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Planning for groundwater in South Africa

A MAHERRY
CSIR Natural Resources and the Environment, PO Box 395, Pretoria, 0001, South Africa
Email: amaherry@csir.co.za – www.csir.co.za

INTRODUCTION

Ecosystems that rely on groundwater as a water source have a natural and inherent resilience to climate change. Under natural conditions aquifers are stable water sources – in fact, ecosystems reliant on groundwater are literally the refuge vegetation from previous climate changes. However, this time round, groundwater dependent ecosystems are more vulnerable to climate change as groundwater is no longer a stable water resource as a result of anthropogenic impacts.

As groundwater is a hidden resource, the impact of pollution is only noticed when it discharges above surface. For these reasons groundwater is essential but difficult to plan for. Traditionally, groundwater has not been incorporated into conservation planning because of the complex nature and lack of integration.

PLANNING FOR GROUNDWATER

Groundwater and surface water interaction zones

Groundwater surface water interaction zones have been mapped on a regional level based on a variety of input data (**Table 1**),with a groundwater surface water interaction map for the Klein Karoo in **Figure 1**. This map was generated using various spatial geographic information systems (GIS) layers and combining these layers in order to obtain a raster output for a spatial representation of the probability of groundwater and surface water interaction.

Table 1: GIS data layers used to map the probability of groundwater-surface water interaction for the Klein Karoo (Smith-Adao *et al.* 2010).

Layer	Description	Source	Weighting
Hydroterrains	Hydroterrains based on aquifer type and characteristics	Reclassified 1:1 Million Geology, CGS	2
Table Mountain Group Buffer	A 300m buffer zone to incorporate contact zones	1:1 Million Geology, CGS	2
Mega-faults	A 300m buffer was applied to lineaments	1:1 Million Geology, CGS	2
Baseflow	K. Sami Baseflow estimates	DWAF, 2005	2
Springs	A 300m buffer was applied to the 1:50 000 springs	Surveys and mapping	2
Groundwater Levels	Poor resolution groundwater levels were classified	GRAII (DWAF, 2005)	1
National Land Cover 2000	NLC was reclassified according to groundwater/surface water interaction probability	ARC and CSIR (Van den Berg *et al.* 2008)	1
Jan Vlok Vegetation Map	Vegetation reclassified according to groundwater/surface water interaction probability	SKEP	1
National Wetland Map	Beta version	SANBI	1
NBI GDE Probability	Based on high, medium and low.		2

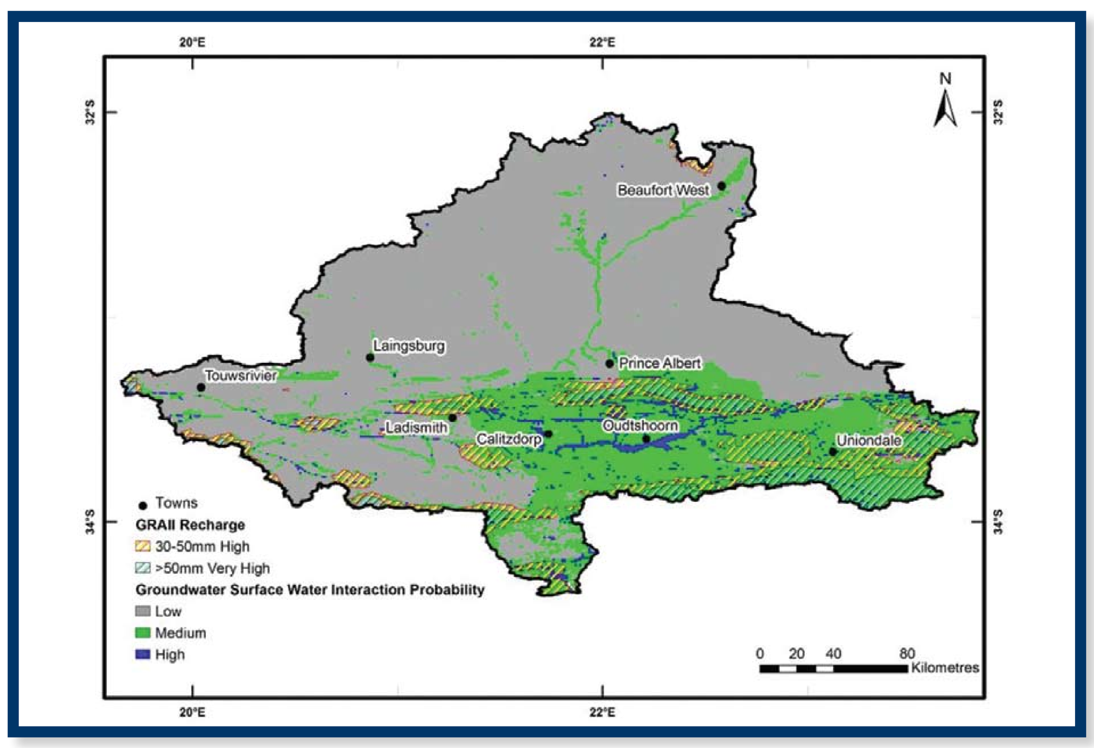

Figure 1: Probability of groundwater and surface water interaction for the Klein Karoo (From Smith-Adao *et al.*, 2010)

It is important to note that GDEs are only the end point of the process. Therefore, in order to conserve it, the entire process needs to be planned for. This can be achieved by:

- Planning for recharge
- Planning for areas of groundwater surface water interaction
- Planning for groundwater dependent ecosystems
- Planning for corridors along groundwater surface water interaction features for climate change adaptation.

CASE STUDIES

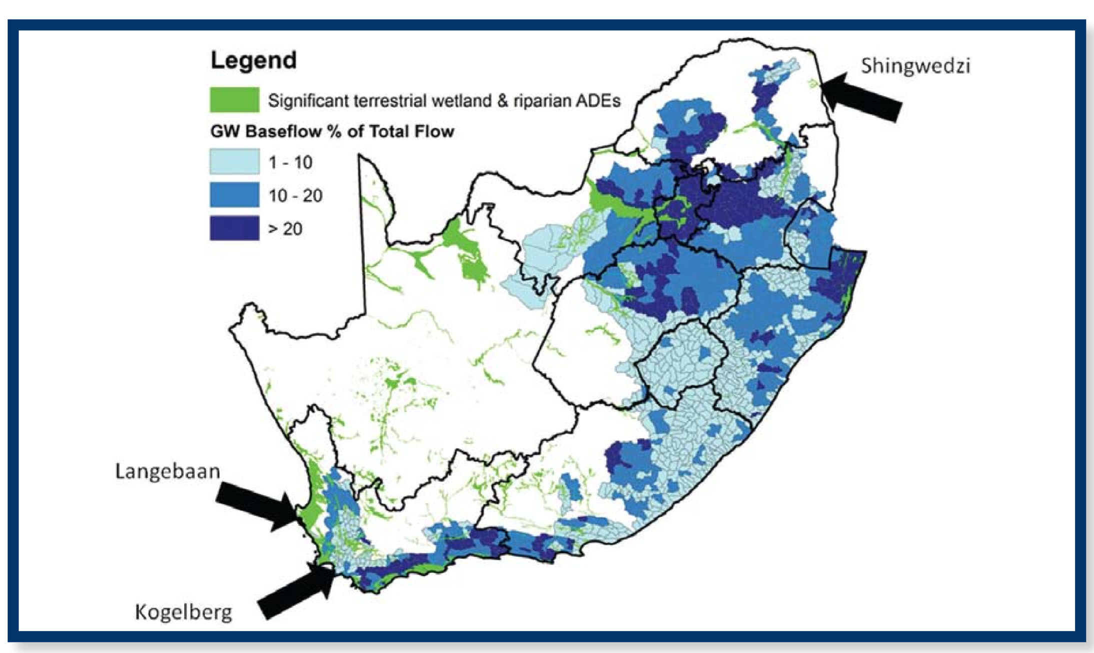

Figure 2: Case study locations on a national scale are indications of terrestrial ADEs (based on NBI vegetation classes) and aquatic ADEs (based on GRAII calculated groundwater-fed baseflow as a percentage of total flows in quaternary catchments in South Africa (from Colvin *et al.*, 2007)

Langebaan

Langebaan Lagoon is unique in that it is the only purely groundwater-fed estuary in South Africa. Groundwater discharges into Langebaan Lagoon near Geelbek, with phragmites reeds (common reed), typically associated with freshwater, occurring in a marine lagoon without a river flowing into it. Langebaan is a wetland of international importance under the Ramsar Convention and a very important bird migration site. The phragmites reeds are a breeding ground for the Black Harrier (classified as vulnerable according to the International Union for the Conservation of Nature), with less than an estimated 1,000 birds remaining.

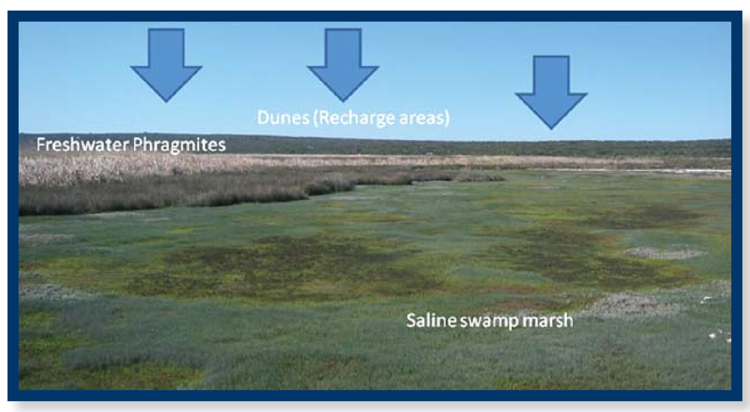

Figure 3: Photo from the Bird Hut at Geelbek, showing the saline swamp marsh in the foreground and the freshwater phragmites (nesting ground for Black Harrier) behind it, with the vegetated dunes in the background

The phragmites represent the groundwater dependent ecosystem, but the recharge and groundwater flow take place kilometres away, and only some of it occurs in the West Coast National Park.

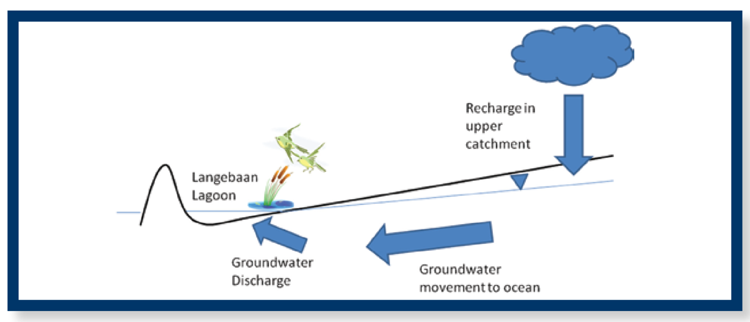

Figure 4: Conceptual diagram for Langebaan Lagoon showing recharge taking place in the upper catchment and discharge occurring in the lagoon

In order to properly plan for groundwater in this type of setting (see **Figure 4**), the following needs to be taken into consideration:

(1) Securing and monitoring the recharge area both inside and outside the park, paying attention to land use, abstraction and pollution
(2) Close monitoring of the freshwater-saline interface as any shift in the groundwater surface water interface could impact on the Black Harrier
(3) Further research to understand the groundwater dependent ecosystem as the phragmites reeds only form part of the ecology
(4) Identification of new climate change adaption methods, such as a corridor. Freshwater vegetation is the most vulnerable as there are no options left to retreat – therefore efforts should focus on securing the groundwater resource and ensuring that fresh groundwater continues to flow into the lagoon.

Kogelberg

The Kogelberg Biosphere Reserve (KBR) is a UNESCO site and boasts over 1,800 different plant species of which 77 occur only within the KBR. Fynbos flora rely on complex groundwater and surface water interaction with the Table Mountain Group sandstone and geological features like faults, fractures, joints and contact zones.

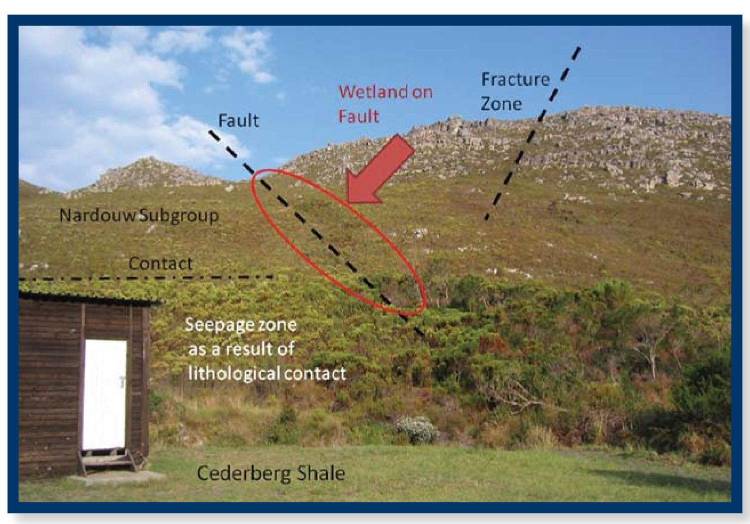

Figure 5: Photo shows fynbos associated with faults and fracture zone, and the dense vegetation associated with the Cederberg Shale

The Cederberg Shale forms an aquitard, separating the older Peninsula Formation and the younger Nardouw Subgroup.

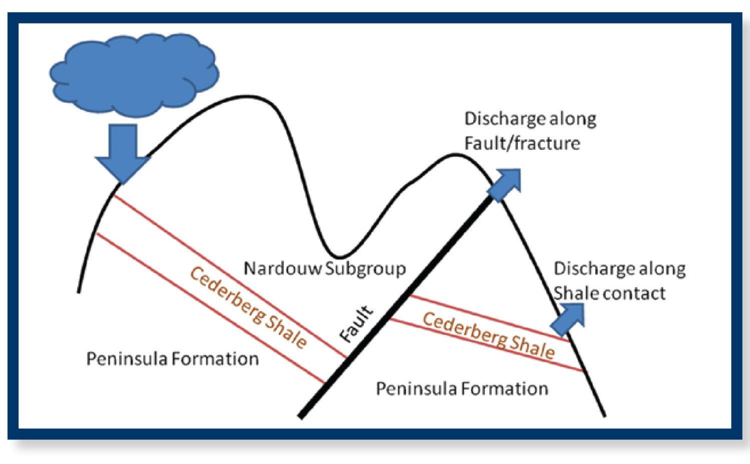

Figure 6: Diagram showing a simplified conceptual model of the recharge and discharge mechanisms at Kogelberg

In order to conserve the fynbos dependent on groundwater in the KBR, the following would need to be planned for:

(1) Recharge areas – typically the mountains with higher rainfall and more vertical bedding planes
(2) Groundwater surface water interaction zones associated with the faults (both small faults and mega faults), fractures associated with folding and faulting, contact zones of the Cederberg Formation with the Nardouw Subgroup and Peninsula Formation
(3) The isolated fynbos associated with springs and seeps
(4) Migration corridors along faults, fractures and lithological contacts. It is important to note that a migration corridor for climate change to a south-facing slope (with a predicted cooler climate) would fail in this type setting as the groundwater and aquifer dependent ecosystems would only be able to migrate along geological features like faults, fractures and contact zones.

SHINGWEDZI

Shingwedzi is a camp located next to the Shingwedzi River in the Kruger National Park. The riparian zone along the Shingwedzi River is characterised by green vegetation and huge trees, in contrast to the adjacent smaller and seasonal mopaniveld.

South Africa's groundwater resources should be protected and maintained through an integrated planning process, otherwise this important source of water will not withstand the impact of climate change.

Figure 7: CSIR researchers taking a water sample from the Shingwedzi River, showing the typical braided streams, the alluvium river bed and the thick, dense, tall riparian vegetation

During the summer rainfall periods when the river is at its fullest, the alluvial aquifer is recharged by the river and water is stored in the banks. The riparian vegetation uses stored groundwater in the dryer months, providing food for the elephants and game.

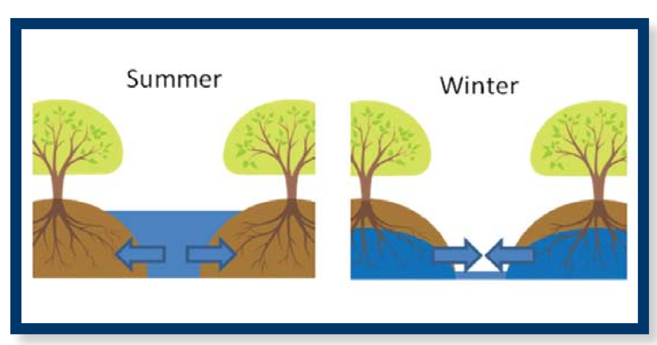

Figure 8: Graphic showing recharge into the alluvium banks during summer rainfall and high river flow, and the winter graphic showing the riparian vegetation having access to water in the dryer months as the groundwater discharges back into the river

In order to conserve the vegetation in this type setting the following needs to be planned for:

(1) The seasonal flow of the river serves as recharge during flooding and heavy rain, with recharge occurring laterally into the banks and vertically into the river bed;
(2) The water table in the alluvium in the riparian zone which the trees on the surface are utilising in the drier periods;
(3) The riparian vegetation may be dependent on groundwater all year round or just during the dryer months; and
(4) Migration corridors can only exist along the riparian zones where the alluvium exists, thus geology is a key factor in determining migration corridors. A climate change adaption technique for this type setting would be to remove all alien vegetation and to prevent any abstraction of groundwater from the riparian zone. This technique will be particularly useful outside the park.

REFERENCES

1. Colvin, C., Le Maitre, D., Saayman, I. and Hughes, S. 2007 An introduction to Aquifer Dependent Ecosystems in South Africa. WRC TT 301/07. ISBN 978-1-77005-531-5.
2. Smith-Adao, L.B., Nel, J.L., Le Maitre, D., Maherry, A.C. and Swartz, E.R. 2010. A spatial assessment of riverine ecosystems and water supply in a semi-arid environment (p n/a). *River Research and Applications*. Published Online: Jun 28 2010 2:20AM.

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