UG4 Longwalls 401 to 408 Extraction Plan

Surface Water Technical Report

Moolarben Coal Operations Pty Ltd

0926-40-B5, 2 November 2021

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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], Yancoal Moolarben [YM] Pty Ltd and a consortium of Korean power companies). MCO, MCM and YM 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.

MCO is planning to commence secondary extraction of underground mining area UG4 and is in the process of developing an Extraction Plan for Longwalls 401 to 408. Longwall operations in LW401 are anticipated to commence in 2022.

The Extraction Plan is being prepared by MCO (with input from suitably qualified and experienced persons) for Longwalls 401-408 of the UG4 Underground Mine to satisfy the requirements of Project Approval (05_0117) (as modified) and the NSW Department of Planning, Industry and Environment (DPIE) 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 DPIE.

Longwalls 401-408 (shown in Figure 1.1 and Figure 1.2) are a subset of a total of 14 proposed longwalls including Longwalls 401-408 within the study area and a remaining six longwalls just north of the study area, which together form the UG4 Underground Mine at the Moolarben Coal Complex. A separate Extraction Plan will be prepared for the longwalls north of the study area prior to secondary extraction of these longwalls commencing.

Since the Stage 1 Approval in 2007, extensive additional environmental monitoring and studies have been undertaken in the Ulan Coalfields, including MCO's Underground 1 and neighbouring mining operations. The additional studies and monitoring data associated with the inter-mine data sharing have improved the understanding of the predicted underground mining impacts. This contemporary knowledge, supplemented with targeted site surveys, underpins this technical report and the refined impact predictions, performance indicators, management and monitoring measures for the UG4 LW401-408 Extraction Plan.

1.2 SCOPE OF THIS REPORT

The surface water impacts of the UG4 project were considered in a previous Subsidence Impact Assessment investigation undertaken by Strata Engineering (SE, 2006), in support of the Stage 1 environmental assessment (EA). The UG4 configuration assessed in the SE (2006) 'Preferred Project Report' is referred to in this report as the 'Stage 1 EA Layout'.

After the SE (2006) assessment was completed, the proposed coal seam extraction height has been reduced from 4.2 m to 3.0 m. Approval was subsequently granted for an updated

UG4 layout referred to in this report as the ‘Approved Layout’, which is based on a 3.0 m extraction height.

Updated subsidence predictions for LW401-408 have since been undertaken by Mine Subsidence Engineering Consultants (MSEC, 2021) for the Approved Layout as well as for an updated UG4 configuration referred to in this report as the ‘Extraction Plan Layout’. The Extraction Plan Layout incorporates minor shortening of lengths of extraction compared to the Approved Layout.

This surface water technical report:

- reviews the recent subsidence predictions (prepared by MSEC [2021]) for the Extraction Plan Layout in comparison to MSEC (2021) subsidence predictions for the Approved Layout and the previous subsidence predictions (prepared by SE [2006]) for the Stage 1 EA Layout;
- discusses the key surface water risk issues for LW401-408; and
- presents proposed monitoring and management measures to minimise these surface water environmental risks.

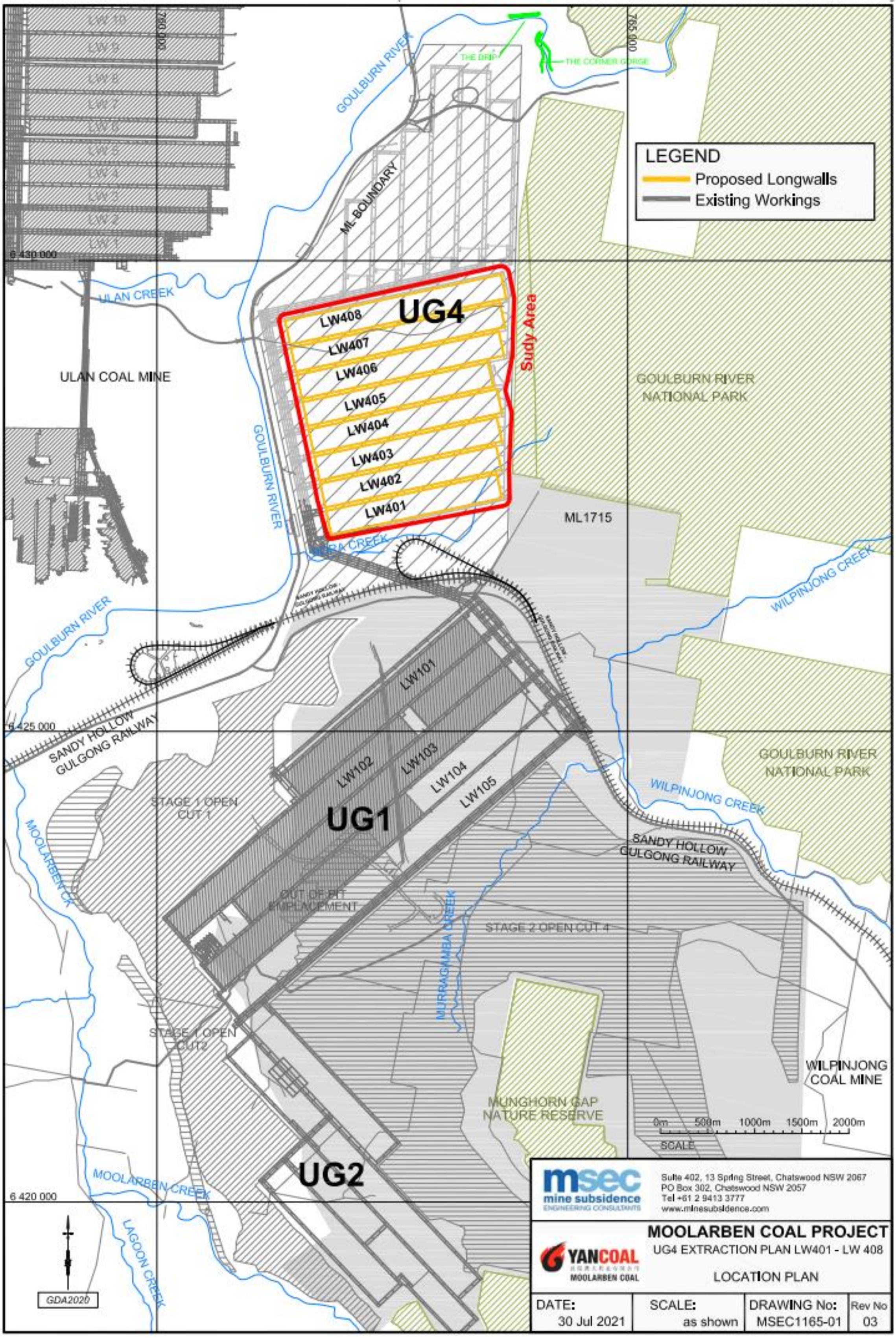

Figure 1.1 – Locality plan – UG4

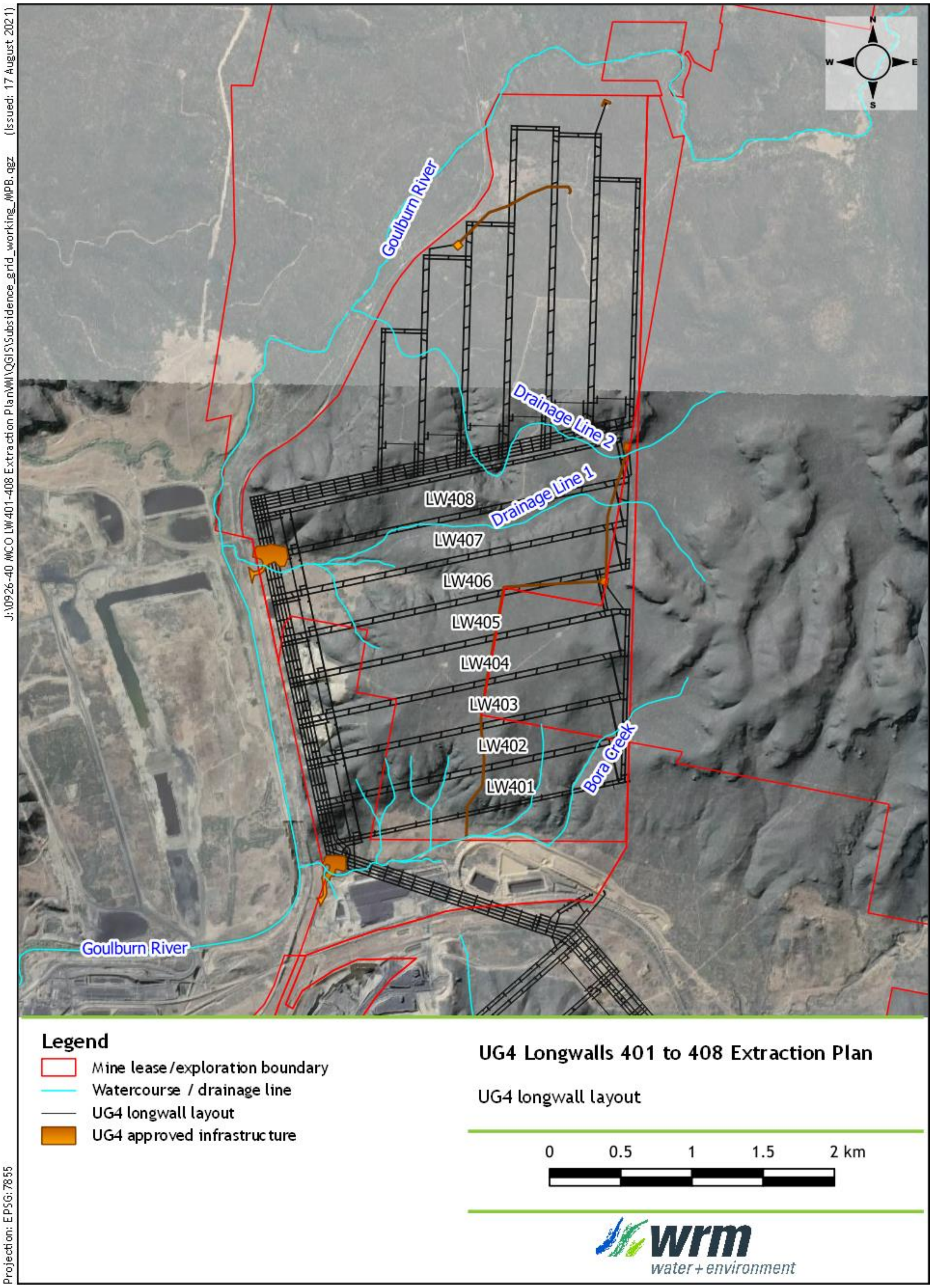

Figure 1.2 – UG4 longwall layout (Extraction Plan Layout)

2 Baseline conditions

2.1 TOPOGRAPHY AND SURFACE DRAINAGE

Figure 2.1 shows the various drainage lines overlying LW401-408 including Bora Creek above LW401-LW402 and another two key drainage lines (Drainage Line 1 and 2) above LW407-LW408.

Longwalls 401 to 408 (LW401-408) are located beneath a topographical plateau (referred to as the 'Moolarben Plateau' in SE (2006)), with steep catchments that generally fall to the north and south towards tributaries of the Goulburn River and to the west to the Goulburn River. The gullies above LW401-403 drain south to Bora Creek, a tributary of the Goulburn River. The gullies above LW404-408 drain north to a drainage line that enters the Goulburn River.

Figure 2.2 shows the surface level contours and natural features including drainage lines and cliff lines (CLs) above LW04-LW408. Surface drainage over the area of LW401-408 is characterised by steep, first and second order gullies. The higher elevations are typically forested, eventually draining to flatter grass-covered floodplain with sparse trees. Stream gradients in the upper reaches of the gullies within the area affected by subsidence are typically in the range of 5% to 20%. The upper reaches of these gullies typically drain to steep rock features or cliffs (with gradients of 20% to 80%) and then to flatter areas in the downstream reaches before joining the Goulburn River.

2.2 VEGETATION AND GEOMORPHOLOGY – MINOR GULLIES

The Moolarben Plateau itself consists of deeply incised gullies and sub-vertical cliff lines. Numerous sandstone boulders exist along the cliff bases due to natural weathering processes. Shallow alluvial/slope wash-filled gullies and flats exist between the broad, prominent ridges.

In the upper reaches of the gullies above LW401-408, topographic data and areal imagery indicate that the first order drainage lines typically consist of deeply incised drainage path with numerous trees and significant quantities of large woody debris.

The SE (2006) report noted that the soil profile on the upper to mid-slopes of the ridges typically comprises residual gravelly, sandy clays, overlying extremely to highly weathered sandstone and conglomerate.

The MSEC (2021) report noted that the drainage lines within the Study Area comprise a rounded gravel to sandy and silty base. There is also debris along sections of the streams, including boulders, tree branches and other vegetation. The valley profiles of the drainage lines are predominantly broad and shallow with some incised sections as shown in Figure 2.3.

The upper reaches of the gullies above LW401-408 drain to a rock feature which runs roughly along the southern, western and northern extents of LW401-406.

The lower reaches of the gullies above LW401-408 are generally second order drainage lines. Clearing of trees and deeper soils on the flatter slopes has permitted better growth of grass cover. Just south of LW401, these gullies lose definition and flow spreads across a wide, poorly defined flow path before draining back into Bora Creek. The lower reaches of Bora Creek itself appear relatively well defined until it joins the Goulburn River. The lower reaches of drainage line 1 above LW407 also appears relatively well-defined until it joins the Goulburn River.

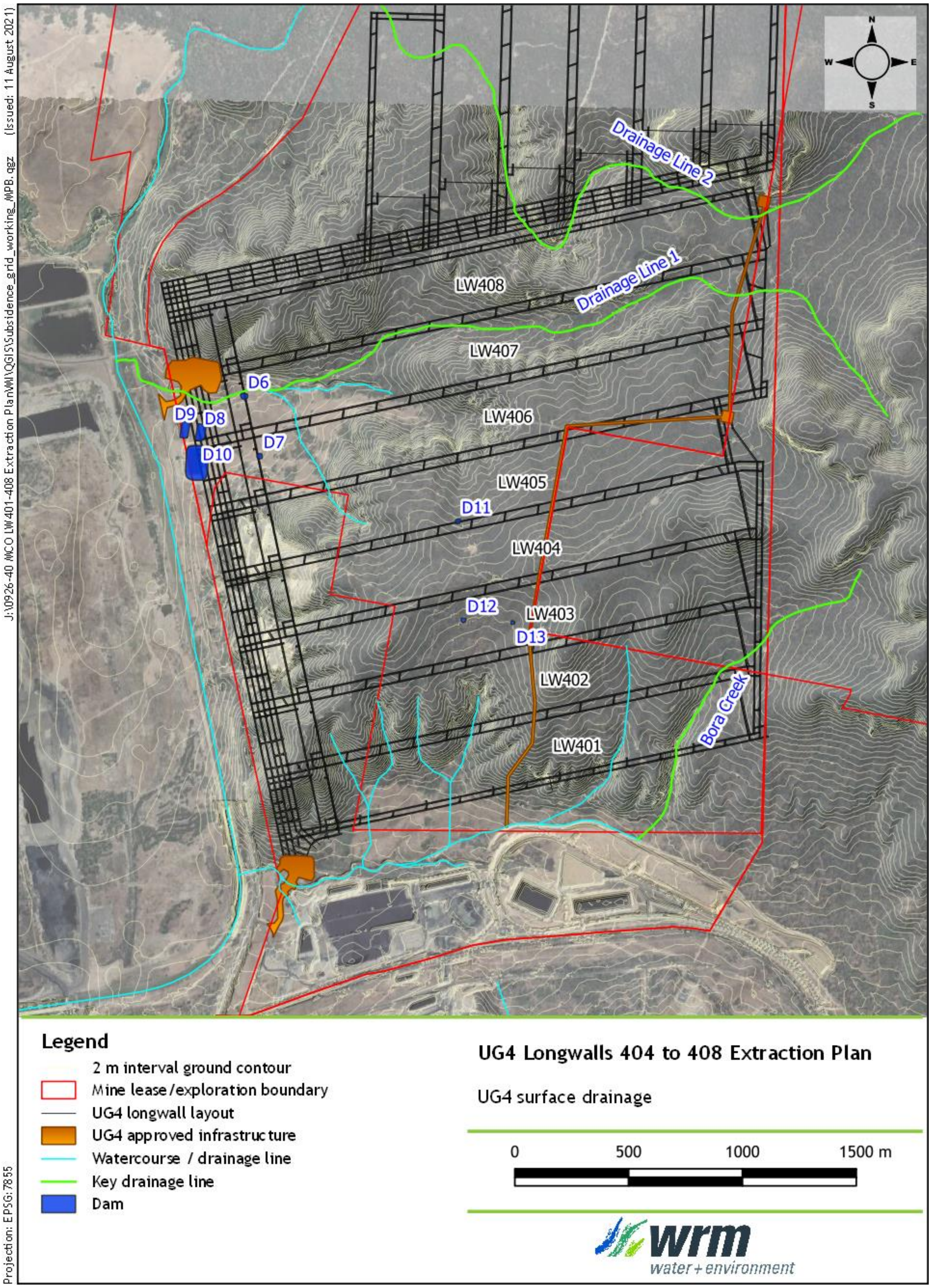

Figure 2.1 – Ground level contours and surface drainage features above LW401-LW408

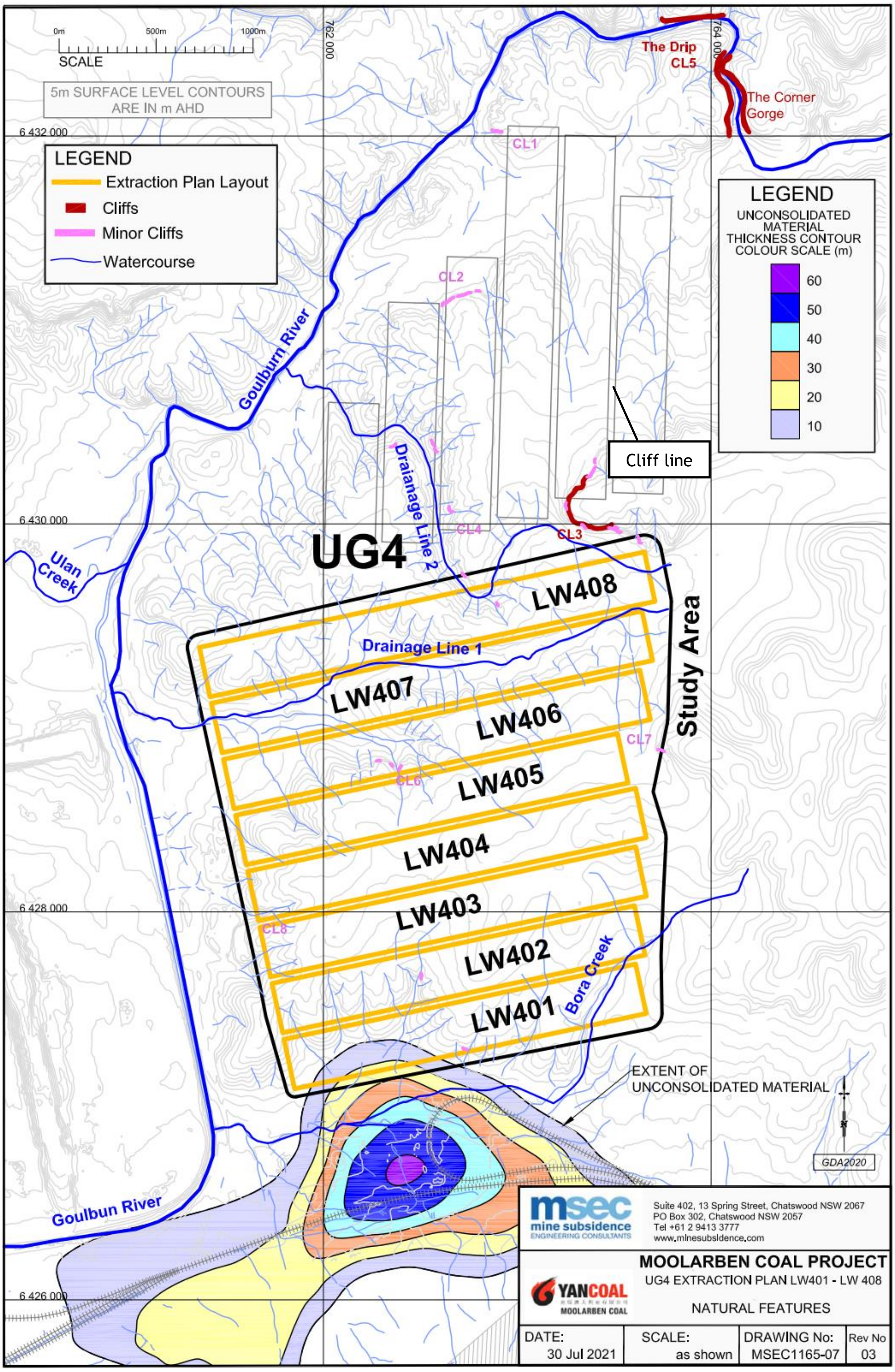

Figure 2.2 – Ground level contours and ground slopes (Source: MSEC, 2021)

Figure 2.3 – Photographs showing Drainage Line 2 (Source: MSEC, 2021)

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 Surface Water Management Plan (MCO, 2020). The locations of flow, water quality and stream health monitoring are shown in Figure 2.4. 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 Surface Water Management Plan (MCO, 2020).

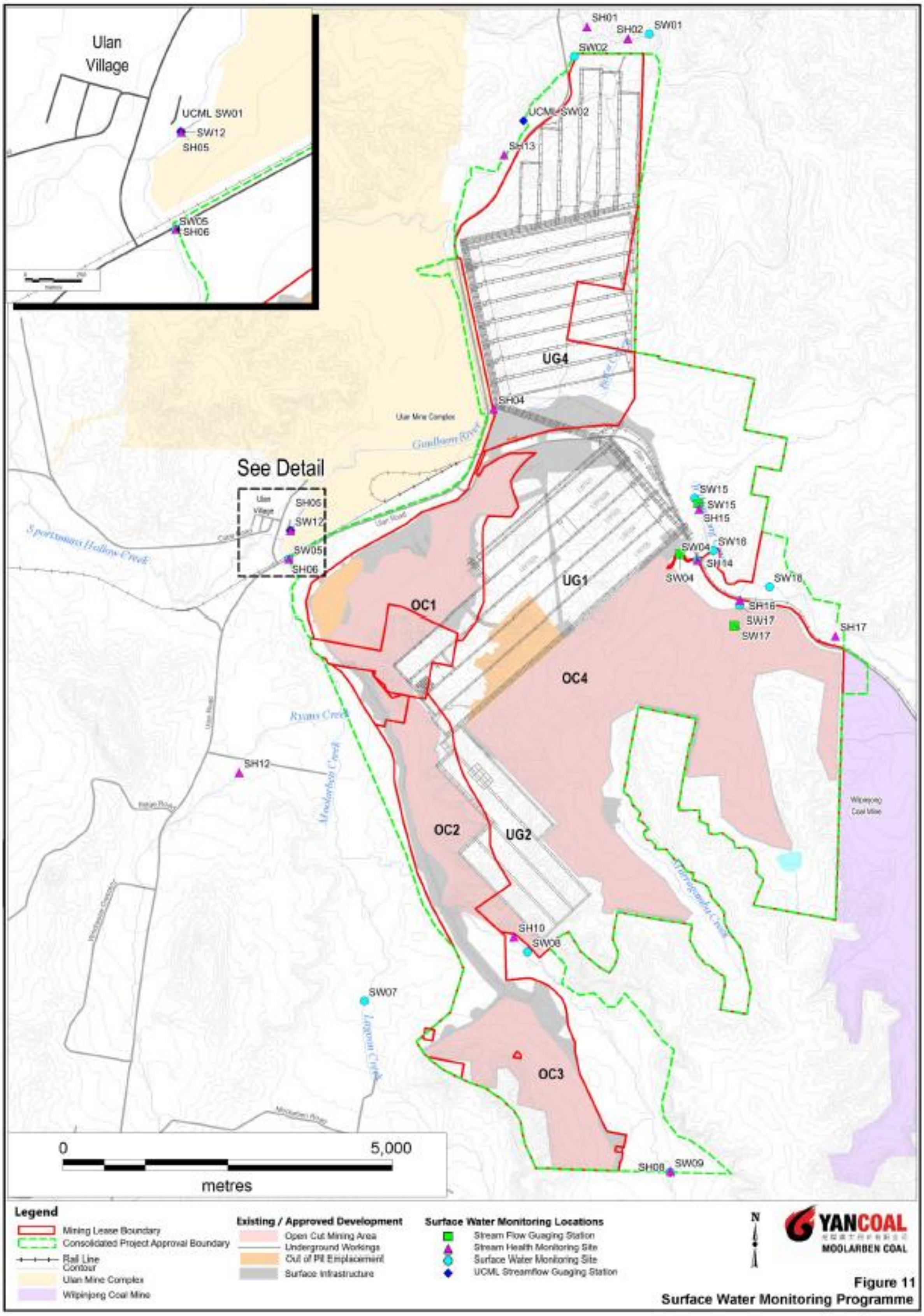

Figure 2.4 – Surface water flow, water quality and stream health monitoring locations

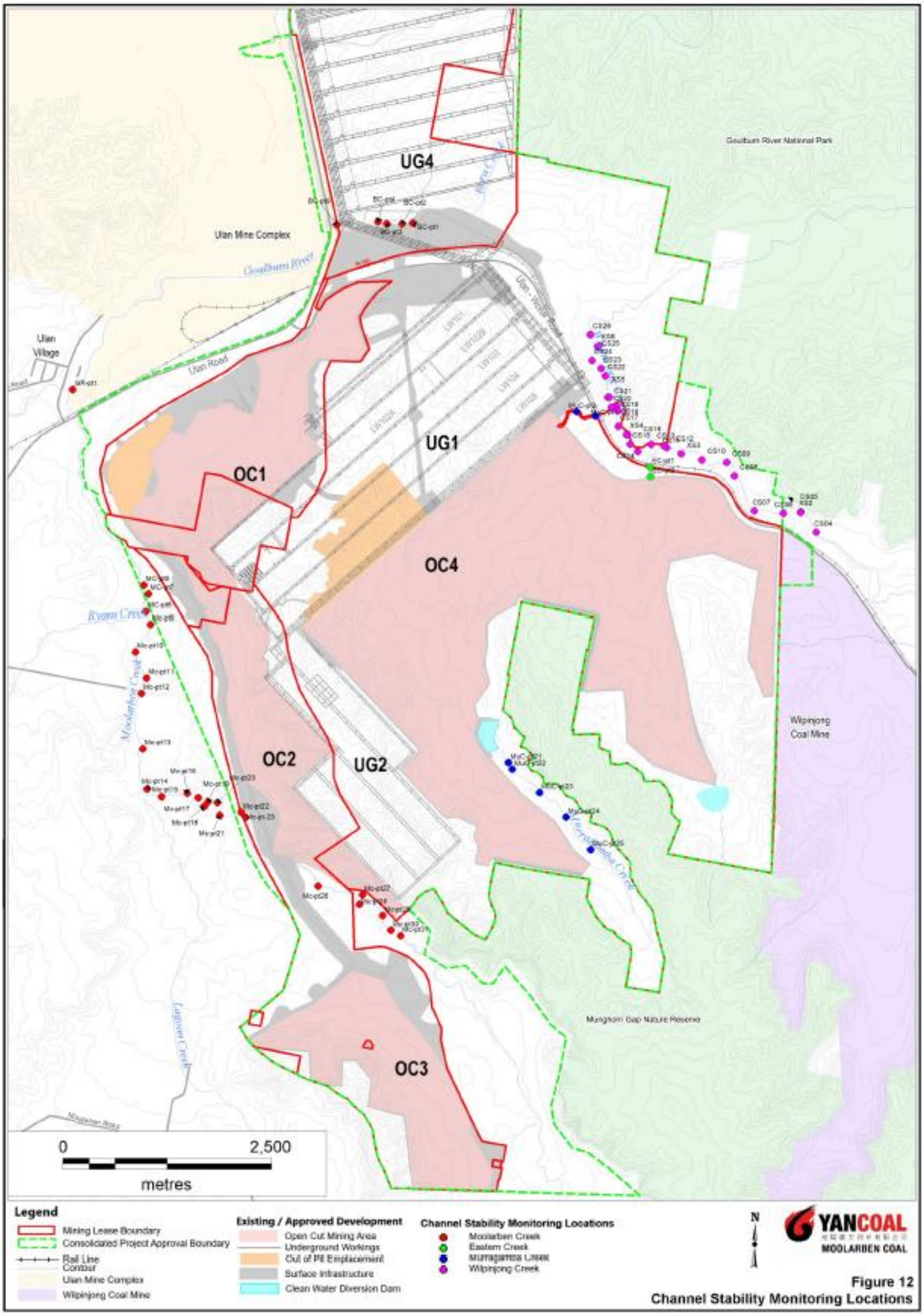

Figure 2.5 – Channel stability monitoring locations

3 Review of subsidence predictions

3.1 OVERVIEW

This section compares the MSEC (2021) subsidence depth predictions for the Extraction Plan Layout against the MSEC (2021) subsidence predictions for the Approved Layout as well as the SE (2006) subsidence predictions for the Stage 1 EA Layout.

3.2 COMPARISON OF SUBSIDENCE PREDICTIONS

Figure 3.1 and Figure 3.2 show the predicted subsidence depth estimates for the Extraction Plan Layout from MSEC (2021) and for the Stage 1 EA Layout from SE (2006) respectively.

Table 3.1 compares the maximum predicted subsidence depths at each longwall panel (LW401-408). Note that LW401-408 were previously named LW1-8 in the SE (2006) assessment. It can be seen in Table 3.1 that the maximum subsidence depths for the Extraction Plan Layout range from 0.33 m to 0.64 m lower than those estimated for the Stage 1 EA Layout based on the SE (2006) assessment.

Table 3.1 - Comparison of maximum predicted total subsidence for the Extraction Plan Layout (MSEC, 2021) and the Stage 1 EA Layout (SE, 2006)

LW panel no.	Maximum predicted subsidence depth (m)	
	Extraction Plan Layout (MSEC, 2021)	Stage 1 EA Layout (SE, 2006)
LW401	1.80	2.44
LW402	1.90	2.44
LW403	1.90	2.44
LW404	1.90	2.24
LW405	1.90	2.23
LW406	1.90	2.31
LW407	1.90	2.44
LW408	1.90	2.44

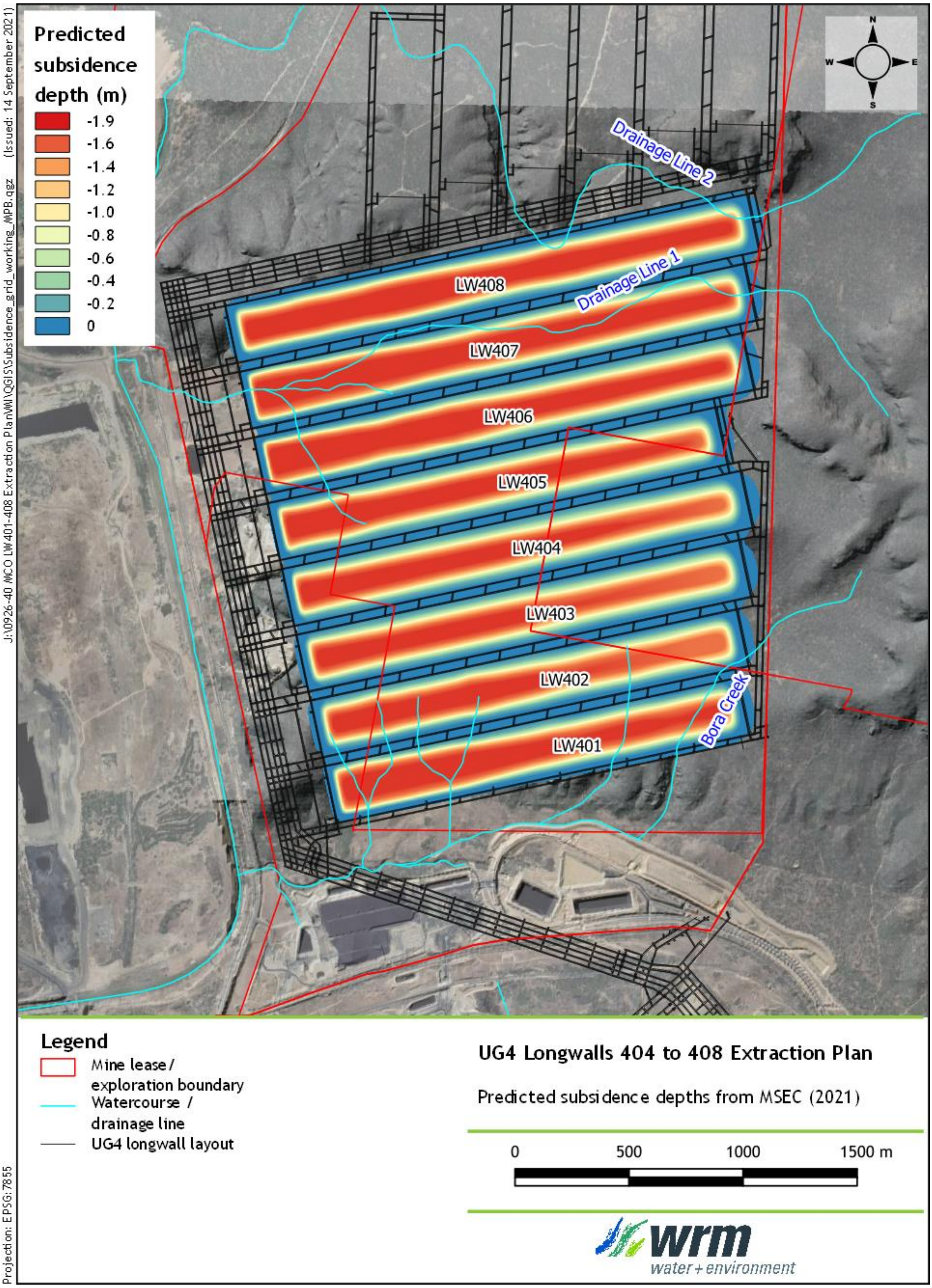

Figure 3.1 – Predicted subsidence estimates for the Extraction Layout (MSEC, 2021)

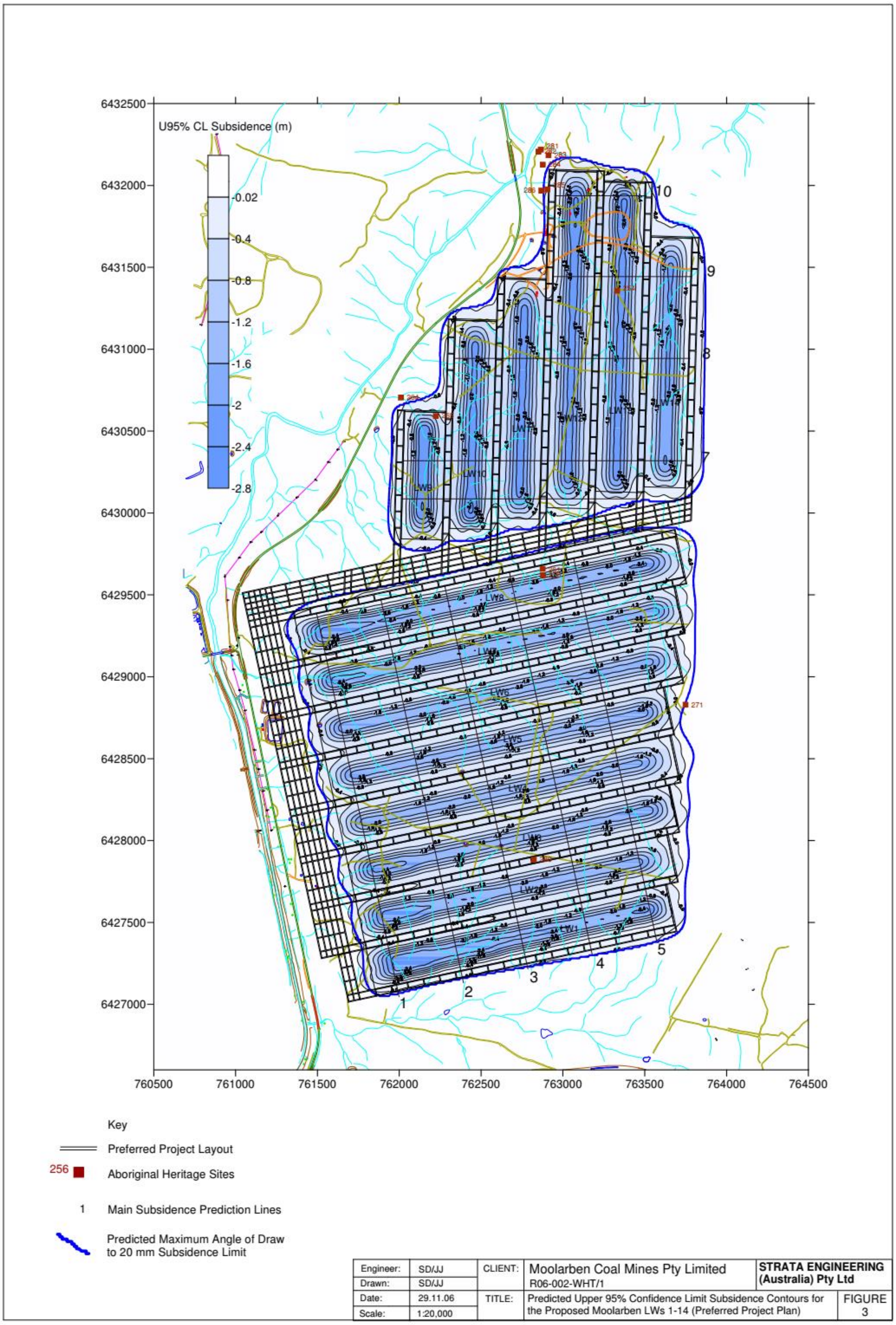

Figure 3.2 – Predicted subsidence estimates for the Stage 1 EA Layout

Table 3.2 (MSEC [2021]) compares the maximum predicted subsidence characteristics for the Extraction Plan Layout from MSEC (2021) against the subsidence predictions for the Approved Layout from MSEC (2021) and the subsidence predictions for the Stage 1 EA Layout from SE (2006). It shows that the maximum predicted total subsidence parameters based on the Approved Layout are the same as those for the Extraction Plan Layout for LW401-408. The maximum predicted total subsidence parameters based on the Extraction Plan Layout are also less than the maximum predicted total subsidence parameters for the Stage 1 EA Layout.

Table 3.2 - Comparison of maximum predicted subsidence characteristics for the Extraction Plan Layout based on MSEC (2021), the Approved Layout based on MSEC (2021) and the Stage 1 EA Layout from SE (2006)

UG4 layout	Maximum predicted total conventional subsidence (mm)	Maximum predicted total conventional tilt (mm/m)	Maximum predicted total conventional hogging curvature (km^{-1})	Maximum predicted total conventional sagging curvature (km^{-1})
Stage 1 EA Preferred Project Report (SE, 2006)	2,440	96	> 3.0	> 3.0
Approved Layout (MSEC, 2021)	1,900	60	> 3.0	> 3.0
Extraction Plan Layout (MSEC, 2021)	1,900	60	> 3.0	> 3.0

4 Subsidence impacts

4.1 OVERVIEW

Subsidence impacts on surface water features for the Extraction Plan Layout are discussed in Section 5.2 (Drainage Lines), Section 5.3 (the Goulburn River) and Section 8.2 (Farm Dams) of the MSEC (2021) Subsidence Impact Assessment. The MSEC (2021) assessment also compared the subsidence impacts for the Extraction Plan Layout against the subsidence impacts for the Approved Layout. The following sections provide a summary of the relevant findings from the MSEC (2021) assessment.

4.2 DRAINAGE LINES AND BORA CREEK

LW401 and LW402 potentially impact the upper reaches of Bora Creek. The lower two thirds of Bora Creek are downstream of LW401 and will be unaffected by subsidence. These lower reaches of Bora Creek have previously been modified, including a diversion of the creek channel, as part of approved works to facilitate mine development.

LW407 potentially impacts Drainage Line 1 (DL1). LW408 potentially impacts Drainage Line 2 (DL2).

Table 4.1 compares the maximum predicted subsidence characteristics for Bora Creek and Drainage Lines 1 and 2 after the extraction of LW401-408 for the Extraction Plan Layout (obtained from the MSEC [2021] report). Tilt and curvature are the key factors affecting ponding or erosion risk. However, the predicted maximum values occur only within about 100 m of where the drainage lines cross the chain pillars. There is negligible change in drainage characteristics in reaches where uniform subsidence occurs.

Figure 4.1, Figure 4.2, and Figure 4.3 show the predicted profiles of vertical subsidence, tilt and curvature along the alignment of Bora Creek and Drainage Lines 1 and 2 for the Extraction Plan Layout and compares them with those predicted for the Approved Layout. Figure 2.1 show the locations of these drainage lines.

Table 4.1 - Comparison of maximum predicted subsidence parameters along the alignments of Bora Creek and Drainage Lines 1 and 2, between the Approved Layout and the Extraction Plan Layout (MSEC, 2021)

UG4 layout	Drainage line	Maximum predicted total conventional subsidence (mm)	Maximum predicted total conventional tilt (mm/m)	Maximum predicted total conventional hogging curvature (km^{-1})	Maximum predicted total conventional sagging curvature (km^{-1})
Approved Layout	Bora Creek	1,800	25	0.50	0.45
	Drainage Line 1	1,900	60	> 3.0	> 3.0
	Drainage Line 2	1,000	20	0.75	0.70
Extraction Plan Layout	Bora Creek	1,800	25	0.55	0.40
	Drainage Line 1	1,900	60	> 3.0	> 3.0
	Drainage Line 2	1,000	20	0.85	0.75

MSEC (2021) noted that the predicted total subsidence for the drainage lines based on the Extraction Plan Layout is the same as that for the Approved Layout. The predicted total curvature and tilt based on the Extraction Plan Layout is similar to that based on the Approved Layout. The potential impacts for the drainage lines, based on the Extraction Plan Layout are the same as those assessed based on the Approved Layout.

The drainage lines within the Study Area are ephemeral as water only flows during and for short periods after each rain event. Ponding naturally develops along some sections of the drainage lines, for short periods of time, after major rain events. The predicted changes in grade along the drainage lines after the completion of the longwalls are generally less than most of the natural grades, however the magnitudes of tilt will result in increases and decreases in grade and reversal of grade at some locations. Additional ponding may occur along the drainage lines resulting from the extraction of Longwalls 401 to 408, predominantly upstream of the chain pillars.

Sections of beds downstream of the additional ponding areas may erode during subsequent rain events, especially during times of high flow. It is expected that, over time, the gradients along the drainage lines would approach grades similar to those that existed before mining. The extent of additional ponding along the drainage lines would, therefore, be expected to decrease with time.

Fracturing, dilation and buckling of the bedrock would occur as a result of the extraction of these longwalls. Surface cracking is expected to develop in the bases of the drainage lines.

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.

If adverse impacts were to develop as the result of increased ponding along the streams, these could be remediated by locally re-grading the beds to re-establish the natural gradients. The streams have shallow incisions in the natural surface soils and, therefore, it is expected that the mining-induced ponding areas could be reduced by locally excavating the channels downstream of these areas. The larger ponding areas may require excavation into the topmost bedrock, depending on the thickness of the overlaying surface soils. It would be expected that the majority of fracturing in the underlying bedrock would gradually be filled with the surface soils during subsequent flow events, especially during times of heavy rainfall. If the surface cracks were found not to fill naturally, some remedial measures may be required at the completion of mining. Where necessary, any significant surface cracks in the stream beds could be remediated by infilling with the surface soil or other suitable materials, or by locally regrading and recompacting the surface.

MSEC (2021) recommends that the drainage lines are visually monitored as the longwalls mine beneath them and that management strategies are developed for the drainage lines, such that the impacts can be identified and remediated if and as they are required. Management strategies based on extraction of the Extraction Plan Layout are the same as those for the Approved Layout.

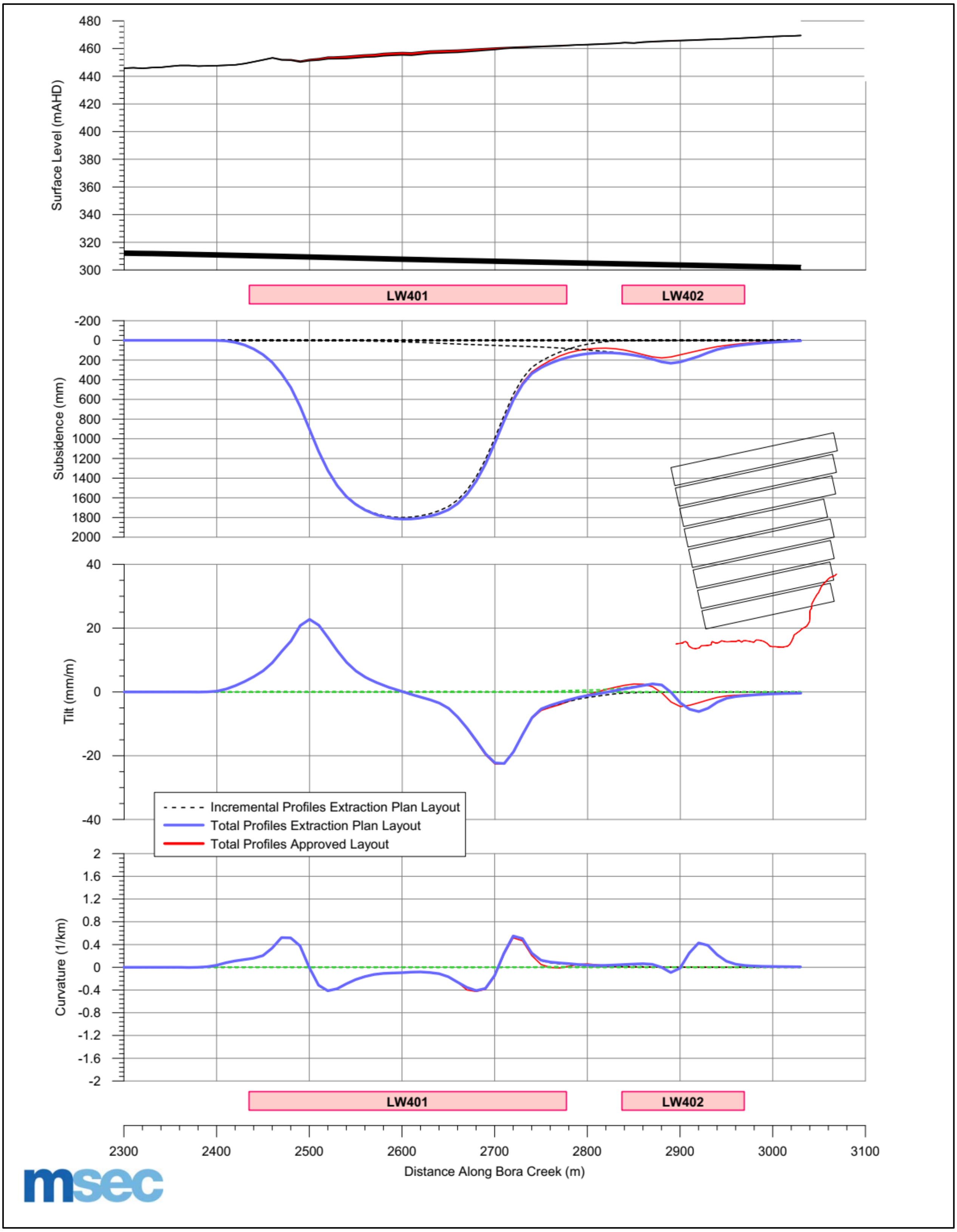

Figure 4.1 – Comparison of predicted profiles of subsidence, tilt and curvature along Bora Creek due to LW401 to 408, between the Extraction Plan Layout and the Approved Layout (source: MSEC, 2021)

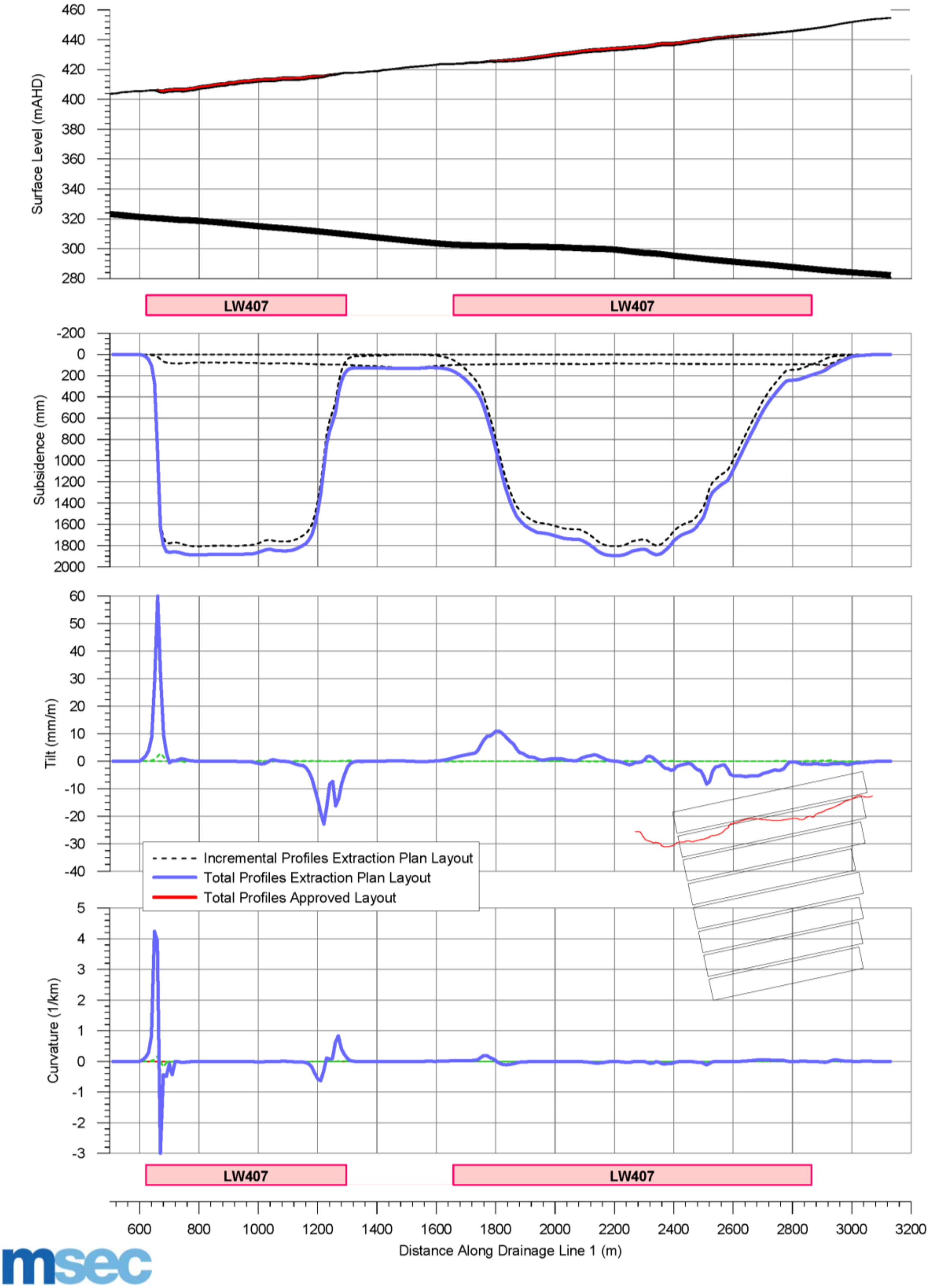

Figure 4.2 – Comparison of predicted profiles of subsidence, tilt and curvature along Drainage Line 1 due to LW401 to 408, between the Extraction Plan Layout and the Approved Layout (source: MSEC, 2021)

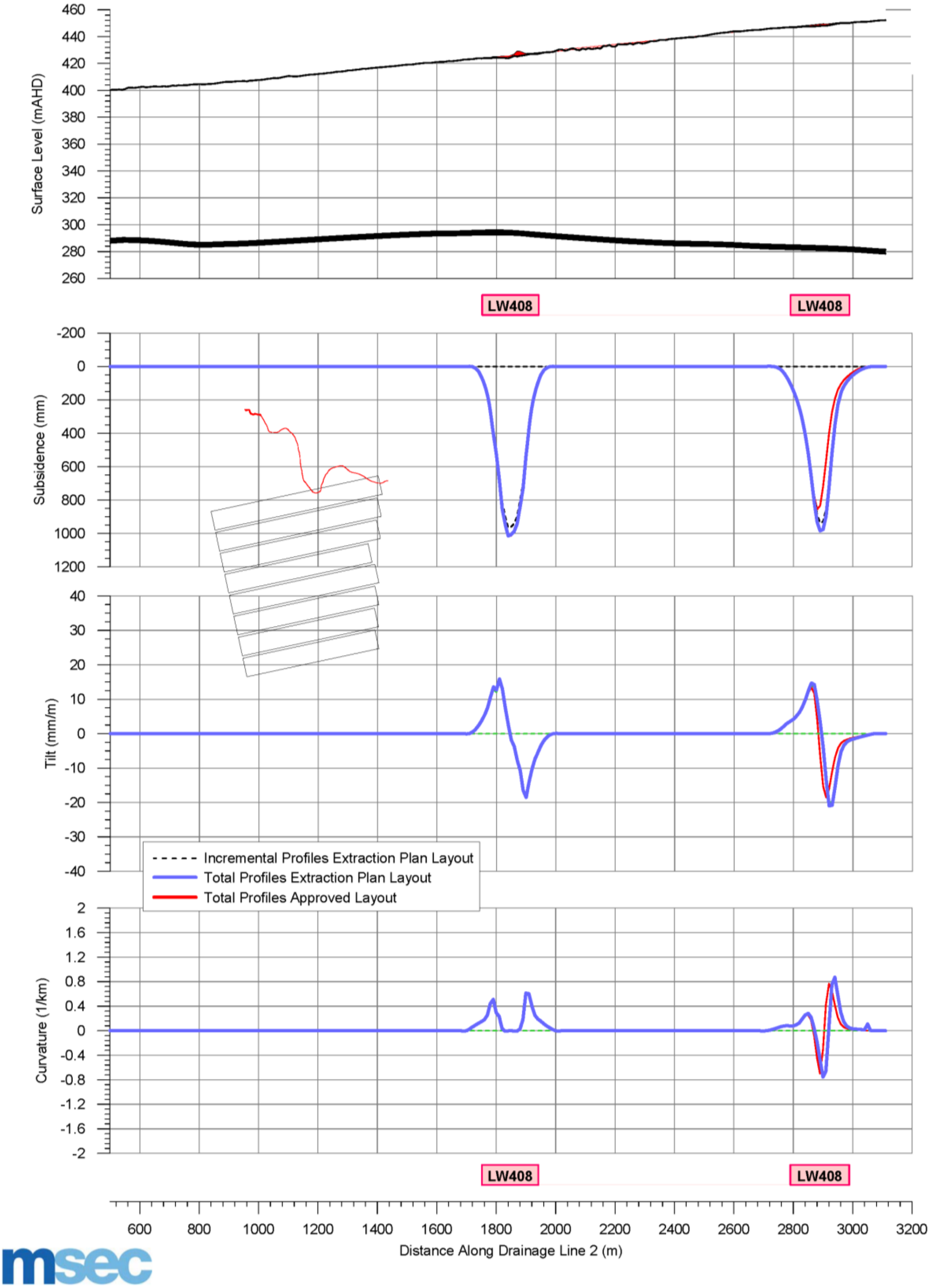

Figure 4.3 – Comparison of predicted profiles of subsidence, tilt and curvature along Drainage Line 2 due to LW401 to 408, between the Extraction Plan Layout and the Approved Layout (source: MSEC, 2021)

4.3 GOULBURN RIVER

The Goulburn River is located on the western side of LW401 to LW408 at distances of 425 m to 500 m from the longwall finishing ends. The location of the Goulburn River is shown in Figure 2.1. The river flows in a northerly direction and comprises a diverted section of the river around Ulan Coal Mine (UCM).

MSEC (2021) noted that the distances to the Goulburn River represent about 5 to 6 times the depth of cover from LW401 to LW408. At these distances conventional mine subsidence ground movements and valley related movements are expected to be less than limits of survey accuracy. However, the river may experience far-field horizontal movements. The predicted upper limit of observed horizontal movements at 5 times the depth of cover from the Extraction Plan Layout is 50 mm with the majority of the observed data less than typical limits of survey accuracy of 25 mm.

MSEC (2021) noted that the subsidence impacts to the Goulburn River based on the Approved Layout do not change based on the Extraction Plan Layout. It is unlikely that fracturing of the bed of the Goulburn River would occur due to the extraction of the Extraction Plan Layout. If fracturing does occur, it is likely that the fractures will be localised in nature and relatively minor in size, and they will only be visible in areas where the bedrock is exposed. It is expected that the majority of the bedrock in the bed of the river will be covered with alluvial deposits, which would cover any minor fractures that may develop in the bedrock. Minor fractures that potentially develop outside extracted longwalls are not generally associated with any increased rate of diversion of surface water into near-surface substrata.

4.4 WATER STORAGE DAMS

Figure 2.1 shows a total of eight dams identified within the LW401-408 footprint, including five farm dams (D6, D7, D11, D12 and D13) and three dams that are part of the Millers Dam Compound (D8, D9 and D10).

The SE (2006) assessment noted that the farm dams within the UG4 footprint are typically small earth embankment dams, with a storage capacity of about 0.1 - 0.2 ML (10 m to 20 m x 10 m x 1 m deep). All five farm dams are located on land owned by MCO. MSEC (2021) noted that these dams were understood to be previously used for livestock watering but are no longer in use.

Table 4.2 summarises the maximum predicted subsidence characteristics for the farm dams within the study area resulting from extraction of LW401-408 based on the Extraction Plan Layout (obtained from the MSEC [2021] report). Table 4.3 compares the maximum predicted subsidence characteristics for these farm dams between the Extraction Plan Layout and the Approved Layout.

Table 4.2 – Summary of maximum predicted subsidence parameters or the farm dams within the study area (MSEC, 2021)

Dam	Maximum predicted total conventional subsidence (mm)	Maximum predicted total conventional tilt (mm/m)	Maximum predicted total conventional hogging curvature (km^{-1})	Maximum predicted total conventional sagging curvature (km^{-1})
D6	290	35	> 3.0	0.02
D7	975	60	> 3.0	0.14
D11	400	14	1.0	< 0.01
D12	1,875	25	1.2	2
D13	1,875	14	1.2	2

Table 4.3 – Comparison of maximum predicted subsidence parameters or the farm dams within the study area, between the Approved layout and the Extraction Plan Layout (MSEC, 2021)

UG4 layout	Maximum predicted total conventional subsidence (mm)	Maximum predicted total conventional tilt (mm/m)	Maximum predicted total conventional hogging curvature (km^{-1})	Maximum predicted total conventional sagging curvature (km^{-1})
Approved Layout	1,900	60	> 3.0	> 3.0
Extraction Plan Layout	1,900	60	> 3.0	1.0

The maximum predicted total subsidence characteristics for the farm dams within the Study Area based on the Extraction Plan Layout are less than the parameters for the Approved Layout for Longwalls 401 to 408. The changes to the predicted subsidence parameters for the dams do not change the impact assessments for the dams.

MSEC (2021) noted the following potential impacts to the farm dams due to extraction of LW401 to LW408:

- Changes in freeboard of up to 200 mm are predicted for the farm dams located above the extracted longwalls.
- Farm dams are typically constructed of cohesive soils with reasonably high clay contents and are likely to be capable of withstanding tensile ground strains up to 3 mm/m without impact. The predicted strains based on the Extraction Plan Layout are greater than 3 mm/m.

The farm dams located above the extracted longwalls are expected to experience cracking and leakage of water. Any loss of water from the farm dams would flow into the drainage line in which the dam was formed. Impacts to the farm dams located outside the longwall footprints is considered unlikely to occur.

The MSEC (2021) Subsidence Impact Assessment recommends that farm dams, where not decommissioned, are visually monitored as the longwalls are extracted, such that any impacts can be identified and remediated accordingly. In this way the farm dam within the Study Area can be maintained in a safe condition throughout the mining period.

4.5 ENVIRONMENTAL RISK ASSESSMENT

A quantitative environmental risk assessment for LW401-408 is presented in the Subsidence Risk Assessment Report (RM, 2021). The following surface water issues are 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.

All other surface water risks are identified as Low risk.

5 Monitoring and management measures

5.1 SUBSIDENCE IMPACT PERFORMANCE MEASURES

Subsidence impacts and potential environmental consequences for surface drainage features are discussed in Section 4 of this report.

The Stage 1 approval conditions (05_0117) do not include any performance measures for specific drainage lines in the UG4 area. However Bora Creek, which is potentially subject to subsidence from LW401 and LW402, includes a stream health monitoring site and a licensed discharge point. For this reason, the following recommendations are provided for Bora Creek:

- Objectives and performance indicators for subsidence impacts;
- Proposed monitoring activities for surface water subsidence impacts;
- Proposed remedial measures and contingencies; and
- The triggers for proposed management actions.

5.2 OBJECTIVES AND PERFORMANCE INDICATORS

Table 5.1 shows the recommended objectives and performance indicators for the issues identified in Section 4, focusing on Bora Creek.

Table 5.1 – Recommended surface water subsidence management objectives and performance indicators

Risk issue	Subsidence Impact Performance Indicator	Proposed monitoring
Bora Creek	Change in visible bed or bank erosion Development of or change in headcut erosion along Bora Creek	Walkover visual inspection of Bora Creek Photographic record of high-risk reaches of Bora Creek
	Change in vegetation character such as vegetation loss through erosion or drowning by ponded water Extent and duration of water ponding	Walkover visual inspection of Bora Creek Photographic record of high-risk reaches of Bora Creek
	Receiving water quality	Continue current receiving water quality monitoring program
	Appearance of unsealed surface cracking across the bed of Bora Creek	Walkover visual inspection of Bora Creek Photographic record of high-risk reaches of Bora Creek

5.3 MONITORING OF IMPACTS

As described in Section 4, the surface water impacts of subsidence for LW401-408 are likely to be limited in spatial extent. In the absence of specific performance measures for drainage lines in the UG4 area in the Stage 1 approval conditions (05_0117), the monitoring of potential impacts will be limited to sections of Bora Creek above LW401 and LW402. Periodic visual inspection is also recommended for the reach of Goulburn River adjacent to UG4 LW401-408 (although subsidence is not predicted to impact Goulburn River).

Due to the small catchment areas of the affected drainage lines, 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;
- 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 Surface Water Management Plan (MCO, 2020). 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 a catchment larger than the subsidence area, making it impossible to isolate the water quality impacts of subsidence.

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, including collection of photographic records to confirm changes in erosion and vegetation over time along the upper reaches of Bora Creek.

Details of the proposed monitoring activities are given in Table 5.2.

5.4 TRIGGER ACTION RESPONSE

Table 5.3 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 5.2 - Proposed monitoring for surface water impacts

Monitoring task	Methodology	Timing
Water quality & stream health monitoring	As per Surface Water Management Plan	As per Surface Water Management Plan
Walkover visual inspection and photographic record of upper reaches of Bora Creek	Identify and mark the upstream and downstream limits of LW401 and LW402 along Bora Creek	Prior to undermining of Bora Creek
	Undertake a baseline inspection by walking along the upper reaches of Bora Creek over LW401 and LW402 and noting the condition of vegetation in the channel and any areas of active erosion, sediment deposition, water ponding or streambed cracking	Prior to undermining of Bora Creek
	Collect photographic record of channel condition along Bora Creek over LW401 and LW402	Prior to undermining of Bora Creek
	Undertake periodic walkover inspection and update photographic record	Within 3 months of undermining of Bora Creek Ongoing inspections every 6 months for one year after undermining
Visual inspection at access points along Goulburn River	Undertake a baseline inspection at access points along Goulburn River adjacent to UG4 LW401-408, noting the condition of vegetation in the channel and any areas of active erosion, sediment deposition, water ponding or streambed cracking. Collect photographic record of channel condition along Goulburn River.	Prior to completion of first UG4 longwall panel
	Undertake periodic walkover inspection and update photographic record	Ongoing inspections every 6 months until 1 year after completion of UG4 LW401-408 extraction

Table 5.3 - Surface water response actions - subsidence drainage impacts

Issue	Performance indicator	Trigger event	Action
Bora Creek	Change in visible bed or bank erosion	Noticeable new areas of erosion or expansion of existing erosion	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.
	Development of or change in headcut erosion along Bora Creek	Initiation of headcut or noticeable upstream advance of existing headcut	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.
	Extent and duration of water ponding	Development of new pools or drainage of existing pools	Obtain survey of ponded area to identify ponding depth and extent. Investigate potential drainage works to restore existing drainage characteristics.
Goulburn River	Unpredicted impacts on Goulburn River	Visible cracking of bed or banks, or notable change in erosion or existing pools identified during monitoring inspections	Engage suitably qualified subsidence expert to determine if impact is related to UG4 LW401-408 extraction. Engage suitably qualified hydrologist to determine any potential downstream impacts. Obtain specialist advice on appropriate remediation works. Notify DPIE that performance measure has been exceeded as soon as practicable and complete Preliminary investigation report and provide to DPIE within 7 days of identifying the performance measure exceedance.

6 References

MCO, 2020	*'Surface Water Management Plan'*, Version 5, October 2020.
MSEC, 2021	Mine Subsidence Engineering Consultants Pty Ltd, November 2021, *Moolarben Coal Complex: Moolarben Project Stage 1 – Longwalls 401 to 408, Subsidence Predictions and Impact Assessments for the Natural and Built Features in Support of the Extraction Plan*.
RM, 2021	Risk Mentor Pty Ltd, July 2021, *Moolarben Coal UG4 – Longwalls 401 to 408 Subsidence Risk Assessment Report*
SE, 2006	Strata Engineering Pty Ltd, December 2006, *Preferred Project Report for the Proposed Longwalls 1 to 14 in the No. 4 Underground Area, Moolarben (Stage 1)*.