Review of Future Rehabilitation Options for Loy Yang, Hazelwood and Yallourn Coal Mines in the Latrobe Valley

Hazelwood Mine Fire Inquiry

Final Report

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Important note about this report

The review of future rehabilitation options for Loy Yang, Hazelwood and Yallourn Coal Mines in the Latrobe Valley has been prepared for the Hazelwood Mine Fire Inquiry (Inquiry) to inform the Inquiry's consideration of Terms of Reference 8 and 9. Terms of Reference 8 and 9 relate to:

Short, medium and long term options to rehabilitate:

a) *land on which work has been, is being or may lawfully be done in accordance with a Work Plan approved for the Hazelwood Mine, the Yallourn Mine, and the Loy Yang Mine; and*
b) *land in relation to which an application for variation of the Work Plan is under consideration for the Hazelwood Mine, the Yallourn Mine, or the Loy Yang Mine;*

For each rehabilitation option identified:

a) *whether, and to what extent, the option would decrease the risk of a fire that could impact the mine and if so, the cost of the option relative to the cost of other fire prevention measures;*
b) *whether, and to what extent, the option would affect the stability of the mine;*
c) *whether, and to what extent, the option would create a stable landform and minimise long term environmental degradation;*
d) *whether, and to what extent, the option would ensure that progressive rehabilitation is carried out as required under the Mineral Resources (Sustainable Development) Act 1990;*
e) *the estimated timeframe for implementing the option;*
f) *the option's viability, any associated limitations and its estimated cost;*
g) *the impact of the option on any current rehabilitation plans for each mine;*
h) *whether, and to what extent, the option would impact the future beneficial use of land areas impacted by the mines; and*
i) *whether the option is otherwise sustainable, practicable and effective.*

In considering Terms of Reference 8 and 9 Jacobs were requested to:

a) *Consider the findings of a desktop scan of international rehabilitation practices suitable for brown coal mines;*
b) *Participate in community consultation and consider the views expressed at the community consultation*
c) *Consider the views expressed by interested parties through public submissions to the Inquiry*
d) *Consider (against the criteria set out in Term of Reference Nine) the lake option contained in the Work Plan of each mine operator;*
e) *In assessing the options use the technical data from each mine operator and from the Department of*
f) *Economic Development, Jobs, Transport and Resources (DEDJTR); and*
g) *For options considered sustainable, practicable and effective, prepare a high level work program (including indicative timeframes and costs)*

The services undertaken by Jacobs in connection with preparing this report were limited to those specifically detailed in above and are subject to the scope limitations set out in the report.

The opinions and conclusions in this report are based on information reviewed at the date of preparation of the report. Jacobs has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions and conclusions in this report are based on information provided to Jacobs and described in this report. Jacobs disclaims liability arising from any of the assumptions being incorrect.

Jacobs has prepared this report on the basis of information provided by the Inquiry. Jacobs has not independently verified or checked beyond the agreed scope of work.

Jacobs does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

Executive Summary

The "Hazelwood Mine Fire Inquiry" (Inquiry) was re-opened by the Victorian Government on 26 May 2015 and given specific Terms of Reference. Terms of Reference Eight and Nine asked the Inquiry to examine future rehabilitation options for three Latrobe Valley coal mines:

- Yallourn Mine (scheduled for closure in 2032);
- Hazelwood Mine (scheduled for closure in 2033); and
- Loy Yang (scheduled for closure in 2048).

The Inquiry engaged Jacobs Group (Australia) on 24 July 2015 to identify future rehabilitation options. Preliminary rehabilitation options were examined for:

- Impact on the risk of fire;
- Effect on the stability of the mine and final landform;
- Capacity to minimise long term environmental degradation (groundwater, surface water, biodiversity);
- Impact on future beneficial land uses; and
- Capacity to achieve a rehabilitated landform in the short, medium or long term.

Potential viable options were examined in closer detail including a risk assessment (fire, landform stability, groundwater, surface water, and biodiversity), estimated cost to achieve the rehabilitation option, capacity to undertake progressive rehabilitation and timeframe (short, medium or long term) to implement the option.

Jacobs assembled a multi-disciplinary study team over the period August to October 2015 to:

- Consider the findings of a desktop scan of international rehabilitation practices suitable for brown coal mines;
- Participate in community consultation and consider the views expressed at the community consultation;
- Consider the views expressed by interested parties through public submissions to the Inquiry; and
- Using the criteria contained in Term of Reference Nine and existing information, consider rehabilitation (landform) options for each mine. This involved undertaking a high-level, strategic, assessment of preliminary and potential rehabilitation options (focused on strategic issues, risks and challenges in order to identify potential viable options).

Coal mining in the Latrobe Valley (see section 2)

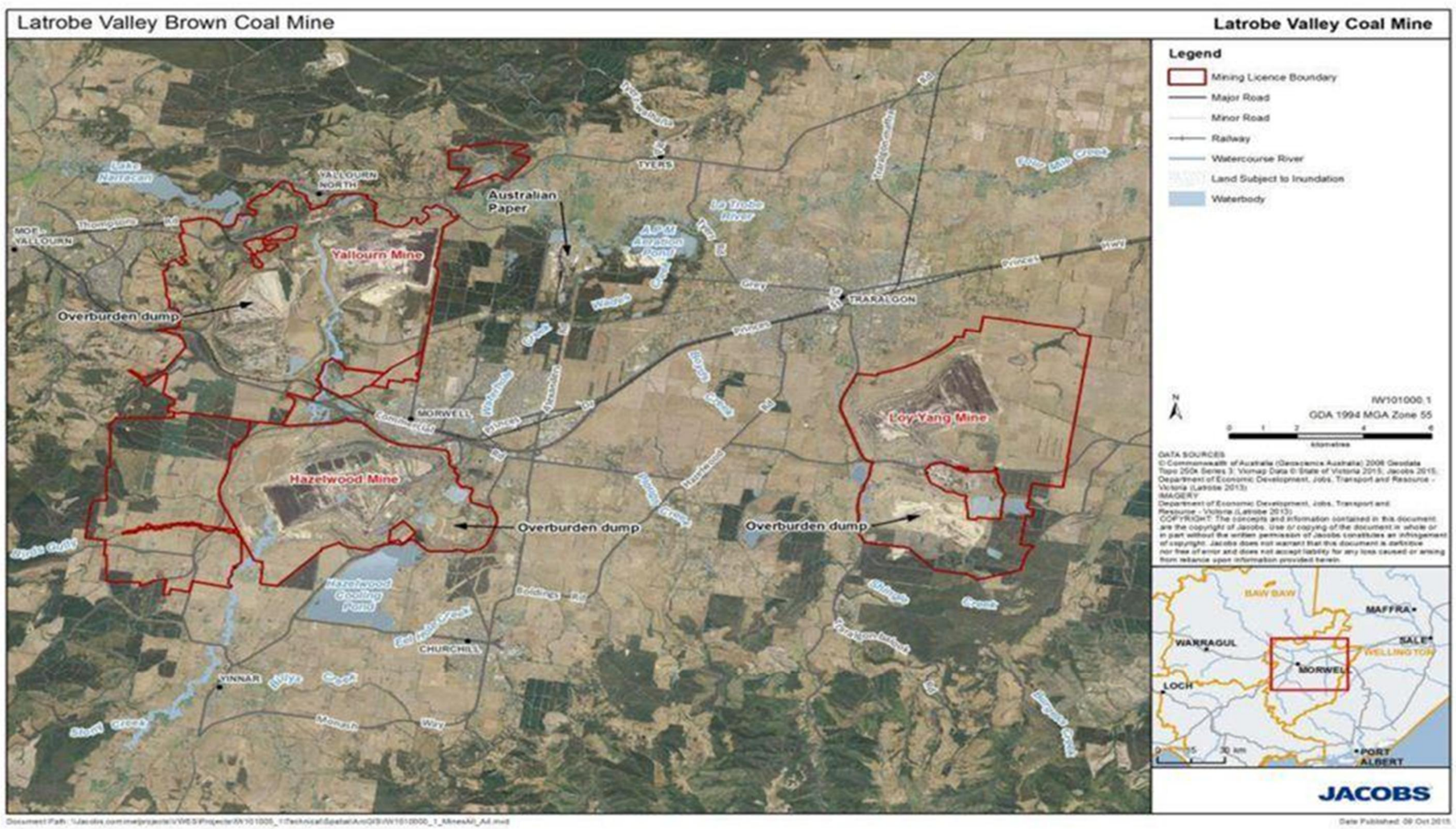
The GunaiKurnai people lived in Gippsland for many thousands of years. Only since the nineteenth century has the Latrobe Valley experienced changes in land use. Firstly gold, agriculture and farming started to change the Latrobe Valley landscape.

Exploration and subsequent development of what is one of the world's largest brown coal deposits (estimated 430 billion tonnes) further redefined land use and landform in the Latrobe Valley. Large scale coal mining has been underway since the mid 1950's with Hazelwood coal mine joining Yallourn. Loy Yang followed shortly after (see Figure 1-1).

For the last 60 years the Latrobe Valley has known expanding operational coal mines that provide local employment and electricity for a growing Victoria. The next 60 years looks very different. According to each of the mine operators it is presently possible that each mine could cease operations within a 16 year period of each other (Yallourn 2032, Hazelwood 2033 and Loy Yang 2048). At this point each mine would transition from progressive rehabilitation to actively rehabilitating their mined areas in pursuit of a post-mining landform that is safe, stable and non-polluting over the long term.

Yallourn the oldest and shallowest of the three mines (currently 600 Ha and 80m deep) will seek to achieve a partially flooded mine void combined with dumped waste and a lowered landform around the mined void and above the lake. Progressive rehabilitation at Yallourn has been underway for many years and Jacobs' understands good progress has been in internal mine void dumping to cover the base of the void.

Figure 1-1: Aerial photography of the three Latrobe Valley coal mines



Hazelwood is 50% deeper than Yallourn (currently approximately 500 Ha, 120m deep). Like Yallourn Hazelwood plans to rehabilitate their mined void through a combination of lowered landform, pit water body and internal dumping of waste. Jacobs's understands Hazelwood are well advanced with the rehabilitation of their external waste dump and have commenced some mine batter rehabilitation. Hazelwood's proximity to the Morwell township and Princess Freeway creates technical challenges for a long term landform that is safe and stable.

By 2048, Loy Yang is forecasted to cease mining operations. Loy Yang is the deepest of the three mines (currently 500 Ha, 200m deep). Like Hazelwood and Yallourn, Loy Yang also plan to transform their mined void into a partially filled water body, with a lowered landform and internal waste dumped into the pit. Of the three, Loy Yang is likely to have the smallest waterbody in comparison to the mine void, based on current plans.

It is conceivable (based on current mine Work Plans) that by 2060/2070 the Latrobe Valley could feature three "small lakes" (or more accurately pit water bodies) of differing sizes instead of three very large mined voids. Land surrounding the "pit water body" would be lowered, gradually sloping up and away from the "pit water body". This type of landform is likely to suit dryland agriculture and plantations, possibly irrigated agriculture, wetland conservation and if sufficiently safe some form of recreational use. The slopes up and away from the mine will vary in height between the mines. Yallourn is currently planning to have the highest level lakes of the three.

Are there alternatives and if so are they potentially viable?

Important issues for coal mine rehabilitation in the Latrobe Valley (see section 3)

An important set of issues need to be taken into account when considering long term mine rehabilitation in the Latrobe Valley.

Latrobe Valley coal mines are somewhat unique in terms of the low amount of waste material produced from mining (referred to as low overburden strip ratio). Unlike other typical mining operations the low amount of waste produced constrains the capacity to refill the mined voids with spare or un-needed mined material..

The three brown coal mines also differ from many black coal and hard rock mines, because they are interconnected by surface water and groundwater, which is a trigger for potential instability. It is rare to find a comparable mining setting in Australia.

Surface water, from rain or adjacent rivers, can enter the "joints" (continuous cracks in the coal) so that coal starts to move. Since brown coal is only slightly heavier than water, the mining excavation itself can cause movement of the coal slopes and, hence, an entry pathway for water.

Groundwater is present in aquifers below the mine void and in the slopes of the pits after mining has passed. Groundwater under pressure provides uplift to the base of the mine and its slopes. Major movements can occur if these groundwater pressures are not reduced and controlled by continuous pumping.

Current coal mining operations are a significant user of surface water and groundwater. The current planned "pit water body" landform will require significant, on-going, access to Gippsland's highly sought after water resources. Jacobs's note that approval for any future allocation has yet to be granted by licencing agencies). Consequently a better understanding is required of the relationship between water use and impacts across the Gippsland region to inform any future request for on-going water allocations.

Local communities experience with the recent Hazelwood mine fire has heightened concern regarding how long term rehabilitation of the mines can be done in manner to manage fire risk. In the medium and long term fire risk is mitigated primarily by the treatment of the final landform. This involves the covering of exposed coal seams beneath non-combustible materials, such as overburden or water. The risk of re-exposure of the coal seam must be understood and managed through design, construction and on-going management of the final landform.

A better understanding of community values and expectations is critical to informing how rehabilitated mines could provide for positive social outcomes. Providing landforms that create long term economic development opportunities is a key challenge, particularly with the younger demographic profile of the Latrobe Valley and coupled with the physical constraints of mining in this setting..

It is noticeable that despite the volumes of information that has been produced about mine rehabilitation in the Latrobe Valley (the bibliography of this study contains 85 different references) Jacobs' was unable to locate one report which simply articulated all these issues in the context of an individual mine and the Latrobe Valley region. The complexity of the topic has tended to lead to detailed and fragmented analyse, It is important to make sure all key stakeholders appreciate the breath of issues prior to promoting different future post-mining landforms.

Need for a regional mine rehabilitation vision and broad set of outcomes (see section 4)

In dealing with these issues, Jacobs recognised the current absence of **a regional vision and a broad set of outcomes** to guide decision makers and the community regarding the future direction of mine rehabilitation. Each mine operator has an approved Work Plan that sets out their planned final landform. This is an agreement between the mine operator and Victoria's mining regulator framed in a specific legislative context of safety, stability and non-polluting.

Consultations conducted by the Inquiry gave any interested person an opportunity to provide their views.

Twenty-five submissions were received by the Inquiry from a wide range of individuals and groups. More than 70 people attended open consultation meetings held by the Inquiry and provided their views and thoughts on specific questions.

An analysis of the public submissions and community consultation revealed aspirations and expectations broader and inclusive of safe, stable and non-polluting. Taking the views and expectations expressed a suggested starting long term region wide vision for the mine rehabilitation could be titled "Reshaping the Valley":

Reshaping the Valley to maximise economic and social benefits of rehabilitating the Latrobe Valley mine sites. Important environmental, resource, and heritage values of the region are respected. Opportunities are created and shared with the Latrobe Valley community, transitioning industries and mine operators."

Participants in the Inquiry's consultation processes identified desired regional outcomes from mine rehabilitation to:

- Ensure landforms are safe, stable and non-polluting;
- Improve the liveability of neighbouring towns;
- Support employment through diversification of the regional economy;
- Protect and improve the health of environmental values/assets; and
- Not exclude future resource exploitation and development.

There are six preliminary mine rehabilitation options (final landforms) (see Section 5)

Six preliminary mine rehabilitation options for the three mines were identified from:

- Views expressed about land uses and landforms by interested stakeholders through the community consultation and public submissions;
- Jacobs' extensive mine rehabilitation and closure experience;
- A desktop review of leading practices in rehabilitation and closure of open pit coal mines; and
- Current mine Work Plans.

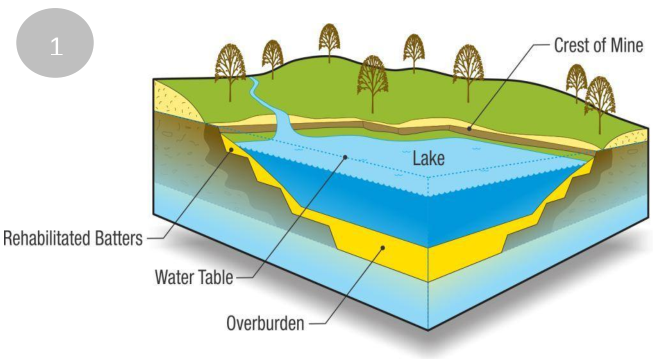
Most public submissions and community consultation recommended the consideration of a wide range of post-mining land uses without expressing a definitive preference.

Potential beneficial land uses identified through community consultation and public submissions included agriculture and grazing, forestry, aquaculture, conservation, recreation/tourism (including gardens, sporting venues, hiking, camping etc.) waste management and industrial or research based development, renewable energy (solar, hydro and wind), ongoing development of the coal resource, residential and industrial development.

This study found that the merits of different long term land uses for the mined areas has not been assessed for economic and community impacts. This study was not required to perform such an assessment.

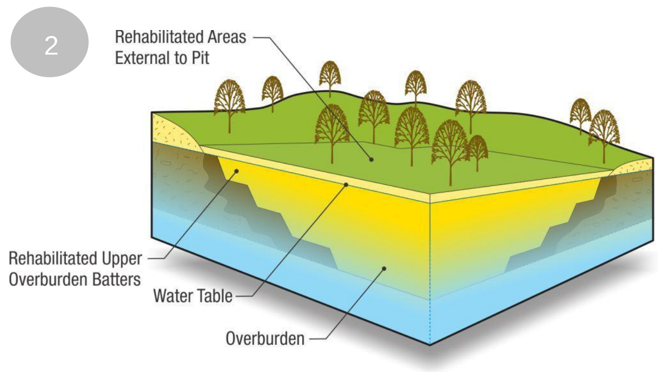
Six preliminary mine rehabilitation options were identified. The key test was to ensure all prospective land uses would be likely to be enabled by one or more preliminary mine rehabilitation option.

Preliminary mine rehabilitation options identified for rehabilitating a mined void (the pit) are illustrated and described below. The disturbed land outside of pit void are reshaped and rehabilitated to suit an agreed land use.



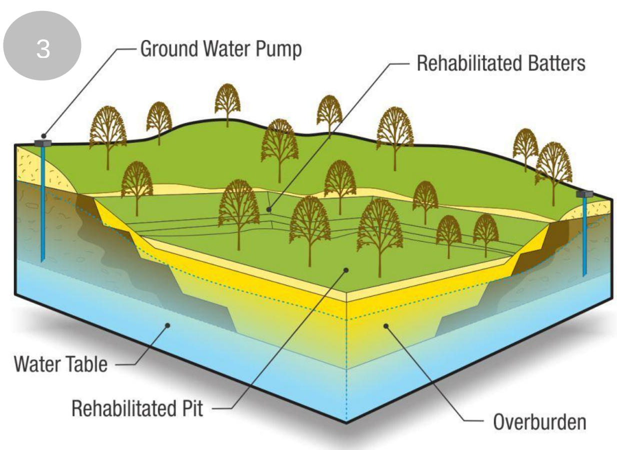
PIT LAKE LANDFORM

A large, deep lake is formed by filling the final mine void to the pit crest with water. Minimial overburden or mine waste is placed back in the pit



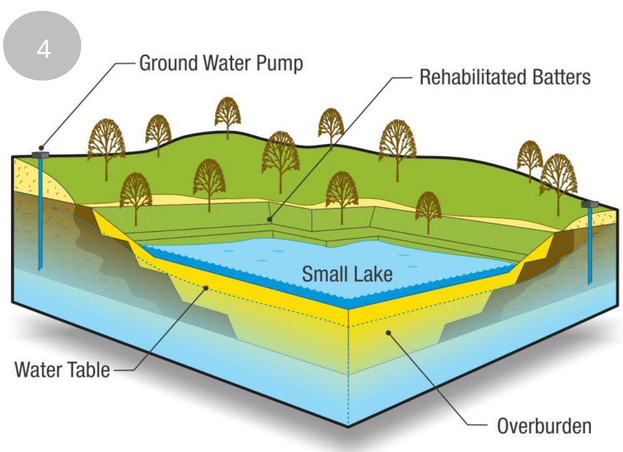
FULL BACKFILL LANDFORM

The final mine void is fully backfilled to the pit crest level using all available non-polluting overburden and mineral waste. This landform will return the mine void area to approximately natural relief (original level) allowing for dryland rehabilitation of all disturbed areas.



PARTIAL BACKFILL ABOVE THE WATER TABLE

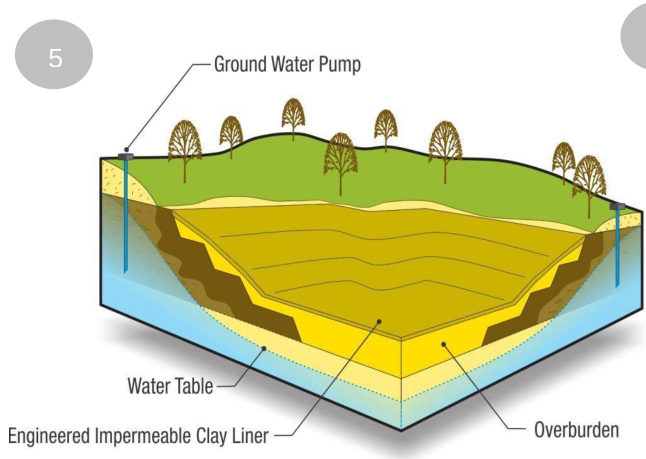
The final mine void is partially backfilled with non-polluting overburden and additional materials to a level above the natural groundwater level creating a dry lowered landform.



PARTIAL BACKFILL BELOW THE WATER TABLE

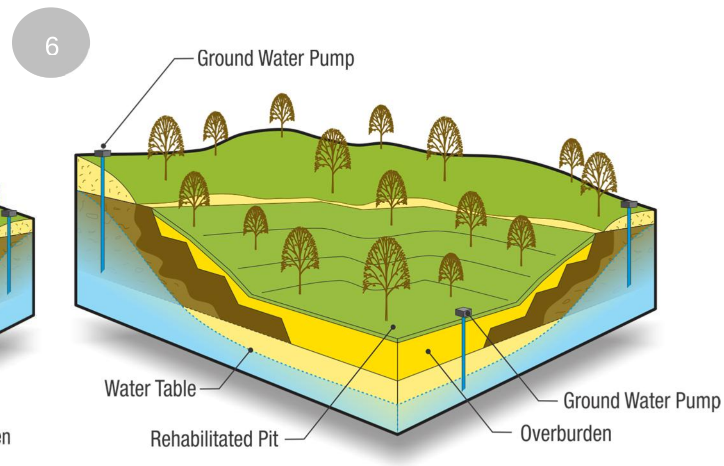
The final mine void is partially backfilled using available overburden and other mine wastes. Areas below the natural groundwater level are filled with water to create a pit water body (shallow lake). Backfilled areas above the groundwater level will remain dry but at a significantly lower relief than the surrounding remaining batters.

This preliminary landform option most closely matches the final landforms planned by each of the mine operators.



LINED VOID LANDFORM

The final mine void is lined with clay or similar material across all batters to create an impermeable lining to inhibit the flow of water either in or out of the void.



REHABILITATED VOID

The final mine void is maintained dry through continuation of groundwater extraction with general reshaping and dryland rehabilitation of all internal areas. A rehabilitated void retains the existing mine pit configuration largely in its current form.

Two of the six preliminary landform options represent potential viable options for each of the three coal mines (see Section 7)

Fourteen assessment criteria were established for each preliminary landform option. These criteria reflect key issues and challenges identified through consultations and submissions and align with the Inquiry's Terms of Reference 8 and 9. Jacobs' technical advisors conducted a multi-criteria assessment of the six preliminary options against each criteria.

Since the mines are interdependent with respect to surface water and groundwater connectivity, it was possible to assess the interdependence of the preliminary options within the assessment criteria.

To be assessed as a potential viable option, a preliminary option must be able to mitigate potential fire, landform stability, biodiversity, groundwater and surface water risks and be capable of supporting beneficial future land uses. While all preliminary options could potentially be achieved through rehabilitation of the mines, only those options which generally complied with the ten assessment criteria were deemed potentially viable.

Preliminary options were assessed on their capacity to support multiple future beneficial land uses. Table 1-1 indicates the future beneficial land uses likely to be supported by a preliminary option. Landforms and land use “matches” marked as “least likely” implies very significant financial, human and physical resources (e.g. materials, water, enabling infrastructure such as roads and utilities) would be needed to achieve the landform. Landforms and land use “matches” marked as “least likely” does not imply the relationship is impossible but improbable.

Table 1-1 – Land uses likely to be supported by Preliminary Options

Table legend:

✓ = Landform most likely to support land use

- = Landform unlikely to support land use

Land Uses Identified By The Study		**Preliminary Options (Landform)**					
		Pit Lake	Full Back Fill	Partial Backfill above the Water Table	Lined Void	Partial Backfill below the Water Table	Rehabilitated Void
Conservation and Natural Environment		✓	✓	✓	-	✓	-
Production from Dryland Agriculture and Plantations		-	✓	✓	-	✓	✓
Production from Irrigated Agriculture and Plantations		-	✓	✓	-	✓	✓
Intensive Uses	Waste - treatment & disposal	-	-	-	✓	-	-
	Waste - recycling, recovery, salvage	-	-	-	✓	-	-
	Residential	-	✓	✓	-	✓	-
	Manufacturing and industrial	-	✓	✓	-	✓	-
	Mining (future)	-	-	-	✓	✓	✓
	Services (parklands, education, sport and/or cultural facilities)	✓	✓	✓	✓	✓	✓
Utilities	Hydro electricity generation	✓	-	-	-	-	-
	Bioenergy electricity generation	-	-	-	✓	-	-
	Wind electricity generation	-	✓	✓	✓	-	✓
	Solar electricity generation	✓	✓	✓	✓	✓	✓
Water	Lake - intensive use	✓	-	-	-	✓	-
	Lake – production	✓	-	-	-	✓	-
	Reservoir	✓	-	✓	✓	✓	✓
	Wetland – conservation	✓	-	-	-	✓	-

The Multiple Criteria Analysis results of the six possible preliminary options were consistent across the three mines. The four preliminary options considered unviable were:

- Full pit backfill and Partial Backfill above the Water Table – due to the likely lack of readily and practically available fill material and also in relation to the Partial Backfill above the Water Table the need for extensive drainage to address instability risks associated with water entering the mine pit;
- Lined void – due to high technical difficulty likely impact on environmental amenity, potential high costs associated with creating a pit lining and the dependence on a specific end land use (e.g. waste disposal); and
- Rehabilitated void – due to high fire risk and need to maintain ongoing landform stability works such as extensive long term dewatering and drainage..

All preliminary options can be implemented to achieve a safe and stable landform. It is the very substantial cost, high fire risk and sheer practicality of the preliminary options above that currently preclude them being seriously considered potentially viable.

The potential viable options that broadly meet Terms of Reference 8 and 9 and were considered appropriate for further investigation are:

- **Pit lake;**
- **Partially backfilling the mined void to a level below the water table.**

The potential viability of the Pit Lake and Partial Backfill below the Water Table landforms acknowledges the fact that key risks (e.g. fire, stability, water) are most effectively mitigated and managed through the combination of in-pit overburden placement and filling of the residual void to achieve fire cover and weight balance. These options are close to the landforms that are proposed in the current work plans. Given the practical physical constraints of the mine voids this is not surprising. They key finding of this study is that in the light of a comprehensive review of landform options we have not identified a markedly different landform option from those currently envisaged. This finding is important and should inform future assessments of the management of these sites.

Key differences between the two landform options include:

- The extent, area and depth of batters, above backfill and water level, to be reshaped, covered and rehabilitated;
- The extent and area of backfill above the water table level to be rehabilitated; and
- The extent and depth of the final pit lake/pit water body;

While recognised as providing cost effective long term fire and landform stability risk management, each potential viable option faces uncertainty regarding:

- Effort to achieve final water level based on water allocation and impact from other water users;
- Ongoing management requirements to maintain water level and quality; and
- Some uncertainty about material availability (especially for cover of coal seams)

The volume of water needed to achieve the Pit Lake landform will be substantially more than the Partial Backfill below the Water Table. Jacobs' noted that allocation of the future water use is yet to be obtained by the three mines. There will need to short-term studies to understand the implications on other users and regional environmental values to inform future allocation decisions. The Gippsland Catchment is already under stress and potential future climate change impacts add uncertainty to the availability, security and reliability of water resources.

For each coal mine, each potential viable mine option was subjected to a risk assessment (focused on fire, landform stability, groundwater, surface water, and biodiversity), examination of capacity to undertake progressive rehabilitation, implementation timing, cost estimation and comparison with existing mine rehabilitation plans.

Due to the conceptual and strategic nature of the study Jacobs' made a number of important assumptions in further investigating potential viable options. These included:

- Use of a standard set of fire, groundwater, surface water and biodiversity risk controls and tailoring them to unique mine setting to assess the likely residual risk. In regards to fire risk novel or new techniques to control fire risk without cover were not specifically identified by Jacobs in the material and time available, but are potentially an option (e.g. possibly spraying exposed coal surfaces with fire retardant materials or chemicals). An important fire risk controls applied by Jacobs' was the use of cover (from overburden and mine waste) to ensure that all coal seam areas have an appropriate depth of cover. The exact depth required is not clear from the material available to Jacobs. Establishment of a 2m cover over coal seams above the backfill and water levels would provide a low level of residual fire risk at each of the three mines. Cost to achieve the low level of fire risk ranges per mine over the short, medium and long term range from $20m through to $60m (due to the varying size of the mines). The majority of the cost incurred in the short to medium term while the mine void is being filled with material and water. This differs from mine operators Work Plan's where up to 1 m of cover is generally proposed. Rationale for an additional one metre of cover is based on achievement of an as low as reasonably practical level of residual risk;

- Set of standard progressive rehabilitation actions would need to be undertaken by each mine for each potential viable option. In the time and scope available Jacobs' didn't obtain a detailed understanding of the current status of each mine's progressive rehabilitation and therefore has made assumptions regarding the extent of progressive rehabilitation each mine has performed and will achieve by the cessation of mining activities;

- Set of standard short, medium and long term implementation actions for each potential viable option; and

- Cost estimates are only for the purpose of comparing the potential viable options. Costs estimated are not final closure costs for each mine. These are not final costs as Jacobs' scope did not extending to a detailed examination of current and future progressive rehabilitation plans. Costs are provided in section 8 for each mine for each option and each risk issue (e.g. fire, groundwater, surface water, biodiversity and landform stability).

Study found potential viable options may support future agricultural and recreational beneficial land uses (see Section 8)

Wetland conservation, production from irrigated agriculture and plantations, solar electricity generation are some of the types of land uses either potential viable option could support in the future. Specific viable options (e.g. Pit Lake option could theoretically support future hydro electricity and a Partial Backfill below the Water Table option could support dryland agriculture) also could support other land uses.

Loy Yang has relatively flatter slopes in some parts of the mine and the fact that there are less physical constraints around the perimeter creates potentially broader land uses opportunities than Hazelwood or Yallourn, which are more constrained.

Are these the most beneficial future land uses for the Latrobe Valley? The longer decisions take on whether alternate land uses are more preferable to those described above the more short term mine rehabilitation decisions will be made that may restrict future beneficial land use options.

Using the analysis completed in this study combined with a detailed assessment of different land uses, stakeholders (community, mine operators, Victorian Government, local councils, potential investors/financiers etc.) can make an informed decision as to whether benefits of a specific land use could outweigh the risks and implementation challenges associated with delivering the different rehabilitated landforms.

Biodiversity risks were assessed as being low to moderate for both landforms for all three mines (refer Section 8.5)

The mine areas are highly modified and will require active intervention to support biodiversity goals in the long term. Active rehabilitation of the disturbed areas above the water levels is likely to be achieved through the appropriate uses of soils and vegetation. Biodiversity risks exist also in terms of potential impacts from instability events.

Implementation schedules for each mine show final landforms are likely to be achieved in the longer term (greater than 15 years after mine closure) (refer Section 8.3.5)

Pit Lake and Partial Backfill below the Water Table landforms are more likely to be achieved in the long term (15 years after each of the mines have closed). Due to the lower water volumes required for the Partial Backfill below the Water Table it is conceivable to achieve this option within the medium term if the mines were able to access sufficient water. Conditions most favourable to achieving a Partial Backfill below the Water Table option in the medium term (within 15 years of closure) exist at Yallourn due to the smaller overall size of the final void and the proximity to the Morwell and Latrobe Rivers.

At Hazelwood, both landforms would most likely be achieved in the long term (minimum of 15 years after cessation of mining activities), in part because of the volume of water required to reach the eventual long term water level.

Key factors that will determine when the final landforms could be achieved are:

- Final pit water body/lake volume;
- Final pit water body/lake level;
- Water quality management and the ability to discharge from the pit lake;
- Rate of progressive rehabilitation during mining; and
- Eventual slope profile for high risk walls/slope areas (close to critical infrastructure).

Interactions between the mines and key rivers (Yallourn - Morwell and Latrobe Rivers, Hazelwood - Morwell River and Loy Yang – Traralgon Creek) must be very carefully managed due to risks such as impact on water allocations to other uses and downstream impact on ecological water requirements.

Progressive rehabilitation should capable for either potential viable option (refer section 8)

Progressive rehabilitation includes the undertaking of rehabilitation activities which reduce the overall liability associated with the disturbed land. Progressive rehabilitation occurs as part of normal operations until end of mining operations.

Each mine has been progressively rehabilitating their mined voids with a lake or pit water body in mind. Additional progressive rehabilitation action identified by the study relates primarily to fire risk. The use of cover to reduce fire risk in the short term doesn't appear to be consistently part of the mine's current progressive rehabilitation.

To varying extents, the information available to Jacobs's illustrated that each mine is continuing to seek to understand their required future weight balance and whether there will be sufficient material available on-site.

Jacobs's assessed potential viable options as not presenting significant impediments to undertaking on-going progressive rehabilitation works in accordance with the *MRSDA* or require a significant change in the nature of mining operations in order to achieve mitigation of key risks (e.g. landform stability and fire) within the short term.

Impact on the mine's current Work Plans (refer section 8)

In examining current mine operator Work Plans it is Jacobs' view that their planned final landforms generally align with the concept of a Partial Backfill below the Water Table landform. While a shift to a Pit Lake landform would not represent a significant deviation from current mine operator Work Plans it is considered that greater understanding of the key issues of pit water quality, water allocation requirements and groundwater connectivity between the three mines would be required to assess the practicality and achievability of the Pit Lake option.

This study identified a range of risk controls in relation to the Pit Lake and Partial Backfill below the Water Table landform (e.g. fire cover, water treatment) not present in the Work Plans reviewed by Jacobs. In regards to Loy Yang many these controls are identified in the proposed Work Plan variation, including areas of research or study to inform the long term rehabilitation options. For Yallourn and Hazelwood as design and engineering continue consideration will need to be given to how these or alternate controls can effectively, proportionately and adequately achieve an acceptable level of fire, groundwater, surface water, landform stability and biodiversity risk.

Assessment of potential viable options for Yallourn (refer Section 8.5)

Two viable landforms were identified for Yallourn: Pit Lake Landform and Partial Backfill below the Water Table. In these landforms a combination of backfill, cover and water body will be used in the final landform. Through the assessment of residual risk, the Partial Backfill below the Water Table was identified as the landform most likely to achieve the lowest residual risk. At Yallourn there is potential for a water body or pit lake to be developed. Through this assessment Jacobs' have identified there some critical risk controls required for viable landforms:

Landform Stability

Fill, overburden and other materials will be needed to provide long term stability for the mine walls (in particular the batters/walls close to Yallourn and the walls that are adjacent to the Latrobe River and the Morwell River diversion). Yallourn mine does not face the same scale of underlying aquifer pressures as the other mines and so has more options for weight balance (weight balance is the technically important for achieving landform stability).

Water Management

Water quality in the pit water body will be key to addressing long term risks. Given the proximity to surface water (the two rivers) and considering that limited groundwater is pumped from the mine at present, it is likely that the water body in the final landform will require inflow from surface water in the long term to maintain required water quality.

Fire Risk

Over the long term water will cover a large part of the coal seams and prevent fire. In the medium term cover of exposed coal seams (by rising water level or placement of material) has been assessed as key to managing the risks of fire. In the short term cover and other operational controls are needed to avoid the risk of fire. Jacobs' have not identified any impediments in the two viable landforms to managing fire risk.

Assessment of potential viable options for Hazelwood (refer section 8.6)

Two viable landforms were identified for Hazelwood: Pit Lake Landform and Partial Backfill below the Water Table. In these landforms a combination of backfill, cover and water body will be used in the final landform. Through the assessment of residual risk, the Partial Backfill below the Water Table was identified as the landform most likely to achieve the lowest residual risk. At Hazelwood the level of eventual lake within the pit void is important for the extent of batters exposed. Depending on the long term water sources this level could be high or could be set low into the landscape. Through this assessment we have identified there are some critical controls required for viable landforms:

Landform Stability

Fill, overburden and other non-polluting materials will be needed to provide long term stability for the mine walls. In particular the batters/walls close to Morwell and the walls that are adjacent to the Princes freeway. Hazelwood mine has significant underlying aquifer pressures that will need control by a combination of weight balance and groundwater level management.

Water Management

Water quality in the pit water body will be key to long term water risk. Sources of water for the long term management of pit water body need to be resolved. This will determine the eventual level of the water body and interaction with the surrounding catchment. Given the depth of the mine and the likely availability of water, it is considered that Partial Backfill below the Water Table is likely to be the lowest risk landform.

Fire Risk

Cover of exposed coal seams in the medium to long term has been assessed as key to managing the risks of fire. In the short term, cover and other controls are needed to avoid the risk of fire. Jacobs' have not identified any impediments in the two viable landforms to managing fire risk.

Assessment of potential viable options for Loy Yang (refer Section 8.6)

Two viable landforms were identified for Loy Yang: Pit Lake Landform and Partial Backfill below the Water Table. In these landforms a combination of backfill, cover and water body will be used in the final landform. Through the assessment of residual risk, the Partial Backfill below the Water Table was identified as the landform most likely to achieve the lowest residual risk.

The size and scale of the eventual lake within the pit void is important in Loy Yang. Given the proposed eventual mine development, the height and scale of the northern batters and the slopes on the southern batters, Jacobs' conclude the final landform will be a mix of water and dry land across the base of the pit. This level is likely to be low in the landscape. An ongoing source of water is likely to be required to replace evaporation so as to maintain weight balance. Depending on the long term water sources this level could be high or could be set low into the landscape.

Through this assessment Jacobs' have identified there some critical controls required for viable landforms:

Landform Stability

Fill, overburden and other materials will be needed to provide long term stability for the mine walls, in particular the northern batters/wall. Loy Yang mine has significant underlying aquifer pressures that will need control by a combination of weight balance and groundwater level management. The future requirements for groundwater pumping to control underlying pressures have not been finally determined, as this will depend on the availability of allocations of water.

Water Management

Water quality in the pit water body will be key to long term water risk. Sources of water for the long term management of pit water body need to be resolved. This will determine the eventual level of the water body and interaction with the surrounding catchment. Given the depth of the mine and the likely availability of water, it is considered Partial Backfill below the Water Table is likely to be the lowest residual risk landform.

Fire Risk

Cover of exposed coal seams in the medium to long term has been assessed as key to managing the risks of fire. In the short term, cover and other controls are needed to avoid the risk of fire. We have not identified any impediments in the two viable landforms to managing fire risk.

Use of mine waste material and flooding to achieve weight balance and a suitable treatment (including fire cover) of mine batter walls above the flood level is most likely to create a safe, stable and environmentally sustainable final landform.

This conceptual level study of future mine rehabilitation options in the Latrobe Valley has generally shown that with effective implementation of required risk controls the approach of a lowered landform, combination of water and material to collectively fill the mined void is likely to represent a low to moderate level of risk in the short, medium and long term.

At present each mine's Work Plan (or proposed Work Plan variation) is generally taking this strategic direction towards their final landforms. The assessment presented in this report has taken a step back from the current plans and reviewed a wide set of options and has not identified a markedly different option that would provide significantly better fire, stability and other outcomes

The capacity for one mine site to implement their proposed final landform is greatly influenced by the rehabilitation decisions and actions taken at the other mines due to the collective water and physical material requirements.

There needs to be a very well planned and choreographed staging and sequencing of short, medium and long term rehabilitation strategies between the three mines in order to optimise costs, allocate scarce resources (e.g. water and material) and provide greatest opportunity for the Latrobe Valley to attract investments in post mining land uses.

While the long term continuation of coal mining at all three mines is uncertain the current scheduled closure dates for each mine are within 16 years of each other (i.e. Yallourn Mine – 2032; Hazelwood Mine – 2033; Loy Yang – 2048). This would effectively result in short and medium term actions for each mine being implemented concurrently. Throughout the assessment it was apparent that current Work Plans for each site have been prepared in isolation and while background documentation viewed by Jacobs's acknowledge the potential interdependencies between rehabilitation options the *MRSDA* does not require or facilitate consideration of such interdependencies.

Such interdependencies identified in include:

- The impact of groundwater connectivity on the ability of adjacent mine to dewater and depressurize concurrently;
- The appropriateness and ability of current and future water allocations to allow the three mines to access sufficient water to achieve each landform option;
- The opportunity to establish overburden purchase agreements between the three mines to optimise overall landform options (e.g. Yallourn is likely to have an excess of overburden should it pursue a Pit Lake landform option); and
- The potential for integrated water management and treatment options across all three mines to minimize long term costs and community burden.

While it has not been possible within the timeframe and scope of the study to investigate these interdependencies it is Jacobs considered opinion careful thought should be given in future planning to the regional impacts and interdependencies.

Important information gaps

The next steps in effective regional rehabilitation planning need to collaboratively address:

1. Key information gaps, namely:

    - Weight balance – Studies required to establish weight balance requirements (especially in the long term) and correlations with depressurisation;
    - Water quality - Water quality investigation to establish the likely quality of water in the pit water body as well as runoff from various areas around the site and how this will be managed in the long term;
    - Long term stability especially in regards to more specific criteria for factors of safety that can be applied to site and batter specific conditions may be more appropriate to facilitate achievement of final landforms; and
    - Regional water balance modelling in order to understand the likely filling rates and water level fluctuations, as well as the interaction/influence of the three sites. Regional water balance modelling should take into consideration latest coal mining water use projections, future agricultural trends, potential bushfire impact on water availability/quality, potential climate change impact, offshore oil and gas usage, mechanisms to more efficiently identify and allocate surplus water and potential ecological impacts of river diversions.

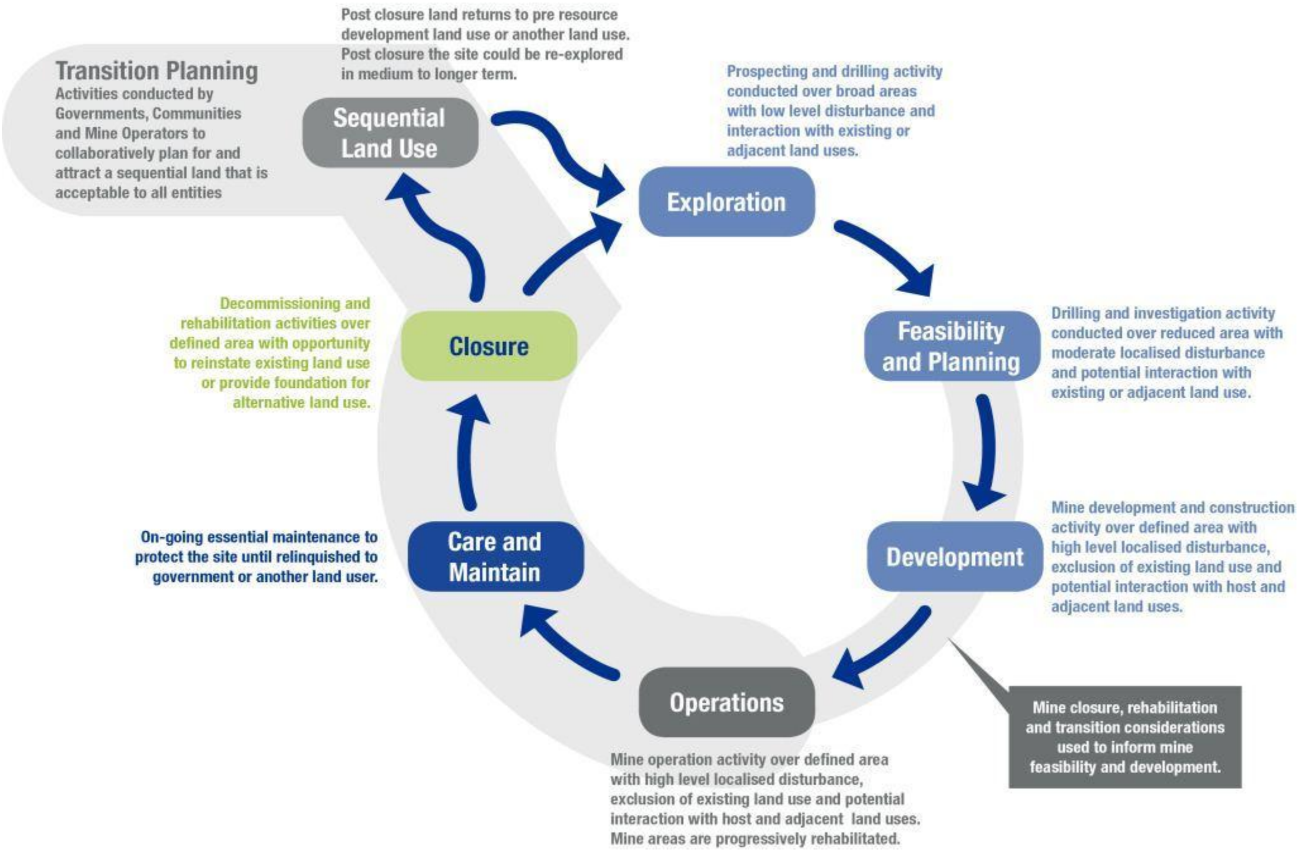
2. Setting a long term region mine rehabilitation vision and outcomes to guide decision making; and

3. Examining the benefits of alternate land uses to establish if they represent future benefits sufficient enough to justify a third party contributing funding to achieve another landform (e.g. Line Void and Rehabilitated Void landform options could be achieved within the medium term but these were considered unviable due to high establishment and maintenance costs and uncertainty regarding associated final land uses).

1. Introduction

Mine closure and transition to alternative land uses are key elements of a mine's lifecycle (Figure 1-1). In Australia this is growing in importance as resources become depleted, assets reach their design life and new technologies evolve. Achieving positive and lasting community, economic and environmental benefits from post mining land use(s) requires early, robust and coordinated regional and mine rehabilitation and transition planning (COAG Standing Committee on Energy, 2013).

Figure 1-1 : Phases of a mine lifecycle including post mining transition



In the Latrobe Valley, one fundamental question confronting Latrobe Valley local communities, Victorian government, coal mine operators, local council, other regional industries and interest groups is what post coal mining safe and stable final landform(s) of the remediated mined areas (e.g. mined voids, overburden stockpiles) are viable to support future use?

1.1 Terms of Reference for examining rehabilitation options for the three Latrobe Valley coal mines

On 26 May 2015, The Honourable Lily D'Ambrosio MP, Minister for Energy and Resources, and The Honourable Jill Hennessy MP, Minister for Health, announced the re-opening of the Hazelwood Mine Fire Inquiry (Inquiry). The Inquiry was asked to examine future rehabilitation options for the three Latrobe Valley coal mines (Loy Yang, Hazelwood and Yallourn). Terms of Reference Eight and Nine (Figure 1-2)[1]: cover the issues associated with rehabilitation.

[1] Full terms of reference of the Hazelwood Mine Fire Inquiry can be viewed at http://hazelwoodinquiry.vic.gov.au/terms-of-reference/

Figure 1-2: Hazelwood Mine Fire Inquiry Terms of Reference 8 and 9

8. *Short, medium and long term options to rehabilitate:*

   a) *land on which work has been, is being or may lawfully be done in accordance with a Work Plan approved for the Hazelwood Mine, the Yallourn Mine, and the Loy Yang Mine; and*
   b) *land in relation to which an application for variation of the Work Plan is under consideration for the Hazelwood Mine, the Yallourn Mine, or the Loy Yang Mine;*

9. For each rehabilitation option identified:

   a) *whether, and to what extent, the option would decrease the risk of a fire that could impact the mine and if so, the cost of the option relative to the cost of other fire prevention measures;*
   b) *whether, and to what extent, the option would affect the stability of the mine;*
   c) *whether, and to what extent, the option would create a stable landform and minimise long term environmental degradation;*
   d) *whether, and to what extent, the option would ensure that progressive rehabilitation is carried out as required under the Mineral Resources (Sustainable Development) Act 1990;*
   e) *the estimated timeframe for implementing the option;*
   f) *the option's viability, any associated limitations and its estimated cost;*
   g) *the impact of the option on any current rehabilitation plans for each mine;*
   h) *whether, and to what extent, the option would impact the future beneficial use of land areas impacted by the mines; and*
   i) *whether the option is otherwise sustainable, practicable and effective.*

Jacobs was engaged by the Inquiry on the 24th July 2015 to research and report back on potential rehabilitation options for the three Latrobe Valley coal mines. The Inquiry requested Jacobs to:

a) *Consider the findings of a desktop scan of international rehabilitation practices suitable for brown coal mines;*

b) *Participate in community consultation and consider the views expressed at the community consultation;*

c) *Consider the views expressed by interested parties through public submissions to the Inquiry;*

d) *Consider (against the criteria set out in Term of Reference Nine) the lake option contained in the Work Plan of each mine operator;*

e) *In assessing the options use the technical data from each mine operator and from the Department of Economic Development, Jobs, Transport and Resources (DEDJTR); and*

f) *For options considered sustainable, practicable and effective, prepare a high level work program (including indicative timeframes and costs).*

1.2 Report Structure

This report contains Jacobs' analysis, findings and conclusions. The structure of the report is:

- **Section 1 – Introduction** – overview of Terms of Reference, summary of study approach, definitions of key terms and concepts, overview of study scope and statement regarding potential conflict of interests;
- **Section 2 – Coal mining in the Latrobe Valley** – brief profile of the Latrobe Valley, the three coal mines and description of their planned final landforms and progressive rehabilitation plan;
- **Section 3 – Important Issues for Mine Rehabilitation Planning –** description of the significant issues and challenges that need to be considered in the long term rehabilitation of the three coal mines;
- **Section 4 – Regional Mine Rehabilitation Vision and Outcomes** - suggested long term regional vision for post mining land uses/landforms and the desired rehabilitation outcomes expressed by different stakeholders

- **Section 5 – Preliminary Mine Rehabilitation Options** - preliminary list of potential final landforms/rehabilitation options based on a high-level understanding of potential post coal mining land uses;
- **Section 6 – Mine Rehabilitation Assessment Criteria** - description of the assessment criteria used to assess preliminary and potentially viable final landform/rehabilitation options;
- **Section 7 – Preliminary Mine Rehabilitation Options Assessment** - summary of findings of a Multi-Criteria Analysis (MCA) used to identify potential viable final landforms/rehabilitation options for further assessment;
- **Section 8 – Assessment of Potential Viable Mine Rehabilitation Options** - summary of a more detailed assessment of potential viable final landforms/rehabilitation options each mine;
- **Section 9 – Conclusion** – presents summary of Jacobs' findings for the study;
- **Section 10 – Bibliography;**
- Appendix A – Overview of study method;
- Appendix B – Overview of land use planning instruments in the Latrobe Valley;
- Appendix C – Results of assessment of preliminary options;
- Appendix D – Risk assessment;
- Appendix E - Comparison with current mine Work Plans;
- Appendix F – Cost estimates; and
- Appendix G – Indicative Implementation Schedules

1.3 Study Approach

The study was conducted over the period August to October 2015. The study was multidisciplinary in nature, drawing on professionals from across the fields of mine closure/rehabilitation, hydrogeology, hydrology, slope stability, fire management for rehabilitated landforms, environmental management, quantity surveying and land use strategic planning.

Using data and information made available by the Inquiry, including outcomes of public consultation and public submissions, Jacobs identified and refined 18 possible final landforms/ rehabilitation options (six per mine) into a set of six potential viable final landform/rehabilitation options (two per mine).

The study began with data gathering using the information collected. From this the study team formed an appreciation of coal mining in the Latrobe Valley (refer section 2) and consensus regarding the important issues and challenges confronting mine rehabilitation (refer section 3).

A suggested regional long term mine rehabilitation vision and outcomes (refer section 4) was formulated which is intended to guide decision making for more detailed future studies. Land uses identified via data gathering and vision/outcome setting were matched to a required landform (refer section 5.1). This process was used to identify preliminary final landform/rehabilitation options (refer section 5.2).

Multi-criteria analysis (MCA) was undertaken to inform an assessment of these preliminary final landforms/ rehabilitation options (refer sections 6 and 7). A more detailed assessment of each potential viable final landform/rehabilitation option (refer section 8) followed. For each viable option the following was completed:

- A risk assessment using Failure Mode Analysis;
- A comparison of risk controls and implementation actions required for the potential viable option and the mine operator's current Work Plans;
- An estimate of costs to implement the risk controls for the viable option;
- An assessment of the capacity for progressive rehabilitation and;
- An implementation schedule.

An overview of the study approach and key study milestones is provided in Figure 1-3. Figure 1-4 provides an overview of the study method and how the study progressed from initial data and information capture to a high-level assessment of potential viable final landform/mine rehabilitation options. A detailed description of the approach used is provided in Appendix A.

Figure 1-3 : Overview of Study Approach

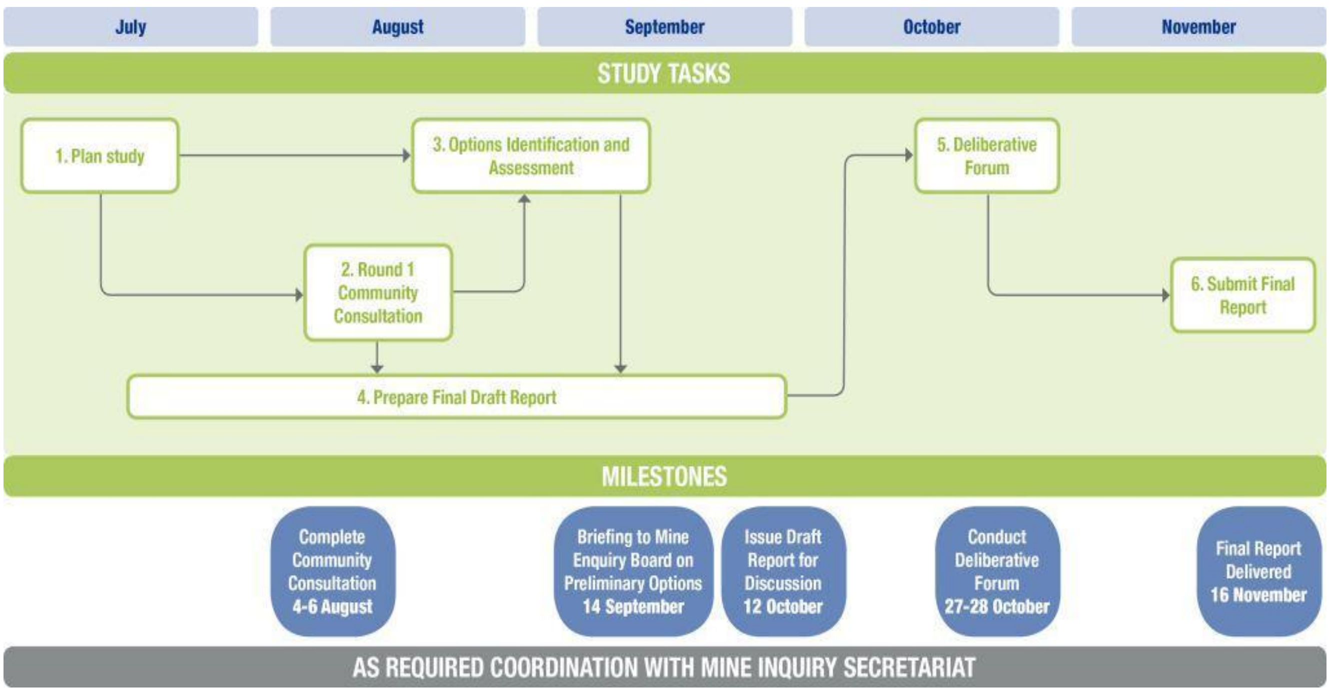
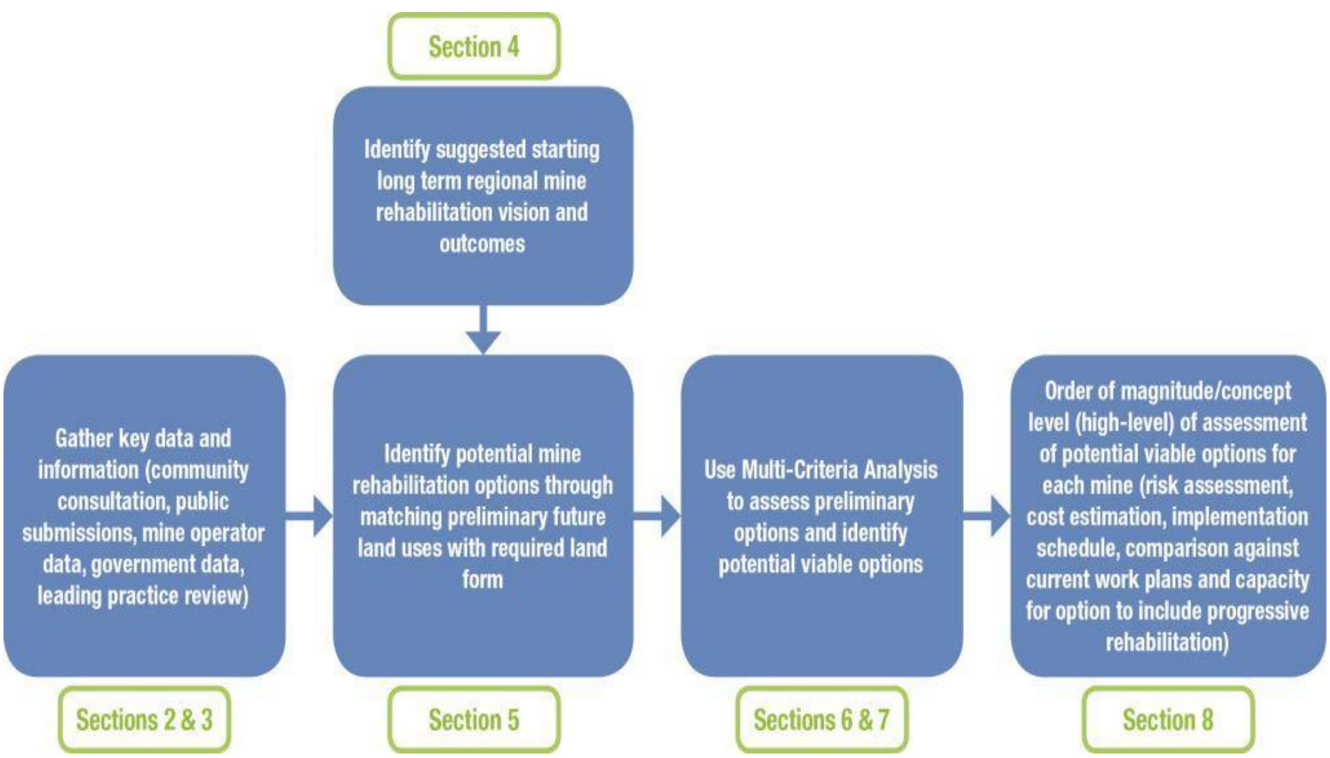


Figure 1-4: Overview of Study Method



1.4 Technical Definitions, Terms and Concepts

In the information provided to Jacobs by the Inquiry, technical terms and concepts have often been used inter-changeably in different reports depending on author, subject, mine and date.

In preparing the report Jacobs have used the definitions for the following important terms and concepts (refer to Appendix A for a full list of technical definitions, terms and concepts):

- A Work Plan is a legal requirement to undertake work on a Mining Licence area under the MRSDA. In addition to being appropriate to the nature and scale of the proposed mining activities and specifying how the mine operator will eliminate or minimise key risks, the Work Plan must include a rehabilitation plan for land to be disturbed by mining activities;

- Land use is the collective term that encompasses the ownership, the activity and the biophysical surface cover of the land. Land use describes all aspects of activity continuously across a landscape, such as; agricultural uses, environmental uses and residential/industrial uses (Department of Economic Development, Jobs, Transport and Resources, 2015);

- Landform is the shape (morphology) and character of the land surface that result from the interaction of physical processes (United States National Soil Survey Centre, 2005); and

- Mine rehabilitation involves the establishment of a final landform that meets key risk mitigation criteria (e.g. stability, groundwater, surface water, fire, public safety, biodiversity, public and private infrastructure) agreed under the relevant regulatory statute and which facilitates the agreed post mining land use.

- Pit Lake - A body of water that fills the mine void to, or approximately to, the pit crest and which covers the majority of the pit surface area; and

- Pit Water Body - A body of water that partially fill the mine void to a level below the pit crest and which covers a portion of the pit surface area. For the purpose of this report the term pit water body has been used to distinguish between a pit lake that completely fills the pit void and pit lake that only partially fills a pit void.

1.4.1 Short, Medium and Long Term Options

An option is a final landform and whether it is possible to achieve some, all or none of the final landform in the short, medium or long term.

For the reminder of the report a future mine rehabilitation option is referred to as either:

- Preliminary option – an option that exists but potential viability is untested at each mine site. The study tests preliminary options and establish their potential viability. A preliminary option is graded as either a potential viable or currently unviable option; and
- Potential viable option – an option that is potentially viable for a mine site. The study assesses the risks, costs, schedule etc. of potential viable options and provides findings regarding issues that warrant more detailed investigation.

In consultation with the Inquiry the study has interpreted the short, medium and long term as follows:

- Short Term - From now until end of mining operations. During this period the mine operators are required to progressively rehabilitate the mine to meet the landform agreed with ERR within the approved Work Plan. Each mine operator advised the Inquiry of their current scheduled mine closure date:
  - Yallourn Mine – scheduled closure 2032;
  - Hazelwood Mine – scheduled closure 2033;
  - Loy Yang – scheduled closure 2048.

- Medium Term – from end of mining operations to 15 years after end of mining operations. During this time mine operators will be actively rehabilitating mined areas to achieve their final landform;
- Long Term – the period 15 years after end of mining operations. Achievement of the final agreed landform may take an undefined number of years depending on the landform and impacting factors. The final landform would be expected to be available for post mining land use during this period however it is possible that ongoing maintenance and management requirements would exist.

1.5 Study Scope

The scope of the study was defined by (refer to Appendix A for a full overview of study scope):

- Inquiry's timeframe and Terms of Reference - Jacobs was formally appointed to commence on 24th July 2015 and a draft report was required by the Inquiry on 12th October 2015. Over this 11 week period Jacobs' analysed 18 different preliminary options (six options per mine) and six potential viable options (two per mine). The criteria used to assess the options were set by the Inquiry's Terms of Reference;
- Focus on landforms and potential land uses - the purpose of this study is not to establish the viability (or otherwise) of the potential post-mining land use(s) but to consider the impact of the choice of landform on land use(s);
- High-level study assessment - the study has been completed at an order of magnitude/concept level of study for the cost estimation and features of an early pre-feasibility level of study for assessment of the preliminary and potential viable options (e.g. Risk assessment has used a Failure Mode Analysis technique and a relatively comprehensive assessment criteria has used);
- Geographical extent of the mine site rehabilitation evaluated - purpose of this study was to assess options focused on the open pit;
- Options in the context of planned closure - in a planned closure of a mine there is an orderly wind down of mining operations and a co-ordinated transition to active mine site rehabilitation;
- Available technical data and information - only data provided by the Inquiry and available within the public domain was used in the development of this report. Jacobs has relied on the accuracy of all data provided;
- Community consultation and public submissions - a member of the Jacobs team attended and participated in community consultation workshops and Jacobs' team members have reviewed public submissions to the Inquiry to inform the study; and
- Engagement with a Technical Review Group (referred to as a Deliberative Forum) - on the 27th and 28th October 2015 Jacobs participated in a Deliberative Forum organised and facilitated by an independent facilitator appointed by the Inquiry. Over one and half days Jacobs outlined the draft findings of their study and the members of the Deliberative Forum provided comment on technical validity and merit.

1.6 Conflict of Interest Statement

No member of the Jacobs study team nor their sub-consultants have in the period between 2009 and 2015 directly advised one or more of the Latrobe Valley Power Stations owners or operators on how to rehabilitate or close their mine pits and associated over-burden/stock-piles. In 2012 several Jacobs staff (Andrew Tingay and Darren Murphy) and sub-consultant (Charlie Speirs) produced a high-level roadmap for the development of a Latrobe Valley Mine Closure Strategy for Clean Coal Victoria. A number of mechanisms were put in place by Jacobs Australia and its sub-consultants to prevent any unauthorised disclosure of the study findings prior to their release to either the Latrobe Valley Power Station owners/operators, Victorian Government departments and general public.

2. Coal Mining in the Latrobe Valley

Key Finding

Based on the current mine operator's Work Plans it is conceivable that during the second half of the twenty first century the three current mine pits will have been replaced with substantial water bodies surrounded by a shaped lowered landform (e.g. slopes not as steep as current mine pits).

Using information available to Jacobs' the final planned landform for each of the mines are based on similar concepts and would therefore take broadly similar forms:

- Using material to partially fill some of the mine pit;
- Using water to partially fill some of the mine pit and therefore creating a "small lake" (pit water body); and
- Lowering of the landform around the water body.

As mine rehabilitation takes on greater importance in the coming years it would be useful to establish some common language and terms to describe, compare and contrast planned final landforms between the three mines.

The Latrobe Valley is situated in the foothills of the Great Dividing Range at the confluence of the Latrobe and Morwell Rivers. The community of the Latrobe Valley is spread across the numerous rural townships and farm holdings. The largest townships are Traralgon, Moe and Morwell which, with Churchill, collectively form the "Latrobe City". Current population is just above 75,000 people with more than 95% centred in the Latrobe City.

2.1 Brief History of Land Use in Latrobe Valley

The GunaiKurnai people are recognised under the *Traditional Owners Settlement Act 2010* as the Traditional Owners of Latrobe Valley lands. GunaiKurnai have been in Gippsland for many thousands of years, their land extends from Warragul in the south to the Snowy River in the North and from the coast through to the Great Dividing Range.

Settlement of the region, beginning in 1840 and escalating with the decline of the gold rush, was primarily for agriculture and farming (e.g. forestry, grazing and later, dairy). Completion of the railway from Melbourne to Sale in 1870 saw the establishment of rural townships including Morwell, Moe and Traralgon.

An influx of migrants in 1920's (many had fought in World War I) provided a source of labour for Old Brown Coal Mine (Latrobe City Council, 2010). This was a key milestone, marking the region's transition from primarily agriculture to primarily industrial.

2.2 The Coal Resource

The Latrobe Valley coalfield consists of primarily brown coal (lignite) and, with an estimated resource of 430 billion tonnes, represents one of the largest known deposits in the world. To date industry has used just under three billion tonnes to power Victoria in the past 90 years. This included briquetting operation through the 1930's to 1980's for domestic heating and since then for industrial purposes such as hospitals, milk factories and as an auxiliary fuel for power generators.

In excess of 4000 bore holes have been drilled, logged and used to define the coal reserve. A 3D geological model of the coal has been developed. It is known the coal stretches for around 50km (from the western to eastern end of the Latrobe Valley) and varies from 8 to 16 km wide across the Latrobe Valley.

The coal is a low grade originating from forests and swampy environments. The coal ranges in age from 7 to 25 million years old, depending on the depth of the coal seam (is very young compared to black coals that are in excess of 250 million years old). The coal has energy values in the range of 6.5 to 9.5 MJ/kg with the low energy coals being younger and generally nearer the surface. It is very low in impurities and therefore low in ash production.

2.3 Development of the Coal Resource

Search for coal began in the mid nineteenth century. Victoria sought to free itself of dependence on coal imported from NSW. In the late nineteenth century the coal fields were developed by the Great Morwell Coal Mining Company. Initially producing a modest amount of briquettes, the company ceased operations due to poor sales.

State Director of the Geological Survey, Dr H Herman completed a map of the size of Latrobe Valley coal fields by the beginning of the twentieth century. At the end of World War I coal fields were developed for electricity production by Sir John Monash. Monash established the Yallourn mine and power plant.

Demand for electricity post World War II meant that operations expanded beyond the Yallourn mine to the Hazelwood mine. The Hazelwood mine was developed from 1955 and construction on the Hazelwood power station began in 1974. The Hazelwood pondage was constructed in the early 1970s to supply Power Station cooling water.

Loy Yang mining and power generation began in the early 1980s.

Ownership and operation of the mines and power generation was vested in the State through the State Electricity Commission of Victoria (SECV) until the mid-1990s when the industry was privatised.

Today, power generation in the Latrobe Valley is vested in AGL (Loy Yang), Energy Australia (Yallourn) and GDF Suez (Hazelwood). The three open cut mines in the Latrobe Valley produce nearly 60Mtonnes of coal each year and generate around 75% of Victoria's power. Figure 2-1 illustrated the location of the three mines in relation to each other.

2.4 About the Coal Mines

More detailed information about each mine's operation, closure and rehabilitation planning is available from the Inquiry's website. Each mine operator provided a public submission to the Inquiry.

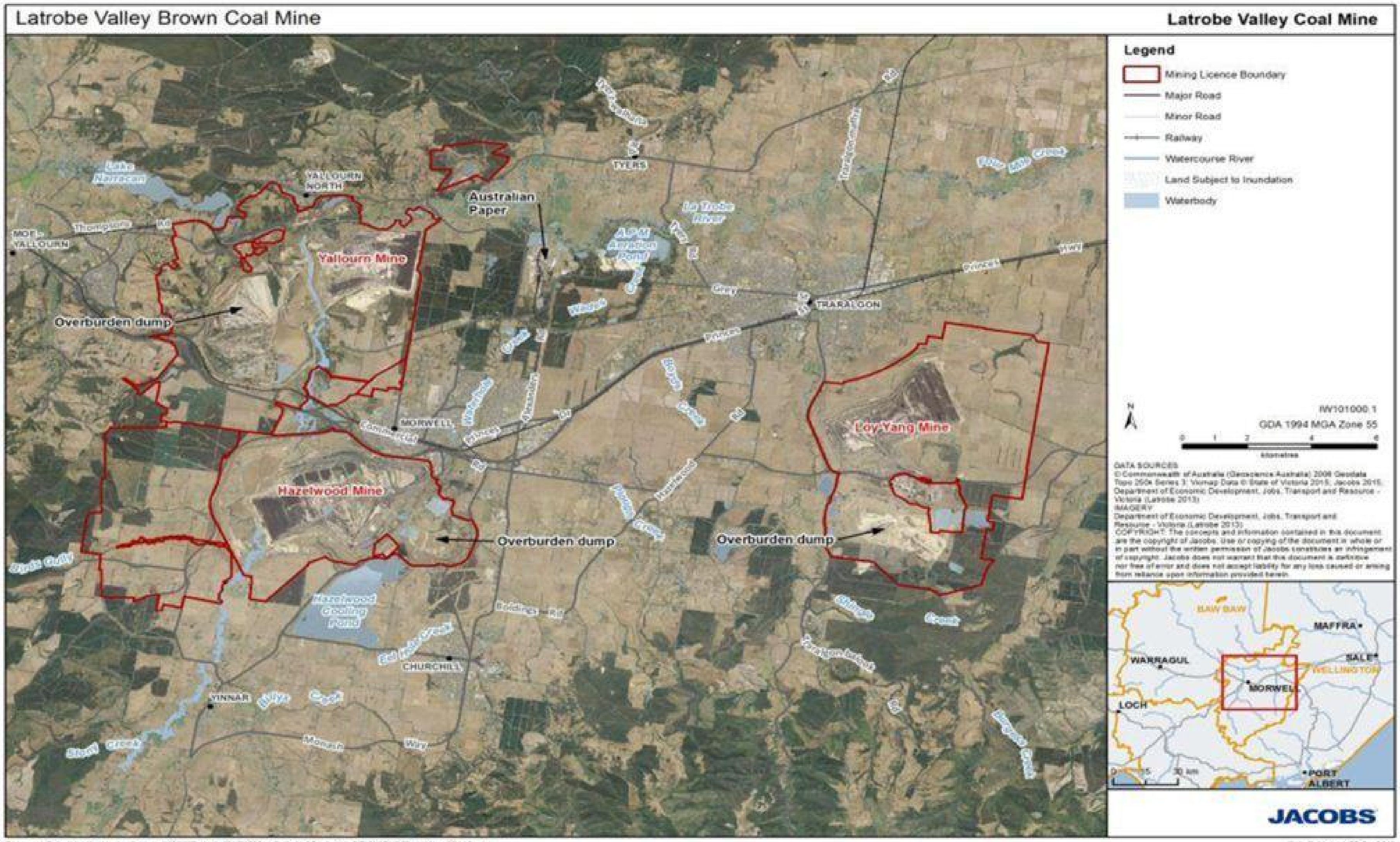
2.4.1 General overview of rehabilitation planning and progressive rehabilitation at the three coal mines

The progressive rehabilitation of the external dumps has been the main focus of the Latrobe Valley coal mines over the past 15 to 20 years. There has been some progress rehabilitation to reshape upper batters by cut and fill and revegetation.

From a fire safety perspective the original rehabilitation plans were to use the mine benches, clay covered during normal mining operations to provide access and fire protection. Cover was used to plant revegetation and provide a visual screen to the exposed coal batter.

Over the past 15 years the coal mines have planned for closure. More recently Yallourn and Loy Yang have applied for variations to their mining licenses. Both coal mines have developed a concept of internal dumping and flooding but to a lower level. This revised concept shapes the mine voids as a lowered landform with an internal dump. The remainder of the mine void is flooded to a level that provides a stable environment. The batters above this level are to be shaped and revegetated to suit a safe and stable mine landscape for future use.

Figure 2-1 - Aerial image of the three Latrobe Valley coal mines



The coal mines' generally seek to rehabilitate a portion of land equivalent to at least the area of mining that has been disturbed by that year's operations. Coal mines will generally prioritise rehabilitation to the parts of the mine that:

- Are complete or clear of current and future operations;
- Can be rehabilitated to fit the long term rehabilitation plan and;
- Give the best return for safety, visual and operational requirements

All mines in the Latrobe Valley commenced with external waste dumping and have progressed to internal dumping once the mine reached the bottom of the mining seams and created room to establish an internal dump.

Internal dumping assists with achieving mine weight balance and allows a reduction in mine dewatering for stability reasons. Two of the three mines (Yallourn and Hazelwood) are already dumping internally and the third (Loy Yang) is planned to commence in 2017-18.

The older external dumps have been progressively reshaped and grassed and returned to forestry, agriculture or recreational areas and are progressing to be part of the surrounding environment.

2.4.2 About Yallourn Coal Mine

2.4.2.1 Overview

Yallourn is the oldest and shallowest of the three mines. It covers an area of approximately 600Ha and is 80m deep. Mining at Yallourn generally extends to 80m below ground level and comprises of a single seam open pit and internal waste dump. Approximately 18Mt/annum of coal is extracted from the site.

Due to its low depth and deep aquifers it has a relatively small amount of dewatering. Therefore Yallourn is in a good position to plan and implement an effective mine closure and rehabilitation plan.

The Morwell and Latrobe Rivers border the mine to the east and north respectively.

Several diversions of local water courses, including a diversion of the Latrobe River following a batter failure in 2007, have been undertaken to progress and maintain mining operations. A notable feature of the mine is the Morwell River Drain which carries the Morwell River between the Township and East Fields.

2.4.2.2 Mine closure and final landform

Table 2-1 presents the expected date Yallourn will cease mining and what their planned final landform will be[2].

Table 2-1: Yallourn's expected closure date and proposed final landform

Expected closure date	2032
Proposed final landform	Flooding to a nominated level with plans to shape (flatten) the batters above the water level.

[2] Based on Yallourn's approved Work Plan

Figure 2-2 : Yallourn Coal Mine (source Department of Primary Industry, 2013)

The key features of the planned final landform at Yallourn include:

- In-pit overburden placement across floor and batters to extent allowed by operations;
- Filling of final pit void with water to create a lake (initially by aquifer depressurisation and then naturally over the decade until equilibrium is reached);
- Landscaping and public access around lake perimeter;
- Water supply from Latrobe River by lowering flood levees and rain fall run off;
- Remaining topsoil will be used to stabilise above the water line of the proposed future flooded mine void; and
- River diversion remains in place surrounded by lakes.

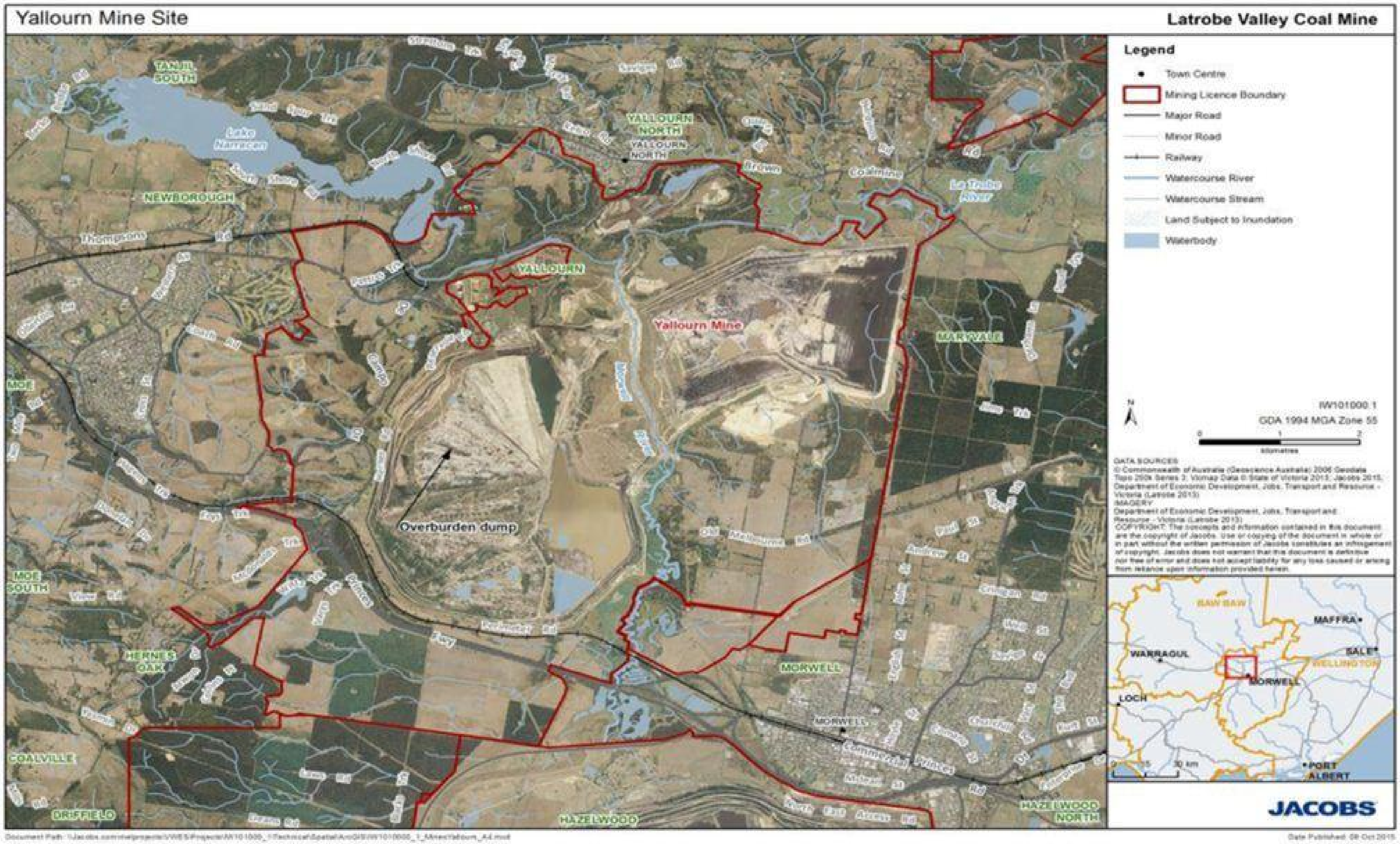
2.4.2.3 Progressive Rehabilitation

Progressive rehabilitation proposed for Yallourn involves:

- Transfer of overburden during mining and placement into the mine void (the East Field and East Field Extension);
- Establishment and maintenance of native vegetation offsets.

Yallourn has been internal dumping for many years (over 25) and has made significant progress in covering the base of the mine. It has established a significant fire reservoir at the base of the mine.

Figure 2-3 : Aerial photo of Yallourn mine site and nearby population centres, public infrastructure, adjacent land uses and environmental values



2.4.3 About Hazelwood Coal Mine

2.4.3.1 Overview

Hazelwood coal mine is approximately 500 Ha, 120m deep and generally a single seam open cut mine. Approximately 16Mt/annum of coal is extracted from the site. Artesian aquifer pressures at the site require management through significant dewatering of the pit, the scheme at times pumps up to 1,000 L/s. The estimated final size of open cut mine by the proposed completion of mining is 1260 hectares.

The southern urban boundary of Morwell (zoned General Residential) is located approximately 60m to the Special Use Zone containing the Hazelwood open cut, with the Princes Highway running in between. Proximity to the Morwell and the Princess Highway reduces the options for treating these batters to achieve a safe and stable buffer between the township and the closed mine. It is likely material will need to be placed at the base of the batters to reduce their overall steepness and then cover them to reduce fire risk.

Figure 2-4 : Hazelwood Coal Mine (source Department of Primary Industry, 2013)

In contrast to Yallourn coal mine, Hazelwood mine is nearly 50% deeper and has similar mine strip ratios. Careful use of available material will be essential to achieving the desired final landform.

2.4.3.2 Mine closure and final landform

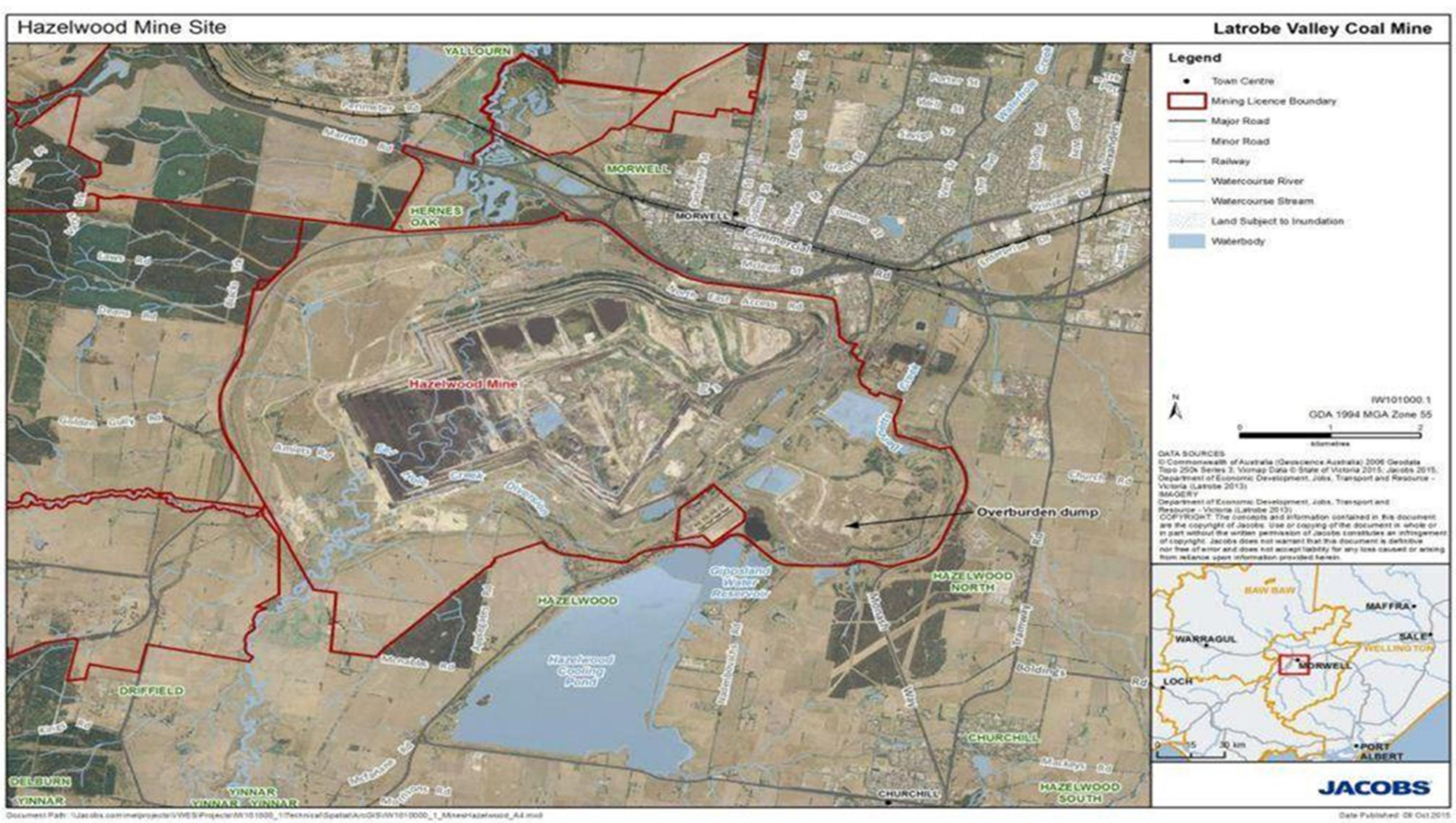
Table 2-2 presents the expected date Hazelwood will cease mining and their planned final landform (according to Hazelwood's approved Work Plan).

Table 2-2 – Hazelwood's planned mine closure date and proposed final landform

Expected closure date	2033[3]
Proposed final landform	Internally dumped ash and overburden and flood completed mine void

[3] Jacobs' understand that Hazelwood mine operators reported in the community consultation that scheduled closure is 2033. The Hazelwood Work Plan states expected closure date as 2031.

Figure 2-5 - Aerial photo of Hazelwood coal mine and nearby population centres, public infrastructure, adjacent land uses and environmental values



Key features of the proposed final landform include:

- In-pit overburden placement across floor and batters to extent allowed by operations;
- Filling of final pit void with water to create a lake (initially by aquifer depressurisation and then naturally over the decade until equilibrium is reached);
- Ash placed in the eastern end of the void;
- Overburden batters reshaped to a 3h :1v[4] slope gradient and grassed; and
- Coal batter faces reshaped to between 2.5 to 3h:1v slope gradient depending on geology.

Dewatering of the artesian aquifers below the mine may need to continue these post mining. The availability of waste material to maximize the internal dump and water are challenges to achieving this final landform.

2.4.3.3 Progressive rehabilitation

Progressive rehabilitation is proposed to include:

- Place sands from the original Morwell River into the South East field internal overburden dump;
- Bulldozing and seeding of some permanent void batters; and
- Planting of native trees and grasses on eastern overburden dump.

Jacobs' currently understands Hazelwood's are well advanced with the rehabilitation of their external waste dump and have commenced some mine batter rehabilitation work in areas of the mine that are completed.

2.4.4 Loy Yang Coal Mine

2.4.4.1 Overview

Loy Yang mine is the deepest of the three mines. It is more than twice the depth of Yallourn and 50% deeper than Hazelwood. Covering approximately 500ha, the mine comprises a 200m deep multiple mine seam and inter-seam open pit, with external waste dump. As the mine extends below water table, the pit requires significant dewatering. Approximately 30Mt/annum is extracted from the site.

Traralgon is located approximately 2km to the north of Loy Yang. In the future the proposed Traralgon bypass may be located between the mine and the township.

Figure 2-6 : Loy Yang Coal Mine (source Department of Primary Industry, 2013)

[4] Where (h) is horizontal run and (v) is vertical rise.

2.4.4.2 Mine closure and final landform

Table 2-3 presents the expected date Loy Yang will cease mining and their planned final landform (according to Loy Yang's approved Work Plan).

Table 2-3 – Loy Yang's planned closure date and proposed final landform

Expected closure date	2048
Proposed final landform	Mined void to be partially water-filled and lowered landform

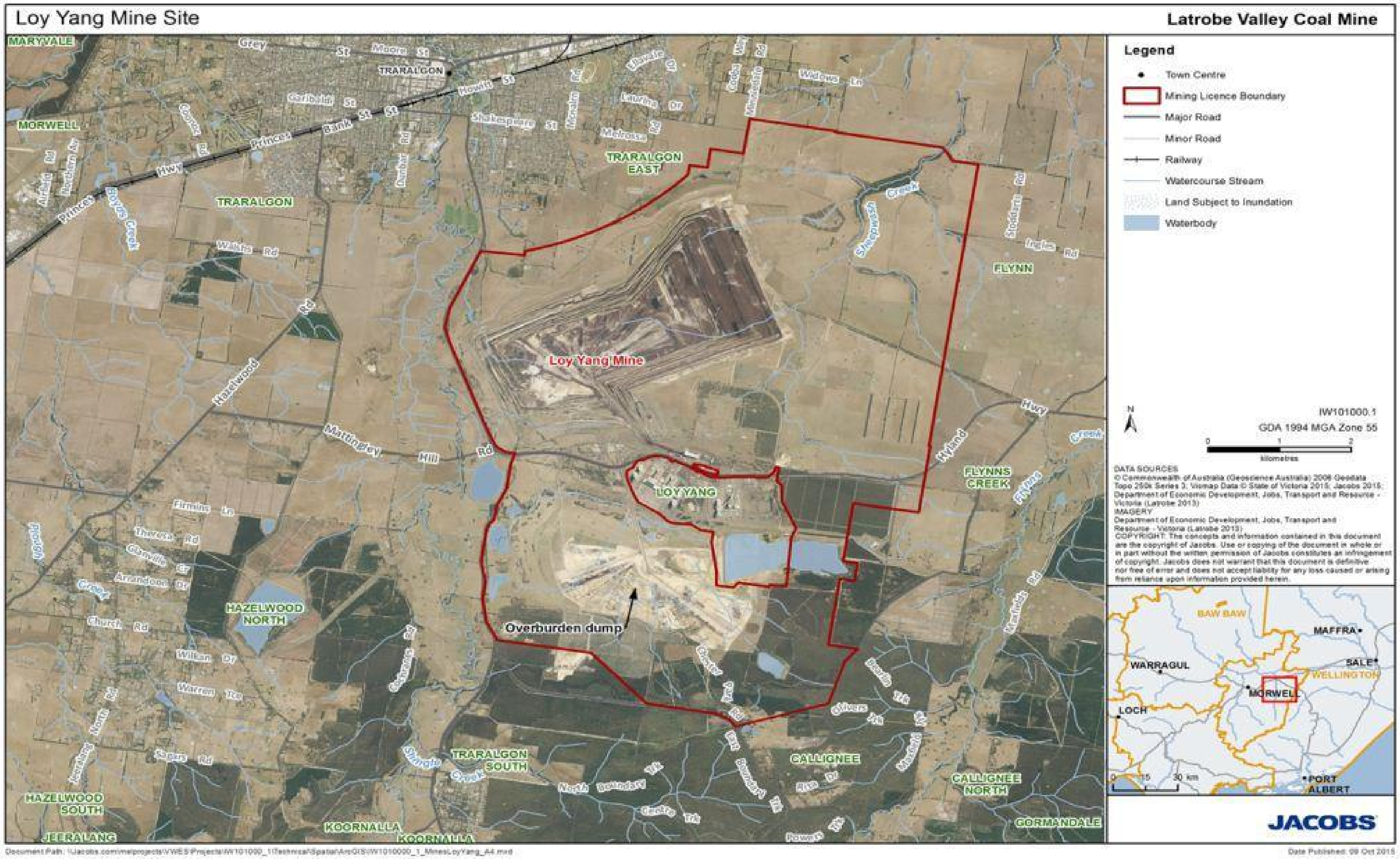
Loy Yang commenced the process of planning a transfer of external dumping into the mine in 2017-2018 (according to their recently submitted Work Plan variation). A design of the internal dump has been complete. A lake to a suitable level is proposed to help achieve the required weight balance. Walls above the lake are planned to be reshaped. The current proposed land use for the Loy Yang mine is agricultural grazing on non-flooded areas of the pit.

Similar to Hazelwood, Loy Yang will need to carefully use of spare/waste material in order to achieve the desired rehabilitation outcome.

2.4.4.3 Progressive Rehabilitation

Rehabilitation is occurring progressively within the Loy Yang mine in accordance with operational needs. To date, over 80% of areas available for rehabilitation have undergone some form of remediation. The levels of the external waste dump that are completed have been rehabilitated and returned to agricultural purposes. The northern batters of the mine have had initial cut and fill rehabilitation treatment. Jacobs understand that the northern batters have taken good shape and natural vegetation has taken up.

Figure 2-7 : Aerial photo of Loy Yang mine site and nearby population centres, public infrastructure, adjacent land uses and environmental values



3. Important Mine Rehabilitation Issues

Key Finding

The Study has been unable to locate a single short report or document that succinctly explains the important array of issues and challenges confronting the long term rehabilitation of the Latrobe Valley Coal Mines. Issues and challenges are either:

- Single issue for the region (e.g. conceptual mine water balance study of the Latrobe Valley);
- Multiple issues for an individual mine (e.g. environmental impact assessment at a specific mine) or;
- Single issue for an individual mine (e.g. review of internal overburden dump and its hydrogeological impacts at an individual mine).

Jacobs' have prepared this section as a basis for a possible standalone document regarding important mine rehabilitation issues (e.g. amount of backfill available to coal mines in the Latrobe Valley, uncertainty regarding timing of closure, geotechnical and hydrogeological issues, access to water, on-going fire management, on-going funding/management of risks, climate change, changing community expectations over the long term, creating economic growth opportunities from post-mining land uses and planning/executing rehabilitation with regulatory certainty).

To find solutions to many of the issues and challenges stakeholders need to appreciate the inter-dependencies and inter-relationships of the issues and challenges (at an individual mine scale and more importantly a regional Latrobe Valley scale).

Important issues summarised in this section bring into play a wide array of stakeholders (community, local council, State Government regulators, mine operators, staff employed directly or indirectly by the mines, State and Commonwealth Government Departments responsible for different policy areas, community groups, peak bodies, organisations representing environmental issues, unions etc.). The breath of issues and stakeholders lend themselves to some form of over-arching co-ordination of short, medium and long term rehabilitation.

Mine rehabilitation planning and implementation in the Latrobe Valley coal mines is a highly complex, contestable and dynamic exercise due to all the geological, bio-physical, economic, community and political factors involved.

3.1 Low overburden strip ratios creates challenges to backfilling mine voids

The Latrobe Valley coalfield is characterised by its relatively low overburden cover of between 6 and 30 meters. Individual deposits may consist of coal seams each up to 100m thick. In addition Loy Yang has several coal seams inter-dispersed with interseam materials (waste material between coal seams). The relatively low strip ratio of overburden to ore within the Latrobe Valley presents favourable and cost effective operating conditions.

An impact of the mines having a favourable strip ratio is the volume of the final pit void and relative lack of material to backfill the mine voids. Internal dumping of waste (e.g. overburden) is needed to contribute to achieving weight balance and a stable mine void.

3.2 Uncertainty in electricity market creates uncertainty for mine closure planning

On-going viability of the Latrobe Valley coal mines is heavily influenced by the pace of change in the composition of Victoria's energy mix.

Coal fire powered electricity generation represents the significant amount of Victoria's electricity generation. The rate of transition to lower emission gas plants and renewable energy will be a key determinant of the viability of the coal mines. The speed of the transition will be largely determined by community uptake of renewable energy sources (reliability, cost and concerns regarding climate change) and Government's policies regarding the composition of Victoria's energy mix.

Advancement in technologies to generate "cleaner" electricity from brown coal will be another major determinant on the viability of the coal mines. Brown coal has high moisture content of between 55% to 67% which requires large boilers to process and convert the coal energy into steam energy for power generation.

3.3 The coal mines have complex geotechnical and hydrogeological characteristics

Significant challenges exist in understanding the cause, likelihood and impact of a mine stability incident due to the geotechnical and hydrogeological characteristics at and around the three coal mine sites.

Coal seams make up the majority of the mine slopes and from a geotechnical perspective the coal is very light (e.g. not much heavier than water) and is jointed (e.g. it has numerous "cracks" that are continuous). Unlike most other hard rock and coal mines, the critical trigger for landform instability in the Latrobe Valley is water (surface or groundwater).

Since coal is so light mining excavation causes movement of the coal slopes, opening of cracks and, hence, creates a pathway for water to enter. Surface water (from rain or adjacent rivers) can enter the joints ("cracks"), resulting in movement of the coal.

Groundwater exists in aquifers below the mine void or in the slopes after mining has passed. When under pressure the aquifers uplift the base of the mine and its bottom slopes. If these groundwater pressures are not reduced by continuous pumping then major movements can occur, leading to potential large landform instability. Figure 3-1 shows a general diagram that describes the force on the floor and walls that is exerted by uncontrolled groundwater pressure. Figure 3-2 shows a representation of the effects of uncontrolled pressure on mine open pits.

Figure 3-1 : Diagram representing the forces on an open cut in the Latrobe Valley that are exerted by uncontrolled groundwater pressure

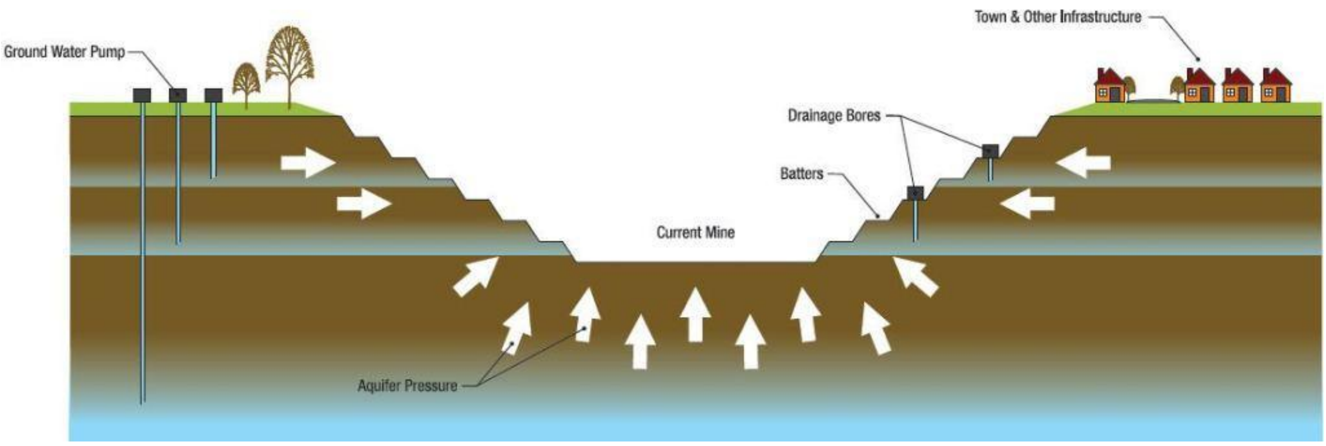
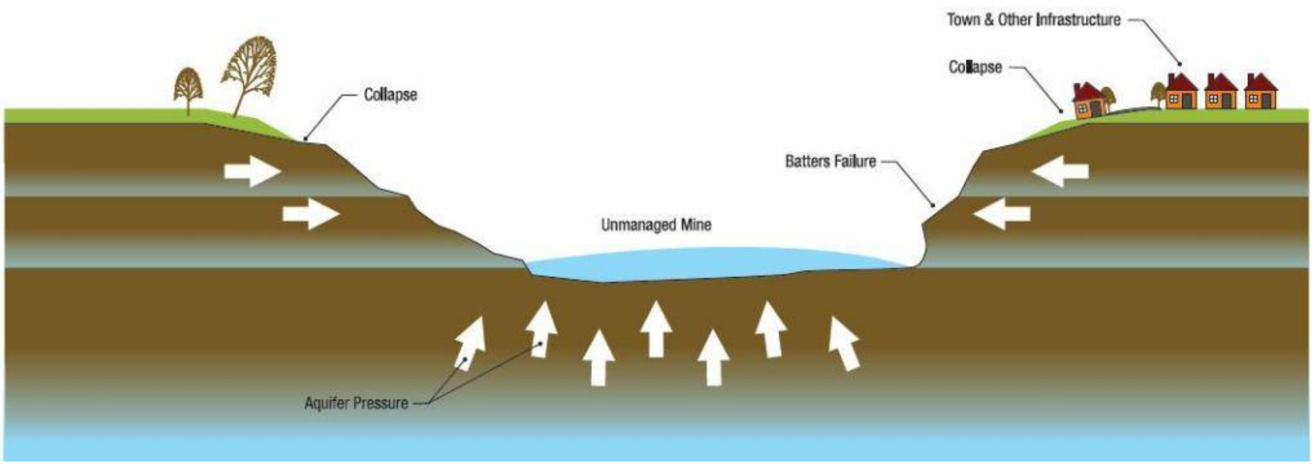


Figure 3-2 : Diagram showing the types of failures that can be bought about by uncontrolled groundwater pressure



In addition to water, batter stability is influenced by:

- Slope angle and vertical height;
- Material strength and structure (e.g. number and orientation of joints/cracks); and
- Method of slope construction (dozer rip/push, pre-split, etc.).

All these factors need to be considered in designing a suitable slope angle. Incorrect data and/or analysis will lead to the wrong slope angle.

Location and “life” of the slope are important factors. For example a conservative design is needed for slopes near mine or town infrastructure and where the public are likely to frequent.

The proximity of the mines to a range of public infrastructure and environmental assets substantially increases the consequences of slope movement and landform instability. The infrastructure can be within the mine (e.g. a river diversion, power station) or outside the mine (e.g. freeways, rivers and towns). Slope failure can result in a range of impacts including high financial cost, injuries and fatalities.

A poor understanding of the interaction of these factors over different time scales (short, medium and long term) and mine scale (e.g. single batter, multiple batters, whole of mine site, outside of mine site) can result in single or multi-batter collapse. For example:

- Pit floor heave due to uncontrolled groundwater back pressure;
- Incorrect geotechnical design of slope angles (and fracture planes); and
- Erosion of batter due to uncontrolled run-on or changes in pit fill material competency (due to water ingress). The possible result of erosion on mine slopes is to remove the tow (e.g. bottom) of the slope which then leads to gravity collapse of material above.

Over the last decade there have been notable recent slope failures and large slope movements (e.g. Latrobe River collapse in 2007, Morwell River Diversion in 2011 and Morwell Main Drain in 2012) (Parliament of Victoria, 2008, DEJTR 2013). These incidents have caused significant disruption to coal production and/or major disturbance to nearby infrastructure (freeways, rivers).

In the undertaking this study Jacobs’ needed to consider both individual mine specific stability hazards as well as stability risks at a regional scale. A regional mine stability map showing the location and proximity of high risk public and private infrastructure and environmental assets to each of the mines and potential linkages would have been a highly useful tool.

3.4 Water access and allocation in an already stressed water system

Current coal mining operations are a significant user of water, in the Gippsland region, sourced both from groundwater and surface water (West Gippsland Regional Catchment Strategy, 2013). If the current proposed final landform for each mine are pursued[5] it is likely the mines will require significant on-going access to the Region's water resources. Further some of the final landforms may require periods of higher than current water use. **Table 3-1** shows the current annual surface water and groundwater allocations for each mine.

Table 3-1 – Annual surface water allocations for each mine (Victorian Water Accounts, 2012)

	Yallourn Mine	Loy Yang Mine	Hazelwood Mine
Annual Surface Water Allocations	36,500 ML/yr	60,000 ML/yr	By agreement with Gippsland water

Current and desired future mine water use is in the context that the catchments in west Gippsland are under water stress and efforts are underway to return water to support environmental values. Particularly in the case of groundwater, the combined effects of mine use, irrigation use and off-shore oil and gas extraction contribute to declining groundwater levels.

Water serves several purposes in coal mining in the Latrobe Valley, including:

- Mine dewatering;
- Fire and dust suppression.

These uses make coal mining a significant consumer of water within the Gippsland region, consuming approximately 95 GL of surface water and approximately 25GL of groundwater each year (the second largest groundwater consumption after irrigation use in the onshore Gippsland region).

Coal mines currently use less water than their annual water surface and groundwater entitlements. Large-scale coal mining is a net producer of groundwater, generated from the aquifer depressurisation process required for a mine to remain "safe and stable". This extracted groundwater is re-used for cooling at thermal power stations.

Groundwater extraction in the Gippsland region is currently greater than groundwater replenishment through rainfall recharge, which has led to continual lowering of the levels of groundwater. This has caused two main impacts:

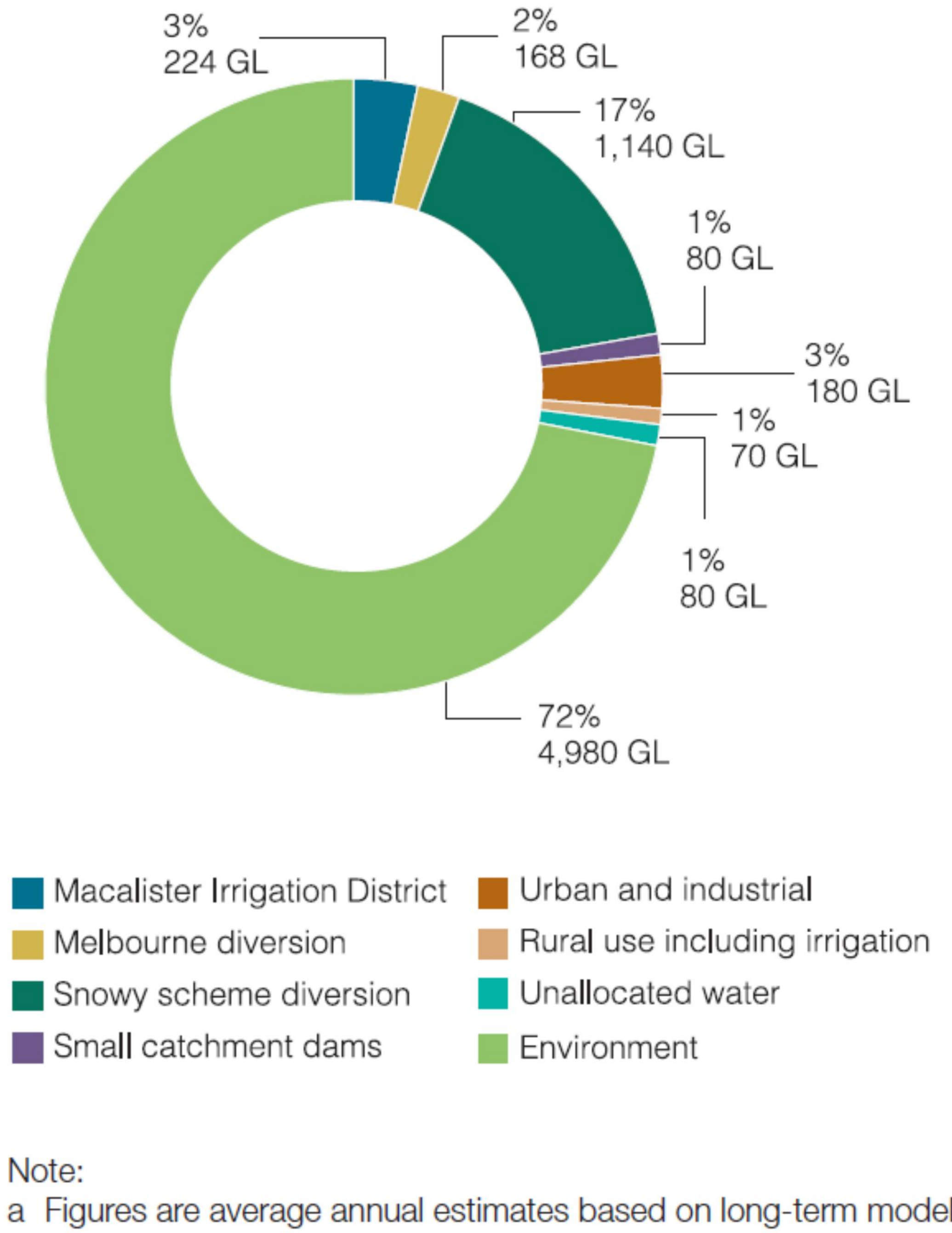
- Declining aquifer pressures regionally, with the greatest declines near the mines (about 90 metres decline around Morwell since commencement of mine dewatering in the late 1960s) (CSIRO, 2004);
- Subsidence induced by long-term decline in aquifer pressures. Whilst subsidence has occurred in the Latrobe Valley (about 2.5 metres around Morwell since commencement of mine dewatering), it has been small elsewhere in Gippsland to date (CSIRO, 2004).

Gippsland is wet relative to other areas of Victoria but is still viewed as being under pressure. Presently surface water is fully allocated. Minimum environmental water requirements for the Latrobe River and Gippsland Lakes are currently not fully met.

Figure 3-3[6] indicates that the majority of water used in the Gippsland Region is sourced from surface water. On average, the supply to industrial water users is a small component of the overall water resource in the region.

[5] Hazelwood - Internally dumped ash and overburden and flood completed mine void, Loy Yang - mined void to be partially water-filled, Yallourn - flooding to a nominated level with plans to shape (flatten) the batters above the water level.
[6] The Gippsland Water Factory provides recycled water to some industrial customers and is contained within the volume of alternative water sources.

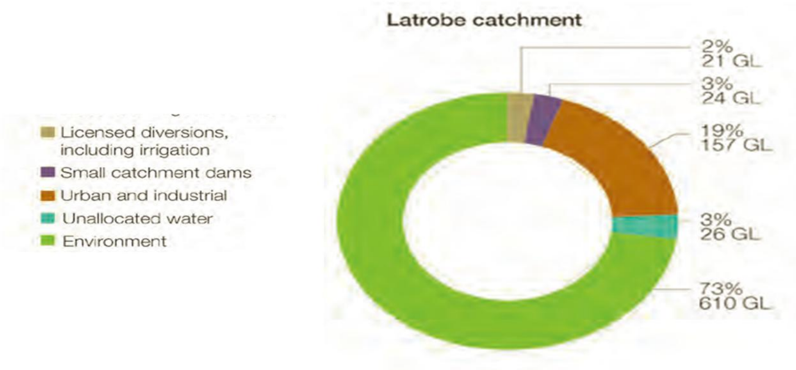
Figure 3-3 - Water availability within Gippsland region



Source: Victorian Department of Sustainability and Environment (2012) Gippsland Region Sustainable Water Strategy

Figure 3-4 shows that urban and industrial surface water use (which includes the supply to the power stations, other industrial water users and the towns) is the largest consumptive water user in the catchment.

Figure 3-4 Water use in Latrobe Catchment



Source: Victorian Department of Sustainability and Environment (2012) Gippsland Region Sustainable Water Strategy

In regards to currently proposed mine's final landform[7] each mine faces a range of water related challenges including:

- Acidification or salinization of pit body water or the introduction of nutrients or algae from surface water runoff. This could affect pit water body quality and may result in contamination of groundwater, depending on the relative levels between the pit water body and groundwater;
- Initial groundwater resource requirement for filling of pit water body or ongoing maintenance of pit water level through the injection of groundwater, resulting in the limitation of groundwater availability to other users. For example at Loy Yang the formation of a pit water body is challenged by evaporation that exceeds rainfall (by approximately 200mm per year (source)) and by the small catchment area of the pit relative to the pit water body;
- The final landform changes the existing drainage features in the mined area and effects local runoff patterns, resulting in reduced water quantity in surrounding watercourses; and
- Pit water body quality deteriorates or the pit water body overtops with uncontrolled discharge of poor quality water into a local river (due to flooding event) resulting in surface water contamination.

3.5 On-going fire management and prevention

Coal is a combustible material. Coal seams exposed during mining are susceptible to ignition from internal (e.g. mine operations) and external (e.g. spotting from bushfires) sources.The Hazelwood Mine Fire Inquiry board concluded that the February 2014 Hazelwood mine fire was most likely caused by embers spotting into the mine from one of two nearby bushfires. Spontaneous combustion may also occur within coal seams under certain aerobic and thermal conditions.

In the short term (e.g. during mining operations) mine operators are required to implement operational controls which mitigate and minimise the risk of fire. This includes establishment and maintenance of fire suppression and response systems, as well as minimising the area of exposed coal seams within the mining area. Important fire management controls are covered worked out benches and a fire defence system. System should be capable of containment (e.g. wetting the area and thereby reducing risk of fire spreading).

The Latrobe Valley coal mines currently use clay covered access roads and non-operational mine benches to reduce exposed coal. Clay cover is generally half a meter thick and usually sufficient for the mining operations phase. Clay covered is complemented by significant resources and fire protection equipment. Some recent experimentation with fire retardant materials has occurred to better understand their effectiveness, efficiency and durability.

[7] Hazelwood - Internally dumped ash and overburden and flood completed mine void, Loy Yang - mined void to be partially water-filled and lowered landform and Yallourn - flooding to a nominated level with plans to shape (flatten) the batters above the water level.

Once mining ceases exposed coal will need treatment to reduce medium to long term fire risk fire. The risk level needs to be informed by understanding of the likelihood of the fire source (e.g. internal mine activity such as driving machinery, rehabilitation works and potential recreational activity and external sources such as bushfire spotting etc.). A risk assessment should inform the size and scale of the treatment needed to be enduring, proportional and effective. Treatment should be monitored to assess their integrity in light of medium and long term minor movement, cracking, erosion and settlement.

Recognised fire protection treatments and methods could include a combination of:

- Maintaining the fire network and defence systems used to presently protect the mines. (Method is resource intense due to long term commitment maintenance and operation);
- Flooding - keep the coal wet and quench fire risk;
- Cover by some fire retardant material. Jacobs's understand fire retardant materials have been trialled but their effectiveness is still inconclusive; and
- Cover the coal with a layer of clay and ensure that it is sealed and maintained so that the fire source cannot get into the dried coal in the worked out mine.

In the medium and long term fire risk is mitigated primarily by the nature of the final landform. This involves the covering of exposed coal seams beneath non-combustible materials, such as overburden or water. The risk of re-exposure of the coal seam must be understood and managed through design, construction and on-going management of the final landform.

Regardless of the final landform the exposed coal above any water body that exists in the mine void will have to be treated to ensure there is no risk of fire to exposed drying and fretting coal. A reliable and dependable fire control is to cover the coal by water or sufficient clay to protect the coal from exposure to fire sources.

In Jacob's consideration of fire risk and landform interaction Jacobs' have adopted a concept of shaped batters to the proposed design slope and a clay cover of 2 meter thickness to make sure the depth is sufficient to achieve the purpose for land use that will be in place post mining. Jacobs' recognises the importance of on-going monitoring as the cover will have to be effective over the long term (decades if not centuries).

3.6 On-going management of risks

Final rehabilitated landforms will require some level of on-going management of fire, stability and water related risks and their associated risk controls. Management of and responsibility for these risk controls is dependent on the final land use(s) supported by the final rehabilitated landform. Appropriate and sustainable financial mechanisms will be needed to fund future risk controls to effectively manage long term fire, stability and water risks.

3.7 Potential impacts of climate change

The capacity for long term mine rehabilitation to protect and improve the health of local and regional environmental values is impacted by a range of factors, most notably potential climate change.

Research concerning the potential impact of climate change in the Latrobe Valley has found that, like much of Australia, there will be significant impacts to the climate and the climate dependent ecosystems (CSIRO, 2005, Federation University Australia, 2015). Overall, the impact of climate change on the Latrobe Valley is likely to be an increase in fire potential and a decrease in water availability.

In terms of average response, it's likely that:

- Rainfall will decrease both seasonally and annually;
- Evaporation will increase annually although the trend is likely to be stronger in Winter and Spring than Summer and Autumn;
- There is likely to be a decrease in humidity; and

- Solar radiation (sunlight) is likely to increase due to decreased cloud cover.

The impact on extremes of rainfall and temperature could include:

- An increase in the expected storm activity and rainfall intensity; and
- An increase in the number of days with temperature exceeding 35°C and a decrease in the number of days where temperature is below 0°C.

3.8 Mine rehabilitation is an inter-generational issue

People of all ages in the Latrobe Valley may be impacted in some way by short, medium and long term actions taken to rehabilitate the mines. The impacts could be most felt for the longest period of time by younger people (currently 0 – 30 years old).

What are their aspirations for the type of community they wish to grow up and possibly raise their own families in and how do they differ from past or current community values? How important to this age group will be social stability, the beauty of nature, a quiet neighbour, safety and security, access to open spaces, preservation of historical features, a vibrant community, ease of access to services and ease of movement?

Understanding current and long term community values is critical to informing how rehabilitated mines could provide for positive social outcomes.

The Latrobe Valley's largest age sector is the 0-25 year old group, representing just under 35% and the smallest sector is the 65 and over age bracket, representing approximately 15% (Gippsland Regional Growth Plan, 2014).

The movement of people into the Latrobe Valley (attracted by affordable housing, semi-rural lifestyles etc.) brings different experiences and community expectations. For the last 20 years, the Latrobe Valley population has been growing at slightly less than 1% and is predicted to continue at just over 1% for the next 20-30 years (consistent with other parts of Regional Victoria). Young families account for a significant number of the people shifting to the Latrobe Valley.

3.9 Supporting industries of the future

Providing landforms that create long term economic development opportunities rather than significant economic constraints is an important challenge. Predicting the industries of the future is complicated by a range of market factors (e.g. rapid advancements in technology, increasing access to overseas markets, growing competition from overseas etc.).

Governments have given consideration to future industries in the Latrobe Valley (Latrobe Valley Industry and Employment Roadmap, 2013). A 2010 study by Latrobe City Council specifically focused on 'Positioning Latrobe City for a Low Carbon Emissions Future.' Realising opportunities, contingency planning and working together were seen as the main elements of an effective approach to a variable future. Specifically, opportunities were envisaged in:

- Ongoing development of the coal industry either through improved coal to energy processes or through diversified uses for coal such as fertiliser production;
- Growth and strengthening of the agricultural and food production sector, taking advantage of the relative climate security and the opportunity to increase the number of food processing industries located within the Latrobe Valley;
- Building on the existing opportunities to grow the education and training sector with both local and international students across both TAFE and University education; and
- Business support functions such as call centres which the Latrobe Valley is able to provide in a cost competitive and stable manner.

In 2014, the Victorian Government released the Gippsland Regional Growth Strategy which identified several areas to target economic growth within the Latrobe Valley including:

- Diversification in manufacturing and industry;
- Innovation in agriculture and fisheries; and
- Strengthening of the energy sector including the development of renewables.

3.10 Political cycles over the course of rehabilitating the mines

Over the next 30 years there will be many Commonwealth, State and Local Government elections and with that changes in legislation, regulation and policy governing energy, climate, environmental, earth resources and industry. To effectively plan a set of long term desirable economic, community and environmental outcomes from mine rehabilitation will require clarity of purpose and a rationale capable of withstanding scrutiny over time.

4. Regional Mine Rehabilitation Vision and Outcomes

Key Finding

There is no current Latrobe Valley wide vision or set of preferred/agreed outcomes relating to the rehabilitation of the three mines other than what is required under the *Minerals Resources (Sustainable Development) Act 1990.*

Past studies, inquiries and research into future strategies for the Latrobe Valley, including coal mining, acknowledge the role of the Latrobe Valley as an economic and energy powerhouse for Victoria. While most discuss the future of coal and energy production in a low carbon scenario, only a few proactively deal with mine rehabilitation.

An effective vision and clear set of outcomes delivers direction for decision making. A shared long term vision and set of clear outcomes are necessary to:

- Build a shared identity;
- Guide transition phases;
- Enable testing of final landform options against their likely contribution towards the vision and outcomes;
- Improve understanding of possible limitations and opportunities and;
- Facilitate better choices for sequencing future landforms and related land uses.

Given the important issues associated with the long term rehabilitation of the Latrobe Valley mines, it is essential mine operators, governments and Latrobe Valley community have a shared long term vision and set of desired outcomes for rehabilitating the three mine sites over the next 50 years.

4.1 Inquiry's community consultations helped set the scene for expanding focus from safety and closure to transition and coping with change

The Inquiry has provided an opportunity for interested stakeholders to provide their views on the outcomes they are seeking from the long term mine rehabilitation. Consultation conducted by the Inquiry showed that the community wants a strategic, Region-wide approach to mine rehabilitation that embraces open communication and transparency from the mine operators.

More than 25 submissions were received by the Inquiry from a wide range of individuals and groups including[8]:

- The Gunaikurnai Land and Waters Aboriginal Corporation, representing the Traditional Owners;
- Individuals and businesses within the Latrobe Valley;
- The mine operators – AGL, Energy Australia and GDF Suez;
- The Construction, Forestry, Mining and Energy Union (CFMEU);
- The Australian Labor Party;
- Government bodies including the Latrobe City Council and the Victorian Government; and
- Environmental Non-Government Agencies including Environment Victoria.

Over 70 people attended open consultation sessions held by the Inquiry and provided their views and thoughts on the following questions:

[8] Refer to Appendix A for list of public submissions. Copies of the submissions are available on the Hazelwood Mine Fire Inquiry web site.

- What is the long term infrastructure needs of the Latrobe Valley which this/these mine site(s) could deliver?
- What should be done towards these desired ends while this/these mine(s) are still operating?

Public submissions and community consultation has been used to inform:

- A suggested starting long term regional vision for mine rehabilitation;
- A suggested set of potential outcomes that final landforms could be evaluated against.

4.2 Suggested starting long term regional vision for mine rehabilitation

'Reshaping the Valley' is a starting point. New information, emergent technologies and changes in community preferences will enable the vision to be refined. The final *'Reshaping the Valley'* vision will provide decision makers and the community with clear direction to holistically plan mine rehabilitation.

Figure 4-1 – Suggested starting long term regional vision for mine rehabilitation

> *"Reshaping the Valley to maximise economic and social benefits of rehabilitating the Latrobe Valley mine sites. Important environmental, resource, and heritage values of the region are respected. Opportunities are created and shared with the Latrobe Valley community, transitioning industries and mine operators".*

A 2013 study by RMIT (RMIT 2013) used computer simulations to investigate the main components of rehabilitation - soil, vegetation, water and energy. An international design competition was part of RMIT's Study. The winning entry conceptualised the Latrobe Valley as a complex system of inter connected flows of industrial processes, ecological systems and cultural networks. These relationships were employed to create new land use opportunities and structurally integrate ecosystem services into future land use planning.

In 2010, the Gippsland Regional Growth Plan (2010) identified a vision: *By 2020 we will have harnessed our diversity to create a sustainable and economically confident Gippsland.* This Plan explored the impact of a low carbon future on the Latrobe Valley including utilising the region's coal assets through 'clean coal technology' and the potential to develop coal derivatives. Five main drivers were identified as:

1. Developing economic resilience;
2. Addressing growth;
3. Protecting natural assets;
4. Supporting community well-being; and
5. Improving accessibility.

This vision challenges the Latrobe Valley to be proactive about transitioning and repositioning. The "*Reshaping the Valley*" vision is a starting point and reference for regular reviews to ensure the direction of mine rehabilitation is sustainable, practicable and effective.

4.3 Desired regional outcomes from mine rehabilitation

Desired regional outcomes from mine rehabilitation are to:

- Ensure landforms are safe, stable and non-polluting;
- Improve the liveability of neighbouring towns;
- Support employment through diversification of regional economy;
- Protect and improve the health of environmental values/assets; and
- Not exclude future resource exploration and development.

A draft report, Latrobe Valley Mine Closure Study, was prepared for Clean Coal Victoria (SKM, 2012). This report identified the need to align community expectations for the rehabilitated mine sites to contribute to the regional economy and jobs, environmental sustainability and community liveability.

4.3.1 Safe, Stable and Non-Polluting Landforms

MRSDA makes provision for the rehabilitation of the mines at the cessation of mining by requiring each mine operator to develop a Rehabilitation Plan. Under Section 79 of the Act, the Rehabilitation Plan must allow for (Victorian Government, 2015):

- Any special characteristics of the land and the surrounding environment;
- The need to stabilise the land;
- The desirability or otherwise of returning agricultural land to a state that is as close as is reasonably possible to its state before the mining licence or extractive industry work authority was granted; and
- Any potential long term degradation of the environment.

The Inquiry received several submissions (Environment Victoria 2015, Minerals Council of Australia – Victorian Chapter 2015) relating to a desire for MRSDA reform. In particular, the complexity of the legislative framework was raised as was the desire to shift to a risk based, outcomes focussed framework.

In addition to the MRSDA, mining in the Latrobe Valley is subject to the requirements of numerous other laws relating to land use planning, environmental protection, native title, Aboriginal heritage, heritage, water resource management and health and safety.

4.3.2 Improve the liveability of neighbouring towns

Community concern regarding the impact of coal mining on liveability, as reflected in the public submissions and consultation process, focuses primarily on health and safety impacts of coal mining both during the operational period and post closure.

Fire prevention and the role of progressive rehabilitation to prevent mine fires was raised numerous times in the submissions by the community, government, mine operators and industry and union bodies. Additionally, the planning of the rehabilitated landform to avoid bush and mine fires after the cessation of mining was also raised (CMFEU 2015, Latrobe City Council 2015, Yallourn North Action Group 2015).

There was a consistent expression for the need for a positive legacy to be created from mining operations (ALP 2015, Caffery D 2015, Langmore D 2015, GLaWAC 2015, Bush K 2015, Latrobe City Council 2015, Bull L 2015, Gaulton M 2015, Sait R 2015). Public submissions expressed a positive legacy in terms of a desire for jobs, economic strengthening and the creation of positive, post mining land uses that celebrate the natural attributes of the Latrobe Valley.

4.3.3 Support employment through diversification of regional economy

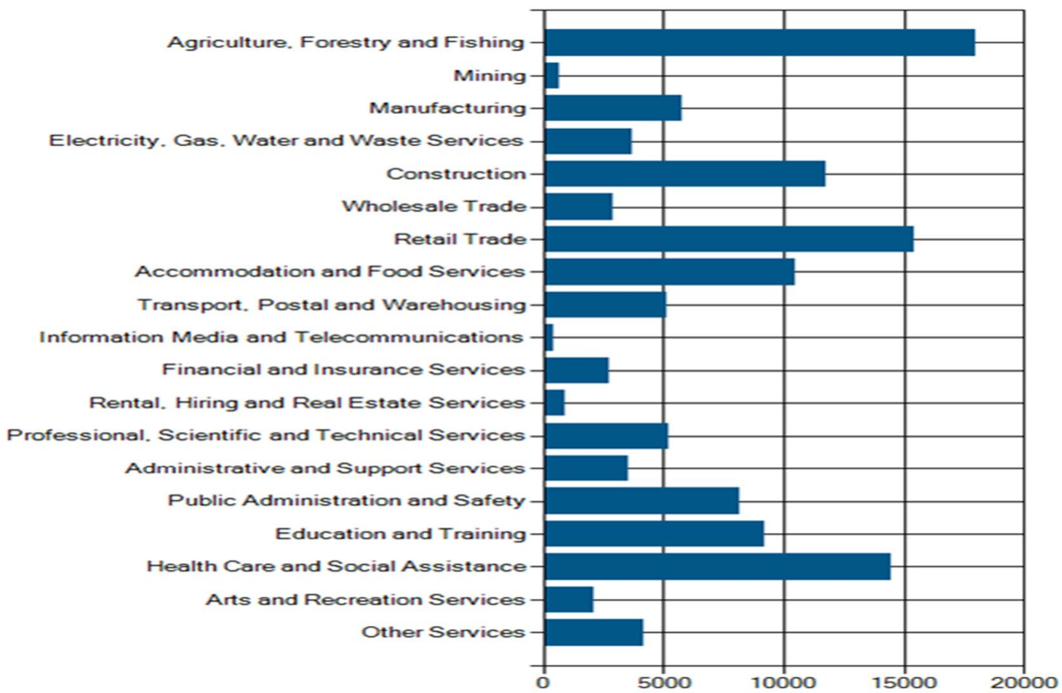
Historically unemployment in Latrobe City has been much higher (up to 12%) than the Victorian average (approximately 6%). In recent times unemployment has dropped to around the current State average of 5.0% (Latrobe City 2014). Community consultation feedback highlighted strong preference for this trend to continue with rehabilitated mined areas being able to provide jobs, finding alternatives for coal, energy generation and reuse of materials, such as fly ash.

Potential beneficial land uses identified through community consultation and public submissions included agriculture and grazing, forestry, aquaculture, conservation, recreation/tourism (including gardens, sporting venues, hiking, camping, boat racing and hang gliding etc.), waste management and industrial or research based development, renewable energy (solar, hydro and wind), ongoing development of the coal resource and residential and industrial development (Energy Australia 2015, AGL 2015, Sait R 2015, Latrobe Valley Prefabricated Energy Efficient Buildings 2015, Caffrey J 2015, Caffrey D 2015). Most public submissions recommended the consideration of a wide range of post-mining land uses without expressing a definitive preference.

Currently across the Gippsland Region the agriculture, forestry and fishing and construction sectors are the most significant, together making up nearly 30% of the Gross Region Product (GRP) (Department of Transport, Planning and Local Infrastructure, 2014).

Employment is currently spread across a diverse base with the largest employment sectors (nearly 40%) in agriculture, forestry and fishing, retail trade and health and social assistance. Significant employment (just over 30%) is also within the construction, accommodation and food services, education and training and public administration and safety.

Figure 4-2 : Current employment distribution in Latrobe City



Source: Australian Government Department of Employment, Labour Market Information Portal

4.3.4 Protect and improve the health of environmental and cultural values

A further theme reflected in the public submissions and community consultation was the need to protect the environmental and cultural values of the Latrobe Valley. Particular concerns were raised over management of water quality (Latrobe City Council, 2015) and availability in the river systems and recognition of the rights and responsibilities of the Gunaikurnai, the recognised Traditional Owners under the *Traditional Owner Settlement Act (2010)* (GLAWAC, 2015).

4.3.5 Continued brown coal resource exploration and development

The need to continue future exploration and development of brown coal is driven by the emergence of potential new coal uses (e.g. dried coal products such as modern briquettes and high efficiency coal pellets, liquids and gasses and the transformation of the coal into fertilisers such as Urea). Final landforms based on good engineering and mine rehabilitation practices should be able to maintain a reasonable level of on-going access to some of the resource.

The Special Use Zone 1 (Department of Environment, Land, Water and Planning, 2015) restricts land uses from establishing in the vicinity of the mines which may conflict with mining of coal and generation of electricity. In the broader area the State Resource Overlay (Department of Environment, Land, Water and Planning, 2015) seeks to protect the coal resource in the ground to enable its future extraction, from building, works and subdivision of land which may need to be acquired in the future.

5. Preliminary Mine Rehabilitation Options

Key Finding

Given the breadth of potential post mining land uses identified the study has identified six preliminary mine rehabilitation options. Each option is capable of supporting one or more of the identified land uses. Preliminary mine rehabilitation options include:

- Pit Lake - A large, deep lake is formed by filling the final mine void to the pit crest;
- Full Backfill - The final mine void is fully backfilled to the pit crest level using all available overburden and inert mineral waste;
- Partial Backfill above the Water Table - The final mine void is partially backfilled with overburden and additional materials to a level above the natural groundwater;
- Partial Backfill Below the Water Table - The final mine void is partially backfilled using available overburden. Areas Below the natural groundwater level are filled with water to create a pit water body (shallow lake);
- Lined Void - The final mine void is lined with clay across all batters to create an impermeable lining to inhibit the flow of water either in or out of the void; and
- Rehabilitated Void – The void is partially backfilled with available overburden and is rehabilitated as a dry lowered landform.

The identification of the preliminary options for the three Latrobe Valley coal mines was informed by:

- Interested stakeholders through community consultation and public submissions;
- A desktop review of leading practice in the rehabilitation and closure of open cut coal mines; and
- Current mine operator Work Plans.

5.1 Possible Post Mining Land Uses

A wide array of potential post mining land uses[9] were identified (see Table 5-1). Identified land uses are not necessarily mutually exclusive and it is likely that multiple and complimentary land uses are possible within a post-mining landscape. No assessment of social and economic viability of identified land uses was undertaken as part of this study.

Table 5-1 : Potential Post Mining Land Uses

Land Use	Description
Conservation and Natural Environment	Establishment of natural areas for the protection of threatened species and general nature conservation.
Production from Dryland Agriculture and Plantations	Establishment of non-irrigated plantation forestry or grazing activities.
Production from Irrigated Agriculture and Plantations	Establishment of irrigated cropping, forestry or modifier pastures for grazing.
Utilities - Hydro Electricity Generation	Power generation from pumped hydroelectricity energy storage (Caffrey 2015).
Utilities - Bioenergy Electricity Generation	Power generation from in-pit methane production or landfill.

[9] Land uses have been classified according to the Australian Land Use and Management Classification Version 7, May 2010 published by Australian Government Department of Agriculture and Water Resources.

Land Use	Description
Utilities - Wind Electricity Generation	Power generation through development of wind turbines
Utilities - Solar Electricity Generation	Power generation through the development of large scale solar farms.
Intensive Use - Waste Treatment & Disposal	Disposal of non-hazardous waste and refuse.
Intensive Use - Waste Recycling , Recovery and Salvage	Development of downstream waste recycling, recovery and salvage including reprocessing of fly ash and other mining by-products (Latrobe Magnesium, 2015).
Intensive Use – Residential	Development of residential estates and associated retail facilities.
Intensive Use - Manufacturing and Industrial	Development of manufacturing and industrial facilities.
Intensive Use – Mining	Exploitation of mineral resources.
Intensive Use – Services	Establishment of parklands, education, sport and/or cultural facilities including tourism facilities specific to the coal mining and power generation industries. For example research facility already exists at Federation University.
Water – Lake (Intensive Use)	Development of recreational boating, swimming, fishing and related water sports.
Water – Lake (Production)	Storage of water to support aquaculture or similar aquatic production.
Water – Reservoir	Storage and management of excess water to support adjacent productive land use such as intensive agriculture or power generation or provide protection from flooding.
Water - Wetlands (Conservation)	Development of wetlands for primary conservation. For example there are wetlands already developed along the Morwell River at both Yallourn and Hazelwood mine.

Currently timber production is a key land use in and around the Latrobe Valley coal mines. Large timber plantations are located to the west of the Hazelwood open cut and immediately south of the Yallourn open cut mine. Significant plantations exist on adjoining land immediately to the east of the Yallourn open cut mine, between the mine and Australian Paper's Maryvale paper mill. Further plantations exist to the south and east of the Maryvale paper mill. Plantations adjoin land to the south and east of Loy Yang's external overburden dump.

More generally, agricultural pursuits in the area immediately surrounding the open cuts predominately consist of grazing, dairy and some cropping. Recreational uses occur on the water and land adjacent to the Hazelwood pondage.

Future land use zoning may need to be revised with specific regard to potential post-mining land uses and rehabilitated mine landforms to prevent historical planning and environmental regulations constrain future land uses. At present there are several regional and mine specific planning controls in the Latrobe planning scheme that may need to be reviewed and potentially revised to enable future post-mining land uses (refer to Appendix B for overview of some of the current land use planning controls).

5.2 Possible Final Landforms (Preliminary Options)

Mine operators are required to rehabilitate disturbed areas to landforms consistent with an agreed land use. Given that agreed land uses consistent with a regional vision for mine rehabilitation are yet to be fully developed the study has identified six preliminary options that may support all or some of the above identified land uses.

In accordance with the high-level nature of the study these options are conceptual only and are considered to reflect the basic principles of landform construction available to coal mines within the Latrobe Valley.

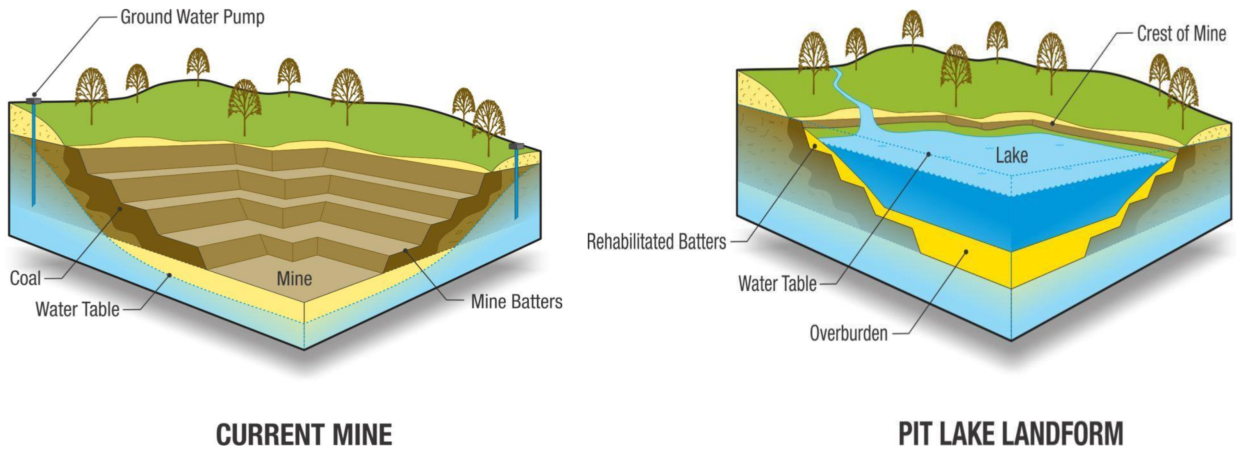
Jacobs acknowledge that specific sites may consider single or multiple landform options as part of their Work Plans and as such the conceptual options (landforms) may not reflect fully those landforms currently proposed by the mine operators. It is however, for the purposes of describing the conceptual landforms, assumed that direct in pit placement of overburden will occur to the maximum possible as part of routine operations.

The likely final mine voids associated with each of the three coal mines are significant in size and depth. Each mine void will represent the most significant feature contributing to the final landform. Jacobs has focused the identification of preliminary options on treatment of the final mine void.

5.2.1 Preliminary Option - Pit Lake Landform

A large, deep lake is formed by filling the final mine void to the pit crest. Disturbed areas outside of pit void are reshaped and rehabilitated in accordance with agreed land use.

Figure 5-1 – Graphical representation of a conceptual Pit Lake Landform[10]



Key characteristics of a Pit Lake Landform include:

- Groundwater allowed to recover to natural equilibrium;
- Water level of lake to be at approximately pit crest level;
- Water likely to be diverted from adjacent natural water ways to maintain water level;
- Water depth likely to be in excess of 50m;
- Lake to extend across full breadth and width of open pit void;
- Batters above lake water level reshaped to land use requirements; and

[10] Graphical representations are not graphical representations of the exact features and attributes of any of the Latrobe Valley coal mines. The graphical images are purely conceptual.

- Underwater batters to remain steep.

Example Case Study - Lake Kepwari, Collie, Western Australia (McCullough 2013, Mine Water and Environment Research Centre, 2015)

Lake Kepwari is a man-made lake situated in south west of Western Australia. It was formerly an open cut coal mine from 1970 to 1996. The lake is approximately 2kms long, 1 km wide, 70 metres deep, has a total area of around 100 hectares and holds roughly 30 gigalitres. Lake Kepwari took about five years to fill with water diverted from the Collie River South.

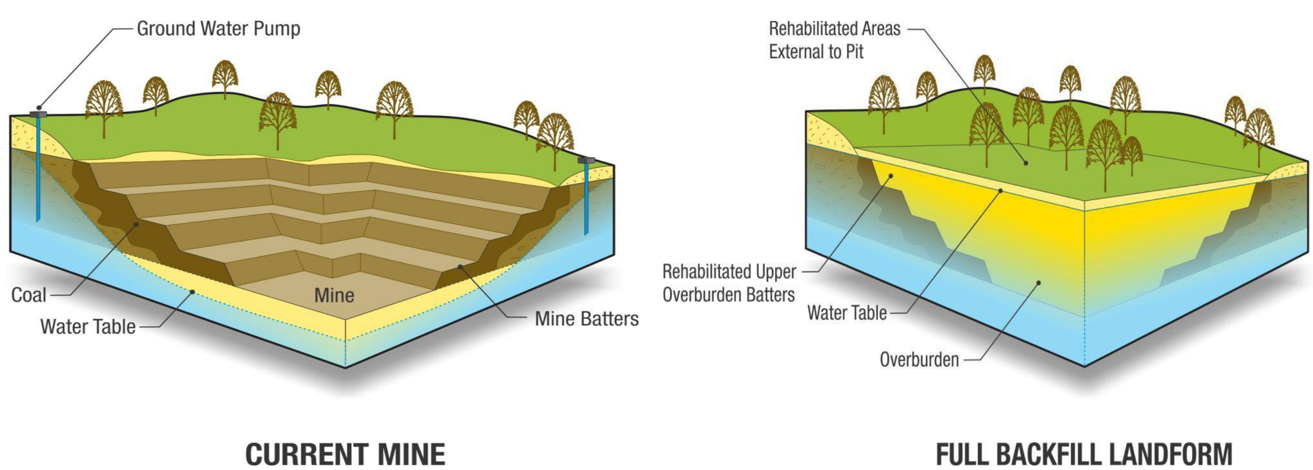
Lake Kepwari was meant to provide for recreational uses such as boating and water skiing. Public access to the lake was delayed for a number of years due to concerns about lower pH levels. Lake Kepwari was reconnected to Collie South River to create a flushing effect. In 2014 the Western Australian Government announced Lake Kepwari open to water skiing.

Other examples of pit lakes can be found in Penrith Lakes, Western Sydney, NSW and numerous locations in German (e.g. Markkleeburg Lake).

5.2.2 Preliminary Option - Full Backfill Landform

The final mine void is fully backfilled to the pit crest level using all available overburden and inert mineral waste. This landform will return the mine void area to approximately natural relief allowing for dryland rehabilitation of all disturbed areas. Disturbed areas outside of pit void are reshaped and rehabilitated in accordance with agreed land use.

Figure 5-2 – Graphical representation of a conceptual Full Backfill Landform[11]



Key characteristics of a Full Backfill final landform include:

- Pit void returned to approximately pre-mining relief;
- Pit void area reshaped to be free draining to natural adjacent water ways;
- Groundwater allowed to recovery to natural equilibrium; and
- No formation of lake.

[11] Graphical representations are not graphical representations of the exact features and attributes of any of the Latrobe Valley coal mines. The graphical images are purely conceptual.

Example Case Study - Community Forest Programme, United Kingdom (DETR, 1998)

The Community Forestry Project was established in response to the multiple challenges of degraded land on the urban fringe, old rehabilitated coal mines, competing demands of forestry conservation and agricultural production, unemployment and the desire to maximise the benefits of social investment. Community Forests were selected from an open invitation to local communities and were ultimately established in 8 areas across England, cover nearly 4000Km2. Approved land uses include agriculture, forestry, recreation and urban townships.

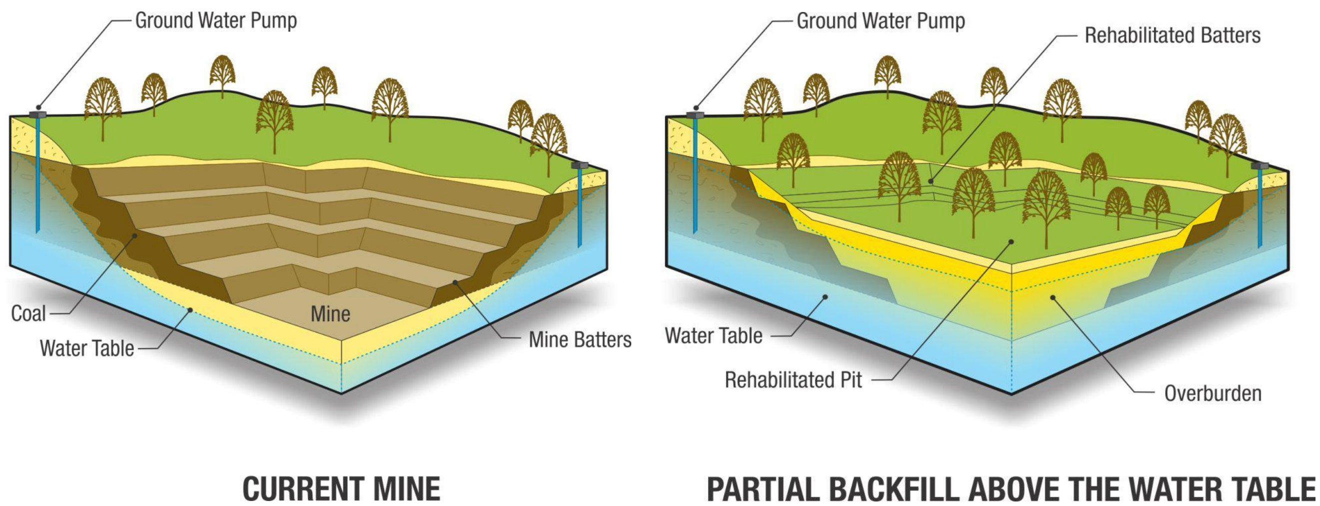
The accepted Community Forests were funded nationally for a period of 12 years and then subsequently by local government and, to a lesser extent, private funding sources. They are managed by “Forest Teams” whose role is largely to coordinate and promote the vision of the Community Forest across the many community, government and business groups within the managed area.

Since 1990, England’s Community Forests have planted over 10,000 hectares of new woodland, created or improved 12,000 hectares of other habitats opened up 16,000 hectares of woods and green-space for recreation and leisure and engaged and involved hundreds of thousands of people in finding out about and improving their local areas.

5.2.3 Preliminary Option - Partial Backfill above the Water Table

The final mine void is partially backfilled with overburden and additional materials to a level above the natural groundwater level creating a dry lowered landform. Disturbed areas outside of pit void are reshaped and rehabilitated in accordance with agreed land use.

Figure 5-3 – Graphical representation of a conceptual Partial Backfill above the Water Table Landform[12]



Key characteristics of a Partial Backfill above the Water Table landform include:

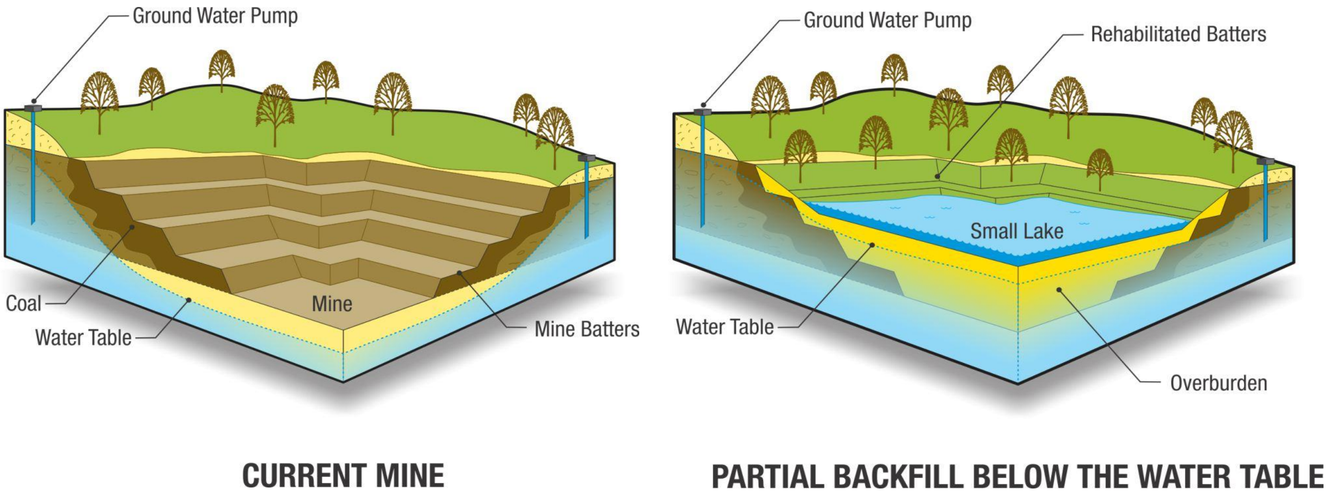
- Area internal to void likely to be a significantly lower relief and non-free draining;
- Groundwater allowed to recovery to natural equilibrium;
- No formation of lake; and
- Batters above backfill area reshaped to land use requirements.

[12] Graphical representations are not graphical representations of the exact features and attributes of any of the Latrobe Valley coal mines. The graphical images are purely conceptual.

5.2.4 Preliminary Option - Partial Backfill below the Water Table

The final mine void is partially backfilled using available overburden. Areas below the natural groundwater level are filled with water to create a pit water body (shallow lake). Backfilled areas above the groundwater level will remain dry but at a significantly lower relief than the surrounding remaining batters.

Figure 5-4 – Graphical representation of conceptual Partial Backfill below the Water Table Landform[13]



Key characteristics of Partial Backfill below the Water Table landform include:

- Groundwater allowed to recovery to natural equilibrium;
- Water level of pit water body to be at approximately natural groundwater level;
- Pit water body depth likely to be less than 50m;
- Pit water body to extend less than full breadth and width of open pit void;
- Batters above pit water body level reshaped to land use requirements;
- Area internal to void likely to be a significantly lower relief and non-free draining and;
- Underwater batters likely to be shallow.

Jacobs were unable to identify, within the time available, an applicable case study, which illustrates land uses on or surrounding a Partial Backfill below the Water Table landform. Some case studies in Germany have residential development on and near a pit water body. It was concluded that these do not provide sufficient comparison with this landform.

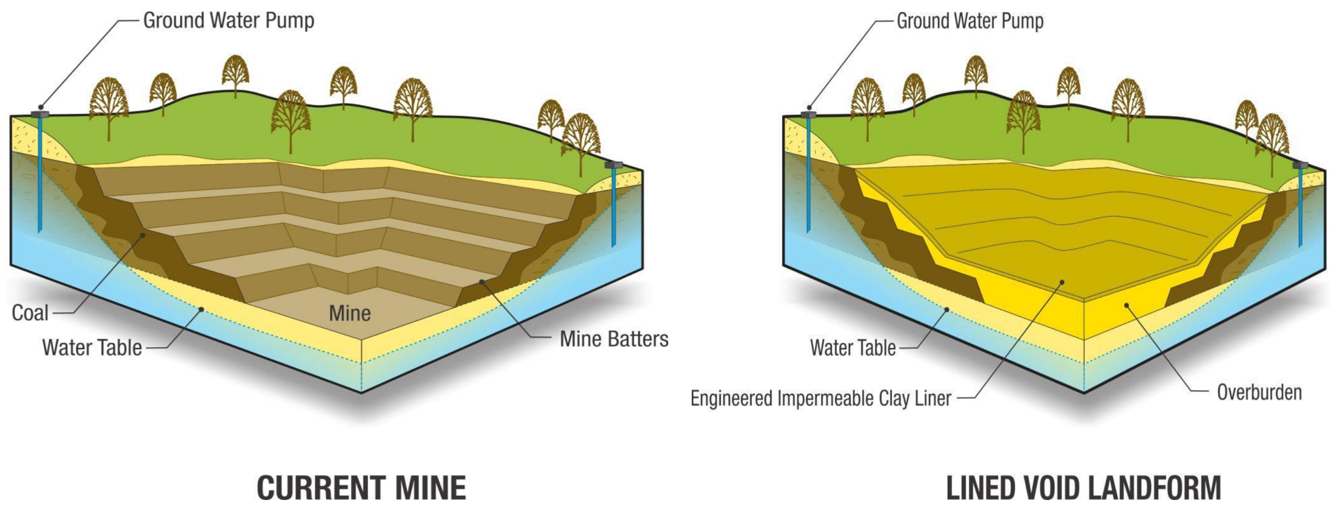
It is likely a Partial Backfill below the Water Table landform would enable the expansion of existing adjacent land uses to the mine sites (e.g. timber production, agriculture such as grazing, dairy, cropping etc.).

5.2.5 Preliminary Option - Lined Void landform

The final mine void is lined with clay across all batters to create an impermeable lining to inhibit the flow of water either in or out of the void.

[13] Graphical representations are not graphical representations of the exact features and attributes of any of the Latrobe Valley coal mines. The graphical images are purely conceptual.

Figure 5-5 – Graphical representation of conceptual Lined Void landform[14]



Key characteristics Lined Void landform includes:

- Area internal to void to be a significantly lower relief and non-free draining;
- Groundwater dewatering likely to be required and;
- No formation of lake or pit water body.

Example Case Study – Woodlawn Bioreactor, NSW (Collins, 2014)

The Collex Woodlawn Bioreactor is located south of Goulburn in New South Wales. Woodlawn was a worked out copper, lead and zinc mine. Shortly after the operated went bankrupt, Collex brought the site including a 3,000 hectare adjacent farm (to be used to run sheep and locate 20 – 25 wind turbines) assuming employment and remediation liabilities of the former owner.

It has taken Collex 10 years to establish a Bioreactor at the site capable of handling 400,000 tonnes of municipal waste from Sydney. The waste will be hauled by train from Sydney (about 250 kms away). The facility has the capacity to generate (with the wind farms) sufficient electricity to power estimated 3,000 homes per year. The facility and associated remediation works have cost approximately $60 million.

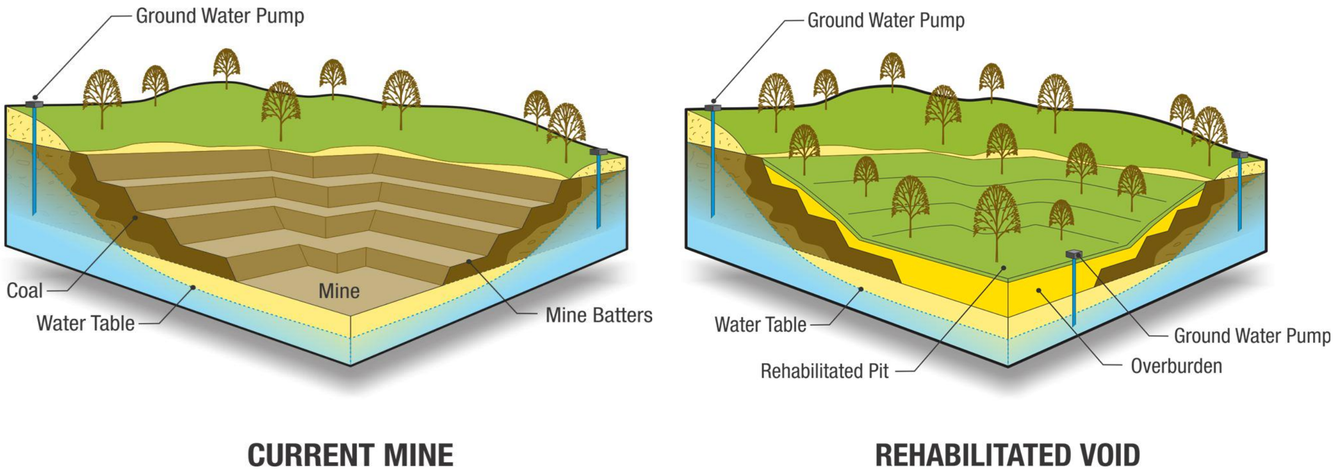
To remediate the open cut mine, Collex have re-graded and secured the road into the pit, pumped out the water, put a liner in place and constructed leachate and groundwater sumps.

5.2.6 Preliminary Option - Rehabilitated Void landform

The void is partially backfilled with available overburden and is rehabilitated as a dry lowered landform.

[14] Graphical representations are not graphical representations of the exact features and attributes of any of the Latrobe Valley coal mines. The graphical images are purely conceptual

Figure 5-6 – Graphical representation of conceptual Rehabilitated Void landform



Key characteristics of Rehabilitated Void landform includes:

- Area internal to void to be a significantly lower relief and non-free draining;
- Groundwater dewatering likely to be required; and
- No formation of lake or pit water body.

Example Case Study – Klettwitz Wind Farm, Brandenburg, Germany (GICON, 2015)

The Klettwitz Wind Farm is located in the State of Brandenburg in Germany. The site is a former open cast coal mine that has been fully backfilled in some places and rehabilitated mine voids in other places. In total 27 wind turbines have been constructed in a 12 month period providing capacity to generate 93 MW of power.

The construction of the turbines needed to take into account the loose tipping ground of a former open cast coal mine. The wind farm used technology called “vibro-compaction” of the ground and implemented purpose built combined pile raft foundations to secure the stability of the wind turbines.

6. Mine Rehabilitation Option Assessment Criteria

To facilitate a greater understanding of the viability of preliminary options at each site Jacobs' have considered relevant criteria to:

- Assess of preliminary options in order to identify potential viable options for each mine (refer section 7); and
- Assess the risks and estimated costs of potential viable final options for each mine (refer section 8).

Assessment criteria reflected the key issues and challenges and aligned to the Inquiry's Terms of Reference. These criteria are briefly explained below.

6.1 Fire Risk

Fire risk associated with mine operation and rehabilitation is fundamental to the Inquiry. Mine operators are required to maintain fire suppression and response system for active mine areas in accordance with the *MRSDA* and site specific conditions associated with their approved Work Plan.

For the purposes of the assessment of rehabilitation options it is assumed that operational fire suppression and response systems are maintained for active mining areas within the short term. The assessment therefore focuses on the extent to which a specific rehabilitation option allows for the mitigation of fire risk following the cessation of active mining.

6.2 Mine Stability

Mine operators are required to maintain stability of the mined landform in accordance with the *MRSDA* and site specific commitments and conditions associated with their approved Work Plan. Operational stability is primarily achieved by depressurisation of mined coal seams through dewatering of groundwater aquifers and by mine design. In respect of mine design the geology and geotechnical characteristics of the coal seam are taken into account to establish the heights, width and slopes of specific batters and benches.

For the purposes of the assessment it is assumed that operational dewatering of mine voids is maintained for active mining areas within the short term. The assessment therefore focused on the extent to which a specific rehabilitation option allows for the mitigation of stability risks following the cessation of active mining.

6.3 Final Landform Stability

Mine stability, as indicated above, is achieved through the implementation of active controls and measures which require ongoing management and funding. Implicit within the concept of rehabilitation is stability of the final landform must be achieved through the implementation of passive controls and measures which do not require ongoing management or funding.

The assessment has therefore focused on the extent to which a specific rehabilitation option may achieve and maintain stability through implementation of passive controls and measures.

6.4 Environmental Degradation

Environmental degradation is the deterioration of the environment through depletion of resources such as air, water and soil; the destruction of ecosystems and the extinction of wildlife. Mine operators are required to minimise environmental degradation within the short term in accordance with the *MRSDA* and site specific conditions associated with their approved Work Plan.

For the purposes of the assessment, environmental degradation has focused on the extent to which a specific rehabilitation option may impact on groundwater, surface water and biological resources following the cessation of active mining.

6.4.1 Groundwater

The significance of the potential impact of rehabilitation on regional groundwater quality and water allocations is discussed within Section 3. The extent to which rehabilitation options may impact on ground water quality and availability was included in the assessment.

6.4.2 Surface water

The significance of the potential impact of rehabilitation on regional surface water quality and water allocations is similarly discussed within Section 3. The extent to which a specific rehabilitation option may impact on surface water quality and availability was included in the assessment.

6.4.3 Biodiversity

Revegetation of final landforms should be consistent with the agreed post mining land use. Notwithstanding, rehabilitation presents an opportunity to re-establish a level of biodiversity lost through the clearing and disturbance of land for mine development. The extent to which specific rehabilitation options facilitates re-establishment of biodiversity was included in the assessment.

6.5 Future beneficial land use

As identified within Section 5.1 there are many land uses that could potentially be achieved through rehabilitation of Latrobe Valley coal mines. Not all land uses however may be supported by the options identified. The extent to which an option supports multiple and flexible land uses is assessed giving regard to the types of community expectations expressed in the community consultation and public submissions (as broadly described in section 4).

6.6 Compatibility

As indicated within the discussion important issues and challenges for rehabilitation planning (see section 3) connectivity between the three coal mines exists through groundwater aquifers and surface water interactions. Whilst all three mines continue dewatering activities to maintain operational stability, this may impact on one of the other mines. Once dewatering ceases at any mine however it is possible that dewatering requirements could increase at other mines. Similarly if a mine is seeking to facilitate full or partial recovery of pre-mining groundwater conditions as part of its rehabilitation plan then such plans be impacted upon, or even prevented, by continued dewatering at adjacent mines. The extent to which a specific rehabilitation options may impact on rehabilitation options at adjacent mines is therefore assessed.

6.7 Extent of variation to the current mine operator work plan

As presented in Section 2.4 each of the three coal mines within the Latrobe Valley currently operates under an approved Work Plan that includes a rehabilitation plan. Mine operators are legally obligated to implement and comply with the rehabilitation plan. Any variation to the Work Plan (rehabilitation plan) requires a formal Work Plan Variation to be prepared and issued by the mine operator for approval by ERR. Any significant departure from the current approved rehabilitation plan may also result in significant operational and cost burdens to the mine operator. The extent to which a specific rehabilitation option may require variation to the existing Work Plan is therefore assessed.

6.8 Progressive rehabilitation was considered in assessing potential viable options

The assessment of potential viable rehabilitation options included consideration of the Terms of Reference question regarding if the proposed option could ensure progressive rehabilitation.

Mine operators are required to undertake progressive rehabilitation within the short term in accordance with the *MRSDA* and site specific conditions associated with the approved Work Plan. This question was considered for the potential viable options as an understanding of potential short, medium and long term implementation actions was needed to inform the assessment. Short, medium and long term implementation actions were only produced for the potential viable options.

7. Preliminary Options Assessment

Key Finding

The study assessed each of the six preliminary options at each of the three mine sites using a Multi-Criteria Analysis based on the assessment criteria described in Section 6. The findings were similar across the three mines.

Preliminary options deemed unviable at each mine were:

- Partial Backfill above the Water Table and Full Backfill - Due to the lack of available fill material onsite or locally and the significant costs associated with the import of material;
- Lined Void - Due to likely impact on environmental amenity, potentially high costs associated with creating the lining and uncertainty regarding support for associated land use; and
- Rehabilitated Void - Due to high costs and risk associated with ongoing landform stability works such as dewatering.

Two potential viable rehabilitation options have been identified for each of the three mines:

- Pit Lake - Due to low fire risk and likely onsite availability of material sourcing requirements in order to achieve this landform;
- Partial Backfill Below the Water Table - Due to low fire risk and ability of the landform to achieve weight balance through a combination of both fill and water, as well as the likely onsite availability of material sourcing requirements.

Both potential viable options represent long term options (final landform achieved 15 years after mine closure). Under certain favourable conditions (e.g. access to significant water deviation, use of flood water etc) it is conceivable to achieve the Partial Backfill Below the Water Table option.

Preliminary mine rehabilitation options for each mine site were evaluated against the assessment Criteria presented in Section 6, using the semi-quantitative Multiple Criteria Analysis (MCA) technique.

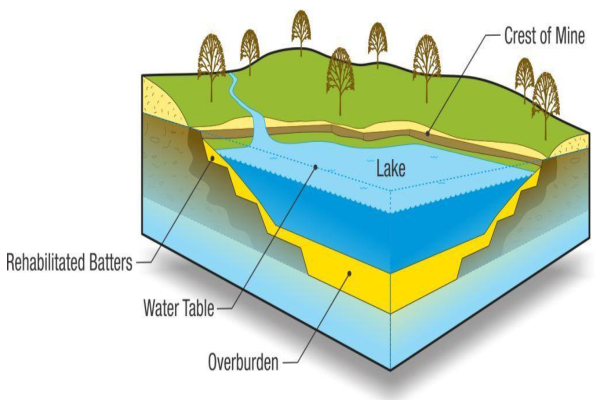
Compliance Statements were developed for each Criterion to assist with the MCA, these Compliance Statements considered specific risks identified within the Inquiry's Terms of Reference and are presented in Appendix A.2.4

To complete the assessment the extent to which a preliminary option is likely to comply with each Criterion and associated Compliance Statement was qualitatively reviewed and assessed by consensus during a multidisciplinary workshop.

The outcomes of the MCA are presented in the sections below, on a site by site basis for each preliminary option. Ratings are made on the basis that compliance can be achieved with reasonable technical certainty, acceptable residual risk and reasonable cost.

7.1 Assessment of Preliminary Options – Yallourn

All six preliminary options were assessed for Yallourn. Results from the assessment are summarised below and in Appendix C**.**

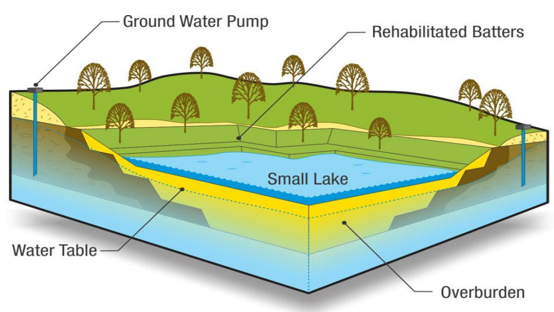


PIT LAKE LANDFORM

POTENTIAL VIABLE OPTION

The **Pit Lake**, while presenting challenges relating to ongoing management of aquifer pressure and water quality, was considered a viable option at the MCA level due to:

- The fire risk exceeds compliance as coal seams will be covered, largely with water, but also overburden where batters are above lake water level;
- Stability risks, partly comply, but may be managed through selective placement of material on less critical walls (e.g. less material on township field batter);
- Additional water may be sourced from the nearby Morwell and Latrobe Rivers to facilitate filling and flushing of the Pit Lake;
- The Yallourn Mine has low aquifer pressures. Intersecting only one aquifer unit (M2), groundwater pressures; are lesser at this site compared to other mines in the area and are therefore likely to be easier to control;
- The landform has the potential to support multiple land uses such as residential, hydro-electricity generation or conservation and natural environment;
- The material volumes required to develop this option are likely to be available on site or locally; and
- This option requires some amendment to the existing Work Plan (e.g. inclusion of programmed maintenance of cover/capping, including; monitoring or top up to mitigate fire risk).

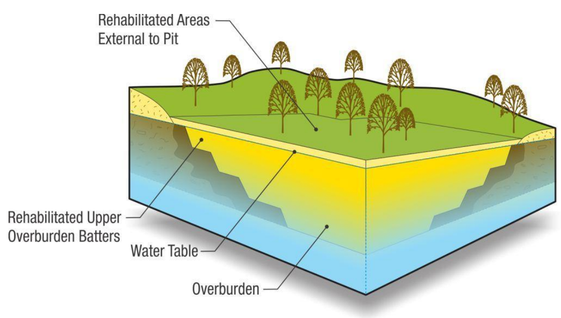


PARTIAL BACKFILL BELOW THE WATER TABLE

POTENTIAL VIABLE OPTION

The option of **Partial Backfill below the Water Table** is considered viable as:

- Compliance with fire risk criteria, as exposed coal seams will be covered by water, or overburden where batters are above pit water body level;
- Pit water body management will minimise any risks to surface water (offsite);
- The partial backfill will assist with maintaining weight balance and is the key difference in stability compliance rating between this option and the Pit Lake;
- This option aligns most closely with the current Work Plan;
- This option supports multiple land uses (e.g. solar electricity generation or a reservoir); and
- Given the relatively shallow depth of groundwater associated with the Yallourn mine this option is not considered significantly different from the Pit Lake option and the depth of water within the pit water body driven primarily by weight balance considerations.

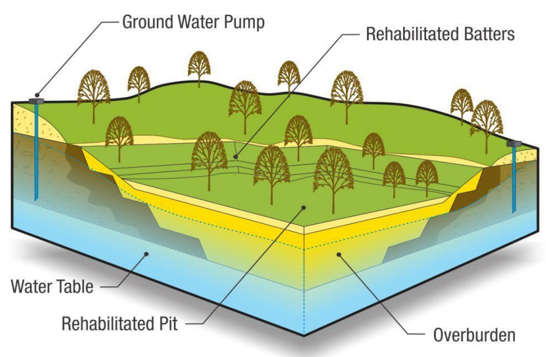


FULL BACKFILL LANDFORM

CURRENTLY UNVIABLE OPTION

The **Full Back Fill** option, while likely to achieve a safe and stable landform and considered best practice in the broader mining industry, is determined to be currenty unviable due to:

- Insufficient onsite material to allow for backfill; whilst the shallowest site, a considerable volume of material would still need to be externally sourced at significant cost;
- The landform has potential to support multiple land uses (e.g.manufactoring and industrial or residential);
- The requirement to access additional off site backfill material may prevent adjacent mines from achieving weight balance or backfill based landforms; and
- The Full Back Fill is not supported at all by the current Work Plan and would have a very significant impact on current progressive rehabilitation activities

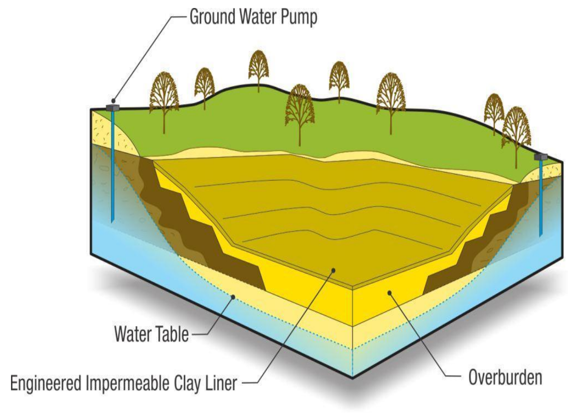


PARTIAL BACKFILL ABOVE THE WATER TABLE

CURRENTLY UNVIABLE OPTION

The **Partial Backfill above the Water Table** option while expected to achieve weight balance and facilitate long term stability, is currently considered unviable because:

- Significant volumes of material would be required to backfill the pit to above water table given the close proximity of the groundwater to the natural surface level of the pit. Sufficient backfill volumes are unlikely to be available on site and would need to be sourced at significant cost;
- Complete coverage of the exposed batters would be required to achieve compliance with fire risk criteria, and it is likely that insufficient backfill material will be available onsite;
- Large scale drainage around the pit is required to be managed in order to prevent external inflows from entering the pit; and
- The Partial Backfill above the Water Table is not supported at all by the current Work Plan and would have a very significant impact on current progressive rehabilitation activities

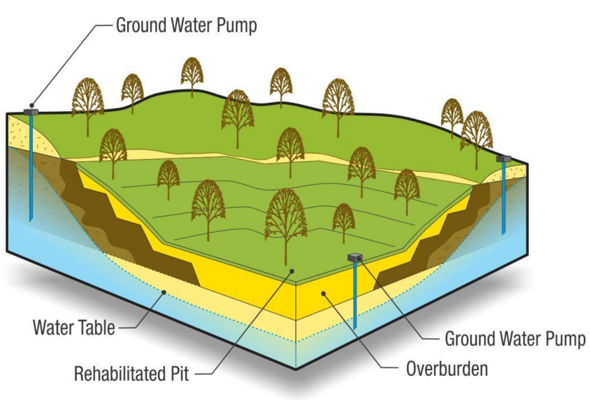


LINED VOID LANDFORM

CURRENTLY UNVIABLE OPTION

The MCA shows that the **Lined Void** is not currently viable:

- This landform is unlikely to protect or enhance environmental values (e.g. the ecological function of this landform does not align, nor in turn comply, with regional catchment strategy);
- It requires a massive amount of clay material (liner) to establish hydraulic barrier and would be sourced at very significant cost (e.g. a cost that could make mining unviable in the short term);
- For pit of this scale the engineering design would be highly complex;
- It requires substantial ongoing management to maintain aquifer pressure both leading to significant on-going costs to manage and maintain;
- Requirements for dewatering may prevent the ability of adjacent mines to achieve weight balance and water based landforms;
- Drainage around the pit is required to be managed to exclude external inflows into the long term;
- Whilst associated land use options potentially offer economic benefits through job creation, it is untested whether these benefits outweigh the substantial economic costs required to achieve this landform; and
- Lined void is not supported at all by the current Work Plan and would have a significant impact on current progressive rehabilitation activities.



REHABILITATED VOID

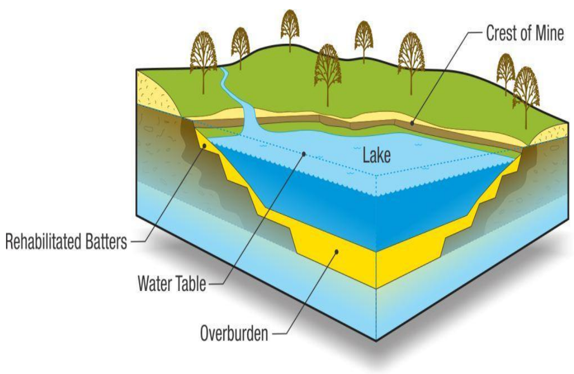
CURRENTLY UNVIABLE OPTION

The option of a **Rehabilitated Void** was assessed as not viable due to:

- Partial compliance with stability criteria, due to the exposed nature of the pit walls and coal seam;
- The rehabilitated site would require significant ongoing management (similar to the current operational level) to maintain the dewatering processes and associated geological and aquifer stability;
- The requirement for dewatering may prevent ability of adjacent mines to achieve weight balance and water based landforms;
- Very significant and costly ongoing requirement for water management in the medium and long term;
- Limited availability of sufficient cover (i.e topsoil)or alternative growth media volumes to support vegetation establishment;
- Significant drainage system around the pit would be required to be managed to exclude external inflows. Regular monitoring required to check integrity of drainage and as failure in the drainage system could significant stability consequences; and
- The Rehabilitated Void is not supported at all by the current Work Plan and would have a significant impact on current progressive rehabilitation activities.

7.2 Assessment of Preliminary Options – Hazelwood

All six preliminary options were assessed for Hazelwood. Results from the assessment are summarised below and in Appendix C.2.



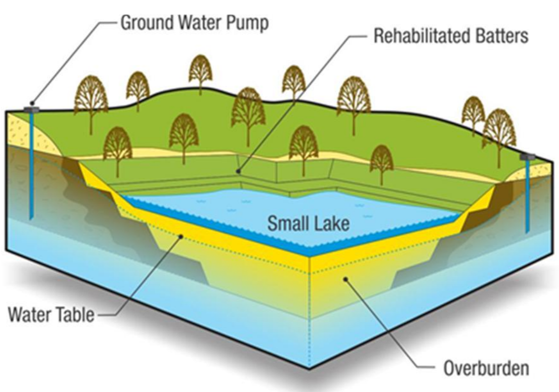
PIT LAKE LANDFORM

POTENTIAL VIABLE OPTION

The **Pit Lake** option had several partial compliance ratings. There were no non-compliances were seen and so it is considered viable at the initial screening level due to:

- The fire risk exceeds compliance with criteria, due to exposed coal seams being largely covered by water, or overburden where batters are above lake water level;
- The landforms potential to support multiple land uses (e.g. hydro-electricity generation, residential or wetland);
- The material volumes required to develop this option are likely to be available on site; and
- This option requires some changes to the existing Work Plan.

However, the Pit Lake option presents significant challenges at Hazelwood relating to ongoing management of aquifer pressure and water quality due to the pits size and depth. Key to this management challenge would be the protection of the aquifer water quality by maintaining the Pit Lake so that groundwater flowed into the lake but the lake water did not flow back into the aquifer.



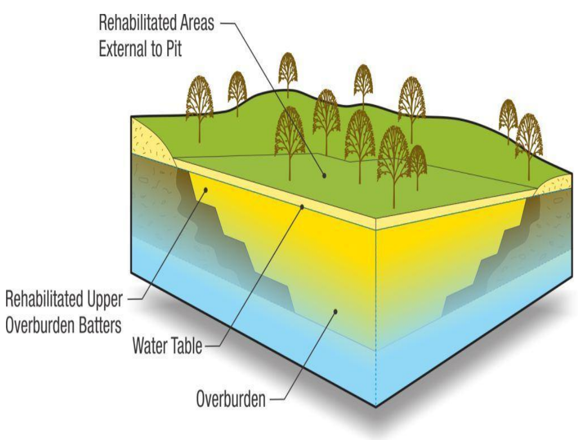
PARTIAL BACKFILL BELOW THE WATER TABLE

POTENTIALLY VIABLE OPTION

The option of **Partial Backfill below the Water Table** due to:

- Compliance with fire risk criteria; coal seams will be covered by water, or overburden where batters are above pit water level;
- Risk to surface water (off-site), by discharge from the pit water body is likely to be able to be effectively treated by lake level management and control of inflows;
- This landform supports multiple land uses (e.g. reservoir, wetland or conservation)
- This option aligns most closely with the existing Work Plan.

It should be recognised that additional effort will be needed to manage long term groundwater levels and to protect aquifer water quality and availability to local users.

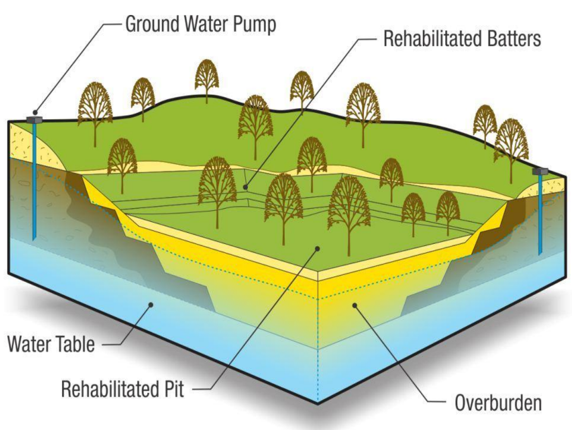


FULL BACKFILL LANDFORM

CURRENTLY UNVIABLE OPTION

The **Full Back Fill** option, while likely to achieve a safe and stable landform and considered best practice in the broader mining industry, is determined to be currenty unviable due to:

- Insufficient onsite material to allow for backfill; given the size of Hazelwood a considerable volume of material will need to be externally sourced at significant cost amd could threatened short term viability of mining;
- The requirement to access additional off site material likely to prevent adjacent mines from achieving weight balance or backfill based landforms; and
- The Full Backfill landform is not supported at all by the current Work Plan and would have a significant impact on current progressive rehabilitation activities.

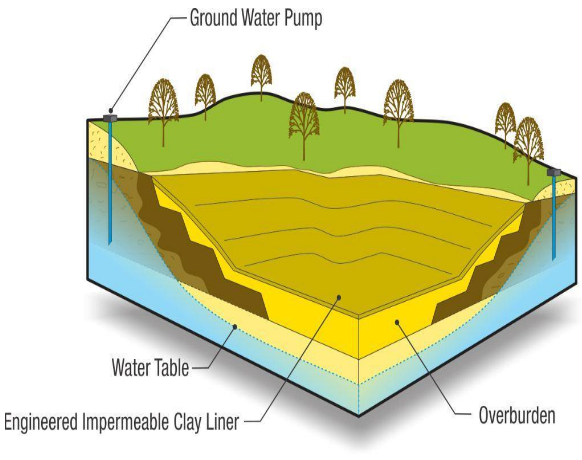


PARTIAL BACKFILL ABOVE THE WATER TABLE

CURRENTLY UNVIABLE OPTION

The **Partial Backfill above the Water Table** option while expected to achieve weight balance, is considered currently unviable due:

- Large volumes of material would be required to backfill the pit to above water table given the close proximity of the groundwater to the natural surface level of the pit. Sufficient backfill volumes are unlikely to be available on site and would need to be externally sourced at significant cost;
- Complete coverage of the exposed batters would be required to achieve compliance with fire risk criteria, and it is likely that insufficient backfill material will be available onsite to do this;
- Drainage around the pit is required to be managed in order to prevent external inflows from entering the pit. Significant drainage system around the pit would be required to be managed to exclude external inflows. Regular monitoring required to check integrity of drainage and as failure in the drainage system could significant stability consequences; and
- The Partial Backfill above the Water Table is not supported at all by the current Work Plan and would have a significant impact on current progressive rehabilitation activities.

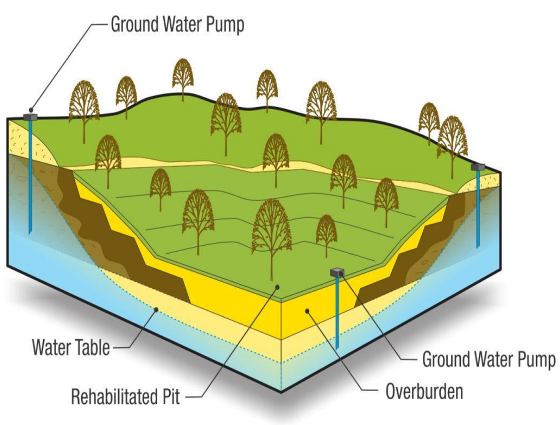


LINED VOID LANDFORM

CURRENTLY UNVIABLE OPTION

The MCA shows that the **Lined Void** is not currently viable:

- This landform is unlikely to protect or enhance environmental values, sustaining limited to no ecological function;
- It requires sufficient clay material (liner) to establish a hydraulic barrier, material is unlikely to be available onsite and would have a very significant cost to source;
- It requires very complex engineering to successfully create a stable lining;
- It requires substantial ongoing management to maintain aquifer pressure leading to significant on-going costs;
- Requirements for dewatering may prevent the ability of adjacent mines to achieve weight balance and water based landforms;
- Drainage around the pit is required to be managed to exclude external inflows;
- Whilst associated land use options such as waste- treatment and disposal or recylcing potentially offer significant economic benefits through job creation, it is untested if these benefits outweigh the substantial costs associated with the development of the landform itself; and
- Lined void is not supported at all by the current Work Plan and would have a significant impact on current progressive rehabilitation activities



REHABILITATED VOID

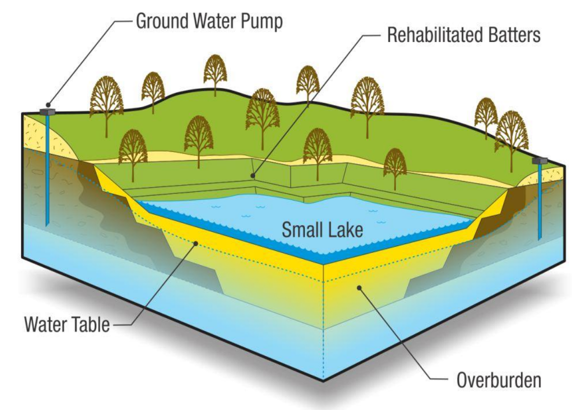
CURRENTLY UNVIABLE OPTION

The option of a **Rehabilitated Void** was assessed as not viable due to:

- Partial compliance with stability criteria due to the exposed nature of the pit walls and coal seam;
- The rehabilitated site would require significant ongoing management (similar to the current operational level) to maintain the dewatering processes and associated geological and aquifer stability;
- The requirement for dewatering may prevent ability of adjacent mines to achieve weight balance and water based landforms;
- Drainage around the pit would be required to be managed to exclude external inflows. Extensive on-going monitoring of drainage would be required to check integrity. Failure in drainage system could have significant stability implications;
- Limited onsite availability of sufficient cover (i.e topsoil) or alternative growth media volumes to support vegetation establishment; and
- Rehabilitated void is not supported at all by the current Work Plan and would have a significant impact on current progressive rehabilitation activities

7.3 Assessment of Preliminary Options – Loy Yang

All six preliminary options were assessed for Loy Yang. Results from the assessment are summarised below and in Appendix C.3.

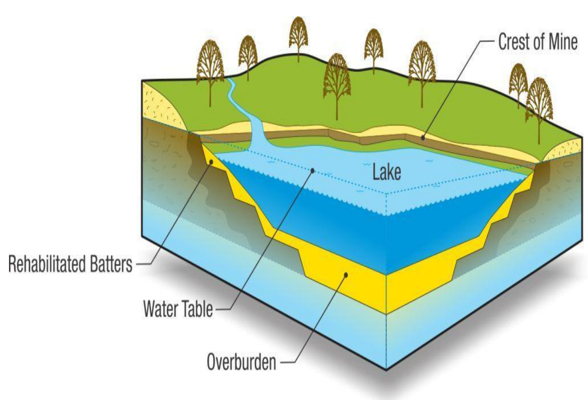


PARTIAL BACKFILL BELOW THE WATER TABLE

POTENTIAL VIABLE OPTION

The option of **Partial Backfill below the Water Table** is considered viable due to:

- Compliance with the fire risk criteria; coal seams will be covered by water or overburden where batters are above lake water level;
- The landform is likely to achieve minimum safety requirements as many of the walls are low slope and generally low risk of collapse as a result of the local geology of the coal and sediments;
- This landform supports multiple land uses such as future mining, a reservoir or wetland
- This option aligns most closely with the existing Work Plan.

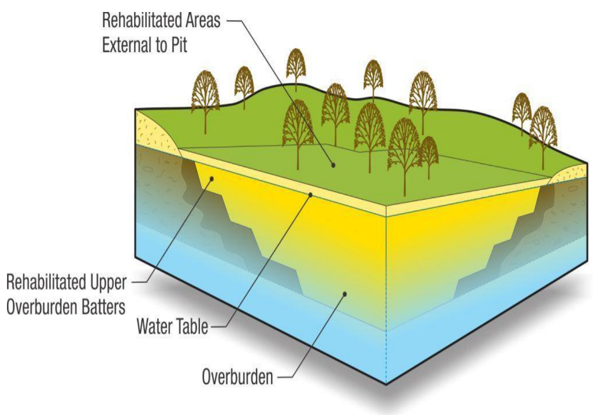


PIT LAKE LANDFORM

POTENTIAL VIABLE OPTION

The **Pit Lake**, while presenting challenges regarding aquifer pressures, water quality and availability, was considered a viable option at the initial screening level due to:

- Compliance with fire risk criteria as the exposed coal seams will largely be covered by water or overburden where batters are above lake water level;
- The landform is likely to achieve minimum safety requirements as many of the walls are lower slope and generally moderate risk of collapse as a result of the local geology of the coal and sediments;
- The landforms potential to support multiple land uses such as hydro-electricity generation, residential or wetland
- The material volumes required to develop this option are likely to be available on site; and
- This option requires some changes to the existing Work Plan.

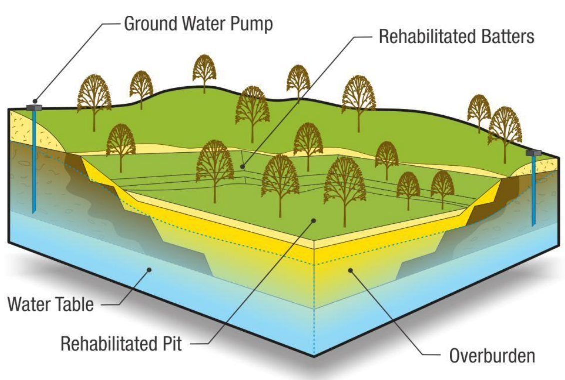


FULL BACKFILL LANDFORM

CURRENTLY UNVIABLE OPTION

The **Full Back Fill** option, while likely to achieve a safe and stable landform and considered best practice in the broader mining industry, is determined to be currenty unviable due to:

- A lack of onsite or local material of required quality for backfill; Loy Yang is the deepest mine and a considerable volume of material will need to be externally sourced at a significant economic cost (potentially threaten short term viability of mining);
- The requirement to access additional off site material likely to prevent adjacent mines from achieving weight balance or backfill based landforms; and
- Full Back Fill is not supported at all by the current Work Plan and would have a significant impact on current progressive rehabilitation activities

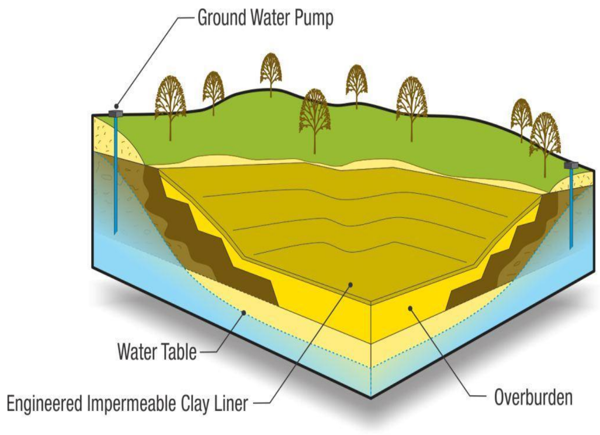


PARTIAL BACKFILL ABOVE THE WATER TABLE

CURRENTLY UNVIABLE OPTION

The **Partial Backfill above the Water Table** option, while expected to achieve weight balance and facilitate long term stability, is considered currently unviable due to:

- Significant volumes of material would be required to backfill the pit to above water table given the close proximity of the groundwater to the natural surface level of the pit;
- Complete coverage of the exposed batters would be required to achieve compliance with fire risk criteria, and it is likely that insufficient backfill material will be available onsite;
- Drainage around the pit is required to be managed in order to prevent external inflows from entering the pit. Extensive on-going monitoring of drainage would be required to check integrity. Failure in drainage system could have significant stability implications;
- Partial Backfill above the Water Table is not supported at all by the current Work Plan and would have a significant impact on current progressive rehabilitation activities

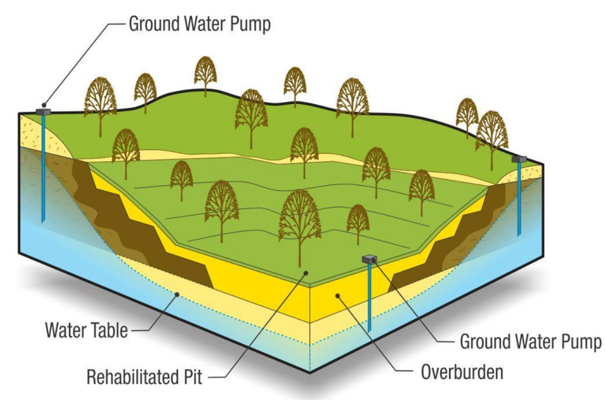


LINED VOID LANDFORM

CURRENTLY UNVIABLE OPTION

The MCA shows that the **Lined Void** is not currently viable:

- This landform is unlikely to protect or enhance environmental values, sustaining limited to no ecological function;
- It requires sufficient clay material (liner) to establish a hydraulic barrier, material is unlikely to be available onsite and would have a very significant cost to source;
- It requires very complex engineering to successfully create a stable lining;
- It requires substantial ongoing management to maintain aquifer pressure leading to significant on-going costs;
- Requirements for dewatering may prevent the ability of adjacent mines to achieve weight balance and water based landforms;
- Drainage around the pit is required to be managed to exclude external inflows;
- Whilst associated land use options potentially offer significant economic benefits through job creation, it is untested if these benefits outweigh the substantial costs associated with the development of the landform itself; and
- Lined void is not supported at all by the current Work Plan and would have a significant impact on current progressive rehabilitation activities



REHABILITATED VOID

CURRENTLY UNVIABLE OPTION

The option of a **Rehabilitated Void** was assessed as not viable due to:

- Partial compliance with stability criteria due to the exposed nature of the pit walls and coal seam;
- The rehabilitated site would require significant ongoing management (similar to the current operational level) to maintain the dewatering processes and associated geological and aquifer stability
- The requirement for dewatering may prevent ability of adjacent mines to achieve weight balance and lake based landforms, and will require ongoing management into long term
- Limited availability of sufficient cover and alternative growth media volumes
- Drainage around the pit would be required to be managed to exclude external inflows
- A resubmission of Work Plan would be required.

7.4 Short, medium and long term options

While progressive rehabilitation may be undertaken toward achievement of all landform within the short term it is unlikely that options, other than the Line Void and Rehabilitated Void could be achieved within the medium term. This is considered to be the case for all options at all sites. Rationale for implementation timeframes for each options is presented in Table 7-1.

Table 7-1 Assessment of preliminary options regarding whether they represent short, medium or long term options

Landform	Implementation Timeframe			Rationale
	Short Term	Medium Term	Long Term	
Pit Lake	■	■	■	Fire and landform stability risks can be mitigated in the short to medium term, the time required for the pit lake/pit water body to fill and reach final landform is likely to be in the long term (>15 years post closure).
Partial Backfill below the Water Table	■	■	■	
Partial Backfill above the Water Table	■	■	■	Fire and stability risks can be mitigated in the short to medium term given potential availability material of sufficient quantity and quality to backfill these landforms it is likely these landforms would be achieved in the long term (> 15 years post closure).
Full Backfill	■	■	■	
Lined Void	■	■		These landforms may be achieved in the medium term (<15 years post-closure). This is only possible if a specific land use was identified that provided the necessary resources (financial, human and technical) to achieve the significant landform re-development (e.g. waste disposal).
Rehabilitated Void	■	■		

7.5 Future Beneficial Land Uses

An analysis of the different benefits (e.g. economic, community and environmental), costs (e.g. design, construction/development and management) and risks (e.g. risks associated with the land use activity as distinct from the final landform) of different land uses was not performed.

Preliminary options were assessed on their potential capability to support multiple land uses. Based on the analysis of preliminary options Table 7-2 identifies the land uses Jacobs' believe each preliminary option could support. It was acknowledged that multiple land use and landform combinations may exist for a specific mine site and that land uses and landforms may not be mutually exclusive.

Landforms and land use "matches" marked as "least likely" implies it is theoretically possible for the preliminary option to support the land use but it would require very significant financial, human and physical resources (e.g. materials, water, enabling infrastructure such as roads and utilities) to achieve the requisite developable landform. In conducting the assessment Jacobs' took into account the theoretical possibility of a preliminary option supporting a land use but adopted a more practical and pragmatic approach in assessing future beneficial land use.

This comparison suggests that while all preliminary options different land uses there is no single preliminary option that is likely to support all land uses. Majority of land uses are only supported by a few preliminary options.

Several land uses are supported by multiple preliminary options (e.g. Irrigated Agriculture, Dryland Agriculture, Wind Electricity Generation, Solar Electricity Generation, and Reservoir). It is noted that the Partial below the Water Table preliminary option is likely to support (either directly or indirectly) the greatest number of land uses (the key aspect of the assessment criteria applied).

Table legend:

✓ = Landform most likely to support land use

- = Landform least likely to support land use

Table 7-2 – Land uses likely to be supported by preliminary options (final landforms)

Land Uses Identified By The Study		Preliminary Options (Landform)					
		Pit Lake	Full Back Fill	Partial Backfill above the Water Table	Lined Void	Partial Backfill below the Water Table	Rehabilitated Void
Conservation and Natural Environment		✓	✓	✓	-	✓	-
Production from Dryland Agriculture and Plantations		-	✓	✓	-	✓	✓
Production from Irrigated Agriculture and Plantations		-	✓	✓	-	✓	✓
Intensive Uses	Waste - treatment & disposal	-	-	-	✓	-	-
	Waste - recycling, recovery, salvage	-	-	-	✓	-	-
	Residential	-	✓	✓	-	✓	-
	Manufacturing and industrial	-	✓	✓	-	✓	-
	Mining (future)	-	-	-	✓	✓	✓
	Services (parklands, education, sport and/or cultural facilities)	✓	✓	✓	✓	✓	✓
Utilities	Hydro electricity generation	✓	-	-	-	-	-
	Bioenergy electricity generation	-	-	-	✓	-	-
	Wind electricity generation	-	✓	✓	✓	-	✓
	Solar electricity generation	✓	✓	✓	✓	✓	✓
Water	Lake - intensive use	✓	-	-	-	✓	-
	Lake – production	✓	-	-	-	✓	-
	Reservoir	✓	-	✓	✓	✓	✓
	Wetland – conservation	✓	-	-	-	✓	-

The assessment of preliminary options from a future beneficial land use perspective has a number of implications in regards to realising the desired regional mine rehabilitation outcomes of (refer to section 4):

- Ensuring landforms are safe, stable and non-polluting
- Improving the liveability of neighbouring towns
- Supporting employment through diversification of the regional economy
- Protecting and improving the health of environmental values/assets
- Not excluding future resource exploration and development

The low viability of the Full Pit Backfill, Partial Backfill above the Water, Lined Void and Rehabilitated Void landform options for all three mines may preclude some potential future beneficial land uses, such as those listed in **Table 7-3.**

Table 7-3 : Potentially Precluded Beneficial Land Uses

Landform	Potentially Precluded Land Uses			
	Waste - treatment & disposal	Waste - recycling, recovery, salvage	Bioenergy electricity generation	Wind electricity generation
Full Back Fill				✓
Partial Backfill above the Water Table				✓
Lined Void	✓	✓	✓	✓
Rehabilitated Void				✓

Based on the potential viability of the Pit Lake and Partial Backfill below Water Table landforms a range of potential beneficial land uses remain possible. Potential future beneficial lands supported by potential viable options are discussed further in section 8.3.3.

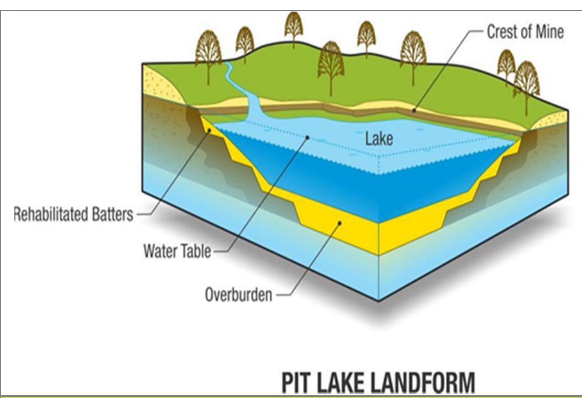
An assessment of the potential of the waste, bioenergy and wind electricity generation sectors could be undertaken to inform whether these land uses offer sufficient benefits to justify entertaining the requisite landform as potentially viable.

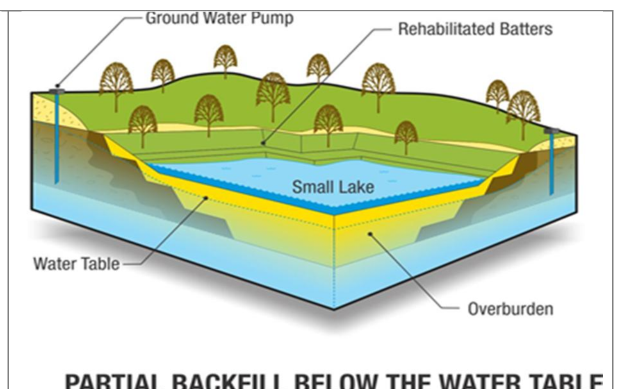
7.6 Summary of preliminary options analysis

The MCA conclusions were consistent across the three mines. **Table 7-4, Table 7-5** and **Table 7-6** show the preliminary options that broadly met the Criteria and associated Compliance Statements, and have therefore been considered at potential viable options for all three mines.

Table 7-4 : Potential viable rehabilitation options for each of the three Latrobe Valley coal mines

POTENTIAL VIABLE OPTIONS





	Pit Lake Landform	Partial Backfill Below the Water Table
Yallourn	Due to low fire risk and likely onsite availability of material sourcing requirements in order to achieve this landform.	Due to low fire risk and ability of the landform to achieve weight balance through a combination of both fill and water, as well as the likely onsite availability of material sourcing requirements. Likely to support the most land uses.
Hazelwood		
Loy Yang		

Table 7-5: Currently unviable preliminary options for each of the three Latrobe Valley coal mines

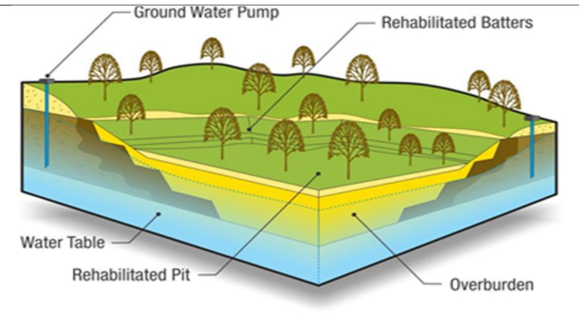
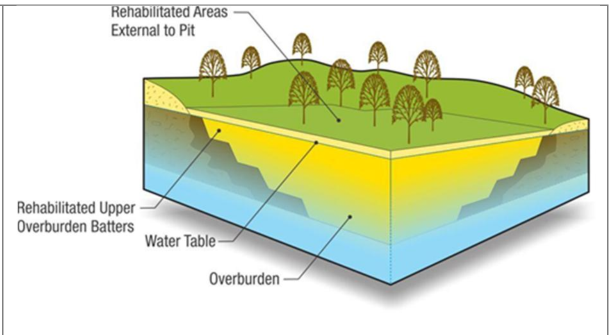
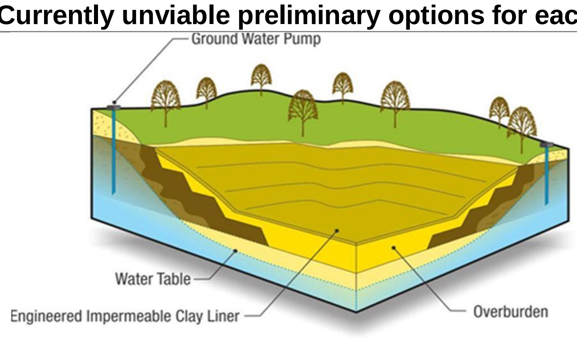
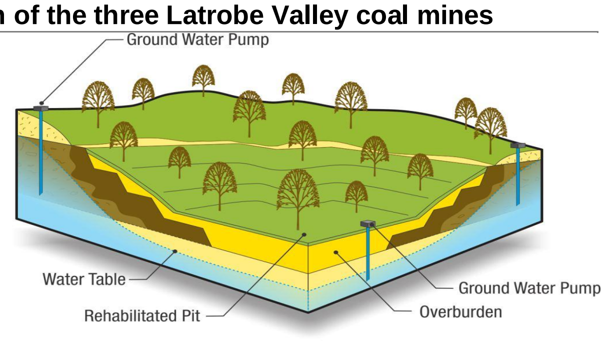
CURRENTLY UNVIABLE OPTIONS	 PARTIAL BACKFILL ABOVE THE WATER TABLE	 FULL BACKFILL LANDFORM
Yallourn	Due to the lack of available fill material onsite or locally and the significant costs associated with the import of material.	
Hazelwood		
Loy Yang		

Table 7-6: Currently unviable preliminary options for each of the three Latrobe Valley coal mines

CURRENTLY UNVIABLE OPTIONS	 LINED VOID LANDFORM	 REHABILITATED VOID
Yallourn	Due to likely the impact on environmental amenity and the potentially high costs associated with creating the lining.	Due to need to maintain ongoing landform stability activities such as dewatering, with significant costs.
Hazelwood		
Loy Yang		

8. Assessment of Potential Viable Mine Rehabilitation Options

Key Finding

For each of the three mines the Pit Lake and Partial Backfill Below the Water Table were assessed as providing the lowest level of overall residual risk (low to moderate) across fire, landform stability, groundwater, surface water and biodiversity without any significant differences in potential future beneficial land uses.

Each option for each mine would not represent a significant impediment to undertaking progressive rehabilitation in accordance with the MRSDA. The Partial Backfill Below the Water Table option is broadly aligned with the mine operator's existing final planned landform and therefore additional risk controls identified as needed for a Partial Backfill Below the Water Table and Pit Lake would be generally minimal. Possible exception is the study's use of 2 metres of material cover in the short term for both options to contribute to achieving a low short term residual fire risk. This differs from mine operators Work Plan's where up to 1 m of cover is generally proposed. Rationale for an additional one metre of cover is based on achievement of an ALARP level of residual risk. Short, medium and long term costs to achieve the low residual fire risk ranges from $20m through $70m depending on mine size.

Partial Backfill Below the Water Table was assessed as being likely to provide a low to moderate level of landform stability risk through differential placement of in-pit overburden across the batters and pit floor, and filling of the residual void to equilibrium, to achieve weigh balance. Each mine however has unique mine stability risks that must receive a high level of focus and rigor as potential consequences of significant instability events could be very significant (e.g. proximity of water courses and risk of uncontrolled flooding, required slope gradients above backfill and water levels to achieve acceptable factors of safety). Impacts to groundwater and surface water must be carefully managed using appropriate controls. If this occurs the risks were generally assessed as being low to moderate.

Further research and investigation is required into how the water quality of the pit water body will be managed. In documentation reviewed by Jacobs' this risk issue appears yet to be adequately considered however and understanding of likely land use is required to establish acceptable residual risk and mitigation controls. On-going research is needed to confirm the required weight balance (combination of water and material in the mined void to help achieve landform stability).

This section assesses the two potential viable options for each mine:

- Pit Lake Final Landform; and
- Partial Backfill below the Water Table Final Landform.

The assessment for each mine is presented in:

- Key similarities between potential viable options relevant to each mine – refer section 8.3;
- Yallourn Mine – refer section 8.4;
- Hazelwood Mine – refer section 8.5; and
- Loy Yang Mine – refer section 8.6;

The purpose of the assessment was not to compare options between mines. Limited comparison of potential viable options between the mines has been made only in instances where Jacobs' believe it is important to highlight differences.

The assessment comprised:

- Risk assessment (fire, landform stability, groundwater, surface water, biodiversity);
- Capacity to carry out progressive rehabilitation;
- Implementation Timing (short, medium and long term actions required to implement final landform/mine rehabilitation option);
- Cost (estimated cost to implement short, medium and long term actions);
- Extent of difference between the actions required to implement the final landform/mine rehabilitation option and the mine operator's existing approved rehabilitation plans; and
- Capacity to support future beneficial land uses.

Jacobs' assessment findings for each mine and each potential viable option are presented under the headings above (in accordance with the Inquiry's Terms of Reference and explained in section 6).

Due to the number of potential viable options (six in total, two per mine) and the breadth of the assessment (risks, costs, and comparison to existing Work Plans) a large volume of information has been generated by the study to inform the findings contained in this section. Contained in this section are regular references:

- Appendix D – Risk assessment findings;
- Appendix E – Comparison with current mine Work Plans;
- Appendix F – Estimated costs for potential viable options; and
- Appendix G – Implementation schedules

Important information in the context of this section is the risk rating (likelihood and consequence) parameters used to inform the risk assessments. This information can be found in Figure 10-3, Appendix A.

8.1 Overview of potential viable options

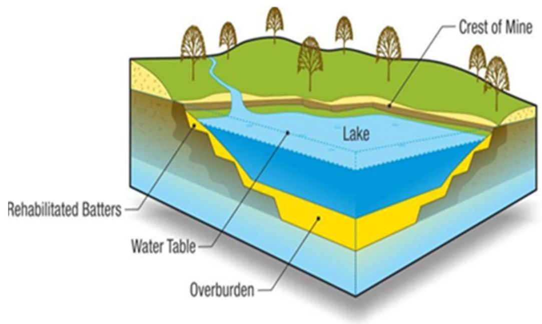
The potential viability of the Pit Lake and Partial Backfill below the Water Table landforms acknowledges the fact that key risks (e.g. fire, stability, water) are most effectively mitigated and managed through the combination of in-pit overburden placement and filling of the residual void to achieve fire cover and weight balance. Key differences between the two landform options include:

- The extent, area and depth of batters, above backfill and water level, to be reshaped, covered and rehabilitated;
- The extent and area of backfill above the water table level to be rehabilitated;
- The extent and depth of the final pit lake/pit water body;
- The uncertainty regarding ability to achieve final water level based on water allocation and impact from other water users; and
- The uncertainty regarding ongoing management requirements to maintain water level and quality.

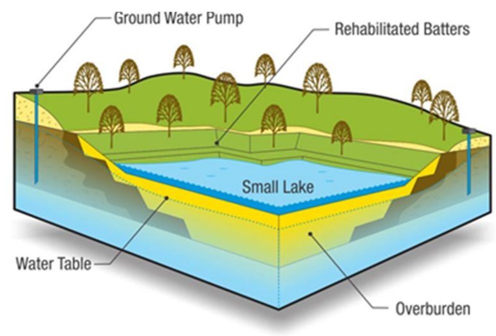
Table 8-1 provides further description of the physical landforms for each of the potential viable options.

Table 8-1: Overview of potential viable options

Landform feature

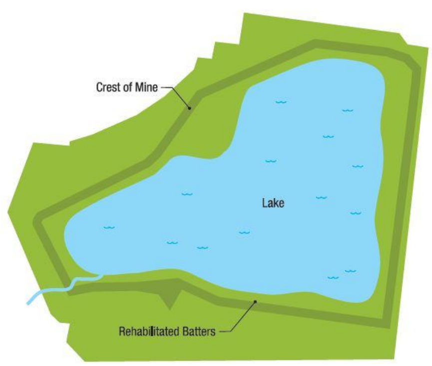


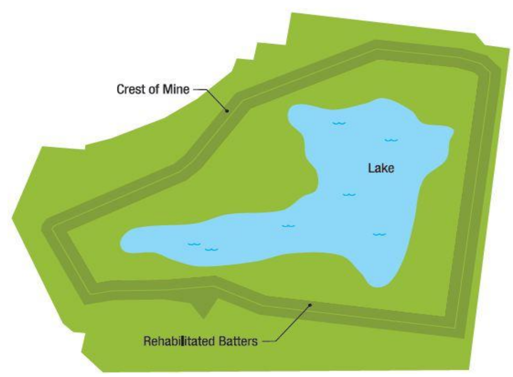
PIT LAKE LANDFORM



PARTIAL BACKFILL BELOW THE WATER TABLE

Surface





8.2 Important assumptions about assessment of potential viable final options

A number of assumptions have been made in conducting the assessment. This study and the assessment present have been carried out at an ‘order of magnitude/concept level’ using documented material made available to Jacobs. The conclusions provided are presented at a strategic level, in keeping with the brief and the time frame available.

8.2.1 Short, medium and long term

Jacobs’ has applied the following definitions for short, medium and long term:

- Short-term – now until the cessation of mining operations and covering the period of progressive rehabilitation (scheduled mine closure dates are Yallourn 2032, Hazelwood 2033 and Loy Yang 2048);
- Medium-term – a period of 15 years after the cessation of mining operations; and
- Long-term – the period beyond 15 years after the cessation of mining operations.

8.2.2 Risk Assessment Assumptions

The identification, assessment and treatment of short, medium and long term risks associated with achieving and maintaining the potential viable options (landforms) has been assessed. The assessment used a workshop based Failure Mode Analysis (FMA) risk assessment technique.

Through this method, primary and secondary controls required to achieve an as low as reasonably practical (ALARP) level of residual risk were identified at a strategic level across multiple risk types (i.e. safety, environment, stakeholder acceptance, technical feasibility, statutory compliance). For each identified control the highest residual risk considered across risk types was adopted as the overall residual risk. No attempt was made to establish inherent risk (refer to Appendix A – Study Method).

Because of the time frame for the study, the complexity of the technical issues and the amount of detail in each mine there is a degree of commonality in the assessments. This has been used to find the strategic issues or areas that are shared and also to identify at a high level where there are differences. It is clear that in detail the three sites considered have many differences. This assessment however takes a step back and looks at the overall picture to seek to find major gaps in understanding of future mine rehabilitation risks and opportunities.

8.2.2.1 Risk assessment applied a set of standard controls with some tailoring to site specific conditions

Assumptions have had to be made in the time available for this assessment regarding the use of a set of risk controls for fire, landform stability, groundwater, surface water and biodiversity risks. **Table 8-2** presents a set of controls that have been identified as required to implement each of the potential viable options to an ALARP residual risk level.

The precise detail of how these controls would be applied to each site and the precise nature of the application of each control was not able to be undertaken in the time available. The risk controls applied are generally accepted mine operation, rehabilitation and closure practices performed to avoid, mitigate or minimise the likelihood and/or impact of a potential risk event in order to achieve an ALARP residual risk rating.

Residual risk profiles presented for each landform option relates to the specific conceptual landform assessed, within the context of the mine being assessed. It does not reflect any assessment of residual risk assessment by Jacobs associated with either current or future Work Plans for each mine.

The following tables summarise the risk controls used to assess the residual risks in regards to:

- Fire risks;
- Landform stability risks;
- Groundwater risks;
- Surface water risks; and
- Biodiversity risks

Novel or new techniques to control fire risk without cover were not applied by Jacobs in the time available but potentially are an option (e.g. spraying exposed coal surfaces with fire retardant materials or chemicals). These fire controls may be an alternative to physical cover in the short and medium term.

Table 8-2 – Fire Risk Controls

Residual fire risk rating for each potential viable option assumes following controls can or have been effectively implemented by the mine operator…..	The basis for the risk controls identified was…
• Coal faces will be covered or capped to prevent exposure; • Programmed maintenance of the cover/ capping, including: monitoring, top up of the cover will be undertaken; • Use of shallow rooted species for vegetation to prevent breach of the cover in critical areas; • Erosion prevention to avoid cover breach in the long term; • Control of activities within the landform, (e.g. vehicle use in areas where there are coal seams or restrict public access to rehabilitated (high risk) areas); • Include (and maintain) fire breaks in re-vegetation design; • Cover with water (e.g. fill pit to maximum extent). Consideration should be given transition period prior to filling. Fill pit as fast as possible with surface water if cover is not used in the transition phase. Filling rate can be slower if cover is used on areas eventually below the water level; • Limiting the amount of coal exposure at any point in time; • Maintenance of water level using controlled surface water to ensure that uncovered areas are not exposed by water level fluctuations.	• Fire risk on the open pits is reported to be fundamentally associated with open or exposed coal faces. The reported dominant fire mechanisms involve loose or exposed coal coming into contact with ignition sources. • In all cases the risk of fire starting or spreading can be mitigated or controlled by an appropriate depth of cover material over coal. It is not clear from the information available to Jacobs that there is a consensus for the three mines on the depth of cover that will be needed in the long term landform to provide the required level of fire protection and; • The controls identified are fundamentally based on providing enough cover to prevent ignition and to restrict the spread of fire should one occur.

Table 8-3 – Landform Stability Risk Controls

Residual landform stability risk rating for each potential viable option assumes following controls can or have been effectively implemented by the mine operator…..	The basis for the risk controls identified was…
• Placement of overburden (mine waste material), inter-seam materials and/or other fill over the floor of the pit and the lower batters and benches to contribute to achieving a weight balance between the pit and the underlying and surrounding groundwater (aquifer) pressure. Note that in the case of Yallourn's mine areas the aquifer pressure is low and limited material is needed to achieve weight balance alone compared with the other two mines; • Design and execution of the overall slope angle on batters and benches so that long term slope stability is achieved in keeping with the geology of each face. The angle and design of each face in each pit will likely be different because of the different geology and risk profile for each face (this practice is used now); • Controlled re-pressurisation of the aquifer recovery of water level following the cessation or reduction of pumping) to achieve weight balance. A balance between the aquifer pressure and material (or water) in the pit is needed; • Design and construction of both the overall slopes and the slope of individual batters to a suitable (long term) gradient in keeping with the risk profile of the wall in question (geology and setting); • Water management (water addition) to maintain (or achieve) weight balance; • Buttressing of selected high risk faces prior to pit filling; • Installation of pressure relief wells / horizontal drains to control shallow water pressure in upper batters; • Source additional overburden, interseam and/or backfill materials off lease to reach the final long term slope profile required for each wall; • Design of drainage diversion and control on above water level batters to avoid water seeping into upper slope areas that reduces stability; and • Infiltration control in critical upper slope areas for faces/walls that are close to important features (rivers, roads or other infrastructure) outside mine site boundary	• In the two deeper mines (Hazelwood and Loy Yang) the pits will need to achieve a balance of weight against the underlying aquifer pressures; • Stability of the walls will be related to the geology of the wall and constructing an appropriate slope angle that provides the required long term factor of safety. Jacobs has identified that while the design parameters are well known in the context of an operational mine that long term risk management does not appear to have been documented to the same extent and this will require work. Accordingly Jacobs has not attempted to define a target slope angle and this will need to be developed for the region and most likely for each face in each mine based on the local conditions; • In some areas that are close to critical infrastructure or features material will need to be placed to achieve a long term stable landform; • There is opportunity to optimise the achievement of stability and fire control through movement of material; and • There is opportunity to use remaining waste material (to be removed over the mine's remaining life) to assist in creating improved stability in known risk areas.

Table 8-4 –Groundwater Risk Controls

Residual groundwater risk rating for each potentially viable mine rehabilitation option assumes following controls have been effectively implemented by the mine operator…..	The basis for the risk controls identified was…
• Avoid introduction of pollutants from outside the pit by diversion of any shallow groundwater or surface water prior to entering the pit, and treatment of it if the quality is not suitable for the long term management of the pit water body; • Treatment of water prior to entering pit or accumulating within the pit, including any acidic water so that the pit water body does not become a concentrator of pollutants that is in connection with the regional groundwater system; • Maintain appropriate salinity in the pit water body for the end land use and the surrounding groundwater; • Pre-emptive treatment of the pit lake (or other water body) water quality to maintain appropriate water quality in the pit and in connection with adjacent groundwater aquifers; • Regulate and limit land uses adjacent to the pit (e.g. nothing that may introduce critical contaminants into the groundwater catchment for the pit). The focus of this is the shallow groundwater system (unconfined aquifer); • Appropriate groundwater use allocations maintained for groundwater during and post pit filling so that sharing of the aquifer with other users is allowed for; • Management of excess water between available storage areas (e.g. other pits). This allows for the optimisation of the total groundwater take for the area; • Appropriate allocations maintained for surface water during and post pit filling; and • Ensure that fundamental design parameters involving other water elements are robust enough to cope with variability/ changes.	• Groundwater pressure and interaction is a major feature of the two deeper pits (Hazelwood and Loy Yang). For Yallourn the proximity to surface water features, such as the Latrobe River (runs parallel and to the north of the mine) and Morwell River (runs through the mine on a river embankment and is planned to be maintained in that role) means that groundwater connection in some form is highly likely; • Management of the take of groundwater from the environment in the long term is prudent and sensible and is in keeping with water management principles; and • Pit water bodies are likely to be in connection with surrounding groundwater to some extent and even low rates of connection may be important for regional groundwater in the long term. Control of water quality and management of the interaction with any pit water body will be required into the long term.

Table 8-5 – Surface Water Risk Controls

Residual surface water risk rating for each potentially viable mine rehabilitation option assumes following controls have been effectively implemented by the mine operator…..	The basis for the risk controls identified was…
• Ensure fundamental design parameters involving other water elements are robust enough to cope with variability/ changes; • Maintenance of “good” water quality in the water body for discharge. This may involve treatment systems; • Maintenance of “good” surface water quality in the water body for land uses; • Design of surface water management facilities around the pit which drain away from pit to avoid introducing contaminants; • Bunds around pits and running pits with freeboard to ensure that inflows are controlled and managed and the ability to exclude water of undesirable quality is available; and • Minimise the area that is lost to the surrounding catchments (e.g. external areas surrounding pit reshaped to design the appropriate and agreed lake catchment). Create a controlled system.	• Surface water management will be a central part of the maintenance of any pit water body. The degree to which any pit is connected with the local catchment will depend in large part on the management of appropriate water quality in the pit water body; and • Management options and controls are expected to enable long term management of water quality and volume in the pit water body.

Table 8-6 – Biodiversity Risk Controls

Residual Biodiversity risk rating for each potentially viable mine rehabilitation option assumes following controls have been effectively implemented by the mine operator…..	The basis for the risk controls identified was…
• Re-vegetation planning commensurate with final land use, stability and groundwater requirements; and • Consider using natural soil improvement agents to improve the soil microbial condition and nutrient load.	• Biodiversity risk is controlled essentially by managed re-instatement of required flora and fauna. In large part this will be dependent on final land use; • Management of risk includes allowance for biodiversity goals in the final landform and reservation of material, especially top soil to establish areas; and • The mine areas are highly modified and will require active intervention to support biodiversity goals in the long term.

8.2.3 Ensure Progressive Rehabilitation

For the purposes of the assessment progressive rehabilitation is considered to include the undertaking of rehabilitation activities which reduce the overall liability associated with disturbed land and in part achieve the agreed final landform. Progressive rehabilitation occurs as part of normal operations until end of mining operations (in each mine). Accordingly progressive rehabilitation is complimentary to a short term activity that then merges with the medium and long term rehabilitation actions.

In assessing if a potential viable option ensures progressive rehabilitation Jacobs' assumed the implementation of minimum of rehabilitation actions as early as is practical. These include (and have been assumed for both the Pit Lake and Partial Backfill below the Water Table landforms):

- Placement of in-pit overburden/waste and mine clean up waste to treat fire and stability risks;
- Reshaping of upper batters/benches to slopes with the required (long term) Factor of Safety;

- The use of future mining to address the final batter slope to ensure the rehabilitated slopes are achievable with low cost;
- Buttressing (supporting) of high risk batters below water level;
- Covering of upper batters with overburden for fire risk and water management;
- Installation of horizontal drains in upper batters for stability (key areas of high risk where slope alone cannot be used to provide safety);
- Reshaping of ex-pit areas to control pit surface water catchment and divert surface waters as required or desired; and
- Limit infiltration of water into upper batters in key high risk areas where slopes are steeper.

8.2.4 Estimated Costs

An estimated cost to achieve the acceptable level of residual risk for each potential viable option for each mine has been provided to a Jacobs' Class 5 (Order of Magnitude) level with an expected accuracy range of ±50%[15]. Given time and data availability limitations it has not been possible to determine a cost of site closure for each option at each mine. Costs provided therefore are relative only and are provided for comparison of risk controls for each potential viable option. Costs presented do not represent an estimate of the full cost of closure liability for each mine.

Cost for the implementation of identified risk controls were estimated based on conceptual quantities determined from available data on pit and site geometry. Costs have provided for:

- Short-term - estimated costs over and above operational costs e.g. in-pit placement of overburden. Costs relate to the implementation of the short term actions listed in **Table 8-8** and risk controls described in section 8.2.2.1;
- Medium-term costs - estimated rehabilitation costs associated with achieving the final landform. Costs relate to the implementation of medium term actions in **Table 8-8** – Most likely short, medium and long term implementation actions for each potential viable option for each mineand risk controls outlined in section 8.2.2.1 and;
- Long-term costs - estimated rehabilitation costs associated with achieving the final landform where this will take longer than 15 years and on-going landform maintenance costs. Costs relate to implementation of long terms actions in **Table 8-8** and risk controls described in section 8.2.2.1 .

The basis of estimated costs provided by this study will vary from future mine rehabilitation costs published elsewhere and should not be directly compared.

General assumptions applying to estimated costs and relevant to all potential viable options and mines are:

- Sufficient in-pit placement of overburden and buttressing of batters will be undertaken to achieve short-term weight balance and stability requirements as an operational cost;
- No recovery of ex-pit overburden dumps is required to achieve either the Pit Lake or Partial Backfill below the Water Table landform options;
- In-pit overburden dumps will be constructed to specification of the required landform option without requirement for double handling;
- Regrading of slopes above the final water table level will be completed as an operational stability control and have not been costed;
- Placement of fire cover on batters above the pit floor is not included within current mine operator Work Plans nor their operational costs; and

[15] While it is acknowledged that a level of accuracy of ±40% was targeted it is Jacobs opinion that insufficient time and data was available to achieve an accuracy of less than ±50%.

- Management and treatment of pit water body quality is required for both the Pit Lake and Partial Backfill below the Water Table Landforms at all mines.

The following general qualifications are made:

- Costs are inclusive of direct costs based on the determination of relevant quantities and rates;
- Costs are exclusive of indirect costs, contingency and costs not associated with direct risk controls (refer section 8.2.2.1). For example costs exclude demolition of infrastructure, remediation of contaminated sites, regulatory approvals and community consultation/engagement;
- Quantities have been based on data identified within information provided by the Inquiry or available in the public domain only without verification;
- Costs associated with in-pit placement of overburden are considered an operational cost and excluded;
- Due to insufficient information available at some mines costs do not account (e.g. exclude) progressive rehabilitation activities conducted to date;
- Costs are reported in current dollars and have not been discounted; and
- Where possible costs have accounted for duplication of risk controls activities however no attempt has been made to present cumulative costs.

A more detailed basis of estimate is provided within Appendix A.2.5.

8.2.5 Impact of the potential viable option on current rehabilitation plans for each mine

It is acknowledged that the level of design for the proposed final landform applied within the current mine operator Work Plans are generally conceptual and that more detailed design is required to identify and address key risks associated with establishment of their planned final landform.

8.3 Potential viable options have key similarities across the three mines

At a conceptual level of assessment the potential viable options share a number of similarities across the three mines.

8.3.1 Biodiversity risks is not a key differentiating factor between potential viable options

Risk to biodiversity is an important but non differentiating factor in choosing between a Pit Lake and Partial Backfill below the Water Table landform at each mine.

An assessment of biodiversity risks for each mine and each potential viable option revealed risks are low to moderate due to the use of standard risk controls (refer Table 8-6).

Table 8-7 – Assessment of biodiversity risks

Impact Scenario	Residual Risk Level					
	Yallourn		Hazelwood		Loy Yang	
	Pit Lake	Partial Backfill below the Water Table	Pit Lake	Partial Backfill below the Water Table	Pit Lake	Partial Backfill below the Water Table
Inability to vegetate above water level batters and disturbed areas to required standard.	Low	Moderate	Low	Moderate	Low	Moderate

Generally it was acknowledged that the some trade-off would be required between biodiversity and fire control due to the need to minimise the potential impact on fire cover from deep rooted vegetation and potential fire risk presented by fuel loads above covered coal seams. Such a requirement for trade off would be driven significantly by the final target land use and associated biodiversity objectives.

The moderate risk for the Patrial Backfill below the Water Table landform option at each site is primarily due to the considered lack of available topsoil to rehabilitate a larger surface area above the final water level.

8.3.2 Implementation schedules for each mine show final landforms are likely to be achieved in long term

Figure 8-1 and Figure 8-2 show the estimated short, medium and long term implementation schedules for each option. At a conceptual level of assessment the implementation schedules (short, medium and long term) are broadly similar for each option at each mine. The schedules show the commencement and completion timing of the important risk controls for each option. The important short, medium and long term implementation actions (common to both options) most likely to drive implementation schedules are:

- Short (progressive rehabilitation up to closure):
  - Landform stability - maintain weight balance primarily through buttressing and slope management
  - Fire risk - address fire risk through use of cover on exposed coal;
- Medium term (active rehabilitation for a period of 15 years post closure):
  - Landform stability - continue to address landform stability by maintaining weight balance and progress towards achieving target weight balance (combination of dumping material into the pit and use of surface and groundwater to fill the pit);
  - Groundwater and surface water – establish water level and quality controls (i.e. bunding, diversions, treatment plants) and commence filling the pit with water; and
  - Fire Risk – continue to address fire risk by use of cover on exposed coal while reaching target water level.
- Long term (period 15 years after closure):
  - Groundwater and surface water - achieve target water level through continue filling of lake and commence on-going management of water level and quality. Continue to preserve landform stability (weight balance) in response to regional aquifer level changes

There are key differences between the implementation schedules and actions of the Partial Backfill below the Water Table and Pit Lake landform. Most notable are the Partial Backfill below the Water Table landform requires:

- Less water to fill and therefore likely to be achieved in a shorter timeframe, albeit still within the long term;
- Greater medium to long term focus regarding on-going maintenance of cover used to address fire risk. The Pit Lake primarily uses water to cover exposed coal; and
- Greater short term effort to re-establish larger amounts of vegetation and biodiversity. The higher water level for the Pit Lake greatly reduces need to re-establish as much vegetation and biodiversity.

Figure 8-1: Implementation Schedule for Pit Lake landform at each mine (All Sites)

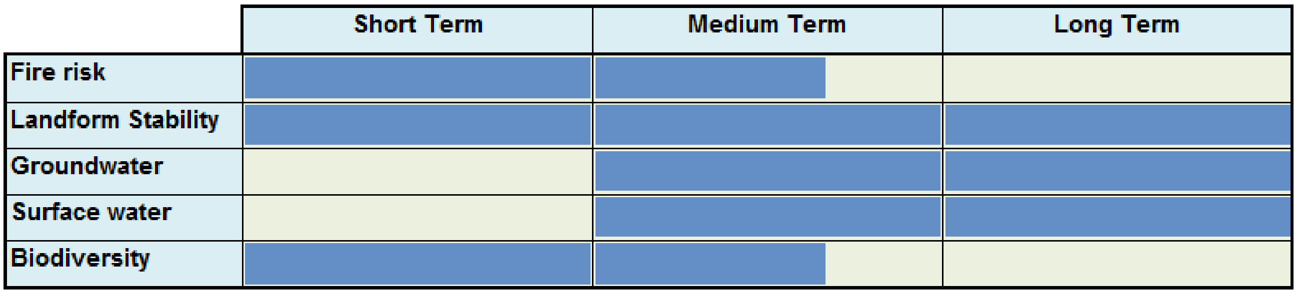
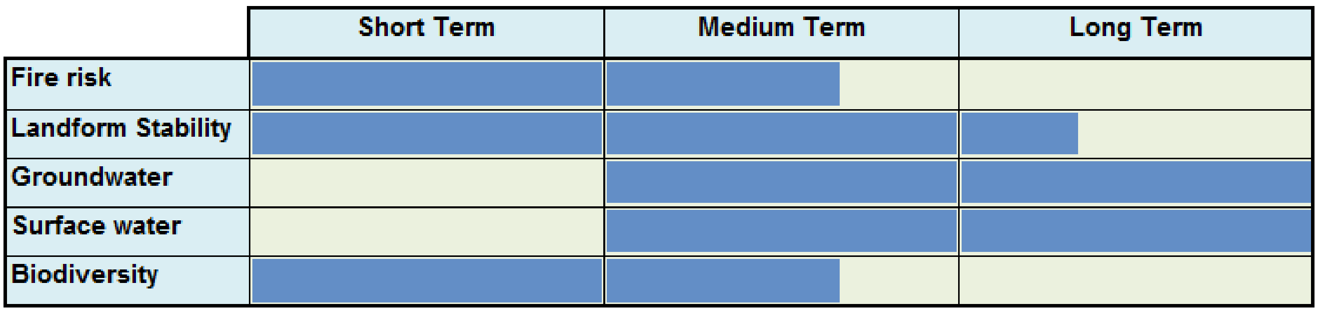


Figure 8-2: Implementation Schedule for Partial Backfill below the Water Table at each mine (All Sites)



The implementation schedules (short, medium and long term actions) shown above have been informed by the evaluated risks and identified risk controls developed for each potential viable option for each mine[16] . The implementation schedule is based on the actions needed to plan, design, implement and evaluate the required risk controls (refer to Appendix G).

Table 8-8 lists the assumed short, medium and long term implementation actions that would most likely need to be carried out at each mine for each potential viable option.

Factors that will influence the final timing of the achievement either landform include:

- Final pit water body/lake volume;
- Final pit water body/lake level; and
- Water quality management and the ability to discharge from the pit lake.

Factors specific to the Partial Backfill below the Water Table landform include:

- Rate of progressive rehabilitation during mining;
- Eventual slope profile for high risk walls/slope areas (close to critical infrastructure).

Yallourn is a possible exception in regards to achieving a Partial Backfill below the Water landform in the medium term. Provided access to water allocations, concerted effort and safely managed river diversion to achieve the required rate of filling (factoring in a rate of evaporation) it could be possible to achieve Partial Backfill below the Water Table landform in the medium term (within 15 years of closure). The on-going management of the interaction with Latrobe and Morwell Rivers will be an important determinant in regards to the achieving the landform.

At Hazelwood and Loy Yang, the Pit Lake landform would be achieved in the long term (minimum of 15 years after cessation of mining activities), in large part because of the volume of water required to reach the eventual long term water level. Even with significant diversion of water to the Pit Lake, neither site is likely to achieve the

[16] Refer to section 8.2.2.1 for an overview of risk controls, section 8.4 for an assessment of risks for each option at Yallourn, section 8.5 for an assessment of risks for each option at Hazelwood and section 8.6 for an assessment of risks for each option at Loy Yang.

Pit Lake within the medium term. Similar to Yallourn on-going effective management of the interaction with the Morwell River and Traralgon Creek will be important for the Hazelwood and Loy Yang mines respectively.

In making the assessment of landform implementation Jacobs' recognises the potential use of flood waters to assist in filling the mine pit with the short and medium terms. It is considered that use of flood waters, unless carefully controlled, presents moderate risk to the stability and integrity of the landforms and that capacity to use flood waters would need to be agreed with the water regulator.

Table 8-8 – Most likely short, medium and long term implementation actions for each potential viable option for each mine

Short Term Actions	Medium Term Actions	Long Term Actions
• Revise mine plan to ensure it compliments future rehabilitation (e.g. overall pit wall slopes); • Placement of in-pit overburden; • Reshaping of upper batters to slopes to required Factor of Safety (based on risk of individual faces); • Buttressing of high risk batters below water level prior to filling; • Covering of long term exposed (upper) batters; • Installation of horizontal drains in upper batters; • Reshaping of ex-pit areas to control pit catchment and manage surface waters; and • Limit infiltration of water into upper batters.	• Controlled cessation of dewatering; • Source additional water to achieve pit water body level; • Collection and treatment of water from diversions and horizontal drains as required; • Vegetate upper batters and ex-pit areas to suit land use; and • Establish fire breaks and access to upper batters.	• Regulate water level of pit water body to help maintain water quality; • Treatment of pit water to help maintain water quality; • Regulate land use and access adjacent to pit water body for risk management; and • Maintain cover and vegetation on upper batters and ex-pit areas, especially over coal seams.

While the long term continuation of coal mining at all three mines is uncertain the current scheduled closure dates for each mine are within 15 years of each other (i.e. Yallourn Mine – 2032; Hazelwood Mine – 2033; Loy Yang – 2048). This would effectively result in short and medium term actions for each mine being implemented concurrently. Throughout the assessment it was apparent that current work plans for each site have been prepared in isolation and that while each of the mine operators acknowledges the potential interdependencies between rehabilitation options current regulation does not require or facilitate consideration of such interdependencies.

Such interdependencies identified in include (refer to Appendix F for the identification of potential inter-dependencies for each option and each mine):

- The impact of groundwater connectivity on the ability of adjacent mine to dewater and depressurize concurrently;
- The appropriateness and ability of current and future water allocations to allow the three mines to access sufficient water to achieve each landform option;
- The opportunity to establish overburden purchase agreements between the three mines to optimise overall landform options (e.g. Yallourn is likely to have an excess of overburden should it pursue a Pit Lake landform option); and
- The potential for integrated water management and treatment options across all three mines to minimize long term costs and community burden.

While it has not been possible within the timeframe and scope of the study to investigate these interdependencies it is Jacobs considered opinion careful consideration is given in future planning to the regional impacts and interdependencies. Such understanding should be integrated with ongoing assessment and identification of regional land use strategy.

8.3.3 Potential viable options are likely to support some future beneficial recreational and agricultural land uses

Potential viable options offer a range of possible future land use opportunities. **Table 8-9** summarises the likely and unlikely future beneficial land uses associated with a Pit Lake and Partial Backfill below the Water Table final landform.

Loy Yang has relatively flatter slopes in some parts of the mine and the fact that there are less physical constraints around the perimeter creates potentially broader land uses opportunities than Hazelwood or Yallourn, which are more constrained.

At present there is insufficient information available to commit to a land use (or mix of land uses) for the rehabilitated mines that will maximise the economic, environmental or community strength of the Latrobe Valley.

Based on current mine rehabilitation plans it is conceivable that by 2060/2070 the Latrobe Valley could well feature three mined voids, partially filled with water and lowered landforms, the primary difference between the three being the size of the mined void. This type of landform is likely to suit dryland agriculture and plantations, possibly irrigated agriculture, wetland conservation and if sufficiently safe some form of recreational use.

Mine operators are generally targeting a return to some form of agricultural land use for the mined areas. This is consistent with their obligations are under the *MRSDA* (e.g. return the land to former use).

Table 8-9: Likely and unlikely future beneficial land uses potentially supported by potential viable options

Land Use		Potential Viable Options	
		Pit Lake	Partial Backfill below the Water
Conservation and Natural Environment		Likely land use	
Production from Dryland Agriculture and Plantations		Unlikely land use	Likely land use
Production from Irrigated Agriculture and Plantations		Likely land use	
Intensive uses	Manufacturing and industrial	Unlikely land use	Likely land use
	Mining	Unlikely land use	Likely land use
	Services (parklands, education, sport and/or cultural facilities)	Likely land use	
Utilities	Hydro electricity generation	Likely land use	Unlikely land use
	Solar electricity generation	Likely land use	
Water	Lake - intensive use	Likely land use	
	Lake – production	Likely land use	
	Reservoir	Likely land use	
	Wetland – conservation	Likely land use	

Regional land use options for the mined areas need to be quantified, understood and assessed over the long term to find the land use that could best support economic growth and prosperity. Once the best land use option has been identified, the costs of creating the enabling landform can be weighed against the benefits the land use may provide.

The following key questions need to be answered in order for all stakeholders to proceed with mine rehabilitation planning with greater certainty:

- What is the optimal set of final landforms for the three mines? The potential viable options have the capability to support the growth in the existing non-irrigated and irrigated agriculture and plantations. Could the Latrobe Valley play a role in wind or solar electricity generation (potentially enabled by a Partial Backfill below the Water Table final landform) and/or should there be a long term strategy of pursuing the Pit Lake option with potential for hydro-electricity generation scheme?

- Do all of the rehabilitated mine sites need to contribute to the diversification of the regional economy? Which rehabilitated mined areas could contribute to nature conservation (e.g. wetland)?
- Could the potential economic and community benefits (e.g. available land for residential development providing long term construction and service related employment, affordable housing to attract an influx of people to the region and/or a biomass energy generation facility capable of employing people and providing electricity etc.) afforded by the currently unviable Full Backfill, Lined Void and Fully Rehabilitated Mine Void options outweigh the expected very significant costs of procuring sufficient material to fill the void and perform the required on-going care and maintenance requirements?
- What is the potential mix of public open space with other land uses to contribute to improved community liveability?
- What commercial arrangements would be needed to attract any potential investor to fund transition costs that go beyond what is needed to achieve a safe and stable landform?

The longer decisions take on alternate land uses for the mined areas the more decisions will be made that may restrict land use options. As mine operators undertake progressive rehabilitation and plan for long term landforms, decisions will be made and implemented that could reduce the viability of particular land uses.

Given the level of complexity and contestability faced, a long term regional mine rehabilitation vision and set of clear outcomes should be finalised in the short term and continually used to guide holistic rehabilitation and land use transition planning. The goals and outcomes should and could present a coherent framework for a holistic approach to regional scale rehabilitation that offers the opportunity to significantly improve the likely outcome when compared with the alternative.

In the short term a systematic and considered process involving mine operators, local council, local community and relevant State Government Departments and Agencies (representing environment, regional development, energy, earth resources) could be undertaken to arrive at an enduring vision and clearly articulate the types of outcomes desired from the rehabilitated mined. Potential land uses could be identified which are consistent with the vision and outcomes. Their benefits could be assessed in terms of:

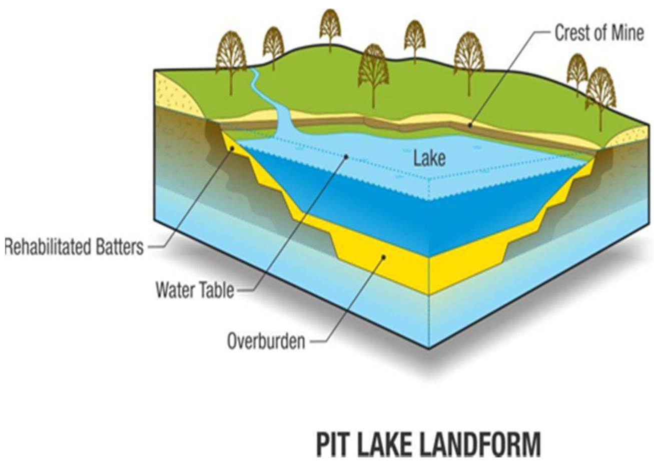
- Improved liveability of neighbouring towns – how can rehabilitated mines make a positive and enduring contribution to the improved short, medium and long term liveability of local communities?;

- Support employment through diversification of regional economy – what are the industries of the future that the Latrobe Valley could be competitive in, generate sustained employment for the local population and what role could a rehabilitated mine have in diversifying the regional economy?

The findings from this study inform the “deliverability assessment” of the selection of preferred land uses. This study has outlined the viability and feasibility (risk, estimated cost and implementation schedule) of different potential viable options for each of the mines. Using the analysis completed in this study combined with the detailed assessment of different land uses, stakeholders (community, mine operators, Victorian Government, local councils, potential investors/financiers etc.) can make an informed decision as to whether benefits of a specific land use could outweigh the risks, estimated costs and implementation challenges associated with delivering the enabling rehabilitated landform.

8.4 Yallourn Mine – Assessment of potential viable options

8.4.1 Assessment of Pit Lake landform



This section assesses the Pit Lake landform as a potential viable option for Yallourn.

Yallourn's current planned final landform does not completely correspond to the landform option of a Pit Lake as described here. It is flooding to a nominated level with plans to shape (flatten) the batters above the water level. The current preferred option in the Yallourn Work Plan is for the lake to be filled to RL 37 or RL 20. This is more in keeping with a Partial Backfill below the Water Table landform (refer to section 8.4.2 for an assessment of the Partial Backfill below the Water Table landform), with the lake covering the existing rehabilitated areas in the lower part of the mine.

Figure 8-3: Conceptual representation of a Pit Lake landform

Noted key physical differences between the pit lake landform and the partial backfill landform is in the volume of water that is will be needed to fill and maintain the water body. By way of comparison, the current Yallourn Work Plan estimates that to fill the water body to RL 37 will require approximately 748 GL. In contrast, to fill to a level 17 metres below at RL 20 this will require approximately 105 GL.

8.4.1.1 Risk Assessments

This section summarises the assessment of the fire, stability and environmental degradation risks associated with the Pit Lake landform.

Fire Risks

Effective use of fire risk controls (refer to **Table 8-2**) for the Pit Lake landform was assessed as sufficient to achieve a low residual fire risk at Yallourn. This involves the use of cover (from overburden and mine waste) to ensure that all coal seam areas have an appropriate depth of cover. The exact depth required is not clear from the material available to Jacobs and we have assumed the 2 m of cover will provide appropriate long term control. The cover may be able to come from Yallourn's stated need to remove over height material (truck and shovel operation) from its future overburden operations or by cut and filling batters with waste from the buffer zone around the mine.

Table 8-10 – Residual fire risk rating for Pit Lake Landform

Impact Scenario	Residual Risk Level
Ignition of exposed mine coal through spontaneous combustion of loose coal.	Low
External fire igniting coal seam	
Internal fire igniting coal seam	

A low residual fire risk for the Pit Lake landform at Yallourn (refer Appendix D1) is primarily due to:

- Water will cover a large part of the coal seams and prevent fire;
- Cover over coal will provide isolation from ignition for remaining areas;
- Operational controls in the short term can provide mitigation and containment of fire risk;

It is estimated to implement the required fire risk controls over the short, medium and long term for the Pit Lake landform at Yallourn may cost approximately $22m (refer

Table 8-11 and Appendix E1 and E2).

Table 8-11 Estimated short, medium and long term costs ($m) to implement standard fire risk controls at Yallourn for Pit Lake Landform[17].

Risk Issue	Estimated Short Term Costs	Estimated Medium Term Costs	Estimated Long Term Costs	Estimated Total Cost
Fire Risk	$13.60m	$6.90m	$2.40m	$22.80m

Costs are reported in current dollars and have not been discounted. Costs are rounded to the nearest hundred thousand.

Landform Stability

Landform stability risks for the Pit Lake Landform at Yallourn were assessed as high (refer to Appendix D1). Uses of the standard landform stability risk controls (refer to Table 8-3) were deemed insufficient to achieve a low to moderate residual risk rating. This assessment is complicated by the degree of progressive rehabilitation that has already been undertaken. Based on Yallourn's current Work Plan the Pit Lake Landform as described in this study is not the likely landform.

The degree of cover and progressive placement of material across the mine areas essentially means that the current form of the mine is closer to the Partial Backfill below the Water Table landform. To assess a Pit Lake Landform against the Partial Backfill below the Water Table option we have assessed that some material would be moved or removed for use elsewhere in the mine or Latrobe Valley. This looks unlikely to occur based on Yallourn's current Work Plan.

Table 8-12 – Landform stability residual risk rating for Pit Lake Landform at Yallourn

Impact Scenario	Residual Risk Level
Multi-batter collapse	High
Single batter collapse	

The following factors regarding the Pit Lake landform at Yallourn contributed to the high residual risk rating:

- Less placement of material on critical walls (e.g. township field batter, the final eastern batter and the batter along the Latrobe River);
- Limited control of slope angles below water; and
- Potential of batter collapse to result in injury in the long term.

We acknowledge that there are no plans to remove material from the current progressive rehabilitation and as such this option analysis is theoretical, but has been used to provide a counterpoint to the Partial Backfill below the Water Table option (refer to section 8.4.2).

Groundwater

Residual risks to groundwater for the Pit Lake landform at Yallourn were assessed as high (refer to Appendix D1). Uses of only standard groundwater risk controls (refer **Table 8-4**) were deemed as being insufficient to address the likelihood and consequence of potential groundwater risks.

[17] Short term costs have been difficult to estimate as the degree of progressive rehabilitation to date was not able to be determined in detail within the time available. Also, there is an expectation that the short term costs are generally incorporated in operational costs, thus are difficult to separate out from overall mining costs.

Table 8-13 – Residual risk rating for groundwater risks for Pit Lake landform at Yallourn

Impact Scenario	Residual Risk Rating
Water contamination (reflects both surface water and groundwater)	High
Limitation of groundwater availability to other users	

Groundwater related risks remained high due to:

- A large body of water in direct connection with upper aquifers;
- Potential for exchange of water between the aquifer and the Pit Lake;
- Limited control of the exchange of water between the shallow aquifer and the Pit Lake in the vicinity of the Latrobe and Morwell river giving potential for modification of base flow quality; and
- Reduced availability of groundwater has been assessed as due to potential constraints imposed by direct connection between surface water and groundwater with a high level Pit Lake.

Surface water

Similar to groundwater, standard controls (refer to **Table 8-5**) were insufficient to achieve a low to moderate risk rating (refer to Appendix D1) for the risk of reduced water quantity in surrounding watercourses (e.g. Latrobe River). Standard controls were assessed as sufficient to achieve a moderate residual risk rating in regards to off mine site surface water (e.g. mine catchment runoff) being affected by discharges from the Pit Lake.

Table 8-14 – Residual risk ratings for surface water risks for Pit Lake Landform at Yallourn

Impact Scenario	Residual Risk Rating
Surface water (off site) affected by discharge from the pit lake.	Moderate
Reduced water quantity in surrounding watercourses	High

Risk of reduced water quantity in surrounding watercourses remained a high risk due to:

- Lack of information and evidence that the water quality in the Pit Lake can be controlled to the extent required to avoid impacts in the broader catchment. This risk may be lowered by research and further study to better explain water quality impacts; and
- Water quality changes in a Pit Lake will have an impact if released into the environment.

8.4.1.2 Ensure Progressive Rehabilitation

If Yallourn Mine was to seek to implement a Pit Lake landform a range of operational changes to their current rehabilitation plan would need to be made. A larger Pit Lake alone would involve less progressive cover; although this is difficult to assess in the time available to this study and would require a detailed analysis of progressive rehabilitation to date. This option as described is not a good fit with the current mine plan and we would expect that a pure Pit Lake landform as described here is not likely based on the approved Work Plan. For example, the recent review of the Work Plan identified that over 550 ha had been progressively rehabilitated.

Key changes that are likely to be required are the additional cover to ensure that all coal areas have cover and inclusion of an allowance for water quality management.

We have assessed that a Pit Lake Landform presents few impediments to progressive rehabilitation actions in the short-term, and rehabilitation to date has been undertaken with a lake or large water body anticipated.

8.4.1.3 Estimated Implementation Costs

Table 8-15 summarises the estimated short, medium and long term costs (refer Appendix E1 and E2) to implement the Pit Lake Landform in a manner that would achieve the residual risk ratings[18].

Table 8-15 – Estimated implementation costs for Pit Lake landform at Yallourn

Risk Issue	Estimated Short Term Costs	Estimated Medium Term Costs	Estimated Long Term Costs	Estimated Total Cost
Landform Stability	$0.40m	$23.40m	$3.60m	$27.20m
Groundwater	No costs incurred	$8.20m	$3.60m	$11.70m
Surface water	No costs incurred	$14.80m	$1.20m	$16.00m
Biodiversity	No costs incurred	$3.10m	No costs incurred	$3.10m
Fire Risk	$13.60m	$6.90m	$2.40m	$22.80m

Costs are reported in current dollars and have not been discounted. Note costs are rounded to the nearest hundred thousand.

Significant costs noted for this landform include:

- The potential importing of materials to reshape external pit areas to minimise the pit lake catchment area and create a controlled water management zone with low residual impact on surrounding catchments; and
- Construction of bunding and levees to divert run-off away from pit lake catchment area to minimise erosion to rehabilitated areas external to pit.

Limitations

In regards to Yallourn and a Pit Lake landform the key limitations on the accuracy of the estimated costs are:

- In the time available Jacobs' were not able to develop a detailed understanding of the extent of progressive rehabilitation and how this affected the quantities in the short and medium term;
- The cost share between operations and rehabilitation in the short term cannot be distinguished based on information available to Jacobs and;
- The volume of cover for fire control is strongly related to the assumed thickness of cover. Costs are proportional to the volume.

8.4.1.4 Impact of the option on current rehabilitation plans

Yallourn's current Work Plan proposes a final landform of flooding to a nominated level (RL37) with plans to shape (flatten) the batters above the water level. Whilst Work Plan refers to the final landform as a lake, it is our assessment that Yallourn's approved Work Plan is closer to Partial Backfill below the Water Table landform. Both of these options involve a lake feature.

If Yallourn was to adopt a Pit Lake landform the risk controls summarised in **Table 8-16** need to be added to their approved Work Plan. In Jacobs' opinion this would represent a small to moderate deviation from the current Work Plan. The current rehabilitation plans present a conceptual framework for rehabilitation and in the case of Yallourn the Work Plan review acknowledges that further detailed assessment is needed on some aspects of slope and water as the plan progresses.

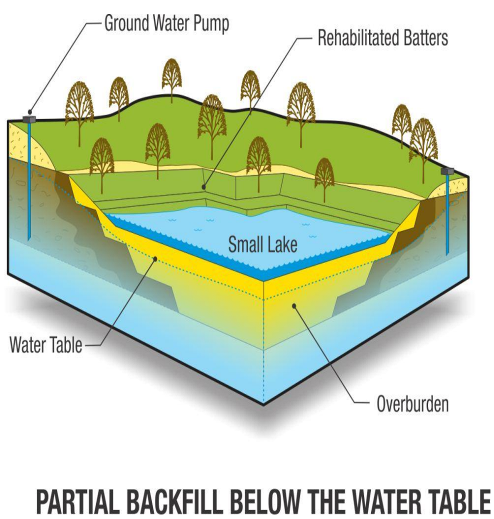
It is acknowledged that current Work Plans are supported by a conceptual level of design and that as Yallourn undertakes more detailed design such controls may well be considered (refer to Appendix F1).

[18] General assumptions and clarification regarding estimated costs are presented in Section 8.2.4. Specific assumptions for the Pit Lake Options at Yallourn are presented within the relevant cost schedule – refer to Appendix E1 and E2.

Table 8-16 : Additional risk controls to the current Work Plan for the Pit Lake landform

Risk Issue	Additional Risk Controls
Fire	Coal face would need to be covered or capped to prevent exposure.
	Programmed maintenance of the cover/ capping, including: monitoring, top up of the cover would need to occur.
	Use of appropriate species for vegetation to prevent breach of the cover.
	Use of erosion prevention to avoid cover breach.
	Include (and maintain) fire breaks in re-vegetation design.
	Fill pit faster with surface water addition.
Landform Stability	Design and construction of slopes to suitable gradient, taking into account long term rather than operational safety requirements.
Groundwater	Diversion of the shallow groundwater or surface water prior to entering the pit, and treatment of it.
	Treatment of water either prior to entering pit, or acidic water, as required.
	Maintain appropriate pit water body salinity for end land use.
	Treatment of the pit lake water or restore and maintain appropriate water quality.
	Appropriate allocations maintained for groundwater post pit filling.
	Ensure that fundamental design parameters involving other water elements are robust enough to cope with variability/ changes.
Surface Water	Maintenance of good water quality in the Pit Lake for discharge.
	Maintenance of good surface water quality in the Pit Lake for land uses.
	Design of surface water management facilities around the pit which allow management of inflow or diversion.
	Bunding around pit and operating Pit Lake with freeboard in a controlled manner.
	Management of excess water between available storage areas (e.g. other pits if direct connection to rivers is planned).
	Ensure that fundamental design parameters involving other water elements are robust enough to cope with variability/ changes.
	Minimise the area that is lost to the surrounding catchments (e.g. external areas surrounding pit reshaped to minimise Pit Lake catchment). Create a controlled system that is managed
	Add material for reshaping lake edge.

8.4.2 Assessment of Partial Backfill below the Water Table landform



This section assesses the Partial Backfill below the Water Table option for Yallourn.

The Partial Backfill below the Water Table option most closely resembles Yallourn's current Work Plan and relatively little change would be needed to achieve this option compared with the current plan. This may appear confusing as the current Work Plan refers to a flooding option as preferred. This landform includes flooding. The type of activities that are included in this landform for example are: planning for complete cover of all coal seams and areas, continued buttressing of walls and slopes that are close to high value assets (e.g. township field western batters, eastern batters, Latrobe River batter and securing the Morwell River diversion batters) or are regarded to be a high risk, implementation of water quality management actions and options to control the pit water body water quality to within acceptable bounds (which are as yet not defined).

Figure 8-4: Conceptual representation of landform[19]

8.4.2.1 Risk Assessments

This section summarises the assessment of the fire, stability and environmental degradation risks associated with the Partial Backfill below the Water Table landform.

Fire Risks

Effective use of standard fire risk controls (refer to **Table 8-2**) for the Partial Backfill below the Water Table Landform option was assessed as sufficient to achieve a low residual fire risk at Yallourn (refer to Appendix D2).

Table 8-17 – Residual fire risk ratings for Partial Backfill below the Water Table landform

Impact Scenario	Residual Risk Rating
Ignition of exposed mine coal through spontaneous combustion of loose coal.	Low
External fire igniting coal seam	
Internal fire igniting coal seam	

A low residual fire risk for the Partial Backfill below the Water Table landform is primarily due to:

- Water will cover a large part of the coal seams and prevent fire;
- Cover over coal will provide isolation from ignition for remaining area;
- Protection to the fire cover will be established through diversion of surface water run-on, restriction of access to high risk areas and use of shallow rooted vegetation cover (e.g. grasses)
- During the short term, operational controls such as suppression and fire containment systems will remain.

It is estimated to implement the required fire risk controls over the short, medium and long term for the Partial Backfill below the Water Table landform at Yallourn would cost in the range of $22m (refer Appendix E1 and E3).

[19] Image should not be interpreted as representing final proposed landform at Yallourn

Table 8-18 Estimated short, medium and long term costs ($m) to implement fire risk controls at Yallourn for Partial Backfill below the Water Table landform[20].

Risk Issue	Estimated Short Term Costs	Estimated Medium Term Costs	Estimated Long Term Costs	Estimated Total Cost
Fire Risk	$13.60m	$6.90m	$2.40m	$22.80m

Costs are reported in current dollars and have not been discounted. Costs are rounded to the nearest hundred thousand.

Landform Stability

Landform stability risks for the Partial Backfill below the Water Table landform at Yallourn were assessed as low to moderate (refer to Appendix D2). Uses of the standard landform stability risk controls (refer to **Table 8-3**) were deemed sufficient.

Table 8-19 – Residual landform stability risk ratings for Partial Backfill below the Water Table landform at Yallourn

Impact Scenario	Residual Risk Rating
Multi-batter collapse	Low
Single batter collapse	Moderate

The following factors contributed to the low to moderate residual risk rating:

- Progressive rehabilitation and placement of fill provides stability for the walls in most locations;
- Water provides weight and stability for many areas; and
- Only limited areas of upper batters remain above water level. Given the proximity to sensitive features (e.g. township western batter, eastern batter in final mining area and the northern batter along the Latrobe River) and infrastructure the risk of a batter collapse in the upper parts of the wall is classed as moderate. The river diversion is considered the focus areas. Not all walls or areas will be moderate risk and may be a lower risk (e.g. southern batters in the old mine are low in height, have the internal dump and have been stable for a long time).

The key uncertainty associated with landform stability risk (due to the time available to this study) is whether there is sufficient material available in all cases to achieve the long term landform with cover of coal and ability to reshape tightly constrained walls. This risk may be lowered with further analysis and investigation of potential options such as using overburden within the buffer zone rather than imported material as a cost effective alternative. There is some indication in the material available to Jacobs that this material is potentially available and is not a major impediment, however, detailed studies are required to define the source.

Groundwater

Residual risks to groundwater for the Partial Backfill below the Water Table at Yallourn were assessed as moderate (refer to Appendix D2). Uses of standard groundwater risk controls (refer to **Table 8-4**) were deemed as being sufficient.

Table 8-20 – Residual groundwater risk ratings for Partial Backfill below the Water Table landform

Impact Scenario	Residual Risk Rating
Water contamination	Moderate
Limitation of groundwater availability to other users	

Groundwater related risks were assessed as moderate due to:

[20] Short term costs have been difficult to estimate as the degree of progressive rehabilitation to date was not able to be determined in detail within the time available. Also, there is an expectation that the short term costs are generally incorporated in operational costs, thus are difficult to separate out from overall mining costs.

- High potential for direct connection between the shallow aquifers and the pit water body:
- Close relationship to the Latrobe and Morwell rivers and other surface water features; and
- Large uncertainty about the need for and methods of control of water quality;

Surface water

Similar to groundwater, risk controls (refer to **Table 8-5**) were sufficient to achieve a low risk rating for the risk of reduced water quantity in surrounding watercourses (refer to Appendix D2). Risk controls were assessed as sufficient to achieve a moderate residual risk rating in regards to off mine site surface water being affected by discharges from the pit water body.

Table 8-21 – Residual surface water risk ratings for Partial Backfill below the Water Table landform

Impact Scenario	Residual Risk Rating
Surface water (off site) affected by discharge from the pit lake.	Moderate
Reduced water quantity in surrounding watercourses	Low

Residual risks were able to be assessed as low to moderate due to:

- Risk of surface water (off-site) affected by discharge from the pit water body is considered to be able to be effectively treated by water level management and control of inflows and freeboard;
- Reduced water quantity in surrounding watercourses is effectively mitigated by water treatment of discharge waters.

8.4.2.2 Ensure Progressive Rehabilitation

A Partial Backfill below the Water Table landform presents few physical or technical impediments that could prevent progressive rehabilitation actions in the short-term. This option is the closest match to Yallourn's current Work Plan.

The key areas where impediments may exist (yet to be conclusively demonstrated) are:

- Whether sufficient back fill material is available to achieve both weight balance and coal cover for fire control. It is likely that material is available but without a detailed examination of progressive rehabilitation progress to date, which was beyond the scope of this study, it has not been confirmed and;
- The requirement for and method of water quality management and control.

8.4.2.3 Estimated Implementation Costs

Table 8-22 summarises the estimated short, medium and long term costs to implement the Partial Backfill below the Water Table landform in a manner that would achieve the residual risk ratings (refer to Appendix E1 and E3).

Table 8-22 – Estimated implementation costs ($m) for Partial Backfill below the Water Table landform[21]

Risk Issue	Estimated Short Term Costs	Estimated Medium Term Costs	Estimated Long Term Costs	Estimated Total Cost
Landform Stability	$1.30m	$23.40m	$3.60m	$28.10m
Groundwater	No costs incurred	$8.20m	$3.60m	$11.70m
Surface water	No costs incurred	$14.80m	$1.20m	$16.00m
Biodiversity	No costs incurred	$3.10m	No costs incurred	$3.10m
Fire Risk	$13.60m	$6.90m	$2.40m	$22.80m

Costs are reported in current dollars and have not been discounted. Costs are rounded to the nearest hundred thousand.

Significant costs noted for this landform include:

- The potential importing of materials to reshape external pit areas to minimise the pit lake catchment area and created a controlled water management zone with low residual impact on surrounding catchments;
- Construction of bunding and levees to divert run-on away from pit lake catchment area to minimise erosion to rehabilitated areas and batters.

Limitations

In regards to Yallourn and a Partial Backfill below the Water Table landform the key limitations on the accuracy of the estimated costs are:

- The detail of progress with progressive rehabilitation and the effect that this has on quantities of material to move;
- The ability of operations to achieve cover of coal for fire risk reduction during mining operations; and
- The requirement for and nature of water quality management system(s).

8.4.2.4 Impact of the option on current rehabilitation plans

Yallourn's current Work Plan proposes a final landform of flooding to a nominated level with plans to shape (flatten) the batters above the water level. **Table 8-23** below identifies those controls identified by this study which may require consideration to achieve a Partial Backfill below the Water Table landform as defined in this study, beyond the risk controls identified in Yallourn's current Work Plan. The current rehabilitation plans present a conceptual framework for rehabilitation and in the case of Yallourn; the Work Plan review acknowledges that further detailed assessment is needed on some aspects of slope and water as the plan progresses.

It is acknowledged that current Work Plans are supported by a conceptual level of design and that as Yallourn undertakes more detailed design such controls may well be considered (refer to Appendix F2).

[21] General assumptions and clarification regarding estimated costs are presented in Section 8.2.4. Specific assumptions for the Partial Backfill Below the Water Table Option at Yallourn are presented within the relevant costing schedule (see Appendix E1 and E3).

Table 8-23 – Risk controls identified as required for a Partial Backfill below the Water Table landform by the study and not present in Yallourn's current Work Plan

Risk Issue	Additional Risk Controls
Fire	Coal face must be covered or capped to prevent exposure.
	Programmed maintenance of the cover/ capping, including: monitoring, top up of the cover.
	Use of appropriate species for vegetation to prevent breach of the cover.
	Erosion prevention to avoid cover breach.
	Include (and maintain) fire breaks in revegetation design.
	Fill pit faster with surface water addition.
Landform Stability	Design and construction of slopes to suitable gradient, with appropriate long term risk controls. This will vary by face and wall depending on the risk
Groundwater	Diversion of the shallow groundwater or surface water prior to entering the pit, and treatment of it.
	Treatment of water either prior to entering pit, or acidic water, as required.
	Maintain appropriate salinity for end land use.
	Treatment of the pit water body or restore and maintain appropriate water quality.
	Appropriate allocations maintained for groundwater post pit filling.
	Ensure that fundamental design parameters involving other water elements are robust enough to cope with variability/ changes.
Surface Water	Maintenance of good water quality in the pit water body for discharge.
	Maintenance of good surface water quality in the pit water body for land uses.
	Design of surface water management facilities around the pit which drain away from pit and allow controlled discharge to pit as required.
	Bunding around pit and running pit with freeboard (controlled water management options).
	Management of excess water between available storage areas (e.g. other pits, especially during floods).
	Ensure that fundamental design parameters involving other water elements are robust enough to cope with variability/ changes.
	Minimise the area that is lost to the surrounding catchments (e.g. external areas surrounding pit reshaped to minimise pit water body catchment). Create a controlled system
	Source material for reshaping the pit water body edge and shore area.
	Consider using natural soil improvement agents to improve the soil microbial condition and nutrient load.

8.4.3 Summary of important strengths and weaknesses of potential viable options for Yallourn

8.4.3.1 Risk Assessment

Partial Backfill below the Water Table is likely to have the lowest overall risk. The Partial Backfill below the Water Table is likely to represent an overall low to moderate risk if the appropriate risk controls are effectively implemented.

Table 8-24: Comparison of risk assessment – Pit Lake and Partial Backfill below the Water Table

Risk Issue	Impact Scenario	Residual Risk Rating	
		Pit Lake	Partial Backfill below the Water Table
Fire	Ignition of exposed mine coal through spontaneous combustion of loose coal.	Low	Low
	External fire igniting coal seam		
	Internal fire igniting coal seam		
Landform Stability	Multi-batter collapse	High	Low
	Single batter collapse		Moderate
Surface water	Surface water (off site) affected by discharge from the pit lake.	Moderate	
	Reduced water quantity in surrounding watercourses	High	Low
Ground water	Water contamination	High	Moderate
	Limitation of groundwater availability to other users		

Fire Risks

Both potential viable options were rated as low residual fire risk. The control of fire risk is primarily driven by either water saturation or placement of cover over exposed coal seams to create an anaerobic environment with secondary controls focusing on the maintenance and integrity of the primary control. The residual risk for fire management was considered low across both viable landforms due to the stringent controls assumed for fire management.

For Yallourn costs for fire risk are generally the same however a more detailed analysis of the volume of cover required and the appropriate depth of cover is needed. Also, assessment of progressive rehabilitation to date and restrictions posed by mine infrastructure are needed to assess the relative difficulty and implementation timing of these controls.

Landform Stability Risks

Achievement of sufficient weight within the final landform to counteract the inherent stability within coal seams and pit floor is a significant risk issue for both potential viable options.

The relative use of backfill and water to achieve weight balance and stability is the key difference in identified controls between the options. Determination of appropriate slopes to achieve the required factor of safety and management of run off on upper batter slopes above the final backfill/water level are common controls across both landform options.

For the Pit Lake and Partial Backfill below Water Table landforms for Yallourn consideration will need to be given to the long term repressurisation of groundwater in the upper aquifer (M2 aquifer) and how this changes over time. This may have implications for weight balance and stability.

Groundwater Risks

Key control for both options is the maintenance of the water level above the level required for weight balance and below the water table thereby limiting the flow of water from the pit into the adjacent groundwater aquifers. This is expected on the basis that the water quality in the pit will be different to the aquifer and uncontrolled outflow is assumed to be undesirable. With high evaporations rates in the Latrobe Valley, maintenance of the water level will require both passive and active ‘topping up’ of the water level from sources other than natural groundwater recovery.

Water quality risks apply to both options. Facilitating the landform as a groundwater sink could result in the concentration of contaminants and salts. Over time this is likely to reduce the water quality. Effective controls for water recycling and possible treatment will be critical.

Surface Water Risks

Given known groundwater levels and based on projected water levels it is Jacobs' assessment that flow through connectively with natural surface water systems will be complex to achieve with either option. Control of the landforms in floods and management of water quality of any discharge waters are therefore the key controls for management of surface water risk.

8.4.3.2 Estimated Cost

A comparison of estimated total costs between the two viable mine rehabilitation options at Yallourn is presented in **Table 8-25.** Similarities in costs may be attributed to the assumption that bulk civil works (e.g. slope battering, overburden placement and backfilling) are to be undertaken during operations and are subsequently excluded from costs. Increased costs associated with management of landform stability for the Partial Backfill below the Water Table landform are associated with additional reshaping of overburden placed during operations as part of the pit backfill.

Table 8-25 Comparison of Estimated Cost – Yallourn

Risk Issue	Pit Lake Landform Estimated Total Cost	Partial Backfill below the Water Table Landform Estimated Total Cost
Landform Stability	$27.20m	$28.10m
Groundwater	$11.70m	$11.70m
Surface water	$16.00m	$16.00m
Biodiversity	$3.10m	$3.10m
Fire Risk	$22.80m	$22.80m

Costs are reported in current dollars and have not been discounted. Costs are rounded to the nearest hundred thousand.

8.5 Hazelwood Mine - Assessment of Potential Viable Mine Rehabilitation Options

8.5.1 Assessment of Pit Lake landform

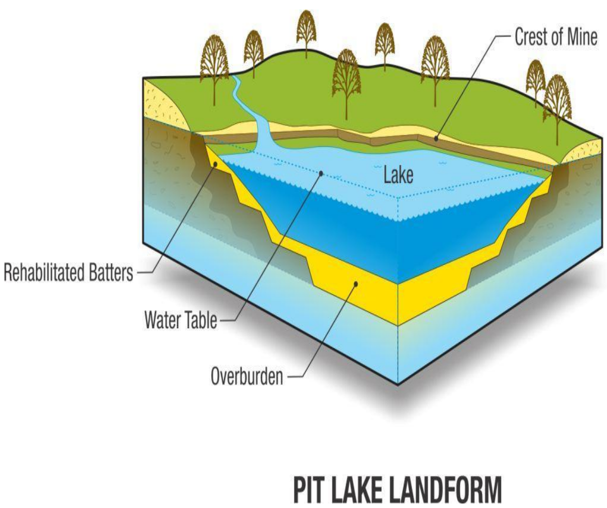


Figure 8-5: Conceptual representation of landform only[22]

This section assesses a Pit Lake landform at Hazelwood mine.

The current Work Plan for Hazelwood has an option of a pit water body. The way that the Work Plan is described (e.g. internally dumped ash and overburden and flood completed mine void), Jacobs' have assessed that the Work Plan is a hybrid of the Pit Lake landform and the Backfill below the Water Table landform (refer to section 8.5.2 for assessment of Partial Backfill below the Water Table option at Hazelwood).

Accordingly the risks described in this section should not be read as the risks of the current Work Plan, as elements are different (e.g. placement of overburden in mine areas and the eventual level of the water body at RL 8).

8.5.1.1 Risk Assessment

This section summarises the assessment of the fire, stability and environmental degradation risks associated with the Pit Lake landform option.

Fire Risks

The assessed level of fire risk for a Pit Lake landform is estimated to be low (refer to Appendix D3).

Table 8-26 - Residual fire risk ratings for Pit Lake Landform at Hazelwood

Impact Scenario	Residual Risk Rating
Ignition of exposed mine coal through spontaneous combustion of loose coal.	Low
External fire igniting coal seam	
Internal fire igniting coal seam	

A low residual fire risk for the Pit Lake landform at Hazelwood is primarily due to the inclusion of controls (refer Table 8-2) as follows:

- Water will cover a large part of the coal seams and prevent fire;
- Cover over coal will provide isolation from ignition for remaining areas;
- In the short term operational controls and suppression will be employed; and
- During progressive rehabilitation Jacobs' have assumed that some form of cover or fire control will be used on exposed areas that will eventually be under water.

It is estimated to implement the required fire risk controls over the short, medium and long term for the Pit Lake landform at Hazelwood could approximately cost $46m (refer Appendix E4 and E5).

In Jacobs' assessment it appears that the amount of short term cover used for control of fire is limited at Hazelwood and that during progressive rehabilitation allowance may need to be provided for more temporary or

[22] Image should not be interpreted as a representation of potential final landform at Hazelwood.

intermediate cover for fire control. Jacobs have been unable to determine whether there is sufficient material on site for this purpose due to time and resources constraints in this study. This should be assessed in the future.

Table 8-27 Estimated short, medium and long term costs ($m) to implement fire risk controls at Hazelwood for Pit Lake landform[23].

Risk Issue	Estimated Short Term Costs	Estimated Medium Term Costs	Estimated Long Term Costs	Estimated Total Costs
Fire Risk	$30.60m	$11.90m	$3.60m	$46.00m

Costs are reported in current dollars and have not been discounted. Costs are rounded to the nearest hundred thousand.

Landform Stability Risks

The assessed level of residual stability risk for a Pit Lake landform is estimated to be high (refer to Appendix D3).

Table 8-28: Residual landform stability risk ratings for Pit Lake landform at Hazelwood

Impact Scenario	Residual Risk Level
Multi-batter collapse	High
Single batter collapse	

For the Pit Lake landform the controlled repressurisation of groundwater to maintain weight balance in addition to overburden placement will be required. The Pit Lake landform retains a high risk rating due to:

- The presence of steep slopes and high walls in close proximity to township areas (e.g. Morwell) and key infrastructure (e.g. Princess Freeway). In the Pit Lake landform it is assumed that limited placement of additional fill material will be undertaken and that the majority of weight balance and slope control will come from water and slope angles. In certain key wall areas (such as close to the freeway) there is not a lot of room for changing slope angles without additional fill for buttressing;
- Constraints for slope angle change and uncertainty over the availability of material for slope control once fire risk has been dealt with;
- The highest residual risk is in the health and safety class[24] based on the proximity of key walls to Morwell and important infrastructure (e.g. freeway);
- Uncertainty about the final aquifer pressure and thus the resulting weight balance to be achieved by water level has also been identified. This risk may be reduced upon further analysis.

Groundwater

Water resource issues arise for the Pit Lake landform due to the volume of groundwater required to the fill the lake and therefore the potential limited availability of water for other users (refer to Appendix D3). The assessed levels of residual groundwater risks are high to critical.

Table 8-29: Residual groundwater risk ratings for Pit Lake landform

Impact Scenario	Residual Risk Level
Water contamination	High
Limitation of groundwater availability to other users	Critical

[23] Short term costs have been difficult to estimate as the degree of progressive rehabilitation to date was not able to be determined in detail in the time available. Also, there is an expectation that the short term costs are generally incorporated in operational costs, thus are difficult to separate out from overall mining costs.

[24] Class refer to a risk consequence rating. Risk consequences can be found in Appendix A.

With high evaporations rates in the Latrobe Valley maintenance of the water level will require both passive and active 'topping up' of the lake level from sources other than natural groundwater recovery. The Pit Lake landform as envisioned in this option has a very large volume and is likely to require a large volume of water to fill and maintain.

Facilitating the Pit Lake landform as a groundwater sink may lead to a concentration of contaminants and salts. Over time this may reduce lake water quality. Controls for the water recycling and possible treatment of lake water will be essential.

Groundwater risks remained high - critical due to:

- A large body of water in direct connection with upper and middle aquifers and close to lower aquifers;
- Potential for exchange of water between the aquifer and the Pit Lake landform with possibility of cross flow between aquifers that are exposed in the wall of the Pit Lake;
- Limited control of the exchange of water between the shallow aquifer and the Pit Lake in the vicinity of the Morwell river giving potential for modification of base flow quality and;
- Critical risk of reduced availability of groundwater has been assessed as due to potential constraints imposed by direct connection between surface water and groundwater with a high level Pit Lake and the likely evaporation from the lake surface. Future analysis of the requirement for pumping from deeper aquifer and the eventual level of pressure control may reduce the risks in this area.

Surface water

Water resource issues arise for the Pit Lake due to the high volume of surface water required to the fill the lake and therefore the limited availability of the water for other users (refer to Appendix D3). Surface water risks for the Pit Lake are assessed as high and critical.

Table 8-30: Residual surface water risk ratings for Pit Lake landform

Impact Scenario	Residual Risk Level
Surface water (off site) affected by discharge from the pit lake.	High
Reduced water quantity in surrounding watercourses	Critical

Management of water quality and thus of any discharge waters and the provision of make-up water to maintain the lake level are important key controls for management of surface water risk. For the Pit Lake landform the key aspects that underpin the residual risk assessment are:

- Potential for a large lake to concentrate contaminants from a variety of sources;
- Concern for the environmental impact of the long term water quality;
- As water would provide the bulk of weight balance for underlying aquifer pressures there would be an imperative to maintain Pit Lake level even in times of low catchment water availability, which is likely to see the Pit Lake as a competitor for other users; and
- The Pit Lake may not result in the freeing up of any entitlement back to the catchment in the long term.

8.5.1.2 Ensure Progressive Rehabilitation

If the Pit Lake landform was selected as the final landform there are no significant barriers to undertaking actions at Hazelwood in the short term as part of a progressive rehabilitation strategy. Jacobs have identified that in the short term it is likely that effort is required to provide temporary or medium term cover over coal seams before the Pit Lake would reach its eventual level (in the long term). This study has not had the time or resources to resolve the detailed status of current progressive rehabilitation at Hazelwood (both Yallourn and Hazelwood are internal dumping and Loy Yang plan to commence in 2017-2018) but there are indications in the background documents that suggest that this will cover part of the coal and further effort is required to provide the suggested level of cover in the short term.

8.5.1.3 Estimated Costs

Table 8-31 summarises the estimated short, medium and long term costs to implement the Pit Lake landform in a manner that would achieve the residual risk ratings (refer to Appendix E4 and E5)[25].

Table 8-31 – Estimated implementation costs ($m) for Pit Lake landform

Risk Issue	Estimated Short Term Costs	Estimated Medium Term Costs	Estimated Long Term Costs	Estimated Total Costs
Landform Stability	$1.00m	$35.00m	$3.60m	$39.40m
Groundwater	No costs incurred	$13.90m	$3.60m	$17.40m
Surface water	No costs incurred	$22.50m	$1.20m	$23.60m
Biodiversity	No costs incurred	$4.80m	No costs incurred	$4.80m
Fire Risk	$30.60m	$11.90m	$3.60m	$46.00m

Costs are reported in current dollars and have not been discounted. Costs are rounded to the nearest hundred thousand.

Achieving landform stability and addressing fire risk carry the greatest cost due to haulage and placement of overburden.

Significant costs noted for this landform include:

- The potential importing of materials to reshape external pit areas to minimise the pit lake catchment area and created a controlled water management zone with low residual impact on surrounding catchments;
- Construction of bunding and levees to divert run-on away from pit lake catchment area to minimise erosion to rehabilitated areas external to pit; and
- Likely requirement to maintain water quality through active treatment of pit lake water.

Limitations

In regards to Hazelwood and a Pit Lake landform the key limitations on the accuracy of the estimated costs are:

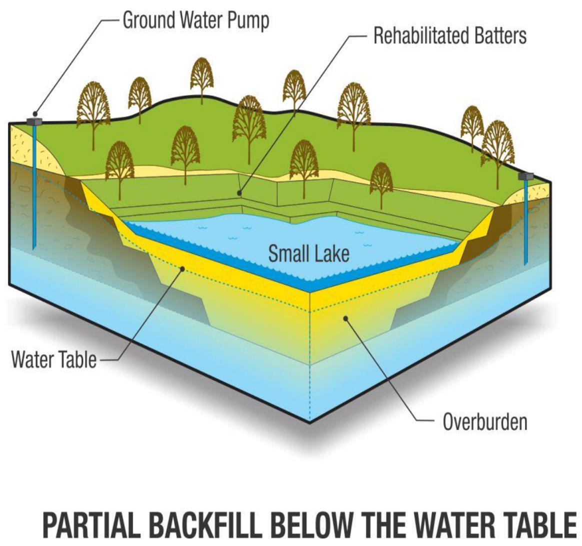
- In the time available Jacobs' were not able to develop a detailed understanding of the extent of progressive rehabilitation and how this affected the quantities in the short and medium term;
- The cost share between operations and rehabilitation in the short term cannot be distinguished based on information available to Jacobs and;
- The volume of cover for fire control is strongly related to the assumed thickness of cover. Costs are proportional to the volume.

8.5.1.4 Impact of the option on current rehabilitation plans for each mine

Hazelwood's current Work Plan proposes a long term landform of a flooded mine void. Based on expected final pit lake water levels (RL 8) this landform is assumed to be most similar to a Partial Backfill below the Water Table landform. Thus it is not anticipated that there is any major disagreement or conflict between this landform and current mine plan. As described above, the current mine plan outlines a conceptual approach to progressive rehabilitation and the assessment in this report has identified areas of detail, that it is possible were anticipated for the mine, but were not clearly identifiable in the material available to Jacobs.

[25] General assumptions and clarification regarding estimated costs are presented in Section 8.2.4. Specific assumptions for the Pit Lake Option at Hazelwood presented within the relevant cost schedule (see Appendix E4 and E5).

8.5.2 Assessment of Partial Backfill below the Water Table landform



This section assesses the Partial Backfill below the Water Table landform at Hazelwood mine. Jacobs' have assessed this option most closely matches the planned final landform described in Hazelwood's Work Plan (e.g. internally dumped ash and overburden and flood completed mine void).

Figure 8-6: Conceptual representation of landform only[26]

8.5.2.1 Risk Assessments

This section summarises the assessment of the fire, stability and environmental degradation risks associated with the Partial Backfill below the Water Table landform.

Fire Risks

Jacobs' saw a need to cover exposed coal to reduce the fire risk in the final mine voids. Effective use of fire risk controls (refer **Table 8-2**) for the Partial Backfill below the Water Table landform option was assessed as sufficient to achieve a low residual fire risk at Hazelwood. This involves the use of cover (from overburden and mine waste) to ensure that all coal seam areas have an appropriate depth of cover. The exact depth required is not clear from the material available to Jacobs and we have assumed the 2m of cover will provide appropriate long term control (refer Appendix D4).

[26] Image should not be interpreted as a representation of final landform at Hazelwood.

Table 8-32: Residual fire risk ratings for Partial Backfill below the Water Table landform

Impact Scenario	Residual Risk Level
Ignition of exposed mine coal through spontaneous combustion of loose coal.	Low
External fire igniting coal seam	
Internal fire igniting coal seam	

A low residual fire risk is primarily due to:

- Water will eventually cover a large part of the coal seams and prevent fire; and
- Cover over coal in the short to medium term will provide isolation from ignition for remaining areas; and,
- In the short term use of operational controls and suppression activities to control fire risk on working areas.

It is estimated to implement the required fire risk controls over the short, medium and long term for the Partial Backfill below the Water Table landform at Hazelwood could cost approximately $46m (refer to Appendix E4 and E6).

Table 8-33 Estimated short, medium and long term costs ($m) to implement standard fire risk controls at Hazelwood for Partial Backfill below the Water Table landform[27]

Risk Issue	Estimated Short Term Costs	Estimated Medium Term Costs	Estimated Long Term Costs	Estimated Total Costs
Fire Risk	$30.60m	$11.90m	$3.60m	$46.00m

Costs are reported in current dollars and have not been discounted. Costs are rounded to the nearest hundred thousand.

Landform Stability Risks

Landform stability risks for the Partial Backfill below the Water Table landform at Hazelwood were assessed as low to moderate (refer to Appendix D4). Uses of the standard landform stability risk controls (refer **Table 8-3**) were deemed sufficient.

Table 8-34: Residual landform stability risk ratings for Partial Backfill below the Water Table landform

Impact Scenario	Residual Risk Level
Multi-batter collapse	Low
Single batter collapse	Moderate

The following factors contributed to the low to moderate residual risk rating:

- Progressive rehabilitation and placement of fill provides stability for the walls in most locations;
- Water provides weight and stability for many areas on top of the fill;
- Only limited areas of upper batters remain above water level. Given the proximity to sensitive features and infrastructure (Princess Freeway and Morwell Township) the risk of a batter collapse in the upper parts of the wall is classed as moderate. The Western walls nearest the Morwell River and the northern wall near the Princess Freeway and Morwell township are considered to be focus areas. Not all walls or areas will be moderate risk;
- Moderate risk rating is based the technical (e.g. engineering design) uncertainty regarding availability of sufficient material at Hazelwood. Based on available documentation is it unclear in the time available to this

[27] Short term costs have been difficult to estimate as the degree of progressive rehabilitation to date was not able to be determined in detail within the time available. Also, there is an expectation that the short term costs are generally incorporated in operational costs, thus are difficult to separate out from overall mining costs.

study as to whether there is sufficient material available in all cases to achieve the Partial Backfill below the Water Table landform with cover of coal. Further analysis and investigation is required to better understand important issues such as material volume, ability to reshape tightly constrained walls and high underlying aquifer pressures.

Groundwater Risks

Residual risks to groundwater for the Partial Backfill below the Water Table at Hazelwood were assessed as moderate (refer Appendix D4). Uses of standard groundwater risk controls (refer Table 8-4) were deemed as being sufficient.

The key difference between Partial Backfill below the Water Table landform and Pit Lake landform is the volume of water that is required and the ability for fill to provide separation from the deeper aquifers and the pit water body. Lower final water level means that there is potentially more exposed coal seams that will require cover. Also, the volume of make-up water required to maintain the water body is expected to be greater for a larger lake.

Table 8-35: Residual groundwater risk ratings for Partial Backfill below the Water Table landform

Impact Scenario	Residual Risk Level
Water contamination (reflects both surface water and groundwater)	Moderate
Limitation of groundwater availability to other users	

Groundwater risks were assessed as moderate due to:

- Potential for direct connection between the shallow and intermediate aquifers and the pit water body, as well as relatively close distance between the base of the mining area and the deep aquifers;
- Close relationship to Morwell River, the wetland north west of the mine and the Main Drain on the northern edge of the mine around the edge of the mining area;
- Uncertainty about the need for and methods of control of water quality; and
- Likely moderate to high volume of ongoing groundwater pumping will be needed to maintain the pit water body and potentially provide dewatering and pressure reduction in key areas of the void. The eventual recovered groundwater level is not clear and thus the targets for control are not clear.

Surface Water Risks

Standard controls were sufficient to achieve a low risk rating for the risk of reduced water quantity in surrounding watercourses (refer to Appendix D4). Standard controls (refer **Table 8-5**) were assessed as sufficient to achieve a moderate residual risk rating in regards to off mine site surface water being affected by discharges from the pit water body.

Table 8-36: Residual surface water risk ratings for Partial Backfill below the Water Table at Hazelwood

Impact Scenario	Residual Risk Level
Surface water (off site) affected by discharge from the pit lake.	Moderate
Reduced water quantity in surrounding watercourses	Low

Residual risks were assessed as low to moderate due to:

- Risk of surface water (off-site) affected by discharge from the pit water body is likely to be able to be effectively treated by lake level management and control of inflows and freeboard, but the size of the lake and the proximity to surface water (Morwell River and the wetlands provides additional risks that may be less easy to mitigate) and;

- Reduced water quantity in surrounding watercourses is effectively treated by water quality management techniques. Given the size of the pit water body and the requirement for top up water it is likely that a reasonable amount of the existing entitlement may be required in the long term.

8.5.2.2 Ensure Progressive Rehabilitation

Partial Backfill below the Water Table landform most closely resembles Hazelwood's current mine plan. Some change would be needed to achieve this option compared with the current plan. If Hazelwood Mine was to seek to implement a Partial Backfill below the Water Table Landform option some operational changes to their current progressive rehabilitation plan would need to be made. For example planning for complete cover of all coal seams and areas, continued buttressing of walls and slopes that are close to high value assets (e.g. Princess Freeway and Morwell township) and are regarded to be a high risk, implementation of water quality management actions and options to control the pit water body water quality to within acceptable bounds (which are as yet not defined).

In addition the definition of and securing of long term water supply sources would need to be achieved. It is also not clear to Jacobs in the time and resources available for this study as to whether there is sufficient material available on site and nearby to achieve both fire risk control cover and weight balance for partial fill. A material balance to confirm the availability of material would help to make this assessment.

Partial Backfill below the Water Table Landform presents some physical or technical impediments that could prevent progressive rehabilitation actions in the short-term. This option is the closest match to the current Work Plan.

8.5.2.3 Estimated Implementation Costs

Table 8-37 summarises the estimated short, medium and long term costs to implement the Partial Backfill below the Water Table in a manner that would achieve the residual risk ratings (Appendix E4 and E6).

Table 8-37 – Estimated implementation costs ($m) for Partial Backfill below the Water Table landform[28]

Risk Issue	Estimated Short Term Costs	Estimated Medium Term Costs	Estimated Long Term Costs	Estimated Total Costs
Landform Stability	$4.10m	$35.00m	$3.60m	$42.60m
Groundwater	No costs incurred	$13.90m	$3.60m	$17.40m
Surface water	No costs incurred	$22.50m	$1.20m	$23.60m
Biodiversity	No costs incurred	$4.80m	No costs incurred	$4.80m
Fire Risk	$30.60m	$11.90m	$3.60m	$46.00m

Costs are reported in current dollars and have not been discounted. Costs are rounded to the nearest hundred thousand.

Significant costs noted for this landform include:

- The potential importing of materials to reshape external pit areas to minimise the pit lake catchment area and created a controlled water management zone with low residual impact on surrounding catchments;
- Construction of bunding and levees to divert run-on away from pit lake catchment area to minimise erosion to rehabilitated areas and batters and;
- Likely requirement to maintain water quality through active treatment of pit lake water.

Limitations

In regards to Hazelwood and a Partial Backfill below the Water Table landform the key limitations on the accuracy of the estimated costs are:

[28] General assumptions and clarification regarding estimated costs are presented in Section 8.2.4. Specific assumptions for the Partial Backfill Below the Water Table Level Option at Hazelwood are presented within the relevant cost schedule (see Appendix E4 and E6).

- The detail of progress with progressive rehabilitation and the effect that this has on quantities of material to move;
- The ability of operations to achieve cover of coal for fire risk reduction during mining operations; and
- The requirement for and nature of water quality management system(s).

8.5.2.4 Impact of the option on current Work Plan

Table 8-38 lists risk controls identified during the current study which may require consideration to achieve a Partial Backfill below the Water Table landform and which are beyond the risk controls identified within the current Hazelwood Work Plan. The current mine plan outlines a conceptual approach to progressive rehabilitation and the assessment in this report has identified areas of detail, that it is possible were anticipated for the mine, but were not clearly identifiable in the material available to Jacobs (refer Appendix F4).

Table 8-38: Risk controls identified as required for a Partial Backfill below the Water Table landform by the study and not identified in Hazelwood's current Work Plan

Risk Issue	Additional Risk Controls
Landform Stability	Detailed design of slopes to suitable long term safe aspect.
	Potential for additional buttressing of selected high risk batters prior to pit filling, including the definition of regional risk areas for focus of this activity.
	Determine the need to source additional overburden, inter-seam and fill materials off site from other mine sites if onsite material is not sufficient.
Groundwater	Diversion of the shallow groundwater or surface water prior to entering the pit, and treatment of it to maintain pit water body quality in the long term.
	Treatment of water either prior to entering pit or any acidic water generated within the pit.
	Maintain appropriate salinity of the pit water body for end land use.
	Treatment of the pit lake water to maintain appropriate water quality.
	Appropriate allocations maintained for groundwater post pit filling (this issue is identified in Work Plan documents but does not appear to have been resolved).
	Ensure that fundamental design parameters involving other water elements are robust enough to cope with variability/ changes.
Surface Water	Maintenance of good water quality in the pit water body for discharge or other management as required.
	Maintenance of good surface water quality in the pit water for land uses.
	Design of surface water management facilities around the pit which drain away from pit and/or allow for the management of controlled inflow to the pit in a managed way.
	Bunding around pit and running pit with freeboard to enable managed inflow and potential capacity for flood events.
	Appropriate allocations maintained for surface water post pit filling.
	Ensure that fundamental design parameters involving other water elements are robust enough to cope with variability/ changes.
	Minimise the area that is lost to the surrounding catchments, (e.g. external areas surrounding pit reshaped to minimise lake catchment). Create a controlled system.
	Use material for reshaping the pit water body edge and shoreline for the waterbody.
Fire	Coal face must be covered or capped to prevent exposure.
	Programmed maintenance of the cover/ capping, including: monitoring, top up of the cover.

Risk Issue	Additional Risk Controls
	Use of appropriate species for vegetation to prevent breach of the cover.
	Erosion prevention to avoid cover breach.
	Include (and maintain) fire breaks in revegetation design.
	Rate of filling pit will need to balance water availability with potential coal seam exposure.
	Maintenance of water level using controlled surface water addition.

8.5.3 Summary Evaluation of Potential Viable Options for Hazelwood

8.5.3.1 Risk Assessment

Table 8-39 Pit Lake landform is unlikely to achieve overall acceptable residual risk with critical and high residual risks associated with landform stability, groundwater and surface water, based on the information and resources available for this assessment. It is possible that further analysis could reduce the identified risks.

Table 8-39: Comparison of risk assessment – Pit Lake and Partial Backfill below the Water Table

Risk Issue	Impact Scenario	Residual Risk	
		Pit Lake	Partial Backfill below the Water Table
Fire	Ignition of exposed mine coal through spontaneous combustion of loose coal.	Low	
	External fire igniting coal seam		
	Internal fire igniting coal seam		
Landform stability	Multi-batter collapse	High	Low
	Single batter collapse		Moderate
Groundwater	Water contamination	High	Moderate
	Limitation of groundwater availability to other users	Critical	
Surface water	Surface water (off site) affected by discharge from the pit lake.	High	Moderate
	Reduced water quantity in surrounding watercourses	Critical	Low

As part of the risk assessment there was a perceived lack of material and water to achieve mine weight balance therefore of the two viable final landform options assessed for the Hazelwood Mine, Partial Back Fill below the Water Table landform is most likely to achieve an acceptable level of residual risk across all identified risk issues.

Those controls with a high degree of uncertainty for the Pit Lake and Partial Backfill below the Water Table landforms were observed to be primarily associated with achievement of weight balance to address landform stability risk and management of pit water level to address overall water risk. Specifically it was considered that a high level of uncertainty existed regarding the volumes and availability of overburden and water to achieve weight balance. In part this uncertainty is due to this study not being able to undertake a detailed assessment of the progressive rehabilitation to date and undertake a comprehensive material balance for the void and landform options.

Given the expected size of the final Hazelwood Mine void it is considered that volumes of both overburden and water required to achieve weight balance and final landform for the Pit Lake landform will be challenging and presents a risk to achieving the final landform.

Fire Risk

The control of fire risk is primarily driven by either water saturation or placement of cover over exposed coal seams to create an anaerobic environment with secondary controls focusing on the maintenance and integrity of the primary control. The residual risk for fire management was considered low across both viable landforms due to the stringent controls assumed for fire management.

For Hazelwood costs for fire risk are generally the same however a more detailed analysis of the volume of cover required and the appropriate depth of cover is needed. Also, assessment of progressive rehabilitation to date and restrictions posed by mine infrastructure are needed to assess the relative difficulty and implementation timing of these controls.

Landform Stability

Landform instability and water impact risks are the key areas of difference between the Partial Backfill below the Water Table and the Pit Lake landforms.

The Pit Lake landform is considered high risk on the basis of public safety concerns. While the likelihood of failure of the batters is considered low, the consequence for public safety should anyone be in the vicinity of the pit at the time of collapse is significant.

The potential for public access to the Pit Lake is higher than for the Partial Backfill below the Water Table landform due to the nature of the shaping of each landform to accommodate stability. There are likely to be constraints on the extent of shaping in some sectors of the mine due to proximity to the lease boundary and key external infrastructure.

The Partial Backfill below the Water Table landform is able to achieve a low instability risk rating as it has been assumed that public access to the pit site will be limited by the shape and form of the batters that sit above the water line, which will be developed as part of the process of providing fill and shape for the landform. These outcomes are in part dependent on the eventual land use and access that is expected for the previously mined area.

Groundwater

The key control is maintenance of the pit body water level above the level required for weight balance and below the natural groundwater table thereby limiting the flow of water from the pit into adjacent groundwater aquifers. With high evaporations rates in the Latrobe Valley maintenance of the water level will require both passive and active ‘topping up’ of the lake level from sources other than natural groundwater recovery.

For Partial Backfill below the Water Table landform and Pit Lake landform the controlled repressurisation of groundwater, especially in the deeper Traralgon Formation aquifer to maintain weight balance in addition to overburden placement will be required. There is uncertainty in the likely final recovered level of groundwater in the different aquifer layers, which in turn feeds uncertainty in the final landform. This expresses as environmental risk in this assessment. Further analysis of groundwater levels and trends may enable the reduction of this risk with better quantification of the issues.

Recycling and possible treatment of pit water body quality will be required to achieve as low as reasonably practicable risk.

While less water is required for the Partial Backfill below the Water Table landform, it still represents a moderate risk to the availability of water for other uses.

8.5.3.2 Estimated Cost

A comparison of estimated total costs between the two viable mine rehabilitation options at Hazelwood is presented in **Table 8-40**. Achieving landform stability and addressing fire risk carry the greatest cost due to the haulage and placement of overburden or capping materials.

Similarities in costs may be attributed to the assumption that bulk civil works (e.g. slope battering, overburden placement and backfilling) are to be undertaken during operations and are subsequently excluded from costs. Increased costs associated with management of landform stability for the Partial Backfill below the Water Table landform are associated with additional reshaping of overburden placed during operations as part of the pit backfill.

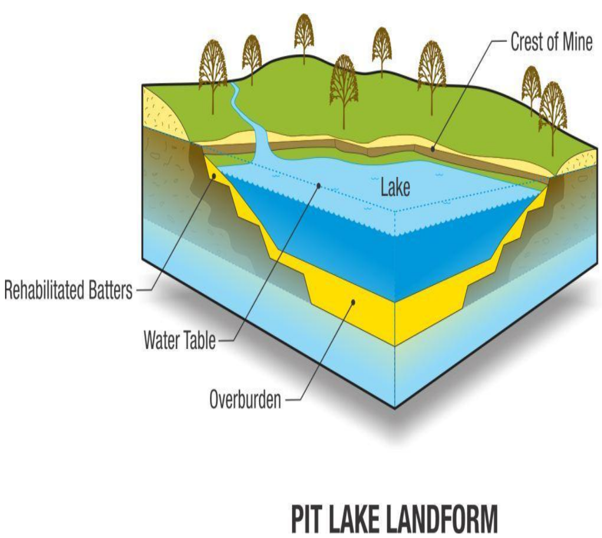
Table 8-40 Comparison of Estimated Cost – Hazelwood

Risk Issue	Pit Lake Landform Estimated Total Cost	Partial Backfill BWT Landform Estimated Total Cost
Landform Stability	$39.40m	$42.60m
Groundwater	$17.40m	$17.40m
Surface water	$23.60m	$23.60m
Biodiversity	$4.80m	$4.80m
Fire Risk	$46.00m	$46.00m

Costs are reported in current dollars and have not been discounted. Costs are rounded to the nearest hundred thousand.

8.6 Loy Yang Mine

8.6.1 Assessment of Pit Lake Landform Option



This section assesses the Pit Lake landform for Loy Yang. The Pit Lake landform is not the closest match to the current Loy Yang Work Plan (nor the proposed revised Work Plan).

Loy Yang's current Work Plan proposes a long term landform of a mined void partially water-filled and lowered landform. Based on expected backfill levels and final pit lake water levels this landform is assumed to equate to a Partial Backfill below the Water Table landform (refer to section 8.7.2).

The revised Work Plan for Loy Yang describes the end use concept as "partially flood the final open cut to form a lake". This lake is likely to be at a low level in the open pit, perhaps at around RL0.

Figure 8-7: Conceptual representation of landform only

8.6.1.1 Risk Assessments

This section summarises the assessment of the fire, stability and environmental degradation risks associated with the Pit Lake landform.

Fire Risks

Uses of fire risk controls (refer section 8.2.1) were deemed sufficient to achieve a low residual risk rating (refer to Appendix D5).

Table 8-41: Residual fire risk ratings for Pit Lake landform

Impact Scenario	Residual Risk Level
Ignition of exposed mine coal through spontaneous combustion of loose coal.	Low
External fire igniting coal seam	
Internal fire igniting coal seam	

A low residual fire risk is primarily due to the inclusion of controls as follows:

- Cover over coal (internal dumping) will provide isolation from ignition for the coal in the western part of the mine progressing into the eastern part) and the remaining areas, including the tall northern wall area;
- Water will cover a part of the coal seams and prevent fire, especially on the eastern side of the mine where the lake will be deeper as to replace the lack of internal dumping; and
- During progressive rehabilitation Jacobs' have assumed that some form of cover or fire control will be used on exposed areas that will eventually be under water (instituted during progressive rehabilitation);

It is estimated to implement the required fire risk controls over the short, medium and long term for the Pit Lake landform at Loy Yang could cost approximately $60m (refer to Appendix E7 and E8).

At Loy Yang there is a planned large extension of the mined area and much of the progressive rehabilitation that needs to be considered is planned for the future (this is a key difference between Loy Yang and Yallourn mine). As a result there is still reasonable scope for planning for fire controls.

Table 8-42: Estimated short, medium and long term costs ($m) to implement standard fire risk controls for Pit Lake landform[29].

Risk Issue	Estimated Short Term Costs	Estimated Medium Term Costs	Estimated Long Term Costs	Estimated Total Costs
Fire Risk	$43.10m	$13.40m	$3.20m	$59.60m

Costs are reported in current dollars and have not been discounted. Costs are rounded to the nearest hundred thousand.

Landform Stability

The residual risk of landform stability was assessed as high (refer to Appendix D5). This risk was assessed in terms of health as safety. The reason that the risk is high is that, over the long term there remains a small likelihood that slope failure could result in injury and as the consequence is large, this results in a high residual risk. One aspect of this, that is especially pertinent for Loy Yang, is that risk assessment parameters are well defined for operational phases but not as well-defined for the long term for these sites and in this environment.

Table 8-43: Residual landform stability risk ratings for Pit Late Landform at Loy Yang

Impact Scenario	Residual Risk Level
Multi-batter collapse	High
Single batter collapse	

For the Pit Lake landform the controlled repressurisation of groundwater to maintain weight balance in addition to overburden placement in the base of the pit will be required. It is unlikely that water alone will provide sufficient weight to balance aquifer pressures in Loy Yang in the long term. The Pit Lake landform retains a high risk rating due to:

[29] Short term costs have been difficult to estimate as the degree of progressive rehabilitation to date was not able to be determined in detail within the time available. Also, there is an expectation that the short term costs are generally incorporated in operational costs, thus are difficult to separate out from overall mining costs.

- The presence of steep slopes and high walls in proximity to key infrastructure (e.g. the railway line and potential Princess Freeway Traralgon Bypass). In the Pit Lake landform it is assumed that limited placement of additional fill material will be undertaken and that the majority of weight balance and slope control will come from water and slope angles, with fill only being used to make the difference. In certain key wall areas (e.g. northern batters) there is not a lot of room for changing slope angles without additional fill for buttressing, however this can be complimented by the effective use of future internal dumping in strategic areas;
- Constraints for slope angle change (on the north in particular) and uncertainty over the availability of material for slope control once fire risk has been dealt with;
- The highest residual risk is in the health and safety class based on the proximity of key (high) walls to infrastructure (e.g. future Princess freeway – Traralgon Bypass); and
- Uncertainty about the final aquifer pressure and thus the resulting weight balance to be achieved by water level has also been identified. This risk may be reduced upon further analysis and understanding of groundwater pressures.

Groundwater

The residual risk to groundwater for the Pit Lake landform is assessed as high for contamination and critical for availability to other users (refer to Appendix D5).

Table 8-44: Residual groundwater risk ratings for Pit Lake landform

Impact Scenario	Residual Risk Level
Water contamination (reflects both surface water and groundwater)	High
Limitation of groundwater availability to other users	Critical

The main reasons for this risk assessment are:

- A Pit Lake landform would have a wide and deep water body that would potentially allow for connection between multiple aquifer layers, including potential for discharge from the deeper Traralgon Formation aquifer;
- The Pit Lake landform would have a very large area of lake that would be subject to a large amount of water loss from evaporation. These losses are most likely to be made up from groundwater and, if available, surface water. The water and salute balance is thus likely to be difficult to manage and control and there is a high risk of the lake increasing in concentration of solutes over time. If management of this includes discharge to the catchment this presents a risk to surrounding surface water;
- As a result of the shape of the mined void, the water level for a Pit Lake is likely to be at least tens of meters below the upper most batter level. The final lake level will not likely to be able to gravity outfall or flush without pumping and so if outfall is required to maintain water quality this will likely need to be provided by mechanical means. As a terminal lake system water quality management is likely to require effort in the long term. Our assessment is that there is very little detail on water quality management requirements and this uncertainty leads to an assessed high risk; and
- To provide for weight balance and to feed make-up water to the Pit Lake we have assessed that it is likely that ongoing groundwater pumping would be required. In addition, due to the likely level of the Pit Lake groundwater inflow from upper and middle aquifer units is also likely. This is expected to have a long term influence on the availability of groundwater in the immediate area. This has been assessed as critical because Jacob's have assessed that long term provision of water allocation for this purpose has not yet been secured.

Surface water

Surface water residual risks are assessed as high (refer to Appendix D5) for off-site discharge and critical for water quantity.

Table 8-45: Residual surface water risk ratings for Pit Lake landform

Impact Scenario	Residual Risk Level
Surface water (off site) affected by discharge from the pit lake.	High
Reduced water quantity in surrounding watercourses	Critical

The main reasons for this risk assessment are similar to those provided in the groundwater section above:

- A Pit Lake in Loy Yang mine would cover a very large area and would be subject to high evaporation losses and thus potentially concentrate solutes within the water body;
- Management of water quality has not been described in detail in material available to Jacobs and so Jacobs' have identified a risk that discharge from the Pit Lake will be required in the long term to manage water quality and this presents a risk to the surround surface water systems;
- The likely final level of the Pit Lake has been assessed as well below the upper levels of the mine and so pumping is likely to be required to achieve flushing; and
- Top up water from surface water is likely to be required to manage water level and water quality and Jacobs' have assessed that long term allocation for this has not yet been provided.

8.6.1.2 Ensure Progressive Rehabilitation

If the Pit Lake landform was selected as the final landform there are no significant barriers to undertaking actions in the short term as part of a progressive rehabilitation strategy. Jacobs have identified that in the short term it is likely that effort is required to provide temporary or medium term cover over coal seams before the Pit Lake would reach its eventual level (in the long term).

This study has not had the time or resources to resolve the detailed status of current progressive rehabilitation to compare this risk control. Loy Yang has plans for significant further expansion (as part of the mine plan) and this expansion is away from the already mined areas. This provides scope for progressive rehabilitation and cover. Jacobs' assessment is that progressive rehabilitation has and is occurring at Loy Yang. Jacobs' note in particular that the proposed revision to the mine plan that is being prepared is expected to address progressive rehabilitation plans.

8.6.1.3 Estimated Implementation Costs

Table 8-46 summarises the estimated short, medium and long term costs to implement the Pit Lake landform in a manner that would achieve the residual risk ratings (refer to Appendix E7 and E8).

Table 8-46: Estimated implementation costs ($m) for Pit Lake landform[30]

Risk Issue	Estimated Short Term Costs	Estimated Medium Term Costs	Estimated Long Term Costs	Estimated Total Costs
Landform Stability	$0.50m	$29.80m	$3.60m	$33.70m
Groundwater	No costs incurred	$13.70m	$3.60m	$17.20m
Surface water	No costs incurred	$10.70m	$1.20m	$11.90m
Biodiversity	No costs incurred	$4.20m	No costs incurred	$4.20m
Fire Risk	$43.10m	$13.40m	$3.20m	$59.60m

Costs are reported in current dollars and have not been discounted. Costs are rounded to the nearest hundred thousand.

Significant costs noted for this landform include:

[30] General assumptions and clarification regarding estimated costs are presented in Section 8.2.4. Specific assumptions for the Pit Lake landform at Loy Yang are presented within the relevant cost schedule (see Appendix E7 and E8).

- The potential importing of materials to reshape external pit areas to minimise the pit lake catchment area and created a controlled water management zone with low residual impact on surrounding catchments;
- Construction of bunding and levees to divert run-on away from pit lake catchment area to minimise erosion to rehabilitated areas external to pit; and
- Likely requirement to maintain water quality through active treatment of pit lake water.

Limitations

In regards to Loy Yang and a Pit Lake landform the key limitations on the accuracy of the estimated costs are:

- In the time available Jacobs' were not able to develop a detailed understanding of the extent of progressive rehabilitation and how this affected the quantities in the short and medium term;
- The cost share between operations and rehabilitation in the short term cannot be distinguished based on information available to Jacobs and;
- The volume of cover for fire control is strongly related to the assumed thickness of cover. Costs are proportional to the volume.

8.6.1.4 Impact of the option on current rehabilitation plans

Pit Lake landform is unlikely to be a barrier or present limitations on current rehabilitation plans. To achieve the pit lake a sizeable volume of water in addition to that identified would be required in the medium to long term. This is not incompatible with the current Work Plan but is not the proposed end point. It should be noted that the Pit Lake landform is not the closest match to Loy Yang's Work Plan (nor the proposed revised Work Plan).

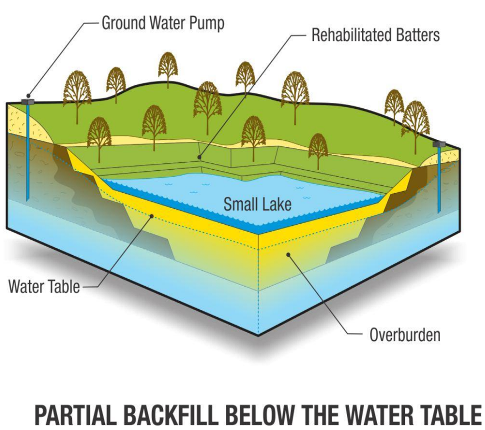
Loy Yang's current Work Plan proposes a long term landform of a flooded mine void. Based on expected backfill levels and final pit lake water levels this landform is assumed to equate to a Partial Backfill below the Water Table landform (refer to section 8.6.2). Table 8-47 identifies those controls identified during the current study which may require consideration to achieve a Pit Lake landform beyond the controls identified within the current Work Plan. For Loy Yang Mine there is a proposed Work Plan variation that adds considerable detail to the Work Plan over the current approved Work Plan. Many aspects of the Work Plan are identified in the proposed variation, including areas of research or study to inform the long term rehabilitation options. It is likely that elements of the following table are included or anticipated in the proposed Work Plan variation in some form. For clarity all of the elements are listed here (refer to Appendix F5).

Table 8-47: Risk controls identified as required for a Pit lake landform by the study and not identified in Loy Yang's current Work Plan

Risk Issue	Additional Risk Controls
Landform Stability	Design and construction of slopes to suitable long term safe gradient.
Groundwater	Diversion of shallow groundwater or surface water prior to entering the pit, and appropriate treatment of it in the medium and long term.
	Maintain appropriate lake salinity for end land use.
	Treatment of the Pit Lake water to maintain appropriate water quality.
	Appropriate allocations maintained for groundwater and surface water post pit filling, to maintain level.
	Ensure that fundamental design parameters involving other water elements are robust enough to cope with variability/ changes.
Surface Water	Maintenance of good water quality in the Pit Lake.
	Maintenance of good surface water quality in the Pit Lake for land uses.
	Design of surface water management facilities around the pit which drain away from pit.

Risk Issue	Additional Risk Controls
	Appropriate allocations maintained for surface water post pit filling (may be large volumes).
	Ensure that fundamental design parameters involving other water elements are robust enough to cope with variability/ changes.
	Minimise the area that is lost to the surrounding catchments (e.g. external areas surrounding pit reshaped rehabbed, to minimise lake catchment). Create a controlled system.
Fire	Coal face must be covered or capped to prevent exposure.
	Programmed maintenance of the cover/ capping, including: monitoring, top up of the cover.
	Use of appropriate species for vegetation to prevent breach of the cover.
	Erosion prevention to avoid cover breach.
	Include (and maintain) fire breaks in revegetation design.
	Maintenance of water level using controlled surface water addition.

8.6.2 Assessment of Partial Backfill below the Water Table Landform Option



The Partial Backfill below the Water Table landform in Jacobs' assessment is closest to Loy Yang's current Work Plan and the proposed Work Plan. This landform would provide the placement of cover and fill in the base of the mine void and over key batters. Given the shape of the mine void and the difference in slope between different segments of the mine, there will be a range of land and water features present in the landform.

For the purposes of the assessment it is expected that the Partial Backfill below the Water Table will have a water body feature that will not occupy the entire surface area of the mine. Areas of dry land and a smaller area water body are envisioned. Given the depth of the mine the water body is likely to be at a very low level (probably around RL 0).

Figure 8-8: Conceptual representation of landform[31]

8.6.2.1 Risk Assessments

This section summarises the assessment of the fire, stability and environmental degradation risks associated with the Partial Backfill below the Water Table landform.

Fire

The residual risk for fire has been assessed as low (refer to Appendix D6) through the application of the key control of cover over exposed coal seams and uses of complementary standard controls (refer **Table 8-2**).

[31] Conceptual representation should not be interpreted as final landform for Loy Yang.

Table 8-48: Residual fire risk ratings for Partial Backfill below the Water Table Landform at Loy Yang

Impact Scenario	Residual Risk Level
Ignition of exposed mine coal through spontaneous combustion of loose coal.	Low
External fire igniting coal seam	
Internal fire igniting coal seam	

The primary reasons for a low residual risk assessment are:

- It has been assumed that during ongoing operations that cover can be placed on all exposed coal seams (especially the wide southern batter coal seams);
- Water will eventually cover some the coal seams and prevent fire;
- Cover over coal in the short to medium term will provide isolation from ignition for remaining areas; and
- In the long term areas that are outside of the water body should be adequately covered.

It is estimated to implement the required fire risk controls over the short, medium and long term for the Partial Backfill below the Water Table landform at Loy Yang could cost approximately $60 (refer to Appendix E7 and E9).

Table 8-49: Estimated short, medium and long term costs ($M) to implement fire risk controls at for Partial Backfill below the Water Table[32]

Risk Issue	Estimated Short Term Costs	Estimated Medium Term Costs	Estimated Long Term Costs	Estimated Total Costs
Fire Risk	$43.10m	$13.40m	$3.20m	$59.60m

Costs are reported in current dollars and have not been discounted. Costs are rounded to the nearest hundred thousand.

Landform Stability

Residual risk for landform stability in the Partial Backfill below the Water Table landform has been assessed as low for multi-batter collapse and moderate for single batter collapse (refer to Appendix D6).

Table 8-50: Residual landform stability risk rating for Partial Backfill below the Water Table landform

Impact Scenario	Residual Risk Level
Multi-batter collapse	Low
Single batter collapse	Moderate

The primary reasons for this assessment are:

- The mine is ongoing and is able to provide stabilising cover and buttressing for the walls;
- Many of the walls are low slope and generally low risk of collapse as a result of the geology of the coal and sediments (this is a key difference to the Pit Lake landform option);
- Use of fill and cover provides the opportunity to stabilise and control overall stability so that multi-batter collapse is considered a low risk; and

[32] Short term costs have been difficult to estimate as the degree of progressive rehabilitation to date was not able to be determined in detail within the time available. Also, there is an expectation that the short term costs are generally incorporated in operational costs, thus are difficult to separate out from overall mining costs.

- Some individual batters that are at high elevations are considered to be at moderate risk in the long term as they are well above the general level of the lowered landform, are exposed to water and wind erosion. This is of particular issue in the northern wall.

Groundwater

Residual risk of groundwater contamination and impacts of groundwater availability are considered moderate (refer to Appendix D6).

Table 8-51: Residual groundwater risk rating for Partial Backfill below the Water Table landform

Impact Scenario	Residual Risk Level
Water contamination	Moderate
Limitation of groundwater availability to other users	

The primary reasons for this assessment are:

- This landform is likely to have a water body area that although large will not cover the full areas of the open void. Inflow of groundwater from upper and middle aquifers will be constrained by fill in some areas;
- The smaller water body (when compared with the Pit Lake landform) will have smaller losses and will have a lesser requirement for make-up water. Despite this the pit water body is planned to still be large and will need water to maintain the pit water body;
- Make up water will be required for the pit water body and some of this is assessed to be likely to come from groundwater; and
- Groundwater pumping to control aquifer back pressure is assessed as being likely to be less than for the Pit Lake landform.

Surface water

Residual risk for the Partial Backfill below the Water Table landform is assessed as moderate for off site discharge to surface water and low for impacts on surface water quantity (refer to Appendix D6).

Table 8-52: Residual surface water risk rating for Partial Backfill below the Water Table landform

Impact Scenario	Residual Risk Level
Surface water (off site) affected by discharge from the pit lake.	Moderate
Reduced water quantity in surrounding watercourses	Low

The primary reasons for this residual risk assessment are:

- Management of water quality in the long term has been assessed by Jacobs as likely to require some discharge from the water body. In the long term this may present a water quality risk to surrounding surface water depending on the effectiveness of water quality management in the pit water body over time; and
- Make up water to maintain the water body level is likely to require surface water for which a long term allocation has not been secured.

8.6.2.2 Ensure Progressive Rehabilitation

Jacobs has assessed that there are no apparent barriers to progressive rehabilitation inherent in the Partial Backfill below the Water Table landform at Loy Yang. This option is close in landform to that proposed in Loy Yang's current and revised Work Plans.

8.6.2.3 Estimated Implementation Costs

Table 8-53 summarises the estimated short, medium and long term costs to implement the Partial Backfill below the Water Table landform in a manner that would achieve the residual risk ratings (refer to Appendix E7 and E9)[33].

Table 8-53: Estimated implementation costs ($m) for Partial Backfill below the Water Table landform

Risk Issue	Estimated Short Term Costs	Estimated Medium Term Costs	Estimated Long Term Costs	Estimated Total Costs
Landform Stability	$2.70m	$29.80m	$3.60m	$36.00m
Groundwater	No costs incurred	$14.90m	$2.40m	$17.20m
Surface water	No costs incurred	$7.90m	$1.20m	$9.10m
Biodiversity	No costs incurred	$4.20m	No costs incurred	$4.20m
Fire Risk	$43.10m	$13.40m	$3.20m	$59.60m

Costs are reported in current dollars and have not been discounted. Costs are rounded to the nearest hundred thousand.

Significant costs noted for this landform include:

- The potential importing of materials to reshape external pit areas to minimise the pit lake catchment area and created a controlled water management zone with low residual impact on surrounding catchments;
- Construction of bunding and levees to divert run-on away from pit lake catchment area to minimise erosion to rehabilitated areas external to pit; and
- Likely requirement to maintain water quality through active treatment of pit lake water.

Limitations

In regards to Loy Yang and a Partial Backfill below the Water Table Landform the key limitations on the accuracy of the estimated costs are:

- In the time available Jacobs' were not able to develop a detailed understanding of the extent of progressive rehabilitation and how this affected the quantities in the short and medium term;
- The cost share between operations and rehabilitation in the short term cannot be distinguished based on information available to Jacobs and;
- The volume of cover for fire control is strongly related to the assumed thickness of cover. Costs are proportional to the volume.

8.6.2.4 Impact of the option on current rehabilitation plans

Loy Yang's current Work Plan proposes a long term landform of a partially flooded mine void at a low level. Based on expected backfill levels and final pit water body levels this landform is assumed to equate to a Partial Backfill below the Water Table landform. **Table 8-54** identifies those controls identified during the current study which may require consideration to achieve a Partial Backfill below the Water Table landform beyond the controls identified within the current Work Plan. For Loy Yang Mine there is a proposed Work Plan variation that adds considerable detail to the Work Plan over the current approved Work Plan.

Many aspects of the Work Plan are identified in the proposed variation, including areas of research or study to inform the long term rehabilitation options. It is likely that elements of the following table are included or anticipated in the proposed Work Plan variation. For clarity all of the elements are listed here (refer to Appendix F6).

[33] General assumptions and clarification regarding estimated costs are presented in Section 8.2.4. Specific assumptions for the Partial Backfill below the Water Table landform at Loy Yang are presented within the relevant cost schedule (see Appendix E7 and E9).

Table 8-54: Risk controls identified as required for a Partial Backfill below the Water Table landform by the study and not identified in Loy Yang's current Work Plan

Risk Issue	Additional Risk Controls
Landform Stability	Design and construction of slopes to suitable gradient
	Buttressing of selected high risk batters prior to pit filling.
Groundwater	Diversion of the shallow groundwater or surface water prior to entering the pit, and treatment of it.
	Treatment of water either prior to entering pit, or acidic water.
	Maintain appropriate salinity for end land use.
	Treatment of the pit lake water or restore and maintain appropriate water quality.
	Appropriate allocations maintained for groundwater post pit filling.
	Ensure that fundamental design parameters involving other water elements are robust enough to cope with variability/ changes.
Surface Water	Maintenance of good water quality in the pit lake for discharge.
	Maintenance of good surface water quality in the pit lake for land uses.
	Design of surface water management facilities around the pit which drain away from pit.
	Bunding around pit and running pit with freeboard.
	Management of excess water between available storage areas (e.g. other pits).
	Appropriate allocations maintained for surface water post pit filling.
	Ensure that fundamental design parameters involving other water elements are robust enough to cope with variability/ changes.
	Minimise the area that is lost to the surrounding catchments (e.g. external areas surrounding pit reshaped to minimise lake catchment). Create a controlled system.
	Source material for reshaping.
	Consider using natural soil improvement agents to improve the soil microbial condition and nutrient load.
Fire	Coal face must be covered or capped to prevent exposure.
	Programmed maintenance of the cover/ capping, including: monitoring, top up of the cover.
	Use of shallow rooted species for vegetation to prevent breach of the cover.
	Erosion prevention to avoid cover breach.
	Include (and maintain) fire breaks in revegetation design.
	Maintenance of water level using controlled surface water addition.

8.6.3 Summary Evaluation of potential viable landforms for Loy Yang Mine

Loy Yang mine is a very large mine and it is set well into the landscape. Geology and structure of the coal seams create significant differences in the slope and shape of different mine segments.

As a result the Pit Lake landform whilst potentially viable is not likely to be a target landform for Loy Yang. For example, given the height of the northern batters/wall area and compered with the broad expanse and low slope of the southern batters, a simple filling of the whole void area with water is not considered to be the most sensible target landform.

The proposed mine plan variation seeks to build an internal dump covering most of the base of the mine and then flood to a design level and reshape the coal batters above the water level to a safe and stable slope. The enormous southern batters will be much flatter and have high potential to be turned back to agriculture following suitable treatment for fire safety.

8.6.3.1 Risk Assessment

Of the assessed potential viable options, the Partial Backfill below the Water Table is the most likely to achieve an acceptable level of residual risk. The Partial Backfill below the Water Table landform had the lowest overall risk rating and no high or critical risks. The Pit Lake Landform is unlikely to achieve overall acceptable residual risk with critical and high residual risks associated with landform stability, groundwater and surface water.

Table 8-55: Risk assessment comparison – Pit Lake and Partial Backfill below the Water Table

Risk Issue	Impact Scenario	Residual Risk	
		Pit Lake	Partial Backfill below the Water Table
Fire	Ignition of exposed mine coal through spontaneous combustion of loose coal.	Low	
	External fire igniting coal seam		
	Internal fire igniting coal seam		
Landform stability	Multi-batter collapse	High	Low
	Single batter collapse		Moderate
Ground water	Water contamination	High	Moderate
	Limitation of groundwater availability to other users	Critical	
Surface water	Surface water (off site) affected by discharge from the pit lake.	High	Moderate
	Reduced water quantity in surrounding watercourses	Critical	Low

The uncertainty of controls with regard to technical practicality and achievability was also assessed for each landform. Those controls with a high degree of uncertainty for the Pit Lake and Partial Backfill below the Water Table were observed to be primarily associated with the achievement of weight balance to address landform stability risk and the management of pit water level to address groundwater risk and overall water quality risk.

Landform instability and water impact risks are the key areas of difference between the Partial Backfill below the Water Table and Pit Lake landform.

Fire Risks

The control of fire risk is primarily driven by either water saturation or placement of cover over exposed coal seams to create an anaerobic environment with secondary controls focusing on the maintenance and integrity of the primary control. The residual risk for fire management was considered low across both viable landforms due to the stringent controls assumed for fire management.

For Loy Yang costs for fire risk are generally the same however a more detailed analysis of the volume of cover required and the appropriate depth of cover is needed. Also, assessment of progressive rehabilitation to date and restrictions posed by mine infrastructure are needed to assess the relative difficulty and implementation timing of these controls.

Landform Stability Risks

The Pit Lake landform has been assessed, using the information available and in the constraints of this study as high residual risk on the basis of public safety concerns. While the likelihood of failure of the batters is considered small, the consequence for public safety should anyone be in the vicinity of the pit at the time of collapse is significant. The tall northern batters have the highest risk and this can be mitigated by the fact that half the batters are not excavated yet and can be profiled as the mine develops. . They also have the added security of the natural geology wedging in the coal and therefore strengthening the batter safety. That part of the northern and western batter that requires addition treatment can be improved by effective and strategic placement of future overburden to buttress the batter as necessary. The southern batters have a low risk as they will be mined to a relatively flat slope. The final eastern batters should be mined to a shape/profile to ensure their safety following batter shaping and cover for fire risk. This assessment is dependent on the eventual land use and public access.

The Partial Backfill below the Water Table landform is able to achieve a low instability risk rating as it has been assumed that the additional use of fill will provide a more stable environment than the Pit Lake alone and that as a result of the landform, public access to the pit site will be modified by the shape and form of the batters that sit above the water line. The final land use and access are key parts of this assessment and the risk would change if the assumptions about public access to the site in the long term were to change.

Achievement of sufficient weight within the final landform to counteract the inherent stability within coal seams and pit floor is an important issue for both landforms. The relative use of backfill and water to achieve weight balance and stability is the key difference in identified controls between the landform options. Loy Yang has identified the critical nature of achieving weight balance and understanding the parameters that impact the outcome and have commenced study into this area.

Determination of appropriate slopes to achieve the required factor of safety and management of run off on upper batter slopes above the final backfill/water level are common controls across landform options.

For the Pit Lake and Partial Backfill below the Water Table options the controlled repressurisation of groundwater to maintain weight balance in addition to overburden placement will be required, especially during the medium term.

Groundwater Risks

Water resource issues arise for the Pit Lake due to the high volume of groundwater and surface water required to the fill the lake and therefore the limited availability of the resource for other users. While less water is required for the Partial Backfill below the Water Table landform, it still represents a moderate risk to the availability of water for other uses, as a level at or around RL 0 is still likely to require groundwater pressure reduction (aquifer pumping) in the long term. In the long term, resolution of water allocations for the landforms is needed.

Controls for the mitigation of groundwater risk apply to the Pit Lake and Partial Backfill below the Water Table landform options. This key control is the maintenance of the lake water level above the level required for weight balance and below the natural groundwater table thereby limiting the flow of water from the pit water body into the adjacent groundwater aquifers. Both of the landform options will facilitate this

With high evaporation expected, maintenance of the water level will require both passive and active ‘topping up’ of the lake level from sources other than natural groundwater recovery and so the control of lake level should be achieved. This assessment has not included uncontrolled flood entry to the mine void. The issue of use for flood protection (a land use issue) is beyond the scope of this assessment of landform but may have implications for the way water is managed in the long term.

The landform as a groundwater sink is likely to result in the concentration of contaminants and salts thereby reduce the water quality within the pit water body / lake over time. Controls for the recycling and possible treatment of water have therefore also been identified.

Given known groundwater levels it is unlikely that flow through connectively with natural surface water systems will be achieved by either Pit Lake or Partial Backfill below the Water Table. Protection of the landforms from uncontrolled flooding and management of water quality of any discharge waters are therefore the key controls for management of surface water risk.

Surface water risks

Loy Yang mine is relatively separated from the surface water catchment when compared with the other two mines. This reduces the overall risk to surface water on one hand. On the other hand, the final landform is likely to be very low in the landscape, so can potentially capture flood water. The lake will require a significant volume of water from the surrounding catchment to fill and maintain.

The main risks for surface water relate to the volume needed to fill the lake at a fast rate and the need for capture of local run-off to maintain the lake. Should lake quality decline over the long term it is an open question as to whether pumped discharge would be required as part of managing water quality. In this case there may be impacts on surrounding surface waters.

8.6.3.2 Estimated Cost

A comparison of estimated total costs between the two viable mine rehabilitation options at Loy Yang is presented in **Table 8-56.** Addressing fire risk carries the greatest cost at Loy Yang due to the large area and multiple coal seams requiring the application of cover or capping materials to prevent spontaneous combustion.

Similarities in costs may be attributed to the assumption that bulk civil works (e.g. slope battering, overburden placement and backfilling) are to be undertaken during operations and are subsequently excluded from costs. Increased costs associated with management of landform stability for the Partial Backfill below the Water Table landform are associated with additional reshaping of overburden placed during operations as part of the pit backfill.

Table 8-56 Comparison of Estimated Cost – Loy Yang

Risk Issue	Pit Lake Landform Estimated Total Cost	Partial Backfill below the Water Table Landform Estimated Total Cost
Landform Stability	$33.70m	$36.00m
Groundwater	$17.20m	$17.20m
Surface water	$11.90m	$9.10m
Biodiversity	$4.20m	$4.20m
Fire Risk	$59.60m	$59.60m

Costs are reported in current dollars and have not been discounted. Costs are rounded to the nearest hundred thousand.

9. Conclusions

Of the six preliminary mine rehabilitation options identified for each of the three Latrobe Valley coal mines four were assessed as potentially unviable:

- Partial Backfill above the Water Table and Full Backfill option – Unviable due to lack of available fill material onsite or locally and the significant costs associated with the import of material;
- Lined Void option – Unviable due to likely impact on environmental amenity and the potential high costs associated with creating the lining; and
- Rehabilitated Void - High fire risk and the need to maintain ongoing landform stability works such as dewatering (involve significant ongoing costs).

For the unviable options (Partial Backfill above the Water Table, Full Backfill and Lined Void) to become viable land uses would need to be identified that could deliver sufficient benefits to justify the substantial costs to acquire the materials necessary to develop the landform. Assessment of the economic viability of potential intensive land uses (e.g. manufacturing, residential, services and utilities) appears not to have been done in the Latrobe Valley yet. While the Line Void and Rehabilitated Void landform options could be achieved within the medium term these were considered unviable due to high establishment and maintenance costs and uncertainty regarding associated final land uses.

Two potential viable options remain - a Pit Lake and Partial Backfill below the Water Table landform.

Both potential viable options are more likely to be achieved in the long term (15 years after each of the mines have closed). Due to the lower water volumes required for the Partial Backfill below the Water Table it is conceivable to achieve this option within the medium term if the mines were able to access a significant diversion of water. Conditions most favourable to achieving a Partial Backfill below the Water Table option in the medium term (within 15 years of closure) exist at Yallourn due to the smaller overall size of the final void and the proximity to the Morwell and Latrobe Rivers.

Key factors that will determine when the final landforms could be achieved are:

- Final pit water body/lake volume;
- Final pit water body/lake level;
- Water quality management and the ability to discharge from the pit lake;
- Rate of progressive rehabilitation during mining; and
- Eventual slope profile for high risk walls/slope areas (close to critical infrastructure).

Interactions between the mines and key rivers (Yallourn - Morwell and Latrobe Rivers, Hazelwood - Morwell River and Loy Yang – Traralgon Creek) must be very carefully managed due to risks such as impact on water allocations to other uses and downstream impact on ecological water requirements.

The volume of water needed to achieve the Partial Backfill below the Water Table will be substantial and Jacobs' noted that allocation of the future water use is yet to be obtained by the three mines. There will need to short-term studies to understand the implications on other users and regional environmental values (see Table 9-1 below) to inform future allocation decisions. As highlighted in section 3.4, the Gippsland water system is already under stress and potential future climate change impacts add uncertainty to the availability, security and reliability of water resources.

This conceptual level study of future mine rehabilitation options in the Latrobe Valley has generally shown that with effective implementation of required risk controls the approach of a lowered landform, combination of water and material to collectively fill the mined void is likely to represent a low to moderate level of risk in the short, medium and long term across the areas of:

- Fire risk – establishment of a 2m cover over coal seams above the backfill and water levels would provide a low level of residual fire risk at each of the three mines. Cost to achieve the low level of fire risk ranges over the short, medium and long term range from $20m through to $60m (due to the varying size of the mines) with the majority of the cost incurred in the short to medium term;
- Landform stability – determination of required slope gradients, considered backfill placement strategies and optimal size and volume of the final pit water body could be implemented leading to a low to moderate level of residual risk for landform stability. Each mine has their unique challenges with regard to short, medium and long term stability (e.g. surface water interaction, batter characteristics, groundwater rebound). Site specific and regional studies in the short term will be needed to carefully understand the required weight balance needed to achieve long term stability (see Table 9-1 below);
- Groundwater – management of water level and pit water quality could be implemented leading to a likely moderate level of residual risk for groundwater in the areas of water quality and impact on other resource users; and
- Surface water – management of water diversion and water quality discharge could be implemented leading to a likely moderate level of residual risk for surface water quality and other resource users.

Managing biodiversity risks is not a key differentiator between either of the two potential viable options due to uncertainty in final target land use and the likelihood that trade-offs for mitigation of fire risk would be required for all landform options. Both potential viable options were assessed to most likely achieve a low to moderate residual risk.

Each potential landform offers a range of possible future beneficial land uses. Agriculture (e.g. expansion of plantations that already exist near the mine sites), recreational uses (e.g. on the basis that the water quality of the pit water body can be safely managed) and conservation and natural environment (e.g. creation of wetlands) are the most probable future uses. Some potential industrial type development (e.g. both the Pit Lake and Partial Backfill below the Water Table could theoretically support solar electricity generation through placement of solar arrays around the rehabilitated land) may be possible however Jacobs' search for relevant case studies didn't reveal directly relevant examples.

Are these the most appropriate uses of land in the second half of the 21st century given the community's desire for sustained employment and the proximity of the land to Latrobe City and major infrastructure (e.g. Princess Highway)? An assessment of the economic, community and environmental benefits of different possible land uses could be undertaken to inform the broad regional strategic direction for mine rehabilitation.

No assessed landform was considered to present significant impediments to undertaking on-going progressive rehabilitation works in accordance with the *MRSDA* or require a significant change in the nature of mining operations in order to achieve mitigation of key risks (e.g. landform stability and fire) within the short term.

In examining current mine operator Work Plans it is Jacobs' view that their planned final landforms generally align with the concept of a Partial Backfill below the Water Table landform. Given the practical physical constraints of the mine voids this is not surprising. They key finding of this study is that in the light of a comprehensive review of landform options we have not identified a markedly different landform option from those currently envisaged. This finding is important and should inform future assessments of the management of these sites.

While a shift to a Pit Lake landform would not represent a significant deviation from current mine operator Work Plans it is considered that greater understanding of the key issues of pit water quality, water allocation requirements and groundwater connectivity between the three mines would be required to assess the practicality and achievability of the Pit Lake option.

This study identified a range of risk controls in relation to the Pit Lake and Partial Backfill below the Water Table landform (e.g. fire cover, water treatment) not present in the Work Plans reviewed by Jacobs. In regards to Loy Yang many these controls are identified in the proposed Work Plan variation, including areas of research or study to inform the long term rehabilitation options. For Yallourn and Hazelwood as design and engineering continue consideration will need to be given to how these or alternate controls can effectively, proportionately and adequately achieve an acceptable level of fire, groundwater, surface water, landform stability and biodiversity risk.

The next stage of investigation of potential viable options for Yallourn, Loy Yang and Hazelwood should seek to address the issues summarised in Table 9-1. The common theme across the areas of investigation is a regional approach is needed (e.g. collaborative approach between mine operators, regulators and local council to understand broader regional implications of issues relating to each key risk area).

Table 9-1: Summary of key issues for further investigation

Key Risk Areas	Key issues requiring further investigation
Fire Risk	• Investigation of the depth of cover required in the long term to provide adequate smothering of coal and resistance to erosion and breaching; • Further information on the risks of horizontal drainage bores as a conduit for fire or possible source of spontaneous combustion in the long term (information of the short and medium term is available, but the long term management appears to need further work).
Landform Stability	• Studies required to establish weight balance requirements and correlations with depressurisation; • Undertake research to develop tolerance limits around design criteria; • Assessment of current regulatory requirements for stability. The 1:3 batter slope criteria is generically applied and does not appear to specifically provide appropriate guidance to mine operators in the Latrobe Valley looking to mitigate key stability risks. A more specific criteria for factors of safety that can be applied to site and batter specific conditions may be more appropriate to facilitate achievement of final landforms; • Work Plans should include detailed basis of design including design and construction criteria for each area of batter. Basis of Design should be risk based; and • Regional assessment of water allocation and sensitivity to pit water body options required to be undertaken;
Groundwater and Surface water	• Water quality investigation to establish the likely quality of water in the pit water body as well as runoff from various areas around the site; • Establishment of improved completion criteria for groundwater and surface water risks based on potential land uses and impact on regional water allocations; • Regional water balance modelling is recommended, in order to understand the likely filling rates and water level fluctuations, as well as the interaction/influence of the three sites. Regional water balance modelling should take into consideration: o Latest projections for future coal mining operations to scheduled closure dates. Coal mining projections should incorporate technological advancements. Cleaner coal technology (and other advances) may influence how coal is used and how much water is required for coal processing. Technology advances are seeking to make electricity generation more water efficient; o Future agriculture trends; o Bushfire impact on water availability/quality; o Future potential climate change impacts; o Tree Plantation and other potential land use changes; o Complex relationships between water use and impacts across the Gippsland region. Water resources in the Latrobe Valley are connected directly and indirectly to other water assets in the wider region, e.g. the Gippsland Lakes and Macalister Irrigation District. Decisions about how water is used in Gippsland must be made in the context of understanding potential direct and indirect impacts on adjacent regions. The regional impact of fluid abstraction for offshore oil and gas projects also carries a considerable degree of uncertainty, particularly given cumulative impacts on groundwater levels from multiple industries/users and the technical complexities inherent in predicting associated impacts such as land subsidence;

Key Risk Areas	Key issues requiring further investigation
	o More efficiently identifying and allocating surplus water. Compared to northern Victoria there is currently not the same level of water trading in Gippsland. There are numerous reasons for this e.g. relative availability and security of water and the size of consumptive pools; o Uncertainty regarding the impact on river health of diverting rivers for mine rehabilitation purposes. The course of the Morwell River has been diverted on several occasions in the past to access coal. These diversions require extensive ecological and geomorphological assessment to minimise the impact of the diversion.

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