APPENDIX 3C – SURFACE WATER MONITORING DATA

Summary of 2018 Surface Water Monitoring Results

SW Monitoring Point	EC (µS/cm)			pH			SO4 (mg/L)			Turbidity (NTU)		
	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave
CC1	228.0	1280.0	491.7	6.70	7.60	7.23	19.0	384.0	84.2	20.0	5520.0	1321.9
CC2	364.0	7570.0	6262.4	7.60	8.10	7.92	67.0	3000.0	2379.7	1.4	499.0	57.1
CC3	40.0	40.0	40.0	7.80	7.80	7.80	4.0	4.0	4.0	141.0	141.0	141.0
WIL (U)	-	-	-	-	-	-	-	-	-	-	-	-
WIL (U2)	1790.0	4380.0	3441.8	3.50	7.40	6.03	80.0	446.0	58.5	5.1	159.0	58.5
WIL (PC)	-	-	-	-	-	-	-	-	-	-	-	-
WIL (NC)	239.0	383.0	319.1	6.70	7.50	7.28	41.0	100.0	66.3	0.4	2.8	1.4
WIL (D)	278.0	2020.0	669.7	5.20	8.00	6.92	20.0	553.0	134.7	1.3	288.0	44.3
WIL (D2)	236.0	569.0	386.3	4.20	7.80	6.84	33.0	204.0	80.9	1.6	396.0	104.3
WOL1	425.0	2150.0	1260.1	7.20	8.40	8.01	41.0	494.0	294.1	1.0	19.6	6.8
WOL2	1730.0	2850.0	2404.5	7.00	7.90	7.51	209.0	740.0	447.7	1.0	36.2	6.1

Summary of 2017 Surface Water Monitoring Results

SW Monitoring Point	EC (µS/cm)			pH			SO4 (mg/L)			Turbidity (NTU)		
	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave
CC1	279.0	5380.0	2392.3	7.00	8.30	7.58	45.0	1790.0	787.0	4.4	1970.0	600.9
CC2	5470.0	8230.0	6306.0	7.70	8.30	7.99	1700.0	3170.0	2145.0	0.6	15.8	4.1
CC3	4100.0	4990.0	4520.0	8.30	8.50	8.40	1490.0	1920.0	1688.0	0.6	1.8	1.2
WIL (U)*	-	-	-	-	-	-	-	-	-	-	-	-
WIL (U2)	1360.0	3890.0	2851.7	5.40	8.00	6.58	13.0	121.0	20.9	2.4	70.8	20.9
WIL (PC)*	-	-	-	-	-	-	-	-	-	-	-	-
WIL (NC)	230.0	411.0	313.2	6.80	8.30	7.27	10.0	85.0	48.1	0.2	15.2	3.7
WIL (D)	248.0	1480.0	493.5	7.30	7.80	7.55	7.0	87.0	46.4	2.2	5.6	3.8
WIL (D2)	256.0	650.0	386.8	7.30	7.90	7.53	2.0	83.0	47.7	1.7	31.9	10.3
WOL1	336.0	1490.0	872.4	8.10	8.60	8.25	19.0	184.0	97.2	0.9	6.1	2.9
WOL2	1800.0	2950.0	2133.6	7.40	8.00	7.82	184.0	440.0	304.2	0.4	21.1	3.2

Notes: mg/L = micrograms per litre. mS/cm= micro Siemens per centimetre. NTU = nephelometric turbidity units. *Dry

Summary of 2016 Surface Water Monitoring Results

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	170.0	4470.0	2802.9	7.10	7.90	7.41	28.0	1710.0	978.9	4.6	6270.0	936.0
CC2	3020.0	7540.0	5036.3	7.50	8.00	7.84	920.0	2940.0	1738.8	0.5	26.4	5.0
CC3	80.0	4860.0	2771.7	7.40	8.40	8.18	8.0	1920.0	972.5	0.7	126.0	25.1
WIL (U)	520.0	950.0	632.0	6.20	7.40	6.94	13.0	83.0	36.8	5.8	43.5	21.2
WIL (U2)	440.0	4420.0	2140.0	6.50	7.60	7.04	14.0	102.0	34.8	3.3	153.0	34.8
WIL (PC)	260.0	1340.0	682.0	6.90	7.40	7.16	7.0	48.0	28.6	9.7	64.6	38.3
WIL (NC)	240.0	1650.0	560.8	7.10	7.80	7.39	8.0	265.0	64.5	8.6	201.0	54.2
WIL (D)	580.0	3030.0	1189.2	6.80	8.00	7.46	12.0	603.0	165.5	1.2	39.4	10.0
WIL (D2)	390.0	1840.0	796.1	6.90	8.10	7.50	9.0	466.0	159.1	3.9	323.0	43.8
WOL1	780.0	2220.0	1226.3	7.80	8.30	8.11	104.0	475.0	205.8	1.3	11.2	5.0
WOL2	740.0	3160.0	1693.3	7.20	8.00	7.56	97.0	650.0	303.1	0.9	70.7	15.3
SGC_1*	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Notes: mg/L = micrograms per litre. mS/cm= micro Siemens per centimetre. NTU = nephelometric turbidity units. *Dry

Summary of 2015 Surface Water Monitoring Results

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= micro Siemens per centimetre. NTU = nephelometric turbidity units.

Summary of 2014 Surface Water Monitoring Results

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= micro Siemens per centimetre. NTU = nephelometric turbidity units. * Indicates no sample available during the schedule monitoring programme.

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Summary of 2013 Surface Water Monitoring Results

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

2018 Results for Surface Water Monitoring

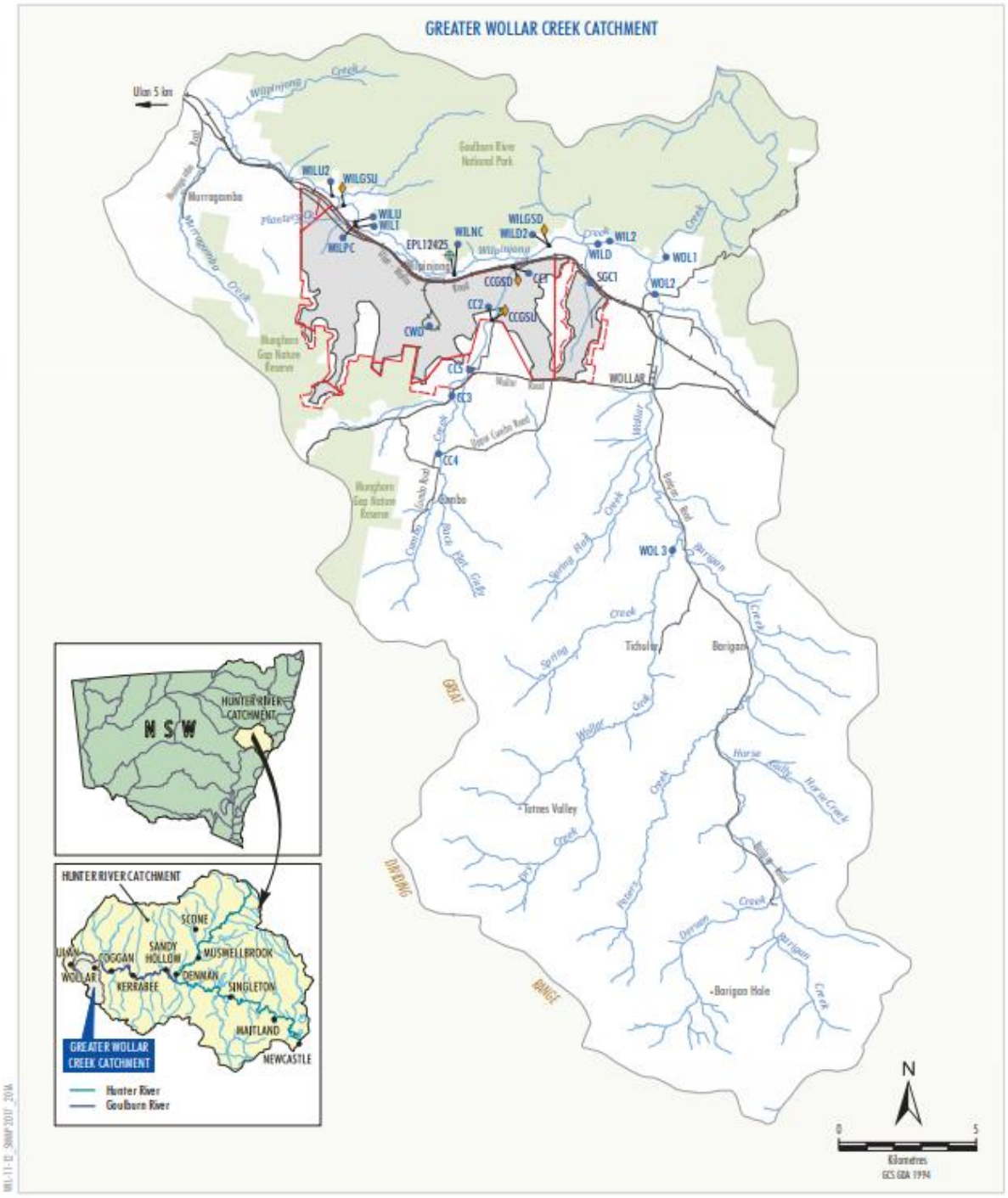
Sample Number	Sample Location	Sampling Date	Electrical Conductivity (Field Reading) µS/cm	pH - Field pH Unit	Sulfate mg/L	Turbidity NTU
ME1800081001	CC_1	17-Jan-2018				
ME1800081002	CC_2	17-Jan-2018				
ME1800081003	CC_3	17-Jan-2018				
ME1800081004	WIL_U	17-Jan-2018				
ME1800081005	WIL_U2	17-Jan-2018	4110	6.1	154	159
ME1800081006	WIL_NC	17-Jan-2018				
ME1800081007	WIL_PC	17-Jan-2018				
ME1800081008	WIL_D	17-Jan-2018	629	7.6	36	4.1
ME1800081009	WIL_D2	17-Jan-2018	569	7.7	37	358
ME1800081010	WOL_1	17-Jan-2018	499	8.4	41	2.2
ME1800081011	WOL_2	17-Jan-2018	2820	7.7	209	2.1
ME1800081012	SGC_1	17-Jan-2018				
ME1800223001	CC_1	14-Feb-2018	476	7.3	66	5520
ME1800223002	CC_2	14-Feb-2018				
ME1800223003	CC_3	14-Feb-2018				
ME1800223004	WIL_U	14-Feb-2018				
ME1800223005	WIL_U2	14-Feb-2018				
ME1800223006	WIL_NC	14-Feb-2018				
ME1800223007	WIL_PC	14-Feb-2018				
ME1800223008	WIL_D	14-Feb-2018	1500	8	149	27
ME1800223009	WIL_D2	14-Feb-2018				
ME1800223010	WOL_1	14-Feb-2018				
ME1800223011	WOL_2	14-Feb-2018				
ME1800223012	SGC_1	14-Feb-2018				
ME1800345001	CC_1	12-Mar-2018	1280	6.7	384	20
ME1800345002	CC_2	12-Mar-2018	6100	7.9	2960	28.8
ME1800345003	CC_3	12-Mar-2018				
ME1800345004	WIL_U	12-Mar-2018				
ME1800345005	WIL_U2	12-Mar-2018	4360	3.5	446	19.3
ME1800345006	WIL_NC	12-Mar-2018				
ME1800345007	WIL_PC	12-Mar-2018				
ME1800345008	WIL_D	12-Mar-2018	2020	6.6	553	4
ME1800345009	WIL_D2	12-Mar-2018				
ME1800345010	WOL_1	12-Mar-2018	1420	8	433	1.5
ME1800345011	WOL_2	12-Mar-2018	2370	7.2	740	3.8
ME1800345012	SGC_1	12-Mar-2018				
ME1800522001	CC_1	19-Apr-2018	308	7	48	1610
ME1800522002	CC_2	19-Apr-2018	364	7.6	67	499
ME1800522003	CC_3	19-Apr-2018	40	7.8	4	141
ME1800522004	WIL_U	19-Apr-2018				
ME1800522005	WIL_U2	19-Apr-2018	4380	5.3	358	45.7
ME1800522006	WIL_NC	19-Apr-2018	345	6.7	80	0.9
ME1800522007	WIL_PC	19-Apr-2018				
ME1800522008	WIL_D	19-Apr-2018	673	5.2	308	1.3
ME1800522009	WIL_D2	19-Apr-2018	507	4.2	204	1.6

Sample Number	Sample Location	Sampling Date	Electrical Conductivity (Field Reading) µS/cm	pH - Field pH Unit	Sulfate mg/L	Turbidity NTU
ME1800522010	WOL_1	19-Apr-2018	1170	7.8	494	1.9
ME1800522011	WOL_2	19-Apr-2018	2850	7.3	570	4
ME1800522012	SGC_1	19-Apr-2018				
ME1800666001	CC_1	17-May-2018				
ME1800666002	CC_2	17-May-2018	6950	7.9	2280	1.7
ME1800666003	CC_3	17-May-2018				
ME1800666004	WIL_U	17-May-2018				
ME1800666005	WIL_U2	17-May-2018	3910	5.7	103	5.1
ME1800666006	WIL_NC	17-May-2018	383	7	82	0.9
ME1800666007	WIL_PC	17-May-2018				
ME1800666008	WIL_D	17-May-2018	442	6	129	9.6
ME1800666009	WIL_D2	17-May-2018	405	4.7	127	5
ME1800666010	WOL_1	17-May-2018	497	7.2	147	4.9
ME1800666011	WOL_2	17-May-2018	1730	7	292	3.8
ME1800666012	SGC_1	17-May-2018				
ME1800785001	CC_1	14-Jun-2018	401	7.1	48	372
ME1800785002	CC_2	14-Jun-2018	7150	7.9	2620	1.4
ME1800785003	CC_3	14-Jun-2018				
ME1800785004	WIL_U	14-Jun-2018				
ME1800785005	WIL_U2	14-Jun-2018	3250	7.4	151	21.4
ME1800785006	WIL_NC	14-Jun-2018	360	7.5	100	0.7
ME1800785007	WIL_PC	14-Jun-2018				
ME1800785008	WIL_D	14-Jun-2018	377	7	102	32.9
ME1800785009	WIL_D2	14-Jun-2018	325	7.1	92	9.5
ME1800785010	WOL_1	14-Jun-2018	425	7.9	117	11.1
ME1800785011	WOL_2	14-Jun-2018	2580	7.1	417	2.4
ME1800785012	SGC_1	14-Jun-2018				
ME1800952001	CC_1	18-Jul-2018				
ME1800952002	CC_2	18-Jul-2018	6820	8.1	2620	1.6
ME1800952003	CC_3	18-Jul-2018				
ME1800952004	WIL_U	18-Jul-2018				
ME1800952005	WIL_U2	18-Jul-2018	3190	5.9	159	13.4
ME1800952006	WIL_NC	18-Jul-2018	262	7.4	54	2.8
ME1800952007	WIL_PC	18-Jul-2018				
ME1800952008	WIL_D	18-Jul-2018	388	7.1	90	36.6
ME1800952009	WIL_D2	18-Jul-2018	361	7.4	96	33.4
ME1800952010	WOL_1	18-Jul-2018	1360	8.1	326	9.6
ME1800952011	WOL_2	18-Jul-2018	2570	7.9	645	1
ME1800952012	SGC_1	18-Jul-2018				
ME1801045001	CC_1	08-Aug-2018	380	7.6	86	277
ME1801045002	CC_2	08-Aug-2018	6930	8.1	2400	4.6
ME1801045003	CC_3	08-Aug-2018				
ME1801045004	WIL_U	08-Aug-2018				
ME1801045005	WIL_U2	08-Aug-2018	3010	6.4	127	12.1
ME1801045006	WIL_NC	08-Aug-2018	301	7.5	54	1.1
ME1801045007	WIL_PC	08-Aug-2018				
ME1801045008	WIL_D	08-Aug-2018	375	7.1	69	44.8
ME1801045009	WIL_D2	08-Aug-2018	336	7.6	57	26.3
ME1801045010	WOL_1	08-Aug-2018	1560	8.1	390	11.3
ME1801045011	WOL_2	08-Aug-2018	2360	7.9	526	1.3
ME1801045012	SGC_1	08-Aug-2018				

Sample Number	Sample Location	Sampling Date	Electrical Conductivity (Field Reading) µS/cm	pH - Field pH Unit	Sulfate mg/L	Turbidity NTU
ME1801229001	CC_1	18-Sep-2018	441	7.6	33	375
ME1801229002	CC_2	18-Sep-2018	6600	8	2410	5
ME1801229003	CC_3	18-Sep-2018				
ME1801229004	WIL_U	18-Sep-2018				
ME1801229005	WIL_U2	18-Sep-2018	2960	6.2	140	29.2
ME1801229006	WIL_NC	18-Sep-2018	239	7.5	41	1.6
ME1801229007	WIL_PC	18-Sep-2018				
ME1801229008	WIL_D	18-Sep-2018	414	7.4	42	31.4
ME1801229009	WIL_D2	18-Sep-2018	355	7.7	52	48.4
ME1801229010	WOL_1	18-Sep-2018	1560	8.2	287	4.7
ME1801229011	WOL_2	18-Sep-2018	2110	7.8	422	3.8
ME1801229012	SGC_1	18-Sep-2018				
ME1801371001	CC_1	17-Oct-2018	528	7.4	41	493
ME1801371002	CC_2	17-Oct-2018	6730	8	2530	11.7
ME1801371003	CC_3	17-Oct-2018				
ME1801371004	WIL_U	17-Oct-2018				
ME1801371005	WIL_U2	17-Oct-2018	3270	6.6	80	84.8
ME1801371006	WIL_NC	17-Oct-2018	292	7.5	48	0.4
ME1801371007	WIL_PC	17-Oct-2018				
ME1801371008	WIL_D	17-Oct-2018	452	7.4	30	28.1
ME1801371009	WIL_D2	17-Oct-2018	383	7.7	41	83.7
ME1801371010	WOL_1	17-Oct-2018	2150	8.2	389	19.6
ME1801371011	WOL_2	17-Oct-2018	2220	7.7	397	2.5
ME1801371012	SGC_1	17-Oct-2018				
ME1801504001	CC_1	14-Nov-2018	383	7.2	33	1370
ME1801504002	CC_2	14-Nov-2018	7570	8.1	2910	14.3
ME1801504003	CC_3	14-Nov-2018				
ME1801504004	WIL_U	14-Nov-2018				
ME1801504005	WIL_U2	14-Nov-2018	3630	6.4	80	157
ME1801504006	WIL_NC	14-Nov-2018	371	7.1	71	2.6
ME1801504007	WIL_PC	14-Nov-2018				
ME1801504008	WIL_D	14-Nov-2018	488	7.4	20	23.8
ME1801504009	WIL_D2	14-Nov-2018	386	7.8	33	81
ME1801504010	WOL_1	14-Nov-2018	1960	8.2	317	1
ME1801504011	WOL_2	14-Nov-2018	2500	7.4	413	5.9
ME1801504012	SGC_1	14-Nov-2018				
ME1801638001	CC_1	13-Dec-2018	228	7.2	19	1860
ME1801638002	CC_2	13-Dec-2018	7410	7.6	3000	2.4
ME1801638003	CC_3	13-Dec-2018				
ME1801638004	WIL_U	13-Dec-2018				
ME1801638005	WIL_U2	13-Dec-2018	1790	6.8	100	96.1
ME1801638006	WIL_NC	13-Dec-2018				
ME1801638007	WIL_PC	13-Dec-2018				
ME1801638008	WIL_D	13-Dec-2018	278	6.2	88	288
ME1801638009	WIL_D2	13-Dec-2018	236	6.5	70	396
ME1801638010	WOL_1	13-Dec-2018	242	7.5	43	371
ME1801638011	WOL_2	13-Dec-2018	2340	7.6	294	36.2

Sample Number	Sample Location	Sampling Date	Electrical Conductivity (Field Reading) µS/cm	pH - Field pH Unit	Sulfate mg/L	Turbidity NTU
ME1801638012	SGC_1	13-Dec-2018				

Surface Water Monitoring Locations



LEGEND
- Mining Lease Boundary
- Mining Lease Application Boundary
- Approved/Existing Open Cut and Contained Infrastructure Area

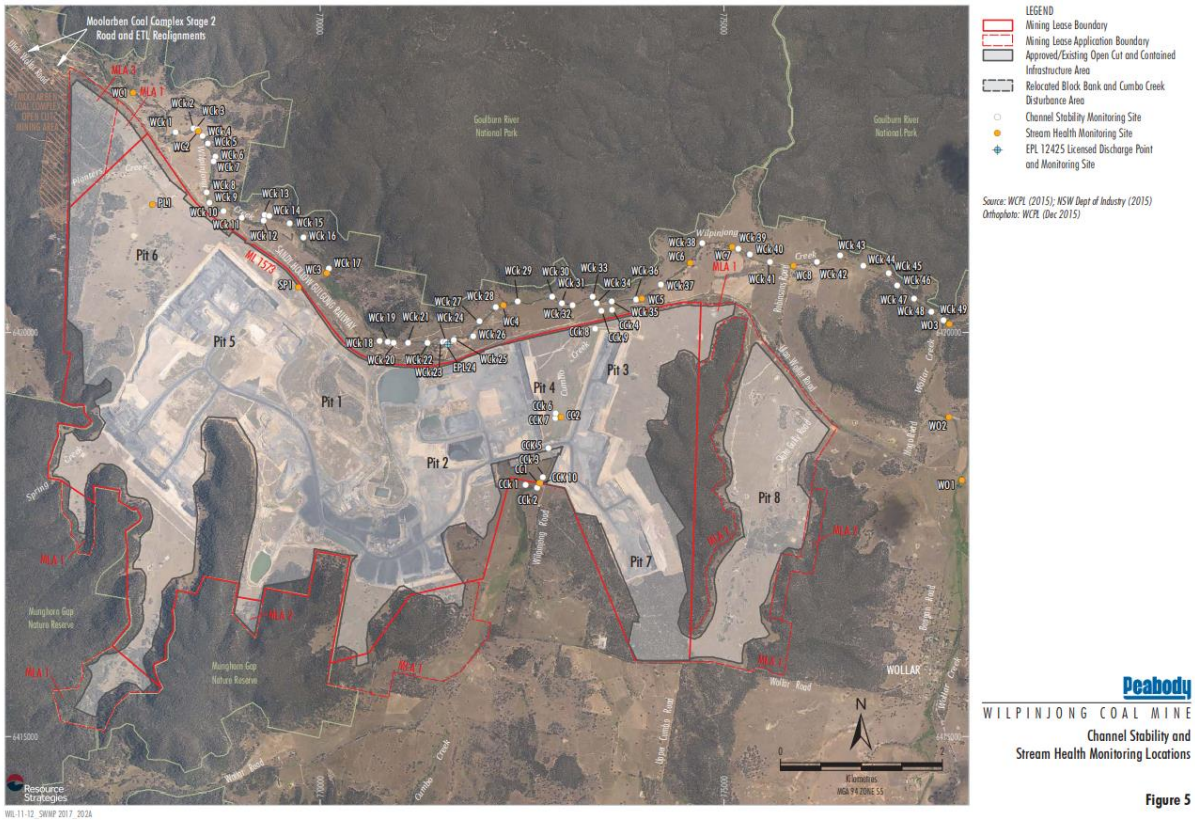
WCPL Monitoring
- Surface Water Monitoring Site
- WCPL Gauging Station
- EPL 12425 Licensed Discharge and Monitoring Point

Source: WCPL (2017); After DIPNR (2003); DPI Water (2015); NSW Land & Property Information (2013)

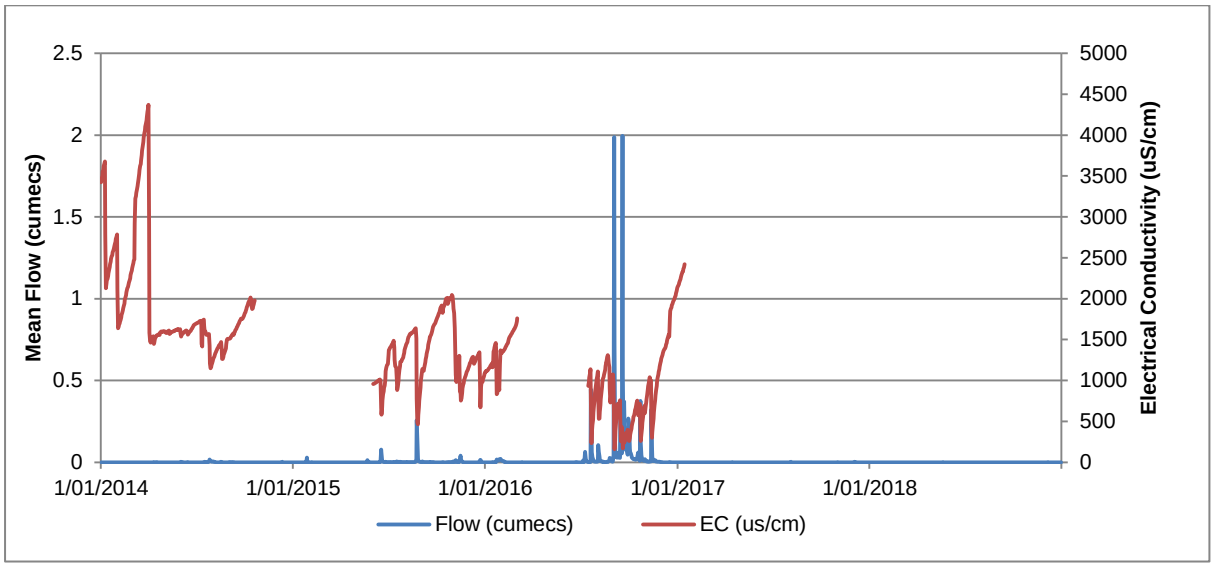
Peabody
WILPINJONG COAL MINE
Wilpinjong Coal Mine
Surface Water Monitoring Network

Figure 3

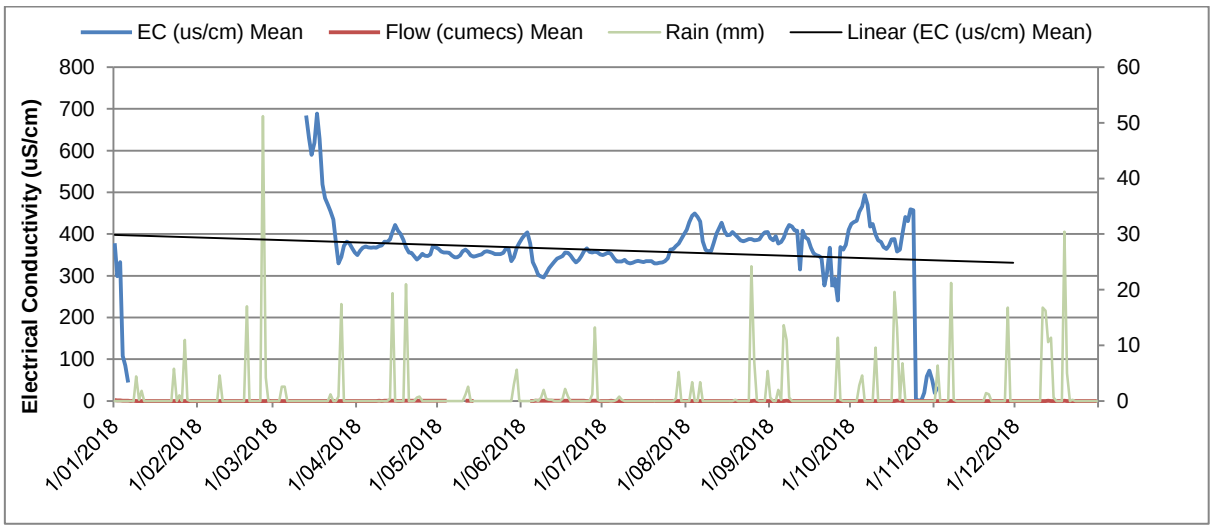
Channel Stability & Stream Health Monitoring Locations



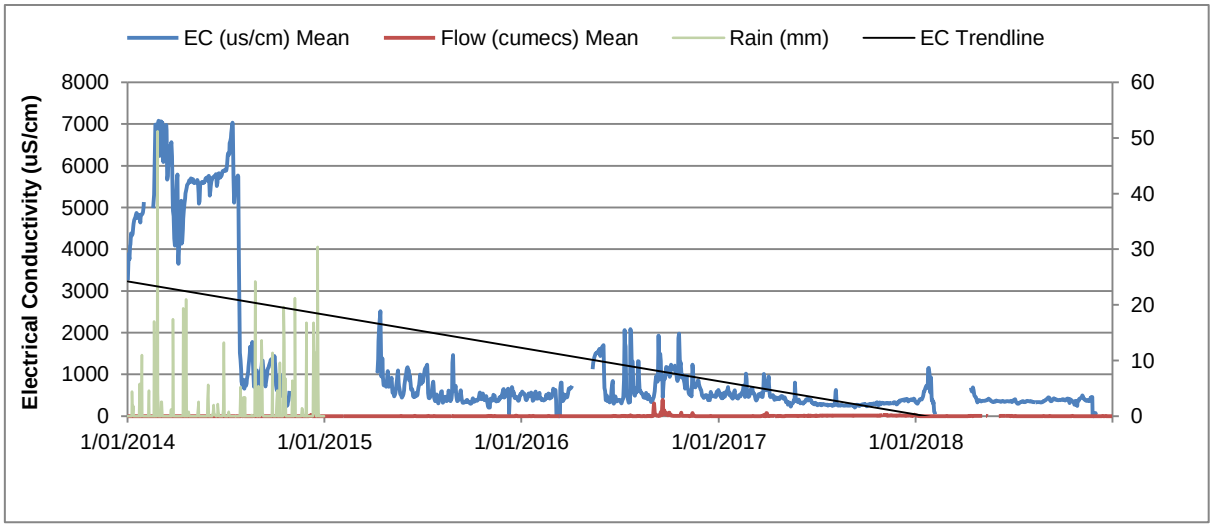
2014-2018 Wilpinjong Creek Upstream Gauging Station



2018 Wilpinjong Creek Downstream Gauging Station

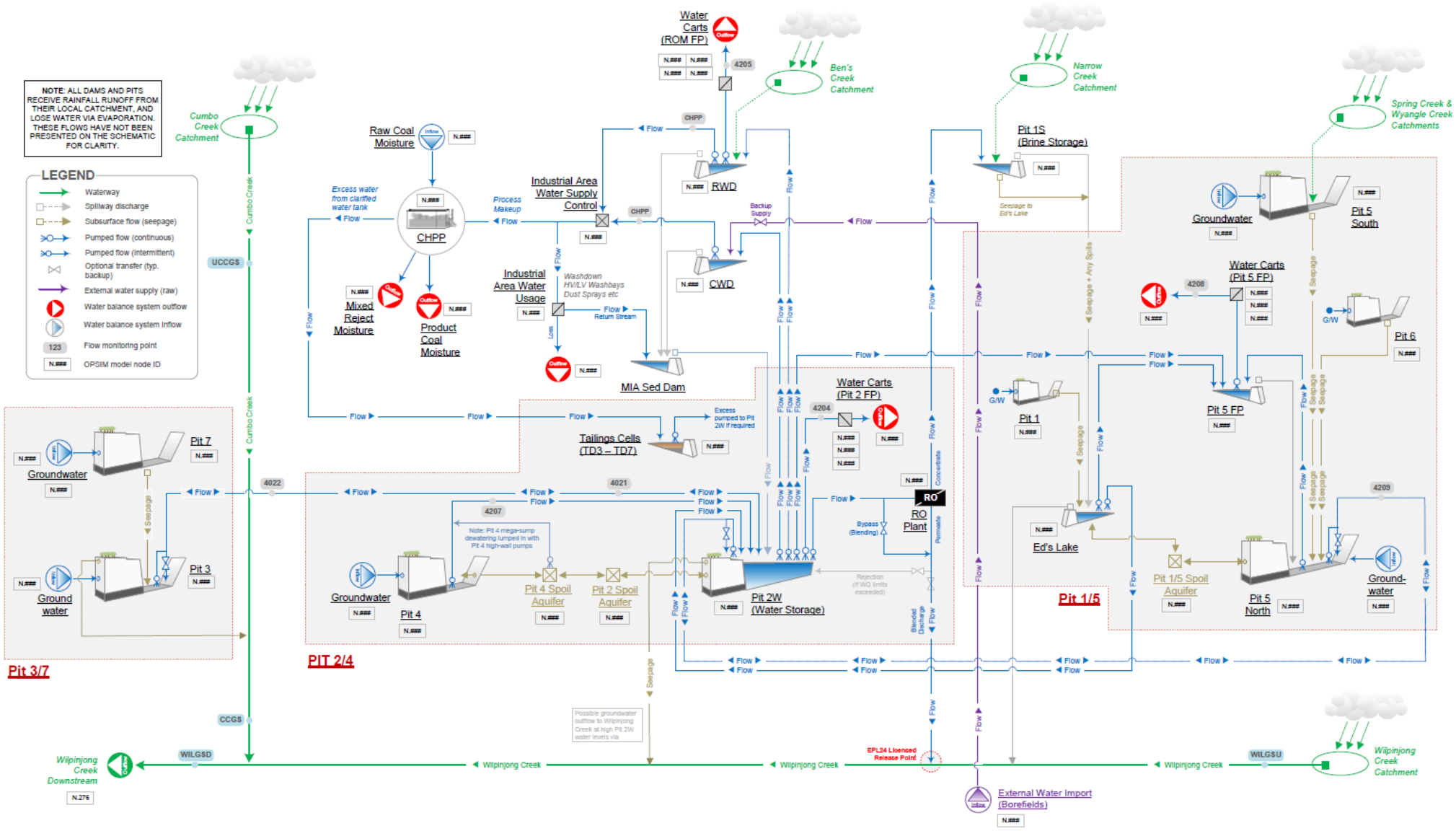


2014-2018 Wilpinjong Creek Downstream Gauging Station



OPSIM Schematic: Major Components of the WCPL Water Management System

Wilpinjong Coal Pty Ltd - 2016 Water Balance Model Update
Baseline OPSIM Model Setup - 31 Mar 2017



Water Management Performance Measures

A summary of the water management performance measures was undertaken by WCPL as they related to the Development Consent SSD-6764 (1 January 2018 to 31 December 2018)

Assessment of Water Management Performance Measures

Feature	Performance Measure	Complied with Performance Measure (Yes/No)	Comments/Actions
General	Maintain separation between clean, dirty and mine water management systems. Minimise the use of clean water on site. Design, install, operation and maintain water management systems in a proper and efficient manager.	Yes	Refer to Site Water Balance (Section 7.7) Refer to Estimate Groundwater Take (Section 7.2) Refer to Surface Water Results (Section 7.6)
Clean water diversion and storage infrastructure	Maximise as far as reasonable and feasible the diversion of clean water around disturbed areas on site.	Yes	Refer to Erosion and Sediment Control (Section 7.5)
Sediment dams	Design, install and/or maintain sediment dams to ensure no discharges to surface waters, except in accordance with an EPL or in accordance with Section 120 of the POEO Act.	Yes	Refer to Erosion and Sediment Control (Section 7.5) Refer to Water Treatment Facility (Section 7.8)
Mine water storages	Design, install and/or maintain mine water storage infrastructure to ensure no discharge of untreated mine water off-site. Discharge treated mine water in accordance with an EPL or in accordance with Section 120 of the POEO Act.	Yes	Refer to Site Water Balance (Section 7.7) Refer to Surface Water Results (Section 7.6) Refer to Water Treatment Facility (Section 7.8)
Wilpinjong, Cumbo and Wollar Creeks	No greater impact than predicted for the development for water flow and quality.	Yes	Refer to Surface Water Results (Section 7.6) Refer to Stream Health (Section 7.9)

Feature	Performance Measure	Complied with Performance Measure (Yes/No)	Comments/Actions
Aquatic, riparian and groundwater dependent ecosystems	Negligible environmental consequences beyond those predicted for the development.	Yes	Refer to Surface Water Results (Section 7.6) Refer to Stream Health (Section 7.9)
Flood mitigation measures*	Ensure all open cut pits, CHPP, coal stockpiles and main mine facilities areas exclude flows for all flood events up to and including the 1 in 100 year ARI. All final voids designed to exclude all flood events up to include the PMF event.	Yes	The Wilpinjong Coal Mine open cuts are located outside the extent of flooding from Wilpinjong Creek in the 1 in 1,000 AEP design flood. Flood mitigation works for open cut infrastructure in the vicinity of Cumbo Creek are already being implemented at the Wilpinjong Coal Mine and have been designed to a 1 in 100 AEP flood protection (WRM Water and Environment, 2015).
Overburden, CHPP Reject and Tailings	Design, install and maintain emplacements to prevent or minimise the migration of pollutants due to seepage.	Yes	Waste rock emplacements and coal reject management in accordance with the MOP
Chemical and hydrocarbon storage	Chemical and hydrocarbon products to be stored in bunded areas or structures in accordance with relevant Australian Standards.	Yes	Chemical and hydrocarbon products stored in bunded areas in accordance with relevant Australian Standards

Notes:* Consistent with Condition 29, Schedule 3 of Development Consent (SSD-6764), WCPL have maintained all open cut pits, CHPP, coal stockpiles and main mine facilities areas so that they exclude flows for all flood events up to and including the 1 in 100 year ARI. The final voids would be designed to exclude all flood events up to the probable maximum flood.

Creek Stability Monitoring Reports

Wilpinjong Coal Mine

2018 Channel Stability Monitoring Report

Prepared for
Wilpinjong Coal Pty Ltd

30 March 2019

DOCUMENT TRACKING

Item	Detail
Project Name	WCPL Channel Stability Monitoring
Project Number	18MUD-9579
Project Manager	Kalya Abbey Mudgee Office 02 4302 1238 / 0410 503 959 / kalyaa@ecoaus.com.au
Prepared by	Angelina Siegrist and Tom Kelly
Reviewed by	Mark Southwell, Kalya Abbey
Approved by	Daniel Magdi
Status	Draft
Version Number	V1
Last saved on	30 March 2019
Cover photo	Site WCk39 (credit: T. Kelly)

This report should be cited as 'Eco Logical Australia 2019. *Wilpinjong Coal Mine – 2018 Channel Stability Monitoring Report*. Prepared for Wilpinjong Coal Pty Ltd.'

ACKNOWLEDGEMENTS

This document has been prepared by Eco Logical Australia Pty Ltd with support from Wilpinjong Coal Pty Ltd.

Contents

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Abbreviations

Abbreviation	Description
BEHI	Bank Erosion Hazard Index
ELA	Eco Logical Australia
ML	Mining Lease
SWMMP	Surface Water Management and Monitoring Plan
WCPL	Wilpinjong Coal Pty Ltd

Summary of key findings

Channel stability monitoring was undertaken during spring 2018 to provide an assessment of overall riparian stability and health within the Wilpinjong Mine and surrounds. Fifty-nine (59) permanent survey sites were monitored along Wilpinjong and Cumbo Creeks. Monitoring assessed channel stability indicators including bank height and angle, streambank protection and riparian vegetation cover. Channel Stability ratings at monitoring sites along Wilpinjong Creek ranged from Moderately Unstable to Highly Stable, and Stable to Highly Stable along Cumbo Creek.

Comparison of monitoring data from 2016 to 2018 found that the stability rating has either improved or remained constant for most monitoring sites (53 of 59) across both Wilpinjong and Cumbo Creeks. This reflects the overall stable nature of both creeks in what has been a prolonged dry period, despite no management intervention.

Channel stability issues evident within Wilpinjong and Cumbo Creeks relate to agricultural practices, including vegetation clearing and stock access to the riparian zone.

Revegetation and remediation works are recommended in order to restore degraded sections of the channels, to mitigate further erosion and promote regeneration of the riparian zone. Areas experiencing lateral erosion, including the established erosion points, should be prioritised for vegetation works.

1 Introduction

Eco Logical Australia (ELA) was engaged by Wilpinjong Coal Pty Ltd (WCPL) to undertake annual monitoring of channel stability along Wilpinjong and Cumbo Creeks. Channel stability monitoring is required to satisfy Schedule 3, Condition 32 (e) of WCPL's Project Approval (05-0021), and the channel stability monitoring criteria detailed in Appendix 2 of the Wilpinjong Water Management Plan (WCPL 2017).

This report details the findings from the 2018 monitoring program and provides a comparison of the regeneration progress of both Wilpinjong and Cumbo Creeks against previous monitoring conducted since 2011.

1.1 Background

A baseline channel stability assessment of Wilpinjong and Cumbo Creeks was undertaken in 2005 as part of the Environmental Impact Statement for the Wilpinjong Coal Project (WCPL 2005) to characterise the existing condition of the Wilpinjong and Cumbo creek stream channels prior to mining. The Wilpinjong Creek survey included 49 sites and extended 12.5 km from the upstream gauging station to the confluence with Wollar Creek to the east. The Cumbo Creek survey included 10 sites and extended 3 km from the southern boundary of Mining Lease (ML) 1573 north to the confluence with Wilpinjong Creek.

The baseline surveys concluded both Wilpinjong and Cumbo Creeks have been affected by pre-mining land management practices dominated by sheep and cattle grazing. These land management practices involved the clearing of riparian vegetation on both creeks to maximize grazing areas and stock access to drinking water. The clearing of this vegetation is assumed to have contributed significantly to bank instability. Disturbance from burrowing animals, both native (e.g. Common Wombat) and introduced (e.g. European Rabbit), is also likely to have contributed to instability.

Subsequent annual surveys have been undertaken in 2011, 2014, 2015, 2016 and 2017 to assess the ongoing stability of the Wilpinjong and Cumbo Creeks during mining. Barnson (2017) developed a proforma to assist in the assessment of creek stability at each survey location and to enable comparisons to be made between annual survey periods.

1.2 Objectives

The channel stability monitoring program aims to provide qualitative measures of stream bed and bank erosion and channel instability along Wilpinjong and Cumbo Creeks.

The key objectives of the 2018 channel stability monitoring program are to:

- Evaluate erosional or depositional features of the creek banks
- Record the details of permanent monitoring sites with written descriptions and photographs
- Assess the stability of Wilpinjong and Cumbo Creeks using a rapid assessment methodology
- Compare visual channel stability at each of the permanent monitoring sites against previous monitoring records.

2 Methodology

2.1 Field survey - stability & comparative assessment

The field survey was conducted by ELA ecologists Tom Kelly and Elise Keane between 27 and 30 November 2018.

A total of 59 (49 on Wilpinjong Creek and 10 on Cumbo Creek) permanent monitoring locations were surveyed (Figure 2-1). Consistent with previous monitoring, surveys involved surveying the designated reach of each site (approximately 100 m) and completing the Bank Erosion Hazard Index (BEHI) assessment. BEHI assessment involves scoring a site on eight quantitative categories outlined below and in **Appendix A**.

The eight BEHI indicators of channel stability that were used to evaluate erosion at each site include:

- Bank Height (m)
- Bank Angle (°)
- Percentage of Bank Height with a Bank Angle Greater than 80°
- Evidence of Mass Wasting (% of Bank)
- Unconsolidated Material (% of Bank)
- Streambank Protection (% of Streambank covered by plant roots, vegetation, logs, branches, rocks etc.)
- Established Beneficial Riparian Woody - Vegetation Cover
- Stream Curvature Descriptor.

The channel stability indicators produce an activity rating that classifies each location from 'Highly Unstable', indicating the drainage line is experiencing severe on-going erosion, to 'Highly Stable', indicating the drainage line is highly stable in function and form. This rating system enables any deterioration or improvement in bank stability to be detected over time. The classification system is detailed below in Table 2-1.

Table 2-1: BEHI score ranges for each rating class

Rating	BEHI Score
Highly Stable	0-25
Mod Stable	26-35
Stable	36-45
Unstable	46-55
Mod Unstable	56-65
Highly Unstable	66-85

Field notes and photographs were taken to allow qualitative assessment through comparisons between monitoring periods. This process included written site descriptions using the previous monitoring report (ELA 2018) to make comparisons *in situ*, as well as taking upstream and downstream photographs at each of the permanent monitoring sites. Site descriptions are provided in **Section 3** and copies of site photos are provided in **Appendix B.** Comparison of the 2018 monitoring sites to 2011 – 2017 monitoring photographs has been made by referring to previous reports prepared by Barnson (2017) and ELA (2018).

Previously established erosion points along the Wilpinjong Creek were also assessed (**Figure 2-2**). These are in areas with moderate to severe erosion and are monitored to determine the presence and extent of on-going erosion.

Management issues and threatened species are recorded opportunistically throughout the surveys, to highlight areas where management intervention is needed.

2.2 Rainfall and flood analysis

Previous WCPL channel stability monitoring reports have included an analysis of rainfall Intensity-Frequency-Duration (IFD) and exceedance likelihood, with its effect on erosion (Barnson 2017). Consistent with 2017 monitoring, it was determined that due to below average annual rainfall received during 2018 and the absence of significant erosion events at the monitoring sites, IFD and exceedance analysis would not be conducted for the purposes of this report. Rainfall data is included in **Appendix C.**

Figure 2-1: Monitoring locations

Figure 2-2: Active erosion points assessed in 2018

3 Results

The results of the channel stability monitoring are presented below in Table 3-1 and **Table 3-2**. Site descriptions and comparison notes can be found in **Table 3-3**.

Table 3-1: Bank Erosion Hazard Index (BEHI) for Wilpinjong Creek.

Site	Bank (L/R)	Bank Height (m)	Bank Face Length	BEHI Indicator								Total	Rating
				1	2	3	4	5	6	7	8		
WCk1	L	4	10	5	2	5	0	2.5	7.5	7.5	5	34.5	Mod Stable
WCk2	R	3.5	9	5	2	5	2.5	2.5	2.5	10	0	34.5	Mod Stable
WCk3	L	3	12	5	2	2.5	5	7.5	10	12.5	5	49.5	Unstable
WCk4	L	3.5	7	5	4	7.5	7.5	7.5	12.5	12.5	0	56.5	Mod Unstable
WCk5	L	3	7	5	2	2.5	2.5	5	7.5	7.5	0	32	Mod Stable
WCk6	L	3	6	2.5	2	2.5	2.5	2.5	2.5	7.5	2.5	24.5	Highly Stable
WCk7	L	2.5	6	2.5	2	2.5	2.5	2.5	2.5	7.5	0	22	Highly Stable
WCk8	L	5	12	7.5	2	0	2.5	5	7.5	15	2.5	42	Stable
WCk9	R	2	9	2.5	2	7.5	5	5	2.5	15	2.5	42	Stable
WCk10	R	1.5	15	2.5	0	0	0	5	7.5	15	2.5	32.5	Mod Stable
WCk11	R	1.5	18	0	0	0	0	2.5	7.5	10	2.5	22.5	Highly Stable
WCk12	R	2	12	2.5	2	0	0	0	2.55	12.5	5	24.5	Highly Stable
WCk13	L	4	8	5	4	0	2.5	5	7.5	10	5	39	Stable
WCk14	L	1.8	7	2.5	2	0	0	2.5	2.5	12.5	0	22	Highly Stable

Site	Bank	Bank	Bank	BEHI Indicator								Total	Rating
WCk15	L	1.8	6	2.5	2	2.5	2.5	2.5	10	10	2.5	34.5	Mod Stable
WCk16	L	2	7	2.5	2	5	2.5	7.5	7.5	7.5	0	34.5	Mod Stable
WCk17	R	1.8	4	2.5	2	0	0	2.5	2.5	15	2.5	27	Mod Stable
WCk18	R	2.5	5	2.5	2	5	2.5	2.5	7.5	15	2.5	39.5	Stable
WCk19	L	2	4	2.5	2	5	5	5	7.5	15	0	42	Stable
WCk20	L	1.8	5	2.5	2	2.5	2.5	2.5	2.5	12.5	0	27	Mod Stable
WCk21	R	1.3	5	0	2	2.5	2.5	2.5	2.5	15	2.5	29.5	Mod Stable
WCk22	R	1.6	8	2.5	2	0	2.5	5	10	12.5	2.5	37	Stable
WCk23	R	2.5	12	2.5	2	0	0	7.5	10	15	5	42	Stable
WCk24	R	1.7	10	2.5	0	2.5	5	10	12.5	15	2.5	50	Unstable
WCk25	L	1.7	7	2.5	2	2.5	7.5	5	10	15	2.5	47	Unstable
WCk26	L	3.5	10	5	2	7.5	5	7.5	10	15	2.5	54.4	Unstable
WCk27	R	2.8	5	2.5	6	7.5	5	7.5	10	15	2.5	56	Mod Unstable
WCk28	L	2.5	5	2.5	2	5	5	5	7.5	12.5	2.5	42	Stable
WCk29	L	3.6	8	5	2	5	5	2.5	7.5	15	2.5	44.5	Stable
WCk30	R	2.8	12	2.5	2	0	2.5	2.5	0	12.5	2.5	24.5	Highly Stable
WCk31	R	3	6	2.5	4	5	5	7.5	10	15	2.5	51.5	Unstable
WCk32	R	3.2	7	5	4	7.5	5	7.5	10	15	2.5	56.5	Mod Unstable

Site	Bank	Bank	Bank	BEHI Indicator								Total	Rating
WCk33	L	3.2	6	5	4	7.5	5	7.5	10	10	5	54	Unstable
WCk34	R	2.4	6	2.5	4	5	5	7.5	7.5	15	5	51.5	Unstable
WCk35	R	2.2	13	2.5	2	0	2.5	5	7.5	15	2.5	37	Stable
WCk36	R	2	15	2.5	2	0	2.5	2.5	2.5	15	2.5	29.5	Mod Stable
WCk37	R	2	10	2.5	2	2.5	2.5	7.5	10	15	2.5	44.5	Stable
WCk38	L	3.1	6	5	2	2.5	2.5	5	7.5	10	5	39.5	Stable
WCk39	L	3.2	7	5	4	2.5	5	10	10	15	2.5	54	Unstable
WCk40	R	3.2	14	5	2	0	5	10	12.5	15	0	49.5	Unstable
WCk41	R	2.8	8	2.5	2	2.5	2.5	2.5	7.5	15	0	34.5	Mod Stable
WCk42	R	3.8	6	5	4	5	7.5	10	10	12.5	2.5	56.5	Mod Unstable
WCk43	L	3.1	5	5	4	7.5	2.5	5	7.5	15	2.5	49	Unstable
WCk44	R	1.7	3	2.5	2	2.5	2.5	5	2.5	15	2.5	34.5	Mod Stable
WCk45	L	3.2	7	5	2	2.5	5	5	7.5	7.5	5	39.5	Stable
WCk46	R	2.2	5	2.5	4	5	2.5	5	2.5	10	2.5	34	Mod Stable
WCk47	R	2.2	6	2.5	2	2.5	5	5	7.5	12.5	0	37	Stable
WCk48	L	2.7	8	2.5	2	2.5	5	5	7.5	12.5	2.5	39.5	Stable
WCk49	L	3.8	10	5	4	2.5	2.5	7.5	7.5	12.5	2.5	44	Stable

Table 3-2: Bank Erosion Hazard Index (BEHI) for Cumbo Creek.

Site	Bank (L/R)	Bank Height (m)	Bank Face Length	BEHI Indicator								Total	Rating
				1	2	3	4	5	6	7	8		
CCk1	R	1.8	10	2.5	0	0	0	0	2.5	15	0	20	Highly Stable
CCk2	R	1.3	8	0	2	2.5	5	5	7.5	15	5	42	Stable
CCk3	L	0.4	2	0	0	0	0	0	0	15	2.5	17.5	Highly Stable
CCk4	R	1	13	0	0	0	0	0	2.5	15	2.5	20	Highly Stable
CCk5	R	1	8	0	0	0	0	5	2.5	15	2.5	25	Highly Stable
CCk6	R	1.8	10	2.5	2	0	2.5	2.5	2.5	15	2.5	29.5	Mod Stable
CCk7	R	0.5	2	0	2	2.5	0	0	0	15	2.5	22	Highly Stable
CCk8	L	2	15	2.5	0	0	0	0	0	15	2.5	20	Highly Stable
CCk9	L	0.7	2	0	2	2.5	2.5	0	0	15	2.5	24.5	Highly Stable
CCk10	L	0.7	4	0	2	2.5	2.5	0	0	15	2.5	24.5	Highly Stable

Table 3-3: monitoring site descriptions – Wilpinjong Creek and Cumbo Creek

Site	Upstream	Downstream
WCk1	- Increased cover of *Phragmites australis* (Common Reed) and *Chloris truncata* (Windmill Grass) in channel bed compared to 2017 - Stream bed still bare directly adjacent to weir - Localised erosion along stock tracks - Sandstone bedrock exposed	- Abundant *Angophora floribunda* (Rough-barked Apple) regeneration on left bank - No apparent recent stock access - Instream vegetation has increased compared to 2017 - Bedrock exposed in creek bed - *Rosa rubiginosa* (Sweet Briar) present on left bank
WCk2	- Reasonable vegetation cover, native and exotic grasses and herbs still dominant, but *Phragmites australis* growing back - Localised erosion along stock tracks	- Vegetation cover is moderate, with no recent signs of active grazing - High leaf litter cover - *Rubus fruticosus* (Blackberry) has died off
WCk3	- Short vegetation cover of native and exotic grasses and herbs - Localised erosion along stock tracks	- Good instream cover of native and exotic grasses and herbs - Left bank active lateral erosion - Low vegetation cover on left bank and exposed bedrock
WCk4	- Short vegetation cover of native and exotic grasses and herbs on channel bed - Right bank stable except for stock tracks - Left bank unstable, significant bank collapse and under-cutting	- Left bank collapse and erosion, with low vegetation cover - Stock tracks causing erosion on right bank near fence - No signs of recent stock access - Good vegetation cover in channel bed
WCk5	- Eucalypt natural regeneration in the channel bed - *Phragmites australis* re-growth evident - Wombat burrows on right bank down to channel bed - Stock track erosion on both banks - Active gully cutting on left bank	- Good cover of vegetation and logs on right bank - Left bank has reasonable cover of grass/herbs/shrubs - *Phragmites australis* re-growth evident, high cover in channel bed

Site	Upstream	Downstream
WCk6	- Stock tracks on both banks - *Gahnia aspera* (Rough Saw-sedge) and native shrubs growing on left bank - Fallen trees into channel bed - Good litter cover in creek bed	- Wombat burrow on right bank - Small amount of Blackberry present on right bank, dying off on left bank - Good canopy regeneration on both banks - Good cover of leaf litter - Some re-growth of *Phragmites australis* on channel bed
WCk7	- Wombat burrows in right bank - *Phragmites australis* re-growth evident, high cover in channel bed - Good cover of vegetation and debris on both banks	- Good Large Woody Debris (LWD) cover on right bank - Good vegetation growth on both banks and channel bed - *Phragmites australis* re-growth evident
WCk8	- Original site surveyed - Good vegetation cover on both banks and some of channel bed - Bare section in channel veg filled with debris - Wombat burrows on both banks - Some debris accumulation in channel	- Original site surveyed - Animal tracks, wombat burrows on left-hand bank and bare patches on steep banks - Parts of channel bed bare - Good vegetation cover on right bank
WCk9	- Original site surveyed - Good vegetation cover in channel bed - Left bank vegetation cover is sparse - Right bank steep and bare, with some erosion	- Assessed at old site - Steep eroded banks on right bank - High cover of *Phragmites australis* in channel - Rabbit and Wombat burrows on left bank
WCk10	- Banks well vegetated with grasses, herbs and rushes - Wombat burrows in left bank - Large bare patch in channel bed	- Site is at creek crossing - Sparse vegetation cover in channel, large bare patch, leading to high vegetation cover patch - Bare soil on steep sections of right bank where erosion is - Left bank is stable

Site	Upstream	Downstream
WCk11	- Increased Wombat activity on bench of right bank compared to 2017 - Generally good vegetation cover in channel bed - Good litter cover in channel bed	- Reasonably well-vegetated - Wombat burrows on right bank bench
WCk12	- Good vegetation cover on banks - Some minor *Casuarina cunninghamiana* (River Sheoak) regrowth on left bank - Wombat holes on left-hand bank - Blackberry noted along left-hand bank	- Good vegetation cover on right bank, moderate vegetation cover on left bank - LWD, litter and wombat burrows on right-hand bank bench
WCk13	- Wombat burrows noted on left bank - Some bare exposed areas on left bank in steep sections - Blackberry present	- Some undercutting on left bank downstream of reach - Left bank steep and bare - Sand and gravel in channel bed - Pig digging evident on left bank
WCk14	- Wombat burrows in right bank - Pig digging in channel - Very little vegetation cover in channel bed - Some debris in channel	- Wombat burrows on both banks - Pig digging in channel bed - Good vegetation cover of native and exotic grasses and herbs on both banks - Very little vegetation cover in channel bed
WCk15	- Wombat burrows in both banks - Good vegetation cover on right bank, moderate on left bank - Some older erosion on left bank - Some leaf litter accumulation in channel	- Good vegetation growth on right bank, moderate on left bank - LWD on left bank - Some *Phragmites australis* re-growth in channel bed
WCk16	- Sand/gravel accumulation in channel - Wombat holes in channel bed - Good vegetation cover on right bank - Left bank steep and bare	- Sand/gravel deposits in channel - Right bank has good vegetation cover with good cover of *Phragmites australis* - Left bank very little vegetation cover - LWD on right bank and in channel bed

Site	Upstream	Downstream
WCk17	- Well vegetated banks and channel bed with *Phragmites australis* - Sand/gravel accumulations in channel with some iron staining - Animal tracks present - Wombat burrows in both banks	- Thick covering of *Phragmites australis* in channel bed and on bank - Animal tracks crossing the creek - Sand/gravel substrate in channel
WCk18	- Wombat burrows in both banks - Reasonably good vegetation cover of grasses/ruches in channel and on banks - Animal tracks across channel beds	- Wombat burrows in both banks - Current erosion on right - Good vegetation cover inn channel bed, with thick *Phragmites australis* - Sand and gravel substrate in channel
WCk19	- Good vegetation cover of grasses/rushes in channel bed and banks - Some animal tracks on left bank - Wombat holes on right bank	- Good vegetation cover in channel and on right-hand bank - Some mass wasting on top of left-hand bank
WCk20	- Bank and channel well vegetated - Some lateral erosion on left bank - Saffron Thistles	- Channel and banks well-vegetated with *Phragmites australis* and *Lomandra* spp. - Minor active lateral erosion still evident on both banks - Some regeneration on left bank
WCk21	- Good vegetation cover in channel and on right bank - Some bare exposed areas on left bank, mainly due to animal tracks - Debris and leaf litter build up in channel	- Good vegetation growth in channel and right bank - Erosion on left bank
WCk22	- Good vegetation cover in channel and of left bank - Moderate vegetation cover of native and exotic grasses and herbs on right bank - Wombat burrows in left bank - Erosion on right bank	- Erosion evident on right-hand bank - Good vegetation cover in channel and left-hand bank - No riparian tree cover

Site	Upstream	Downstream
WCk23	- Good in channel vegetation cover - Left bank moderate vegetation cover with some bare patches - Erosion at top of both banks, leading to are exposed patches	- Good vegetation cover in channel - Significant bare soil on both banks - Canopy species regeneration on both banks
WCk24	- Good cover of *Lomandra* spp. on left bank - Some bare exposed patches with animal tracks on right bank - Good vegetation cover in channel bed - Wombat and rabbit burrows present on left bank	- Good vegetation cover in channel (*Typha orientalis* (Broadleaf Cumbungi)) - Good vegetation cover on left bank with the exception of animal tracks - Bare soil patches and erosion on right bank, downstream of Cumbo Ck confluence
WCk25	- Left bank actively eroding - Bank vegetation dominated by thistles - No riparian zone - Thistles on left bank	- Significant bare soil patches with notching erosion occurring - Some gullying erosion starting to form on left-hand bank - LWD on right bank
WCk26	- Vegetation instream and on left bank remains similar to 2016 and 2017 - Exposed areas on top of left bank - Right bank remains stable - Some wombat and rabbit burrows in top of left bank - Blackberry dying off	- No salt crusting evident as was the case in 2017 - Some active erosion downstream - Wombat burrows on top of left bank
WCk27	- In channel vegetation remains similar to 2016 and 2017 - Active erosion on right bank, leading to steep and bare bank	- Active erosion evident (rill and notching) on right bank
WCk28	- Reasonable vegetation cover in channel and on right bank - Bare sections present on left bank	- Good cover of vegetation in channel - Sections of left bank steep and eroded - Right bank good vegetation cover, with some animal tracks

Site	Upstream	Downstream
WCk29	- Good vegetation cover in channel and on right bank - Left bank not as steep and good cover of grass cover than downstream	- Good vegetation cover in channel and right-hand bank - Wombat burrows present - Top half of left-hand bank very steep and actively eroding, some notching present - Good vegetation cover on bottom half of left bank, with some animal tracks - Blackberry in channel
WCk30	- Increase in ground cover compared to 2017, the only areas of bare soil are associated with wombat burrows - Blackberry present on right bank - Wombat burrows in both banks - Good general regeneration on both banks	- Gully forming on right-hand bank on downstream end of reach - Bare soil exposed on right-hand bank at downstream end of reach - Left bank eroded section with exposed bare soil
WCk31	- Instream vegetation remains similar to 2016 and 2017 - Right bank is still actively eroding with large areas of bare soil present - No salt crystallisation evident	- Stable instream vegetation, with some thistles - Right bank soil exposure from animal tracks and steep slop - Some minor gullying evident on right-hand bank - Good vegetation cover on left bank, with some erosion mid bank
WCk32	- Good cover of in channel vegetation - Left bank showing signs of erosion - Right bank very steep erosion leading to exposed tree roots - Wombat burrows in right bank	- Right-hand bank is steep and actively eroding - Gullying appears to be stabilised with addition of rock battering - Blackberry in right bank gully
WCk33	- Good cover of grasses in channel and on right bank - Areas of active erosion evident on left bank leading to steep bare bank - Wombat burrows in both banks - Tree cover present on left bank, with some regeneration but little ground cover	- Good vegetation cover in channel and right bank - Wombat burrows on both banks - Left-hand bank steep, bare and actively eroding with exposed tree roots - Tree cover moderate, but no groundcover on left bank - LWD on left bank

Site	Upstream	Downstream
WCk34	- In channel vegetation cover remains high - Right bank stable but some wombat burrows - Active erosion on face of left bank and right bank	- Right-hand bank actively eroding and several bare animal tracks - Good vegetation cover on left bank - Blackberry at top of right bank
WCk35	- Instream vegetation cover remains high - Lower section of left bank remains stable and well vegetation, however some block failure is evident on top of left bank - Right bank active erosion and bare soil predominant	- Right-hand bank has improved in vegetation cover - Regeneration downslope of reach on left bank
WCk36	- Right bank largely consistent, signs of grazing remain evident - Some bare dirt from stock tracks and erosion - Left bank remains steeply slowed and concave - Top of left bank still steep, showing signs of erosion - Good grass cover in channel and lower banks	- Slumping still occurring on right bank - Some undercutting and exposed bare soil at downstream end of left bank - Good grass cover in channel and lower banks
WCk37	- Left bank remains well vegetated (grazed) with some lateral erosion - Some Wombat burrows in left bank - Right bank bare, with very little vegetation cover - Stock tracks causing bare areas and erosion on right bank	- Wombat burrows on left-hand bank - Right bank groundcover appears to have deteriorated with increased bare soil compared to 2017 - Stock tracks evident on right-hand bank - Moderate vegetation cover on left bank, with some lateral erosion
WCk38	- Instream vegetation remains similar, continues to be grazed by cattle - Wombat burrows on left bank - Stock tracks causing localised erosion on both banks - Right bank has reasonable vegetation cover though grazed - Left bank active erosion, is steep and bare	- Stock access causing localised erosion - Good vegetation cover in channel and on banks, however it is being actively grazed

Site	Upstream	Downstream
WCk39	- Right bank well vegetated and stable, with some animal tracks - Left bank is actively eroding and bare - Wombat burrows on both banks - In channel vegetation cover good, continues to be grazed by cattle	- Right bank well vegetated, but left-hand bank actively eroding with steep bare upper-bank - Minor gullying forming on left bank - Wombat burrows on right bank - In channel vegetation cover good, continues to be grazed by cattle
WCk40	- Good vegetation cover in channel though grazed and evidence of stock hoof prints - Left bank well vegetated, with some lateral erosion - Bare patches of exposed bank still present on right bank, consistent with previous years	- Creek bed remains well vegetated and stable but actively grazed - Right bank has bare slope and exposed bedrock
WCk41	- In channel vegetation cover good, continues to be grazed by cattle - Stock in channel bed and on left bank - Left bank has good vegetation cover - Right bank has exposed soil, bedrock and erosion is active - Stock tracks in left bank and right bank	- Creek bed and left bank well vegetated and stable - Well established wombat holes on left bank - Right bank is steep and still actively eroding - Cattle accessing creek
WCk42	- Good vegetation cover in channel - Stock on left bank, and hoof prints in channel bed - Right bank still eroding significantly, with bedrock exposed, and sand and gravel sediment deposits - Gully developing on right bank upstream of large tree, with roots of tree exposed - Rehabilitation activities required on right bank, along with stock removal	- Channel remains well vegetated but actively grazed by cattle - Wombat burrows on left bank - Right bank actively eroding, with exposed tree roots
WCk43	- Good vegetation cover in channel bed - Some unstable sections on left bank from erosion and stock tracks - Good vegetation cover on right bank albeit grazed	- Large patch of dead blackberry, some re-growth also present - Vegetation cover good and stable but actively grazed - Left bank slope steep and actively eroding

Site	Upstream	Downstream
WCk44	- Still good vegetation cover overall, but actively grazed - Bare sections on both banks due to stock tracks - Wombat burrows in left bank - Left bank lateral erosion	- Vegetation cover good and stable in channel bed but actively grazed - Both banks lateral erosion and patchy bare soil
WCk45	- Channel well vegetated - Both banks stable and vegetated, though some minor exposure around stock tracks and vegetation has been grazed	- Good and stable vegetation as per previous years - Minor localised erosion caused by stock access on left bank
WCk46	- Channel well vegetated - Both banks stable and well vegetated though grazed - Only bare sections on right bank due to animal tracks - Signs of cattle activity, including hoof prints	- Good and stable vegetation but actively grazed - Left bank remains stable, right bank has minor exposed steep sections vulnerable to erosion - Abundant leaf litter on both banks
WCk47	- Instream vegetation cover remains good, though some impact of grazing noted below fence - Steep erosion around fence on right bank - Right bank bare where animal tracks are	- Stock causing localised erosion on banks - Good vegetation cover in channel - Good level of debris and litter in stream an on lower banks
WCk48	- Good vegetation cover in channel - Some steep erosion points and bare soil on left bank - Right bank stabilised by rock cover - Good leaf litter and native and exotic grasses and herbs vegetation cover on right bank	- Stock and macropod access on left bank instigating lateral erosion - Abundant exposed *Angophora floribunda* roots on left bank - Good debris in channel
WCk49	- Good cover of grasses on channel and on right bank - Left bank showing signs of stock tracks and localised erosion - Vegetation has been heavily grazed	- Vegetation cover good in channel and right-hand bank - Left bank steep but presently stable - Localised erosion caused by stock access - Wombat burrows on right bank

Site	Upstream	Downstream
CCk1	- Site remains well vegetated and stable - Mid and upper parts of right bank dominated by Saffron Thistle - No tree cover	- Good cover and stable bank with increased groundcover on right bank however, dominated by exotic species
CCk2	- Good vegetation cover in channel and on left bank - Evidence of erosion on mid and upper sections of right bank - Bare at erosion points and animal tracks - Some debris in channel	- Good vegetation cover and stable in channel and left bank - Some erosion, bare soil and bed rock exposure on right bank
CCk3	- Water pooled upstream of crossing - Good grass, herb and rush cover in channel and on banks - Some minor soil exposure on right bank - No tree cover	- Good vegetation cover and stable - Strong exotic cover on banks
CCk4	- Good groundcover in channel and on both banks - Some animal tracks on right bank	- Site remains stable - Good and stable vegetation cover - Animal track along right bank - Sweet Briar present in channel
CCk5	- Area is well vegetation, with a bare patch along right bank - Eucalypt regeneration downstream towards culvert	- No woody riparian vegetation on either bank - Remains well vegetated and stable - Site remains consistent with 2017
CCk6	- Site is consistent with 2017	- Site is consistent with 2017
CCk7	- Good cover of grasses in channel and on left bank - Very limited riparian zone - Some minor erosion on face of right bank - Some bare bank noted low of left bank near pool	- Good and stable groundcover in channel and right bank - Minor erosion on left bank on downstream end of reach

Site	Upstream	Downstream
CCk8	- Good vegetation cover in channel and on both banks - Very limited riparian zone apart from groundcover	- Site remains stable with good vegetation cover
CCk9	- Some minor lateral erosion on top right bank - Site remains well vegetated - Saffron Thistle prevalent on both banks	- Some minor lateral erosion, exposing soil on both banks - Animal track across creek
CCk10	- Site remains well vegetated in channel and on both banks - Very limited riparian zone apart from groundcover	- Site remains stable with good vegetation cover - Lateral erosion on left bank - Strong exotic cover

Three species, *Xanthium spinosum* (Bathurst Burr), Blackberry and Sweet Briar, which are classified as regional priority weeds under the Central Tablelands Regional Strategic Weed Management Plan 2017 – 2022, were identified along the Wilpinjong creek. *Climacteris picumnus victoriae* (Brown Treecreeper eastern subspecies) and A*rtamus cyanopterus cyanopterus* (Dusky Woodswallow), which are both listed under the BC Act, were also recorded during the monitoring period. These management issues are mapped below, in **Figure 3-2**.

Figure 3-1: Active erosion points assessed in 2018

Figure 3-2: Management Issues and Threatened Species

4 Discussion and Recommendations

Of the 49 sites surveyed along Wilpinjong Creek, six were classified as Highly Stable, 13 Moderately Stable, 16 Stable, 10 Unstable and four Moderately Unstable (**Table 3-1**). As such, a total of 35 sites recorded scores in the stable range, whilst 14 sites recorded scores in the unstable range. The lowest scoring sites (all Moderately Unstable) were WCk4, WCk32 and WCk42, and were typified by severely undercut banks, mass sediment wasting and a low percentage of streambank protection and riparian vegetation cover.

The western section of Wilpinjong Creek (incorporating sites WCk1 to WCk8) contains good areas of natural regeneration with overall moderate to good riparian vegetation and habitat present. At the time of survey, there was abundant birdlife occupying the canopy and shrub layer, including the threatened species Dusky Woodswallow and Brown Treecreeper (eastern subspecies) (**Figure 3-2**). The influence of riparian vegetation on channel stability is well demonstrated in this section of Wilpinjong Creek, with well vegetated sites recording stable BEHI scores, by comparison two cleared sections around sites WCk3 and WCk4 showed significant lateral erosion and associated unstable BEHI scores.

The middle section of Wilpinjong Creek (incorporating sites WCk18 to WCK44) is characterised by cleared adjacent paddocks and a narrow and scattered riparian vegetation zone (where present). Widespread historic clearing in this section of the creek has a pronounced influence on the channel stability scores with unstable BEHI scores recorded for *Streambank Protection* and *Established Beneficial Riparian Woody Vegetation Cover*. The prevalence of significant erosion sites (**Figure 2-2**) in this section of Wilpinjong Creek further demonstrates the impact of historic vegetation clearing on channel stability. Continued stock access to this section of the creek and associated impacts on channel stability through reduced vegetation cover has resulted in increased areas of bare soil and erosion potential.

The eastern section of Wilpinjong Creek (incorporating sites WCk45 to WCk49) is characterised by a relatively steep and narrow valley, which has resulted in a straight channel with high bank height. The riparian vegetation is partly intact, with sites in this section of the creek recording Stable to Moderately Stable scores.

Of the ten sites surveyed along Cumbo Creek, eight were Highly Stable, one Moderately Stable and one Stable (**Table 3-2**). The reach of Cumbo Creek surveyed is characterised by a shallow, meandering channel with low stable banks. The adjacent paddocks have been historically cleared with only very sparse riparian vegetation remaining. Despite the lack of woody riparian vegetation, the creek remains in a stable condition as evidenced by stable BEHI scores.

4.1 Multi-year comparisons

Following on from the baseline channel stability assessment of Wilpinjong and Cumbo Creeks undertaken in 2005 as part of the WCPL EIS (WCPL 2005), annual monitoring has been undertaken during 2011, 2014, 2015, 2016 and 2017. The EIS concluded that both Wilpinjong and Cumbo Creeks were affected by pre-mining agricultural land management practices, resulting in erosion and creek bank instability at numerous points. Annual monitoring since 2011 shows that the channel stability has remained constant or improved since the baseline assessment, despite minimal management intervention. This indicates that mining activities are not contributing further to channel instability, with any changes likely resulting from seasonal variations in rainfall and continued stock access.

4.1.1 Site stability scores

Site channel stability data in the form of BEHI scores are available from 2016 and 2017 for direct comparison. Site stability ratings (based on BEHI scores) for Wilpinjong Creek sites are presented in **Table 4-1** with Cumbo Creek ratings presented in **Table 4-2**. Differences in ratings were only noted as 'Improved' or 'Declined' where a trend was observed over two consecutive years. For Wilpinjong Creek, ratings improved at 24 sites, remained the same at 20 sites and declined at five sites. For Cumbo Creek, ratings improved at three sites, remained the same at six sites and declined at one site.

Overall, the results from 2016 to 2018 are relatively consistent, reflecting the overall stable nature of both creeks in what has been a prolonged dry period with no management intervention undertaken. The trend of improving stability ratings can be partly attributed to increased vegetation cover, resulting in increased scores for *Streambank Protection* and associated reduced scores for *Unconsolidated Material*. There is potential that some variation in ratings can to be attributed to observer variation between years, given the subjective nature of some of the BEHI indicators. In particular, variation in ratings is noted between 2016 (Barnson) and 2017 (ELA). To account for this variability, multi-year comparisons have been completed based on ratings, rather than scores, to highlight overall trends rather than minor variation.

Table 4-1: Wilpinjong Creek site stability scores 2016 – 2018 comparison

Site	2016 Rating	2017 Rating	2018 Rating	Difference
WCk1	Stable	Moderately Stable	Moderately Stable	Improved
WCk2	Stable	Moderately Stable	Moderately Stable	Improved
WCk3	Unstable	Unstable	Unstable	Same
WCk4	Highly Unstable	Moderately Unstable	Moderately Unstable	Improved
WCk5	Stable	Moderately Stable	Moderately Stable	Improved
WCk6	Stable	Moderately Stable	Highly Stable	Improved
WCk7	Moderately Stable	Highly Stable	Highly Stable	Improved
WCk8	Stable	Stable	Stable	Unchanged
WCk9	Unstable	Stable	Stable	Improved
WCk10	Highly Stable	Highly Stable	Moderately Stable	Declined
WCk11	Moderately Stable	Highly Stable	Highly Stable	Improved
WCk12	Moderately Stable	Highly Stable	Highly Stable	Improved
WCk13	Stable	Moderately Stable	Stable	Unchanged
WCk14	Stable	Highly Stable	Highly Stable	Improved
WCk15	Stable	Moderately Stable	Moderately Stable	Improved
WCk16	Highly Stable	Moderately Stable	Moderately Stable	Declined
WCk17	Moderately Stable	Moderately Stable	Moderately Stable	Unchanged
WCk18	Stable	Stable	Stable	Unchanged

Site	2016 Rating	2017 Rating	2018 Rating	Difference
WCk19	Unstable	Stable	Stable	Improved
WCk20	Unstable	Moderately Stable	Moderately Stable	Improved
WCk21	Unstable	Moderately Stable	Moderately Stable	Improved
WCk22	Moderately Unstable	Stable	Stable	Improved
WCk23	Moderately Unstable	Stable	Stable	Improved
WCk24	Unstable	Unstable	Unstable	Unchanged
WCk25	Unstable	Unstable	Unstable	Unchanged
WCk26	Unstable	Unstable	Unstable	Unchanged
WCk27	Stable	Unstable	Moderately Unstable	Declined
WCk28	Unstable	Stable	Stable	Improved
WCk29	Unstable	Stable	Stable	Improved
WCk30	Stable	Moderately Stable	Highly Stable	Improved
WCk31	Unstable	Unstable	Unstable	Unchanged
WCk32	Moderately Unstable	Moderately Unstable	Moderately Unstable	Unchanged
WCk33	Moderately Unstable	Unstable	Unstable	Improved
WCk34	Unstable	Unstable	Unstable	Unchanged
WCk35	Stable	Moderately Stable	Stable	Unchanged
WCk36	Stable	Moderately Stable	Moderately Stable	Improved
WCk37	Stable	Stable	Stable	Unchanged
WCk38	Stable	Stable	Stable	Unchanged
WCk39	Stable	Unstable	Unstable	Declined
WCk40	Unstable	Unstable	Unstable	Unchanged
WCk41	Stable	Moderately Stable	Moderately Stable	Improved
WCk42	Highly Unstable	Moderately Unstable	Moderately Unstable	Improved
WCk43	Not surveyed	Unstable	Unstable	Unchanged
WCk44	Stable	Moderately Stable	Moderately Stable	Improved
WCk45	Stable	Stable	Stable	Unchanged
WCk46	Stable	Moderately Stable	Moderately Stable	Improved
WCk47	Stable	Moderately Stable	Stable	Unchanged
WCk48	Stable	Stable	Stable	Unchanged
WCk49	Stable	Stable	Stable	Unchanged

Table 4-2: Cumbo Creek site stability score 2017 – 2018 comparison

Site	2016 Rating	2017 Rating	2018 Rating	Difference
CCK1	Highly Stable	Highly Stable	Highly Stable	Unchanged
CCK2	Moderately Stable	Stable	Stable	Declined
CCK3	Moderately Stable	Highly Stable	Highly Stable	Improved
CCK4	Highly Stable	Highly Stable	Highly Stable	Unchanged
CCK5	Moderately Stable	Highly Stable	Highly Stable	Improved
CCK6	Moderately Stable	Highly Stable	Moderately Stable	Unchanged
CCK7	Not surveyed	Moderately Stable	Highly Stable	Improved
CCK8	Highly Stable	Highly Stable	Highly Stable	Unchanged
CCK9	Highly Stable	Highly Stable	Highly Stable	Unchanged
CCK10	Highly Stable	Highly Stable	Highly Stable	Unchanged

4.1.2 Photographic comparisons

Photographic comparisons between sites during 2017 and 2018 monitoring are included in **Appendix B**. Photos taken from 2011, 2014, 2015 and 2016 monitoring were also compared, however, digital copies were not available to be included in this report.

Comparisons indicate that there has been little observable change in the stream channel at each monitoring site, with no new significant erosional features evident. Some notable differences were apparent relating to vegetation cover which may be attributed to seasonal variation. Rainfall which occurred in the month preceding 2018 monitoring appears to have resulted in re-growth of in-stream macrophytes at multiple sites, with an increase in vegetation cover also recorded in the BEHI scores (see **section 4.1.1**). Despite this rainfall, water levels were noticeably lower in 2018 compared to 2017 for both Wilpinjong and Cumbo creeks, as well as both upstream and downstream of the WCPL water discharge location. Water levels appear significantly lower across both 2017 and 2018 compared to previous monitoring seasons.

4.2 Erosion points

Table 4-3 provides a photo log of the significant erosion points along Wilpinjong and Cumbo Creeks (see also **Figure 3-1**). These sites were identified as having moderate to severe erosion resulting from historical clearing and agricultural practices and have been recommended for remediation works. Overall, the erosion points appear largely consistent with 2016 and 2017, with no evidence of recent downstream erosion. Given the large areas of bare soil and multiple erosional gullies present at these sites, it is highly likely that lateral erosion would still be occurring during rainfall events, because of increased runoff velocities from the surrounding cleared landscape.

Revegetation and remediation methods are discussed below in **Section 4.3**.

Table 4-3: Significant erosion points and suggested remediation works

Erosion point	Image	Notes / suggested works
E1 (768557, 6422438)		Revegetation and check dams (**Section 4.3**).
E2 (768469, 6422527)		Revegetation and mulching (**Section 4.3)**

Erosion point	Image	Notes / suggested works
E3 (768558, 6422432)		Revegetation and check dams (**Section 4.3**).
E4 (768614, 6422382)		Check dams (**Section 4.3**).
E6 (772166, 6420287)		Revegetation and check dams (**Section 4.3**).

Erosion point	Image	Notes / suggested works
E7 (772431, 6420352)		Revegetation (**Section 4.3**).
E8 (773014, 6420339)		Continue to monitor change
E9 (773397, 6420376)		Revegetation (**Section 4.3**).

Erosion point	Image	Notes / suggested works
E10 (773772, 6420328)		Revegetation and mulching (**Section 4.3**).
E11 (771670, 6419956)		Revegetation and mulching (**Section 4.3**).
WCk24 (771555, 6419882)		Revegetation and mulching (**Section 4.3**).

Erosion point	Image	Notes / suggested works
WCk44 (776155, 6420870)		Exclude stock (fencing), revegetation, mulching and check dams (**Section 4.3**).

4.3 Revegetation and remediation

Re-establishment of riparian corridors along the Wilpinjong and Cumbo Creek systems should be undertaken to provide sustainable long-term solutions to current channel instability issues. It is recommended that revegetation of native trees and shrubs be implemented along the sections of Wilpinjong and Cumbo Creeks devoid of riparian vegetation. **Table 4-4** below lists native and locally-suitable tree and shrub species for use in revegetation works. Areas experiencing lateral erosion, including the significant erosion points detailed above should be considered priority areas for revegetation works.

Revegetation works should extend to a minimum distance equal to the height of the adjacent eroded bank, to re-enforce the existing bank and provide space for the bank to partially erode whilst the vegetation becomes established (Abernathy and Rutherford 1999). The application of mulch to the bank sides is recommended to assist stabilisation until vegetation establishes, along with the installation of coarse-rock and/or hay bale check dams to reduce water flow. Fencing works will also be required to exclude native and introduced fauna from remediation areas, as well as assist with natural regeneration (see **section 4.4** below).

Scattered Regional Priority Weeds were present throughout Wilpinjong Creek and included Blackberry, Sweet Briar and Bathurst Burr (**Figure 3-2**). It was noted that Blackberry has died off since 2017 monitoring at sites WCk2, WCk26 and WCk43, although minor re-growth was also observed at WCk43. The targeted spot spraying of these weeds is recommended in association with remediation works.

Table 4-4: Suggested native tree and shrub species for revegetation works

Scientific Name	Common Name
Native Trees	
Angophora floribunda	Rough-barked Apple
Casuarina cunninghamiana	River Sheoak
Eucalyptus blakelyi	Blakely's Red Gum

Scientific Name	Common Name
Eucalyptus melliodora	Yellow Box
Native Shrubs	
Acacia decora	Western Silver Wattle
Acacia implexa	Hickory Wattle
Acacia linearifolia	Narrow-leaved Wattle
Exocarpos cupressiformis	Native Cherry

4.4 Exclusion of livestock

Livestock (cattle) access to the riparian zone continues to impact on the overall stability and health along sections of both Wilpinjong and Cumbo Creeks. By contrast, sections where stock are excluded show natural regeneration and improved channel stability. **Figure 4-1** below clearly demonstrates the impacts that cattle continue to exert on sections of Wilpinjong Creek. As evidenced by the photograph, the left-hand side of the fence line has significantly lower macrophyte biomass, high turbidity and large patches of bare soil on the right bank (foreground of photograph) resulting from cattle accessing the creek.

Stock have been observed within the eastern section of Wilpinjong Creek (incorporating sites WCk36 to WCk45), as well as the far-western section (incorporating sites WCk1 to WCk8). Excluding stock from the riparian zone through the installation of fencing is recommended. This is likely to provide additional benefits to natural regeneration through reducing grazing pressure from native herbivores.

Figure 4-1: Effects of stock access in the riparian zone (left-hand side of the fence line), contrasted with the results of stock exclusion (right-hand side of the fence line)

5 Conclusion

The channel stability of both Wilpinjong and Cumbo Creeks is characteristic of ephemeral systems in agricultural landscapes, consistent with other creeks in the surrounding region. Both creeks systems exhibit characteristic channel stability issues associated with agricultural landscapes including:

- Degraded riparian vegetation and the presence of exotic species, including Regional Priority Weeds such as Bathurst Burr, Blackberry and Sweet Briar
- Lateral gully-erosion at several locations, formed due to higher velocity runoff from adjacent cleared paddocks occurring perpendicular to the creek line
- Continued stock access contributing to bank instability, reducing in-stream and riparian vegetation and hampering natural regeneration
- Other introduced and native fauna (e.g. European Rabbit and Common Wombat) burrowing within the riparian zone

Erosion and bank stability issues within the Wilpinjong and Cumbo Creeks are strongly linked to historic agricultural practices within the riparian zone, including widespread clearing and direct animal access to the channels. The consistency of ratings since the commencement of monitoring indicates that mining activities are not contributing further to channel stability issues.

Revegetation and remediation works are recommended to restore degraded sections of the creeks, limit on-going erosion and promote natural regeneration of the riparian zone. Where possible this should be achieved through landscaping techniques (tree and shrub planting) and non-intrusive mitigation such as check dams, mulching and fencing.

6 References

Abernathy, B. and Rutherford, I.D. 1999. *Guidelines for stabilising streambanks with riparian vegetation.* Cooperative Research Centre for Catchment Hydrology.

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Wilpinjong Coal Pty Limited 2005. *Wilpinjong Coal Project Environmental Impact Statement*, prepared by Resource Strategies Pty Ltd for Wilpinjong Coal Pty Limited.

Wilpinjong Coal Pty Limited 2017. *Wilpinjong Coal Water Management Plan (Appendix 2) WI-ENV-MNP-0006*.

Appendix A : BEHI Assessment Scoring

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

Appendix B : Site Photo Comparisons

Figure B- 1: WCk1 site photos clockwise from top left: 2017 upstream, 2018 upstream, 2018 downstream, 2017 downstream

Figure B- 2: WCk2 site photos clockwise from top left: 2017 upstream, 2018 upstream, 2018 downstream, 2017 downstream

Figure B- 3: WCk3 site photos clockwise from left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 4: WCk4 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 5: WCk5 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 6: WCk6 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 7: WCk7 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 8: WCk8 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 9: WCk9 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

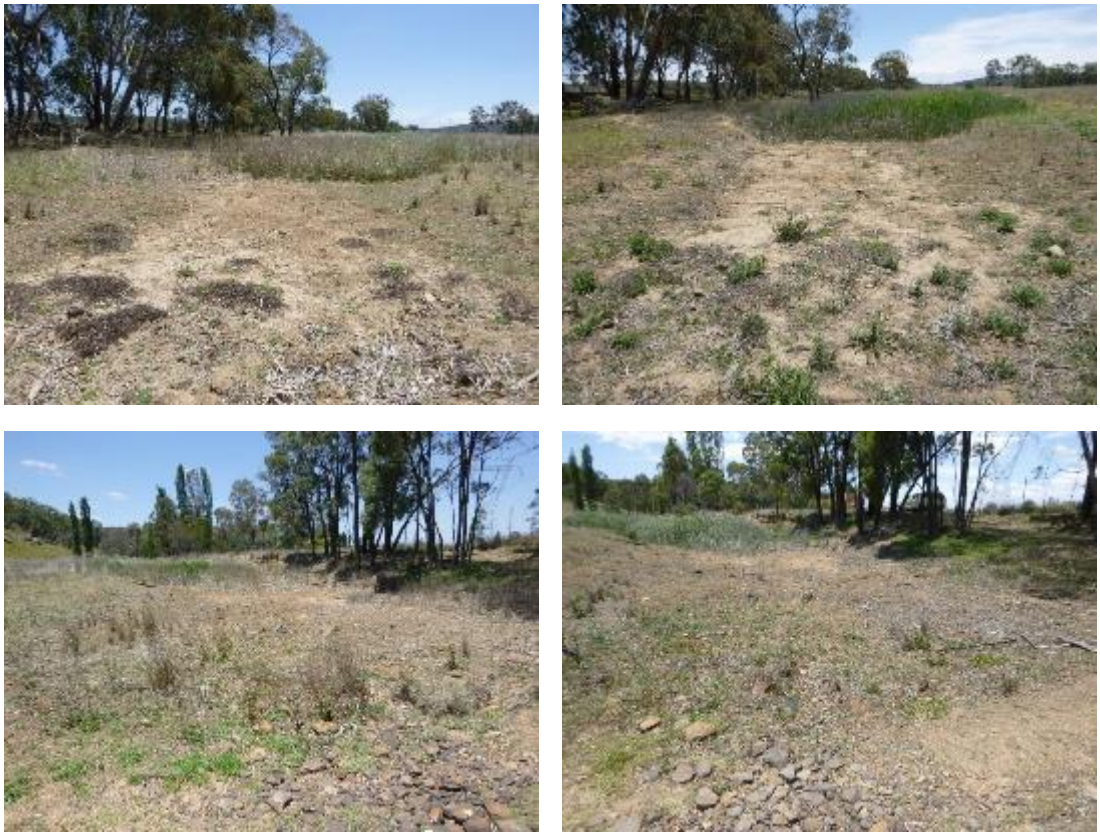

Figure B- 10: WCk10 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 11: WCk11 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 12: WCk12 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 13: WCk13 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 14: WCk14 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 15: WCk15 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 16: WCk16 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 17: WCk17 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 18: WCk18 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 19: WCk19 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 20: WCk20 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 21: WCk21 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 22: WCk22 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 23: WCk23 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 24: WCk24 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 25: WCk25 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 26: WCk26 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 27: WCk27 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 28: WCk28 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 29: WCk29 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 30: WCk30 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 31: site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 32: WCk32 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 33: WCk33 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream (note: 2017 photos taken from opposite bank)

Figure B- 34: WCk34 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 35: WCk35 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 36: WCk36 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 37: WCk37 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 38: WCk38 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 39: WCk39 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 40: WCk40 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 41: WCk41 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 42: WCk42 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 43: WCk43 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 44: WCk44 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 45: WCk45 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 46: WCk46 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 47: WCk47 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 48: WCk48 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 49: WCk49 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 50: CCk1 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 51: CCk2 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 52: CCk3 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 53: CCk4 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 54: CCk5 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 55: CCk7 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 56: CCk8 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 57: CCk9 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Figure B- 58: CCk10 site photos clockwise from top left: 2017 upstream, 2018 upstream. 2018 downstream, 2017 downstream

Appendix C : Monthly Rainfall Data

Table 6-1: Monthly rainfall from 2014 - 2017 (mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
2014	15.6	60.0	112.6	62.8	13.8	29.8	28.6	28.8	14.6	15.4	24.4	126.7	533.1
2015	127.6	11.6	9.4	108.4	42.8	42.8	38.0	53.8	7.8	61.0	59.0	118.4	680.6
2016	152.1	7.2	23.5	14.8	66.8	104.2	101.1	40.9	198.7	86.6	51.9	90.6	938.4
2017	27.8	34.2	146	23	32.4	10.4	5.8	25.2	3	28.4	92.6	102.6	531.4
2018	24.4	77	24.6	42.2	12.4	21.6	1.2	43.8	39.6	56.8	47.4	91.2	482.2
Historical Mean	66.5	62.4	52.5	39.1	37.6	44.2	42.2	41.1	41.3	51.1	56	60.1	**590.6**

Source: WCPL and Bureau of Meteorology, 2017 (Historical averages) Wollar (Barrigan St) Weather station number:62032.

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