



# Wilpinjong & Cumbo Creek Stability Assessment, 2014

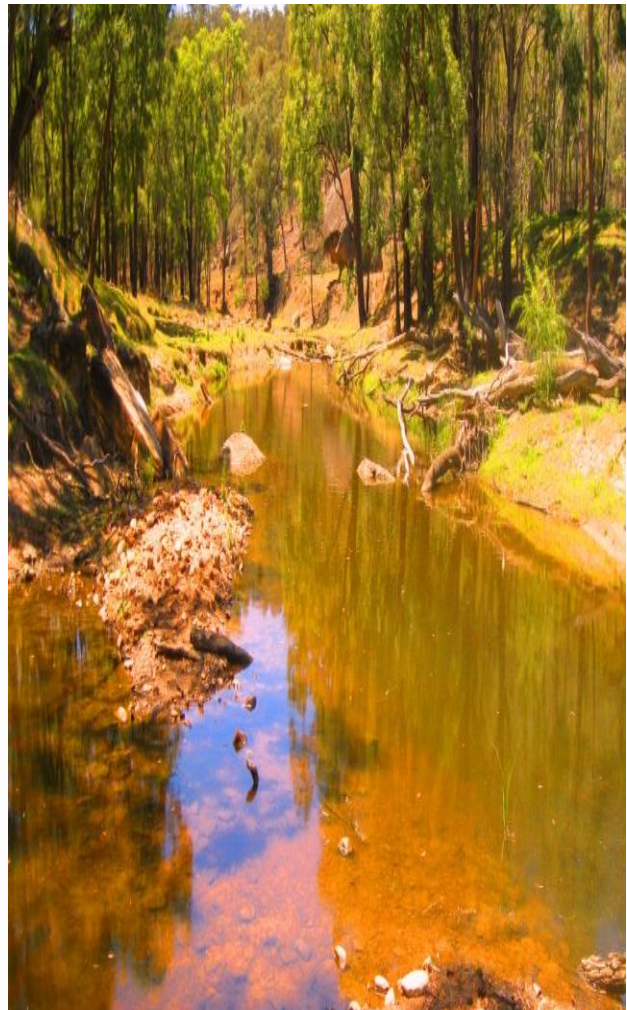
Wilpinjong Coal Mine

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t 1300138 657  
e [generalenquiry@barnson.com.au](mailto:generalenquiry@barnson.com.au)  
w [www.barnson.com.au](http://www.barnson.com.au)

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## DOCUMENT TRACKING

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ITEM	DETAILS
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Project Manager	Kristy Bennetts Environmental Scientist
Report Preparation	Kristy Bennetts
Peer Reviewed	Natalie Richards
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By

Barnson Pty Limited  
Unit 2,  
108-110 Market Street,  
Mudgee NSW 2850

Complied by:



Kristy Bennetts

**Environmental Scientist**

Peer Reviewed:



Natalie Richards

**Environmental Scientist**

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## 1.0 INTRODUCTION

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Wilpinjong Coal Proprietary Limited (WCPL) commissioned Barnson Pty Ltd (Barnson) in September 2014 to undertake a stability assessment of Wilpinjong and Cumbo Creeks. The 2014 assessment was undertaken to assess any improvement in creek stability, erosion and riparian areas within the Wilpinjong Creek catchment.

This report provides details on the fieldwork undertaken in 2014, and compares Wilpinjong and Cumbo Creeks with the previous assessment in 2013.

### 1.1 Project Overview

Wilpinjong Coal Mine is situated in the Central Tablelands of NSW. It is located in the Mid-Western Regional Council Local Government Area, approximately 40 km north-east of Mudgee, near the Village of Wollar. The mine is located at the headwaters of the Goulburn River catchment, which is a major tributary of the Hunter River. The mine is wholly owned and operated by Peabody Energy Ltd.

The basis of this report is to satisfy Schedule 3, Condition 32 (e) of Project Approval (05-0021), together with the Channel Stability Monitoring Programme as outlined in Section 7 of the site Surface Water Management and Monitoring Plan. The plan states that *'the channel stability monitoring programme aims to provide qualitative measures of stream bed and bank erosion and channel instability along Wilpinjong and Cumbo Creeks.'* Monitoring details are provided in the plan and are largely based on obtaining cross sectional and longitudinal survey data and making comparisons in relation to change over time. This is with the exception of point four which states *'Photographs and written descriptions "of each site will be also undertaken, focusing on evidence of erosion and exposed soils'.*

This Environmental Stability Assessment builds on previous surveys undertaken by Barnson, for comparative purposes.

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## 1.2 Project Objectives

There are two main objective of this assessment. They are:

- Assess the stability of Wilpinjong and Cumbo Creeks using a rapid assessment methodology, which was refined in 2013.
- Compare visual channel stability at each of the pre-selected sites against a previous survey undertaken in 2013.

The visual assessment relies upon the established GPS photographic points previously determined.

## 1.3 Project Background

During 2007 permanent survey locations were selected by Peabody Energy. These survey locations are generally in use today. Updated site localities are identified in **Figure 1**. These points are along 13km of Wilpinjong Creek and 3km of Cumbo Creek. Barnson has undertaken monitoring of this creek on several occasions, including 2010, 2011, 2012 and 2013.

Wilpinjong Creek is located within the Greater Wollar catchment area. The dominant non-mining land use within and around the project area is cattle and sheep grazing with some intermittent cropping (fodder crops). Cumbo Creek drains into Wilpinjong Creek approximately 4km upstream of the confluence of Wilpinjong Creek and Wollar Creek. Both creeks suffer moderate to severe erosion and poor riparian health as a result of past practises. The Environmental Impact Statement (EIS) undertaken for the Wilpinjong Coal project described Wilpinjong Creek in Table 3.4 of Section 3.2.2 of the EIS as being *a- well incised channel (3-4m deep). Varies significantly including dry areas, semi-permanent soaks, pools and riffle sequences and swampy areas with extensive areas of reed growth along the creek bed. Severely impacted by grazing of livestock and kangaroos. Vegetation on the banks and overbank areas is predominantly grass with occasional trees and little riparian vegetation.* Cumbo Creek was described as - *Upper parts of the creek drain through low-lying marshes with stream bank and stream bed erosion. Heavily modified by land clearing and grazing. Little riparian vegetation.*

The Aquatic Ecosystem Assessment undertaken by Bio-Analysis for the EIS (Appendix AH) states in HD7 that *in general, the aquatic habitats were found to be in very poor condition and generally reflected the degraded nature of the immediate catchments.* This report indicates that *stock exclusion, weed control and establishment of vegetation in the riparian areas would lead to improved habitats for aquatic biota.*

A comprehensive surface water assessment was also undertaken by Resource Strategies in 2005 as part of the EIS. The assessment found that runoff (total catchment yield) is a small percentage of rainfall, and that baseflow (comprising both deeper groundwater and interflow/underflow) is estimated to account for some 40% of total flow. It was predicted that the Project has the potential to reduce flows in Wilpinjong Creek by up to 11%, as a result of a reduction in overland flow from the Project catchment and indirectly through reductions in the rate of groundwater discharge to the creek. This should, in general terms, reduce baseflow induced erosion, such as sheeting.

Mitigation measures suggested in the EIS include the enhancement of riparian vegetation in sections of Wilpinjong and Cumbo Creeks. These enhancement works are expected to have a positive impact on the in-stream ecology of Wilpinjong and Cumbo Creeks. In terms of channel stability, enhancement works would also allow for improved creek stability and reduced erosion of the creek beds and banks.

Surface waters within the project area were re-assessed by Gilbert and Associates Pty Ltd in 2013 as part of the s75W modification to the current conditions of consent. No creek stability issues or recommendations were raised in this assessment.

Over the past several years the creek has been subject to drought and flooding. To date, no control sites along any other local creeks have been established or utilised for comparative purposes, nor has an historical assessment based on old aerial photographs been undertaken.

## **1.4** Report Limitations

It is not within the scope of this stability monitoring project to undertake extensive creek analysis in terms of the following forms of assessment. WCPL may consider undertaking some or all of these assessments in the future. Assessments not included in this project including, but not limited to:

- Geophysical Survey, including assessment of subsurface conditions
- Cross Sectional Analysis utilising accurate survey instrumentation and
- LiDAR (Light Detection and Ranging) Analysis.

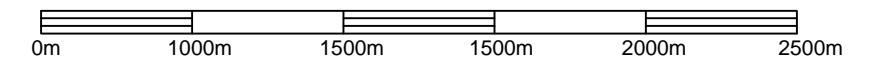
No permanent marker/survey pegs have been installed along either of the creeks for ongoing monitoring purposes.



FIGURE 1 - WILPINJONG CREEK & CUMBO CREEK SURVEY POINTS

SCALE: 1:25,000

Coordinate System: GDA94 MGA Zone 55





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## 2.0 METHODOLOGY

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### 2.1 Rainfall and Flood Analysis

The intensity and amount of rainfall can result in flooding and thus influence erosion by way of scouring, slumping and surface destabilisation within rural creeks. The amount of erosion is influenced by vegetation cover, topography, climatic factors and soil characteristics. The rate of soil erosion is influenced by the erosivity - the amount of rainfall and precipitation intensity.

IFD stands for Intensity-Frequency-Duration, of rainfall. The processes of determining IFD is known as frequency analysis, is an important part of hydrological design procedures. An IFD table for the Wilpinjong catchment was generated using the Bureau of Meteorology's (BoM) 'Rainfall IFD Data System', available at:

<http://www.bom.gov.au/hydro/has/cdirswebx/cdirswebx.shtml>.

Rainfall data for 2014 only by WCPL. Rainfall data was collected from the WCPL Meteorology Station and provided to Barnson in 5 minute and hourly increments. This data was examined in consultation with the IFD table to determine the ARI (average recurrence interval) or rarity of rainfall events over the 12 month period to determine if any rainfall events would impact creek stability or erosion.

### 2.2 Field Survey - Stability & Comparative Assessment

To satisfy the project objectives, a field survey was undertaken by Kristy Bennetts (Environmental Scientist) and Trevor Hoar (Survey Assistant) in September 2014. This involved walking each creek from the creek headwater to its confluence. Photographs of each site (upstream, downstream and across) were taken for comparative purposes, a field proforma was completed and any signs of bed lowering or erosion were identified and recorded. The pre-selected monitoring points are illustrated in **Figure 1**, and were found using survey GPS instrumentation. For the 2014 survey, the same proforma updated in 2013 was utilised. This updated proforma was refined using a number of sources, including:

- CSIRO Ephemeral Assessment Methodology;
- Australian Soil and Land Survey Field Handbook (2009);
- Heeren, D.M et al (2012) *Using Rapid Geomorphic Assessments to Assess Streambank Stability in Oklahoma Ozark Streams*, American Society of Agriculture and Biological Engineers.

The field proforma is contained at **Appendix A**, with a summary of results located in Section 3. A Bank Erosion Hazard Index (BEHI), as proposed by Heeren et al, was also completed for each site.

### 3.0 RESULTS

#### 3.1 Rainfall and Flood Analysis

The current (2012) total catchment area of Wilpinjong creek upstream of the Project Area (from the upstream gauging station) was calculated to be 81km<sup>2</sup>, with the downstream catchment calculated to be 175km<sup>2</sup> (Gilberts & Associates, 2013). The Cumbo Creek catchment area (upstream of the confluence with Wilpinjong Creek) was reported to be 70km<sup>2</sup>. Both Creeks are ephemeral in nature, meaning flow is limited to after prolonged rainfall or heavy storm events. Unfortunately, information relating to velocities of flow versus scouring potential of soils within each of these creeks has not been calculated. In general, a well vegetated creek bank and bed will not scour during a minor storm event (ie a 1 in 5 year ARI storm event).

An IFD table was generated using the BoM website and is provided at Table 1, together with the corresponding ARI's for the area.

**Table 1 : Rainfall intensity in mm/h for varies durations and average reoccurrence intervals - WCPL**

DURATION	1 Year		2 Years		5 Years		10 Years		20 Years		50 Years		100 Years	
	mm/hr	mm	mm/hr	mm	mm/hr	mm	mm/hr	mm	mm/hr	mm	mm/hr	mm	mm/hr	mm
5 Mins	64.1	5.34	83.7	6.98	110	9.17	127	10.58	149	12.42	181	15.08	206	17.17
6 Mins	59.7	5.97	78	7.8	102	10.2	118	11.8	139	13.9	168	16.8	192	19.2
10 Mins	48.7	8.12	63.5	10.58	82.6	13.77	94.9	15.82	111	18.5	135	22.5	153	25.5
20 Mins	35.6	11.87	46.2	15.4	59.4	19.8	67.8	22.6	79.3	26.43	95.1	31.7	108	36
30 Mins	28.9	14.45	37.3	18.65	47.7	23.85	54.3	27.15	63.2	31.5	75.6	37.8	85.4	42.7
1 Hr	19.3	19.3	24.9	24.9	31.5	31.5	35.6	35.6	41.3	41.3	49.1	49.1	55.4	55.4
2 Hrs	12.3	24.6	15.9	31.8	20	40	22.6	45.2	26.2	52.4	31	62	34.9	69.8
3 Hrs	9.39	28.17	12.1	36.3	15.2	45.6	17.2	51.6	19.9	59.7	23.5	11.75	26.5	79.5
6 Hrs	5.85	35.1	7.52	45.12	9.47	56.82	10.7	64.2	12.3	73.8	14.6	87.6	16.4	98.4
12 Hrs	3.64	43.68	4.68	56.16	5.87	70.44	6.61	79.32	7.64	91.68	9.04	108	10.2	122.4
24 Hrs	2.25	54	2.89	69.36	3.6	86.4	4.04	96.96	4.66	111.84	5.49	131.76	6.15	147.6
48 Hrs	1.34	64.32	1.72	82.56	2.13	102.24	2.38	114.24	2.73	131.04	3.2	153.6	3.58	171.84
72 Hrs	0.959	69.05	1.23	88.56	1.52	109.44	1.69	121.68	1.93	138.96	2.27	163.44	2.53	182.16

The total rainfall for the period 1 January 2014 – 31 December 2014 was calculated to be 683 mm, with the wettest day being December 4<sup>th</sup> 2014, with 54.2mm of rain being recorded by the WCPL meteorological station in the 24 hour period from 9am-9am. The WCPL Annual Environment Management Report (AEMR) for the 2013 reporting period identified the cumulative annual rainfall from as 496.2mm and the 2012 reporting period as 629.2mm. The Bureau of Meteorology long term average rainfall for the area is 653mm. This indicates that 2014 was a far wetter year than 2013 and the long term average.

On inspection of the available 5 minute and hourly rainfall data for 2014, the following was observed:

- A rainfall event on 7 March 2014 recorded in between a 1 in 2 and a 1 in 5 year storm event for both for both the 5 minutes (7.4mm) and hourly (15.8mm) IFD calculations. However, only 18.8mm of rain fell for the 24 hour period;
- Rainfall events on 6 December 2014 and 25 December 2014 recorded in 1 in 2 year storm events for the 5 minute IFD with 6.4mm recorded in 5 minute increments;
- A rainfall event on 3 December 2014 recorded in between a 1 in 1 and a 1 in 2 year storm event for the 5 minute IFD with 6mm recorded in a 5 minute increment.
- A rainfall event on 14 March 2014 recorded in between a 1 in 2 and a 1 in 5 year storm event for the hourly IFD with 28.2mm recorded for the 18<sup>th</sup> hour.

The velocity of Wilpinjong creek after these events were provided by WCPL and are as follows:

- 7 March – Upstream – no flow, Downstream – 0.1m/s;
- 14 March – Upstream – no flow, Downstream – 0.1m/s;
- 3 December – Upstream – no flow, Downstream – 0.45m/s;
- 6 December Upstream – no flow, Downstream – 0.45m/s;

The velocity of Cumbo creek after these events were provided by WCPL and are as follows:

- 7 March – Not measureable ;
- 14 March – Upstream – Not measureable ;
- 3 December – Upstream – 0.2m/s
- 6 December Upstream – 0.35m/s;

The velocities provided are estimates, and as a result of the very dry conditions these 'events' hardly registered. It should be noted that these estimates are at the control points and not averages of flow down the creek channel (these would be much slower). It correctly estimate creek velocities detailed cross sections upstream and downstream of each site is required to obtain accurate channel velocities. It should also be noted that flow rates in Cumbo Creek are variable due to the silted pipe and FlowPro only working with a nearly full pipe (after silt washed off the sensor). Therefore none of the identified event in the reporting period are considered to be highly scouring or eroding events.

All other rainfall events were within or under a rating less than a 1 in 1 year storm event.

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### 3.2 Field Survey - Stability Results

Creek bank stability during low flow is, in areas, continuing to improve along much of the Wilpinjong Creek. Destocking along much of the creek, as well as fencing out riparian areas, continues to allow for natural regeneration to occur. Of the 47 sites assessed along Wilpinjong Creek, 22 were within the stable classifications and 27 were within the unstable classifications. This is relatively similar to last year. The creek bed still remains largely obscured by in-stream vegetation, particularly in the upper reaches. However, there was a noticeable reduction of in-stream flora abundance and growth over the extent of the creek. This is possibly due to recent flooding and/or an extended dry period. There is little evidence of bed erosion, bed lowering, knickpoints and sediment deposition along much of the creek. Instream species diversity also remains low, with minimal snags and habitat features. There remains visible areas of bank erosional features along the length of the creek – including large areas of undercutting, sheet wash and gulying, however groundcover continues to improve. The upper banks are subject to high erosional potential during high flows or flooding. Riparian health along much of the creek continues to remain poor. This is the result of a floristic profile being dominated by grasses. Tree and shrub layers are largely absent along most of the creek. Noxious weed species such as blackberry and prickly pear still exist in pockets along the length of the creek.

Creek Stability along Cumbo Creek remains stable for the length of the creek surveyed. **Table 3** provides BEHI results for the creek. No sites were assessed as being within the unstable classification. This creek continues to lack species diversity and structural diversity. It possesses low banks with moderate to low slopes. Banks are largely stable as a result of a high degree of groundcover. Erosional features continue to remain minimal. The creek bed is largely obscured by in stream vegetation, which is again dominated by one species. Riparian health along the creek remains largely poor. This is the result of a floristic profile being dominated by grasses and a tree and shrub layer being largely absent along the creek. As a result of the low slopes and high ground cover, Cumbo creek remains largely stable.

**Table 2: Stability - Bank erosion hazard index (BEHI) for Wilpinjong Creek**

Site Number									
Questions	1	2	3	4	5	6	7	8	9
1	5	7.5	7.5	7.5	7.5	7.5	7.5	5	5
2	2	4	4	6	2	4	2	2	4
3	7.5	2.5	5	7.5	5	7.5	2.5	5	2.5
4	5	7.5	7.5	10	2.5	5	5	2.5	5
5	2.5	5	7.5	10	2.5	5	2.5	2.5	5
6	7.5	12.5	12.5	12.5	2.5	2.5	2.5	7.5	10
7	7.5	12.5	15	12.5	10	12.5	10	12.5	12.5
8	2.5	0	2.5	0	0	0	0	0	2.5
<b>Total</b>	<b>39.5</b>	<b>51.5</b>	<b>61.5</b>	<b>66</b>	<b>32</b>	<b>44</b>	<b>32</b>	<b>37</b>	<b>46.5</b>
<b>Rating</b>	Stable	Unstable	Mod Unstable	Highly Unstable	Stable	Stable	Mod Stable	Stable	Unstable
Site Number									
Questions	10	11	12	13	14	15	16	17	18
1	2.5	5	2.5	2.5	2.5	10	0	0	5
2	2	2	2	2	4	4	0	0	2
3	0	2.5	0	2.5	5	2.5	0	2.5	2.5
4	0	2.5	2.5	5	2.5	2.5	0	2.5	5
5	2.5	2.5	2.5	5	2.5	5	0	0	7.5
6	2.5	2.5	7.5	10	10	7.5	2.5	2.5	10
7	12.5	12.5	12.5	10	12.5	10	15	2.5	15
8	0	0	5	5	0	0	0	0	0
<b>Total</b>	<b>22</b>	<b>29.5</b>	<b>34.5</b>	<b>42</b>	<b>39</b>	<b>41.5</b>	<b>17.5</b>	<b>10</b>	<b>47</b>
<b>Rating</b>	Highly Stable	Mod Stable	Mod Stable	Stable	Stable	Stable	Highly Stable	Highly Stable	Unstable

Site Number									
Questions	19	20	21	22	23	24	25	26	27
1	2.5	7.5	2.5	5	5	5	5	7.5	5
2	6	6	6	4	4	2	6	4	8
3	10	10	7.5	0	2.5	2.5	5	5	7.5
4	10	10	7.5	7.5	7.5	5	7.5	5	7.5
5	7.5	7.5	7.5	7.5	10	7.5	7.5	7.5	7.5
6	12.5	10	10	15	12.5	10	12.5	12.5	15
7	15	15	12.5	15	15	15	15	15	15
8	0	0	0	2.5	5	2.5	0	2.5	2.5
<b>Total</b>	<b>63.5</b>	<b>66</b>	<b>53.5</b>	<b>56.5</b>	<b>61.5</b>	<b>49.5</b>	<b>58.5</b>	<b>59</b>	<b>68</b>
<b>Rating</b>	Mod Unstable	Highly Unstable	Unstable	Mod Unstable	Mod Unstable	Unstable	Mod Unstable	Mod Unstable	Highly Unstable
Site Number									
Questions	28	29	30	31	32	33	34	35	36
1	7.5	7.5	7.5	5	7.5	7.5	7.5	5	7.5
2	6	6	4	4	6	6	4	4	4
3	7.5	7.5	2.5	5	7.5	7.5	5	7.5	2.5
4	7.5	7.5	5	5	5	7.5	5	5	5
5	7.5	7.5	2.5	7.5	7.5	7.5	5	2.5	2.5
6	12.5	15	7.5	10	10	12.5	10	2.5	7.5
7	15	15	10	15	15	10	15	15	15
8	2.5	0	2.5	0	0	2.5	2.5	2.5	0
<b>Total</b>	<b>66</b>	<b>66</b>	<b>41.5</b>	<b>51.5</b>	<b>58.5</b>	<b>61</b>	<b>54</b>	<b>44</b>	<b>44</b>
<b>Rating</b>	Highly Unstable	Highly Unstable	Stable	Unstable	Mod Unstable	Mod Unstable	Unstable	Stable	Stable

Site Number									
Questions	37	38	39	40	41	42	43	44	45
1	7.5	10	2.5	5	2.5	10	5	2.5	5
2	6	2	6	4	4	6	6	6	4
3	7.5	2.5	10	5	2.5	10	7.5	10	5
4	2.5	2.5	5	5	2.5	7.5	5	5	2.5
5	5	2.5	7.5	7.5	2.5	7.5	7.5	7.5	2.5
6	2.5	10	12.5	12.5	7.5	12.5	10	10	7.5
7	15	10	15	15	15	12.5	15	15	10
8	0	2.5	2.5	0	0	0	0	0	2.5
<b>Total</b>	<b>46</b>	<b>42</b>	<b>61</b>	<b>54</b>	<b>36.5</b>	<b>66</b>	<b>56</b>	<b>56</b>	<b>39</b>
<b>Rating</b>	Unstable	Stable	Mod Unstable	Unstable	Stable	Highly Unstable	Mod Unstable	Mod Unstable	Stable

Site Number				
Questions	46	47	48	49
1	5	5	5	7.5
2	6	6	4	6
3	7.5	7.5	5	5
4	0	7.5	5	7.5
5	2.5	5	5	5
6	7.5	2.5	7.5	7.5
7	7.5	15	15	12.5
8	2.5	0	0	2.5
<b>Total</b>	<b>38.5</b>	<b>48.5</b>	<b>46.5</b>	<b>53.5</b>
<b>Rating</b>	Stable	Stable	Stable	Unstable

**Table 3: Stability - Bank erosion hazard index (BEHI) for Cumbo Creek**

Site Number										
Questions	1	2	3	4	5	6	7	8	9	10
1	2.5	0	2.5	2.5	5	2.5	Removed	2.5	2.5	0
2	2	2	2	2	2	6		2	2	2
3	0	2.5	2.5	0	2.5	7.5		0	2.5	0
4	0	2.5	0	0	0	0		0	0	0
5	0	2.5	0	0	2.5	0		0	0	0
6	0	7.5	2.5	0	2.2	2.5		0	0	0
7	15	15	15	15	15	15		15	15	15
8	0	2.5	5	2.5	2.5	0		2.5	2.5	0
<b>Total</b>	<b>19.5</b>	<b>34.5</b>	<b>29.5</b>	<b>22</b>	<b>31.7</b>	<b>33.5</b>		<b>22</b>	<b>24.5</b>	<b>17</b>
<b>Rating</b>	Highly Stable	Mod Stable	Mod Stable	Highly Stable	Mod stable	Mod Stable		Highly Stable	Highly Stable	Highly Stable



### 3.3 Comparative Results

**Appendix B (upstream)** and **C (downstream)** provides a comparison of site photographs from the December 2013 survey to the September 2014 survey for Wilpinjong and Cumbo Creeks. Most notably, differences relate to changes in in-stream flora abundance, groundcover and general groundcover health as a result of a lack of rainfall over the past several years.

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## 4.0 RECOMMENDATIONS & CONCLUSIONS

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The following dot points provide recommendations for continued assessment and ongoing improvement of Wilpinjong and Cumbo Creeks:

- Stability monitoring during low flow should continue for both creeks. It is suggested that panoramic photographs be considered in future sampling rounds;
- Cross sectional analysis is recommended to be undertaken every 3-5 years. This should be undertaken by survey instrumentation such as GNSS equipment with a base and rover unit. This equipment holds accuracies of approximately 30mm in x, y and z coordinates, making it reliable for future cross-sectional comparisons;
- Consideration should be given to installation of permanent coloured wooden survey pegs on the high bank to enable ease of site location;
- Consideration of the installation of erosion pins at some or all survey points should be given. These pins are surveyed in and bench marked with cross sectional analysis of the creek undertaken. Ongoing surveys will identify qualitatively bank erosion and widening, as well as areas of deposition;
- Continued works to improve the riparian zone of Wilpinjong creek should be considered in future site remediation works;
- Incorporation of bank soil testing at random locations, including aggregate stability testing – which involves dispersability and solidity calculations;
- Best Practise Management of weeds in areas along both creeks – sightings of blackberry, prickly pear, Bathurst Burr and several other noxious weeds were noted during the survey; and
- Continued Best Practise Management of stock around watercourses should continue.

This report provides WCPL with a stability assessment and photographic survey for future comparative purposes relating to ongoing monitoring of erosion, remediation and stability of both creeks. There is currently no visible indication that mining within the vicinity of the creek has resulted in any creek bed lowering or increased erosion, beyond natural occurrence.

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## 5.0 REFERENCES

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Abernethy B, and Rutherford I.D. (1999) *Guidelines for Stabbing Stream banks with Riparian Vegetation*, Cooperative Research Centre for Catchment Hydrology, Technical Report 99/10.

CSIRO (2009) *Australian Soil and Land Survey Field Handbook – 3<sup>rd</sup> Edition*, CSIRO Publishing, Collingwood Victoria.

CSIRO (n.d) *The Ephemeral Stream Assessment*, CSIRO, viewed October 2012  
<http://www.cse.csiro.au/research/efa/resources/EphemeralDrainageLineAssessment.pdf>

Heeren D.M, Mittelstet A.R, Fox G.A, Storm D.E, Al-Madhhachi T, Midgley T.L, Stringer A.F, Stunkel K.B and Tejral R.D (2012), *Using Rapid Geomorphic Assessments to Assess Streambank Stability in Oklahoma Ozark Streams*, American Society of Agricultural and Biological Engineers Vol. 55 (3) 957-968.

Land and Water Australia (2002), *River Landscapes – Streambank Stability*, Land and Water Australia, viewed October 2012,  
<http://lwa.gov.au/files/products/river-landscapes/pf020254/pf020254.pdf>

Appendix A  
*Field Sheet Proforma*

## Wilpinjong Creek Stability Survey 2014

<b>Site No :</b>	<b>Date:</b>	<b>Assessor:</b>
<b>Easting:</b>	<b>Northing:</b>	<b>Photos collected:</b>

Snags and or Habitat Features present (non living) : \_\_\_\_\_ Estimated Percentage (cross sectional cover) \_\_\_\_\_

Sediment Deposition (circle): Yes No Unable to Tell

Bed Erosional Features (Circle) : Yes No Unable to tell

Vegetation Rating	Tick
1 Little or no vegetation growing on drainage line floor (<20% cross sectional cover).	
2 Minor vegetation cover growing on drainage line floor (20-40% cross section cover)	
3 Fair vegetation cover growing on drainage line floor (40-60% cross section cover)	
3 Moderate vegetation cover growing on drainage line floor (60-80 cross section cover)	
4 Dense vegetation cover growing on drainage line floor (80%+ cross section cover)	

Ground Cover and Exposed Soil on Bank (Rating)

Vegetation Rating	Tick LEFT	Tick RIGHT
1 Little or no vegetation growing on bank wall (<10%)		
2 Minor vegetation growing on bank wall (10- 20%)		
3 Moderate vegetation growing on bank wall (20-50%)		
4 Dense vegetation growing on bank wall (50-90%)		

Material Rating (tick)	Left Bank	Right Bank	Stability Rating	Left Bank	Right Bank
1 Dispersive material is exposed for greater than 1m of the wall height – evidence of erosion			1 Unstable, many eroded areas, 'raw' area frequenta along straight sections and beds, obvious bank sloughing 60-100% of bank has erosional scars		
2 Materials that slake rapidly, or disperse are exposed on greater than 0.3m and less than 1m of vertical wall height (the sum of multiple layers if present) – evidence of erosion			2 Moderately unstable, 30-60% of bank has areas of erosion, high erosion potential during floods		
3 Materials that slake and/or disperse are exposed on less than 0.3m of wall height – minor evidence of erosion			3 Moderately stable, infrequent, small area of erosion mostly healed over, 5-30% of bank has areas of erosion		
4 Materials that do not slake or disperse are exposed on wall surface – no evidence of erosion			4 Excellent – Bank stable, evidence of erosion or bank failure absent or minimal, little potential for future problems, <5% of bank affected by erosion.		

Vegetation Rating (tick)	Left Bank*	Right Bank**	Riparian General Health (tick)	Left Bank	Right Bank
0 Little to no grasses growing on drainage line walls. No trees or shrubs.			0 Very Poor - No canopy cover, minor ground cover and minor leaf litter. Dominated by exotic species		
1 Minor grasses and shrubs growing on drainage line walls.			1 Poor - Little canopy and understorey cover between 1-30%, groundcover 1-30%, minor leaf litter, mixture of native and exotic species		
2 Moderate vegetation cover of grasses and shrubs. Several trees			2 Fair - Canopy and understorey cover between 6-30%, groundcover between 30-60%, some leaf litter, mixture of native and exotic species		
3 Dense perennial plant cover similar to vegetation on flood plain or riparian zone.			3 Good - Canopy and understorey cover between 6-30%, groundcover between 30-60%, large amount of leaf litter, dominated by native species, exotics sparse		
			4 Excellent - Canopy and understorey cover greater than 30%, groundcover greater than 60%, large amount of leaf litter, some habitat features (fallen logs), dominated by native species, exotics sparse		

Note: \* Left Bank = left bank when looking downstream

\*\* Right Bank = right bank when looking downstream

**Stability Rating - Using Critical Bank**











Circle - Left Bank      Right Bank

Bank Height - \_\_\_\_\_m      Bank Face, length - \_\_\_\_\_m













<b>1.</b>	<b>Bank Height (m)</b>						
(m)	0 - 1.5	1.5-3	3-4.5	4.5-6	6+	Value	
Value	0	2.5	5	7.5	10	Score	
<b>2.</b>	<b>Bank Angle</b>						
(°)	0-20	21-60	61-80	81-90	91-120	> 120	Value
Value	0	2	4	6	8	10	Score
<b>3.</b>	<b>Percentage of Bank Height with a Bank Angle Greater than 80°</b>						
%	0-10	11-25	26-50	51-75	76-100	Value	
Value	0	2.5	5	7.5	10	Score	
<b>4.</b>	<b>Evidence of Mass Wasting (% of Bank)</b>						
%	0-10	11-25	26-50	51-75	76-100	Value	
Value	0	2.5	5	7.5	10	Score	
<b>5.</b>	<b>Unconsolidated Material (% of Bank)</b>						
%	0-10	11-25	26-50	51-75	76-100	Value	
Value	0	2.5	5	7.5	10	Score	
<b>6.</b>	<b>Streambank Protection (% of Streambank covered by plant roots, vegetation, logs, branches, rocks etc)</b>						
%	0-10	11-25	26-50	51-70	70-90	90-100	Value Score
Value	15	12.5	10	7.5	2.5	0	
<b>7.</b>	<b>Established Beneficial Riparian Woody - Vegetation Cover</b>						
%	0-10	11-25	26-50	51-70	70-90	90-100	Value Score
Value	15	12.5	10	7.5	2.5	0	
<b>8.</b>	<b>Stream Curvature</b>						
Descriptor	Meander	Shallow Curve	Straight	Value Score			
	5	2.5	0				
<b>Total</b>	<b>0 - 25</b>	<b>26-35</b>	<b>36-45</b>	<b>46-55</b>	<b>56-65</b>	<b>66-85</b>	<b>Rating</b>
	Highly Stable	Mod Stable	Stable	Unstable	Mod Unstable	Highly Unstable	













Appendix B  
*Photo Comparison Upstream*










**Wilpinjong Creek Photo Comparison Upstream December 2013 to September 2014**











Site	Upstream December 2013	Upstream December 2014	Main Comparison
1			<ul style="list-style-type: none"> <li>• Increase in active channel creek width;</li> <li>• Increased sediment deposition midstream, creating a bar feature;</li> <li>• Increase in green groundcover on the bank faces and within the riparian zone between 2013-2014.</li> </ul>
2			<ul style="list-style-type: none"> <li>• A reduction in in-stream growth;</li> <li>• Increase in wombat activity in the general area;</li> <li>• Increased groundcover over the reporting period;</li> <li>• Stock activity noted.</li> </ul>
3			<ul style="list-style-type: none"> <li>• Increased soil exposure and erosion of the left bank;</li> <li>• Increased growth and regeneration of instream flora;</li> <li>• Reduction in leaf litter on the creek bank faces.</li> </ul>
4			<ul style="list-style-type: none"> <li>• Stabilisation on the right bank;</li> <li>• A reduction in instream flora;</li> <li>• An increase in the active channel;</li> <li>• Continued regression of the left bank.</li> </ul>
5			<ul style="list-style-type: none"> <li>• A reduction in in stream flora;</li> <li>• An increase in the active channel;</li> <li>• An increase in green groundcover on the creek bank faces;</li> <li>• A reduction in woody debris on the creek banks;</li> <li>• Increased stability of the left bank in this location.</li> </ul>
























Site	Upstream December 2013		Upstream December 2014	Main Comparison
6				<ul style="list-style-type: none"> <li>• A reduction in in stream flora growth;</li> <li>• An increase in the active channel width;</li> <li>• Increased stability of the creek banks;</li> <li>• Increase in in stream debris;</li> <li>• Increased stock activity in the area;</li> <li>• Increase in blackberry.</li> </ul>
7				<ul style="list-style-type: none"> <li>• A reduction in instream flora growth;</li> <li>• Increase in bank undercutting;</li> <li>• Increase exposure of bedrock on the right bank.</li> </ul>
8				<ul style="list-style-type: none"> <li>• Large reduction in instream flora growth;</li> <li>• Increased exposure of the bank faces;</li> <li>• Reduction in green growth on the creek banks and in the riparian areas;</li> <li>• Evidence of stock in the area;</li> <li>• Blackberry noted.</li> </ul>
9				<ul style="list-style-type: none"> <li>• Large reduction in instream flora growth;</li> <li>• Increased exposure of the bank faces;</li> <li>• Increased bleaching of exposure soils of the bank faces;</li> <li>• Reduction in green growth on the creek banks and in the riparian areas.</li> </ul>
10				<ul style="list-style-type: none"> <li>• Large reduction in instream flora growth;</li> <li>• Increased exposure of the bank faces;</li> <li>• Reduction in green growth on the creek banks and in the riparian areas;</li> <li>• Evidence of stock in the area;</li> <li>• Blackberry noted.</li> </ul>
11				<ul style="list-style-type: none"> <li>• Large reduction in instream flora growth;</li> <li>• Reduction in the active channel;</li> <li>• Reduction in green growth on the creek banks and in the riparian areas;</li> <li>• Evidence of stock in the area.</li> </ul>

Site	Upstream December 2013		Upstream December 2014	Main Comparison
12				<ul style="list-style-type: none"> <li>• Large reduction in instream flora growth;</li> <li>• Reduction in green growth on the creek banks and in the riparian areas;</li> <li>• A reduction in the active creek width;</li> <li>• Increased exposure of the left bank face;</li> <li>• Site is relatively stable.</li> </ul>
13				<ul style="list-style-type: none"> <li>• Large reduction in instream flora growth;</li> <li>• Reduction in green growth on the creek banks and in the riparian areas;</li> <li>• A reduction in the active creek width;</li> <li>• Increased exposure of the right bank face;</li> <li>• Reduction in leaf litter on the bank faces resulting in increased exposure of the surface soils.</li> </ul>
14				<ul style="list-style-type: none"> <li>• Large reduction in instream flora growth;</li> <li>• A reduction in the active creek width;</li> <li>• Increased exposure of the bank faces;</li> <li>• Banks relatively stable.</li> </ul>
15				<ul style="list-style-type: none"> <li>• Large reduction in instream flora growth;</li> <li>• Increased exposure of the creek bed with some bed erosion noted;</li> <li>• A reduction in the active creek width;</li> <li>• A reduction in groundcover on the creek bank faces;</li> <li>• Banks relatively stable;</li> <li>• Blackberry present;</li> <li>• Evidence of wombats.</li> </ul>
16				<ul style="list-style-type: none"> <li>• Large reduction in instream flora growth;</li> <li>• Increased exposure of the creek bed;</li> <li>• Banks stable.</li> </ul>
17				<ul style="list-style-type: none"> <li>• Slightly different location as a result of access;</li> <li>• Increased exposure of soils along access track;</li> <li>• Reduction in healthy instream flora growth;</li> <li>• Creek bank exposure almost 100% in areas as a result of low groundcover;</li> <li>• Little to no riparian zone.</li> </ul>


Site	Upstream December 2013	Upstream December 2014	Main Comparison
18			<ul style="list-style-type: none"> <li>• Reduction in instream flora health;</li> <li>• Reduction in green growth on the creek banks and in the riparian areas;</li> <li>• Increased exposure of the left bank face;</li> <li>• Right bank appears to be suffering slippage;</li> <li>• Little to no riparian zone.</li> </ul>
19			<ul style="list-style-type: none"> <li>• Reduction in healthy instream flora;</li> <li>• Sight remains stable;</li> <li>• Little to no riparian zone.</li> </ul>
20			<ul style="list-style-type: none"> <li>• Reduction in healthy instream flora;</li> <li>• Increased bleaching of exposed soils on the left bank face;</li> <li>• Right bank remains stable;</li> <li>• Little to no riparian zone.</li> </ul>
21			<ul style="list-style-type: none"> <li>• Reduction in healthy instream flora;</li> <li>• Little to no riparian zone.</li> </ul>
22			<ul style="list-style-type: none"> <li>• Reduction in healthy instream flora;</li> <li>• Increased bleaching of exposed soils on the right bank face;</li> <li>• Left bank remains stable;</li> <li>• Reduction of the active channel;</li> <li>• Little to no riparian zone.</li> </ul>
23			<ul style="list-style-type: none"> <li>• Reduction in healthy instream flora;</li> <li>• Increased bleaching of exposed soils on the bank faces;</li> <li>• An increase in sheet erosion;</li> <li>• Reduction of the active channel;</li> <li>• Little to no riparian zone.</li> </ul>

Site	Upstream December 2013	Upstream December 2014	Main Comparison
24			<ul style="list-style-type: none"> <li>• Reduction in healthy instream flora;</li> <li>• Increased bleaching of exposed soils on the right bank face;</li> <li>• An increase in sheet erosion of the right bank;</li> <li>• Left bank remains stable;</li> <li>• Reduction of the active channel;</li> <li>• Little to no riparian zone.</li> </ul>
25			<ul style="list-style-type: none"> <li>• Reduction in healthy instream flora;</li> <li>• Site remains similar.</li> </ul>
26			<ul style="list-style-type: none"> <li>• Reduction in healthy instream flora;</li> <li>• Stabilisation of the left bank face, with a minor decrease in groundcover;</li> <li>• Right bank exposure remains stable.</li> </ul>
27			<ul style="list-style-type: none"> <li>• Reduction in healthy instream flora;</li> <li>• Site remains similar.</li> </ul>
28			<ul style="list-style-type: none"> <li>• Reduction in healthy instream flora;</li> <li>• Increased stability of the right bank;</li> <li>• Site remains similar.</li> </ul>





Site	Upstream December 2013		Upstream December 2014	Main Comparison
29				<ul style="list-style-type: none"> <li>• Reduction in healthy instream flora;</li> <li>• Increased stability of the right bank;</li> <li>• Site remains similar.</li> </ul>
30				<ul style="list-style-type: none"> <li>• Reduction in healthy instream flora;</li> <li>• Increased stability of the right bank;</li> <li>• Site remains similar;</li> <li>• Good general regeneration in the riparian areas as a result of destocking.</li> </ul>
31				<ul style="list-style-type: none"> <li>• Reduction in healthy instream flora;</li> <li>• Increased soil exposure of the left bank due to increased dryness during 2014.</li> <li>• Salt crystallisation on the right bank in exposed areas.</li> </ul>
32				<ul style="list-style-type: none"> <li>• Reduction in healthy instream flora;</li> <li>• Reduction in the active channel width;</li> <li>• Continued regression and erosion of the right bank;</li> <li>• Continued exposure of surface soils on the left and right bank due to increased dryness during 2014;</li> </ul>
33				<ul style="list-style-type: none"> <li>• Reduction in healthy instream flora;</li> <li>• Reduction in the active channel width;</li> <li>• Continued regression and erosion of the left bank;</li> <li>• Right bank remains similar.</li> </ul>
34				<ul style="list-style-type: none"> <li>• Reduction in healthy instream flora;</li> <li>• Site remains similar.</li> </ul>

Site	Upstream December 2013	Upstream December 2014	Main Comparison
35			<ul style="list-style-type: none"> <li>• Increased regeneration of the left bank as a result of destocking;</li> <li>• Decreased surface soil exposure on the left bank as a result of improved ground cover;</li> <li>• Right bank remains similar;</li> <li>• Reduction in healthy instream flora;</li> <li>• Reduction in the active channel width;</li> <li>• Prickly pear noted in the vicinity of the site.</li> </ul>
36			<ul style="list-style-type: none"> <li>• Reduction in healthy instream flora;</li> <li>• Reduction in the active channel width;</li> <li>• Continued regression and erosion of the right and left banks;</li> <li>• Continued exposure of surface soils on the right and left banks due to increased dryness during 2014;</li> </ul>
37			<ul style="list-style-type: none"> <li>• Reduction in healthy instream flora;</li> <li>• Reduction in the active channel width;</li> <li>• Continued regression and erosion of the right banks;</li> <li>• Continued exposure of surface soils on the right banks due to increased dryness during 2014;</li> <li>• Left bank remains well vegetated and stable.</li> </ul>
38			<ul style="list-style-type: none"> <li>• Reduction in abundance of instream flora at the site;</li> <li>• Continued regression and erosion of the right banks;</li> <li>• Continued exposure of surface soils on the right banks due to increased dryness during 2014;</li> <li>• Left bank remains well vegetated and stable;</li> <li>• Blackberry noted upstream of the site.</li> </ul>
39	No Access		<ul style="list-style-type: none"> <li>• Creek bed is well vegetated with little to no exposure of the creek bed;</li> <li>• Both banks are well vegetated;</li> <li>• Blackberry noted close to the site.</li> </ul>









Site	Upstream December 2013	Upstream December 2014	Main Comparison
40	No Access		<ul style="list-style-type: none"> <li>• Creek bed is well vegetated with little to no exposure of the creek bed;</li> <li>• Both banks suffering from soil exposure and sheet erosion;</li> <li>• Lack of riparian zone on both banks.</li> </ul>
41	No Access		<ul style="list-style-type: none"> <li>• Creek bed is well vegetated with little to no exposure of the creek bed;</li> <li>• Left bank is well vegetated;</li> <li>• Right bank suffering from minor soil exposure and erosion;</li> <li>• Lack of riparian zone on both banks;</li> <li>• Evidence of stock in the creek bed.</li> </ul>
42			<ul style="list-style-type: none"> <li>• Creek bed is well vegetated with little exposure of the creek bed;</li> <li>• Left bank is well vegetated, with minor pockets of undercutting;</li> <li>• Increase in soil exposure, erosion and regrowth of the right bank, as noted by an increase in bank steepness and rootlet exposure in 2014;</li> <li>• An increase in undercutting of the inner right bank;</li> <li>• Lack of riparian zone on both banks.</li> <li>• Channel width has remained similar.</li> </ul>
43			<ul style="list-style-type: none"> <li>• A reduction in instream flora and an increase in bed exposure and water pooling in 2014;</li> <li>• Increased bank stability as a result of an increase in vegetation coverage on the right bank;</li> <li>• Left bank remains stable and well vegetated;</li> <li>• Active channel width remains stable.</li> </ul>









Site	Upstream December 2013	Upstream December 2014	Main Comparison
44			<ul style="list-style-type: none"> <li>• An increase in bed exposure and water pooling in 2014;</li> <li>• An increase in the active channel width over the year;</li> <li>• Increased bank stability as a result of an increase in vegetation coverage on both banks;</li> <li>• Reduction in soil exposure and erosion of the right bank.</li> </ul>
45			<ul style="list-style-type: none"> <li>• Bedrock material exposure appears to have increased over the year;</li> <li>• Creek bed width remains stable;</li> <li>• Increased vegetation coverage and therefore a reduction in soil exposure on the left bank;</li> <li>• Right bank remains stable.</li> </ul>
46			<ul style="list-style-type: none"> <li>• Creek bed is well vegetated with little to no exposure of the creek bed;</li> <li>• Both banks are well vegetated and stable;</li> <li>• There is an increase in the active channel width.</li> </ul>
47			<ul style="list-style-type: none"> <li>• An increase in the in stream flora coverage, resulting in a reduction in creek bed exposure;</li> <li>• Both banks continue to regenerate as groundcover on the bank faces increases;</li> <li>• Site continues to stabilise.</li> </ul>



Site	Upstream December 2013	Upstream December 2014	Main Comparison
48			<ul style="list-style-type: none"> <li>• Reduction in the active channel width;</li> <li>• Increased undercutting and gullyng of the left bank face, however vegetation coverage has increased over the year;</li> <li>• Soil exposure remains stable instream and on the right bank face. There has been an increase in groundcover on the right bank face as result of natural regeneration;</li> </ul>
49			<ul style="list-style-type: none"> <li>• A reduction in the active channel width;</li> <li>• There has been a significant increase in groundcover within the creek bed, resulting in a reduction of soil and bed exposure;</li> <li>• There is an increase in groundcover on both bank faces, as a result of natural regeneration;</li> <li>• Site continues to regenerate.</li> </ul>

**Cumbo Creek Photo Comparison Upstream December 2013 to September 2014**

Site	Upstream December 2013	Upstream September 2014	Main Comparison
1			<ul style="list-style-type: none"> <li>• Site remains well vegetated and stable.</li> </ul>
2			<ul style="list-style-type: none"> <li>• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2013-2014.</li> <li>• An increase in soil exposure of both bank faces is noted during 2014.</li> </ul>
3			<ul style="list-style-type: none"> <li>• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2013-14.</li> <li>• Site remains well vegetated and stable.</li> </ul>
4			<ul style="list-style-type: none"> <li>• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2013-2014.</li> <li>• Site remains well vegetated and stable.</li> </ul>

5			<ul style="list-style-type: none"> <li>• A reduction in 'green' groundcover on the bank faces and within riparian areas between 2013-14.</li> <li>• Site remains well vegetated and stable.</li> </ul>
6			<ul style="list-style-type: none"> <li>• A reduction in 'green' groundcover on the bank faces and within riparian areas between 2013-2014.</li> <li>• Site remains well vegetated and stable.</li> </ul>
7	Removed from survey due to works in area.		
8			<ul style="list-style-type: none"> <li>• A reduction in 'green' groundcover on the bank faces and within riparian areas between 2013-2014.</li> <li>• Site remain well vegetated and stable.</li> </ul>
9			<ul style="list-style-type: none"> <li>• A reduction in 'green' groundcover on the bank faces and within riparian areas between 2013-2014</li> <li>• Site remain well vegetated and stable.</li> </ul>







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- A reduction in 'green' groundcover on the bank faces and within riparian areas between 2013-2014.
- Site remain well vegetated and stable.

Appendix C  
*Photo Comparison Downstream*













**Wilpinjong Creek Photo Comparison Downstream December 2013 to September 2014**













Site	Downstream December 2013	Downstream September 2014	Main Comparisons
1			<ul style="list-style-type: none"> <li>• A reduction in instream plant growth;</li> <li>• An increase in green plant growth on the creek bank faces and in the riparian zone;</li> <li>• Stabilisation of bank erosion.</li> </ul>
2			<ul style="list-style-type: none"> <li>• A reduction in instream plant growth;</li> <li>• Slight increase in groundcover on the creek bank faces;</li> <li>• Increase in wombat activity in the general area;</li> <li>• Stock activity noted.</li> </ul>
3			<ul style="list-style-type: none"> <li>• Increase in groundcover on the creek bank faces;</li> <li>• Continued bleaching of exposed soils within the bank faces;</li> </ul>
4			<ul style="list-style-type: none"> <li>• Increased soil exposure and erosion of the right bank;</li> <li>• An increase in green groundcover of the left bank;</li> <li>• An increase in active channel activity;</li> <li>• A reduction in instream flora.</li> </ul>
5			<ul style="list-style-type: none"> <li>• A reduction in instream plant growth;</li> <li>• An increase in the active channel;</li> <li>• An increase in green groundcover on the creek bank faces.</li> </ul>

6					<ul style="list-style-type: none"> <li>• A reduction in in stream flora growth;</li> <li>• An increase in the active channel width;</li> <li>• Increased stock activity in the area;</li> <li>• Increased stability of the creek banks;</li> <li>• Increase in blackberry.</li> </ul>
7					<ul style="list-style-type: none"> <li>• A reduction in instream flora growth;</li> <li>• Increase in bank undercutting;</li> <li>• Stability of banks similar.</li> </ul>
8					<ul style="list-style-type: none"> <li>• Large reduction in instream flora growth;</li> <li>• Increased exposure of the bank faces;</li> <li>• Reduction in green vegetation on the creek banks and riparian areas;</li> <li>• Evidence of stock in the area;</li> <li>• Blackberry noted.</li> </ul>
9					<ul style="list-style-type: none"> <li>• Large reduction in instream flora growth;</li> <li>• Increased exposure of the bank faces;</li> <li>• Reduction in green growth on the creek banks and in the riparian areas.</li> </ul>
10					<ul style="list-style-type: none"> <li>• Large reduction in instream flora growth;</li> <li>• Increased exposure of the bank faces;</li> <li>• Increased erosion of the left bank;</li> <li>• Reduction in green growth on the creek banks and in the riparian areas;</li> <li>• Evidence of stock in the area;</li> <li>• Blackberry noted.</li> </ul>
11					<ul style="list-style-type: none"> <li>• Large reduction in instream flora growth;</li> <li>• Reduction in the active channel;</li> <li>• Increase in soil exposure of the creek bank faces;</li> <li>• Reduction in green growth on the creek banks and in the riparian areas;</li> <li>• Evidence of stock in the area.</li> </ul>









12						<ul style="list-style-type: none"> <li>• Large reduction in instream flora growth;</li> <li>• Reduction in green growth on the creek banks and in the riparian areas;</li> <li>• A reduction in the active creek width;</li> <li>• Site is relatively stable with good ground coverage.</li> </ul>
13						<ul style="list-style-type: none"> <li>• Large reduction in instream flora growth;</li> <li>• A reduction in the active creek width;</li> <li>• Increased exposure of the right bank face;</li> <li>• Reduction in leaf litter on the bank faces resulting in increased exposure of the surface soils.</li> </ul>
14						<ul style="list-style-type: none"> <li>• Large reduction in instream flora growth;</li> <li>• A reduction in the active creek width;</li> <li>• Increased exposure of the bank face;</li> <li>• Banks relatively stable.</li> </ul>
15						<ul style="list-style-type: none"> <li>• Large reduction in instream flora growth;</li> <li>• Increased exposure of the creek bed with some bed erosion noted;</li> <li>• A reduction in the active creek width;</li> <li>• A reduction in groundcover on the creek bank faces;</li> <li>• Banks relatively stable;</li> <li>• Blackberry present;</li> <li>• Evidence of wombats.</li> </ul>
16						<ul style="list-style-type: none"> <li>• Instream flora abundant, however is in poor health;</li> <li>• Evidence of wombats in the creek bed;</li> <li>• Banks stable with no soil exposure.</li> </ul>
17						<ul style="list-style-type: none"> <li>• Slightly different location as a result of access;</li> <li>• Increased exposure of soils along access track;</li> <li>• Reduction in healthy instream flora growth;</li> <li>• Creek bank exposure almost 100% in areas as a result of low groundcover;</li> <li>• Little to no riparian zone.</li> </ul>







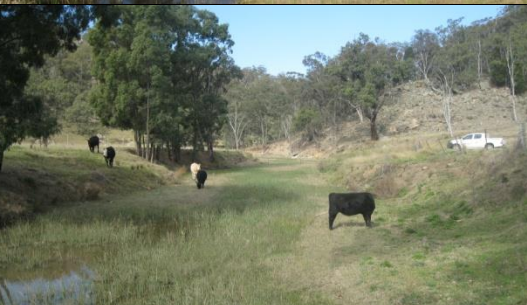









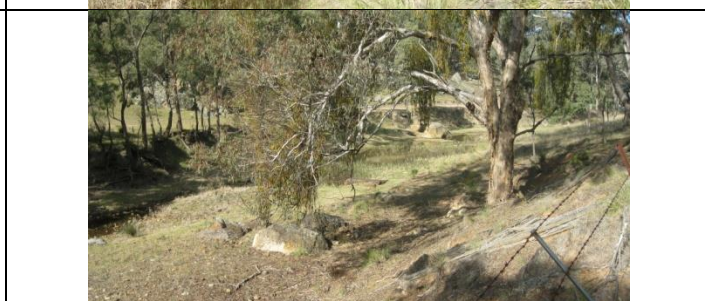
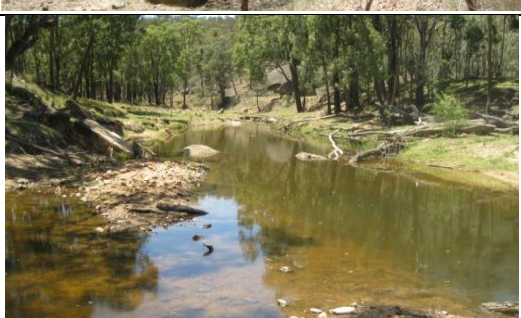

18			<ul style="list-style-type: none"> <li>• Reduction in instream flora health;</li> <li>• Reduction in green growth on the creek banks and in the riparian areas;</li> <li>• Increased exposure of the left bank face;</li> <li>• Right bank appears to be suffering slippage;</li> <li>• Little to no riparian zone.</li> </ul>
19			<ul style="list-style-type: none"> <li>• Reduction in healthy instream flora;</li> <li>• Increased exposure of the right bank as a result of a reduction in groundcover;</li> <li>• Sight remains stable;</li> <li>• Little to no riparian zone.</li> </ul>
20			<ul style="list-style-type: none"> <li>• Reduction in healthy instream flora;</li> <li>• Increased bleaching of exposed soils on the left bank face;</li> <li>• Right bank remains stable;</li> <li>• Little to no riparian zone.</li> </ul>
21			<ul style="list-style-type: none"> <li>• Reduction in healthy instream flora;</li> <li>• Increased bleaching of exposed soils on the bank faces;</li> <li>• Increased erosion and regression of the right bank;</li> <li>• Little to no riparian zone.</li> </ul>
22			<ul style="list-style-type: none"> <li>• Reduction in healthy instream flora;</li> <li>• Increased bleaching of exposed soils on the right bank face;</li> <li>• Left bank remains stable;</li> <li>• Reduction of the active channel;</li> <li>• Little to no riparian zone.</li> </ul>
23			<ul style="list-style-type: none"> <li>• Reduction in healthy instream flora;</li> <li>• Increased bleaching of exposed soils on the right bank face;</li> <li>• Left bank remains stable;</li> <li>• Reduction of the active channel;</li> <li>• Little to no riparian zone.</li> </ul>

24			<ul style="list-style-type: none"> <li>• Reduction in healthy instream flora;</li> <li>• Increased bleaching of exposed soils on the right bank face;</li> <li>• An increase in sheet erosion of the right bank;</li> <li>• Left bank remains stable;</li> <li>• Reduction of the active channel;</li> <li>• Little to no riparian zone.</li> </ul>
25			<ul style="list-style-type: none"> <li>• Reduction in healthy instream flora;</li> <li>• Stabilisation of left bank erosion, however an increase in salt crusting on the soil surfaces;</li> <li>• An increase in slumping and undercutting of the left bank;</li> <li>•</li> </ul>
26			<ul style="list-style-type: none"> <li>• Reduction in healthy instream flora;</li> <li>• Stabilisation of the left bank face, with a minor decrease in groundcover;</li> <li>• Right bank exposure remains stable.</li> </ul>
27			<ul style="list-style-type: none"> <li>• Reduction in healthy instream flora;</li> <li>• Stabilisation of the left bank face, with a minor decrease in groundcover;</li> <li>• Right bank exposure has increased as a result of a reduction in groundcover.</li> </ul>
28			<ul style="list-style-type: none"> <li>• Reduction in healthy instream flora;</li> <li>• Increased bank stability of the right bank;</li> <li>• Site remains similar.</li> </ul>
29			<ul style="list-style-type: none"> <li>• Reduction in healthy instream flora;</li> <li>• Increased bank stability of the right bank;</li> <li>• Erosion of the left bank continues as a result of with a lack of groundcover and steep slope.</li> <li>• Reduction in the active channel width in 2013.</li> </ul>

30				<ul style="list-style-type: none"> <li>• Reduction in healthy instream flora;</li> <li>• Increased bank stability of the right bank;</li> <li>• Left bank face continues to erode naturally as a result of steep slopes and lack of ground cover;</li> <li>• Good general regeneration in the riparian areas as a result of destocking.</li> </ul>
31				<ul style="list-style-type: none"> <li>• Reduction in healthy instream flora;</li> <li>• Increased soil exposure of the left bank due to increased dryness during 2014.</li> <li>• Salt crystallisation on the right bank in exposed areas</li> <li>• Reduction in the active channel width.</li> </ul>
32				<ul style="list-style-type: none"> <li>• Reduction in healthy instream flora;</li> <li>• Increased soil exposure of the left bank due to increased dryness during 2014;</li> <li>• Increased soil exposure of the right bank;</li> <li>• Reduction in the active channel width.</li> </ul>
33				<ul style="list-style-type: none"> <li>• Reduction in healthy instream flora;</li> <li>• Increased soil exposure of the left bank due to increased dryness during 2014;</li> <li>• Right bank remain similar.</li> <li>• Reduction in the active channel width.</li> </ul>
34				<ul style="list-style-type: none"> <li>• Reduction in healthy instream flora;</li> <li>• Soil exposure and erosion of the left bank remains stable;</li> <li>• Site remains similar.</li> </ul>
35				<ul style="list-style-type: none"> <li>• Increased regeneration of the left bank as a result of destocking;</li> <li>• Decreased surface soil exposure on the left bank as a result of improved ground cover;</li> <li>• Right bank remains similar;</li> <li>• Reduction in healthy instream flora;</li> <li>• Reduction in the active channel width;</li> <li>• Prickly pear noted in the vicinity of the site.</li> </ul>

36				<ul style="list-style-type: none"> <li>• Right bank remains well vegetated;</li> <li>• Increased soil exposure of the left bank due to increased dryness during 2014;</li> <li>• Reduction in the active channel width;</li> <li>• Channel bed remains similar.</li> </ul>
37				<ul style="list-style-type: none"> <li>• Increased exposure of the surface soils on the right bank resulting from increased dryness during 2014;</li> <li>• Left bank remains well vegetated and stable.</li> </ul>
38				<ul style="list-style-type: none"> <li>• Reduction in abundance of instream flora at the site;</li> <li>• Increase in water pooling;</li> <li>• Both banks remain well vegetated and stable.</li> </ul>
39	No Access			<ul style="list-style-type: none"> <li>• Creek bed is well vegetated with little to no exposure of the creek bed;</li> <li>• Right bank well vegetated;</li> <li>• Left bank suffering from soil exposure and minor sheet erosion;</li> <li>• Blackberry noted close to the site;</li> <li>• Lack of riparian zone on both banks.</li> </ul>
40	No Access			<ul style="list-style-type: none"> <li>• Creek bed is well vegetated with little to no exposure of the creek bed;</li> <li>• Left bank is well vegetated;</li> <li>• Right bank suffering from soil exposure and sheet erosion;</li> <li>• Lack of riparian zone on both banks.</li> </ul>

41	No Access		<ul style="list-style-type: none"> <li>• Creek bed is well vegetated with little to no exposure of the creek bed;</li> <li>• Left bank is well vegetated;</li> <li>• Right bank suffering from minor soil exposure and erosion;</li> <li>• Lack of riparian zone on both banks;</li> <li>• Evidence of stock in the creek bed.</li> </ul>
42			<ul style="list-style-type: none"> <li>• Creek bed is well vegetated with little exposure of the creek bed;</li> <li>• Left bank is well vegetated;</li> <li>• Increase in soil exposure, erosion and regrowth of the right bank, as noted by an increase in bank steepness and rootlet exposure in 2014;</li> <li>• An increase in undercutting of the inner right bank;</li> <li>• Lack of riparian zone on both banks.</li> <li>• Channel width has remained similar.</li> </ul>
43			<ul style="list-style-type: none"> <li>• An increase in bed exposure and water pooling in 2014;</li> <li>• An increase in the active channel width over the year;</li> <li>• Banks stability and ground coverage remains similar.</li> </ul>
44			<ul style="list-style-type: none"> <li>• Instream flora abundance and coverage remains similar over the year;</li> <li>• Active channel width appears to have increased';</li> <li>• Bank face exposure and vegetation coverage remains similar on both banks over the year;</li> <li>• Stock evident in the creek bed.</li> </ul>
45			<ul style="list-style-type: none"> <li>• Creek bed width remains stable;</li> <li>• Increased vegetation coverage and therefore a reduction in soil exposure on the right bank;</li> <li>• Right bank remains stable, as largely bedrock.</li> </ul>

46					<ul style="list-style-type: none"> <li>• Creek bed is well vegetated with little to no exposure of the creek bed;</li> <li>• Both banks are well vegetated and stable;</li> <li>• Site continues to stabilise.</li> </ul>
47					<ul style="list-style-type: none"> <li>• An increase in the in stream flora coverage, resulting in a reduction in creek bed exposure;</li> <li>• Both banks continue to regenerate as groundcover on the bank faces increases;</li> <li>• Site continues to stabilise.</li> </ul>
48					<ul style="list-style-type: none"> <li>• Reduction in the active channel width;</li> <li>• Increased undercutting of the left inner bank, however the outer embankment is well vegetated;</li> <li>• Soil exposure remains stable instream and on the right bank face. There has been an increase in groundcover on the right bank face as result of natural regeneration;</li> </ul>
49					<ul style="list-style-type: none"> <li>• A reduction in the active channel width;</li> <li>• Instream flora remains minimal with continued deposition of sands and pebbles;</li> <li>• Inner banks remain sparsely vegetated as a result of a dry 2014;</li> </ul>

**Cumbo Creek Photo Comparison Downstream December 2011, 2012 & 2013**

Site	Downstream December 2013	Downstream September 2014	Main Comparisons
1			<ul style="list-style-type: none"> <li>• A slight reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2013-2014.</li> <li>• Site remains well vegetated and stable.</li> </ul>
2			<ul style="list-style-type: none"> <li>• A slight reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2013-2014.</li> <li>• Site remains well vegetated and stable.</li> </ul>
3			<ul style="list-style-type: none"> <li>• Site remains well vegetated and stable.</li> </ul>
4			<ul style="list-style-type: none"> <li>• Site remains well vegetated and stable.</li> </ul>

5			<ul style="list-style-type: none"> <li>• Site remains well vegetated and stable.</li> </ul>
6			<ul style="list-style-type: none"> <li>• Site remains well vegetated and stable.</li> </ul>
7	Removed from survey due to works in area.		
8			<ul style="list-style-type: none"> <li>• Site remain well vegetated and stable.</li> </ul>
9			<ul style="list-style-type: none"> <li>• A reduction in 'green' groundcover on the bank faces and within riparian areas between 2013-2014.</li> <li>• Site remain well vegetated and stable.</li> </ul>



10



- A reduction in 'green' groundcover on the bank faces and within riparian areas between 2013-2014.
- Site remain well vegetated and stable.