

## **APPENDIX 2b**

### **Subsidence Assessment: Amended Ulan No.3 and Ulan West Mine Plans**



**R E P O R T T O :**

**ULAN COAL MINES LIMITED**

Assessment of Subsidence Impacts for Amended  
Ulan No 3 and Ulan West Mine Plans

**ULA3839**

**REPORT TO**

Jamie Lees  
Environment & Community  
Manager  
Ulan Coal Mines Limited -  
Complex  
PMB 3006  
4505 Ulan Road  
MUDGEES NSW 2850

**SUBJECT**

Assessment of Subsidence  
Impacts for Amended Ulan No 3  
and Ulan West Mine Plans

**REPORT NO**

ULA3839

**PREPARED BY**

Ken Mills

**DATE**

9 June 2011

Ken Mills  
Senior Geotechnical Engineer

## SUMMARY

Ulan Coal Mines Ltd (UCML) is seeking minor amendments to the existing Ulan No.3 and Ulan West mine plans as part of a Section 75W modification. The NSW Department of Planning and Infrastructure has requested confirmation that the predictions and associated impacts previously predicted for the mine area (in the Environmental Assessment - SCT Report ULA3730) are still relevant to the modified mine layout. UCML commissioned SCT Operations Pty Ltd to assess any changes in subsidence impacts that may result from the amended mine plan. This report presents an assessment of the revised layout as an addendum to SCT Report ULA3730 and should be read in conjunction with this earlier assessment.

Our assessment indicates that the minor amendments to the existing Ulan No.3 and Ulan West mine plan proposed by UCML as part of a Section 75W modification do not significantly change the subsidence impacts previously described in the Environmental Assessment (SCT Report ULA3367).

The results of recent subsidence monitoring conducted since the Environmental Assessment (Umwelt 2009) do not indicate any significant change in subsidence behaviour. The subsidence monitoring program has been extended and enhanced to quantify far field ground movements that extend beyond the area defined by half depth (26.5° angle of draw) from the goaf edge. These movements are, however, so small as to have no potential to cause perceptible impacts and the area defined by half depth is still considered appropriate to use as the basis to define the assessment area.

The amended mine plan has caused additional impacts on a 40m wide strip to the east of Longwall 1 at Ulan West and a slight change in the areas affected by subsidence where Ulan West longwalls have been shortened and Ulan No.3 longwalls have been extended.

Features identified as having potential to be affected by the amended mine plan and that are reassessed in this report include Ulan Creek, the European heritage site at Old Ulan Village, and fourteen Aboriginal heritage sites. The subsidence impact assessment for other sites remains as described in SCT Report ULA3367.

The western bank of Ulan Creek is located some 95m from the nearest goaf edge of Longwall 1. The protection barrier to the western bank is half depth plus 58m. No significant physical disturbance to the creek gradient, stability of creek banks, or creek alignment is expected as a result of the proposed mining.

The chimney at Old Ulan Village is protected by a distance of half depth plus 11m. The remnant chimney structure at Old Ulan Village is not expected to be impacted by mining.

A revision of the likely subsidence impacts on rock shelters and potential archaeological sites for the amended layout has indicated twelve sites where the probability of perceptible impacts has increased above 10% as a result

of the amendments. Two other sites previously assessed in SCT Report ULA3367, as having greater than 50% probability of being impacted will now have probability of being perceptibly impacted of less than 5%. South East Archaeology (2011) has advised that the significance of the sites potentially impacted is generally low and the net change to management strategies as a result of the amended plans is negligible.

## TABLE OF CONTENTS

	<b>PAGE No</b>
SUMMARY .....	I
TABLE OF CONTENTS .....	III
1. INTRODUCTION .....	1
2. AMENDED MINING GEOMETRY .....	1
3. PREDICTED SUBSIDENCE BEHAVIOUR .....	1
3.1 Updated Subsidence Monitoring Experience.....	3
3.2 Subsidence Predictions .....	5
3.3 Reliability and Accuracy of Subsidence Predictions.....	6
4. IMPACT ASSESSMENT FOR AREAS NOT COVERED IN ENVIRONMENTAL ASSESSMENT .....	7
4.1 Ulan Creek and Old Ulan Village.....	7
4.2 Aboriginal Heritage Sites.....	9
5. CONCLUSIONS .....	10
6. REFERENCES .....	12

## **1. INTRODUCTION**

Ulan Coal Mine Ltd (UCML) is seeking minor amendments to the existing Ulan No.3 and Ulan West mine plans as part of a Section 75W modification. The NSW Department of Planning and Infrastructure has requested confirmation that the predictions and associated impacts previously predicted for the mine area (in the Environmental Assessment - SCT Report ULA3730) are still relevant to the modified mine layout. UCML commissioned SCT Operations Pty Ltd to assess any changes in subsidence impacts that may result from the amended mine plan. This report presents an assessment of the revised layout as an addendum to SCT Report ULA3730 and should be read in conjunction with this earlier assessment.

The report is structured to provide a description of the minor amendments in Section 2. Section 3 presents a summary of the subsidence behaviour that is expected for the revised layout. Section 4 assesses the changes to surface impacts that are expected in the vicinity of the areas where the mine plan has changed.

## **2. AMENDED MINING GEOMETRY**

Figure 1, reproduced from Umwelt (2011) Figure 3.3, shows a plan of the revised mining layout and illustrates the differences between the amended plan and the plan approved under Project Approval O8\_0184. The differences include:

- Re-alignment of the approved Ulan West Mining area 40m to the east.
- Reduction of Ulan West Longwall panels West 5 (by approximately 1675m) to enable this area to be mined by extending adjacent Ulan No.3 to the west.
- Extension of Ulan No.3 Longwall West panels 4-6 by approximately 490m to the west to mine areas to be previously mined by Ulan West 5.

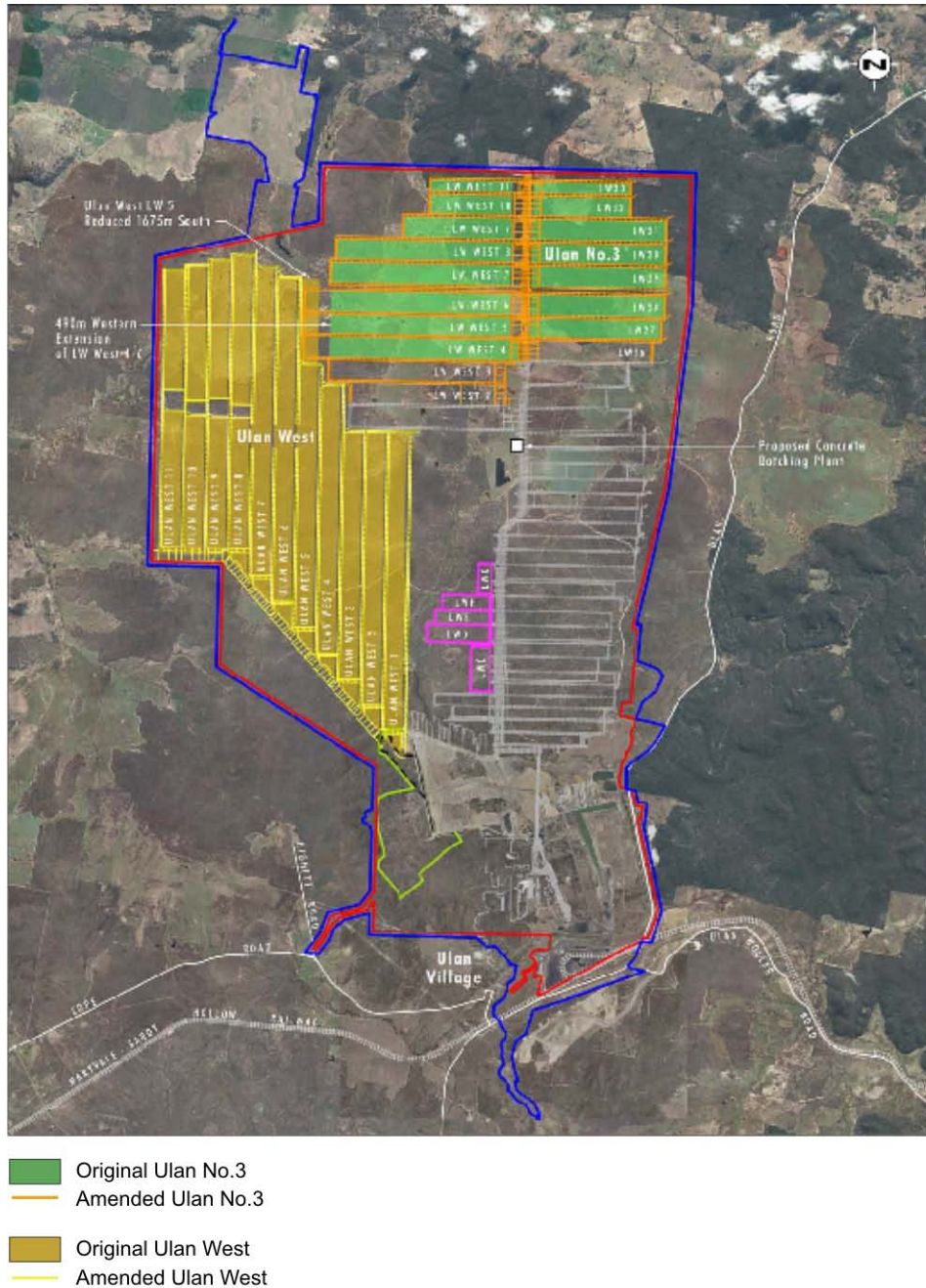
There are no changes in proposed longwall widths or chain pillar geometries.

## **3. PREDICTED SUBSIDENCE BEHAVIOUR**

Subsidence behaviour above the proposed longwall panels is expected to be similar to subsidence behaviour measured over the previous longwall panels at Ulan and similar to the subsidence behaviour predicted in SCT Report ULA3367 "Part 3A Subsidence Assessment – Ulan Coal Continued Operations".

Two further longwall panels have been mined since the Part 3A Assessment was conducted and the results from these panels are presented in Table 1. The subsidence predictions presented in ULA3367 are not changed as a result of these recent measurements and the areas affected by the

proposed amendments to the mine plan are expected to experience subsidence behaviour similar to that which has previously been observed.



**Figure 1: Proposed modifications to Ulan West and Ulan No.3 mine plans**  
*(refer Figure 3.3, Umwelt Report).*

### **3.1 Updated Subsidence Monitoring Experience**

Table 1 presents a summary of the subsidence monitoring results measured over previous longwall panels at Ulan Coal Mine, including those from the two most recent longwall panels, Longwall 25 and Longwall W2. The most recent subsidence monitoring results have not indicated any change in subsidence behaviour compared to that discussed previously in SCT Report ULA3367.

The improvements in survey technique associated with the far field survey control network have meant that it is now possible to provide reliable survey control from much further outside the immediate area of mining. A consequence of this improvement has been that small movements outside the mining area can now be detected more reliably and with greater accuracy.

The nominal angle of draw to 20mm of vertical subsidence has increased as a result of these improvements in survey technique and low level horizontal movements associated with stress relief have been observed to extend outside the nominal angle of draw.

Notwithstanding the recent detection of low level movements beyond the nominal angle of draw, the assessment area defined by a distance equal to half depth (equivalent to an angle of draw of 26.5°) from the goaf edge is still regarded as entirely appropriate for defining the area of potential subsidence impact. The ground movements outside of this area are so small as to be imperceptible for all practical purposes.

There has been no change in ground behaviour, but the greater survey accuracy now means that the angle of draw to 20mm which was previously in the range 15-40° has increased, typically to about 40-55°, but up to 72° on one subsidence line over the northern edge of Longwall W2. Small horizontal movements have also been able to be detected to distances of approximately 1.6km from the goaf edge. These far field movements are associated with stress relief within the overburden strata. They are of low magnitude (approximately 200mm at the goaf edge tapering linearly to 20mm at 1.6km). Strains and tilts are less than 0.1mm/m and all movements are of a general body nature associated with elastic relief of horizontal stresses within the overburden strata. These small movements are of no consequence for surface features as evidenced by experience over previous longwall panels when it was not possible to measure them.

**Table 1: Summary of Previous Subsidence Monitoring at Ulan Coal Mines**

LW	DEPTH (m)	MAX SUBS (m)	GOAF EDGE SUBS (mm)	ANGLE OF DRAW (°)	MAX TILT (mm/m)	MAX STRAIN (mm/m)	HORZ DISP (mm)
1	67-110	1.5-1.6	70	15	>50	N/A	N/A
5	130-190	1.0	51	10	20	10	400
A	130-150	1.2	85	13	35	20	500
B	150-170	0.93	107	14	25	10	300
6	180	0.13	54	15	5	3	100
7	170	1.0	63	26	30	7	200
8	160	1.0	87	29	15	9	300
9	150	1.2	45	19	20	9	350
10	140	1.3	99	20	20	8	200
11	150-160	1.4	85	17	40	20	350
11X	150	1.4*	-	-	32	6	200
11C	140-155	1.4*	-	-	30*	4	200*
12D	155-165	1.3	75	8	20	14	200
13D	170	1.3	-	-	20	14	250
14D	170	1.1	70	13	20	(25)	50
15D	170-180	0.96	102	39	17	7	150
16D	185-200	1.1	98	30	20	9	200
17D	200-215	1.2	64	17	14	7	200
18E	250-260	1.1	86	24	11	6	200
19E	230-240	1.2	102	27	13	3	300
22	220-285	0.8*	-	-	10*	3*	100*
23	250-280	1.4	121-206	16-41	12	6	270
24	240-280	1.4	137-154	30	15	5	220
W1	195-240	0.9-1.4	71	(17)	14	5	350
25	230-265	1.3	110	43	17	4-5 (8)	300
W2	200-240	1.4	140	72	15 (27)	7 (10)	400

\* Based on estimate from incomplete subsidence records.

### **3.2 Subsidence Predictions**

Subsidence predictions for the amended mine layout are the same as those reported in SCT Report ULA3367 with appropriate modifications for the revised layout.

For a mining section of 2.9m, the maximum vertical subsidence is expected to be in the range 0.9-1.5m (1.4m typical in Ulan No 3 mining area and 1.2 typical in Ulan West mining area) with the possibility of increasing up to 1.6m at the southern end of the first three Ulan West longwall panels in areas where there is no Triassic Sandstone. Subsidence over the chain pillars is expected to increase with overburden depth ranging from 0.2m in shallow areas of Ulan West and over the isolation barrier pillar in Ulan No 3 Mine up to approximately 0.8m in the deeper areas of Ulan No 3 Mine over the normal chain pillars.

In shallow areas, maximum subsidence of 200mm is expected over the chain pillars with the higher values up to 800mm expected in areas where the overburden depth is greater than 300m.

As discussed in the previous section, angles of draw have appeared to increase as a result of improved survey technique, but an angle of draw of 26.5° (half depth) is considered to give a reasonable approximation of the extent of subsidence impacts for practical assessment purposes. Subsidence impacts outside of the mining area, and particularly those outside the 26.5° angle of draw, are effectively imperceptible.

Subsidence over each panel is likely to be substantially complete once the panel has been mined, but additional subsidence is likely when the next longwall panel is mined, mainly within 100-150m of the intermediate chain pillar.

Figure 2 shows contours of subsidence that are expected at the completion of the modified plan. These subsidence contours are based on goaf edge subsidence profiles measured previously at Ulan Coal Mine with an upper limit of maximum subsidence of 1.6m over most of the area. The actual maximum subsidence is expected to range between 0.9m and 1.5m over most of the area, so the contours shown can be regarded as an upper limit.

Maximum tilts of 10-20mm/m are expected over most of the mining area (overburden depth greater than 150m) increasing to 20-40mm/m in areas where the overburden is less than 150m but greater than 120m, and to 40-120mm/m where the overburden depth is less than 120m at the southern end of the first Ulan West longwall panels. These estimates are consistent with experience elsewhere in the Western Coalfield reported by Holla (1991) which indicate tilts of up to 100mm/m in the shallower areas in the south, with maximum tilts over most of the mining area in the range 15-40mm/m.

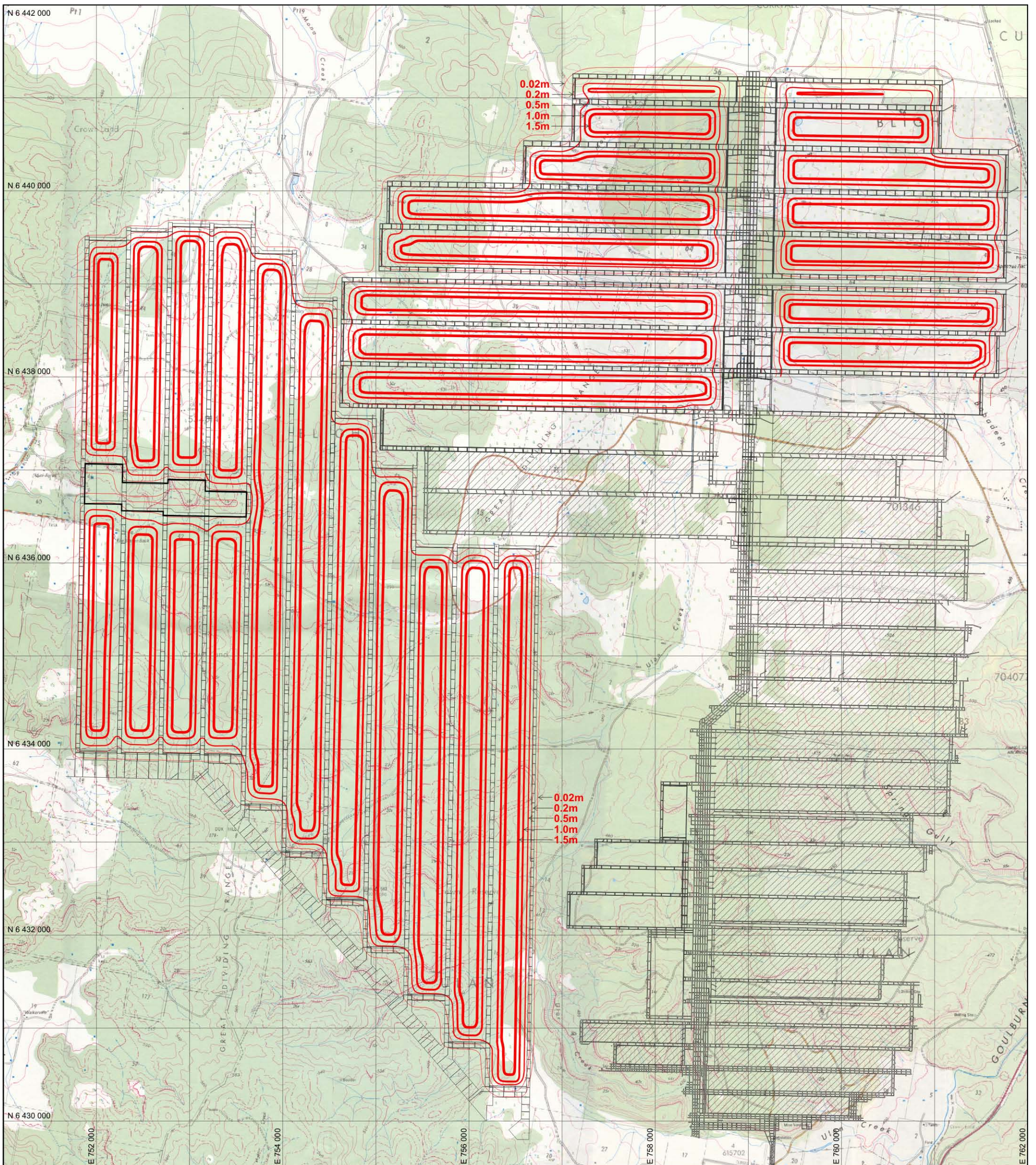


Figure 2: Contours of subsidence expected for modified mine plan.

Horizontal ground movements occur at the surface in response to vertical subsidence movements within the overburden strata. There are three main components of horizontal movement apparent at Ulan, a systematic component that occurs in close proximity to the longwall panel, a topographic component that occurs as a result of sloping terrain, and a far field component that occurs as a result of stress relief toward the goaf.

Systematic horizontal ground movements are expected to occur in a direction toward the goaf and then in the direction of mining once the longwall face has passed. The magnitude of systematic horizontal movements is typically less than 150mm in total.

Horizontal movements associated with topography occur in a downslope direction with larger horizontal movements expected in areas where mining is in the same direction as the slope. The magnitude and direction of the topographic component is strongly dependent on surface topography, but is generally less than 500mm.

Far field stress relief movements are generally less than 200mm in magnitude but taper gradually away from the goaf to 20mm at 1.6km from the goaf edge.

Horizontal strains are a measure of the rate of change of horizontal ground movements. Maximum horizontal strains of 5-15mm/m are expected over most of the project mining area. Strains up to 50mm/m may occur in areas of less than 120m overburden depth at the southern end of the first few Ulan West longwall panels.

Permanent tension cracks are expected in the vicinity of panel edges and along the tops of topographic highs. Tension cracks are expected to be greatest at the start of each panel and most apparent on hard surfaces. They may also occur at regular intervals along the centre of the panel interspersed with compression humps. Previous experience indicates that cracks are generally less than 150mm wide at overburden depths of 150m and less than 40mm at overburden depths of 250m. Cracks are likely to be generally more perceptible in areas of low overburden depth, especially near the southern end of the first few longwall panels in the Ulan West mining area where they may reach 250mm wide parallel to the panel edges.

Permanent compression humps are expected at topographic lows such as drainage channels and at regular intervals along the panel.

### **3.3 Reliability and Accuracy of Subsidence Predictions**

The approach to estimating subsidence used in this assessment is based on previous monitoring and the concept of estimating the maximum likely subsidence based on this data. This approach is expected to provide conservative estimates of subsidence, recognising that in the particular circumstances at Ulan, none of the impacts are likely to be particularly sensitive to the specific magnitude of subsidence, but rather to the general nature of the ground movements expected.

#### **4. IMPACT ASSESSMENT FOR AREAS NOT COVERED IN ENVIRONMENTAL ASSESSMENT**

The amended mine plan has caused additional impacts on a 40m wide strip to the east of Longwall 1 at Ulan West and a slight change in the areas affected by subsidence where Ulan West longwalls have been shortened and Ulan No.3 longwalls have been extended.

Features that are reassessed in this section include Ulan Creek, the European heritage site at Old Ulan Village, and fourteen Aboriginal heritage sites.

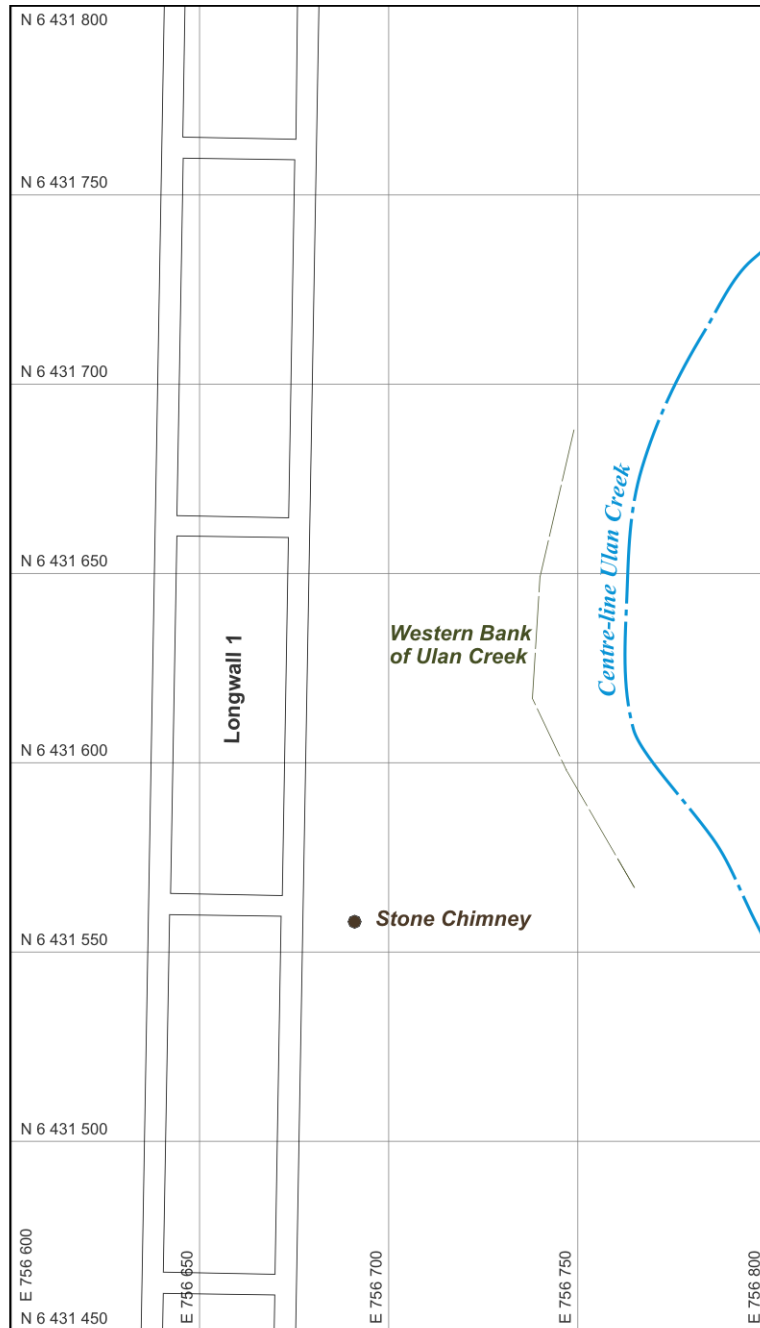
##### **4.1 Ulan Creek and Old Ulan Village**

Figure 3 shows the location of the western bank of Ulan Creek and the remnant chimney at Old Ulan Village relative to the nearest goaf edge of Longwall 1 at Ulan West. The overburden depth to the Ulan Seam at this site is approximately 75m. The chimney and the closest point of the western bank of Ulan Creek are located approximately 49m and 95m respectively from the eastern goaf edge of Longwall 1 at Ulan West.

The chimney at Old Ulan Village is protected by a distance of half depth (26.5° angle of draw) plus 11m. Any ground movements at the location of the chimney are expected to be of low magnitude and of a general body nature where the whole ground moves together without significant differential movement. If there are significant stress relief movements, which is considered unlikely at shallow depth, vertical subsidence at the chimney is expected to be less than about 20mm and horizontal movement toward the west less than about 100mm. Horizontal strains are expected to be less than 0.1mm/m. Tilts are expected to also be less than 0.1mm/m. If there are no stress relief movements, ground movements are expected to be less than 10-20mm in any direction and still of a general body nature.

At these levels of ground movement, no significant impacts on the remnant chimney structure are expected as a result of mining subsidence. Barnson (2009) undertook a structural assessment of the chimney and concluded that it would be capable of sustaining differential subsidence of 20mm across the base of the chimney. There is considered to be no potential for this level of differential subsidence to occur as a result of adjacent longwall mining, so no subsidence impacts on the chimney structure are expected.

The western bank of Ulan Creek is located some 95m from the nearest goaf edge of Longwall 1. The protection barrier to the western bank is therefore half depth plus 58m. No significant physical disturbance to the creek gradient, stability of creek banks, or creek alignment is expected as a result of the proposed mining.



**Figure 3: Location of Ulan Creek and stone chimney at old Ulan village relative to amended location of Longwall 1 Ulan West.**

## 4.2 Aboriginal Heritage Sites

A revision of the likely subsidence impacts on rock shelters and potential archaeological sites for the amended layout has indicated twelve sites where the probability of perceptible impacts has increased above 10%, the threshold considered to represent a significant impact, as a result of the amendments. Two other sites previously assessed in the Environmental Assessment, SCT Report ULA3367, as having greater than 50% probability of being impacted will now have a much lower probability of being impacted.

These sites are summarised in Table 2 and their location is shown in Figure 4. The assessments of probabilities of impacts are based on previous observation of mining below similar features at Ulan.

South East Archaeology (2011) has advised that the significance of the sites potentially impacted is generally low and the net change to management strategies as a result of the amended plans is negligible.

**Table 2: Aboriginal Heritage Sites Affected by Amended Mine Layout**

Ulan ID	Site Name	Site Type	Probability of Perceptible Impact	General Location	Change
Sites with Increased Potential for Impact					
484	MC46/B	Rockshelter with Artefacts	30%	#3 LWW4	increase from 5%
485	MC46/C	Rockshelter with Artefacts	30%	#3 LWW4	increase from 5%
486	MC46/D	Rockshelter with Artefacts	30%	#3 LWW4	increase from 5%
668	MC180	Rockshelter with PAD	50%	#3 LWW4	increase from 5%
669	MC181	Rockshelter with Artefacts	50%	#3 LWW4	increase from 5%
670	MC182	Rockshelter with PAD	50%	#3 LWW4	increase from 5%
671	MC183	Rockshelter with PAD	50%	#3 LWW4	increase from 5%
809	MC320	Rockshelter with PAD	50%	#3 LWW4	increase from 5%
1013	UC35	Rockshelter with Artefacts	20%	UW LW1	increase from 10%
1014	UC36	Rockshelter with Artefacts	20%	UW LW1	increase from 10%
1018	UC40	Rockshelter with Artefacts	20%	UW LW1	increase from 10%
1020	UC42	Rockshelter with PAD	50%	UW LW1	Increase from 5%
Sites with Reduced Potential for Impact					
822	MC333	Rockshelter with PAD	5%	Boundary	reduced from 50%
827	MC338	Rockshelter with PAD	5%	Boundary	reduced from 50%

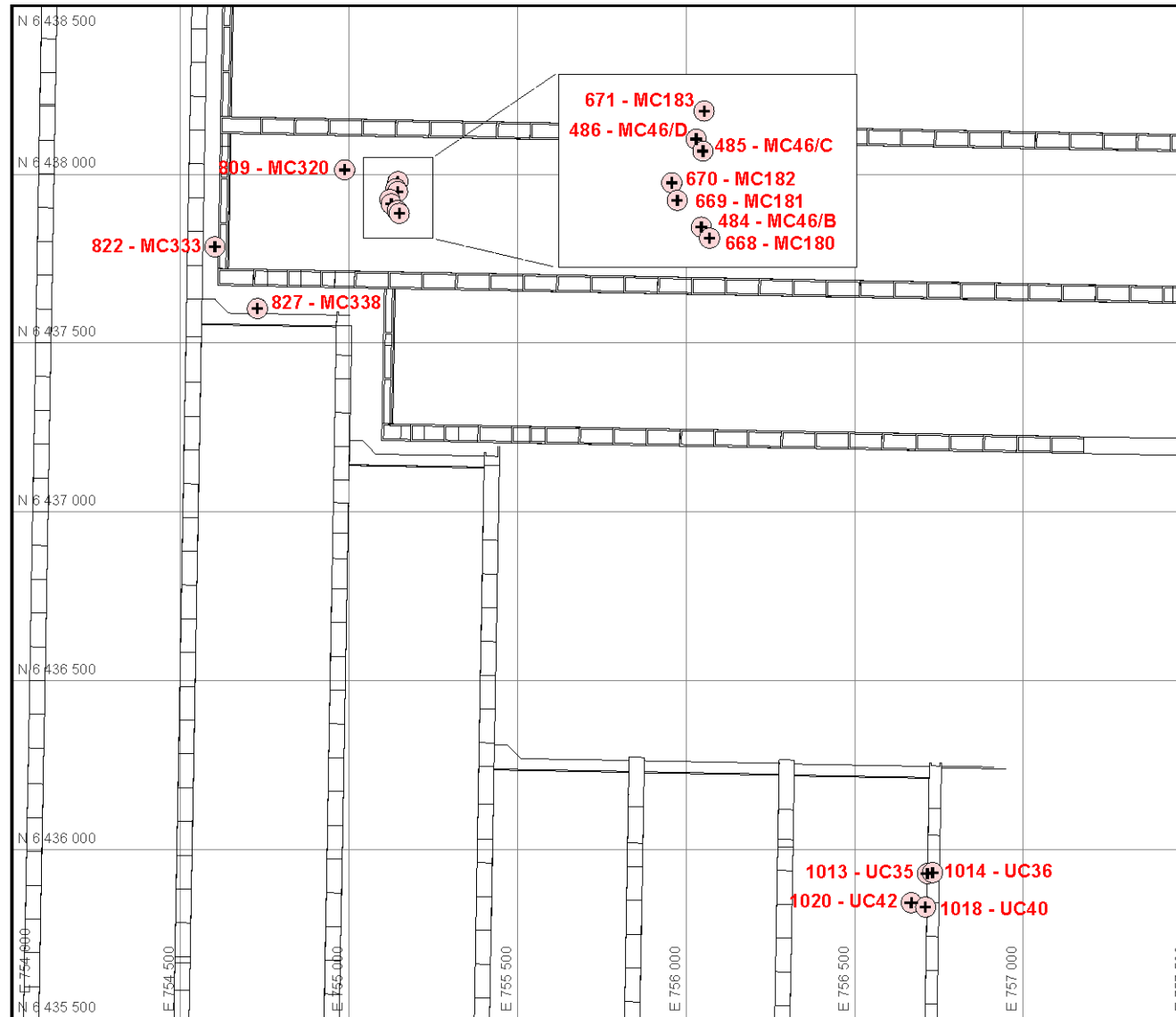


Figure 4: Location of Aboriginal heritage sites identified as being significantly affected by proposed modifications.

## **5. CONCLUSIONS**

Our assessment indicates that the minor amendments to the existing Ulan No.3 and Ulan West mine plan proposed by UCML as part of a Section 75W modification do not significantly change the subsidence impacts previously described in the Environmental Assessment (SCT Report ULA3367).

The results of recent subsidence monitoring conducted since the Ulan Coal Continued Operations Environmental Assessment (Umwelt 2009) do not indicate any significant change in subsidence behaviour. The subsidence monitoring program has been extended and enhanced to quantify far field ground movements. This monitoring has identified low level horizontal and vertical movements that extend beyond area defined by the half depth (26.5° angle of draw) from the goaf edge. These movements are, however, so small as to have no potential to cause perceptible impacts and the area defined by half depth is still considered appropriate to use as the basis to define the Environmental Assessment area.

The amended mine plan has caused additional impacts on a 40m wide strip to the east of Longwall 1 at Ulan West and a slight change in the areas affected by subsidence where Ulan West longwalls have been shortened and Ulan No.3 longwalls have been extended.

Features identified as having potential to be affected by the amended mine plan and that are reassessed in this report include Ulan Creek, the European heritage site at Old Ulan Village, and twelve Aboriginal heritage sites. The subsidence impact assessment for other sites remains as described in SCT Report ULA3367.

The western bank of Ulan Creek is located some 95m from the nearest goaf edge of Longwall 1. The protection barrier to the western bank is half depth plus 58m. No significant physical disturbance to the creek gradient, stability of creek banks, or creek alignment is expected as a result of the proposed mining.

The chimney at Old Ulan Village is protected by a distance of half depth (26.5° angle of draw) plus 11m. The remnant chimney structure at Old Ulan Village is not expected to be impacted by mining.

A revision of the likely subsidence impacts on rock shelters and potential archaeological sites for the amended layout has indicated twelve sites where the probability of perceptible impacts has increased above 10% as a result of the amendments. Two other sites previously assessed in SCT Report ULA3367, as having greater than 50% probability of being impacted will now have probability of being perceptibly impacted of less than 5%. South East Archaeology (2011) has advised that the significance of the sites potentially impacted is generally low and the net change to management strategies as a result of the amended plans is negligible.

## **6. REFERENCES**

Barnson Letter Report, 2009, 'Stone Chimney – Old Ulan Village, Ulan, NSW', Letter Report to UCML dated Monday 23 March 2009.

Holla, L. 1991, 'Evaluation of Surface Subsidence Characteristics in the Western Coalfield of NSW', The Australian Coal Journal, No. 31, 1991, pp19-30.

SCT Report ULA3367, 2009, 'Part 3A Subsidence Assessment Ulan Coal – Continued Operations'.

South East Archaeology 2011 Personal Communication

Umwelt (Australia) Pty Limited, 2009 "Ulan Coal – Continued Operations Environmental Assessment"  
<http://www.ulancoal.com.au/EN/OperatingApprovals/Pages/EnvironmentAssessment.aspx>