ROWE GROUP DESIGN

LOCAL STRUCTURE PLAN

PRECINCT 2A – PICTON INDUSTRIAL PARK SOUTHERN PRECINCT

OUR REF: 9013 17/01/2020

Appendix E

Groundwater Monitoring Results

Table E. 1: Depth to groundwater (m) from natural surface as provided by TME with the exception of the 2019 sampling occasion

Date	Bore No.								
	Bore 1	Bore 2	Bore 3	Bore 4	Bore 5	Bore 6	Bore 7	Bore 8	Bore 9
28/09/2010	0.93	0.34	0.8	0.71	1.07	1.34	2.04	2.17	1.4
26/10/2010	1.06	0.5	1.03	1.01	1.2	1.43	2.06	2.32	1.50
19/01/2011	1.65	0.74	1.41	1.79	1.64	1.74	3.08	Dry	1.86
18/04/2011	2.19	0.77	1.94	2.16	1.78	1.88	Dry	Dry	2.18
10/05/2011	2.14	0.71	1.9	1.98	1.76	1.88	3.46	Dry	2.12
10/06/2011	1.66	0.37	1.39	1.31	1.6	1.58	1.40	Dry	1.70
12/07/2011	0.9	0.15	0.54	0.53	1.02	1.21	1.24	2.6	1.28
25/08/2011	0.4	0.05	0.14	0.31	0.51	0.8	0.74	0.92	0.92
27/09/2011	0.3	0.09	0.18	0.34	0.46	0.85	0.74	0.96	0.92
21/10/2011	0.43	0.2	0.52	0.62	0.63	0.99	0.88	1.17	1.06
28/11/2011	0.56	0.43	0.85	1.01	0.84	1.19	1.20	1.5	1.26
15/12/2011	0.72	0.35	0.9	1.16	0.87	1.21	1.26	1.66	1.06
24/07/2012	0.68	0.18	0.8	0.53	0.83	1.14	1.30	1.51	1.26
24/08/2012	0.50	0.08	0.19	0.35	0.66	1.02	1.14	1.31	1.10
11/09/2012	0.4	0.13	0.2	0.4	0.59	0.95	1.10	1.17	1.02
18/10/2012	0.45	0.25	0.55	0.67	0.66	Equipment error	1.04	1.28	Equipment error
19/11/2012	0.65	0.45	0.54	0.97	0.84	1.16	1.30	1.61	1.28
17/12/2012	0.45	0.21	0.37	0.55	0.64	0.89	1.04	1.34	1.08
22/08/2019	0.63	0.06	0.24	0.51	0.76	1.06	1.13	Destroyed	1.10

Table E. 2: Groundwater quality at Bore 1 as provided by TME

Analyte	26/10/2010	18/04/2011	21/10/2011	15/12/2011	18/10/2012
OH^- Alkalinity *(mg/L, LOR = 1)*	<1	<1	<1	<1	<1
CO_3^{2-} Alkalinity *(mg/L, LOR = 1)*	<1	<1	<1	<1	<1
HCO_3^- Alkalinity *(mg/L, LOR = 1)*	34	13	7	7	13
Total Alkalinity *(mg/L, LOR = 1)*	34	13	7	7	13
Aluminium *(mg/L, LOR = 0.01)*	2.2	5.71	21.9	10.4	
Arsenic *(mg/L, LOR = 0.001)*	<0.001	<0.001	0.001	0.001	
Cadmium *(mg/L, LOR = 0.0001)*	<0.0001	0.0001	0.0002	0.0001	
Chromium *(mg/L, LOR = 0.001)*	0.003	0.01	0.021	0.015	
Copper *(mg/L, LOR = 0.001)*	0.008	0.033	0.042	0.038	
Lead *(mg/L, LOR = 0.001)*	0.002	0.012	0.036	0.012	
Manganese *(mg/L, LOR = 0.001)*	0.074	0.029	0.043	0.023	
Zinc *(mg/L, LOR = 0.005)*	0.03	0.081	0.096	0.062	
Iron *(mg/L, LOR = 0.05)*	6.92	6.48	19.5	8.43	

Table E. 2: Groundwater quality at Bore 1 as provided by TME (continued)

Analyte	26/10/2010	18/04/2011	21/10/2011	15/12/2011	18/10/2012
Ammonia *(mg/L, LOR = 0.01)*	0.22	0.11	0.04	<0.05	<0.02
Nitrite *(mg/L, LOR = 0.01)*	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate *(mg/L, LOR = 0.01)*	<0.01	<0.01	<0.01	0.04	<0.05
NO_x *(mg/L, LOR = 0.01)*	<0.01	<0.01	<0.01	0.04	<0.05
TKN *(mg/L, LOR = 0.1)*	0.6	1.2	8	4.8	6.1
Total Nitrogen *(mg/L, LOR = 0.1)*	0.6	1.2	8	4.8	6.1
Reactive P *(mg/L, LOR = 0.01)*	<0.01	<0.01	0.02	0.01	0.01
Total P *(mg/L, LOR = 0.01)*	0.07	0.13	0.58	0.31	0.2

Table E. 3: Groundwater quality at Bore 2 as provided by TME

Analyte	26/10/2010	18/04/2011	21/10/2011	15/12/2011	18/10/2012
OH^- Alkalinity *(mg/L, LOR = 1)*	<1	<1	<1	<1	<1
CO_3^{2-} Alkalinity *(mg/L, LOR = 1)*	<1	<1	<1	<1	<1
HCO_3^- Alkalinity *(mg/L, LOR = 1)*	87	66	151	71	124

Table E. 3: Groundwater quality at Bore 2 as provided by TME

Analyte	26/10/2010	18/04/2011	21/10/2011	15/12/2011	18/10/2012
Total Alkalinity *(mg/L, LOR = 1)*	87	66	151	71	124
Aluminium *(mg/L, LOR = 0.01)*	25.6	23.8	5.09	9.77	
Arsenic *(mg/L, LOR = 0.001)*	<0.001	0.002	0.001	0.002	
Cadmium *(mg/L, LOR = 0.0001)*	<0.0001	<0.0001	<0.0001	<0.0001	
Chromium *(mg/L, LOR = 0.001)*	0.049	0.01	0.008	0.018	
Copper *(mg/L, LOR = 0.001)*	0.056	0.06	0.009	0.019	
Lead *(mg/L, LOR = 0.001)*	0.05	0.057	0.008	0.018	
Manganese *(mg/L, LOR = 0.001)*	0.057	0.036	0.252	0.05	
Zinc *(mg/L, LOR = 0.005)*	0.03	0.05	0.025	0.023	
Iron *(mg/L, LOR = 0.05)*	43.6	42.4	15.4	20.5	
Ammonia *(mg/L, LOR = 0.01)*	1.07	2.13	0.42	1.12	0.28
Nitrite *(mg/L, LOR = 0.01)*	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate *(mg/L, LOR = 0.01)*	0.01	0.01	<0.01	0.04	0.02

Table E. 3: Groundwater quality at Bore 2 as provided by TME

Analyte	26/10/2010	18/04/2011	21/10/2011	15/12/2011	18/10/2012
NO_x *(mg/L, LOR = 0.01)*	0.01	0.01	<0.01	0.04	0.02
TKN *(mg/L, LOR = 0.1)*	5	4.4	2.4	3	1.8
Total Nitrogen *(mg/L, LOR = 0.1)*	5	4.4	2.4	3	1.8
Reactive P *(mg/L, LOR = 0.01)*	<0.01	<0.01	<0.01	<0.01	<0.01
Total P *(mg/L, LOR = 0.01)*					

Table E. 4: Groundwater quality at Bore 3 as provided by TME

Analyte	26/10/2010	18/04/2011	21/10/2011	15/12/2011	18/10/2012
OH^- Alkalinity *(mg/L, LOR = 1)*	<1	<1	<1	<1	<1
CO_3^{2-} Alkalinity *(mg/L, LOR = 1)*	<1	<1	<1	<1	<1
HCO_3^- Alkalinity *(mg/L, LOR = 1)*	151	96	<1	163	216
Total Alkalinity *(mg/L, LOR = 1)*	151	96	<1	163	216
Aluminium *(mg/L, LOR = 0.01)*	29.2	42	22.1	27.8	
Arsenic *(mg/L, LOR = 0.001)*	<0.001	0.002	0.001	<0.001	

Table E. 4: Groundwater quality at Bore 3 as provided by TME

Analyte	26/10/2010	18/04/2011	21/10/2011	15/12/2011	18/10/2012
Cadmium *(mg/L, LOR = 0.0001)*	<0.0001	<0.0001	<0.0001	<0.0001	
Chromium *(mg/L, LOR = 0.001)*	0.049	0.06	0.037	0.042	
Copper *(mg/L, LOR = 0.001)*	0.026	0.037	0.022	0.025	
Lead *(mg/L, LOR = 0.001)*	0.018	0.026	0.019	0.019	
Manganese *(mg/L, LOR = 0.001)*	0.132	0.268	0.087	0.176	
Zinc *(mg/L, LOR = 0.005)*	0.05	0.041	0.021	0.05	
Iron *(mg/L, LOR = 0.05)*	16.9	20.8	14	15	
Ammonia *(mg/L, LOR = 0.01)*	0.01	0.04	0.07	<0.05	0.03
Nitrite *(mg/L, LOR = 0.01)*	<0.01	<0.01	0.05	<0.01	<0.01
Nitrate *(mg/L, LOR = 0.01)*	0.59	0.02	0.42	0.02	0.01
NO_x *(mg/L, LOR = 0.01)*	0.59	0.02	0.47	0.02	0.01
TKN *(mg/L, LOR = 0.1)*	6.2	4.5	3.4	2.5	4.7
Total Nitrogen *(mg/L, LOR = 0.1)*	6.8	4.5	3.9	2.5	4.7

Table E. 4: Groundwater quality at Bore 3 as provided by TME

Analyte	26/10/2010	18/04/2011	21/10/2011	15/12/2011	18/10/2012
Reactive P *(mg/L, LOR = 0.01)*	<0.01	<0.01	0.01	<0.01	<0.01
Total P *(mg/L, LOR = 0.01)*	0.54	0.43	0.24	0.26	0.38

Table E. 5: Groundwater quality at Bore 4 as provided by TME

Analyte	26/10/2010	18/04/2011	21/10/2011	15/12/2011	18/10/2012
OH^- Alkalinity *(mg/L, LOR = 1)*	<1	<1	<1	<1	<1
CO_3^{2-} Alkalinity *(mg/L, LOR = 1)*	<1	<1	<1	<1	<1
HCO_3^- Alkalinity *(mg/L, LOR = 1)*	60	61	85	68	78
Total Alkalinity *(mg/L, LOR = 1)*	60	61	85	68	78
Aluminium *(mg/L, LOR = 0.01)*	4.56	8.8	16.5	11.8	
Arsenic *(mg/L, LOR = 0.001)*	<0.001	<0.001	<0.001	<0.001	
Cadmium *(mg/L, LOR = 0.0001)*	<0.0001	<0.0001	<0.0001	<0.0001	
Chromium *(mg/L, LOR = 0.001)*	0.013	0.02	0.032	0.024	
Copper *(mg/L, LOR = 0.001)*	0.014	0.025	0.071	0.055	

Table E. 5: Groundwater quality at Bore 4 as provided by TME

Analyte	26/10/2010	18/04/2011	21/10/2011	15/12/2011	18/10/2012
Lead *(mg/L, LOR = 0.001)*	0.007	0.011	0.022	0.012	
Manganese *(mg/L, LOR = 0.001)*	0.086	0.043	0.119	0.041	
Zinc *(mg/L, LOR = 0.005)*	0.028	0.051	0.067	0.038	
Iron *(mg/L, LOR = 0.05)*	10.9	17.3	23.6	19.4	
Ammonia *(mg/L, LOR = 0.01)*	0.03	0.03	0.06	<0.05	0.02
Nitrite *(mg/L, LOR = 0.01)*	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate *(mg/L, LOR = 0.01)*	0.17	0.03	<0.01	0.08	<0.01
NO_x *(mg/L, LOR = 0.01)*	0.17	0.03	<0.01	0.08	<0.01
TKN *(mg/L, LOR = 0.1)*	0.6	0.4	4.2	1.2	1.6
Total Nitrogen *(mg/L, LOR = 0.1)*	0.8	0.4	4.2	1.3	1.6
Reactive P *(mg/L, LOR = 0.01)*	<0.01	<0.01	0.01	<0.01	0.01
Total P *(mg/L, LOR = 0.01)*	0.24	0.03	0.42	0.14	0.08

Table E. 6: Groundwater quality at Bore 5 as provided by TME

Analyte	26/10/2010	18/04/2011	21/10/2011	15/12/2011	18/10/2012
OH^- Alkalinity *(mg/L, LOR = 1)*	<1	<1	<1	<1	<1
CO_3^{2-} Alkalinity *(mg/L, LOR = 1)*	<1	<1	<1	<1	<1
HCO_3^- Alkalinity *(mg/L, LOR = 1)*	31	37	<1	38	16
Total Alkalinity *(mg/L, LOR = 1)*	31	37	<1	38	16
Aluminium *(mg/L, LOR = 0.01)*	15.5	11.5	2.15	3.28	
Arsenic *(mg/L, LOR = 0.001)*	<0.001	0.003	<0.001	0.001	
Cadmium *(mg/L, LOR = 0.0001)*	0.0002	<0.0001	<0.0001	<0.0001	
Chromium *(mg/L, LOR = 0.001)*	0.017	0.01	0.002	0.003	
Copper *(mg/L, LOR = 0.001)*	0.034	0.036	0.01	0.007	
Lead *(mg/L, LOR = 0.001)*	0.029	0.024	0.007	0.006	
Manganese *(mg/L, LOR = 0.001)*	0.094	0.055	0.063	0.061	
Zinc *(mg/L, LOR = 0.005)*	0.049	0.044	0.016	0.012	
Iron *(mg/L, LOR = 0.05)*	25.7	17.4	30.5	37.8	

Table E. 6: Groundwater quality at Bore 5 as provided by TME

Analyte	26/10/2010	18/04/2011	21/10/2011	15/12/2011	18/10/2012
Ammonia *(mg/L, LOR = 0.01)*	0.21	0.23	0.07	0.06	<0.05
Nitrite *(mg/L, LOR = 0.01)*	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate *(mg/L, LOR = 0.01)*	0.05	<0.01	<0.01	0.06	0.05
NO_x *(mg/L, LOR = 0.01)*	0.05	<0.01	<0.01	0.06	0.05
TKN *(mg/L, LOR = 0.1)*	6.4	1.5	3	1.5	3.3
Total Nitrogen *(mg/L, LOR = 0.1)*	6.5	1.5	3	1.6	3.4
Reactive P *(mg/L, LOR = 0.01)*	<0.01	<0.01	<0.01	<0.01	<0.01
Total P *(mg/L, LOR = 0.01)*	0.34	0.19	0.16	0.14	0.2

Table E. 7: Groundwater quality at Bore 6 as provided by TME

Analyte	26/10/2010	18/04/2011	21/10/2011	15/12/2011	18/10/2012
OH^- Alkalinity *(mg/L, LOR = 1)*	<1	<1	<1	<1	Dry
CO_3^{2-} Alkalinity *(mg/L, LOR = 1)*	<1	<1	<1	<1	
HCO_3^- Alkalinity *(mg/L, LOR = 1)*	5	38	<1	39	

Table E. 7: Groundwater quality at Bore 6 as provided by TME

Analyte	26/10/2010	18/04/2011	21/10/2011	15/12/2011	18/10/2012
Total Alkalinity *(mg/L, LOR = 1)*	5	38	<1	39	
Aluminium *(mg/L, LOR = 0.01)*	20	146	2.84	30.4	
Arsenic *(mg/L, LOR = 0.001)*	<0.001	0.066	0.002	0.031	
Cadmium *(mg/L, LOR = 0.0001)*	<0.0001	<0.0010	<0.0001	<0.0001	
Chromium *(mg/L, LOR = 0.001)*	0.017	0.09	0.002	0.023	
Copper *(mg/L, LOR = 0.001)*	0.042	0.104	0.005	0.029	
Lead *(mg/L, LOR = 0.001)*	0.022	0.12	0.003	0.021	
Manganese *(mg/L, LOR = 0.001)*	0.047	0.088	0.031	0.044	
Zinc *(mg/L, LOR = 0.005)*	0.058	<0.052	0.018	0.033	
Iron *(mg/L, LOR = 0.05)*	21.6	114	3.47	31.2	
Ammonia *(mg/L, LOR = 0.01)*	0.11	0.25	0.05	0.11	
Nitrite *(mg/L, LOR = 0.01)*	0.01	<0.01	<0.01	<0.01	
Nitrate *(mg/L, LOR = 0.01)*	2.76	0.01	0.24	0.68	

Table E. 7: Groundwater quality at Bore 6 as provided by TME

Analyte	26/10/2010	18/04/2011	21/10/2011	15/12/2011	18/10/2012
NO_x *(mg/L, LOR = 0.01)*	2.77	0.01	0.24	0.68	
TKN *(mg/L, LOR = 0.1)*	3.5	9.2	1.2	4.2	
Total Nitrogen *(mg/L, LOR = 0.1)*	6.3	9.2	1.4	4.9	
Reactive P *(mg/L, LOR = 0.01)*	0.01	<0.01	1.64	0.05	
Total P *(mg/L, LOR = 0.01)*	1.69	0.79	2	4.6	

Table E. 8: Groundwater quality at Bore 7 as provided by TME

Analyte	26/10/2010	18/04/2011	21/10/2011	15/12/2011	18/10/2012
OH^- Alkalinity *(mg/L, LOR = 1)*	<1		<1	<1	<1
CO_3^{2-} Alkalinity *(mg/L, LOR = 1)*	<1		<1	<1	<1
HCO_3^- Alkalinity *(mg/L, LOR = 1)*	12		28	33	29
Total Alkalinity *(mg/L, LOR = 1)*	12		28	33	29
Aluminium *(mg/L, LOR = 0.01)*	23.8		15	11.7	
Arsenic *(mg/L, LOR = 0.001)*	<0.001		0.001	<0.001	

Table E. 8: Groundwater quality at Bore 7 as provided by TME

Analyte	26/10/2010	18/04/2011	21/10/2011	15/12/2011	18/10/2012
Cadmium *(mg/L, LOR = 0.0001)*	<0.0001		0.0001	<0.0001	
Chromium *(mg/L, LOR = 0.001)*	0.041		0.018	0.018	
Copper *(mg/L, LOR = 0.001)*	0.073		0.053	0.041	
Lead *(mg/L, LOR = 0.001)*	0.022		0.029	0.012	
Manganese *(mg/L, LOR = 0.001)*	0.075		0.074	0.032	
Zinc *(mg/L, LOR = 0.005)*	0.18		0.026	0.022	
Iron *(mg/L, LOR = 0.05)*	33.5		19.7	18.1	
Ammonia *(mg/L, LOR = 0.01)*	0.05		0.01	0.1	<0.01
Nitrite *(mg/L, LOR = 0.01)*	<0.01		<0.01	<0.01	<0.01
Nitrate *(mg/L, LOR = 0.01)*	0.13		<0.01	0.06	0.01
NO_x *(mg/L, LOR = 0.01)*	0.13		<0.01	0.06	0.01
TKN *(mg/L, LOR = 0.1)*	1.5		7.4	2.9	5.8
Total Nitrogen *(mg/L, LOR = 0.1)*	1.6		7.4	3	5.8

Table E. 8: Groundwater quality at Bore 7 as provided by TME

Analyte	26/10/2010	18/04/2011	21/10/2011	15/12/2011	18/10/2012
Reactive P *(mg/L, LOR = 0.01)*	0.01		<0.01	<0.01	<0.01
Total P *(mg/L, LOR = 0.01)*	0.31		0.56	0.24	0.85

Table E. 9: Groundwater quality at Bore 8 as provided by TME

Analyte	26/10/2010	18/04/2011	21/10/2011	15/12/2011	18/10/2012
OH^- Alkalinity *(mg/L, LOR = 1)*	<1		<1	<1	<1
CO_3^{2-} Alkalinity *(mg/L, LOR = 1)*	<1		<1	<1	<1
HCO_3^- Alkalinity *(mg/L, LOR = 1)*	59		<1	10	8
Total Alkalinity *(mg/L, LOR = 1)*	59		<1	10	8
Aluminium *(mg/L, LOR = 0.01)*	8.3		28.2	20.3	
Arsenic *(mg/L, LOR = 0.001)*	<0.001		0.001	<0.001	
Cadmium *(mg/L, LOR = 0.0001)*	<0.0001		<0.0001	<0.0001	
Chromium *(mg/L, LOR = 0.001)*	0.019		0.052	0.04	
Copper *(mg/L, LOR = 0.001)*	0.031		0.151	0.069	

Table E. 9: Groundwater quality at Bore 8 as provided by TME

Analyte	26/10/2010	18/04/2011	21/10/2011	15/12/2011	18/10/2012
Lead *(mg/L, LOR = 0.001)*	0.01		0.068	0.035	
Manganese *(mg/L, LOR = 0.001)*	0.205		0.075	0.044	
Zinc *(mg/L, LOR = 0.005)*	0.055		0.046	0.031	
Iron *(mg/L, LOR = 0.05)*	21.2		45.2	43.9	
Ammonia *(mg/L, LOR = 0.01)*	0.05		0.02	<0.05	0.01
Nitrite *(mg/L, LOR = 0.01)*	<0.01		<0.01	<0.01	<0.01
Nitrate *(mg/L, LOR = 0.01)*	0.02		<0.01	0.03	0.03
NO_x *(mg/L, LOR = 0.01)*	0.02		<0.01	0.03	0.03
TKN *(mg/L, LOR = 0.1)*	2.2		7.2	3.3	2.6
Total Nitrogen *(mg/L, LOR = 0.1)*	2.2		7.2	3.3	2.6
Reactive P *(mg/L, LOR = 0.01)*	<0.01		0.03	<0.01	<0.01
Total P *(mg/L, LOR = 0.01)*	0.52		1.06	0.55	0.22

Table E. 10: Groundwater quality at Bore 9 as provided by TME

Analyte	26/10/2010	18/04/2011	21/10/2011	15/12/2011	18/10/2012
OH^- Alkalinity *(mg/L, LOR = 1)*	<1	<1	<1	<1	Dry
CO_3^{2-} Alkalinity *(mg/L, LOR = 1)*	<1	<1	<1	<1	
HCO_3^- Alkalinity *(mg/L, LOR = 1)*	55	<1	<1	21	
Total Alkalinity *(mg/L, LOR = 1)*	55	<1	<1	21	
Aluminium *(mg/L, LOR = 0.01)*	11.6	31.8	23.3	20.2	
Arsenic *(mg/L, LOR = 0.001)*	<0.001	0.011	0.002	0.002	
Cadmium *(mg/L, LOR = 0.0001)*	<0.0001	0.0001	<0.0001	<0.0001	
Chromium *(mg/L, LOR = 0.001)*	0.018	0.06	0.022	0.021	
Copper *(mg/L, LOR = 0.001)*	0.056	0.125	0.084	0.051	
Lead *(mg/L, LOR = 0.001)*	0.019	0.073	0.025	0.014	
Manganese *(mg/L, LOR = 0.001)*	0.084	0.193	0.121	0.094	
Zinc *(mg/L, LOR = 0.005)*	0.033	0.061	0.018	0.033	
Iron *(mg/L, LOR = 0.05)*	22	169	37.4	34.6	

Table E. 10: Groundwater quality at Bore 9 as provided by TME

Analyte	26/10/2010	18/04/2011	21/10/2011	15/12/2011	18/10/2012
Ammonia *(mg/L, LOR = 0.01)*	0.11	<0.10	0.07	0.06	
Nitrite *(mg/L, LOR = 0.01)*	<0.01	<0.01	<0.01	<0.01	
Nitrate *(mg/L, LOR = 0.01)*	<0.01	0.03	<0.01	0.04	
NO_x *(mg/L, LOR = 0.01)*	<0.01	0.03	<0.01	0.04	
TKN *(mg/L, LOR = 0.1)*	4.3	29.8	11	3.9	
Total Nitrogen *(mg/L, LOR = 0.1)*	4.3	29.8	11	3.9	
Reactive P *(mg/L, LOR = 0.01)*	<0.01	<0.01	<0.01	<0.01	
Total P *(mg/L, LOR = 0.01)*	0.3	2.52	1.79	0.7	

Appendix F

Groundwater Monitoring Report

Town Planning Management Engineering

Groundwater Levels & Quality Monitoring Report

Lot 103 Harris Road & 96 Martin Pelusey Road, Picton East

Research, Design & Delivery of Sustainable Development

10334
March 2012

Project Management Planning Environmental Engineering

DOCUMENT QUALITY CONTROL

AUTHOR
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DATE
15.03.2012

CHECKED BY
Brendan Oversby

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2	Revisions for Client	02.04.2012

TME Town Planning Management Engineering Pty Ltd

PO BOX 733, BUNBURY

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EXECUTIVE SUMMARY

TME Town Planning Management Engineering Pty Ltd (TME) has prepared this report on behalf of Harris Road Pty Ltd for the proposed industrial development. The subject land consists of Lot 103 on Diagram 96575 Harris Road and Lot 603 on Plan 246179 (96) Martin Pelusey Road, Picton East (see *Figure 1*).

The subject land is located in an area that exhibits high groundwater levels, including Multiple Use wetlands. This necessitated the requirement for monitoring of the superficial groundwater level across the land as per advice provided by the Department of Water. The Department of Water also required monitoring of physical and chemical parameters of the groundwater on-site due to the risks involved with the industrial nature of the development, and the close proximity of the Ferguson River to the subject land.

TME monitored groundwater levels at 9 monitoring bore sites across the subject land with regular measurements between October 2010 and December 2011. Quarterly quality sampling was undertaken at all bores over a period of 14 months.

The rainfall from April to December 2011 was approximately within the 50th percentile or greater for the land. However May and July were lower, approximately 40th and 20th percentiles respectively. The total rainfall during this period was less than 10mm greater than the long term average total. This data suggest that 2011 was a representative year for the average rainfall at the subject land, which therefore suggests that the seasonal peak high groundwater levels measured would be close the average annual maximum groundwater level (AAMGL).

The quality sampling of the groundwater found that Total Nitrogen and Total Phosphorus levels on the subject land exceeded the ANZEEC and Department of Water Swan Coastal Plain trigger values. These results were however not unexpected given the past agricultural land uses. Iron and Aluminium also had high concentrations, however this is typical of the natural soils on the Swan Coastal Plain.

The subject land's high seasonal groundwater levels were modelled at less than 1 metre below the surface level across the majority of the subject land.

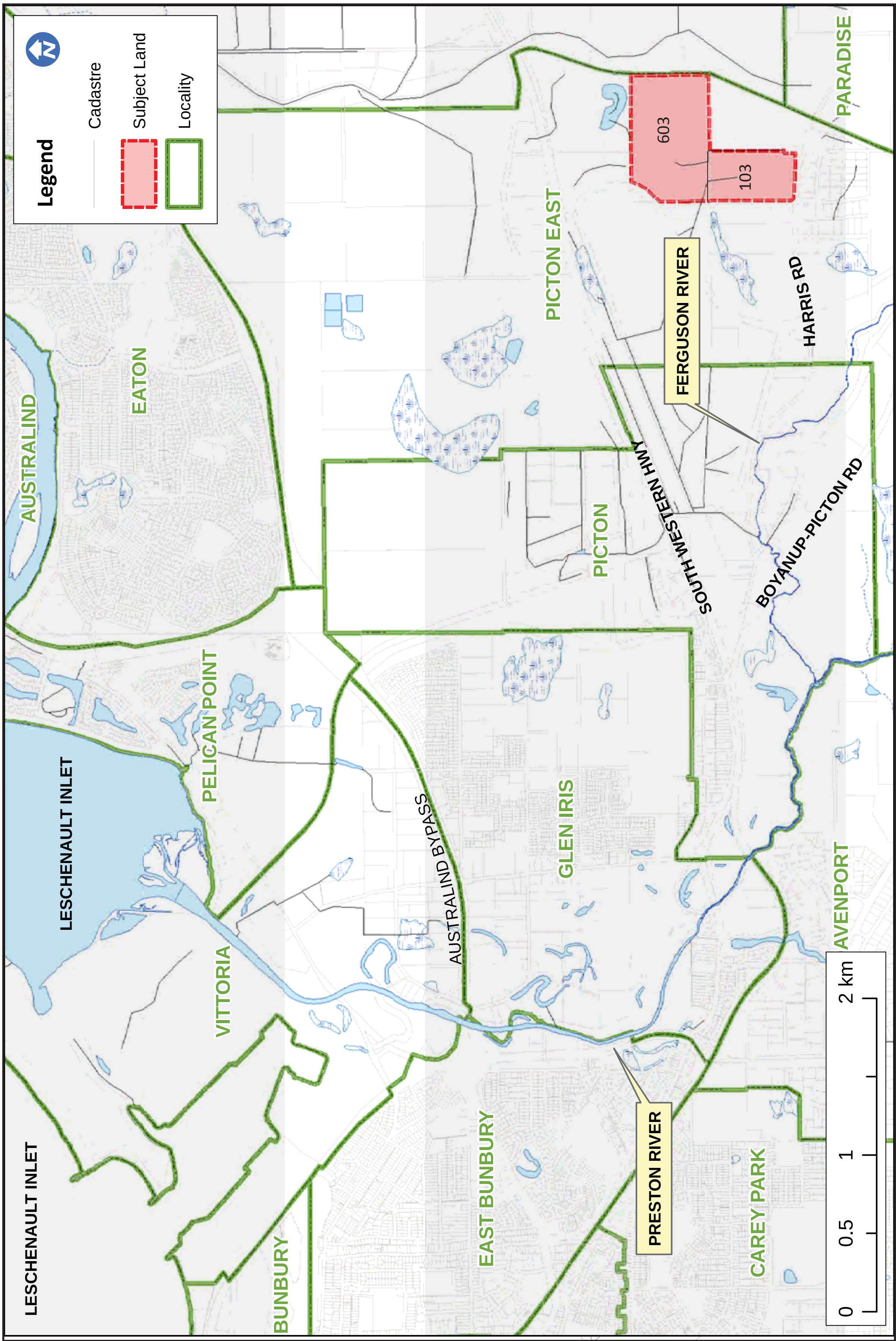


Figure 1 - Location Plan

METHODOLOGY

In September 2010 9 water table monitoring bores were installed on the subject land and TME verified their installation (see *Figure 2* for locations). Monitoring bores were constructed to an average depth of 3m below the natural surface level. PVC casing pipes with slots were placed within the holes and the bottom of the pipe was capped. The monitoring bores were finished with free draining sand backfill and a bentonite plug.

TME monitored groundwater levels from October 2010 to December 2011. A total of 12 measurements were taken for each monitoring bore site during this period of time. All measurements were undertaken on the same day for every monitoring bore.

To obtain the measurement of the groundwater's level, an electrical sounder groundwater probe was lowered into the pipe until it signalled that it had reached the water table. The depth was recorded, and in the office the pipe height above the surface level was subtracted from the recorded measurement to ascertain the depth to the groundwater from the ground's surface.

Groundwater quality samples were taken from each of monitoring bores on 4 separate occasions in October 2010, April, October and December 2011. Physical and chemical parameters of the groundwater were tested. The physical parameters were measured in the field, and samples were taken and submitted to ALS Laboratory Group (NATA Accredited) for chemical analysis.

The physical and chemical parameters sampled from each of the monitoring bores are listed below. The trigger values used for analysis are shown in *Appendix 2*.

Physical Parameters

- Temperature
- pH
- Conductivity
- Dissolved oxygen
- Oxidation reduction potential
- Salinity

Chemical Parameters

- Alkalinity
- Nitrate-N
- Nitrite-N
- Ammonia-N
- Total Kjeldahl Nitrogen (TKN)
- Total Nitrogen (TN)
- Total Phosphorus (TP)
- Reactive Phosphorus
- Metals (Aluminium, Arsenic, Cadmium, Chromium, Copper, Lead, Manganese, Zinc and Iron)

Figure 2 -Monitoring Program and Groundwater Contour Plan

RESULTS

LEVELS

The general trend observed in the groundwater records across all bores was an increase in depths to groundwater (i.e. a lower groundwater table) between September and April or May, and a decrease in depths to groundwater (i.e. a rising groundwater table) between April or May and September (see *Figure 3*).

The following table (*Table 1*) summarises the highest seasonal groundwater levels (HSGL) and lowest seasonal groundwater levels (LSGL) recorded and the months when recorded, also the seasonal range of groundwater levels is included. All records within this report's tables are relative to the distance (in millimetres) of the water below the natural surface level measured at each monitoring bore.

For full details of recordings for each monitoring bore site please refer to *Appendix 1*.

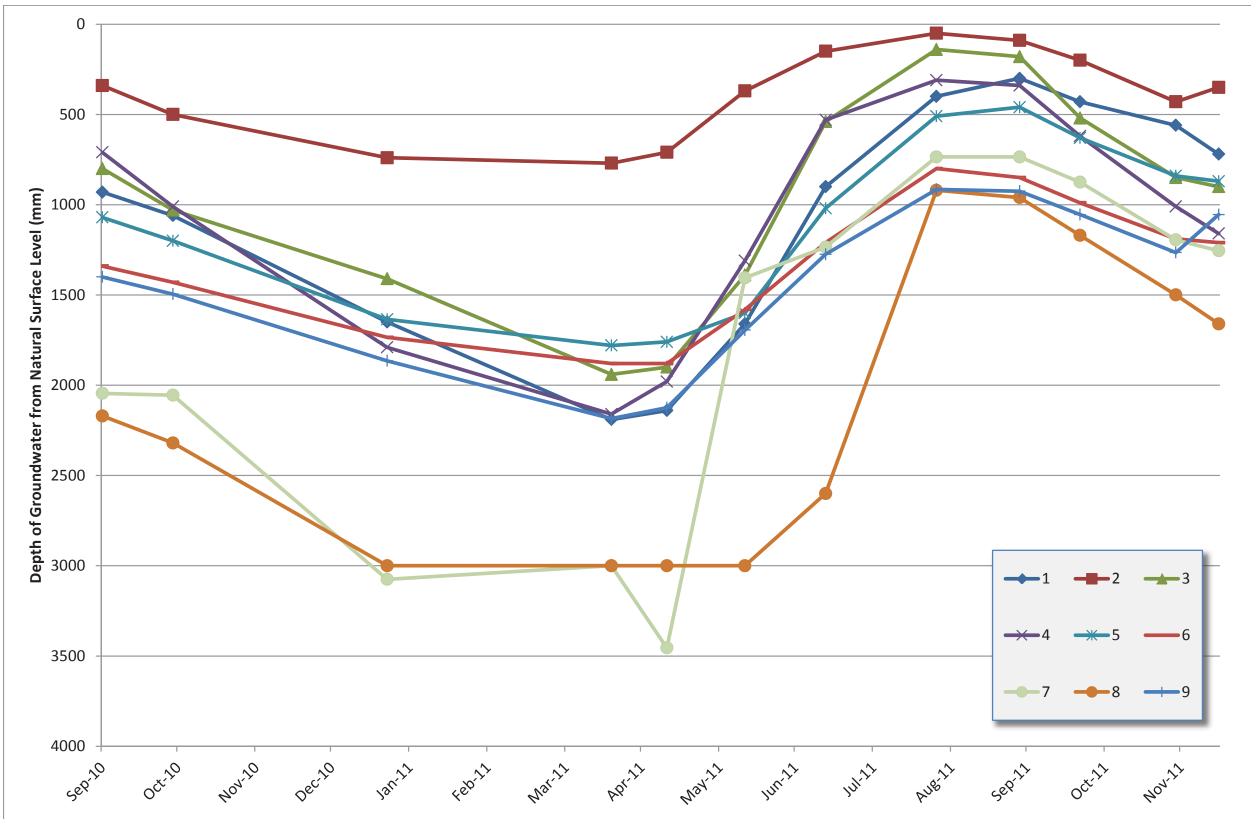


Figure 3 - Groundwater Hydrograph

Monitoring Bore No.	HSGL (mm)	Date(s) Recorded	LSGL (mm)	Date(s) Recorded	Range (mm)
1	300	Sep-11	2190	Apr-11	1890
2	50	Aug-11	770	Apr-11	720
3	140	Aug-11	1940	Apr-11	1800
4	310	Aug-11	2160	Apr-11	1850
5	460	Sep-11	1780	Apr-11	1320
6	80	Aug-11	1880	Apr to May-11	1080
7	735	Aug to Sep-11	DRY (>3000)	Apr-11	>2265
8	920	Aug-11	DRY (>3000)	Jan to Jun-11	>2080
9	915	Aug-11	2185	Apr-11	1270

Table 1 - Summary of Groundwater Levels Monitoring Results

The '>' recordings for the monitoring bores were made when no water was present within the bore's pipe when monitored. This meant that at the time of measurement, the groundwater level was lower than the base of the bore.

PHYSICAL PARAMETERS

The physical parameter results for the four sample runs for each monitoring bore are shown in *Appendix 3*. The sample records were compared to the Australian Drinking Water Guidelines (ADWG) and ANZEEC Guidelines for south Western Australia.

The pH across the site was generally low (slightly acidic) with pH results predominantly between 5.01 and 6.71, which is generally below the ANZEEC trigger value for surface waters in wetlands (7.0) and for the ADWG (aesthetic only) range of 6.5 to 8.

The dissolved oxygen saturated percentages were significantly less than the minimum value of 85%. These values however are based on surface water values, and are not an accurate in comparison to groundwater values, as there is minimal interaction to the atmosphere to oxygenate the water.

CHEMICAL PARAMETERS

Total Nitrogen (TN)

Each bore had at least one sample that exceeded the Swan Coastal Plain target value of 1.0mg/L. The concentrations ranged from 0.4 to 29.8mg/L. The majority of the nitrogen is comprised of Total Kjeldahl Nitrogen (TKN). Results are shown in *Table 2*.

Monitoring Bore	Total Nitrogen (mg/L)			
	26/10/2010	18/04/2011	21/10/2011	15/12/2011
1	0.6	1.2	8.0	4.8
2	5.0	4.4	2.4	3.0
3	6.8	4.5	3.9	2.5
4	0.8	0.4	4.2	1.3
5	6.5	1.5	3.0	1.6
6	6.3	9.2	1.4	4.9
7	1.6		7.4	3.0
8	2.2		7.2	3.3
9	4.3	29.8	11.0	3.9

Table 2 – Total Nitrogen Sample Results.

The yellow cell indicates that the value exceeds the Swan Coastal Plain trigger value (1.0mg/L), green cell indicates that the value exceeds the ANZEEC wetland river trigger value (1.5mg/L), and orange cell indicated the value exceeds the ANZEEC long-term irrigation trigger value (5.0mg/L).

Total Phosphorus (TP)

The sample results exceeded the Swan Coastal Plain target value of 0.1 mg/L for all runs at all bores, except for Bore 4's sample in April 2011. The TP ranged from 0.03 to 2.52mg/L. The results are shown in *Table 3*.

Monitoring Bore	Total Phosphorous (mg/L)			
	26/10/2010	18/04/2011	21/10/2011	15/12/2011
1	0.07	0.13	0.58	0.31
2	0.29	0.19	0.14	0.31
3	0.54	0.43	0.24	0.26
4	0.24	0.03	0.42	0.14
5	0.34	0.19	0.16	0.14
6	1.69	0.79	2.00	4.60
7	0.31		0.56	0.24
8	0.52		1.06	0.55
9	0.30	2.52	1.79	0.70

Table 3 – Total Phosphorus Sample Results.

The green cell indicates that the value exceeds the ANZEEC wetland river trigger value (0.06mg/L), and the yellow cell indicates that the value exceeds the Swan Coastal Plain trigger value (0.1mg/L).

Total Metals

From the results two metals are of note. Aluminium (Al) and Iron (Fe) regularly exceeded all trigger values (including short and long term irrigation). The maximum Aluminium recorded was at Bore 6, with a result of 146.0mg/L. This exceeds the short-term irrigation trigger value by 126mg/L. The lowest Aluminium record was 2.15mg/L at Bore 5, which is lower than the short-term (20mg/L) and long-term (5mg/L) irrigation trigger values

The other metal of note was Iron, with results regularly exceeding the short-term irrigation trigger value of 10mg/L. Bore 6 also recorded the highest Iron sample (146mg/L) in the same sampling period (18th April 2011), which is 136mg/L higher than the short-term irrigation trigger value. The lowest Iron record was 3.47mg/L at Bore 6 (6 months after recording the highest Iron value for the whole land).

The full results from the metal samples and remaining quality parameters tested are shown in *Appendix 4*.

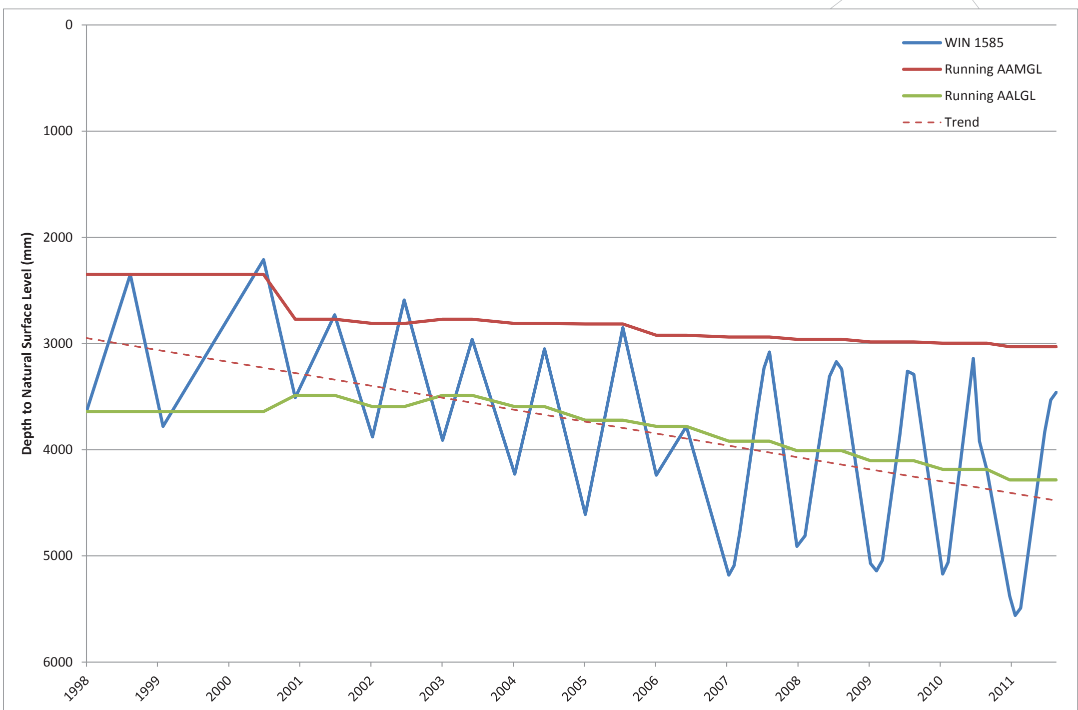


Figure 4 - DoW Bore (WIN 1585) Hydrograph

DISCUSSION

COMPARISON TO DEPARTMENT OF WATER MONITORING BORES

To ascertain the long-term water table patterns for the subject land a query of all the Department of Water (DoW) shallow groundwater monitoring bores within a 3km radius of the subject land was undertaken

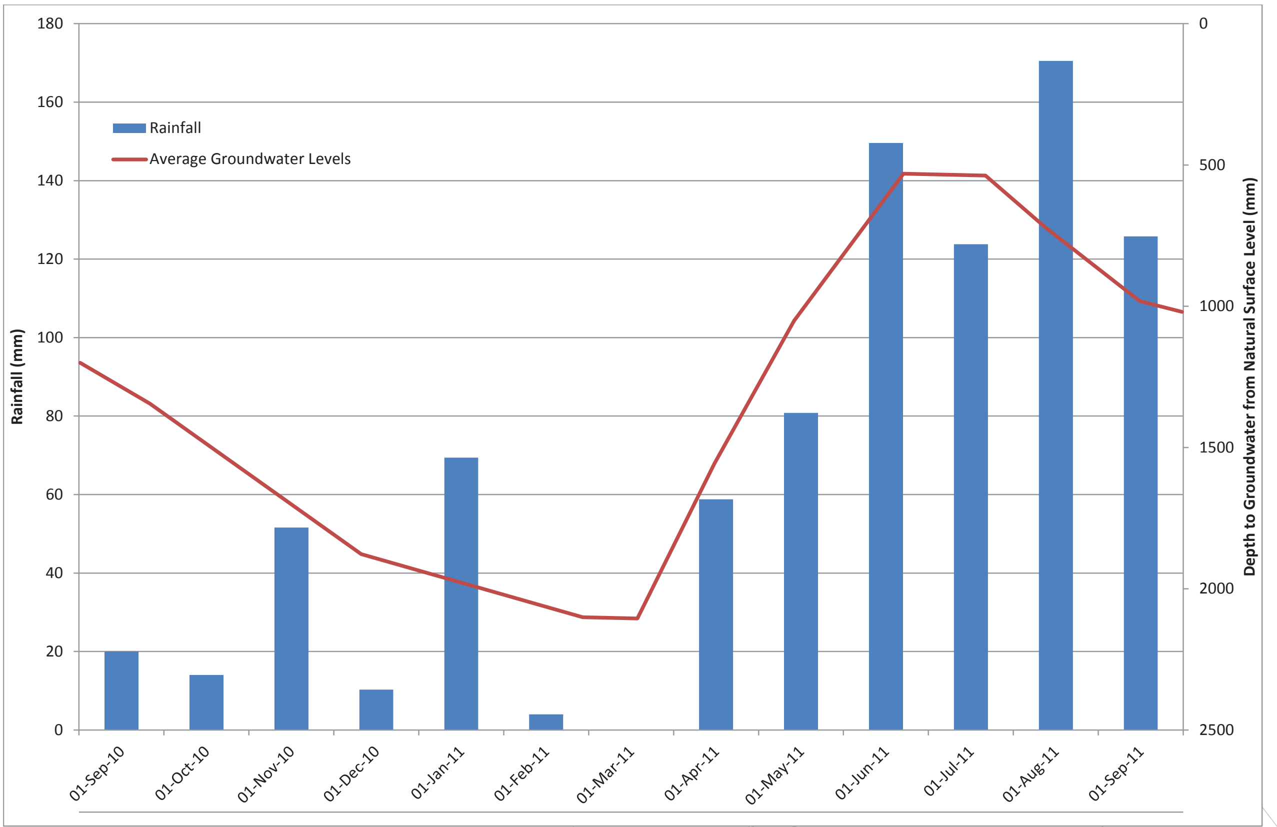


Figure 5 - Rainfall Hydrograph

by DoW on TME's behalf. Only one monitoring bores was determined to provide information considered marginally useful to compare with the subject land.

The monitoring bore shows a falling trend in the groundwater table since the commencement of records in 1998 (see *Figure 4*). The AAMGL at bore (WIN ID) 1585 has fallen over 650mm since 1998, and the 2011 highest peak level was 800mm deeper than the AAMGL in 2011. The AAMGL and average annual lowest groundwater level (AALGL) have steadily deepened since 1998.

The on-site drainage of surface water on the subject land, and the presence of groundwater at the surface across the majority suggest that comparisons with the DoW bore are not that useful. The DoW bore's AAMGL is around 3000mm below the natural ground surface, whilst the deepest seasonal high peak on the subject land was less than 1000mm below the natural surface. The majority of the bores were within 100mm of the surface. This suggests the DoW bore does not have a similar on-site drainage infrastructure or ponding of groundwater on the land as is evident at the subject land. The general trends observed in the DoW bore are the only real useful information available for comparison to the subject land.

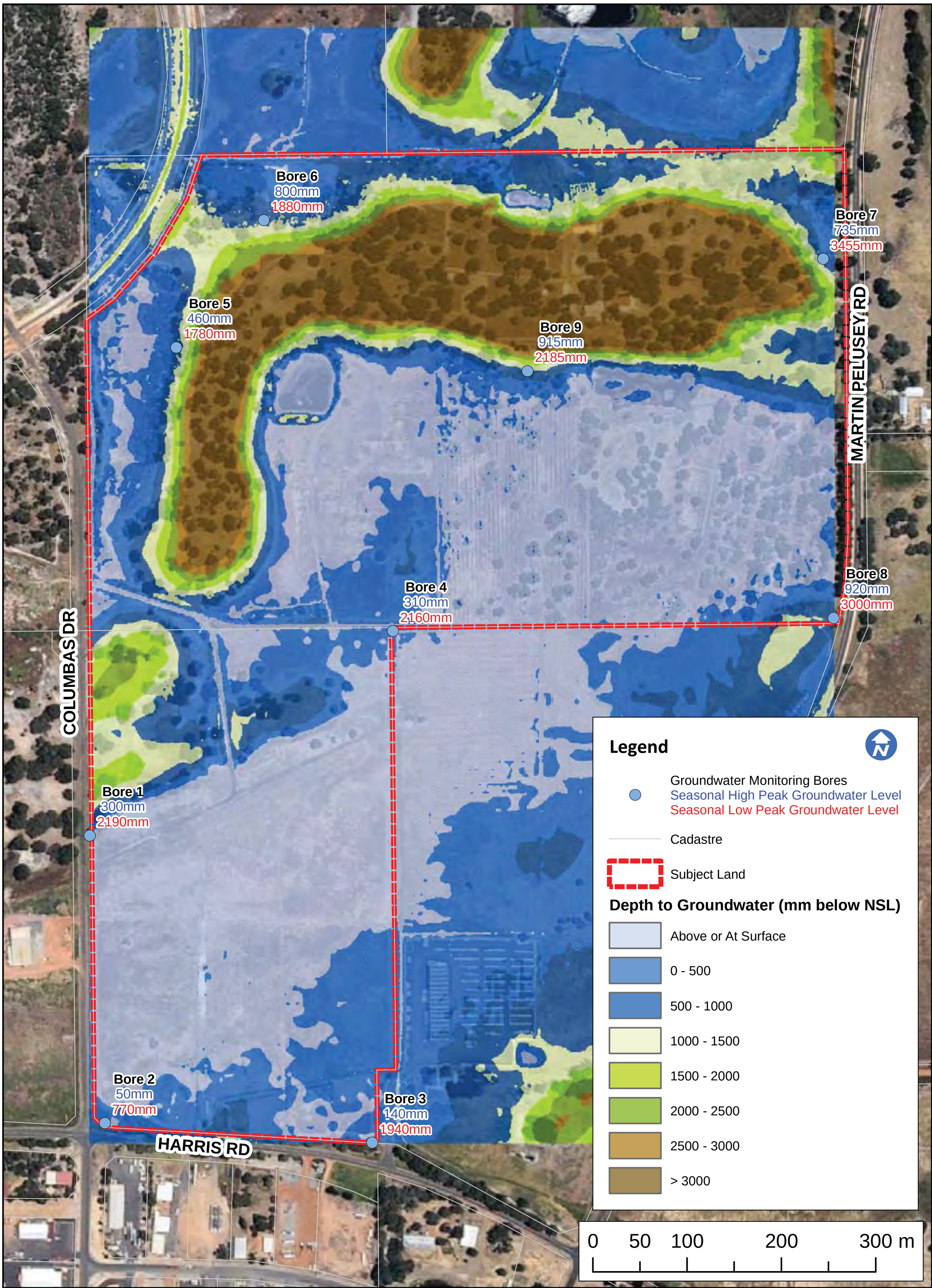


Figure 6 - Depth to Groundwater

COMPARISON TO RAINFALL PATTERNS

The graph in *Figure 5* visually depicts a relationship between rainfall events and the water table level. The groundwater levels rose closer to the surface as rainfall increased. This implies that rainfall may directly recharge the shallow groundwater table at the site, and that there is little influence on the shallow water table from flows outside of the site.

DEPTH TO AVERAGE ANNUAL MAXIMUM GROUNDWATER LEVELS (AAMGL)

The depth to the AAMGL across the subject land has been modelled in *Figure 6*. The depth to AAMGL for each bore was derived from modelling the groundwater contours for the site, and then subtracting the natural surface levels from these contours. There was no adjustment of the seasonal high peaks against the DoW bore because of the issues discussed in the last paragraph of the DoW comparison section, i.e. direct comparisons of the subject land and DoW bore were unrepresentative.

Figure 8 shows that the groundwater depth is very shallow (less than 1m below natural surface level) for the majority of the subject land (shades of blue). It would be expected that groundwater levels may be shallower than modelled for the maximum groundwater levels (MGL). The ridge in the north is clearly visible in the model by the dark brown shading. This represents areas where the groundwater is greater than 3m below the natural surface level.

QUALITY

The high values of TN and TP within the groundwater were not unexpected given the past land use and presence of wetlands on the subject land. Sources of TN would include plant decay, animal wastes (especially from previous livestock grazing) and the use of fertilisers. The TP sources would primarily be from the agricultural practices on the land. Phosphorus and nitrogen in high concentrations (as recorded on the subject land) indicate the potential for algal growth and blooms in receiving water bodies, including the surrounding wetlands. The removal of stock and reduction of fertilisers on the land could assist in reducing TN and TP concentrations.

The sands on the Swan Coastal Plain are coated with both iron and aluminium oxides, and are the reason for the high concentrations of Aluminium and Iron recorded on the site. The high Iron and Aluminium concentrations in the groundwater may also suggest that these metals are coating the sand grains, which may increase the sands capacity to retain phosphorus. The Iron and Aluminium concentrations at each bore did at one stage exceed the guidelines for short and long term irrigation uses.

CONCLUSION

The results of this monitoring program should be utilised in any future studies and/or designs that require site specific information regarding groundwater levels (especially seasonal highs) and quality data. The results from 2011 provide a representative seasonal high level to model an maximum groundwater level for the subject land, which can be used for detailed designs.

APPENDICES

Appendix 1 - Field Sheet Level Measurements

Appendix 2 - Trigger Values for Water Quality

Appendix 3 - Quality (Physical Parameters) Results

Appendix 4 - Complete Quality Results

Appendix 5 - Enclosed CD

Certificate of Analysis

Raw Results

APPENDIX 1

Field Sheet Level Measurements

TME Groundwater Monitoring Program - Field Sheets

Project Name: Harris Road Groundwater Monitoring
Client: Harris Road Pty Ltd
Job No: 10334

Bore Number: **1**
Eastings: 381439.00 *Northings:* 6308872.00
Height of TOC above Surface Level (mm): 480

Date	Depth to Water (mm)	Groundwater Level (mm)	Comments
28/09/2010	1410	930	
26/10/2010	1540	1060	
19/01/2011	2130	1650	
18/04/2011	2670	2190	
10/05/2011	2620	2140	
10/06/2011	2140	1660	
12/07/2011	1380	900	
25/08/2011	880	400	
27/09/2011	780	300	
21/10/2011	910	430	
28/11/2011	1040	560	
15/12/2011	1200	720	

Bore Number: **2**
Eastings: 381455.00 *Northings:* 6308567.00
Height of TOC above Surface Level (mm): 530

Date	Depth to Water (mm)	Groundwater Level (mm)	Comments
28/09/2010	870	340	
26/10/2010	1030	500	
19/01/2011	1270	740	
18/04/2011	1300	770	
10/05/2011	1240	710	
10/06/2011	900	370	
12/07/2011	680	150	
25/08/2011	580	50	
27/09/2011	620	90	
21/10/2011	730	200	
28/11/2011	960	430	
15/12/2011	880	350	

Project Name: Harris Road Groundwater Monitoring
Client: Harris Road Pty Ltd
Job No: 10334

Bore Number: **3**
Eastings: 381739.00 *Northings:* 6308546.00
Height of TOC above Surface Level (mm): 440

Date	Depth to Water (mm)	Groundwater Level (mm)	Comments
28/09/2010	1240	800	
26/10/2010	1470	1030	
19/01/2011	1850	1410	
18/04/2011	2380	1940	
10/05/2011	2340	1900	
10/06/2011	1830	1390	
12/07/2011	980	540	
25/08/2011	580	140	
27/09/2011	620	180	
21/10/2011	960	520	
28/11/2011	1290	850	
15/12/2011	1340	900	

Bore Number: **4**
Eastings: 381761.00 *Northings:* 6309089.00
Height of TOC above Surface Level (mm): 450

Date	Depth to Water (mm)	Groundwater Level (mm)	Comments
28/09/2010	1160	710	
26/10/2010	1460	1010	
19/01/2011	2240	1790	
18/04/2011	2610	2160	
10/05/2011	2430	1980	
10/06/2011	1760	1310	
12/07/2011	980	530	
25/08/2011	760	310	
27/09/2011	790	340	
21/10/2011	1070	620	
28/11/2011	1460	1010	
15/12/2011	1610	1160	

Project Name: Harris Road Groundwater Monitoring
Client: Harris Road Pty Ltd
Job No: 10334

Bore Number: **5**
Eastings: 381531.00 *Northings:* 6309390.00
Height of TOC above Surface Level (mm): 460

Date	Depth to Water (mm)	Groundwater Level (mm)	Comments
28/09/2010	1530	1070	
26/10/2010	1660	1200	
19/01/2011	2095	1635	
18/04/2011	2240	1780	
10/05/2011	2220	1760	
10/06/2011	2060	1600	
12/07/2011	1480	1020	
25/08/2011	970	510	
27/09/2011	920	460	
21/10/2011	1090	630	
28/11/2011	1300	840	
15/12/2011	1330	870	

Bore Number: **6**
Eastings: 381624.00 *Northings:* 6309525.00
Height of TOC above Surface Level (mm): 480

Date	Depth to Water (mm)	Groundwater Level (mm)	Comments
28/09/2010	1820	1340	
26/10/2010	1910	1430	
19/01/2011	2215	1735	
18/04/2011	2360	1880	
10/05/2011	2360	1880	
10/06/2011	2060	1580	
12/07/2011	1690	1210	
25/08/2011	1280	800	
27/09/2011	1330	850	
21/10/2011	1470	990	
28/11/2011	1670	1190	
15/12/2011	1690	1210	

Project Name: Harris Road Groundwater Monitoring
Client: Harris Road Pty Ltd
Job No: 10334

Bore Number: **7**
Eastings: 382218.00 *Northings:* 6309484.00
Height of TOC above Surface Level (mm): 495

Date	Depth to Water (mm)	Groundwater Level (mm)	Comments
28/09/2010	2540	2045	
26/10/2010	2550	2055	
19/01/2011	3570	3075	
18/04/2011	NA	DRY	No water encountered
10/05/2011	3950	3455	
10/06/2011	1900	1405	
12/07/2011	1730	1235	
25/08/2011	1230	735	
27/09/2011	1230	735	
21/10/2011	1370	875	
28/11/2011	1690	1195	
15/12/2011	1750	1255	

Bore Number: **8**
Eastings: 382229.00 *Northings:* 6309103.00
Height of TOC above Surface Level (mm): 520

Date	Depth to Water (mm)	Groundwater Level (mm)	Comments
28/09/2010	2690	2170	
26/10/2010	2840	2320	
19/01/2011	NA	DRY	No water encountered
18/04/2011	NA	DRY	No water encountered
10/05/2011	NA	DRY	No water encountered
10/06/2011	NA	DRY	No water encountered
12/07/2011	3120	2600	
25/08/2011	1440	920	
27/09/2011	1480	960	
21/10/2011	1690	1170	
28/11/2011	2020	1500	
15/12/2011	2180	1660	

Project Name: Harris Road Groundwater Monitoring
Client: Harris Road Pty Ltd
Job No: 10334

Bore Number: **9**
Eastings: 381904.00 *Northings:* 6309365.00
Height of TOC above Surface Level (mm): 525

Date	Depth to Water (mm)	Groundwater Level (mm)	Comments
28/09/2010	1925	1400	
26/10/2010	2020	1495	
19/01/2011	2390	1865	
18/04/2011	2710	2185	
10/05/2011	2650	2125	
10/06/2011	2220	1695	
12/07/2011	1800	1275	
25/08/2011	1440	915	
27/09/2011	1450	925	
21/10/2011	1580	1055	
28/11/2011	1790	1265	
15/12/2011	1580	1055	

APPENDIX 2

Trigger Values for Water Quality

	ADWG (2004)		ANZEEC (2000)	DoH (2006)	Swan Coastal Plain	ANZEEC (2000)	
	Health	Aesthetic	Wetland	Non-Pot Gwater Use	WQIP	Long Term Irrigation	Short Term Irrigation
TP	-	-	0.06	-	0.1	-	-
FRP	-	-	0.03	-	-	-	-
TN	-	-	1.5	-	1	5	-
NO_x	-	-	0.1	-	-	-	-
Amonia (NH_3)	-	*0.5*	0.9	5	-	-	-
Nitrate	50	-	0.7	500	-	-	-
Nitrite	3	-	-	30	-	-	-
Ammonium (NH_4)	-	-	0.04	5	-	-	-
DO% (Sat)	-	*85*	90 120	-	-	-	-
pH	-	*6.5 8*	7 8.5	-	-	6 8.5	-
SPC (mS/cm)	-	-	0.3 1.5	-	-	-	-
Sulfate (SO_4)	500	*250*	-	5000	-	-	-
Chloride	-	*250*	-	2500	-	-	-
Aluminium	-	*0.2*	0.055	2	-	5	20
Arsenic	0.007	-	0.024	0.07	-	0.1	2
Cadmium	0.002	-	0.00002	0.02	-	0.01	0.05
Chromium	0.05	-	-	0.5	-	0.1	1
Copper	2	*1*	0.0014	20	-	0.2	5
Iron	-	*0.3*	-	3	-	0.2	10
Lead	0.001	-	0.0014	0.1	-	2	5
Manganese	0.5	*0.1*	1.9	5	-	0.2	10
Mercury (total)	0.001	-	0.0006	0.01	-	0.002	0.002
Nickel	0.02	-	0.011	0.2	-	0.2	2
Selenium (total)	0.01	-	0.011	0.1	-	0.02	0.05
Zinc	-	*3*	0.008	30	-	2	5

APPENDIX 3

Quality (Physical Parameters) Results

	Bore 1				Bore 2				Bore 3			
	26/10/2010	18/04/2011	21/10/2011	15/12/2011	26/10/2010	18/04/2011	21/10/2011	15/12/2011	26/10/2010	18/04/2011	21/10/2011	15/12/2011
Temperature *(˚C)*	16.5	21.2	17.2	18.1	17.8	23.2	17.1	19.0	17.7	22.0	17.5	18.3
Conductivity SPC *(mS/cm)*	2.3140	2.0100	0.4200	2.1200	0.4221	0.4220	0.6700	1.5920	1.6290	3.0800	2.4000	3.3380
Dissolved Oxygen *(ppm)*	1.38	0.03	0.28	0.13	2.06	0.05	0.01	0.00	2.08	0.09	0.00	0.02
pH *(scale)*	6.07	5.86	5.42	5.94	6.71	6.41	6.30	5.90	6.64	6.00	6.22	6.24
Salinity *(ppt)*		1.11	0.20	1.09		0.21	0.33	0.81		1.71	1.24	1.76
Diss. Oxygen % *(Saturated)*	14.5	0.4	3.0	1.3	21.3	0.6	0.1	0.0	21.2	1.0	-0.2	0.2
ORP *(mV)*	24.8	-74.7	57.2	-186.5	-25.2	-156.6	-100.0	-150.5	103.2	58.0	54.0	-104.2

Table A

The green fill shown in the tables denotes the variable was outside of the ANZEEC trigger value ranges for a wetland. However both these trigger values are based on surface water in wetlands and not groundwater in particular. The light green fill denotes the variable was less than the ADWG (aesthetic only) trigger value.

	Bore 4				Bore 5				Bore 6			
	26/10/2010	18/04/2011	21/10/2011	15/12/2011	26/10/2010	18/04/2011	21/10/2011	15/12/2011	26/10/2010	18/04/2011	21/10/2011	15/12/2011
Temperature *(˚C)*	18.0	23.1	18.2	19.4	16.7	19.8	16.9	18.6	18.4	24.2	18.1	19.3
Conductivity SPC *(mS/cm)*	2.9020	1.7500	2.2200	2.5260	0.5210	0.5600	0.5700	0.6300	0.7040	0.9600	0.4200	0.9070
Dissolved Oxygen *(ppm)*	2.48	0.19	0.03	0.15	1.37	0.07	0.02	0.01	1.43	0.01	0.00	0.00
pH *(scale)*	6.52	6.03	6.46	6.00	6.17	5.95	5.88	5.78	6.52	6.18	5.31	6.18
Salinity *(ppt)*		0.92	1.14	1.31		0.30	0.29	0.31		0.49	0.20	0.45
Diss. Oxygen % *(Saturated)*	26.3	2.2	0.3	1.6	13.5	0.9	0.4	0.1	16.2	0.2	-0.4	0.0
ORP *(mV)*	125.5	-119.1	43.8	0.9	14.2	-141.4	-25.5	-96.6	22.2	-209.7	84.7	-124.0

Table B

	Bore 7				Bore 8				Bore 9			
	26/10/2010	18/04/2011	21/10/2011	15/12/2011	26/10/2010	18/04/2011	21/10/2011	15/12/2011	26/10/2010	18/04/2011	21/10/2011	15/12/2011
Temperature *(˚C)*	17.1		18.0	18.6	18.1		18.1	19.0	17.5	20.8	17.7	18.3
Conductivity SPC *(mS/cm)*	1.5690		5.0200	1.2100	3.1210		0.1700	0.2420	1.0140	1.9000	1.2500	1.1270
Dissolved Oxygen *(ppm)*	2.60		0.08	0.12	1.60		2.24	0.42	3.34	0.68	0.09	0.01
pH *(scale)*	5.82		5.56	6.32	5.87		5.46	5.01	6.32	5.16	5.04	5.43
Salinity *(ppt)*			0.24	0.60			0.08	0.12		1.06	0.63	0.56
Diss. Oxygen % *(Saturated)*	28.0		0.9	1.3	16.2		23.8	4.3	35.1	7.7	1.0	0.1
ORP *(mV)*	148.7		55.2	-187.2	60.5		79.9	-2.1	72.7	127.3	99.6	-14.5

Table C

APPENDIX 4

Complete Quality Results

	Bore 1				Bore 2				Bore 3			
	26/10/2010	18/04/2011	21/10/2011	15/12/2011	26/10/2010	18/04/2011	21/10/2011	15/12/2011	26/10/2010	18/04/2011	21/10/2011	15/12/2011
OH^- Alkalinity *(mg/L, LOR = 1)*	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
CO_3^{2-} Alkalinity *(mg/L, LOR = 1)*	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
HCO_3^- Alkalinity *(mg/L, LOR = 1)*	34	13	7	7	87	66	151	71	151	96	<1	163
Total Alkalinity *(mg/L, LOR = 1)*	34	13	7	7	87	66	151	71	151	96	<1	163
Aluminium *(mg/L, LOR = 0.01)*	2.20	5.71	21.90	10.40	25.60	23.80	5.09	9.77	29.20	42.00	22.10	27.80
Arsenic *(mg/L, LOR = 0.001)*	<0.001	<0.001	0.001	0.001	<0.001	0.002	0.001	0.002	<0.001	0.002	0.001	<0.001
Cadmium *(mg/L, LOR = 0.0001)*	<0.0001	0.0001	0.0002	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium *(mg/L, LOR = 0.001)*	0.003	0.01	0.021	0.015	0.049	0.01	0.008	0.018	0.049	0.06	0.037	0.042
Copper *(mg/L, LOR = 0.001)*	0.008	0.033	0.042	0.038	0.056	0.060	0.009	0.019	0.026	0.037	0.022	0.025
Lead *(mg/L, LOR = 0.001)*	0.002	0.012	0.036	0.012	0.050	0.057	0.008	0.018	0.018	0.026	0.019	0.019
Manganese *(mg/L, LOR = 0.001)*	0.074	0.029	0.043	0.023	0.057	0.036	0.252	0.050	*0.132*	0.268	0.087	*0.176*
Zinc *(mg/L, LOR = 0.005)*	0.030	0.081	0.096	0.062	0.030	0.050	0.025	0.023	0.050	0.041	0.021	0.050
Iron *(mg/L, LOR = 0.05)*	6.92	6.48	19.50	8.43	43.60	42.40	15.40	20.50	16.90	20.80	14.00	15.00
Ammonia *(mg/L, LOR = 0.01)*	0.22	0.11	0.04	<0.05	1.07	2.13	0.42	1.12	0.01	0.04	0.07	<0.05
Nitrite *(mg/L, LOR = 0.01)*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.05	<0.01
Nitrate *(mg/L, LOR = 0.01)*	<0.01	<0.01	<0.01	0.04	0.01	0.01	<0.01	0.04	0.59	0.02	0.42	0.02
NO_x *(mg/L, LOR = 0.01)*	<0.01	<0.01	<0.01	0.04	0.01	0.01	<0.01	0.04	0.59	0.02	0.47	0.02
TKN *(mg/L, LOR = 0.1)*	0.6	1.2	8.0	4.8	5.0	4.4	2.4	3.0	6.2	4.5	3.4	2.5
Total Nitrogen *(mg/L, LOR = 0.1)*	0.6	1.2	8.0	4.8	5.0	4.4	2.4	3.0	6.8	4.5	3.9	2.5
Reactive P *(mg/L, LOR = 0.01)*	<0.01	<0.01	0.02	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01
Total P *(mg/L, LOR = 0.01)*	0.07	0.13	0.58	0.31	0.29	0.19	0.14	0.31	0.54	0.43	0.24	0.26

Table D

Refer to Quality Trigger Values Key

ADWG (2004)		ANZEEC (2000)	DoH (2006)	Swan Coastal Plain	ANZEEC (2000)	
Health	Aesthetic	Wetland	Non-Pot Gwater Use	WQIP	Long Term Irrigation	Short Term Irrigation

	Bore 4				Bore 5				Bore 6			
	26/10/2010	18/04/2011	21/10/2011	15/12/2011	26/10/2010	18/04/2011	21/10/2011	15/12/2011	26/10/2010	18/04/2011	21/10/2011	15/12/2011
OH^- Alkalinity *(mg/L, LOR = 1)*	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
CO_3^{2-} Alkalinity *(mg/L, LOR = 1)*	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
HCO_3^- Alkalinity *(mg/L, LOR = 1)*	60	61	85	68	31	37	<1	38	5	38	<1	39
Total Alkalinity *(mg/L, LOR = 1)*	60	61	85	68	31	37	<1	38	5	38	<1	39
Aluminium *(mg/L, LOR = 0.01)*	4.56	8.80	16.50	11.80	15.50	11.50	2.15	3.28	20.00	146.00	2.84	30.40
Arsenic *(mg/L, LOR = 0.001)*	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	<0.001	0.001	<0.001	0.066	0.002	0.031
Cadmium *(mg/L, LOR = 0.0001)*	<0.0001	<0.0001	<0.0001	<0.0001	0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0010	<0.0001	<0.0001
Chromium *(mg/L, LOR = 0.001)*	0.013	0.02	0.032	0.024	0.017	0.01	0.002	0.003	0.017	0.09	0.002	0.023
Copper *(mg/L, LOR = 0.001)*	0.014	0.025	0.071	0.055	0.034	0.036	0.010	0.007	0.042	0.104	0.005	0.029
Lead *(mg/L, LOR = 0.001)*	0.007	0.011	0.022	0.012	0.029	0.024	0.007	0.006	0.022	0.120	0.003	0.021
Manganese *(mg/L, LOR = 0.001)*	0.086	0.043	*0.119*	0.041	0.094	0.055	0.063	0.061	0.047	0.088	0.031	0.044
Zinc *(mg/L, LOR = 0.005)*	0.028	0.051	0.067	0.038	0.049	0.044	0.016	0.012	0.058	<0.052	0.018	0.033
Iron *(mg/L, LOR = 0.05)*	10.90	17.30	23.60	19.40	25.70	17.40	30.50	37.80	21.60	114.00	3.47	31.20
Ammonia *(mg/L, LOR = 0.01)*	0.03	0.03	0.06	<0.05	0.21	0.23	0.07	0.06	0.11	0.25	0.05	0.11
Nitrite *(mg/L, LOR = 0.01)*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01
Nitrate *(mg/L, LOR = 0.01)*	0.17	0.03	<0.01	0.08	0.05	<0.01	<0.01	0.06	2.76	0.01	0.24	0.68
NO_x *(mg/L, LOR = 0.01)*	0.17	0.03	<0.01	0.08	0.05	<0.01	<0.01	0.06	2.77	0.01	0.24	0.68
TKN *(mg/L, LOR = 0.1)*	0.6	0.4	4.2	1.2	6.4	1.5	3.0	1.5	3.5	9.2	1.2	4.2
Total Nitrogen *(mg/L, LOR = 0.1)*	0.8	0.4	4.2	1.3	6.5	1.5	3.0	1.6	6.3	9.2	1.4	4.9
Reactive P *(mg/L, LOR = 0.01)*	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	1.64	0.05
Total P *(mg/L, LOR = 0.01)*	0.24	0.03	0.42	0.14	0.34	0.19	0.16	0.14	1.69	0.79	2.00	4.60

Table E

	Bore 7				Bore 8				Bore 9			
	26/10/2010	18/04/2011	21/10/2011	15/12/2011	26/10/2010	18/04/2011	21/10/2011	15/12/2011	26/10/2010	18/04/2011	21/10/2011	15/12/2011
OH^- Alkalinity *(mg/L, LOR = 1)*	<1		<1	<1	<1		<1	<1	<1	<1	<1	<1
CO_3^{2-} Alkalinity *(mg/L, LOR = 1)*	<1		<1	<1	<1		<1	<1	<1	<1	<1	<1
HCO_3^- Alkalinity *(mg/L, LOR = 1)*	12		28	33	59		<1	10	55	<1	<1	21
Total Alkalinity *(mg/L, LOR = 1)*	12		28	33	59		<1	10	55	<1	<1	21
Aluminium *(mg/L, LOR = 0.01)*	23.80		15.00	11.70	8.30		28.20	20.30	11.60	31.80	23.30	20.20
Arsenic *(mg/L, LOR = 0.001)*	<0.001		0.001	<0.001	<0.001		0.001	<0.001	<0.001	0.011	0.002	0.002
Cadmium *(mg/L, LOR = 0.0001)*	<0.0001		0.0001	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001	0.0001	<0.0001	<0.0001
Chromium *(mg/L, LOR = 0.001)*	0.041		0.018	0.018	0.019		0.052	0.040	0.018	0.06	0.022	0.021
Copper *(mg/L, LOR = 0.001)*	0.073		0.053	0.041	0.031		0.151	0.069	0.056	0.125	0.084	0.051
Lead *(mg/L, LOR = 0.001)*	0.022		0.029	0.012	0.010		0.068	0.035	0.019	0.073	0.025	0.014
Manganese *(mg/L, LOR = 0.001)*	0.075		0.074	0.032	0.205		0.075	0.044	0.084	*0.193*	*0.121*	0.094
Zinc *(mg/L, LOR = 0.005)*	0.180		0.026	0.022	0.055		0.046	0.031	0.033	0.061	0.018	0.033
Iron *(mg/L, LOR = 0.05)*	33.50		19.70	18.10	21.20		45.20	43.90	22.00	169.00	37.40	34.60
Ammonia *(mg/L, LOR = 0.01)*	0.05		0.01	0.10	0.05		0.02	<0.05	0.11	<0.10	0.07	0.06
Nitrite *(mg/L, LOR = 0.01)*	<0.01		<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate *(mg/L, LOR = 0.01)*	0.13		<0.01	0.06	0.02		<0.01	0.03	<0.01	0.03	<0.01	0.04
NO_x *(mg/L, LOR = 0.01)*	0.13		<0.01	0.06	0.02		<0.01	0.03	<0.01	0.03	<0.01	0.04
TKN *(mg/L, LOR = 0.1)*	1.5		7.4	2.9	2.2		7.2	3.3	4.3	29.8	11.0	3.9
Total Nitrogen *(mg/L, LOR = 0.1)*	1.6		7.4	3.0	2.2		7.2	3.3	4.3	29.8	11.0	3.9
Reactive P *(mg/L, LOR = 0.01)*	0.01		<0.01	<0.01	<0.01		0.03	<0.01	<0.01	<0.01	<0.01	<0.01
Total P *(mg/L, LOR = 0.01)*	0.31		0.56	0.24	0.52		1.06	0.55	0.30	2.52	1.79	0.70

Table F

APPENDIX 5

C.D OF ATTACHMENTS:

CERTIFICATE OF ANALYSIS

RAW RESULTS

Appendix G

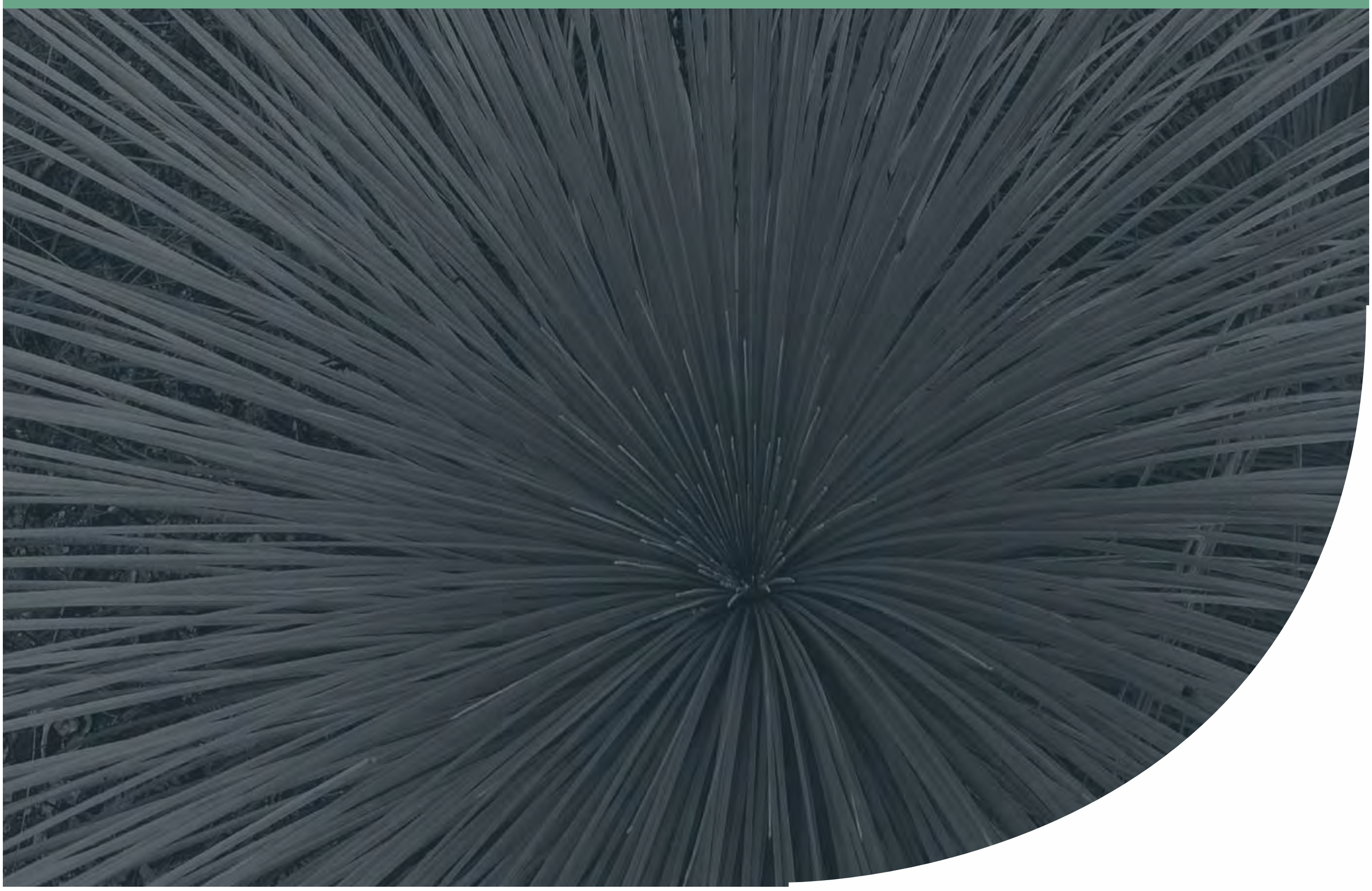
Modelling Assumptions Report

Modelling Assumptions Report

Local Structure Plan, Lots 103, 110 and 603, Picton East

Project No: EP12-039(01)

Prepared for Harris Road Pty Ltd
November 2019



Document Control

Doc name:	**Modelling Assumptions Report Local Structure Plan, Lots 103, 110 and 603, Picton East**				
Doc no.:	**EP12-039(01)--014 HB**				
Version	**Date**	**Author**		**Reviewer**	
1	November 2019	Hannah Badrzadeh	HB	Aisha Chalmers	ASC
				David Coremans	DPC
	Appendix for LWMS				

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Abbreviation Tables

Table A1: Abbreviations – General terms

General terms	
AEP	Annual exceedance probability
ARI	Average recurrence interval
DWMS	District water management strategy
LDA	Lot detention area
ROS	Regional open space
Ct	Catchment

Table A2: Abbreviations – units of measurement

Units of measurement	
ha	Hectare
m	Metre
m AHD	Metres Australian height datum
m/day	Metres per day
mm	Millimetre
n	Manning's n
%	Percentage

1 Modelling Assumptions

In order to assess the surface water runoff volumes and peak flows within the Lots 103, 110 and 603, Picton East (the site), a 1D model has been developed using XPSTORM hydrologic and hydraulic modelling software (v19.1).

The hydrologic component of the software uses the Laurenson non-linear runoff-routing method to simulate runoff from design storm events. Key assumptions regarding the hydrologic model include:

- Runoff is proportional to slope, area, infiltration and percentage of imperviousness of a catchment.
- Sub-catchment areas and slopes are determined from surveyed topographical data and earthworks plans.
- Infiltration rates and percentage imperviousness have been selected based on experience with model preparation for similar soil conditions.

Runoff from each sub-catchment is routed through the catchment using the hydraulic component of XPSTORM. Assumptions associated with the hydraulic component of the model include:

- Virtual links (i.e. purely for model construction, not equivalent to flow paths onsite) between nodes within a sub-catchment are given the length of 10 m and slope of approximately 0.05 to minimise the lag time of conveying the water from a sub-catchment node to a ‘storage’ node, a ‘dummy intermediate’ node or a conduit/link.
- Links between sub-catchment storages act as conveyance channels (e.g. sheet flow within roads in a 1% annual exceedance probability (AEP)). These links are given lengths and slopes that are representative of the site conditions and actual pathway lengths between catchments.
- Virtual links are designed with a width of 5 m, roughness of 0.014 (Manning’s n) and are trapezoidal in shape. This allows for easy conveyance and represents concrete pipes and road surfaces within the model.
- Conveyance swales and lot detention areas (LDAs) are modelled as a nodal-reservoirs with infiltration depth-rating curves to account for differential infiltration rates with changing depth.
- Detention areas are modelled as nodal-reservoirs with no infiltration.

A post-development model has been prepared to demonstrate that the peak 1% AEP and 10% annual exceedance probability (AEP) flow rates leaving the site are within allowable discharge rates documented within the overarching *District Water Management Strategy to support the Picton South District Structure Plan* (DWMS) (Calibre Consulting 2017).

2 Post-development Model

A post-development model was developed using XPSTORM software to determine the hydrology of the site, estimate runoff volumes, peak discharges and storage requirements within the site.

2.1 Catchment hydrology

An "initial loss - continual loss" infiltration model was adopted to represent the post-development environment. Loss values were determined based on the proposed land use, the underlying site conditions and project team experience with similar land uses and site conditions. **Table 1** provides the infiltration and roughness parameters used within the post-development model.

Table 1: Post-development loss parameters

Land type	Initial loss (mm)	Continual loss (mm/hr)	Manning's 'n'
Road surface	1	0.1	0.02
Road verge	9	1.5	0.03
Lot impervious	1	0.1	0.02
Lot pervious	15	1.5	0.03
Regional open space (ROS) and railway	20	2.5	0.08

The site is located within Catchment 3 and Catchment 4 of the DWMS. For modeling purposes, sub-catchments within the site are referred to as Catchment 1 and Catchment 2 and the remainder of DWMS Catchment 3 and 4 are referred to as Catchment 3 US and Catchment 4 US. These are shown in Figure 6 of LWMS. The ultimate discharge location for the site is located along the western boundary of Catchment 2. Stormwater runoff that discharges from the site encompasses runoff from Catchment 1, Catchment 2 and both upstream catchments.

A summary of post-development catchment land use assumptions is provided in **Table 2**. Consistent with the DWMS, future industrial areas within Catchment 3 US and Catchment 4 US are assumed to be 20% road reserve, 75% industrial lot, and 5% drainage.

Table 2: Post-development catchment areas

Catchment	Area (ha)				
	Total area	Road reserve	Industrial lot	Drainage	ROS/railway
Catchment 1	10.95	1.34	6.91	0.87	1.83
Catchment 2	63.26	9.41	47.88	3.87	2.10
Catchment 3 US	29.40	5.21	19.53	1.30	3.36
Catchment 4 US	13.55	8.34	5.06	0.14	0
Total	117.16	24.30	84.12	1.44	7.29

The infiltration rates used in the post-development model were predominantly based upon the following assumptions:

- Lots on average will be consistent with other new industrial developments in the South-West and have large roof areas, a small pervious landscaped area, and the remainder of the lots paved/impervious. Therefore, it is assumed that lots are 90% impervious and 10% pervious, which is consistent with the assumptions made in the DWMS.
- Road reserves are 60% pervious verge and 40% impervious bitumen.
- There will be no infiltration on roads, pavements and driveways. There will however be some minor absorption storage loss, which is accounted for in the initial and continuing loss values.
- The road verge area is similar in characteristics to open space except that it will also have an impervious footpath and some driveway crossovers. The averaged initial loss will be lower than open space initial loss rates.
- ROS area is considered 100% pervious.
- The site has low infiltration due to the soil conditions and shallow groundwater table. It is assumed that there is no infiltration from the base of detention areas.
- A hydraulic conductivity of 2 m/day is assumed for the infiltration in swales. An additional 50% clogging factor has also been applied.
- A hydraulic conductivity of 2 m/day is assumed for the infiltration in LDAs in Catchment 1 and 2.
- Volumes leaving the system through evapotranspiration were assumed to be negligible when compared to the total runoff volume, and as the duration of model run was comparatively short, XPSTORM default evapotranspiration assumptions are used.

2.2 Hydraulic structures

Stormwater management structures for the treatment and detention of stormwater runoff were modelled to ensure allowable flow rates are maintained in the post-development scenario.

2.2.1 Lot drainage assumptions

Lot drainage assumptions include:

- Lots will retain 2 m^3 per 65 m^2 of hardstand/roof in accordance with the Shire of Dardanup's requirements (SoD 2018).
- LDAs are modelled as 1 m deep square basins with 1:6 side slopes.

2.2.2 Site and upstream assumptions

Site and upstream drainage assumptions include:

- Roadside swales in each catchment are represented by one storage node.
- Swales will be located along one side of each road reserve to treat the small rainfall event off road reserves. However, only 80% of the total swale length is assumed to be available for storage to account for cross-overs.
- Swales are nominally assumed to be 500 mm deep have a 1 m wide base and 1:4 side slopes.
- Minor and major event runoff will be detained in square detention areas modelled with 1:6 side slopes at the downstream end of each catchment.
- Detention Area 1 is assumed to have an invert of approximately 13 mAHD (based on the maximum groundwater level) and a conservatively shallow depth of 500 mm.
- The invert of Detention Area 2 will be set at 12.05 mAHD (based on the invert of the existing culverts beneath Columbas Drive), and has a depth of 950 mm.
- It is assumed that there is one detention area at the downstream point of Catchment 2. The volume required to be provided in Catchment 2 could potentially be provided by multiple detention areas (i.e. within Detention Area 2 and 3 as shown in the LWMS).
- Upstream detention areas were modelled as 1 m deep square basins with 1:6 side slopes.
- Detention areas are provided with a low flow pipe outlet and a weir to allow runoff to discharge from site according to the allowable peak flow discharge rates.

2.2.3 Downstream assumptions

Downstream assumptions include:

- Runoff from site (i.e. the ultimate discharge from Catchment 2) is conveyed within the existing drain (320 m in length) towards the 1200 mm culvert beneath the railway.
- A free outfall is assumed at the railway culvert.

2.3 Critical duration event analysis

Several rainfall durations varying from 30 minutes to three days were analysed to determine the 10% AEP and 1% AEP event critical durations for peak flows discharging from the Detention Area 1 and Detention Area 2. The analysis (shown in **Plate 1** to **Plate 4**) indicates that for both catchments, the 12 hour and 6 hour duration events are the critical duration for the 10% AEP and 1% AEP event events, respectively.

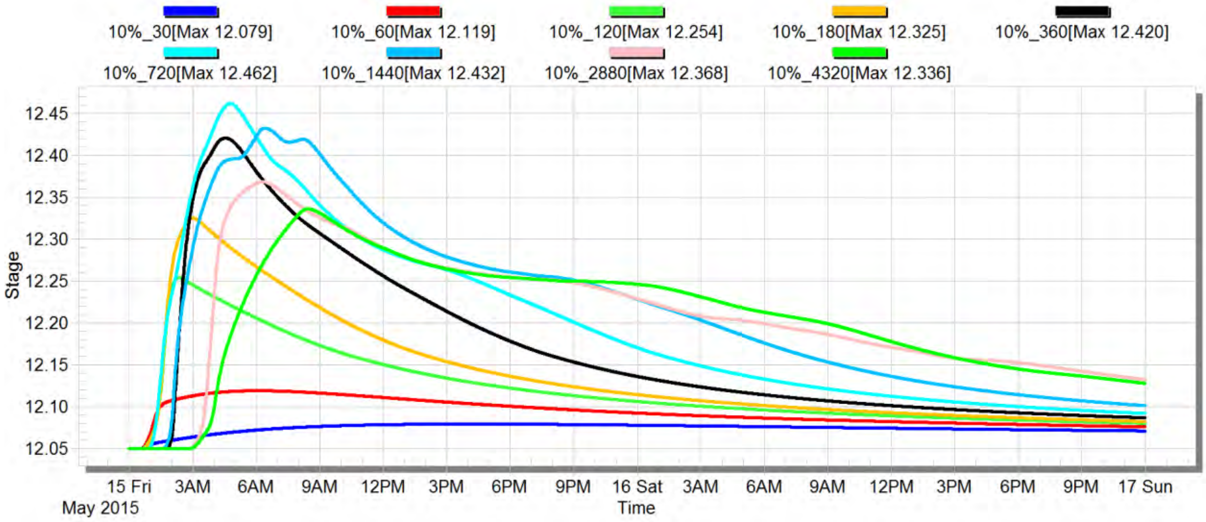

Plate 1: 10% AEP critical duration analysis of Detention Area 1

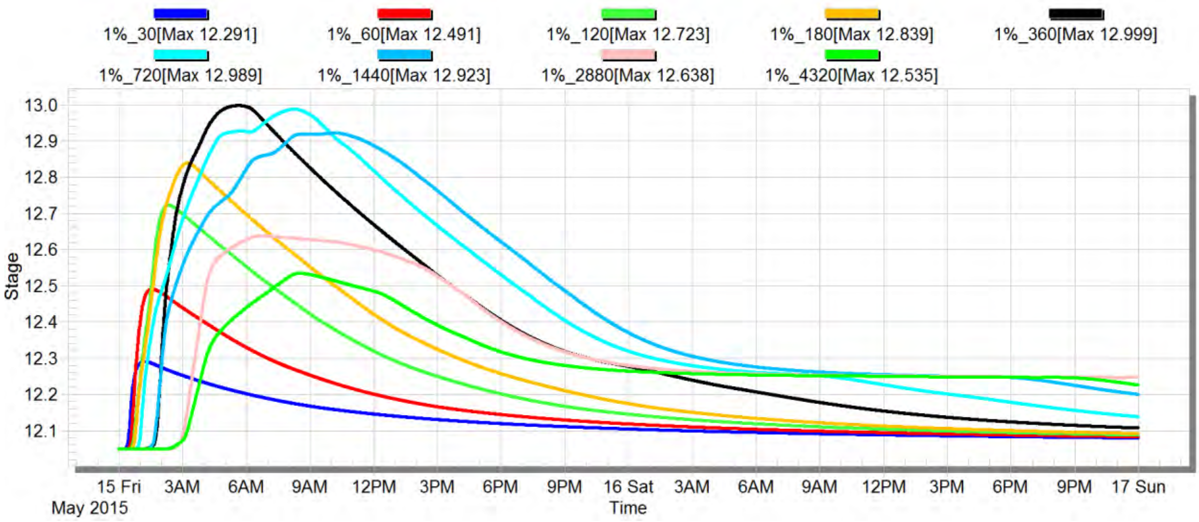

Plate 2: 1% AEP critical duration analysis of Detention Area 1

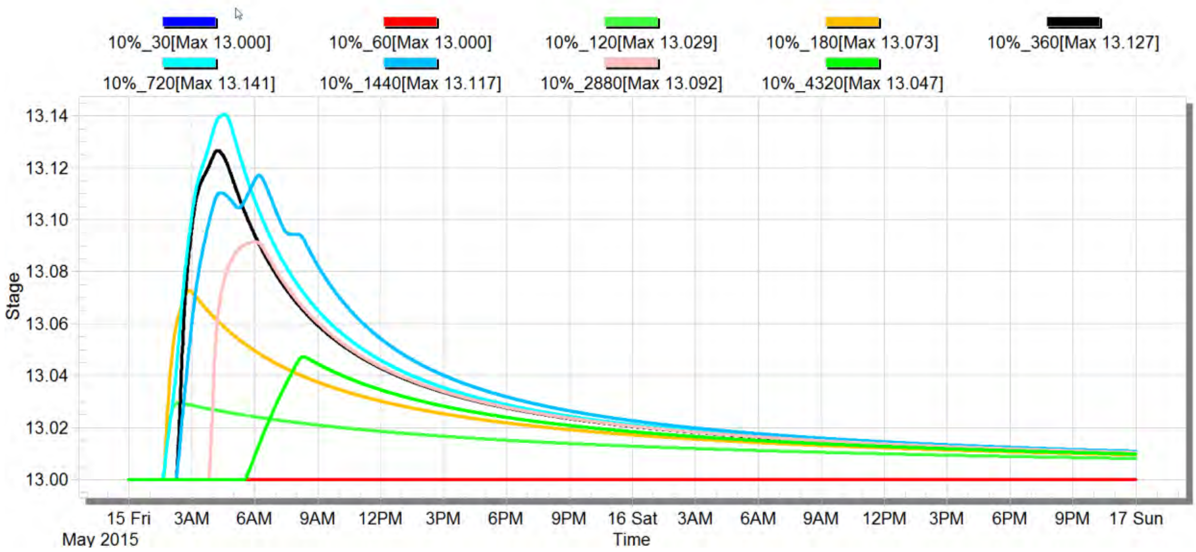

Plate 3: 10% AEP critical duration analysis of Detention Area 2

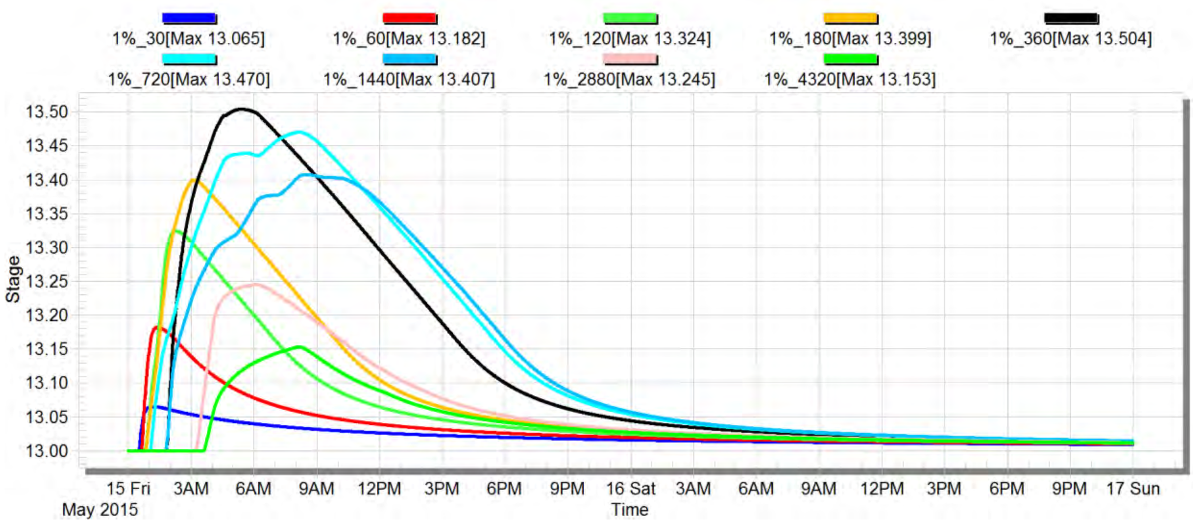

Plate 4: 1% AEP critical duration analysis of Detention Area 2

3 References

3.1 General references

Calibre Consulting 2017, District Water Management Strategy to support the Picton South District Structure Plan, 17-000073, Rev D.

Shire of Dardanup (SoD) 2018a, Policy No CP060 - Storm Water Discharge from Buildings, Eaton.

Calibre Consulting 2017, District Water Management Strategy to support the Picton South District Structure Plan, 17-000073, Rev D.

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