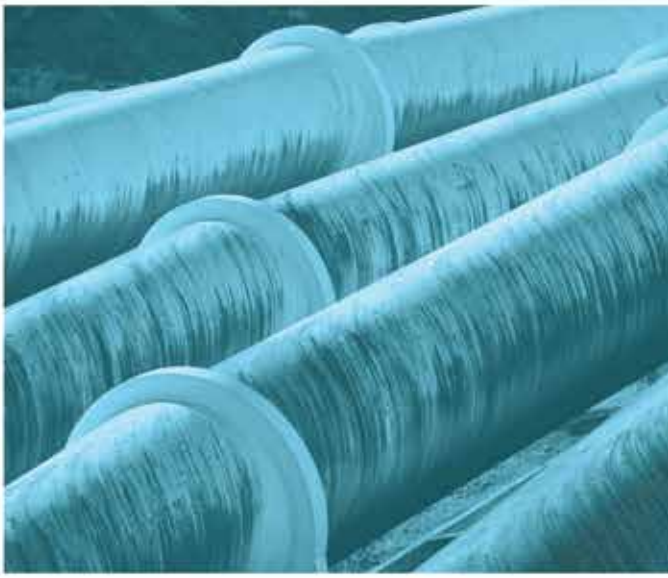



Wongawilli Colliery Modification Report

PA 09_0161 MOD 2 - North West Mains Development
Volume 10 - Appendix K

Prepared for Wollongong Coal Limited
December 2020

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Appendix K

Subsidence impact assessment

Strata Control Technology

WOLLONGONG COAL LIMITED

Wongawilli Colliery: Subsidence and Geotechnical Assessment for Application to Modify Project Approval 09_0161

WCW05136

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TITLE

Wongawilli Colliery: Subsidence and Geotechnical Assessment for Application to Modify Project Approval 09_0161

REPORT NO

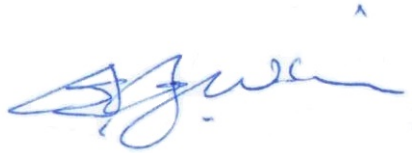
WCW05136

PREPARED BY

Ken Mills
Stephen Wilson

DATE

10 November 2020



Stephen Wilson
Mine Planner

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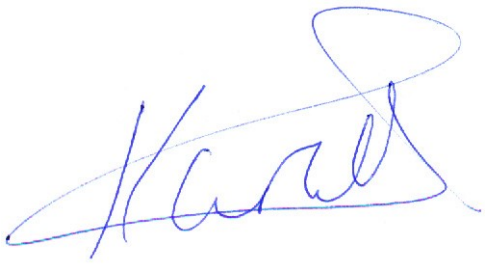

Ken Mills
Principal Geotechnical Engineer

SUMMARY

Wollongong Coal Limited (WCL) owns Wongawilli Colliery, an underground coal mine located approximately 15km southwest of Wollongong. WCL is applying to modify the Nebo Area Project Approval 09_0161 (MOD2) which includes extending the approval timeframe and continuation of development of main headings known as the Western Driveages or NW Mains in a similar layout to that currently approved. WCL commissioned SCT Operations Pty Ltd (SCT) to prepare a subsidence and geotechnical assessment report forecasting geotechnical conditions, subsidence effects and potential surface and sub-surface impacts from the proposed mining. This report presents the results of our assessment to support the application for MOD2.

Our assessment indicates that there is no potential for the proposed main heading development roadways to cause surface ground movements of any consequence. Any surface subsidence is expected to be so small as to be imperceptible for all practical purposes. Impacts to natural and built features are expected to be imperceptible.

The main headings are located within the Sydney Water Supply Catchment (Metropolitan Special Area) of Avon Reservoir. They are planned to pass 90m beneath the Moss Vale - Unanderra Railway, 215m below a 330kV powerline, twice below Gallahers Creek, an arm of Avon Reservoir, and once more below the Bellbird Creek arm of the reservoir. The depth of the headings below the base of the reservoir is 60m (as per the approved alignment), 113m at the second crossing point and 134m at the third crossing point. A geological structure, a dyke, is projected to pass near the base of Avon Reservoir at the first crossing point. This dyke is not expected to be hydraulically conductive remote from secondary extraction mining areas consistent with experience nearby along the same dyke and elsewhere in the Southern Coalfield. The proposed first workings are not expected to cause significant changes to the hydraulic conductivity of the overburden strata. Nevertheless, a precautionary approach is recommended including such measures as drilling ahead to confirm the absence of zones of elevated hydraulic conductivity.

The proposed main headings are to be formed in the 1-2m thick Bulli Seam and the immediate Bulli Seam roof and floor. These headings are planned to pass 25-30m above areas of previous mining in the Wongawilli Seam including five areas of full or partial secondary extraction. Experience of mining the Bulli Seam above areas of secondary extraction in the Wongawilli Seam indicates the strata is likely to be significantly disturbed. This disturbance may include changes in grade around the edges of goaf in the Wongawilli Seam, open fracturing of Bulli Seam roof and floor strata, locally elevated vertical stresses in some areas and reduced vertical and horizontal stresses in others.

The pillars to be formed in the Bulli Seam are assessed as being long-term stable. Rib deterioration is expected adjacent to full extraction in the underlying Wongawilli Seam and where the overburden depth is greater than 250m or pillar load is greater than 6MPa. The use of specialist road-headers or other fit-for-purpose machinery is recommended to manage excavation of the contrasting rock strata of the Bulli Seam coal, the mid-seam split and the immediate roof and floor strata.

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1. INTRODUCTION

Wollongong Coal Limited (WCL) owns Wongawilli Colliery, an underground coal mine located approximately 15km southwest of Wollongong. WCL is applying to modify the Nebo Area Project Approval 09_0161 (MOD2) which includes extending the approval timeframe and continuation of development of main headings known as the Western Driveages or NW Mains in a similar layout to that currently approved. WCL commissioned SCT Operations Pty Ltd (SCT) to prepare an updated subsidence and geotechnical assessment report forecasting geotechnical conditions, subsidence effects and potential surface and sub-surface impacts from the proposed mining. This report presents the results of our assessment to support the application for MOD2.

This report is structured to provide:

- Section 2: a summary of conclusions and recommendations.
- Section 3: a site description including geological structure.
- Section 4: a review of the previous subsidence assessment and forecasts for subsidence effects and impacts.
- Section 5: a review of geotechnical conditions expected in the main heading developments.
- Section 6: a review of the potential for inflows where the main headings cross below Avon Reservoir and strategies to identify and manage potential inflows.

Figure 1 shows a plan of the approved layout and proposed main heading developments of MOD2, superimposed onto a 1:25,000 series topographic map of the area.

2. CONCLUSIONS AND RECOMMENDATIONS

Our assessment indicates that there is no potential for the proposed main heading development roadways to cause surface ground movements of any consequence. Any surface subsidence is expected to be so small as to be imperceptible for all practical purposes. Impacts to natural and built features are also expected to be imperceptible.

The main headings are located within the Sydney Water Supply Catchment (Metropolitan Special Area) of Avon Reservoir. They are planned to pass 90m beneath the Moss Vale - Unanderra Railway, 215m below a 330kV powerline, twice below Gallahers Creek, an arm of Avon Storage Reservoir, and once more below the Bellbird Creek arm of the reservoir. The depth of the headings below the base of the reservoir is 60m at the first crossing point, 113m at the second crossing point and 134m at the third crossing point. The alignment of the proposed development roadways below the first crossing point is similar to the alignment that has previously been approved.

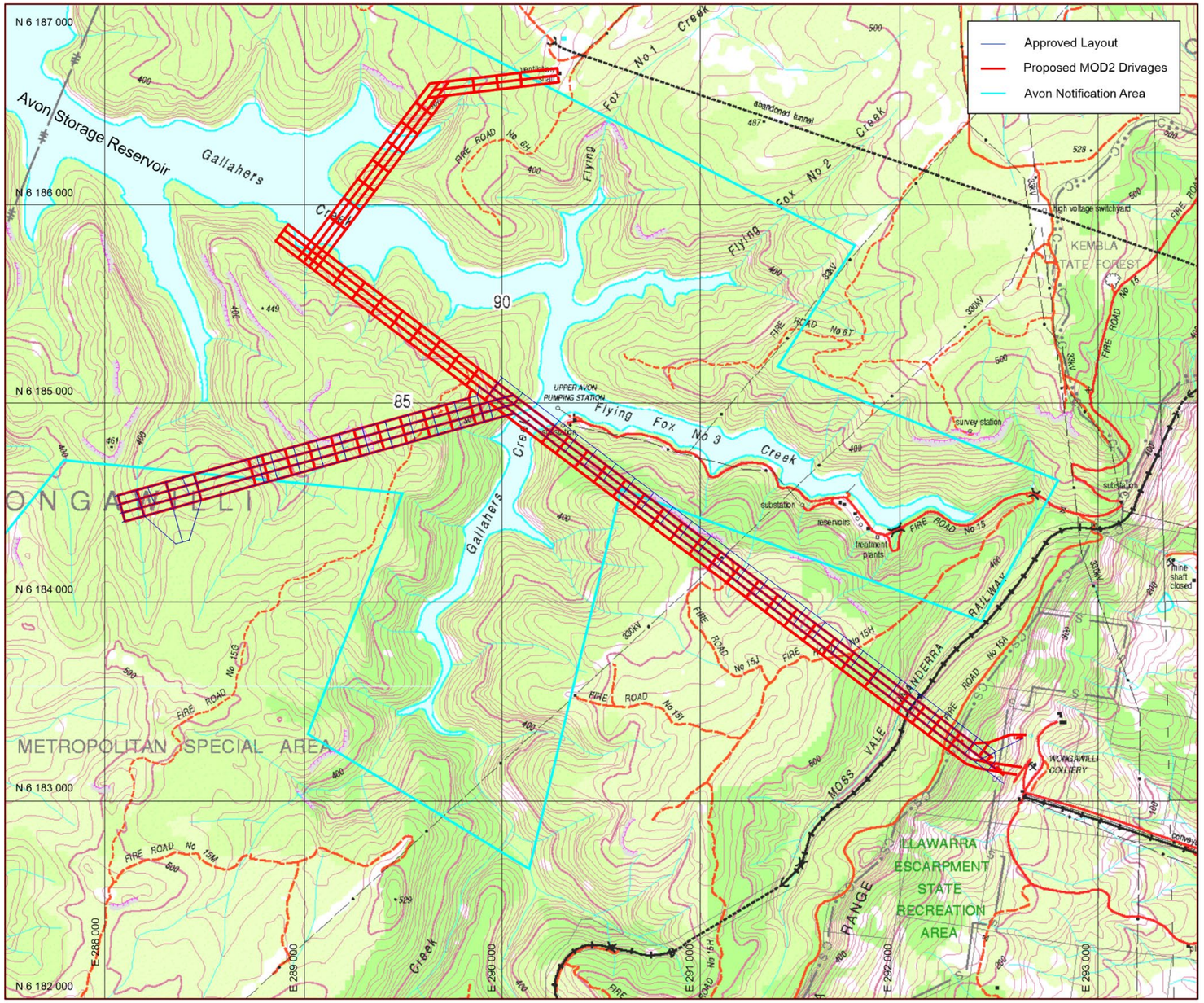


Figure 1: Site Plan with approved layout and proposed main heading developments of MOD2.

There is no potential for the proposed development headings to cause surface subsidence movements or subsidence related impacts to any of the surface features directly above these headings or nearby.

A geological structure, a dyke, is projected to pass near the base of the reservoir at the first crossing point. This dyke is not expected to be hydraulically conductive remote from secondary extraction mining consistent with experience nearby along the same dyke and elsewhere in the Southern Coalfield. The proposed first workings are not expected to cause significant changes to the hydraulic conductivity of the overburden strata. Nevertheless, a precautionary approach is recommended. Strategies to manage any potential for inflows would include drilling ahead to confirm the absence of any high conductivity pathways.

Most of the proposed main headings are to be formed in the 1-2m thick Bulli Seam and the immediate roof and floor of this seam. These headings are planned to pass 25-30m above areas of previous mining in the Wongawilli Seam including five areas were there has been full or partial secondary extraction. Experience of mining the Bulli Seam above areas of secondary extraction in the Wongawilli Seam indicates the strata is likely to be significantly disturbed. This disturbance may include changes in grade around the edges of extracted Wongawilli Seam, open fracturing of Bulli Seam roof and floor strata, locally elevated vertical stresses in some areas and reduced vertical and horizontal stresses in others.

The pillars to be formed in the Bulli Seam are assessed as being long-term stable. Rib deterioration is expected adjacent to areas of secondary extraction in the underlying Wongawilli Seam and where the overburden depth is greater than 250m or pillars are loaded to greater than 6MPa.

Approximately 340m of stone driveage in each of three headings is likely to be required to access the Wongawilli Ventilation Shaft 1 once these headings cross the Wongawilli Fault. By remaining above the existing Bulli Seam workings, it will be possible to backfill the shaft to above the Bulli Seam and isolate the existing Bulli Seam and Wongawilli Seam workings from the future ventilation circuit. Backfilling of the shaft would allow disposal of some of the waste rock material from the stone driveages.

The use of specialised road-headers or other fit-for-purpose, low-height machinery is recommended to manage excavation of the shale material in the mid-seam split of the Bulli Seam over the first approximately 1500m of the NW Mains, the immediate roof and floor strata of the Bulli Seam and the stone driveages to access the Wongawilli Ventilation Shaft 1.

3. SITE DESCRIPTION

As shown in Figure 1, a large section of the proposed mining is within the Avon Notification Area (NA) under the jurisdiction of Dams Safety NSW. The main headings are being developed as first workings for the purpose of access and to provide a ventilation circuit connecting into the existing Wongawilli Ventilation Shaft 1. No secondary extraction mining is planned for this modification to the existing approval.

3.1 Surface Features

The site is located almost entirely below the Sydney Water Supply Catchment (Metropolitan Special Area) of Avon Storage Reservoir with a small area in the east located below the Illawarra Escarpment State Recreation Area. Surface features of significance in the immediate vicinity of the proposed main heading developments include:

- five fire roads numbered 15A, 15H, 15J and 15G, and 6H
- the Moss Vale to Unanderra Railway Line
- Transgrid's Avon to Marulan 330kV power transmission line
- Avon Reservoir
- Upper Avon Pumping Station
- Wongawilli Ventilation Shaft 1.

No other significant surface or sub-surface features, both natural and man-made, have been identified that are sensitive to the expected subsidence effects and impacts from the proposed mining of first workings.

3.2 Mining Geometry

Figure 2 shows the proposed main heading developments, identified surface features and previous mining activity in the Wongawilli Seam. The proposed main heading developments are planned to be mined in the 1-2m thick Bulli Seam located some 25-30m above the Wongawilli Seam. The alignment of the proposed NW Mains is parallel to the approved Western Driveages alignment and offset one heading centre (35m) to the south to avoid the protective barrier around the Upper Avon Pumping Station.

SCT understands the main headings are planned to be mined 2.4m high. The Bulli Seam coal thickness is a maximum of approximately 1.9m in the areas of the proposed main headings. In most areas, it is envisaged the mining section would include the full height of the Bulli Seam, including any stone bands or intrusions within the seam, and whatever roof and floor strata required to achieve the nominal 2.4m mining height.

The proposed main heading developments include the NW Mains driven below the Illawarra Escarpment, the NE Mains branching to the northeast and the SW Mains branching to the southwest. Four headings are proposed in all but a short section in the north where the NE Mains are reduced to three headings near the Wongawilli Ventilation Shaft 1. The NW and NE Mains are planned to be developed at 35m centres with cut-throughs typically at 120m centres. The SW mains are planned to be developed at 45m centres with cut-throughs also at 120m centres. The roadway width is nominally 5.5m.

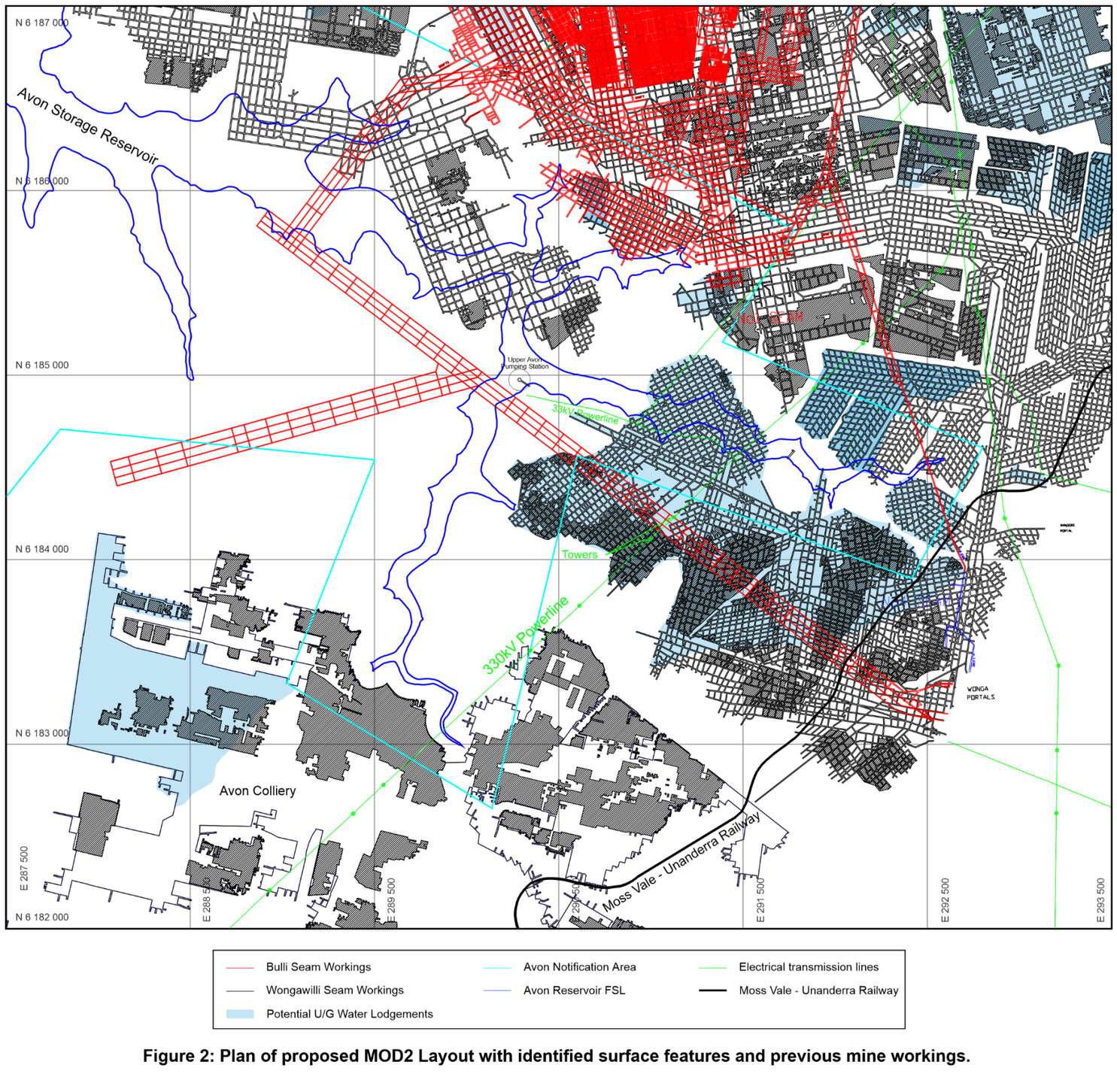
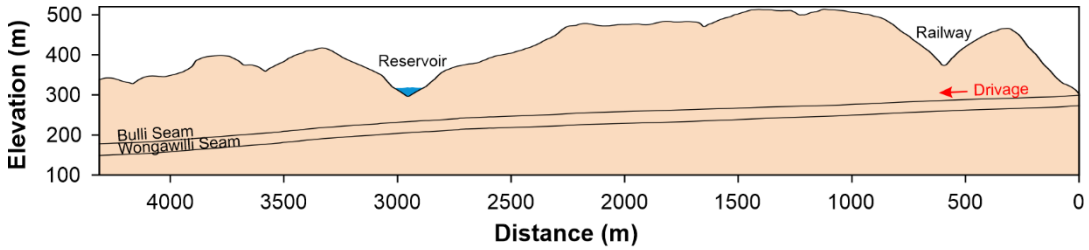


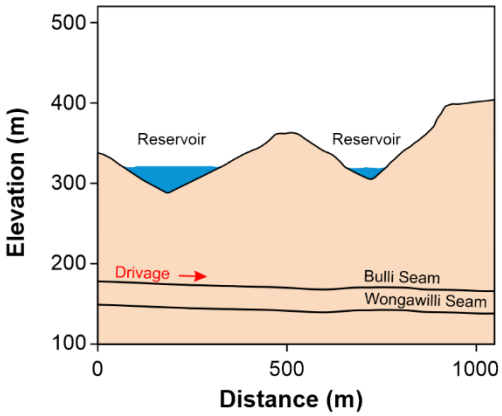
Figure 2: Plan of proposed MOD2 Layout with identified surface features and previous mine workings.

3.3 Surface Topography

Figure 3 shows cross-sections along the centre of the alignment of the NW Mains and NE Mains from a three dimensional (3D) model constructed for the site.



a) NW Mains cross section.



b) NE Mains cross section.

Figure 3: Cross-sections of NW Mains and NE Mains.

The Bulli Seam and Wongawilli Seams dip gently to the west at a grade of 1 in 50 steepening to 1 in 25 to the west of the reservoir. The surface topography along the NW Mains rises steeply from RL260m at the existing portals to RL460m at the top of the Illawarra Escarpment, dips into the valley where the railway line is located and then rises to a high of RL515m where the overburden depth to the Bulli Seam locally reaches 255m.

Further to the west, the surface dips at a similar rate to the coal seams before descending into the valley where the Avon Reservoir is located. The base of this valley is interpreted from original dam construction data (Department of Public Works NSW 1925) to be RL496m, approximately 60m above the roof of the Bulli Seam at this location.

On the western side of the valley, the surface topography rises to approximately RL420m below a northeast facing slope.

The NE Mains turn away to cross below the Gallahers Creek arm of Avon Reservoir. The elevation of the base of the reservoir at this location is RL288m, approximately 113m above the roof of the Bulli Seam.

The surface rises to the northeast to a high of RL363m, where the overburden depth to the Bulli Seam is 195m, before descending again below the Bellbird Creek arm of the reservoir to RL305m, approximately 134m above the roof of the Bulli Seam. The surface rises to RL404m and an overburden depth to the Bulli Seam of 238m at the point where the mains turn to the east towards the Wongawilli Ventilation Shaft 1 and the proposed layout reduces to three headings.

The surface topography rises to a high at the Wongawilli Ventilation Shaft 1 of RL445m and an overburden depth to the proposed mining horizon in stone of approximately 260m.

Figure 4 show a view of the 3D model of the site with the vertical scale exaggerated by two times. The 3D model includes the surface topography, the valley floor below the Avon Reservoir Full Supply Level (FSL) and the Bulli and Wongawilli Seam horizons. The seam horizon data includes existing geological features and structure with existing and proposed workings.

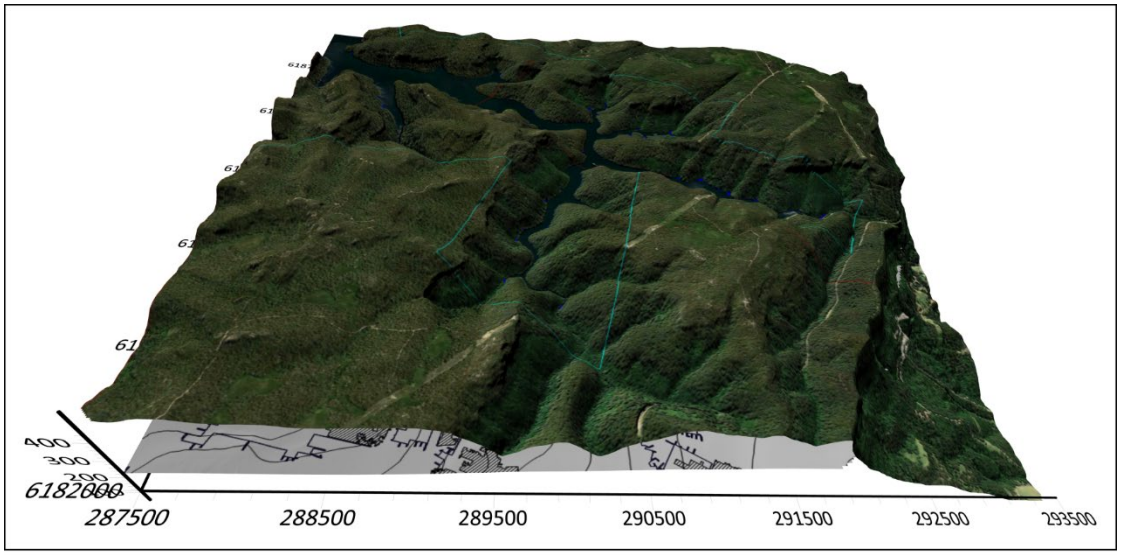


Figure 4: View from 3D model for site.

3.4 Geological Structure

Figure 5 shows a plan of the proposed main heading developments relative to geological structure and other geological features in the area.

The geological structure shown was intersected and mapped during previous mining in the Wongawilli Seam. Most of the dyke structures are vertical and laterally extensive for, in some cases, tens of kilometres. Interpolation between intersections in Wongawilli Colliery to the north and intersections of the same feature in Avon Colliery to the south provide a well-constrained basis to estimate intersections likely to be encountered in the Bulli Seam. The extent of silling in the Bulli Seam is based predominantly on borehole intersections and is therefore less reliable.

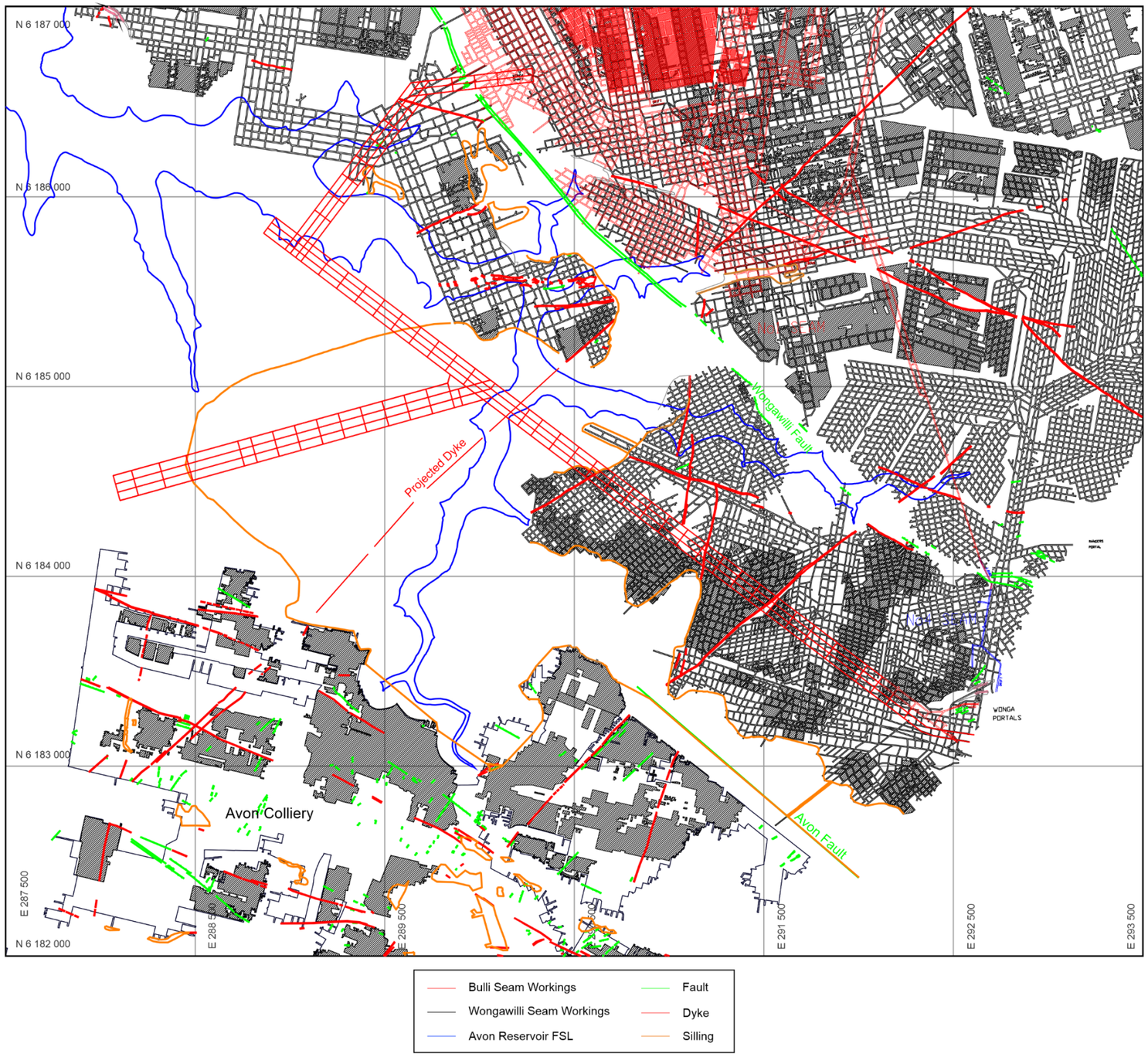


Figure 5: Plan of Proposed MOD2 Layout relative to geological structure and existing mine workings.

3.4.1 Major Geological Faults

There are two major geological fault structures in the vicinity of the proposed main heading developments.

A major fault is evident by the absence of workings in the Wongawilli Seam along a northwest-southeast alignment 600-1100m to the north of the proposed NW Mains headings. This fault is downthrown to the north east by up to 45m. The three heading mains that intersect the Wongawilli Ventilation Shaft 1 will need to cross this structure and mine through stone for approximately 340m to intersect the shaft approximately 20m above the Bulli Seam. There are workings present in the Bulli Seam and Wongawilli Seam on the eastern, downthrown side of the fault.

A second parallel fault is located approximately 750m to the south of the NW Mains between Wongawilli and Avon Collieries. This structure does not affect the proposed development headings.

Doyle (2017) found in a review of experience of mining through geological structures in the Dendrobium area of the Southern Coalfield that geological fault structures are not hydraulically conductive.

3.4.2 Dykes and Sills

Dykes are thin vertical planar features formed when hot volcanic material is injected into the rock strata under pressure. The fluid pressure opens as a hydraulic fracture against the lowest horizontal stress acting in the rock at the time. Dykes tend to be laterally extensive, vertical and, in the Southern Coalfield, generally less than a few metres wide.

Near the surface, the vertical stress becomes lower than either of the two horizontal stresses, so it becomes easier for injected volcanic material to extend sideways to form a horizontal intrusion known as a sill. Sills commonly develop in coal seams more easily than in the surrounding strata. The injected material causes the roof and floor to be jacked apart. Coal quality is degraded by intrusion of hot material and the harder sill material makes mining more difficult, so areas of silling tend not to be mined. The extent of mining in the Wongawilli Seam below the NW Mains is largely dictated by the extent of silling.

The NW Mains are expected to cross five dykes that have been intersected by previous mining in the Wongawilli Seam. Their position, thickness and difficulty to mine can be determined from the records of previous mining.

The first of these dykes crosses the NW Mains at approximately 1300m from the existing portals. This dyke appears to have been difficult to mine through in the Wongawilli Seam. The dyke is indicated as being 4-7m thick. The two nearest roadways to penetrate the dyke in the Wongawilli Seam are more than 100m either side of the proposed NW Mains. Pillars are fully extracted on both sides of this dyke. Further work is required to determine the hardness of this dyke but it appears likely to be difficult to mine through.

The second dyke at approximately 1700m from the portals also appears to have been difficult to mine through, but the presence of multiple penetrations indicate it was easier to mine through than the dyke at 1300m. The thickness of this dyke is indicated as being 1-3m thick. Pillars are fully extracted on one side of this dyke.

A third dyke is mapped parallel to the second and 130m to the west. This dyke appears to taper out on the northern edge of the NW Mains. The absence of mining directly below the NW Mains in this area does not necessarily indicate the absence of the dyke and may indicate the presence of a localised sill in the Wongawilli Seam or the presence of a feeder pipe. It is possible that mining conditions in the Bulli Seam through this area may also be difficult.

A fourth dyke at approximately 2400m from the portals coincides with the edge of silling in the Wongawilli Seam that prevented mining further to the west. This dyke appears to be less than 3m thick and a regular panel of multiple headings have been mined through it in the Wongawilli Seam.

A fifth dyke at approximately 3000m from the portals is projected to intersect the NW Mains where they pass below Avon Reservoir at a depth below surface of approximately 75m. This dyke extends for more than 8km through workings in Wongawilli Colliery in the north and Avon Colliery in the south. The Wongawilli Seam is silled out in the area where the NW Mains would cross this dyke so there is no mining and the characteristics of the dyke at this location can only be inferred from intersections 350m to the north and 1600m to the south. The dyke in these locations is less than 3m thick and does not appear to significantly inhibit mining. There are multiple entries through the dyke in a relatively regular pattern in Blue 4 Panel at Wongawilli Colliery.

The estimated extent of silling in the Wongawilli Seam is shown in Figure 4. The extent of silling within the project area is well defined where intersected by underground mining. Elsewhere, the extent is estimated from borehole intersections and is therefore subject to interpretation.

3.4.3 Seam Split

The NW Mains are not expected to encounter silling in the Bulli Seam but will encounter up to about 1m of shale (siltstone/claystone) material associated with a seam split within approximately 1500m of the existing portals. The coal thickness above the split is typically only 100mm thick. The coal thickness below the split is initially about 1m. Mining the shale and upper coal member is expected to give better roof conditions because of the Coalcliff Sandstone located above these units. If the roof of the mining horizon is located below the shale band, the material in the roof is likely to provide less favourable mining conditions.

The shale band, creating the seam the split, is expected to reduce in thickness to the west as the coal members increase in thickness and coalesce.

4. FORECAST OF SUBSIDENCE EFFECTS AND IMPACTS

This section reviews the subsidence effects and impacts forecast for the currently approved layout and updates of these forecasts for the proposed MOD2 layout taking account of the slight changes in geometry.

4.1 Subsidence Effects

MSEC (2010) predict subsidence for the Part 3A application for the Nebo Area Project 09_0161. MSEC (2010) states "No subsidence is expected as a result of the proposed Western Driveages and, hence, no subsidence predictions have been undertaken for these Western Driveages" (p27).

Our assessment of the subsidence effects is consistent with MSEC's. The development of four roadways in the Bulli Seam at 35m centres in overburden depths ranging from 60m to 250m are not expected to cause any perceptible surface subsidence. The only potential for first workings to cause surface subsidence would be if there was any potential for widespread pillar instability and this potential is assessed as negligible.

4.2 Pillar Stability Assessment

The long-term stability of the main headings pillars is assessed in this section. These pillars are found to be long-term stable.

The roadways in the Western Driveages are proposed to be formed at 35m centres. The pillars are therefore nominally 29.5m wide (measured rib to rib). The thickness of the Bulli Seam is expected to range 1-2m but the mining height is planned to be 2.4m. A pillar height of 2.4m and width to height ratio of 12 is used for stability assessment purposes.

The UNSW (1999) pillar design formula indicates a nominal pillar strength of 41MPa for a pillar with a width to height ratio of 12. The weight of overburden strata at a maximum 250m is estimated to be less than 7.8MPa remote from abutment loading conditions. The factor of safety against failure is therefore nominally 5.2. This factor of safety implies long-term stability.

In areas where there has been secondary extraction of pillars in the Wongawilli Seam, vertical loading in the Bulli Seam has potential to increase. The largest area of such extraction below the Western Driveages is approximately 430m wide. The maximum abutment loading is estimated to be 14MPa over a 30m distance. The factor of safety against pillar instability under full abutment loading is estimated to be 2.9. The pillars are therefore expected to be long-term stable.

Any effects from mining first workings roadways in the Bulli Seam are expected to be generally limited to a few metres around the proposed roadways and not expected to significantly impact workings in the Wongawilli Seam.

4.3 Subsidence Impacts

Surface infrastructure above or in the vicinity of the Western Driveages were not specifically assessed for impacts in MSEC (2010) for the Nebo Area Project EA as no subsidence was predicted. However, while no perceptible subsidence effects are forecast for MOD2 to Project Approval 09_0161, we have undertaken an assessment of potential impacts to the major built features for completeness.

4.3.1 Moss Vale – Unanderra Railway Line

The Moss Vale – Unanderra Railway Line passes directly above the proposed NW Mains as shown in Figures 1 and 2. Subsidence effects and impacts on the railway are expected to imperceptible for all practical purposes.

The railway was built between 1925 and 1932. Wongawilli Colliery commenced mining in the Wongawilli Seam in 1915 and formed first workings, i.e. bord and pillar workings, in areas below where the railway was later constructed. When secondary workings, i.e. pillar extraction, was subsequently conducted in the area, a barrier of unworked pillars was left to protect the railway and associated infrastructure from subsidence impacts.

The barrier of pillars left to protect the railway was originally designed to be 300 links wide (approximately 60m wide) on either side of the railway lands. This equates to a barrier of generally greater than 80m wide on each side of the railway centreline or a total width of more than 160m. This barrier is equivalent to an angle of draw of 36° at the location where the NW Mains cross below the railway line. The barrier has been effective in providing protection to the railway line from subsidence impacts.

Coal pillars located in the Wongawilli Seam within the railway barrier are typically in the range of 17m to 20m wide with a few as small as 9m wide, but these small width pillars are adjacent to larger pillars. The smallest pillars directly below the railway are square in shape with minimum dimensions of 17m, 20m and 30m. At 110m depth and a mining height of 2.8m, the 17m square pillar has a width to height ratio of greater than 6. Using the UNSW (1999) methodology, these pillars have an estimated strength of 15MPa (assuming a roadway width of 6m) and carry an estimated load of 5MPa. The nominal factor of safety is greater than 3 and the probability of instability is estimated to be greater than 1 in 1,000,000.

The mining of the NW Mains in the Bulli Seam, approximately 25m above the barrier pillars left in the Wongawilli Seam, is not expected to cause any significant change in loading conditions at the Wongawilli Seam mining horizon or result in any perceptible impacts to the railway and associated infrastructure.

4.3.2 Powerlines

Two electricity transmission lines traverse the surface above or adjacent to the NW Mains. The location of the 330kV and 33kV powerlines is shown on Figures 1 and 2. No perceptible subsidence effects at, or impacts to, this infrastructure are expected.

The Avon to Marulan 330kV powerline owned by TransGrid crosses the alignment of the NW Mains in a north-south alignment. Two towers on this powerline are located above or adjacent to the NW Mains. The northern tower supports a 1030m long span across an arm of the Avon Reservoir associated with the Flying Fox No 3 Creek. The southern tower supports a 530m span across a small unnamed tributary to the Avon Reservoir.

The northern tower is positioned above solid coal in the Wongawilli Seam and close to the centre of the proposed four roadways of the Western Driveages in the Bulli Seam. The depths to the Bulli and Wongawilli Seams are approximately 210m and 240m respectively. Proposed mining of the NW Mains is not expected to cause any perceptible subsidence effects or impacts at the location of the northern tower.

The southern tower is positioned approximately 180m to the south of the northern tower and 60m south of the NW Mains above an area where pillars in the Wongawilli Seam have been extracted. The depths to the Bulli and Wongawilli Seams at this location are approximately 235m and 265m, respectively.

The first workings in the Wongawilli Seam below the southern tower were developed in the 1930's. Secondary extraction of these pillars was undertaken in the 1940's. The powerline was constructed well after this mining was complete and subsidence was fully developed. Proposed mining of the NW Mains in the Bulli Seam some 30m above and offset horizontally from the area of pillar extraction is not expected to cause significant interactions with this goaf area located below the southern tower. No perceptible subsidence effects or impacts are expected at the southern tower due to mining the NW Mains.

A 33kV powerline that supplies the Avon Pumping Station and other water supply infrastructure crosses the Flying Fox No 3 Creek from the north and runs along the edge of the reservoir adjacent to and almost parallel to the direction of the NW Mains. The location of this infrastructure owned by Integral Energy is shown on Figures 1 and 2. The Western Driveages would not mine below any section of this power line or associated substations/switch yards. Proposed mining of the Western Driveages is not expected to have any perceptible subsidence effects or impacts on these 33kV powerlines and associated equipment.

4.3.3 Water Intake Structure

The NW Mains mine close to the Avon Water Intake Structure (Upper Avon Pumping Station) near where the headings would pass under Avon Reservoir. The structure is protected by a barrier and the proposed mining does not extend into this barrier. The proposed four headings have no potential to cause ground movements at the surface that would cause impacts to this structure.

5. EXPECTED MINING CONDITIONS

This section discusses the nature of the mining conditions expected in the development of the proposed Western Driveages.

5.1 Areas above First Workings in the Wongawilli Seam

In areas where there has been no secondary extraction in the Wongawilli Seam below, mining conditions are expected to be similar to conditions that would be typical of mining in the Bulli Seam at overburden depths less than 250m. The vertical stresses are expected to be generally less than the 6MPa threshold usually associated with the onset of rib deterioration. Horizontal stresses in the sandstone roof and floor of the Bulli Seam are expected to be generally less than the stresses required to cause fracturing of the roof and floor strata. Locally elevated stresses are possible, but strata conditions are expected to be generally good.

The low seam thickness of the 1-2m thick Bulli Seam, a seam split in the middle of the seam and possible silling west of the Avon Reservoir are expected to make mining conditions more difficult than would be typical of mining a full 2.4m thick section of the Bulli Seam. Non-coal material in the roof and floor and within the seam are likely to be harder to cut than coal. These materials are also likely to dilute the coal product significantly. Fit-for-purpose machinery such as a suitably designed road-header is likely to be required to manage the variable mining conditions and achieve a satisfactory level of productivity.

5.2 Areas above Secondary Extraction in the Wongawilli Seam

The Bulli Seam strata is likely to be significantly disturbed above areas of secondary pillar extraction in the Wongawilli Seam. Vertical stresses are likely to be locally elevated to greater than 20MPa near the edges of extracted panels and above any remnant pillar in the Wongawilli Seam goaf areas. Rib deterioration is expected to become evident at these elevated stress levels. Meshing and additional rib support is likely to be required in these areas to control roadway width.

Open fractures are expected above the panel edges and may be present elsewhere. Zones of low horizontal stress may occur in these areas with potential for roof drop-out.

Elevated horizontal stresses are also possible near the central parts of each extracted panel. Greater fracturing of the roof and floor strata may occur in these areas with a requirement for higher levels of reinforcement for the roof. The presence of open fractures may compromise the effectiveness of some types of support. A program of monitoring and response is recommended to match the support requirements to the strata and stress conditions.

Changes in elevation of up to 2m or so are likely to occur near the edges of extracted panels. These changes may occur over several metres or be concentrated at geological structures such as dykes. Drill ahead strategies to confirm the presence of coal on the other side of dykes are recommended to manage the vertical alignment of the belt road through these areas.

5.3 Dykes

Difficult mining conditions are expected where dykes cross the NW Mains.

Mine plans of the Wongawilli Seam workings indicate that some of the dykes are mineable with only minor difficulty. The dyke at 1300m from the portal appears likely to be an exception. This dyke is indicated as being 5-7m thick and there are no entries through it in the Wongawilli Seam for 100m either side of the alignment of the proposed NW Mains.

A fit-for-purpose miner capable of mining Bulli Seam roof and floor material is likely to be able to penetrate the dyke material more effectively than standard continuous miners, but provision should be made in case there is a need to drill and blast through this section of the proposed driveages.

5.4 Flooded Workings

The largest area of the Wongawilli Seam workings located below the NW Mains is expected to be flooded to the RL257m elevation of the overflow point as shown in Figure 2. When the proposed NW Mains drop below RL257m at approximately 2000m from the existing portals, water within the Wongawilli Seam lodgement is expected to percolate up through fractures in the interburden and flow into the Bulli Seam workings down-dip of this connection point. The water level in this lodgement will need to be drawn down by a minimum of 10m to avoid water entering the inbye Bulli Seam workings of the NW Mains. Additional drawdown is recommended to accommodate inflows into the lodgement after heavy rainfall. This requirement will be ongoing for the life of the main headings.

5.5 Gas

Historical in situ gas sampling of the Bulli Seam at Wongawilli Colliery indicates gas is generally very low with typical contents of around $1m^3/t$. The composition of the gas is a high percentage of methane (CH_4). Similarly, the Wongawilli Seam, at shallower depths and close to the outcrop, has low levels of in situ gas at around $3\text{-}4m^3/t$ of primarily methane.

Gas is not expected to be a significant issue for the proposed mining of the NW Mains under statutory ventilation requirements. However, the risk of gas migrating from the top of the goaf areas of the Wongawilli Seam workings into the Bulli Seam above, needs to be considered.

Experience of mining the Bulli Seam above areas of secondary extraction in the Wongawilli Seam indicates increased gas levels from the migration of methane up through the fractured interburden.

This may be an issue for the NW Mains driveages in areas where any potential gas accumulation has not been displaced by water in the flooded workings.

5.6 Wongawilli Ventilation Shaft 1

The three heading mains that are planned to intersect the Wongawilli Ventilation Shaft 1 would cross a major geological structure known as the Wongawilli Fault. This structure is downthrown to the east by approximately 20m i.e. the mining horizon in the Bulli Seam on the western side of the fault would be approximately 20m above the existing roadways in the Bulli Seam on the eastern side of the fault.

Figure 6 shows a cross section of the proposed Bulli Seam driveages in the vicinity of the Wongawilli Fault and the Wongawilli Ventilation Shaft 1.

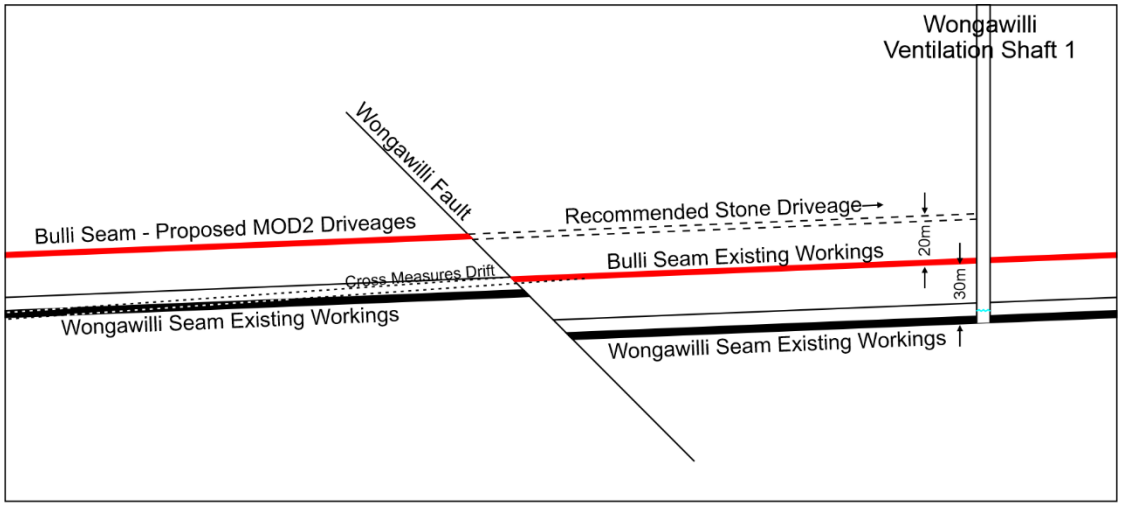


Figure 6: Cross section of drivage concept in vicinity of Wongawilli Fault and Wongawilli Ventilation Shaft 1.

It is recommended to stay above the existing Bulli Seam workings in this area to avoid all the legacy issues associated with mining through old workings. An approximately 340m section of the three-heading development would be in stone after crossing the fault plane. Mining conditions are likely to be variable due to the presence of the fault and the extended length of stone driveage. The Wongawilli Seam near the Wongawilli Ventilation Shaft 1 is known to have experienced high horizontal stress conditions in proximity to the Wongawilli Fault. The higher horizontal stress is likely to affect the Wongawilli Seam roof conditions more than the Bulli Seam roof due to the difference in roof strengths.

The recommended approach has several advantages. Among them are:

- there would be no need to intersect the existing Bulli Seam workings which are old, low height and relatively poorly supported
- the shaft could be back filled to above the Bulli Seam and sealed to prevent circulation loss into existing workings in the Bulli Seam and Wongawilli Seam
- waste rock material from the stone driveage could be disposed of into the shaft.

The Wongawilli Ventilation Shaft 1 (also known as Wongawilli Air Shaft, Wongawilli No1 Shaft and Wonga Shaft) was constructed between 1970 and 1972 to intersect the Bulli and Wongawilli Seam workings. The shaft terminates at the Wongawilli Seam floor level. There is no sump. The shaft operated was an upcast shaft with a main fan installation. The shaft was decommissioned in 1999 when a large area of Bulli and Wongawilli Seam workings was sealed during the period of longwall mining at Elouera Colliery.

The Wongawilli Seam roadways around the base of the shaft were in poor condition soon after development in 1972 due to the local stress conditions and support techniques at that time. The Wongawilli Seam near the Wongawilli Ventilation Shaft 1 is known to experienced high horizontal stress conditions in proximity to the fault (early attempts at stress relief roadways can be seen on the mine plan).

The roadways around the base of the shaft were only used for ventilating Wongawilli Seam workings until 1975 with both seams then being ventilated via the shaft inset at the Bulli Seam level. After 1975 the Wongawilli Seam workings were allowed to flood and were used as the largest sump for the whole mine. The four Wongawilli Seam roadways at the base of the shaft have substantial stoppings in place but these are not rated seals. The water level in the shaft column was used to provide a ventilation seal.

The Bulli Seam workings at and to the west of the Wongawilli Ventilation Shaft 1 were developed in 1965. The workings to the east of the shaft were developed during 1969 and 1970. An inspection of these roadways, circa 1998, indicates they were in poor condition at that time . Three roadways were maintained around the shaft for the ventilation of the western Wongawilli Seam workings (towards the Blue Panels) via the Bulli to Wongawilli Seam cross-measures drifts. The three Bulli Seam roadways were approximately 1.8m high but there were numerous roof falls. These roadways were high resistance, high-pressure and low quantity return airways.

Avoiding the existing Bulli Seam roadways in favour of newly constructed roadways/drifts is recommended. The envisaged drifts would be driven on the grade of the strata at the location. The number and dimensions of the all-stone drifts could be decided based on the specifications of the fit-for-purpose mining equipment and ventilation requirements for future operations.

The decommissioning of the axial flow fan at the Wongawilli Ventilation Shaft 1 in 1999 included the sealing of large areas of both the Bulli and Wongawilli Seam workings. Six seals in the Bulli Seam just west of U/G bins and four seals in the Wongawilli Seam in Red 3 panel were constructed. However, the mining of Longwalls 11, 12 and 20 at Elouera Colliery effectively by-passed these seals. The atmosphere and water storages of the previously “sealed’ workings were connected to the Elouera longwall area ventilation and dewatering systems through the fractured interburden strata between the Bulli and Wongawilli Seams. As a result, the Wongawilli Seam around the base of the Wongawilli Ventilation Shaft 1 may now be dry.

Holing into the Wongawilli Ventilation Shaft 1 above the Bulli Seam level provides an opportunity to seal the old workings to prevent gas and water related issues, from below the holing level, impacting on future operations. This also removes the requirements of inspections and maintenance of old roadways. Filling the shaft from the base to the holing level with floor stone from the planned Bulli Seam mining may be a viable option.

6. POTENTIAL FOR INFLOW

This section reviews the potential for inflows to occur where the main headings cross below Avon Reservoir and strategies to identify and manage this potential. Mining within the Avon NA will require the consent of Dams Safety NSW.

Dams Safety NSW prohibit mining below stored waters at a depth of less than 60m. The approved alignment of the NW Mains mine below the base of Avon Reservoir at close to this minimum. The base of the reservoir is interpreted from original dam construction data (Department of Public Works NSW 1925) to be RL496m. The roof of the Bulli Seam is estimated to be RL436m through interpolation between nearby borehole intersections. Surface to Wongawilli Seam boreholes are located all around the site; the nearest is 230m away.

The NW Mains are likely to intersect a dyke at approximately 3000m from the existing portals where the planned headings pass below Avon Reservoir at a depth below surface of approximately 75m. This dyke extends for more than 8km through workings in Wongawilli Colliery in the north to Avon Colliery in the south. The dyke is estimated to be less than 3m thick. Mine plans indicate the dyke has not significantly impacted regular mining geometries. There are multiple entries through the dyke in a relatively regular pattern in a nearby panel at Wongawilli Colliery to the north and various panels at Avon Colliery to the south.

The dyke itself was not noted as being hydraulically conductive when intersected by first workings in nearby Blue 3 and Blue 4 Panels. These panels are located close to and down-dip of the largest area of flooded Wongawilli Seam workings and some seepage through the coal seam is typically observed in such situations. Flow rates of 0.14Ml/day were observed when this section of Blue Panels was developed.

Pillar extraction in Blue 3 and 4 Panels occurred up to the dyke in an area 75m from the northern edge of Avon Reservoir at its closest point and 115m below the FSL of the reservoir. This secondary extraction mining was observed to cause a steady inflow of water consistent with the increase in hydraulic conductivity that would be expected from caving related ground movements. The magnitude of flow was recorded as being 0.7Ml/day at the completion of these panels.

Secondary extraction of pillars in the adjacent Blue 2 Panel on the southern side of the reservoir remote from the dyke led to higher inflows from the goaf causing the cessation of further mining in this area. Total inflows peaked at 2.4Ml/d but reduced over time to approximately 0.75Ml/d.

The dyke is not expected to be particularly conductive where it would be intersected by the four roadways of the NW Mains. The nearest secondary extraction is 320m away on the other side of the reservoir. This secondary extraction is not expected to have significantly increased the hydraulic conductivity of the dyke.

The proposed four roadways of the NW Mains would pass 60m below the floor of the reservoir in the vicinity of a vertical dyke structure that extends through to the surface. The inflow rates expected, based on experience in the nearby Blue Panels, are estimated to be less than 0.2Ml/day and therefore likely to be acceptable based on Dams Safety NSW guidelines for tolerable loss. While no significant inflows are expected, a precautionary approach is nevertheless recommended to manage the potential for inflows from the reservoir into these roadways.

The FSL of Avon Reservoir is at RL320.2m. The existing NW Mains portals are at approximately RL260m, so there is a 60m head difference that would need to be managed in the event of high inflows.

The strategy considered most effective to manage the potential for inflows involves being able to drill ahead in the Bulli Seam through the dyke and below the base of Avon Reservoir. This would be to confirm there are no zones of increased hydraulic conductivity that could lead to high flows into the underground roadways from the reservoir. It would be possible to undertake this drilling from the underground roadways once they have been developed.

We recommend horizontal holes are drilled in the Bulli Seam when the NW Mains are still further than 50m from the edge of the reservoir. The collar systems on these holes should be designed so that the holes can be sealed off and fully grouted if high water flows are encountered.

The concept of providing a plug to seal each of the four roadways is unlikely to be effective over the long-term because of the challenges associated with access for maintenance and the potential for 60m of water pressure to hydraulically fracture the coal and bypass the plug.

7. REFERENCES

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