A LIVING PROCESS - INTEGRATED AND ADAPTIVE BULK WATER RECONCILIATION PLANNING

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ABSTRACT

The paper will by way of an example discuss an integrated planning approach, as implemented for various regional bulk water supply systems in South Africa. This approach provides an innovative adaptive management decision-support framework to ensure water security and timeous decision-making. This approach can assist in the management of water supply systems in a co-ordinated and environmentally sound fashion, with community consultation being a key component. The development of appropriate scenarios will be discussed, thereby enabling water authorities to effectively achieve the desired strategic planning outcomes and to efficiently adapt their provision of services and their operations to best meet the challenges of an uncertain future. Water Authorities can use the developed scenarios to inform their future planning activities and then utilise these as a basis to conduct a full review of their strategic and infrastructure plans. Scenario planning will ensure that water authorities are best positioned to respond strategically to emerging trends and are able to continue to provide the appropriate level of services to their customers at an affordable cost. The use of the interactive Reconciliation Planning Support Tool to aid the integrated Scenario Planning Process and to meet future water resource analysis needs will be illustrated.

KEYWORDS

Integrated planning, planning tool, supply/demand strategy, Reconciliation Planning Support Tool, scenario planning

1 INTRODUCTION

Cape Town, with 3.2 million residents, has the highest net migration rate in South Africa, doubling in size during the past 20 years. The Western Cape Water Supply System (WCWSS) serves the City of Cape Town (CCT) and surrounding areas. The geographical area covered by the strategy is shown in Figure 1. This area is the second largest contributor to the national economy and houses the third largest population concentration in the country. To avoid exceedence of acceptable risks of supply, largely as a result of drought, system users have in recent years been subjected to water-use restrictions. In addition, the existing sources of supply from the system can only supply sufficient water to meet the expected system demands until about 2015, under high-growth demand conditions. Thereafter, additional sources of supply will be required or the demands will have to be controlled.

The national South African Department of Water Affairs (the DWA), as the custodian of the country's water resources, and the CCT, as the main local user, therefore initiated a strategy study to evaluate medium to long-term water resources vulnerability and develop an appropriate response. The strategy provides a decision-support framework, which enables timely decisions to be made on water resource interventions, to meet future water demands. This paper will by way of example discuss an integrated bulk water resource planning approach.

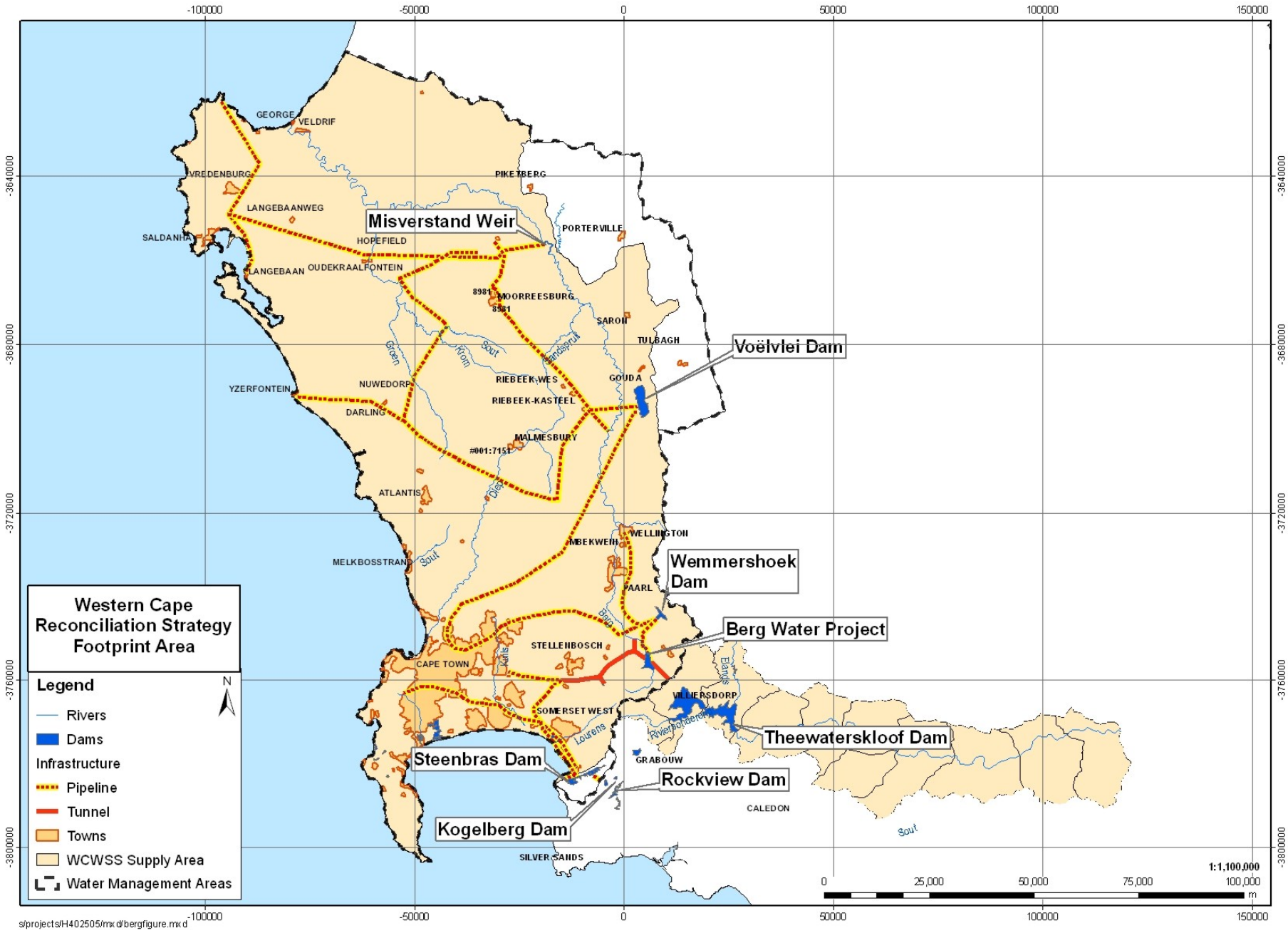


Figure 1: The Western Cape Water Supply System

2 SOUTH AFRICAN WATER LEGISLATION AND MANAGEMENT

South Africa has undergone major recent and ongoing water reforms, notably following the publishing of the National Water Act that centralised the management of water in South Africa. There has been an increased focus on improved efficiency and sustainability, with a move from a development focus to improved water allocation management and protection of the environment and further to the sharing of water between economic and environmental uses. In terms of bulk urban water planning, there has been a gradual and ongoing shift from supply-side to demand-side management.

2.1 THE NATIONAL WATER ACT (NWA)

The NWA of 1998 is the principal legal instrument relating to water resource management in South Africa. The Act is being incrementally implemented.

2.2 THE NATIONAL WATER RESOURCE STRATEGY (NWRS)

The NWRS is the implementation strategy for the NWA and provides the framework within which the water resources of South Africa will be managed in the future. All authorities and institutions exercising powers or performing duties under the NWA must give effect to the NWRS. This strategy sets out policies, strategies, objectives, plans, guidelines, procedures and institutional arrangements for the protection, use, development, conservation, management and control of the country's water resources. The purpose of the NWRS is to provide the following:

- The national framework for managing water resources.
- The framework for preparation of catchment management strategies in a nationally consistent way.
- Information, in line with current legislation, regarding transparent and accountable public administration.
- The identification of development opportunities and constraints with respect to water availability.

Current government objectives for managing water resources in South Africa are set out in the National Water Resource Strategy (NWRS) as follows:

- To achieve **equitable access** to water. That is, equity of access to water services, to the use of water resources, and to the benefits from the use of water resources.
- To achieve **sustainable use of water**, by making progressive adjustments to water use to achieve a balance between water availability and legitimate water demands, and by implementing measures to protect water resources and the natural environment.
- To achieve **efficient and effective water use** for optimum social and economic benefit.

The NWRS also lists important proposals to facilitate achievement of these policy objectives, such as:

- Water will be regarded as an indivisible national asset. The Government will act as the custodian of the nation's water resources, and its powers in this regard will be exercised, as a public trust.
- Water required to meet basic human needs and to maintain environmental sustainability will be guaranteed as a right, whilst water use for all other purposes will be subject to a system of administrative authorisations.
- The responsibility and authority for water resource management will be progressively decentralised by the establishment of suitable regional and local institutions, with appropriate representation.

2.3 CATCHMENT MANAGEMENT STRATEGIES (CMS)

The country has been divided into 19 Water Management Areas. The delegation of water resource management from central government to catchment level will be achieved by establishing Catchment Management Agencies at Water Management Area level. Each Catchment Management Agency will progressively develop a Catchment Management Strategy for the protection, use, development, conservation, management and control of water resources within its Water Management Area.

2.4 RECONCILIATION STRATEGIES

So-called Reconciliation Strategies, or Demand-Supply Strategies, are incrementally being undertaken for all the large metropolitan areas of South Africa, to ensure that planning for bulk water infrastructure is timeously implemented. Reconciliation Strategies for towns are also being done incrementally.

3 THE WESTERN CAPE WATER SUPPLY SYSTEM

The WCWSS is an intricate system of dams, pipelines and tunnels which is cooperatively managed by the DWA's Regional Office and the CCT. The underlying principle is to optimise available water resources by drawing preferentially from dams that might spill, thus ensuring that sufficient water is available for all users during periods when water demands are high (summer) and/or during droughts.

The WCWSS provides water to the communities of the CCT and some Overberg, Boland, West Coast and Swartland towns, and irrigators along the Berg, Eerste and Riviersonderend rivers. Urban use within the CCT represents the largest water use from the WCWSS (63%) with approximately 32% of the total volume of water supplied used by irrigators. The remaining 5% is taken up by other towns in the supply area.

The highest recorded unrestricted water use within the WCWSS area to date is 499 Gℓ/a in 1999, and has since declined due to drought conditions and the implementation of water demand management measures. The current water supply is 556 Gℓ/a (Van der Berg et al., 2007). The actual water usage from the WCWSS for 2009 amounted to approximately 505 Gℓ /a.

The WCWSS supports a strong and diversified economy. As a result of economic growth, improved standards of living and migration, urban water demands are expected to grow at between 1.4% and 3.1%, if the influence of water conservation and demand management measures, which have already significantly curtailed the former higher growth rate, are not taken into account (Moosa, 2007). On the other hand, irrigation demands in the Berg and Eerste River valleys will grow to their full allocations, and are unlikely to grow significantly thereafter, on account of the high cost of additional water to be supplied as well as the likely capping of allocations for irrigation.

Photograph 1: Cape Town city centre

The two main storage dams supplying the WCWSS are the Theewaterskloof and Voëlvlei dams. The DWA's Riviersonderend Berg River Tunnel system conveys water from the catchment of the Riviersonderend River into the catchments of the Berg and Eerste rivers for irrigation and then onwards to CCT. Pipelines from the other dams and treatment works also convey water to CCT. The estimated replacement value of the current bulk water supply and wastewater infrastructure and reticulation is approximately $ 5.5 billion. High levels of expertise and skills are required to plan, manage and maintain these essential and valuable assets.

The WCWSS is situated in a winter rainfall area, characterised by wet winters and dry summers. Approximately 50% of the dams' volumes are required for storage during winter so that the high water demands during summer can be met. The other 50% of the combined dams' volumes is required to provide long-term carry-over storage for periods of drought (Van der Berg et al., 2007). The effects of droughts are mitigated by progressively curtailing water demands.

4 DEVELOPMENT OF THE RECONCILIATION STRATEGY AND IMPLEMENTATION PLAN

4.1 STRATEGY OBJECTIVES AND APPROACH

The strategy's main objective is to reconcile long-term future water demands with the supply from the WCWSS to limit system vulnerability. It will further ensure regular review of future water balance scenarios, and the available options and actions needed for meeting these water demands.

The strategy provides a decision-support framework that will allow timely decisions to be made (at various levels of decision-making and at varying confidence levels, as more information becomes available) that will steer the course of actions for effective reconciliation - to be able to continue along the appropriate implementation scenario/s. The strategy will put in place a programme of studies and other investigations considered necessary to support the strategy. This will ensure that the necessary interventions are investigated timeously and to the appropriate level of detail.

Continuous informing of, or where required, involvement of the stakeholders and the public is recommended, to ensure that key stakeholders reach consensus on broad responsibilities, and accept their individual responsibilities. It is important that the strategy remains well aligned with the provincial, regional and local frameworks and plans.

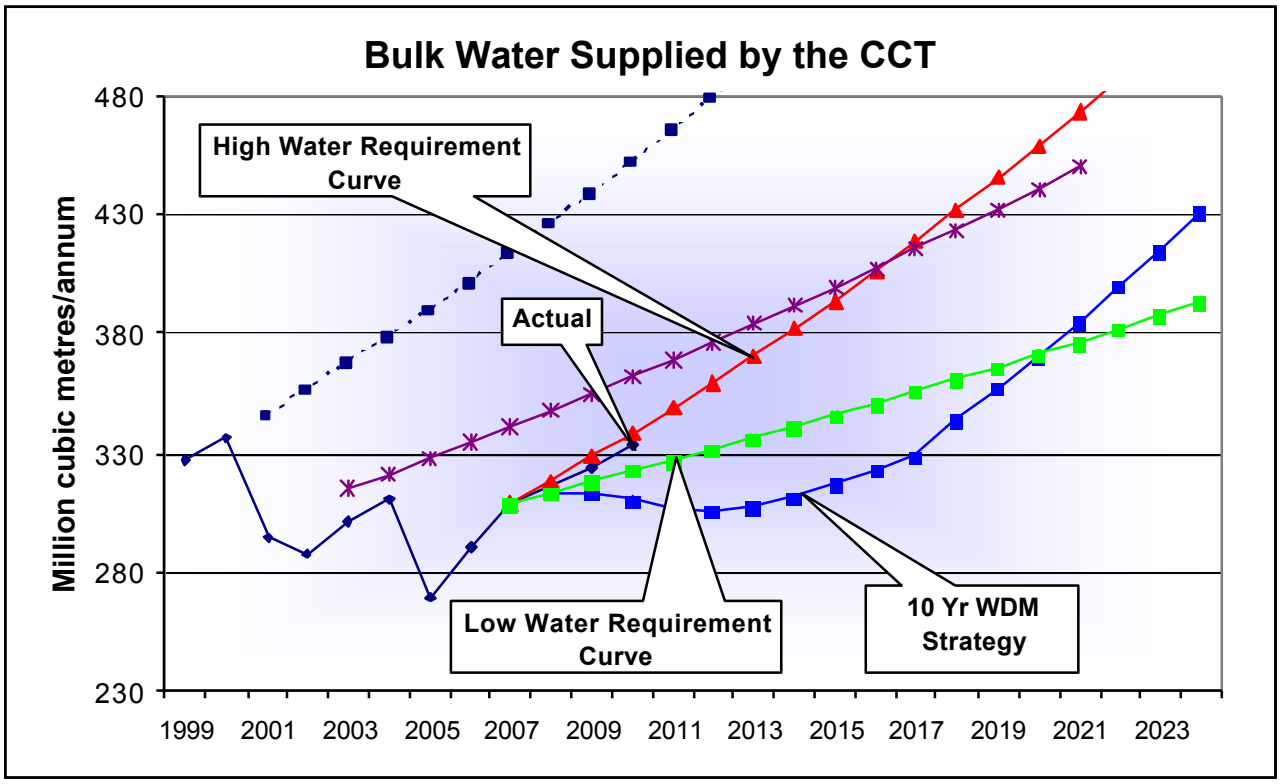
The approach adopted for the strategy's was to move away from the traditional augmentation approach of dealing mainly with the need for augmentation and the selection, planning and development of projects. The strategy rather aimed to achieve reconciliation in a structured integrated water resources management environment, following an adaptive management approach.

4.2 WATER DEMAND SCENARIOS

The key driver for population growth in the study area is migration, which is linked to the relative performance of the regional, local and competing economic centres and the growth inhibiting influence of HIV/Aids. The performance of the local economy is tied, in many ways, to the performance of both the national and international economies, as illustrated during the recent global financial and economic turmoil and downturn. It is anticipated that the future growth in water demand will be lower than the economic growth rate, but higher than the population growth rate.

Water demand scenarios, agreed to by stakeholders, are used as the basis from which more detailed scenario planning is undertaken. A water demand model was used to establish alternative scenarios for the future water demands of the WCWSS. Population growth rates were shown to decline with time owing to the impact of HIV Aids, the out-migration of working-age residents and a decline in fertility rates.

Based on the assumptions used in the modelling, it is anticipated that the water demands for the WCWSS are



predicted to grow to approximately 935 Gℓ/a in 2030, for the High Growth Scenario and to approximately 670 Gℓ/a for the Low Growth Scenario (Moosa, 2007). Figure 2 shows various water demand scenarios.

Figure 2: Water demand scenarios

There is a need for water authorities to continually review and develop improved demand forecasting and analysis tools. The importance of understanding specific details and patterns regarding end water use will improve demand forecasting capabilities.

4.3 THE INTEGRATED PLANNING PROCESS

Following the determination of the water balance, a step-wise process is recommended to identify the most favourable interventions or groups of interventions to meet possible future water demand scenarios, when these exceed the available supplies. The term 'interventions' has been coined to describe demand-side initiatives as well as supply-side schemes and other options. The steps in the reconciliation strategy process are shown in Figure 3.

Options that reduce demand are therefore compared on an equal basis with options that increase supply. The outcome of the process is a list of interventions that should be studied or implemented, by specific dates, to facilitate the implementation of a range of reconciliation scenarios. This evaluation involves the use of an integrated water resource planning tool to evaluate any identified reconciliation scenarios.

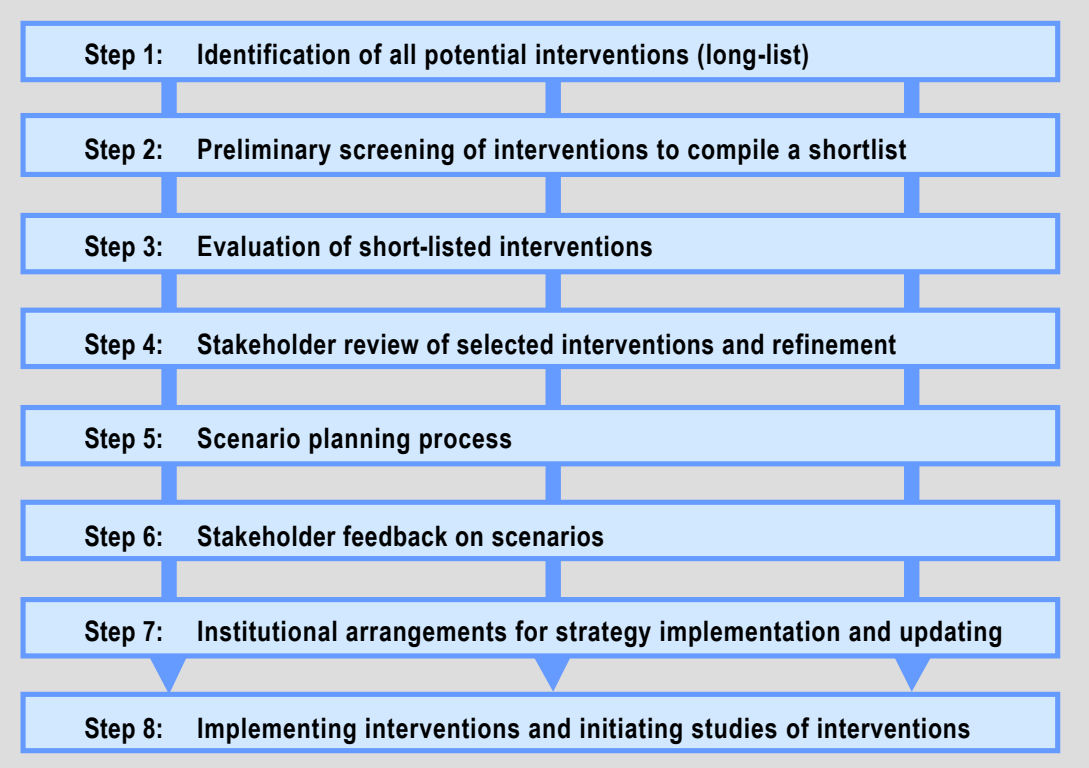


Figure 3: The integrated planning process

4.4 STRATEGY THEMES

This Strategy details the strategic to is ners and includes an Implementation Plan to addres d called themes (and underlying sub-themes), which co uture ctiviti ed and developed (Van der Berg et al., 2007a), as illustrat

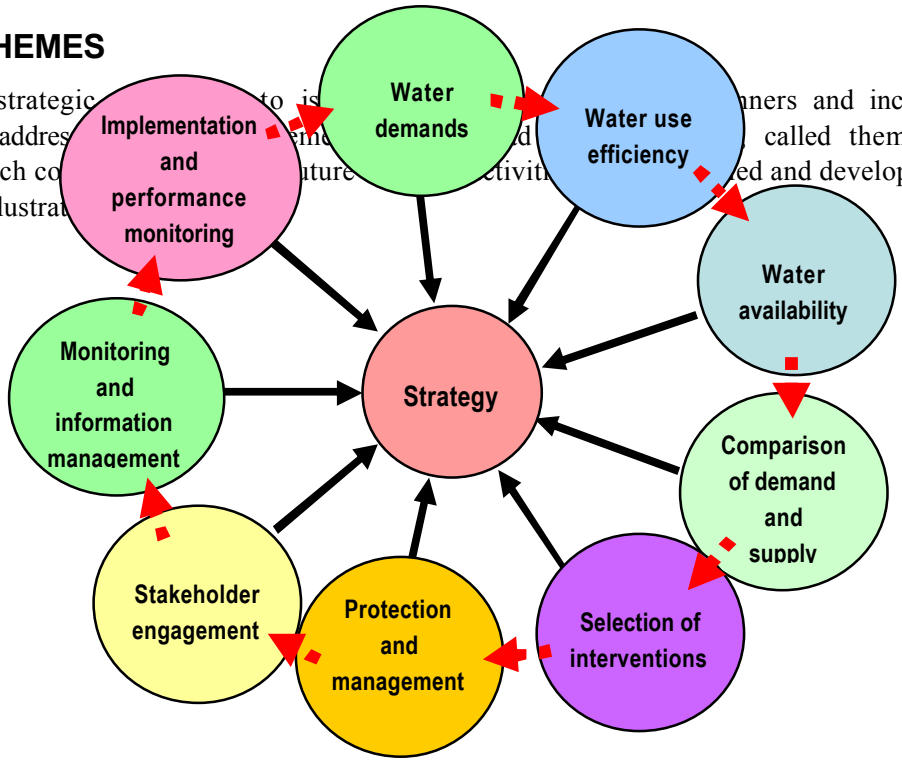


Figure 4: Themes addressed in the Strategy

An Action Plan, comprised of *actions* per key issue, *responsibility* per action and *programme* and *timing* per action, was developed for each theme. The themes were mainly developed in a series of working sessions by a *Technical Focus Group*, which comprised key stakeholders from national and local government and the consultant team, including specialists to provide specific perspectives.

The following themes have been developed:

- **Water demands,** addressing aspects relating to the estimation of future water use through the development of urban and agricultural water use scenarios, and the management of allocations.

- **Water use efficiency**, addressing aspects relating to urban and agricultural water use efficiency, and potable and non-potable use of treated wastewater.

- **Water availability and system operation**, addressing water availability from the WCWSS, as well as the requirement for optimal use of existing water resources and bulk infrastructure, operating rules to meet ecological water demands and operational management.

- **Comparison of demands and availability**, addressing the reconciliation of demands and availability to identify potential future shortfalls in supply.

- **Selection of interventions and decision-making process**, dealing with the identification of interventions for reconciliation, evaluating and selecting them, and ensuring that adequate information is available to support the decision-making process.

- **Water resources protection and management**, addressing interaction with the processes for ecological classification of resources, determination of environmental water flows and ensuring protection of current and potential future water sources and allocations, reservation of water for future water interventions and monitoring requirements.

- **Stakeholder engagement**, dealing with stakeholder engagement at various tiers of government and engagement with water institutions, raising awareness of water-related issues and building capacity of officials, politicians, stakeholders and the public.

- **Monitoring and information management**, addressing effective monitoring, data capturing processes and information and knowledge management systems to ensure sustainable planning and management.

- **Strategy implementation and performance assessment**, addressing the establishment and financial responsibilities of the committees that will implement the strategy as well as performance and compliance monitoring and revision of the strategy.

5 SCREENING OF INTERVENTIONS

As the implementation of large projects can take up to ten years or more from feasibility study to completion in a skills and data-scarce developing economy such as South Africa, it is essential that potential future sources of supply be confirmed as soon as possible, in order for the CCT and other water service providers to be able to plan future bulk infrastructure for the conveyance and treatment of water. A very diverse and complex range of factors influences the selection of interventions, some of which are scheme-specific.

5.1 OBJECTIVE

The objective of the screening process is to identify and select the most favourable interventions, or groups of interventions, that will meet the water demand of the system when this exceeds available supply. This is addressed in the Strategy under the *Selection of interventions and decision-making process* theme (Van der Berg et al., 2007a).

5.2 SELECTION, SCREENING AND PUBLIC REVIEW OF INTERVENTIONS

All identified interventions were initially evaluated in terms of cost, yield, reduction of risk, socio-economic and environmental considerations and other benefits, to approximately a common base of information. The time required to implement each intervention was considered and a detailed likely implementation programme for each intervention was drafted and reviewed. Stakeholder and public input was then obtained on interventions and the potential list of all potential interventions was amended accordingly.

A workshop was held where a widely representative, multi-stakeholder group took part in the screening process, as described by Killick and Anderson (2007) and helped eliminate non-starter interventions. The viability of including these 'non-starters' in the interventions list would only be revisited if new information on them became known. Overall, 66 interventions were discussed and the participants agreed to screen out 19 interventions. The ranking for each of the criteria for each intervention were discussed and agreed to by participants at the workshop. Further refinements were made in the following months, integrating new information from the extensive public process.

Some of the interventions considered for reconciling supply with the increasing demands are water conservation and demand management (WC/WDM), increased operational efficiency, effluent reuse, eradication of invasive alien plants, water trading, desalination of brackish water or sea water and new groundwater and surface water schemes.

6 THE RECONCILIATION PLANNING SUPPORT TOOL

6.1 OVERVIEW

The selection of interventions, either to be studied further or to be implemented, to reconcile water availability of the WCWSS with demand, is a complex task, with many diverse issues and criteria to consider. The need for a customised planning tool, to provide support for this task to water managers, was identified. A graphical support tool, called the Reconciliation Planning Support Tool (RPS Tool), was therefore developed, to aid the process of integrated resource planning. It allows the user to compare potential interventions, or groups of interventions, with one another, and with one or more selected future water demand scenarios (Killick and Anderson, 2007).

Information is populated in the RPS Tool, including various water demand scenarios, the current system yield, intervention parameters and programmes and various financial parameters. The RPS Tool is run in Excel, with Visual Basic macro-programmes. It is interactive, and the user can adjust all input data. The RPS Tool graphically shows the time-related implementation programmes for the selected interventions, the effects of water conservation and demand management in reducing demands and the increases in system yield provided by water schemes. The required study start dates to ensure a continuous system water balance, for the various interventions of a selected suite that comprise a scenario, is shown.

A basic multi criteria decision-making function has been included to assist the user in the selection process. This enables the user to alter the weightings of the criteria and to alter the criteria themselves. A set of filters has been included for all the criteria so that interventions can be analysed in various ways.

Output from the RPS Tool graphically shows when decisions to study selected interventions need to be taken to achieve a water balance, in order to either implement demand reduction measures, or to make the yield from a new source available, by a certain date (year). The RPS Tool also displays financial parameters, such as operating costs, capital costs and the unit cost of water per intervention selected. It calculates the net present

value and expected cash flow for a selected suite of interventions. It can illustrate the effect that a selected suite of selected interventions for reconciliation would have on the water tariff of a water utility.

6.2 BENEFITS OF THE RPS TOOL

- It assists managers to deal with a very diverse and complex range of factors that influences the water balance, in a **well-structured** and **transparent** process.
- It is **rigorous** as it has been proven in many applications.
- It provides a **graphical interface** in an **interactive environment** with water managers, key stakeholders or policy makers, which greatly assists to **get the message across effectively**.
- Provides **quick answers** to what-if questions**.**
- The tool **can be customised** as needed.
- **Flexibility**: Because the number of potential projects can vary with time, the tool is designed to be flexible, in terms of evaluation period, number of projects, detailed project information and project programmes. A facility has been provided to allow for overlapping project phases; for example a water allocation licensing process and an environmental approval process can be concurrent, and therefore only the longer of the two periods is taken into account.
- **Scalability**: The tool can be used for very large, complex systems and for small towns.
- **Output data** is in an **easily usable format** for reporting purposes.
- It is **interactive**, and the **user can adjust all input data**.

7 APPLICATION OF THE RPS TOOL: THE SCENARIO PLANNING PROCESS

The objective of the Scenario Planning Process is to identify, evaluate and assess alternative groupings and phasing of interventions to determine the most appropriate combination of interventions that should be implemented to reconcile water supply and demand in the WCWSS. A specific combination of interventions selected to meet the demand over time, is termed a water balance scenario. The scenario planning process considers a range of possible scenarios to reconcile water supply and demand. The objective is not to select one 'favourable scenario' but rather to identify which interventions should be studied to allow consideration of a range of possible scenarios. This will allow the DWA and the CCT as the water managers, and other stakeholders, the maximum amount of flexibility in making informed decisions on which interventions to implement.

A total of 56 interventions were analysed in the Scenario Planning Process, and 11 scenarios were considered (Killick and Anderson, 2007), to *inter alia* assess the following:

a) The benefits of implementing WC/WDM;
b) The reconciliation and water supply implications of implementing environmental flows for existing water resources;
c) The reconciliation and water supply implications arising from climate change.

Scenarios were mainly evaluated against the High Water Demand curve (which assumes a high population growth and a high economic growth) without any WC/WDM measures. This provides the most conservative approach.

Figure 5 contains a graphic illustration of the water balance sheet output, one of a range of output sheets. This is fairly typical of water balance planning in a developing county, where significant investments are still being made to develop surface and groundwater schemes, as shown by the colourful bands increasing the system yield.

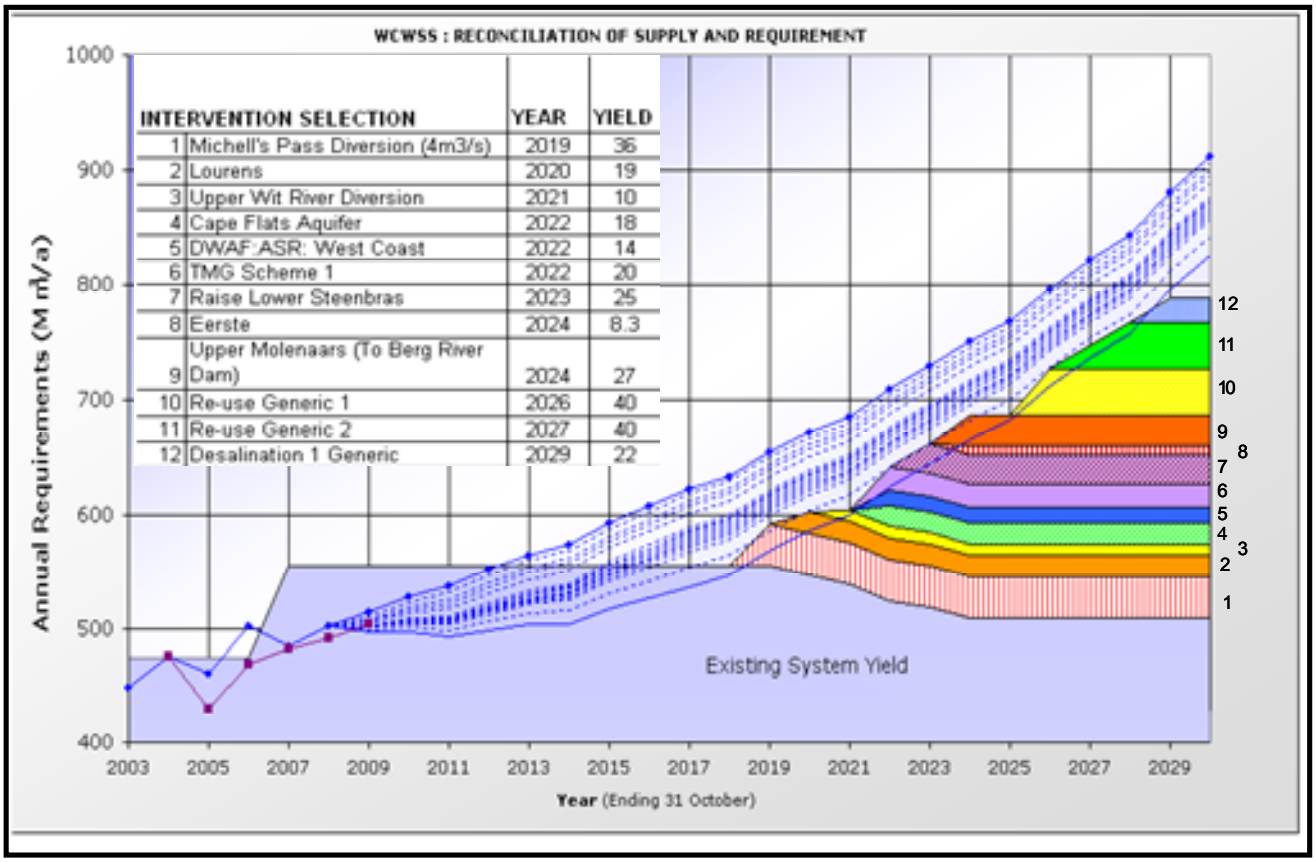


Figure 5: Typical water balance from the Tool for a developing country

8 CONCLUSIONS

The major findings of the strategy were (Van der Berg et al., 2007b and the Western Cape Reconciliation Strategy Newsletter 7):

a) Climate change could have serious implications, the impact of which needs to be properly co-ordinated and monitored:
   i. Climate change projections for the Western Cape indicate a potential drying trend from west to east; a weakening summer rainfall – with possible increased summer rainfall (mainly in the east); a shift to more irregular rainfall of possibly greater intensity; and rising summer temperatures across the region.
   ii. A task team has been established by the SSC to determine the resilience of the WCWSS against scenarios such as "Can we cope with longer or more severe droughts?"; "What will the effect of more bush fires, less cold units, more intense rainfall be"; and "What effect will seasonal change or variability have on water use?".

b) The importance of CCT's Water Conservation and Demand Management Plan, as well as the importance of implementing additional water conservation and demand management initiatives in the longer-term:
   i. The CCT is targeting to reduce the 'unaccounted for' water loss to 20% in the 2010/11 financial year – and eventually to 15% by the year 2015/16. Almost two-thirds of the present 'unaccounted for' water is attributed to water that is used but not metered (mainly standpipes) whilst the remainder is water that is actually lost to the system because of technical problems (burst mains and meter leaks).

c) Many proposed groundwater interventions form an integral part to the strategy. These interventions need to be thoroughly investigated:
   i. The Table Mountain Group (fractured rock) Aquifer has been identified as a potentially significant groundwater resource. The CCT started an exploratory drilling programme in 2008 and the geological and hydrogeological information from the core drilling during this phase is being analysed at present.

d) Re-use of effluent is a very important future source:
   i. CCT is seriously looking into the potential of re-using water that is at present discharged to the rivers or oceans. The planned indirect method (treating water from wastewater treatment works to a suitable

standard and then discharging it into a water body where it mixes with the natural inflow, where after this 'raw water' is treated in the normal way to potable standards) would most probably be more pursued. A service provider to investigate the various options will be appointed during the course of 2010. This option is regarded as significantly cheaper than desalination.

e) Desalination, although still regarded as expensive, would need to be implemented in the future. It was therefore deemed necessary to start with investigations immediately:
   i. CCT's intends to commission a feasibility study for the large scale abstraction of seawater and the implementation of a pilot desalination plant by end 2010, subject to the Mayoral Committee's approval.

f) The implementation of environmental flows for existing dams could have significant socio-economic implications, and has to be properly planned, co-ordinated and monitored.

g) Establishment of a Strategy Steering Committee.
   i. The Strategy Steering Committee was established in 2007 and is responsible for ensuring the implementation of the Reconciliation Strategy and to make strategic recommendations on interventions required. It consists of representatives of all government departments whose planning depends on the availability of water, as well as all municipalities who receive their water from the WCWSS, as well as organised agriculture. It is administered by the national Department of Water Affairs, supported by the Western Cape regional office.

ACKNOWLEDGEMENTS

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