UG1 Longwalls 101 to 103
Extraction Plan
Surface water technical report

Moolarben Coal Operations Pty Ltd
0926-19-B3, 5 May 2017
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1 Introduction

1.1 PROJECT OVERVIEW

The Moolarben Coal Complex is located approximately 40 kilometres (km) north of Mudgee in the Western Coalfield of New South Wales (NSW).

Moolarben Coal Operations Pty Ltd (MCO) is the operator of the Moolarben Coal Complex on behalf of the Moolarben Joint Venture (Moolarben Coal Mines Pty Ltd [MCM], Sojitz Moolarben Resources Pty Ltd and a consortium of Korean power companies). MCO and MCM are wholly owned subsidiaries of Yancoal Australia Limited (Yancoal).

Mining operations at the Moolarben Coal Complex are currently approved until 31 December 2038 and would continue to be carried out in accordance with NSW Project Approval (05_0117) (Moolarben Coal Project Stage 1) as modified and NSW Project Approval (08_0135) (Moolarben Coal Project Stage 2) as modified.

Stage 1 at the Moolarben Coal Complex has been operating for several years and at full development will comprise three open cut mines (OC1, OC2 and OC3), a longwall underground mine (UG4) and mining related infrastructure (including coal processing and transport facilities).

Stage 2 at the Moolarben Coal Complex has commenced and at full development will comprise one open cut mine (OC4), two longwall underground mines (UG1 and UG2) and mining related infrastructure.

Secondary extraction at UG1 is scheduled to commence in Quarter 4 of 2017 and will involve extraction of coal by longwall mining methods from the Ulan seam within Mining Lease (ML) 1605, ML 1606, ML 1628, ML 1691 and ML 1715.

An Extraction Plan is being prepared by MCO (with input from suitably qualified and experienced persons) for Longwalls 101 to 103 (LW101-103) of UG1 to satisfy the requirements of Project Approval (08_0135) (as modified) and the NSW Department of Planning and Environment (DP&E) and NSW Division of Resources and Energy (DRE) (2015) Guidelines for the Preparation of Extraction Plans. The appointment of the team of suitably qualified and experienced persons has been endorsed by the Secretary of the DP&E.

LW101-103 (shown in Figure 1.1) are a subset of Longwalls 101 to 105, which together form UG1 at the Moolarben Coal Complex. A separate Extraction Plan will be prepared for Longwalls 104 and 105 prior to secondary extraction of these longwalls commencing.

1.2 SCOPE OF THIS REPORT

Surface water impacts were previously considered in a Surface Water Assessment Review (Appendix F of the Moolarben Coal Complex UG1 Optimisation Modification; WRM Water & Environment, 2015) and Subsidence Assessment (Appendix A of the Moolarben Coal Complex UG1 Optimisation Modification; MSEC, 2015). Potential surface water impacts due to the extraction of LW101-103 were considered in a recent Subsidence Assessment (MSEC, 2017).

This surface water technical report summarises the key potential environmental risks related to surface water for LW101-103, and presents proposed monitoring and management measures to minimise these surface water environmental risks.
Figure 1.1 Locality plan - UG1, LW101 - 103
2 Baseline conditions

2.1 TOPOGRAPHY AND SURFACE DRAINAGE

LW101-103 are located beneath a ridge that separates the catchment of Murragamba Creek to the south from the catchments of Bora Creek and Goulburn River to the north and Moolarben Creek to the west. Murragamba Creek is a tributary of Wilpinjong Creek.

Surface drainage over the area of LW101-103 is characterised by steep, first and second order gullies. The higher elevations are typically forested, draining to flatter floodplain areas that are mostly cleared of significant vegetation. Stream gradients in the area are typically in the range of 2% to 7%.

Gullies on the northern and western side of the ridge drain to the disturbed areas of OC1 and OC2 (including areas in various stages of rehabilitation), Bora Creek or Moolarben Creek. Gullies on the southern side of the ridge drain to Murragamba Creek or OC4.

Figure 2.1 shows the various drainage lines (DL) overlying LW101-103, including the more significant drainage lines (DL4, DL5, DL6 and DL7) on the southern side of LW101-103.

2.2 VEGETATION AND GEOMORPHOLOGY - MINOR GULLIES

In the upper reaches, the first order drainage lines typically consist of a shallow incised drainage path of low sinuosity with numerous trees and significant quantities of large woody debris. Figure 2.2 shows several photographs taken along the upper reaches of DL6. Soils appear to be shallow with underlying rock exposed at some locations. Understory vegetation is limited.

Despite the steep slopes and lack of vegetative cover, active bed and bank erosion appears minimal with rock bars and large woody debris providing bed control. Smaller woody debris and leaf litter also act to protect the bed against erosion.

In the lower reaches of the second order drainage lines (see Figure 2.3), the main drainage path loses definition on the flatter slopes and flow spreads across a wide, poorly defined flow path. Clearing of trees and deeper soils on the flatter slopes has permitted better growth of grass cover. The combination of wide, shallow flow, good grass cover and flatter longitudinal gradient provides good protection against erosion.
Figure 2.1 Ground level contours and drainage lines (Source: MSEC, 2017)
Figure 2.2 Photographs showing Drainage Line 6, upper reaches
2.3 **FLOW, WATER QUALITY, STREAM HEALTH AND CHANNEL STABILITY**

Surface water monitoring for receiving watercourses is undertaken for flow, water quality, stream health and channel stability as described in the site wide Surface Water Management Plan (MCO, 2016). The locations of flow, water quality and stream health monitoring are shown in Figure 2.4. Baseline channel stability monitoring locations are shown in Figure 2.5. A summary of baseline flow, water quality, stream health and channel stability data is provided in the site wide Surface Water Management Plan (MCO, 2016).
Figure 2.4 Surface water flow, water quality and stream health monitoring locations
Figure 2.5 Channel stability monitoring locations
3 Subsidence impacts

3.1 OVERVIEW

A summary of relevant potential subsidence impacts to surface water features is provided in the following sections.

3.2 DRAINAGE LINES

Drainage lines in the vicinity of LW101-103 include DL4, DL5, DL6 and DL7, as shown in Figure 2.1.

DL4 and DL5 are located within the footprint of the approved northern out of pit (NOP) emplacement and hence these drainage lines will be buried beneath overburden. DL6 is located above LW104 and is not predicted to be impacted by subsidence caused by the extraction of LW101-103. DL4, DL5 and DL6 are not considered further in this surface water technical report.

DL7 directly overlies Longwalls 103, 104 and 105. The maximum predicted subsidence characteristics for DL7 due to the extraction of Longwall 103 are as follows (MSEC, 2017):

- Maximum predicted total subsidence = 2100 millimetres (mm); and
- Maximum predicted tilt = 45 millimetres per metre (mm/m).

These maximum predicted subsidence characteristics are consistent with those predicted for the approved layout for the Moolarben Coal Complex UG1 Optimisation Modification.

DL7 is ephemeral, so water typically flows during and for short periods after a rainfall event.

Ponding naturally develops along some sections of the drainage lines, for short periods of time, after major rainfall events. Additional ponding may occur along DL7 as a result of subsidence from LW101-103.

The predicted changes in grade along the drainage lines are generally less than most of the natural grades, which vary from approximately 20 mm/m to 500 mm/m. DL7 contains predominantly alluvial and colluvial deposits and it is expected that sections of beds downstream of the additional ponding areas may erode during subsequent rain events, especially during times of high flow. The predicted changes in grade are expected to increase the risk of erosion over a reach length of about 100 metres (m) immediately downstream of the chain pillar and increase the potential for ponding over a similar length immediately upstream of the chain pillar. The areas of DL7 predicted to be at increased risk of erosion or ponding are shown in Figure 3.1.

It is expected over time that the gradients along the drainage lines would approach grades similar to those which existed before mining. The extent of additional ponding along the drainage lines would therefore be expected to decrease with time.

The maximum predicted systematic tensile and compressive strains at the drainage lines, at any time during or after the extraction of the proposed longwalls, are 23 mm/m and 18 mm/m respectively. The minimum radii of curvatures associated with the maximum predicted systematic tensile and compressive strains are 2.3 kilometres (km) and 1.8 km. It is expected, at strains of these magnitudes, that fracturing and dilation of the bedrock would occur as a result of the extraction of the proposed longwalls. The drainage lines may have relatively thin alluvial and colluvial deposits above the bedrock but it is still expected that fracturing in the bedrock would be observed at the surface, especially around the locations of natural jointing in the bedrock and where the depths of soil above the bedrock are the shallowest.
In times of heavy rainfall, the majority of the surface water runoff would be expected to flow over the surface cracking in the beds and only a small proportion of the flow would be diverted into the fractured and dilated strata below. In times of low flow, however, a larger proportion of the surface water flow could be diverted into the strata below the beds and this could affect the quality and quantity of this water flowing through the cracked strata beds. Nevertheless, during high flow or low flow times this small quantity is expected to have little impact on the overall quality of water flowing out of the drainage lines.

It is also expected that with time the fracturing in the bedrock would be filled with alluvial and colluvial materials during subsequent flow events, reducing the diversion of surface water flows into subsurface flows. It may be necessary, however, that some remediation of the beds of the drainage line would be required, such as the infilling of surface cracks with materials comprising a high clay content, or by locally regrading and re-compacting the surface.

It is recommended that the drainage lines are visually monitored as the proposed longwalls mine beneath them. It is also recommended that management strategies (refer Section 4) are developed for the drainage lines, such that the impacts can be identified and remediated, as and if they are required.

### 3.3 NORTHERN OUT OF PIT EMLACEMENT

The predicted subsidence at the natural ground surface and additional settlement of the emplacement area can initiate downhill slumping of the soils in the NOP emplacement. Other factors such as the presence of natural steep ground slopes, and surface water ingress may increase the risk of downhill slumping of the sides of the emplacement area. Longwall extraction will create depressions in the flat areas of the emplacement and surface cracks, which will increase the risk of water ingress into the emplacement soils during rain periods.

The Subsidence Assessment (MSEC, 2017) recommends that management strategies are developed for the surface and the slopes of the NOP emplacement as the UG1 longwalls are located beneath the NOP emplacement. Such management should include surface crack repair and remediation of the ground surface to ensure that adequate surface water drainage is maintained.

On the uphill sides of the NOP emplacement, drainage lines will flow towards the NOP emplacement. Measures should be incorporated to provide for the adequate management of the flows in these drainage lines around or over the NOP emplacement, including preventing the erosion of the NOP emplacement and preventing unplanned ponding on the surface of the NOP emplacement following extraction of the longwalls.

The NOP emplacement is subject to slumping as the emplaced material settles. As such, inspections of drainage around and over the NOP emplacement occur as required as part of MCO’s operations to confirm the functionality of the drainage lines.

### 3.4 ENVIRONMENTAL RISK ASSESSMENT

A quantitative environmental risk assessment for LW101-103 is presented in the Moolarben Coal UG1 - Longwalls 101 to 103 Subsidence Risk Assessment Report (Operational Risk Mentoring [ORM], 2017). The following surface water issues were identified by the risk assessment as Medium risk:

- potential changes to the gradients of drainage lines and the corresponding impact on erosion risk; and
- changes in water quality due to a potential increase in erosion.
Figure 3.1 Subsidence impacts on Drainage Line 7 (Source: MSEC, 2017)
4 Monitoring and management measures

4.1 SUBSIDENCE IMPACT PERFORMANCE MEASURES

Schedule 4 of the Project Approval (08_0135) lists the following performance measure for subsidence impacts on water resources:

- Drainage Lines (DL1-DL7):
  - No greater subsidence impacts or environmental consequences than predicted in the EA.

Subsidence impacts and potential environmental consequences for surface drainage features are discussed in Section 3 of this report and are consistent with those previously predicted.

The following sections provide:

- detailed objectives and performance indicators for potential subsidence impacts on surface drainage;
- proposed monitoring activities for potential surface water subsidence impacts;
- proposed remedial measures and contingencies; and
- triggers for proposed management actions.

4.2 OBJECTIVES AND PERFORMANCE INDICATORS

Table 4.1 shows the objectives and performance indicators for potential surface water related issues.
<table>
<thead>
<tr>
<th>Risk issue</th>
<th>Objective</th>
<th>Performance indicator</th>
<th>Proposed monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drainage lines</td>
<td>No increase in active erosion of bed and banks in DL7</td>
<td>• Change in visible bed or bank erosion</td>
<td>Walkover visual inspection of DL7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Development of, or change in, headcut erosion along DL7</td>
<td>Photographic record of high-risk reaches of DL7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Change in vegetation character such as vegetation loss through erosion or drowning by ponded water</td>
<td>Walkover visual inspection of DL7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Extent and duration of water ponding</td>
<td>Photographic record of high-risk reaches of DL7</td>
</tr>
<tr>
<td></td>
<td>No change in stream character for DL7</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No measurable change in downstream water quality</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimise change in catchment hydrology caused by loss of surface flow in cracks caused by subsidence</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
<th>Monitoring Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>DL7</td>
<td>Visual inspection</td>
<td>Walkover visual inspection of DL7</td>
</tr>
<tr>
<td></td>
<td>Photographic recording</td>
<td>Photographic record of high-risk reaches of DL7</td>
</tr>
</tbody>
</table>

Continue current water quality monitoring program as described in the site wide Surface Water Management Plan (MCO, 2016)
4.3 MONITORING OF IMPACTS

As described in Section 3, the potential surface water impacts of subsidence for LW101-103 are likely to be limited in spatial extent. Hence, monitoring of potential impacts will be focussed on high risk locations.

Due to the small catchment areas of the affected drainage line, surface runoff will occur infrequently and only for a very short time during and immediately after significant rainfall. Water quality sampling under these conditions is not a reliable method to assess impacts because:

- runoff occurs infrequently;
- baseline water quality is likely to be highly variable depending on the magnitude of rainfall; and
- accessing sampling locations in the upper catchments during the very short time that surface runoff is flowing is likely to be extremely difficult.

For these reasons, water quality sampling of the minor drainage lines is not proposed. Water quality sampling of receiving streams will continue to be undertaken in accordance with the site wide Surface Water Management Plan (MCO, 2016). However, it is unlikely that this sampling could detect any impacts due to subsidence because the expected impacts on runoff quality are minimal and the receiving watercourses collect runoff from large catchments that include significant areas of land disturbing activities that pose a significantly larger risk of affecting water quality.

Due to the difficulty in detecting subsidence impacts by water quality monitoring, the primary monitoring activity for surface water subsidence impacts will be visual inspection of high risk locations, including collection of photographic records to confirm changes in erosion and vegetation over time. Details of the proposed monitoring activities are given in Table 4.2.

4.4 TRIGGER ACTION RESPONSE

Table 4.3 shows trigger events for each of the performance indicators, as well as required actions to manage the potential impacts. A key principle for the remediation of surface water impacts due to subsidence is to minimise land disturbance associated with intervention measures. Hence, once an issue is identified, it is recommended that specialist advice be obtained to ensure that any proposed intervention is effective. Wherever possible, proposed remediation works should be undertaken using soft engineering measures that minimise land disturbance and maximise vegetative cover.
Table 4.2 - Proposed monitoring for surface water impacts

<table>
<thead>
<tr>
<th>Monitoring task</th>
<th>Methodology</th>
<th>Timing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water quality monitoring</td>
<td>As per the site wide Surface Water Management Plan (MCO, 2016)</td>
<td>As per the site wide Surface Water Management Plan (MCO, 2016)</td>
</tr>
<tr>
<td>Walkover visual inspection and photographic record of DL7</td>
<td>Identify and mark the upstream and downstream limits of LW103 along DL7</td>
<td>Prior to undermining of DL7</td>
</tr>
<tr>
<td></td>
<td>Undertake a baseline inspection by walking along DL7 over LW103 and noting the condition of vegetation in the channel and any areas of active erosion, sediment deposition, water ponding or streambed cracking</td>
<td>Prior to undermining of DL7</td>
</tr>
<tr>
<td></td>
<td>Collect baseline photographic record of channel condition along DL7 over LW103</td>
<td>Prior to undermining of DL7</td>
</tr>
<tr>
<td></td>
<td>Undertake periodic walkover inspections and compare against the baseline photographic record</td>
<td>Within 3 months of undermining of DL7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ongoing inspections every 6 months. Minimum of 2 inspections per year for 1 year after undermining</td>
</tr>
</tbody>
</table>
### Table 4.3 - Surface water response actions

<table>
<thead>
<tr>
<th>Issue</th>
<th>Performance indicator</th>
<th>Trigger event</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drainage lines</td>
<td>• Change in visible bed or bank erosion</td>
<td>• Noticeable new areas of erosion or expansion of existing erosion</td>
<td>• Obtain specialist advice on appropriate remediation works. Disturbance of existing vegetation increases the risk of erosion. Hence, machinery access for remediation works can potentially cause greater impacts than those caused by subsidence.</td>
</tr>
<tr>
<td></td>
<td>• Development of or change in headcut erosion along DL7</td>
<td>• Initiation of headcut or noticeable upstream advance of existing headcut</td>
<td>• Obtain specialist advice on appropriate remediation works. Preferred management strategies would include slope stabilisation, revegetation and bed control using natural materials such as local rock and large woody debris.</td>
</tr>
<tr>
<td></td>
<td>• Change in vegetation character such as vegetation loss through erosion or drowning by ponded water</td>
<td>• Dieback of vegetation</td>
<td>• Obtain specialist advice on likely cause of vegetation change and remediation strategy.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Invasion of new species or weeds</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Extent and duration of water ponding</td>
<td>• Development of new pools or drainage of existing pools</td>
<td>• Obtain survey of ponded area to identify ponding depth and extent.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Investigate potential drainage works to restore existing drainage characteristics.</td>
</tr>
<tr>
<td></td>
<td>• Downstream water quality</td>
<td>• Downstream turbidity exceeds trigger values in the site wide Surface Water Management Plan (MCO, 2016)</td>
<td>• Proceed with response actions for downstream surface water quality in the site wide Surface Water Management Plan (MCO, 2016).</td>
</tr>
</tbody>
</table>
5 References


WRM, 2015 ‘Moolarben Coal Complex UG1 Optimisation Modification Surface Water Assessment Review’, Report prepared by WRM Water & Environment for Moolarben Coal Mines Pty Ltd.