INDEPENDENT EXPERT ADVISORY PANEL FOR MINING

ADVICE RE:

CHAIN VALLEY CONSOLIDATION PROJECT (SSD-17017460)

Subsidence Impact Assessment

December 2024

IEAPM Report No. 202412-1

EXECUTIVE SUMMARY

On 21 November 2023, the NSW Department of Planning and Environment, now the Department of Planning, Housing and Infrastructure (DPHI - the Department) requested advice from the Independent Expert Advisory Panel for Mining (IEAPM – the Panel) in relation to the Chain Valley Consolidation Project (CVCP), lodged by Great Southern Energy Pty Ltd (trading as Delta Coal). The CVCP entails the consolidation of existing operations and associated development consents for both Chain Valley Colliery (CVC) and Mannering Colliery (MC) under a single approval.

The Scope of Advice stated that:

The Department requests that the Panel undertake a comprehensive review of the subsidence impact assessment completed for the Chain Valley Consolidation project including:

- *Consideration of whether the assumptions used are reasonable, appropriate, and suitably justified;*
- *The adequacy of the methodology, analysis and assessment presented in evaluating the subsidence impacts of the proposed development;*
- *Identification of any areas of deficiency and recommendations to improve or resolve these issues in the assessment;*
- *The significance of impacts, key environmental risks, and issues for consideration during the assessment process;*
- *Suitability and adequacy of the proposed mitigation and/or management and/or protection measures to avoid, mitigate or minimise the likelihood, extent, and significance of impacts;*
- *Consideration and recommendation of any additional measures to further avoid, minimise and/or mitigate any identified impacts of the project; and*
- *Any recommendations (if required) for additional information to inform the assessment of the Project.*

Based on the material presented to the Panel and the supplementary information supplied by Delta Coal (and Umwelt (Australia) Pty Ltd, on behalf of Delta Coal), the Panel has made the following conclusions and recommendations:

SUMMARY CONCLUSIONS

Overarching

1. The CVCP assessment process is based on conceptual mine planning and, as such, does not go into as much detail as that which will be required at a later date to permit secondary extraction in the subject area. Hence:
2. The subsidence impact assessment presented in the EIS and supporting documentation is relatively concise and confined.
3. This IEAPM review and advice has a focus on geotechnical factors associated with the conceptual mine design and the related surface subsidence impacts and is not as comprehensive as that which may subsequently be required if the CVCP is approved.
4. The conceptual mine layout provides an adequate basis for the purpose of assessing the merits of the CVCP.

Zone A Workings

1. The proposed herringbone pillar layout for the first workings in Zone A provides a suitable basis for assessing the CVCP.

2. Should the CVCP be approved, it would be judicious, given the geological and geotechnical conditions and mining history in the area, for approval conditions to provide for regular monitoring of stability in the long term and annual reporting of the performance of the mine workings.

Zone B Workings

1. The proposed mine layout for second workings in Zone B provides a suitable basis for assessing the CVCP.
2. Should the CVCP be approved, it would be judicious, given geological and geotechnical conditions and mining history in the area for approval conditions to provide for staged approval of Extraction Plans for second workings, premised on predicted versus measured performance.

SUMMARY RECOMMENDATIONS

Overarching

1. The conceptual mine layout as proposed is suitable for the purpose of assessing the merits of the CVCP.
2. Should the CVCP be approved, it would be judicious, given the geological and geotechnical conditions and mining history in the area, for approval conditions to provide for:
    a. Monitoring of the performance of first workings in the long-term, supported by annual reporting that is audited by an independent third party endorsed by the Secretary.
    b. Staged approval of Extraction Plans for second workings, premised on predicted versus measured performance and advances in knowledge bases.

Zone A Workings

1. The Department should consider replacing the current 20mm subsidence limit for Zone A workings with a negligible impact set of mining consequence criteria for all relevant parameters (including the built infrastructure), noting that this should achieve the same objectives as those intended to be achieved by the now legacy issue of specifying an extremely low level of permissible subsidence, such that it becomes an impractical and unmanageable control in practice.

2. Further design criteria should be specified for first workings, being that these workings should be designed to:
    a. be long-term stable, and to
    b. exhibit no ongoing time dependent deformation either within the coal pillars themselves, or the immediately surrounding roof or floor strata.

3. Should the CVCP be approved, approval conditions should provide for:
    a. regular monitoring and annual reporting of the response of all first workings over time.
    b. the proposed herringbone pillar layout for the first workings in Zone A being subject to ongoing monitoring and annual reporting of localised roof and floor strata conditions in each panel, especially with respect to the nature and extent of claystone stratum, with a view to identifying any need to modify the mine design accordingly to limit pillar loading so as to avoid excessive stress levels that could lead to foundation failure of the coal pillar system.
    c. auditing of annual reports by an independent third party endorsed by the Secretary.

Zone B Workings

1. Should the CVCP be approved, approval conditions should provide for:
    a. local conglomerate and claystone properties and thicknesses to be investigated for each set of extraction panels prior to finalising extraction and barrier width parameters.
    b. the overall number of panels in any location be limited to no more than two, without the inclusion of a more substantial barrier separating adjacent mining regions.

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1.0 SCOPE OF WORKS

1.1. DEPARTMENT REQUEST FOR ADVICE

The NSW Department of Planning, Housing and Infrastructure (DPHI – the Department) has established the Independent Expert Advisory Panel for Mining (IEAPM - the Panel). The Panel's purpose is to give DPHI and the Independent Planning Commission access to specialist knowledge and expert advice when assessing mining proposals under the *Environmental Planning and Assessment Act 1979*.

On 21 November 2023, the NSW Department of Planning and Environment (now the Department of Planning, Housing and Infrastructure) requested advice from the IEAPM in relation to the Chain Valley Consolidation Project (CVCP) which entails the consolidation of existing operations and associated development consents for both Chain Valley Colliery (CVC) and Mannering Colliery (MC) under a single approval. The application would also allow a two-year extension of the life of mine operations to 2029, resulting in the additional recovery of approximately 9.5 Mt of Run-Of-Mine (ROM) coal.

The Scope of Advice stated that:

The Department requests that the Panel undertake a comprehensive review of the subsidence impact assessment completed for the Chain Valley Consolidation project including:

- *Consideration of whether the assumptions used are reasonable, appropriate, and suitably justified;*
- *The adequacy of the methodology, analysis and assessment presented in evaluating the subsidence impacts of the proposed development;*
- *Identification of any areas of deficiency and recommendations to improve or resolve these issues in the assessment;*
- *The significance of impacts, key environmental risks, and issues for consideration during the assessment process;*
- *Suitability and adequacy of the proposed mitigation and/or management and/or protection measures to avoid, mitigate or minimise the likelihood, extent, and significance of impacts;*
- *Consideration and recommendation of any additional measures to further avoid, minimise and/or mitigate any identified impacts of the project; and*
- *Any recommendations (if required) for additional information to inform the assessment of the Project.*

The Chair of IEAPM (Em. Professor Jim Galvin) convened the following Panel for this purpose:

- Em. Professor Jim Galvin - Subsidence and Mining
- Em. Professor Bruce Hebblewhite - Subsidence and Mining

More background on Panel members is provided in Appendix B.

The lease consolidation assessment process is based on conceptual mine planning and, as such, does not go into as much detail as that which will be required at a later date to permit secondary extraction in the subject area. Hence, the subsidence impact assessment present in the EIS and supporting documentation is relatively concise and confined.

Therefore, this IEAPM review and advice has a focus on geotechnical factors associated with the conceptual mine design and the related surface subsidence impacts and is not as comprehensive as that which may subsequently be required if the lease consolidation is approved.

1.2. PROJECT BACKGROUND

The project entails the consolidation of existing operations and associated development consents under a single approval for both Chain Valley Colliery (CVC) (SSD-5465) and Mannering Colliery (MC) (MP06_0311). The operations are located in the Lake Macquarie and Central Coast LGAs, approximately 60 kilometres south of Newcastle (see Figures 1 and 2).

Great Southern Energy Pty Ltd (trading as Delta Coal) owns and operates the Vales Point Power Station (VPPS) located to the immediate west of the pit tops of the two mining operations. Both CVC and MC have historically supplied the majority of coal produced at these operations to VPPS.

The CVC and MC pit top facilities are located at Mannering Park within the Central Coast LGA, while approved mining areas for the operations are located within both the Lake Macquarie and Central Coast LGAs.

Delta Coal operates CVC and MC as integrated operations with access to the underground mining areas from both pit tops. Coal is transported via an existing overland conveyor from MC to VPPS. CVC is currently approved to extract coal from the Fassifern Seam, however it has previously extracted coal from the Wallarah, Great Northern and Fassifern Seams. MC is currently approved to continue to extract coal from both the Great Northern and Fassifern Seams.

The project would provide for the consolidation of the existing operations under a single development consent, which Delta Coal contends would allow it to align its approved extraction and production rates at both collieries in order to maximise the use of its assets to supply coal to the VPPS. The project would also allow for secondary extraction in the approved MC areas under Lake Macquarie to maintain consistency with the existing CVC consent and provide an extension of the life of mine for an additional two years to 2029. The extension would also align the life of both mining operations with the planned operational period of the VPPS.

Figure 1 shows the overall consolidated project plan with the two different mining zones marked where the current consent conditions place limits on the maximum allowable surface subsidence (vertical movement) – Zone A: limited to no more than 20mm; and Zone B limited to no more than 780mm. Figure 2 is a plan of the current and proposed consolidated Chain Valley Colliery workings. The areas shown in light blue and in pink in this plan are the proposed workings under Zones A and B respectively.

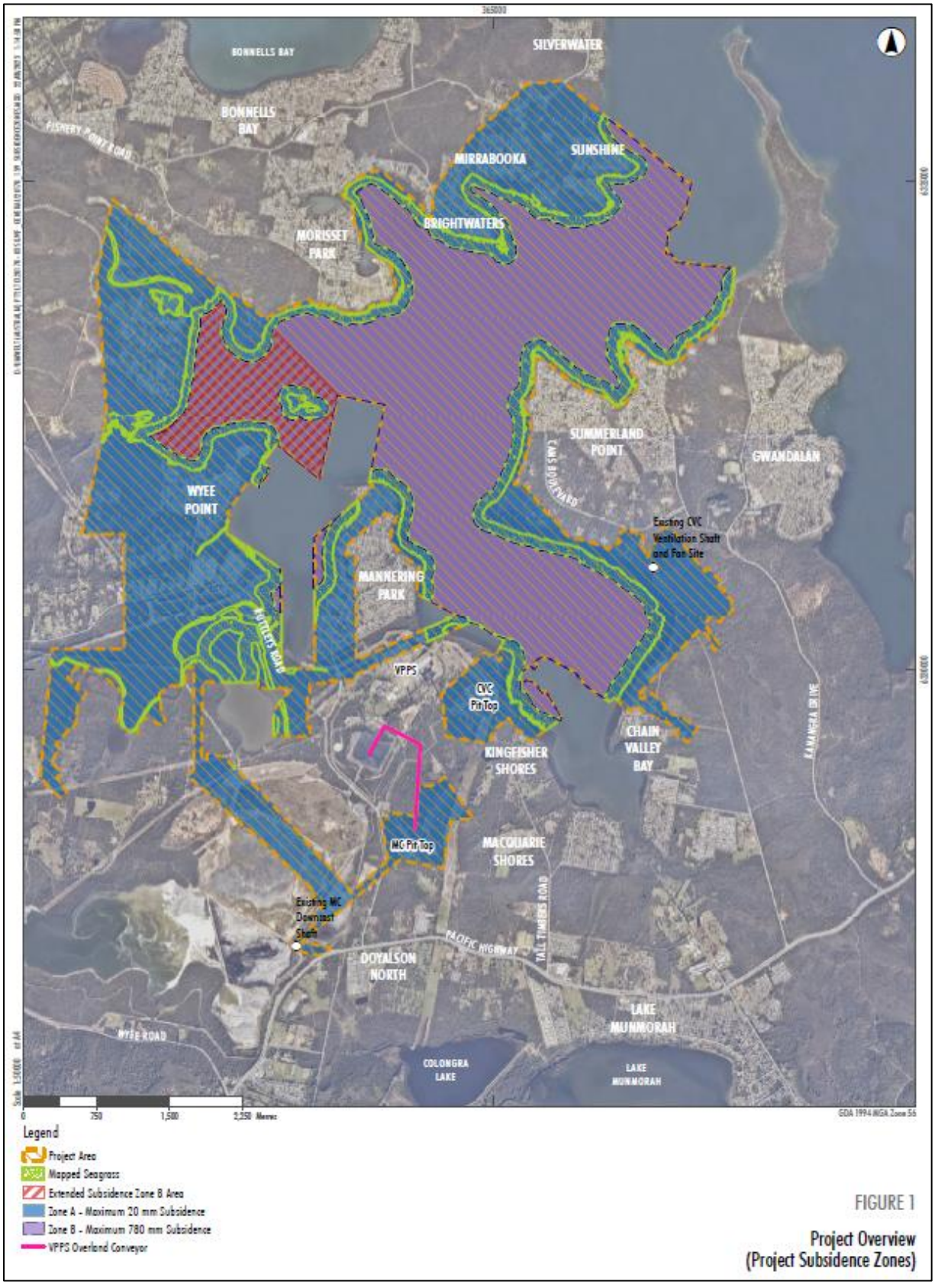

Figure 1. Project Plan showing approved subsidence zones A and B
(source: Umwelt Report (10 November 2023))

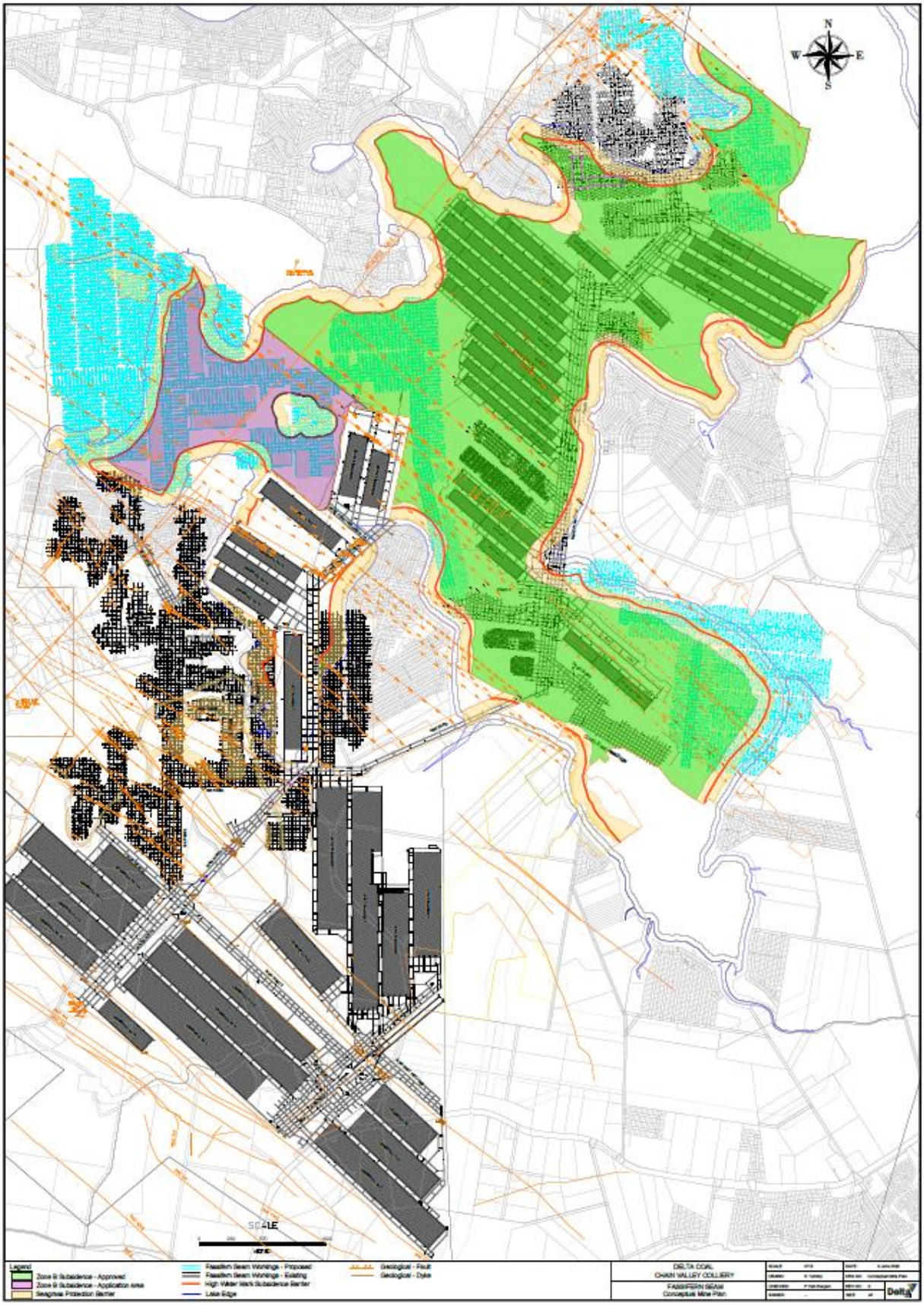

Figure 2. Consolidated Chain Valley Colliery mine plan
(source: Umwelt Report (10 November 2023))

2.0 METHOD OF OPERATION

The Panel convened by videoconference during the preparation of its advice and was administratively supported by Secretariat staff provided by DPHI - Major Projects Advisory. The Panel convened and received the supply of initial documentation in November 2023. This and subsequent communication and documentation between the Panel and Delta Coal (and its associates) is listed in Table 1.

Table 1: Key documents reviewed by the Panel

Stage	Document Reference	Document Name
Initial Documentation	Assessment documents from Chain Valley Coal	• Chain Valley Consolidation EIS(Main Report) (September 2022) • Chain Valley Consolidation Response to Submissions Report (March 2023) • Chain Valley Consolidation Request for Further Information (RFI) Response (Subsidence) (dated 10 November 2023)
Supplementary Information	Additional information	• CVC (Umwelt) response to DPHI RFI of 5 May 2023 – dated 10 November 2023 - with attached Byrnes Geotechnical Report – dated October 2023 • IEAPM review and commentary on above Umwelt documentation and RFI – dated 22 January 2024 • Delta Coal letter seeking clarification on IEAPM 22 January 2024 RFI – dated 4 March 2024 • Delta Coal response to IEAPM RFI of 22 January 2024 – dated 18 June 2024 • IEAPM response to Delta Coal, requesting copies of original geotechnical advice report used to prepare the 18 June 2024 response – dated 10 July 2024 • Delta Coal further response including copy of requested report by Byrnes Geotechnical (dated 5 June 2024) – dated 21 August 2024 • IEAPM further RFI – dated 19 September 2024 • Delta Coal response (RFI V5 Response) to IEAPM RFI of 19 September 2024 – dated 15 October 2024

The Panel convened several times over the course of preparing its advice. Table 2 summarises in chronological order, the schedule of meetings held.

Table 2: Schedule of meetings held

Meeting Date	Meeting Information
22 July 2024	Panel discussion with DPHI
18 August 2024	Project meeting discussion
29 August 2024	Subsidence issues RFI discussion with Planning
18 September 2024	Videoconference briefing meeting between IEAPM and Delta Coal
20 November 2024	Report review meeting
5 December 2024	Report review meeting

3.0 PRIMARY FOCUS OF THIS ADVICE

As indicated in Figures 1 and 2, the proposed workings under this consolidation plan are divided into two zones. Zone A consists of first workings only, where current consent conditions limit surface subsidence to no more than 20mm of vertical movement. Zone B consists of proposed secondary or pillar extraction workings to form a series of extraction panels and barrier pillars where surface subsidence is permitted up to a maximum of 780mm under current consent conditions.

This advice is therefore structured around the proposed workings under the two nominated zones and the related types of mining proposed in each zone. All mining is to be conducted using continuous miner equipment (as opposed to earlier secondary extraction mining at Chain Valley where longwall-based miniwall extraction panels were operated).

The Zone A sections of the mine plan are located under a range of surface infrastructure features as well as foreshores and sections of lake where seagrass beds are present.

It is important to note that the detailed mine plans to be used in Zone B will still be subject to an Extraction Plan which must be submitted to the Department for approval and may involve minor plan variations to that currently shown. This is acknowledged in the November 2023 Umwelt Report, as follows:

> *"This current CVC Consent regulatory framework enables Delta Coal to adapt underground mining operations within the Zone B area to local geological conditions and production requirements. This approval framework does not lock Delta Coal into a particular mine layout or production schedule which must be carried through into an extraction plan, but rather allows the mine plan to be adjusted provided the performance criteria are satisfied. Should second workings be proposed, the Extraction Plan will contain further detail regarding the proposed mining methods and layout and detail management measures to ensure the performance criteria applicable to second workings are met".*

Both Zone A and Zone B sections of the mine plan include seagrass protection barriers around the edges of the undermined sections of Lake Macquarie.

4.0 PANEL COMMENTARY

4.1. IMPLICATIONS OF GEOLOGICAL SETTING AND LEGACY CONSENT

The proposed mine workings are required to restrict surface subsidence. In underground coal mining, this is achieved primarily by:

1. restricting extraction height;
2. limiting the width of mining excavation in order to restrict caving and sagging of the overburden; and
3. designing the surrounding coal pillars to be both sufficiently strong to carry the weight of the bridging strata and sufficiently stiff so as not to compress excessively under this weight.

The conceptual mine plan for the CVCP relies on actions 2 and 3 to satisfy consent conditions relating to maximum subsidence. Due to both the nature of the geological setting and the inappropriate and now outdated concept of specifying upper values of permissible surface subsidence, there are significant complexities associated with applying these approaches to mine design on this occasion.

The geology of the Lake Macquarie region (in which the CVCP is located) is characterised by layers of consolidated volcanic ash, or tuff, which are referred to as 'claystone'. This stratum has variable material properties but is generally weak and soft and can be reactive in the presence of water (which is inevitable when mines close, if not before). It comprises the roof and/or floor strata over extensive areas of some coal seams, as well as being present as thin bands within coal seams. This is the situation regarding the Fassifern Seam in the CVCP. The significance of the claystone is that it constitutes the weakest element of the coal pillar support system for controlling subsidence, rather than the coal strata as is the norm in most mining situations.

In these circumstances, the stability of the pillar support system can be compromised by instability of the claystone pillar foundations (roof and/or floor) and in-seam bands, well before the compressive strength of the loaded coal elements of the pillar system are exceeded. Instability is associated with the coal pillars punching the claystone and/or with lateral extrusion of soft claystone, which has the effect of subjecting the coal pillar to lateral tension and tearing it apart (coal, like most rocks, being much weaker in tension than compression). The compressible nature of claystone when subjected to load can also result in additional subsidence.

There is a history of unplanned subsidence events in the Lake Macquarie region that are associated with claystone roof, floor and in-seam bands, with a spike in these events during the 1980s. These events motivated significant research into the mechanical and time-dependent properties of claystone in the Lake Macquarie region with the aim of developing appropriate mine design methodologies for these circumstances. However, due to deficiencies and gaps associated the underpinning data base and the knowledge base, there is still an elevated level of uncertainty associated with coal mine design in the presence of claystones.

Another geological-related complexity associated with mine design in the Lake Macquarie region that is relevant to this matter is the presence in the overburden of variable thicknesses of conglomerate strata that have the capacity to span over extensive areas when undermined. This can result in not only high pillar loading situations but also in loading conditions that change in response to variability in conglomerate thickness and the lateral extent of mining. This behaviour has also contributed to a number of past excessive subsidence events in the region.

The Panel members applied their considerable research and practical experience in designing mine workings in these situations when evaluating the conceptual mine design proposed by Delta Coal for the CVCP. Nevertheless, some design aspects could not be resolved but, for reasons arising out of this review and noted later, there is little point in reporting in detail on them in this advice.

The CVCP is also complicated by the subsidence performance measures being specified in terms of values of maximum permissible surface subsidence; that is subsidence *effects*. It was recognised almost two decades ago that this was not an appropriate and, in many cases, not a workable approach to specifying mining-induced outcomes for the environment. Largely as a result of the findings of the

Southern Coalfield Inquiry in 2008 (DoP, 2008), this approach has been superseded by the concept of performance measures based on the consequences of mining.[1]

Irrespective of the presence of claystone, there are serious impediments to being able to manage maximum surface subsidence to such low prescribed levels as 20mm. In this matter, they relate for example, to being able to distinguish natural climatic ground movements on land from mining-induced movements and to only being able to measure surface subsidence of the floor of Lake Macquarie to an order of accuracy of ±200mm (as advised by Delta Coal). The Panel also devoted considerable time to this matter which has led to a proposed re-defining of the Performance Measure in a manner that makes it practical to achieve the original objectives of setting a 20mm limit on subsidence.

4.2. ZONE A FIRST WORKINGS

Figure 3 shows a conceptual layout for the proposed bord and pillar first workings in Zone A. These are based on a form of herringbone pillar configuration that results in chevron-shaped pillars formed by angled cut-throughs being driven from both sides of each pillar.

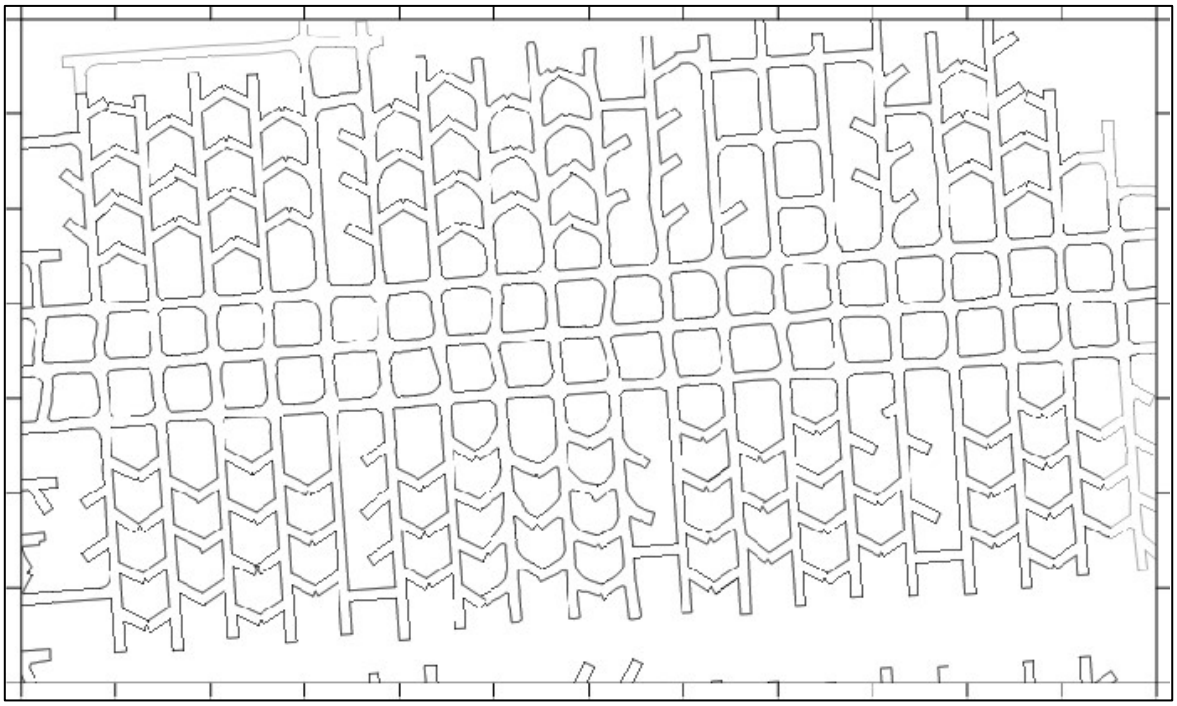

Figure 3. Proposed herringbone first workings layout for Zone A
(source: Umwelt Report, attached Byrnes Geotechnical Report (October 2023))

The Panel has reviewed the Zone A layout design and the analysis and validation documentation provided by Byrnes Geotechnical, through Umwelt/Delta Coal. This has involved a number of iterations

[1] The following definitions of subsidence effects, subsidence impacts and subsidence consequences evolved out of the Southern Coalfield Inquiry:

- *Effect* - the nature of mining-induced deformation of the ground mass (e.g. vertical displacement or subsidence).
- *Impact* - any physical change caused by subsidence effects to the fabric of the ground, the ground surface, or a structure (e.g. cracking).
- *Consequence* - any change caused by a subsidence impact to the amenity, function or risk profile of a natural or constructed feature (e.g. water loss down a crack).

in the review process following questions raised by the Panel and further responses provided by Delta Coal. Delta Coal contends that the proposed first workings layouts in Zone A will result in less than 20mm of vertical subsidence (mining-induced).

4.2.1. Consideration of Past Surface Subsidence

Delta Coal has provided historical subsidence data from a survey line along Ruttleys Road where first workings in the Fassifern Seam were mined beneath this region at a depth of about 180m. This survey data from 2008 is reported to show vertical subsidence in the range of 0mm to 43mm. Delta Coal's geotechnical consultant's analysis of this data has concluded that a maximum vertical subsidence was only 15mm. Delta Coal has also advised that there has been previous demonstrated compliance with the 20mm subsidence limit over herringbone pillar panels in the Fassifern Seam elsewhere in the colliery.

The Panel requested further documentation to support the statement regarding previous compliance over herringbone pillar panels. Subsequent correspondence from Delta Coal has referred to previous multiple survey lines over portions of the foreshore, that were advised as being compliant with a 20mm limit. However, the full nature and extent of this historical data relative to mining panel geometries was not sufficiently robust to permit the Panel to be confident of compliance with the 20mm limit.

Review by the Panel of the Ruttleys Road survey data raises concerns regarding some anomalous higher subsidence values, which may or may not reflect a degree of survey peg damage or other non-mining surface movements. Delta Coal's consultants adopted an averaging technique to arrive at their assessment of no more than 15mm subsidence. However, the Panel is yet to be convinced that this is a valid or appropriate approach, given the high level of uncertainty in the data involved.

One of the major concerns that the Panel has with the proposed workings under the current Zone A consent condition limitation of 20mm maximum subsidence is not that the first workings layout may not be compliant with such a condition, but with the extreme difficulty in differentiating between natural variations in surface ground movement (due to factors such as clay swelling, shrinkage, weathering etc) and mining-induced movements at such low levels. This is particularly the case where surface soils and related strata contain clay-bearing material which is particularly susceptible to moisture effects. The Ruttleys Road data, and other survey results, may well be impacted by such non-mining ground movements, and it has not been possible to identify the magnitude of such movements other than recognising from non-mining locations that the magnitudes of non-mining movements can be greater than the 20mm limit being imposed on mining-induced subsidence.

Following the Panel forming this view regarding the difficulty in working within a 20mm prescribed limit, it suggested to DPHI that an alternative, risk-based measure of conformance with consent conditions that was based on consequence rather than an arbitrary prescribed upper limit of subsidence effect, was more appropriate and consistent with contemporary approaches to managing mining-induced impacts and their associated consequences. Such an approach would be consistent with the recommendation of the 2008 Southern Coalfield Inquiry (DoP, 2008) which has subsequently become the endorsed and accepted approach in NSW. In response to the Panel's suggestion, the most recent Delta Coal response (Delta Coal, 15 October 2024) includes a proposed set of performance measures as a potential replacement for the quite prescriptive 20mm limit that the Panel believes is unmanageable.

4.2.2. Proposed Alternative Consent Condition

Table 1 from the Delta Coal response of 15 October 2024 is reproduced below as Table 3. It lists some definitions and then a set of consequence-based performance measures for:

- natural and heritage features;
- built features and public safety; and
- first workings.

The performance measures are based on specifying negligible impact for each category and sub-category. The Panel considers that this is an appropriate approach and supports it. However, the proposal does not follow this same approach for the built features category. On this occasion, because the intent of a 20mm limit on subsidence is to prevent any detectable mining-induced impacts, the Panel is of the opinion that a similar "negligible impact" requirement should be adopted for the built features

category, rather than specifying "serviceable and repairable" which could allow a level of subsidence that could be considered excessive and could clearly give rise to greater than negligible impacts.

Table 3: Excerpt from Delta Coal response of 15 October 2024

Definitions	
First Workings	The extraction of coal from underground workings by bord and pillar mining methods (including herringbone pattern workings) as well as from main headings and cut-throughs.
Negligible	Small and unimportant, such as to be not worth considering.
Performance Measures – Natural and Heritage Features etc.	
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.
Benthic Communities	Minor environmental consequences, including minor changes to species composition and/or distribution.
Water Resources	No environmental consequences to water quality, water flows (including baseflow), groundwater dependent ecosystems or stream health (including riparian vegetation) as a result of the development beyond what is predicted in the EIS.
Land	Negligible subsidence impacts or environmental consequences.
Biodiversity	Negligible impacts on threatened species, populations or communities due to mining induced subsidence.
Heritage sites	Negligible subsidence impacts or environmental consequences.
Mine Workings – First Workings	To remain long term stable and non-subsiding.
Performance Measures – Built Features & Public Safety	
All built features	• Always safe. • Serviceability should be maintained wherever practicable. Loss of the Serviceability must be fully compensated. • Damage must be fully repaired, replaced or fully compensated.
Public Safety	• Negligible additional risk.
Performance Measures - First Workings	
First Workings	• The applicant may carry out underground first workings within the approval boundary, other than in accordance with an approved Extraction Plan, provided that the Resources Regulator is satisfied that the first workings are designed to remain stable and non-subsiding in the long term, except insofar as they may be impacted by approved second workings. *Note: The intent of this condition is to ensure that first workings are built to geotechnical and engineering standards sufficient to ensure long-term stability, with negligible direct subsidence impacts.*

The Panel does have a concern with the term "long-term stable and non-subsiding" used to describe the pillars in references to first workings in Table 3. The Panel considers that "long-term stable" is an acceptable criterion, but the wording of "non-subsiding" may be confusing or ambiguous in terms of the intention or meaning of this criterion. The words used should more clearly reflect performance of pillars that do not exhibit any ongoing time-dependent vertical deformation (compression), either within the coal pillars themselves, or the surrounding immediate roof or floor strata.

4.2.3. Review of Pillar Design

Delta Coal has provided the calculations used to determine pillar stability for the proposed herringbone panel layouts. The Panel recognises that use of the commonly adopted pillar strength determination formulae requires some assumptions and approximations to be applied to these types of more complex pillar shapes. Nevertheless, the Panel is satisfied with the approximations and overall methodology adopted by Delta Coal for the herringbone pillars, even though the Panel remains to be convinced on some points of detail.

An area of concern with respect to the pillar design relates to the presence of potentially weak/soft claystone strata in both the immediate floor and roof adjacent to the coal seam. These strata horizons have the potential to contribute to different forms of underlying (and overlying) foundation failure when the pillars are more highly loaded. The Panel understands that Delta Coal has taken account of these issues in relation to the presence of claystone in the floor. However, the question of claystone in the roof is a matter that may require further localised mine plan design variations on a panel-by-panel basis, depending on the local roof geology.

4.2.4. Conclusions re Zone A Workings

The Panel concludes that:

1. The proposed herringbone pillar layout for the first workings in Zone A provides a suitable basis for assessing the CVCP.
2. Should the CVCP be approved, it would be judicious, given the geological and geotechnical conditions and mining history in the area, for approval conditions to provide for regular monitoring of stability in the long term and annual reporting of the performance of the mine workings.

4.2.5. Recommendations re Zone A Workings

The Panel recommends:

1. The Department should consider replacing the current 20mm subsidence limit for Zone A workings with a negligible impact set of mining consequence criterion for all relevant parameters (including the built infrastructure), noting that this should achieve the same objectives as those intended to be achieved by the now legacy issue of specifying an extremely low level of permissible subsidence, such that it becomes an impractical and unmanageable control in practice.

2. Further design criteria should be specified for first workings, being that these workings should be designed to:
   a. be long-term stable, and to
   b. exhibit no ongoing time-dependent deformation either within the coal pillars themselves, or the immediately surrounding roof or floor strata.

3. Should the CVCP be approved, approval conditions should provide for:
   a. regular monitoring and annual reporting of the response of all first workings over time.
   b. the proposed herringbone pillar layout for the first workings in Zone A being subject to ongoing monitoring and annual reporting of localised roof and floor strata conditions in each panel, especially with respect to the nature and extent of claystone stratum, with a view to identifying any need to modify the mine design accordingly to limit pillar loading so as to avoid excessive stress levels that could lead to foundation failure of the coal pillar system.
   c. auditing of annual reports by an independent third party endorsed by the Secretary.

4.3. ZONE B PILLAR EXTRACTION WORKINGS

Figure 4 shows the proposed pillar extraction layout to be adopted in Zone B, based on double-sided lifting on the retreat, forming up typically 103m wide panels, separated by barriers of solid coal and first workings development barriers, as indicated.

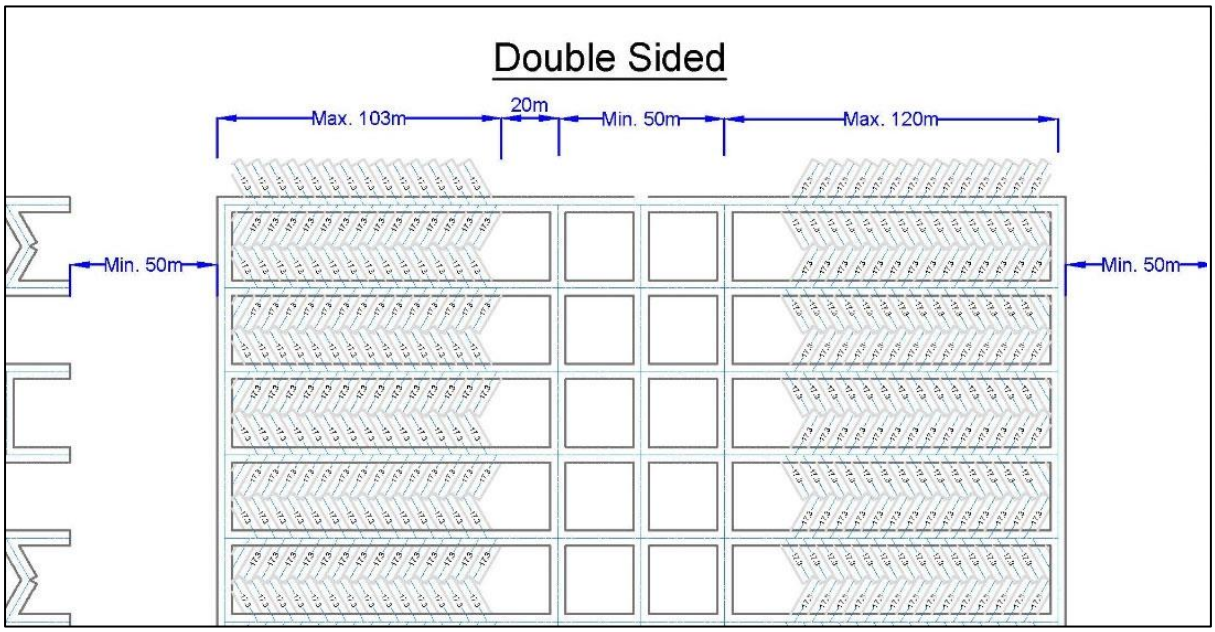

Figure 4. Proposed double-sided lifting secondary extraction layout for Zone B
(source: Umwelt Report, attached Byrnes Geotechnical Report (October 2023))

The current consent conditions require that the subsidence above such panels does not exceed 780mm. The design of the proposed secondary extraction panels by Delta Coal's geotechnical consultants is primarily based on a reliance on the bridging effect of the massive overlying conglomerate strata (Teralba Conglomerate Unit) present in the overburden above the Fassifern Seam. On the basis of the above proposed panel layouts (both extraction widths and barrier pillar widths) a maximum subsidence of 475mm has been predicted by Delta Coal.

4.3.1. Previous Secondary Extraction Subsidence Impacts

Delta Coal has drawn on previous miniwall extraction panel data to demonstrate the effect of different panel and barrier widths on surface subsidence. Much of the miniwall data is taken from bathymetric survey records of the floor of Lake Macquarie. These techniques are acknowledged to have a relatively low level of survey accuracy – stated to be up to ±200mm. Nevertheless, relative survey data over the same survey lines can still be useful to indicate trends, even if the exact subsidence values are subject to a high level of error.

The initial bathymetric survey data was presented in commonly used coloured "heat maps" such as Figure 5 below. However, such maps are difficult to discern actual magnitudes and comparisons with subsequent survey data, in terms of recognising time-dependant trends in ongoing movement.

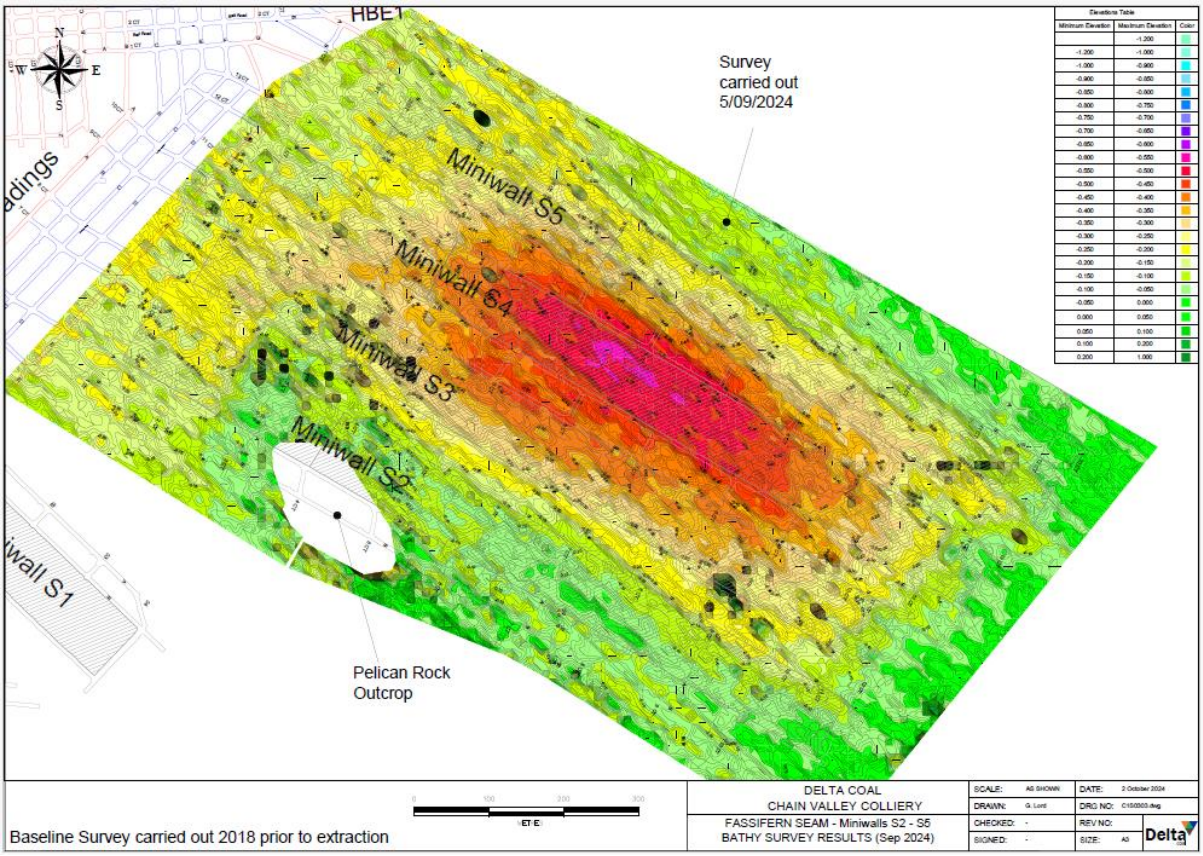

Figure 5. Typical bathymetric survey subsidence "heat maps" – Miniwalls S2 to S5
(source: Delta Coal Response Report (October 2024))

The Panel requested that Delta Coal provide survey data drawn from such heat maps but shown for all survey time intervals along a representative cross-section over the workings. Figures 6 and 7 are the resultant plots received – both for Miniwalls S2 to S5 (Figure 6); and for Miniwalls 1 to 12 (Figure 7).

The S2 to S5 survey data (Figure 6) is taken from a pre-mining baseline of 2018, with the surveys taking place in September of each of 2021, 2022, 2023 and 2024. Whilst these results indicate that the majority of subsidence was complete by 2022, there is some indication that a low level of ongoing movement may still be occurring, even in 2024.

The Miniwall 1 to 12 data in Figure 7 presents survey data after mining, in 2015, 2016, 2017, 2018 and two surveys in 2019. This data appears to indicate a more stabilised set of results over time, although there is no data after 2019 to provide full verification that subsidence has plateaued.

The Miniwall 1 to 12 panel layouts involved barrier pillar widths of only 33m and led to a maximum subsidence level of 1,150mm developing over the centre of the twelve-panel extraction region, compared to the predicted level of only 720mm, in contrast to the S2 to S5 panels where wider (40m) barrier pillar widths were used.

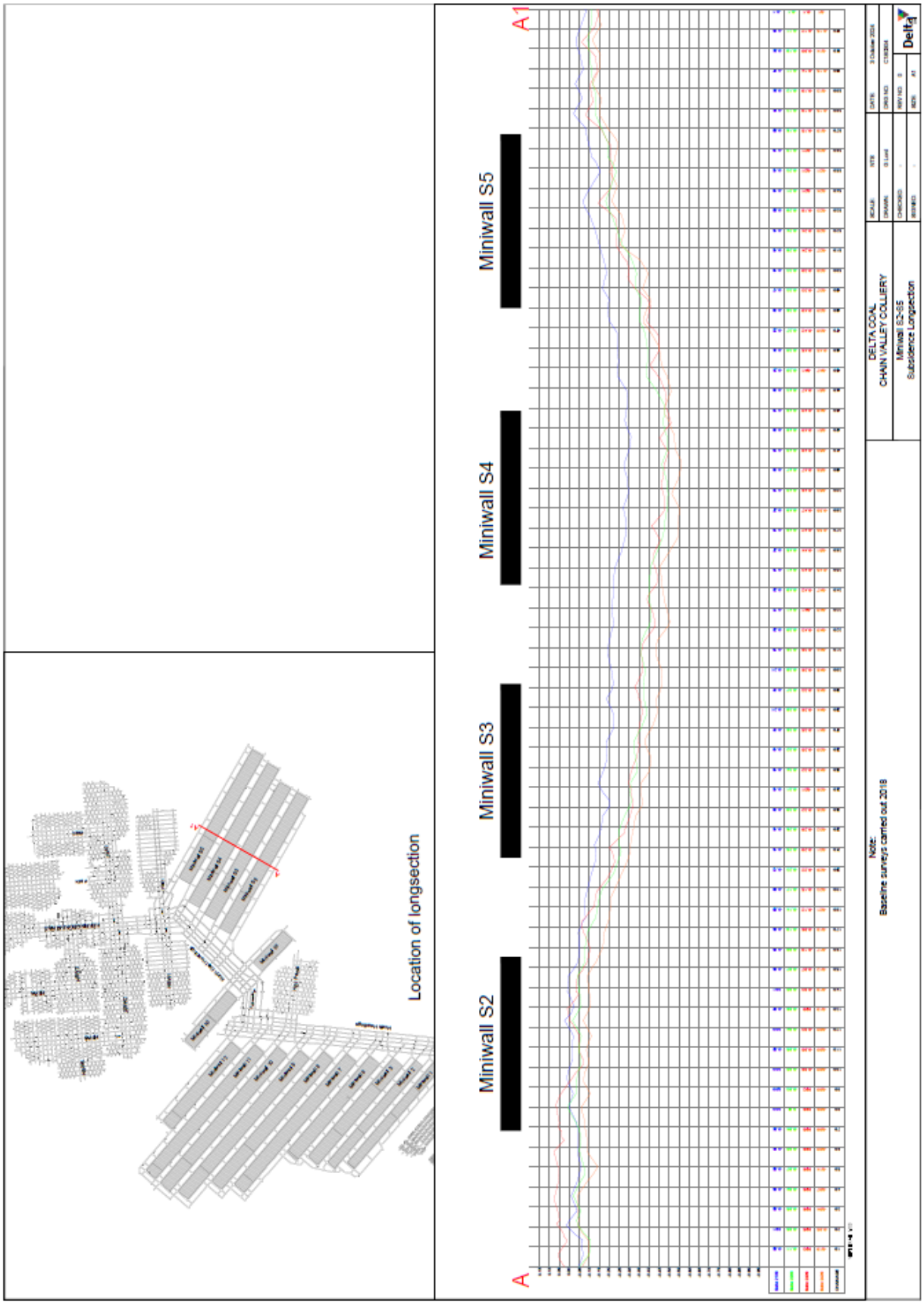

Figure 6. Cross-sectional survey data from 2018 to 2024 – Miniwalls S2 to S5
(source: Delta Coal Response Report (October 2024))

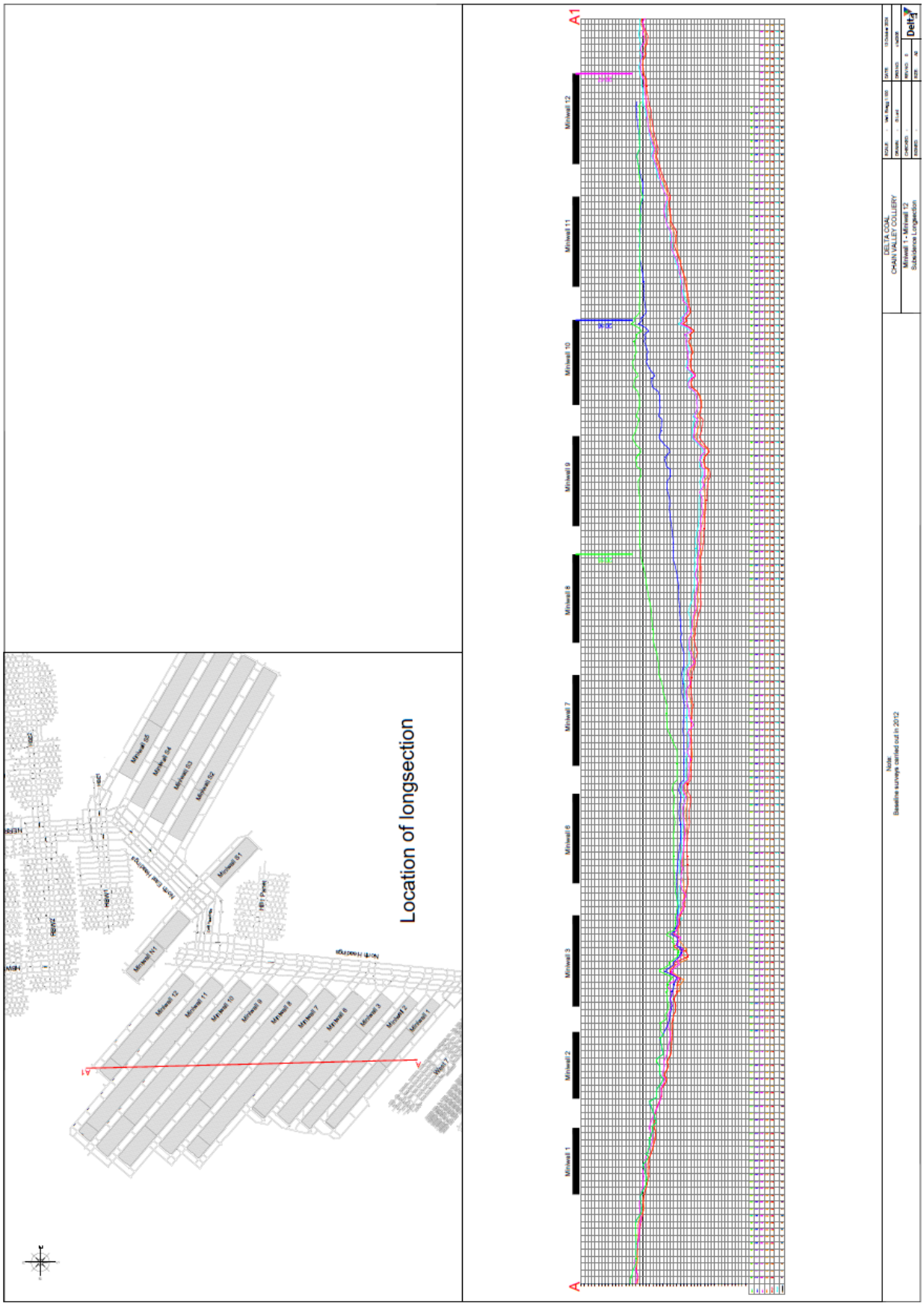

Figure 7. Cross-sectional survey data from 2018 to 2024 – Miniwalls 1 to 12
(source: Delta Coal Response Report (October 2024))

The Panel requested an explanation, or at least a technical review of the likely reasons for the subsidence exceedance over Miniwalls 1 to 12. Delta Coal provided a number of reports prepared by Ditton Geotechnical Services (DGS) who had prepared the original miniwall layout subsidence predictions. This set of DGS documentation provided a detailed review of the original design and prediction, and the subsequent actual performance relative to prediction, in particular, the DGS Report titled *"Updated Investigation Report into the Maximum Subsidence Prediction Exceedance over Miniwalls 1 to 12 at Chain Valley Colliery, Vales Point",* DGS Report No. CHV-002/10b, 31 March 2018.

This is a very helpful report that provides useful insight into the likely cause(s) of the excessive subsidence behaviour. The following is an extract from the DGS conclusions in this report:

> *"Based on the extensive review undertaken, it is assessed that the subsidence exceedance over MW1-12 was caused by over-loading of the chain pillars. This was in turn primarily a result of:*
>
> *(i) reducing overburden stiffness due to the progressive widening of the overall mined-out area, and*
> *(ii) reducing pillar system strength due to a gradual increase in the overall thickness of the claystone units in the Fassifern Seam floor northwards towards MW12.*
>
> *In summary:*
>
> *• Subsidence was initially limited by spanning conglomerate units in the overburden.*
>
> *• Accordingly, for a mined-out area equivalent to two panels, subsidence was < 0.3 m.*
>
> *• Extraction of a third panel increases the overall span to >300m, a width / depth ratio of >1.4. The mined-out area moves from "sub-critical / critical" to "critical / super-critical".*
>
> *• Once the mined-out area becomes super-critical, inadequacies in the chain pillars begin to manifest. The pillars lack the strength and stiffness to resist overburden deflection.*
>
> *• At super-critical overall spans, failure initiates in the conglomerate units below the uppermost Munmorah Conglomerate.*
>
> *• As the overburden breaks down, load on the chain pillars and goaf increases. The pillars are much stiffer than the goaf and (initially at least) accept most of the load.*
>
> *• At super-critical spans, average chain pillar stress is estimated at 15 to 20 MPa. This is of the same order as the bearing capacity of the claystone floor (15 to 21 MPa).*
>
> *• As mining progresses towards MWs 10-12, the claystone in the floor thickens, bearing capacity reduces and the nominal Factor of Safety against bearing failure falls below 1.*
>
> *• Yielding of the claystone floor is unlikely to have resulted in true "bearing failure". More likely, the most softened claystone at the pillar periphery would tend to deform laterally, reducing confinement and reducing the pillar core width. As pillar stiffness reduces, overburden deformation increases and more load sheds to the goaf.*
>
> *• The goaf strain-hardens under load produced by increasing overburden deflection. This provides support and assists the Munmorah Conglomerate to behave elastically and span until a late stage in the process.*
>
> *• It is likely that the Munmorah Conglomerate spans to almost 500m, limiting subsidence to < 720 mm, even though the overall width to depth ratio is 2.6 and chain pillar stress is > 15MPa.*
>
> *• However, once the mined-out width is > 500m (after MW10), the spanning ability of the Munmorah Conglomerate has been reduced, allowing full loading on the chain pillars to occur.*
>
> *• Subsidence then becomes simply a function of the resistance offered by the failed pillars and goaf.*
>
> *• Subsidence then increases further, reaching a maximum of 1.15 m in the area of thicker claystone / weaker floor, north-east of MW8.*

Based on the outcomes of this study, the key recommendations are summarised as follows:

- *Future mining subsidence will be controlled to currently approved limits by maintaining a pillar Stability Index of at least 2.5, where the effective width to depth ratio is >1.4. As a result, average pillar sizes will need to be increased.*
- *Consider the local geological conditions (e.g. total thickness of claystone in the floor) at the design stage.*
- *Consider increasing the frequency of bathometric surveys to allow primary subsidence consolidation and pillar creep rates to be better defined and understood.*
- *Undertake further modelling to determine appropriate geometries in future mining areas.*
- *Undertake further creep modelling to assess long-term effects in future areas".*

These conclusions and recommendations are considered to be particularly pertinent to the currently proposed Zone B secondary extraction at Chain Valley.

The key learnings relate to:

1. Ensuring proper consideration of the adequacy of barrier pillar widths so as to prevent pillar over-loading, particularly when considering the potential for foundation failure in underlying claystone strata.
2. Consideration of the conglomerate spanning capability – not just for individual panel widths, but across the mining region as a whole.

4.3.2. Panel Design Parameters

Delta Coal has conducted a number of sensitivity studies in its design analysis, based on different thicknesses and strength/stiffness of the overlying conglomerate unit. An average strength (UCS) of 65-MPa has been used, representing a range of values between 12 MPa and 108 MPa. (This wide range illustrates the need to consider site-specific values for each panel/barrier region of the proposed workings). Similarly, the conglomerate thickness has been described as approximately 40m, and a design figure of 30m has been used. However, the data presented includes reference to conglomerate thickness as low as 20m.

Clearly, such a low thickness, combined with some low strengths, could lead to significantly different spanning capabilities.

4.3.3. Conclusions re Zone B Workings

The Panel concludes that:

1. The proposed mine layout for second workings in Zone B provides a suitable basis for assessing the CVCP.
2. Should the CVCP be approved, it would be judicious, the given geological and geotechnical conditions for approval conditions to provide for staged approval of Extraction Plans for secondary workings, premised on predicted versus measured performance.

4.3.4. Recommendations re Zone B Workings

The Panel recommends that:

1. Should the CVCP be approved, approval conditions should provide for:
    a. local conglomerate and claystone properties and thicknesses to be investigated for each set of extraction panels prior to finalising extraction and barrier width parameters.
    b. the overall number of panels in any location be limited to no more than two, without the inclusion of a more substantial barrier separating adjacent mining regions.
    c. staged approval of Extraction Plans for second workings, premised on predicted versus measured performance.

5.0 SUMMARY CONCLUSIONS

Overarching

1. The CVCP assessment process is based on conceptual mine planning and, as such, does not go into as much detail as that which will be required at a later date to permit secondary extraction in the subject area. Hence:
2. The subsidence impact assessment presented in the EIS and supporting documentation is relatively concise and confined.
3. This IEAPM review and advice has a focus on geotechnical factors associated with the conceptual mine design and the related surface subsidence impacts and is not as comprehensive as that which may subsequently be required if the CVCP is approved.
4. The conceptual mine layout provides an adequate basis for the purpose of assessing the merits of the CVCP.

Zone A Workings

1. The proposed herringbone pillar layout for the first workings in Zone A provides a suitable basis for assessing the CVCP.
2. Should the CVCP be approved, it would be judicious, given the geological and geotechnical conditions and mining history in the area, for approval conditions to provide for regular monitoring of stability in the long term and annual reporting of the performance of the mine workings.

Zone B Workings

1. The proposed mine layout for second workings in Zone B provides a suitable basis for assessing the CVCP.
2. Should the CVCP be approved, it would be judicious, given geological and geotechnical conditions and mining history in the area for approval conditions to provide for staged approval of Extraction Plans for second workings, premised on predicted versus measured performance.

6.0 SUMMARY RECOMMENDATIONS

Overarching

1. The conceptual mine layout as proposed is suitable for the purpose of assessing the merits of the CVCP.
2. Should the CVCP be approved, it would be judicious, given the geological and geotechnical conditions and mining history in the area, for approval conditions to provide for:
    a. Monitoring of the performance of first workings in the long-term, supported by annual reporting that is audited by an independent third party endorsed by the Secretary.
    b. Staged approval of Extraction Plans for second workings, premised on predicted versus measured performance and advances in knowledge bases.

Zone A Workings

1. The Department should consider replacing the current 20mm subsidence limit for Zone A workings with a negligible impact set of mining consequence criteria for all relevant parameters (including the built infrastructure), noting that this should achieve the same objectives as those intended to be achieved by the now legacy issue of specifying an extremely low level of permissible subsidence, such that it becomes an impractical and unmanageable control in practice.

2. Further design criteria should be specified for first workings, being that these workings should be designed to:
    a. be long-term stable, and to
    b. exhibit no ongoing time dependent deformation either within the coal pillars themselves, or the immediately surrounding roof or floor strata.

3. Should the CVCP be approved, approval conditions should provide for:
    a. regular monitoring and annual reporting of the response of all first workings over time.
    b. the proposed herringbone pillar layout for the first workings in Zone A being subject to ongoing monitoring and annual reporting of localised roof and floor strata conditions in each panel, especially with respect to the nature and extent of claystone stratum, with a view to identifying any need to modify the mine design accordingly to limit pillar loading so as to avoid excessive stress levels that could lead to foundation failure of the coal pillar system.
    c. auditing of annual reports by an independent third party endorsed by the Secretary.

Zone B Workings

1. Should the CVCP be approved, approval conditions should provide for:
    a. local conglomerate and claystone properties and thicknesses to be investigated for each set of extraction panels prior to finalising extraction and barrier width parameters.
    b. the overall number of panels in any location be limited to no more than two, without the inclusion of a more substantial barrier separating adjacent mining regions.

7.0 REFERENCES

Delta Coal (November 2023) Chain Valley Consolidation RFI Response (Subsidence) (dated 10 November 2023).

Delta Coal (March 2024) Delta Coal letter seeking clarification on IEAPM 22 January 2024 RFI – dated 4 March 2024.

Delta Coal (June 2024) Delta Coal response to IEAPM RFI of 22 January 2024 – dated 18 June 2024.

Delta Coal (August 2024) Delta Coal further response including copy of requested report by Byrnes Geotechnical (dated 5 June 2024) – dated 21 August 2024.

Delta Coal (October 2024) Delta Coal response (RFI V5 Response) to IEAPM RFI of 19 September 2024 – dated 15 October 2024.

DoP. (2008). Impacts of Underground Coal Mining on Natural Features in the Southern Coalfield - Strategic Review. Hebblewhite, B.K., Galvin, J.M., Mackie, C.D., West, R. & Collins, D. ISBN 978 0 7347 5901 6. Sydney: NSW Government, Department of Planning.

IEAPM (January 2024) IEAPM review and commentary on Umwelt documentation and RFI – dated 22 January 2024.

IEAPM (July 2024) IEAPM response to Delta Coal, requesting copies of original geotechnical advice report used to prepare the 18 June 2024 response – dated 10 July 2024.

IEAPM (September 2024) IEAPM further RFI – dated 19 September 2024.

Umwelt (September 2022), Chain Valley Collery Consolidation Project EIS V3 (Main Report).

Umwelt (March 2023), Chain Valley Colliery Consolidation Project Submissions Report.

Umwelt (October 2023), response to DPHI RFI of 5 May 2023 – dated 10 November 2023 - with attached Byrnes Geotechnical Report – dated October 2023.

APPENDIX A – DPHI REQUEST FOR ADVICE

APPENDIX B – PANEL BIOGRAPHY

Professor Bruce Hebblewhite

Bruce Hebblewhite is an Emeritus Professor and was formerly the Professor of Mining Engineering at the University of New South Wales until his retirement from UNSW in 2020. He has over 45 years of international mining experience, specialising in the fields of underground mining systems, geomechanics, mine safety and risk management. He has held senior positions with Australian Coal Industry Research Laboratories (ACIRL Ltd), has served 25 years at the University of New South Wales including 12 years as the Head of Mining Engineering, and was also the Secretary General of the international Society of Mining Professors. He was also the Chair of the NSW Independent Panel for the Southern Coalfield Inquiry (2008).

Emeritus Professor Jim Galvin

Professor Galvin is an Emeritus Professor (University of New South Wales) in Mining Engineering and former member of the NSW Planning Assessment Commission. He has professional qualifications in science, engineering and mine management and extensive international experience in mining and geotechnical engineering, risk management and workplace health and safety. Professor Galvin is one of the world's foremost experts on underground coal mining and ground subsidence. He was a member of the Independent Panel for the Southern Coalfield Inquiry (2008), several subsequent reviews of mining projects in the Southern Coalfield and most recently, Chair of the Independent Expert Panel on Mining in the Catchment.