Appendix A Summary of registered bores within 5 km of the project

RN	Type	Status	Easting	Northing	Date drilled	Screen interval (mbGL)	Base of casing/hole	Lithology
51011	Unknown	Abandoned & destroyed	735275	7807175	2/08/1974	6.4 - 12.8	21.34	Alluvium
109879	Water supply	Abandoned & destroyed	739521	7810621	19/07/2005	-	49.39	Granite
109881	Water supply	Abandoned & destroyed	739625	7811098	20/07/2005	-	49.39	Granite
163268	Unknown	Abandoned & destroyed	736682	7803012	27/10/2013	11 - 20	52	Sandstone
163296	Water supply	Existing	734636	7807323	16/01/2019	43 - 55	55	Sandstone
Rockspear Bore	Water supply	Existing	734913	7805494	Unknown	Unknown	Unknown	Unknown

Note: *Coordinates are in GDA94, Zone 54*

Appendix B Groundwater quality data

Bore ID	Date	pH (field)	Electrical Conductivity (field)	Total Dissolved Solids (TDS)	Sulfate as SO4	Dissolved Aluminium	Dissolved Arsenic	Dissolved Boron	Dissolved Cadmium	Dissolved Chromium	Dissolved Cobalt	Dissolved Copper	Dissolved Iron	Dissolved Lead	Dissolved Manganese	Dissolved Mercury	Dissolved Molybdenum	Dissolved Nickel	Dissolved Selenium	Dissolved Zinc
			µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
MB1B	6/04/2018	6.80	10,870.0	8,860.0		<0.005	0.01	0.26	<0.0001	<0.001		<0.001	0.21	<0.001	1.16	<0.0005				<0.004
MB1B	2/09/2018	6.77	10,630.0	8,818.0		<0.005	0.01	0.3	<0.0001	0.01		0.02	0.25	<0.001	0.88					0.01
MB1B	10/12/2018	6.72	11,975.0	7,111.0		0.0063	0.0031	0.25	0.0001	0.0023		0.013	0.26	<0.001	0.6					<0.004
MB1B	27/04/2019	6.73	10,550.0	8,790.0		0.0061	0.0068	0.24	<0.0001	<0.0005		<0.0005	1.8	0.00018	4.3					<0.004
MB1B	11/08/2019	6.89	9,532.0	7,986.0	830	0.0065	0.0058	0.23	<0.0001	<0.0005		<0.0005	1.9	<0.0001	4.8					0.038
MB1B	11/11/2019	6.80	11,840.0	10,090.0		0.0058	0.0062	0.3	<0.0001	<0.0005		<0.0005	2	<0.0001	6					<0.004
MB1B	7/03/2020	7.01	10,530.0	8,759.0		0.0079	0.0054	0.23	<0.0001	<0.0005		<0.0005	1.4	<0.0001	5.1					0.026
MB1B	2/08/2020	6.95	12,620.0	10,680.0																
MB1B	28/11/2020	6.83	12,670.0	10,740.0																
MB1B	3/05/2021	7.11	7,540.0	6,026.0	1230	0.02	0.006	0.2	<0.0001	<0.001	<0.001	<0.001	0.3	<0.001	1.18	<0.0001	0.002	0.005	<0.01	0.013
MB1B	4/05/2021	6.96	12,680.0	10,700.0	1580	0.01	0.006	0.34	<0.0001	<0.001	0.011	<0.001	1.51	<0.001	4.22	<0.0001	0.004	0.004	<0.01	0.023
MB1B	1/09/2021	6.93	11,770.0	10,320.0	1670	<0.01	0.005	0.23	<0.0001	<0.001	0.008	<0.001	1.31	<0.001	3.42	<0.0001	0.004	0.004	<0.01	<0.005
MB1B	13/11/2021	7.00	12,570.0	10,720.0	1640	<0.01	0.006	0.28	<0.0001	<0.001	0.011	<0.001	1.38	<0.001	4.28	<0.0001	0.006	0.005	<0.01	<0.005
MB2A	9/04/2018	6.98	1,044.0	699.0	110	<0.005	<0.001	0.05	<0.0001	<0.001		<0.001	0.09	<0.001	1.16	<0.0005				0.01
MB2A	3/09/2018	7.01	914.0	627.7		<0.005	<0.001	0.04	<0.0001	<0.001		<0.001	0.13	<0.001	1.13					0.01
MB2A	8/12/2018	6.89	823.0	481.0		<0.005	0.0022	0.029	<0.0001	<0.001		<0.001	0.083	<0.001	0.7					<0.004
MB2A	26/04/2019	7.05	736.0	494.6	55	<0.005	0.0021	0.046	<0.0001	<0.0005		<0.0005	0.015	0.0014	0.32					<0.004
MB2A	10/08/2019	6.96	788.2	539.6	52	<0.005	0.0022	0.044	<0.0001	<0.0005		<0.0005	0.15	0.00015	0.75					0.005
MB2A	10/11/2019	7.31	754.4	508.4	56	<0.005	0.002	0.049	<0.0001	<0.0005		<0.0005	0.078	<0.0001	0.66					0.005
MB2A	8/03/2020	8.16	743.8	499.4	53	<0.005	0.0022	0.038	<0.0001	<0.0005		<0.0005	0.045	0.00034	0.47					0.009
MB2A	1/08/2020	6.98	734.2	493.1																
MB2A	28/11/2020	7.31	739.1	494.4																
MB2A	4/05/2021	7.03	718.0	482.1	60	<0.01	0.005	0.08	<0.0001	<0.001	0.007	<0.001	1.98	<0.001	2.2	<0.0001	<0.001	0.004	<0.01	0.011
MB2A	1/09/2021	6.73	683.8	476.5	54	<0.01	0.005	<0.05	<0.0001	<0.001	0.006	<0.001	1.98	<0.001	1.97	<0.0001	<0.001	0.003	<0.01	<0.005
MB2A	13/11/2021	7.15	726.4	491.4	56	<0.01	0.004	<0.05	<0.0001	<0.001	0.004	<0.001	1.02	<0.001	1.45	<0.0001	0.001	0.005	<0.01	<0.005
MB2B	10/04/2018	7.85	1,357.0	918.9	140	0.04	0.01	0.11	<0.0001	<0.001		<0.001	0.08	<0.001	0.75	<0.0005				<0.004
MB2B	4/09/2018	7.86	1,450.0	1,010.0		0.03	0.01	0.15	<0.0001	<0.001		<0.001	0.05	<0.001	0.82					<0.004
MB2B	8/12/2018	7.71	1,476.0	871.0		0.021	0.004	0.058	<0.0001	<0.001		<0.001	0.089	<0.001	0.27					<0.004
MB2B	26/04/2019	7.73	1,410.0	977.4	150	0.022	0.012	0.28	<0.0001	<0.0005		<0.0005	0.11	<0.0001	0.71					<0.004
MB2B	10/08/2019	7.71	1,427.0	1,008.0	160	0.048	0.014	0.26	<0.0001	<0.0005		<0.0005	0.3	<0.0001	0.64					<0.004
MB2B	10/11/2019	7.89	1,441.0	1,001.0	140	0.024	0.0072	0.21	<0.0001	<0.0005		<0.0005	0.027	<0.0001	0.49					<0.004
MB2B	8/03/2020	8.84	1,462.0	1,010.0	120	0.028	0.015	0.21	<0.0001	<0.0005		<0.0005	0.051	<0.0001	0.56					<0.004
MB2B	1/08/2020	8.07	1,607.0	1,127.0																
MB2B	28/11/2020	8.18	1,644.0	1,150.0																
MB2B	4/05/2021	8.19	1,580.0	1,105.0	93	0.13	0.022	0.36	<0.0001	<0.001	<0.001	<0.001	0.14	<0.001	0.448	<0.0001	0.016	<0.001	<0.01	<0.005
MB2B	1/09/2021	8.01	1,486.0	1,076.0	85	0.02	0.019	0.28	<0.0001	<0.001	<0.001	<0.001	<0.05	<0.001	0.374	<0.0001	0.01	<0.001	<0.01	<0.005
MB2B	13/11/2021	8.10	1,465.0	1,026.0	86	0.04	0.028	0.38	<0.0001	<0.001	<0.001	<0.001	0.12	<0.001	0.408	<0.0001	0.021	<0.001	<0.01	<0.005
MB3B	10/04/2018	6.29	257.7	162.7	10	0.01	<0.001	0.01	<0.0001	<0.001		<0.001	0.91	<0.001	0.61	<0.0005				0.01
MB3B	4/09/2018	6.35	227.9	146.0		0.02	<0.001	0.02	<0.0001	<0.001		<0.001	2	<0.001	0.32					0.01
MB3B	10/12/2018	6.11	253.1	152.8		0.012	0.0054	0.14	<0.0001	<0.001		0.0011	1.8	<0.001	2.38					<0.004
MB3B	27/04/2019	6.17	220.8	142.7	8.7	<0.005	0.0013	0.031	<0.0001	<0.0005		<0.0005	1.1	<0.0001	0.13					<0.004
MB3B	10/08/2019	6.12	218.8	145.1	7.7	0.01	0.001	0.028	<0.0001	<0.0005		<0.0005	0.88	0.00019	0.074					0.004
MB3B	10/11/2019	6.35	202.1	129.1	7.2	0.013	0.0013	0.035	<0.0001	<0.0005		0.0017	0.82	0.00015	0.072					0.005
MB3B	8/03/2020	7.14	205.1	131.3	7.5	<0.005	0.00068	0.029	<0.0001	<0.0005		<0.0005	0.63	<0.0001	0.046					0.006
MB3B	1/08/2020	6.27	191.6	122.3																
MB3B	28/11/2020	6.57	191.6	121.9																
MB3B	4/05/2021	6.37	195.4	124.6	6	0.07	0.001	0.06	<0.0001	<0.001	0.002	<0.001	0.62	<0.001	0.095	<0.0001	<0.001	0.003	<0.01	0.045
MB3B	1/09/2021	6.38	181.8	120.2	5	<0.01	<0.001	<0.05	<0.0001	<0.001	<0.001	<0.001	0.29	<0.001	0.02	<0.0001	<0.001	0.001	<0.01	<0.005
MB3B	13/11/2021	6.65	185.0	118.1	5	<0.01	<0.001	<0.05	<0.0001	<0.001	<0.001	<0.001	<0.05	<0.001	0.006	<0.0001	<0.001	0.001	<0.01	0.021
MB4B	11/04/2018	7.76	1,455.0	982.3	35	0.01	0.01	0.09	<0.0001	<0.001		<0.001	0.43	<0.001	2.47	<0.0005				<0.004
MB4B	4/09/2018	7.66	1,454.0	1,012.0		0.01	0.01	0.1	<0.0001	<0.001		<0.001	0.54	<0.001	2.13					0.01
MB4B	10/12/2018	7.53	1,693.0	994.5		0.012	0.011	0.1	<0.0001	<0.001		0.002	0.47	<0.001	1.92					<0.004
MB4B	27/04/2019	7.64	1,471.0	1,031.0	26	0.0097	0.0091	0.13	<0.0001	<0.0005		<0.0005	0.27	<0.0001	1.8					<0.004
MB4B	11/08/2019	7.72	1,470.0	1,040.0	21	0.02	0.0084	0.16	<0.0001	<0.0005		<0.0005	0.3	<0.0001	1.6					<0.004
MB4B	11/11/2019	7.85	1,460.0	1,024.0	18	0.015	0.0078	0.17	<0.0001	<0.0005		<0.0005	0.15	<0.0001	1.5					<0.004
MB4B	8/03/2020	8.61	1,471.0	1,025.0	6.5	0.013	0.0083	0.12	<0.0001	<0.0005		<0.0005	0.29	<0.0001	1.6					<0.004
MB4B	2/08/2020	7.85	1,467.0	1,020.0																
MB4B	28/11/2020	8.05	1,468.0	1,018.0																
MB4B	4/05/2021	7.89	1,474.0	1,025.0	<1	0.02	0.009	0.19	<0.0001	<0.001	<0.001	<0.001	0.57	<0.001	1.32	<0.0001	0.004	<0.001	<0.01	<0.005
MB4B	1/09/2021	7.85	1,437.0	1,034.0	<1	<0.01	0.012	0.16	<0.0001	<0.001	<0.001	<0.001	0.53	<0.001	1.55	<0.0001	0.003	<0.001	<0.01	<0.005
MB4B	13/11/2021	7.98	1,489.0	1,049.0	<1	<0.01	0.016	0.16	<0.0001	<0.001	<0.001	<0.001	0.97	<0.001	1.56	<0.0001	0.005	<0.001	<0.01	<0.005
MB5B	8/04/2018	7.37	1,440.0	974.5	2	<0.005	0.01	0.1	<0.0001	<0.001		<0.001	0.98	<0.001	2.98	<0.0005				<0.004
MB5B	4/09/2018	7.22	1,168.0	800.8		0.03	0.01	0.14	<0.0001	<0.001		<0.001	1.3	<0.001	2.24					<0.004
MB5B	8/12/2018	7.16	1,188.0	676.0		<0.005	0.0019	0.019	<0.0001	<0.001		<0.001	1.7	<0.001	0.24					<0.004
MB5B	26/04/2019	7.20	1,168.0	813.5	<0.01	0.0089	0.0028	0.085	<0.0001	<0.0005		<0.0005	2.2	0.0014	2.2					<0.004
MB5B	10/08/2019	7.07	1,127.0	783.1	<0.01	0.0088	0.0029	0.077	<0.0001	<0.0005		<0.0005	2.4	0.00069	2.1					<0.004
MB5B	10/11/2019	7.22	1,151.0	801.0	<0.01	0.0061	0.0033	0.1	<0.0001	<0.0005		<0.0005	2.3	0.0012	2.2					<0.004
MB5B	7/03/2020	7.90	1,131.0	778.2	1	<0.005	0.0035	0.073	<0.0001	<0.0005		<0.0005	2.5	0.0017	2.2					0.019
MB5B	1/08/2020	7.15	1,131.0	781.9																
MB5B	27/11/2020	7.36	1,143.0	778.9																
MB5B	3/05/2021	7.29	1,137.0	782.8	<1	0.02	0.005	0.26	<0.0001	<0.001	<0.001	<0.001	1.7	<0.001	2.12	<0.0001	0.01	0.013	<0.01	0.006
MB5B	31/08/2021	7.17	1,109.0	785.3	<1	<0.01	0.008	0.21	<0.0001	<0.001	0.001	<0.001	2.15	<0.001	2.27	<0.0001	0.009	0.012	<0.01	<0.005
MB5B	13/11/2021	7.22	1,140.0	792.3	<1	<0.01	0.008	0.22	<0.0001	<0.001	0.001	<0.001	2.37	<0.001	2.24	<0.0001	0.011	0.013	<0.01	<0.005
MB6B	9/04/2018	7.01	12,690.0	10,490.0		<0.005	0.02	0.08	<0.0001	0.01		<0.001	<0.003	<0.001	7.27	<0.0005				<0.004
MB6B	3/09/2018	6.99	12,520.0	10,690.0		<0.005	0.02	0.1	<0.0001	0.01		0.02	0.02	<0.001	11					0.01
MB6B	10/12/2018	6.81	14,340.0	8,502.0		<0.005	0.0098	0.083	0.0001	0.0031		0.012	3.7	<0.001	18					<0.004
MB6B	26/04/2019	6.98	9,953.0	8,170.0		0.012	0.0025	0.085	<0.0001	<0.0005		<0.0005	0.15	<0.0001	14					<0.004
MB6B	10/08/2019	6.85	11,760.0	9,991.0	830	0.0067	0.0042	0.079	<0.0001	<0.0005		<0.0005	1.8	<0.0001	15					0.033
MB6B	10/11/2019	7.17	10,240.0	8,483.0		<0.005	0.0059	0.099	<0.0001	<0.0005		<0.0005	4.1	<0.0001	13					<0.004

Bore ID	Date	pH (field)	Electrical Conductivity (field)	Total Dissolved Solids (TDS)	Sulfate as SO4	Dissolved Aluminium	Dissolved Arsenic	Dissolved Boron	Dissolved Cadmium	Dissolved Chromium	Dissolved Cobalt	Dissolved Copper	Dissolved Iron	Dissolved Lead	Dissolved Manganese	Dissolved Mercury	Dissolved Molybdenum	Dissolved Nickel	Dissolved Selenium	Dissolved Zinc
			µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
MB6B	7/03/2020	7.14	11,870.0	10,000.0		0.013	0.0062	0.077	<0.0001	<0.0005		<0.0005	3.1	0.00014	16					0.043
MB6B	1/08/2020	6.98	12,510.0	10,600.0																
MB6B	27/11/2020	6.99	12,560.0	10,550.0																
MB6B	3/05/2021	7.17	10,730.0	8,663.0	1360	0.02	0.006	0.12	<0.0001	<0.001	<0.001	<0.001	<0.05	<0.001	2.42	<0.0001	0.005	0.014	<0.01	0.033
MB6B	1/09/2021	6.85	11,890.0	10,410.0	1480	<0.01	0.007	0.09	<0.0001	<0.001	0.006	<0.001	7.49	<0.001	12.1	<0.0001	0.003	0.003	<0.01	<0.005
MB6B	13/11/2021	7.08	9,698.0	7,983.0	1290	<0.01	0.002	0.1	<0.0001	<0.001	<0.001	<0.001	5.85	<0.001	13.9	<0.0001	0.001	<0.001	<0.01	<0.005
MB7A	6/04/2018	6.86	461.8	297.6	4.4	0.01	0.02	0.04	<0.0001	<0.001		<0.001	0.74	<0.001	4.5	<0.0005				0.11
MB7A	1/09/2018	6.69	340.1	220.2		0.03	0.02	0.02	<0.0001	<0.001		<0.001	3.7	<0.001	2.38					0.09
MB7A	8/12/2018	6.56	441.2	256.8		<0.005	0.023	0.017	<0.0001	<0.001		<0.001	8.5	<0.001	5.51					<0.004
MB7A	26/04/2019	6.61	426.1	279.8	12	<0.005	0.029	0.027	<0.0001	<0.0005		<0.0005	11	0.00026	4.2					0.0045
MB7A	10/08/2019	6.57	403.7	267.5	12	<0.005	0.019	0.029	<0.0001	<0.0005		<0.0005	9	0.00019	3.8					0.006
MB7A	11/11/2019	6.77	400.7	265.7	25	0.0075	0.027	0.035	<0.0001	<0.0005		<0.0005	11	0.00061	3.4					0.011
MB7A	7/03/2020	7.01	385.8	252.5	9	<0.005	0.027	0.024	<0.0001	<0.0005		<0.0005	12	0.0007	3.4					<0.004
MB7A	1/08/2020	6.89	378.0	247.9																
MB7A	27/11/2020	6.67	357.2	357.2																
MB7A	4/05/2021	6.65	423.6	279.1	28	<0.01	0.004	<0.05	<0.0001	<0.001	0.017	<0.001	2.21	<0.001	2.33	<0.0001	0.002	0.006	<0.01	0.039
MB7A	31/08/2021	6.51	366.5	248.1	20	<0.01	0.027	<0.05	<0.0001	<0.001	0.017	<0.001	8.45	<0.001	2.21	<0.0001	<0.001	0.003	<0.01	0.006
MB7A	13/11/2021	6.92	365.5	240.2	12	<0.01	0.034	<0.05	<0.0001	<0.001	0.01	<0.001	10.5	<0.001	2.45	<0.0001	<0.001	0.001	<0.01	<0.005
MB7B	8/04/2018	7.75	727.2	476.7	13	0.02	<0.001	0.07	<0.0001	<0.001		<0.001	0.01	<0.001	0.75	<0.0005				<0.004
MB7B	2/09/2018	7.54	725.6	488.3		0.02	<0.001	0.07	<0.0001	<0.001		<0.001	0.03	<0.001	0.96					0.01
MB7B	8/12/2018	7.39	764.0	442.0		0.021	<0.001	0.034	<0.0001	<0.001		<0.001	0.063	<0.001	0.42					0.006
MB7B	26/04/2019	7.46	742.3	498.3	0.55	0.013	0.0061	0.08	<0.0001	<0.0005		<0.0005	0.14	<0.0001	1.1					0.0042
MB7B	11/08/2019	7.55	744.4	515.2	0.83	0.013	0.0087	0.079	<0.0001	<0.0005		<0.0005	0.42	<0.0001	1.3					<0.004
MB7B	10/11/2019	7.43	797.3	539.2	0.84	<0.005	0.01	0.099	<0.0001	<0.0005		<0.0005	0.67	<0.0001	1.4					0.005
MB7B	7/03/2020	7.81	767.3	516.5	9	<0.005	0.012	0.074	<0.0001	<0.0005		<0.0005	0.017	<0.0001	1.7					<0.004
MB7B	1/08/2020	7.45	771.5	518.1																
MB7B	27/11/2020	7.41	786.5	526.1																
MB7B	4/05/2021	7.74	790.7	532.3	<1	0.01	0.013	0.13	<0.0001	<0.001	<0.001	<0.001	2.02	<0.001	2.18	<0.0001	0.002	<0.001	<0.01	<0.005
MB7B	31/08/2021	7.38	771.5	538.3	<1	<0.01	0.02	0.1	<0.0001	<0.001	<0.001	<0.001	3.05	<0.001	2.5	<0.0001	0.002	<0.001	<0.01	<0.005
MB7B	13/11/2021	7.43	839.3	571.8	<1	<0.01	0.021	0.09	<0.0001	<0.001	<0.001	<0.001	3.56	<0.001	2.58	<0.0001	0.002	<0.001	<0.01	<0.005

Appendix C Field investigation results

Australasian Groundwater and Environmental Consultants Pty Ltd
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VW PIEZOMETER INSTALLATION RECORD

Project name: Woolgar Gold Project

Borehole name: LR0272

Installation date: 2 November 2017

Piezometer Hole Identification

BH ID	Easting	Northing	RL (m)
LR0272	739245	7805294	386

Coordinates in GDA94 (z54)

HMA Logger Serial No: 06422

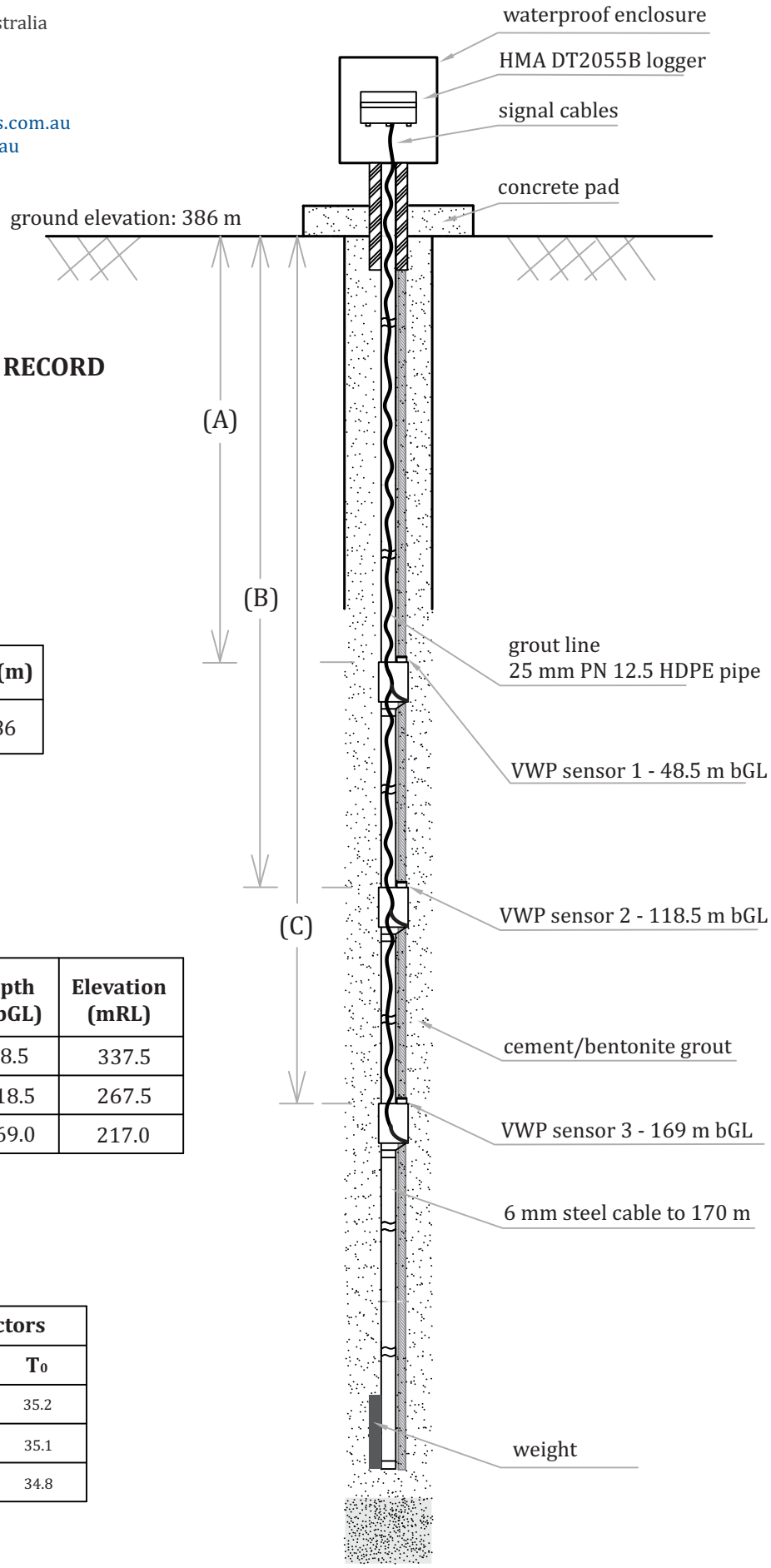
Piezometer Installation Details

Symbol	Piezometer Name	S/N	Depth (mbGL)	Elevation (mRL)
(A)	VWP01	24173	48.5	337.5
(B)	VWP02	24133	118.5	267.5
(C)	VWP03	24044	169.0	217.0

Piezometer Calibration Details

ID	Piezometer Calibration Factors			
	F_0	C_P	C_T	T_0
VWP01	8760.6	0.2872	0.1130	35.2
VWP02	8810.1	0.5671	0.4049	35.1
VWP03	8782.0	0.8260	0.5840	34.8

No Scale



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VW PIEZOMETER INSTALLATION RECORD

Project name: Woolgar Gold Project

Borehole name: LR0290

Installation date: 30 October 2017

Piezometer Hole Identification

BH ID	Easting	Northing	RL (m)
LR0290	739624	7806633	375

Coordinates in GDA94 (z54)

HMA Logger Serial No: 06428

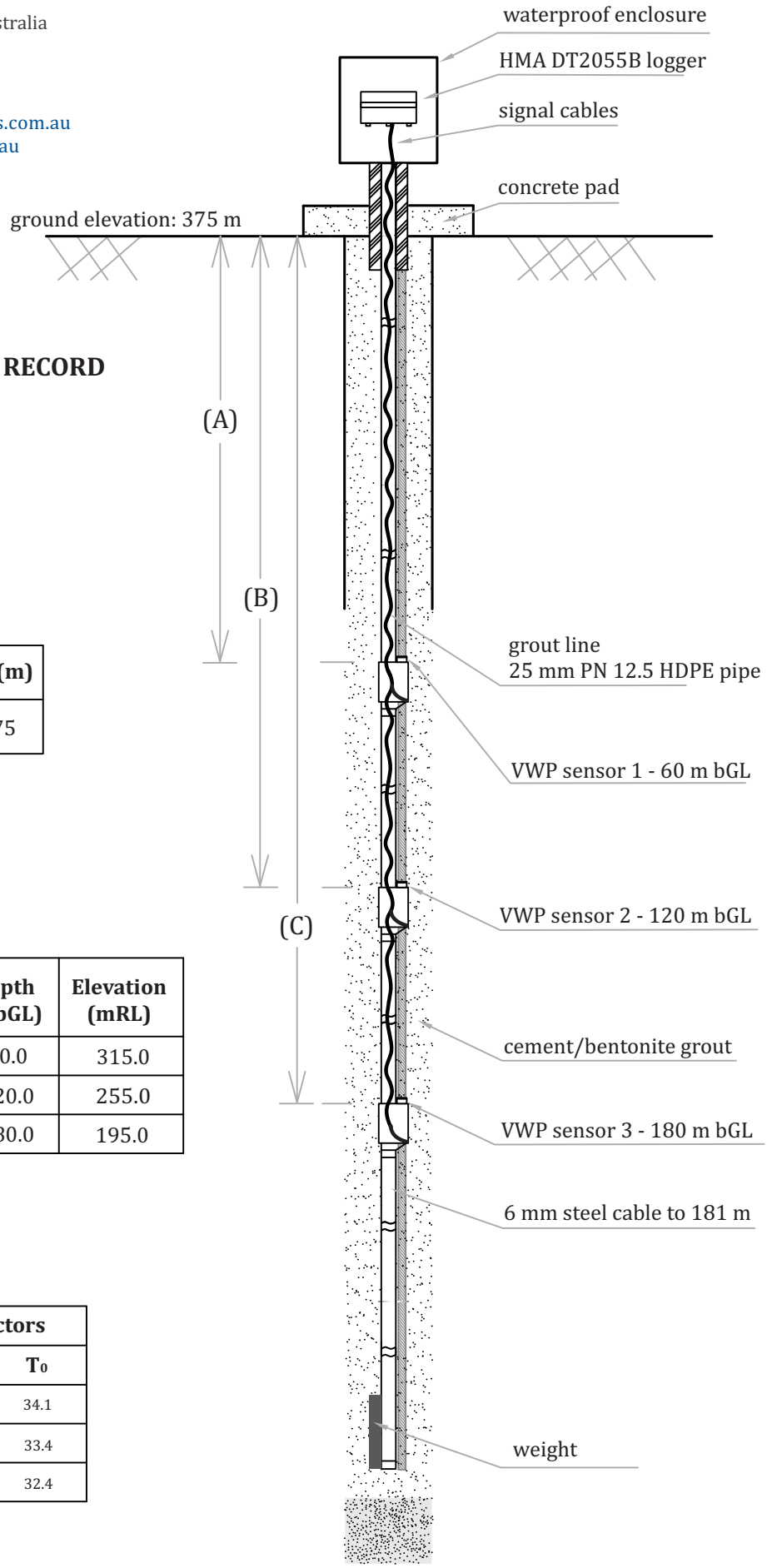
Piezometer Installation Details

Symbol	Piezometer Name	S/N	Depth (mbGL)	Elevation (mRL)
(A)	VWP01	24128	60.0	315.0
(B)	VWP02	24135	120.0	255.0
(C)	VWP03	24045	180.0	195.0

Piezometer Calibration Details

ID	Piezometer Calibration Factors			
	F_0	C_P	C_T	T_0
VWP01	8727.1	0.2774	0.1224	34.1
VWP02	8777.0	0.5586	0.3450	33.4
VWP03	8670.4	0.8231	0.5456	32.4

No Scale



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VW PIEZOMETER INSTALLATION RECORD

Project name: Woolgar Gold Project

Borehole name: LR0309

Installation date: 3 November 2017

Piezometer Hole Identification

BH ID	Easting	Northing	RL (m)
LR0309	739356	7806219	380

Coordinates in GDA94 (z54)

HMA Logger Serial No: 06420

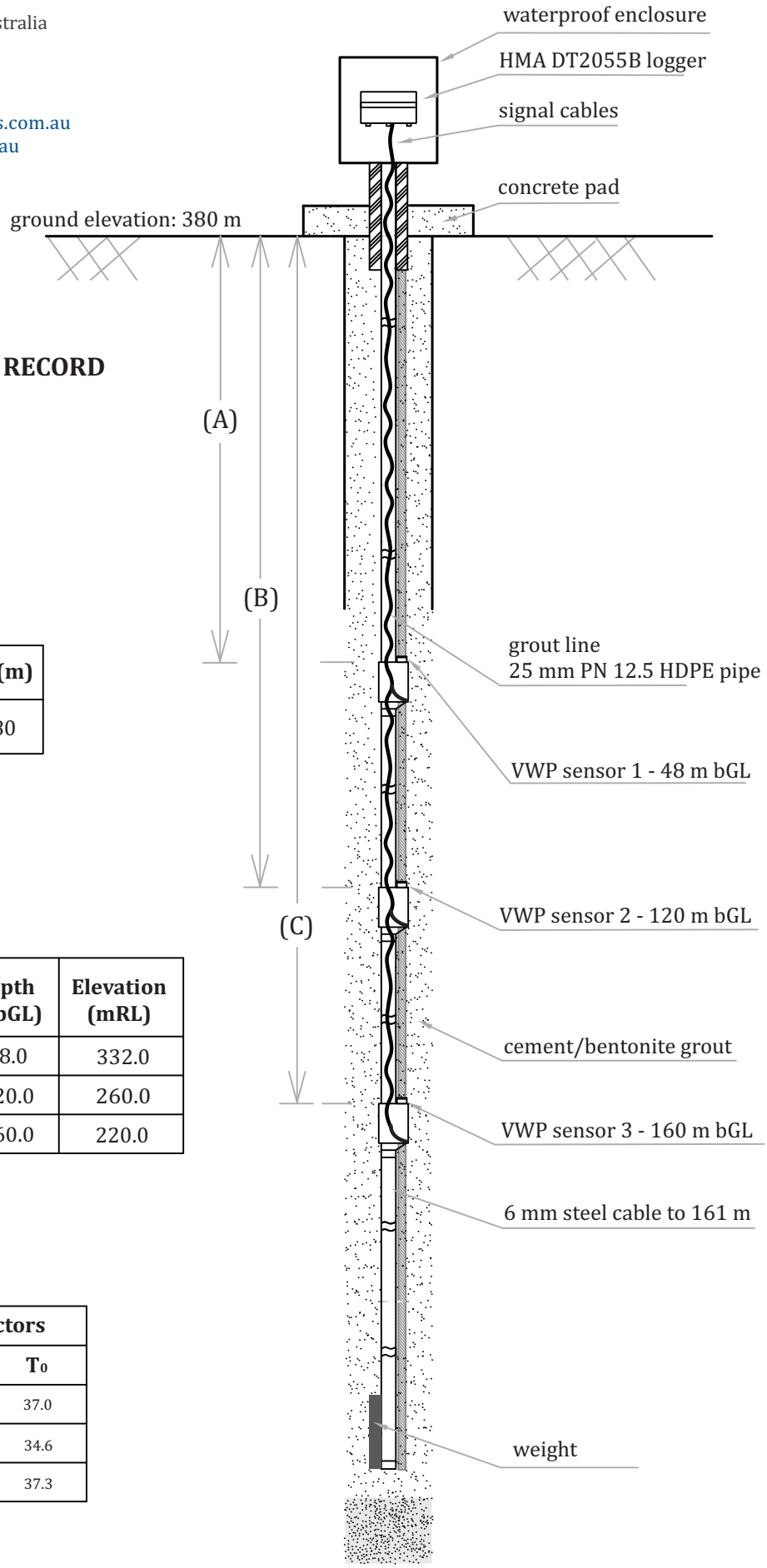
Piezometer Installation Details

Symbol	Piezometer Name	S/N	Depth (mbGL)	Elevation (mRL)
(A)	VWP01	24127	48.0	332.0
(B)	VWP02	24134	120.0	260.0
(C)	VWP03	24046	160.0	220.0

Piezometer Calibration Details

ID	Piezometer Calibration Factors			
	F_0	C_P	C_T	T_0
VWP01	9032.7	0.2873	0.09746	37.0
VWP02	8772.8	0.5558	0.2432	34.6
VWP03	9871.7	0.8209	0.3466	37.3

No Scale



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Project No.: 4090

Project Name: Big Vein South

MONITORING BORE

MB1A

Geological Units	Material Description	Graphic Log	R.L. (mAHD) / Depth (mbGL)	Bore Construction	Bore Description
			370 / 0		Protective lockable steel collar: +0.6 m Stick up: +0.5 m
Weathered profile	Schist: dark greyish, brown,distinctly weathered, low strength, dry				Bentonite grout (2.5 %): 0 m to 1 m 50 mm uPVC Class 18 blank casing: 0 m to 3 m
	Schist: light bluish, grey, slightly weathered, medium strength, dry		368 / 2		Bentonite seal: 1 m to 2 m 139.7 mm Hammer: 0 m to 6 m (Air rotary)
Proterozoic	Schist: light bluish, grey, fresh, high strength, dry		366 / 4		3 - 5 mm washed, rounded, quartz gravel pack: 2 m to 6 m 50 mm uPVC Class 18 machine slotted casing, slot aperture: 1 mm, slot length: mm, slots / m, 3 m to 6 m
			364 / 6		End cap End of hole: 6 m BGL
					Dry

Date Drilled:22/10/2017

Driller: Anthony Watkinson

Drill Rig: Edson 8000

Drilling Company: Strategic Minerals

Drilling Method: Air Rotary

Logged By: Brad North

Easting: 738374 mE

Northing: 7807485 mN

RL: 369.6

TD: 6.0

Datum: MGA94z54

hydrogeologist.com.au

Project No.: 4090

Project Name: Big Vein South

MONITORING BORE

MB1B

Geological Units	Material Description	Graphic Log	R.L. (mAHD) / Depth (mbGL)	Bore Construction	Bore Description
			370 / 0		Protective lockable steel collar: +0.6 m Stick up: +0.5 m
Weathered profile	Schist: dark greyish, brown, distinctly weathered, low strength, dry				
	Schist: light greyish, brown, slightly weathered, medium strength, dry		368 / 2		190.7 mm Blade: 0 m to 3 m (Air rotary)
	Schist: light bluish, grey, distinctly weathered, fresh, dry				
Proterozoic	Schist: light bluish, grey, fresh, high strength, dry		366 / 4		139.7 mm Hammer: 3 m to 25 m (Air rotary) Bentonite grout (2.5 %): 0 m to 5.6 m Gravel backfill: 5.6 m to 13 m
			364 / 6		50 mm uPVC Class 18 blank casing: 0 m to 22 m
	Schist: light bluish, grey, fresh, high strength, dry		362 / 8		
			360 / 10		
			358 / 12		
	Schist: dark bluish, brown, fresh, high strength, dry		356 / 14		Bentonite seal: 13 m to 14 m
	Schist: light bluish, grey, fresh, high strength, damp		354 / 16		3 - 5 mm washed, rounded, quartz gravel pack: 14 m to 25 m
	Schist: light bluish, grey, fresh, high strength, wet				
	Schist: light bluish, grey, fresh, high strength, wet		352 / 18		
	Schist: light bluish, grey, fresh, high strength, wet				
	Schist: light bluish, grey, fresh, high strength, wet		350 / 20		
			348 / 22		50 mm uPVC Class 18 machine slotted casing, slot aperture: 1 mm, slot length: mm, slots / m, 22 m to 25 m Bore development: 30 minutes; EC: 10690 □S/cm; pH: 8.53 15 seconds to fill 5L. Developed clear after 5 minutes. Airlift flow rate: 0.33 L/s
	Schist: light bluish, grey, fresh, high strength, wet		346 / 24		
			344 / 26		End cap End of hole: 25 m BGL

Date Drilled:22/10/2017

Driller: Anthony Watkinson

Drill Rig: Edson 8000

Drilling Company: Strategic Minerals

Drilling Method: Air Rotary

Logged By: Brad North

Easting: 738354 mE

Northing: 7807499 mN

RL: 369.5

TD: 25.0

Datum: MGA94z54

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Project No.: 4090

Project Name: Big Vein South

MONITORING BORE

MB2A

Geological Units	Material Description	Graphic Log	R.L. (mAHD) / Depth (mbGL)	Bore Construction	Bore Description
			374 / 0		
Alluvium	Sand: dark reddish, brown, residual soil, very low strength, dry				Protective lockable steel collar: +0.6 m Stick up: +0.5 m
Weathered profile	Sand: dark reddish, orange, extremely weathered, low strength, dry		372 / 2		254 mm Blade: 0 m to 18 m (Air rotary)
	Silt: light reddish, brown, extremely weathered, low strength, dry		370 / 4		Bentonite grout (2.5 %): 0 m to 5.5 m
	Clay: dark reddish, brown, distinctly weathered, very low strength, dry				
	Sand: dark reddish, orange, slightly weathered, low strength, dry		368 / 6		
Jurassic strata	Sand: light reddish, brown, fresh, low strength, dry		366 / 8 364 / 10		Gravel backfill: 5.5 m to 10 m Bentonite seal: 10 m to 12 m
	Gravel: light reddish, brown, fresh, medium strength, wet		362 / 12 360 / 14 358 / 16		3 - 5 mm washed, rounded, quartz gravel pack: 12 m to 20.5 m 50 mm uPVC Class 18 blank casing: 0 m to 17.5 m
	Gravel: light reddish, brown, fresh, medium strength, wet		356 / 18 354 / 20		50 mm uPVC Class 18 machine slotted casing, slot aperture: 1 mm, slot length: mm, slots / m, 17.5 m to 20.5 m 190.7 mm Blade: 18 m to 24 m (Air rotary)
	Gravel: light reddish, brown, fresh, medium strength, wet		352 / 22 350 / 24		End cap Hole collapse: 20.5 m to 24 m Bore development: 60 minutes; EC: 752 □S/cm; pH: 8.85 Airlift flow rate: 0.1 L/s Diffiicult to develop clean groundwater
			348 / 26		End of hole: 24 m BGL

Date Drilled:20/10/2017

Driller: Anthony Watkinson

Drill Rig: Edson 8000

Drilling Company: Strategic Minerals

Drilling Method: Air Rotary

Logged By: Brad North

Easting: 739339 mE

Northing: 7810012 N

RL: 373.7

TD: 24.0

Datum: MGA94z54

hydrogeologist.com.au

Project No.: 4090

Project Name: Big Vein South

MONITORING BORE

MB2B

Geological Units	Material Description	Graphic Log	R.L. (mAHD) / Depth (mbGL)	Bore Construction	Bore Description
Quaternary	Sand: dark reddish, brown, residual soil, low strength, dry		374 / 0		Protective lockable steel collar: +0.6 m Stick up: +0.5 m 190.7 mm Blade: 0 m to 24 m (Air rotary)
Weathered profile	Sand: dark reddish, orange, extremely weathered, low strength, dry		372 / 2		
	Sand: light reddish, brown, extremely weathered, low strength, dry		370 / 4		
	Sand: light reddish, brown, extremely weathered, low strength, dry				
	Sand: light yellowish, brown, extremely weathered, low strength, dry		368 / 6		
	Sand: light reddish, brown, slightly weathered, low strength, dry		366 / 8		
	Sand: light yellowish, brown, slightly weathered, low strength, dry		364 / 10		
Jurassic strata	Sand: light yellowish, grey, fresh, low strength, damp		362 / 12		Bentonite grout (2.5 %): 0 m to 12 m
	Sand: dark reddish, brown, fresh, low strength, damp				
	Gravel: dark reddish, brown, fresh, low strength, wet		360 / 14 358 / 16		
	Gravel: light yellowish, brown, fresh, low strength, wet		356 / 18		
	Gravel: light reddish, black, fresh, low strength, wet		354 / 20 352 / 22		50 mm uPVC Class 18 blank casing: 0 m to 67 m
Proterozoic	Schist: dark bluish, grey, fresh, medium strength, wet		350 / 24		
	Schist: dark bluish, grey, fresh, very high strength, wet		348 / 26 346 / 28		139.7 mm Hammer: 24 m to 70 m (Air rotary)
	Schist: dark bluish, grey, fresh, very high strength, wet		344 / 30 342 / 32		
	Schist: dark bluish, grey, fresh, very high strength, dry		340 / 34 338 / 36		
	Schist: dark bluish, grey, fresh, very high strength, dry		336 / 38 334 / 40 332 / 42		
	Schist: dark bluish, grey, fresh, very high strength, dry		330 / 44 328 / 46 326 / 48 324 / 50 322 / 52 320 / 54 318 / 56 316 / 58 314 / 60 312 / 62 310 / 64 308 / 66		Bentonite seal: 48 m to 50 m 3 - 5 mm washed, rounded, quartz gravel pack: 50 m to 70 m Bore development: 30 minutes; EC: 652 □S/cm; pH: 8.5 Airlift flow rate: 0.01 L/s Airlift initially clean, very low recharge. Becoming silty after 5 minutes, airlifted until dry.
	Schist: dark bluish, grey, fresh, very high strength, dry		306 / 68 304 / 70 302 / 72		50 mm uPVC Class 18 machine slotted casing, slot aperture: 1 mm, slot length: mm, slots / m, 67 m to 70 m End cap

Date Drilled:19/10/2017

Driller: Anthony Watkinson

Drill Rig: Edson 8000

Drilling Company: Strategic Minerals

Drilling Method: Air Rotary

Logged By: Brad North

Easting: 739341 mE RL: 373.6

Northing: 7809994 mN TD: 70.0

Datum: MGA94z54

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Project No.: 4090

Project Name: Big Vein South

MONITORING BORE

MB3A

Geological Units	Material Description	Graphic Log	R.L. (mAHD) / Depth (mbGL)	Bore Construction	Bore Description
					Protective lockable steel collar: +0.6 m Stick up: +0.5 m
Alluvium	Sand: dark reddish,brown, residual soil, low strength, dry		0		Bentonite grout (2.5 %): 0 m to 1 m 50 mm uPVC Class 18 blank casing: 0 m to 2 m
	Sand: dark reddish, orange, residual soil, low strength, dry		364		Bentonite seal: 1 m to 1.7 m
	Sand: light reddish, orange, extremely weathered, low strength, dry		2		190.7 mm Blade: 0 m to 5 m (Air rotary) 3 - 5 mm washed, rounded, quartz gravel pack: 1.7 m to 5 m
	Gravel: light reddish, orange, extremely weathered, low strength, dry		362		50 mm uPVC Class 18 machine slotted casing, slot aperture: 1 mm, slot length: mm, slots / m, 2 m to 5 m
	Sand: light reddish, orange, distinctly weathered, low strength, dry		4		
			360		End cap End of hole: 5 m BGL Dry

Date Drilled:19/10/2017

Driller: Anthony Watkinson

Drill Rig: Edson 8000

Drilling Company: Strategic Minerals

Drilling Method: Air Rotary

Logged By: Brad North

Easting: 735694 mE

Northing: 7807936 mN

Datum: MGA94z54

RL: 365.2

TD: 5.0

hydrogeologist.com.au

Project No.: 4090

Project Name: Big Vein South

MONITORING BORE

MB3B

Geological Units	Material Description	Graphic Log	R.L. (mAHD) / Depth (mbGL)	Bore Construction	Bore Description
			366 / 0		Protective lockable steel collar: +0.6 m Stick up: +0.5 m
Alluvium	Sand: dark reddish, brown, extremely weathered, very low strength, dry				
	Sand: dark reddish, brown, extremely weathered, very low strength, dry		364 / 2		190.7 mm Blade: 0 m to 17 m (Air rotary)
	Sand: light reddish, brown, extremely weathered, very low strength, dry		362 / 4		Bentonite grout (2.5 %): 0 m to 7 m
Weathered profile	Siltstone: light reddish, brown, distinctly weathered, low strength, Dry		360 / 6		50 mm uPVC Class 18 blank casing: 0 m to 17.5 m
	Siltstone: light reddish, brown, distinctly weathered, low strength, Dry		358 / 8		Bentonite seal: 7 m to 9 m
	Siltstone: dark bluish, grey, distinctly weathered, low strength, damp		356 / 10		
	Siltstone: light bluish, grey, distinctly weathered, low strength, damp		354 / 12		
	Siltstone: light bluish, grey, distinctly weathered, low strength, wet				3 - 5 mm washed, rounded, quartz gravel pack: 9 m to 20.5 m
	Siltstone: light greyish, brown, slightly weathered, low strength, wet		352 / 14 350 / 16		
	Siltstone: light greyish, brown, slightly weathered, medium strength, wet		348 / 18 346 / 20		139.7 mm Hammer: 17 m to 34 m (Air rotary) 50 mm uPVC Class 18 machine slotted casing, slot aperture: 1 mm, slot length: mm, slots / m, 17.5 m to 20.5 m End cap
			344 / 22		Bentonite seal: 20.5 m to 21.5 m
Proterozoic	Schist: dark bluish, grey, fresh, medium strength, wet		342 / 24 340 / 26 338 / 28 336 / 30 334 / 32 332 / 34		Gravel backfill: 23 m to 34 m

Date Drilled:18/10/2017

Driller: Anthony Watkinson

Drill Rig: Edson 8000

Drilling Company: Strategic Minerals

Drilling Method: Air Rotary

Logged By: Brad North

Easting: 735714 mE RL: 365.1

Northing: 7807928 mN TD: 34.0

Datum: MGA94z54

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Project No.: 4090

Project Name: Big Vein South

MONITORING BORE

MB4A

Geological Units	Material Description	Graphic Log	R.L. (mAHD) / Depth (mbGL)	Bore Construction	Bore Description
			388 / 0		Protective lockable steel collar: +0.6 m Stick up: +0.5 m
Weathered profile	Sand: dark reddish, brown, extremely weathered, very low strength, dry		386 / 2		190.7 mm Blade: 0 m to 2 m (Air rotary) 139.7 mm Hammer: 2 m to 13 m (Air rotary)
	Sand: Dark Reddish, Brown, distinctly weathered, low strength, dry		384 / 4		Bentonite grout (2.5 %): 0 m to 5 m 50 mm uPVC Class 18 blank casing: 0 m to 10 m
	Gravel: light reddish, brown, slightly weathered, low strength, dry		382 / 6		Bentonite seal: 5 m to 7 m
	Gravel: light reddish, brown, slightly weathered, low strength, dry		380 / 8 378 / 10 376 / 12		3 - 5 mm washed, rounded, quartz gravel pack: 7 m to 13 m 50 mm uPVC Class 18 machine slotted casing, slot aperture: 1 mm, slot length: mm, slots / m, 10 m to 13 m
			374 / 14		End cap 13 m End of hole: 13 m BGL Dry

Date Drilled:23/10/2017

Driller: Anthony Watkinson

Drill Rig: Edson 8000

Drilling Company: Strategic Minerals

Drilling Method: Air Rotary

Logged By: Brad North

Easting: 740184 mE RL: 387.3

Northing: 7805478 mN TD: 13.0

Datum: MGA94z54

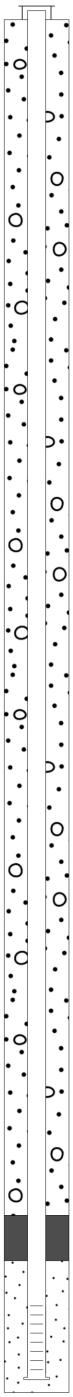
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Project No.: 4090

Project Name: Big Vein South

MONITORING BORE

MB4B

Geological Units	Material Description	Graphic Log	R.L. (mAHD) / Depth (mbGL)	Bore Construction	Bore Description
Weathered profile	Sand: dark reddish, brown, distinctly weathered, very low strength, dry		390 / 388 / 386 / 384 / 382 / 380 / 378 / 376 / 374 / 372 / 370 / 368 / 366 / 364 / 362 / 360 / 358 / 356 / 354 / 352 / 350 / 348 / 346 / 344 / 342 / 340 / 338 / 336 / 334 / 332 / 330 / 328 / 326 / 324		Protective lockable steel collar: +0.6 m Stick up: +0.5 m 190.7 mm Blade: 0 m to 10 m (Air rotary)
	Sand: light reddish, black, slightly weathered, very low strength, dry		0 / 2 / 4 / 6 / 8 / 10 / 12 / 14 / 16 / 18 / 20 / 22 / 24 / 26 / 28 / 30 / 32 / 34 / 36 / 38 / 40 / 42 / 44 / 46 / 48 / 50 / 52 / 54 / 56 / 58 / 60 / 62 / 64		
	Sand: Light Greyish, Black, slightly weathered, very low strength, dry				
	Sand: light yellowish, grey, slightly weathered, low strength, dry				
	Gravel: light yellowish, grey, slightly weathered, very low strength, dry				
	Gravel: light yellowish, grey, slightly weathered, very low strength, dry				
	Gravel: light yellowish, grey, slightly weathered, very low strength, dry				139.7 mm Hammer: 10 m to 60 m (Air rotary)
Jurassic strata	Sandstone: light yellowish, brown, distinctly weathered, medium strength, dry				
Proterozoic	Granite: light bluish, grey, fresh, high strength, dry				Gravel backfill: 0 m to 53 m
	Granite: light bluish, grey, fresh, high strength, dry				Bentonite seal: 53 m to 55 m 3 - 5 mm washed, rounded, quartz gravel pack: 55 m to 60 m 50 mm uPVC Class 18 machine slotted casing, slot aperture: 1 mm, slot length: mm, slots / m, 57 m to 60 m End cap End of hole: 60 m BGL

Date Drilled:22/10/2017

Driller: Anthony Watkinson

Drill Rig: Edson 8000

Drilling Company: Strategic Minerals

Drilling Method: Air Rotary

Logged By: Brad North

Easting: 740147 mE

Northing: 7805488 mN

RL: 387.1

TD: 60.0

Datum: MGA94z54

hydrogeologist.com.au

Project No.: 4090

Project Name: Big Vein South

MONITORING BORE

MB5A

Geological Units	Material Description	Graphic Log	R.L. (mAHD) / Depth (mbGL)	Bore Construction	Bore Description
			380 / 0		Protective lockable steel collar: +0.76 m Stick up: +0.54 m
Weathered profile	Sandstone: dark reddish, brown, extremely weathered, very low strength, dry		378 / 2		190.7 mm Blade: 0 m to 2 m (Air rotary)
	Sandstone: dark reddish, orange, distinctly weathered, low strength, dry		376 / 4		Bentonite grout (2.5%): 0 m to 5 m
			374 / 6		
			372 / 8		139.7 mm Hammer: 2 m to 40 m (Air rotary)
	Sandstone: light reddish, brown, slightly weathered, low strength, dry		370 / 10		
			368 / 12		Gravel backfill: 5 m to 28 m
	Sandstone: light reddish, orange, slightly weathered, low strength, dry		366 / 14		
			364 / 16		
			362 / 18		
			360 / 20		50 mm uPVC Class 18 blank casing: 0 m to 40.7 m
			358 / 22		
			356 / 24		
Jurassic strata	Sandstone: light greyish, white, fresh, low strength, dry		354 / 26		
			352 / 28		
			350 / 30		Bentonite seal: 28 m to 30 m
	Sandstone: light greyish, orange, fresh, low strength, dry		348 / 32		
			346 / 34		3 - 5 mm washed, rounded, quartz gravel pack: 30 m to 40 m
	Sandstone: light greyish, white, fresh, low strength, dry		344 / 36		
			342 / 38		
	Sandstone: light greyish, white, fresh, low strength, dry		340 / 40		50 mm uPVC Class 18 machine slotted casing, slot aperture: 1 mm, slot length: mm, slots / m, 37 m to 40 m
			338 / 42		End cap End of hole: 40 m BGL

Date Drilled:24/10/2017

Driller: Anthony Watkinson

Drill Rig: Edson 8000

Drilling Company: Strategic Minerals

Drilling Method: Air Rotary

Logged By: Brad North

Easting: 738475 mE

Northing: 7804999 mN

RL: 378.9

TD: 40.0

Datum: MGA94z54

hydrogeologist.com.au

Project No.: 4090

Project Name: Big Vein South

MONITORING BORE

MB5B

Geological Units	Material Description	Depth (mbGL) / R.L. (mAHD)	Bore Construction	Bore Description
Weathered profile	Sandstone: dark reddish, brown, extremely weathered, very low strength, dry	0 / 378		Protective lockable steel collar: +0.6 m Stick up: +0.5 m
	Sandstone: dark reddish, brown, distinctly weathered, very low strength, dry	2 / 376		190.7 mm Blade: 0 m to 14 m (Air rotary)
	Sandstone: light reddish, brown, slightly weathered, very low strength, dry	4 / 374		Bentonite grout (2.5 %): 0 m to 5 m
	Sandstone: light yellowish, brown, slightly weathered, very low strength, dry	6 / 372		
	Sandstone: light greyish, orange, slightly weathered, low strength, dry	8 / 370 – 24 / 354		
Jurassic strata	Sandstone: light greyish, white, fresh, low strength, dry	24 / 354 – 40 / 338		Gravel backfill: 5 m to 79 m
Proterozoic	Schist: light bluish, grey, fresh, high strength, dry	40 / 338 – 64 / 314		139.7 mm Hammer: 14 m to 90 m (Air rotary)
	Schist: light bluish, grey, fresh, high strength, dry	64 / 314 – 74 / 304		50 mm uPVC Class 18 blank casing: 0 m to 87 m
	Schist: light bluish, grey, fresh, high strength, dry	74 / 304 – 76 / 302		
	Schist: light bluish, grey, fresh, high strength, dry	76 / 302 – 80 / 298		Bentonite seal: 79 m to 81 m
	Schist: light bluish, grey, fresh, high strength, dry	80 / 298 – 90 / 288		3 - 5 mm washed, rounded, quartz gravel pack: 81 m to 90 m 50 mm uPVC Class 18 machine slotted casing, slot aperture: 1 mm, slot length: mm, slots / m, 87 m to 90 m End cap End of hole: 90 m BGL Dry

Date Drilled:23/10/2017

Driller: Anthony Watkinson

Drill Rig: Edson 8000

Drilling Company: Strategic Minerals

Drilling Method: Air Rotary

Logged By: Brad North

Easting: 738484 mE RL: 378.7

Northing: 7805001 mN TD: 90.0

Datum: MGA94z54

hydrogeologist.com.au

Project No.: 4090

Project Name: Big Vein South

MONITORING BORE

MB6A

Geological Units	Material Description	Graphic Log	R.L. (mAHD) / Depth (mbGL)	Bore Construction	Bore Description
			378		
			0		Protective lockable steel collar: +0.6 m Stick up: +0.5 m
Weathered profile	Sand: dark reddish, brown, extremely weathered, very low strength, dry		376		139.7 mm Hammer: 0 m to 10.5 m (Air rotary)
	Sand: light reddish, orange, distinctly weathered, low strength, dry		2		Bentonite grout (2.5 %): 0 m to 4.4 m
	Sandstone: Light Reddish, Brown, distinctly weathered, low strength, dry		374 4 372		50 mm uPVC Class 18 blank casing: 0 m to 7 m Bentonite seal: 4.4 m to 5.4 m
	Sandstone: light greyish, white, slightly weathered, low strength, dry		6 370 8		3 - 5 mm washed, rounded, quartz gravel pack: 7 m to 10 m 50 mm uPVC Class 18 machine slotted casing, slot aperture: 1 mm, slot length: mm, slots / m, 7 m to 10 m
	Sandstone: light greyish, brown, slightly weathered, low strength, dry		368		Failed to airlift
Proterozoic	Schist: dark bluish, grey, fresh, low strength, dry		10		End cap Bentonite seal: 10 m to 10.5 m End of hole: 10.5 m BGL

Date Drilled:21/10/2017

Driller: Anthony Watkinson

Drill Rig: Edson 8000

Drilling Company: Strategic Minerals

Drilling Method: Air Rotary

Logged By: Brad North

Easting: 737520 mE

Northing: 7806379 mN

RL: 377.0

TD: 10.5

Datum: MGA94z54

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Project No.: 4090

Project Name: Big Vein South

MONITORING BORE

MB6B

Geological Units	Material Description	Graphic Log	R.L. (mAHD) / Depth (mbGL)	Bore Construction	Bore Description
			380 /		
			378 /		
Weathered profile	Sandstone: dark reddish, brown, extremely weathered, very low strength, damp		376 / 0		Protective lockable steel collar: +0.6 m Stick up: +0.5 m
	Sandstone: dark reddish, brown, distinctly weathered, low strength, dry		374 / 2		
	Sandstone: light reddish, brown, distinctly weathered, low strength, dry		372 / 4		Bentonite grout (2.5 %): 0 m to 5 m
	Sandstone: light greyish, brown, slightly weathered, low strength, dry		370 / 6		190.7 mm Blade: 0 m to 6 m (Air rotary)
	Sandstone: light greyish, white, slightly weathered, low strength, dry		368 / 8		
			366 / 10		
			364 / 12		
			362 / 14		
Proterozoic	Schist: light greyish, brown, fresh, low strength, dry		360 / 16		
			358 / 18		
	Schist: dark reddish, brown, fresh, low strength, dry		356 / 20		
			354 / 22		
			352 / 24		
			350 / 26		
	Schist: light reddish, brown, fresh, medium strength, dry		348 / 28		
			346 / 30		139.7 mm Hammer: 6 m to 84 m (Air rotary)
			344 / 32		
			342 / 34		
			340 / 36		
			338 / 38		
	Schist: light bluish, brown, fresh, high strength, dry		336 / 40		
	Schist: light bluish, grey, fresh, high strength, dry		334 / 42		
			332 / 44		50 mm uPVC Class 18 blank casing: 0 m to 63 m
	Schist: light bluish, grey, fresh, high strength, dry		330 / 46		
			328 / 48		
			326 / 50		
			324 / 52		
			322 / 54		
			320 / 56		Bentonite seal: 56 m to 58 m
			318 / 58		
			316 / 60		3 - 5 mm washed, rounded, quartz gravel pack: 58 m to 66 m
			314 / 62		
			312 / 64		50 mm uPVC Class 18 machine slotted casing, slot aperture: 1 mm, slot length: mm, slots / m, 63 m to 66 m
			310 / 66		Bentonite seal: 66 m to 67 m
	Schist: light bluish, grey, fresh, high strength, dry		308 / 68		
			306 / 70		
			304 / 72		Gravel backfill: 67 m to 84 m
			302 / 74		
			300 / 76		Very low recovery after initial lift. Sampled after 15 minutes, then purged dry. Bore development: 15 minutes; EC: 14630 □S/cm; pH: 8.2 Airlift flow rate: <0.01 L/s
			298 / 78		
	Schist: light bluish, grey, fresh, high strength, dry		296 / 80		
			294 / 82		
			292 / 84		End cap End of hole: 84 m BGL
			290 / 86		
			/ 88		

Date Drilled:21/10/2017

Driller: Anthony Watkinson

Drill Rig: Edson 8000

Drilling Company: Strategic Minerals

Drilling Method: Air Rotary

Logged By: Brad North

Easting: 737493 mE RL: 376.8

Northing: 7806364 mN TD: 84.0

Datum: MGA94z54

hydrogeologist.com.au

Project No.: 4090

Project Name: Big Vein South

MONITORING BORE

MB7A

Geological Units	Material Description	Graphic Log	R.L. (mAHD) / Depth (mbGL)	Bore Construction	Bore Description
			390 / 0		Protective lockable steel collar: +0.6 m Stick up: +0.5 m
Weathered profile	Sandstone: dark reddish, brown, extremely weathered, low strength, dry				
	Sandstone: light reddish, orange, extremely weathered, low strength, dry		388 / 2		190.7 mm Blade: 0 m to 4 m (Air rotary)
	Sandstone: light reddish, grey, distinctly weathered, low strength, dry		386 / 4 384 / 6 382 / 8 380 / 10		139.7 mm Hammer: 4 m to 33 m (Air rotary) Bentonite grout (2.5 %): 0 m to 7 m 50 mm uPVC Class 18 blank casing: 0 m to 33 m
	Sandstone: light greyish, white, slightly weathered, low strength, dry		378 / 12 376 / 14 374 / 16		Gravel backfill: 7 m to 25.5 m
Jurassic strata	Siltstone: dark greyish, black, fresh, low strength, dry		372 / 18		
	Siltstone: dark greyish, black, fresh, low strength, dry		370 / 20		
	Sandstone: light greyish, white, fresh, low strength, dry		368 / 22 366 / 24 364 / 26		Bentonite seal: 25.5 m to 27.5 m
	Sandstone: light reddish, brown, fresh, medium strength, dry		362 / 28 360 / 30		3 - 5 mm washed, rounded, quartz gravel pack: 27.5 m to 33 m 50 mm uPVC Class 18 machine slotted casing, slot aperture: 1 mm, slot length: mm, slots / m, 30 m to 33 m
Proterozoic	Gravel: light reddish, brown, fresh, medium strength, dry		358 / 32 34		End cap End of hole: 33 m BGL Dry

Date Drilled:18/10/2017

Driller: Anthony Watkinson

Drill Rig: Edson 8000

Drilling Company: Strategic Minerals

Drilling Method: Air Rotary

Logged By: Brad North

Easting: 740039 mE RL: 390.9

Northing: 7803777 mN TD: 33.0

Datum: MGA94z54

hydrogeologist.com.au

Project No.: 4090

Project Name: Big Vein South

MONITORING BORE

MB7B

Geological Units	Material Description	Graphic Log	R.L. (mAHD) / Depth (mbGL)	Bore Construction	Bore Description
Weathered profile	Sandstone: dark reddish, brown, extremely weathered, low strength, dry		390 / 0		Protective lockable steel collar: +0.6 m Stick up: +0.5 m
	Sandstone: reddish, brown, extremely weathered, low strength, dry		388 / 2		
	Sandstone: light reddish, brown, distinctly weathered, low strength, dry		386 / 4		190.5 mm Blade: 0 m to 3 m (Air rotary)
	Sandstone: light reddish, orange, slightly weathered, low strength, dry		384 / 6		
	Sandstone: light greyish, orange, fresh, medium strength, dry		382 / 8		Bentonite grout (2.5 %): 0 m to 7.5 m
	Sandstone: light greyish, orange, slightly weathered, low strength, dry		380 / 10		
	Sandstone: light reddish, orange, slightly weathered, low strength, dry		378 / 12		
	Sandstone: light greyish, grey, slightly weathered, low strength, dry		376 / 14		
	Sandstone: light greyish, orange, slightly weathered, low strength, dry		374 / 16		
	Siltstone: light greyish, black, slightly weathered, low strength, dry		372 / 18		
Jurassic strata	Siltstone: light greyish, grey, fresh, low strength, dry		370 / 20		
	Sandstone: light greyish, white, fresh, low strength, dry		368 / 22		139.7 mm Hammer: 3 m to 90 m (Air rotary)
	Sandstone: light reddish, grey, fresh, low strength, dry		366 / 24		
	Sandstone: light bluish, grey, fresh, low strength, dry		364 / 26		
Proterozoic	Schist: light bluish, grey, fresh, medium strength, dry		362 / 28		50 mm uPVC Class 18 blank casing: 0 m to 87 m
	Schist: light greenish, grey, fresh, medium strength, dry		360 / 30		
	Schist: dark greenish, grey, fresh, medium strength, dry		358 / 32		
	Schist: dark greenish, grey, fresh, medium strength, dry		356 / 34		
			354 / 36		
			352 / 38		
			350 / 40		
			348 / 42		
			346 / 44		
			344 / 46		
			342 / 48		
			340 / 50		
			338 / 52		Gravel backfill: 7.5 m to 61 m
			336 / 54		
			334 / 56		
			332 / 58		
			330 / 60		
			328 / 62		Bentonite seal: 61 m to 63 m
			326 / 64		
			324 / 66		
	Schist: dark greenish, grey, fresh, high strength, dry		322 / 68		3 - 5 mm washed, rounded, quartz gravel pack: 63 m to 90 m
			320 / 70		
			318 / 72		
			316 / 74		Slow recovery/recharge. Purger dry. Bore development: 40 minutes; EC: 422.5 □S/cm; pH: 8.5 Airlift flow rate: 0.01 L/s
			314 / 76		
			312 / 78		
			310 / 80		
			308 / 82		
			306 / 84		
			304 / 86		
			302 / 88		50 mm uPVC Class 18 machine slotted casing, slot aperture: 1 mm, slot length: mm, slots / m, 87 m to 90 m End cap End of hole: 90 m BGL
			300 / 90		
			298 / 92		
			296 / 94		

Date Drilled:17/10/2017

Driller: Anthony Watkinson

Drill Rig: Edson 8000

Drilling Company: Strategic Minerals

Drilling Method: Air Rotary

Logged By: Brad North

Easting: 740023 mE

Northing: 7803794 mN

RL: 390.7

TD: 90.0

Datum: MGA94z54

Appendix D Numerical groundwater modelling report

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Appendix D 1 Calibration hydrographs

Big Vein South
Numerical Groundwater Modelling Report

Prepared for

Strategic Minerals Corporation NL

D1. Introduction

hydrogeologist.com.au has developed a 3D numerical groundwater flow model for the Big Vein South (BVS) Project (the project) to simulate the existing conditions of the groundwater regime and provide predictions of the potential impacts of the proposed mining activities.

The model represents the hydrogeology of the project area and its surrounds based on the conceptual groundwater model described in Section 5 of the Groundwater Report and the proposed mine plan and mining schedule.

The groundwater modelling used conservative parameters and values and is considered to represent the worst-case scenario for potential groundwater impacts resulting from the project.

The modelling results presented in this report have been used to support the assessment of groundwater impacts presented in the Groundwater Report. The specific objectives of the model included:

- predicting changes to local and regional groundwater flow regimes due to the project;
- predicting project-specific drawdown on groundwater resources, users and the environment;
- estimating groundwater inflow into the proposed open pits;
- predicting cumulative drawdown on groundwater resources, users and the environment; and
- addressing regulatory requirements in relation to groundwater modelling.

This report provides a detailed description of the modelling, including model design and construction, calibration, predictions and sensitivity analysis. This report is presented as a technical appendix to the Groundwater Report and is intended to be read in conjunction with the groundwater assessment presented in the Groundwater Report.

The report is structured as follows:

- Section D1 – Introduction and overview of the report scope and structure.
- Section D2 – Model design, construction and calibration.
- Section D3– Model predictive simulation and sensitivity analysis.
- Section D4 – References.

D2. Model design

D2.1. Model code selection

MODFLOW-USG (Panday *et al.*, 2015) was used as the modelling code. MODFLOW-USG is an "unstructured grid" version of MODFLOW that optimises the model grid and increases numerical stability by using unstructured, variably sized cells (Panday *et al.*, 2013). These cells take any polygonal shape, with variable size constraints allowing for refinement in areas of interest. It also facilitates implementation of pinching-out layers and/or layer discontinuities within the model domain. This can greatly reduce the number of grid cells within the model domain and thus reduce the model runtimes.

MODFLOW-USG is also able to simulate unsaturated conditions, allowing progressive dewatering and rewetting to be represented by the model.

MODFLOW-USG is widely used and accepted by groundwater modelling specialists for mining projects.

D2.2. Model domain

The model domain is shown in Figure D 1. The domain covers an area of approximately 123 km^2, extending approximately 15 km northeast-southwest and 8 km northwest-southeast.

The model domain extents were designed to be large enough to:

- encompass the full extent of drawdown associated with the project; and
- remove significant interaction (i.e., boundary effects) between the drawdown associated with mining activities and the model boundary conditions.

Natural geological, hydrological and hydrogeological features such as groundwater units, geological structures, watercourses and catchment boundaries were also considerations in determining the extents of the model domain, as required. Details are provided in Section 5 of the Groundwater Report.

D2.3. Model processing and discretisation

Algomesh (Merrick, 2016) was used to develop an unstructured grid based on Voronoi polygons and to calculate cell conductivities along with geometries of connected cell interfaces necessary for execution of the MODFLOW-USG model. The model mesh is comprised of 12,049 active cells, which range in area of between 200 m^2 to 363,000 m^2. The model mesh was refined around the Woolgar River and its tributaries, proposed mine footprints, geological boundaries and the location of observation sites. The extent of the model mesh, illustrating the refinement around the various spatial definition features, is shown in Figure D 1.

The transient period used for model calibration consists of quarterly stress periods, as detailed in Table D 1 below. The prediction uses variable stress period lengths, alternating between three months and nine months (two stress periods per year) to accommodate the seasonality of recharge and surface stream flow. Variable time-steps were applied within each stress period, ranging from a minimum of 0.1 days to a maximum of three months.

Table D 1 Model temporal discretisation

Stress period	Stress period length	Dates	Modelling phase
1	N/A	N/A	Steady state, pre-mine development
2 – 21	3 months	01/01/2017 – 31/12/2021	Transient calibration period
22 – 43	3 months, 9 months	01/01/2022 – 31/12/2032	Prediction (mining) period

D2.4. Model layers

The relevant hydrogeological units of the project site and its surrounds broadly comprise:

- shallow, localised deposits of alluvium associated with the Woolgar River;
- a weathered zone developed on the Jurassic strata and Proterozoic basement;
- Jurassic strata; and
- Proterozoic basement.

The model was constructed with four layers to represent these hydrogeological units. Table D 2 lists the model layer numbers and the corresponding hydrostratigraphic units.

Table D 2 Model layer definition

Model layer	Hydrogeological unit	Average thickness (m)	Maximum thickness (m)	# Cells per layer
1	Cainozoic alluvium	3.9	6.0	775
2	Weathered profile	15.3	42.5	12,049
3	Jurassic strata	28.7	156.3	9,661
4	Proterozoic basement	178.0	245.3	12,049

The combined surface elevation of Layers 1 and 2 (topography) was obtained from the proponent. The thickness of the layers was developed from data provided by the proponent, supplemented with publicly available data as discussed in Section 4 of the Groundwater Report.

Layer 1 and Layer 2 represent the unconfined Cainozoic alluvium and the weathered profile. Layer 3 represents the Jurassic strata. Layer 4 represents the Proterozoic basement.

The extent and elevation of the top of the Cainozoic alluvium (Layer 1), weathered profile (Layer 2), Jurassic strata (Layer 3) and Proterozoic basement (Layer 4) are shown in Figure D 2 to Figure D 5.

Layers 2 and 4 are present across the entire model domain, with Layer 1 pinching out where it sub-crops against Layer 2, and Layer 3 pinching out where it sub-crops against Layer 4.

D2.5. Model boundary conditions

Boundary conditions are necessary for solution of the 3D groundwater flow equation that is implemented by MODFLOW-USG. They also provide a means by which auxiliary groundwater fluxes and stresses can be specified within the model. The following boundary conditions have been adopted in the model.

D2.5.1. Rainfall recharge

Recharge was applied in zones based on the extents of outcropping geological units, using the MODFLOW Recharge (RCH) module. Recharge was calculated as a percentage of rainfall and the porosity of the strata through which it infiltrates. The zones are defined by the extents of Cainozoic alluvium, weathered profile, Jurassic strata and Proterozoic basement, and are shown in Figure D 6. The percentage of rainfall that enters the model as recharge in each zone was optimised during calibration.

D2.5.2. Evapotranspiration

Evapotranspiration was applied in zones, using the MODFLOW Evapotranspiration (EVT) module. The zones were defined by the extent of the Cainozoic alluvium and weathered profile and are shown in Figure D 7. An extinction depth of 1.5 m was applied to the Cainozoic alluvium, while an extinction depth of 1.0 m was applied to the weathered profile. The maximum rate of evapotranspiration was set to 80% of the average annual evapotranspiration.

D2.5.3. Surface drainage

Surface water drainage was applied using the MODFLOW River (RIV) module along the extent of the Woolgar River and its minor tributaries (Figure D 8). The RIV module simulates a head-dependent flux boundary and is an appropriate boundary type to simulate the ephemeral river and creeks in the vicinity of the project site.

The RIV cells representing the Woolgar River (Zone 1) and a main tributary (Zone 3) were set as intermittently flowing for the first three months of the year, while the remaining surface streams (Zone 2) were set as dry with no head and acted as drains to remove water from the system. A vertical hydraulic conductivity of 1.411 m/day was applied to Zones 1 and 3, with a vertical hydraulic conductivity of 0.181 m/day applied to the remaining surface streams (Zone 2).

A stream width of 15 m was applied to the Woolgar River (Zone 1), while a stream width of 2 m was applied to Zones 2 and 3. Bed thicknesses of 3 m were applied to the Woolgar River (Zone 1), 2 m to the main Woolgar River tributary (Zone 3), and 1 m to the remaining surface streams (Zone 2). Hydraulic conductance was calculated for each individual cell based on the cell geometry and stream dimensions.

D2.5.4. General head boundaries

General head boundary cells were applied to the perimeter of the model domain using the MODFLOW General Head Boundary (GHB) module. This boundary type allows for the regional groundwater flow system to be reliably replicated at a sub-regional scale and ultimately improves the predictive capability of the model. 'No-flow' boundaries were applied parallel to regional groundwater flow (across the north-western and south-eastern model boundaries). A general head boundary was applied along the south-western model boundary to Layer 2 to Layer 4. The head elevation along this boundary was derived from the CSIRO GAB potentiometric surfaces dataset (Potentiometric surface of the Cadna-owie – Hooray Aquifer, catalogue number 76929). The general head boundary was optimised as part of the calibration process. The location of the general head boundary is shown in Figure D 9.

D2.5.5. Mining

Mine dewatering for the project was simulated using the MODFLOW Drain (DRN) module. The drain cells allow for one-way flow of water out of the model. When the computed head drops below the stage elevation of the drain, the drain cells become inactive. This is an effective way of theoretically representing the removal of water seeping into a mine over time, with the actual removal of water being via pumping and evaporation.

To simulate the open cut mines, drain cells were applied to all active layers from the surface to the Proterozoic basement to ensure full desaturation of the layers above the Proterozoic. The conductance of the drain cells was set to 100 m^2/day.

The extent of the drain cells applied to represent mining activity are shown in Figure D 10.

D2.6. Calibration process and metrics

Model calibration was performed to optimise the model parameter values so that the model can better replicate historical observations of the system state. The outcome of the calibration process also provides the initial conditions for the transient predictive simulations used to assess the potential impacts of the project on the groundwater regime.

D2.6.1. Calibration approach

The calibration process was initially run in steady state. The results of the steady state calibration were used to establish the initial groundwater levels for the transient calibration.

The transient calibration encompassed the period of January 2017 to December 2021. A quarterly stress period length was applied to represent seasonal climactic variations and intermittent surface flows.

Calibration was performed by applying both automated PEST (Doherty, 2019a, 2019b) routines and a manual trial-and-error approach. Both approaches assumed that all hydraulic parameters, recharge rate, and the general head boundary, were uncertain and able to be modified to achieve a better calibration fit. Prior to calibration, upper and lower bounds were set for each of the tested parameters based on available hydraulic testing within the vicinity of the project. The industry-accepted calibration software PEST was employed in estimation mode to streamline the calibration process and provide rapid indication of the most sensitive parameters, and which parameters required adjustment to improve the calibration fit. PEST is a powerful tool that provides rapid feedback on the adequacy of a conceptual model. Where PEST reports that limits on particular parameters, or groups of parameters, are required to be breached to achieve a better calibration fit, there can be increased scrutiny on the field and model data supporting the parameter limit. Following PEST calibration, manual calibration optimisation was undertaken to individually adjust key parameters identified by PEST.

D2.6.2. Convergence criteria

Model convergence occurs when the maximum absolute change in groundwater level (hydraulic head) between model calculation steps is less than the specified convergence criteria (also called the "head change" criteria). The Australian Groundwater Modelling Guidelines (AGMG) (Barnett *et al.*, 2012), recommends[1] that the convergence criteria are set one or two orders of magnitude smaller than the level of accuracy required by the groundwater level predictions.

The convergence criteria adopted for the groundwater model are as follows:

- 0.0005 m (0.5 mm) for the steady-state model calibration; and
- 0.005 m (5 mm) for the transient model calibration.

Section 6.2.1 of the Groundwater Report explains that a 1 m change in groundwater level represents the reasonable limit of accuracy that can be inferred from groundwater modelling. Hence, the convergence criteria adopted are more than two orders of magnitude smaller than the level of accuracy required from the model and therefore exceed the convergence criteria specified in the AGMG.

The model achieved the adopted convergence criteria at all modelled time steps/stress periods.

[1] See Table 5-1 of the Australian Groundwater Modelling Guidelines (AGMG).

D2.6.3. Calibration targets

A total of 454 individual measurements from 12 observation sites were used in the calibration process. These measures represented the most reliable water level measurements available over the transient simulation period. Section 4 of the Groundwater Repot describes how these data were sourced. The location of the observation sites is shown in Figure D 11.

The calibration data were weighted in accordance with the AGMG recommendations to balance the contribution of each monitoring site to the model calibration and ensure that that no single monitoring site unduly dominates the calibration (i.e. to avoid population biases). This applied weighting is based on the inverse of the square root of the sample count which ensures an equal weighting across monitoring sites without any population bias. This is a classical statistical weighting method and is the standard weighting method used for groundwater model calibration in Australia.

D2.6.4. Calibration results

The calibration results are shown as follows:

- A scatter plot of predicted versus observed hydraulic heads (for both the unweighted and weighted calibration data) is presented in Figure D 12. This plot shows the correlation between all measured and modelled groundwater levels.
- The calibration hydrographs comparing measured and modelled data are provided in Appendix D 1. These hydrographs show the temporal distribution of modelled and observed groundwater levels over the calibration period.
- The statistics from the calibrated model are reported in Table D 3, and include both the unweighted and weighted results.

The quality of the transient calibration results was evaluated in accordance with the guiding principles of the AGMG and using the key quantitative measures and qualitative measures recommended in the AGMG, as follows:

- Key qualitative measures:
    - The hydrographs presented in Appendix D1 demonstrate visually that the model has replicated the observed groundwater level trends and patterns.
    - The model replicates the vertical hydraulic gradients shown in Figures 12 to 15.
    - The model replicates the observed groundwater flow patterns described in Section 5 of the Groundwater Report.
- Key quantitative measures:
    - Correlation and residual error – Figure D12 demonstrates that the measured and modelled groundwater levels are suitably correlated (i.e. that the model achieved a "good fit" to the measurements).
    - Scaled Root Mean Squared (SRMS) error –
        - The SRMS error is a useful descriptor of goodness of fit when the objective is to fit historical measurements of heads. The SRMS error calculation method is described in Section 5.3.3 of the AGMG. It is summarised in Equation 5.2 of the AGMG as the root mean squared (RMS) divided by the range of measured heads (Δh) and expressed as a percentage, with weighting (W) introduced as necessary to account for different levels of confidence in different measurements.
        - Table D3 shows that the calibration achieved a weighted SRMS error of 1.67% which demonstrates a very good fit to the weighted groundwater level observations used in the calibration.
        - Table D3 also shows that the calibration achieved an unweighted SRMS error of 9.83% which, although less relevant than the weighted SMRS error, shows that the model still provides a good match to the raw groundwater level observations (i.e. less than 10% error).

Table D 3 Summary of model calibration performance

Statistical measure		Unit	Value (unweighted)	Value (weighted)
Number of observations	n	-	454	
Range of measured heads	ΔH	m	36.15	
Sum of squared residuals	SSQ, Φ	m^2	5,728.83	164.78
Residual mean	MSR	m	1.51	0.25
Scaled absolute residual mean	SMSR	%	4.17	0.70
Root mean squared error	RMS	m	3.55	0.60
Scaled root mean squared error	SRMS	%	9.83	1.67

These results show that the model achieved the optimal overall calibration of quantitative and qualitative measures including groundwater levels and trends, vertical hydraulic gradients and the observed groundwater flow patterns and on this basis the model calibration is considered to be robust.

D2.7. Calibrated hydraulic parameters

Table D 4 lists the calibrated hydraulic conductivity values and the calibrated storage parameters for each model layer. Hydraulic conductivity values in Layers 2 to 4 were applied in zones based on geology mapping. The extent of these zones is illustrated in Figure D 13 to Figure D 15.

Table D 4 Summary of calibrated hydraulic properties

Layer	Zone	Geological unit	Calibrated Kh	Calibrated Kz	Calibrated Ss (m^{-1})	Calibrated Sy (-)
1	1	Cainozoic alluvium	20	4.17	1.00×10^{-2}	8.27×10^{-2}
2	2	Weathered profile	2.27	1.25	1.00×10^{-3}	1.06×10^{-4}
2	3	Weathered profile	1.73	6.96×10^{-1}	3.16×10^{-5}	3.74×10^{-4}
2	4	Weathered profile	6.00	2.52	1.00×10^{-3}	1.31×10^{-3}
2	5	Weathered profile	1.00×10^{-3}	5.71×10^{-4}	3.11×10^{-5}	1.61×10^{-4}
2	6	Weathered profile	1.00×10^{-3}	5.71×10^{-4}	3.11×10^{-5}	1.61×10^{-4}
2	7	Weathered profile	5.50×10^{-1}	1.39×10^{-1}	3.11×10^{-5}	1.61×10^{-4}
2	8	Weathered profile	8.29×10^{-2}	3.63×10^{-2}	6.46×10^{-5}	8.02×10^{-4}
2	9	Weathered profile	2.27	1.25	1.00×10^{-3}	1.06×10^{-4}
3	10	Jurassic strata	4.00	3.55×10^{-1}	5.00×10^{-5}	6.00×10^{-4}
3	11	Jurassic strata	1.00×10^{-3}	1.12×10^{-6}	4.49×10^{-6}	1.02×10^{-6}
3	12	Jurassic strata	1.00×10^{-3}	1.41×10^{-6}	5.00×10^{-4}	5.00×10^{-4}
3	13	Jurassic strata	4.00	3.55×10^{-1}	5.00×10^{-5}	6.00×10^{-4}
3	14	Jurassic strata	4.00	3.55×10^{-1}	5.00×10^{-5}	6.00×10^{-4}
4	15	Proterozoic basement	5.00×10^{-3}	5.00×10^{-5}	7.50×10^{-5}	1.00×10^{-4}
4	16	Proterozoic basement	3.00×10^{-2}	3.00×10^{-2}	7.50×10^{-5}	1.00×10^{-4}
4	17	Proterozoic basement	1.00×10^{-3}	1.00×10^{-5}	7.50×10^{-5}	1.00×10^{-4}
4	18	Proterozoic basement	1.50×10^{-2}	1.16×10^{-2}	7.50×10^{-5}	1.00×10^{-4}
4	19	Proterozoic basement	1.00×10^{-3}	4.90×10^{-4}	7.50×10^{-5}	1.00×10^{-4}
4	20	Proterozoic basement	5.00×10^{-3}	5.00×10^{-5}	7.50×10^{-5}	1.00×10^{-4}
4	21	Proterozoic basement	5.00×10^{-3}	5.00×10^{-5}	7.50×10^{-5}	1.00×10^{-4}

D2.8. Calibrated recharge

Recharge was calibrated against the recorded annual rainfall within the model domain for each stress period of the calibration model run. The percentages of average annual rainfall that converts to recharge were estimated during calibration and are shown below in Table D 5.

Table D 5 Summary of calibrated recharge values

Zone	Geological Unit	Recharge as a % of average annual rainfall
1	Cainozoic alluvium	1.000
2	Weathered profile	0.400
3	Weathered profile (atop elevated Jurassic strata)	0.018
4	Weathered profile (central)	0.110
5	Weathered profile (southern)	0.010

A chloride mass balance (CMB) was performed to independently validate the recharge rates derived through model calibration. A CMB estimates recharge based on annual precipitation and the concentration of chloride in groundwater, rainwater and dry deposition using the following formula:

$$R = PC_{P+D} / C_g$$

Where:

- R is recharge;
- P is rainfall;
- CP+D is the chloride deposition in rainfall and dry deposition (atmospheric fall out); and
- Cg is the chloride concentration in groundwater.

The atmospheric (rainfall and dry deposition) chloride contribution was assumed to be 5.16 kg/ha/year based on indicative data for inland areas of Australia (Davies and Crosbie, 2014). The recorded groundwater chloride concentration varied from 21 to 210 mg/L, as measured in MB2 to MB7 during the project field campaign. Using these values, the CMB-derived groundwater recharge rate was 1.0% to 4.0% of average annual rainfall. This is similar to the recharge rate derived through calibration for zones 1 and 2, which comprise the majority of the model domain (see Figure D 6) and validates the model-derived values.

D2.9. Calibrated general head boundary

Calibrated values applied to the south-western general head boundary ranged from 282 mAHD to 297 mAHD, which reflects the generally flat nature of the topography in this area. An average conductance of 120 m^2/day for the Jurassic strata (Layer 3) and 0.35 m^2/day for the Proterozoic basement(Layer 4) were also applied.

D2.10. Calibrated water balance

The mass balance error of the transient calibration model is the difference between model inflows and model outflows throughout the calibration period. The mass balance error provides an indication as to how well the computed flows (in and out of the model) balance.

Section D2.6.2 describes the convergence criteria that have been applied to the steady state and transient calibration models. An excessively large convergence criterion typically results in unbalanced flows and larger water budget errors (>1%) while a smaller convergence criterion typically results in more precise water budget (e.g. <0.1%).

The AGMG (Barnett *et al.*, 2012), recommends[2] that a mass balance error of less than 1% should be achieved at all times and cumulatively. Hence an error below 1% is generally considered acceptable.

The water budget error for the final stress period in the transient calibration model (December 2021) is presented in Table D 6. The water balance error for the final stress period is zero, indicating that the model is numerically stable and has achieved a perfect numerical solution at the end of the model calibration.

The water budget error for the whole calibration period varied between -0.001 m^3/day to 0.001 m^3/day (~0.0003%). This equates to a total error of less than 0.0063% for all time steps. The 'calibration period' of the model run was numerically stable and has achieved an accurate numerical solution for each timestep and cumulatively over the calibration period.

This outcome confirms that the selected convergence criteria (head change criteria) are appropriate.

Table D 6 Water budget and mass balance error (December 2021)

Water budget item	Inflow (m^3/d)	Outflow (m^3/d)
Woolgar River	258.0	5.9
Recharge	607.4	-
Evapotranspiration	-	141.1
Regional GW flow (GHB)	-	622.9
Storage	407.0	502.5
Total	1272.4	1272.4
Mass balance error	**0.00%**	

[2] See Table 5-1 of the Australian Groundwater Modelling Guidelines (AGMG).

D2.11. Overall calibration performance

The model has been appropriately calibrated to transient conditions based on the following criteria:

- the conceptual model for groundwater flow has been honoured by the calibration;
- calibration-optimised hydraulic data for the key hydrogeological units are within the range of values measured during the field campaigns and derived using independent studies;
- quantitative calibration metrics (e.g., residual errors) are within guideline-recommended ranges (e.g., Barnett *et al.*, 2012); and
- the relative contributions of recharge/discharge processes in the model water balance are within the ranges expected and are supported by independent calculations and field observations (e.g., absence of baseflow in project-site watercourses).

The calibrated model is therefore deemed to be a suitable tool for assessing the regional drawdown impacts from proposed mining operations within the model domain. The predictive scenarios based on the calibrated model are presented in Section D2.12.

D2.12. Confidence level classification

The degree of confidence in the model predictions can be described using a 'confidence classification' scale as presented in the AGMG (Barnett *et al.*, 2012). The classification scale conveys the degree of confidence in the model predictions given the model complexity, available data, level of calibration and consistency between the calibration and predictive analysis. Models can be classified as one of three classes:

- *Class 1* – simple models based on little data that often cannot be calibrated, that are typically used to provide an initial assessment. Class 1 models have the lowest confidence level.
- *Class 2* – more complex models based on moderate amounts of data with reasonable calibration statistics, that are typically used to assess medium risk aquifers. Class 2 models have a moderate confidence level.
- *Class 3* – detailed and complex models based on large amounts of data with good calibration statistics, that are typically used to assess high risk or high value aquifers. Class 3 models have a high confidence level.

The numerical model has been scoped and developed to achieve a Class 2 classification. Table D 7 to Table D 9 below summarizes the classification indicators recommended in the groundwater modelling guidelines (Barnett *et al.*, 2012) for the available data, calibration and consistency between the model calibration and model predictions.

Table D 7 Model classification – available data indicators

Classification indicator	Classification
Climate data	*Class 2*
• Long term rainfall and evaporation data is available in the form of long-term synthetic/interpolated dataset. (Class 2)	
Land use information	*Class 2*
• Local field survey/mapping is available to complement generalised state-wide datasets. (Class 2)	
Surface drainage (streams) and SW/GW interaction	*Class 2*
• Streamflow data and baseflow estimates available. (Class 2)	
Groundwater flow system – hydraulic properties	*Class 2*
• Key aquifer parameters were defined by in-situ aquifer tests. The tests spatially cover the area of interest and adjacent hydrostratigraphic units.	

Classification indicator	Classification
Groundwater flow system – structure, aquifer geometry	*Class 2*
• Good quality and adequate spatial coverage of digital elevation model to define ground surface elevation. (Class 3) • Spatial distribution of bore logs and associated stratigraphic interpretations clearly define aquifer geometry. (Class 2)	
Observations of water levels	*Class 2*
• Groundwater head observations and bore logs are available but do not provide adequate coverage throughout the model domain. • Transient observation data are available for a number of bores / VWPs with temporal extent covering the whole calibration period.	
Groundwater and surface water use (recharge and discharge)	*Class 1*
• No available records of metered groundwater extraction or injection. • Little useful data on river flows and/or stage elevations.	

Table D 8 Model classification – calibration indicators

Classification indicator	Classification
Calibration statistics	*Class 2*
• Calibration statistics are acceptable. (Class 2) • Mass balance closure error is less than 0.5% of total. (Class 3)	
Long term trends replication, temporal discretization	*Class 2 – Class 3*
• Seasonal fluctuations are evident in the data. (Class 2) • Transient calibration to observed historic data, using all available data to achieve the optimum calibration result (Class 3). Consistent with Chapter 5 of the AGMG, a subset of the observed historic data was not reserved for verification because this would result in sub-optimal model calibration.	
Types of calibration targets, spatial distribution of calibration targets	*Class 2 – Class 3*
• Transient calibration is current, i.e., uses recent data. (Class 3) • Observations of the key modelling outcomes (water levels in Project observation bores) are used in calibration. (Class 3) • Calibration only to water level dataset, predicting both water levels (water levels change) and flows (pit inflows). (Class 2)	

Table D 9 Model classification – consistency between calibration and prediction

Classification indicator	Classification
Model run length and temporal discretisation	*Class 2*
• Length of predictive model is consistent with the length of calibration period. (Class 2) • Temporal discretization used in the prediction is no different to that used in transient calibration (Class 2)	
Boundary conditions and stresses	*Class 3*
• Level and type of stresses included in the predictive model are within the range of those used in the transient calibration. (Class 3)	
Steady state vs. transient	*Class 3*
• Both calibration and prediction are based on transient model. Steady state model is used to establish initial conditions for the transient predictive model. (Class 3)	

Overall, the model meets the Class 2 requirements under the AGMG (Barnett *et al.*, 2012).

D3. Model simulations

D3.1. Modelling approach

The transient model for the predictive scenarios was an extension of the transient calibration model and comprised 22 stress periods (3 months and 9 months length, two stress periods per year) covering the period from 1/1/2022 until 31/12/2032.

Mine development for the predictive scenarios involved the progressive assignment of MODFLOW drain cells to represent mining at the project within the model domain. Drain cells were assigned elevations specified by annual progression pit shells. A high drain conductance value of 100 m^2/d was applied to each drain.

The results of the predictive model are discussed in Section 6.4 of the Groundwater Report.

D3.2. Sensitivity analysis

D3.2.1. Overview

A sensitivity analysis was performed to assess the response of the model to change in either boundary condition (recharge, stream bed conductance) or hydraulic properties (Kx, Kz, Ss, Sy). This analysis provides for a comparison of the influence of these properties on the outcomes of predictions made by the model. Impacts to the predicted maximum drawdown due to changes in properties have been examined.

Sensitivity analysis of the hydraulic properties of the model (horizontal and vertical hydraulic conductivity and specific storage) was limited to Layer 4 (Proterozoic bedrock) as this layer represents the hydrogeological unit that will be most impacted by the project.

The parameters that were assessed during the predictive sensitivity analysis were grouped and varied in the following manner:

- recharge rates were increased by 100% and decreased by 50% from their calibrated values;
- horizontal (Kx) and vertical (Kz) hydraulic conductivity in Layer 4 was increased and decreased by factor of five above and below their calibrated values;
- specific storage (Ss) in Layer 4 was varied by factor of five above and below their calibrated values; and
- stream conductance was varied by an order of magnitude above and below their calibrated values.

D3.2.2. Drawdown extents

Figure D 16 to Figure D 19 show the drawdown extent of the sensitivity scenarios for Layer 4 (Proterozoic basement).

These results show that the extent of drawdown is sensitive to changes in hydraulic parameters and storage, but insensitive to changes in recharge and stream bed conductance values.

D4. References

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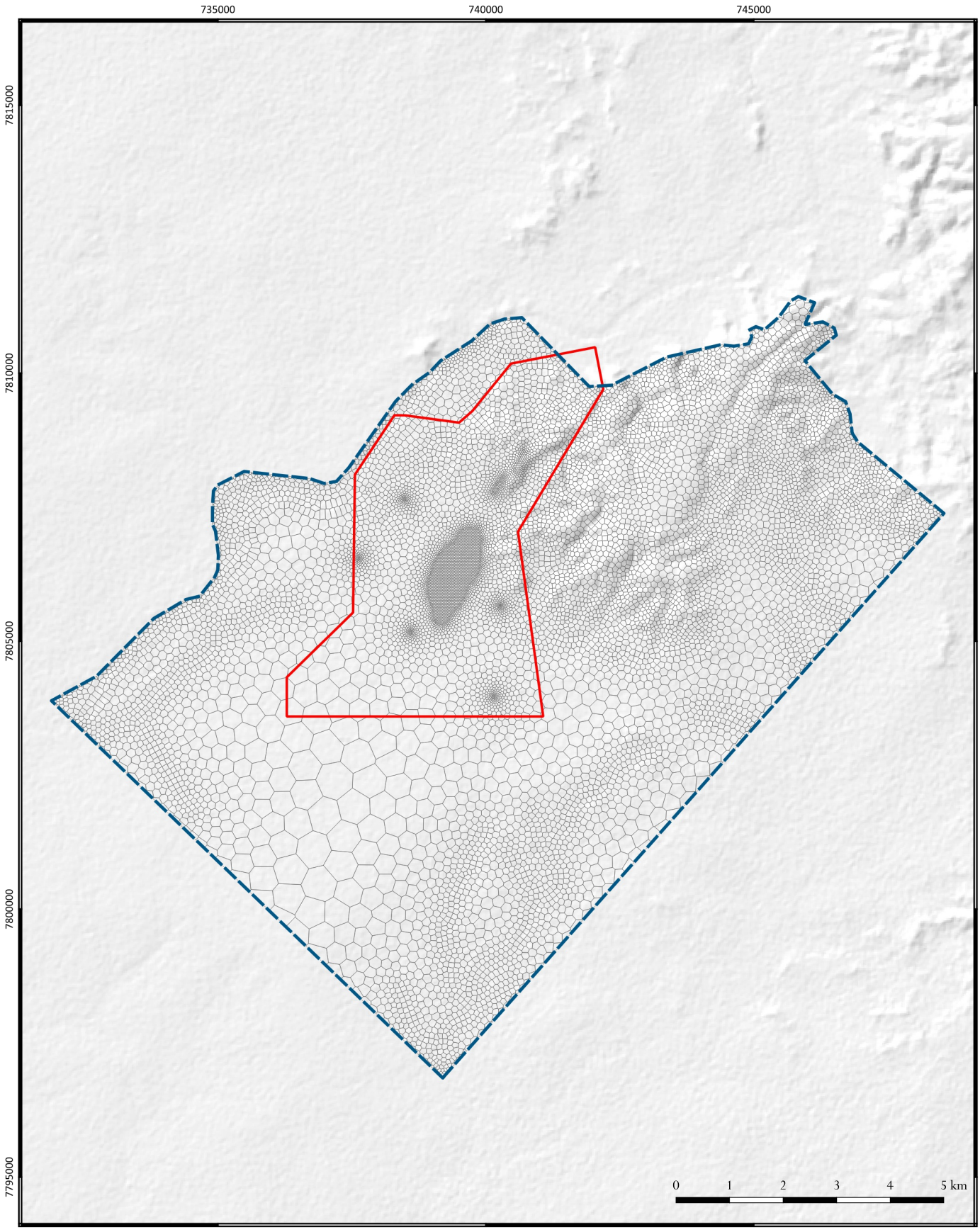
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LEGEND

- Project site boundary
- Model domain
- Model mesh

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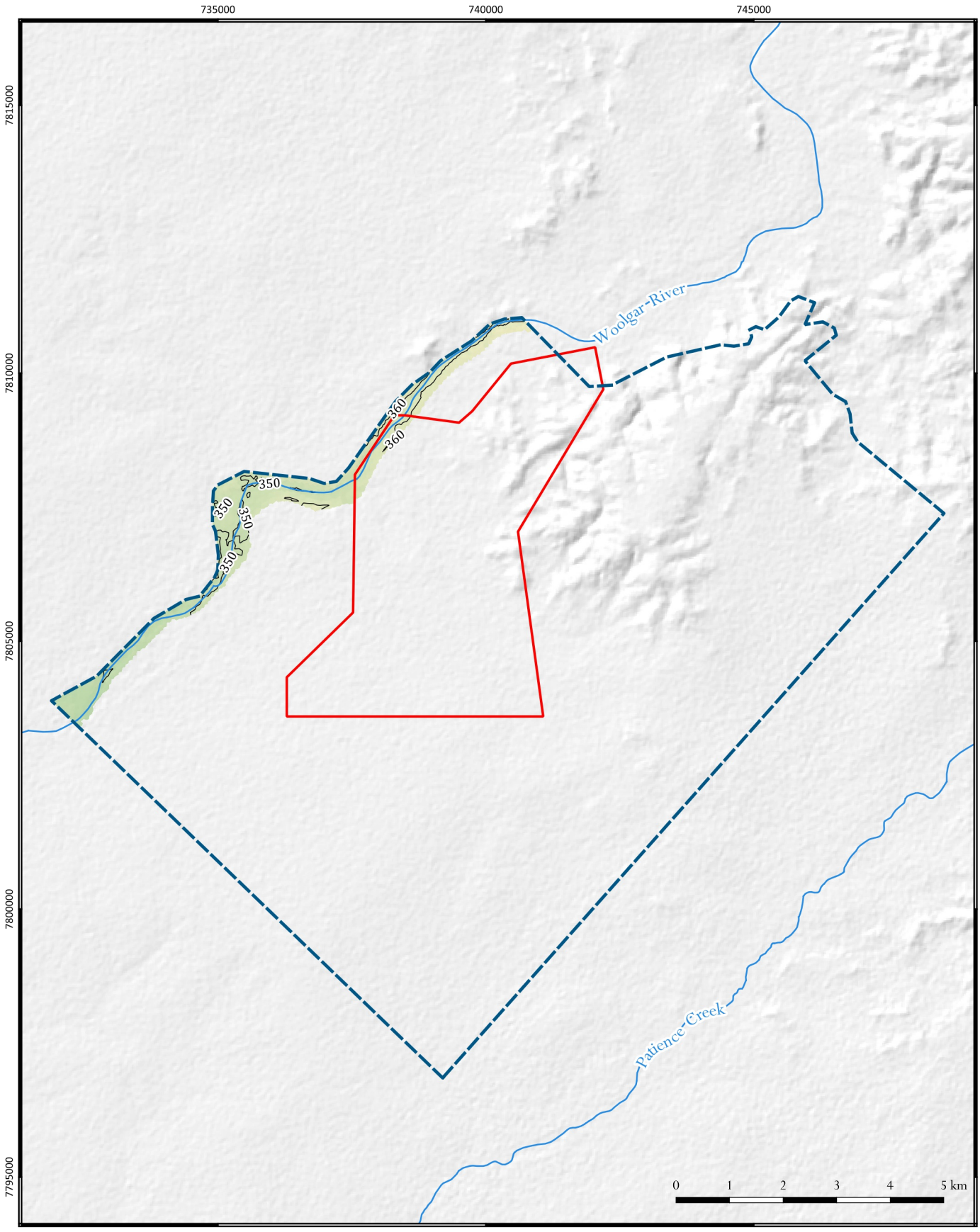
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Model mesh

FIGURE No.
D1

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LEGEND

- Project site boundary
- Model domain
- Watercourse
- Layer 1 top elevation contours

Elevation (mAHD)

- 300
- 375
- 450
- 525
- 600

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10/05/2022

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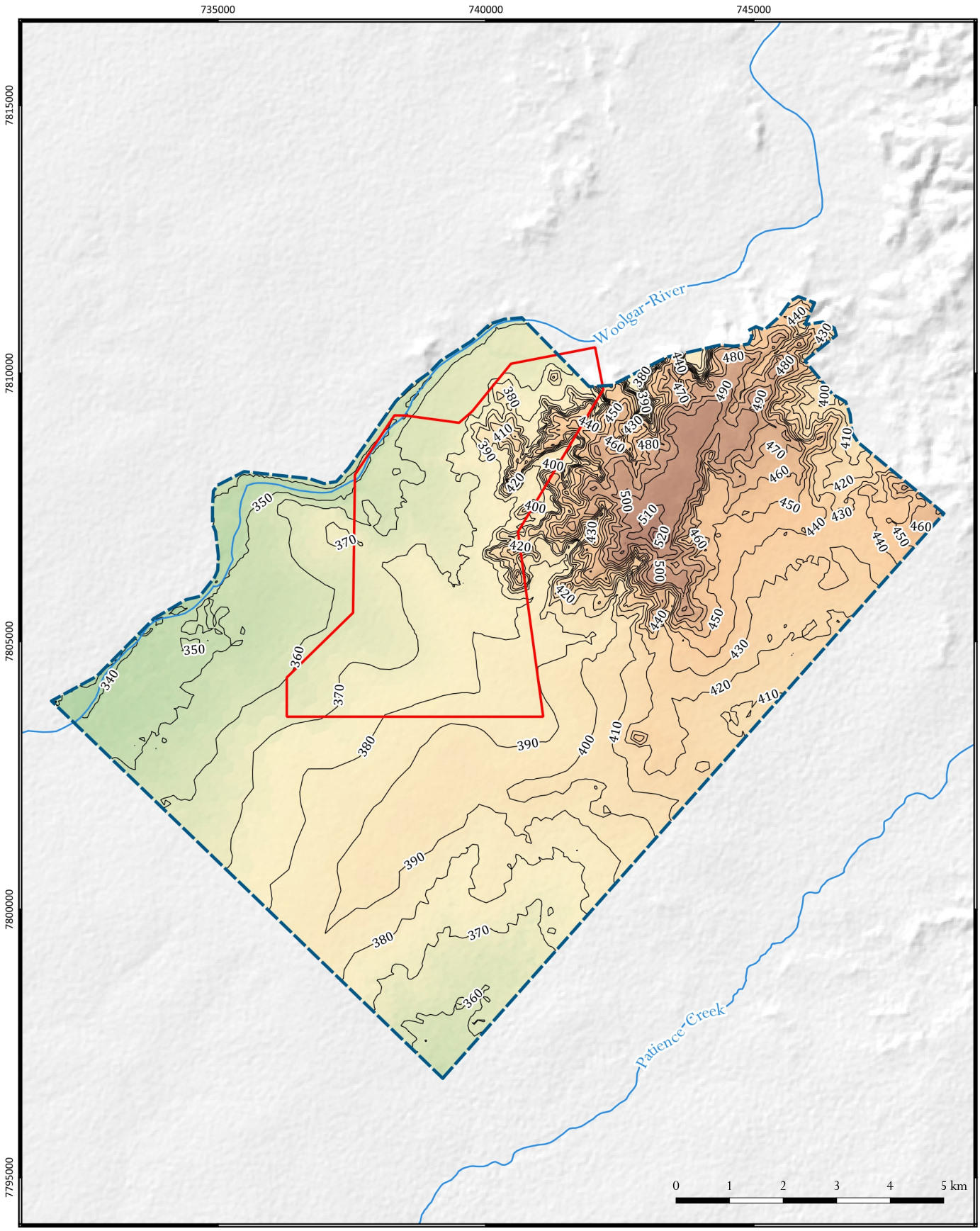
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Layer 1 top elevation

FIGURE No.
D2

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LEGEND

- Project site boundary
- Model domain
- Watercourse
- Layer 2 top elevation contours

Elevation (mAHD)

- 300
- 375
- 450
- 525
- 600

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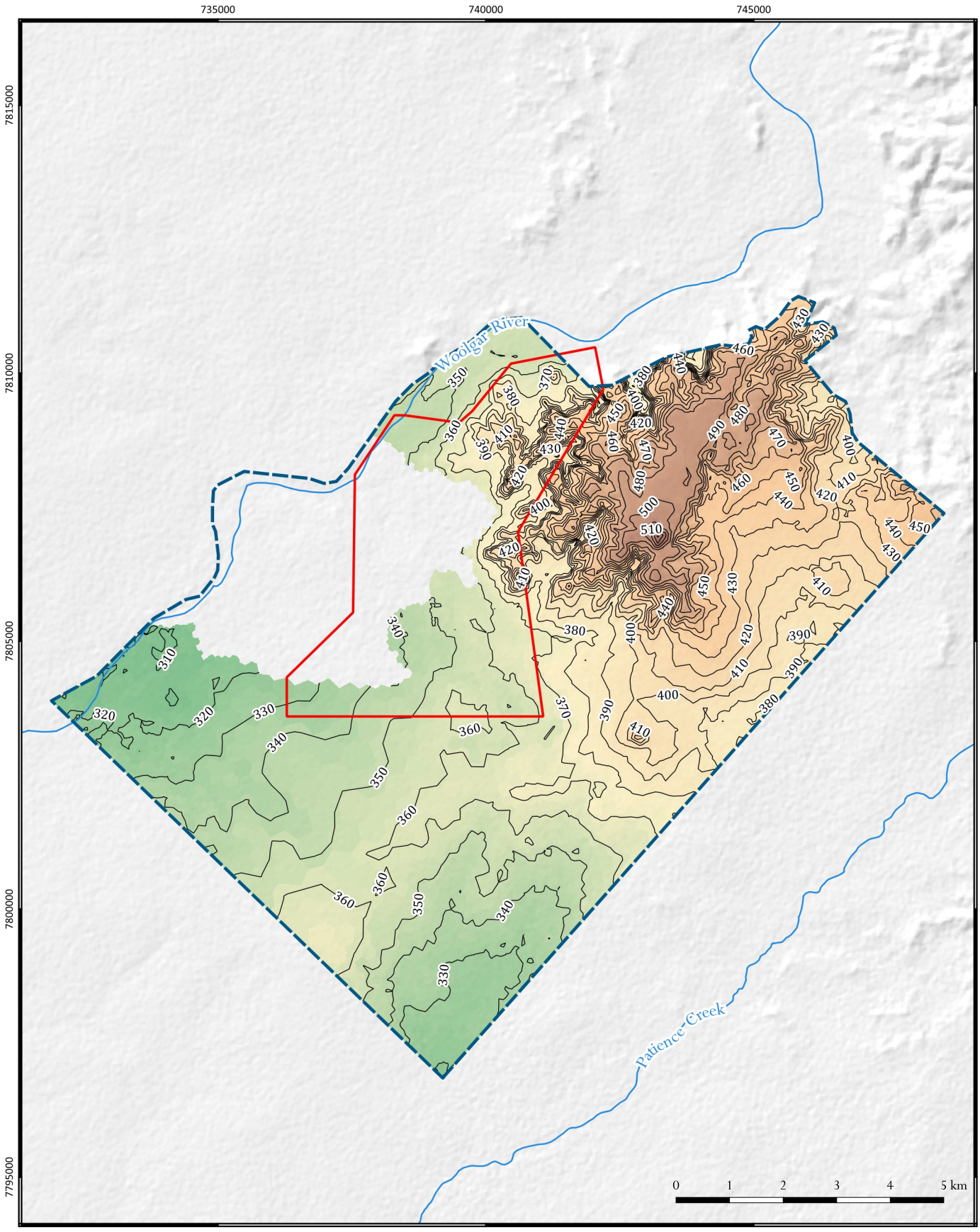
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Layer 2 top elevation

FIGURE No.
D3

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LEGEND

- Project site boundary
- Model domain
- Watercourse
- Layer 3 top elevation contours

Elevation (mAHD)

- 300
- 375
- 450
- 525
- 600

DATE
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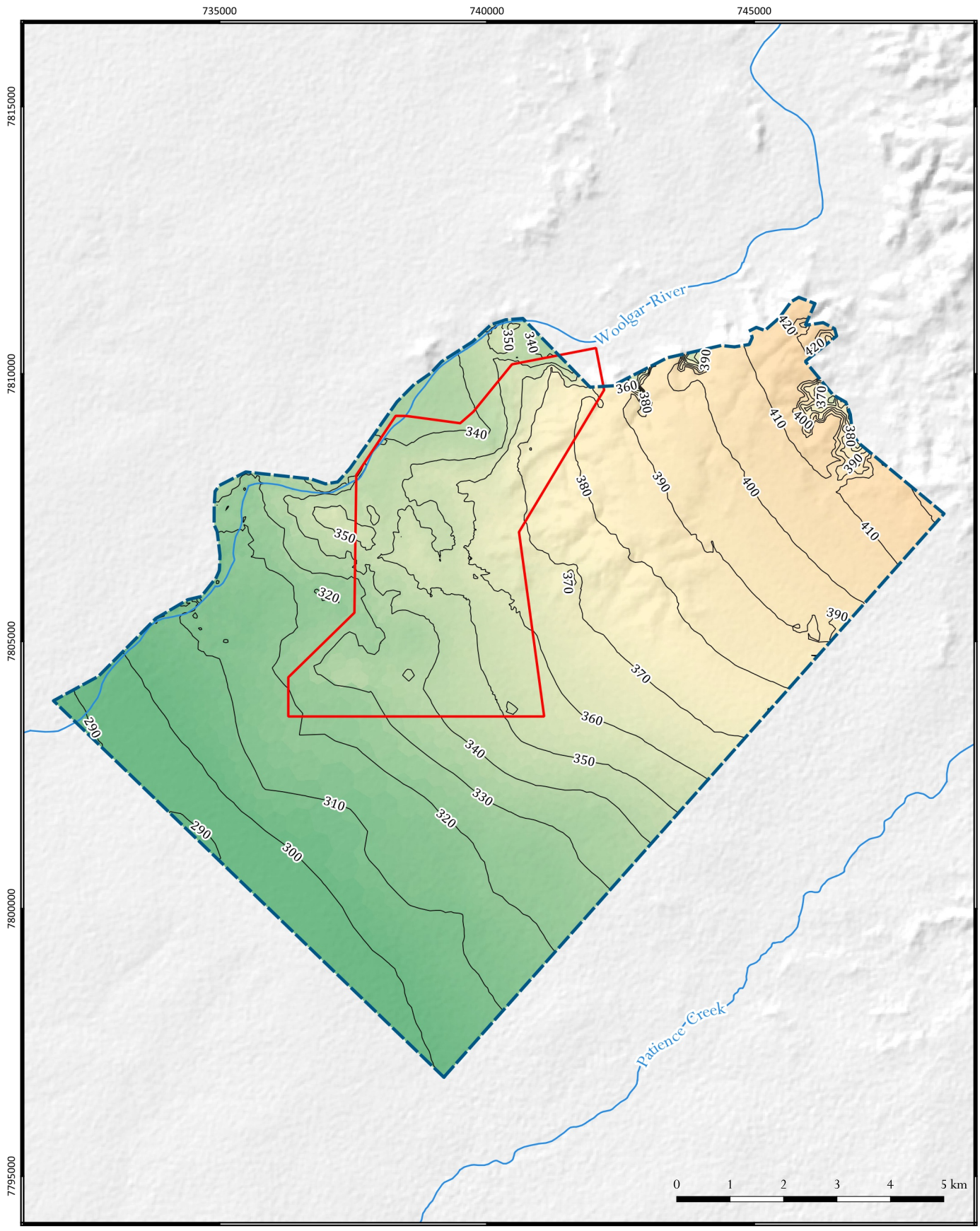
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Layer 3 top elevation

FIGURE No.
D4

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LEGEND

- Project site boundary
- Model domain
- Watercourse
- Layer 4 top elevation contours

Elevation (mAHD)

- 300
- 375
- 450
- 525
- 600

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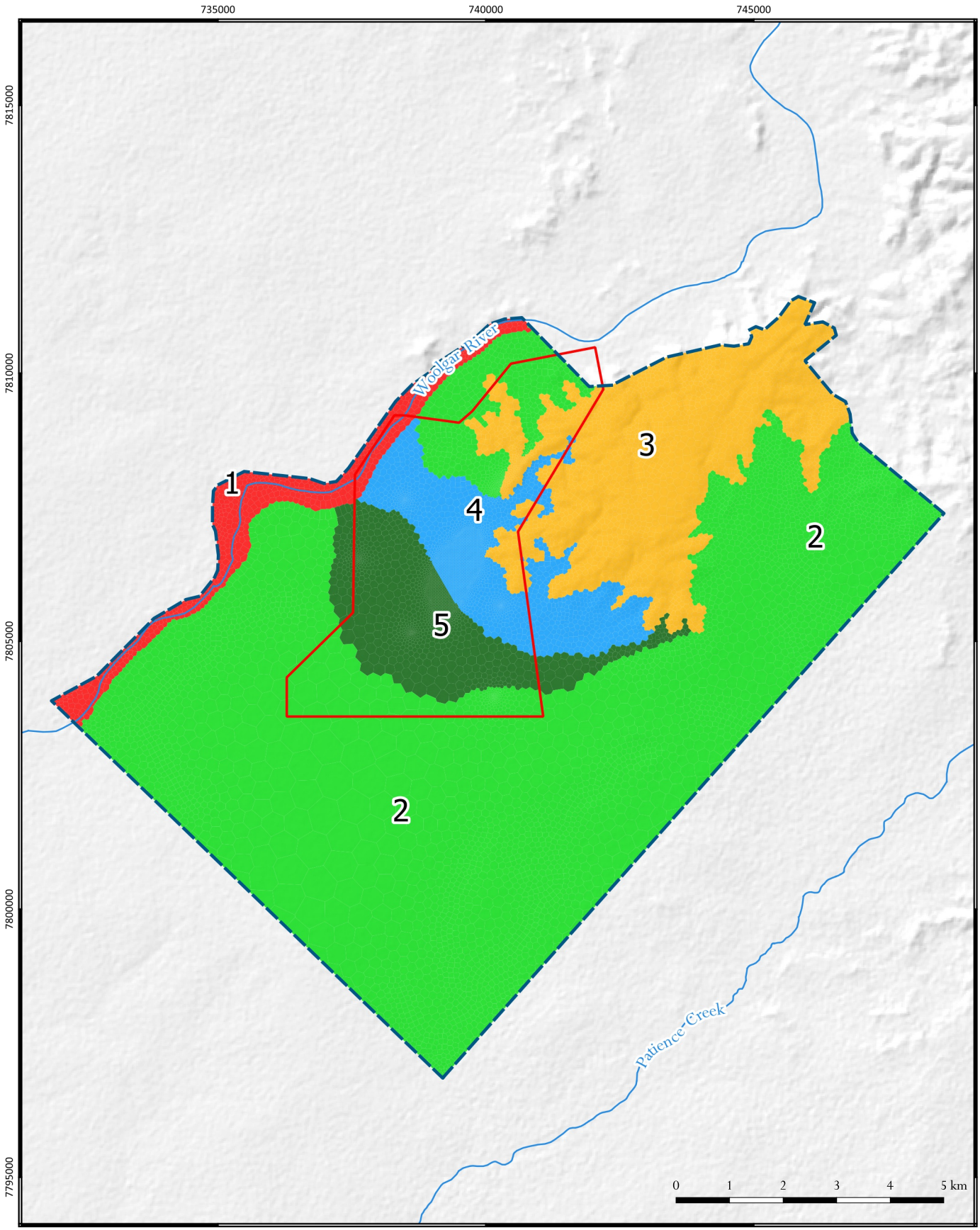
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Layer 4 top elevation

FIGURE No.
D5

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LEGEND

- Project site boundary
- Model domain
- Watercourse

Recharge zones

- 1 - Cainozoic alluvium
- 2 - Weathered profile
- 3 - Weathered profile (atop elevated Jurassic strata)
- 4 - Weathered profile (central)
- 5 - Weathered profile (southern)

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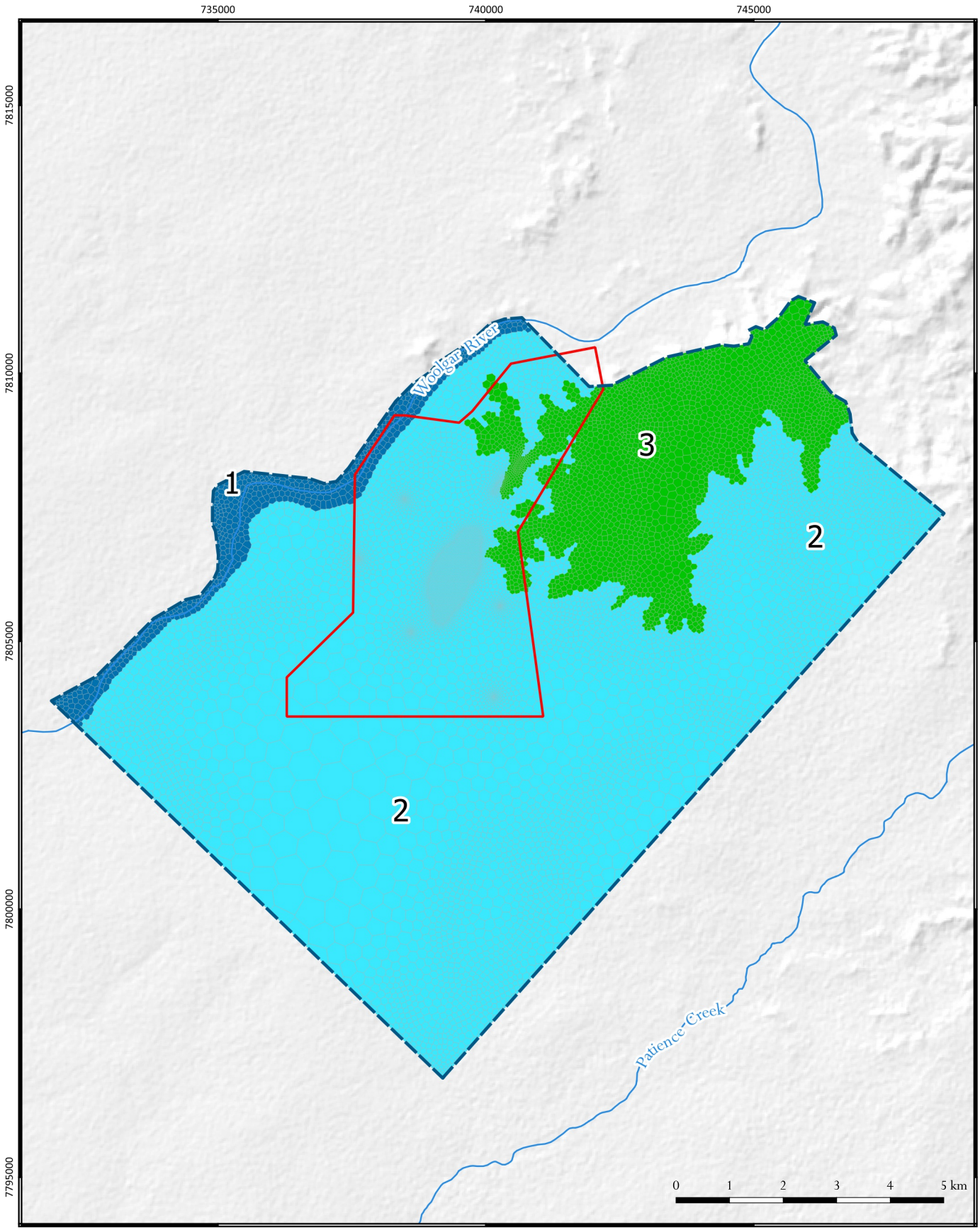
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Recharge zones

FIGURE No.
D6

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LEGEND

- Project site boundary
- Model domain
- Watercourse

Evapotranspiration zones

- 1 - Cainozoic alluvium
- 2 - Weathered profile
- 3 - Weathered profile (Jurassic sandstone caps)

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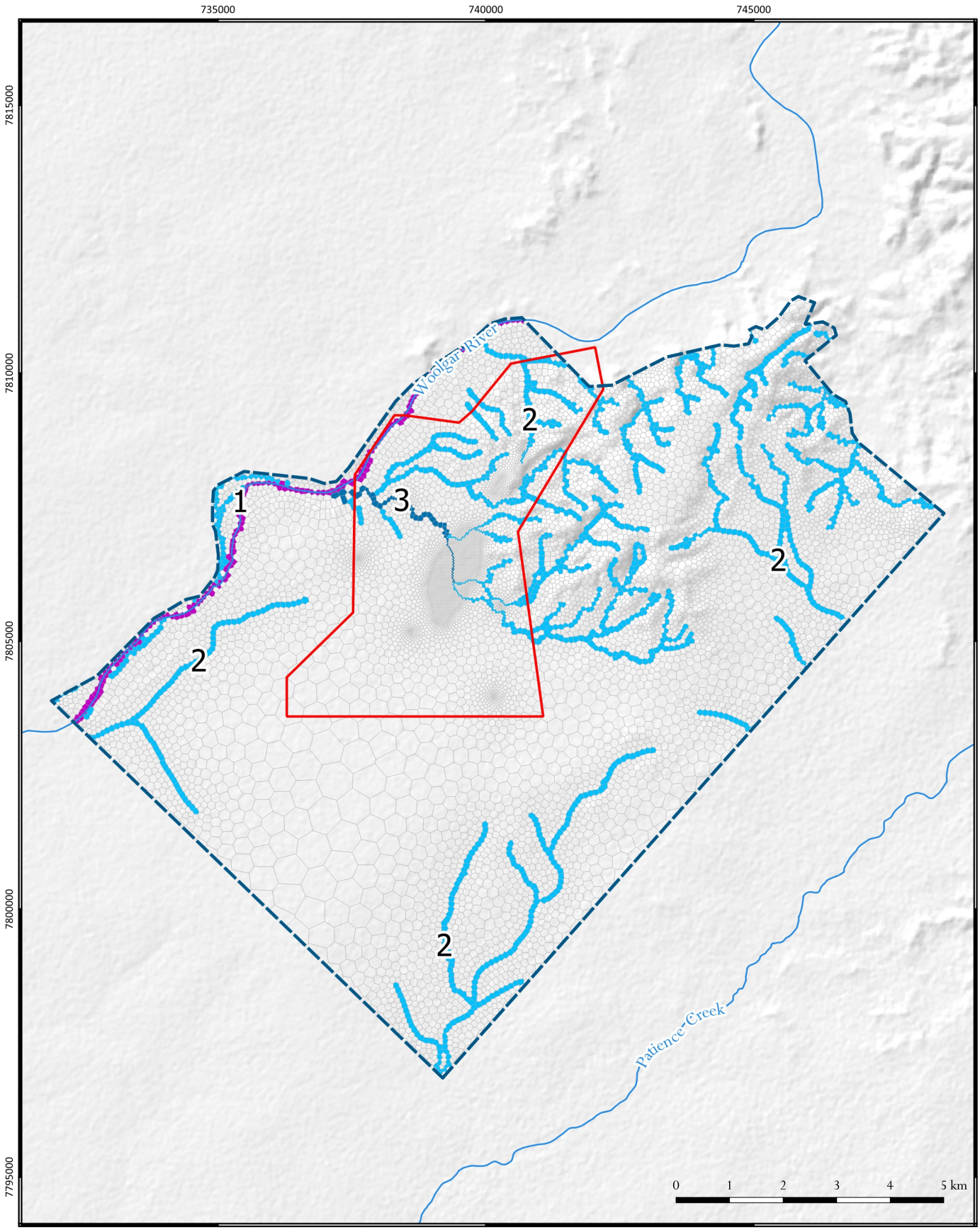
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Evapotranspiration zones

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D7

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LEGEND

- Project site boundary
- Model domain
- Watercourse

Surface water drainage zones

- 1 - Woolgar River
- 2 - Minor surficial drainage
- 3 - Woolgar River tributary

DATE
10/05/2022

GDA94, Zone 54
EPSG: 28354

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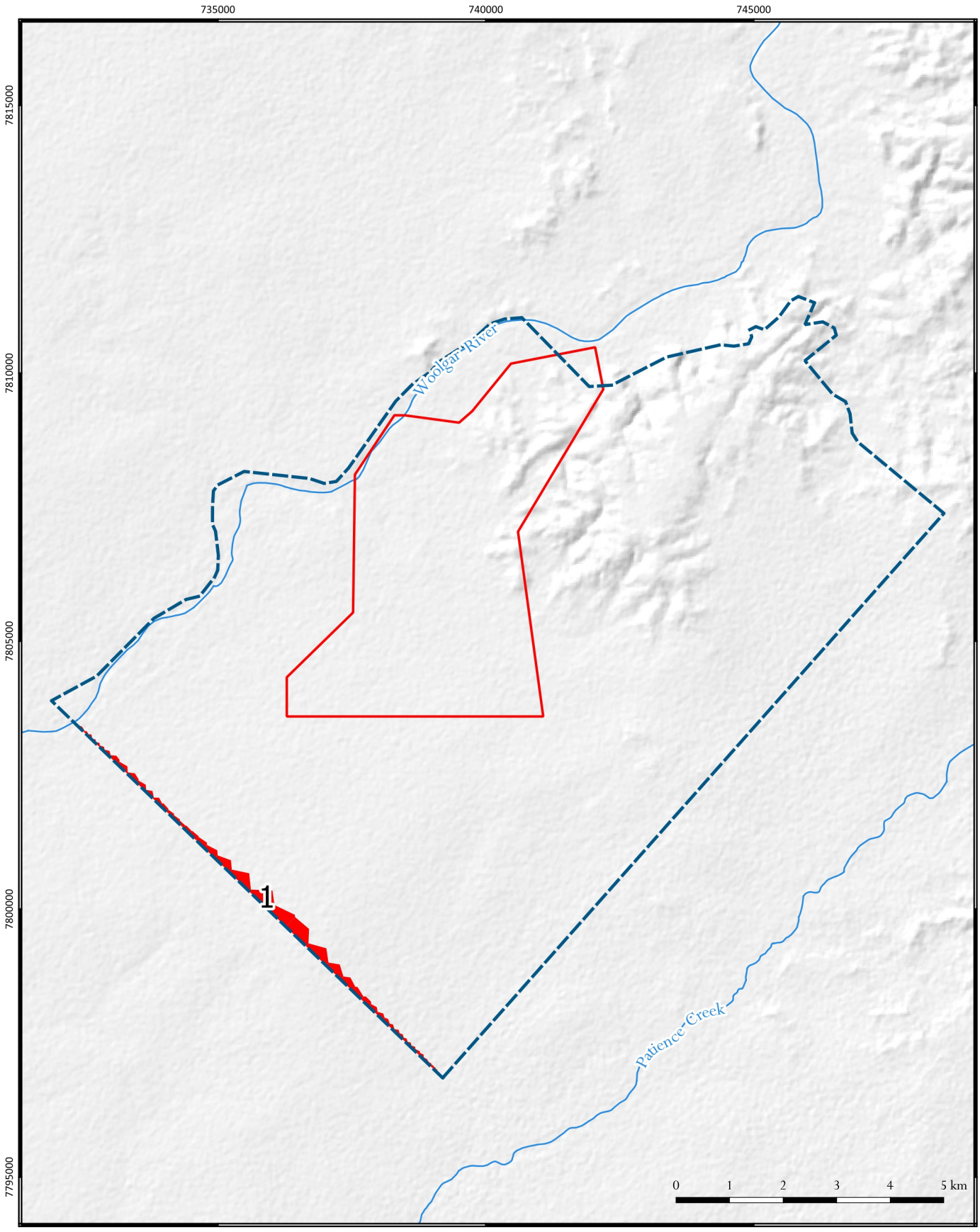
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Big Vein South - Groundwater Report (4090)

Surface water drainage zones

FIGURE No.
D8

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LEGEND

- Project site boundary
- Model domain
- Watercourse
- GHB zone

DATE
10/05/2022

GDA94, Zone 54
EPSG: 28354

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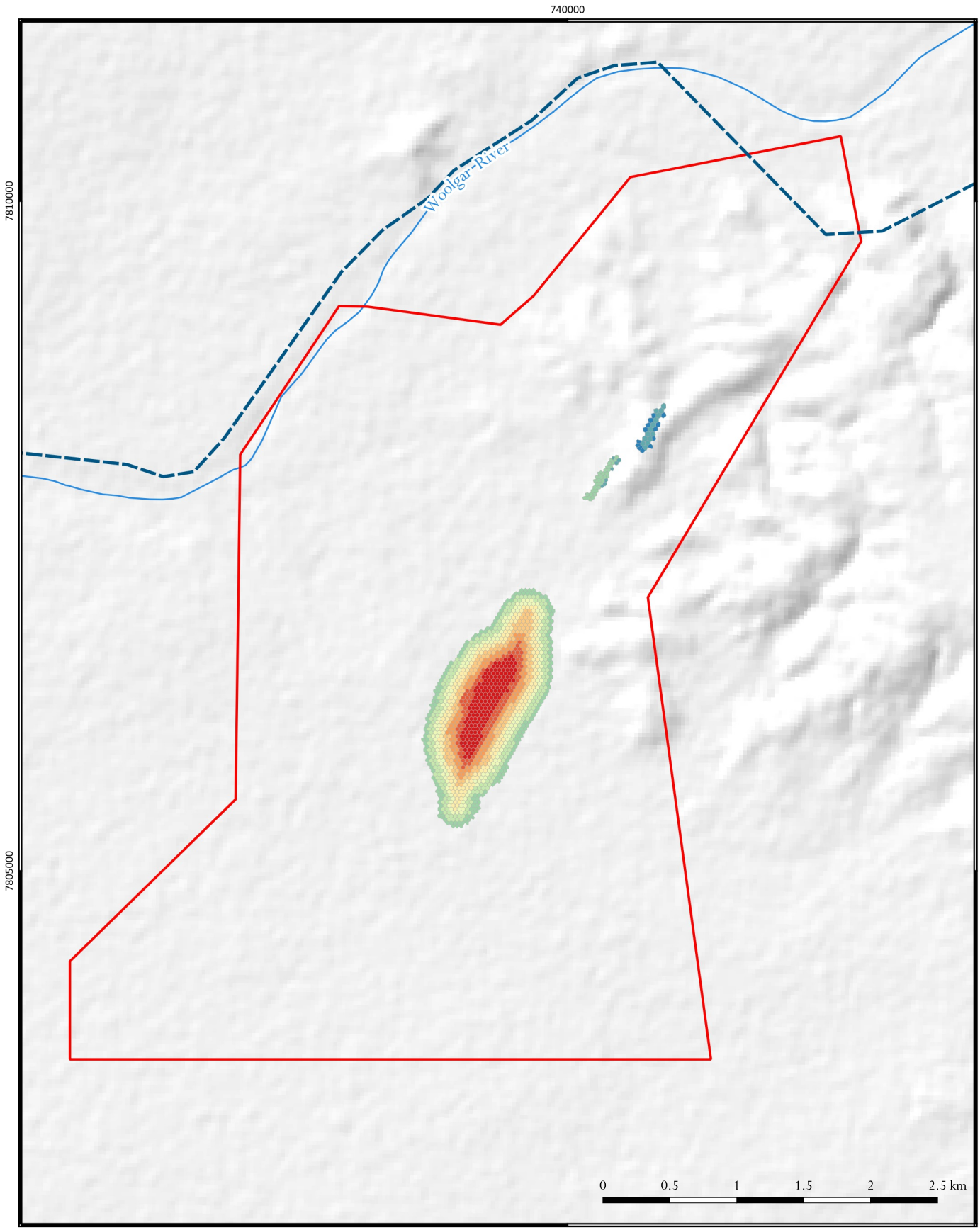
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General head boundary conditions

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D9

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Z:\4000_Projects\4090_HEC_Big Vein South Project\3_GIS\3_11_Workspaces_QGIS\Figures\D01_4090_Mesh.qgz



LEGEND

- Project site boundary
- Model domain
- Watercourse

Minimum pit floor elevation (m AHD)

180 - 205	305 - 330
205 - 230	330 - 355
230 - 255	355 - 380
255 - 280	380 - 405
280 - 305	405 - 430

DATE
10/05/2022

GDA94, Zone 54
EPSG: 28354

1:40,000

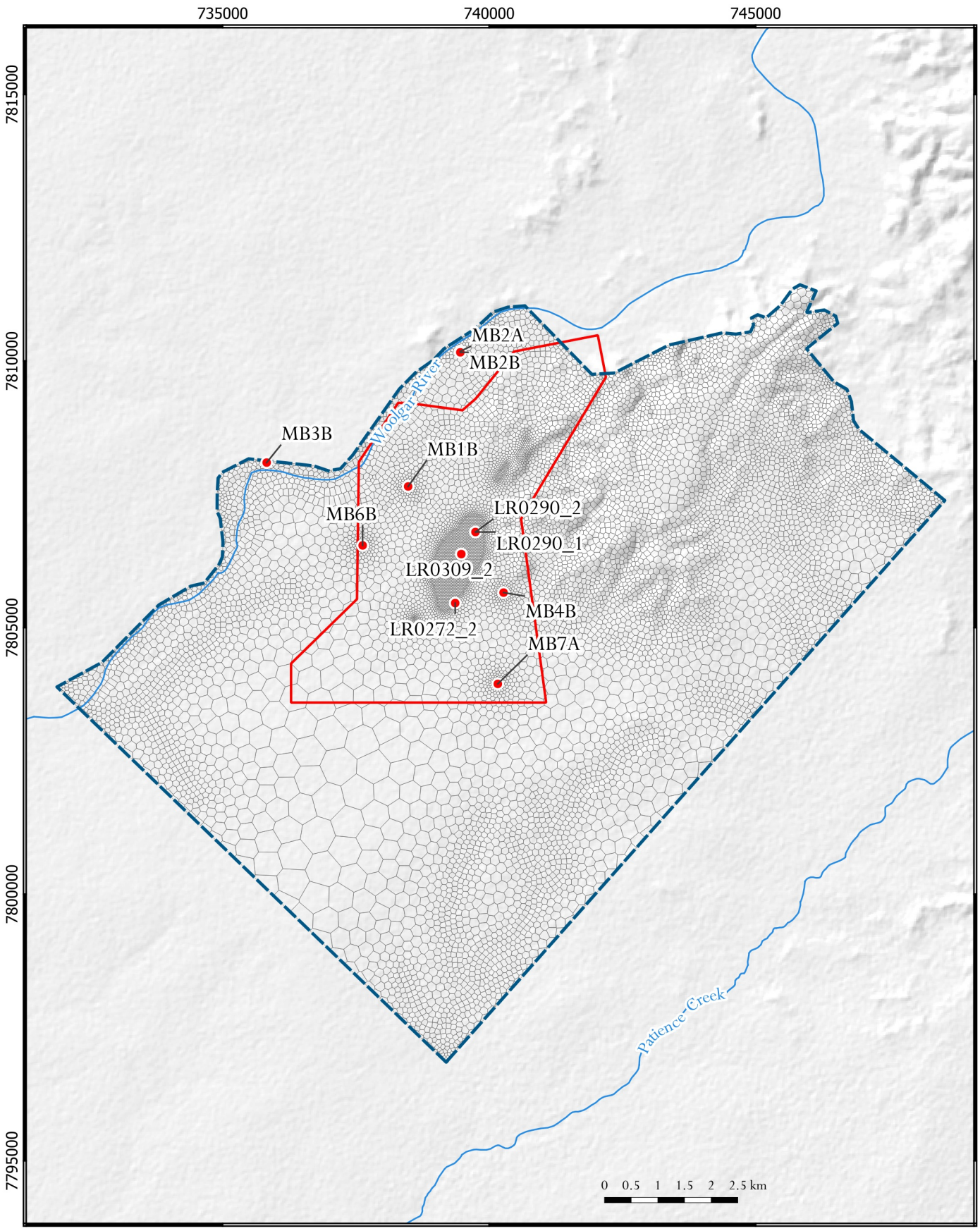
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Big Vein South - Groundwater Report (4090)

Mining drain cells

FIGURE No.
D10

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LEGEND

- Project site boundary
- Model domain
- Watercourse
- Monitoring bore

DATE
10/05/2022

GDA94, Zone 54
EPSG: 28354

1:100,000

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Big Vein South - Groundwater Report (4090)

Model observation sites

FIGURE No.
D11

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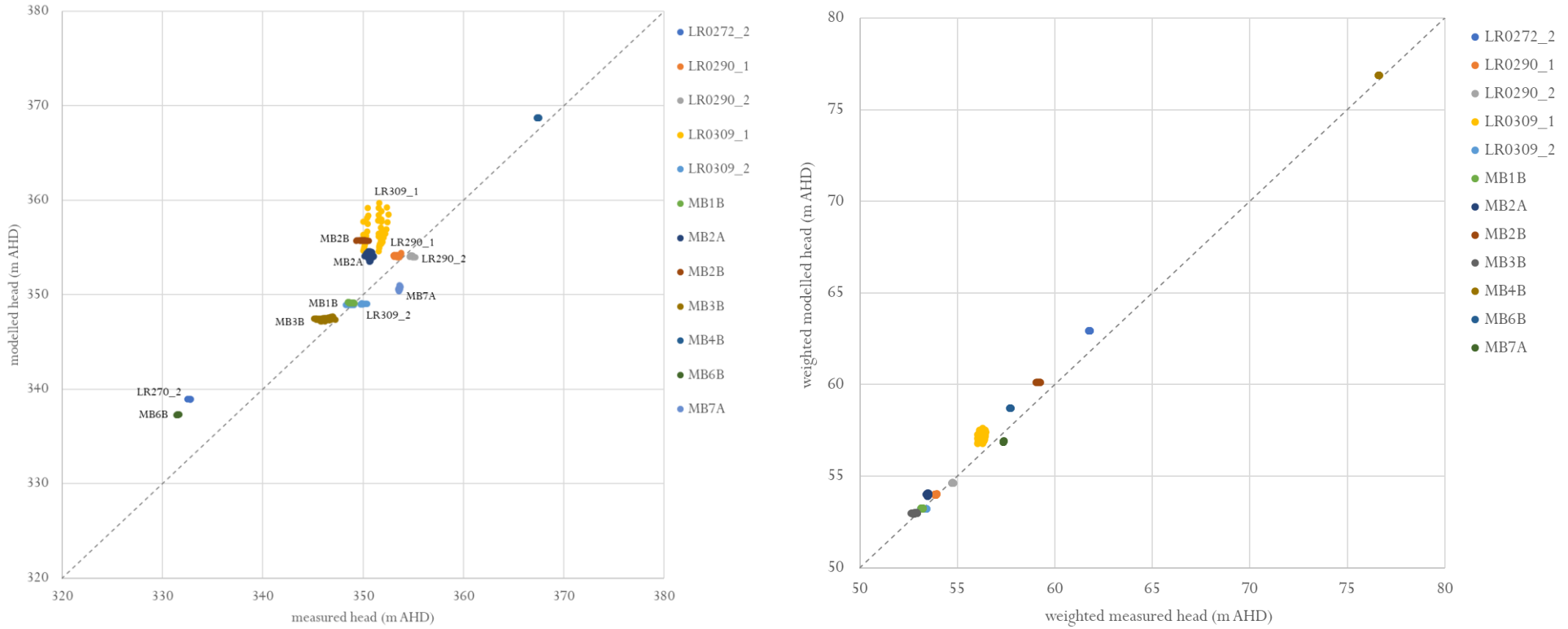
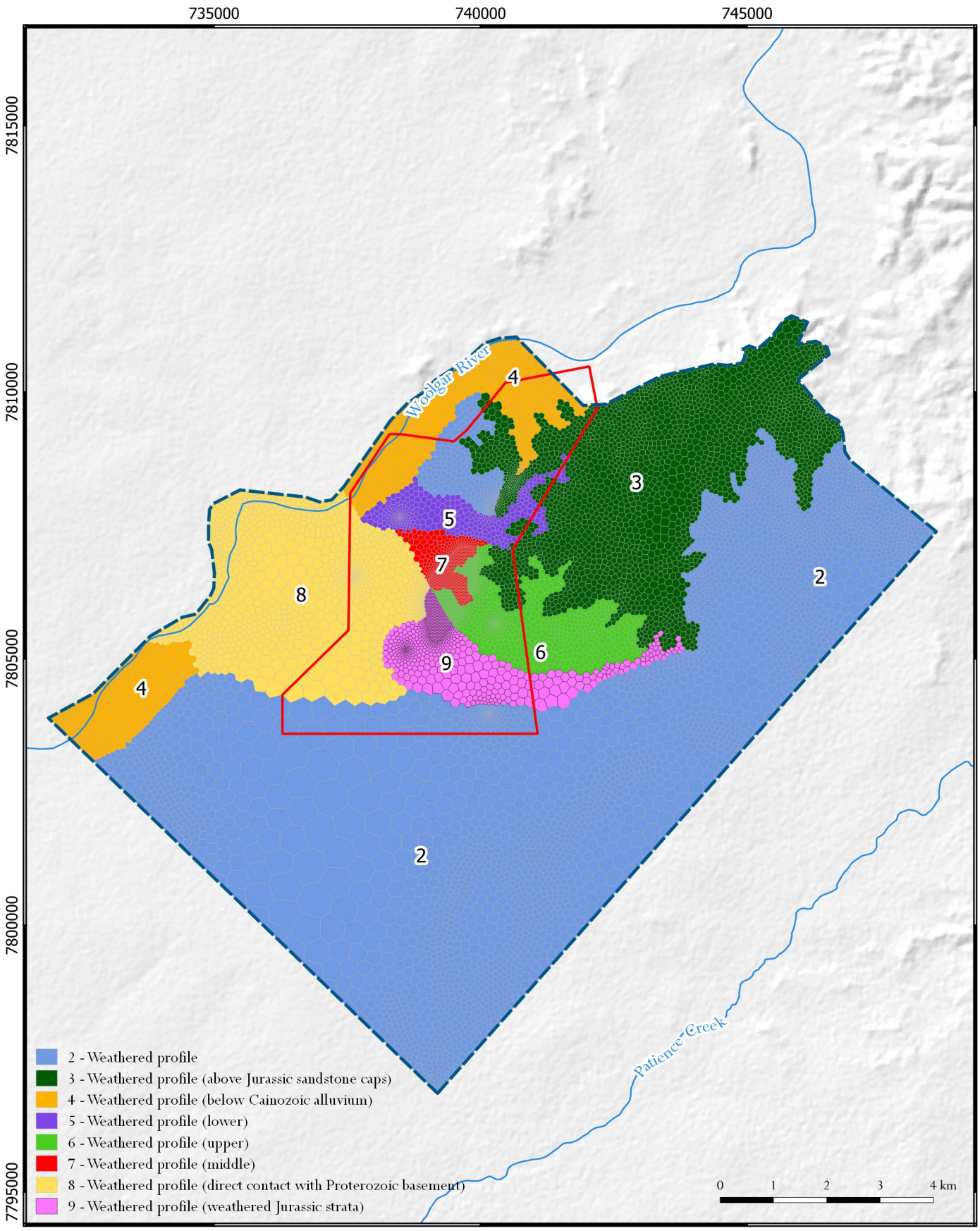


Figure D 12 Calibrated residuals – unweighted and weighted



LEGEND

- Project site boundary
- Model domain
- Watercourse

DATE
10/05/2022

GDA94, Zone 54
EPSG: 28354

1:100,000

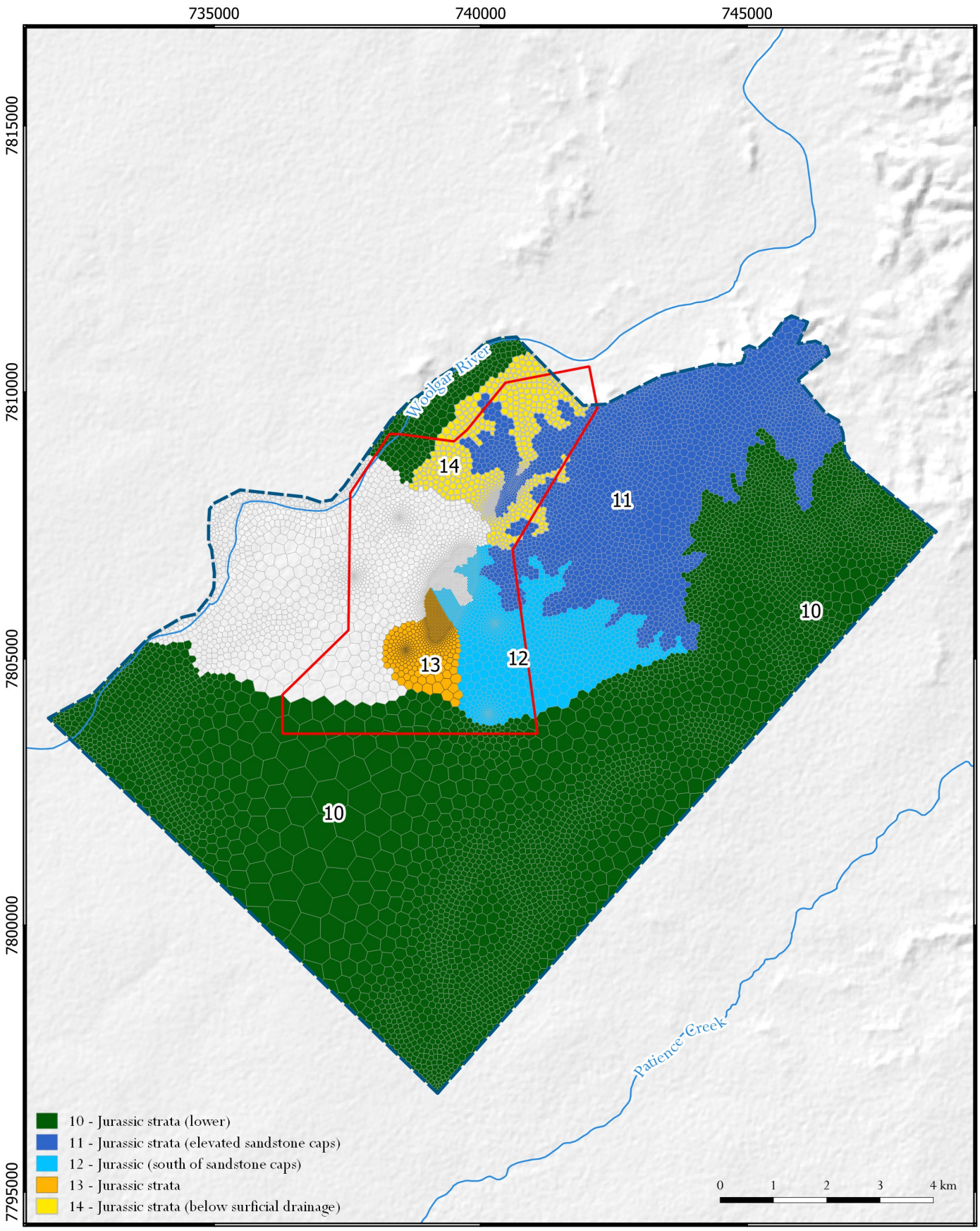
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Hydraulic conductivity zones in Layer 2

FIGURE No.
D13

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LEGEND

- Project site boundary
- Model domain
- Watercourses

DATE
10/05/2022

GDA94, Zone 54
EPSG: 28354

1:100,000

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Big Vein South - Groundwater Report (4090)

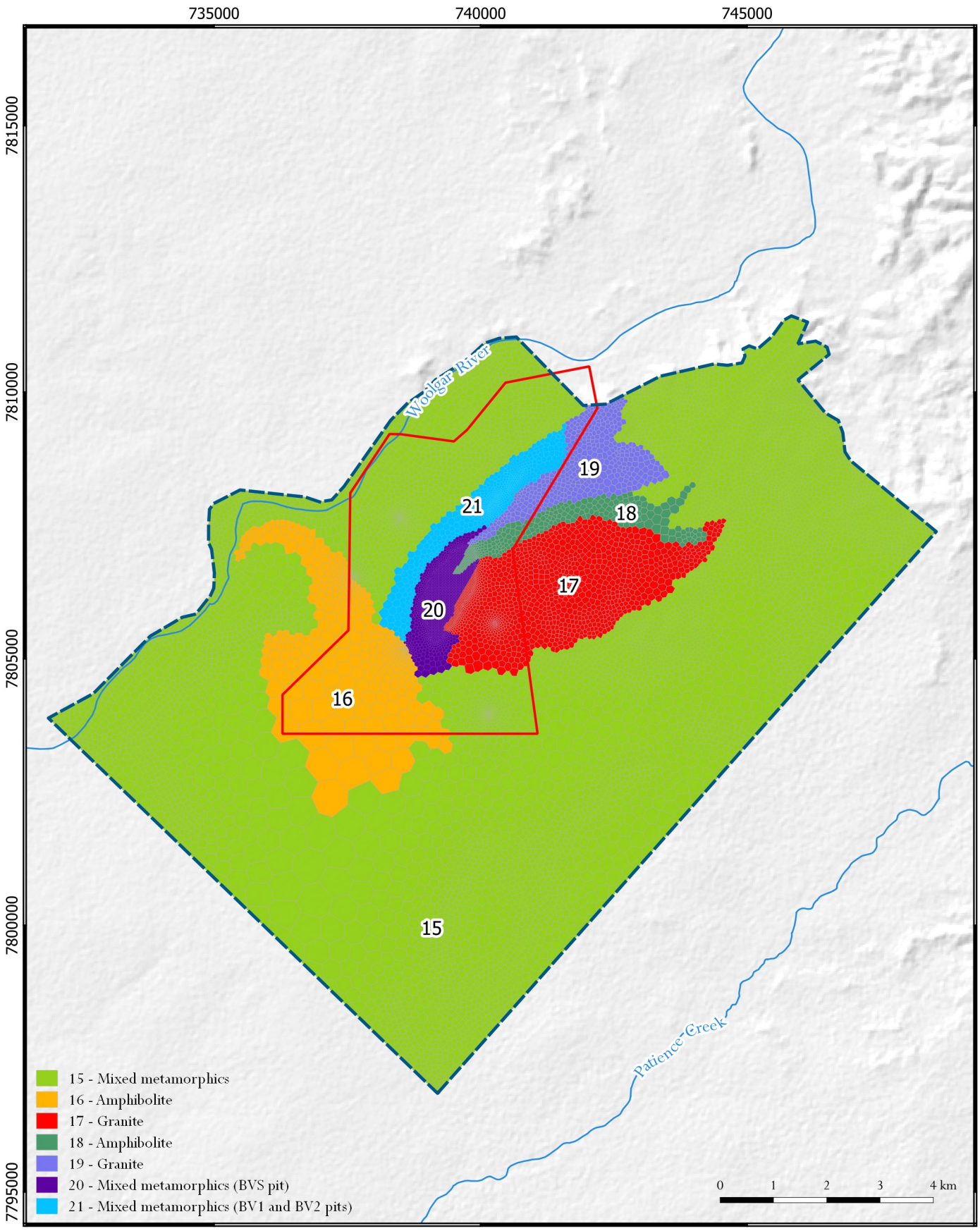
Hydraulic conductivity zones in Layer 3

FIGURE No.
D14

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Z:\4000_Projects\4090_HEC_Big Vein South Project\3_GIS\3_11_Workspaces_QGIS\Figures\D13-15_4090_hydraulic_prop_zones.qgz



LEGEND

- Project site boundary
- Model domain
- Watercourse

DATE
10/05/2022

GDA94, Zone 54
EPSG: 28354

1:100,000

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Big Vein South - Groundwater Report (4090)

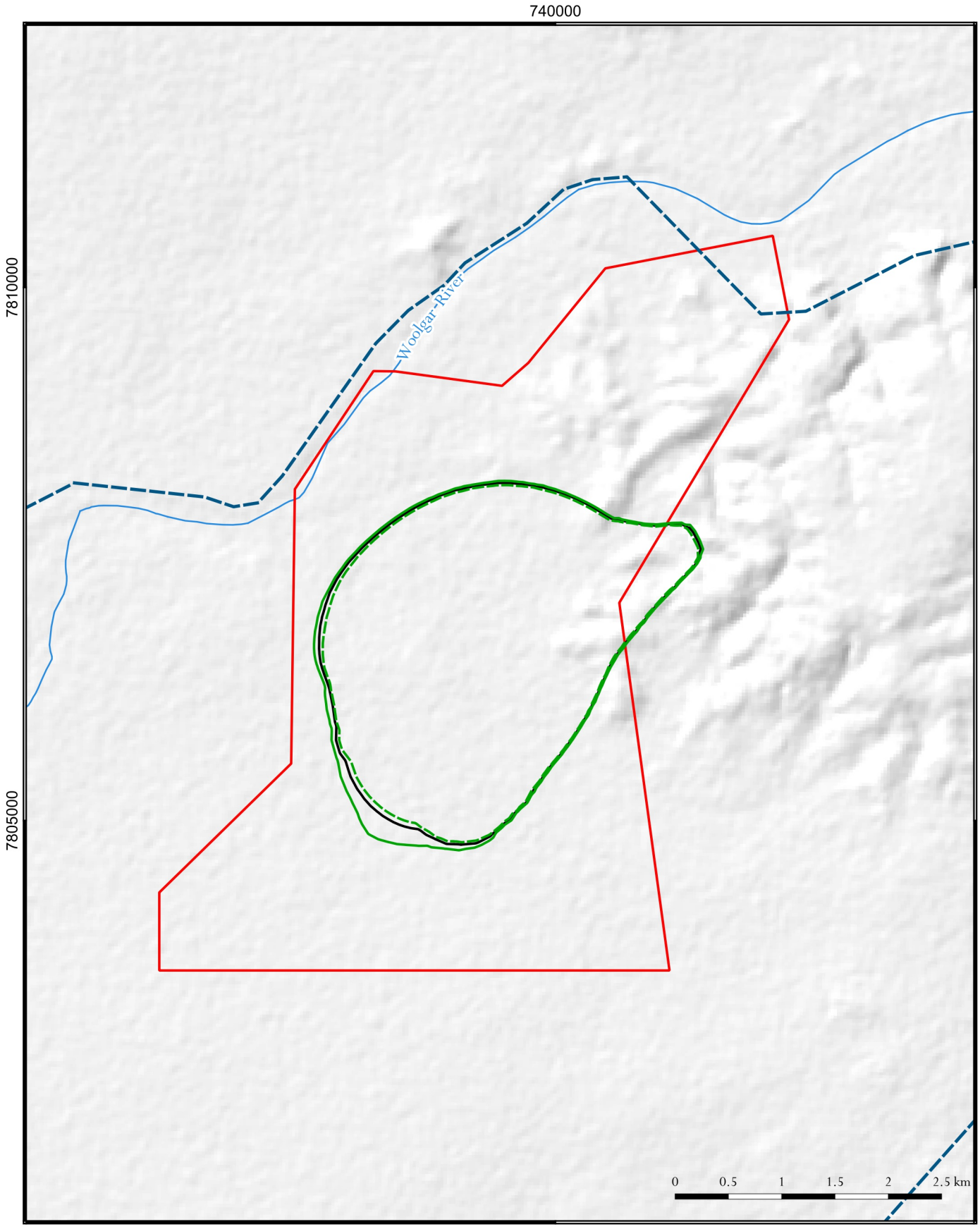
Hydraulic conductivity zones in Layer 4

FIGURE No.
D15

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Z:\4000_Projects\4090_HEC_Big Vein South Project\3_GIS\3_11_Workspaces_QGIS\Figures\D13-15_4090_hydraulic_prop_zones.qgz



LEGEND

- Project site boundary
- Model domain
- Watercourse
- 1m drawdown contour (baseline)
- 1m drawdown contour (increased recharge)
- 1m drawdown contour (decreased recharge)

DATE
10/05/2022

GDA94, Zone 54
EPSG: 28354

1:50,000

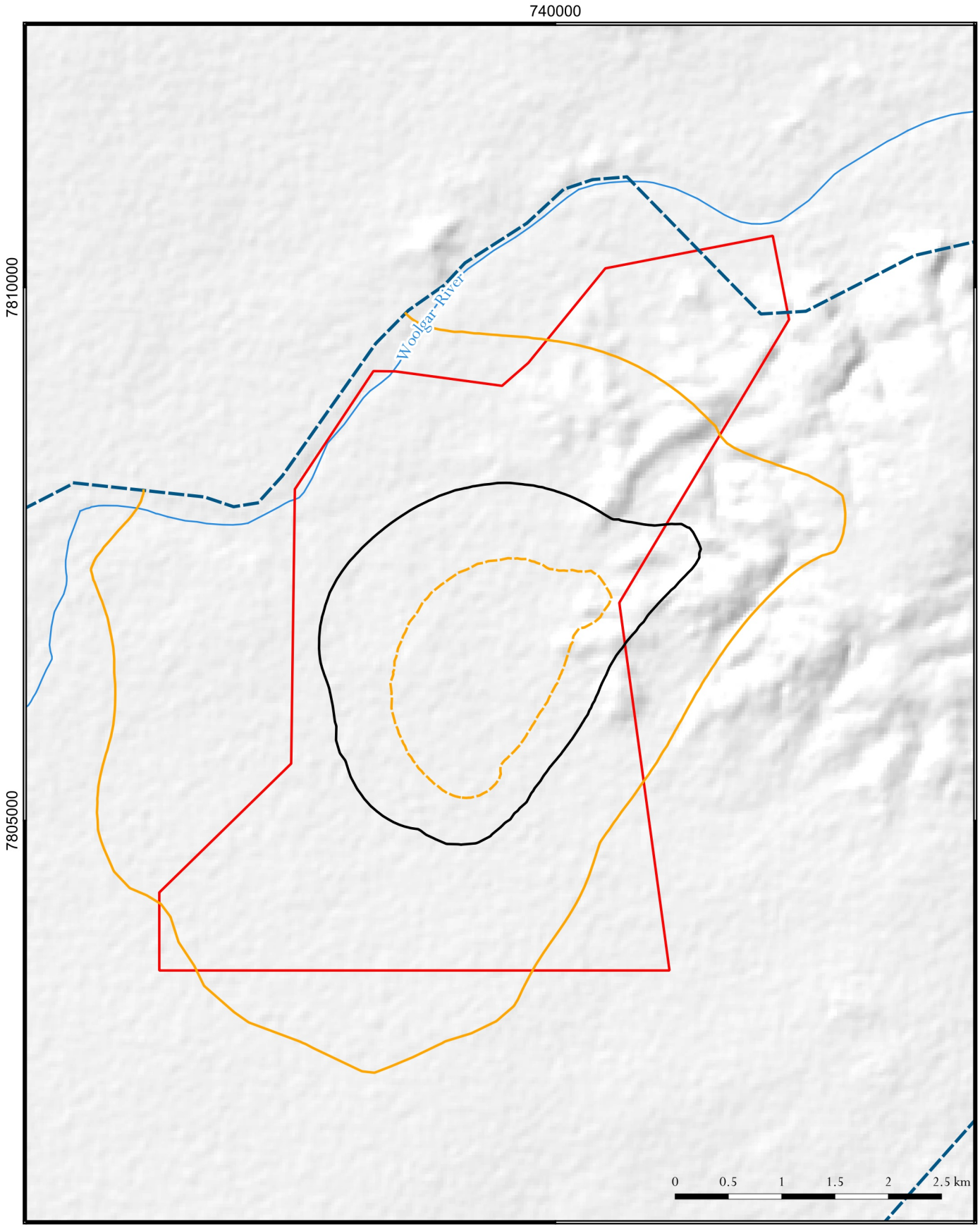
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Big Vein South - Groundwater Report (4090)

Layer 4 - 1 m sensitivity drawdown contours for recharge

FIGURE No.
D16

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LEGEND

- Project site boundary
- Model domain
- Watercourse
- 1m drawdown contour (baseline)
- 1m drawdown contour (increased Kx, Kz)
- 1m drawdown contour (decreased Kx, Kz)

DATE
10/05/2022

GDA94, Zone 54
EPSG: 28354

1:50,000

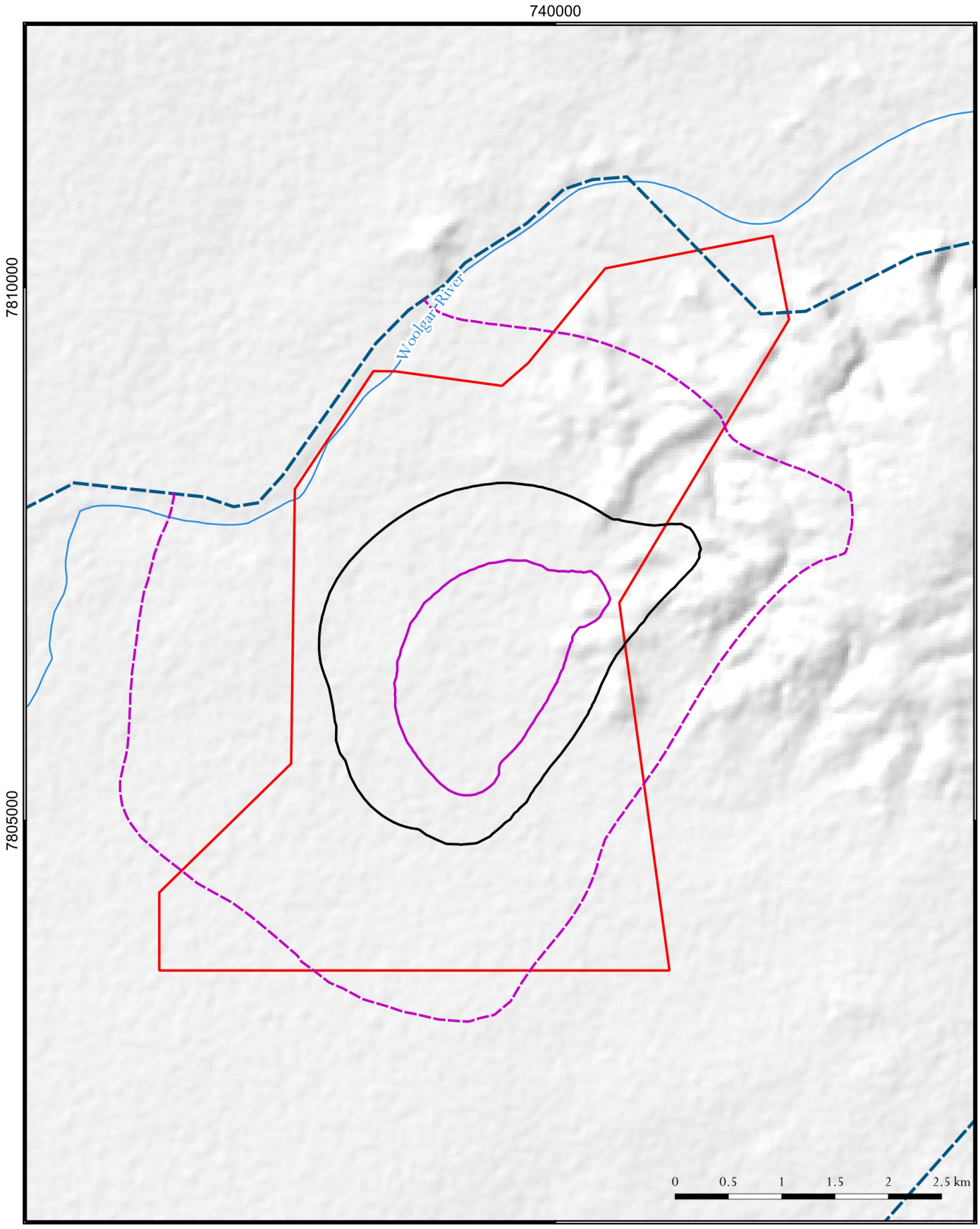
hydrogeologist.com.au

Big Vein South - Groundwater Report (4090)

Layer 4 - 1 m sensitivity drawdown contours for Kx and Kz

FIGURE No.
D17

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LEGEND

- Project site boundary
- Model domain
- Watercourse
- 1m drawdown contour (baseline)
- 1m drawdown contour (increased Ss)
- 1m drawdown contour (decreased Ss)

DATE
10/05/2022

GDA94, Zone 54
EPSG: 28354

1:50,000

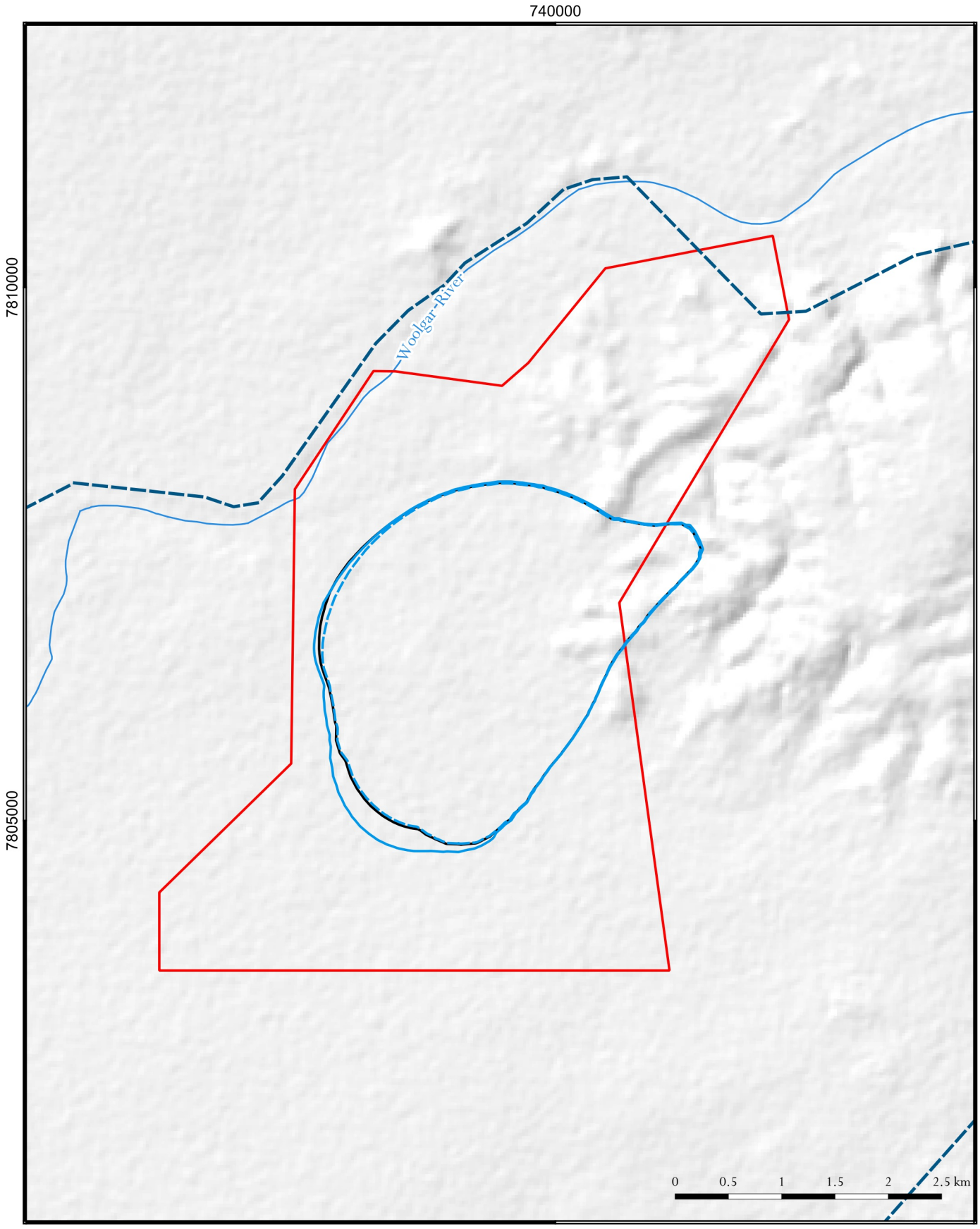
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Big Vein South - Groundwater Report (4090)

Layer 4 - 1 m sensitivity drawdown contours for Ss

FIGURE No.
D18

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Z:\4000_Projects\4090_HEC_Big Vein South Project\3_GIS\3_11_Workspaces_QGIS\Figures\D16-19_4090_sensitivity_drawdowns.qgz



LEGEND

- Project site boundary
- Model domain
- Watercourse
- 1m drawdown contour (baseline)
- 1m drawdown contour (increased RIV conductance)
- 1m drawdown contour (decreased RIV conductance)

DATE
10/05/2022

GDA94, Zone 54
EPSG: 28354

1:50,000

hydrogeologist.com.au

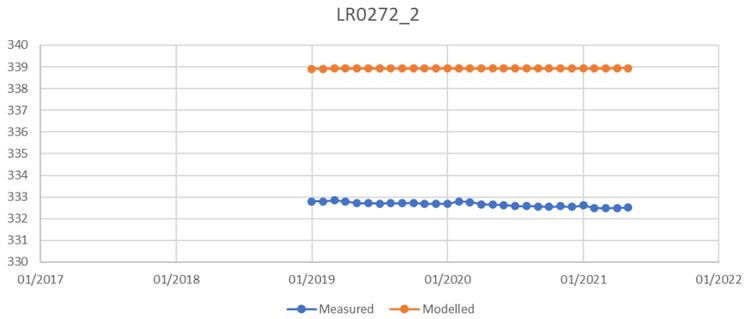
Big Vein South - Groundwater Report (4090)

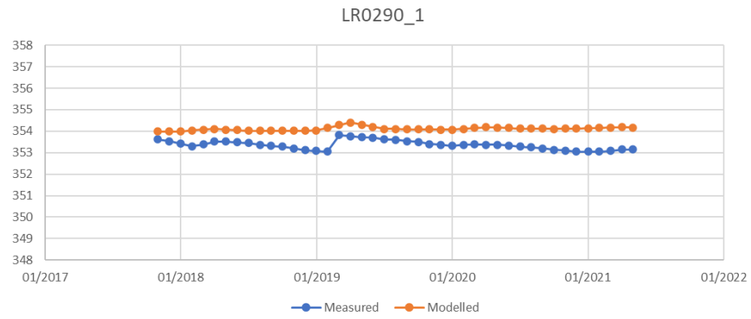
Layer 4 - 1 m sensitivity drawdown contours for stream bed conductance

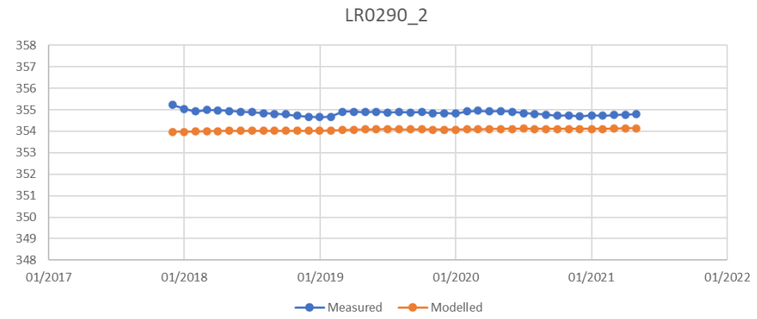
FIGURE No.
D19

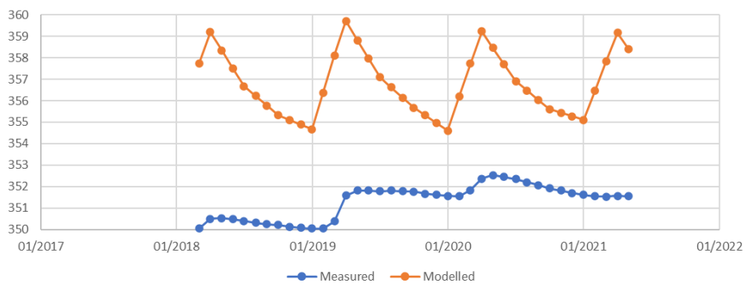
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Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.
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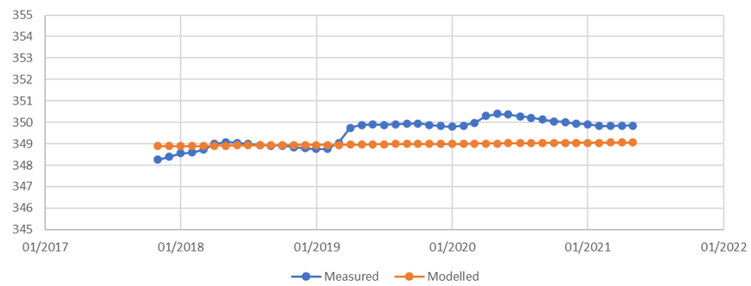
Appendix D 1 Calibration hydrographs

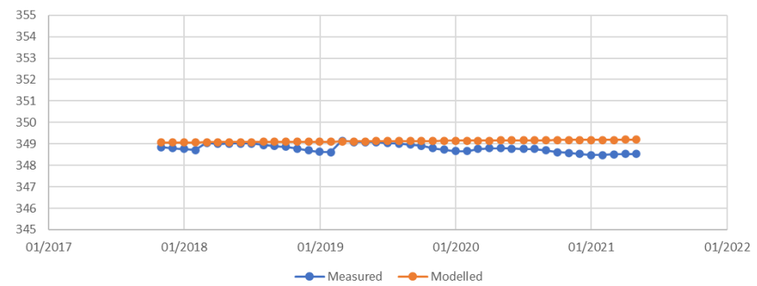

LR0272_2
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01/2017
01/2018
01/2019
01/2020
01/2021
01/2022
Measured
Modelled

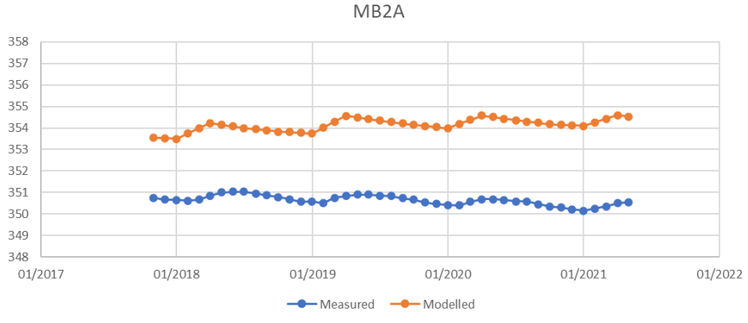

LR0290_1
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01/2017
01/2018
01/2019
01/2020
01/2021
01/2022
Measured
Modelled

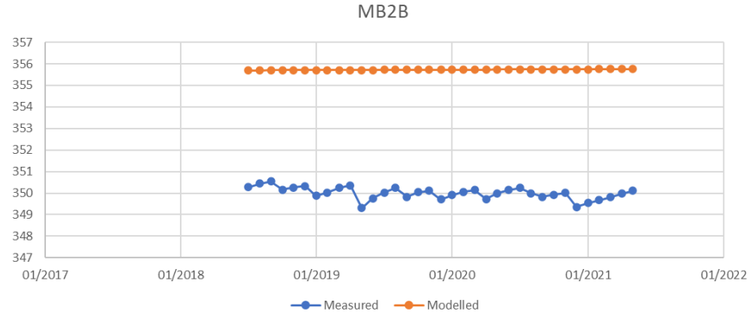

LR0290_2
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01/2018
01/2019
01/2020
01/2021
01/2022
Measured
Modelled

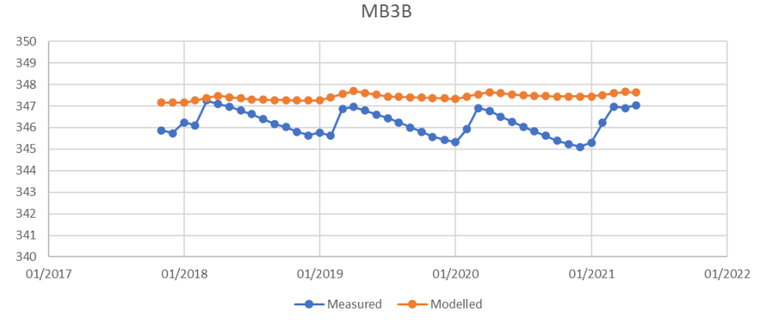

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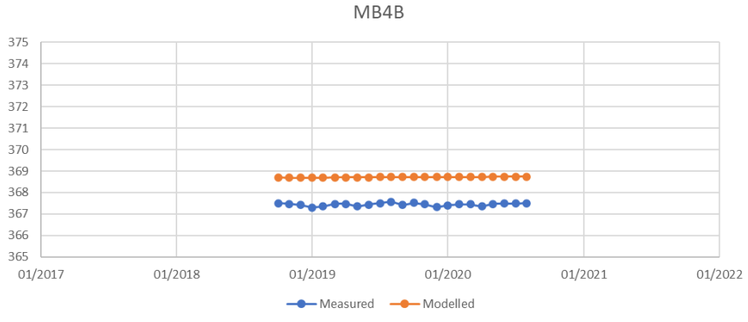

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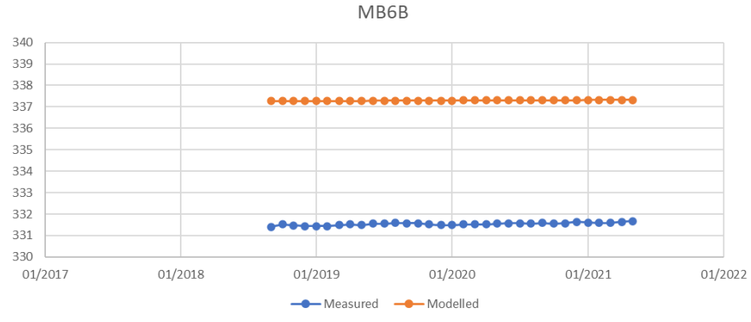

MB1B
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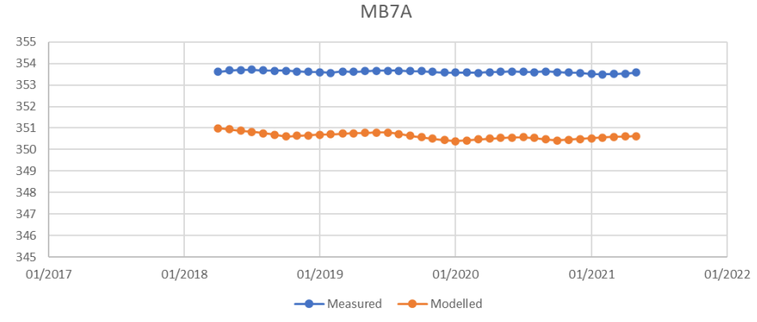

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Measured
Modelled


MB2B
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Modelled


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Modelled


MB4B
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Measured
Modelled


MB6B
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Modelled


MB7A
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Measured
Modelled