

ABERGELDIE MINING PTY LTD

WHITE PAPER AND CASE STUDY OF DENDROBIUM MINE SHAFTS 2 AND 3



Sydney

5 George Young St, Regents Park NSW
PO Box 10, Regents Park NSW 2143
p: 02 8717 7777 f: 02 8717 7778

Brisbane

97 Old Toombul Rd, Northgate QLD
PO Box 135, Banyo QLD 4014
p: 07 3621 0000 f: 07 3630 4100

Newcastle

1/16 Huntingdale Dr, Thornton NSW
PO Box 326, Thornton NSW 2322
p: 02 4966 3899 f: 02 4966 3859

Canberra

1/92 Hoskins St, Mitchell ACT
PO Box 56, Mitchell ACT 2911
p: 02 6241 1755 f: 02 6241 0712

Introducing Abergeldie Mining

Abergeldie Mining was created in 2001 by Mick Boyle and John Zeni. The company was originally known as Ardent Underground until it became part of Abergeldie Complex Infrastructure™ in 2007. The company is an Australian leader in blind bore shaft drilling, a method of mechanised vertical drilling conducted by only a handful of companies worldwide.

Originally developed in Europe in the 1950's blind boring it was later used for nuclear detonation at the U.S Military's Nevada Test Site. Today, blind boring is primarily used to construct ventilation and access shafts for underground mining. Our goal has always been to provide a faster, safer and more reliable way of providing large diameter shafts.

Abergeldie own four sophisticated drill rigs which we have designed and built using cutting edge technology. Our rigs are designed to drill and line in ground conditions that have been previously considered unmanageable. In short, our equipment sets a benchmark for mechanised shaft excavation.

Abergeldie Complex Infrastructure™ is a diversified organisation and it can also provide other facets of mining infrastructure including civil, building and process engineering works.

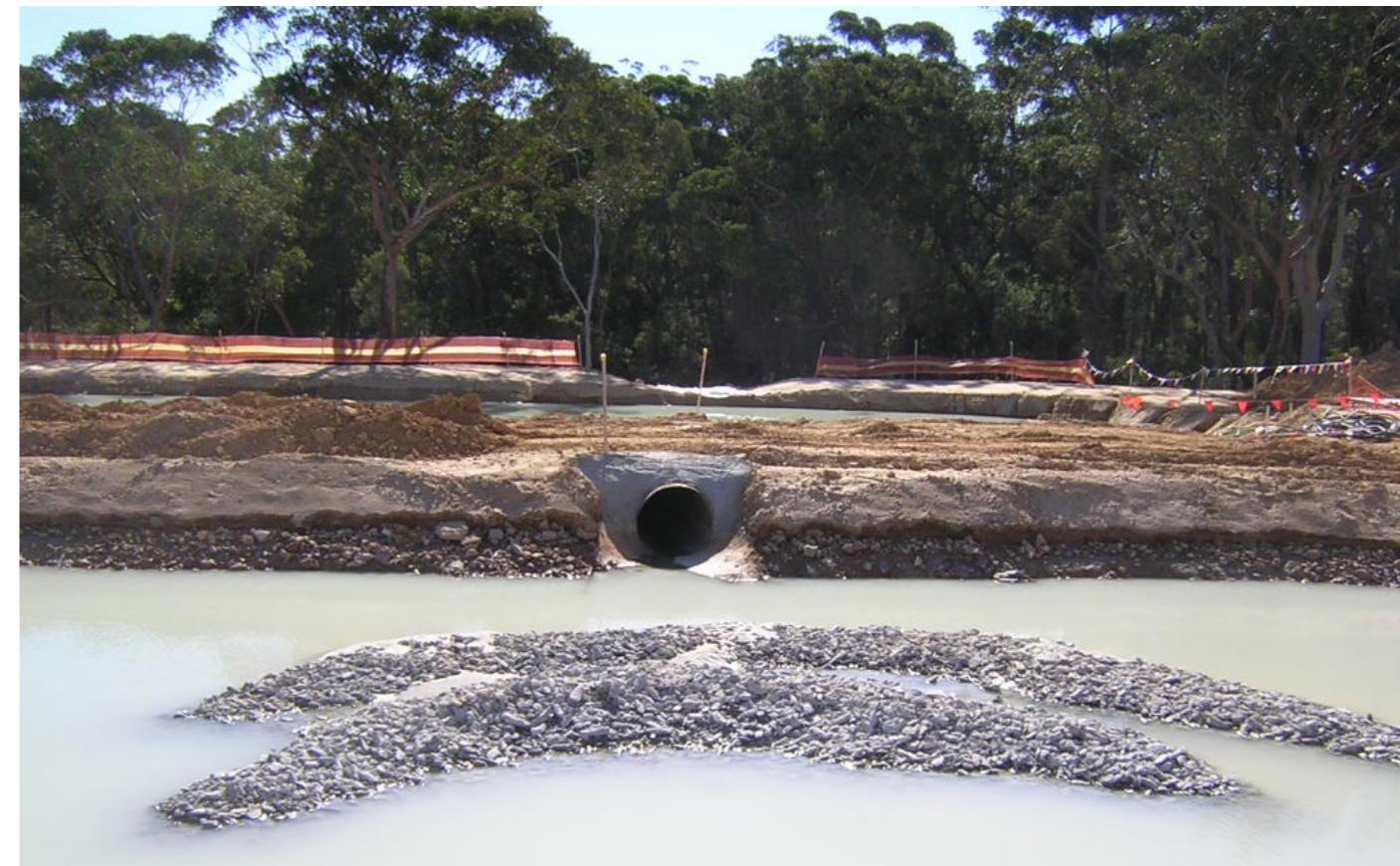


The Blind Boring Method

The blind bore shaft drilling method used by Abergeldie is an innovative construction technique and an alternative to the traditional methods of sinking deep and large diameter shafts, namely raise boring and conventional drill and blast shaft sinking. The technique involves drilling from the surface using the weight of the drilling assembly to apply force through rock cutters on the drilling head. The shaft is kept full of water during the drilling process. Water in the shaft does three important things:

- It provides a counter pressure to contain naturally occurring aquifers, oil or gas that might be encountered within the strata
- It reduces the risk of potential problems with sidewall stability; the water can be enhanced with additives to further support and condition exposed shaft walls which will preserve their integrity prior to the installation of the permanent shaft lining.
- And it allows permanent shaft linings to be installed and grouted under pressure. A balance or slight overbalance with the naturally occurring pressures in the ground eliminates water flow from the strata into the shaft that could otherwise wash away the cement grout.

Reverse circulation is used to force the spoil up to the surface through the drilling pipe where it is deposited into circulation ponds. The cuttings settle out in the ponds and the water is pumped back into the shaft in a closed loop system.



Dendrobium Vent Shafts 2 and 3

Abergeldie has utilised its blind boring method to construct three ventilation shafts for BHP Billiton Dendrobium Mine. Shaft No 1 was originally constructed in 2002. By 2007 Dendrobium Coal required two additional shafts to provide ventilation to the expanding operations of the underground coal mine. The ventilation shafts were bored at 4.81m and 5.91m diameter to provide fully lined shafts of 4m and 5m diameter both to a depth of 270m. The shafts needed to be designed for a life span of 50 years and were required to be smooth and fully hydrostatic.

The scope of work also included:

- Clearing and establishing an 11km access road,
- Electrical substation,
- Design and construction of three access bridges,
- Site clearing, fencing and establishment of a site compound,
- Water reticulation from Cordeaux Dam,
- Construction of settling ponds, required for the reverse circulation process,
- Design and construction of 174 liner segments, and
- Foundations for fans, shaft collar and the drill rig.

The Blind Bore method of shaft construction was chosen over more traditional methods as it completely removed the requirement for persons to enter the shaft during construction. This was the key safety objective of the project. There was also no interface with existing underground workings. The shaft was completed prior to Dendrobium Coal's underground drive reaching the location of the shaft bottom.



Site Mobilisation

The location of Dendrobium Coal Mine's underground workings meant that the ventilation shafts had to be situated on the Illawarra escarpment west of Wollongong, NSW within the highly environmentally sensitive Sydney Catchment Authority area for Cordeaux Dam. The actual site was less than 500m uphill from the shore of Lake Cordeaux. This location resulted in a number of environmental challenges. The first step was to establish an environmentally sound construction site around the proposed shafts. A rainwater runoff retention pond and surface water diversion was incorporated to control drainage and prevent contamination and a primary sedimentation pond was constructed to retain the waste rock.



Pre-grouting

Prior to the construction of No 2 shafts collar and drilling foundation, pre-grouting of on the level areas around the shaft was performed. Pre-grouting involved the use of a mobile drill rig to drill a series of holes in a circular pattern at 3m radius. The holes were drilled to approximately 60m depth except for two holes which were drilled for the entire depth of the shaft.

The holes were then filled with a cement grout mix to provide a grout curtain. The two holes drilled for the entire length of the shaft were drilled to confirm rock strata and permeability and need for further grouting.

The resulting grout curtain was implemented for two reasons:

- To minimise loss of water to the surrounding strata during the drilling phase as the shaft was kept full of water during the drilling phase; and
- Minimise ingress of water after the shaft was emptied of water. This was required to assist with the shaft lining adhering to the shaft strata; and to assist in minimising water ingress into the mine proper.

In total twenty five (25) pre-grout holes were drilled and grouted.

Shaft Pad and Collar

After demobilisation of the pre-grouting equipment, the shaft pad and collar were constructed. The shaft collar and pad are required to stabilise the top eight (8) metres of the shaft and to provide a base for the vent air fan duct elbow.

The collar was constructed by drilling a circular pattern of presplit holes at a 2.5m radius. Following this presplit, an excavator with a rock breaker attachment was used to construct a 5m diameter by 8m deep excavation. This excavation was called the pre-sink and was concrete lined to form a 4.5 metre diameter hole.

Rig Assembly

Upon completion of the No 2 shafts collar and pad, the drill rig was assembled on the pad and stabilized at two points to control deviation to within half a percent of depth. The drill rig consisted of a 450 tonne lifting capacity derrick. The derrick winch was powered by 2 x 160kW variable speed controlled electric motors. The drill head of the rig consisted of 6 x 55kW motors driving into planetary gear reducers combined onto a final drive helical gear.

The drill head consisted of cutting discs arranged in a hemispherical profile cutting head assembly. The cutting discs are not powered but rotate as the drill head is rotated due to friction of the strata on the discs. The drill head rotated at approximately 5rpm. Controlling the winch and drill head motors by variable speed drives provided precise control over torque and speed.



Shaft Excavation (Drilling)

The shaft was excavated using blind bore rotary drilling method. This method employed an assembly of drill weights attached to the drill head to maintain drilling pressure on the cutting face. The cutting discs crushed the rock immediately beneath each disc to create concentric troughs in the strata. The rock between each cutter breaks in tension as the troughs created by the discs reach a critical depth. This depth depends on the strata type.

Throughout the shaft drilling phase, the vent shaft remained full of water. Rock cuttings from the bottom of the shaft were transported from the cutting face through the 500mm diameter drill pipe where they were discharged into a sedimentation pond. Negative pressure was induced in the drill stem by introducing air bubbles into the drill string near the cutter head via a small diameter air tube. The resultant rising air bubbles created pneumatic lift and expelled the cuttings at the surface. The picture below shows the discharge hose from the top of the motors down to the pond. After sufficient retention time to allow the solids to fall out of the water, the water was then returned to the shaft by a return water pump to complete the circulation system.



Shaft Lining

Both shafts were lined using fully hydrostatic composite steel and concrete liners. This meant that on completion we were able to provide a completely dry shaft. Abergeldie constructed 174 composite liners, including welding of steel sections and casting of concrete lining on site within the environmentally sensitive Sydney Catchment Authority lands.

The composite steel and concrete liners used by Abergeldie are not provided by anyone else in Australia. The installation of the liner was a technically complex process involving the fitting of a 'stem' of liners weighing in excess of 2000 tonnes. As the capacity of the drilling rig was limited to 450 tonnes, the liners were installed from the surface with the aid of buoyancy by 'floating' them into the water filled shaft. This involved first placing a liner full of concrete (known as the plug) into the shaft and sequentially welding liners on top of the stem before lowering them into



the shaft. By then carefully placing calculated quantities of water into the liner stem as the liners were installed, the balance of hydrostatic pressures was used to keep the weight on the rig at around 150 tonnes.

Once shaft No 2 had reached the intended depth and the shaft lining had been installed and grouted, the water was removed and the drilling equipment was demobilised and relocated to shaft No 3 to repeat the process again.

The site was then rehabilitated in preparation for the installation of the mine vent fans.

The project was completed within the required timeframe and received an internal BHP Award due to safety and environmental performance during the project

Innovations During the Project

The traditional cutter type for blind boring has been a ring type cutter which is best suited to fracturing hard rock. However, the strata at the Dendrobium site were relatively weak (Although highly abrasive) sandstones, conglomerates and shales. An innovative soft rock cutter was developed by Abergeldie. This cutter could fit into the housings for the ring type cutters, removing the need to make major modifications to the drilling head. The soft rock cutter proved to be highly effective both in drilling rates and the wear rate on the cutters.

Advantages of the Blind Bore Method

The shaft can be completed prior the mine workings reaching its location, as all work is completed from the surface. The mine can work its way to the shaft, which can be ready and waiting to provide essential ventilation straight away. This is not possible with raise boring, which must have access to the mine to enable it to be carried out.

Drilling in difficult ground conditions or strata with high pressure aquifers is possible. Because the shaft is full of water throughout the drilling process, the water pressure assists in maintaining the integrity of the strata that is being drilled, and will counteract the effect of aquifers.

There is also the opportunity to use a drilling 'mud' with additives such as salt or polymers that stabilise the unstable strata.

Safety is greatly enhanced as there is no need to enter the shaft during its excavation and lining. Conventional drill and blast shaft sinking has major risks associated with working in the shaft during the construction period.

Spoil Management - Spoil is deposited on the surface and can be conveniently stockpiled after it is removed from the circulation ponds. It does not require the spoil to be taken out through the mine.

Cost Savings - When attempting to construct large diameter shafts using conventional sinking methods severe delays, cost overruns and safety hazards are likely to be encountered. Blind bore shaft drilling is nearly always cheaper over time when the savings recouped from less delays, reduced OH&S risk to personnel and the reduction in shaft maintenance is properly compared.

Environmental - During the entire blind shaft drilling and lining process, the water level inside the shaft is maintained at or near the surface. In some situations, keeping the hole filled with water eliminates the requirement for expensive ground freezing or grouting treatment that might otherwise be required prior to the start of shaft construction.

The Abergeldie Difference

Abergeldie has drilled shafts up to 6.5m diameter and 400m deep. Our shaft lining options are specifically tailored to provide economical and permanent support of the shaft wall through any ground conditions. Our lining options include:

- Remotely applied shotcrete for reasonably dry strata,
- Non-hydrostatically designed steel liners or precast concrete segments as an economical solution in ground with significant aquifers, and
- Hydrostatically designed steel or composite steel and concrete liners for completely watertight shafts through virtually any strata including severe ground conditions and high pressure aquifers.

Abergeldie Mining possess the technology carry out the most rapid and safest access to underground mines. The Abergeldie drills provide a reliable machine to bore shafts that are deeper and wider than previously thought viable and they were designed with the aim of:

- Reducing risks,
- Compliance with mine OH&S requirements,
- Environmental control and monitoring, and
- Distancing employees from work face hazards.

Abergeldie provide our clients with a total shaft drilling, lining and associated infrastructure package that includes all complex process and civil infrastructure. Contact us to discover how Abergeldie can assist with your complex infrastructure requirements

www.abergeldie.com