# Dewatering Impacts of a South African Underground Coal Mine

P.J.H. Lourens[1], P.D. Vermeulen[2]

*[1]University of the Free State, Institute for Groundwater Studies, 205 Nelson Mandela Drive, Bloemfontein 9300, South Africa, lourenspjh@ufs.ac.za*
*[2]University of the Free State, Faculty of Natural and Agricultural Sciences, 205 Nelson Mandela Drive, Bloemfontein 9300, South Africa, vermeulend@ufs.ac.za*

**Abstract** The University of the Free State investigated the possible dewatering of boreholes situated on the farm properties in the vicinity of an underground coal mine. The investigation consisted of a hydrocensus phase, pumping tests and groundwater sample collection in underground mine workings phase. It was concluded that the boreholes on the farm properties not situated directly above the underground mine workings, are not affected by the dewatering activities. To determine the origin of the water flowing down the ventilation shaft, a detailed study of a possible geological structure to the west of the shaft is recommended.

**Key Words** Dewatering, hydrocensus, pumping test, geological structure

## Introduction

The Institute for Groundwater Studies at the University of the Free State investigated the possible dewatering of boreholes situated on the farm properties in the vicinity of an underground coal mine. An investigation was required as the land owners complained that there is a reduction in the yield of their boreholes supplying domestic and livestock water to their properties as a result of the underground mining activities.

## Methods

The investigation consisted of three phases. Phase one was a hydrocensus on the farm properties gathering boreholes geographical position, boreholes water level depth, equipment (pumps) installed in the boreholes and collection of water samples (where possible) for inorganic quality analysis. Phase two consisted of borehole yield determination by conducting pumping tests on the boreholes identified in the hydrocensus phase. Phase three included a visit to the underground mine workings, where water samples were collected at different groundwater inflow locations (especially water flowing in at a ventilation shaft).

Groundwater sample collection was done according the guidelines set out in the Groundwater Sampling Manual (2$^{nd}$ Edition) that was published by the Water Research Commission in 2007. The pumping tests were performed according to the guidelines set out in the Manual on Pumping Test Analysis in Fractured-Rock Aquifers that was published by the Water Research Commission in 2002.

All the data was converted into a format that is compatible with the FC and WISH software packages. The FC software package is used to analyse pumping test data and the WISH software package is used to graphically represent the data gathered. Monthly groundwater monitoring data of the underground mine was also incorporated for interpretation purposes.

## Topography and Hydrological Regime

The study area is drained by a non-perennial stream and its tributaries with flow in a northerly direction (Figure 1). The topography ranges between 1450 and 1511 metres above main sea-level (mamsl). The annual rainfall is approximately 660 mm per annum, and mostly received in the summer season (Weatherbase 2017).

## Hydrogeological Regime

The local groundwater regime of the study area comprises of the following hydro-stratigraphic subdivisions:

- The ***shallow weathered groundwater regime*** associated with Quaternary deposits of the Karoo Supergroup i.e. alluvium, collucium and weathered Karoo rocks.
- The ***intermediate groundwater regime*** associated with hard fractured Karoo rocks i.e. sandstone and dolerite of the Karoo Supergroup.
- The ***deep groundwater regime associated*** with pre-Karoo rocks i.e. karst aquifer comprised of dolomitic rocks of the Transvaal Supergroup.
- The ***unnatural groundwater regime*** (mine groundwater regime) – is still being developed (mine voids) as a result of mining.

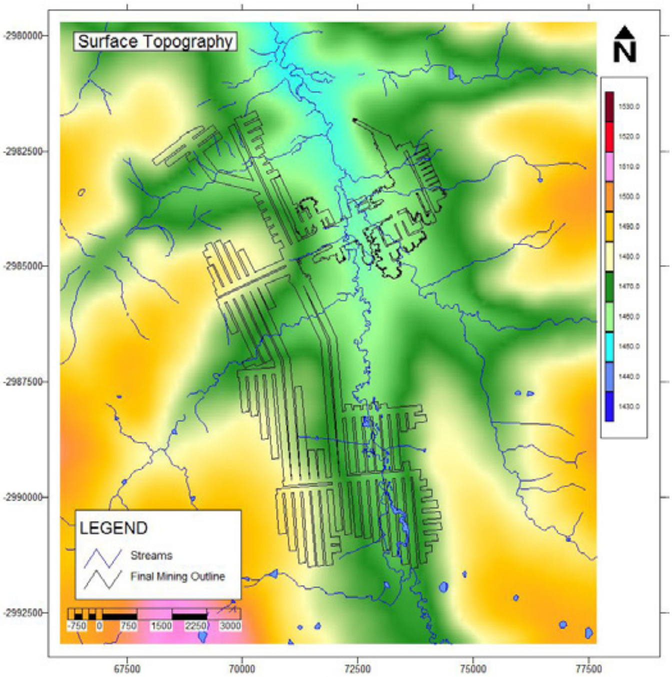


***Figure 1*** *Surface topography and drainage streams of the study area.*

## Proportional Water Level Distribution

A total of fifty two boreholes were identified on the surrounding farm properties (Figure 2). The total depth of these boreholes ranges between 30 and 90 metres. Therefore it can be assumed that these boreholes only intersects the shallow weathered and intermediate groundwater regimes. Thus, the farmers only utilises groundwater from these two hydrogeological regimes.

The water levels of the hydrocensus boreholes ranges between 2.58 and 46.18 mbgl, with most water levels shallower than 10 mbgl (Figure 2). The water levels of the boreholes monitoring the shallow weathered and intermediate groundwater regimes ranges between 2.15 and 66.74 mbgl (Figure 3), which are very similar to that of the hydrocensus boreholes. An interesting observation, is that the deep water levels (>50 mbgl) are all situated along the contact zones of dolerite and the surrounding host rock (Figure 4). This may also be a geological structure related to the Vredefort Meteorite Impact Structure.

## Water Level Trends

Figure 5 and Figure 6 illustrates the water level depth time graphs for the boreholes monitoring the shallow weathered, intermediate and deep groundwater regimes. The water levels in boreholes MK004, MK009, MK011, MK022 and MK025 remained sideways over time. MK022 is equipped with a submersible pump which supplies water on a daily basis to the adjacent dairy farm, from there the erratic behaviour.

The water levels in MK001, MK002, MK008, MK010, MK012, MK023, MK024 and MK026 indicate a declining trend since 2008. The rate of water level decline in MK001, MK002 and MK010 started to increase in 2008 until September 2012, after which it flattened out again. The decline in water level is probably the intermediate groundwater regime that drains into the underground mine workings as a result of mine dewatering activities. This is especially the case for MK001 and MK002 which is situated directly above the underground mine workings.

The declining water level trends for the deep boreholes MK012, MK023, MK024 and MK026 may be associated with the response to goafing which occurred in 2008. Most of the water levels of the boreholes that indicated a rapid decline seems to be at a stabilizing level. An interesting observation is that the water levels of the monitoring boreholes that is not situated directly above the underground mine workings (0.3 km to 1.2 km from the nearest underground mine operations), does not seem to be affected by the dewatering activities.

## Hydrochemistry

The chemical character of the boreholes situated along the possible geological structure identified in the west are similar to the chemical character as the water that flows down the ventilation shaft (Figure 7). This strengthens the hypothesis that the water flowing down the ventilation shaft originates from this structure or structures. The chemical character of the water in the eastern section of the underground workings is similar to the chemical character of the monitoring boreholes above the eastern section. Thus implies that the water in the eastern section originates from the overlying aquifer.

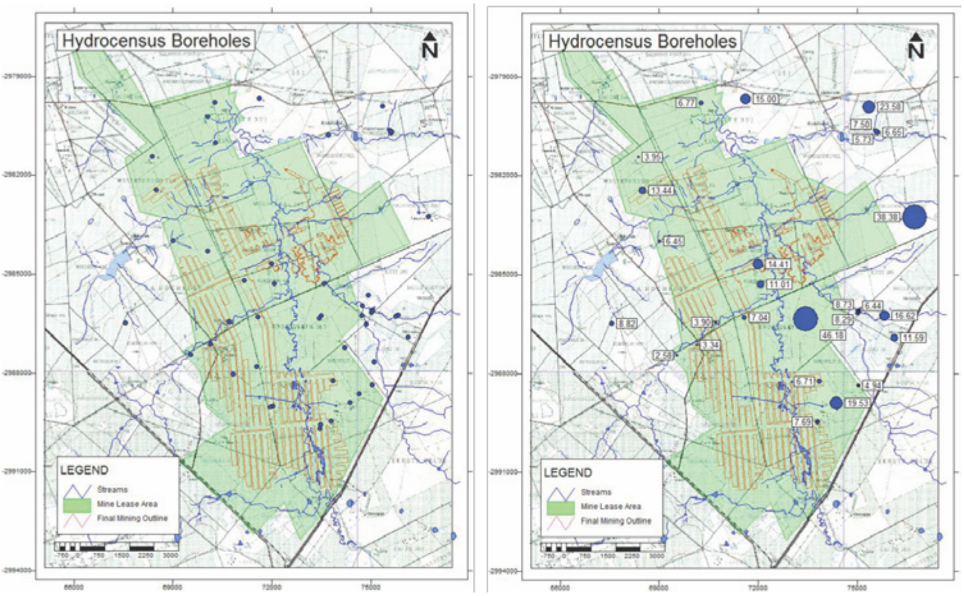


***Figure 2*** *Hydrocensus boreholes (blue circles) location (left) and proportional water levels distribution (right) maps.*

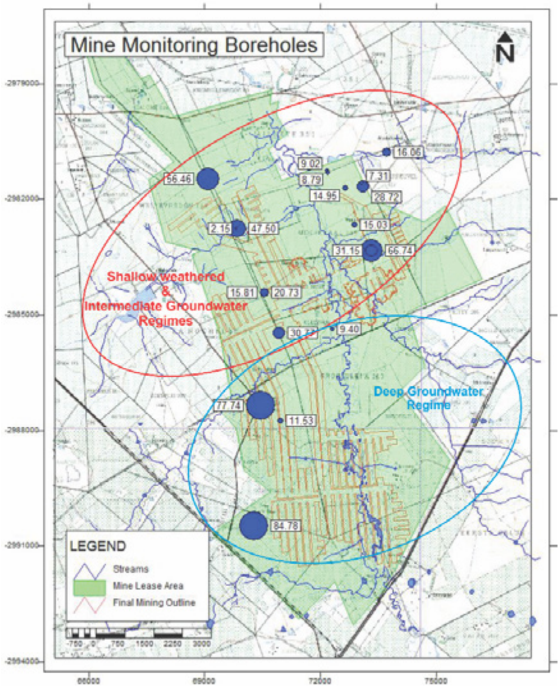


***Figure 3*** *Proportional water level distribution map of the boreholes monitoring the shallow weathered, intermediate and deep groundwater regimes.*

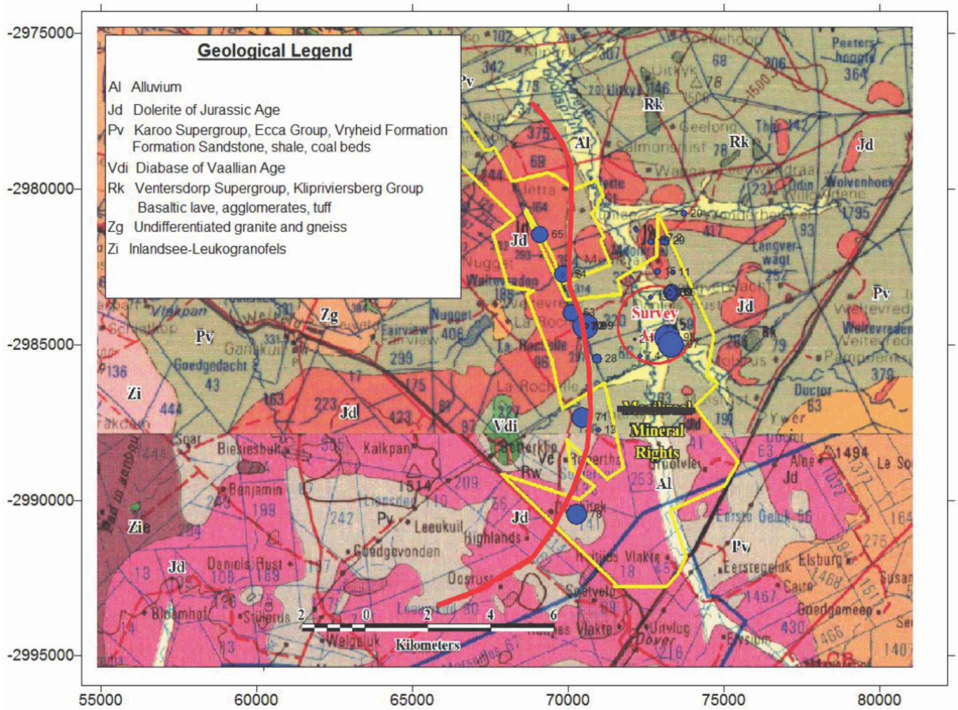


***Figure 4*** *Proportional water level distribution map superimposed over the geological map. Red Line – Contact between dolerite and host rock, also possible Vredefort Meteorite Impact Structure.*

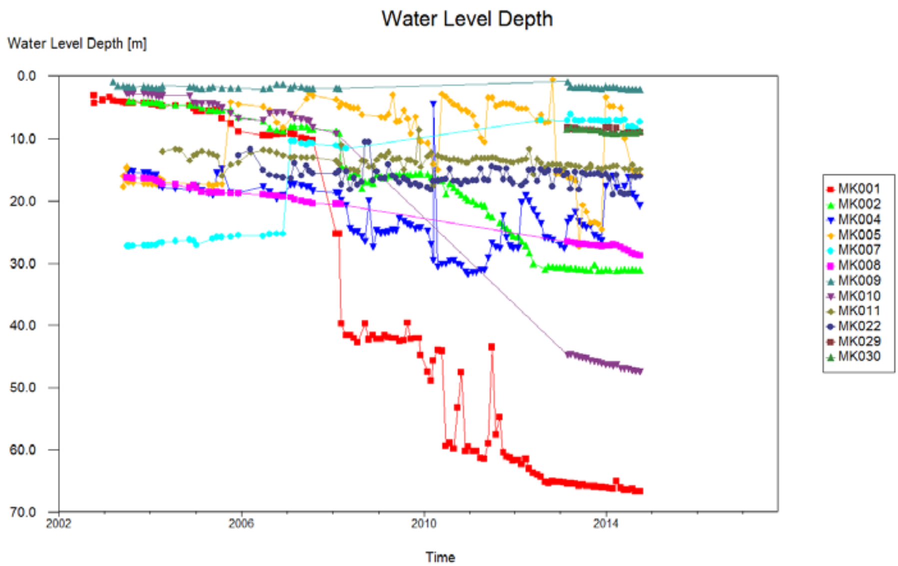


***Figure 5*** *Water level time graph of the boreholes monitoring the shallow weathered and intermediate groundwater regimes.*

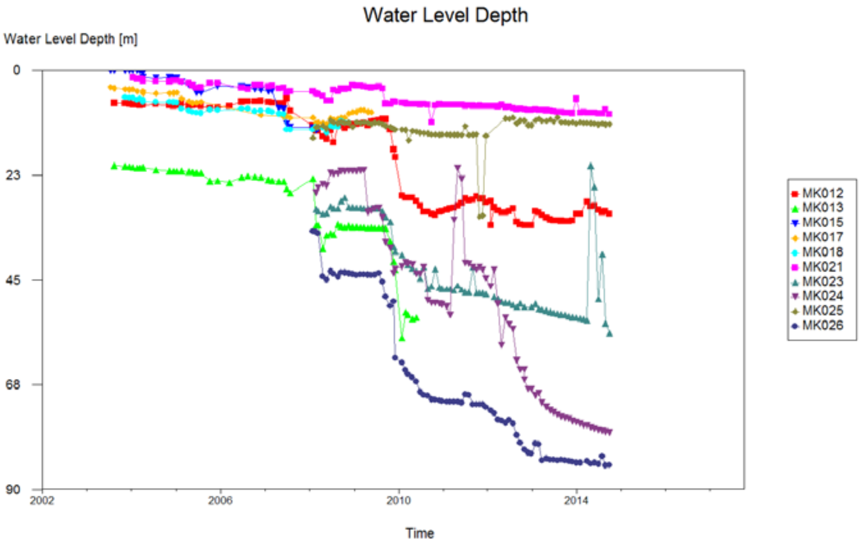


***Figure 6** Water level time graph of the boreholes monitoring the deep groundwater regime.*

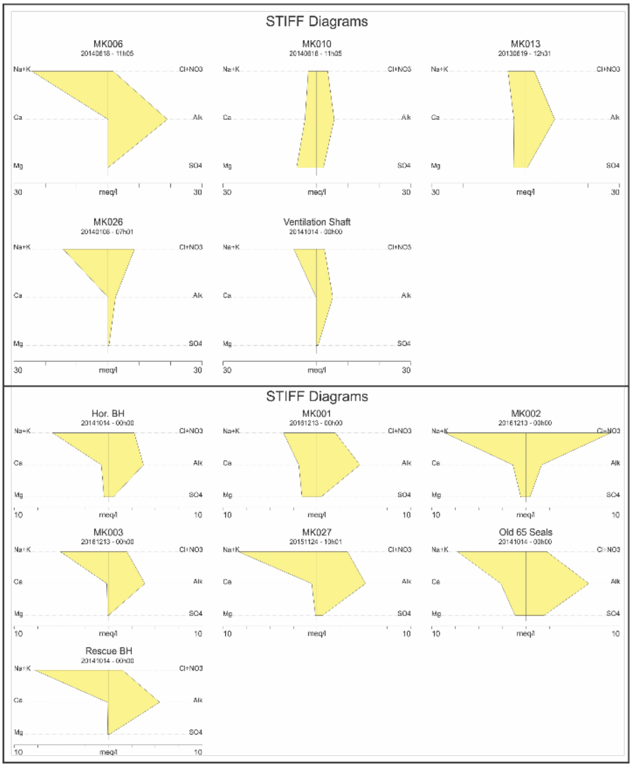


***Figure 7** Stiff diagrams of the ventilation shaft vs that of the boreholes situated on the possible geological structure (top) and stiff diagrams of the eastern section vs that of the overlying aquifer (bottom).*

## Borehole Yields

Pumping tests was performed on nine boreholes. The transmissivity of the boreholes and their sustainable yield varies (Table). The yields of these boreholes are typical yields associated with the Karoo formations i.e. between 0.5 and 1.5 L/s. Two boreholes situated towards the south (GV2; GV23) have yields less than 0.1 L/s, which can be classified as being unproductive (uneconomical).

The borehole with the highest transmissivity (272.3 $m^2/d$) is situated directly above the mine out area. The higher yielding boreholes obviously have higher transmissivities, ranging between 12.5 and 272.3 $m^2/d$. According to the pump test data, the average transmissivity of the shallow weathered aquifer and intermediate aquifer is approximately 71 $m^2/d$.

***Table 1*** *Transmissivity and sustainable yield of boreholes pump tested.*

| SiteName | Transmissivity ($m^2d$) | Sustainable Yield (L/s for 24hr abstraction duration) |
|---|---|---|
| GV21 | 0.8 | 0.01 |
| GV23 | 1.9 | 0.01 |
| GV25 | 67.8 | 1.5 |
| GV26 | 118.6 | 3.5 |
| GV27 | 23.1 | 0.9 |
| LR2 | 272.3 | 2.0 |
| LR5 | 83.2 | 1.0 |
| MR1 | 12.5 | 0.4 |
| WH2 | 16.8 | 0.6 |

## Conclusions

The boreholes of the farm properties intersects the shallow weathered and intermediated groundwater regimes. Thus, the farmers only utilises groundwater from these two hydrogeological regimes. The water levels of the hydrocensus boreholes are very similar to that monitoring the shallow weathered and intermediate groundwater regime.

The water levels of the monitoring boreholes not situated directly above the underground mine workings, does not seem to be affected by the dewatering activities. Therefore, it can be concluded that the boreholes on the farm properties not situated directly above the underground mine workings, are not affected by the dewatering activities.

The deep water levels (>50 mbgl) are all situated along the contact zones of dolerite and the surrounding host rock. This may also be a geological structure related to the Vredefort Meteorite Impact Structure. Considering the similar chemical character of these boreholes to that of the water flowing down the ventilation shaft, the hypothesis that the water originates from these structure or structures are strengthened. The aquifer overlying the underground mine workings in the eastern section drains into mine workings due to dewatering activities. The sustainable yields determined are very similar to that expected of Karoo formations in South Africa, i.e. between 0.5 and 1.5L/s. According to the pumping test data, the average transmissivity of the shallow weathered and intermediate groundwater regimes is approximately 66 $m^2$/d.

The possible dewatering structure or structures identified in the west should be further investigated. This is to test the hypothesis that the water flowing down the ventilation shaft originates from these structure of structures.

**References**

Van Tonder GJ, Bardenhagen I, Riemann K, Van Bosch J, Dzanga P, Xu Y (2002) Manual on pumping test analysis in fractured-rock aquifers. Water Research Commission (WRC) of South Africa, Report No 1116/1/02, ISBN No 1 86845 861 X. Pretoria

Weatherbase (2016) Sasolburg, South Africa [Online] Available at: http://www.weatherbase.com/weather/weather-summaryphp3?s=605018&cityname=Sasolburg%2C+Orange+Free+State%2C+south+Africa& units= [Accessed 15 September 2016]

Weaver JMC, Cavé L, Talma AS (2007) Groundwater Sampling (2nd Ed). Water Research Commission (WRC) of South Africa, Report No. TT 303/07, ISBN No 978-1-77005-545-2. Pretoria