APPENDIX 3C – SURFACE WATER MONITORING

Table 10 - Water Quality Impact Assessment Criteria

Creek	Monitoring Site	Parameter	Trigger[1]
Wilpinjong Creek (Downstream)	WIL_NC, WIL_D2, WIL_D, WIL_2	EC	If recorded value at the monitoring site is greater than **5,166 µS/cm** for 3 consecutive readings
		Turbidity	If recorded value at the monitoring site is greater than **24 NTU** for 3 consecutive readings
		pH (lower)	If recorded value at the monitoring site is less than **6.9 pH** for 3 consecutive readings
		pH (upper)	If recorded value at the monitoring site is greater than **7.7 pH** for 3 consecutive readings
Cumbo Creek (Downstream)	CC1	EC	If recorded value at the monitoring site is greater than **7,510 µS/cm** for 3 consecutive readings
		Turbidity	If recorded value at the monitoring site is greater than **77 NTU** for 3 consecutive readings
		pH (lower)	If recorded value at the monitoring site is less than **7.5 pH** for 3 consecutive readings
		pH (upper)	If recorded value at the monitoring site is greater than **8.2 pH** for 3 consecutive readings

Notes: [1]Trigger is only triggered if the recorded value at monitoring site is greater than (or less than for lower pH Trigger) all values from the upstream monitoring sites sampled on the same day. In the event that a single result is recorded above/below the 80th/20th percentile value, WCPL will undertake a preliminary investigation to ascertain whether the result was caused by an obvious anomaly or whether further testing is required.

Table 11 - Summary of 2015 Results for Surface Water Monitoring

SW Monitoring Point	EC (µS/cm)			pH			SO_4 (mg/L)			Turbidity (NTU)		
	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave
CC1	120.0	4380.0	2316.3	6.60	7.80	7.31	13.0	1660.0	237.7	3.3	13000.0	3415.4
CC2	350.0	5970.0	3591.4	7.30	7.90	7.67	1400.0	2290.0	1977.8	0.4	20.8	4.7
CC3	150.0	5130.0	2220.0	7.00	8.40	7.93	17.0	2100.0	946.0	1.2	359.0	93.7
WIL (U)	1650.0	7550.0	4306.7	4.80	6.80	5.93	38.0	146.0	99.0	7.4	263.0	77.0
WIL (U2)	790.0	5580.0	3353.8	5.60	7.40	6.71	22.0	118.0	41.9	1.5	158.0	41.9
WIL (PC)	1170.0	6100.0	3256.3	6.80	7.90	7.23	3.0	42.0	16.0	1.8	222.0	90.4
WIL (NC)	410.0	3960.0	1987.1	6.60	7.80	7.31	4.0	106.0	43.0	1.2	1440.0	284.5
WIL (D)	340.0	5880.0	2713.0	7.10	8.10	7.67	29.0	607.0	253.2	2.6	363.0	63.1
WIL (D2)	500.0	6520.0	2457.5	7.50	8.20	7.73	16.0	693.0	148.4	7.5	557.0	113.2
WOL1	160.0	5540.0	2223.0	7.50	8.20	7.96	208.0	956.0	445.8	1.1	61.8	13.3
WOL2	400.0	5550.0	1830.0	7.30	7.80	7.54	262.0	822.0	532.8	0.6	486.0	53.9

Notes:. mg/L = micrograms per litre. mS/cm= microSiemens per centimetre. NTU = nephelometric turbidity units.

Table 12 Summary of 2014 Results of Surface Water Monitoring

SW Monitoring Point	EC (µS/cm)			pH			SO_4 (mg/L)			Turbidity (NTU)		
	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave
CC1	610.0	5430.0	2055.7	7.10	9.20	8.00	120.0	1880.0	785.0	2.3	352.0	91.3
CC2	160.0	6590.0	4944.0	6.90	7.80	7.44	85.0	2520.0	1733.5	0.2	151.0	16.4
CC3	400.0	5260.0	3522.5	7.60	8.00	7.80	23.0	2100.0	1380.8	1.1	346.0	96.0
WIL (U)	980.0	1540.0	1260.0	6.00	7.10	6.55	70.0	174.0	122.0	3.2	30.0	16.6
WIL (U2)	1340.0	5970.0	2886.0	6.30	7.40	6.78	10.0	110.0	50.1	4.5	290.0	50.1
WIL (PC)*	-	-	-	-	-	-	-	-	-	-	-	-
WIL (NC)	310.0	790.0	445.0	7.00	7.40	7.25	6.0	96.0	27.0	1.8	2410.0	664.4
WIL (D)	1520.0	6010.0	3728.3	6.90	8.40	7.68	205.0	1680.0	634.8	1.0	26.8	6.6
WIL (D2)	780.0	7550.0	3756.0	7.00	8.70	8.02	120.0	1670.0	932.4	0.8	42.7	11.7
WOL1	1870.0	3680.0	2582.5	7.00	8.90	8.13	434.0	1120.0	635.6	1.2	18.6	3.8
WOL2	1670.0	4060.0	2779.2	7.20	7.80	7.46	452.0	842.0	589.9	0.6	69.7	16.1

Notes:. mg/L = micrograms per litre. mS/cm= microSiemens per centimetre. NTU = nephelometric turbidity units. * Indicates no sample available during the schedule monitoring programme.

Table 13 Summary of 2013 Results of Surface Water Monitoring

SW Monitoring Point	EC (µS/cm)			pH			SO_4 (mg/L)			Turbidity (NTU)		
	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave
CC1	3150.0	5710.0	4568.5	6.9	8.2	7.9	828.0	3160.0	1647.0	0.4	1770	169.6
CC2	4380.0	6070.0	5040.0	7.4	8.1	7.7	1610.0	3110.0	2040.0	0.2	2.6	0.9
CC3	225.0	4890.0	3130.6	7.8	8.2	8.0	94.0	2270.0	1454.1	0.8	360.0	59.4
WIL (U)	448.0	1390.0	1065.0	6.5	7.0	6.8	7.0	63.0	38.1	1.5	74.5	26.5
WIL (U2)	413.0	4620.0	2165.5	6.3	7.6	6.7	4.0	89.0	47.4	6.1	473.0	62.8
WIL (PC)	395.0	1730.0	1158.0	6.7	7.1	6.9	31.0	186.0	93.8	5.2	148.0	47.6
WIL (NC)	340.0	930.0	510.0	7.4	7.9	7.7	5.0	140.0	59.6	2.2	4000	941.5
WIL (D)	1656.0	4200.0	2942.6	7.8	8.8	8.1	216.0	822.0	475.2	1.4	59.1	9.3
WIL (D2)	1500.0	4950.0	3051.6	7.8	8.1	7.9	217.0	1360.0	646.7	1.2	21.8	7.0
WOL1	1180.0	2710.0	1982.3	8.1	8.7	8.4	326.0	675.0	464.8	0.6	8.9	3.0
WOL2	1460.0	3150.0	2153.9	7.3	8.3	7.9	286.0	793.0	487.7	0.6	14.9	6.0

Notes:. mg/L = micrograms per litre. mS/cm= microSiemens per centimetre. NTU = nephelometric turbidity units.

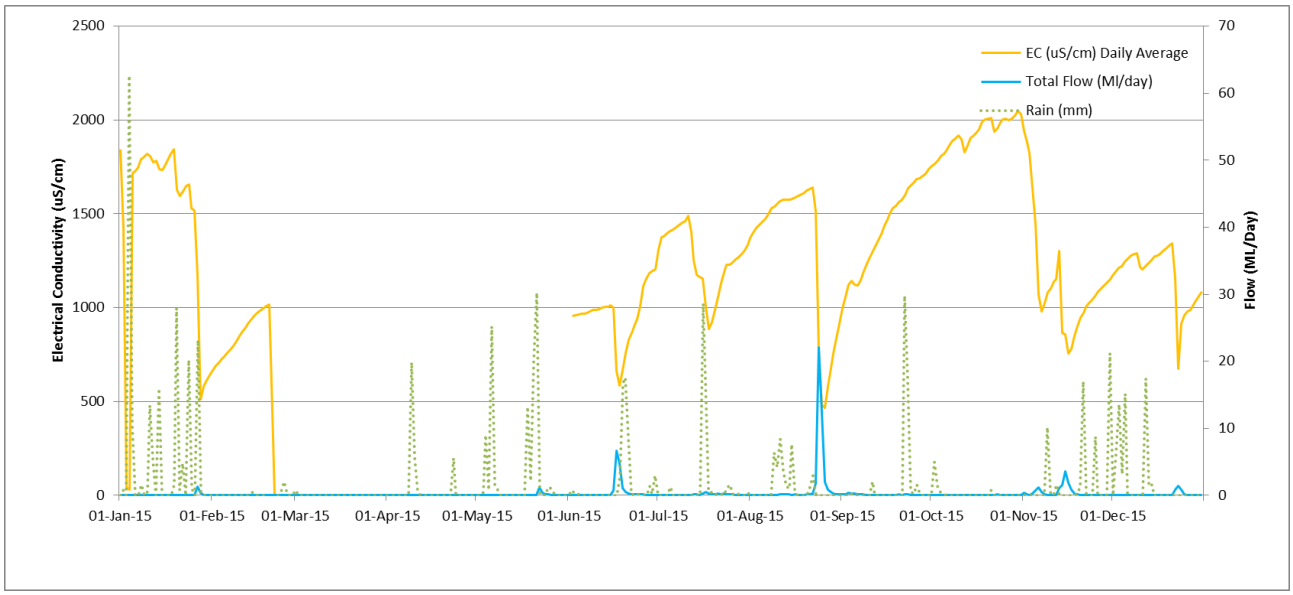
Table 14 – Surface Water Monitoring Results 2015

Sample Number	Sample Location	Sampling Date	Electrical Conductivity (Field Reading) µS/cm	Flow Rate	No Sample	pH - Field pH Unit	Sulfate mg/L	Turbidity NTU
ME1500117001	CC_1	23-JAN-2015	310	No Flow		6.9	45	467
ME1500117002	CC_2	23-JAN-2015	5180	No Flow		7.3	2010	2.7
ME1500117003	CC_3	23-JAN-2015		No Flow	Dry			
ME1500117004	WIL_U	23-JAN-2015		No Flow	Dry			
ME1500117005	WIL_U2	23-JAN-2015	3760	Low		7.3	22	20.7
ME1500117006	WIL_NC	23-JAN-2015	620	Low		7.6	51	304
ME1500117007	WIL_PC	23-JAN-2015		No Flow	Dry			
ME1500117009	WIL_D2	23-JAN-2015	1750	No Flow		8.5	693	13.5
ME1500117010	WOL_1	23-JAN-2015	2700	Low		8.2	704	1.5
ME1500117011	WOL_2	23-JAN-2015	2860	Low		7.4	617	13.3
ME1500259001	CC_1	18-FEB-2003			Dry			
ME1500259002	CC_2	18-FEB-2004			Dry			
ME1500259003	CC_3	18-FEB-2005			Dry			
ME1500259004	WIL_U	18-FEB-2006			Dry			
ME1500259005	WIL_U2	18-FEB-2007			Soft Mud Only			
ME1500259006	WIL_NC	18-FEB-2008			Dry			
ME1500259007	WIL_PC	18-FEB-2009			Dry			
ME1500259009	WIL_D2	18-FEB-2011			Dry			
ME1500259010	WOL_1	18-FEB-2012			Dry			
ME1500259011	WOL_2	18-FEB-2013	3450	No Flow		7.6	679	15.3
ME1500425001	CC_1	19-MAR-2015			Mud Only			
ME1500425002	CC_2	19-MAR-2015			Dry			
ME1500425003	CC_3	19-MAR-2015			Dry			
ME1500425004	WIL_U	19-MAR-2015			Dry			
ME1500425005	WIL_U2	19-MAR-2015	4120	Nil		5.6	118	39.9
ME1500425006	WIL_NC	19-MAR-2015	300	Nil		7.3	6	35.9
ME1500425007	WIL_PC	19-MAR-2015			Dry			
ME1500425009	WIL_D2	19-MAR-2015			Dry			
ME1500425010	WOL_1	19-MAR-2015	3610	Nil		7.5	956	5.5
ME1500425011	WOL_2	19-MAR-2015			Dry			
ME1500591001	CC_1	23-APR-2015	320	No Flow		6.6	74	2050
ME1500591002	CC_2	23-APR-2015	6290	Low Flow		7.4	2090	5.8
ME1500591003	CC_3	23-APR-2015	4430	No Flow		7.6	1680	1.6
ME1500591004	WIL_U	23-APR-2015		No Flow	Dry			
ME1500591005	WIL_U2	23-APR-2015	2280	No Flow		6.7	63	23.9
ME1500591006	WIL_NC	23-APR-2015	260	Mod. Flow		7.4	4	8.9
ME1500591007	WIL_PC	23-APR-2015		No Flow	Dry			
ME1500591009	WIL_D2	23-APR-2015	830	Low Flow		7.5	186	20.6
ME1500591010	WOL_1	23-APR-2015	1790	Low Flow		7.6	532	12.1
ME1500591011	WOL_2	23-APR-2015	3330	No Flow		7.4	711	28.8
ME1500747001	CC_1	20-MAY-2015	230	No Flow		7	43	11200
ME1500747002	CC_2	20-MAY-2015	6650	Low Flow		7.3	2290	2.7
ME1500747003	CC_3	20-MAY-2015	80	No Flow		7.8	17	359
ME1500747004	WIL_U	20-MAY-2015			Dry			
ME1500747005	WIL_U2	20-MAY-2015	1930	Low Flow		7.2	45	9.8
ME1500747006	WIL_NC	20-MAY-2015	500	No Flow		7.7	70	1440
ME1500747007	WIL_PC	20-MAY-2015			Dry			
ME1500747009	WIL_D2	20-MAY-2015	640	Low Flow		7.5	120	22.9
ME1500747010	WOL_1	20-MAY-2015	1770	Low Flow		8.2	479	11.8
ME1500747011	WOL_2	20-MAY-2015	4080	Low Flow		7.4	822	21.3
ME1500852001	CC_1	17-JUN-2015	240	Low		7.5	47	925
ME1500852002	CC_2	17-JUN-2015	5240	Medium		7.6	1710	5.4
ME1500852003	CC_3	17-JUN-2015	4260	Medium		8	1550	1.9
ME1500852004	WIL_U	17-JUN-2015			Dry			
ME1500852005	WIL_U2	17-JUN-2015	310	Medium		7.4	27	142

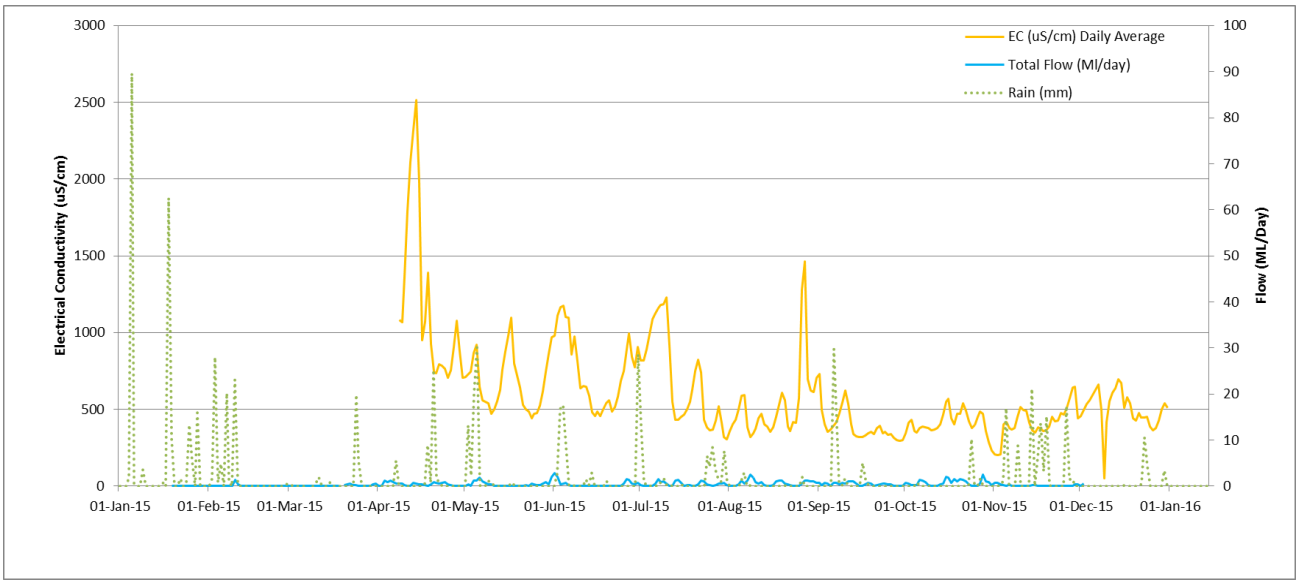
Sample Number	Sample Location	Sampling Date	Electrical Conductivity (Field Reading) µS/cm	Flow Rate	No Sample	pH - Field pH Unit	Sulfate mg/L	Turbidity NTU
ME1500852006	WIL_NC	17-JUN-2015	410	No Flow		7.8	80	202
ME1500852007	WIL_PC	17-JUN-2015	140	Low		7.9	15	222
ME1500852009	WIL_D2	17-JUN-2015	450	Medium		7.8	70	336
ME1500852010	WOL_1	17-JUN-2015	1650	Medium		8	369	10.4
ME1500852011	WOL_2	17-JUN-2015	2340	Medium		7.5	500	4.6
ME1510175001	CC_1	22-July-2015	600	No Flow		7.8	112	171
ME1510175002	CC_2	22-July-2015	5630	Low		7.9	1940	0.4
ME1510175003	CC_3	22-July-2015	5620	Medium		8.4	2100	1.2
ME1510175004	WIL_U	22-July-2015	1080	Low		6.5	92	7.4
ME1510175005	WIL_U2	22-July-2015	1210	Low		6.4	103	1.5
ME1510175006	WIL_NC	22-July-2015	1250	No Flow		6.6	106	4.6
ME1510175007	WIL_PC	22-July-2015	140	Low		7.2	3	3.9
ME1510175009	WIL_D2	22-July-2015	620	Medium		7.5	119	34
ME1510175010	WOL_1	22-July-2015	2080	Medium		8.2	446	1.1
ME1510175011	WOL_2	22-July-2015	2090	Medium		7.8	447	0.6
ME1510335001	CC_1	25-Aug-2015	4340	Medium		7.3	1660	3.3
ME1510335002	CC_2	25-Aug-2015	4730	Medium		7.9	1400	0.8
ME1510335003	CC_3	25-Aug-2015	3700	Medium		8.3	1330	1.4
ME1510335004	WIL_U	25-Aug-2015	540	High		6.8	38	263
ME1510335005	WIL_U2	25-Aug-2015	350	High		6.7	28	158
ME1510335006	WIL_NC	25-Aug-2015	340	Low		7.4	28	150
ME1510335007	WIL_PC	25-Aug-2015	390	No Flow		6.8	42	134
ME1510335009	WIL_D2	25-Aug-2015	720	High		7.6	149	106
ME1510335010	WOL_1	25-Aug-2015	1570	High		8.1	331	18.1
ME1510335011	WOL_2	25-Aug-2015	1900	High		7.8	408	4.6
ME1510500001	CC_1	24-Sep-2015		No Flow				
ME1510500002	CC_2	24-Sep-2015	5610	Low		7.9	1930	2.1
ME1510500003	CC_3	24-Sep-2015		No Flow				
ME1510500004	WIL_U	24-Sep-2015	1270	No Flow		5.6	120	27.2
ME1510500005	WIL_U2	24-Sep-2015	1880	Low		6.5	114	5.7
ME1510500006	WIL_NC	24-Sep-2015	210	Low		7.1	6	18.3
ME1510500007	WIL_PC	24-Sep-2015		No Flow				
ME1510500009	WIL_D2	24-Sep-2015	380	Low		8	30	7.5
ME1510500010	WOL_1	24-Sep-2015	1650	Low		7.6	300	10
ME1510500011	WOL_2	24-Sep-2015	2390	Low		7.5	499	2.1
ME1510657001	CC_1	22-Oct-2015	290	No Flow		7.3	55	13000
ME1510657002	CC_2	22-Oct-2015	6030	Low		7.7	2210	1.3
ME1510657003	CC_3	22-Oct-2015	140	No Flow		7	25	178
ME1510657004	WIL_U	22-Oct-2015		No Flow				
ME1510657005	WIL_U2	22-Oct-2015	2160	Low		6.8	61	6.8
ME1510657006	WIL_NC	22-Oct-2015		No Flow				
ME1510657007	WIL_PC	22-Oct-2015	190	Medium		7	4	1.8
ME1510657009	WIL_D2	22-Oct-2015	500	Medium		7.7	34	18.4
ME1510657010	WOL_1	22-Oct-2015	1640	Low		8.2	297	12.6
ME1510657011	WOL_2	22-Oct-2015	3110	Low		7.3	638	13.5
ME1510789001	CC_1	12-Nov-2015	570	No Flow		7.7	90	92.7
ME1510789002	CC_2	12-Nov-2015		No Flow				
ME1510789003	CC_3	12-Nov-2015	2490	No Flow		8.4	848	6.7
ME1510789004	WIL_U	12-Nov-2015	1480	No Flow		4.8	146	10.5
ME1510789005	WIL_U2	12-Nov-2015	2170	No Flow		7.1	46	2.3
ME1510789006	WIL_NC	12-Nov-2015	200	Low Flow		7.2	4	1.2
ME1510789007	WIL_PC	12-Nov-2015		No Flow				
ME1510789009	WIL_D2	12-Nov-2015	600	No Flow		8.2	16	16.5
ME1510789010	WOL_1	12-Nov-2015	1540	Low Flow		8.2	282	1.7
ME1510789011	WOL_2	12-Nov-2015	1560	Low Flow		7.6	278	2.6
ME1510985001	CC_1	22-Dec-2015	120	Flow			13	2830
ME1510985002	CC_2	22-Dec-2015	5750	Flow			2220	20.8
ME1510985003	CC_3	22-Dec-2015	150	Flow			18	200

Sample Number	Sample Location	Sampling Date	Electrical Conductivity (Field Reading) µS/cm	Flow Rate	No Sample	pH - Field pH Unit	Sulfate mg/L	Turbidity NTU
ME1510985004	WIL_U	22-Dec-2015		No Flow				
ME1510985005	WIL_U2	22-Dec-2015	1720	Flow			28	50.7
ME1510985006	WIL_NC	22-Dec-2015	410	Flow			75	680
ME1510985007	WIL_PC	22-Dec-2015		No Flow				
ME1510985009	WIL_D2	22-Dec-2015	500	Flow			67	557
ME1510985010	WOL_1	22-Dec-2015	1260	Flow			208	61.8
ME1510985011	WOL_2	22-Dec-2015	1470	Flow			262	486

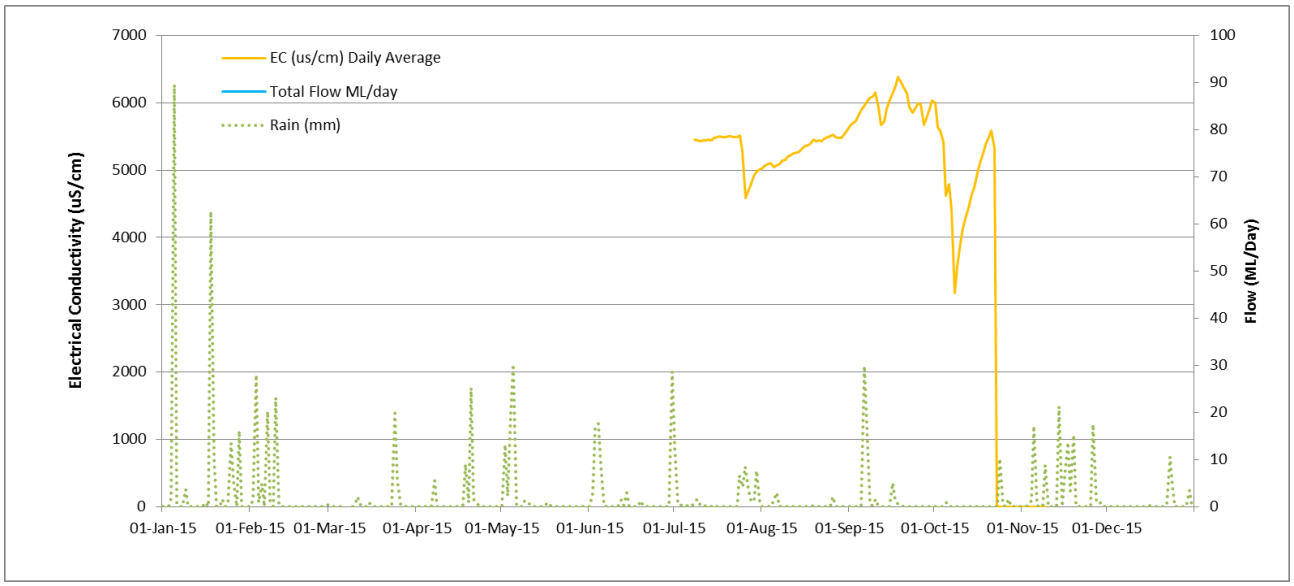
Graph 4 – Wilpinjong Creek Upstream Gauging Station



Graph 5 – Wilpinjong Creek Downstream Gauging Station



Graph 6 - Cumbo Creek Upstream Gauging Station



Graph 7 - Cumbo Creek Downstream Gauging Station

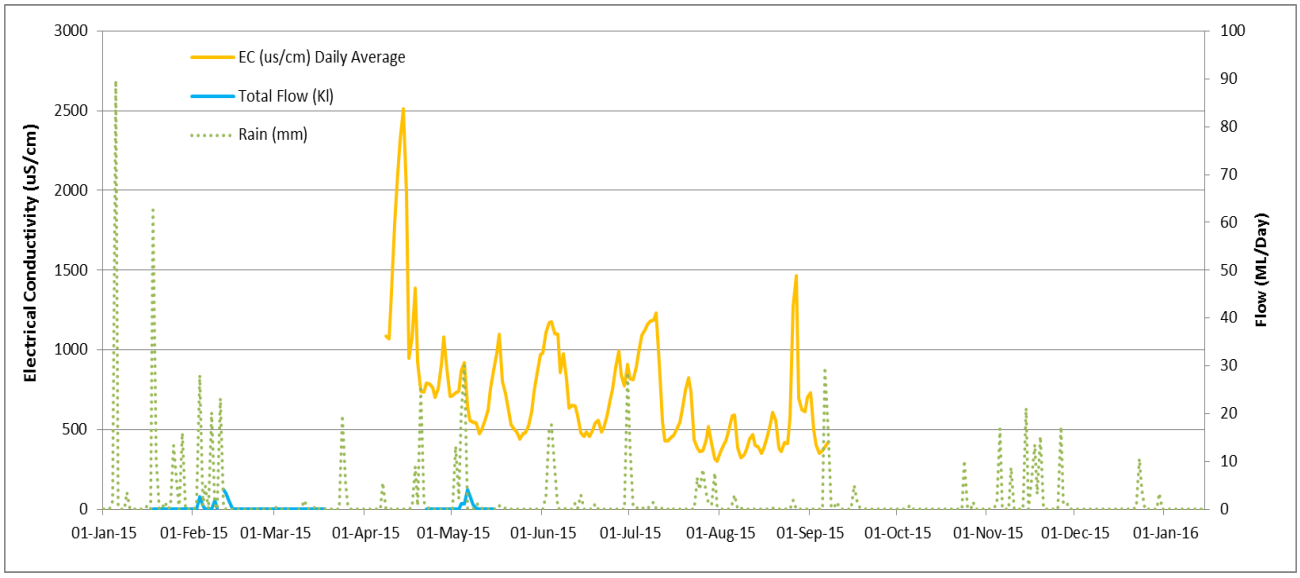


Figure 5 – Surface Water Monitoring Locations

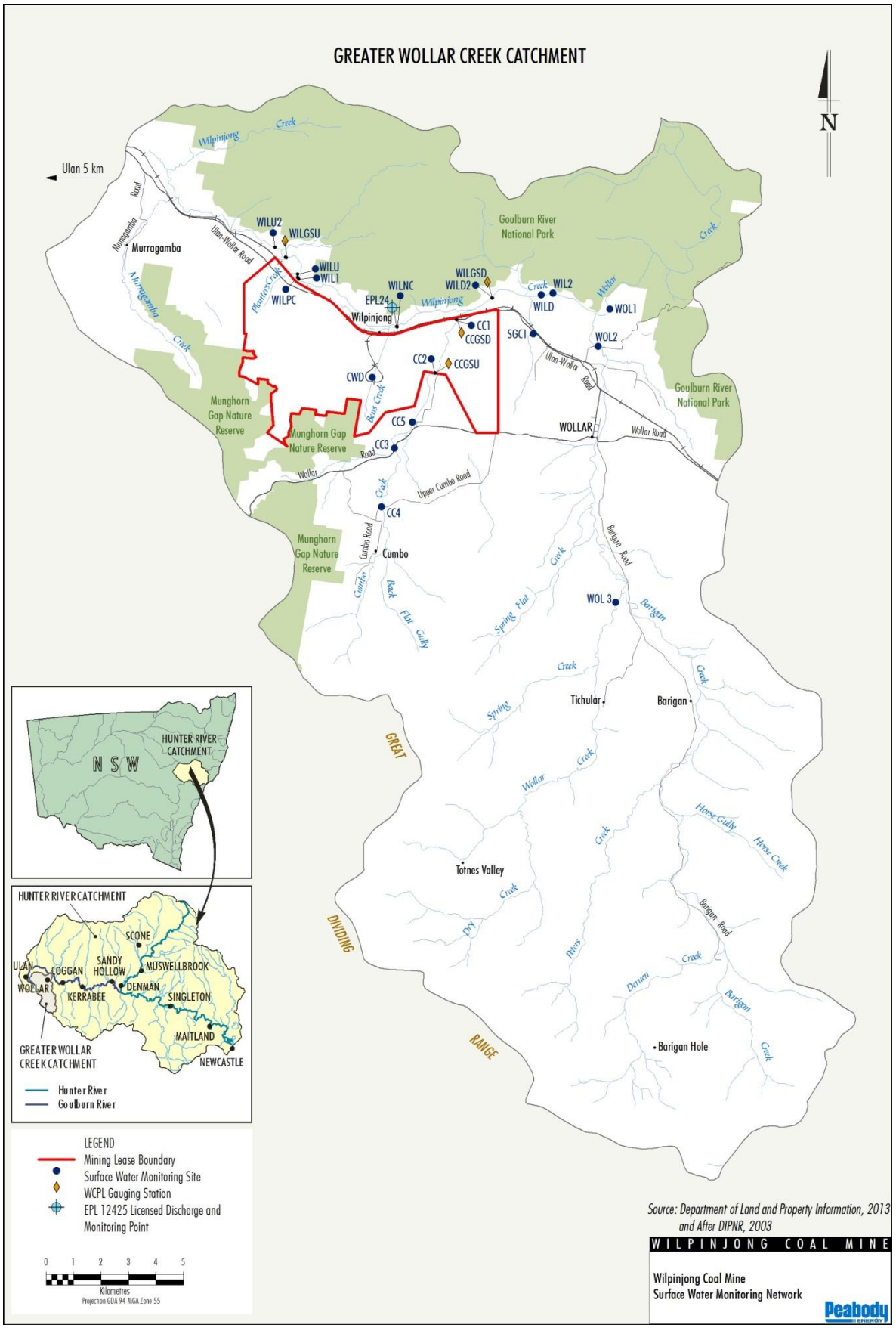
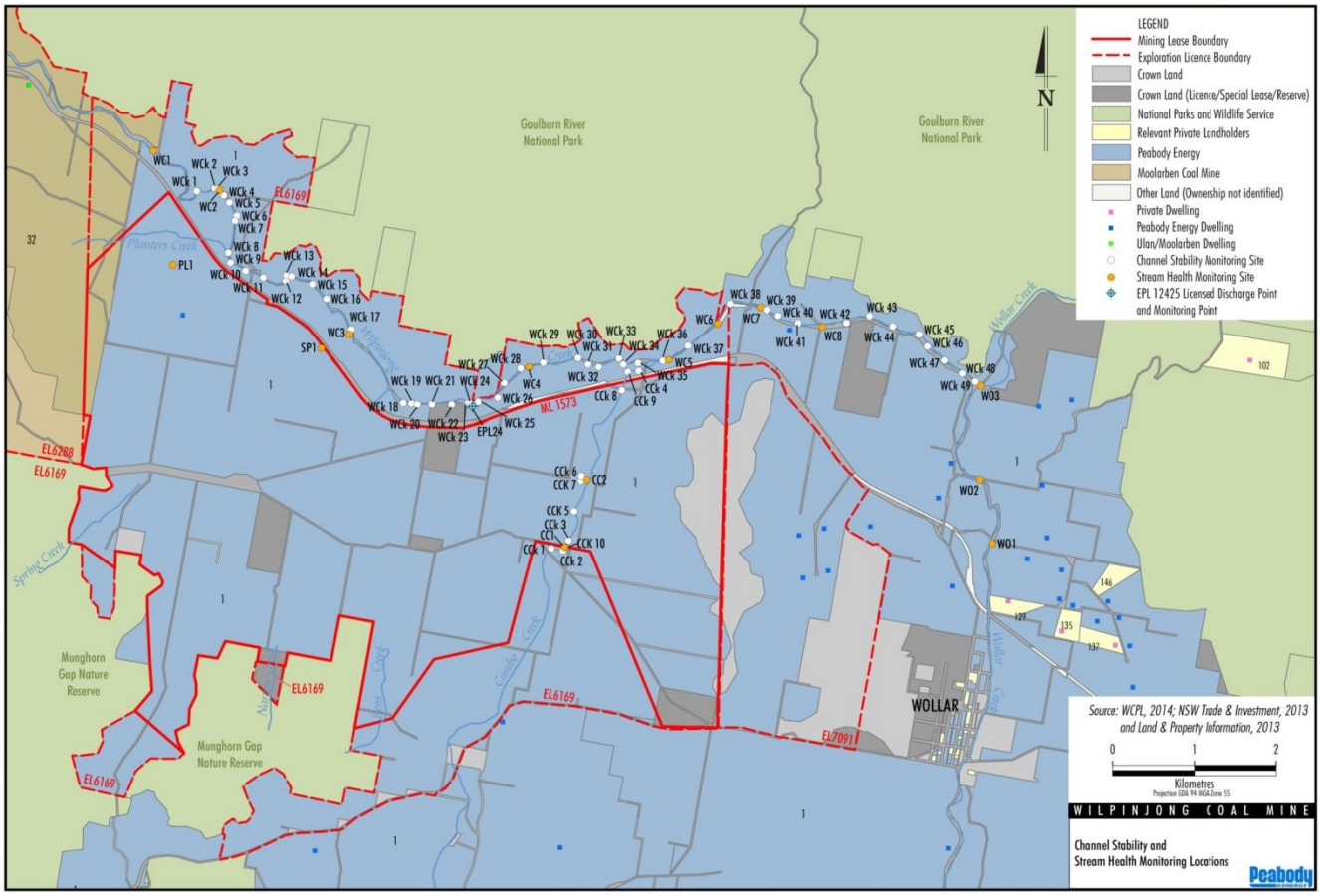


Figure 6 – Channel Stability & Stream Health Monitoring Locations



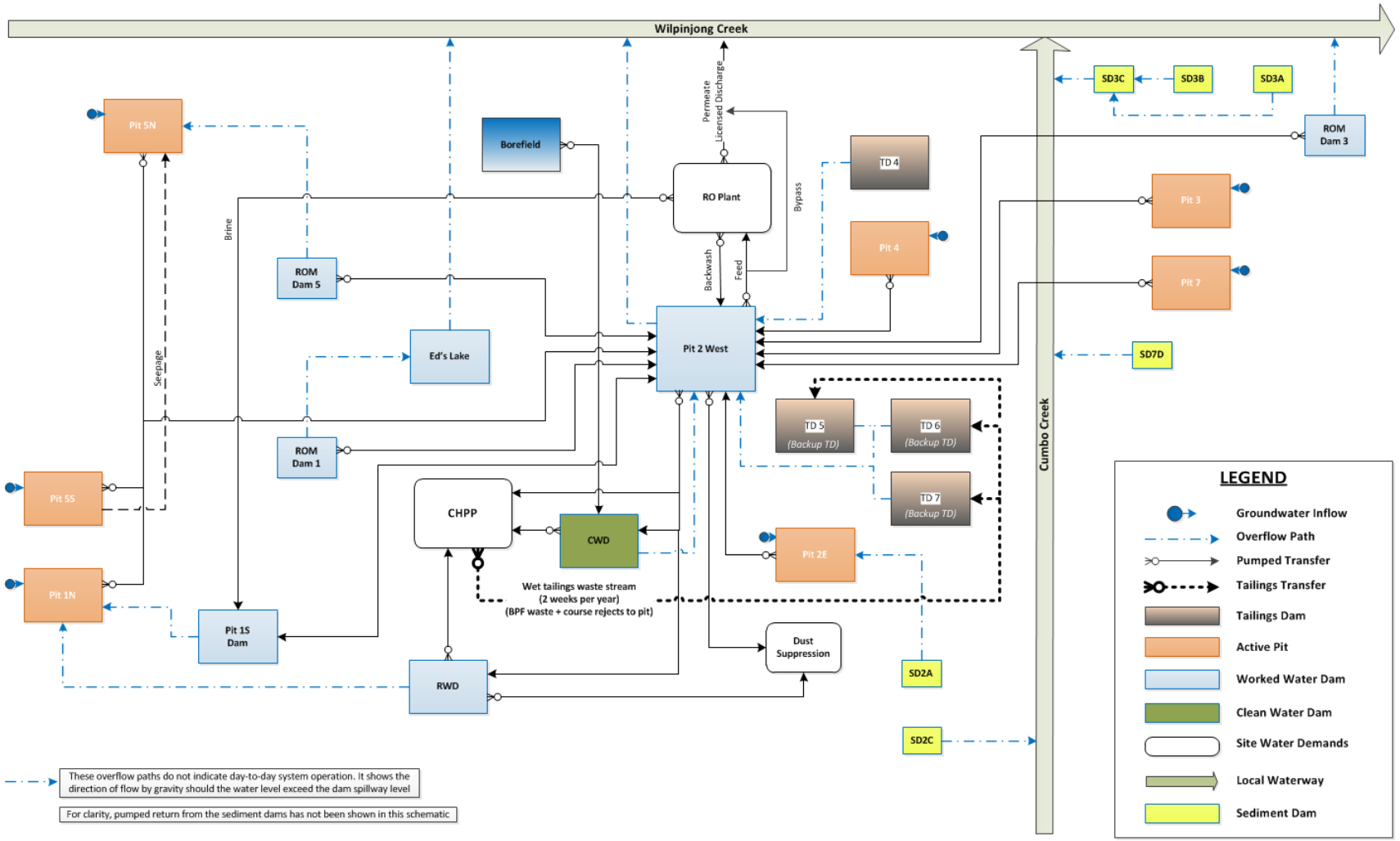


Figure 4.3 – Water management system schematic – Year 2016

Creek Stability Monitoring Reports

Wilpinjong & Cumbo Creek Stability Assessment, 2015

Wilpinjong Coal Mine

For: Ian Flood

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project management
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registered surveyors
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APPENDICES

Appendix A: Field Proforma
Appendix B: Upstream Photo Comparison
Appendix C: Downstream Photo Comparision

DOCUMENT TRACKING

ITEM	DETAILS
Project Name & Number	Wilpinjong and Cumbo Creek Stability Assessment 2015 # 23823
Document Name	23823_E02
Project Manager	Kristy Bennetts Environmental Scientist
Report Preparation	Kristy Bennetts
Peer Reviewed	Natalie Richards
Status	FINAL
Version	B
Date	10 March 2016

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1.0 INTRODUCTION

Wilpinjong Coal Proprietary Limited (WCPL) commissioned Barnson Pty Ltd (Barnson) in December 2015 to undertake the annual stability assessment of Wilpinjong and Cumbo Creeks. The 2015 assessment was undertaken as a qualitative assessment to review natural regeneration of the creek. This includes improved creek bank stability, reduction in erosional areas and improved riparian zones within the Wilpinjong Creek catchment.

This report provides details on the fieldwork undertaken in 2015, and compares Wilpinjong and Cumbo Creeks with the previous assessment in 2014, and 2011.

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.

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 2014, and 2011.

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

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 qualitative monitoring of this creek annually from 2010-2015.

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 periods of drought and flooding. To date, no rehabilitation 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.

MGA

FIGURE 1 – WILPINJONG CREEK & CUMBO CREEK SURVEY POINTS

0m 1000m 2000m 3000m 4000m 5000m

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Client: PEABODY ENERGY LIMITED

Project:
WILPINJONG CREEK
STABILITY

Drawing Title:
FIGURE 1
WILPINJONG CREEK &
CUMBO CREEK SURVEY POINTS

Design	Drawn	Rev	Date	Amendment
	BS	A	11.01.2016	
Check	QA			
KB	KB			

Drawing Sheet
A3 - Scales as noted

Certification

Drawing Number
23823–A01

Revision
A

2.0 METHODOLOGY

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 2015 was provided 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 late December 2015. This involved walking each creek from the creek headwater to its confluence. Photographs of each site (upstream, downstream) 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 and updated where required in 2015.

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^2, with the downstream catchment calculated to be 175km^2 (Gilberts & Associates, 2013). The Cumbo Creek catchment area (upstream of the confluence with Wilpinjong Creek) was reported to be 70km^2. 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 (i.e. 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 Year		5 Year		10 Year		20 Year		50 Year		100 Year	
	mm/hr	mm	mm/hr	mm	mm/hr	mm	mm/hr	mm	mm/hr	mm	mm/hr	mm	mm/hr	mm
5min	64.30	5.36	84.00	7.00	110.00	9.17	127.00	10.58	149.00	12.42	181.00	15.08	207.00	17.25
6min	59.80	5.98	78.20	7.82	102.00	10.20	118.00	11.80	139.00	13.90	168.00	16.80	192.00	19.20
10min	48.90	8.15	63.70	10.62	82.80	13.80	95.10	15.85	112.00	18.67	135.00	22.50	153.00	25.50
20min	35.80	11.93	46.40	15.47	59.60	19.87	68.00	22.67	79.50	26.50	95.30	31.77	108.00	36.00
30min	29.00	14.50	37.50	18.75	47.90	23.95	54.40	27.20	63.40	31.70	75.70	37.85	85.60	42.80
1hr	19.30	19.30	24.90	24.90	31.60	31.60	35.70	35.70	41.40	41.40	49.30	49.30	55.50	55.50
2hr	12.40	24.80	15.90	31.80	20.10	40.20	22.60	45.20	26.20	52.40	31.10	62.20	34.90	69.80
3hr	9.41	28.23	12.10	36.30	15.20	45.60	17.20	51.60	19.90	59.70	23.60	70.80	26.50	79.50
6hr	5.86	35.16	7.53	45.18	9.48	56.88	10.70	64.20	12.30	73.80	14.60	87.60	16.40	98.40
12hr	3.64	43.68	4.67	56.04	5.86	70.32	6.60	79.20	7.62	91.44	9.02	108.24	10.10	121.20
24hr	2.24	53.76	2.88	69.12	3.58	85.92	4.03	96.72	4.64	111.36	5.47	131.28	6.12	146.88
48hr	1.33	63.84	1.71	82.08	2.11	101.28	2.37	113.76	2.72	130.56	3.19	153.12	3.56	170.88
72hr	0.96	69.05	1.22	87.84	1.51	108.72	1.68	120.96	1.92	138.24	2.26	162.72	2.52	181.44

Table 2 : Rainfall depth for Durations, Exceedance per Year (EY), and Annual Exceedance Probabilities (AEP)

Duration	Duration	EY	Annual Exceedance Probability (AEP)					
	in min	1EY	50%	20%	10%	5%	2%	1%
1 min	1	1.80	2.00	2.60	3.10	3.50	4.20	4.70
2 min	2	3.00	3.30	4.30	5.00	5.80	6.70	7.40
3 min	3	4.20	4.60	6.00	7.00	8.00	9.30	10.30
4 min	4	5.20	5.80	7.60	8.90	10.10	11.80	13.10
5 min	5	6.20	6.90	9.00	10.50	12.00	14.10	15.70
10 min	10	9.80	10.90	14.30	16.70	19.20	22.60	25.30
15 min	15	12.20	13.50	17.80	20.80	23.90	28.20	31.60
30 min	30	16.30	18.00	23.70	27.80	31.90	37.60	42.10
1 hour	60	20.30	22.50	29.60	34.60	39.60	46.40	51.70
2 hour	120	24.70	27.30	35.80	41.80	47.70	55.60	61.80
3 hour	180	27.60	30.60	40.10	46.70	53.30	62.20	69.10
6 hour	360	33.90	37.60	49.60	57.80	66.10	77.30	86.20
12 hour	720	42.30	47.10	62.70	73.70	84.70	100.20	112.50
24 hour	1440	52.90	59.10	79.90	95.00	110.60	132.60	150.50
48 hour	2880	64.60	72.50	99.50	119.80	141.30	171.60	196.80
72 hour	4320	71.20	80.00	110.40	133.50	158.00	192.90	222.30
96 hour	5760	75.40	84.90	117.10	141.40	167.30	204.70	236.40
120 hour	7200	78.40	88.20	121.40	146.10	172.20	210.80	243.70
144 hour	8640	80.70	90.80	124.20	148.80	174.40	213.20	246.60
168 hour	10080	82.60	92.80	126.10	150.20	174.70	213.40	246.80

The total rainfall for the period 1 January 2015 – 31 December 2015 was calculated to be 761.6 mm, with the wettest day being December 22nd 2015, with 93.6mm 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 2014 reporting period identified the cumulative annual rainfall as 683mm, 2013 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 2015 was a far wetter year than 2014 and the long term average.

On inspection of the available 5 minute and hourly rainfall data for 2015, the following was observed:

- A rainfall event on 4 January 2015 recorded > 1 in a 100 year storm event for both for the 20 minute (39.0mm) and 30 minute (46.4mm) IFD calculations. With 62.6mm of rain falling in the 24 hour period;
- A rainfall event on 10 March 2015 recorded a storm event between 1 in 10 & 1 in 20 year for the 10 minute IFD with 16.8mm recorded;
- A rainfall event on 6 April 2015 recorded in between a 1 in 1 and a 1 in 2 year storm event for the 5 minute IFD with 6.4mm recorded.

- A rainfall event on 3 November 2015 recorded in between a 1 in 2 and a 1 in 5 year storm event for the 5 minute IFD with 7.4mm recorded in a 5 minute increment.

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

- 4 January – Upstream – no flow, Downstream - no flow;
- 10 March – Upstream – no flow, Downstream – 0.15m/s;
- 6 April – Upstream – no flow, Downstream – 0.6m/s;
- 3 December Upstream – no flow, Downstream – 0.8m/s;

No velocity data for Cumbo creek was available for the above events because of excessive siltation – a result of Ulan Wollar Road runoff. Wilpinjong Creek velocities provided above are estimates and as a result of conditions prior to these rainfall events Wilpinjong and Cumbo creeks did not always flow. It should be noted that velocity estimates are made using gauging station monitored parameters on Wilpinjong Creek (control pool height and cross sectional area across the controlling feature). Velocities in Wilpinjong Creek will vary from those estimated at the gauging station's dependant on cross sectional area.

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

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 48 sites assessed along Wilpinjong Creek, 23 were within the stable classifications and 25 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 an increase in flora species growth in the lower reaches, due to recent rainfall. 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 gullying, 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, various thistle species 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 3: 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	5	10	2.5	5	2.5	2.5	5
6	7.5	12.5	7.5	12.5	2.5	2.5	2.5	7.5	10
7	7.5	10	7.5	12.5	10	12.5	10	12.5	12.5
8	2.5	0	2.5	0	0	0	0	0	2.5
Total	39.5	44	44	66	32	44	32	37	46.5
Rating	Stable	Stable	Stable	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	10	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	15	15
8	0	0	5	5	0	0	0	0	0
Total	22	29.5	34.5	42	39	41.5	17.5	32.5	47
Rating	Highly Stable	Mod Stable	Mod Stable	Stable	Stable	Stable	Highly Stable	Mod Stable	Unstable

Site Number									
Questions	19	20	21	22	23	24	25	26	27
1	2.5	2.5	2.5	5	5	5	5	7.5	7.5
2	6	6	6	4	4	2	6	4	4
3	10	10	7.5	0	2.5	2.5	5	5	5
4	5	5	7.5	7.5	7.5	5	7.5	5	2.5
5	2.5	2.5	7.5	7.5	10	7.5	7.5	7.5	5
6	12.5	12.5	10	15	12.5	10	12.5	12.5	7.5
7	12.5	12.5	12.5	15	15	15	15	15	15
8	0	0	0	2.5	5	2.5	0	2.5	2.5
Total	51	51	53.5	56.5	61.5	49.5	58.5	59	49
Rating	Unstable	Unstable	Unstable	Mod Unstable	Mod Unstable	Unstable	Mod Unstable	Mod Unstable	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	5	5	5	5	5	7.5	5	5	5
5	5	5	2.5	7.5	7.5	7.5	5	2.5	2.5
6	10	10	7.5	10	10	12.5	10	2.5	10
7	15	15	10	15	15	10	15	15	15
8	2.5	2.5	2.5	0	0	2.5	2.5	2.5	0
Total	58.5	58.5	41.5	51.5	58.5	61	54	44	46.5
Rating	Unstable	Unstable	Stable	Unstable	Mod Unstable	Mod Unstable	Unstable	Stable	Unstable

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	2.5	5	2.5	7.5	5	2.5	2.5
5	5	2.5	2.5	7.5	2.5	7.5	7.5	2.5	2.5
6	2.5	10	10	12.5	7.5	12.5	7.5	7.5	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
Total Rating	46 Unstable	42 Stable	51 Unstable	54 Unstable	36.5 Stable	66 Highly Unstable	53.5 Unstable	53.5 Unstable	39 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	2.5
7	7.5	15	15	12.5
8	2.5	0	0	2.5
Total Rating	38.5 Stable	48.5 Stable	46.5 Stable	49.5 Unstable

Table 4: Stability - Bank erosion hazard index (BEHI) for Cumbo Creek

Questions	1	2	3	4	5	6	7	8	9	10
1	2.5	0	2.5	2.5	5	2.5	2.5	2.5	2.5	0
2	2	2	2	2	2	6	6	2	2	2
3	0	2.5	2.5	0	2.5	7.5	7.5	0	2.5	0
4	0	2.5	0	0	0	0	0	0	0	0
5	0	2.5	0	0	2.5	0	0	0	0	0
6	0	7.5	2.5	0	2.2	2.5	2.5	0	0	0
7	15	15	15	15	15	15	15	15	15	15
8	0	2.5	5	2.5	2.5	0	0	2.5	2.5	0
Total	19.5	34.5	29.5	22	31.7	33.5	33.5	22	24.5	17
Rating	Highly Stable	Mod Stable	Mod Stable	Highly Stable	Mod 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 2011 survey, to September 2014 and December 2015 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.

4.0 RECOMMENDATIONS & CONCLUSIONS

4.1 Remediation Areas

Table 5 identifies areas of concern that could be considered in future bank remedial works. These areas suffer moderate to severe erosion and poor riparian health as a result of past practises. It is suggested that WCPL consider some form of remedial works during the next year. Therefore, further surveys can monitor success.

4.2 Weed Control

There are a number of areas along Wilpinjong Creek suffering from weed infestations – including blackberry, thistle and prickly pear. The following provides an overview of locations that eradication works should be considered:

- Between Sites 3-4 Blackberry was noted;
- Around site 21 – large number of thistles;
- Between sites 24-31 – weeds including thistles and blackberry dominate;
- Site 34 – Bathurst Burr and other thistles were noted;
- Site 38 – Bathurst Burr and other thistles were noted;
- Site 43 – Blackberry noted;
- Site 44 – Bathurst Burr and blackberry noted;
- Sites 46-47 – Blackberry and prickly Pear noted.

4.3 Potential Asbestos

At the old house located near Site 40 – a pile of sheeting has been dumped and it is recommended that it be investigated as potentially containing asbestos by an appropriately qualified occupational hygienist /contaminated sites investigator.

Table 5: Suggested Remediation Areas

Reference Point	Photograph	Suggested Works
764487E 6422509N		• Bank stabilisation works – reshaping/battering • Revegetation
768557E 6422438N		• • Bank stabilisation works • Fence repairs; – reshaping/battering • Revegetation

Reference Point	Photograph	Suggested Works
Site 25		• Bank stabilisation works – reshaping/battering • Revegetation
Site 26		• Bank stabilisation works – reshaping/battering • Revegetation

Reference Point	Photograph	Suggested Works
Site 29		• Bank stabilisation works – reshaping/battering • Revegetation

4.4 Other Recommendations

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 dispensability 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.

4.5 Conclusion

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.

5.0 REFERENCES

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Appendix A

Field Sheet Proforma

Wilpinjong Creek Stability Survey 2015

Site No :	Date:	Assessor:
Easting:	Northing:	Photos collected:

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 aling 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

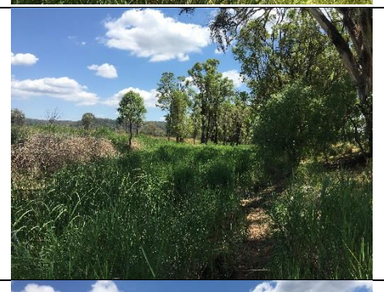
1.	Bank Height (m)						
(m)	0 - 1.5	1.5-3	3-4.5	4.5-6	6+	Value	
Value	0	2.5	5	7.5	10	Score	
2.	Bank Angle						
(°)	0-20	21-60	61-80	81-90	91-120	> 120	Value
Value	0	2	4	6	8	10	Score
3.	Percentage of Bank Height with a Bank Angle Greater than 80°						
%	0-10	11-25	26-50	51-75	76-100	Value	
Value	0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

Appendix B

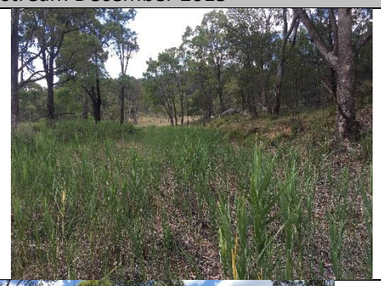
Photo Comparison Upstream

Wilpinjong Creek Photo Comparison Upstream December 2011, September 2014 and December 2015

Site	Upstream December 2011	Upstream December 2014	Upstream December 2015	Main Comparison
1				▪ Reduction in vegetative groundcover over the years; ▪ Reduction in instream flora ▪ Increased sediment deposition midstream, creating a bar feature;
2				▪ Although there is a reduction of instream growth since 2011, instream flora (grasses) is maintained between 2014-2015; ▪ Increased sediment deposition between 2014-2015; ▪ Riparian vegetation maturing; ▪ Increased leaf litter on both banks – 2014-2015; ▪ Evidence of stock, wombats and pigs in and around the creek.
3				▪ Although there is a reduction of instream growth since 2011, instream flora (grasses) is maintained between 2014-2015; ▪ Increased sediment deposition between 2014-2015; ▪ Riparian vegetation maturing; ▪ Increased leaf litter on both banks – 2014-2015; ▪ Evidence of stock, wombats and pigs in and around the creek.
4				▪ Increased erosion and exposure of the left bank; ▪ Stabilisation of instream flora – reduction from 2011; ▪ Continued sediment deposition instream,; ▪ Riparian Areas improving in growth, no evidence of stock.

Site	Upstream December 2011	Upstream December 2014	Upstream December 2015	Main Comparison
5				▪ Increased growth of grass species in the creek bed in 2015; ▪ Increased exposure of the left bank; ▪ An increase in the active channel; ▪ Natural regeneration since 2011; ▪ No evidence of stock in 2015.
6				▪ Increased growth of grass species in the creek bed in 2015; ▪ Improved groundcover on both banks; ▪ An increase in the active channel; ▪ Natural regeneration since 2011; ▪ No evidence of stock in 2015.
7				▪ Increased growth of grass species in the creek bed in 2015; ▪ Improved groundcover on both banks; ▪ An increase in the active channel; ▪ Stabilisation of the banks; ▪ Natural regeneration since 2011; ▪ No evidence of stock in 2015.
8				▪ Reduced exposure of the bank faces, increased grass coverage – 80% on both banks; ▪ No evidence of stock in the area; ▪ Blackberry sprayed ▪ Minimal riparian zone
9				▪ Right bank suffering scolding and sheet erosion – ongoing over the years; ▪ Minimal riparian zone; ▪ Natural regeneration slow in this area. ▪ Increased bleaching of exposure soils of the bank faces;

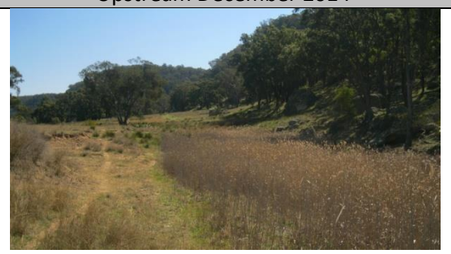
Site	Upstream December 2011	Upstream December 2014	Upstream December 2015	Main Comparison
10				▪ Increased growth of grass species in the creek bed in 2015; ▪ Improved groundcover on both banks; ▪ Stabilisation of the banks; ▪ Continued Natural regeneration since 2011; ▪ Evidence of pigs in 2015
11				▪ Area has been fenced out allowing for natural regeneration to occur; ▪ Increased growth of flora species in the creek bed since 2014; ▪ Increased coverage of grass species on the creek banks; ▪ Riparian zone remains stable; ▪ Increased active channel width in 2015.
12				▪ Site remains relatively stable in 2015; ▪ Area has been fenced out allowing for natural regeneration to occur; ▪ Increased growth of flora species in the creek bed since 2014; ▪ Increased coverage of grass species on the creek banks; ▪ Increased active channel width in 2015; ▪ Evidence of wombats in the area in 2015.
13				▪ Site remains relatively stable in 2015; ▪ Area has been fenced out allowing for natural regeneration to occur; ▪ Increased growth of flora species in the creek bed since 2014; ▪ Increased coverage of grass species on the creek banks; ▪ Increased pooling at site in 2015;
14				▪ Area has been fenced out allowing for natural regeneration to occur; ▪ Increased growth of flora species in the creek bed since 2014; ▪ Increased coverage of grass species on the creek banks; ▪ Increased active channel width in 2015; ▪ Evidence of wombats in the area in 2015

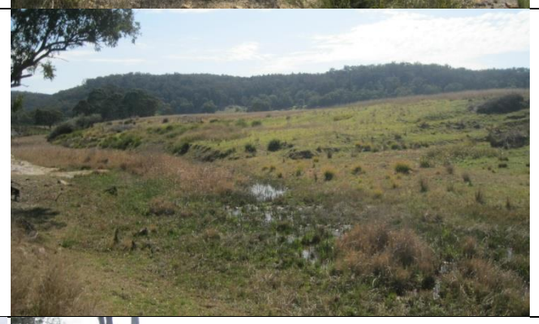
Site	Upstream December 2011	Upstream December 2014	Upstream December 2015	Main Comparison
15				▪ Site remains relatively stable in 2015; ▪ Area has been fenced out allowing for natural regeneration to occur; ▪ Increased growth of flora species in the creek bed since 2014; ▪ Increased coverage of grass species on the creek banks; ▪ Increased active channel width in 2015; ▪ Evidence of wombats in the area in 2015
16				▪ Site moved due to lack of access in 2015; ▪ No evidence of stock in the lcation; ▪ Evidence of natural regeneration occurring at the site; ▪ Banks stable.
17				▪ Increased exposure of soils along access track and in the creek bed; ▪ Bank ground coverage 100%; ▪ Active sediment deposition zone; ▪ Little to no woody riparian zone.
18				▪ Increased exposure of soils along access track and in the creek bed; ▪ Bank ground coverage 100%; ▪ Active sediment deposition zone; ▪ Little to no woody riparian zone.
19				▪ Site remains relatively stable in 2015; ▪ Area has been fenced out allowing for natural regeneration to occur; ▪ Increased growth of flora species in the creek bed since 2014; ▪ Increased coverage of grass species on the creek banks;

Site	Upstream December 2011	Upstream December 2014	Upstream December 2015	Main Comparison
20				▪ Increase in healthy instream flora; ▪ Increased growth of flora species in the creek bed since 2014; ▪ Increased coverage of grass species on the creek bank; ▪ Increased bleaching of exposed soils on the left bank face – continued exposure and erosion; ▪ Right bank remains stable; ▪ Little to no riparian zone.
21				▪ Site remains relatively similar in 2015; ▪ Some increase in exposed soil on the right bank; ▪ Little to no riparian zone.
22				▪ Increase in healthy instream flora from 2014; ▪ Increased bank groundcover growth – both banks – scotch thistles noted; ▪ Increased bleaching of exposed soils on the right bank face; ▪ Left bank remains stable; ▪ Reduction of the active channel; ▪ Little to no riparian zone.
23				▪ Increase in healthy instream flora; ▪ Increased bleaching of exposed soils on the bank faces; ▪ An increase in sheet erosion; ▪ Active channel – remains stable; ▪ Little to no riparian zone.
24				▪ Increase in healthy instream flora; ▪ Reduction in exposed soils on the right bank face – increased regeneration; ▪ An increase in sheet erosion of the right bank; ▪ Left bank remains stable; ▪ Active channel remains stable; ▪ Little to no riparian zone; ▪ Evidence of wombats

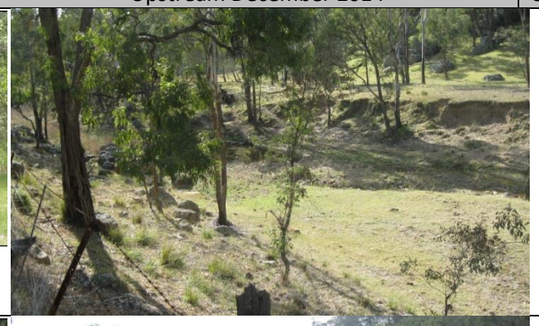
Site	Upstream December 2011	Upstream December 2014	Upstream December 2015	Main Comparison
25				▪ Increase in growth of flora species in stream from 2014; ▪ An increase in sheet erosion of the exposed bank faces; ; ▪ Active channel remains stable; ▪ Little to no riparian zone; ▪ Evidence of wombats.
26				▪ Increase in growth of flora species in stream from 2014; ▪ An increase in sheet erosion of the exposed bank faces – scold remains active; ▪ Active channel remains stable; ▪ Little to no riparian zone; ▪ Evidence of wombats and rabbits; ▪ Blackberry noted around the site
27				▪ Increase in growth of flora species in stream from 2014; ▪ Left bank increase in soil exposure and soil bleaching; ▪ Active channel remains stable; ▪ Little to no riparian zone; ▪ Evidence of wombats and rabbits; ▪ Blackberry noted around the site Reduction in healthy instream flora; ▪ Site remains similar.
28				▪ Increase in growth of flora species in stream from 2014; ▪ An increase in sheet erosion of the exposed bank faces, especially the left bank; ▪ Active channel remains stable; ▪ Little to no riparian zone; ▪ Evidence of wombats and rabbits; ▪ Blackberry noted around the site
29				▪ Increase in growth of flora species in stream from 2014; ▪ Increased stability of the right bank; ▪ Site remains similar.

Site	Upstream December 2011	Upstream December 2014	Upstream December 2015	Main Comparison
30				▪ Evidence of natural regeneration occurring; ▪ Good coverage of the creek bed and banks; ▪ Riparian zone limited to non-woody vegetation; ▪ Good general regeneration in the riparian areas as a result of destocking.
31				▪ Increase in growth of flora species in stream from 2014; ▪ An increase in sheet erosion of the exposed bank faces, especially the right bank; ▪ Active channel remains stable; ▪ Little to no riparian zone; ▪ Evidence of wombats and rabbits; ▪ Evidence of water ponding in the area in 2015; ▪ No evidence of salt crystallisation on the right bank in exposed areas in 2015.
32				▪ Increase in growth of flora species in stream from 2014; ▪ An increase in sheet erosion of the exposed bank faces, Active channel remains stable; ▪ Little to no riparian zone; ▪ Evidence of water ponding in the area in 2015; ▪ Continued regression and erosion of the right bank;
33				▪ Increase in growth of flora species in stream from 2014; ▪ Active channel remains stable; ▪ Little to no riparian zone; ▪ Evidence of wombats and rabbits; ▪ Continued regression and erosion of the left bank; ▪ Right bank remains similar.
34				▪ Increase in growth of flora species in stream from 2014; ▪ Increase in exposure on the bank surfaces, resulting in sheet erosion; ▪ Site remains similar.

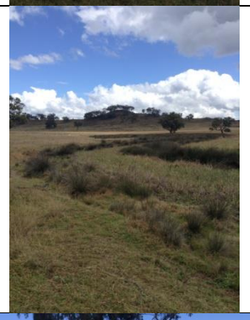
Site	Upstream December 2011	Upstream December 2014	Upstream December 2015	Main Comparison
35				▪ Increase in growth of flora species in stream from 2014; ▪ An increase in sheet erosion of the exposed bank faces, especially the right bank; ▪ Active channel remains stable; ▪ Little to no riparian zone; ▪ Evidence of wombats and rabbits;
36				▪ Instream flora remains similar in the creek bed; ▪ An increase in sheet erosion of the exposed bank faces, especially the right bank; ▪ Little to no riparian zone
37				▪ Instream flora remains similar; ▪ Active channel width remains stable; ▪ Continued regression and erosion of the right banks; ▪ Continued exposure of surface soils on the right banks due to increased dryness during 2014; ▪ Left bank remains well vegetated and stable; ▪ Little to no riparian zone.
38				▪ Natural regeneration of the site evident – increased ground coverage of the creek banks; ▪ Instream flora remains similar; ▪ Active channel width remains stable; ▪ Reduction in exposure of surface soils on the right banks in 2015; ▪ Increase in woody debris in 2015; ▪ Riparian zone developing.
39	No Access - Private property			▪ Natural regeneration of the site evident – increased ground coverage of the creek banks; ▪ Instream flora remains similar; ▪ Active channel width remains stable; ▪ Increase in woody debris in 2015; ▪ Some evidence of stock noted; ▪ Riparian zone developing.

Site	Upstream December 2011	Upstream December 2014	Upstream December 2015	Main Comparison
40	No Access - Private property			▪ Increase in growth of flora species in stream from 2014; ▪ An increase in sheet erosion of the exposed bank faces, especially the right bank; ▪ Active channel remains stable; ▪ Creek bed is well vegetated with little to no exposure of the creek bed; ▪ Both banks suffering from soil exposure and sheet erosion; ▪ Lack of riparian zone on both banks.
41	No Access - Private property		No Access – 2015 - cropping	▪ No comparison in 2015
42			No Access – 2015 - cropping	▪ No comparison in 2015
43				▪ Instream flora in the creek bed remains similar; ▪ Increased exposure of the right bank resulting in sheet erosion and soil exposure; ▪ Minor woody vegetation coverage in the riparian zone; ▪ Active channel width remains stable.

Site	Upstream December 2011	Upstream December 2014	Upstream December 2015	Main Comparison
44				▪ Active channel remains stable; ▪ Banks remain stable, however there is an increase in soil exposure and potential sheet erosion of the right bank ▪ Increased bank stability as a result of an increase in vegetation coverage on both banks; ▪ Little to no woody riparian zone in the area.
45				▪ Increase in instream flora growth in the creek bed; ▪ Bedrock material exposure appears to have reduced over the year; ▪ Creek bed width remains stable; ▪ Increased vegetation coverage and therefore a reduction in soil exposure on the left bank; ▪ Banks remains stable.
46				▪ Creek bed is well vegetated with little to no exposure of the creek bed; ▪ Both banks are well vegetated and stable; ▪ There is an increase in the active channel width; ▪ Some woody riparian zone – natural regeneration continuing. .
47				▪ An increase in the in stream flora coverage, resulting in a reduction in creek bed exposure; ▪ Both banks continue to regenerate as groundcover on the bank faces increases; ▪ Site continues to stabilise.

Site	Upstream December 2011	Upstream December 2014	Upstream December 2015	Main Comparison
48				▪ Reduction in the active channel width; ▪ Increased undercutting and gullying of the left bank face, as a result of reduced coverage; ▪ Soil exposure reamins stable instream and on the right bank face. ▪ Riparian zone naturally regenerating.
49				▪ A reduction in the active channel width; ▪ There has been an increase in groundcover within the creek bed, resulting in a reduction of soil and bed exposure; ▪ There is an increase in groundcoverage on both bank faces, as a result of natural regeneration; ▪ Site continues to regenerate.

Cumbo Creek Photo Comparison Upstream December 2013 to September 2014

Site	Upstream December 2011	Upstream September 2014	Upstream December 2015	Main Comparison
1				▪ Site remains well vegetated and stable; ▪ Lack of woody riparian zone.
2				▪ Site remains well vegetated and stable; ▪ Lack of woody riparian zone.
3				▪ Ponding site – lack of groundcover and growth due to inundation in the creek bed; ▪ Site banks remain well vegetated and stable.
4				▪ Site remains well vegetated and stable; ▪ Lack of woody riparian zone.

5				▪ Site remains well vegetated and stable; ▪ Lack of woody riparian zone.
6				▪ Site remains well vegetated and stable; ▪ Lack of woody riparian zone.
7		Missing due to construction		▪ Area exposed due to construction activities – lack of bed coverage and bank coverage in 2015
8				▪ Site remains well vegetated and stable; ▪ Lack of woody riparian zone.

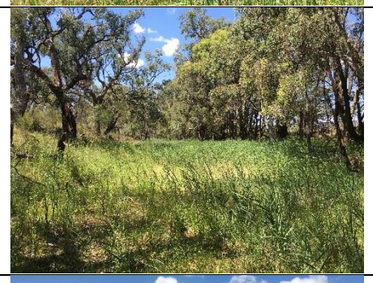
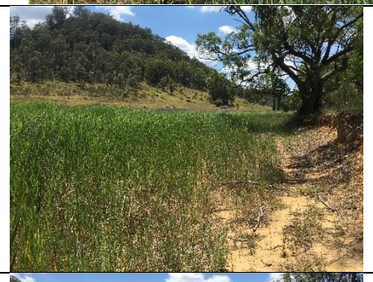
9				▪ Site remains well vegetated and stable; ▪ Lack of woody riparian zone.
10				▪ Site remains well vegetated and stable; ▪ Lack of woody riparian zone.

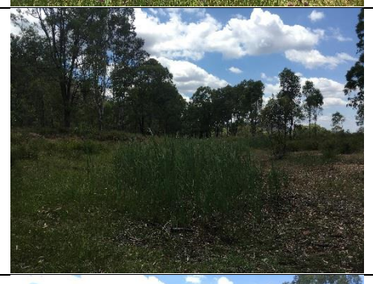
Appendix C

Photo Comparison Downstream

Wilpinjong Creek Photo Comparison Downstream December 2011, September 2014 and December 2015

Site	Downstream December 2011	Downstream September 2014	Downstream December 2015	Main Comparisons
1				▪ Increase pooling zone in 2015 to 2014; ▪ Reduction in vegetative groundcover over the years; ▪ Reduction in instream flora; ▪ Increased sediment deposition midstream, creating a bar feature;
2				▪ Continued growth of instream flora in 2015 from 2014. Reduction since 2011; ▪ Increased sediment deposition between 2014-2015; ▪ Riparian vegetation maturing; ▪ Increased leaf litter on both banks – 2014-2015; ▪ Evidence of stock, wombats and pigs in and around the creek.
3				▪ Although there is a reduction of instream growth since 2011, instream flora (grasses) is maintained between 2014-2015; ▪ Increased sediment deposition between 2014-2015; ▪ Riparian vegetation maturing; ▪ Increased leaf litter on both banks – 2014-2015; ▪ Increased exposure of bedrock on the right bank; ▪ Evidence of stock, wombats and pigs in and around the creek.
4				▪ Increased erosion and exposure of the left bank; ▪ Stabilisation of instream flora – reduction from 2011; ▪ Continued sediment deposition instream,; ▪ Riparian Areas improving in growth, no evidence of stock.
5				▪ 2015 drier than the previous seasons; ▪ Reduction in vegetative groundcover on the banks over the years; ▪ Stabilisation instream flora in this location ▪ Increased sediment deposition midstream, creating a bar feature;

Site	Downstream December 2011	Downstream September 2014	Downstream December 2015	Main Comparisons
6				▪ Increased growth of grass species in the creek bed in 2015; ▪ An increase in the active channel; ▪ Natural regeneration since 2011; ▪ No evidence of stock in 2015.
7				▪ Increased growth of grass species in the creek bed in 2015; ▪ Improved groundcover on both banks; ▪ An increase in the active channel; ▪ Natural regeneration since 2011; ▪ No evidence of stock in 2015.
8				▪ Increased growth of flora species in the creek bed in 2015; ▪ Improved groundcover on both banks; ▪ An increase in the active channel; ▪ Stabilisation of the banks; ▪ Lack of riparian vegetation still apparent; ▪ No evidence of stock in 2015.
9				▪ Increased growth of flora species in the creek bed in 2015; ▪ Right bank suffering scolding and sheet erosion – ongoing over the years; ▪ Minimal riparian zone; ▪ Natural regeneration slow in this area. ▪ Increased bleaching of exposure soils of the bank faces;
10				▪ Increased natural regeneration occuring; ▪ Increased growth of flora species in the creek bed since 2015; ▪ Improved bank stability in 2015; ▪ Evidence of pigs at site in 2015.

Site	Downstream December 2011	Downstream September 2014	Downstream December 2015	Main Comparisons
11				▪ Area has been fenced out allowing for natural regeneration to occur; ▪ Increased growth of flora species in the creek bed since 2014; ▪ Increased coverage of grass species on the creek banks; ▪ Riparian zone remains stable; ▪ Increased active channel width in 2015 – pooling at site
12				▪ Site remains relatively stable in 2015; ▪ Area has been fenced out allowing for natural regeneration to occur; ▪ Increased growth of flora species in the creek bed since 2014; ▪ Some reduction in ground coverage of grass species on the creek banks; ▪ Increased active channel width in 2015; ▪ Evidence of wombats in the area in 2015.
13				▪ Site remains relatively stable in 2015; ▪ Area has been fenced out allowing for natural regeneration to occur; ▪ Increased growth of flora species in the creek bed since 2014; ▪ Increased coverage of grass species on the creek banks – reduction in soil exposure; ▪ Increased pooling at site in 2015;
14				▪ Area has been fenced out allowing for natural regeneration to occur; ▪ Increased growth of flora species in the creek bed since 2014; ▪ Reduction of bank exposure in 2015; ▪ Increased coverage of grass species on the creek banks; ▪ Evidence of wombats in the area in 2015
15				▪ Site remains relatively stable in 2015; ▪ Area has been fenced out allowing for natural regeneration to occur; ▪ Increased growth of flora species in the creek bed since 2014; ▪ Increased coverage of grass species on the creek banks; ▪ Increased active channel width in 2015; ▪ Evidence of wombats in the area in 2015

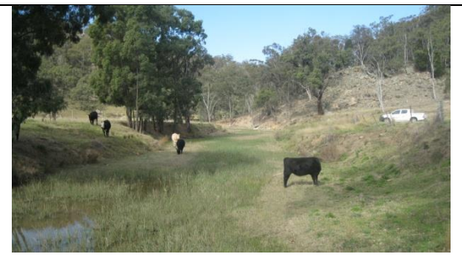
Site	Downstream December 2011	Downstream September 2014	Downstream December 2015	Main Comparisons
16				▪ Site remains relatively stable in 2015; ▪ Area has been fenced out allowing for natural regeneration to occur; ▪ Increased growth of flora species in the creek bed since 2014; ▪ Increased coverage of grass species on the creek banks; ▪ Increased active channel width in 2015; ▪ Evidence of wombats in the area in 2015
17				▪ Site moved due to lack of access in 2015; ▪ No evidence of stock in the location; ▪ Evidence of natural regeneration occurring at the site; ▪ Banks stable.
18				▪ Increased exposure of soils along access track and in the creek bed; ▪ Bank ground coverage 100%; ▪ Active sediment deposition zone; ▪ Little to no woody riparian zone.
19				▪ Site remains relatively stable in 2015; ▪ Area has been fenced out allowing for natural regeneration to occur; ▪ Increased growth of flora species in the creek bed since 2014; ▪ Increased coverage of grass species on the creek banks;
20				▪ Increase in healthy instream flora; ▪ Increased growth of flora species in the creek bed since 2014; ▪ Increased coverage of grass species on the creek bank; ▪ Little to no riparian zone.

Site	Downstream December 2011	Downstream September 2014	Downstream December 2015	Main Comparisons
21				▪ Site remains relatively similar in 2015; ▪ Some increase in exposed soil on the left bank; ▪ Little to no riparian zone.
22				▪ Increase in healthy instream flora from 2014; ▪ Increased bank groundcover growth – both banks – scotch thistles noted; ▪ Increased bleaching of exposed soils on the right bank face; ▪ Left bank remains stable; ▪ Reduction of the active channel; ▪ Little to no riparian zone.
23				▪ Increase in healthy instream flora; ▪ Increased bleaching of exposed soils on the bank faces; ▪ Active channel – remains stable; ▪ Little to no riparian zone.
24				▪ Increase in healthy instream flora; ▪ Reduction in exposed soils on the right bank face – increased regeneration; ▪ An increase in sheet erosion of the right bank; ▪ Left bank remains stable; ▪ Active channel remains stable; ▪ Little to no riparian zone; ▪ Evidence of wombats.
25				▪ Increase in growth of flora species in stream from 2014; ▪ An increase in sheet erosion of the exposed bank faces; ; ▪ Active channel remains stable; ▪ Little to no riparian zone; ▪ Evidence of wombats; ▪ Stabilisation of left bank erosion; ▪ Continued slumping and undercutting of the left bank.

Site	Downstream December 2011	Downstream September 2014	Downstream December 2015	Main Comparisons
26				▪ Increase in growth of flora species in stream from 2014; ▪ An increase in sheet erosion of the exposed bank faces – scold remains active; ▪ Active channel remains stable; ▪ Little to no riparian zone; ▪ Evidence of wombats and rabbits; ▪ Blackberry noted around the site
27				▪ Increase in growth of flora species in stream from 2014; ▪ Left bank reduction in soil exposure; ▪ Active channel remains stable; ▪ Little to no riparian zone; ▪ Evidence of wombats and rabbits; ▪ Blackberry noted around the site Reduction in healthy instream flora; ▪ Site remains similar
28				▪ Increase in growth of flora species in stream from 2014; ▪ An increase in sheet erosion of the exposed bank faces, especially the left bank; ▪ Active channel remains stable; ▪ Little to no riparian zone; ▪ Evidence of wombats and rabbits; ▪ Blackberry noted around the site
29				▪ Increase in growth of flora species in stream from 2014; ▪ Increased stability of the right bank; ▪ Site remains similar. ▪
30				▪ Evidence of natural regeneration occurring; ▪ Good coverage of the creek bed and banks; ▪ Riparian zone limited to non-woody vegetation; ▪ Good general regeneration in the riparian areas as a result of destocking. ▪ Increased bank stability of the right bank; ▪ Left bank face continues to erode naturally as a result of steep slopes and lack of ground cover;

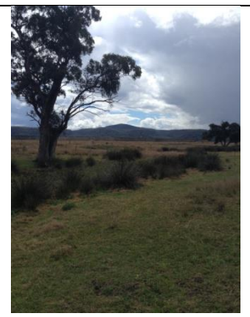
Site	Downstream December 2011	Downstream September 2014	Downstream December 2015	Main Comparisons
31				▪ Increase in growth of flora species in stream from 2014; ▪ An increase in sheet erosion of the exposed bank faces, especially the right bank; ▪ Active channel remains stable; ▪ Little to no riparian zone; ▪ Evidence of wombats and rabbits; ▪ Evidence of water ponding in the area in 2015; ▪ No evidence of salt crystallisation on the right bank in exposed areas in 2015.
32				▪ Increase in growth of flora species in stream from 2014; ▪ An increase in sheet erosion of the exposed bank faces, Active channel remains stable; ▪ Little to no riparian zone; ▪ Evidence of water ponding in the area in 2015; ▪ Continued regression and erosion of the right bank;
33				▪ Similar growth of flora species in stream from 2014; ▪ Active channel remains stable; ▪ Little to no riparian zone; ▪ Bank remains similar.
34				▪ Reduction in healthy instream flora; ▪ Soil exposure and erosion of the left bank remains stable; ▪ Site remains similar.
35				▪ Reduction in growth of flora species in stream from 2014; ▪ Increase in exposure on the bank surfaces, resulting in sheet erosion; ▪ Site remains similar. ▪ Little to no riparian zone;

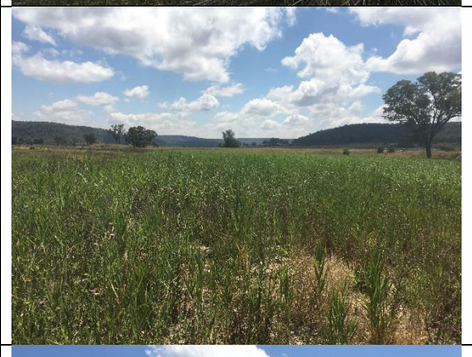
Site	Downstream December 2011	Downstream September 2014	Downstream December 2015	Main Comparisons
36				▪ Instream flora remains similar in the creek bed; ▪ An increase in sheet erosion of the exposed bank faces, especially the right bank; ▪ Little to no riparian zone
37				▪ Instream flora remains similar; ▪ Active channel width remains stable; ▪ Continued regression and erosion of the right banks; ▪ Left bank remains well vegetated and stable; ▪ Little to no riparian zone.
38				▪ Natural regeneration of the site evident – increased ground coverage of the creek banks; ▪ Instream flora remains similar; ▪ Active channel width remains stable; ▪ Reduction in exposure of surface soils on the right banks in 2015; ▪ Increase in woody debris in 2015; ▪ Riparian zone developing.
39	No Access - Private property			▪ Natural regeneration of the site evident – increased ground coverage of the creek banks; ▪ Instream flora remains similar; ▪ Active channel width remains stable. Creek bed is well vegetated with little to no exposure of the creek b ▪ Some evidence of stock noted; ▪ Riparian zone developing.; ▪ Right bank well vegetated; ▪ Left bank suffering from soil exposure and minor sheet erosion; ▪ Lack of riparian zone on both banks.
40	No Access - Private property			▪ Increase in growth of flora species in stream from 2014; ▪ Sheet erosion of the exposed bank faces, especially the right bank, continuing in 2015;; ▪ Active channel remains stable; ▪ Creek bed is well vegetated with little to no exposure of the creek bed; ▪ Lack of riparian zone on both banks.

Site	Downstream December 2011	Downstream September 2014	Downstream December 2015	Main Comparisons
41	No Access - Private property		No Access – 2015 - cropping	▪ No comparison
42			No Access – 2015 - cropping	▪ No comparison
43				▪ Instream flora in the creek bed remains similar; ▪ Knick point noted in the creek bed; ▪ Increased exposure of the right bank resulting in sheet erosion and some soil exposure; ▪ Minor woody vegetation coverage in the riparian zone; ▪ Active channel width remains stable.
44				▪ Increase in growth of flora species in the creek bank since 2014; ▪ Banks remain stable, however there is an increase in soil exposure and potential sheet erosion of the right bank ▪ Increased bank stability as a result of an increase in vegetation coverage on both banks; ▪ Little to no woody riparian zone in the area.
45				▪ Increase in instream flora growth in the creek bed; ▪ Bedrock material exposure appears to have reduced over the year; ▪ Creek bed width remains stable; ▪ Increased vegetation coverage and therefore a reduction in soil exposure on the left bank; ▪ Banks remains stable.

Site	Downstream December 2011	Downstream September 2014	Downstream December 2015	Main Comparisons
46				▪ Creek bed is well vegetated with little to no exposure of the creek bed; ▪ Both banks are well vegetated and stable; ▪ There is an increase in the active channel width; ▪ Some woody riparian zone – natural regeneration continuing. .
47				▪ An increase in the in stream flora coverage, resulting in a reduction in creek bed exposure; ▪ Both banks continue to regenerate as groundcover on the bank faces increases; ▪ Site continues to stabilise.
48				▪ Reduction in the active channel width; ▪ Increased undercutting and gullying of the left bank face, as a result of reduced coverage; ▪ Soil exposure reamins stable instream and on the right bank face. ▪ Riparian zone naturally regenerating.
49				▪ A reduction in the active channel width; ▪ There has been an increase in groundcover within the creek bed, resulting in a reduction of soil and bed exposure; ▪ There is an increase in groundcoverage on both bank faces, as a result of natural regeneration; ▪ Site continues to regenerate.

Cumbo Creek Photo Comparison Downstream December 2011, 2012 & 2013

Site	Downstream January 2011	Downstream September 2014	Downstream December 2015	Main Comparisons
1				▪ Site remains well vegetated and stable; ▪ Lack of woody riparian zone.
2				▪ Site remains well vegetated and stable; ▪ Lack of woody riparian zone.
3				Site remains well vegetated and stable; Lack of woody riparian zone.
4				▪ Site remains well vegetated and stable; ▪ Lack of woody riparian zone.

5				▪ Site remains well vegetated and stable; ▪ Lack of woody riparian zone.
6				▪ Site remains well vegetated and stable; ▪ Lack of woody riparian zone.
7	Removed from survey due to works in area.			▪ Site remains well vegetated and stable; ▪ Lack of woody riparian zone.
8				▪ Site remains well vegetated and stable; ▪ Lack of woody riparian zone.

9				▪ Site remains well vegetated and stable; ▪ Lack of woody riparian zone.
10				▪ Site remains well vegetated and stable; ▪ Lack of woody riparian zone.