

T-03

## **The Effect of Vegetation (Prosopis Sp.) on Groundwater levels in Rugseer River, Kenhardt, South Africa**

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### **ABSTRACT**

The objective of the study was to qualify if invading Prosopis Sp. is utilizing groundwater and if, to quantify the volume utilized. To reach this objective the Rugseer River, Kenhardt, South Africa was identified and the groundwater levels, rainfall and groundwater quality were monitored to investigate the effect of clearing of the Prosopis Sp. on the groundwater levels and to quantify the volume.

Water levels declined during summer (October to March) because of evapotranspiration. Declines of between 0.97m and 1.57m were measured. Water levels rises immediate after surface runoff and quickly after non-surface runoff rainfall events. There are 4 superimposed water level trend cycles.

50% of the study area was cleared and the effect was measured. The water levels followed the declining trend in the summer months but decline on average 45% less.

**Keywords:** groundwater, water level, rainfall, Prosopis Sp., vegetation-groundwater interaction, recharge

### **INTRODUCTION**

Invading alien plants are one of the biggest threats to plant, animal biodiversity and to water resources in the world. In arid areas of the Northern Cape Province the invading alien plants are 'drinking' the scarce water resources dry. By monitoring the groundwater levels in area invaded by Prosopis Sp. trees a large number of question are clarified. A number of studies have been done to verify these effects and a lot of assumptions been made to try clarifying this effect. Different types of alien invading plants have been declared invaders nationally. South Africa also has identified the most invading plants per each region. Northern Cape was found to be more invaded by Prosopis Sp. The objective of the study are to qualify if invading Prosopis Sp. is utilizing groundwater (phase 1) and if the volume utilized can be quantified (phase 2).

### **STUDY AREA**

The principle objective of this project was to examine the effect of alien vegetation to groundwater resources, with special focus on water levels trends and water quality characteristics of the Kenhardt (Rugseer) area. Rugseer River situated in the D53B catchment that flows into the Hartbees River 3 kilometers southeast of Kenhardt town, South Africa.

This catchment is 1713.2km<sup>2</sup> and the study area is 98ha. A small relatively flat topographical farm owned by Kenhardt Municipality and used for stock farming.

**Geology**

Generally, the study area is covered by loose sandy soils. These soils extend to the entire surface of the catchment and to surrounding areas. The resistivity surveys were undertaken by Nonner (1979) to establish roughly the dimensions of the sandy deposits in the river valleys and weathered metamorphic rocks underneath. Sandy deposits of a maximum of 10m cover the weathered metamorphic rocks. Due to the nature of these soils, they have a significant role in the hydrological and geohydrological response of the catchment.

The geology from the drilled boreholes (geologic log) is summarized in figure 1 below.



Figure 1: Geology

**Land Use**

The study area covers an area of about 979 958 m<sup>2</sup> or 98 ha. The larger part of the study area can be considered open. 72% of the study area is not covered by tree canopy. 28 % tree canopy can be considered as scatter in other parts of the country, but in the Karringveld it is highly dens. The natural tree canopy in the Karringveld is 7 percent. With three measure types of trees is the area, which consists of Prosopis (*Chileansis*), Soetdoring (*Acacia Karroo*) and Tamarisk (*Abiqua Tree*), Prosopis Sp. constituted about 96 % and the trees that grow naturally in the area are only 4 %. Prosopis Sp. covers about 74 % of the areas canopy, while they represent about 96 % in quantity. This indicates that Prosopis Sp. does not have a large canopy cover. The reason for this is the large amount of relatively small trees present in the area. The large trees represent only 12 % of the Prosopis trees counted; the large trees represent 70 % of the total Prosopis canopy cover. In the north of the study area there are more large trees (>3m) than small trees (<1.5m) and the water table is between 6m-8m. In the south there are a lot of small trees and the water table is between 10-12m.

**INSTRUMENTATION (METHODOLOGY)**

**System Components**

It consists of 22 boreholes drilled in the study area, with 8 equipped with electronical data loggers (Orphimedes) with sensors for water levels, 10 are open boreholes and piezometers were installed in 5. See figure 2.

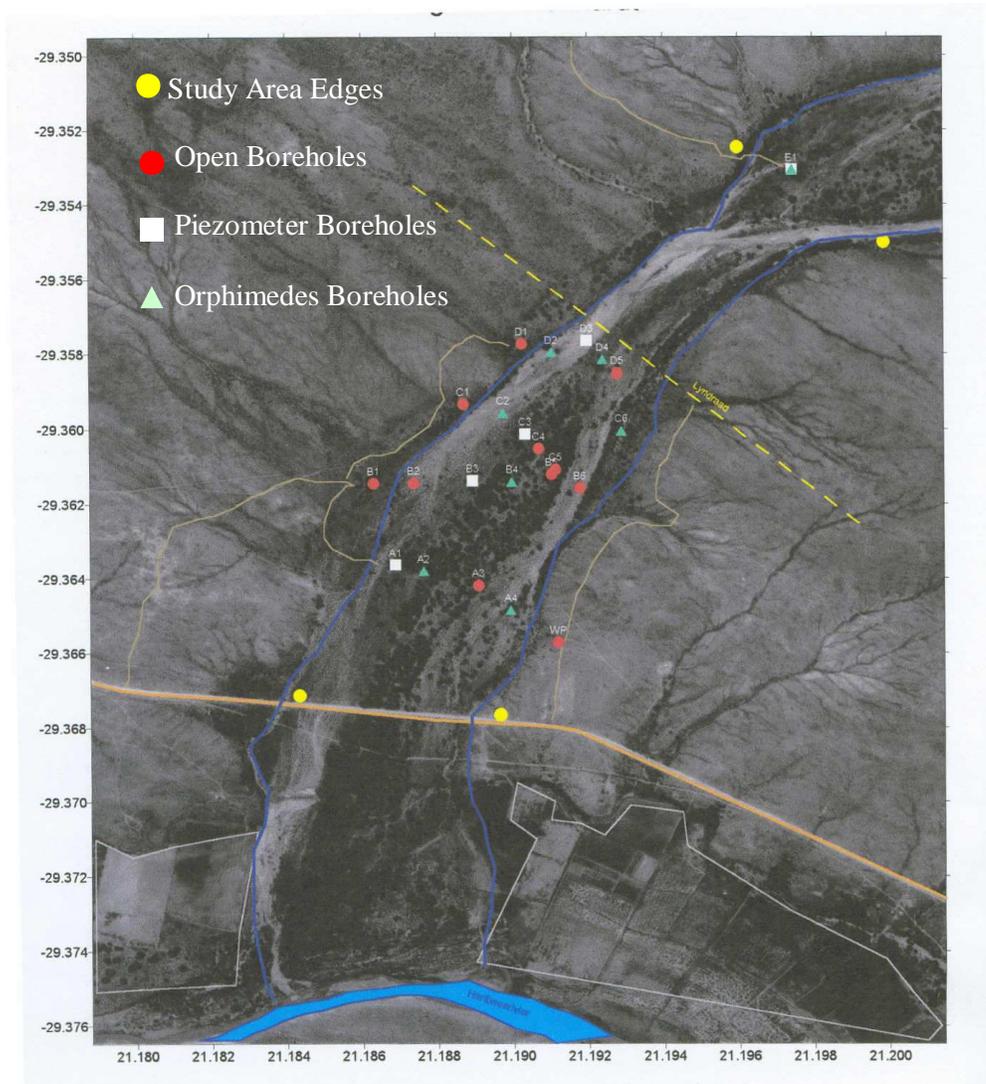


Figure 2 Boreholes drilled in the Study Area.

### Field measurements

The data loggers (Ott Orphimedes) were installed in 8 boreholes and programmed to record the water levels every 2 hours or 12 times a day. The water levels trends continuously measured by the data loggers, which were downloaded every three months. Physical water quality measurements were taken of the water quality (conductivity, pH and temperature). The data from the two rainfall stations were used for this study: Kenhardt Police station (South African Weather Services) in Kenhardt town that is 3km away from the study area, and Voordeelspan (Department of Agriculture), a farm  $\pm 30$ km upstream near the catchment boundary to the north of the study area.

### DISCUSSION OF RESULTS

- All 4 boreholes fluctuated correspondingly with only a difference in magnitude and the depth below ground level. The reason for the magnitude difference is explained by considering the physical topography and geology of the study area. There is a decrease in the river's width between line E and C. The sand dunes narrowed the river to such an extent that effects on the water level is amplified when the same volume of water flows through the narrower stream, resulting in a higher magnitude in D4 than E1 and C2. The water is almost

“squeezed through the gorge”. The flow obtain by Darcy’s Law is 107 m<sup>2</sup>/d stream down of line C.

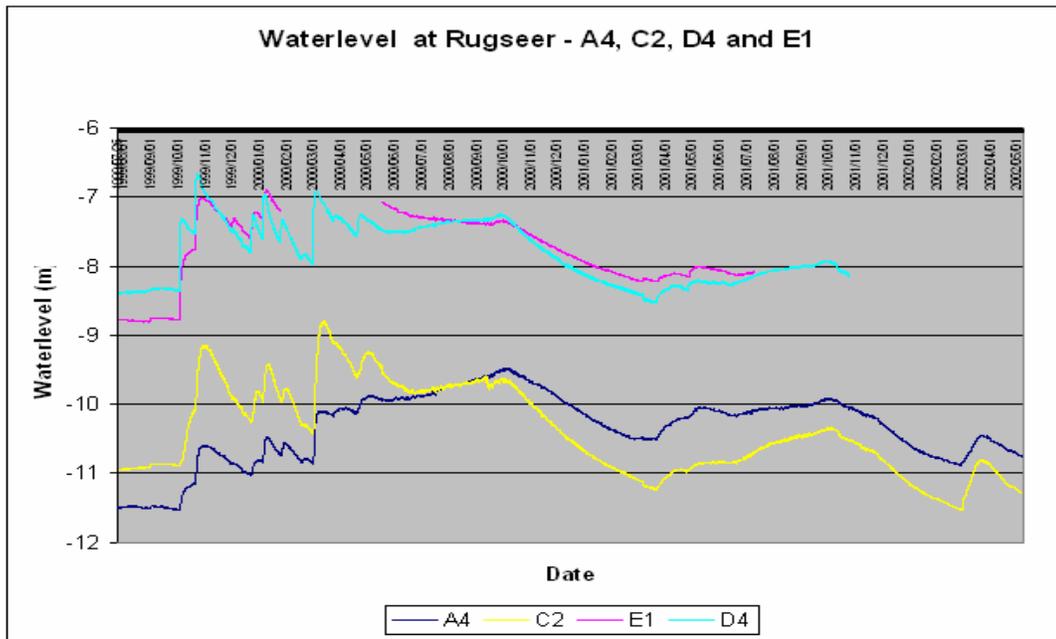


Figure 3: The water level fluctuations for boreholes G45745 (A4); G45731 (C2); G45737 (D4) and G45746 (E1) from Jul 1999 to May 2001.

- The groundwater level difference between lines E to D and C to A. The groundwater level difference of >2m may be attributed to the topographical fall. The difference is surface elevation is however less 1.5m. A contributing factor to this phenomenon is the amphibolite dyke sub-outcrop that is situated between lines D and C. Behind which, damming effect results. The amphibolite outcrop with large epidote crystals can be seen very clearly on the western side of the river.
- The fluctuations in the first year of monitoring are directly related to time of surface flow / runoff of the river. High rainfall days in the second part of 1999 and the first part of 2000 at Voordeelspan, a farm higher up in the catchment. The rainfall occurs usually as thunderstorms with simultaneous runoff. For most rainfall events there is a rise in water level. Water infiltrates directly from the surface to the aquifer/water level and rises in the water level occur very quickly. Rainfall thus plays a critical part in evaluating the groundwater levels.
- Sometimes no, or minor, rise in groundwater level occur with rainfall events, such as February 2001 and November 2001. The reason for this is that water is taken out of the system and the rainfall water is abstracted before it reach the water table and no, or very little, reach the water table because of evaporation and evapotranspiration.
- The decrease in groundwater level starts to occur at the end of September – beginning of October each year and the increase start to occur at the end of February each year. These dates indicate the growth period of the Prosopis Sp. There was no or very little rainfall during these periods that could account for rising water level. The effect could not been seen during the 1999/2000 summer because of the exceptional high rainfall and runoff. The effect of the abstraction of water can be seen in Figure 3, at C2 with a decrease in water level of 1.57m in 2000/2001 summer and 1.15m in 2001/2002 summer. At A4 the decrease was 0.97m for both summers. The reason for the more pronounced decrease of the water level at C2 than at A4 could be attributed to the predominance of large trees with deeper and more extensive root systems. At A4 small ‘pencil’ type trees with less developed root systems predominate. To quantify the volume of the water abstracted is very difficult because of numerous factors such as transitivity, porosity, area of flow through, etc. to be considered.

- The gradient of decrease in groundwater level is constant as seen in Figure 4 and 5 with the yellow and red gradient lines over the study period. The decrease in the time of a non cleared area is 0.2m per month. The decreased gradient groundwater levels changed to 0.1m per month after the area were cleared as can be seen with the red gradient lines in Figures 4 and 5.

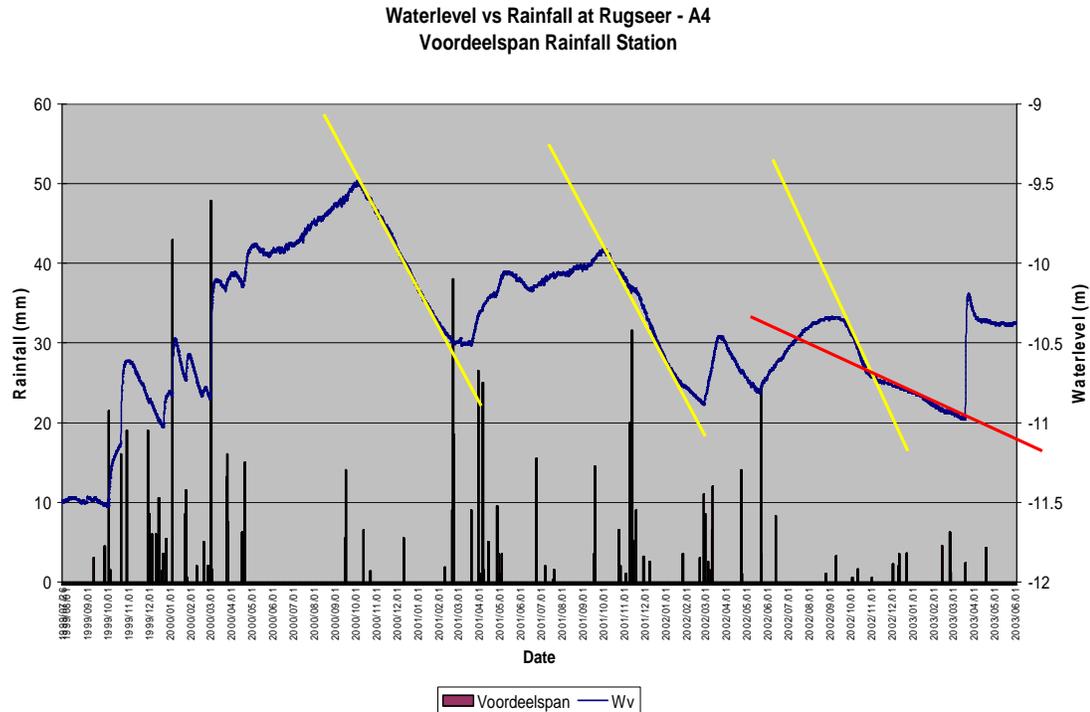


Figure 4: The water level fluctuation at A4 in comparison with the daily rainfall at the farm Voordeelspan. Period from 1999/07/26 till 2003/06/01

- The water level is rises during the winter months when there was no, or very little, rainfall. The only winter precipitation occurred in April and May. To explain the rising water level during winter the natural flow of the groundwater from the Rugseer River into the Hartbees River constituted a saline river system with shallow water table. This shallow saline water acts as a barrier to the water flowing into the Hartbees River from the Rugseer River with deeper water table. The ‘damming’ effect before water from Rugseer River starts flowing into the Hartbees River causes a rise in water table. The water responsible for the rise constitutes drainage from the surrounding gneiss in the catchment that release water on a very slow rate. This process of releasing of water is a constant process and occur also in the summer but is taken up by the Prosopis Sp. trees.

### Water balance

The water balance of a catchment is given as:

$$Inflow = Outflow$$

In more detail

$$I_r - (E_t + E + R_a) + R_r = O$$

$I_r$  = Inflow (rainfall);  $E_t$  = evapotranspiration;  $E$  = evaporation;  $R_a$  = rock absorption;  $R_r$  = rock release;  $O$  = Outflow (in river)

In the summer when most of the rainfall events occur, the trees are in a growth period and the temperature is high the outflow will be positive. In winter months the contribution of these elements are minimal and it would be expected that with no, or very little, rainfall no outflow would occur but the fractured gneiss in the catchment slowly releases water into the system.

### Water level trend cycles

There are 4 superimposed water level trend cycles.

**Firstly** the wet and dry or flood and drought cycle. 1988 and 1995/6 were extremely wet years with frequent surface flow. Summer of '99/'00 and 2006 also represents a wet event in this study. 1986/87, 1992/93 and 2003/2004 were extremely dry years with no surface flow. Although 2000 to 2002 was not a dry year, the rainfall was much less than 1999.

**Secondly** the seasonal or summer and winter cycle. Rugseer River fall in summer rainfall region and thus receives most of its rainfall in summer months (Feb-Apr).

**Thirdly** the rainfall cycle. Normal rainfall events with flow through the system take  $\pm 2$  months e.g. 1999/10/01 to 2000/01/01 (see figure 4).

**Fourthly** the abstraction and release cycle. This includes the taking of water out of the system in the summer months such as evapotranspiration; and the releasing of water from the rocks into the system in the winter months. This cycle and the third cycle are the most dominant of all four cycles.

### Water Quality

The groundwater quality from boreholes C6 and D4 has the lowest EC values. The position of these boreholes indicates that fresher water occurs on the eastern side of the Rugseer River. The current main surface drainage is also on the eastern side. It can then be postulated that the current surface drainage is reflected by the groundwater quality. The groundwater quality did not change after the clearing over the study period.

B/H No.	Conductivity (mS/m)		pH	Temperature
	When drilled Beginning '99	March '02		
G45726 (A2)	1330	1320	6,9	29,00
G45745 (A4)		530	7,5	27,00
G45744 (C6)	400	370	7,6	26,00
G45729 (B4)		700	7,1	26,00
G45731 (C2)	1060	1170	7,4	26,00
G45735 (D2)		1540	7,1	26,00
G45737 (D4)	310	310	7,4	26,00

Table 1 Showing physical groundwater quality of the study area before the clearing of vegetation.

### Rainfall Trends

When surface runoff occur the recharge were immediate (see figure 4). Recharge in the Karringveld is estimated at 3% (Nonner, 1979 and ACGIS, 2003. At Voordeelspan the rainfall over the studied time (1999/07/26 to 2002/05/07) was 690mm, or 247mm per year. At Kenhardt Police Station it was 476mm or 171mm per year for the same period and 139mm per year for the following period (2002/05/07 to 2006/02/26). The years 2003 and 2004 were very dry years with rainfall of 54mm and 87mm respectively.

### Evapotranspiration

50% for the study area were cleared of the 98ha after 3years and monitored for another 3 and half years (see Figure 5). The lost of storage from before clearing was on average 0.20m per month in summer months and after clearing 0.11m per month in the summer months. The volume of water that was lost to evapotranspiration is 2469m<sup>3</sup> per month for the 49ha cleared or 50m<sup>3</sup> per month per hectare. In Free Basic Water terms it means 8 households per hectare can be served or 6m<sup>3</sup> per household per 1200m<sup>2</sup> cleared. If one household cleared 1200m<sup>2</sup> (30m x 40m) of invaded area it will have 6m<sup>3</sup> per month available "for ever".

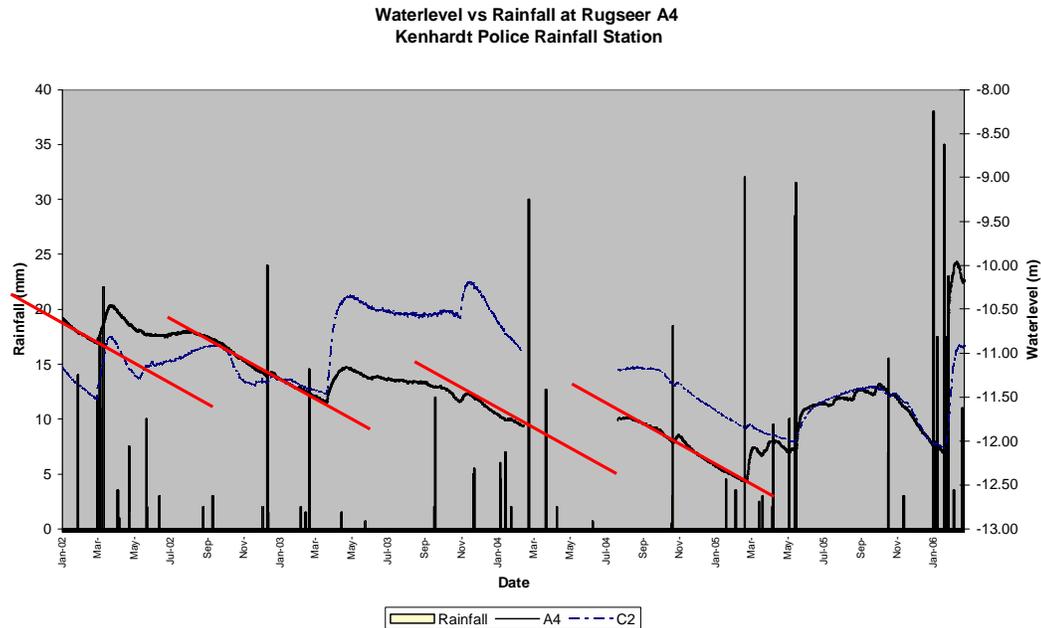


Figure 5: After clearing. Period 2003/01/01 till 2006/02/21

### Recharge

Recharge occur in high rainfall events in summer months if the rain period is 2 to 3 day or rainfall is higher as 15mm or runoff in river occur. The unsaturated zone in summer is much deeper as in winter months. In winter months recharge is from the river bank rocks or winter rainfall.

### CONCLUSIONS

The objective of the study are to qualify if invading *Prosopis* Sp. is utilizing groundwater and if the volume utilized can be quantified. To reach this objective the Rugseer River, Kenhardt was identified and the groundwater levels were monitored to see what the effect of clearing of the *Prosopis* sp. on the groundwater levels and to quantify the volume.

The water levels from the boreholes were found to be fluctuating very much to most of the boreholes. The rainfall correlates very well with the water level fluctuations. It is clear invading alien plants growth period begins in the beginning of October and end at the end of February. A volume of 50m<sup>3</sup> per month per hectare can SAVE by clearing 1 hectare *Prosopis* Sp. or 6m<sup>3</sup> per month per 1200m<sup>2</sup>.

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