Appendix A-1

Bore Details

Bore ID	Type	Status	Easting	Northing	Ground elevation (mAHD)	Collar height (maGL)	Bore depth (mbGL)	Tof of screen (mbGL)	Base of screen (mbGL)	VWP sensor (mAHD)	VWP sensor (mbGL)	Bore diameter (mm)	Lithological description	Location
HV3	MB	EX	310776	6400546	67.7	0.5	16.6	-	16.7	-	-	-	Hunter River Alluvium	Alluvial Lands
HV4	MB	AD	310069	6401183	67.0	-	-	-	13.0	-	-	-	Hunter River Alluvium	Alluvial Lands
PZ6CH2450	MB	AD	311233	6400727	67.1	0.1	14.1	>14.5	15.0	-	-	50	Hunter River Alluvium	Alluvial Lands
PZ1CH200	MB	EX	312646	6402256	62.2	0.1	10.5	>8.9	11.1	-	-	50	Alluvium	Alluvial Lands
PZ2CH400	MB	EX	312635	6402051	62.7	0.1	11.1	>9.9	11.2	-	-	50	Hunter River Alluvium	Alluvial Lands
PZ3CH800	MB	EX	312522	6401674	64.2	-	10.4	-	-	-	-	50	Hunter River Alluvium	Alluvial Lands
PZ4CH1380	MB	EX	312196	6401176	65.0	0.1	14.5	-	-	-	-	50	Hunter River Alluvium	Alluvial Lands
PZ5CH1800	MB	EX	311852	6400928	66.2	0.1	14.9	-	-	-	-	50	Hunter River Alluvium	Alluvial Lands
GA3	MB	EX	310159	6400876	65.5	-	-	-	-	-	-	-	Coal or alluvium?	Alluvial Lands
GW_114_extra	MB	AD	312272	6403981	98.2	-	120.0	111.0	114.0	-	-	50	Bayswater Seam	Alluvial Lands
HVN-R-050	MB	AD	312268	6403985	108.0	-	-	-	-	-	-	50	Bayswater Seam	Alluvial Lands
HV2	MB	AD	310675	6400584	68.6	-	-	-	-	-	-	-	Interburden?	Alluvial Lands
4113P	MB	EX	310729	6401304	70.4	1.3	66.5	62.9	65.5	-	-	50	Spoil	Alluvial Lands
4114P	MB	AD	310734	6401306	69.6	0.7	21.5	17.9	20.5	-	-	50	Spoil	Alluvial Lands
4116P	MB	EX	310681	6400978	71.5	1.3	25.8	20.9	23.5	-	-	50	Spoil	Alluvial Lands
4117P	MB	EX	310670	6400980	71.4	1.2	91.0	87.0	87.6	-	-	50	Spoil	Alluvial Lands
4118P	MB	AD	312501	6402040	64.9	1.3	49.5	43.6	46.2	-	-	50	Spoil	Alluvial Lands
4119P	MB	EX	312501	6402048	64.7	1.2	20.8	14.9	17.5	-	-	50	Spoil	Alluvial Lands
DM1	MB	EX	311778	6405164	103.1	0.3	28.8	-	-	-	-	50	Spoil (Base)	Alluvial Lands
DM2	MB	AD	311640	6404635	106.8	-	-	-	-	-	-	-	Pit Floor	Alluvial Lands
DM3	MB	EX	311971	6403310	95.0	0.8	40.7	50.0	-	-	-	50	Spoil (Base)	Alluvial Lands
DM4	MB	EX	312222	6401418	65.7	0.8	-	55.0	-	-	-	50	Spoil (Base)	Alluvial Lands
DM5_20	MB	AD	311431	6400961	68.8	-	-	-	-	-	-	-	Spoil	Alluvial Lands
DM5_40	MB	AD	311431	6400961	68.8	-	-	-	-	-	-	-	Spoil	Alluvial Lands
DM5_75	MB	AD	311431	6400961	68.8	-	-	-	-	-	-	-	Spoil	Alluvial Lands
DM6 Dewatering Bore	MB	AU	310796	6400980	70.3	-	-	-	-	-	-	-	Spoil	Alluvial Lands
DM7	MB	EX	311136	6400961	70.4	1.1	-	32.0	-	-	-	400	Spoil	Alluvial Lands
DM9	MB	AD	310284	6401095	70.8	1.2	-	32.0	-	-	-	400	Spoil	Alluvial Lands
GW_114	MB	EX	312272	6403981	98.2	-	33.0	27.0	30.0	-	-	50	Spoil	Alluvial Lands
MB14HVO001	MB	AU	310587	6401003	71.3	-	90.0	-	-	-	-	-	Spoil	Alluvial Lands
MB14HVO02	MB	AU	310469	6401001	70.9	-	90.0	-	-	-	-	-	Spoil	Alluvial Lands
MB14HVO03	MB	AU	311387	6400950	67.1	-	80.0	-	-	-	-	-	Spoil	Alluvial Lands
MB14HVO04	MB	AU	311491	6401392	67.1	-	55.0	-	-	-	-	-	Spoil	Alluvial Lands
MB14HVO05	MB	AU	310675	6401127	71.7	-	85.0	-	-	-	-	-	Spoil	Alluvial Lands
BUNC13	MB	AD	313145	6401730	78.6	-	-	-	-	-	-	-	Alluvium	Barry's Pit
CHPZ10A	MB	EX	313334	6402297	63.4	0.8	12.6	9.5	12.6	-	-	50	Alluvium	Barry's Pit
CHPZ14A	MB	EX	312883	6401639	66.0	0.4	16.0	12.8	16.0	-	-	50	Alluvium	Barry's Pit
CHPZ1A	MB	EX	312820	6401697	65.9	1.0	18.7	15.0	18.7	-	-	50	Alluvium	Barry's Pit
CHPZ9A	MB	EX	313538	6402383	62.1	0.4	11.2	8.0	11.2	-	-	50	Alluvium	Barry's Pit
BUNC39B(Shallow)	MB	EX	313500	6401823	66.9	0.4	13.5	10.5	13.5	-	-	50	Regolith - Sandy clay	Barry's Pit
BUNC45A	MB	EX	313667	6402055	73.3	0.3	21.2	17.3	20.3	-	-	50	Regolith	Barry's Pit
CHPZ11A	MB	EX	313429	6402129	61.9	1.0	10.6	7.2	10.6	-	-	50	Alluvium	Barry's Pit
CHPZ12A	MB	EX	313238	6402013	63.5	0.3	11.5	9.5	11.5	-	-	50	Alluvium	Barry's Pit
CHPZ13A	MB	EX	313009	6401801	65.5	0.8	15.3	10.6	15.3	-	-	50	Alluvium	Barry's Pit
CHPZ2A	MB	EX	312941	6401539	65.8	0.6	16.9	13.7	16.9	-	-	50	Alluvium	Barry's Pit
CHPZ3A	MB	EX	313086	6401756	63.9	0.7	14.5	14.5	11.5	-	-	50	Alluvium	Barry's Pit
CHPZ4A	MB	EX	312904	6402123	66.3	0.8	14.2	10.9	14.2	-	-	50	Alluvium	Barry's Pit
CHPZ5A	MB	EX	312926	6401838	65.4	0.4	15.5	12.9	15.5	-	-	50	Alluvium	Barry's Pit
CHPZ7A	MB	EX	313600	6402238	60.3	0.1	11.2	8.0	11.0	-	-	50	Regolith, alluvium	Barry's Pit
CHPZ8A	MB	EX	313503	6402051	60.9	0.8	6.3	4.0	6.0	-	-	50	Regolith, alluvium	Barry's Pit
BUNC39A(Deep)	MB	EX	313500	6401823	66.8	0.4	19.9	16.6	19.9	-	-	50	Mt Arthur Seam	Barry's Pit
BUNC44D	MB	EX	313601	6401922	65.2	0.7	16.4	13.0	16.0	-	-	50	Mt Arthur Seam	Barry's Pit
BUNC45D	MB	EX	313677	6402060	73.8	0.4	30.7	25.9	28.9	-	-	50	Mt Arthur Seam	Barry's Pit
BUNC46D	MB	EX	313328	6401782	65.8	0.2	24.0	21.0	24.0	-	-	-	Mt Arthur Seam	Barry's Pit
CHPZ12D	MB	EX	313236	6402019	63.6	0.3	14.3	12.0	15.0	-	-	50	Mt Arthur Seam	Barry's Pit
CHPZ13D	MB	EX	313014	6401801	65.1	0.3	17.3	23.4	20.5	-	-	50	Mt Arthur Seam	Barry's Pit
CHPZ14D	MB	EX	312891	6401639	65.9	0.3	18.8	28.8	25.6	-	-	50	Mt Arthur Seam	Barry's Pit
CHPZ3D	MB	EX	313094	6401756	63.7	0.6	16.0	20.5	23.6	-	-	50	Mt Arthur Seam	Barry's Pit
CHPZ8D	MB	EX	313508	6402047	61.2	1.1	9.5	6.0	9.5	-	-	50	Mt Arthur Seam	Barry's Pit
BUNC14	MB	AU	313115	6401693	80.8	-	-	-	-	-	-	-	Sandstone	Barry's Pit
BUNC46D-barrys	MB	AU	313335	6401769	69.3	0.4	25.6	22.6	25.6	-	-	50	Interburden	Barry's Pit
4032P	MB	EX	308609	6402945	70.3	0.9	14.4	7.4	13.4	-	-	50	Palaeochannel alluvium	Carrington
4033P	MB	EX	308877	6402939	69.9	1.0	10.1	7.0	17.0	-	-	50	Palaeochannel alluvium	Carrington
4034P	MB	EX	308239	6402959	71.5	0.3	15.0	5.6	14.6	-	-	50	Palaeochannel alluvium	Carrington
4035P	MB	EX	308386	6402778	70.5	1.0	12.8	5.7	11.7	-	-	50	Palaeochannel alluvium	Carrington
4037P	MB	EX	308277	6402702	71.8	1.0	15.4	8.3	14.3	-	-	50	Palaeochannel alluvium	Carrington
4038C	MB	EX	308502	6403116	70.0	1.0	13.0	6.0	12.0	-	-	50	Palaeochannel alluvium	Carrington
4039C_1	VWP	EX	308468	6402673	70.7	-	-	-	-	-	13.5	-	Palaeochannel alluvium	Carrington
4040P	MB	EX	308675	6402724	70.1	1.0	12.9	5.9	11.9	-	-	50	Palaeochannel alluvium	Carrington
4052P	MB	EX	307924	6402680	72.6	1.1	15.6	8.4	14.4	-	-	50	Palaeochannel alluvium	Carrington
4053P	MB	EX	308112	6402680	71.6	1.0	15.8	8.8	14.8	-	-	50	Palaeochannel alluvium	Carrington
CFW55R	MB	EX	310439	6402180	70.3	0.5	16.4	9.4	16.4	-	-	50	Palaeochannel alluvium	Carrington
CFW56	MB	AD	310333	6402255	69.9	-	-	-	-	-	-	-	Palaeochannel alluvium	Carrington
CFW57	MB	EX	310084	6402053	70.8	0.7	16.4	8.4	15.4	-	-	50	Palaeochannel alluvium	Carrington
CGW32	MB	EX	308598	6404872	79.2	-	-	-	-	-	-	-	Palaeochannel alluvium	Carrington
CGW52a	MB	EX	309902	6402249	71.4	0.8	18.6	-	-	-	-	50	Alluvium	Carrington
CGW53a	MB	EX	309606	6402333	70.5	0.7	14.7	-	-	-	-	50	Alluvium	Carrington
CGW54a	MB	EX	310196	6402159	70.0	0.8	17.1	-	-	-	-	50	Alluvium	Carrington
CGW55a	MB	EX	309840	6402457	71.0	0.5	18.5	-	-	-	-	50	Alluvium	Carrington
CGW6	MB	EX	308756	6402770	70.1	0.8	21.8	-	-	-	-	80	Alluvium	Carrington
GW_101	MB	EX	304374	6406728	100.5	-	12.0	9.0	12.0	-	-	50	Regolith, alluvium	Carrington
GW_106	MB	AU	309092	6405224	82.3	0.8	30.0	24.0	27.0	-	-	50	Palaeochannel alluvium or weathered sandstone?	Carrington
GW_112	MB	AU	312955	6404810	73.0	-	-	-	-	-	-	50	Base of alluvium	Carrington
GW_113	MB	AU	313160	6403740	64.0	-	-	-	-	-	-	50	Base of alluvium	Carrington
PB2(d)	MB	AD	309665	6402643	70.3	-	14.5	11.5	14.5	-	-	50	Alluvium - sandy gravel (base of alluv)	Carrington
PB2(s)	MB	AD	309665	6402643	70.3	-	9.0	6.0	9.0	-	-	50	Alluvium - silty sand (top of alluv)	Carrington
PB3(d)	MB	AD	309815	6402620	70.9	-	16.1	13.1	16.1	-	-	50	Base of alluvium	Carrington
PB3(s)	MB	AD	309815	6402620	70.9	-	7.8	4.8	7.8	-	-	50	Silty clay - top of alluvium	Carrington
PB6(d)	MB	AD	310256	6402424	68.5	-	16.8	13.8	16.8	-	-	50	Base of alluvium	Carrington
PB6(s)	MB	AD	310256	6402424	68.5	-	8.5	4.5	7.5	-	-	50	Top of Gravels	Carrington
PB7(d)	MB	AD	310421	6402335	69.2	-	15.4	12.4	15.4	-	-	50	Base of alluvium	Carrington
PB7(s)	MB	AD	310421	6402335	69.2	-	9.1	6.1	9.1	-	-	50	Top of Gravels	Carrington
CFW70	MB	AD				-	-	-	-	-	-	-	Alluvium/ weathered overburden?	Carrington
CFW71	MB	AD				-	-	-	-	-	-	-	Alluvium/ weathered overburden?	Carrington
CGW1	MB	AD	309930	6402690	70.6	-	-	-	-	-	-	-	Alluvium/ weathered overburden?	Carrington
CGW18	MB	AD	308824	6405101	86.8	-	-	-	-	-	-	-	Alluvium/ weathered overburden?	Carrington
CGW19	MB	AD				-	-	-	-	-	-	-	Alluvium/ weathered overburden?	Carrington
CGW2	MB	AD	310156	6402685	70.7	-	-	-	-	-	-	-	Alluvium/ weathered overburden?	Carrington
CGW3	MB	AD	310360	6402679	71.2	-	-	-	-	-	-	-	Alluvium/ weathered overburden?	Carrington
CGW34	MB	AD	310012	6403588	78.6	-	-	-	-	-	-	-	Alluvium/ weathered overburden?	Carrington
CGW35	MB	AD	309725	6403446	77.0	-	-	-	-	-	-	-	Alluvium/ weathered overburden?	Carrington
CGW37	MB	AD				-	-	-	-	-	-	-	Alluvium/ weathered overburden?	Carrington
CGW38	MB	AD	309691	6403638	76.6	-	-	-	-	-	-	-	Alluvium/ weathered overburden?	Carrington

Bore ID	Type	Status	Easting	Northing	Ground elevation (mAHD)	Collar height (maGL)	Bore depth (mbGL)	Tof of screen (mbGL)	Base of screen (mbGL)	VWP sensor (mAHD)	VWP sensor (mbGL)	Bore diameter (mm)	Lithological description	Location
CGW4	MB	AD				-	-	-	-	-	-	-	Alluvium/ weathered overburden?	Carrington
CGW40	MB	AD	309853	6403220	75.3	-	-	-	-	-	-	-	Alluvium/ weathered overburden?	Carrington
CGW41	MB	AD	310132	6403259	76.4	-	-	-	-	-	-	-	Alluvium/ weathered overburden?	Carrington
CGW42	MB	AD	309833	6402991	72.6	-	-	-	-	-	-	-	Alluvium/ weathered overburden?	Carrington
CGW43	MB	AD	310074	6402959	72.2	-	-	-	-	-	-	-	Alluvium/ weathered overburden?	Carrington
CGW44a	MB	AD				-	-	-	-	-	-	-	Alluvium/ weathered overburden?	Carrington
CGW5	MB	AD	309666	6402712	71.0	-	-	-	-	-	-	25	Alluvium/ weathered overburden?	Carrington
CGW39	MB	EX	308566	6403694	70.2	0.5	13.5	5.0	14.0	-	-	-	Alluvium?	Carrington
CGW48a	MB	AD	308418	6402919	70.2	-	-	-	-	-	-	50	Alluvium?	Carrington
CGW50	MB	AD	308778	6403098	69.4	-	-	-	-	-	-	-	Alluvium?	Carrington
CGW8	MB	AD	309929	6403414	77.1	-	-	-	-	-	-	-	Alluvium?	Carrington
4039C_2	VWP	EX	308468	6402673	70.7	-	-	-	-	-	52.3	-	Broonie Seam	Carrington
4039C_3	VWP	AD	308468	6402673	70.7	-	-	-	-	-	65	-	Bayswater Seam	Carrington
CFW56A	MB	AD			68.9	-	-	-	-	-	-	-	Permian Coal Seam	Carrington
CFW57A	MB	AD	310088	6402049	70.9	0.9	7.9	1.5	6.0	-	-	50	Permian Coal Seam	Carrington
CGW45	MB	EX	308042	6403349	72.5	0.3	14.4	-	-	-	-	25	Bayswater Seam	Carrington
CGW45a	MB	AD	308044	6403349	72.6	0.5	-	-	-	-	-	65	Broonie Seam	Carrington
CGW46	MB	EX	308413	6403276	72.0	-	13.6	-	-	-	-	25	Bayswater Seam	Carrington
CGW46a	MB	EX	308415	6403276	72.0	-	-	-	-	-	-	65	Broonie Seam	Carrington
CGW47	MB	EX	308729	6403406	70.8	0.4	16.5	-	-	-	-	25	Bayswater Seam	Carrington
CGW47a	MB	EX	308731	6403405	70.8	0.4	-	-	-	-	-	50	Broonie Seam	Carrington
CGW49	MB	EX	308778	6403098	69.6	0.5	13.3	-	-	-	-	80	Bayswater Seam	Carrington
CGW52	MB	EX	309906	6402255	71.4	0.7	45.3	-	-	-	-	25	Broonie Seam	Carrington
CGW53	MB	EX	309606	6402333	70.5	0.6	43.0	-	-	-	-	25	Broonie Seam	Carrington
CGW54	MB	AD	310196	6402159	70.0	0.7	36.6	-	-	-	-	25	Broonie Seam	Carrington
GW_103	VWP	AU	306769	6404610	103.2	-	120.0	-	-	-	25.5 64.5 119.5	-	Coal - undifferentiated and weathered Siltstone and coal Sandstone - mg, fresh	Carrington
GW_105	VWP	AU	308597	6405442	93.1		154.0	-	-		33 103.5 154	-	Coal - undifferentiated Coal - tuffaceous Coal	Carrington
GW_109	VWP	AU	309232	6402706	85.2	-	-	-	-		31.5 65 89.5	-	Coal - slightly weathered Coal - tuffaceous Bayswater Seam	Carrington
GW_111a	VWP	AU	312090	6405800	84.0	-	-	-	-	-	-	-	Coal	Carrington
GW_112a	VWP	AU	312955	6404810	73.0	-	-	-	-		-	-	Bayswater Seam	Carrington
CGW44	MB	AD	310281	6402794	72.5						-		Coal?	Carrington
CGW48	MB	AD	308418	6402919	70.4	0.5	15.9	-	-	-	-	25	Coal?	Carrington
4036C	MB	EX	308272	6402688	71.8	1.1	35.2	33.1	34.1		-	50	Interburden (Siltstone/Sandstone)	Carrington
4051C	MB	EX	308664	6402721	69.9	1.0	31.5	31.8	32.8		-	50	Interburden (Siltstone/Sandstone)	Carrington
CFW59	MB	EX	310245	6402370	68.9	0.5	16.0	7.5	13.3	-	-	50	Interburden (Siltstone/Sandstone)	Carrington
CFW63	MB	AD	310828	6403724	101.0	0.7	-	-	-	-	-	-	Carrington Spoil (Base)	Carrington
CFW64	MB	AD	310877	6403617	104.3	0.7	44.5	29.5	-	-	-	-	Carrington Spoil (Base)	Carrington
CGW51a	MB	EX	310149	6402419	70.2	0.2	17.2	-	-	-	-	50	Interburden (Siltstone/Sandstone)	Carrington
GW_100a	VWP	EX	303722	6406445	89.4	-	60.0	-	-	-	51	-	Barrett Seam and Interburden	Carrington
GW_101a	VWP	AU	304362	6406721	100.5	-	52.0	-	-	-	51	-	Interburden (Siltstone/Sandstone)	Carrington
GW_102	VWP	AU	305280	6406668	114.6	-	60.5	-	-	-	60.5	-	Interburden (Sandstone with minor coal)	Carrington
GW_104	VWP	AU	307549	6404657	86.7	-	136.0	-	-	-	59 107 135	-	Lower Pikes Gully Seam Sandstone IB (near Upper Liddell Seam) Sandstone (above Barret)	Carrington
GW_110	VWP	AU	310503	6404598	124.6	-	-	-	-	-	38 63 93	-	Sandstone - fresh Sandstone Bayswater Seam	Carrington
G10	MB	AD	310932	6403357	88.8	-	-	-	-	-	-	-	Bayswater Seam	Carrington
CFW58	MB	AD			0.0	-	-	-	-	-	-	-	Interburden?	Carrington
GW_111	MB	AU	312090	6405800	84.0	-	-	-	-	-	-	50	Interburden?	Carrington
GS1	MB	AU	310690	6403854	94.2	0.5	-	-	-	-	-	-	Base of Spoil	Carrington
GS2	MB	AU	310899	6403921	100.5	0.9	31.7	-	-	-	-	-	Base of Spoil	Carrington
GS5	MB	AU	310890	6403612	104.4	0.2	-	-	-	-	-	-	Base of Spoil	Carrington
GS8	MB	AU	310901	6403304	101.0	0.9	40.7				-		Carrington Spoil (Base)	Carrington
GW_107	MB	EX	308738	6404103	73.5		28.6	24.2	27.2		-	50	Carrington Spoil	Carrington
GW_108	MB	EX	309695	6403971	84.4	-	61.5	52.5	58.5	-	-	50	Carrington Spoil	Carrington
GW_113a	VWP	AU	313160	6403740	64.0	-	-	-	-		-	-	Base of Spoil	Carrington
GW_115	MB	EX	312227	6402216	68.3		28.7	22.2	28.2		-	50	Spoil	Carrington
GW_116	MB	AU	310735	6401295	69.0	-	-	-	-	-	-	50	Spoil	Carrington
BC1	MB	AU	312421	6401010	66.4	0.3	8.5	-	-	-	-	-	Alluvium	Cheshunt
BUNC12	MB	AD	313180	6401753	75.9	-	-	-	-	-	-	-	Alluvium	Cheshunt
BZ1-2	MB	AU	311472	6400483	71.8	0.4	-	7.0	10.0	-	-	-	Alluvium	Cheshunt
BZ2B	MB	AD	311668	6400560	71.3	-	-	-	-	-	-	-	Alluvium	Cheshunt
BZ8-1	MB	AD	312685	6401010	67.8	-	-	-	-	-	-	-	Alluvium	Cheshunt
Hobden's Well	MB	EX	312540	6401093	71.0	0.7	13.9	-	-	-	-	-	Alluvium	Cheshunt
Bay13_VW2	VWP	AD	312216	6399356	83.0	-	-	-	-	-57.5	-	-	Vaux Seam	Cheshunt
Bay13_VW3	VWP	AD	312216	6399356	83.0	-	-	-	-	-87.7	-	-	Broonie Seam	Cheshunt
Bay13_VW4	VWP	AD	312216	6399356	83.0	-	-	-	-	-127	-	-	Bayswater Seam	Cheshunt
Bay16_VW1	VWP	AD	311611	6399602	67.7	-	-	-	-	-27.78	-	-	Mt Arthur Seam	Cheshunt
Bay16_VW2	VWP	AD	311611	6399602	67.7	-	-	-	-	-51.58	-	-	Vaux Seam	Cheshunt
Bay16_VW3	VWP	AD	311611	6399602	67.7	-	-	-	-	-75.88	-	-	Broonie Seam	Cheshunt
Bay16_VW4	VWP	AD	311611	6399602	67.7	-	-	-	-	-127.08	-	-	Bayswater Seam	Cheshunt
Bay19_VW1	VWP	AD	311335	6399886	74.7	-	-	-	-	-11.28	-	-	Mt Arthur Seam	Cheshunt
Bay19_VW2	VWP	AD	311335	6399886	74.7	-	-	-	-	-47.43	-	-	Vaux Seam	Cheshunt
Bay19_VW3	VWP	AD	311335	6399886	74.7	-	-	-	-	-73.98	-	-	Broonie Seam	Cheshunt
Bay19_VW4	VWP	AD	311335	6399886	74.7	-	-	-	-	-116.48	-	-	Bayswater Seam	Cheshunt
Bay19_VW5	VWP	AD	311335	6399886	74.7	-	-	-	-	-135.08	-	-	LAU - Lower Arties Upper	Cheshunt
BC1a	MB	EX	312421	6400872	66.4	0.3	21.1	-	-	-	-	-	Mt Arthur Seam	Cheshunt
BZ1-3	MB	EX	311472	6400483	71.8	0.4	35.0	-	-	-	-	-	Mt Arthur Seam	Cheshunt
BZ2A(1)	MB	EX	311671	6400561	71.7	0.4	39.0	-	-	-	-	-	Mt Arthur Seam	Cheshunt
BZ3-3	MB	EX	311840	6400640	70.3	0.4	38.0	-	-	-	-	-	Mt Arthur Seam	Cheshunt
BZ4A(2)	MB	EX	312029	6400705	74.4	0.6	41.4	-	-	-	-	-	Mt Arthur Seam	Cheshunt
BZ5-1	MB	AD	312192	6400804	66.9	-	-	-	-	-	-	-	Mt Arthur Seam	Cheshunt
BZ5-2	MB	AD	312192	6400804	66.9	-	-	-	-	-	-	-	Mt Arthur Seam	Cheshunt
BZ8-3	MB	AD	312685	6401010	67.8	-	-	-	-	-	-	-	Mt Arthur Seam	Cheshunt
HG2A	MB	EX	312469	6400886	67.5	0.6	27.8	-	-	-	-	-	Mt Arthur Seam	Cheshunt
Bay13_VW1	VWP	AD	312216	6399356	83.0	-	-	-	-	-15	-	-	FCL - Fairford Claystone	Cheshunt
BZ1-1	MB	EX	311472	6400483	71.8	0.4	-	21.0	24.0	-	-	-	Interburden	Cheshunt
BZ2A(2)	MB	EX	311671	6400561	71.7	0.6	20.9	-	-	-	-	-	Interburden	Cheshunt
BZ3-1	MB	EX	311840	6400640	70.3	0.3	26.2	-	-	-	-	-	Interburden	Cheshunt
BZ3-2	MB	AD	311840	6400640	70.3	0.3	11.7	-	-	-	-	-	Interburden	Cheshunt
BZ4A(1)	MB	EX	312029	6400705	74.4	-	-	-	-	-	-	-	Interburden	Cheshunt
BZ4B	MB	AD	312029	6400705	74.1	-	-	-	-	-	-	-	Interburden	Cheshunt
BZ8-2	MB	EX	312685	6401010	67.8	-	-	-	-	-	-	-	Interburden	Cheshunt
HG1	MB	EX	312390	6400882	66.1	0.7	14.7	-	-	-	-	-	Interburden	Cheshunt
HG2	MB	EX	312469	6400886	67.5	0.6	15.5	-	-	-	-	-	Interburden	Cheshunt
HG3	MB	EX	312541	6400940	66.8	-	-	-	-	-	-	-	Interburden	Cheshunt
Appleyard Farm	MB	EX	315491	6394639	43.4	0.8	10.0	7.0	10.0	-	-	-	Alluvium	Lemington
C919(ALL)	MB	EX	315192	6395655	58.0	0.3	11.5	-	-	-	-	-	Alluvium	Lemington

Bore ID	Type	Status	Easting	Northing	Ground elevation (mAHD)	Collar height (maGL)	Bore depth (mbGL)	Tof of screen (mbGL)	Base of screen (mbGL)	VWP sensor (mAHD)	VWP sensor (mbGL)	Bore diameter (mm)	Lithological description	Location
D317(ALL)	MB	EX	315044	6396018	59.5	0.3	14.7	9.2	12.2	-	-	-	Alluvium	Lemington
D725(ALL)	MB	AD				-	-	-	-	-	-	-	Alluvium	Lemington
PB01(ALL)	MB	EX	314754	6396026	55.0	-	-	-	-	-	-	-	Alluvium	Lemington
B334(BFS)	MB	EX	316684	6394088	73.0	0.3	51.8	58.5	-	-	-	-	Bowfield Seam	Lemington
B425(WDH)	MB	EX	316010	6395024	58.0	-	55.0	-	-	-	-	-	Woodlands Hill Seam	Lemington
B631(BFS)	MB	EX	316425	6394319	72.0	0.3	36.1	78.0	-	-	-	-	Bowfield Seam	Lemington
B631(WDH)	MB	EX	316424	6394319	72.0	-	30.7	-	-	-	-	-	Woodlands Hill Seam	Lemington
B925(BFS)	MB	EX	315921	6394604	65.0	0.4	41.2	81.0	-	-	-	-	Bowfield Seam	Lemington
C1(WJ039)	MB	EX	317142	6400707	71.2	-	-	-	-	-	-	-	Piercefield Seam	Lemington
C122(BHS)	MB	EX	315501	6395007	58.0	-	-	-	-	-	-	-	Bowfield Seam	Lemington
C122(WDH)	MB	EX	315501	6395007	58.0	0.3	22.7	-	-	-	-	-	Woodlands Hill Seam	Lemington
C130(AFS1)	MB	EX	316400	6394916	63.0	0.3	42.2	-	-	-	-	-	Arrowfield Seam	Lemington
C130(BFS)	MB	EX	316400	6394916	63.0	0.0	64.5	55.0	61.0	-	-	-	Bowfield Seam	Lemington
C130(WDH)	MB	EX	316400	6394916	63.0	0.4	21.6	-	-	-	-	-	Woodlands Hill Seam	Lemington
C317(BFS)	MB	EX	315054	6395007	60.0	0.4	76.2	-	-	-	-	-	Bowfield Seam	Lemington
C317(WDH)	MB	EX	315054	6395007	60.0	0.2	33.9	-	-	-	-	-	Woodlands Hill Seam	Lemington
C613(BFS)	MB	EX	314688	6395243	63.0	0.3	85.5	-	-	-	-	-	Bowfield Seam	Lemington
C621(BFS)	MB	EX	315421	6395321	58.0	0.3	57.5	-	-	-	-	-	Bowfield Seam	Lemington
C630(BFS)	MB	EX	316378	6395306	69.0	0.3	49.1	-	-	-	-	-	Bowfield Seam	Lemington
C809 (GM/WDH)	MB	EX	314207	6395493	59.0	0.3	28.7	28.0	38.0	-	-	-	Woodlands Hill Seam	Lemington
D010(BFS)	MB	EX	314355	6395687	56.0	0.4	68.1	-	-	-	-	-	Bowfield Seam	Lemington
D010(GM)	MB	EX	314355	6395687	56.0	-	-	-	-	-	-	-	Glen Munro Seam	Lemington
D010(WDH)	MB	EX	314355	6395687	56.0	0.3	17.0	-	-	-	-	-	Woodlands Hill Seam	Lemington
D2(WH236)	MB	AD	316847	6399926	61.9	-	-	-	-	-	-	-	Piercefield Seam	Lemington
D214(BFS)	MB	EX	314768	6395831	56.5	0.3	53.5	43.0	52.5	-	-	-	Bowfield Seam	Lemington
D317(BFS)	MB	EX	315043	6396019	59.5	0.3	44.0	39.0	44.2	-	-	-	Bowfield Seam	Lemington
D317(WDH)	MB	AD	315044	6396018	59.5	-	-	-	-	-	-	-	Woodlands Hill Seam	Lemington
D406(AFS)	MB	EX	313931	6396074	57.0	0.3	-	-	-	-	-	-	Arrowfield Seam	Lemington
D406(BFS)	MB	EX	313931	6396074	57.0	0.3	61.3	-	-	-	-	-	Bowfield Seam	Lemington
D406(WDH)	MB	AD	313931	6396074	57.0	-	-	-	-	-	-	-	Woodlands Hill Seam	Lemington
D510(AFS)	MB	EX	314380	6396141	54.8	0.3	30.5	25.5	30.5	-	-	-	Arrowfield Seam	Lemington
D510(BFS)	MB	EX	314380	6396141	54.8	0.3	38.0	34.0	38.0	-	-	-	Bowfield Seam	Lemington
D612(AFS)	MB	EX	314524	6396314	62.0	0.4	0.0	-	-	-	-	-	Arrowfield Seam	Lemington
D612(BFS)	MB	EX	314524	6396314	62.0	0.3	35.1	-	-	-	-	-	Bowfield Seam	Lemington
D807(BFS)	MB	EX	314002	6396484	59.7	0.4	41.0	36.0	41.0	-	-	-	Bowfield Seam	Lemington
F1.5(WF533)	MB	EX	316607	6398247	54.9	-	-	-	-	-	-	-	Vaux Seam	Lemington
GW9701	MB	EX	315901	6401798	93.6	-	-	-	-	-	-	-	Piercefield Seam	Lemington
GW9702	MB	EX	316436	6401479	98.6	-	-	-	-	-	-	-	Piercefield Seam	Lemington
GW9710	MB	EX	316700	6400486	82.6	-	-	-	-	-	-	-	Piercefield Seam	Lemington
Lemington	MB	AD	316683	6394088	75.3	-	-	-	-	-	-	-	Bowfield Seam	Lemington
GW9706	MB	AD	322404	6387589	64.2	-	-	-	-	-	-	-	Coal?	Lemington
GW9707	MB	AD	322319	6387569	63.9	-	-	-	-	-	-	-	Coal?	Lemington
GW9708	MB	AD	322158	6387209	73.1	-	-	-	-	-	-	-	Coal?	Lemington
GW9809	MB	AD	322251	6388026	60.3	-	-	-	-	-	-	-	Coal?	Lemington
C130(ALL)	MB	EX	316400	6394916	63.0	0.3	17.0	-	-	-	-	-	Interburden?	Lemington
GW_117	MB	EX	309579	6400676	68.3	-	15.8	9.9	15.8	-	-	50	Upper clay layer and pebbles, sub-angular, poorly sorted within a granular matrix.	Riverview
GW_119	MB	EX	310129	6400322	73.5	-	13.5	10.0	13.0	-	-	50	Clay	Riverview
E5038/5	MB	EX	309650	6398915	122.4	-	-	-	-	-	-	-	Coal	Riverview
H5032/5	MB	EX	309960	6398320	116.3	-	-	-	-	-	-	-	Coal	Riverview
H5038/5	MB	EX	309950	6398920	111.7	-	-	-	-	-	-	-	Coal	Riverview
E5035/5	MB	AD	309950	6398920	111.7	-	-	-	-	-	-	-	Coal?	Riverview
SR002	MB	EX	319079	6394620	56.8	-	41.0	38.0	41.0	-	-	-	Bayswater Seam	Southern
SR003	MB	EX	318863	6394864	61.3	-	-	-	-	-	-	-	Bayswater Seam?	Southern
SR004	MB	EX	318994	6395506	76.6	-	-	-	-	-	-	-	Bayswater Seam?	Southern
SR005	MB	EX	318831	6396128	65.3	-	-	-	-	-	-	-	Bayswater Seam?	Southern
SR006	MB	EX	318555	6395732	83.0	-	-	-	-	-	-	-	Bayswater Seam?	Southern
SR007	MB	EX	318772	6394373	60.9	-	37.5	31.5	37.5	-	-	-	Overburden and Vaux Seam coal	Southern
SR008	MB	EX	319290	6395111	56.8	-	30.4	24.4	30.4	-	-	-	Siltstone/sandstone below Lemington Seam	Southern
SR009	MB	EX	319338	6394746	56.1	-	36.4	30.4	36.4	-	-	-	Lemington Seam	Southern
SR010	MB	EX	317319	6395338	57.5	-	30.6	24.6	30.6	-	-	-	Conglomerate and Warkworth Seam	Southern
SR011	MB	EX	317699	6394412	88.2	-	47.4	41.4	47.4	-	-	-	Mt Arthur Seam and underburden	Southern
SR001	MB	EX	319146	6394094	58.2	-	-	-	-	-	-	-	Coal?	Southern
SR012	MB	EX	318354	6393926	76.2	-	29.5	23.4	29.4	-	-	-	Overburden - conglomerate and sandstone	Southern
G1	MB	EX	305694	6407301	110.0	-	-	-	-	-	-	-	Regolith, alluvium	West Pit
G2	MB	EX	305660	6407451	110.6	-	-	-	-	-	-	-	Regolith, alluvium	West Pit
G3	MB	EX	305636	6407556	108.6	-	-	-	-	-	-	-	Regolith, alluvium	West Pit
GW_100	MB	EX	303729	6406436	89.6	-	6.0	4.4	5.0	-	-	50	Regolith, alluvium	West Pit
S6	MB	AD	312994	6410517	69.0	-	-	-	-	-	-	-	Regolith, alluvium	West Pit
G4(d)	MB	AD	310415	6402342	69.2	-	-	-	-	-	-	-	Bayswater Seam	West Pit
HF3	MB	AD	311576	6409139	0.0	-	-	-	-	-	-	-	Coal	West Pit
HF7	MB	AD	312586	6409158	0.0	-	-	-	-	-	-	-	Coal	West Pit
S2	MB	AD	311502	6407889	135.6	-	-	-	-	-	-	-	Coal	West Pit
S4	MB	AD	312853	6408417	68.5	1.1	11.7	-	-	-	-	50	Coal	West Pit
Wes136c	VWP	AD	309641	6406484	136.2	-	-	-	-	33.5	102	-	Lower Pikes Gully	West Pit
Wes158c-VW1	VWP	AD	310312	6406963	119.3	-	-	-	-	31.78	83.5	-	Lower Pikes Gully	West Pit
Wes158c-VW2	VWP	AD	310312	6406963	119.3	-	-	-	-	29.32	143.6	-	Upper Liddell	West Pit
Wes158c-VW3	VWP	AD	310312	6406963	119.3	-	-	-	-	133.67	181.8	-	Barrett Seam	West Pit
G4(s)	MB	AD	310415	6402342	69.2	-	-	-	-	-	-	-	Coal?	West Pit
NPz1	MB	EX	305240	6406100	138.1	0.8	59.0	56.0	59.0	-	-	-	Sandstone/Siltstone	West Pit
NPz2	MB	EX	307800	6411340	199.6	0.6	60.0	57.0	60.0	-	-	-	Sandstone/Siltstone	West Pit
NPz3	MB	EX	306305	6409131	148.4	-	>20	-	-	-	-	-	Siltstone	West Pit
NPz3R	MB	AD	307024	6407896	147.1	0.8	96.6	93.6	96.6	-	-	-	Sandstone/Siltstone	West Pit
NPz4	MB	EX	306240	6404584	121.7	1.0	74.0	71.0	74.0	-	-	-	Sandstone/Siltstone	West Pit
NPz5	MB	EX	310730	6406550	134.7	0.9	43.0	40.0	43.0	-	-	-	Sandstone/Siltstone	West Pit

Notes:

MB Monitoring bore
EX Existing
AD Abandoned and destroyed

VWP Vibrating wire piezometer
AU Abandoned but usable

Appendix A-2

Bore Logs

Australasian Groundwater & Environmental Consultants Pty Ltd
Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

GW117

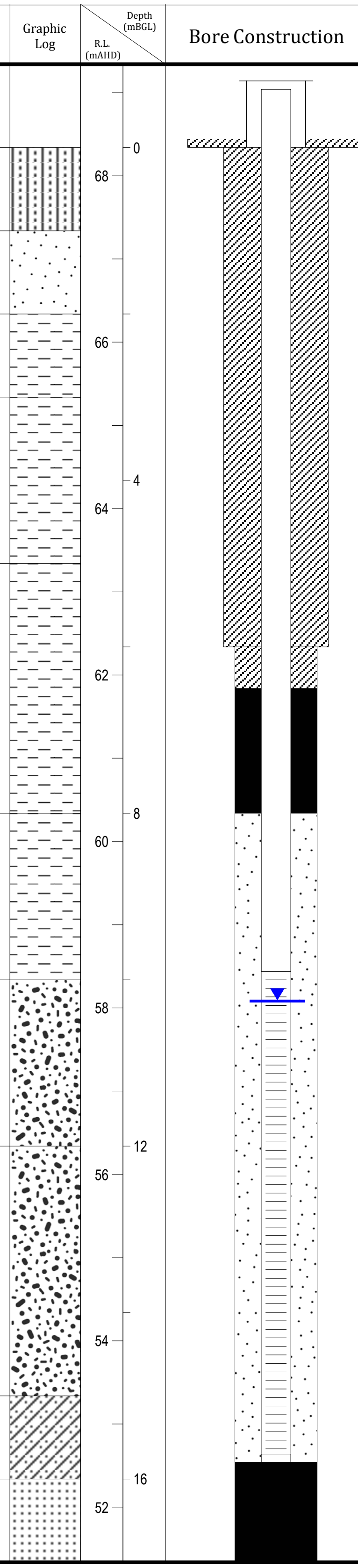
PROJECT No: **G1737B**
PROJECT NAME: **HVO South EIS**
DATE DRILLED: **18/09/2015**
LOGGED BY: **BC**
LICENCED DRILLER: **J. Bonard (DL2309)**

DRILLING COMPANY: **Lucas Drilling**
DRILLER: **J. Bonnard**
DRILLING METHOD: **Mud Rotary**
DRILL RIG: **Sandvik 810 Top Head Drive**

EASTING: **309578.89 mE**
NORTHING: **6400676.28 mN**
DATUM: **GDA MGA94 (Z55)**
RL: **68.34 mAHD**
TD: **17 mBGL**

COMMENTS:

Soil or Rock Field Material Description
SOIL: dark black, residual soil, soft, sandy in part
SAND: light orange, extremely weathered, soft
CLAY: dark brown, extremely weathered, soft, sandy in part
CLAY: dark brown, extremely weathered, stiff
CLAY: dark black, distinctly weathered very stiff
CLAY: brown, distinctly weathered very stiff, sandy in part
GRAVEL: medium gravel, sub-angular, poorly graded, mottled yellow, distinctly weathered loose
GRAVEL: medium gravel, sub-angular, poorly graded, mottled bluish slightly weathered, loose
SANDY CLAY (60 %): dark grey, very low strength, fresh, sandstone throughout / SANDSTONE (40 %): fine sand, light grey, very low strength, fresh
SANDSTONE (60 %): fine sand, light grey, very low strength, fresh, / SANDY CLAY (40 %): dark grey, very low strength, fresh



Bore Description

- Protective lockable steel collar: -0.85 m
- Stick up: 0.8 m
- 50 mm uPVC (class 18) blank casing: -0.8 m to 9.9 m
- 178 mm Blade bit: 0 m to 6 m (Mud rotary)
- 150 mm (OD) uPVC (class 18) (6 mm) surface casing: -0.8 m to 6 m
- Grout - 0 m to 6.5 m
- 140 mm Tri cone: 6 m to 17 m (Mud rotary)
- Bentonite seal: 6.5 m to 8 m
- 5 mm washed, rounded, quartz gravel pack: 8 m to 15.8 m
- 50 mm uPVC (class 18) machine slotted casing, slot apperture: 0.4 mm, 9.9 m to 15.7 m
- Airlift flow rate: 0.067 L/s
- End cap - 15.8 m
- Bentonite seal: 15.8 m to 17 m
- End of hole: 17 m

Australasian Groundwater & Environmental Consultants Pty Ltd

Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

GW119

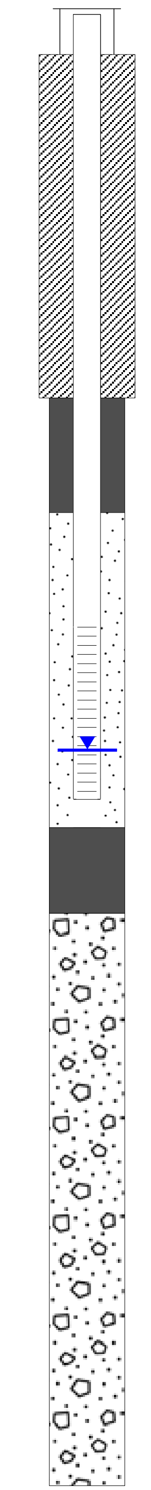
PROJECT No: **G1737B**
PROJECT NAME: **GW119**
DATE DRILLED: **23/09/2015**
LOGGED BY: **BC**
LICENCED DRILLER: **J. Bonard (DL2309)**
COMMENTS:

DRILLING COMPANY: **Lucas Drilling**
DRILLER: **J. Bonnard**
DRILLING METHOD: **Mud Rotary**
DRILL RIG: **Sandvik DE810 Top Head Drive**

EASTING: **310128.52 mE**
NORTHING: **6400322.47 mN**
DATUM: **GDA MGA94 (Z55)**
RL: **73.5 mAHD**
TD: **25 mBGL**

Soil or Rock Field Material Description	Depth (mBGL)
CLAY: dark brown, residual soil, stiff	0–1
CLAY (90 %): dark orange, extremely weathered, stiff, / SAND (10 %): fine sand, light yellow, extremely weathered	1–2
SAND (90 %): fine sand, light yellow, extremely weathered, soft, / CLAY (10 %): dark orange, extremely weathered	2–3
SAND (60 %): dark orangey yellow, extremely weathered, soft, / CLAY (40 %): light whitish brown, extremely weathered	3–5
CLAY: light pinkish red, extremely weathered, soft	5–7
CLAY (80 %): light pinkish red, extremely weathered, soft, / SAND (20 %): light brown, extremely weathered	7–9
CLAY: light pinkish red, distinctly weathered soft	9–10
CLAY: light pinkish brown, distinctly weathered soft	10–11
CLAY: dark brownish black, distinctly weathered soft, carbonaceous in part	11–12
CLAY: dark brownish black, slightly weathered, firm	12–13
CLAY: light grey, fresh, firm	13–14
CLAY: dark blackish grey, fresh, firm	14–15
SANDSTONE (80 %): fine sand, light grey, very low strength, fresh, / CLAYSTONE (20 %): light grey, very low strength, fresh	15–16
SANDSTONE: fine sand, light greyish white, very low strength, fresh	16–17
COAL (80 %): black, very low strength, fresh, / SANDSTONE (20 %): fine sand, light greyish white, very low strength, fresh	17–18
CLAYSTONE (90 %): light grey, very low strength, fresh, / SANDSTONE (10 %): fine sand, light whitish grey, very low strength, fresh	18–19
SANDSTONE: fine sand, light grey, low strength, fresh	19–20
SANDSTONE (90 %): fine sand to medium sand, light grey, low strength, fresh, / CLAYSTONE (10 %): light greyish white, very low strength, fresh	20–22
SANDSTONE (80 %): fine sand, light grey, low strength, fresh, / CLAYSTONE (20 %): light greyish white, very low strength, fresh	22–23
SANDSTONE (70 %): fine sand, light grey, low strength, fresh, / CLAYSTONE (30 %): light greyish white, very low strength, fresh	23–25

Bore Construction



Bore Description

- Protective lockable steel collar: 0.8 m
- Casing stick up: 0.7 m
- 150 mm (OD) uPVC (class 18) (6 mm) surface casing: -0.7 m to 5.5 m
- 50 mm uPVC (class 18) blank casing: -0.7 m to 10 m
- 178 mm Blade bit: 0 m to 5.5 m (Mud rotary)
- Grout 0 m to 6 m
- 140 mm Tri cone: 5.5 m to 26 m (Mud rotary)
- Bentonite seal: 6 m to 8 m
- 5 mm washed, rounded, quartz gravel pack: 8 m to 13.5 m
- 50 mm uPVC (class 18) machine slotted casing, slot apperture: 0.4 mm, 10 m to 13 m
- End cap - 13 m
- Bentonite seal: 13.5 m to 15 m
- Backfill 15 m to 25 m
- End of hole: 25 m BGL

Appendix A-3

Groundwater Levels

Bore ID	Type	Status	Easting	Northing	Ground elevation (mAHD)	Collar height (maGL)	SWL date	SWL (mAHD)	Lithological description	Location
PZ1CH200	MB	EX	312646	6402256	62.2	0.1	6/11/2014	54.9	Alluvium	Alluvial Lands
GA3	MB	EX	310159	6400876	65.5	-	23/12/2014	55.2	Coal or alluvium?	Alluvial Lands
HV3	MB	EX	310776	6400546	67.7	0.5	23/12/2014	47.2	Hunter River Alluvium	Alluvial Lands
PZ2CH400	MB	EX	312635	6402051	62.7	0.1	14/01/2015	54.7	Hunter River Alluvium	Alluvial Lands
PZ3CH800	MB	EX	312522	6401674	64.2	-	14/01/2015	54.9	Hunter River Alluvium	Alluvial Lands
PZ4CH1380	MB	EX	312196	6401176	65.0	0.1	6/11/2014	55.2	Hunter River Alluvium	Alluvial Lands
PZ5CH1800	MB	EX	311852	6400928	66.2	0.1	6/11/2014	55.5	Hunter River Alluvium	Alluvial Lands
4113P	MB	EX	310729	6401304	70.4	1.3	23/12/2014	40.4	Spoil	Alluvial Lands
4116P	MB	EX	310681	6400978	71.5	1.3	23/12/2014	49.1	Spoil	Alluvial Lands
4117P	MB	EX	310670	6400980	71.4	1.2	23/12/2014	39.7	Spoil	Alluvial Lands
4119P	MB	EX	312501	6402048	64.7	1.2	23/12/2014	55.0	Spoil	Alluvial Lands
DM7	MB	EX	311136	6400961	70.4	1.1	23/12/2014	38.5	Spoil	Alluvial Lands
GW_114	MB	EX	312272	6403981	98.2	-	30/12/2014	67.8	Spoil	Alluvial Lands
DM1	MB	EX	311778	6405164	103.1	0.3	23/12/2014	78.3	Spoil (Base)	Alluvial Lands
DM3	MB	EX	311971	6403310	95.0	0.8	6/01/2015	63.1	Spoil (Base)	Alluvial Lands
DM4	MB	EX	312222	6401418	65.7	0.8	29/10/2014	48.7	Spoil (Base)	Alluvial Lands
CHPZ10A	MB	EX	313334	6402297	63.4	0.8	5/11/2014	54.9	Alluvium	Barry's Pit
CHPZ11A	MB	EX	313429	6402129	61.9	1.0	15/01/2015	53.9	Alluvium	Barry's Pit
CHPZ12A	MB	EX	313238	6402013	63.5	0.3	15/01/2015	54.2	Alluvium	Barry's Pit
CHPZ13A	MB	EX	313009	6401801	65.5	0.8	15/01/2015	54.2	Alluvium	Barry's Pit
CHPZ14A	MB	EX	312883	6401639	66.0	0.4	5/11/2014	54.4	Alluvium	Barry's Pit
CHPZ1A	MB	EX	312820	6401697	65.9	1.0	5/11/2014	55.1	Alluvium	Barry's Pit
CHPZ2A	MB	EX	312941	6401539	65.8	0.6	5/11/2014	54.7	Alluvium	Barry's Pit
CHPZ3A	MB	EX	313086	6401756	63.9	0.7	14/01/2015	54.3	Alluvium	Barry's Pit
CHPZ4A	MB	EX	312904	6402123	66.3	0.8	5/11/2014	55.1	Alluvium	Barry's Pit
CHPZ5A	MB	EX	312926	6401838	65.4	0.4	15/01/2015	54.0	Alluvium	Barry's Pit
CHPZ9A	MB	EX	313538	6402383	62.1	0.4	3/03/2014	54.5	Alluvium	Barry's Pit
BUNC39A(Deep)	MB	EX	313500	6401823	66.8	0.4	21/02/2014	51.1	Mt Arthur Seam	Barry's Pit
BUNC44D	MB	EX	313601	6401922	65.2	0.7	21/02/2014	52.5	Mt Arthur Seam	Barry's Pit
BUNC45D	MB	EX	313677	6402060	73.8	0.4	5/11/2014	49.5	Mt Arthur Seam	Barry's Pit
BUNC46D	MB	EX	313328	6401782	65.8	0.2	21/02/2014	50.9	Mt Arthur Seam	Barry's Pit
CHPZ12D	MB	EX	313236	6402019	63.6	0.3	15/01/2015	54.5	Mt Arthur Seam	Barry's Pit
CHPZ13D	MB	EX	313014	6401801	65.1	0.3	15/01/2015	51.7	Mt Arthur Seam	Barry's Pit
CHPZ14D	MB	EX	312891	6401639	65.9	0.3	5/11/2014	51.9	Mt Arthur Seam	Barry's Pit
CHPZ3D	MB	EX	313094	6401756	63.7	0.6	15/01/2015	52.2	Mt Arthur Seam	Barry's Pit
CHPZ8D	MB	EX	313508	6402047	61.2	1.1	15/01/2015	53.9	Mt Arthur Seam	Barry's Pit
BUNC45A	MB	EX	313667	6402055	73.3	0.3	5/11/2014	53.9	Regolith	Barry's Pit
BUNC39B(Shallow)	MB	EX	313500	6401823	66.9	0.4	21/02/2014	50.7	Regolith - Sandy clay	Barry's Pit
CHPZ7A	MB	EX	313600	6402238	60.3	0.1	3/03/2014	54.1	Regolith, alluvium	Barry's Pit
CHPZ8A	MB	EX	313503	6402051	60.9	0.8	5/11/2014	54.9	Regolith, alluvium	Barry's Pit
CGW52a	MB	EX	309902	6402249	71.4	0.8	7/01/2015	58.6	Alluvium	Carrington
CGW53a	MB	EX	309606	6402333	70.5	0.7	7/01/2015	58.7	Alluvium	Carrington
CGW54a	MB	EX	310196	6402159	70.0	0.8	7/01/2015	58.5	Alluvium	Carrington
CGW55a	MB	EX	309840	6402457	71.0	0.5	7/01/2015	57.7	Alluvium	Carrington
CGW6	MB	EX	308756	6402770	70.1	0.8	30/12/2014	60.5	Alluvium	Carrington
CGW39	MB	EX	308566	6403694	70.2	0.5	30/12/2014	58.8	Alluvium?	Carrington
CGW45	MB	EX	308042	6403349	72.5	0.3	30/12/2014	51.1	Bayswater Seam	Carrington
CGW46	MB	EX	308413	6403276	72.0	-	30/12/2014	59.0	Bayswater Seam	Carrington
CGW47	MB	EX	308729	6403406	70.8	0.4	2/10/2014	59.7	Bayswater Seam	Carrington
CGW49	MB	EX	308778	6403098	69.6	0.5	30/12/2014	60.2	Bayswater Seam	Carrington
4039C_2	VWP	EX	308468	6402673	70.7	-	7/01/2015	44.0	Broonie Seam	Carrington
CGW46a	MB	EX	308415	6403276	72.0	-	30/01/2014	59.4	Broonie Seam	Carrington
CGW47a	MB	EX	308731	6403405	70.8	0.4	7/01/2015	58.4	Broonie Seam	Carrington
CGW52	MB	EX	309906	6402255	71.4	0.7	7/01/2015	34.7	Broonie Seam	Carrington
CGW53	MB	EX	309606	6402333	70.5	0.6	30/12/2014	37.6	Broonie Seam	Carrington
GW_107	MB	EX	308738	6404103	73.5		30/12/2014	44.1	Carrington Spoil	Carrington
GW_108	MB	EX	309695	6403971	84.4	-	30/12/2014	23.3	Carrington Spoil	Carrington
4036C	MB	EX	308272	6402688	71.8	1.1	30/12/2014	39.3	Interburden (Siltstone/Sandstone)	Carrington
4051C	MB	EX	308664	6402721	69.9	1.0	30/12/2014	49.4	Interburden (Siltstone/Sandstone)	Carrington
CFW59	MB	EX	310245	6402370	68.9	0.5	30/12/2014	56.1	Interburden (Siltstone/Sandstone)	Carrington
CGW51a	MB	EX	310149	6402419	70.2	0.2	7/01/2015	55.7	Interburden (Siltstone/Sandstone)	Carrington
4032P	MB	EX	308609	6402945	70.3	0.9	30/12/2014	60.7	Palaeochannel alluvium	Carrington
4033P	MB	EX	308877	6402939	69.9	1.0	7/01/2015	59.9	Palaeochannel alluvium	Carrington
4034P	MB	EX	308239	6402959	71.5	0.3	7/01/2015	59.6	Palaeochannel alluvium	Carrington
4035P	MB	EX	308386	6402778	70.5	1.0	31/03/2014	60.9	Palaeochannel alluvium	Carrington
4037P	MB	EX	308277	6402702	71.8	1.0	30/12/2014	60.8	Palaeochannel alluvium	Carrington
4038C	MB	EX	308502	6403116	70.0	1.0	30/12/2014	60.6	Palaeochannel alluvium	Carrington
4039C_1	VWP	EX	308468	6402673	70.7	-	7/01/2015	63.7	Palaeochannel alluvium	Carrington
4040P	MB	EX	308675	6402724	70.1	1.0	7/01/2015	59.6	Palaeochannel alluvium	Carrington
4040P	MB	EX	308675	6402723	70.1	1.0	7/01/2015	59.6	Palaeochannel alluvium	Carrington
4052P	MB	EX	307924	6402680	72.6	1.1	31/03/2014	61.0	Palaeochannel alluvium	Carrington

Bore ID	Type	Status	Easting	Northing	Ground elevation (mAHD)	Collar height (maGL)	SWL date	SWL (mAHD)	Lithological description	Location
4053P	MB	EX	308112	6402680	71.6	1.0	30/12/2014	60.8	Palaeochannel alluvium	Carrington
CFW57	MB	EX	310084	6402053	70.8	0.7	30/12/2014	59.2	Palaeochannel alluvium	Carrington
CGW32	MB	EX	308598	6404872	79.2	-	30/12/2014	59.8	Palaeochannel alluvium	Carrington
GW_101	MB	EX	304374	6406728	100.5	-	23/12/2014	87.8	Regolith, alluvium	Carrington
GW_115	MB	EX	312227	6402216	68.3	-	6/01/2015	53.6	Spoil	Carrington
Hobden's Well	MB	EX	312540	6401093	71.0	0.7	5/11/2014	59.2	Alluvium	Cheshunt
BZ1-1	MB	EX	311472	6400483	71.8	0.4	5/11/2014	54.9	Interburden	Cheshunt
BZ2A(2)	MB	EX	311671	6400561	71.7	0.6	6/03/2014	50.9	Interburden	Cheshunt
BZ3-1	MB	EX	311840	6400640	70.3	0.3	5/11/2014	55.0	Interburden	Cheshunt
BZ4A(1)	MB	EX	312029	6400705	74.4	-	6/03/2014	49.7	Interburden	Cheshunt
BZ8-2	MB	EX	312685	6401010	67.8	-	5/11/2014	47.6	Interburden	Cheshunt
HG1	MB	EX	312390	6400882	66.1	0.7	5/03/2014	54.9	Interburden	Cheshunt
HG2	MB	EX	312469	6400886	67.5	0.6	5/11/2014	55.3	Interburden	Cheshunt
HG3	MB	EX	312541	6400940	66.8	-	5/03/2014	55.0	Interburden	Cheshunt
BC1a	MB	EX	312421	6400872	66.4	0.3	5/11/2014	48.8	Mt Arthur Seam	Cheshunt
BZ1-3	MB	EX	311472	6400483	71.8	0.4	15/01/2015	25.8	Mt Arthur Seam	Cheshunt
BZ2A(1)	MB	EX	311671	6400561	71.7	0.4	15/01/2015	25.8	Mt Arthur Seam	Cheshunt
BZ3-3	MB	EX	311840	6400640	70.3	0.4	5/11/2014	27.9	Mt Arthur Seam	Cheshunt
BZ4A(2)	MB	EX	312029	6400705	74.4	0.6	15/01/2015	33.9	Mt Arthur Seam	Cheshunt
HG2A	MB	EX	312469	6400886	67.5	0.6	5/11/2014	42.2	Mt Arthur Seam	Cheshunt
Appleyard Farm	MB	EX	315491	6394639	43.4	0.8	13/01/2015	48.2	Alluvium	Lemington
C919(ALL)	MB	EX	315192	6395655	58.0	0.3	13/01/2015	47.0	Alluvium	Lemington
D317(ALL)	MB	EX	315044	6396018	59.5	0.3	13/01/2015	44.5	Alluvium	Lemington
PB01(ALL)	MB	EX	314754	6396026	55.0	-	31/12/2014	46.8	Alluvium	Lemington
C130(AFS1)	MB	EX	316400	6394916	63.0	0.3	12/11/2014	44.8	Arrowfield Seam	Lemington
D406(AFS)	MB	EX	313931	6396074	57.0	0.3	13/11/2014	42.3	Arrowfield Seam	Lemington
D510(AFS)	MB	EX	314380	6396141	54.8	0.3	13/11/2014	31.3	Arrowfield Seam	Lemington
D612(AFS)	MB	EX	314524	6396314	62.0	0.4	13/11/2014	40.5	Arrowfield Seam	Lemington
B334(BFS)	MB	EX	316684	6394088	73.0	0.3	13/01/2015	27.1	Bowfield Seam	Lemington
B631(BFS)	MB	EX	316425	6394319	72.0	0.3	13/01/2015	43.0	Bowfield Seam	Lemington
B925(BFS)	MB	EX	315921	6394604	65.0	0.4	13/01/2015	27.9	Bowfield Seam	Lemington
C122(BHS)	MB	EX	315501	6395007	58.0	-	12/11/2014	-0.7	Bowfield Seam	Lemington
C130(BFS)	MB	EX	316400	6394916	63.0	0.0	10/11/2014	30.1	Bowfield Seam	Lemington
C317(BFS)	MB	EX	315054	6395007	60.0	0.4	13/11/2014	29.6	Bowfield Seam	Lemington
C613(BFS)	MB	EX	314688	6395243	63.0	0.3	13/11/2014	36.5	Bowfield Seam	Lemington
C621(BFS)	MB	EX	315421	6395321	58.0	0.3	12/11/2014	30.3	Bowfield Seam	Lemington
C630(BFS)	MB	EX	316378	6395306	69.0	0.3	13/11/2014	35.1	Bowfield Seam	Lemington
D010(BFS)	MB	EX	314355	6395687	56.0	0.4	11/11/2014	29.9	Bowfield Seam	Lemington
D214(BFS)	MB	EX	314768	6395831	56.5	0.3	12/11/2014	30.3	Bowfield Seam	Lemington
D317(BFS)	MB	EX	315043	6396019	59.5	0.3	13/01/2015	30.3	Bowfield Seam	Lemington
D406(BFS)	MB	EX	313931	6396074	57.0	0.3	13/11/2014	25.8	Bowfield Seam	Lemington
D510(BFS)	MB	EX	314380	6396141	54.8	0.3	13/01/2015	28.1	Bowfield Seam	Lemington
D612(BFS)	MB	EX	314524	6396314	62.0	0.3	13/11/2014	29.0	Bowfield Seam	Lemington
D807(BFS)	MB	EX	314002	6396484	59.7	0.4	13/11/2014	25.9	Bowfield Seam	Lemington
D010(GM)	MB	EX	314355	6395687	56.0	-	11/11/2014	48.6	Glen Munro Seam	Lemington
C130(ALL)	MB	EX	316400	6394916	63.0	0.3	31/12/2014	47.6	Interburden?	Lemington
CFW55R	MB	EX	310439	6402180	70.3	0.5	8/01/2015	58.6	Palaeochannel alluvium	Carrington
C1(WJ039)	MB	EX	317142	6400707	71.2	-	5/11/2014	51.7	Piercefield Seam	Lemington
GW9701	MB	EX	315901	6401798	93.6	-	14/11/2014	56.7	Piercefield Seam	Lemington
GW9702	MB	EX	316436	6401479	98.6	-	14/11/2014	67.2	Piercefield Seam	Lemington
GW9710	MB	EX	316700	6400486	82.6	-	14/11/2014	63.7	Piercefield Seam	Lemington
F1.5(WF533)	MB	EX	316607	6398247	54.9	-	10/11/2014	40.7	Vaux Seam	Lemington
B425(WDH)	MB	EX	316010	6395024	58.0	-	12/11/2014	30.3	Woodlands Hill Seam	Lemington
B631(WDH)	MB	EX	316424	6394319	72.0	-	13/11/2014	46.5	Woodlands Hill Seam	Lemington
C122(WDH)	MB	EX	315501	6395007	58.0	0.3	12/11/2014	46.5	Woodlands Hill Seam	Lemington
C130(WDH)	MB	EX	316400	6394916	63.0	0.4	10/11/2014	47.6	Woodlands Hill Seam	Lemington
C317(WDH)	MB	EX	315054	6395007	60.0	0.2	31/12/2014	46.7	Woodlands Hill Seam	Lemington
C809 (GM/WDH)	MB	EX	314207	6395493	59.0	0.3	13/11/2014	48.1	Woodlands Hill Seam	Lemington
D010(WDH)	MB	EX	314355	6395687	56.0	0.3	11/11/2014	47.5	Woodlands Hill Seam	Lemington
GW_119	MB	EX	310129	6400322	73.5	-	9/10/2015	61.4	Clay	Riverview
GW_117	MB	EX	309579	6400676	68.3	-	9/10/2015	58.9	Alluvium	Riverview
E5038/5	MB	EX	309650	6398915	122.4	-	2/04/2014	78.5	Coal	Riverview
H5032/5	MB	EX	309960	6398320	116.3	-	30/12/2014	61.8	Coal	Riverview
H5038/5	MB	EX	309950	6398920	111.7	-	2/04/2014	80.1	Coal	Riverview
SR002	MB	EX	319079	6394620	56.8	-	17/12/2014	43.6	Bayswater Seam	Southern
SR003	MB	EX	318863	6394864	61.3	-	19/12/2014	44.0	Bayswater Seam?	Southern
SR004	MB	EX	318994	6395506	76.6	-	18/12/2014	42.3	Bayswater Seam?	Southern
SR005	MB	EX	318831	6396128	65.3	-	18/12/2014	43.1	Bayswater Seam?	Southern
SR006	MB	EX	318555	6395732	83.0	-	19/12/2014	42.8	Bayswater Seam?	Southern
SR001	MB	EX	319146	6394094	58.2	-	19/12/2014	47.0	Coal?	Southern
SR010	MB	EX	317319	6395338	57.5	-	17/12/2014	47.5	Conglomerate and Warkworth Seam	Southern

Bore ID	Type	Status	Easting	Northing	Ground elevation (mAHD)	Collar height (maGL)	SWL date	SWL (mAHD)	Lithological description	Location
SR009	MB	EX	319338	6394746	56.1	-	18/12/2014	49.5	Lemington Seam	Southern
SR011	MB	EX	317699	6394412	88.2	-	17/12/2014	54.2	Mt Arthur Seam and underburden	Southern
SR012	MB	EX	318354	6393926	76.2	-	19/12/2014	52.0	Overburden - conglomerate and sandstone	Southern
SR007	MB	EX	318772	6394373	60.9	-	17/12/2014	26.3	Overburden and Vaux Seam coal	Southern
SR008	MB	EX	319290	6395111	56.8	-	18/12/2014	47.5	Siltstone/sandstone below Lemington Seam	Southern
G1	MB	EX	305694	6407301	110.0	-	23/12/2014	108.4	Regolith, alluvium	West Pit
G2	MB	EX	305660	6407451	110.6	-	23/12/2014	109.5	Regolith, alluvium	West Pit
G3	MB	EX	305636	6407556	108.6	-	23/12/2014	108.1	Regolith, alluvium	West Pit
GW_100	MB	EX	303729	6406436	89.6	-	7/01/2015	84.7	Regolith, alluvium	West Pit
NPz1	MB	EX	305240	6406100	138.1	0.8	24/12/2014	83.5	Sandstone/Siltstone	West Pit
NPz2	MB	EX	307800	6411340	199.6	0.6	24/12/2014	171.0	Sandstone/Siltstone	West Pit
NPz4	MB	EX	306240	6404584	121.7	1.0	6/01/2015	106.8	Sandstone/Siltstone	West Pit
NPz5	MB	EX	310730	6406550	134.7	0.9	24/12/2014	125.8	Sandstone/Siltstone	West Pit
NPz3	MB	EX	306305	6409131	148.4	-	6/01/2015	135.0	Siltstone	West Pit

Notes:

MB Monitoring bore

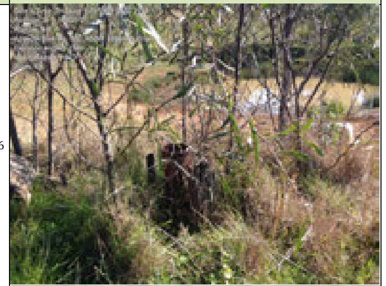
EX Existing

SWL Standing water level as groundwater elevation

VWP Vibrating wire piezometer

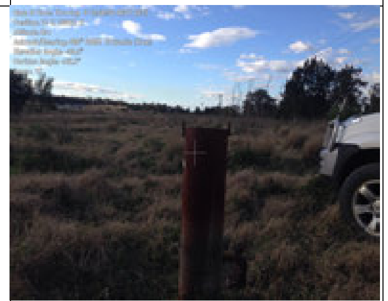
Appendix A-4

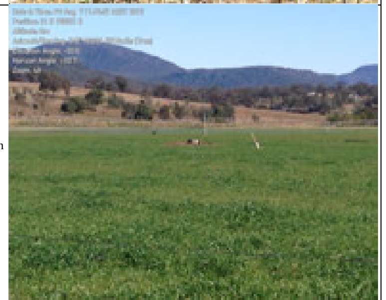
Bore Census Results

Date	Bore Registration Number	Positon	Easting	Northing	Elevation (Height Above Sea Level*)	Bore Status	Casing Material	Diameter (mm)	Depth to Bottom (m)	Casing/Monument Height Above Ground (mm)	Bore Use	Frequency	Pumping Rate	Depth To Water (m) Casing/Monument Top	Depth of Water (m)	Conductivity (uS/cm)	pH	Temperature (deg C)	Colour	Odour	Comments	Photo
6/08/2015	GW060780	UTM UPS	305961	6399379	107	Abandoned	Steel	120	24.80	380	Nil	NA	No Pump	18.62	6.18	1552	7.1	20.0	Grey	Brackish	TSS visiable in Sample, Private Bore, 4//700476 Karen Marie Muller	
6/08/2015	GW080963	UTM UPS	315997	6397208	59	Monitoring Bore	PVC	100	81.30	550	Monitoring	NA	No Pump	31.80	49.50	1258	5.9	19.8	Clear	Nil	Bore contained a In-Situ Level Troll 500 Ground Water Logger, Range 11m/35ft/Vented s/n 124372	
6/08/2015	GW047240	UTM UPS	NA	NA	NA	Unable to Locate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Possibly Destroyed	NA
6/08/2015	GW030731	UTM UPS	316680	6397640	63	Not in Use	PVC	100	17.02	960	Unknown	NA	No Pump	13.33	3.69	2460	7.0	19.5	Cloudy	Nil	TSS visible particulates	

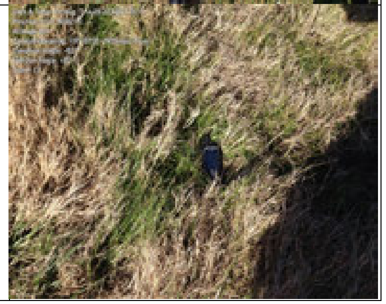
Date	Bore Registration Number	Positon	Easting	Northing	Elevation (Height Above Sea Level*)	Bore Status	Casing Material	Diameter (mm)	Depth to Bottom (m)	Casing/Monument Height Above Ground (mm)	Bore Use	Frequency	Pumping Rate	Depth To Water (m) Casing/Monument Top	Depth of Water (m)	Conductivity (uS/cm)	pH	Temperature (deg C)	Colour	Odour	Comments	Photo
6/08/2015	GW030732	UTM UPS	316743	6397646	69	Not in Use	Concrete	1230	8.17	70	Blocked	NA	NA	8.17	Blocked	NA	NA	NA	NA	NA	Bore Blocked By Pump Infrustructure	
6/08/2015	GW030733	UTM UPS	316743	6397646	69	Not in Use	Concrete	1100	12.91	190	Not Used	NA	No Pump	12.91	Small Shallow Pool	NA	NA	NA	NA	NA	nsufficent Water to Sampl	
6/08/2015	GW042364	UTM UPS	316824	6397645	63	Not in Use	Steel	190	16.14	440	Unknown	NA	NA	12.77	3.37	1077	7.2	19.2	Orange	Metalic	Nil	
6/08/2015	GW030734	UTM UPS	316595	6397799	62	Destroyed/ Blocked	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	

Date	Bore Registration Number	Positon	Easting	Northing	Elevation (Height Above Sea Level*)	Bore Status	Casing Material	Diameter (mm)	Depth to Bottom (m)	Casing/Monument Height Above Ground (mm)	Bore Use	Frequency	Pumping Rate	Depth To Water (m) Casing/Monument Top	Depth of Water (m)	Conductivity (uS/cm)	pH	Temperature (deg C)	Colour	Odour	Comments	Photo
6/08/2015	GW030735	UTM UPS	316484	6397827	62	Destroyed/ Blocked	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	No Photo
6/08/2015	GW030737	UTM UPS	316500	6398112	63	Destroyed/ Blocked	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
6/08/2015	GW030736	UTM UPS	NA	NA	NA	Unable to Locate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Unable to Locate	No Photo
6/08/2015	GW030738	UTM UPS	NA	NA	NA	Unable to Locate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Unable to Locate	No Photo

Date	Bore Registration Number	Positon	Easting	Northing	Elevation (Height Above Sea Level*)	Bore Status	Casing Material	Diameter (mm)	Depth to Bottom (m)	Casing/Monument Height Above Ground (mm)	Bore Use	Frequency	Pumping Rate	Depth To Water (m) Casing/Monument Top	Depth of Water (m)	Conductivity (uS/cm)	pH	Temperature (deg C)	Colour	Odour	Comments	Photo
6/08/2015	GW030739	UTM UPS	NA	NA	NA	Unable to Locate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Unable to Locate	No Photo, See Area Photos Separate Photo Files
6/08/2015	GW030740	UTM UPS	316640	6398365	63	Monitoring Bore	PVC	100	17.34	1020	Montioring	NA	NA	12.31	5.03	2540	7.4	19.3	Clear	Nil	Particulates visible, Plate on bore matches bore number 30740	
6/08/2015	GW034568	UTM UPS	316634	6398301	63	Unable to Locate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Most Probable Bore Location Under Conrete Slab, See Photo	
6/08/2015	GW034569	UTM UPS	NA	NA	NA	Unable to Locate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	No sign of bore at the map location	No Photo

Date	Bore Registration Number	Positon	Easting	Northing	Elevation (Height Above Sea Level*)	Bore Status	Casing Material	Diameter (mm)	Depth to Bottom (m)	Casing/Monument Height Above Ground (mm)	Bore Use	Frequency	Pumping Rate	Depth To Water (m) Casing/Monument Top	Depth of Water (m)	Conductivity (uS/cm)	pH	Temperature (deg C)	Colour	Odour	Comments	Photo
7/08/2015	GW029155	UTM UPS	305661	6402042	76	Burried	Unknown	Unknown	Unknown	Unknown	No	NA	NA	NA	NA	NA	NA	NA	NA	N	Bore Covered by Approx 200 to 300mm of Top Soil, Has not been used for some time according to landowner. Possibly destroyed during 2007 flood event.	
7/08/2015	Unknow, See Comments	UTM UPS	305357	6401901	79	Irrigation Well	Concrete	1230	10.68	450	Irrigation	NA	NA	10.15	0.53	1767	8.1	16.2	Cloudy	Oily	Wee Aprrox 200m South of GW029155.	
7/08/2015	GW027120	UTM UPS	309501	6401185	77	Not in Use	Concrete	1370	13.50	290	NA	NA	NA	10.75	2.75	822	7.8	19.1	Brown	Metalic	Nil	
7/08/2015	GW027121	UTM UPS	309563	6401648	78	Destroyed/Filled In	Unknown	Unknown	Unknown	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	

Date	Bore Registration Number	Positon	Easting	Northing	Elevation (Height Above Sea Level*)	Bore Status	Casing Material	Diameter (mm)	Depth to Bottom (m)	Casing/Monument Height Above Ground (mm)	Bore Use	Frequency	Pumping Rate	Depth To Water (m) Casing/Monument Top	Depth of Water (m)	Conductivity (uS/cm)	pH	Temperature (deg C)	Colour	Odour	Comments	Photo
7/08/2015	GW021773	UTM UPS	309559	6401872	79	Blocked at 0.45m	Steel	100	Unknown	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
7/08/2015	GW053123	UTM UPS	309631	6402062	78	Unused	Concrete	1530	14.84	1300	Unused	NA	NA	12.55	2.29	993	7.6	17.1	Clear	Metalic	Nil	
7/08/2015	GW037734	UTM UPS	309553	6401502	83	Unused	Concrete	1270	13.49	660	Unused	NA	NA	11.36	2.13	1022	7.5	17.4	Clear	Metalic	Casting height measured on south side of weel. Particulates visible in the sample	
7/08/2015	GW057775	UTM UPS	309074	6401517	78	Destroyed	Unknown	Unknown	Unknown	Unknown	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Old pump concrete block near poosible well site	

Date	Bore Registration Number	Positon	Easting	Northing	Elevation (Height Above Sea Level*)	Bore Status	Casing Material	Diameter (mm)	Depth to Bottom (m)	Casing/Monument Height Above Ground (mm)	Bore Use	Frequency	Pumping Rate	Depth To Water (m) Casing/Monument Top	Depth of Water (m)	Conductivity (uS/cm)	pH	Temperature (deg C)	Colour	Odour	Comments	Photo
7/08/2015	GW053173	UTM UPS	309101	640317	76	Unused	Concrete	1250	15.23	220	Unused	NA	NA	13.38	1.85	967	8.1	18.2	Clear	Metalic	Casting height measured on eastern side of well	
7/08/2015	GW022685	UTM UPS	309088	6401184	75	Used	Concrete	1200	14.95	550	Irrigation, Stock and Domestic	Continuous	Unknown	10.67	4.28	1022	7.2	20.2	Clear	Nil	Casting height measrued on north side of well	
7/08/2015	GW053690	UTM UPS	308423	6402268	77	Unable to Locate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	N	Photo indicates most probable location from supplied co-ordinates	

Appendix B

Modelling Appendix

B1 Introduction

Predictive numerical modelling was undertaken to assess the impact of the proposed modification on the groundwater regime. The objectives of the predictive modelling were to:

- assess the groundwater inflow to the mine workings as a function of mining extraction over time;
- simulate and predict the extent and area of influence of mining on the watertable and in particular, the extent and rate of drawdown at specific locations; and
- identify areas of potential mine influence where groundwater mitigation/control measures may be necessary.

The modelling work included conceptualisation of the groundwater regime, followed by calibration of the model against observed data. The conceptual model is a simplified representation of the hydrogeological groundwater system and was developed based on data sources that included:

- geological and topographical maps;
- geological information from coal exploration bores drilled across HVO;
- geological models developed by the proponent and Wambo/United mines through a data sharing agreement; and
- results from previous hydrogeological investigations and relevant data from the publicly available datasets.

Reliable impact predictions can be quantified using a calibrated model, which aims to replicate measured processes as accurately as possible. The calibration process reduces the uncertainty and quantifies the identifiability of parameters most influential to the model objectives.

The main report details the conceptual understanding of the hydrogeological regime at the HVO South.

B2 Model construction and development

B2.1 Model code

MODFLOW-USG Beta (Panday *et. al*, 2013) was determined to be the most suitable modelling code to meet the model objectives. MODFLOW-USG is the latest derivative of the standard MODFLOW code, and has some distinct advantages. MODFLOW-USG allows use of an unstructured mesh, meaning that the cells in the model are not restricted to rectangular shapes. Small cells can be used in the area of interest to represent geological or mining features, with larger cells outside these areas where refinement is not required. This produces an optimal model grid, aiding numerical stability and limiting the number of cells. In addition, model layering does not need to be continuous over the model domain, and layers can terminate where geological units pinch out or outcrop. This is also particularly useful when simulating thin, discontinuous hydrostratigraphic units, such coal seams and faults. Flow transfer processes between systems such as bedrock and alluvial groundwater systems can therefore be more accurately represented. In earlier versions of MODFLOW, flow between these systems was limited to vertical connections, or required separate zonation within the same layer.

MODFLOW-USG also simulates unsaturated conditions, allows the process of progressive drawdown/depressurisation during active mine operations, followed by water table recovery after closure. MODFLOW-USG also has robust numerical solution schemes to handle the more complex numerical situations. In addition to a robust solution scheme adaptive time-stepping can overcome in most cases, solution non-convergence.

The input files for the MODFLOW-USG model were created using Fortran code and a MODFLOW-USG edition of the Groundwater Data Utilities by Watermark Numerical Computing. These were used to provide for the additional capabilities of MODFLOW-USG. The cells in the model were generated using Algomesh (HydroAlgorithmics, 2014).

B2.2 Model design

B2.2.1 Model grid

The model cell domain was designed to be sufficiently extensive to prevent any mining drawdown/depressurisation at maximum development associated with the modification from intersecting any model boundaries. Where necessary, natural hydrogeological boundaries such as geological units and regional catchment boundaries were adopted in the model.

The model domain is of rectangular shape, 27km wide (west to east direction) and 39km long (north to south direction) as shown in Figure B -1. The boundaries of this model domain included those as follows:

- West – set over 10km west of the HVO South, encompassing the Hunter River alluvium and the United and Wambo mine operations.
- North – set over 20km north of HVO South; the boundary accommodates the northernmost extent of the basal coal seam targeted at the HVO South (Bayswater Seam). The northern extent also encompasses the HVO, Ravensworth and Narama mines, which target equivalent geological units to the proposed modification, as well as the underlying coal measures.
- East – set over 7km east of the HVO South, the boundary again includes the full lateral extent of the basal coal seam targeted at the proposed modification (Bayswater Seam). The eastern extent also encompasses the historic North Lemington mine, as well as the current Mount Thorley and Warkworth (MTW) mines, which all target equivalent geological units to the proposed modification.
- South – set over 11km south of HVO South, the boundary lies at the southern boundary of MTW and whilst topographically up-gradient, is down-dip in the coal measures sequence.

The model domain was divided into variable sized cells and hydrogeological units divided into 34 layers comprising up to 71,049 cell nodes in each layer with the dimensions of the cells varying. Within the mining areas at HVO South the cells were aligned with the proposed mine plan and refined into 50m by 50m regular hexagonal cells. Greater refinement was also focused along the major waterways (i.e. Hunter River and Wollombi Brook) and alluvium. Where possible the cells were also aligned to the progression of surrounding mines. Overall, the model comprises 1,103,800 cells across the 34 layers.

As shown in Figure B -1, the model includes the full extents of the Hunter Valley Operations (HVO) North and HVO South, as well as Ravensworth, Narama, Wambo, United and MTW operations. These mining areas were included within the model domain as they target and/or mine several of the equivalent coal seams intersected at the proposed modification and are therefore necessary to assess the possible cumulative drawdown.

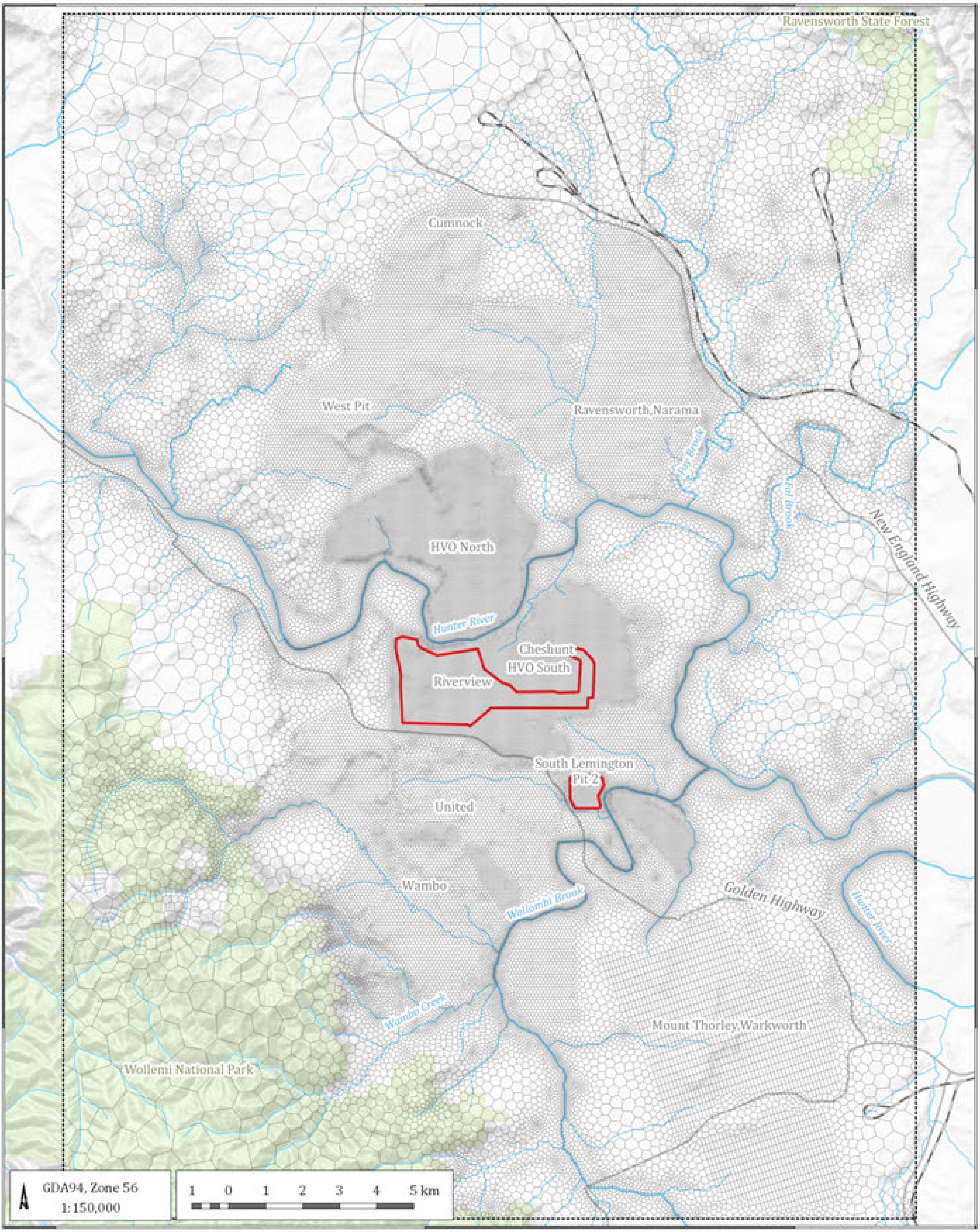
B2.2.2 Model boundary conditions

'No-flow' boundary conditions were adopted for the northern and eastern edges of model domain. These boundaries lie beyond the outcrop/subcrop limit of the Bayswater Seam, which is the lowermost coal seam of Wittingham Coal Measures and is also the lowermost coal seam to be mined by the proposed modification. This approach is considered conservative as does not allow depressurisation to be buffered by groundwater inflow beyond the defined limit of the boundary, should drawdown encroach the model boundaries.

The western boundary was set as a general head boundary, which uses a linear relationship based on a reference head to control the flux into and out of the model.

The southern extent of the model domain occurs between the Mt Thorley mine and Bulga Mine. Bulga Mine was not included within the model due to its distance from HVO South and position down-dip and up-gradient of the coal measures intercepted by the HVO South mine. However, in order to account for the potential influence of Bulga Mine, a general head boundary was assigned along the southern border of the model domain. The heads assigned at the boundary were from publicly available, modelled groundwater levels generated for Bulga Mine (Mackie, 2013).

Flows into and out of the model included gross recharge from rainfall; baseflow in creeks; evapotranspiration; 'drains' to represent mine inflow discharge and pumping bores.



LEGEND

- Proposed modification pit depth extension
- Model extent
- Model mesh
- Rail
- Major road
- Major drainage
- Minor drainage
- Reserve

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Grid layout

DATE 08/01/2016

FIGURE No: **B-1**

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B2.2.3 Model layers

The hydrogeological units representing the 34 model layers are summarised in Table B-1. The layer divisions were based on hydro-stratigraphic horizons as depicted in available geological stratigraphic models, and extrapolated beyond the limit of these using all available data and experience.

Table B-1 Model layers

Geological age	Stratigraphic unit		Model layer
Quaternary	Colluvium / regolith (CSIRO, 2015) and less productive alluvium (Qa)		1
	Highly productive alluvium (basal gravels)		2
Triassic	Narrabeen Group		3
Permian	Newcastle Coal Measures	Newcastle Coal Measures	4
		Watts Sandstone	5
	Wittingham Coal Measures (Jerrys Plains Subgroup)	Sandstone / siltstone / shale	6
		Whybrow Seam	7
		Sandstone / siltstone / shale	8
		Wambo Seam	9
		Sandstone / siltstone / shale	10
		Whynot Seam	11
		Sandstone / siltstone / shale	12
		Blakefield, Glen Munro and Woodlands Hill seams	13
		Sandstone / siltstone / shale	14
		Arrowfield Seam	15
		Sandstone / siltstone / shale	16
		Bowfield Seam	17
		Sandstone / siltstone / shale	18
		United and Wambo Bowfield split (not present at HVO)	19
		Sandstone / siltstone / shale	20
		Warkworth Seam	21
		Sandstone / siltstone / shale	22
		Mt Arthur Seam	23
		Sandstone / siltstone / shale	24
		Piercefield and Vaux seams	25
		Sandstone / siltstone / shale	26
		Broonie and Bayswater seams	27
		Archerfield Sandstone and interburden units	28
	Wittingham Coal Measures (Vane Subgroup)	Lemington and Pikes Gully seams	29
		Sandstone / siltstone / shale	30
		Arties and Liddell seams	31
		Sandstone / siltstone / shale	32
		Barrett and Hebden seams	33
		Sandstone / siltstone / shale (underburden)	34

LIDAR data was provided across the mine areas, which formed the basis for the top elevation of model Layer 1. Beyond the extent of the LIDAR data, one second SRTM derived digital elevation model (DEM) was used.

The Quaternary sediments are represented in the model as zones within the first two model layers. The extent of Quaternary sediments was defined by regional geology maps and site specific data, including previous reports and lithological logs. The thickness of the Quaternary alluvium was largely derived from the CSIRO (2015) soil and landscape grid, with localised adjustments again using lithological logs and previous studies that identified the depth of alluvium. As detailed within the main report, the site specific data indicates that along the major waterways (i.e. Hunter River and Wollombi Brook) the Quaternary alluvium contains a basal gravel unit overlain by silty sands and clays. Therefore, two alluvial layers were created:

- an upper layer with a maximum thickness of 8 m that represents the silty sands and clays of the less productive alluvium; and
- second layer representing the basal sands and gravels within the extent of the highly productive alluvium.

Where the Quaternary sediments were not present, a regolith layer was included in the model. Coal & Allied provided surfaces of key units from the geological models for HVO North, HVO South, West Pit and MTW. The model layers were based on the available geological model surfaces, which included the individual coal seams of the Wittingham Coal Measures. Where data gaps existed, regional geological mapping (Beckett 1988; Glenn and Beckett 1993) and available data from registered bore lithological logs were used to interpolate surfaces beyond the mining areas.

The thickness of each coal seam was calculated by combining each seam ply[1] within the geological model, ensuring that the groundwater model represented the full thickness of coal, and therefore the equivalent transmissivity of the separate plies in a single layer. The depressurisation within the Wittingham Coal Measures is more enhanced within the coal seams, as they exhibit higher permeability compared to the interbedded rocks that comprise sandstones, conglomerates, siltstones and shales.

It should be noted that while the seams are largely contiguous, there are differences in the nomenclature for the coal seams between the different mining operations. The coal seam nomenclature used within this report reflects that used for HVO South.

[1] Ply refers to physical subdivisions of a coal zone

B2.2.4 Simulated Mining Sequence

The calibration involved an initial steady state calibration to obtain pre-mining conditions, followed by a transient calibration. The transient calibration covered historic mining from 1970 to 2015. Due to limited detail on historic mining and groundwater levels prior to 2003, the transient calibration was set up in two stages as follows:

- **Initial** (1970 – 2003) representing mining across the model domain prior to 2003. There is limited historical data available on the progress of mines during this period, therefore the initial run was divided into three stress periods in order to approximate mining induced drawdown and recovery within rehabilitated/abandoned mine areas up to 2003. The stress periods were divided as follows:
    - Stress period 1 = 1970 - 1982
    - Stress period 2 = 1982 - 1992
    - Stress period 3 = 1992 - 2003
- **Historic** (2003-2015) represented the period when more detailed water level monitoring data and information on mining was available for calibration. This period ends at the present day (2015) and covers 13 years with 52 quarterly stress periods.

The calibration model captures historical mining that occurred at HVO South and surrounding mines that intersected the Wittingham Coal Measures. Table B-2 depicts the timing and coal seams mined at the various open cut and underground coal mines surrounding HVO South. The timing and seams mined to for the surrounding mines are represented in the calibration and predictive models, dependent on timing.

Table B-2 Model domain historic and approved mine progression

<table>
<tr><th rowspan="3">Wittingham Coal Measures coal seams</th><th colspan="12">Mine</th></tr>
<tr><th>HVO South</th><th>HVO North</th><th>West Pit/ Cumnock</th><th colspan="2">Wambo</th><th colspan="2">United</th><th>MTW</th><th colspan="2">North Lemington and Lemington Underground</th><th colspan="2">Ravensworth Narama and Ashton</th></tr>
<tr><th>OC</th><th>OC</th><th>OC</th><th>OC</th><th>UG</th><th>OC</th><th>UG</th><th>OC</th><th>OC</th><th>UG</th><th>OC</th><th>UG</th></tr>
<tr><td>Whybrow</td><td></td><td></td><td></td><td rowspan="4">1974 - 2017</td><td>1979 - 2018</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Redbank Creek</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Wambo</td><td></td><td></td><td></td><td>2009 - 2019</td><td rowspan="2">1989 - 1992</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Whynot</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Blakefield to Woodlands Hill</td><td></td><td></td><td></td><td rowspan="5">2017 – 2039*</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Arrowfield</td><td rowspan="4">1997 – 2017 Proposed modification 2017 - 2030</td><td></td><td></td><td>2017 - 2031</td><td></td><td>1992 - 2002</td><td rowspan="4">1980 - 2035</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Bowfield</td><td></td><td></td><td>2021 - 2028</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Warkworth</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Mt. Arthur</td><td>1979 - 2021</td><td></td><td></td><td></td><td></td><td>1971 - 1999</td><td>1971 - 1992</td><td></td><td></td></tr>
</table>

Wittingham Coal Measures coal seams	Mine											
	HVO South	HVO North	West Pit/ Cumnock	Wambo		United		MTW	North Lemington and Lemington Underground		Ravensworth Narama and Ashton	
	OC	OC	OC	OC	UG	OC	UG	OC	OC	UG	OC	UG
Piercefield and Vaux												
Broonie and Bayswater												
Lemington and Pikes Gully			West Pit: 1952 – 2025 Cumnock: 1949 – 2008								1972 - 2039	2007- 2024
Arties and Liddell												
Barrett and Hebden												

Note: *OC – open cut* *UG – underground*

** - includes modification currently proposed at United and Wambo*

B2.3 System stresses and natural processes

B2.3.1 Recharge and evapotranspiration

MODFLOW USG simulates diffuse rainfall recharge using the recharge package, and evapotranspiration from shallow water tables with the evapotranspiration package. The model represented evapotranspiration in the upper most model cells across the model domain with an extinction depth of 1.5m and a maximum rate of 365mm/yr.

The dominant mechanism for recharge to the groundwater system is through infiltration and deep drainage of rainfall. River leakage to the groundwater system can also be significant in alluvial areas. Given the clayey nature of the upper alluvial sediments and the low permeability of the regolith, the recharge rate to the groundwater regime is relatively low. A spreadsheet based soil moisture deficit calculation (SMDC) was used to estimate the timing and magnitude of recharge events into the model, which accounts for the re-saturation delay in deep drainage/recharge. The soil moisture deficit factor relates to the proportion of annual rainfall that recharges the groundwater system, and is based on an annual rainfall rate of 645mm/yr.

Table B-3 represents the calibrated rate of recharge for each geological unit, while Figure B -2 shows the recharge distribution zones.

Table B-3 Modelled recharge rates

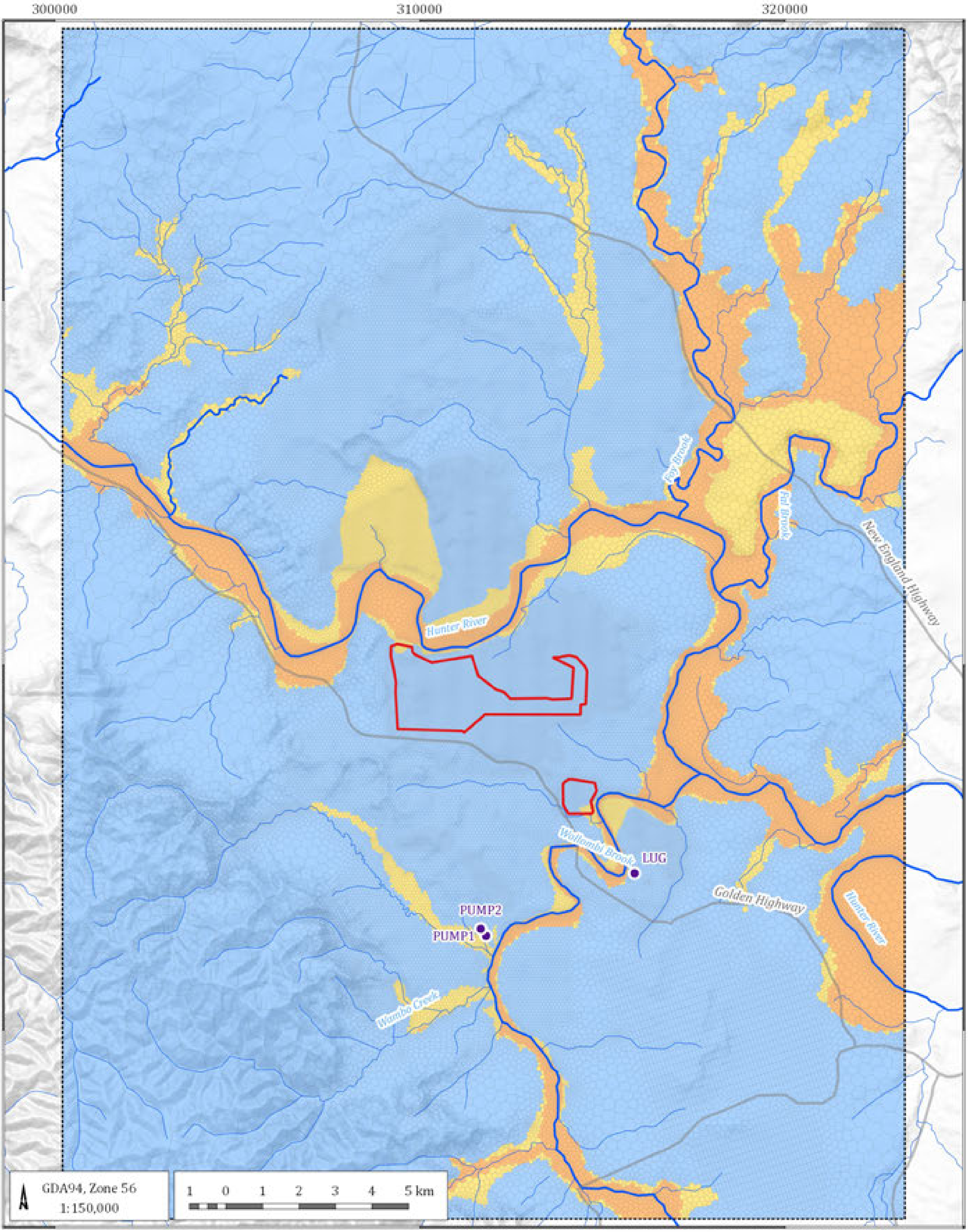
Zone	Diffuse recharge rate – steady state (% of annual)	Diffuse recharge rate - transient	
		% of annual	% of quarterly SMDC
Colluvium and less productive alluvium	5.4	4.5	15.0
Highly productive (basal) alluvium	12.0	9.9	30.0
Regolith	1.0	1.5	5.0
Spoil	-	3.3	10.0

Note: *SMDC - soil moisture deficit calculation*

B2.3.2 Abstraction

Available data indicates that groundwater has been abstracted from the Lemington Underground (LUG) bore since 2013. When in operation, LUG bore abstracts between 0.3ML/day and 1.2ML/day. Groundwater has also been abstracted at Wambo from the Bowfield Underground at bores “pump1” and “pump2” since 2012. The abstracted water is used for mine water supply, with the bores abstracting up to 0.04ML/day (142ML/year).

The MODFLOW Well (WEL) package was used to simulate the water abstraction from the bores. The WEL package assigned the quarterly seasonal pumping rates to a model cell and layer according to the coordinates and screen depth of each individual bore. The pumping rates varied at each bore on a quarterly basis according to available individual monthly abstraction volumes. The location of the bores is included on Figure B -2.



LEGEND

- Proposed modification pit depth extension
- Model extent
- Major road
- Major drainage
- Minor drainage
- WEL

Recharge zones

- Highly productive alluvium
- Less productive alluvium
- Regolith

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Recharge zones

DATE 08/01/2016

FIGURE No: **B-2**

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B2.3.3 Surface drainage

Groundwater interaction with surface drainage was modelled using the river package. This package requires the level of the river bed and the depth of perennial water above this level. The river bed conductance was calculated from river width, length, riverbed thickness, and the vertical hydraulic conductivity of the riverbed material. The water level above the river bed was set at 0m for all minor ephemeral streams and creeks within the model domain. Table B-4 summarises the parameters representing the drainage lines and creeks.

The stage height for rivers and creeks where persistent streamflow occurs (i.e. Hunter River and Wollombi Brook) was based on interpolated gauge levels from NOW stream gauges (NSW DPI, 2014). The river stage heights recorded from these gauges were linearly interpolated and applied at a cell-by-cell level to the model river cells, per stress period. The location of the river cells in the groundwater model were assigned to layer 2 along the Hunter River and Wollombi Brook to replicate the conceptualised hydraulic connection to the productive alluvial aquifer. Figure B -3 displays the different river zones.

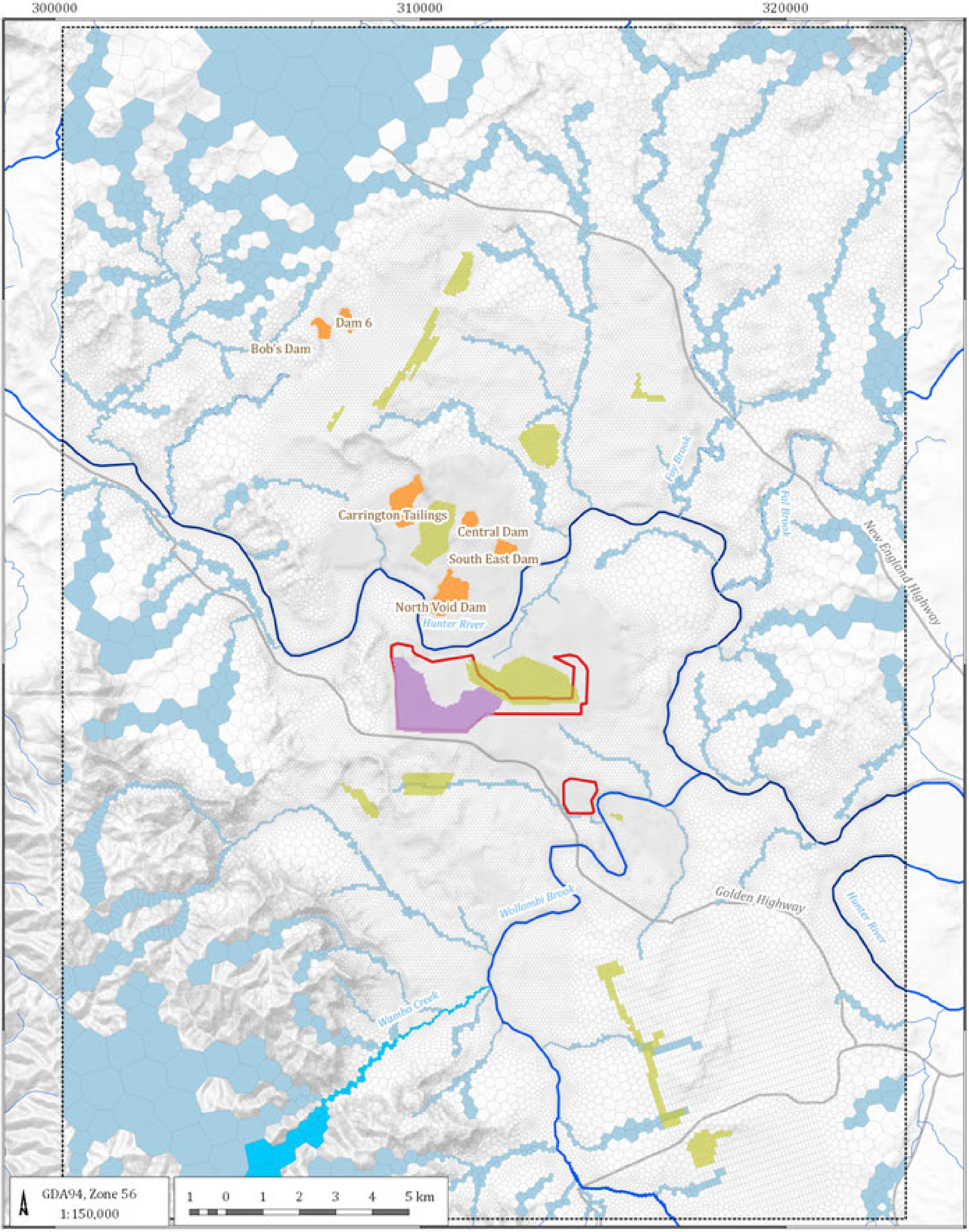
Table B-4 Modelled river bed parameters

Zone	Vertical hydraulic conductivity Kz (m/day)	Width (m)	Incised depth (m)	Stage height (m)	Bed thickness (m)	ID
1	0.5	15.5	1 (layer 2)	0 – 2.4	5	Hunter River
2	1.0	9.8	1 (layer 2)	0 – 1.5	5	Wollombi Brook
3	1.0	6.0	2	0	1.8	Wambo Creek
4	3.0	3.5	2	0	1.8	Minor drainage

Note: ** Hunter River and Wollombi Brook assigned to Layer 2 to represent direct connection to the highly productive alluvium*

B2.3.4 Tailings

The river package (RIV) represented the approved tailings emplacements in the predictive model. A constant height of water above the tailings sediment was assumed, which provided a constant water flux through the tailings sediments. The location of the tailings facilities included in the calibration and prediction models are shown in Figure B -3. The in-pit tailings facilities, South East, Central, North Void, Bobs and Dam 6, were active within the calibration model. The approved out-of-pit tailings facility at Carrington (Carrington Tailings) was included in the predictive model from 2016. The vertical hydraulic conductivity for the base of the tailings facilities was set at 8.6×10^{-5}m/day, as was adopted by AGE (2013) for the HVO North modification tailings emplacement groundwater assessment.



LEGEND

- Proposed modification pit depth extension
- Model extent
- Major road
- Major drainage
- Minor drainage
- Approved tailings facility

River and surface drainage cells

- Hunter River
- Wolombi Brook
- Wambo Creek
- Other drainage
- Approved final voids
- Proposed final void

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River and surface drainage cells

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FIGURE No: **B-3**

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B3 Model calibration

The groundwater model was calibrated with pre-mining steady state run, and a transient run (1970 to 2015) using available groundwater level data and documented pit inflows. The model was calibrated by adjusting aquifer parameters and stresses and boundary conditions to produce the best match between the observed and simulated water levels. Manual testing and automated parameterisation software (PEST, Doherty 2010) were used to determine optimal hydraulic parameters and recharge rates to achieve the best statistical calibration of the groundwater model.

B3.1 Model confidence level classification

Barnett and co-authors (2012) developed a system to classify the confidence-level for groundwater models. Models are classified as either Class 1, Class 2 or Class 3 in order of increasing confidence (i.e. Class 3 has the highest level of confidence). Several factors are considered in determining the model confidence level:

- available data;
- calibration procedures;
- consistency between calibration and predictive analysis; and
- level of stresses.

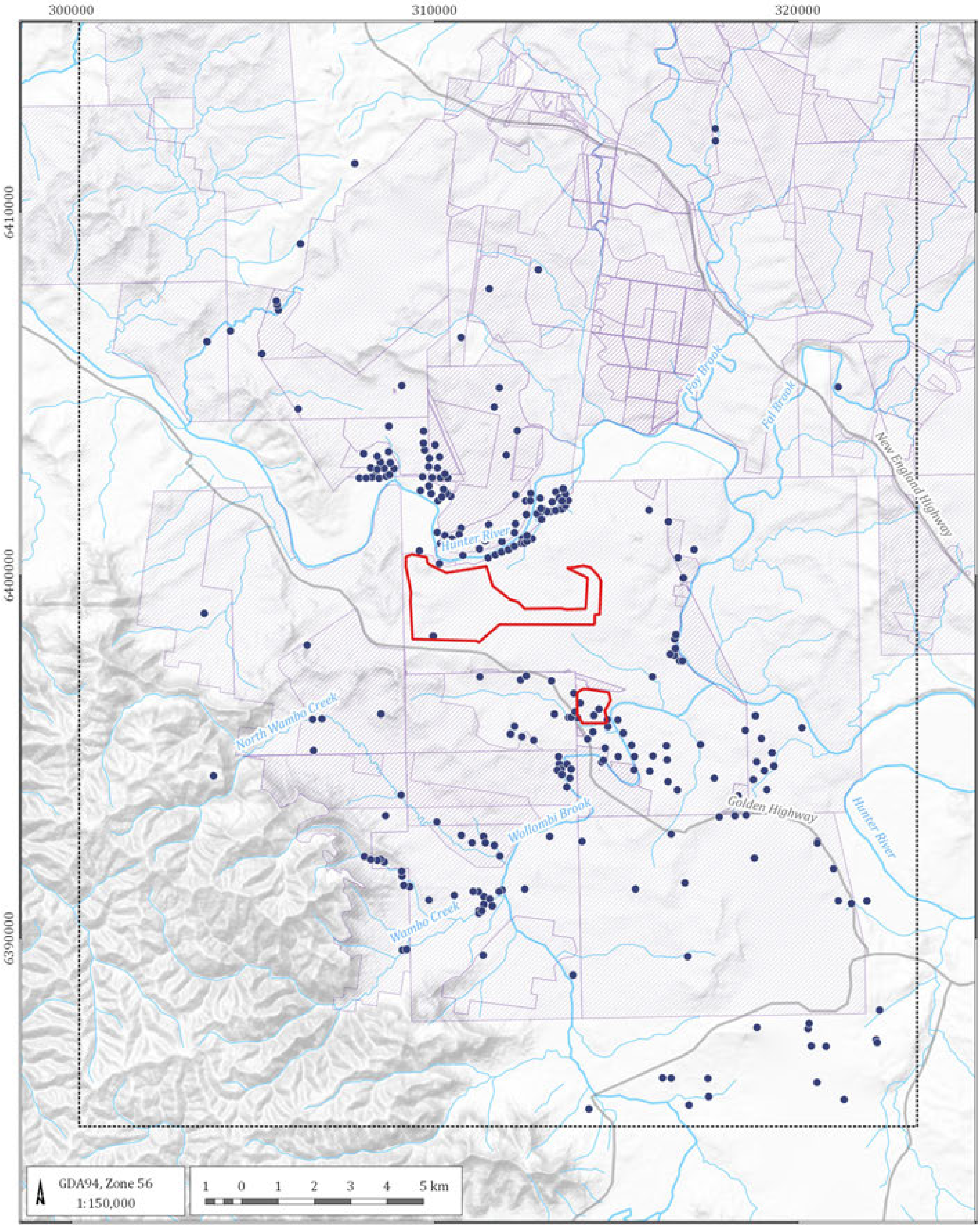
The model was developed to achieve the criteria considered for a Class 2 model, and to meet some of the criteria for a Class 3 confidence level classification. It does this by simulating a similar calibration period to the predictive model, replicating seasonal and responses to surface water/rainfall interaction, and meeting calibration and model error statistics.

B3.2 Calibration targets

The model simulated water levels in all available monitoring bores within the bedrock and alluvial aquifers. A total of 368 monitoring points were used to calibrate the model, and are comprised of:

- 196 monitoring points at 187 locations from the HVO monitoring network, which includes bores and VWP's that screen the alluvium and Permian coal measures;
- 16 private registered bores with available water level data, the majority of which intersect Quaternary alluvium;
- 39 monitoring points across Mt Thorley Warkworth that screen the alluvium and Permian coal measures; and
- 117 monitoring points from Wambo and United that screen the alluvium and Permian coal measures.

Figure B -4 presents the observation bores that were used in the transient calibration.



LEGEND

- Proposed modification pit depth extension
- Model extent
- Coal titles
- Major road
- Major
- Minor
- Observation target location

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Observation target locations

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FIGURE No: **B-4**

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B3.3 Calibration results

Figure B -5 presents the observed and simulated groundwater levels graphically as a scattergram for the initial and historic transient calibration (1970 – 2015). Appendix B-1 presents the historic calibration hydrographs, showing the fit between modelled and observed groundwater levels from 1970 to 2015.

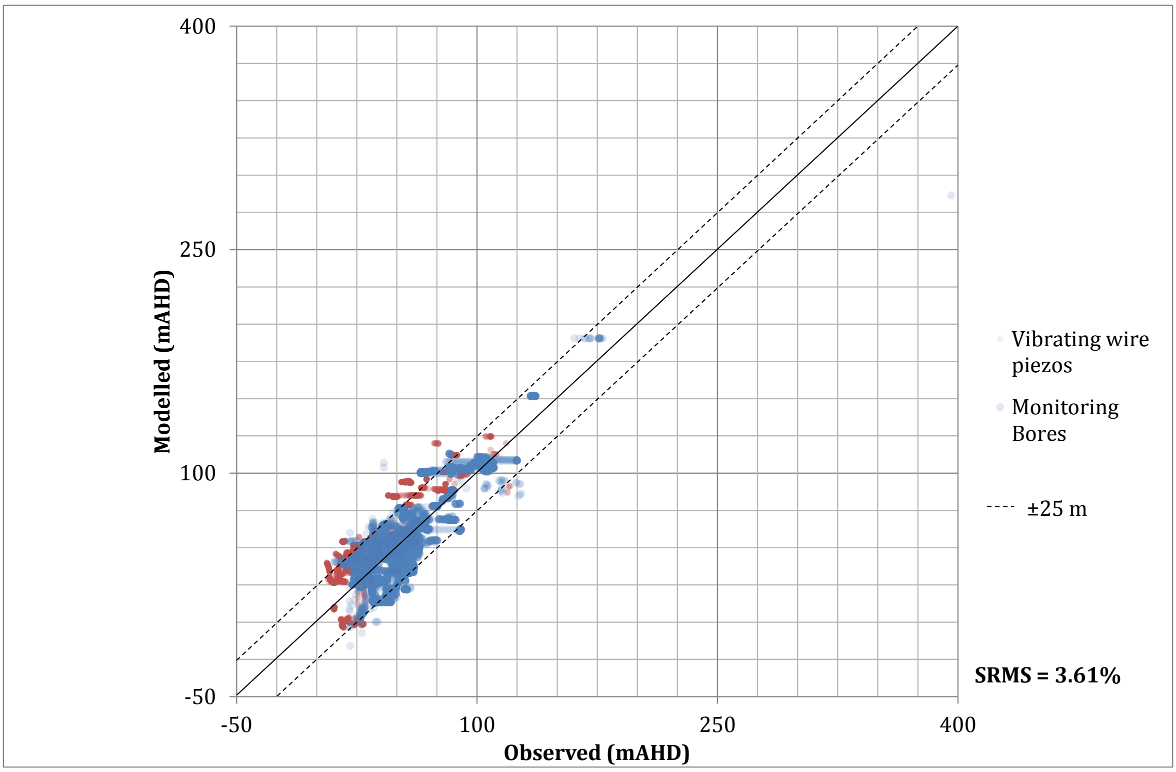


Figure B -5 Transient calibration – modelled vs observed groundwater levels

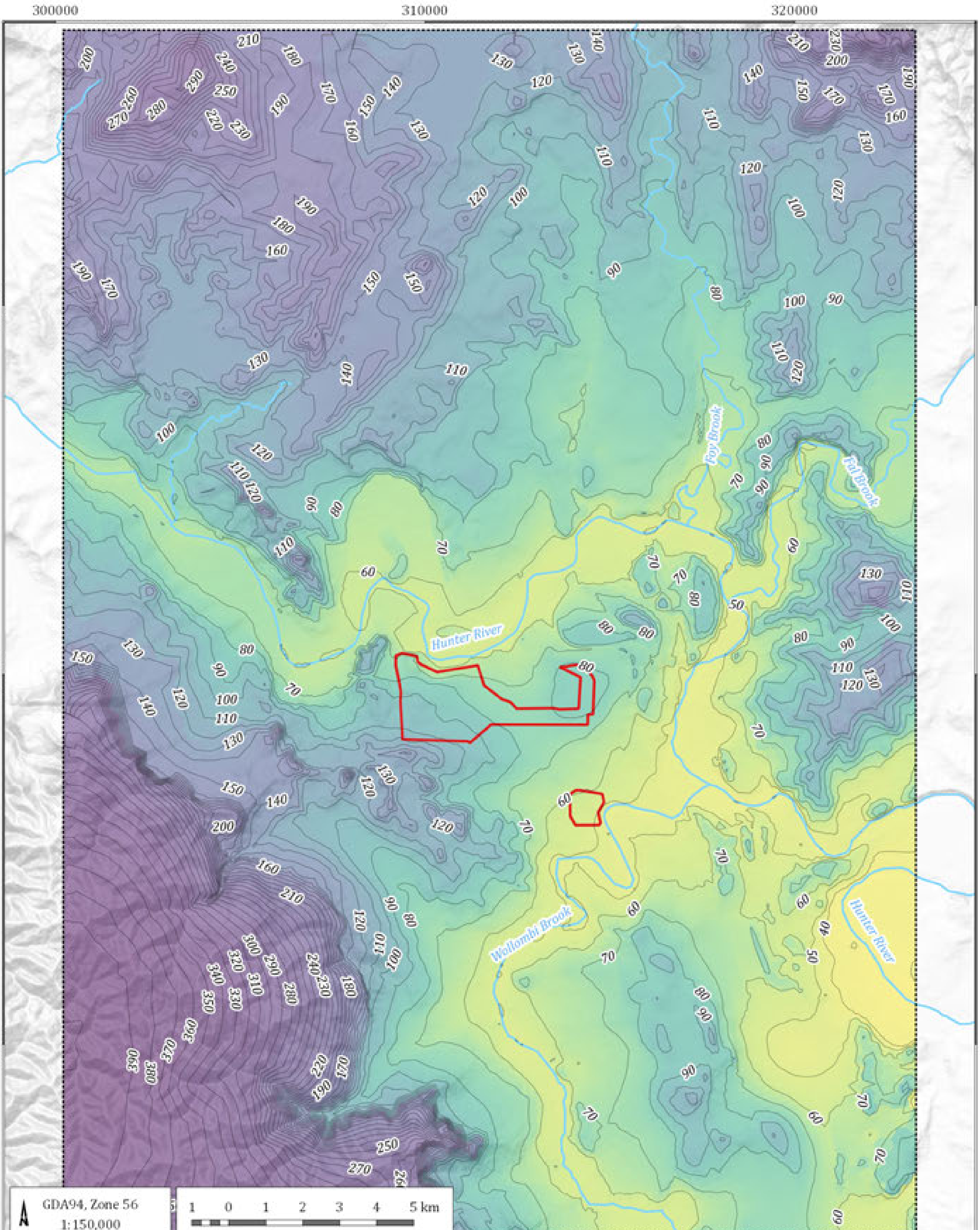
The RMS error calculated for the calibrated model was 14.06m. The total measured head change across the model domain was 389.50m; with an SRMS of 3.61%, indicating a good calibration. Excluding bore GW064382, which is located within the Narrabeen Group sandstones within Wollemi National Park, reduces the range in measured head range to 172.25m. This increases the SRMS to 8.16%, but this still indicates a good calibration.

Appendix B1 includes a table of calibration target details and residuals, as well as hydrographs from the transient calibration model. Generally, the model has replicated the complex response to the numerous mining activities over the 45 year calibration period. Some instances in groundwater responses to mining show possible limitations with the replication of historic mining across the model domain. However, responses to depressurisation from longwall mining and open cut mining have been replicated adequately to meet the modelling objectives. Groundwater level responses to seasonal fluctuations have also been replicated adequately, which is most evident in the hydrographs (Appendix B1) for bores within the Hunter River alluvium (i.e. PZCH bores).

B3.3.1 Calibration heads

The calibrated heads from the steady state calibration model are presented in Figure B -6 and Figure B -7 for the unconsolidated sediments (alluvium and regolith) and coal seams (Vaux and Bayswater seams) respectively. The figures show groundwater generally flows northeast to the local drainage systems without the presence of active open cut and longwall mining.

The calibrated heads at the end of the transient calibration model (2015) are presented in Figure B -8 and Figure B -9 for the unconsolidated sediments (alluvium and regolith) and coal seams (Vaux and Bayswater seams) respectively. Groundwater levels representing 2015 conditions show the depressurised zones within the potentiometric surface caused by the advancement of mining since 2003.



LEGEND

- Proposed modification pit depth extension
- Model extent
- Major drainage
- Predicted groundwater level contours (mAHD, 10m interval)

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Predicted pre-mining groundwater levels - alluvium and regolith

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FIGURE No: **B-6**

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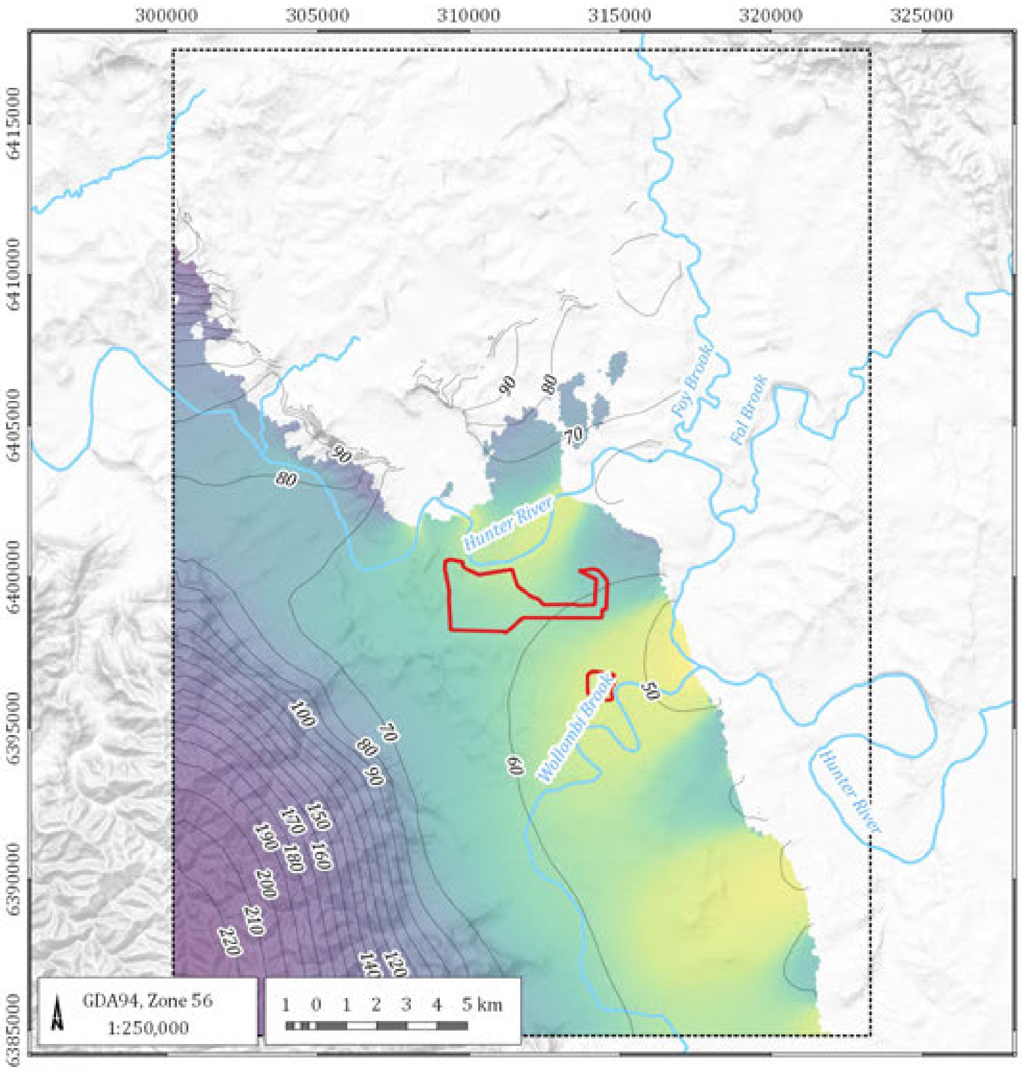
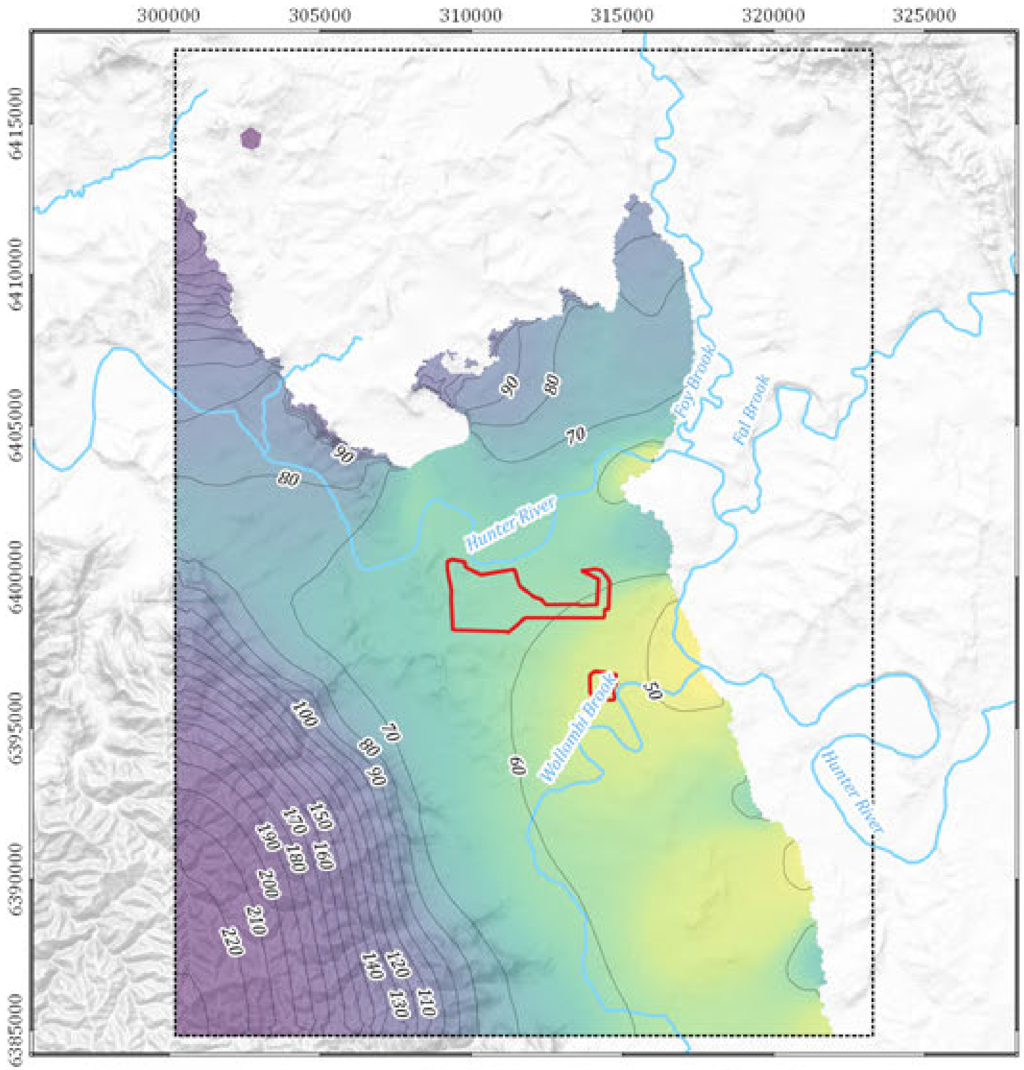
Vaux Seam



Bayswater Seam



LEGEND

- Proposed modification pit depth extension
- Model extent
- Major drainage
- Predicted groundwater level contours (mAHD, 10m interval)

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Predicted pre-mining groundwater levels - Vaux and Bayswater seams

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FIGURE No:
B-7

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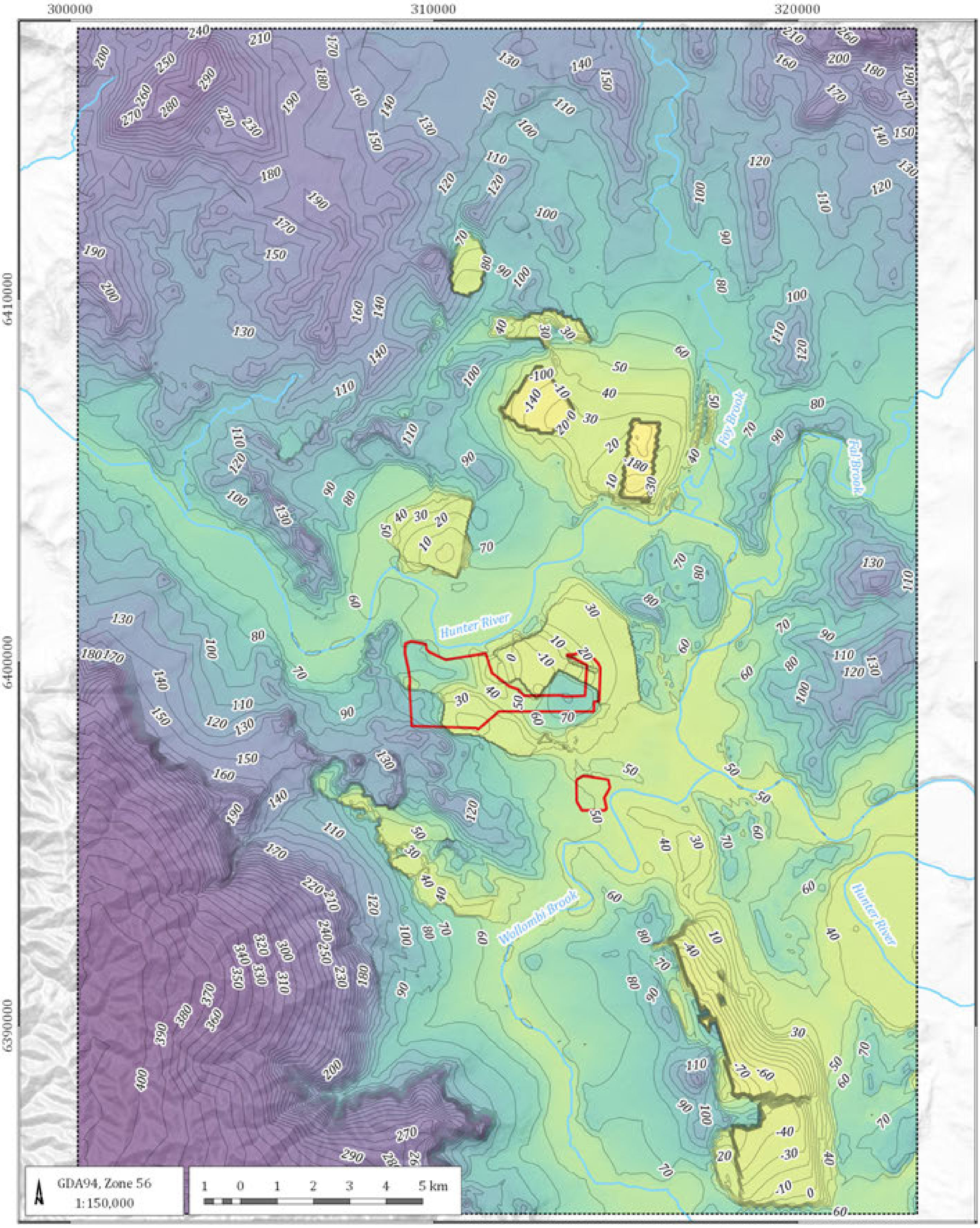

LEGEND

- Proposed modification pit depth extension
- Model extent
- Major drainage
- Predicted groundwater level contours (mAHD, 10m interval)

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Predicted groundwater levels (2015) - alluvium and regolith

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FIGURE No: **B-8**

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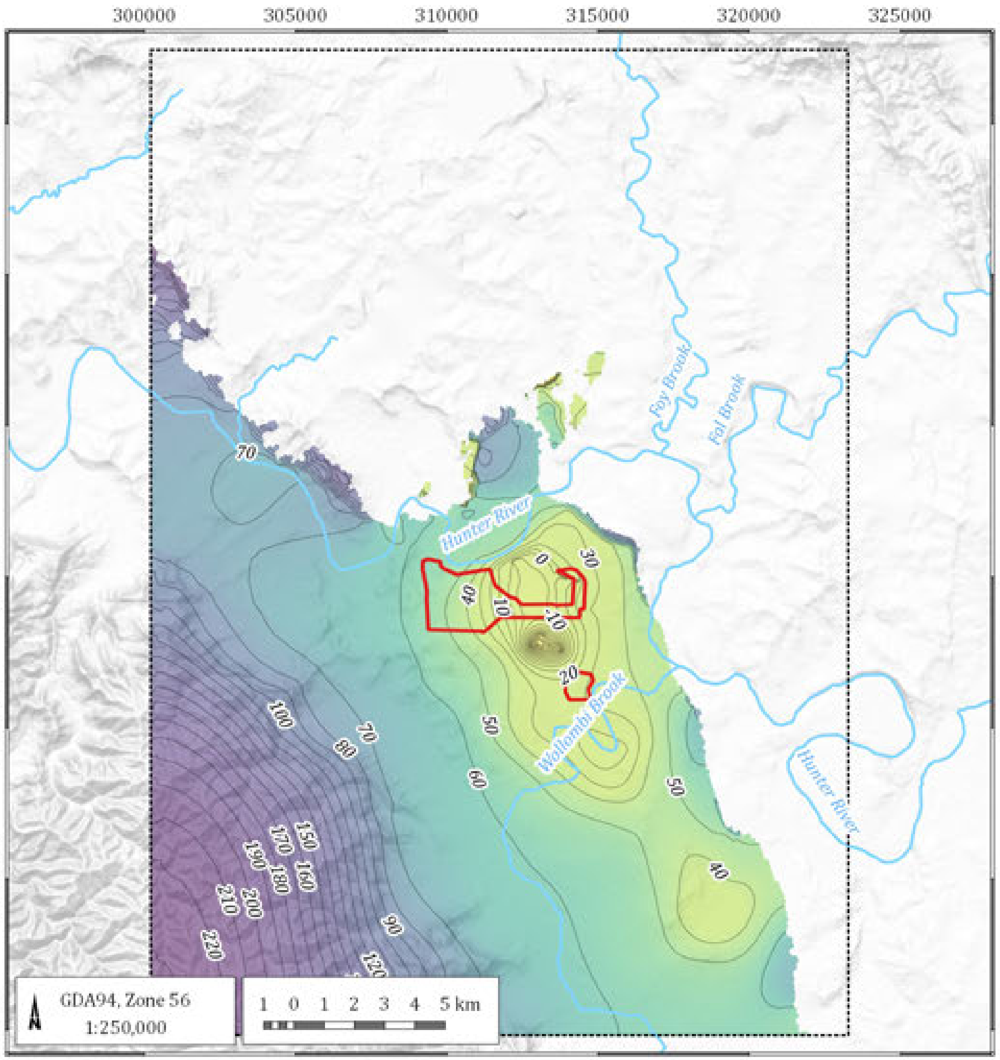
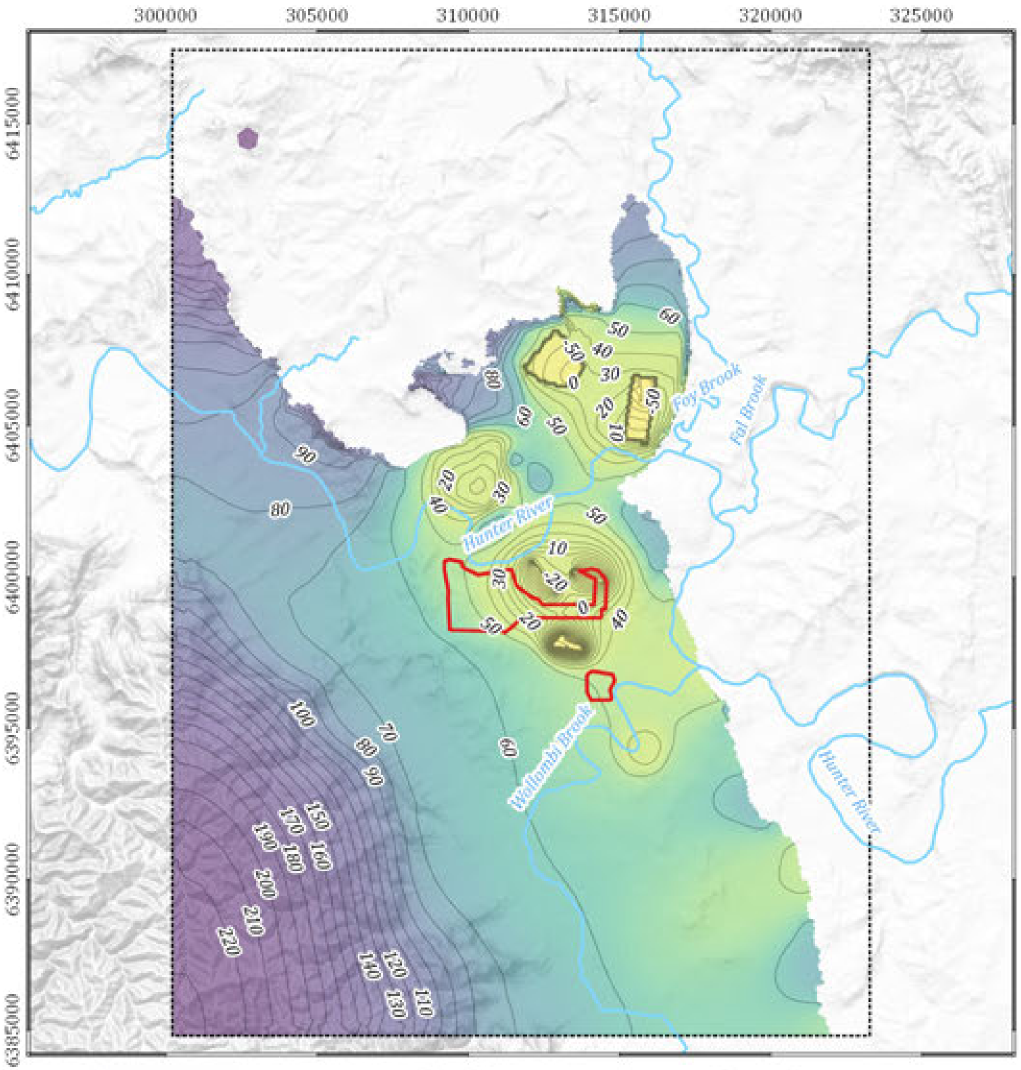
Vaux Seam



Bayswater Seam



LEGEND

- Proposed modification pit depth extension
- Model extent
- Major drainage
- Predicted groundwater level contours (mAHD, 10m interval)

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Predicted groundwater levels (2015) - Vaux and Bayswater seams

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FIGURE No:
B-9

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B3.3.2 Hydraulic parameters

Table B-5 summarises the calibrated maximum hydraulic conductivity for each of the hydrostratigraphic units within the model domain, and the vertical hydraulic conductivity multipliers applied to the horizontal K value each unit. Figure B -10 presents the uniform hydraulic conductivity values for layers 1, 2, 3 and 5. The hydraulic properties of the coal measures (layer 4 and layer 6 to layer 34) decrease with depth. Therefore, the values presented for the coal and interburden in Table B-5 are the uppermost hydraulic conductivity value for each layer. The relationship with depth is further discussed below.

Table B-5 Calibrated hydraulic conductivity values (at surface)

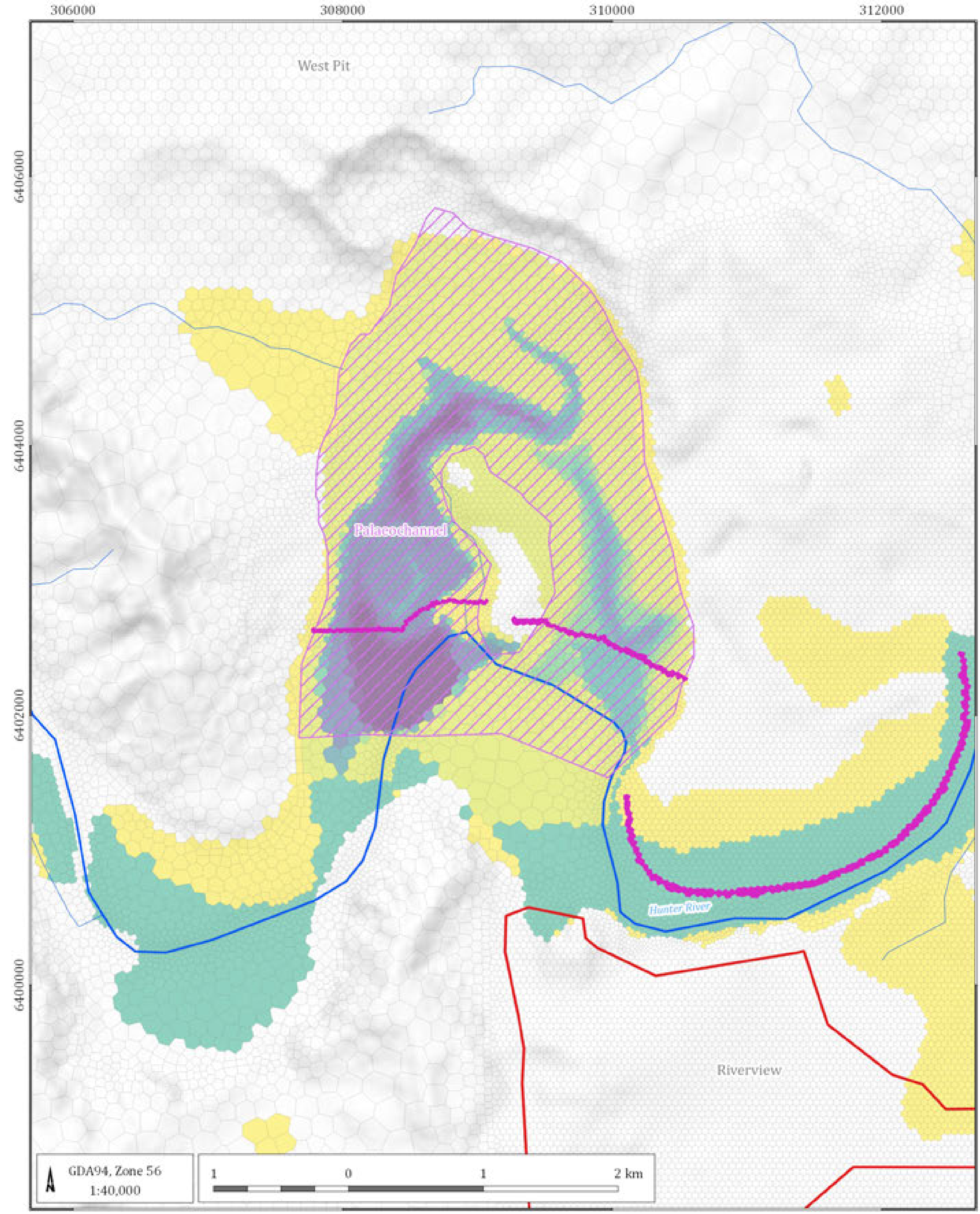
Model layer	Lithology	Horizontal hydraulic conductivity (m/day)*	Vertical hydraulic conductivity multiplier
1,2	Less productive alluvium (Qa)	1.0	1.00×10^{-2}
1,2	Colluvium / regolith	0.5	5.00×10^{-2}
1	Highly productive alluvium (Qa)	2.13	5.98×10^{-1}
2	Highly productive alluvium (basal gravels)	10	5.00×10^{-2}
3	Narrabeen Group	7.24×10^{-3}	5.00×10^{-2}
4	Newcastle Coal Measures	1.19×10^{-2}	2.78×10^{-2}
5	Watts Sandstone	5.0×10^{-3}	5.00×10^{-1}
6	Sandstone / siltstone / shale	5.66×10^{-3}	5.10×10^{-2}
7	Whybrow Seam	5.83×10^{-1}	1.28×10^{-2}
8	Sandstone / siltstone / shale	9.82×10^{-3}	1.11×10^{-1}
9	Wambo Seam	6.87×10^{-1}	1.90×10^{-2}
10	Sandstone / siltstone / shale	9.83×10^{-3}	1.49×10^{-1}
11	Whynot Seam	7.88×10^{-1}	1.88×10^{-2}
12	Sandstone / siltstone / shale	8.92×10^{-3}	1.08×10^{-1}
13	Blakefield, Glen Munro and Woodlands Hill seams	4.09×10^{-1}	2.02×10^{-2}
14	Sandstone / siltstone / shale	7.64×10^{-3}	8.27×10^{-2}
15	Arrowfield Seam	1.83×10^{-1}	2.06×10^{-2}
16	Sandstone / siltstone / shale	1.18×10^{-2}	1.18×10^{-1}
17	Bowfield Seam	6.39×10^{-1}	2.06×10^{-2}
18	Siltstone / shale (interburden)	2.34×10^{-2}	1.02×10^{-1}
19	United and Wambo Bowfield split (not present at	7.13×10^{-1}	2.10×10^{-2}
20	Siltstone / shale (interburden)	1.31×10^{-2}	1.47×10^{-1}
21	Warkworth Seam	1.25	2.08×10^{-2}
22	Siltstone / shale (interburden)	5.74×10^{-3}	6.14×10^{-2}
23	Mt Arthur Seam	1.46	2.09×10^{-2}
24	Siltstone / shale (interburden)	1.41×10^{-2}	1.23×10^{-1}
25	Piercefield and Vaux seams	6.26×10^{-1}	2.80×10^{-2}
26	Siltstone / shale (interburden)	1.56×10^{-2}	1.95×10^{-1}

Model layer	Lithology	Horizontal hydraulic conductivity (m/day)*	Vertical hydraulic conductivity multiplier
27	Broonie and Bayswater seams	1.09	2.27×10^{-2}
28	Archerfield Sandstone and interburden units	1.11×10^{-2}	2.00×10^{-1}
29	Lemington and Pikes Gully seams	1.09	2.27×10^{-2}
30	Siltstone / shale (interburden	5.74×10^{-3}	6.14×10^{-2}
31	Arties and Liddell seams	1.09	2.27×10^{-2}
32	Siltstone / shale (interburden)	5.74×10^{-3}	6.14×10^{-2}
33	Barrett and Hebden seams	1.09	2.27×10^{-2}
34	Siltstone / shale (underburden)	5.74×10^{-3}	6.14×10^{-2}
-	Spoil	1.00	1.00×10^{-1}

Note: ** upper hydraulic conductivity derived from depth of 20m below surface and using dependence formula*

Several studies undertaken by Coal & Allied have found that the hydraulic conductivity of the alluvium within the palaeochannel at HVO North is high, ranging from 1m/day to 100m/day. These hydraulic properties were incorporated into previous groundwater models used across HVO North. As the model domain covers HVO North, for Layer 2 the model adopted the hydraulic conductivity distribution developed by MER (2010), as presented in Figure B -10.

Figure B -10 also shows the location of the existing grout barrier walls that were installed along Alluvial Lands and south of the Carrington Pit at HVO South, as well as the proposed barrier wall to the west (West Wing). The barrier wall was constructed by excavating down to competent rock and pumping in a grout slurry to seal off the alluvium. To represent this in the model, a hydraulic conductivity of 5.8×10^{-5}m/day was applied along the barrier wall zone down to the base of alluvium (base of Layer 2). The hydraulic conductivity used was derived from field studies and previous modelling (MER 2010; AGE 2013).



LEGEND

- Proposed modification pit depth extension
- Barrier wall
- Palaeochannel (MER, 2005)
- Major drainage
- Minor drainage

Hydraulic conductivity (m/day)

0.5	20
1	30
5	40
6	50
10	60
15	70
	80

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Hydraulic conductivity

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FIGURE No: **B-10**

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Figure B -11 compares the distribution of available field hydraulic conductivity (horizontal) data against the modelled hydraulic conductivity for each unit at 20m below surface. It should be noted that the depth interval for the field data is variable, with some units (i.e. Wambo Seam underburden) only having available data at depths of over 200m. Accounting for the limitations of the available field data, Figure B -11 graphically shows a relatively good match between the field data and the model parameters.

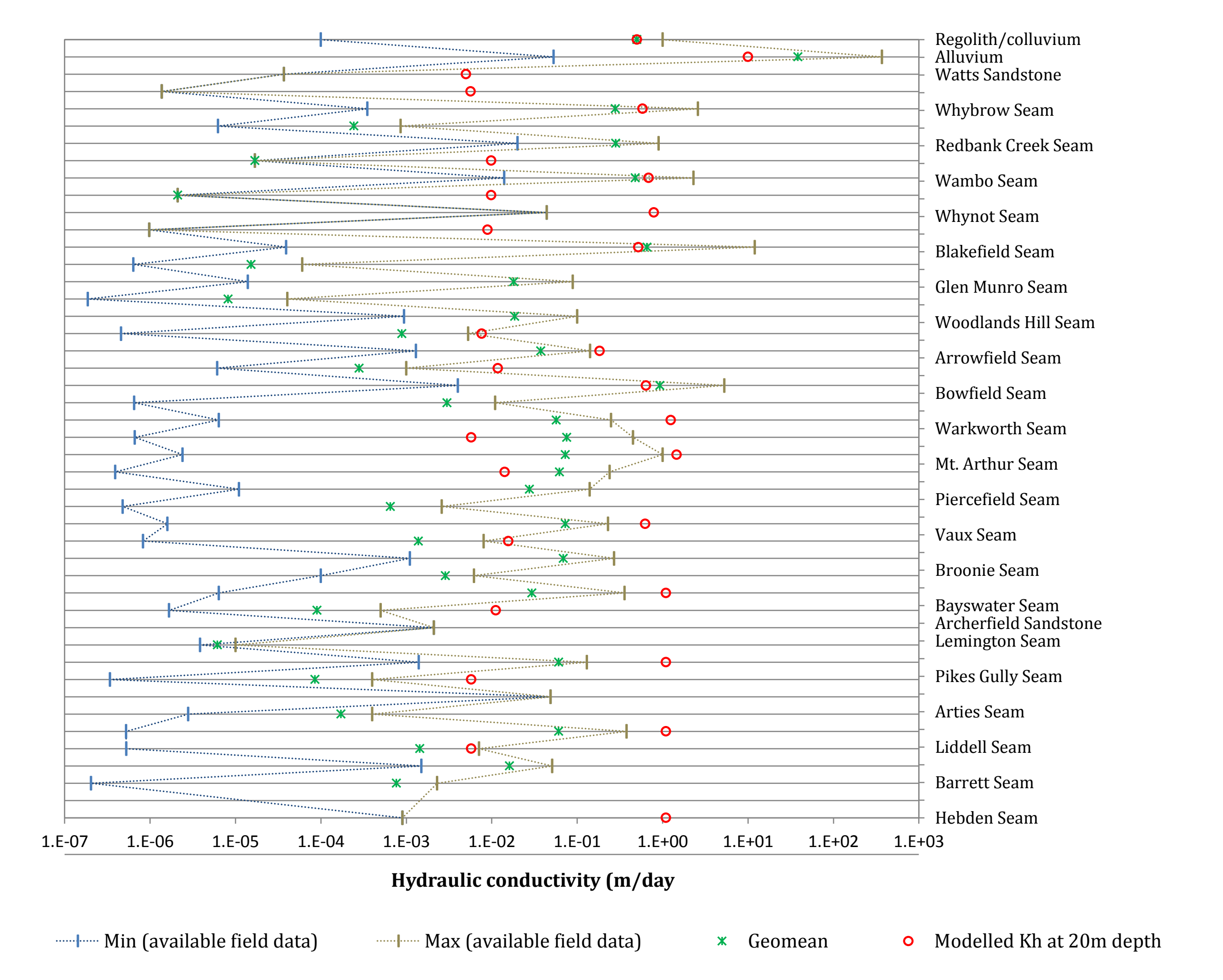


Figure B -11 Hydraulic conductivity distribution graph

The hydraulic conductivity of the Permian interburden (siltstone, sandstone) material decreases with depth in order to reflect field observations. Because the decrease of Kh within interburden rock units is driven by increase of pore pressure, the relationship between Kh and depth is different from that of coal seams. The hydraulic conductivity for the interburden material is capped at a minimum between 4.8 x 10^{-7} and 7.4 x 10^{-7}m/day and the hydraulic conductivity of the coal seams is capped at a minimum between 5 x 10^{-7} and 2.0 x 10^{-6}m/day.

The hydraulic conductivity of the coal seam and interburden layers decreases with depth according to Equations 1 (exponential) and 2 (power):

Coal: $HC = HC_0 \times e^{(slope \times depth)}$ (Eq. 1)

Interburden: $HC = HC_0 \times depth^{slope}$ (Eq. 2)

Where: *HC* is horizontal hydraulic conductivity at specific depth

HC_0 is horizontal hydraulic conductivity at depth of 0m (intercept of the curve)

depth is depth of the floor of the layer (thickness of the cover material)

slope is a term representing slope of the formula (steepness of the curve)

The slope function and coefficient of the coal and interburden depth dependence equations were calibrated. The Kh vs. depth relationship for the individual coal seams are presented in Figure B -12, while the calibrated relationships for the interburden units are presented in Figure B -13.

As shown in Figure B -12 and Figure B -13, the calibrated depth dependence trends for the various coal and interburden layers largely follow the averaged trend identified for the available field data within the main report.

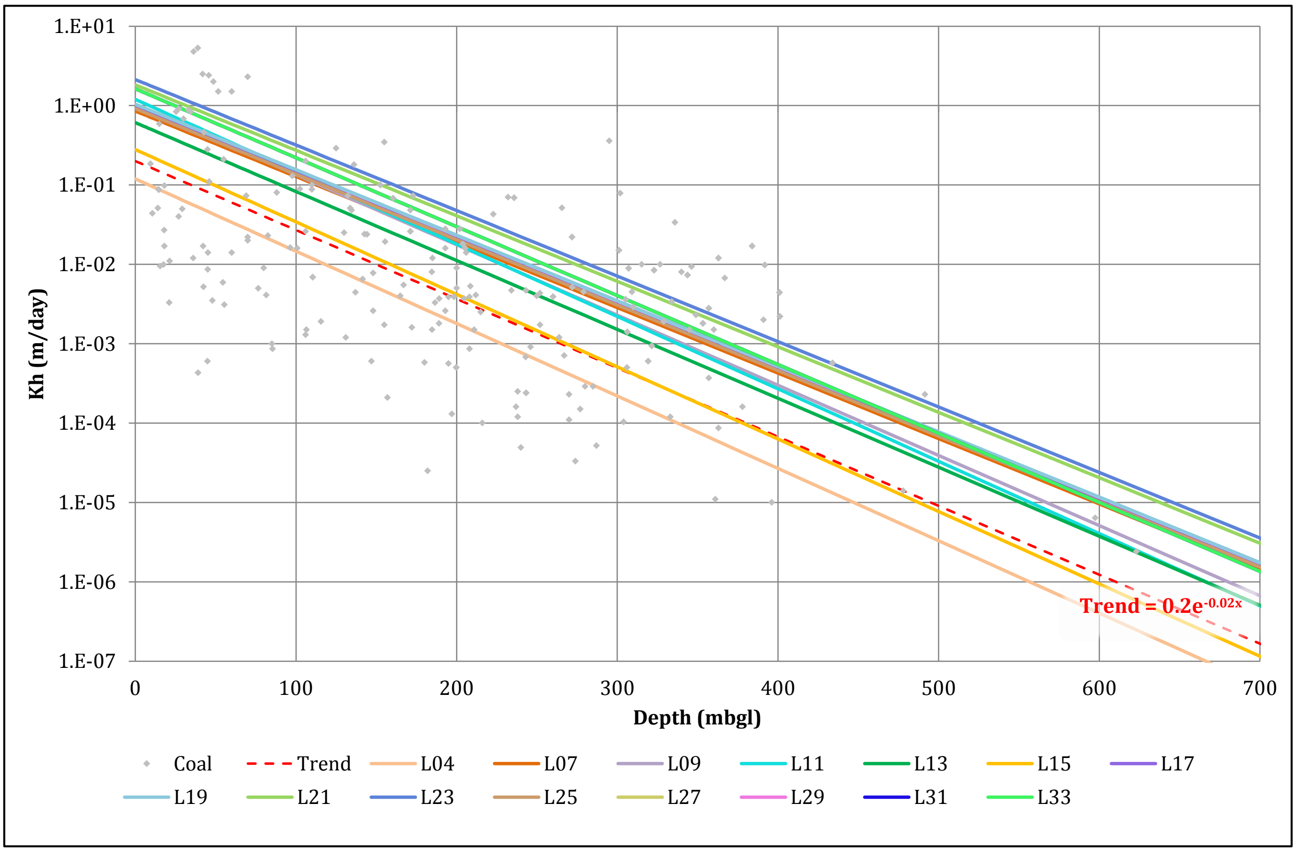


Figure B -12 Hydraulic conductivity vs. depth – coal layers (L)

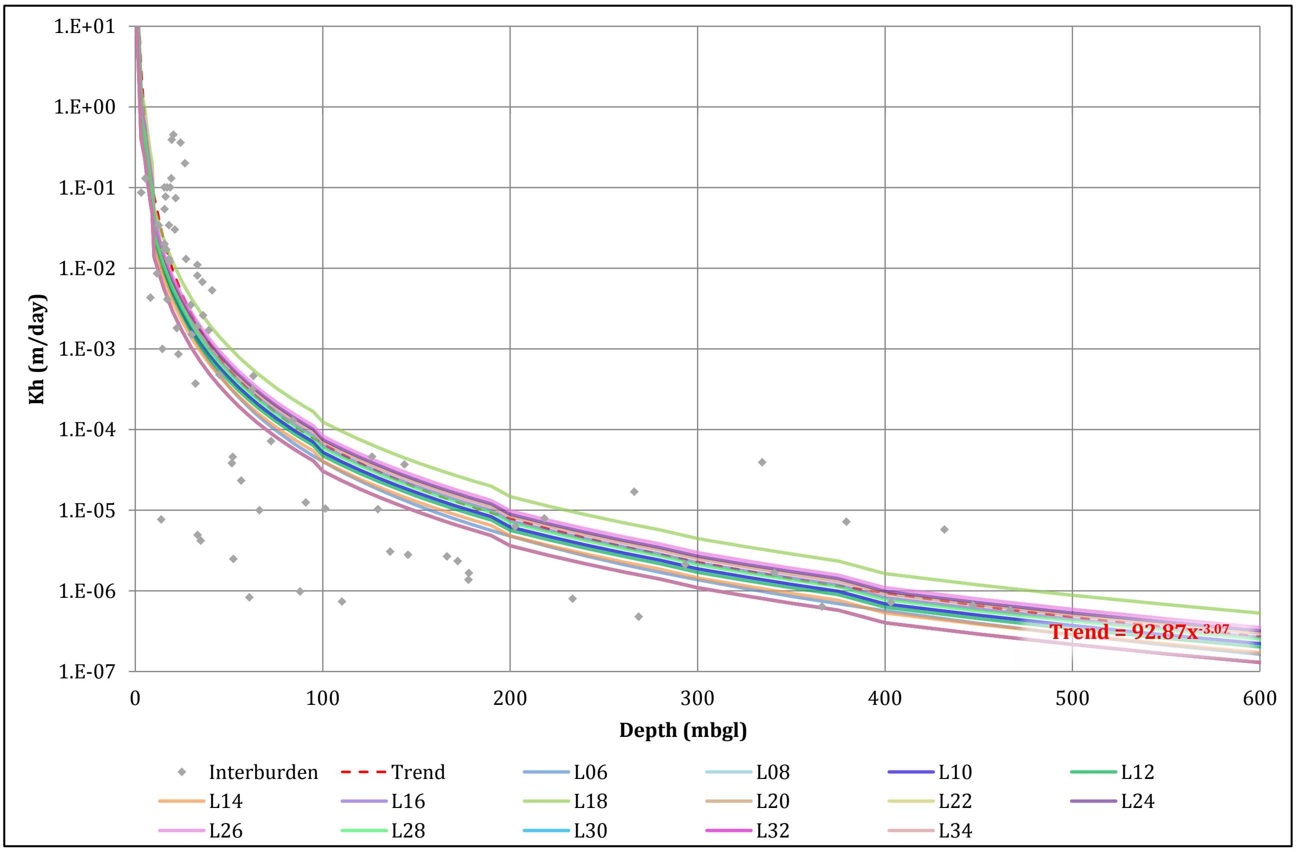


Figure B -13 Hydraulic conductivity vs. depth – interburden layers (L)

Table B-6 shows the calibrated fractured values used in the transient calibration model. These values are applied to the strata above each longwall panel simultaneously with longwall mining, at the same temporal resolution as the drain cells (i.e. quarterly). These values are also applied above bord and pillar mining areas at the completion of mining and removal of pillars.

Table B-6 TVM fractured parameters

Parameter	Fracture height (m)	Vertical Hydraulic conductivity (m/day)
Goaf	0	5.30×10^{-2}
Fracture zone 1	12.5	1.52×10^{-2}
Fracture zone 2	25	5.63×10^{-3}
Fracture zone 3	50	1.95×10^{-3}
Fracture zone 4	78	6.98×10^{-4}
Fracture zone 5	110	1.40×10^{-4}

B3.3.3 Storage properties

Table B-7 summarises the calibrated values for specific storage and specific yield.

Table B-7 Model layer storage properties

Model layer	Lithology	Specific yield Sy	Specific storage Ss (m^{-1})
1	Colluvium / regolith and less productive alluvium (Qa)	$3.00x10^{-2}$ to $6.00x10^{-2}$	$3.00x10^{-3}$ to $3.10x10^{-4}$
2	Productive alluvium (basal gravels)	$3.00x10^{-2}$ to $7.00x10^{-2}$	$3.00x10^{-3}$ to $2.78x10^{-4}$
3	Narrabeen Group	$2.92x10^{-2}$	$1.65x10^{-4}$
4	Newcastle Coal Measures	$7.35x10^{-3}$	$3.40x10^{-5}$
5	Watts Sandstone	$8.97x10^{-3}$	$3.12x10^{-4}$
6	Sandstone / siltstone / shale	$6.36x10^{-3}$	$5.21x10^{-5}$
7	Whybrow Seam	$8.69x10^{-3}$	$3.73x10^{-5}$
8	Sandstone / siltstone / shale	$6.53x10^{-3}$	$7.18x10^{-5}$
9	Wambo Seam	$6.18x10^{-3}$	$3.49x10^{-5}$
10	Sandstone / siltstone / shale	$5.65x10^{-3}$	$6.20x10^{-5}$
11	Whynot Seam	$6.02x10^{-3}$	$2.57x10^{-5}$
12	Sandstone / siltstone / shale	$5.05x10^{-3}$	$5.71x10^{-5}$
13	Blakefield, Glen Munro and Woodlands Hill seams	$6.73x10^{-3}$	$3.29x10^{-5}$
14	Sandstone / siltstone / shale	$7.24x10^{-3}$	$8.20x10^{-5}$
15	Arrowfield Seam	$5.29x10^{-3}$	$3.38x10^{-5}$
16	Sandstone / siltstone / shale	$7.00x10^{-3}$	$6.41x10^{-5}$
17	Bowfield Seam	$5.07x10^{-3}$	$2.96x10^{-5}$
18	Siltstone / shale (interburden)	$8.99x10^{-3}$	$3.78x10^{-5}$
19	United and Wambo Bowfield split (not present at HVO)	$6.35x10^{-3}$	$3.08x10^{-5}$
20	Siltstone / shale (interburden)	$6.20x10^{-3}$	$6.89x10^{-5}$
21	Warkworth Seam	$6.61x10^{-3}$	$2.79x10^{-5}$
22	Siltstone / shale (interburden)	$7.47x10^{-3}$	$6.21x10^{-5}$
23	Mt Arthur Seam	$6.07x10^{-3}$	$2.81x10^{-5}$
24	Siltstone / shale (interburden)	$5.99x10^{-3}$	$5.39x10^{-5}$
25	Piercefield and Vaux seams	$7.75x10^{-3}$	$2.60x10^{-5}$
26	Siltstone / shale (interburden)	$7.35x10^{-3}$	$5.98x10^{-5}$
27	Broonie and Bayswater seams	$8.00x10^{-3}$	$2.91x10^{-5}$
28	Archerfield Sandstone and	$8.03x10^{-3}$	$5.53x10^{-5}$

Model layer	Lithology	Specific yield Sy	Specific storage Ss (m^{-1})
	interburden units		
29	Lemington and Pikes Gully seams	$8.00x10^{-3}$	$2.91x10^{-5}$
30	Siltstone / shale (interburden	$7.47x10^{-3}$	$6.21x10^{-5}$
31	Arties and Liddell seams	$8.00x10^{-3}$	$2.91x10^{-5}$
32	Siltstone / shale (interburden)	$7.47x10^{-3}$	$6.21x10^{-5}$
33	Barrett and Hebden seams	$8.00x10^{-3}$	$2.91x10^{-5}$
34	Siltstone / shale (underburden)	$7.47x10^{-3}$	$6.21x10^{-5}$
-	Spoil	$1.00x10^{-1}$	$1.00x10^{-3}$

Note: *Parameters used in the model are conservative estimates using a combination of field data, hydrogeological expertise and knowledge of the region.*

Direct testing data are not generally available for specific storage (Ss) of coal seams or interburden. However, good estimates can be made based on Young's Modulus and porosity. For coal, Ss generally lies in the range $5\times10^{-6}m^{-1}$ to $5\times10^{-5}m^{-1}$, and interburden is generally slightly higher than this due to the greater porosity (Mackie, 2009). The calibrated parameters for coal fall within these bounds.

B3.3.4 Water budget

The mass balance error, that is, the difference between calculated model inflows and outflows at the completion of the steady state calibration was 0.00%. This value indicates that the model is stable and achieves an accurate numerical solution. Table B-8 shows the water budget for the steady state (pre-mining) model.

Table B-8 Model budgets – steady state

Parameter	In (ML/day)	Out (ML/day)	In - Out (ML/day)
Rainfall recharge	31.5	-	31.5
River	11.3	44.2	-32.9
Evapotranspiration	-	7.6	-7.6
General head boundary	16.7	7.7	9.0
Total	**59.5**	**59.5**	**0.0**

The water budget indicates that recharge to the groundwater system within the model averages 59.5ML/day, with approximately 44.2ML/day being discharged via surface drainage, and 7.6ML/day lost to evapotranspiration in areas where the water table is within 1.5m of the land surface. This value of evaporation is comparatively low, namely because surface drainage via the river cells removes a significant portion of the total evaporation in the model.

Table B-9 shows the average water budget for the transient calibration (1970 – 2015). The water budget indicates that the groundwater system departs from steady state conditions because of extensive mining in the model domain. Recharge (rainfall and river leakage) within the model averages 62.8ML/day, with approximately 44.9ML/day being discharged via surface drainage and 22.7ML/day from mines.

Table B-9 Model budgets – transient calibration

Parameter	In (ML/day)	Out (ML/day)	In - Out (ML/day)
Storage	27.4	27.1	0.3
Rainfall recharge	41.6	-	41.6
River	21.2	44.9	-23.7
Evapotranspiration	-	7.1	-7.1
Wells	-	0.1	-0.1
Drains	-	22.7	-22.7
Total	**90.2**	**101.9**	**-11.7**

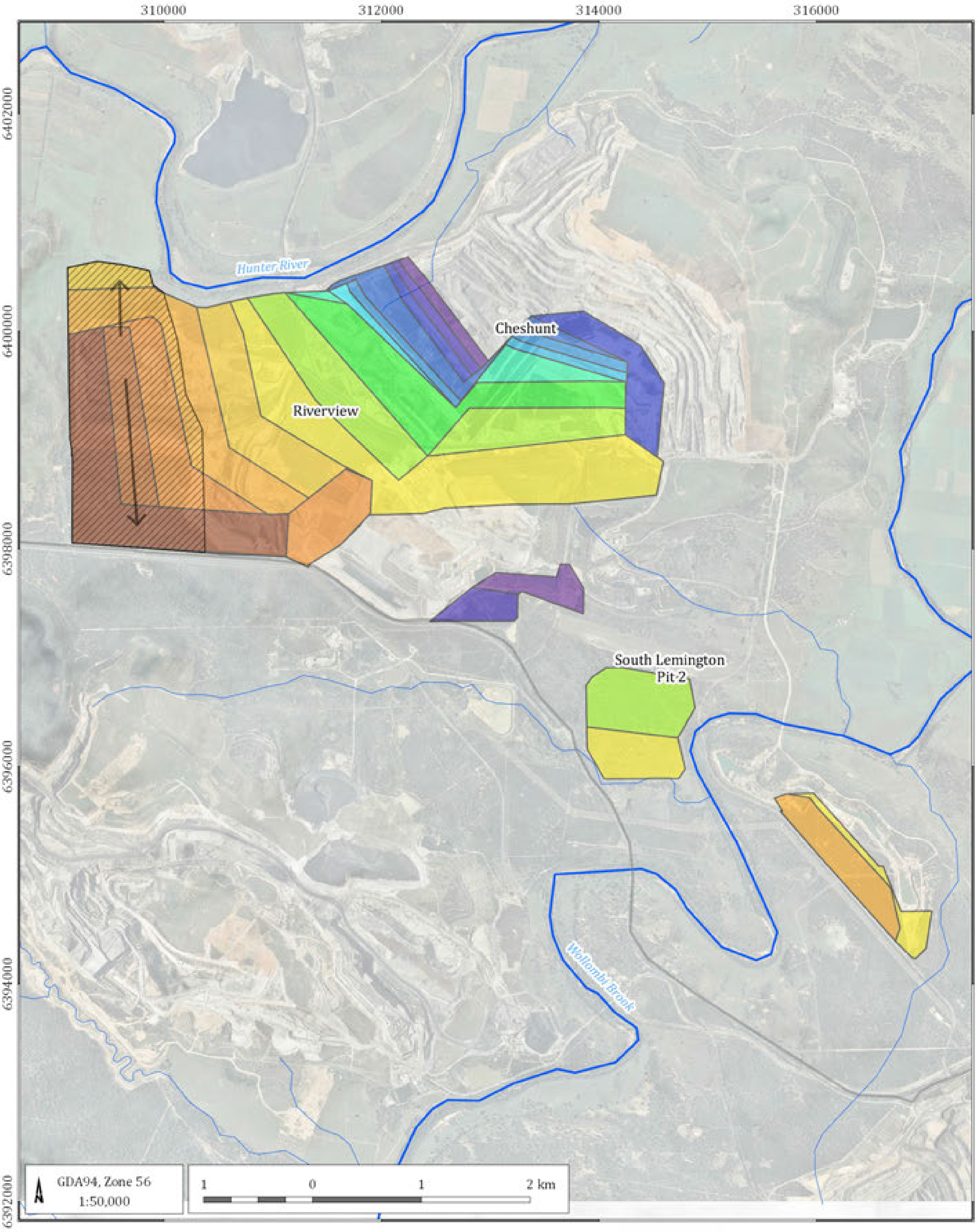
The model was used to identify the influence of the modification on the groundwater regime by comparing the approved and proposed future mine plans for HVO South. All currently approved and foreseeable mine plans within the region (i.e. United Wambo Project, MTW, Ravensworth) were included in order to account for cumulative impacts. These include both underground and open-cut operations.

Two predictive model simulations were run, one with all currently approved and foreseeable mine plans, and one with all currently approved and foreseeable mine plans plus the proposed modification. The proposed modification involves progression of Cheshunt Pit and deepening of Riverview Pit and South Lemington Pit 2 within the currently approved mine footprints. Therefore, the approved mine plan for HVO South was represented in the model by setting the drain cells for Riverview Pit and South Lemington Pit 2 to layer 25 (Vaux Seam) and layer 17 (Bowfield Seam), respectively. The modified mine plan was represented by setting the drain cells at Riverview Pit 2 to layer 27 (Bayswater Seam) and South Lemington Pit 2 to layer 25 (Vaux Seam). In addition, the drain cells at the south-eastern section of Riverview Pit were also set to layer 27 (Bayswater Seam).

B3.4 Time slices

The staged transient model ran from 1/12/2015 in Year 1 to 1/12/2039 (Year 24). The model was divided into quarterly (3 month) stress periods with the mining activities associated with the proposed modification commencing in 2017. Quarterly stress periods were used so that seasonal variability in recharge and stream flows could be represented in the model. The model simulates mining with drain cells, which progress on a quarterly basis. Figure B -14 shows the progress of the proposed mining, with future mining at the surrounding mines detailed in Table B-2.

The proposed modification runs from year 2 to year 15. From year 15 there is no active mining at HVO South or HVO North. However, mining is active at surrounding operations Ravensworth, United, Wambo and MTW. In order to capture cumulative groundwater impacts from active mines after the life of the proposed modification, the model was left to run until year 24, which coincides with closure of all surrounding operations. To represent this, the drain cells at HVO were turned off from year 15 and cells converted to represent spoil material. The void parameters, rainfall runoff and EVT were not initiated over mined areas at HVO until commencement of the recovery model. As a result the predicted drawdown and water take post mining (from year 15) is considered conservative, as the groundwater take does not factor in potential recharge to the mined out spoils at HVO South over this time.



LEGEND

- Major road
- Major drainage
- Minor drainage
- Riverview prestrip 2015-2023

Mine progression (Years)

2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023, 2024, 2025, 2026, 2027, 2028, 2029, 2030

HVO South Modification 5 Groundwater Study (G1737) - Numerical Modelling Report

Predictive mine progression

DATE 08/01/2016

FIGURE No: **B-14**

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B3.5 Mine drainage

The model represented mining using the drain (DRN) package. During the predictive run, drain cells were used to simulate the effect of the proposed mine and other mines in the area. A nominally high drain conductance of 100m^2/day was applied to the drain cells and the elevation of the base of the modelled layer was used as the drain level. For the open-cut mines, the drain cells were set in all layers from the lowermost mined seam to the surface. Groundwater levels in the model are compared to the reference elevation in each cell, and when the groundwater level was above the reference level, water was removed from the model domain at a rate determined by the head difference and the conductance term.

B3.6 Changes to hydraulic properties with mining

At each quarter the mine progression was assessed for completion of the assumed four year operational window, and when an area has reached this, the drains undertaking the dewatering are removed and spoil parameters are assigned to these model cells. Spoil recharge rates were adjusted at the end of mining.

The model simulated the gradual changes to the hydrostratigraphic units in response to mining (e.g. longwall goafing and spoil emplacement) using the MODFLOW-USG TVM (time varying materials) package. Underground mining is present at surrounding mines, therefore goafing and fracturing was simulated within the numerical groundwater model. This was achieved by changing the parameters within the coal seam and overlying strata as the longwall panel was developed. This was achieved by applying a ramp function to vertical hydraulic conductivity (Kv), gradually decaying to the estimated maximum height of_connective cracking. The maximum height of connective cracking was calculated from the average width of the longwall panels (275m) multiplied by 0.4. Changes to hydraulic parameters used a logarithmic stepping function across stress periods. Storage was changed in a step-wise manner above the mined seam to avoid creating water in partly saturated layers.

The model represented the growth of spoil piles by progressively changing the hydraulic properties of cells (Kh, Kv, Sy and Ss) behind the active open cut mining area. No recharge was applied to the spoil emplacement areas immediately after drain cells were removed to represent the gradual rewetting of the unsaturated spoil over time.

B3.7 Recovery modelling

At the completion of mining, drain cells were removed and the model simulated post-mining conditions (e.g. final void). A transient model was created to ascertain post-mining inflows. A 1000 year recovery simulation was run, with all drain cells removed, thus allowing the groundwater levels in the coal seams and the overlying water-bearing strata to recover. Model cells located within the final voids were assigned a high horizontal and vertical hydraulic conductivity (1000m/day) and storage parameters (specific yield of 1.0, storage coefficient of 5.0 x 10^{-5} compressibility of water), to simulate free water movement within the void. This approach is often referred to as a 'high-k' lake.

The percentage of the rainfall becoming recharge across the void pit was set to 120% annual rainfall recharge and the pan evaporation rate was set at 0.7.

Groundwater inflows to the void during recovery were provided to the surface water consultants and the results were incorporated in a high-resolution surface water model. Pit lake level recovery rates from the surface water model were reinstated to the groundwater model using the CHD package and the model was rerun for 1000 years. This ensures the two assessments are consistent and simulated at the higher level of accuracy.

Water level within the pit void lake was predicted to recover to an equilibrium water level lower than the pre-mining water level. This still provides for a sink whereby regional groundwater will migrate towards the void and any contamination of the water in the void is contained.

The predicted water level within the pit void recovers to an elevation of 30mAHD. After 240 years the water has largely recovered of its final level, while at 400 years the void is fully recovered.

In order to assess the drawdown impacts post mining due to the proposed final landform, the approved final landform was also remodelled for comparison. WRM (2016) remodelled the approved final landform and predicted an approved final pit lake level of approximately 32mAHD. Results from the WRM (2016) study were used for the remodelled approved groundwater recovery model scenario. The remodelled approved final void was replicated by applying a series of constant heads over time, as per the recovery model for the proposed modification.

B4 Model Predictions

In order to comply with the AIP, all groundwater take, either direct or indirect, must be accounted for. All groundwater calculated to be intercepted from the mining area is considered a direct take from the Permian groundwater system, whilst the changes in fluxes occurring within the alluvium and rivers resulting from depressurisation of the underling Permian is considered an indirect take.

Annual predictions of direct water take from the Permian coal measures are presented in the main report. The indirect water take from alluvial groundwater systems is presented in Sections B4.1 and B4.2, and summarised within the main report.

B4.1 Groundwater indirectly influenced by mining within alluvial water resources

The following sections describe the change in flow to and from the alluvial water resources due to the remodelled approved HVO South and the proposed modification, both during the life of the mine and post mining. The change in alluvial water resources was determined by comparing water budgets for alluvial zones using versions of the numerical model that contained and excluded the proposed modification. The two main alluvial resources are alluvium associated with Wollombi Brook and the Hunter River. Results for the Wollombi Brook alluvium were calculated using the full length of the Wollombi Brook within the model domain. The results for the Hunter River alluvium were also based on the full length of the Hunter River within the model, which included sections upstream and downstream of Glennies Creek.

B4.1.1 During mining

The model was used to determine the potential for mining to interfere with the alluvial groundwater systems and provide estimates of indirect 'water take' in accordance with the AIP. Mining will not directly intercept alluvial aquifers, however, an indirect impact or 'water take' occurs as the Permian strata become depressurised and the volume of groundwater flowing from the Permian to the alluvium within the zone of depressurisation progressively reduces. Whilst this water does not necessarily enter the mine workings, the volume of groundwater entering the alluvial groundwater systems is reduced by lower pressures within the Permian due to mining, and this has been considered 'water take' that needs to be accounted for with water licences.

Whilst mining reduces the volume of groundwater entering the alluvium from the Permian, the quality of the Permian water entering the Permian is often poor due to high concentrations of dissolved salts. The reduced flow of Permian groundwater to the alluvium can therefore have a short term beneficial effect as it reduces the proportion of higher salinity water entering the alluvial system.

Figure B 15 and subsequent figures show two graphs. The upper graph shows the net groundwater flow from the Permian to the alluvium for the:

- remodelled approved and foreseeable mining - blue line;
- remodelled approved and foreseeable mining, plus the proposed modification - red line; and
- remodelled approved and foreseeable mining at surrounding operations, but excluding all mining at HVO South from 2015- brown line.

The second graph shows the change in groundwater flow calculated from the upper graph, and represents the water take due to the:

- proposed modification - green line (difference between red and blue lines);
- the remodelled approved HVO South - grey line (difference between brown and blue lines); and
- remodelled approved HVO South plus proposed modification – purple dashed line (sum of green and grey lines).

The net flow shown in the upper graph in Figure B -15 presents the difference between groundwater flows into the alluvium (from gaining zones) and out of the alluvium (from losing zones). The negative fluxes indicate Hunter River alluvium is overall losing flow into the underlying Permian. The influence of final voids is captured within the post mining recovery model results, which are discussed further in the main report. The remodelled approved mining includes the approved and foreseeable mine plans for HVO North, Ravensworth, Cumnock, Ashton, United, Wambo and MTW.

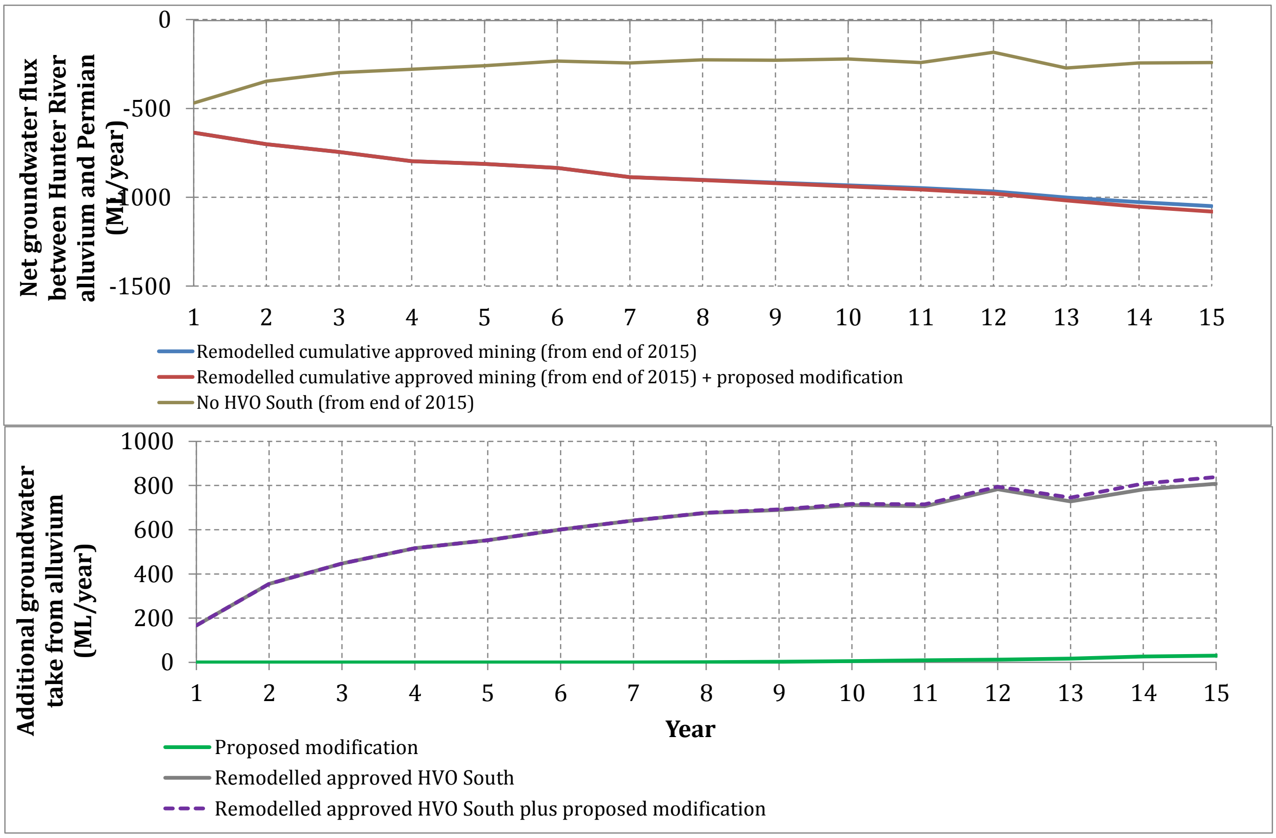


Figure B -15 **Net change in flow from Permian to Hunter River alluvium due to mining**

The combined peak take for the remodelled approved HVO South plus the proposed modification is 838ML/year in the year 15. The proposed modification accounts for less than 5% of the peak take, with the rest due to the approved mining. This is because the approved mining targets the shallower geological units that are hydraulically better connected with the overlying alluvium.

Previous modelling of mining at HVO South did not estimate 'water take' from the alluvium using the methodology described above. However; ERM (2008a) did conclude that about one third of mine pit inflows were likely to be from alluvium for Cheshunt and Riverview pits. This equates to 994ML/year of alluvial groundwater intercepted by the approved HVO South operations, which is higher than the 845ML/year estimated for the remodelled approval plus the proposed modification. As noted previously, differing underlying assumptions mean it is difficult to compare the current model with previous versions. The current version of the model is considered to provide more representative estimates. This is because it was subject to a more rigorous calibration and the approach for calculating indirect 'water take' from the alluvial groundwater systems is more conservative as groundwater does not have to enter the mine pit to be accounted for.

Figure B -16 shows the flow between the Wollombi Brook alluvium and the Permian strata, as well as the water take from the alluvium due to the proposed modification.

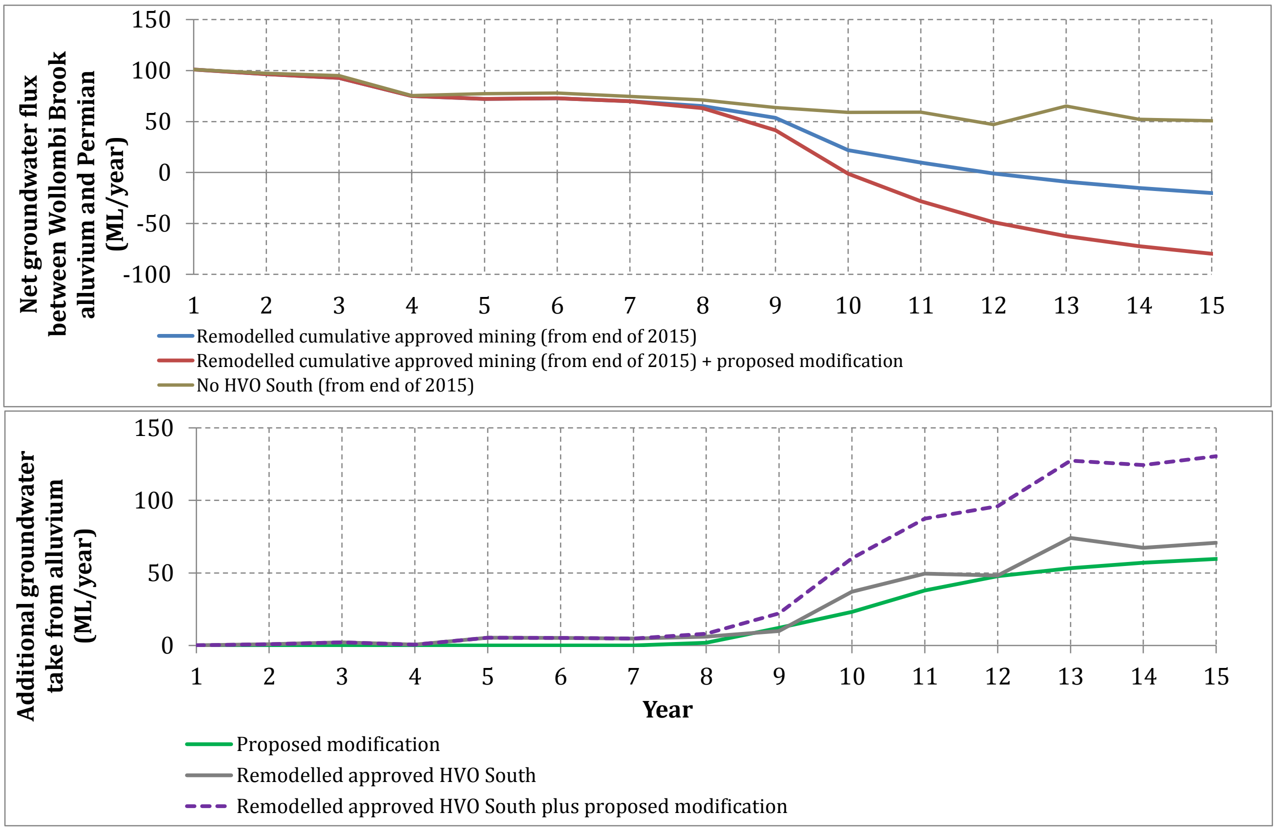


Figure B -16 Net change in flow from Permian to Wollombi Brook alluvium due to mining

The upper graph shows the Wollombi Brook alluvium is gaining groundwater from the Permian on a net basis, but switches to a net losing system in year 10, for both the remodelled approved HVO South and the proposed modification. The remodelled approved HVO South and the proposed modification create a combined peak take of 131ML/year in the final year of mining. The proposed modification accounts for about 50% of the peak, which is largely due to extension of South Lemington Pit 2 from the Bowfield Seam (layer 17) down to the Vaux Seam (layer 25) within the proposed modification. However, when combined with the indirect take from the Hunter River alluvium, the proposed modification accounts for approximately 10% of the total indirect alluvial take for the proposed modification plus remodelled approved HVO South operations.

As detailed earlier, ERM (2008a) did not estimate the 'water take' from each groundwater system. However, due to the location of the pit, the majority of groundwater inflows at South Lemington are potentially from the alluvium. ERM (2008a) predicted peak inflows to South Lemington Pits 1 and 2 of 317ML/year. This current study predicted less take from the Wollombi Brook alluvium for the remodelled approved HVO South compared to the historic studies. This is due to timing of the mining, with South Lemington Pit 1 already largely mined out and backfilled with spoil. Therefore, the peak is expected to have already occurred, and the current version of the model makes predictions from 2015 onwards only.

A summary of the change in alluvial groundwater flow (indirect take) is presented in Table B-10 for the remodelled approved HVO South operations plus the proposed modification.

Table B-10 Predicted annual indirect interception of alluvial groundwater for remodelled approved HVO South operations plus proposed modification

Model year	Hunter River alluvium (ML/year)	Wollombi Brook alluvium (ML/year)
1	167	0
2	355	1
3	447	2
4	517	0
5	553	5
6	601	5
7	642	5
8	677	8
9	692	22
10	716	60
11	715	88
12	795	96
13	745	127
14	809	124
15	838	131

B4.1.2 After mining

The potential for a residual indirect 'water take' to occur from the alluvial groundwater systems post mining was assessed using the numerical model, including the assumption that there would be no mining within the region beyond 2039. The recovery model was run for 1000 years with water levels from the end of the predictive model used as starting heads to ensure the model represented cumulative impacts from surrounding mining at the start of the recovery process. The recovery model therefore used starting heads nine years after mining which is when surrounding mines are also forecast to close.

As outlined earlier, the peak inflows from the Permian coal measures into the mining areas occur within the final years of the project life. The groundwater impacts continue on after the end of mining in year 15 due to the low hydraulic conductivity of the Permian coal measures, which cause a delay in the extent of depressurisation and subsequent indirect take from alluvium. As a result, groundwater impacts are generally most significant at the end of mining, gradually reducing over time and reaching equilibrium around year 400.

It should be noted that there are slight differences in groundwater flux between the predictive and recovery model runs. This is due to differences in model development and inputs. For example, the predictive model represented rainfall recharge as changing over the seasons, whereas, due to the length of the recovery run, average annual climatic conditions were used in the recovery model.

Figure B -17 and Figure B -18 present the net flow and the 'water take' from the Permian to the alluvium post mining for the Hunter River and Wollombi Brook alluvium respectively.

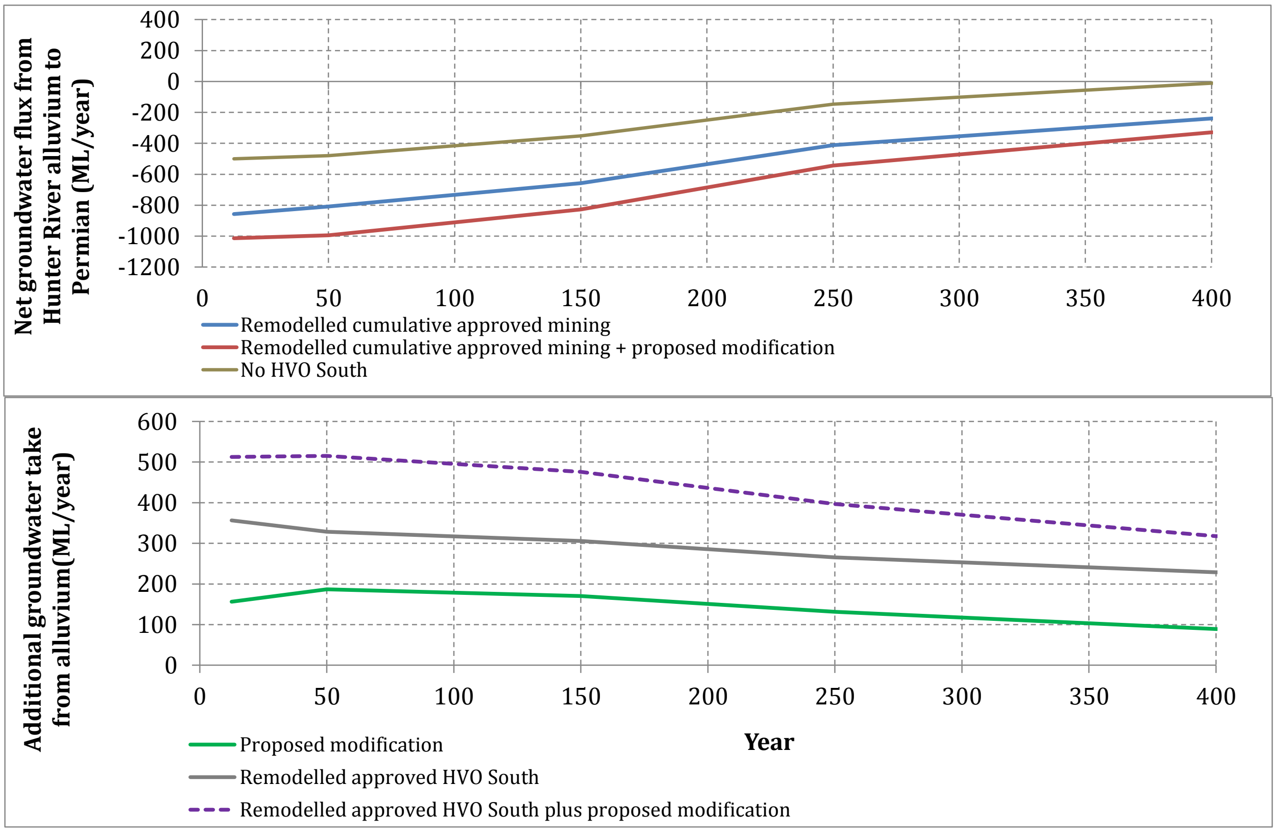


Figure B -17 Net change in flow from Permian to Hunter River alluvium post mining

Figure B -17 indicates the indirect 'water take' from the Hunter River alluvium slowly reduces over time from the peak at the end of mining as water levels recover within the residual voids. The post mining take due to the approved mining plus the proposed modification reduces from 513ML/year within the first 12 years of closure and 318ML/year around 400 years after closure.

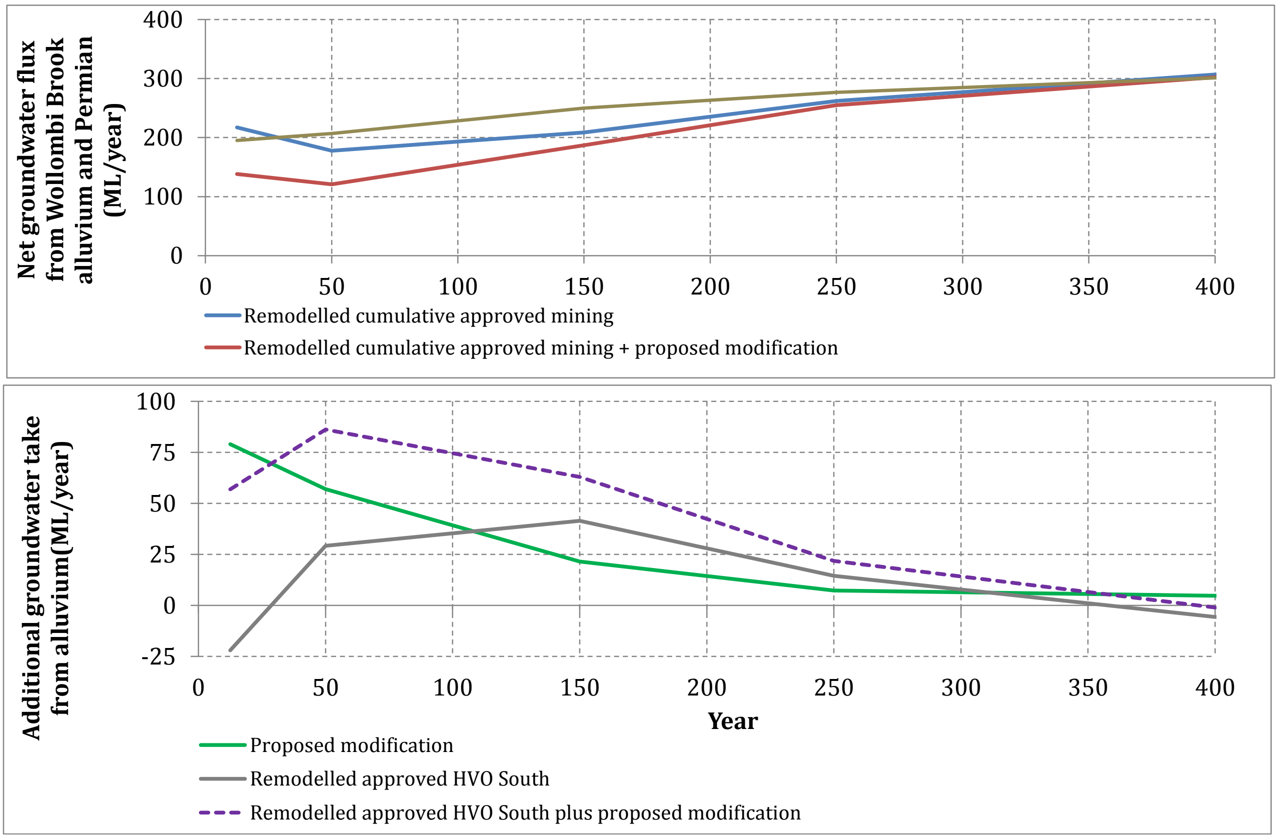


Figure B -18 Net change in flow from Permian to Wollombi Brook alluvium post mining

Figure B -18 shows that, in contrast to the Hunter River alluvium, the impact of mining on the flows from the Permian to the Wollombi Brook alluvium is less significant post mining. As the groundwater system equilibrates post mining and flow from the Permian to the alluvium increases the Wollombi Brook alluvium returns to being a net gaining system from the Permian post mining.

The 'water take' from the remodelled approved HVO South plus the proposed modification peaks at 86ML/year around 50 years post mining, and reduces to zero at 400 years post mining.

B4.2 Changes in stream baseflow

A reduction in groundwater flux from the Permian strata into the overlying alluvium also has the potential to reduce the rate of groundwater discharge into the Hunter River and Wollombi Brook, i.e the baseflow rate. Water budgets for baseflow in the Hunter River and Wollombi Brook are presented within sections below. When considering the water budgets it is important to note the underlying assumptions in the model. The model assumes direct hydraulic connection between the river and the aquifer, and no limit on the volume of water that can leak from the river into the underlying aquifer. In reality 'losing zones' where river water moves downwards into the underlying alluvial aquifer can be physically separated from the underlying water table in the aquifer by unsaturated zones. In this case drawdown within the alluvium or Permian strata does not increase the rate of flux from the river as it does in the model. Where the river and the aquifer are directly connected through the saturated zone, the 'water take' from the alluvium directly accounts for 'water take' from the river, and therefore there is no need to account for this water separately with water licenses.

B4.2.1 During mining

Figure B -19 below shows the predicted change in the Hunter River baseflow for the life of the proposed modification. The negative flux shows that overall the Hunter River is a net gaining system, with water flowing from the alluvium to the river.

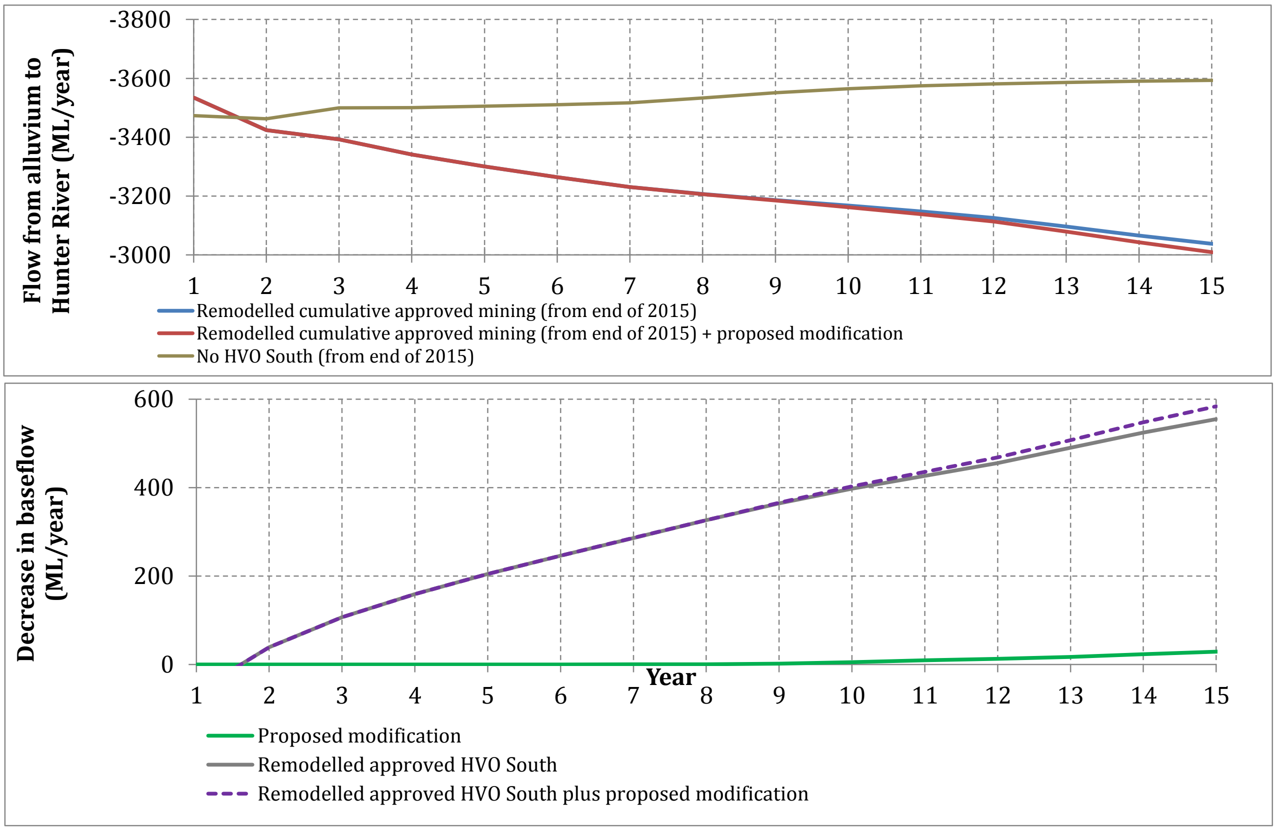


Figure B -19 Hunter River baseflow change

Figure B -19 shows the Hunter River baseflow reduces gradually over the project life. The approved plus the proposed modification create a peak take of 584ML/year in the final year of mining. The proposed modification accounts for about 5% of the peak water take.

Stream gauge data (station 2100083) indicates that the Hunter River flows at an average rate of 343,137ML/year (between 1997-2015). Therefore, the peak predicted reduction in baseflow of 584ML/year accounts for only a minor proportion (0.2%) of total flows.

The estimated take for the remodelled approved HVO South is larger than previous estimates by ERM (2008a). ERM predicted that the approved HVO South mine plan would reduce baseflow to the Hunter River by up to 69ML/year. The difference in results relates to underlying assumptions in the model development and the use of steady state conditions by ERM.

Figure B -20 shows that similar to the Hunter River, Wollombi Brook is a net gaining system, but the cumulative impacts reduce the net baseflow over the project life.

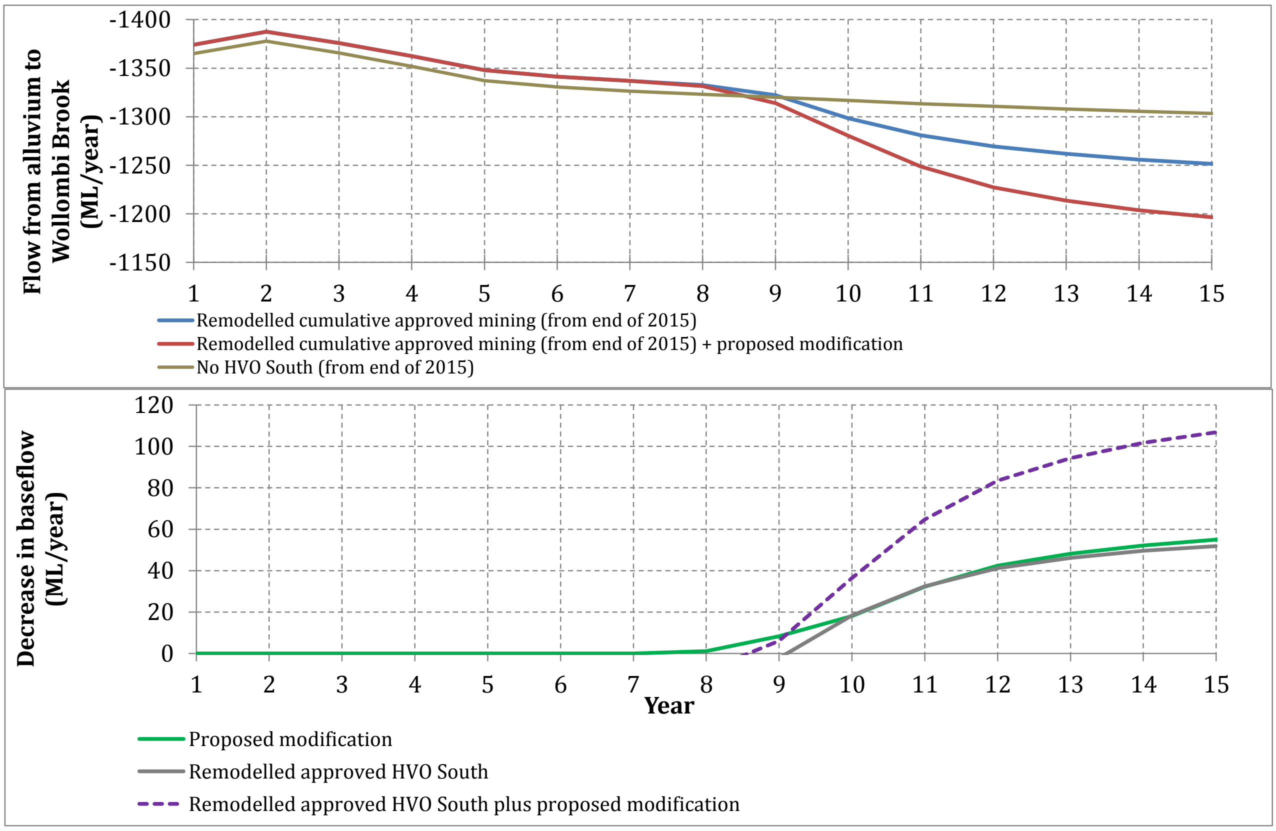


Figure B -20 Wollombi Brook baseflow change

The remodelled approved HVO South plus proposed modification has a peak take of 107ML/year in the final year of mining (year 15). The proposed modification accounting for about 50% of the indirect take from the Wollombi Brook, with the remainder attributable to approved mining of shallower seams. However, when combined with the indirect take from the Hunter River, the proposed modification accounts for less than 12% of the total indirect baseflow take for the proposed modification plus remodelled approved HVO South operations.

Stream gauge data (station 2100004) indicates that Wollombi Brook flows at an average rate of 73,883ML/year (between 1997-2015). Therefore, the maximum predicted reduction in baseflow contributions of 107ML/year due to approved and proposed operations at HVO South accounts for only a minor proportion (0.2%) of total flows.

A summary of the reduction in baseflow contributions to the Hunter River and Wollombi Brook is presented in Table B-11 for the remodelled approved HVO South operations plus the proposed modification.

Table B-11 Predicted annual reduction in baseflow contributions for remodelled approved HVO South operations plus proposed modification

Model year	Hunter River (ML/year)	Wollombi Brook (ML/year)
1	0	0
2	39	0
3	107	0
4	159	0
5	205	0
6	246	0
7	286	0
8	327	0
9	366	6
10	403	36
11	436	65
12	468	84
13	507	94
14	548	102
15	584	107

B4.2.2 After mining

Figure B -21 shows the predicted flow budgets for the Hunter River (surface water base flow).

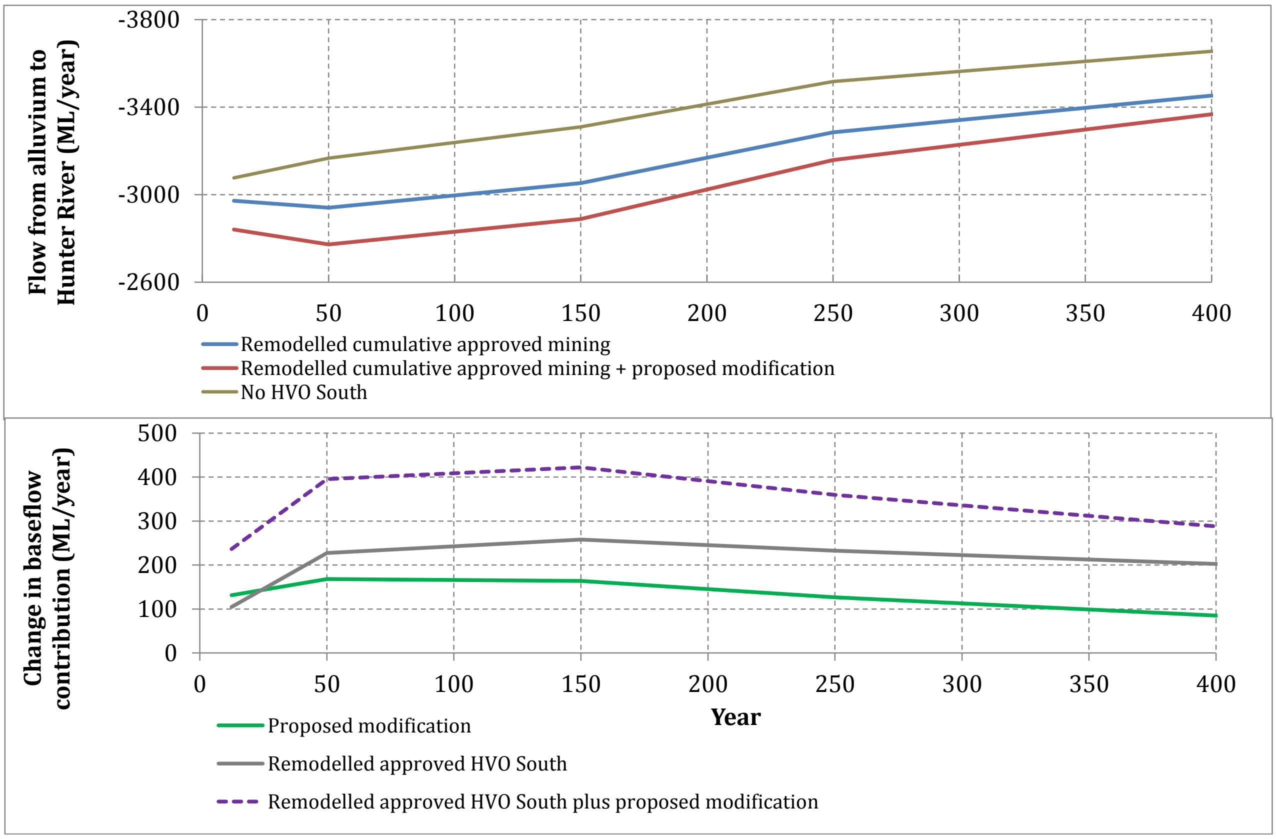


Figure B -21 Hunter River baseflow change post mining

As discussed earlier, peak inflows from the Permian coal measures occur within the final year of the project life. The groundwater impacts continue on after the end of mining in year 15 due to the low hydraulic conductivity of the Permian coal measures, which delay the propagation of depressurisation and the subsequent indirect take from alluvium.

Figure B -21 shows that, post mining, the Hunter River maintains net gaining conditions for both the remodelled approved HVO South and the proposed modification. The remodelled approved HVO South plus the proposed modification generates a peak take of 422ML/year at 150 years post mining, which reduces to 288ML/year around 400 years post mining.

Figure B -22 shows the predicted flow budgets for Wollombi Brook (surface water base flow). The negative flux shows that overall the Wollombi Brook is a net gaining system, with water flowing from the alluvium to the surface water feature (baseflow).

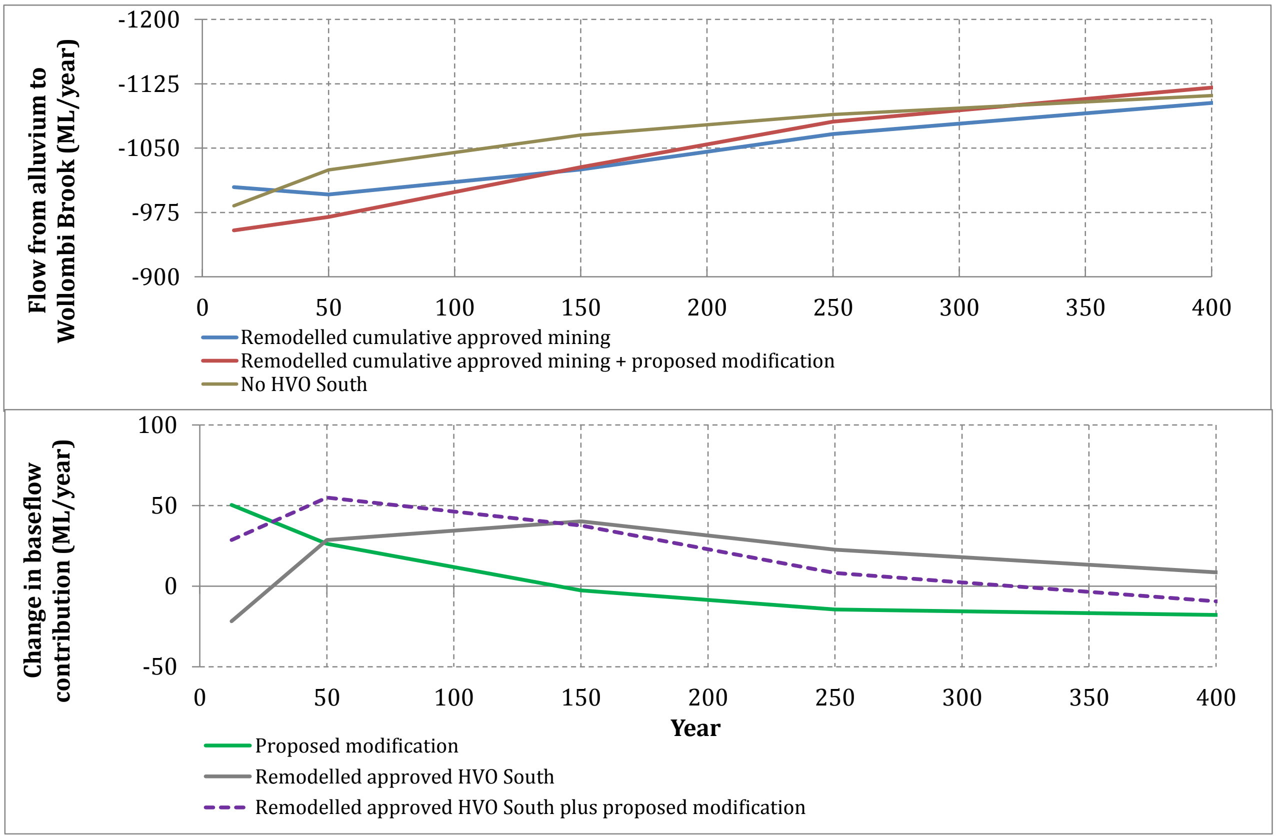


Figure B -22 Wollombi Brook baseflow change post mining

Figure B -22 shows that, post mining, the Wollombi Brook maintains net gaining conditions for both the remodelled approved HVO South and the proposed modification. The results show that there is a peak reduction in baseflow of 55ML/year due to depressurisation associated with the remodelled approved HVO South plus the proposed modification. The remodelled approved HVO South plus the proposed modification results in a net increase in baseflow post mining by a peak of 9ML/year by year 400. This is primarily due to deepening of the South Lemington Pit 2 and a slight change in the final landform for South Lemington Pit 1. These cause a slight change in hydraulic gradients surrounding the Wollombi Brook alluvium compared to the remodelled approved mine plans.

B4.3 Water licensing

The AIP requires accounting for all groundwater take, which includes indirect take from alluvial and surface water sources (ie Hunter River). The predicted indirect take per year is presented in Section B4.1 and Section B4.2 for alluvium and surface water, respectively. These results are used to estimate indirect take under the Hunter Unregulated WSP and the Hunter Regulated WSP.

The predicted indirect take from the Hunter River falls under licensing requirements of the Hunter Regulated WSP. The predicted indirect take from the Wollombi Brook alluvium falls under the Lower Wollombi Brook Water Source of the Hunter Unregulated WSP. While indirect take from the Hunter River alluvium falls under the Glennies Creek Management Zone of the Hunter Unregulated WSP. It should be noted that to prevent double accounting, the take under the Hunter Regulated WSP (Hunter River) is discounted from take from the Hunter River alluvium for the Hunter Unregulated WSP take.

Predicted indirect take under the various WSP's and management zones are presented in Table B-12 below. The estimated water licensing volumes are for already approved HVO South operations plus the proposed modification.

Table B-12 Water licensing under Regulated and Unregulated WSP for approved HVO South operations and proposed modification

Model year	Hunter Regulated WSP (take from Hunter River) (ML/year)	Hunter Unregulated WSP (ML/year)		
		Component from Hunter River alluvium*	Component from Wollombi Brook alluvium	Total take
1	0	167	0	167
2	39	316	1	317
3	107	340	2	342
4	159	358	0	358
5	205	348	5	353
6	246	355	5	360
7	286	355	5	360
8	327	350	8	358
9	366	326	22	348
10	403	314	60	374
11	436	280	88	367
12	468	327	96	423
13	507	238	127	365
14	548	261	124	385
15	584	254	131	385

Note ** To prevent double accounting, this is calculated as the Hunter River alluvium take (see Table B10) minus take captured under the Hunter Regulated WSP (from the Hunter River).*

B5 Sensitivity

A sensitivity analysis was carried out on an early iteration of the predictive model to assess the response of the regional-scale model to varying input parameters. The objective of the sensitivity analysis was to rank the input parameters in terms of their influence on the predicted results. The model parameters were adjusted to encompass the range of likely uncertainty in key parameters.

This was achieved by changing and assessing the following:

- ±1 order of magnitude change in horizontal hydraulic conductivity (hc) of all geological units (excluding overburden emplacements);
- ±1 order of magnitude change in the rainfall recharge (R) rate across the model domain; and
- + order of magnitude change in the tailings storage facility and river bed conductance.

These changes represent the expected bounds of the groundwater regime. The following sections present the results of these sensitivity analyses in terms of their influence on the groundwater inflow predictions and groundwater level changes (zone of drawdown/depressurisation).

B5.1.1 Calibration summary of sensitivity analysis

Table B-13 shows the changes to the calibration statistics resulting from changing model parameters.

Table B-13 Calibration sensitivity statistics

Case	RMS (m)	SRMS (%)	SRMS change
basecase	14.06	3.61	-
hydraulic conductivity + 1 OM	17.38	4.46	124%
hydraulic conductivity - 1 OM	23.80	6.11	169%
recharge + 1 OM	*	*	*
recharge - 1 OM	13.88	3.56	99%
river vertical hydraulic conductivity+ 1 OM	14.11	3.62	100%

Note: ** model failed to converge to a solution with assigned changes to parameters*

Table B-13 demonstrates that varying some parameters had little influence on the RMS and SRMS, with some results showing little to no change. However, increasing recharge had the largest impact on the calibration statistics. This change resulted in an uncalibrated model and is therefore considered extreme. This indicates the model is most sensitive to these parameters and thus field measurements are valuable to constrain the parameter within a realistic range in the model. The increase and decrease in hydraulic conductivity (horizontal) resulted in the greatest variation from the baseline calibration. However, the statistics still meet criteria of the model being calibrated. Increasing the vertical conductivity of the river cells had little impact to the calibration.

B5.1.2 Mining area total inflows

Predicted mine inflows are directly related to the aquifer parameters and the recharge rates, and therefore provide a good measure of the relative sensitivities of the calibrated and adopted parameter set in the transient model. The sensitivity of the predicted groundwater inflow rates to changes in the model parameters are shown in Figure B -23. It should be noted that the total inflows presented below relate to total inflows from drain budgets, which largely comprises contributions from saturated spoil.

The proposed modification requires re-mining of spoil materials, where water has accumulated (re-saturated) over time. As a result, during the re-mining of the area down to the deeper coal seams, stored water within the spoil material will be captured within the model. Water held within the spoil is not considered groundwater, but stored rainfall runoff. In order to address licensing requirements under the North Coast Fractured and Porous Rock WSP, the predicted take from the Permian coal measures were quantified. As a result the total inflows from the Permian coal measures are presented in the main report. These results are based on modelled inflows derived from budget zones through the in-situ material, excluding contributions from spoil material.

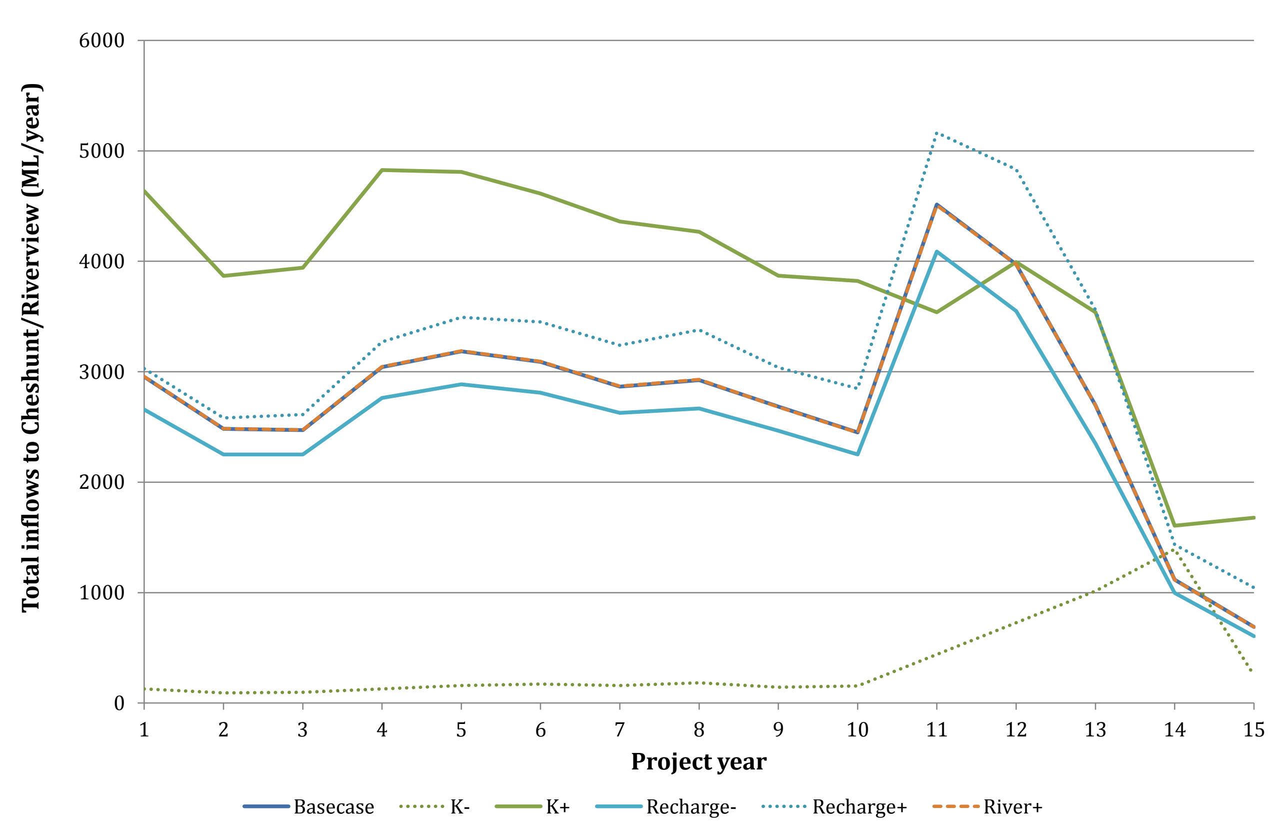


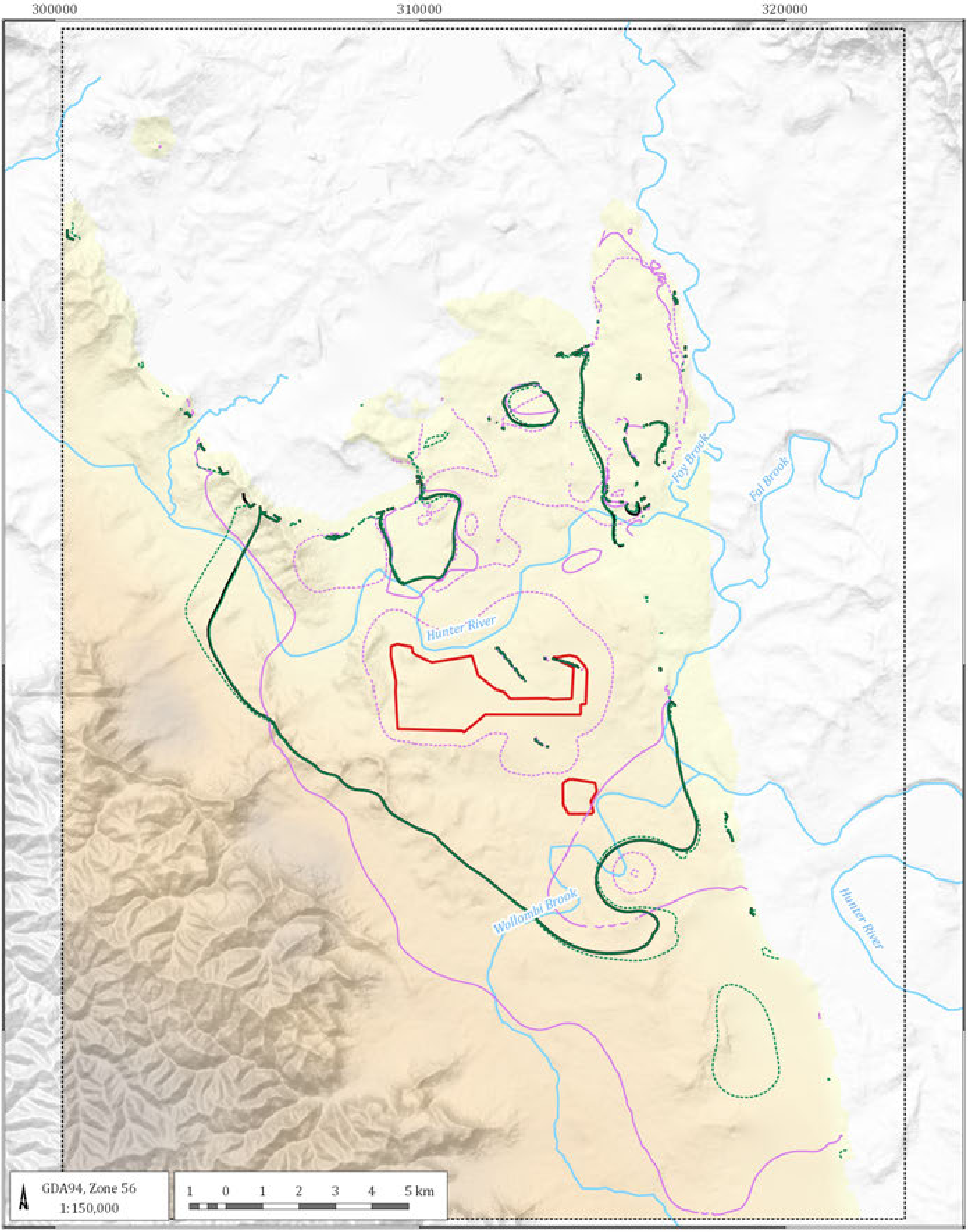
Figure B -23 Sensitivity of total groundwater inflow

The predicted inflow to the Cheshunt/Riverview pit zone is most sensitive to an increase in hydraulic conductivity. Increasing hydraulic conductivity by one order of magnitude resulted in the inflow rate in the initial years of mining increasing by approximately 60%. A decrease in hydraulic conductivity by one order of magnitude resulted in minimal inflows recorded in the initial years of mining.

B5.1.3 Zone of depressurisation

The sensitivity analysis assessed the change to the zone of depressurisation in the Bayswater Seam. Figure B -24 shows the 1 m maximum groundwater drawdown extent from the sensitivity analysis for the Bayswater Seam. The results show that predicted groundwater depressurisation resulting from the proposed modification is most sensitive to changes in hydraulic conductivity. The higher hydraulic conductivity extends the impacts further by offering increased connection between cells, while the lower hydraulic conductivity restricts the extent of drawdown impacts.

The change in drawdown extent is largely localised along the strike of the coal seam, to the north-west and south-east of HVO South, where the Bayswater Seam is shallowest. This is most likely due to the decreasing depth of the coal measures to the south-west, and the corresponding reduction in horizontal hydraulic conductivity with depth. Changes in recharge have minimal influence on the extent of drawdown. This shows climatic conditions have minimal influence on the groundwater predictions compared to other system stresses, such as the extensive approved mining within the region.



LEGEND

- Proposed modification pit depth extension
- Model extent
- Major drainage
- Basecase
- K+
- K-
- Recharge+
- Recharge-

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Sensitivity of cumulative zone of depressurisation during mining - Bayswater Seam

DATE 08/01/2016

FIGURE No: **B-24**

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B5.1.4 Sensitivity classification

The Murray Darling Basin Modelling Guidelines (MDBC, 2000) recommends classifying sensitivity by the resultant changes to the model calibration and predictions. The four sensitivity types are as follows:

- Type I: Insignificant changes to calibration and prediction;
- Type II: Significant changes to calibration – insignificant changes to predictions;
- Type III: Significant changes to calibration –significant changes to predictions; and
- Type IV: Insignificant changes to calibration –significant changes to predictions.

Types I and II are of no concern as these sensitivities either have an insignificant impact on model predictions. Type III is only of concern for un-calibrated models. Types I to III are of no concern for the current assessment, as the model developed for the proposed modification is a well calibrated, high complexity model.

Type IV is classed as 'a cause for concern' as non-uniqueness in a model input might allow a range of valid calibrations but the choice of value impacts significantly on a prediction (Middlemis, 2000).

There are no Type IV parameters in the model, which provides confidence in the range of predictions. The limited impact of the vertical hydraulic conductivity changes on the level of calibration made it a potential issue, however the corresponding extent of drawdown, and predicted mine inflow make it a Type I sensitivity. The other parameters tested in this analysis were either Type II or III and thus are also of no concern.

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Appendix B-1

Calibration Residuals and Hydrographs

Bore	Easting (GDA94 Z56)	Northing (GDA94 Z56)	Layer	Average residual	Range in residuals	
					Minimum	Maximum
4032P	308609	6402945	2	3.0	2.6	3.8
4033P	308877	6402939	2	2.5	1.8	3.4
4034P	308239	6402959	2	2.5	1.9	3.1
4035P	308386	6402778	2	3.3	2.5	3.9
4036C	308272	6402688	26	-13.3	-16.3	-9.8
4037P	308277	6402702	2	3.2	2.5	3.8
4038C	308502	6403116	2	3.6	2.9	4.2
4039C_1	308468	6402673	2	5.6	4.5	6.4
4039C_2	308468	6402673	27	-4.5	-10.8	-1.4
4039C_3	308468	6402673	27	9.7	8.9	10.7
4040P	308675	6402724	2	2.3	1.9	4.1
4051C	308664	6402721	26	-2.7	-3.9	-1.6
4052P	307924	6402680	2	3.0	2.3	3.5
4053P	308112	6402680	2	3.1	2.4	3.7
4113P	310729	6401304	26	-7.1	-11.8	-3.3
4116P	310681	6400978	23	-4.7	-7.6	-3.0
4117P	310670	6400980	25	-11.9	-16.8	-8.2
4119P	312501	6402048	24	1.5	-0.3	3.4
APP_FARM	315491	6394639	2	2.5	2.2	3.5
B334_BFS	316684	6394088	17	1.3	-3.3	4.5
B425_WDH	316010	6395024	13	-11.2	-14.5	-9.5
B631_BFS	316425	6394319	17	16.3	11.1	28.0
B631_WDH	316424	6394319	13	5.1	3.6	6.9
B925_BFS	315921	6394604	17	-1.4	-9.3	23.9
BC1	312421	6401010	2	-1.1	-1.7	-0.3
BC1A	312421	6400872	23	0.9	0.1	2.6
BUNC12	313180	6401753	2	6.5	5.5	7.6
BUNC39A_D	313500	6401823	23	11.2	5.3	13.8
BUNC39B_S	313500	6401823	2	10.4	1.2	15.0
BUNC44D	313601	6401922	23	8.9	3.2	11.5
BUNC45A	313667	6402055	1	8.9	5.7	11.3
BUNC45D	313677	6402060	23	4.6	1.3	7.0
BUNC46D	313328	6401782	23	6.6	1.7	13.4

Bore	Easting (GDA94 Z56)	Northing (GDA94 Z56)	Layer	Average residual	Range in residuals	
					Minimum	Maximum
BZ1-1	311472	6400483	24	24.1	16.3	35.3
BZ1-2	311472	6400483	1	17.1	13.0	20.3
BZ1-3	311472	6400483	23	0.5	-17.5	11.6
BZ2A_1	311671	6400561	23	-3.5	-16.7	10.8
BZ2A_2	311671	6400561	24	16.9	14.2	21.3
BZ2B	311668	6400560	1	21.9	18.7	24.7
BZ3-1	311840	6400640	24	25.8	20.6	32.6
BZ3-2	311840	6400640	21	19.0	14.1	22.2
BZ3-3	311840	6400640	23	-3.6	-14.4	8.7
BZ4A_1	312029	6400705	22	6.8	4.0	9.7
BZ4A_2	312029	6400705	23	-4.6	-11.4	5.8
BZ5-1	312192	6400804	23	6.6	-3.1	16.7
BZ8-2	312685	6401010	24	12.5	9.5	15.3
BZ8-3	312685	6401010	23	-5.4	-6.5	-3.4
C1_WJ039	317142	6400707	34	-10.7	-11.2	-10.2
C122_WDH	315501	6395007	13	0.9	0.4	1.4
C130_AFS1	316400	6394916	15	12.1	10.7	13.0
C130_ALL	316400	6394916	14	13.1	12.1	15.0
C130_BFS	316400	6394916	17	6.0	3.2	7.6
C130_WDH	316400	6394916	13	11.9	10.4	14.4
C317_BFS	315054	6395007	17	-7.5	-10.9	-5.8
C317_WDH	315054	6395007	13	-1.3	-1.7	-0.7
C613_BFS	314688	6395243	17	-4.6	-6.0	-1.8
C621_BFS	315421	6395321	17	-6.2	-8.3	-4.4
C630_BFS	316378	6395306	17	8.8	5.6	13.4
C809_WDH	314207	6395493	13	-3.7	-4.3	-3.3
C919_ALL	315192	6395655	2	1.1	0.9	1.9
CFW55R	310439	6402180	2	2.6	-1.3	6.0
CFW56	310333	6402255	2	5.3	3.6	6.7
CFW57	310084	6402053	2	4.2	3.1	4.7
CFW57A	310088	6402049	1	8.0	6.7	8.9
CFW59	310245	6402370	2	1.1	-1.7	26.2
CGW1	309930	6402690	2	2.7	1.8	4.0

Bore	Easting (GDA94 Z56)	Northing (GDA94 Z56)	Layer	Average residual	Range in residuals	
					Minimum	Maximum
CGW2	310156	6402685	2	2.9	2.0	4.7
CGW3	310360	6402679	2	2.5	1.3	5.2
CGW34	310012	6403588	2	4.8	4.3	7.1
CGW35	309725	6403446	2	3.1	3.0	3.1
CGW38	309691	6403638	2	3.8	2.9	5.6
CGW40	309853	6403220	2	3.0	2.5	4.7
CGW41	310132	6403259	2	3.4	2.9	4.9
CGW42	309833	6402991	2	2.5	-5.1	4.6
CGW43	310074	6402959	2	-0.5	-12.2	2.9
CGW44	310281	6402794	2	4.3	3.6	5.3
CGW45	308042	6403349	27	-0.4	-9.6	4.9
CGW45A	308044	6403349	26	-1.1	-10.9	1.7
CGW46	308413	6403276	27	12.4	3.4	16.8
CGW46A	308415	6403276	27	10.5	3.2	16.6
CGW47	308729	6403406	2	15.1	1.9	24.6
CGW47A	308731	6403405	27	11.9	-15.7	23.5
CGW48	308418	6402919	26	-2.2	-24.6	5.3
CGW48A	308418	6402919	2	1.7	0.5	3.3
CGW49	308778	6403098	2	2.9	1.6	4.4
CGW5	309666	6402712	2	1.9	-0.9	9.3
CGW52	309906	6402255	27	17.8	6.6	30.7
CGW52A	309902	6402249	2	3.3	2.5	5.2
CGW53	309606	6402333	27	16.8	4.6	31.7
CGW53A	309606	6402333	2	2.7	1.9	3.2
CGW54A	310196	6402159	2	3.7	2.0	5.6
CGW55A	309840	6402457	2	2.3	1.1	3.1
CGW6	308756	6402770	2	2.2	1.5	3.1
CHPZ10A	313334	6402297	2	2.4	1.9	3.1
CHPZ11A	313429	6402129	2	3.8	2.5	5.1
CHPZ12A	313238	6402013	2	2.8	1.2	3.9
CHPZ12D	313236	6402019	24	5.7	4.7	6.8
CHPZ13A	313009	6401801	2	1.3	0.5	2.8
CHPZ13D	313014	6401801	23	1.3	-0.4	2.9

Bore	Easting (GDA94 Z56)	Northing (GDA94 Z56)	Layer	Average residual	Range in residuals	
					Minimum	Maximum
CHPZ14A	312883	6401639	2	-2.4	-3.3	-0.8
CHPZ14D	312891	6401639	23	-0.4	-1.0	0.5
CHPZ1A	312820	6401697	2	-1.6	-2.5	0.0
CHPZ2A	312941	6401539	2	-4.3	-5.1	-3.0
CHPZ3A	313086	6401756	2	1.8	0.8	3.4
CHPZ3D	313094	6401756	23	2.4	1.2	3.9
CHPZ4A	312904	6402123	2	1.3	0.4	2.7
CHPZ5A	312926	6401838	2	1.6	0.8	2.9
CHPZ7A	313600	6402238	1	5.7	5.0	6.4
CHPZ8A	313503	6402051	1	8.3	5.8	9.5
CHPZ8D	313508	6402047	24	8.8	7.6	10.2
CHPZ9A	313538	6402383	2	1.8	1.2	3.2
D010_BFS	314355	6395687	17	-12.5	-15.2	-9.9
D010_GM	314355	6395687	13	-2.4	-3.0	-2.0
D010_WDH	314355	6395687	13	-3.6	-4.1	-3.2
D2_WH236	316847	6399926	34	-6.1	-6.3	-5.8
D214_BFS	314768	6395831	17	-9.7	-15.2	1.4
D317_ALL	315044	6396018	2	0.8	0.5	5.0
D317_BFS	315043	6396019	17	-6.4	-13.0	14.8
D317_WDH	315044	6396018	16	6.8	6.4	7.3
D406_AFS	313931	6396074	15	-10.0	-11.8	-8.9
D406_BFS	313931	6396074	17	-19.2	-22.5	-14.8
D406_WDH	313931	6396074	13	-11.1	-11.1	-11.1
D510_AFS	314380	6396141	17	-14.2	-16.7	-11.3
D510_BFS	314380	6396141	17	-18.3	-20.4	-3.0
D612_AFS	314524	6396314	15	-7.7	-9.6	-5.6
D612_BFS	314524	6396314	17	-17.5	-19.0	-15.2
D807_BFS	314002	6396484	17	-15.5	-24.0	-6.5
DM1	311778	6405164	26	-4.5	-7.4	0.1
DM2	311640	6404635	24	-4.3	-18.6	16.3
DM3	311971	6403310	24	-12.2	-19.6	0.8
DM4	312222	6401418	24	10.2	-3.3	20.1
DM5_40	311431	6400961	24	17.5	17.5	17.5

Bore	Easting (GDA94 Z56)	Northing (GDA94 Z56)	Layer	Average residual	Range in residuals	
					Minimum	Maximum
DM5_75	311431	6400961	24	11.2	6.1	14.9
DM6	310796	6400980	24	2.4	-6.8	12.8
DM7	311136	6400961	24	-8.1	-16.0	-2.0
DM9	310284	6401095	24	-7.7	-10.1	-5.9
F1_WF533	316607	6398247	25	-3.7	-5.7	-2.1
G1	305694	6407301	1	1.0	-65.0	3.5
G2	305660	6407451	1	4.9	-61.9	7.0
G3	305636	6407556	1	2.9	1.2	4.0
GA3	310159	6400876	1	-0.5	-1.8	1.6
GW_100	303729	6406436	1	-3.7	-4.4	-3.2
GW_101	304374	6406728	1	-11.1	-11.2	-11.0
GW_106	309092	6405224	2	9.7	-1.6	29.5
GW_107	308738	6404103	27	-10.3	-10.6	-9.4
GW_108	309695	6403971	27	-3.5	-3.9	-1.5
GW_114	312272	6403981	25	-16.5	-23.4	-4.8
GW_114B	312272	6403981	27	-16.8	-16.8	-16.8
GW_115	312227	6402216	24	-2.5	-4.1	-0.8
GW02	309109	6389680	1	-4.5	-5.9	-2.7
GW030732	316743	6397646	2	-1.4	-2.4	0.3
GW030734	316595	6397799	2	-2.0	-2.8	-1.5
GW030735	316484	6397827	2	-0.2	-1.1	0.4
GW030736	316628	6397985	2	-2.8	-3.6	-2.3
GW030740	316640	6398365	1	-1.7	-3.3	0.7
GW035474	317725	6412301	1	3.8	3.8	3.8
GW042364	316824	6397645	2	-2.0	-2.2	-1.6
GW042998	320112	6395799	2	-6.5	-6.5	-6.5
GW043225	303653	6398949	6	-7.4	-9.2	-4.9
GW064382	303908	6394477	3	76.7	76.7	76.7
GW079060	314595	6394852	14	2.4	1.3	6.3
GW079793	317730	6411962	1	-1.2	-2.2	-0.4
GW08	311793	6392266	1	-1.2	-3.0	0.3
GW080952	314643	6394904	2	7.5	7.5	7.5
GW080963	315997	6397208	24	-18.6	-22.0	-15.7

Bore	Easting (GDA94 Z56)	Northing (GDA94 Z56)	Layer	Average residual	Range in residuals	
					Minimum	Maximum
GW080964	314246	6385300	4	-8.2	-8.7	0.3
GW080968	321110	6405185	34	-10.4	-12.0	-8.2
GW09	311643	6392563	1	-1.4	-3.3	0.7
GW11	309228	6389699	1	-3.1	-4.5	-2.3
GW117	309579	6400676	2	-5.1	-5.1	-5.1
GW119	310129	6400322	1	1.9	1.9	1.9
GW12	309841	6391056	4	8.5	6.8	9.7
GW13	313810	6388990	6	0.4	-0.1	0.8
GW14	312478	6391358	2	-3.8	-4.1	-3.5
GW15	313164	6392807	8	-4.6	-5.2	-3.7
GW16	306641	6396034	6	-7.2	-9.8	-4.4
GW17	306895	6396048	2	-7.6	-9.1	-4.3
GW18	310061	6393206	8	-5.2	-5.7	-3.8
GW20_009	309076	6393949	1	-5.0	-5.2	-4.8
GW20_061	309076	6393949	7	-31.7	-33.2	-29.7
GW20_129	309076	6393949	9	-20.9	-21.8	-19.4
GW21	308647	6393378	5	-30.6	-30.8	-30.2
GW22	311335	6389535	4	-18.7	-19.4	-16.7
GW9701	315901	6401798	26	-22.5	-27.5	-19.7
GW9702	316436	6401479	26	-5.6	-8.1	-4.3
GW9708	322158	6387209	34	-4.4	-4.4	-4.4
GW9710	316700	6400486	34	7.3	5.9	9.4
GW9809	322251	6388026	34	-12.0	-12.0	-12.0
GWAR981	322186	6387132	34	-16.1	-16.5	-15.9
H5032_5	309960	6398320	25	21.1	12.0	26.4
HG1	312390	6400882	24	19.3	17.5	21.8
HG2	312469	6400886	24	19.8	17.3	22.5
HG2A	312469	6400886	23	-6.0	-7.6	-4.7
HG3	312541	6400940	24	19.9	17.3	23.2
HOBDEN	312540	6401093	2	-3.3	-7.2	-1.4
HV3	310776	6400546	2	-8.3	-16.7	-4.0
HV4	310069	6401183	2	3.5	-0.1	10.0
MB14HVO01	310587	6401003	25	-20.4	-20.4	-20.4

Bore	Easting (GDA94 Z56)	Northing (GDA94 Z56)	Layer	Average residual	Range in residuals	
					Minimum	Maximum
MB14HVO02	310469	6401001	25	-20.7	-20.7	-20.7
MB14HVO03	311387	6400950	25	-18.9	-18.9	-18.9
MB14HVO04	311491	6401392	25	-16.9	-16.9	-16.9
MB14HVO05	310675	6401127	25	-21.3	-21.3	-21.3
MG09_009	310539	6391186	2	-10.4	-10.4	-10.4
MG09_030	310539	6391186	6	-22.8	-24.0	-20.8
MG09_170	310539	6391186	8	-13.4	-15.7	-11.6
MG09_192	310539	6391186	9	-10.6	-11.7	-9.8
MG8_009	311028	6392637	2	-6.0	-6.6	-5.2
MG8_046	311028	6392637	7	-20.1	-31.7	-13.8
MTD517_P1	317521	6386147	23	-25.9	-27.9	-22.8
MTD517_P2	317521	6386147	13	-4.3	-13.2	11.1
MTD517_P3	317521	6386147	9	6.3	-1.7	22.4
MTD518_P2	316512	6386156	13	-1.6	-3.2	0.2
MTD518_P3	316512	6386156	9	-15.2	-15.6	-14.9
MTD605_P1	316274	6386162	6	-16.3	-16.4	-16.1
MTD605_P2	316274	6386162	7	-8.6	-20.3	-3.1
MTD605_P3	316274	6386162	12	-3.8	-4.8	-2.5
MTD605_P4	316274	6386162	13	2.2	0.7	2.8
MTD613	320778	6387025	27	6.2	5.6	6.7
MTD639_2	320369	6387036	23	-6.1	-6.1	-6.1
MTD640	321275	6385562	1	-39.2	-39.2	-39.2
MTD642	320284	6387508	1	36.9	36.9	36.9
MTD643	320311	6387660	1	24.4	24.4	24.4
MTOH611	320528	6386035	17	13.7	13.7	13.7
MTOH612	318876	6387547	13	6.7	6.7	6.7
NPZ1	305240	6406100	32	-22.9	-35.9	-5.3
NPZ2	307800	6411340	32	-17.3	-29.7	-11.7
NPZ3	306305	6409131	34	-16.8	-18.3	-14.9
NPZ4	306240	6404584	32	-2.4	-27.0	16.6
NPZ5	310730	6406550	26	22.3	-4.2	40.2
OH1121	321902	6391030	34	-17.7	-34.3	7.7
OH1123_1	316967	6389501	13	11.1	0.6	18.2

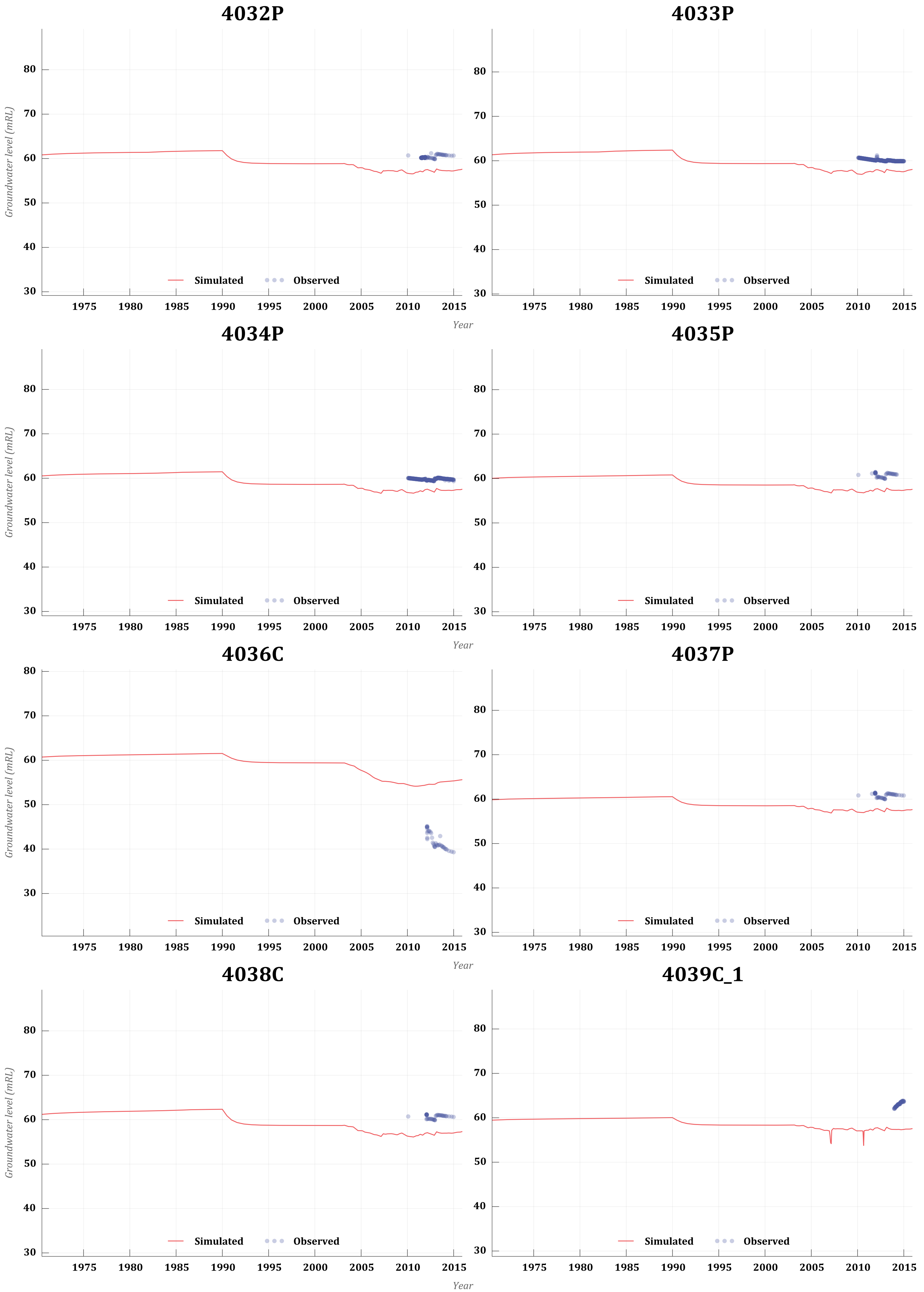
Bore	Easting (GDA94 Z56)	Northing (GDA94 Z56)	Layer	Average residual	Range in residuals	
					Minimum	Maximum
OH1123_2	316967	6389501	13	19.3	3.6	29.1
OH1123_3	316967	6389501	17	22.5	20.8	25.7
OH1124_2	316893	6391526	13	44.0	26.7	100.4
OH1124_3	316893	6391526	17	65.5	-0.4	111.6
OH1125_1	316511	6392875	13	-23.5	-34.5	-14.1
OH1125_2	316511	6392875	13	-10.3	-30.5	1.8
OH1125_3	316511	6392875	17	21.2	8.8	36.1
OH1126	318579	6393394	25	-13.6	-28.1	-3.8
OH1137	318266	6393377	25	0.2	-3.6	4.1
OH1138_1	317835	6393346	24	14.9	11.2	19.6
OH1138_2	317835	6393346	24	-4.2	-13.7	6.6
OH786	320542	6392674	1	4.3	-13.0	9.5
OH787	320982	6391921	1	-11.7	-12.3	-11.2
OH788	321482	6390967	1	12.9	11.2	14.3
OH942	320536	6392622	1	11.4	7.0	13.0
OH943	321476	6390963	1	13.6	12.0	15.2
OH944	321113	6391035	1	7.8	5.3	9.0
P1	312199	6395840	12	-11.4	-16.2	-8.6
P104	311349	6391156	2	-5.6	-6.5	-2.9
P106	311518	6391084	2	-6.9	-12.8	-2.6
P108	311349	6390933	2	-6.3	-6.7	-6.0
P109	311215	6390768	2	-3.6	-6.5	-2.3
P11	312728	6395462	12	-20.7	-22.2	-19.2
P110	311217	6390690	2	-2.3	-5.2	-0.2
P111	311301	6390761	2	-4.8	-6.0	-3.2
P114	311205	6391288	2	-4.2	-5.7	-3.4
P116	311057	6391293	2	-2.4	-3.9	-0.3
P12	313644	6394797	12	-0.8	-1.6	0.2
P13	313722	6394412	12	-1.0	-2.1	0.2
P15	313431	6394803	1	0.5	-0.3	1.6
P16	313480	6394655	1	1.5	0.8	2.6
P17	313376	6394631	1	-1.3	-2.1	-0.4
P18	313503	6394512	1	1.8	0.9	3.2

Bore	Easting (GDA94 Z56)	Northing (GDA94 Z56)	Layer	Average residual	Range in residuals	
					Minimum	Maximum
P2	312403	6395552	12	-7.1	-12.1	-2.5
P20	313639	6394166	2	0.7	0.2	3.0
P202	311859	6391330	6	-2.2	-3.5	3.1
P206	311772	6391293	6	-15.3	-18.9	-9.4
P209	311584	6390893	6	-11.8	-12.0	-11.5
P27	311344	6392810	1	-1.2	-2.8	0.4
P28	311396	6392632	1	-3.0	-6.2	-1.1
P3	313412	6395006	12	-3.5	-4.8	-2.4
P301	309311	6391425	4	-13.2	-20.2	-10.3
P302	309149	6391462	4	-12.4	-12.7	-12.1
P303	309103	6391713	4	-27.5	-27.7	-27.3
P310	308245	6392172	4	-46.2	-48.1	-44.7
P311	308064	6392255	4	-18.1	-20.8	-16.3
P312	309100	6391713	4	-12.0	-13.3	-8.1
P314	309149	6391462	4	-6.8	-7.0	-6.6
P315	309091	6391852	4	-7.8	-10.0	-5.1
P316	308611	6392106	4	-4.7	-6.4	-3.8
P317	308506	6392181	4	-2.4	-3.4	-1.4
P318	308422	6392153	4	-8.0	-8.1	-8.0
P319	308242	6392172	4	-2.9	-3.5	-2.3
P32	310735	6392842	1	-5.2	-8.4	-3.6
P33_113	313757	6394659	16	-22.0	-30.1	-12.0
P33_13	313757	6394659	12	2.1	0.7	6.2
P33_58	313757	6394659	13	-19.2	-24.1	-11.7
P35_60	312086	6395627	15	-21.4	-29.2	-5.2
PB01_ALL	314754	6396026	2	-0.5	-1.1	0.4
PZ1CH200	312646	6402256	2	5.4	-0.4	23.1
PZ2CH400	312635	6402051	2	3.9	-0.4	33.4
PZ3CH800	312522	6401674	2	2.5	1.5	6.8
PZ4CH1380	312196	6401176	2	7.1	3.4	8.6
PZ5CH1800	311852	6400928	2	11.0	4.6	17.9
PZ6CH2450	311233	6400727	2	5.3	4.4	6.8
PZ7D	314057	6392684	8	-22.1	-22.4	-21.9

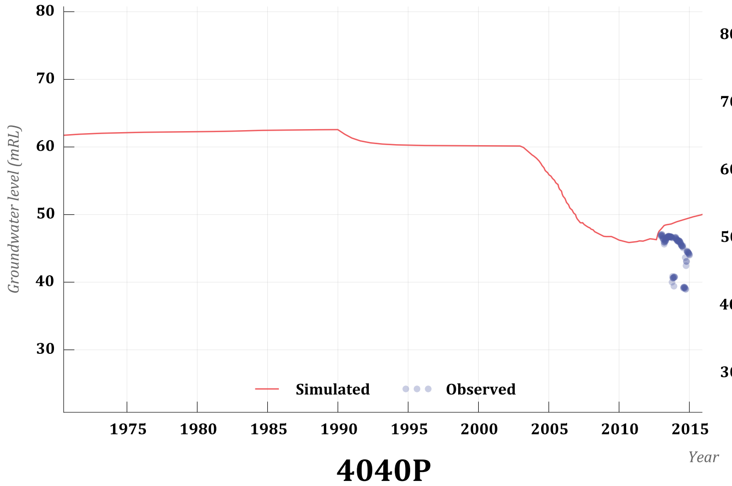
Bore	Easting (GDA94 Z56)	Northing (GDA94 Z56)	Layer	Average residual	Range in residuals	
					Minimum	Maximum
PZ7S	314055	6392671	1	-23.1	-24.6	-22.2
PZ8D	317001	6385418	6	-28.8	-29.1	-28.5
PZ8S	317002	6385411	1	-26.1	-26.9	-25.8
PZ9D	317541	6385652	8	-26.9	-30.1	-21.1
PZ9S	317542	6385642	1	-18.3	-18.4	-18.0
S2	311502	6407889	26	30.4	28.7	32.8
S4	312853	6408417	27	-5.7	-16.5	4.9
SR001	319146	6394094	33	-10.9	-11.8	-10.1
SR002	319079	6394620	33	-11.8	-12.9	-10.2
SR003	318863	6394864	33	-10.4	-11.7	-7.4
SR004	318994	6395506	33	-10.1	-12.1	-7.6
SR005	318831	6396128	33	-6.2	-7.7	-5.0
SR006	318555	6395732	27	-19.4	-23.0	-15.9
SR007	318772	6394373	33	-22.5	-30.9	-9.0
SR008	319290	6395111	34	-6.4	-6.7	-6.2
SR009	319338	6394746	34	-6.8	-8.1	-5.8
SR010	317319	6395338	23	4.3	1.7	5.7
SR011	317699	6394412	23	11.1	9.0	12.8
SR012	318354	6393926	24	-10.0	-10.7	-9.0
UG133_168	313297	6396177	23	-21.8	-22.7	-17.9
UG133_180	313297	6396177	25	-12.8	-16.5	-7.7
UG133_45	313297	6396177	14	-11.7	-12.1	-11.1
UG133_96	313297	6396177	18	-35.7	-37.6	-33.9
UG135_110	313831	6396748	21	-24.2	-24.6	-23.7
UG135_176	313831	6396748	24	1.2	0.6	2.2
UG135_186	313831	6396748	27	-27.2	-28.5	-26.3
UG135_50	313831	6396748	16	-25.2	-26.2	-23.9
UG138_215	308517	6396181	14	-39.8	-42.9	-36.6
UG138_245	308517	6396181	16	-39.7	-41.5	-37.8
UG139_329	306665	6395173	15	-38.5	-39.3	-37.2
UG139_375	306665	6395173	17	-7.2	-10.4	-2.9
UG139_402	306665	6395173	20	-27.7	-41.8	-20.9
UG147_249	311245	6397207	25	-10.6	-10.6	-10.6

Bore	Easting (GDA94 Z56)	Northing (GDA94 Z56)	Layer	Average residual	Range in residuals	
					Minimum	Maximum
UG166A_130	306488	6398076	8	-27.3	-29.0	-24.0
UG166A_153	306488	6398076	12	-21.9	-22.6	-20.3
UG166A_200	306488	6398076	15	-24.4	-25.3	-22.7
UG166A_238	306488	6398076	18	-22.9	-24.4	-20.1
UG192R_110	313683	6396084	14	-38.6	-39.3	-37.0
UG192R_140	313683	6396084	20	-25.0	-26.9	-23.2
UG192R_170	313683	6396084	24	16.7	12.7	20.7
UG192R_210	313683	6396084	26	-27.9	-30.2	-23.1
UG192R_30	313683	6396084	14	-25.3	-25.9	-23.2
UG192R_60	313683	6396084	16	-26.9	-28.3	-23.2
UG192R_94	313683	6396084	20	-24.1	-26.4	-22.3
UG193_160	313757	6396090	23	-16.1	-17.8	-10.3
UG193_27	313757	6396090	14	-14.0	-17.2	-10.5
UG193_61	313757	6396090	16	-11.1	-14.8	-6.1
UG193_85	313757	6396090	20	-4.9	-11.0	-0.7
UG196_137	312364	6397122	20	-14.0	-14.3	-13.3
UG196_160	312364	6397122	23	-0.8	-2.5	12.8
UG196_230	312364	6397122	26	-23.5	-24.4	-22.8
UG196_45	312364	6397122	14	-3.9	-14.0	1.1
UG196_80	312364	6397122	16	-9.1	-10.9	-3.4
UG220_106	312522	6397233	18	1.7	-0.7	5.3
UG220_110	312522	6397233	20	-6.4	-7.1	-4.8
UG220_152	312522	6397233	22	15.6	9.4	18.5
UG220_207	312522	6397233	24	-11.7	-12.9	-10.1
UG224_105	313860	6396243	20	-9.2	-10.5	-8.5
UG224_163	313860	6396243	24	20.1	16.8	25.7
UG224_172	313860	6396243	24	26.3	20.1	30.7
UG224_191	313860	6396243	26	-15.1	-19.0	-13.6
UG224_69	313860	6396243	18	-27.2	-29.8	-26.5
UG225_100	313214	6397095	20	-7.1	-9.1	-4.2
UG225_128	313214	6397095	23	-4.1	-10.6	20.7
UG225_178	313214	6397095	25	-0.9	-3.1	15.3
UG225_58.5	313214	6397095	17	-2.3	-6.4	0.3

Bore	Easting (GDA94 Z56)	Northing (GDA94 Z56)	Layer	Average residual	Range in residuals	
					Minimum	Maximum
UG225_93.2	313214	6397095	18	-3.1	-6.2	9.0
WD462_P1	315529	6391358	25	-14.5	-17.9	-13.7
WD462_P3	315529	6391358	13	-4.5	-7.8	2.5
WD609	318803	6392211	1	5.8	5.5	6.3
WD615_P1	319281	6391347	Vaux25	10.9	9.5	12.0


4032P
4033P
4034P
4035P
4036C
4037P
4038C
4039C_1
Groundwater level (mRL)
Year
Simulated
Observed
1975
1980
1985
1990
1995
2000
2005
2010
2015
30
40
50
60
70
80

4039C_2



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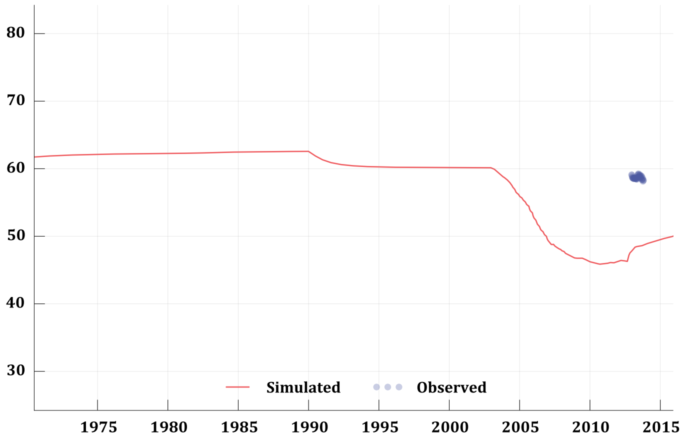

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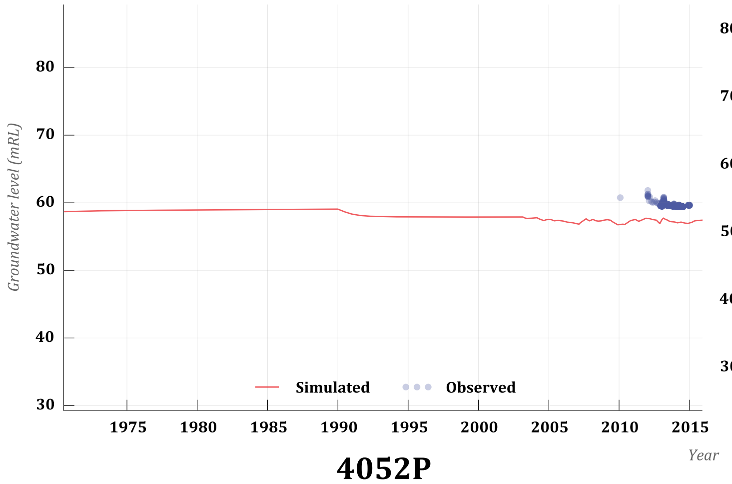

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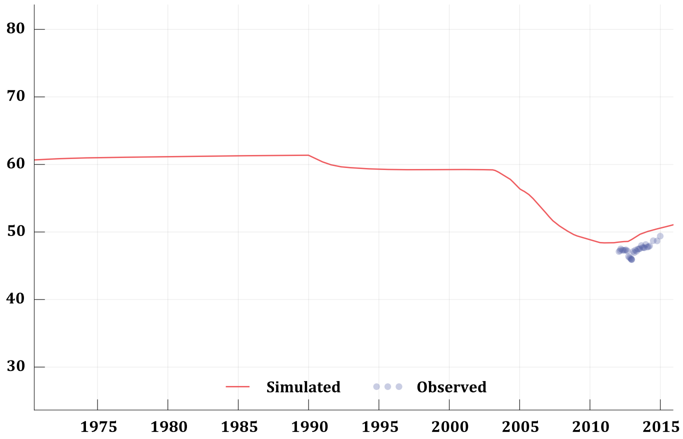

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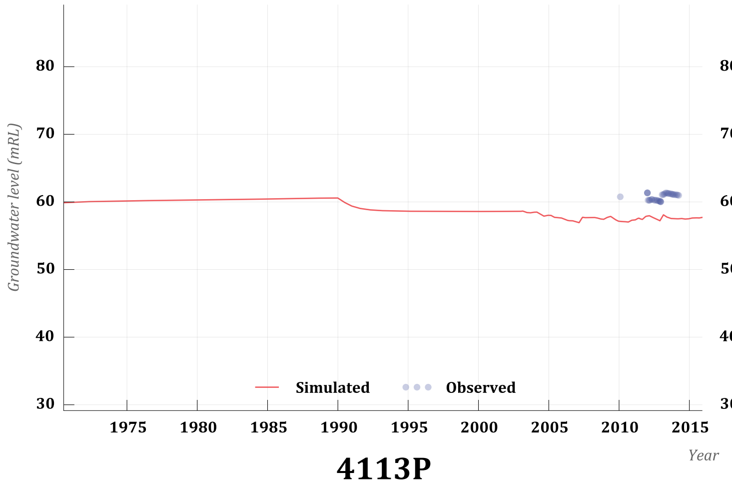

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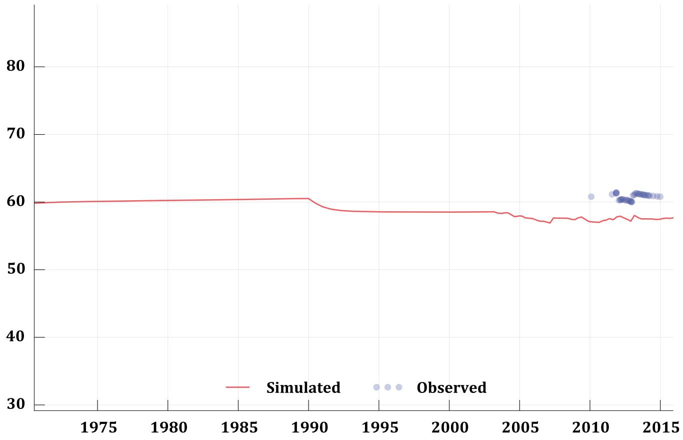

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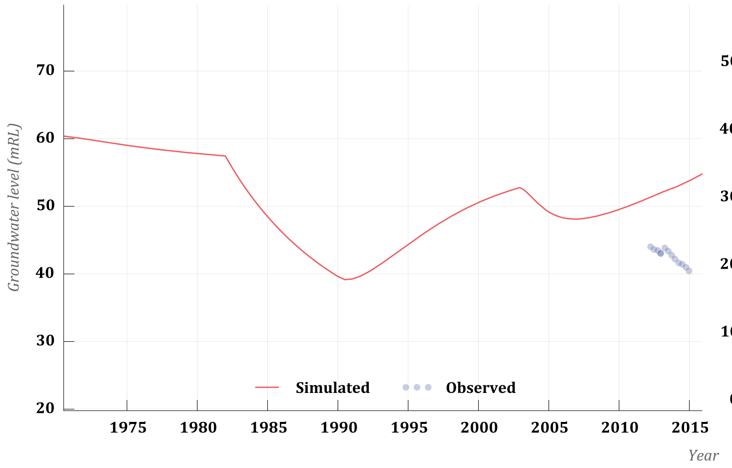

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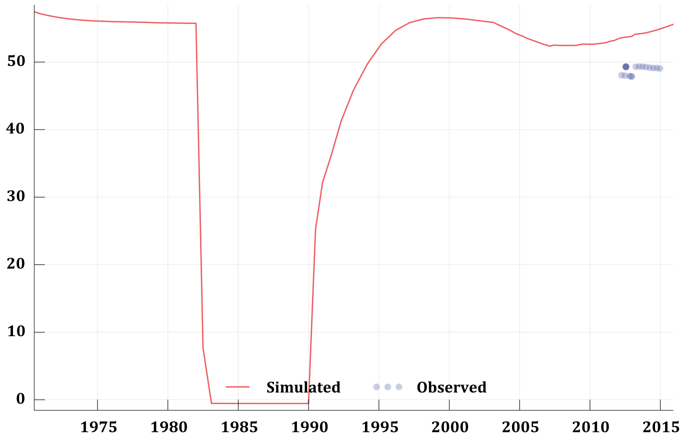

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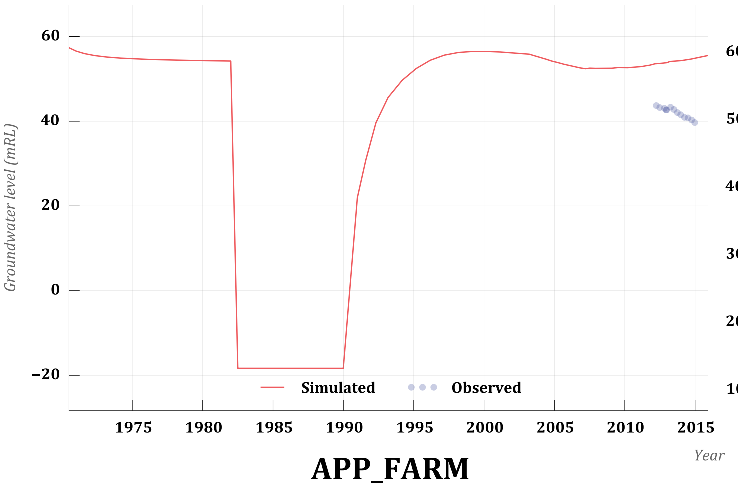

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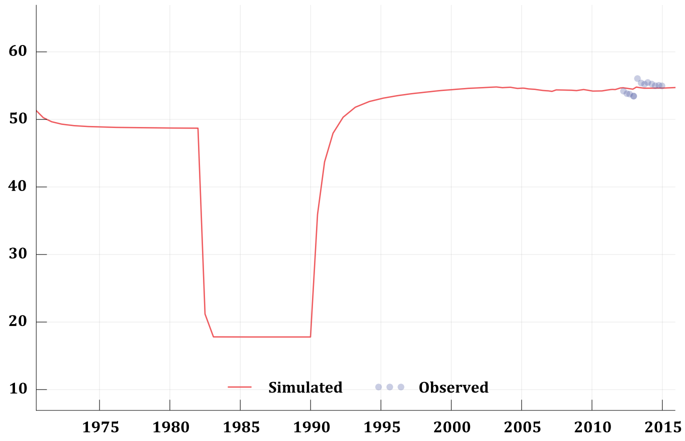

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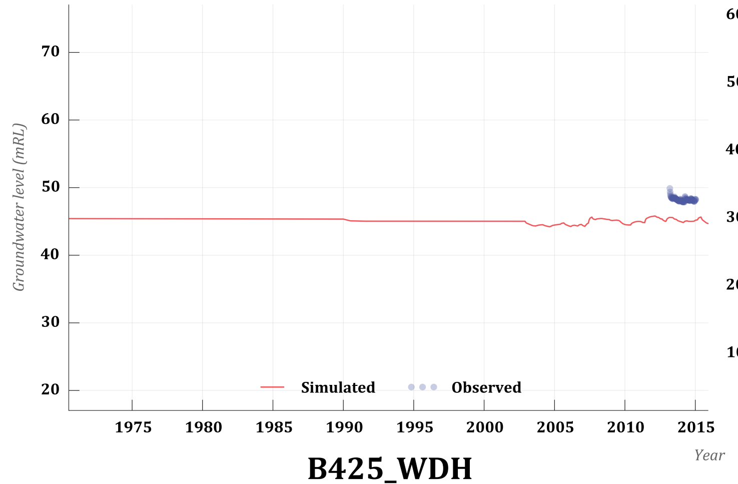

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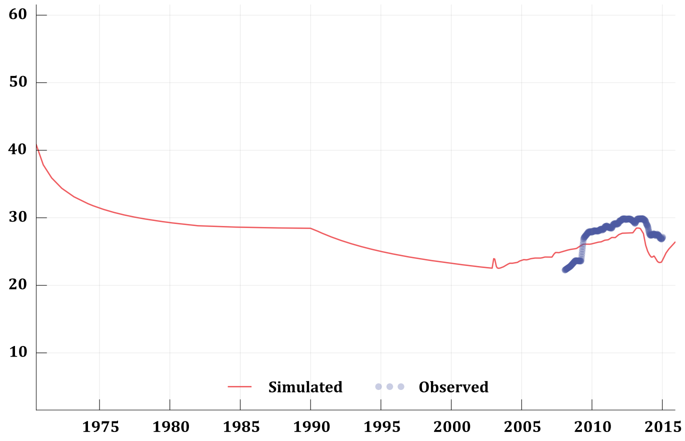

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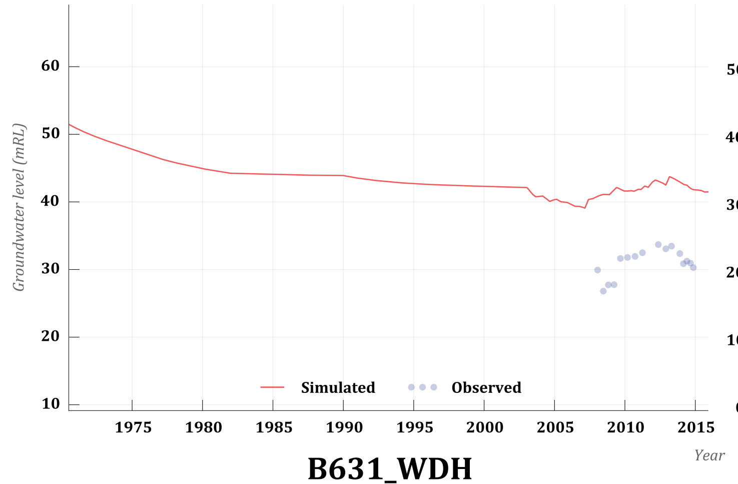

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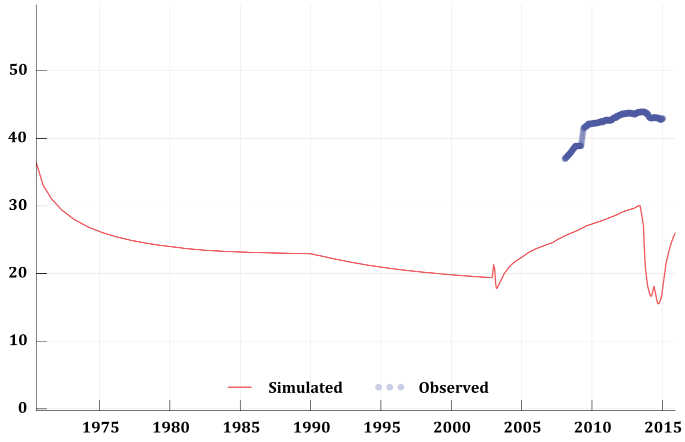

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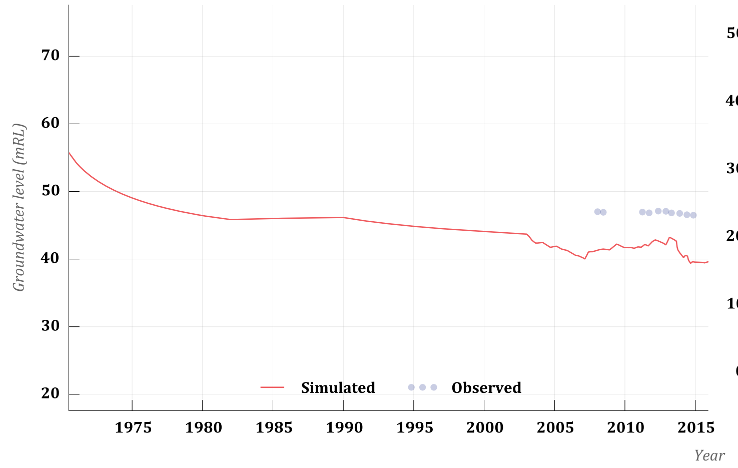

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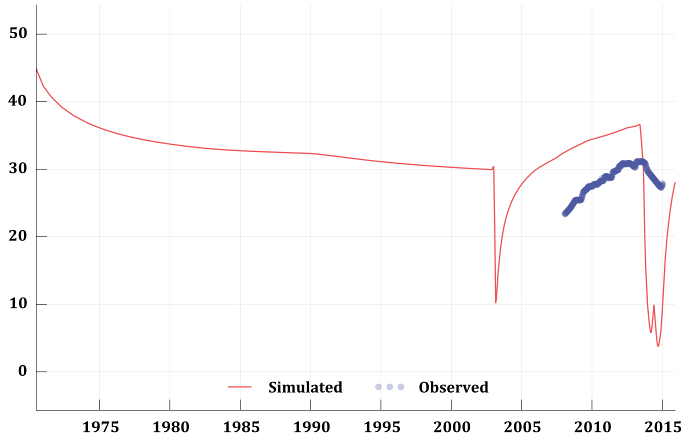

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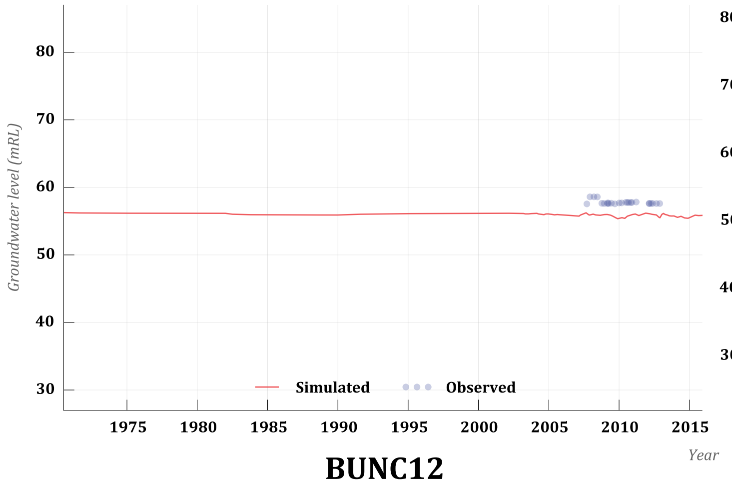

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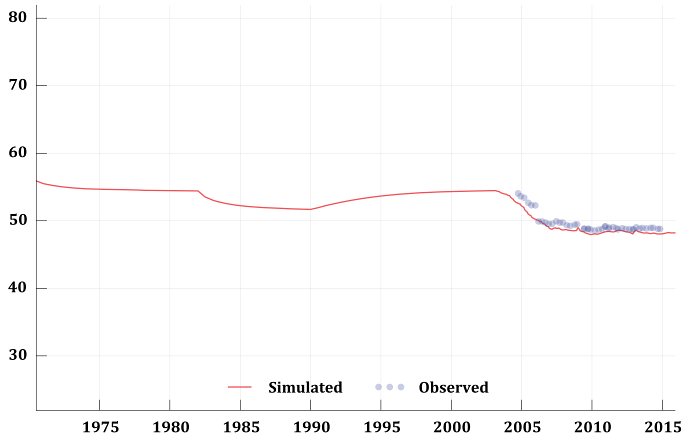

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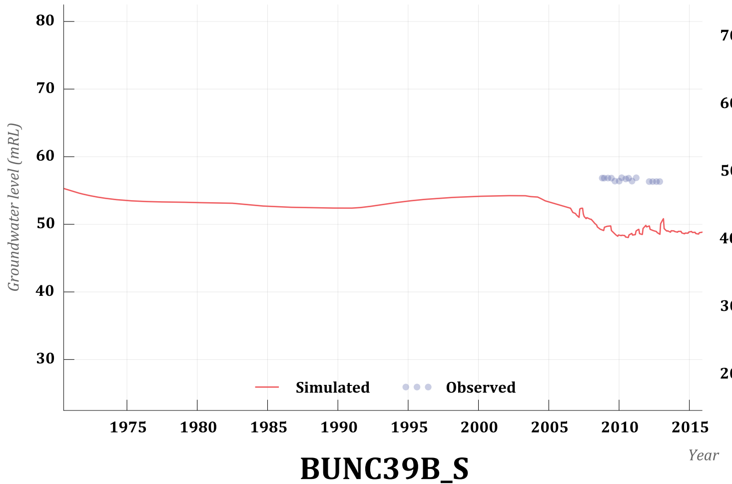

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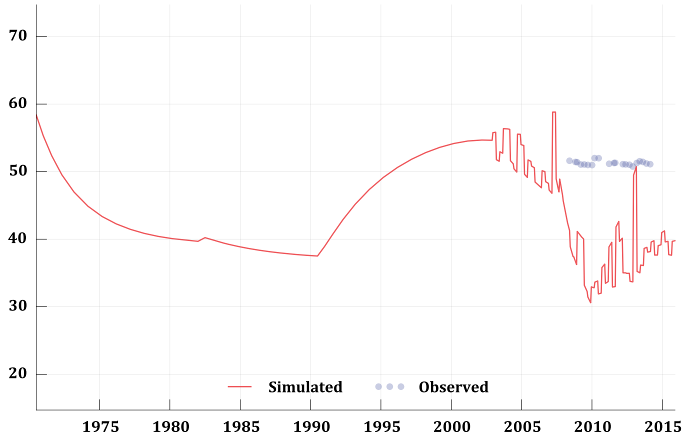

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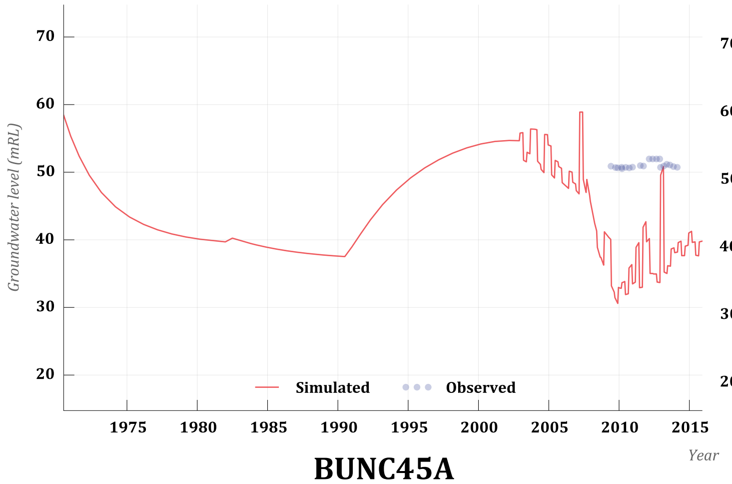

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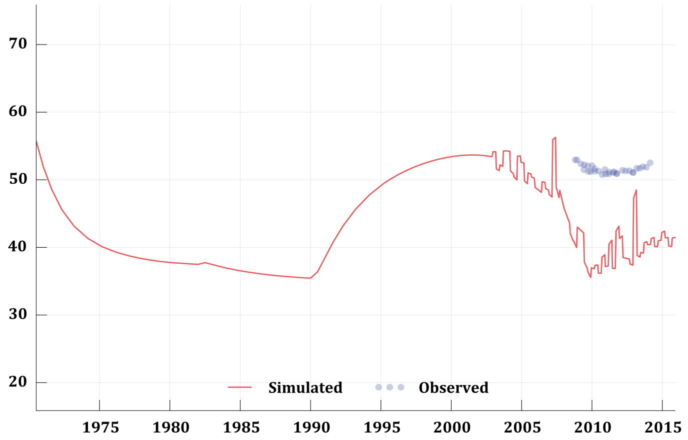

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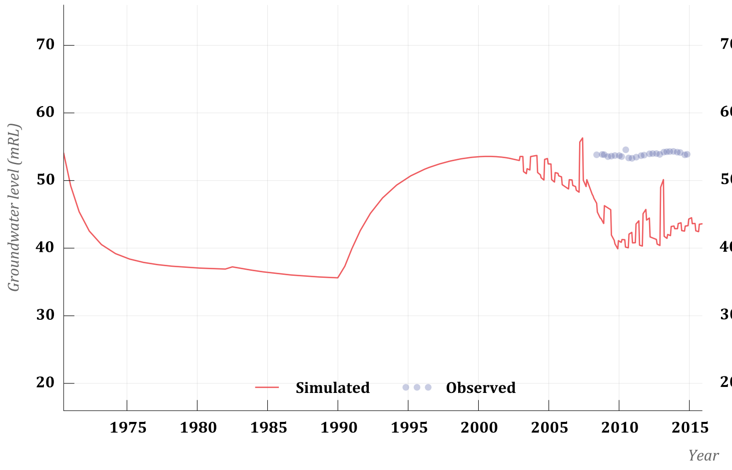

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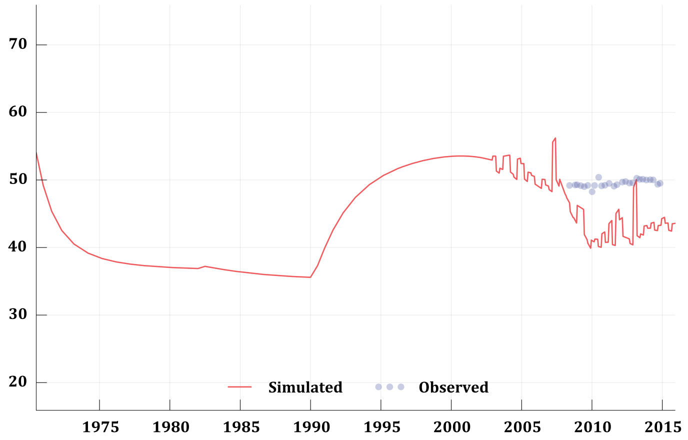

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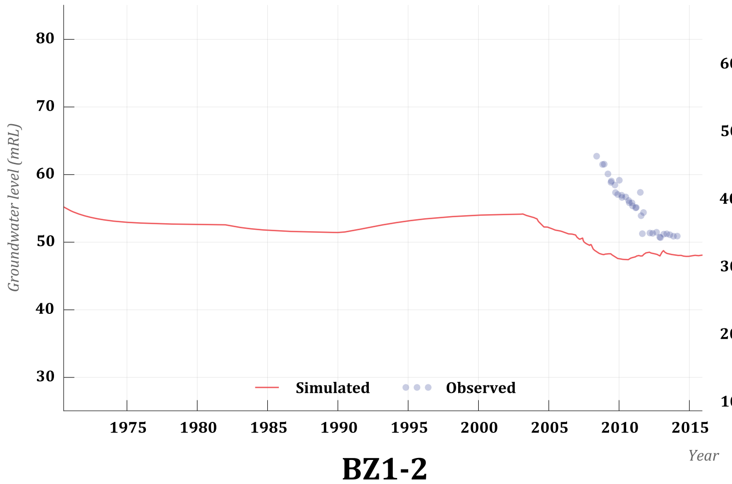

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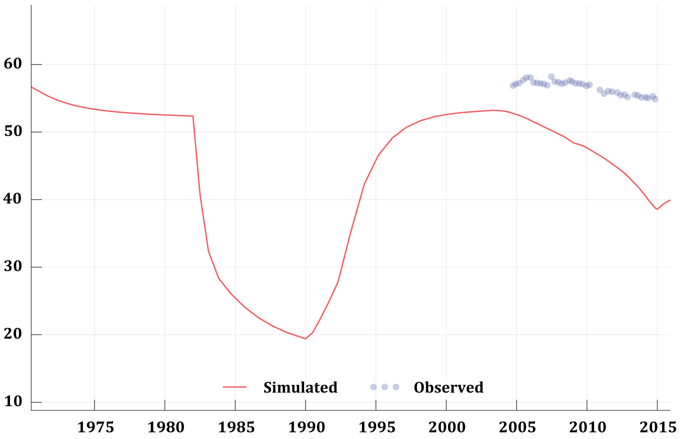

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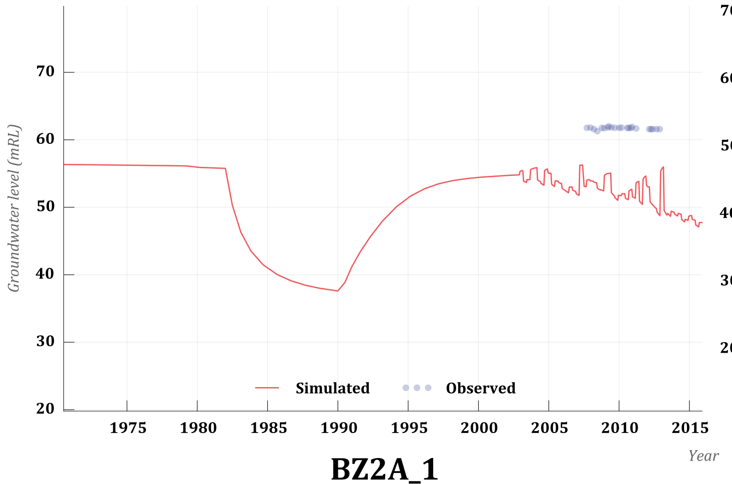

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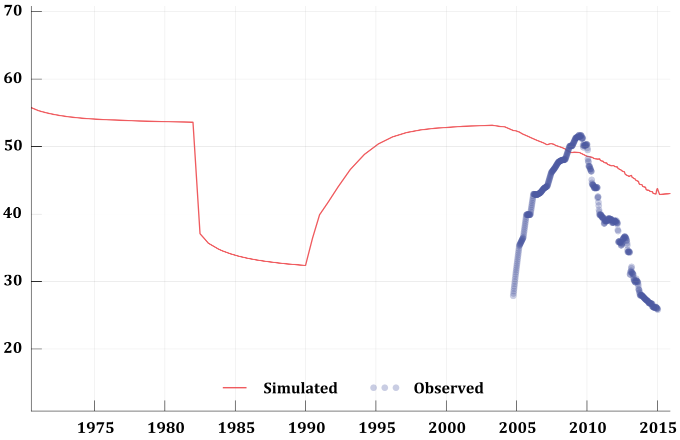

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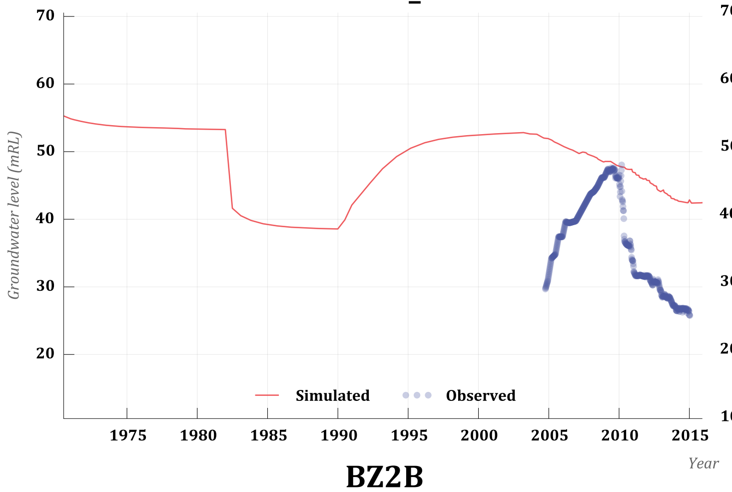

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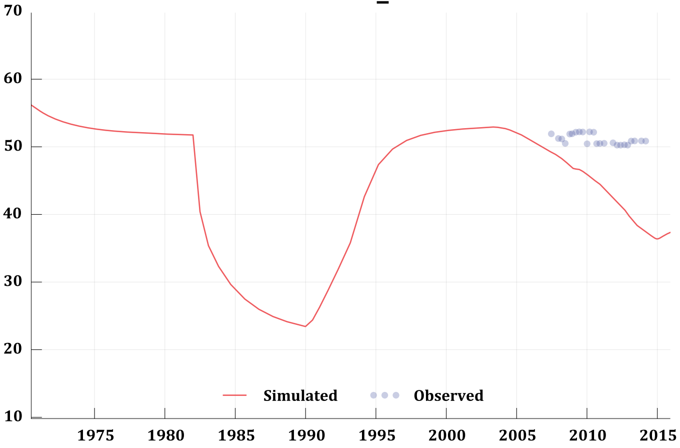

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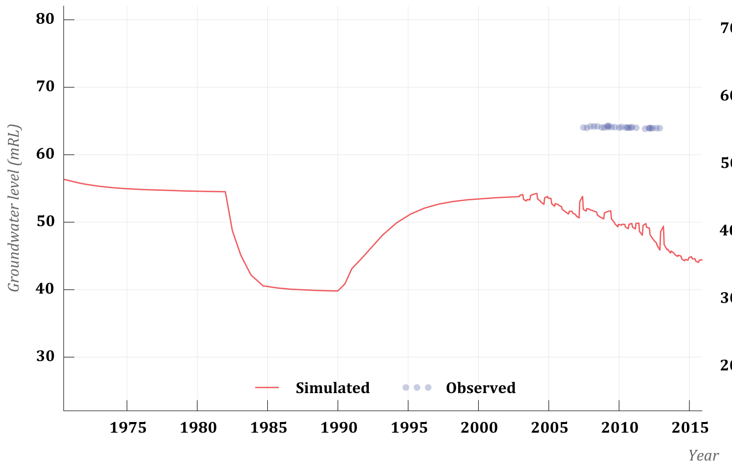

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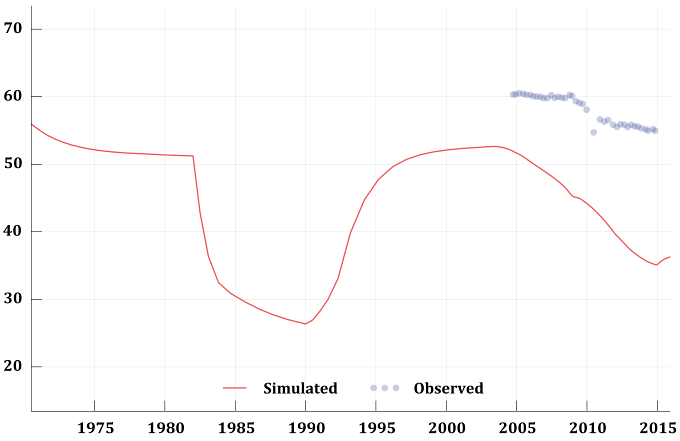

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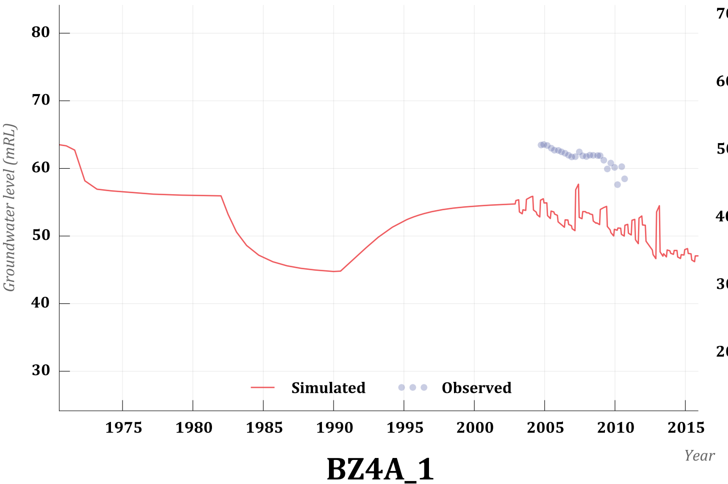

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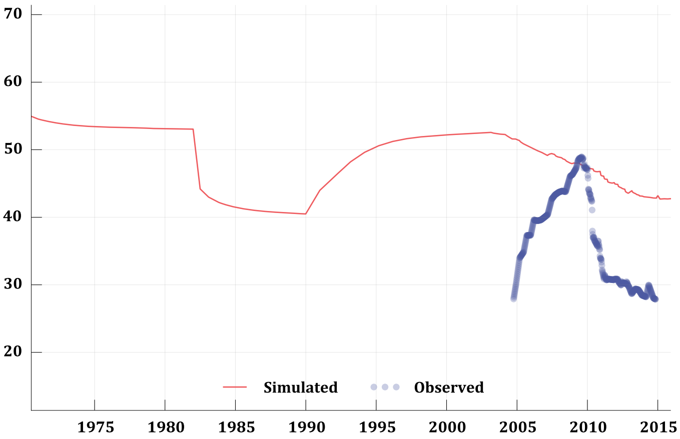

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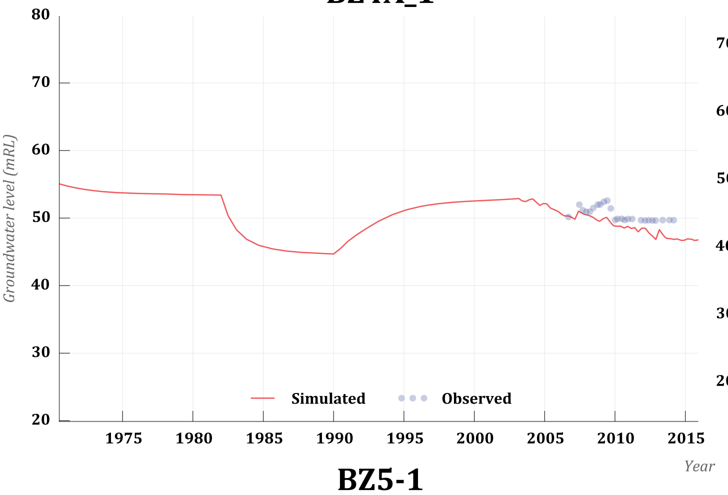

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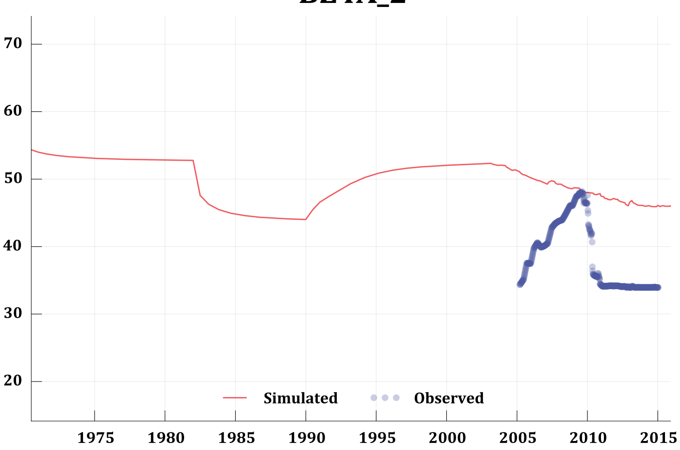
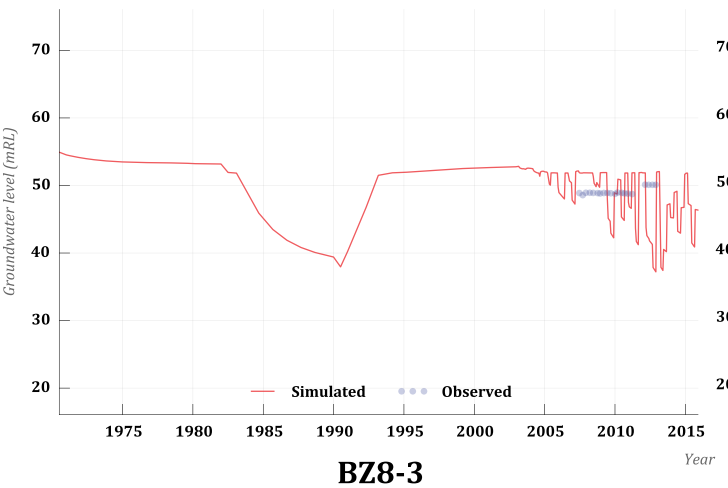
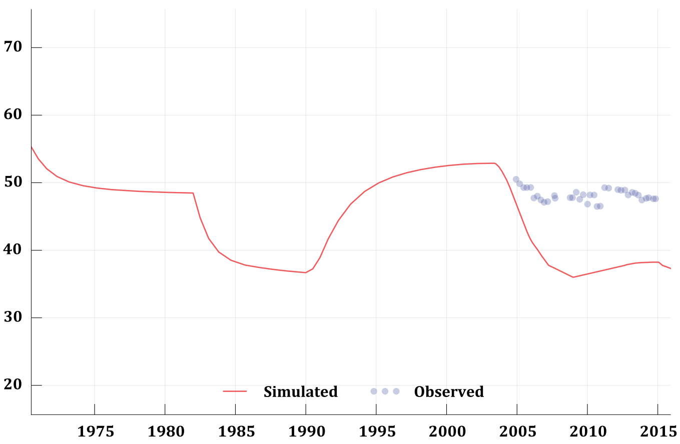


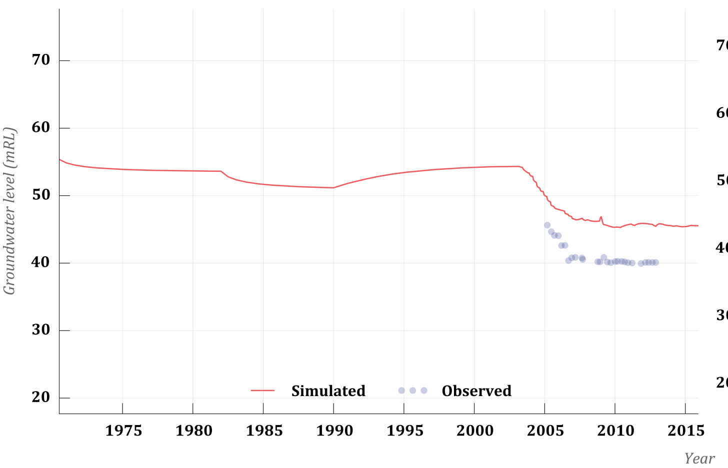
BZ5-1



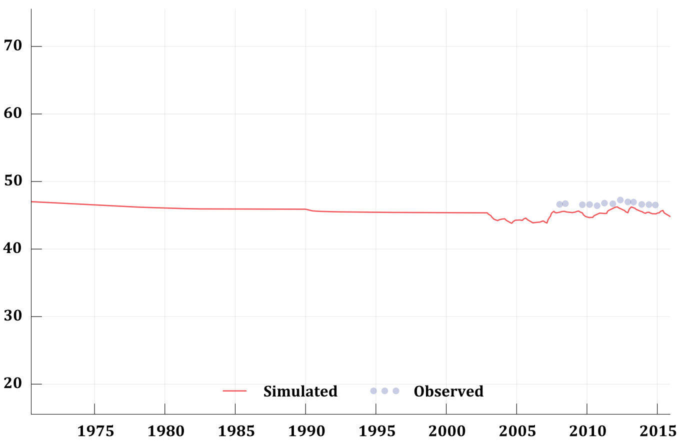
BZ8-2

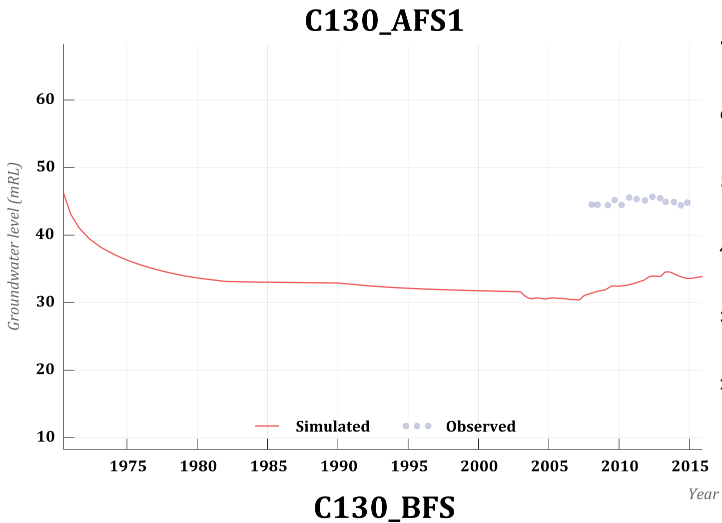


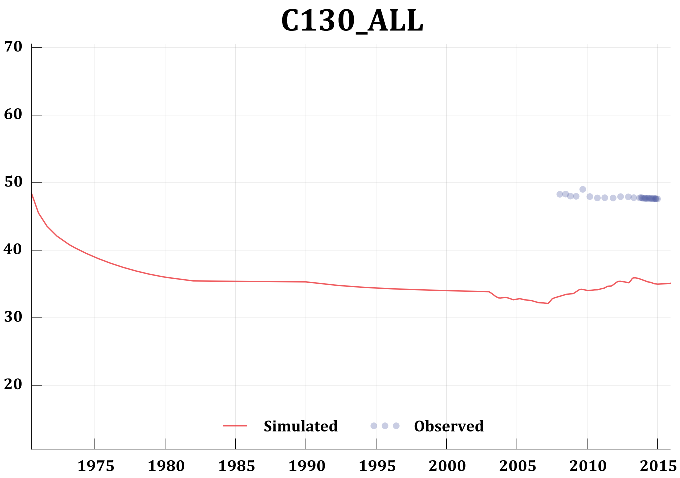
BZ8-3



C122_WDH




C130_AFS1
Groundwater level (mRL)
10
20
30
40
50
60
1975
1980
1985
1990
1995
2000
2005
2010
2015
Simulated
Observed
Year


C130_ALL
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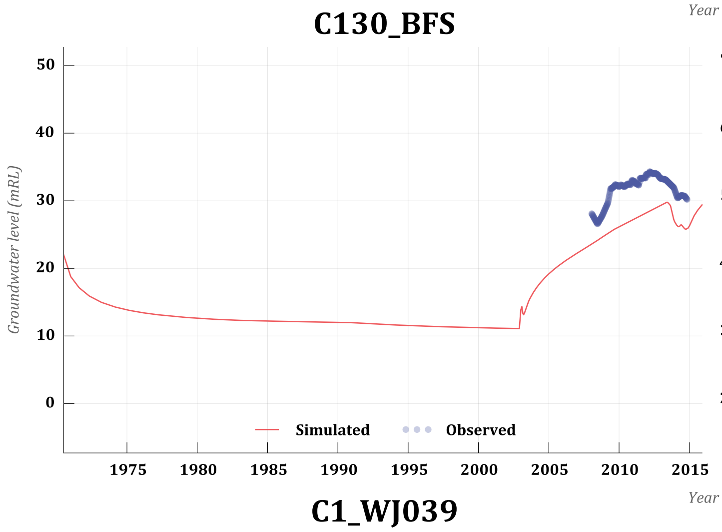
60
70
1975
1980
1985
1990
1995
2000
2005
2010
2015
Simulated
Observed


C130_BFS
Groundwater level (mRL)
0
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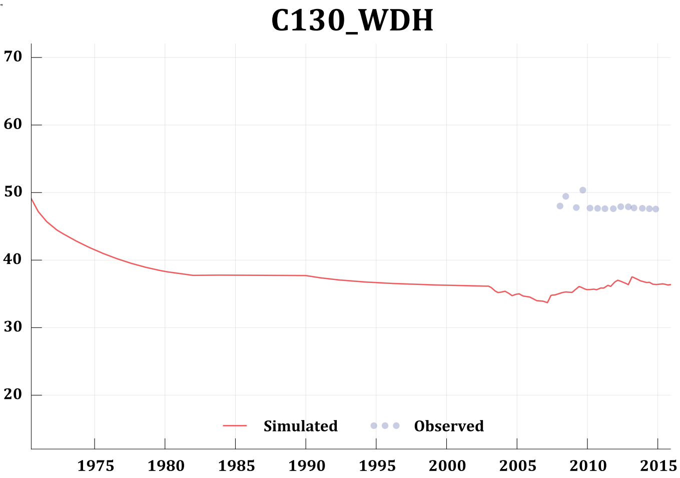
50
1975
1980
1985
1990
1995
2000
2005
2010
2015
Simulated
Observed
Year


C130_WDH
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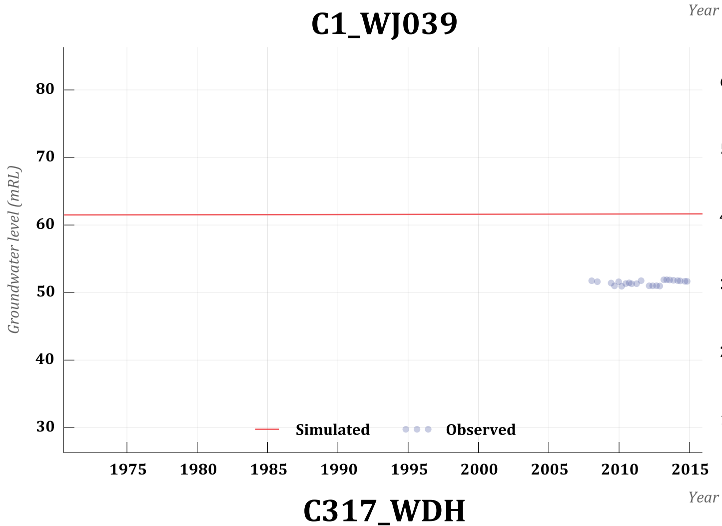
Simulated
Observed


C1_WJ039
Groundwater level (mRL)
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1975
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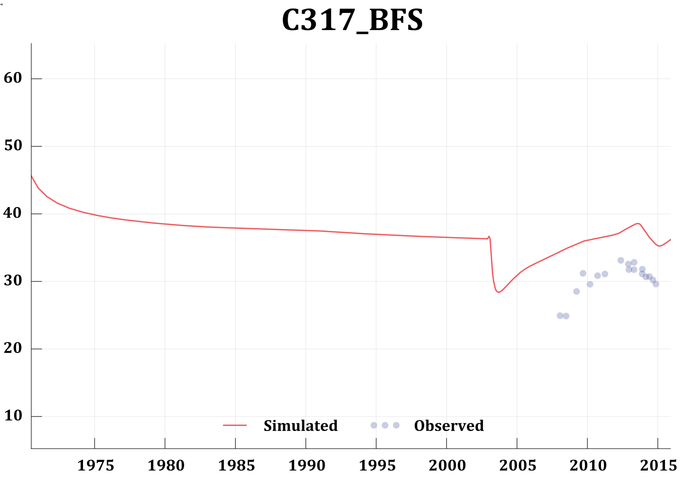
Simulated
Observed
Year


C317_BFS
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1975
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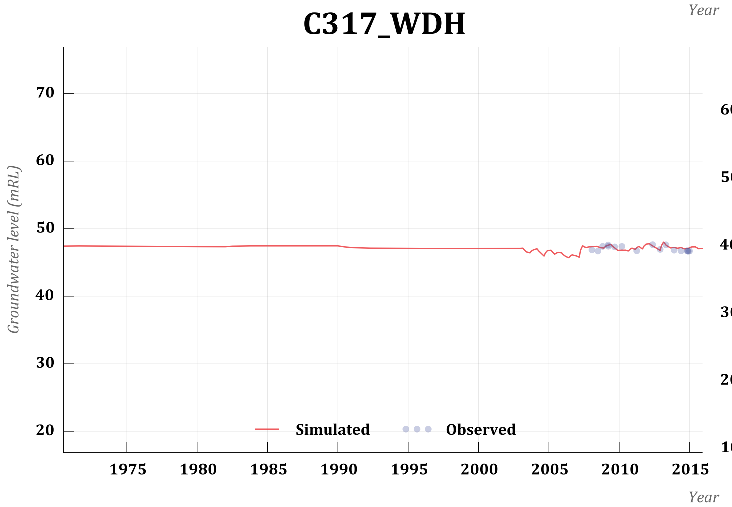
Simulated
Observed


C317_WDH
Groundwater level (mRL)
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1975
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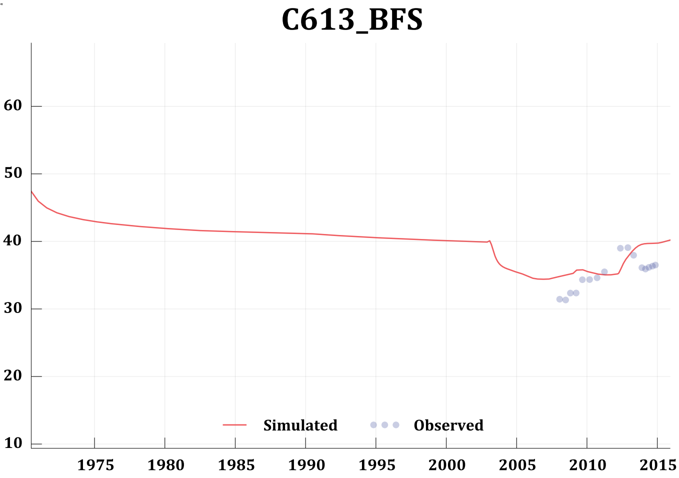
2015
Simulated
Observed
Year


C613_BFS
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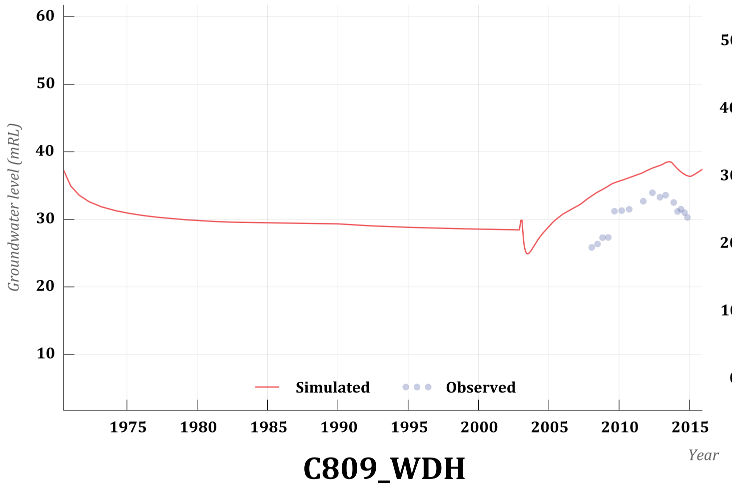
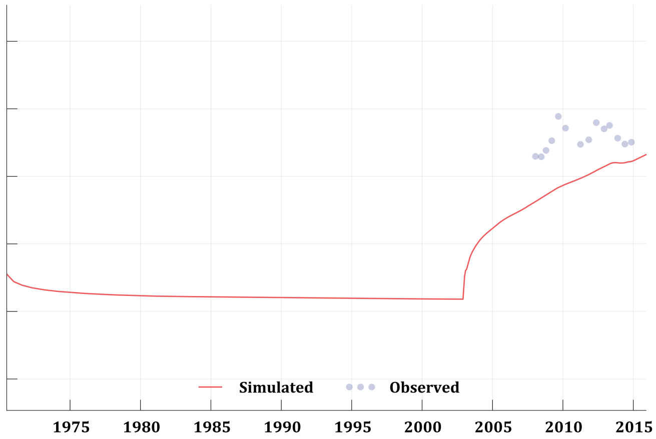
Simulated
Observed

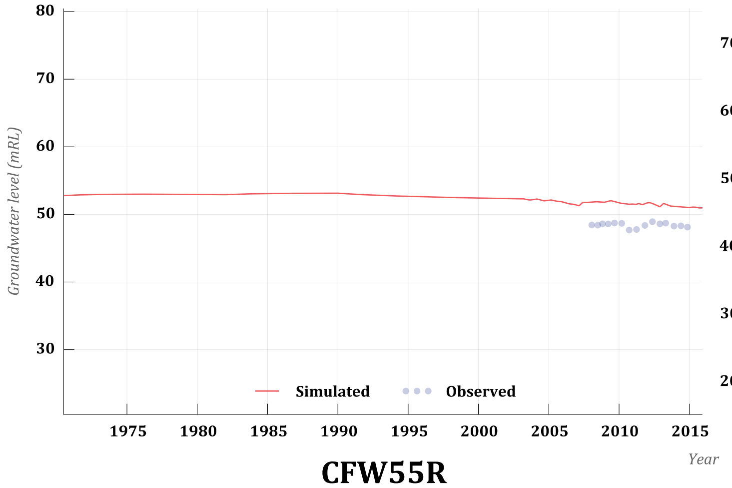
C621_BFS



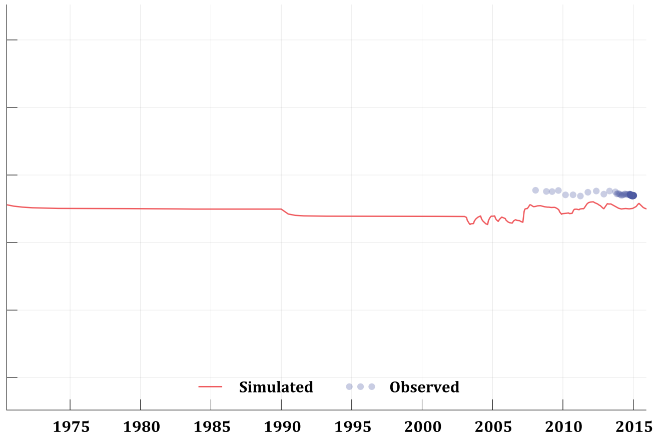
C630_BFS



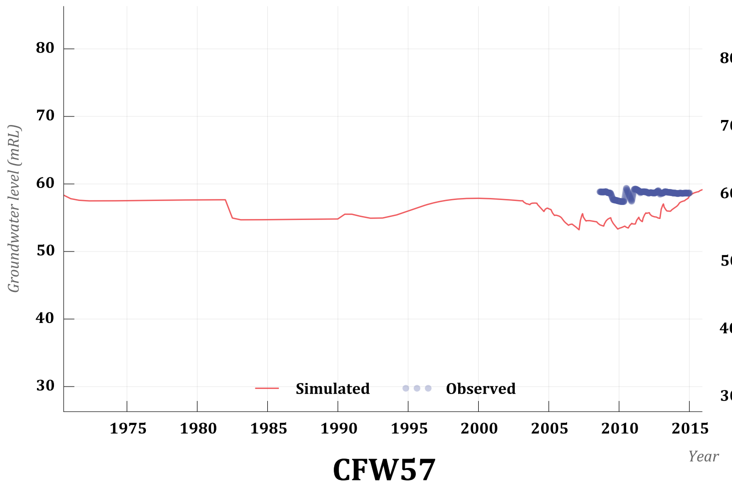
C809_WDH



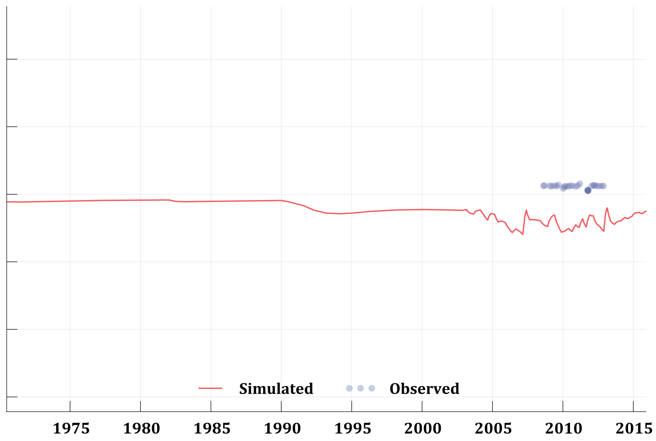
C919_ALL



CFW55R



CFW56



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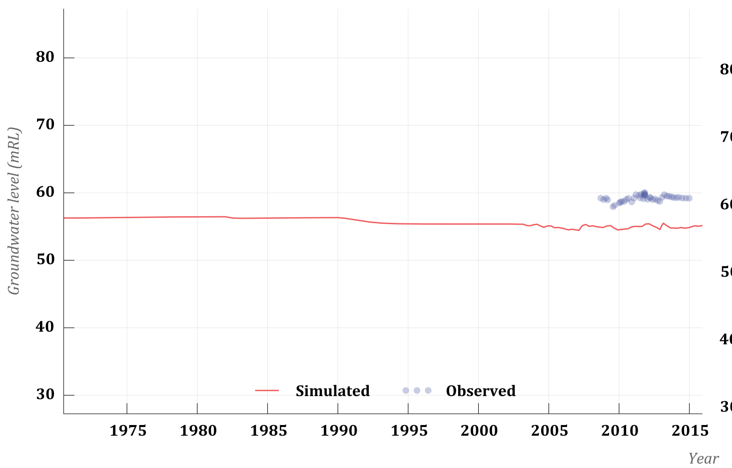

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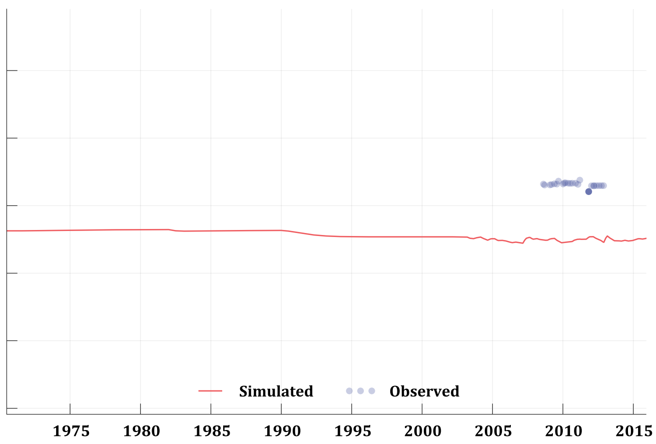
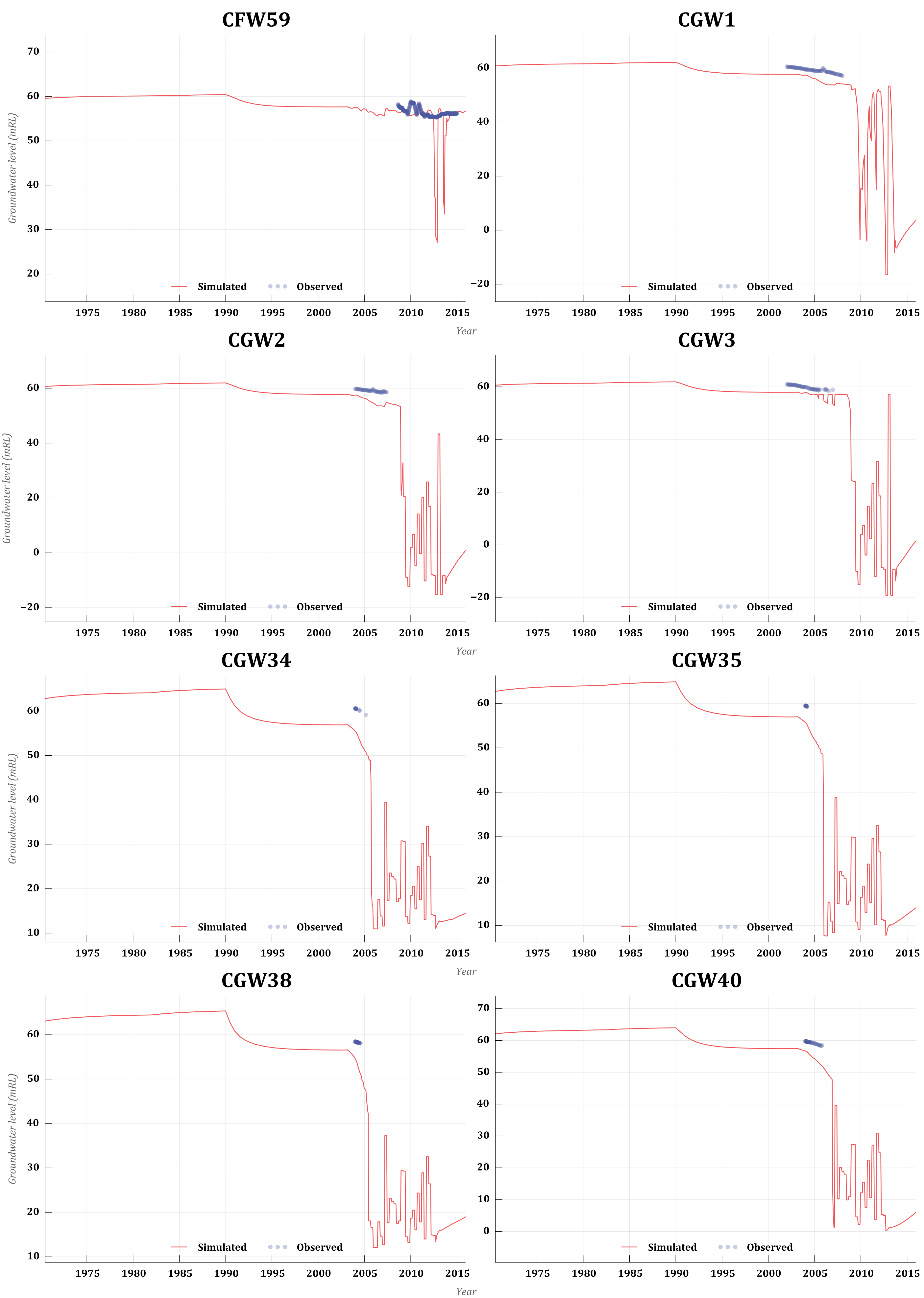
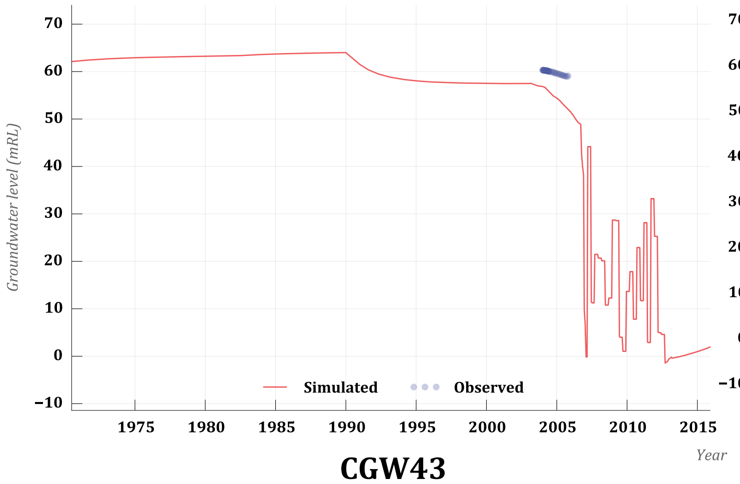
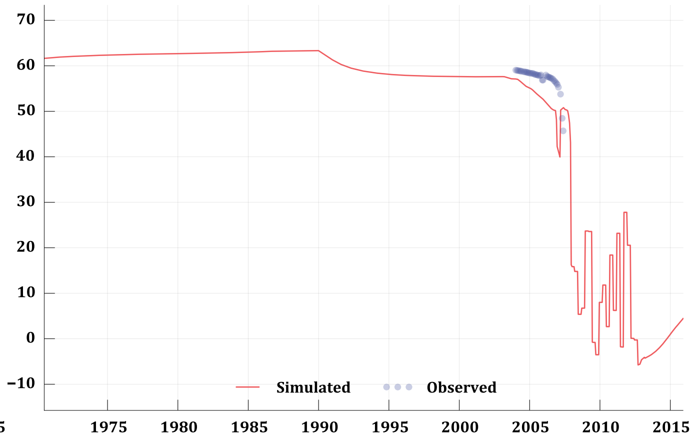



CFW59
CGW1
CGW2
CGW3
CGW34
CGW35
CGW38
CGW40
Groundwater level (mRL)
Year
Simulated
Observed
1975 1980 1985 1990 1995 2000 2005 2010 2015

CGW41



CGW42



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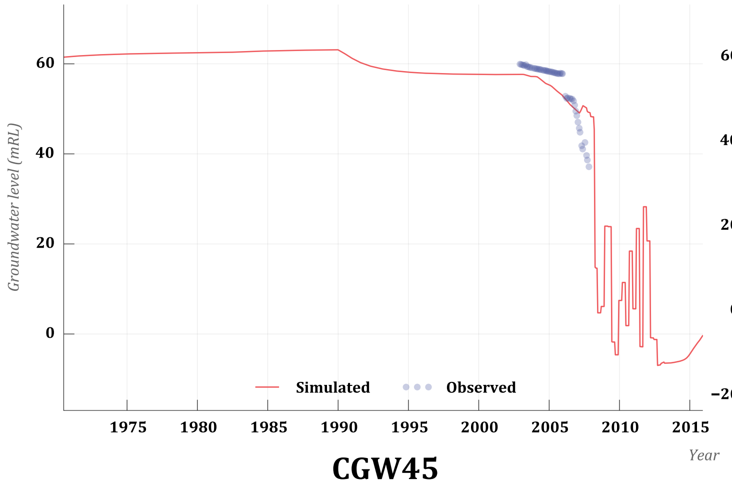

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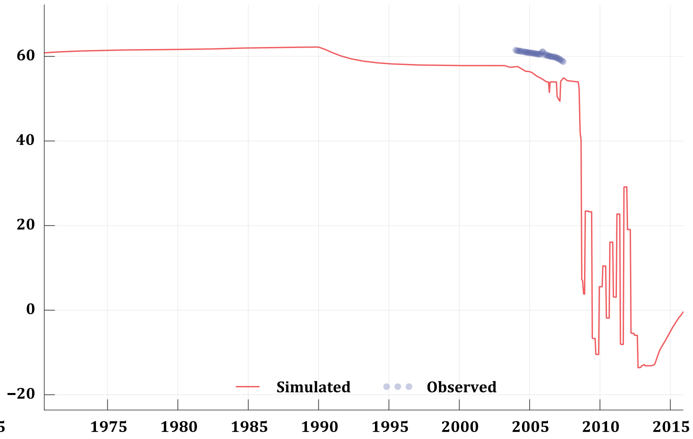

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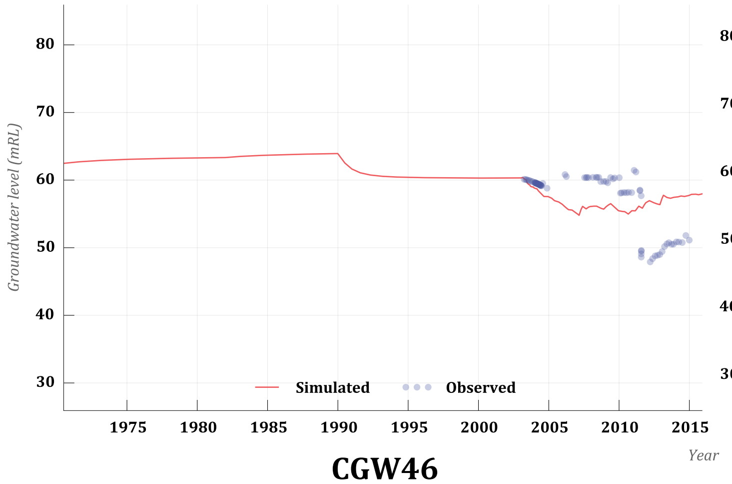

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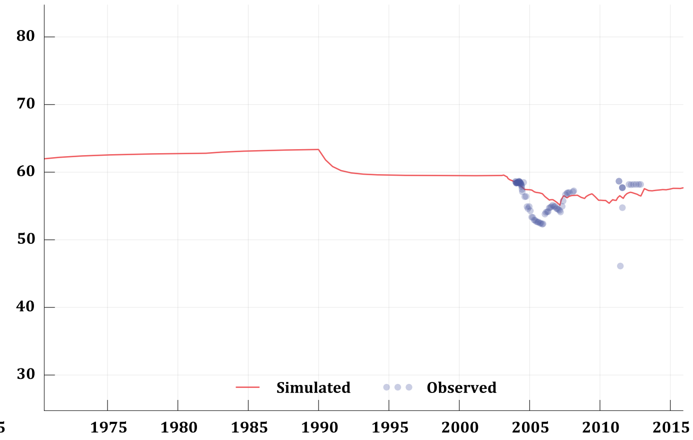

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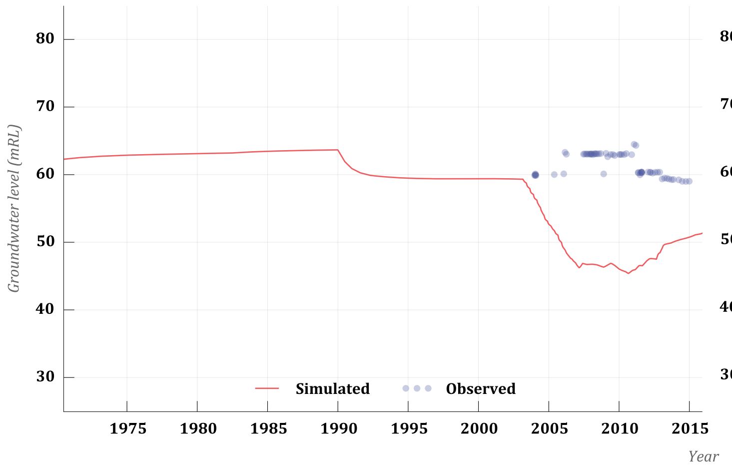

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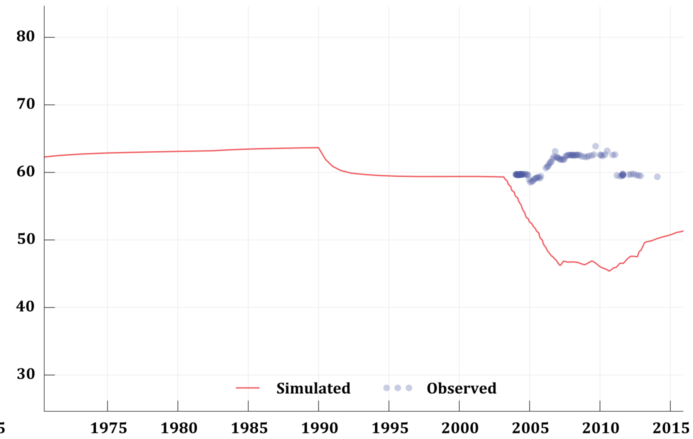

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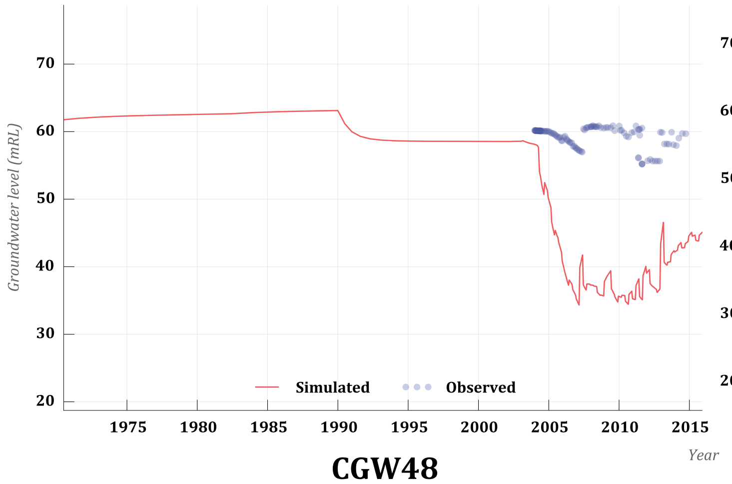

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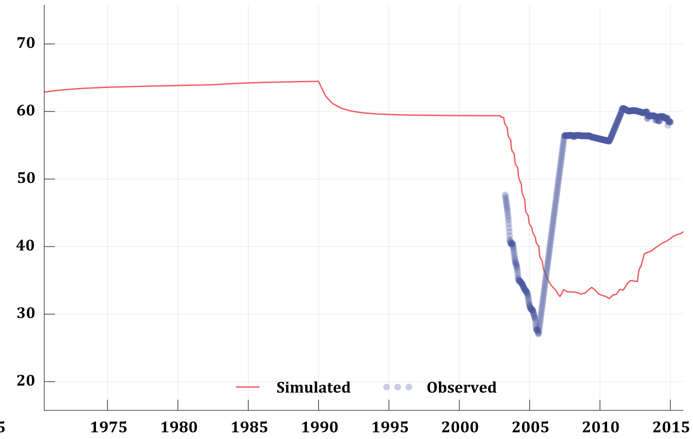

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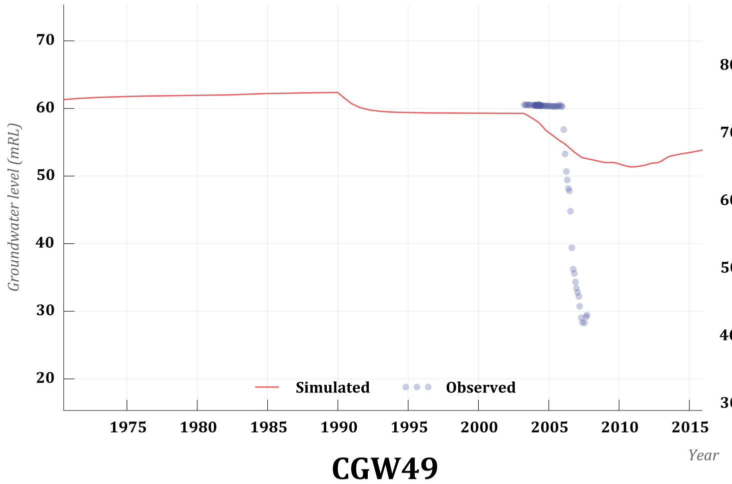

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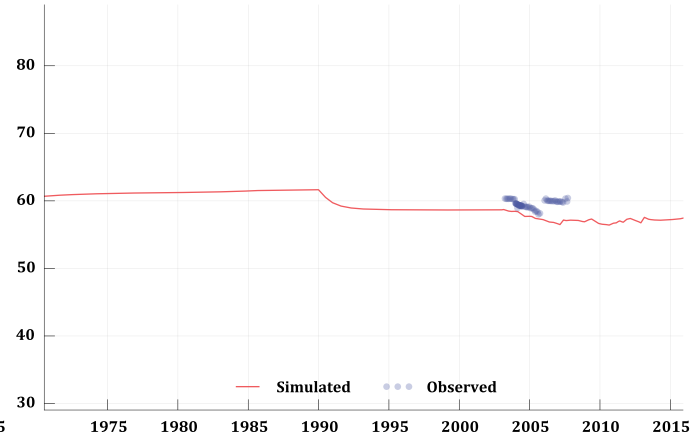

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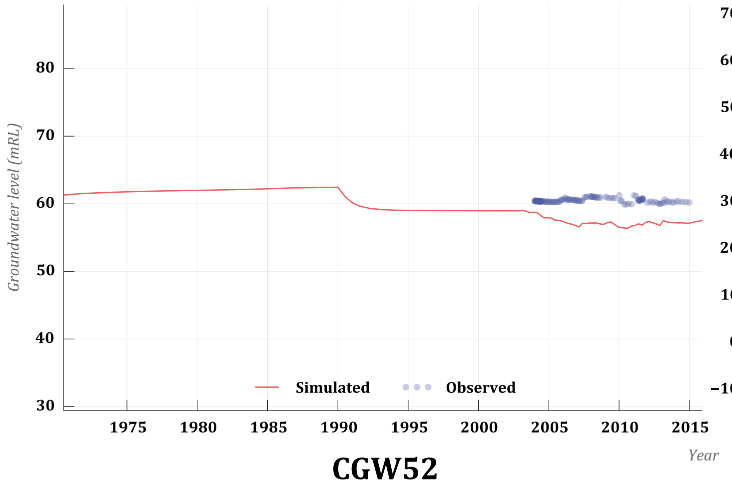

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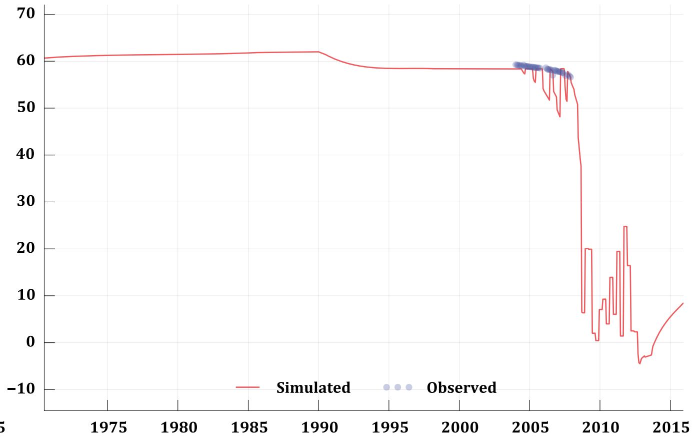

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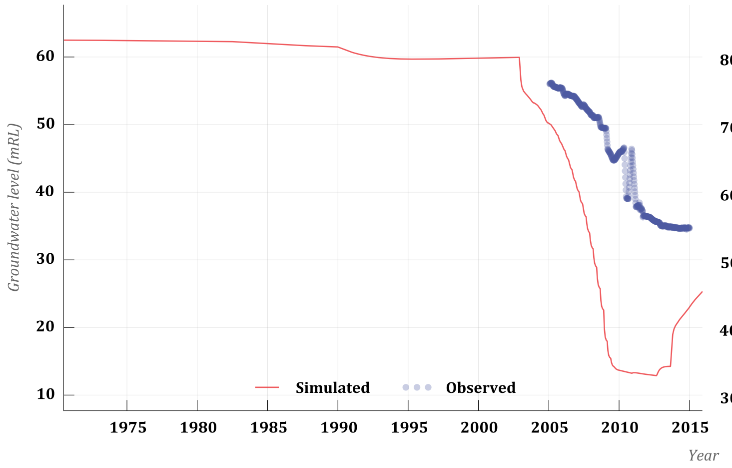

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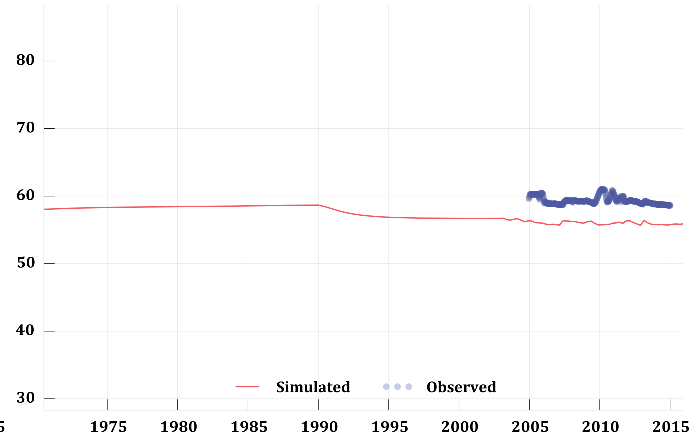

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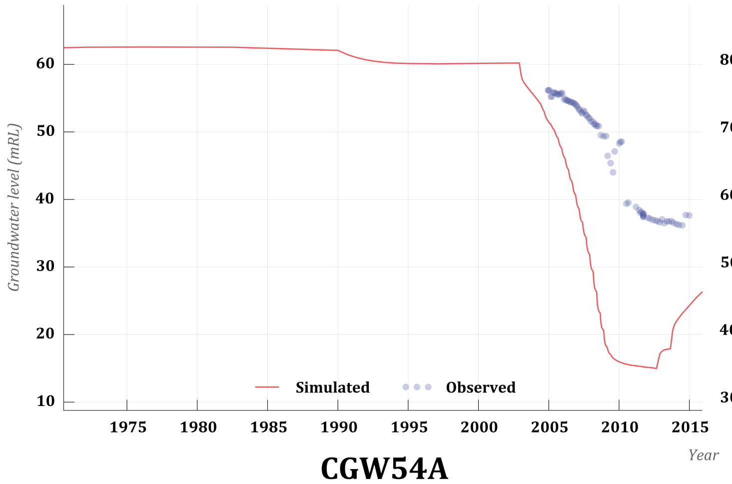

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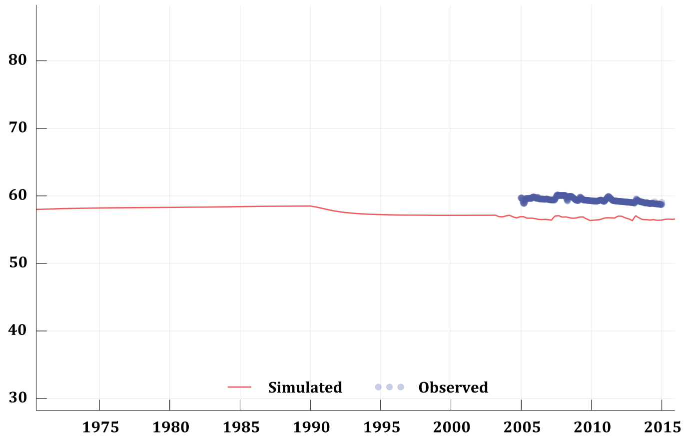

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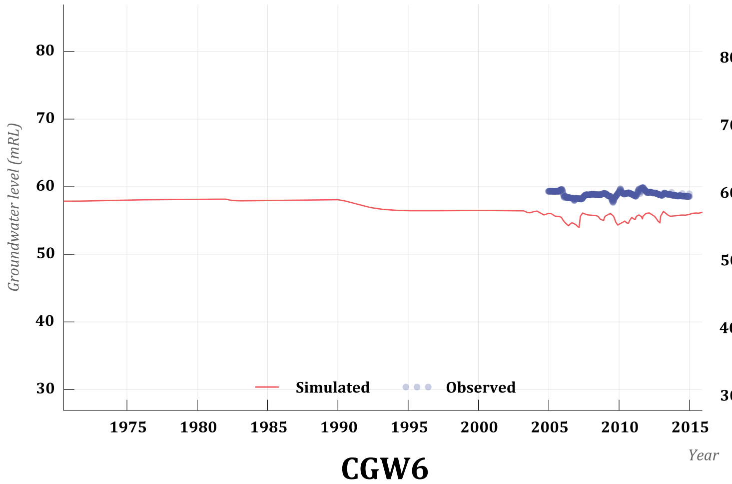

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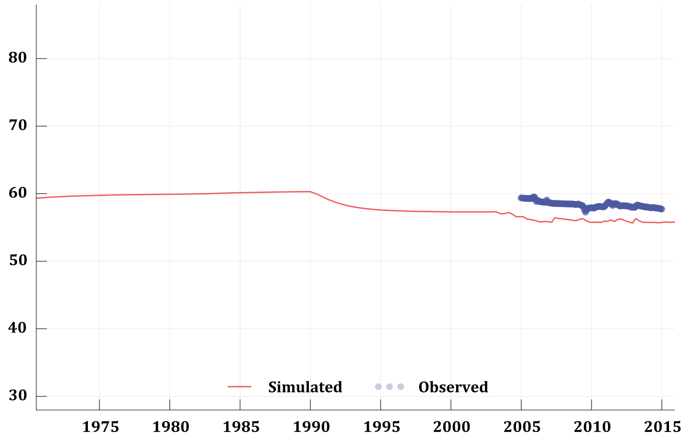

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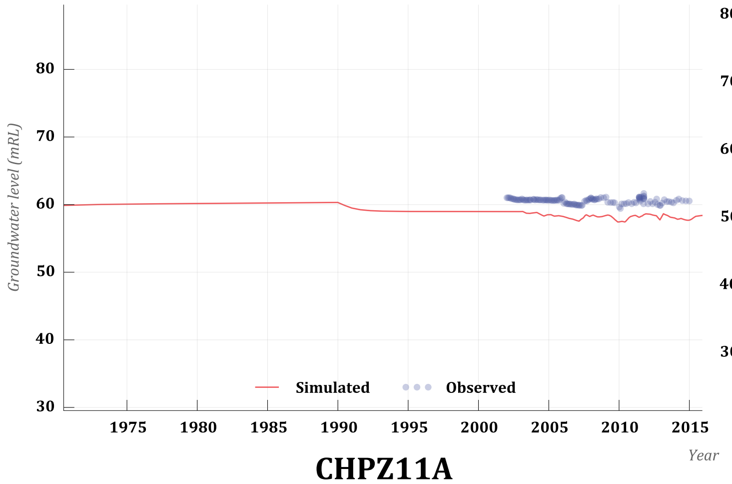

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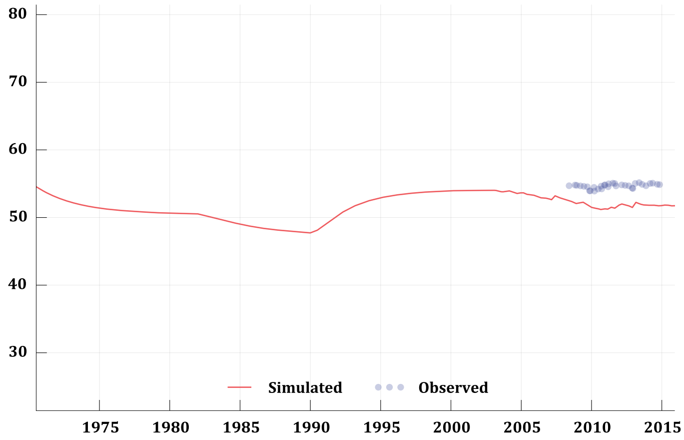

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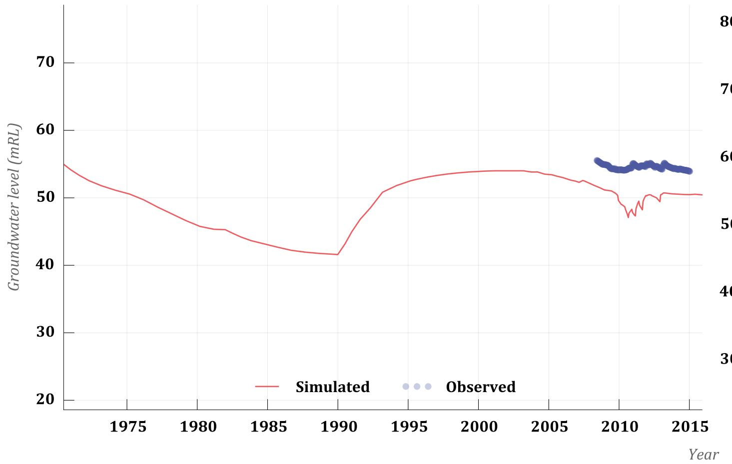

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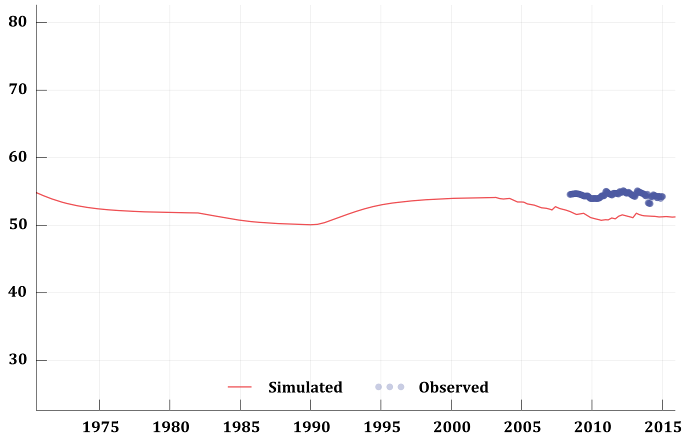

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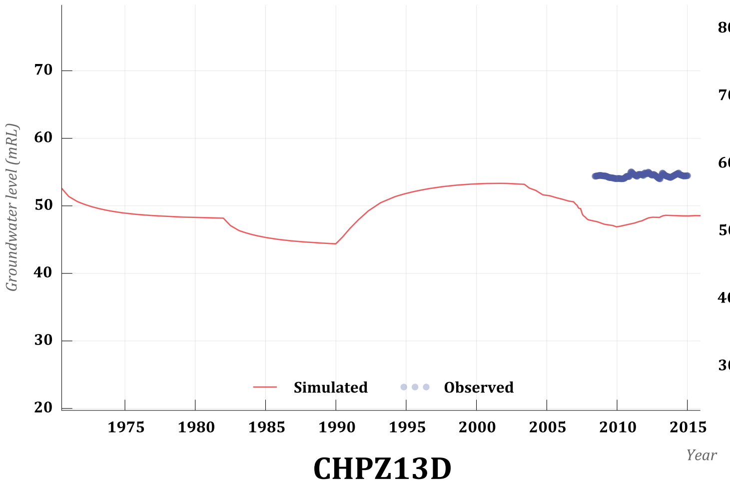

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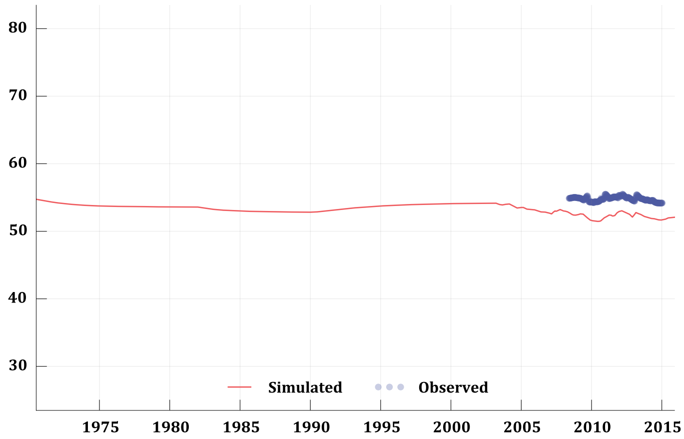

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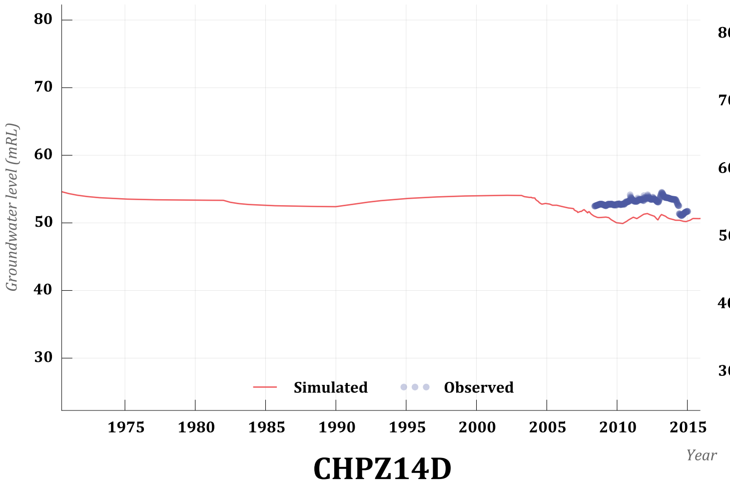

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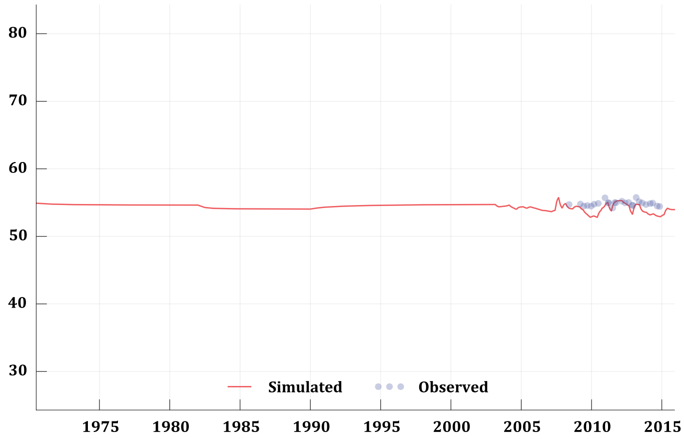

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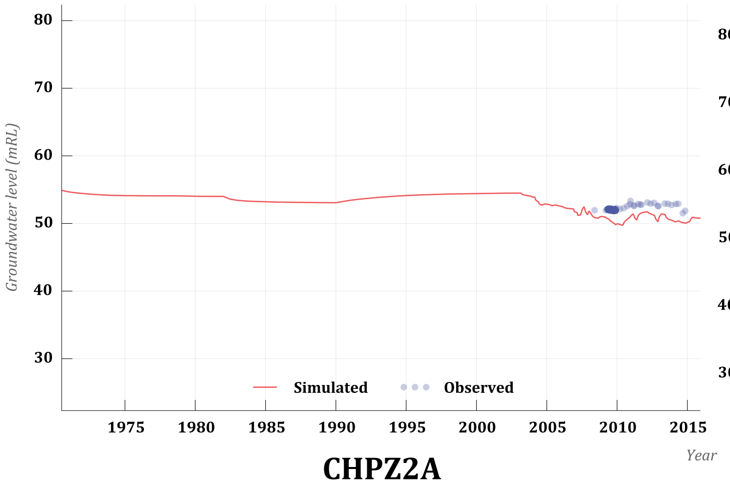

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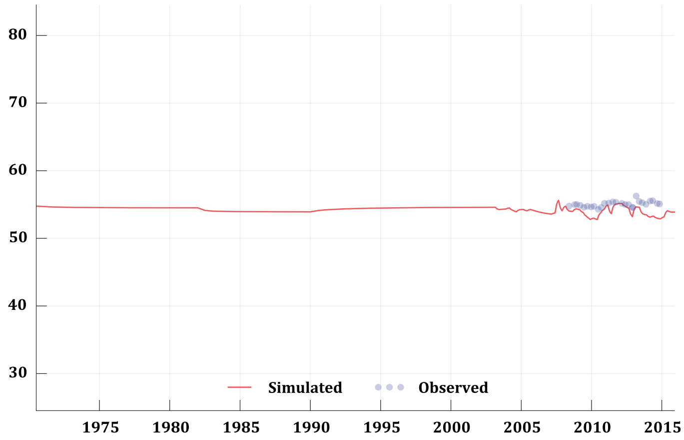

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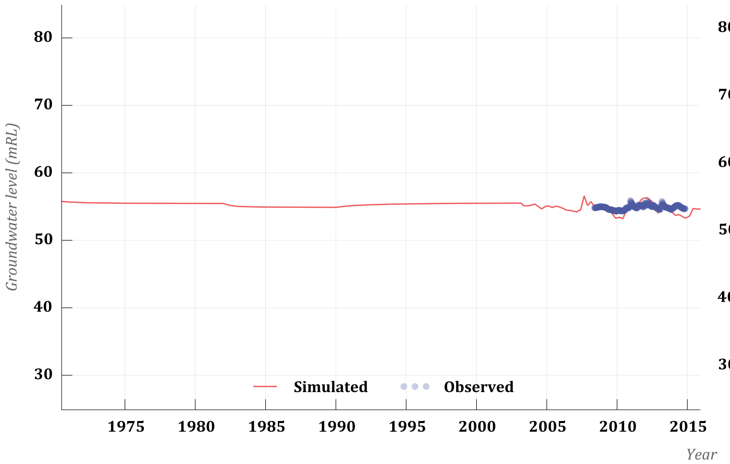

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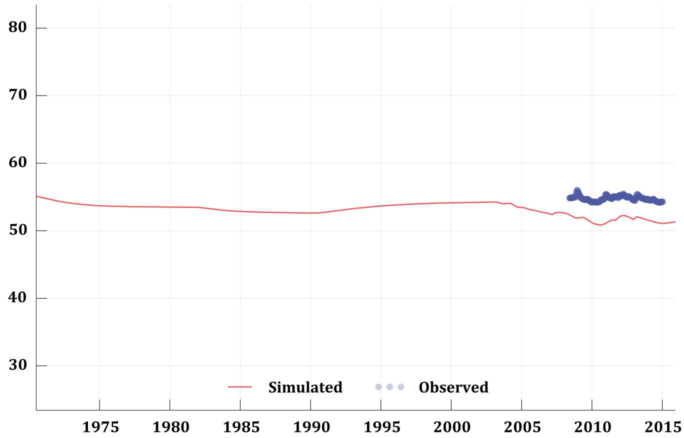

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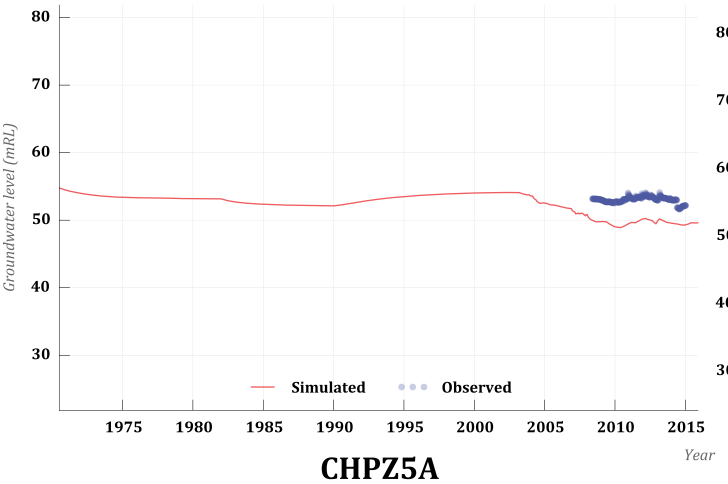

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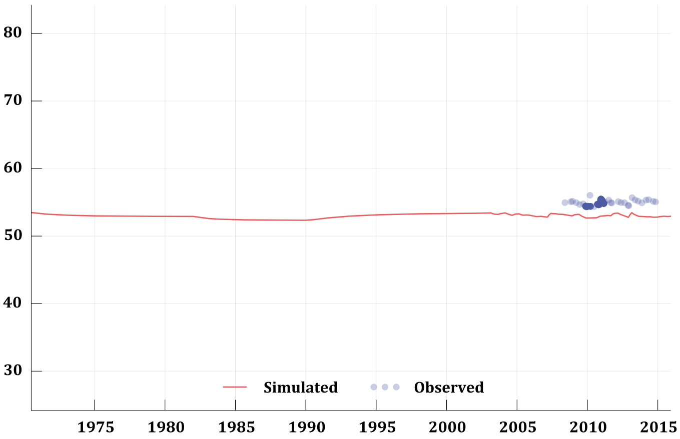

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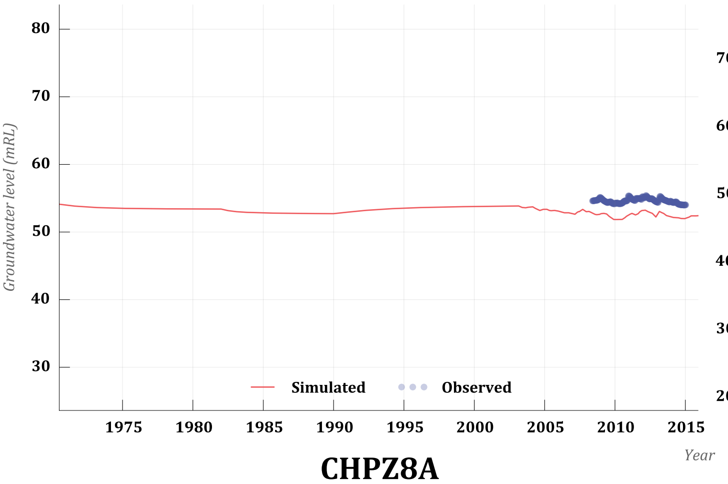

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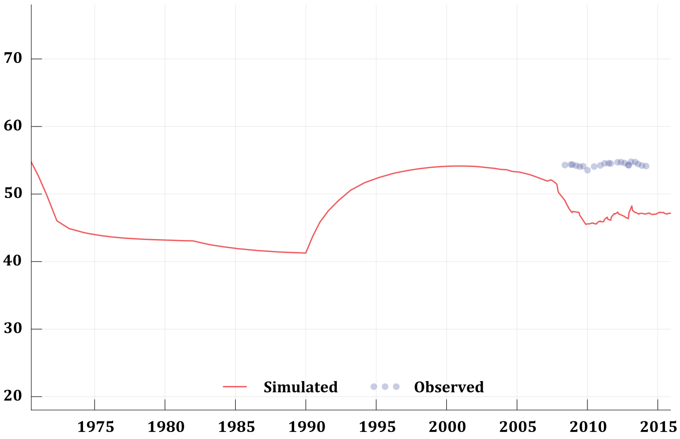

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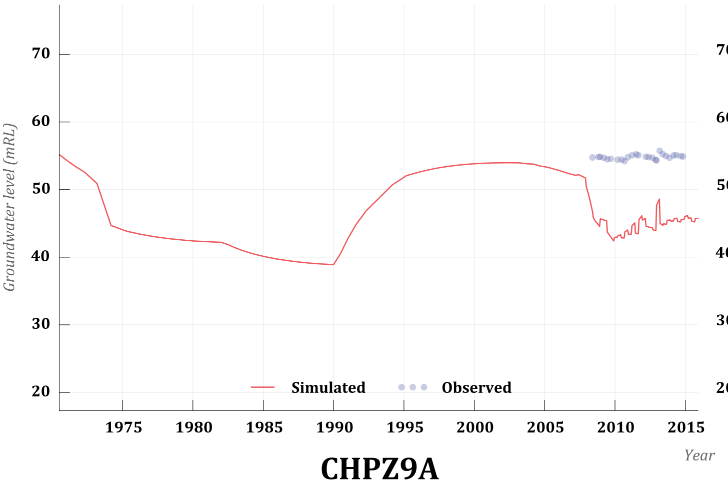

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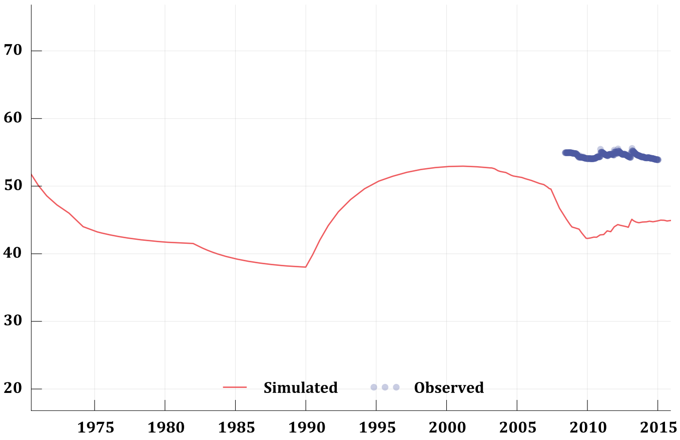

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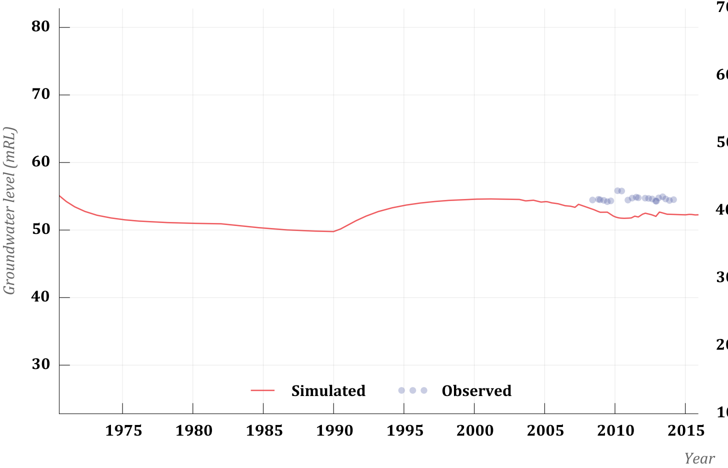
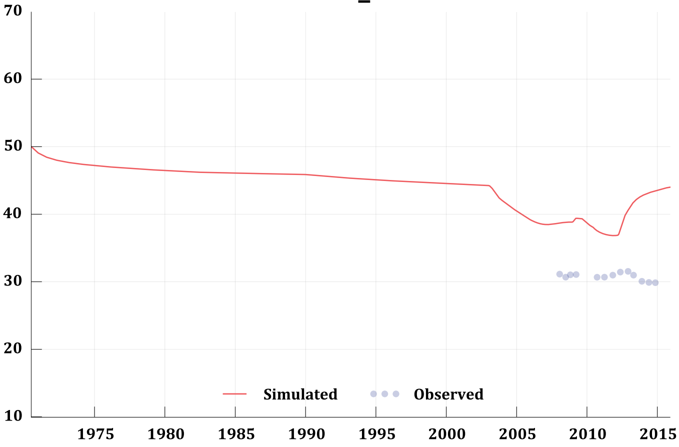
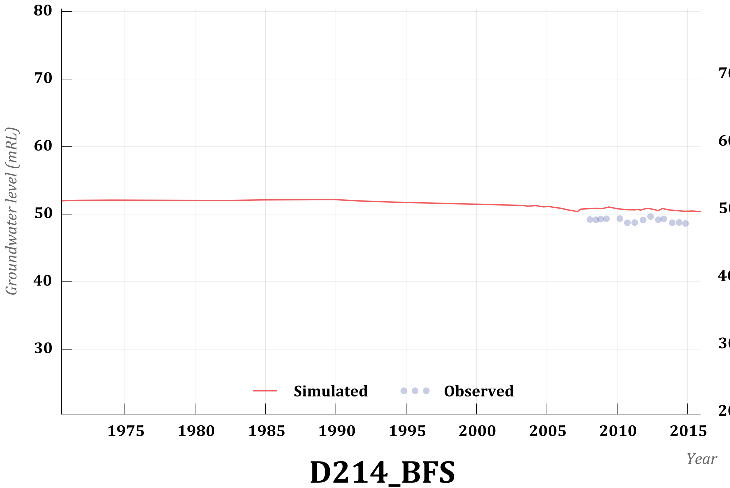


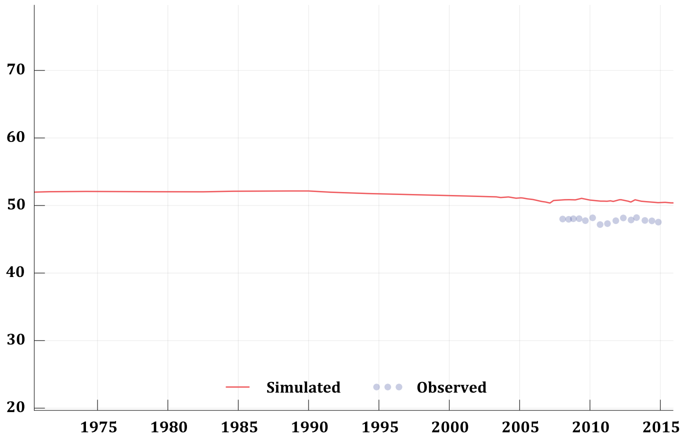
D010_BFS



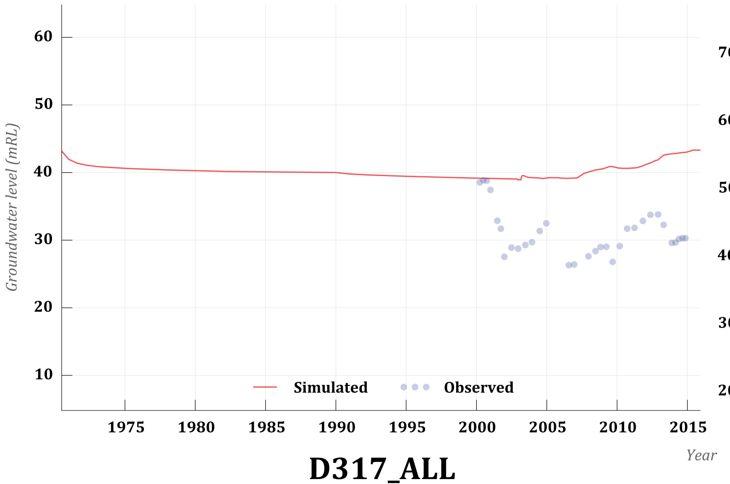
D010_GM



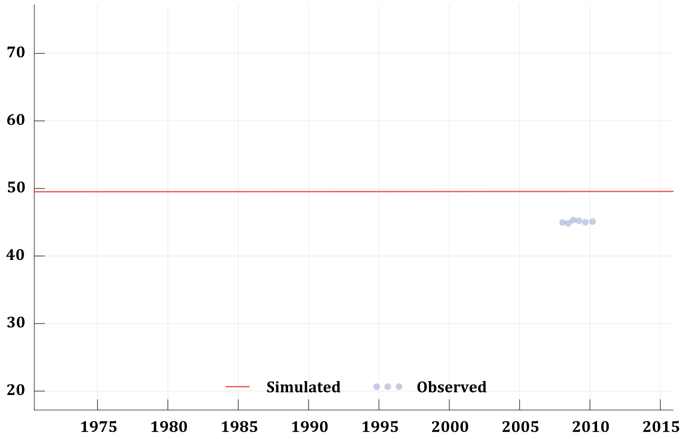
D010_WDH



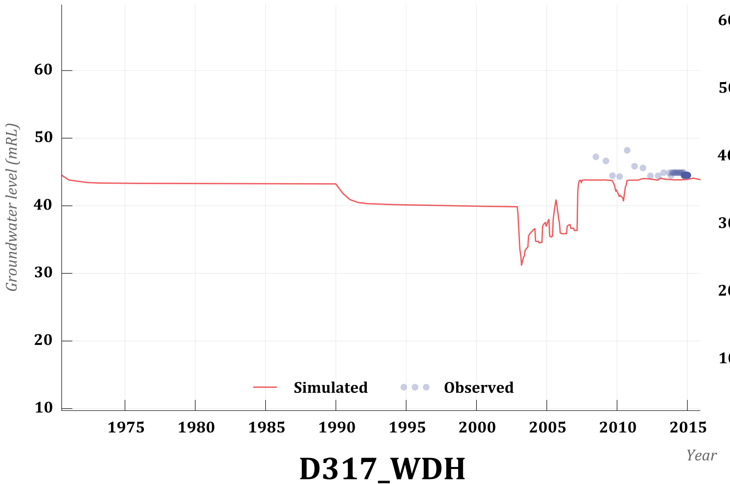
D214_BFS



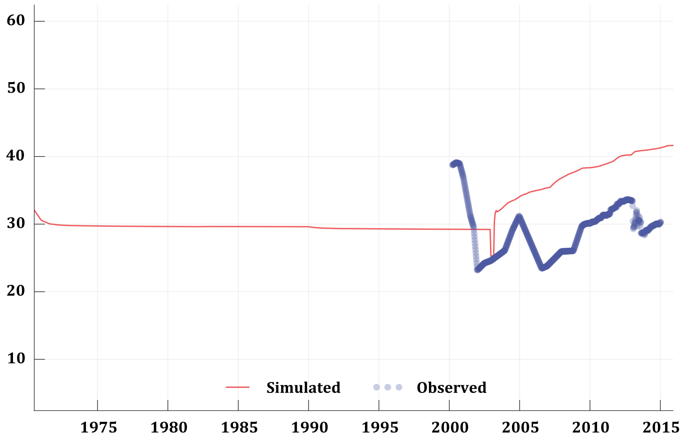
D2_WH236



D317_ALL



D317_BFS



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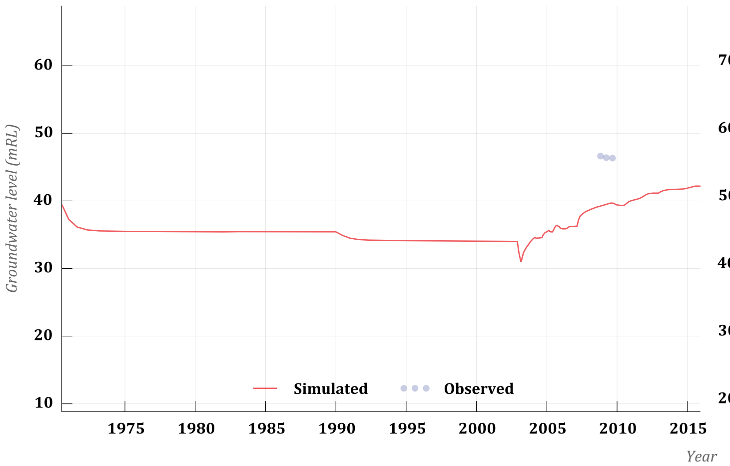
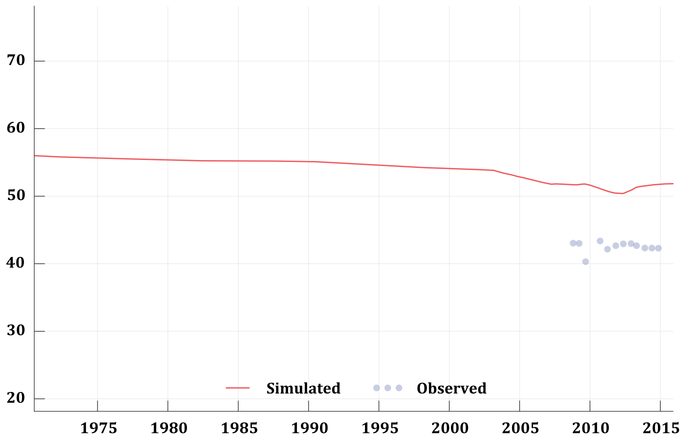


D406_AFS



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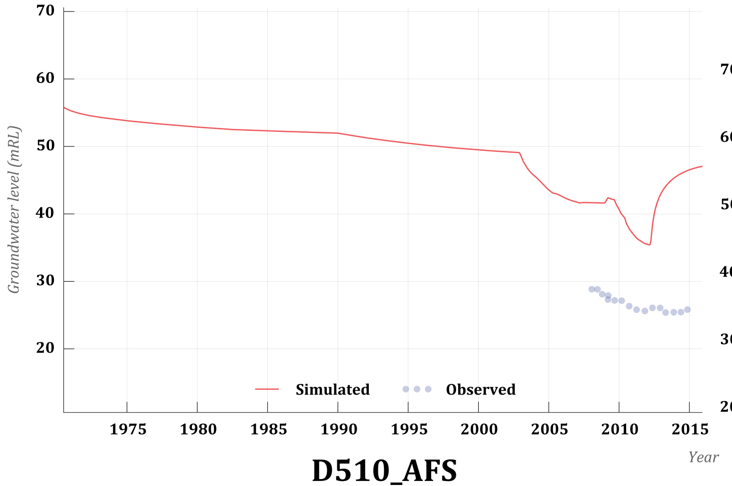

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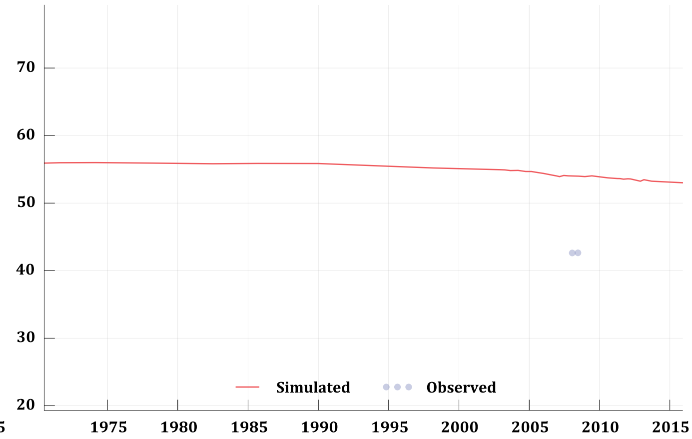

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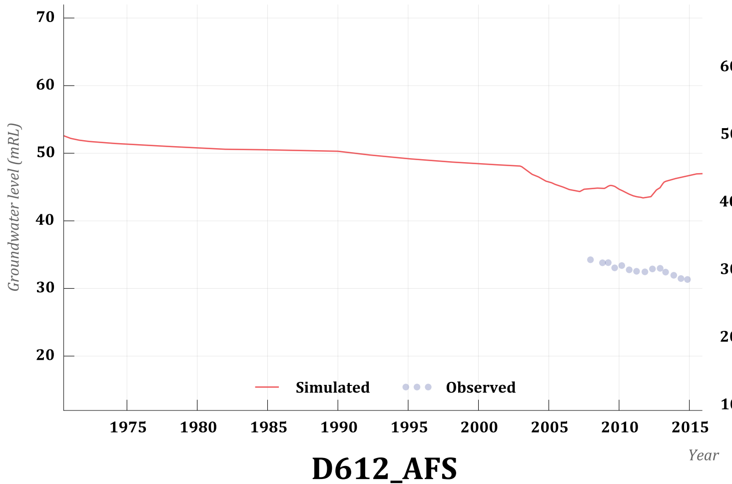

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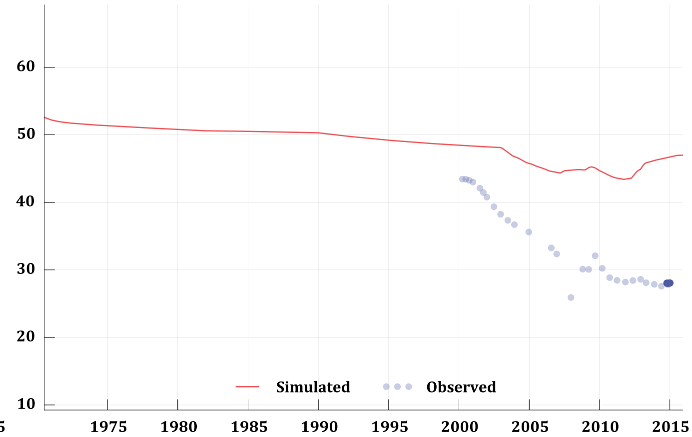

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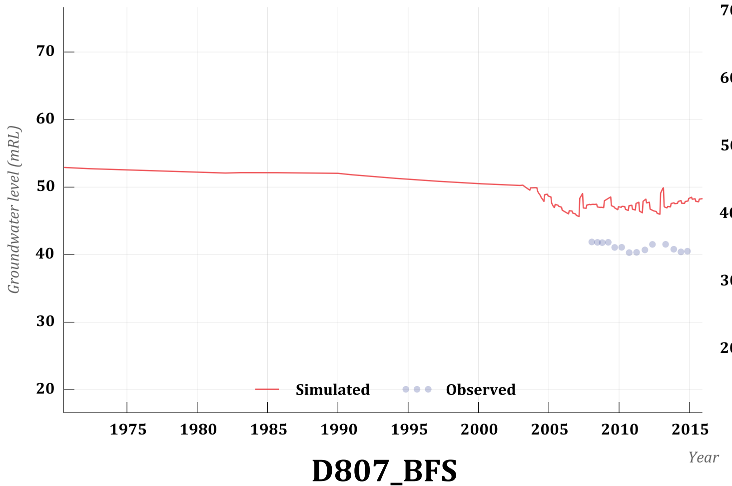

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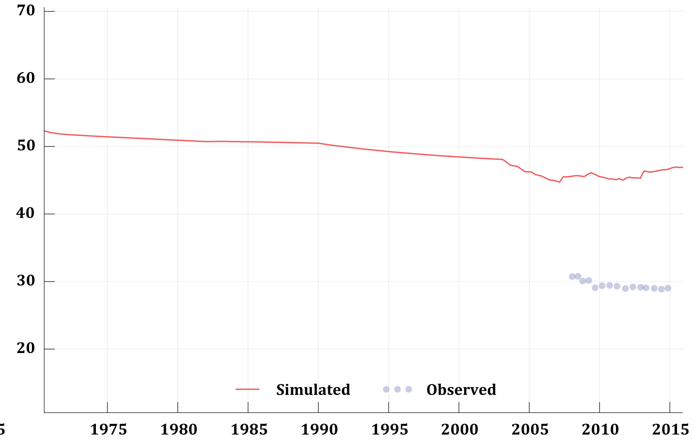

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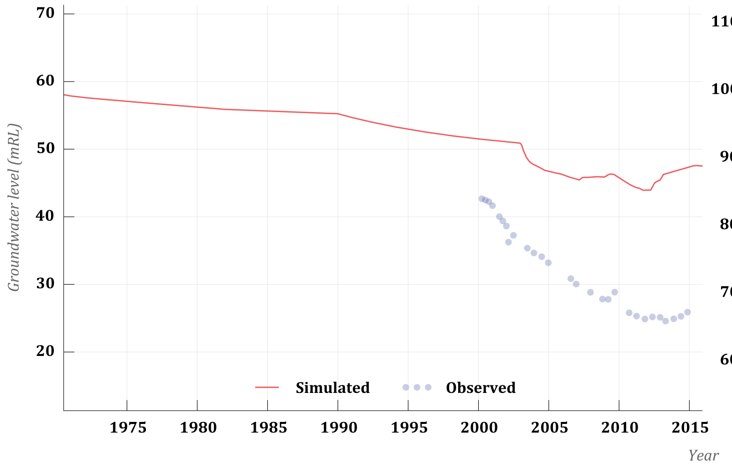

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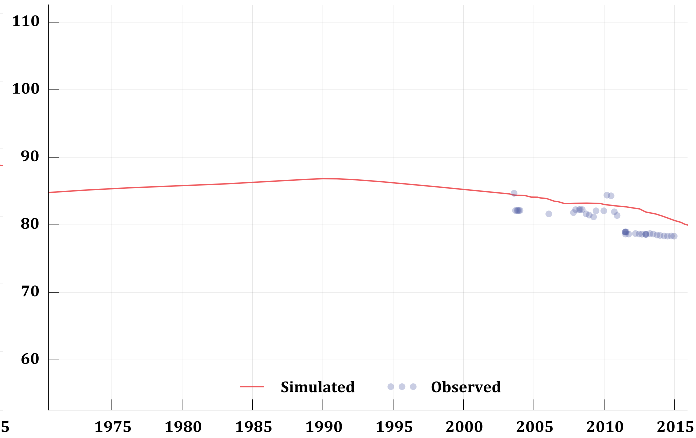

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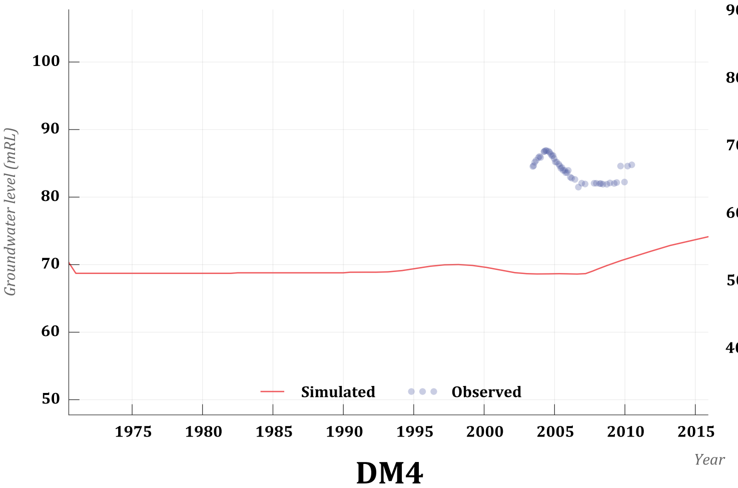

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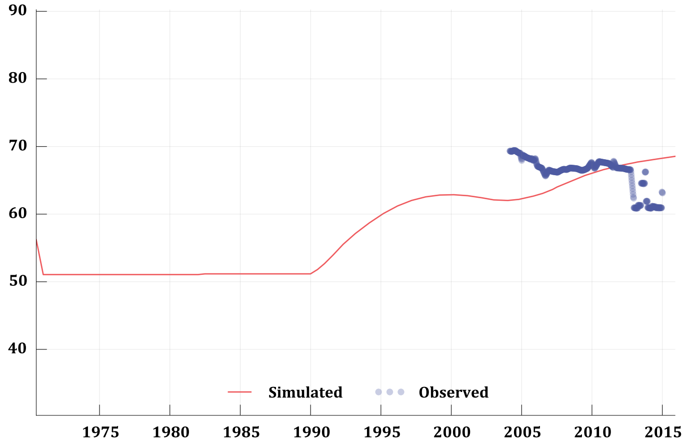

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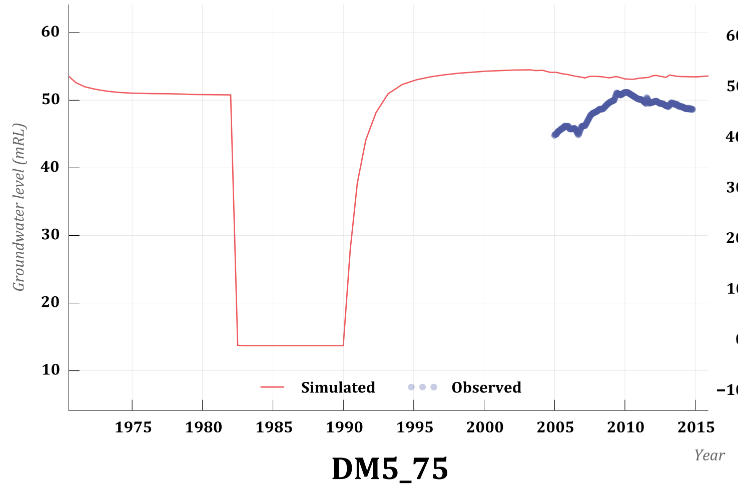

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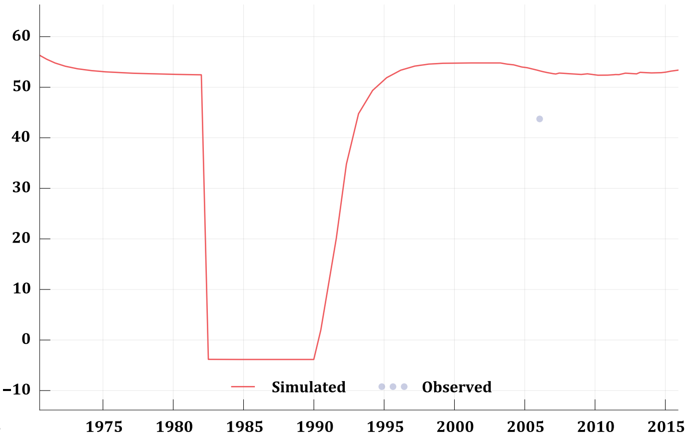

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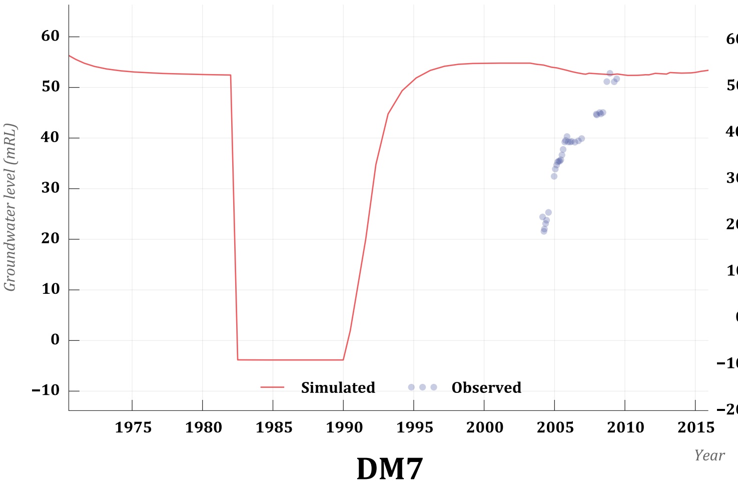

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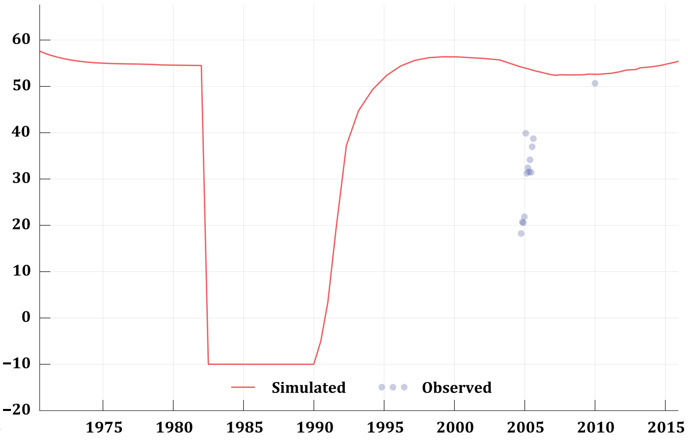

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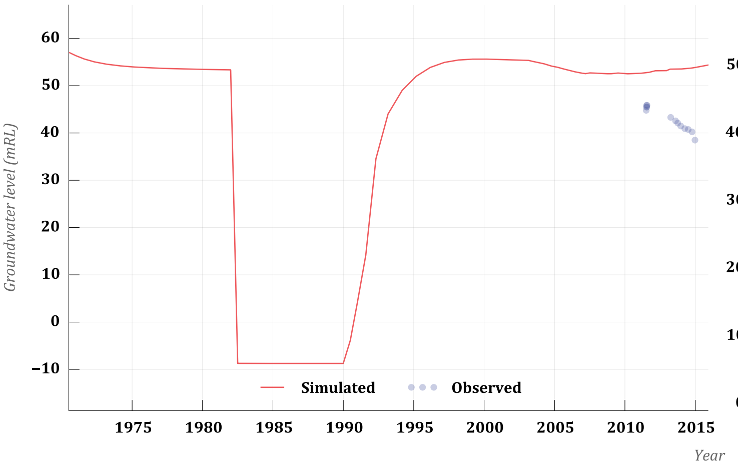

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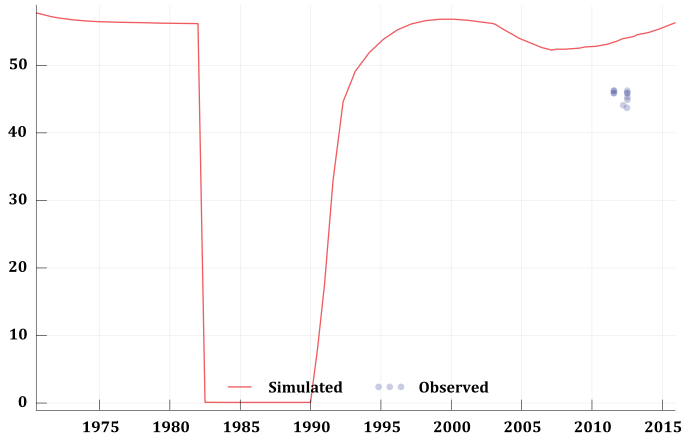

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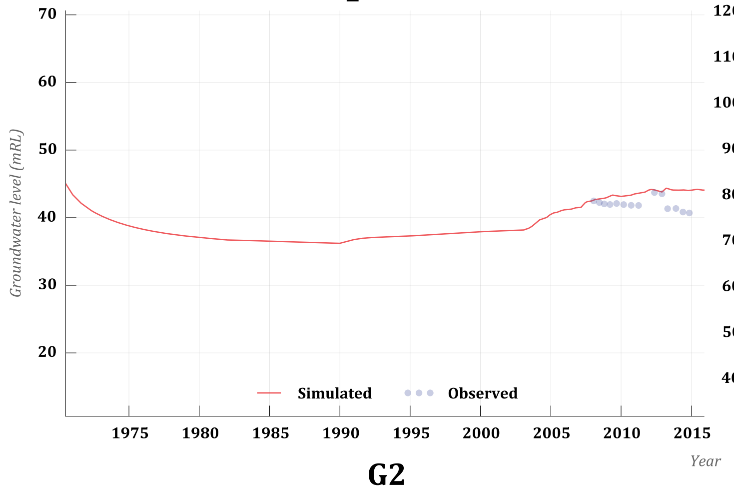

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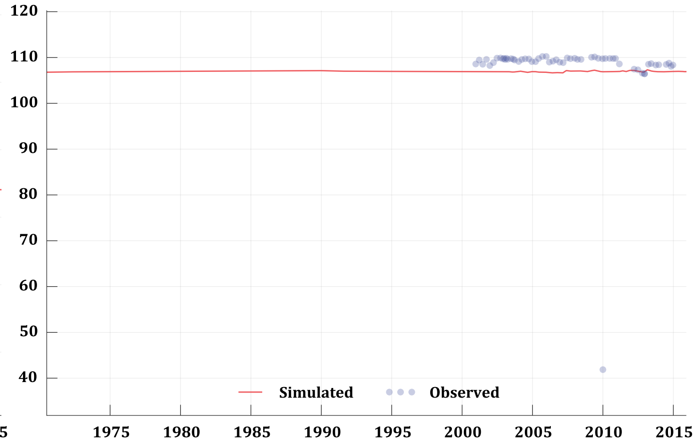

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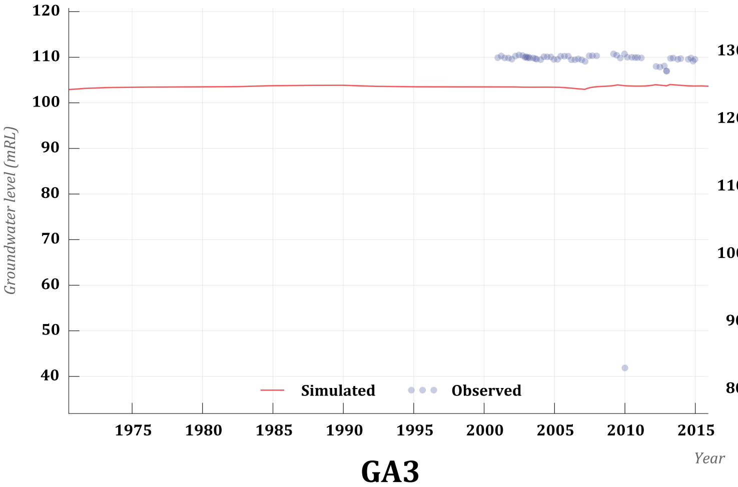

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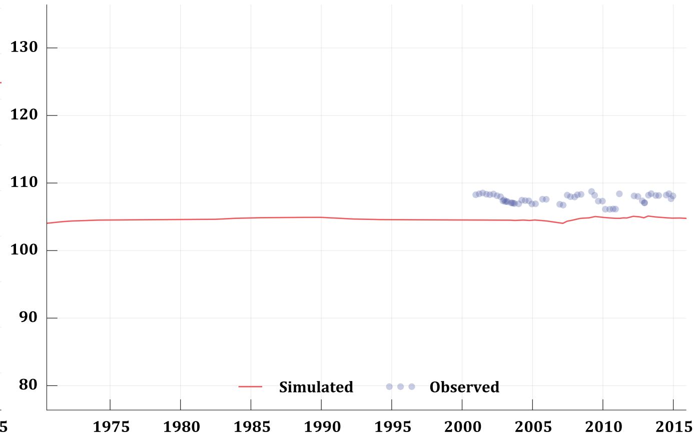

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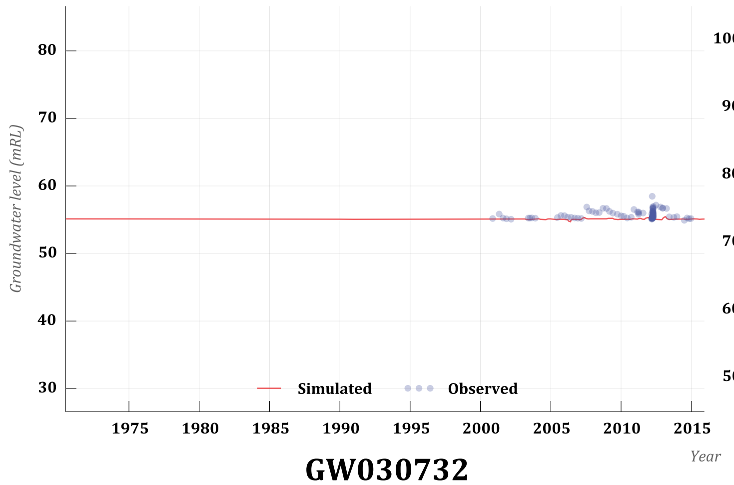

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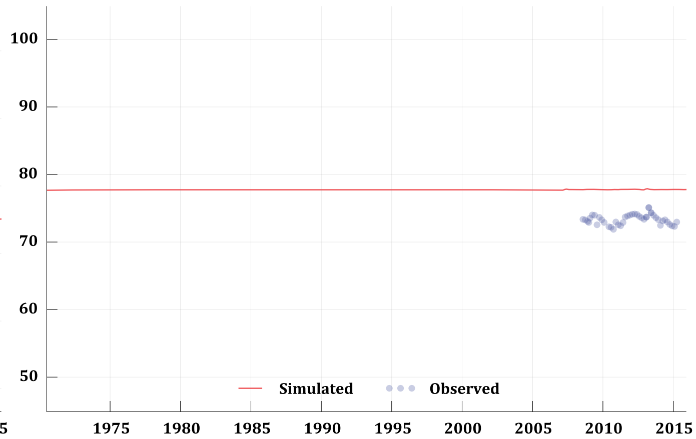

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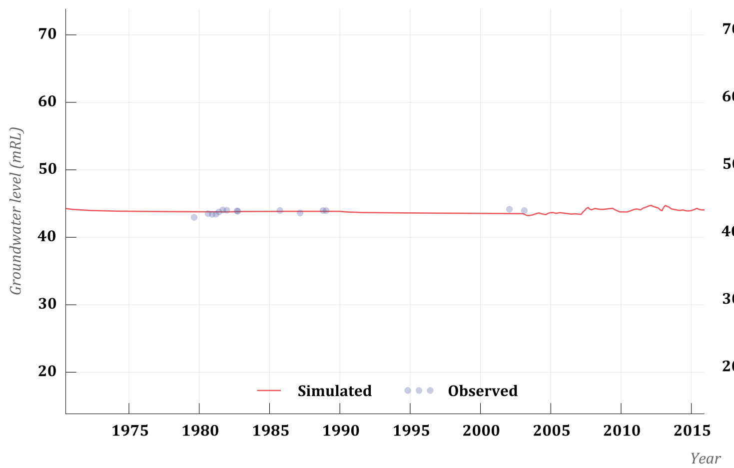

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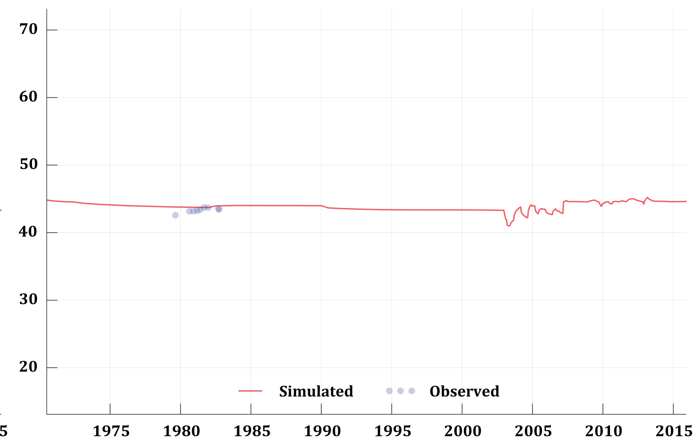

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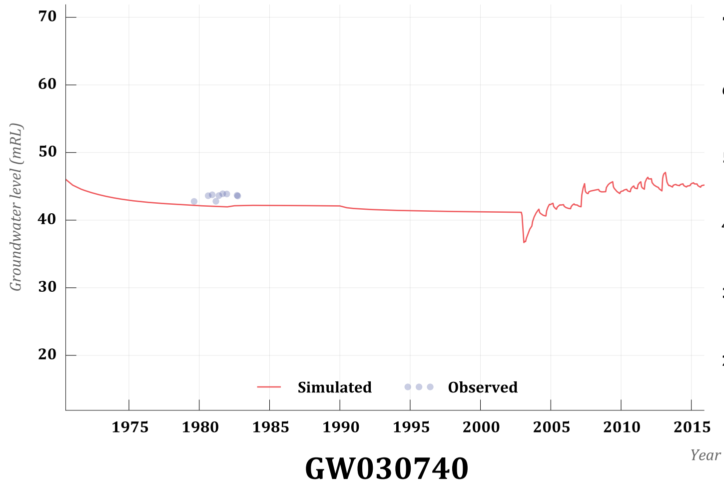

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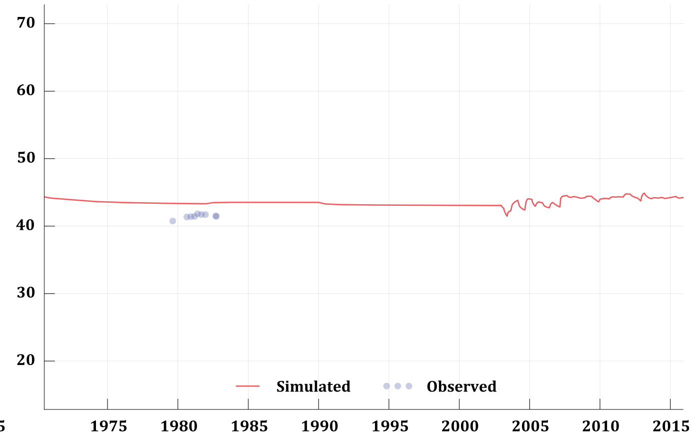

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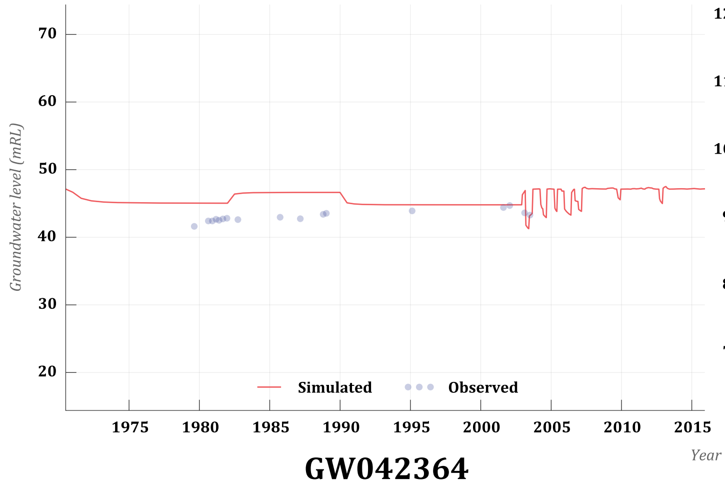

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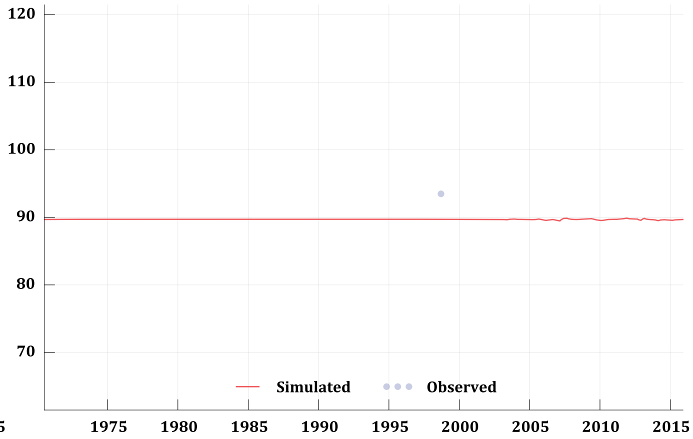

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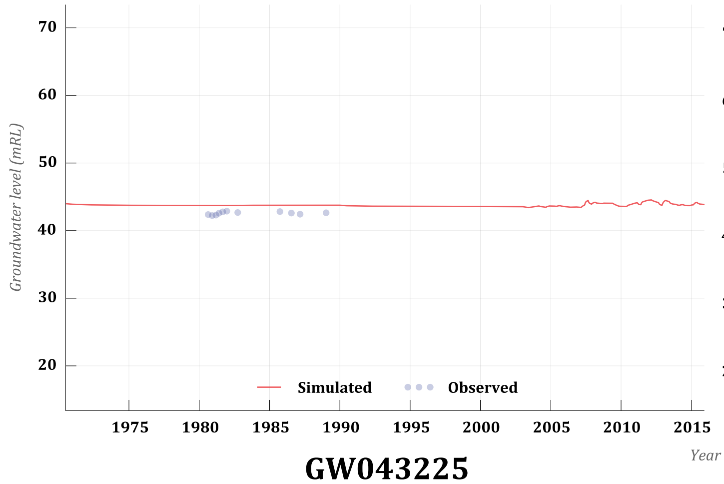

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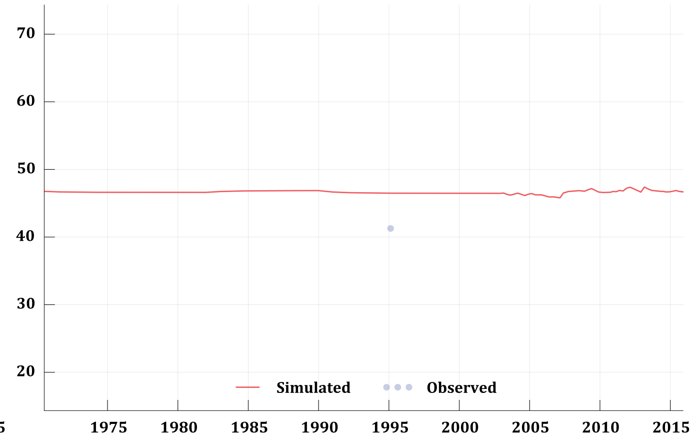

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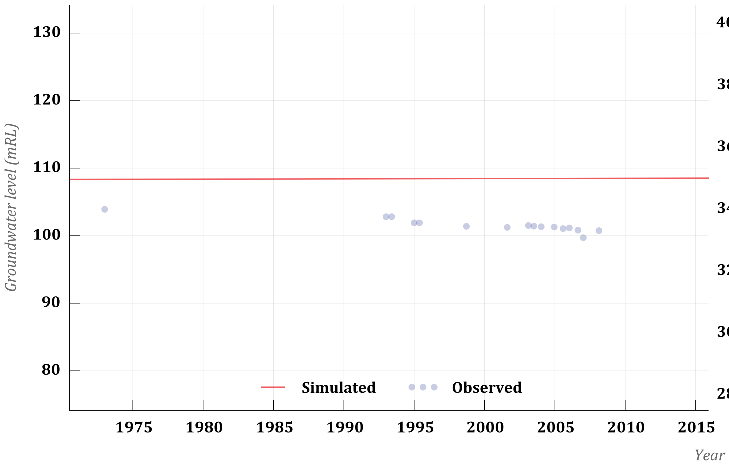

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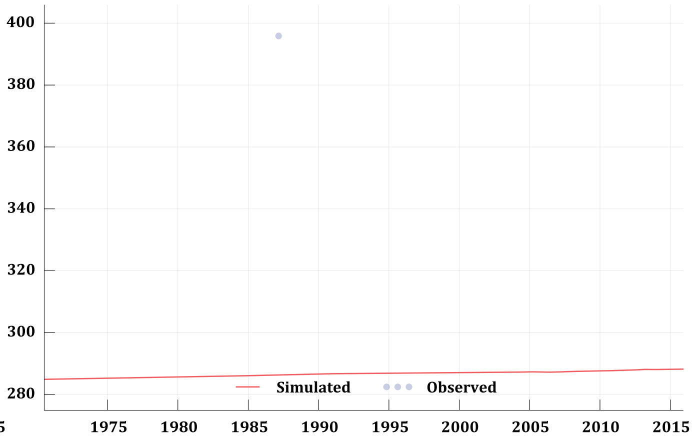

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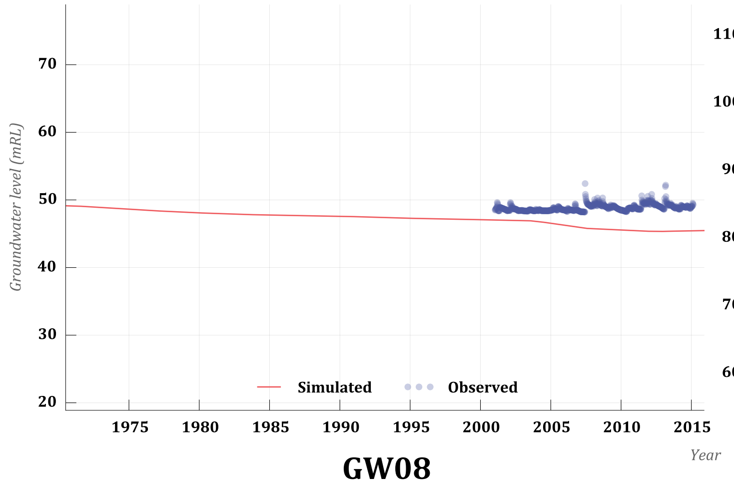

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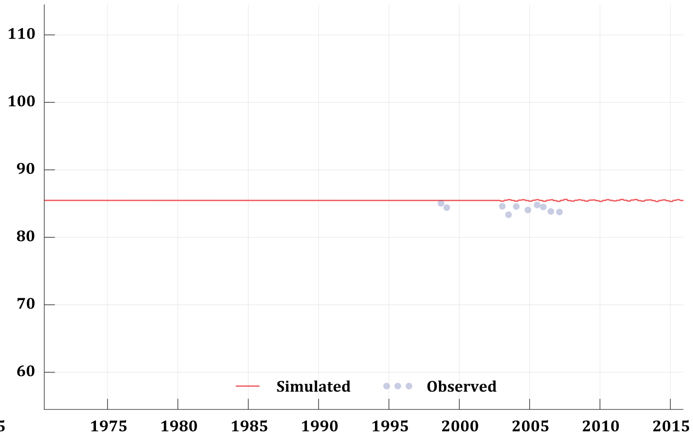

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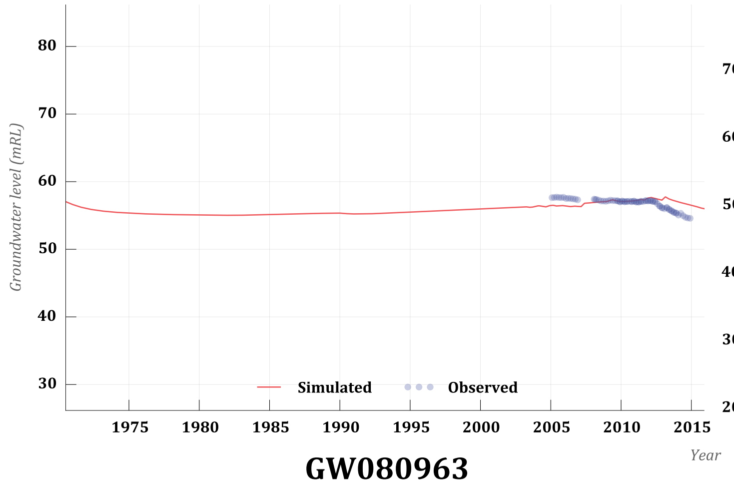

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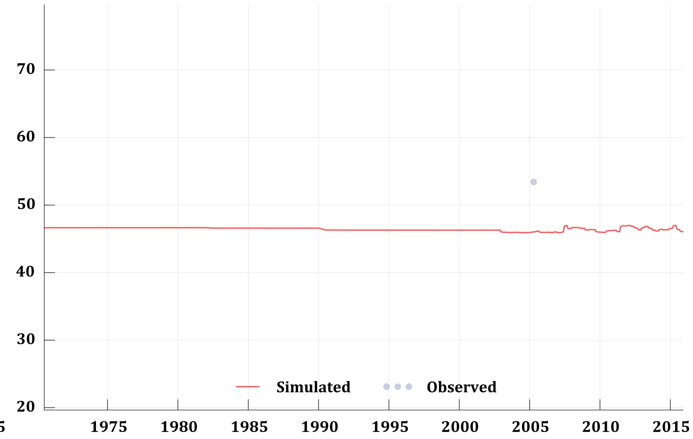

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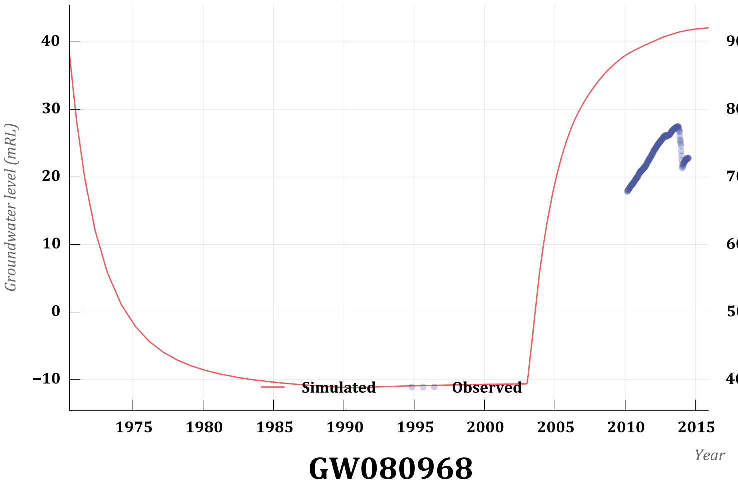

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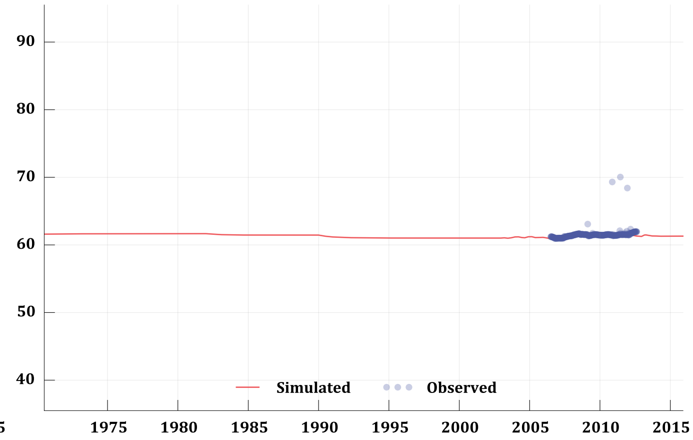

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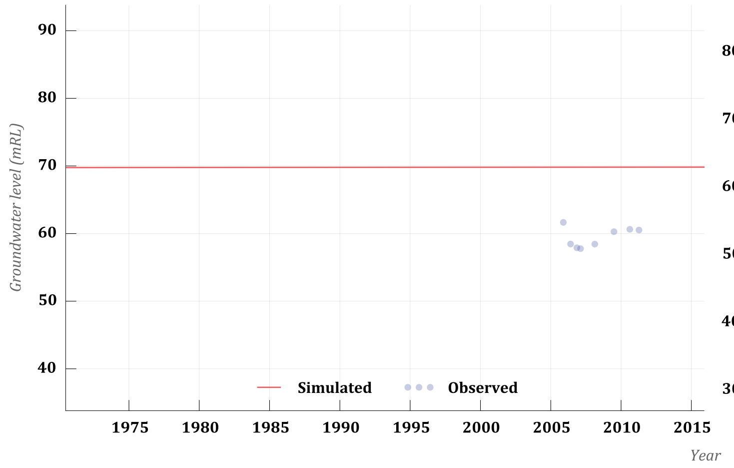

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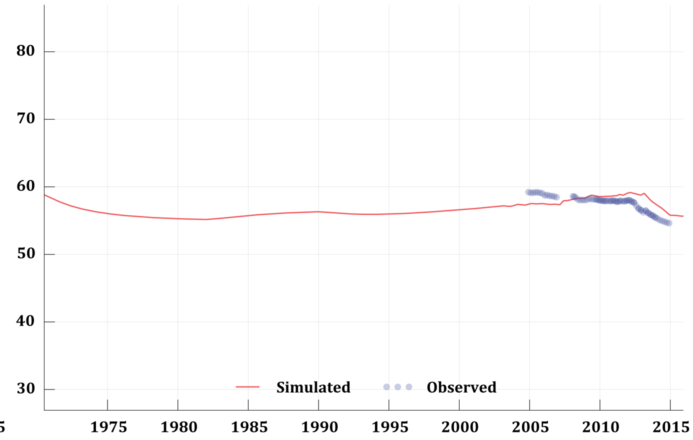

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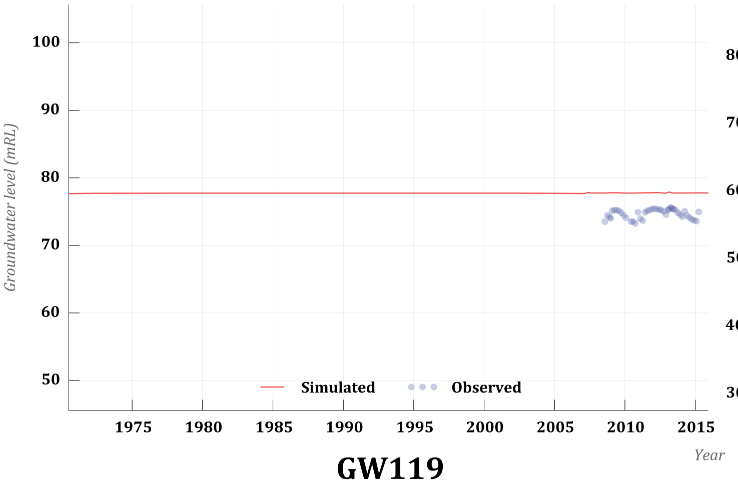

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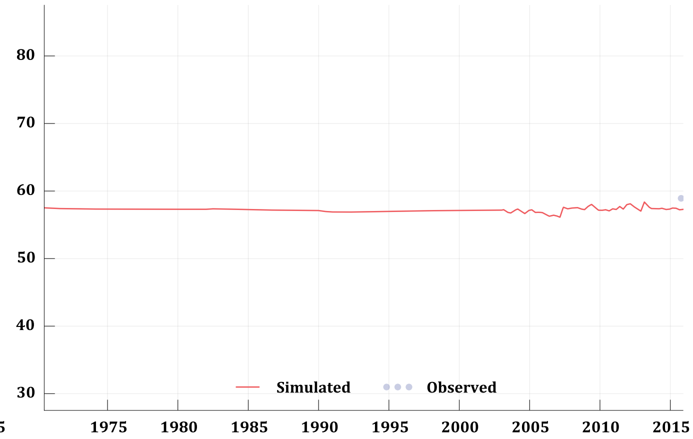

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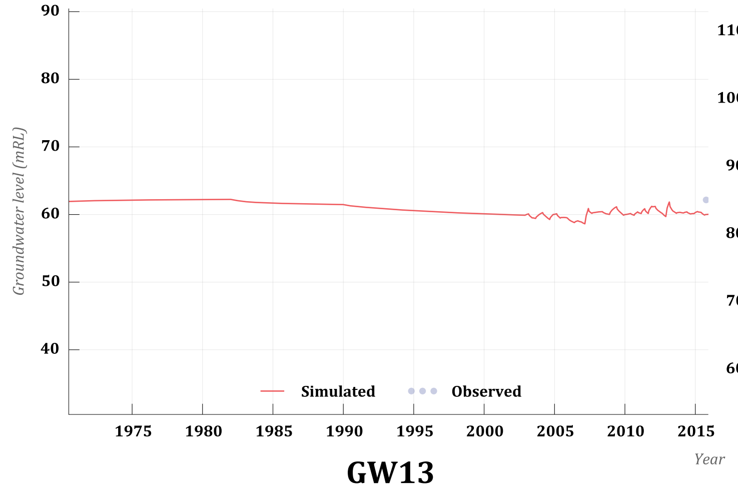

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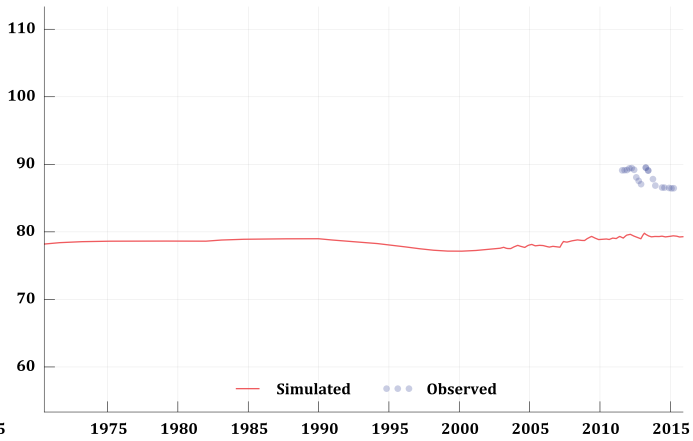

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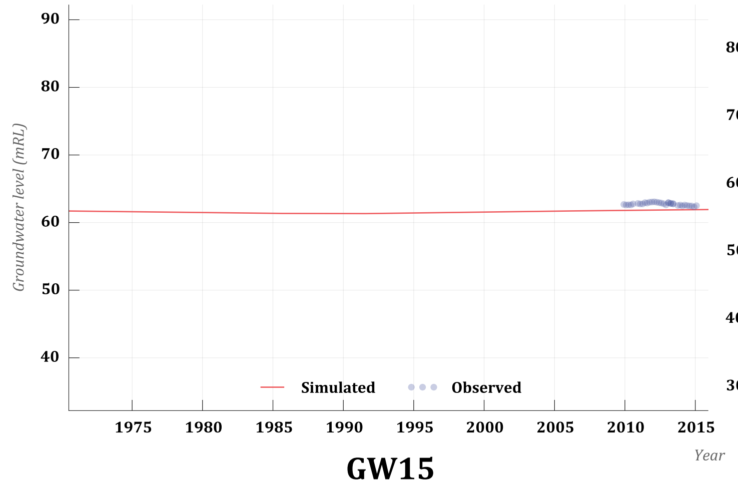

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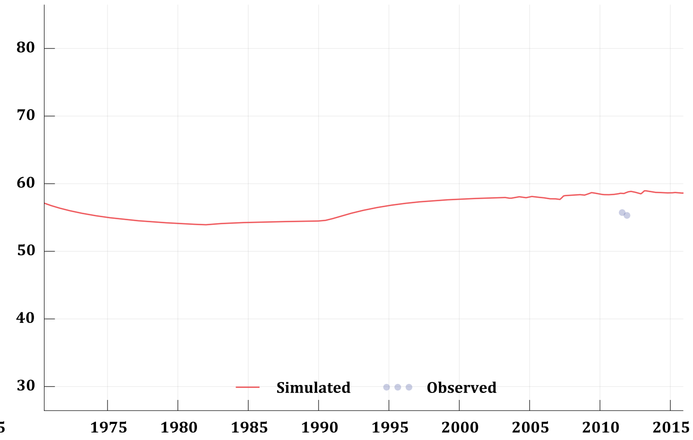

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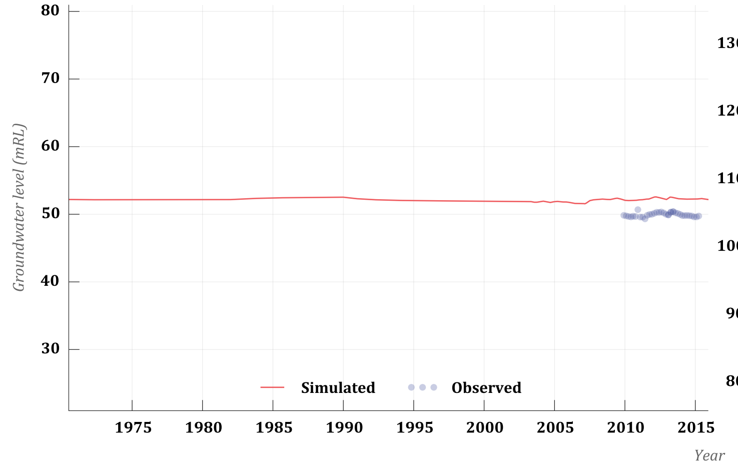

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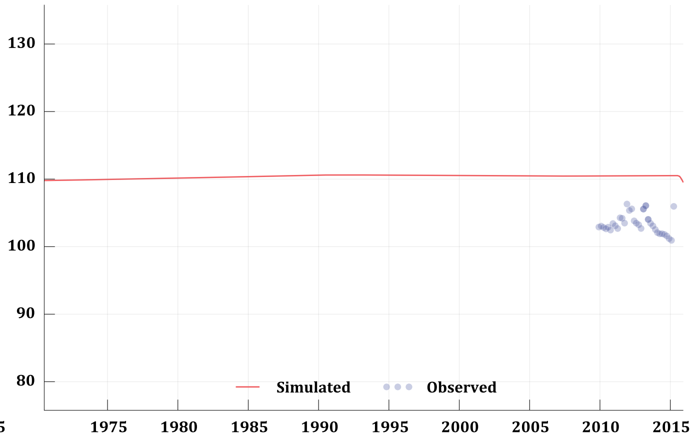

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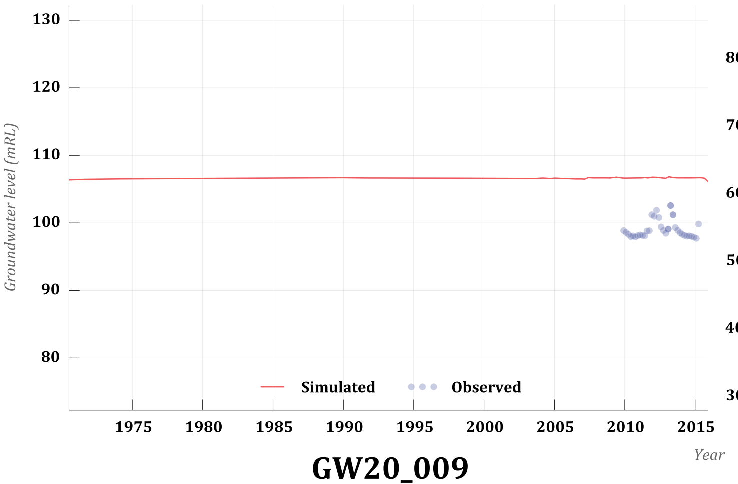

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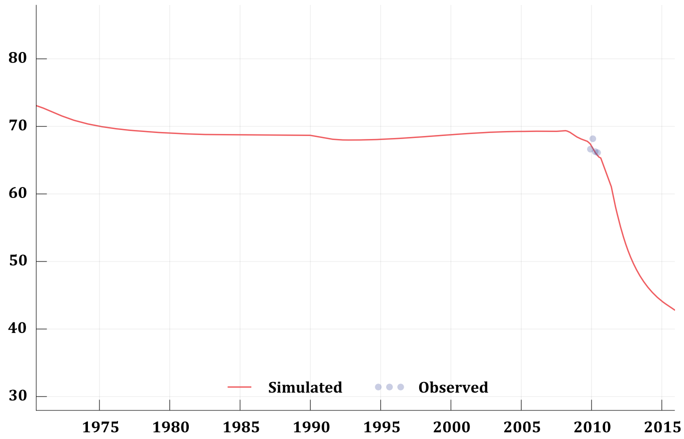

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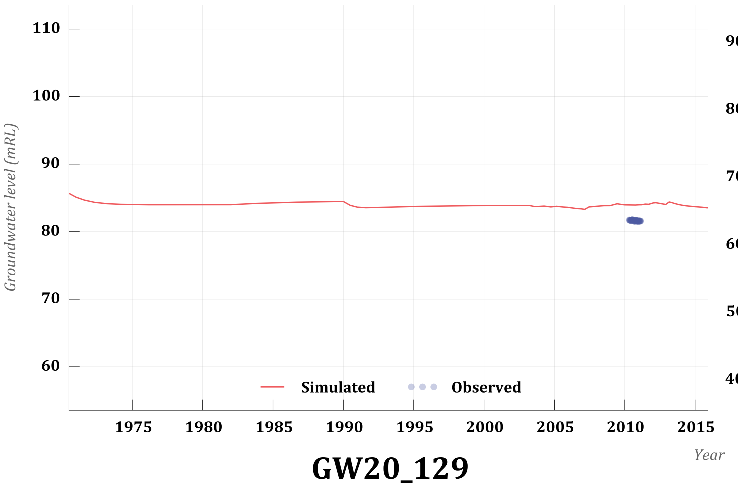

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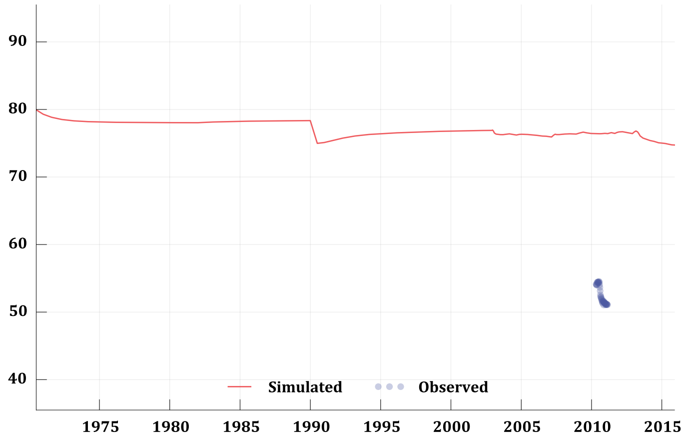

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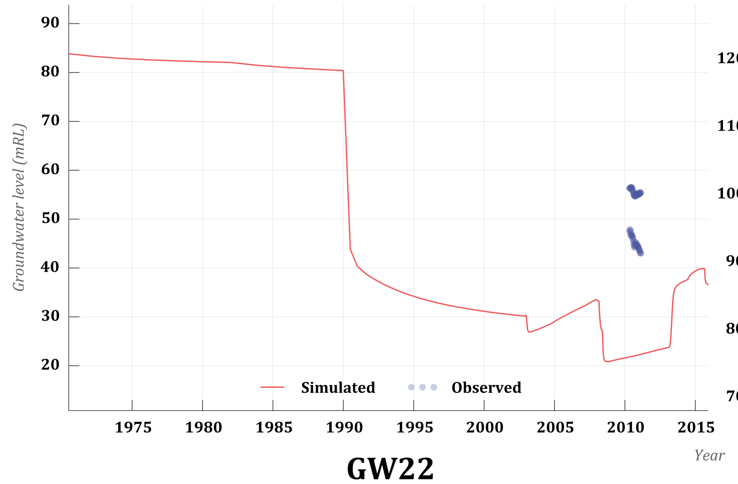

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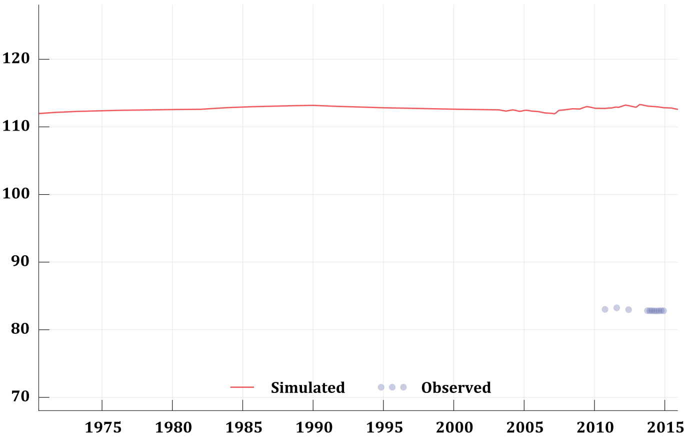

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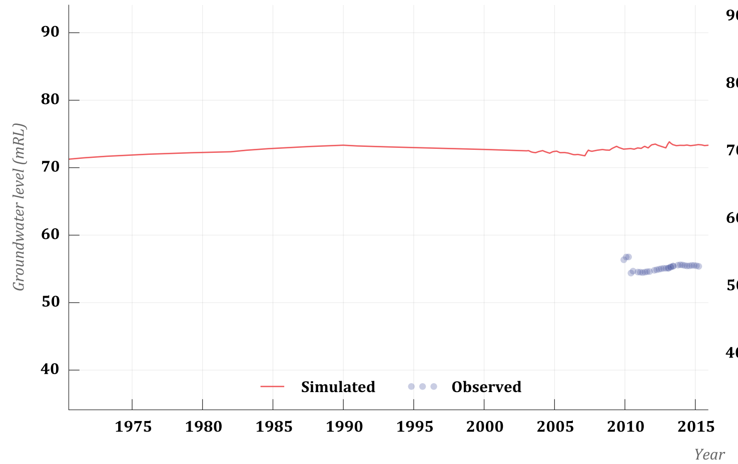

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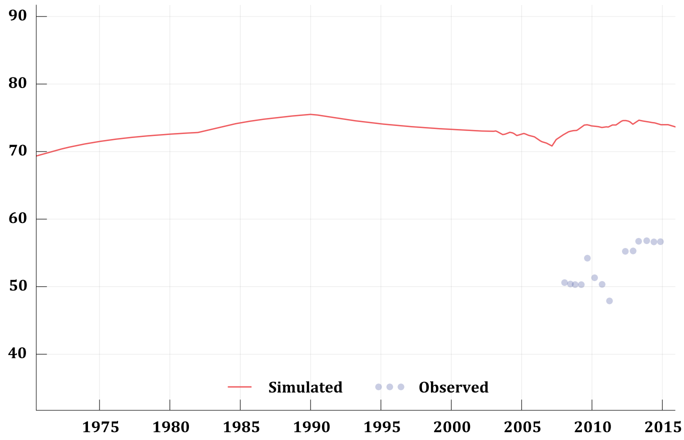

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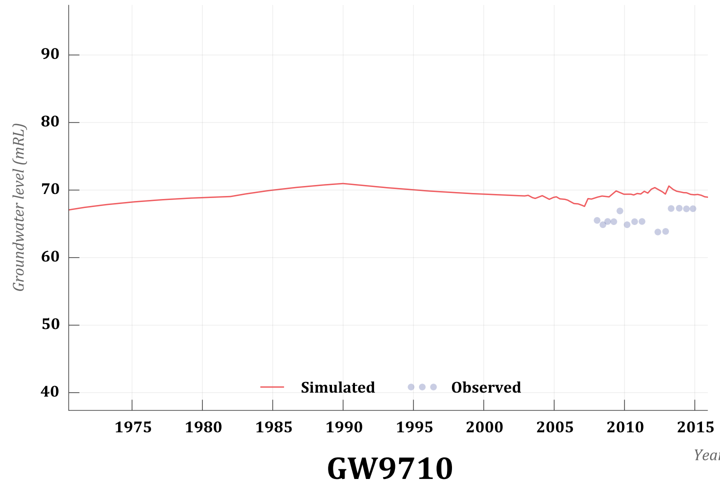

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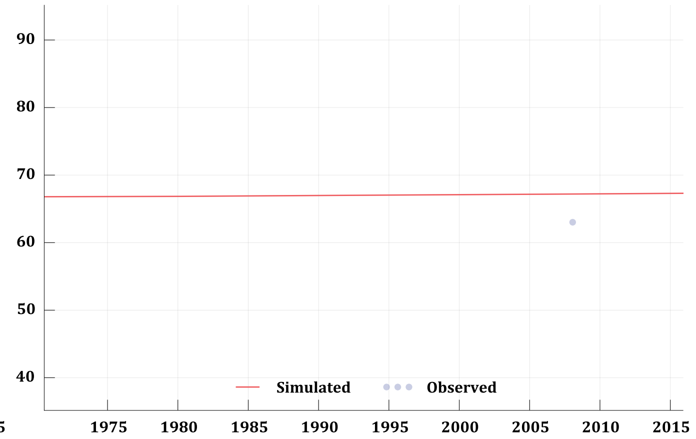

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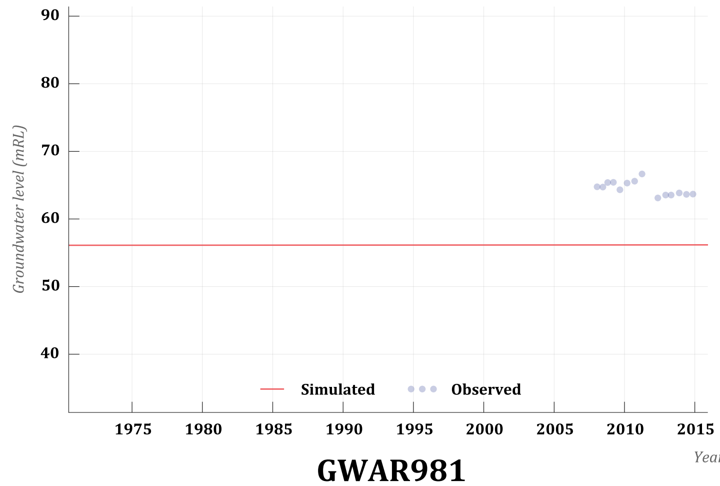

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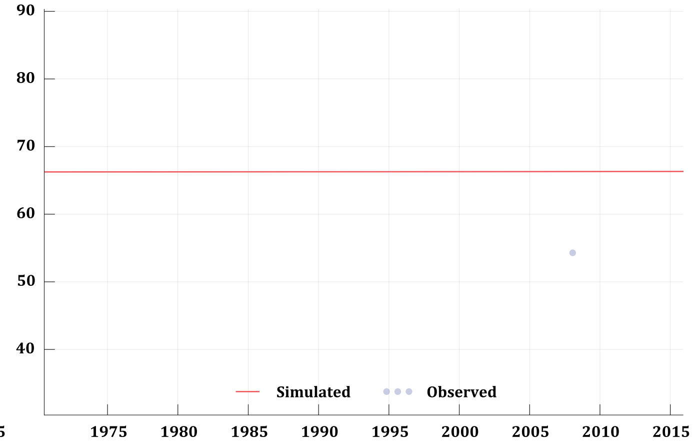

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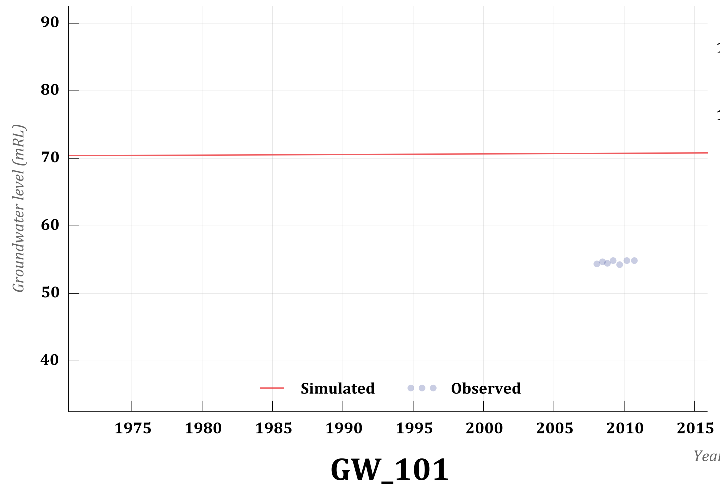

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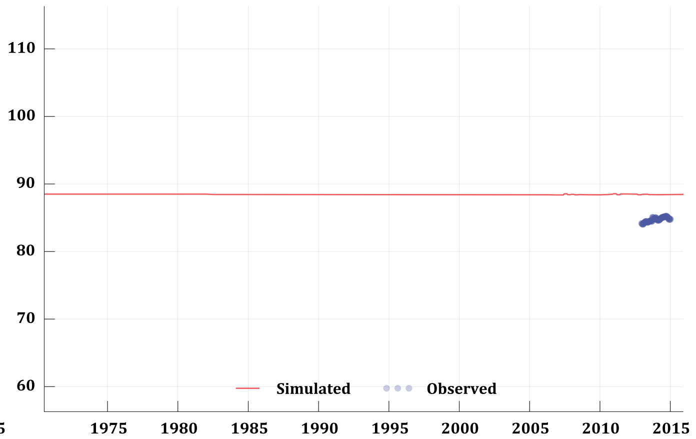

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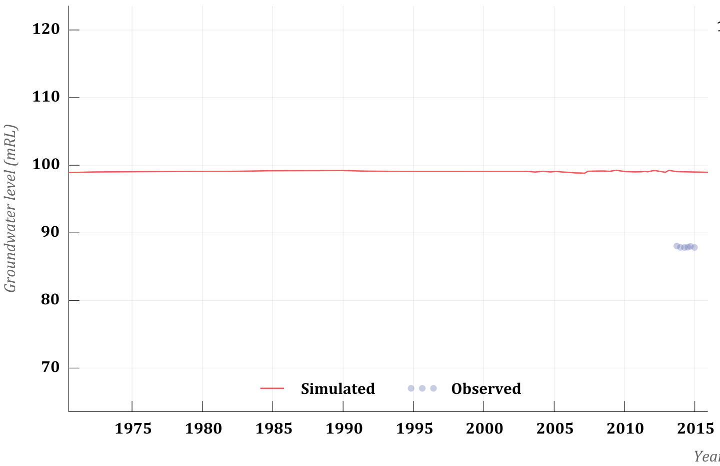

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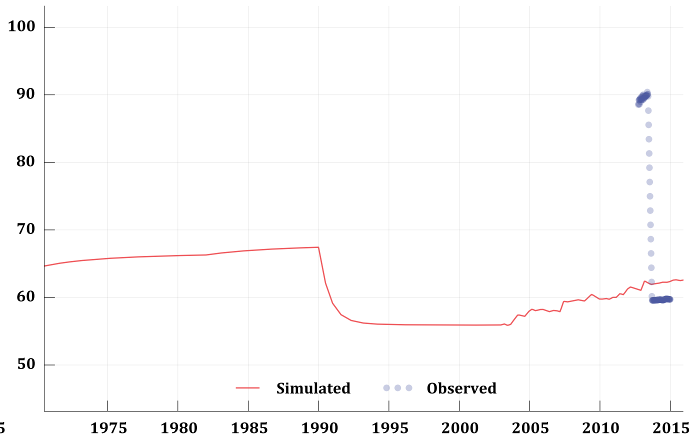

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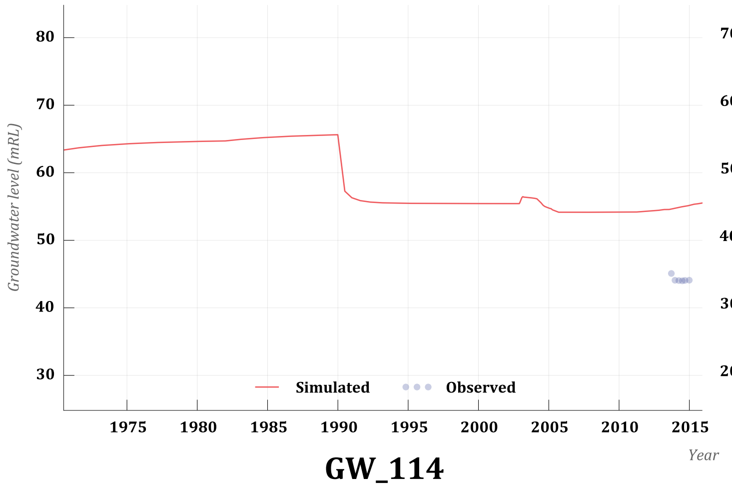

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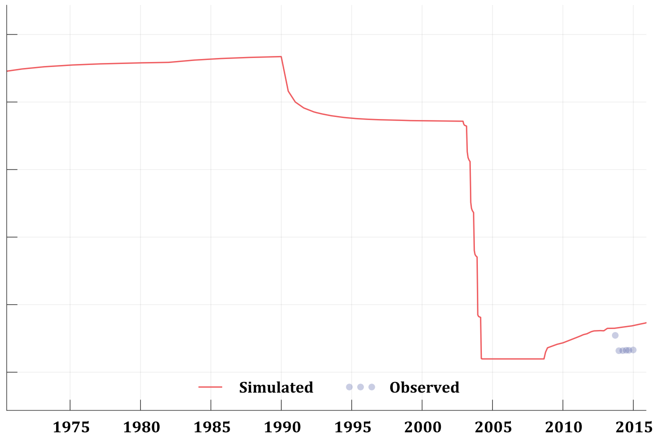

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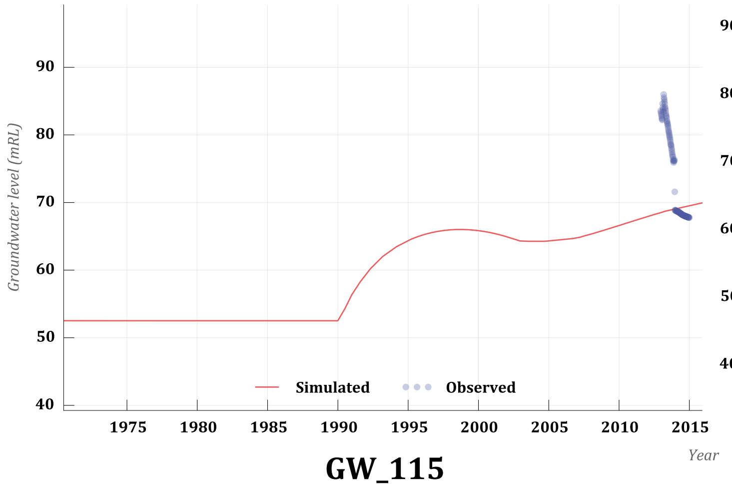

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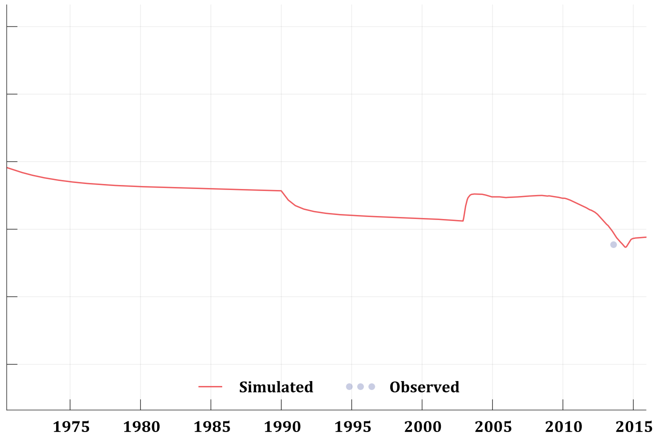

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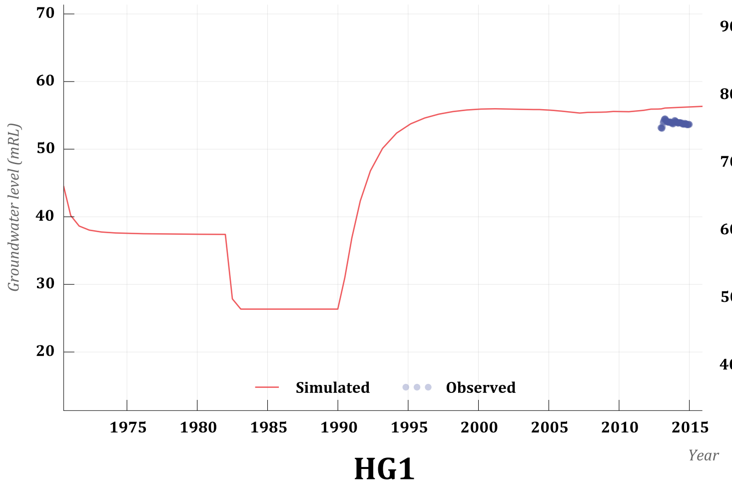

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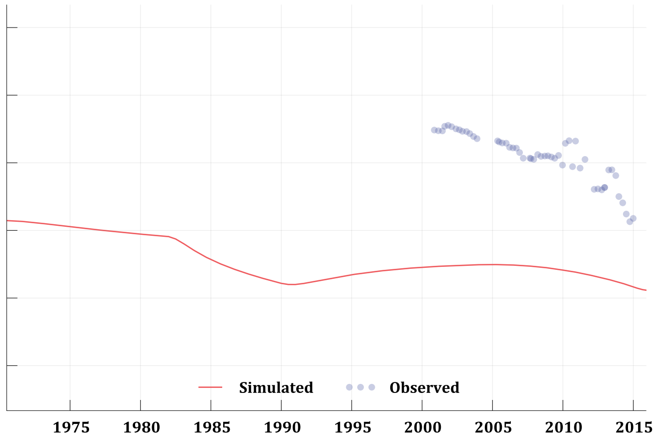

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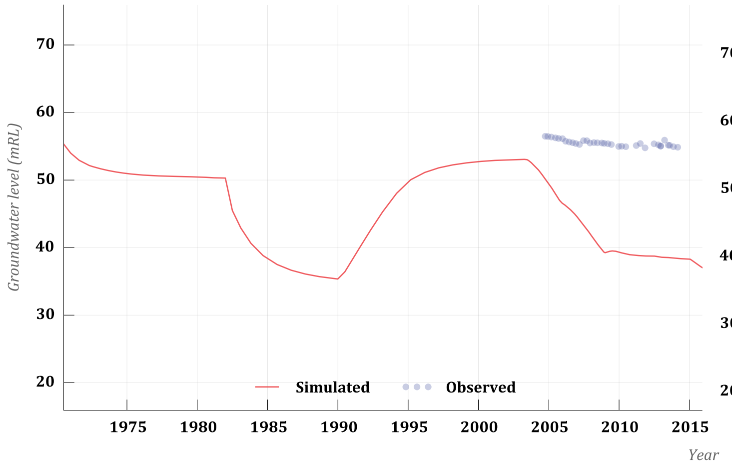

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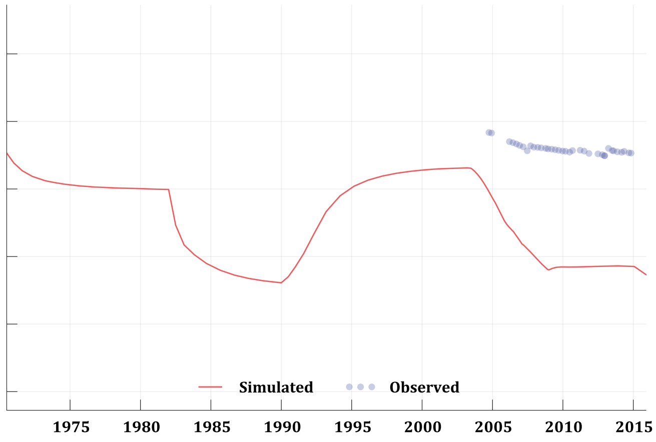
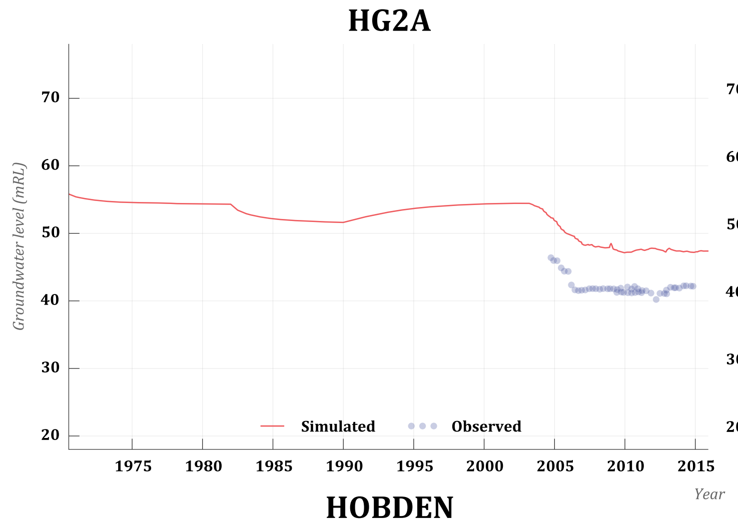
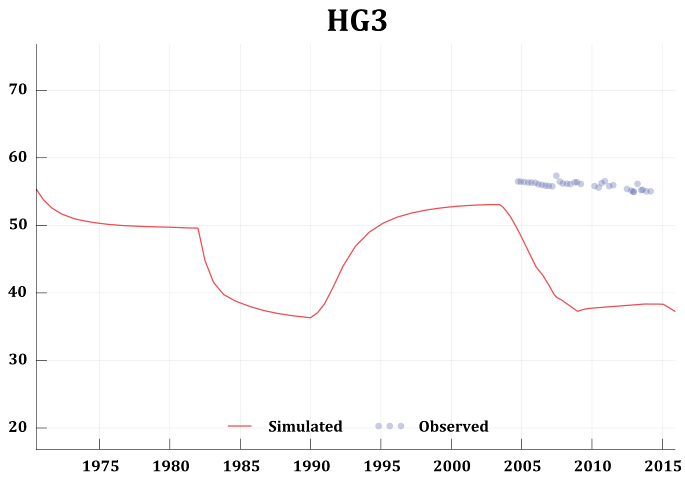
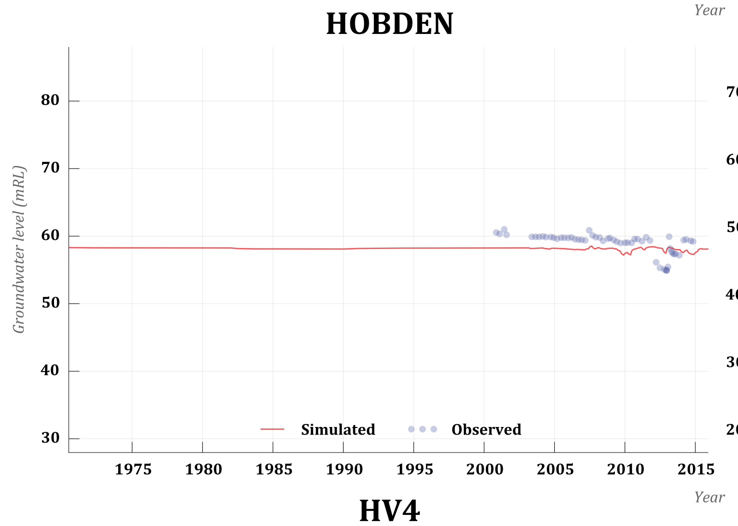
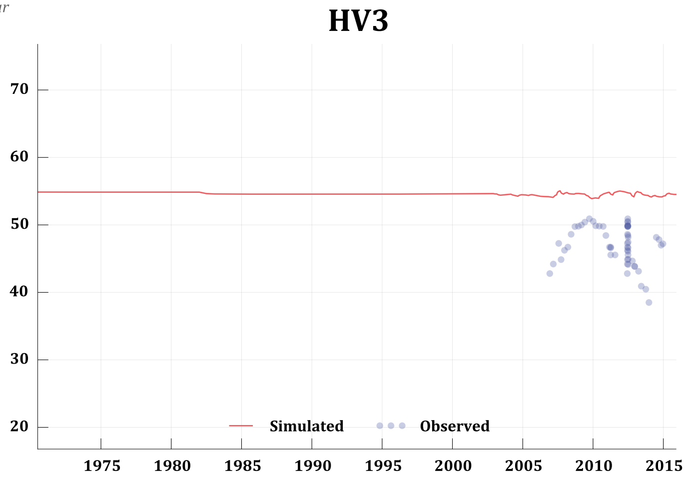
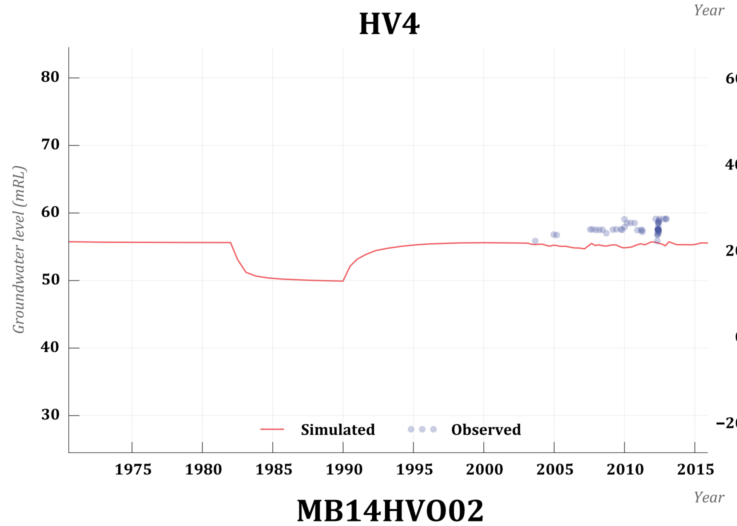



HG2A
Groundwater level (mRL)
20
30
40
50
60
70
Simulated
Observed
1975
1980
1985
1990
1995
2000
2005
2010
2015
Year


HG3
20
30
40
50
60
70
Simulated
Observed
1975
1980
1985
1990
1995
2000
2005
2010
2015


HOBDEN
Groundwater level (mRL)
30
40
50
60
70
80
Simulated
Observed
1975
1980
1985
1990
1995
2000
2005
2010
2015
Year


HV3
20
30
40
50
60
70
Simulated
Observed
1975
1980
1985
1990
1995
2000
2005
2010
2015


HV4
Groundwater level (mRL)
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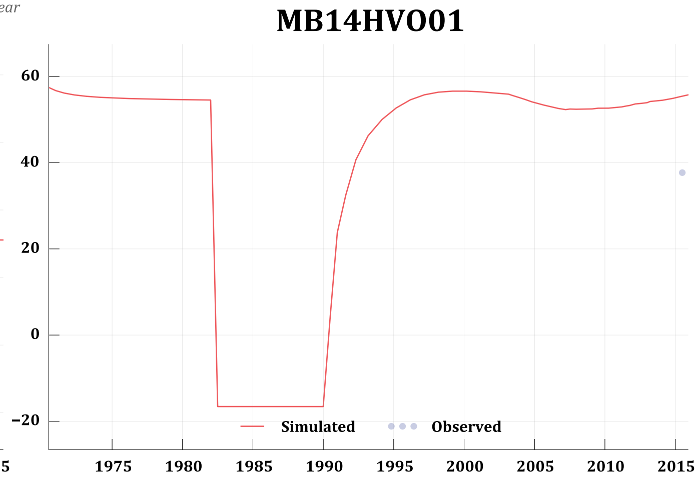
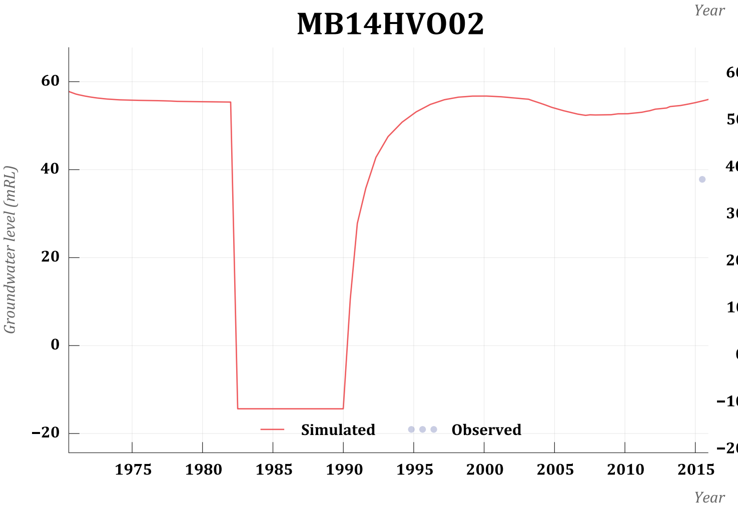
40
50
60
70
80
Simulated
Observed
1975
1980
1985
1990
1995
2000
2005
2010
2015
Year


MB14HVO01
−20
0
20
40
60
Simulated
Observed
1975
1980
1985
1990
1995
2000
2005
2010
2015


MB14HVO02
Groundwater level (mRL)
−20
0
20
40
60
Simulated
Observed
1975
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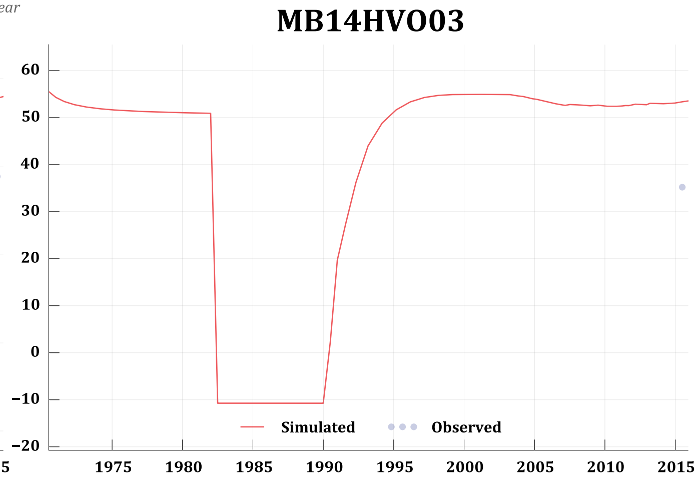
2005
2010
2015
Year


MB14HVO03
−20
−10
0
10
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30
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50
60
Simulated
Observed
1975
1980
1985
1990
1995
2000
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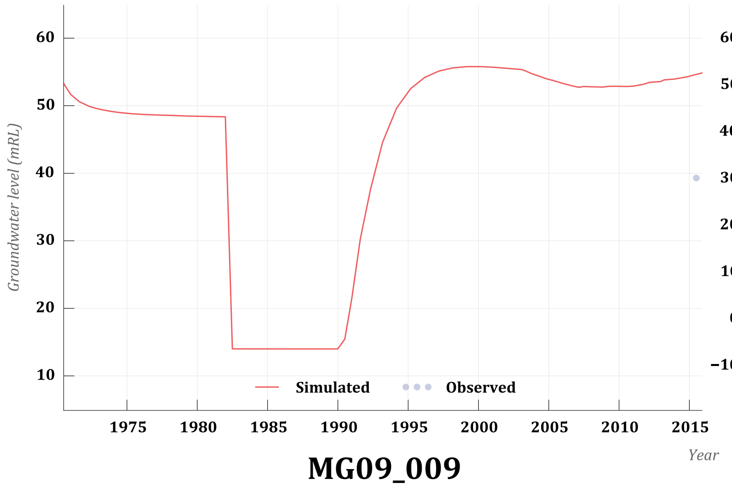
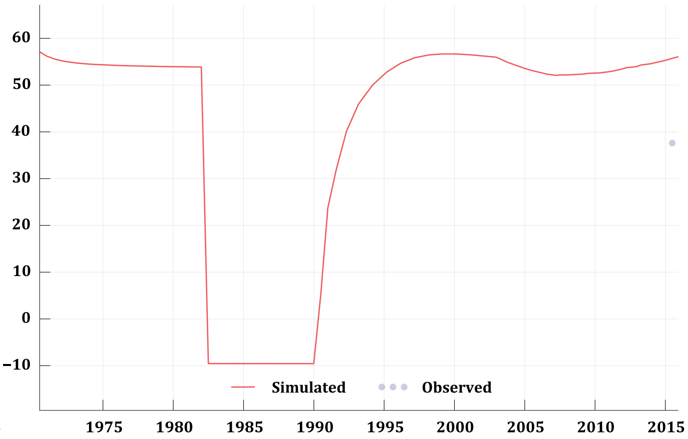
2010
2015

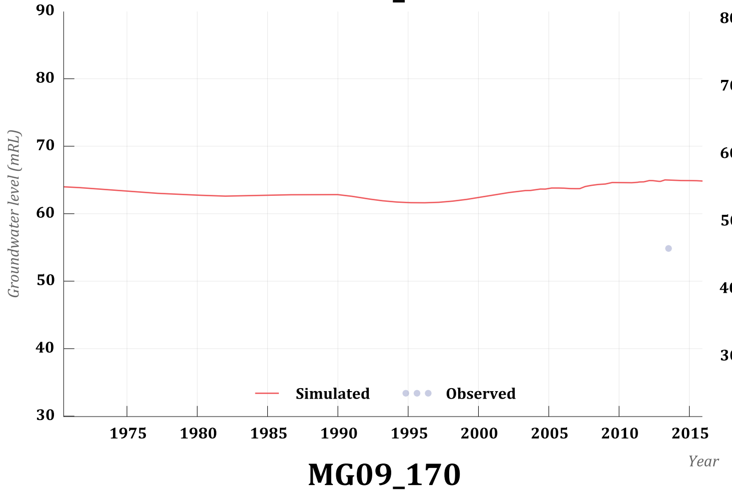
MB14HVO04



MB14HVO05



MG09_009



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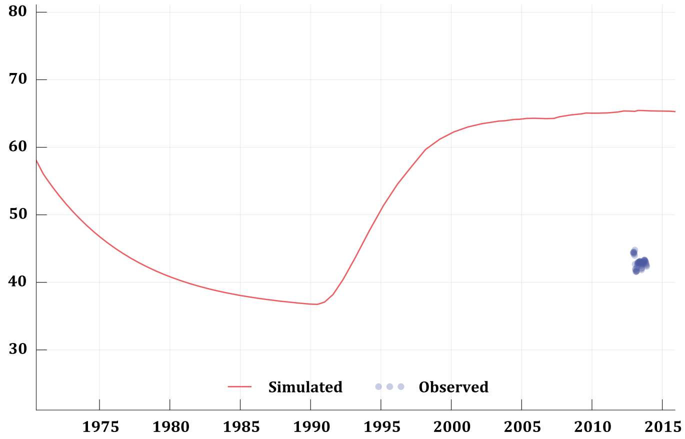

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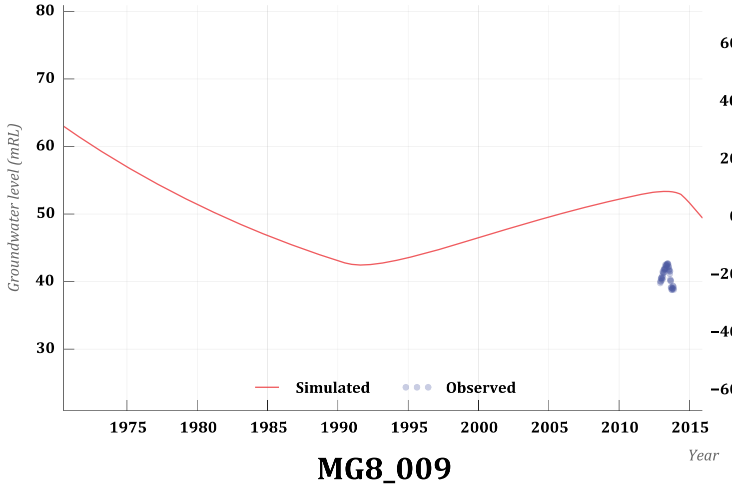

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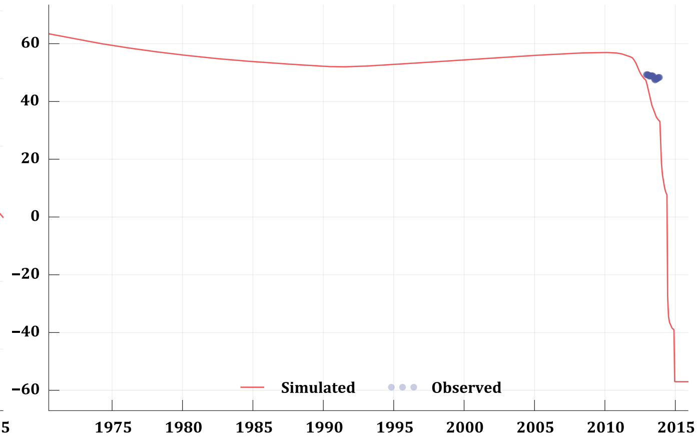

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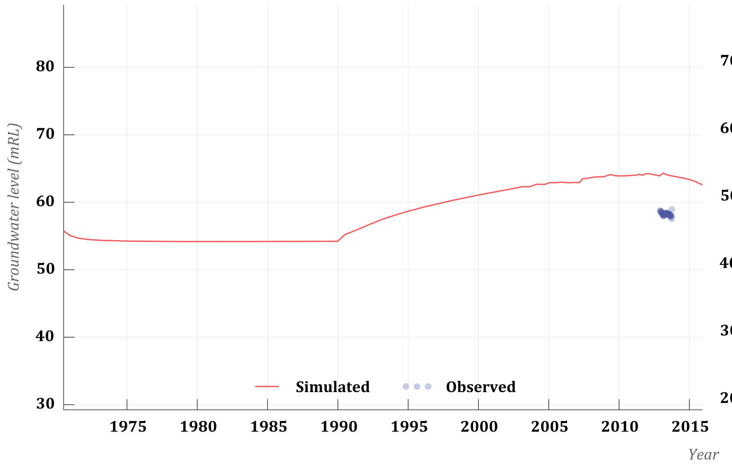

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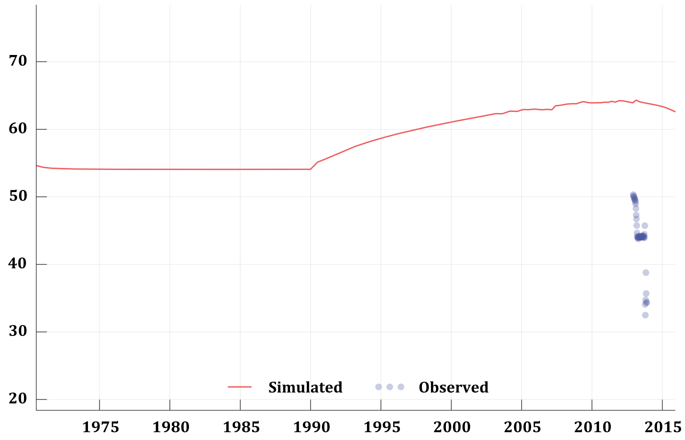

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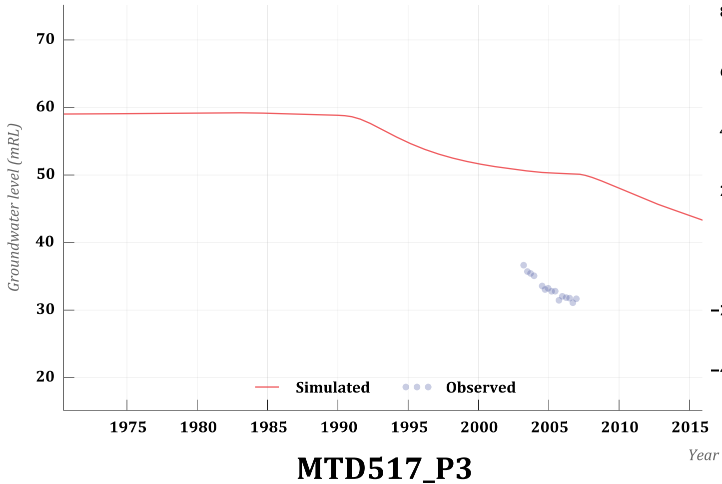

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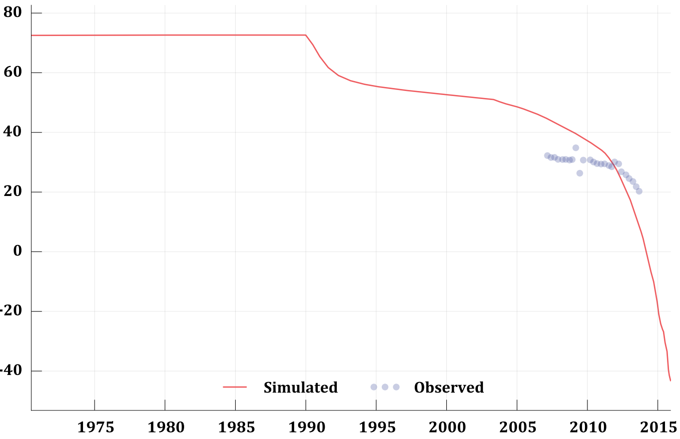

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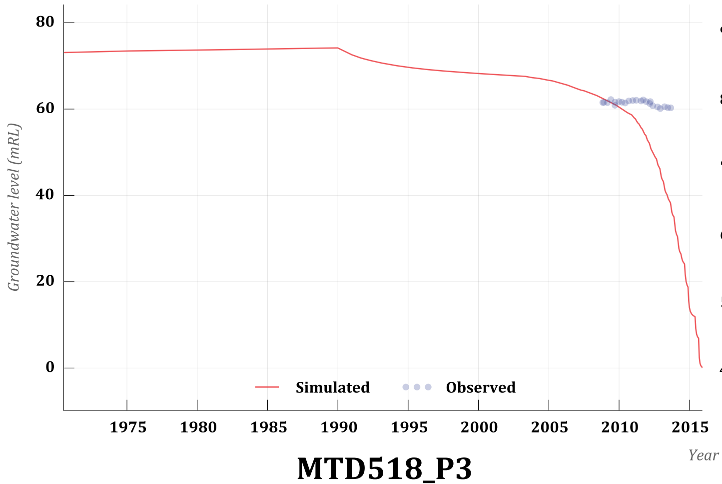

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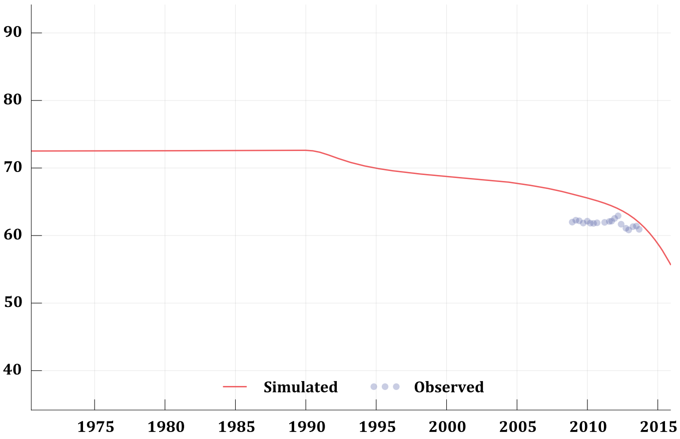

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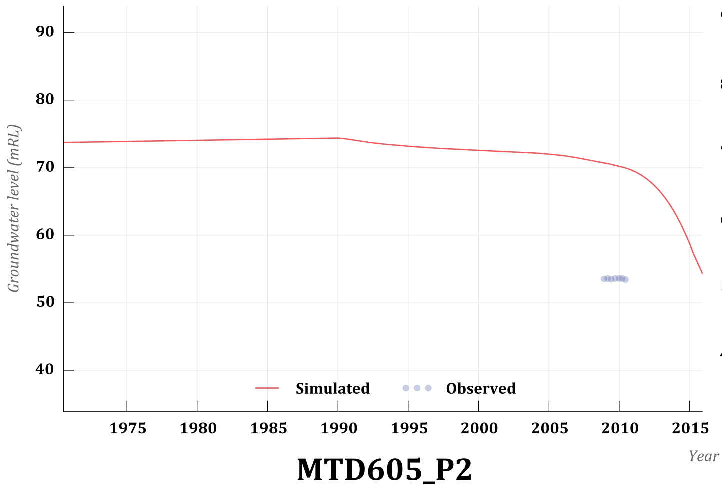

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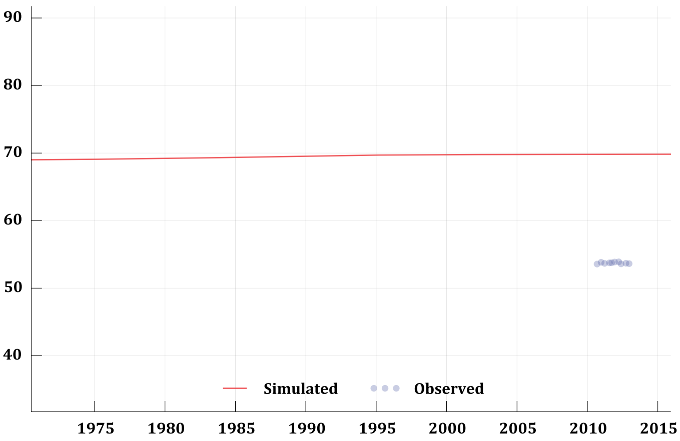

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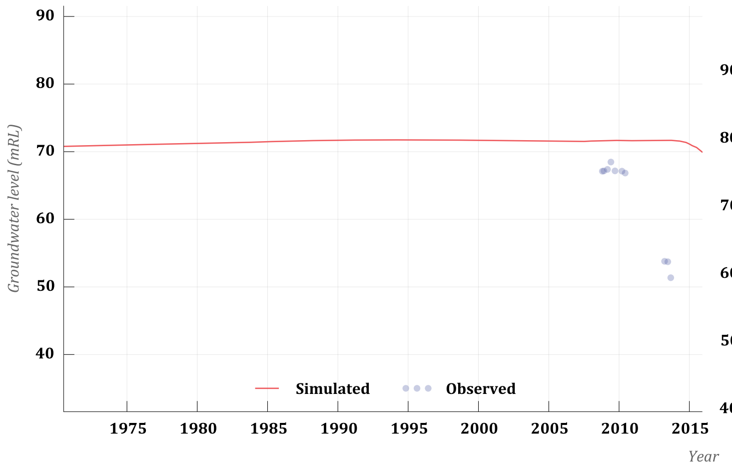

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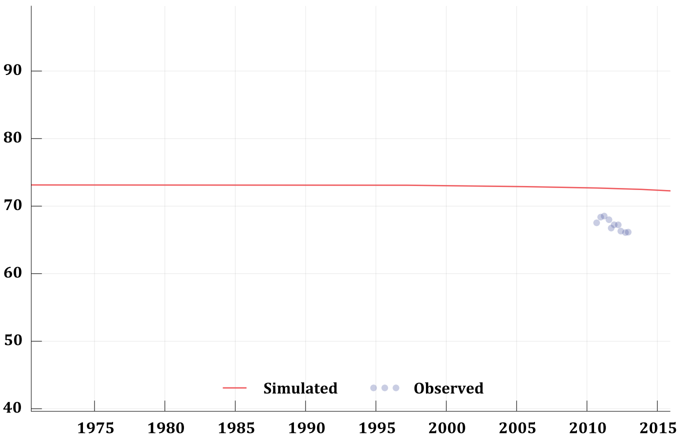

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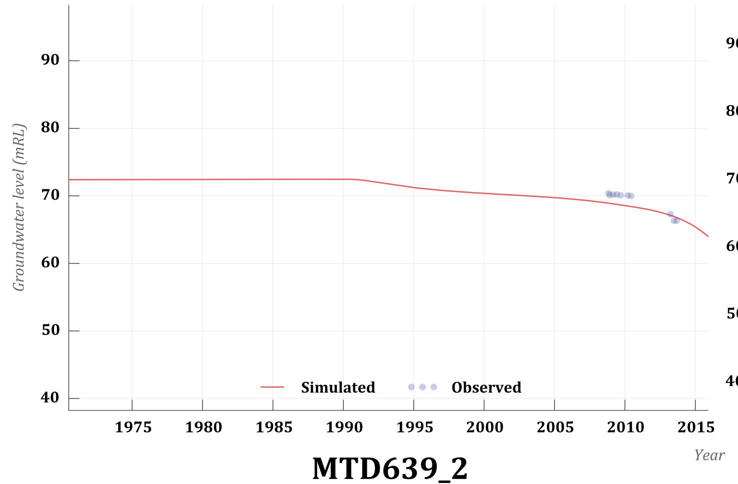
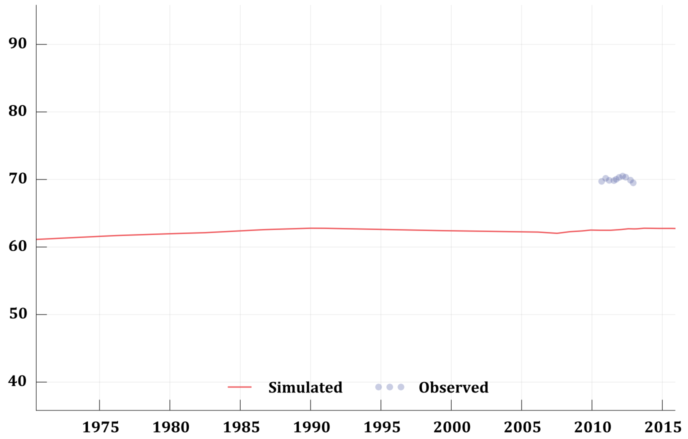
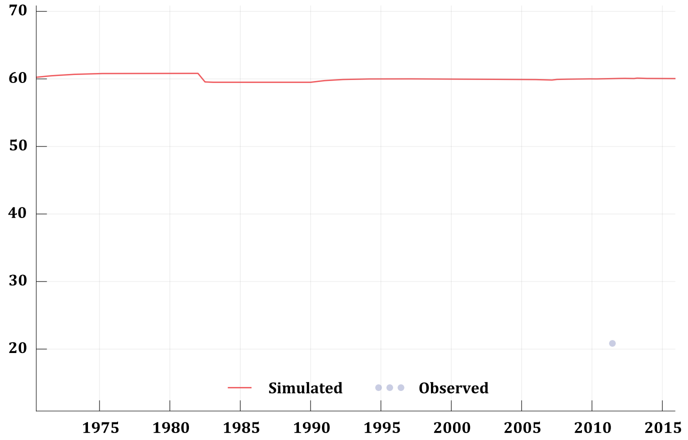


MTD613

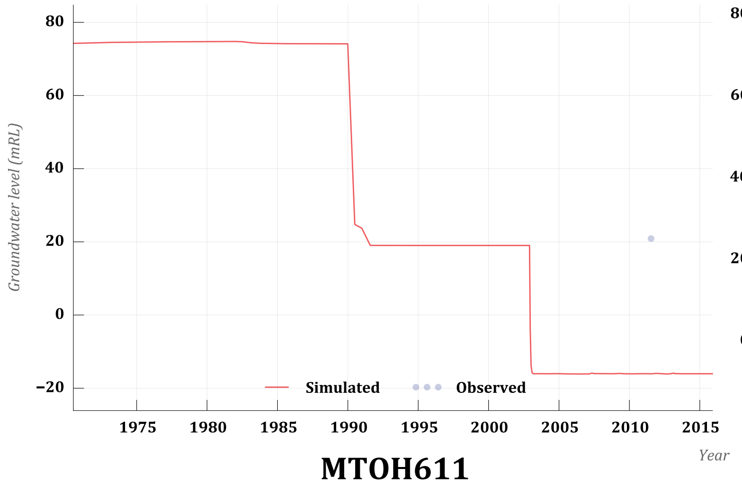


MTD639_2

MTD640



MTD642



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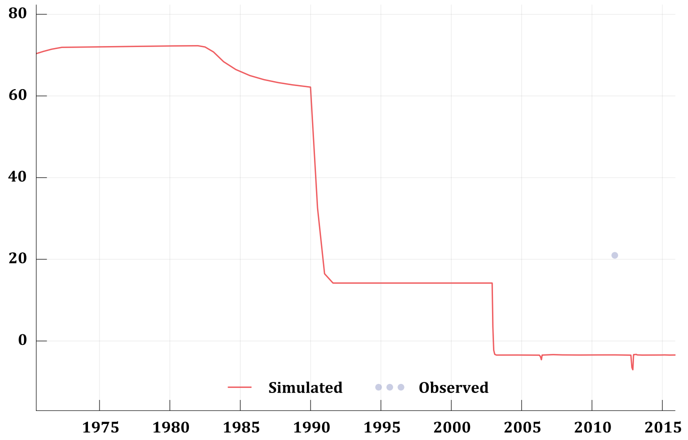
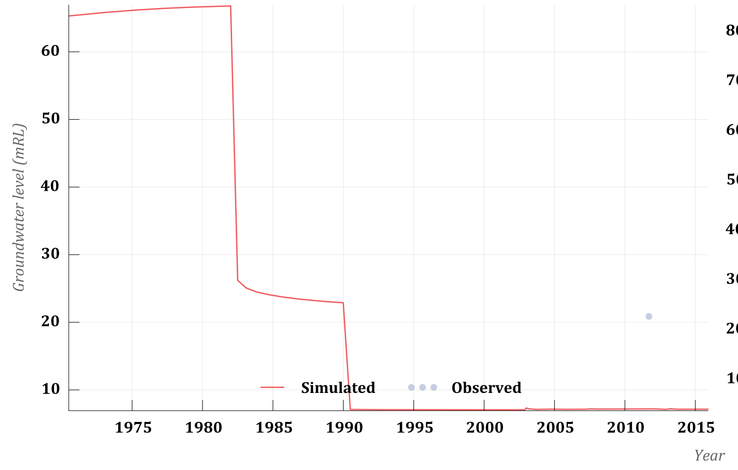


MTOH611



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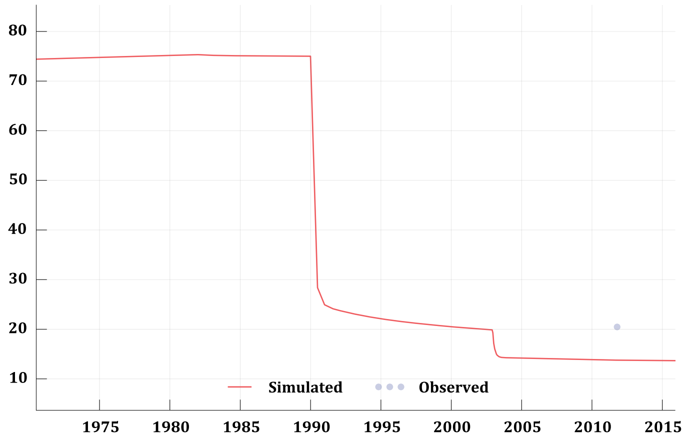
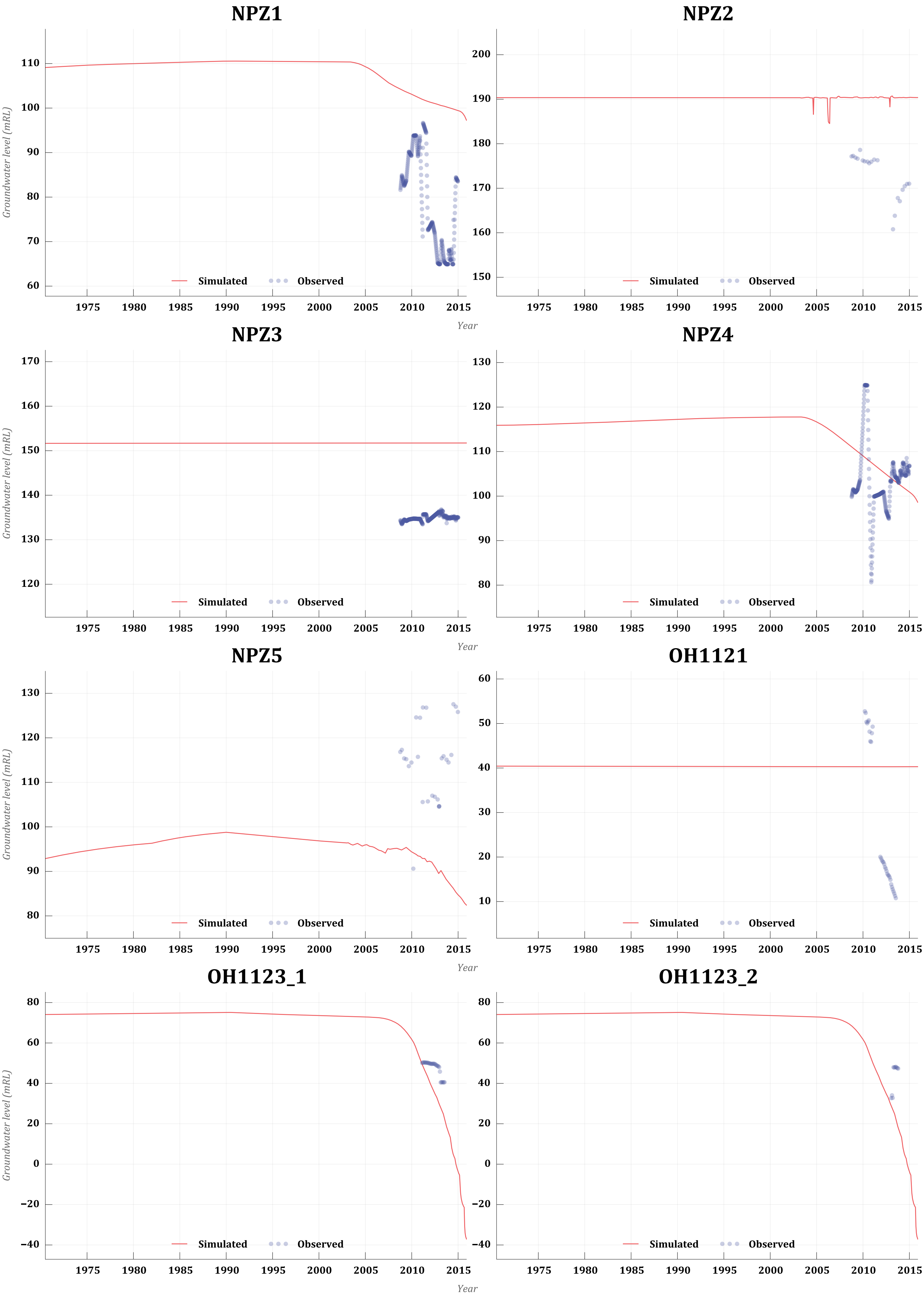
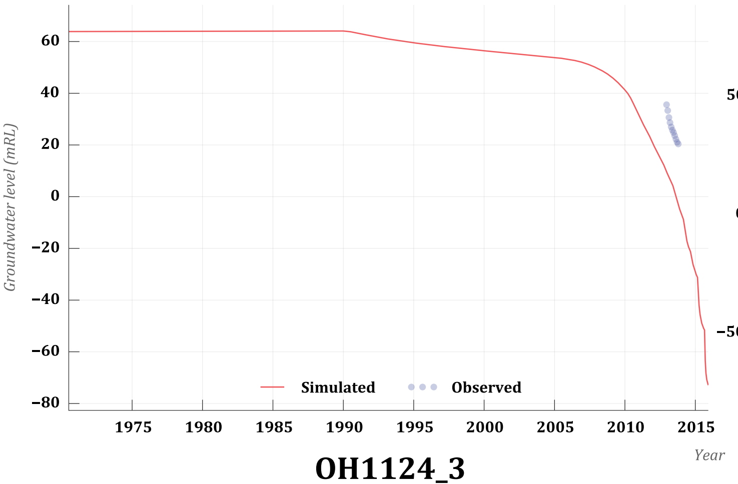



NPZ1
NPZ2
NPZ3
NPZ4
NPZ5
OH1121
OH1123_1
OH1123_2
Groundwater level (mRL)
Year
Simulated
Observed
1975
1980
1985
1990
1995
2000
2005
2010
2015

OH1123_3



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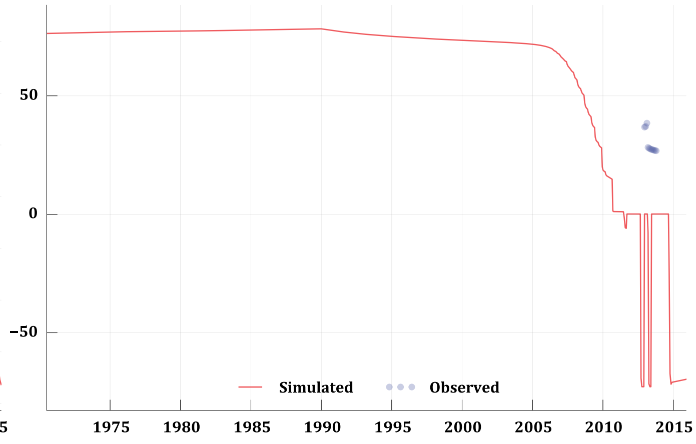

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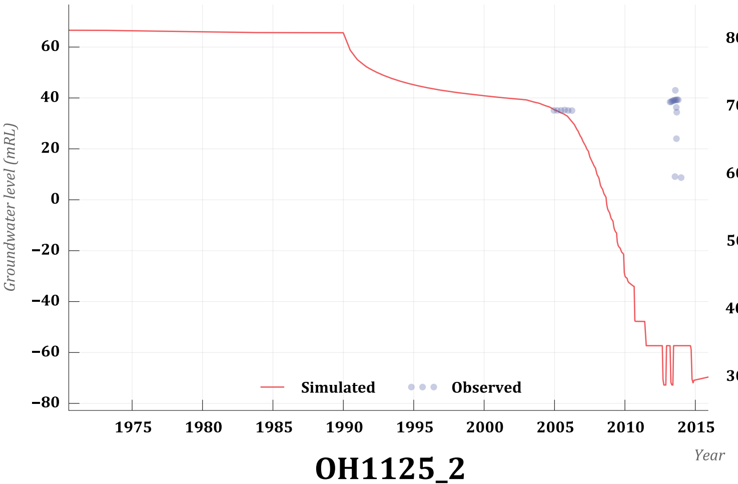

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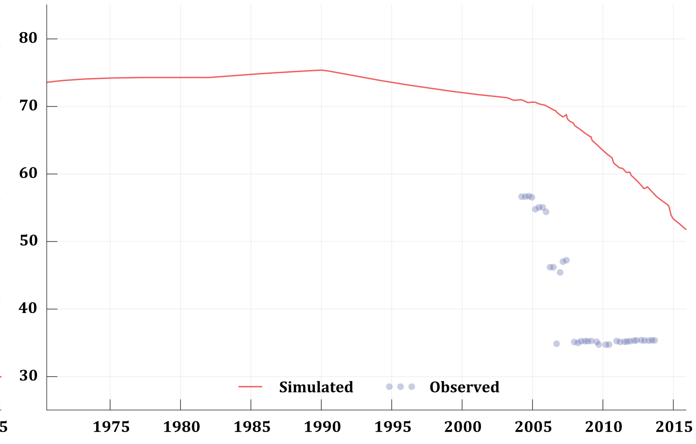

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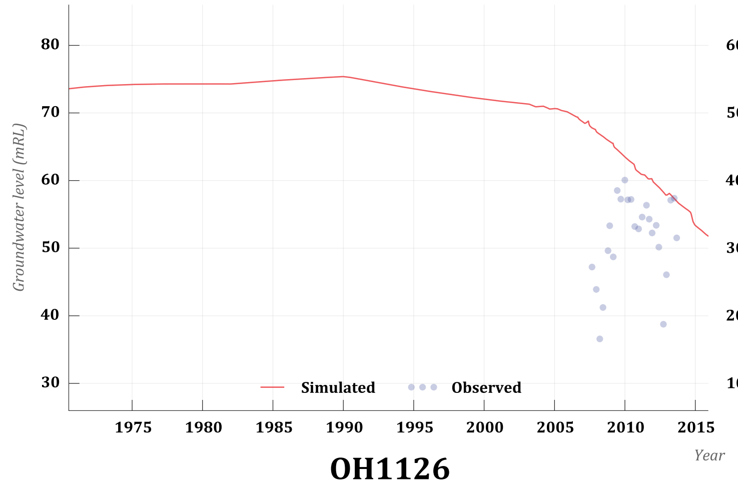

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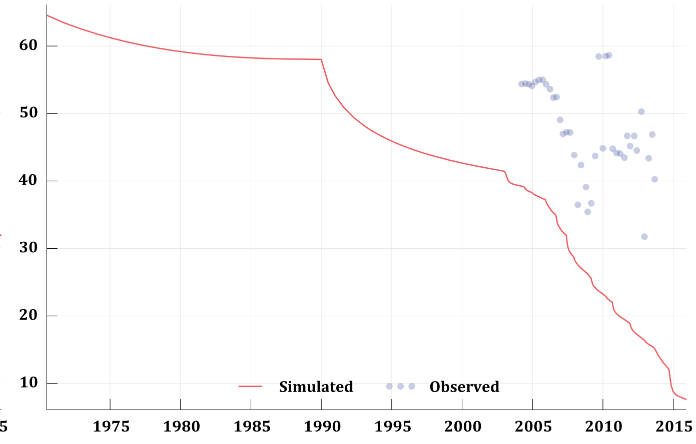

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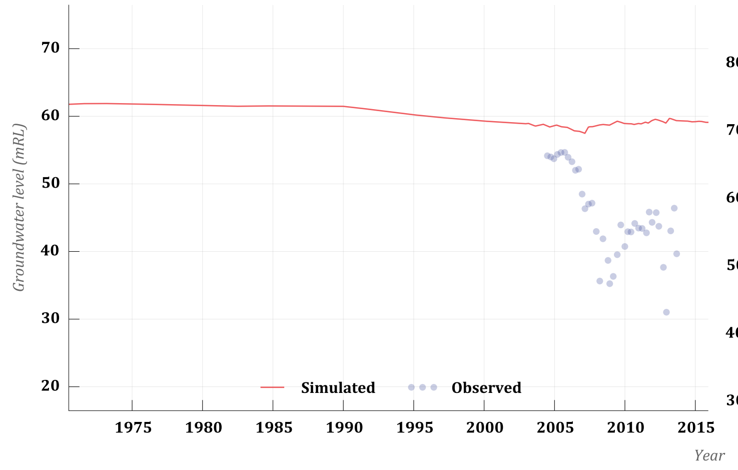

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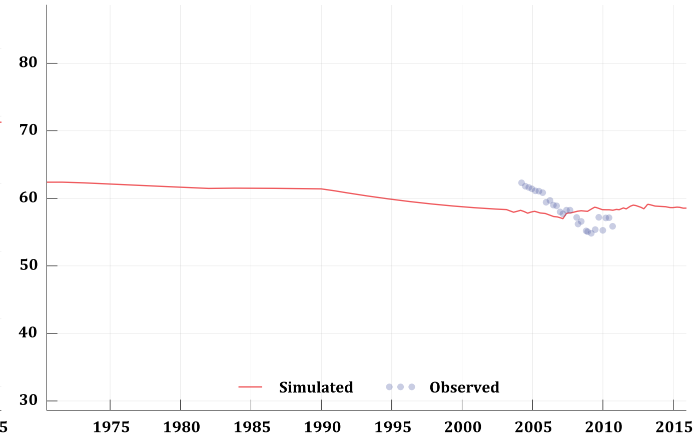

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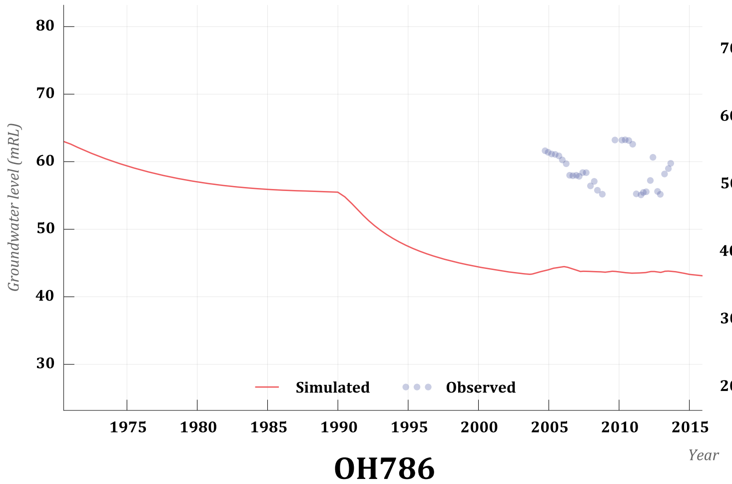
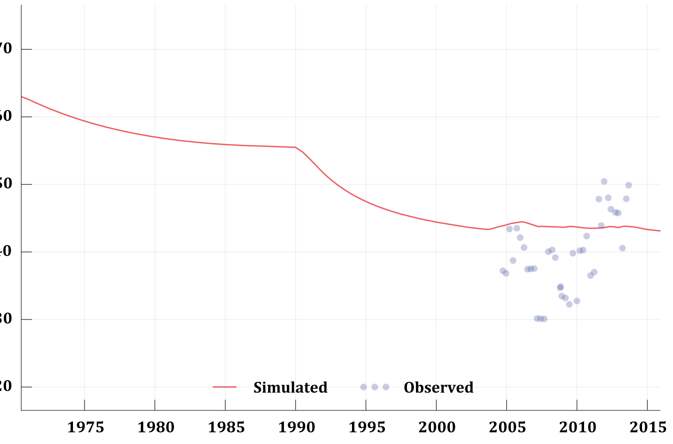


OH1138_2



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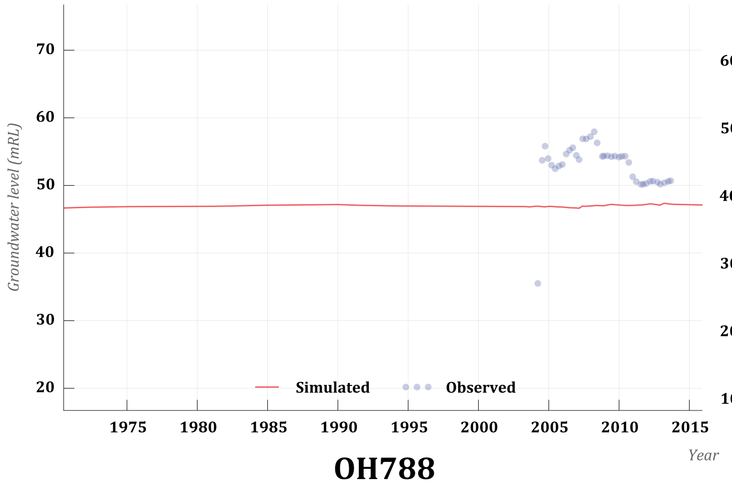
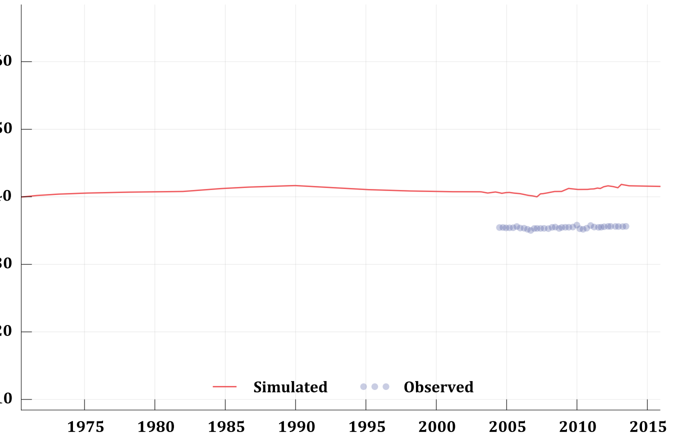
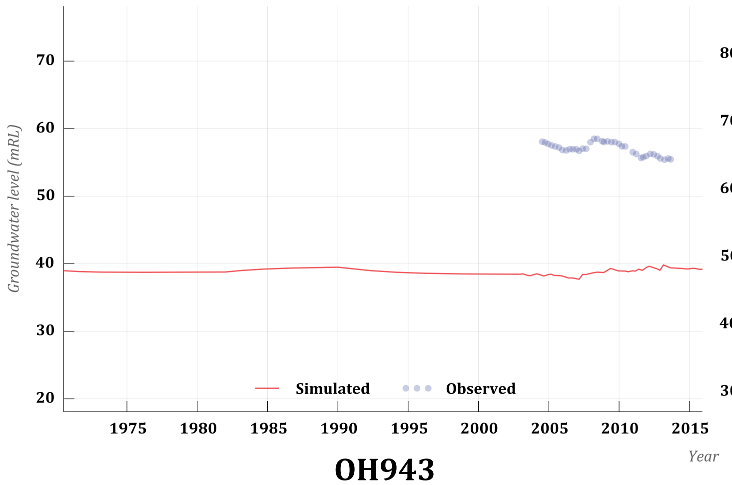


OH787



OH788



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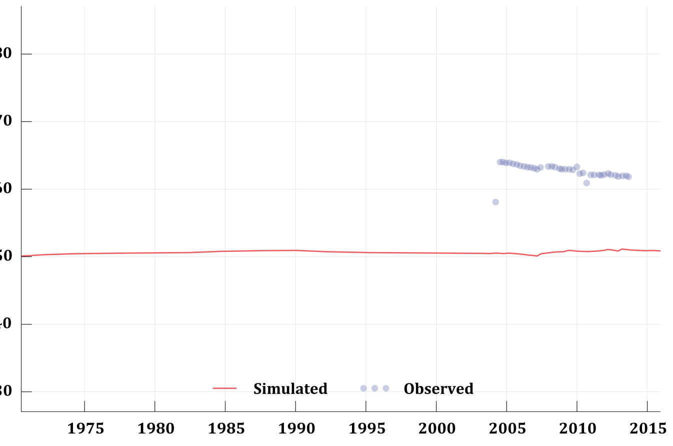

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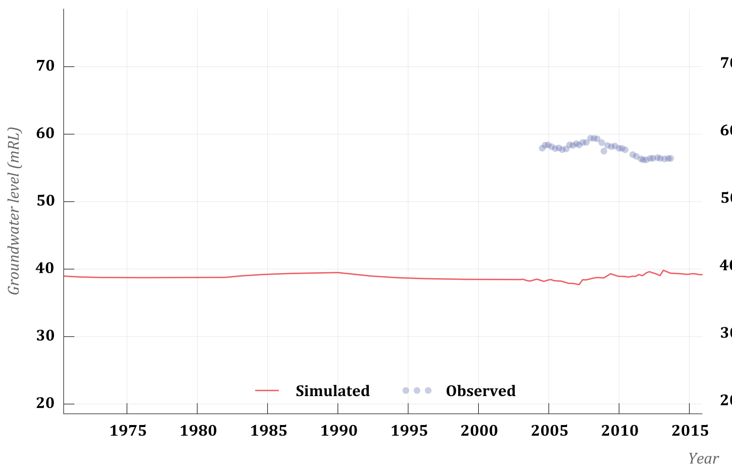

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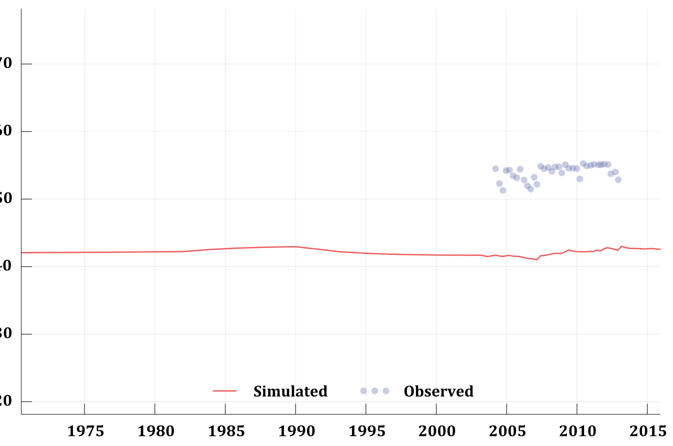

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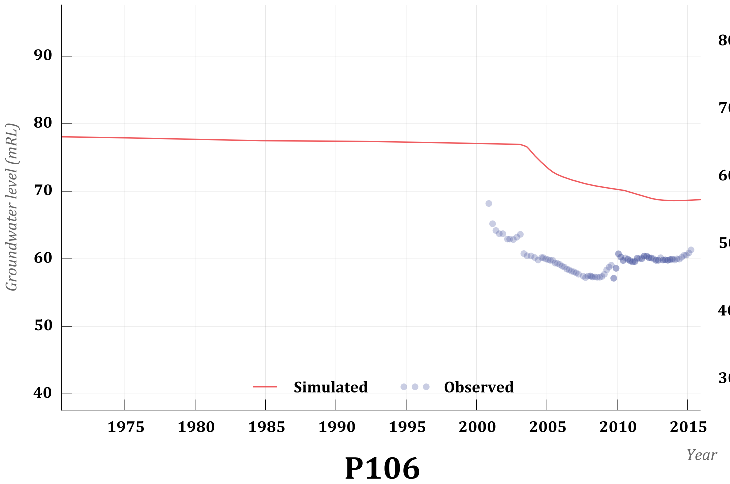
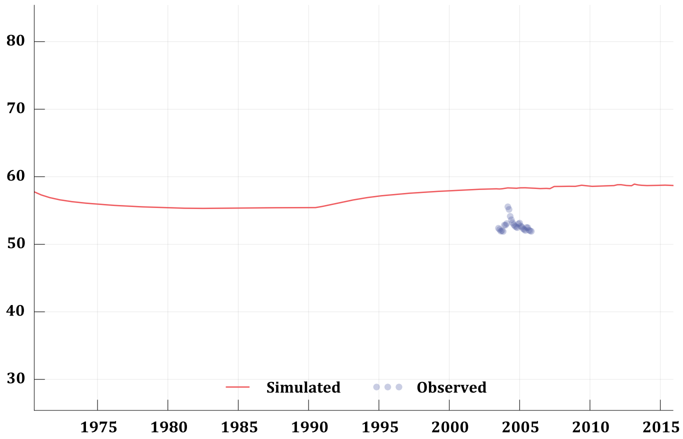


P104



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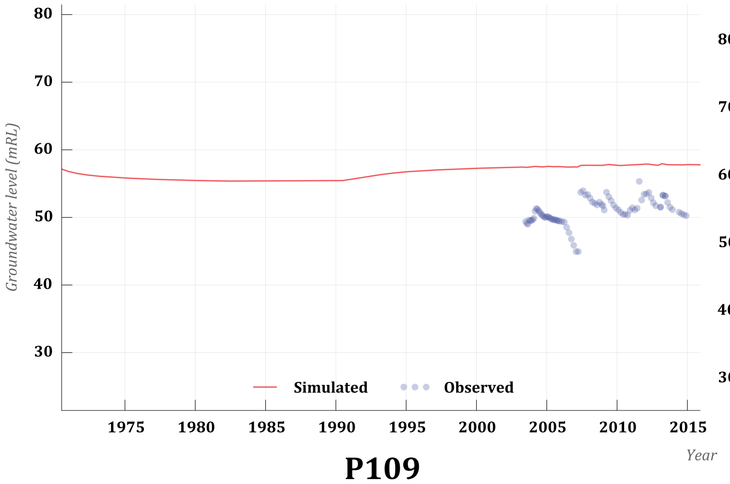

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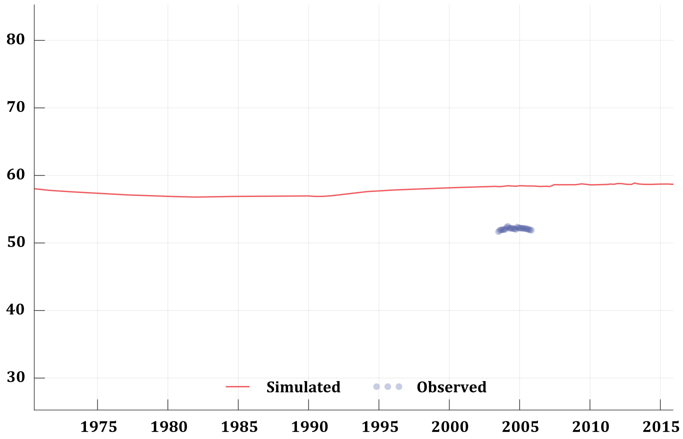

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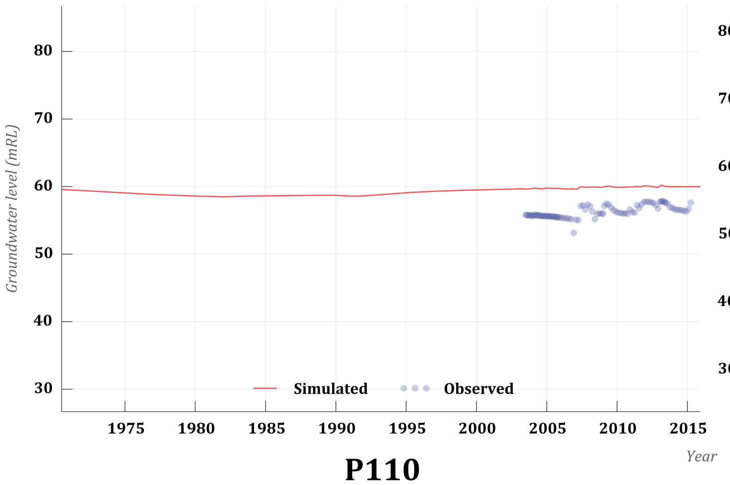

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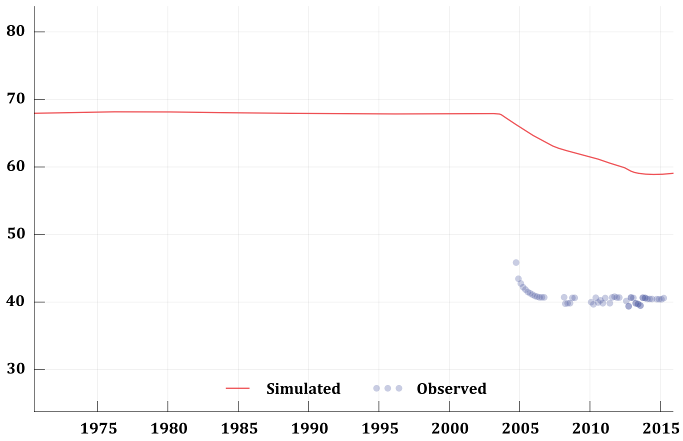

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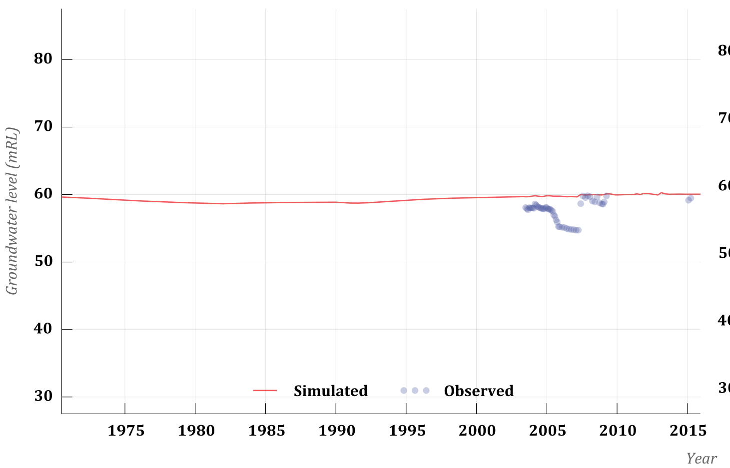

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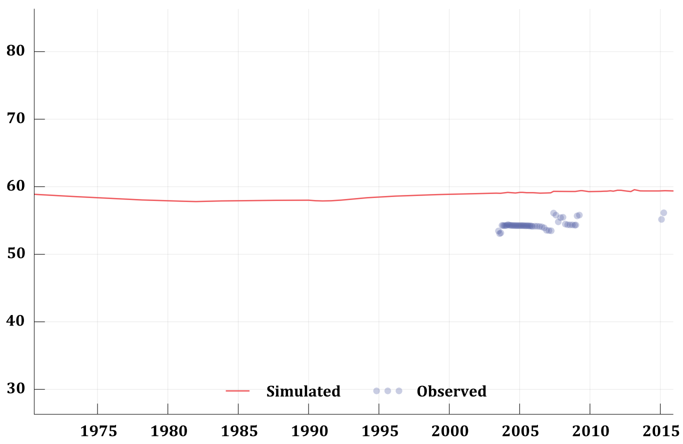

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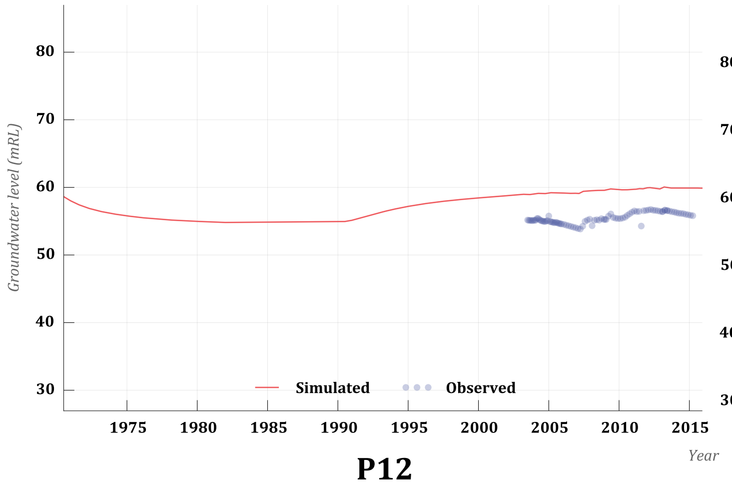

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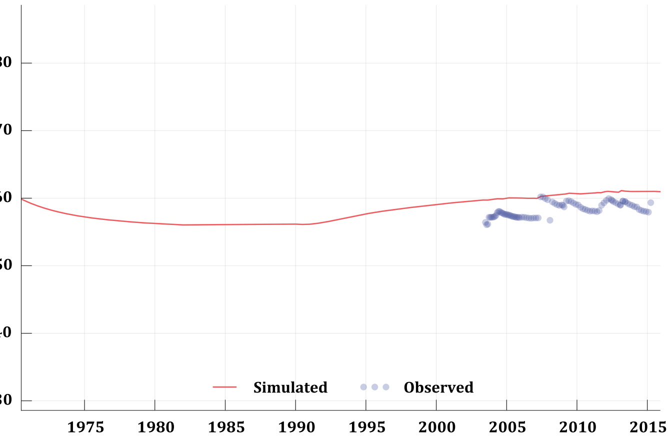

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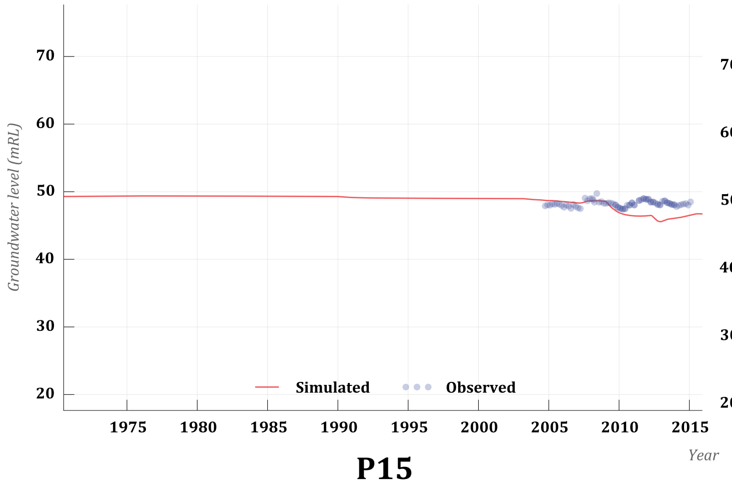

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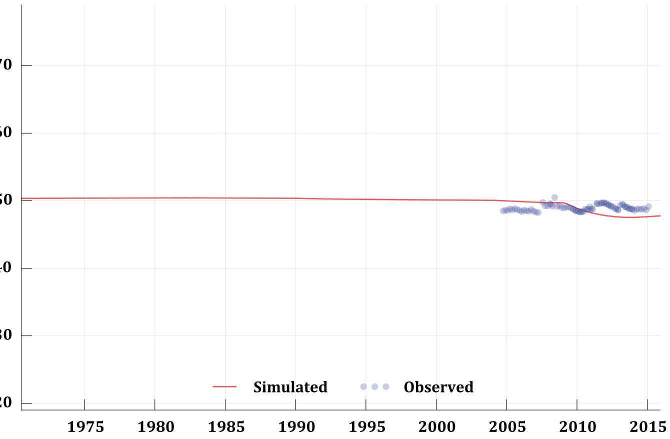

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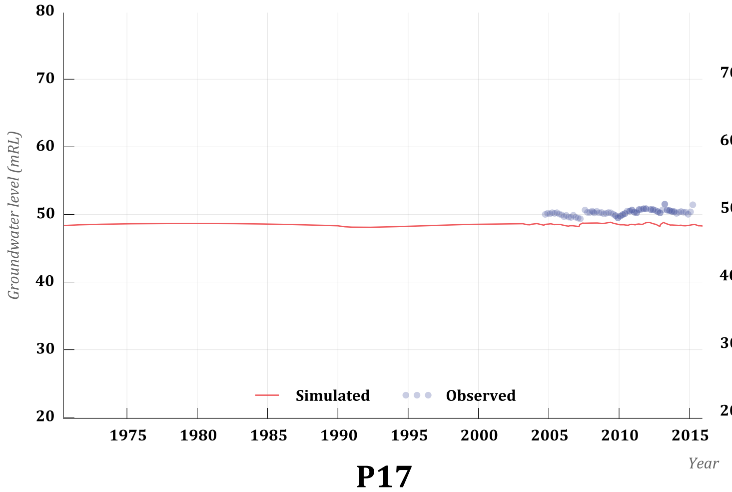

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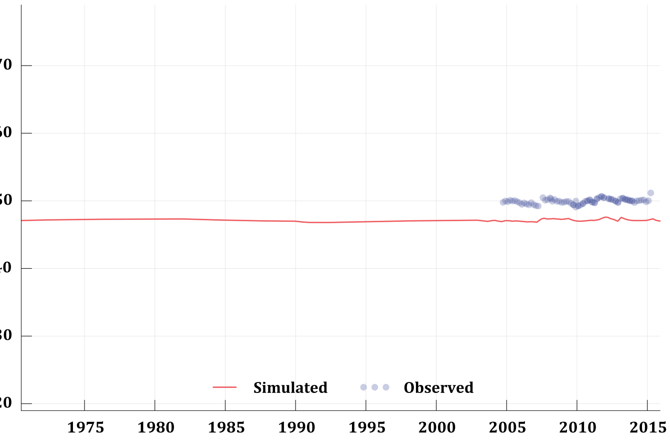

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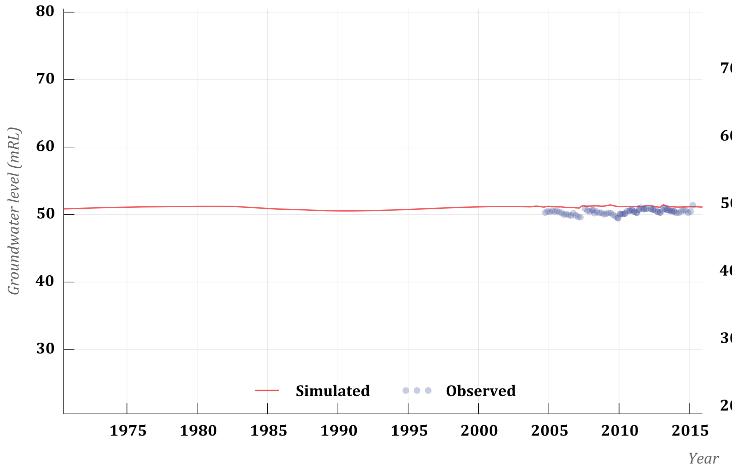

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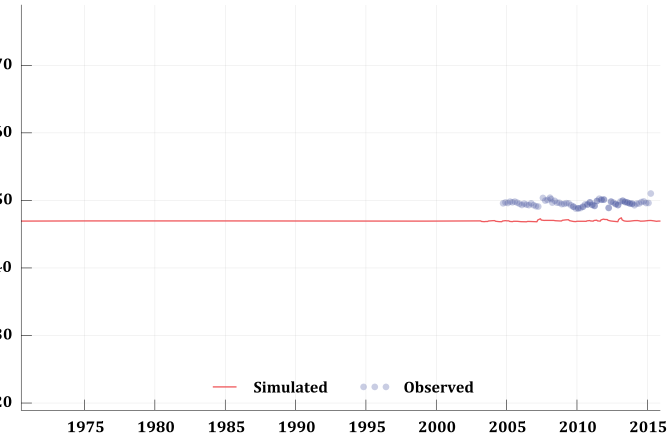

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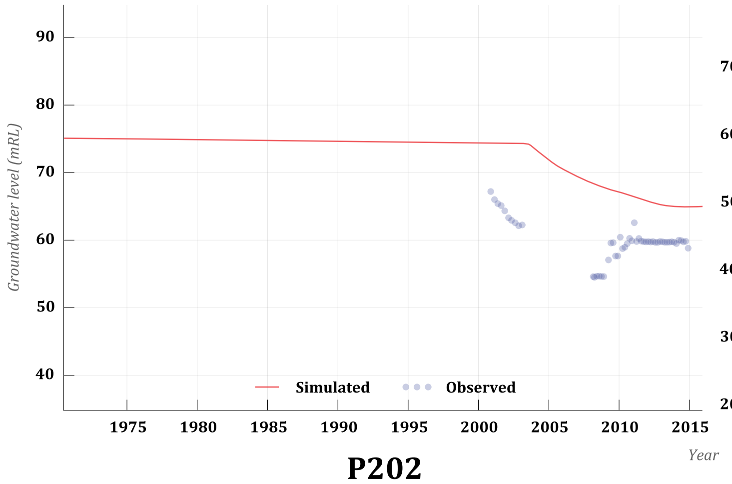

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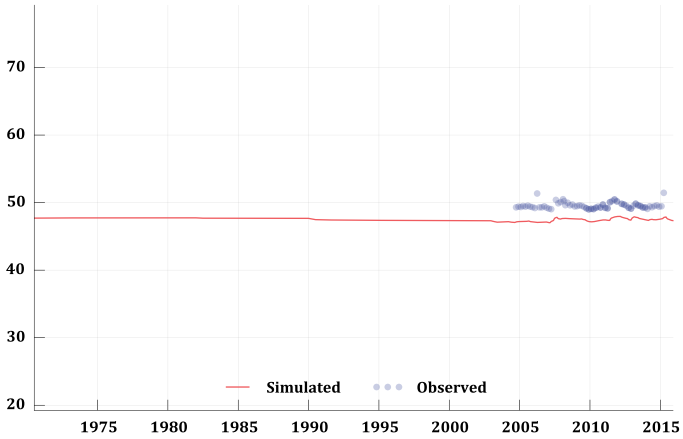

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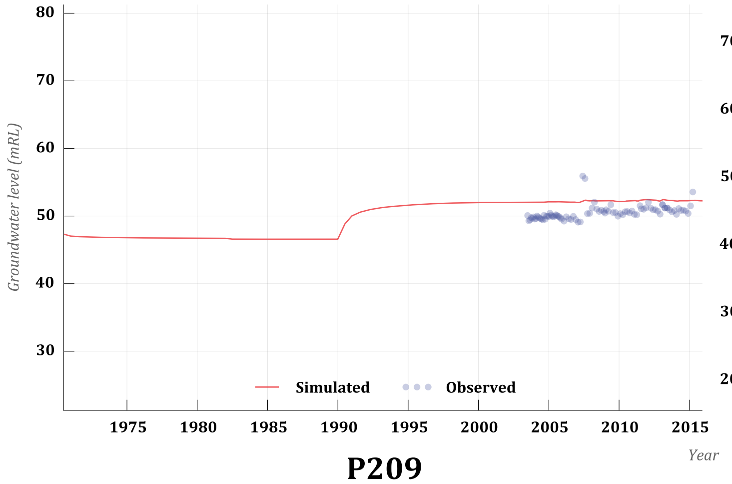

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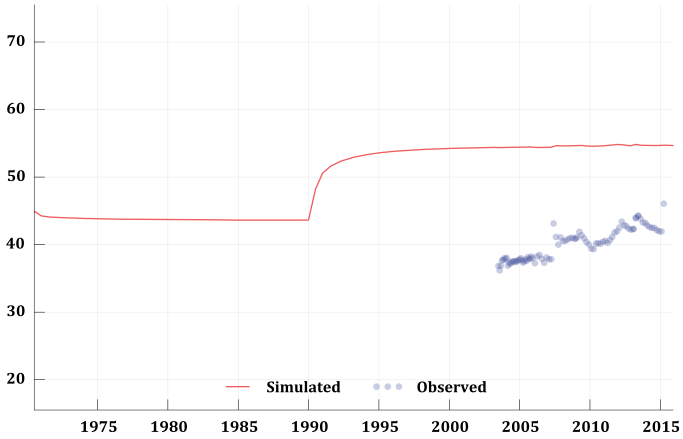

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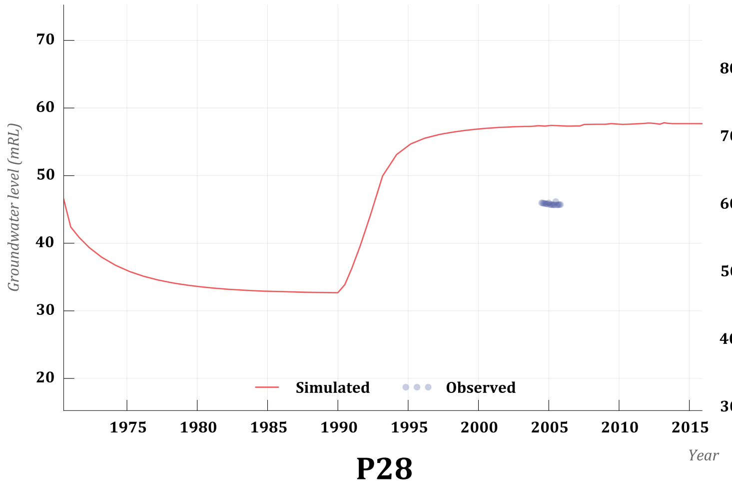

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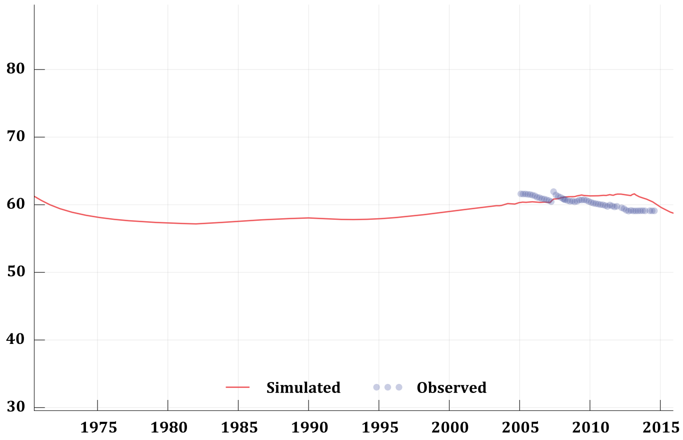
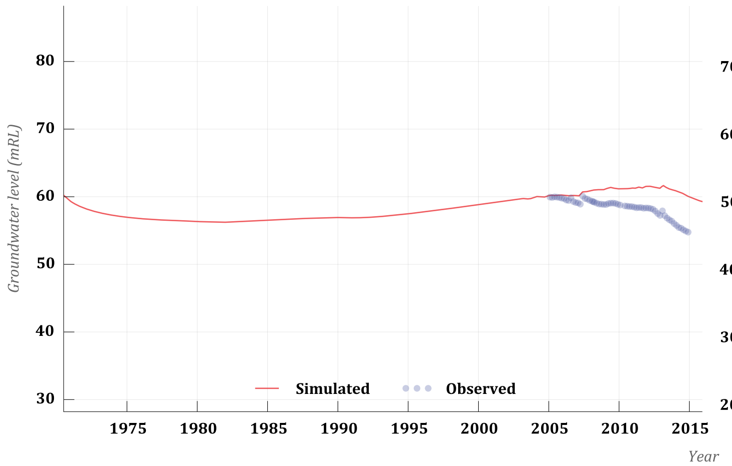
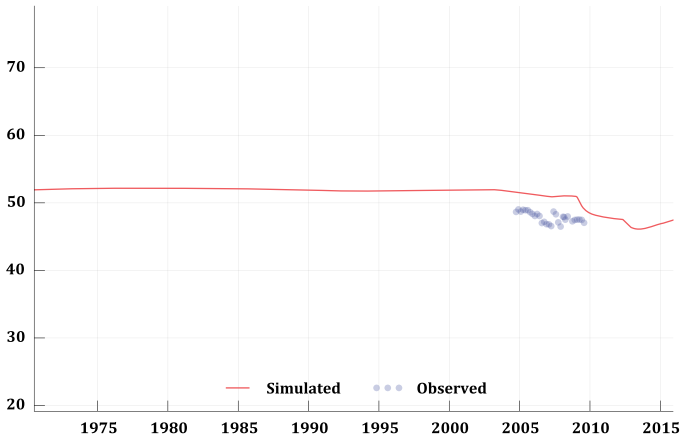


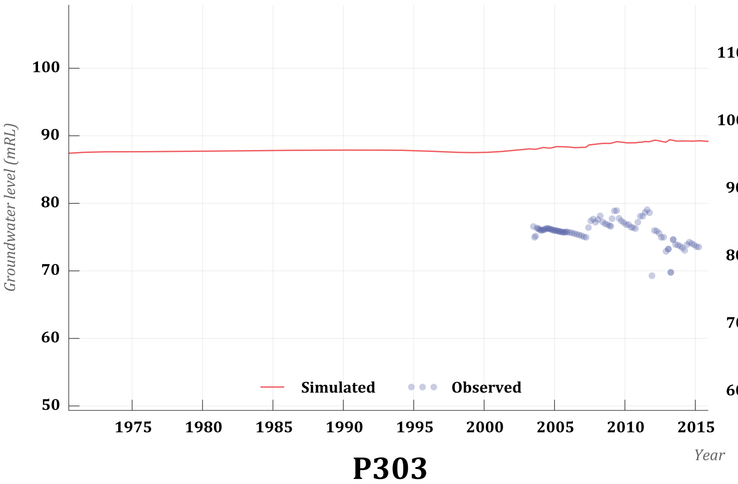
P28



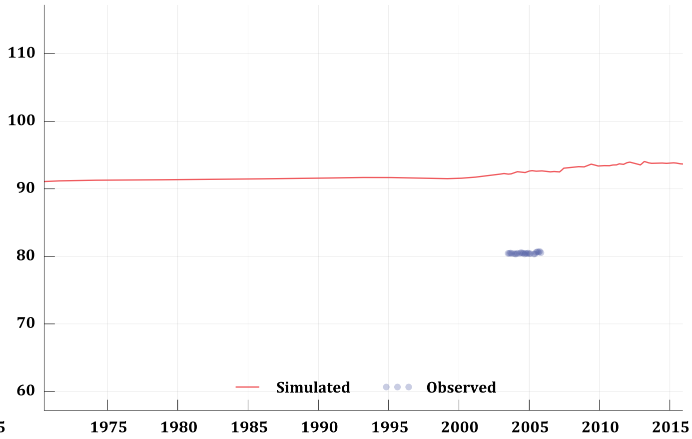
P3



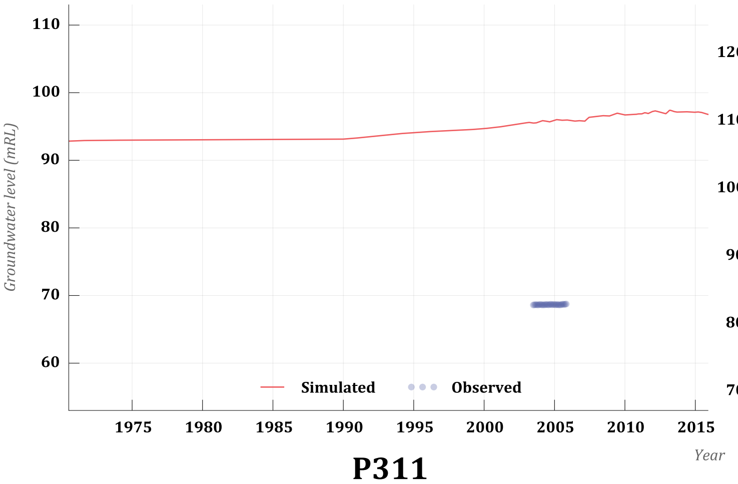
P301



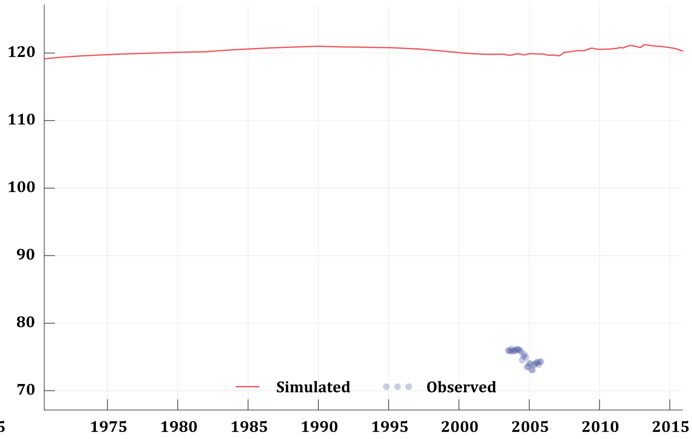
P302



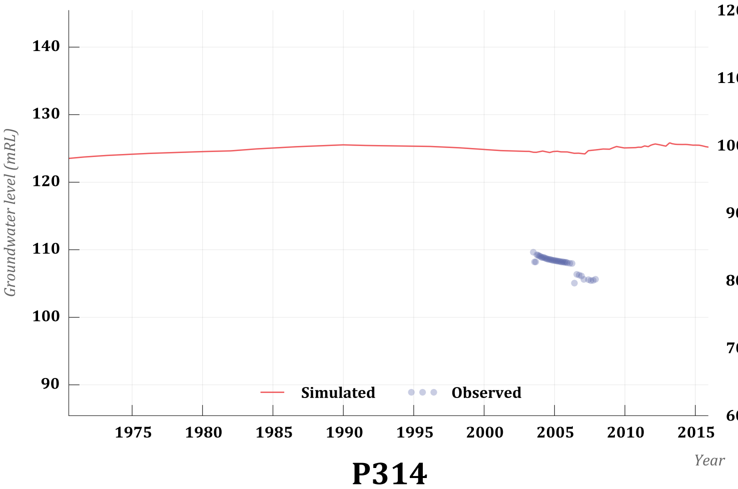
P303



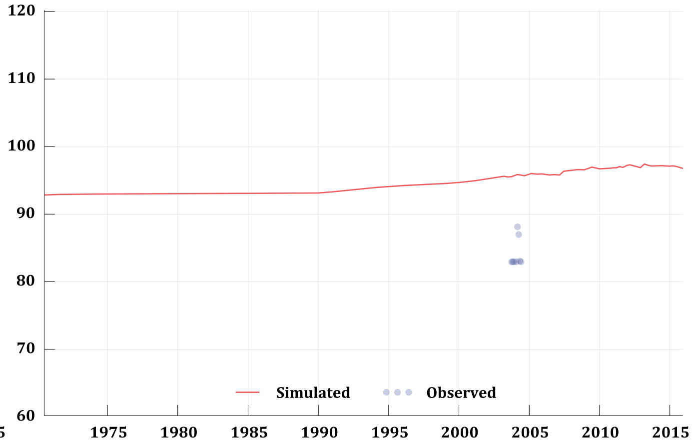
P310



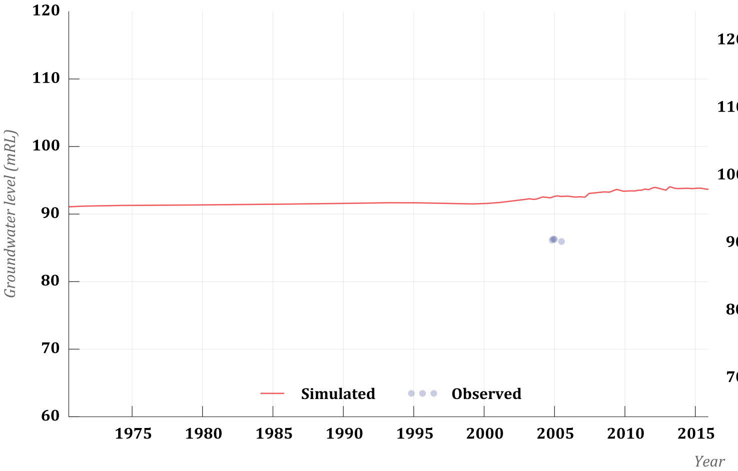
P311



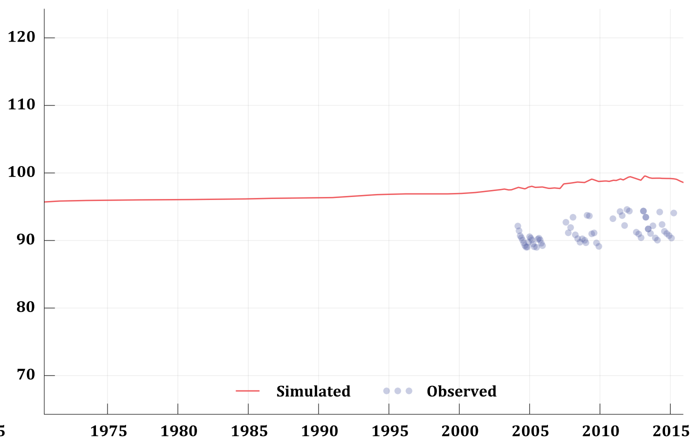
P312



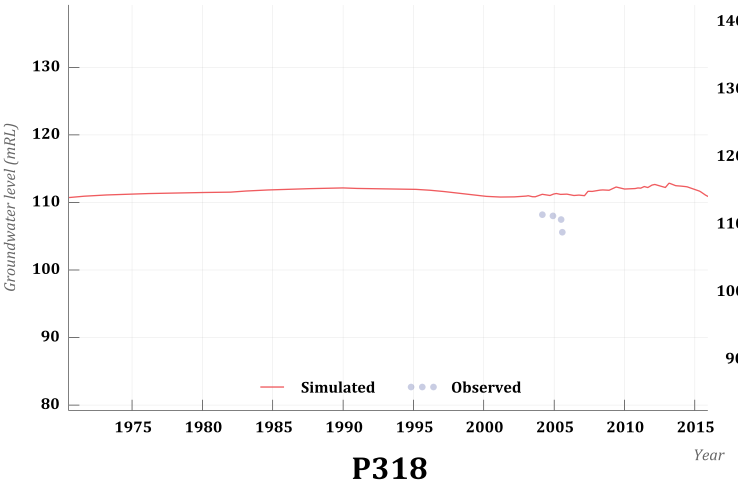
P314



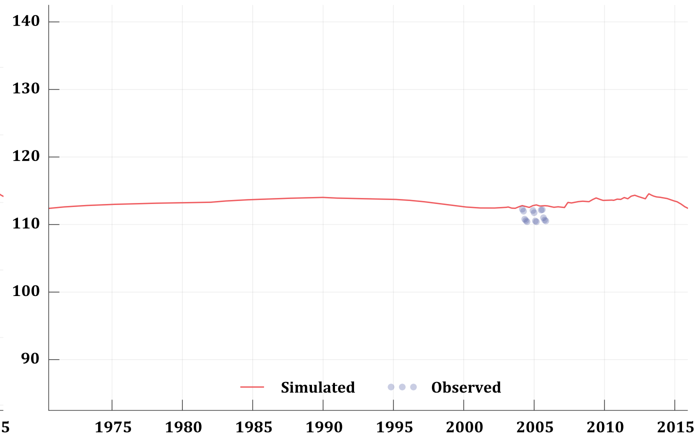
P315



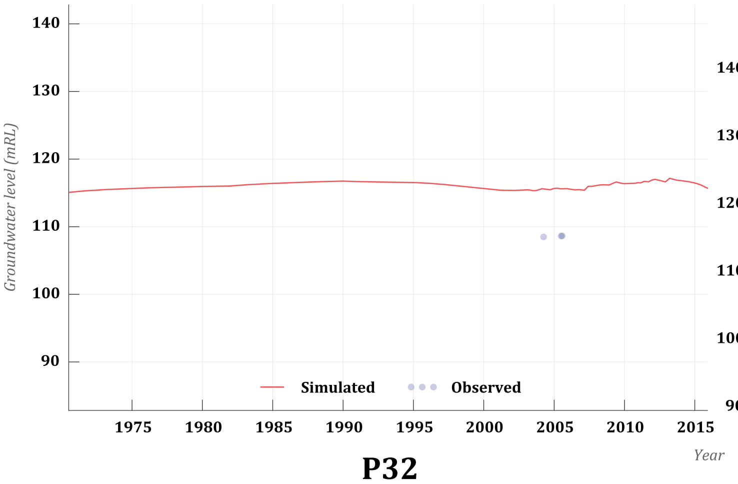
P316



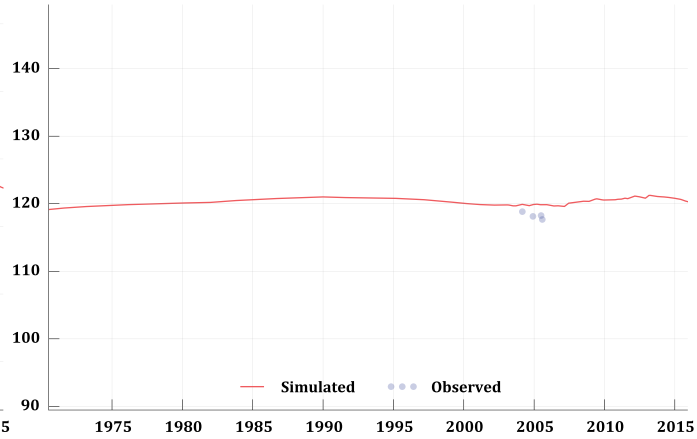
P317



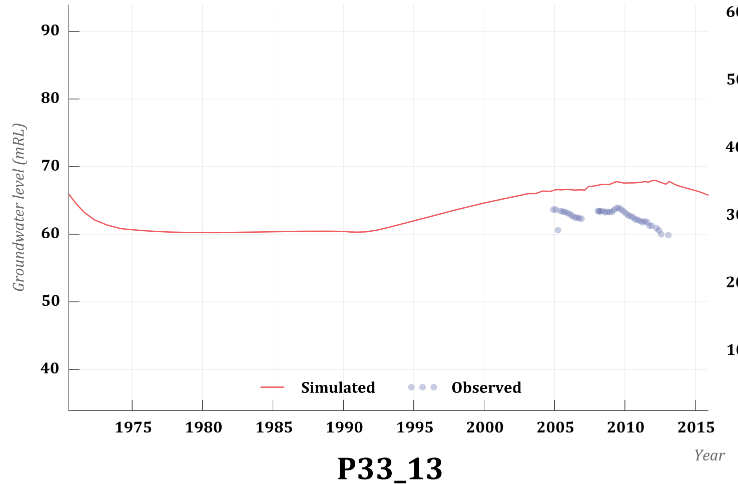
P318



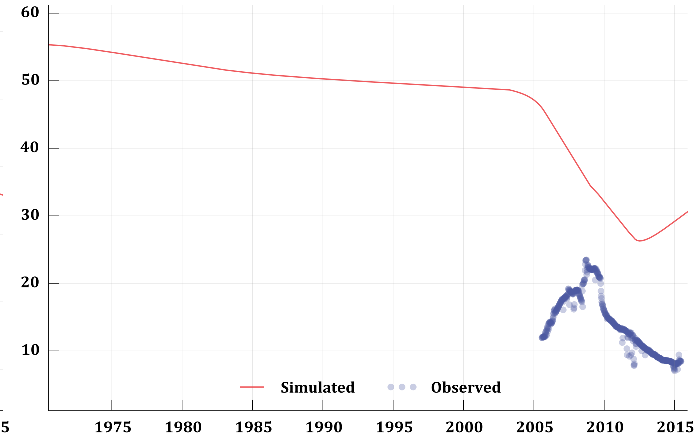
P319



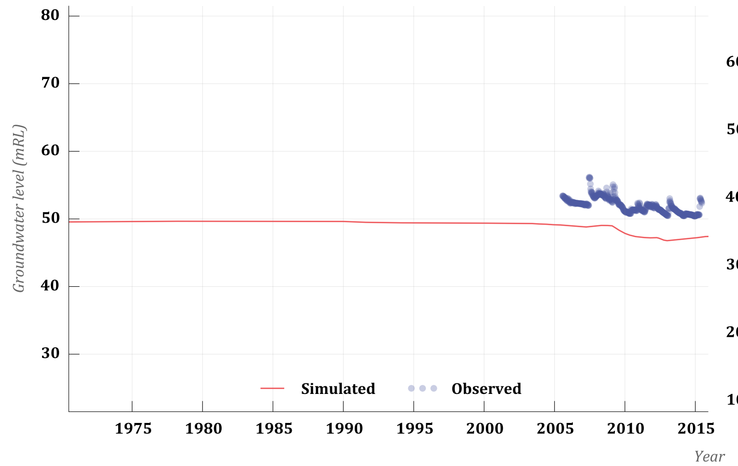
P32



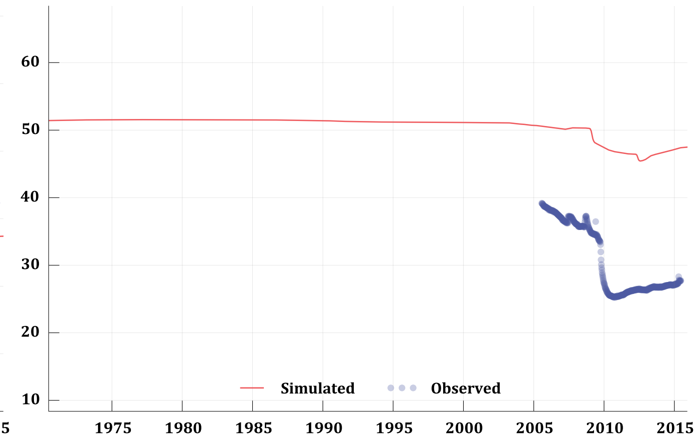
P33_113



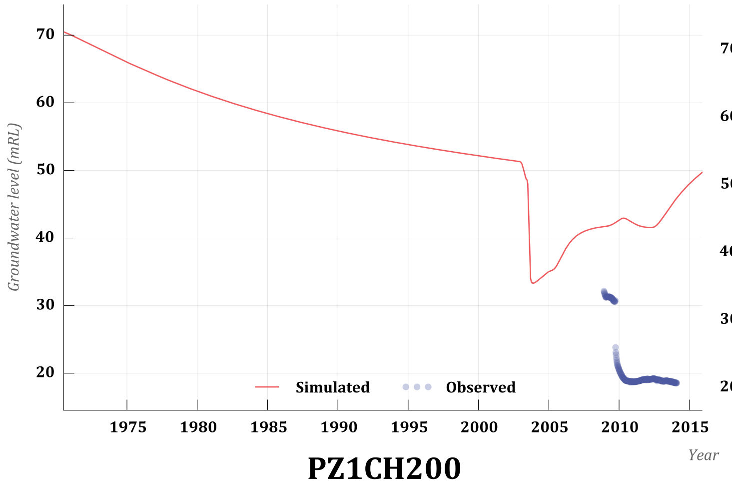
P33_13



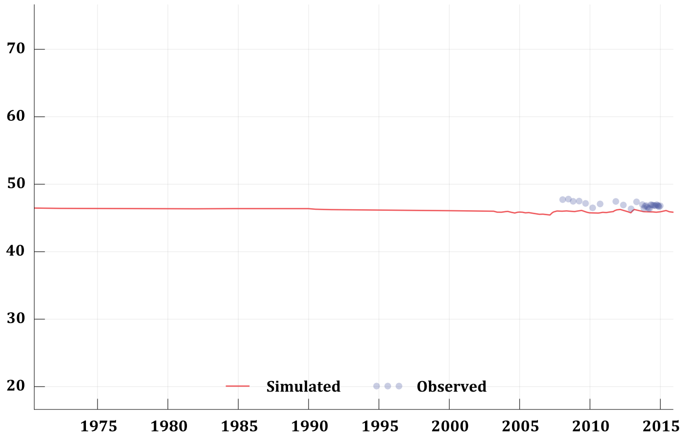
P33_58



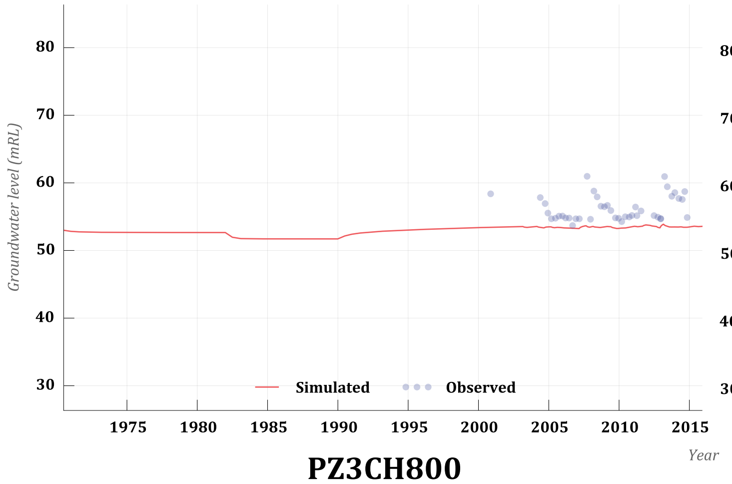
P35_60



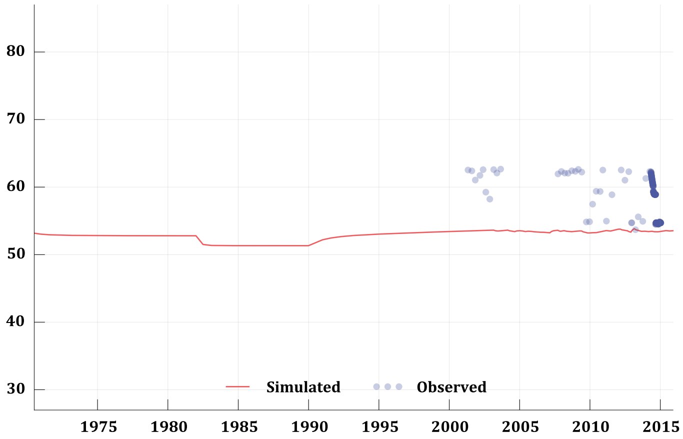
PB01_ALL



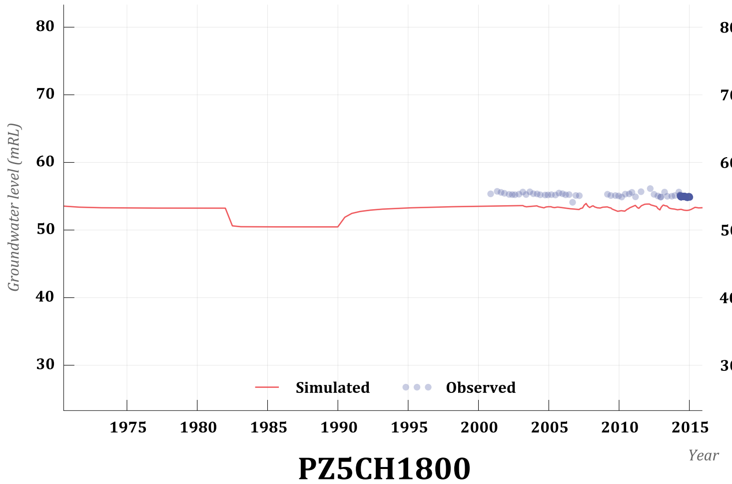
PZ1CH200



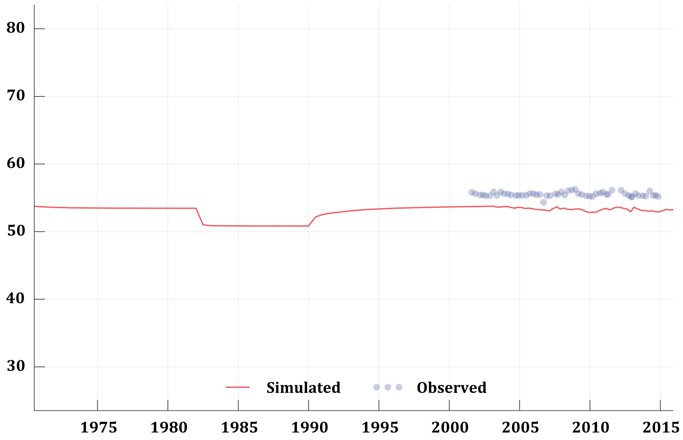
PZ2CH400



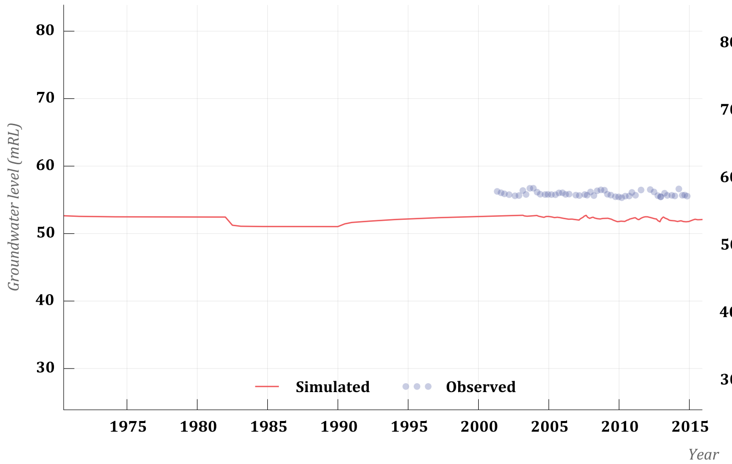
PZ3CH800



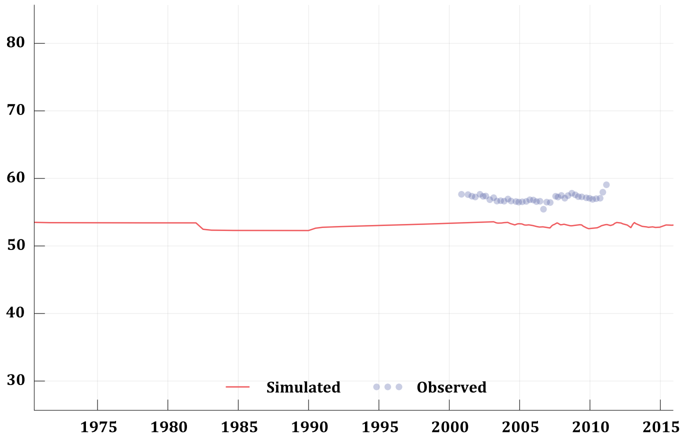
PZ4CH1380



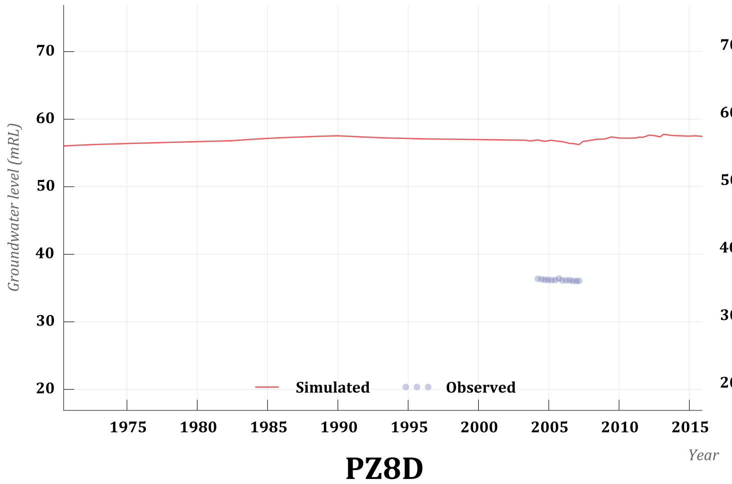
PZ5CH1800



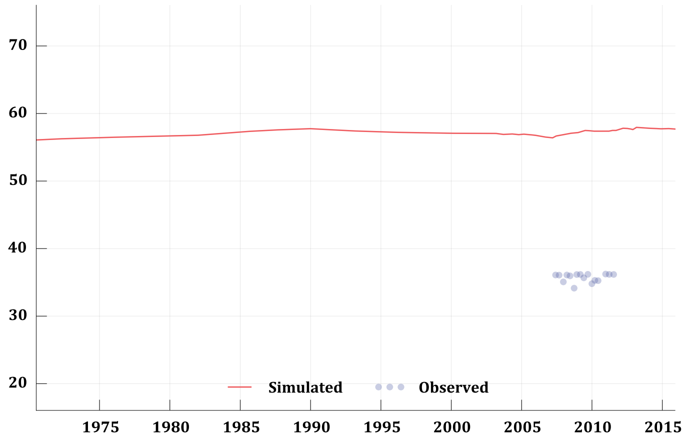
PZ6CH2450



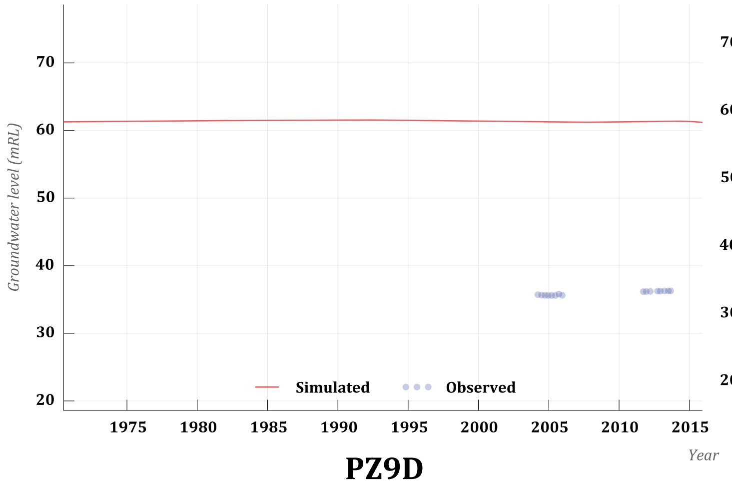
PZ7D



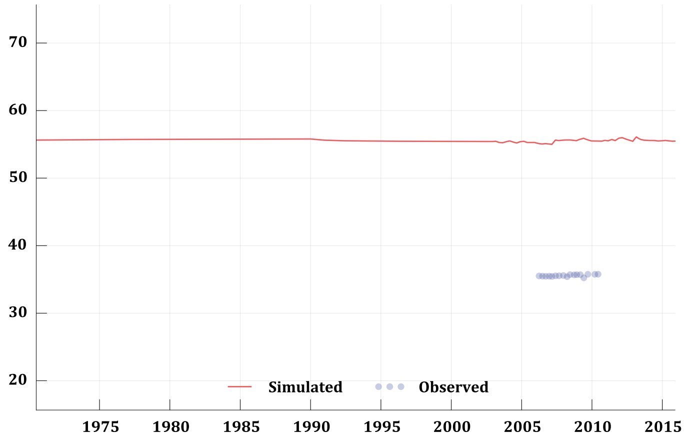
PZ7S



PZ8D

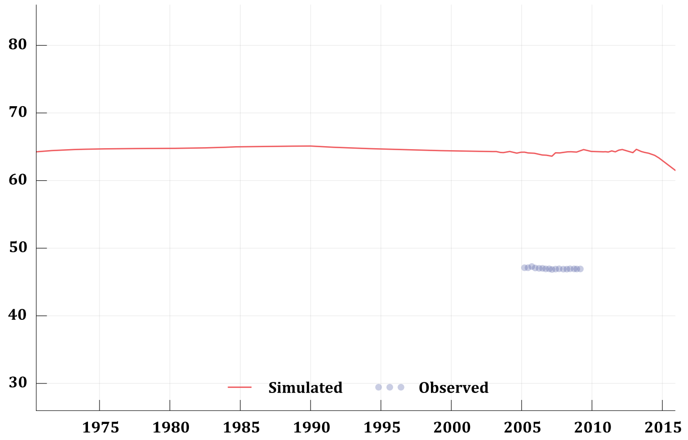


PZ8S

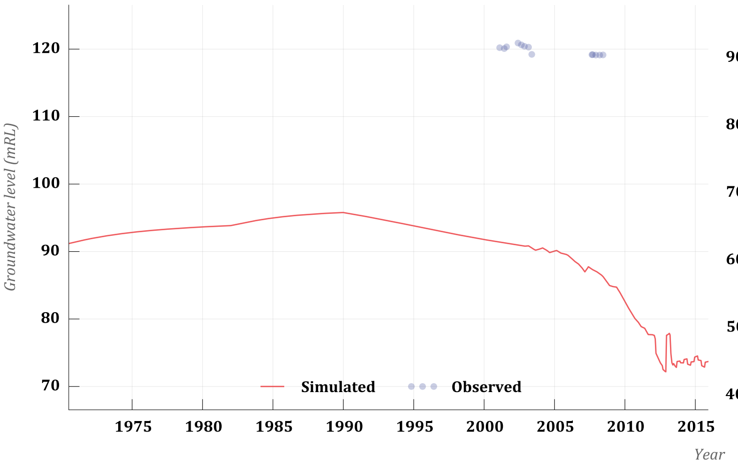


PZ9D

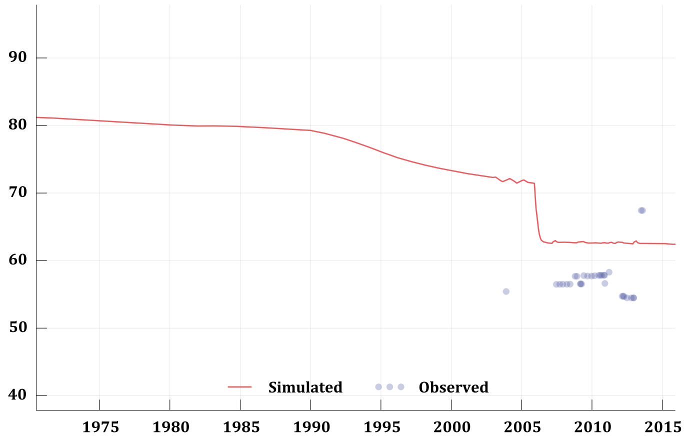
PZ9S

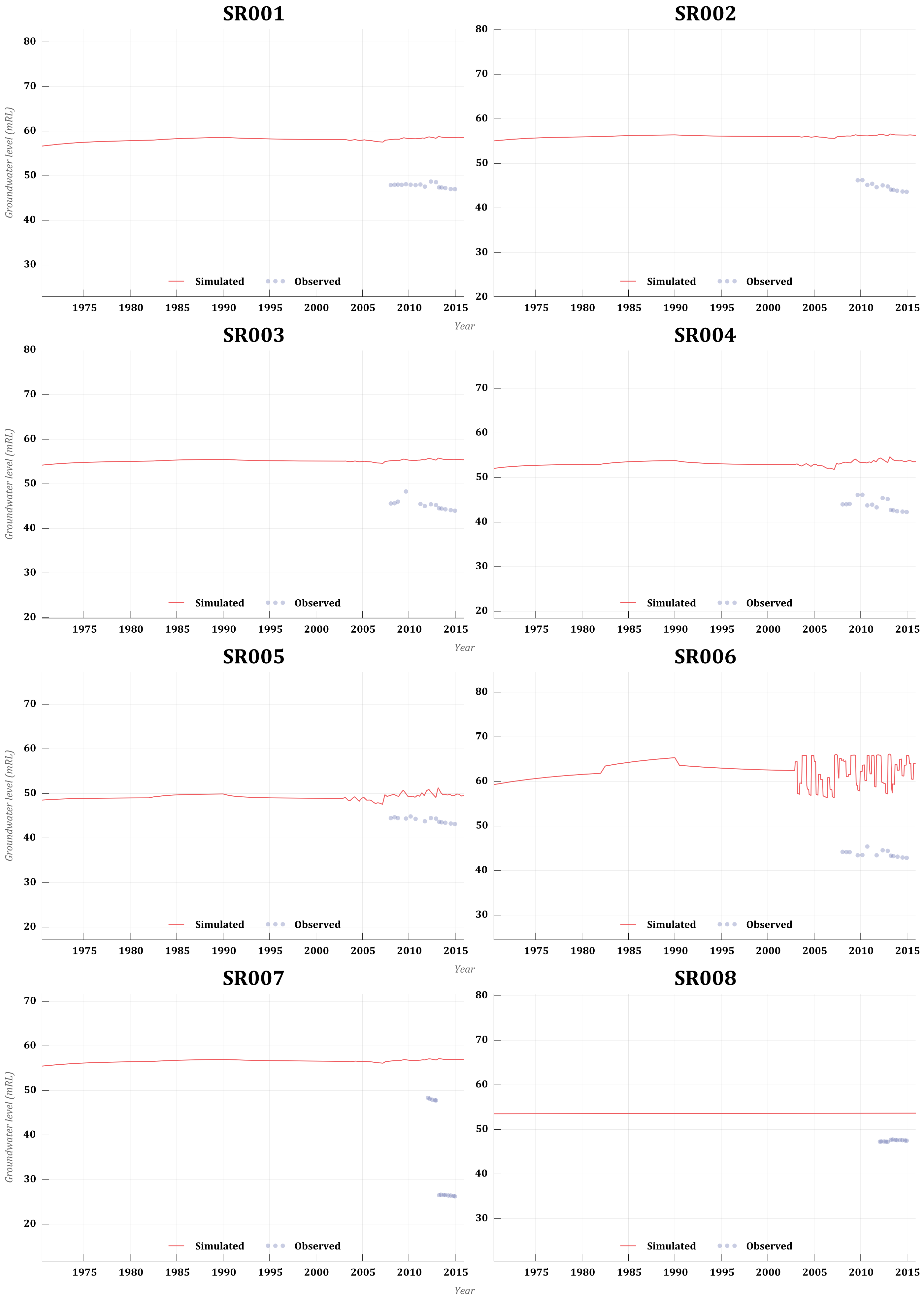


S2



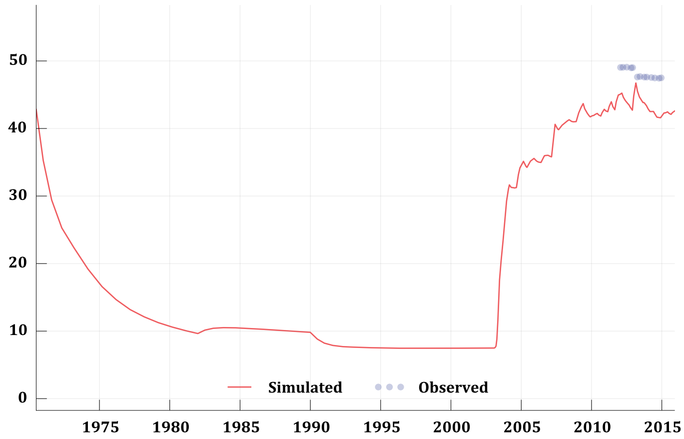
S4



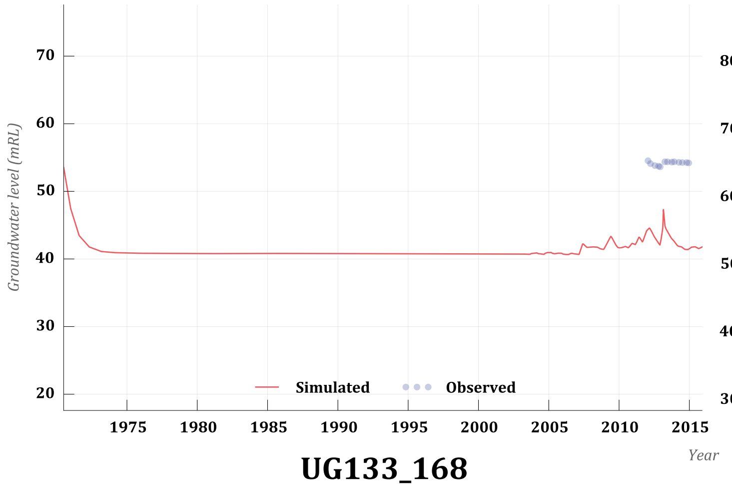

SR001
SR002
SR003
SR004
SR005
SR006
SR007
SR008
Groundwater level (mRL)
Year
Simulated
Observed
1975
1980
1985
1990
1995
2000
2005
2010
2015
20
30
40
50
60
70
80

SR009

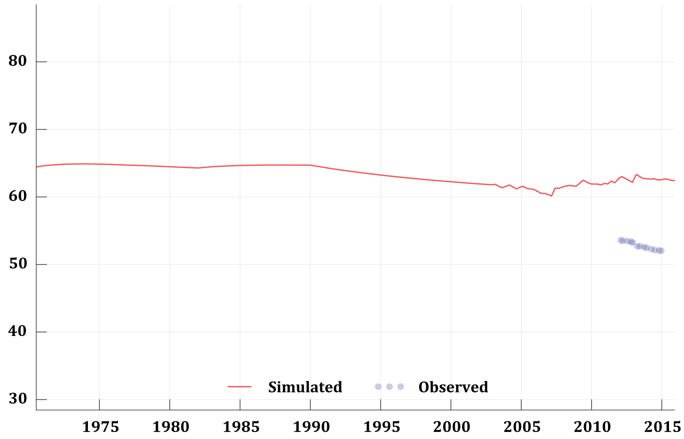
SR010



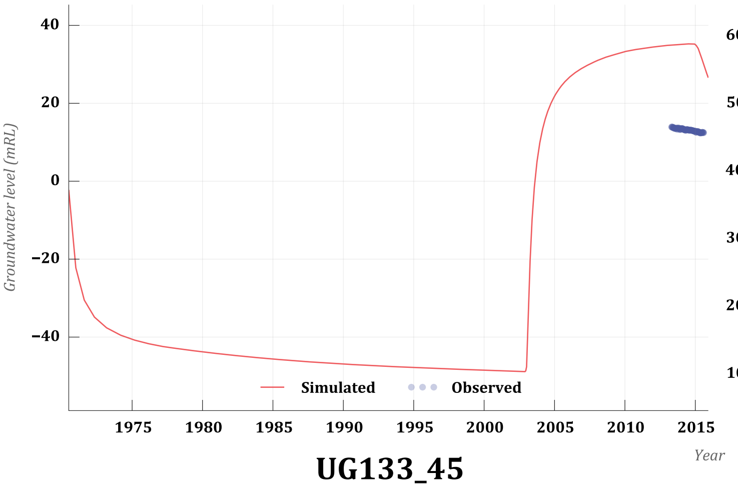
SR011



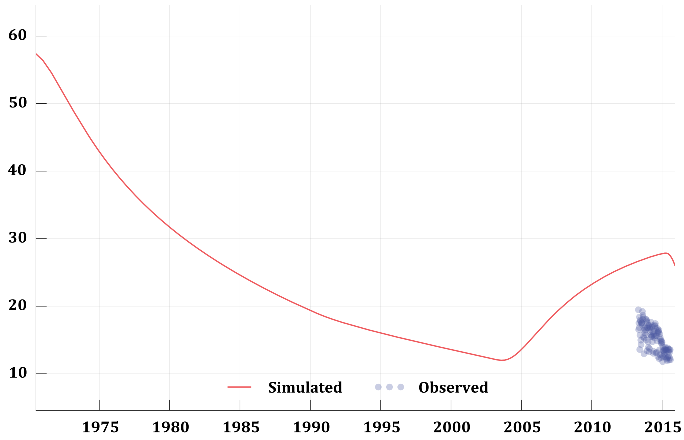
SR012



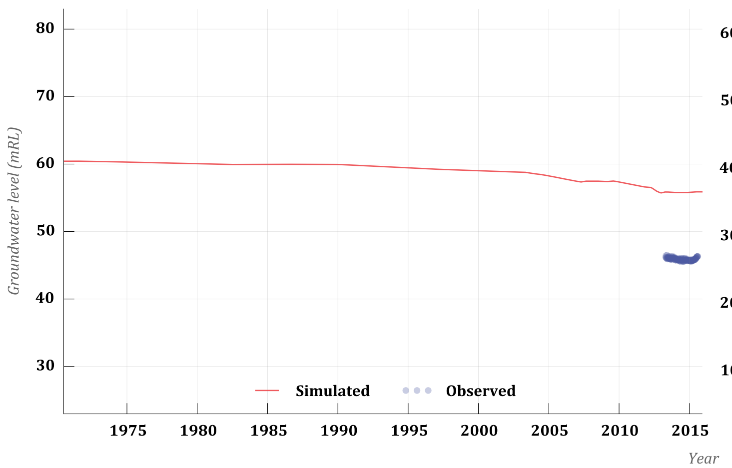
UG133_168



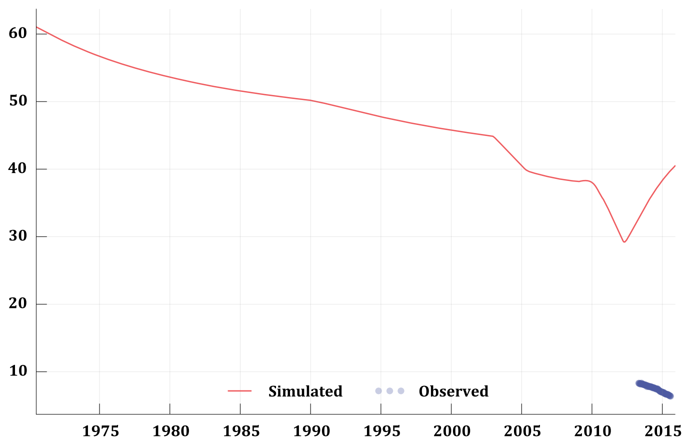
UG133_180

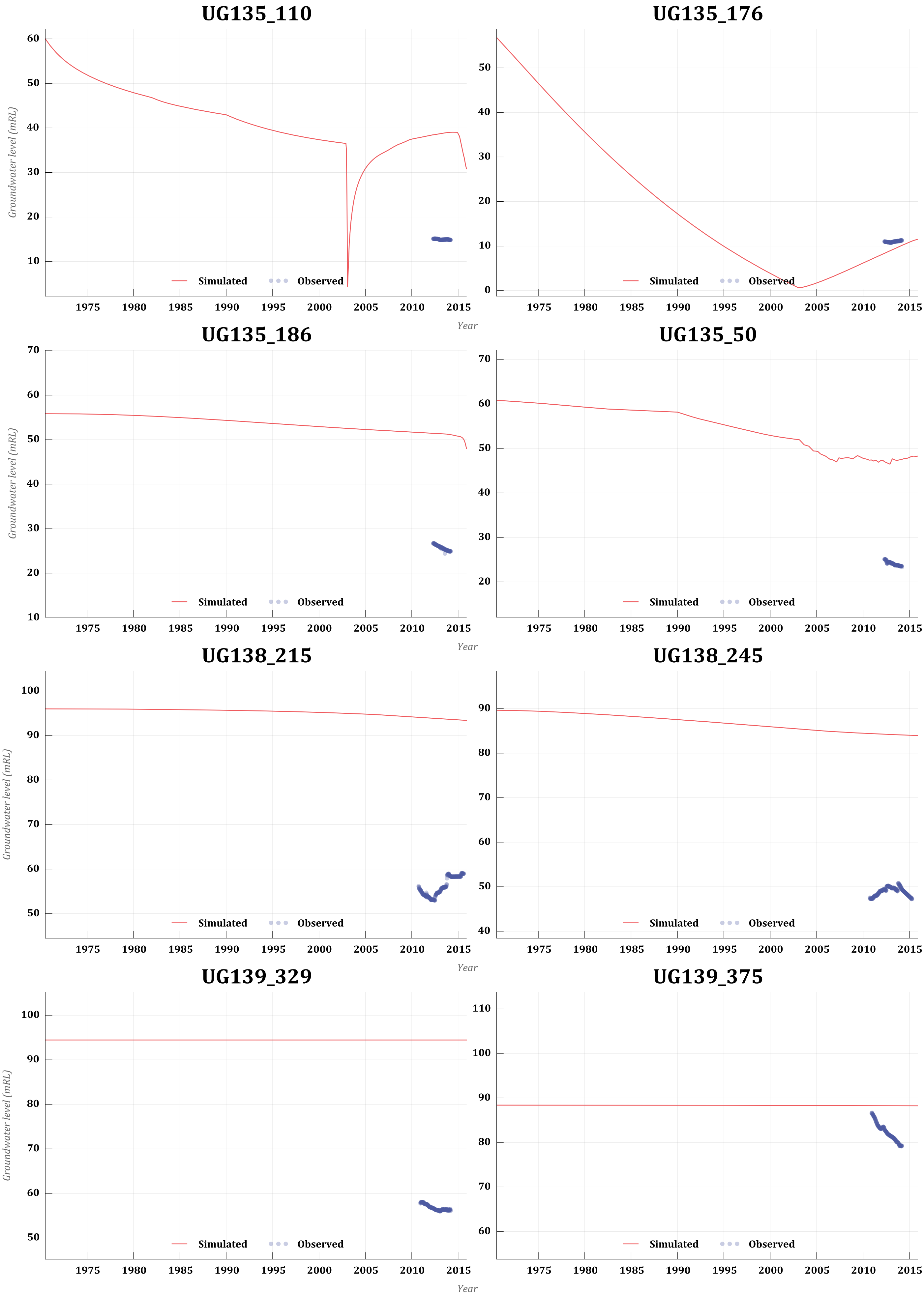


UG133_45

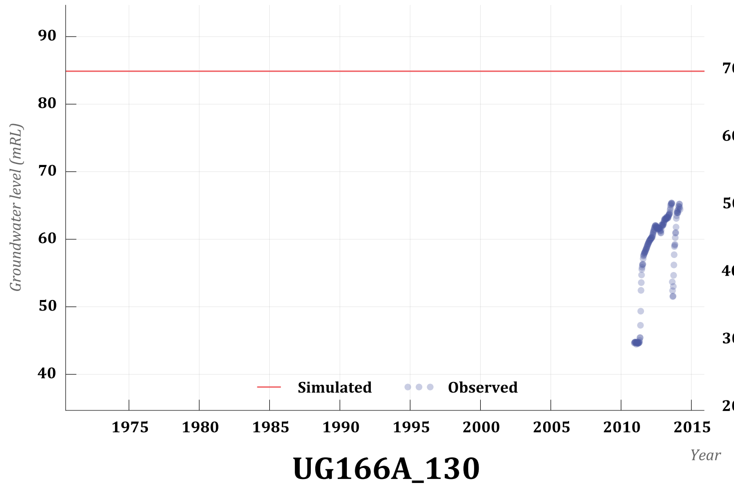


UG133_96

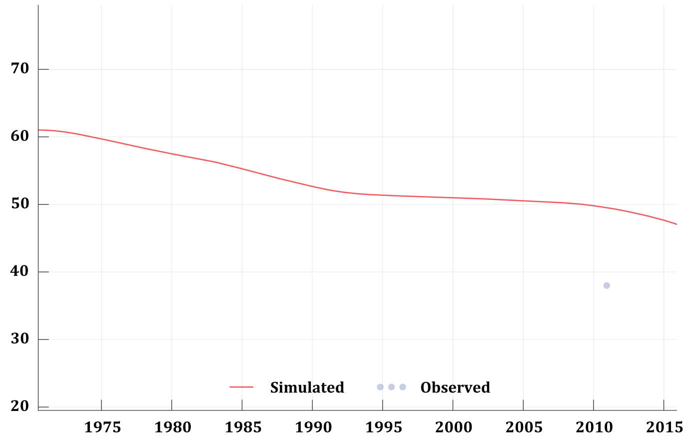



UG135_110
UG135_176
UG135_186
UG135_50
UG138_215
UG138_245
UG139_329
UG139_375
Groundwater level (mRL)
Year
Simulated
Observed
1975
1980
1985
1990
1995
2000
2005
2010
2015

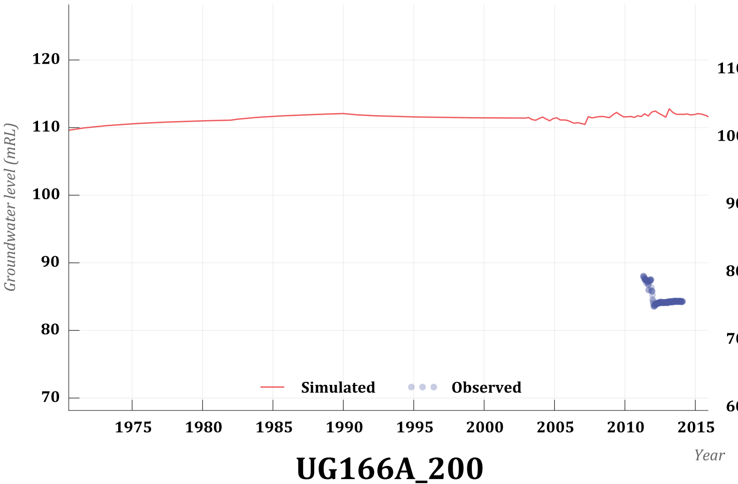
UG139_402



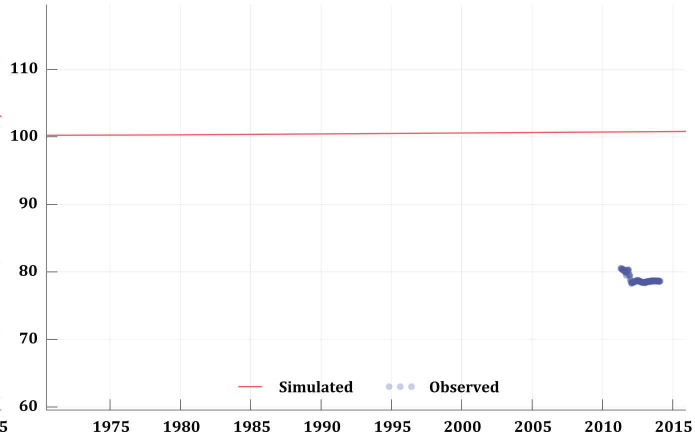
UG147_249



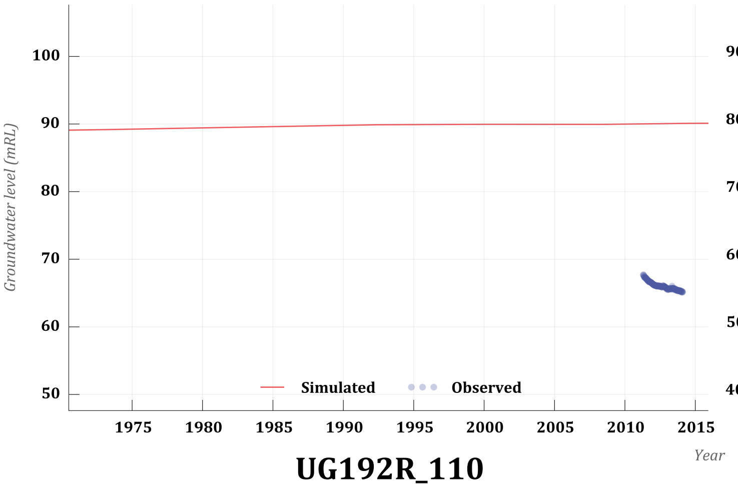
UG166A_130



UG166A_153

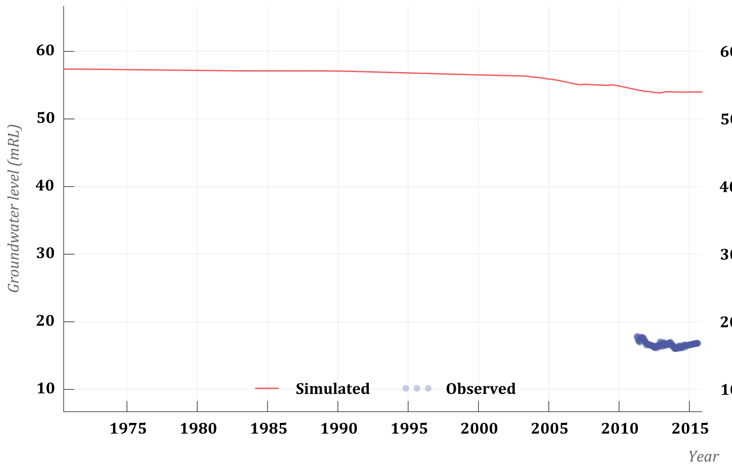


UG166A_200

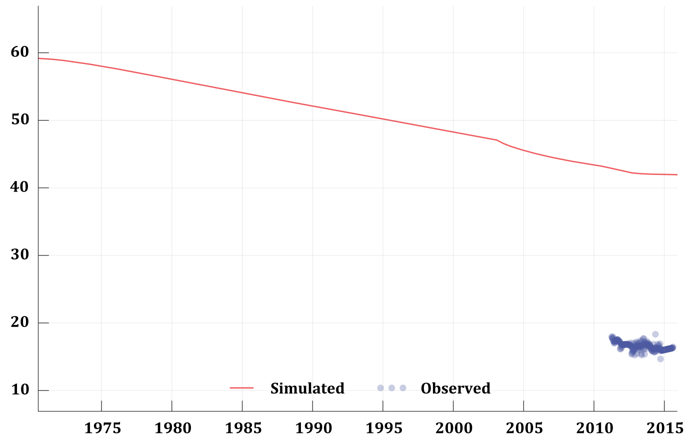


UG166A_238

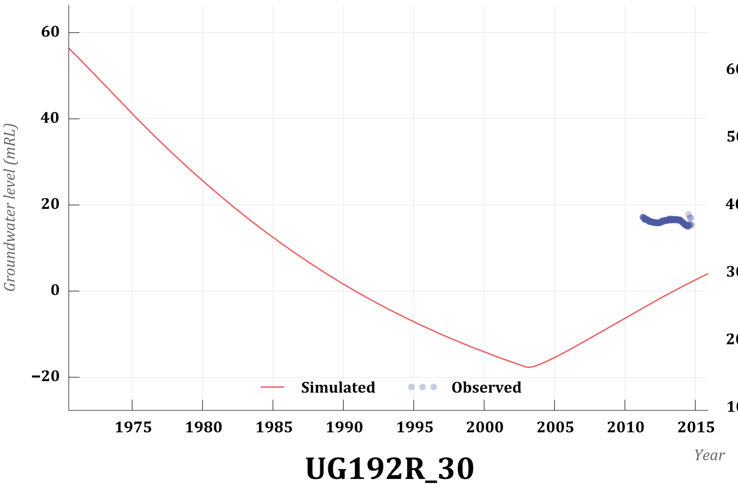
UG192R_110



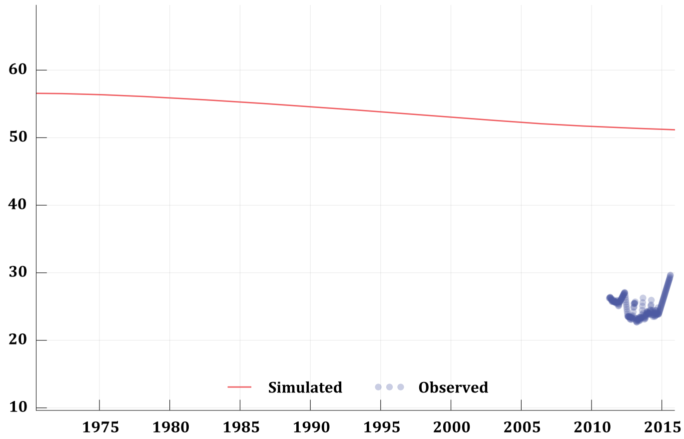
UG192R_140



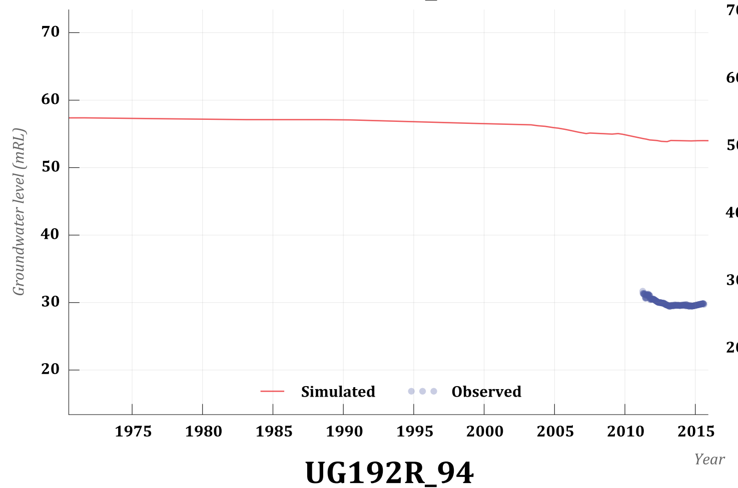
UG192R_170



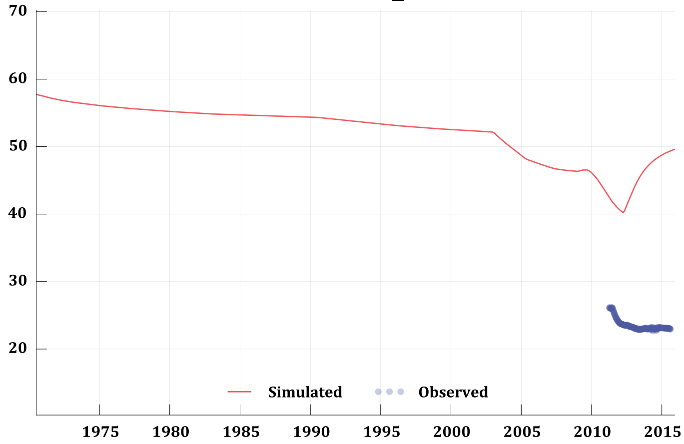
UG192R_210



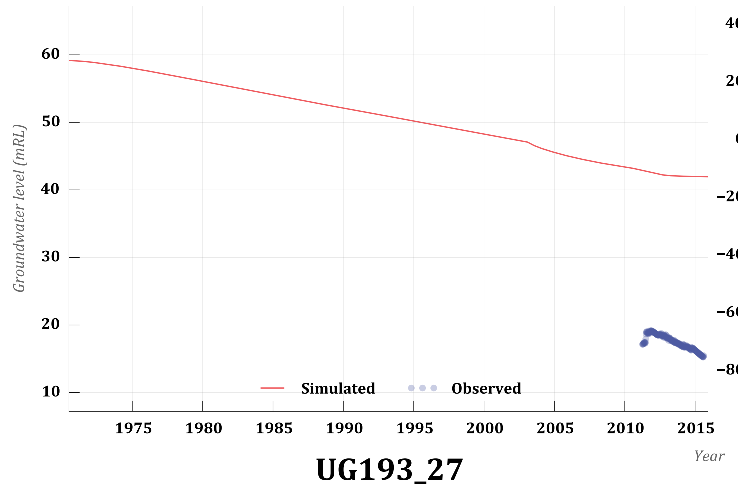
UG192R_30



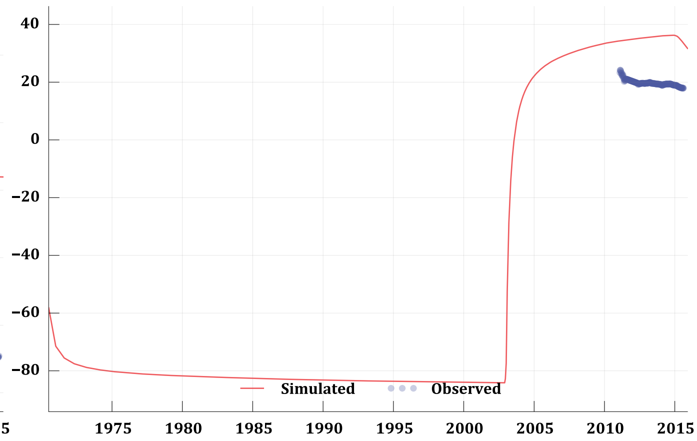
UG192R_60



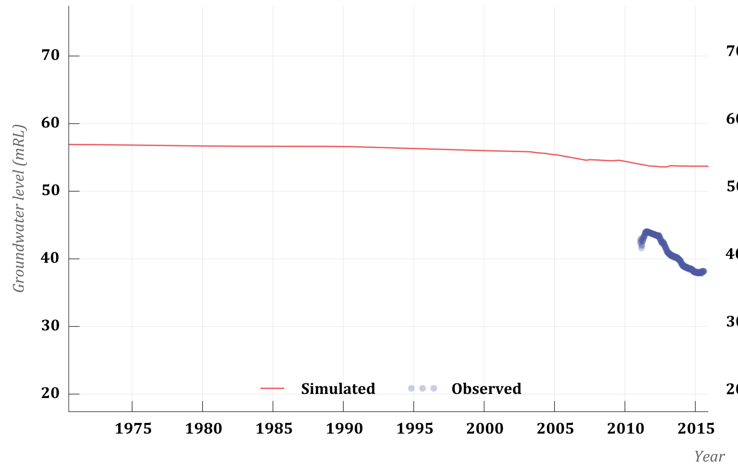
UG192R_94



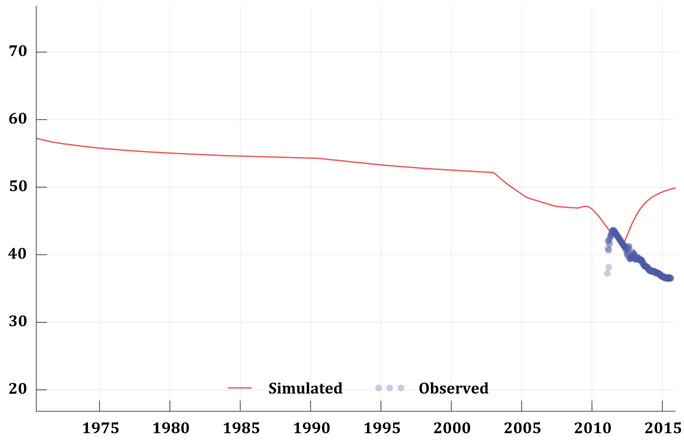
UG193_160

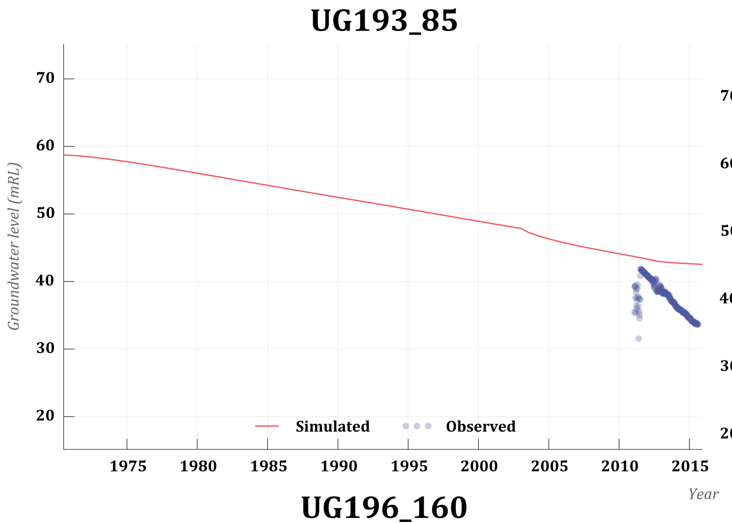


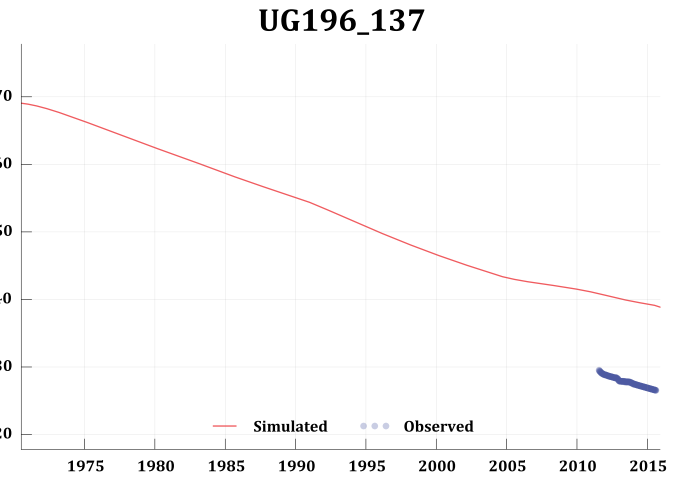
UG193_27

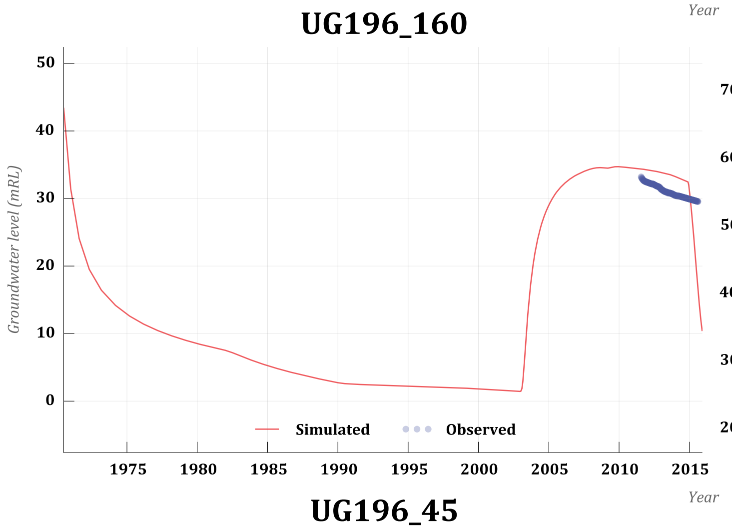


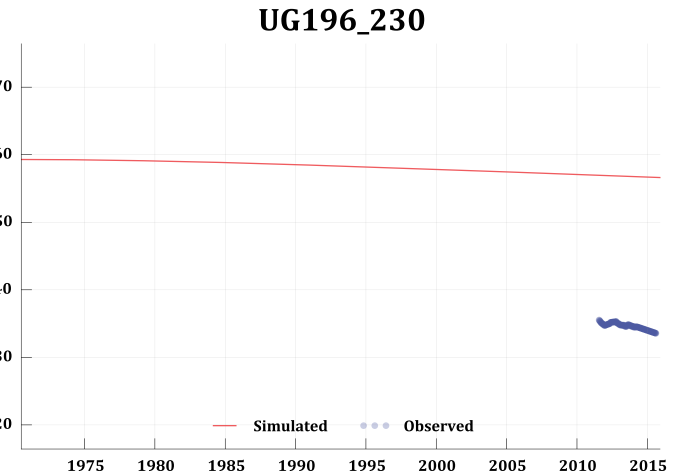
UG193_61

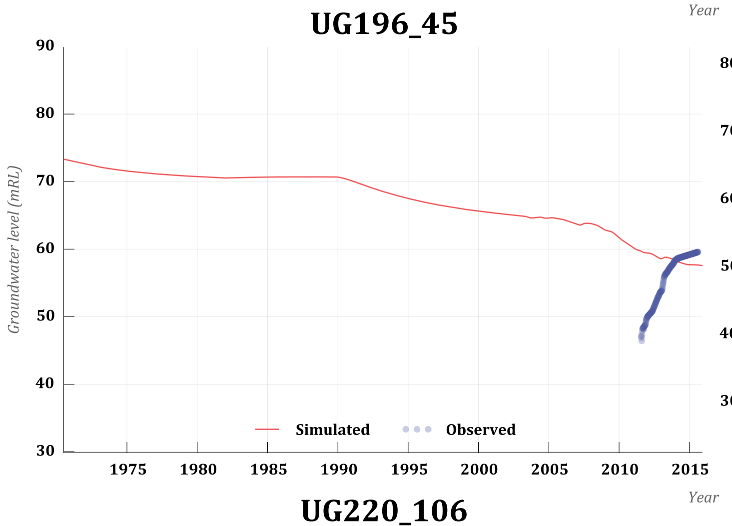


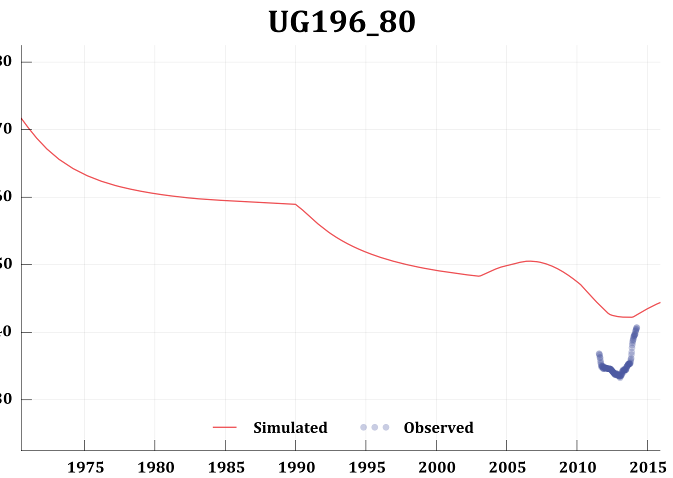

UG193_85
Groundwater level (mRL)
Simulated
Observed
Year

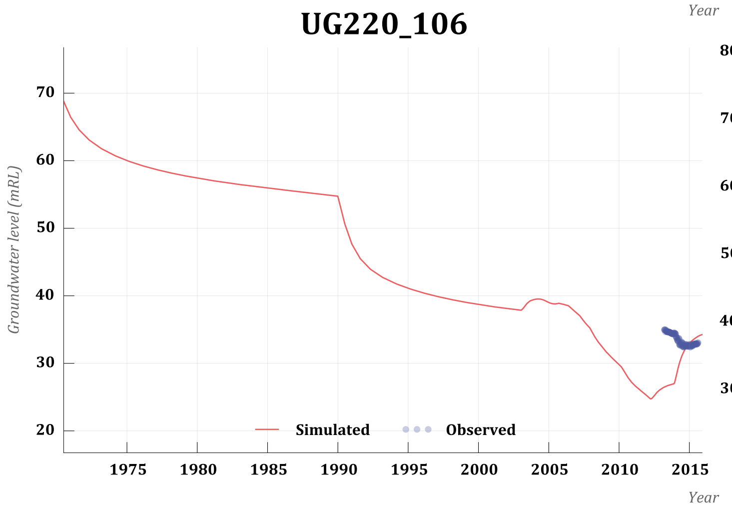

UG196_137
Simulated
Observed

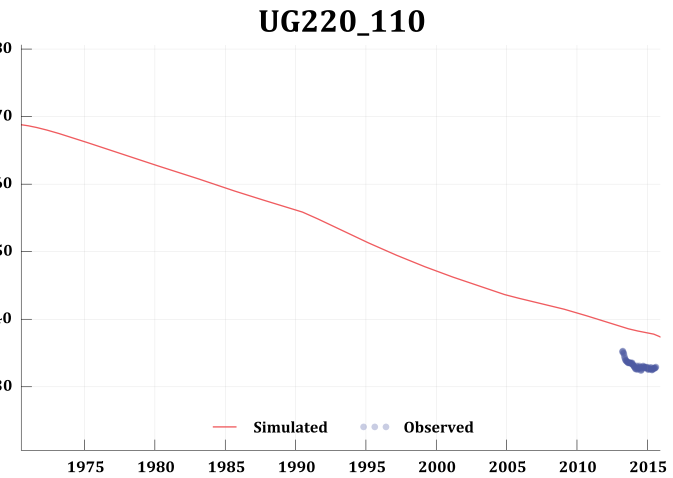

UG196_160
Groundwater level (mRL)
Simulated
Observed
Year

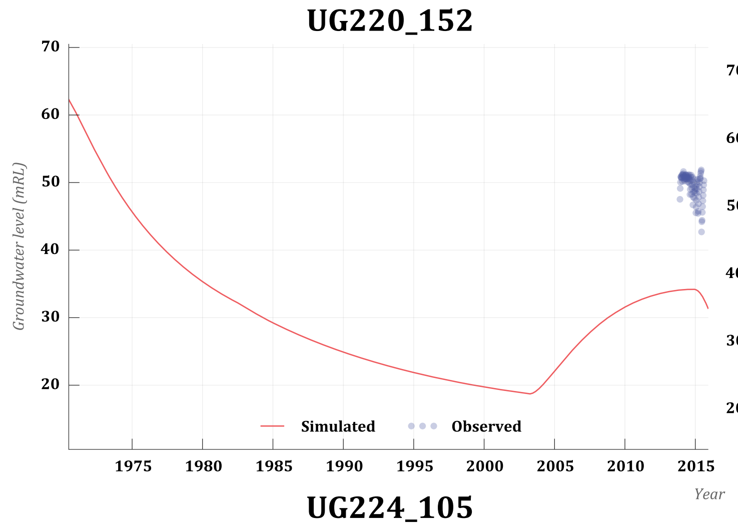

UG196_230
Simulated
Observed

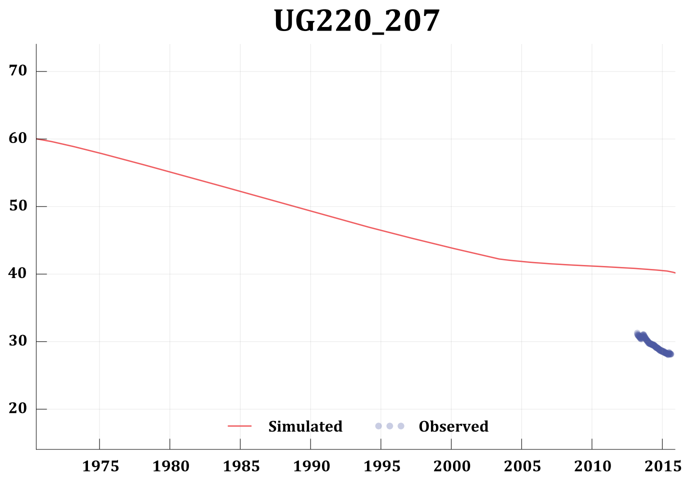

UG196_45
Groundwater level (mRL)
Simulated
Observed
Year

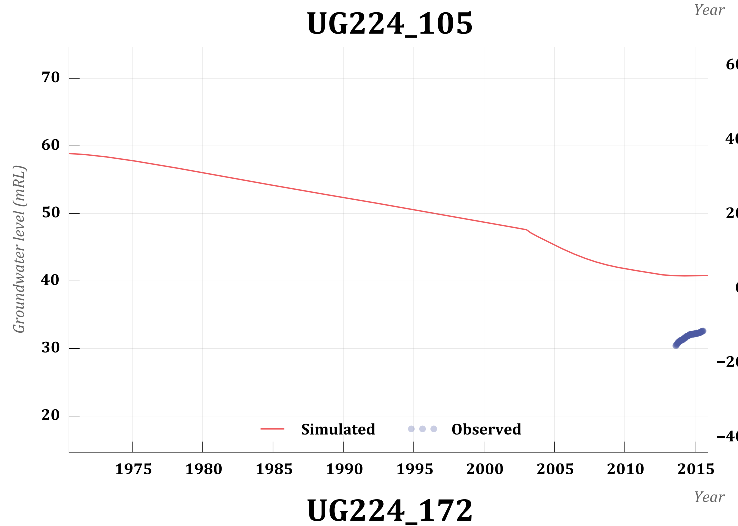

UG196_80
Simulated
Observed

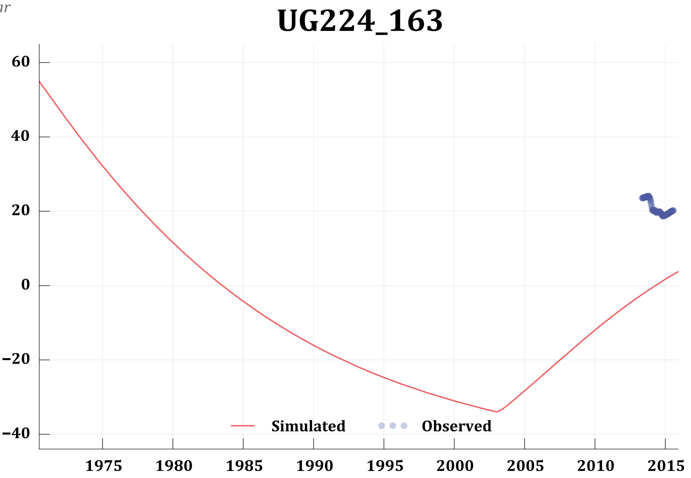

UG220_106
Groundwater level (mRL)
Simulated
Observed
Year

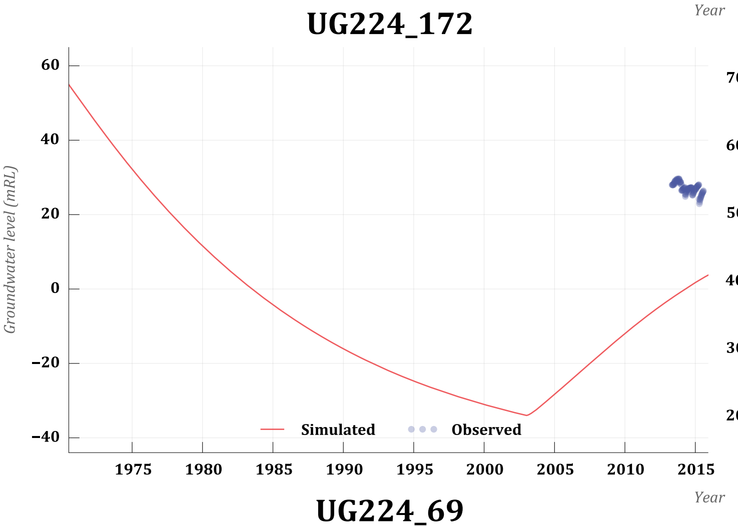

UG220_110
Simulated
Observed

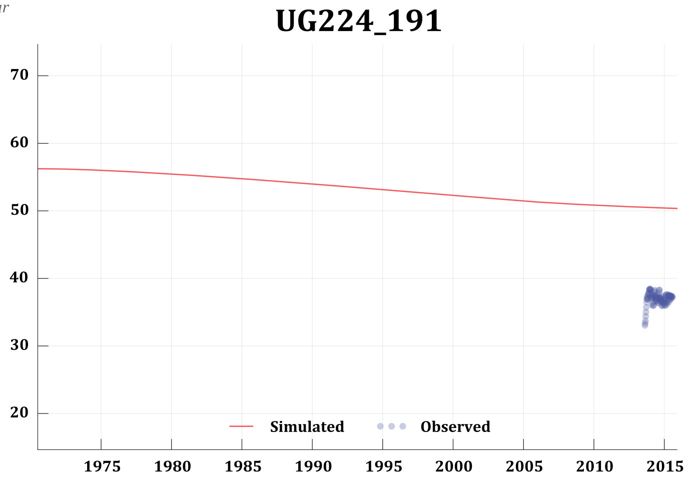

UG220_152
Groundwater level (mRL)
Simulated
Observed
Year

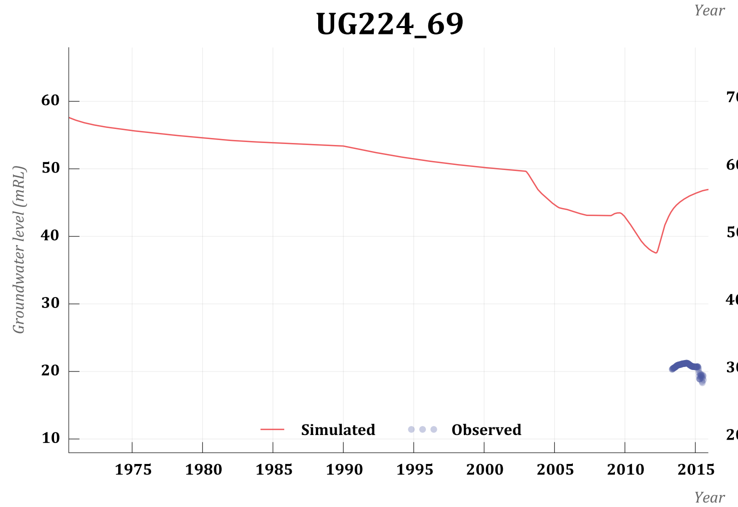

UG220_207
Simulated
Observed

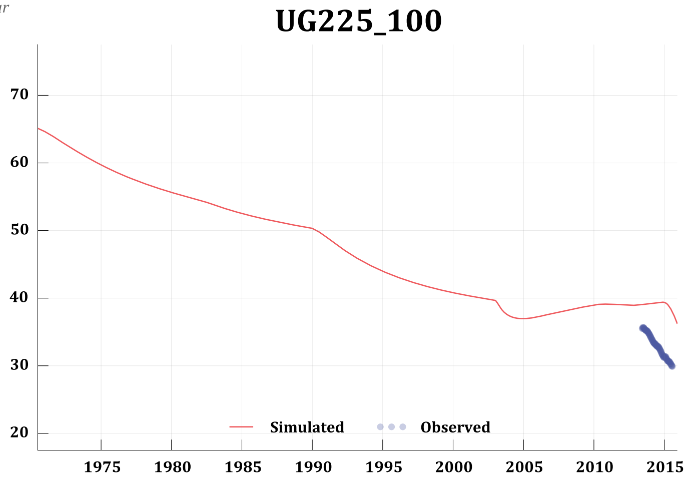

UG224_105
Groundwater level (mRL)
Simulated
Observed
Year


UG224_163
Simulated
Observed

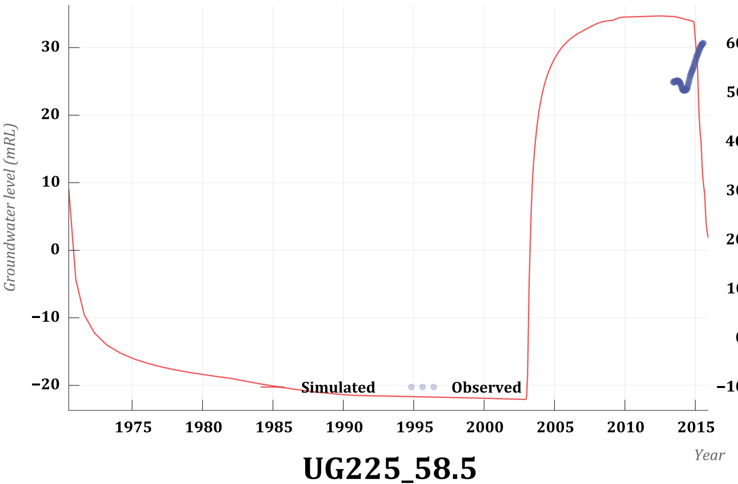

UG224_172
Groundwater level (mRL)
Simulated
Observed
Year


UG224_191
Simulated
Observed


UG224_69
Groundwater level (mRL)
Simulated
Observed
Year


UG225_100
Simulated
Observed

UG225_128



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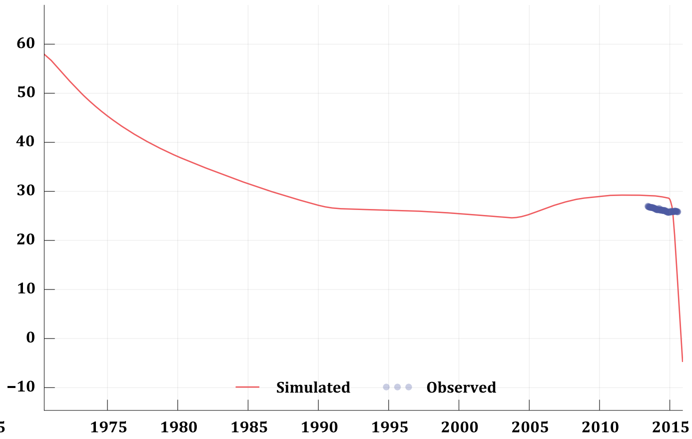

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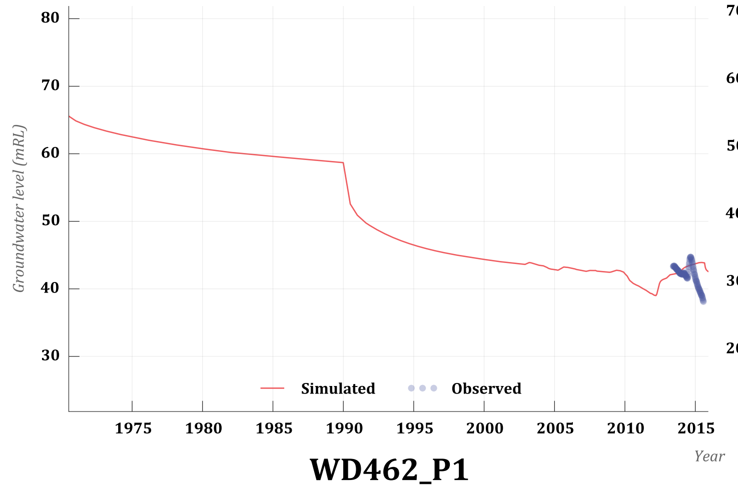

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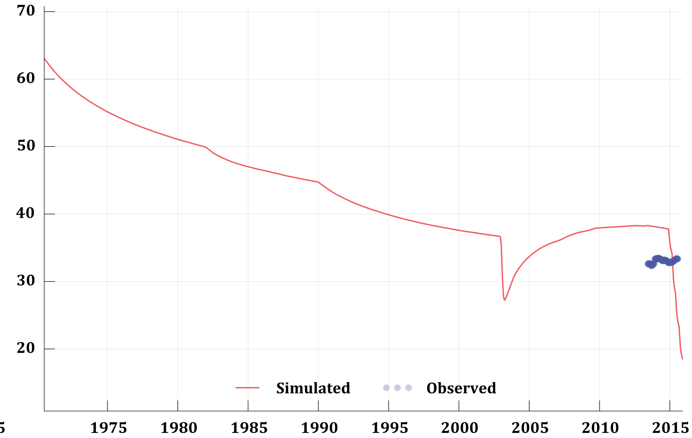

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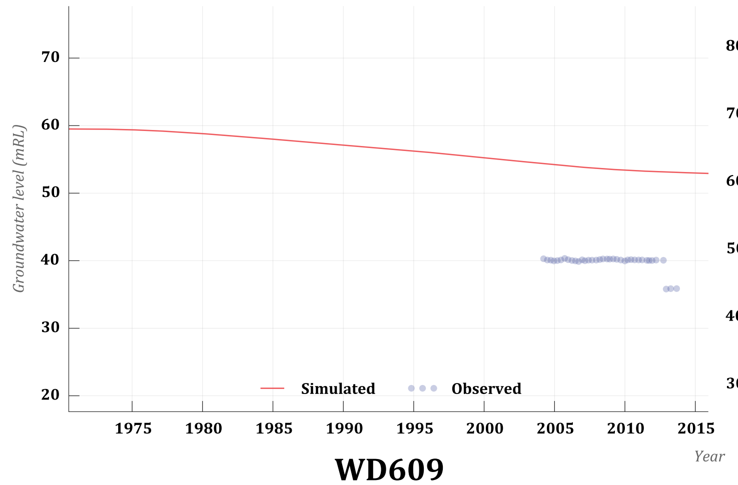

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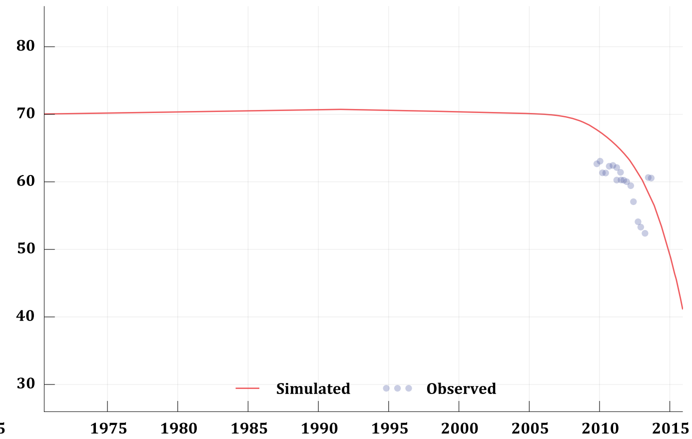

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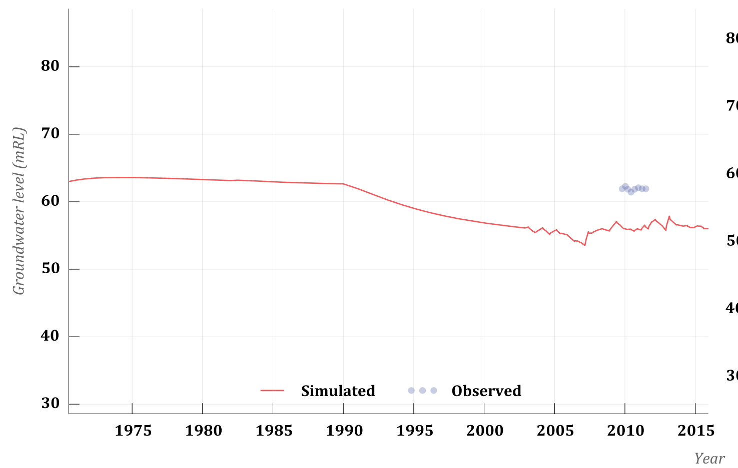

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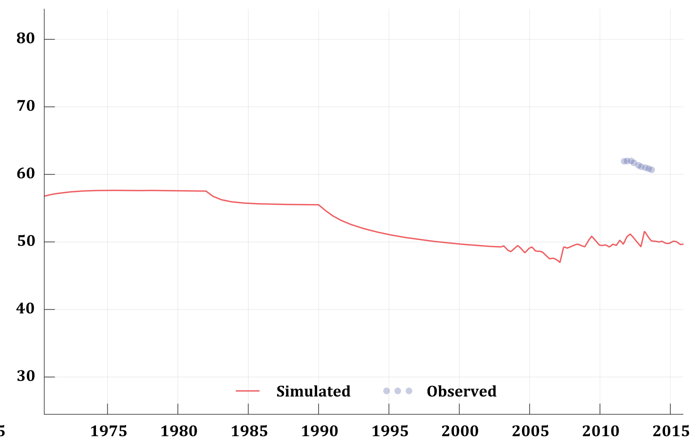

Appendix C

External Review Report

KALF AND ASSOCIATES Pty Ltd
Hydrogeological, Numerical Modelling Specialists

KA Peer Review of AGE 2016 Groundwater Assessment of the HVO South Modification 5 Project

Dr F. Kalf
B.Sc. M.App.Sc PhD
25 July 2016

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Background and Brief Summary

This report is the Kalf and Associates Pty Ltd (KA) peer review commissioned by Coal and Allied Operations Pty Ltd (Coal and Allied) for the Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) hydrogeological and groundwater modelling assessment. The AGE report is part of the impact assessment being prepared by EMM Consulting Pty Ltd. This KA review of the final draft of the AGE report follows on from contributions by KA to earlier comments submitted during the conceptual modelling stage a subsequent draft version of the AGE report and a more recent update of that report. For the modelling review herein the available Modelling Guideline documents (NWC 2012, MDBC 2001) content have been taken into consideration in this assessment. A modelling appraisal checklist is provided herein as an attached Appendix.

Current and proposed mining operations occur within the underlying geological Wittingham Coal Measures overlain by weathered overburden with adjacent alluvial sediments associated with the Hunter River, Wollombi Brook, and to a minor extent in other tributary streams.

Coal and Allied is seeking approval to extend mining at the current operational and previously approved Cheshunt, Riverview mine footprints zones located south of the Hunter River. The extended mining modification to the existing mine plan in these zones involves mining down and into the Bayswater seam that lies below the Vaux seam. Mining in the South Lemington pit No 2 is proposed to extend into Vaux seam. Consequently, changes to the overburden emplacement, final landform and final void will be required.

Modelling of mining at the Hunter Valley Operations (HVO) South has included the influence of previous and currently mined zones, the proposed Modification, as well as the influence of a number of longwall mines situated in the region. Both the Modification alone and cumulative depressurisation have been determined for the coal seams and drawdown of the shallower watertable within the alluvial sediments. Coal seam depressurisation (lowering of the potentiometric head) due to the Modification and cumulative influence, as expected, expands out, up to several kilometres. This depressurisation would not result in widespread dewatering of the seam and would be of no significant consequence to any groundwater users or to the environment (AGE 2016, Figs 7-2, 7.3 and 7.5, 7-6). Alluvial watertable drawdown on the other hand is much more restricted in its propagation (AGE 2016 Fig 7-1, 7-4) with limited isolated drawdown influence due to the Modification. The report indicates that no private bore is predicted to be affected in excess of the 2m maximum as stipulated in the Aquifer Interference Policy (AIP) either in the Permian strata or alluvial sediments as a result of the Modification and approved mining.

The modelling results indicate no additional influence to identified ecosystems due to the Modification over and above influence due to approved mining (AGE 2016, Section 7.5).

Groundwater inflow into all currently approved pits and the Modification will increase progressively over time. The maximum peak take from all sources that includes the modification influence and existing approved water sources is predicted to be 2,598 ML/year. Of this total 1,591 ML/year would be derived from the Permian strata with one third of this total due to the Modification. The remaining 1007 ML/year would be sourced from indirect take from Hunter Unregulated and Regulated Water Sources. Model predicted baseflow reduction in either the Hunter River or Wollombi Brook would not be measurable. The Modification alone is predicted to derive less than 12% of the alluvial and surface water take in the mining zone.

Groundwater quality in the region of the mine site is variable ranging from fresh to highly saline but predominately moderately saline (1500 to 7000 mg/L) and unsuitable for irrigation and stock due to component concentrations. The naturally occurring variability in salinity in groundwater is due to evapotranspiration of a watertable at shallow depth, intermittent influence of better quality runoff and rainfall and naturally occurring higher salinity in the Permian interburden strata.. Local private water usage is predominately from surface water sources.

At completion of mining and rehabilitation there would a final void within the post-mining landform. The pit lake is predicted to have a final water level of up to 30m below pre-mining watertable levels. The proposed void is situated further from the Hunter River than the currently approved void and will therefore have less influence on the alluvium associated with the River. The void will also act as a sink in perpetuity with no escape of contained void water. The void will therefore also attract groundwater from the surrounding spoil materials.

KA is in agreement with the assessment of the key issues presented in the AGE report as summarised above based on the AGE reporting and model predictions.

Peer Review Assessment

Previous Studies and Reviews

Previous studies are discussed in Section 5.7 in the AGE (2016) report..

Hydrogeological and Modelling Description

The hydrogeological description of the region and modelling work described in the AGE (2016) report is detailed and comprehensive in my opinion.

The report covers a wide range of topics that are included within the main headings of: Introduction; Regulatory framework; Environmental setting; Geological setting; Hydrogeology; Numerical groundwater model design; Model predictions and impacts assessment; Compliance with NSW government policy; Groundwater monitoring and management plan and Conclusions; References; Glossary and acronyms.

Model Conceptualisation and Simulation Methods

Model conceptualisation for HVO South Modification by AGE is considered suitable as well as the model layering configuration described in the AGE report. The number of layers (34) used exceeds the number normally accepted for this type of simulation.

AGE have used a method of cell construction that is the basis of a relatively new groundwater modelling computer code issued by the United States Geological Survey known as MODFLOW-USG as opposed to the availability of the well-known MODFLOW-SURFACT (MS) code previously used by AGE. AGE has also used software, ‘AlgoMesh’ developed by HydroAlgorithmics, for generating cell mesh.

One of the main advantages of USG code is that it is possible to focus into the overall mesh with much higher resolution cells in various orientations compared to MS as well as allowing, a significant reduction in cell count. While the mesh generation is different to MS, practically all of the boundary conditions applied are similar to those used in the MS computer code.

The boundaries chosen for the model area are also suitable as well as the depiction of the various ephemeral and perennial stream channels. Rivers have been modelled using the

USG 'river' package with the ability to set stage such that the creeks can act either as a gaining or losing streams. This is considered suitable for the modelled area. Ponding in tailings areas and dams have also been simulated in an acceptable manner.

The model uses variable gross recharge as a percentage of rainfall and evapotranspiration as input and output respectively, which is suitable, rather than application of variable net recharge. During recovery void inflow 'rainfall' was set to 120% to account for surface inflow and pan evaporation applied.

Steady-state simulation was used to set up initial conditions and was combined with transient runs in the AGE model. This is a suitable and desirable methodology. Open-cut mining was simulated using the standard 'drain' methodology with subsequent spoil infilling and changes in hydraulic parameters and rainfall recharge.

Hydraulic parameters are based on measured values and those used in previous modelling studies of the mining site. Calibrated hydraulic conductivity parameters used in the model are provided in Table B-5 and comparison between field and model values Figure B-11 (AGE 2016).Whilst storage properties are given in Table B-7. All values of hydraulic conductivity and storage appear plausible.

Model Calibration and Prediction

Calibration has been conducted under both steady-state and transient conditions. Both manual (trial and error) and automated parameter estimation (PEST) software was used. A total of 368 monitoring sites were adopted to calibrate the model (AGE 2016 Figure B-4).

Calibration fit statistic for the transient case is 3.6% SRMS (scaled root mean square) which is well within the target maximum recommended of 10% in the modelling guidelines document (MDBC 2001). Comparison made between measured and modelled hydrographs are considered to be reasonable and acceptable given the very extensive and mixed mining activity in the region and uncertainty regarding mining operations in surrounding areas.

All data was used for calibration without verification which is normally the case depending on the duration of the water level record available. Verification can be conducted after an additional few years of mine Modification operation.

The total water balance presented in Tables B-8 and B-9 (AGE 2016) for steady state and transient cases are considered plausible

Calibrated sensitivity analysis was conducted on hydraulic conductivity, recharge and river bed vertical hydraulic conductivity but was found to have little influence on the calibration statistic with SRMS remaining well below 10%. As would be expected the greatest change occurred in inflow rates as these are directly proportional to hydraulic conductivity variation whereas head changes are not.

Groundwater Monitoring and Mitigation

There is currently a groundwater monitoring network in place at the HVO South mine and surrounding area (Sections 10, A2 AGE 2016 and Figure A.2, A-3). It is agreed that this network should be adequate for current and future mining model recalibration if required, prediction comparison and water quality variations (Section A3.2 AGE 2016).

No mitigation measures are anticipated but any significant interference as stipulated in the AIP due to mine drawdown will be addressed under the *"make good measures"* policy

(Section 9.5 AGE 2016). KA is also in agreement with the proposed data management and reporting as outlined in Sections 10.5 (AGE 2016).

Conclusions and Considerations

This peer review has assessed the adequacy of the hydrogeological data and the numerical model for predicting the drawdown influences of the proposed Modification that includes deepening of the current mined seams at the current operational HVO South mine. The hydrogeological description, conceptualisation, model design, simulations and reporting have been conducted in a professional manner and described in detail. No fatal flaws have been detected in the description or modelling work conducted.

All drawdown predictions, and in particular water table drawdown within alluvial sediments, are considered plausible.

Predictions of drawdown due to the proposed Modification together with the existing approved mine plan and cumulative effects will have minimal influence on the environment. No private bores would be affected by the Modification mining proposal.

Monitoring bore data should be reviewed and compared with modelling results every 5 years as agreed to in the AGE report (Section 10.4).

References

Australasian Groundwater and Environmental Consultants Pty Ltd (AGE). 2016. *Report on HVO South Modification 5 Groundwater Study. Report prepared for EMM Consulting Pty Ltd. Project No G1737. July.*

National Water Commission (NWC) 2012 *Australian Groundwater Modelling Guidelines. Report prepared by Barnett, B., et. al. Waterlines Report Series No 82, June.*

Murray Darling Basin Commission (MDBC) 2001. *Groundwater Flow Modelling Guideline. Report prepared by Middlemis, H., Merrick, N., and Ross, J., Jan.*

APPENDIX

MODEL APPRAISAL

	ISSUES	Not applicable or Unknown					COMMENTS
1.0	**THE REPORT**						
1.1	Is there a clear statement of project objectives in the modelling report?		Missing	Deficient	Adequate	Very good	
1.2	Is the level of model complexity clear or acknowledged?		Missing	No	Yes		
1.3	Is a water or mass balance reported?		Missing	Deficient	Adequate	Very good	
1.4	Has the modelling study satisfied project objectives?		Missing	Deficient	Adequate	Very good	
1.5	Are the model results of any practical use?			No	Maybe	Yes	
2.0	**DATA ANALYSIS**						
2.1	Has hydrogeology data been collected and analysed?		Missing	Deficient	Adequate	Very good	
2.2	Are groundwater contours or flow directions presented?		Missing	Deficient	Adequate	Very good	
2.3	Has all relevant potential recharge data been collected and analysed?		Missing	Deficient	Adequate	Very good	
2.4	Has all relevant potential discharge data been collected and analysed?		Missing	Deficient	Adequate	Very good	
2.5	Have the recharge and discharge datasets been analysed for their groundwater response?		Missing	Deficient	Adequate	Very good	
2.6	Are groundwater hydrographs used for calibration?			No	Maybe	Yes	
2.7	Have consistent data and standard elevation units been used?			No	Yes		
3.0	**CONCEPTUALISATION**						
3.1	Is the conceptual model consistent with project objectives and the required model complexity?		Unknown	No	Maybe	Yes	
3.2	Is there a clear description of the conceptual model?		Missing	Deficient	Adequate	Very good	
3.3	Is there a graphical representation of the modeller's conceptualisation?		Missing	Deficient	Adequate	Very good	
3.4	Is the conceptual model unnecessarily simple or unnecessarily complex?			Yes	No		
4.0	**MODEL DESIGN**						
4.1	Is the spatial extent of the model appropriate?			No	Maybe	Yes	
4.2	Are the applied boundary conditions plausible and unrestrictive?		Missing	Deficient	Adequate	Very good	
4.3	Is the software appropriate for the objectives of the study?			No	Maybe	Yes	
5.0	**CALIBRATION**						
5.1	Is there sufficient evidence provided for model calibration?		Missing	Deficient	Adequate	Very good	
5.2	Is the model sufficiently calibrated against spatial observations?		Missing	Deficient	Adequate	Very good	

5.3	Is the model sufficiently calibrated against temporal observations?		Missing	Deficient	Adequate	Very good	
5.4	Are calibrated parameter distributions and ranges plausible?		Missing	No	Maybe	Yes	
5.5	Does the calibration statistic satisfy agreed performance criteria?		Missing	Deficient	Adequate	Very good	
5.6	Are there good reasons for not meeting agreed performance criteria?		Missing	Deficient	Adequate	Very good	Performance criteria have been met
6.0	**VERIFICATION**						
6.1	Is there sufficient evidence provided for model verification?		Missing	Deficient	Adequate	Very good	All data used for calibration Verification with ongoing monitoring
6.2	Does the reserved dataset include stresses consistent with the prediction scenarios?		Unknown	No	Maybe	Yes	
6.3	Are there good reasons for an unsatisfactory verification?		Missing	Deficient	Adequate	Very good	
7.0	**PREDICTION**						
7.1	Have multiple scenarios been run for climate variability?		Missing	Deficient	Adequate	Very good	Included in rainfall uncertainty analysis
7.2	Have multiple scenarios been run for operational management alternatives?		No	Deficient	Adequate	Very good	
7.3	Is the time period for prediction comparable with the duration of the calibration period?		Missing	Greater than	Similar to	Less than	46 years calibration 24 years prediction
7.4	Are the model predictions plausible?			No	Maybe	Yes	
8.0	**SENSITIVITY ANALYSIS**						
8.1	Is the sensitivity analysis sufficiently intensive for key parameters/		Missing	Deficient	Adequate	Very good	
8.2	Are sensitivity results used to qualify the reliability of model calibration?		Missing	Deficient	Adequate	Very good	
8.3	Are sensitivity results used to qualify the accuracy of model prediction?		Missing	Deficient	Adequate	Very good	
9.0	**UNCERTAINTY ANALYSIS**						
9.1	If required by the project brief, is uncertainty quantified in any way?		Missing	No	Adequate	Yes	
9.2	**Is the model 'fit-for-purpose'?**			No		Yes	

Appendix D

Study Requirements

D1 Study requirements

D1.1 Independent Expert Scientific Committee (IESC)

The Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (IESC) has information guidelines for advice on coal seam gas and large coal mining development proposals. The following section specifies where the IESC information requirements for individual proposals have been addressed within this report.

D1.1.1 Description of the proposal

Does the description of the proposal include details of the:	addressed in section
purpose	Section 1 and Section 6.2
location	Section 1
scale	Section 1
proposal's status within the regulatory assessment process	Section 1 and Section 2
character	Section 1
duration	Section 1
means by which a significant impact on water resources is likely	Section 1
water management policies or regulations applicable to the proposal	Section 2

D1.1.2 Contextual information

Does the contextual information include details of the:	addressed in section
water resources of the site and region	Section 5 and refer to EIS Surface Water Assessment
geological sequence of the area, including names and descriptions of the formations	Section 4 and refer to main EIS report
hydraulic characteristics for each hydrogeological unit	Section 5
likely recharge sources, direction of discharge and discharge pathways for all hydrogeological units	Section 5
assessments of the frequency, volume and direction of interactions between water sources	Section 5
relevant information generated by a bioregional assessment, or best available information	see EIS Ecology Assessment
geology and hydrogeology at an appropriate level of spatial and vertical resolution	Section 4 and Section 5
geological structures and their influence on groundwater	Section 4

Does the contextual information include details of the:	addressed in section
depths to the hydrogeological units and associated standing water levels or potentiometric heads, including, contours, maps and hydrochemical characteristics	Section 5 and Appendix A
descriptions of hydrology, water quality data and geomorphology for all watercourses across the site	refer to EIS Surface Water Assessment
water related assets	refer to EIS Surface Water Assessment
conceptual modelling	Section 5

D1.1.3 Model-data analysis, including water and salt balances

Model-data analysis builds on background data and conceptual modelling to enable an analysis. The information provided should include:	addressed in section
surface water and groundwater assessments and modelling, including detailed hydrology and water quality assessments	This report and refer to EIS Surface Water Assessment
quality of and risks and uncertainty inherent in the data and modelling	Appendix B

Has a groundwater model that is calibrated to baseline conditions and enables a probabilistic evaluation of potential future scenarios been provided? Does the groundwater modelling include:	addressed in section
the model conceptualisation of the hydrogeological system or systems, including key assumptions and model limitations	Section 5 and Appendix B
the various stages of the proposed development and predictions of water level/pressure declines in each hydrogeological unit	Appendix B
the volumes predicted to be dewatered with an indication of the proportion supplied from each a hydrogeological unit	Section 7
consider a variety of boundary conditions for stream across model domain	Appendix B
be undertaken in accordance with the Australian groundwater modelling Guidelines, including being peer reviewed	Appendix B
each hydrogeological unit, including storage and flow characteristics, their existing recharge/discharge pathways and any linkages between units	Appendix B
maximum drawdown and the time for post development drawdown equilibrium to be reached	Section 7
potential water level recovery rates and timeframes for each hydrogeological unit	Section 7.3
include a sensitivity analysis of stream boundary conditions and justification of the conditions applied in the final model	Appendix B
recommendations and a program for review and update of the model	Section 10

Do the water and salt balances provide details on specific flows and changes, including:	addressed in section
any changes that occur to the salt loads of the groundwater and surface water systems	Section 7.7
water infiltration from surface stores	Appendix B
waste water from the operation	refer to EIS Surface Water Assessment
volumes and quality of water used during mining	refer to EIS Surface Water Assessment
all interactions and flows that exist that are part of the background (baseline) water flows	Appendix B
hydrogeological unit storage properties and groundwater flows and pressures resulting from depressurisation	Appendix B
an estimation of flow/exchange of water between hydrogeological units and the target coal measure	Section 7
all volumes and quality of water intended for injection	not applicable
any water that must be imported from elsewhere	not applicable
estimates of water use in transpiration by vegetation, and the predicted changes to vegetation water use	Appendix B

D1.1.4 Assessment of impacts on water resources and water related assets

Does the assessment of impacts include details of:	addressed in section
likely changes to water and salt balances	Section 7
the hydrogeological units that will be directly impacted by mining operations	Section 7
impacts on hydrological interactions between water resources	Section 7
impacts associated with surface water diversions	refer to EIS Surface Water Assessment
impacts on hydraulic properties of hydrogeological units	not addressed as part of this report
effects of depressurisation due to gas extraction	not applicable
the quality and quantity of operational discharges of water	refer to EIS surface water report
landscape modifications	Section 7 (final voids)
the cumulative impacts (see section titled Assessment of cumulative impacts)	Section 7.2
proposed mitigation actions for each identified impact	Section 10
subsidence and effects from dewatering and depressurisation	not applicable

Does the assessment of impacts include details of:	addressed in section
the hydrogeological units that will be dewatered or indirectly impacted by dewatering	Section 5 and Section 7
the extent of the cone of depression and consequential impacts on water resources	Section 7
direct and indirect impacts on water related assets	Section 7
potential for physical transmission of water within and between hydrogeological units	Section 7
estimates of likelihood of leakage of contaminants from coal beds through geological formations	not addressed as part of this report
vulnerability to contamination and likely impacts of contamination on water related assets	Section 7
long term impacts from final landform design	Section 7
measures taken to avoid and minimise impacts	Section 10

D1.1.5 Assessment of cumulative impacts

Does the assessment of cumulative impacts include:	addressed in section
a summary of CSG and large coal mining developments within the region	Section 3.5
existing and planned water entitlements, and the actual take of water for consumptive, industrial and agricultural purposes	Section 7
the proportional increase in water resource use	Section 7
catchment and regional scale information (from bioregional/other relevant assessments)	Section 4 and Section 5
existing water quality guidelines, targets, environmental flow objectives and requirements for the surface catchment and groundwater basin	Section 2 and Section 5
the overall level of risk to water related assets	Section 7

D1.1.6 Assessment of risk

Does the assessment of risk identify:	addressed in section
water related assets in the area	Section 7
the likelihood and consequence of impacts occurring	Section 7
the overall level of risk to assets that combine probability of occurrence with consequence or severity of impact	Section 7
potential impacts to water related assets	Section 7
the magnitude or severity of impact in the event that the impact was to occur	Section 7
the residual risk following the application of mitigation measures	Section 10

D1.1.7 Ongoing management and monitoring

Does ongoing management and monitoring include:	addressed in section
a robust monitoring plan to inform management and mitigation of all impacts identified through the assessment	Section 10
comprehensive baseline monitoring dataset prior to commencement of the development	Appendix A and Section 10
the hypotheses to be tested	Section 10
the analytical methods to be used	Section 10
water quality monitoring that is managed in accordance with the relevant National Water Quality Management Strategy (NWQMS) guideline	Section 10
regular reviews and revisions of the monitoring program	Section 10
clearly defined monitoring objectives and performance indicators	Section 10
maps and coordinates of monitoring locations	Section 10
the ability to capture seasonal and inter-annual variability and enable valid statistical analysis of results	Section 10
groundwater, surface water and associated ecological attributes and be capable of tracking changes from pre-development conditions	Section 10
the rationale and design for the monitoring program	Section 10
the temporal and spatial frequency of monitoring and the potential indicators to be monitored	Section 10
the identified triggers and threshold and proposed management actions if levels are reached and exceeded	Section 10
a commitment to regular reporting of findings from monitoring programs, including raw data, analysis of data, and the results and conclusions	Section 10
an adaptive management approach to manage changes in the predicted impacts	Section 10
a description of local and regional surface water regime/s and detailed historical baseline data against which monitoring results can be assessed	Section 10
the number and spatial distribution of monitoring sites and monitoring frequency	Section 10
a monitoring network that extends beyond the predicted impact area	Section 10 – due to extensive mining in region, unable to extend outside the cumulative impacts zone

Does the groundwater monitoring program include:	addressed in section
a network to collect sufficient physical aquifer parameters and hydrogeochemical data to establish pre-development (baseline) conditions	Section 10 and Appendix A
dedicated groundwater monitoring wells	Section 10and Appendix A
information on the groundwater regime, recharge and discharge processes and identify changes over time in the groundwater system	Section 10 and Appendix A
a comprehensive assessment of all relevant chemical parameters to inform changes in groundwater quality and detect potential contamination events	Section 10 and Appendix A
specific aquifers for monitoring and management	Section 10 and Appendix A
appropriate management responses to mitigate impacts to groundwater resources	Section 10 and Appendix A

Does the surface water monitoring program include:	addressed in section
sufficient data to detect and identify the cause of any changes from baseline conditions	refer to EIS Surface Water Assessment
a rationale for selected monitoring variables	refer to EIS Surface Water Assessment
dedicated sites to monitor hydrology, water quality and channel geomorphology throughout the life of the proposal	refer to EIS Surface Water Assessment
satellite or aerial impact, if required.	refer to EIS Surface Water Assessment

Does the ecological monitoring program include:	addressed in section
an evaluation of the effectiveness of impact prevention or mitigation measures	refer to EIS Ecology Assessment
measurements of trends in ecological responses and whether ecological responses are within identified thresholds of acceptable change	refer to EIS Ecology Assessment