CASE STUDY ON THE REMEDIATION OF THE DEFUNCT COAL MINE ARBOR COLLIERY, IN MPUMALANGA SOUTH AFRICA[1]

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Abstract. Arbor Colliery is an abandoned colliery in the Loskop Dam catchment. The mine comprises a series of opencast pits, as well as poorly defined underground workings. The water within the opencast pits shows high levels of acidity, elevated sulfate levels and elevated metals (Al, Fe and Mn). Some 100 families live adjacent to the mine, and this presents interesting social challenges in terms of remediation. The mine will be rehabilitated over a period of several years. The remediation strategy proposed is discussed, together with some of the ongoing tests and issues still to be resolved.

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Introduction

South African coal mining occurs primarily within the Vryheid and Volksrust Formations of the Karoo basin (Brink, 1983). Along the northern and north-eastern boundary of the Karoo basin, mining has been undertaken since the late 1800's. Consequently there are various abandoned and defunct coal mines which either are impacting or have the potential to impact the water quality in the catchment. Unfortunately, several more recent mines have also entered the category of abandoned and defunct mines. Because of the concentration of mining within the Loskop Dam catchment, the Department of Water Affairs and Forestry (DWAF) commissioned a study to determine the total number of abandoned and defunct coal mines within this area (DWAF – 2001).

The initial stages of the project identified and investigated 27 apparently abandoned and defunct mines. This number has been reduced over the years either through companies reopening defunct mines or as responsible parties have been identified and held accountable. The reduction in the number of abandoned mines has in itself has been a major step forward, with a process implemented to follow up on rehabilitation planning and financial provision, potentially avoiding major liabilities for the State.

Arbor Colliery (locality shown in Figure 1) was identified as one of the 27 mines with a high priority, based on the potential impact on water quality as well as safety issues. A major factor in this assessment was the presence of a large informal community living in close proximity to the mined out area.

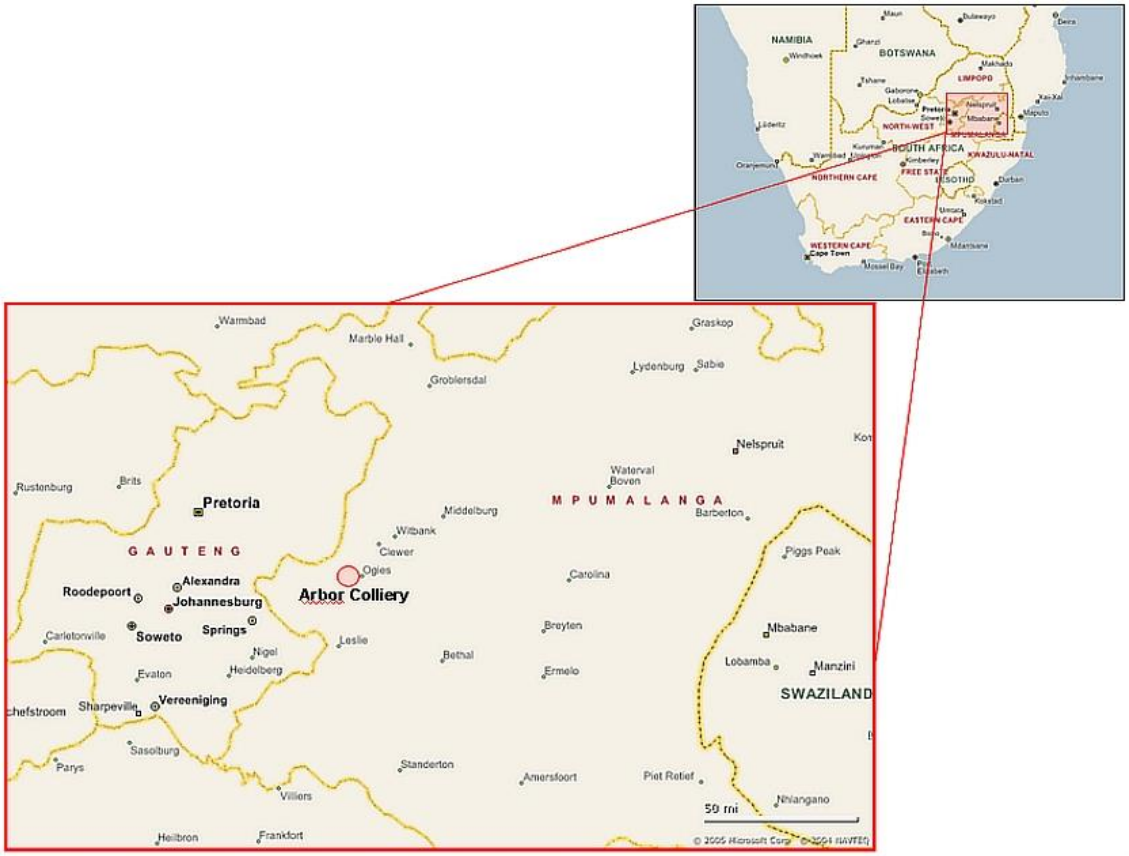

Figure 1: Location of Arbor Mine

Initial Studies

An aerial view of the mine is shown in Figure 2. Various pits can be noted, and sampling of water within the pits indicated acidic conditions in the pits (pH of between 2 and 3), elevated sulfate levels (between 106 and 1353 mg/l) and elevated metals (Fe ranging from 0.2 to 17.6 mg/l; Mn ranging from 2.3 to 2.8 mg/l; and Al ranging from 9 to 102 mg/l).

Figure 2: Aerial view of Arbor Mine

A series of studies were undertaken on the site to address the alternatives available and associated costs to rehabilitate Arbor Mine, and these are detailed below.

Legal review

A legal review was undertaken by DWAF to determine whether a responsible party could be identified and costs recovered to assist with the rehabilitation. The review identified current surface rights owners, but could link the current owners to the mining activities. While there is provision in the South African Water Act to hold surface owners liable for potential contamination regardless of whether they benefited or not from historical activities, the financial return that can be achieved by legal action is often limited, particularly where the owner has not benefited directly from the mining activities.

It is interesting to note that an application for prospecting in the area was made several years ago covering some of the portions of land earmarked for rehabilitation. Should mining proceed, there would be potentially a significant reduction in the rehabilitation cost. However, until a mining application is submitted, there is no legal basis to hold the new proponent liable for historical activities. Given that there is no guarantee that mining will occur in the area in future, and after discussions with the prospecting parties, a decision was taken to proceed with rehabilitation, but starting initially away from potential future mining areas.

Socio–Economic Survey

Two communities live adjacent to Arbor Colliery on the farm Vlakvarkfontein. The major community is to the north of the mine and consists of approximately 100 families. The second is to the south of the mine and it comprises only three families.

A socio-economic survey was undertaken by Nemai Consulting (Naidoo et al, 2003) using a combination of questionnaires and focus group sessions with the main focus being on the following:

- Community demographics (age, gender, family units, education and employment)
- Community income levels, sources and amenities available to the community
- Sources, quality and quantity of water available to the community
- Resources extracted from Arbor Colliery by the community, the techniques used to extract these resources, and the use of the resources extracted
- The community's concerns with regard to Arbor Colliery in general and its rehabilitation.

From the socio-economic study (based on a sample of 35% of the community), several interesting facts emerged that have a bearing on the rehabilitation strategy. Firstly, approximately 80% of the community is unemployed. Average income for the entire community was indicated to be less than $150(US) per month (2003):

Secondly, as may be expected, water supply is a critical issue in the life of the community. Water is obtained from three wells and two boreholes located in the area. While the boreholes are the favored source of water, both in terms of quality, as well as reliability of supply, waste management as currently practiced by the community has the risk of impacting on the water supply. Rising water levels within the mined out pits also poses a risk to long term water quality.

However, the defunct mining area is also a resource for the community, providing wood from the trees that have established in and around the pits, water for washing, and coal in areas where it has not been mined. The extraction of the coal is hazardous, and there has been one fatality due to rock falls during informal mining. This mining takes the form of pillar robbing underground, together with some coal reclamation on surface. While the community indicated that coal is only mined for personal use and not for sale, the risks involved in mining have led to some people being paid to mine coal for others, so in a sense, there is a commercial component to the mining activities.

Further, burning discard material exists in certain areas, and one child has suffered burns while playing in the area of the spoils. Not all of the hot areas are easily identified on surface, and the possibility of serious injuries through falling into hot or burning areas with soils cannot be excluded. It was also reported (but could not be verified) that one person drowned while swimming in the pits.

As a consequence of the above, the study found the community to be generally in favor of rehabilitation, provided that some form of access to the coal could remain, the inherent safety issues in mining the coal not withstanding.

Void depth measurements

As no maps of the mine workings for Arbor Mine could be located, the volumes and depths of each of the pits were unknown. The volumes were quantified by the use of an ultrasonic

depth finder on board a small inflatable boat, from which the quantity of both the voids and the volumes of water on the site were estimated.

In-stream water quality measurements

A temporary weir was constructed approximately 1.5km downstream of the site, where a continuous logger was installed. The results from the continuous logger show little impact on the water quality at the weir, with generally good electrical conductivity values and neutral water.

The water quality information from grab sample up and downstream of the mine and the results from the continuous logger indicate that there was no decant from the mine during the period of monitoring, although there is evidence of precipitate on the vegetation downstream of certain mining areas suggesting that spillage has occurred in the past.

It is important to note that the original assessment of Arbor Colliery as a high-risk mine was based on the potential volume of acidic water that could be generated by the mine, and the consequent sulfate loadings on the catchment. At an average pH of 3 and sulfate concentrations of 1000mg/l, the potential average sulfate loading is expected to be between 180 and 250t SO_4^{-2}/annum. This is based on a provisional water balance undertaken for the voids, which indicates that although evaporation will limit the volumes spilled, there will be spillage from the workings, even for average rainfall events.

Proposed Rehabilitation

The preferred policy for the site is to backfill pits to make them free draining (DWAF, 2004). The more acid generating material will be placed below the decant water level (as low as is practical), and the acidic water will be neutralized (preferably) prior to backfilling. While this does not prevent decant of affected water, it does maximize the volume of clean runoff returned to the catchment. Neutralization and flooding of the more carbonaceous material is aimed at maximizing the quality of future decant, while removing the surface ponds is seen as avoiding the issues around evapo-concentration of mine water, with inherent safety risks to the community. Capping systems tend to be based on the utilization of available soils, leaning towards a store and release cover where there is sufficient material available.

From the community perspective, backfilling of all of the areas is not desirable, as it removes access to the coal. However, the informal mining is illegal, as well as dangerous, and some form of compromise is required if the rehabilitation is to be seen as a positive step by the community. The following key aspects of the rehabilitation have been proposed as described below.

Landform

Arbor Colliery consists of five opencast pits, of varying sizes and depths, with vertical highwalls of up to 30m. All the open pits are filled with water. There also are numerous unsealed shafts. A total of 21 discard dumps of varying sizes have been identified.

A general shortfall exists in terms of material, so that the mined areas can be made freedraining only if “valleys” are cut to allow surface runoff at a lower elevation than the natural ground level. This shortfall in material opened the possibility of forming a soccer field at Pit 1 or Pit 2, with 1:5 side slopes used for spectator viewing. This is currently proposed, subject to community acceptance. Issues around maintenance and surfacing have still to be resolved if the field is to remain a usable asset to the community.

The other pits will be backfilled and made freedraining, although in the interim, it has been agreed to not backfill the primary pit used for coal mining until issues around sustainable mining from the area can be resolved. On the one hand, access to coal safely could be achieved (for example) by removing overburden, or providing training and proper support systems. Conversely, providing easy access to coal could result in ingress of people to commercially utilize the coal, after which the system will return to the largely unsafe pillar mining type operation. Experience elsewhere on sealing the shafts has also not been favorable, with alternative access being constructed, while the extreme option of collapsing the workings then excludes the community from the resource. Various government departments will be enlisted to address this issue, since it occurs at several places in South Africa, and is not unique to Arbor Colliery.

Water Management

Experience on other defunct mines has indicated the potential to underestimate seepage from the area during backfilling operations. As the pits are backfilled water levels will rise, but not necessarily evenly due to variations in the permeability of the backfill material. Further, increases in hydraulic conductivity around the pits related to blasting can result in seepage from the pits at lower levels than might normally be expected. To minimize this risk, provision has been made to pump a proportion of water out of the pits prior to backfilling.

Initially water will be cascaded from one pit to the next to avoid spilling as backfilling progresses, but longer term options for water management have also been considered. These include:

- Discharge of water to the catchment after treatment to remove sulfates, probably using biological treatment systems. Operation of these treatment systems will offer some employment opportunities to the community.
- Pumping of water to a nearby underground mine, from where an operational mine abstracts water for use in their coal washing plant.

In terms of water treatment, pH adjustment will be required. In the past, DWAF have utilized the Council for Scientific and Industrial Research (CSIR) to neutralize water in mined out pits using their patented fluidized bed lime reactor. Jones & Wagener were also involved in a successful large scale dosing of a dam for industrial purposes using gypsum washed into a trench, eventually discharging into a pipe floating on the dam surface in order to reduce fluoride concentrations. While the exact methodology has not been finalized yet, options that can offer labor opportunities will probably be considered more favorably. The likelihood is that a more labor intensive system of water with pressure hoses to monitor powdered lime into a mixing trench with slurry discharged on to the surface of the pits will be employed.

In terms of clean water supply to the community provisions have been made at this stage for additional boreholes to ensure that the groundwater supply is outside of any potential plume development that may occur from the rehabilitated pits in future.

Safety issues

A high priority during rehabilitation will be to address issues around burning discard on surface, and open adits to the underground workings. As backfilling is undertaken, highwalls will also be flattened. Currently Pit 5 (where coal is mined from the highwall by the community) will be left open subject to resolution of the problem of safe access to coal for the community.

Issues to be addressed

Work at Arbor Colliery was scheduled to commence in October 2005, shortly after the time of writing. The initial construction activities will address only backfilling of the first pit, together with surface clean up.

Outstanding issues that still remain on the site include the following:

- The short and long term strategy in terms of access to coal for the community.
- The extent to which long term benefits to the community can be achieved have still to be resolved. While the improvement of the environment and removal of numerous safety hazards will be achieved, employment opportunities will probably remain limited. Current activities identified for possible community involvement include construction activities such as sowing of seeds, and possibly manual labor during water treatment. Post rehabilitation, some ongoing water treatment and maintenance may be required, with a low level of employment.

A possible increase in the occurrence of Aids due to the influx of construction workers during construction projects has been postulated. However, DWAF will be undertaking the construction in-house with a relatively small team that has been involved in various training and awareness projects to address this issue.

Conclusions

From the investigations, it was concluded that there is an urgent need for this mine to be rehabilitated, given the current risk to the community. However, the social issues associated with the mine are probably more significant than the engineering interventions required, and there are issues still to be resolved with the community over a period of the next few years.

The current rehabilitation proposed will only address an initial pit, with the intention to remove discard on surface, close defunct mine shafts and address the burning discard. This improvement in terms of safety issues, together with the planned provision of a soccer field on completion makes this the easiest component of the work in terms of community acceptance. Long term issues around access to coal remain to be resolved, with the current planning being to backfill all of the pits, except possibly a portion of Pit 5 if an acceptable resolution can be found to this problem. If not, the entire area will have to be closed to prevent unsafe mining practices.

Water treatment will also be undertaken during this initial phase, allowing some ideas in terms of community involvement in this operation to be tested. Provision of additional water supply points to the community will assist in securing a viable long terms water supply, but employment opportunities into the future are expected to remain relatively low, primarily around some maintenance required, and potentially for water treatment systems.

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Literature Cited

Brink A.B.A, 1983. Engineering Geology of Southern Africa. Building Publications, RSA.

Naidoo. N, Mathabatha S.K., 2003. Arbor Socio-Economic Impact Study Report. Nemai Consulting, Sunninghill, South Africa.

Department of Water Affairs and Forestry, 2001 - Report Number 16/3/4/68/1. Compiled in association with Jones and Wagener. Reference JW30/01/7492.

Department of Water Affairs and Forestry, 2004 – Update on Report Number 16/3/4/68/1. Compiled in association with Jones and Wagener. Reference JW72/04/9326.