19 August 2015

Submission to Hazelwood Mine Fire Inquiry
Medium and Long Term Rehabilitation Options for Latrobe Valley Mines

Introduction

GHD offers this contribution as a long term supplier of engineering, environmental and mine design services to the mining industry and government in the Latrobe Valley and around the world. This submission is not made on behalf of any of the existing mines or mine development proponents, nor does it aim to represent mine rehabilitation options for any of the mines in the Latrobe Valley. However this paper aims to raise a number of issues related to the rehabilitation of these mines that are important for consideration to help achieve safe, sustainable mine closure plans can be implemented for the long term benefit of Victorians. GHD is concerned that the government approach of requiring finalisation of mine closure plans many years before the completion of their life, may not lead to appropriate or optimal solutions as insufficient knowledge is available to help achieve designs that will be sustainable in the long term. Investigations and research is needed to advance the level of knowledge necessary to attain the best solutions for the long term.

GHD would be pleased to discuss issues in greater detail should this be requested. A summary of our conclusions is provided on page 12.

Background

The Latrobe Valley contains extensive low cost brown coal resources of global significance. These resources have powered the Victorian economy for more than 85 years. Importantly, with the development of new conversion techniques to suit a carbon constrained world, the future use of these resources offers great potential for future development.

Mines in the Latrobe Valley are among the largest in Australia and utilise highly efficient continuous mining techniques. The mines are large and deep with long project lives, with the current mines possessing between 35 to 80 years of continuous operation. Critical to the approval for the operation of existing mines or for new mines is the planning for progressive rehabilitation and mine closure that provides sustainable long term uses beyond mining.

The practice of progressive rehabilitation of external and internal (inside mine void) overburden dumps is well established and many overburden dump areas have been successfully returned into the natural environment. These dumps have had a variety of rehabilitation works including direct seeding to natives, natural regeneration and weed control as well as grassland sown into topsoil or overburden profile. The development of wetlands and the use of appropriate native species (flora and fauna) in rehabilitation solutions is also practiced widely.

Figure 1 Typical rehabilitated external overburden dump.

However, there are few examples of satisfactorily rehabilitated mine voids in the Latrobe Valley. Figure 2 is typical of a mining void created in an advancing mine.

Figure 2 Mining Voids have different challenges

Successful and appropriate mine rehabilitation, particularly of the worked out mined voids, is of great significance to regional land planning. A rehabilitated land form that provides a sustainable land use to balance available coal and water resources and that can incorporate the needs of local communities would be ideal. However as there is insufficient overburden waste to completely fill these worked out mines, finding complete or a substantial number of rehabilitation solutions for the remaining voids is difficult. In addition the depth of the mines, thickness of coal in the final mine batters and pressures in deep aquifers, make determining practical end use solutions a challenge. At this time there are a number of “known unknowns”, some of regional significance, that are a further complication to finding suitable sustainable long term solutions. Leadership is required from government with the active participation of mining companies to investigate these issues so that optimal and sustainable solutions can be found. Flexibility in the current process is suggested as better long term solutions and outcomes could be established following further investigation. This should be preferable and appealing to all parties.

With a focus on individual mine rehabilitation plans, regional opportunities or requirements are likely to be ignored and benefits lost for Victorians. Attempts by the SECV to develop a regional rehabilitation plan do not appear to have been advanced since privatisation. Since that time a number of innovative regional solutions were discussed in the LV 2100 Coal Project (2005). These included the potential to reduce the use of external overburden dumps for new mines and also suggested engaging the community in discussions about possible mine rehabilitation options on a regional scale. Regional issues were also discussed in a report for government in 2009 (Mine Rehabilitation Options and Scenarios for the Latrobe Valley – Developing a Rehabilitation Framework). It is suggested that if these studies and recommendations had been advanced this would have assisted in the development of individual mine rehabilitation options at this time.

Having said this, practical options are required for the final land form utilising the available overburden waste and water to achieve safe and stable solutions that can be sustainable for the long term. Mine closure options examined by GHD include: Mine Flooding, Lowered Landscape and the treatment of batters above the lake or in-fill dump. GHD has also given consideration to the requirements for long term geotechnical stability and the potential for on-going aquifer pumping requirements. It is in this area that a number of “known unknowns” exist.

Mine rehabilitation options include grazing, forest or industrial lands; flora or fauna habitats; water storage, water treatment, or fish farming; walking, hiking or climbing tourism; and other recreational activities.

Regional Implications with the rehabilitated mines

The large size of mines in the Latrobe Valley mean their rehabilitation is of regional significance. The mines span areas where roads and railways once existed and some rehabilitation options are likely to involve integration with the river system. Rehabilitation options provide opportunities for the region, including re-routing transport corridors, industrial zones, farming land, plantations or water storages. Within reasonable and economical bounds the mines should be rehabilitated to fit into a commonly agreed long term vision of the Latrobe Valley. GHD questions how the current request for individual mines to finalise their rehabilitation plans can fit into a regional vision if that vision and strategic / holistic approach hasn't been developed.

A number of examples follow where it is suggested government should take leadership in planning activities and discussion with mine operators: -

- Preparation of a regional mine rehabilitation plan that is acceptable to the community, mines and government.
- Government might prefer parts of a mine to be rehabilitated to near natural surface to accommodate aspects of regional development e.g. interconnecting roads.
- As mining companies are issued licences within a boundary that often is not beyond an economic limit of coal mining the future extension of the mine into adjacent coal areas may be contemplated by government, or by prospective miners. In these cases rehabilitation of the adjacent mine faces could be deferred until after the new mine development is commenced unless this is not expected for many years.
- Aside from the short term practical and cost implications on when to commence internal overburden dumping, a related question is the implication of sterilizing unmined coal resources beneath the base of the planned mine. Unless mining the deeper coal is considered viable in the short term, proceeding with internal overburden dumping early will assist in providing a rehabilitated mine site with long term stability.
- For new mines there will be the requirement to commence operations with an external overburden dump, at least until the base of their new mine is reached and sufficient area is created. During the development of a new mine a logical solution is to utilise the void space within an adjacent mine for overburden dumping. There are Win-Win opportunities for both mine operators if this could be arranged.
- For existing mines it is difficult to predict the future deep aquifer pumping (by others) after their mine closure. Hence it is difficult to predict the long term aquifer water pressure so important to the long term stability of a mine void. Government should consider the longer term need for water and the sustainable aquifer levels they would likely approve. This is important to determine the long term stability of the rehabilitated mine.

Final Land Form and Approval

A prospective mine operator is required to include a rehabilitation plan as part of the mine Work Plan application. The focus is often on the rehabilitated uses for the closed mine that could be 10, 20 or even 50 years into the future. More important in the planning stages is to identify a safe and stable final land form, rather than the eventual uses of the rehabilitated mine site as these can be more effectively decided closer to the end of these long life mines.

The appropriate Final Land Form for a rehabilitated mine area should ensure: -

- The mine rehabilitated areas are safe and stable;
- Minimise fire risk from exposed coal seams;
- It optimises the recovery of coal and the use of water resources;
- Reduce the need for continued pumping from regional aquifers; and
- Provide the community with a rehabilitated land area with opportunities for land uses that are safe for use and sustainable into the future (i.e. provide a lasting legacy to the community.).

Whilst the Final Land Form needs to be part of the mine design it is important that there is enough flexibility to modify the plan from time to time based on new mining requirements and where better ways to create the Final Land Form are identified.

Progressive rehabilitation should be carried out during the life of the mine as areas are worked out. This particularly applies to external overburden dumps, but should also include placement of internal overburden dumps and rehabilitation of worked out parts of the mine.

When a mine is constructed in a safe and stable Land Form, a significant number of alternative long term uses of the area are likely to be possible. This means the design should be flexible enough so that the rehabilitated mine area can accommodate those options found to be desirable at the end of the mine life. Many of the mines can have lives of more than 50 years so it is difficult at the start of operation to predict desirable sustainable options at the end of life. The area could be used for water storage; flora or fauna specialist habitats, forestry, agriculture, industry; waste; or even for tourism - concerts, rock climbing or trail biking. Ponds could be used for storage, water treatment, fish farming etc. The appropriate mix can be decided prior to the final mine closure activity. The environment management committees at each mine provide a forum for identifying the final rehabilitation solution.

Large Mine Rehabilitation Options

There is likely to be no single mine rehabilitation option to suit any of the current or potential future mines in the Latrobe Valley.

As the majority of material excavated from each mine has been coal there is insufficient overburden or interseam to refill the mines back to the natural surface. For a mine with a 3 (coal) : 1 (overburden + interseam) ratio, less than one third of the material mined would be available for backfilling). GHD has examined a range of options that could be utilised to suit mine site rehabilitation in Latrobe Valley mines. These include Mine Flooding; Lowered Landscape; the Rehabilitation Treatment of Batters above the lake or infill dump; and a Long Term Pumping Solution. These are discussed below:

- **Mine Flooding Option**

As it is not possible to totally backfill the large and deep Latrobe Valley Mines with waste overburden or interseam, the potential of filling the mine with water should be part of the consideration set. At least a small lake would have to be incorporated in any rehabilitated mine option to manage collected rainfall or seepage. The lake could be contained below the natural surface depending on the mine catchment area, rainfall and evaporation. Where there was sufficient water the internal water level could match river levels. This arrangement could allow interconnection with nearby river systems or be used to regulate river flood flows during extreme events. There are a number of worked out brown coal mines in Germany that have successfully used this method as a rehabilitation strategy (Figure 3).

Figure 3 Interconnected work out lignite mines in Germany

This option reduces the requirement to treat all of the coal batters to minimise fire risk. However as these mines are large and deep it might be difficult to find sufficient water to fully flood any mine within a

reasonable rehabilitation period. A large catchment area will also be required to replenish evaporation. Where a river is interconnected with the mine this could provide flood relief to downstream areas. Catchment Management Authorities with their single focus are unlikely to support such a solution at this time. While this may not appear feasible today, the future may allow the consideration of a large water storage and a flooded mine could become a highly valued community asset in the future.

- **Lowered Landscape Options**

An alternative to fully flooding the mine during the rehabilitation phase is to create a lowered landscape within the mined out area. The lowered landscape would be attained after partial backfilling with overburden and interseam, and with associated small water storages. There needs to be sufficient backfilling with overburden, interseam or water to help achieve long term mine stability from deep aquifer pressure. Some aquifer pressure controlling pumping may also be needed on an on-going basis. A lowered landscape could be 50m or 100m below the previous natural surface. As the mines are extremely large, this lowered landscape could fit well in the overall Latrobe Valley landscape of rolling hills, valleys and lakes. On the base of the mine, internal overburden dumps could be shaped and rehabilitated. The lowered landscape could potentially be used for agricultural cropping, grazing or plantations or industrial purposes. With small lakes the land could be similar to other parts of the Latrobe Valley. The lakes could be balanced with catchment inflows matching evaporation or some pumping of collected surface water may be required (Figure 4).

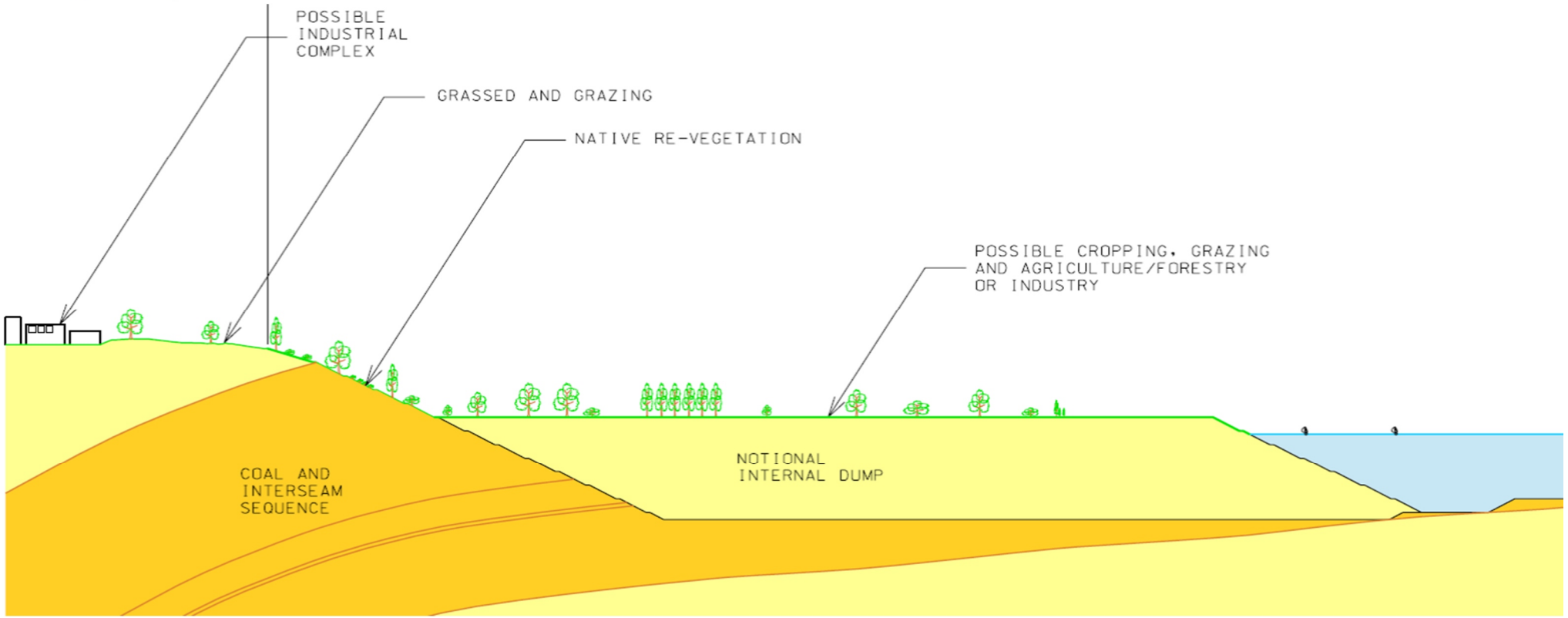

Figure 4 Lowered Landscape option

- **Rehabilitation Treatment of Batters above the lake or infill dump.**

In a lowered landscape rehabilitation option, above the lake or infill dumps, there are likely to be exposed overburden, coal and interseam batters at the end of mining. Coal and overburden batter slopes near the top of the mine will require some treatment to reduce fire risk, fretting and dust emission. As each mine is different, it is difficult to propose a preferred solution. The challenge for mine planners and for government is to find appropriate solutions for each (often unique) situation rather than being prescriptive.

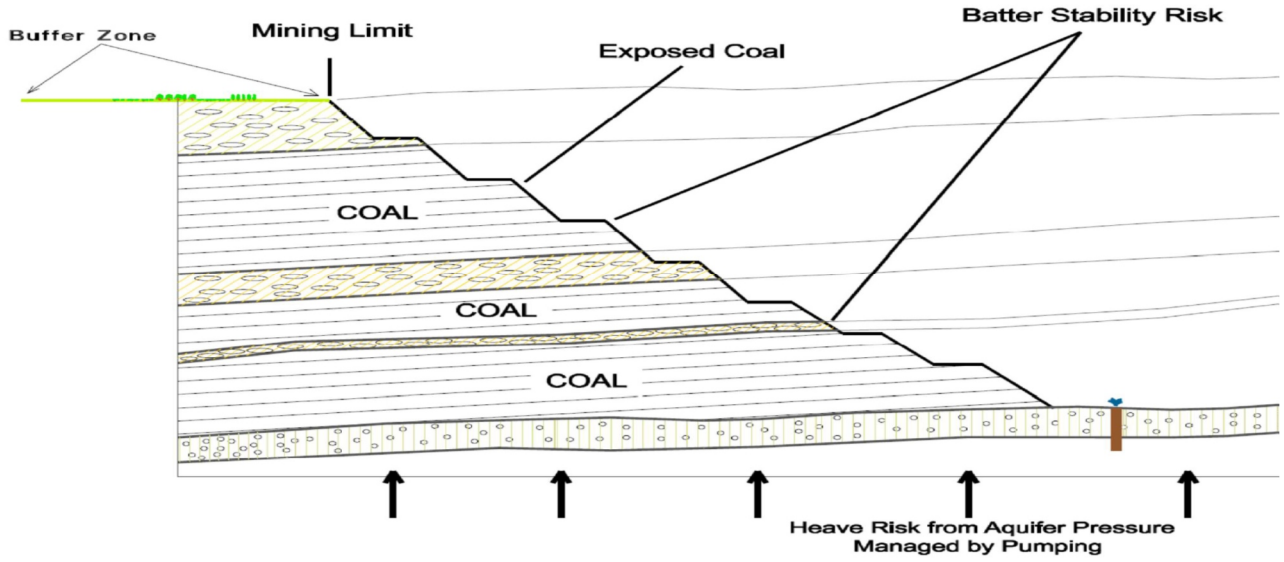

Figure 5 Mining Faces

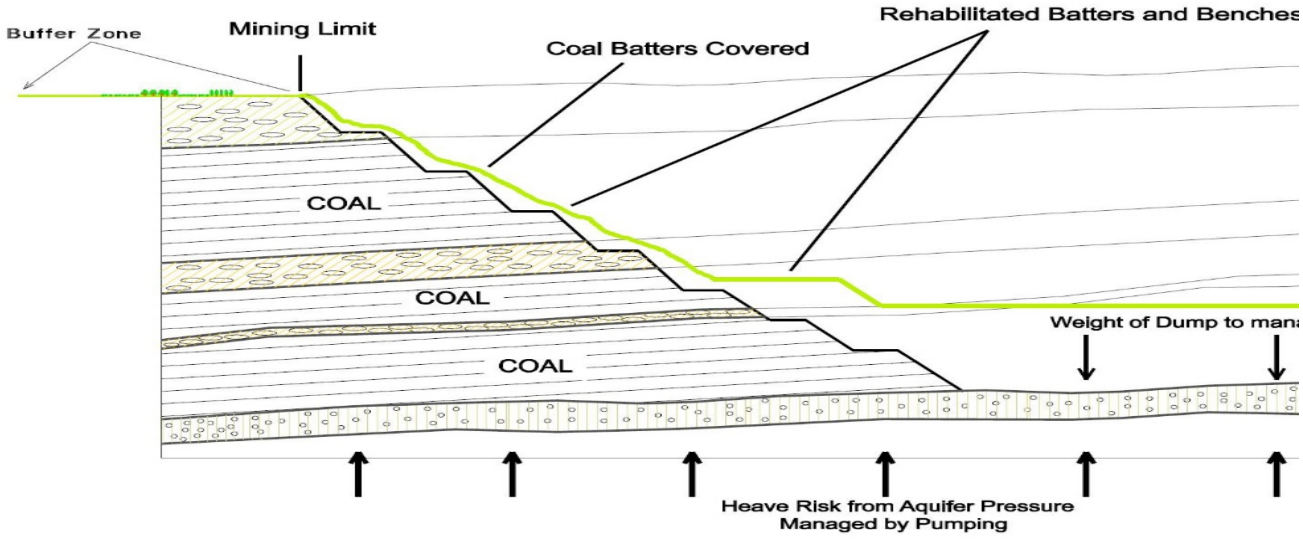

Figure 6 Potential Rehabilitation of Mine Void batters

A range of solutions have been considered by GHD to rehabilitate these batters including:

- Flattening individual and overall batter slopes

To maximise coal recovery, mine plans often result in an overall final mine batter slope of about 1V : 2H (1 vertical to 2 horizontal) to 1V : 2.5H with individual batters at 1V : 1H (i.e. at a slope angle of 45^{o}). Government regulators expectations are a much flatter final batter for the rehabilitated mine (maybe 1V : 3H). The reason for suggesting the overall batter should be at this slope is not clear. It should be noted that there are many farmed slopes in the region with a steeper slopes than 1V : 3V.

Flattening batters by any method can be quite expensive unless designed to be accomplished as part of the mining operation. Flatter individual batters can be achieved by cut, fill or cut and fill. If it is necessary to cut back the batters, this will require the removal of a lot of coal and potentially the need to push the crest of the mine back, beyond the work plan, into the buffer zone or closer to regional infrastructure.

If the rehabilitation strategy is to have flatter batters, mine planning could set the final rehabilitated crest position and restrict mining of deep coal that could have been achieved with a steeper batter system. This could mean a reduced coal recovery, affect mining economics and result in sterilisation of coal resources.

If filling is chosen as a solution to create the final batter slope this will require substantial overburden or interseam to be transported to the site.

- Covering flattened batters

Once the batters are flattened they could be covered with a thin layer of overburden sub soil and top soil, to reduce the risk of fire in exposed coal and provide a suitable rehabilitated surface capable of supporting vegetation.

In most mines there is limited overburden available to cover exposed batters, and the cost of transporting and placing this material will be large. For a batter with say a 50 m depth of exposed coal and with 2 m of covering, the quantity of overburden would be about 320,000 cubic metres / km of batter length, ignoring requirements for benches, and would cost millions of dollars and in some instances may compromise the overall batter stability through impeding groundwater drainage.

- Design issues

There are a number of issues that need to be considered for any of these flattened batter design options. These include:

- How to manage fire risk;
- how to avoid erosion of the covering material as a result of rain, wind and other factors;
- How to prevent covering material from slumping;
- How to prevent wave action erosion where the fill is at or below a future lake level and how to manage the long term stability of the batters.
- Availability of growth mediums for rehabilitation (topsoil and topsoil alternatives)

Mine Safety Implications for the Final Land Form

The main management issues for a safe and stable Final Land Form include:

- **Public Safety**

This needs to be a key priority for any rehabilitation plan/option that are considered.

After mining has finished, it is important that the mine closure design provides safety for those utilising the rehabilitated mine areas, or restrict access to areas where the dangers are not significantly reduced. Potential public safety risks include steep or high batters; deep water; poor access etc.

Closure planning should incorporate an agreed Land Form, which provides a long-term safe environment through maintaining stability of the mine base and batters, and the risk of fire and flood is similarly controlled.

- **Floor Heave**

The Latrobe Valley mines are extremely large and deep and their safe operation depends on appropriate management of the deep aquifer pressure level. During mining with the removal of coal, interseam and overburden weight there is the need to minimise the risk of mine floor heave from the uplift pressure of deep aquifers. During mining, pump bores are used to extract aquifer water to reduce uplift pressure sufficiently below the weight of the remaining material above the aquifer, so as to reduce the risk of heave. The same principles apply to the rehabilitated mine prepared for mine closure.

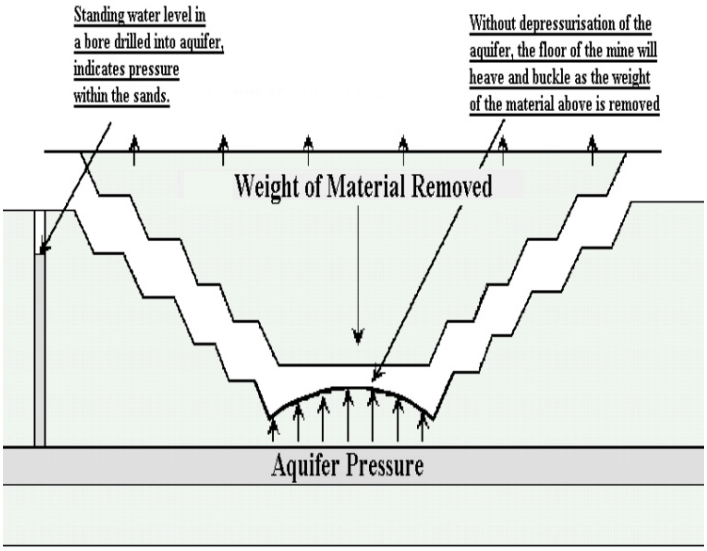

Figure 7 Simple Heave model at the base of a mine from aquifer pressure

Depending on the final land form and the aquifer pressure regime in the longer term, some aquifer pumping may be necessary to maintain the stability of the rehabilitated mine.

For mine closure a range of strategies are likely to be used, including:

- Backdumping of overburden and the use of small ponds to create a landscape, lower than natural surface, and / or
- Some level of flooding within the mine.

During the transition period from full mining to mine closure, continued aquifer pumping is likely to be needed to keep aquifer pressure levels below critical balance levels until internal overburden dumping or flooding create an adequate weight to counteract the uplift pressure.

The aquifer pressures within the mine will rise as pumping is reduced after closure. In the short to medium term the expected rise in aquifer pressure can be predicted and would be expected to be included in the mine closure stability plans. However over the longer term pumping from aquifers in adjacent mines will change, and as these aquifers are connected across the Latrobe Valley the aquifer pressure in the rehabilitated mine area could rise further.

It is unlikely that the aquifers would return to pressure levels pre-mining, because water is being extracted for many purposes (mining, agriculture, power, oil and gas removal, town water supply etc.). A target aquifer pressure level is needed for both mine and government assessment of the long term stability of the mine. If the aquifer pressures rises above the level where heave could occur this will lead to instability in the rehabilitated mine and pumping bores would need to be installed to manage the aquifer pressures.

Predicting the future aquifer pressures across the region, when considering all of the long term factors, has not been completed and is beyond what could be expected of individual mines. Government should take the

lead and define a reasonable acceptable aquifer pressure level that each mine should consider in their final rehabilitation plans.

- **Stability of the coal batters**

Prior to mining the stability of the batters includes an assessment of the safe height and slope; the investigation of any weak layers; as well as controlling and monitoring ground movement and pore water pressure. Whilst there are a range of geotechnical issues requiring management during the mining activity, probably of major concern in the rehabilitated mine is the potential of movement of coal blocks sliding on interseam layers within the final batter slope (Figure 8).

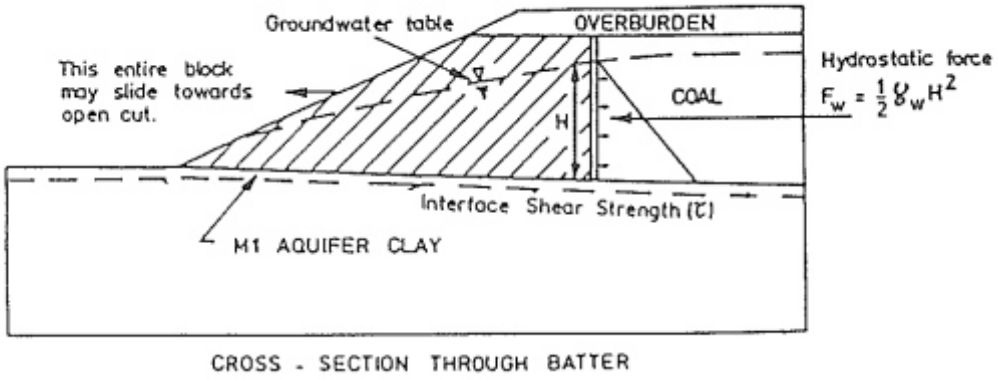

Figure 8 Block sliding mechanism in permanent batters

During the mining operation, considerable attention is placed on reducing the water pressure within vertical joints in the coal as this is very influential on the stability of the coal faces. Surface cracks are sealed to reduce the potential for water ingress into coal cracks and horizontal bores drilled many hundreds of metres into the coal face have been used to aid drainage of the joints.

For the rehabilitated mine proper geotechnical design of the mine and overburden dump batters is also required to help achieve appropriate stability. Batter stability conditions are likely to differ after rehabilitation as the result of changes to the slope and height of the batters, clay or overburden covering of coal batters, partial backfilling of the mine by overburden and interseam, or by flooding. However, despite these differences, as the majority of the final batter slopes in Latrobe Valley mines are within unmined coal seams, there will be the risk of block sliding failure batter stability if coal joint water levels rise.

There has been a recent emphasis by Government regulators on the need to reduce the slopes of mine void batters to 1V : 3H. It is difficult to ascertain why this standard is being set other than appreciating that it could make covering the coal with overburden and working the rehabilitated surface easier by agricultural tractor. Whilst the reason for this slope is unknown to GHD, it should be pointed out that a 1V : 3H slope in coal may not be more stable than a steeper batter due to overall failure mechanisms and drivers. In addition a thin layer of overburden or interseam laid over the coal batter will not change the stability significantly, in fact there is the potential that unless the overburden is highly porous it could worsen batter stability by preventing drainage from the coal section of the batter.

Horizontal drains found to be effective in draining coal joint water levels during mining are likely to be required during the life of the rehabilitated mine. It is not known how effective these drains will be over time or whether they will need to be replaced from time to time. Research is needed here.

- **Fire Risk**

As there are extensive areas of exposed coal on working faces, benches, batters and along conveyor corridors the risk of fires is present in any Latrobe Valley mining operation. During mining fire suppression systems are used to lessen the risk of ignition and to control the spread of fire is exposed coal areas. Once an area has been mined through, clay covering of benches can be used to further help lessen the risk of ignition in these areas. Operational manning and trained fire crews need to be on hand to immediately tackle any outbreak with quick access to CFA back-up resources.

As part of rehabilitation of the mine, controlling and limiting the fire risk from exposed coal is an important factor. Recent fires in the operating mines indicate how difficult coal fires can be to extinguish.

Current general rehabilitation practice is to flatten the batters and at least partially cover coal with clay. Whilst such a method may be seen to reduce the risk of coal fires in the rehabilitated mine, does this method cause other issues of concern for the long term sustainability of the rehabilitated area. Three main concerns are likely to be identified if this solution were studied:

- the cost to flatten the coal batters and the availability of suitable overburden to provide the cover;
- the potential erosion or slumping of a overburden layer laid on the coal batter; and
- the potential to reduce the stability of the batter system if the clay covering reduces the ability of the coal batter to effectively drain (note: horizontal drains may need to be retained).

Fixing on a single batter rehabilitation strategy without considering all of the implications could lead to a sub optimal solution. Each of the existing mines have potential lives of 10 to 50 years. Research into other possible options to seal the coal surface to reduce the fire risk in the batters may result in better rehabilitation options.

- **Avoidance of flooding.**

During mining, levee banks and other civil structures are used to minimise the direct ingress of floodwater from local streams and rivers. Within the mine area collection drains, storage ponds and dewatering pumps are used to cater for heavy rain events. In addition to managing surface water inflows, water recovered from deep aquifers is collected separately and pumped from the mine.

After mine closure many of these requirements will need to be retained and there will need to be a pond in the final void of each mine. This may require the retention of pumping stations within the rehabilitated mine to manage the water level. It is possible that if the quantity of rainfall catchment matches evaporation a reasonably consistent pond water level could be attained without pumping. Dependent on the size of the pond wave erosion around its perimeter may need to be a consideration.

Other Important Factors in the Rehabilitated Mine Design

In addition to the mine safety implications for the final land form there are a number of other significant factors to consider in a successful rehabilitated mine. Although beyond this paper these include: -

- Community aspirations and interface with towns, neighbours etc.
- Regional road, railways and other infrastructure
- Environment, water quality, connection with aquifers, dust, vegetation, habitats, etc.
- Sustainability
- Productive Uses

Conclusions

The Latrobe Valley mines are projected to have significant further life before mine closure. Technical challenges associated with mine rehabilitation can be complex and vary by site, often with competing requirements. GHD recommend that rehabilitation plans currently being sought by government should provide flexibility for future improvements. Rehabilitation strategies should be dynamic to cater for improved design and better outcomes likely to be developed in future years. The intention should not be to continue to change the regulatory requirements as business investment need certainty, but to encourage the search for and implementation of better outcomes than what can be decided upon early in a projects life. If we do not actively seek design improvements and better outcomes, we are unlikely to find a way to implement them.

Design improvements could reduce costs and provide better outcomes for the Latrobe Valley community. Research should be encouraged as there are a number of relevant known unknowns of significance to help achieve mine closure plans meeting the important objectives of a safe and stable environment, and offer long term sustainability. Research should be encouraged and possibly included in licence conditions. Rather than just increasing the Rehabilitation Bond, as has been rumoured, government should offset money being put into research to resolve some of the uncertainties in long term rehabilitation of the mines in the Latrobe Valley.

Direction from government is required, especially on regional matters to assist the mines in preparing long term mine closure plans that provide the most effective outcomes for the Latrobe Valley community.

The following summarises issues of uncertainty that make design of mine closure difficult for individual mine owners and possibly not optimising solutions at this time: -

- Is there a regional mine rehabilitation strategy for the Latrobe Valley ?
- What is the development sequence for future mines and whether allowance is to be made to develop from any existing mine into new mining areas ?
- What is the availability of water for timely, partial or full flooding of any mine ?
- After aquifer pumping ceases in any of the mines what is expected to happen to pumping across the Latrobe Valley and to what recovered aquifer levels should the stability of the mine be tested ?
- Are there alternative methods to protect coal batters from fire risk than covering with overburden ?
- What is the optimum slope of the rehabilitated batters ?
- Range of possible ways to help achieve continued drainage from batters in the rehabilitated mine ?
- What is the life of horizontal drains ?
- What additional community end use scenarios are possible ?
- Final Land Form Requirements Versus Land Use expectations ?

We would welcome the opportunity to discuss this submission at your convenience.