WATER RESEARCH COMMISSION

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The WRC operates in terms of the Water Research Act (Act 34 of 1971) and its mandate is to support water research and development as well as the building of a sustainable water research capacity in South Africa.

TECHNICAL BRIEF

Water & mining

The potential impact of coal-mining on water in the Waterberg

A recently completed WRC-funded project investigated the potential impact of planned coal-mining on water resources in the Lephalale region of the Waterberg.

Scaling up of coal-mining in the Waterberg: Questions to be answered

The Lephalale region of the Waterberg in Limpopo Province ranks third in size in terms of its contribution to South Africa's coal reserves. This provides the Waterberg District with the opportunity of becoming one of the country's key areas for coal-fuelled electricity production. The area generally has a dry climate with average rainfall between 285 and 560 mm per year and mean annual evaporation approaching 2 000 mm. Owing to the planned expansion of the mining enterprises, it is important to determine to what extent mining activities and accompanying developments will impact on the scarce water resources of the region.

A scoping level investigation was consequently performed to consolidate existing information on:

- The different aquifers in the study area and their geohydrological parameters;
- Pre-mining water quantity and quality of water resources associated with the Waterberg Coalfield;
- The acid generating potential of the geology of the area;
- Expected impact of additional mines in the area;
- Potential of mine-water reaching decant levels; and
- Recommended management methods that are applicable in and have relevance to the area.

Methods of Investigation

Acquisition of the necessary information took place in a number of stages. Initially a hydrocensus was carried out, the aim being to locate as many boreholes in the study area as possible and thereafter to collect samples from these boreholes for water quality determinations. In addition to the hydrocensus, information on the geology of the area was gathered from relevant sources and geological samples obtained for determining the acid potential of the rocks in the study area.

Numerous field tests were conducted to determine the aquifer parameters of the different aquifers present in the area. These parameters were necessary for the determination of aquifer yields and for use in groundwater flow modelling.

To account for influx of water, groundwater recharge was calculated by means of the Chloride Mass Balance method and the E.A.R.T.H. model. Acid-Base Accounting (ABA) was performed on the collected rock samples to determine if certain rocks would become acidic upon oxidation, recognising that the method provides no indication of the amount and rate of acid generation. Samples from beneficiation plants at the Grootegeluk colliery were also analysed for acid potential.

Numerical modelling was used in order to determine the impact the mines would have on groundwater and its direction of flow. During the course of the modelling, attention was also given to simulating different scenarios in an attempt to establish the dewatering and decant potential of the mine pits.

Geology and mining method

The Waterberg Coalfield, part of the Karoo Supergroup, trends east to west and is heavily faulted. One of three major faults, the Daarby fault, subdivides the coalfield into the shallow western part where opencast mining is possible and the deeper north-eastern part where underground mining is required.

The coal is of low quality and needs to be beneficiated to maintain profitability. Beneficiation plants require large volumes of water to operate, which would increase the strain on the groundwater systems if the required water is to be abstracted from boreholes. Furthermore, the discard from the beneficiating plants contains minerals that are prone to acid generation.

The entire area west of the Daarby fault would be mined using the opencast method due to the shallow depths of the coal. The form of opencast mining found to be most economical by the Grootegeluk mine in the area is known as bulk mining, which involves the removal and processing of all relevant material, consisting of coal inter-bedded with thin layers of shale and mudstone. New opencast mines planned for the area will in all probability follow the example of Grootegeluk with regard to mining methods, spoil handling, water management and rehabilitation.

Some form of water control is usually required to prevent an opencast mine pit from becoming an acidic lake. In the Waterberg area, however, the problem of an open pit becoming a lake is of lesser concern owing to the low levels of annual precipitation, low transmissivities, high evaporation and the deep groundwater levels found in the area.

Pre-mining water quality

In the area under investigation, the quality of water that has been unaffected by activities such as mining and power generation can at best be classified as moderate, with a fine line existing between groundwater that is usable or not. The water in general has high electrical conductivity (EC) and Cl- values, with pH being near-neutral. It is predicted that the addition of new mines will have an adverse effect on the groundwater by increasing the EC and SO42- values, owing to acid rock drainage (ARD) in the immediate vicinity of the mines.

Water levels

From observations made regarding the influence that the Grootegeluk Mine and its dewatering have had on surrounding aquifers, it is expected that the excavation of new open pits in the central parts of the area will alter the topography and result in changes to the direction of flow of groundwater.

Aquifer parameter testing

According to the slug and pumping tests in the western parts of the study area, vast differences exist in the transmissivity of formations and yields of the boreholes. In general, though, the yields and transmissivities of the aquifers in the area are found to be low. New mines planned for the study area should thus not have problems with regard to large volumes of water flooding the mines. Also because of the low rainfall, water levels in the mines are not expected to reach decant levels.

Recharge

The recharge determinations indicated a value of between 1.5-1.6% for the entire study area. Furthermore, the low recharge coupled with the low transmissivities found in the study area present both positive and negative situations for the mines and farmers in the area. For mining it is positive in the sense that there will be little inflow of water into the mines. For farmers the situation is predominantly negative, since dewatered boreholes will take long times to reach their initial levels and those in the immediate vicinity of the mines are unlikely ever to recover. Therefore, precautions should be taken before and during mining activity to minimise the impact of the mining on the groundwater.

Acid-Base Accounting analyses

ABA suggests that, in most cases, there is sufficient potential for acid generated to be neutralised, provided every ton of acid rock is mixed with a ton of base potential rock. There are some areas, however, where this does not necessarily apply, such as where insufficient calcite is available to completely eliminate the potential for acid generation or where sandstone, with its higher acid-generating potential, occurs.

Modelling

Numerical modelling has provided insight into the quantities of groundwater flowing into mines, which has implications for dewatering and mines reaching decant levels.

Dewatering: The dewatering simulations indicated that there is very little groundwater in the area under investigation. Water movement is also slow and predominantly along dykes, fractures and faults. This is consistent with observations in boreholes located near such structures, which record higher yields than boreholes located further away. Accordingly, the intersection of a fault during mining operations would cause a greater volume of water to flow into the mine.

Decant: Model simulations suggested that although pits may have water flowing into them, they will never decant, confirming inferences drawn from aquifer parameter determinations based on pumping tests. Indications are that 50 years after cessation of mining, water levels in the modelled pits will have risen from an average depth of 28 m by no more than 2-3 m, the largest contributor to the rise being surface runoff during periods of high rainfall.

Management

Owing to the small volumes of water expected to enter the mine workings from both groundwater and surface runoff sources, water levels can easily be kept under control by pumping out the water and using it for run of mine operations such as dust suppression or washing of ore. Steps should, however, be taken to minimise the risk of intersecting a fault during mining. Dewatering a fault could impact severely on water levels along the fault and cause a significant decline in water levels of farm boreholes.

Many possible water quality control measures can be used to either prevent groundwater contamination or to contain any possible contaminants in the study area. Mine rehabilitation methods linked to water quality management as employed at the Grootegeluk mine largely focus on containment of contaminants and have evolved to become particularly effective under the conditions prevailing in the area, thus serving as a sound example for new mining operations.

As far as possible, rocks removed during excavation are placed back in the same order. The pit is backfilled as a series of benches, each lined and sealed, until all the backfill material has been used. Spoils from the beneficiation process are placed into the pit and covered with the rock removed during mining. The spoils, along with other rock units that have the potential to produce acid, are placed at a higher level to keep them as dry as possible to limit acid production. Although the generation of some acidity is unavoidable, the low volume of water entering the pit makes it possible to contain effluent in one location, where it can be more easily treated.

Conceptual model

The results and conclusions from the scoping-scale investigations have been drawn together and summarised in a conceptual model of the Waterberg Coalfield. The model displays the locations of primary geological structures and coal seams and the position of a single pit, modelled on the Grootegeluk pit. The model also displays the rehabilitation methods used at the Grootegeluk mine in an effort to reduce the amount of acid generated.

The average water level is shown at 28 m below the surface. Also displayed is the average groundwater recharge of 1.5% and the expected rise of approximately 2 m in water level once mining has stopped. Furthermore, the effect of the mining infrastructure on the groundwater in the vicinity of the mine is demonstrated.

The conceptual model summarises the results of ABA, performed according to the weathering depth of the geology and yielding information on the acid generating potential of various rock and beneficiation plant discard samples at various locations in the area. Finally, the model provides insight into the quality of water in various localities, including areas both unaffected and affected by mining activities and areas affected by power generation waste products.

In conclusion .....

The establishment of new mines will have a deleterious effect on the quality and quantity of the groundwater in the Waterberg coalfield. In particular, the small volumes of water available in the area will be further reduced, with effects being more pronounced west of the Daarby fault owing to the impermeable nature of this fault, which will prevent groundwater movement from the east to the west of the fault.

Since the methods of mining, beneficiation, remediation and water management currently being employed by the Grootegeluk mine have been proven to be optimal for existing conditions it is recommended that such methods be employed by new mines to be established in the area.

The further refinement of such methods should, however, be considered based on the outcome of studies that focus, *inter alia*, on the following:

- Determination of the percentage of water moving into the groundwater system from washing plants and the effect thereof on the water quality;
- Confirmation of the need to vary the size of the material placed back into the pits as backfill in order to decrease the porosity of the backfilled pit and slow the movement of contaminants;
- Pumping back into the mine of slurried discard and spoils, and the sealing thereof with bentonite clay in an attempt to prevent the movement of the pollutants into the groundwater system;
- Additional ABA testing over a larger area and an expansion of the testing programme to include kinetic tests; and
- Potential positive and negative impacts of using water imported into the area via a new pipeline.

Further reading:
To obtain the report, *Assessment of how water quality and quantity will be affected by mining of the Waterberg coal reserves west of the Daarby fault* (**Report No: 1830/1/10**), contact Publications at Tel: (012) 330-0340; Fax: (012) 331-2565; E-mail: orders@wrc.org.za; or Visit: www.wrc.org.za