16th April 2018

Secretary
NSW Department of Planning and Environment
GPO Box 39
Sydney, NSW, 2001

Attn: Howard Reed
CC: Colin Phillips

Dear Howard,

RE: CHAIN VALLEY COLLIERY – EXTACTION PLAN Miniwalls S1 and N1

In accordance with Schedule 4, Condition 7 of SSD-5465, relating to the preparation of an Extraction Plan, LakeCoal seeks endorsement by the Secretary of the Chain Valley Colliery Extraction Plan for its Northern Mining Area Miniwalls S1 and N1.

LakeCoal has today provided an electronic version of the Extraction Plan and associated documentation via a file exchange. Please note that LakeCoal is still waiting on the completed peer reviews (Appendix 11) of the subsidence assessment and extraction plan from Ismet Canbulat which will be sent later this week.

Please also note that LakeCoal has previously provided copies of the Seagrass and Benthic Management Plans to the relevant authorities and is currently working through feedback received from these agencies. A final version of these plans will be provided in the coming weeks.

Should you require any further information, please do not hesitate to contact myself.

Yours sincerely

Wade Covey
Environment and Community Coordinator
Chain Valley Colliery
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CHAIN VALLEY COLLIERY

EXTRACTION PLAN

MINIWALLS S1 and N1

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Mine	Chain Valley Colliery	
Development Consent	SSD-5465 MOD 2	
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Author(s)	Adrian Moodie, Tim Chisholm, Wade Covey	
Document	Chain Valley Colliery Extraction Plan – Miniwalls S1 and N1	
Revision	0	Date: 06/4/18
Reviewed by:		Dr Ismet Canbulat UNSW
Authorised by:		Dave McLean Operations Manager

1.0 *Introduction*

1.1 Background

Chain Valley Colliery (CVC) is an underground coal mine located at the Southern end of Lake Macquarie approximately 40km South of Newcastle. Mining at CVC first commenced in 1962 and since then, both primary and secondary coal extraction has occurred in the Wallarah, Great Northern and Fassifern Seams, primarily using Bord and Pillar mining methods.

In August 1960, J&A Brown and Abermain Seaham Collieries Ltd commenced clearing the present pit top site with drift and shaft sinking starting a few months later. Production of coal from the Wallarah Seam, commenced with the first delivery to the adjacent Vales Point Power Station in April 1963. In October 2006, Peabody Energy acquired 100% of LakeCoal Pty Limited, which has an 80% stake of the Wallarah Coal Joint Venture. The Sojitz Corporation (a Japanese trading house) owned the remaining 20% of the Wallarah Coal Joint Venture. In November 2009 LDO Coal Pty Limited purchased LakeCoal Pty Limited. LDO Coal is a consortium consisting of LD Operations, AMCI and private investors. In March 2011 the 20% share in the WCJV which Sojitz held was acquired by LDO Coal shareholders through the entity Fassi Coal Pty Ltd. In 2016 RWE NSW Pty Ltd acquired a portion of AMCI shares in the joint venture.

Of the three coal seams to be mined the Wallarah Seam was discontinued in 1997, the Great Northern Seam was discontinued in May 2008. The Chain Valley mine peaked with a workforce of approximately 380 men in the mid 1980’s. Today, Chain Valley Colliery has a workforce of approximately 160 full-time employees.

Mining commenced in the Fassifern Seam in 2006 and continued using place change methods with both partial and full extraction taking place until the introduction of miniwall mining in the latter half of 2011. The Fassifern Seam reserves amount to 20 million tonnes of coal at less than 25% raw ash.

Since 1979 the Colliery had been operating under existing use rights, but due to the repeal of existing use rights under the Mining Act 1992 an Environmental Assessment process was undertaken between 2009 and 2012, culminating in project approval of MP 10_0161 on the 23 January 2012. Subsequent to this approval, a section 75W modification was also completed in 2012 to permit a wider miniwall face than originally identified in MP 10_0161. This modification MP 10_0161 MOD 1 was approved on the 30 August 2012.

In December 2013, development consent was received from the NSW Department of Planning under Section 89E of the Environmental Planning and Assessment Act 1979 for CVC to continue mining via miniwall mining methods to the North of the previous approval boundary until 31st December 2027. Subsequently modifications in November 2014 (MOD 1) and December 2015 (MOD 2) provided approval of the Link Rd to Mannering Colliery and changes to production limits and panel layout including maximum subsidence. The approved mining boundary extends beyond the Northern boundary of mining lease ML1051 (held by LakeCoal and into lease areas held by Centennial Coal (ML1632 and CCL721). Agreements have been reached between Centennial Coal and Lake Coal allowing CVC to extract within a defined parcel of these lease areas, namely Sub-lease A and Sub-lease B. Both now form part of the Chian Valley Colliery Holding.

This Extraction Plan is related to a small portion of the mining area approved by the NSW Department of Planning, located within "Area A". The proposed miniwall panels, S1 and N1, have been designed such that all extraction is located beneath the lake and all secondary extraction is outside of both the High Water Mark Subsidence Barrier (HWMSB) and the Seagrass Protection Barrier zones (**Figure 1**). The final limits of extraction and mine design requirements for subsidence management were also informed by updated subsidence modelling following an exceedance of predicted subsidence over the miniwall 1 to 12 area (**Appendix 10:** DGS report **CHV-002-**10b). Important outcomes of the report were:

- Shortening of the S1 Panel to ensure no stress interaction with the adjacent Wallarah Seam partial extraction workings.
- Shortening of the N1 Panel due to a re-examination of the seagrass extent adjacent the extraction plan area, which has been shown to be slightly extended from that originally mapped in 2012. The reduction in the length of the N1 panel has also reduced the subsidence impacts on the Sugar Bay navigational marker.

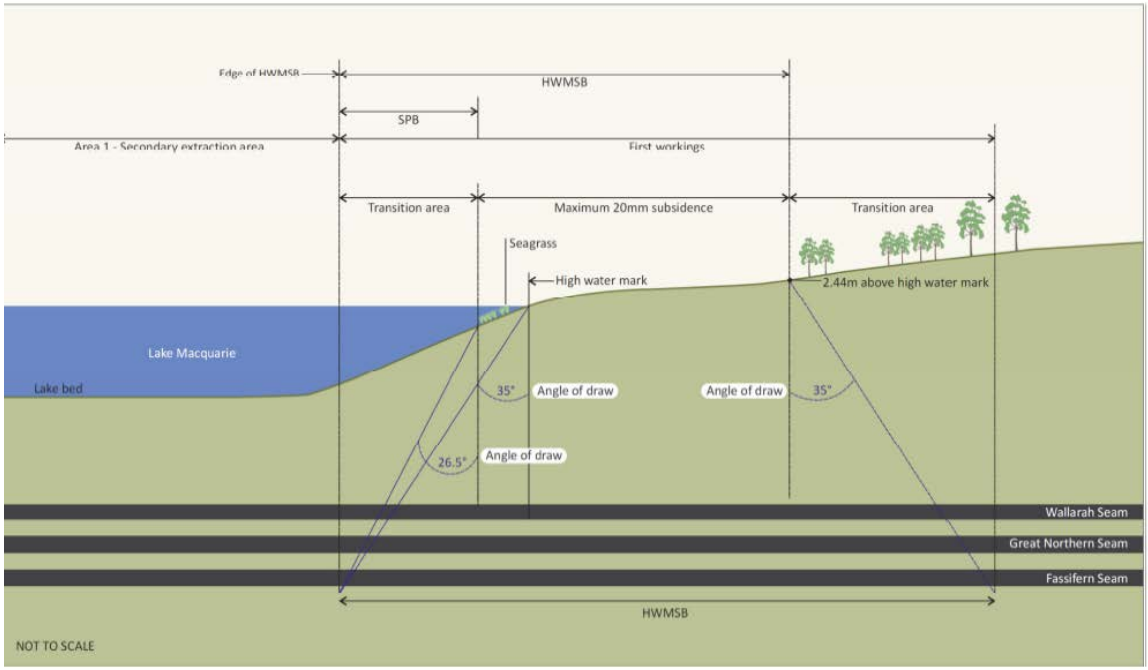


Figure 1- Protection Barrier Schematic

1.2 Scope

Prior to commencement of secondary extraction within the approved Mining Extension 1 project area, the CVC approval conditions (Schedule 4, Condition 7) state that:

"The Applicant shall prepare an Extraction Plan for all second workings on site, to the satisfaction of the Secretary."

As such, this Extraction Plan has been developed in accordance with Schedule 4, Condition 7 of the Development Consent and details proposed subsidence management techniques to be implemented during secondary extraction to ensure that there are no exceedances of the key performance measures identified in the Development Consent.

This extraction plan is limited to S1 and N1 Panels (**Figure 2**) and as such, does not cover the entire Mining Extension 1 approval plan (**Figure 3**). The limited scope of this Extraction Plan aims to:

(i) address short term mine planning requirements in a conservative manner (i.e. by limiting the plan to the two isolated panels) and

(ii) enable a re-assessment of the remainder of the panel layout for the Northern Mining Area, incorporating the learning outcomes from the subsidence exceedance with regard to multiple contiguous panels, as well as other learnings and opportunities for layout optimisation.

Whilst current miniwall extraction is being undertaken under previous approvals and a current Extraction Plan approval, the extraction of the S1 and N2 Panel will not commence until this document is approved. Subsequent Extraction Plans will be submitted for future panels in the Mining Extension 1 area, but are outside the scope of this document.

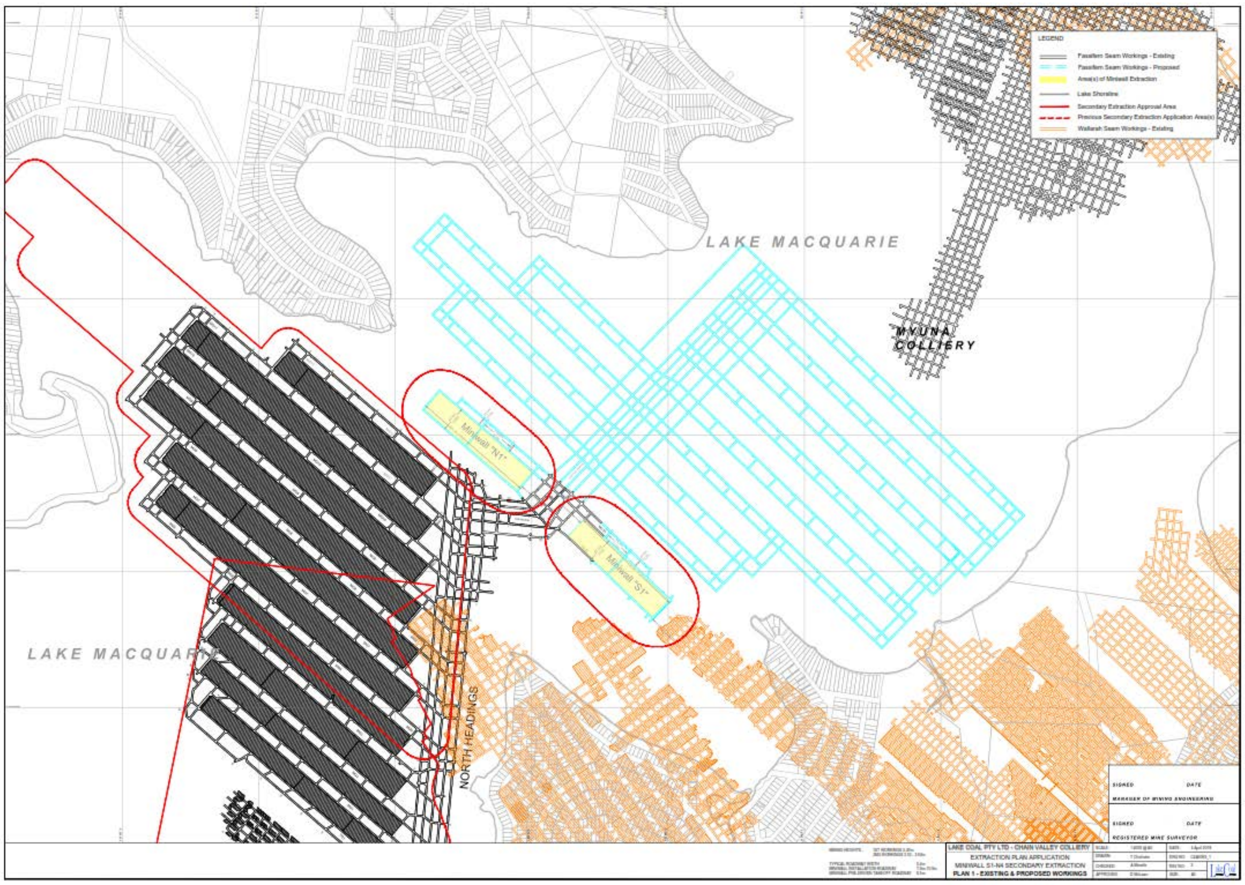


Figure 2- S1 and N1 Extraction Plan Locality.

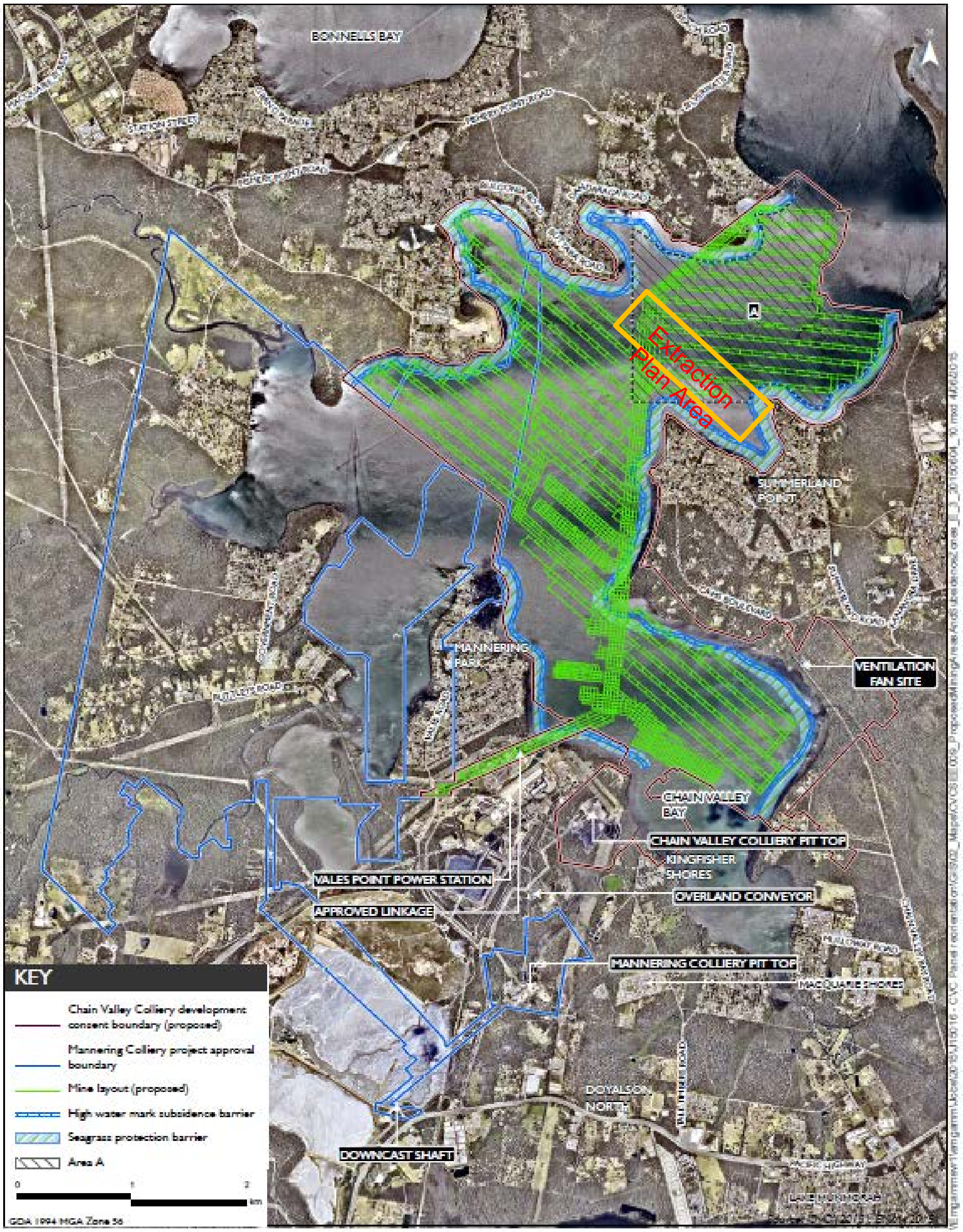


Figure 3- Approved Mining Extension Area Including Proposed S1 and N1 Location within Area A

1.3 Development Consent Conditions

This document has been developed in accordance with Schedule 4 of the site's Development Consent. The associated management plans have been developed in accordance with Schedule 6, Condition 3 of the Approval Conditions and the Guidelines for the Preparation of Extraction Plans. The requirements prescribed in the Approval Conditions relevant to this document are listed in **Table 1.**

Table 1 – Development Consent Conditions

Development Consent Condition - Condition 7 of Schedule 4	Document Reference
The Applicant shall prepare an Extraction Plan for all second workings on site, to the satisfaction of the Secretary. Each Extraction Plan must: a) Be prepared by suitably qualified and experienced persons whose appointment has been endorsed by the Secretary	Section 2.1
b) Be approved by the Secretary before the Applicant carries out any second workings covered by the plan	Section 2.1
c) Include detailed plans of existing and proposed first and secondary workings and any associated surface development, including any applicable adaptive management measures	Appendix 9 Section 3.4.4
d) Include detailed performance indicators for each of the performance measures in Tables 8 and 9	Sections 3.3 & 4.0 Appendix 1
e) Provide revised predictions of the potential subsidence effects, subsidence impacts and environmental consequences of the proposed second workings, incorporating any relevant information obtained since this consent	Section 2.5 and 3.2
f) Describe the measures that would be implemented to ensure compliance with the performance measures in Tables 8 and 9, and manage or remediate any impacts and/or environmental consequences	Sections 3.4 & 4.0 Appendix 1
g) Include a Built Features Management Plan, which has been prepared in consultation with DRE and the owners of affected public infrastructure, to manage the potential subsidence impacts and/or environmental consequences of the proposed second workings, and which • Addresses in appropriate detail all items of public infrastructure and other public infrastructure and all classes of other built features • Has been prepared following appropriate consultation with the owner/s of potentially affected feature/s • Recommends appropriate remedial measures and includes commitments to mitigate, repair, replace or compensate all predicted impacts on potentially affected built features in a timely manner	Section 4

• Include a Benthic Communities Management Plan, which has been prepared in consultation with OEH, LMCC, and DPI Fisheries, which provides for the management of the potential impacts and/or environmental consequences of the proposed second workings on benthic communities, which includes: • Surveys of the lake bed to enable contours to be produced and changes in depth following subsidence to be accurately measured	Section 4 Appendix 4
• Benthic species surveys within the area subject to second workings, as well as control sites outside of the area subject to second workings (at similar depths) to establish baseline data on species number and composition within the communities • A program of ongoing seasonal monitoring of benthic species in both control and impact sites • Development of a model to predict subsidence impact of increased depth and associated subsidence impacts and effects, including but not limited to light reduction and sediment disturbance, on benthic species number and benthic communities composition, incorporating the monitoring and survey data collected; and • Updating the model every 2 years using the most recent monitoring and survey data	
a) Include a Seagrass Management Plan, which has been prepared in consultation with OEH, LMCC, and DPI Fisheries, which provides for the management of the potential impacts and/or environmental consequences of the proposed second workings on seagrass beds, and which includes: • A program of ongoing monitoring of seagrasses in both control and impact sites • A program to predict and manage subsidence impacts and environmental consequences to seagrass beds to ensure the performance measures in Table 8 are met	Section 4 Appendix 5
b) Include a Public Safety Management Plan, which has been prepared in consultation with DRE, to ensure public safety	Section 4 Appendix 6
c) Include a Subsidence Monitoring Program which has been prepared in consultation with DRE, to: • Provide data to assist with the management of the risks associated with subsidence • Validates the subsidence predictions • Analyses the relationship between the predicted and resulting subsidence effects and predicted and resulting impacts under the plan and any ensuing environmental consequences • Informs the contingency plan and adaptive management process	Section 5 Appendix 7
d) Include a contingency plan that expressly provides for adaptive management where monitoring indicates that there has been an exceedance of any performance measures in Tables 8 and 9, or where any such exceedance appears likely	Section 3.4.2 Appendix 1

e)	Include appropriate revisions to the Rehabilitation Management Plan required under Condition 28 of Schedule 3	Section 3.4.3 Appendix 9
f)	Include a program to collect sufficient baseline data for future Extraction Plans	Section 4

1.4 Objective

The objective of this Extraction Plan is to provide adequate management techniques to ensure the protection of the overlying land and lake environment from direct and indirect subsidence impacts associated with the extraction of S1 and N1. This objective will be achieved by:

- The implementation of monitoring and management measures to reduce identified subsidence risks to as low as reasonable practicable; and
- Implement a review and audit system as well as proactive management techniques to ensure that the proposed monitoring and management strategies are effectively controlling subsidence risks and allow for mitigation measures to be implemented if required.

2.0 Extraction Plan Development

This extraction plan has been informed by the Statement of Environmental Effects (SEE 2013 and 2015) and the Multi-Seam Mining Feasibility Investigation (MSMFI). The MSMFI has provided additional detailed assessment over that provided in the SEE's as to the impacts of multi-seam mining and pillar system mechanisms in weak floor environments. Further recent reporting relating to the subsidence exceedance over Miniwalls 1 to 12 (**DGS Report CHV-002-10b**) and updated subsidence assessments for the proposed S1 and N1 layout (**DGS Report CHV-002-11a**), have additionally contributed to the operation's understanding of local subsidence development mechanisms, and the associated required mine design controls for S1 and N1 to maintain subsidence and height of fracturing within currently predicted and approved limits. This has informed risk assessments as to the likelihood of irregular subsidence occurring and what monitoring and subsidence management controls are required. This has culminated in updated subsidence predictions, mine design change recommendations and adaptive management strategies, which have been applied throughout this Extraction Plan.

2.1 Project Team

The project team responsible for the preparation of this Extraction Plan and supporting documents is listed in **Table 2**. In accordance with Schedule 4, Condition 7(a) of the approval conditions, the project team was endorsed by the nominee of the Secretary for the Department of Planning and Environment on 16th January 2018.

Table 2- Project Team

Name	Company	Technical Area
Wade Covey	LakeCoal Pty Ltd	Environmental management
Adrian Moodie	LD Operations Pty Ltd	Subsidence Management, Public Safety, Infrastructure management
Tim Chisholm	LakeCoal Pty Ltd	Mine Surveying, Titles Management, Subsidence monitoring and reporting

Various specialist consultants have been utilised to conduct analysis as part of the SEE and updated subsidence predictions. The technical reports resulting from these analyses have been used to formulate and update the relevant management plans by the project team. The project team worked closely with each of the specialist consultants and corresponded with them throughout the SEE development phase and/or whilst developing the attached management plans. A peer review of this Extraction Plan (**Appendix 11**) has been undertaken by Dr Ismet Canbulat of UNSW, as an independent expert endorsed by the Secretary of the Department of Planning and Environment. Dr Canbulat has also peer reviewed the updated subsidence assessment report (**DGS CHV-002-11a**).

The specialist consultants used are listed in **Table 3.**

Table 3 - Specialist Consultants

Management Plan	Developed By	Associated SEE Specialist Assessment	SEE Specialist	Specialisation/Notes
Extraction Plan Main Document	Wade Covey (LakeCoal)	DGS	Steve Ditton	Subsidence Consultant also utilised for exceedance review and updated subsidence predictions

Management Plan	Developed By	Associated SEE Specialist Assessment	SEE Specialist	Specialisation/Notes
Groundwater Management Plan	Geoterra	Geoterra	Andrew Dawkins	As S1 and N1 EP area contained wholly below Lake Macquarie, only relates to groundwater and water bores
Land Management Plan	Not applicable. S1 and N1 EP area contained wholly below Lake Macquarie			
Biodiversity Management Plan	Wade Covey (Lakecoal)	JSA Environmental	Jemma Sargent	Marine Ecology Assessment (including seagrass and benthic community assessment)
Heritage Management Plan	Not applicable. S1 and N1 area contained wholly below Lake Macquarie			
Built Features Management Plan	Not applicable. S1 and N1 EP area contained wholly below Lake Macquarie. Any further unanticipated requirement for BFMP triggered via Subsidence Management TARP			
Public Safety Management Plan	Wade Covey (Lakecoal)	NA	NA	As relates to adjacent foreshore area features
Rehabilitation Management Plan	Wade Covey (Lakecoal)	NA	NA	As S1 and N1 EP area contained wholly below Lake Macquarie not requiring implementation of rehabilitation. Plan only relevant if impact outside of expected and impact to foreshore occurs
Subsidence Monitoring Program	Tim Chisholm (LakeCoal)	DGS	Steve Ditton	Subsidence predictions including updated prediction

2.2 Agency Consultation

The Department of Planning and Environment have been consulted at the commencement of Extraction Plan development, and during the preparation of the subsidence exceedance report relating to previous Miniwalls 1 to 12, which further relates to this application. The Department of Resources and Energy have been consulted via a High Risk Activity Notification for secondary extraction in Panels S1 and N1 which was submitted on 11 January 2018.

2.3 *Landholder and Community Consultation*

Landholders with registered water bores near Chain Valley Bay were contacted during the environmental assessment. No currently active water bores were identified as requiring management. Similarly, no further impacts to landholders are anticipated from the proposed extraction and thus no further consultation has been required.

Consultation with the local community is undertaken via the site approved Community Consultative Committee (CCC). The committee meets quarterly and is provided with an operational update on Chain Valley Collieries underground operations. The CCC been provided with regular updates on the status of the sites subsidence monitoring and reporting, and the Extraction Plan for the application area.

2.4 *Infrastructure Owner Consultation*

The only infrastructure identified within the S1 and N1 extraction plan area of impact, relates to Navigational markers located off Sugar Bay and Summerland Points. Roads and Maritime Services Project Officer (North Area) has been contacted during the development of the Extraction Plan and referred the matter to the RMS asset team, resulting in no further immediate actions required in regard to management of the markers.

It is noted that the revised mine plan for the S1 and N1 Panels prepared for this EP Application results in negligible impact to these markers.

2.5 *Subsidence Predictions and Impact Review*

The subsidence assessment (**DGS, 2015**) completed to support the modification SEE (MOD 2) reviewed available subsidence data as at the time of reporting (Chapter 7). This included updated subsidence data from Miniwalls 1 to 8 along with existing historic subsidence data from surrounding extracted areas. More recent subsidence data over Miniwall's 1 to 12, revealed that the actual incremental subsidence from bathymetric survey was approximately 0.37m above maximum predicted (**DGS CHV-002-10b**).

It was assessed that time-dependent subsidence associated with chain pillar overloading in soft floor conditions was resulting in subsidence above original predictions (0.78m maximum predicted), with the data and associated analyses indicating that the subsidence is likely to be driven by:

(i) the increase in span of the Munmorah Conglomerate and subsequent decrease in overburden stiffness, and

(ii) the increased stress applied to the central chain pillars by the deflecting conglomerate likely to having exceeded the bearing strength of the moisture sensitive claystone floor strata. Updated numerical modelling calibrated to these results and representing these mechanisms, has now been allowed for in updated subsidence modelling (**DGS CH-002-11a**) for the Extraction Plan area.

Further detailed review as a part of the Multi Seam Mining Feasibility Investigation (“MSMFI”) for Chain Valley Bay has provided a detailed analysis analytical approach for multi-seam workings and associated pillar stability effects. This is relevant to a localised area of potential interaction super-adjacent to the inbye end of Miniwall S1 (refer to **Section 3.1.5** for summary outcomes and proposed management strategy).

The following surface and subsurface features of significance were identified from the assessments and area inspections within the zone of predicted subsidence (**Figure 4**), or with the potential to be affected by far-field movements as a result of the proposed Fassifern Seam workings. These include:

- Lake Macquarie and its bed sediments;

  Benthic fauna communities on the lake bed
- Groundwater
- The Northern Navigational Marker within the Lake
- Jetties, retaining walls
- Steep slopes/ cliff areas

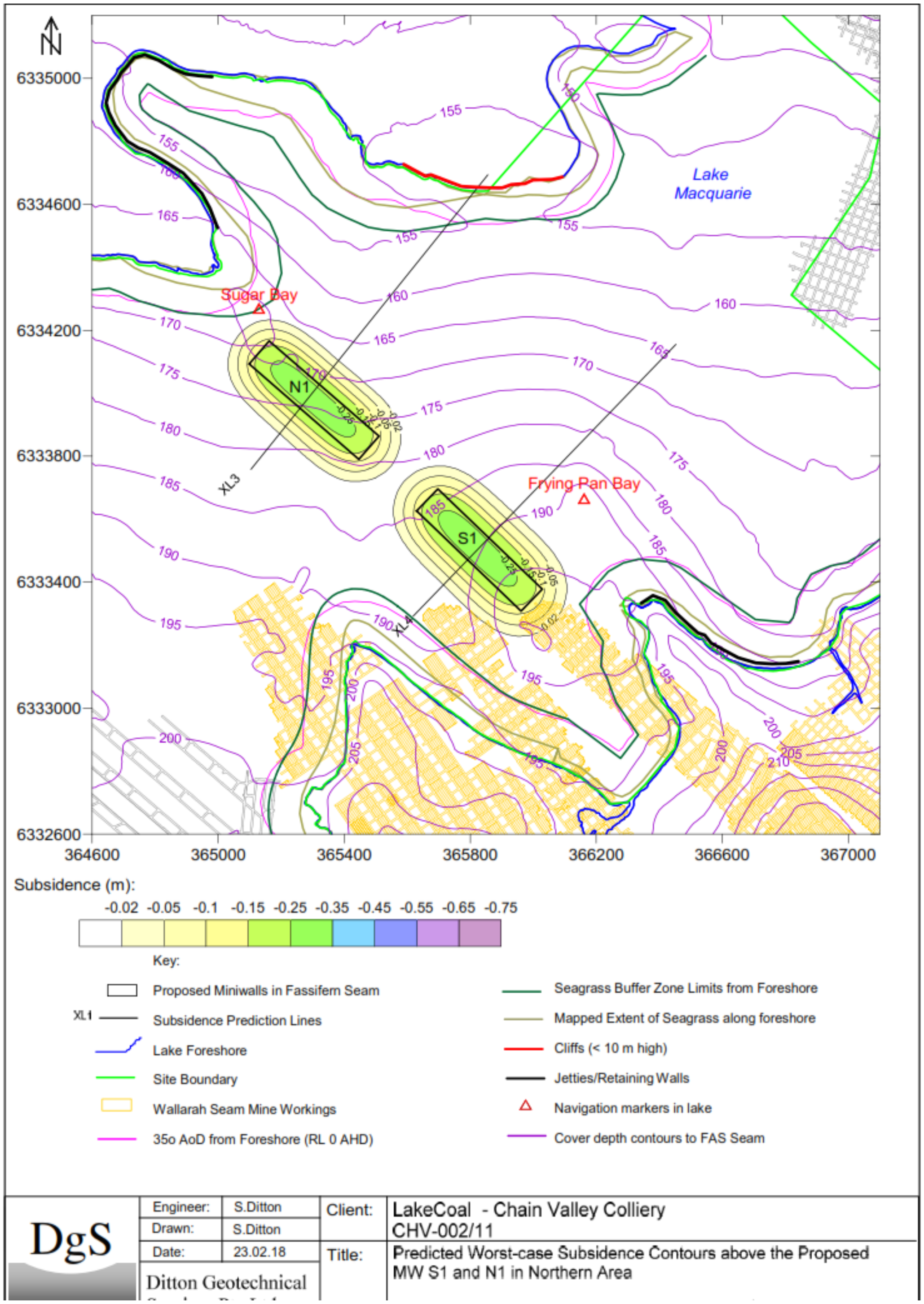


Figure 4: Predicted Subsidence after S1 and N1

These have all been reassessed in terms of the updated subsidence predictions in **DGS CHV 002-11a**, following a similar process to the previous SEE and via the Extraction Plan Risk Assessment (**Appendix 2**).

Additionally, the following surface and subsurface features are located adjacent to the immediate area of subsidence and as such will be managed, should unexpected changes / impacts occur in association with Fassifern Seam mining in the S1 and N1 Panels:

- Seagrass beds;
- High water mark (RL 0.0m to RL 2.44m AHD) along the lake foreshore
- Residential buildings and other built features adjacent the foreshore
- Moorings

3.0 <u>Overview</u>

3.1 Mine Planning and Design

3.1.1 Area covered by this Extraction Plan

The area adjacent the proposed workings has been extensively mined over the past 60 years, primarily in the overlying Wallarah Seam and, to a lesser extent, the Fassifern Seam (see **Plan 4, Appendix 9**). The North Mains first workings access the mining area on the Fassifern Seam, noting that previously extracted miniwall and bord and pillar panels are outside the angle of draw.

The Extraction Plan area consists of 2 miniwall panels (S1 and N1) with a surface effect area covering 37ha wholly beneath Lake Macquarie (see **Figure 5**). Panels are aligned in a south-east to north-west orientation and S1 is planned to be extracted first. This could be changed without impact to subsidence management outcomes.

As all extraction and subsidence impacts from the proposed mining layout are beneath the lake, surface features are limited to the lake floor and the northern marine navigational marker. It is not expected that the lake foreshore or surrounding seagrass will be impacted (see **Figure 5**). Mine design has been the primary control to limit impact or prevent predicted subsidence exceedance; thus the application of the High Water and Seagrass barriers, as well as the various mine plans changes ~~and~~ indicated below.

3.1.2 Proposed mine layout

In 2016, the operation unexpectedly encountered large-scale faulting, necessitating alternative mining areas be extracted whilst the Northern Domain could be further explored, mine plans re-evaluated and approvals sort. This has resulted in the mine plan variation in this application. A primary consideration in this plan was management of the large-scale normal fault structures with respect to safety, productivity and subsidence management. Miniwall's S1 and N1 are thus orientated SE-NW, near-parallel to the structures, but with significant barriers. As such, extraction will not pass through or beneath the hade (hanging wall) of the faults. The location and impact of the proposed mine design is generally consistent with the current State Significant Development Consent (SSD-5465 MOD 2). A summary of the mine design changes, informed by the mining studies and updated subsidence assessments implemented by LakeCoal in the proposed mining area are outlined below.

Table 4: Mine Plan Changes

Approved Layout Change	Justification for Modification
Re-orientation of panels from E-W to SE-NW	Maximise recovery, whist avoiding the large faults thus managing potential subsidence impacts or risk of inter-connective fracturing irregularities.
Reduction in S1 Panel length	Creation of a sufficient barrier between the S1 Panel and the adjacent Wallarah Seam partial extraction workings to have negligible stress interaction.
Reduction in N1 Panel length	Implementation of the approved seagrass barrier following remapping and ground truthing undertaken as part of this extraction plan.

These modifications are considered generally consistent with the Development Consent and result in an overall reduction in impact, providing an example of adaptive management being applied to extraction within the mining area.

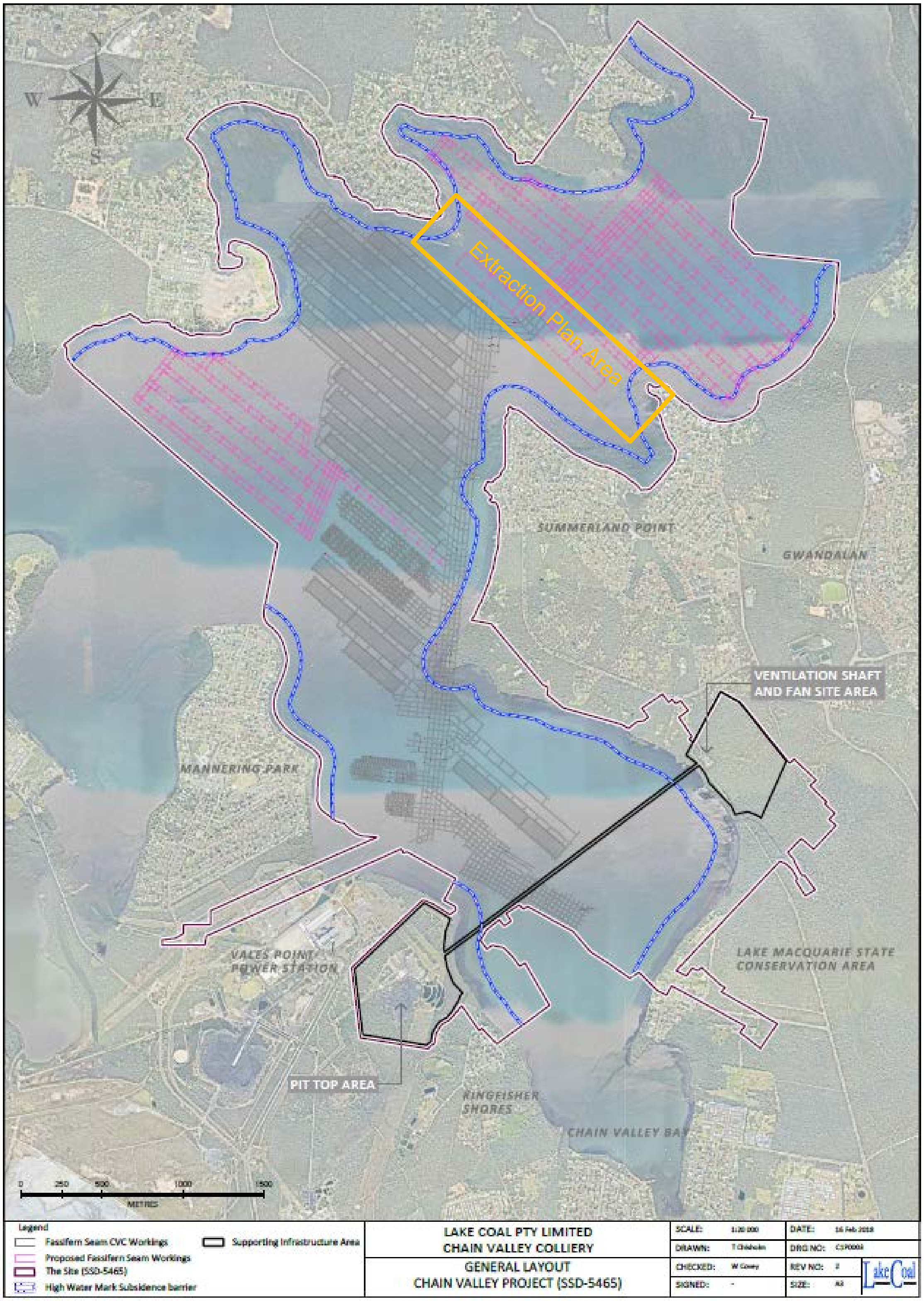


Figure 5- Varied Northern Domain Proposed Mine Plan

3.1.3 Mining Domains (extracted and approved)

The extraction plan area is covered by the following leases:

1. ML1051
2. ML 1632

These leases and the domain areas described below are shown on **Figure 6,** and referenced in Plan 5, Appendix 9.

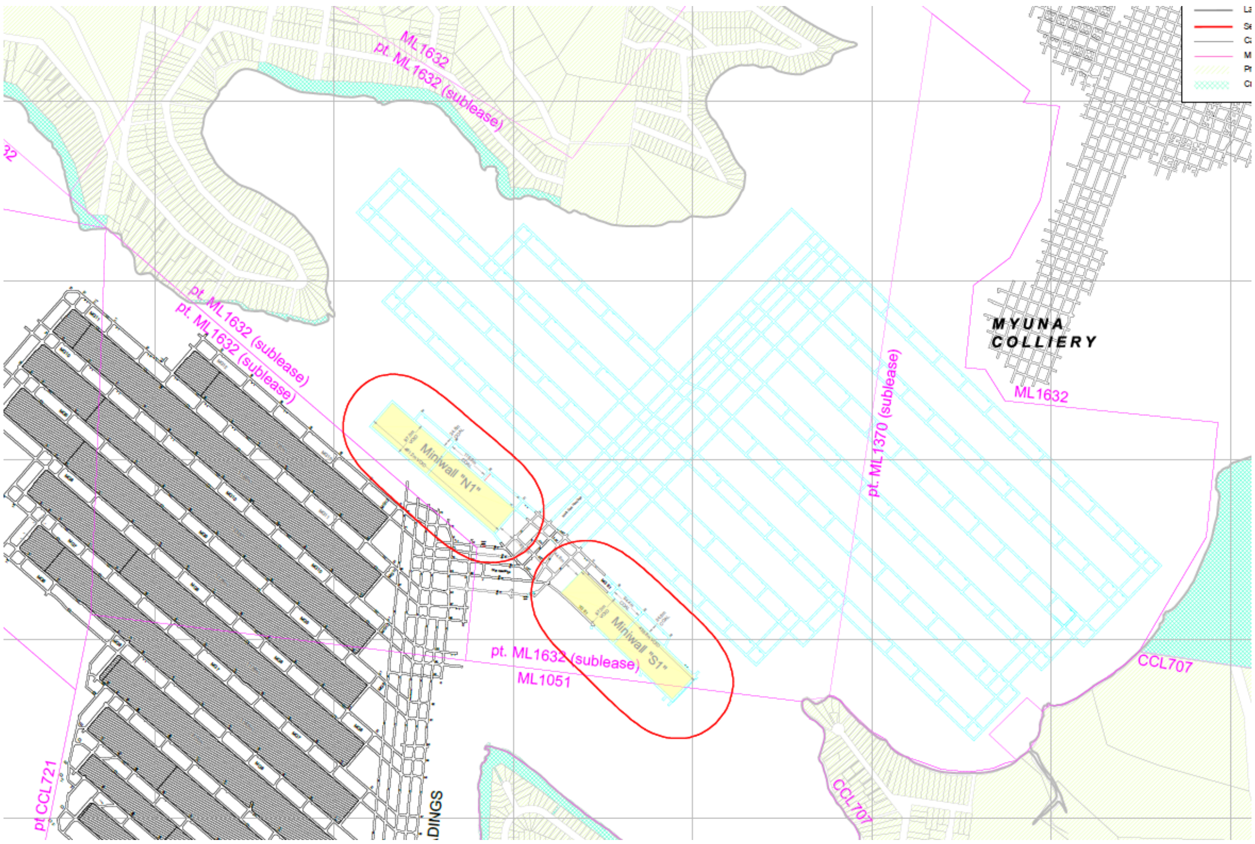


Figure 6- Chain Valley Bay Leases and Land Ownership

Overlying Wallarah Seam Workings

Only previous Wallarah Seam partial extraction workings are associated with the Extraction Plan area; these are adjacent to, but not directly above the proposed workings. The Wallarah Seam workings are some 80m above the Fassifern Seam, with the interburden consisting of claystone, sandstone, coal seams and thick conglomerate beds.

Existing Chain Valley First Workings and Extraction

Extraction has occurred in Fassifern Seam Miniwall's 1 to 12, adjacent to the area and covered by a previous Extraction Plan. The first workings currently used to access Chain Valley Colliery and the Extraction Plan application area panels adjoin these extraction areas. No subsidence or abutment loading interaction would be expected between these domains, due to the adequate barrier pillars and long-term stable (life of mine) main heading pillars.

Future Chain Valley Mining

As outlined in **DGS CHV002-10b** (updated MW1-12 exceedance report) and **DGS CHV002-11a** (updated S1 and N1 subsidence assessment report), it is proposed to limit extraction in the initial approval area to two panels (S1 and N1). This is intended to enable the mine to:

- gain additional monitoring data to validate the updated subsidence predictions, improve knowledge on the subsidence development mechanisms and controls, as well as
- optimise the future layout.

This provides continuity of operations and minimises the risk of any further exceedance of predicted subsidence.

Accordingly, a future Extraction Plan will be prepared for Panels S2-8 and N2-4, directly north of this area. It is important to note that the future area to the north is sufficiently isolated to have no practical bearing on the proposals in this current Extraction Plan application.

3.1.4 Mining parameters

The proposed mining is via miniwall methods with panel widths of 97m (total extracted void) accessed by a combination of:

- twin gateroads separated by 24.6m (solid width) chain pillars and
- single entries in the inbye portions and tailgates (see **Plan 1, Appendix 9**).

A miniwall is essentially a longwall with a reduced face width. Miniwall methods offer a low operating cost, high production rate and operationally safer alternative to pillar extraction mining methods previously employed at CVC. The reduced panel widths allow for the maintenance of bridging overburden conditions, reducing subsidence and improving face conditions.

The Fassifern Seam in the application area ranges between 4.8m and 5.6m thick, Depth of Cover is between 170m and 200m. It is proposed to extract a maximum of 3.5m on the miniwall and 3.2m in development, leaving coal both on the floor and in the immediate roof. Floor coal provides a protective layer above the underlying claystones, which are highly susceptible to deterioration, if exposed to water and atmosphere. They are also readily broken up by mining equipment, greatly impacting roadway conditions where exposed. The roof coal is of significantly higher ash content and would negatively impact on the saleability of the coal product; left in place, it contributes to improved roadway roof conditions on development.

The maximum extraction height has been required to be adjusted where the potential for the minimum constrained zone thickness (12T +10m where T is the extraction thickness) to not be present at 3.5m extraction height, and thus present an increased risk of water inflows. Where sub-critical panel geometries can be reasonably assumed (ie single or two adjacent panels) the Ditton and Merrick (2014) geology model has been applied to determined heights of fracturing. Where supercritical panels geometries are assumed, the Forster (1995) model has been utilised. As reported in DGS CHV002-11, the following maximum extraction heights (**Table 7**) are thus recommended and are to be applied. Where sufficient information has been gained to accurately determine the depth of sediments and weather rock (ie rock head RL), via methods such as sonar, then this may be adjusted by removing additional 10m requirement above 12T.

Tables 5 to 8 provide a summary of key mining parameters for S1 to N1.

Table 5- Coal Recovery within the Extraction Plan Area

Total Resource (Extraction Plan area 37ha)	**2.7Mt**
Total Development extraction	**0.10Mt**
Total Miniwall Extraction	**0.41Mt**
Total Reserves Extracted	**0.51Mt**
Percentage Recovery	**20%**

Table 6-Miniwall Panel Geometry

Panel	Panel Length (m)	Void Width (m)	Extraction Height (m)	ROM Tonnes (Mt)
S1	437	97	3.5	0.2
N1	461	97	3.5	0.21

Table 7- Fassifern Seam Parameters and Development Roadway Geometry

Panel	Seam Thickness (m)	Depth of Cover (m)	Drivage Width (m)	Drivage Height (m)
S1	5.0-5.2	185-195	5.4	3.2
N1	5.2-5.5	170-180		

Table 8- Estimated Mining Schedule

Panel	Start Date	End Date	Estimated Duration (months)
S1	May-2018	Aug-2018	4
N1	Sep-18	Dec-18	4

3.1.5 Existing workings and multi-seam interactions

The following was concluded in **DGS Report CHV-002-11a**:

- If the inbye end of S1 Panel is immediately sub-adjacent to the limit of the Wallarah Seam partial extraction workings, the potential for additional subsidence due to abutment stress interaction is 'high', given the marginal Stability Indices (between 2.0 and 2.2) of the first four rows of Wallarah Seam pillars.
- The Stability Indices of the Wallarah Seam pillars improve to >3 beneath the seagrass and foreshore areas.

- A minimum pull-back distance of 72.5 m from the S1 Panel void to the first row of Wallarah Seam pillars is recommended to minimise potential stress interaction impacts (this reduces the estimated stress increase on the closest row of Wallarah Seam pillars to only 0.2MPa). This is the equivalent of a horizontal buffer width of 30 m between the S1 Panel start in the Fassifern Seam and the Wallarah Seam goaf.
- The faults are not anticipated to create any adverse or irregular stress interactions between the workings.

Having considered the S1 Panel situation in the context of recent experiences, the mine has elected to increase the buffer zone between between S1 and the Wallarah workings by a further 21.5m (total barrier width of 94m). Using the same analysis as the DGS report, this results in a zero stress situation on the Wallarah Seam pillars. It is also the equivalent of a 33º angle of draw between the limits of the Fassifern and Wallarah Seam workings.

3.1.6 Special subsidence management features

Thin beds of claystone in the Fassifern Seam floor have been attributed to increases in floor heave under higher pillars loads associated with the extraction of multiple panels. The potential for increased subsidence effects associated with softening and lateral squeezing of the claystone has been noted and accounted for in the updated analyses. As per **DGS Report CHV-002-11a**, the low final (single abutment) pillar stresses associated with the isolated S1 and N1 Panels are not anticipated to have any adverse or irregular subsidence effects.

Also as per **DGS Report CHV-002-11a**, the S1 and N1 Panels are offset from the faults, which are therefore not anticipated to have any adverse or irregular subsidence effects.

3.2 Subsidence Predictions

Subsidence magnitudes and impacts have previously been estimated for the proposed Life of Mine design for Chain Valley Colliery, including the area associated with this Extraction Plan (**DGS, 2015**). The methodology used to predict subsidence was originally based on the results of **ACARP Project C10023 (ACARP, 2003)** as well as a review of subsidence data from previously extracted MWs 1 to 9 at Chain Valley Colliery and nearby Mannering (Wyee) Colliery's LW17 to 23. This information was re-analysed for the Miniwall 1 to 12 exceedance investigation (**DGS Report CHV-002-10b)**, culminating in an updated Extraction Plan subsidence assessment specific to the proposed S1 and N1 Panels (**DGS Report CHV-002-11a**).

In assessing factors that affected subsidence for this Extraction Plan, consideration was given to:

- depth of cover,
- rock head cover,
- panels width,
- the spanning capabilities of the conglomerate-dominated overburden,
- the properties of the floor (in particular the weak and moisture sensitive claystone units),
- the potential for additional long-term subsidence / creep,
- the location of the proposed extraction outside of both the HWMSB and the Seagrass Protection Barriers,
- the area of potential multi-seam interaction.

Predicted subsidence effect parameters for S1 and N1 Panels are summarised in **Table 9**.

Table 9 - Predicted Subsidence Effects

Panel	Subsidence (m)		Angle of Draw	Long-Term Tilt & Strain Maxima (mm/m)		
	Short-Term	Long-Term		Tilt	Tensile Strain	Compressive Strain
S1	0.1	< 0.5	<35	< 5	<1.5	<2.5
N1	0.1	< 0.5	<35	< 5	<1.5	<2.5

3.2.1 Lakebed fracturing

Ditton (2015) indicates that, based on previous experience at nearby mines, it can be assumed that any surface cracking to the rock head below the lake bed sediments is likely to be minor for the predicted range of surface subsidence magnitudes. Tensile strains are predicted to be up to 1.5mm.

Based on a predicted maximum tensile strain of 1.5 mm/m, maximum crack widths are estimated to be < 20 mm at rock head. It is likely that any cracks that occur will be naturally 'filled' by lake bed sediments with no impact on the lake bed itself. The strains at the lake bed surface itself will also be more uniformly distributed and are therefore more likely to be absorbed by the plastic nature of the sediments.

3.2.2 Sub-surface Fracturing

Figure 7 illustrates the sub-surface fracturing model adopted for this application, based primarily on **Forster (1995)**. A predicted height of connective cracking of 21 to 33 times the extraction height (T) is considered worst-case for 'supercritical' panel or mining width geometries overlain by massive conglomerate units in the Lake Macquarie Coalfield.

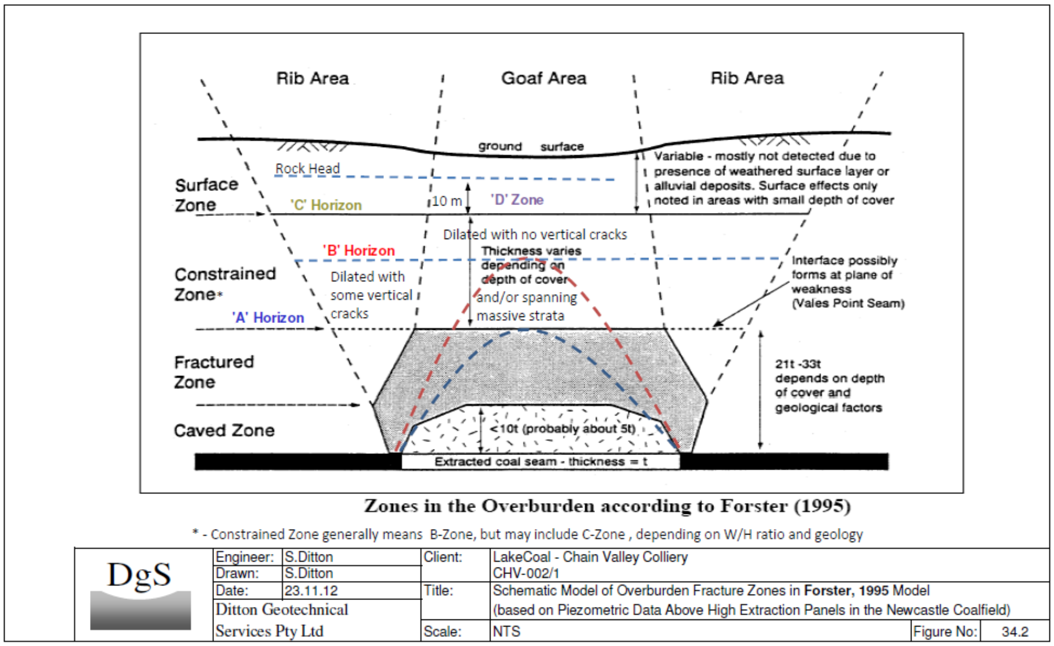


Figure 7- Overburden Fracture Zones (Ditton, 2013)

The **Ditton & Merrick (2014)** model includes the Forster data and may be used to assess both sub-critical and supercritical panel geometries. **DSG Report CHV-002-11a** back analysed sub-critical and supercritical behaviour relating to height of fracturing for previous Wyee and Chain Valley panels and found these models to provide reliable height of fracturing predictions. The results for a mining height (T) of 3.5m are summarised in **Table 10**.

Table 10 - Predicted Heights of Fracturing Above Panels S1 and N1 (DGS Report CHV-002-11a)

Panel (S=Start) (F=Finish)	Effective Cover Depth (m)	Rock Cover (m)	21 – 33T (Forster, 1995) (m)	A Zone Height Range for Sub-Critical Panels (Ditton and Merrick, 2014) (m)	Constrained Zone Thickness below Rock Head (m)	
					Predicted Minimum from Ditton and Merrick (m)	12T+10 / 12T Criterion (m)
N1 (S)	170	153	73.5 – 115.5	81 - 96	57	52 / 42
N1 (F)	177	158		83 - 98	60	52 / 42
S1 (S)	198	184		88 - 103	81	52 / 42
S1 (F)	185	168		85 - 100	68	52 / 42

Based on the sub-critical nature of the isolated panels, the **Ditton and Merrick** model indicates that there is sufficient cover to meet a minimum constrained zoned thickness of 12T +10m (**Forster, 1995)**. This is consistent with the successful application of the model in the MW1-12 area, noting that MWs 11 and 12 involve similar depths of cover.

If the rock cover thickness variation is known, then the minimum cover requirement may be reduced to 12T or 42 m (refer **Li et al, 2006**). LakeCoal is investigating options to more accurately determine the depth to solid rock head over the Extraction Plan area, with a view to adopting the ‘12T’ criterion.

3.2.3 Potential Environmental Consequences

Based on the same level of predicted maximum panel subsidence, tilt and strain values for the miniwall panel layouts, the potential for the following subsidence related impacts and their likely effect on the natural and man-made features within the Site have been assessed in the Statement of Environmental Effects (SEE) (2013 and 2015) and Extraction Plan Risk Assessment (**Appendix 2**):

- Changes to lake bed level;
- Surface cracking beneath the lake bed;
- Height of sub-surface fracturing above the panels (direct and in-direct hydraulic connection zones) potentially impacting groundwater; and
- Impacts on the foreshore of Lake Macquarie and surrounding natural and man-made features inclusive of public safe risks

The Extraction Plan risk assessment additionally evaluated overall environmental risk (as it relates to subsidence impact) for the extraction plan area. From this and via application of mine design controls (**Section 3.1.2**) along with monitoring and response management systems (i.e. TARPs), the risk of irregular subsidence impacting the foreshore or sensitive environmental features was considered unlikely.

In terms of changes to the lake bed level as a result of subsidence, the resultant impact on Benthic communities, Seagrass communities and wave climate have been assessed within the SEE. A Marine Ecology Impact Assessment was conducted by JSA Environmental as part of the SEE completed by EMM in 2013 and reviewed in 2015 which included the full Extraction Plan area. As part of this assessment, an aquatic biological survey was conducted including soft bottom benthic communities and seagrass mapping. Recent ground truthing of the seagrass beds since the original mapping has been utilised along with additional mapping data and satellite imagery to provide the most accurate location of seagrass beds and as such protection barrier offsets for mine design.

Considering the survey results, the proposed mine plan and the modelled subsidence predictions, JSA Environmental concluded that there would be no more than minor impacts on Benthic Communities and negligible impacts on seagrass levels as a result of the proposed mining. This has been supported through the monitoring results over time. Given the additional mine plan controls since the SEE, these impacts would not be expected to increase. Bathymetric surveys conducted by Astute Surveying will increase to 6 monthly to validate and update predictions and control effectiveness, including survey prior to any secondary extraction within the application area. The results of the bathymetric surveys will be used to confirm the predicted subsidence levels and the mapping of seagrass levels and benthic communities will be ongoing throughout the period of extraction within the application. This will confirm that subsidence and associated impacts are being maintained within predicted levels.

Leading wave climate experts from the University of New South Wales, Water Research Laboratory concluded that the predicted subsidence will not affect the wave climate sufficiently to have adverse shoreline impacts. Change’s to the sea bed level will also have the potential to impact man made features.

In regards to surface cracking beneath the lake bed, as stated above, the strains at the lake bed surface itself are expected to be more uniformly distributed and are therefore more likely to be absorbed by the plastic nature of the sediments. Any cracks are therefore likely be naturally filled by lake sediments with no significant impact on the lake bed itself. The predicted heights of continuous and discontinuous fracturing above the proposed miniwalls are below the logged rock head thickness above the panels, and provide for sufficient constrained zone thickness at the adjusted extraction heights. As such, it is considered very unlikely that hydraulic connection between the lake and the mine workings will occur, or that connection between mining related fractures and the lake will cause significant impacts on the lake. Additional monitoring, including extension of the sites water balance and management TARP, will be put in place to monitor for early signs of unexpected interaction of the lake with the major geological faults and mine workings.

In regard to the surface features, namely the lake foreshore and features surrounding the foreshore, both the HWMSB and the Seagrass Protection Barrier have been closely applied in the mine design process. Monitoring and TARPs will still be applied to identify and respond to any unanticipated changes as a result of Fassifern extraction, and further adaptive management and contingency controls will be implemented as required. The risk assessment for the extraction plan area identified the potential impact to navigational markers as a key variable for the extraction plan. At the predicted subsidence levels each is considered easily manageable and will also be done so via the Subsidence Management TARP.

Table 13- Navigation Marker Predicted Subsidence Parameters

Location / ID	Predicted Subsidence (m)	Predicted Tilt (mm/m)
Sugar Bay (Adjacent to N1)	0.1	1

3.3 Performance Objectives

3.3.1 Development Consent Approval Requirements

Condition 1, Schedule 4 of SSD-5465 states:
"*The Applicant shall ensure that vertical subsidence within the High Water Mark Subsidence Barrier and within Seagrass beds is limited to a maximum of 20 millimetres (mm). If at any stage predicted subsidence levels are exceeded within these area, an ecological monitoring program shall be initiated to assess the impacts to ecological communities and threatened species and if appropriate, offsets are to be provided for any impacts detected*"

At present there is no expectation that predicted subsidence levels will be exceeded based on actual subsidence monitoring and the recently (2017/18) updated subsidence predictions. The adopted mine design has been developed to result in no additional subsidence impact due to Fassifern Seam extraction in the High Water barrier or Seagrass. Despite this, a Subsidence Management TARP is to be implemented as outlined in **Section 3.4** of this management plan to deal with unanticipated subsidence monitoring results in a proactive manner should in the unlikely event they occur.

In addition to the above, Condition 2 within Schedule 4 of SSD-5465 also requires that:

"The Applicant shall ensure that the development does not cause any exceedance of the performance measures in Table 8 to the satisfaction of the Secretary."

The relevant subsidence requirements from Table 8 within Schedule 4 of the Development Consent, including the relevant notes, are recreated in **Table 14**.

Table 14 - Performance Measures - Natural & Heritage Features

Biodiversity	
Threatened species or endangered populations	Negligible environmental consequences
Seagrass beds	Negligible environmental consequences including: • Negligible changes in size and distribution of seagrass beds; • Negligible change in the function of seagrass beds; and • Negligible change to the composition or distribution of seagrass species within seagrass beds.
Benthic communities	Minor environmental consequences, including minor changes to species composition and/or distribution
Mine Workings	
First Workings under an approved Extraction Plan beneath any feature where performance measures in this table require negligible environmental consequences	To remain long term stable and non-subsiding
Second Workings	To be carried out only in accordance with and approved Extraction Plan.

Notes:

• The Applicant will be required to define more detailed performance indicators (including impact assessment criteria) for each of these performance measures in the various management plans that are required under this consent (see Condition 7 below).

• Measurement and/or monitoring of compliance with performance measures and performance indicators is to be undertaken using generally accepted methods that are appropriate to the environment and circumstances in which the feature or characteristic is located. These methods are to be fully described in the relevant management plans. In the event of a dispute over the appropriateness of proposed methods, the Secretary will be the final arbiter.

• The requirements of this condition only apply to the impacts and consequences of mining operations, construction or demolition undertaken following the date of approval of this consent.

Fassifern first workings in the Extraction Plan area, are not beneath any feature outlined in **Table 14**. Should a change to first workings necessitate this, the first workings will be designed to be long term stable.

Again a Subsidence Management TARP will be implemented as outlined in **Section 3.4** of this management plan to deal with such matters in a proactive manner should in the unlikely event more than negligible/minor impacts occur. The TARP also includes more detailed performance indicators.

Condition 4 within Schedule 4 of SSD-5465 also requires that:

"The Applicant shall ensure that the development does not cause any exceedances of the performance measures in Table 9, to the satisfaction of the Secretary.

The relevant subsidence requirements from Table 9 within Schedule 4 of the Development Consent, including the relevant notes, are recreated in **Table 15**.

Table 15 – Subsidence Impact Performance Measures – Built Features

Built Features	
Trinity Point Marina Development Other built features	• Always safe • Serviceability should be maintained wherever practicable. Loss of serviceability must be fully compensated • Damage must be fully compensated
Public Safety	
Public Safety	Negligible additional risk

Notes:

- *The Applicant will be required to define more detailed performance indicators (including impact assessment criteria) for each of these performance measures in measures in the Built Features Management Plans or Public Safety Management Plan (see Condition 7 below).*
- *Measurement and/or monitoring of compliance with performance measures and performance indicators is to be undertaken using generally accepted methods that are appropriate to the environment and circumstances in which the feature or characteristic is located. These methods are to be fully described in the relevant management plans. In the event of a dispute over the appropriateness of proposed methods, the Secretary will be the final arbiter.*
- *The requirements of this condition only apply to the impacts and consequences of mining operations, construction or demolition undertaken following the date of approval of this consent.*
- *Requirement's regarding safety or serviceability do not preclude preventative actions or mitigation being taken prior to or during mining in order to achieve or maintain these outcomes.*
- *Requirement's under this condition may be met by measures undertaken in accordance with the Mine Subsidence Compensation Act 1961.*

The extraction plan area is outside any zone that may affect the Trinity Point Marina Development.

Again a Subsidence Management TARP will be implemented as outlined in **Section 3.4** of this management plan to deal with other Built Feature or Public Safety matters in a proactive manner. The TARP also includes more detailed performance indicators.

3.3.2 Other Approval Requirements

Additional to Approvals required under Development Consent SSD-5465, LakeCoal will require the following related approvals or notifications prior to extraction in the area:

- Secondary Extraction High Risk Activity Notification required under Clause 33 (1) of the Work Health and Safety (Mines) Regulations 2014.

3.4 Subsidence Management Strategies

3.4.1 Mine design elements

Mine design parameters such as panel start and finish position, panel width, chain pillar width and barrier pillar width in conjunction with an assessment of overlying strata, depth of cover and depth of rock head all contribute to the management of vertical subsidence effect and impacts. Whilst, restricting the mine design such that no secondary extraction occurs within the High Water Mark Subsidence Barrier and the Seagrass Protection Barrier to ensure that there are no significant impacts on the foreshore of Lake Macquarie or the seagrass communities in the shallow foreshore areas.

The outcomes of the updated subsidence predictions have further informed the mine design strategies to be undertaken as outlined in **Section 3.1.2**. The mine design adaptive management recommendations have been applied to the final mine design.

3.4.2 Subsidence Monitoring and Management

The overall framework for subsidence monitoring and management of impacts under this Extraction Plan may is described by:

Figure 10- Subsidence Monitoring and Management Framework

Details as to the respective triggers/performance indicators (including actual measured subsidence and inspections for environmental impact) as they relate to each environmental management function are found in the respective Key Component Plans (**Section 4**). These management plans also include specific information regarding the subsidence monitoring requirements (including baseline monitoring), remediation and adaptive management techniques and contingency plans. All of which are summarised in the Subsidence Management Triggered Action Response Plan (TARP) included in **Appendix 1**. The TARP aims to consolidate all subsidence management requirements into a central focus point, triggering a response or set of responses commensurate with the nature of the measurement or the impact that has been identified.

3.4.3 Remediation strategies

Remediation strategies are incorporated into the Subsidence Management TARP (**Appendix 1**). These also follow the principals outlined in the current Rehabilitation Management Plan (see **Appendix 8**). Mining and associated impacts in the extraction area are identical to that proposed elsewhere in the current MOP and as such, no modifications to the existing Rehabilitation Management Plan are required for the submission of this document.

3.4.4 Adaptive Management Strategy

The CVC Subsidence Management TARP includes a series of triggers and responses to impacts that exceed those predicted. The extensive mining history in and around this area of the lake has greatly improved the ability to predict subsidence levels and developed mine design guidelines to protect against foreshore, seagrass and lake bed impacts. That combined with the recent history at CVC using similarly designed miniwall panels suggests that exceedances of predicted subsidence effects and impacts are unlikely. However, the routine collection of data such as regular bathymetric surveys, foreshore subsidence surveys, ground water assessment, seagrass mapping and benthic community surveys will allow rapid and proactive verification of both initial and final subsidence effects and impacts such that adaptive measures such as mine design changes, increased barrier pillars, widening of protection zones etc can all be undertaken in a timely manner to mitigate against and minimise the impact of these unforeseen exceedances.

3.4.5 Procedures for investigation of incidents

In accordance with Condition 6 Schedule 7 of Development Consent SSD-5465 CVC will notify the Secretary and any other relevant agencies, of any incident or non-compliance or exceedance of performance criteria associated with the Extraction Plan performance at the mine complex as soon as practicable after CVC becomes aware of the incident.

Within 7 days of the date of the incident or non-compliance, CVC will provide a detailed report on the incident to the Director-General and any other relevant agencies notified. The incident investigation will follow the CVC incident reporting and investigation policy.

3.4.6 Procedures for quality assurance and review

The results of monitoring undertaken in accordance with this Extraction Plan will be provided on a quarterly basis to the CVC Community Consultative Committee.

Regular review of the Extraction Plan and/or any of the sub-plans is required by SSD-5465. In particular, CVC is required to review, and if necessary revise, the strategies, plans, and programs of this Extraction Plan within 3 months of the submission of an:

- Audit under condition 9 of schedule 6;
- Incident report under condition 7 of schedule 6; and
- Annual Review under condition 4 of schedule 6.

Any revision to the Extraction Plan including component sub-plans must be completed to the satisfaction of the Secretary.

3.4.7 Complaints

Complaints in relation to the management of subsidence will be managed using the established protocols in the CVC Environmental Management System.

4.0 Key Component Plans

Management of impacts identified via the Subsidence Monitoring Program under this Extraction Plan (**Section 5**), are commensurate with the nature of the measurement or the impact which has been identified. The Extraction Plan relies on a set of individual management (Key Component) plans to address these impacts to particular environmental or built features within the Extraction Plan Area. As per the Guidelines, six (6) key component plans are to be considered as per **Table 16**, however following risk assessment (**Appendix 2**) for the extraction plan area, particular to S1 to N4 only three (3) are relevant and as such have been developed as a part of this Extraction Plan.

Whilst a Built Features, Land Management Plan and a Heritage Management Plan are specific requirements of the Approval Condition 7 in Schedule 4, the notes below Condition 3 of Schedule 6 in the Approval Conditions state "*The Secretary may waive some of these requirements if they are unnecessary or unwarranted for particular management plans*", and as such it is considered that these plans are not required. All proposed secondary extraction is located outside of both the High Water Mark Subsidence Barrier and Seagrass Protection Zone and as such, no adverse impacts are anticipated on the immediate foreshore of Lake Macquarie.

Table 16 –Key Component Plan Requirements

	Relevant to S1 and N1	Comments
Water Management Plan	Yes	Ground water extraction and water bore drawdown managed via existing Site Water Management Plan
Land Management Plan	No	S1 and N1 is wholly contained below lake Macquarie and as such extraction itself will not have any effect on land management being controlled via the application of the High Water Mark Subsidence Barrier and Mine Design recommendations
Biodiversity Management Plan	Yes	The existing site Biodiversity Management Plan incorporates two separate management plans relevant to S1 to N1 extraction; the Seagrass and Benthic Community Management Plans
Heritage Management Plan	No	S1 to N1 is wholly contained below lake Macquarie and as such extraction itself will not have any effect on Heritage items being controlled via the application of the High Water Mark Subsidence Barrier
Built Features Management Plan	No	S1 to N1 is wholly contained below lake Macquarie and as such extraction itself will not have any effect on built features above the High Water Mark. No features were identified as requiring direct management within the lake area impacted by S1 to N1. Navigation markers will be monitored but are not expected to require any management and thus will be triggered via a TARP for unexpected impact.
Public Safety Management Plan	Yes	Foreshore potentially only impacted due to far field movement near cliffs with very low likelihood of impact resulting in public safety risk increase

Each of the relevant Key Component Plans are located in the Appendices. Below provides a summary of the intent of each and where an existing site management plans is utilised, how it relates to the S1 to N1 Extraction Plan Area.

Water Management Plan

As it relates to S1 to N1 extraction, the CVC Ground Water Management Plan (contained within the CVC Water Management Plan) covers the risk assessment (**Appendix 2**) identified impacts of regional groundwater drawdown and reduction of private water bore yields. Whilst in both instances due to the existing large extent of depressurisation from historical mining, the impact created via the extraction plan area is considered negligible, controls have been adopted including:

- Continuation of the groundwater monitoring program
- Faults or dykes within the extraction panel are to be assessed case by case as to whether an extraction barrier is required to prevent hydraulic connection.
- Where access is available monitoring of bore yields, saturated thickness and quality. Where additional mining related impact can be proven an alternative water supply will be provided until the bore recovers

Other potential water related impact risks due to extraction are either not applicable due to the extraction being contained wholly below Lake Macquarie, or not relevant due to no risk of impact.

Biodiversity Management Plan

The site Biodiversity Management Plan was reviewed in 2016. As it relates to S1 to N1 extraction, only the Seagrass and Benthic Community Management Plan components are applicable to this Extraction Plan. These are located in **Appendices 5 and 4** respectively. As the Seagrass Management Plan also directly relates to potential biodiversity impact to the only threatened species (sea turtles), this management plan also serves to manage this aspect. Both have been reviewed as a part of this extraction plan development, including the addition of new control and sample monitoring sites. Both of these management plans have been submitted for consultation with the relevant stakeholders.

Bathymetric surveys and update of seagrass and benthic monitoring location will be the primary control to then allow for any unlikely requirement to apply adaptive management. This would be aimed at ensuring negligible change as per Consent Conditions Performance Measures. As per

Consent SSD-5465 Schedule 4 Condition 3, offsets commensurate with the level of impact above "negligible" will be provided for where it is not reasonable or feasible to remediate.

Public Safety and Built Features Management Plans

All mining activities within the application area are to occur beneath Lake Macquarie and as such will have no direct impact on surface facilities and infrastructure. One Navigational marker located off Sugar Bay (N1) is predicted to have negligible subsidence impacts. Roads and Maritime have been consulted in relation to these and the level of subsidence impact, and have concluded that no direct management will be required and the markers will be able to be monitored as a part of their routine inspections. All proposed secondary extraction is located outside of both the High Water Mark Subsidence Barrier and Seagrass Protection Zone and as such, no adverse impacts are anticipated on the immediate foreshore of Lake Macquarie as a result of Fassifern extraction.

The foreshore areas are not predicted to result in any significant impacts. Despite this, CVC will monitor the foreshore for any sign of change and if impacts are observed to be occurring, a review of public safety would be triggered via the Subsidence Management TARP. Actions can be immediately implemented to reduce exposure in any such unlikely circumstance.

No other immediate increase in public safety risks were identified, associated with horizontal movement about the foreshore.

5.0 Subsidence Effects and Environmental Monitoring Program

5.1 Monitoring Program Summary

The proposed Subsidence Monitoring Program is included in **Appendix 7** of this document. Environmental monitoring programs are contained within each of the relevant Key Component Plans. Essentially, subsidence management at CVC is achieved through a combination of mine design and continual monitoring of key subsidence related effects and impacts via the Subsidence Management TARP. Regular and routine monitoring of the foreshore, lake bed, seagrass communities and benthic communities provide a means to verify and validate that predicted subsidence levels are not being exceeded, and that the resultant levels of subsidence are not resulting in excessive impacts beyond those predicted. The mine design can then be adapted and refined as required if exceedances occur or are likely to occur.

Bathymetric surveys of the lake bed and surveys of the foreshore will be used to validate and confirm the predicted vertical subsidence around the miniwall panels. In addition ongoing environmental monitoring in the form of benthic and seagrass community surveys will ensure that the resultant vertical subsidence levels are not resulting in more significant impacts than predicted. **Appendix 4 and 5** contain the mines Benthic Community and Seagrass Management Plans.

Monitoring of sub-surface fracture heights above some of the miniwall panels would usually be recommended within the mining area to confirm the predictions of potential areas of connective surface cracking. Due to the presence of the lake however, measurement of sub-surface fracture heights above the proposed miniwalls is not recommended due to the risks associated with the drilling from a barge and potential intersection with goafs from barge mounted drilling rigs after mining a given panel. However, monitoring of groundwater inflow rates will be utilised to provide an indirect measure of connectivity between the lake and mine workings.

Ongoing inspections, monitoring and mapping of the stability of underground workings will continue along with assessment of groundwater monitoring data. In particular, the presence of a fault, dyke or joint shear zone that may have the potential to cause a hydraulic connection between the fracture zones, causing abnormal inflows, will be assessed on a case by case basis.

As stated above, the strains at the lake bed surface itself will also be more uniformly distributed and are therefore more likely to be absorbed by the plastic nature of the sediments. Accordingly, no monitoring or remediation for the potential minor cracking will be required as may be undertaken for land based cracking.

All of these management and monitoring techniques are consolidated in the Subsidence Management TARP (**Appendix 1**). The overall system not only provides an effective means of management of subsidence effects and impacts, but also the collection of appropriate data to inform future extraction plans.

6.0 Plan Implementation

6.1 Reporting

Incident Reporting

Refer to **Section 3.4.5** of this document.

Regular Reporting

Regular reporting will be undertaken in accordance with the Approval Conditions and the relevant site environmental management plans. This reporting will be provided to all relevant agencies as well as posted on the mines' website and discussed at the mine operated community consultation committee meetings.

Annual Reporting

As per Condition 4 of Schedule 6, by the end of March each year, or other timing as may be agreed by the Secretary), the mine will review the environmental performance for the previous year and submit this review as an annual report.

This review will include:

(a) Describe the development (including any rehabilitation) that was carried out in the past calendar year, and the development that is proposed to be carried out over the current calendar year;

(b) Include a comprehensive review of the monitoring results and complaints records of the development over the past calendar year, which includes a comparison of these results against the:

- relevant statutory requirements, limits or performance measures/criteria;
- requirements of any plan or program required under this consent;
- monitoring results of previous years; and relevant predictions in the EIS;

(c) Identify any non-compliance over the past calendar year, and describe what actions were (or are being) taken to ensure compliance;

(d) Identify any trends in the monitoring data over the life of the development;

(e) Identify any discrepancies between the predicted and actual impacts of the development, and analyse the potential cause of any significant discrepancies; and

(f) Describe what measures will be implemented over the current financial year to improve the environmental performance of the development.

6.2 Review

Reviews of this document and all other relevant environmental management plans will be undertaken within 3 months of the submission of the annual review and/or incident report or independent audits. If necessary, this review will also include required revisions to the associated plans. If revisions are made, within 4 weeks of the review, the revised plans will be submitted to the Secretary for approval. In addition to routine auditing and reviewing of the environmental management plans, by the end of February 2016 and on a 3 yearly basis after that, the mines' environmental management systems will be independently review by external experts suitably qualified to undertake such a review.

6.3 Responsibilities

Whilst the overall responsibility for the implementation of this extraction plan sits with the Manager of Mining Engineering, various others within the organisational structure have responsibilities under this plan to ensure that it is effectively implemented. **Table 17** outlines the key personnel and their individual responsibilities with regard to the implementation of this plan.

Table 17 - Roles and Responsibilities

Role	Responsibilities
Manager of Mining Engineering	• Provide adequate resources for the activities required under this plan • Ensure all operations are undertaken in accordance with this plan • Ensure all mining is undertaken in accordance to approved mine plans
Environment and Community Coordinator	• Coordinate and undertake all environmental monitoring required under this document • Ensure all reporting and monitoring is completed to an appropriate standard and in a timely manner • Ensure any discrepancies between actual monitoring results and predicted outcomes are reported to appropriate stakeholders as soon as practicable • Manage the implementation of all environmental management plans under this document • Be responsible for all environmental reports, management plans, community consultation and communication with stakeholders and departmental authorities
Mine Surveyor	• Preparation of the Subsidence monitoring program • Coordinate and undertake all subsidence monitoring require under the Subsidence Monitoring Program • Maintain plans and records of all subsidence monitoring • Distribute survey data to the relevant stakeholders within agreed timeframes • Report any discrepancies and/or exceedances of actual survey results from expected/predicted data to the E&C Coordinator and Manager of Mining Engineering • Prepare all subsidence related reporting to an appropriate standard

7.0 References

EMM 2013, **Chain Valley Colliery Mining Extension 1 Project, Environmental Impact Statement,** Consultant Report (May 2013)

EMM 2015, **Chain Valley Colliery Modification 2, Statement of Environmental Effects,** Consultant Report (June 2015)

DgS, 2017, **Multi Seam Mining Feasibility Study for the Proposed Miniwalls CVB1 to CVB4 at Chain Valley Colliery** Consultant Report (May 2017)

DgS, 2017. **Investigation Report into the Maximum Subsidence Prediction Exceedances over the Miniwalls 7 to 12 at Chain Valley Colliery.** Consultant Report CHV-002-10a (December 2017)

DgS, 2018. **Subsidence Impact Assessment of the Proposed Northern Area Miniwalls (S1 and N1) at Chain Valley Colliery. DGS CHV-002-11a** – (January 2018).

Ditton and Merrick, 2014, **A New Sub-surface Fracture Height Prediction Model for Longwall Mines in the NSW Coalfields.** Presentation given at the Australian Earth Sciences Convention, 2014.

Appendix 1

Subsidence Management TARP

Version 1 - 13/04/18

CHAIN VALLEY COLLIERY- SUBSIDENCE MANAGEMENT TRIGGER ACTION RESPONSE PLAN (TARP)

SUBSIDENCE MANAGEMENT NORTHERN MINING DOMAIN S1 and N1

		DETAILED PERFORMANCE INDICATORS	MONITORING REQUIREMENTS	CONTAINMENT / REMEDIATION MEASURES	ADAPTIVE MANAGEMENT MEASURES	CONTINGENCY PLANS
Triggers	SUBSIDENCE PARAMETERS (Input Variable Validation)	**Normal** Constrained Zone thickness (as per DGS Report CHV-002-11a) exceeds the 12T + 10m Minimum Criterion by at least 10m (refer to EP Table 10)	Miniwall supervisors to record extraction height shiftly Mine Surveyor to confirm weekly that the average extraction height is ≤ 3.5m			
		Trigger Level 1 Constrained Zone thickness exceeds the 12T + 10m Minimum Criterion by <10m (refer to EP Table 9)	Undertake survey to improve rock head thickness accuracy		Where rock head survey results necessitate, reduce the extraction height to maintain a minimum Constrained Zone thickness of 12T	Review mine plan and extraction height capabilities. Adjust extraction areas accordingly.
		Trigger Level 2 Constrained Zone thickness is <12T		**Cease extraction and review**	Further reduce extraction height where feasible	Conduct risk assessment Review mine plan, including extraction height, geological mapping and panel geometry to confirm that sub-critical behaviour still applies
	SUBSIDENCE PARAMETERS (Bathymetric Survey)	**Normal** Subsidence ≤ 300mm	As per SM Program			
		Trigger Level 1 Subsidence > 300mm to ≤ 500mm	6 monthly surveys until subsidence stabilises, then as per SM Program		Update subsidence predictions based on monitoring data Identify controlling mechanisms Review potential change in impact on natural and built features & update management plans if reqd	Review ability to limit further increases based on understood mechanisms
		Trigger Level 2 Subsidence >500m to ≤ 780mm	6 monthly until subsidence stabilises then as per SM Program	Review if increase likely to create impact at foreshore/seagrass or exceed final subsidence prediction Notify DP&E and DRE Notify OEH, affected landholders or infrastructure owner	Implement further controls as applicable from review Update subsidence predictions based on monitoring data Update impact assessment on natural and built features	Review mine plan including panel width, pillar widths, extraction height and panel length in consultation with DP&E and DRE Review and update Extraction Plan
	SUBSIDENCE PARAMETERS (Foreshore Survey over minimum of 2 adjacent pegs)	**Normal** <20mm recorded movement	Monitoring as per SM Program			
		Trigger Level 1 <20mm recorded movement with slow (3-5mm/month) creep	Validate increase with additional monthy survey/s then as per SM program		Update subsidence predictions based on monitoring data Identify controlling mechanisms Review potential change in impact on natural and built features & update management plans if reqd	
		Trigger Level 2 >20mm recorded movement (assoicated to mining)	Implement Ecological Monitoring program for HWMSB exceedance Increase frequency of subsidence parameter monitoring to until rates stabilises. Then as per SM program	**Cease extraction where occuring in adjacent panel until review of cause of impact and ongoing risk evaluated in consultation with DP&E and DRE** Notify DP&E and DRE Notify OEH, affected landholders or infrastructure owner	Investigate cause of exceedance (ie validate impact due to FAS extraction or not). Consider potential of creep event in old workings adjacent S1. Update subsidence predictions based on monitoring data Update impact assessment on natural and built features	Provide offsets for any ecological communities or threatened species in the HWMSB if impacts detected Review mine plan including panel width, pillar widths, extraction height in consultation with DP&E and DRE Review and update Extraction Plan
	BUILT FEATURES	**Normal** No damage requiring remediation	Monitoring as per SM Program RSM routine moniotirng navigation markers			
		Trigger Level 1 Subsidence parameters exceeded such that Fassifern workings indicated to have potential impact on foreshore Private bore capacity reduced	Monitoring as per BFMP (Built Feature M.Plan)	Review navigational marker freeboard and notify RMS if impacted Notify DP&E and DRE Notify potentially affected landholders or infrastructure owner. Provide temporary waterif required		Develop BFMP in conjunction with owner for built features surrounding potential impact area
		Trigger Level 2 Impact to built feature	Monitoring as per BFMP	**Cease extraction where occuring in adjacent panel until review of cause of impact and ongoing risk evaluated in consultation with DP&E and DRE** Assist owner with information to aid in MSB claim in accord with BFMP	Update impact assessment based on observed damage	Review mine plan including panel width, pillar widths in consultation with DP&E and DRE Review and update Extraction Plan

Version 1 - 13/04/18

CHAIN VALLEY COLLIERY- SUBSIDENCE MANAGEMENT TRIGGER ACTION RESPONSE PLAN (TARP)

SUBSIDENCE MANAGEMENT NORTHERN MINING DOMAIN S1 and N1

		DETAILED PERFORMANCE INDICATORS	MONITORING REQUIREMENTS	CONTAINMENT / REMEDIATION MEASURES	ADAPTIVE MANAGEMENT MEASURES	CONTINGENCY PLANS
Triggers	PUBLIC SAFETY (Foreshore area and steep slopes)	**Normal** No impact	Monitoring as per SM Program and Public Safety MP Increase visual inspection to forthnightly about N4 until satisfied no change in public risk			
		Trigger Level 1 Subsidence parameters exceeded such that Fassifern workings indicated to have potential impact on foreshore	Increase visual inspection of foreshore to daily until public safety risk quantified as low Inspect foreshore in vicinity of steep slopes and retaining walls for signs of movement ASAP. Implement TARP as required.		Review potential of flooding and drainage impacts about foreshore or stability concerns at steep slopes/ retaining walls. Undertake risk assessmentas to such	
		Trigger Level 2 Area around foreshore becomes unstable/ shows sings of mining inducted impact Flooding or drainage impacts considered likely as result of Fassifern extraction	Visual inspections frequency to be commensurate with level of risk (ie increase until controls put in place) Inspect foreshore in vicinity of other steep slopes and retaining walls for signs of movement ASAP. Implement TARP as required.	**Cease extraction where occuring in adjacent panel until review of cause of impact and ongoing risk evaluated in consultation with DP&E and DRE** Immediately implement temporary safety controls (barricades and signage available from mine site). Arrange for assistance and stay at site if immediate risk to public exists Inform ECC as to result of inspection Geotechnical Engineer to inspect area ASAP. Notify Council and RMS Notify OEH, DP&E and DRE	Implement longer term safety controls	Foreshore stabilisation of unsafe areas in consultation with Council and DRE Flooding and drainage rectification works in consultation with infrastructure owner
	BENTHIC COMMUNITIES	**Normal** ANOVA/ANOSIM >5%	Monitoring as per Benthic MP			
		Trigger Level 1 ANOVA/ANOSIM level is approaching 5%	Liaise with monitoring consultant & undertake internal review to determine if impacts are related to mining Arrange a peer review of the monitoring results and statistical analysis			
		Trigger Level 2 ANOVA/ANOSIM <5%	Undertake follow up monitoring at affected sites to obtain confirmation of impacts. Incident Report to be completed and distributed to relevant agencies	Notify DPI-Fisheries, Council and DP&E	Consult with relevant authorities about monitoring and management controls	Consult with relevant authorities to identify if offsets are required and how these are to be implemented.
	SEAGRASS	**Normal** Negligible impact	Monitoring as per Seagrass MP			
		Trigger Level 1 Approaching 20% decline in condition Approaching 20mm of additional mine induced subsidence within mapped seagrass	Liaise with monitoring consultant & undertake internal review to determine if impacts are related to mining		Review if variation is within broader background variation range for the site.	
		Trigger Level 2 >20% decline in conditions from year baseline survey ≥150mm of additional mine induced subsidence at survey location	Incident Report to be completed and distributed to relevant agencies	Notify DPI-Fisheries, Council and DP&E	Consult with relevant authorities about monitoring and management controls	Consult with relevant authorities to identify if offsets are required and how these are to be implemented.
	WATER INFLOW	Ongoing monitoring of water inflows and site water management through operational Water Management and Monitoring TARP process				
Responsibilities	ECC	Coordinate and undertake all environmental monitoring as outlined in TARP Implement TARP actions in consultation with regulatory agencies as/if required Notify the relevant Government agencies and other affected parties of exceedance of performance measures Coordinate Subsidence Review as a aprt of Annual Environmental Reporting Arrange for subsidence prediction and impact updates as required Update Extraction Plan as required Audit public safety controls (barricades and signage) regularly				
	Mine Surveyor	Co-ordinate subsidence monitoring Review subsidence monitoring results against TARP triggers Inform relevant stakeholders as to subsidence monitoring trends				
	Mine Manager	Ensure adequate financial and personnel resources are made available for implementation of this plan Review and approve required mine plan changes				

Appendix 2

Extraction Plan Risk Assessment

LakeCoal

WRAC Risk Assessment

Workplace Risk Assessment & Control

NMD S1 to N4 Extraction Plan Risk Assessment

Site: Chain Valley Colliery

Date: 4/1/18

No:	RA00191		
Topic	NMD S1 to N4 Extraction Plan (Subsidence Management)		
Venue	CVC		
Requested by:	Wade Covey E&C Coordinator	**Date:** 4/1/18	**Time allowed:** 1/2 day
Facilitator	Adrian Moodie Senior Mining Engineer		

Persons participating in Risk Assessment

Name	Position	Years' Experience in Industry	Signature
ADRIAN MOODIE	MINING ENG	17	
Chris Nicholas	Bus Dev Mgr	13	
Tim Chisholm	Reg. Mine Surveyor	12	
Wade Covey	Env & Comm Coordinator	12	
WILLIAM CRUICKSHANK	DEPUTY (CHECK INSPECTOR)	34	
Steven Ditton	Subsidence Consultant.	26	

Purpose

This risk assessment has been conducted to assess and document potential surface and sub-surface subsidence risks associated with mining of Northern Mining Domains (NMD) Miniwall's S1 to N4.

Objectives and Scope

The objectives of this risk assessment are to:

- Identify hazards and assess the risk associated with environmental, public safety and surface built feature impacts from extraction.
- Ensure compliance with the WHS (Mines) Regulation 2014 Clause 67 Subsidence:
  - (1) In complying with clause 9, the mine operator of an underground coal mine must manage risks to health and safety associated with subsidence at the mine.
  - (2) Without limiting subclause (1), the mine operator must ensure that:
    - (a) So far as is reasonably practicable, the rate, method, layout, schedule and sequence of mining operations do not put the health and safety of any person at risk from subsidence, and
    - (b) Monitoring of subsidence is conducted, including monitoring of its effects on relevant surface and subsurface features, and
    - (c) Any investigation of subsidence and any interpretation of subsidence information is carried out only by a competent person, and
    - (d) All subsidence monitoring data is provided to the regulator in the form and at the times required by the regulator, and
    - (e) So far as reasonably practicable, procedures are implemented for the effective consultation, co-operation and co-ordination of action with respect to subsidence between the mine operator and relevant persons conducting any business or undertaking that is, or is likely to be, affected by subsidence.
- Meet (where applicable) the standards for assessing and managing risks of subsidence as outlined in the "Managing Risks of Subsidence Guideline", February 2017.
- Place a particular focus on recently updated subsidence predictions and recommendations for the area including a review of causal factors behind the exceedance of subsidence predictions over the MW 1 to 12 area.
- Identify the existing and potential controls to reduce the risk to a reasonable practicable level.

The scope of the risk assessment focuses on the extraction area defined by a 35 degree angle of draw or to the predicted 20mm subsidence contour of S1 to N4 (see **Figure 1**). The level of monitoring strategy required will be commensurate with the assessed level of risk (ie after controls are put in place) or potential consequence. The corresponding residual risk will determine if these controls are sufficiently acceptable.

The list of surface and sub-surface features outlined in Appendix B of the 2003 NSW Department of Mineral Resources Guidelines for Application for Subsidence Management Approvals, along with items outlined in the 2017 Managing Risks of Subsidence Guideline, have been used as a starting reference list of features for assessment. All features on the list were assessed as to whether they exist within the defined extraction plan area. Where a feature is not noted in the WRAC assessment, it has not been identified within the area of interest.

Figure 1- NMD S1 to N4 Extraction Impact area (area of change) due to Fassifern Miniwall Mining

Risk Assessment Process

1. Present results of the updated subsidence modelling, highlighting any particular identified risks or adaptive management/mine planning recommended controls.
2. Hazard identification (scoped pre-risk assessment) with reference to the 2003 Guideline for Application for Subsidence Management Approvals and 2017 Guidelines for Managing Risks of Subsidence and previous environmental studies.
3. Identified hazards were evaluated with regard to consequence and then the likelihood of that consequence outcome, assuming existing controls to be effectively implemented.
4. Risk rankings were derived.
5. Additional controls were proposed where possible for medium and high risks and the hazards were re-evaluated to arrive at the residual risk.
6. Likelihood and consequence were assessed in accordance AS/NZS ISO 31000:2009 Risk Management – Principles and guidelines.
7. This risk assessment was conducted in general compliance with MDG1010 and MDG1014.
8. As low as reasonably practicable (ALARP) is determined from WHS Act 2011, Section 18.
9. Subsidence risks were assessed to evaluate each in terms of required controls for an acceptable risk based outcome. This process attempts to reduce risks associated with each to ALARP and allow for a risk based decision for mining to proceed with identified controls applied, or determine if more controls are required and feasible (ie mine design change)
10. Hazardous Manual Tasks should be identified and controlled to a reasonable practicable level of risk using the Risk Assessment Worksheet for Hazardous Manual Tasks Form and actions recorded in this risk assessment.
11. Actions and outcomes from the risk assessment are recorded with a due date of action completion and responsible person.

12. Risk Assessments are monitored and reviewed as detailed by the LakeCoal Site Work Health and Safety Management System.

Risk Assessment Checklist based on Hazard / Energy Types

Energy Type	POTENTIAL HAZARDS			
	To People	**To Equipment**	**To Production**	**To The Environment**
Electrical	• Electric Shock • Burns • Smoke Inhalation	• Unplanned movement • Fire • Circuit Damage	• Supply fails causing shutdown • Inadequate supply causing process slowdown	• Fire
Mechanical	• Crushed • Struck by Moving or Flying Objects • Caught Between Moving Objects	• Collision • Breakdown • Unplanned Movement • Breakages • Vibration	• Fails & Causes Shutdown • Slows Down Production	• Physical Damage • Fire
Chemical	• Burns • Skin Irritation • Ingestion • Inhalation (Toxic atmospheres) • Explosion (Mixing incompatible)	• Fire • Internal Damage • Corrosion	• Causes Delays or Shutdowns (Not enough, wrong type to much)	• Spillage (Water contamination, soil contamination, air pollution, vegetation destroyed)
Pressure (Fluids/Gases)	• Fluid Injection • Crush • Respiratory Problems	• Unplanned Movement • Poor Performance • Breakdown	• Equipment Failure Shutdown (No fluids or to much fluids, no gases or to much gases)	• Contamination (Dust, fuel/oil, dirty water0
Radiation	• Burns • Eye Damage (welding flash) • Internal problems		• Source fails (Causing delays or shutdown)	• Contamination
Thermal	• Burns • Heat Exhaustion • Frostbite	• Overheating • Freezing	• Shutdown (Overheating or freezing)	
Biochemical	• Sprains • Strains		• Slowdown due to loss of staff	
Noise/Vibration	• Hearing damage	• Mechanical damage	• Slowdown due to people not accessing area	• Community complaints
Biological	• Illness • Disease		• Shutdown due to lack of people	
Gravitational	• Falling from Heights • Objects falling on Personnel	• Rollover • Collapse • Failure • Damage from fall • Damage from objects falling	• Objects falling causing slowdown or shutdown	• Contamination

Hierarchy of Control		LIKELIHOOD			
Elimination	Do we still have to do this?				
Substitution	Is there another way or product?	A	Almost certain to happen	FREQUENCY	1 per week to 1 per month
Redesign/Engineer	Can the equipment or process be modified?	B	Likely to happen at some point		1 per month to 1 per year
Isolation/Guarding	Will guarding or some type of barrier help?	C	Moderate, possible; heard of so it might happen		1 per year to 1 per 10 years
Administration	Will a written procedure and/or training help?	D	Unlikely, not likely to happen		1 per 10 years to 1 per 100 years
PPE	Is personal protective equipment adequate?	E	Rare, practically impossible		Less than 1 per 100 years

Maximum Reasonable Consequence

Consequence	Injury (I)	Environmental (E)	Loss (L)
1 - Critical	Could kill, permanently disable	Regional environmental impact/ecosystem damage. Impact causing mine or business closure. E.g. Major release off site with long term detrimental effect	Could cause very major damage > $10M
2 - High	Could cause serious injury (major LTI)	Substantial environmental damage which could result in major financial loss and/or prosecution. E.g Off-site release resulting in local ecosystem damage	Could cause major damage $3M - $10M
3 - Medium	Could cause typical MTC/LTI	Substantial temporary or minor long term damage, release immediately contained with outside assistance eg. A minor water discharge or large hydrocarbon spill. Legal non-compliance.	Could cause moderate damage $500K - $3M
4 - Low	Could cause first aid injury	Temporary or minor damage, non-compliance with internal environmental target, no legal breach, eg. Minor spill	Could cause damage $20K - $500K
5 - Insignificant	Couldn't cause injury	No detrimental effect, low financial loss, negligible environmental impact	Couldn't cause damage, or <$20K damage

Risk Score Matrix

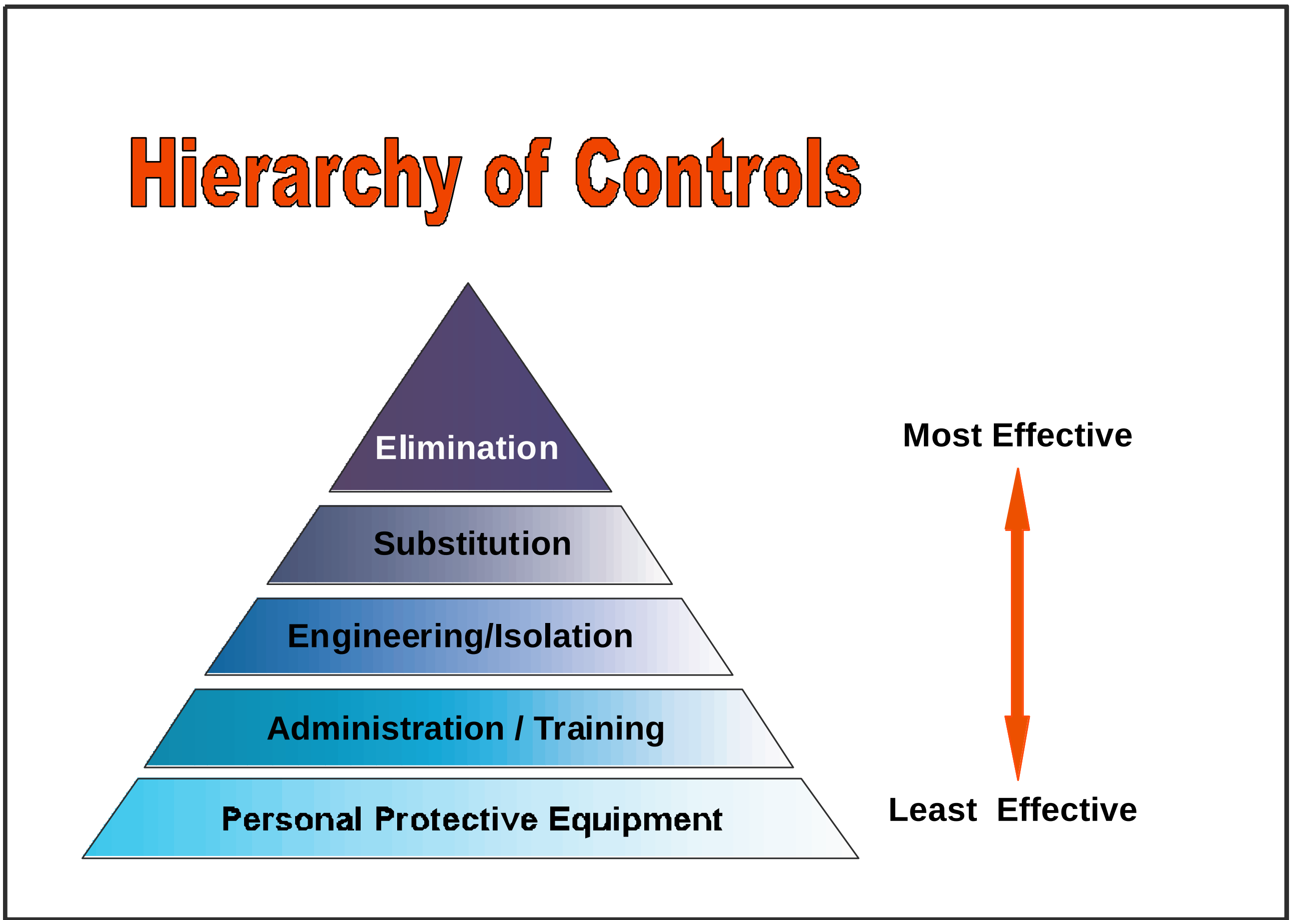
Risk Score	Risk	What should I do?
1 to 3	Critical	STOP WORK Immediate action required, inform senior management
4 to 10	High	Risk Assessment required. Action plan required, senior management attention needed
11 to 15	Medium	Specific monitoring of procedures required management responsibility must be specified
16 to 25	Low	Manage through routine procedures

CONSEQUENCE \ LIKELIHOOD	A- Certain	B - Likely	C - Moderate	D - Unlikely	E - Rare
1 - Critical	1	2	4	7	11
2 - High	3	5	8	12	16
3 - Medium	6	9	13	17	20
4 - Low	10	14	18	21	23
5 - Insignificant	15	19	22	24	25

Least Effective

Most Effective

Hierarchy of Controls (as per WHS Regulations 2011 Clause 36)



HIERARCHY OF CONTROLS 1-6 Descending Order(as per WHS Regulations 2011 Clause 36)	
Elimination	Remove the hazard from the workplace (Re-Design)
Substitution	Substituting (wholly or partly) the hazard giving rise to the risk with something that gives rise to a lesser risk. (Alternative product / plant)
Isolation	Isolating the hazard from any person exposed to it. Use barriers to shield or isolate the hazard (Guards on machines, enclosures for noises)
Engineering controls	Design & install equipment to counteract or lessen the hazard
Administrative controls	change to a system of work, a process or a procedure to lessen the hazard
Personal Protective Equipment	ensuring the provision and use of suitable personal protective equipment

Hazard Analysis and Risk Assessment

The risk management methodology as described in WHS Act 2011, WHS Regulations 2011, WHS Code of Practice WHS Act 2011, Section 274, Code of Practice –How to Manage Work, Health and Safety Risks 2011, MDG1010 and AS/NZS ISO 31000:2009 is used to identify the various processes and activities at LakeCoal sites.

Risk analyses shall be completed for each activity based on the following matrix. The subsequent risk ranking shall then determine the frequency of re-assessments.

Likelihood	Consequences
A. Almost certain to happen	1. Permanently disable.
B. Like to happen at some point	2. Could cause serious injury (Major LTI)
C. Moderate, possible, heard of so it might happen	3. Could cause Medical Treatment Case/ LTI
D. Unlikely, not likely to happen	4. Could cause First Aid Treatment
E. Rare, practically Impossible	5. Could not cause injury

Likelihood and Consequences are applicable to Table 1 below.

		LIKELIHOOD				
CONSEQUENCE		A – Certain	B – Likely	C – Moderate	D – Unlikely	E - Rare
	1 - Critical	1	2	4	7	11
	2 - High	3	5	8	12	16
	3 - Medium	6	9	13	17	20
	4 - Low	10	14	18	21	23
	5 - Insignificant	15	19	22	24	25

Facts

- Extraction is to occur in the Fassifern seam utilising miniwall extraction methods and solely beneath Lake Macquarie (ie outside the High Water Mark Subsidence Barrier and Seagrass Protection Barrier).

- S1 to N4 extraction depth of cover ranges between an effective depth of 155-200m. The panels are at >35^0 angle of draw to the foreshore.

- No extraction is planned within the High Water Mark Subsidence Barrier (HWMSB) and Seagrass Protection Barrier (SPB)

- Updated predictions for subsidence over the MW1 to 12 area of 720mm were exceeded in the MW7 to 10 area with up to 1100mm recorded (a further 150mm of creep movement could be expected). The subsidence model has since been reviewed and amended to align with this increase, and to gain an understanding of the potential mechanisms behind the increase. This model and information has been utilised to develop a mine plan and updated predictions for the NMD such that predicted subsidence is planned to remain within the approved 780mm for the domain allowing for anticipated longer term creep.

- The location of the maximum predicted subsidence is located beneath Lake Macquarie within the FAS working footprint (ie outside the foreshore and mapped seagrass areas) **Figure 1**.

- Mining of miniwall's 7 to 9 has occurred with panel ends finishing directly adjacent overlying partially worked Wallarah workings. There has been no discernible increase in subsidence or angle of draw at this location from the forward abutment effects.

Assumptions

- Employees are trained and assessed in relevant contents of the LakeCoal site WHSMS and Environmental Management Systems as a minimum.

- Compliance with the Environmental Protection Act 1994, Environmental Planning and Assessment Act 1979, Work Health and Safety Act 2011 and Work Health and Safety Regulations 2011, Code of Practice –How to Manage Work, Health and Safety Risks 2011, AS/NZS ISO 31000:2009 Risk Management – Principles and Guidelines.

- Compliance with the Lake Coal Environmental Management System

- Wallarah working directly adjacent the start end of S1 will be similarly effected as those adjacent MW9 whereby no irregular subsidence or changes in angle of draw were noted.

- The large scale faulting (to 13m graben structure) encountered has to date shown no increase in surrounding strata deformation or water make compared with other similarly orientated (to panels) structures that have been retreated through/adjacent to without observation of irregular subsidence or water inflows. Thus whilst continued assessment of the nature of the graben structure will occur, current indications are despite the increase in fault displacement, the structure is excepted to behave similarly to other structures. Further supporting this the same structure has had partial and full extraction within the shallower Wallarah workings undertaken which to our knowledge also did not cause any irregularities.

- The panel layout is very similar to that assessed in the 2013 EIS and thus impacts are anticipated to be the same.
- Impacts associated with APZ's are not subsidence management related and are thus not included in this assessment.

Monitoring and Review

LakeCoal site monitoring and review processes should encompass all aspects of the risk management process for the purposes of:

- ensuring that controls are effective and efficient in both design and operation;
- obtaining further information to improve risk assessment;
- analyzing and learning lessons from events (including near-misses), changes, trends, successes and failures;
- Identifying emerging risks.

References

- AS/NZS ISO 31000:2009 Risk Management – Principles and Guidelines
- MDG1010 – Risk Management Handbook for the Mining Industry
- MDG1014 - Guideline to reviewing a risk assessment of mine equipment and operations
- Work Health and Safety Act 2011
- Work Health and Safety Regulations 2011
- Codes of Practice –WHS Act 2011, Section 274.
- Work Health and Safety Mines Act 2013
- Work Health and Safety Mines Regulations 2014
- Environmental Protection Act 1994
- Environmental Planning and Assessment Act 1979

- DGS, 2017. Multi-Seam Mining Feasibility Study for the Proposed Miniwalls CVB to CVB4 at Chain Valley Colliery
- EMM, 2015. Chain Valley Colliery- Modification 2- SoEE
- EMM, 2013. Chain Valley Colliery Mining Extension project 1- EIS
- Lake Coal, 2013. Chain Valley Colliery Extraction Plan MW7 to MW12.
- NSW DMR, 2003. Guideline for Applications for Subsidence Management Approvals
- NSW DRE Mine Safety, 2017. Guideline Managing Risk of Subsidence
- PHMP 00021- Mannering and Chain Valley Collieries Principal Hazard Management Plans
- Draft Subsidence PHMP Risk Assessment Dated 15/12/16.

Definitions

Hazard

Means a situation or thing that has the potential to harm a person. Hazards at work may include: environmental impact, noisy machinery, a moving forklift, chemicals, electricity, working at heights, a repetitive job, bullying and violence at the workplace.(reference Code of Practice –How to Manage Work, Health and Safety Risks 2011)

Hazardous Manual Task

Defined in the WHS Regulations 2011, means a task that requires a person to lift, lower, push, pull, carry or otherwise move, hold or restrain any person, animal or thing involving one or more of the following:

- repetitive or sustained force
- high or sudden force
- repetitive movement
- sustained or awkward posture
- exposure to vibration.

Musculoskeletal disorder

Defined in the WHS Regulations 2011, means an injury to, or a disease of, the musculoskeletal system, whether occurring suddenly or over time. It does not include an injury caused by crushing, entrapment (such as fractures and dislocations) or cutting resulting from the mechanical operation of plant.

Risk Assessment

Risk management process applied to a scope of work, overall activities, equipment and machinery to determine how often specified events may occur and the magnitude of their consequence. When applied to a specific and sequential set of job steps/activities this may be referred to as a Job Safety Analysis.

Risk

Is the possibility that harm (death, injury or illness) might occur when exposed to a hazard. (Reference Code of Practice –How to Manage Work, Health and Safety Risks 2011)

Risk control

Means taking action to eliminate health and safety risks so far as is reasonably practicable, and if that is not possible, minimising the risks so far as is reasonably practicable. Eliminating a hazard will also eliminate any risks associated with that hazard. .(reference Code of Practice –How to Manage Work, Health and Safety Risks 2011)

WRAC
Workplace Risk Assessment & Control

Subsidence
Movement of the ground surface as a result of readjustments of the overburden due to collapse or failure of underground mine workings and/or compression of remnant pillars

Subsidence Effects
The term used to define the subsidence and differential subsidence parameters (i.e. subsidence, tilt, strain and horizontal displacement) that may or may not have an impact on natural or man-made surface and sub-surface features above a mining area

Subsidence Impacts
The impact that a subsidence effect has on natural or man-made surface and sub-surface features above a mining area

Tilt
The rate of change of subsidence between two points (A and B), measured at set distances apart (usually 10 m).

Strain
The change in horizontal distance between two points at the surface after mining, divided by the pre-mining distance between the points, may be tensile, compressive or shear.

Rock Head
The geological boundary in the overburden between competent rock and unconsolidated sediments and weathered rock

Abbreviations

ALARP As low as reasonably practicable (ALARP) - determined from WHS Act 2011, Section 18.

CVC Chain Valley Colliery

DISRD	Department of Industry, Skills and Regional Development
EMP	Environmental Management Plan
FOS	Factor of Safety
JSA	Job Safety Analysis
LTA	less than adequate
LAK	LakeCoal
MC	Mannering Colliery
MSD	Musculoskeletal Disorder
MSMFI	Multi-seam Mining Feasibility Investigation
PCP	Principle Control Plans
PMHMP	Principle Mining Hazard Management Plans
PPE	Personal protective Equipment
STD	Standard
STF	Slip/Trips/Falls
SMP	Safety Management Plan
SWP	Standard Work Procedure

Risk Table

The hazards were analysed and risks derived. The existing control mechanisms were identified prior to establishment of risk. Proposed risk reductions were discussed and agreed and a residual risk determined based on implementation of existing and proposed risk reductions. Consequences assessed through this risk assessment were taken as the reasonable practicable level of risk considering Injury to Personnel as a primary consideration and Environmental Impact and Financial Loss as a secondary consideration as defined in the Risk Assessment Matrix.

No	Activity	Potential Hazard	Existing Controls	Cons I,E,L	Likelihood	Consequence	Risk Rank	Proposed Controls	Likelihood	Consequence	Risk Rank	Risk Level	Responsible Person	Due Date
1.	**Natural Features**													
1.1a	Groundwater	Loss of groundwater from aquifers due to subsidence induced fracturing impacts users or dependant ecosystems	• Mine design (panel width and extraction height to limit height of hydraulic fracturing) • Existing extraction has already influenced groundwater levels (minimal further impact predicted) • Avg dewatering volume is within predictions • Ground water assessment (SEE) • GWMP	E	D	3	17	1. Faults/dykes to be assessed case by case as to whether extraction barrier required				ALARP	A Moodie	30/3/18

No	Activity	Potential Hazard	Existing Controls	Cons I,E,L	Likelihood	Consequence	Risk Rank	Proposed Controls	Likelihood	Consequence	Risk Rank	Risk Level	Responsible Person	Due Date
1.1b		Abnormal groundwater loss due to extraction of N1 and S1 between graben fault zone	• Mine design (panel width and extraction height to limit height of hydraulic fracturing) • S1 and N1 panels designed to exclude direct extraction and indirect interconnection with fault plane/dip • Existing extraction has already influenced groundwater levels (minimal further impact predicted) • Avg dewatering volume is within predictions • Ground water assessment (SEE) • GWMP	E	C	3	13	Extend CVB subsidence and water management TARP to also cover NMD with particular focus on graben fault area				ALARP	A Moodie	30/3/18
1.1c		Impact on registered groundwater bores in proximity to extraction effects their ongoing use (GW24575)	• Minimal impact based on assessment and existing mining (SEE) • Confirmed integrity and if in use	E	C	4	18	Monitor yields, saturated thickness and quality where access granted Provide alternative water supply until impacted bore recovers where proven to be related to mining impact	C	5	22	LOW	W Covey	30/5/18

No	Activity	Potential Hazard	Existing Controls	Cons I,E,L	Likelihood	Consequence	Risk Rank	Proposed Controls	Likelihood	Consequence	Risk Rank	Risk Level	Responsible Person	Due Date
1.2a	Sea/Lake	Increased depth/lakebed cracking resulting in impacts outside predictions	• Mine design (panel width and extraction height to limit height of hydraulic fracturing) • Subsidence assessment including updated predictions (CWC 95% CL) based on MW1-12 subsidence exceedance event • Extensive subsidence model including bathymetric survey • Subsidence monitoring program	E	D	3	17	Faults/dykes to be assessed case by case as to whether extraction barrier required Increase frequency of bathyo surveys to 6 monthly				ALARP	T Chisholm	30/3/18

No	Activity	Potential Hazard	Existing Controls	Cons I,E,L	Likelihood	Consequence	Risk Rank	Proposed Controls	Likelihood	Consequence	Risk Rank	Risk Level	Responsible Person	Due Date
1.2b		Increased depth/lakebed cracking due to S1 and N1 extraction between graben fault zone resulting in impacts outside predictions	• Mine design (panel width and extraction height to limit height of hydraulic fracturing) • S1 and N1 panels designed to exclude direct extraction and indirect interconnection with fault plane/dip • Only single extraction panel separated by >150m barriers. Unlikely to cause subsidence exceedance of 780mm. • Subsidence assessment including updated predictions (CWC 95% CL) based on MW1-12 subsidence exceedance event • Extensive subsidence model including bathymetric survey • Subsidence monitoring program • No previous evidence of irregularities around geological structures in previous MW areas	E	D	3	17	Faults/dykes to be assessed case by case as to whether extraction barrier required (inbye structure) Increase batho survey to 6 monthly				ALARP		

No	Activity	Potential Hazard	Existing Controls	Cons I,E,L	Likelihood	Consequence	Risk Rank	Proposed Controls	Likelihood	Consequence	Risk Rank	Risk Level	Responsible Person	Due Date
1.3a	Shoreline	Increased flooding risk due to subsidence	• HWMSB/Mine design • Subsidence assessment • Subsidence monitoring program	E	E	2	16	6 monthly bathyo monitoring Develop foreshore monitoring program in consultation with DRE, landholders and relevant agencies				ALARP	A Moodie	30/1/18
1.3b		Foreshore ecology impacted by increased flooding or erosion	• HWMSB/Mine Design • Subsidence assessment • Subsidence monitoring program	E	E	3	20	6 monthly bathyo monitoring Develop foreshore monitoring program in consultation with DRE, landholders and relevant agencies				ALARP		
1.3c		Changes in depth and wave climate result in increased erosion	• HWMSB/Mine Design • Low wave height environment (SEE) • Subsidence assessment • Subsidence monitoring program	E	E	4	23	6 monthly bathyo monitoring Develop foreshore monitoring program in consultation with DRE, landholders and relevant agencies				ALARP		

No	Activity	Potential Hazard	Existing Controls	Cons I,E,L	Likelihood	Consequence	Risk Rank	Proposed Controls	Likelihood	Consequence	Risk Rank	Risk Level	Responsible Person	Due Date
1.4	Ecosystems (Seagrass)	Increased depth from subsidence reduces presence/health of seagrass	• Seagrass mapping (no threatened species identified in extraction plan area) • SPB/Mine design • Subsidence assessment • Subsidence monitoring program	E	D	4	21	Routine monitoring Bathymetric surveys Update Seagrass Management plan (review transect locations)				ALARP	W Covey	30/1/18
1.5	Ecosystems (Benthic Communities)	Increased depth from subsidence reduces colony numbers/health	• Benthic surveys (6 monthly) • Subsidence assessment • Subsidence monitoring program • Predictive modelling	E	D	4	21	Routine monitoring Bathymetric surveys Update benthic management plan (inc new monitoring locations)				ALARP	W Covey	30/1/18
1.6	Threatened and Protected Species (Loggerhead and Green Turtles)	Increased depth from subsidence results in reduction in food source (seagrass)	• Seagrass mapping • SPB/Mine design • Mobile and no impact predicted to food source	E	E	5	25					ALARP		
1.7	Cliff/Steep Slope(Frying Pan Point)	Horizontals movements of cliff face results in rock failure	• Subsidence assessment • Subsidence monitoring program • HWMSB/Mine Design	E I	D D	3 2	17 12	Inspect and confirm existence as a risk Develop public safety management plan (if required)	(I)E	3	20	LOW	A Moodie	30/1/18

No	Activity	Potential Hazard	Existing Controls	Cons I,E,L	Likelihood	Consequence	Risk Rank	Proposed Controls	Likelihood	Consequence	Risk Rank	Risk Level	Responsible Person	Due Date
1.8	Rock outcrops within lake (adjacent S2 and N1)	Change in depth results in public safety risk	• Subsidence assessment • Subsidence monitoring program •					Inspect and confirm existence as a risk Develop public safety management plan (if required) in consultation with RMS					A Moodie	30/1/18
2.	**Public Utilities**													
2.1	Telecommunication line	Nil. Outside extraction area	•											
2.2	Services	Services not identified within impact area during original SEE impacted by subsidence	• Impact area under lake thus limited likelihood of services	L	D	3	17	Undertake a final search prior mining	E	3	20	LOW	T Chisholm	30/3/18

No	Activity	Potential Hazard	Existing Controls	Cons I,E,L	Likelihood	Consequence	Risk Rank	Proposed Controls	Likelihood	Consequence	Risk Rank	Risk Level	Responsible Person	Due Date
3. Public Amenities														
	Nil		•											
4. Farm Land and Facilities														
	Nil		•											
5. Industrial, Commercial and Business Establishments														
	Nil													

No	Activity	Potential Hazard	Existing Controls	Cons I,E,L	Likelihood	Consequence	Risk Rank	Proposed Controls	Likelihood	Consequence	Risk Rank	Risk Level	Responsible Person	Due Date
6. Areas of Archaeological and/or Heritage Significance														
6.1	Summerland Point AHIMS sites (adjacent extraction plan area)	Arch sites near foreshore impacted by flooding or erosion increases due to subsidence	• Locations identified (approx.) via AHIMS register • Heritage Management Plan (EMP-D-16371) • HWMSB (no impact predicted) • Subsidence assessment • Subsidence monitoring program	E	E	4	23	Review Cultural Heritage monitoring regime to cover sites within EP locality				ALARP	W Covey	30/3/18
7. Items of Architectural Significance														
	Nil													

No	Activity	Potential Hazard	Existing Controls	Cons I,E,L	Likelihood	Consequence	Risk Rank	Proposed Controls	Likelihood	Consequence	Risk Rank	Risk Level	Responsible Person	Due Date
8. Permanent Survey Control Marks														
8.1	State Survey Marks/Permanent Survey Marks	Survey marks near foreshore effected by horizontal/vertical movement	• HWMSB/Mine Design • Subsidence assessment • Subsidence monitoring program	E	C	4	18	Search for existing marks and include in SMP				ALARP	T Chisholm	30/1/18
9. Residential Establishments														
	Nil		•											

No	Activity	Potential Hazard	Existing Controls	Cons I,E,L	Likelihood	Consequence	Risk Rank	Proposed Controls	Likelihood	Consequence	Risk Rank	Risk Level	Responsible Person	Due Date
10. Other identified items requiring particular assessment														
10.1a	Public Safety	Shallow water buoy (or other markers including sailing markers) within extraction plan area impacted due to subsidence resulting public safety risk	• Subsidence assessment	I	C	3	13	Investigate marker locations. Identify any at risk Provide subsidence prediction of actual locations Consult Maritime services regarding potential depth increase and mitigation strategy Keep CCC informed of actions taken in relation to public safety risks	E	3	20	LOW	A Moodie A Moodie A Moodie W Covey	30/1/18 30/1/18 30/1/18 30/3/18
10.1b		Jetties within extraction plan area impacted due to subsidence	• Subsidence assessment	E	D	4	21	Investigate locations. Identify any at risk Consult Maritime services regarding potential depth increase and mitigation/monitoring strategy Consultation with affected landholders Keep CCC informed of actions taken				ALARP	A Moodie A Moodie W Covey W Covey	30/1/18 30/1/18 30/3/18 30/3/18

No	Activity	Potential Hazard	Existing Controls	Cons I,E,L	Likelihood	Consequence	Risk Rank	Proposed Controls	Likelihood	Consequence	Risk Rank	Risk Level	Responsible Person	Due Date
		Moorings within extraction plan area impacted due to subsidence	• Subsidence assessment	E	D	4	21	Investigate locations. Identify any at risk Consult Maritime services regarding potential depth increase and mitigation strategy Consultation with affected landholders Keep CCC informed of actions taken				ALARP	A Moodie A Moodie W Covey W Covey	30/1/18 30/1/18 30/3/18 30/3/18
10.2	Consultation	LTA community, stakeholder or agency consultation results in concerns over impact	• CCC • Website • Extraction Plan Guidelines	E	C	4	18	Develop a stakeholder consultation strategy	D	4	21	LOW	W Covey	30/3/18

No	Activity	Potential Hazard	Existing Controls	Cons I,E,L	Likelihood	Consequence	Risk Rank	Proposed Controls	Likelihood	Consequence	Risk Rank	Risk Level	Responsible Person	Due Date
10.3a	Subsidence Impact (general)	Subsidence predictions exceeded result in increased impact/community concern/ breach of conditions	• Subsidence assessment including updated predictions (CWC 95% CL) based on MW1-12 subsidence exceedance event • Extensive subsidence model including bathymetric survey • Subsidence monitoring program	E	D	3	17	Update subsidence monitoring plan to include 6 monthly bathyo Extend Summerland Point foreshore monitoring where access granted Consider Fassifern floor cores for assessment against subsidence model assumptions Review mine design and contingency plans/adaptive management measures in each management plan/TARP Revise predictions as required	E	3	20	Low	A Moodie T Chisholm A Moodie A Modie	30/1/18 30/3/18 30/3/18

No	Activity	Potential Hazard	Existing Controls	Cons I,E,L	Likelihood	Consequence	Risk Rank	Proposed Controls	Likelihood	Consequence	Risk Rank	Risk Level	Responsible Person	Due Date
10.3b		Failure/yield of pillars at shoreline in adjacent Wallarah workings (adjacent S1) results exceedance of subsidence limits	• FOS shoreline pillars 1.7. Stability Index 2.1 (and not directly undermined. Narrow area of partial extraction. • Assumptions used in predictions are conservative ○ assumed full seam thickness for pillar height ○ Used 21deg abutment angle (greater than measured) ○ Conservative stress assumptions ○ Risk mitigation from overlying conglomerates not included ○ MW9 experience no change in impact	E L	D D	3 4	17 21	Review mine design and contingency plans/adaptive management measures in each management plan Implement ecological monitoring program (if exceedance occurs) Review frequency of any available monitoring in area adjacent overlying workings				ALARP	A Moodie	30/1/18

No	Activity	Potential Hazard	Existing Controls	Cons I,E,L	Likelihood	Consequence	Risk Rank	Proposed Controls	Likelihood	Consequence	Risk Rank	Risk Level	Responsible Person	Due Date
10.3d		Known or unknown geological structure in the workings increases subsidence impact	• Geological database and mapping from old workings • Known major structures incorporated into updated model • All pillars squat pillars thus confinement not reduced by structures • Subsidence monitoring to date has not indicted significant variation in areas of geological structure	E	D	3	17	Faults/dykes to be assessed case by case as to whether extraction barrier required				ALARP	As reqd	

No	Activity	Potential Hazard	Existing Controls	Cons I,E,L	Likelihood	Consequence	Risk Rank	Proposed Controls	Likelihood	Consequence	Risk Rank	Risk Level	Responsible Person	Due Date
10.3e		Irregular subsidence from FAS extraction S1 and N1 between graben fault zone.	• Mine design (panel width and extraction height to limit height of hydraulic fracturing) • S1 and N1 panels designed to exclude direct extraction and indirect interconnection with fault plane/dip • Only single extraction panel separated by >150m barriers. Unlikely to cause subsidence exceedance of 780mm. • Subsidence assessment including updated predictions (CWC 95% CL) based on MW1-12 subsidence exceedance event • Extensive subsidence model including bathymetric survey • Subsidence monitoring program • No previous evidence of irregularities around geological structures in previous MW areas	E	D	3	17	Faults/dykes to be assessed case by case as to whether extraction barrier required (inbye structure) Increase batho survey to 6 monthly				ALARP		

No	Activity	Potential Hazard	Existing Controls	Cons I,E,L	Likelihood	Consequence	Risk Rank	Proposed Controls	Likelihood	Consequence	Risk Rank	Risk Level	Responsible Person	Due Date
10.3f		Massive strata failure causes abrupt or irregular subsidence (potential influence by graben faults)	• No history of dynamic loading in CVC working to date • S1 and N1 panels designed to exclude direct extraction and indirect interconnection with fault plane/dip • Subsidence data doesn't show any irregularities • Strata PHMP-0001 • Geological model	E	D	3	17					ALARP		

No	Activity	Potential Hazard	Existing Controls	Cons I,E,L	Likelihood	Consequence	Risk Rank	Proposed Controls	Likelihood	Consequence	Risk Rank	Risk Level	Responsible Person	Due Date
10.3g	Overall S1 to N4 Subsidence Risk (consideration of all risks and required controls)	Irregular subsidence due to Failure/yield of pillars or floor resulting in subsidence exceedance	• Mine design (panel width and extraction height to limit height of hydraulic fracturing) • S1 and N1 panels designed to exclude direct extraction and indirect interconnection with fault plane/dip • Only single extraction panel separated by >150m barriers. Unlikely to cause subsidence exceedance of 780mm. • Subsidence assessment including updated predictions (CWC 95% CL) based on MW1-12 subsidence exceedance event • Extensive subsidence model including bathymetric survey • Subsidence monitoring program • No previous evidence of irregularities around geological structures in previous MW areas	E L I	C C D	2 2 3	8 8 17	Develop EP based on risk assessment outcomes Bathometric and foreshore monitoring TARP including containment, adaptive and contingency measures comparing to sub parameters after each panel. Revise predictions and management strategies as required Modify chain pillar size after two adjacent panels to ensure CWC 95% CL predictions do not exceed approved 780mm over whole (ie future) area based on updated modelling Apply further mine design and contingency plans/adaptive management measures in each management plan based on ongoing monitoring	(E)D	2	12	Mod	A Moodie A Moodie	30/1/18 30/1/18

Actions

No	Clause(s) No from RA Tables	Action	Person responsible for Action	Action timeframe	Comments	Database Action No	Responsible Person signature
1.	1.1a	Faults/dykes to be assessed case by case as t whether extraction barrier required	A Moodie	30/3/18			
2	1.1b	Extend subsidence and water management tarp to also cover NMD with particular focus on graben fault zone	A Moodie	30/3/18			
3	1.1c	Monitor yields, saturated thickness and quality of bore where access granted	W Covey	30/5/18			
4	1.2	Increase bathymetric survey to 6 monthly	T Chisholm	30/3/18			
5	1.3a	Develop foreshore monitoring program in consultation with DRE, landholders and relevant agencies	T Chisholm	30/3/18			
6	1.4	Update seagrass management plan (review transect locations)	W Covey	30/1/18			
7	1.5	Update benthic management plan (review locations)	W Covey	30/1/18			
8	1.7	Inspect steep slopes and confirm risk. Develop public safety management plan of required	A Moodie	30/1/18			
9	1.8	Inspect rock outcrops and confirm risk. Develop public safety management plan of required	A Moodie	30/1/18			

10	2.2	Undertake final services search	T Chisholm	30/3/18			
11	6.1	Review cultural heritage monitoring regime to cover EP area	W Covey	30/3/18			
12	8.1	Search for existing survey marks and include in SMP	T Chisholm	30/1/18			
13	10.1a	Investigate nav marker location and identify any risk. Consult Maritime Services regarding management. Include in public safety MP.	A Moodie	30/1/18			
14	10.1a	Keep CCC informed of public safety outcomes/actions	W Covey	30/3/18			
15	10.1b	Investigate jetty/ mooring location and identify any risk. Consult Maritime Services and owner regarding management. Include in built feature MP as required.	A Moodie	30/1/18			
16	10.2	Implement stakeholder consultation strategy	W Covey	30/1/18			
17	10.3a	Update subsidence monitoring program for 6 monthly bathymetric survey	A Moodie	30/1/18			
18	10.3a	Extend Summerland Point foreshore monitoring where access granted	T Chisholm	30/5/18			
19	10.3a	Consider Fassi floor cores	A Moodie	30/3/18			
20	10.3.a	Review mine design/contingency and adaptive management plans and TARP	A Moodie	30/1/18			

21	10.3b	Review frequency of foreshore monitoring in area adjacent WAL workings during start S1	T Chisholm	30/3/18			
22	10.3g	Develop Extraction Plan	A Moodie	30/1/18			
23	10.3g	Modify chian pillar after 2 adjacent panels to ensure CWC predictions do not exceed approved 780mm.	A Moodie	30/1/18			

____ ____

[Facilitator Name] **[Signature]** **[Date]**

____ ____

(Manager of Mining Engineering Name) **[Signature]** **[Date]**

MDG 1014 Review Checklist
RISK ASSESSMENT REVIEW CHECKLIST

Risk Assessment Title: TYPE TITLE HERE ***Date:*** insert date

Site: TYPE IN SITE OR WORKPLACE

1. Report
[Circle or Highlight Yes or No for the following]

1.1	Is there a description of the operation or equipment being assessed?	Yes / No
1.2	Is there a summary of the strategic, corporate and risk management context?	Yes / No
1.3	Is there a list of the people involved in the risk identification step, together with their organizational roles and experience relevant to the risk assessment topic?	Yes / No
1.4	Is there an adequately detailed outline of the approach used to identify the risks?	Yes / No
1.5	Is there an outline of the method used for assessing the likelihood and consequences of the risks?	Yes / No
1.6	Is there, discussion of the basis for defining either the safety standard to be achieved, or the level of risk management expenditure?	Yes / No
1.7	Is there a list of the main actions to be taken to reduce risks and to manage risks?	Yes / No
1.8	Is there a timetable for implementing the main actions?	Yes / No
1.9	Does the report specify a requirement for a working audit requirement after completion of all stages?	Yes / No

2. Process

How do you rate the following? [Circle or Highlight Poor to Very Good]		Poor/Very Good
2.1	The range of expertise of team which did the study.	**1 2 3 4 5**
2.2	The appropriateness of the degree of detail of the study.	**1 2 3 4 5**
2.3	The comprehensiveness of the systematic approach.	**1 2 3 4 5**
2.4	The identification of the key risk scenarios to be addressed.	**1 2 3 4 5**
2.5	The basis for deciding the required safety level or effort.	**1 2 3 4 5**
2.6	The method for assessing likelihood and consequences.	**1 2 3 4 5**
2.7	The thoroughness of consideration of planned risk reduction actions.	**1 2 3 4 5**
2.8	The thoroughness of consideration of existing or planned risk controls.	**1 2 3 4 5**
2.9	The objectivity and balance of the study (ie not unduly optimistic or pessimistic)	**1 2 3 4 5**

Signed: ____

Position: ____ Date: __________________

Appendix 3

Ground Water Management Plan

GeoTerra

LAKECOAL PTY LTD

CHAIN VALLEY COLLIERY

GROUNDWATER MANAGEMENT PLAN

Lake Macquarie, NSW

LDO3-R1G

5 JANUARY 2015

GeoTerra Pty Ltd **ABN 82 117 674 941**

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Authorised on behalf of GeoTerra Pty Ltd:	
Name:	Andrew Dawkins
Signature:	
Position:	Managing Geoscientist

Date	Rev.	Comments
03.08.2012		Initial Draft
23.08.2012	A	Final
29.09.2014	B	Revision of original GwMP
22.10.2014	C	Incorporate Review Comments
14.11.2014	D	Incorporate Review Comments
21.11.2014	E	Incorporate Review Comments
10.12.2014	F	Incorporate Review Comments
05.01.2015	G	FINAL

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FIGURES

TABLES

1. INTRODUCTION

This revised Groundwater Monitoring Program (GwMP) has been prepared in compliance with Schedule 3 (Condition 18(D)) of the LakeCoal Pty Ltd Chain Valley Colliery Extension Project Approval SSD 5465.

This report is to be read in conjunction with the Water Management Plan prepared for the Colliery (LD Operations, 2014).

The plan includes:

- a groundwater water quality and quantity monitoring program,
- trigger levels for mining impacts on groundwater systems,
- procedures to be followed in the event that monitoring of groundwater indicates an exceedance of trigger levels,
- measures to mitigate, remediate and/or compensate for identified impacts,
- a protocol for the notification of trigger level exceedances, and;
- a contingency plan where, in the event of adverse effects on groundwater quality and/or quantity due to mining impacts, the Colliery will provide an equivalent supply until the affected supply is restored, or as agreed with the landowner and the NSW Office of Water (NOW).

Current groundwater related operations at Chain Valley Colliery include the;

- historic Great Northern and Wallarah seams bord and pillar workings;
- current Fassifern Seam development as well as miniwall workings; and
- water storage and management facilities owned and operated by the Colliery.

Operation of the GwMP needs a high level of management input to operate the Colliery within the relevant requirements and various water licences, particularly to ensure compliance with the water discharges authorised by Environment Protection Licence 1770.

An essential part of the plan is monitoring of all groundwater inflows and extraction into and out of the underground with reliable flow meters, as well as monitoring of groundwater levels and water quality in private bores.

This information is necessary for periodical reviews of the groundwater management system and to support any updates/changes to licences.

The proposed mitigation measures minimise and manage the impacts of any potential adverse effects on local aquifers within the GwMP area.

The proposed mitigation measures minimise, where possible, the impacts of the proposed mining on the various groundwater sources, aquifers or groundwater dependent ecosystems that may be present in the Project Area.

1.1 Objectives

The objective of the GwMP is to operate the Colliery so that the subsurface mining operations will be conducted in a manner which minimises the potential impacts on groundwater flow and quality, aquifer integrity, groundwater dependent ecosystems and other off-site groundwater related impacts.

In order to achieve this goal, the GwMP will be used to establish procedures to:-

- measure, control, mitigate and repair potential impacts that could, or do, occur to the groundwater system overlying Chain Valley Colliery, and;
- identify, measure, minimise or where possible, avoid potential significant adverse impacts that can result from mining and subsidence on the groundwater systems within the Project Area.

In addition, the GwMP will be used to

- monitor groundwater system changes in relation to the leaseholder's mining activities;
- assess the pre and post-mining condition of groundwater systems in the lease area;
- ensure all relevant groundwater criteria are met;
- minimise and manage any impacts on the availability of groundwater to potentially impacted residents, landholders or other groundwater users;
- minimise adverse changes on groundwater dependent ecosystems, where present
- provide a forum to record and discuss mining impacts, and;
- provide an annual report on the monitoring, observations and actions conducted within the preceding 12 months to NOW.

These objectives will be met by:

- monitoring groundwater seepage and groundwater quality in the workings during mining within the mine lease area;
- installation of water monitoring appliance(s) to measure pumped water volumes to and from the mine workings. These appliances will be maintained in good working order. If required the mine will supply a test certificate to certify the current accuracy of the appliance(s) furnished by the manufacturer or by some duly qualified person or organisation. The mine water pumping records will be maintained and supplied to NOW upon request;
- providing a plan of action in the event that the impacts of mining are greater than anticipated and initiate action to mitigate or remedy potential significant impacts that may occur;
- ensuring that any tailwater drainage will not be allowed to discharge onto adjoining roads, crown land or other lands, or into any unauthorised stream, or any aquifer, by surface or subsurface drains or pipes or any other means without appropriate approval;
- ensuring that any groundwater extracted from the works will not be discharged into any watercourse or source of groundwater except in compliance with the *Protection of the Environment Operations Act (1997);*
- any works used for the purpose of conveying, distributing or storing groundwater from the works will not be constructed or installed so as to obstruct the free passage of floodwaters flowing in, to or from a river or lake;
- all groundwater extracted from the works will be used or applied only on such land, and for such purposes, as approved by NOW, and;
- providing a forum to report, discuss and record impacts to the groundwater system that involves the Chain Valley Colliery, stakeholders, NOW and DII as required.

1.2 Scope

The GwMP is to be used to protect, monitor and manage the condition of the groundwater system within the Chain Valley Colliery lease area that may potentially be impacted due to coal mining and mine subsidence within the lease area.

The GwMP also applies to persons employed or engaged by the Colliery when carrying out activities described by this plan.

This GwMP is to be read in conjunction with the current version of the Water Management Plan (EMP-D-16368) which outlines the monitoring and management of specific factors relating to surface water and groundwater issues due to the predicted subsidence.

All other water management components not directly related to the GwMP are contained as part of the Water Management Plan (EMP-D-16368).

The GwMP covers mining until completion of Domains 1 and 2, although the plan may be used beyond that benchmark with appropriate modification.

1.3 Definitions

For the purpose of this document, the GwMP area is defined as the groundwater systems within the Chain Valley Colliery Lease area. The main features in the GwMP area shown in **Figure 1** include the;

- current Chain Valley Colliery workings in the Fassifern Seam, and;
- the proposed outline of Domains 1 and 2.

1.4 Limitations

This GwMP is based on current monitoring data and the proposed and approved operational aspects relating to Chain Valley Colliery. The relevant groundwater features have been identified from;

- existing studies;
- data supplied by Colliery representatives, and from;
- associated consultant's reports in the lake Macquarie area.

The impacts of mining on the groundwater system have been assessed in previous studies (see references). However, it is recognised that prediction and assessment of changes to, and effects from, operation of the colliery on the groundwater system can be relied upon only to a certain extent.

The environmental assessment groundwater study (GeoTerra, 2013) determined there is a low potential for the mine's impacts on the groundwater system to exceed the predictions and assessments. However, the possibility of impacts above predictions has been considered in this plan.

The GwMP will not necessarily prevent impacts from the proposed mining, but does identify appropriate procedures to manage the impacts within tolerable limits and identifies procedures that can be followed should evidence of increased impacts and unacceptable risk emerge.

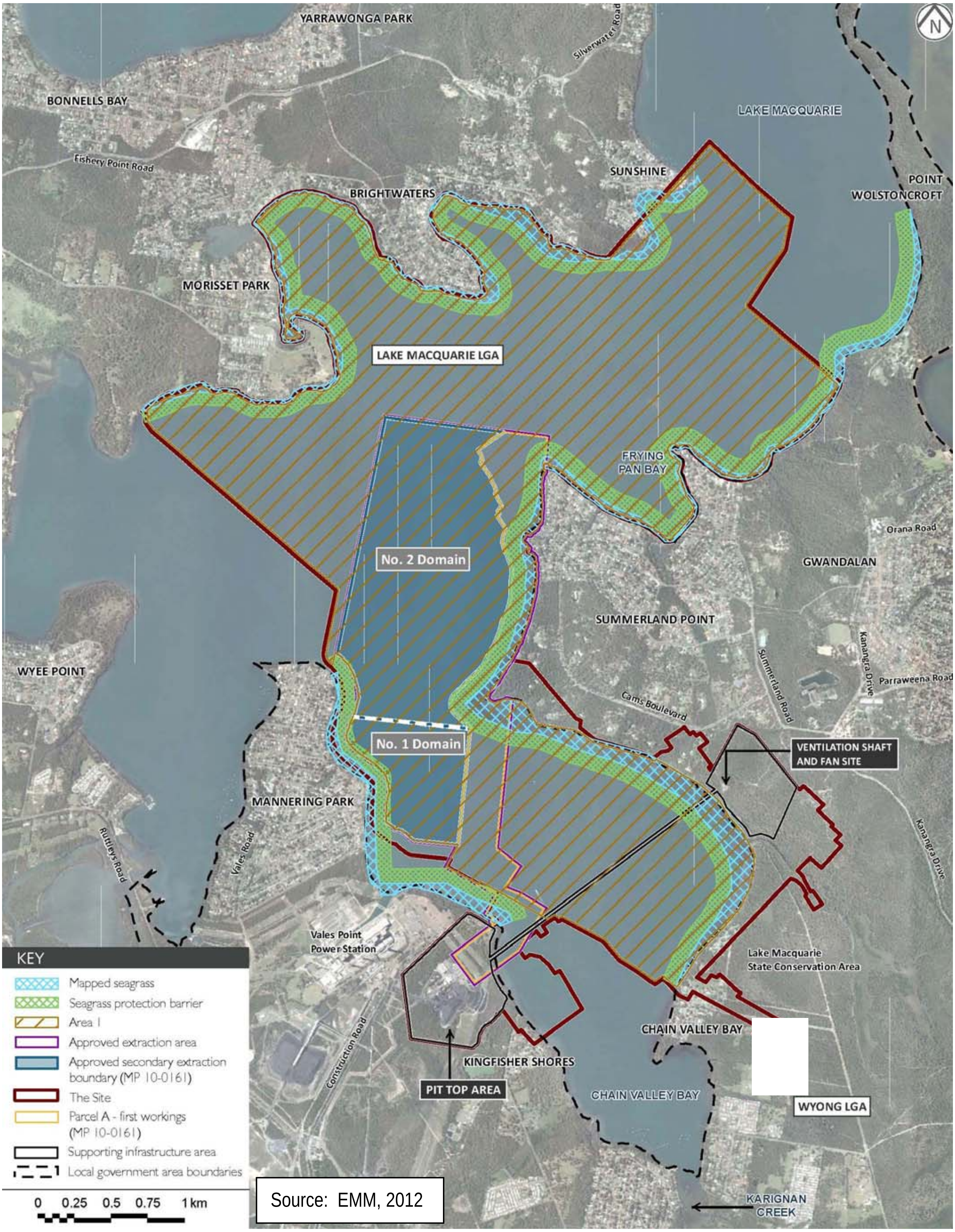

Figure 1 **Chain Valley Colliery Mining Areas**

2. LEGISLATION

The following sub-sections outline New South Wales statutory requirements that apply to the proposed mining operation with respect to groundwater.

2.1 Water Management Act 2000

The key legislation for the management of water in the Project Area is *Water Management Act 2000*, which regulates water use for rivers and aquifers where water sharing plans have commenced.

The Project area is located in the *South Lake Macquarie Water Source* section of the Water Sharing Plan - Hunter unregulated water sources.

The object of the *Water Management Act 2000* is the sustainable and integrated management of the State's water for the benefit of both present and future generations. The Act provides arrangements for controlling land-based activities that affect the quality and quantity of the State's water resources. It provides for four types of approval:

- Water use approvals – authorise the use of water at a specified location for a particular purpose, for up to ten years;
- Water management work approvals;
- Controlled activity approvals; and
- Aquifer interference activity approvals – authorise the holder to conduct activities that affect the aquifer. This approval is for activities that intersect groundwater, other than water supply bores and may be issued for up to ten years.

For controlled activities and aquifer interference activities, the Act requires that the activities avoid or minimise impacts on the water resource and land degradation, and where possible the land must be rehabilitated.

Under the *Water Management Act 2000*, the NSW Office of Water has prepared a range of statutory water management plans covering aspects such as water sharing, water use, drainage management and floodplain management. In NSW, 36 water sharing plans have commenced, covering 80 percent of water currently extracted. The plans cover most of the regulated river systems (those controlled by major dams for rural water supplies), a number of unregulated river systems and the major inland alluvial aquifers.

2.2 State Groundwater Policy

The *NSW State Groundwater Policy* (Framework Document) was adopted in 1997 and aims to manage the State's groundwater resources to sustain their environmental, social and economic uses. The policy has three component parts:

- The *NSW Groundwater Quality Protection Policy*, adopted in December 1998;
- The *NSW State Groundwater Dependent Ecosystems Policy*, adopted in 2002; and
- The *NSW Groundwater Quantity Management Policy*.

2.2.1 Groundwater Quality Protection

The *NSW Groundwater Quality Protection Policy* (Department of Land and Water Conservation, 1998), states that the objectives of the policy will be achieved by applying the management principles listed below.

- All groundwater systems should be managed such that their most sensitive identified beneficial use (or environmental value) is maintained.
- Town water supplies should be afforded special protection against contamination.
- Groundwater pollution should be prevented so that future remediation is not required.
- For new developments, the scale and scope of work required to demonstrate adequate

groundwater protection shall be commensurate with the risk the development poses to a groundwater system and the value of the groundwater resource.

- A groundwater pumper shall bear the responsibility for environmental damage or degradation caused by using groundwaters that are incompatible with soil, vegetation and receiving waters.
- Groundwater dependent ecosystems will be afforded protection.
- Groundwater quality protection should be integrated with the management of groundwater quality.
- The cumulative impacts of developments on groundwater quality should be recognised by all those who manage, use, or impact on the resource.
- Where possible and practical, environmentally degraded areas should be rehabilitated and their ecosystem support functions restored.

2.2.2 Groundwater Dependent Ecosystems

The *NSW State Groundwater Dependent Ecosystems Policy* (Department of Land and Water Conservation, 2002) is specifically designed to protect valuable ecosystems which rely on groundwater for survival so that, wherever possible, the ecological processes and biodiversity of these dependent ecosystems are maintained or restored for the benefit of present and future generations. The policy defines Groundwater Dependent Ecosystems (GDEs), as *"communities of plants, animals and other organisms whose extent and life processes are dependent on groundwater".*

Five management principles establish a framework by which groundwater is managed in ways that ensure, whenever possible, that ecological processes in dependent ecosystems are maintained or restored. A summary of the principles follows:

- GDEs can have important values. Threats should be identified and action taken to protect them;
- Groundwater extractions should be managed within the sustainable yield of aquifers;
- Priority should be given to ensure that sufficient groundwater is available at all time to identified GDEs;
- Where scientific knowledge is lacking, the precautionary principle should be applied to protect GDEs; and
- Planning, approval and management of developments should aim to minimise adverse effects on groundwater by maintaining natural patterns, not polluting or causing changes to groundwater quality and rehabilitating degraded groundwater systems.

2.2.3 Groundwater Quantity Protection

The objectives of managing groundwater quantity in New South Wales are to:

- achieve the efficient, equitable and sustainable use of the State's groundwater;
- prevent, halt and reverse degradation of the State's groundwater and/or its dependent ecosystems;
- provide opportunities for development which generate the most cultural, social and economic benefits to the community, region, state and nation, within the context of environmental sustainability; and to;
- involve the community in the management of groundwater resources.

3. CURRENT AND PROPOSED OPERATIONS

Chain Valley Colliery is an underground coal mine operated by LakeCoal Pty Ltd (LakeCoal).

The Colliery is located in the Newcastle Coalfields at the southern end of Lake Macquarie in NSW, and is approximately 60 kilometres south of Newcastle, within the Swansea-North Entrance Mine Subsidence District.

The Management Plan Area incorporates the relatively flat pit top area, existing ventilation shaft and fan site on Summerland Point, as well as foreshore areas and Lake Macquarie.

The terrestrial land within the GwMP Area is gently undulating and drains to Lake Macquarie.

Chain Valley commenced operation in the 1960's extracting coal from the Wallarah seam, the Great Northern seam and the Fassifern seam, and currently conducts mining within leases ML 1051, CCL 721 and ML 1632.

The current Fassifern Seam miniwalls are located underneath Lake Macquarie, within and to the north of Chain Valley Bay.

No current or proposed secondary extraction underlies any terrestrial based surface water catchments, with all secondary extraction proposed to be underneath the saline, tidal region of Lake Macquarie.

The Colliery currently has Development Consent (SSD-5465) for:

- extraction of up to a maximum of 1.5 million tonnes per annum until 31 December 2027 through continued mining via first workings and miniwall methods within the Fassifern Seam;
- continued coal transport for the surface facilities site;
- continued use of the existing surface facilities, and;
- continuation of passive underground activities within the old workings of the Wallarah seam, Great Northern seam and the Fassifern seam.

The proposed mining areas lie approximately 200m below the sediments of Lake Macquarie, within a boundary set to exclude secondary extraction within the High Water Mark Subsidence Barrier or the Seagrass Protection Barrier.

Bord and pillar mining has previously been undertaken within the Fassifern seam, however currently miniwall mining has been introduced and is proposed for all future secondary extraction within the Fassifern seam.

The miniwall panels will be 97m wide (rib to rib) with 30.6m wide inter-panel pillars. The panel widths are significantly less than those previously proposed for Chain Valley and adjacent mines – for example, at Wyee Colliery Longwalls 17 to 21 were up to 150m wide, and were extracted between 150m and 180m below surface.

The Development Consent (SSD-5465) was approved on 23/12/2013 which permitted the above activities.

Historically, Chain Valley Colliery has mined within the Wallarah and Great Northern seams to the east with via bord and pillar methods, while to the south west and west Wyee State Mine (now named Mannering Colliery) has mined the Great Northern Seam and Fassifern using bord and pillar and longwall extraction.

Mining within the Wallarah and Great Northern Seams will not be undertaken as part of the Project.

The maximum water depth within the proposed mining areas is approximately 9m and the maximum depth to rock head is 20m.

Sediment on the bottom of the lake varies in thickness up to about 10m.

The overburden above the Fassifern Seam, determined by subtracting the rock head from the seam level depth, ranges from 175 – 185m.

3.1 Adjacent Workings

Chain Valley Mine is entirely surrounded by the existing Mannering, Myuna and Wallarah Collieries as well as by the historic Newvale and Moonee Collieries.

Mannering Colliery (formerly the Wyee State Mine), has conducted longwall mining in the Great Northern and Fassifern seams since the 1960s. Extraction continued until 2002, when mining became uneconomic. The mine was temporarily shut down until 2004 when it was reopened by Centennial Coal. Since 2004, mining has progressed in the Fassifern Seam using bord and pillar methods.

The Myuna Colliery commenced operation in 1981 and is currently mining the Wallarah and Fassifern seams via bord and pillar techniques.

Wallarah Colliery operated from 1979 until 2002, when it was placed under care and maintenance.

Munmorah, Mandalong and Cooranbong Collieries are also nearby, but are not immediately adjacent to the Chain Valley Colliery holding boundary.

3.2 Predicted Subsidence

The maximum subsidence after completion of mining will be located under Lake Macquarie, with the 20mm subsidence line to be contained within the lake high water mark (Ditton Geotechnical Services, 2013).

The maximum predicted subsidence, tilts and strains over the proposed workings (assuming a 200m depth of cover) are summarised in **Table 1**.

TABLE 1 Maximum Predicted Subsidence

Parameter	**Miniwall Workings**
Vertical subsidence	620mm
Tilt	17mm/m
Strain (compressive and Tensile)	6.0mm/m

It is predicted there will be no measureable subsidence at the lake foreshore (Ditton Geotechnical Services, 2013).

3.3 Rainfall and Evaporation

Analysis of climatic data from the Bureau of Meteorology (BoM) weather station at Peats Ridge indicates the following rainfall data;

- Maximum 2186 mm/annum
- 90th percentile 1685 mm/annum
- 75th percentile 1418 mm/annum
- Median 1226 mm/annum
- 20th percentile 902 mm/annum
- Minimum 567 mm/annum

The annual evaporation patterns at Peats Ridge BoM Station indicate the following;

- Maximum 1420 mm/annum
- 90th %ile 1247 mm/annum
- 75th %ile 1210 mm/annum
- Median 1170 mm/annum
- 20th %ile 1090 mm/annum
- Minimum 410 mm/annum

4. LOCAL GROUNDWATER SYSTEM

For management purposes, groundwater within the GwMP area has been divided into the following classes;

(Mine water) groundwater and town water that is pumped into or out of the underground workings

(Groundwater) water contained within strata overlying the mine workings

(Seeps and springs) groundwater that discharges to surface water catchments within the Project Area.

Groundwater flows from the "terrestrial" recharge areas, outside of Lake Macquarie, as well as from the saline waters of Lake Macquarie into the overburden under a regional hydraulic gradient, with dominantly horizontal confined flow along discrete discontinuities and fractures within bedding planes, and / or above fine grained, relatively impermeable strata within the overburden sequence.

The overburden generally contains low yielding aquifers with low hydraulic conductivities.

A schematic of the stratigraphic sequence is shown in **Figure 2.**

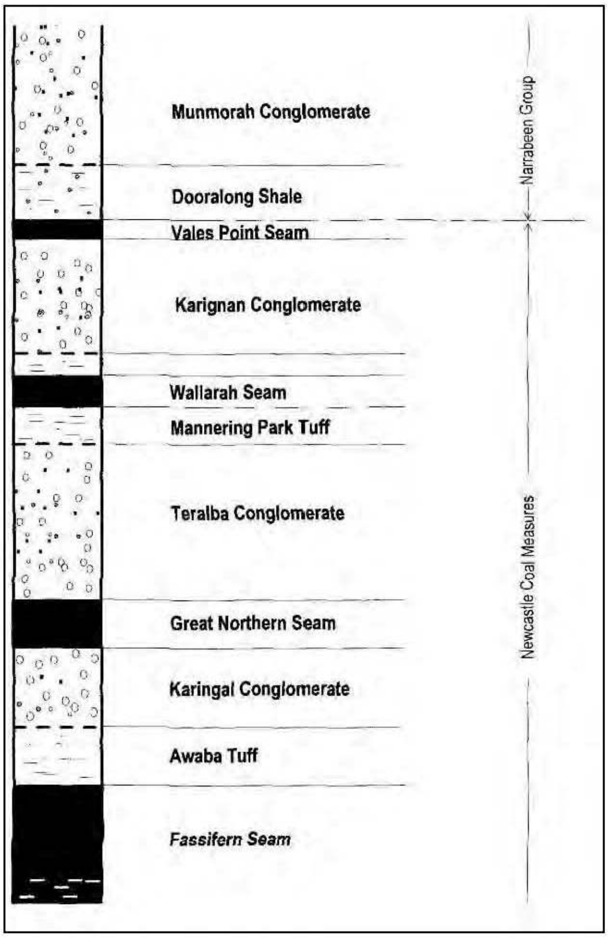

Figure 2 Local Area Stratigraphy

4.1 Alluvial Aquifers

Quaternary to recent alluvial terrestrial sediments comprising sand, gravel, clay and silt are associated with creeks and drainage channels in the local area, to the east, west and south the shores of Lake Macquarie.

Alluvium in the vicinity of the Project area is likely to be present associated with the drainage lines which discharge to Lake Macquarie.

No data is available for the thickness or lithology of alluvium within the Project area. However it is anticipated, if present, to be thin, with limited aerial extent, and no significant water storage or transmitting capacity.

Alluvial sediments within the "terrestrial" areas, outside of the Project Area, are generally too shallow and limited in extent to be used for groundwater supply.

4.2 Lake Macquarie Sediments

Sediments within Lake Macquarie consist of unconsolidated sands, clays, silts and gravels from 6 – 10m thick, with a maximum depth to bedrock from the surface of Lake Macquarie being approximately 20 metres.

4.3 Shallow Bedrock

The shallow bedrock comprises weathered bedrock which potentially contains discontinuous perched aquifers developed at the interface between the soil and bedrock and along zones of locally increased permeabilities caused by weathering of bedrock and faulting.

The depth and permeability of any aquifers is likely to be dependent on the depth of weathering and the extent and frequency of any permeable fracture systems.

Recharge to the shallow bedrock aquifer is primarily through rainfall infiltration, with some infiltration into to the underlying basement through fractures, joints and faults.

4.4 Deep Bedrock

The Newcastle Coal Measures are overlain by the Munmorah Conglomerate and the Dooralong Shale of the Triassic Narrabeen Group which comprise the majority of the overburden.

The Munmorah Conglomerate extends to a depth of approximately 120m in the vicinity of the Project area and comprises mostly quartz-lithic sandstone interbedded with pebble conglomerate.

The Dooralong Shale is up 20m thick and comprises cross-bedded sandstone intercalated with siltstone and claystone (Forster and Enever, 1992).

Fractured bedrock aquifers would be present within the Narrabeen Group and the Newcastle Coal Measures with discrete water yielding horizons associated with zones of increased permeability i.e. faults and the coal seams.

The overburden and interburden is a low yielding sequence of essentially dry conglomerates and shales.

Joints and fractures associated with fractured bedrock systems tend to be laterally and vertically discontinuous, resulting in poor hydraulic connection and low groundwater yields.

Forster and Enever (1992) state that "*neither the Narrabeen Group nor the Newcastle Coal Measures contain any significant quantities of groundwater and their permeabilities are known to be generally low (<10-7 m/s).*

Any permeable zones which do occur are usually due to jointing, faulting and shearing on bedding planes.

Because of the extremely low permeability of the rock substance, groundwater flow through the overburden strata is almost exclusively by interconnecting defects such as joints and bedding.

For this reason, coal seams with their interconnecting cleat and joint patterns are often found to be 'aquifers' relative to the surrounding strata. Despite this, most underground coal mines on the Central Coast are quite dry, and rarely have any major groundwater problems."

Groundwater in the deep bedrock aquifer is of poor quality with salinity levels ranging from 3000 - 7000 µS/cm.

Recharge to the deep bedrock aquifer is generally from infiltration of rainfall from overlying aquifers and the flow direction is expected to reflect the local topography.

4.5 Coal Seams

The coal deposits historically or currently mined in the area include the Wallarah, Great Northern and Fassifern seams of the Newcastle Coal Measures which are generally interbedded with tuffaceous claystone.

The coal seams generally have a low primary or inter-granular porosity and permeability, with bedding planes, joints, fractures and cleating imparting an enhanced secondary permeability.

The 4.5 – 5.5m thick Fassifern seam underlies the Wallarah and Great Northern seams within the Project area, and lies between 185m and 220m below surface, with a proposed mining height of up to 3.5m.

4.6 Structure and Intrusions

The overburden dips at approximately two degrees to the south-west.

Superimposed on the regional dip is the Macquarie Syncline, with an axis that runs through the Chain Valley Colliery holding, along with associated faulting and igneous intrusions.

Mapped and inferred geological structures in the Project Area include a number of faults and dykes.

The current Fassifern Seam workings have intersected these geological structures, however, no significant inflows were observed when installing the main headings.

4.7 Private Bores Within or Adjacent to the Proposed Mining Area

Fifteen NOW registered bores are located within or near the GwMP area as shown in **Figure 3** and **Table 2**.

From the available data, the majority of bores are completed in shallow (<18.3mbgl) sandy alluvium with one coal exploration bore converted for use as a domestic water supply (GW31646)

All remaining private bores in the GwMP are potentially used for domestic garden or limited irrigation water supply.

Where the data is available from the NOW records, groundwater has been obtained from the shallow sandy alluvial / colluvial aquifers with low to moderate yields ranging from 0.13L/sec to 1.50L/sec.

The private bore suite enables groundwater monitoring at various locations within and outside the proposed coal extraction area.

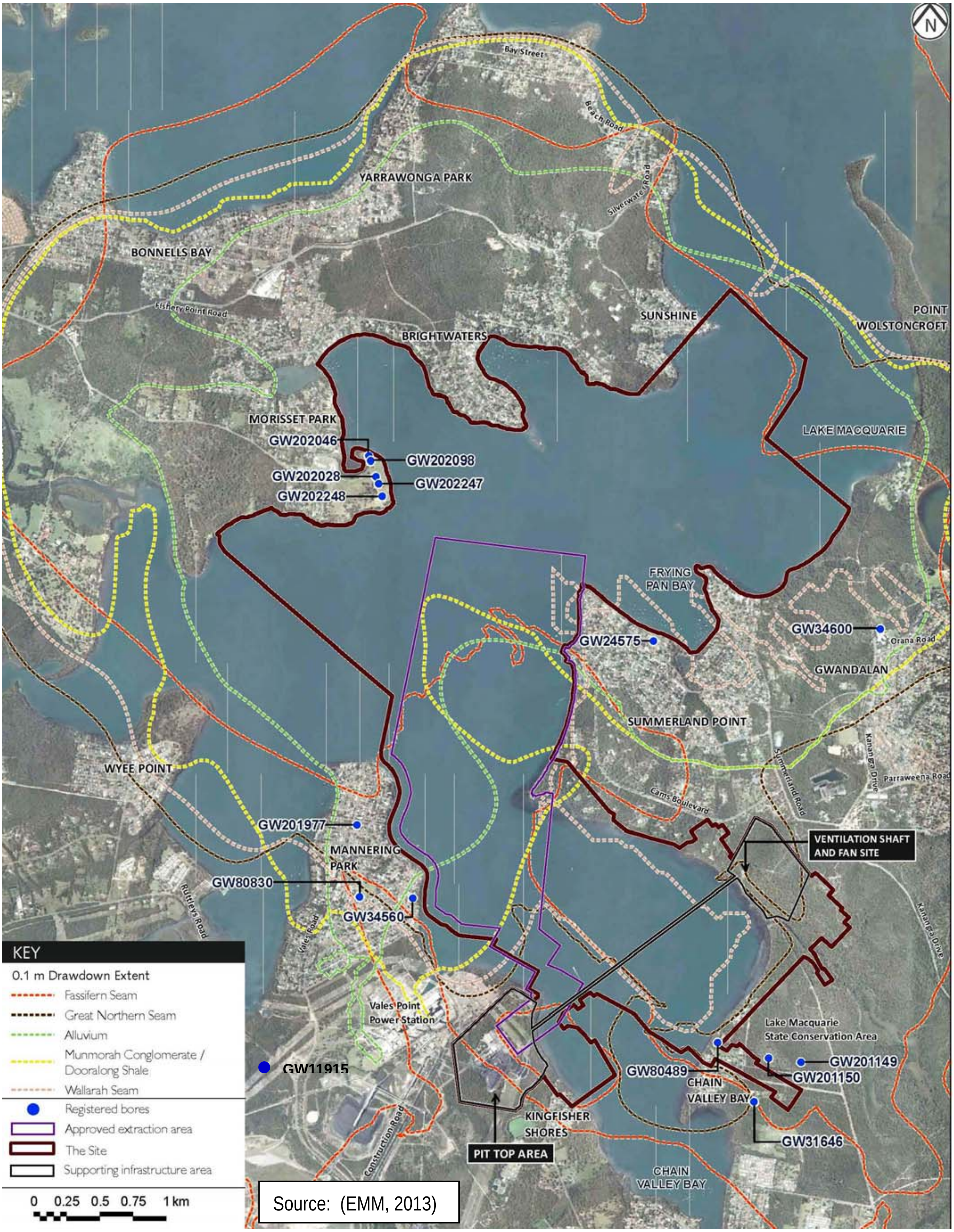

Figure 3 Local Groundwater Bores

Table 2 Registered Local Private Bores

GW	E	N	Drilled	Depth (m)	SWL (m)	Aquifer (mbgl)	YIELD (L/s)	Purpose	Bore Currency
11915	363007	6329604	-	5.4	-	-	-	Poultry	no response
24575	365969	6332788	1965	15.2	-	-	-	Domestic	no response
31646	366742	6329317	1960	277.5	3.0	3.0 – 10.6	0.13	Dom. / Coal Explore	not present
34560	364130	6330883	1970	18.3	5.5	5.5	-	Domestic	not present
34600	367678	6332873	1971	61.0	5.7	18.2	0.06	Waste disposal	-
80489	366441	6329674	2003	-	-	-	-	Domestic	no internal access
80830	363757	6330850	2004	-	-	-	-	Test bore	capped / covered
201149	367104	6329608	2006	4.0	1.0	1.0 – 4.0	1.50	Irrigation spear	no response
201150	366840	6329640	2006	4.0	1.0	1.0 – 4.0	1.50	Irrigation spear	no response
201977	363730	6331388	2008	7.1	6.0	6.0 – 7.0	-	Monitoring	-
202028	363872	6334034	2007	5.5	1.6	-	-	Test bore	not present
202098	363829	6334141	2007	4.0	0.8	-	-	Test bore	not present
202246	363834	6334174	2007	3.5	1.2	0.6 – 3.5	-	Test bore	not present
202247	363899	6333964	2007	5.0	3.6	2.0 – 5.1	-	Test bore	not present
202248	363918	6333881	2007	5.0	-	2.0 – 5.0	-	Test bore	not present

Note: - no data available

4.8 Regional Groundwater Use

The NOW database indicates 17 registered bores lie within a 5 km radius of the colliery, with one registered bore located within the GwMP area.

Registered bores in the vicinity of the GwMP area are generally installed into the Munmorah Conglomerate to a maximum depth of 61m, with the majority of bores installed to less than 30m.

Groundwater yields are generally less than 1 L/s, with one bore reporting a yield of 5 L/s.

The authorised uses of the bores include:

- stock watering;
- poultry
- industrial;
- domestic, and;
- waste disposal.

While it is recognised that not all existing bores are likely to be registered, the database gives an indication of groundwater usage in the area.

Overall, it is concluded that the importance and reliance on groundwater by local landowners and residents is limited.

5. PREVIOUS MINING EFFECTS

The Chain Valley Mine is surrounded by other collieries which have been extracting coal from as early as the 1940s using both longwall and bord and pillar methods.

Historical and current mining operations have resulted in extensive dewatering and depressurisation within and overlying the extracted coal seams.

Water is pumped out of the mines which results in a lowering of the potentiometric surface within the overlying aquifers.

Due to the extent of mining in the region, the subsidence effects would have partly depressurised the overburden.

5.1 Wyee State Mine

An extensive study by (Forster and Enever, 1992) at the adjacent Wyee State Mine (now called Mannering Colliery) assessed the impact of 150m wide longwall mining on the hydrogeological properties of the overburden.

The study assessed that longwall mining of the Great Northern Seam resulted in measurable changes in the hydrogeological properties over a large proportion of the overburden as a result of the redistribution of stresses. The changes reported for the overburden were:

- **Upper Strata** (more than 115 m above the Great Northern Seam) - the hydrogeological properties of the strata after mining were generally similar to those measured prior to mining. Some strata reported a temporary drop in piezometric pressure which recovered soon after the completion of mining in that area.
- **Intermediate Strata** (65 to 115 m above the Great Northern Seam) – experienced significant permanent piezometric pressure increases after mining. The cause of the increase in pressure was uncertain, however it was concluded that *“since the intermediate strata have not lost piezometric pressure, it is certain that significant vertical drainage has not occurred from these strata and they have formed an effective barrier against vertical hydraulic connection between the surface and the mine.”*
- **Lower Strata** (less than 65 m above the Great Northern Seam) – showed significant increased permeability and permanent decreases in piezometric pressure which indicated that significant cracking has occurred and allowed partial drainage into the workings.

Although measured changes in the lower strata indicate hydraulic connection was generated and groundwater seepage to the workings had occurred, the changes in the intermediate and upper strata was not significant, and were due to minor strata movements and the formation of fractures that were vertically discontinuous.

It was assessed that the intermediate and upper strata would form a barrier to vertical drainage and that aquifers from 65 - 115m above the workings should not be hydraulically vertically connected to the workings, and should not be drained as a result of subsidence.

Aquifers greater than 115m above the mine workings should not be impacted at all.

It should be noted that the subsidence studied over the Wyee mine related to 150m wide longwalls, whilst the maximum width of the proposed Chain Valley miniwalls is 97m, with 30.6m wide pillars. As a result, the predicted subsidence and the height of fracturing over the proposed workings will be significantly less than was observed over the Wyee longwalls

6. MINE WATER

6.1 Potable Water Supply

The mine has a single potable water supply connection from the Wyong Council town-water system.

Approximately 132ML/year of potable water is supplied to the mine, of which approximately 20ML/year (15%) is used for pit top operations and 112ML/year (85%) is used for dust suppression in the underground.

The EIS water balance indicates potable water used in the pit top area may be reduced by 11.8 ML/year as a result of proposed water saving measures at the Colliery, including the use of rainwater tanks and re-use of water within the sedimentation ponds for dust suppression purposes.

The proposed miniwall extraction is assessed to require an additional increase of approximately 25% to account for any additional underground potable water demand, which is interpreted to be in the order of 28 ML/yr of potable water supply.

As required by Schedule 3, Condition 18(b) of SSD-5465, practical measures to minimise potable water consumption and maximise recycled water use have been implemented and continue to be investigated by LakeCoal, as discussed in the associated WMP. However, the use of non-potable water in all operational activities is not possible due to its quality, work health and safety and equipment requirements.

6.2 Licensed Discharges

The discharge of mine water from the sedimentation and pollution control ponds is licensed under the *Protection of the Environment Operations Act* 1997 by the Environment Protection Authority (EPA).

Under the Environmental Protection Licence (EPL) No. 1770 there is a single licensed discharge point for Chain Valley Mine (LDP1), which has a maximum discharge volume of 12,161 kL/day.

The Colliery applied for a 4443 ML/year Groundwater Licence on the 5th October 2011 under the *Water Act, 1912* which is seeking to pump water from the underground workings to the sedimentation and pollution control ponds at the pit top. The licence (20BL173107) was subsequently granted on the 12 March 2013 under the Water Act 1912.

6.3 Mine Water Pumping and Groundwater Inflow

Recent data indicates that an average of 118KL/day, or 43.07ML/year (between March 2013 and October 2014) of potable water is pumped into the underground, whilst 2,305 - 2536ML/year of groundwater is extracted from the mine via two pumps in the Great Northern Seam workings sump as shown in **Figure 4**

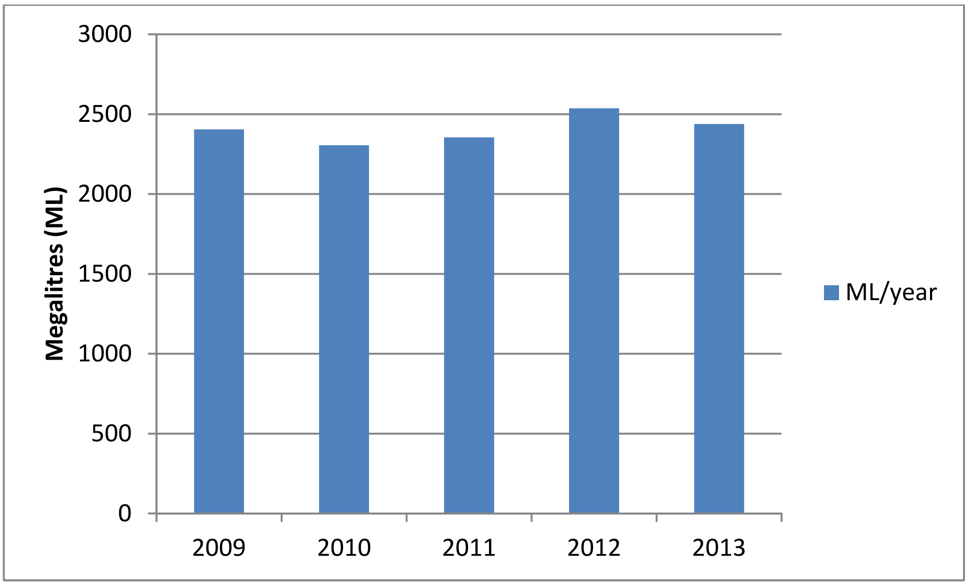

Figure 4 Annual Average Mine Dewatering Volumes

The net groundwater seepage into the workings is estimated from the difference between the annual potable water intake and the annual water volume extracted from the underground workings.

The annual groundwater make for the current mine workings is estimated at 2439ML/yr, or 6.68ML/day.

Temporary increases in groundwater inflows to the mine have been reported in the vicinity of faults and associated fractures. The increases in inflow are usually short lived as the structures associated with fractured bedrock systems tend to be laterally and vertically discontinuous, resulting in poor hydraulic connection and have low groundwater yields (GeoTerra, 2013).

In general, the Fassifern Seam has to date been the driest seam, whilst mining of the overlying Wallarah Seam has been conducted without major adverse impacts to the overlying aquifers or inflow of water from Lake Macquarie (GeoTerra, 2013).

6.4 Groundwater Quality

Groundwater monitored within the current and historic underground mining areas in the Chain Valley mine indicates the inflow water is brackish to relatively saline in subsided areas over the Great Northern Seam workings (11,800 – 28,200mg/L) with a circum-neutral to mildly alkaline pH (7.30 – 7.76).

Groundwater seepage from a dyke at the northern end of the current Fassifern seam workings, over the unsubsided main headings, had a brackish salinity of 2,390mg/L and an alkaline pH of 8.63 as shown in **Tables 3 and 4**.

The data indicates that groundwater within the underground is significantly above the ANZECC 2000 criteria (default trigger values for physical & chemical stressors in SE Aust lowland rivers and 95% protection of freshwater species) for;

- pH (Fassifern dyke);
- electrolytical conductivity (all samples);
- total nitrogen (all samples);
- total phosphorous (Fassifern dyke), as well as,
- filterable copper (GNS sump , Fassifern dyke), and

- filterable zinc (all samples except GNS2)

The exceedance in the mine water seepage depends on the guideline applied for the end use of the water.

The groundwater seepage is not generally suitable for potable, livestock or irrigation use, but is suitable for discharge under the EPA licence to Lake Macquarie.

Table 3 Water Chemistry - Major Ions

	pH	EC (uS/cm)	TDS	Na	Ca	K	Mg	Cl	F	HCO3	SO4	Total P	Total N	DOC
ANZECC 2000	6.5 -8.0	2,200	-	-	-	-	-	-	-	-	-	0.05	0.5	-
Karignan Ck	6.93	185	100	29	2.2	2.3	3.5	54	0.10	10	6	**0.15**	**0.6**	17
Chain Valley Bay	7.64	47,300	36,100	10500	470	470	1100	19400	1.3	125	2200	**0.06**	0.4	<1
GNS SUMP	7.48	35,600	23,200	7640	590	125	690	13600	0.25	360	1200	0.04	**2.3**	2
GNS1 (roof)	7.30	40,400	28,200	7980	730	80	840	15600	0.47	435	1320	<0.01	**3.4**	<1
GNS2 (pond)	7.76	19,500	11,800	3950	140	38	230	6730	0.57	385	250	0.02	**0.6**	3
Fassifern dyke	**8.63**	3,500	2,390	925	1.9	9.1	2.1	310	5.6	2040	7	**0.65**	**4.1**	3

NOTE: all values in mg/L
samples collected 22/6/2012

Table 4 Water Chemistry - Metals

	Fe(T)	Fe	Mn(T)	Mn	Cu	Pb	Zn	Ni	Al	As	Li	Ba	Sr
ANZECC 2000	-	-	1.9	1.9	0.0014	0.0034	0.008	0.011	0.055	0.013 / 0.024	-	-	-
Karignan Ck	1.3	0.82	0.03	0.03	**0.003**	<0.001	**0.014**	<0.01	0.05	<0.01	<0.001	0.026	0.10
Chain Valley Bay	0.10	0.02	0.02	0.01	**0.003**	<0.001	**0.013**	<0.01	0.03	<0.01	0.38	0.041	4.8
GNS SUMP	0.18	0.07	0.06	0.04	**0.004**	<0.001	**0.018**	<0.01	0.04	<0.01	0.98	0.084	31
GNS1 (roof)	0.12	0.07	0.27	0.16	<0.001	<0.001	**0.010**	<0.01	0.03	<0.01	1.3	0.080	44
GNS2 (pond)	0.05	<0.01	<0.01	<0.01	<0.001	<0.001	0.003	<0.01	0.01	<0.01	0.59	0.17	11
Fassifern dyke	2.4	0.08	0.06	0.02	**0.004**	<0.001	**0.019**	<0.01	0.04	<0.01	0.28	0.37	1.0

NOTE: all values in mg/L
metals reported as acidified and 45um filtered samples except where Total (T) values are shown
samples collected 22/6/2012

No adverse changes to groundwater quality in subsided private bores over the historic mining areas have been reported by land owners.

7. POTENTIAL GROUNDWATER IMPACTS

It is anticipated that subsidence over the 185 - 220m deep proposed miniwall workings may affect the overlying groundwater system through;

- surface cracking to approximately 20m below surface;
- goaf fracturing to less than 115m above the seam, with partial loss of groundwater if fracturing extends into an overlying aquifer, which can cause minor groundwater inflow from the goaf to the workings;
- an exponential decrease in overburden permeability with height above the workings;
- connectivity between the mine workings and overlying aquifers within the fractured goaf, which can result in depressurisation of the aquifers;
- dewatering and depressurisation of the Great Northern and Fassifern seams as mining progresses;
- increased aquifer permeability, and potentially
- reduced groundwater quality in the overlying aquifers.

7.1 Hydraulic Connection to Lake Macquarie

The (Forster and Enever, 1992) study art Wyee, with 150m wide longwalls, indicated there was no hydraulic connection at heights over 115m above the extracted workings.

It should be noted that the proposed miniwalls have a maximum width of 97m, which means the height of fracturing would be less than that observed over the 150m wide Wyee longwalls.

As a result, hydraulic connection between the mine and Lake Macquarie over the proposed workings is not likely as the minimum depth of cover is at least 185m.

7.2 Aquifer / Aquitard Interconnection

Mining induced cracking and vertical subsidence of strata over the extraction area may potentially extend up to 20m below surface, with bedding dilation below from below the surface zone down to the upper goaf.

In the upper horizons, subsidence can alter the dominance of the pre-mining horizontal flow along or above aquitards to generate a combination of vertical and horizontal flow regimes as aquitards are breached and water drains to lower elevations in the strata.

Vertical flow continues down the strata until the drainage is restricted by intact aquitards, at which the depth the flow then resumes its horizontal dominance.

Below the surface cracked zone, an increase in horizontal flow component can occur due to dilation and bending of strata, even though the layers are not actually breached by vertical cracking. The increased horizontal permeability extends across the subsided area, gradually diminishing as the subsidence and dilation decreases out to the edge of the subsidence zone.

No adverse interconnection of aquifers and aquitards is anticipated within 20m of the lake bed as there are no recorded aquifers in this interval.

However, there may be an increased rate of recharge into the upper overburden from the lake waters due to the increased secondary porosity and permeability of the subsided, fractured overburden.

7.3 Regional Groundwater Depressurisation

Extensive mining of the Fassifern, Wallarah and Great Northern seams at Chain Valley and surrounding collieries for more than 60 years has significantly depressurised the overburden within the vicinity of the proposed workings.

Groundwater levels within the Fassifern seam has already been extensively impacted by mining in the area and therefore the proposed mining is likely to have little additional impact, if any.

The deeper basement lithologies have increased permeability in areas of partial or full extraction due to subsidence induced caving and fracturing over the workings which results in an increased groundwater storage capacity of the overburden through increased secondary porosity.

Groundwater flow rates within the deeper aquifers are likely to increase within the caved and fractured areas due to greater hydraulic connectivity between horizontal and vertical fractures.

A temporary lowering of the regional piezometric surface over the subsidence area of up to 1.0m due to horizontal dilation of strata may occur due to the increase in secondary porosity and permeability (GeoTerra, 2013). This effect will be more notable directly over the area of greatest subsidence and dilation, and will dissipate laterally out to the edge of the subsidence zone.

Based on similar observations in NSW with similar mining layouts, surficial and mid depth strata groundwater levels may reduce by up to 15m, and may stay at that reduced level until maximum subsidence develops at a specific location. The duration of the reduction depends on the time required to develop maximum subsidence, the time for subsidence effects to migrate away from a location as mining advances to subsequent panels, and the length of time required to recharge the secondary voids.

The degree of groundwater level decline under the lake due to subsidence is predominantly determined by the proximity to a mined panel, however it can also be significantly affected by the rate of lake water infiltration and terrestrial rainfall recharge to an aquifer, as well as changes in the rate or duration of groundwater extraction in any adjacent groundwater bores.

On the basis that the pre-mining circumstances of lake water and rainfall recharge as well as any local bore pumping remain the same, it is anticipated that groundwater levels will recover over a few months as the secondary void space is recharged by lake water and rainfall infiltration.

There is generally no permanent post mining reduction in groundwater levels under the lake, as no new hydraulically connected outflow paths from within the overburden develop.

7.4 Private Bore Yields and Serviceability

Although 6 registered bore sites are located within the predicted 1.0m groundwater depressurisation area, no private bore yields or serviceability are anticipated to be affected by subsidence or regional groundwater depressurisation associated with the proposed workings, which are entirely located under Lake Macquarie.

No beneficial users of the deep bedrock/coal measures aquifers have been identified in the vicinity of the GwMP Area.

7.5 Groundwater Dependent Ecosystems

Cumulative impacts from the proposed mining are not anticipated to adversely impact on groundwater dependant ecosystems in the 20mm subsidence area.

This is primarily because no groundwater dependent ecosystems have been identified in the proposed subsidence area within or under Lake Macquarie

7.6 Groundwater Quality

Previous observations in NSW Coalfields indicates that groundwater quality within the subsided overburden is not generally adversely affected, however there may be increased iron hydroxide precipitation and a lowering of pH if the groundwater is exposed to “fresh” surfaces in the strata with dissolution of unweathered iron sulfide (marcasite) or iron carbonate (siderite).

The degree of iron hydroxide and pH change due to subsidence is difficult to predict, and can range from no observable effect to a distinct discolouration of water pumped out of bores.

The discolouration does not pose a health hazard, however it can cause clogging of pumping equipment and piping in extreme cases.

It should be noted that many bores in the local area can already have significant iron hydroxide levels, and a pre-mining survey of the active bores is required to assess the baseline water quality prior to undermining.

Acidity (pH) changes of up to 1 order of magnitude can occur, however the change can be reduced if the bore has sufficient bicarbonate levels.

The potential for groundwater contamination also exists from spills of fuels, oils and chemicals from both the surface and underground mine workings. Spills may result in the contamination of soil, while the infiltration of rainfall or direct migration of contaminants to the water table has the potential to contaminate shallow aquifers.

The potential for impacts can be minimised through the appropriate storage of fuels and hazardous chemicals, the implementation of appropriate work procedures and regular inspections and maintenance of equipment and plant.

Leaks and spills should be handled in accordance with the Environmental Management Plan prepared for the project, and remediated as required on a case by case basis.

Infiltration of potentially contaminated water from the sedimentation dams also has the potential to impact groundwater quality. As the dams receive all site runoff, amenities water and mine water, as well as workshop and wash down water after treatment by an oil separator, there is potential for the water within the dams to be contaminated by dissolved petroleum hydrocarbons and heavy metals. It is understood the dams are not lined with a low permeability layer, and as such, seepage of potentially contaminated water within the dams may be infiltrating alluvial or shallow aquifers.

7.7 Groundwater Seepage to or From Terrestrial Streams

No known springs or streams are present in the GwMP area that would be affected by subsidence and associated regional groundwater depressurisation with the existing and proposed workings.

Overall, the terrestrial streams within the GwMP area will be subjected to no or very low tensile and compressive strains and are not anticipated to be adversely affected by subsidence related stream bed cracking.

No loss of overall stream flow or regional change in stream water quality within the local streams is anticipated to occur.

7.8 Groundwater Inflow to Mine Workings

Loss of lake water or any significant loss of connate groundwater within the overburden to the underlying workings has not been observed in mines in the local area at similar depths of cover to the proposed workings.

Vertical hydraulic connection to the workings would be restricted by the Dooralong Shale and the Mannering Park Tuff aquitards, which are not anticipated to be breached by subsidence over the proposed Fassifern seam workings and are both below the surficial and above the goaf, vertically connected, dilation zones.

The horizontal permeability above and between the aquitards may be enhanced after subsidence, however there is no additional vertical connectivity through or below them to the underlying workings.

Based on available records, the current indicated groundwater seepage averages 2396ML/yr (6.56ML/day).

No distinctive relationship between expansion of the mine and increase in groundwater inflow to the workings is evident in the current data.

Based on a groundwater modelling assessment (GeoTerra, 2013) the current inflow of 6.56ML/day may increase up to 10.5ML/day as the Colliery expands.

8. GROUNDWATER MONITORING PLAN

The groundwater monitoring program at locations shown in **Figure 3** is designed to provide a database that enables:

- comparison of anticipated vs observed impacts on the groundwater system through miniwall as well as bord and pillar extraction of the Fassifern seam at Chain Valley Colliery and any associated subsidence effects, and;
- procedures to assess, manage or rehabilitate any adverse effects that exceed specified trigger levels.

As the proposed workings, and the anticipated associated subsidence impacts, are wholly located underneath or within Lake Macquarie, the monitoring plan specifically deals with the following issues.

8.1 Mine Groundwater Inflow

The active underground mining area should be monitored by the underground deputy to assess whether observable groundwater inflow is occurring to the active panels and to note if any changes are noted.

Water flow monitoring appliances have been installed in the mine to measure pumped water volumes to and from the mine workings. These appliances will be maintained in good working order, and if required, the mine will supply a test certificate to certify the current accuracy of the appliances furnished by the manufacturer or by some duly qualified person or organisation.

Daily total mine water pumping records will be maintained, plotted and interpreted annually and will be supplied to NOW annually within the AEMR.

8.2 Private Bore Water Levels

Where property access is granted and access inside a bore is possible, water levels within the private bores will be measured at least once before and once after mining is conducted in the GwMP Area to assess if any adverse effects due to subsidence have occurred as shown in **Table 5**.

Where monitoring of groundwater levels is not possible due to installed pump head-works, the mine will assess any reports from landowners in regard to adverse effects on bore water availability that may occur during or after extraction of the proposed workings.

Each property owner will be interviewed before and after the proposed mining to assess the bore’s status, pumping rate, its general duration of pumping as well as the type and set up of the pump. The bore yield should also be measured, and water levels measured where access inside the bore is possible.

Where private bores are being occasionally or frequently pumped, and could thereby temporarily distort the static regional groundwater levels, the depth to groundwater, where accessible, should be monitored during pump resting periods to assess the regional piezometric surface across the area.

Table 5 Private Bore Water Level Monitoring

GW	Monitoring Frequency	Monitoring Method	Units
11915	Upon access / post mining	Dip meter	mbgl
24575	Upon access / post mining	Dip meter	mbgl
34600	Upon access / post mining	Dip meter	mbgl
201149	Upon access / post mining	Dip meter	mbgl
201150	Upon access / post mining	Dip meter	mbgl
201977	Upon access / post mining	Dip meter	mbgl

Note: mbgl = metres below ground level

8.3 Groundwater Quality

8.3.1 Inactive Private Bores

Where property access is granted and access inside a bore is possible, a pre-mining water sample collection and analysis will be conducted within one month of access being granted and available, and will be repeated at the end of mining in the Project Area to enable assessment of any subsidence related changes in groundwater quality.

Each bore will be purged prior to sampling until pH and salinity measurements stabilise, which usually involves removal of at least three bore volumes of water.

Samples will be collected, appropriately preserved, kept on ice and transported under chain of custody documentation to arrive at the laboratory within appropriate holding times.

In addition, each piezometer or inactive bore will be monitored in the field for bi-monthly salinity (µS/cm) and pH measurements.

8.3.2 Active Private Bores

Where property access is granted and access to the groundwater bore is possible, an initial water sample collection and analysis will be conducted within one month of access being granted and available, and will be repeated at the end of mining in the Project Area to enable assessment of any subsidence related changes in groundwater quality.

To date, access to one current bore has been granted (GW80489), however no sample could be obtained as the installed pump was not working.

The use, and any treatment, of the bore water should be ascertained and observations made on the quantum of iron hydroxide precipitating from the pumped water before and after mining.

Each bore will be purged prior to sampling until pH and salinity measurements stabilise, which usually involves removal of at least three bore volumes of water.

Samples will be collected from bores that are current and accessible as shown in **Table 5**, and will be appropriately preserved, kept on ice and transported under chain of custody documentation to arrive at the laboratory within appropriate holding times.

Table 6 Private Bore Water Quality Monitoring

GW	Monitoring Frequency	Monitoring Method	Units
11915	Upon access / post mining	In situ pump / bailer	pH EC mg/L (ions, metals, nutrients)
24575	Upon access / post mining	In situ pump / bailer	pH EC mg/L (ions, metals, nutrients)
34600	Upon access / post mining	In situ pump / bailer	pH EC mg/L (ions, metals, nutrients)
201149	Upon access / post mining	In situ pump / bailer	pH EC mg/L (ions, metals, nutrients)
201150	Upon access / post mining	In situ pump / bailer	pH EC mg/L (ions, metals, nutrients)
201977	Upon access / post mining	In situ pump / bailer	pH EC mg/L (ions, metals, nutrients)

During extraction within the GwMP area, the frequency of monitoring and the parameters to be monitored may be varied in consultation with NOW once the baseline groundwater quality and its response to mining (if any) is established.

The frequency of post mining monitoring will be reassessed after mining is complete in the GwMP Area as it may be possible, depending on results, to lengthen the intervals.

Table 7 presents the physical groundwater quality parameters to be measured.

Table 7 Groundwater Quality Monitoring Parameters

SUITE	ANALYTES
Initial monitoring / After mining is completed	Field EC, Eh, pH, temp TDS, Na, K, Ca, Mg, F, Cl, SO4, HCO3, NO3, Total N, Total P Cu, Pb, Zn, Ni, Fe, Mn, As, Se, Cd, Cr, Li, Ba, Cs, Rb, Sr (filtered)

8.4 Groundwater Contamination

In accordance with the sites Environmental Protection Licence, surface water discharged from the dams is monitored monthly for a range of pollutants as specified in the site EPL and associated Water Management Plan.

The range of analysis for surface water also includes oil and grease, which allows the assessment of impact, if any, that these dams may be having on underlying aquifers.

9. GROUNDWATER ASSESSMENT CRITERIA AND TRIGGERS

Management of impacts within predictions follow standard assessment review and response protocols.

Contingent measures are included in this plan to ensure the timely and adequate management of the proposed extraction and subsidence impacts outside of anticipated levels.

Where and if required, specialist hydrogeological / hydrological investigations and reports may include:

- the study scope and objectives
- consideration of any relevant aspect from this plan
- analysis of trends
- assessment of any impacts against prediction
- assessment of the cause of a change or impact
- options for management and mitigation
- assessment for the need for contingency measures
- any recommended changes to this plan, and;
- appropriate consultation with NOW, DRE and EPA

Site specific mitigation / remediation action plans may include:

- a description of the impact to be managed
- results of the specialist investigations
- aims and objections for the plan
- specific actions required to mitigate/manage
- timeframes for implementation
- roles and responsibilities
- identification of and gaining appropriate approvals from landholders and government agencies, and;
- a consultation and communication plan.

Trigger values for further assessment of potential subsidence effects on groundwater systems within the plan area are discussed in the following sections.

The triggers have been developed to reflect the current variability in relevant parameters and to enable the identification of any changes that may be due to either subsidence effects, landowner impacts and/or natural causes.

If trigger values are exceeded, the cause and effect will be investigated and a management plan developed if it is directly related to mining.

The Manager Environment shall be responsible for the implementation of agreed actions and shall communicate such actions to the relevant landowners or authorities.

9.1 Mine Water Extraction and Discharge

Chain Valley Colliery holds a NOW license (20BL173107) to extract up to 4443 ML/year from the workings, and currently holds EPL 1770 which permits volumetric discharge of up to 12,161 kL/day via its licensed discharge point into Lake Macquarie.

Mine water extraction will be measured daily and daily discharge volumes will be reported publically on a monthly basis via LakeCoal's website.

As part of the AEMR the average monthly groundwater extraction rates will be determined by assessing the difference between the potable water pumped into the workings and the total water pumped out of the workings.

A trigger for the groundwater extraction will be where the monthly average extracted underground mine water exceeds **10.5ML/day** (75^{th} percentile groundwater inflow – refer Table 3), and this average continues for at least 2 months.

9.2 Private Bore Groundwater Levels

It should be noted that landowners pumping their own bores, as well as the interference effect from other landholders pumped bores can significantly affect temporary standing water levels in a bore, without any influence from mining or subsidence.

On this basis, if the combined monitoring of the outlined private bores indicates a sustained drawdown of **greater than 2m over a 2 month period** in a private bore, or, if a landowner reports a lack of groundwater availability in a bore that cannot be accessed internally, then the cause of the exceedance will be investigated to assess whether the >2m drawdown or lack of supply is due to;

- lack of rainfall recharge, using comparison to the cumulative sum of daily rainfall,
- operation of landowner bores either within or outside an affected bores property,
- subsidence, or
- any or all of the above.

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The 2m drawdown trigger level has been derived through extrapolation of similar mining subsidence related effects in similar mining layouts and geomorphological areas in NSW and to be consistent with the minimal impact considerations of the NSW Aquifer Interference Policy.

9.3 Private Bore Groundwater Quality

If a landowner reports an increase in iron hydroxide precipitation or water salinity, as an initial default, the ANZECC 2000 irrigation and livestock guidelines shown in **Table 8** will be used as trigger levels to assess bore water quality.

As no bores are used for drinking water in the GwMP, drinking water quality criteria and triggers are not specified.

Table 8 Groundwater Chemistry Criteria (mg/L)

	pH	TDS	Hardness as CaCO3	Cu	Pb	Zn	Ni	Fe	Mn	As	Cd
Irrigation	*6 - 8.5*	-	*>60-350*	*5*	*5*	*5*	*2*	*10*	*10*	*2.0*	*0.05*
Livestock	-	*<4000/5000*	-	*1 / 0.4*	*0.1*	*20*	*1*	-	-	*0.5*	*0.01*

NOTE: all metals values are for filtered metals

irrigation criteria for short term trigger values (< 20 years)

Livestock criteria for beef / sheep

10. POTENTIAL GROUNDWATER AMELIORATIVE ACTIONS

10.1 Private Bore Yield

Although it is not anticipated due to the separation distance from the bores to the proposed subsidence area, should the accessibility, available drawdown or yield of a bore be impacted due to subsidence, the Colliery is required to provide an alternative water supply until the bore recovers.

If the level does not sufficiently recover and the effect is due to subsidence rather than regional climatic or anthropogenic factors, repairs or maintenance to a bore can be undertaken after maximum subsidence has developed. At this time the pump intake can be lowered, the bore extended to a greater depth or a new bore can be established.

With these mitigation measures in place it is unlikely that water supply to properties will be significantly impacted by the proposed mining.

In the event of a monitored or reported adverse impacts on the yield or saturated thickness of a private registered bore, the cause will be investigated.

If a groundwater level drop of over 2m for a period of over 2 months is recorded, and the reduction in bore yield is a consequence of subsidence, the mine will enter into negotiations with the affected landowners and the Mine Subsidence Board with the intent of formulating an agreement which provides for one, or a combination of;

- re-establishment of saturated thickness in the affected bore(s) through bore deepening;
- establishment of additional bores to provide a yield at least equivalent to the affected bore prior to mining;
- provision of access to alternative sources of water; and/or
- compensation to reflect increased water extraction costs, e.g. due to lowering pumps or installation of additional or alternative pumping equipment.

10.2 Private Bore Groundwater Quality

In the event of an adverse change in groundwater quality to a private bore, particularly in regard to salinity and / or iron levels, the mine will implement an investigation to determine if the cause is due to subsidence.

Although it is not anticipated due to the separation distance from the bores to the proposed subsidence area, if subsidence cracking has caused a notable increase in iron hydroxide precipitates or the landowner reports an adverse change in salinity, and that change that exceeds the trigger levels, the mine will enter into negotiations with the affected landowner with the intent of formulating an agreement which provides for one, or a combination of;

- re-establishment of the water supply from a new bore to provide water equivalent to the pre mining status of the bore (on the basis that the landholder has allowed for pre-mining status of the bore to be established);
- provide access to an alternative source of water, or;
- compensate the bore owner to reflect the economic costs incurred due to the subsidence effects on the water quality.

11. CONTINGENCIES

In the event that the proposed monitoring indicates that a trigger has been reached or is being approached, LakeCoal will commission a hydrogeologist or hydrologist to review the data, with the outcomes of that review, including any recommendations, being subject to consultation with NOW.

A trigger of pH or EC would initially lead to an increase in the analytes monitored and/or frequency of sampling to confirm the magnitude and extent of the change in groundwater chemistry and verify the change is a consequence of mining.

Should the standing water level trigger be achieved in any bore, the mine staff shall notify the affected landowner(s) and, if it is the hydrogeologist's opinion that the reduction is a consequence of mining, mitigation measures identified in previous sections will be initiated.

An independent authority may also be used where a dispute arises as to the cause of the change, given that groundwater supply and quality can be affected by non-mining related factors such as bore siltation, aquifer depletion by adjoining mining operations, agricultural users, bacterial infection, fertilizer contamination etc.

12. AUDIT AND REVIEW

This document shall be reviewed, and if necessary revised, within 3 months of the following;

- the submission of an Annual Environmental Management Report;
- the submission of an incident report;
- the submission of an independent environmental audit; and
- following any modification to the project approval.

Other factors that may require a review of the GwMP are;

- observation of greater impacts on surface features due to mine subsidence than was previously expected;
- observation of fewer impacts or no impacts on surface features due to mine subsidence than was previously expected, and/or;
- observation of significant variation between observed and predicted subsidence.

Internal and external audits of this document will be carried out as described below. If possible internal and external audits shall be objective and be conducted by a person or organisation independent of the document being audited.

Audits shall be carried out by personnel who have the necessary qualifications and experience to make an objective assessment of the issues. The extent of the audit, although pre-determined may be extended if a potentially serious deviation from this document is detected.

Any audit non-conformances and/or improvement opportunities will have corrective and preventative actions implemented to avoid recurrence, these actions will be loaded into the site Incident Database to ensure the actions are assigned to the relevant people and completed.

12.1 Internal Audits

Internal audits of this document and all other Environmental Management System documents are to be undertaken every three years. Improvements from the audit are to be incorporated in the site action database to ensure the actions are assigned to the relevant people and completed.

12.2 External Audits

External audits will be conducted utilising external specialists and will consider the document and related documents. External auditors shall be determined based on skills and experience and upon what is to be accomplished. External audits will be periodically at a frequency determined by the site General Manager, or in response to significant environmental incidents for which a systems failure has been determined as a contributor to the incident.

An Independent Environmental Audit will be undertaken every three years (or as otherwise required by the Department of Planning and Infrastructure) by an audit team whose appointment has been endorsed by the Director-General of the Department of Planning and Infrastructure.

Any actions arising from external audits will be loaded into the site actions database to ensure the actions are assigned to the relevant people and completed.

13. RECORDS

Generally the Environmental Specialist will maintain all Environmental Management System records, which are not of a confidential nature. Records that are maintained include:

- Monitoring data and equipment calibration;
- Environmental inspections and auditing results;
- Environmental incident reports;
- Complaint register; and
- Licenses and permits.

All records are stored so that they are legible, readily retrievable and protected against damage, deterioration and loss. Records are maintained for a minimum of 4 years.

14. RESPONSIBILITIES AND ACCOUNTABILITIES

14.1 General Manager

- Ensure that the requisite personnel and equipment are provided to enable this plan to be implemented effectively;

14.2 Environmental Coordinator

- Authorise the Plan and any amendments thereto;
- Ensure this plan is reviewed should any changes to the mine plan or if levels of subsidence are greater than predicted. Notify the relevant authorities of any triggers being exceeded;
- Reporting in the Annual Environmental Management Report
- Ensure that inspections are undertaken in accordance with the schedule;
- Ensure that persons conducting the inspection are appropriately trained, understand their obligations and the specific requirements of this plan;
- Review and assess monitoring results and inspection checklists;
- Promptly notify the General Manager of any identified environmental issue

14.3 Contract Hydrogeologist / Hydrologist

- Review the monitoring to the standard and frequency as outlined in this plan;
- Promptly notify the Environment and Community Coordinator of any identified environmental issue; and
- Compile the reports ready for submission as required by NOW.

15. TRAINING

All personnel who conduct inspections will be trained in the requirements of the plan.

Training will be conducted on maintaining and downloading monitoring equipment, operation of the field testing equipment and sampling procedure for laboratory analysis identification of the various subsidence impacts detailed in this plan.

16. REPORTING

16.1 Annual Environmental Management Report

An Annual Environmental Management Report (AEMR) will be submitted to NOW each year. As part of the AEMR the groundwater section will include;

- groundwater related activities, and the level of compliance with the GwMP;
- all groundwater monitoring volumes and rates taken by the works;
- the volume groundwater extracted from the works that was discharged via the Licensed Discharge Point;
- all groundwater extraction data;
- the extent of groundwater depressurisation and any groundwater salinity impacts compared with predictions in the Environment Assessment;
- interpretation of the data, discussion of trends and their implications;
- an overall comparison of groundwater performance with predictions for the life of the mine provided in the Environmental Assessment, and;
- an outline of proposed adaptive or remediation actions if required.

Notification of the groundwater monitoring results and interpretations will be reported within the required annual period to outline the natural trends and any impacts from mining on the groundwater system.

17. REFERENCES

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DISCLAIMER

The advice herein relates only to this project and all results, conclusions and recommendations made should be reviewed by a competent and experienced person with experience in environmental and / or hydrological investigations before being used for any other purpose. The client should rely on its own knowledge and experience of local conditions in applying the interpretations contained herein.

To the extent permitted by law, GeoTerra, excludes all warranties and representations relating to the report. Nothing in these terms will exclude, restrict or modify any condition, warranty, right or remedy implied or imposed by any statute or regulation to the extent that it cannot be lawfully excluded, restricted or modified. If any condition or warranty is implied into this license under a statute or regulation and cannot be excluded, the liability of GeoTerra for a breach of the condition or warranty will be limited to the supply of the service again.

Appendix 4

Benthic Communities Management Plan

LakeCoal	Doc Owner: **Environment and Community Coordinator**
	Doc No: Draft - ENV 00006 - Benthic Communities Management Plan

CHAIN VALLEY COLLIERY

Benthic Communities Management Plan

ENVIRONMENTAL MANAGEMENT PLAN

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	Technical Services Manager
Date:	22/02/2018

Table of Contents

1 Introduction

Chain Valley Colliery is an underground coal mine located on the southern end of Lake Macquarie, approximately 100km north of Sydney and 60km south of Newcastle, adjacent to the Vales Point Power Station, producing thermal coal for the domestic and export markets.

A formal Environmental Management System (EMS) has been developed as a systematic and structured approach to managing environmental issues at the operation. This has been developed in general accordance with the requirements of the international standard ISO 14001.

This Benthic Communities Management Plan (BCMP) is an element of the Chain Valley Colliery Environmental Management System.

This Benthic Communities Management Plan has also been completed to satisfy the requirement of Condition 7(h), Schedule 4 of Development Consent SSD-5465 (Modification 2), which states:

"The Applicant shall prepare an Extraction Plan for all second workings on site, to the satisfaction of the Secretary. Each Extraction Plan must:

> (h) include a Benthic Communities Management Plan, which has been prepared in consultation with OEH, LMCC, and DPI Fisheries, which provides for the management of the potential impacts and/or environmental consequences of the proposed second workings on benthic communities, and which includes:

- surveys of the lake bed to enable contours to be produced and changes in depth following subsidence to be accurately measured;
- benthic species surveys within the area subject to second workings, as well as control sites outside the area subject to second workings (at similar depths) to establish baseline data on species number and composition within the communities;
- a program of ongoing seasonal monitoring of benthic species in both control and impact sites;
- development of a model to predict likely impact of increased depth and associated subsidence impacts and effects, including but not limited to light reduction and sediment disturbance, on benthic species number and benthic communities composition, incorporating the monitoring and survey data collected; and
- updating the model every 2 years using the most recent monitoring and survey data;

The relevant requirements from Table 8 within Condition 2, Schedule 4 of SSD-5465 (Modification 2), including the relevant notes, are recreated in **Table 1**.

Table 1: Subsidence Impact Performance Measures

Biodiversity	
Benthic Communities	Minor environmental consequences, including minor changes to species composition and/or distribution

Notes:

- *The Applicant will be required to define more detailed performance indicators (including impact assessment criteria) for each of these performance measures in the various management plans that are required under this consent (see Condition 7 below).*
- *Measurement and/or monitoring of compliance with performance measures and performance indicators is to be undertaken using generally accepted methods that are appropriate to the environment and circumstances in which the feature or characteristic is located. These methods are to be fully described in the relevant management plans. In the event of a dispute over the appropriateness of proposed methods, the Secretary will be the final arbiter.*
- *The requirements of this condition only apply to the impacts and consequences of mining operations, construction or demolition undertaken following the date of approval of this consent.*

2 Purpose

The purpose of this Benthic Communities Management Plan is to:

- outline details of the benthic communities monitoring data collected;
- outline existing and predicted subsidence levels;
- outline the methodology to be used to identify depth changes at monitoring locations;
- identify benthic community monitoring locations;
- identify reporting requirements;
- detail benthic community management measures;
- identify the requirements for incident or exceedances reporting and reviews of the document; and
- identify persons responsible for implementation of requirements.

3 Background

3.1 Baseline Data on Benthic Communities

Both species diversity and abundance are recorded as part of the 6 monthly seasonal (autumn and spring) benthic communities monitoring, which commenced in 2012.

The mud basin off Summerland Point, in Chain Valley Bay and Bardens Bay, was found to be inhabited by 21 species of organisms greater than 1mm in size. Polychaete worms and bivalve molluscs were the most frequently encountered animals.

Bottom sediment in the study area was composed of a small fraction of black sand and shell fragments of various sizes. Most of the sediment was fine black or grey mud.

The sampling results of the benthos undertaken at six monthly intervals between February 2012 and September 2017 revealed the following:

- The similar suite of organisms dominated each of the 19 sample stations. These were polychaete worms and bivalves.
- Stations were distinguished by the relative abundance of the dominant species.
- Water depth was not the key parameter in determining the species composition at a station.
- Physical variables such as salinity (conductivity), dissolved oxygen concentration and turbidity of the bottom water, measured only on the day the benthos was sampled, had little influence on the species composition of the benthos over the period sampled.

The results collated to date appear to support the notion that increasing the water depth by the predicted levels of subsidence has, to date, had no discernible effect on the composition and abundance of organisms making up the benthos of the mud basin.

3.2 Bathymetric Surveys

Bathymetric data from the NSW Office of Environment and Heritage (OEH) was obtained in draft format during 2012. LakeCoal was granted a license to use this OEH data for the purposes of monitoring changes in the bed of Lake Macquarie, and acknowledges the OEH's data which has enabled the subsidence comparison to be undertaken based on this 2010 data and data subsequently obtained in 2012 by LakeCoal.

OEH notes that the data was obtained via use of differential GPS and a 200 kHz echosounder, which is noted to provide a general data accuracy of 0.1m.

LakeCoal commissioned Astute Surveying in March 2012 to undertake a bathymetric survey over the areas of current and proposed workings. The primary purpose of this survey was to obtain accurate baseline data for future subsidence assessments and to enable comparison with the draft OEH data from 2010. Importantly, the 2012 survey provided accurate details of the Lake depth within the proposed mining areas, which would enable future surveys to use as baseline data to monitor the future subsidence levels as a result of mining activities. Prior to 2018 bathymetric surveys have been conducted annually.

Following an exceedance of the subsidence predictions over Chain Valley Colliery's MW7-12 mining area in 2017 LakeCoal has committed to undertaking future bathymetric surveys at 6 monthly intervals to further understand the behavior of subsidence over the active mining areas.

The latest bathymetric survey results for Chain Valley Colliery are shown on

Figure 1. The surveys have shown that subsidence from the miniwall mining can be monitored with a useful level of accuracy and the surveys will be continued bi-annually to cover future mining areas and areas where mining has been completed.

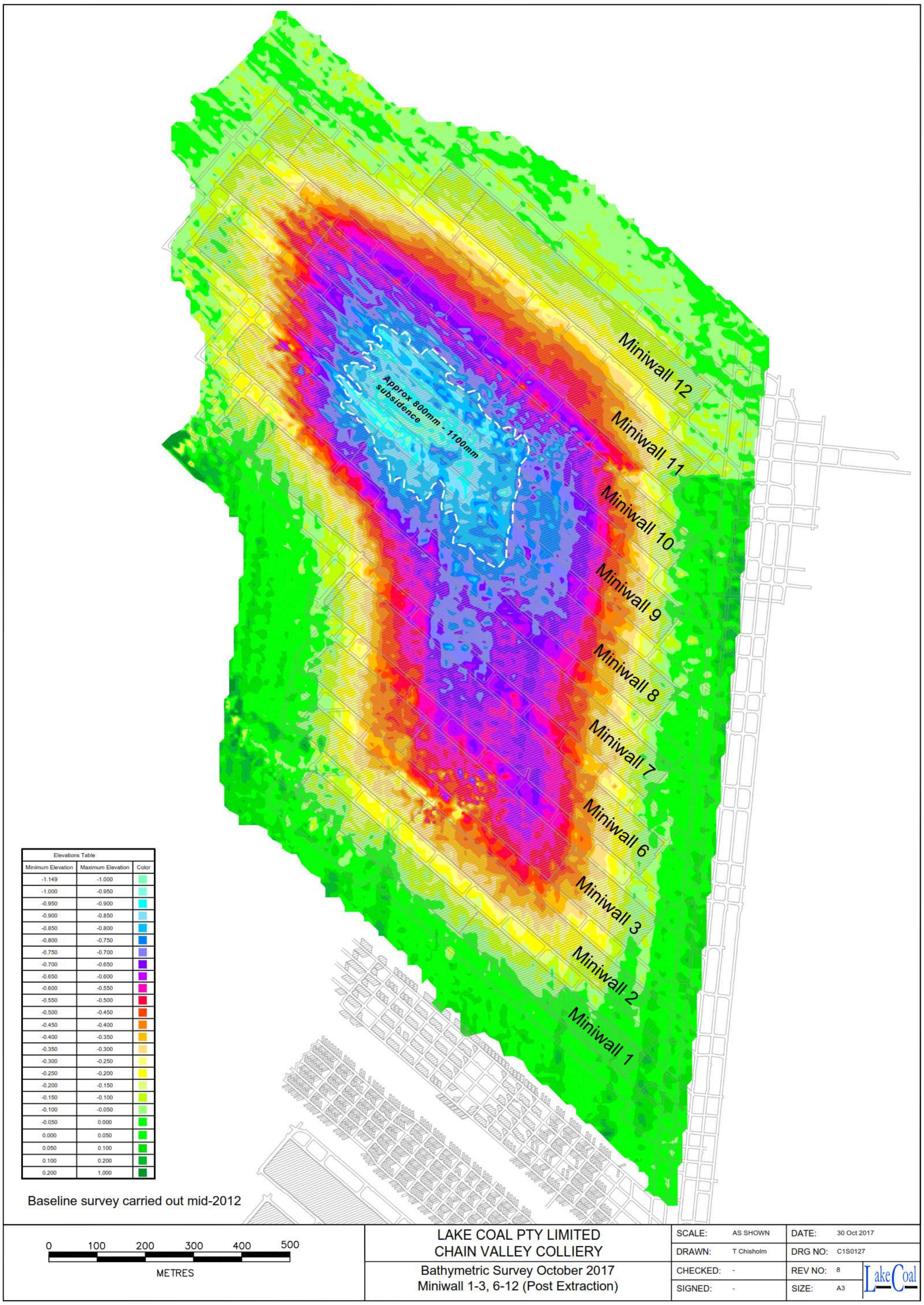


Figure 1: 2012-2017 Lake Bed Subsidence Results

3.3 Subsidence Predictions and Management

Subsidence modelling has predicted up to approximately 1.23 metres of subsidence to the Lake floor associated with the planned miniwall mining where there is overlying workings, and 780mm where only single seam extraction is undertaken.

As outlined in **Section 3.2** LakeCoal recorded a subsidence exceedance over its Miniwall 7-12 area during the 2017 bathymetric survey where 1100mm of subsidence occurred. As a result of the exceedance LakeCoal has re-designed its future mining its future mining areas to ensure that subsidence values are within the approved predictions.

3.4 Consultation

The Benthic Communities Management Plan is required to be prepared in consultation with the OEH, LMCC and DPI Fisheries.

The original Benthic Communities Management Plan was developed in consultation with the OEH, DPI Fisheries and LMCC. These agencies were contacted on the 28 March 2012, and at this time a face-to-face meeting was offered to discuss the development of the methodologies and management plan, however all stakeholders requested information be provided for comment due to resource constraints. As a result each stakeholder was provided a summary of the survey methods for comment on the 11 April 2012. A response was received from LMCC on the 23 May 2012 regarding mitigation measures and these comments were addressed in the BCMP. No comments were received from OEH or DPI Fisheries.

Copies of the draft Benthic Communities Management Plan (Revision 1) were distributed to the OEH, LMCC and DPI Fisheries on the 13th March 2014 with comments requested back by the 1st April 2014, as of the 7th April 2014 only one response from the OEH had been received, dated the 21st March 2014. The OEH noted that while they encourage the development of such plans, they do not approve or endorse these documents and accordingly no comments were provided.

The previous version of the Benthic Communities Management Plan was sent to OEH, DPI Fisheries and LMCC on 4 November 2016 for review and comment. All three agencies provided comments on the revised Plan. LMCC and DPI Fisheries confirmed that the document was acceptable in its revised form while OEH noted that while they encourage the development of such plans, they do not approve or endorse these documents and accordingly no comments were provided on the content of the Plan.

This current revision of the Benthic Communities Management Plan was provided to OEH, DPI Fisheries and LMCC on 26 February 2018. LakeCoal is currently awaiting feedback from the relevant government authorities on this revision. Due to approval timeframe constraints this version of the revised management plan has been included within the Extraction Plan application for Chain Valley Colliery's Northern Mining Area (NMA). The Management Plan will be updated and resubmitted once feedback and comments have been received by the relevant authorities.

4 Benthic Communities Monitoring Program

Based on contour mapping of Lake Macquarie and LakeCoal hydrographic surveys, it was identified that the mining operations are largely proposed to occur beneath areas of the Lake at water depths between 4-6m which represent the general Lake depths where subsidence is proposed and under which mining activities have been, will be or are proposed to occur. Accordingly, the monitoring program was designed to sample benthic invertebrate communities from these depths and to provide ongoing monitoring of the potential effects of subsidence. The methodology and monitoring details are presented in the following sections.

4.1 Sampling Locations

In order to analyse the community assemblages and determine potential impacts of subsidence over time, sampling was, and will continue to be undertaken across two depth intervals from numerous site locations within three site types. The site types consist of;

- Impacted (site prefix "IM"): Sites which are currently, or were historically impacted upon by subsidence;
- Reference (site prefix "R"): Sites which are not currently impacted by subsidence but fall within the proposed future mining footprint. Following undermining, Reference sites are designated as Impacted sites; and
- Control (site prefix "C"): Sites which will not be impacted upon by subsidence.

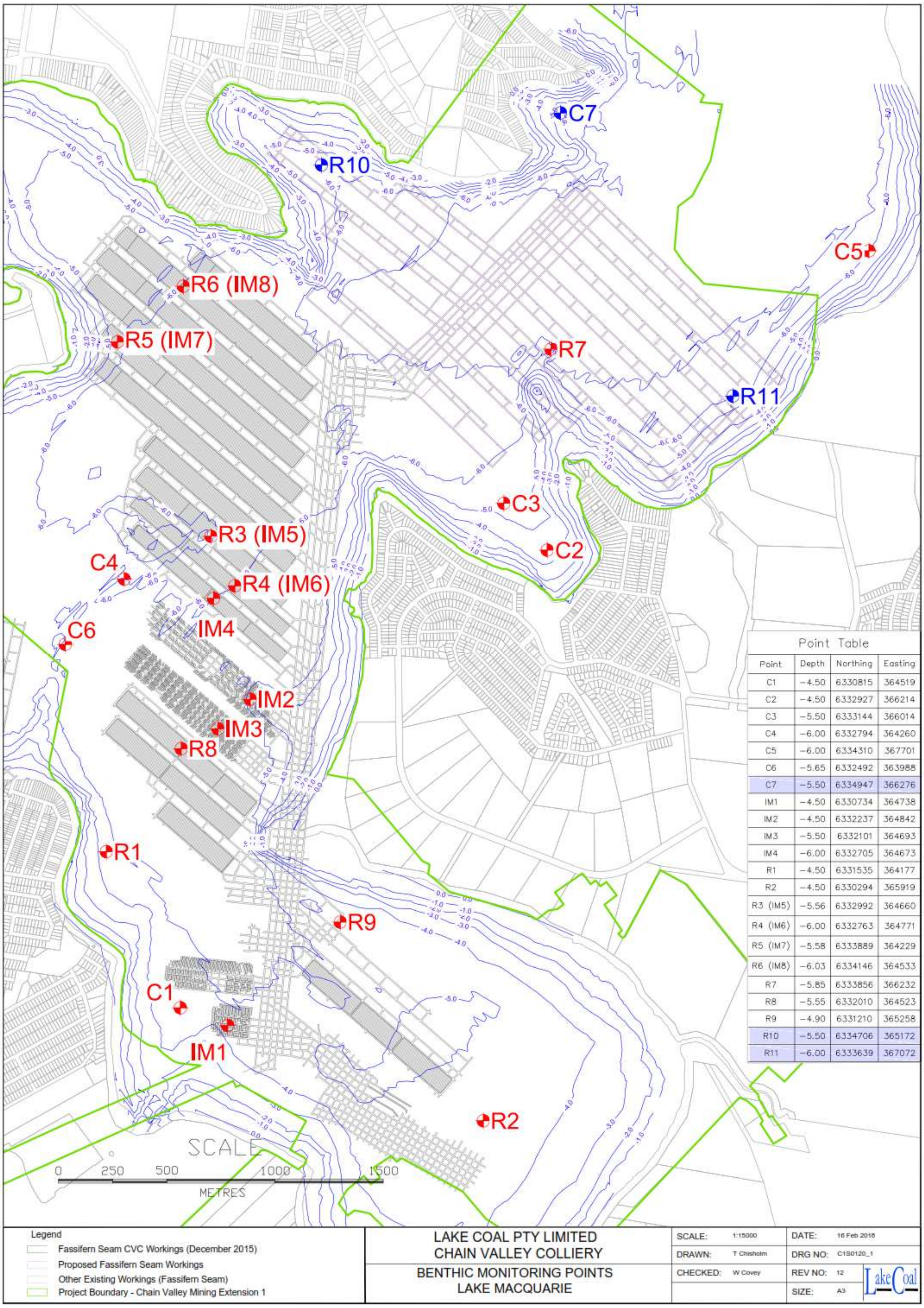
The sampling locations are identified in **Table 2** and

Figure 2.

Table 2: Benthic Community Sampling Locations

Site Name	Sample Depth (m)	Easting	Northing
C1	-4.5	364519	6330815
C2	-4.5	366214	6332927
C3	-5.5	366014	6333144
C4	-6	364260	6332794
C5	-6.0	367701	6334310
C6	-5.5	363988	6332492
C7	-5.5	366276	6334947
R1	-4.5	364177	6331535
R7	-6.0	366232	6333856
R9	-4.5	365258	6331210
R10	-5.5	365172	6334706
R11	-6.0	367072	6333639
IM1	-4.5	364738	6330734
IM2	-4.5	364842	6332237
IM3	-5.5	364693	6332101
IM4	-6	364673	6332705
IM5 (previously R3)	-6	364771	6332763
IM6 (previously R4)	-5.5	364660	6332992
IM7 (previously R5)	-5.5	364229	6333889
IM8 (previously R6)	-6.0	364533	6334146

IM9 (Previously R8)	-5.5	364523	6332010
IM10 (Previously R2)	-4.5	365919	6330294



Point Table

Point	Depth	Northing	Easting
C1	−4.50	6330815	364519
C2	−4.50	6332927	366214
C3	−5.50	6333144	366014
C4	−6.00	6332794	364260
C5	−6.00	6334310	367701
C6	−5.65	6332492	363988
C7	−5.50	6334947	366276
IM1	−4.50	6330734	364738
IM2	−4.50	6332237	364842
IM3	−5.50	6332101	364693
IM4	−6.00	6332705	364673
R1	−4.50	6331535	364177
R2	−4.50	6330294	365919
R3 (IM5)	−5.56	6332992	364660
R4 (IM6)	−6.00	6332763	364771
R5 (IM7)	−5.58	6333889	364229
R6 (IM8)	−6.03	6334146	364533
R7	−5.85	6333856	366232
R8	−5.55	6332010	364523
R9	−4.90	6331210	365258
R10	−5.50	6334706	365172
R11	−6.00	6333639	367072

Figure 2: Monitoring Locations

4.2 Sampling Methods

Each of the sites will be surveyed for biotic (benthic invertebrates) and environmental (water quality, benthic sediment) variables. The surveys will be undertaken during spring and autumn.

4.2.1 Water Quality

General physico-chemical water quality variables will be measured at the sites during sampling. The water quality parameters will be measured at 0.5m below the surface and 0.5m above the Lake bed. The variables measured will include temperature (^{o}C), pH, turbidity (NTU), conductivity (µS/cm), dissolved oxygen (mg/L and % saturation) and oxygen radiation potential (ORP) or photosynthetically active radiation (PAR).

4.2.2 Benthic Sediment

Sediment samples will be collected to a depth of 20cm at each of the sites using 250mL jars. The jars will be labelled and transported to the laboratory for analysis via settlement method.

4.2.3 Benthic Invertebrates

At each site, five replicate samples of benthic sediment will be collected by a diver using 200x200x100mm sieve boxes with 1mm mesh.

The samples will be sieved to remove sediment particles less than 1mm in diameter. The residual material will then be transferred to a labelled 250mL plastic jar and preserved with formaldehyde. Large fragments of shell will be removed from the sample at this time to ensure that the sample volume did not exceed 250mL and the samples are retained for later inspection at the laboratory.

4.3 Laboratory Analysis

4.3.1 Benthic Sediment

The 250mL sample of the entire sediment from each site will be transferred into a 500mL clear glass measuring cylinder and the volume made up to 500mL with seawater. The cylinder is then to be stoppered and shaken vigorously to suspend the sediment in the seawater. The sample will then be allowed to settle and the volumes of each fraction (shell and coarse sand, fine sand, mud and fine silt) calculated and recorded. Results are then determined relative to the initial volume of sediment collected in the 250mL jar.

4.3.2 Benthic Invertebrate Identification

The contents of each jar is run through a 1mm mesh sieve and washed free of formalin and any remaining mud.

The washed material is then placed into two enamel dishes and portions of each sample placed in a 100mm diameter petri dish for examination under a stereoscopic binocular microscope to detect and recover small organisms. Organisms and parts of organisms are removed, counted, identified and the results entered into a spread sheet. The benthic invertebrates are identified to genera and species where possible. This process is repeated until the debris of the entire sample had been examined. The results for each site are then entered into an excel spreadsheet for summary and analysis. All shell remaining in the sample is kept for later examination.

4.4 Data Analysis

The biotic and environmental data will be analysed using a variety of univariate and multivariate analysis (**Table 3**). The statistical methods used to analyse the data were determined based on earlier monitoring data to provide the most statistically robust assessment of comparison between impacted and reference and control sites and environmental data. It must be noted that control and reference sites are the same until undermined.

Table 3: Data Analysis

Variable Type	Analysis	Description
Environmental: Water quality	ANZECC/ARMCANZ Guidelines (ANZECC Guidelines)	Trigger values for slightly – moderately disturbed ecosystems: Estuaries.
Biotic and Environmental	Univariate	Descriptive graphical statistics. Analysis of Variance and Similarity (2 way nested)
Biotic and Environmental	Multivariate	A square-root transformation was performed on the data and Bray-Curtis Similarity matrices created. Cluster analysis was then performed for each site and dendrogram plots produced.
	Multidimensional Scaling Ordination	The analysis represents the sites as points in space so the relative distances between samples show similarities in community structure. Samples that are placed closer together are more similar than samples further apart.
	BIOENV	The analysis matches environmental variables against biotic data which have been measured at the same sites. This analysis enables analysis of the extent to which the physio-chemical data is related to the observed biological patterns. Correlations were performed for each site between the biotic and environmental factors using the BIOENV function in PRIMER5.

4.5 Monitoring Frequency

The baseline sampling program methods outlined in **Section 4** will form the basis for a seasonal monitoring program that will be undertaken during spring and autumn each year to survey biotic (benthic invertebrates) and environmental variables (water quality and sediment). The program has been designed to enable analysis and reporting of the data to monitor the impacts of subsidence and effects, including but not limited to light reduction and sediment disturbance, on benthic species number and benthic communities composition and distribution.

In addition to the above, annual lake bed bathymetric surveys will be undertaken prior to each autumn survey. The annual bathymetric surveys will enable any change to the lake floor to be identified and addressed during the data analysis process.

4.6 Program Refinement

The survey methods will be reviewed every two years of seasonal sampling to refine the sampling program if required. Prior to each seasonal sampling event the sites will be reviewed against the mine plans to ensure that any reference sites that have become impacted upon by mining are reclassified as impact sites, and replacement reference sites are identified and sampled. This will result in additional reference sites being added to the program during the monitoring period.

5 Modelling to Monitor Potential Impacts

5.1 Model Background

Maximum subsidence for the proposed future mining activities is predicted to be 1230mm, or 780mm where no overlying workings exist. The analysis undertaken on the baseline data provides an initial assessment of biotic and environmental variables associated with the study area and forms the basis of the formation of the predictive modelling (JSA 2012). The results will be reported in biannual monitoring reports and the Annual Review.

The aim of the predictive modelling is to compare the condition of the baseline benthic community assemblages prior to mining to the benthic community assemblages after mining has occurred, to ensure that only minor environmental consequences occur due to mining activities. The effects of subsidence are required to result in only minor changes to species composition and/or distribution. As the environmental variables which affect benthic communities are complex, in order to determine whether community dynamics at reference sites are related to subsidence, seasonal biotic survey data will be analysed against environmental data and between impacted types. The analysis and modelling will be undertaken to determine whether:

- Overall community dynamics are related to seasonal and environmental variables and/or subsidence impacts;
- Abundance and diversity changes to community composition at reference sites that have been undermined are related to seasonal and environmental variables or subsidence impacts; and
- Changes identified in reference sites that have been undermined are considered minor.

5.2 Analysis

In order for the model to identify whether the environmental consequences of subsidence are considered minor (and therefore whether mitigation measures will be required) a series of statistical analysis will be undertaken and reported seasonally and annually. Based on the expected timing of subsidence impacts, the analysis will model scenarios to determine:

- Changes in undermined reference sites with the baseline conditions at the same sites; and
- Similarity of impacted sites to control and reference sites at similar depths.

The modelling will be based on Multi-dimensional Scaling (MDS) Ordination, two way ANOVAs (analysis of variation) and ANOSIM (analysis of similarity) techniques to identify any links in community structure between sites at the same depth profiles. The modelling will be based on the existing benthic community structure, actual subsidence levels (determined from annual bathymetric surveys), predicted levels of increased subsidence and collection of seasonal data.

Figure 2 identifies the reference sites applicable to the project. The communities at the reference sites will be compared against control and reference sites at a similar depth profile. The determination of the level of impact of subsidence, once other environmental variables have been discounted by the model will be based on ANOVA/ANOSIM techniques.

Essentially, if ANOVA/ANOSIM results indicate that undermined reference site communities are changing at a rate of ANOVA/ANOSIM test of significance <5 % then the impacts will be considered to be moderate or major mitigation measures to manage impacts will be required. The use of 5% (the p significance level of 0.05) is a standard statistical method of determining level of significance, another is p= 0.01. Because the data set used in the initial analysis represents a single sampling event the use of the conservative 5% significance rule has been applied to determine minor impacts(other methods such as ranking and scaling were applied to the data but did not provide adequate measurable results). The 5% significance will be applied to seasonal data and revisited with regard to suitability based on data outcomes.

The options for mitigation measures to manage subsidence on the lake floor are largely limited to changes to mine design. If impacts are determined to be moderate or major, mine planning will be required to modify mine plans.

The benthic community results of surveys and annual monitoring undertaken have identified that while communities at some sites were defined by dominant species, the abundance and diversity of the communities did not identify clear links to location or impact type. Rather the analysis identified that natural environmental fluctuations in water quality, benthic substrate composition and natural depth intervals were influencing the communities (JSA 2013).

The results of sampling between February 2012 and September 2017 appear to support the notion that increasing the water depth by the predicted subsidence will have no discernible effect on the composition and abundance of organisms making up the benthos of the mud basin (Laxton & Laxton, 2017). This is supported by the statistical modelling of results which is undertaken every 3 years.

In January 2018 LakeCoal engaged JSA environmental to undertake the 3 yearly statistical modelling of the sites Benthos data set. Detailed ANOSIM analysis of the benthic community data between un-impacted and impacted sites between 2012 – 2017 identified a significance p value of 24.1%. This value indicates that there had been no significant differences between the un-impacted and impacted sites over the last 5 years.

If the assessment of results from future analysis indicate that impacts are outside the defined trigger level LakeCoal will investigate the cause of incident and implement corrective actions where required as outlined in Section 6.

6 Incident & Compliance Management

6.1 Introduction

The benthic community monitoring results will be reviewed on a biannual basis as survey reports are received to confirm compliance with the conditions specified in the *Subsidence Impact Performance Measures* found in **Table 1**.

The Annual Review will also include a summary of monitoring results during the past year, discussion with reference to the impact assessment criteria, and any relevant details related to comparisons between actual results and predictions in the Environmental Impact Statement. The Annual Review will be forwarded to the relevant authorities including Department of Planning and Environment, and Environment Protection Authority. The Annual Review will also be forwarded to members of the Community Consultative Committee and local Councils (Central Coast and Lake Macquarie). It will also be placed on the company's website along with a summary of environmental monitoring results.

6.2 Incident or Non Compliance Reporting

If monitoring reveals that, as a result of mining activities, greater than minor impacts have occurred, then LakeCoal will conduct an investigation into the cause of the non-compliance. The investigation will consider any activities or other factors that may have generated the non-compliance. The report will be provided to OEH, LMCC and Department of Planning and Environment.

The report will:

a) describe the date, time and nature of the exceedance / incident;
b) identify the cause (or likely cause) of the exceedance / incident;
c) describe what action has been taken to date; and
d) describe the proposed measures to address the exceedance / incident.

LakeCoal would implement the recommendations of the investigation in order to address any future non-compliance issues.

Additional details of the incident reporting process are provided in the Environmental Management Strategy.

7 Stakeholder Management and Response

7.1 Complaint Protocol

LakeCoal has a 24-hour telephone hotline (1800 687 557) for members of the public to lodge complaints, concerns, or to raise issues associated with the operation. This service aims to promptly and effectively address community concerns and environmental matters.

The full details of the complaints line are covered in the Environmental Management Strategy, but in summary, all complaints are recorded and responded to, if for some reason no action is taken then the reason why is recorded. The information recorded in the complaint register includes;

- date and time the complaint was lodged;
- personal details provided by the complainant;

- nature of the complaint;
- action taken or if no action was taken, the reason why; and
- follow up contact with the complainant.

7.2 Dispute Resolution

If any disputes are not adequately addressed by the complaints handling process then they will be handled by the site Environment and Community Coordinator, if the response of LakeCoal is not considered to satisfactorily address the concern of the complainant, a meeting will be convened with the Mine Manager together with the Environment and Community Coordinator.

The complainant will be advised of the outcomes from the meeting and the actions to be implemented as a result.

After implementation of the proposed actions, the complainant will be contacted and advice sought as to the satisfaction or otherwise with the measures taken.

If no agreed outcome is determined or the complainant is still not satisfied by the action taken, then an Independent Review may be requested by the complainant. If determined to be warranted by the Secretary, an Independent Review will be undertaken in accordance with the requirements of the project approval to achieve an outcome to the satisfaction of the Secretary.

8 Roles and Responsibilities

Roles, responsibilities specific to completing the requirements of Benthic Communities Management Plan are identified in **Table 4**.

Table 4: Roles and Responsibilities

Role	Responsibilities
Mine Manager	• Ensure that adequate financial and personnel resources are made available for the implementation of the Benthic Communities Management Plan.
Environment and Community Coordinator	• Co-ordinate benthic community monitoring. • Review benthic community monitoring results on a seasonal and annual basis. • Develop management actions in consultation with regulatory agencies as/if required from the monitoring results. • Compile the Annual Review (including a summary of the benthic community monitoring). • Respond to any potential or actual non-compliance and report these as required to regulatory bodies and other stakeholders. • Undertake reviews of this document as per **Section 9.** • Undertake or coordinate the required audits of this document, in accordance with **Section 9.2**. • Notify DPI Fisheries, Department of Industry – Resources and Energy and Department of Planning and Environment if there are any exceedances in impact thresholds outlined in **Section 1**. • Ensure complaint handling and response is undertaken, including determination of sources and potential remedial action to avoid recurrence.

8.1 Training, Awareness and Competence

Training is an essential component of the implementation phase of this Benthic Communities Management Plan. Any person or position that has a role or responsibility under this document will be provided with a copy of the document and be advised verbally regarding their requirements by the Environment and Community Coordinator.

As the document owner, the Environment and Community Coordinator is the contact point for any person that does not understand this document or their specific requirements, and will provide guidance and training to any person that requires additional training regarding this management plan.

9 Audit and Review

9.1 Overview

This document shall be reviewed, and if necessary revised, within 3 months of the following:

- The submission of an Annual Review;
- The submission of an incident report under **Section 6.2**;
- The submission of an independent environmental audit; and
- Following any modification to the development consent.

As outlined in **Section 6.1**, the annual review will include a review of the seasonal monitoring program and mine plans to ensure that any reference sites that have been impacted by mining reclassified as impacted impact sites, and replacement reference sites identified and sampled. Survey methods will be reviewed every two years to refine the sampling program if required. Improvements identified during reviews or audits will be incorporated into the Benthic Communities Management Plan.

9.2 External Audits

An Independent Environmental Audit of the Chain Valley Colliery development consent will be undertaken every three years (or as otherwise required by Department of Planning and Environment) by an audit team whose appointment has been endorsed by the Secretary. This audit will review the relevant management plans that apply to the operation.

Any actions arising from external audits will be loaded into the site action management database to ensure the actions are assigned to the relevant people and completed.

10 Records

Generally the Environment and Community Coordinator will maintain all Environmental Management System records, which are not of a confidential nature. Records that are maintained include:

- monitoring data and equipment calibration;
- environmental inspections and auditing results;
- environmental incident reports;
- complaint register; and
- licenses and permits.

All records are stored so that they are legible, readily retrievable and protected against damage, deterioration and loss. Records are maintained for a minimum of 4 years.

11 Document Control

This document and all others associated with the Environmental Management System shall be maintained in a document control system which is in compliance with AS/NZS 4804; section 4.3.3.4 (Document Control) and in compliance with the site Document Control Standard which is available to all personnel.

Any proposed change to this document shall be via the document control administrator who is the only person able to access the controlled documents.

12 References & Associated Documents

AS/NZS ISO 14001:2004	Environmental management systems – Requirements with guidance for use
AS/NZS ISO 14004:2004	Environmental management systems – General guidelines on principles, systems and support techniques
ANZECC (2000)	Australian and New Zealand Guidelines for Fresh and Marine Water Quality.
SSD-5465	Development Consent SSD-5465 (Modification 2), 16 December 2015
JSA Environmental 2013	Chain Valley Colliery Mining Extension 1 Project Marine Ecology Assessment LakeCoal
JSA Environmental 2015	Chain Valley Colliery Modification 2 Marine Ecology Assessment LakeCoal
Laxton & Laxton, 2013	Lake Macquarie Benthos Survey Results of Sampling No. 4. September 2013.
Laxton and Laxton 2015	Benthic Communities Survey of Chain Valley Bay, Summerland Point and Crangan Bay, Lake Macquarie, NSW
Laxton and Laxton 2016	Lake Macquarie Benthos Survey Results No.10 September 2016. J.H. & E.S. Laxton - Environmental Consultants P/L. Report for Lake Coal Pty Ltd Chain Valley Colliery.

13 Definitions

CVC
LakeCoal - Chain Valley Colliery

DTIRIS – Resources and Energy
Department of Trade, Investment, Regional Infrastructure and Services – Resources and Energy

DPI Fisheries
Department of Primary Industries – Fisheries NSW

EMS
Environmental Management System

LMCC
Lake Macquarie City Council

OEH
Office of Environment and Heritage

Secretary
Secretary of the Department of Planning and Environment, or nominee

SSD-5465
Development Consent SSD-5465 (for the Chain Valley Colliery Mining Extension 1 Project)

Appendix 1 – Agency Consultation

Appendix 5

Seagrass Management Plan

LakeCoal	Doc Owner: **Environment and Community Coordinator**
	Doc No: Draft - ENV 00009 - Seagrass Management Plan

CHAIN VALLEY COLLIERY

Seagrass Management Plan

ENVIRONMENTAL MANAGEMENT PLAN

Author	Wade Covey
	Environment and Community Coordinator
Authorised by:	Adrian Moodie
	Technical Services Manager
Date:	22/02/2018

Table of Contents

1 Introduction

Chain Valley Colliery is an underground coal mine located on the southern end of Lake Macquarie, approximately 100km north of Sydney and 60km south of Newcastle, adjacent to the Vales Point Power Station, producing thermal coal for the domestic and export markets.

A formal Environmental Management System (EMS) has been developed as a systematic and structured approach to managing environmental issues at the operation. This has been developed in general accordance with the requirements of the international standard ISO 14001.

This Seagrass Management Plan is an element of the Chain Valley Colliery Environmental Management System.

This Seagrass Management Plan has also been completed to satisfy the requirements of Development Consent SSD–5465 (Modification 2), Schedule 4 Condition 7(i) and Schedule 4 Table 8, which states:

"7. The Applicant shall prepare an Extraction Plan for all second workings on site, to the satisfaction of the Secretary. Each Extraction Plan must:

> (i) include a Seagrass Management Plan, which has been prepared in consultation with OEH, LMCC, and DPI Fisheries, which provides for the management of the potential impacts and/or environmental consequences of the proposed second workings on seagrass beds, and which includes:
>
> - a program of ongoing monitoring of seagrasses in both control and impact sites; and
> - a program to predict and manage subsidence impacts and environmental consequences to seagrass beds to ensure the performance measures in Table 8 are met."

In addition to the above, Condition 2 within Schedule 4 of SSD-5465 (Modification 2) also requires that:

"The Applicant shall ensure that the development does not cause any exceedance of the performance measures in Table 8 to the satisfaction of the Secretary."

The relevant seagrass requirements from Table 8 within Schedule 4 of the Development Consent, including the relevant notes, are recreated in **Table 1**.

Table 1: Subsidence Impact Performance Measures - Natural and Heritage Features

Biodiversity	
Seagrass beds	Negligible environmental consequences including: • *negligible* change in the size and distribution of seagrass beds; • *negligible* change in the functioning of seagrass beds; and • *negligible* change to the composition or distribution of seagrass species within seagrass beds.

Notes:

- *The Applicant will be required to define more detailed performance indicators (including impact assessment criteria) for each of these performance measures in the various management plans that are required under this consent (see Condition 7 below).*
- *Measurement and/or monitoring of compliance with performance measures and performance indicators is to be undertaken using generally accepted methods that are appropriate to the environment and circumstances in which the feature or characteristic is located. These methods are to be fully described in the relevant management plans. In the event of a dispute over the appropriateness of proposed methods, the Secretary will be the final arbiter.*
- *The requirements of this condition only apply to the impacts and consequences of mining operations, construction or demolition undertaken following the date of approval of this consent.*

2 Purpose

The purpose of this Seagrass Management Plan is to:

- outline details of the seagrass monitoring data collected;
- outline subsidence prediction methodology;
- outline the methodology to be used to identify depth changes at monitoring locations;
- identify seagrass monitoring locations;
- identify reporting requirements;
- detail seagrass management measures;
- identify the requirements for incident or exceedances reporting and reviews of the document; and
- identify persons responsible for implementation of requirements.

3 Background

3.1 Operations

Chain Valley Colliery is an underground coal mine with current coal mining methods including development of roadways in the coal seam known as first workings and secondary extraction. These first workings develop panels to support the installation of a miniwall, a modern secondary coal extraction method.

Lake Macquarie is the largest saline lake in New South Wales. It lies on the central coast between Sydney and Newcastle within the local government areas of Central Coast and Lake Macquarie Council's. Lake Macquarie has a catchment of 700 square kilometers and a water surface area of 125 square kilometers (Bell & Edwards, 1980). The lake has a permanent entrance to coastal waters at Swansea and has an average depth of around 6 meters (Laxton, 2005).

The catchment of Lake Macquarie is largely rural with large areas of bush land and grazing land. The shoreline of Lake Macquarie is heavily urbanised, especially the eastern, western and northern shorelines. The region has a relatively long history of coal mining and power generation, with mining occurring since the late 1800s and the first power station at Lake Macquarie commencing operations in 1958.

The Chain Valley Colliery is situated on the southern shores of Lake Macquarie near Mannering Park, NSW. The mine has been operating since 1962. Mining is currently undertaken using miniwall methods with first workings to support the development in advance of each miniwall panel. All secondary extraction is currently occurring in the Fassifern seam, in line with Development Consent SSD–5465 (Modification 2). The general layout of the Chain Valley Extension Project in respect to Lake Macquarie is shown on **Figure 1**.

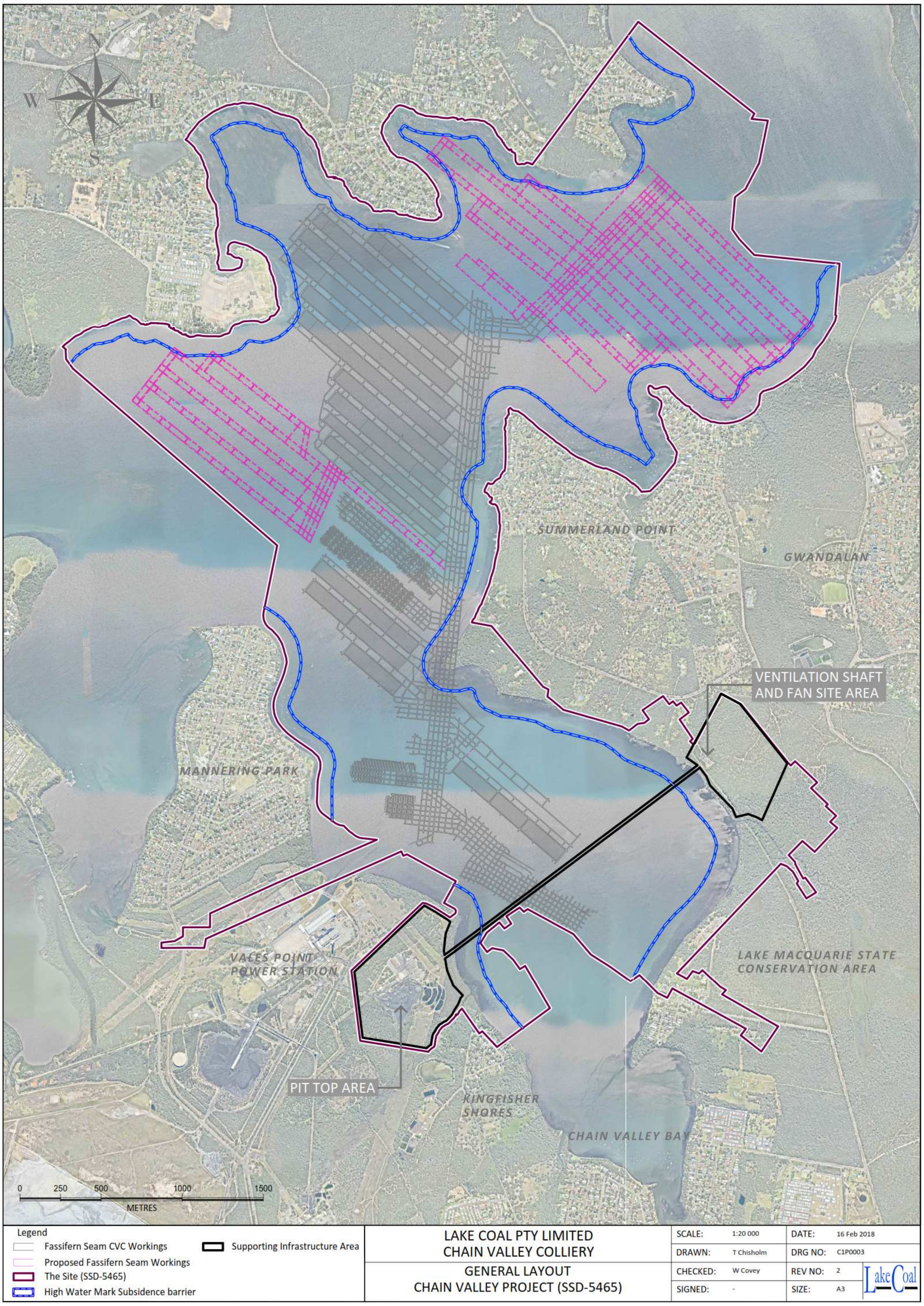


Figure 1: General Layout of the Chain Valley Extension Project

3.2 Seagrass Communities

Lake Macquarie contains approximately 10% of the total area of seagrass beds in NSW (DPI 2007). Four species of seagrass occur in Lake Macquarie: eel grass (*Zostera capricorni*); paddle weed (*Halophila ovalis*); *Ruppia sp.*; and strapweed (*Posidonia Australia*) which is listed as an endangered species under the Fisheries Management Act, 1994.

Seagrass distribution within estuaries is naturally influenced by light penetration, depth, salinity, nutrient status, bed stability, wave energy, estuary type, and the evolutionary stage of the estuary. Light is a major limiting factor for the growth of seagrasses and the effects of shading either by artificial structures or increased turbidity associated with sediment re-suspension are common light reducing factors in estuaries (BioAnalysis 2008).

Seagrass communities in Lake Macquarie appear to have declined since 1953, though there was a general increase in the cover of seagrass in Lake Macquarie between 2000 and 2004 due to a change in light penetration following a period of lower freshwater inputs (King and Barclay 1986; Wellington 2000; Gray and Wellington 2004).

Annual surveys of seagrass communities in Summerland Point, Chain Valley and Crangan Bay (i.e. within and adjacent to the current mining areas) have been undertaken on behalf of LakeCoal since 2008 by J.H. & E.S. Laxton - Environmental Consultants Pty Ltd. Additional survey locations in Bardens Bay were added in 2014. Two species of seagrass are present in these areas, namely, eel grass and paddle weed. The 2017 survey report *Seagrass Survey of Chain Valley Bay, Summerland Point, Bardens Bay and Crangan Bay, Lake Macquarie, NSW (Results for 2008 to 2017)* (JH & ES Laxton - Environmental Consultants, June 2017) reported seagrass cover along the transects ranged from 90.44 to 100% of the substratum in 2017. Since 2011 seagrass cover has generally increased progressively. This annual increases in seagrass cover is most likely attributable to the cessation of commercial fishing in Lake Macquarie which were known to impact on the seagrass beds through land based netting practices.

In 2017 there were no changes in sea bed height across transects greater than 0.10m (0.15m trigger level) compared with the datum from previous years.

Several studies have been conducted on the seagrass beds in Chain Valley Bay and Summerland Point that are relevant to this Seagrass Management Plan.

In July and August 2007, LakeCoal engaged JH & ES Laxton – Environmental Consultants to identify the environmental factors that included seagrasses, benthic fauna and bathymetry. The study area was the area east of Mannering Park. It was found that the seagrass beds were composed of *Zostera capricorni* (Eel grass) only.

It was concluded that seagrasses in Chain Valley Bay commenced along the lake edge and appeared to have a depth limit of less than 2m, and that any mining beneath the beds could lead to subsidence which would cause a decline of seagrasses along the outer edge of the seagrass beds. It was also concluded that the distribution and density of seagrass beds in Chain Valley Bay could change due to events unrelated to underground coal mining.

In July 2008, the seagrass survey was conducted to the west of Summerland Point (see **Figure 1**), from Frying Pan Point to Sandy Beach Reserve, Summerland Point, Lake Macquarie. The 2008 seagrass survey provided the baseline data for seagrass distribution, density and condition to which annual surveys are compared. It was determined that seagrass densities in Chain Valley Bay and Crangan Bay ranged from 17.74 to 99.32% of the substratum in the -0.19 to -2.34 A.H.D zone around the shore. Two forms of the seagrass *Zostera capricorni* were present; short leaved and long leaved forms. In Lake Macquarie, the distinction between these two forms of *Zostera capricorni* appeared to be arbitrary. In 2010 a second species of seagrass, *Halophila ovalis* (paddle weed), was discovered for the first time at transect E6 in Chain Valley Bay on 12th June 2010.

Subsequent annual seagrass surveys discovered large and unexplained changes in seagrass cover which were unrelated to underground coal mining, as no mining had impacted seagrass beds since commencement of monitoring. The precise reasons for these longer term changes in seagrass distribution are not always obvious but may be related to changes in water transparency, salinity, nutrient concentrations and the proliferation of epiphytic algae. Migration of sediment may also change the distribution of seagrasses over time. It is also thought that the cessation of commercial fishing in Lake Macquarie has positively contributed to the regrowth of seagrass beds around the Lake.

Seagrass is a vital component of Lake Macquarie's marine ecosystem. It captures the sun's energy and converts it into organic matter that may be utilised by the whole food chain. Destruction of seagrass beds could lead to a reduction in available organic matter for marine flora and faunal species. Seagrass also improves water quality as it decreases sediment within the water column and takes in many nutrients and heavy metals entering the waterway. Hence a reduction in seagrass population may also result in decreased water quality.

3.3 Seagrass Mapping

The seagrass bed assessment completed for Chain Valley Colliery by JH & ES Laxton – Environmental Consultants P/L found that two forms of the seagrass *Zostera capricorni* were present adjacent to the proposed mining operations. These were short leaved and long leaved forms of *Zostera capricorni*. It observed the seagrass beds commenced along the lake edge and terminated when water depths approached 2m.

Further mapping undertaken as part of the Chain Valley Mining Extension 1 Project in 2011/2012, enabled the maximum depths and locations of seagrass to be considered in the mine design for the Mining Extension 1 Project. This resulted in the generation of a broader seagrass protection barrier, extending to the proposed mining areas, which was then used to refine the mine design and ensure subsidence impacts to seagrass communities could be avoided. This study found that the communities were dominated by *Zostera capricorni* and that in general, the areas were characterised by patchy individuals of *Zostera*. The seagrass beds were found to exist to a maximum depth of 1.9m.

Further visual assessments and remapping of seagrass beds within the areas of Sugar Bay, Frying Pan Bay and Point Wolstoncroft was undertaken by LakeCoal, JH & ES Laxton – Environmental Consultants P/L and Daly Smith Surveyors in February 2018. The mapping was commissioned by LakeCoal as part of the development of it's next extraction plan for its Northern Mining Area (NMA).

Details from these studies have been combined to produce the mapping of seagrass over the entirety of the historic, current and future mining areas, and enabled the seagrass protection barrier to be further defined. The current seagrass mapping is shown on **Figure 2**.

3.4 Subsidence Predictions and Management

Subsidence modelling has predicted up to approximately 1.23 metres of subsidence to the Lake floor associated with the planned miniwall mining where there is overlying workings, and 780mm where only single seam extraction is undertaken.

LakeCoal recorded a subsidence exceedance over its Miniwall 7-12 area during the 2017 annual bathymetric survey where 1100mm of subsidence was identified. As a result of the exceedance LakeCoal has re-designed its future mining areas to ensure that subsidence values are within the approved predictions in accordance with SSD 5465.

The seagrass communities within the entirety of the proposed mining areas have been mapped and the majority of the seagrass beds appear to extend to depths around 2 – 2.5m. As a result, if mining takes place beneath the seagrass beds, and subsidence takes place, it could be expected that the lower areas of the seagrass beds will potentially retreat with increased depth as a result of reduced light available for photosynthesis.

In light of Condition 7 (i) Schedule 4 and to ensure the performance measures in **Table 1** are met an essential component of this Seagrass Management Plan is the Seagrass Protection Barrier to ensure that any impacts associated with its mining operations are negligible. This barrier is further described in **Section 4.1**.

3.5 Consultation

The original version of this Seagrass Management Plan was provided to OEH, LMCC and DPI Fisheries for comment. Both LMCC and DPI Fisheries reviewed the Seagrass Management Plan, with comments from DPI Fisheries provided on the 28th June 2013. At that time DPI Fisheries had no objection to the plan being implemented as written. Comments from Lake Macquarie City Council were received on the 19th July 2013, which were addressed and incorporated into the document, this final version was then sent back to Council who confirmed on the 19th August 2013 that the changes had addressed their comments. The changes made previously to address Council's comments remain in the current version.

Revision 2 of the draft Seagrass Management Plan was provided to OEH, DPI Fisheries and LMCC on the 12th March 2014, with comments on the draft plan requested back by the 1st April 2014. The only response received was from OEH, dated the 21st March 2014. The OEH noted that while they encourage the development of such plans, they do not approve or endorse these documents and accordingly no comments were provided.

Revision 3 of the Seagrass Management Plan was sent to OEH, DPI Fisheries and LMCC on 4 November 2016 for review and comment. All three agencies provided comments on the revised Plan. LMCC and DPI Fisheries confirmed that the document was acceptable in its revised form while OEH noted that while they encourage the development of such plans, they do not approve or endorse these documents and accordingly no comments were provided on the content of the Plan.

This current revision of the Seagrass Management Plan was provided to OEH, DPI Fisheries and LMCC on 26 February 2018. LakeCoal is currently awaiting feedback from the relevant government authorities on this revision. Due to timeframe constraints this version of the revised management plan has been included within the Extraction Plan application for Chain Valley Colliery's Northern Mining Area (NMA). The Seagrass Management Plan will be updated and resubmitted once feedback and comments have been received by the relevant stakeholders.

4 Seagrass Management

No secondary extraction is being undertaken, nor is it planned to be undertaken beneath seagrass beds.

In addition, to achieve negligible impact on seagrass beds due to subsidence effects, a seagrass protection barrier has been established. This barrier is based on the seagrass mapping and the application of an “angle of draw” of 26.5^{o} from the seagrass area to the coal seam being mined, as depicted in **Figure 2** and **Figure 3**.

Only first workings are to be undertaken within the seagrass protection barrier. In these areas subsidence will be limited to less than 20mm which is considered to be negligible.

The purpose of this plan is to monitor and report on any changes in seagrass communities over time. The monitoring program also includes physical surveys to detect if there is any vertical movement that could attributable to mine subsidence and if identified, determine if subsidence has caused anything other than a negligible impact. To achieve this, the following will be undertaken:

- an annual survey of the study area with 50 seagrass transects using differential GPS survey methods. These differential GPS survey methods will establish the precise location and height of the lake bed at inner and outer ends of each transect and compare these values against those of previous years and the baseline survey;
- a survey to determine the maximum seaward extent of the seagrass beds and the maximum depth at which they occurred;
- photographic survey of seagrass distribution, density and condition along each transect to be recorded using a video camera enclosed within a waterproof housing and mounted on a floating platform;
- conduct annual seagrass surveys while mining operations have the potential to impact seagrass communities. Reports of annual surveys will be sent to the Department of Primary Industries – Fisheries and Lake Macquarie City Council.
- a summary of the annual seagrass survey will be included in the Annual Review;
- responding to any potential or actual non-compliances and reporting as required to regulatory bodies and other stakeholders; and
- all complaints will be recorded in the complaints register with actions taken also noted.

The personnel responsible for the above management measures are detailed in **Section 8** (Roles and Responsibilities).

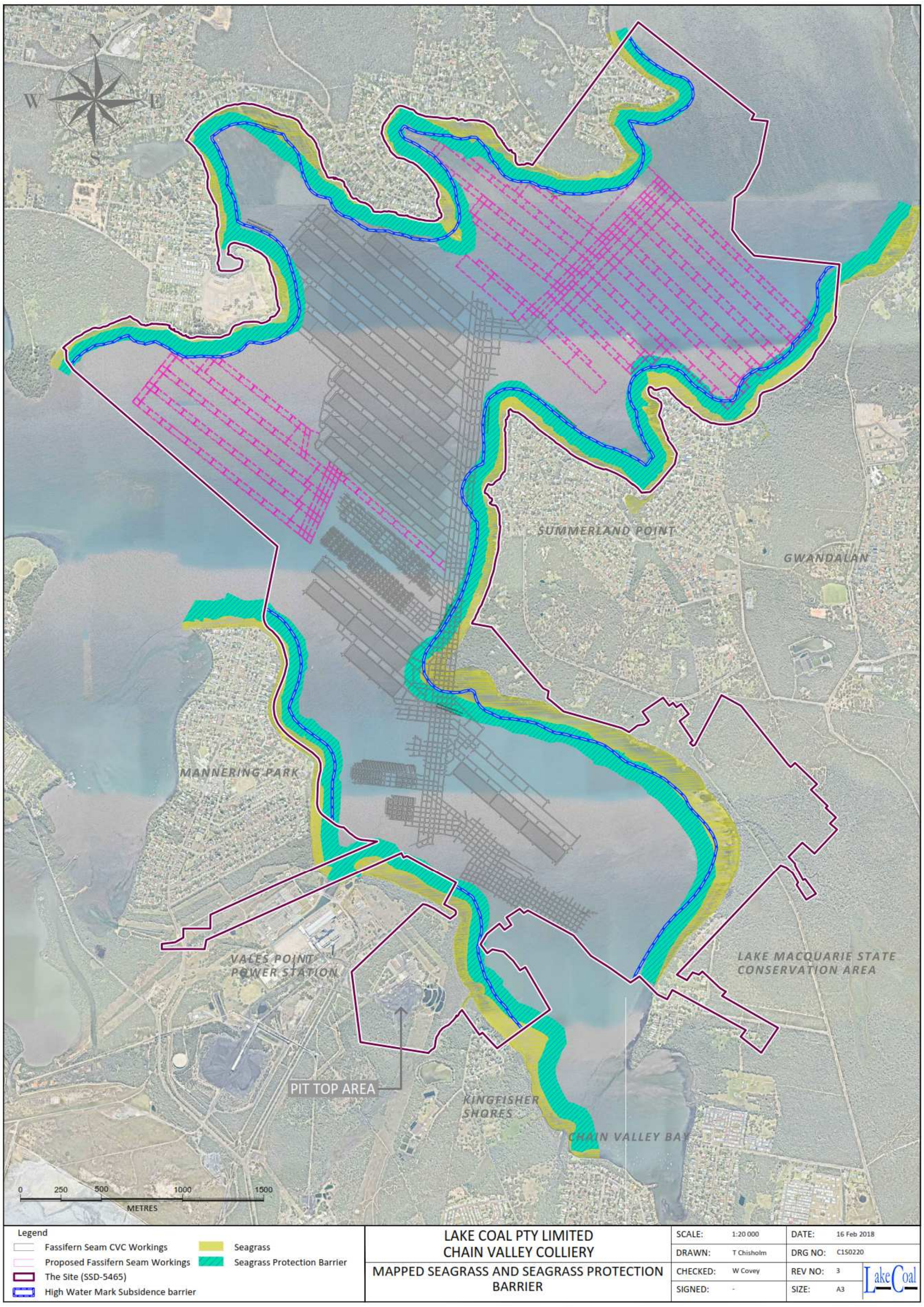


Figure 2: Mapped Seagrass and Seagrass Protection Barrier

4.1 Seagrass Protection/Limits

As part of the protection of the lake foreshore, the Colliery holding mining leases require a protection barrier around the foreshore. This is known as the High Water Mark (HWM) Subsidence Barrier and is shown on **Figure 1**. The barrier is approximately 130 metres wide, but varies based on the depth of cover, and no secondary extraction occurs within this zone. Although similar in some locations, the HWM Subsidence Barrier and the Seagrass Protection Barrier are separate barriers, with the mine layout limited (among other factors) by either barrier at any specific location. The application of the HWM Subsidence Barrier and Seagrass Protection Barrier is depicted on **Figure 3**.

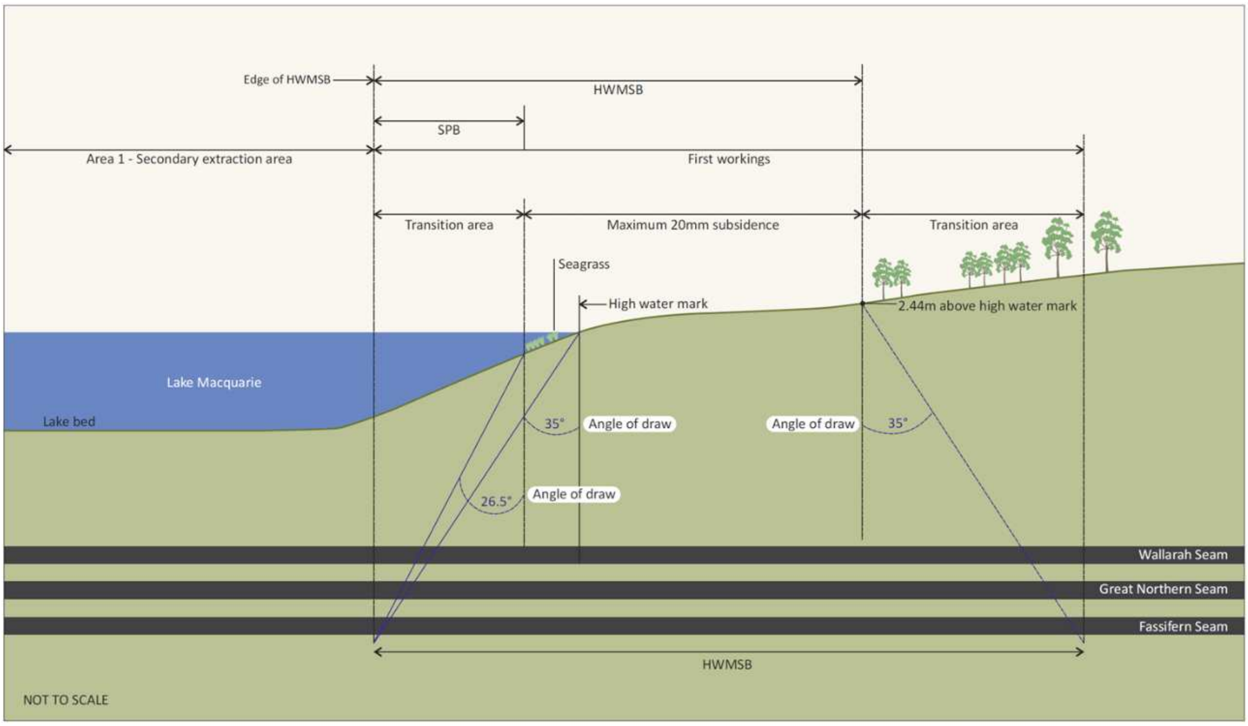


Figure 3: Protection Barrier Schematic

Despite the above barriers which are in place to protect the seagrass and foreshore areas, monitoring thresholds have been established based on observable change to seagrass beds or bed height, the following triggers have been set:

1. 20% decline in condition from the base year survey (i.e. earliest survey prior to mining occurring nearby).

2. Mining induced subsidence of 150mm or greater being recorded at one of the monitoring sites.

The LakeCoal Environment and Community Coordinator will notify DPI Fisheries, Lake Macquarie City Council and the Department of Planning and Environment if either of the above impact thresholds are exceeded, if deemed necessary by any of the parties, a meeting will be convened to discuss the results and determine any required future action.

It is noted that in prior years the 20% decline in baseline condition has been seen at a number of seagrass monitoring sites in the absence of any subsidence, as such, reaching a threshold may not in itself warrant the convening of a meeting or the requirement for further actions.

4.2 Seagrass Impact Mitigation

If, through the monitoring program (refer **Section 5**), subsidence is found to occur in areas known to contain seagrass beds (as identified in **Figure 2**) and loss of seagrass habitat has been determined to have occurred as a direct result of this subsidence, then LakeCoal would commit to undertaking remediation strategies to replace an equal area of any loss of seagrass habitat that has occurred.

While LakeCoal's approach to manage seagrass is aimed at protection, if an investigation were to identify that an exceedance / incident has occurred that was a direct result of the mining activities and associated subsidence, then LakeCoal would develop a remediation plan, which would be submitted to DPI Fisheries, identifying the proposed remediation strategy. The strategy would identify proposed remediation measures which could include:

- Transplanting existing communities with additional fast growing locally occurring seagrass plants;
- Regrading: topographical restoration; and/or
- Fertilising: to stimulate lateral ingrowth of seagrass communities.

The exact method of remediation would be determined based on the existing integrity of the seagrass beds, existing species and specific impacts that have occurred, that is, the remediation strategy would be "site specific" to ensure the most appropriate remediation methodology is implemented in consultation with DPI Fisheries.

Should remediation on-site not be viable, mitigation could be undertaken at other sites within Lake Macquarie in consultation with DPI Fisheries and LMCC, that is, work would be completed to offset the impact arising as a result of mining activities.

5 Seagrass Monitoring

5.1 General Requirements

The detailed methods used to conduct the surveys to determine subsidence of the lake bed and the photographic surveys of seagrass distribution, density and conditions are described below. The same or similar methods should be used in future seagrass surveys to ensure consistency of results.

Seagrass photography

A video camera, fitted with a wide conversion lens and enclosed in an underwater housing is used to capture the video footage.

The camera in the underwater housing is mounted vertically in the centre of a 1m long surfboard. This rig is towed alongside a workboat. Experimentation revealed that the best photographic results are obtained when the boat and photographic rig were poled very slowly along the transect line on windless days. Good quality photographs were obtained both in boat shadow and full sunlight although half shadow sequences could still be evaluated satisfactorily.

The water depth along most of the transect lines ranges from around 0.5 to 2m (depending on the lake level). At the end of the transect line the water depth could be around 2m. Transect lines are photographed from the outer end to the inner end. The beginning of each transect is marked by photographing a plate with the transect number printed in large type.

At the end of the each day's photography, the hard drive of the video camera is downloaded, the film is paused at around 1m intervals along the transect line. Each still frame is examined and the following information is recorded on a data sheet:

1. The file name and number of the video segment being examined.
2. The transect number and date the video was taken.
3. The percentage areas occupied by the following organisms in each still or quadrat was determined:
   (a) % area occupied by long leaved seagrass (*Zostera capricorni*)
   (b) % area occupied by short leaved seagrass (*Zostera capricorni*)
   (c) % area occupied by the small seagrass (*Halophila ovalis*)
   (d) degree of fouling of the seagrass leaves by algae 1=no fouling, 2=light fouling, 3=heavy fouling.
   (e) % area occupied by the large brown alga (*Sargassum* sp., *Hormosira banksii* or *Cystoseira trinodis*)
   (f) % area occupied by filamentous and thallous algae (green or brown algae)
   (g) Number of the large bivalve *Pinna bicolor*
   (h) % area of uncolonised (by macroscopic epibenthos) ground (bare ground).

At the end of the analysis of the photographs, the results are entered into a work sheet and mean values for each category of organism are calculated.

Surveying Methods

Surveyors have established base stations with their differential GPS equipment along the shore of Chain Valley Bay. A carbon fibre staff fitted with a 110mm diameter aluminium base plate (to prevent penetration into the sediment) is used to take the readings. Survey data (x, y & z coordinates) are recorded on a separate hand piece. Communication between the GPS receiver, the base stations and the hand piece is by coded radio signals.

The boat is maneuvered into position at the inshore end of each transect. The staff is placed on the lakebed and held vertically until the observation is made and recorded. The boat is then moved outwards from the shore where intermediate points along the transect were established and recorded. When the outer end of the transect is reached, the staff is placed alongside the concrete marker and the position and height of the lake bed was recorded.

The memory of the hand held gps is downloaded and the following plots made:

- A map of the position of transects in Chain Valley Bay, Summerland Point and Bardens Bay.
- A table of the coordinates of inner and outer ends of each transect and the coordinates of the base stations are made.
- The elevations of the seabed at the inner and outer ends of each transect, relative to AHD, are established and tabulated.

The results from the seagrass monitoring, including determination of compliance with seagrass impact thresholds, is undertaken and reported back to LakeCoal in a formal report to be provided annually following the completion of each annual seagrass survey.

5.2 Monitoring Locations

Monitoring locations have been chosen based on the proposed mining activities that will be covered by the Seagrass Management Plan, over time, as this management plan is updated to reflect future mining locations, it is anticipated that additional monitoring transects will be incorporated and others removed from the monitoring regime as time progresses. More specifically, the monitoring locations proposed to be monitored are those that are adjacent to past, current and proposed mining activities that are within the review period of this management plan.

The monitoring locations are substantially derived from the original experimental and control transects selected by JH & ES Laxton – Environmental Consultants Pty Ltd and JSA Environmental Pty Ltd who completed the Marine Ecology assessment that supported the Environmental Assessment for the Mining Extension 1 Project. An additional 15 transects were added to the seagrass monitoring program as part of the latest revision to this plan to obtain baseline information within the areas of Frying Pan Bay, Sugar Bay and the Northern side of Point Wolstoncroft. Two additional Control Points (C5 and C6) were also added to the monitoring program in 2018.

The current monitoring locations are;

- Transects E1 to E16 Transects primarily in Chain Valley Bay and adjacent Summerland Point
- Transects T1 to T8 Transects adjacent Summerland Point
- Transects C1 to C6 Control stations in Crangan Bay and Frying Pan Bay
- Transects A1 to A6 Transects primarily in Bardens Bay
- Transect L1 Transect above potential future first workings in Chain Valley Bay
- Transects S1 to S6 Transect adjacent Sugar Bay
- Transects F1 to F7 Transects adjacent Frying Pan Bay and along Point Wolstoncroft.

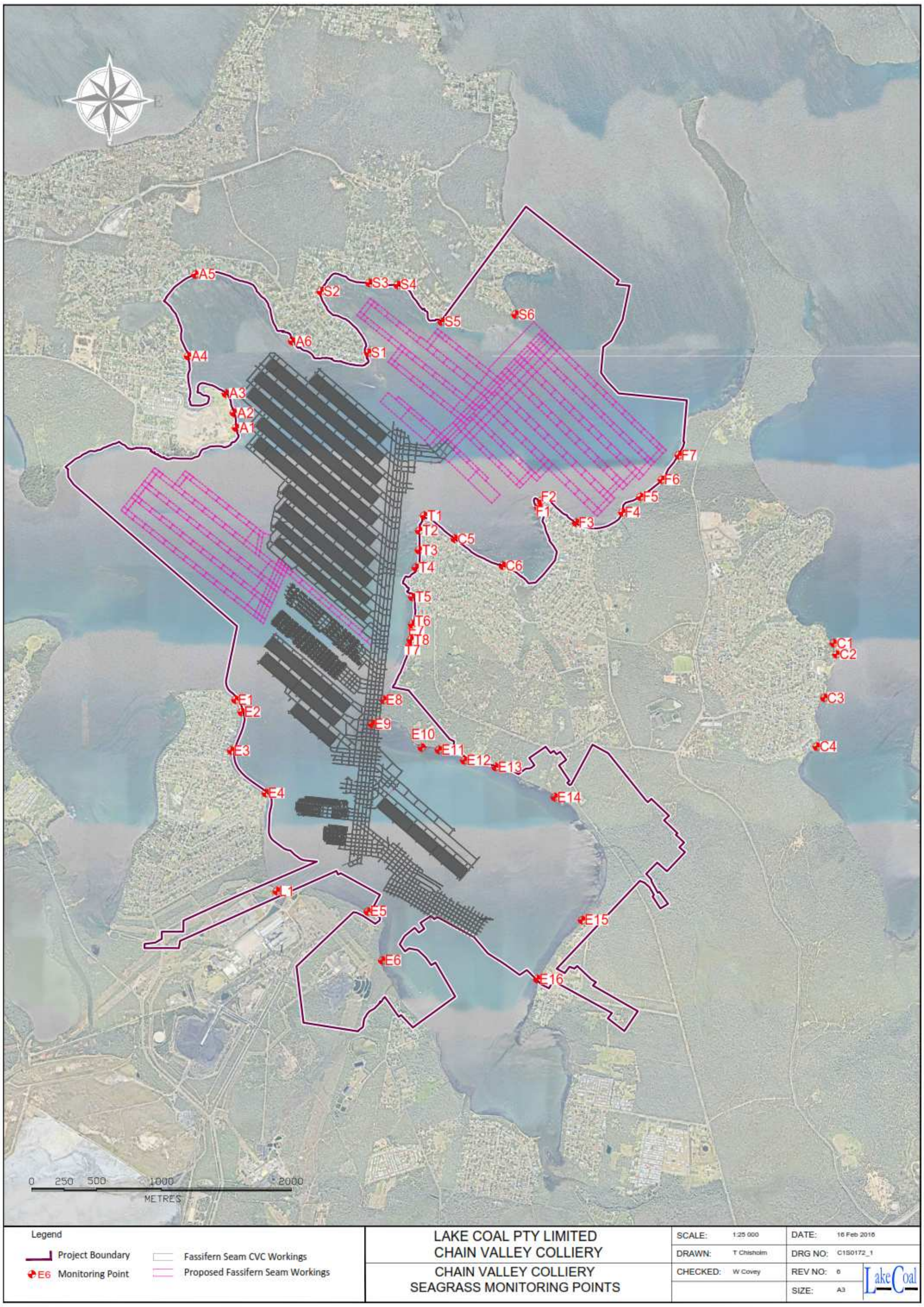


Figure 4: Locations of Seagrass Monitoring Transects

Table 2 shows the GPS locations of the inner ends of the seagrass monitoring transects. Where available, reduced levels of the lakebed measured historically are presented. For sites that have not yet been surveyed by differential GPS, baseline depth levels will be obtained prior to any secondary extraction undertaken in the vicinity of the site. Transects in Crangan Bay were for control purposes only, i.e. no mining or subsidence impact potential, and accordingly no differential GPS depths/locations are required. Relocation of the control stations is done with hand held GPS.

Table 2: Seagrass Monitoring Transect Coordinates

Site	Easting	Northing	Reduced Level (m) – inner transect	Reduced Level (m) – outer transect
E1	363986	6331797	-0.68	-1.00
E2	364035	6331701	-0.64	-1.78
E3	363953	6331405	-0.32	-2.34
E4	364220	6331078	-0.46	-1.69
E5	365006	6330164	-0.46	-1.68
E6	365118	6329788	-0.48	-1.21
E7	365351	6332350	-0.24	-1.68
E8	365128	6331796	-0.27	-0.99
E9	365040	6331608	-0.19	-1.07
E10	365423	6331427	-0.41	-1.74
E11	365554	6331410	-0.40	-1.09
E12	365750	6331329	-0.59	-1.50
E13	365991	6331278	-0.59	-1.44
E14	366447	6331047	-0.52	-1.34
E15	366657	6330098	-0.39	-1.22
E16	366310	6329644	-0.55	-1.08
T1	365440	6333217	-0.40	-1.15
T2	365403	6333101	-0.70	-1.31
T3	365400	6332952	-0.29	-1.01
T4	365377	6332817	-0.46	-1.12
T5	365350	6332590	-0.42	-1.38
T6	365348	6332380	-0.47	-1.61
T7	365321	6332207	-0.17	-1.64
T8	365337	6332262	-0.20	-1.14
C1	368596	6332235	N/A	N/A
C2	368619	6332147	N/A	N/A
C3	368524	6331811	N/A	N/A
C4	368467	6331435	N/A	N/A
C5	365676	6333038	N/A	N/A
C6	366045	6332831	N/A	N/A
A1	363991	6333894	-0.51	-1.19
A2	363974	6334009	-0.39	-0.81
A3	363912	6334156	-0.33	-1.44
A4	363621	6334445	-0.16	-0.72
A5	363678	6335072	-0.30	-0.96
A6	364423	6334560	-0.14	-0.68
L1	364306	6330322	-1.12	-1.63
S1	365009	6334470	-0.64	-1.78
S2	364642	6334943	-0.28	-1.59
S3	365017	6335008	-0.11	-1.87
S4	365235	6334992	-0.11	-1.73
S5	365575	6334709	-0.69	-1.39
S6	366144	6334765	-0.1	-0.92
F1	366321	6333281	-0.25	-1.31
F2	366342	6333330	-0.24	-1.98

Site	Easting	Northing	Reduced Level (m) – inner transect	Reduced Level (m) – outer transect
F3	366611	6333163	-0.11	-1.88
F4	366968	6333242	-0.11	-2.45
F5	367106	6333361	-0.33	-2.46
F6	367271	6333493	-0.3	-2.81
F7	367402	6333682	-0.48	-1.4

6 Incident & Compliance Management

6.1 Introduction

The seagrass monitoring results will be reviewed on an annual basis as survey reports are received to confirm compliance with the conditions specified in the *Subsidence Impact Performance Measures - Natural and Heritage Features* found in **Table 1** and the criteria outlined in **Section 4.1**.

The Annual Review will also include a summary of monitoring results during the past year, discussion with reference to the impact assessment criteria, and any relevant details related to comparisons between actual results and predictions in the Environmental Impact Statement. The Annual Review will be forwarded to the relevant authorities including Department of Planning and Environment, and Environment Protection Authority. The Annual Review will also be forwarded to members of the Community Consultative Committee and local Councils (Central Coast and Lake Macquarie). It will also be placed on the company's website along with a summary of environmental monitoring results.

6.2 Incident or Non Compliance Reporting

If seagrass monitoring reveals that, as a result of mining activities, the criterion outlined in **Section 4.1** have been exceeded, then LakeCoal will conduct an investigation into the cause of the non-compliance. The investigation will consider any mining activities or other factors that may have generated the non-compliance. The report will be provided to DPI Fisheries and the Department of Planning and Environment.

The report will:

a) describe the date, time and nature of the exceedance / incident;
b) identify the cause (or likely cause) of the exceedance / incident;
c) describe what action has been taken to date; and
d) describe the proposed measures to address the exceedance / incident.

LakeCoal would implement the recommendations of the investigation in order to address any future non-compliance issues.

Additional details of the incident reporting process are provided in the Environmental Management Strategy.

7 Stakeholder Management and Response

7.1 Complaint Protocol

LakeCoal has a 24-hour telephone hotline (1800 687 557) for members of the public to lodge complaints, concerns, or to raise issues associated with the operation. This service aims to promptly and effectively address community concerns and environmental matters.

The full details of the complaints line are covered in the Environmental Management Strategy, but in summary, all complaints are recorded and responded to, if for some reason no action is taken then the reason why is recorded. The information recorded in the complaint register includes;

- date and time the complaint was lodged;
- personal details provided by the complainant;
- nature of the complaint;
- action taken or if no action was taken, the reason why; and
- follow up contact with the complainant.

7.2 Dispute Resolution

If any disputes are not adequately addressed by the complaints handling process then they will be handled by the site Environment and Community Coordinator, if the response of LakeCoal is not considered to satisfactorily address the concern of the complainant, a meeting will be convened with the Mine Manager together with the Environment and Community Coordinator.

The complainant will be advised of the outcomes from the meeting and the actions to be implemented as a result.

After implementation of the proposed actions, the complainant will be contacted and advice sought as to the satisfaction or otherwise with the measures taken.

If no agreed outcome is determined or the complainant is still not satisfied by the action taken, then an Independent Review may be requested by the complainant. If determined to be warranted by the Secretary, an Independent Review will be undertaken in accordance with the requirements of the development consent to achieve an outcome to the satisfaction of the Secretary.

8 Roles and Responsibilities

Roles and responsibilities specific to completing the requirements of the Seagrass Management Plan are identified in **Table 3**.

Table 3: Seagrass Management Roles and Responsibilities

Role	Responsibilities
Mine Manager	• Ensure that adequate financial and personnel resources are made available for the implementation of the Seagrass Management Plan.
Environment and Community Coordinator	• Co-ordinate seagrass monitoring, through the use of differential GPS surveying and photographic monitoring of seagrass beds. • Develop management actions in consultation with regulatory agencies as/if required from the monitoring results. • Review seagrass monitoring results on an annual basis. • Send Annual Seagrass Monitoring reports to DPI Fisheries and • Compile the Annual Review (including a summary of the annual seagrass survey). • Respond to any potential or actual non-compliance and report these as required to regulatory bodies and other stakeholders. • Undertake reviews of this document as per **Section 9** • Undertake or coordinate the required audits of this document, in accordance with **Section 9**. • Notify the DPI Fisheries, Department of Industry – Resources and Energy and Department of Planning and Environment if there are any exceedances in impact thresholds outlined in **Section 4.1** • Ensure complaint handling and response is undertaken, including determination of sources and potential remedial action to avoid recurrence.

8.1 Training, Awareness and Competence

Training is an essential component of the implementation phase of this Seagrass Management Plan. Any person or position that has a role or responsibility under this document will be provided with a copy of the document and be advised verbally regarding their requirements by the Environment and Community Coordinator.

As the document owner, the Environment and Community Coordinator is the contact point for any person that does not understand this document or their specific requirements, and will provide guidance and training to any person that requires additional training regarding this management plan.

9 Audit and Review

9.1 Overview

This document shall be reviewed, and if necessary revised, within 3 months of the following:

- The submission of an Annual Review;
- The submission of an incident report under **Section 6.2**;
- The submission of an independent environmental audit; and
- Following any modification to the development consent

9.2 External Audits

An Independent Environmental Audit will be undertaken every three years (or as otherwise required by Department of Planning and Environment) by an audit team whose appointment has been endorsed by the Secretary.

Any actions arising from external audits will be loaded into the site Incident Database to ensure the actions are assigned to the relevant people and completed.

10 Records

Generally the Environment and Community Coordinator will maintain all Environmental Management System records, which are not of a confidential nature. Records that are maintained include:

- monitoring data and equipment calibration;
- environmental inspections and auditing results;
- environmental incident reports;
- complaint register; and
- Licenses and permits.

All records are stored so that they are legible, readily retrievable and protected against damage, deterioration and loss. Records are maintained for a minimum of 4 years.

11 Document Control

This document and all others associated with the Environmental Management System shall be maintained in a document control system which is in compliance with AS/NZS 4804; section 4.3.3.4 (Document Control) and in compliance with the site Document Control Standard which is available to all personnel.

Any proposed change to this document shall be via the document control administrator who is the only person able to access the controlled documents.

12 References & Associated Documents

AS/NZS ISO 14001:2004	Environmental management systems – Requirements with guidance for use
AS/NZS ISO 14004:2004	Environmental management systems – General guidelines on principles, systems and support techniques
EPL 1770	Environment Protection License 170, version date: 30 Oct 2015
EIS	Environmental Impact Statement Chain Valley Colliery Mining Extension 1 Project 28 May 2013
SSD–5465	Development Consent SSD-5465 (Modification 2) dated 16 December 2015 for the Mining Extension 1 Project
POEO Act 1997	Protection of the Environment Operations Act, 1997

Bell, F.C. and Edwards, A.R. (1980) *An Environmental Inventory of Estuaries and Coastal Lagoons in New South Wales*. Total Environment Centre.

BioAnalysis (2008) assessment of seagrasses associated with proposal to expand the Lake Macquarie yacht club in Belmont Bay.

EMM (June 2015) *Chain Valley Colliery Modification 2 Statement of Environmental Effects*, prepared by EMGA Mitchell McLennan (EMM) dated 29 June 2015.

NSW DPI (2007) PrimeFacts 629 - Seagrasses.

Laxton, J.H. (2005) *Water Quality of Lake Macquarie*. J.H. & E.S. Laxton – Environmental Consultants P/L. Unpublished Report.

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Laxton, J.H. and Laxton, E. (2011). Seagrass Survey of Chain Valley Bay, Summerland Point and Crangan Bay, Lake Macquarie, NSW (Results from 2008, 2010 and 2011) J.H. & E.S. Laxton – Environmental Consultants P/L. Unpublished report prepared for Chain Valley Colliery.

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Laxton, J.H. and Laxton, E.S. (2016) Seagrass Survey of Chain Valley Bay, Summerland Point, Bardens Bay and Crangan Bay, Lake Macquarie, NSW (Results for 2008 to 2016). J.H. & E.S. Laxton – Environmental Consultants P/L. Unpublished report prepared for Chain Valley Colliery.

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13 Definitions

CVC
LakeCoal - Chain Valley Colliery

DPI Fisheries
NSW Department of Primary Industries – Fisheries

EMS
Environmental Management System

HWM
High Water Mark

LMCC
Lake Macquarie City Council

OEH
Office of Environment and Heritage

Secretary
Secretary of the Department of Planning and Environment, or nominee

Appendix 1 – Agency Consultation

Appendix 6

Public Safety Management Plan

Safety Management Plan

Public Safety Management Plan
Northern Mining Domain

Author	Wade Covey LakeCoal – Chain Valley Colliery
Authorised by:	Dave McLean Operations Manager
Date:	12/04/18

1 Table of Contents

2 Introduction

Chain Valley Colliery is an underground coal mine located on the southern end of Lake Macquarie, approximately 100km north of Sydney and 60km south of Newcastle, adjacent to the Vales Point Power Station, producing thermal coal for the domestic and export markets.

An Extraction Plan has been developed in order to manage the process of mining layout design and mitigate any subsidence impacts on surface infrastructure and/or stakeholders. A part of the Extraction Plan is this Public Safety Management Plan, which has been developed from a risk assessment process.

The Public Safety Management Plan is an element of the Chain Valley Colliery Extraction Management Plan, and has been developed to satisfy the requirements of Development Consent SSD-5465, condition 7(j) and Table 9 in Schedule 4, which both state:

7. The Applicant shall prepare and implement an Extraction Plan for all second workings on site, to the satisfaction of the Director-General. Each Extraction Plan must:

(j) include a Public Safety Management Plan, which has been prepared in consultation with DRE, to ensure public safety.

Condition 4 within Schedule 4 of SSD-5465 also requires that:

“The Applicant shall ensure that the development does not cause any exceedances of the performance measures in Table 9, to the satisfaction of the Director-General.

The relevant Public Safety requirements from Table 9 within Schedule 4 of the Development Consent, including the relevant notes, are recreated in Table 1.

Table 1: Subsidence Impact Performance Measures – Built Features

Public Safety	
Public Safety	Negligible additional risk

Notes:

- *The Applicant will be required to define more detailed performance indicators (including impact assessment criteria) for each of these performance measures in the Built Features Management Plans or Public Safety Management Plan (see Condition 7 below).*

- *Measurement and/or monitoring of compliance with performance measures and performance indicators is to be undertaken using generally accepted methods that are appropriate to the environment and circumstances in which the feature or characteristic is located. These methods are to be fully described in the relevant management plans. In the event of a dispute over the appropriateness of proposed methods, the Secretary will be the final arbiter.*

- *The requirements of this condition only apply to the impacts and consequences of mining operations, construction or demolition undertaken following the date of approval of this consent.*
- *Requirement’s regarding safety or serviceability do not preclude preventative actions or mitigation being taken prior to or during mining in order to achieve or maintain these outcomes.*
- *Requirement’s under this condition may be met by measures undertaken in accordance with the Mine Subsidence Compensation Act 1961.*

3 Purpose and Scope

The purpose of this Public Safety Management Plan is to:

- Outline subsidence predictions associated with the mining of miniwall Panels S1 and N1;
- Identify potential public safety risks arising out of subsidence from extraction particular to the miniwall panels S1 and N1;
- Identify public safety monitoring requirements;
- Identify public safety reporting requirements;
- Ensure negligible additional public safety risk as a result of subsidence arising from Extraction associated with the mining of Panels S1 and N1.

4 Background

4.1 Operations

Chain Valley Colliery is an underground coal mine with current coal mining methods including development of roadways in the coal seam known as first workings and secondary extraction (miniwall). These first workings develop panels to support the installation of a miniwall, a modern secondary coal extraction method.

Lake Macquarie is the largest saline lake in New South Wales. It lies on the central coast between Sydney and Newcastle within the local government areas of Wyong and Lake Macquarie. Lake Macquarie has a catchment of 700 square kilometers and a water surface area of 125 square kilometers (Bell & Edwards, 1980). The lake has a permanent entrance to coastal waters at Swansea and has an average depth of around 6 meters (Laxton, 2005).

The catchment of Lake Macquarie is largely rural with large areas of bush land and grazing land. The shoreline of Lake Macquarie is heavily urbanised, especially the eastern, western and northern shorelines. The region has a relatively long history of coal mining and power generation, with mining occurring since the late 1800s and the first power station at Lake Macquarie commencing operations in 1958.

Chain Valley Colliery is situated on the southern shores of Lake Macquarie near Mannering Park, NSW. The mine has been operating since 1962. Mining is currently undertaken using miniwall methods with first workings to support the development in advance of each miniwall panel. All secondary extraction is currently occurring in the Fassifern seam, in line with Development Consent SSD–5465. The general layout of the Chain Valley Extension Project in respect to Lake Macquarie is shown on **Figure 1**.

4.2 Subsidence Predictions

Subsidence modelling has predicted up to approximately 440mm of subsidence to the Lake floor associated with the planned miniwall mining of Panels S1 and N1 within the sites Northern Mining Domain (**Figure 2),** with an approved maximum of 780mm. No additional subsidence is expected to occur within the seagrass or foreshore areas as a result of Fassifern extraction (**Figure 1**) due to the application of High Water and Seagrass Protection Barriers (extraction separation).

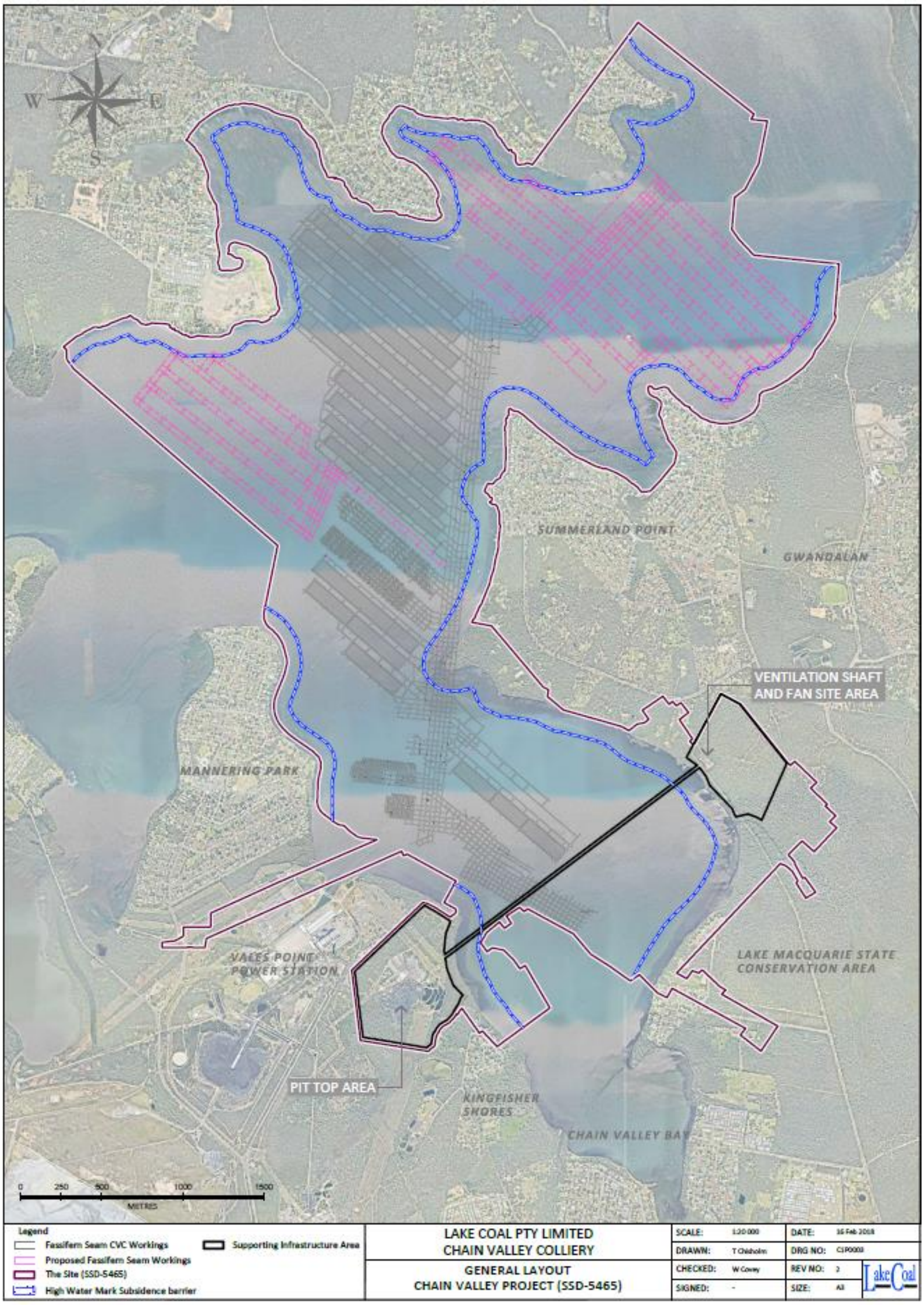

Figure 1: General Layout of the Chain Valley Northern Mining Domain

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12/04/18	12/04/20	0	Mine Manager - Chain Valley Colliery
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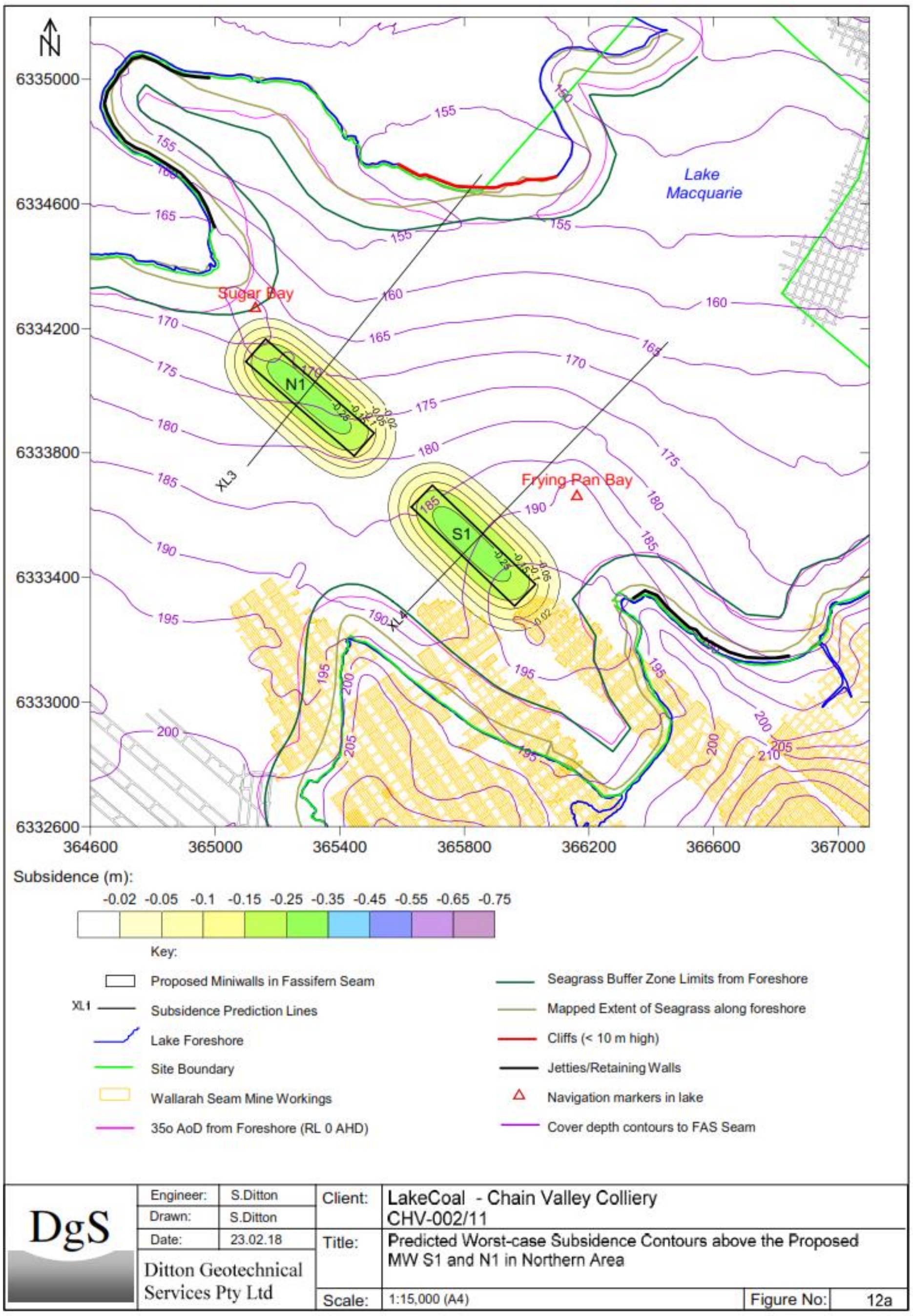

Figure 2: Predicted Subsidence Associated with Panels S1 and S2.

4.3 Public Safety Management - Scope

4.3.1 Identified Features

All mining activities within the Extraction Plan application area are to occur beneath Lake Macquarie and as such will have no direct impact on surface facilities and infrastructure due to vertical subsidence. Despite this, CVC will monitor the foreshore for change and if impacts were observed to be occurring, a review of public safety would be triggered via the Subsidence Management TARP. This focuses on potential changes to flooding and drainage as well as steep slopes.

The navigational markers located off Summerland Point and Sugar Bay are not predicted to see any significant impacts as a result of the mining of Panels S1 and N1. The marker located adjacent the N1 miniwall panel is expected to see less than 100mm of vertical subsidence. Roads and Maritime have been consulted in relation to the markers and the level of subsidence impact, and have concluded that no direct management will be required and the markers will be able to be monitored as a part of their routine inspections. It is thus considered no additional public safety risk exists to these features.

The predicted low strains indicate a very low likelihood of impact to any sensitive features such as steep slopes/cliffs, retaining walls or jetties as a result of the extraction of Panels S1 and N1, with horizontal movement and strain less than accuracy of measurement techniques. As such routine visual inceptions during subsidence monitoring is proposed as sufficient to identify any changes outside those expected.

5 Public Safety Monitoring

5.1 Subsidence Monitoring Methods

5.1.1 Bathymetric Surveys

Bathymetric Surveys of the lake beds will occur across the area as described by the Subsidence Monitoring Program. These routine surveys will allow for identification of subsidence starting to develop outside predicted levels and thus trigger a review of any potentially new Public Safety concerns.

5.1.2 Foreshore Monitoring

Established and proposed (subject to access restrictions) survey monitoring points will be monitored around the southern and northern foreshore areas about the extraction plan area. These will consist of either star pickets, feno pegs or survey pins (**Figure 3**). The marks will be monitored as per the Subsidence Monitoring Program. These routine surveys prior, during and after extraction will allow for the identification and review of any subsidence starting to develop outside predicted levels and thus trigger a review of any potentially new Public Safety concerns.

During the routine foreshore monitoring, observations and records for change will be noted as outlined in the Subsidence Monitoring Program. This will include observations for surface cracking, embankment movement, cracking, and validation of impacts to drainage or dwellings in areas of measured subsidence increase outside predicted.

Figure 3: Example subsidence monitoring point with safety cap.

6 Public Safety Management

6.1 Management Practices

Survey pegs installed for monitoring will be clearly identified and as appropriate have ‘ safety caps’ placed on them as per **Figure 3.**

Given the expected negligible impact to public safety, any management practices will be triggered via the aforementioned monitoring strategies and the Subsidence Management TARP included in the Extraction Plan. Triggering of a potential requirement for a public safety response will be based on the following management strategy:

1. Subsidence measured indicates potentially increased impact at the foreshore or to sensitive features;
2. Notify DP&E and DRE;
3. Investigate area of potential increase for any change in public safety risk;
4. Inform relevant parties that may be further impacted in relation to public safety (this may include, landholders, infrastructure owners, Roads and Maritime Services, Lake Macquarie City Council)
5. Where required immediately implement public safety controls to control immediate risk (i.e. identification, barriers and signage, all of which are available at the mine site)
6. Develop long term safety control with relevant parties.

6.2 Consultation

The Public Safety Management Plan is required to be prepared in consultation with DRE. DRE have been consulted as a part of the Extraction Plan Submission, and also as a part of the High Risk Activity Notification, which also deals with public safety.

Roads and Maritime Services Project Officer (North Area) has been contacted during the development of the Extraction Plan and referred the matter to the RMS asset team, resulting in no further immediate actions being required in regard to the management of the navigation markers.

The LakeCoal Community Consultative Committee (CCC) was consulted on the proposed monitoring program during the most recent community meeting at the mine on 22 February 2018. The CCC will be routinely updated as to subsidence monitoring results and any change in impact or public safety concern.

7 Roles and Responsibilities

Roles, responsibilities specific to completing the requirements of this Subsidence Monitoring Program are identified in **Table 2**.

Table 2: Public Safety Management Roles and Responsibilities

Role	Responsibilities
Operations Manager	• Ensure that adequate financial and personnel resources are made available for the implementation of the Subsidence Monitoring Program and Public Safety Management Plan
Appointed Mine Surveyor	• Co-ordinate subsidence monitoring, through the use of bathymetric surveys & conventional surveys along foreshore • Review subsidence monitoring results against Subsidence Management TARP triggers • Inform E&C Coordinator and Mine Manager of results and outcomes of monitoring reviews.
Environment and Community Coordinator	• Develop management actions in consultation with regulatory agencies as/if required from the monitoring results. • Respond to any potential or actual non-compliance and report these as required to regulatory bodies and other stakeholders. • Notify the relevant Government Agencies and other affected parties should exceedances in impact thresholds potentially be reached • Regularly audit the public safety equipment made available at the mine site • Ensure complaint handling and response is undertaken, including determination of sources and potential remedial action to avoid recurrence. • Review, and if necessary revise this document: o In the event of any exceedance in impact thresholds o Following any modification to the development consent

Appendix 7

Subsidence Monitoring Program

LakeCoal	Doc Owner: Mine Surveyor

CHAIN VALLEY COLLIERY

Subsidence Monitoring Program

MINIWALLS S1 to N1

Author	Tim Chisholm LakeCoal
Authorised by:	Dave McLean Operations Manager LakeCoal – Chain Valley Colliery
Date:	13/04/18

1 Table of Contents

2 Introduction

Chain Valley Colliery is an underground coal mine located on the southern end of Lake Macquarie, approximately 100km north of Sydney and 60km south of Newcastle, adjacent to the Vales Point Power Station, producing thermal coal for the domestic and export markets.

A formal Extraction Management Plan has been developed in order to manage the process of mining layout design and mitigate any subsidence impacts on surface infrastructure and/or stakeholders.

The Subsidence Monitoring Program is an element of the Chain Valley Colliery Extraction Management Plan, and has been developed to satisfy the requirements of Development Consent SSD-5465, condition 7(k) and Tables 8-9 in Schedule 4, which states:

"7. The Applicant shall prepare and implement an Extraction Plan for all second workings on site, to the satisfaction of the Director-General. Each Extraction Plan must:

(k) include a Subsidence Monitoring Program which has been prepared in consultation with DRE, which:

- Provides data to assist with the management of the risks associated with subsidence;
- Validates the subsidence predictions
- Analyses the relationship between the predicted and resulting subsidence effects and predicted and resulting impacts under the plan and any ensuing environmental consequences; and
- Informs the contingency plan and adaptive management process;

Condition 1, Schedule 4 of SSD5465 states:

"The Proponent shall ensure that vertical subsidence within the High Water Mark Subsidence Barrier and within Seagrass beds is limited to a maximum of 20 millimeters (mm)."

In addition to the above, Condition 2 within Schedule 4 of SSD-5465 also requires that:

"The Applicant shall ensure that the development does not cause any exceedance of the performance measures in Table 8 to the satisfaction of the Director-General."

The relevant subsidence monitoring requirements from Table 8 within Schedule 4 of the Development Consent, including the relevant notes, are recreated in Error! Reference source not found..

Table 1 - Subsidence Impact Performance Measures - Natural and Heritage Features

Biodiversity	
Threatened species or endangered populations	Negligible environmental consequences
Seagrass beds	Negligible environmental consequences including: • Negligible changes in size and distribution of seagrass beds; • Negligible change in the function of seagrass beds; and • Negligible change to the composition or distribution of seagrass species within seagrass beds.

Benthic communities	Minor environmental consequences, including minor changes to species composition and/or distribution
Mine Workings	
First Workings under an approved Extraction Plan beneath any feature where performance measures in this table require negligible environmental consequences	To remain long term stable and non-subsiding
Second Workings	To be carried out only in accordance with and approved Extraction Plan.

Notes:

• *The Applicant will be required to define more detailed performance indicators (including impact assessment criteria) for each of these performance measures in the various management plans that are required under this consent (see Condition 7 below).*

• *Measurement and/or monitoring of compliance with performance measures and performance indicators is to be undertaken using generally accepted methods that are appropriate to the environment and circumstances in which the feature or characteristic is located. These methods are to be fully described in the relevant management plans. In the event of a dispute over the appropriateness of proposed methods, the Secretary will be the final arbiter.*

• *The requirements of this condition only apply to the impacts and consequences of mining operations, construction or demolition undertaken following the date of approval of this consent*

Condition 4 within Schedule 4 of SSD-5465 also requires that:

“The Applicant shall ensure that the development does not cause any exceedances of the performance measures in Table 9, to the satisfaction of the Director-General.

The relevant subsidence monitoring requirements from Table 9 within Schedule 4 of the Development Consent, including the relevant notes, are recreated in Error! Reference source not found..

Table 2 - Subsidence Impact Performance Measures – Built Features

Built Features	
Trinity Point Marina Development Other built features	• Always safe • Serviceability should be maintained wherever practicable. Loss of serviceability must be fully compensated • Damage must be fully compensated
Public Safety	
Public Safety	Negligible additional risk

Notes:

- *The Applicant will be required to define more detailed performance indicators (including impact assessment criteria) for each of these performance measures in the various management plans that are required under this consent (see Condition 7 below).*

- *Measurement and/or monitoring of compliance with performance measures and performance indicators is to be undertaken using generally accepted methods that are appropriate to the environment and circumstances in which the feature or characteristic is located. These methods are to be fully described in the relevant management plans. In the event of a dispute over the appropriateness of proposed methods, the Secretary will be the final arbiter.*

- *The requirements of this condition only apply to the impacts and consequences of mining operations, construction or demolition undertaken following the date of approval of this consent.*
- *Requirement's regarding safety or serviceability do not preclude preventative actions or mitigation being taken prior to or during mining in order to achieve or maintain these outcomes.*
- *Requirement's under this condition may be met by measures undertaken in accordance with the Mine Subsidence Compensation Act 1961.*

3 Purpose

The purpose of this Subsidence Monitoring Program is to:

- define the subsidence monitoring scope;
- outline subsidence predictions;
- outline the methodology to be used to monitor subsidence impacts
- identify subsidence monitoring locations;
- identify reporting requirements;
- analyse the relationship between predicted and resulting subsidence effects;
- identify the requirements for incident or exceedances reporting.

4 Background

4.1 Operations

Chain Valley Colliery is an underground coal mine with current coal mining methods including development of roadways in the coal seam known as first workings and secondary extraction. These first workings develop panels to support the installation of a miniwall, a modern secondary coal extraction method.

Lake Macquarie is the largest saline lake in New South Wales. It lies on the central coast between Sydney and Newcastle within the local government areas of Wyong and Lake Macquarie. Lake Macquarie has a catchment of 700 square kilometers and a water surface area of 125 square kilometers (Bell & Edwards, 1980). The lake has a permanent entrance to coastal waters at Swansea and has an average depth of around 6 meters (Laxton, 2005).

The catchment of Lake Macquarie is largely rural with large areas of bush land and grazing land. The shoreline of Lake Macquarie is heavily urbanised, especially the eastern, western and northern shorelines. The region has a relatively long history of coal mining and power generation, with mining occurring since the late 1800s and the first power station at Lake Macquarie commencing operations in 1958.

The Chain Valley Colliery is situated on the southern shores of Lake Macquarie near Mannering Park, NSW. The mine has been operating since 1962. Mining is currently undertaken using miniwall methods with first workings to support the development in advance of each miniwall panel. All secondary extraction is currently occurring in the Fassifern seam, in line with Development Consent SSD–5465. The general layout of the Chain Valley Extension Project in respect to Lake Macquarie is shown on

Figure 1.

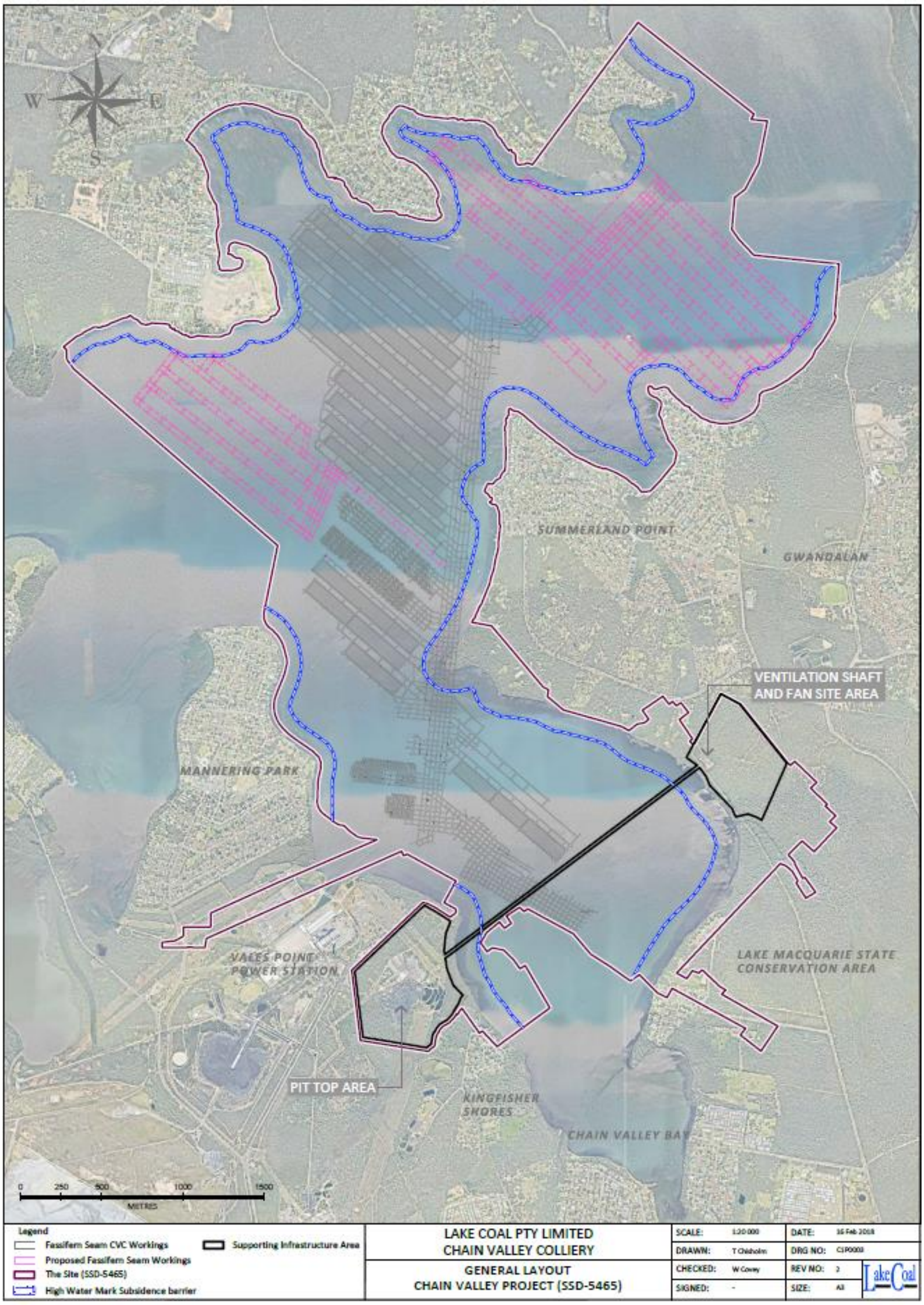

Figure 1: General Layout of the Chain Valley Norther Mining Domain

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			0	Technical Services Manager - Chain Valley Colliery
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4.2 Subsidence Predictions

Subsidence modelling has predicted up to approximately 130mm of subsidence to the Lake floor associated with the planned miniwall mining in N1 and S1 **(Figure 2),** with an approved maximum of 780mm. No additional subsidence is expected to occur within the seagrass or foreshore areas as a result of Fassifern extraction. The worst case S_{max} accounting for long term creep modelling has been predicted as 381mm and 444mm for N1 and S1 respectively.

The subsidence parameters beneath the lake, after each panel are included in **Table 3** for reference of monitoring results against. Respective triggers points for additional monitoring and response are included in the Subsidence Management TARP.

Table 3 - Northern Mining Domain Incremental Subsidence Parameters Beneath Lake Macquarie (DGS Report CHV-002-11a)

	Predicted Maximum Subsidence* (mm)	Average MG Chain Pillar Stress (MPa) RS2 [S.I.]	Average Goaf Stress (MPa)	Pillar Strength[#] (MPa)	Pillar Stability Index RS2 [S.I.]	Claystone UCS below pillars (UCS)	Pillar Stress/ Strength Ratio[+] (SSR)	Elastic Pillar Settle ment (mm)	Long-term Creep Estimate (50-year post-mining) (mm)	Worst-Case S_{max} (Long-Term) (mm)
Miniwall N1	120 (130 - 420)	9.13 [12.25]	0.5	27.3	2.98 [2.23]	2.3 (current)	*0.45* [0.60]	*94* [126]	*97* [205]	*191* [331]
						1.65 (flooded)	*0.63* [0.84]	*116* [155]	*160* [226]	*276* [381]
Miniwall S1	130 (120 - 410)	11.20 [13.2]	0.5	27.3	2.44 [2.07]	2.3 (current)	0.59 [0.69]	125 [148]	195 [275]	320 [423]
						1.65 (flooded)	0.82 [0.97]	154 [182]	189 [262]	343 [444]

** - numerical model subsidence with values in (brackets) showing the empirical model results for single miniwall panels; # - based on **Mills & Edwards, 1997** and a 3.2 m roadway development height; ^ - Long-term stable pillars indicated without creep for S.I. > 2.7; Creep 'likely' for an S.I. between 2 and 2.7, with bearing failure indicated by S.I. < 2; + - SSR based on floor bearing strength and predicted abutment stress from numerical model.*

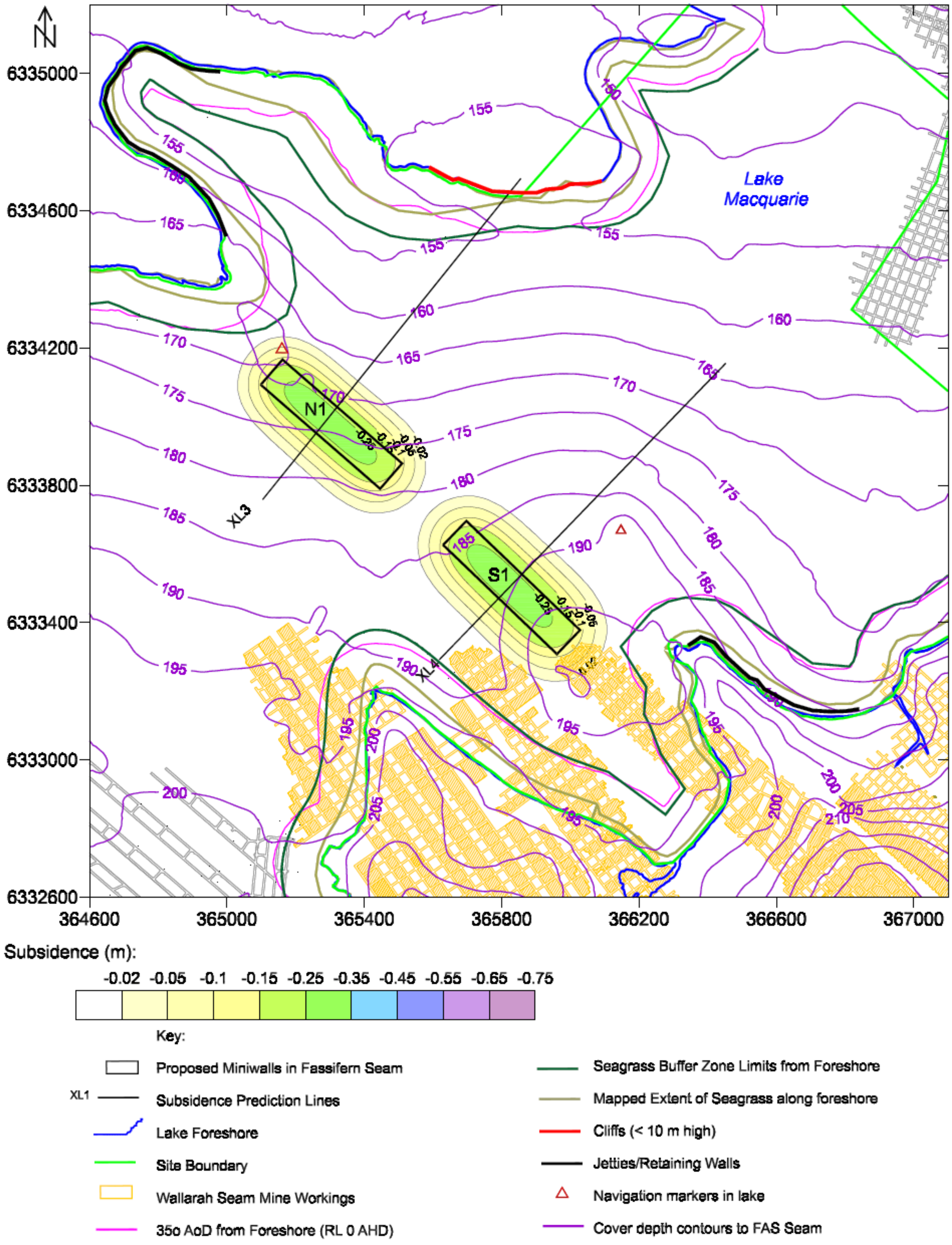

Figure 2 - Predicted Subsidence After N1 and S1

4.3 Subsidence Monitoring - Scope

4.3.1 Shoreline (High Water Mark)

The shoreline of Lake Macquarie is protected under Mining Lease Conditions requiring Ministerial Approval to carry out mining operations within the High Water Mark Subsidence Barrier (HWMSB). The HWMSB is defined in the seam by a line defined by an angle of draw of 35° drawn lakewards from the high water level of Lake Macquarie, and on the land side, a line drawn from the 2.44m contour at 35° towards the land (refer to **Figure 3**).

Condition 1, Schedule 4 of SSD5465 states:

"The Proponent shall ensure that vertical subsidence within the High Water Mark Subsidence Barrier and within Seagrass beds is limited to a maximum of 20 millimeters(mm)…."

A key objective of the mine design was to minimise vertical subsidence within the HWMSB and prevent additional subsidence above the high water mark. To ensure effectiveness of the mine design, monitoring of the shoreline is proposed via the installation and monitoring of fixed reference marks surveyed at regular intervals.

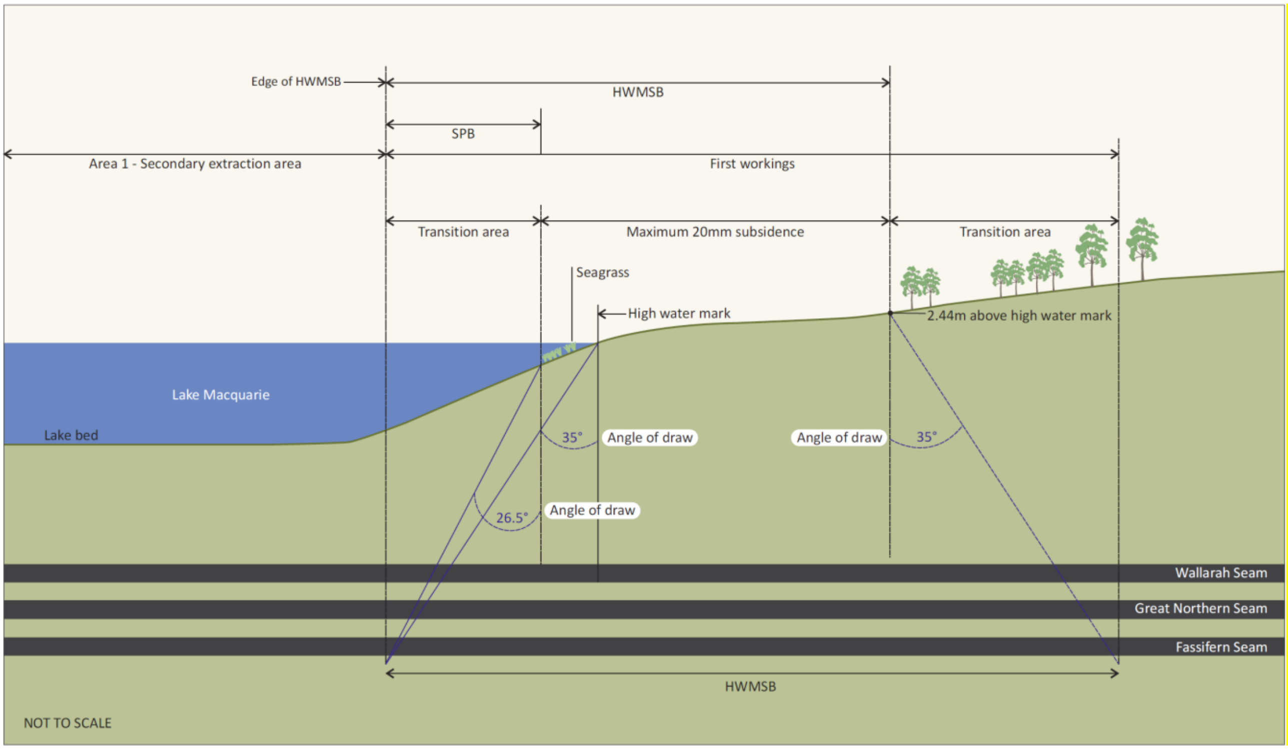

Figure 3 - High Water Mark Subsidence Barrier

4.3.2 Seagrass

Condition 2, Schedule 4 of SSD-5465 specifies negligible environmental impacts on the species of seagrass found within the current area of mining operations as a condition of approval.

Seagrass distribution within estuaries is naturally influenced by light penetration, depth, salinity, nutrient status, bed stability, wave energy, estuary type, and the evolutionary stage of the estuary.

LakeCoal's Seagrass Management Plan ENV 00009 outlines the methodology used to determine changes to composition and quantity of seagrass populations in Lake Macquarie.

In addition, a 26.5° line taken from the lake side of the mapped seagrass location projected to the Fassifern Seam has been defined as a protection barrier, and no miniwall extraction is to take place within this barrier.

Subsidence Monitoring of the lakebed is also proposed via bathymetric survey over the current mining area in order to validate the subsidence prediction model.

4.3.3 Benthic Communities

The mud basin is inhabited by a diverse number of marine organisms. Condition 2, Schedule 4 of SSD-5465 specifies minor environmental consequences on the Benthic communities, including minor changes to species composition and/or distribution as a condition of approval.

Six-monthly surveys of the lake bed are undertaken in order to monitor variations in the composition and density of benthos due to mining, environmental and/or other seasonal factors.

LakeCoal's Benthic Communities Management Plan ENV 00006 outlines the methodology used to determine changes to species diversity and abundance.

Subsidence Monitoring of the lakebed is also proposed via bathymetric survey over the current mining area in order to validate the subsidence prediction model, and to determine approximate levels of subsidence on specific benthic sample locations.

5 Subsidence Monitoring

5.1 Subsidence Monitoring Methods

5.1.1 Bathymetric Surveys

Bathymetric data from the NSW Office of Environment and Heritage (OEH) was obtained in draft format during 2012. LakeCoal was granted a license to use this OEH data for the purposes of monitoring changes in the bed of Lake Macquarie, and acknowledges the OEH's data which has enabled the subsidence comparison to be undertaken based on this 2010 data and data subsequently obtained in 2012 by LakeCoal. OEH notes that the data was obtained via use of differential GPS and a 200 kHz echosounder, which is noted to provide general data accuracy of 0.1m.

LakeCoal commissioned Astute Surveying in 2017 to undertake a bathymetric survey over the areas of current and proposed workings. The primary purpose of this survey was to obtain accurate baseline data for future subsidence assessments and to enable comparison with the draft OEH data from 2010. Importantly, the 2017 survey provided accurate details of the Lake depth within the proposed mining areas, which would enable future surveys to use as baseline data to monitor the future subsidence levels as a result of mining activities. Bathymetric surveys are to be conducted at least annually subsequent to this baseline survey.

Comparative analysis of the surveys highlights some elevation changes which are unrelated to mining, generally however these appear to be minor movements, perhaps related to movement of sediment as a result of the wave climate in the Lake. The surveys have shown that subsidence from the miniwall mining can be monitored with a useful level of accuracy and the surveys will be continued to cover future mining areas and areas where mining has been completed.

5.1.2 Foreshore Monitoring

Subsidence monitoring around Summerland Point and into Frying Plan Bay has already been established due to previous mining operations to the immediate southwest of the extraction area. Each line will be extended past the area of effect prior extraction (**Figure 4**)

Monitoring points are established along the foreshore at approximately 20-30m intervals and have been reestablished where missing. New monitoring locations will be subject to landholder access arrangements and permission.

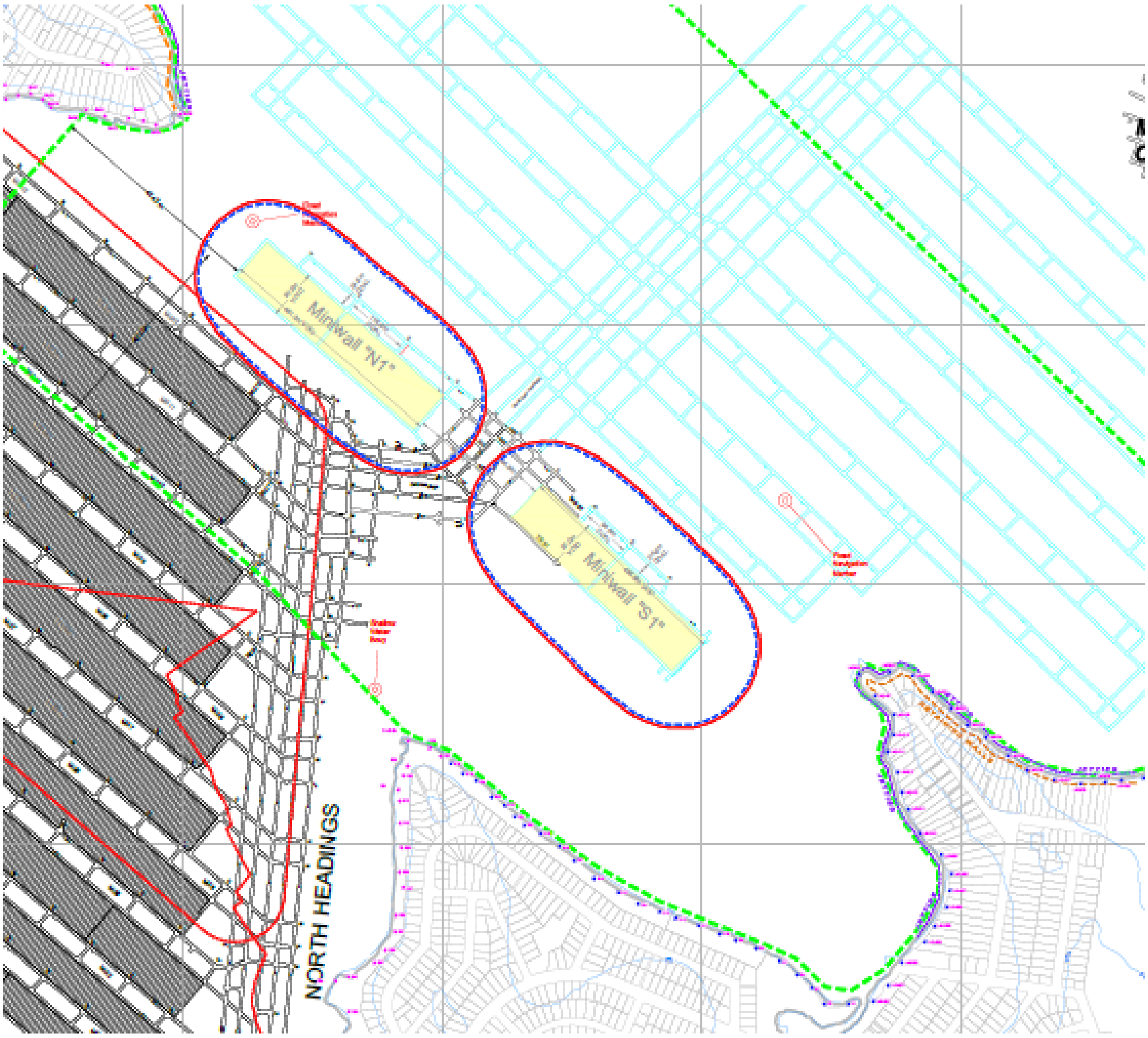

Figure 4 - Proposed Shoreline Subsidence Monitoring Locations, Summerland Point

The foreshore monitoring points will be monitored as follows:

- The points are to be established as per S1 to N1 Extraction Plan- Plan 7.
- X and Y locations will be measured using GPS equipment for plotting purposes (±0.025m)
- AHD RL (Z) component will be leveled using Automatic or Digital levelling equipment to an accuracy of 5mm/km.
- Surveys are to be conducted at intervals prescribed below, during mining operations and at the end of a panel.
- The results are uploaded to DRE's online subsidence web portal within 14 days of survey.

Additional as a part of the foreshore survey monitoring, observations will be made for visual impact or changes to public safety risk. The Subsidence Inspection Proforma will be completed with each survey. The proforma includes visual inspection of steep slopes, boulder or tree instability, ponding and other potential effects of mine subsidence.

Navigation markers will continue to be monitored by Roads and Maritime Services, who will inform LakeCoal of any abnormal changes poetically attributable to mine subsidence.

5.1.3 Subsidence Monitoring Frequency Requirements

Based on the monitoring program outlined above, the following monitoring frequencies are to be established to validate model outcomes, enable early detection of subsidence trending to increased impact levels over that predicted, allow early application of containment, adaptive and contingency measures to prevent impact outside approved and particularly increased impact to the foreshore; and allow evaluation as to whether CVB3 can be extended back to originally planned finish end position.

All evaluations are to be made against the criteria outlined in the Subsidence Monitoring TARP.

Table 2: Subsidence Monitoring Frequencies

	Pre-Extraction	During Extraction	Post Extraction
Bathymetric	Single baseline survey	6 monthly	Annual for 3 years unless TARP triggered
Foreshore Level Monitoring	Baseline survey	Monthly in proximity to S1 during retreat, then 6 monthly	Annual for 3 years unless TARP triggered

5.2 Subsidence Monitoring Review

Chain Valley Colliery will undertake a review of available subsidence monitoring data against predictions and expected outcomes annually within its Annual Review as required by SSD-5465.

5.3 Consultation

The Subsidence Monitoring Plan is required to be prepared in consultation with DRE. DRE have been consulted during the submission of the Extraction Plan and also as a part of the High Risk Activity Notification.

Roads and Maritime Services Project Officer (North Area) has been contacted during the development of the Extraction Plan and referred the matter to the RMS asset team, resulting in no further immediate actions required in regard to management of the navigation markers.

The Community Consultative Committee (CCC) for the mine will be routinely updated on subsidence monitoring results and any change in impact or public safety concern.

6 Roles and Responsibilities

Roles, responsibilities specific to completing the requirements of this Subsidence Monitoring Program are identified in **Table 4**.

Table 4: Subsidence Monitoring Program Roles and Responsibilities

Role	Responsibilities
Mine Manager	• Ensure that adequate financial and personnel resources are made available for the implementation of the Subsidence Monitoring Program

Mine Surveyor	• Co-ordinate subsidence monitoring, through the use of bathymetric surveys, conventional surveys along foreshore and underground data collection.
	• Review subsidence monitoring results against Subsidence Management TARP triggers
	• Inform relevant stakeholders as to the subsidence monitoring results
	• Review, and if necessary revise this document:
	    o In the event of any exceedance in impact thresholds
	    o Following any modification to the development consent

Environment and Community Coordinator	• Develop management actions in consultation with regulatory agencies as/if required from the monitoring results. • Respond to any potential or actual non-compliance and report these as required to regulatory bodies and other stakeholders. • Notify the relevant Government Agencies and other affected parties of any exceedances of the performance measures • Coordinate the meeting of the Subsidence Review Committee • Ensure complaint handling and response is undertaken, including determination of sources and potential remedial action to avoid recurrence.

Subsidence Inspection Proforma

SUBSIDENCE INSPECTION CHECKLIST

Where and when to Inspect

Foreshore along monitored survey lines during each survey.

What to look for

Signs of Subsidence Induced Impact	Change Observed (Y / N)	Comments/ Actions Taken
Step change in land surface - associated with cracking		
Slope, retaining wall, boulder or tree instability		
Surface slumping, erosion		
Evidence of ponding		
General vegetation condition (in particular dieback of vegetation)		
Changes to culverts or drains		

Actions if there is a public safety risk:

- Implement the **Public Safety Management Plan**; including
- Immediately notify the Mine Manager and Environment and Community Coordinator (ECC)
- The ECC will notify the Landholder or relevant Stakeholder (or responsible person) of the issue;
- take immediate actions to remediate the issue (if possible and safe to do so);
- as soon as possible erect “DANGER DO NOT ENTER” tape/signage around the affected area if safe to do so. Arrange for the rapid response public safety supplies to be accessed from the Mine Site compound (star pickets, safety barrier mesh, warning signage).
- Area is not to be left if immediate risk to public exists, arrange for assistance from site if it is unsafe to leave the affected area; and
- notify the Environment & Community Coordinator to coordinate actions.
- Notify the Manager of Mining Engineering of the occurrence

Survey Line Reference:______________________________

Inspection Undertaken By: __________________________________

Inspection Date:______________________

Appendix 8

Rehabilitation Management Plan

Lake Coal	Doc Owner:	**Environment and Community Coordinator**
	Doc No:	EMP-D-16373

CHAIN VALLEY COLLIERY

Rehabilitation Management Plan

ENVIRONMENTAL MANAGEMENT PLAN

Authors	Original Authors: Peter Stewart (EMGA Mitchell McLennan Pty Limited), Chris Ellis – Environmental Specialist, Ben Johnston – HSEC Advisor
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	Author (V3): Chris Ellis – Environmental Specialist
Authorised by:	
	Chris Ellis
	Environmental Specialist
Date:	05/12/2014

Table of Contents

1 Introduction

Chain Valley Colliery (the Colliery) is an underground coal mine located on the southern end of Lake Macquarie, approximately 100km north of Sydney and 60km south of Newcastle, adjacent to the Vales Point Power Station. The Colliery produces thermal coal for the domestic and export markets.

A formal Environmental Management System (EMS) has been developed as a systematic and structured approach to managing environmental issues at the operation. The EMS has been developed in general accordance with the requirements of the international standard ISO 14001.

This Rehabilitation Management Plan (RMP) is an element of the Colliery's EMS. The RMP is intended to be dynamic and changes will be made as warranted over time. The formal life of this RMP is three years and will be reviewed and amended, as required, as outlined in Section 14.

Mining operations in NSW are required, as a condition of an authorisation issued under the *Mining Act 1992*, to conduct mining operations in accordance with a Mining Operations Plan (MOP) that has been approved by the NSW Department of Trade and Investment, Regional Infrastructure and Services - Division of Resources & Energy (DRE). A MOP sets out in detail how mines will be rehabilitated over the course of the mining project. Each MOP has a maximum seven year period of application and has to be renewed as appropriate.

The existing guidelines for the preparation of MOPs state that premature or unplanned closure would typically require a new MOP to be developed. This new MOP should be prepared using the current MOP guidelines at the time, with additional information as required from the "Strategic Framework for Mine Closure", published by the Australian and New Zealand Minerals and Energy Council, and the Minerals Council of Australia.

The Colliery has Development Consent SSD-5465 (as modified) for mining operations to occur until 31 December 2027.

This RMP, as well as being an element of the Colliery's EMS, has also been completed to satisfy the requirements of Condition 27 within Schedule 3 of Development Consent SSD-5465 (as modified), which states:

"The Applicant shall prepare and implement a Rehabilitation Management Plan for the development, in consultation with OEH, NOW, WSC, LMCC, and the CCC, and to the satisfaction of the Executive Director Mineral Resources. This plan must:

(a) be submitted to the Secretary and the DRE for approval within 12 months of the date of approval of this development consent;

(b) be prepared in accordance with any relevant DRE guideline and be consistent with the rehabilitation objectives in the EIS and in Table 7;

(c) describe how the performance of the rehabilitation would be monitored and assessed against the objectives in Table 7;

(d) describe the process whereby additional measures would be identified and implemented to ensure the rehabilitation objectives are achieved;

(e) provide for detailed mine closure planning, including measures to minimise socio-economic effects due to mine closure, to be conducted prior to the site being placed on care and maintenance; and

(f) be integrated with the other management plans required under this consent.

Note: The Rehabilitation Management Plan should address all land impacted by the development whether prior to, or following, the date of this consent."

In addition to the above requirements, Condition 26, within Schedule 3 also requires that "the Applicant shall carry out the rehabilitation of the site progressively, that is, as soon as reasonably practicable following disturbance".

2 Purpose

The purposes of this RMP are to:

- set out the rehabilitation objectives and proposals for the Colliery;
- meet the requirements of the Development Consent in respect of the RMP; and
- complement the role of the Chain Valley Colliery MOP as an instrument to attain desired rehabilitation outcomes.

3 Background

This section provides an overview of the operations of the Colliery that are relevant to the future rehabilitation of the Colliery, with **Figure 3.1** showing the main surface features of the Colliery.

3.1 Site History

In August 1960, J&A Brown and Abermain Seaham Collieries Ltd commenced clearing the present site with drift and shaft sinking starting a few months later. Production of coal from the Wallarah seam, commenced with the first delivery to the adjacent Delta Electricity's Vales Point Power Station in April 1963.

LakeCoal was formed in 2001 to acquire BHP Billiton's 80% share in the Wallarah Coal Joint Venture (WCJV), the remaining 20% share was owned by Sojitz. In October 2006, Peabody Energy, a US listed company acquired LakeCoal Pty Limited.

In November 2009 LDO Coal Pty Limited purchased LakeCoal Pty Limited. LDO Coal is a consortium consisting of LD Operations, AMCI and private investors.

In March 2011 the 20% share in the WCJV which Sojitz held was acquired by LDO Coal shareholders through the entity Fassi Coal Pty Ltd.

The WCJV had operated the Wallarah, Moonee and Chain Valley underground coal mines and the Catherine Hill Bay Coal Preparation Plant, all located at the southern end of Lake Macquarie. At the time of LakeCoal's acquisition by LDO Coal, both the Wallarah and Moonee mines were closed.

LakeCoal is currently undertaking the mine closure/rehabilitation process for the Moonee Colliery and the Catherine Hill Bay Coal Preparation Plant, subject to a separate Mining Operations Plan. The rehabilitation process for Wallarah Colliery has been completed and the lease in that area relinquished.

Chain Valley Colliery peaked with a workforce of approximately 380 men in the mid 1980's. As of mid 2014, Chain Valley Colliery has a workforce of approximately 150 full time employees/contractors.

The Wallarah, Great Northern and Fassifern seams have been mined at Chain Valley Colliery to produce a raw, crushed thermal coal with low sulphur, which is suitable for both export and domestic markets.

Mining in the Wallarah seam is complete in the Colliery holding area and mining was discontinued in the late 1990's. There is still some remaining resource within the Great Northern seam, however the focus of operations and current approval only permits mining within the Fassifern seam.

LAKE COAL PTY LIMITED CHAIN VALLEY COLLIERY	SCALE: 1:2000	DATE: 13 Nov 2014	
	DRAWN: T Chisholm	DRG NO: C1S0154_1	
REHABILITATION MANAGEMENT PLAN FIGURE 3.1 - SURFACE FACILITIES	CHECKED: C Ellis	REV NO: 1	Lake Coal
	REVISION: 1	SIZE: A3	

3.2 Land Tenure and Use

Chain Valley Colliery comprises two individual surface areas, the main pit top area directly adjacent to the Vales Point Power Station and the ventilation shaft site on Summerland Point. The pit top area is comprised five (5) separate lots while the ventilation shaft site is a single lot, details of the lots and ownership is detailed in **Table 3.1** and shown on **Figure 3.2**.

Table 3.1: Land ownership details

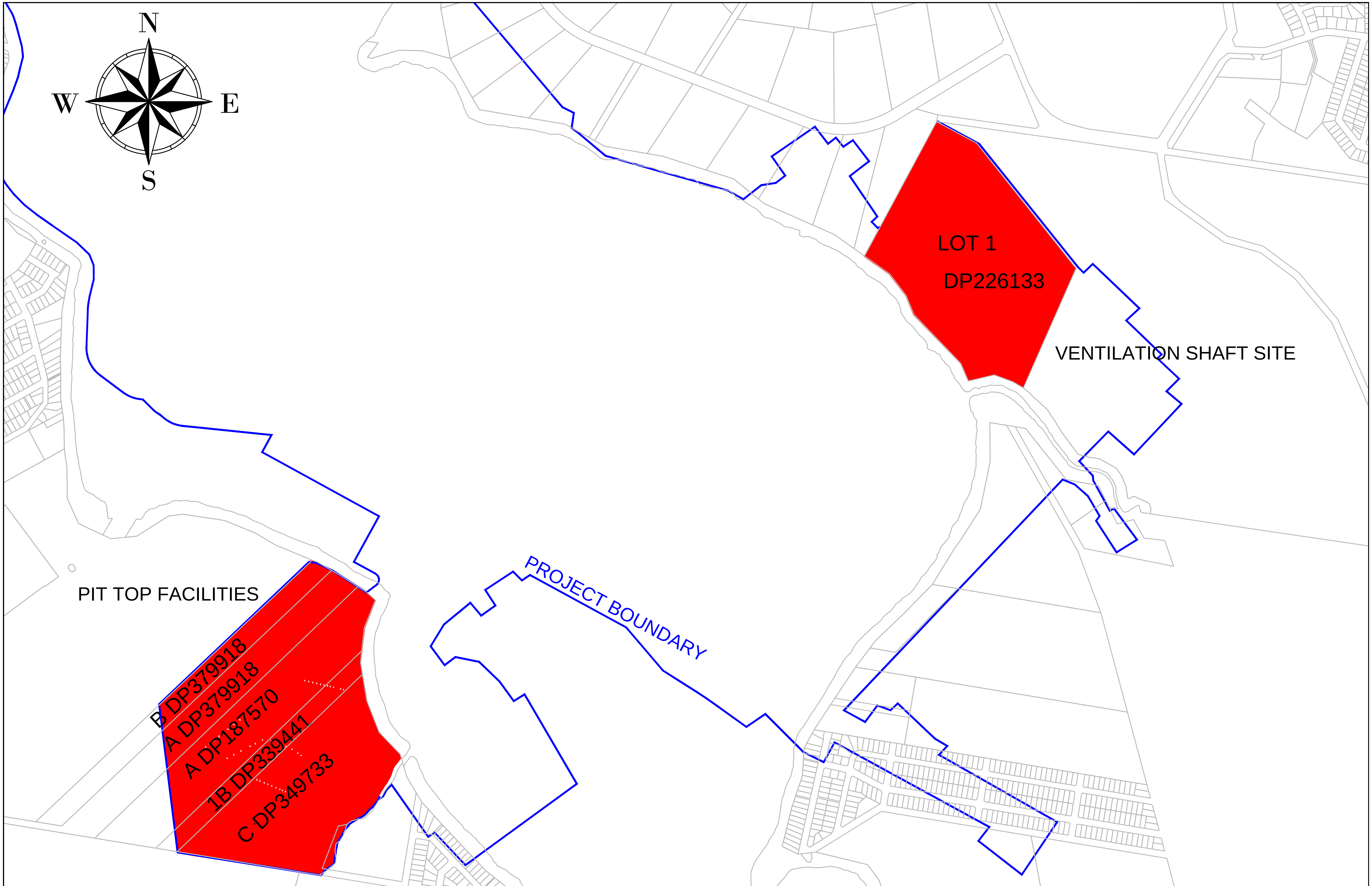
Site	Owner	Lot	Deposited Plan
Pit top area	Delta Electricity (utilised under access agreement)	A	379918
		B	379918
		C	349733
		A	187570
		1B	339441
Ventilation shaft site	LakeCoal Pty Ltd	1	226133

3.3 Mining methods

Coal mining at the Colliery has occurred since 1962 and consists of two phases: first workings where an initial cut of coal is extracted and negligible surface subsidence occurs; and secondary extraction where the majority of the coal resource is extracted and, therefore, is the more productive phase of mining. Secondary extraction is generally necessary for the commercial viability of a mine, whereas first workings are necessary to establish roadways for access and ventilation.

Up until 2011, operations consisted of bord and pillar methods for secondary extraction. Since 2011, secondary extraction at the Colliery has employed the miniwall mining method. Historically coal has been extracted from three seams – the Wallarah, Great Northern and Fassifern seams. Current mining activities are limited to the Fassifern seam.

Historic workings are located under the southern extent of Lake Macquarie and areas of Summerland Point, Chain Valley Bay, Mannering Park and Kingfisher Shores. Areas of these historic Colliery workings are being used for passive operational activities such as ventilation; water drainage; movement of personnel, materials and coal; conveyors; and services.



LAKE COAL PTY LIMITED CHAIN VALLEY COLLIERY	SCALE:	1:10000	DATE:	13 Nov 2014
	DRAWN:	T Chisholm	DRG NO:	C1S0154_2
REHABILITATION MANAGEMENT PLAN FIGURE 3.2 - SURFACE FACILITY AREAS	CHECKED:	C Ellis	REV NO:	1
	REVISION:	1	SIZE:	A3

LakeCoal

3.4 Coal processing

The Colliery produces a raw crushed thermal coal with relatively low sulphur, suitable for both export and domestic markets. Raw coal is screened, crushed and sized on site to the market demands of specific export or domestic customers. No coal beneficiation is undertaken.

3.5 Waste management

Waste management at Colliery consists of two main areas; solid waste management and liquid waste management. As there is currently no beneficiation of coal product at Colliery and there is no resultant reject requiring disposal.

A licenced waste contractor is engaged to remove and dispose of waste from the Colliery. Through the implementation of a total waste management system with the waste management contractor, continuous improvements are made on site to increase recycling and decrease waste to landfill.

Liquid waste product from washdown bays and the oil separator is removed from site via a licenced waste contractor under appropriate waste tracking. Stormwater runoff from the potentially hydrocarbon containing areas flow to the wash down sump which is subsequently treated by an oil water separator. Solids are removed in a grit trap and oil is removed from the water by packed bed oil water separator and stored in a waste oil tank prior to removal from site. Excess oil from the compressors (condensate) and surrounds is contained and piped to a separator tank which is inspected weekly and pumped out as required.

Coal fines, which are captured by sediment dams, sumps and other sediment control devices are recovered and re-incorporated to final product coal, further reducing potential waste streams.

3.6 Coal stockpiles

A ROM stockpile exists to the east of the pit top area (**Figure 3.1**) which is designed to balance market demands during times of lower production, extended maintenance or mine shutdown and shipping requirements. The stockpile has a maximum capacity of approximately 150,000 tonnes but more typically contains around 40,000 tonnes. There is no coal reject generated from production at Chain Valley Colliery.

3.7 Water management

A significant portion of the Colliery leases are under Lake Macquarie, with the predominately saline but otherwise uncontaminated groundwater seepage pumped to the surface prior to discharge via a licenced discharge point.

The underground mine water from the Wallarah, Great Northern and Fassifern Seams is dewatered or migrates naturally and is pumped to a central underground sump area in the Great Northern Seam. It is then pumped to the surface and mixed with bathhouse wastewater and stormwater runoff in the dams to the east of the pit top area. The dams act as settling and diffusing ponds and allow the water to migrate via the series of dams into a waterway which discharges into Lake Macquarie. Discharges are licenced under Environment Protection Licence 1770. Average mine water discharges to the surface settling ponds is approximately 50 megalitres a week.

3.8 Hydrocarbon Management

Oil and diesel fuel at Colliery is stored within a number of bunded areas. Drainage from the bunded areas is connected to the oil separator and sedimentation sumps. In the event of a major spill, the drainage system can be blocked off to contain any spill in the outdoor storage area. Spill kits, booms and absorbent are available on site if required. The diesel fuel storage tank of 14,900 litres is situated behind the main workshop.

4 Consultation

A key component for the development of the RMP is consultation. As this version of the RMP is a revision of a prior version, which was also prepared in consultation with a number of stakeholders, this prior consultation and outcomes are detailed below (in **Table 4.1**). **Table 4.1** also provides a summary of the most recent items raised, and responses or changes as a result of the consultation for the current version of the document.

Table 4.1 Consultation Summary

Stakeholder	Comments	Response/Action
Community Consultative Committee	• No comments were received	• N/A
Fisheries NSW	• Raised concern over the potential for groundwater to build up post closure and breach surface seals, impacting Lake Macquarie	• Addressed in Section 5.2.2
Wyong Shire Council (original comments)	• Requested consideration of mine portals being used as habitat for microbats and site dams being used as fauna habitat.	• Both of these comments were incorporated and addressed in Section 4.3.3
	• Suggested the document be updated to include habitat augmentation such as nest boxes, hollow logs and frog ponds etc.	• This comment was addressed in Section 6.7.2, however nest boxes and hollow logs were not incorporated as no clearing is proposed that would require such offsets. Reference to retaining or constructing small dams was however incorporated.
Wyong Shire Council (comments on Revision 3)	• Suggested including some details in the plan to enable rehabilitation efforts to commence in the shorter term prior to the detailed closure being developed. For example, providing a list of suitable plant species for the native revegetation to be re-established, which would allow these species to be propagated while the detailed closure plan is developed.	• Suggestion has been incorporated into Section 7.6.
	• Questioned to the alignment of rehabilitation completion criteria and performance measures in Table 7.2, for example considered that the criteria of a 'clear trend of increasing species diversity' may not equate to the objective of a 'self-sustaining ecosystem' as required by the rehabilitation objectives from the Development Consent.	• Notwithstanding the detailed mine closure plan may expand on the performance measures, it is considered that increasing species diversity would be a significant indicator of a self-sustaining ecosystem, i.e. additional species are propagating within the rehabilitation area, which relies on the rehabilitation being able to support this propagation and diversity. Self-propagation in revegetated areas is also an existing completion criteria within ecosystem,/land use establishment. In addition, one of the performance measures proposed is monitoring and comparison to adjacent control

Table 4.1 Consultation Summary

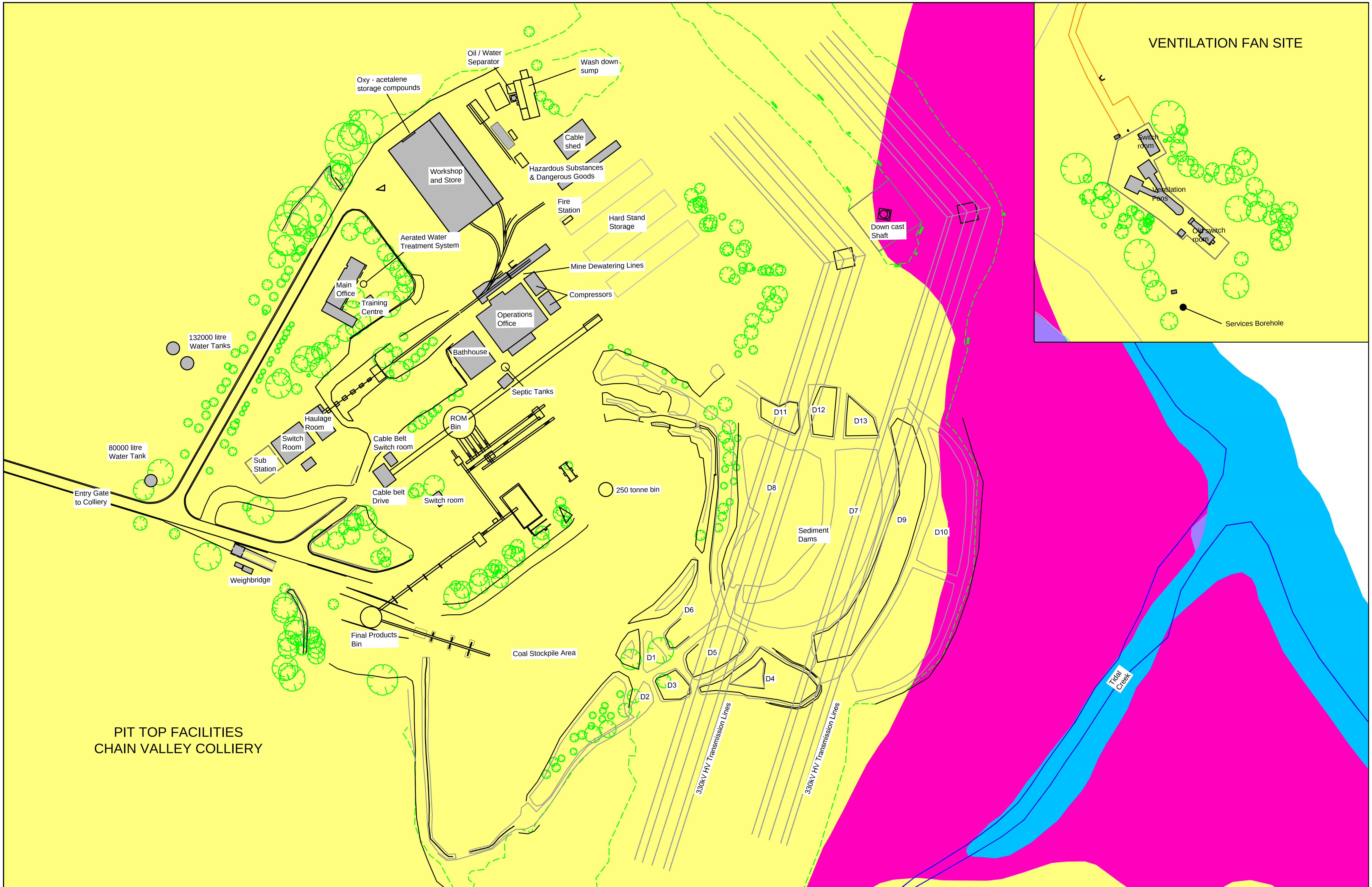
Stakeholder	Comments	Response/Action
		sites, which will enable comparison with these adjacent self-sustaining sites.
	• Recommended that Section 10 (Risk Management) be updated to include hazards of bushfire, pests and disease/pathogens.	• The Rehabilitation Management item that existed in Section 10 was further expanded to specifically mention these items.
Department of Planning & Environment	• Provided comments on Section 10 (risk factors) and agency names and structures.	• Both these sections (Section 10 and Section 12) were updated to incorporate / address comments provided.
Office of Environment and Heritage	• No comments were received	• N/A
NSW Office of Water	• No comments were received	• N/A
Lake Macquarie City Council	• No comments were received	• N/A
Delta Electricity	• Delta notes that closure is not planned and approval to continue operations exists until 31 December 2027.	• Noted
	• Delta advised they have no material additions to the plan other than some consideration should be given to the management of the current Licenced Discharge Point and what monitoring conditions will be required post closure and surrender of the EPL (if any)	• Section 7.7.2 (Water Management) has been updated to provide additional information on proposed EPL surrender and water monitoring.

5 Environmental Characterisation

5.1 Physical Environment

The climate at the Colliery is borderline oceanic/humid subtropical with warm summers, mild winters and heavy precipitation in late autumn and early winter. A review of Bureau of Meteorology weather stations in the Lake Macquarie region found that the average annual rainfall in the vicinity of the Colliery is 1,206 mm with an average annual evaporation of 824 mm.

The pit top area and Summerland Point ventilation shaft site are located on lands comprising the Doyalson and Wyong soil landscapes. Doyalson soils are strongly acidic with low fertility and slight to high erodibility. Wyong soils are strongly acidic, poorly drained, impermeable, and saline with very low fertility.
The *NSW Acid Sulfate Soil Risk Maps* for the Lake Macquarie area shows that acid sulfate soils are likely to occur at a depth of 1 to 2m along the foreshore of Lake Macquarie adjacent to the pit top area and the Summerland Point ventilation shaft. The acid sulfate soil risk warrants consideration during the development of the detailed mine closure plan and accordingly in provided as **Figure 4.1.**



CLASS 1 - ALL WORKS

CLASS 2 - WORKS BELOW GROUND SURFACE

CLASS 4 - WORKS BEYOND 2m BELOW GROUND SURFACE

CLASS 5 - WORKS WITHIN 500m OF ADJACENT CLASSES 1 - 4

LAKE COAL PTY LIMITED CHAIN VALLEY COLLIERY	SCALE: 1: 2000	DATE: 13 Nov 2014
	DRAWN: T Chisholm	DRG NO: C1S0154_3
FIGURE 4.1 - ACID SULFATE SOILS WITHIN PROPOSED REHABILITATION AREAS	CHECKED: C Ellis	REV NO: 1
	REVISION: 1	SIZE: A3

5.2 Hydrology

5.2.1 Surface water

The Colliery has a series of 13 sediment dams (**Figure 3.1**) into which receive inflow from surface catchment runoff, septic treated bathhouse wastewater, treated water from the oil water separator and, primarily, underground mine water. These ponds treat the wastewater and runoff through settlement of fines and suspended solids prior to discharge from the Colliery. The discharge is licenced under Environment Protection Licence 1770, which includes a volumetric limit of 12,161 kilolitres per day. The dams have been constructed with a mixture of earth, crushed road base and crushed recycled brick and stone, and are interconnected through a series of overflow pipes and spillways.

Potable water is supplied to the Colliery via a mains connection from the Wyong Shire Council water supply, while currently utilised for operational activities, the potable supply will be an important source of clean water when undertaking site rehabilitation works.

Details of the site surface water management are provided in the Water Management Plan (EMP-D-16368).

5.2.2 Groundwater

The hydrogeological regime of the mining area and its surrounds comprises a Quaternary terrestrial and marine / estuarine alluvial / coalluvial groundwater system. There is also underlying Permian strata with low permeability and yielding sandstone, siltstone, conglomerate and tuff with low to moderately permeable coal seams which are the predominant water bearing strata.

The groundwater is naturally saline and migrates into the Colliery's underground workings in the Wallarah, Great Northern and Fassifern seams with the majority of inflows currently seen in the Great Northern and Wallarah seams. All water is transferred to a main sump within the Great Northern Seam, and then to the sediment dams on the surface via the main underground pumps. The groundwater cannot be used for operational purposes due to being highly saline and would not be suitable for use in mine rehabilitation for the same reason.

As the groundwater table is lower than any of the mine entries or shafts, there will be no risk of groundwater exiting through sealed drifts or shafts post mine closure.

Details of the groundwater systems in the vicinity of the Colliery are provided in the Water Management Plan (EMP-D-16368).

5.3 Natural Environment

5.3.1 Geology

The stratigraphy in the local area comprises the Permian coal measures overlain by the Triassic Narrabeen subgroup and Quaternary lacustrine and terrestrial alluvial / colluvial deposits.

There are a number of faults and dykes which have been mapped or are inferred within the Colliery and its surrounds. The current Fassifern Seam workings have intersected some of these geological structures, which have impacted on approved mining activities; however, no significant inflows were observed when installing the main headings.

The Fassifern Seam is mined at a depth of approximately 200 m with the seam being approximately 30 m deeper than the Great Northern seam, which underlies the Wallarah seem by approximately 30 m also. The Fassifern seam is overlain by a tuffaceous claystone material which varies in thickness between 20-30 metres. The Fassifern seam measures up to 5 metres in thickness with roadway development carrying a coal roof and floor.

Figure 5.1 shows the typical stratigraphy at Chain Valley Colliery including the Wallarah, Great Northern and Fassifern seams.

5.3.2 Aquatic Ecology

The current mine workings are located in the southern part of Lake Macquarie, west of Summerland Point. Lake Macquarie is a large barrier estuarine lake characterised by an open water area of 115.1km^2. The Lake opens to the sea and strong tidal flows occur at the entrance channel, where the tidal range is 1.23m (Watterson *et al. 2011*). However, in areas removed from the Lake's entrance such as Chain Valley Bay which is 13km from the entrance, tidal range and influence is not as pronounced. Lake Macquarie is a wave-dominated estuary, with a high sediment trapping efficiency, naturally low turbidity and salt wedge/partially mixed circulation where there is likely to be sedimentation (Cardno Ecology Lab, 2011). The average depth of the Lake is 7m and exhibits a relatively flat floor characterised by fine soft silt/mud sediments. The approximate water depth in the vicinity of the mining areas ranges from 0.5m to 8.5m and depth of sediment varies in thickness up to approximately 10m (AECOM, 2011).

Seagrass communities within the Lake have been mapped adjacent to current workings and a seagrass protection barrier has been applied to the mine plan to ensure the seagrass beds are not subsided. Annual seagrass monitoring and reporting is also undertaken in accordance with the current Seagrass Management Plan (EMP-D-16674).

Studies of benthic communities have also been undertaken both above the mining areas as well as at control sites and no correlation between mining activities and community abundance and/or diversity was found to exist, however, ongoing monitoring in accordance with the Benthic Communities Management Plan (EMP-D-16672) is planned and will ensure that potential impacts to benthic communities are monitored throughout mining activities.

Given the above, no rehabilitation at mine closure is expected in relation to the aquatic environment above the mining areas.

5.3.3 Terrestrial Ecology

Vegetation mapping undertaken during 2012 in areas surrounding the pit top identified the surrounding vegetation communities as coastal open woodland, swamp oak forest and swamp sclerophyl forest. Mapping was also undertaken at the ventilation shaft site and identified coastal open woodland, grassy open woodland and swamp sclerophyl forest as the vegetation communities surrounding the site. Additional details on the terrestrial ecology are contained within the Biodiversity Management Plan (EMP-D-16372).

From the above both the swamp oak forest and swamp sclerophyl forest are listed as Endangered Ecological Communities under the Threatened Species Conservation Act, 1995.

The surrounding vegetation communities are also known to provide habitat for threatened fauna species such as the Squirrel Glider (*Petaurus norfolcensis*), Regent Honeyeater (*Anthochaera phrygia*), Swift Parrot (*Lathamus discolor*), Grey-headed Flying-fox (*Pteropus poliocephalus*) and microbats.

Accordingly, consideration of the valuable vegetation communities and habitat they provide will be an essential part of the detailed mine closure plan.

In additional to the natural habitat within the site, built structures are also known to provide potential habitat for a number of fauna species. Of relevance to the Colliery, it is known that endangered mircobat populations have inhabited mine portals elsewhere in NSW (Olsen Consulting Group, 2009), in addition the Colliery sediment dams have become used by a number of native fauna species. As a result of the potential impact to endangered mircobat populations and other fauna species as a result of undertaking mine closure activities these potential impacts will need to be considered as part of the mine closure plan, including undertaking a risk assessment in relation to the closure works.

Figure 5.1: Typical Stratigraphy at Chain Valley Colliery

6 Socio-economic and Cultural Environment

6.1 Workforce Profile

While not specifically related to mine rehabilitation, LakeCoal employees and contractors are major stakeholders when considering mine closure and subsequent rehabilitation. A workforce survey was undertaken in 2012 to identify the workforce demographics and other important features. The survey was undertaken over all shifts (day, afternoon and night) and rosters (mid-week and weekend), with the results of this survey summarised below.

While the below details are not exhaustive of the survey undertaken, they give a snapshot of the workforce profile which can be considered in the socio-economic aspects of mine closure planning to reduce potential impacts due to mine closure.

6.1.1 Demographics

- approximately 80% of the Colliery workforce are LakeCoal employees, while 20% are contractors to the company;
- approximately 60% of the Colliery workforce have been working at the Colliery for under 2 years, 15% between 5 to 7 years, 13% greater than 15 years and 12% between 3 to 5 years; and
- the largest working age group is 25 to 34 year olds (39%), followed by 45 to 54 year olds (25%) and 35 to 44 year olds (14%).

6.1.2 Residential location

- the majority of the Colliery workforce live in Lake Macquarie LGA (60%) followed by Wyong LGA (26%) and Newcastle LGA (8%). Approximately 27% of contractors come from outside these LGAs;
- a high proportion of the Colliery workforce have resided in their locality for more than 15 years (72.2%) indicating low levels of residential mobility; and
- approximately 85% of the Colliery workforce stated they already lived in the area when they commenced employment at the Colliery, indicating that the Colliery sources employment from the local labour pool.

6.1.3 Housing and household composition

- a high proportion of the Colliery workforce have either a mortgage or own their own homes (85%) with a smaller proportion living in rental accommodation (15%);
- approximately 55% of the Colliery workforce had partners in paid employment, while 27% of partners were not working (18% of workers had no partners);
- of those partners in employment, the highest proportion was full-time employment (32%) compared to part-time (23%), largely in areas of healthcare and office and administration support (11% each);
- the highest proportion of people living in a household is two people households (29%), followed by four people (27%) and three people (22%);
- the average family household size for the Colliery workforce is 3.11;

6.1.4 Household expenditure and service usage

- the majority of the Colliery workforce purchase their weekly household goods in Lake Macquarie LGA (55%), predominantly at Swansea and Belmont, followed by Wyong LGA (26%), primarily at Lake Haven;
- consistent with the above trend, the Colliery workforce use local medical facilities close to their place of residence (Lake Macquarie LGA - 56% and Wyong LGA - 25%); and

- of all households, 17% have a family member attending high school, 16% attending primary school and 13% attending childcare or preschool.

6.1.5 Charitable contributions

- over half the Colliery workforce (56%) makes voluntary donations, with 31% making donations to local schools, 17% to Salvation Army, 14% to the local surf club and 13% to local sporting clubs; and
- a small proportion of the Colliery workforce (16%) participates in local voluntary services, and of these 60% volunteer with the local surf club and 12% with schools and animal rescue groups.

6.2 Cultural Environment

LakeCoal has developed a Heritage Management Plan (EMP-D-16371), which should be referenced for detailed background in relation to the cultural environment and stakeholders, the below sections build on this management plan in relation to rehabilitation and mine closure only.

6.2.1 Aboriginal heritage

Prior to European settlement, the Lake Macquarie area was inhabited by people of the Awabakal language group (also spelt Awabagal), a language name derived from the ‘Awaba’ place name for Lake Macquarie and the group of people belonging to that place (Awaba-gal). The Awabakal is bordered generally by the Darkinjung to the south west, Wonnarua to the north west and by the Worimi to the north beyond Newcastle.

Monitoring of the a single Aboriginal site, above the main headings, commenced in January 2013 in accordance with the Heritage Management Plan (EMP-D-16371). Monitoring of this site and other sites as identified in the Heritage Management Plan will continue as required throughout the life of the mine.

As part of the site rehabilitation and closure final monitoring of these sites for any mine subsidence related affects will be considered, if not completed prior to this date.

6.2.2 Historic heritage

There are no identified sites of historic significance at the Colliery, however the Lake Macquarie Local Environmental Plan (LEP) 2004 identifies the “Wyee Coal Conveyor Railway Loop” as an item of local heritage significant. While the Wyee rail loop is over 5km away from the Colliery, the address of the “Wyee Coal Conveyor Railway Loop is identified in the Lake Macquarie LEP as “North of Wyee to Vales Point Power Station” which indicates that the conveyor linking the Wyee rail loop and power station form part of the local heritage item. Considering that the Colliery is directly adjacent to, and closely associated with, the Vales Point Power Station, this item of local heritage significance is considered to be proximate enough to the site to warrant consideration as part of RMP.

In addition to the above the Wyong Shire Council Heritage Review (Scobie Architects Pty Ltd, 2010) investigated the historical context of Wyong and identified areas of historic heritage significance. It identified the Vales Point Power Station, located directly adjacent to the Colliery as an item of local heritage significance and has recommended the power station be included in the Schedule of heritage items within the Wyong LEP (Scobie Architects Pty Ltd 2010).

Based on the above, there are no items of heritage significant within the Colliery surface areas or any that overlie mine workings. However the Vales Point Power Station, Wyee rail loop and conveyor from the Wyee rail loop to the power station have been identified as having local heritage significance.

In consideration of the above, and that Chain Valley Colliery has been providing coal to the power station since 1963, final mine closure and rehabilitation planning should include consultation with Delta Electricity (or future owners) of the Vales Point Power Station in relation to representing the historic linkage between the Colliery and the power station.

7 Rehabilitation Management

7.1 Proposed rehabilitation during life of the current MOP

The current Colliery MOP was approved on the 29 January 2014, with a completion date of 30 November 2015. The current Development Consent will expire on 31 December 2027. Due to the continuing need for surface infrastructure for operational use, there is relatively little rehabilitation anticipated over the life of the current or proceeding MOP. Surface works are expected to be limited to replacement, upgrade or maintenance work for the existing surface improvements.

Final rehabilitation will not be achieved under the current MOP. However, the anticipated rehabilitation status at mine closure is generally rehabilitation to a semi-natural vegetation cover (while maintaining the existing 330kV power line easement) with a view to lease relinquishment. Rehabilitation to be implemented under a future MOP at mine closure is described in Section 5 of the current MOP.

7.2 Mine closure planning

A detailed mine closure plan will be prepared at least one year before the mine is closed. The plan will be comprehensive and not only consider such issues as the physical rehabilitation of the Colliery site and the decommissioning and removal of plant but also community engagement and socio-economic issues. It is not expected that such a plan would be required until approximately 2026, however this date would be dependant on future approvals and access to resources and reserves. This RMP will be revisited on a three yearly basis, and, as it will be reasonably up to date at the time the mine closure plan is being prepared, it will inform the plan and vice versa.

Should events occur that result in the Colliery being placed into temporary closure or care and maintenance, a risk assessment will be triggered with the resulting actions being included in a care and maintenance plan to be developed for the Colliery. The care and maintenance plan would be implemented until such a time that the Colliery resumes mining activities or a detailed mine closure plan is developed and approved.

7.3 Mine closure and final rehabilitation objectives

The current MOP describes LakeCoal's objectives for closure of the Colliery which are:

- prevent access to former underground workings;
- remove unwanted infrastructure from surface areas;
- ensure any remaining infrastructure is "fit for purpose" through identifying and managing associated risks;
- develop final landforms that are safe, permanent and suitable for subsequent land use as determined through consultation with stakeholders, including landowners (principally Delta Electricity), local communities and government departments;
- minimise maintenance requirements for remaining infrastructure and landforms; and
- progressively relinquish leases as rehabilitation is completed and accepted by the Department of Trade and Investment, Regional Infrastructure and Services (DTIRIS).

Generally, it is proposed to revegetate the surface facilities areas to a near-native ecosystem compatible with the surrounding vegetation communities (with exception of the area that lies within the 330kV power line easement, which will remain a grassland community). As the goal is to return the areas of disturbance to a native plant community (or communities) aligned with the surrounding bushland, no introduced species (e.g., *Melaleuca armillaris*, *Pinus radiata* and non-endemic eucalypts) would be used in the revegetation program. Rather, the focus of the works would be the use of plant material grown from locally sourced species. The Colliery is on land owned by Delta Electricity who will, therefore, be a key stakeholder in determining the final revegetation and landform of the area.

In addition to reinforcing the objectives of the MOP, the objectives of this RMP are prescribed in Table 7 of Condition 25, Schedule 3 of the Development Consent and are reproduced in **Table 7.1**.

Table 7.1 Rehabilitation objectives

Feature	Objective
Mine site (as a whole)	• Safe, stable and non-polluting. • Final land use that is compatible with surrounding land uses.
Surface infrastructure	• To be decommissioned and removed, unless the Executive Director Mineral Resources agrees otherwise.
Portals and ventilation shafts	• To be decommissioned and made safe and stable. • Retain habitat for threatened species (eg bats), where practicable.
Other land affected by the development	• Restore ecosystem function, including maintaining or establishing self-sustaining ecosystems comprised of; - local native plant species (unless the Executive Director Mineral Resources agrees otherwise); and - a landform consistent with the surrounding environment
Built features damaged by mining operations	• Repair to pre-mining condition or equivalent unless: - the owner agrees otherwise; or - the damage is fully restores, repaired or compensated under the *Mine Subsidence Compensation Act 1961.*
Community	• Ensure public safety. • Minimise the adverse socio-economic effects associated with mine closure.

Notes:

- *These rehabilitation objectives apply to all subsidence impacts and environmental consequences caused by mining taking place after the granting of project approval MP 10_0161, and to all development surface infrastructure part of the development, whether constructed prior to or following the date of this consent.*
- *Rehabilitation of subsidence impacts and environmental consequences caused by mining which took place prior to the date of project approval (MP 10_0161) may be subject to the requirements of other approvals (eg under a mining lease or an Subsidence Management Plan approval).*

7.4 Final rehabilitation planning criteria & performance measures

The main planning considerations for rehabilitation prior to mine closure are:

- consideration of the success and practicalities of previously implemented revegetation techniques;
- issues relating to soil contamination and the burial and/or removal from site of the building debris;
- the sealing of any unsealed boreholes and mine shafts in accordance with the guidelines and standards that pertain at the time;
- the rehabilitation of existing and historically used sediment and water control dams in relation to the decanting of existing water, removal of contaminated material, mixing of sediment and non contaminated material, filling and capping of the areas and establishment of a stable surface;
- management of existing weed populations, with particular emphasis on the reduction of Lantana (*Lantana camara*) and Bitou Bush (*Chrysanthemoides monilifera*);
- control of unauthorised access, particularly motor bikes and 4wd vehicles and rubbish dumping;
- mitigation of socio-economic impacts related to mine closure;
- ensuring public safety;
- management of the Colliery site rehabilitation while still facilitating access for bushfire fighting;
- suitable locations for the burial of “clean” material;
- removal of residual coal from stockpiles;
- availability of suitable capping material for disturbed areas such as dams and coal stockpiles;
- availability of seed, and brush material to assist with the revegetation of the Colliery site; and

- reshaping, burial and removal of hardstand area material that includes bitumen, concrete and building rubble.

Table 7.2 below details the specific closure objectives, completion criteria and performance measures to be applied during the mine closure process.

Table 7.2 Rehabilitation Completion Criteria and Performance Measures

Phase	Objective	Completion criteria	Performance measures
Decommissioning.	No risk to public safety - All plant and equipment removed	All mining related plant and equipment removed from site (unless approved to remain, e.g. for heritage purposes)	Visual inspection and photos of site confirm plant and equipment has been removed. Photos included within Closure Report.
	No risk to public safety - All buildings and structures removed	Buildings and structures removed (unless approved to remain).	Visual inspection and photos of site confirm buildings have been removed. Photos included within Closure Report.
	No risk to public safety - All underground infrastructure (protruding above ground surface) removed.	Visible surface components of buried infrastructure removed (unless approved to remain).	Visual inspection and photos of site confirm infrastructure has been removed. Photos included within Closure Report.
	No risk to public safety - Access to former workings prevented	All surface entries to mine are sealed in accordance with MDG 6001 (Guidelines for the Permanent Filling and Capping of Surface Entries to Coal Seams). Note: currently MDG 6001 guidelines suggest that the void from the inbye bulkhead (at a 15 depth of cover to solid rock strata) to the drift entrance of the mine should be completely filled, and a substantial bulkhead seal erected at the portal mouth, such as would not permit retention of habitat for threatened species.	Engineer provides certification that bulkheads were constructed in accordance with the design. Copy of certification to be included within Closure Report As constructed drawings are provided to the Chief Inspector for inclusion with the abandonment file for the mine.
	No risk to public safety - All borehole connectivity to former workings sealed	All boreholes to the mine are sealed in accordance with EDG01 (Borehole Sealing Requirements on Land: Coal Exploration).	Closure report includes evidence that sealing has been completed to EDG01.
	Non-polluting - clean-up of potential/actual contamination.	Hydrocarbons less than assessment criteria. Heavy metals less than assessment criteria. No asbestos remains (unless bonded within buildings approved to remain)	Environmental Site Assessment report completed and identifies any levels of contamination is below acceptable levels. Environmental Site Assessment appended to Closure Report.
Landform establishment	Slopes are stable.	Re-profiled areas are stable with slopes not exceeding 10°.	No evidence of slumping of slopes. Survey pick up of rehabilitated site confirms no slopes exceed 10°. Final landform survey detail

Table 7.2 Rehabilitation Completion Criteria and Performance Measures

Phase	Objective	Completion criteria	Performance measures
			included within Closure Report.
	Growth medium replacement to permit vegetation establishment	Depth - ≥ 0.1 m.	Sampling / testing regime following placement and spreading of material to confirm depths. Revegetation becomes established
	Land use compatible with surrounds	Majority of established rehabilitation species are present in surrounding communities	Visual inspection and photos of rehabilitation confirm species established. Photos included within Closure Report.
Landform establishment (surface water)	Mine water discharges discontinued.	No discharge of underground mine water / water impacted by mining operations	Discharge water flow monitoring and reporting. Pipes that deliver water from underground to surface are disconnected Environment Protection Licence surrendered
	Appropriate management of surface water.	Diversion channels/drains to remain are stable and non-eroding. Remaining dams are stable and non-eroding	Visual inspection and photos of dams/drains to confirm non-eroding. Photos included within Closure Report.
	Non-polluting	Not contributing excess sediment load to downstream watercourses.	Surface water monitoring and reporting for upstream and downstream locations in unnamed creek.
Ecosystem / land use establishment.	Establishment of vegetation communities.	Clear trend of increasing species diversity.	Monitoring and comparison to adjacent control sites. Details of monitoring included within Closure Report.
		Number of weeds species and surface area cover ≤ adjacent control sites.	Monitoring and comparison to adjacent control sites Details of monitoring included within Closure Report.
		Self-propagation in revegetated areas.	Visual inspection and photos of species self-propagation. Photos included within Closure Report.
	Vegetation cover to minimise erosion.	Clear trend of increasing density with no significant erosion.	Monitoring and comparison to adjacent control sites Details of monitoring included within Closure Report.
		Clear trend of increasing foliage cover.	Monitoring and comparison to adjacent control sites Details of monitoring included within Closure Report.
Sustainable ecosystem / land use.	Landform generally blends in with surrounding landscape and is	Absence of gullies >300mm wide or deep and gullies stable.	Monitoring and details of monitoring included within Closure Report.
		Landscape function analysis (or other methodology) shows	Monitoring and details of monitoring included within Closure

Table 7.2 Rehabilitation Completion Criteria and Performance Measures

Phase	Objective	Completion criteria	Performance measures
	stable	continued ecosystem function improvements	Report.
	Weeds invasion adequately controlled by ecosystem	Stable or reducing weed presence (i.e. weed presence not increasing)	Monitoring and comparison to adjacent control sites and/or prior monitoring. Details of monitoring included within Closure Report.

7.5 Interaction with other environmental management plans

As indicated in **Section 1**, this RMP is but one plan in a series of plans that sit under the Colliery's EMS. Like this plan, all of these plans have a three year review period at which time they will be revisited and updated. As the time approaches to prepare the mine closure plan, the latest version of the RMP is expected to inform the mine closure plan. Additionally, some of the other environmental management plans, specifically the Biodiversity Management Plan, Water Management Plan, Benthic Communities Management Plan, Seagrass Management Plan and Heritage Management Plan could be used to inform the RMP. For example the Biodiversity Management Plan might indicate what endemic species may be used in the rehabilitation seed mix / tube stock to meet the needs of surrounding fauna communities and what weeds may be targeted during closure works. The Water Management Plan might give direction on how watering needs for rehabilitation might be met post closure, such as the retention of the potable water supply until vegetation establishment is complete.

7.6 Progressive rehabilitation

Wherever possible LakeCoal would undertake rehabilitation on a progressive basis throughout the life of the mine. Opportunities for progressive rehabilitation are however considered limited due to the surface disturbance being restricted to areas required for operational activities. Notwithstanding, should opportunities arise which allow areas of the site to be rehabilitated, then the rehabilitation activities these would be planned, undertaken and reported in the Annual Review.

Preparation for rehabilitation may also be able to be undertaken once a decision for mine closure has been made, but prior to the completion of the detailed mine closure plan. This preparation would include undertaking longer lead time requirements that will come from the detailed mine closure plan, but are already known, such as native seed collection and propagation of species specifically to be used in the rehabilitation.

Seed would be collected only from native species in the vicinity of the site, in line with the closure objectives. A number of these species are detailed in the Biodiversity Management Plan, however a species list for seed collection is not provided here as it should not be limited to specific dominant species within the surrounding vegetation communities (although these likely form a significant component of the collection). Rather, the collection should be completed by suitably competent personnel experienced in native seed collection for use in rehabilitation, which will then inform the detailed mine closure plan to the extent that the species list can be commensurate with the availability of seed from endemic species in the vicinity of the site.

7.7 Final rehabilitation proposals

The following sub-sections provide a description of the elements of the final rehabilitation, as currently proposed.

7.7.1 Disturbed land

Vegetation communities surrounding areas impacted by mining are discussed in Section 5.3.3. LakeCoal proposes to progressively revegetate all disturbed land not required for future use to a vegetation type consistent or compatible with the surrounding vegetation communities and future land use. As with any revegetation program, the success will rely on the effectiveness of the methods utilised, which are currently expected to include a combination of revegetation methods, such as:

- Growth medium development;
- direct seeding;
- the use of sterile cover crops;
- planting of tube stock; and
- hydro seeding for steeper slopes and batters (if required).

It is noted that due to the age of the mine and the lack of topsoil preservation in times past, there is a limited amount of topsoil stockpiled that will be available for use in the final rehabilitation activities. While this will be a significant consideration for the detailed mine closure plan, there are a substantial number of recycled organics that have been successfully utilised in mine rehabilitation (Kelly, 2006). Recycled organics used successfully in rehabilitation include fly ash, a source of which is available from the Vales Point Power Station, directly adjacent to the Colliery.

A maintenance component to address items such as erosion, weed control and plant mortalities will also be essential for effective rehabilitation.

As the goal for the revegetation program is to return disturbed land to a native plant community aligned to the surrounding bushland the use of introduced and non-endemic species will be avoided in the revegetation program. Focus will be placed on the use of plant material grown from locally sourced species or, if possible, seed collection and propagation from the surrounding vegetation for use in rehabilitation activities. A portion of the pit top area, primarily in the vicinity of the existing sediment dams, has existing high voltage (330kV) transmission lines and an associated easement for the lines. Rehabilitation of the site within the easement boundary is proposed to be a grassland community only, such as to be compatible with the current and future use of these high voltage transmission lines.

Consideration of bushfire risk and potential management measures for the LakeCoal owned houses, should they remain, will also need to be incorporated into the detailed mine closure plan.

7.7.2 Water management

The removal of large areas of sealed surfaces and buildings at mine closure could result in increased sediment load in the runoff during the early stages of the rehabilitation program. Conversely, the removal of the majority of the coal stockpiles and ensuing the removal of historically compacted surfaces will result in increased infiltration rates during the first few months of the rehabilitation program and reduce the amount of runoff reporting to the sediment dams. In addition as mining operations would have ceased, including the pumping of groundwater into the dams, a significant volume of the water managed within these dams would have been removed.

The current water management system and sediment dams will be retained during the rehabilitation program. Once the primary earthworks and initial revegetation are completed, including the removal of the hardstand areas, bitumen, concrete and the bulk of the coal stockpiles then a program of consolidation of the dams will be undertaken.

Where appropriate, the dams will be used as receptacles for excavated or crushed inert material. Once these are filled, the walls and batter will be used to cap the dams. These surfaces will then be stabilised using a cover crop consisting of a mixture of fast growing sterile species and native longer-lived seed.

Water quality will continue to be monitored at the licenced discharge point in accordance with the EPL, however at a point in closure, likely after the groundwater pumping ceases and the majority of water management structures are rehabilitated, the EPL would be surrendered. The timing of the EPL surrender is expected to be driven by the monitoring results showing that no environmental harm is occurring, rather than a specific point in rehabilitation progress. After this point no specific monitoring as required by the EPL would be undertaken, however as noted in Section 8, specific rehabilitation monitoring would be undertaken, which may include some water monitoring.

Consideration will also need to be given in the detailed mine closure plan of the potential retention and/or construction of small dams or ponds which could either continue to provide habitat or allow fauna to relocate to these areas when the main sediment dams are rehabilitated upon closure, currently 3 dams are proposed to remain as part of the final rehabilitation design however this will be given further consideration during development of the detailed mine closure plan.

7.7.3 Rehabilitation trials and research

The proposed final rehabilitation program will be based on extensive experience of rehabilitation in coastal areas undertaken by Councils and mineral sand mining companies and research on mine rehabilitation in the hunter valley. Given this, and the limited amount of area disturbed, major rehabilitation trials or research programs are not expected to be necessary.

7.7.4 Community

The aims of the RMP with respect to communities are public safety and the minimisation of adverse socio-economic effects from mine closure. However, the mine is not expected to be closing for another thirteen years (dependent on a number of factors). The socio-economic environment of the local area, the region and indeed Australia will change in this period. Accordingly, it is not feasible to address socio-economic issues in detail in this RMP. Rather they will addressed in detail closer to the time of mine closure in the mine closure plan. It is expected though that the following principles would be considered.

- The establishment of the Colliery has brought significant infrastructure to the mine site, to the local community and to the broader region. Planning for mine closure could assist in mitigating the consequent reduction in access to useful infrastructure. With advanced and careful planning, it may be possible to develop capacity to maintain certain infrastructure facilities and services for future community or local government ownership or as part of arising business development opportunities.

- Planning for mine closure should be raised with the community as early as possible prior to the planning and design phase of the closure. The planning should consider how to minimise the adverse impacts of mine closure and to optimise the opportunities for community development.

- An early and effective community engagement strategy should be established and the community engaged.

- Planning for mine closure should ensure that the future public health and safety of the community is not compromised; the community's resilience to the adverse impacts of mine closure is strengthened; and the community can maximise opportunities for consequential land use and retain mining infrastructure of value to the community

7.7.5 Remaining features

During mine closure the following actions will be taken with respect to the buildings and structures associated with the mining, preparation and transport of the coal:

- preferentially any plant, structures, buildings or conveyors would be sold and/or relocated for reuse at another mining operation;

- the remaining the coal bins, surface conveyor plant, buildings and build structures will be demolished or removed. All demolition is to occur in accordance with *AS 2601-2001: The Demolition of Structures* (or its latest version);

- concrete pads and footings will either be covered with at least 300mm of growth medium or broken up and disposed of in an appropriate place;

- roadways not required for access to the mine site or other areas for purposes such as bushfire management will be rehabilitated; and

- below-grade structures such as concrete sumps will be filled and covered with growth medium.

These proposals could be subject to change during the mine closure process depending on requests by the landowner for infrastructure to be left in accordance with alternative future land use options.

7.7.6 Other infrastructure and services

The Colliery has numerous services such as electricity, water and communications – both above and underground. All services not required will be disconnected. Above ground infrastructure will be removed while underground structures such as cables and pipes will be terminated at each end and remain buried. All areas where structures are removed will be decommissioned and rehabilitated to ensure public safety at mine closure and relinquishment.

7.8 Conceptual site land works

Figure 7.1 shows the conceptual land works planned for the Colliery at this stage. Generally the western two thirds of the Colliery and the ventilation shaft site will be cleared of all infrastructure items that are not required post mine closure and the land levelled. The eastern one third will be cut and filled generally to the original land levels, as deemed appropriate to match with the surrounding levels, during this process established native trees will be retained wherever possible.

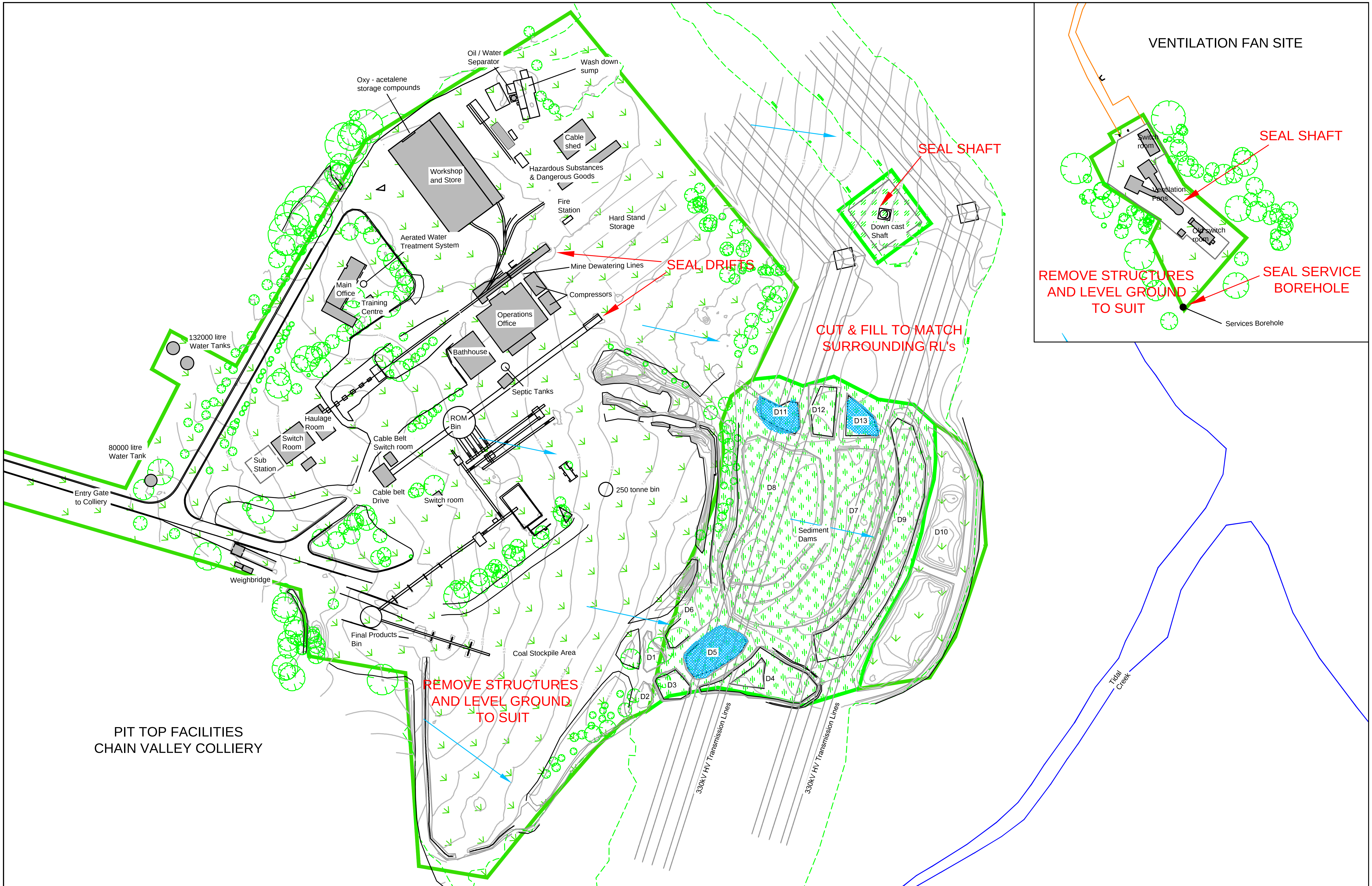
8 Rehabilitation Monitoring

Detailed management and monitoring proposals for the final rehabilitation will be formulated closer to the time that the rehabilitation works will be required, currently estimated to be around 2027 (based on current Development Consent limits). The details will be included in both the MOP in force at the time and the mine closure plan which would be prepared at least one year prior to cessation of mining activities.

Detailed monitoring is likely to include monitoring of the following:

- decommissioning of infrastructure;
- landform;
- excessive erosion or sedimentation from areas with establishing vegetation cover;
- success of initial cover crop or grass cover establishment;
- success of tree and shrub plantings;
- extent of natural regeneration of native species;
- adequacy of drainage controls;
- general stability of rehabilitation areas;
- public safety of all rehabilitated areas; and
- socio-economic effects of closure.

Rehabilitation will be monitored to identify improvements that could be implemented to maximise the level of success for subsequent rehabilitation programs.



Rehabilitation - Bushland

Rehabilitation -Grassland

Rehabilitation - Surface Water Flow

Rehabilitation - Proposed Dams

LAKE COAL PTY LIMITED
CHAIN VALLEY COLLIERY

FIGURE 7.1 CONCEPTUAL FINAL REHABILITATION

SCALE:	1:2000	DATE:	13 Nov 2014
DRAWN:	T Chisholm	DRG NO:	C1S0154_4
CHECKED:	C Ellis	REV NO:	1
REVISION:	1	SIZE:	A3

LakeCoal

9 Financial provisioning

The objective of financial provisioning is to ensure the cost of closure is adequately assessed and budgeted for by LakeCoal so that the community is not left with a liability.

The provision includes costs associated with the removal of infrastructure, sealing of all drifts, mine accesses and boreholes, rehabilitation and management of any contamination (if present) along with ongoing monitoring and statutory reporting obligations. Should any infrastructure be kept for specific purposes post mine closure provisions would be made to ensure these are safe and serviceable for the future owners.

These costs are determined on the basis of current costs and current legal requirements, over the life of the mine the costs will be reviewed and updated as required.

9.1 Planned Mine Closure

Chain Valley Colliery has no planned mine closure date. Current operations are expected to continue under the current development consent (SSD-5465) into the future. Approval for continuation of mining within the Fassifern seam exists until the 31st December 2027.

The main mechanism used to calculate (and recalculate) mine closure costs is DRE's Rehabilitation Cost Calculation Tool (ESB26), available from http://www.resources.nsw.gov.au/environment/pgf.

A rehabilitation cost estimate for the Colliery is required to be submitted by LakeCoal whenever a potential change in rehabilitation liabilities occurs. The rehabilitation cost estimate is used by DRE to assist in determining the amount of the security deposit. During this process DRE will review the calculation, if DRE rejects the calculation it needs to be recompleted until it is accepted. In line with DRE's Rehabilitation Cost Estimate Guidelines (ESG1), security reviews may also be triggered by title renewals, audits, environmental incidents or other changes to rehabilitation liabilities.

At this time of writing a combined security of $5,928,000 is held by DRE in the event of any default by LakeCoal to undertake the rehabilitation obligations within current lease holdings.

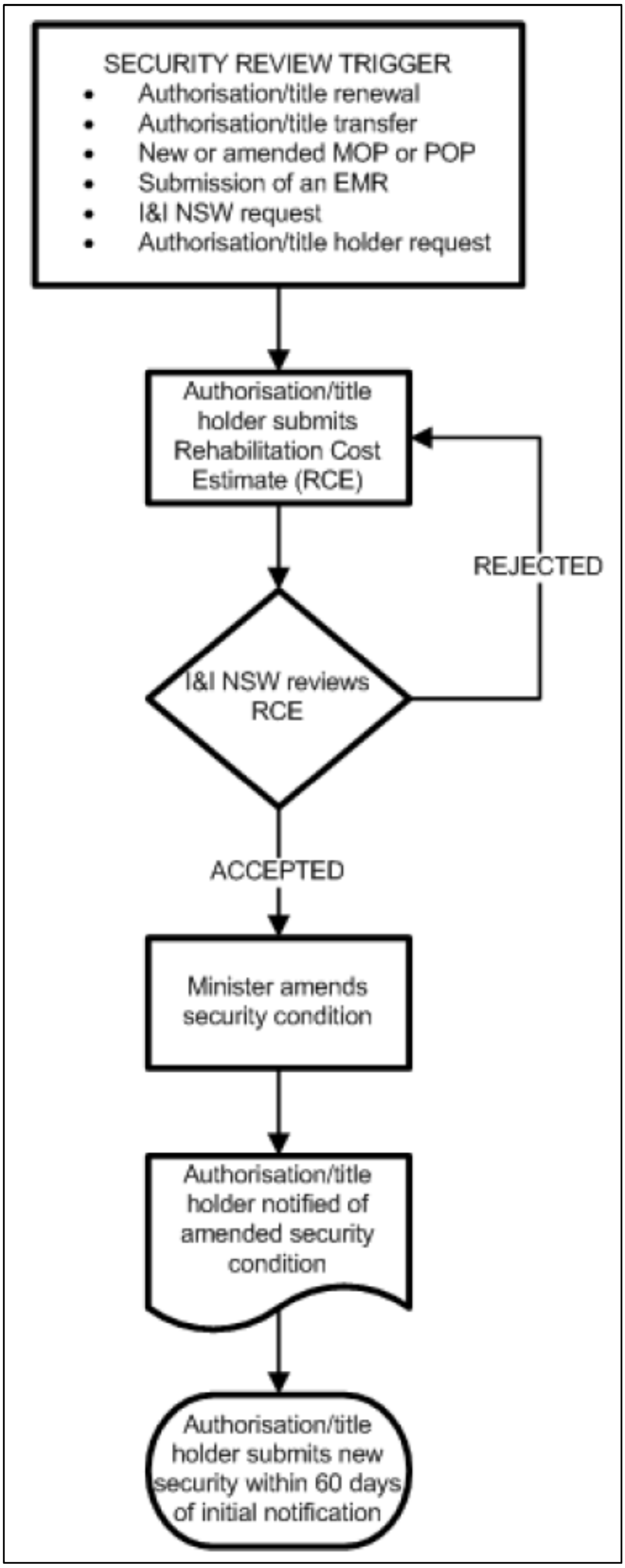
9.2 Unplanned Closure

In the event of unplanned closure and default by LakeCoal to undertake rehabilitation activities on the site a comprehensive process has been put in place by DRE to ensure that liabilities are not passed onto the community. This process is based on DRE Policy EDP11 – Rehabilitation Security Deposits, is underpinned by the *Mining Act (1992)* and ensures that, at all times, throughout the life of the mine a suitable security deposit is held by DRE.

The current security deposit of $5,928,000 is based on relevant DRE publications including the ESG1: Rehabilitation Cost Estimate Guidelines and ESB26: Rehabilitation Cost Calculation Tool and is a single security held for all of LakeCoal's leases, which include;

- Mining Lease Numbers 1051, 1052 and 1308;
- Mining Purposes Lease Numbers 211, 1349, 1389, 1400 and 337; and
- Consolidated Coal Lease Numbers 706 and 707.

In accordance with DRE policy EDP11: Rehabilitation Security Deposits, security deposit must cover the Government's full costs in undertaking rehabilitation in the event of default by the authorisation / title holder. This requirement is intended to minimise potential liabilities to the State in the event that the authorisation/title holder defaults on their rehabilitation obligations. The security review process is shown in **Figure 9.1**.



Source: ESG1: Rehabilitation Cost Estimate Guidelines

Figure 9.1: Security review process

9.3 Temporary Closure (care and maintenance)

The financial provisions for management during temporary closure in the event of the Colliery entering care and maintenance status will be provided by LakeCoal for the duration of the care and maintenance phase.

10 Risk Management

Closure risk management will be undertaken prior to the Colliery being placed on care and maintenance or closing permanently. The purpose of closure risk management is to reduce the likelihood and/or consequence of events related to the closure to levels deemed as low as reasonably practicable by the selected risk assessment team.

The closure risk assessment to be conducted for Chain Valley Colliery may include the following issues depending upon relevance at the time of closure (or temporary closure):

- Rehabilitation provisioning
- Environmental baseline data availability
- Legal obligations
- Stakeholder involvement
- Potential risk legacies
- Surface water and groundwater
- Acid sulfate soils
- Spontaneous combustion
- Rehabilitation management (including bushfire, pests and disease/pathogens)
- Employees and workforce
- Ongoing resource requirements
- Compensation cases
- Closure plan adequacy; and
- DTIRIS - Division of Resources and Energy approval

10.1 Residual Risk Register

A formal risk assessment will be undertaken approximately one year prior to planned mine closure to best determine levels of residual risks posed upon potential end land users and relevant stakeholders. This risk assessment would take into account all relevant issues listed above in Section 10.

11 Incident and Compliance Management

When rehabilitation commences, implementation and success will be reviewed at minimum on an annual basis to confirm compliance with the relevant Development Consent and corrective action implemented where results or trends indicate risk of future non-compliance or environmental risk.

The current MOP identifies and ranks risks for rehabilitation activities, accordingly these risks will be managed during the closure process in accordance with the risk assessment for closure activities to be completed prior to commencement of closure works.

If monitoring reveals that the Colliery rehabilitation actions have resulted in an environmental issue or that there has been non-compliance in relation to rehabilitation, then LakeCoal will conduct an investigation into the cause of the non-compliance.

12 Stakeholder Management and Response

Stakeholder management and response will not be an issue until the final rehabilitation begins, planned to be around 2027 (dependent on the approval of the proposed mining extension). Detailed stakeholder management and response will be planned closer to the mine closure date and will be incorporated in the mine closure plan.

12.1 Mine Closure and Rehabilitation Stakeholders

Relevant stakeholders at the time of preparing this plan are listed below, the below list should be reviewed and if necessary revised closer to mine closure, to ensure all relevant future stakeholders are identified and considered and where necessary consulted as part of the mine closure planning process. Relevant stakeholders include;

- Chain Valley Colliery
  - LakeCoal employees
  - Contractors
  - Suppliers
  - Community consultative committee

- Community
  - Neighbours
  - Local community members
  - Delta Electricity (Vales Point Power Station)
  - Local indigenous groups and land councils
  - Local progress associations and precinct committees

- Local Councils
  - Lake Macquarie City Council
  - Wyong Shire Council

- Regulators
  - Department of Planning and Environment
    - Environment Protection Authority
    - Office of Environment and Heritage
      - Heritage Council of NSW
      - National Parks and Wildlife Service
  - Department of Trade and Investment, Regional Infrastructure and Services
    - Department of Primary Industries
      - Fisheries NSW
      - Office of Water
    - Resources and Energy
    - Mine Subsidence Board
  - Transport for NSW
    - Roads and Maritime Services

12.2 Complaints Handling / Community Hotline

LakeCoal has a 24-hour community hotline (1800 687 557) for members of the public to lodge complaints, concerns, or to raise issues associated with the operation. This service aims to promptly and effectively address community concerns and environmental matters.

The full details of the complaints line are covered in the Environmental Management Strategy (OMP-D-16374), but in summary, all complaints are recorded and responded to, and, if for some reason no action is taken then the reason why is recorded. The information recorded in the complaint register includes;

- date and time the complaint was lodged;
- personal details provided by the complainant;
- nature of the complaint;
- action taken or if no action was taken, the reason why; and
- follow up contact with the complainant.

The same community hotline number also serves as a community information line, whereby members of the public can contact the Colliery to have specific questions answered by a representative of LakeCoal.

12.3 Dispute Resolution

If any disputes are not adequately addressed by the complaints handling process then they will be handled by the Colliery Environment and Community Coordinator. If the response of LakeCoal is not considered to satisfactorily address the concern of the complainant, a meeting will be convened with the General Manager together with the Environment and Community Coordinator.

The complainant will be advised of the outcomes from the meeting and the actions to be implemented as a result.

For mine closure and rehabilitation the requirements will be agreed in the detailed mine closure plan which will require approval from DRE. Disputes on the mine closure activities and site outcomes should be minimised through the consultation process to be undertaken as part of the mine closure plan development.

13 Roles and Responsibilities

Roles and responsibilities specific to completing the requirements of the RMP are identified in **Table 12.1**.

Table 12.1 Roles and responsibilities for rehabilitation management

Role	Responsibilities
General Manager	• Ensure that adequate financial and personnel resources are made available for the implementation of the RMP. Including rehabilitation activities and security deposits.

Role	Responsibilities
Environment and Community Coordinator	• Coordinate socio-economic mitigation measures prior to mine closure in accordance with the MOP. • Compile the Annual Review. • Follow up complaints or disputes. • Complete environmental monitoring data summaries and place on the company's website. • Respond to any potential or actual non-compliances and report these as required to regulatory bodies and other stakeholders. • Undertake reviews of this document as per Section 14. • Undertake or coordinate the required audits of this document, in accordance with Section 14.2 and 14.3. • Complete notification process for any noncompliance or incident. • Coordinate the closure risk assessment process. • Coordinate the development of a detailed mine closure plan. • Consult Delta Electricity (or future owners) of the Vales Point Power Station in relation to preserving or representing the historic linkage between the Colliery and the power station during the development of the mine closure plan. • Ensure acid sulfate soil risks are considered during the mine closure plan development. • Consider Endangered Ecological Communities and habitat they provide to protected fauna during the development of the mine closure plan. • Consideration of bushfire risk in the development of the mine closure plan. • Coordinate stakeholder engagement during the development of the mine closure plan. • Ensure established native trees are retained wherever possible during rehabilitation activities. • Ensure that ongoing rehabilitation in accordance with the MOP is being implemented. • Develop a care and maintenance plan for the Colliery should it be proposed to place the Colliery on care and maintenance.

14 Audit and Review

The RMP will be kept up to date through LakeCoal's standard audit and review process, however it is noted that significant planning for the detailed mine closure plan is not expected until around 2026. Current site audit and review arrangements are set out below.

14.1 Overview

This document will be reviewed, and if necessary revised, within three months of the following;

- The submission of an Annual Review;
- The submission of an incident report;
- The submission of an independent environmental audit; and

- Following any modification to the project approval.

Internal and external audits of this document will be carried out as described below. If possible, internal and external audits will be objective and be conducted by a person or organisation independent of the document being audited.

Audits will be carried out by personnel who have the necessary qualifications and experience to make an objective assessment of the issues. The extent of the audit, although pre-determined, may be extended if a potentially serious deviation from this document is detected.

Any audit non-conformances and/or improvement opportunities will have corrective and preventative actions implemented to avoid recurrence, these actions will be loaded into the Colliery Incident Database to ensure the actions are assigned to the relevant people and completed.

14.2 Internal audits

Internal audits of this document and all other EMS documents will be undertaken every three years. Improvements from the audit will be incorporated in the Colliery Incident Database to ensure the actions are assigned to the relevant people and completed.

14.3 External audits

External audits will be conducted utilising external specialists and will consider the document and related documents. External auditors shall be determined based on skills and experience and upon what is to be accomplished. External audits will be periodically at a frequency determined by the Colliery General Manager, or in response to significant environmental incidents for which a systems failure has been determined as a contributor to the incident.

An Independent Environmental Audit will be undertaken every three years (or as otherwise required by the DP&E) by an audit team whose appointment has been endorsed by the Secretary of DP&E.

Any actions arising from external audits will be loaded into the Colliery Incident Database to ensure the actions are assigned to the relevant people and completed.

15 Records

Generally the Environment and Community Coordinator will maintain all EMS records that are not of a confidential nature. Current record keeping arrangements are set out below.

Records that are maintained include:

- monitoring data and equipment calibration;
- environmental inspections and auditing results;
- environmental incident reports;
- complaint register; and
- licenses and permits.

All records are stored so that they are legible, readily retrievable and protected against damage, deterioration and loss. Records are maintained for a minimum of four years.

16 Document Control

This document and all others associated with the EMS will be maintained in a document control system which is in compliance with AS/NZS 4804; section 4.3.3.4 (Document Control) and in compliance with the Colliery Document Control Standard (STD-0058) which is available to all personnel.

Any proposed change to this document will be via the document control administrator who is the only person able to access the controlled documents. A Document Change / Review Request Form (FRM-0010) in compliance with Change Management Health and Safety Standard (HSSTD-0009) is required to be completed to modify controlled documents.

17 References and Associated Documents

AS/NZS ISO 14001:2004	Environmental management systems – Requirements with guidance for use
SSD-5465	Development Consent SSD-5465 (as modified)
STD-D-11231	Document Control Standard
STD-D-11232	Record Keeping Standard
HSSTD-D-13553	Information and Communication Health and Safety Standard
HSSTD-D-13551	Incident Reporting Health and Safety Standard
OMP-D-16374	Environmental Management Strategy
REG-D-13444	Complaints Register
EMP-D-16368	Water Management Plan
EMP-D-16371	Heritage Management Plan
EMP-D-16372	Biodiversity Management Plan
EMP-D-16674	Seagrass Management Plan
EMP-D-16672	Benthic Communities Management Plan

AECOM (2011). Environmental Assessment Chain Valley Colliery Domains 1 &2 Continuation Project, prepared for LakeCoal.

Cardno Ecology Lab (2011), Mannering Colliery Extension of Mining – Aquatic Ecology Assessment, prepared for Centennial Coal.

Commonwealth Department of Industry, Tourism and Resources Mine Closure and Completion Handbook 2006

Kelly, G.L., (2006) Recycled Organics in Mine Site Rehabilitation - A review of scientific literature, prepared for the Department of Environment and Conservation NSW, available online <http://www.environment.nsw.gov.au/resources/warr/2006184_ORG_MineLitReview.pdf> [accessed 17/1/2013]

LakeCoal (2013) *Mine Operation Plan Chain Valley Colliery 2013 - 2015*

Olsen Consulting Group (2009), Review of Environmental Factors: Dendrobium Portals Sealing, available online <http://www.resources.nsw.gov.au/__data/assets/pdf_file/0004/300676/20090917-ML-1596-REF-Dendrobium-Portals-Sealing-Gujarat-NRE-Minerals.Aug-09-.pdf> [accessed 06/03/2103]

NSW Department of Trade and Investment, *EDG01: Borehole Sealing Requirements on Land*

NSW Department of Trade and Investment, 2013, *ESG3 Mining Operations Plan (MOP) Guidelines, September 2013.*

NSW Department of Trade and Investment, *ESG1: Rehabilitation Cost Estimate Guidelines*

NSW Department of Trade and Investment, *ESB26: Rehabilitation Cost Calculation Tool V1.12*

NSW Department of Trade and Investment, *ESB26A: Schedule of Rehabilitation Costs V1.12*

NSW Department of Trade and Investment, 2012, *EDP11: Rehabilitation security deposit policy* (Version 1.1)

Minerals Council of Australia and Australian and New Zealand Minerals and Energy Council (ANZMEC) (2000) *Strategic Framework for Mine Closure*

Watterson, E.K., Burston, J.M., Stevens, H. and Messiter, D.J., (2011) *The hydraulic and morphological response of a large coastal lake to rising sea levels*. Worley Parsons. pp 1-14.

Scobie Architects (2010) Wyong Shire-wide Heritage Review, prepared for Wyong Shire Council.

18 Definitions

CCC	Community Consultative Committee
DP&E	NSW Department of Planning and Environment
DRE	NSW Department of Trade and Investment, Regional Infrastructure and Services, Division of Resources & Energy
LEP	Local Environmental Plan
LGA	Local Government Area
EMS	Environmental Management System
MOP	Mining Operations Plan
RMP	Rehabilitation Management Plan

Appendix 9 – Plans

SIGNED DATE 16.4.2018

MANAGER OF MINING ENGINEERING

SIGNED DATE 13.04.18

REGISTERED MINE SURVEYOR

MINING HEIGHTS - 1ST WORKINGS 3.20m
2ND WORKINGS 3.30 - 3.50m

TYPICAL ROADWAY WIDTH	5.4m
MINIWALL INSTALLATION ROADWAY	7.9m-10.0m
MINIWALL PRE-DRIVEN TAKEOFF ROADWAY	6.5m

LAKE COAL PTY LTD - CHAIN VALLEY COLLIERY

EXTRACTION PLAN APPLICATION
MINIWALL S1-N1 SECONDARY EXTRACTION
PLAN 1 - EXISTING & PROPOSED WORKINGS

SCALE:	1:4000 @ A0	DATE:	12 April 2018
DRAWN:	T Chisholm	DRG NO:	C4A0069_1
CHECKED:	A Moodie	REV NO:	3
APPROVED:	D McLean	SIZE:	A0

LAKE COAL PTY LTD - CHAIN VALLEY COLLIERY	SCALE:	1:4000 @ A0	DATE:	12 April 2018
EXTRACTION PLAN APPLICATION	DRAWN:	T Chisholm	DRG NO:	C4A0069_2
MINIWALL S1-N1 SECONDARY EXTRACTION	CHECKED:	A Moodie	REV NO:	3
PLAN 2 - SURFACE FEATURES	APPROVED:	D McLean	SIZE:	A0

LakeCoal

LAKE COAL PTY LTD - CHAIN VALLEY COLLIERY	SCALE:	1:4000 @ A0	DATE:	12 April 2018
EXTRACTION PLAN APPLICATION MINIWALL S1-N1 SECONDARY EXTRACTION **PLAN 3 - GEOLOGICAL FEATURES**	DRAWN:	T Chisholm	DRG NO:	C4A0069_3
	CHECKED:	A Moodie	REV NO:	3
	APPROVED	D McLean	SIZE:	A0

SIGNED DATE 16.4.2018

MANAGER OF MINING ENGINEERING

SIGNED DATE 13.04.18

REGISTERED MINE SURVEYOR

LAKE COAL PTY LTD - CHAIN VALLEY COLLIERY	SCALE: 1:4000 @ A0	DATE: 12 April 2018
EXTRACTION PLAN APPLICATION	DRAWN: T Chisholm	DRG NO: C4A0069_4
MINIWALL S1-N1 SECONDARY EXTRACTION	CHECKED: A Moodie	REV NO: 3
PLAN 4 - OVERLYING WORKINGS	APPROVED: D McLean	SIZE: A0

SIGNED DATE 16.4.2018

MANAGER OF MINING ENGINEERING

SIGNED DATE 13.04.18

REGISTERED MINE SURVEYOR

Lease No	Area (total)	Particulars
CCL 721 (Sublease	2405.8ha	Expires 30/06/2022
ML 1051	259ha	Expires 07/07/2022
ML1370 (Sublease)	112.7ha	Expires 30/06/2022
ML1632 (Sublease)	494.9ha	Expires 30/06/2022

LAKE COAL PTY LTD - CHAIN VALLEY COLLIERY

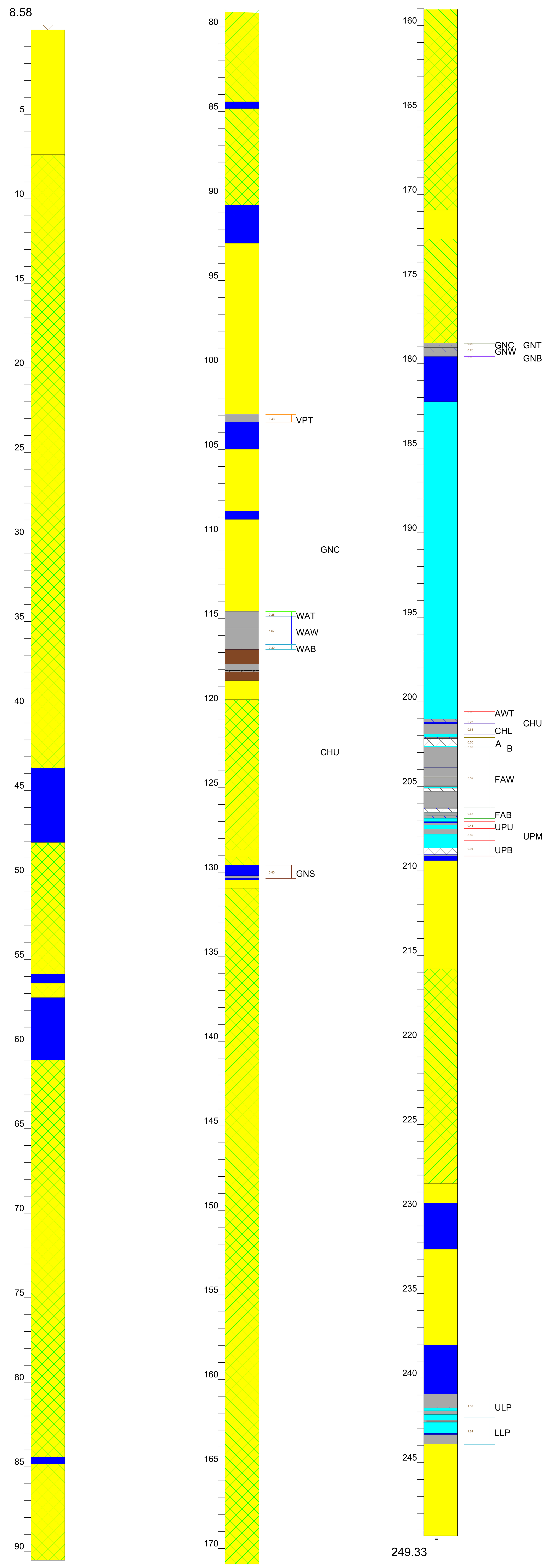
EXTRACTION PLAN APPLICATION
MINIWALL S1-N1 SECONDARY EXTRACTION

PLAN 5 - TITLES

SCALE:	1:4000 @ A0	DATE:	12 April 2018
DRAWN:	T Chisholm	DRG NO:	C4A0069_5
CHECKED:	A Moodie	REV NO:	3
APPROVED:	D McLean	SIZE:	A0

Lake Coal

JCV3



Legend

Lithology Reference

SOIL	GRAVEL
SANDSTONE	Pebble Conglomerate
CLAYSTONE	NO RECOVERY
CONGLOMERATE	SIDERITE
SILTSTONE	AIR
COAL Stony	WATER
COAL	ALLUVIUM
MUDSTONE	SILT
CORE-LOSS / NOT RECOVERED	COAL Heat altered
SHALE	Rock Mass Boundary
COAL Shaly	CLAY
CARB. SHALE	COAL Smutty
CALCITE	NON-CORED
CHERT	COAL Weathered
IGNEOUS	COAL Undifferentiated
COAL Cindered	COAL Shaly
SAND	Siltshale

Seam Legend

Seam Expansion Reference

VPT - Vales Point
WAT - Wallarah - tops
WAW - Wallarah - working secti
WAB - Wallarah - bottoms
LWA - Wallarah Lower / Toukley
TBC - Great Northern - conglom
GNN - Great Northern - non-con
GNS - Great Northern - Split
GNC - Claystone
GNT - Great Northern - Tops
GNW - Great Northern - Working
GNB - Great Northern - Bottoms
AWT - Awaba Tuff
CHU - Chain Valley Upper
CHL - Chain Valley Lower
FAT - Fassifern - Tops
A - Fassifern - A ply
B - Fassifern - B ply Clayst
FAW - Fassifern - Working Sect
FAB - Fassifern - Bottoms
UPU - Upper Pilot Upper
UPM - Upper Pilot Middle
UPB - Upper Pilot Lower
ULP - Lower Pilot Upper
LLP - Lower Pilot Lower

LAKE COAL PTY LTD - CHAIN VALLEY COLLIERY	SCALE:	1:133 @ A1	DATE:	12 April 2018
EXTRACTION PLAN APPLICATION	DRAWN:	T Chisholm	DRG NO:	C4A0069_6
MINIWALL S1-N1 SECONDARY EXTRACTION	CHECKED:	A Moodie	REV NO:	3
PLAN 6 - GEOLOGICAL INFORMATION	APPROVED:	D McLean	SIZE:	A1

LakeCoal

LAKE COAL PTY LTD - CHAIN VALLEY COLLIERY	SCALE:	1:4000 @ A0	DATE:	12 April 2018
EXTRACTION PLAN	DRAWN:	T Chisholm	DRG NO:	C4A0069_7
MINIWALL S1-N1 SECONDARY EXTRACTION	CHECKED:	A Moodie	REV NO:	3
PLAN 7 - SUBSIDENCE MONITORING PLAN	APPROVED	D McLean	SIZE:	A0

SIGNED DATE 16.4.2018

MANAGER OF MINING ENGINEERING

SIGNED DATE 13.04.18

REGISTERED MINE SURVEYOR

MINING HEIGHTS - 1ST WORKINGS 3.20m
2ND WORKINGS 3.30m to 3.50m

TYPICAL ROADWAY WIDTH	5.4m
MINIWALL INSTALLATION ROADWAY	7.9m-10.0m
MINIWALL PRE-DRIVEN TAKEOFF ROADWAY	6.5m

LAKE COAL PTY LTD - CHAIN VALLEY COLLIERY

EXTRACTION PLAN APPLICATION
MINIWALL S1-N1 SECONDARY EXTRACTION
PLAN 8 - EXISTING & PROPOSED WORKINGS WITH AERIAL OVERLAY

SCALE:	1:4000 @ A0	DATE:	12 April 2018
DRAWN:	T Chisholm	DRG NO:	C4A0069_8
CHECKED:	A Moodie	REV NO:	3
APPROVED:	D McLean	SIZE:	A0

LakeCoal

Appendix 10

DGS N1/S1 Subsidence Assessment Report

Ditton Geotechnical Services Pty Ltd
82 Roslyn Avenue Charlestown NSW 2290
PO Box 5100 Kahibah NSW 2290

LakeCoal Pty Ltd

Subsidence Impact Assessment of the Proposed Northern Area Miniwalls (N1 and S1) at Chain Valley Colliery

DGS Report No. CHV-002/11

Date: 12 April 2018

12 April 2018

Mr Wade Covey
Environmental & Community Coordinator
Chain Valley Colliery
Off Construction Rd
Off Ruttleys Rd
Mannering Park
NSW 2259

Report No. CHV-002/11a

Dear Wade,

Subject: Subsidence Impact Assessment of the Proposed Northern Area Miniwalls (N1 and S1) at Chain Valley Colliery

This report has been prepared in accordance with the brief provided on the above project.

Please contact the undersigned if you have any questions regarding this matter.

For and on behalf of
<u>Ditton Geotechnical Services Pty Ltd</u>

Steven Ditton
Principal Engineer

Executive Summary

This report provides an assessment of the predicted maximum subsidence and zones of sub-surface fracturing in the northern area of the mining lease above the proposed miniwalls (MW) N1 and S1 in the Fassifern Seam at Chain Valley Colliery, Vales Point.

The mine was granted approval in the 2015 Modified Project Approval Conditions for a maximum subsidence of 780 mm over the proposed miniwall layout in a single seam environment. The predictions were derived for multiple adjacent panels with a void width of 97 m, mining height of 3.5 m and solid chain pillar widths of 32.6 m.

The miniwall panels for this study include one northern panel (N1) and one southern panel (S1) relative to the mains. The panels will be located within a 13 m down-thrown section of the seam between several north-west striking fault lines with opposing hades of 50° to 75° towards the NE and SW. Subsidence effect predictions have been made for a single panel with a void width of 97 m and a mining height of 3.5 m. There will be chain pillars on the main gate side only with a solid width of 24.6 m. The depth of cover to N1 and S1 ranges from 170 m to 200 m, giving sub-critical panel geometries with W/H ratio ranges from 0.49 to 0.57.

Surface features within the zone of influence of the proposed miniwalls include Lake Macquarie, sea grass beds and foreshore plus one fixed navigational marker in Sugar Bay.

It was assessed in the Modified EA 2015 report that for 97 m (void) width panels with rock cover depths < 150 m, it would be necessary to reduce the mining height to between 3.0 m and 3.5 m in order to control connective crack development above the panels and maintain the minimum Constrained Zone thickness of 12T (+ 10 m) beneath tidal waters (refer **Li *et al* 2006**)[1]. The rock cover over the first two panels will range between 150 m to 170 m and will therefore not require mining height reduction.

This report refers to the findings of the subsidence exceedance review presented in **DgS, 2017** for MW1-12. As the likely mechanisms that lead to the subsidence exceedance were found to be due to undersized chain pillars after multiple adjacent panels were mined, it will not be necessary to apply the findings of the review report to the proposed isolated panels in this study.

The following key outcomes from this assessment are provided for the proposed northern area miniwalls N1 and S1:

- The two panels may be extracted from the 13 m down-thrown area provided the miniwalls do not directly undermine the opposing hade fault planes. It is noted that the miniwalls will not encroach within 30 m of the faults.

- The predicted height of continuous fracturing above the proposed miniwalls ranges between 81 m to 103 m (23T to 29T) based on *sub-critical* panel geometries, providing a

[1] **Li et al, 2006** discusses the use of 12T for a minimum Constrained Zone thickness over the Wyee longwalls. The plus 10m was suggested in **Foster, 1995** to allow for rock cover variation uncertainty.

constrained zone thickness ranging from 57 m to 81 m. The minimum required constrained zone between the lake and continuous fracture zone is defined in **Li et al, 2006** as 12T (+10m) below the rock head or 52 m for a mining height of 3.5 m.

- The maximum long-term subsidence above the panels is likely to be less than 0.38 m and 0.44 m for MW N1 and S1 respectively.

- Maximum tilt is expected to be < 5 mm/m with tensile strains < 1.5 mm/m and compressive strains < 2.5 mm/m.

- Stability analysis of the claystone beds beneath the 24.6 m wide chain pillars indicates side abutment loading may cause local yielding of the floor and pillars at some point after mining, and possibly when first flooding occurs. The overburden strata however, is likely to behave like a 'stiff' loading system and transfer pillar stress away from the yielding pillar edges to adjacent solid coal (or goaf).

- The maximum subsidence is therefore unlikely to exceed the allowable limit of subsidence to within 780 mm.

- The angle of draw to the 20 mm subsidence contour for the two panels is estimated to range between 22^{o} and 26.5^{o}.

- The navigational marker and rock outcrop located 41 m inbye from the starting position of miniwall N1 is expected to be subsided by < 100 mm, with tilt < 2 mm/m and tensile strain < 0.8 mm/m.

- The potential for the proposed mining layout to cause significant water inflows due to dilation and shear along the faults to the north and south of the panels is assessed to be 'low' as the miniwalls will be set back a minimum distance of 30 m to the faults. The relatively high horizontal stress and opposing hade of the fault planes will also limit shear displacements.

The following recommendations are provided based on the outcomes of this assessment:

- Continued bathymetric surveys of the MW1-12 area are recommended to improve the post-mining residual subsidence and/or creep estimate range of 150 mm to 250 mm.

- Undertake consultation with the Roads and Maritime service regarding the preferred management measures required for the potential subsidence impacts associated with the Sugar Bay navigational marker.

- The measurement of sediment thickness variation across the northern area using surface radar imaging is likely to improve the site's ability to model these parameters accurately and potentially allow the minimum required constrained zone of 12T to be applied instead of 12T +10 m.

- A minimum buffer distance of 72.5 m from the 1st row of WAL seam pillars adjacent to the starting end of MW S1 is recommended to minimise the potential stress interaction impact for a maximum applied stress of < 0.3 MPa.

- It is assessed that the potential for significant additional subsidence due to abutment stress interaction with the WAL Seam mine workings above the starting end of MW S1 is 'negligible' with the above controls in place.

Contents

Attachments:

Figures 1 - 13

1.0 Introduction

This report provides an assessment of the predicted maximum subsidence and zones of sub-surface fracturing in the northern area of the mining lease above the proposed miniwalls (MW) N1 and S1 in the Fassifern Seam at Chain Valley Colliery, Vales Point.

The mine was granted approval in the 2015 Modified Project Approval Conditions for a maximum subsidence of 780 mm over the proposed miniwall layout in a single seam environment. The predictions were derived for multiple adjacent panels with a void width of 97 m, mining height of 3.5 m and solid chain pillar widths of 32.6 m.

Due to the presence of the significant fault zone encountered in the northern area during the initial first workings in mid-2016, the panels will now be developed and extracted in two groups relative to the access mains; see **Figure 1a**. The proposed miniwalls that are to the northeast of S1 and N1 are indicative only at this stage and not included in this study.

The two miniwall panels will be located within a 13 m down-thrown section of the seam between several north-west striking fault lines with opposing hades of 50^{o} to 75^{o}. Subsidence effect predictions have been made for a single panel with a void width of 97 m and a mining height of 3.5 m. There will be chain pillars on the main gate side only with a solid width of 24.6 m. The depth of cover to N1 and S1 ranges from 170 m to 200 m, giving sub-critical panel geometries with W/H ratio ranges from 0.49 to 0.57; see **Figures 1a** and **1b**.

It was assessed in the Modified EA 2015 report that for 97 m (void) width panels with rock cover depths < 150 m, it would be necessary to reduce the mining height to between 3.0 m and 3.5 m in order to control connective crack development above the panels and maintain the minimum Constrained Zone thickness of 12T (+ 10 m) beneath tidal waters (refer **Li *et al* 2006**)[2]. The rock cover over the first two panels will range between 150 m to 170 m and will therefore not require mining height reduction.

This report refers to the findings of the subsidence exceedance review presented in **DgS, 2018** for MW1-12. As the likely mechanisms that lead to the subsidence exceedance were found to be due to undersized chain pillars after multiple adjacent panels were mined, it will not be necessary to apply the findings of the review report to the proposed isolated panels in this study.

[2] **Li et al, 2006** discusses the use of 12T for a minimum Constrained Zone thickness over the Wyee longwalls. The plus 10m was suggested in **Foster, 1995** to allow for rock cover variation uncertainty.

2.0 Background to Current Study

The development of the mine plan in the northern area has required several adjustments due to the following circumstances that have arisen since the 2015 Approval was granted by the Department of Planning & Environment (DPE):

- A significant normal fault system (horst and graben structures) with 13 m to 2 m vertically displaced seam sections was encountered during development of the gate roads for the first approved miniwall panel (previously numbered MW13); **Figure 1b**.

- The annual bathometric survey data for 2017 after the completion of MW1-12 (extracted between 2012 and 2016) shows that maximum subsidence of 1.15 m has developed above the MW 9 goaf and tailgate chain pillar; **Figure 2a**.

- The measured subsidence above MW7 to 10 therefore represented an exceedance of 0.37 m of the maximum approved subsidence of 0.78 m.

- Subsequent analysis of the exceedance mechanisms indicates that increased pillar widths will be required for multi-panel layouts.

- The layout for Panels N2-N4 and S2-S8 is therefore still under review and will be subject to a separate extraction plan.

- As an interim measure, this study has focussed on Panels S1 and N1 only.

- The two panels (N1 & S1) will be located in the faulted zone and will be isolated from the subsequent panels, which will be mined in an up-thrown section of the seam approximately 95 m to the north east.

- The proposed starting end of MW S1 is planned to be located just outside the limits of a second workings goaf in the WAL Seam (circa 1990s), which is 80 m to 85 m above the FAS at this point; see **Figure 2b**.

- The overburden stratigraphy includes 10 m ~ 20 m of the lake bed sediments and 2 m to 5 m of residual soil and weathered rock; see **Figure 2c**. Estimated competent rock cover over the northern area ranges between 184 m and 150 m; see **Figure 2d**. The rock cover is approximately 20 m thinner than previous mining areas to the south east.

- The cumulative thickness of the claystone beds below the FAS seam MW N1 and S1 ranges from 1.1 m to 1.2 m; see **Figure 2e**;

3.0 Scope of Work

The scope of work for this study includes assessment of the following:

- Subsidence effects and impacts due to the extraction of Panels S1 and N1.
- Required mining heights to meet the minimum Constrained Zone thickness of 12T (+ 10m) below rock head (refer **Li *et al*, 2006**);
- The potential impacts of the fault zone on subsidence above the first two panels (N1 & S1), using evidence from Wyee longwalls (**Li et al 2006**), a numerical model of the faults, and previous CVC experience.
- The potential multi-seam impacts to the WAL seam pillar extraction panels adjacent to the mining limits of MW S1, based on empirical abutment load estimation models for single seams, a numerical model of stress interaction (Lamodel) and the Stability Index model (**Mills and Edwards, 1997**) for pillar extraction panels with a strong conglomerate roof and weak claystone floor.

The geological model for the northern mining area has also been reviewed from earlier assessments, with reference to exploration boreholes and recent underground core drilling and sampling data from the Fassifern (FAS) Seam floor near the northern faulted area (MG13), Chain Valley Bay and the access headings to the Mannering Mine, refer to **DgS, 2017** and **Zhang & Canbulat, 2017**.

The numerical model RS^2 (a 2-D Finite Element Model by Rocscience) has been used to estimate the effects of the faults and bedding partings on subsidence development. A strain-hardening model of goaf, with consideration of analytical and laboratory derived stress v. strain curves for shale has also been applied.

4.0 Surface Conditions

Natural features within the northern mining area include:

- Lake Macquarie, foreshore, rock outcrops and seagrass beds
- Approximately 500 m of steep slopes and minor cliffs (< 10 m high) along the northern foreshore of Sugar Bay.

The proposed miniwalls are located outside the foreshore highwater mark and seagrass buffer zones of 35^{o} and 26.5^{o} respectively. The steep slopes and cliffs are > 750 m to the north east or > 4.4 times the cover depth from the proposed miniwall N1.

Built features that exist along the northern and southern foreshores include:

- several timber jetties that extend 20 m to 30 m out from foreshore,
- blockwork retaining walls and reinforced concrete boat ramps.

- Two fixed navigational markers exist on low level rock outcrops in Sugar Bay and Frying Pan Bay. The markers are 41 m and 300 m from MW N1 and S1 respectively.

Only the Sugar Bay Fixed Navigation Marker is located close enough to MW N1 (within the angle of draw of 26.5°) for it to be affected by mine subsidence of more than 20 mm.

The locations of the above features are shown in **Figure 1a**.

5.0 Sub-Surface Conditions

5.1 Mining Geometry & Geology

The proposed northern miniwalls will have void widths of 97 m and solid chain pillar widths of 24.6 m on the maingate side only. The tailgate and a proportion of the maingate will have single entries and no chain pillars. The gate roads will have nominal widths of 5.4 m and heights of 3.2 m.

The mine workings will be located in the Fassifern Seam at cover depths below the lake bed ranging between 200 m and 170 m; see **Figure 1a**. The rock cover decreases towards the north-east and ranges between 185 m to 150 m above the panels; see **Figure 2d**, which has been derived from the measured sediment + soil thickness contours (below the lake bed) presented in **Figure 2c**.

The section through the proposed mining area (**Figure 1b**) shows the positioning of the miniwalls in relation to the faults. The faulted zone consists of a series of north west striking normal faults (Tertiary-aged) with down-throws of 13 m to 2 m and up throws of 11 m to 1 m (horst-and graben structure).

The seam dips towards the south west and generally decreases from 3.5^{o} to 1^{o} with distance away from the faulted area. It is noted in **Li et al, 2006** that faults have the potential to affect the full thickness of the overburden, which was deposited during the Permian and Triassic Ages.

The first two panels (N1 and S1) will be offset from the fault planes by 30 m to 50 m and will not undermine the faults. The faults are sub-vertical to mid-angled (i.e. dips of 50^{o} to 75^{o}) or hade underneath N1 and S1.

Underground inspection of the faults indicates they are typically planar with minimal gouge or fragmented strata adjacent to them. There have been some minor increases in seepage flows from the faults when exposed in both the WAL and FAS mine workings, but no evidence of hydraulic connectivity to the lake has been detected to-date.

A small area of WAL Seam mine workings exists 80 m to 85 m above the proposed starting position of MW S1; see **Figure 1a**.

The geological conditions for the remaining panels to the north east of the faulted zone are expected to be similar to the previous mining areas at Chain Valley.

5.2 Geomechanical Properties of Strata

The geomechanical properties (strength, stiffness, and moisture sensitivity) affect the stability of the system. The properties have been derived from available borehole testing data for the mine, reference to previous reports and subsidence measurements for the Chain Valley Bay and MW1-12 areas.

A summary of the lithology in the northern mining area is presented in **Table 1**.

Table 1 - Summary of Overburden Lithology & Geomechanical Properties

Unit	Depth (m)	Thickness (m)	Density (t/m3)	UCS (MPa)	Young's Modulus (GPa)	Poissons Ratio
Sediment/Soil Cover	6 - 9*	15 - 18	2.2	0.1	0.02	0.35
Munmorah Conglomerate (Upper)	21 - 27	25 - 30	2.5	60	12 - 15	0.25
Sandstone/Siltstone	46 - 51	15 - 20	2.5	20 - 30	3 - 4.5	0.25
Munmorah Conglomerate (Lower)	64 - 66	15 - 20	2.5	60	12 - 15	0.25
Dooralong Shale	81 - 89	12 - 22	2.5	12 - 15	1.8 - 2.25	0.25
Karignan Conglomerate	95 - 105	5 - 6	2.5	40	12 - 15	0.25
Wallarah Seam	100 - 110	2.5 - 3.5	1.4	15 - 20	1.5 - 2.0	0.25
Mannering Park Tuff	103 - 104	1.0 - 1.3	2.2	1.65 - 2.15	0.05 - 0.15	0.35
Coaly Shale/Shaley Coal	104 - 105	8 - 40	2.5	12 - 15	1.8 - 2.25	0.25
Teralba Conglomerate	112 - 145	10 - 12	2.5	60	12 - 15	0.25
Booragul Tuff	122 - 155	1.0 - 1.1	2.2	1.65 - 2.15	0.05 - 0.15	0.35
Great Northern Seam	123 - 156	2.0 - 3.0	1.4	15 - 20	1.5 - 2.0	0.25
Awaba Tuff	125 - 159	10 - 12	2.5	1.65 - 2.15	2.25 - 3.0	0.25
Karingal Conglomerate	137 - 169	10 - 15	2.5	40	12 - 15	0.25
Shale/Shaley Coal	157 - 179	8 - 21	2.5	12 - 15	1.8 - 2.25	0.25
Fassifern Seam	165 - 200	5.0 - 6.2	1.4	15 - 20	1.5 - 2.0	0.25
Claystone (tuff)	170 - 206	1.1 - 1.2	2.2	1.0 - 1.65	0.05 - 0.2	0.35
Shaley Coal/Coaly Shale	171 - 208	1 - 2	2.5	12 - 15	1.80 - 2.25	0.25
Sandstone/Siltstone	172 - 210	10 - 20	2.5	30 - 40	4.5 - 6.0	0.25

* - water depth in lake.

5.3 Regional Stress Field

The regional horizontal stress field assumed in this study has been based on measured borehole stress measurements in conglomerate and sandstone beds presented in **Coffey, 2015** and **Lohe and Dean-Jones, 1995**.

The major principal stress is orientated approximately NNE to NE (Bearing 012^o to 31^o) with minor principal stress orientated W to WNW (Bearing of 282^o to 300^o) . The miniwall panels that have been extracted to-date have been orientated sub-parallel to the NW orientated geological structures. The major horizontal stress will therefore largely be orientated across the miniwalls.

By combining the data from the above references, the principal stress field magnitudes were derived from the following depth-dependent relationships for the conglomerate units:

$\sigma_1 = 6.46 + 3.93\sigma_v$ (major principal horizontal stress)

$\sigma_2 = 2.54\sigma_v$ (minor principal horizontal stress)

$\sigma_v = 0.025H$ (vertical stress)

The above relationships are presented in **Figure 2f**.

The numerical model developed for the miniwall panels assumed the pre-mining major principal horizontal stress was acting across the panels and the minor principal horizontal stress was acting along the panels (or out of plane to the model).

The above stress magnitudes were only adopted in the conglomerate and sandstone units, which are stiffer and stronger than the finer grained beds (coal, carbonaceous shale and claystone). A hydraulic stress condition was adopted for the fine-grained strata beds (i.e. horizontal stress = vertical stress) prior to mining effects.

6.0 Sub-Surface Fracture Height Predictions

6.1 Review of MW 1-12 Performance

A review of the performance of the overburden in regard to likely heights of connective cracking above MW1-12 and Wyee longwalls 17 to 23 has been completed using the **Ditton & Merrick, 2014** Geology Model and the **Forster**, **1995** model. Details of the models were presented in the 2015 Mod Report (refer **DgS 2015**).

As discussed earlier, the yielding of the chain pillar roof & floor system (primarily the very low strength claystone floor) for MW1-12 has resulted in maximum subsidence of 1.15 m to-date. This has also allowed 'pseudo' super-critical subsidence profiles to develop over the mining area, with super-panel width to cover depth (W'/H) ratios ranging between 3.5 and 4; see **Figures 3a & 3b**.

Average pillar stresses between the central panels ranged between 15 MPa and 20 MPa, which were likely to be greater or equal to the estimated bearing capacity of the FAS floor claystone units (see **DgS, 2018**).

The cover depth over MW1-12 ranged from 170 m to 205 m (**Figure 4a**) and the rock cover ranged from 154 m to 185 m (**Figure 4b**). The depth to bed rock or sediment thickness contours across the area are shown in **Figure 4c**.

The predicted "A-Zone" horizon of 33T (T= mining height) from **Forster, 1995** is considered to be the worst case for 'supercritical' panel or mining width geometries that are overlain by massive Munmorah Conglomerate units in the Lake Macquarie Coalfield[3].

The **Ditton & Merrick, 2014** model may be used to assess sub-critical panel geometries where it can be demonstrated that chain pillars of adequate width will limit 'super-panel' geometries to individual panel widths.

The predicted values for continuous (A-Zone) and Constrained Zone thickness (rock cover less A-Zone height) above the Wyee LW1 and 17 to 23 and MW1-12 are summarised in **Tables 2A/B** and **3A/B** respectively, for sub-critical and super-critical panel behaviour.

The mean 'geology' model values, infer an effective strata unit thickness of t' = 19 m for the Wyee longwalls and known massive strata units present in the overburden. Reference to the borehole data indicates that two Munmorah Conglomerate Units are located between 115 m and 125 m above the seam, as shown in **Figures 4d-e** (lower unit) and **Figures 4f-g** (upper unit).

The maximum height of the A-Zone was checked against the minimum constrained zone thickness of 12T+10m at both Wyee and Chain Valley. It is noted in **Forster, 1995** that the above equation includes the surface cracking zone (the "D-Zone"), which is likely to be less than 15 m below rock-head in relatively flat terrain (< 5^o gradients).

[3] The Lake Macquarie Coalfield is considered different to the Newcastle Coalfield, in that the former has Triassic Munmorah Conglomerate strata units, whereas the Newcastle Coalfield does not. Both coalfields include conglomerate units of Permian Age (Karignan, Teralba and Karingal Conglomerate Members).

The *continuous* sub-surface fracture heights (A-Horizon) have been plotted against depth of rock cover for Wyee LW17-23 (**Figure 5a**) and MW1-12 (**Figure 5b**). Minimum Constrained Zone (12T+10m) thicknesses are also indicated on the above figures.

Table 2A - Predicted A-Zone Fracture Heights & Constrained Zone Thicknesses for Wyee LW1, 17 - 23, based on *Sub-critical* Panel Behaviour (after Ditton & Merrick, 2018)

Panel No	Panel Width W (m)	Cover Depth Below Surface or the Lake Bed H (m)	Mining Width W' (m)	W'/H	T (m)	Rock Cover Depth H_r (m)	Height of Connective Fracturing [a.] (mean-U95%CL) (m)	Constrained Zone Thickness below Rock Head, C_z (m)		Height of Mun. Cong. Units Above FAS (m)
								Predicted Minimum Thickness (m)	Minimum Required (12T+10) (m)	
1	216	212	216	1.02	3.44	202	*126* - 151	51	51	75 & 155
17	130	174	130	0.75	3.2	160	89 - 108	52	48	75 - 80 & 145 - 155
18	130	172	304.8	1.78	3.2	160	89 - 108	52	48	
19	130	170	479.6	2.82	3.2	156	88 - 107	49	48	
20	140	180	140	0.78	3.2	163	94 - 113	50	48	75 & 145
21	140	175	140	0.80	3.2	161	92 - 112	49	48	75 - 85 & 145 - 155
22	150	185	150	0.81	3.2	170	98 - 118	52	48	80 - 90 & 154 - 168
23	150	195	345	1.78	3.2	179	101 - 122	57	48	

Italics = Measured A-Zone height (published value); **Bold** - Predicted Constrained Zone Thickness below rock head < minimum required for lakes (i.e. 12T+10);
a. - effective strata thickness in Geology Model, t' = 19 m, required for mean predictions to match the measured value at Wyee LW1.

Table 2B - Predicted A-Zone Fracture Heights & Constrained Zones for Wyee LW1, 17 - 23, based on *Super-critical* Panel Behaviour (Forster, 1995)

Panel No	Panel Width W (m)	Cover Depth Below Surface or the Lake Bed H (m)	Mining Width W' (m)	W'/H	T (m)	Rock Cover Depth H_r (m)	Height of Connective Fracturing (21T -33T) (m)	Constrained Zone Thickness below Rock Head, C_z (m)		Height of Mun. Cong. Units Above FAS (m)
								Predicted Minimum Thickness (m)	Minimum Required for 12T+10 (m)	
1	216	212	216	1.02	3.44	202	72 - 114	88	51	75 & 155
17	130	174	130	0.75	3.2	160	67 - 106	54	48	75 - 80 & 145 - 155
18	130	172	304.8	1.78	3.2	160	67 - 106	54	48	
19	130	170	479.6	2.82	3.2	156	67 - 106	50	48	
20	140	180	140	0.78	3.2	163	67 - 106	57	48	75 & 145
21	140	175	140	0.80	3.2	161	67 - 106	55	48	75 - 85 & 145 - 155
22	150	185	150	0.81	3.2	170	67 - 106	64	48	80 - 90 & 154 - 168
23	150	195	345	1.78	3.2	179	67 - 106	73	48	

Italics = Measured A-Zone height (published value); **Bold** - Predicted Constrained Zone Thickness below rock head < minimum required for protecting lakes (i.e. 12T+10).

Table 3A - Predicted A-Zone Fracture Heights and Constrained Zone Thickness for Chain Valley MW 1 - 12, based on *Sub-Critical* Panel Behaviour (after Ditton & Merrick, 2014)

Panel No	Panel Width W (m)	Cover Depth Below Surface or the Lake Bed H (m)	Mining Width W' (m)	W'/H	T (m)	Rock Cover Depth H_r (m)	Height of Connective Fracturing [a.] (mean-U95%CL) (m)	Constrained Zone Thickness below Rock Head, C_z (m)		Height of Munmorah Conglomerate Units Above FAS (m)
								Predicted Minimum Thickness	Minimum Required for 12T+10	
1	72	200	72	0.36	3.4	182	76 - 87	95	51	100 - 120 &150 -160
2	72	200	174.8	0.87	3.4	183	76 - 87	96	51	
3	97	200	302.4	1.51	3.4	183	76 - 87	96	51	
6	97	198	432	2.18	3.4	182	85 - 100	82	51	
7	97	195	561.6	2.88	3.4	178	85 - 99	79	51	
8	97	193	691.2	3.58	3.5	173	85 - 100	73	52	
9	97	191	820.8	4.30	3.5	171	85 - 99	72	52	
4	97	196	97	0.49	3.4	179	85 - 99	80	51	80 - 90 & 150 - 160
5	97	200	234	1.17	3.4	183	86 - 100	83	51	
5a	97	200	350	1.75	3.4	183	86 - 100	83	51	
7	97	190	97	0.51	3.5	170	85 - 99	71	52	100 - 120 &150 -160
8	97	188	226.6	1.21	3.5	168	84 - 99	69	52	
9	97	185	356.2	1.93	3.5	165	83 - 98	67	52	
10	97	183	485.8	2.65	3.5	163	83 - 98	65	52	
11	97	178	615.4	3.46	3.5	159	82 - 96	63	52	
12	97	173	745	4.31	3.5	155	81 - 95	60	52	

Bold - Predicted Constrained Zone Thickness below rock head < minimum required for protecting lakes (i.e. 12T+10); a. Effective Strata Thickness in Geology Model, t' = 19 m required for mean predictions to match the measured value at Wyee LW1.

Table 3B - Predicted A-Zone Fracture Heights and Constrained Zone Thickness for Chain Valley MW 1 - 12, based on *Super-Critical* Panel Behaviour (Forster, 1995)

Panel No	Panel Width W (m)	Cover Depth Below Surface or the Lake Bed H (m)	Mining Width W' (m)	W'/H	T (m)	Rock Cover Depth H_r (m)	Height of Connective Fracturing Super-critical Panel (21T -33T) (m)	Constrained Zone Thickness below Rock Head, C_z (m)		Height of Munmorah Conglomerate Units Above FAS (m)
								Predicted Minimum Thickness	Minimum Required (12T+10)	
1	72	200	72	0.36	3.4	182	71 - 112	70	51	100 - 120 &150 -160
2	72	200	174.8	0.87	3.4	183	71 - 112	71	51	
3	97	200	302.4	1.51	3.4	183	71 - 112	71	51	
6	97	198	432	2.18	3.4	182	71 - 112	70	51	
7	97	195	561.6	2.88	3.4	178	71 - 112	66	51	
8	97	193	691.2	3.58	3.5	173	74 - 116	58	52	
9	97	191	820.8	4.30	3.5	171	74 - 116	56	52	
4	97	196	97	0.49	3.4	179	71 - 112	67	51	80 - 90 & 150 - 160
5	97	200	234	1.17	3.4	183	71 - 112	71	51	
5a	97	200	350	1.75	3.4	183	71 - 112	71	51	
7	97	190	97	0.51	3.5	170	74 - 116	55	52	100 - 120 &150 -160
8	97	188	226.6	1.21	3.5	168	74 - 116	53	52	
9	97	185	356.2	1.93	3.5	165	74 - 116	**50**	52	
10	97	183	485.8	2.65	3.5	163	74 - 116	**48**	52	
11	97	178	615.4	3.46	3.5	159	74 - 116	**44**	52	
12	97	173	745	4.31	3.5	155	74 - 116	**40**	52	

Bold - Predicted Constrained Zone Thickness below rock head < minimum required for protecting lakes (i.e. 12T+10).

It is apparent from **Table 3B** that the last four miniwalls (MW9-12) could have the A-Zone extending to between 40 m and 50 m below rock-head, based on super-critical panel geometry models and reference to **Forster, 1995**. This indicates that the minimum for the Constrained Zone is possibly 2 m to 12 m thinner than the recommended 52 m.

It is also possible that fracturing of the overburden has been controlled to some degree by the chain pillars, despite the yielding of the system after MW10-12 were extracted, such that the Constrained Zone is probably between the sub-critical and super-critical model estimates.

Another possibility that has not been directly considered, is that the HoF could be closer to 21T than 33T, as discussed in **Forster, 1995**.

It is also noted that underground mine-water make sampling has not detected any abnormal water-make or water quality the FAS miniwall mining to date. The measurement of sediment thickness variation across the northern area using surface radar imaging may also allow the minimum required Constrained Zone of 12T to be applied.

6.2 Miniwall Mining Heights in the Northern Area

The maximum mining heights required to meet the minimum Constrained Zone thickness of 12T + 10 m or 12T (depending on measured lake bed sediment thickness) above the A-Zone for 'sub-critical' mining geometries are presented in **Table 4** and **Figure 6** for Panels N1/S1 (sub-critical single panels).

Table 4 indicates that it is not necessary to adjust the mining height from 3.5 m for the first two panels (N1 and S1) as they are essentially isolated panels with set-back distances of > 50 m from future panels and > 30 m from the fault planes. The HoF predictions for 'sub-critical' panels therefore apply to N1 and S1.

Table 4 also demonstrates that the mining height would need to be reduced over N1 as shown to satisfy minimum required Constrained Zone thickness criteria of 12T+10m above a 'supercritical' panel geometry with a maximum fracture height of 33T.

Table 4 - Predicted Mining Heights for Northern Area Panels N1 and S1

Panel No. (S=Start) (F=Finish)	Panel Width W (m)	Effective Cover Depth H (m)	Mining Width W' (m)	W'/H	T (Tmax) (m)	Rock Cover Depth H_r (m)	A-Zone Height (m): Sub-critical Panels [a.] (mean- U95%CL)		A-Zone Height (m): Super-critical Panels (33T)	Constrained Zone Thickness below Rock Head, C_z (m): Predicted Minimum Thickness for mining height, T	Constrained Zone Thickness below Rock Head, C_z (m): Minimum Required using 12T+10	Height of Munmorah. Conglomerate Units Above FAS (m)
Sub-Critical Panel Behaviour (Likely)												
N1 (S)	97	170	97	0.57	3.5	153	81	96	-	57	52	117 - 120 & 145 - 147
N1 (F)	97	177	97	0.55	3.5	158	83	98	-	60	52	
S1 (S)	97	198	97	0.49	3.5	184	88	103	-	81	52	121- 125 & 147 - 152
S1 (F)	97	185	97	0.52	3.5	168	85	100	-	68	52	
Super-Critical Panel Behaviour (Unlikely)												
N1 (S)	97	170	97	0.57	3.2 - **3.5**	153	-	-	105 - **116**	48 - **37**	48 - 38	117 - 120 & 145 - 147
N1 (F)	97	177	97	0.55	3.3 - 3.5	158	-	-	108.5 - 116	49 - 42	49.5 - 39	
S1 (S)	97	198	97	0.49	3.5	184	-	-	116	68	52	121 - 125 & 147 - 152
S1 (F)	97	185	97	0.52	3.5	168	-	-	116	52	52	

Bold - Predicted Constrained Zone Thickness below rock head < minimum required for lakes (i.e. 12T+10); a. - Effective Strata Thickness in Geology Model, t' = 19 m (**Ditton & Merrick, 2014**).

6.3 Summary

Based on the performance outcomes of the Wyee and MW1-12, it is assessed that S1/N1 can reasonably be assumed to be sub-critical and thus allow the full extraction height of 3.5 m (see the ‘sub-critical mining heights’ section in **Table 4**).

7.0 Maximum Subsidence Predictions for the Northern Area

7.1 Empirical Model

The predicted subsidence for the proposed miniwalls is presented in **Table 5** and **Figures 7a** (cover depth model) and **7b** (rock cover depth model).

Table 5 - Predicted Subsidence over the Proposed Northern Panels

MW#	Mining Area Width W' (m)	Cover Depth H (m)	W'/H	Rock Cover H_r	W'/H_r	Mining Height T (m)	First S_{max} (mean) (m)	Final S_{max} (U95% CL) (m)	Goaf stress (MPa)
Northern Panels									
N1	97	170	0.57	153	0.63	3.5	0.13	0.42	0.54
	97	177	0.55	158	0.61	3.5	0.13	0.42	
Southern Panels									
S1	97	198	0.49	184	0.53	3.5	0.11	0.40	0.54
	97	185	0.52	168	0.58	3.5	0.12	0.41	

Maximum subsidence after mining is estimated to be < 0.42 m above the panels, based on the MW1-12 data. Goaf consolidation effects are 'unlikely' to add > 0.29 m of additional subsidence above these panels in the long-term.

7.2 Numerical Modelling (RS^2/Phase2)

7.2.1 General

Due to the subsidence exceedance above MW1-12 and the complexity of the geology encountered in the northern mining area, the subsidence predictions for MW N1 and S1 have also been estimated using a jointed, elastic-plastic 2-D Finite Element modelling program (RS^2 or Phase2 V.9). The creep phase has been assessed using the RS^2 model subsidence profiles and a spreadsheet-based Burgers model.

The RS^2 model (where R=Rock, S=Soil, 2= 2-D model) allows interaction of the strong conglomerate roof units, the weak claystone floor layers and slip on geological structure (faults, joints and bedding) to be included in the subsidence profile assessment.

All lithological units have been modelled with persistent bedding partings to allow realistic modelling of potential slip between materials and significant rock mass defects (i.e. faults with throws > 0.5 times the mining height) during subsidence development. The yielding of the various materials will also affect the performance of the mining layout.

The model mesh and materials are shown in **Figure 8a** for XL3.

7.2.2 Modelling Input Parameters

The Mohr-Coulomb constitutive model has been applied to both the strengths of the various rock mass layers and the joints or bedding partings between the layers that are likely to be present in the mining area. All details of the modelling input assumptions are presented in **DgS, 2018** and summarised in **Figure 8b**.

Burgers creep model under single abutment loading conditions has been used to estimate the subsidence at 1 and 50 years after mining is complete (see **DgS, 2018** for further creep model details). There are six parameters in the model to estimate the initial elastic response and depending on the stress-strength ratio (SSR), the primary and secondary creep components.

Triaxial creep tests have been applied by **Yu, 1998** to derive the shear modulus & viscosity relationships defined in Burgers Model below for very low strength, bentonite-cement-water cylinders with SSRs ranging from 0.2 to 1.0. The samples were tested after 15 days of curing and had a UCS of ~ 1 MPa and Youngs Modulus of 300 MPa.

Elastic parameters:

Solid Youngs Modulus, $E_m = 300.UCS$ (MPa)

Solid Shear Modulus, $G_m = E_m/(2(1+v))$ (MPa)

Creep Parameters - Primary Creep (solid mechanics model by Kelvin):

Shear Modulus, $G_k = 219e^{(-3.075*SSR)}$ (MPa)

Viscosity, η_k = maximum of $9701e^{(4.719*SSR)}$ and 4.28×10^5 (MPa.day)

Creep Parameters - Secondary Creep (fluid flow mechanics model by Maxwell):

Viscosity, $\eta_m = 1.9152 \times 10^8\ e^{(-4.147*SSR)}$ (MPa.day)

A summary of each parameter v. SSR is presented in **Figure 8c.**

As is the case for all studies involving rock mechanics, the elastic and creep parameters are sensitive to scale effects between laboratory samples and rock mass prototypes. By applying the above relationships to the Chain Valley subsidence data, it was possible to determine the UCS and Modulus/UCS ratio for a given seam.

The subsidence data for stable second workings in the Wallarah Seam (Line 23 along the foreshore) returned a UCS of 2.3 MPa and E/UCS ratio of 110 to provide a very good fit to ~25 years of data.

The subsidence data for the FAS seam miniwalls 1 - 12 however, required the E/UCS ratio to be reduced to 11 (or 10%) to obtain a good fit[4]. This suggests that bearing failure had indeed occurred in the MW 1-12 area.

The calibrated input parameters for 2 to 3 m of interbedded claystone and carbonaceous shale/shaley coal beds below the FAS Seam pillars are summarised in **Table 6A**.

Table 6A - Summary of Pillar Creep Material Input Parameters for FAS Seam Floor Claystone

Claystone UCS (MPa)	Youngs Modulus Em (MPa)	Poisson's Ratio	Shear Modulus G_m (MPa)	SSR*	Shear Modulus G_k (MPa)	Viscosity η_m (MPa. day)	Viscosity η_K (MPa. day)
Panel N1 (H=175 m; Pillar Stress = 9.13 MPa (RS2) & 12.25 MPa (S.I.)							
2.3 (current)	253	0.3	97	0.45 (0.60)	55 (34)	2.96e7 (1.56e7)	8.13e4 (1.68e5)
1.65 (flooded)	182	0.3	70	0.63 (0.84)	32 (16)	1.42e7 (5.81e6)	1.88e5 (4.28e5)
Panel S1 (H=190 m; Pillar Stress = 11.2 (RS2) & 13.2 MPa (S.I)							
2.3 (current)	253	0.3	97	0.59 (0.69)	36 (26)	1.68e7 (1.08e7)	1.54e5 (2.56e5)
1.65 (flooded)	182	0.3	70	0.82 (0.97)	18 (11)	6.46e6 (3.47e6)	4.28e5 (4.28e5)

m = Maxwell series spring & dashpot primary creep model; k = Kelvin parallel spring & dashpot secondary creep model parameters; * - refer to **Sections 7.2.4 & 7.2.5**.

The above parameters were applied in the Burgers model to estimate short-term (after 1 year) and long-term (after 50 years) post-mining subsidence for the proposed panels. The mechanical properties for the *non-creeping* shale and sandstone units in the zone of influence (one pillar width) below the FAS mine workings floor that were also included in the model are summarised in **Table 6B**. The values assumed were adapted from the MSFI study for Chain Valley Bay (refer **DgS, 2017**).

Table 6B - Summary of Material Input Parameters for Non-Claystone Units in FAS Seam Floor

Material	Unit Thickness t (m)	UCS (MPa)	Laboratory Youngs Modulus (MPa)	Rock Mass Youngs Modulus Em (MPa)	Poisson's Ratio
Non-Swelling Shale	2	14	4,200	2100	0.3
Sandstone	27.6	40	12,000	9600	0.25
Total	**29.6**		**Equivalent**	**9093**	

[4] Alternatively, the E/UCS may be kept constant at 110 and the UCS reduced to 10% or 0.22 MPa to give an E=24 MPa.

7.2.3 Numerical Model Stress Contours

The post-mining pillar vertical and horizontal stress contours after MW N1 extraction are presented in **Figures 9a-c**. The yielded elements and safety factors associated with the mining layout are shown in **Figure 9d-e**.

7.2.4 Subsidence and Stress Predictions for Panel N1

The predicted credible worst-case subsidence, vertical FAS seam stress and creep profiles after MW N1 has been extracted are shown in **Figures 10a - 10d** along XL3 (see **Figure 1a**).

The maximum subsidence effects panel N1 is extracted is summarised in **Table 7A**.

Table 7A - Maximum Subsidence Summary for MW N1

Predicted Maximum Subsidence* (mm)	Average MG Chain Pillar Stress (MPa) RS2 [S.I.]	Average Goaf Stress (MPa)	Pillar Strength# (MPa)	Pillar Stability Index Range RS2 [S.I.]	Claystone UCS below pillars (UCS)	Pillar Floor Stress/ Strength Ratio+ (SSR)	Elastic Pillar Settle-ment (mm)	Long-term Creep Estimate (50-year post-mining) (mm)	Worst-Case S_{max} (Long-Term) (mm)
120 (130 - 420)	9.13 [12.25]	0.5	27.3	2.98 [2.23]	2.3 (current)	0.45 [0.60]	94 [126]	97 [205]	191 [331]
					1.65 (flooded)	0.63 [0.84]	116 [155]	160 [226]	276 [381]

* - numerical model subsidence with values in (brackets) showing the empirical model results for single miniwall panels; # - based on **Mills & Edwards, 1997** and a 3.2 m roadway development height; ^ - Long-term stable pillars indicated without creep for S.I. > 2.7; Creep 'likely' for an S.I. between 2 and 2.7, with bearing failure indicated by S.I. < 2; + - SSR based on floor bearing strength and measured abutment stress.

The results indicate the following pillar stress and subsidence development outcomes:

- The modelling indicates that stress concentrations will develop at the fault locations after mining adjacent to MW N1 and cause localised yielding but not wide-spread instability of the panel chain pillars.

- The initial maximum subsidence of 0.12 m over MW N1 according to the numerical model confirms that the faulting is 'unlikely' to increase the maximum subsidence above 0.78 m. The result is comparable to the mean single panel value for the empirical model of 0.13 m.

- An average pillar stress of 9.1 MPa is expected to develop based on the numerical modelling with 9.24 MPa estimated from abutment stress increase measurements at the finishing end of MW7 (**LDO, 2015**). The worst-case pillar stress of 12.25 MPa has been estimated from the S.I. assessment for sub-critical panel geometry using an abutment angle of 90^{o} (less goaf loading of 0.5 MPa estimated for a caving height of 17.5 m).

- The Stability Index Model (**Mills and Edwards, 1997**) indicate an S.I. range from 2.98 to 2.23, which suggests the proposed chain pillars are likely to be within the steady-state 'creep' zone (i.e. 2.0 > S.I. < 2.7).

- Burger models of potential post-mining creep have subsequently been assessed for creep potential under both current conditions and post-flooding conditions by reducing the claystone UCS from 2.3 MPa to 1.65 MPa to simulate moisture softening effects (refer to **DgS, 2017** for further details).

- Attenuation of the creep movements are expected after flooding of the mine workings and effective stress on the pillars decreases.

- The Burger Model for N1 tailgate indicates a pillar system creep of 97 mm to 226 mm (primary & secondary) due to the applied stress and claystone UCS for current and worst-case pillar-floor system scenarios (i.e. dry and flooded cases).

- The long-term subsidence predictions of 214 mm to 381 mm are within the U95%CL value of 420 mm estimated from the empirical subsidence model for single longwalls.

7.2.5 Subsidence and Stress Predictions for Current Layout of Panel S1

The maximum subsidence after Panel S1 is extracted is summarised in **Table 7B**. The predicted credible worst-case subsidence, vertical FAS seam stress and creep profiles after miniwall S1 has been extracted are shown in **Figures 11a - 11d** along XL4 (see **Figure 1a**).

Table 7B - Maximum Subsidence Summary for MW S1

Predicted Maximum Subsidence* (mm)	Average MG Chain Pillar Stress (MPa) RS2 [S.I.] *Meas.*	Average Goaf Stress (MPa)	Pillar Strength[#] (MPa)	Pillar Stability Index Range RS2 [S.I.]	Claystone UCS below pillars (UCS)	Pillar Floor Stress/ Strength Ratio[+] (SSR)	Elastic Pillar Settle-ment (mm)	Long-term Creep Estimate (50-year post-mining) (mm)	Worst-Case S_{max} (Long-Term) (mm)
130 (120 - 410)	11.2 [13.2]	0.5	27.3	2.44 [2.07]	2.3 (current)	0.59 [0.69]	125 [148]	195 [275]	320 [423]
					1.65 (flooded)	0.82 [0.97]	154 [182]	189 [262]	343 [444]

* - numerical model subsidence with values in (brackets) showing the empirical model results for single miniwall panels; # - based on **Mills & Edwards, 1997** and a 3.2 m roadway development height; ^ - Long-term stable pillars indicated without creep for S.I. > 2.7; Creep 'likely' for an S.I. between 2 and 2.7, with bearing failure indicated by S.I. < 2; + - SSR based on floor bearing strength and predicted abutment stress from numerical model.

The results indicate the following pillar stress and subsidence development outcomes:

- The modelling indicates that stress concentrations are likely to develop at panel ribs and where the faults occur at seam level. The stress increases are expected to cause localised ‘yielding’ of the claystone floor units and pillar ribs only.

- The initial maximum subsidence of 0.13 m over MW S1 indicates that the faulting has no impact, as the result is comparable to the mean single panel value for the empirical model of 0.12 m.

- An average pillar stress of 11.2 MPa is expected to develop, based on the numerical modelling, with 10.2 MPa estimated from abutment stress increase measurements at the finishing end of MW7 (**LDO, 2015**). The worst-case pillar stress of 13.2 MPa has been estimated from the S.I. assessment for sub-critical panel geometry using an abutment angle of 90° (less goaf loading of 0.5 MPa estimated for a caving height of 17.5 m).

- The Stability Index Model (**Mills and Edwards, 1997**) indicates a S.I. of 2.67 to 2.07, which suggests the proposed chain pillars are likely to be within the steady-state ‘creep’ zone (i.e. 2.0 > S.I. < 2.7).

- Burger models of potential post-mining creep have been assessed for current conditions and post-flooding conditions by reducing the claystone UCS from 2.3 MPa to 1.65 MPa to simulate moisture softening effects (refer to **DgS, 2017** for further details).

- The Burger model for MW S1 chain pillars indicate worst-case creep (primary & secondary) of 195 mm to 262 mm. A worst-case subsidence of 320 mm to 444 mm is predicted 50 years after mining is completed for dry and flooded conditions respectively. The results are generally within the empirical U95%CL value of 410 mm for single longwalls.

Overall, it is assessed that the proposed mining layout will not lead to long-term subsidence of > 0.78 m. Worst-case subsidence effect contours have been derived from the predicted 50-year post-mining subsidence using SDPS software and local subsidence profile data from the Newcastle Coalfield; see **Figures 12a** to **12c**.

The tilt and strain contours were generated using the 3-D calculus coding in Surfer12. The horizontal strains were estimated from the curvature contours using an assumed strain/curvature ratio of 15 (refer to **DgS, 2013**). The maximum subsidence effect parameters for MW N1 and S1 are summarised in **Table 8**.

Table 8 - Predicted Maximum Subsidence Effects

Panel	Cover	Smax (mm)	Tilt (mm/m)	Horizontal Strain* (mm/m)	Horizontal Displacement (mm)
N1	170 - 180	380	5	+1.5 to -2.5	200
S1	185 - 198	440	5	+1.5 to -2.5	200

* - Tensile Strain is positive.

7.3 Bearing Capacity of Two-Layered Floor System

The floor of the Fassifern Seam workings includes interbedded coal/shaley coal and moisture sensitive claystone beds between 50 mm and 300 mm thick within 3 m of the floor horizon. The cumulative thickness of the claystone beds below MW N1 and S1 range between 1.1 m and 1.2 m; see **Figure 2e**.

It is assessed that the bearing capacity of the claystone floor may be estimated by using either the **Mills and Edwards, 1997** approach (if claystone moisture contents and UCS values are unknown) and/or **Brown and Meyerhoff, 1969**, if data for claystone floor is available.

The unconfined compressive strength (UCS) of the claystone beds have been previously determined from laboratory testing results on bore core at in-situ moisture contents (refer **DgS, 2017**).

Overall, the bearing capacity of the claystone floor is considered to be primarily a function of:

(i) the UCS and cumulative thickness of the claystone units;

(ii) the width of the pillar and proximity of other pillars;

(iii) the applied stress to strength ratio (creep or failure mode).

For the combined pillar-floor system strength, the pillar height is also a critical factor.

Other workers have suggested that bearing capacity equations derived from shallow, isolated footing theories for buildings might not be applicable to underground mine workings pillars due to the confining effects of adjacent pillars, which can increase the strength of the claystone units. It is therefore likely that the single pillar assumption is likely to provide conservative strength estimates for the claystone floor units.

The published performance of the following mine workings with moisture sensitive claystone floor strata in the above seams at several Lake Macquarie mines has also been referred to for model calibration/validation purposes:

- Chain Valley Colliery (WAL Seam), Cooranbong (GN Seam) and Wyee (FAS Seam)**; Seedsman & Gordon, 1992**.

- Moonee Colliery (GN Seam); **Mills and Edwards, 1997,**

- Munmorah Colliery (GN Seam); **Vusundhara et al, 1998.**

The bearing capacity of the floor in the FAS seam has been estimated using the 2-layered bearing capacity model presented in **Brown & Meyerhof, 1969**. The model assumes a strip footing on a weak layer overlying a stronger one, so it is likely to indicate conservative floor strengths for weak units interbedded with stronger ones. The model allows estimates of undrained bearing capacity for a range of weak claystone thicknesses, pillar widths and UCS.

The theory indicates that the undrained bearing capacity of the weaker layer below a pillar will be increased if the stronger unit is within 0.5 times the width of the pillar as follows:

$$q_u = N' \times UCS_1/2 = [4.14 + 0.5(w/t)]UCS_1/2$$

where N'_{square} = Modified bearing capacity coefficient for a square footing
w = pillar width;
UCS_1 = claystone or mudstone strength;
t = thickness of weaker claystone layer.

Together with **Mills and Edwards, 1997**, the above theory may be used to illustrate the performance of tuffaceous claystone floor units interbedded with higher strength rocks (shale/coal) in the Lake Macquarie Coalfield and to explain observed floor heave and lateral bearing failures of softened claystone layers from beneath pillars.

As discussed in **DgS, 2017**, the UCS will decrease exponentially with increasing moisture content. The moisture content will largely be controlled by the confining pressure developed below the core of the pillar, with significant strength losses occurring within 2 m of the ribs. The average UCS across the chain pillars is likely to range between 5 MPa +/- 3 MPa in the current mine workings conditions (a value of 2.3 MPa was back analysed from the subsidence data as was mentioned earlier).

The results of a detailed underground sampling and laboratory testing program of the Chain Valley workings in the WAL, GN and FAS Seams are presented in **DgS, 2017**. It has been assessed that average UCS below the pillars is likely to decrease from the current value of ~ 2.3 MPa to a flooded workings value of ~ 1.65 MPa. The previous report noted that the confinement of the pillar core will limit further strength reduction for swell pressures < 3 MPa.

The bearing capacity results for MW N1 and S1 are summarised in **Table 9** and provide a relative indication of the potential for increased floor-related deformation.

Table 9 – Bearing Capacity of Claystone Beds below the Proposed MW N1 and S1 Chain Pillars

MW No.	Workings (Load) Type [Goaf width]	Cover Depth H (m)	Pillar Dimensions w x l x h (m)	Total Pillar Stress (MPa)	Weak Claystone Floor Units				
					UCS* (MPa)	Clay t (m)	Undrained Bearing Strength* (MPa)	Bearing FoS Range	Stability Index Range
N1	Single Side Abutment	175	24.6 x 94.5 x 3.2	9.13-12.25	2.3	1.1	20.26	2.23 - 1.65	2.98 - 2.23
					1.65		14.54	1.59 - 1.19	
S1	Single Side Abutment	190	24.6 x 94.5 x 3.2	11.2-13.2	2.3	1.2	19.03	1.70 - 1.44	2.44 - 2.07
					1.65		13.65	1.22 - 1.03	

* - likely moisture sensitive claystone UCS range;

The FoS against lateral bearing failure of the FAS floor ranges from 2.23 to 1.03 for the estimated working stress range of 9.13 to 13.2 MPa after mining. It is considered that a FoS value of 1.5 roughly corresponds to a Stability Index of 2.5 and that they both represent the point at which steady-state secondary creep and possibly bearing failures may develop. Lateral bearing failures are considered likely for values below 1.0 and 2.0 for each model respectively.

It is expected however, that as the pillars are located adjacent to solid coal, it is unlikely that a complete crush of the pillars will eventuate and result in significant subsidence (> 780 mm). This is because:

(i) the stiffness or spanning capability of the various conglomerate units between the opposing *hading* faults will limit subsidence over the isolated panel goaves and pillars by transferring load away from the yielding pillar edges, and

(ii) The regional horizontal stress is likely to confine the faults and limit 'slip' movements, which will also be limited by the opposing structure hade.

These outcomes have also been demonstrated by the numerical modelling.

Furthermore, should the chain pillars punch into the floor and effectively increase the span of the panels out to the solid coal barrier (i.e. a potential void width of 97 m + 24.6 m + 5.4 m = 127 m) it would be expected that the resultant subsidence would be approximately the same magnitude as the observed subsidence of 0.4 m to 0.65 m that occurred above the 130 m to 150 m longwalls (LW 17 to 23) at Wyee Colliery. It is noted that the cover depth above the Wyee Panels similarly ranged between 175 m and 195 m and that the mining height was 3.2 m.

8.0 Multi-seam Subsidence Interaction Predictions

8.1 WAL Workings Mining Geometry and Multi-Seam Stress Increase Estimates

The WAL Seam pillar extraction panels have been considered for long-term stability after MW S1 is completed. The following pillar and panel width geometries exist between the proposed start of MW S1 and the foreshore (see **Figure 13a**):

- Five rows of 18 m x 18 m square chain pillars will be located 85 m above and 72.5 m, 132.5 m, 192.5, 252.5 m and 312.5 m outside of the front abutment limits of MW S1 respectively.

- Two subsequent pillar rows beneath the seagrass and foreshore increase in pillar width to 24 m and 31 m respectively.

- Eight extracted pillar goaves between the chain pillars that are each 42 m wide (rib-rib).

Predicted single and multi-seam stress profiles for the 18.5 m wide WAL pillars and 42 m wide x 130 m long goafs due to an adjacent miniwall in the FAS has been assessed in **DgS, 2016** for the previously proposed extension of a 97 m wide miniwall (MW13, now MWS1).

The WAL workings extend some 400 m to 500 m back to the foreshore from the start of MW S1 with five to six rows of alternating goaf and pillars, see **Figure 13a**. The pillars and goaf are orientated normally to the proposed S1 panel end and extend between the NW striking faults as shown in **Figures 1a** and **1b**.

Multi-seam stress analysis was done using LaModel in **DgS, 2016** to derive vertical stress increase contours at the WAL seam, due to miniwalls in the FAS Seam; **Figure 13b**.

The decay of the stress increase in the WAL workings from the sides of the proposed 97 m wide panel limits in the FAS has been determined from the figure at the relevant pillar row distances from MW S1 (see **Table 9**).

Table 9 - Pillar Stability Assessment Summary for Wallarah Seam Pillar Extraction Panels (Void width = 42 m)

Distance from Goaf Edge (m)	Cover Depth H (m)	Chain Pillar Width w (m)	Chain Pillar Length l (m)	Chain Pillar w/h (h=2.4m)	FTA Stress (MPa)	Chain Pillar Strength^ (MPa)	S.I.	Chain Pillar Stress Increase (MPa)	Chain Pillar Final Stress (MPa)	Pillar Floor SI Final
55	115	18.5	18.5	7.7	12.2	*27.3*	*2.24*	0.3	12.5	2.18
116	117.5	18.5	18.5	7.7	12.5	*27.3*	*2.19*	0.0	12.5	*2.19*
177	120	18.5	18.5	7.7	12.7	*27.3*	*2.15*	0.0	12.7	*2.15*
237	122.5	18.5	18.5	7.7	13.0	*27.3*	*2.10*	0.0	13.0	*2.10*
298	125	18.5	18.5	7.7	13.3	*27.3*	*2.06*	0.0	13.3	*2.06*
358	127.5	24	34	10	10.2	33.9	3.33	0.0	10.2	3.33
424	130	30	41	12.5	8.8	41.1	4.65	0.0	8.8	4.65

h = mining height; * - approximately 85% of coal extracted, allowing for remnant stooks. Shaded - 18.5 m wide pillars; ^ - Pillar strength according to Stability Index model.

Based on **Mills and Edwards, 1998**, the Stability Index (S.I.) for the WAL pillars under their current worst-case loading condition ranges between 2.06 and 2.24. The smaller pillars are considered marginal due to observed instability at other mines where S.I. < 2 occurred.

The S.I. for the larger pillars below the foreshore ranges between 3.33 and 4.65. SI values > 2.7 are considered to be long-term stable according to the authors.

The above analysis indicates that the stability of the smaller WAL workings pillars may be sensitive to additional loading from the proposed FAS workings. It was therefore considered appropriate to provide a buffer zone or minimum set-back distance for the starting position of MW S1 to avoid applying significant additional load to the WAL mine workings; see **Section 8.2**.

8.2 Set-back Distance from the WAL Mine Workings

Reference to **Peng and Chiang, 1984**, indicates that 90% of the front abutment load should occur at the FAS seam level within a distance of $5.13\sqrt{H}$ or 72.5 m for a cover depth of 200 m. Forward abutment stress monitoring for MWs 7 to 8 (**LDO, 2015**) measured abutment load distances of < 50 m, see **Figure 13c**. These results are comparable to the numerical modelling outcomes and infers 'negligible' stress interaction between the seams. The sub-critical width of the WAL seam goaf also means that it can be ignored in the set-back analysis.

A minimum buffer distance of 72.5 m from the last row of in-bye WAL seam pillars adjacent to the starting end of MW S1 is therefore recommended to minimise the potential stress interaction impacts between the seams (as shown in **Figure 13a**). Potential pillar stress increases of < 0.3 MPa are predicted according to the numerical modelling (see **Figure 13b**).

9.0 Predicted Impacts to Surface Features

9.1 Angle of Draw

The angles of draw for the *sub-critical* panels (W/H ratios ranging from 0.51 to 0.58) have been estimated based on reference to **ACARP, 2003**. The predicted angle of draw for the sub-critical, single seam panels ranges between 22^o and 26.5^o.

9.2 Foreshore and Seagrass Beds

The predicted subsidence due to the proposed miniwalls at the foreshore and seagrass beds is expected to be < 20 mm. No impact to these features is expected after mining.

9.3 Steep Slopes and Minor Cliffs

Negligible subsidence and far-field displacements (i.e. within measurable limits) are predicted along any of the the steep slopes and minor cliffs in Sugar Bay as a result of the extraction of panels N1 and S1. No impact to these features is expected after mining.

9.4 Fixed Navigation Markers / Rock Outcrops

Only the fixed navigation marker and rock outcrop that is 41 m to the north-east of proposed miniwall N1 could be affected by mining. Worst-case subsidence due to MW N1 is predicted to be < 100 mm with < 2 mm/m tilt and < 0.8 mm/m tensile strain predicted at the marker and outcrop (see **Figures 12a-c**).

It will be necessary to consult and agree on appropriate management measures with Roads and Maritime Services prior to impact on the navigational marker. At this stage, it is not expected that mitigation works will be required to restore loss of freeboard and/or cracking from subsidence impacts after MW N1 and S1 are completed.

10.0 Conclusions and Recommendations

The following are the key outcomes for proposed northern area miniwalls N1 and S1:

- The two panels are isolated by faults forming a graben down-thrown by around 13 m.
- The miniwalls do not encroach within 30 m of the faults.
- The miniwalls do not undermine the fault planes, which are mid-angled (50^o to 75^o) and hade beneath the panels (i.e. with negligible impact on overburden integrity in the extraction area).
- The potential for the proposed panels to cause significant water inflows due to dilation and shear along the faults is accordingly assessed to be 'negligible'.
- The predicted height of continuous fracturing above the proposed panels ranges between 81 m and 103 m (equivalent to between 23T and 29T for a mining height of 3.5 m).
- The associated constrained zone thickness ranges from 57 m to 81 m. This exceeds the minimum required constrained zone, as defined in **Li et al, 2006** of 12T (+10m) below the rock head (i.e. 52 m for a mining height of 3.5 m).
- The maximum long-term subsidence above the panels is likely to be less than 0.38 m and 0.44 m for MW N1 and S1 respectively.
- Maximum tilt is expected to be < 5 mm/m with tensile strains < 1.5 mm/m and compressive strains < 2.5 mm/m.
- Stability analysis of the claystone beds beneath the 24.6 m wide chain pillars indicates side abutment loading may cause local yielding of the floor and pillars at some point after mining, and possibly when first flooding occurs. The overburden strata however, is likely to behave like a 'stiff' loading system and transfer pillar stress away from the yielding pillar edges to adjacent solid coal (or goaf).
- The maximum subsidence is therefore unlikely to exceed the allowable limit of subsidence to within 780 mm.
- The predicted angle of draw for the sub-critical, single seam panels ranges between 22^o and 26.5^o.
- The Fixed Navigation Marker in Sugar Bay may be subsided by up to 100 mm, with tilt < 2 mm/m and tensile strain < 0.8 mm/m. It is the only surface feature in the northern mining area (besides the lake bed itself) that will be affected by mine subsidence at this stage. The impact to the marker is not expected to require mitigation works to restore loss of freeboard or cracking impacts.

The following recommendations are provided based on the outcomes of the assessment:

- Measurement of sediment thickness across the northern area using surface radar imaging. This is likely to allow a minimum required constrained zone of 12T to be applied, instead of 12T +10 m.

- Undertake consultation with the Roads and Maritime service regarding the preferred management measures required for the potential subsidence impacts associated with the Sugar Bay navigational marker/rock outcrop.

- A minimum horizontal buffer distance of 72.5 m should be maintained from the MW S1 installation road to the first row of Wallarah Seam pillars in the overlying and adjacent partial extraction panel.

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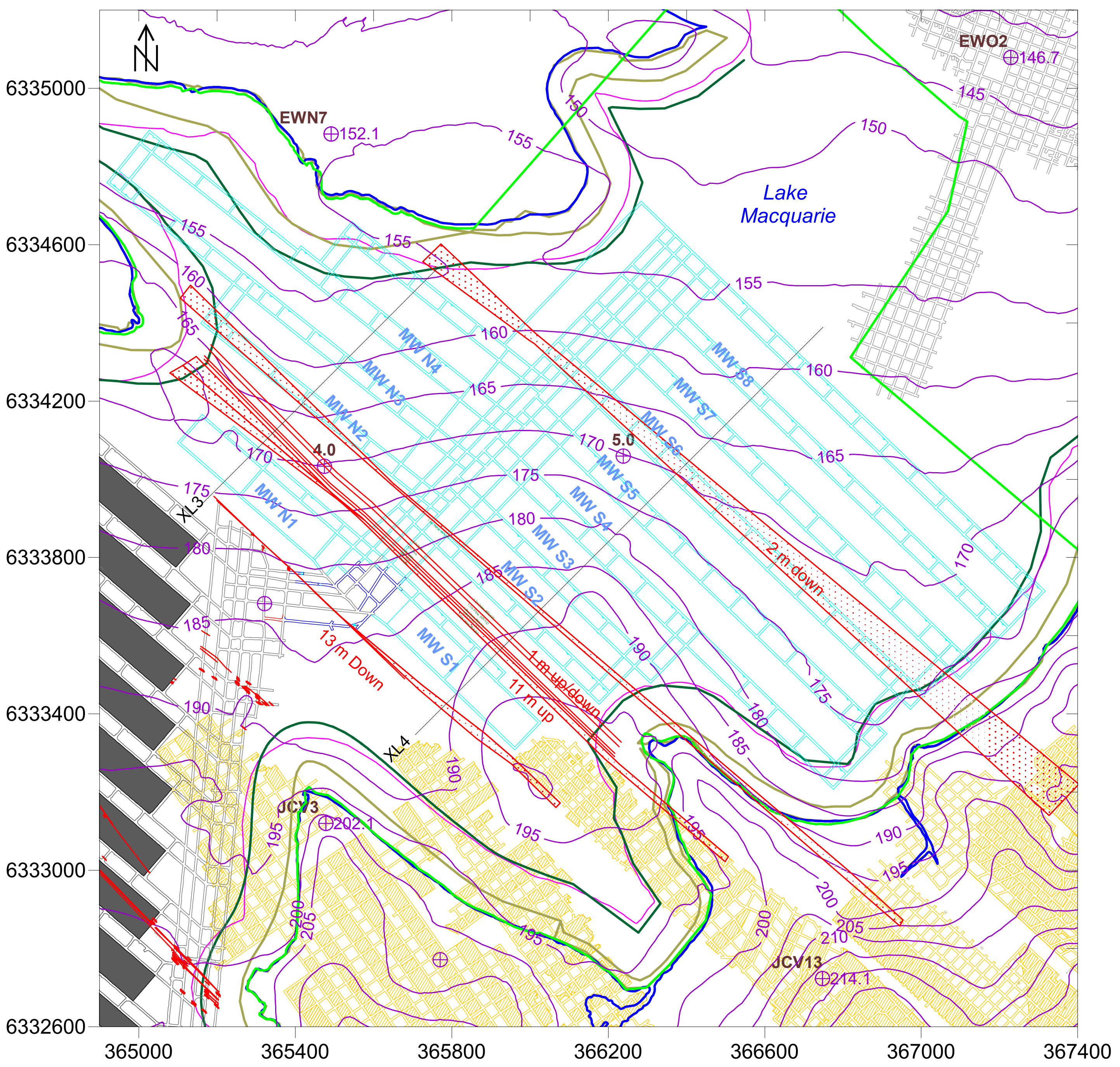
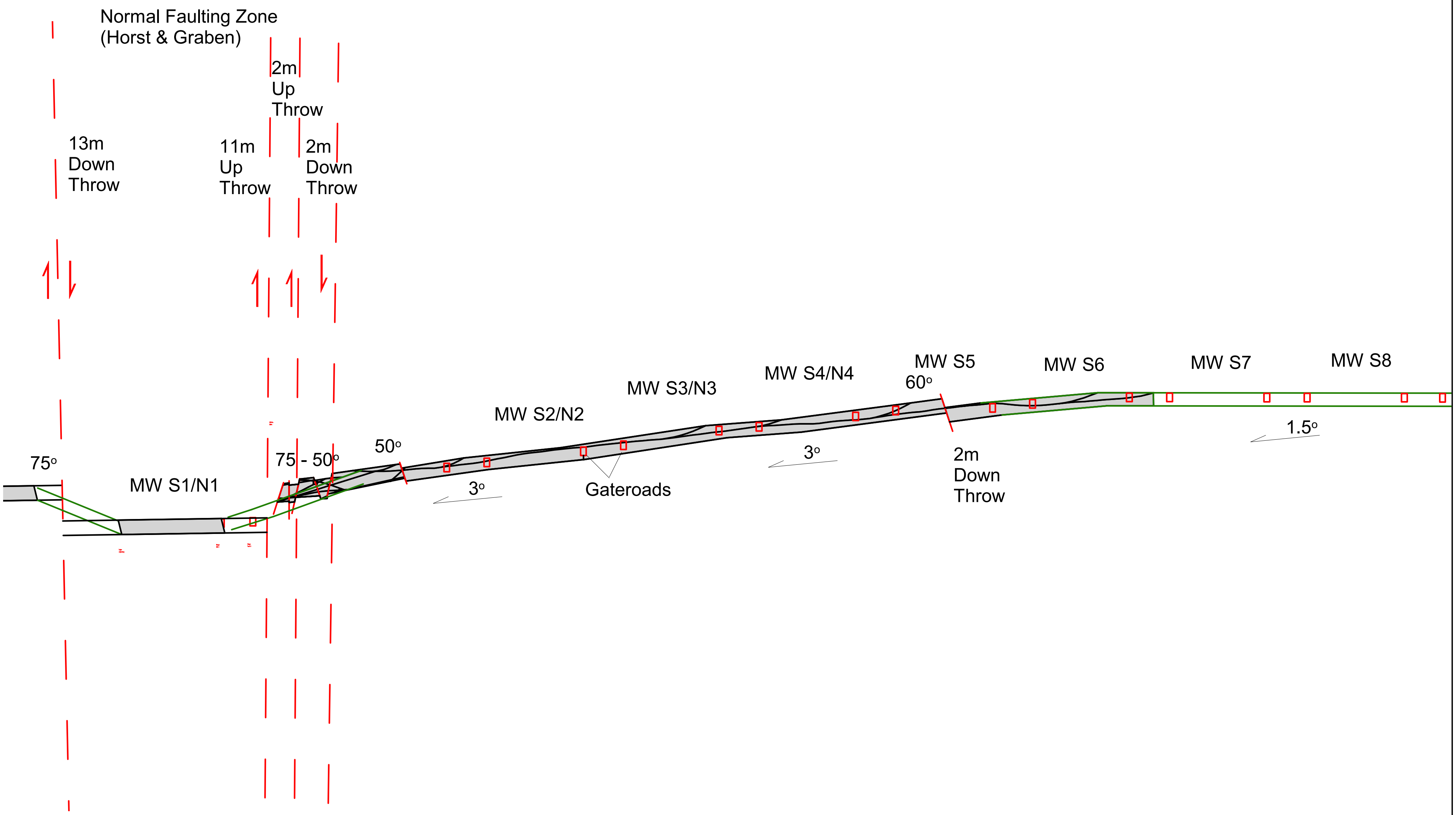


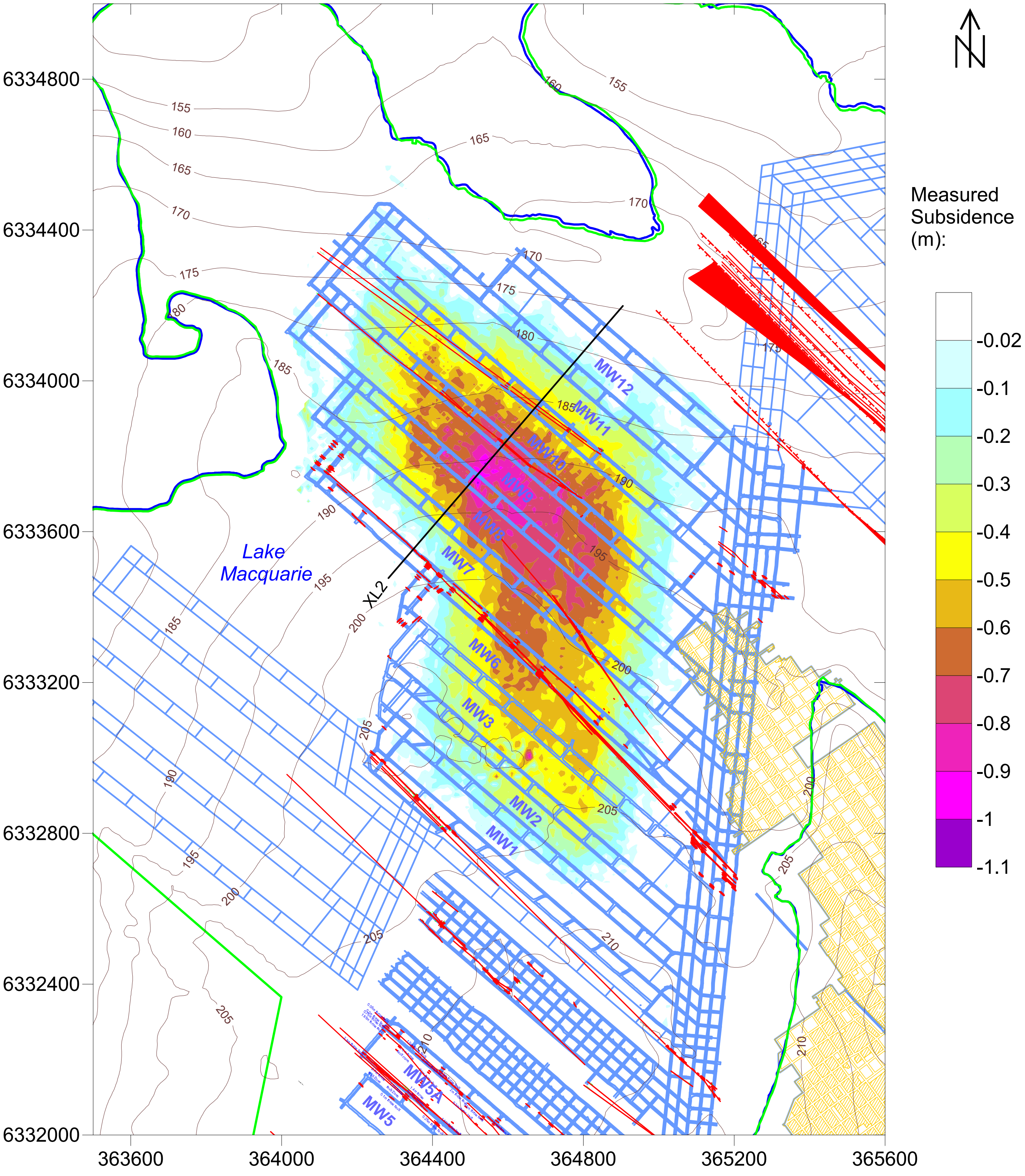
Key:

MW S1	Proposed Miniwalls in Fassifern Seam
XL1	Subsidence Prediction Lines
	Lake Foreshore
	CVC Project Boundary
	Wallarah Seam Mine Workings
	35o AoD from Foreshore (RL 0 AHD)
	Extracted Miniwall Panels
	Seagrass Buffer Zone Limits from Foreshore
	Mapped Extent of Seagrass along Foreshore
	Depth of Cover below Lake Bed (m)
	Normal Fault Zones (Horst & Graben) (Faults have 0.5m to 3m throws unless otherwise noted)

DgS	Engineer:	S.Ditton	Client:	LakeCoal - Chain Valley Colliery CHV-002/11
	Drawn:	S.Ditton	Title:	FAS Cover Depth Contours above the Proposed MW S1 to S8 and N1 to N4 in Northern Domain Area
	Date:	6.12.17		
	Ditton Geotechnical Services Pty Ltd		Scale:	1:15,000 (A4)
			Figure No:	1a



DgS	Engineer:	S.Ditton	Client:	Lake Coal - Chain Valley Colliery CHV-002/11
	Drawn:	S.Ditton		
	Date:	15.12.17	Title:	Indicative Faulted Section along XL4 with Proposed Miniwall Layout in the Northern Area
	Ditton Geotechnical Services Pty Ltd			
			Scale:	H: 1V:50H V: 1V:20H — Figure No: 1b



Key

Approved Chain Valley Mine Workings in Fassifern Seam

Wallarah Seam Workings

Site Boundary

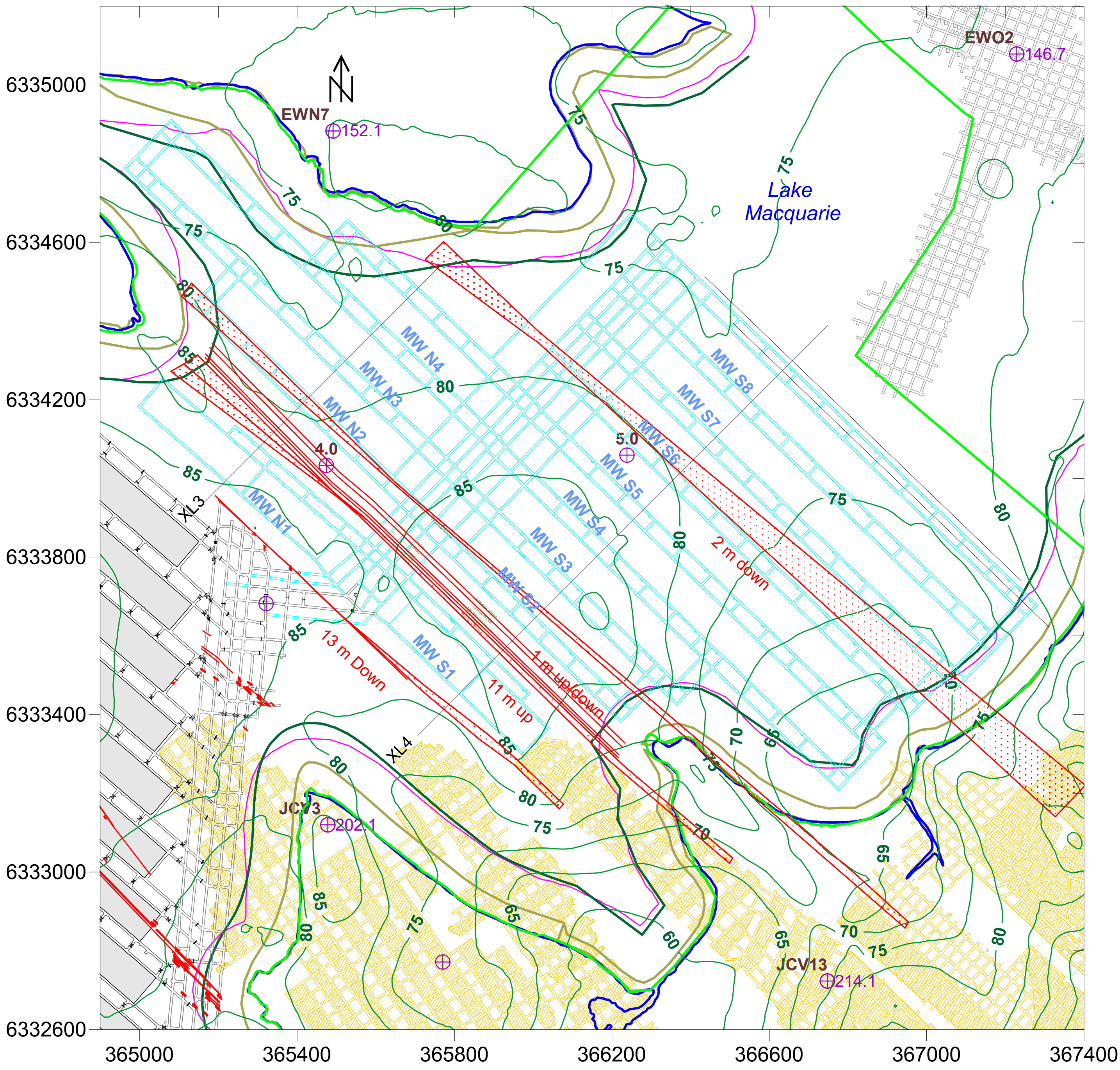
Mw1-12 Extracted Chain Valley Panels in Fassifern Seam

XL1 Subsidence Prediction Line

Lake Foreshore

Normal Faults

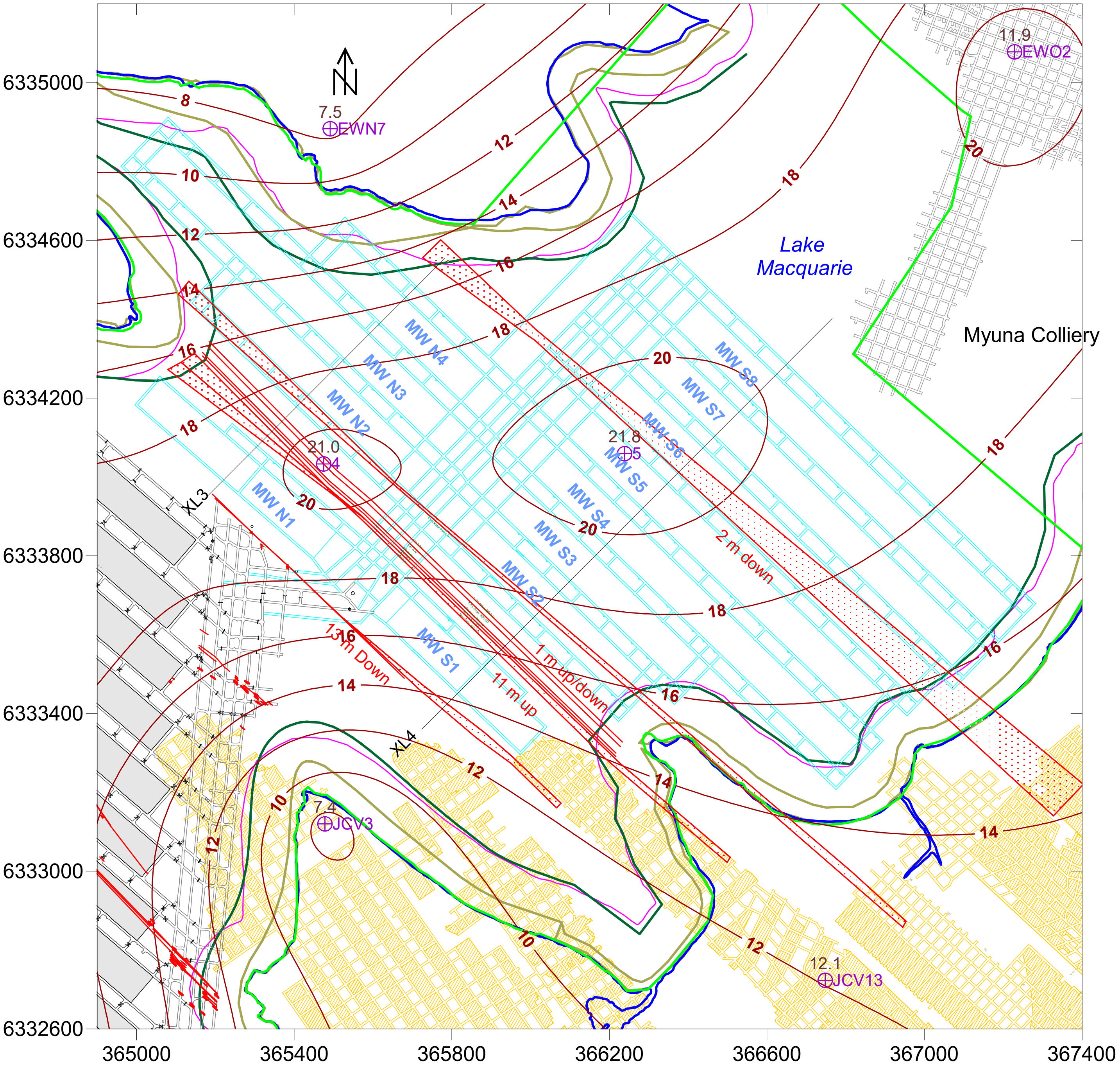
DgS	Drawn: S.Ditton	Client:	LakeCoal - Chain Valley Colliery CHV-002/11
	Engineer: S.Ditton	Title:	Measured Bathymetric Subsidence above MWs 1 to 10 in the Fassifern Seam at Chain Valley Colliery (Survey Date: August 2017)
	Date: 15.10.17		
Ditton Geotechnical Services Pty Ltd		Scale:	1:1,500 (A4) Figure No: 2a



Key:

MW S1	Proposed Miniwalls in Fassifern Seam
XL1	Subsidence Prediction Lines
	Lake Foreshore
	Site Boundary
	Wallarah Seam Mine Workings
	35o AoD from Foreshore (RL 0 AHD)
	Extracted Miniwall Panels
	Seagrass Buffer Zone Limits from Foreshore
	Mapped Extent of Seagrass along foreshore
	Interburden Thickness (m)
	Normal Fault Zones (Horst & Graben) (Faults have 0.5m to 3m throws unless otherwise noted)

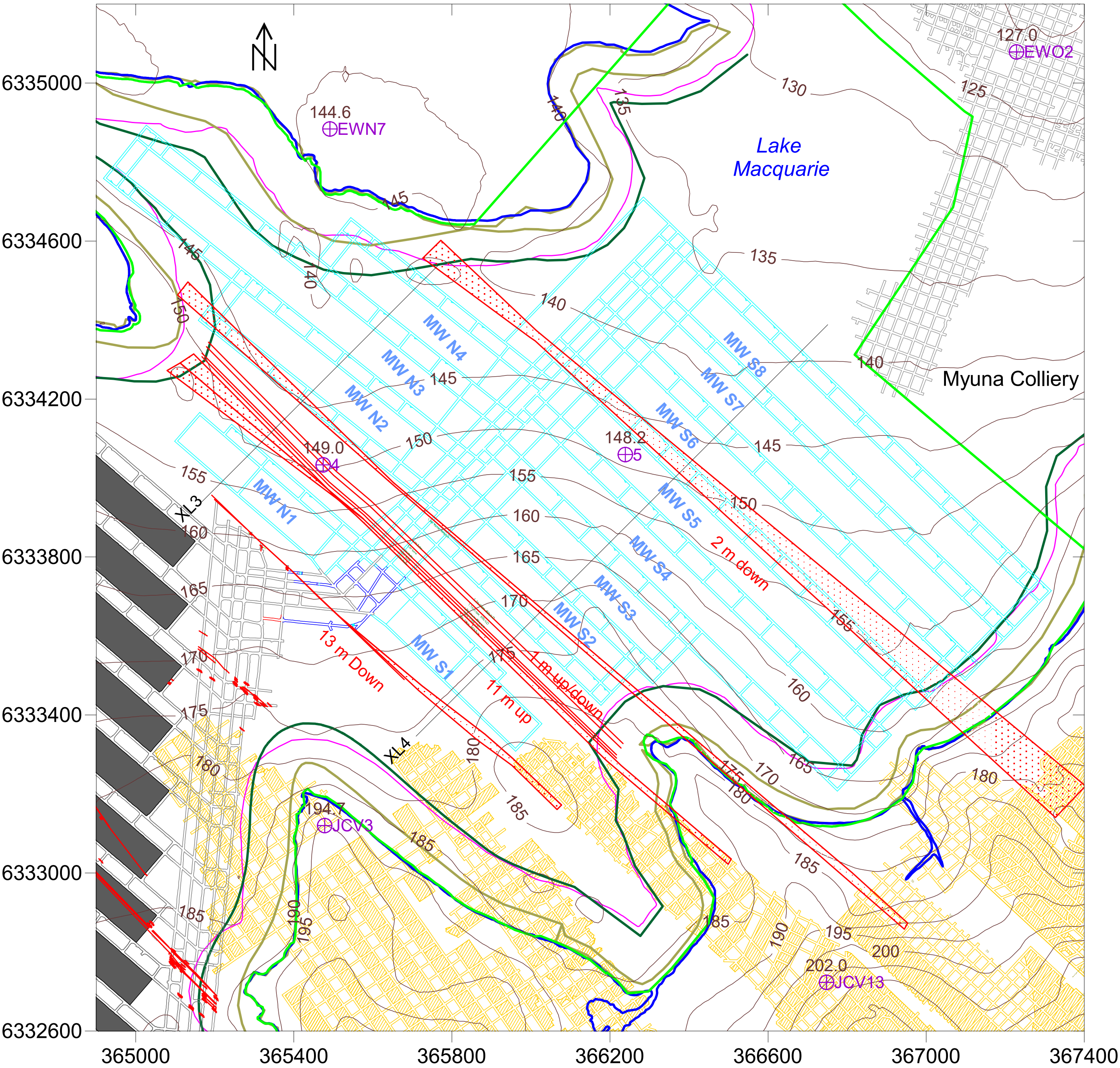
DgS Ditton Geotechnical Services Pty Ltd	Engineer: S.Ditton Drawn: S.Ditton Date: 6.12.17	Client:	LakeCoal - Chain Valley Colliery CHV-002/11
		Title:	FAS - WAL Interburden Thickness Contours above the Proposed MW S1 to S8 and N1 to N4 in Northern Area
		Scale:	1:15,000 (A4) — Figure No: 2b



Key:

MW S1	Proposed Miniwalls in Fassifern Seam		Extracted Miniwall Panels
XL1	Subsidence Prediction Lines		Seagrass Buffer Zone Limits from Foreshore
	Lake Foreshore		Mapped Extent of Seagrass along Foreshore
	Site Boundary		Depth of Rock Cover (m)
	Wallarah Seam Mine Workings		Normal Fault Zones (Horst & Graben) (Faults have 0.5m to 3m throws unless otherwise noted)
	35o AoD from Foreshore (RL 0 AHD)		

DgS	Engineer:	S.Ditton	Client:	LakeCoal - Chain Valley Colliery CHV-002/11
	Drawn:	S.Ditton		
	Date:	6.12.17	Title:	Estimated Depth to Rock Contours above the Proposed MW S1 to S8 and N1 to N4 in Northern Area
	Ditton Geotechnical Services Pty Ltd		Scale:	1:15,000 (A4)
			Figure No:	2c

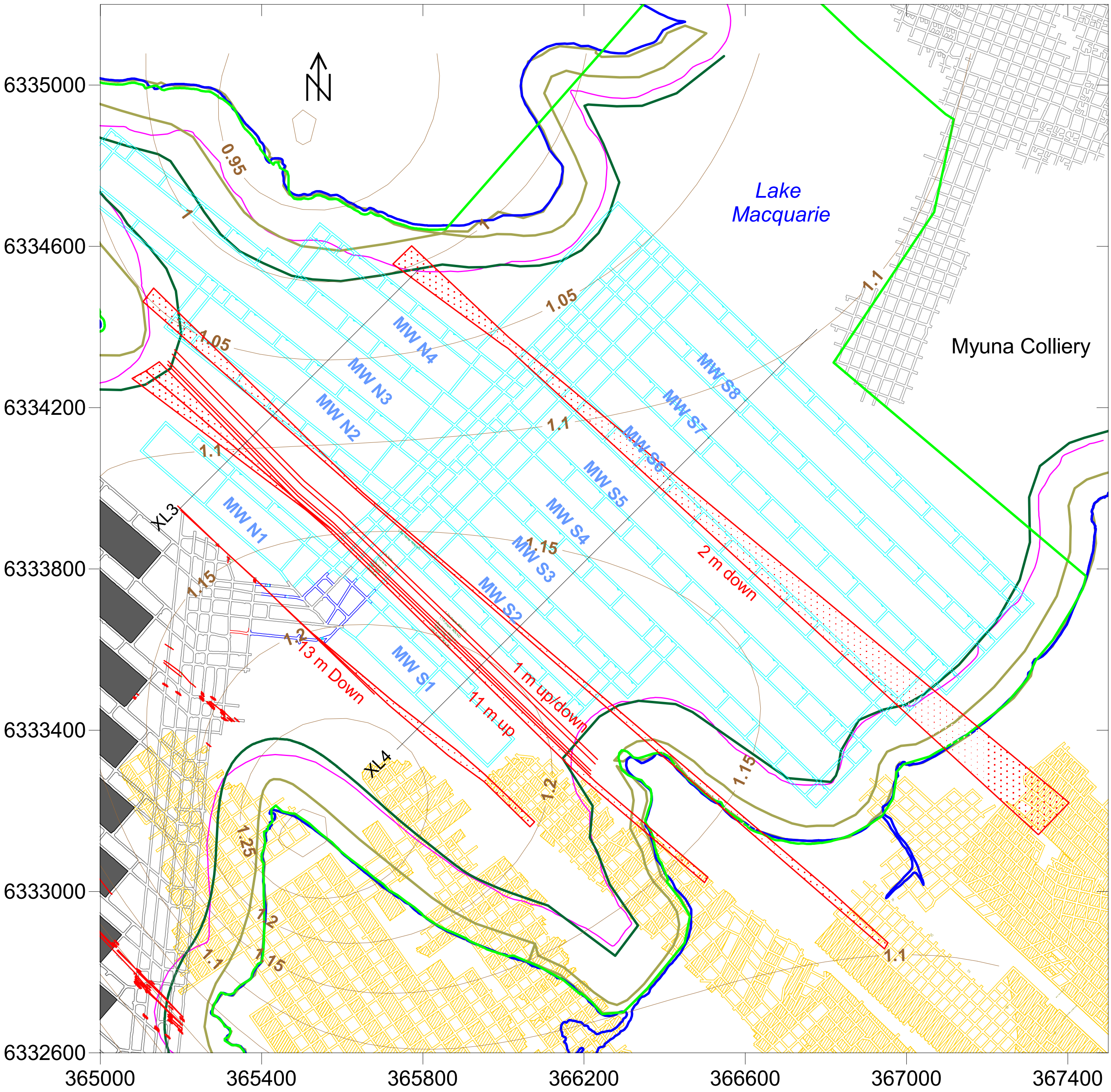


Key:

MW S1	Proposed Miniwalls in Fassifern Seam
XL1	Subsidence Prediction Lines
	Lake Foreshore
	Site Boundary
	Wallarah Seam Mine Workings
	35o AoD from Foreshore (RL 0 AHD)
	Extracted Miniwall Panels
	Seagrass Buffer Zone Limits from Foreshore
	Mapped Extent of Seagrass along Foreshore
	Depth of Rock Cover (m)
	Normal Fault Zones (Horst & Graben) (Faults have 0.5m to 3m throws unless otherwise noted)

DgS	Engineer:	S.Ditton
	Drawn:	S.Ditton
	Date:	6.12.17
Ditton Geotechnical Services Pty Ltd		

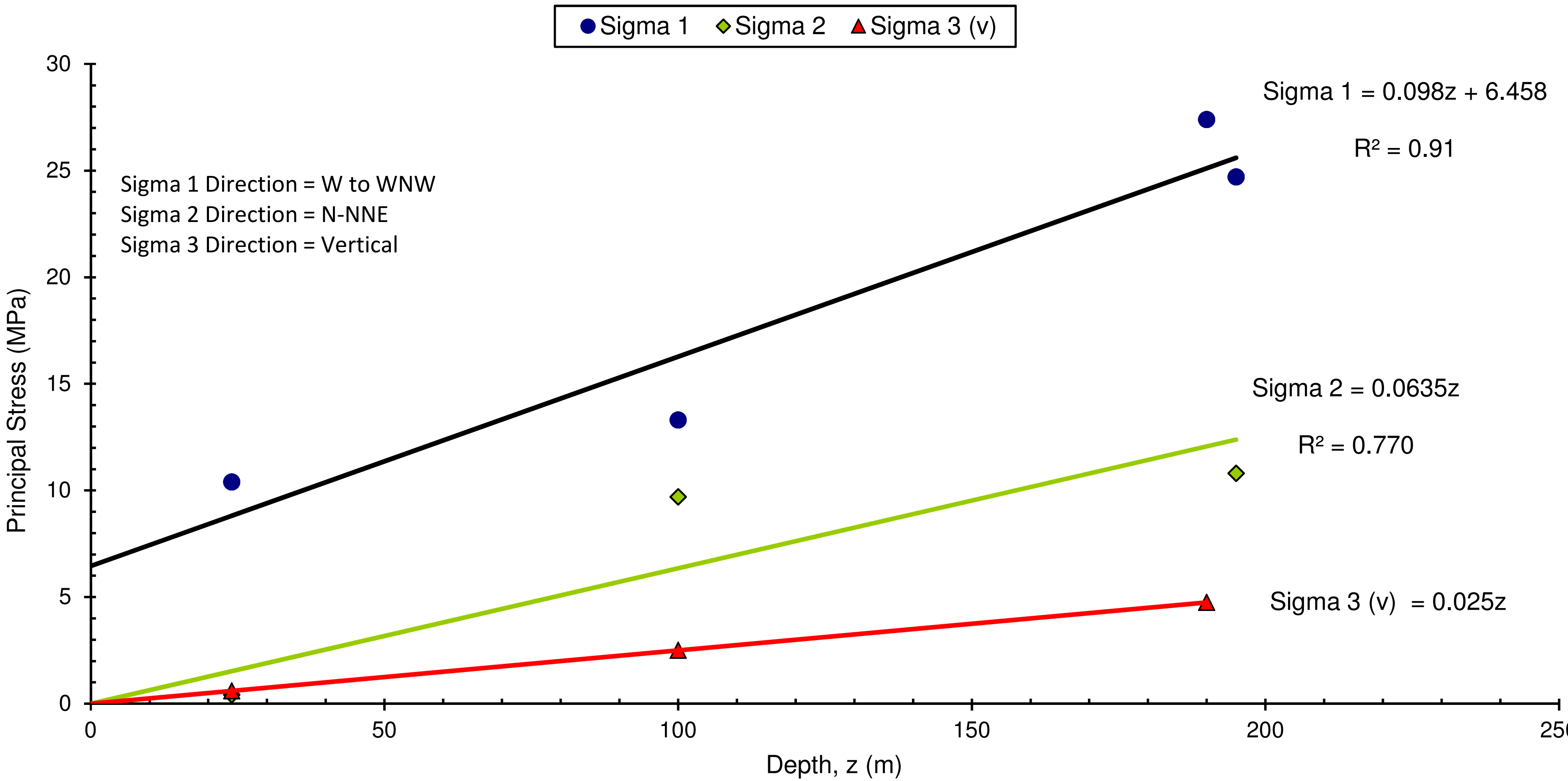
Client:	LakeCoal - Chain Valley Colliery CHV-002/11
Title:	FAS Rock Cover Depth Contours above the Proposed MW S1 to S8 and N1 to N4 in Northern Domain Area
Scale:	1:15,000 (A4)
Figure No:	2d



Key:

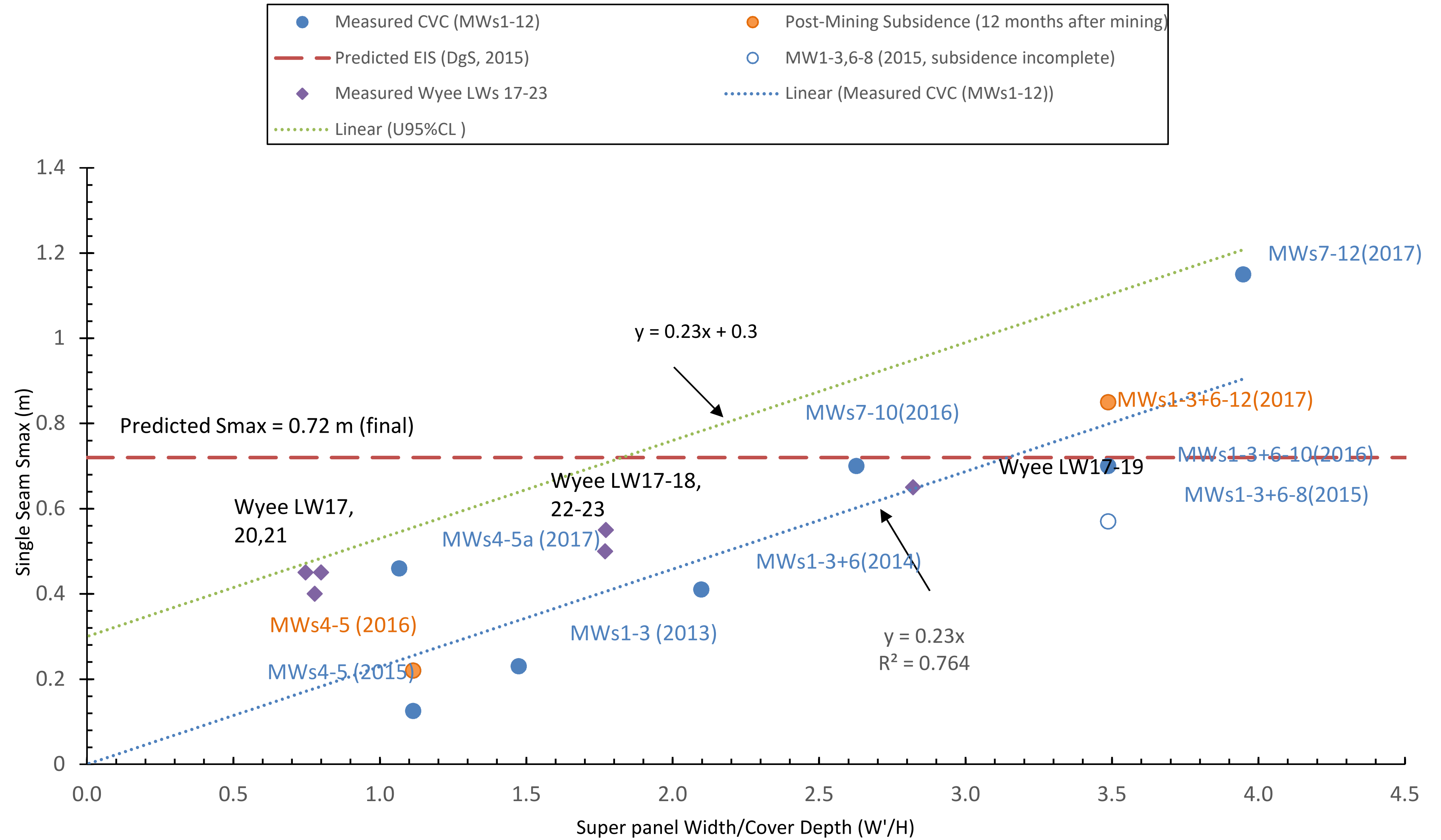
MW S1	Proposed Miniwalls in Fassifern Seam		Extracted Miniwall Panels
XL1	Subsidence Prediction Lines		Seagrass Buffer Zone Limits from Foreshore
	Lake Foreshore		Mapped Extent of Seagrass along foreshore
	Site Boundary		Total FAS Floor Claystone thickness (m)
	Wallarah Seam Mine Workings		Normal Fault Zones (Horst & Graben) (Faults have 0.5m to 3m throws unless otherwise noted)
	35o AoD from Foreshore (RL 0 AHD)		

DgS	Engineer:	S.Ditton	Client:	LakeCoal - Chain Valley Colliery CHV-002/11
	Drawn:	S.Ditton		
	Date:	6.12.17	Title:	FAS Floor Claystone Thickness Contours below the Proposed MW S1 to S8 and N1 to N4 in Northern Area
	Ditton Geotechnical Services Pty Ltd		Scale:	1:15,000 (A4) — Figure No: 2e

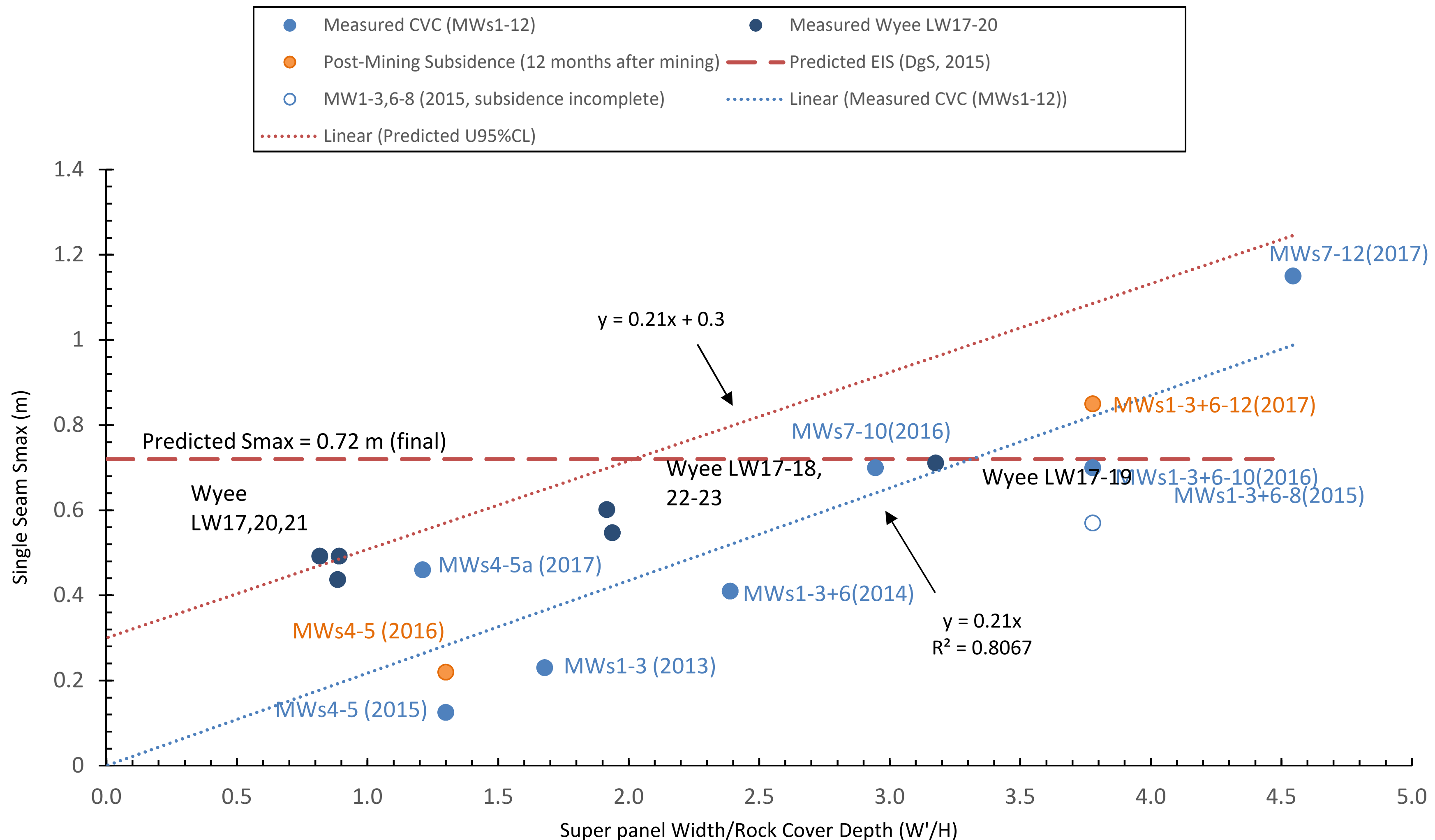


Based on **Lohe and Dean Jones, 1995 & Coffey, 2015**

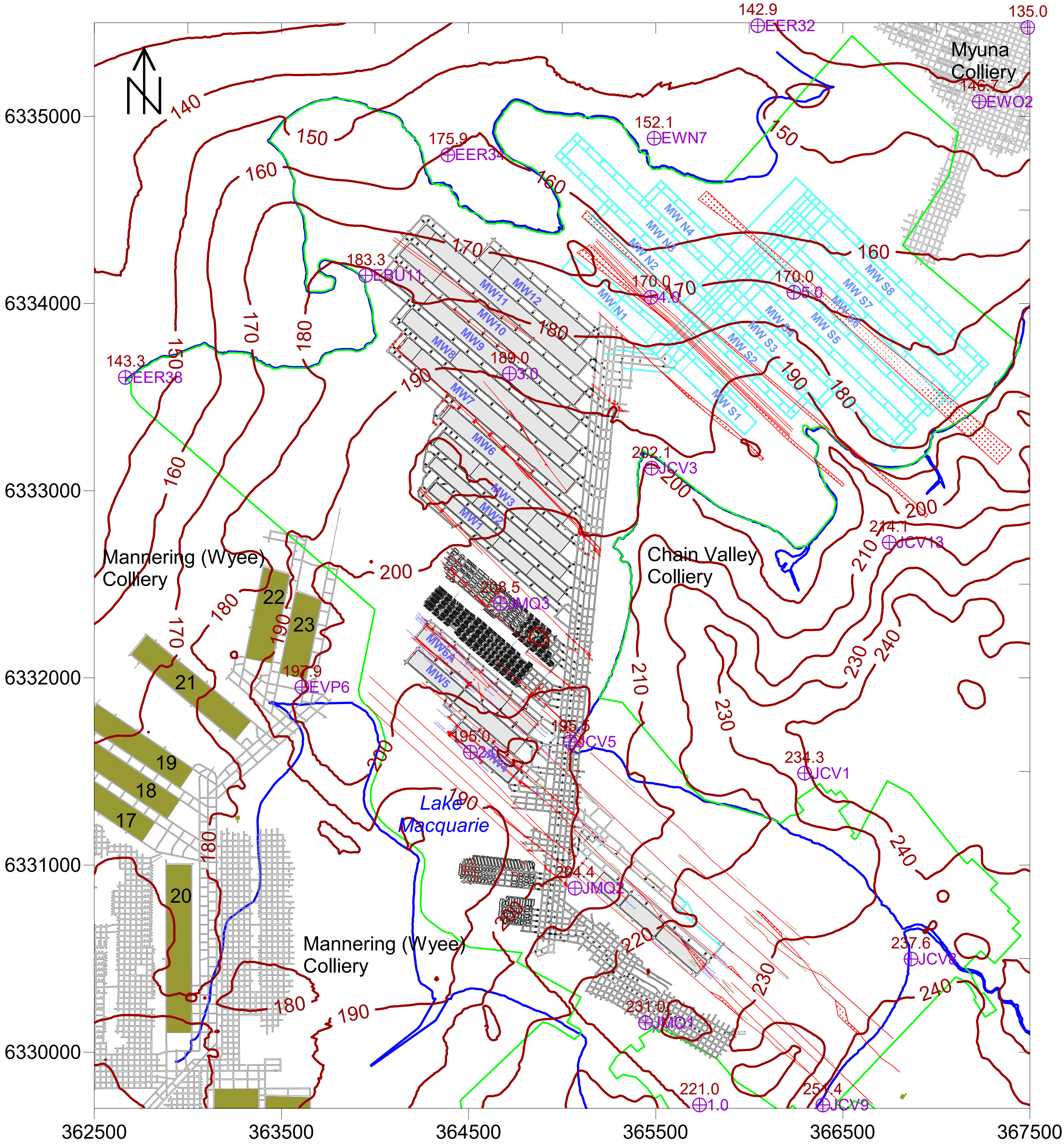
DgS	Engineer:	S.Ditton	Client:	LakeCoal - Chain Valley Colliery CHV-002/11			
	Drawn:	S.Ditton					
	Date:	6.12.17	Title:	Regional Horizontal Stress Field Assumed above Chain Valley Colliery			
	Ditton Geotechnical Services Pty Ltd						
			Scale:	NTS		Figure No:	2f



DgS	Engineer:	S.Ditton	Client:	LakeCoal - Chain Valley Colliery CHV-002/11
	Drawn:	S.Ditton		
	Date:	12.12.17	Title:	Measured Maximum Subsidence over Miniwalls 1 to 12 v. Superpanel Width/Cover Depth Ratios (includes chain pillar effects)
	Ditton Geotechnical Services Pty Ltd		Scale:	NTS
			Figure No:	3a



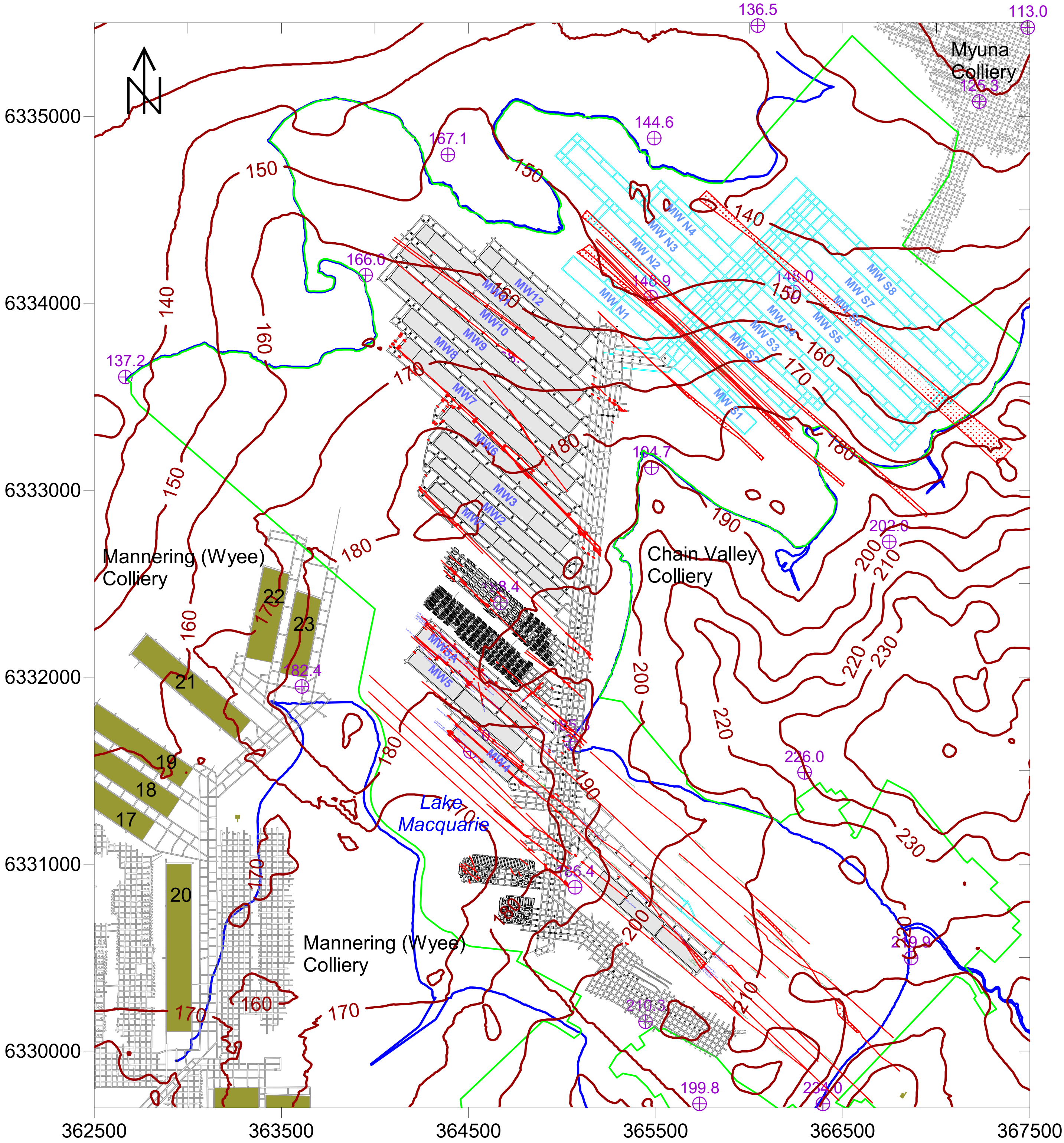
DgS	Engineer:	S.Ditton	Client:	LakeCoal - Chain Valley Colliery CHV-002/11		
	Drawn:	S.Ditton				
	Date:	22.07.17	Title:	Measured Maximum Subsidence over Miniwalls 1 to 12 v. Superpanel Width/Rock Cover Depth Ratios (includes chain pillar effects)		
	Ditton Geotechnical Services Pty Ltd		Scale:	NTS	Figure No:	3b



Key

Modified Mine Workings in Fassifern Seam	Extracted Chain Valley Panels in Fassifern Seam
Existing Mine Workings in Fassifern Seam	Extracted Wyee Panels in Fassifern Seam
Rock Cover Depth Contours (m)	Geological Structure (faults/dykes)
Site Boundary	Lake Foreshore
	Borehole Locations

DgS	Engineer:	S.Ditton	Client:	LakeCoal - Chain Valley Colliery CHV-002/11
	Drawn:	S.Ditton		
	Date:	20.03.15	Title:	Effective Cover Depth Contours (below lake bed) above the Existing & Proposed FAS Mine Workings
	Ditton Geotechnical Services Pty Ltd			
			Scale:	1:12,000 (A4) Figure No: 4a



Key

Modified Mine Workings in Fassifern Seam

Existing Mine Workings in Fassifern Seam

Rock Cover Depth Contours (m)

Site Boundary

Extracted Chain Valley Panels in Fassifern Seam

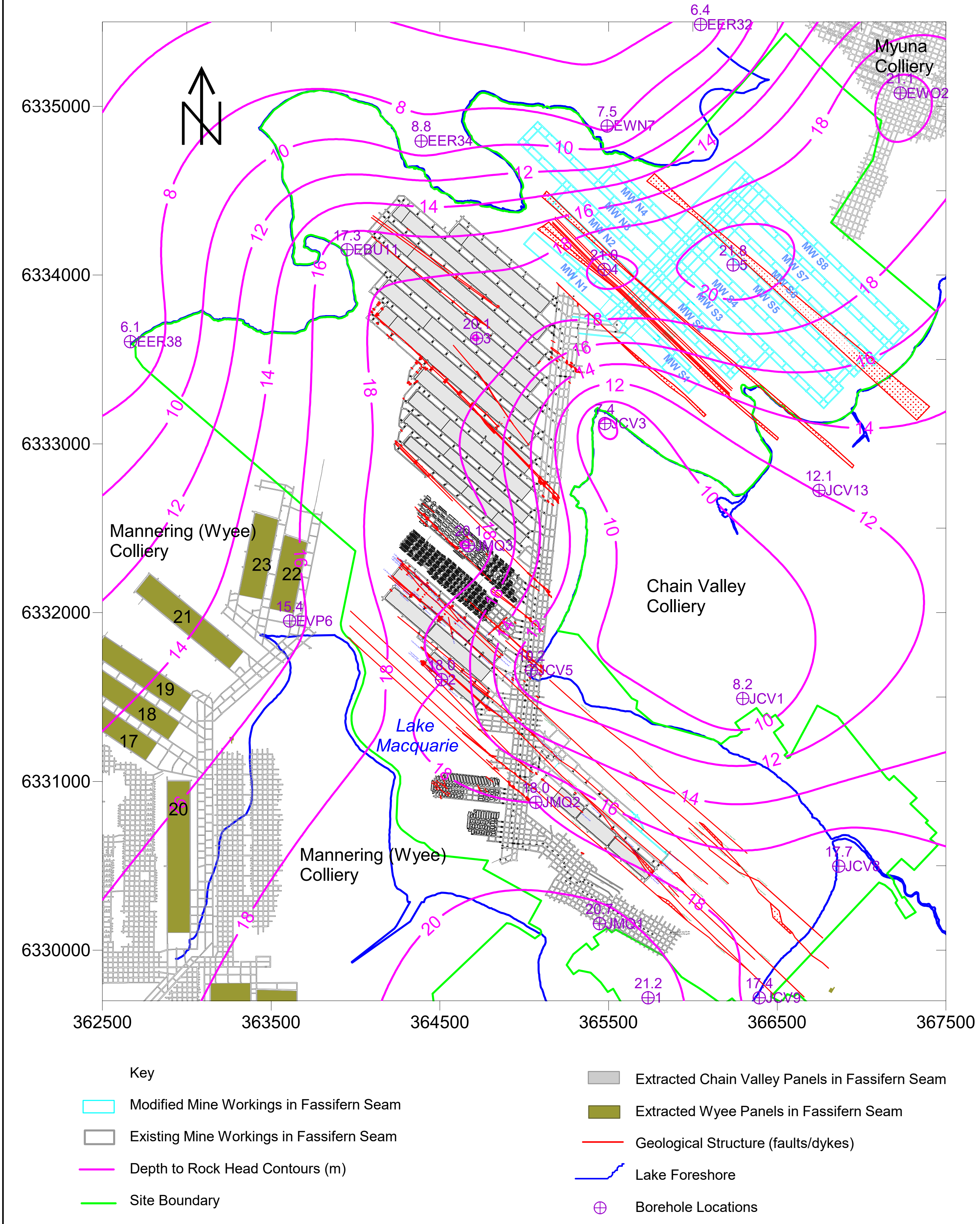
Extracted Wyee Panels in Fassifern Seam

Geological structure (faults/dykes)

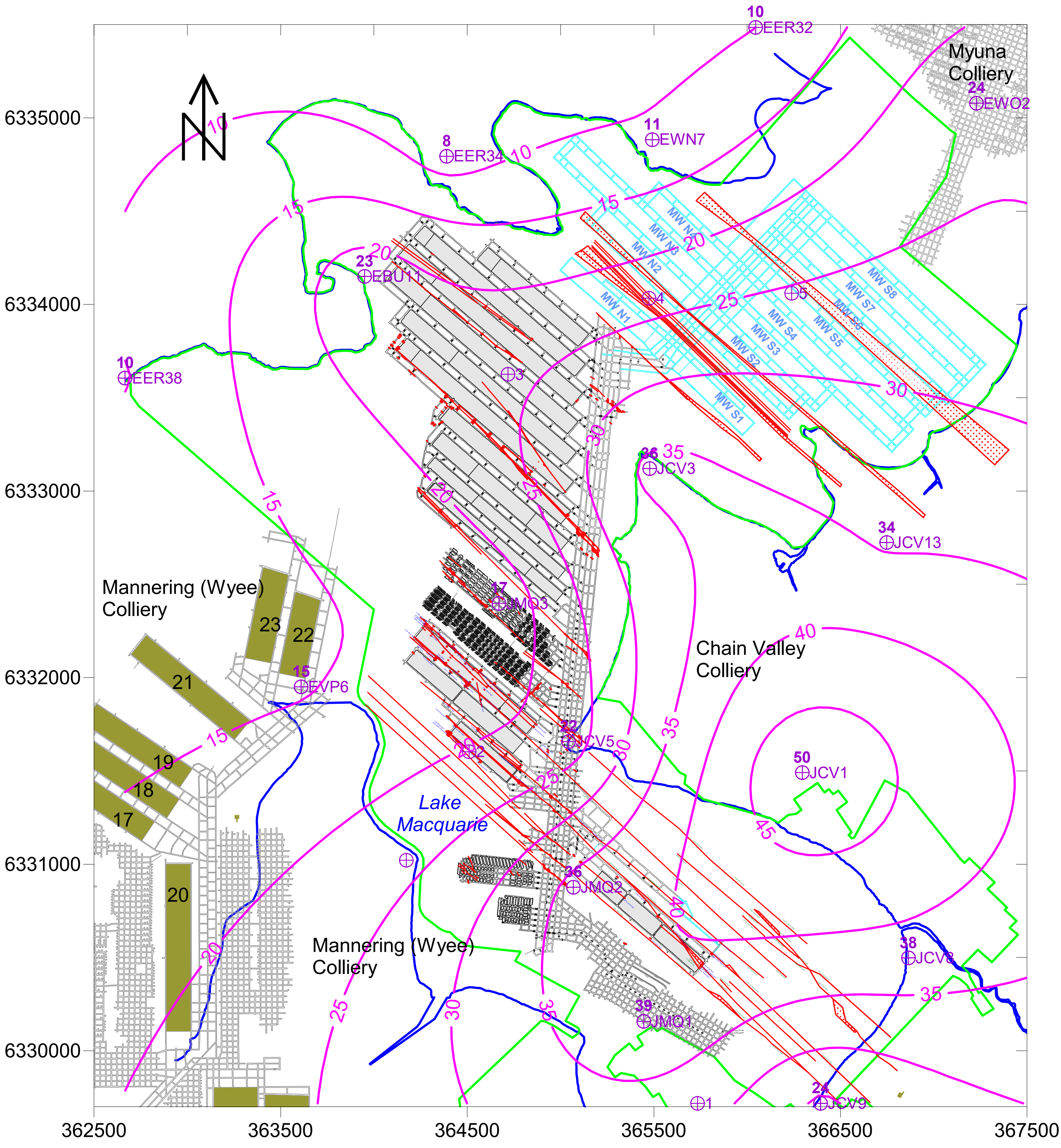
Lake Foreshore

Borehole Locations

DgS	Engineer: S.Ditton	Client:	LakeCoal - Chain Valley Colliery CHV-002/11
	Drawn: S.Ditton	Title:	Rock Cover Depth Contours (below lake bed) above the Existing & Proposed FAS Mine Workings
Ditton Geotechnical Services Pty Ltd	Date: 20.03.15	Scale:	1:12,000 (A4) — Figure No: 4b



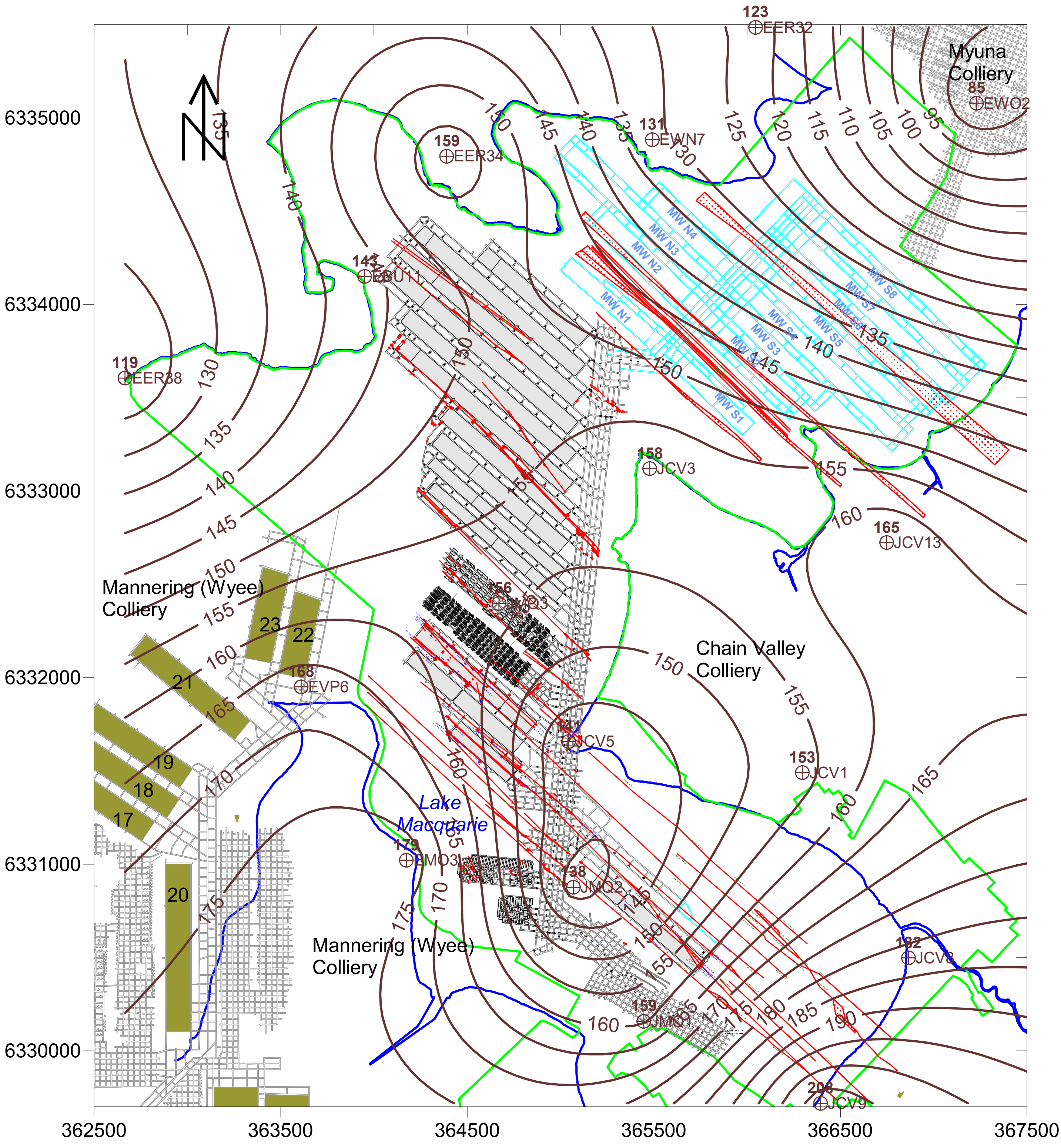
DgS	Engineer:	S.Ditton	Client:	LakeCoal - Chain Valley Colliery CHV-002/11
	Drawn:	S.Ditton		
	Date:	12.01.17	Title:	Depth to Rock Head Contours above the Existing & Proposed FAS Mine Workings
	Ditton Geotechnical Services Pty Ltd			
			Scale:	1:12,000 (A4)
			Figure No:	4c



Key

- Modified Mine Workings in Fassifern Seam
- Existing Mine Workings in Fassifern Seam
- Parameter Contours (m)
- Site Boundary
- Extracted Chain Valley Panels in Fassifern Seam
- Extracted Wyee Panels in Fassifern Seam
- Geological Structure (faults/dykes)
- Lake Foreshore
- Borehole Locations

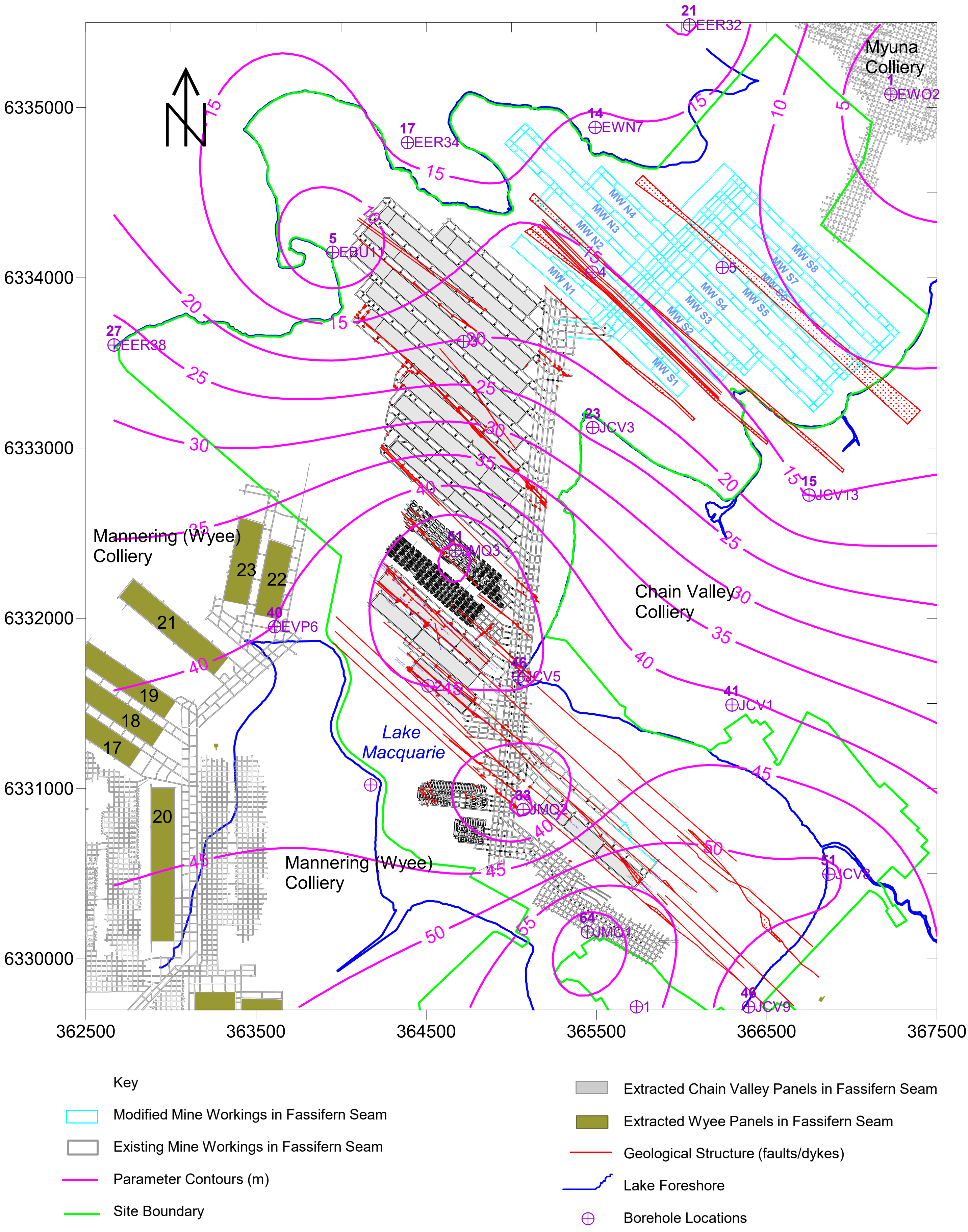
Engineer:	S.Ditton	Client:	LakeCoal - Chain Valley Colliery CHV-002/11
Drawn:	S.Ditton		
Date:	12.01.17	Title:	Munmorah (Upper) Conglomerate Thickness Contours above the Existing & Proposed FAS Mine Workings
Ditton Geotechnical Services Pty Ltd		Scale:	1:12,000 (A4)
		Figure No:	4d



Key

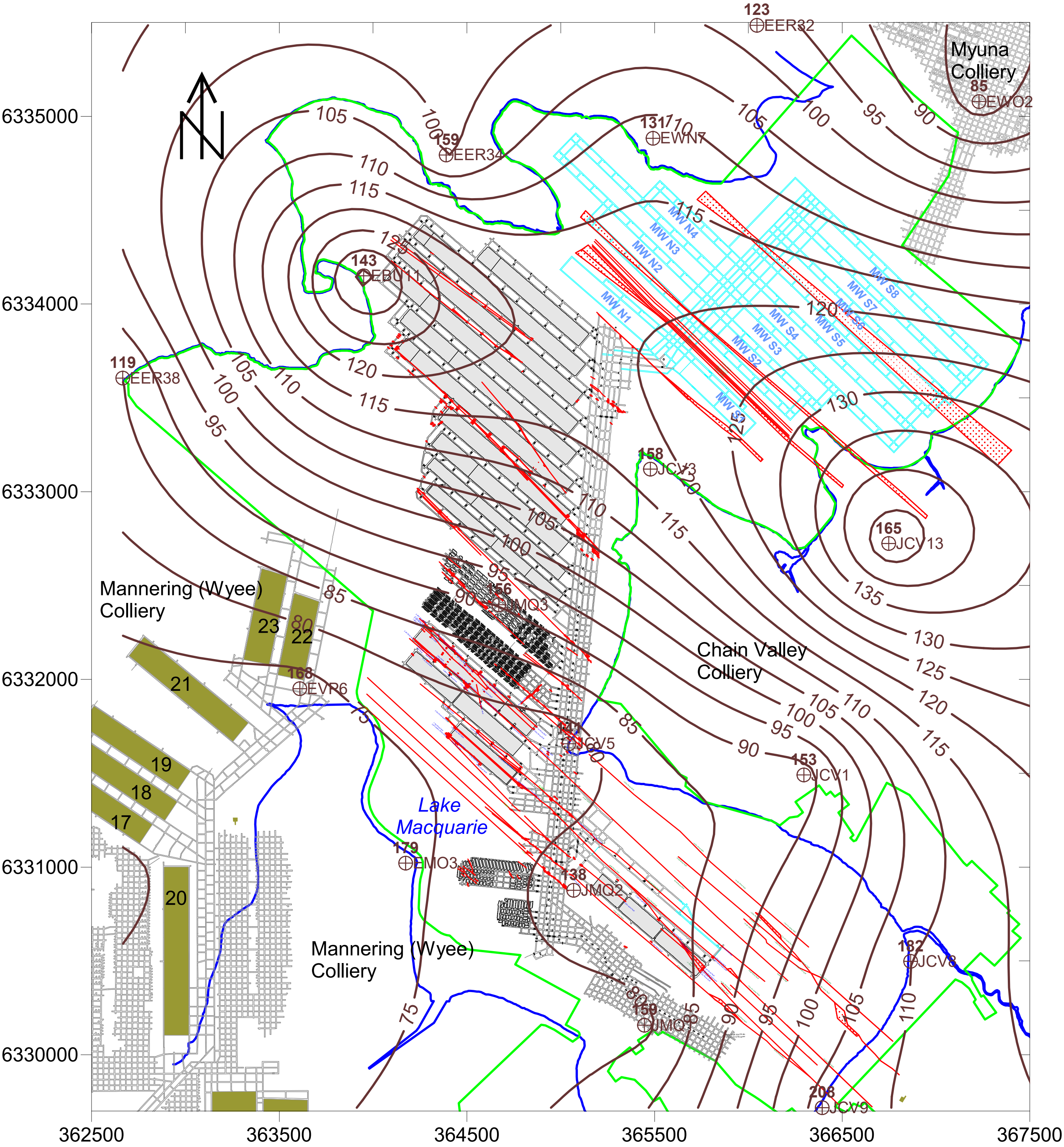
Modified Mine Workings in Fassifern Seam	Extracted Chain Valley Panels in Fassifern Seam
Existing Mine Workings in Fassifern Seam	Extracted Wyee Panels in Fassifern Seam
Parameter Contours (m)	Geological Structure (faults/dykes)
CVC Project Boundary	Lake Foreshore
	Borehole Locations

DgS Ditton Geotechnical Services Pty Ltd	Engineer: S.Ditton		Client:	LakeCoal - Chain Valley Colliery CHV-002/11
	Drawn: S.Ditton			
	Date: 12.01.17		Title:	Interburden Thickness Contours between the Munmorah Conglomerate (Upper) and the Existing & Proposed FAS Mine Workings
			Scale:	1:12,000 (A4) — Figure No: 4e



DgS

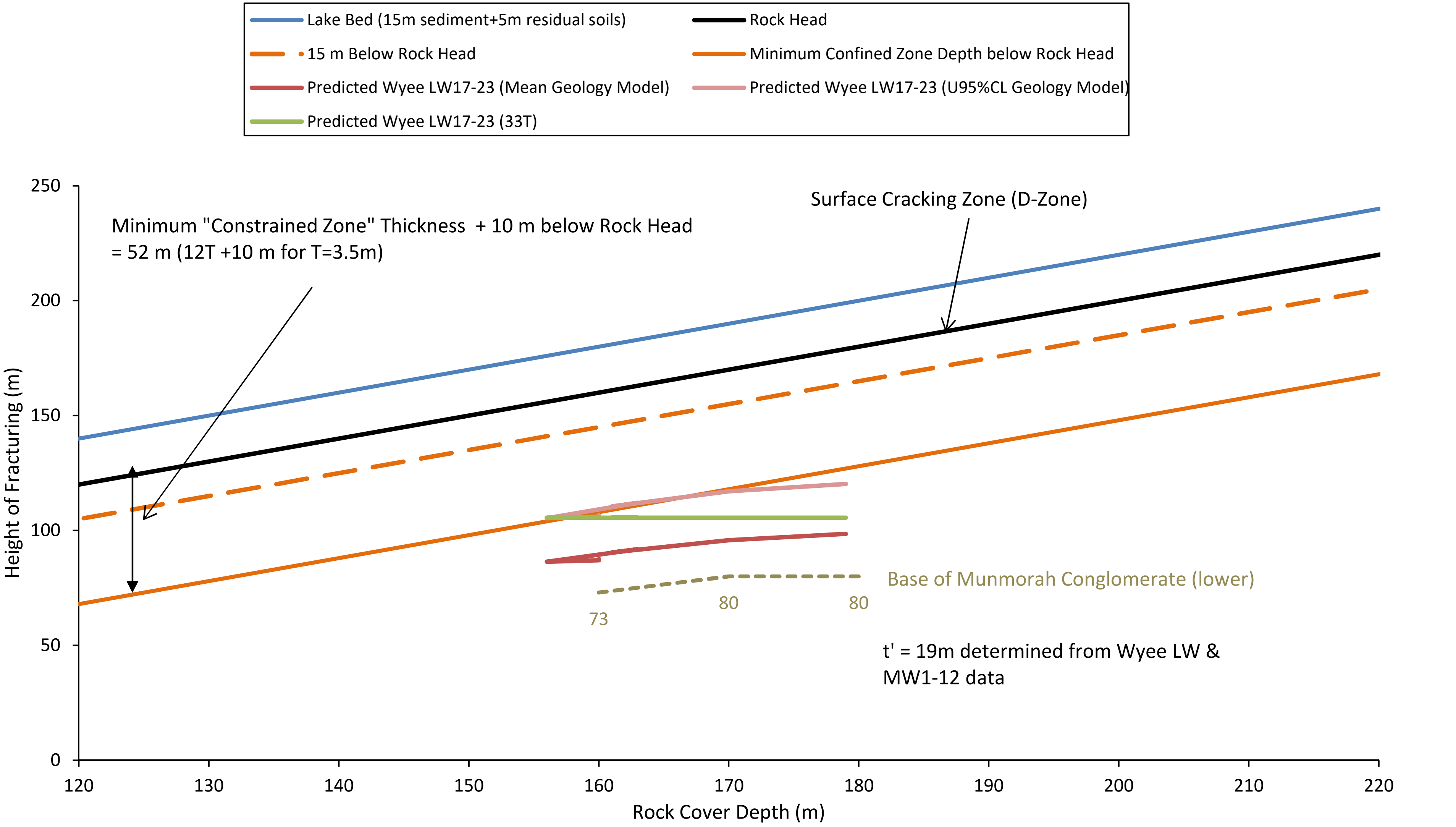
Engineer:	S.Ditton	Client:	LakeCoal - Chain Valley Colliery CHV-002/11
Drawn:	S.Ditton		
Date:	12.01.17	Title:	Munmorah (Lower) Conglomerate Thickness Contours above the Existing & Proposed FAS Mine Workings
Ditton Geotechnical Services Pty Ltd		Scale:	1:12,000 (A4)
		Figure No:	4f



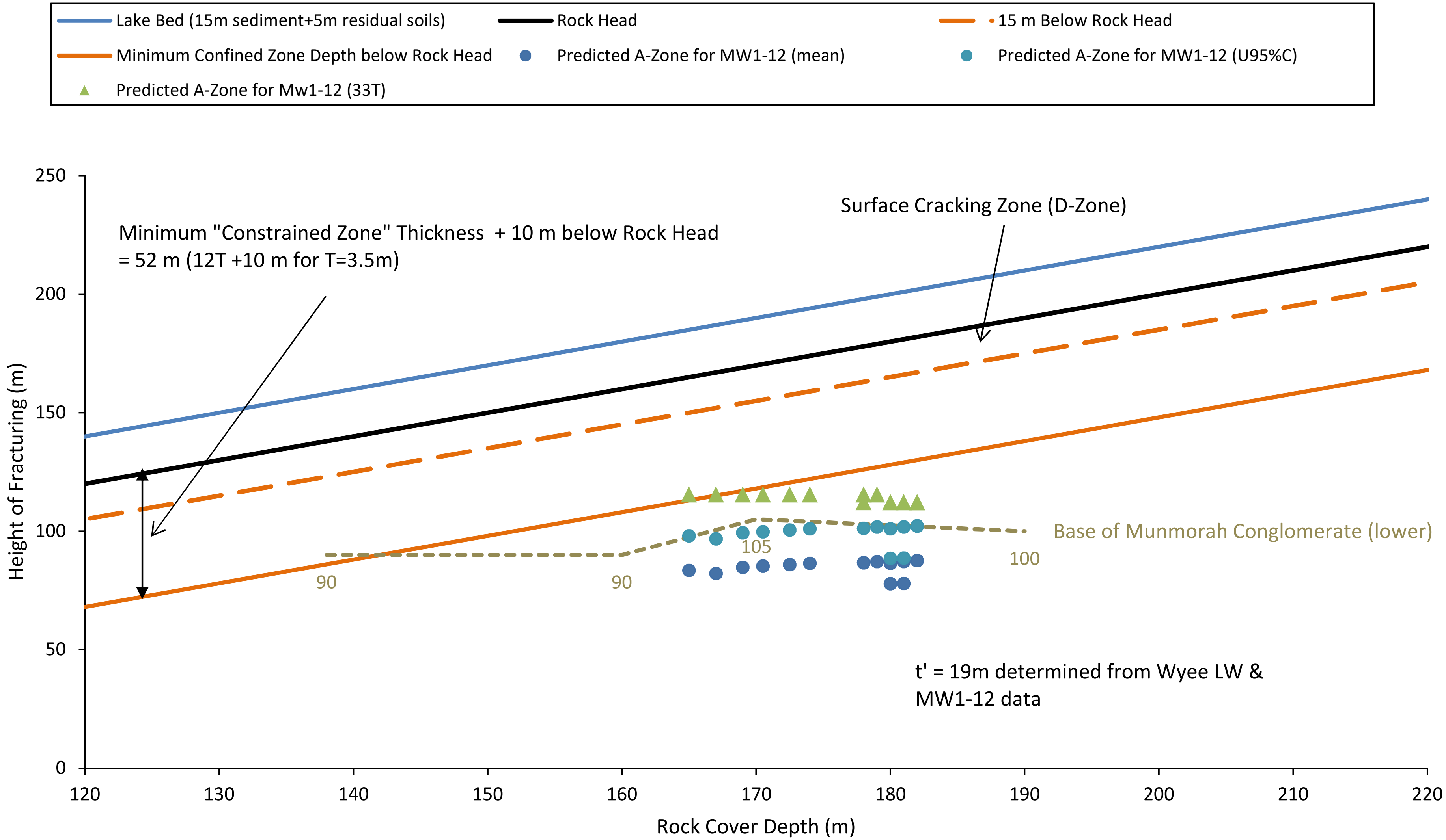
Key

- Modified Mine Workings in Fassifern Seam
- Existing Mine Workings in Fassifern Seam
- Parameter Contours (m)
- Site Boundary
- Extracted Chain Valley Panels in Fassifern Seam
- Extracted Wyee Panels in Fassifern Seam
- Geological Structure (faults/dykes)
- Lake Foreshore
- Borehole Locations

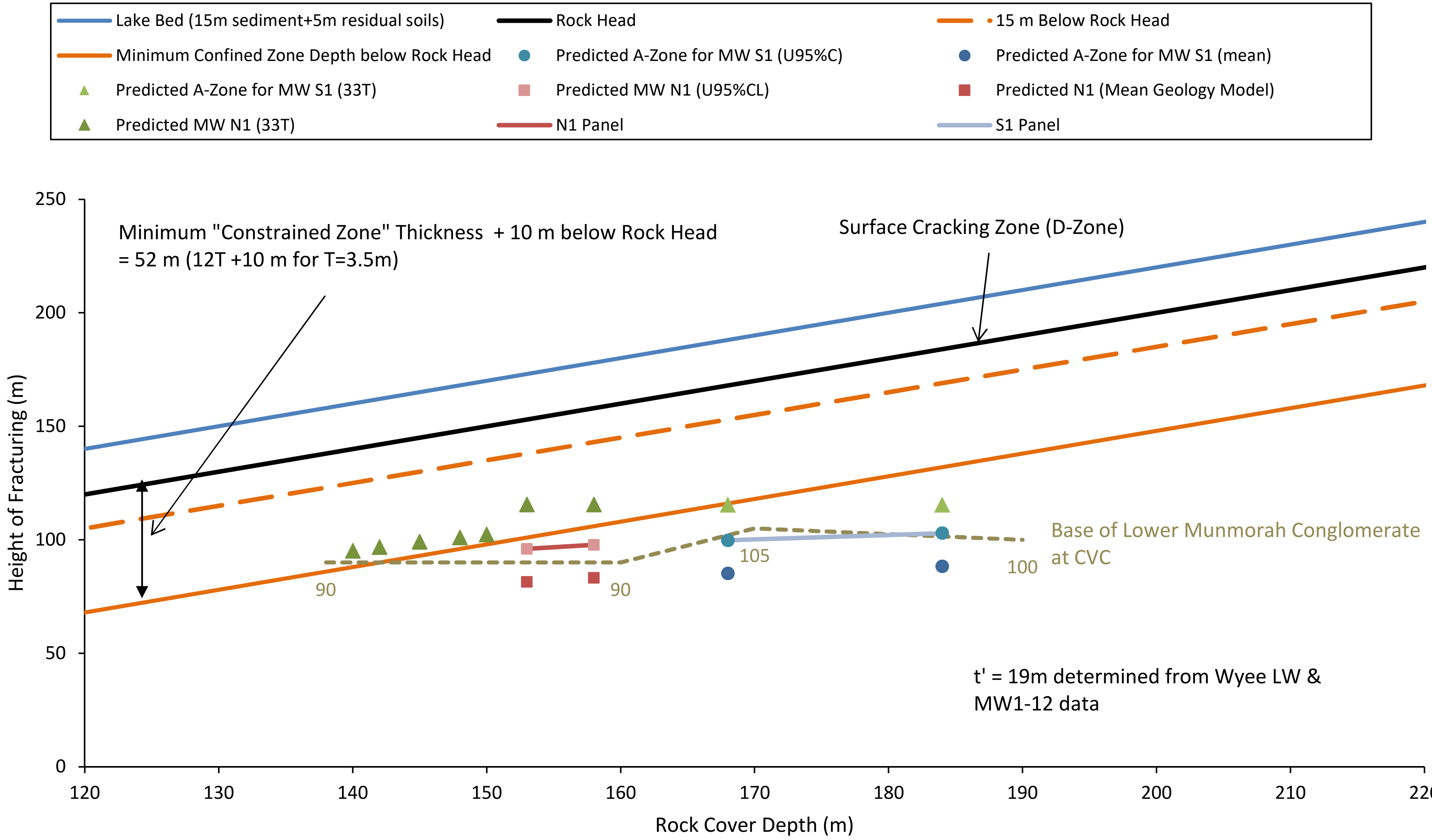
DgS	Engineer:	S.Ditton	Client:	LakeCoal - Chain Valley Colliery CHV-002/11
	Drawn:	S.Ditton		
	Date:	12.01.17	Title:	Distance to Munmorah (Lower) Conglomerate Contours above the Existing & Proposed FAS Mine Workings
	Ditton Geotechnical Services Pty Ltd			
			Scale:	1:12,000 (A4) Figure No: 4g



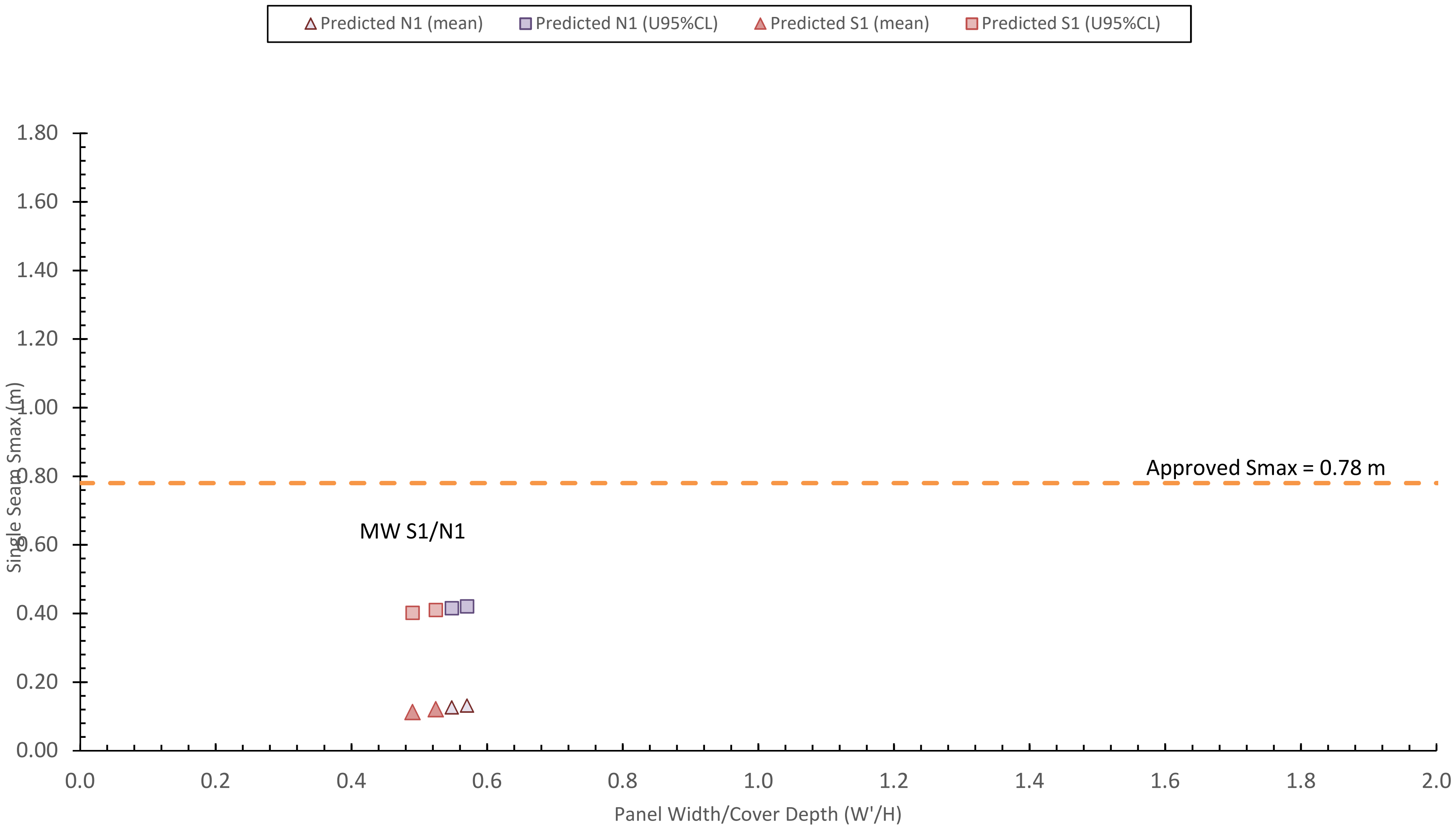
DgS	Engineer:	S.Ditton	Client:	LakeCoal - Chain Valley Colliery		
	Drawn:	S.Ditton		CHV-002/11		
	Date:	20.03.15	Title:	Continuous (A-Zone) Sub-Surface Fracture Heights and Constrained Zone Thickness above Wyee LW17-23 in the Fassifern Seam (Sub-critical panels)		
	Ditton Geotechnical Services Pty Ltd		Scale:	NTS	Figure No:	5a



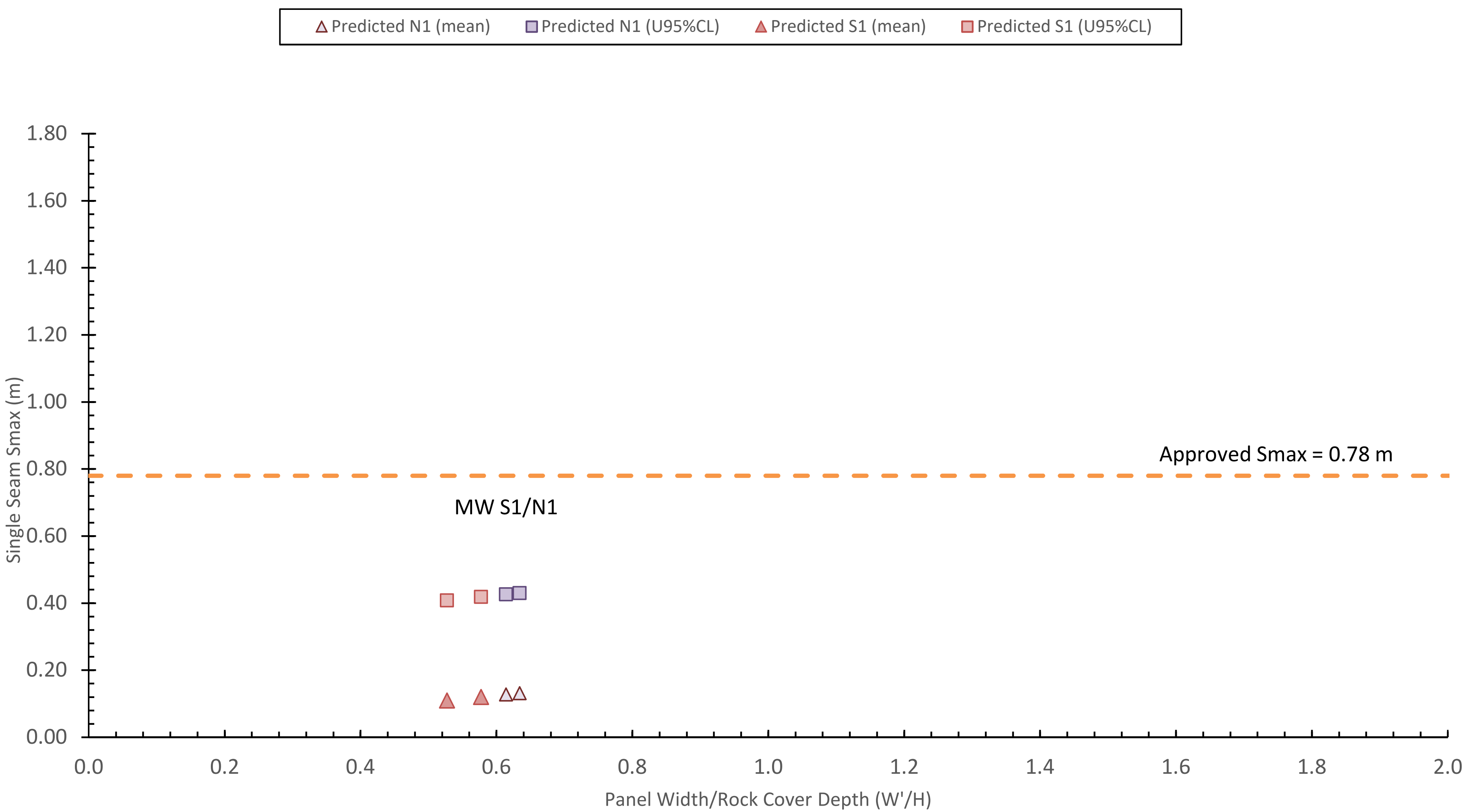
DgS	Engineer: S.Ditton	Client:	LakeCoal - Chain Valley Colliery	
	Drawn: S.Ditton		CHV-002/11	
	Date: 20.03.15	Title:	Continuous (A-Zone) Sub-Surface Fracture Heights and Constrained Zone Thickness above MW1 to 12 in the Fassifern Seam (Sub-critical Panels)	
	Ditton Geotechnical Services Pty Ltd	Scale:	NTS	Figure No: 5b



DgS	Engineer:	S.Ditton	Client:	LakeCoal - Chain Valley Colliery		
	Drawn:	S.Ditton		CHV-002/11		
	Date:	06.01.18	Title:	Continuous (A-Zone) Sub-Surface Fracture Heights and Constrained Zone Thickness		
	Ditton Geotechnical			above MW N1 and S1 in the Fassifern Seam (Sub-critical)		
	Services Pty Ltd		Scale:	NTS	Figure No:	6

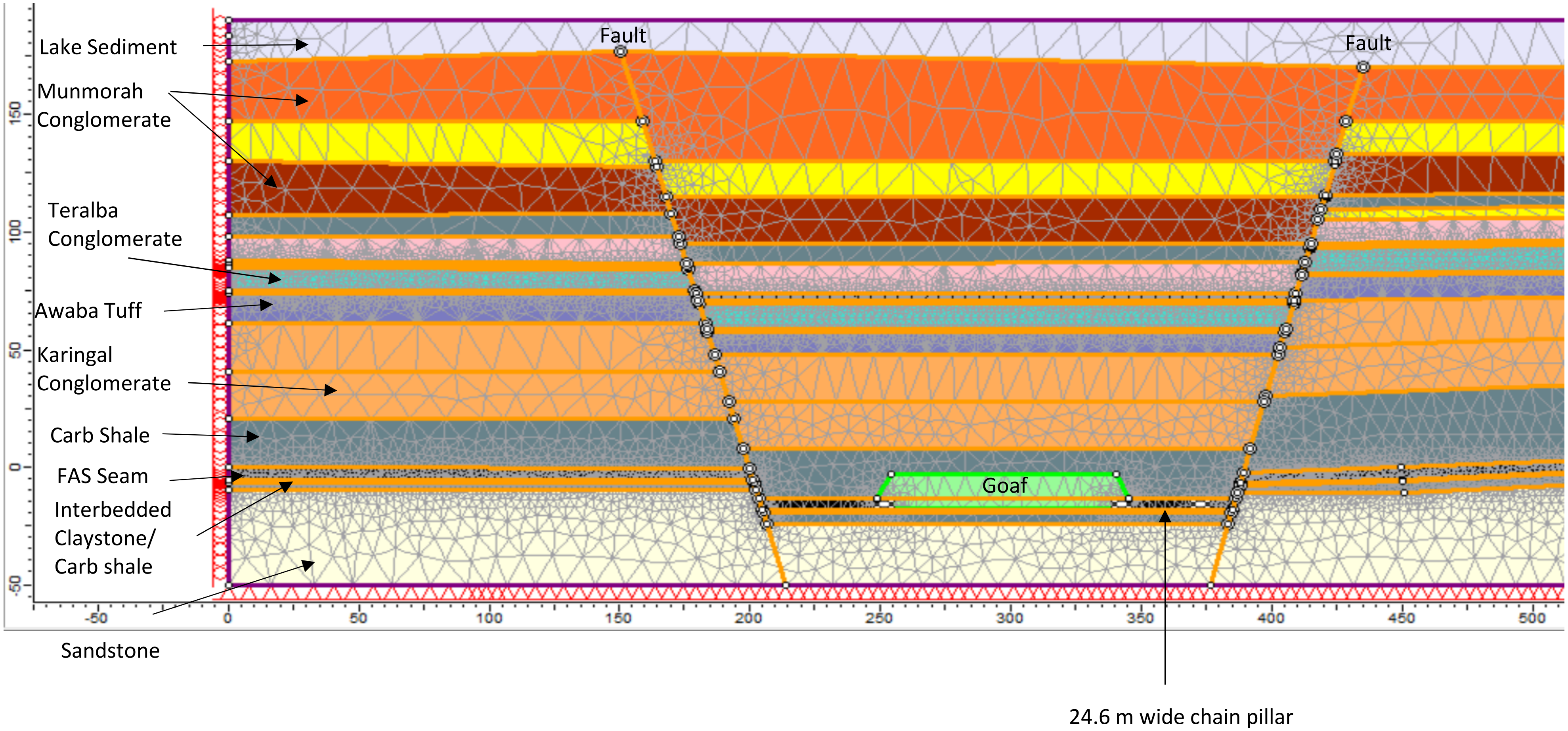


DgS	Engineer:	S.Ditton	Client:	LakeCoal - Chain Valley Colliery CHV-002/11
	Drawn:	S.Ditton		
	Date:	12.12.17	Title:	Predicted Maximum Subsidence over Proposed Miniwalls N1 & S1 versus Panel Width/Cover Depth Ratios (based on total cover)
	Ditton Geotechnical Services Pty Ltd		Scale:	NTS
			Figure No:	7a



Engineer:	S.Ditton	Client:	LakeCoal - Chain Valley Colliery CHV-002/11
Drawn:	S.Ditton		
Date:	12.12.17	Title:	Predicted Maximum Subsidence over Proposed Miniwalls N1 & S1 versus Panel Width/Cover Depth Ratios (based on rock cover)
Ditton Geotechnical Services Pty Ltd		Scale:	NTS
		Figure No:	7b

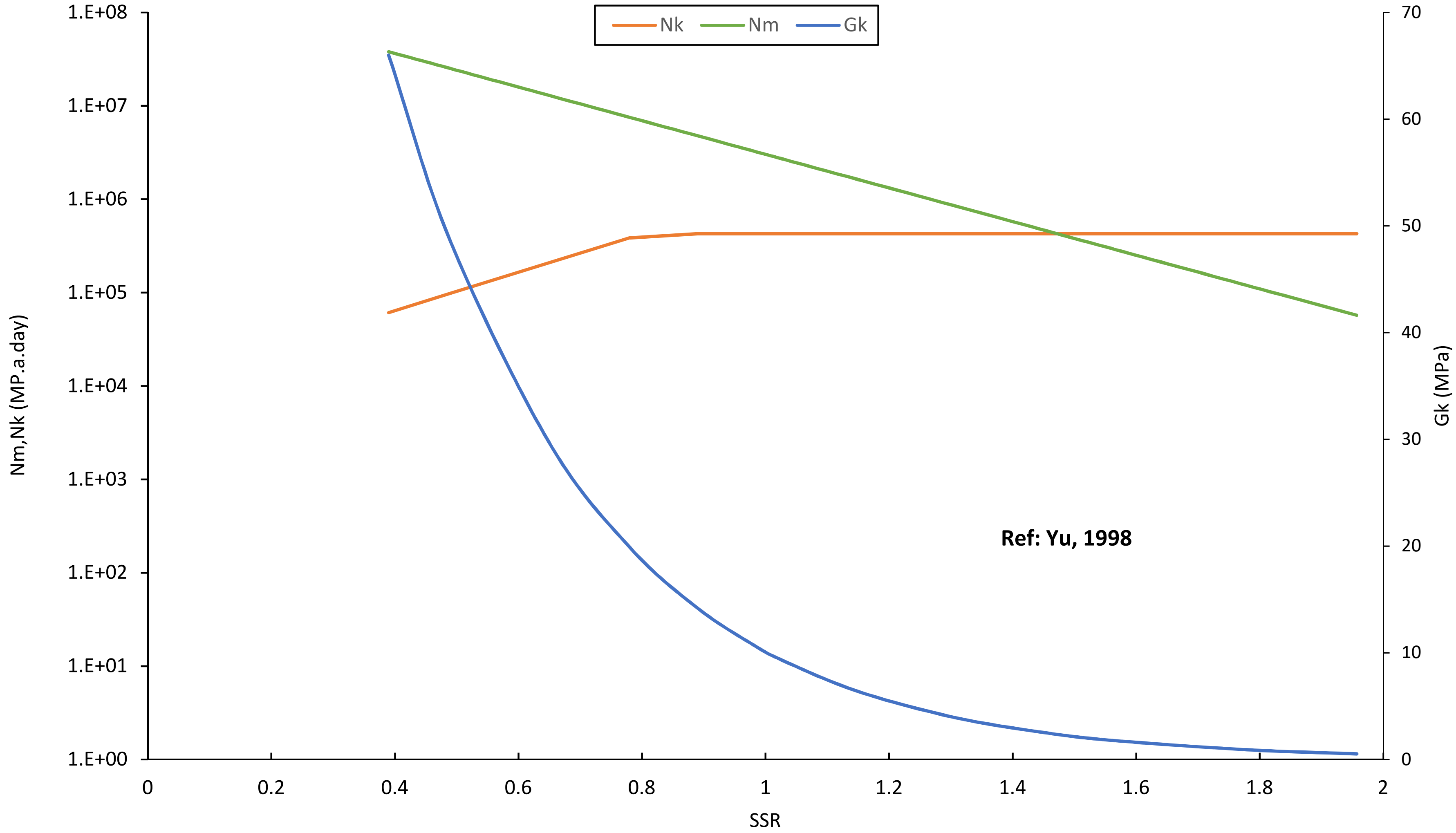
DgS



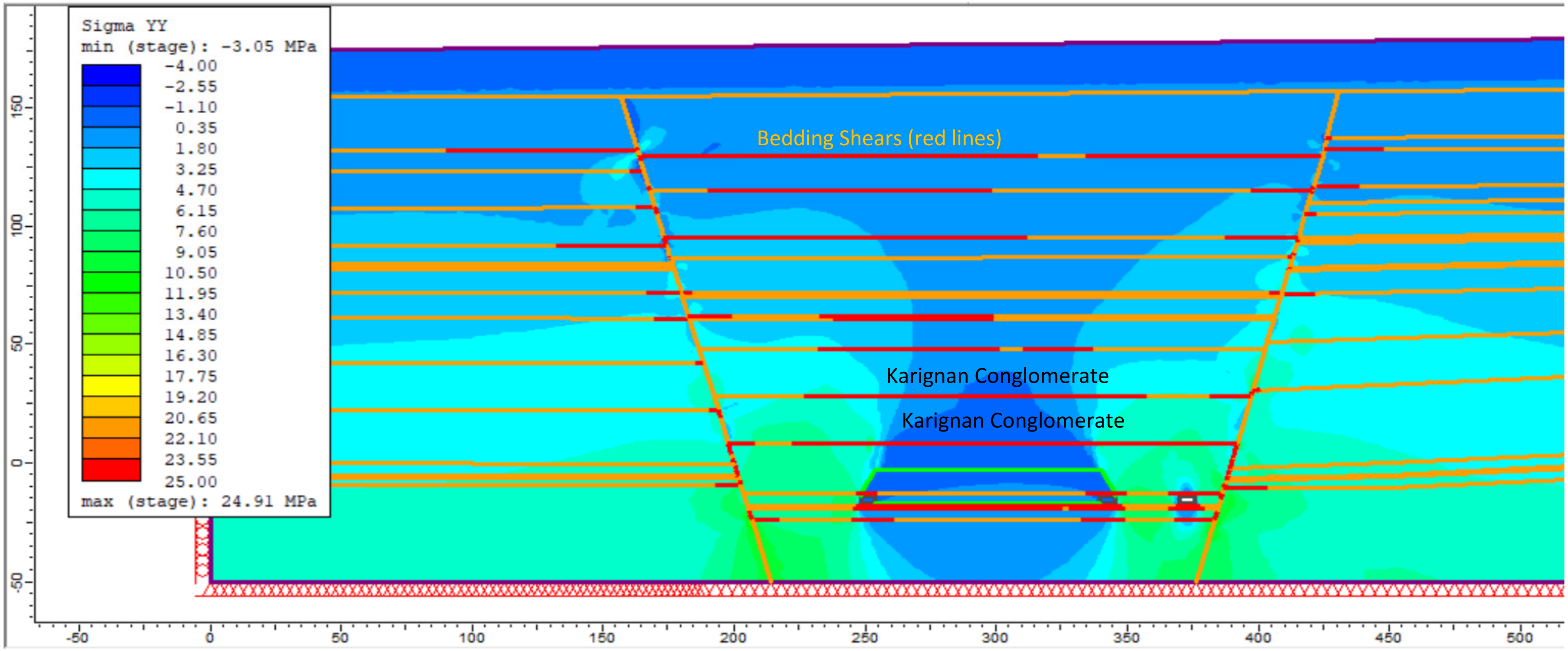
DgS	Engineer:	S.Ditton	Client:	LakeCoal - Chain Valley Colliery CHV-002/11		
	Drawn:	S.Ditton				
	Date:	27.03.18	Title:	RS2 Model Layers, structure and mesh elements for Miniwall N1 along XL3		
	Ditton Geotechnical Services Pty Ltd					
			Scale:	NTS	Figure No:	8a

Material Name	Color	Initial Element Loading	Unit Weight (MN/m3)	Elastic Type	Young's Modulus (MPa)	Young's Modulus (res) (MPa)	Poisson's Ratio	Failure Criterion	Material Type	Tensile Strength (MPa)	Tensile Strength (res) (MPa)	Dilation Angle (deg)	Friction Angle (peak) (deg)	Friction Angle (res) (deg)	Cohesion (peak) (MPa)	Cohesion (res) (MPa)	Jointed?	Properties Staged?	Piezo Line	Ru
Sediment		Field Stress and Body Force	0.02	Isotropic	10		0.3	Mohr Coulomb	Elastic	0			20		0		No		None	0
Karigan Conglomerate		Field Stress and Body Force	0.025	Isotropic	12000		0.25	Mohr Coulomb	Plastic	2	0	5	45	35	8.28	0.828	No		None	0
Wallarah Seam		Field Stress and Body Force	0.014	Isotropic	1500		0.25	Mohr Coulomb	Plastic	1.42	0	5	35	25	7.4	0.74	No		None	0
Teralba Conglomerate		Field Stress and Body Force	0.025	Isotropic	12000		0.25	Mohr Coulomb	Plastic	2	0	5	45	35	12.4	1.24	No		None	0
Great Northern Seam		Field Stress and Body Force	0.014	Isotropic	1500		0.25	Mohr Coulomb	Plastic	1.42	0	5	35	25	7.4	0.74	No		None	0
Karingal Conglomerate		Field Stress and Body Force	0.025	Isotropic	12000		0.25	Mohr Coulomb	Plastic	2	0	5	45	35	8.28	0.828	No		None	0
Fassifern Seam		Field Stress and Body Force	0.014	Isotropic	1500		0.25	Mohr Coulomb	Plastic	1.42	0	5	35	25	7.4	0.74	No		None	0
Claystone		Field Stress and Body Force	0.022	Isotropic	100		0.35	Mohr Coulomb	Plastic	0	0	2	20	10	0.577	0.057	No		None	0
Munmorah Conglomerate Beam 2		Field Stress and Body Force	0.025	Isotropic	12000		0.25	Mohr Coulomb	Plastic	2	0	5	45	35	12.4	1.24	No		None	0
Sandstone		Field Stress and Body Force	0.025	Isotropic	3000		0.25	Mohr Coulomb	Plastic	1.5	0	5	35	25	7.8	0.585	No		None	0
Awaba Tuff		Field Stress and Body Force	0.025	Isotropic	3000		0.25	Mohr Coulomb	Plastic	1.5	0	5	35	25	7.8	0.78	No		None	0
Goaf		Body Force Only	0.025	Isotropic	10		0.35	Mohr Coulomb	Elastic	0			30		0		No		None	0
Lower Sandstone		Field Stress and Body Force	0.027	Isotropic	4500		0.25	Mohr Coulomb	Plastic	2	0	5	35	25	10.4	1.04	No		None	0

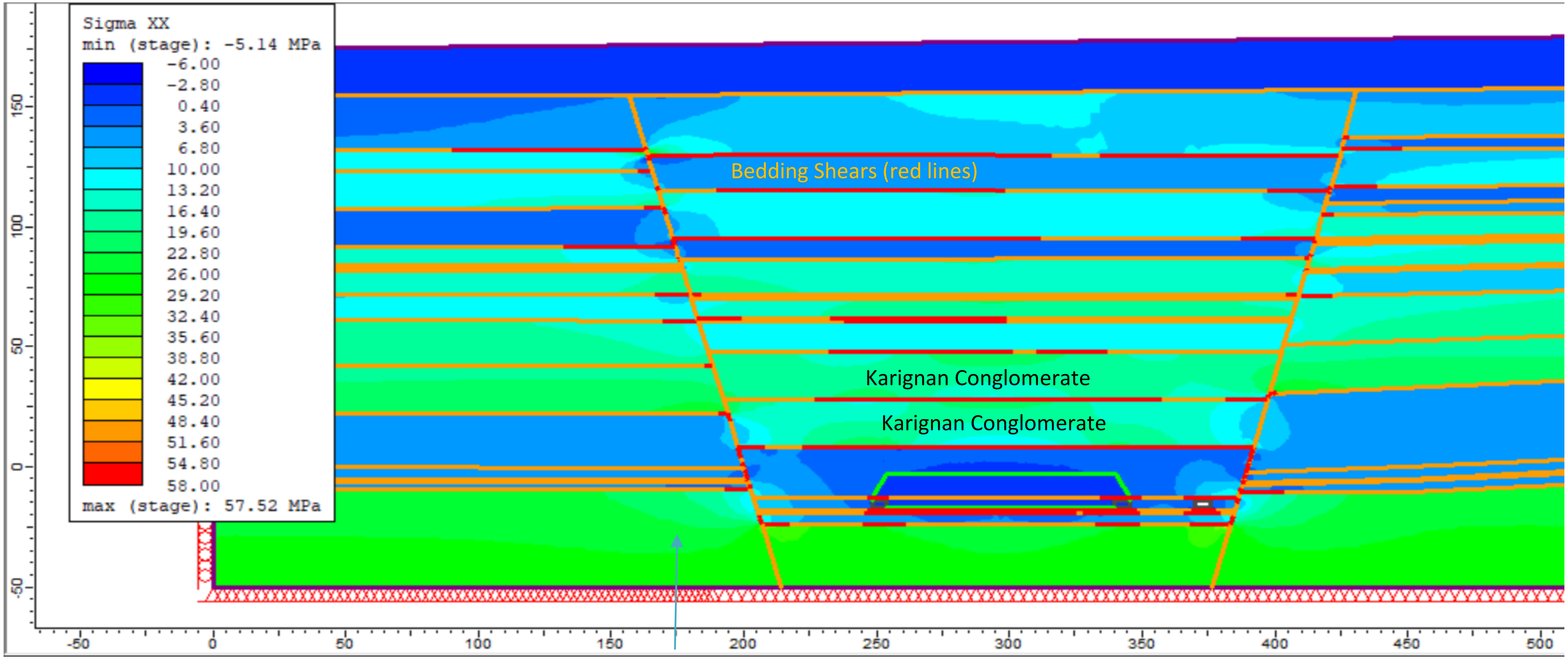
Engineer:	S.Ditton	Client:	LakeCoal - Chain Valley Colliery CHV-002/11
Drawn:	S.Ditton	Title:	RS2 Model Input Parameters for Rockmass
Date:	27.03.18	Scale:	NTS
Ditton Geotechnical Services Pty Ltd		Figure No:	8b



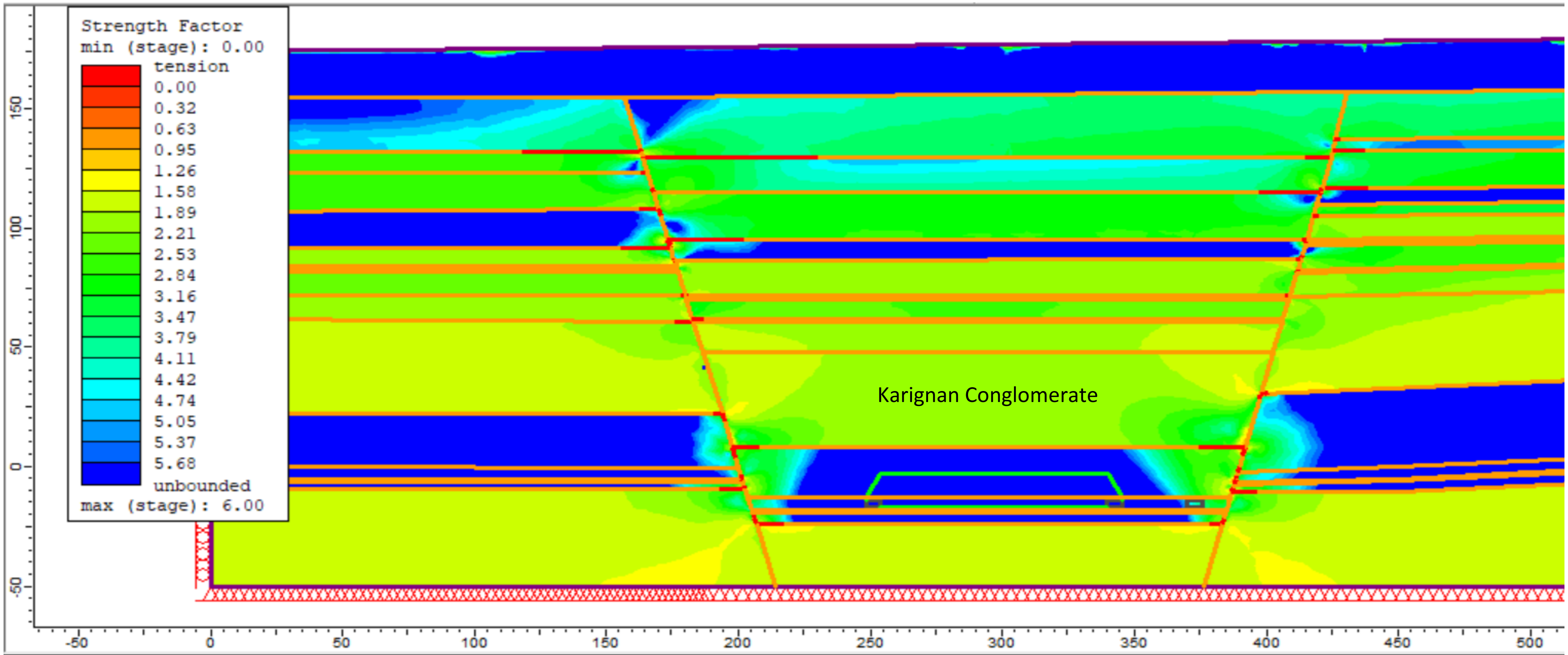
DgS	Engineer:	S.Ditton	Client:	LakeCoal - Chain Valley Colliery CHV-002/11a		
	Drawn:	S.Ditton				
	Date:	27.03.18	Title:	Creep Model Parameters (based on Triaxial Creep Tests on Bentonite-Cement-Water Cylinders with UCS = 1 Mpa and Modulus of 300 Mpa)		
	Ditton Geotechnical Services Pty Ltd		Scale:	NTS	Figure No:	8c



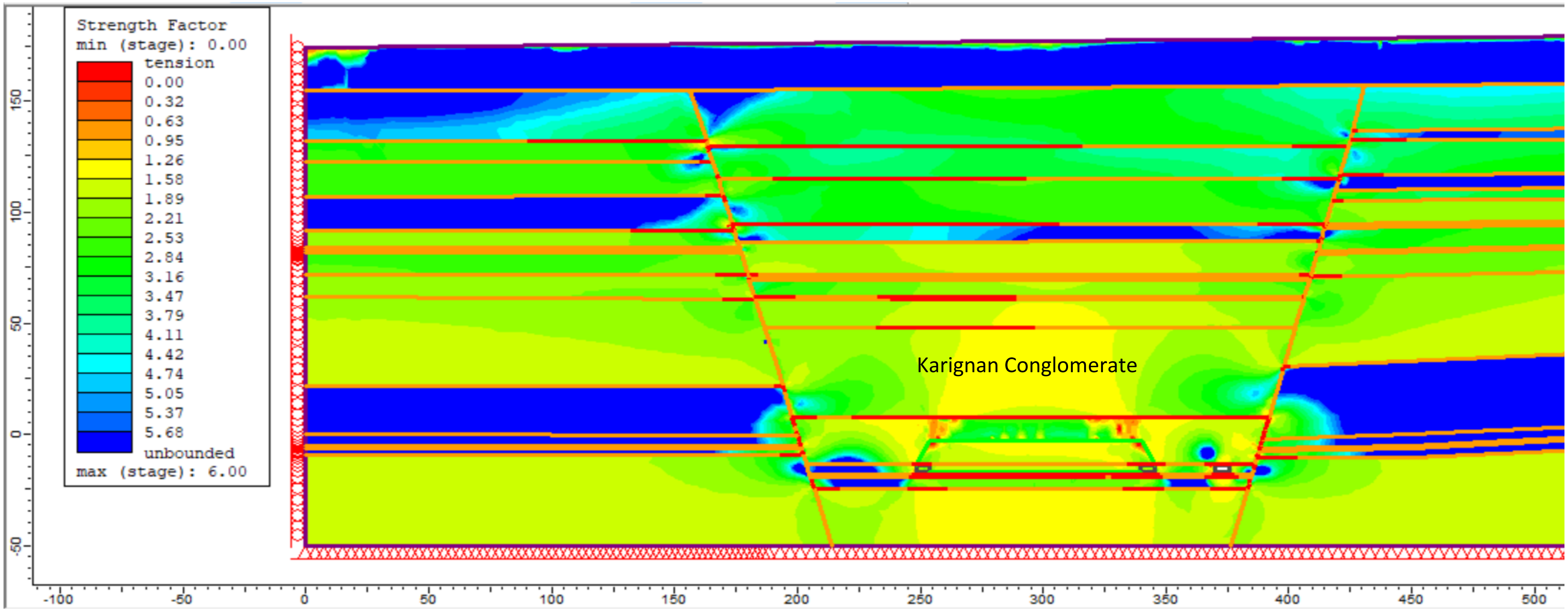
DgS	Engineer:	S.Ditton	Client:	LakeCoal - Chain Valley Colliery CHV-002/11
	Drawn:	S.Ditton		
	Date:	27.03.18	Title:	RS2 Vertical Stress Contours after MW N1 along XL3 (Karignan Conglomerate shears into Two Beams)
	Ditton Geotechnical Services Pty Ltd		Scale:	NTS — Figure No: 9a



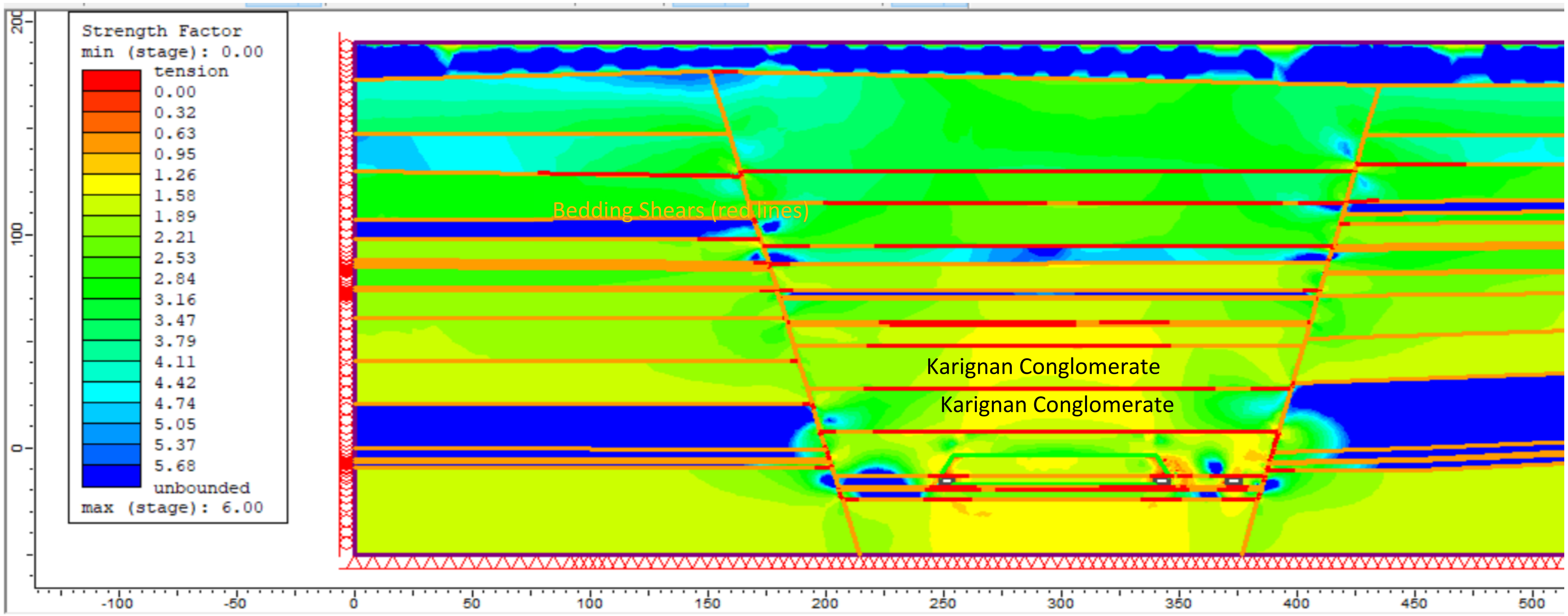
DgS Ditton Geotechnical Services Pty Ltd	Engineer:	S.Ditton	Client:	LakeCoal - Chain Valley Colliery CHV-002/11
	Drawn:	S.Ditton		
	Date:	27.03.18	Title:	RS2 Horizontal Stress Contours after MW N1 along XL3 (Karignan Conglomerate shears into Two Beams)
			Scale:	NTS; Figure No: 9b



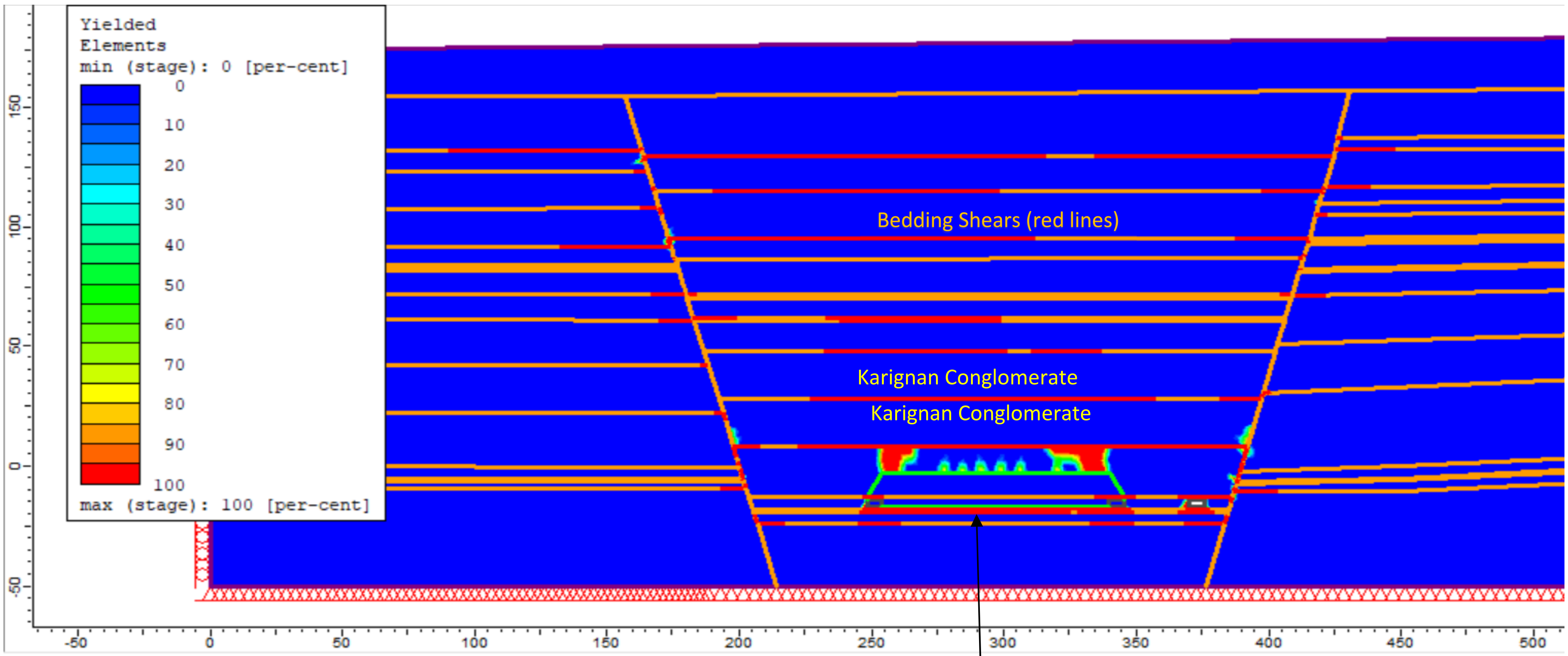
DgS	Engineer:	S.Ditton	Client:	LakeCoal - Chain Valley Colliery CHV-002/11		
	Drawn:	S.Ditton				
	Date:	27.03.18	Title:	Pre-mining Safety Factor for MW N1 along XL3		
	Ditton Geotechnical Services Pty Ltd					
			Scale:	NTS	Figure No:	9c



DgS	Engineer:	S.Ditton	Client:	LakeCoal - Chain Valley Colliery CHV-002/11		
	Drawn:	S.Ditton				
	Date:	27.03.18	Title:	Post-mining Safety Factor for MW N1 along XL3		
	Ditton Geotechnical Services Pty Ltd		Scale:	NTS	Figure No:	9d

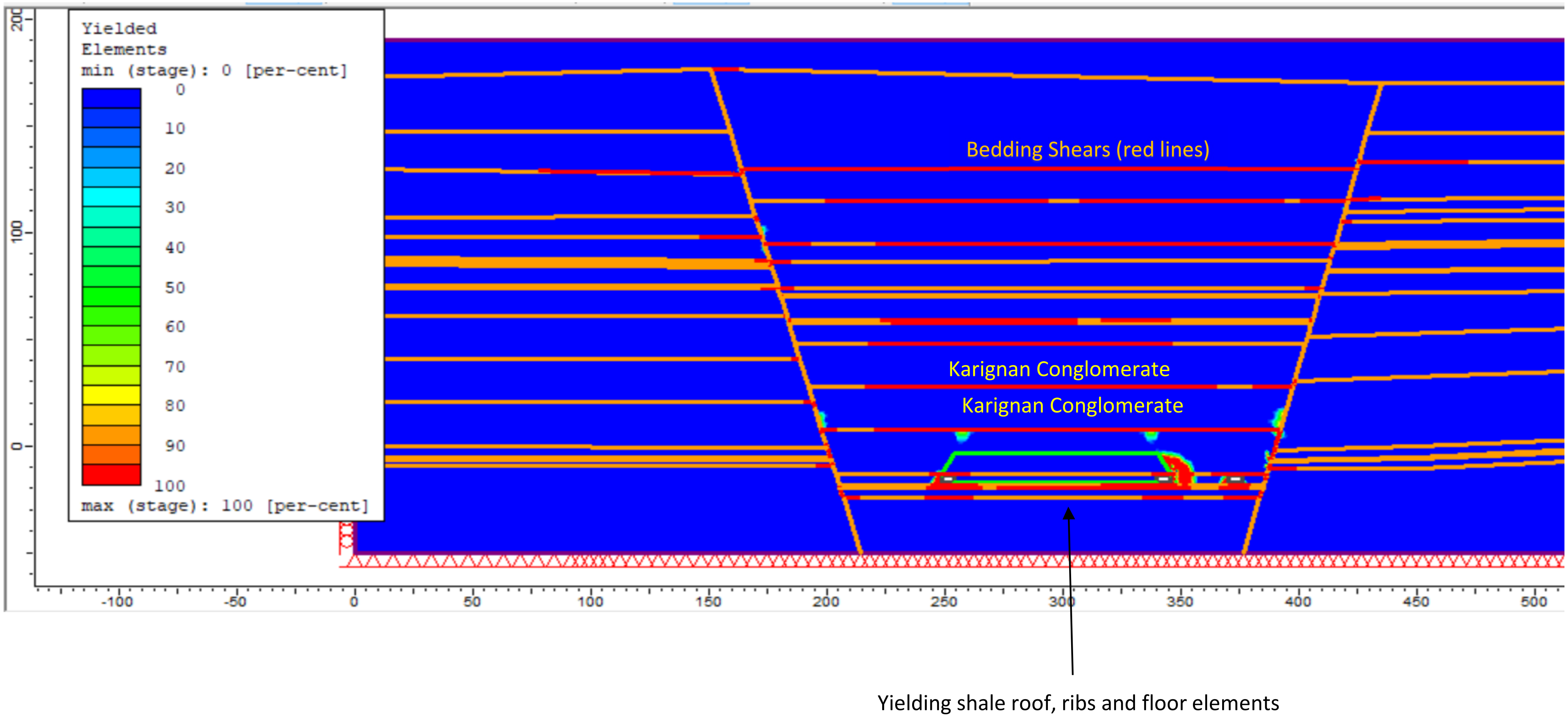


DgS	Engineer:	S.Ditton	Client:	LakeCoal - Chain Valley Colliery CHV-002/11		
	Drawn:	S.Ditton				
	Date:	27.03.18	Title:	Post-mining Safety Factor for MW S1 along XL4 (Karignan Conglomerate shears into two beams)		
	Ditton Geotechnical Services Pty Ltd		Scale:	NTS	Figure No:	9e

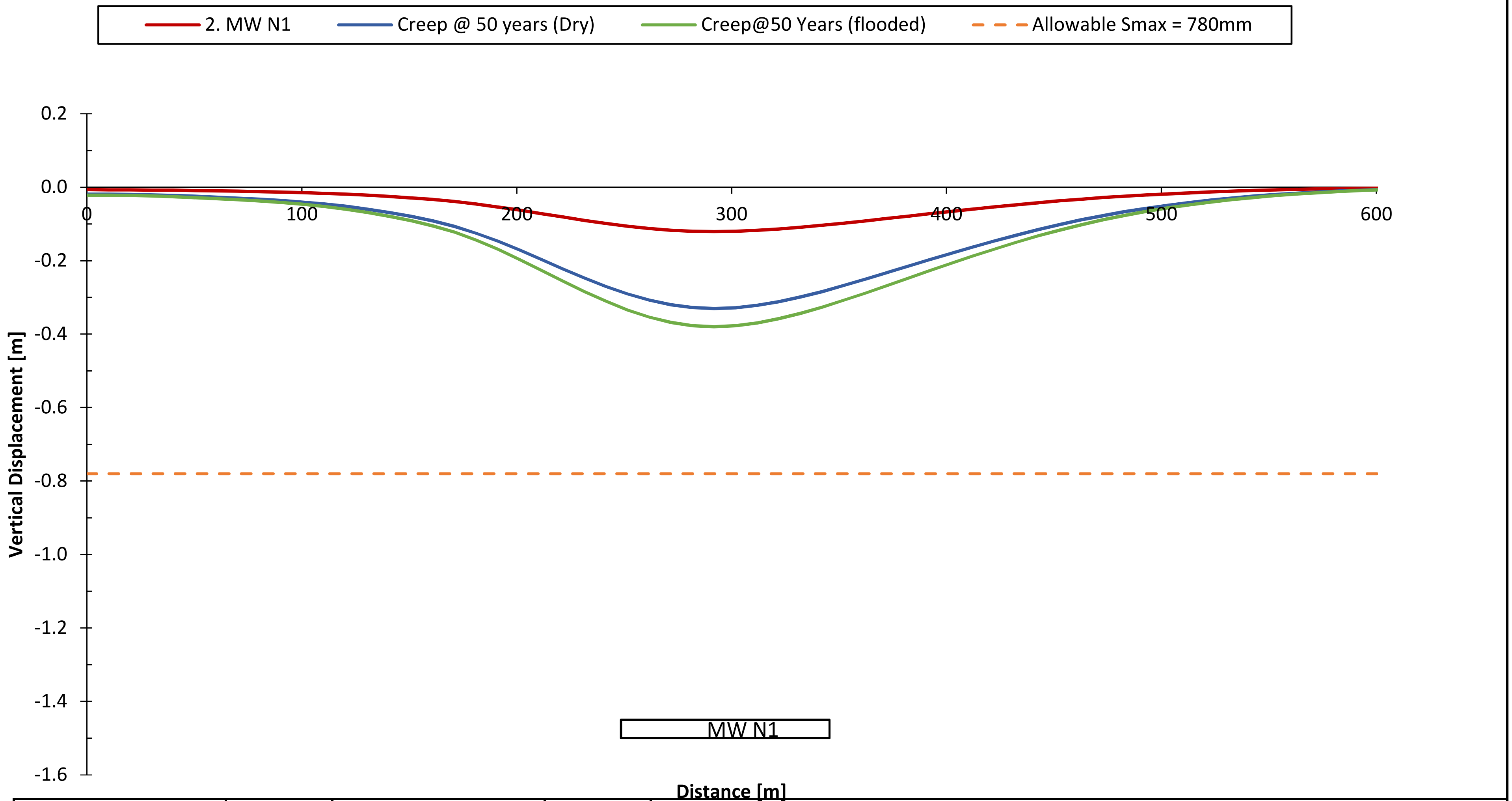


Yielding shale roof, ribs and floor elements

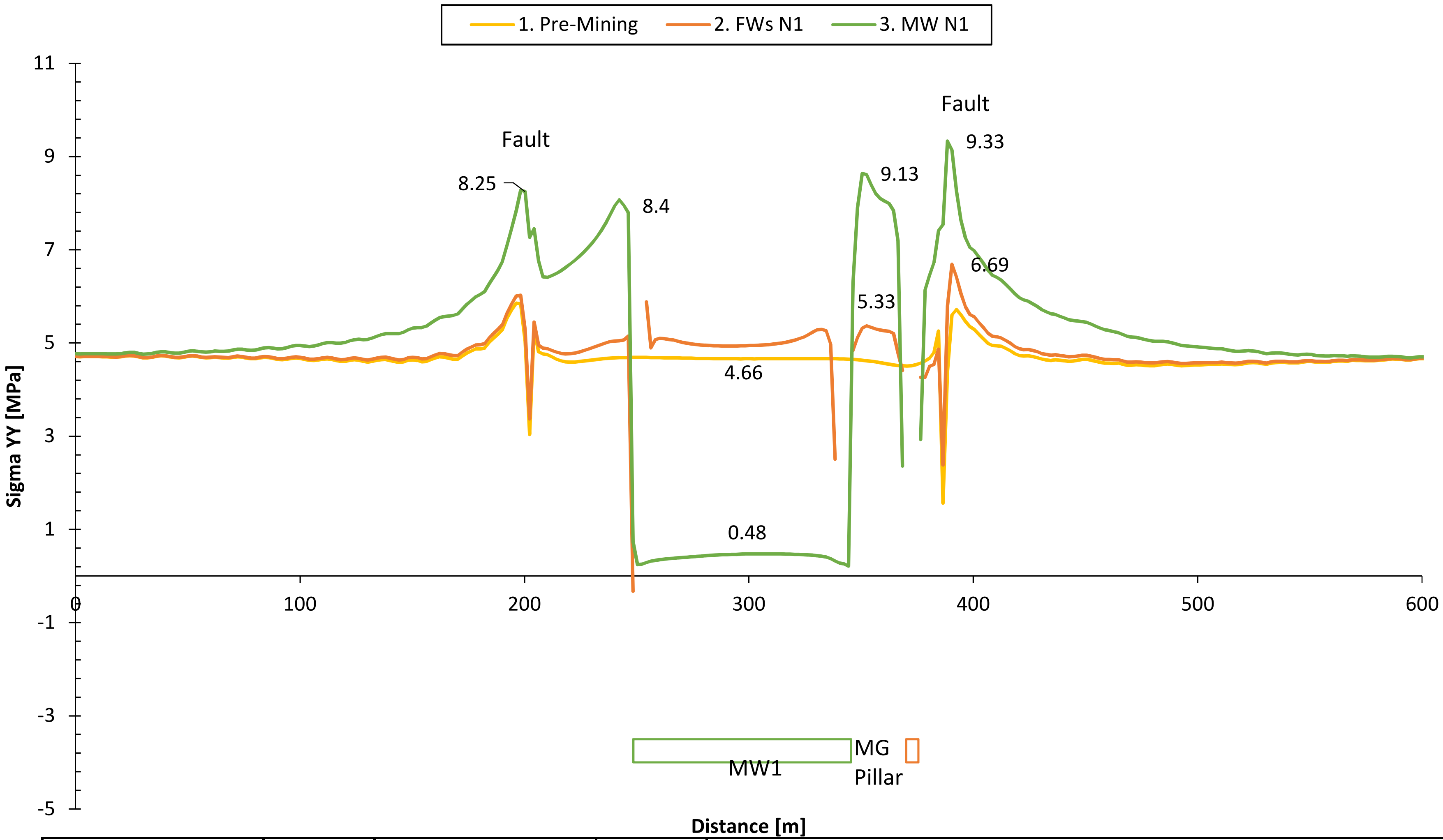
DgS	Engineer: S.Ditton	Client:	LakeCoal - Chain Valley Colliery CHV-002/11		
	Drawn: S.Ditton				
	Date: 27.03.18	Title:	Yielded Element Development in RS2 Model of Rockmass after MW N1 (Karignan Conglomerate shears into two beams)		
	Ditton Geotechnical Services Pty Ltd	Scale:	NTS	Figure No:	9f



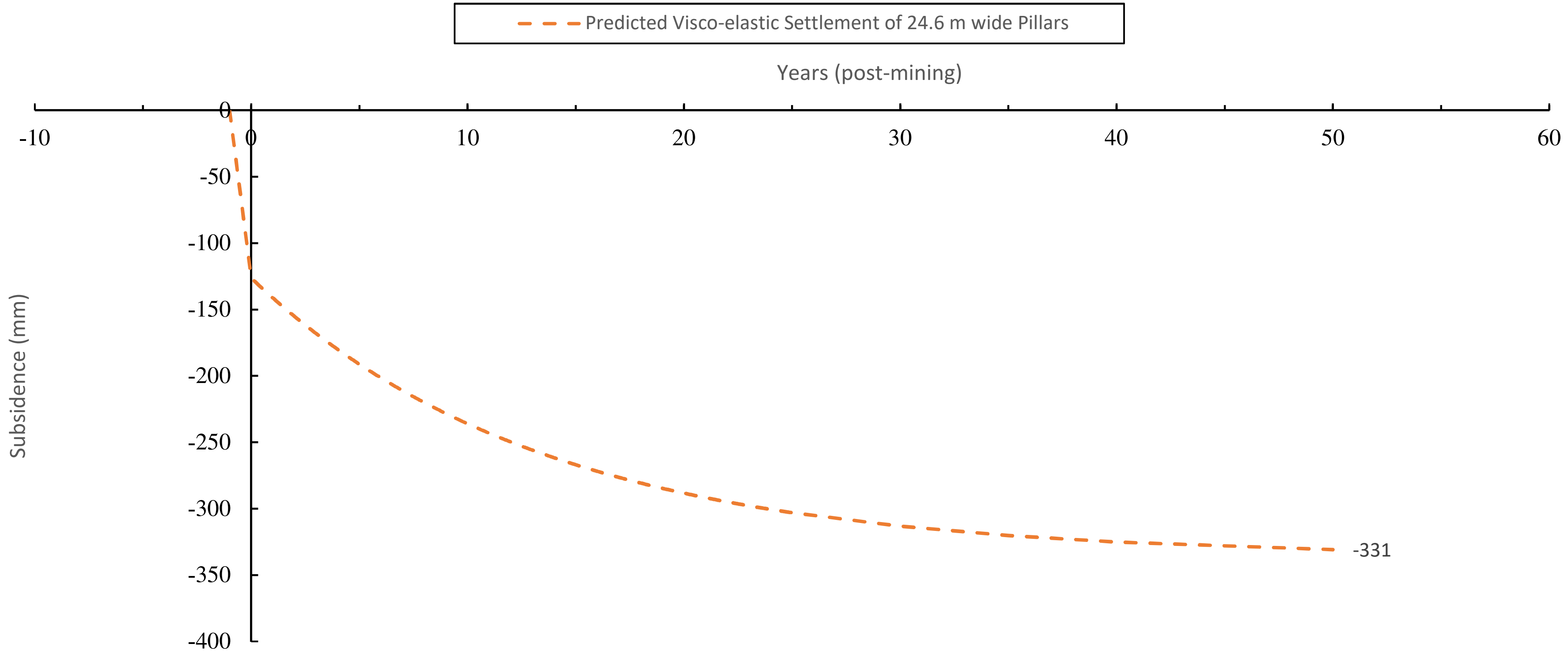
DgS	Engineer:	S.Ditton	Client:	LakeCoal - Chain Valley Colliery CHV-002/11
	Drawn:	S.Ditton		
	Date:	27.03.18	Title:	Yielded Element Development in RS2 Model of Rockmass after MW S1 (Karignan Conglomerate shears into two beams)
	Ditton Geotechnical Services Pty Ltd			
			Scale:	NTS Figure No: 9g



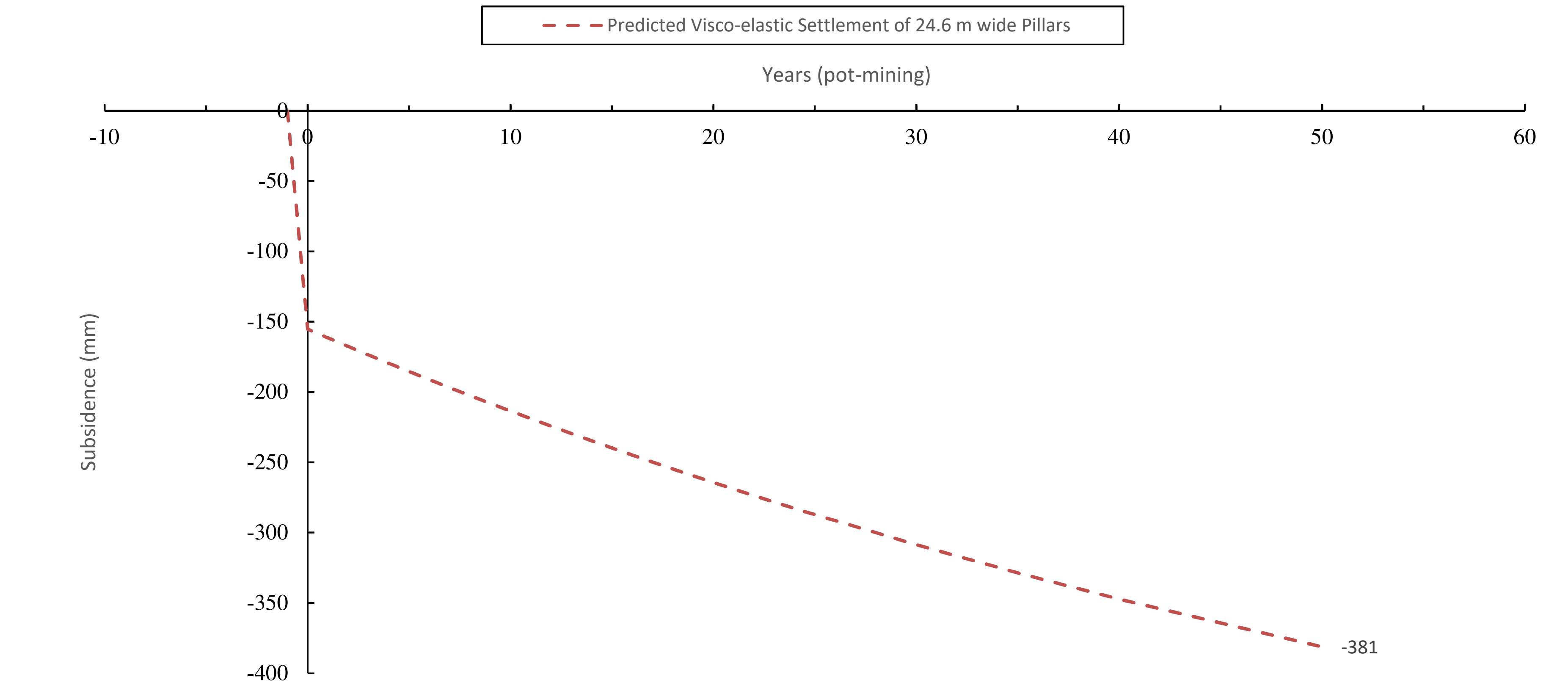
DgS	Engineer:	S.Ditton	Client:	LakeCoal - Chain Valley Colliery		
	Drawn:	S.Ditton		CHV-002/11		
	Date:	01.02.18	Title:	Predicted RS2 Model Subsidence Profiles over Miniwall N1 in Northern Area		
	Ditton Geotechnical Services Pty Ltd		Scale:	NTS	Figure No:	10a



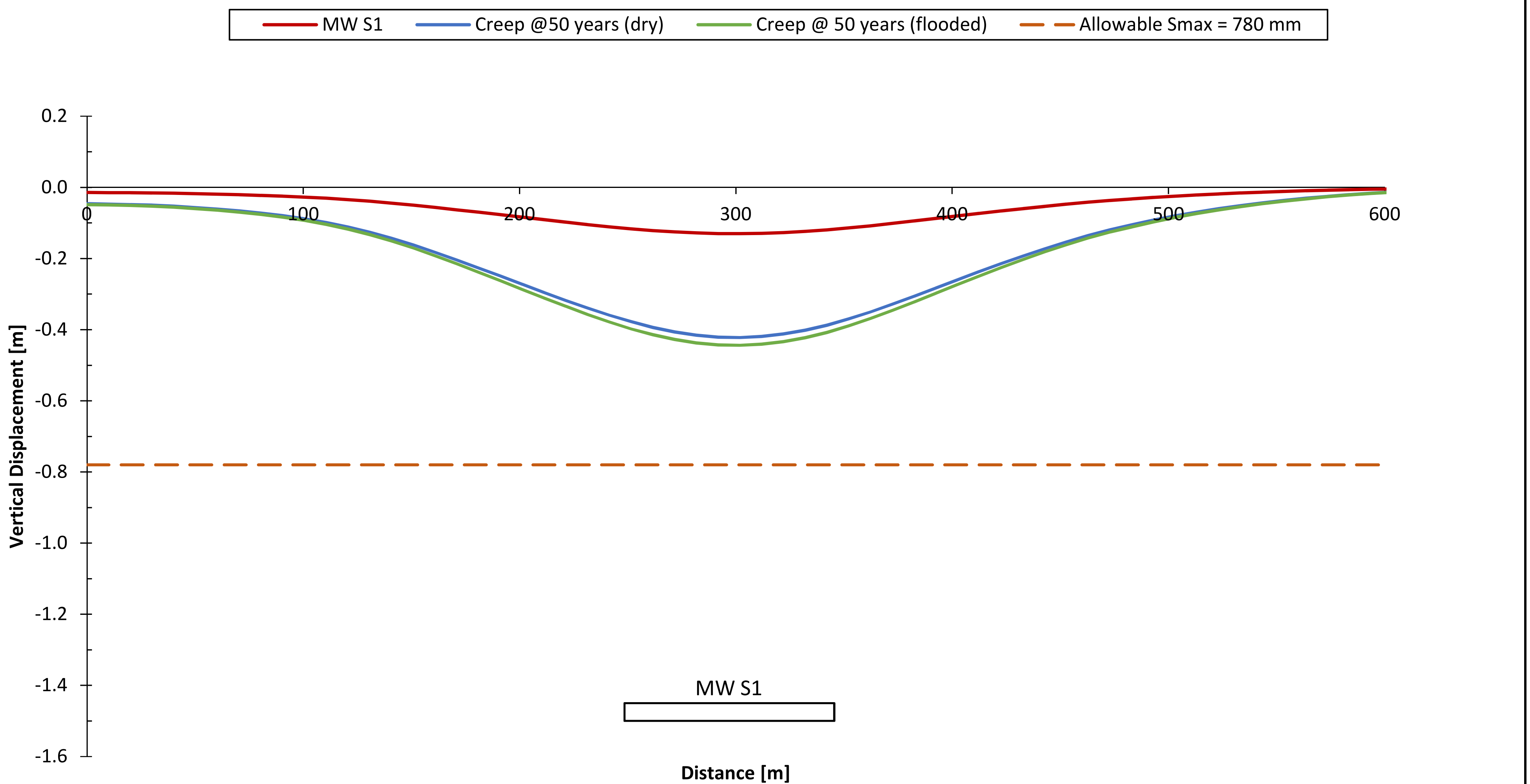
DgS	Engineer:	S.Ditton	Client:	LakeCoal - Chain Valley Colliery CHV-002/11		
	Drawn:	S.Ditton				
	Date:	27.03.18	Title:	Predicted RS2 Model Vertical Stress Profiles over Miniwalls N1 in Northern Area		
	Ditton Geotechnical Services Pty Ltd		Scale:	NTS	Figure No:	10b



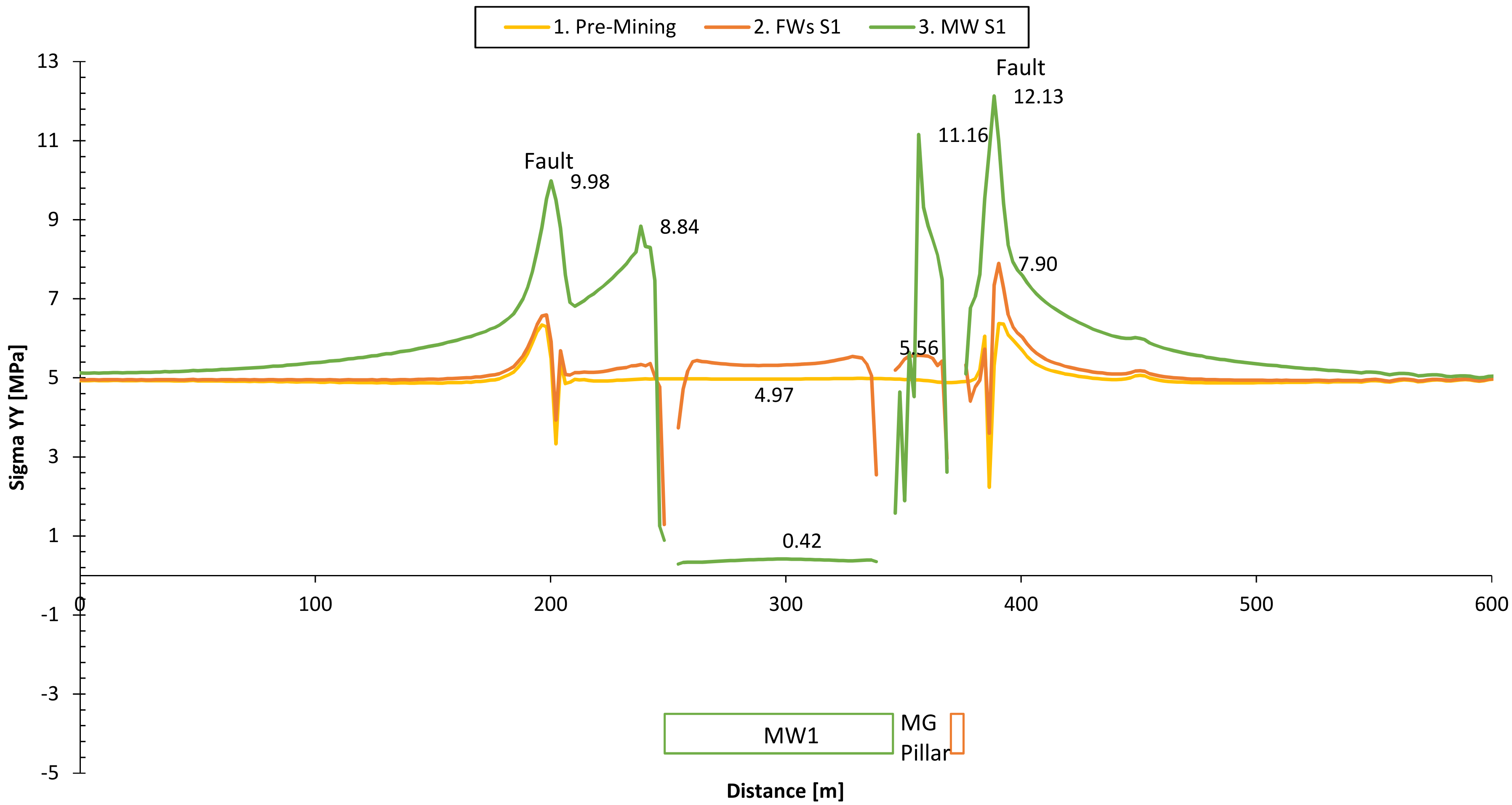
DgS	Engineer:	S.Ditton	Client:	LakeCoal - Chain Valley Colliery CHV-002/11		
	Drawn:	S.Ditton				
	Date:	27.03.18	Title:	Predicted Burgers Creep Model for Chain Pillars adjacent to Miniwall N1 with Claystone UCS of 2.0 MPa (current condition)		
	Ditton Geotechnical Services Pty Ltd					
			Scale:	NTS	Figure No:	10c



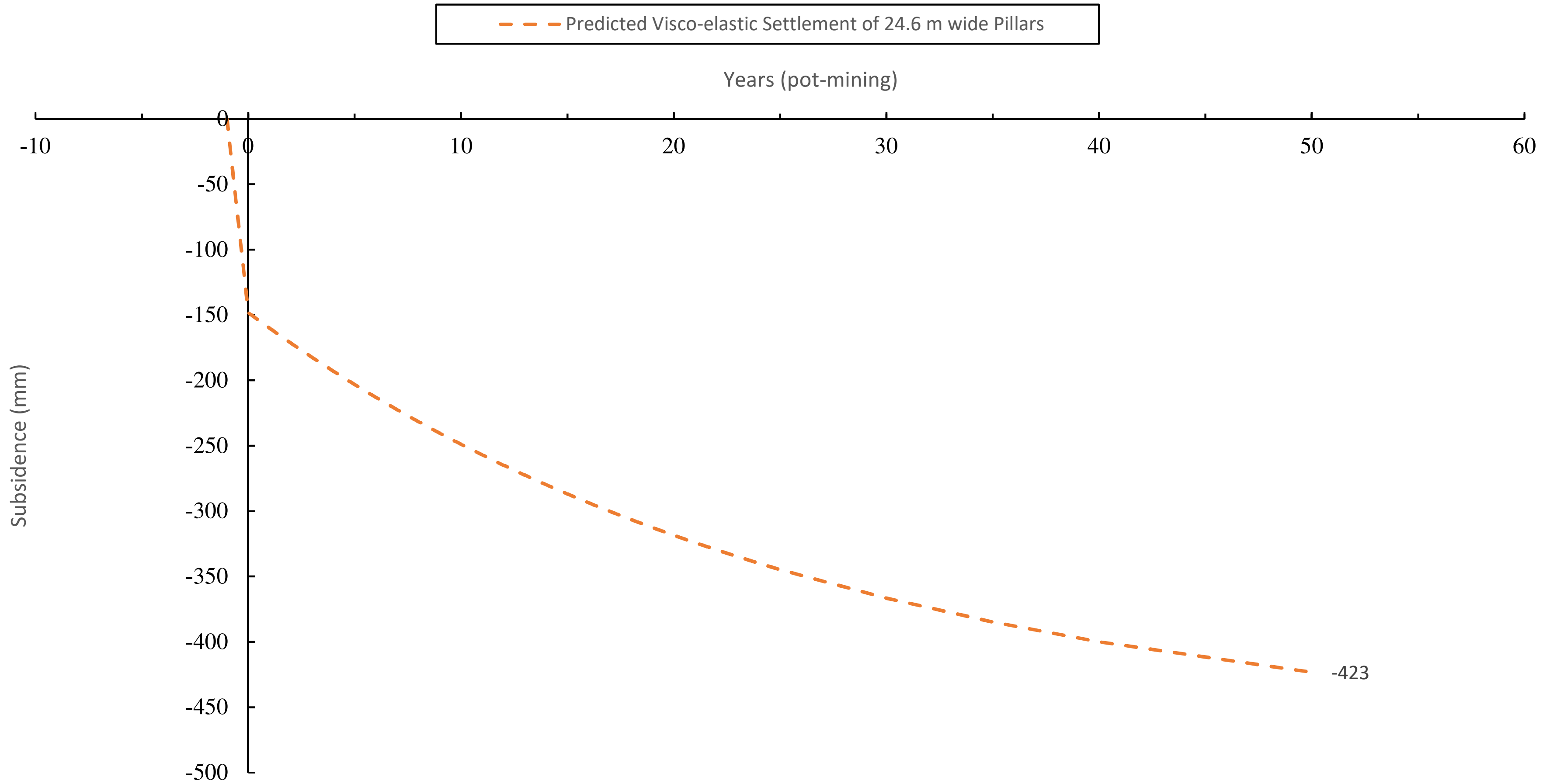
DgS	Engineer:	S.Ditton	Client:	LakeCoal - Chain Valley Colliery CHV-002/11		
	Drawn:	S.Ditton				
	Date:	27.03.18	Title:	Predicted Burgers Creep Model for Chain Pillars adjacent to Miniwall N1 with Claystone UCS of 1.65 MPa (flooded condition)		
	Ditton Geotechnical Services Pty Ltd		Scale:	NTS	Figure No:	10d



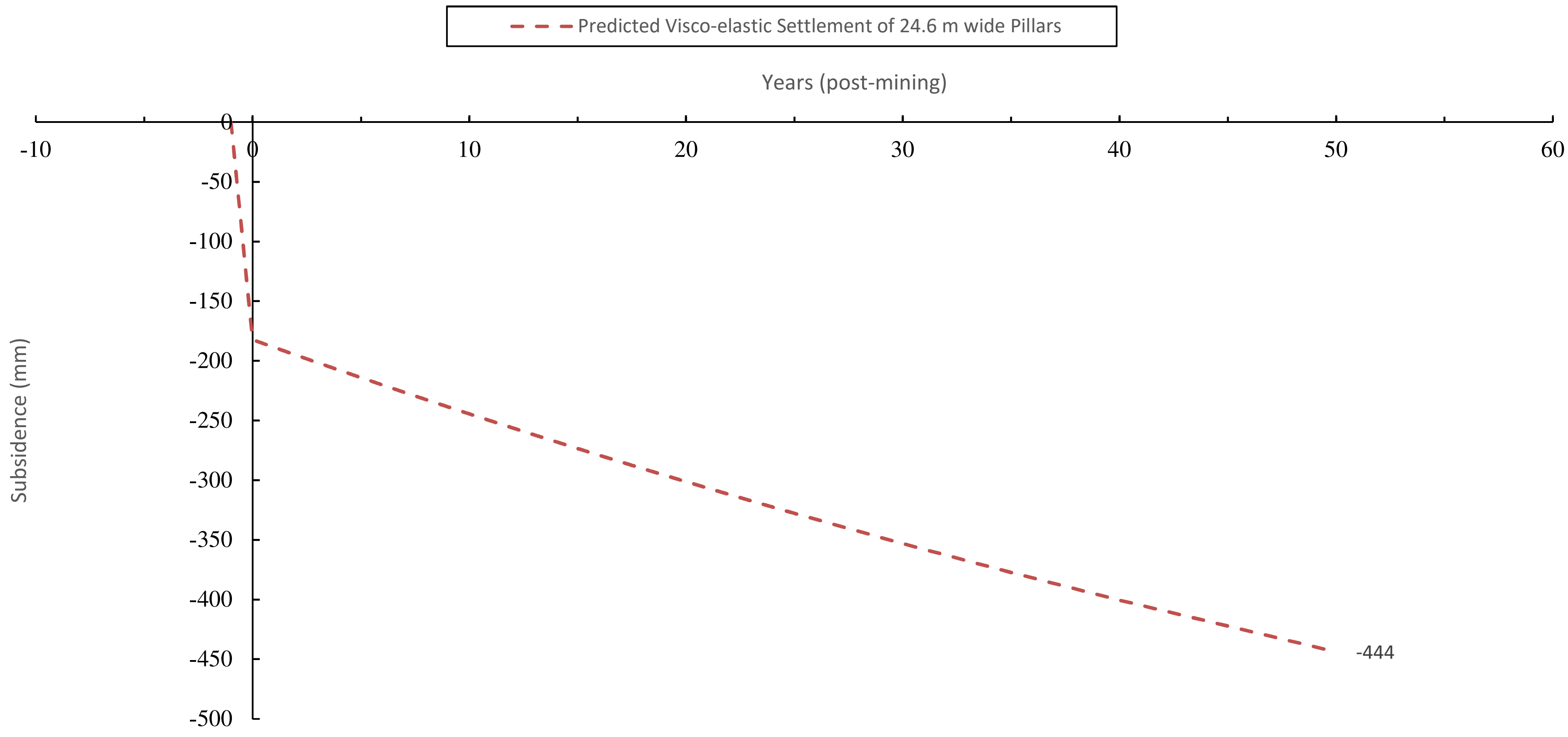
DgS	Engineer:	S.Ditton	Client:	LakeCoal - Chain Valley Colliery CHV-002/11			
	Drawn:	S.Ditton					
	Date:	27.03.18	Title:	Predicted RS2 Model Subsidence Profiles over Southern Miniwall S1 in Northern Area			
	Ditton Geotechnical Services Pty Ltd		Scale:	NTS	Figure No:	11a	



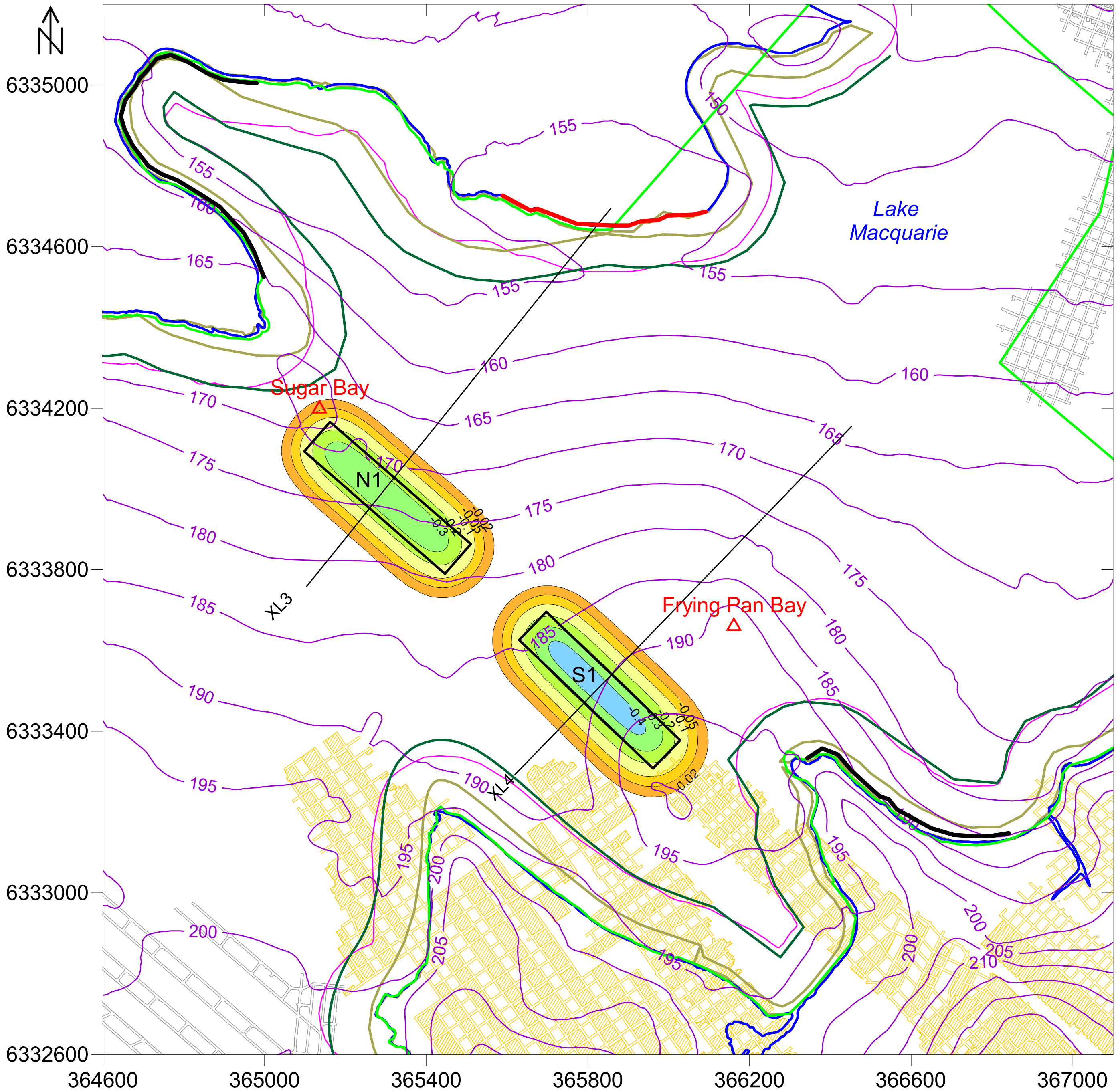
DgS	Engineer:	S.Ditton	Client:	LakeCoal - Chain Valley Colliery CHV-002/11	
	Drawn:	S.Ditton			
	Date:	27.03.18	Title:	Predicted RS2 Model Vertical Stress Profiles over Miniwalls S1 in Northern Area	
	Ditton Geotechnical Services Pty Ltd				
			Scale:	NTS	Figure No: 11b



DgS	Engineer:	S.Ditton	Client:	LakeCoal - Chain Valley Colliery CHV-002/11	
	Drawn:	S.Ditton			
	Date:	27.03.18	Title:	Predicted Burgers Creep Model for Chain Pillars adjacent to Miniwall S1 with Claystone UCS of 2.0 MPa (current condition)	
	Ditton Geotechnical Services Pty Ltd		Scale:	NTS	Figure No: 11c



DgS	Engineer:	S.Ditton	Client:	LakeCoal - Chain Valley Colliery CHV-002/11		
	Drawn:	S.Ditton				
	Date:	27.03.18	Title:	Predicted Burgers Creep Model for Chain Pillars adjacent to Miniwall S1 with Claystone UCS of 1.65 MPa (flooded condition)		
	Ditton Geotechnical Services Pty Ltd		Scale:	NTS	Figure No:	11d



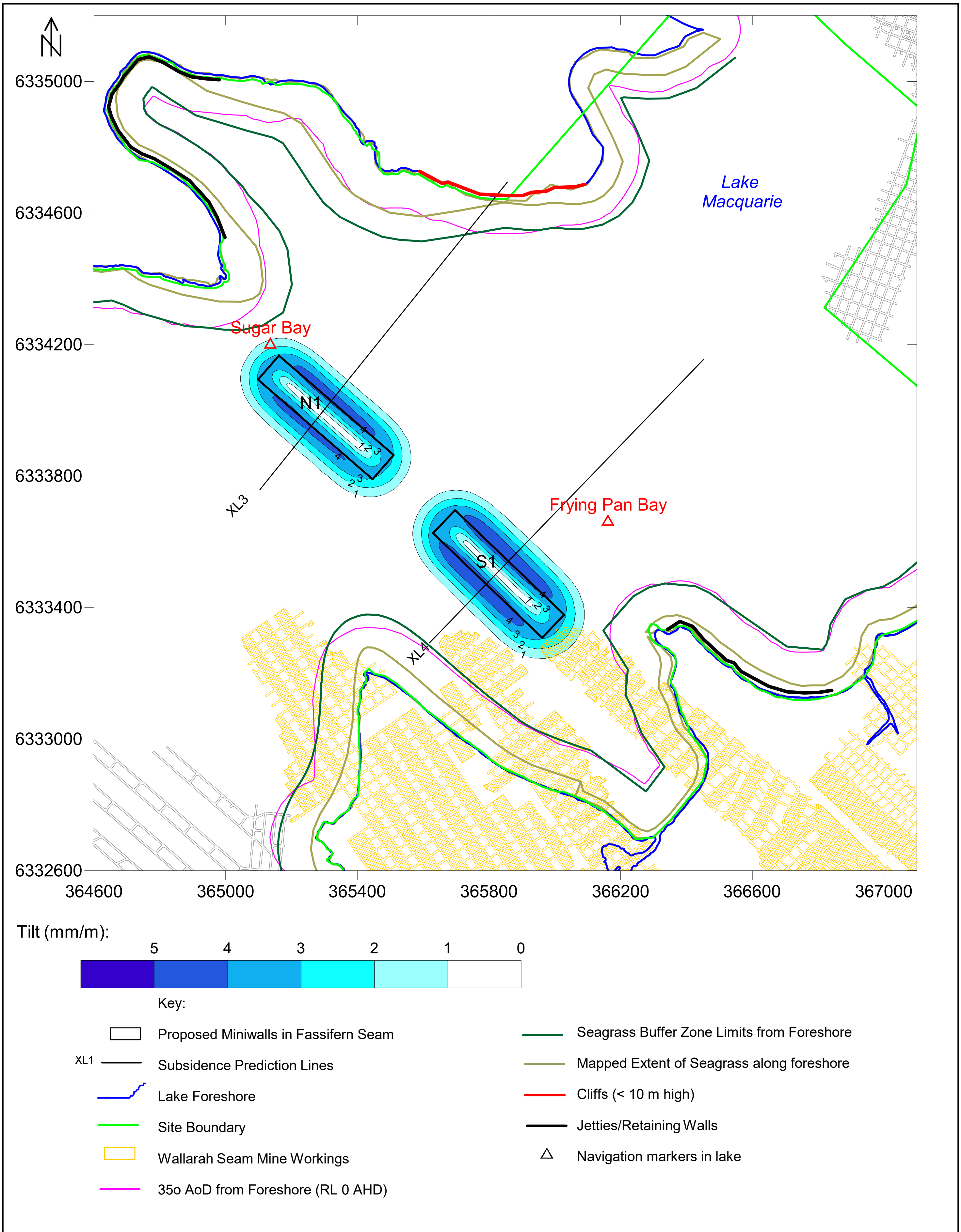
Subsidence (m):

	-0.02	-0.05	-0.1	-0.2	-0.3	-0.4	-0.5

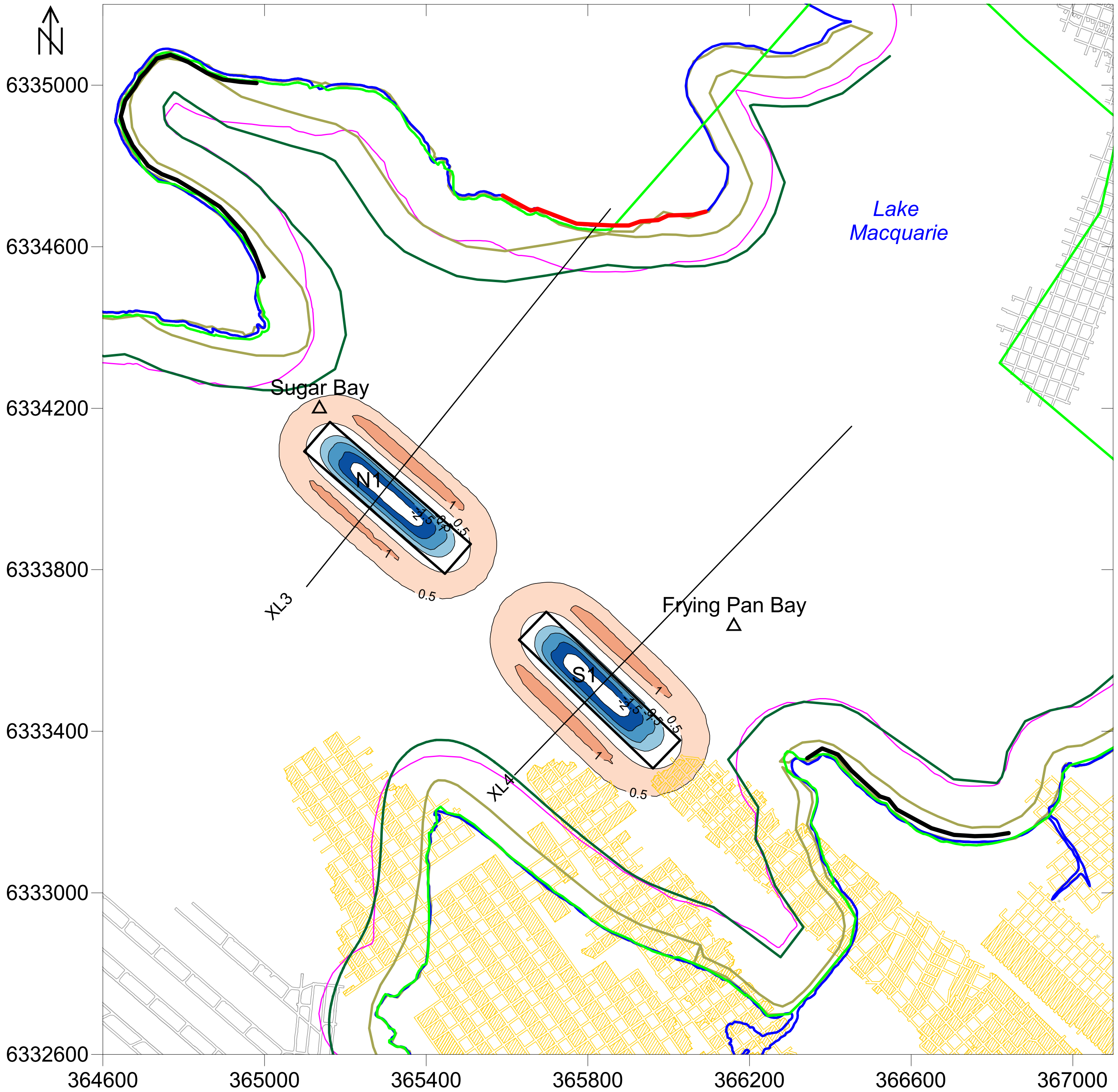
Key:

- Proposed Miniwalls in Fassifern Seam
- XL1 Subsidence Prediction Lines
- Lake Foreshore
- Site Boundary
- Wallarah Seam Mine Workings
- 35o AoD from Foreshore (RL 0 AHD)
- Seagrass Buffer Zone Limits from Foreshore
- Mapped Extent of Seagrass along foreshore
- Cliffs (< 10 m high)
- Jetties/Retaining Walls
- Navigation markers in lake
- Cover depth contours to FAS Seam

DgS	Engineer:	S.Ditton	Client:	LakeCoal - Chain Valley Colliery CHV-002/11	
	Drawn:	S.Ditton	Title:	Predicted Worst-case Subsidence Contours above the Proposed MW S1 and N1 in Northern Area	
	Date:	23.02.18			
Ditton Geotechnical Services Pty Ltd			Scale:	1:15,000 (A4)	Figure No: 12a



DgS	Engineer:	S.Ditton	Client:	LakeCoal - Chain Valley Colliery CHV-002/11	
	Drawn:	S.Ditton			
	Date:	23.02.18	Title:	Predicted Worst-case Tilt Contours above the Proposed MW S1 and N1 in Northern Area	
	Ditton Geotechnical Services Pty Ltd		Scale:	1:15,000 (A4)	Figure No: 12b



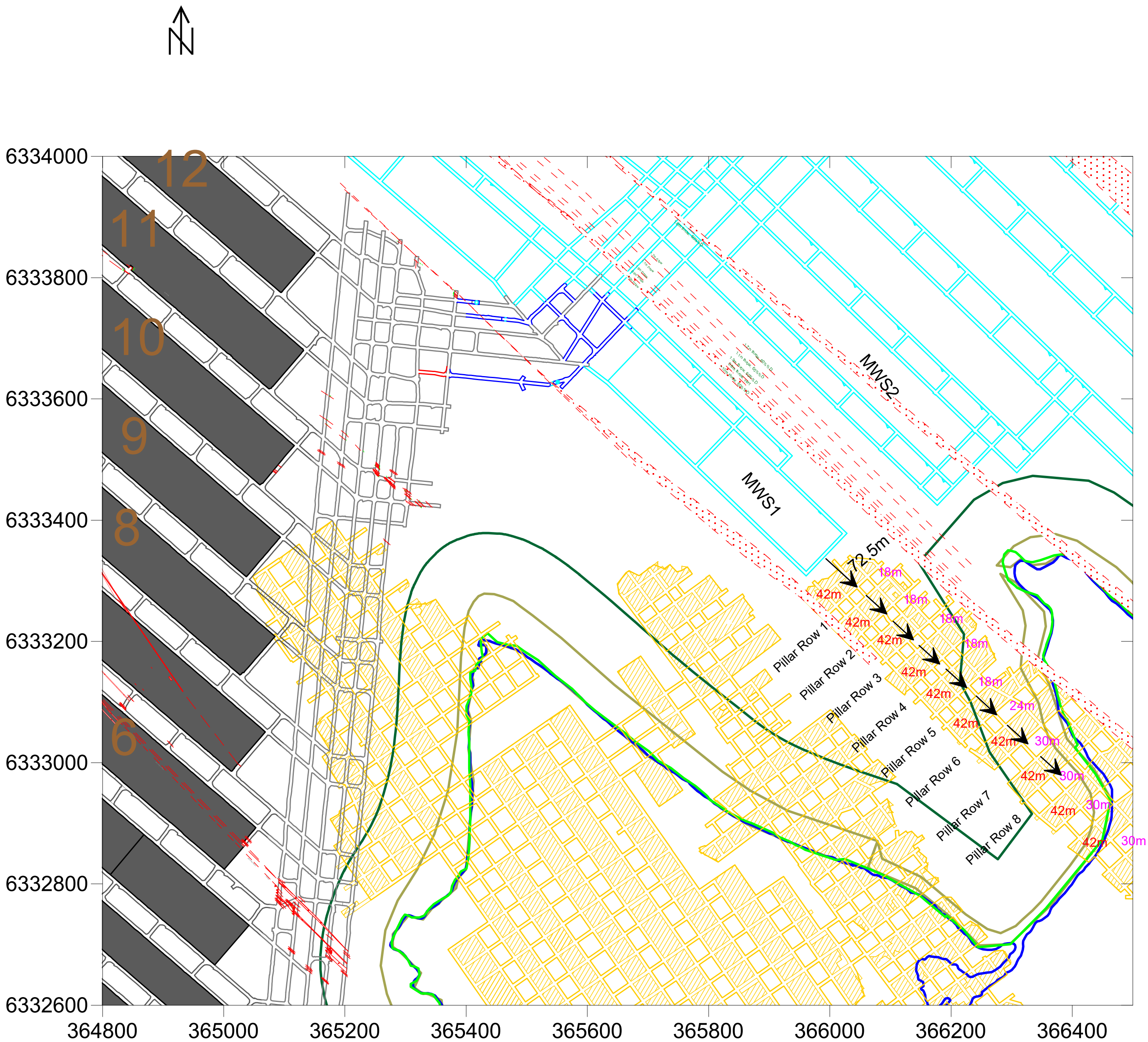
Strain (mm/m):

2	1.5	1	0.5	0	-0.5	-1	-1.5	-2

Key:

- Proposed Miniwalls in Fassifern Seam
- XL1 Subsidence Prediction Lines
- Lake Foreshore
- Site Boundary
- Wallarah Seam Mine Workings
- 35o AoD from Foreshore (RL 0 AHD)
- Seagrass Buffer Zone Limits from Foreshore
- Mapped Extent of Seagrass along foreshore
- Cliffs (< 10 m high)
- Jetties/Retaining Walls
- Navigation markers in lake

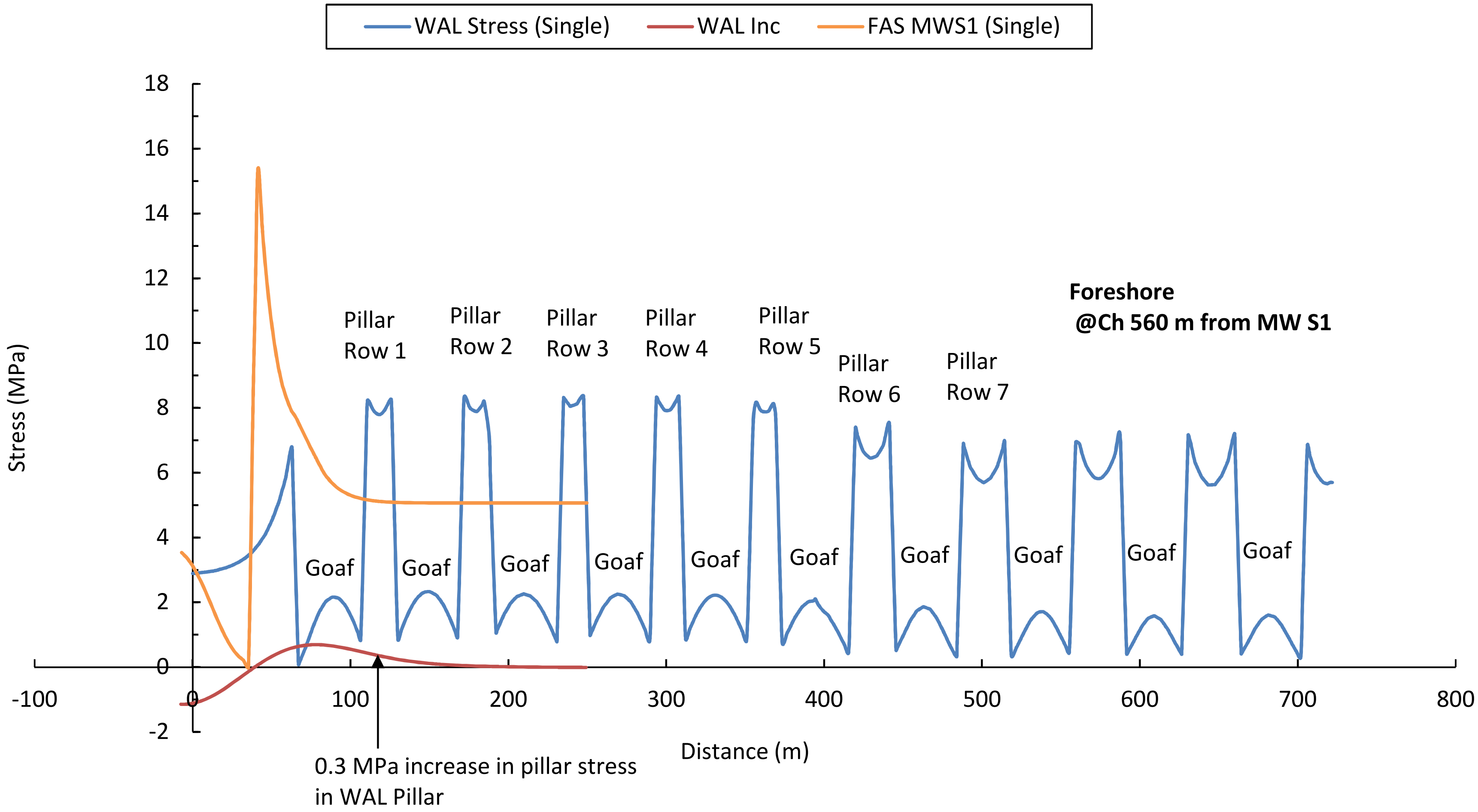
DgS	Engineer: S.Ditton	Client:	LakeCoal - Chain Valley Colliery CHV-002/11
	Drawn: S.Ditton		
	Date: 23.03.18	Title:	Predicted Worst-case Horizontal Strain Contours above the Proposed MW S1 and N1 in Northern Area
	Ditton Geotechnical Services Pty Ltd	Scale:	1:15,000 (A4) — Figure No: 12c



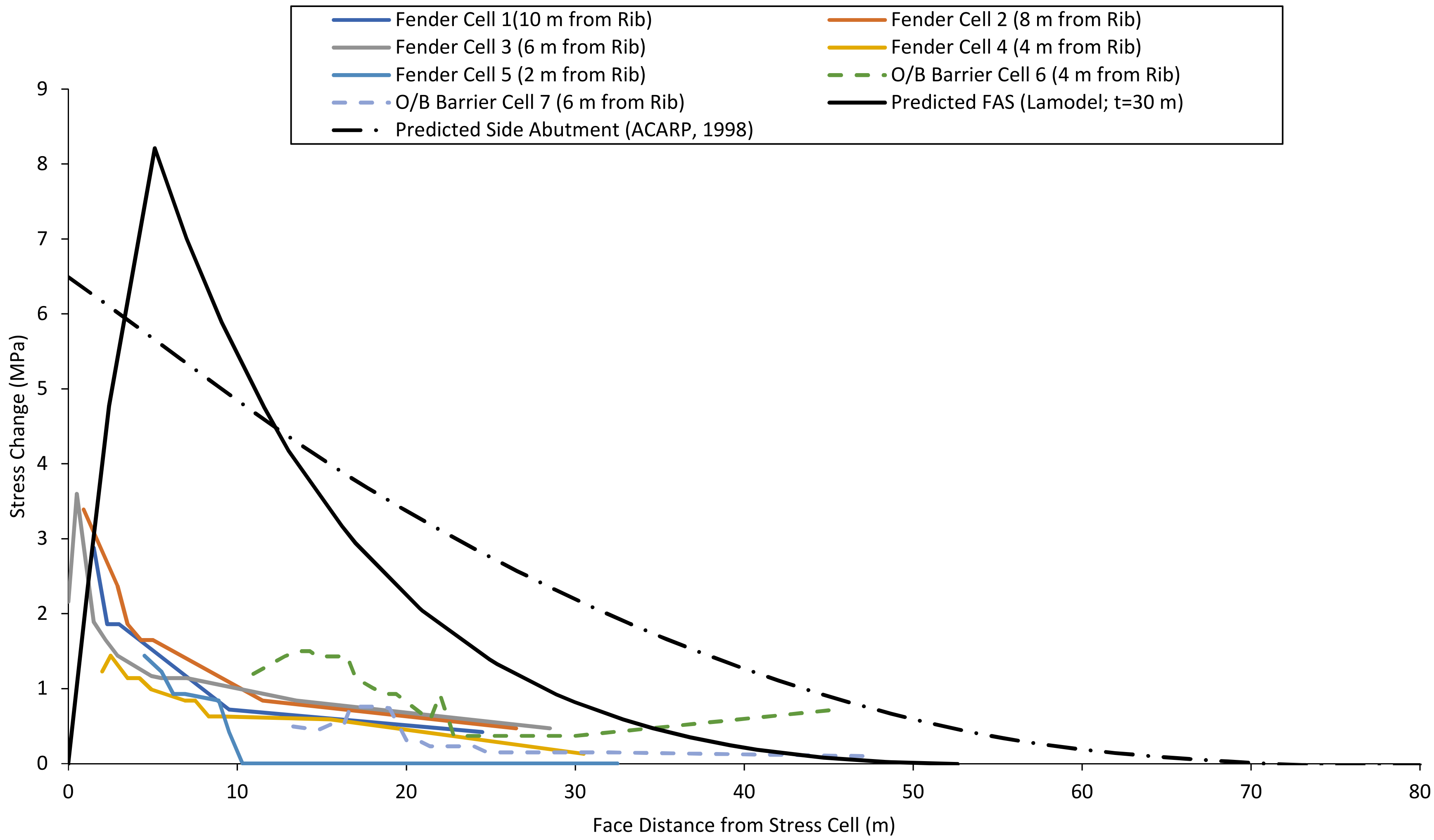
Key:

- Approved Miniwalls in Fassifern Seam
- Extracted MW Panels in Fassifern Seam
- Lake Foreshore
- Site Boundary
- Wallarah Seam Pillar Extracted Mine Workings
- Seagrass Buffer Zone Limits
- Mapped Extent of Seagrass
- Geological Structure

DgS Ditton Geotechnical Services Pty Ltd	Engineer: S.Ditton Drawn: S.Ditton Date: 18.02.18	Client:	LakeCoal - Chain Valley Colliery CHV-002/11
		Title:	Location of Proposed FAS Seam MW S1 to Existing WAL Seam Pillar Extraction Panel Workings and Lake Foreshore
		Scale:	1:2,000 (A4) — Figure No: 13a



DgS	Engineer:	S.Ditton	Client:	LakeCoal - Chain Valley Colliery CHV-002/11	
	Drawn:	S.Ditton			
	Date:	27.03.18	Title:	Predicted Pillar Stress Increase in the WAL Seam due to Forward Abutment Stress from MW S1 in FAS (refer **DgS, 2016** for model details)	
	Ditton Geotechnical Services Pty Ltd		Scale:	NTS	Figure No: 13b



DgS	Engineer:	S.Ditton	Client:	LakeCoal - Chain Valley Colliery CHV-002/11			
	Drawn:	S.Ditton					
	Date:	27.03.18	Title:	Measured v. Predicted MW7 Forward Abutment Stress Profiles			
	Ditton Geotechnical Services Pty Ltd		Scale:	NTS		Figure No:	13c

Appendix 11

Extraction Plan and NMA Assessment Report Peer Review