³/a
 - Balancing dam 320 000 m³
- Pipelines
 - 1.5 km of 550 mm diameter rising main,
 - 14 km of 500 mm diameter gravity main
- Pump stations
 - Pumping station at the dam (1.0 MW)

f) Programme

- The implementation program taken from the Reconciliation Strategy and updated where necessary. Construction possible to begin in 2018 with the earliest delivery of water in 2020.

g) Maintenance and operation

- Determined as per the standard assumptions.

h) Losses

- No losses were included.

i) Energy requirement

- The energy requirement to pump the full volume of water will be 1.0 MW.

j) Other

- The cost of a new WTP was not included to give an indication of the cost of raw water.

14.6 Desalination of seawater**a) Description of development option**

Seawater assumed to be desalinated from the Indian Ocean at a plant on the KZN coastline at East London. The water would be delivered into the local water supply system.

b) Description of scenarios

Only one scenario was investigated:

- 25 million m³/a scheme

c) Source(s) of information on costs

- *Water Reconciliation Strategy Study for the KwaZulu Natal Coastal Metropolitan Areas (2008), and*
- The work conducted by WRC for desalination for Municipalities 2006.

d) Base date of costs

- Dec 2007 and an escalation factor of 1.14 was used to bring the costs to July 2009.

e) Infrastructure

- Pipelines
 - A nominal amount of pipeline was assumed (R6 million) to deliver water from the desalination plant into the existing supply system.
- Pump stations
 - A new pump station was assumed (R14 million)
 - A balancing reservoir to facilitate pumping into the existing system
- Treatment plant
 - A desalination plant to desalinate 25 million m³/a.
 - The intake and outlet works were assumed to be 30 % of the capital cost of the desalination plant.

f) Programme

- The earliest implementation date was estimated from a program based on the generic timeline. The earliest date construction to be 2018 with delivery of water in 2021.

g) Maintenance and operation

- Determined as per the standard assumptions, but an additional R1.94/m³ of water for operation cost of the desalination plant (excl. energy) was included.

h) Losses

- No losses were included.

i) Energy requirement

- The energy required to desalinate the seawater is 7.5 kWh/m³, which equates to about 23 MW for a 25 million m³/a plant.
- An additional 3 000 MWh/a (0.8 MW) for pumping of water.

j) Other

- A reduction in the total URV of R2/m³ was made to bring the potable desalinated seawater to a raw water basis.

15 DEVELOPMENT OPTIONS – NOTES ON PHASING

The implementation of the reserve at existing dams is assumed to be phased in over 5 years beginning in 2017 when a new scheme can come on line to resolve the short term deficit and reduce the impact of implementing the reserve.

APPENDIX J

**ASSUMPTIONS AND OBSERVATIONS PERTAINING TO
THE ALGOA AREA**

APPENDIX J

ASSUMPTIONS AND OBSERVATIONS PERTAINING TO THE ALGOA AREA

- J1 WATER REQUIREMENTS AND WATER AVAILABILITY
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- J3 ECOLOGICAL WATER REQUIREMENTS (EWR)
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 - J4.13 *Desalination of seawater*
- J5 DEVELOPMENT OPTIONS – NOTES ON PHASING

APPENDIX J – ASSUMPTIONS AND OBSERVATIONS PERTAINING TO THE ALGOA AREA

J1 WATER REQUIREMENTS AND WATER AVAILABILITY

The following reports were primarily used to obtain and abstract information about water requirements and water availability in the Algoa area:

- *Water Reconciliation Strategy Study for the Algoa Water Supply Area: Preliminary Reconciliation Strategy, 2009* – Various reports prepared by Aurecon.
- *Urban water demand forecast for Algoa Water Supply System, 2009* – Report by PDG.
- An irrigation water requirement of 50 million m³/a was included in the water requirements. The future water requirements of the irrigation sector have been assumed to remain constant, as it is unlikely that further allocations will be made for irrigated agriculture from the AWSS.
- 2.5% linear growth was assumed for urban/industrial water requirements.
- For the URV calculations the existing system yield from all sources were taken as 159.4 million m³/a assuming that the allocation from the Orange-Fish tunnel is still 17 million m³/a (use is 26 million m³/a therefore this was, as in the *Reconciliation Strategy*, included rather than the 17 million m³/a allocation).
- For the graphs the existing system yield was assumed to grow from 159.4 million m³/a in 2009 to 192 million m³/a to include the 41 million m³/a additional allocation from the ORP that were approved in 2009 (from 17 million m³/a to 58 million m³/a). However, this additional amount was only assumed to start from 2013 as the infrastructure to deliver the additional amount will only be ready by this date.

J2 WATER CONSERVATION AND WATER DEMAND MANAGEMENT (WC/WDM)

A saving of 10% (phased in over 5 years) on water demands as a result of WC/WDM in the Algoa WSS was assumed. Ms. Isa Thompson, in a telephonic conversation, suggested a 15% saving, however, based on actual savings in the Vaal River catchment this number was reduced to 10% to be in line with all other catchments.

J3 ECOLOGICAL WATER REQUIREMENTS (EWR)

Ms. Isa Thompson confirmed that Impofu Dam is currently the only dam in the Algoa WSS from which environmental releases can be made (2 million m³/a). Other dams in the catchment are very small and lie high up in the catchment (except for Loerie Dam which is off-channel storage). They also don't have sufficient infrastructure and therefore the costs to implement EWRs here will be very high. The only other dams in the catchment that might possibly release EWRs in future is the Kouga Dam (once it's raised) and the new proposed Guernakop Dam. However, it is highly unlikely that either of these schemes will ever come about, therefore it is realistic to keep the current 2 million m³/a constant for future water demands. Also, as the EWR in the Algoa only comprises 1.3% of the total water demands (2 million m³/a), a decision was made that the phasing in this catchment will be discarded.

J4 DEVELOPMENT OPTIONS – ASSUMPTIONS FOR URV'S

J4.1 *Groundwater schemes (Jeffreys Arch, Van Stadens, Bushy Park, South Eastern Coega Fault)*

a) Description of development option

This development option comprises the implementation of the Jeffreys Arch, Van Stadens River Mouth Arch, Bushy Park and the South-eastern Coega fault new groundwater schemes. Some of these schemes

could either supply Nelson Mandela Bay Municipality (NMBM) or alternatively supply small coastal towns, freeing up water for NMBM.

b) Description of scenarios

- Only one scenario considered.

c) Source of information on costs

- *Water Reconciliation Strategy Study for the Algoa Water Supply Area: Preliminary Reconciliation Strategy, 2009.*

d) Base date of costs

- Base date June 2009, therefore all costs escalated with a factor of 1.02

e) Infrastructure

Infrastructure included in this augmentation option is as follows:

- Drilling boreholes
- Equipping boreholes
- Treating water to reduce iron precipitation and to neutralize acidity
- Linking the boreholes to the bulk supply scheme

The maximum yield of the respective boreholes are summarised in **Table J1**.

Table J1 Maximum yields of boreholes

	Jeffreys Arch	Van Stadens	Bushy Park	SE Coega Fault	TOTAL
Maximum yield (Mm ³ /a)	3	4	2	3	12

f) Programme

- The construction period for this option is estimated on 1.5 years and no filling time is required.

g) Maintenance and operation

- As the available information from the *Algoa Water Supply Area: Preliminary Reconciliation Strategy* only included a fixed cost for 'maintenance and operation', energy use (MWh/a) per scheme were obtained from Aurecon and the annual electricity cost calculated based on an energy tariff of R0.50 (based on Aurecon's calculations). The remainder of the 'maintenance and operation cost' could therefore be attributed to an annual maintenance and operation cost.

h) Losses

- 0% losses assumed for transfer of water as water feeds into the bulk supply scheme of the Algoa WSS.

i) Energy requirement

The power consumption of the respective boreholes are summarised in **Table J2**.

Table J2 Maximum power consumption of boreholes

	Jeffreys Arch	Van Stadens	Bushy Park	SE Coega Fault	TOTAL
Maximum power consumption - Full utilisation (MWh/a)	1 700	3 000	960	1 900	7 560
Maximum power consumption - Full utilisation (MW)	0.2	0.4	0.1	0.2	0.9

j) Other

- The URV excludes:
 - Chemical treatment costs
- The URV includes:
 - Infrastructure and operating costs

J4.2 Nooitgedagt Low Level Scheme**a) Description of development option**

This development option comprises an increase in supply from the Orange River to NMBM, supplied from the Nooitgedagt Water Treatment Works (WTW) via a new pipeline to the Olifantskop Reservoir. This scheme would also offer significant energy savings on account of the reduced pumping heads needed.

b) Reason for exclusion

According to DWA the temporary license for an additional 41.3 million m³/a from the Orange River has been approved since the *Water Reconciliation Strategy for the Algoa Water Supply Area*. This additional amount was therefore included on the final graphs (as part of the demand on the ORP and an increase in the AWSS existing system yield (see Item J1)).

J4.3 Maximising yield of Kouga/Loerie scheme**a) Description of development option**

This development option involves, in order to increase the yield, lowering of the operational level to which water can be abstracted from Loerie Dam (from 40% of FSC to 12% of FSC). It requires no additional infrastructure or operating staff, but improved operation and increased periods of pumping at maximum capacity.

b) Reason for exclusion

This development option was not included as it comprises mainly a change in operation of the system and doesn't entail an additional source of water available for the Algoa Water Supply System.

J4.4 Straits Chemicals supply option

a) Description of development option

This development option comprises the purchasing of potable water by NMBM of reverse-osmosis desalinated seawater, as a by-product of the process at the Straits Chemicals chlor-alkaline plant. This option is heavily dependent on the construction of a bulk seawater intake system for the Coega IDZ.

b) Description of scenarios

- Only one scenario considered.

c) Source(s) of information on costs

- *Water Reconciliation Strategy Study for the Algoa Water Supply Area: Preliminary Reconciliation Strategy, 2009.*

d) Base date of costs

- Base date June 2009, therefore all costs escalated with a factor of 1.02.

e) Infrastructure

Infrastructure included in this augmentation option is as follows:

- Pump station at Straits Chemicals
- Rising pipeline to Olifantskop Reservoir
- Balancing storage and gravity pipeline to Motherwell Reservoir

The maximum yield of this development option is 29 million m³/a.

f) Programme

- The construction period for this option is assumed to be 2 years and no filling time is required.

g) Maintenance and operation

As the available information from the *Algoa Water Supply Area: Preliminary Reconciliation Strategy* only included a fixed cost for 'maintenance and operation', energy use (MWh/a) per scheme were obtained from Aurecon and the annual electricity cost calculated based on an energy tariff of R0.50 (based on Aurecon's calculations). The remainder of the 'maintenance and operation cost' could therefore be attributed to an annual maintenance and operation cost.

h) Losses

- 0% losses assumed for transfer of water as water feeds into the bulk supply scheme of the Algoa WSS.

i) Energy requirement

- The maximum power consumption at full utilization for this scheme is 12 200 MWh/a (1.5 MW).

j) Other

- The URV excludes:
 - Sea-intakes and pumping costs to Straits site;
 - Desalination infrastructure and operating costs; and
 - Water treatment and post treatment (water stabilization costing) costs.
- The URV includes:
 - The Unit Sales Cost at which NMBM will purchase potable water from the manufacturer on site as a by-product (R5.00/m³). An assumption was made that 50% of this Unit Sales Cost will go towards covering electricity costs and therefore it was adjusted for nuclear by the same proportion as was observed in KZN Coastal and the Western Cape to just over R7/m³;
 - Capital costs for the pump station and rising pipeline to Olifantskop and balancing storage and a gravity pipeline to Motherwell Reservoir (which would be in place should the Nootgedacht LLS go ahead).

J4.5 Lower Sundays River return flows**a) Description of development option**

This development option comprises the abstraction of return flows in the Sundays River downstream of the Sundays River Water User Association, desalination, and blending at Olifantskop reservoir with treated Orange River water supplied from the Nootgedacht WTW.

b) Description of scenarios

- Only one scenario considered.

c) Source(s) of information on costs

- *Water Reconciliation Strategy Study for the Algoa Water Supply Area: Preliminary Reconciliation Strategy, 2009.*

d) Base date of costs

- Base date June 2009, therefore all costs escalated with a factor of 1.02.

e) Infrastructure

Infrastructure included in this augmentation option is as follows:

- Raw water abstraction pump station (Lower Sundays River near Barkley Bridge)
- Off channel storage and filtration, RO and pump station
- Pipelines
 - Raw water abstraction to off-channel balancing dam (4.3 km)
 - Off-channel balancing dam to Olifantskop reservoir (9.0 km)
 - Pipeline from Nootgedacht WTW for blending
 - Gravity pipeline system from balancing storage to mouth of Sundays River for brine discharge (20 km).

The maximum yield of this development option is 26.4 million m³/a.

f) Programme

- The construction period for this option is assumed to be 2 years and no filling time is required.

g) Maintenance and operation

- As the available information from the *Algoa Water Supply Area: Preliminary Reconciliation Strategy* only included a fixed cost for 'maintenance and operation', energy use (MWh/a) per scheme were obtained from Aurecon and the annual electricity cost calculated based on an energy tariff of R0.50 (based on Aurecon's calculations). The remainder of the 'maintenance and operation cost' could therefore be attributed to an annual maintenance and operation cost.

h) Losses

- 0% losses assumed for transfer of water as water feeds into the bulk supply scheme of the Algoa WSS.

i) Energy requirement

- The maximum power consumption at full utilization for this scheme is 26 000 MWh/a (3 MW).

j) Other

- The URV excludes:
 - Cost of land and servitudes;
 - Transfer pipelines from Olifantskop;
- The URV includes:
 - Capital costs for all infrastructure from river abstraction to balancing storage at Olifantskop
 - Operating costs to treat water from raw to potable (The original URV calculation excluded water treatment chemicals; therefore this cost was included by adding 10c/m³)
 - Operating costs of all conveyance

J4.6 Re-use to industrial standards**a) Description of development option**

This development option comprises the re-use of water from the Fishwater Flats WWTW, to meet requirements for industrial quality water within the Coega IDZ. This has been set by the Eastern Cape Department of Economic Affairs, Environment and Tourism (DEAET) as a condition of water supply to the Coega IDZ.

b) Description of scenarios

- Only one scenario considered.

c) Source(s) of information on costs

- *Water Reconciliation Strategy Study for the Algoa Water Supply Area: Preliminary Reconciliation Strategy, 2009.*

d) Base date of costs

- Base date June 2009, therefore all costs escalated with a factor of 1.02.

e) Infrastructure

Infrastructure included in this augmentation option is as follows:

- Balancing tank at FWF WTW;
- Pipelines
 - Gravity and pumping pipeline from FWF WTW to Redhouse Reclamation Works
 - Rising main pipeline to Olifantskop
- Post-treatment site (Water Reclamation Works at Redhouse); and
- Pump stations.

The maximum yield of this development option is 16.4 million m³/a.

f) Programme

- The construction period for this option is assumed to be 2 years and no filling time is required.

g) Maintenance and operation

As the available information from the *Algoa Water Supply Area: Preliminary Reconciliation Strategy* only included a fixed cost for 'maintenance and operation', energy use (MWh/a) per scheme were obtained from Aurecon and the annual electricity cost calculated based on an energy tariff of R0.50 (based on Aurecon's calculations). The remainder of the 'maintenance and operation cost' could therefore be attributed to an annual maintenance and operation cost.

h) Losses

- 0% losses assumed for transfer of water as water feeds into the bulk supply scheme of the Algoa WSS.

i) Energy requirement

- The maximum power consumption at full utilization for this scheme is 28 000 MWh/a (3.4 MW).

j) Other

- The URV excludes:
 - Capital for supply and distribution from Olifantskop (to be provided by Coega Development Corporation)
- The URV includes:
 - Infrastructure and operating costs
- As water is treated to industrial standards for this option R1.00 was subtracted to get it to raw water standards (to be comparable with other options).
- Only the industrial demand (assumed to be 30% of the total demand of the Algoa WSS) was included in the URV calculation for this option.

J4.7 Water trading – Baviaanskloof River**a) Description of development option**

This development option comprises purchasing of water use entitlements from farmers in the Baviaanskloof River valley, to be supplied to NMBM via the existing Kouga/Loerie system.

b) Reason for exclusion

This development option was not included as it mainly comprises a change in operation of the system and doesn't entail an additional source of water available for the Algoa Water Supply System.

J4.8 Guernakop Dam**a) Description of development option**

This development option comprises the construction of a dam on the Kouga River.

b) Description of scenarios

- Only one scenario considered.

c) Sources of information on costs

- *Water Reconciliation Strategy Study for the Algoa Water Supply Area: Preliminary Reconciliation Strategy, 2009.*

d) Base date of costs

- Base date June 2009, therefore all costs escalated with a factor of 1.02.

e) Infrastructure

Infrastructure included in this augmentation option is as follows:

- Rollcrete dam
- Duplication of the Loerie WTW
- Duplication of the Loerie to Summit Rising Main
- Installation of booster pumps on the Summit to Chelsea Main

The maximum yield of this development option is 34 million m³/a.

f) Programme

- The construction period for this option is assumed to be 3 years with a 0.5 year filling time allowed.

g) Maintenance and operation

- Taken from the *Algoa Water Supply Area: Preliminary Reconciliation Strategy*.

h) Losses

- 5% losses assumed for transfer of water as water is released into the downstream canal etc. before it feeds into the bulk water supply scheme of the Algoa WSS.

i) Energy requirement

- The maximum power consumption at full utilization for this scheme is 35 000 MWh/a (4.2 MW).

J4.9 Raising of Kouga Dam

a) Description of development option

This development option comprises the raising of Kouga Dam. An option exists to rebuild the dam wall immediately adjacent to the existing wall, e.g. as a concrete gravity dam.

b) Description of scenarios

- Only one scenario considered.

c) Source(s) of information on costs

- *Water Reconciliation Strategy Study for the Algoa Water Supply Area: Preliminary Reconciliation Strategy, 2009.*

d) Base date of costs

- Base date June 2009, therefore all costs escalated with a factor of 1.02.

e) Infrastructure

Infrastructure included in this augmentation option is as follows:

- Mass gravity rollcrete dam
- Duplication of the Loerie WTW
- Duplication of the Loerie to Summit Rising Main
- Installation of booster pumps on the Summit to Chelsea Main

The maximum yield of this development option is 34 million m³/a.

f) Programme

- The construction period for this option is assumed to be 3 years with a 0.5 year filling time allowed.

g) Maintenance and operation

- Taken from the *Algoa Water Supply Area: Preliminary Reconciliation Strategy*.

h) Losses

- 5% losses assumed for transfer of water as water is released into the downstream canal etc. before it feeds into the bulk water supply scheme of the Algoa WSS.

i) Energy requirement

- The maximum power consumption at full utilization for this scheme is 35 000 MWh/a (4.2 MW).

J4.10 Improvements/rehabilitation of Grassridge and Darlington dams

a) Description of development option

This development option comprises the use of the full storage capacity of Darlington Dam on the lower Sundays River, i.e. replacing the existing gates and restoring the original FSL, to store Orange River water and increase the yield of the Orange-Fish-Sundays transfer scheme.

b) Reason for exclusion

This option has not been investigated as part of the *Algoa Water Supply System Reconciliation Strategy*.

J4.11 Proposed new dam on Kabougas River

a) Description of development option

This development option comprises the construction of a dam on the Kabougas River.

b) Reason for exclusion

This option has not been investigated as part of the *Algoa Water Supply System Reconciliation Strategy*.

J4.12 Mzimvubu transfer scheme (Kraai option)

a) Description of development option

This development option comprises the transfer of water from the Mzimvubu catchment to the Orange River via the Orange-Fish-Sundays transfer to the Algoa WSS. An assumption was made that the capacity of the Orange-Fish-Sundays tunnel will be sufficient to accommodate this additional amount.

b) Description of scenarios

Two scenarios were considered in this regard:

- **50 million m³/a from Ntabelanga Dam**
This comprises conveyance from Ntabelanga Dam through a pipeline to the Kraai River. The option of tunnelling was not investigated as tunnelling will be impractical for such a small volume.
- **20 m³/s (631 million m³/a) from series of dams in the Mzimvubu River catchment (*as included in the VAPS*)**
This comprise abstraction from 6 dams in the Mzimvubu catchment (Siqingeni, Thabeng, Pitseng, Hlabakazi, Mpindweni and Ntabelanga dams) with conveyance through a system of pump stations (*7), pipelines, canals, syphons and tunnels to the Bell River, a tributary of the Kraai River. As Algoa's water requirements are much less than what this scheme can supply, it was assumed that part of the water (50 million m³/a) is transferred to the Algoa whereas the remainder of the water is transferred to the Vaal River catchment.

c) Sources of information on costs

- Dams: *DWAF Water Resource Study in support of the ASGISA-EC Mzimvubu Development Project, 2009*
- Conveyance infrastructure for 50 million m³/a scheme: *Calculated based on latest information available on costs for these types of infrastructure*
- Conveyance infrastructure for 631 million m³/a scheme: *Vaal Augmentation Planning Study (VAPS), 1996*

d) Base date of costs

- Dams: Base date March 2008, therefore costs escalated with a factor of 1.08.
- Conveyance infrastructure for 50 million m³/a scheme:
 - Pipelines and balancing reservoirs: Base date 2009, therefore costs were not escalated.
 - Pump stations: Base date 2008, therefore costs escalated with a factor of 1.1.
- Conveyance infrastructure for 631 million m³/a scheme:
 - Base date April 1994, therefore costs escalated with a factor of 3.36.

e) Infrastructure

- **50 million m³/a from Ntabelanga Dam**
 - As 20% conveyance losses were assumed (*see Item J4.12h*) 62 million m³/a had to be released at Ntabelanga Dam for the 50 million m³/a to reach the Algoa. Therefore, Ntabelanga Dam and the pipeline was sized for a release of 62.5 million m³/a. For that reason a 0.3 MAR dam with a 1.35 m pipeline was used.
 - Costs for 5 pump stations (each with a static head of 336 m) were also included. It was assumed that pump stations operate 22 hours per day with a pumping efficiency of 87.3%.
- **20 m³/s (631 million m³/a) from series of dams in the Mzimvubu River catchment (*as included in the VAPS*)**
 - See *Item J4.12b*

f) Programme

- **50 million m³/a from Ntabelanga Dam**
 - A construction time of 3 years was assumed for Ntabelanga Dam as determined as part of the *Mzimvubu Development Project* (start 2013).
 - 2 years were allowed for filling of the dam.
- **20 m³/s (631 million m³/a) from series of dams in the Mzimvubu River catchment (*as included in the VAPS*)**
 - Start of construction = mid 2009; First delivery of water = 2016.
 - Construction times of the various elements, except for the dams, based on the original programme for this scheme from *VAPS*.
 - Construction time of dams taken between 3 and 4 years as determined as part of the *Mzimvubu Development Project* (start 2010).
 - Filling time requirements for the 2.5 MAR dams in the *VAPS* was given as 10 years to fill up to 60% of active storage (as the dams are in series). However, as these dams are now much smaller (1.5 MAR) the filling times as shown in **Table J3** were assumed (based on experience from the *Mzimvubu Development Project*). This entails 20% of the yield delivered in 2016 with full delivery in 2020 (100%).

Table J3 Filling times for dams in the Mzimvubu River catchment

Dam	Filling time (years)
Pitseng	2
Hlabakazi	3
Mpindweni	5
Thabeng	2
Siqingeni	3
Ntabelanga	2

g) Maintenance and operation

- General assumptions on maintenance and operation included.

h) Losses

- 20% conveyance losses were assumed (10% to the Orange River and another 10% through the Orange-Fish-Sundays tunnel to the Algoa).

i) Energy requirement

- Mzimvubu-Kraai transfer of 50 million m³/a: 328 854 MWh/a (39 MW)
- Mzimvubu-Kraai transfer of 631 million m³/a: 1 778 329 MWh/a (214 MW)

* Note that the unit energy requirement (kWh/m³ of raw water) for the 50 million m³/a Mzimvubu-Kraai transfer of 5.3 is much higher than that for the 631 million m³/a Mzimvubu-Kraai transfer of 2.9. This is as a result of the smaller transfer making use of a pipeline to pump water over the divide whereas conveyance to the Orange River for the bigger transfer is through a tunnel.

J4.13 Desalination of seawater**a) Description of development option**

This development option comprises abstraction and desalination of seawater near Port Elizabeth (apart from Straits Chemicals Option). Conveyance will be through a pipeline to feed water into the existing water supply system of the Algoa WSS.

b) Description of scenarios

- Only one scenario considered.

c) Sources of information on costs

Balancing reservoirs, pipelines, pump stations and other infrastructure: Calculated based on latest information available on costs for these types of infrastructure (also based on work considered by WRC for desalination for municipalities, 2006).

d) Base date of costs

- Pipelines and balancing reservoirs: Base date 2009, therefore costs were not escalated
- Pump stations: Base date 2008, therefore costs escalated with a factor of 1.1
- Other infrastructure (WTW): Base date December 2007, therefore costs escalated with a factor of 1.14

e) Infrastructure

- This development option comprise a series of pipelines, pump stations and balancing reservoirs to convey water from the WTP to the bulk supply scheme of the Algoa WSS.

f) Programme

- Start of construction = 2013; First delivery of water = 2016
- Construction time of various infrastructure vary between 2 and 3 years

g) Maintenance and operation

- General assumptions on maintenance and operation included.

h) Losses

- 0% losses assumed for transfer of water as water is assumed to feed into the bulk supply scheme of the Algoa WSS. A small nominal amount has been included for the costs of including the desalinated water into the existing water distribution system. Depending on the location of the desalination plant, this cost will most likely increase.

i) Energy requirement to deliver full yield

- 381 948 MWh/a (46 MW)

J5 DEVELOPMENT OPTIONS – NOTES ON PHASING

- As a result of the additional allocation from the Orange River that was recently approved by DWA (41 million m³/a) the Algoa will only start experiencing deficits by 2025.
- By the time water is needed in the Algoa all schemes can be practically implemented (except for the Mzimvubu transfer which is the most expensive option); therefore augmentation options were only sorted by URV.

APPENDIX K

**ASSUMPTIONS AND OBSERVATIONS PERTAINING TO
THE OUTENIQUA COASTAL AREA**

APPENDIX K

ASSUMPTIONS AND OBSERVATIONS PERTAINING TO THE OUTENIQUA COASTAL AREA

- K1 WATER REQUIREMENTS AND WATER AVAILABILITY
- K2 WATER CONSERVATION AND WATER DEMAND MANAGEMENT (WC/WDM)
- K3 ECOLOGICAL WATER REQUIREMENTS (EWR)
- K4 DEVELOPMENT OPTIONS – ASSUMPTIONS FOR URV'S
 - K4.1 Surface water*
 - K4.2 Groundwater*
 - K4.3 Re-use of water*
 - K4.4 Desalination of seawater*
- K5 DEVELOPMENT OPTIONS – NOTES ON PHASING

APPENDIX K – ASSUMPTIONS AND OBSERVATIONS PERTAINING TO THE OUTENIQUA COASTAL AREA**K1 WATER REQUIREMENTS AND WATER AVAILABILITY**

The Outeniqua coastal Area includes coastal catchments between Stilbaai and Knysna and is bounded by the Goukou River catchment to the west, the Noetzie River catchment to the east and the Outeniqua and Langeberg Mountain ranges to the north. This study will focus on the larger growth centers and associated regional bulk water supply schemes, namely Mossel Bay and George. Although shortages do occur in many of the other smaller centers in the region, small localised schemes such as additional groundwater developments and refurbishment of existing schemes appears to be sufficient.

The water demands of the Mossel Bay Water Supply system were included in the *Outeniqua Coast Water Situation Study* as 16.8 million m³/a in 2005 growing to about 23.8 million m³/a by 2025. No information was provided for water requirements beyond 2025, and a generic curve was applied to extrapolate these requirements, with a slowing in growth beyond 2025. The yield of the 3 regional bulk water supply schemes that supply the Mossel Bay Water Supply System, namely the Mossel Bay RWSS, the Klein Brak/Mid Brak RWSS and the Great Brak RWSS is 22.68 million m³/a. It must be noted that in 2008 the licensed allocation of the yield was 14.59 million m³/a. The additional yield may be licensed, and for the purposes of the study the yield of the system will be used for the water availability.

The water requirements of the George Municipal area were approximately 9.3 million m³/a in 2005/2006. An estimated projection in growth related to a 4% growth rate of 28 million m³/a by 2030 was adopted, although limited information is available on projected water requirements. The George Municipal area is supplied by the George RWSS, the water source of which is the Garden Route Dam. Yields stated for the Garden Route Dam differs slightly, but the 1:100 year yield of 10.4 million m³/a will be used in this study. An additional 1.6 million m³/a has been recently made available by reinstating the Kaaimans River Weir Scheme, making the total yield of the George Water Supply System of 12 million m³/a.

Irrigation water requirements of approximately 160 million m³/a exist in the total Outeniqua study area, but are supplied mostly from small farm dams and run-of-river abstractions, and were not included in the water requirements for Mossel Bay and George. It should also be noted that only about 60% of the irrigation water requirements could be supplied at the 2005 level.

As per the KZN Coastal Region, the two sub-regions of the Outeniqua will be lumped together for the purpose of this study.

K2 WATER CONSERVATION AND WATER DEMAND MANAGEMENT (WC/WDM)

According to the *Outeniqua Coast Water Situation Study*, although the Mossel Bay Municipality had already undertaken certain WC/WDM interventions, no comprehensive WC/WDM strategy had yet been developed. For this study, a saving of 10% of the urban demand is assumed to be achievable as per the other regions where limited information is available. Urban demand is approximately 50% of the total system demands for Mossel Bay and 90% for George.

K3 ECOLOGICAL WATER REQUIREMENTS (EWR)

The implementation of the reserve at the existing dams (Wolwedans and Klipheuwel) has an impact of approximately 4.6 million m³/a in the Mossel Bay system and an impact of approximately 2.1 million m³/a in the George system (Garden route Dam). Releases for EWRs are assumed to be phased in over 5 years implemented beginning in 2015.

K4 DEVELOPMENT OPTIONS – ASSUMPTIONS FOR URV'S

K4.1 Surface water

a) Description of development option

- Surface water development options are still possible in the Mossel Bay and George Areas and comprise a number of smaller schemes. There is very limited surface water development options in the Mossel Bay area, and between the raising of Klipheuwel Dam and a possible new dam on the Moordkuil river, an estimated additional 1.1 to 3 million m³/a could be made available. Possible dam developments to augment the demand in the George area are the Malgas Dam, Upper Kaaimans Dam and the Maalgate Dam, which previous investigations indicated provided incremental yields of 5.2, 2 and 5.8 million m³/a respectively. The water of the existing Hartbeeskul Dam which has a yield of 0.5 million m³/a (after EWR) is currently not being used due to poor water quality. With additional treatment this water could be used and has been included in the surface water total.

K4.2 Groundwater

a) Description of development option

- Groundwater sources in the Mossel Bay area have been investigated at a reconnaissance level. In the region of 1.2 to 2.4 million m³/a is suspected to be able to be feasibly harvested.
- Groundwater in the George area is estimated to have a yield of 0.9 million m³/a.

K4.3 Re-use of water

a) Description of development option

- Re-use of water from Hartenbos WWTWs in the Mossel Bay system is indicated to be in the order of 2 million m³/a. Re-use of water of up to 7.3 million m³/a from the Outeniqua WWTWs in the George system could be used for irrigation and industry and for potable supply, the later option involving indirect re-use with water being diverted back to Garden Route Dam.

K4.4 Desalination of seawater

a) Description of development option

- Desalination in this region is based on the work conducted for the KZN and Algoa Regions. A reference size scheme of 20 million m³/a was chosen.
- During recent extreme water shortages as a result of an ongoing drought, a smaller Desalination plant (1500 kL per day) was built to supply water to Sedgefield for drought relief.

K5 DEVELOPMENT OPTIONS – NOTES ON COSTS AND PHASING

No costs were obtained for the development options and indicative URV's were provided in the *Outeniqua Coast Water Situation Study* only to give an indication of the likely range of cost of water. It should be noted that those URVs are very roughly estimated, based on professional judgment and experience in other areas. No detailed feasibility assessment was undertaken during that study. These indicative URVs, as well as estimated yields for augmentation options for the Mossel Bay area, as abstracted from the previous report are included in Table K1. The URV ranges included in Table K1 will be escalated from July 2007 to July 2009 to give a better indication of the likely range of costs (escalation factor of 1.2).

Table K1 Possible augmentation options for Mossel Bay as included in *Outeniqua Coast Water Situation Study*

Rank	Option	Yield (million m ³ /a)	URV (R/m ³)
1	Various WC/WDM interventions	3 to 5	0.3 to 0.70
2	Additional allocations from surplus yield	3 to 5	0.7 to 1.0
3	Groundwater development	1.2 to 2.4	1.0 to 3.0
4	Surface water schemes	1.1 to 3.0	1.0 to 3.0
5	Use of treated effluent (RO process)	1.0 to 2.0	3.0 to 5.0
6	Use of Hartbeeskuil Dam	0.50	3.0 to 5.0
7	RO desalination of sea water	unlimited	7.0 to 8.0

Note: The URVs of water supplied by the various options are based on available data from previous studies. These are shown for illustration purposes only.

Available documentation of most schemes in the Outeniqua Coastal area is currently only available for investigations at a low level of detail. Dates on possible completion of the present schemes taking further planning and construction times into account, are not currently available.

Given the relatively small size of the schemes for this region compared to those of the other regions such as the Vaal, construction times are expected to be in the order of 1 to 3 years. Further feasibility studies and planning will however add significantly to the implementation programme length. As the individual possible surface water, groundwater and re-use schemes have been lumped together, an indicative phasing of schemes has been chosen, just to give an idea of a the likely implementation of water resources that may be needed. This needed to be done due to the lack of more detailed information needed to provide phasing of individual schemes.

APPENDIX L

**ASSUMPTIONS AND OBSERVATIONS PERTAINING TO
THE WESTERN CAPE WATER SUPPLY SYSTEM**

APPENDIX L

ASSUMPTIONS AND OBSERVATIONS PERTAINING TO THE WESTERN CAPE WATER SUPPLY SYSTEM

- L1 WATER REQUIREMENTS AND WATER AVAILABILITY
- L2 WATER CONSERVATION AND WATER DEMAND MANAGEMENT (WC/WDM)
- L3 ECOLOGICAL WATER REQUIREMENTS (EWR)
- L4 DEVELOPMENT OPTIONS – ASSUMPTIONS FOR URV'S
 - L4.1 Voëlvlei Augmentation (Phase 1 and Phase 2&3)*
 - L4.2 Mitchell's Pass Diversion*
 - L4.3 Upper Molenaars Diversion*
 - L4.4 Upper Wit River Diversion*
 - L4.5 Re-use of Water*
 - L4.6 Groundwater (TMG Aquifer)*
 - L4.7 Groundwater (West Coast and Cape Flats Aquifers)*
 - L4.8 Desalination of seawater*
- L5 DEVELOPMENT OPTIONS – NOTES ON PHASING

APPENDIX L – ASSUMPTIONS AND OBSERVATIONS PERTAINING TO THE WESTERN CAPE WATER SUPPLY SYSTEM

L1 WATER REQUIREMENTS AND WATER AVAILABILITY

The following report and information were primarily used to obtain and abstract information about water requirements and water availability:

- *Western Cape Water Supply system Reconciliation Strategy Study* (various reports from 2007 - 2009, including a follow up Status Report)

The Western Cape Water Supply System includes there water requirements and water availability for the greater Cape Town City and surrounding areas, and development of a number of local rivers such as the Breede, Berg and Molenaars, to name a few.

The high water requirement projection suggests continuing rapid growth well beyond 2025, which is somewhat an anomaly when compared to growth projections in other metropolitan areas which tend to show a slowing in water requirement growth beyond 2025.

Water requirements of the Western Cape water supply system are currently 540 million m³/a, and the availability is 556 million m³/a. Water availability is currently a little higher than the water requirement, due to the Berg River Dam coming on line. The rapid growth of water requirements, however, is likely to result in a deficit occurring again by about 2015. The water requirements includes irrigation, which in 2006 required about 150 million m³/a.

The effects of climate change have been considered and are expected to be the most pronounced and negative in the Western Cape. A reduction in water availability of 15% over the next 25 years has been included to account for the effect of climate change.

L2 WATER CONSERVATION AND WATER DEMAND MANAGEMENT (WC/WDM)

The Western Cape has initiated a 10 year WC/WDM strategy commencing in 2007/2008. This is a revised and more comprehensive WC/WDM strategy than the 2006 draft 8 year strategy on which the Reconciliation Strategy was based which targeted a 44 million m³/a saving. More details of the 10 year program are:

- Targeting a saving of 90 million m³/a by 2016/2017
- Approximately 25 % of high water requirement
- Proposed budget of R759 Million over the ten years

L3 ECOLOGICAL WATER REQUIREMENTS (EWR)

The impact of implementing releases for the reserve at existing dams is would result in a reduction in yield of the Western Cape system of 56 million m³/a.

All future possible developments considered, and the recently completed Berg River Dam, make provision for EWR releases.

L4 DEVELOPMENT OPTIONS – ASSUMPTIONS FOR URV'S

L4.1 Voëlvlei Augmentation (Phase 1 and Phase 2&3)

a) Description of development option

- Phase 1 abstracts water from the Berg River close to Voëlvlei Dam, and has a yield of 35 million m³/a. Phase 1 makes use of spare capacity in the WTP and the pipeline to City of Cape Town (CCT) of about 20 million m³/a. Water can be treated at the WTW and pumped directly for use, or stored in the Voëlvlei Dam. Balance of yield to supplement users from Voëlvlei Dam.
- Phase 2 and 3 requires a larger weir on the Berg River, a 9 m raising of Voëlvlei Dam and a new pipeline to the CCT. Note that these infrastructural developments have been referred to as Phase 2 & 3 in previous reports, but will be lumped together and referred to as Phase 2 for simplicity in this appendix.

b) Description of scenarios

- Only one scenario was considered for each Phase of this augmentation option.

c) Source(s) of information on costs

- *Western Cape Water Supply system Reconciliation Strategy Study* (various reports in 2007, including a follow up Status Report in 2009)

d) Base date of costs

- The base date for costs is June 2005 and an escalation factor of 1.40 was applied to update the cost of the schemes.

e) Infrastructure

Phase 1:

- Small weir on the Berg River (R6.13 – June 2005)
- Settling tank (270 Mℓ/day)
- Pipelines
 - 4.1 km of new 1 500 mm diameter rising main
 - Rehabilitation of existing pipeline to the CCT to realize full extra capacity
- Pump stations
 - New pump stations at (installed capacity 3.2 m³/s and 2.4 MW)

Phase 2:

- Larger weir on Berg River
- Raising of Voëlvlei Dam by 9m
- Settling tank
- Pipelines
 - New 4.1 km of 2 000 mm pipeline to Voëlvlei Dam
 - New 40 km 1 700 mm diameter pipeline to the North Eastern part of the CCT
- Pump stations
 - New pump station at Weir
 - New pump station at Voëlvlei Dam (9 MW)

f) Programme

- Implementation programmes were obtained from the Reconciliation Strategy and if available in the updated Status Report. Programmes were updated where necessary.
- Construction of Phase 1 could start in 2015 with the first delivery of water in 2017.
- Construction of Phase 2 could start in 2019 with the first delivery of water in 2022.

g) Maintenance and operation

- Included as per general assumptions.

h) Losses

- No losses were included.

i) Energy requirement

- Energy requirements were not available and had to be estimated by calculating back from an energy cost with an assumed energy tariff of R0.25/kWh escalated back from current energy costs of R0.35/kWh
- The energy requirement of Phase 1 would be 34 000 MWh/a or 4 MW
- The energy requirement of Phase 2 would be 83 000 MWh/a or 10 MW

L4.2 *Michell's Pass Diversion***a) Description of development option**

The scheme consists of a 10m high weir on the Dwars River with a canal diverting water to the headwaters of the Little Berg River from where it is abstracted further downstream at an existing weir and diverted into the Voëlvlei Dam.

Michell's Pass Diversion scheme cannot be implemented together with the Voëlvlei Augmentation Phase 1 without an additional pipeline to the CCT. The spare capacity in the existing pipeline was assumed to be used up by the Voëlvlei Augmentation phase 1. A new pipeline to the CCT (northern Durbanville) is thus included for the Michell's Pass scheme

Different diversion rates and annual average water delivery options were included in the Reconciliation Strategy Study.

- 4 and 8 m³/s diversion capacities with corresponding average annual delivery rates of 35 and 57 million m³/a respectively.

b) Description of scenarios

- Only the 57 million m³/a scheme was considered for the Mitchells pass diversion for this study.

c) Source(s) of information on costs

- *Western Cape Water Supply system Reconciliation Strategy Study* (various reports in 2007, including a follow up Status Report in 2009)
- Limited cost information was available per infrastructure component and estimates had to be made of the split in costs.

d) Base date of costs

- The base date for costs is June 2005 and an escalation factor of 1.40 was applied to update the cost of the scheme.

e) Infrastructure

- A 10 m diversion weir on the Dwars River with a diversion capacity of up to 8 m³/s
- A canal delivering water from the Weir to the headwaters of the Little Berg River (approximately 12 km)
- Existing diversion from Little Berg River to Voëlvlei Dam
- New 40 km long 1 200 mm diameter pipeline to the north eastern part of the CCT.
- New pump station at Voëlvlei Dam (4 MW)

f) Programme

- The implementation program was obtained from Status Report and updated where necessary.
- Construction of Phase 1 could start in 2016 with the first delivery of water in 2019.

g) Maintenance and operation

- Maintenance of infrastructure costs determined as per the general assumptions.

h) Losses

- 10% losses before Voëlvlei Dam were included (which also included some allocation to irrigation).

i) Energy requirement

- Energy requirements were not available and had to be estimated by calculating back from an energy cost with an assumed energy tariff of R0.25/kWh escalated back from current energy costs of R0.35/kWh.
- Energy requirements for pumping would be about 33 000 MWh/a (4 MW).

L4.3 Upper Molenaars Diversion**a) Description of development option**

The possible scheme comprises run of river abstraction from the Upper Molenaars River, and pumping over the divide to the Berg River through a new pipeline. The pipeline route will pass through the Huguenot Tunnel and make use of the existing 1.3m diameter pipeline in the tunnel. Water would be delivered to the existing infrastructure for Wemmershoek Dam and the Berg River Project

b) Description of scenarios

- Only one scenario considered.

c) Source(s) of information on costs

- *Western Cape Water Supply system Reconciliation Strategy Study* (various reports in 2007, including a follow up Status Report in 2009)
- Limited information on costs was available, however, the scheme is being studied as part of a feasibility study with other possible augmentation options

d) Base date of costs

- The base date for costs was Dec 2001 and an escalation factor of 1.83 applied.

e) Infrastructure

- Small abstraction sump on Upper Molenaars River
- 700 m of 1 700 mm diameter rising main
- 26 km of 1 300 mm diameter gravity main
- Pump station (35 m head at abstraction point)

f) Programme

- Implementation program was obtained from Status Report and updated where necessary.
- Construction of Phase 1 could start in 2016 with the first delivery of water in 2019.

g) Maintenance and operation

- As per general assumptions

h) Losses

- No losses were included.

j) Energy requirement

- Energy requirements were not available and had to be estimated by calculating back from an energy cost with an energy tariff of R0.25/kWh.
- Energy requirements for pumping would be 3 720 MWh/a (0.5 MW).

L4.4 Upper Wit River Diversion**a) Description of development option**

This possible scheme is currently being studied as part of a feasibility study for augmentation options in the Western Cape. The scheme can yield approximately 10 million m³/a. No costs are currently available at the time of finalising the report, and as such no URV calculation was conducted. The scheme was however included in the preliminary possible phasing of schemes exercise.

L4.5 Re-use of Water

a) Description of development option

Re-use of water in the Western Cape involves pre-treating water from various WWTWs and returning the water to Steenbras Reservoir for in-direct re-use. Pre-treatment of the water includes reverse-osmosis desalination. The volume of water and scheme layout is taken from follow up work being conducted by Aurecon on the Reconciliation Strategy. 83 million m³/a of effluent is assumed to be available from the WWTWs for re-use, and the scheme configuration is a revised version of the Faure scheme investigated as part of the Reconciliation Strategy. The scheme includes possible raising of Steenbras Reservoir.

b) Description of scenarios

- Only one scenario was considered.

c) Source(s) of information on costs

- *Western Cape Water Supply system Reconciliation Strategy Study* (various reports in 2007, including a follow up Status Report in 2009)
- Spreadsheets from Aurecon from the follow up work conducted on re-use of water (desalination based on the work conducted by WRC for desalination for Municipalities 2006).

d) Base date of costs

- The base date for costs is June 2005 and an escalation factor of 1.40 was applied to update the cost of the scheme.

e) Infrastructure

- Dams
- Raising of Steenbras Reservoir (R101 million – June 2005)
- 5 Balancing reservoirs (R82 million – June 2005)
- 8 Pipelines
 - 13.5 km of 700 mm diameter pipeline
 - 10.3 km of 1 200 mm diameter pipeline
 - 9.3 km of 1 500 mm pipeline
 - 29.8 km of 1 600 mm diameter pipeline
 - 600 m of 1 700 mm diameter pipeline
 - 5.2 km of 1 800 mm diameter pipeline
 - 1.2 km of 2 000 mm pipeline
- 8 Pump stations
 - Total pumping head (including standby) 29.7 MW.
- Tunnel
 - 1.2 km of tunnel.

f) Programme

- The Implementation program was obtained from the Reconciliation Strategy and if available in the updated Status Report. The program was updated where necessary.
- Construction could start in 2016 with the first delivery of water in 2019.

g) Maintenance and operation

- Determined as per the standard assumptions.

h) Losses

- No losses were included.

i) Energy requirement

- The energy requirement to pump the full volume of water will be 6.6 MW.
- The energy requirement for desalination of the effluent is 17 MW

j) Other

- The operational cost of treating the raw water to potable standard of 55c/m³ was excluded.

L4.6 Groundwater (TMG Aquifer)**a) Description of development option**

Developments of the Table Mountain group (TMG) aquifer, considered as part of the Reconciliation Strategy for reference volumes of 20, 50 and 70 million m³/a respectively.

A scheme of capacity 70 million m³/a was assumed for this study, but the feasibility of sustainably extracting this volume has not been confirmed. More information is needed on the TMG, and the CCT has initiated a feasibility study and pilot project.

The scheme consists of:

- Three wellfield developments (one near Paarl, one near Theewaterskloof Dam and one near Steenbras Reservoir)
- 64 pump-boreholes, 7 stand-by boreholes and 32 monitor-boreholes
- 32 km of pipeline is included to collect the borehole water.
- A 10 km pipeline is included to distribute the water from the boreholes to the nearest large dams, namely Wemmershoek, Theewaterskloof and Steenbras Reservoir, from where it is distributed.

b) Description of scenarios

- Only one scenario was considered.

c) Source(s) of information on costs

- *Western Cape Water Supply system Reconciliation Strategy Study* (various reports in 2007, including a follow up Status Report in 2009)
- Spreadsheets from Umvoto Consultants containing more detail on the schemes as used in the Reconciliation Strategy.

d) Base date of costs

- The base date for costs is June 2005 and an escalation factor of 1.40 was applied to update the cost of the scheme.

e) Infrastructure

- Three wellfield developments (one near Paarl, one near Theewaterskloof Dam and one near Steenbras Reservoir)
- 64 pump-boreholes (600 m depth), 7 stand-by boreholes and 32 monitor-boreholes (250 m depth)
- 32 km of pipeline 200 mm diameter is included to collect the borehole water.
- A 10 km of 1 300 mm diameter pipeline is included to distribute the water from the boreholes to the nearest large dams, namely Wemmershoek, Theewaterskloof and Steenbras Reservoir, from where it is distributed.
- 45 kW pumps for the boreholes (R150 000 each – June 2004)
- Hydraulic tests (Single borehole – R4000, wellfield – R250 000)

f) Programme

- Implementation programmes were obtained from the Reconciliation Strategy and if available in the updated Status Report. Programmes were updated where necessary.
- The program includes a long 5 year feasibility phase which includes the pilot project.
- Construction could start in 2019 with the first delivery of water in 2021.

g) Maintenance and operation

- Determined as per the standard assumptions.

h) Losses

- No losses were included.

i) Energy requirement

- The energy requirement to pump the water stated to be 45 kW per borehole
- Assuming the 64 boreholes in operation the total energy requirement is 69 MWh/day (3 MW).

L4.7 Groundwater (West Coast and Cape Flats Aquifers)**a) Description of development option**

Cape flats and West Coast sand aquifers have potential for some additional supply of relatively small amounts. By harvesting winter runoff and injecting it into the aquifers, the yield of the aquifers can be increased. The confidence in the information on these schemes is low and little detail on the schemes costs is available. The cost will need to include the necessary infrastructure to collect winter runoff. The volumes suggested are approximately 18 million m³/a for the Cape flats aquifer and anywhere from 13 to 85 million m³/a for the west coast aquifers including recharge. Environmental issues are likely, and the aquifers are relatively thin possibly making the drilling of boreholes difficult. The West Coast Aquifers will require a long pipeline to deliver water from near Saldana to the CCT. This will likely make this scheme very expensive.

No URV's were conducted for these aquifers and they were not considered any further for this exercise.

L4.8 Desalination of seawater

a) Description of development option

Seawater could be desalinated from the Atlantic Ocean at a plant on the West Coast outside of the City of Cape Town. The water is then to be pumped and delivered into local reticulation system.

b) Description of scenarios

Two reference scenarios were investigated:

- 100 million m³/a scheme
- 200 million m³/a scheme

c) Source(s) of information on costs

- *Western Cape Water Supply system Reconciliation Strategy Study* (various reports in 2007, including a follow up Status Report in 2009)
- Spreadsheets from Aurecon from the follow up work conducted on desalination of seawater (desalination based on the work conducted by WRC for desalination for Municipalities 2006).

d) Base date of costs

- The base date for costs is June 2005 and an escalation factor of 1.40 was applied to update the cost of the scheme.

e) Infrastructure

- Pipelines
 - An amount of pipeline was included (R215 million – Dec 2007) to deliver water from the desalination plant into the existing supply system.
- Pump stations
 - A new pump station was included (R47 million – Dec 2007)
 - A balancing reservoir was included (R66 million – Dec 2007)
- Treatment plant
 - A desalination plant to desalinate 100 and 200 million m³/a for the two scenarios.
 - The intake and outlet works were assumed to be 30 % of the capital cost of the desalination plant.

f) Programme

- Implementation programmes were obtained from the Reconciliation Strategy and if available in the updated Status Report. Programmes were updated where necessary.
- Construction of Phase 1 could start in 2017 with the first delivery of water in 2020.

g) Maintenance and operation

- Determined as per the standard assumptions, but an additional R1.94/m³ of water for operation cost of the desalination plant (excl. energy) were included.

h) Losses

- No losses were included.

i) Energy requirement

- The energy required to desalinate the seawater is 7.5 kWh/m³, which equates to about 90 MW for a 100 million m³/a, and 179 MW for a 200 million m³/a plant
- An additional 10 MW for pumping of 100 million m³/a of water
- An additional 20 MW for pumping of 200 million m³/a of water

j) Other

- A reduction in the total URV of R2/m³ was made to bring the potable desalinated seawater to a raw water basis.

L5 DEVELOPMENT OPTIONS – NOTES ON PHASING

Phasing of schemes was investigated for a scenario with and without the negative effects of climate change.

The implementation of the reserve at existing dams is assumed to be phased in over 5 years beginning in 2019 when sufficient new schemes can come on line to resolve the short term deficit and reduce the impact of implementing the reserve.

APPENDIX M

DETAILS ON URVs OF DEVELOPMENT OPTIONS

Marginal Cost of Water - Unit Reference Values for Future Water Resources Developments (Coal generated energy switch over to nuclear generated energy)

Without deficits/surpluses in 2016 and without EWR

*Updated: March 2010

No.	Potential augmentation	Year yield is fully utilised	Yield/ Transfer capacity Mm ³ /a	Capital costs		Maintenance costs		Energy Costs		Energy rating @ full capacity kWh/m ³	Capital cost per m ³ Rand per m ³ /a	Other costs		Incremental URV R/m ³	Net URV (raw water) R/m ³	Net URV (potable) R/m ³	Comment	
				R million	NPV as %	R million/a	NPV as %	R million/a	NPV as %			R million/a	NPV as %					
Vaal River System																		
1	Lesotho Highlands Water Project Phase II (Poliha)	2024	437 (393)	10904	70	21	1	-	-	0.00	28	Variable	29	6.14	6.14	8.14		
2a	Thukela-Vaal transfer scheme (Southern tributaries - Jana Dam)	2023	396 (356)	15038	64	45	2	1305	34	3.49	42	-	-	9.84	9.84	11.84		
2b	Thukela-Vaal transfer scheme (Southern tributaries - Mielietuin Dam)	2019	126 (115)	4941	62	17	2	348	35	2.92	43	-	-	8.11	8.11	10.11		
2c	Thukela-Vaal transfer scheme (Southern tributaries - Phased Mielietuin and Jana Dams)	2025	522 (470)	20058	61	62	2	1653	38	3.35	43	-	-	9.16	9.16	11.16		
3	Thukela-Vaal transfer scheme (Northern tributaries)																	
4a	Use of acid mine drainage - Based on select Vaal mines	2017	38	1661	47	105	30	90	23	2.51	44	-	-	9.23	7.23	9.23		
4b	Use of acid mine drainage - Based on all Vaal mines	2019	100	4654	49	288	30	232	21	2.45	47	-	-	10.22	8.22	10.22		
5	Direct re-use of effluent																	
6a	Orange-Vaal transfer scheme (Boskraai Dam with canal)	2024	517 (414)	16992	73	65	3	970	25	1.99	41	-	-	8.47	8.47	10.47		
6b	Orange-Vaal transfer scheme (Boskraai Dam with pipeline)	2025	517 (465)	17639	71	99	4	1041	24	2.13	38	-	-	8.02	8.02	10.02		
6c	Orange-Vaal transfer scheme (Boskraai Dam with phased pipelines)	2025	517 (465)	22063	68	121	4	1150	28	2.35	47	-	-	8.66	8.66	10.66		
7a	Mzimvubu transfer scheme (Kraai option) - Supply to Vaal only	2026	631 (511)	37939	71	175	3	2612	26	4.38	74	-	-	17.38	17.38	19.38	All water to the Vaal	
7b	Mzimvubu transfer scheme (Kraai option) - Supply to Vaal and Algoa	2030	462	35720	70	163	3	2443	26	4.38	77	-	-	17.11	17.11	19.11	Part of the water transferred to Vaal, remainder to Algoa	
8	Mzimvubu transfer scheme (Thukela option)																	
9a	Transfer from the Zambezi River - Largest single practical pipe size - 650 Mm ³ /a	2032	650	47693	77	257	4	2588	19	4.21	73	-	-	17.39	22.39	24.39		
9b	Transfer from the Zambezi River - Demand related pipe size - 350 Mm ³ /a	2023	350	37602	76	211	4	1393	20	4.21	107	-	-	19.45	24.45	26.45		
9c	Transfer from the Zambezi River - 650 Mm ³ /a (Sharing with Oifants & Lephalele)	2033	350	29304	77	170	4	1372	19	4.21	84	-	-	16.35	21.35	23.35		
10a	Desalination of seawater - 100 Mm ³ /a to headwaters of the Vaal	2019	100 (90)	1244	41	270	11	1244	48	13.16	103	-	-	26.92	26.92	28.92		
10b	Desalination of seawater - 200 Mm ³ /a to headwaters of the Vaal	2020	200 (180)	14261	36	497	11	2481	52	13.12	79	-	-	25.10	25.10	27.10		
10c	Desalination of seawater - 100 Mm ³ /a to Vaal Dam WTW	2019	100	13321	49	311	11	1244	40	13.16	133	-	-	29.26	27.26	29.26		
10d	Desalination of seawater - 200 Mm ³ /a to Vaal Dam WTW	2020	200	19904	44	567	11	2481	45	13.12	100	-	-	26.44	24.44	26.44		
10e	Desalination of seawater - 650 Mm ³ /a to Vaal Dam WTW	2032	650	43988	43	1 689	11	8149	46	13.27	68	-	-	26.54	24.54	26.54		
Orange River System																		
1	Dam at Vooltsdrift																	
2	Utilising low level storage at Vanderkloof Dam																	
3a	Boskraai Dam - Supply according to expected growth in demand	2026	227 (216)	918	98	2	2	0	0	0.00	4	-	-	0.65	0.65	2.65		
4a	Mzimvubu Kraai transfer - 618 Mm ³ /a (+20 m ³ /s) from 6 dams in the Mzimvubu	>2045	618 (556)	22183	80	110	4	1681	16	2.88	40	-	-	18.24	18.24	20.24		
4b	Mzimvubu Kraai transfer - 150 Mm ³ /a from Ntabelanga Dam in the Mzimvubu	2023	165 (150)	3989	36	37	4	820	60	5.26	27	-	-	8.74	8.74	10.74		
5a	Desalination of seawater - 100 Mm ³ /a to headwaters of the Orange	2020	100 (95)	10199	41	288	11	1333	48	14.10	107	-	-	27.58	27.58	29.58		
5b	Desalination of seawater - 200 Mm ³ /a to headwaters of the Orange	2025	200 (190)	15606	39	529	11	2658	50	14.06	82	-	-	27.08	27.08	29.08		
5c	Desalination of seawater - 100 Mm ³ /a to Ganep Dam WTW	2020	100	10906	43	303	11	1333	46	14.10	109	-	-	27.27	25.27	27.27		
5d	Desalination of seawater - 200 Mm ³ /a to Ganep Dam WTW	2025	200	16588	41	556	11	2658	48	14.06	83	-	-	26.76	24.76	26.76		
Lephalele Area																		
1	Mokolo Crocodile Augment. Project Ph 1 (Mokolo)	2017	28	1605	84	9	5	23	11	0.86	57	-	-	6.44	6.44	8.44	Very high redundancy in phase 1. Designed to deliver 53.4Mm ³ /a over short term. Limited by Mokolo Dam yield	
2	Mokolo Crocodile Augment. Project Ph 2 (Crocodile)	2034	169	7940	86	38	4	127	10	0.80	47	-	-	7.64	7.64	9.64	URV calculated on the full transfer capacity of 169 Mm ³ /a, but only 40 Mm ³ /a surplus available in the crocodile for transfer at this	
3	Re-use and transfer of water from Vaal	2023	126	1110	47	34	13	115	40	0.87 (1.67)	9	-	-	2.14	9.78	11.78	Incremental URV for delivery into the Crocodile and requires the further transfer of water to Lephalele	
4	Transfers from Vaal River system - 100 Mm ³ /a	2019	90	2338	70	14	5	94	24	1.0 (1.80)	26	-	-	3.96	17.74	19.74	Incremental URV for delivery into the Crocodile and requires the further transfer of water to Lephalele	
5	Transfers from Vaal River system - 200 Mm ³ /a	2042	180	3493	70	23	5	188	25	1.0 (1.80)	19	-	-	3.94	17.72	19.72	Incremental URV for delivery into the Crocodile and requires the further transfer of water to Lephalele	
6	Transfers from Zambezi River - 100 Mm ³ /a	2020	100	13206	84	68	4	231	12	2.44	132	-	-	18.08	23.08	25.08		
7	Transfers from Zambezi River - 200 Mm ³ /a	>2045	200	19084	84	101	4	412	12	2.38	95	-	-	18.65	23.65	25.65		
8	Transfers from Zambezi River - Sharing scheme 200 Mm ³ /a	2020	200	10671	78	59	4	440	18	2.38	53	-	-	12.27	19.27	21.27	3.5 m diameter pipe with 100 to Lephalele, 190 to Oifants and 350 to Pretoria (cost of common portion of scheme split pro-rata)	
9	Desalination of seawater and pumping - 100 Mm ³ /a	2020	100	19072	57	338	10	1306	33	13.82	191	-	-	36.85	34.85	36.85		
10	Desalination of seawater and pumping - 200 Mm ³ /a	>2045	200	27872	58	567	9	2387	33	13.78	139	-	-	38.02	36.02	38.02		
Oifants River System																		
1	Oifants Dam (previously referred to as Rooipoort)	2028	55	1132	97	3	3	-	-	0.00	21	-	-	3.08	3.08	5.08	Water released and abstracted from Havercroft weir	
2	Use of acid mine drainage	2022	31	1494	61	42	16	69	23	2.20	49	-	-	8.87	8.87	10.87	Benefit of reducing drainage into the river is not included, but will reduce the cost of this water	
3	Re-use of water																Re-use does not add any incremental yield to the system as the yield of Loskop dam is reduced	
4	Transfers from Vaal River system - 95 Mm ³ /a	2044	95	2616	81	16	5	102	14	1.07	28	-	-	7.34	13.48	15.48	Delivery to Witbank Dam.	
5	Transfers from Vaal River system - 190 Mm ³ /a	>2045	190	3907	84	25	6	104	10	1.07	21	-	-	10.47	16.61	18.61	Delivery to Witbank Dam.	
6	Transfers from Zambezi river - 100 Mm ³ /a	2044	95	16933	88	90	5	340	8	3.80	178	-	-	45.72	50.72	52.72	Delivery to tributary upstream of Havercroft weir	
6	Transfers from Zambezi river - 190 Mm ³ /a	>2045	190	24853	90	134	5	349	5	3.80	131	-	-	65.47	70.47	72.47		
7	Transfers from Zambezi river - Sharing scheme - 100 Mm ³ /a	2044	95	8957	76	51	4	325	20	3.60	94	-	-	13.56	18.56	20.56	3.5 m diameter pipe with 100 to Lephalele, 190 to Oifants and 350 to Pretoria (cost of common portion of scheme split pro-rata)	
8	Desalination of seawater and pumping - 100 Mm ³ /a	>2045	100	12970	63	310	9	1277	27	13.82	130	-	-	46.45	44.45	46.45	Potable water delivered to Witbank	
9	Desalination of seawater and pumping - 200 Mm ³ /a	>2045	200	19408	71	565	8	1274	20	13.78	97	-	-	61.84	59.84	61.84	Potable water delivered to Witbank	
Mhlatuze System (Richards Bay)																		
1	Lower Thukela Transfer	10 years after const.	40	721	85	12	10	64	35	1.70	18	-	-	4.63	4.63	6.63	Although current growth does not indicate need for scheme, a hypothetical scenario was assumed with full utilisation with 10 years	
2	Re-use of water		30	903	45	32	15	93	40	3.00	30	-	-	7.47	7.47	9.47	Same cost assumed as Western Cape re-use, scaled to smaller scheme	
13	Desalination of seawater - 50 Mm ³ /a		50	1277	33	133	21	361	46	7.64	26	-	-	15.33	13.33	15.33	Same costs assumed as Desalination of seawater from Algoa	
KZN Coastal Metropolitan Areas																		
1	Mooi Umgeni transfer phase II	2023	57	421	77	2	4	13	19	0.24	7	-	-	1.18	1.18	3.18		
2	Re-use of water	2029	53	591	56	12	12	41	32	0.86	11	-	-	2.36	2.36	4.36	Indirect re-use of water back into dams (cost of removing nutrients and salts seems low)	
3	Mkomazi-Mgeni Transfer Ph 1 (Smithfield Dam)	2035	147	3069	93	11	3	21	4	0.15	21	-	-	4.57	4.57	6.57		
4	Mkomazi-Mgeni Transfer Ph 2 (Impendle Dam)	>2045	218	1897	92	7	3	29	5	0.15	9	-	-	2.83	2.83	4.83	Uses spare tunnel capacity from Phase 1 (Smithfield)	
5	Lower Thukela Scheme	2040	37	446	74	3	4	26	22	0.79	12	-	-	3.16	3.16	5.16		
6	Isithundu Dam	>2045	42	1094	86	4	3	34	11	0.88	26	-	-	7.11	7.11	9.11		
7	Umkhulu River Dam	2029	100	2554	66	22	6	172	28	1.7 (1.9)	26	-	-	5.91	5.91	7.91		
8	Desalination of seawater and pumping - 100 Mm ³ /a	2029	100	2438	28	246	20	712	52	7.53	24	-	-	13.40	11.40	13.40		
9	Desalination of seawater and pumping - 200 Mm ³ /a	>2045	200	4467	38	461	17	1367	45	7.42	22	-	-	15.34	13.34	15.34		
Amatole System																		
1	Re-use of water	2028	14.8	247	37	14	18	43	46	2.70	17	-	-	6.10	6.10	8.10	Costs obtained by combining information from Systems analysis report and the Reconciliation strategy for the Western Cape	
2	Keiskamma Transfer (Sandile Dam)	2021	7.5	92	44	1	4	12	52	1.70	12	-	-	3.02	3.02	5.02	Transfer from existing Sandile Dam	
3	Nahoon River Dam (Stone Island)	2019	5.3	108	98	1	2											

APPENDIX N

TIMELINES

APPENDIX N

TIMELINES

- N1 EARLIEST POSSIBLE IMPLEMENTATION DATES OF DEVELOPMENT OPTIONS**
- N2 POSSIBLE PHASING OF DEVELOPMENT OPTIONS**

APPENDIX O

**COMPARISON BETWEEN URVs CALCULATED AS PART
OF THE COMPARATIVE STUDY BETWEEN LHWP PHASE
II AND THE THUKELA WATER PROJECT AND THE
MARGINAL COST OF WATER STUDY**

Comparison between URVs calculated as part of the *Comparative Study between LHWP Phase II and the Thukela Water Project* and the *Marginal Cost of Water Study*

LHWP Phase II

Scheme and scenario	A	B	C
	<i>Comparative Study between LHWP Phase II and Thukela Water Project</i>	<i>Marginal Cost of Water Study</i> (URV recalculated based on same assumptions as in <i>Comparative Study</i>)	<i>Marginal Cost of Water Study</i> (Final URV calculated based on assumptions adopted for this study)
	Unit reference value of water - URV (R/m ³ of raw water)		
LHWP Phase II with incremental Royalties: Polihali Dam at FSL 2075	4.47	4.40	6.14
LHWP Phase II (excluding effect of incremental Royalties): Polihali Dam at FSL 2075	2.81	3.03	No URV calculated
Major differences in assumptions:			
URV parameters (i.e. discount period, time of phasing etc.)	As from <i>Comparative Study</i>	As from <i>Marginal Cost of Water Study</i>	As from <i>Marginal Cost of Water Study</i>
Demands	Vaal demands only (from <i>Comparative Study</i>) - <u>excl.</u> future transfers to Olifants and Lephalale - deficits included in 2016	Vaal demands only (from <i>Marginal Cost of Water Study</i>) - <u>excl.</u> future transfers to Olifants and Lephalale - deficits included in 2016	Vaal demands (from <i>Marginal Cost of Water Study</i>) - <u>incl.</u> future transfers to Olifants and Lepahale - <u>no</u> deficits included in 2016
Base date of costs	October 2007	October 2007	July 2009
Infrastructure	Only Polihali and Vioolsdrift dams included	Only Polihali and Vioolsdrift dams included	Polihali, Vioolsdrift and a portion of Boskraai Dam included

Thukela Water Project

Scheme and scenario	A	B	C
	<i>Comparative Study between LHWP Phase II and Thukela Water Project</i>	<i>Marginal Cost of Water Study</i> (URV recalculated based on same assumptions as in <i>Comparative Study</i>)	<i>Marginal Cost of Water Study</i> (Final URV calculated based on assumptions adopted for this study)
	Unit reference value of water - URV (R/m ³ of raw water)		
Thukela Water Project: Jana Dam at FSL 890	5.31	5.24	9.84
Major differences in assumptions:			
URV parameters (i.e. discount period, time of phasing etc.)	As from <i>Comparative Study</i>	As from <i>Marginal Cost of Water Study</i>	As from <i>Marginal Cost of Water Study</i>
Demands	Vaal demands only (from <i>Comparative Study</i>) - <u>excl.</u> future transfers to Olifants and Lephalale - deficits included in 2016	Vaal demands only (from <i>Marginal Cost of Water Study</i>) - <u>excl.</u> future transfers to Olifants and Lephalale - deficits included in 2016	Vaal demands (from <i>Marginal Cost of Water Study</i>) - <u>incl.</u> future transfers to Olifants and Lepahale - <u>no</u> deficits included in 2016
Base date of costs	October 2007	October 2007	July 2009
Energy	Based on electricity tariffs: Used non-municipal Megaflex electricity charges (calculation by Mr. Peter Ramsden)	Based on electricity tariffs: Used non-municipal Megaflex electricity charges (calculation by Mr. Peter Ramsden)	Based on marginal cost of energy - R0.60/kWh up to 2019 (coal) and R0.90/kWh from 2020 onwards (coal nuclear blend)

General notes:

- 1) All URVs exclude VAT and are reflected at a 8% discount rate
- 2) All URVs assume Vaal high demands (high population-scenario)