7 Sedgefield water augmentation case study

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INTRODUCTION AND BACKGROUND

Since the winter of 2008, and through the following year, the southern Cape has experienced one of the worst drought periods in history. Sedgefield, a seaside town on the Garden Route in the southern Cape, situated within the Knysna local municipal area, effectively ran dry in January 2009 when the Karatara River stopped flowing. This made news headlines as shown in Figure 1 below. Later in the same year, critically low flows were also recorded in the rivers supplying the town of Knysna (the Knysna River and its tributary, the Gouna River), as well as in the Homtini River near Rheenendal.

Figure 1: Local newspapers headlining the Sedgefield Water Crisis

In January 2009, when the Karatara River stopped flowing, potable water was transported by road to Sedgefield. This required the use of water tankers that were sent from disaster management services, provincial authorities, and the military, and hired from private contractors. Running around the clock, this fleet of tankers carted water to Sedgefield from George Municipality's water treatment works at Wilderness. The cost of this exercise was not sustainable for an extended period of time, and, in any case, George Municipality was soon facing its own water supply crisis. And so, to limit the ongoing costs and the logistical difficulties of the tanker operation, the Knysna Municipality had to come up with another plan.

EXISTING WATER SUPPLY

Historically, Sedgefield has always relied on the in-stream flow of the Karatara River, as there are no dams or impoundments to provide water in the event that the river stops flowing. The existing river abstraction system and water treatment works (WTW) may have been able to meet the town's peak demand of nearly 3Ml/day when the river was flowing, but the system failed in severe drought conditions, with the resulting water shortages having the potential to cause major health problems and have a devastating effect on all aspects of the local economy.

THE ORIGINAL 2003 PLAN

By 2003, the Knysna Municipality had already developed a long term plan to meet a predicted average demand of 4.5Ml/day for Sedgefield up to the year 2030 (Ninham Shand 2003). The plan consisted of abstracting water from the Hoogekraal River, storing it in an off-channel dam, down-grading the present Ruigtevlei WTW on the Karatara River to a pumping facility, and constructing a new WTW on the Cloud Nine Hill above Sedgefield town. The plan would be implemented in phases represented by the steps in the system yield line in the typical yield and demand illustration in Figure 2 below.

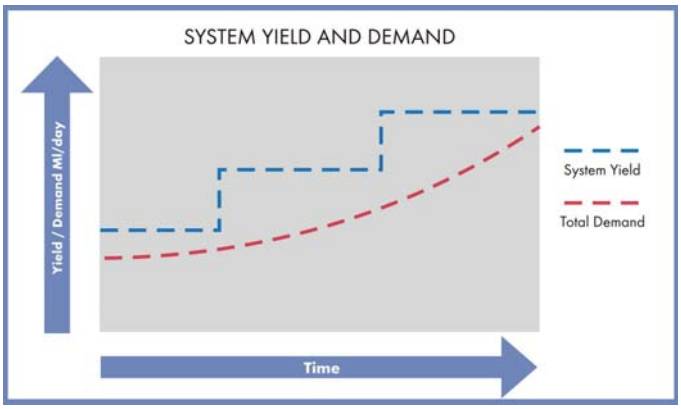

Figure 2: Typical system yield increasing in steps to meet demand over time

However, the plan was not implemented due to a lack of funds, although some funding (R14.2-million) was obtained from National Treasury following the August 2006 floods for relocating the flood-prone WTW. By 2009, the estimated total budget for the scheme was R110-million and, with the river running dry, even the WTW relocation was no longer the priority.

SEDGEFIELD WASTE WATER TREATMENT WORKS

Another scheme waiting for authorization and funding was the upgrading of the existing Waste Water Treatment Works (WWTW), and it will become apparent later how this forms part of the water augmentation plan. The existing WWTW is located on a small site with restricted boundaries, between the dunes and existing residential developments on the eastern side of Sedgefield. It is possible that a portion of the effluent discharged from this facility flows subterraneously into the Groenvlei, which is an environmentally sensitive body of water (Roets et al.2008). This, and the fact that the effluent infiltrates the sandy subsoils at the discharge point near the plant, has resulted in strict plant performance criteria being set by DWA.

Figure 3: Sedgefield Waste Water Treatment Works

The existing Sequential Batch Reactor (SBR) units at the plant are rated to treat up to 750kl/day. In the current configuration, the effluent from the plant does not meet the Special Limit Values (SLVs) required by DWA.

The SLVs are not met due to high hydraulic loading in peak seasons and the higher than average sewage strength. The Municipality initiated a study in 2007, to investigate the upgrading options to meet the SLV standards for effluent discharge (SSI Engineers 2008). This will be discussed further under the long term water augmentation plan below.

SEDGEFIELD WATER AUGMENTATION PLAN 2009

Returning to the crisis conditions in January 2009, it must be noted that water demand management measures (in the form of water restrictions) were already in place over the peak season of 2008/2009. However, the hot and dry weather, and an increase in upstream abstraction from the Karatara River for agricultural use, resulted in an extremely rapid decrease in the flow in the river at the Ruigtevlei WTW. The agricultural sector was not initially targeted in the water demand management strategy.

In the emergency plan that was developed, it was proposed that certain interventions be implemented immediately to prevent interruptions to the town's water supply.

These items are described below, under the Accelerated Water Augmentation Plan, and were chosen as alternatives to the continued transfer of potable water from George by road tanker (an expensive but effective measure that provided initial relief). Short term options were also examined for implementation after the initial crisis measures, and these are also described below under the Accelerated Water Augmentation Plan.

In Figure 4 below, the solid blue line indicates a drop in the system yield due to the drought, and the augmentation measures provide "New water" to make up the initial shortfall in meeting the reduced demands as indicated. These measures will then become part of the town's overall system yield. The assured yield of certain measures like groundwater abstraction from boreholes, will be determined after ongoing monitoring and analysis.

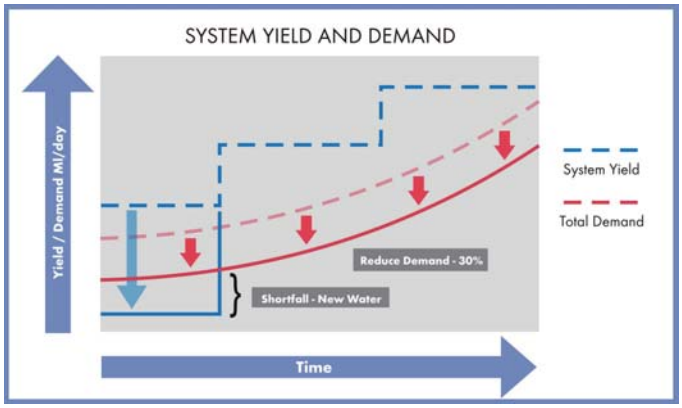

Figure 4: A decrease in system yield and a reduction in water demand illustrated graphically

After addressing the emergency measures, the investigation was expanded to examine the medium and longer term options, and to develop an integrated plan for the proposed water supply augmentation measures. This integrated plan mitigates the risk of overall supply failure, should one, or more, of the sources fail. The investigation also provided data for a cost-benefit analysis and for comparative unit reference values (URVs) of the plan and its components.

The immediate, short, medium and long term supply options proposed and described below, combine the conjunctive use of surface water, ground water, desalinated water and the re-use of final effluent from the waste water treatment works. These sources were ranked based on costs and risk of failure to provide for Sedgefield's long term water needs.

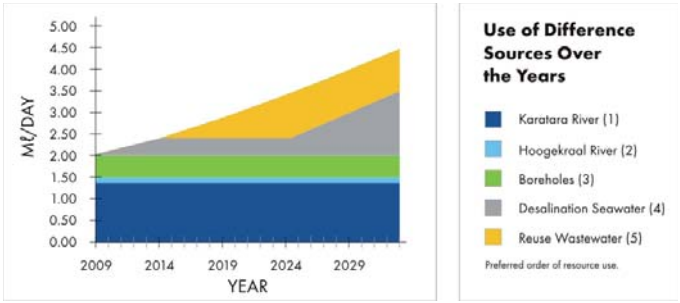

Figure 5: Use of Water Sources (average daily water production)

The proposed scheme is to be phased to provide water as the demands increase. In addition, an important aspect is the ability to provide "insurance" against peak season failure in the short to medium term. At present the peak season month demand is 30% higher than the average monthly demand. A further, and important, aspect of adopting this plan is that the rapidly implemented measures can defer the implementation of costly infrastructure to the medium or long term, as illustrated in Figure 6 below.

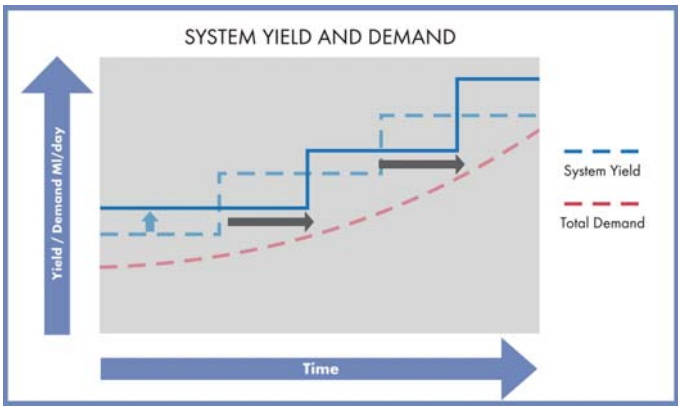

Figure 6: Augmentation measures can defer implementation of new schemes

The water supply augmentation plan that was developed is outlined in the document, Integrated Provision of Water and Sanitation for the Greater Knysna Area, Annexure A: Sedgefield Water Augmentation Business Plan (Knysna Municipality 2009b). This paper draws extensively on the document and certain sections are included as they appear in the Business Plan. The Business Plan was used as part of the documentation submitted to secure funding and technical approval for the projects described below.

ACCELERATED WATER AUGMENTATION PLAN 2009

Hoogekraal River Transfer - Rapid (Complete)

The Hoogekraal River continued to flow throughout the months of December 2008 and January 2009, and the catchment area is steep and responds well to precipitation. The level of the Hoogekraal River upstream of the weir is noticeably higher than the level in the Swartvlei and seawater contamination from Swartvlei is highly unlikely.

As a rapid intervention, a portable pump station and 110mm diameter pipe was installed to pump water from the Hoogekraal River to the

Ruigtevlei WTW on the Karatara River. The pipeline was laid above ground as an interim measure and was then buried to make it a permanent installation. The pipeline is 3600 meters in length and can deliver approximately 1Ml per day to the Ruigtevlei WTW. The cost to implement the permanent scheme, excluding the proposed future Hoogekraal pump station, is R1.3million (Excl VAT).

Well Points – Rapid (Complete)

The use of existing privately-owned well points at Lake Pleasant and Windemere was investigated and two well points were installed. These can be brought into production rapidly if required. The yield of the well points is approximately 0.290Ml/day, and the cost of the equipment and of transferring the water into the supply system is R0.4million (Excl VAT).

Hoogekraal River Transfer - Short Term (Complete)

The Hoogekraal transfer scheme must still be made permanent by burying the 110mm diameter HDPE pipe, and providing a permanent position and electrical power for the pumps. The estimated cost is R0.5million (Excl VAT).

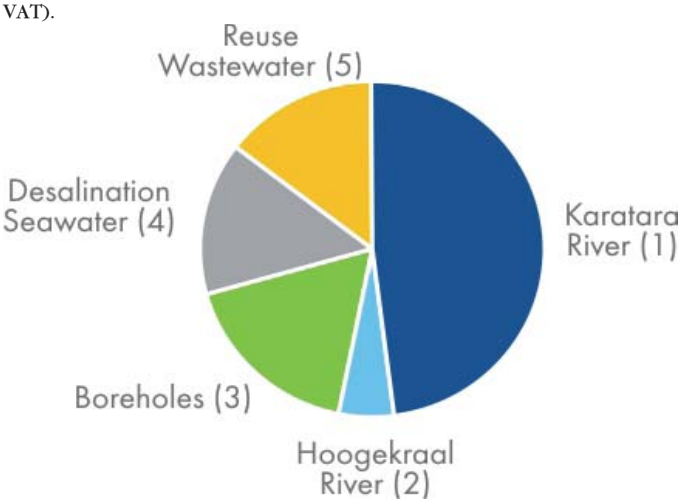

Figure 7: Water produced from Sources

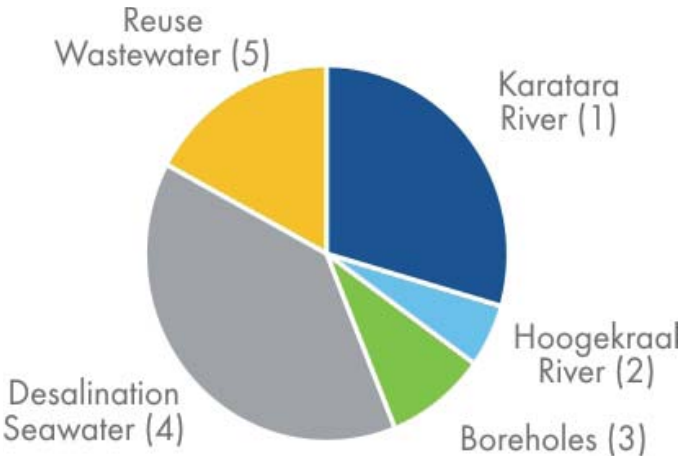

Figure 8: Cost of Water from Sources

Emergency Borehole Drilling Programme - Short Term (Complete)

A number of shallow boreholes were drilled and preliminary tests indicate a borehole yield of up to 1.5Ml/day. The aquifer's sustainable yield has not been accurately determined and for planning purposes, only 0.5Ml/day is included in the scheme. The cost of this borehole field is R3.0million (Excl.VAT).

Karatara River Weir – Short Term (Initiated)

To prevent further seawater contamination from the Swartvlei into the Karatara River at the Ruigtevlei WTW, temporary weir plates have been placed at the culvert openings.

A permanent installation is however required to prevent further contamination. The estimated cost for this work is R2.5million (Excl VAT).

Figure 9: Sedgefield Water Augmentation Plan – Layout

MEDIUM TERM WATER AUGMENTATION PLAN

In the short to medium term the following options were examined for implementation as the water demand grows.

Desalination (Complete)

To meet the projected medium term demand, approximately 3.5Ml/day assured supply is required. The surface water supply from the Karatara and Hoogekraal rivers should be curtailed at 1.5Ml/day and the supply from boreholes at 0.5Ml/day. The difference of 1.5Ml/day will be made up from desalination of seawater.

The Sedgefield desalination plant is a single-pass, reverse osmosis (RO) system that can produce 1. 5Ml/day of potable water. The plant consists of two 0.75Ml/day modules in two separate 12m steel shipping containers. Extracting seawater and disposing of the concentrate (brine) is achieved by using beach wells. More than twice the amount of seawater is required to produce 1.5Ml/day of potable water - with 45% being harvested as product and 55% returned to the sea as concentrate (brine). Initially the plant will be operated by the supplier for one year. This will probably be extended to three or five years.

The team is justifiably proud to have commissioned the plant within three months: the contract award was signed on 1 October 2009 and the plant was functional on 18 December 2009, in time for the anticipated holiday peak in December 2009.

A number of potential locations were investigated with extraction of the feed water from the Swartvlei and directly from the sea. Due to time constraints and the need to have the plant ready for the December holiday period, the Environmental Processes were conducted in parallel to the procurement of the plant. It was decided to procure a containerized (mobile) plant that could be moved should the environmental process show negative impact to the surrounds. The cost reflected in the business plan is based on the option of placing a plant near to the sea at Myoli Beach's parking area and pumping the desalination product water to the Blombosnek reservoirs to blend in with the water from other sources.

The cost of the plant includes for beach well abstraction points and

beach well brine discharge points. The cost of running the plant will be closely monitored and reported. The estimated operating and maintenance costs are as follows:

Table 1: Estimated Operating and Maintenance Costs

Description	Cost* (R/m³)
Power Costs (based on R0.50 per kWh**)	1.90
Consumables (chemicals, filter cartridges)	0.70
Maintenance/Replacement Costs	0.40
Operator Costs	0.40
Total Estimated O&M Cost	3.40

Notes:

* *Based on the plant running 24h/day, producing 1.5Mℓ/day, i.e. lowest unit cost*

** *R0.50 per kWh assumed due to Eskom tariff increases (2009 power costs were initially R0.30 per kWh)*

There are a number of scenarios for the operation of the plant - from running it as much as possible (resulting in the lowest unit cost for the desalinated water), to running as little as possible (resulting in a relatively high unit cost).
The cost of the desalination plant and feed water pumping scheme is R16.0million (Excl. VAT).

Re-commission Ruigetvlei WTW

The Ruigtevlei WTW cannot meet acceptable standards at a supply of 2.2Ml/day. Therefore, it is proposed that the surface water supply be limited to 1.5Ml/day. To meet an acceptable supply standard at 1.5Ml/day and to minimize downtime after flooding of the Karatara River, the works requires refurbishment of the sedimentation and filter units, among other items. The plant will then be able to supply 2.0Ml/day for short periods when necessary.
The costs to refurbish the works to 1.5Ml/day is R4.0million (Excl VAT).

LONG TERM WATER AUGMENTATION PLAN

In the long term, the option of wastewater re-use is proposed as follows:

Waste Water Treatment Works Upgrade

The capacity of the Waste Water Treatment Works (WWTW) must be upgraded from 750kl/day to 2Ml/day. To achieve an effluent quality to meet the required Special Limit Values (SLV), it was recommended (SSI Engineers 2008) that the works be upgraded to a membrane bio-reactor (MBR) plant.
The MBR process, which has an economical footprint, will also provide good quality effluent, which will be the building block to wastewater re-use. The cost for upgrading the works to 2Ml/day is estimated at R15.0million (Excl VAT)

RO for Wastewater Re-use

To provide the ultimate potable water supply of 4.5Ml/day an additional 1Ml/day will be provided from the WWTW through direct reverse osmosis (RO). The cost for this process and the final polishing of treated effluent for use as potable water is estimated at R7.5million (Excl VAT)

Additional Storage

To provide adequate reservoir storage capacity, it is proposed to provide a 4Ml additional storage capacity (or aquifer recharge capacity, depending on the final solution).
The cost to provide additional storage is estimated at R8.0million (Excl VAT).

Cost Benefit Analysis

The proposals were subjected to a cost benefit analysis which was also used to determine the Unit Reference Value (URV) of the proposed plan, as well as that of the individual components of the plan. The URV values and utilization rates for the different sources of supply are shown in Figure 10 below.

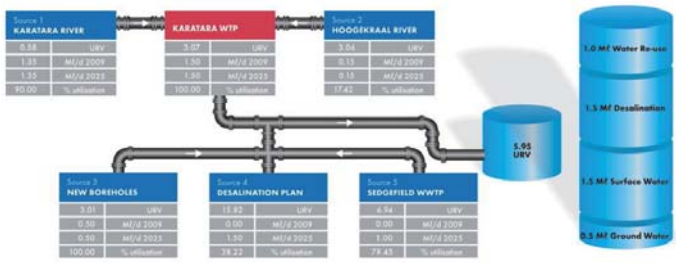

Figure 10: URV values and utilisation of the available water sources

The cost benefit analysis indicates an average positive value of R2.05 per kl of water produced. Further work is planned to develop a cost model to inform the process of optimising the water tariffs for Knysna.
The URV for the overall scheme is calculated to be R5.95 per kl of water produced. It should be noted that this includes for having additional capacity ("insurance") to meet peak season demands.

FUNDING

The funding of the project was achieved with a combination of Disaster Management (CoGTA), MIG, Eden DM, and Knysna LM Funds.

Table 2: Project budget & programme

Scheme	Feb 09	Mar 09	Apr 09	May 09	June 09	Dec 10	Dec 11	Scheme Cost
Rapid Implementation								
Hoogekraal Transfer								1 300 000
Private Well Points								400 000
Short Term								
Hoogekraal perm								500 000
Emergency Drilling								3 000 000
Karatara Weir								2 500 000
Medium Term								
Desalination (RO)								16 000 000
Recommission WTW - 1.5								400 000
Long Term								
Water Reuse - WWTW								15 000 000
Additional Storage								8 000 000
RO on Reuse - 1.0 Meg								7 500 000
Cumulative Yield - Ml/day	1.24	2.0	2.0	2.0	3.5	3.5	4.5	
Cumulative Cost - Million	1.70	5.2	11.4	17.6	23.7	42.7	58.2	58 200 000

Notes:

1 Estimates are based on preliminary costing

2 Estimated costs reflect present value and exclude escalation.

3 The escalation can be covered by Knysna Municipality's contribution

4 Professional fees, site monitoring, investigations and disbursement costs are included
5 The Environmental and Water Licensing authorizations are to be obtained

CONCLUSION

The Sedgefield water crisis prompted the Knysna Municipality to take drastic action, and this resulted in an innovative, demand-based approach being developed to address the situation. This approach was adopted and proved to be cost effective and achievable within the tight time constraints. The Sedgefield Water Augmentation project is the forerunner in conjunctive water use in the southern Cape and paved the way for Mossel Bay, George, Knynsa and Plettenberg Bay to re-assess their available water sources. "New Water" is now mandatory in the water portfolios of the municipalities to limit the risk of complete water supply failure should our rivers run dry.

The approach was based on making better use of the available water resources and supplementing the traditional surface water resources with a combination of ground water, desalinated water and the re-use of final effluent. The conjunctive supply approach limits the risk of supply failure from a single source, and ensures sustainable potable water security for Sedgefield into the future.

There is indeed "Life beyond our rivers" in the Garden Route.

ACKNOWLEDGEMENTS

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