# Removing of High Flows of Acid Water from Disused Mines in Johannesburg

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## ABSTRACT

South Africa is currently dealing with the problem of acid water because underneath the old gold mining city of Johannesburg is a lake containing heavily contaminated water, which spreads horizontally and vertically into the abandoned pits of the former gold mines.

Meanwhile, the water line has reached a critically high level. The corrosive sulphuric acids can in the worst case scenario, result in a pH value of 2, which is enough to cause lasting damage to humans and the environment.

Two state-of-the art pumps have been running since June 2014 in the middle of Johannesburg city centre with each pump capable of bringing 1,500 cubic meters (=1.5 million litres) of water to the surface per hour.

Because of this corrosive acid, these pumps are a customised construction. The design is based on a proven double-flow technology, which uses the concept of a double-suction pump. By the counter-rotating arrangement of the impellers the pumps run without axial thrust. With this design, delivery heads up to 1500 m can be reached. Due to the corrosive acid, the Johannesburg pumps were redesigned. Part of the new system is an encapsulation of the submersible motors. This technology enables the creation of an internal pressure higher than the external pressure, preventing the intrusion of the corrosive water and the components inside the motor being attacked and possibly destroyed. The water being drained is used to cool the motor and if required the motor can be extended by additional heat exchangers.

**Keywords:** Mine Dewatering, AMD Acid Mine Drainage, Pumps for Mine Dewatering, Water Management, Submersible Motor Pumps

## INTRODUCTION

The city of Johannesburg located in South Africa was founded as a result of the Witwatersrand Gold Rush. Since 1886, when gold was discovered in the Central Basin, 40.000 metric tons – 30 percent of the gold of the world – have been extracted from the mines. The two deepest mines in the world are found in the Witwatersrand basin, extending nearly 4 kilometres below the surface.

While mining was operational, the inflowing ground water was pumped out of the mines by the ongoing infrastructure in place. But after the last mine closed down and pumping ceased altogether, the voids began to fill. The Western Basin filled and began to decant in 2002. Pumping ceased in the Central Basin in 2008 and in the Eastern Basin early in 2011.

These abandoned mine shafts of the former gold mines are gradually filling with water and need to be dewatered to avoid contamination of underground water and keep the water at an acceptable and safe level, or to bring this potentially contaminated water to surface for treatment.

Mine Drainage, has become an ecological issue and challenge. The metamorphic rock of the mining district contains abundant pyrite (iron disulphide) which reacts with oxygenated rainwater or groundwater resulting in elevated sulphate concentrations and eventually low pH values. With pH levels as low as two, the sulphuric acid mobilizes aluminium, potentially toxic metals and uranium from the rock and produces iron oxide as a by-product when the pH rises.

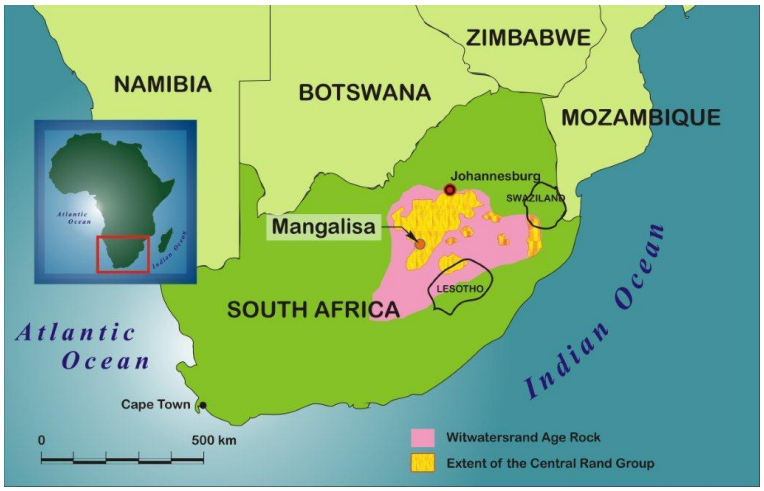


**Figure 1** Map of South Africa (from http://superiormining.com/properties/south_africa; 13.11.2014)

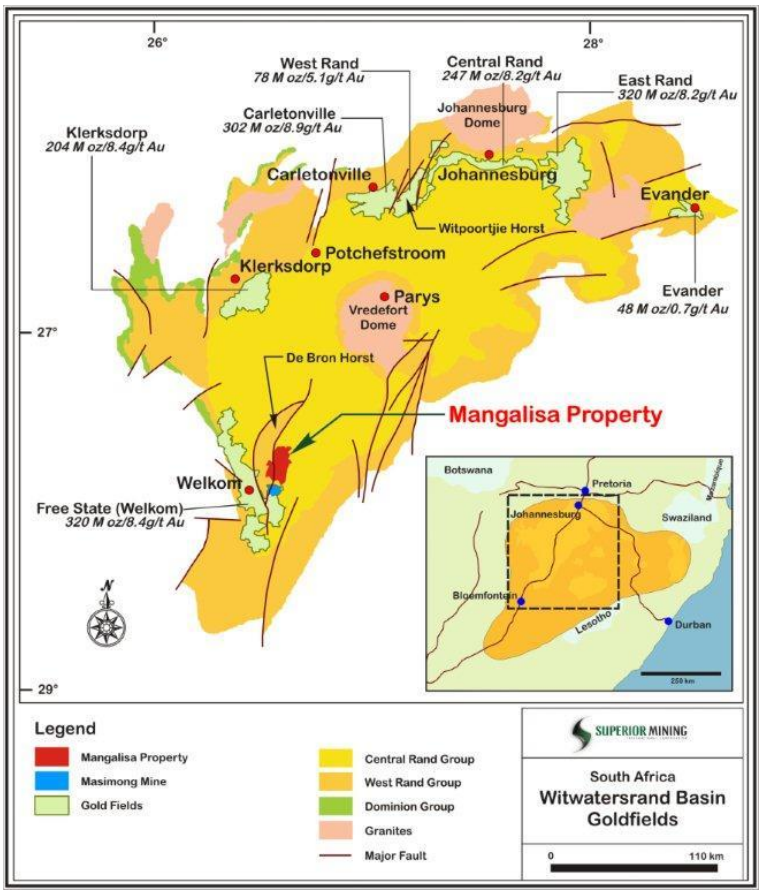


**Figure 2** Landscape of Witwatersrand (from http://superiormining.com/resources/maps/20120213_witwatrand_basin.jpg; 13.11.2014)

## RECOMMENDED MEASUREMENTS

Pumping out underground mine water to prevent reaching the environmentally critical level, controlling the ingress of water into mine shafts and in short term treating the contaminated mine water by neutralising the high acidity.

## CHALLENGE – PUMP SOLUTION

The responsible technical experts looked for a long term draining solution to face the problem. Two main challenges had to be matched in this issue.

The materials which are in contact with the mine water – metals and elastomers – have to resist the medium for a long time. Therefore, the best material to face the medium and the mechanical properties had to be chosen. Multiple material options were taken into account and qualifying tests were necessary. Therefore, the renowned institute FEM (Forschungsinstitut für Edelmetalle) rebuilt artificial mine water based on the chemical analysis out of the mine and put test materials for a term of three months into this medium. Additionally by using higher temperatures, the reaction time gets

faster and a longer period of time could be simulated to get findings of the long-term behavior of the materials.

As a result of these tests, the material selection was refined. Out of the remaining materials the materials with the best mechanical properties for the parts of the pump unit were chosen to enable a compact design of the pump unit.

The used duplex steels combine the features of stainless chromium steels (ferritic or martensitic) and stainless chromium-nickel steels (austenitic). They have those rust and acid resistant properties which are necessary to resist the medium influences. Further they have the required mechanical properties.

Nevertheless, the water analysis may always only be counted as a snapshot of the current situation. As caused by environmental influences the water composition may change. But due to the selected high value materials absolute safety and resistance in operation can be expected.

As a further step and in order to protect the motor of the pump unit against the entrance of the contaminated medium it has been designed encapsulated. That means that the motor is packed into an additional casing to protect the motor materials against the acid medium.

The motor itself is filled with drinking water and put under overpressure. Fresh water is led to the motor through a long pipe from a quench placed on surface. The pressure is controlled constantly and in case of abnormal pressure signals, messages are displayed. Further, the filling level, the flow and the head (*Q* and *H)* are also monitored. The pump performance can be watched from all over the world by remote monitoring. Selected and qualified persons can also change parameters if it is necessary.

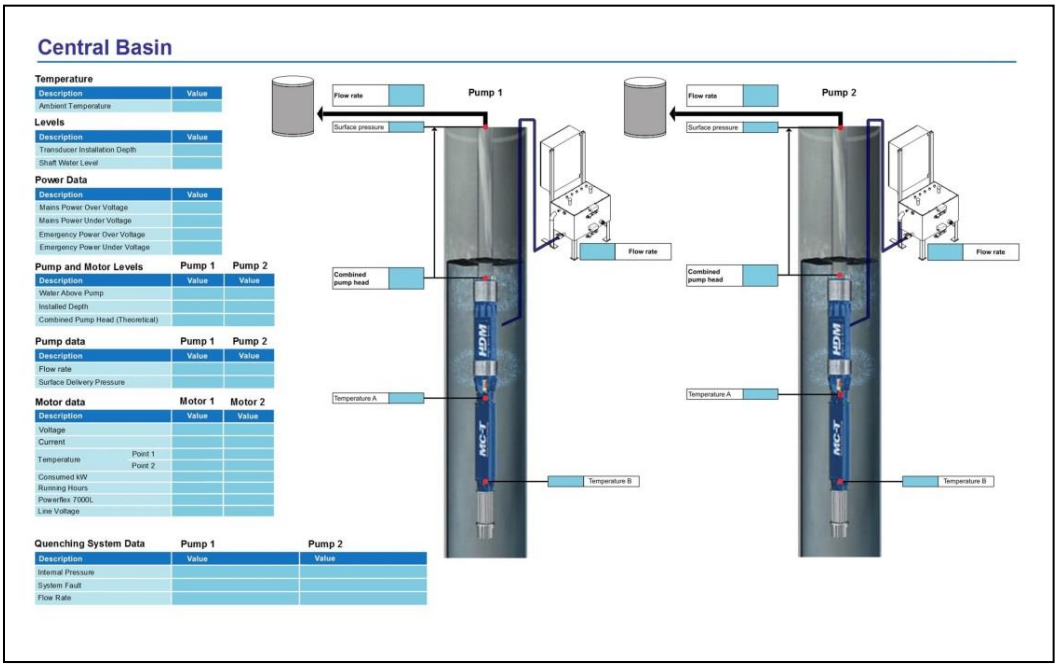


**Figure 3** Monitoring scheme

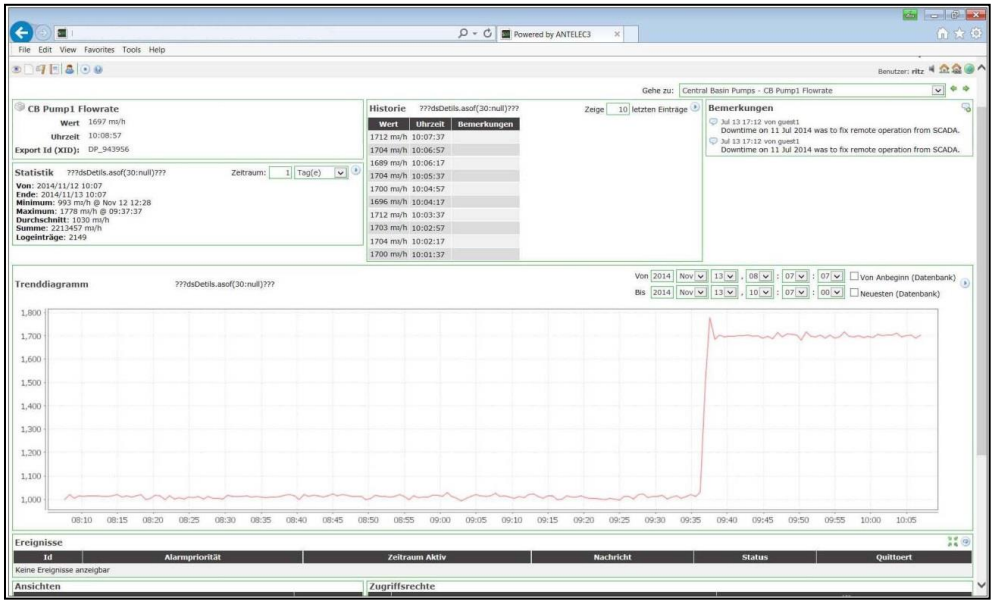


**Figure 4** Remote monitoring display

The mechanical seal is tailored to the requirements of that special application. The sliding surfaces of the mechanical seal are specialized and all components are also matched up to the medium. A special construction of the mechanical seal guarantees absolute reliability and best operational characteristics. It is also charged with the inner pressure from a quench.

Weather conditions like rain influence the medium level as experienced with ground water all over the world. The changing water level requires a specific pump hydraulic to drain the water. Additionally, the level gets more or less steadily lower because of the dewatering. The more medium is pumped the lower is the level of the contaminated mine water. So the pump has to have a widely spread operation range.

The pump works with medium 70 m below the level of the contaminated water. When the level has reached the next lower marking, the pipe is enlarged with another pipe part. For the planning team it was important that the pipe can be enlarged easily and without loss of time. Therefore, quick snaps are used. Additionally to the quick assembly they score with their compact design, low weight and less effort in comparison to conventional screw connections.

With every step down, the pump has to manage a higher pumping head. This has also been considered in pump selection. Furthermore, the pump is equipped with a cooling shroud to guarantee the necessary cooling flow.

The used double-suction design of the pumps reduces any axial thrust nearly to zero. As a result, the pumps are extremely persistent and nearly maintenance free. Some pumps of that type had run in best performance up to 25 years without the need of maintenance. But considering the critical medium the terms of maintenance are shorter in this case. In case of maintenance the use of the quick snaps show their advantages. The pumps can be disassembled and reassembled in a comparably short time.

All pump units are identical, they have the same hydraulic. At least one complete pump unit is stored disassembled at site; which means that one set of parts is immediately available. Additionally a number of selected spare parts are stored at site, too.

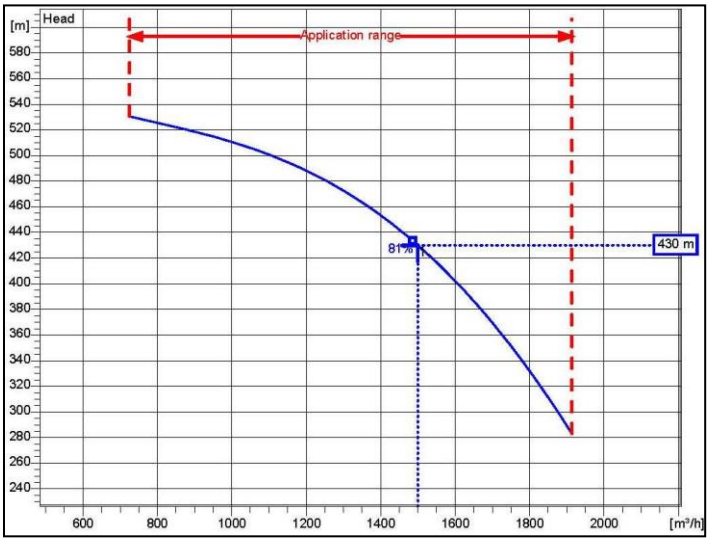


**Figure 5** Performance curve of the pump

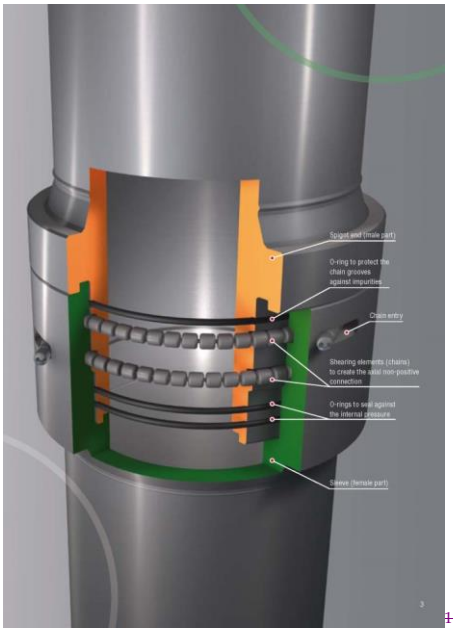

**Figure 6** Quick snap connection (from Carl Hamm Pipesystems; ZSM-Connection Brochure English; issue 07/13)

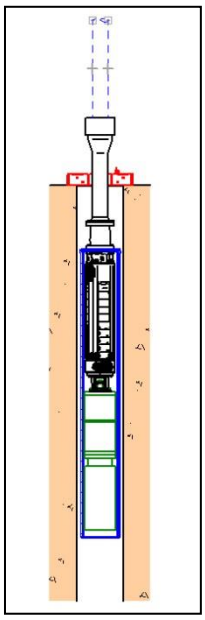

**Figure 7** Assembly scheme


**Figure 8** Assembly

## CONCLUSION – ECOLOGICAL ASPECT

The mine water is being transported to the surface and onwards into an adjacent treatment plant. There, through the addition of lime, the pH value is raised, the acid is neutralised and the dissolved metals in the water are (co-)precipitated as hydroxides.

The South African authorities are planning a total of three pumping stations, which will each be developed at the mines' disused extraction shafts. In addition to the Central Basin in Johannesburg's city centre, pumping plants for the Eastern Basin and the Western Basin are currently in progress. The long term measurement is to force the water level in the flooded mines back from its current level of approx. 200 metres to a depth of 1000 metres and to keep it there, to then be able to begin mining gold and gold ore in the drained upper layers of the mines once again.

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Carl Hamm Pipesystems; ZSM-Connection Brochure English; issue 07/13

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