Ceriodaphnia Partial Life-Cycle Test-Reproduction

Start Date:	11/05/2018 14:30	Test ID:	PR1552/01	Sample ID:	Mixture
End Date:	18/05/2018 14:30	Lab ID:	8649, 8650	Sample Type:	AQ-Aqueous
Sample Date:	25/04/2018	Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:	Mixture- 10% Wises (8560) + 90% Eldridge (8649). W2 as Diluent (8651)				

Auxiliary Data Summary

Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
W2 Diluent	No of Young	12.40	10.00	13.00	1.07	8.36	10
DMW Control		16.30	15.00	18.00	0.95	5.98	10
6.3		16.30	15.00	17.00	0.67	5.04	10
12.5		16.80	14.00	19.00	1.48	7.23	10
25		14.50	13.00	17.00	1.35	8.02	10
50		10.90	8.00	15.00	2.18	13.56	10
100		5.20	3.00	7.00	1.32	22.07	10
W2 Diluent	% unaffected	100.00	100.00	100.00	0.00	0.00	10
DMW Control		100.00	100.00	100.00	0.00	0.00	10
6.3		100.00	100.00	100.00	0.00	0.00	10
12.5		100.00	100.00	100.00	0.00	0.00	10
25		100.00	100.00	100.00	0.00	0.00	10
50		100.00	100.00	100.00	0.00	0.00	10
100		100.00	100.00	100.00	0.00	0.00	10
W2 Diluent	pH	8.10	8.10	8.10	0.00	0.00	1
DMW Control		8.10	8.10	8.10	0.00	0.00	1
6.3		8.30	8.30	8.30	0.00	0.00	1
12.5		8.20	8.20	8.20	0.00	0.00	1
25		8.10	8.10	8.10	0.00	0.00	1
50		8.10	8.10	8.10	0.00	0.00	1
100		8.00	8.00	8.00	0.00	0.00	1
W2 Diluent	DO %	98.00	98.00	98.00	0.00	0.00	1
DMW Control		96.30	96.30	96.30	0.00	0.00	1
6.3		99.30	99.30	99.30	0.00	0.00	1
12.5		98.40	98.40	98.40	0.00	0.00	1
25		97.90	97.90	97.90	0.00	0.00	1
50		98.20	98.20	98.20	0.00	0.00	1
100		8.00	8.00	8.00	0.00	0.00	1
W2 Diluent	Cond uS/cm	106.00	106.00	106.00	0.00	0.00	1
DMW Control		186.00	186.00	186.00	0.00	0.00	1
6.3		511.00	511.00	511.00	0.00	0.00	1
12.5		867.00	867.00	867.00	0.00	0.00	1
25		1475.00	1475.00	1475.00	0.00	0.00	1
50		2590.00	2590.00	2590.00	0.00	0.00	1
100		4660.00	4660.00	4660.00	0.00	0.00	1

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Statistical Printouts for the Duckweed Growth Inhibition Tests

Duckweed Growth Inhibtion Test-Specific Growth Rate

Start Date:	11/05/2018 17:00	Test ID:	PR1552/04	Sample ID:	Mixture
End Date:	15/05/2018 17:00	Lab ID:	8649, 8650	Sample Type:	AQ-Aqueous
Sample Date:	25/04/2018	Protocol:	ESA 112	Test Species:	LA-Lemna aequinoctialis
Comments:	Mixture- 10% Wises (8560) + 90% Eldridge (8649). W2 as Diluent (8651)				

Conc-%	1	2	3	4
W2 Diluent	0.3466	0.3666	0.3010	0.3132
CAAC Control	0.3666	0.3359	0.2882	0.3248
6.3	0.3248	0.3010	0.3466	0.3359
12.5	0.3666	0.3010	0.2882	0.3248
25	0.3359	0.3132	0.3359	0.3666
50	0.3359	0.3132	0.3466	0.3359
100	0.2452	0.2118	0.3248	0.2882

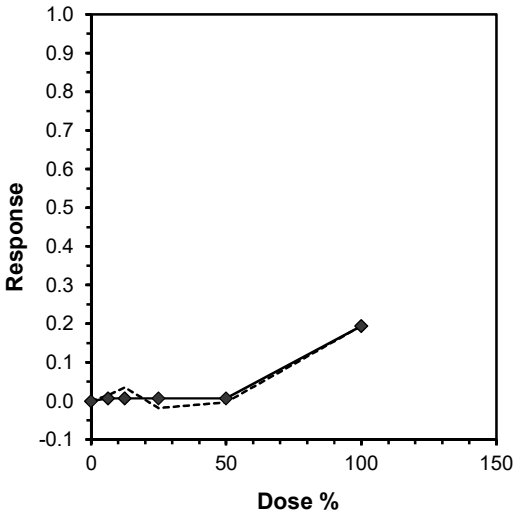
			Transform: Untransformed					1-Tailed			Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
W2 Diluent	0.3318	1.0090	0.3318	0.3010	0.3666	9.080	4	*			0.3318	1.0000
CAAC Control	0.3289	1.0000	0.3289	0.2882	0.3666	9.845	4					
6.3	0.3271	0.9945	0.3271	0.3010	0.3466	5.970	4	0.220	2.410	0.0520	0.3295	0.9930
12.5	0.3201	0.9734	0.3201	0.2882	0.3666	10.772	4	0.542	2.410	0.0520	0.3295	0.9930
25	0.3379	1.0275	0.3379	0.3132	0.3666	6.486	4	-0.281	2.410	0.0520	0.3295	0.9930
50	0.3329	1.0123	0.3329	0.3132	0.3466	4.226	4	-0.050	2.410	0.0520	0.3295	0.9930
*100	0.2675	0.8134	0.2675	0.2118	0.3248	18.452	4	2.980	2.410	0.0520	0.2675	0.8061

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.981457	0.916	0.185402	-0.14152
Bartlett's Test indicates equal variances (p = 0.40)	5.122074	15.08627		
The control means are not significantly different (p = 0.90)	0.133771	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test Treatments vs W2 Diluent	50	100	70.71068	2	0.052031	0.156796	0.002746	0.000932	0.040917	5, 18

Linear Interpolation (200 Resamples)

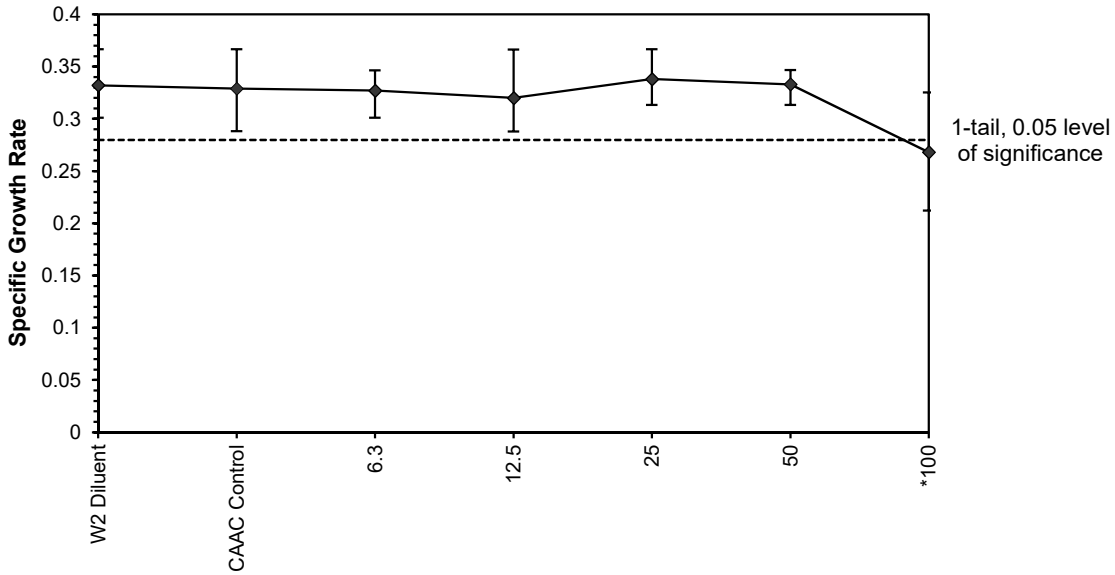
Point	%	SD	95% CL(Exp)		Skew
IC05	61.504	21.929	0.000	98.580	-1.2313
IC10	74.884				
IC15	88.263				
IC20	>100				
IC25	>100				
IC40	>100				
IC50	>100				



Duckweed Growth Inhibtion Test-Specific Growth Rate

Start Date:	11/05/2018 17:00	Test ID:	PR1552/04	Sample ID:	Mixture
End Date:	15/05/2018 17:00	Lab ID:	8649, 8650	Sample Type:	AQ-Aqueous
Sample Date:	25/04/2018	Protocol:	ESA 112	Test Species:	LA-Lemna aequinoctialis
Comments:	Mixture- 10% Wises (8560) + 90% Eldridge (8649). W2 as Diluent (8651)				

Dose-Response Plot



Duckweed Growth Inhibtion Test-Specific Growth Rate

Start Date:	11/05/2018 17:00	Test ID:	PR1552/04	Sample ID:	Mixture
End Date:	15/05/2018 17:00	Lab ID:	8649, 8650	Sample Type:	AQ-Aqueous
Sample Date:	25/04/2018	Protocol:	ESA 112	Test Species:	LA-Lemna aequinoctialis
Comments:	Mixture- 10% Wises (8560) + 90% Eldridge (8649). W2 as Diluent (8651)				

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
W2 Diluent	Specific growth rate	0.33	0.30	0.37	0.03	52.31	4
CAAC Control		0.33	0.29	0.37	0.03	54.71	4
6.3		0.33	0.30	0.35	0.02	42.72	4
12.5		0.32	0.29	0.37	0.03	58.01	4
25		0.34	0.31	0.37	0.02	43.81	4
50		0.33	0.31	0.35	0.01	35.63	4
100		0.27	0.21	0.32	0.05	83.05	4
W2 Diluent	pH	8.10	8.10	8.10	0.00	0.00	1
CAAC Control		6.20	6.20	6.20	0.00	0.00	1
6.3		8.30	8.30	8.30	0.00	0.00	1
12.5		8.20	8.20	8.20	0.00	0.00	1
25		8.10	8.10	8.10	0.00	0.00	1
50		8.10	8.10	8.10	0.00	0.00	1
100		8.00	8.00	8.00	0.00	0.00	1
W2 Diluent	Cond uS/cm	106.00	106.00	106.00	0.00	0.00	1
CAAC Control		186.00	186.00	186.00	0.00	0.00	1
6.3		511.00	511.00	511.00	0.00	0.00	1
12.5		867.00	867.00	867.00	0.00	0.00	1
25		1475.00	1475.00	1475.00	0.00	0.00	1
50		2590.00	2590.00	2590.00	0.00	0.00	1
100		4660.00	4660.00	4660.00	0.00	0.00	1

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Statistical Printouts for *Hydra* Population Growth Tests

Hydra Population Growth Test-Growth Rate

Start Date:	11/05/2018 15:30	Test ID:	PR1552/06	Sample ID:	Mixture
End Date:	15/05/2018 15:30	Lab ID:	8649, 8650	Sample Type:	AQ-Aqueous
Sample Date:	25/04/2018	Protocol:	ESA 125	Test Species:	HV-Hydra viridissima
Comments:	Mixture- 10% Wises (8560) + 90% Eldridge (8649). W2 as Diluent (8651)				

Conc-%	1	2	3	4
W2 Diluent	0.3527	0.3815	0.3647	0.3466
LC Diluent	0.3815	0.3527	0.3922	0.3704
6.3	0.3527	0.3588	0.3466	0.3815
12.5	0.3647	0.3402	0.3466	0.3815
25	0.3402	0.3527	0.3588	0.3527
50	0.2389	0.2291	0.2574	0.2747
100	0.0000	0.0000	0.0000	0.0000

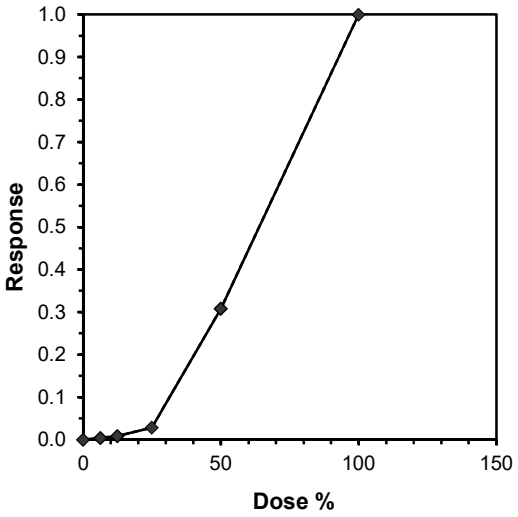
			Transform: Untransformed					1-Tailed			Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
W2 Diluent	0.3614	0.9657	0.3614	0.3466	0.3815	4.257	4	*			0.3614	1.0000
LC Diluent	0.3742	1.0000	0.3742	0.3527	0.3922	4.500	4					
6.3	0.3599	0.9618	0.3599	0.3466	0.3815	4.236	4	0.130	2.360	0.0268	0.3599	0.9959
12.5	0.3582	0.9574	0.3582	0.3402	0.3815	5.204	4	0.276	2.360	0.0268	0.3582	0.9914
25	0.3511	0.9383	0.3511	0.3402	0.3588	2.219	4	0.904	2.360	0.0268	0.3511	0.9717
*50	0.2500	0.6681	0.2500	0.2291	0.2747	8.080	4	9.823	2.360	0.0268	0.2500	0.6918
100	0.0000	0.0000	0.0000	0.0000	0.0000	0.000	4				0.0000	0.0000

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.929908	0.905	0.427296	-0.93344
Bartlett's Test indicates equal variances (p = 0.68)	2.285716	13.2767		
The control means are not significantly different (p = 0.30)	1.1253	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test Treatments vs W2 Diluent	25	50	35.35534	4	0.026757	0.074042	0.009334	0.000257	1.5E-07	4, 15

Linear Interpolation (200 Resamples)

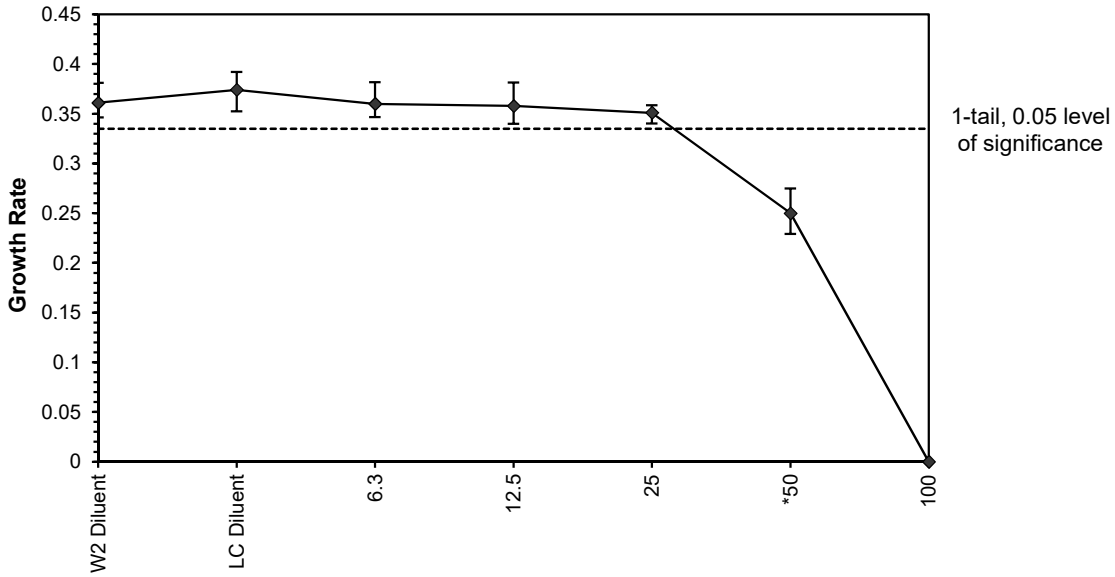
Point	%	SD	95% CL(Exp)		Skew
IC05	26.934	4.399	1.878	30.047	-3.0698
IC10	31.401	1.455	25.818	34.888	-0.0822
IC15	35.868	1.563	30.498	40.538	0.1354
IC20	40.335	1.790	34.607	46.558	0.3252
IC25	44.802	2.075	38.061	51.583	0.3791
IC40	56.636	1.754	49.477	61.156	-0.1969
IC50	63.863	1.461	57.898	67.630	-0.1969



Hydra Population Growth Test-Growth Rate

Start Date:	11/05/2018 15:30	Test ID:	PR1552/06	Sample ID:	Mixture
End Date:	15/05/2018 15:30	Lab ID:	8649, 8650	Sample Type:	AQ-Aqueous
Sample Date:	25/04/2018	Protocol:	ESA 125	Test Species:	HV-Hydra viridissima
Comments:	Mixture- 10% Wises (8560) + 90% Eldridge (8649). W2 as Diluent (8651)				

Dose-Response Plot



Hydra Population Growth Test-Growth Rate

Start Date:	11/05/2018 15:30	Test ID:	PR1552/06	Sample ID:	Mixture
End Date:	15/05/2018 15:30	Lab ID:	8649, 8650	Sample Type:	AQ-Aqueous
Sample Date:	25/04/2018	Protocol:	ESA 125	Test Species:	HV-Hydra viridissima
Comments:	Mixture- 10% Wises (8560) + 90% Eldridge (8649). W2 as Diluent (8651)				

Auxiliary Data Summary

Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
W2 Diluent	Specific growth rate	0.36	0.35	0.38	0.02	34.32	4
LC Diluent		0.37	0.35	0.39	0.02	34.68	4
6.3		0.36	0.35	0.38	0.02	34.31	4
12.5		0.36	0.34	0.38	0.02	38.11	4
25		0.35	0.34	0.36	0.01	25.14	4
50		0.25	0.23	0.27	0.02	56.85	4
100		0.00	0.00	0.00	0.00		4
W2 Diluent	pH	8.10	8.10	8.10	0.00	0.00	1
LC Diluent		7.60	7.60	7.60	0.00	0.00	1
6.3		8.30	8.30	8.30	0.00	0.00	1
12.5		8.20	8.20	8.20	0.00	0.00	1
25		8.10	8.10	8.10	0.00	0.00	1
50		8.10	8.10	8.10	0.00	0.00	1
100		8.00	8.00	8.00	0.00	0.00	1
W2 Diluent	Cond uS/cm	106.00	106.00	106.00	0.00	0.00	1
LC Diluent		32.00	32.00	32.00	0.00	0.00	1
6.3		511.00	511.00	511.00	0.00	0.00	1
12.5		867.00	867.00	867.00	0.00	0.00	1
25		1475.00	1475.00	1475.00	0.00	0.00	1
50		2590.00	2590.00	2590.00	0.00	0.00	1
100		4660.00	4660.00	4660.00	0.00	0.00	1

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Statistical Printouts for the Larval Fish Imbalance Tests

Fish Embryonic Development-% Unaffected

Start Date:	11/05/2018 18:30	Test ID:	PR1552/02	Sample ID:	Mixture
End Date:	23/05/2018 18:30	Lab ID:	8649, 8650	Sample Type:	AQ-Aqueous
Sample Date:	25/04/2018	Protocol:	ESA 126	Test Species:	MS-Melanotaenia splendida
Comments:	Mixture- 10% Wises (8560) + 90% Eldridge (8649). W2 as Diluent (8651)				

Conc-%	1	2	3	4
W2 Diluent	1.0000	1.0000	1.0000	0.8000
DMW Control	1.0000	0.8000	0.8000	1.0000
6.3	1.0000	0.8000	0.6000	1.0000
12.5	1.0000	1.0000	1.0000	1.0000
25	1.0000	1.0000	0.8000	1.0000
50	1.0000	1.0000	1.0000	1.0000
100	0.8000	0.8000	1.0000	1.0000

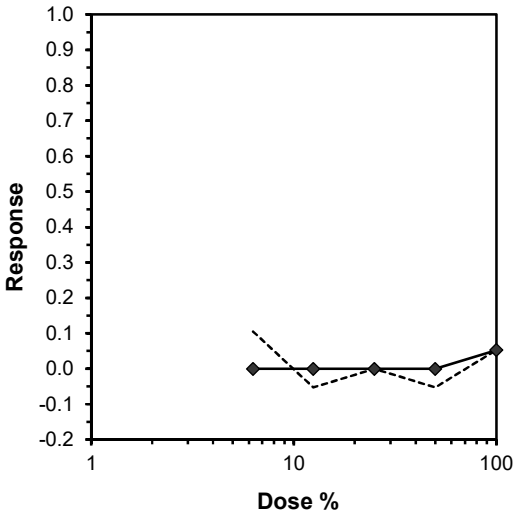
			Transform: Arcsin Square Root					Rank	1-Tailed	Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Mean	N-Mean
W2 Diluent	0.9500	1.0556	1.2857	1.1071	1.3453	9.261	4	*		0.9500	1.0000
DMW Control	0.9000	1.0000	1.2262	1.1071	1.3453	11.212	4				
6.3	0.8500	0.9444	1.1709	0.8861	1.3453	18.840	4	15.50	10.00	0.9500	1.0000
12.5	1.0000	1.1111	1.3453	1.3453	1.3453	0.000	4	20.00	10.00	0.9500	1.0000
25	0.9500	1.0556	1.2857	1.1071	1.3453	9.261	4	18.00	10.00	0.9500	1.0000
50	1.0000	1.1111	1.3453	1.3453	1.3453	0.000	4	20.00	10.00	0.9500	1.0000
100	0.9000	1.0000	1.2262	1.1071	1.3453	11.212	4	16.00	10.00	0.9000	0.9474

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.920884	0.916	-0.77636	0.66368
Equality of variance cannot be confirmed				
The control means are not significantly different (p = 0.54)	0.654654	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	100	>100		1
Treatments vs W2 Diluent				

Log-Logit Interpolation (200 Resamples)

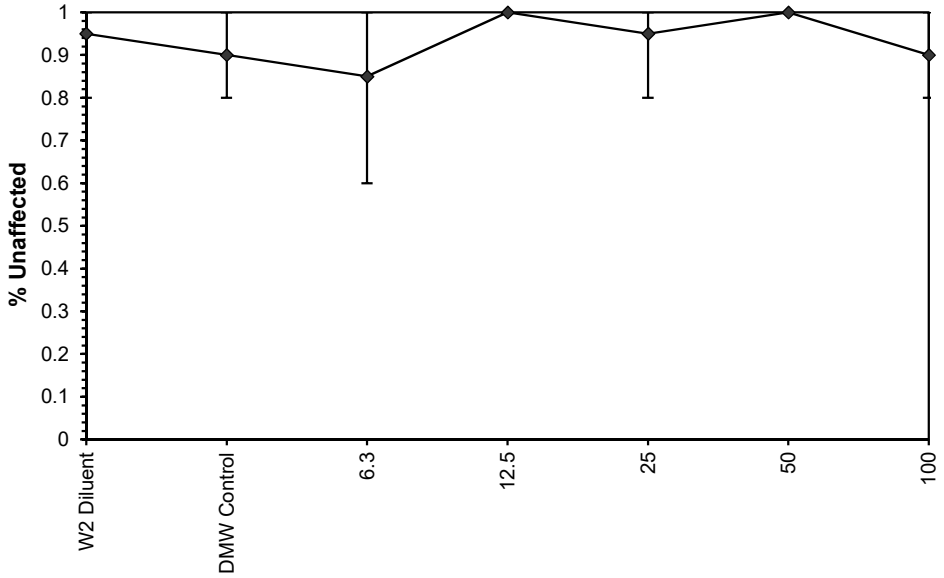
Point	%	SD	95% CL(Exp)	Skew
IC05	97.438			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



Fish Embryonic Development-% Unaffected

Start Date:	11/05/2018 18:30	Test ID:	PR1552/02	Sample ID:	Mixture
End Date:	23/05/2018 18:30	Lab ID:	8649, 8650	Sample Type:	AQ-Aqueous
Sample Date:	25/04/2018	Protocol:	ESA 126	Test Species:	MS-Melanotaenia splendida
Comments:	Mixture- 10% Wises (8560) + 90% Eldridge (8649). W2 as Diluent (8651)				

Dose-Response Plot



Fish Embryonic Development-% Unaffected

Start Date:	11/05/2018 18:30	Test ID:	PR1552/02	Sample ID:	Mixture
End Date:	23/05/2018 18:30	Lab ID:	8649, 8650	Sample Type:	AQ-Aqueous
Sample Date:	25/04/2018	Protocol:	ESA 126	Test Species:	MS-Melanotaenia splendida
Comments:	Mixture- 10% Wises (8560) + 90% Eldridge (8649). W2 as Diluent (8651)				

Auxiliary Data Summary

Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
W2 Diluent	% Unaffected	95.00	80.00	100.00	10.00	3.33	4
DMW Control		90.00	80.00	100.00	11.55	3.78	4
6.3		85.00	60.00	100.00	19.15	5.15	4
12.5		100.00	100.00	100.00	0.00	0.00	4
25		95.00	80.00	100.00	10.00	3.33	4
50		100.00	100.00	100.00	0.00	0.00	4
100		90.00	80.00	100.00	11.55	3.78	4
W2 Diluent	pH	8.10	8.10	8.10	0.00	0.00	1
DMW Control		8.10	8.10	8.10	0.00	0.00	1
6.3		8.30	8.30	8.30	0.00	0.00	1
12.5		8.20	8.20	8.20	0.00	0.00	1
25		8.10	8.10	8.10	0.00	0.00	1
50		8.10	8.10	8.10	0.00	0.00	1
100		8.00	8.00	8.00	0.00	0.00	1
W2 Diluent	Conductivity (uS/cm)	106.00	106.00	106.00	0.00	0.00	1
DMW Control		186.00	186.00	186.00	0.00	0.00	1
6.3		511.00	511.00	511.00	0.00	0.00	1
12.5		867.00	867.00	867.00	0.00	0.00	1
25		1475.00	1475.00	1475.00	0.00	0.00	1
50		2590.00	2590.00	2590.00	0.00	0.00	1
100		4660.00	4660.00	4660.00	0.00	0.00	1
W2 Diluent	DO (% sat)	98.00	98.00	98.00	0.00	0.00	1
DMW Control		96.30	96.30	96.30	0.00	0.00	1
6.3		99.30	99.30	99.30	0.00	0.00	1
12.5		98.40	98.40	98.40	0.00	0.00	1
25		97.90	97.90	97.90	0.00	0.00	1
50		98.20	98.20	98.20	0.00	0.00	1
100		8.00	8.00	8.00	0.00	0.00	1

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Statistical Printouts for the *Chlorella* Growth Inhibition Tests

Microalgal Cell Yield-Cell Yield

Start Date:	11/05/2018 17:30	Test ID:	PR1552/08	Sample ID:	Mixture
End Date:	14/05/2018 17:30	Lab ID:	8649, 8650	Sample Type:	AQ-Aqueous
Sample Date:	25/04/2018	Protocol:	ESA 103	Test Species:	CV-Chlorella vulgaris
Comments:	Mixture- 10% Wises (8560) + 90% Eldridge (8649). W2 as Diluent (8651)				

Conc-%	1	2	3	4
W2 Diluent	31.800	27.200	29.600	27.200
USEPA Diluent	25.600	24.800	26.600	26.800
6.3	28.200	26.600	26.800	27.800
12.5	26.600	25.200	24.600	27.200
25	26.200	26.800	25.000	24.600
50	23.000	26.200	25.600	24.800
100	23.800	25.600	26.800	24.400

			Transform: Untransformed					1-Tailed			Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
W2 Diluent	28.950	1.1156	28.950	27.200	31.800	7.638	4	*			28.950	1.0000
USEPA Diluent	25.950	1.0000	25.950	24.800	26.800	3.581	4					
6.3	27.350	1.0539	27.350	26.600	28.200	2.824	4	1.621	2.410	2.379	27.350	0.9447
*12.5	25.900	0.9981	25.900	24.600	27.200	4.655	4	3.090	2.410	2.379	25.900	0.8946
*25	25.650	0.9884	25.650	24.600	26.800	3.995	4	3.343	2.410	2.379	25.650	0.8860
*50	24.900	0.9595	24.900	23.000	26.200	5.584	4	4.103	2.410	2.379	25.025	0.8644
*100	25.150	0.9692	25.150	23.800	26.800	5.290	4	3.850	2.410	2.379	25.025	0.8644

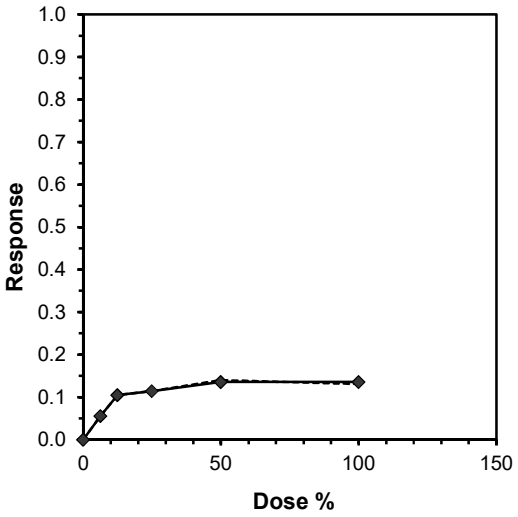
Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.957556	0.916	0.263337	-0.46097
Bartlett's Test indicates equal variances (p = 0.64)	3.399041	15.08627		
The control means are significantly different (p = 0.05)	2.501448	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test Treatments vs W2 Diluent	6.3	12.5	8.87412	15.87302	2.379006	0.082176	9.590667	1.948889	0.005168	5, 18

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)		Skew
IC05*	5.700	3.610	0.929	22.732	1.6698
IC10	11.837				
IC15	>100				
IC20	>100				
IC25	>100				
IC40	>100				
IC50	>100				

* indicates IC estimate less than the lowest concentration



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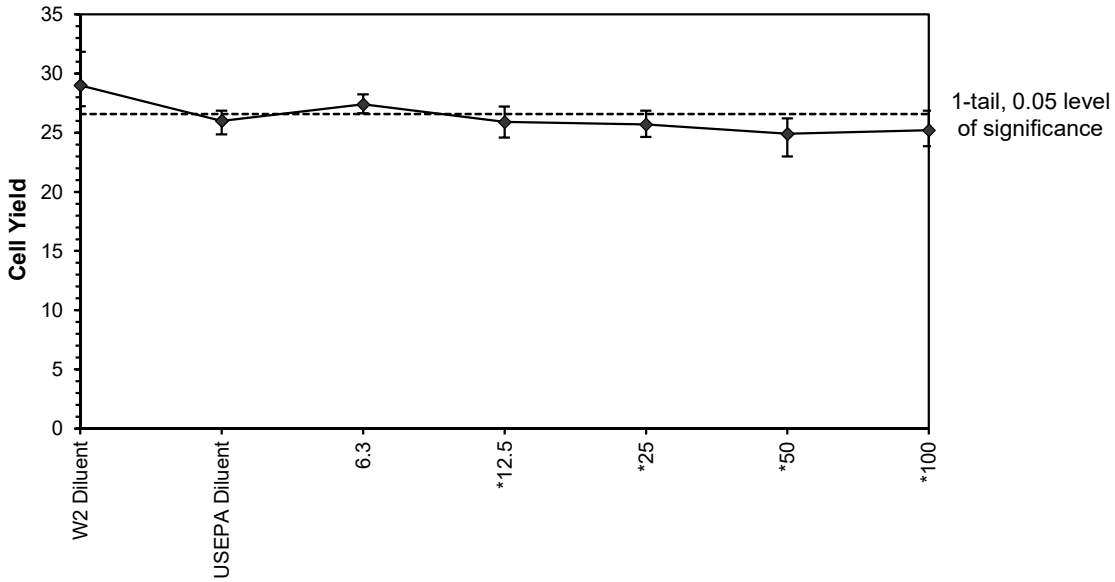
Dose-Response Plot



Microalgal Cell Yield-Cell Yield

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Auxiliary Data Summary

Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
W2 Diluent	Cell Yield	28.95	27.20	31.80	2.21	5.14	4
USEPA Diluent		25.95	24.80	26.80	0.93	3.71	4
6.3		27.35	26.60	28.20	0.77	3.21	4
12.5		25.90	24.60	27.20	1.21	4.24	4
25		25.65	24.60	26.80	1.02	3.95	4
50		24.90	23.00	26.20	1.39	4.74	4
100		25.15	23.80	26.80	1.33	4.59	4
W2 Diluent	pH	8.10	8.10	8.10	0.00	0.00	1
USEPA Diluent		7.60	7.60	7.60	0.00	0.00	1
6.3		8.30	8.30	8.30	0.00	0.00	1
12.5		8.20	8.20	8.20	0.00	0.00	1
25		8.10	8.10	8.10	0.00	0.00	1
50		8.10	8.10	8.10	0.00	0.00	1
100		8.00	8.00	8.00	0.00	0.00	1
W2 Diluent	Conductivity uS/cm	106.00	106.00	106.00	0.00	0.00	1
USEPA Diluent		99.00	99.00	99.00	0.00	0.00	1
6.3		511.00	511.00	511.00	0.00	0.00	1
12.5		867.00	867.00	867.00	0.00	0.00	1
25		1475.00	1475.00	1475.00	0.00	0.00	1
50		2590.00	2590.00	2590.00	0.00	0.00	1
100		4660.00	4660.00	4660.00	0.00	0.00	1

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Appendix G

DTA - June 2018

Hydrobiology

DTA OF POTENTIAL RELEASE WATER FROM THE KIDSTON PUMPED STORAGE HYDRO PROJECT

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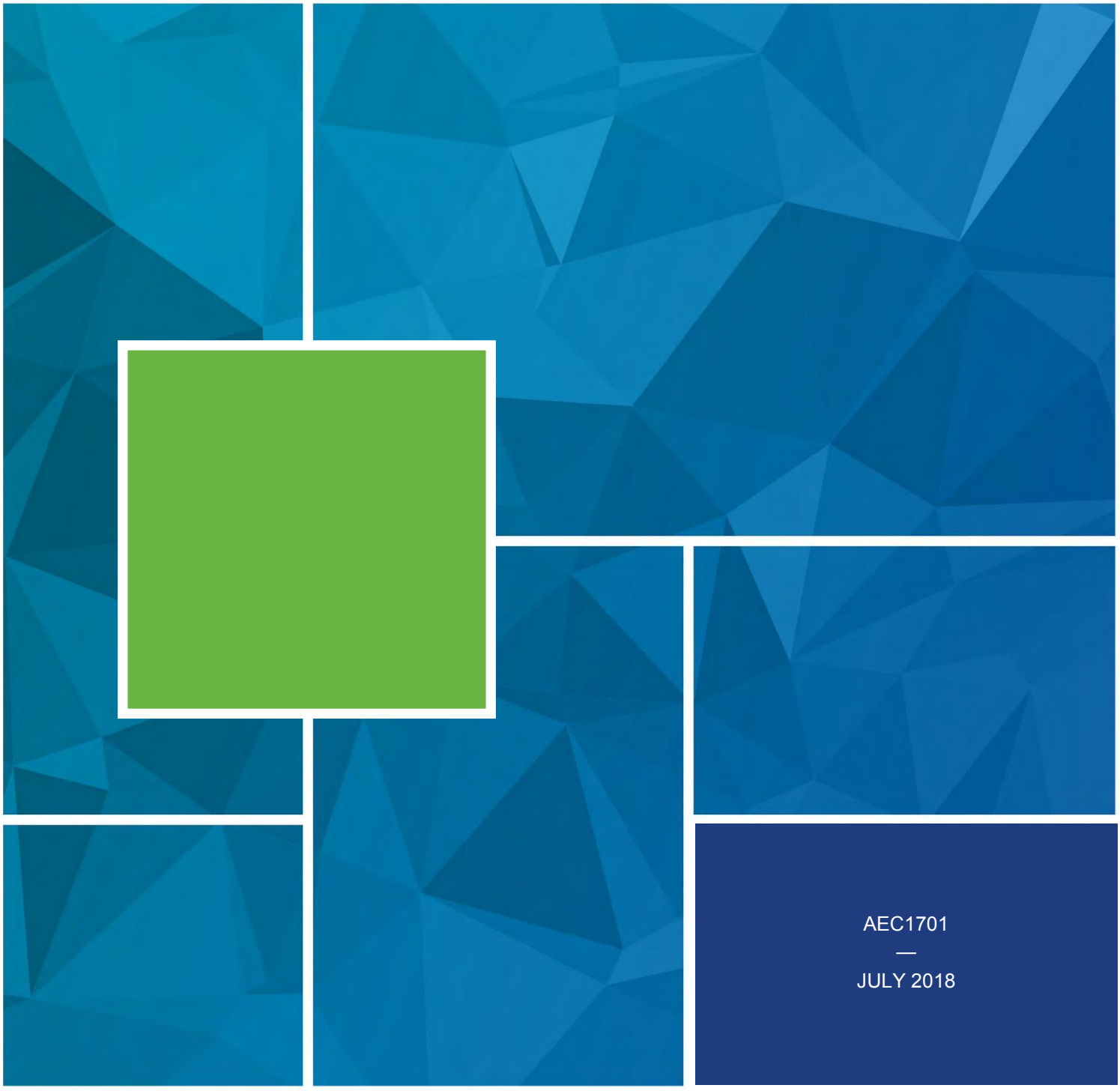

AEC1701
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JULY 2018

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PROJECT SUBTITLE	Prepared for AECOM
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FILENAME	DESCRIPTION	ISSUED TO	ISSUED BY
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V2-0	Final	Reece Fraser Rouven Lau	Marie Bigot

EXECUTIVE SUMMARY

This Direct Toxicity Assessment (DTA) aimed to determine effluent release rates for the Kidston pumped storage Hydro project.

Waters from Wises Pit and Eldridge Pit at the former Kidston gold mine were mixed at a volumetric ratio of 10% to 90% (respectively) to produce a representative composite sample of the proposed discharge into the Copperfield River (Gilbert Basin). Ecotoxicity testing was performed by the NATA accredited laboratories at Ecotox Services Australasia (ESA) on the composite water sample using Copperfield River water as diluent.

The following sub-chronic to chronic toxicity tests were selected for this DTA and satisfied the minimum data requirement of ANZECC & ARMCANZ (2000):

- 96hr growth inhabitation of the freshwater duckweed *Lemna aequinoctialis* based on OECD method 221 (OECD, 2006)
- 72hr microalgal growth inhibition (cell yield) test using the freshwater alga *Chlorella vulgaris* (based on US EPA method 1003.0, (US EPA, 2002))
- 96hr population growth toxicity test using *Hydra viridissima* (based on Riethmuller et al. (2003))
- Fish embryonic development and post-hatch survival toxicity test using the rainbowfish *Melanotaenia splendida splendida* (based on US EPA (2002))
- 7 day reproductive impairment toxicity test using the freshwater cladoceran *Ceriodaphnia cf dubia* (based on US EPA (2002) and Bailey et al. (2000))

The results obtained from these ecotoxicity tests were used to create a species sensitivity distribution (SSD) to predict the concentrations that would protect specified percentages of species in the receiving Copperfield River ecosystem. Trigger values (TVs) were derived in accordance with ANZECC and

ARMCANZ (2000) methods using the BurrliOZ 2.0 software package (Barry and Henderson, 2014) provided by CSIRO. BurrliOZ fits a log-logistic distribution to estimate the concentrations of discharges such that a given percentage of species will be protected. The TV for the protection of 95 % of the receiving ecosystem species corresponded to a concentration of 49 % of the composite pit sample tested. This corresponded to a safe dilution factor of 1.1.

Based on the outcomes of this DTA, it is recommended that the proposed discharge water (composed of 90% Eldridge to 10% Wises pit water) be diluted at least 1.1 times to achieve a minimum protection level of 95% of species in the receiving Copperfield River. A conservative dilution factor of 2 should protect >99% of species.

It is important to note that there appears to be some temporal variability in the composition of Eldridge and Wises pit water. The results from this study apply for a representative mixture as described in Table 2-1. In the case where the composition of the mixture varies (in particular EC levels), the dilution factor may need to be adjusted. The DTA performed in May 2018 (HB 2018) could be considered a worst case scenario.

contents

tables

figures

Glossary of Terms and Acronyms

The following glossary is based on that provided by *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC and ARMCANZ 2000) and Environment Canada (1999) except where otherwise indicated.

Chronic toxicity – A biological response to exposure to a toxicant that takes a prolonged period to appear and persists for a prolonged period. The term can be used to define either the exposure of an aquatic species or its response to an exposure (effect). The ANZECC & ARMCANZ (2000) define chronic exposure as being greater than 96 hours duration for multi-celled organisms and being equal to or greater than 72 hours duration for single-celled organisms.

Control (control treatment) – In toxicity tests, the control is that treatment in which the test organisms are not subjected to the test substance. The control is used as a standard comparison, to check that the outcome of the experiment is a reflection of the test conditions and not some unknown factor.

Direct toxicity assessment (DTA) – The use of toxicity tests to determine the acute and/or chronic toxicity of effluents and other mixtures of potential toxicants.

EC – Electrical Conductivity, which is an estimate of the amount of total dissolved salts (TDS).

EC_{10} – The concentration of a chemical that is estimated to cause a response in 10% of the test organisms or causes the mean response of the organisms to differ from the control by 10%. The EC10 is usually expressed as a time-dependent value, e.g. 24-hour EC_{10} is the concentration estimated to cause an effect on 10% of the test organisms after 24 hours of exposure.

EC_{50} – The concentration of chemical that is estimated to cause a response in 50% of the test organisms or causes the mean response of the organisms to differ from the control by 50%. The EC50 is usually expressed as a time-dependent value, e.g. 24-hour EC_{50} is the concentration estimated to be cause an effect on 50% of the test organisms after 24 hours of exposure.

Endpoint – The biological response of test organisms in toxicity tests that is measured (e.g. lethality, immobilisation).

ESA – Ecotox Services Australasia.

Ecosystem trigger values – These are the concentration (or loads) of the key performance indicators measured for the ecosystem, below which there exists a low risk that adverse biological (ecological) effects will occur. They indicate a risk of impact if exceeded and should 'trigger' some action, either further ecosystem-specific investigations or implementation of management/remedial actions.

Goodness of Fit – A statistical measure of how well a set of observations fit the predicted pattern of a probability distribution function.

ICp – The concentration that inhibits an endpoint by 'p' percent (e.g. the $IC50_{(reprod)}$ is the concentration that inhibits reproduction by 50%). It represents a point estimate of a concentration of test material that causes a designated percent inhibition (p) compared to the control. The ICp is usually expressed as a time-dependent value, e.g. 24-hour IC_{50} is the concentration estimated to cause an effect on 50% of the test organisms after 24 hours of exposure.

LC_{50} – The concentration of material in water that is estimated to be lethal to 50% of the test organisms. The LC_{50} is usually expressed as a time-dependent value, e.g. 24-hour or 96-hour LC_{50}, the concentration estimated to be lethal to 50% of the test organisms after 24 or 96 hours of exposure.

Level of protection – The ANZECC & ARMCANZ (2000) provide three levels of protection depending on the current status of the ecosystem being considered. The levels are (1) high conservation ecosystems where the default is to protect 99% of species (i.e. PC_{99} values apply), (2) slightly to moderately modified ecosystems where the default is to protect 95% of species (i.e. PC_{95} values apply) and (3) highly modified ecosystems where the default is to protect between 80 to 90% of species (i.e. PC_{80} to PC_{90} values apply).

LOEC – The lowest observed concentration of a toxicant used in a toxicity test that has a statistically significant ($P \leq 0.05$) adverse effect on the exposed population of test organisms compared with the controls. This is estimated by hypothesis-based statistical methods and is therefore not a point estimate.

Mixing zones – An explicitly defined area around a discharge point where discharge concentrations may exceed guideline values and therefore result in certain environmental values not being protected. The size of the mixing zone is site specific.

NATA – National Association of Testing Authorities.

NOEC – The highest observed concentration of a toxicant used in a toxicity test that does not exert a statistically significant adverse effect ($P > 0.05$) on the exposed population of test organisms compared to the controls. This is estimated by hypothesis based statistical methods and is therefore not a point estimate.

Protective concentrations (PC) – The concentration predicted by species sensitivity distribution methods that will protect a chosen percentage of species from experiencing toxic effects. For example, the PC_{99} should protect 99% of species in the ecosystem being considered. The toxic effects that are being prevented will depend on the type of toxicity data used to derive the PC values. Thus, if sub-lethal EC_{10} data are used to generate a PC_{95} – it will protect 95% of species from experiencing sub-lethal EC_{10} effects.

Safe dilution factors – The concentration that a chemical or discharge must be diluted by in order to meet a selected PC value. The lower the PC value the higher the dilution factor must be to protect the selected percentage of species.

Species Sensitivity Distribution (SSD) – SSD is a statistical approach for predicting the threshold concentrations of a contaminant or effluent that will protect a specific proportion of aquatic species with a predetermined level of confidence.

Sub-lethal – A biological response that is less severe than death. Examples of sub-lethal effects include inhibition of reproduction, reduction in growth, reduction in population growth, inhibition of fertilisation and inhibition of development.

Toxicity – The inherent potential or capacity of a chemical to cause adverse effects in a living organism.

Toxicity test – A test that exposes living organisms to several concentrations of a substance that is under investigation, and evaluates the organism's responses.

Trigger Value (TV) – The numerical limit for the aqueous concentration of a toxicant which if exceeded leads to further investigation or action to remediate the site or to reduce the concentration of the toxicant.

1. BACKGROUND AND OBJECTIVES

AECOM has commissioned Hydrobiology and Ecotox Services Australia Pty Ltd (ESA) to perform a Direct Toxicity Assessment (DTA) of a mixture of water from Wises Pit and Eldridge Pit at Kidston which is being proposed to be discharged into the Copperfield River (Gilbert Basin, North Queensland). The major contaminants of concern identified in the effluent release were sulphate (as SO_4), arsenic, zinc and nickel.

The scope of this work was to determine acceptable safe dilution factors for discharge of a mixture of pit waters in the Copperfield River which is part of Gilbert Basin. The aim was to achieve a level of aquatic ecosystem protection of 95% of species in the receiving environment corresponding to a slightly to moderately disturbed upland freshwater system.

The specific objectives of this study were to:

- Use the results obtained in ecotoxicity testing performed by ESA to create a species sensitivity distribution (SSD);
- Use the SSD to predict the concentrations that would protect specified percentages of species in the receiving Copperfield River ecosystem; and
- Derive safe dilution factors for protecting this ecosystem.

2. METHODS

2.1 SAMPLE COLLECTION

All water samples used for this investigation were collected by AECOM in June 2018. Two test water samples were provided from the Wises and Eldridge pits. Diluent water was also collected from the Copperfield River. The river sample was collected at site W2, as indicated in Figure 2-1. This point was located directly downstream of the proposed release point and represents the most likely river water quality that will mix with the proposed discharge.

2.2 WATER QUALITY

The two test waters from Eldridge and Wises pits were mixed by AECOM at a ratio of 90% Eldridge to 10% Wises. The DTA was undertaken using this composite sample which was serially diluted using Copperfield River water. Both the Copperfield River and composite pit samples were characterised at Australian Laboratory Services (ALS). Parameters analysed included:

- Physico-chemical parameters
- Cations/Anions
- Metals (total and dissolved)
- Nutrients
- Cyanide

Water quality results for the composite sample and the river water sample used in this DTA are presented in Table 2-1.

Figure 2-1 Map of river sampling locations along the Copperfield River and proposed release points (provided by AECOM)

Table 2-1 Water quality results for the composite and river water samples used in the DTA

Parameter	Unit	Copperfield River sample (June 2018)	Composite pit sample (90% Eldridge+10% Wises) (June 2018)	Composite pit sample (May 2018) used for previous DTA (HB, 2018)
pH	-	8.10	7.78	7.82
EC (at 25˚C)	µS/cm	153	3210	4600
Total Hardness (as $CaCO_3$)	mg/L	50	1230	1530
Sodium adsorption ratio (SAR)	-	0.83	4.02	6.04
Total Alkalinity (as $CaCO_3$)	mg/L	60	48	84
Sulphate (SO_4^{2-})	mg/L	7	1720	2630
Chloride	mg/L	8	107	161
Calcium	mg/L	10	338	410
Magnesium	mg/L	6	94	124
Sodium	mg/L	10	324	544
Potassium	mg/L	2	52	110
Fluoride	mg/L	0.2	2.8	4.9
Total Anions	meq/L	1.57	39.8	61.0
Total Cations	meq/L	1.48	40.0	57.1
Ionic Balance	%	-	0.3	3.25
Ammonia as N	mg/L	0.02	0.16	0.35
Nitrite as N	mg/L	<0.01	<0.01	0.01
Nitrate as N	mg/L	<0.01	5.19	0.31
Total Kjeldahl Nitrogen as N	mg/L	0.2	0.6	0.4

Parameter	Unit	Copperfield River sample (June 2018)	Composite pit sample (90% Eldridge+10% Wises) (June 2018)	Composite pit sample (May 2018) used for previous DTA (HB, 2018)
Total Phosphorous as P	mg/L	<0.01	0.03	0.09
Reactive Phosphorous as P	mg/L	<0.01	0.01	0.04
Arsenic	mg/L	<0.001 (D), <0.001 (T)	0.047 (D), 0.050 (T)	0.247 (D), 0.250 (T)
Beryllium	mg/L	<0.001 (D), <0.001 (T)	<0.001 (D), <0.001 (T)	<0.001 (D), <0.001 (T)
Barium	mg/L	0.023 (D), 0.027 (T)	0.037 (D), 0.050 (T)	0.042 (D), 0.043 (T)
Cadmium	mg/L	<0.0001 (D), <0.0001 (T)	0.0221 (D), 0.0222 (T)	0.0012 (D), 0.0015 (T)
Chromium	mg/L	<0.001 (D), <0.001 (T)	<0.001 (D), <0.001 (T)	<0.001 (D), <0.001 (T)
Cobalt	mg/L	<0.001 (D), <0.001 (T)	0.004 (D), 0.005 (T)	0.002 (D), 0.003 (T)
Copper	mg/L	<0.001 (D), <0.001 (T)	0.003 (D), 0.007 (T)	0.002 (D), 0.002 (T)
Lead	mg/L	<0.001 (D), <0.001 (T)	<0.001 (D), <0.001 (T)	<0.001 (D), <0.001 (T)
Manganese	mg/L	0.004 (D), 0.053 (T)	1.11 (D), 1.21 (T)	0.236 (D), 0.256 (T)
Mercury	mg/L	<0.0001 (D), <0.0001 (T)	<0.0001 (D), <0.0001 (T)	<0.0001 (D), <0.0001 (T)
Nickel	mg/L	<0.001 (D), <0.001 (T)	0.021 (D), 0.022 (T)	0.003 (D), 0.003 (T)
Selenium	mg/L	<0.01 (D), <0.01 (T)	<0.01 (D), <0.01 (T)	<0.01 (D), <0.01 (T)
Vanadium	mg/L	<0.01 (D), <0.01 (T)	<0.01 (D), <0.01 (T)	<0.01 (D), <0.01 (T)
Zinc	mg/L	<0.005 (D), <0.005 (T)	1.09 (D), 1.10 (T)	0.080 (D), 0.081 (T)

Parameter	Unit	Copperfield River sample (June 2018)	Composite pit sample (90% Eldridge+10% Wises) (June 2018)	Composite pit sample (May 2018) used for previous DTA (HB, 2018)
Boron	mg/L	<0.05 (D), <0.05 (T)	0.05 (D), 0.05 (T)	0.08 (D), 0.09 (T)

Notes: (D) denotes dissolved concentrations, (T) denotes total concentrations

Also presented in Table 2-1 are the water quality analysis results of a composite sample that was used in DTA testing in May 2018. We note that water quality of the mixture tested for this DTA (i.e. 90% Eldridge to 10% Wises pit water) was different when compared with the previous mixture tested in May 2018 (which was an unknown mixture ratio). It is important to note that the composition of each pit varied considerably between the two sampling dates. In particular, EC was considerably lower in June (Eldridge sample was 3340 and 2950 µS/cm in May and June, respectively, and Wises sample was 6180 and 4870 µS/cm, respectively) which resulted in a lower EC for the June composite sample compared with the previous (3210 µS/cm compared with 4600 µS/cm in May 2018). The concentrations of major ions (including Ca, Cl, Mg, Na and K), alkalinity and hardness were also lower. In terms of metal contaminants, many were found at higher concentrations in June compared with the mixture from May 2018, these included Cd, Co, Cu, Mn, Ni and Zn, which were found at concentrations above their respective trigger values for freshwater ecosystems in ANZECC & ARMCANZ (2000). Arsenic and boron were found in lower concentrations in June compared with May.

2.3 ECOTOXICITY TESTING

A minimum of five tests on species from four taxonomic groups are required to enable the derivation of "safe" dilutions of discharges using an SSD approach (ANZECC & ARMCANZ, 2000). The following chronic and sub-chronic tests were selected for this DTA:

- 96hr growth inhabitation of the freshwater duckweed *Lemna aequinoctialis* based on OECD method 221 (OECD, 2006)

  Two species of macrophytes were found in the Copperfield River aquatic ecology survey undertaken in April 2018 (C&R Consulting, 2018). The test species, *L. aequinoctialis*, is a small aquatic, flowering macrophyte, commonly known as duckweed. Unlike many other evolutionary more complex plants, their small size and fast growth rates make them ideal for testing in the laboratory. This test was based on the OECD protocol method 221 (OECD, 2006). A standard number of vegetatively reproducing *Lemna* plants were exposed to dilution series of the test solution over 96 hours under controlled conditions. The number of fronds was counted at the end of the test and from this, the degree of plant growth was calculated and compared with an appropriate control to determine the percentage inhibition of growth for each treatment.
- 72hr microalgal growth inhibition (cell yield) test using the freshwater alga *Chlorella vulgaris* (based on US EPA method 1003.0, (US EPA, 2002))

  Chlorella vulgaris (Chlorophyceae) is a unicellular freshwater green alga. Exponentially growing cells of *C. vulgaris* were exposed to dilution series of the test toxicant over several generations under defined conditions. The test was conducted over 72 hours with cell counts undertaken at both 48 and 72 h. From these counts, cell division rates were calculated. The test solution was considered toxic when a statistically significant ($P \leq 0.05$) concentration-dependent inhibition of algal growth occurred. Development of this method is described by Franklin et al. (1998).
- 96hr population growth toxicity test using *Hydra viridissima* (based on Riethmuller et al. (2003))

Hydra viridissima is referred to as 'green' hydra because of its green colouration resulting from the presence of a symbiotic green alga in the gastrodermal cells of the animal. Although the precise distribution of this species has not been mapped, it has been found in a variety of aquatic habitats in northern Australia. Asexually reproducing (budding) test hydra were exposed to a dilution series of the test toxicant for 96 hours. Observations of any changes to the hydra population (i.e. changes in the number of intact hydroids, where one hydroid equals one animal plus any attached buds) were recorded at 24 h intervals. The method is based on the hydra population growth test described by Hyne et al. (1996) and Riethmuller et al. (2003).

- Fish embryonic development and post-hatch survival toxicity test using the rainbowfish *Melanotaenia splendida splendida* (based on US EPA (2002))

  Rainbowfish were chosen as they are common in freshwater areas of the Copperfield River and other north Queensland catchments. The Copperfield River aquatic ecology survey performed in April 2018 reported the presence of checkered rainbowfish (*Melanotaenia splendida inornata*) (C&R Consulting, 2018). The methods adopted by ESA for this test were based on US EPA (2002), but adapted for use with native rainbowfish. The embryo development and post-hatch survival test method covers the first 6 days of embryonic development and 4-days post hatch period (10-day exposure period in total).

- 7 day reproductive impairment toxicity test using the freshwater cladoceran, *Ceriodaphnia* cf. *dubia* (based on US EPA (2002) and Bailey et al. (2000))

  The *Ceriodaphnia* cf. *dubia* freshwater cladoceran (water flea) is the most commonly used test organism to assess the potential harm a toxicant may pose to freshwater aquatic ecosystems around the world. Cladocera species were found in the Copperfield River aquatic ecology survey performed in April 2018 (C&R Consulting, 2018), therefore this test is highly relevant to the study area. The reproductive impairment toxicity test measures chronic toxicity using less than 24 h old neonates during a three-brood (seven-day), static renewal test. The test began with asexually reproducing female freshwater cladocera (waterfleas) that were less than six hours old (i.e. neonates). These neonate females were exposed to a dilution series of the test substance, an effluent or reference toxicant under 'static-renewal' conditions. These females were transferred daily to fresh solutions of the same concentration. Each day, observations were made on the survival of each female, the number of neonates produced and neonate survival. Each female was accounted for as alive, dead or missing, rather than assuming missing animals were dead. The test was terminated when three broods were produced by each surviving control female (normally over a 5 to 7 day period). The method is based on the Ceriodaphnia Survival and Reproduction Test developed by the US EPA (2002).

All tests were performed by ESA which is a NATA endorsed toxicity testing facility.

2.4 STATISTICAL ANALYSIS

The EC_{10} (the effective concentration giving 10% reduction in the endpoint compared with the controls) was calculated by ESA using Trimmed Spearman-Karber analysis (Hamilton, Russo and Thurston, 1977), Maximum Likelihood Probit analysis (Finney, 1971) or Log-Logit Interpolations (US EPA, 2002), depending on which method was appropriate.

2.5 DERIVATION OF PROTECTIVE CONCENTRATIONS

Trigger values (TVs) were derived for the protection of aquatic freshwater species using the SSD method. The TVs were derived in accordance with ANZECC and ARMCANZ (2000) using the BurrliOZ 2.0 software package (Barry and Henderson, 2014) provided by CSIRO. BurrliOZ fits a log-logistic distribution to estimate the concentrations of discharges such that a given percentage of species will

be protected. The EC_{10} data from the DTA was input to the SSD to derive the protective concentrations. The TVs for the 80%, 90%, 95% and 99% protective concentrations were derived as per ANZECC and ARMCANZ (2000).

Safe dilution factors (i.e. the dilution needed for the discharge to have little to no effect on the receiving ecosystem) were extrapolated from the data to ensure protection of 80%, 90%, 95% and 99% species in the aquatic ecosystem of the receiving environment.

2.6 QA/QC

Specific procedures for undertaking toxicity testing activities, procurement and culturing of test organisms, maintenance and calibration of instruments, cleaning, chain-of-custody and sample handling procedures are carried out by ESA as per their Procedures Manual. Quality assurance procedures were undertaken for all toxicity tests.

Quality assurance and quality control of all NATA accredited tests were satisfied. In the case of the *Ceriodaphnia* cf. *dubia* test (not NATA accredited), the control results were satisfactory.

3. RESULTS AND DISCUSSION

A summary of ecotoxicity testing results received from ESA is presented in Table 3-1. The most sensitive species of the testing suite was the freshwater cladoceran, *Ceriodaphnia* cf. *dubia* for which the EC_{10} was estimated at 54.3 %. This is much higher compared with the previous DTA performed on the May 2018 mixture, where the EC_{10} for *C.* cf *dubia* was estimated at 30.9 %, and the most sensitive species of the testing suite was the microalgae *C. vulgaris* with an EC_{10} estimated at 11.8 % (HB, 2018). It is likely that the difference in toxicity observed between the two mixtures was associated with the reduced EC in the mixture prepared in June 2018. It appears that the higher concentrations of metals (Cd, Co, Cu, Mn, Ni and Zn) did not cause further adverse effects.

The five chronic EC_{10} data points were taken forward into the derivation of TVs for the protection of freshwater species using the BurrliOZ program by producing an SSD (Figure 3-1). The SSD was then used to derive ecosystem TVs corresponding to different levels of protection from 80 to 99% of species. These TVs are presented in Table 3-2.

The TV for the protection of 95 % of the receiving ecosystem species corresponded to a concentration of 49 % of the composite pit sample tested (Table 3-2). This result allowed the calculation of the dilution ratio that provides a 95% species protection level for the contaminant mixture proposed to be discharged to the Copperfield River. A safe dilution factor of 1.1 was calculated to achieve the 95% species protection level for the composite pit water in the river. Hydrobiology recommends using a

conservative dilution factor of 2 at the edge of the designated mixing zone to ensure adequate protection of the aquatic ecosystem in the Copperfield River.

Table 3-1 Summary of toxicity test results

Test	NOEC	LOEC	EC10 (95% confidence interval)	EC50 (95% confidence interval)
96-hr Growth inhibition of *Lemna aequinoctialis*	50%	100%	64.3 (52.9-78.5)%	>100%
96-hr acute toxicity test using Hydra *viridissima*	50%	100%	74.6 (49.6-93.9)%	>100%
Fish embryo hatching test using *Melanotaenia splendida splendida*	100%	>100%	>100%	>100%
72-hr microalgal growth inhibition test using *Chlorella vulgaris*	100%	>100%	>100%	>100%
7-day reproduction test using *Ceriodaphnia* cf. *dubia*	50%	100%	54.3 (43.0-58.6)%	99.3 %**

** 95% confidence interval limits not determinable

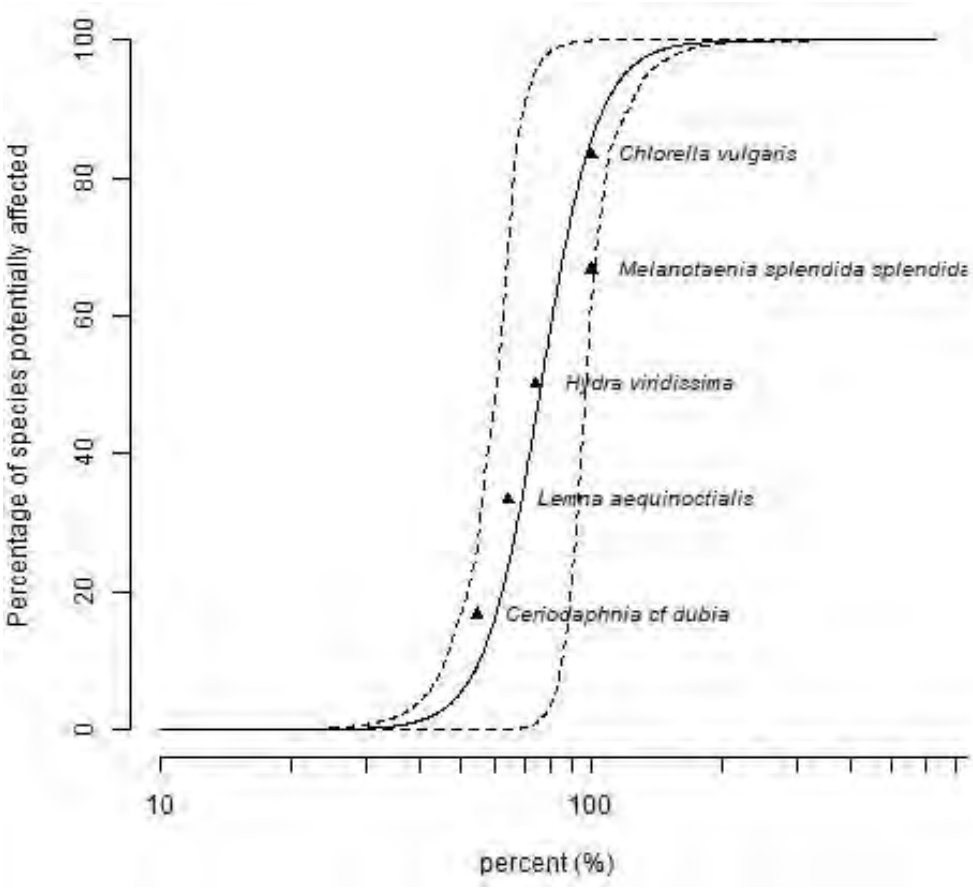

Figure 3-1 Species sensitivity distribution (SSD)

Table 3-2 Calculated safe dilution factors for each level of protection

Solution	Level of protection	Trigger value (TV) [95% confidence interval]	Safe dilution factor estimate
Composite sample 90% Eldridge + 10% Wises	99% species	38 % [31 – 75 %]	1.63
	95% species	**49 %** **[42 – 82 %]**	**1.1**
	90% species	55 % [46 – 86 %]	0.82
	80% species	62 % [52 – 90 %]	0.61

4. CONCLUSION

Based on the composite sample used in this DTA (mixture of 90% Eldridge and 10% Wises pit waters), the proposed discharge water should be diluted at least 1.1 times to achieve a minimum protection level of 95% of species in the receiving Copperfield River. It is recommended that a conservative dilution factor of 2 be applied, which should ensure the protection of >99% of species.

It is important to note that there appears to be some temporal variability in the composition of Eldridge and Wises pit water. The results from this study apply for a representative mixture as described in Table 2-1. In the case where the composition of the mixture varies (in particular EC levels), the dilution factor may need to be adjusted. The DTA performed in May 2018 (HB 2018) could be considered a worst case scenario.

5. REFERENCES

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Bailey, H. C. *et al.* (2000) 'Application of Ceriodaphnia cf. dubia for whole effluent toxicity tests in the Hawkesbury-Nepean watershed, New South Wales, Australia: method development and validation.', *Environmental Toxicology and Chemistry*, 19, pp. 88–93.

Barry, S. and Henderson, B. (2014) *Burrlioz 2.0.*, *Canberra (AU): Commonwealth Science and Industrial Research Organisation.*

C&R Consulting (2018) 'Kidston pumped storage Hydro Project - Aquatic Ecology Survey Report', *report prepared by Geochemical & Hydrobiological Solutions Pty Ltd for AECOM Pty Ltd*.

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Hamilton, M. A., Russo, R. C. and Thurston, R. V. (1977) 'Trimmed Spearman-Karber method for estimating median lethal concentrations in toxicity bioassays', *Environmental Science & Technology*, 11(7), pp. 714–719.

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Hyne, R. V. *et al.* (1996) 'Procedures for the biological toxicity testing of mine waste waters using freshwater organisms', *Supervising scientist report 110*.

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Riethmuller, N. *et al.* (2003) 'Ecotoxicological testing protocols for Australian tropical freshwater ecosystems', *Supervising Scientist Report 173, Supervising Scientist, Darwin NT*, p. 145.

US EPA (2002) 'Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms. 4th Ed.', *United States Environmental Protection Agency, Office of Water, Washington DC.*

APPENDIX A. LABORATORY TOXICITY RESULTS

Prepared for AECOM

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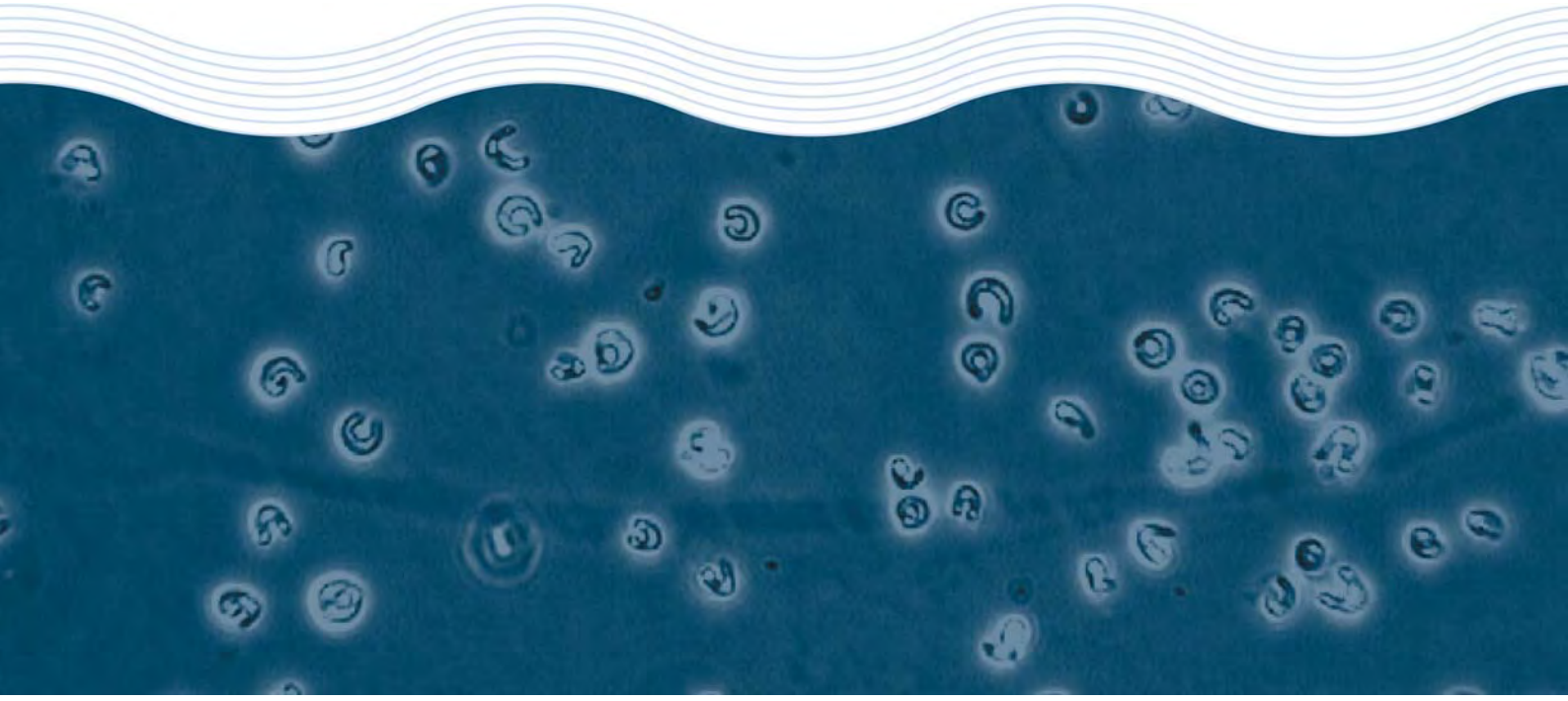
Ecotoxicity of a Composite of Eldridge and Wises Waters to a Suite of Tropical Freshwater Test Species

Aecom

Test Report

June 2018



Toxicity Test Report: TR1552/6

Accredited for compliance with ISO/IEC 17025

Client:	Aecom PO Box 5423 Townsville QLD 4810	**ESA Job #:** **Date Sampled:** **Date Received:**	PR1552 13 June 2018 15 June 2018
Attention:	Reece Fraser	**Sampled By:**	Client
Client Ref:	60544566	**ESA Quote #:**	PR1552_02

Lab ID No.:	Sample Name:	Sample Description:
8666	Composite	Aqueous sample, pH 7.7, conductivity 3370 µS/cm, total ammonia <2.0mg/L. Sample received at 8 ºC in apparent good condition.
8667	W2	Aqueous sample, pH 7.8, conductivity 258 µS/cm, total ammonia <2.0mg/L. Sample received at 8ºC in apparent good condition.

*NATA accreditation does not cover the performance of this service

Test Performed:	Partial life-cycle toxicity test using the freshwater cladoceran *Ceriodaphnia cf dubia*
Test Protocol:	ESA SOP 102 (ESA 2016), based on USEPA (2002) and Bailey *et al*. (2000)
Test Temperature:	The test was performed at 25±1°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The *Composite* sample (8666) was serially diluted with W2 (sample 8667) to achieve the final test concentrations. A Dilute Mineral Water (DMW- culture water) control was tested concurrently with the samples.
Source of Test Organisms:	ESA Laboratory culture
Test Initiated:	15 June 2018 at 1730h

Composite diluted with W2 (Lab ID 8667):

Concentration (%)	% Unaffected at 7 days (Mean ± SD)
DMW Control	100 ± 0.0
W2 Diluent	100 ± 0.0
6.3	100 ± 0.0
12.5	100 ± 0.0
25	100 ± 0.0
50	100 ± 0.0
100	90.0 ± 31.6

7 day EC10 (unaffected) = >100%
7 day EC50 (unaffected) = >100%
NOEC = 100%
LOEC = >100%

Composite diluted with W2 (Lab ID 8667):

Concentration (%)	Number of Young (Mean ± SD)
DMW Control	15.9 ± 1.5
W2 Diluent	16.2 ± 1.3
6.3	15.8 ± 1.3
12.5	16.4 ± 1.4
25	16.0 ± 1.4
50	15.2 ± 1.1
100	8.0 ± 3.3*

7 day IC10 (reproduction) = 54.3 (43.0-58.6)%
7 day IC50 (reproduction) = 99.3%**
NOEC = 50%
LOEC = 100%

* Significantly lower number of young compared with the W2 Diluent (Steels Many-One Rank Test, 1-tailed, P=0.05)
** 95% Confidence Limits not determinable

Toxicity Test Report: TR1552/6

QA/QC Parameter	Criterion	This Test	Criterion met?
DMW Control mean % unaffected	≥80.0%	100%	Yes
Control mean number of young per surviving adult	≥15.0	15.9	Yes
Reference Toxicant within cusum chart limits	192.4-242.9 mgKCl/L	197.2 mgKCl/L	Yes

Test Report Authorised by: Dr Rick Krassoi, Director on 10 July 2018

Results are based on the samples in the condition as received by ESA.

NATA Accredited Laboratory Number: 14709

Citations:

Bailey, H.C., Krassoi, R., Elphick, J.R., Mulhall, A., Hunt, P., Tedmanson, L. and Lovell, A. (2000) Application of *Ceriodaphnia cf. dubia* for whole effluent toxicity tests in the Hawkesbury-Nepean watershed, New South Wales, Australia: method development and validation. *Environmental Toxicology and Chemistry* 19:88-93.

ESA (2016) ESA SOP 102 – *Acute Toxicity Test Using Ceriodaphnia dubia.* Issue No 11. Ecotox Services Australasia, Sydney, NSW.

USEPA (2002) *Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms.4th Ed.* United States Environmental Protection Agency, Office of Water, Washington DC.

Toxicity Test Report: TR1552/7

Performed in compliance with ISO/IEC 17025

Client:	Aecom PO Box 5423 Townsville QLD 4810	**ESA Job #:** **Date Sampled:** **Date Received:**	PR1552 13 June 2018 15 June 2018
Attention:	Reece Fraser	**Sampled By:**	Client
Client Ref:	60544566	**ESA Quote #:**	PR1552_02

Lab ID No.:	Sample Name:	Sample Description:
8666	Composite	Aqueous sample, pH 7.7, conductivity 3370 µS/cm, total ammonia <2.0mg/L. Sample received at 8 ºC in apparent good condition.
8667	W2	Aqueous sample, pH 7.8, conductivity 258 µS/cm, total ammonia <2.0mg/L. Sample received at 8ºC in apparent good condition.

Test Performed:	96-hr Growth inhibition of the freshwater aquatic duckweed *Lemna aequinoctialis*
Test Protocol:	ESA SOP 112 (ESA 2016), based on ASTM (2012)
Test Temperature:	The test was performed at 29±2°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The *Composite* sample (8666) was serially diluted with W2 (sample 8667) to achieve the final test concentrations. A CAAC control was tested concurrently with the samples.
Source of Test Organisms:	ESA Laboratory culture
Test Initiated:	15 June 2018 at 1700h

Composite diluted with W2 (Lab ID 8667):

Concentration (%)	Specific Growth Rate (Mean ± SD)
CAAC Control	0.23 ± 0.01
W2 Diluent	0.23 ± 0.01
6.3	0.22 ± 0.01
12.5	0.24 ± 0.02
25	0.23 ± 0.01
50	0.24 ± 0.02
100	0.15 ± 0.05

96-h IC10 = 64.3 (52.9-78.5)%
96-h IC50 = >100%
NOEC = 50%
LOEC = 100%

Vacant

* Significantly lower growth rate compared with the W2 Diluent (Dunnett's Test, 1-tailed, P=0.05)

Toxicity Test Report: TR1552/7

QA/QC Parameter	Criterion	This Test	Criterion met?
CAAC Control Specific Growth rate	>0.231	0.23	Yes
Reference Toxicant within cusum chart limits	5.6-58.6mg Mg/L	13.8 mg Mg/L	Yes

Test Report Authorised by: Dr Rick Krassoi, Director on 10 July 2018

Results are based on the samples in the condition as received by ESA.

Citations:

ESA (2016) *SOP 112 – Duckweed Growth Inhibition Test.* Issue No. 7. Ecotox Services Australasia, Sydney NSW

OECD (2006) *Lemna sp*. Growth Inhibition Test. Method 221. OECD Guideline for the Testing of Chemicals. Organisation for Economic Cooperation and Development, Paris

Toxicity Test Report: TR1552/8

Performed in compliance with ISO/IEC 17025

Client:	Aecom PO Box 5423 Townsville QLD 4810	**ESA Job #:** **Date Sampled:** **Date Received:**	PR1552 13 June 2018 15 June 2018
Attention:	Reece Fraser	**Sampled By:**	Client
Client Ref:	60544566	**ESA Quote #:**	PR1552_02

Lab ID No.:	Sample Name:	Sample Description:
8666	Composite	Aqueous sample, pH 7.7, conductivity 3370 µS/cm, total ammonia <2.0mg/L. Sample received at 8 ºC in apparent good condition.
8667	W2	Aqueous sample, pH 7.8, conductivity 258 µS/cm, total ammonia <2.0mg/L. Sample received at 8ºC in apparent good condition.

Test Performed:	96-hr acute toxicity test using the freshwater hydra *hydra viridissima*
Test Protocol:	ESA SOP 125 (2016), based on Riethmuller et al. (2003)
Test Temperature:	The test was performed at 28±1°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The *Composite* sample (8666) was serially diluted with W2 (sample 8667) to achieve the final test concentrations. A LC control (culture water) was tested concurrently with the samples.
Source of Test Organisms:	ESA Laboratory culture
Test Initiated:	15 June 2018 at 1830h

Composite diluted with W2 (Lab ID 8667):

Concentration (%)	Population Growth Rate (Mean ± SD)
LC Control	0.34 ± 0.01
W2 Diluent	0.35 ± 0.01
6.3	0.34 ± 0.01
12.5	0.35 ± 0.02
25	0.35 ± 0.01
50	0.34 ± 0.01
100	0.29 ±0.02*

96-h IC10 = 74.6 (49.6-93.9)%
96-h IC50 = >100%
NOEC = 50%
LOEC = 100%

Vacant

* Significantly lower growth rate compared with the W2 Diluent (Dunnett's Test, 1-tailed, P=0.05)

Toxicity Test Report: TR1552/8

QA/QC Parameter	Criterion	This Test	Criterion met?
LC Control mean population growth rate	≥0.259	0.34	Yes
Reference Toxicant within cusum chart limits	2.61-10.30µg Cu/L	3.80 µg Cu/L	Yes

Test Report Authorised by: Dr Rick Krassoi, Director on 10 July 2018

Results are based on the samples in the condition as received by ESA.

Citations:

ESA (2016) SOP 125 –*Hydra Population Growth Test.* Issue No 5. Ecotox Services Australasia, Sydney, NSW

Riethmuller N, Camilleri C, Franklin N, Hogan A, King A, Koch A, Markich SJ, Turley C and van Dam R (2003).

Green Hydra Population Growth Test. In: *Ecotoxicological testing protocols for Australian tropical freshwater ecosystems*. Supervising Scientist Report 173, Supervising Scientist, Darwin NT.

Toxicity Test Report: TR1552/9

Performed in compliance with ISO/IEC 17025

Client:	Aecom PO Box 5423 Townsville QLD 4810	**ESA Job #:** **Date Sampled:** **Date Received:**	PR1552 13 June 2018 15 June 2018
Attention:	Reece Fraser	**Sampled By:**	Client
Client Ref:	60544566	**ESA Quote #:**	PR1552_02

Lab ID No.:	Sample Name:	Sample Description:
8666	Composite	Aqueous sample, pH 7.7, conductivity 3370 µS/cm, total ammonia <2.0mg/L. Sample received at 8 ºC in apparent good condition.
8667	W2	Aqueous sample, pH 7.8, conductivity 258 µS/cm, total ammonia <2.0mg/L. Sample received at 8ºC in apparent good condition.

Test Performed:	Rainbowfish embryo hatching test using *Melanotaenia splendida splendida*
Test Protocol:	ESA SOP 126 (2016), based on USEPA (2002), but adapted for use with native rainbowfish
Test Temperature:	The test was performed at 25±1°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The *Composite* sample (8666) was serially diluted with W2 (sample 8667) to achieve the final test concentrations. A Dilute Mineral Water (DMW) control (culture water) was tested concurrently with the samples.
Source of Test Organisms:	ESA Laboratory culture
Test Initiated:	15 June 2018 at 1900h

Composite diluted with W2 (Lab ID 8667):

Concentration (%)	% Unaffected (Mean ± SD)
DMW Control	95.0 ± 10.0
W2 Diluent	95.0 ± 10.0
6.3	90.0 ± 20.0
12.5	95.0 ± 10.0
25	100.0 ± 0.0
50	95.0 ± 10.0
100	100.0 ± 0.0

12-d EC10 = >100 %
12-d EC50 = >100 %
NOEC = 100%
LOEC = >100%

Vacant

Toxicity Test Report: TR1552/9

QA/QC Parameter	Criterion	This Test	Criterion met?
DMW Control mean % unaffected	≥80.0%	95.0%	Yes
Reference Toxicant within cusum chart limit	14.8-106.7µg Cu/L	87.4µg Cu/L	Yes

Test Report Authorised by: Dr Rick Krassoi, Director on 10 July 2018

Results are based on the samples in the condition as received by ESA.

Citations:

ESA (2016) *SOP 126- Rainbowfish Embryo Hatching Test*. Issue N°6. Ecotox Services Australasia, Sydney NSW

USEPA (2002) *Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms.4th Ed.* United States Environmental Protection Agency, Office of Water, Washington DC.

Toxicity Test Report: TR1552/10

Performed in compliance with ISO/IEC 17025

Client:	Aecom PO Box 5423 Townsville QLD 4810	**ESA Job #:** **Date Sampled:** **Date Received:**	PR1552 13 June 2018 15 June 2018
Attention:	Reece Fraser	**Sampled By:**	Client
Client Ref:	60544566	**ESA Quote #:**	PR1552_02

Lab ID No.:	Sample Name:	Sample Description:
8666	Composite	Aqueous sample, pH 7.7, conductivity 3370 µS/cm, total ammonia <2.0mg/L. Sample received at 8 ºC in apparent good condition.
8667	W2	Aqueous sample, pH 7.8, conductivity 258 µS/cm, total ammonia <2.0mg/L. Sample received at 8ºC in apparent good condition.

Test Performed:	72-hr microalgal growth inhibition test using the green alga *Chlorella vulgaris*
Test Protocol:	ESA SOP 103 (ESA 2016), based on USEPA (2002)
Test Temperature:	The test was performed at 29±1°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The *Composite* sample (8666) was serially diluted with W2 (sample 8667) to achieve the final test concentrations. A USEPA control was tested concurrently with the samples.
Source of Test Organisms:	ESA Laboratory culture
Test Initiated:	15 June 2018 at 1730h

Composite diluted with W2 (Lab ID 8667):		*Vacant*
Concentration (%)	**Cell Yield x10^4 cells/mL (Mean ± SD)**	
USEPA Control	23.1 ± 0.8	
W2 Diluent	23.2 ± 0.7	
6.3	22.8 ± 0.8	
12.5	23.0 ± 0.2	
25	22.8 ± 1.0	
50	23.5 ± 0.6	
100	23.3 ± 0.8	
96-h IC10 = >100% **96-h IC50 = >100%** **NOEC = 100%** **LOEC = >100%**		

Toxicity Test Report: TR1552/10

QA/QC Parameter	Criterion	This Test	Criterion met?
USEPA Control mean cell density	≥16.0x10^4 cells/mL	23.1 x10^4 cells/mL	Yes
Control coefficient of variation	<20%	3.4 %	Yes
Reference Toxicant within cusum chart limits	447-3843mg KCl/L	3809 mg KCl/L	Yes

Test Report Authorised by: Dr Rick Krassoi, Director on 10 July 2018

Results are based on the samples in the condition as received by ESA.
This document shall not be reproduced except in full.

Citations:

ESA (2016) *ESA SOP 103 – Green Alga, Selenastrum capricornutum, Growth Test*. Issue No 11. Ecotox Services Australasia, Sydney, NSW.

USEPA (2002) *Short-term methods for estimating the chronic toxicity of effluents and receiving waters to freshwater organisms*. Fourth Edition. EPA-821-R-02-013. United States Environmental Protection Agency, Office of Research and Development, Washington DC, USA,

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SERVICES AUSTRALIA

Chain-of-Custody Documentation

Chain-of-Custody / Service Request Form

Datasheet ID: 601.1
Last Revised: 15 July 2014

ecotox SERVICES AUSTRALASIA

Customer: AECOM AUSTRALIA PTY LTD
Contact Name: Reece Fraser
Phone: 0747201674 Email: reece.fraser@aecom.com (please provide an email address for sample receipt notification)
Sampled by: Genex

Ship To: ESA
Attention: Rick

Sample Date (day/month /year)	Sample Time	Sample Name (exactly as written on the sample vessel)	Sample Method (eg. Grab, composite etc.)	Number and Volume of Containers (eg 2 x 1L)	Tests Requested (See reverse for guidance)						Comments / Instructions
					Algal growth Sc	Duckweed Ltd	Hydra	Embryo Fish	Chronic Cerio		**Note that testing will be delayed if an incomplete chain of custody is received** • Additional treatment of samples (i.e. spiking) • Sub-contracted services (i.e. chemical analyses) • Dilutions required (if different than 100% down to 6.25%) • Sample holding time restriction (if applicable) • Sample used for litigation (if applicable) *Note: An MSDS must be attached if Available* **ESA Project Number: PR** 1552
~~W1~~											
~~COMPOSITE~~											
8666 13/06/2018		Composite	Composite	2x5L	✓	✓	✓	✓	✓		
8667 13/06/2018		W2	Grab	3x5L	✓	✓	✓	✓	✓		

1) Released By:	Date:	2) Received By:	Date:	3) Released By:	Date:	4) Received By:	Date:
Reece Fraser	14/06/2018	RF	15/6/18				
Of: AECOM	Time: 16:00	Of: ESA	Time: 1130	Of:	Time:	Of:	Time:

Note that the chain-of-custody documentation will provide definitive information on the tests to be performed.

Ecotox Services Australasia . Unit 27, 2 Chaplin Drive, Lane Cove NSW 2066 AUSTRALIA
Phone: 61 2 9420-9481 Fax 61 2 9420-9484 info@ecotox.com.au

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Statistical Printouts for the 3-brood Partial Life Cycle Test with *Ceriodaphnia dubia*

Ceriodaphnia Partial Life-Cycle Test-7 Day Unaffected

Start Date:	15/06/2018 17:30	Test ID:	PR1552/21	Sample ID:	Composite
End Date:	22/06/2018 17:30	Lab ID:	8666	Sample Type:	AQ-Aqueous
Sample Date:	13/06/2018	Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:	Diluted with W2 (sample 8667)				

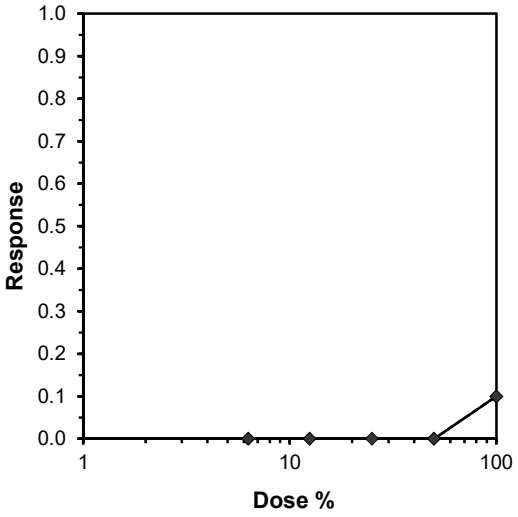
Conc-%	1	2	3	4	5	6	7	8	9	10
DMW	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
W2	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
6.3	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
12.5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
25	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
50	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
100	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Conc-%	Mean	N-Mean	Resp	Not Resp	Total	N	Fisher's Exact P	1-Tailed Critical	Isotonic Mean	Isotonic N-Mean
DMW	1.0000	1.0000	0	10	10	10	0.6238			
W2	1.0000	1.0000	0	10	10	10	*		1.0000	1.0000
6.3	1.0000	1.0000	0	10	10	10	1.0000	0.0500	1.0000	1.0000
12.5	1.0000	1.0000	0	10	10	10	1.0000	0.0500	1.0000	1.0000
25	1.0000	1.0000	0	10	10	10	1.0000	0.0500	1.0000	1.0000
50	1.0000	1.0000	0	10	10	10	1.0000	0.0500	1.0000	1.0000
100	0.9000	0.9000	1	9	10	10	0.5000	0.0500	0.9000	0.9000

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Fisher's Exact Test	100	>100		1
Treatments vs W2				

Log-Logit Interpolation (200 Resamples)

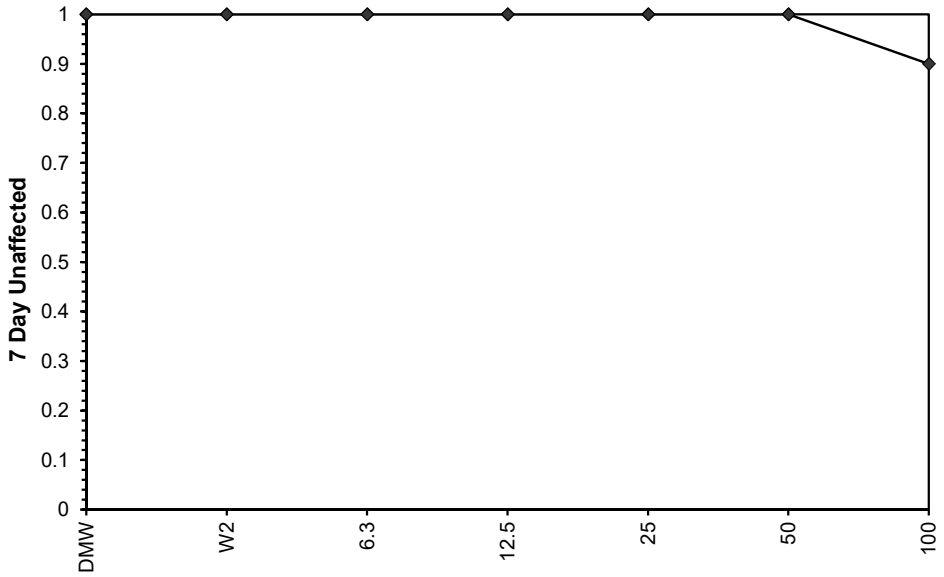
Point	%	SD	95% CL	Skew
IC05	92.908			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



Ceriodaphnia Partial Life-Cycle Test-7 Day Unaffected

Start Date:	15/06/2018 17:30	Test ID:	PR1552/21	Sample ID:	Composite
End Date:	22/06/2018 17:30	Lab ID:	8666	Sample Type:	AQ-Aqueous
Sample Date:	13/06/2018	Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:	Diluted with W2 (sample 8667)				

Dose-Response Plot



Ceriodaphnia Partial Life-Cycle Test-7 Day Unaffected

Start Date:	15/06/2018 17:30	Test ID:	PR1552/21	Sample ID:	Composite
End Date:	22/06/2018 17:30	Lab ID:	8666	Sample Type:	AQ-Aqueous
Sample Date:	13/06/2018	Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:	Diluted with W2 (sample 8667)				

Auxiliary Data Summary

Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
DMW	No of Young	15.90	13.00	18.00	1.45	7.57	10
W2		16.20	14.00	18.00	1.32	7.08	10
6.3		15.80	14.00	18.00	1.32	7.26	10
12.5		16.40	14.00	19.00	1.35	7.08	10
25		16.00	14.00	18.00	1.41	7.43	10
50		15.20	13.00	17.00	1.14	7.01	10
100		8.00	2.00	12.00	3.33	22.82	10
DMW	% unaffected	100.00	100.00	100.00	0.00	0.00	10
W2		100.00	100.00	100.00	0.00	0.00	10
6.3		100.00	100.00	100.00	0.00	0.00	10
12.5		100.00	100.00	100.00	0.00	0.00	10
25		100.00	100.00	100.00	0.00	0.00	10
50		100.00	100.00	100.00	0.00	0.00	10
100		90.00	0.00	100.00	31.62	6.25	10
DMW	pH	8.10	8.10	8.10	0.00	0.00	1
W2		7.90	7.90	7.90	0.00	0.00	1
6.3		7.80	7.80	7.80	0.00	0.00	1
12.5		7.80	7.80	7.80	0.00	0.00	1
25		7.80	7.80	7.80	0.00	0.00	1
50		7.80	7.80	7.80	0.00	0.00	1
100		7.70	7.70	7.70	0.00	0.00	1
DMW	DO %	96.80	96.80	96.80	0.00	0.00	1
W2		97.90	97.90	97.90	0.00	0.00	1
6.3		993.00	993.00	993.00	0.00	0.00	1
12.5		98.90	98.90	98.90	0.00	0.00	1
25		99.10	99.10	99.10	0.00	0.00	1
50		99.10	99.10	99.10	0.00	0.00	1
100		98.90	98.90	98.90	0.00	0.00	1
DMW	Cond uS/cm	187.00	187.00	187.00	0.00	0.00	1
W2		258.00	258.00	258.00	0.00	0.00	1
6.3		428.00	428.00	428.00	0.00	0.00	1
12.5		663.00	663.00	663.00	0.00	0.00	1
25		1104.00	1104.00	1104.00	0.00	0.00	1
50		1912.00	1912.00	1912.00	0.00	0.00	1
100		3370.00	3370.00	3370.00	0.00	0.00	1

Ceriodaphnia Partial Life-Cycle Test-Reproduction

Start Date:	15/06/2018 17:30	Test ID:	PR1552/21	Sample ID:	Composite
End Date:	22/06/2018 17:30	Lab ID:	8666	Sample Type:	AQ-Aqueous
Sample Date:	13/06/2018	Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:	Diluted with W2 (sample 8667)				

Conc-%	1	2	3	4	5	6	7	8	9	10
DMW	17.000	17.000	15.000	15.000	15.000	17.000	13.000	16.000	18.000	16.000
W2	18.000	16.000	14.000	18.000	15.000	16.000	17.000	17.000	15.000	16.000
6.3	18.000	16.000	16.000	17.000	14.000	14.000	16.000	15.000	15.000	17.000
12.5	19.000	17.000	14.000	17.000	16.000	17.000	16.000	15.000	16.000	17.000
25	18.000	16.000	15.000	16.000	14.000	16.000	16.000	18.000	14.000	17.000
50	17.000	16.000	15.000	15.000	15.000	16.000	16.000	14.000	13.000	15.000
100	12.000	8.000	11.000	12.000	10.000	7.000	2.000	7.000	7.000	4.000

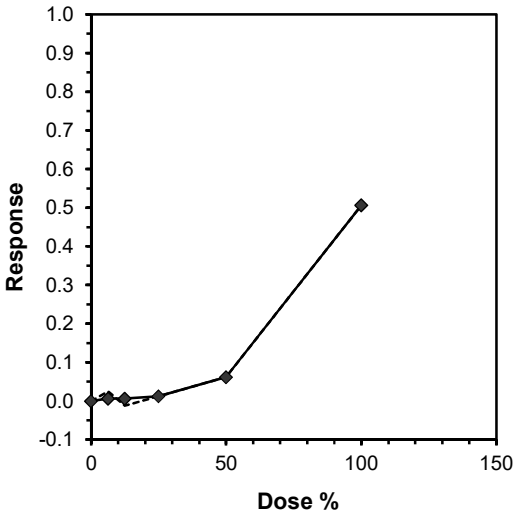
			Transform: Untransformed					Rank	1-Tailed	Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Mean	N-Mean
DMW	15.900	0.9815	15.900	13.000	18.000	9.114	10				
W2	16.200	1.0000	16.200	14.000	18.000	8.127	10	*		16.200	1.0000
6.3	15.800	0.9753	15.800	14.000	18.000	8.333	10	96.50	75.00	16.100	0.9938
12.5	16.400	1.0123	16.400	14.000	19.000	8.231	10	109.00	75.00	16.100	0.9938
25	16.000	0.9877	16.000	14.000	18.000	8.839	10	101.00	75.00	16.000	0.9877
50	15.200	0.9383	15.200	13.000	17.000	7.469	10	84.00	75.00	15.200	0.9383
*100	8.000	0.4938	8.000	2.000	12.000	41.667	10	55.00	75.00	8.000	0.4938

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Kolmogorov D Test indicates normal distribution (p > 0.05)	0.722312	0.895	-0.41555	1.936263
Bartlett's Test indicates unequal variances (p = 3.08E-03)	17.8993	15.08627		
The control means are not significantly different (p = 0.63)	0.484544	2.100922		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	50	100	70.71068	2
Treatments vs W2				

Linear Interpolation (200 Resamples)

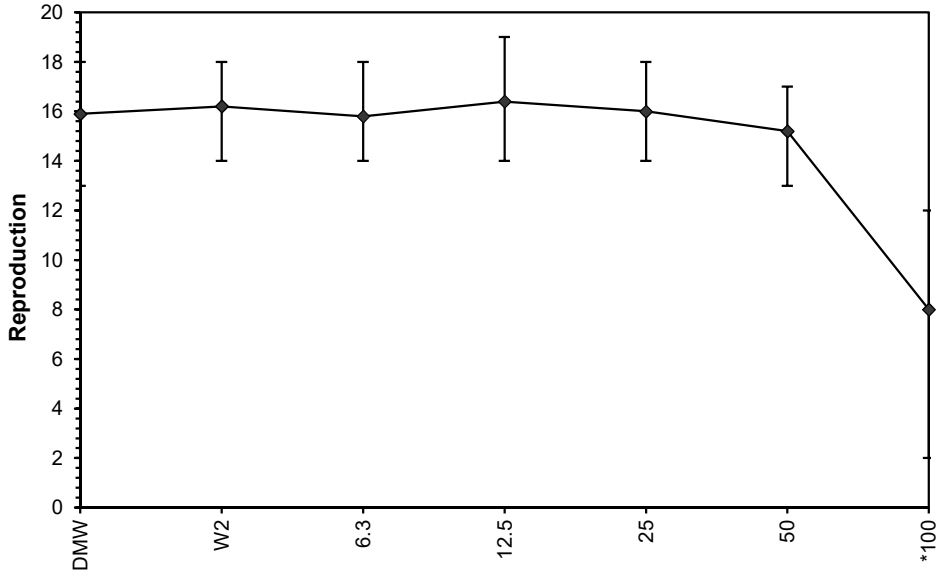
Point	%	SD	95% CL		Skew
IC05	44.063	12.182	10.253	52.722	-0.6631
IC10	54.306	3.762	42.961	58.560	-1.6877
IC15	59.931	2.795	53.641	64.650	0.1689
IC20	65.556	3.084	59.529	71.161	0.5567
IC25	71.181	3.560	64.580	77.981	0.8430
IC40	88.056				
IC50	99.306				



Ceriodaphnia Partial Life-Cycle Test-Reproduction

Start Date:	15/06/2018 17:30	Test ID:	PR1552/21	Sample ID:	Composite
End Date:	22/06/2018 17:30	Lab ID:	8666	Sample Type:	AQ-Aqueous
Sample Date:	13/06/2018	Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:	Diluted with W2 (sample 8667)				

Dose-Response Plot



Ceriodaphnia Partial Life-Cycle Test-Reproduction

Start Date:	15/06/2018 17:30	Test ID:	PR1552/21	Sample ID:	Composite
End Date:	22/06/2018 17:30	Lab ID:	8666	Sample Type:	AQ-Aqueous
Sample Date:	13/06/2018	Protocol:	ESA 102	Test Species:	CD-Ceriodaphnia dubia
Comments:	Diluted with W2 (sample 8667)				

Auxiliary Data Summary

Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
DMW	No of Young	15.90	13.00	18.00	1.45	7.57	10
W2		16.20	14.00	18.00	1.32	7.08	10
6.3		15.80	14.00	18.00	1.32	7.26	10
12.5		16.40	14.00	19.00	1.35	7.08	10
25		16.00	14.00	18.00	1.41	7.43	10
50		15.20	13.00	17.00	1.14	7.01	10
100		8.00	2.00	12.00	3.33	22.82	10
DMW	% unaffected	100.00	100.00	100.00	0.00	0.00	10
W2		100.00	100.00	100.00	0.00	0.00	10
6.3		100.00	100.00	100.00	0.00	0.00	10
12.5		100.00	100.00	100.00	0.00	0.00	10
25		100.00	100.00	100.00	0.00	0.00	10
50		100.00	100.00	100.00	0.00	0.00	10
100		90.00	0.00	100.00	31.62	6.25	10
DMW	pH	8.10	8.10	8.10	0.00	0.00	1
W2		7.90	7.90	7.90	0.00	0.00	1
6.3		7.80	7.80	7.80	0.00	0.00	1
12.5		7.80	7.80	7.80	0.00	0.00	1
25		7.80	7.80	7.80	0.00	0.00	1
50		7.80	7.80	7.80	0.00	0.00	1
100		7.70	7.70	7.70	0.00	0.00	1
DMW	DO %	96.80	96.80	96.80	0.00	0.00	1
W2		97.90	97.90	97.90	0.00	0.00	1
6.3		993.00	993.00	993.00	0.00	0.00	1
12.5		98.90	98.90	98.90	0.00	0.00	1
25		99.10	99.10	99.10	0.00	0.00	1
50		99.10	99.10	99.10	0.00	0.00	1
100		98.90	98.90	98.90	0.00	0.00	1
DMW	Cond uS/cm	187.00	187.00	187.00	0.00	0.00	1
W2		258.00	258.00	258.00	0.00	0.00	1
6.3		428.00	428.00	428.00	0.00	0.00	1
12.5		663.00	663.00	663.00	0.00	0.00	1
25		1104.00	1104.00	1104.00	0.00	0.00	1
50		1912.00	1912.00	1912.00	0.00	0.00	1
100		3370.00	3370.00	3370.00	0.00	0.00	1

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Statistical Printouts for the Duckweed Growth Inhibition Tests

Duckweed Growth Inhibtion Test-Specific Growth Rate

Start Date:	15/06/2018 17:00	Test ID:	PR1552/25	Sample ID:	Composite
End Date:	23/06/2018 17:00	Lab ID:	8666	Sample Type:	AQ-Aqueous
Sample Date:	13/06/2018	Protocol:	ESA 112	Test Species:	LA-Lemna aequinoctialis
Comments:	Diluted with W2 (sample 8667)				

Conc-%	1	2	3	4
LC	0.2483	0.2389	0.2189	0.2189
W2	0.2082	0.2389	0.2291	0.2389
6.3	0.2189	0.2082	0.2389	0.2291
12.5	0.2574	0.2189	0.2483	0.2291
25	0.2389	0.2189	0.2291	0.2389
50	0.2189	0.2389	0.2291	0.2574
100	0.0841	0.1971	0.1469	0.1733

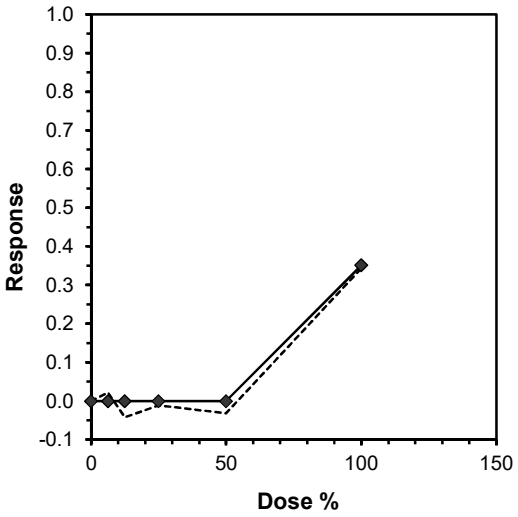
			Transform: Untransformed					1-Tailed			Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
LC	0.2312	1.0108	0.2312	0.2189	0.2483	6.395	4					
W2	0.2288	1.0000	0.2288	0.2082	0.2389	6.317	4	*			0.2317	1.0000
6.3	0.2238	0.9781	0.2238	0.2082	0.2389	5.895	4	0.296	2.410	0.0407	0.2317	1.0000
12.5	0.2384	1.0422	0.2384	0.2189	0.2574	7.377	4	-0.571	2.410	0.0407	0.2317	1.0000
25	0.2314	1.0116	0.2314	0.2189	0.2389	4.132	4	-0.157	2.410	0.0407	0.2317	1.0000
50	0.2361	1.0319	0.2361	0.2189	0.2574	6.952	4	-0.432	2.410	0.0407	0.2317	1.0000
*100	0.1504	0.6573	0.1504	0.0841	0.1971	32.379	4	4.642	2.410	0.0407	0.1504	0.6490

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.922065	0.916	-0.90857	3.714862
Bartlett's Test indicates equal variances (p = 0.06)	10.523	15.08627		
The control means are not significantly different (p = 0.82)	0.238676	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test Treatments vs W2	50	100	70.71068	2	0.040705	0.177935	0.004517	0.000571	4.3E-04	5, 18

Linear Interpolation (200 Resamples)

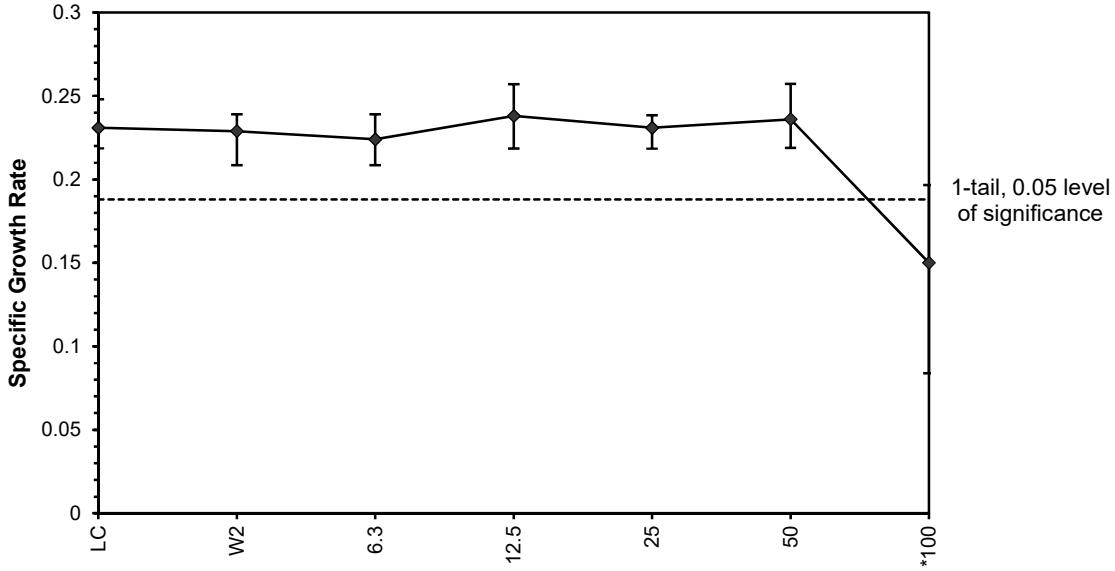
Point	%	SD	95% CL(Exp)		Skew
IC05	57.123	3.452	47.418	64.096	-2.1823
IC10	64.246	4.459	52.883	78.448	0.5617
IC15	71.368	6.448	56.433	94.177	0.7694
IC20	78.491				
IC25	85.614				
IC40	>100				
IC50	>100				



Duckweed Growth Inhibtion Test-Specific Growth Rate

Start Date:	15/06/2018 17:00	Test ID:	PR1552/25	Sample ID:	Composite
End Date:	23/06/2018 17:00	Lab ID:	8666	Sample Type:	AQ-Aqueous
Sample Date:	13/06/2018	Protocol:	ESA 112	Test Species:	LA-Lemna aequinoctialis
Comments:	Diluted with W2 (sample 8667)				

Dose-Response Plot



Duckweed Growth Inhibtion Test-Specific Growth Rate

Start Date:	15/06/2018 17:00	Test ID:	PR1552/25	Sample ID:	Composite
End Date:	23/06/2018 17:00	Lab ID:	8666	Sample Type:	AQ-Aqueous
Sample Date:	13/06/2018	Protocol:	ESA 112	Test Species:	LA-Lemna aequinoctialis
Comments:	Diluted with W2 (sample 8667)				

Auxiliary Data Summary

Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
LC	Specific growth rate	0.23	0.22	0.25	0.01	52.59	4
W2		0.23	0.21	0.24	0.01	52.55	4
6.3		0.22	0.21	0.24	0.01	51.33	4
12.5		0.24	0.22	0.26	0.02	55.63	4
25		0.23	0.22	0.24	0.01	42.25	4
50		0.24	0.22	0.26	0.02	54.27	4
100		0.15	0.08	0.20	0.05	146.74	4
LC	pH	8.10	8.10	8.10	0.00	0.00	1
W2		7.90	7.90	7.90	0.00	0.00	1
6.3		7.80	7.80	7.80	0.00	0.00	1
12.5		7.80	7.80	7.80	0.00	0.00	1
25		7.80	7.80	7.80	0.00	0.00	1
50		7.80	7.80	7.80	0.00	0.00	1
100		7.90	7.90	7.90	0.00	0.00	1
LC	Cond uS/cm	103.00	103.00	103.00	0.00	0.00	1
W2		258.00	258.00	258.00	0.00	0.00	1
6.3		428.00	428.00	428.00	0.00	0.00	1
12.5		663.00	663.00	663.00	0.00	0.00	1
25		1104.00	1104.00	1104.00	0.00	0.00	1
50		1912.00	1912.00	1912.00	0.00	0.00	1
100		3370.00	3370.00	3370.00	0.00	0.00	1

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Statistical Printouts for *Hydra* Population Growth Tests

Hydra Population Growth Test-Growth Rate

Start Date:	15/06/2018 18:30	Test ID:	PR1552/26	Sample ID:	Composite
End Date:	23/06/2018 18:30	Lab ID:	8666	Sample Type:	AQ-Aqueous
Sample Date:	13/06/2018	Protocol:	ESA 125	Test Species:	HV-Hydra viridissima
Comments:	Diluted with W2 (sample 8667)				

Conc-%	1	2	3	4
LC	0.3588	0.3338	0.3466	0.3402
W2	0.3402	0.3527	0.3647	0.3338
6.3	0.3402	0.3202	0.3527	0.3402
12.5	0.3588	0.3704	0.3466	0.3338
25	0.3527	0.3466	0.3647	0.3402
50	0.3338	0.3202	0.3338	0.3527
100	0.2908	0.2662	0.3059	0.2985

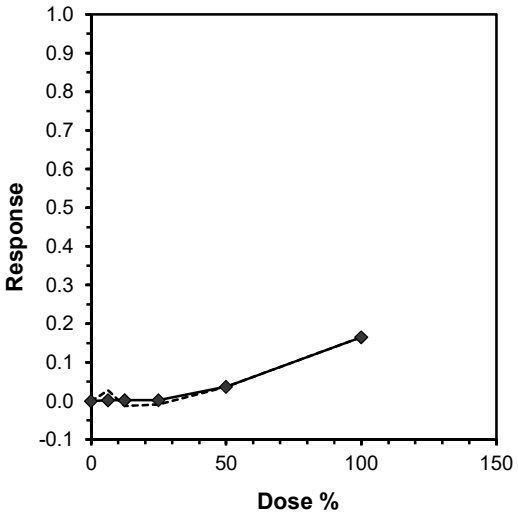
			Transform: Untransformed					1-Tailed			Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
LC	0.3448	0.9913	0.3448	0.3338	0.3588	3.093	4					
W2	0.3478	1.0000	0.3478	0.3338	0.3647	3.938	4	*			0.3478	1.0000
6.3	0.3384	0.9727	0.3384	0.3202	0.3527	3.975	4	0.947	2.410	0.0241	0.3473	0.9983
12.5	0.3524	1.0130	0.3524	0.3338	0.3704	4.476	4	-0.452	2.410	0.0241	0.3473	0.9983
25	0.3511	1.0092	0.3511	0.3402	0.3647	2.964	4	-0.320	2.410	0.0241	0.3473	0.9983
50	0.3351	0.9634	0.3351	0.3202	0.3527	3.989	4	1.272	2.410	0.0241	0.3351	0.9634
*100	0.2903	0.8347	0.2903	0.2662	0.3059	5.945	4	5.745	2.410	0.0241	0.2903	0.8347

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.954494	0.916	-0.20141	-0.90554
Bartlett's Test indicates equal variances (p = 0.98)	0.75652	15.08627		
The control means are not significantly different (p = 0.74)	0.347215	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test Treatments vs W2	50	100	70.71068	2	0.024122	0.069347	0.00218	0.0002	6.1E-05	5, 18

Linear Interpolation (200 Resamples)

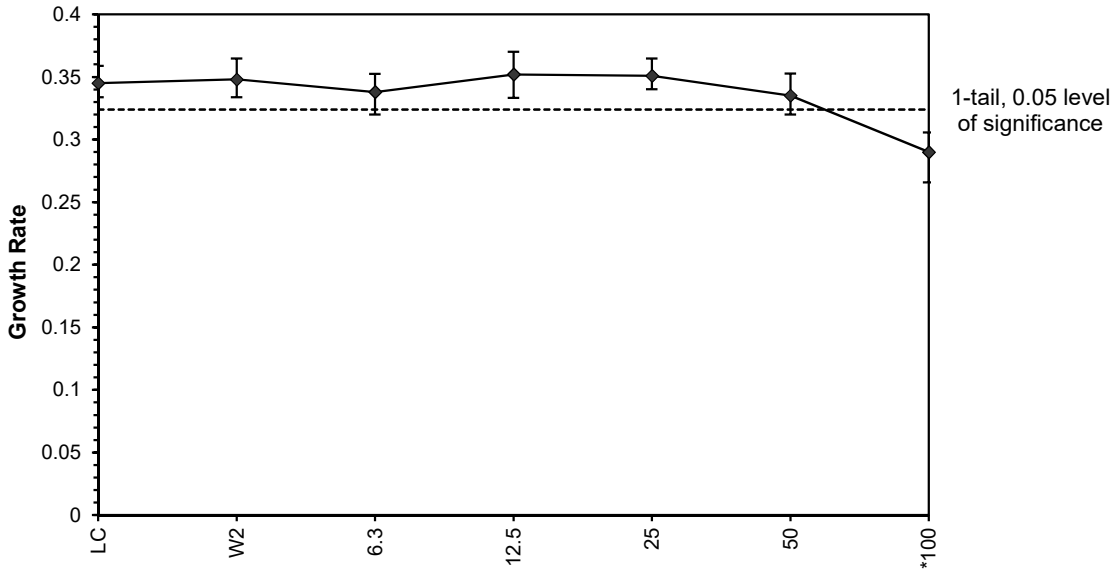
Point	%	SD	95% CL(Exp)		Skew
IC05	55.208	9.464	18.411	73.908	-1.4073
IC10	74.631	7.316	49.633	93.870	0.0588
IC15	94.054				
IC20	>100				
IC25	>100				
IC40	>100				
IC50	>100				



Hydra Population Growth Test-Growth Rate

Start Date:	15/06/2018 18:30	Test ID:	PR1552/26	Sample ID:	Composite
End Date:	23/06/2018 18:30	Lab ID:	8666	Sample Type:	AQ-Aqueous
Sample Date:	13/06/2018	Protocol:	ESA 125	Test Species:	HV-Hydra viridissima
Comments:	Diluted with W2 (sample 8667)				

Dose-Response Plot



Hydra Population Growth Test-Growth Rate

Start Date:	15/06/2018 18:30	Test ID:	PR1552/26	Sample ID:	Composite
End Date:	23/06/2018 18:30	Lab ID:	8666	Sample Type:	AQ-Aqueous
Sample Date:	13/06/2018	Protocol:	ESA 125	Test Species:	HV-Hydra viridissima
Comments:	Diluted with W2 (sample 8667)				

Auxiliary Data Summary

Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
LC	Growth Rate	0.34	0.33	0.36	0.01	29.95	4
W2		0.35	0.33	0.36	0.01	33.65	4
6.3		0.34	0.32	0.35	0.01	34.27	4
12.5		0.35	0.33	0.37	0.02	35.64	4
25		0.35	0.34	0.36	0.01	29.06	4
50		0.34	0.32	0.35	0.01	34.50	4
100		0.29	0.27	0.31	0.02	45.25	4
LC	Conductivity	0.00	0.00	0.00	0.00		0
W2		0.00	0.00	0.00	0.00		0
6.3		0.00	0.00	0.00	0.00		0
12.5		0.00	0.00	0.00	0.00		0
25		0.00	0.00	0.00	0.00		0
50		0.00	0.00	0.00	0.00		0
100		0.00	0.00	0.00	0.00		0
LC	pH	0.00	0.00	0.00	0.00		0
W2		0.00	0.00	0.00	0.00		0
6.3		0.00	0.00	0.00	0.00		0
12.5		0.00	0.00	0.00	0.00		0
25		0.00	0.00	0.00	0.00		0
50		0.00	0.00	0.00	0.00		0
100		0.00	0.00	0.00	0.00		0
LC	DO, % sat	0.00	0.00	0.00	0.00		0
W2		0.00	0.00	0.00	0.00		0
6.3		0.00	0.00	0.00	0.00		0
12.5		0.00	0.00	0.00	0.00		0
25		0.00	0.00	0.00	0.00		0
50		0.00	0.00	0.00	0.00		0
100		0.00	0.00	0.00	0.00		0

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Statistical Printouts for the Rainbowfish Embryonic Development and Post-hatch Survival Tests

Fish Embryonic Development-% Unaffected

Start Date:	15/06/2018 19:00	Test ID:	PR1552/27	Sample ID:	Composite
End Date:	27/06/2018 19:00	Lab ID:	8666	Sample Type:	AQ-Aqueous
Sample Date:	13/06/2018	Protocol:	ESA 126	Test Species:	MS-Melanotaenia splendida
Comments:	Diluted with W2 (sample 8667)				

Conc-%	1	2	3	4
DMW	1.0000	1.0000	1.0000	0.8000
W2	1.0000	1.0000	0.8000	1.0000
6.3	1.0000	1.0000	0.6000	1.0000
12.5	1.0000	1.0000	0.8000	1.0000
25	1.0000	1.0000	1.0000	1.0000
50	0.8000	1.0000	1.0000	1.0000
100	1.0000	1.0000	1.0000	1.0000

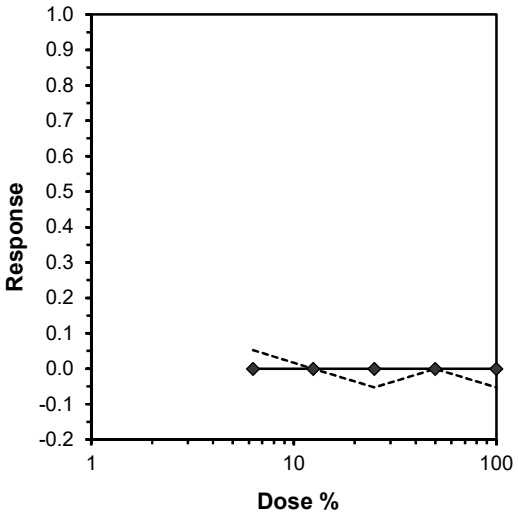
			Transform: Arcsin Square Root					Rank	1-Tailed	Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Mean	N-Mean
DMW	0.9500	1.0000	1.2857	1.1071	1.3453	9.261	4				
W2	0.9500	1.0000	1.2857	1.1071	1.3453	9.261	4	*		0.9583	1.0000
6.3	0.9000	0.9474	1.2305	0.8861	1.3453	18.660	4	17.50	10.00	0.9583	1.0000
12.5	0.9500	1.0000	1.2857	1.1071	1.3453	9.261	4	18.00	10.00	0.9583	1.0000
25	1.0000	1.0526	1.3453	1.3453	1.3453	0.000	4	20.00	10.00	0.9583	1.0000
50	0.9500	1.0000	1.2857	1.1071	1.3453	9.261	4	18.00	10.00	0.9583	1.0000
100	1.0000	1.0526	1.3453	1.3453	1.3453	0.000	4	20.00	10.00	0.9583	1.0000

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.05)	0.762065	0.916	-1.76412	3.060606
Equality of variance cannot be confirmed				
The control means are not significantly different (p = 1.00)	0	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	100	>100		1
Treatments vs W2				

Log-Logit Interpolation (200 Resamples)

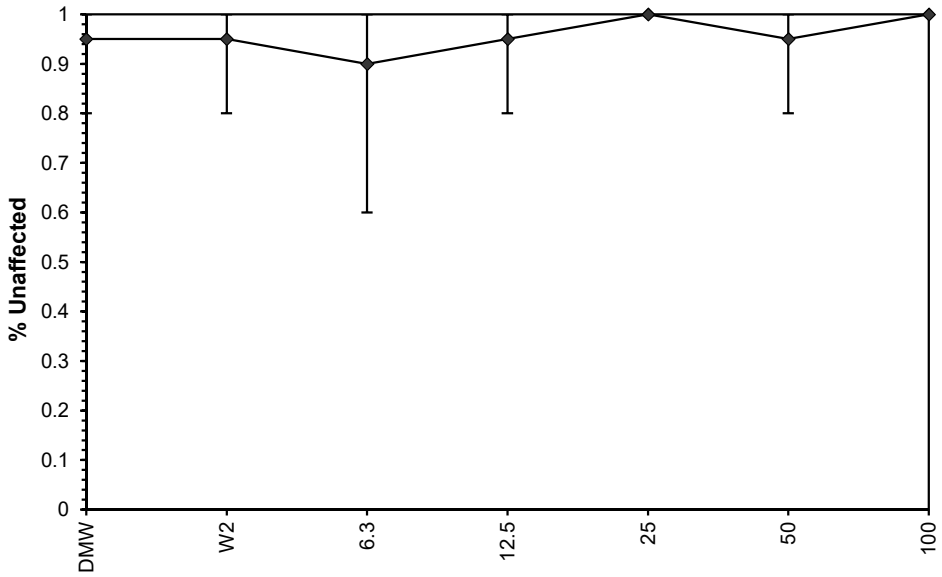
Point	%	SD	95% CL(Exp)	Skew
IC05	>100			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



Fish Embryonic Development-% Unaffected

Start Date:	15/06/2018 19:00	Test ID:	PR1552/27	Sample ID:	Composite
End Date:	27/06/2018 19:00	Lab ID:	8666	Sample Type:	AQ-Aqueous
Sample Date:	13/06/2018	Protocol:	ESA 126	Test Species:	MS-Melanotaenia splendida
Comments:	Diluted with W2 (sample 8667)				

Dose-Response Plot



Fish Embryonic Development-% Unaffected

Start Date:	15/06/2018 19:00	Test ID:	PR1552/27	Sample ID:	Composite
End Date:	27/06/2018 19:00	Lab ID:	8666	Sample Type:	AQ-Aqueous
Sample Date:	13/06/2018	Protocol:	ESA 126	Test Species:	MS-Melanotaenia splendida
Comments:	Diluted with W2 (sample 8667)				

Auxiliary Data Summary

Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
DMW	% Unaffected	95.00	80.00	100.00	10.00	3.33	4
W2		95.00	80.00	100.00	10.00	3.33	4
6.3		90.00	60.00	100.00	20.00	4.97	4
12.5		95.00	80.00	100.00	10.00	3.33	4
25		100.00	100.00	100.00	0.00	0.00	4
50		95.00	80.00	100.00	10.00	3.33	4
100		100.00	100.00	100.00	0.00	0.00	4
DMW	pH	8.10	8.10	8.10	0.00	0.00	1
W2		7.90	7.90	7.90	0.00	0.00	1
6.3		7.80	7.80	7.80	0.00	0.00	1
12.5		7.80	7.80	7.80	0.00	0.00	1
25		7.80	7.80	7.80	0.00	0.00	1
50		7.80	7.80	7.80	0.00	0.00	1
100		7.70	7.70	7.70	0.00	0.00	1
DMW	Conductivity (uS/cm)	187.00	187.00	187.00	0.00	0.00	1
W2		258.00	258.00	258.00	0.00	0.00	1
6.3		428.00	428.00	428.00	0.00	0.00	1
12.5		663.00	663.00	663.00	0.00	0.00	1
25		11047.00	11047.00	11047.00	0.00	0.00	1
50		1912.00	1912.00	1912.00	0.00	0.00	1
100		3370.00	3370.00	3370.00	0.00	0.00	1
DMW	DO (% sat)	96.80	96.80	96.80	0.00	0.00	1
W2		97.90	97.90	97.90	0.00	0.00	1
6.3		99.30	99.30	99.30	0.00	0.00	1
12.5		98.90	98.90	98.90	0.00	0.00	1
25		99.10	99.10	99.10	0.00	0.00	1
50		99.10	99.10	99.10	0.00	0.00	1
100		98.90	98.90	98.90	0.00	0.00	1

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Statistical Printouts for the *Chlorella* Growth Inhibition Tests

Microalgal Cell Yield-Cell Yield

Start Date:	15/06/2018 17:30	Test ID:	PR1552/23	Sample ID:	Composite
End Date:	18/06/2018 17:30	Lab ID:	8666	Sample Type:	AQ-Aqueous
Sample Date:	13/06/2018	Protocol:	ESA 103	Test Species:	CV-Chlorella vulgaris
Comments:	Diluted with W2 (sample 8667)				

Conc-%	1	2	3	4
USEPA	23.800	23.600	22.000	22.800
W2	22.800	24.200	23.000	22.600
6.3	22.400	23.800	22.800	22.000
12.5	22.800	23.000	23.200	22.800
25	24.200	22.600	22.400	22.000
50	22.800	24.200	23.200	23.600
100	24.400	23.000	22.600	23.200

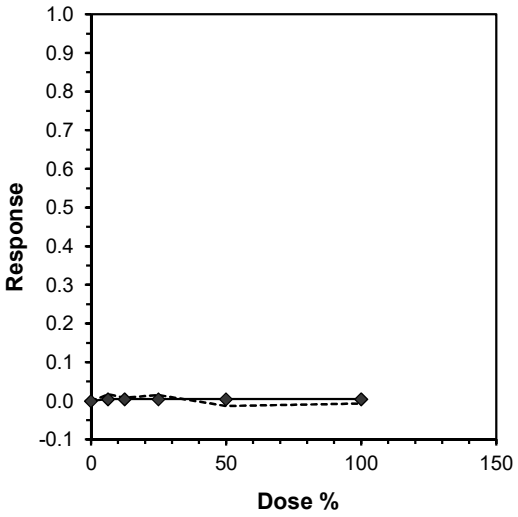
			Transform: Untransformed					Rank	1-Tailed	Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Mean	N-Mean
USEPA	23.050	0.9957	23.050	22.000	23.800	3.569	4				
W2	23.150	1.0000	23.150	22.600	24.200	3.105	4	*		23.150	1.0000
6.3	22.750	0.9827	22.750	22.000	23.800	3.395	4	14.50	10.00	23.050	0.9957
12.5	22.950	0.9914	22.950	22.800	23.200	0.834	4	18.50	10.00	23.050	0.9957
25	22.800	0.9849	22.800	22.000	24.200	4.237	4	14.00	10.00	23.050	0.9957
50	23.450	1.0130	23.450	22.800	24.200	2.547	4	21.00	10.00	23.050	0.9957
100	23.300	1.0065	23.300	22.600	24.400	3.324	4	20.00	10.00	23.050	0.9957

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.05)	0.887465	0.916	0.93118	-0.07202
Bartlett's Test indicates equal variances (p = 0.37)	5.34866	15.08627		
The control means are not significantly different (p = 0.86)	0.183083	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	100	>100		1
Treatments vs W2				

Linear Interpolation (200 Resamples)

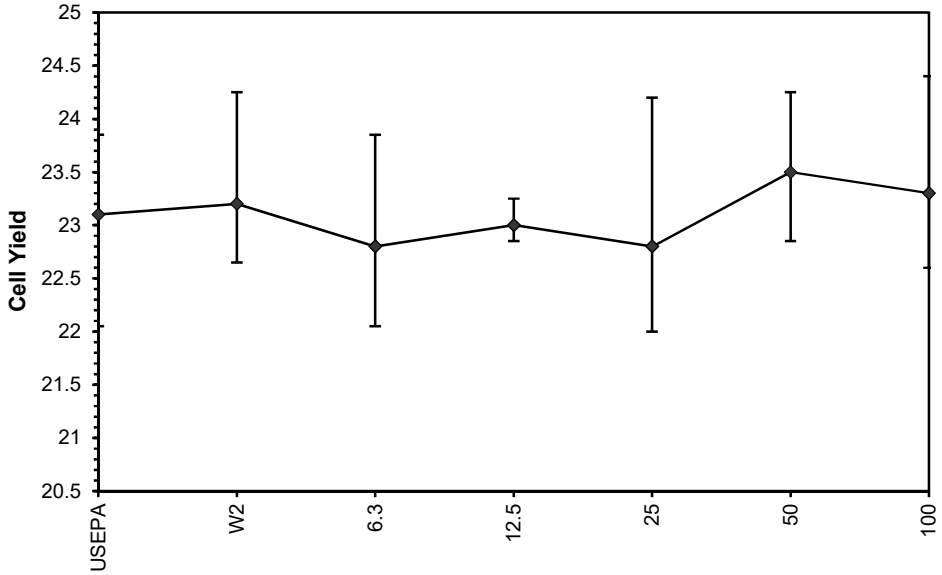
Point	%	SD	95% CL(Exp)	Skew
IC05	>100			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



Microalgal Cell Yield-Cell Yield

Start Date:	15/06/2018 17:30	Test ID:	PR1552/23	Sample ID:	Composite
End Date:	18/06/2018 17:30	Lab ID:	8666	Sample Type:	AQ-Aqueous
Sample Date:	13/06/2018	Protocol:	ESA 103	Test Species:	CV-Chlorella vulgaris
Comments:	Diluted with W2 (sample 8667)				

Dose-Response Plot



Microalgal Cell Yield-Cell Yield

Start Date:	15/06/2018 17:30	Test ID:	PR1552/23	Sample ID:	Composite
End Date:	18/06/2018 17:30	Lab ID:	8666	Sample Type:	AQ-Aqueous
Sample Date:	13/06/2018	Protocol:	ESA 103	Test Species:	CV-Chlorella vulgaris
Comments:	Diluted with W2 (sample 8667)				

Auxiliary Data Summary

Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
USEPA	Cell Yield	23.05	22.00	23.80	0.82	3.93	4
W2		23.15	22.60	24.20	0.72	3.66	4
6.3		22.75	22.00	23.80	0.77	3.86	4
12.5		22.95	22.80	23.20	0.19	1.91	4
25		22.80	22.00	24.20	0.97	4.31	4
50		23.45	22.80	24.20	0.60	3.30	4
100		23.30	22.60	24.40	0.77	3.78	4
USEPA	pH	8.10	8.10	8.10	0.00	0.00	1
W2		7.90	7.90	7.90	0.00	0.00	1
6.3		7.80	7.80	7.80	0.00	0.00	1
12.5		7.80	7.80	7.80	0.00	0.00	1
25		7.80	7.80	7.80	0.00	0.00	1
50		7.80	7.80	7.80	0.00	0.00	1
100		7.90	7.90	7.90	0.00	0.00	1
USEPA	Conductivity uS/cm	103.00	103.00	103.00	0.00	0.00	1
W2		258.00	258.00	258.00	0.00	0.00	1
6.3		428.00	428.00	428.00	0.00	0.00	1
12.5		663.00	663.00	663.00	0.00	0.00	1
25		1104.00	1104.00	1104.00	0.00	0.00	1
50		1912.00	1912.00	1912.00	0.00	0.00	1
100		3370.00	3370.00	3370.00	0.00	0.00	1

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Appendix H

AGE 2019 Groundwater Memorandum

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www.ageconsultants.com.au

AMD:kc
G1789C Kidston K2-Hydro
10 January 2019

Arran McGhie
Genex Power Limited

via email

Dear Arran,

RE: Kidston K2-Hydro – Groundwater Modelling

1 Introduction

Genex Power is assessing the potential groundwater impacts posed by the proposed hydropower scheme that uses the residual voids of the former Kidston Gold Mine. The optimised Kidston K2-Hydro operation will use the Wises pit as an upper storage and the Eldridge Pit as a receiving storage, and these pits will be connected by infrastructure that includes the hydropower plant.

The operation of the hydropower scheme will involve the variation of water levels within the existing pits (including increasing the storage volume and surface area of Wises Pit), and the water level changes will induce changes with how the pits control the regional groundwater levels. Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) were engaged by Genex Power to undertake an assessment of the potential changes to the groundwater regime resulting from the optimised K2-Hydro operation.

2 Goals and scope of work

Goal of this project was to assess the operational design of the K2-Hydro Project in terms of its potential to impact the surrounding groundwater environment.

3 Model development and calibration

AGE used a numerical model to assess the impact of the proposed K2-Hydro modification. A model was originally developed by AGE in 2001 to examine final void hydrology and this assessment has used this model as a basis.

3.1 Update of the 2001 AGE model

The following parts of the 2001 model were changed:

- model mesh – the refinement of the model mesh was changed to reflect the maximum increase ratio for neighbouring cells to be 1.5. The horizontal extent of the new mesh is slightly larger;
- model layers – increased from the previous three to 6 layers to better accommodate the depth of pits and simulate infrastructure;
- modelling code and solver – while the old model used then current version of MODFLOW (MODFLOW 88), the modelling code have been updated to MODFOW-SURFACT that is more suitable for conditions of steep hydraulic gradients with potential of unsaturated flow;
- extending the Wises Pit void to cover the updated area of the upper reservoir (in model layers 1 and 2); and
- implementing a horizontal flow barrier to account for the HDPE liner minimizing lateral seepage of water from the upper sections of the reservoir.

3.2 Current numerical model setup

The current numerical model setup is summarised below.

3.2.1 Model grid

The model covers area of 77.8 km^2 (9.0 km × 8.6 km) and is rotated by -22.35°. The model grid consists of 164 rows, 144 columns and 6 layers (141,696 active cells). The cell size varies from 300 m × 300 m in the areas around the edge of the model to 20 m × 20 m in the area covering the voids.

3.2.2 Model layers

The geotechnical investigations completed by Entura (2015) included seven fully cored diamond drill holes (KDDH series) around Wises Pit. The geotechnical report contains core photographs and logs which describe the degree of weathering, and include measurement of the rock quality designation (RQD) which indicates how fractured or jointed the rock mass is.

The information from the KDDH series holes indicates that the weathered/fractured zone, which is expected to enhance the movement of groundwater, is in the order of 10 m thick around Wises Pit. This is greater than the previously modelled thickness of 2 m to 3 m in the previous version of the model that utilised remote sensing data to estimate the thickness of the weathered zone. The thicknesses of Layer 1 and Layer 2 were therefore increased to a minimum of 5 m each.

The geological units were represented by six model layers:

- Layer 1 – weathered bedrock/topsoil or alluvium and spoil/tailings deposits where present;
- Layer 2 – weathered bedrock or alluvium where present;
- Layer 3 – fresh bedrock, base of layer at approximately 520 m AHD;
- Layer 4 – fresh bedrock, base of layer at approximately 498 m AHD (floor of Wises Pit);
- Layer 5 – fresh bedrock, base of layer at approximately 240 m AHD (floor of Eldridge Pit); and
- Layer 6 – fresh bedrock, base of the model at 30 m AHD.

3.2.3 Hydraulic properties

Based on previous studies and in-situ testing described in AGE (2001), the hydraulic conductivity of bedrock material is characterized as 'tight' and varies from 5×10^{-9} m to 9×10^{-7} m/day. The investigation undertaken by Entura (2015) describes in-situ tests on seven bores (KDDH01 to KDDH07) and shows hydraulic conductivities higher than described previously, varying from less than 8.6×10^{-4} m/day to more than 8.6×10^{-1} m/day with average of 4×10^{-2} m/day. The records indicate that packer tests were undertaken on both 'fresh' and 'weathered' intervals and their results are skewed upwards by testing of the weathered zone. The hydraulic conductivity values were used to constrain the calibration process.

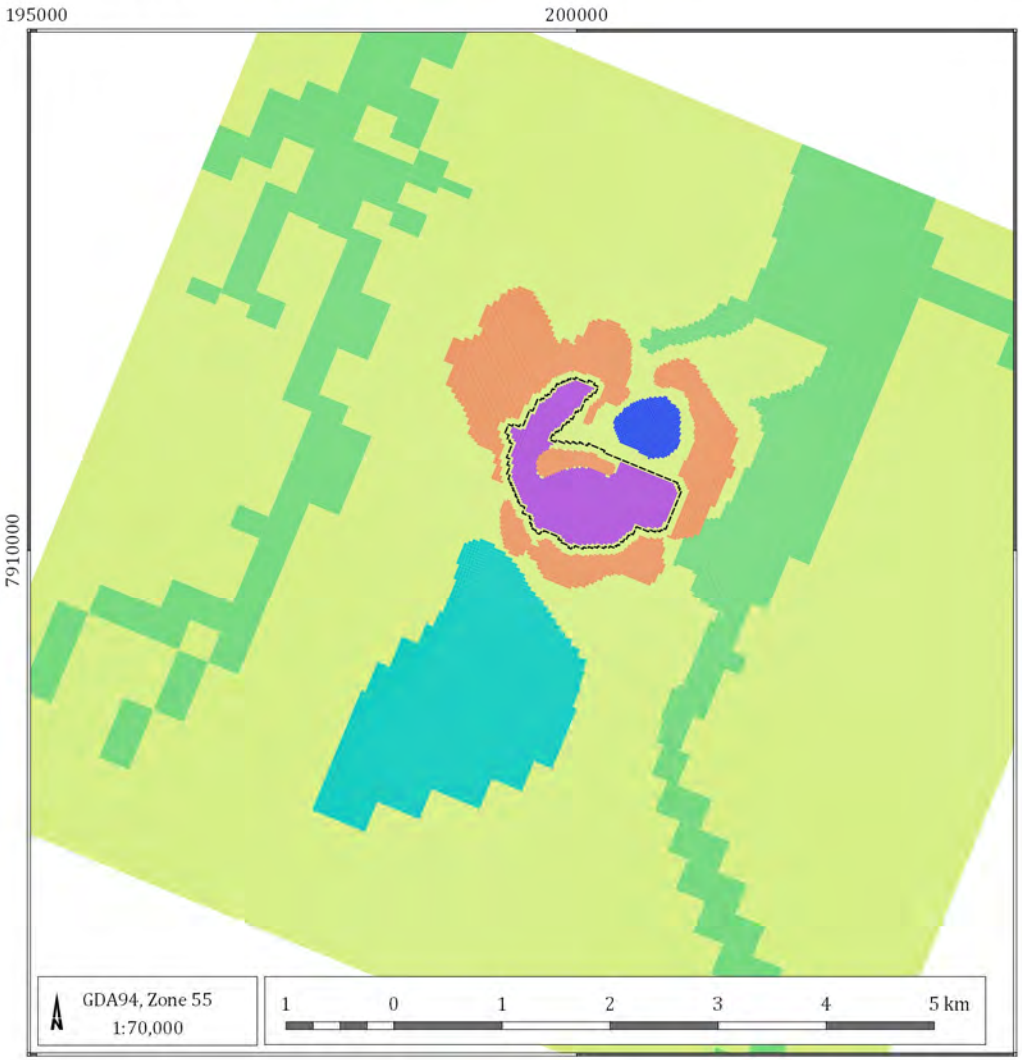
The weathered zone and fresh bedrock in the model were divided into four zones to represent the regionally extensive geological units. These zones represent Oak River granodiorite, Kennedy Province rhyolite, Einasleigh metamorphics and polymict breccias associated with the Kidston ore deposit mineralization. Zones were also created within the model to represent mine waste rock dumps, tailings deposits and alluvium aligned along surface streams.

The updated zonation of hydraulic properties is presented on Figure 1. The increased extent of Wises pit can be seen by the dashed line in the left panel of Figure 1, which represents the liner applied to the upper layers (Layer 1 to 2) in the model, and the purple coloured zone representing the void.

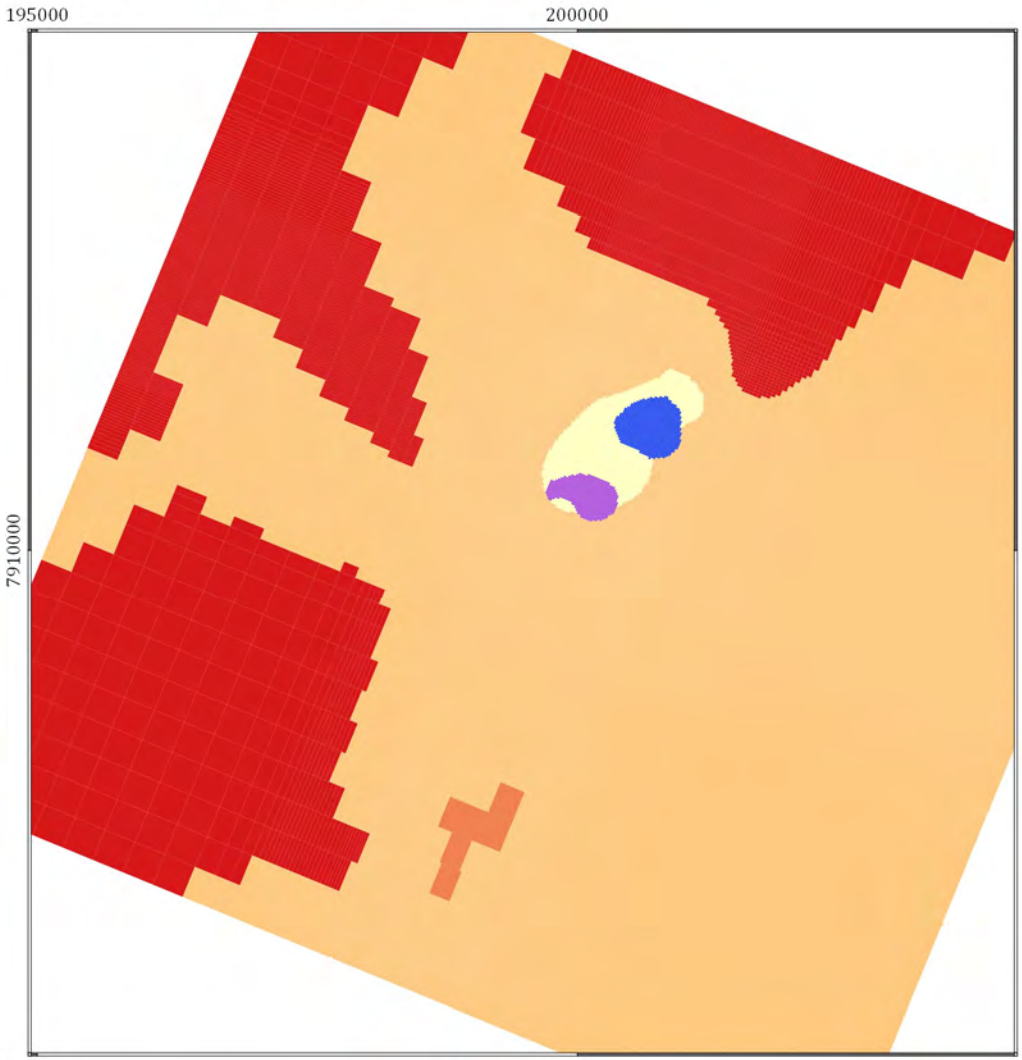
3.2.4 Recharge

Average annual rainfall ranges between 620 mm to 698 mm (AGE 2001) with much higher evaporation rates up to 1868 mm/year (CSIRO 2013) indicating a rainfall deficit. The actual effective recharge is estimated to be quite low – less than 5 mm/year (CSIRO 2013). Recharge within the model was varied using the geological zones described above to represent the potential variability due to geology.

Zones - hydraulic properties - L1-L2



Zones - hydraulic properties - L3-L6



LEGEND

----- horizontal flow barrier

Topsoil, weathered regolith	Oak River granodiorite
Alluvium	Kennedy Province rhyolite
Northern spoil	Einsleigh metamorphics
Tailings dam	Polymict breccia
Void – Wises Pit	Void – Wises Pit
Void – Eldridge Pit	Void – Eldridge Pit

Kidston K2-Hydro (G1789C)

Zonation of hydraulic properties in model layers 1-2 and 3-6

DATE
10/01/2019

FIGURE No:
1

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:/Projects/G1789B.Kidston K2-Hydro/3_GIS/Workspaces/001_Deliverable1/1_zones_hydraulic_properties.qgs

3.3 Model calibration

The model was calibrated against available groundwater level measurements from monitoring bores. Data from 61 observation bores were available, of which 38 sites were actually used during the calibration process (Figure 2). Many of the observed water levels are historical observations collected during periods of active mining and are not expected to accurately reflect current water levels across the site. These bores were therefore removed from the calibration dataset. The majority of recent water level measurements are from piezometers around the tailings dam to the south of the pits. Whilst this provides a high degree of control in this area of the site there are other areas of the model, such as around Eldridge pit, where current water levels are unknown.

Table 1 presents the simulated and the measured groundwater levels for the calibrated model and the difference between these levels (the residuals).

Table 2 summarises the hydraulic conductivity values adopted for each geological zone. The calibrated hydraulic conductivities for the bedrock units in this simulation were at the higher end of the measured ranges. This version of the model is therefore expected to allow groundwater to move more freely through the bedrock than if lower values were adopted.

The calibrated recharge across the undisturbed areas of the model was relatively low at <3 mm/yr, whilst higher rates were incorporated over the alluvium and the areas disturbed by mining (spoil and tailings). A review of water quality measurements indicates the groundwater generally has a low salinity that would suggest moderate recharge rates; the fact the numerical calibrated well to a low recharge indicates some uncertainty in this parameter within the model.

A post-calibration scatter diagram is shown in Figure 3, with the main statistical indicators of the calibration in Table 3.

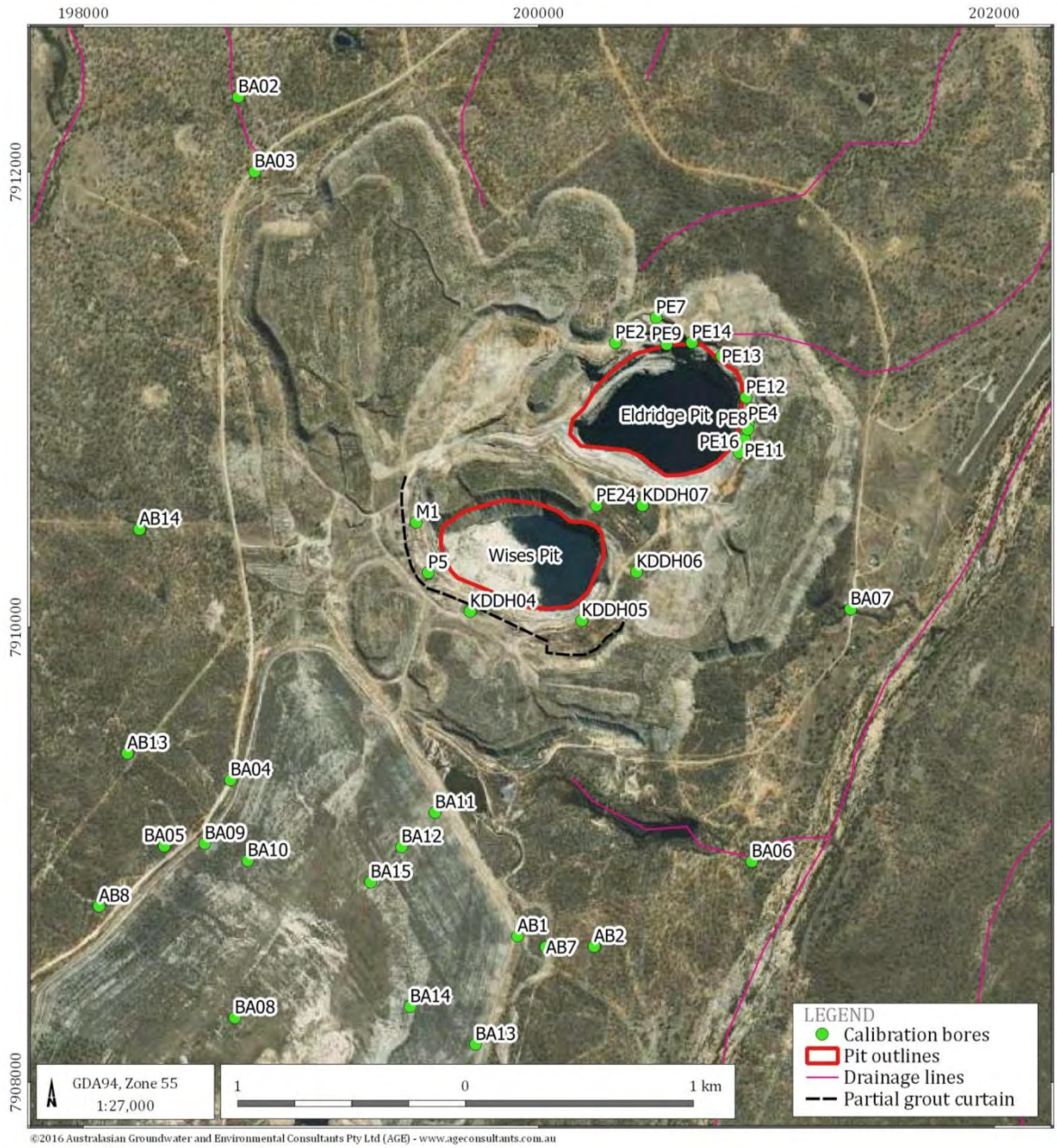


Figure 2 Calibration bore locations

Table 1 Steady state calibration - residuals

Bore ID	Easting (GDA94 Z55)	Northing (GDA94 Z55)	Observed head (m AHD)	Modelled head (m AHD)	Residual (m)
AB1	199908	7908642	544.6	540.3	4.3
AB2	198194	7909446	533.7	537.7	-3.9
AB7	198247	7910431	525.4	526.9	-1.5
AB8	200244	7908597	516.1	527.0	-11.0
AB13	200032	7908593	531.4	533.0	-1.6
AB14	198070	7908774	541.4	544.5	-3.2

Bore ID	Easting (GDA94 Z55)	Northing (GDA94 Z55)	Observed head (m AHD)	Modelled head (m AHD)	Residual (m)
BA02	198681	7912331	521.6	518.9	2.6
BA03	198753	7912003	526.0	517.7	8.2
BA04	198647	7909329	547.3	541.4	6.0
BA05	198357	7909039	545.0	544.0	1.1
BA06	200936	7908971	508.1	512.0	-4.0
BA07	201370	7910080	510.3	508.0	2.2
BA08	198666	7908284	545.8	548.4	-2.6
BA09	198534	7909050	544.2	544.9	-0.6
BA10	198723	7908974	549.4	544.8	4.6
BA11	199545	7909186	540.9	538.8	2.1
BA12	199398	7909035	544.0	540.1	3.9
BA13	199723	7908167	540.0	542.7	-2.7
BA14	199436	7908333	542.0	544.0	-2.0
BA15	199262	7908880	545.3	542.0	3.2
BA16	197379	7910486	524.4	526.5	-2.1
KDDH04	199699	7910069	527.9	513.6	14.3
KDDH05	200189	7910029	515.0	509.8	5.2
KDDH06	200430	7910243	527.3	506.9	20.4
KDDH07	200456	7910535	519.0	495.4	23.5
M1	199462	7910461	516.8	514.0	2.8
P5	199515	7910240	508.5	514.9	-6.4
PE2	200904	7910824	480.9	486.6	-5.7
PE4	200911	7911010	490.4	485.1	5.4
PE7	200804	7911192	503.6	486.9	16.6
PE8	200673	7911252	500.0	483.2	16.8
PE9	200880	7910769	496.0	487.3	8.6
PE11	200337	7911251	509.9	501.3	8.6
PE12	200253	7910535	500.2	498.6	1.6
PE13	200920	7910893	508.4	488.1	20.2
PE14	200516	7911361	531.4	509.2	22.2
PE16	200918	7910870	509.7	487.5	22.2
PE24	200562	7911244	481.2	482.0	-0.8

Table 2 Calibrated hydraulic properties

Matrix description		Hydraulic conductivity (m/day)	
		Horizontal (Kh)	Vertical (Kv)
Topsoil		0.1	0.02
Alluvium		0.5	0.025
Spoil		4.0	0.4
Tailings		0.7	0.0007
Weathered profile	Oak River granodiorite	0.08	0.004
	Kennedy Province rhyolite	0.005	0.005
	Einasleigh metamorphics	0.007	0.007
	Polymict breccia - ore mineralization	0.005	0.00025
Fresh bedrock	Oak River granodiorite	0.007	0.002
	Kennedy Province rhyolite	0.008	0.008
	Einasleigh metamorphics	0.002	0.002
	Polymict breccia - ore mineralization	0.0001	0.0001

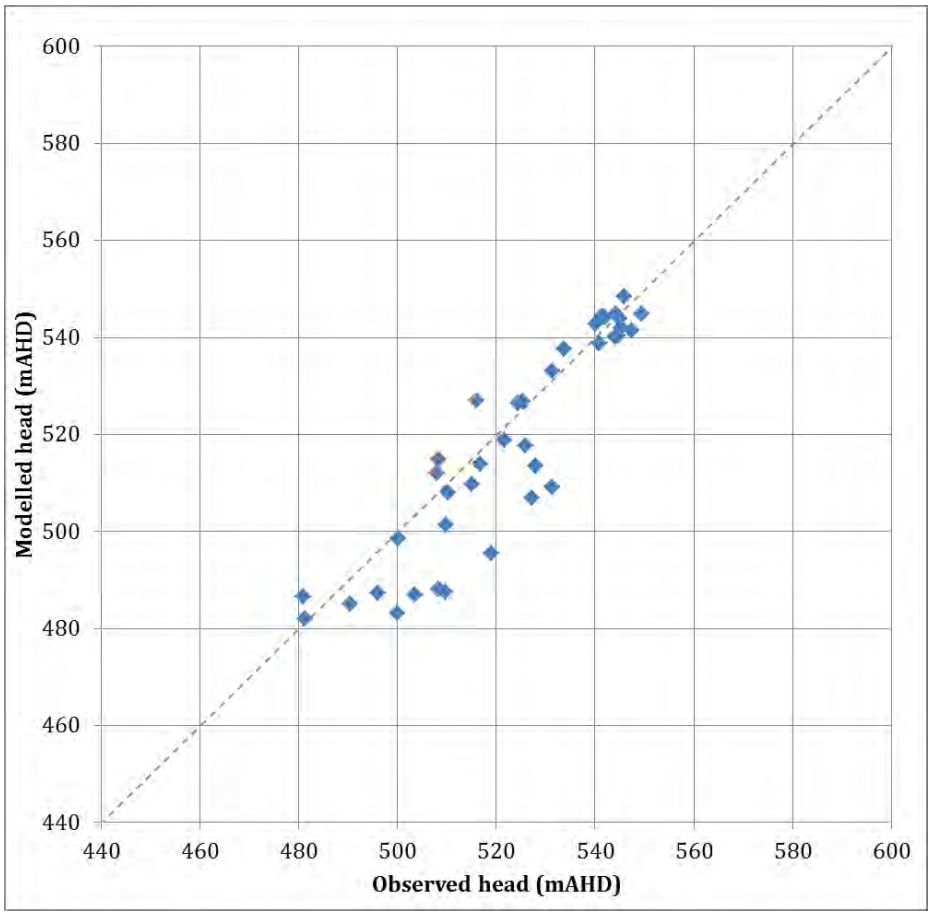


Figure 3 Steady state calibration – scatter diagram of modelled against observed heads

Table 3 Main statistical indicators of calibration process

Statistical indicator		Value	Units
SSQ	Sum of squared residuals	3793	(m^2)
RMS	Root mean square	9.99	(m)
SRMS	Scaled RMS	14.6	(%)

The SRMS is one of the main indicators of calibration fit and at 14.6% it is considered to be slightly poor. This indicates that some processes in the natural environment are not represented in the model. The model was calibrated to assumed steady state water levels, which are estimates of long term average water levels. The available monitoring data suggests the water levels within the mine pits have not reached equilibrium and are therefore not likely to represent the long term average level. The water level measurements within the monitoring bores are also sporadic and may not represent the full fluctuations that occur across the wet season and dry season climatic cycles. The model also assumes the hydraulic properties of the geologic units are uniform across large areas, which is of course not true within the natural environment. These aspects likely combine to result in the slightly poor calibration.

3.4 Model predictions

In order to assess the impact of the Project, each pit was assigned a water level that explores the maximum possible water level gradient between Wises and Eldridge pits. The setup of the model in terms of defined water levels is shown in Table 4.

Table 4 Modelled scenarios – pit water levels

Scenario	Simulated water level in reservoirs (mRL)	
	Wises Pit (upper, shallow)	Eldridge Pit (lower, deep)
Baseline	492.00	480.75
K2-Hydro	551.00 *	328.40

Note: ** This is a conservative level as the Maximum Operating Level for Wises Pit is 546 mRL. The MOL is achieved when the Eldridge Pit water level is at elevation 328.40 mRL.*

4 Modelling results

Two steady state models were run with the setups described in Table 4. The potential impacts of the K2-Hydro modification were determined through comparisons between these two model predictions. The key model outputs used to determine the impact were predicted groundwater table (groundwater mounding and drawdown analysis) and changes to water budgets for predicted pit inflow/outflow and flows to the Copperfield River. A simple particle tracking exercise was also undertaken to better understand the extent of the impacts in the context of the limitations of the steady state model with respect to the real-life duration of the Project (50 years).

4.1 Groundwater levels

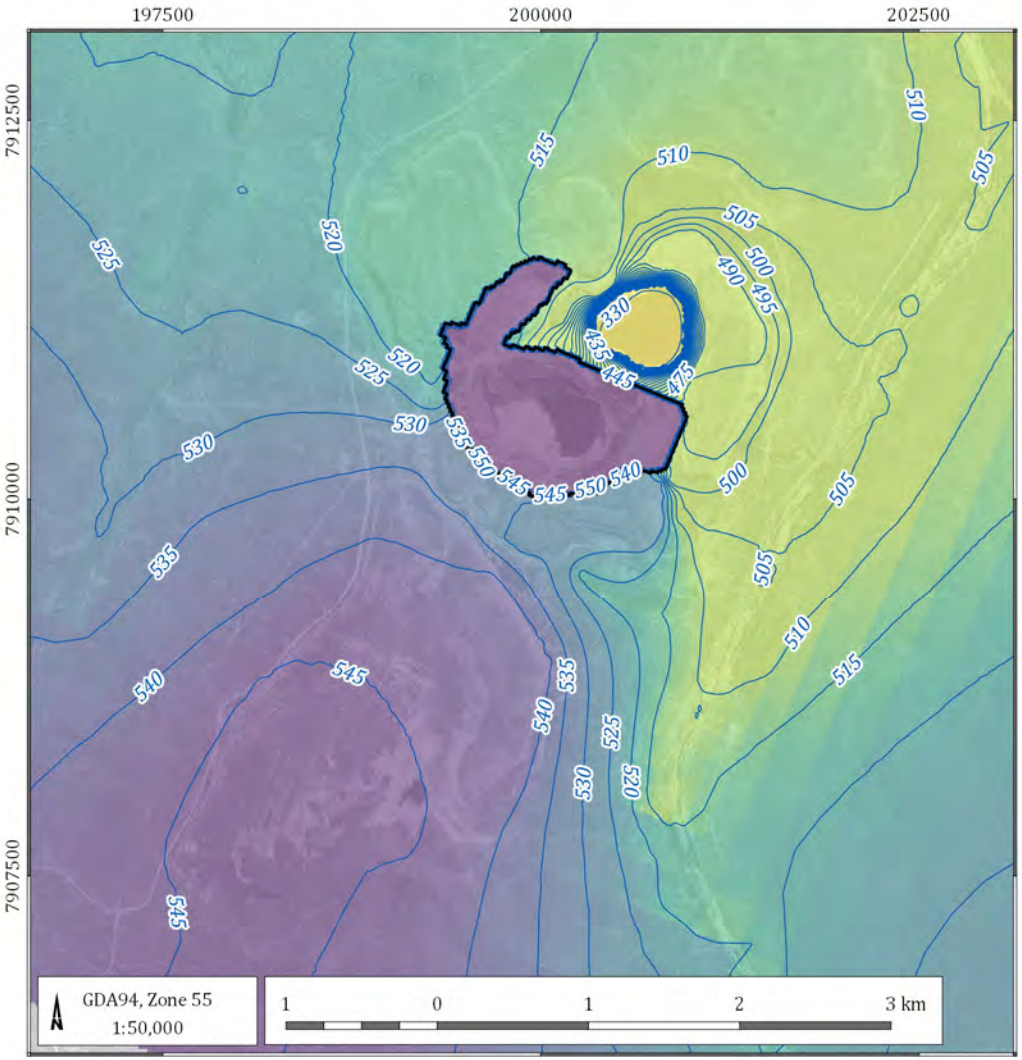
Figure 4 below shows predicted heads (left) and predicted difference to the baseline simulation (right) in model Layer 1 (representing the phreatic surface) for the K2-Hydro setup in Table 4. The predicted difference shows both drawdown (positive contours) and mounding (negative contours). Generally, the water seeps through the floor of the upper reservoir and travels down-gradient where it is either captured by the Eldridge Pit or remains in the groundwater system and results in a rise in the water table level. Because the water level in the Wises reservoir (551 m RL) is relatively high and above the existing water table, the model predicts an increased seepage and water level rise in the immediate vicinity of the pit towards the west, southwest and south. The elevated water table around Wises pit from this seepage 'dams' the regional flow towards the north and the backed up water results in additional mounding in the areas south and southwest from the Wises reservoir.

4.2 Particle tracking

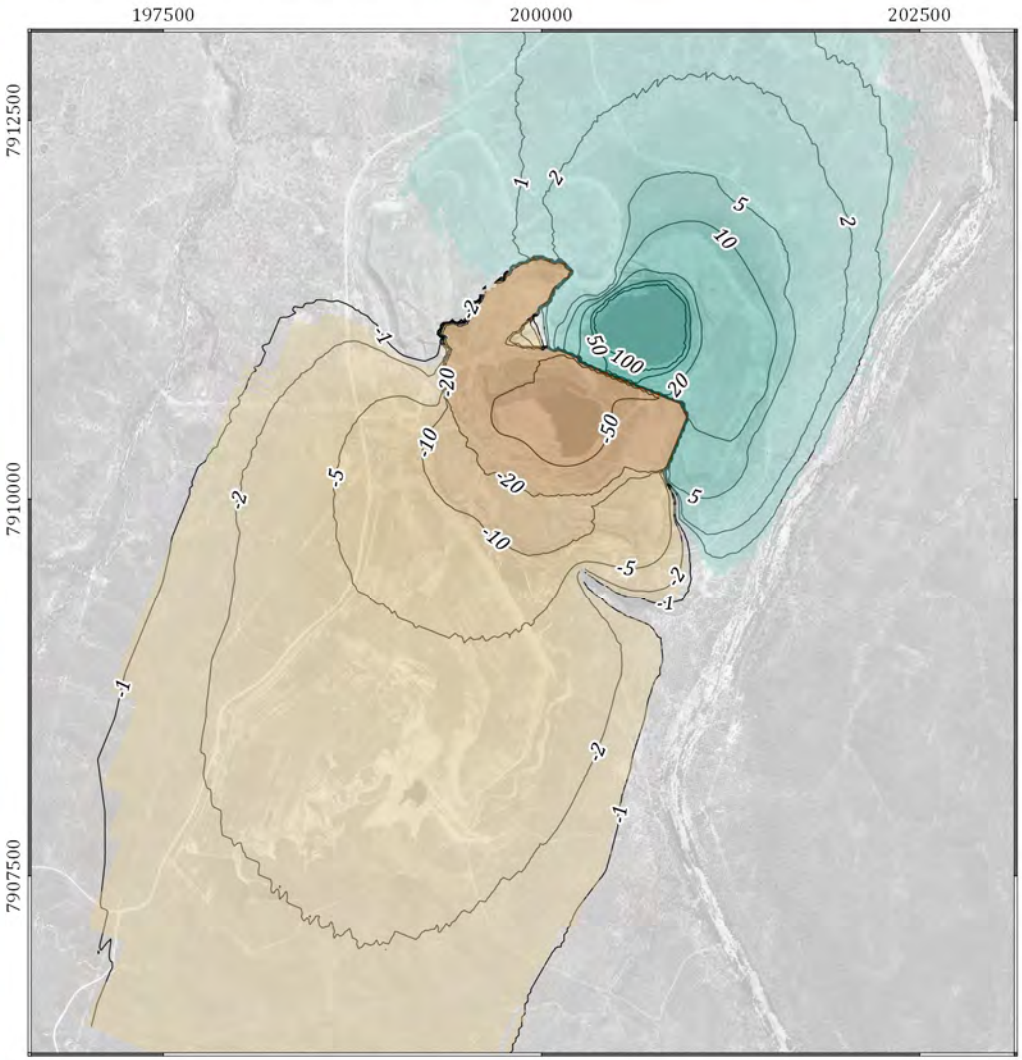
Particle tracking was used to identify the likely travel distances of water particles that start their journey in the Wises reservoir at the start of the Project. The distance of travel of particles indicates the spatial extent of the likely impacts from the Project over its operational phase. The pathlines for 100 years timeframe were generated, as these were comfortably past the expected lifetime of the Project (50 years).

Particles were started inside the lined pond (see Figure 5). Particles released on the north eastern side of Wises Pit generally migrate to the Eldridge pit. However, the particles released in other parts of the reservoir migrate in a west, south or south-west directions remain "active" in the groundwater system. During the 100 year timeframe run, only 4 (out of 54) particles ended up in the Eldridge Pit, all the other particles remained active after moving in the downwards direction through the bedrock units. Regardless of the length of the particle tracking timeframe, the travel of particles in south and southwest direction is limited. This is likely to be due to the northerly gradient being maintained from the tailings dam area towards the north. No particles made it to Copperfield River in the 100 year period.

K2-Hydro - predicted groundwater heads



K2-Hydro - predicted drawdowns



LEGEND

contour - heads

contour - drawdown

Kidston K2-Hydro (G1789C)

Heads and drawdowns

DATE
10/01/2019

FIGURE No:
4

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:/Projects/G1789B.Kidston K2-Hydro/3_GIS/Workspaces/001_Deliverable1/2_heads_drawdowns.qgs