Preliminary Comments on the Dendrobium Area 5 SSI Proposal

SSI-33143123

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General Disclaimer

Dr P. Turner, NSW National Parks Association, June 2022.

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1. Introduction

Comments submitted for the SSD project (SSD 8194) assessment extend to the SSI proposal.[1]

The Dendrobium mine is particularly notable in using markedly greater mining geometry parameters than those used by others in the Special Areas. The mine is accordingly more damaging. Central to the impacts and consequences of the Dendrobium mine is that the drainage zones over many of its extractions reach or approach the catchment surface. Groundwater modelling is then central in predictively estimating water loss volumes and accordingly project consequences. Of note Consultants GeoTerra indirectly advise that the drainage zone doesn't need to reach the surface to exert an adverse influence[2], [3]:

> "*A minimum thickness of unfractured overburden is required to maintain hydraulic separation between a mine and saturated aquifers, with the critical value depending on lithology, structure and topography. The minimum separation has been established through observation and research in NSW mines as ranging from less than 90m up to 150m*."

2. Assessment of groundwater recovery at Dendrobium

The core aspect of the Area 5 groundwater report is the assessment[4] by Watershed HydroGeo (WHG) that the hydrographs obtained from Dendrobiums piezometer network suggest groundwater recovery above the mine's longwall extractions. The WHG modelling is built on this interpretation. The WHG report includes the following comments:

> "*Piezometers installed after longwall extraction show evidence for groundwater recovery and perching. The perched horizons are most extensive in strata between the upper CVSS and lower HBSS (> ~220-250 m above the coal seam) and above longwalls extracted three or more years ago (Section 2.6.2 and Figure 2-19).*
>
> *The observations imply that rainfall recharge (and stream flow loss), which may be enhanced due to surface fracturing, percolates through the fractured strata and is retarded at certain stratigraphic layers or restrictions in the fracture network. The overall hydraulic gradient remains downward; however, the increasing head trends in some piezometers implies that the rate of recharge exceeds the rate of downward drainage at those perched horizons. Therefore, not all rainfall that infiltrates at the surface above the goaf reports directly to the goaf as mine inflow.*
>
> *Regardless of the mechanism, groundwater impact models must account for restricted vertical drainage above a specified height threshold and recovery of groundwater levels in overlying strata*."

The piezometers of direct relevance are those installed in bores over or near the centreline of the extractions. Reflecting approval condition requirements, the mine now has a number of

such sites, both pre- and post-extraction. Of these, LW6 S2442A, LW7 S2443, LW9 S2220, LW12 S2411, LW12 S2420, LW13 S2421, LW14 S2398B, LW15 S2412B and LW16 S2510 are post-extraction centreline bores.

Most of the hydrographs from the sensors in these bores don't appear to suggest long term recovery. Those that do report an ongoing net pressure head accumulation over the recording period, typically the Bald Hill Claystone and shallow Colo Vale Sandstone sensors and Hawkesbury Sandstone sensor closest to the BHCS, also suggest that recovery would be well below pre-mining levels; vertical drainage would continue.

Also of importance, the groundwater assessment report doesn't appear to recognise that, where there is net pressure accumulation, it commences following the end of the 2017-19 drought and the onset of a period of unusually high rainfall. This period is expected to end later this year; its persistence is unlikely. Assumptions and modelling developed with respect to the current unusual circumstances may underestimate longer term water volume losses, in over-estimating the effect of vertical flow restriction at the depths where this appears to be occurring.

There appears to be no pattern in the depth at which the vertical drainage hindrance occurs. That this occurs, in almost all cases, after the end of the drought suggests heavy rain driven 'flushing' of loose above material into the voids between spalls in the collapsed zone.

3. Misleading statements regarding groundwater recovery

The following are examples of comments in the report that may mislead and cause confusion regarding groundwater recovery and water quality:

> "*As also noted in Sections 2.8.3 and 3.4.1, both groundwater and surface water quality are likely to be affected by longwall mining in Area 5. The processes by which this could occur are conceived to be:*
>
> > *1) groundwater recovery and resaturation of shallow fracture networks; and*
> > *2) eventual upward flux of deep groundwater following flooding of workings and re-pressurisation of the goaf."*
>
> *"Many of these effects are caused by recovery of groundwater levels within fracture networks above extracted longwalls (typically from within the surface cracking and dilated zones).*"

And

> "*The corollary to the instance of groundwater recovery leading to an improvement in baseflow and flow quantify at SC10C, noted above, is that iron-staining and water quality effects become more prevalent after groundwater levels recover*."

These comments are made notwithstanding recognition in the report of the most common cause[5], [6] of watercourse quality reduction above an underground mine:

> "*Leakage of water and transmission through the surface fracturing zone and re-emergence downstream can result in effects on water quality (HGEO, 2021d, 2021a; McNally and Evans, 2007)."*

The report's comments may additionally cause confusion in reinforcing the suggestion that groundwater recovery to the surface occurs over longwalls for which the drainage zone reaches the surface (see Section 2 above). There is no evidence to suggest that this is the case.

4. Utilisation of the Ditton and the Tammetta equations

Compounding the concerns above regarding the groundwater report's interpretation of the centreline hydrographs and the consequential possibility of underestimating water losses, is the apparent use of the Ditton equation to estimate the height of free drainage over an extraction. Corresponding modelling could also underestimate water loss.

The groundwater report's account of collapse geomechanics and of the work of Ditton and of Tammetta appears, in parts, misleading. Of particular concern, the report would appear to misunderstand, misrepresent or implicitly reject Tammetta' s work and explicitly use the Ditton model and (geology) equation to represent the zone of free drainage over an extraction and estimate its height:

> "*The top of the vertically connected fracture zone (CFZ) is approximated by the Ditton and Merrick (2014) Geology Zone (95th percentile) A-zone height, which is similar, but slightly higher than Adhikary's (2020) Lower limit*."

Similar comments were made by HydroSimlations and others, before the release of the IEPMC's reports.

The reports comments:

> "*The observations imply that while defects and fracture networks occur through the sequence, they do not necessarily result in surface-to-seam connection over all goaf areas (Section 2.6.2 and Figure 2-19).*"

The report's comments are made in the context of the centreline bores sunk to assess the character and height of the collapsed zone over the respective extraction, and the Tammetta equation. They appear to extrapolate the observation of vertical flow restriction following the onset of a high rainfall period, to suggest that where the Tammetta equation suggests a greater drainage zone height than Ditton's A-zone, fracturing is discontinuous. The report evidently rejects Tammetta' s observations and assessments:

> "*However, observations of perching and recovery above extracted longwalls is counter to the model of Tammetta (2013), which states "This zone is severely disturbed and is completely drained of groundwater during caving. It is subsequently unable to maintain a positive pressure head. It will behave as a drain while the mine void is kept dewatered.*"

The comments appear to overlook the evidence in the hydrographs of relatively free vertical drainage at the sensors vertically above the sensors that report flow restriction.

The report either ignores or is unaware that Tammetta' s work is consistent with and builds on the prior work of others[7], perhaps most notably the extensometer work of Mills and O'Grady[8] and the numerical work of Gale.[9]. Ironically, the report's graphical representation of ground deformation (Figure 3-5) appears to be based on that of Mills and co-workers.

The report's characterisation of the deformation zone above an extraction does not appear to recognise the observation by Mills and Tammetta of free drainage being associated with an inverted-parabolic zone of significant downward movement, and that their respective height estimate methods give similar results for extractions of the kind at Dendrobium. This is not the case for the Ditton equation.

The report does not appear to recognise or reference Tammetta' s assessment of the variation of hydraulic conductivity above an extraction.[10], [11]

5. Inequivalent height estimate comparison

The report incorrectly equates the Ditton 95% confidence level drainage zone height estimate with the 50% level Tammetta estimate. The two may be numerically equivalent (but not statistically) for mining geometries proposed for Area 5.

6. Missing data required by conditions of approval

Considerable insight into the character of the collapsed zone, complementing that of centreline piezometers, would be provided by centreline rock displacement data. This is reflected in approval conditions that include a requirement of such data (given in Appendix 1). The data would be of considerable assistance in understanding the centreline hydrographs and, accordingly, the impacts and consequences of operations at the Dendrobium mine.

Vertical displacement data do appear to have been collected, but do not appear to have been provided and are not publicly available. Detailed assessments of this data do appear to be available.

7. Mine closure and Portal sealing

Notwithstanding the times since the SSD project, the SSI proposal lacks a detailed portal sealing assessment/plan.

8. Water offsetting

The proposal provides no water offset detail. Public availability and transparency is essential in the context of the Special Areas

9. In Perpetuity losses

As is the case at the adjoining Wongawilli mine, some of the consequences of the impacts of the Dendrobium mine would appear to be perpetual. There would appear to be no credible means of providing adequate compensation for such consequences, which are fundamentally inconsistent with the intent of the Special Areas.

10. Recommendations

- Engagement of Paul Tammetta to review the groundwater modelling.
- Suspension of the proposal process at least until the concerns above are addressed.
- Detailed assessment of bord and pillar mining for Area 5.
- Should the longwall project be approved, the extraction width reduced to ensure a 100 metre separation from the surface fracture network.

References

[1] P. Turner, ‘Some Concerns Regarding the Dendrobium Extension Project Proposal SSD 8194’, National Parks Association of NSW, Submission to the IPCN, Dec. 2020.

[2] GeoTerra Pty Ltd, ‘Gujarat NRE Coking Coal Ltd Preliminary Works Surface Water & Groundwater Assessment Bellambi, NSW’, GUJ3-R1C, Sep. 2010.

[3] A. Dawkins, ‘Appin Area 7 Longwalls 705 to 710 Groundwater Assessment’, Geoterra Pty Ltd on behalf of BHP-Billiton Illawarra Coal Pty Ltd, BHP41-R1B, Jun. 2008.

[4] W. Minchin and S. Brown, ‘Dendrobium Mine Extension Project (DMEP) Groundwater Assessment’, Watershed HydroGeo for Illawarra Metallurgical Coal, R029D, Mar. 2022.

[5] B. K. Hebblewhite, J. Galvin, C. Mackie, R. West, and D. Collins, ‘Impacts of Underground Coal Mining on Natural Features in the Southern Coalfield - Strategic Review’. NSW Department of Planning, Jul. 2008. [Online]. Available: http://www.planning.nsw.gov.au/planningsystem/pdf/report_southern_coalfields_final_jul08.pdf

[6] J. Galvin, *Ground Engineering - Principles and Practices for Underground Coal Mining*. Springer International Publishing Switzerland, 2016.

[7] P. Turner, ‘Some Comments on the 2017 PSM, Galvin and Mackie height of cracking reports for the Dendrobium coal mine’, National Parks Association of NSW, Jul. 2018. [Online]. Available: https://drive.google.com/open?id=1BiJQr37B2dPEivoiJn4pizl-vBWy4d9F

[8] K. Mills and P. O’Grady, ‘Impact of longwall width on overburden behaviour’, presented at the Coal 98 Conference, Wollongong, Feb. 1998.

[9] W. Gale, ‘Aquifer Inflow Prediction Above Longwall Panels’, ACARP Project C13013, 2008.

[10] P. Tammetta, ‘Estimation of the Change in Hydraulic Conductivity Above Mined Longwall Panels’, *Groundwater*, vol. 53, no. 1, pp. 122–129, Jan. 2015, doi: 10.1111/gwat.12153.

[11] P. Tammetta, ‘Estimation of the Change in Hydraulic Conductivity Above Mined Longwall Panels. Supporting Information.’, *Groundwater*, vol. 53, no. 1, pp. 122–129, Jan. 2015, doi: 10.1111/gwat.12153.

Appendix 1: Dendrobium Approval condition requirement for geotechnical data

LW 14 and 15 approval conditions

Groundwater Monitoring and Height of Cracking

16. The Applicant must undertake a comprehensive program of groundwater monitoring and assessment, including:
(a) undertaking detailed geotechnical and hydrological investigations of the height of connective cracking in Longwalls 6 to 12, prior to the extraction of Longwall 14;
(b) installing a combination of extensometers and multi-level piezometers directly above Longwalls 14 and 15, in consultation with Water NSW and OEH, prior to the extraction of Longwall 14;

LW16 approval conditions

Groundwater Monitoring and Height of Cracking

The Applicant must undertake a comprehensive program of groundwater monitoring and assessment, including:
(a) undertaking detailed geotechnical and hydrological investigations of the height of connective cracking in Longwalls 6 to 12, prior to the extraction of Longwall 14;
(b) installing a combination of time domain reflectometry and multi-level piezometers directly above Longwalls 14, 15 and 16, in consultation with WaterNSW and OEH, prior to the extraction of Longwall 15;

LW17 approval conditions

Groundwater Monitoring and Height of Cracking

19. The Applicant must undertake a comprehensive program of groundwater monitoring and assessment, including:
(a) undertaking detailed geotechnical and hydrological investigations of the height of connective cracking in Longwalls 6 to 12, prior to the extraction of Longwall 14;
(b) installing a combination of extensometers, time domain reflectometry and/or multi-level piezometers directly above Longwalls 14, 15, 16 and 17 in consultation with WaterNSW and BCD, prior to the extraction of each longwall;

Appendix 2: Terms and Abbreviations

Drainage zone: Zone of essentially free drainage formed over an underground coal extraction.

Collapsed zone: Zone of relatively large downward rock movement over an underground coal extraction.

LW: Longwall

WHG: Watershed HydroGeo Pty Ltd