# Latrobe Valley Brown Coal Mine Batter Stability Research Project –Project Scope

Department of Economic Development, Jobs, Transport and Resources

State Government Victoria

# Batter Stability Research Project – Project Scope

## Executive Summary

This document presents the Project Scope for the Latrobe Valley Brown Coal Mine Batter Stability Research Project ("Batter Stability Project" or "the project"), proposed to be undertaken by Earth Resources Regulation (ERR) branch of the Department of Economic Development, Jobs Transport and Research (DEDJTR or "the Department") in partnership with the Geotechnical and Hydrogeological Engineering Research Group (GHERG) of Federation University.

During the mid-1990s the Victorian electricity industry and associated brown coal mines within the Latrobe Valley were privatised. Prior to this, the State Electricity Commission Victoria (SECV) had a greater emphasis on, and capability for, research compared to the private industry today. As minimal direct research has taken place since privatisation, the result is a reliance of mine stability management on research outcomes that are now 20 years old. While these outcomes still hold relevancy, there are significant gaps in knowledge regarding stability matters specifically relevant to the Latrobe Valley brown coal mine environment, particularly given that the mines are now larger and deeper compared to 20 years ago. Further research is required in order to address these gaps and provide comprehensive knowledge of batter stability.

Batter movement has an impact on the integrity of public and surrounding infrastructure and therefore in-depth research and the modelling that will result from the project, will result in:

- improved knowledge of brown coal mine characteristics specific to the Latrobe Valley;
- improved management of batter stability;
- more informed rehabilitation plans;
- preventative rather than reactive measures to be taken in regards to major mine stability events;
- increased public confidence in the State's leadership and industry capabilities to manage risk;
- development of the brown coal industry's technical capabilities;
- minimisation of risk for new brown coal investors in the region; and
- the potential to minimise the frequency of major events.

The Technical Review Board (TRB) was established in 2009 in response to a batter failure at Yallourn Mine in 2007. The TRB advises the Minister on mine stability issues, with a focus on the Latrobe Valley. The purpose of the Batter Stability Project is to address the recommendation made by the TRB, which specifies the requirement of geotechnical studies to be undertaken at each of the three Latrobe Valley mines in order to re-establish a robust technical platform to manage geotechnical risk (Technical Review Board 2012:6). The TRB has been consulted regarding the Batter Stability Project to ensure consistency with regards to their recommendations.

This project will be conducted at Energy Australia Yallourn Mine and will result in an improved knowledge base regarding brown coal behaviour in the Latrobe Valley and the fundamental principles could be also be applied to Anglesea Mine and any new brown coal mines. The project will also serve as a basis and case study for future research projects. The scope of this project is preliminary in that it is a study at only one mine. While the data generated and interpretation of the data will be invaluable to the management of mines in the Latrobe Valley, greater value will come from further research at both Hazelwood and Loy Yang Mines, which will allow for comparison and more comprehensive interpretation and knowledge of brown coal

behaviour in the region. A further benefit of this project is that it will allow for assessment of the methodologies used, which may result in refined methodologies in the future.

The Batter Stability Project will be undertaken in several stages. The first stage is to create the foundation for the research component of the project by the collation of background data from the Latrobe Valley mines. The second stage is to perform a gap analysis with regards to the available data to establish additional information required to reach a meaningful conclusion on the stability of the batters in the Latrobe Valley. This will be followed by the installation of monitoring equipment on a batter in Yallourn Mine for the purpose of generating real-time data, and assessment of a batter which has similar characteristics and properties to the batter that failed in 2007.

The latter stages of the project involve more comprehensive research and analysis, monitoring and modelling of the data obtained from Yallourn Mine. The information from the project will also be incorporated into the current geotechnical and hydrogeological models. Research results and reports will be produced through GHERG, primarily by PhD students engaged specifically for the project, and led by Professor Rae Mackay and Dr Ali Tolooiyan. Collation of the data, gap analysis and the fieldwork component of the project are expected to be completed by June 2015. The comprehensive research component of the project is expected to be completed by June 2019.

The expected cost for the project is $2.2 million, the whole of which will come from DEDJTR. From the proposed budget of $2.2m, an amount of $1,081,360 will be granted to GHERG in order that they can facilitate their responsibilities. The bulk of the budget is attributed to the field component of the project (45%), followed by funds for key project staff (33%), initial project research and establishment of project knowledge base (10%), contingency allowance (8%) and analysis and reporting (4%).

Table 1 provides a summary of the key points for the project. The following document provides specific details for all aspects of the Batter Stability Project.

**Table 1: Project Summary – Key Points**

| Key Point | Description |
|---|---|
| **Project Description** | To undertake research to better understand the impact of engineering geology and hydrogeological processes on brown coal mine stability and have this published as public information. |
| **Size of the Improvement** | The project target will commence the development of a comprehensive compendium of knowledge and models regarding brown coal and inter-seam properties and their behaviour relevant to the Latrobe Valley brown coal mines. |
| **Cost** | $2.2 million over 5 years. |
| **State Contribution** | Whole amount. |
| **Industry Contribution** | Energy Australia - Yallourn, to allow research to be undertaken on its' mine batters and for the resulting information to be shared with the other brown coal mines, including Alcoa's Anglesea Mine.<br>In-kind contributions from Energy Australia – include assistance from personnel and on-site facilities. |

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| Key Point | Description |
|---|---|
| **DEDJTR Context** | The project results will potentially feed into both areas of responsibility of Earth Resources Regulation (ERR):<br>• Licensing – assessment and approval of applications and work plans.<br>• Standards and Guidelines – establishing, advising, monitoring and enforcing safety, environmental and stability standards/guidelines. |
| **Timing** | Five years from June 2014 |
| **Prime Project Risks to the State** | • No gain from research project<br>• Inadequate project scope leads to wasted effort<br>• Due to length of project, key project personnel are reallocated or leave project<br>• No industry buy-in of outcomes |

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## 1. Introduction and Project Background

Large and expanding brown coal mines in the Latrobe Valley provide an increased challenge for the assessment of mine slope stability risks and the implementation of risk control measures. Risks result from interplay between a range of geotechnical and hydrogeological factors that must be assessed and brought together for mine slope stability management.

Victorian regulations under the *Minerals Resources (Sustainable Development) Act* 1990 (MRSDA) set out a number of mine slope stability requirements, against which the Latrobe Valley coal mines are required to conform. The Regulations specify what must be done but not how it can be achieved. Recent mine slope stability reviews commissioned by government have highlighted a number of technical issues and uncertainties in the way in which mine slope stability management is conducted in the Latrobe Valley brown coal mines.

The government has a role in promoting improved technical capability within industry in the assessment and management of mine slope stability. Given recent slope failure events in the Latrobe Valley, government has a significant focus on improving mine slope stability performance. Without government intervention in this area, industry will be slow to adopt more robust mine stability risk management practices. In the longer term, improvement in the early identification and mitigation of mine slope stability risks will allow government to reprioritise resources to other regulatory issues.

This project will support other mine slope stability initiative activities such as the “Guideline on Ground Control Management Practices in Victorian Brown Coal Mines”. While the project is located in the Latrobe Valley and specific to brown coal, outcomes regarding geotechnical and hydrogeological investigation, analysis and reporting will be broadly transferrable to other mining operations in Victoria.

This project will be undertaken in collaboration with the Latrobe Valley mining industry. Energy Australia (EA) has agreed to provide access to a site suitable for this project and provide historical data for use in the project.

## 2. Overview

### 2.1. Vision

The Batter Stability Project will result in increased public confidence in the State’s leadership and industry capabilities to manage risks with regards to brown coal mine stability and cost benefits to State and industry. The research outcomes will provide State specific data for risk management of mines and form the basis of future in-depth research. The applied outcomes will allow for improved risk assessments, aimed at preventing major failure events.

### 2.2. Project Objective

As the State regulator of mines, DEDJTR is committed to comprehensively understanding mine stability risks in order to effectively fulfil its role in ensuring industry and public safety. The Technical Review Board (TRB), formed in 2009 to assist the department and advise the Minister regarding mine stability issues, recently advised that both the Latrobe Valley Mines and the State will be unable to address stability concerns unless a better understanding of brown coal slope behaviour is obtained. The project proposed in this business case addresses the recommendation in the TRB 2011-2012 Annual Report, which specified that



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geotechnical studies be undertaken. This research project will effectively and comprehensively address the aspects recommended by the TRB.

The outcomes of this project are to:

- Promote a consistent framework of geological, geotechnical and hydrogeological understanding for use by all stakeholders for mine slope stability management in the Latrobe Valley;
- Provide parameters for comparison with regional lignite characteristics as a basis for extrapolating mine slope performance to other areas of the Latrobe Valley;
- Understand the stress and time dependent properties of overburden, lignite and interseam sediments;
- Understand what type of batter movement occurs and identify what parameters control movement;
- Improve capacity to identify and manage geotechnical and hydrogeological risks related to lignite mining;
- Highlight key issues related to the use of material / rock mass parameters, geotechnical and hydrogeological models for slope stability analysis;
- Identify tools and methodologies suitable for the replication of observed mine slope behaviour and for use in prediction of ongoing batter response to mining; and
- Propose a program for monitoring and reporting of slope stability conditions.

## 2.3. Project Location

The project field site is the Yallourn Eastfield Latrobe River Batters at Energy Australia Yallourn Mine. This mine slope has been chosen because it:

- is representative of coal batters in the Latrobe Valley mines;
- has relatively simple geologic conditions of a single coal seam and interseam;
- has an existing monitoring dataset and stability analyses;
- is subject to typical surface water, groundwater and aquifer depressurisation conditions found in many Latrobe Valley mine batters; and
- is an area that has experienced significant movement in the past from which failure ‘back analysis’ can be completed.

## 2.4. Work Program

There are two main study streams:

- Confirmation of lignite material / rock mass parameters and behaviour; and
- Batter stability analysis and modelling.

### 2.4.1. Confirmation of lignite material parameters and behaviour

Historical information and data collected during site investigation for this project will be used to establish conceptual models of the batter, including:

- Geology (including structure);
- Hydrology / hydrogeology; and
- Geotechnical.

The conceptual models will summarise:

- Lignite material properties;
- Stress and time dependent properties of observed movement; and

- Control measures for batter stability management.

### 2.4.2. Batter stability analysis and modelling

The conceptual models will form the basis for establishing numerical models to be used for detailed geotechnical and hydrogeological analysis of batter stability to:

- Confirm the large scale parameters that control observed batter movement;
- Back analysis to investigate the factors controlling:
  - batter movement prior to the mine slope collapse;
  - batter movement after the mine slope collapse.
- Investigate the implications for mine slope stability of interconnection between a significant water source (e.g. Latrobe River) and mine batters.

# 3. The Business Case

## 3.1. The Purpose of the Business Case

This Business Case has been produced to define the problem (lack of understanding of brown coal slope behaviour in Victoria) and analyse the available options to address the problem. The Business Case will also identify the costs and risks associated with the preferred option (the Batter Stability Research Project).

## 3.2. Situational Assessment and Problem Statement

During the mid-1990s the Victorian electricity industry and associated brown coal mines within the Latrobe Valley were privatised. Prior to this, the mines were operated and managed by the State Electricity Commission Victoria (SECV). The SECV had a greater emphasis on, and capability for, research compared to the current operators. Previous studies completed by the SECV include assessment of stability matters at specific mines, for example: stability of permanent batters at Yallourn Mine (Chowdhury 1989), and the effects of ground movement as a result of mining across the Latrobe Valley in general (for example – Golder Brawner & Assoc. 1970; Sax Gloe 1976; and Hutchings *et al* 1977).

Very little research regarding mine stability has been conducted since privatisation and current postulates are based on research outcomes of 20 years ago. While these outcomes still hold relevancy, there are significant gaps in knowledge regarding stability matters, specifically pertaining to the Latrobe Valley coal deposits. In addition, since privatisation, continued mining operations have resulted in increased mining voids across the Latrobe Valley and these areas require additional information and data to ensure safe and stable batter and high wall slopes. As previous research has identified, the nature of brown coal deposits in Victoria is unique compared to the other coal mines in Australia (Sullivan 2008:vi), and further knowledge and understanding of the batter stability of the brown coal mines is vital.

The following three elements have been identified as key issues due to the gaps in contemporary knowledge of the stability of brown coal mines in the Latrobe Valley and these issues are proposed to be addressed by this research project:

1. **Issue Element 1:** Current technical knowledge of brown coal mine stability is inadequate to quantify and assess mine stability risks.
2. **Issue Element 2:** Incidents at brown coal mines are posing a threat to employee and public safety, environment and public infrastructure.

3. **Issue Element 3:** Industry's technical knowledge is regarded as inadequate due to the lack of sufficient research and development funding.

These three elements are considered in more detail hereafter.

### 3.2.1. Issue Element 1

***Current technical knowledge of brown coal mine stability is inadequate to quantify and assess risks***

Very little research regarding mine stability has been conducted in the past 20 years and although knowledge generated by work conducted by the SECV still holds relevancy today, there is a lack of understanding in the behaviour of the brown coal deposits. Recent mine stability events and the work of the TRB have indicated that further research is required to gain knowledge in the behaviour of the batters and provide more comprehensive understandings of the complexities of mine stability in the Latrobe Valley.

The TRB concluded that in order to address the concerns regarding mine stability, a better contemporary understanding and interpretation of the rock mass characteristics in combination with the fluctuation of groundwater pressures is required. Without an updated understanding of mine stability, the topic is likely to pose continuous and unquantifiable risks for current and future stakeholders.

### 3.2.2. Issue Element 2

***Incidents at brown coal mines are posing a threat to public safety, environment and infrastructure***

Mine stability issues have occurred with increasing frequency over the past seven years, often with serious impacts on industry, community, environment and infrastructure. Remediation of these events cost tens or even hundreds of millions of dollars.

Three major events have been recorded since 2007, including:

- **Yallourn Latrobe River Batter Failure November 2007**
  - Major collapse of a batter adjacent to the Latrobe River which resulted in the uncontrolled flow of the Latrobe River into the mine pit, causing significant damages and required the construction of a new river - channel to redirect the Latrobe River.
  - Down stream impacts due to no flow in river
  - The event impacted coal production operations.
  - The event forced the power station to operate at a decreased capacity.
  - Loss of some mine infrastructure.
  - Significant costs in loss and remediation measures (over $160 Million).
  - Decreased community confidence in industry's abilities to manage mine stability.
- **Hazelwood Northern Batter Movement February 2011**
  - Following a significant rainfall, a sinkhole developed in the Morwell Main Drain and cracks were observed in the Princes Highway and surrounding ground surface adjacent to the Morwell Township.
  - The Princes Highway was closed for eight months in 2011.
  - Closure of the Highway had significant impact on local residents, with all traffic diverted through Morwell, resulting in increased pressure on local infrastructure and raising traffic safety concerns.

  - Impact to members of the public travelling between Melbourne and eastern Gippsland towns, due to traffic diversion through Morwell.
  - Decreased community confidence in mine operator's abilities to manage mine stability and its impact on public safety, public infrastructure and the environment.
  - Significant costs to the State and Hazelwood Mine to stabilise the mine batter and surrounding infrastructure.
- **Morwell River Diversion Failure June 2012**
  - Collapse of embankment conveyor tunnel resulted in the uncontrolled release of water from the Morwell River Diversion into Yallourn Mine.
  - Damage to mine infrastructure.
  - Impact on community with concern over resulting environmental issues, particularly pollution in Morwell and Latrobe Rivers and the downstream effects on the Gippsland Lakes (particular concern to local fishermen).
  - Significant costs to rectify the issue (more than $100 million).
  - Decreased community confidence in industry's abilities to manage mine safety.

In addition, the February 2014 fire at Hazelwood Mine has heightened community concern and interest about the potential impact of mining operations on the local residents. A lack of understanding about stability issues will most likely result in continued decreased public confidence in the industry and the State.

If no action is taken to address the technical level of understanding regarding mine stability, it can be expected that unplanned for batter movement will continue to occur. This will negatively impact industry and may have consequences to public safety, the environment and public infrastructure. In addition, lack of knowledge will result in a continued practice of reactionary actions to major events, rather than preventative actions.

### 3.2.3. Issue Element 3

***Industry's technical capabilities are underdeveloped due to conflicting business priorities and high cost***

The likelihood of risk to business operations other than mine stability (such as union action and cost of production, for example) may be considered higher than the likelihood of batter collapse. As stated by the TRB, "mine operators have become conditioned to risk and are normalising risk…and the risk acceptance criteria and risk appetite of the present owners are higher than that of the [government]" (Technical Review Board 2012:5).

The mines now represent only one part of integrated commercial operations which typically include:

- The mine;
- A power station;
- Electricity trading activities; and
- In some cases, associated retailers.

The TRB identifies that ongoing assessment, investigation, design, implementation and re-assessment is required to adequately manage mine stability and risks to an acceptable standard (Technical Review Board 2012:5). The result of privatisation has been a reduction in the scope of these studies and a loss of corporate memory. Without Government involvement, this trend is likely to continue, which would be detrimental to the collective knowledge and management of mine stability within Victoria.

## 3.3. Assumptions and Constraints

The proposed research project requires specialist knowledge and expertise to adequately address the project objectives. Therefore, research proposed in this document is to be undertaken in partnership between ERR and the Geotechnical and Hydrogeological Engineering Research Group (GHERG) of Federation University. This partnership builds on a strong relationship developed over the past five years and the research will be conducted by highly qualified and experienced geotechnical and hydrogeological specialists. GHERG was established in 2009 at the State's instigation to start increasing research, education and training with a special focus on brown coal mines. GHERG, based in the Latrobe Valley, are uniquely placed and resourced to conduct in-depth and valuable research.

The research proposed to be undertaken by GHERG will be overseen by Professor Rae Mackay and Dr Ali Tolooiyan. Professor Mackay is the director of GHERG and has over 30 years' experience in hydrogeological investigations and modelling both as a practicing engineer and as a University based researcher. Much of his experience has also included the development and application of probabilistic risk assessment methods for hydrogeological prediction. Both areas are critical to the development of the knowledge required to implement risk based management of slope stability in the brown coal mines. Professor Mackay has previously designed, and managed a number of successful drilling and field investigation programs to meet different research objectives and will provide strong support in this area to the Technical Leader for the Project. Professor Mackay is presently a member of the Technical Review Board.

Dr Ali Tolooiyan is a geotechnical engineer with strong numerical modelling, experimental laboratory and field investigation skills. Dr Tolooiyan will work closely with the Technical Leader on all aspects of the field and laboratory activities and will deputise for the project leader on an 'as needs' basis. Dr Tolooiyan will take responsibility for the development of the program of modelling that will be required to confirm and inform the major research outcomes of the project.

### 3.3.1. Technical Risk Analysis and Management

A risk workshop was undertaken on 9 May 2014. The prime risks identified for the project and possible mitigation strategies are listed in Table 2 (over page).

| Risk | Mitigation Strategy |
|---|---|
| No gain from the research project | Technical Advisory Group (TAG) established to ensure that the research program addresses geotechnical/hydrogeological data gaps identified in the initial analysis |
| Inadequate project scope leads to wasted effort | Technical Advisory Group (TAG) and Project Control Board (PCB) to ensure that the scope is appropriate (once initial gap analysis is complete) |
| Due to the length of the project, key personnel are reallocated or leave the project | The key roles for the long term analysis are the PhD students. GHERG will need to ensure that this risk is minimised through the recruitment process |
| No industry buy in of results | Ensure that the three Latrobe Valley Mines are actively engaged through the TAG<br><br>Consider requesting formal support to the project from the mines before it commences |

**Table 2: Project risks and mitigation strategies**

### 3.3.2. Public Interest Issues

Due to recent major events and the impact on surrounding infrastructure, as well as impacts to the public from events such as the Hazelwood Mine Fire in February 2014, it is highly likely that the public will take particular interest in the project, its outcomes and the implementation of findings. The seven elements of public interest are addressed below in Table 3.

| Element | Impact and Management |
|---|---|
| Effectiveness | The approach, using GHERG to oversee the research and the private sector to undertake the drilling program, is considered the best approach for value for money. |
| Accountability and transparency | Accountability will be achieved through the project reporting to a project control board. The work will be performed to best industry practices and the outcomes will ultimately be made public. |
| Affected individuals and community | Those living in the areas affected are expected to be supportive of the investments. |
| Equity | No equity concerns are expected. |
| Consumer rights | Consumer rights will not be affected. |
| Public access | The project is not expected to impact on public physical access. The ultimate reports / analysis / models will become public. |
| Security and privacy | No private individual information will be used. |

**Table 3: Elements of public interest, impact and management**

## 3.4. Identification and Analysis of Options

The outcomes resulting from the proposed project supports the proposition to undertake the research as opposed to the option of doing nothing. To do nothing poses a high risk of consequence and probability of further major mine stability events at brown coal open cut mines in the Latrobe Valley and throughout the State. Further major events will have significant negative impacts on the community, industry, environment and infrastructure. Given that the Government has a critical role in addressing mine stability risks, failure to initiate and progress this important research could leave the Government unprepared and ultimately exposed should further major mine stability incidents occur.

As demonstrated by events in the past decade, batter movement can result in significant costs to the mine and subsequent high costs to the State in the event of infrastructure and environmental features being affected. It is therefore required to establish parameters and/or confirm current assumptions used in the mine design criteria to provide a higher level of confidence in protecting human lives, infrastructure and the environment.

The State needs to intervene to protect the interests of all stakeholders, including that of the State. Research undertaken by the State will result in outcomes and learnings that will be publically available and utilised to the benefit of industry, any future investors and the State in its regulatory role. The implementation of results in terms of mine stability management will increase public confidence in the ability of the State and industry to manage mine stability and its impact on public safety, public infrastructure and the environment.

The research, undertaken by GHERG, will be validated through a rigorous academic approach and will therefore provide confidence in the findings for future application. The added benefit of this research is the up-skilling that will likely occur across industry, Government and higher education. This will provide a strong basis for continuous improvement in the understanding of mine stability matters.

## 3.5. Implementation Strategy

### 3.5.1. Project Title

'Latrobe Valley Brown Coal Mine Batter Stability Research Project' ("Batter Stability Project" or "the project").

### 3.5.2. Target Outcomes/ Benefits

There are two primary benefits from undertaking the Batter Stability Project. These benefits are:

1. **Outcome 1:** Increased public confidence in the State's leadership and industry capabilities to manage risks with regards to brown coal mine stability
2. **Outcome 2:** Cost benefits to State and Industry

These two benefits are addressed in more detail hereafter, with reference to the following key performance indicators (KPIs):

**Outcome 1:**

- KPI 1: Rigorously tested research outputs

- KPI 2: Confidence in industry models
- KPI 3: Agreed mine stability model

**Outcome 2:**

- KPI 1: Investment
- KPI 2: Lower risk rehabilitation of mines
- KPI 3: Reduced liabilities and cost

### 3.5.3. Outcome 1

***Increased public confidence in the State's leadership and industry capabilities to manage brown coal mine stability***

Public confidence will increase as a result of various factors, which include:

1. Better evidence for the State to perform its regulatory role (by using the evidence to interrogate information from mines) – KPIs 1 and 3

The State is responsible for approving work plans, which includes standards for mine stability management.

The unique situation of the Latrobe Valley, specifically the proximity of towns and infrastructure to brown coal mines, emphasises the need for comprehensive knowledge of batter stability in the Latrobe Valley for the development of Ground Control Management Plans (GCMPs). The potential risks to community as a result of batter stability failure are particularly pertinent to the Latrobe Valley and therefore, reliance on generic information is not appropriate to adequately manage and regulate the industry in Victoria.

The project will provide an independent, evidence based knowledge and model base to allow the State to interrogate the mines' plans more effectively and meaningfully.

2. Improved management of mine stability at the Latrobe Valley mines (where research will be based) – KPI 2

The operations of the Latrobe Valley brown coal mines have all been affected by mine stability issues. Most batters within the mines are moving, albeit at different rates. Without better, evidence based knowledge of the acceptable level of movement, the mines are not in a position to justify their current mine stability management to either their internal boards or the State.

The project will provide an independent, evidence based knowledge and model base to allow the management of mine stability with a higher degree of reliability.

3. Improved management of mine stability at Anglesea mine (by extrapolation to its own area) – KPI 2

Whilst Anglesea mine is not in the Latrobe Valley, the work is expected to be capable of being extrapolated to the Anglesea mine. Some of the learnings/outcomes to be obtained during the field investigation phase as well as the analysis/research phase will be relevant to all Victorian brown coal mines.

### 3.5.4. Outcome 2

***Cost benefits to the State and Industry***

Cost benefits to the State and Industry will arise from several sources, which include:

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1. Easing the task of the State in its project attraction and facilitation role (by being able to make the information available to prospective mines) – KPI 1

The State is seeking to encourage new investment in the significant Latrobe Valley brown coal resource. Uncertainty regarding unquantified mine stability risk reduces the chance of investments being made.

The project will allow the State to reduce the uncertainty which currently resides around mine stability.

2. Improved planning for potential new mines (who will have access to the body of work to plan their mines) – KPI 1

There are significant brown coal reserves in the Latrobe Valley, which could be exploited by alternative mining companies. The presence of deeper coal seams might become attractive to be mined in the future and will result in deeper mining operations. Such mines are likely to have complex geotechnical management requirements and pose a bigger risk with regards to failure.

Parameters used by the mine operators in the calculation of safety factors in the process of slope design are based on historical information supplied by the SECV and on generic knowledge of similar mines worldwide. This information is incomplete, and consequently, alternative investors are exposed to unquantifiable risks.

The project will provide scientifically based information to be utilised in mine design criteria and consequently reduce the risk to human life, environmental impact and infrastructure collapse.

3. Better information to ensure the rehabilitation of mines is performed appropriately (slopes will be able to be designed to be safe and stable in the long term) – KPI 2

Section 78 of the MRSDA requires a licensee to rehabilitate land in accordance with the rehabilitation plan approved by the Department Head (Department Head as per the *Public Administration Act* 2004). In the past there were generally accepted parameters based on assumptions used in batter design, which was considered adequate by both the mines and the State. Recent events have questioned these assumptions for the purpose of mine rehabilitation design. There are heightened concerns in the community regarding mine stability and mine closure methodologies, which include the option of flooding the voids.

The agreement of the design and management of safe and stable rehabilitated batters have significant financial implications for the mines, both in terms of rehabilitation cost and the cost in relation to the rehabilitation bond required by the State.

The project will provide an independent, scientific based knowledge and updated geotechnical and hydrogeological models which will allow for the design of safe and stable batters.

4. Improved information will allow mines to undertake appropriate work to mitigate high risk, which in turn should reduce the number of significant events and the cost associated with responding to these events – KPI 3

A preventative approach rather than a reactive approach to major mine stability events will reduce the number of failures in mines and reduce the costs associated with responding to those events, for both industry and the State.

The project will provide an independent, scientific based knowledge to be utilised in mine batter design and management and minimisation of mine stability risks. All stakeholders will have increased confidence in the mine design and rehabilitation outcomes.

### 3.5.5. Outputs

The TRB recommendation included a number of elements to be covered by the research project, such as studies of the stratigraphic profiles throughout the Latrobe Valley; the geotechnical engineering properties of the stratigraphic layers or units; distribution of groundwater pressures; current geotechnical and groundwater monitoring and the requirement of additional monitoring equipment; development and probabilistic analysis of a comprehensive stability model; and the development of strategies and time-frames for stabilisation of an area if identified to be necessary.

The expected deliverables of the project include:

- Greater understanding of brown coal slope behaviour, specific to Victoria;
- Improved risk management for coal mines in the State;
- Improved regulatory practice and assessment of GCMPs and Work Plans;
- Increased public confidence in State regulator and industry to manage brown coal mine risks;
- Cost benefits to the State and industry through the use of improved information and increased knowledge.

Stakeholders intended to utilise the knowledge generated by the research project include:

- The State – in its regulatory role;
- Industry – in risk management assessments and continued mining practice; and
- Future Investors – decreased risk for future investors through improved knowledge and identification of risks.

### 3.5.6. Work Plan

There are several key components to the proposed research project, as follows:

- Project establishment/background research – database establishment (in progress), collation of existing data, gap analysis.
- Field component – drilling program, establishment of *in-situ* monitoring equipment, laboratory analysis.
- In-depth research – modelling and creep analysis using data from background research and field component.
- Reporting.
- Application of findings to current practice.

The project will be conducted from June 2014 to June 2019. The timetable for the project is as follows (Table 4, over page):

| Stage/Task | Timeline |
|---|---|
| Establishment of GIS database | June 2014 |
| Initial data collection from mines | July 2014 – Sept 2014 |
| Gap analysis | July 2014 – Oct 2014 |
| Recruit two PhD students | TBC |
| Recruitment of project personnel | TBC |

| | |
|---|---|
| Drilling program | TBC |
| Establishment of *in-situ* monitoring equipment | TBC |
| Initial laboratory analysis | TBC |
| Interim report | TBC |
| First annual workshop by GHERG presenting interim findings | TBC |
| Modelling analysis | TBC |
| Long-term modelling | TBC |
| Long-term creep analysis | TBC |
| Second annual workshop by GHERG presenting interim findings | June/July 2016 |
| Third annual workshop by GHERG presenting interim findings | June/July 2017 |
| Fourth annual workshop by GHRG presenting interim findings | June/July 2018 |
| Publishing final report | June 2019 |
| Final workshop by GHERG to present findings | June/July 2019 |
| Establish on-going monitoring program | TBC |

**Table 4: Projected project timeline**

## 3.5.7. Budget

The project is expected to cost $2.2 million, the whole of which is to be contributed by DEDJTR, as part of the BERC grant (see below for more detail). From the proposed budget of $2.2m, and amount of $1,081,360 will be granted to GHERG in order that they can facilitate their responsibilities. An overview of the budget is presented in Table 5.

| | | | Responsibility | |
|---|---|---|---|---|
| **Item** | **Description** | **% of budget** | **GHERG** | **DEDJTR** |
| Project Staff | GHERG oversight staff, Technical Leader, PhD Students | 33 | $721,600 | - |
| Gap Analysis/ Scoping/ Geotechnical Model | Initial research, knowledge base for the project | 10 | $150,000 | $68,000 |
| Field/ Laboratory Program/ Field report | Field Component of project and interim report | 45 | $127,700 | $869,880 |
| Analysis/ Reporting | PhD outputs, key project deliverables | 4 | $82,000 | - |
| Project Contingency | Provision for additional project costs | 8 | - | $180,000 |
| | | **Totals:** | **$1,081,360** | **$1,117,880** |
| | | | **$2,199,240** | |

**Table 5: Overview of project budget**

**Funding**

Funds for this project have been made available from BERC funding, which was granted to enable the Government to fulfil its role in understanding and improved regulation of mine stability. Objectives of the proposal for the funding relevant to this project included:

- The further development of geotechnical areas including
  - Construction of regional and local geological cross sections;

  - Determination of geotechnical properties of strata to underpin design and stability assessments;
  - Obtaining hydrogeological data; and
  - Updating relevant geotechnical/hydrogeological models.
- Review mine stability of currently approved terminal faces to ensure long term safety and stability.
- Provide the basis for improved inspectorate capacity to better mitigate risks associated with mine stability.
- Mitigate risks to the public, public infrastructure and the environment.
- Strengthen and accelerate current mechanisms used to address mine stability issues.

The outcomes of this research will assist and/or address the following key milestones of the funding proposal:

- Carry out rigorous scrutiny of GCMPs, data and reports;
- Develop and implement a comprehensive plan for ongoing monitoring;
- Develop capability and an operational work program for hazard mapping and risk assessment; and
- In conjunction with GHERG, develop and deliver a tailored training program for [DEDJTRI] and industry.

The initiative funded by the BERC grant will be evaluated based on the extent to which the initiative has improved brown coal mine stability in Victoria and the effectiveness of the initiative in meetings its objectives. The Batter Stability Project will directly assist in achieving the outcomes and ultimately address the evaluation criteria through the development of comprehensive knowledge of the brown coal mine stability issues specific to the Victorian landscape. The information generated from this project will be utilised in various aspects by the Government to enhance its role as regulator and work towards prevention of major mine stability incidents.

### 3.5.8. Other Resources

Other resources necessary for the project include in-kind contributions by Energy Australia - Yallourn Mine. Yallourn have allowed access to a batter for the project, which has similar characteristics to the batter that failed in 2007. Via a contract between DEDJTR and Energy Australia - Yallourn, Yallourn will oversee the drilling program on-site, with direct assistance and provision of technical specifications from GHERG and daily liaison and on-site assistance of the project Technical Leader. They will also provide personnel assistance where necessary and on-site facilities.

## 4. Project Tasks and Schedule

Project planning is currently in progress and involves preparation of project specification in consultation with project stakeholders and the preparation of Requests for Tender (RFTs) and tender evaluation and award.

Specific project tasks include:

- **Task 1** – existing information and gap analysis (2 months)
- **Task 2** – specification of field work (1 month)
- **Task 3** – field testing and monitoring (3 months)
- **Task 4** – laboratory testing program (up to 12 months)
- **Task 5** – revised conceptual models (3 months)

- **Task 6** – stability assessment and analyses (by June 2019)
- **Task 7** – reporting (incremental and by June 2019)
- **Task 8** – core storage (long term)

A number of tasks may be completed concurrently. Total project time is expected to be four years duration. Detailed information about each task is detailed below.

## 4.1. Task 1 – Existing Information and Gap Analysis

### 4.1.1. Objective

To collate existing information and identify additional geologic, geotechnical and hydrogeological interpretation, material sampling, field monitoring (stability / groundwater) and instrument placement needed as input to defining the field program.

### 4.1.2. Responsibility

To be undertaken by GHERG. Short term assistance from a contractor is needed to establish the database and GIS system at GHERG. A contractor has been engaged for this task (GHD) and this task is in progress. On completion, the database will be managed by GHERG for the duration of project.

### 4.1.3. Specific Tasks

- Identify specialist geologic / geotechnical / hydrogeological expertise required for the project and determine what expertise is available via the Project Team and seek complementary and additional external expertise.
- Establish GIS and database requirements (content, structure, output).
- Establish basis for information review and criteria for gap analysis.
- Identify data already held by DEDJTR and liaise with EA to identify other datasets which could be incorporated into the project.
- Collate monitoring instrument details (movement pins and prisms, standpipes, vibrating wire piezometers, horizontal drains with associated time series monitoring measurements, inclinometers, extensometers, etc.) and material property data (coal, interseam, overburden) into database.
- Collate monitoring records into the database.
- Review geological data and plans and establish conceptual geologic / geotechnical / hydrogeological models. Where necessary undertake geologic mapping and field investigation (e.g. test pits) to support model development.
- Review geotechnical / hydrogeological / hydrologic monitoring coverage (interseam, coal, overburden) to determine monitoring coverage laterally and vertically within each formation.
- Review distribution of material property results to determine coverage within formations.
- Determine gaps in monitoring coverage, materials properties and testing that be addressed for the project (additional movement monitoring pins and instruments; additional piezometers for groundwater monitoring; additional overburden, lignite and interseam samples; and additional field and laboratory testing).

#### 4.1.4. Information Sources

The Yallourn Eastfield Latrobe River Batters has an established network of monitoring bores and survey pins. There are also a number of batter stability assessments which will provide background information for this project.

Existing Information (provided by Energy Australia):

- stratigraphic geological / geotechnical / hydrogeological information;
- geological and hydrogeological data (borelogs, geophysical logs);
- conceptual geological / geotechnical / hydrogeological models;
- material / rock mass property data (overburden, coal, interseam);
- structural information;
- stability analyses / reports;
- mining sequence;
- mapped extent of batter collapse (3D);
- site vegetation, topography, surface water features, runoff characteristics.

Existing monitoring data (provided by Energy Australia):

- geotechnical, hydrogeological, horizontal drains;
- hydrologic data (Latrobe River flow);
- movement monitoring network installation details (survey pins, prisms, extensometers, inclinometers);
- groundwater monitoring network details (overburden, coal, deep aquifer);
- horizontal drain details;
- batter surface water drainage; and
- surveyed crack locations.

#### 4.1.5. Gap Analysis

The existing information will be reviewed to identify areas where field monitoring and information datasets could be improved. The analysis will consider the need for and specification of:

- additional movement monitoring instruments;
- additional piezometers for groundwater monitoring;
- additional overburden, lignite and interseam samples; and
- additional field and laboratory testing.

For costing purposes a number of new installations have been planned. Details of these installations will be confirmed by the gap analysis.

### 4.2. Task 2 – Specification of Fieldwork

#### 4.2.1. Objective

To obtain cored geologic samples (coal, interseam, overburden) and water samples (surface water, groundwater).

To install geotechnical and hydrogeological monitoring instruments.

### 4.2.2. Responsibility

To be undertaken by GHERG with assistance from Energy Australia (using existing EA drilling contract service agreement).

### 4.2.3. Specific Tasks

Specify the number, location and type of cored boreholes and instrumented boreholes to be completed.

- Identify specific borehole or other in-ground conditions required for the installation of instrumentation and to incorporate these into drilling specifications.
- Prepare a work program detailing the location, type and sequence of work to be completed.
- Specify the type of drilling and core recovery methods to be used.
- Undertake geologic logging of all recovered core material onsite.
- Identify any requirements specific to the collection, handling, packaging and transport of geologic material and water samples.
- Specify the borehole requirements (depth, diameter, core recovery, sample intervals).
- Procure all instrumentation for timely installation.
- Determine in-borehole testing type and depths (eg. packer testing).
- Provide procedures for the collection, handling and transport of all geologic material and water samples.
- Monitor and record drilling work, field testing and instrumentation installed.
- Record drilling work completed and quantity of materials used relevant to the drilling contract.
- Record instrument installation work completed and quantity of materials used relevant to the instrument supply and install contract.
- Maintain a detailed record of works completed against budget and forecast future expenditure.
- Prepare a report detailing:
  - The work completed
  - Full geological / geotechnical / geophysical logs for the cored boreholes;
  - Details of new instrumentation installed;
  - Records of borehole testing and analysis of results;
  - Initial monitoring results.

### 4.2.4. Borehole Testing

- All boreholes to be fully cored through Yallourn coal and Yallourn interseam to top M1 A coal.
- Boreholes to be geologically / structurally / geotechnically / geophysically logged.
- Within coal open borehole, packer testing will be completed to indicate coal permeability. Injection (lugeon) tests will be used. Packer tests will use a double packer with variable interval between packers. Packer tests will be completed for every 10 metres of bore drilled.

### 4.2.5. In-situ Measurements and Instruments which will be Installed

Geotechnical:

- Inclinometer (traversing biaxial - anchored in M1A coal);
- Vertical extensometer (multi wire - anchored in M1A coal);
- Horizontal extensometer (multi wire); and

- Pressure meter testing at different depths in the coal.

Hydrogeological:
- Vibrating wire piezometers (several per bore – Yallourn interseam, Yallourn coal);
- Single screen sealed standpipes (top Yallourn coal, overburden); and
- Meteorological station.

Some geotechnical instruments and piezometer bores will be set up with automated dataloggers for short interval recording.

### 4.2.6. Information Sources

Information on the number, type, location of boreholes and instruments required will be based on the conceptual ground models developed early in the project and from the gap analysis task.

Drilling contract rates and contract conditions will be as per the EA drilling services contract. All drilling related budgeting and expenditure rates will be as contained in that contract.

EA will provide high level drilling contract administration assistance but liaison with the drilling contractor, recording of work completed and resolution of any contract disputes will be managed by the project Technical Leader.

The installation of hydrogeological and geotechnical instruments will be on a supply and install basis in conjunction with the instrument supplier and drilling contractor. EA will provide some advice and field assistance for the installation of instruments.

### 4.2.7. Notes

The contract for Drilling needs to be flexible in terms of number of boreholes, locations of boreholes, timing of interventions for water sampling and testing, as well as geophysical logging.

It will be essential to have an on-site presence throughout all field activities to ensure the flow of information and interpretation of the information is informing the forward program of field work.

It will be essential for a desk based data management and interpretation program to be run in parallel with the field program to ensure maximum benefit from the field program.

There will be a need for monitoring installations in existing infrastructure including the existing horizontal boreholes.

It would be useful if integrity checks of existing horizontal drains could be included in the contracts for drilling.

Commissioning of all installed instruments and quality assurance/operational checks at regular intervals post installation are both required.

### 4.2.8. New Instrumentation

The established testing and monitoring network will be augmented by further key installations, including:

- Three (3) boreholes fully cored from surface to the base of the Yallourn Interseam;
- Boreholes to be geologically / structurally / geotechnically / geophysically logged;
- Retain cored samples of coal and interseam materials for laboratory testing;
- Boreholes to be used for installation inclinometers and / or extensometers and / or piezometers;
- Inclinometers (at least two per installation) to measure slope movement with extensometers across unit boundaries;
- Piezometers to target specific coal and interseam depths to complement existing bore network;
- Survey pins along survey section lines within existing batter and mine floor pin network; and
- Movement pins between coal blocks or across coal cracks.

## 4.3. Task 3 – Field Testing and Monitoring

### 4.3.1. Objective

To conduct field tests and collect surface water, groundwater and geotechnical information from instruments at the project site and input data to stability analysis activities.

### 4.3.2. Responsibility

GHERG is to coordinate the work, which will be conducted in conjunction with Energy Australia's existing monitoring program.

### 4.3.3. Specific Tasks

- Identify instruments and instrument types within the project area, existing and to be installed during the project.
- Determine the type of monitoring and monitoring equipment required for field data collection. Geotechnical instruments will include movement pins, inclinometers and extensometers. Hydrogeological instruments will include vibrating wire piezometers and standpipes. Hydrologic instruments will include river gauging.
- Review and modify if necessary the project database for storage of monitored data.
- Liaise with EA regarding resourcing of field monitoring and data processing.
- Develop procedure for collection and verification of monitoring data and/ or transfer of data from EA (note: existing EA systems may be appropriate for this task).
- Plan and complete discrete field testing – geotechnical (in-situ stress); shallow hydrogeological (River bed seepage, overburden infiltration and permeameter testing, overburden physical characteristics (shrink / swell), preferential flow paths). Field testing of water samples should be carried out for basic determinands (pH, eH, EC, DO etc).
- Program and conduct monitoring of geotechnical instruments and pins, vibrating wire piezometers, horizontal bore flows, rainfall, river stage height.
- Program, conduct and analyse water samples from the river, horizontal bores, standpipe bores.
- Program inspection and maintenance of field equipment (eg. dataloggers).
- Maintain monitoring database.

### 4.3.4. Information Sources

- Existing EA monitoring program.
- Specific requirements (if any) for new instruments to be installed by this project.

### 4.3.5. Monitoring Equipment

Dataloggers will be used to provide continuous monitoring of key piezometers, river stage height and movement (geotechnical) instruments.

### 4.3.6. Duration

The task will commence in conjunction with EA as soon as possible and continue beyond the current project stage to provide ongoing data for stability analysis in the longer term. Fieldwork needs to be conducted over the 2014-2015 summer period.

### 4.3.7. Notes

Field program should include invasive investigations including trench construction for evaluation of the cracking, jointing and lithological structures in the shallow overburden within the flood plain.

## 4.4. Task 4 – Laboratory Testing Program

### 4.4.1. Objective

To undertake laboratory testing and analysis of geologic material and water samples collected in the field program.

### 4.4.2. Responsibility

To be undertaken by GHERG, with some verification analysis to be completed by contractor.

### 4.4.3. Specific Tasks

- For geologic materials identify the key parameters to be investigated, test methods and any time dependency factors to be considered (e.g. coal & interseam shear strength; deformation (deviatoric and volumetric) behaviour; creep; tensile strength; compressibility and consolidation; overburden – shrink / swell; temperature controlled stress/strain; density pressure relations; weathered strength moduli; chemically controlled stress/ strain; pore water drainage).
- Specify analytes for surface water and groundwater testing and time series analysis if required (e.g. EC, pH, major anions / cations, isotopes, tracer).
- Specify the number and type of coal, interseam and water analyses.
- Confirm testing standards and any modifications required specifically for this project.
- Prepare specification as needed for internal (GHERG) and external (contractor) laboratory work.
- Manage and report QA/QC for both internal (GHERG) and contractor laboratory work.
- Complete duplicate (validation) testing of geologic material and water samples by contractor laboratory.
- Establish and maintain a materials testing database for the project.

#### 4.4.4. Information Sources

Australian Standards for testing of geologic materials and water. Also ASTM and BS Standards might be used if required.

#### 4.4.5. Notes

Water samples should normally be analysed at the earliest opportunity. Field testing of water samples should be carried out for basic determinants (pH, eH, EC, DO etc) prior to transfer to the laboratory or storage.

In addition to standard parameter testing and time-dependent testing, carry out index testing such as coal content, clay content (full particle size distributions), atterburg limits and XRD (clay mineralogy) to assist with mapping properties within the formations.

### 4.5. Task 5 – Revised Conceptual Models

#### 4.5.1. Conceptual Models

Confirm and update stratigraphic / geological / geotechnical / hydrogeological conceptual models

### 4.6. Task 6 – Stability Assessment and Analyses

#### 4.6.1. Objective

To use project data to update models and complete back analysis of the Latrobe river batter failure.

Develop a range of typical ground models and potential failure mechanisms that occur in all three mines.

#### 4.6.2. Responsibility

GHERG is to undertake the work.

#### 4.6.3. Specific Tasks

- Update the geology / geotechnical / hydrogeological conceptual models of the batter the basis for establishing numerical models to be used for detailed geotechnical and hydrogeological analysis of batter stability.
- Use the conceptual models to describe material properties, stress-strain and time dependent properties of observed movement, confirm the large scale parameters that control observed batter movement and control measures for batter stability management.
- Undertake 2D and 3D analysis / modelling of batter movement and stability to replicate observed behaviour of the batter over time and assess long term slope movement mechanisms related to mining, deep aquifer depressurisation and surface water.
- Investigation of modelling techniques that can be used to assess time dependent loading and material strength.
- Investigate the implications for mine slope stability of interconnection between a significant water source (e.g. Latrobe River) and mine batters.



State Government Victoria

- Undertake Back Analysis of the failed Latrobe River Batter to investigate the factors controlling:
  - batter movement prior to the mine slope collapse;
  - batter movement after the mine slope collapse.

### 4.6.4. Notes

A key component of the analyses will be to inform a strategy for obtaining effective or averaged properties for the different formations or faces within formations for the purpose of calculating the stability of the slopes.

Another essential component will be to understand uncertainties in the analyses that will provide a measure of the residual risk in the stability calculations.

## 4.7. Task 7 – Reporting

### 4.7.1. Objectives

To report the work undertaken during the field program and the outcomes of stability analysis and modelling.

### 4.7.2. Responsibility

GHERG is to undertake to work.

### 4.7.3. Report

The following outlines an indicative Table of Contents for the project report.

***Geotechnical Processes at Mine Slope Scale***

**Introduction**
**Project Site**
**Investigation and Data Collection**

- Existing data
- Gap Analysis
- Field program – drilling, new instruments, sample collection

**Monitoring and Testing**

- Laboratory coal and interseam testing
- Field testing of overburden and coal hydraulic properties
- Movement monitoring – pins, inclinometers, extensometers
- Groundwater monitoring – overburden and coal groundwater levels, interseam and deep aquifer pressures
- Surface water and rainfall monitoring

**Conceptual Models**

- Stratigraphy / geology / geotechnical / hydrogeological
- Key parameters for slope movement

**Stability Analysis**

- Geological Model – major units, structure
- Geotechnical Model – key inputs and stresses, load-dependent and time dependent properties, modelling of batter behaviour
- Hydrogeological Model – impacts of hydraulic loading and depressurisation

**Back Analysis of Failed Latrobe River Batter**

- Primary factors controlling batter movement prior to and at batter failure

**Key Issues for Improved Batter Stability Management**

- identify and manage geotechnical and hydrogeological risks
- tools and methodologies suitable for the replication of observed batter behaviour
- material / rock mass parameters - stress and time dependent properties
- geotechnical and hydrogeological models for slope stability analysis
- stability control measures – horizontal drains, surface water management
- investigation and monitoring programs

**Extrapolating batter performance**

- are lignite properties transferrable between sites?
- are there typical responses?
- how should information be used?
- what movements should be considered typical?
- how to assess the interplay between geology / geotechnical / hydrogeology?
- Key data / responses to validate extrapolation?

**Further Recommended Work**

**Conclusions**

### 4.7.4. Notes

Interim factual data reports should be prepared for each borehole and each new instrument installed.

A metadata report should be prepared identifying all data within the data base.

Progress reports should be prepared bimonthly during the drilling and investigation phases to confirm work progress and inform the advisory group.

It would be valuable to report the work completed and the status of the work at the end of the fieldwork component of the project (i.e. after completion of drilling, instrumentation installation, preliminary field program, initial lab work and initial modelling/analysis) as above with an additional section that detailed the follow on work by the research students. This should then be followed at the end of the extended research period by a further report summarising all findings.

### 4.7.5. Workshops

It is proposed that annual workshops be held in June/July of each year of the project, from June 2015, to update project stakeholders on the status of the project and interim findings. This would be an opportunity for GHERG personnel (including PhD students) to share information regarding research methods, findings and goals for the coming year. Annual workshops will provide momentum to the project following the fieldwork component and give project stakeholders an opportunity to ask questions of the researchers and understand the progress of the research.

## 4.8. Task 8 – Core Storage

### 4.8.1. Objective

To store samples of coal, interseam and water under controlled conditions for logging and laboratory physical and chemical testing in the current or following stage of this project.

### 4.8.2. Responsibility

GHERG is to coordinate the facility which will be located at GHERG. Long term storage is available through the Department at their facility in Werribee. Storage following the completion of the project will be discussed between ERR and GHERG.

### 4.8.3. Specific Tasks

- Identify the types of samples to be stored and the optimum storage conditions for each.
- Specify control conditions needed and put in place a storage facility at GHERG (until June2019 and then to be reviewed).
- Monitor the facility to ensure controlled conditions are maintained.
- Maintain records of samples in storage.

### 4.8.4. Duration

The facility should be in place before the commencement of the field program. Sample storage may be required for several years to enable ongoing laboratory testing of the drilling core material in the following stage of the project.

### 4.8.5. Notes

It is desirable that all core is stored in optimum conditions. Ideally all core would be retained in the storage facility but this leads to a potentially large storage requirement. It may be preferable for preliminary logging of all core to be completed on site as drilling proceeds and representative samples to be retained for future investigation.

Preliminary logging of all cores on site as drilling proceeds is good practice but no core should be discarded at that stage. If that is done review is not possible- and the opportunity to go back for a detailed look, as knowledge and understanding improves, is lost.

Samples retained must be sufficient for all planned tests, both short and long term.

A standardised naming convention will be required to identify the source of the materials stored in terms of location, elevation, date collected, and collection method.

Some deterioration of samples is to be expected over the long term, and the extent and form of this deterioration should be determined as part of the monitoring procedures over the storage life.

## 5. Project Outcomes

The project aims to significantly improve contemporary knowledge regarding the characteristics of brown coal mine stability, specifically in the Latrobe Valley, and through extrapolation of models and data, to other mines in the State. This information will improve risk management of stability in mines, potentially preventing major events in the future. Past events, such as the Yallourn Latrobe River Batter Failure in 2007, the Hazelwood Northern Batter Movement in 2011 and the Morwell River Diversion Failure in 2012 have demonstrated the impact of major events on the industry and local community.

Further, the project and its findings will work towards increased community confidence in the capabilities of mine operators and the regulatory body (ERR of DEDJTR) in identifying and effectively mitigating risks from open cut mines. The closure of the Princes Highway in 2011 and the recent fire in Hazelwood Mine in February and March 2014 highlighted the impact such events can have on the community and in turn, the community's perception of mine risk management. This project will be a positive step towards improving public perception of the industry and the regulator and work towards minimising future events.

This project is a preliminary project as it is a study of one mine in the Latrobe Valley, and further similar studies at the other Latrobe Valley Mines will expand the usefulness and meaningfulness of the project outcomes. The data will initially be extrapolated to inform risk management at the other mines in the Latrobe Valley, but as each mine is unique, geotechnical and hydrogeological studies at each mine will be an invaluable resource for the State and industry in managing stability into the future.

# 6. Project Management Framework

## 6.1. Governance

This project is highly visible and therefore includes stringent governance, reporting and stakeholder engagement requirements.

The project will come under the oversight of the mine stability Program Control Board (PCB), which is chaired by the Executive Director (ED), ERR, DEDJTR. The ED ERR has budget responsibility for the project.

A project manager (within DEDJTR) has been appointed. The project manager will have delegated responsibility to manage the project and the various contracts.

A Technical Advisory Group (TAG) will be formed which will include participation by:

- ERR
- The Latrobe Valley mines (Yallourn, Hazelwood and Loy Yang)
- GHERG
- Members of the TRB

A Technical Leader will be appointed to the project by GHERG, who will report to GHERG and provide oversight to all operational elements during the project. In addition the Technical Leader will also report to the project manager and receive technical guidance from the TAG.

The research project will be managed by GHERG who will report to the DEDJTR project manager. GHERG will oversee the appointment and supervision of the PhD students and provide general support from mainstream GHERG operations. In addition, GHERG will also receive technical guidance from the TAG.

The governance and reporting structure is summarised in the Table 6, over page.

# Batter Stability Research Project – Project Scope

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| **1** | | ✓ | | | | | | | |
| **2** | ✓ | | | ✓ | | ✓ | ✓ | | |
| **3** | | ✓ | | ✓ | ✓ | | | ✓ | |
| **4** | | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | |
| **5** | | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ |
| **6** | | ✓ | | ✓ | | | | | |
| **7** | | ✓ | | ✓ | ✓ | | | ✓ | |
| **8** | | | ✓ | ✓ | ✓ | | ✓ | | ✓ |
| **9** | | | | | ✓ | | | ✓ | |

**Table 6: Batter Stability Project Governance and Reporting matrix**

Legend to Governance and Reporting matrix:

1. Minister
2. Project Control Board (PCB)
3. Energy Australia Yallourn Mine
4. Project Manager (Earth Resources Regulation, DEDJTR)
5. Geotechnical and Hydrogeological Engineering Research Group (GHERG)
6. Technical Review Board (TRB)
7. Technical Advisory Group (TAG)
8. Technical Leader
9. PhD Students

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**Technical Review Board**
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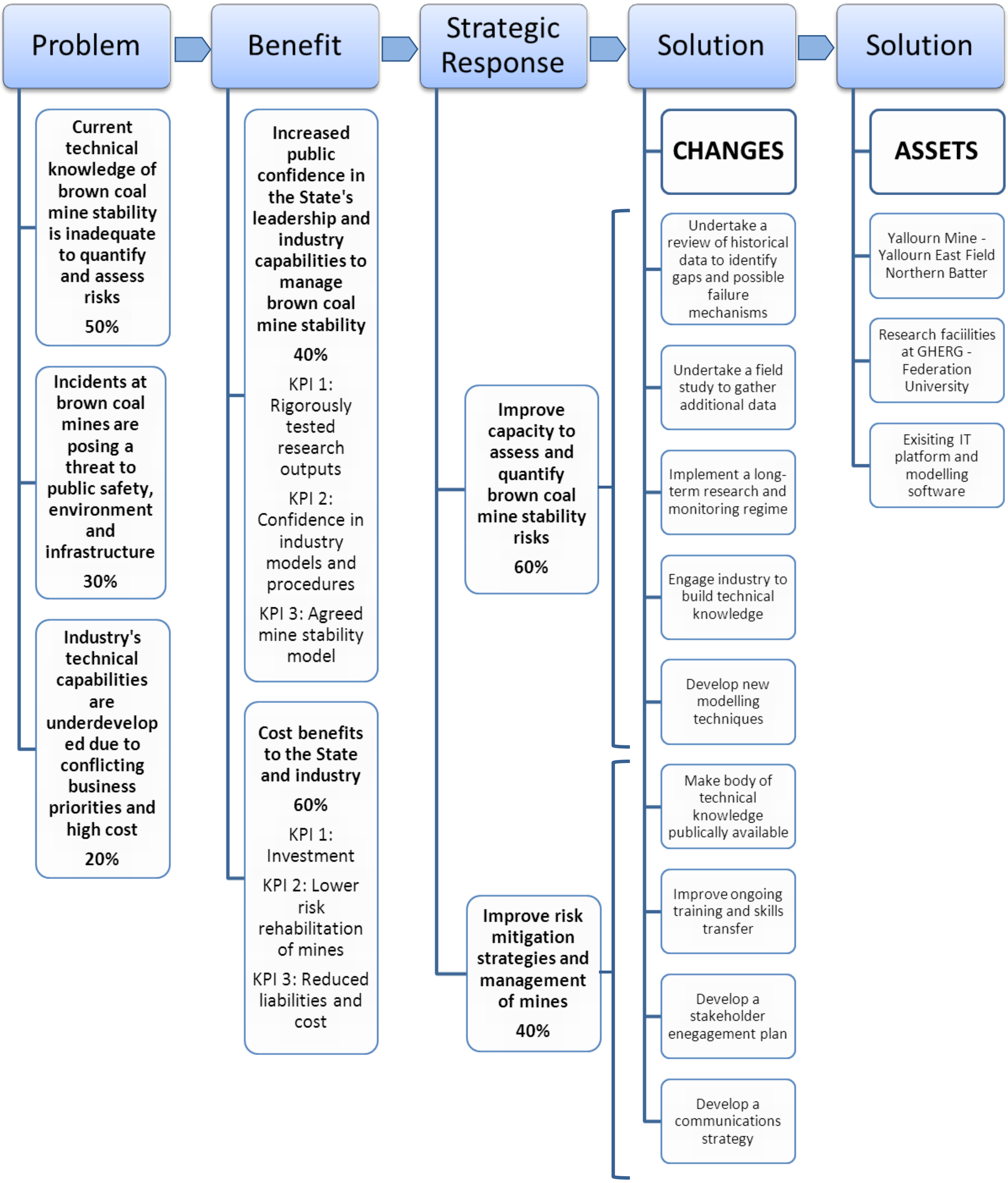
# Appendix 1 – Investment Logic Map



## Appendix 2 – Budget Summary

*(to be updated, new draft will be issued).*

# Appendix 3 – Project Personnel

## DEDJTR

A project manager (within DEDJTR) has been appointed who will report to the PCB, and will be assisted by a project officer. The project manager will have delegated responsibility to manage the project and the various contracts. The project manager and project officer will monitor the progress of the project, maintaining regular contact with the Technical Leader and researchers, and be available to assist project personnel where required.

## GHERG

The research project will be managed by GHERG who will report to the DEDJTR project manager. GHERG will oversee the appointment and supervision of the PhD students and provide general support from mainstream GHERG operations. In addition, GHERG will also receive technical guidance from the TAG. Key personnel at GHERG include Professor Rae Mackay, Dr Ali Tolooiyan, a Technical Leader (to be recruited) and two PhD students (to be recruited).

**Professor Rae Mackay**
Professor Rae Mackay will oversee GHERG's roles and responsibilities for the project and provide expert advice to personnel involved in the project. Professor Mackay is Director of GHERG. He has more than 30 years' experience in hydrogeological investigations and modelling both as a practicing engineer and as a University based researcher. He was Professor of Hydrogeology and Head of the Hydrogeology Research Group at Birmingham University, UK for 14 years from 1997 to 2011. He has worked on a wide range of groundwater engineering and environmental management problems and has worked in many countries in Europe, Africa, Asia and South America. Before moving to Australia in 2011 to take up the position of GHERG's Director, Professor Mackay worked extensively as a researcher and as an advisor on aspects of nuclear waste disposal for the UK government and nuclear waste agencies. This work involved significant research into the interaction between geotechnical and geohydrological processes and properties. Much of his experience has also included the development and application of probabilistic risk assessment methods for hydrogeological prediction. Both areas are critical to the development of the knowledge required to implement risk based management of slope stability in the brown coal mines. Professor Mackay has previously designed, and managed a number of successful drilling and field investigation programs to meet different research objectives and will provide strong support in this area to the Technical Leader for the Project. Professor Mackay is presently a member of the Technical Review Board.

**Dr Ali Tolooiyan**
Dr Ali Tolooiyan is a geotechnical engineer with strong numerical modelling, experimental laboratory and field investigation skills. Dr Tolooiyan will work closely with the Technical Leader on all aspects of the field and laboratory activities and will deputise for the project leader on an 'as needs' basis. Dr Tolooiyan will take responsibility for the development of the program of modelling that will be required to confirm and inform the major research outcomes of the project. Dr Tolooiyan's other role on the project will be as the co- supervisor of the two PhD students. In this role he will lead the training and support on all aspects of numerical

slope modelling and laboratory investigations for all members of the research team. He will also be a member of the Technical Advisory Group for the project.

Dr Tolooiyan gained his MSc in geotechnical engineering on the topic of slope stability in 2006 and completed a PhD in geotechnical engineering in the field of shallow and deep foundations in 2010 at University College Dublin (UCD). After completing his PhD, he spent a year as Post-Doctoral researcher in the field of offshore geotechnical engineering at UCD Geotechnical Research Group (GRG), and associate lecturer/ lecturer in advanced geotechnical engineering at UCD and Cork Institute of Technology (CIT), He joined GHERG in 2012 and is leading a research project focused on realistic geotechnical Finite Element Modelling analysis of open-cut mines. With two PhD students he is respectively developing new methods for laboratory investigation of the geotechnical properties of the brown coal and the interseam materials and exploring approaches to measuring in situ horizontal stresses in Brown coal. Dr Tolooiyan consulted on a wide range of industry projects, including foundation and earth-slope design in Europe, East Asia and Middle East.

**Technical Leader**

The project Technical Leader will play a significant role in the achievement of the project objectives and outcomes. GHERG is seeking a suitably qualified and experienced geotechnical engineer or engineering geologist to fill this position.

The appointment would be for two years and the appointee will be based at GHERG's offices in the Latrobe Valley. The duties of the Technical Leader will be as follows:

To manage the collation of existing geological, geotechnical and monitoring information for the project area and to coordinate with other technical specialists the identification of data gaps related to the testing and *in-situ* monitoring of material properties.

To lead, in conjunction with other technical specialists, the development of geological, geotechnical and hydrogeological conceptual models for the project area relevant to slope stability assessment.

To assist in the development of detailed work scopes for the conduct of activities in the field program which will include drilling, core recovery, installation of instruments and field monitoring.

To coordinate and supervise field activities including liaison with the mine operator regarding site access and the requirements of health and safety requirements for the duration of field activities.

To establish procedures for the recording of field activities and management of field derived data.

To undertake the geotechnical and geologic logging of boreholes and the management of borehole testing such as packer testing.

To liaise and coordinate with other project staff related to research work requirements of the field program.

To report regularly to the project management team regarding the conduct and progress of field activities against the project plan and budget.

To prepare detailed reports at the completion of key project activities.

It is expected that the successful applicant will:

Have geotechnical engineering or engineering geologist qualifications;

Be able to demonstrate experience in the planning and conduct of field investigation programs relevant to slope stability and the development of geotechnical models for the assessment of slope stability;

Have experience in the establishment of geotechnical and geological data management systems and the development of procedures for the systematic recording of field information.
Demonstrate knowledge of geotechnical and geological borehole logging, the conduct of *in-situ* tests such as packer testing and the installation of borehole geotechnical instruments.
Have knowledge of typical mine site health and safety requirements, as well as specific requirements related to the operation of drilling rigs and management of personnel in a field environment.
Be able to prepare detailed technical reports.

**PhD Students**

Existing GHERG students will contribute to the batter stability research project in the areas of in situ stress measurements and three dimensional numerical modelling of slope stability. In addition to these students, two further students will be recruited. The first of these students will investigate the geotechnical controls governing the movement of the investigated batter slopes and the inclusion of representative geomechanical property data in numerical models of batter movement. The second student will investigate the hydrogeological controls governing the movement of the investigated batter slopes and the inclusion of representative geohydrological property data in numerical models of batter movement. A major component of the two PhD projects will be to assess the data collection requirements for adequate modelling of batter performance and the respective monitoring requirements for determination of emerging risks of failure.

Following appropriate training, the students will be responsible for the following activities:
Descriptive and photographic logging of the core obtained from the drilling program
Undertaking material property experimental investigations in the laboratory.
Carrying out field data collection, including downloading of all logged monitoring data and entry to the GIS database.
Contributing to the conceptual interpretation of the field and laboratory data
Performing scoping model calculations to assess the validity of the conceptual models
Developing appropriate methods for the inclusion of the available data in models describing the geotechnical and geohydrological behaviour of the investigated area
Quantifying the residual uncertainties in batter stability arising from different levels of available data.
Contributing to the development of guidelines on best practicable options for data collection and modelling to support batter stability assessment
Contributing to the development of guidelines on best practicable options for monitoring to support the assessment of risks of batter instability.
Evaluating the transferability of the results from the investigated batter to other settings in the Latrobe valley coal mines.
Preparing reports, presentations and publications detailing the results of the research.

The nature of research is that activities will need to change as information and knowledge is acquired. Therefore, while these general responsibilities are not expected to change, the specific details of each activity may be subject to variation.

It is important that the individuals appointed to undertake these two PhD research projects have a background in at least one of the fields of geotechnical engineering, engineering geology or environmental engineering. It is also a requirement that they have good numeracy and mathematical skills. To be eligible to undertake a PhD it is essential that the students meet the requirements for enrolment as a PhD student in Federation University Australia. While prior skills in field and laboratory work as well as numerical modelling are desirable, these are not essential and can be acquired through training by the supervision team. The appointed individuals will need to demonstrate an ability to work within a team, to work to deadlines and to be able to carry out work individually and to a high standard.

## Project Control Board

The project will come under the oversight of the mine stability Program Control Board (PCB), which is chaired by the Executive Director (ED), ERR, DEDJTR. The ED ERR has budget responsibility for the project.

## Technical Advisory Group

A Technical Advisory Group (TAG) will be formed which will include participation by:

- ERR
- The Latrobe Valley mines (Yallourn, Hazelwood and Loy Yang)
- GHERG
- Members of the TRB

The TAG will provide expert advice to the Technical Leader and other project personnel.

## Stakeholders

Key stakeholders for the project include:

- industry – Latrobe Valley Mines, other mines in the State, consultants, sub-contractors;
- community – local residents and interest groups, wider population in the State; and
- Victorian WorkCover Authority.

## Authorised tag to be included as last paragraph