The Use of Minewater to meet Future Urban Water Requirements in the Witbank Dam Catchment

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ABSTRACT

The National Water Resources Strategy (NWRS) presents water balances for the water management areas (WMAs). This exercise resulted in the identification of a number of water stressed WMAs, one of which was the Olifants WMA which has a deficit based on year 2000 water requirements of 193 million m^3/a. The water reconciliation for the Upper Sub-area (Loskop Dam catchment) is in balance. However significant growth is projected in the urban water requirements, particularly for the Emalahleni (Witbank) Local Municipality. The local water resources have been fully developed and the 2004 water requirements currently exceed the 1 in 50 year yield of Witbank Dam.

There are a number of coal mines located in the Witbank Dam catchment close to Witbank Town. Many of these mines have excess mine water which is threatening to sterilise coal reserves and impact on the mining operations. Although polluted, this water is available to meet the water requirements of Emalahleni by abstracting it from the mine workings. Anglo Coal and Ingwe Coal Corporation formed a joint venture to investigate abstracting water from the Greenside, Kleinkopje and South Witbank mines to meet the future water requirements of Emalaheni. In abstracting water from the mine workings, the question that needs to be answered is if the excess mine water abstracted from the mine workings represents a new or additional water resource or is it merely transferring water that would have reported to the Witbank Dam. To address this question, the Department of Water Affairs and Forestry's Water Resources Planning Model (WRPM) was used, with water balance input from the mine water balance models, to determine the impact of such an abstraction on the historic firm yield of Witbank Dam and to quantify the additional water created by mining. This paper presents the results of this water resource study.

Keywords: *Minewater, water supply, water resources*

1 INTRODUCTION

The National Water Resources Strategy (NWRS) presents water balances for the water management areas (WMAs). This exercise resulted in the identification of a number of water stressed WMAs, one of which was the Olifants WMA which has a deficit, based on year 2000 water requirements, of 193 million m^3/a. The water reconciliation for the Upper Sub-area (Loskop Dam catchment) is in balance. However significant growth is projected in the urban water requirements, particularly for the Emalahleni (Witbank) Local Municipality. The local water resources have been fully developed and the 2004 water requirements currently exceed the 1 in 50 year yield of Witbank Dam.

The water reconciliation strategies that could be employed by Emalahleni Local Municipality to meet their projected water requirements are water conservation and demand management or the transfer of water from the Vaal River System to support their current abstraction from Witbank Dam. There is however another source of water and that is the mine water stored in the workings of the collieries in the vicinity of Witbank Town. The collieries have exhausted at source water management options such as separation of runoff from clean and dirty water areas, rehabilitation, storage and re-use of polluted water. Although polluted, the water stored in the workings represents a local source that can be used to reconcile the local water requirements, address the excess mine water stored in the workings as well as a potential water quality problem.

A joint venture project between Ingwe Coal Corporation and Anglo Coal was launched to investigate the use of the excess mine water to meet the local water requirements. The Greenside, Kleinkopje and South Witbank Collieries have been identified as potential sources of water. The project considered the technical aspects of water treatment, impact on the water resource of the abstraction from the workings as well as financial and institutional aspects. The detail of the assessment of the impact of the proposed abstraction on the water resource is addressed in this paper. The assessment was carried out using the Department of Water Affairs and Forestry's Water Resource Planning Model (WRPM). The WRPM was used to assess the impact of the mines on the yield of Witbank Dam.

2 LOCATION AND DESCRIPTION OF MINES

The mines are located in the Upper Olifants (Loskop Dam) catchment. The Kleinkopje and Greenside Collieries fall in the Witbank Dam catchment while South Witbank Colliery is located in the headwaters of the Brugspruit catchment, which is a tributary of the Klipspruit. Greenside Colliery is located in the headwaters of the Noupoortspruit. Kleinkoje Colliery is spread between the Noupoortspruit, Tweefonteinspruit and the Witbank Dam Incremental catchments.

A summary of the catchment and mining areas for the 2006, 2015 and closure mining development levels in the individual catchments is given in. The mining areas included in Table 1 are only the areas of the mines involved in the water supply scheme. There are other mines in the catchments, particularly the Tweefonteinspruit catchment. In the case of Kleinkopje Colliery much of the mining activity involves the re-mining of bord and pillar underground mines using opencast mining techniques. The mined areas given in for Kleinkopje Colliery are those areas that have been fully exploited by opencast mining.

3 IMPACT OF MINING ON SURFACE WATER RESOURCES

The impact of mining on a catchment's surface water resources is illustrated in
Figure 1 and Figure 3. Also shown in
Figure 1 and Figure 3 is the representation of the water cycles used in the WRPM for the two cases.

The natural water cycle consists of a number of processes, starting with the rainfall which gets intercepted on vegetation and fills surface depression storage. Once these stores are full, the water will infiltrate into the upper surface storage or shallow aquifer and surface runoff will be produced if the rainfall intensity exceeds the infiltration rate. The infiltrated water enters the perched or shallow aquifer from where the water discharges back to the streams as interflow. There is evapo-transpiration from the shallow aquifer and evaporation from the interception and depression storages. The deeper aquifer is recharged by water percolating from the shallow aquifer by deep infiltration. Water stored in the deeper aquifer can exit into streams or percolate to deep aquifer storage. Typical recharge rates from the shallow aquifers to the deeper aquifers are 1% to 3% of annual rainfall for the Upper Olifants River Catchment under natural conditions. The natural water cycle and its representation in the WRPM model is shown in
Figure 1

The impact of mining on the catchment water cycle is dependent on the type of mining operation. The opencast mining method has the greatest impact, while the deeper bord-and-pillar mining method has the least impact. The impact of an opencast mine is illustrated in Figure 3. The shallow aquifer is removed by mining and replaced with a broken spoils material. During operations there is rapid infiltration through the spoils heaps into the workings from where the water is pumped for use on the mine or discharge. The rehabilitated portion of the opencast workings consists of a cover layer (typically 600-1 000 mm thick) placed on top of the levelled spoils. The levelled surface is usually made free-draining, so that the surface runoff returns to the natural river system. The water that infiltrates and is stored in the cover can be removed by evapo-transpiration via the vegetation and percolation into the spoils material in the opencast pit. The ability of the rehabilitation cover to hold water depends on the soil types, degree of compaction and thickness. For typical rehabilitation practice, the recharge rate through the rehabilitation cover to the spoils ranges from 12% to 20% of the annual rainfall (Vermaak et al, 2004). This substantially exceeds the natural recharge rates of 1% to 3%. The increase in recharge is water that would have been held in the natural shallow aquifer, from where it would evapo-transpire or provide a contribution to the runoff by means of interflow.

Mines also have polluted surface areas such as coal processing plants and mining waste deposal sites. The runoffs from these polluted areas are collected in pollution control dams for re-use on the mine. These areas are essentially isolated from contributing surface runoff to the natural river system.

The natural hydrological cycle has surface runoff, interflow and a groundwater contribution to the total flow from a catchment. (See
Figure 1). For a mined area, there is only a surface runoff component left, with the groundwater and interflow components removed. The recharge through the cover or disturbed strata reports to a storage facility, where it is held and will accumulate until decant, if it is not abstracted for re-use. The areas isolated by pollution control dams will only contribute to the catchment runoff by means of spills during extreme rainfall events.

The question that is addressed in this paper is whether the removal of the interflow and groundwater flow component from the mining impacted parts of the catchment are compensated for by the additional recharge to the mine workings during and post mining as well as regulating storage provided by the pollution control dams and underground storage compartments.

4 APPLICATION OF THE WRPM

The WRPM was applied to the Witbank Dam catchment using the historic hydrology covering the period 1920 to 1995. The mine module in the WRPM has been set up for all the mines present in the Witbank Dam catchment. As discussed in section 2 of the paper, a mine will reduce the quantity of water reporting to the river system but a mine area, particularly an opencast area, will produce additional water compared to the natural conditions due to the increased recharge rate to the workings. The WRPM was applied to quantify these aspects as follows: -

- The historic firm yield of the Witbank Dam catchment was determined without any mines present. To achieve this the mine modules in the WRPM were removed and the mined area returned to natural conditions. The model was run for the 2005 land use level of development in the Witbank Dam catchment.
- The quantity of water that can be withdrawn from the mine workings at the Greenside and Kleinkopje Collieries was determined. The mine module was set up using the latest water balance information provided by a recent study of the mine water system on the collieries undertaken by Hodgson (2005). The WRPM was run for 2006, 2015 and closure mine development levels.
- The abstraction rate from the workings was set to only abstract the average recharge water from the workings. During low rainfall years some of the mine water stored in the workings will therefore be abstracted. This volume will be replenished during the above average rainfall years.
- In determining the volume of water available for supply to Emalahleni Local Municipality, allowance was made for the discharge of a portion of the water abstracted from the mine workings to meet the mine’s contribution to the Environmental Flow Requirements (EFR) for the Witbank Dam catchment.

5 RESULTS OF THE APPLICATION OF THE WRPM

5.1 Impact of Mining on Historic Firm Yield of Witbank Dam

The historic firm yields computed for the different mine development levels are listed in
Table 3. The modelling showed that the reduction in the yield of Witbank Dam due to mining at the 2006, 2015 and closure level of development for the mines is 1,2, 1,5 and 1,6 million m^3/a respectively. This represents modelled reductions in the historic firm yield (with no mines) of 3.4%, 4,3% and 4,6% for the 2006, 2015 and closure mining development levels respectively. This reduction is due to the removal of the interflow, and the groundwater contributions to the runoff volume because of mining. The reduction in yield from the 2015 to the closure level of development (lower than for the 2006 to 2015 case) is due to the lower percentage increase in mined area from 2015 to the closure level and the return of the runoff from the plant and co-disposal areas to the river system. The yield reduction for the Greenside underground mine sections is overestimated by the model as the interflow component is not completely removed by the underground mining and will still contribute to the surface water system.

5.2 Quantity of Water that can be Abstracted from Mine Workings

The abstraction rates from the mine workings were set in the model so as to only abstract the average recharge rate into the workings. During below average rainfall years, water will be abstracted from the volume stored in the workings to meet the abstraction rate from the workings. The volume stored in the workings being replenished during subsequent above average rainfall years. The plot of the modelled variation in the storage volume in the Greenside workings over time is shown in Figure 5 . The volume shows a cyclical variation around the start volume of 30 million m^3. The modelled abstractions from the workings are sent to a node in the model which represents the proposed desalination plant. Releases are made from the plant to meet the EFR when required. The water volumes that can be supplied from the mines after the EFR requirements have been met, are listed in
Table 5 . The analysis was done for the 2006, 2015 and closure mining levels of development.

5.3 Summary of results

The historic firm yields for the Witbank Dam determined for the different levels of mining development and the yield that can be obtained from the mine workings are shown in
Table 7 . The modelling shows that the reduction in historical firm yield of Witbank Dam due to mining is more than compensated for by the abstracted mine water for the three mining development levels analysed. The additional water represents an addition to the allocatable water resource which can be used to meet urban water requirements.

6 CONCLUSIONS

The following conclusions can be made: -

- The mines do make additional water that more than compensates for the reduction in yield of the Witbank Dam due to mining. The volume of water that can be abstracted from the workings is such that, even after supplementing the Witbank Dam EFR requirements, additional water is available to meet the urban water requirements in the Witbank area.
- The proposed project represents a reconciliation strategy that involves use of a local resource, addresses a potential water quality issue, meeting of the EFR and co-operation between water users within the Upper Olifants Sub-area.
- The project could be expanded to include other mining operations and represents a long term solution to the future post closure decants from the mines and reconciliation of the projected growth in urban water requirements.

REFERENCES

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Table 1: Summary of catchment and mining areas

Catchment		Area (km^2)
1.	Noupoortspruit: Total Catchment Mined area (2006) Mined area (2015) Mined area (closure)	 83 (90 including endoreic areas) 44,6 (53,7%) 47,2 (56,8%) 49,1 (59,1%)
2.	Brugspruit: Total Catchment Mined area	 187 16.9 (9.0%)
3.	Witbank Dam Incremental Total Catchment Mined area (2006) Mined area (2015) Mined area (closure)	 72 14,8 (20,6%) 18,7 (26,0%) 25,5 (35,4%)
4.	Tweefonteinspruit Total Catchment Mined area (2006) Mined area (2015) Mined area (Closure)	 339 6,4 (1,9%) 8,8 (2,6%) 9,1 (2,7%)

Table 3: Historic firm yields for Witbank Dam without any mines and with mines

Simulation Scenario	Historic firm yield of Witbank Dam (million m^3/a)
No mines	34,5
With Collieries (2006 level of development)	33,3
Reduction due to mining (2006)	1.2 (3,4%)
With Collieries (2015 level of development)	33,0
Reduction due to mining (2015)	1.5 (4,3%)
With Collieries (Closure)	32.9
Reduction due to mining (Closure)	1.6 (4,6%)

Table 5: Annual volumes that can be supplied from the treatment plant after EFR requirements have been met

Mine development level	Annual supply volume (million m^3/a)	Annual supply volume (ML/d)
2006	4,5	12,2
2015	5,6	15,3
Closure	8,2	22,4

Table 7: Summary of mine reduced historic firm yield and abstraction from working

Mine Development Level	Witbank Dam Historic firm yield (million m3/a)	Volume abstracted mine workings (million m^3/a)	Total Historic firm yield (million m^3/a)
2006	33,3	4,5	37,8

2015	33,0	5,6	38,6
Closure	32,9	8,2	41,1

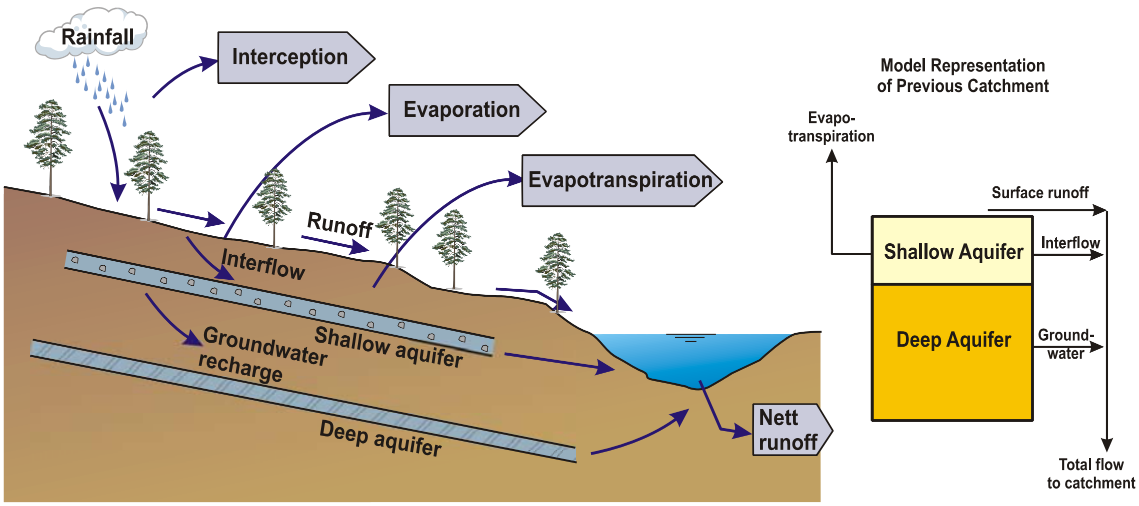

Figure 1: Illustration of the natural water cycle and its model representation

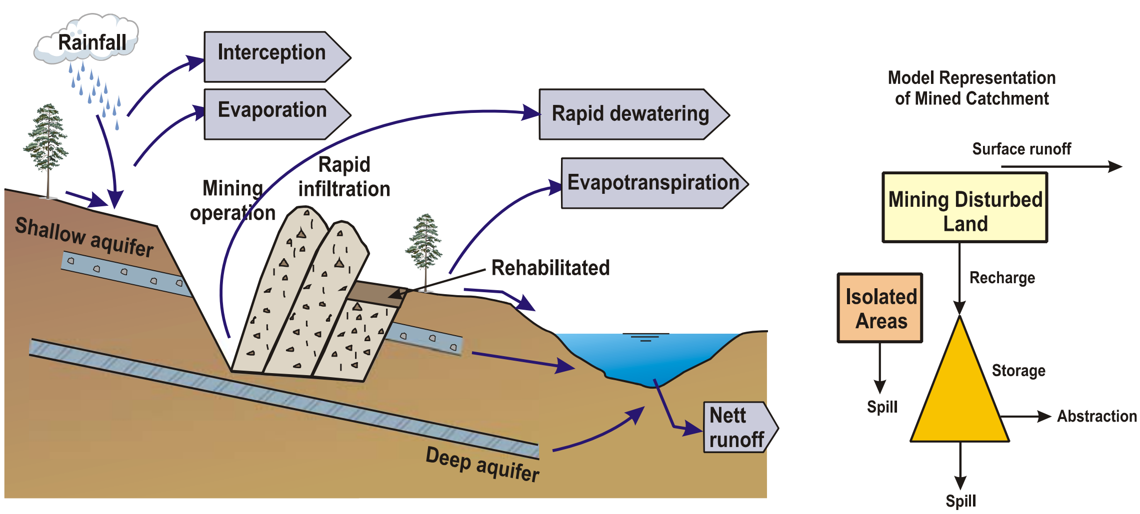

Figure 3: Illustration of impact of mining on the water cycle and its model representation

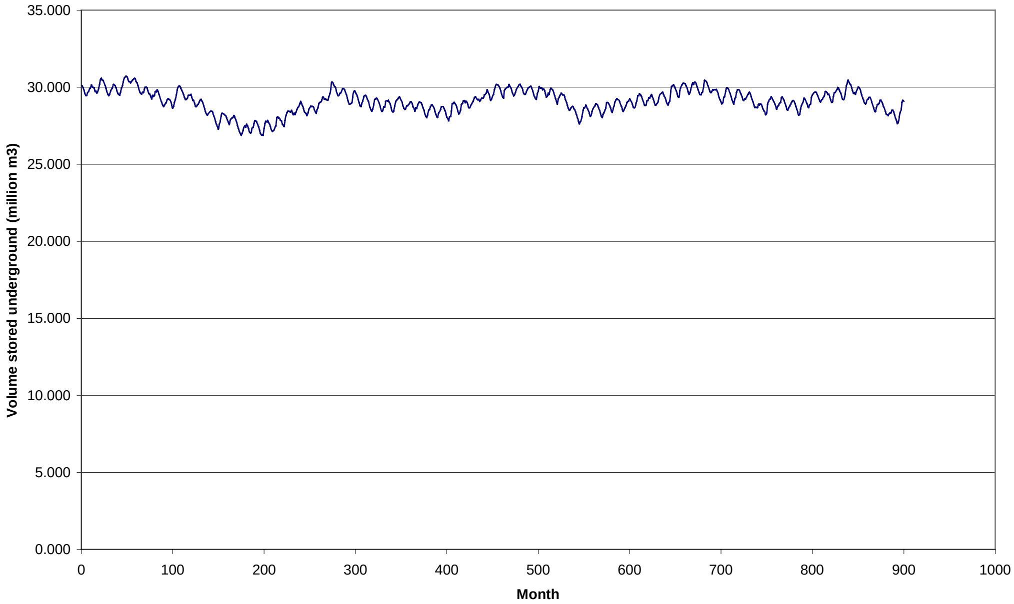

Figure 5 : Plot of volume stored in the Greenside workings for abstraction from workings of 4700 m^3/d