APPIN MINE EXTRACTION PLAN

Groundwater Impact Assessment

Prepared for:

South 32 - Illawarra Metallurgical Coal

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APPENDICES

1 Introduction

The Appin Mine is located approximately 25 km north-west of Wollongong. Appin Mine is owned and operated by Illawarra Metallurgical Coal (IMC), a subsidiary of South32 Limited (South32). The existing mining operations are undertaken in accordance with Project Approval 08_0150 for the Bulli Seam Operations (BSO), granted in December 2011 and modified in October 2016 to incorporate the Appin Ventilation Shaft No. 6 Approval.

IMC is currently extracting Longwall 709 in Appin Area 7 and Longwall 904 in Area 9. In accordance with the development consent conditions, an Extraction Plan (EP) is required to be prepared prior to commencement of secondary extraction. The EP outlines the proposed management, mitigation, monitoring and reporting of potential impacts from the secondary extraction of approved longwalls at Appin Mine. IMC is seeking EP approval for Longwalls 709, 710A, 710B, 711 and 905, henceforth referred to as the Project. Once approved the Extraction Plan will replace the current Longwall 709 Subsidence Management Plan approval.

Heritage Computing (2009) conducted the groundwater impact assessment for the approved operations relevant to the Project. SLR Consulting Australia Pty Ltd (SLR) was engaged by South32 to complete a technical review of the groundwater impacts for the Project (Longwalls 709, 710A, 710B, 711 and 905). SLR has prepared this revision report in response to a review from the Biodiversity and Conservation Division of the NSW Department of Planning, Industry and Environment, dated 6 August 2021. The initial report prepared by SLR was issued in December 2020 and was revised in April 2021. This report presents the latest groundwater modelling methodology and results, as well as discussion on the impact predictions for the Project compared to the remodelled approved operations and predictions by Heritage Computing (2009).

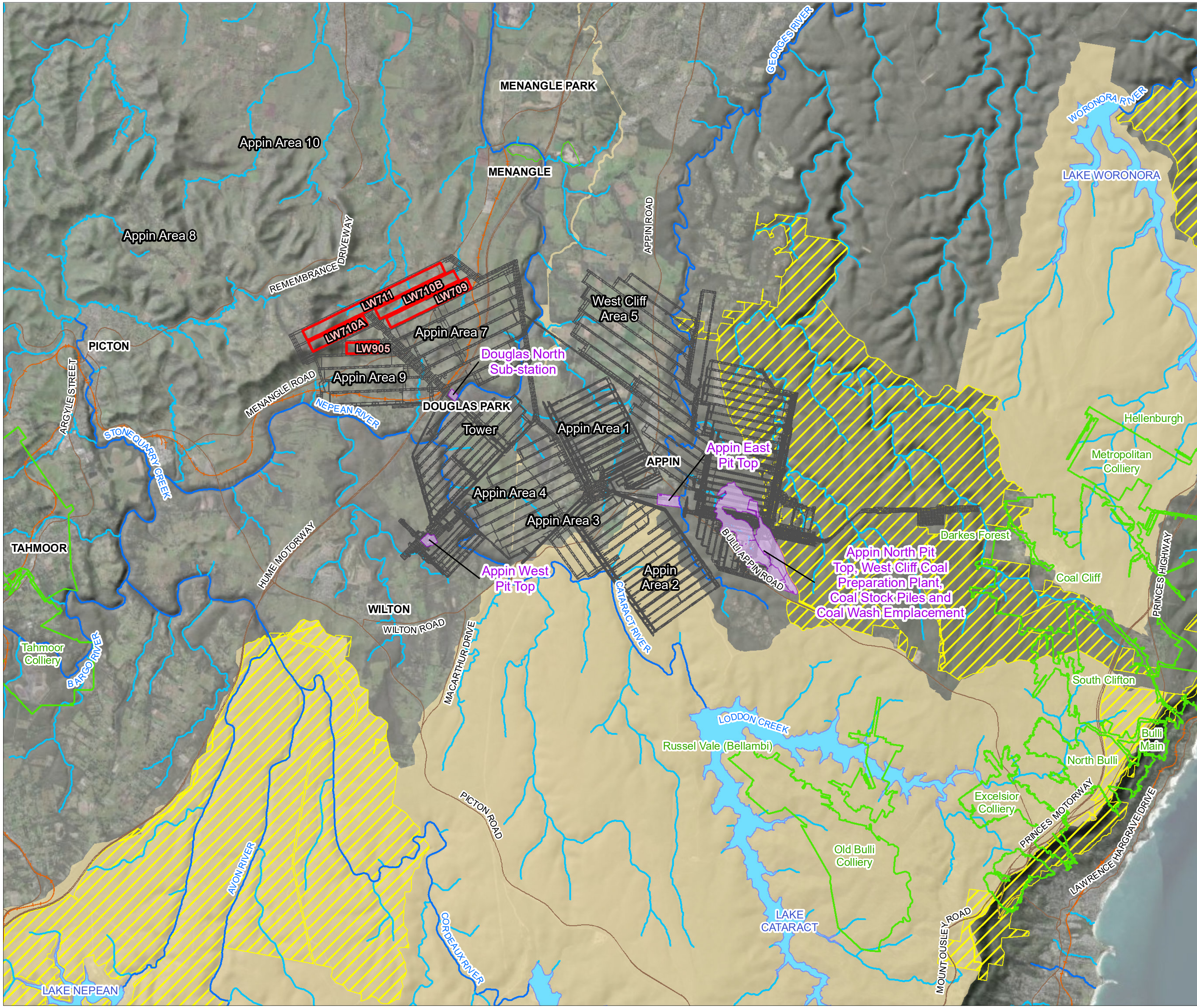
1.1 Project Description

The Project relates to Longwalls 709, 710A, 710B, 711 and 905, as presented in Figure 1. The proposed mining includes:

- Longwall709 – Planned to be mined from January 2022 to July 2023, panel width of 319 m and average extraction height up to 3.02 m;
- Longwall710A – Planned to be mined from July 2023 to April 2025, panel width of 319 m and average extraction height up to 3.10 m;
- Longwall710B – Planned to be mined from July 2023 to April 2025, panel width of 319 m and average extraction height up to 3.00 m;
- Longwall711 – Planned to be mined from April 2025 to October 2026, panel width of 319 m and average extraction height up to 3.15 m; and
- Longwall905 – Planned to be mined from May 2022 to March 2023, panel width of 300 m and average extraction height up to 3.03 m.

The Project is within Areas 7 and 9 of the approved BSO, which has been previously assessed by Heritage Computing (2009). Appin Mine as shown in Figure 1 is defined as the existing and proposed mining operations at Appin from January 2010 to December 2026 including Longwalls 709, 710A, 710B, 711 and 905 in this study.

Details on the approved operations at Appin Mine and the previously predicted groundwater impacts are included in Section 2.4.1.1.



APPIN MINE GROUNDWATER ASSESSMENT

Project Layout

FIGURE 1

- Roads
- Railway
- Major watercourses
- Minor watercourses
- Appin Mine
- Other mine workings
- Lakes
- NPWS estate areas
- Water NSW special areas
- S32 Surface Site Locations
- Project Area

0 2.5 5 km

Projection: GDA 1994 MGA Zone 56
Scale: 1:150,000 at A4

Project No.: 665.10015
Date: 15-Dec-2021
Drawn by: JG

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1.2 Study Objectives

The groundwater assessment comprised two parts:

(i) a description of the existing hydrogeological environment

(ii) an assessment of the potential impacts of mining on the groundwater related environment.

To this end, the stated scope of work was to:

- Brief background on the site setting and conceptual groundwater model utilising work completed for the Appin Mine Groundwater Assessment – Mine Closure report completed in April 2020;
- Construction and calibration of a numerical groundwater flow model suitable for the assessment of potential impacts of the Project, in accordance with the Australian Groundwater Modelling Guidelines (Barnett et al., 2012) and Murray Darling Basin Commission guidelines (Middlemis et al., 2001). Perform predictive modelling for the scale and extent of mining impacts upon groundwater levels, groundwater quality and groundwater users at various stages during mine operations.
- Re-calibrate the model to improve the area which addresses the mismatch between modelled and observed groundwater levels.
- Update the calibration statistics, check the mine inflows changes and depressurisations.
- Calculate the river baseflow/leakage reduction for Navigation Creek, Navigation Creek Tributary 1 or Foot Onslow Creek.
- Predictive modelling of the cumulative impacts of Project, surrounding mines and the other relevant developments (e.g. Camden Gas Project).
- Assess the extent of groundwater impacts due to the Project, including long-term impacts on regional groundwater interception, groundwater depressurisation and incidental water impact. Assessment of potential hydrogeological impacts and management measures relating to subsidence during extraction of the proposed longwalls;
- Provide recommendations for monitoring of impacts;
- Establish groundwater trigger levels for investigating any potentially adverse impacts on water resources or water quality, monitor and report on groundwater inflows, as well as predict, manage and monitor impacts on bores on privately-owned land;
- Address the Before-After-Reference-Impact (BACI) design requirement by updating the Hydrogeology (Section 2.6), Appin Mine Monitoring Network (Section 5.1) plus an additional section to discuss the river baseflow reduction for Navigation Creek and Foot Onslow Creek;

2 Environmental Setting

2.1 Climate

Daily rainfall observations have been recorded by IMC since 2014 at Appin East, Appin North, Appin West (part) and at the Ventilation Shaft No.6. However, due to the short period of monitoring, long-term BoM site data associated to the Scientific Information for Landowners (SILO) point grid has been used for this Project. There are several Bureau of Meteorology (BoM) stations in the area with long-term data, including Darkes Forest (068024), Cataract Dam (068016), Wedderburn (068159), Douglas Park (068200). The BoM data was obtained from SILO point grid (Latitude -34.20 Longitude 150.75) located between Douglas Park and Appin and used to evaluate the climatic conditions at Appin Mine. The data was obtained through the SILO database, from January 1890 to August 2021 Based on the SILO data, the long-term (1890 to 2020) average yearly rainfall for the Project area is 986 mm/yr.

Figure 2 shows the long-term rainfall trends based on the SILO data, as defined by the cumulative departure from mean or cumulative rainfall deficit curve. This shows the historical occurrence of dry periods (downward rainfall trend), wetter than average periods (upward rainfall trend). After the Millennium Drought, there was a period of average conditions, followed by another period of below average rainfall. Over the past two years (2020-2021), rainfall trends have reverted back to average conditions.

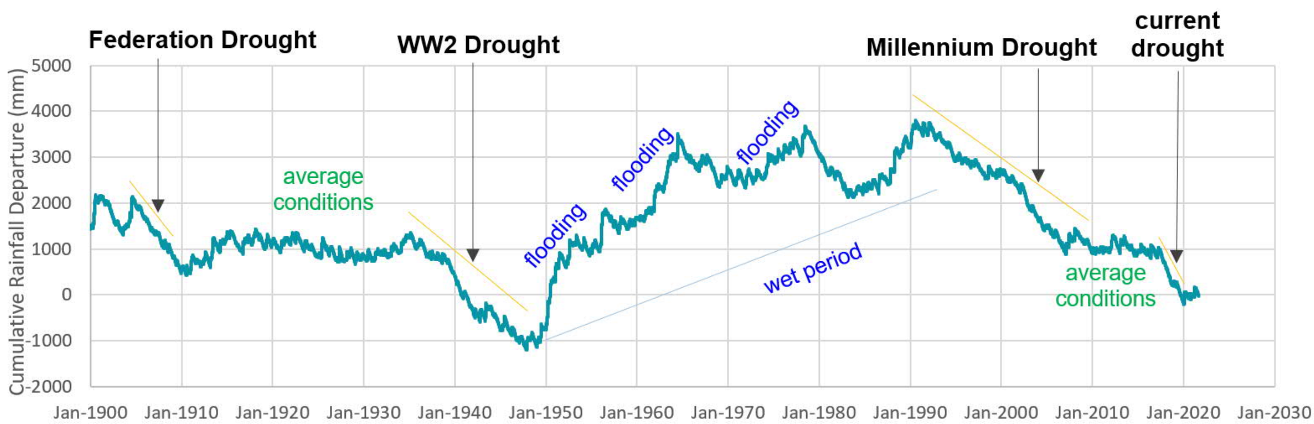


Figure 2 Cumulative Rainfall Departure

Potential evaporation (PE) data is also available from BoM. Long-term average PE is approximately 1576 mm/yr at Appin, and slightly lower at Wollongong on the coast (1520 mm/yr). Actual evapotranspiration (ET) at Appin is approximately 922 mm/yr. A comparison of average daily rainfall for each month and PE is presented in Figure 3. This shows that in July there is a rainfall excess, with a rainfall deficit in all other months.

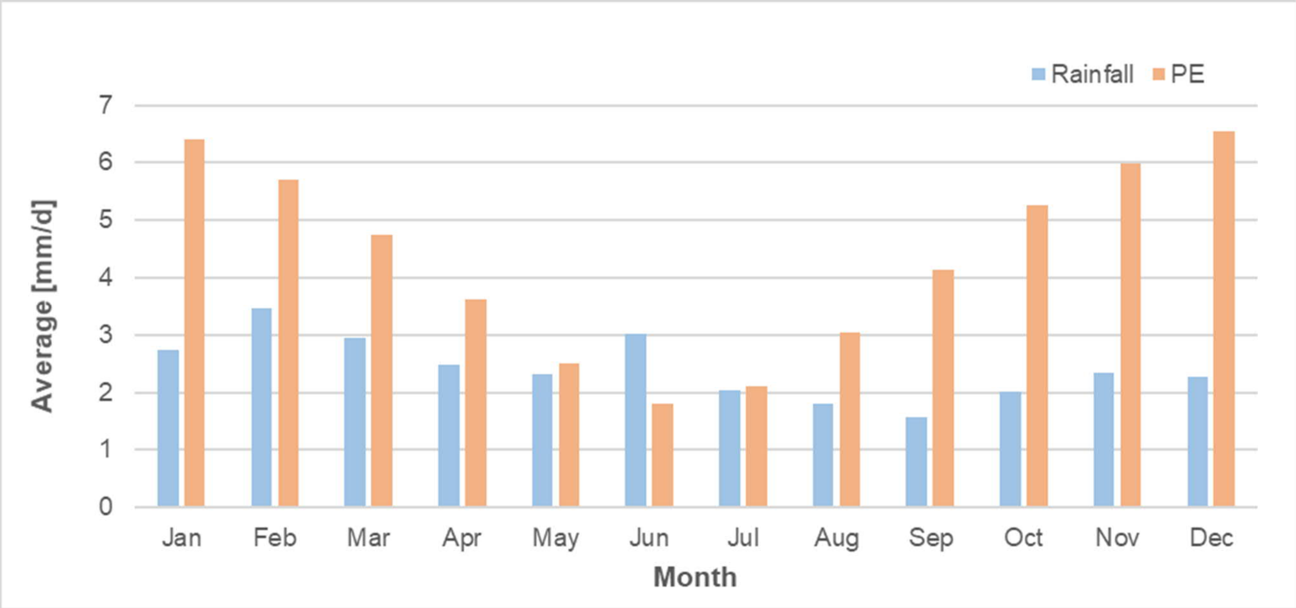
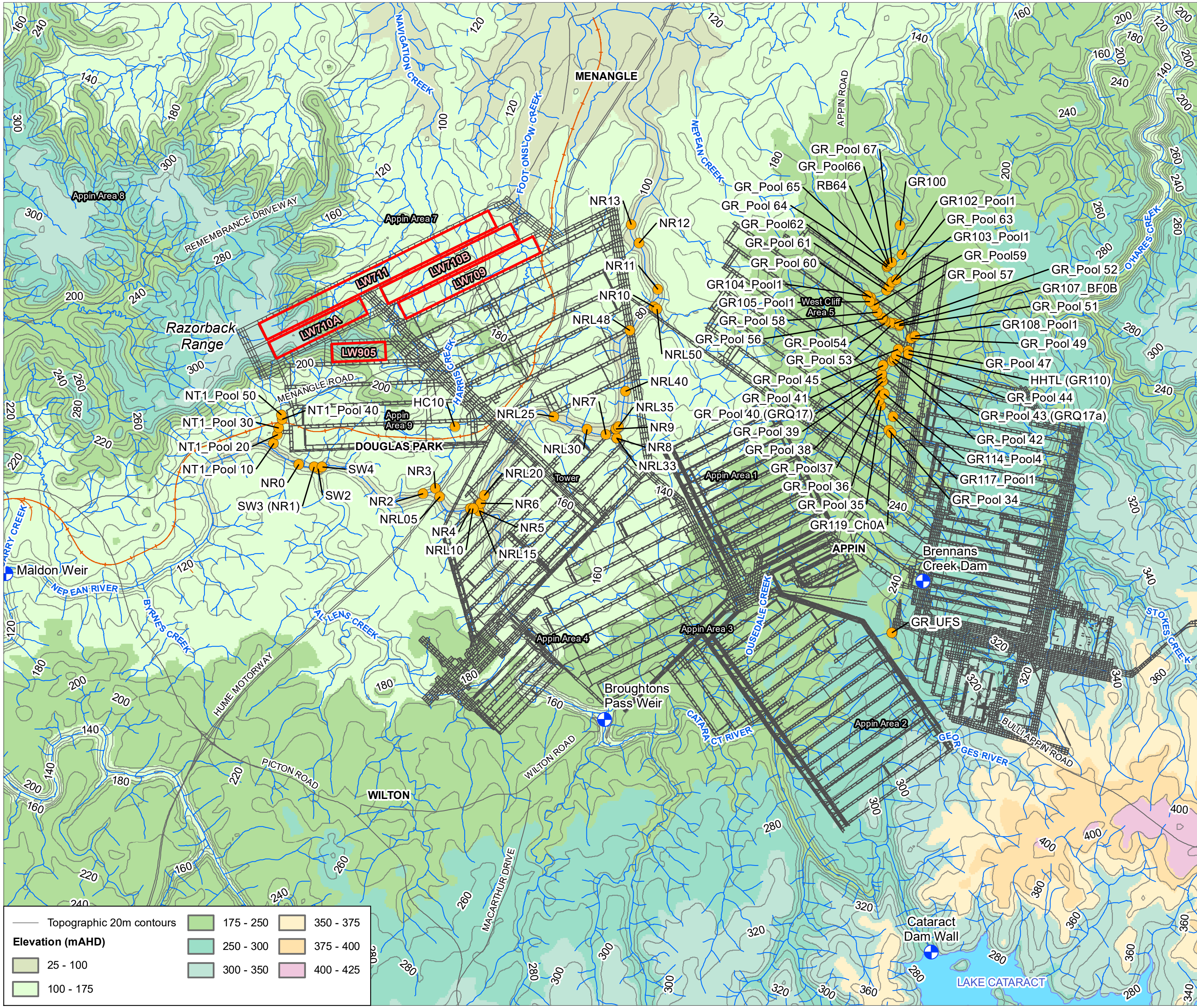


Figure 3 Average Monthly Rainfall and Potential Evaporation

2.2 Topography

Appin Mine is located to the west of the Woronora Plateau and the Cumberland Plain inland of the Illawarra Escarpment approximately 23 km northwest of Wollongong, NSW. Topography within the Project area ranges from 100 mAHD to 320 mAHD, with the topographic high associated with Razorback Range on the western part of the Project area (Figure 4).

On the plateau to the north the topography generally slopes to the north or northwest, toward the center of the Sydney Basin. The topography of the eastern part (West Cliff Area 5) falls from 250 mAHD to 130 mAHD while the western area slopes gently from approximately 250 mAHD (south along the Nepean Valley) to 60 mAHD near Menangle Park to the north.



APPIN MINE GROUNDWATER ASSESSMENT

TOPOGRAPHY AND DRAINAGE OF APPIN MINE

FIGURE 4

- Project Area
- Dams
- Surface water monitoring
- Roads
- Railway
- Appin Mine
- Watercourses
- Lakes

0 0.5 1 km

Projection: GDA 1994 MGA Zone 56
Scale: 1:90,000 at A4

Project No.: 665.10015
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Drawn by: JG

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2.3 Surface Water and Drainage

Appin Mine is located within the Georges River and the Hawkesbury-Nepean catchments. Major rivers in the area include the Nepean River, Cataract River, Stonequarry Creek and Georges River (Figure 4). The rivers within the Appin Mine area generally flow in a northerly direction and have perennial flows influenced by dam releases and baseflow contributions from the incised Hawkesbury Sandstone (HBSS).

The closest river is the Nepean River, which is 1.5 km south of the Project footprint. Minor creeks and tributaries of the Nepean River are present across the Appin Mine area. This includes Navigation Creek, Navigation Creek Tributary 1, Foot Onslow Creek and Harris Creek that are third order streams within the Project area. The creeks are largely ephemeral, but pools have naturally formed in some areas, and farm dams have also been established in some locations (MSEC, 2021).

Surface water monitoring is conducted at the main rivers at government stream gauges. IMC also conduct monitoring of surface water levels and quality at the major rivers as well as creeks and tributaries across the site and to the north. This includes monitoring of ponded water (pools) along Georges River and Nepean River.

Summary details for each of the main rivers near the Project are included in Table 1. River stage levels for Nepean River, Cataract River and Stonequarry Creek are shown in Figure 5, along with IMC observation data for one of the Georges River pools (GR_POOL63). The river levels generally correlate with rainfall trends (CRD), but also show influence from dam releases/regulation where water levels rise during periods of below average rainfall.

Table 1 Major River System at Appin Mine

River	Characteristics	Surface Water Flow
Nepean River	Regulated flows from upstream dams and baseflow contributions where incised into Hawkesbury Sandstone. Present across surface of Appin Mine area (Area 7).	Main government stream gauge 212216 (Nepean River at Camden Weir), as well as 212238 (Menangle Weir) and 212208 (Maldon Weir). Plus IMC Nepean River (NR) monitoring. Flows in a northerly direction, with flow of around 310 ML/day (Maldon Weir) since 2010.
Cataract River	Regulated flows from Lake Cataract. Present across surface of Appin Mine area (Area 4 and Tower).	Main government stream gauge 212230 (Cataract River at Broughtons Pass), as well as 212231 (Jordans Crossing) and 212232 (Cataract Dam). Flows in a northerly direction towards Nepean River, with flow of around 92 ML/day (Broughton Pass Weir) since 2010, with surface water elevations generally around 130 mAHD to 132 mAHD.
Stonequarry Creek	Stonequarry Creek Management Area at north-west side of Area 9.	Government stream gauge 212053 (Stonequarry Creek at Picton). Flows in a general southerly direction to the Nepean River near Maldon. Flow around 22 ML/day (Picton) since 2010, with surface water elevations generally around 148 mAHD.
Georges River	Regulated flows from upstream dam (Brennans Creek Dam). Present across surface of Appin Mine area (West Cliff area).	IMC monitoring of pool levels along Georges River (GR_POOL). River flows in a northerly direction, with flow of around 4.2 ML/day (Brennans Creek Dam) since 2010.

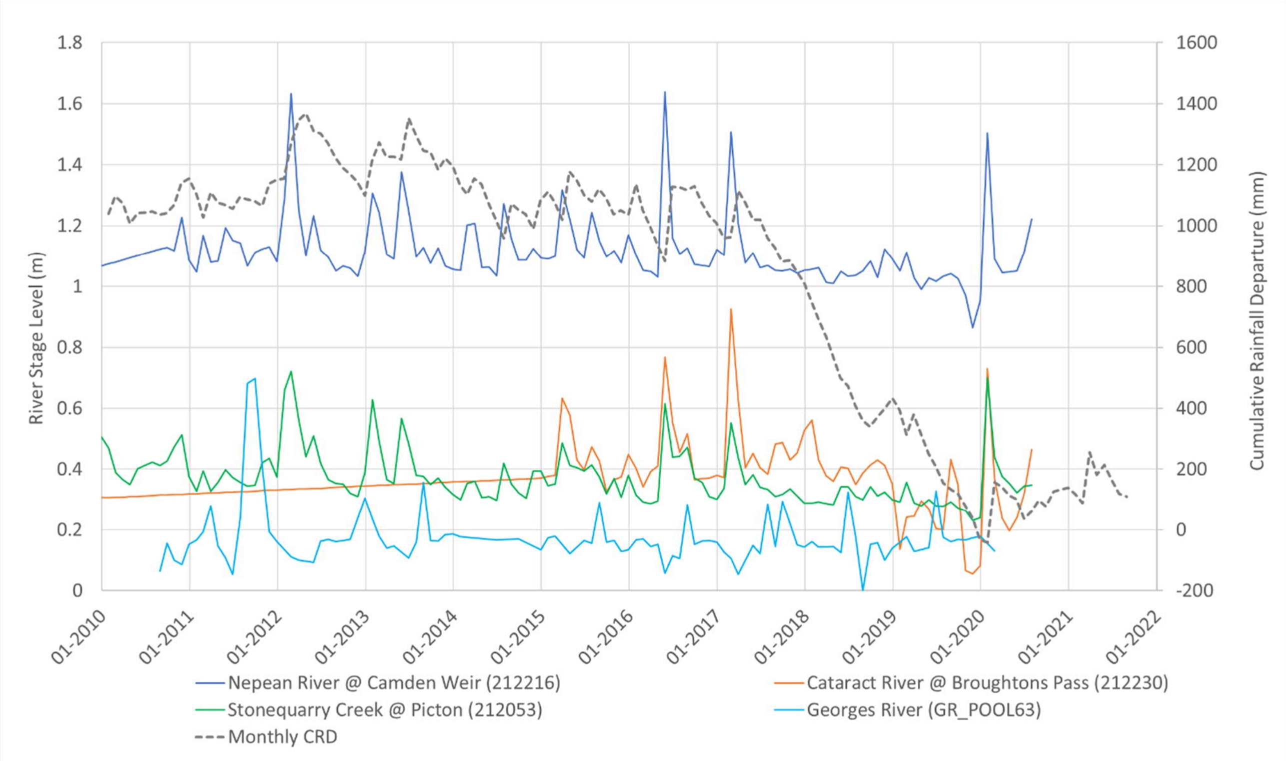


Figure 5 Surface Water Stages

A summary of average water quality monitored at the site surface water monitoring points is included in Table 2. The summary data shows that the major rivers have contributions from dam releases, and are incised into the HBSS (i.e. Nepean River, Cataract River and Georges River) and generally contain fresh (low salinity) water. In contrast the minor tributaries, particularly those that occur where the Wianamatta Group is present at surface (i.e. Navigation Creek), have more brackish water quality and higher total dissolved solids (TDS).

Table 2 Summary of Surface Water Monitoring at Appin Mine

River	Average EC (µS/cm)	pH	TDS (mg/L)	Monitoring Period
Nepean River	291	8	164	2002 - 2020
Cataract River	168	7	97	2002 - 2020
Georges River	929	7	538	2008 - 2020
Ousedale Creek	1478	8	801	2002 - 2020
Menangle Creek	1373	8	725	2003 - 2020
Elladale Creek	1632	8	904	2002 - 2020
Allens Creek	743	8	397	2003 - 2020
Navigation Creek	2793	8	1581	2006 - 2020
Harris Creek	1663	8	924	2002 – 2020 / 2010 - 2020
Foot Onslow Creek	1680	8	944	2008 - 2020

Comparison between rainfall trends and the Nepean River surface water quality over time is presented in Figure 6. The Nepean River at Appin Mine has a long-term EC average of 291 µS/cm and median of 244 µS/cm, with no significant change between its downstream (NR0) and upstream (NR50) segment. The peaks EC correlate to above average rainfall conditions over time, which freshen water in the river system. The peak ET at downstream (NR0) correlate the first flush of the runoff.

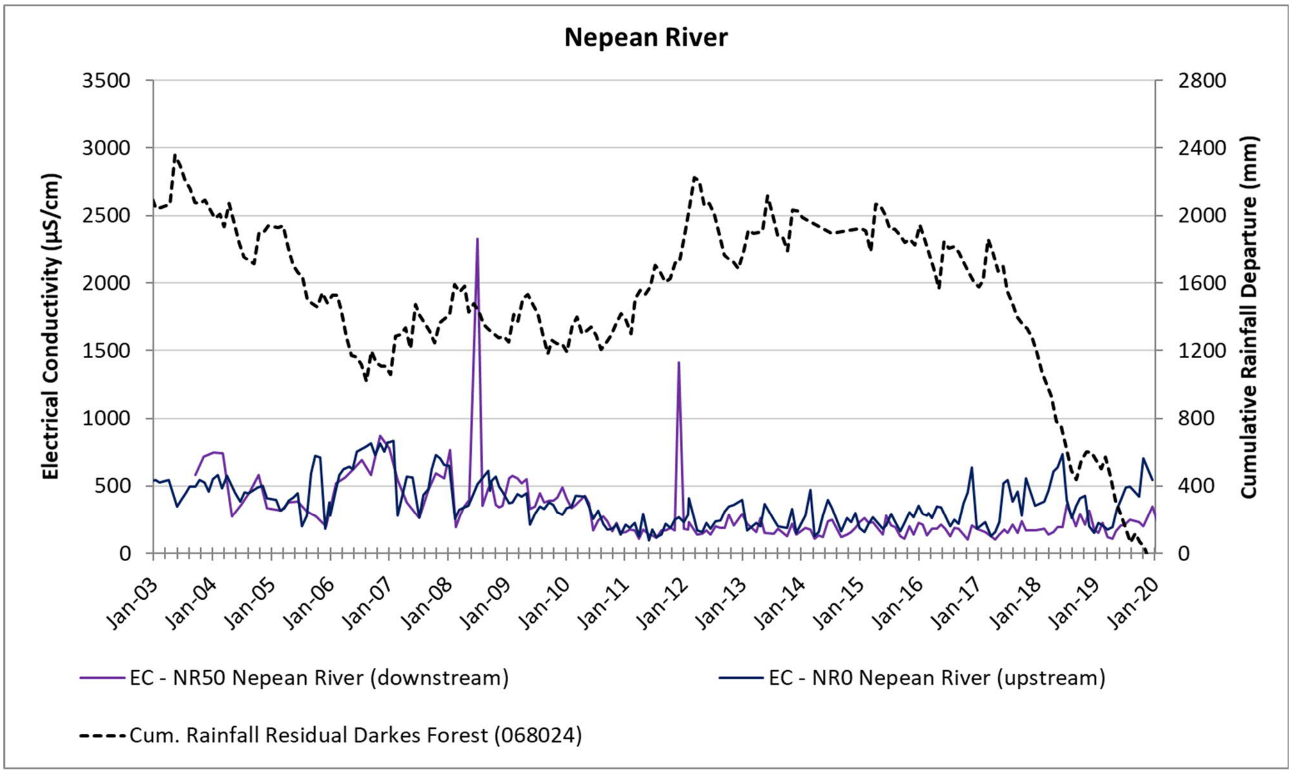


Figure 6 Water Quality along the Nepean River

2.4 Land Use

2.4.1 Mining

2.4.1.1 Approved Operations at Appin Mine

Appin Mine extracts coal from the Bulli Coal Seam within the Permian aged Illawarra Coal Measures via the longwall mining method. The Appin Mine refers to the current and previous mine areas, which comprises the former Tower Colliery and West Cliff Mine.

The Appin Mine includes Area 1, Area 2, Area 3, Area 4, Area 5, Area 7, Area 9 and North Cliff (Figure 1). The current active mine areas are in Area 7 and Area 9. It should be noted that the approved Area 9 (BSO) is more extensive than the currently mined Area 9, as shown in Figure 1. A summary of the mine areas, years mined, and current status is shown in Table 3.

Table 3 Appin Mine Areas and Timing

Mine Area	Longwall Panels	Date From	Date To	Date Approved To	Status/ Comment
Tower	1 - 20	1978	2002	-	Historic mining
Appin Area 1	1 - 12	1969	1986	-	Currently used for underground mine water storage (White Panel), transferred from current mining areas.
Appin Area 2	12 - 29	1986	1997	-	Historic mining
Appin Area 3	301 - 302	1998	2007	-	Historic mining
Appin Area 4	401 - 408	1998	2007	-	Currently used for underground mine water storage, transferred from current mining areas.
West Cliff Area 5	1 - 32	1983	2016	2040 (BSO)	Historic mining
Appin Area 7	701 - 714	2007	Present	2040 (BSO)	Active Mining
Appin Area 9	901 - 910	2016	Present	2040 (BSO)	Active Mining

The groundwater impact assessment for the BSO conducted by Heritage Computing (2009) included development of a numerical groundwater model to predict impacts. The BSO groundwater assessment findings included:

- Negligible loss of groundwater yield to the Cataract Reservoir, Broughtons Pass Weir and Woronora Reservoir;
- Negligible reduction in groundwater contribution to total stream flows;
- Drawdown in Hawkesbury Sandstone (HBSS) with predicted 1 m drawdown contour extending up to 5 km from the mine footprint. The extent of drawdown was most significant north to north-east of Area 8 and Area 9;
- Extensive depressurisation predicted for aquifers beneath the Bald Hill Claystone (i.e. Bulgo Sandstone, Scarborough Sandstone and Bulli Seam), with the 10 m drawdown contour extending over 6 km north of the mine footprint;

- Reduction in water level of up to 23 m at some private production bores intersecting the HBSS and up to 85 m for bores within the Bulgo Sandstone, with main impacts around the Razerback Range at Area 9 (Appin West);
- Mine inflows of around 4 ML/day across the entire BSO operations at the end of mining, averaging 2 ML/day each year over 30 years; and
- At the end of the 100 year recovery period, water levels in the main hydrogeological units had recovered to at least, and often higher than, the levels recorded at the start of mining (Year 1). The higher water levels observed after the recovery period are due to the starting groundwater levels including some residual impacts of historical dewatering at the Appin Mine and West Cliff Colliery, Metropolitan, Darkes Forest, Bellambi West and Tahmoor Colliery. These mines were completely deactivated during the recovery period.

2.4.1.2 Surrounding Mines

Several historic and active mines surround the Appin Mine, as summarised in Table 4, and mine locations shown in Figure 1. The closest mine workings are associated with Russell Vale, which is within approximately 2 km of Appin Mine and extends towards the coast and mined the Bulli Seam, Balgownie Seam and Wongawilli Seam. The proximity of this mine may influence groundwater conditions post-closure.

Table 4 Neighbouring Mines within the Southern Coalfield

Mine	Current Operator	Seam	Status	Distance from Dendrobium
Russell Vale (Bellambi)	Wollongong Coal	Bulli Seam, Balgownie Seam and Wongawilli Seam	Active/ Proposed	Located 2 km south east of Appin Mine. Bulli Seam and Balgownie Seam mined from 1887 to 1950 as bord and pillar. Mining restarted in 1960's as continuous miners then from 1970 to 1982 as longwall. Gibson Colliery then in operation between 2001 to 2003 within Bulli and Balgownie seams, using continuous miner and longwall methods. From 2007 to present in Wongawilli Seam, with a current modification proposed. Historical inflows have been reported between 0.05 ML/day to 0.7 ML/day (SLR 2020) and around 1.1 ML/year for current (NRE 2019, Umwelt 2020).
Tahmoor Mine	SIMEC	Bulli Seam	Active	Located approximately 10 km west of Appin Mine and about 4 km west of the Approved Appin Mine plan. In operation since 1975 and approved until 2020. EIS submitted to extend life of mining to 2035, but not yet approved. Historical inflows to mine workings have been reported between 0.3 ML/day and 5 ML/day.
Coal Cliff (Darkes Forest)	-	Bulli Seam	Mine Closed	Located approximately 5 km east of Appin Mine. In operation from 1877 to 1992.
Metropolitan Mine	Peabody	Bulli Seam	Active	Located approximately 8 km east of Appin Mine. In operation from 1886 to present, approved until at least 2022. Measured mine inflows generally less than 1 ML/day (Peabody 2019).

Mine	Current Operator	Seam	Status	Distance from Dendrobium
Dendrobium	Illawarra Metallurgical Coal	Bulli Seam and Wongawilli Seam	Active	Located 14 km south of Appin Mine. In operation from 2001 and approved until 2043. EIS submitted to extend life of mining to 2048, but not yet approved. Historical inflows vary by region, but in recent years has been recorded between 4 ML/day and 12 ML/day (HydroSimulations 2019).

2.4.1.3 Mine Subsidence

Above Longwalls 709 to 711 and 905 in the Bulli Seam, the depth of cover is between 530 m to 750 m. Potential subsidence impacts to the creeks and watercourses directly above and adjacent to longwalls have been assessed by MSEC (2021). MSEC (2021) found localised ponding could develop in some isolated locations due to subsidence related tilt. However, there are no predicted reversals of stream grade due to the Project, and no large-scale adverse changes in levels of ponding or scouring of banks along creeks due to subsidence related tilt.

Based on the experience of mining beneath ephemeral creeks and tributaries in the Southern Coalfield, it is likely that some fracturing will occur along the streams within the Study Area, particularly those located directly above or adjacent to the mining area. Some standing pools could experience a reduction or loss of water holding capacity. Fracturing will predominately occur where the creeks and tributaries are located directly above the mining area. Impacts can also occur outside the mining area, with minor and isolated fracturing occurring at distances up to approximately 400 m outside the longwalls, as previously observed at Appin Colliery and elsewhere in the Southern Coalfield. The mining-induced compression due to valley closure effects can also result in dilation and the development of bed separation in the topmost bedrock, as it is less confined. This additional dilation due to valley closure is expected to develop predominately within the top 10 m to 20 m of the bedrock. Compression can also result in buckling of the topmost bedrock resulting in heaving in the overlying surface soils.

The maximum predicted total vertical subsidence for the existing, approved and proposed longwalls is 1,550 mm and maximum predicted total tilt is 8 mm (MSEC 2021). The maximum predicted subsidence effects on the Nepean River due to the Project is less than 20 mm vertical subsidence, upsidence and closure (MSEC, 2021). The maximum predicted subsidence effects on the third order creeks (i.e. Navigation, Foot Onslow and Harris) is 1,400 mm vertical subsidence, 525 mm upsidence and 800 mm total closure.

2.4.2 Camden Gas Project

The AGL Camden Gas Project is on Petroleum Production Lease (PPL) 1 to 6 and Petroleum Exploration Licence (PEL2), at the northern end of Appin Mine. The Camden Gas Project has been in operation since 2001. AGL hold two Water Access Licenses (24856 and 24736) and Works and Use Approvals (10WA112288 and 10WA112294) with a current total allocation of 30 ML/year. The Camden Gas Project comprises 137 wells (86 currently active) shown in Figure 27 targeting the Bulli and Balgownie seams north of the Project. Further discussion on the geology is provided in Section 2.5.

The Coal Seam Gas (CSG) activities involve abstraction of water to induce gas flow, resulting in a reduction in water pressure in the target seam. This depressurisation around the CSG wells is observed in the site monitoring data discussed in Section 1.1.1. Previous studies by AGL (2013) predicted limited potential for impact on the overlying stratigraphy, due to the presence of the low permeability claystones preventing any significant vertical flow. IMC groundwater monitoring indicates potential localised depressurisation within the Scarborough Sandstone of the Narrabeen Group (Section 1.1.1). However, there are no impacts predicted or observed within the HBSS due to CSG activities (AGL, 2013).

2.5 Geology

Appin Mine is located within the Southern Coalfield of the Sydney Basin. The stratigraphy of the Southern Sydney Basin is presented in Table 5.

Table 5 Southern Sydney Basin Stratigraphy

Period	Stratigraphic Unit		Description
Quaternary	Alluvium and colluvium and other sediments in floodplains, alluvial fans, and high terraces (Qal, Tal, Qs)		Alluvial and residual deposits comprising quartz and lithic fluvial sand, silt and clay.
Triassic	Wianamatta Group	Camden Sub-group	Shale with sporadic thin lithic sandstone.
		Liverpool Sub-group: Bringelly Shale (Rwb), Minchinbury Sandstone and Ashfield Shale (Rwa)	Dark green and black shales with thin graywacke-type sandstone lenses. Calcareous graywacke-type sandstone and black mudstones and silty shales with sideritic mudstone bands.
	Hawkesbury Sandstone (Rh)		Consists of thickly bedded or massive quartzose sandstone (with grey shale lenses up to several metres thick).
	Narrabeen Group	Newport Formation	Interbedded grey shales and sandstones
		Garie Formation	Cream to brown, massive, characteristically oolitic claystone.
		Bald Hill Claystone	Brownish-red coloured "chocolate shale", a lithologically stable unit.
		Bulgo Sandstone	Strong, thickly bedded, medium to coarse-grained lithic sandstone with occasional beds of conglomerate or shale.
		Stanwell Park Claystone	Greenish-grey mudstones and sandstones.
		Scarborough Sandstone	Mainly of thickly bedded sandstone with shale and sandy shale lenses up to several metres thick.
		Wombarra Claystone	Similar properties to the Stanwell Park Claystone.
		Coal Cliff Sandstone	Basal shales and mudstones that are contiguous with the underlying Bulli Coal seam.
Permian	Illawarra Coal Measures		Interbedded shales, mudstones, lithic sandstones and coals, including the Bulli Seam (2 – 3 m thick), Balgownie Seam (5 – 10 m below Bulli Seam), Loddon Sandstone, Wongawilli Seam (7 – 9 m thick) and Kembla Sandstone.

The surface geology is shown in Figure 7, based on the Southern Coalfield 1:100,000 geological map (Moffitt 1999). A cross section through Area 7, Area 8 and Area 9 has also been created based on the site geological model and presented in Figure 8. The location of the cross section is presented in Figure 7.

2.5.1 Quaternary and Triassic

The Triassic Wianamatta Group is present at surface across the site (Figure 7) and ranges in thickness from less than 10 m to 200 m at Razorback Range. Quaternary floodplain alluvium is also mapped as being present on the northern side of the Project area, localised along Nepean River and its tributaries (i.e. Navigation Creek). The Quaternary alluvium along the Nepean River is currently mined at Menangle Quarry, approximately 4.5 km north-east of the Project Figure 7.

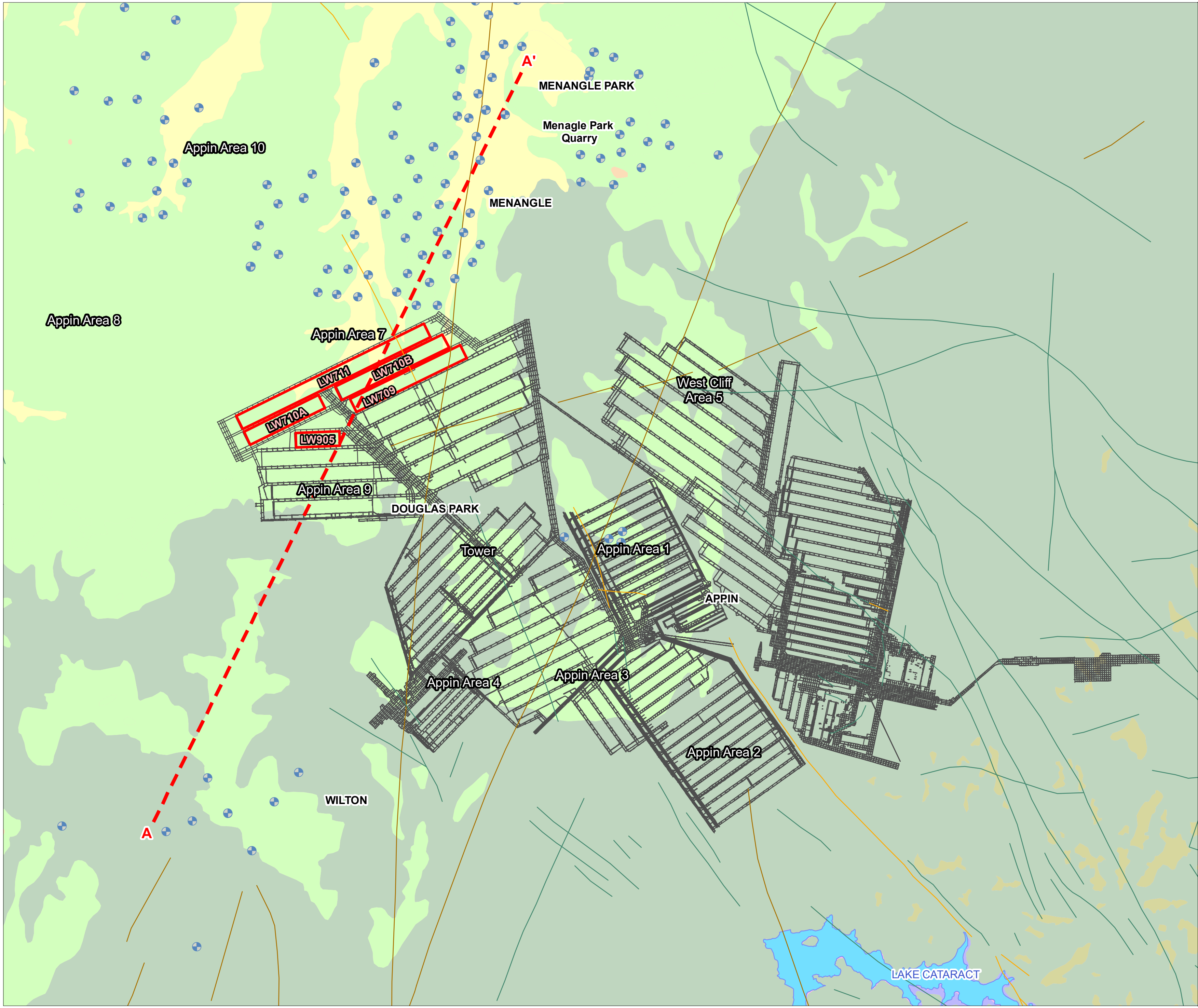
The HBSS is also present at surface and underlies the Wianamatta Group where it is present. The HBSS comprises bedded sandstone units and is around 170 m thick (MSEC, 2021). The HBSS is incised along the major rivers (i.e. Nepean River) and contributes baseflow. Around the Project there are also several registered bores accessing groundwater from the HBSS (Sydney Basin Nepean Groundwater Source) for stock, domestic, irrigation and industrial uses as discussed further in Section 3.4.2.

The HBSS is underlain by the Triassic sandstones, siltstones and claystones of the Narrabeen Group. This includes the Bulgo Sandstone, Scarborough Sandstone and Coal Cliff Sandstone, as well as the Bald Hill Claystone, Stanwell Park Claystone and Wombarra Claystone.

2.5.2 Permian

As illustrated in Figure 8, the Permian aged Illawarra Coal Measures underlie the Narrabeen Group. The Illawarra Coal Measures consist of interbedded sandstone, shale and coal seams, with a thickness of approximately 200 m to 300 m. The Bulli Seam is the primary economic sequence of interest at Appin Mine. Within the Project area the Bulli Seam is around 2.8 m to 3.3 m thick and around 530 m to 750 m below surface (MSEC, 2021). The strata around the Bulli Seam provides good conditions for longwall mining and in particular the floor is hard and competent (Moffitt, 1999). The immediate roof can range from mudstone, interbedded siltstone and, sandstone to sandstone.

The Permian coal measures dip approximately 2 % in a north-westerly direction, towards the Douglas Park syncline (MSEC, 2021). The major geological structures (faults) in the region include the Nepean Fault Zone, O'Hares Fault and J-Line Fault. Within the Project area (Area 7 and 9) there is a series of NNW-SSE orientated dykes and minor faults with displacement of less than 3 m (MSEC, 2021). However, previous mining through these structures at Longwall703 to Longwall706 and Longwall901 to Longwall903 did not cause any change in vertical subsidence (MSEC, 2021). In addition, since the 1970s in-seam drilling has been undertaken in advance of all development underground. No hydraulically charged structures were intersected at Appin Mine during the in-seam drilling process or progression of mining.



APPIN MINE GROUNDWATER ASSESSMENT

GEOLOGY AROUND APPIN MINE

FIGURE 7

- CSG Wells
- Appin Mine
- Cross Sections
- Fault
- Dyke
- Lineament
- Lakes
- Qal/ Tal – Alluvium
- Wianamatta group
- Rh - HBSS
- Project Area

0 0.5 1 km

Projection: GDA 1994 MGA Zone 56
Scale: 1:110,000 at A4

Project No.: 665.10015
Date: 14-Dec-2021
Drawn by: JG

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H:\Projects-SLR\620-BNE\665-WOL\665.10015 Illawarra Coal Closure - Water\CADGIS\ArcGIS\665.10015 F07 Geology around Appin Mine.mxd

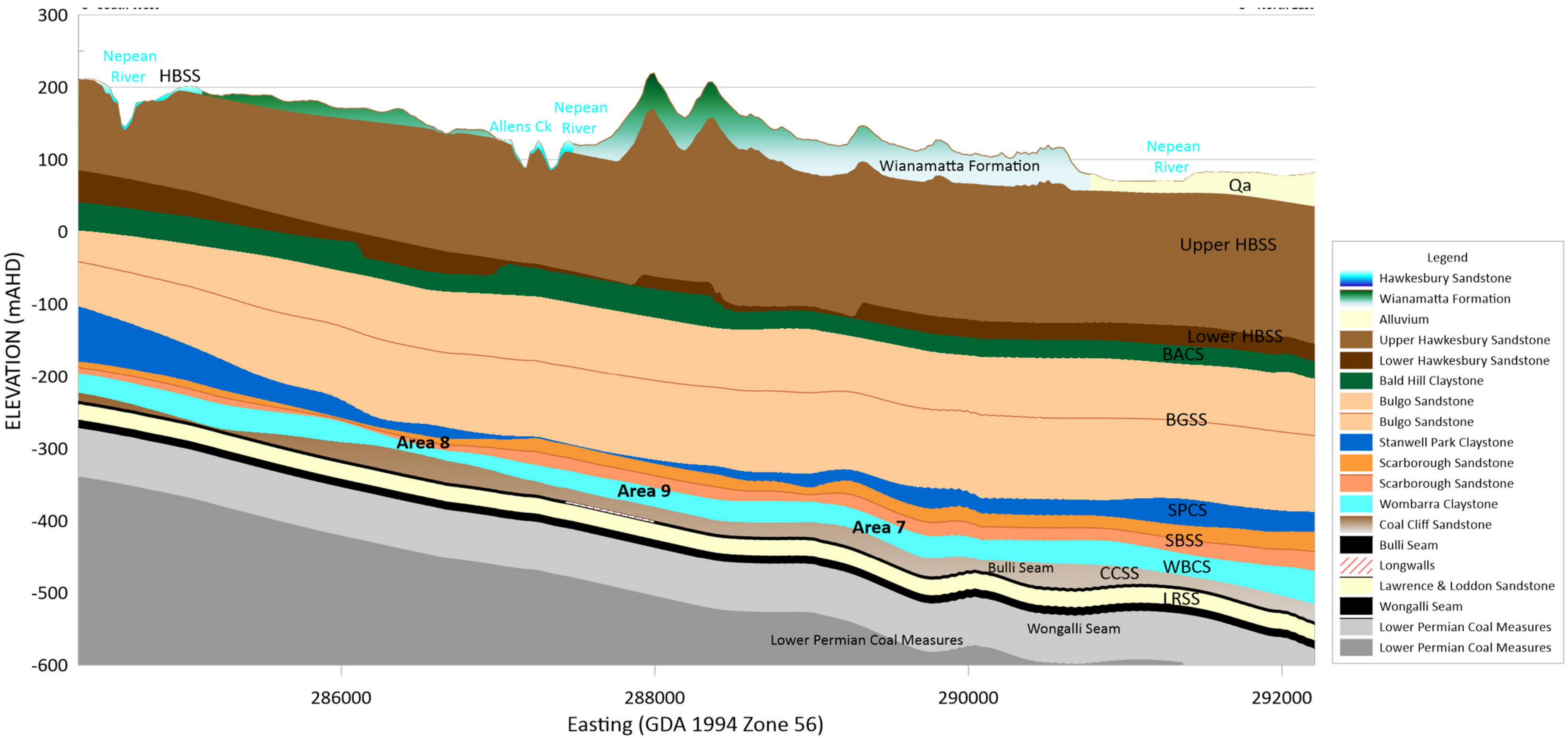


Figure 8 Geological Section A-A' – Appin Area 7, 8 and 9

3 Hydrogeology

3.1 Groundwater Network

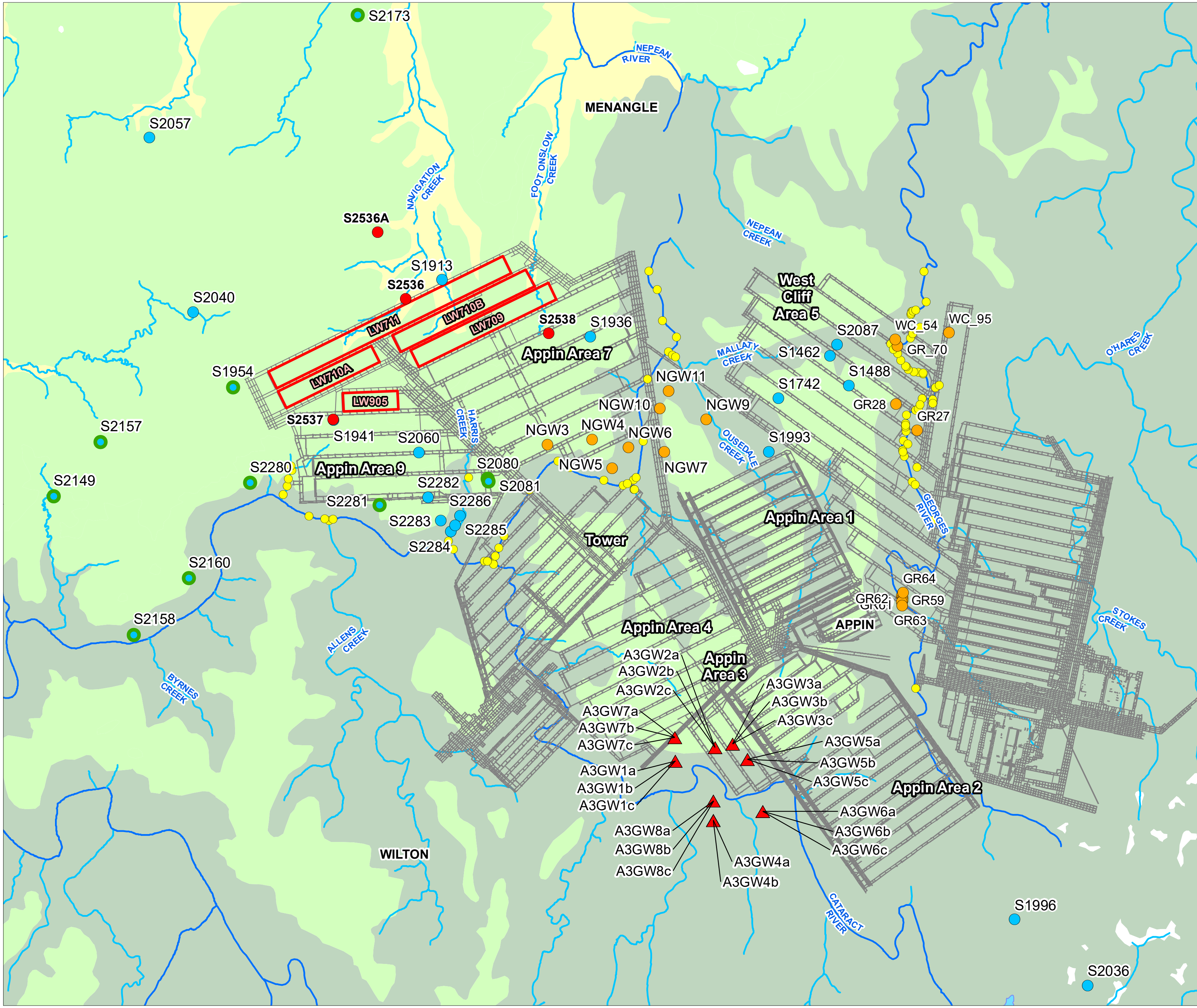
Appin Mine has an extensive network of groundwater monitoring infrastructure that provides the capability to monitor:

- Deep groundwater levels using vibrating wire piezometers (VWPs) in each mining area;
- Shallow groundwater levels using VWPs, shallow screened bores and open standpipes along Nepean River, Georges River and Cataract River; and
- Groundwater quality via in-built borehole pumps and within the mine workings (goaf seep).

Monitoring instruments are positioned throughout the mining lease with instruments installed:

- Above the longwall footprints in all areas;
- Adjacent to the key receptors (alluvium, high economic aquifers, and landholder bores); and
- Adjacent to key watercourses being monitored from mining related subsidence (Nepean River, Georges River, and Cataract River).

IMC has installed four new groundwater monitoring boreholes, two of them located close to Navigation Creek to monitor water levels, as recommended by SLR in a previous version of this groundwater impact assessment (SLR, 2021a). The VWPs, monitoring bores, and the monitored geology are shown in Figure 9. A full list of monitoring bores with their co-ordinates, sensor depths, screened geology and available data range is presented in Appendix A. The groundwater monitoring program includes daily readings of pressure head at the VWP's, and manual measurement of water levels at the monitoring bores, as well as quality sampling and analysis for electrical conductivity (EC), pH, major ions, minor ions, metals, and a range of isotopes.



APPIN MINE GROUNDWATER ASSESSMENT

Appin Groundwater and Surface Water Monitoring Network

FIGURE 9

- New Piezometers
- VWP
- VWP (Sampled for water quality)
- Piezometers
- Multi-level piezometers
- Surface water monitoring points
- Major watercourses
- Minor watercourses
- Appin Mine
- Qal/ Tal – Alluvium
- Wianammatta group
- Rh - HBSS
- Project Area
- Lakes

N

0 0.5 1 km

Projection: GDA 1994 MGA Zone 56
Scale: 1:88,000 at A4

Project No.: 665.10015
Date: 15-Dec-2021
Drawn by: JG

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3.2 Groundwater Levels and Flow

3.2.1 Alluvium

Based on 1:100,000 Southern Coalfield geology mapping (Moffitt, 1999), Quaternary alluvium has been mapped within the Project area along Navigation Creek and Foot Onslow Creek. Quaternary alluvium is also mapped along the Nepean River over 3 km north of the Project.

The alluvium generally comprises heterogenous distribution of clay, silt, sand and gravel. CSIRO (2015) regolith mapping indicates the alluvium within the Project area is likely less than 10 m thick, increasing in thickness to around 20 m with proximity to the north. There are registered bores within alluvium along Navigation Creek and Nepean River (and its tributaries) to the north. The data from these registered bores indicates groundwater is present within the alluvium around 5 m to 8 m below surface. Alluvial groundwater flow likely follows topography and streamflow, flowing in a general northerly direction.

A review of the NSW groundwater registered bores database showed there are no alluvium bores near the Project listed in the database (most of the groundwater bores near the site monitor the HBSS).

To refine the conceptual model near the Project area, South32 installed four monitoring bores during July and August 2021 shown in Figure 9 (S2536 does not have surveyed coordinates) in the alluvium with approximately 600 m southwest of bore S1913. Once available, the measurements from this new bore will be used to in the future groundwater studies on the site.

3.2.2 Wianamatta Group

The Triassic Wianamatta Group is present at outcrops across the Project area. The Wianamatta Group thickens with distance to the north-west and can be up to 100 m thick. The Wianamatta Group is composed of the Bringelly Shale (BrSh), Minchinbury Sandstone and Ashfield Shale (AsSh).

Figure 10 shows a groundwater flow at S1954 (Area 7) controlled by a downward vertical head gradient in the Bringelly Shale from 280 mAHD to 220 mAHD. The water level observations at different depths show large pressure differences, which may indicated a limited vertical connectivity.

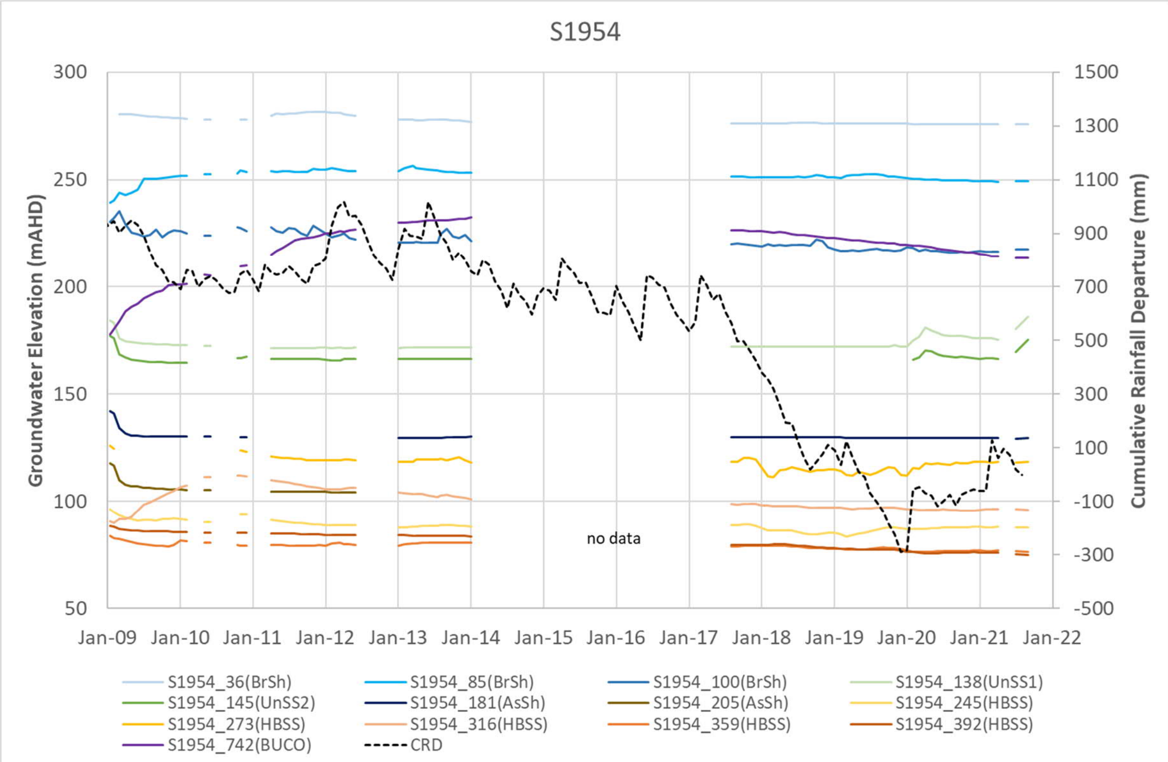


Figure 10 Hydrograph – S1954

3.2.3 Hawkesbury Sandstone (HBSS)

The Triassic HBSS outcrops in the region as the Woronora Plateau and is present across most of the historical mining at Appin (West Cliff, Tower, Area 1, 2, 3 and 4). The HBSS forms a major aquifer, due to its regional extent, coverage at surface that enables rainfall recharge and accessible for landholder water usage (bores). It is a thick aquifer (>200 m) with numerous high and low permeability horizons or lenses. Within the Appin Mine area, it has been described as having low groundwater yields but good groundwater quality (Heritage Computing 2009).

Due to the stratification of the sandstone sequences, groundwater flow is primarily horizontal, with minor vertical leakage. Groundwater movement is controlled by the topography with flow towards major rivers that are deeply incised into the sandstone (i.e. Nepean River).

Surrounding the Project area monitoring within a range of vertical profiles is conducted at VWPs S1954 (Figure 10), S1913 (Figure 11), S1941 (Figure 12) and S2308 (Figure 13).

The groundwater levels at bore S1913 (Figure 11), located 90 m north of Longwall 711, show significant decline in 2018 which is likely combination of response to the drought period and groundwater extraction from three nearby (less than 500 m distance from S1913) pumping bores (GW100289, GW108907 and GW106675) in the HBSS.

The hydrograph for the bore S1941 (Figure 12), located within Longwall 904, shows decline in groundwater levels at sensor depth 201 mbgl during Feb. 2020 and Aug. 2020 which is likely response to the registered bore GW100673 located approximately 950 m west of S1941 and 1,000 m southeast of S1954 extracting water from HBSS.

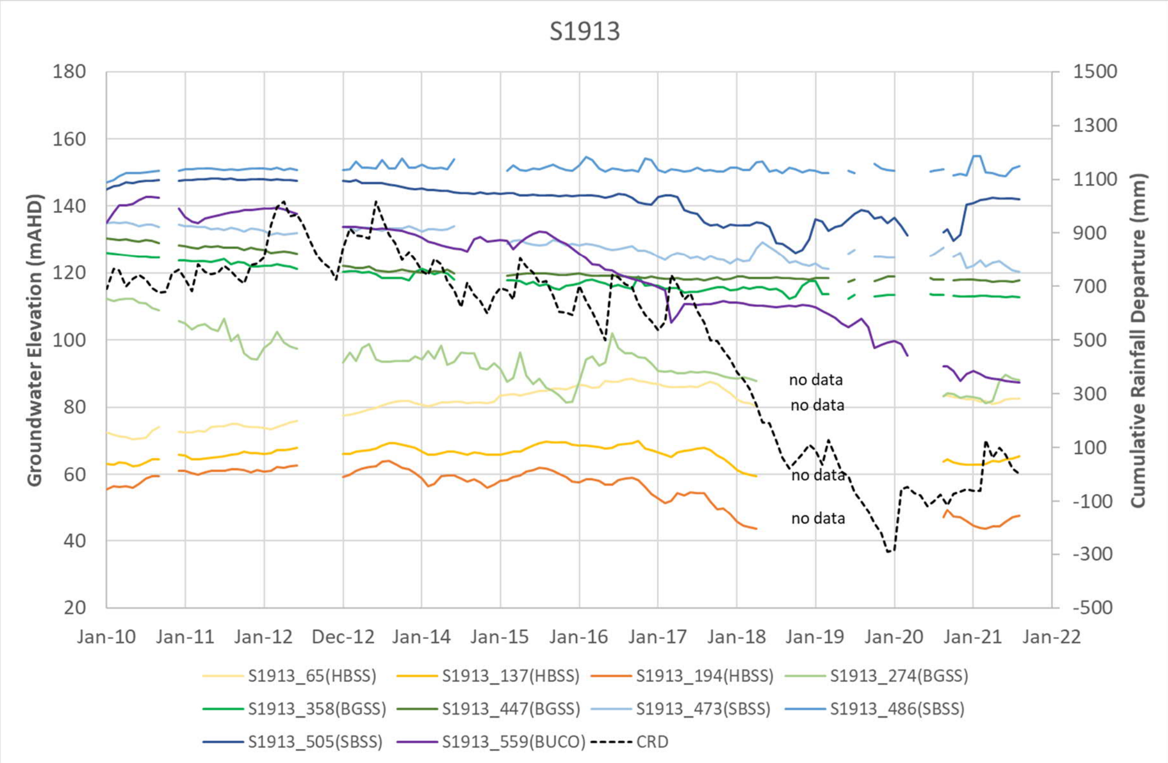


Figure 11 Hydrograph – S1913

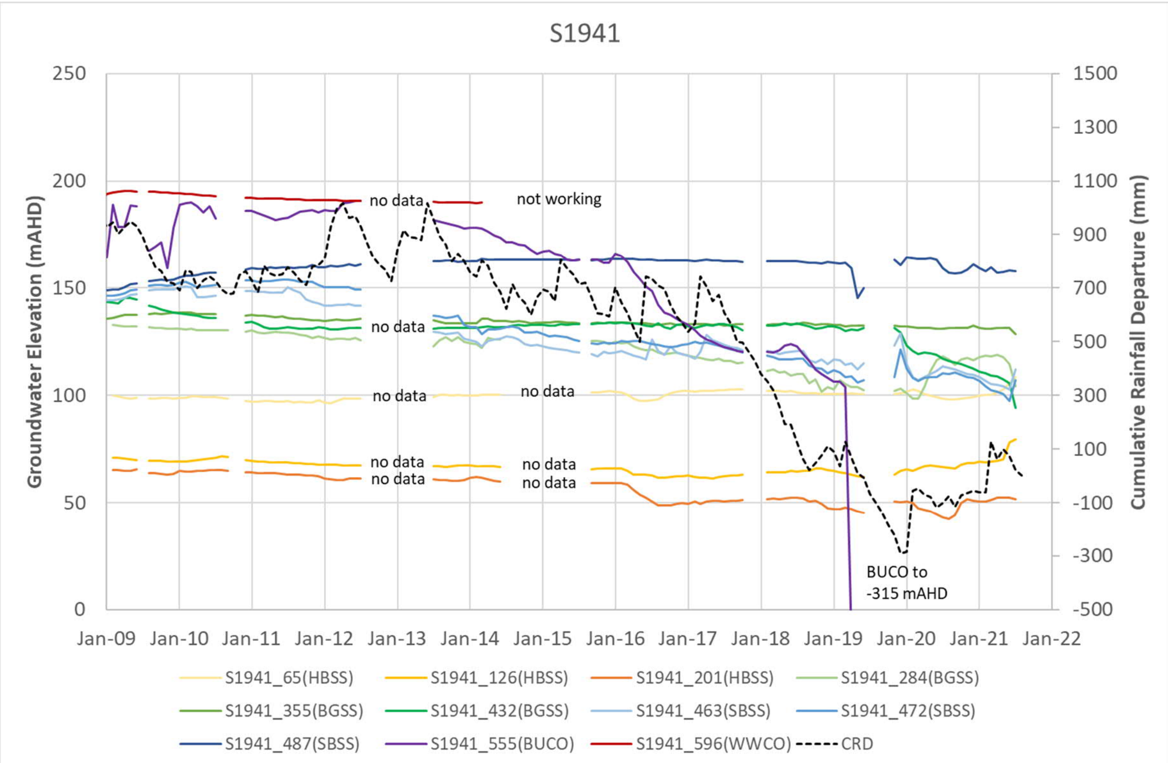


Figure 12 Hydrograph – S1941

In the bore S2308, located within Longwall 710, most of the sensors except the first sensor depth at 70 mbgl in HBSS show decline in groundwater levels (Figure 13). The measured data for the sensor at 70 mbgl has recorded a significant increase in groundwater levels in recent years (approximately 50 m) and appear erroneous. Therefore, the data from this sensor is not considered in this groundwater assessment and model calibration.

The hydrograph for the bore S2080 is shown in Figure 14. The hydrograph for S2080 shows decline in groundwater levels in HBSS is consistent with the timing of the longwall mining but it also shows correlation with the CRD. Therefore, it is likely the groundwater level in S2080 are impacted by a both climate and mining.

S2281, S2282 and S2283 located close to the Harris Creek and Longwall 901, monitor the HBSS. The hydrographs for these bores are shown in Figure 15, Figure 16, and Figure 17, respectively. There was a decline of between 5 to 7 m recorded in the lower sensor in HBSS in S2281, S2282 and S2283 between 2016 to 2017. These changes in groundwater levels correlate with the CRD but also the timing of the longwall mining. Therefore, it is likely the groundwater levels in HBSS were impacted by both mining and climate. The groundwater levels in HBSS in these bores show steady groundwater levels between 2017 to 2020 (during the drought period in NSW). However, since 2020 the bores are showing slight signs of recovery with gradual increase in groundwater levels.

As shown in the hydrographs there is a general downward gradient within the HBSS. To the east groundwater levels range from 380 mAHD across the Woronora Plateau, down to around 70 mAHD to 90 mAHD along the Nepean River (Figure 18).

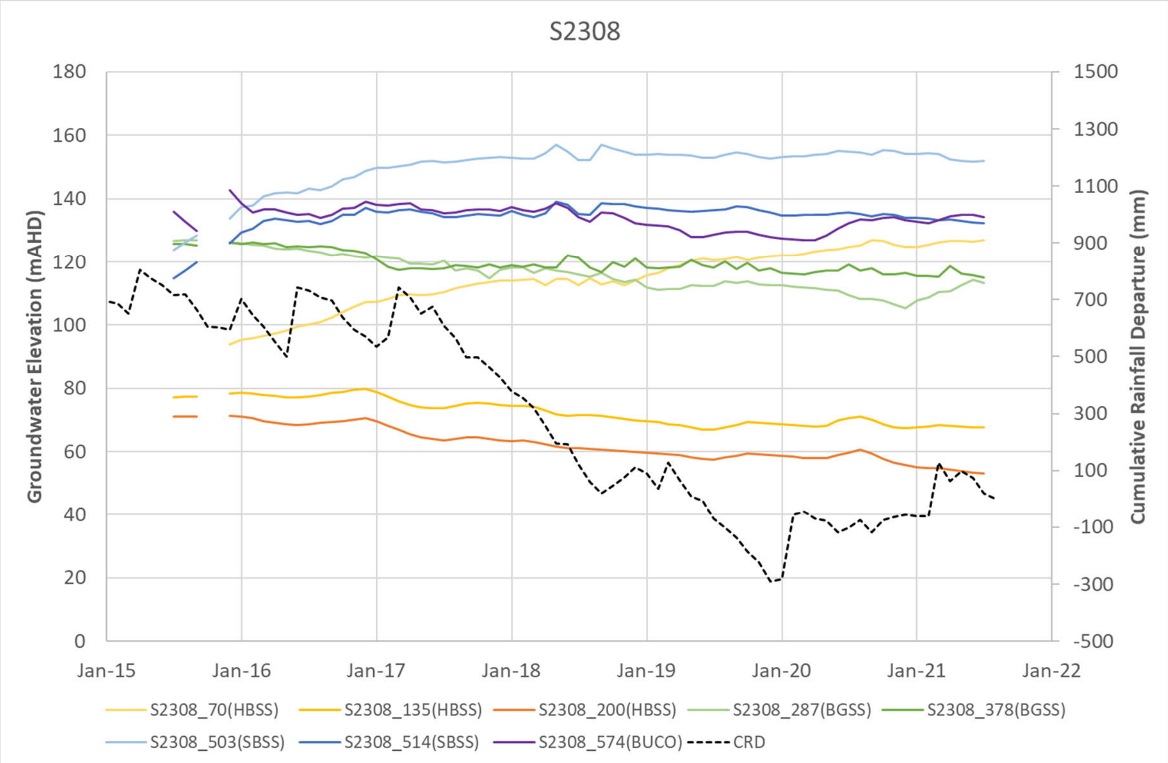


Figure 13 Hydrograph – S2308

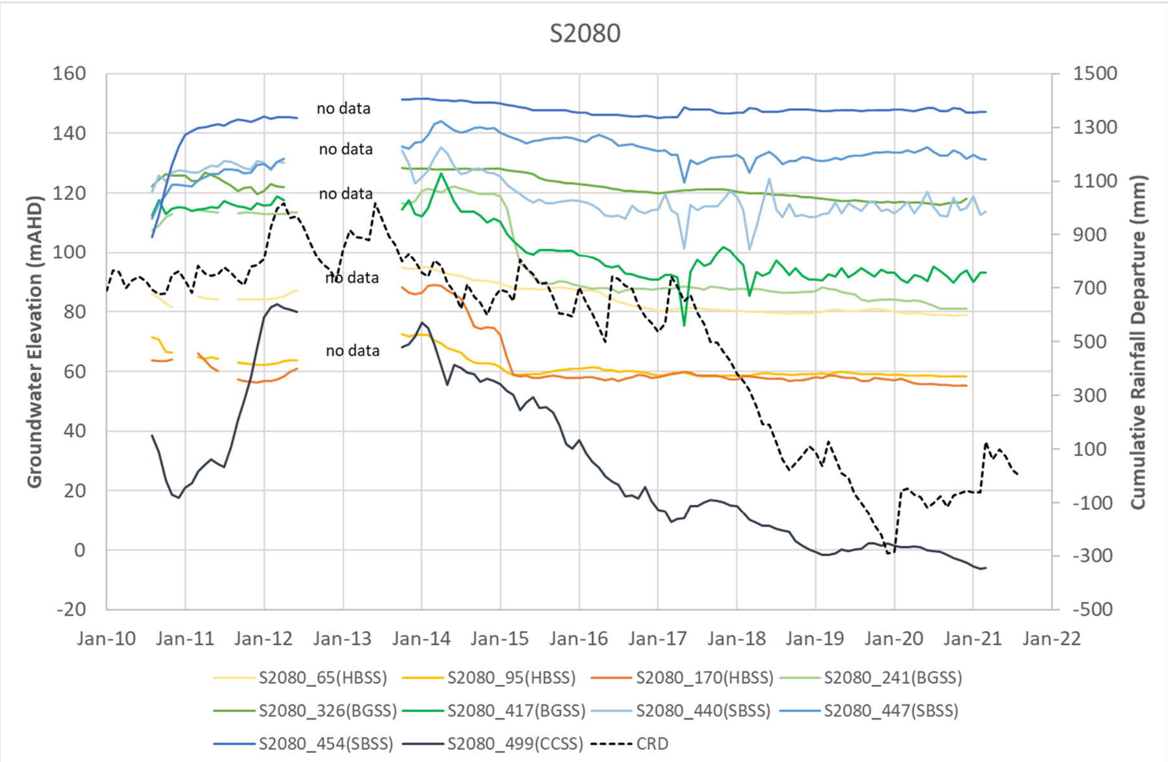


Figure 14 Hydrograph – S2080

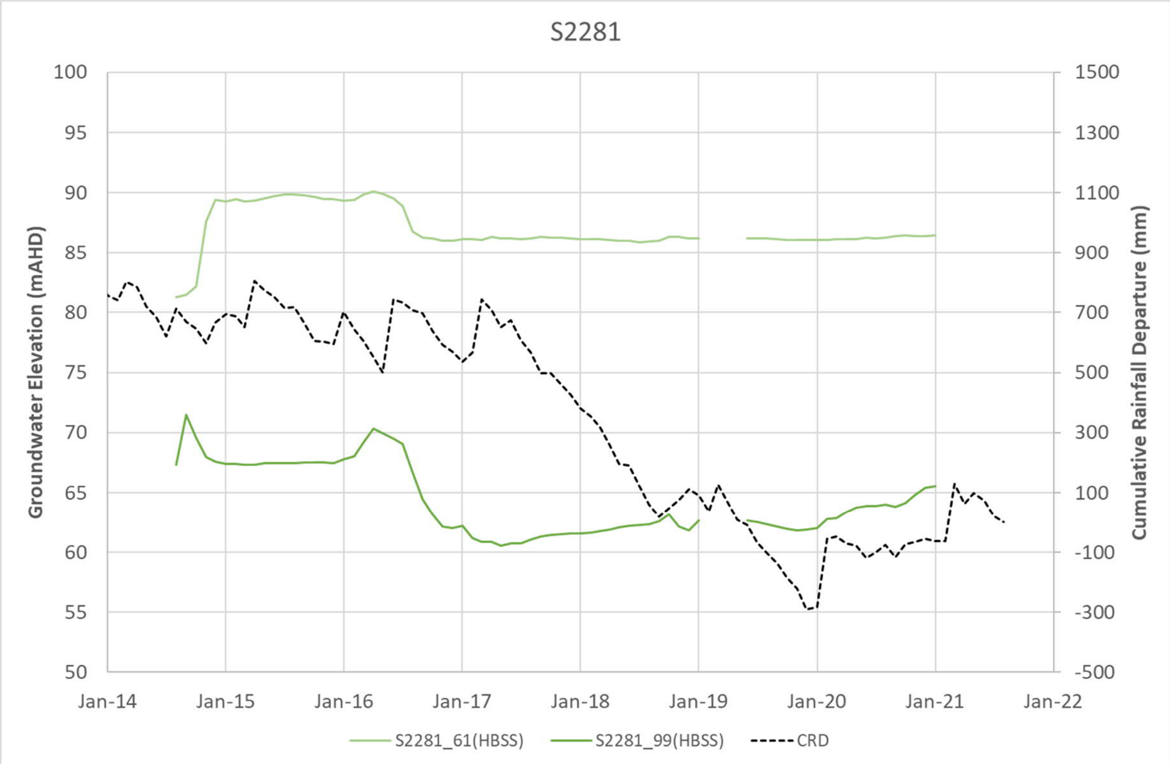


Figure 15 Hydrograph – S2281

Figure 16 Hydrograph – S2282

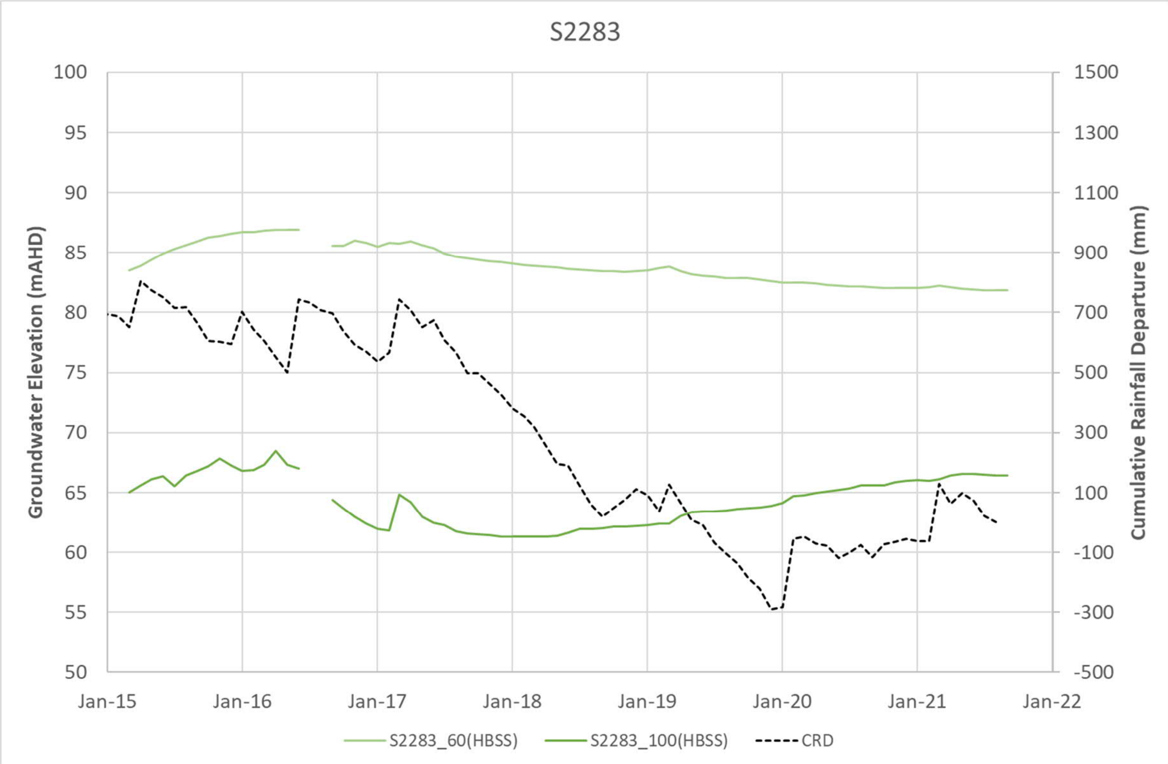
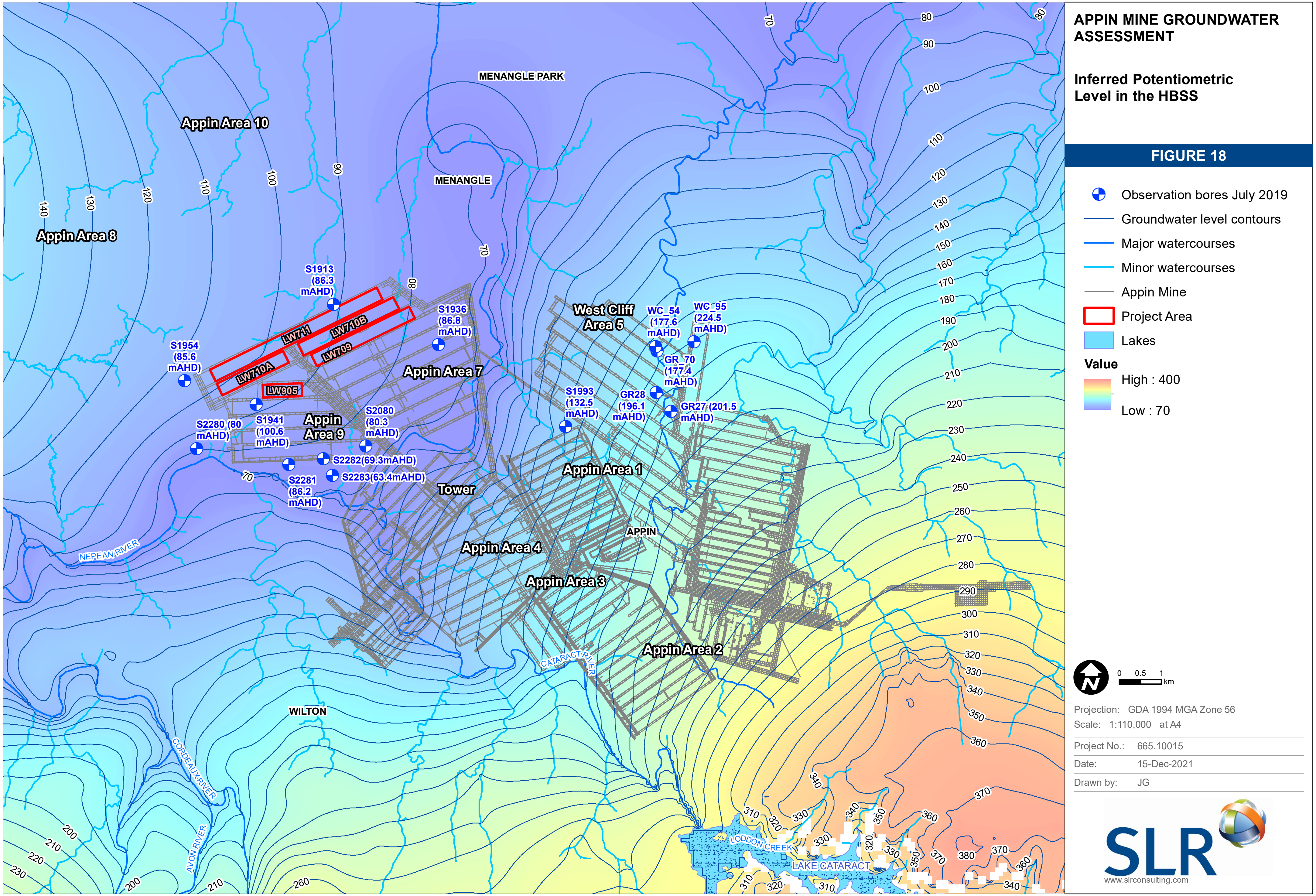


Figure 17 Hydrograph – S2283


APPIN MINE GROUNDWATER ASSESSMENT
Inferred Potentiometric Level in the HBSS
FIGURE 18
Observation bores July 2019
Groundwater level contours
Major watercourses
Minor watercourses
Appin Mine
Project Area
Lakes
Value
High : 400
Low : 70
Projection: GDA 1994 MGA Zone 56
Scale: 1:110,000 at A4
Project No.: 665.10015
Date: 15-Dec-2021
Drawn by: JG
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MENANGLE PARK
Appin Area 10
MENANGLE
Appin Area 8
S1913 (86.3 mAHD)
S1936 (86.8 mAHD)
S1954 (85.6 mAHD)
LW711
LW710B
LW709
LW710A
LW905
Appin Area 7
West Cliff Area 5
WC_54 (177.6 mAHD)
WC_95 (224.5 mAHD)
GR_70 (177.4 mAHD)
S1993 (132.5 mAHD)
GR28 (196.1 mAHD)
GR27 (201.5 mAHD)
S2280 (80 mAHD)
S1941 (100.6 mAHD)
Appin Area 9
S2080 (80.3 mAHD)
S2282(69.3mAHD)
S2283(63.4mAHD)
S2281 (86.2 mAHD)
Tower
Appin Area 1
APPIN
NEPEAN RIVER
Appin Area 4
Appin Area 3
Appin Area 2
CATARACT RIVER
WILTON
CORDEAUX RIVER
AVON RIVER
LODDON CREEK
LAKE CATARACT

3.2.4 Narrabeen Group

The Triassic Narrabeen Group is a sequence of interbedded sandstone, claystone, and siltstone present across the Appin Mine. It thickens north westerly from Appin Area 3 extended to Appin Area 7. The major unit is the Bulgo Sandstone which has a poor groundwater quality. Groundwater flows north-westerly at the base of the unit through bedding planes, joints and fractures. The Narrabeen Group comprises three formations of very low permeability (i.e. aquitards). These aquitards impede vertical flow within the unit and are described below:

- The Bald Hill Claystone at the top of the Bulgo Sandstones interrupts the vertical groundwater flow from the HBSS. The aquitard is present across the Appin Mine and has a thickness of approximately 25 m.
- The Stanwell Park Claystone limits the interaction of groundwater between the Bulgo Sandstone and the Scarborough Sandstone and is present across the Appin Mine with a higher thickness over Area 7 (20 m) than in Area 3 extended (6 m).
- The Wombarra Claystone forms the base of the Narrabeen Group and also impedes vertical flow to the Illawarra Coal Measures. It is present across the Appin Mine and thickens south-easterly from 30 m at Appin Area 7 to 41 m in Area 3 extended.

The hydraulic gradient within the Narrabeen Formation varies spatially due to the differences in hydraulic properties over varying depths. In the Project area, groundwater levels at depth tend to be higher than those observed in the HBSS (see S1913_194, S1913_247 and S1913_473 in Figure 11) indicating an upward gradient.

As shown in Figure 12, the hydrograph for VWP S1941 indicates gradual depressurisation in the lower Bulgo Sandstone (S1941_432) and Scarborough Sandstone (S1941_472 and S1941_478) with progression of mining and depressurisation of the Bulli Seam.

As discussed in Section 2.4.2, impacts from the gas extraction activities at Camden Gas Project is expected in the Narrabeen Group within the Project area. This can be seen by the potentiometric level trends for VWP S2177_510 shown Figure 19, VWP S2177 is located around 5.7 km north of the Project and 500 m to 1 km from five active CSG wells (EM05, EM07, EM09, MP15 and MP30). Figure 19 shows a 40 m decline in potentiometric levels in the Scarborough Sandstone from commencement of monitoring, along with a decline in the Bulli Seam (S2177_621), effected by the CSG extraction activities.

On a regional scale, groundwater flows horizontally from elevated areas in the southeast and western side of Appin Mine, with a hydraulic gradient towards the north. Potentiometric levels in the upper Bulgo Sandstone range from 300 mAHD in the south-east to 90 mAHD to 100 mAHD across Appin Mine (Figure 20)

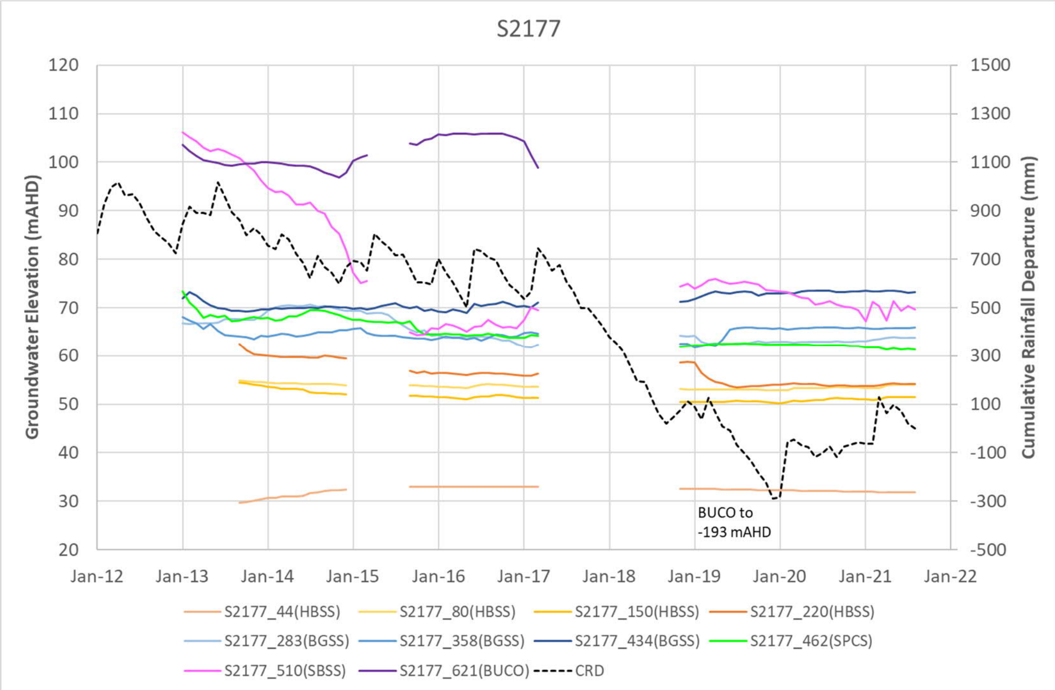
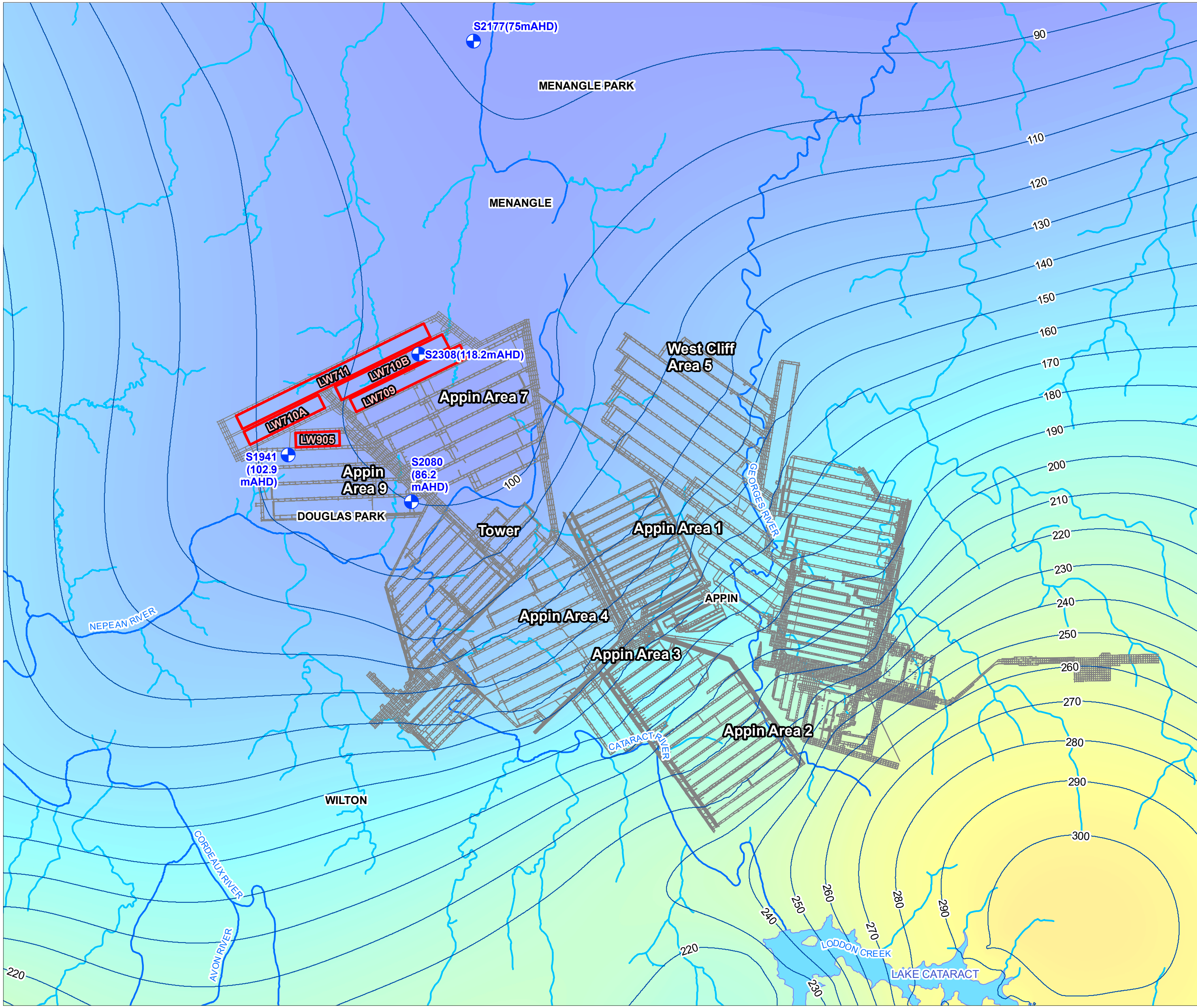


Figure 19 Hydrograph – S2177

APPIN MINE GROUNDWATER ASSESSMENT

Inferred Potentiometric Level in Upper Bulgo Sandstone

FIGURE 20



Observation bores July 2019
Groundwater level contours
Major watercourses
Minor watercourses
Appin Mine
Project Area
Lakes

Groundwater Level
High : 400
Low : 70

0 0.5 1 km

Projection: GDA 1994 MGA Zone 56
Scale: 1:110,000 at A4

Project No.: 665.10015
Date: 15-Dec-2021
Drawn by: JG

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H:\Projects-SLR\620-BNE\665-WOL\665.10015 Illawarra Coal Closure - Water\CADGIS\ArcGIS\665.10015 F20 Inferred Groundwater Level in the Upper Bulgo Sandstone.mxd

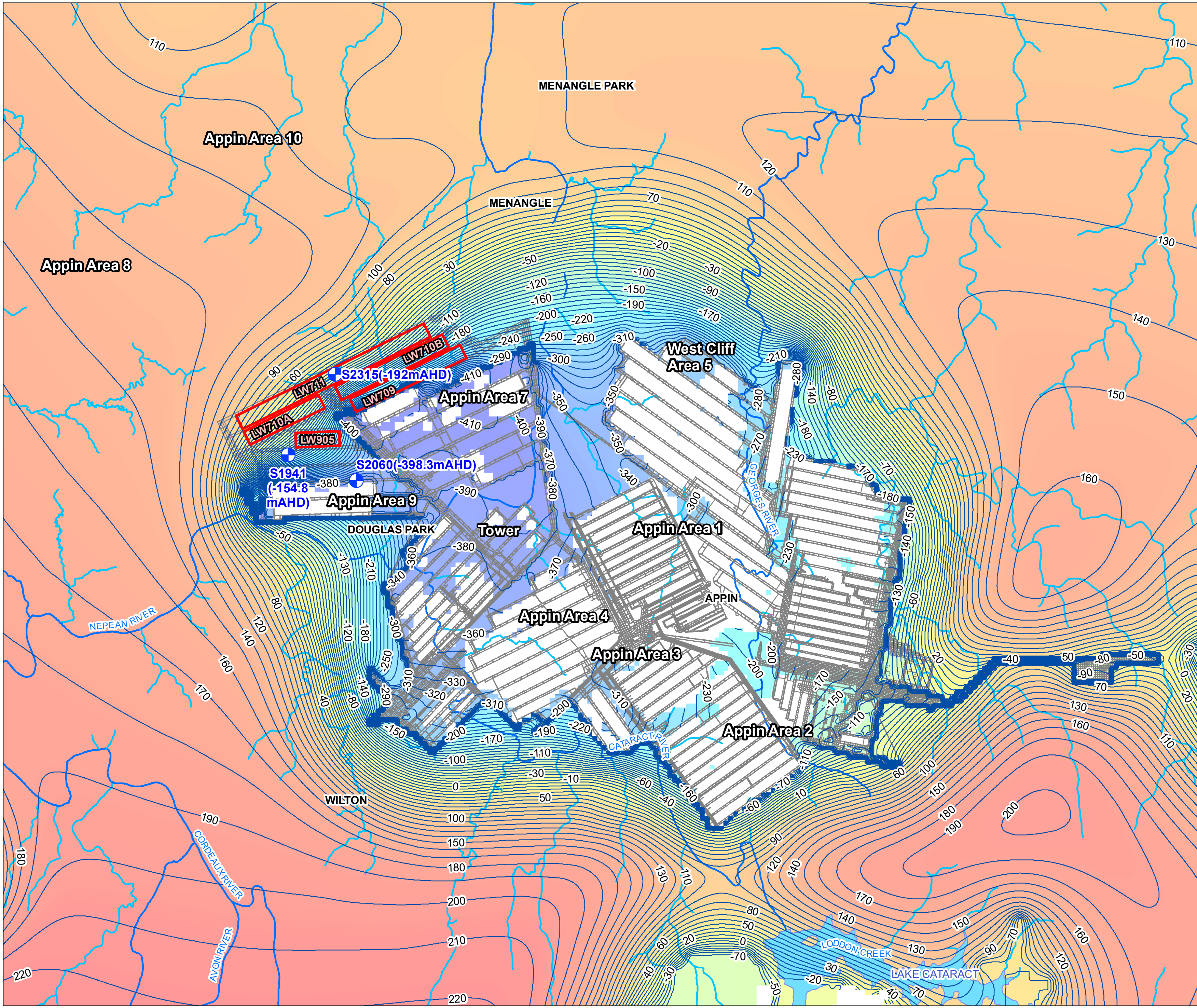
3.2.5 Illawarra Coal Measures

The Illawarra Coal Measures are the primary economic sequence of interest in the Sydney Basin, and consist of interbedded sandstones, shale and coal seams with a thickness of approximately 200 m to 300 m. The two main coal seams mined in the Southern Coalfield are the uppermost Bulli Seam and the Wongawilli Seam (Holla and Barclay, 2000). Within the Project extent of the longwall mining area, the Bulli Seam is around 530 m to 750 m below surface. The coal seams outcrop to the east of Appin Mine, where coal seams are truncated (eroded) along the Illawarra Escarpment.

Figure 21 shows the inferred potentiometric levels in the Bulli Seam in July 2019. As shown in Figure 21, historical mining activities at the Appin Mine have resulted in significant depressurisation the pre-mining groundwater levels in the Bulli Seam. Therefore, on a site scale, the groundwater flow in Bulli Seam and Wongawilli Seam is towards the mine workings. On a regional scale, the groundwater in both Bulli Seam and Wongawilli Seam flows towards the north. Groundwater within the Permian coal measures are semi-confined where they occur at subcrop, becoming confined with depth towards the north-west. Groundwater levels range from 220 mAHD in the south-east to 110 mAHD north of Appin Mine (Figure 21).

The depressurisation of the strata is observed across the historical and active mining areas as seen in bores S1936 and S2315 located in Area 7. All sensors at bore S1936 except the shallowest sensor (65 m) is no longer working since 2014 (Figure 22). This is likely due to the loggers being damaged or destroyed by mining. The hydrograph for S2315 (Figure 23) shows significant decline in groundwater levels in Bulli Coal Seam in response to the longwall mining. However, S2308 located 1.8 km to the west of S2315 has recorded stable groundwater level due to further distance from the current mining works (Figure 13).

As show in Figure 11, the decline in groundwater levels in S1913_559 the which is monitoring the Bulli Seam recorded before commencement of the longwall near this bore and is likely a response to the active CSG well with less than 200 m distance. The depressurisation of the strata is observed across the historical and active mining areas as seen in bores S1941_555 and S2060_603 in Area 9. The significant decline of approximately 250 m is observed in groundwater levels in bore S1941_555 monitoring the Bulli Coal Seam at (Figure 12). There is 500 m depressurisation observed at bore S2060 in Bulli Coal Seam and Balgownie Seam which is a response to the longwall mining (Figure 25).



APPIN MINE GROUNDWATER ASSESSMENT

Inferred Potentiometric Level in the Bulli Seam

FIGURE 21

Observation bores July 2019
Groundwater level contours
Major watercourses
Minor watercourses
Appin Mine
Project Area
Lakes

Groundwater Level
High : 220
Low : -430

0 0.5 1 km

Projection: GDA 1994 MGA Zone 56
Scale: 1:110,000 at A4

Project No.: 665.10015
Date: 15-Dec-2021
Drawn by: JG

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H:\Projects-SLR\620-BNE\665-WOL\665.10015 Illawarra Coal Closure - Water\CADGIS\ArcGIS\665.10015 F21 Inferred Groundwater in the Bulli Seam.mxd

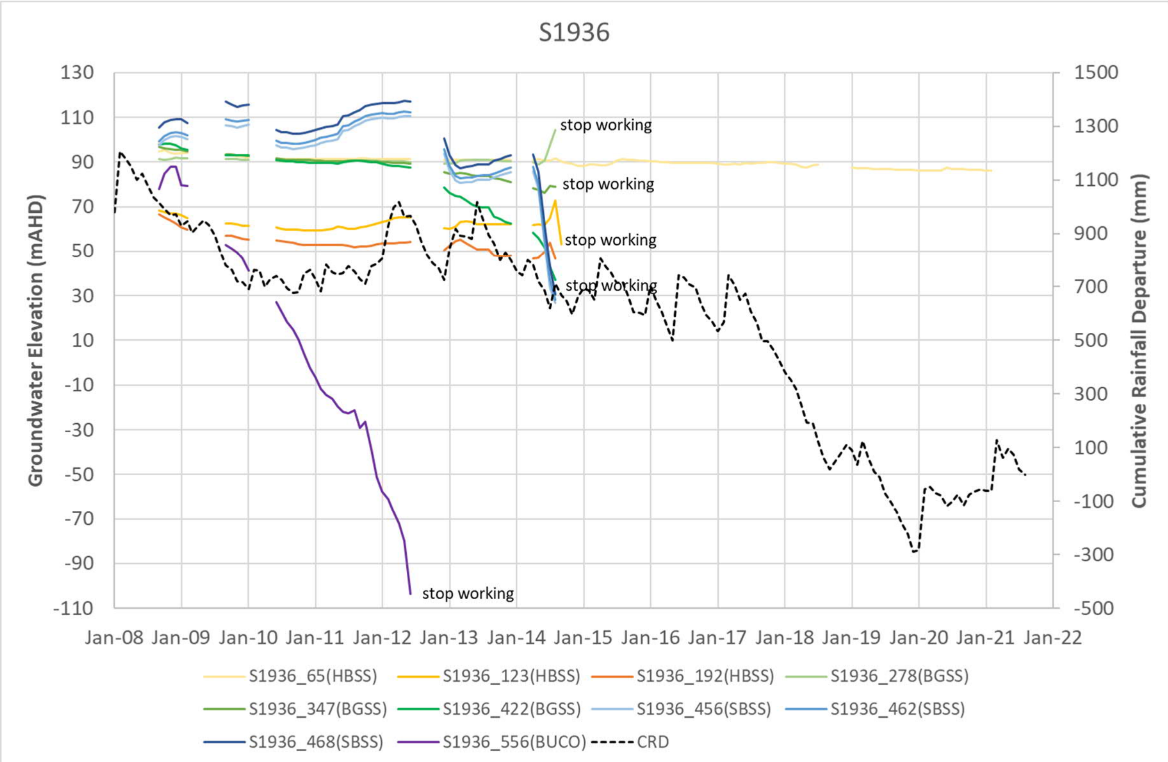


Figure 22 Hydrograph - S1936

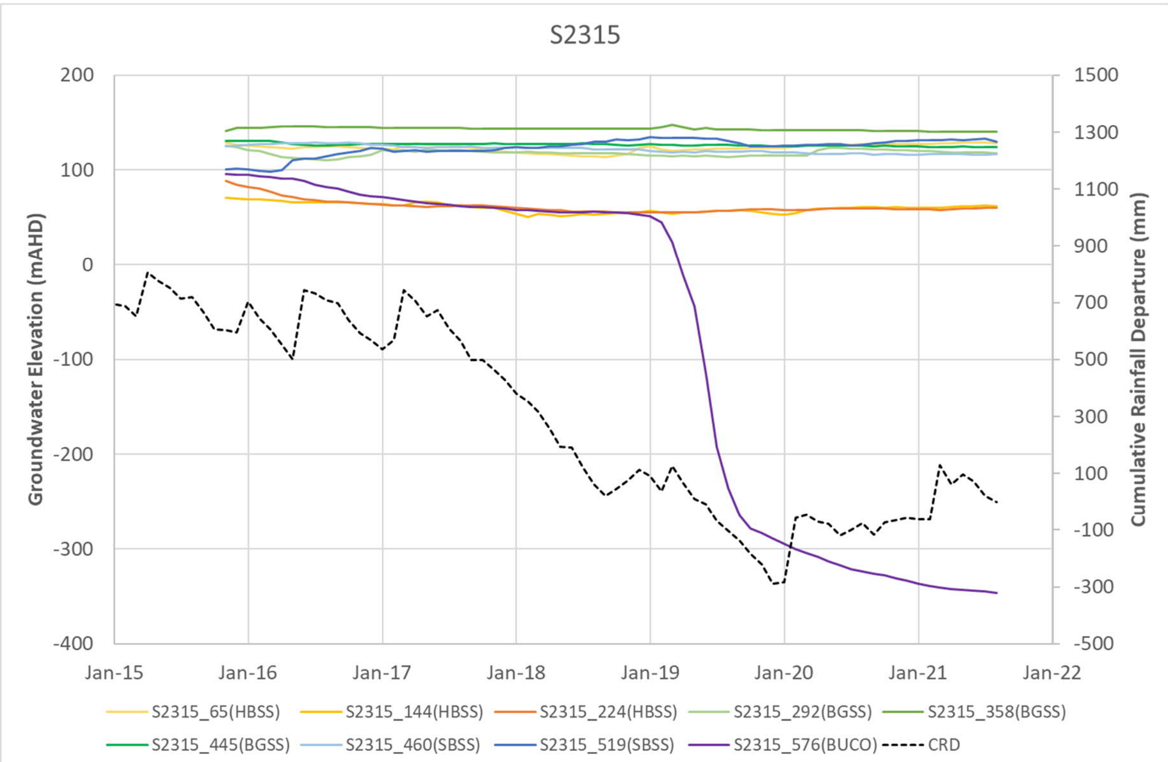


Figure 23 Hydrograph – S2315

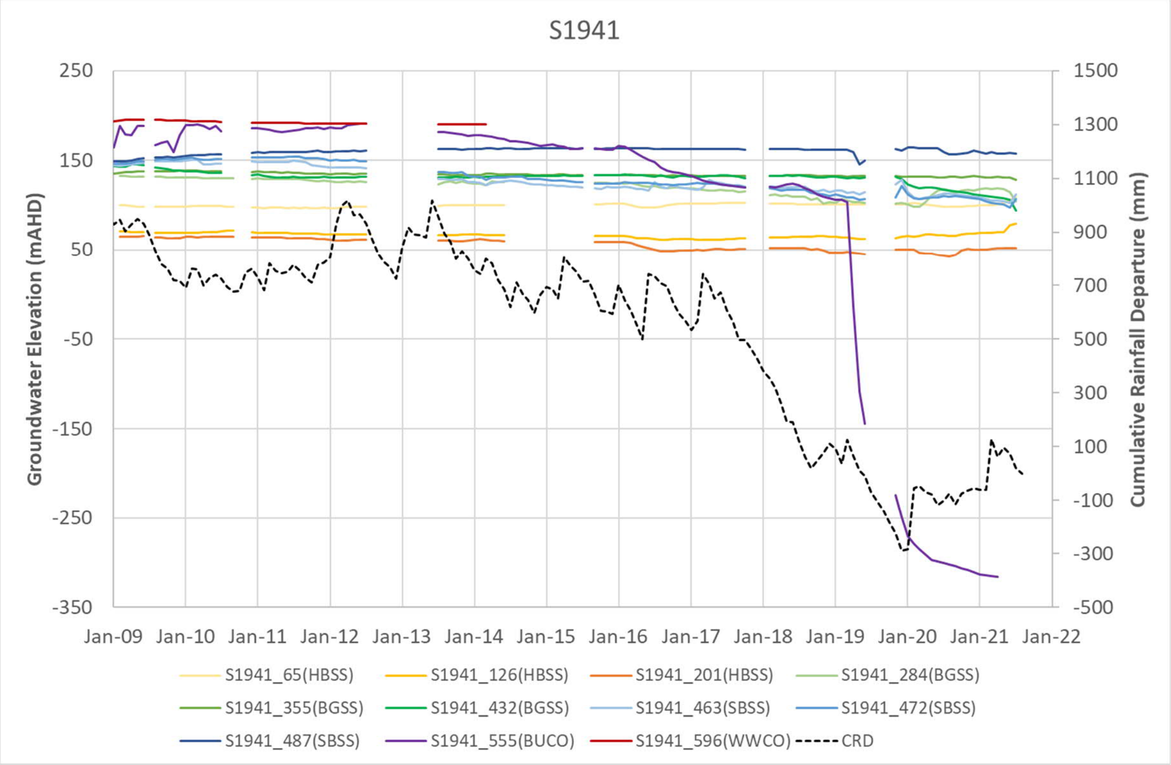


Figure 24 Hydrograph - S1941

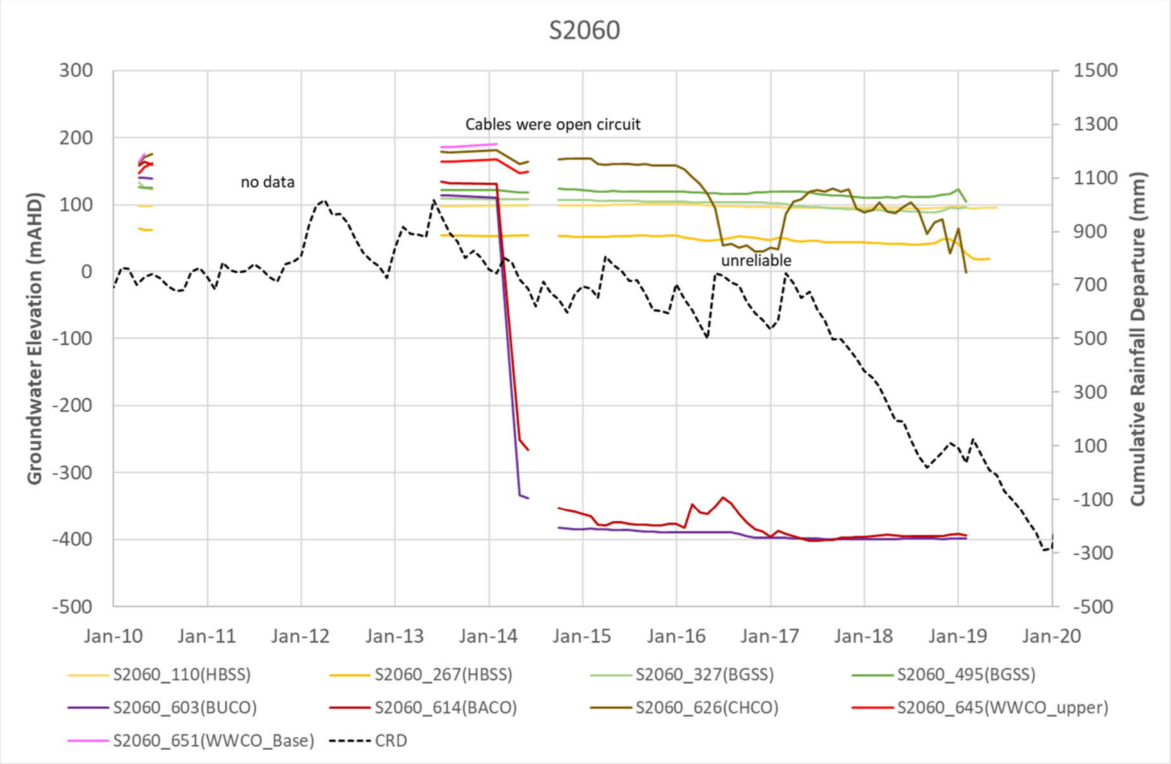


Figure 25 Hydrograph – S2060

3.3 Groundwater Quality

A summary table of groundwater quality data collected at site from bores screened within the Wianamatta Group, HBSS and Narrabeen Group (Bulgo Sandstone) is presented in Appendix B.

In summary, water within:

- Nepean River surface water is generally fresh (median EC 244 µS/cm) and generally has neutral pH (median pH 7.7).
- Wianamatta Group is generally moderately saline (median EC 4,750 µS/cm). The results show that water is not suitable for drinking water, generally suitable for short term irrigation and water for some stock (i.e. sheep and dairy cattle). But generally, has iron concentration above the trigger for long term irrigation water use, and low yields so not considered a productive groundwater source (Heritage Computing, 2009).
- HBSS is brackish (median EC 2,060 µS/cm) but can have variable water quality with the 5^{th} and 95^{th} percentile of site data ranging between 460 µS/cm and 6,458 µS/cm. The groundwater generally has a neutral pH (median pH of 7.5), but is also highly variable with a 5^{th} and 95^{th} percentile of site data ranging between 6.4 and 11.9. The BBSS typically has a sodium-calcium type water, and is generally suitable for short term irrigation and stock water. However, the iron concentrations are generally above the trigger for long term irrigation water use.
- Bulgo Sandstone within the Narrabeen Group is generally moderately saline (median EC ~4,950 µS/cm) and generally has neutral pH (median pH 7.2). The groundwater in the Bulgo Sandstone typically has a sodium-bicarbonate type water and is generally suitable for short term irrigation and water for some stock (i.e. sheep and dairy cattle). However, the iron concentrations are generally above the trigger for long term irrigation water use.

The available data indicates there are no groundwater bores on site where water quality data is collected from the Permian coal measures. It is assumed water within the coal measures would generally be moderately saline to saline. With consideration of mine closure, as groundwater recovers, minerals that were oxidised under the drained conditions (i.e. sulphur) can undergo dissolution, in turn lowering the pH of the infilling waters (Wright et al., 2018). More acidic waters can lead to increased dissolution of precipitated metals such as zinc, iron and nickel (Wright et al., 2018; Price and Wright, 2016). The degree of acidity encountered during the saturation of the mine workings is dependent upon the acid forming potential of the mined material (Harries, 1997).

3.4 Groundwater Receptors

3.4.1 Swamps

Upland headwater swamps have been mapped in the region. However, the closest swamps are approximately 9,000 m from the Project area and are therefore not considered potential receptors for this Project.

3.4.2 Landholder Bores

A search of the BoM's National Groundwater Information System (NGIS) was carried out for registered bores within the model extent (refer to Figure 27). The search indicated that there are 1,006 registered bores, of which 512 are functional, 453 are unknown, 26 are proposed, and 14 are abandoned, non-functional, or removed. The function of all bores identified in the database is presented below in Table 6. There are 49 registered bores within 5 km of Appin Mine/Project area. The location of these bores is shown in Figure 26.

Table 6 Registered Use of Groundwater Bores Within the Model Extent

Use	Count	Percent of Total
Commercial and Industrial	16	1.6
Dewatering	10	1.0
Exploration	9	0.9
Irrigation	139	13.8
Monitoring	379	37.6
Other	9	0.9
Stock and Domestic	33	3.3
Unknown	34	3.4
Water Supply	377	37.5
Total	1,006	100.0

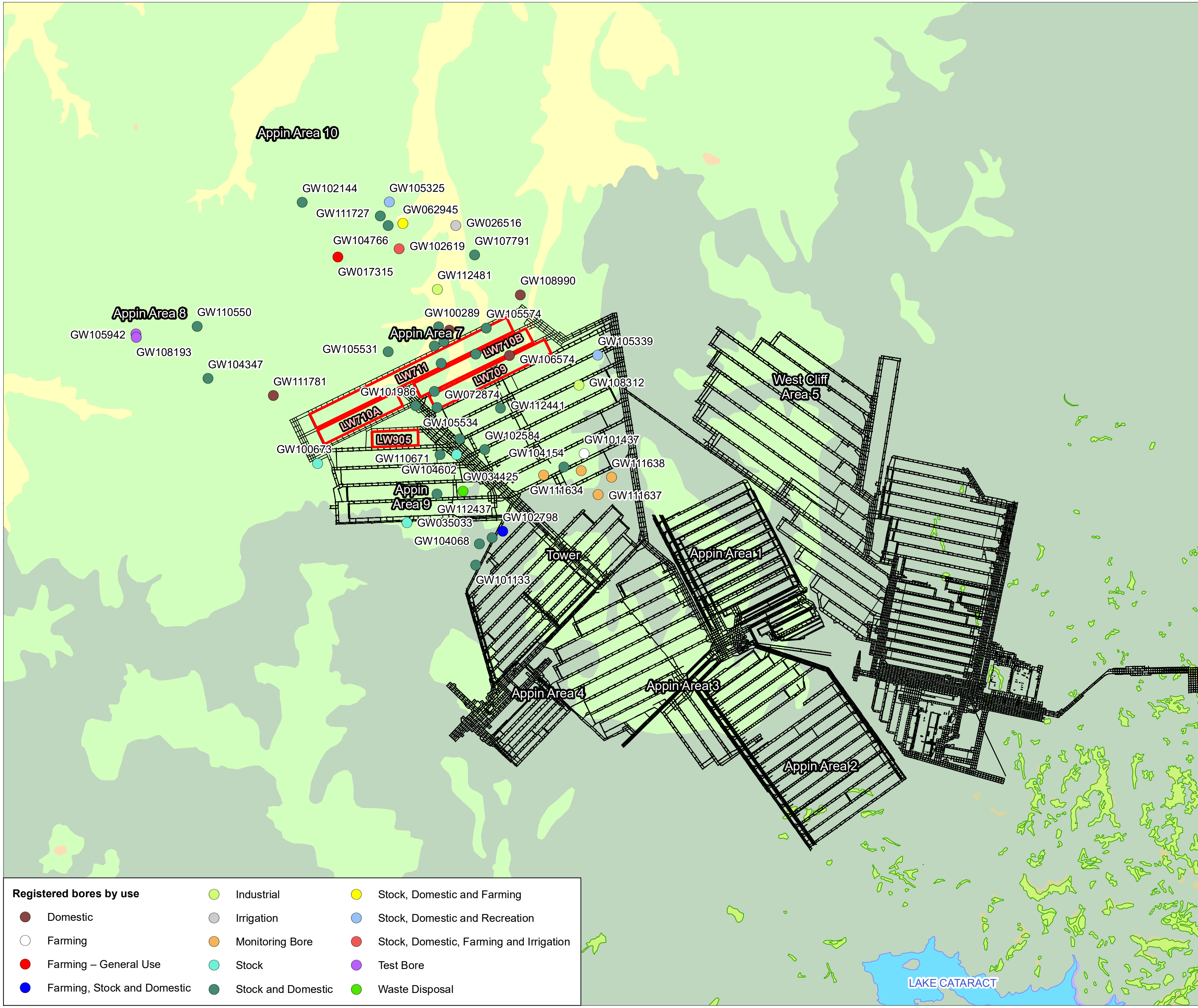
A majority of groundwater users are located to the north of the Project, within the Wianamatta Group outcrop area, and to the southwest, within the HBSS outcrop area. Most landholder bores are located within the HBSS (453 bores) and Bulgo Sandstone (322 bores). Of these, 207 bores could be extracting water from the HBSS for water supply, irrigation, household, stock, and domestic purposes.

There are 237 bores extracting water from the Bulgo Sandstone. Detailed construction details for the bores is missing in most cases. Using the known bore depth and the surface geology map, there is potential for approximately 64 registered bores with depth of less than 30 m targeting alluvium along the Nepean River and the Mount Hunter Rivulet, north to Appin Mine. These bores are used for monitoring (39 bores), irrigation (15 bores), water supply (4 bores), stock (1 bores) and other uses (5 bores). Maximum yield of private bores surrounding Appin Mine does not exceed 1.5 L/s. Details of the registered bores in the Appin Mine Area are shown in Appendix C.

APPIN MINE GROUNDWATER ASSESSMENT

Groundwater Users in the Appin Mine area

FIGURE 26



Appin Mine
Lakes
IC mapped swamp
Qal/ Tal – Alluvium
Wianamatta group
Rh - HBSS
Project Area

0 0.5 1 km

Projection: GDA 1994 MGA Zone 56
Scale: 1:105,000 at A4

Project No.: 665.10015
Date: 15-Dec-2021
Drawn by: JG

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H:\Projects-SLR\620-BNE\665-WOL\665.10015 Illawarra Coal Closure - Water\CADGIS\ArcGIS\665.10015 F26 Groundwater Users in the Appin Mine area.mxd

3.5 Conceptual Groundwater Model

The primary hydrostratigraphic units within the Appin Mine area are:

- Quaternary alluvium – localised along rivers and creeks, likely unconfined and recharged from rainfall and surface water flow. Discharge to surface water (baseflow contributions) possible where gradients enable this, with potential for downward seepage where unconformably overlies HBSS. Groundwater flow likely follows topography and streamflow direction towards the north;
- HBSS – main groundwater source and widely accessed for groundwater supply and provides baseflow contributions where incised along major rivers (i.e. Cataract River, Nepean River and Georges River). Groundwater flow generally in a northerly direction, and locally influenced where intersected by rivers and private abstraction bores;
- Narrabeen Group – sandstones that can be used for groundwater supply, and low permeability claystones that generally act as aquitards; and
- Illawarra Coal Measures – with groundwater occurrence largely associated with the more permeable coal seams, with confined groundwater conditions. Groundwater flow generally in a northerly direction, and locally depressurised due to current and historical mining and CSG.

The Appin Mine intersects the Bulli Seam, which ranges from 530 m to 750 m below surface at the Project, and generally dips in a north-westerly direction. With mine progression at Appin, the hydraulic properties of the stratigraphy overlying the Bulli Seam is changed due to goaf effects from longwall mining. There is no site-specific data on the in-situ post-mining hydraulic properties for Appin, but extensive data for surrounding mines (Dendrobium and Tahmoor) indicates the goaf and fractured zone can result in an enhanced permeability of 2 to 3 orders of magnitude, depending on the strata (HGEO, 2019).

Within overlying stratigraphy, not impacted by goaf effects, the influence from depressurisation of the mined coal seam is limited by the low vertical conductivity and the presence of low permeability claystones that can act as aquitards (i.e. Bald Hill Claystone).

Current groundwater levels indicate depressurisation within the Bulli Seam extends approximately 1 km to 2 km from active mine areas, consistent with previously assessed impacts for the BSO (Heritage Computing 2009). Current monitoring data also shows depressurisation within the Scarborough Sandstone and Bulgo Sandstone due to mining and within the Scarborough Sandstone due to CSG activities (Camden Gas Project). Drawdown within the Scarborough Sandstone, Bulgo Sandstone and lower HBSS was previously predicted for BSO (Heritage Computing, 2009).

Regionally, there is depressurisation or drawdown observed within the HBSS in response to mining or CSG as well as the response to climate. The groundwater levels in landholder borehole GW106574, located above Appin Area 7 Longwall 709, shows decline since September 2020 with approximately 10 m depressurisation in HBSS. This decline is likely an impact by the longwall mining activities.

South32 Illawarra Coal - post-mining inspection report (South32, 2019) indicates that the longwall mining activities had a likely impact on the borehole (GW072249) extraction.

4 Groundwater Modelling

4.1 Groundwater Model Setup

This study utilised the SLR (2020) numerical model, which was based on the groundwater model HydroSimulations (2018) and previously based on the Heritage Computing (2009) which was used for the Appin Mine groundwater assessment (Heritage Computing, 2009). The SLR (2020) groundwater model utilises MODFLOW-USG code and was developed in Groundwater Vistas Version 7 (GWVistas 7).

As part of the study, the following updates were undertaken on the SLR (2020) model:

- Extending the model and create a 3D mesh of Voronoi cells.
- Update model layer elevation to reflect Lidar data (Layer 1).
- Differentiate alluvial materials (Layer 1) from the Wianamatta Group and the weathered HBSS (Layer 2), plus refine thickness of alluvial materials along rivers and across swamps areas.
- Divided the thick groundwater units such as the HBSSs and the Bulgo Sandstones into three separate layers to better accommodate groundwater model targets (i.e. VWP sensors) and to improve the alignment of the height of fracture within the numerical model layers.
- Use the pinch out function in MODFLOW-USG to remove the dummy layers based on geological layers. These features allow the total cell count to be reduced, and the conceptual correctness of the model to be improved.
- Update model timing to quarterly stress periods (SP) to account for seasonal changes and mining schedule.

4.1.1 Model Extent and Mesh Design

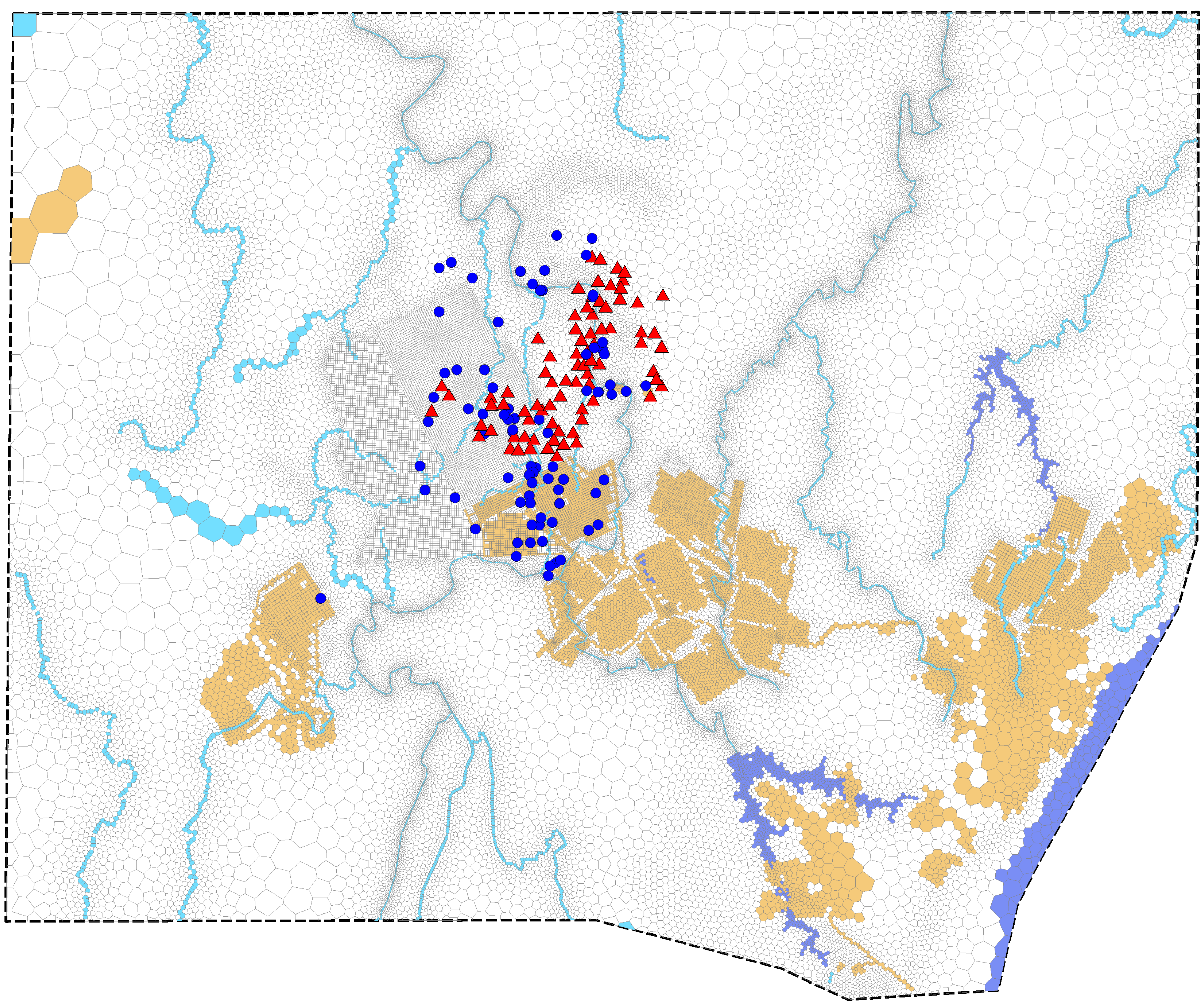
The groundwater model domain is shown in Figure 27. The model extends approximately 52 km from west to east and approximately 43 km from north to south, covering an area of approximately 2070 km^2. The groundwater model extent was designed to be large enough to accommodate future mining at Appin Mine and to cover any potential associated impacts.

The HydroAlgorithmics software “AlgoMesh” was used to generate the 3D Voronoi cells grid. The large spatial area of the model extent resulted in the need for an unstructured grid with varying cells sizes, and refinement in the areas of interest, in order to reduce the total cell count to a manageable size. The mesh over the whole model extent is shown in Figure 27. The following features have been included in the mesh design:

- A regular (aligned) square grid of cells was enforced in Appin Mine proposed and historical longwall mining after 2009, rotated in line with the longwalls (100 m), and in those of Tahmoor Mine (150 m) and Metropolitan Mine (150 m).
- A regular hexagonal grid of cells was used to refine all historical mining before 2009 with cell size of 200 m in Appin, Metropolitan and Russell Vale Mines and 300 m in Tahmoor.
- Polylines along mapped rivers and creeks were used to ensure the mesh conformed to mapped drainage network, and to enforce variable details along streams (e.g. greater detail along streams closest to Appin Mine). Voronoi cells sizes along rivers and creeks varies from 100 m to 300 m.
- A regular hexagonal grid of cells was used to refine the mesh across the different Appin Mine shafts, with maximum cell size of 50 m.

- The mapped alluvial boundaries present across the model extent were used to enforce finer cell resolution in a range of 200 m and 400 m cell size.
- Escarpment areas were refined by 300 m cell size.
- Regular hexagonal grid of cells was used to refine the mesh across the reservoirs (i.e. Cataract and Woronora) with maximum cell size of 200 m.

The cell count for layer one is 56,110. Over the 18 model layers, with pinch-out areas (where a layer is not present) in layers 2 to 17, the total cell count for the model is 8,963,416.



APPIN MINE GROUNDWATER ASSESSMENT

Model Grid and Boundary Conditions

FIGURE 27

Projection: GDA 1994 MGA Zone 56
Scale: 1:230,000 at A4

Project No.:	665.10015
Date:	16-Dec-2021
Drawn by:	JG

SLR
www.slrconsulting.com

4.1.2 Layers

The groundwater model consists of 18 layers as listed in Table 7. Model layer 1 is present across the whole model extent, and includes the Quaternary Alluvium, swamps, Wianamatta Group and HBSS. The Wianamatta Group has been divided across layers 1 and 2 where present. The HBSS has been divided into 5 layers, and the Bulgo Sandstone has been divided into 3 layers to allow vertical gradients through the stratigraphic column to be represented.

The Bulli Seam is represented in layer 15 for the purpose of modelling longwall mining at Appin, Metropolitan, Tahmoor and all other historical mines. The Wongawilli Seam is represented in layer 17 for the purpose of modelling longwall mining at Russell Vale East.

Model layers 2 to 17 are not present across the whole model domain, the layers have been pinched out where the geology has been eroded at outcrop.

Table 7 Groundwater Model Layers

Layer	Geology
1	Alluvium/ Wianamatta Group / Weathered HBSS
2	Wianamatta Group / Weathered HBSS
3	Upper HBSS
4	Upper HBSS
5	Lower HBSS
6	Bald Hill Claystone
7	Bulgo Sandstone
8	Bulgo Sandstone
9	Bulgo Sandstone
10	Stanwell Park Claystone
11	Upper Scarborough
12	Lower Scarborough
13	Wombarra Claystone
14	Coal Cliff Sandstone
15	Bulli Coal Seam
16	Loddon Sandstone
17	Wongawilli Seam
18	Lower Permian Coal Measures

4.1.3 Model Timing

The stress period timing in the model was updated to include more temporal detail to better capture seasonal trends in recharge to alluvium and outcrop formations, as well as a better inclusion of the mine schedule into the model. To achieve this, the historical and predictive stages of the model were updated to:

- Steady-state to represent pre-mining conditions and initials heads;
- Transient warm up period from 1 January 1960 to 31 December 2009 with all historical mines within the model area;
- Transient historical period from 1 January 2010 to 30 June 2021 with quarterly stress periods; and
- Transient predictive period from 1 July 2021 to 31 December 2027 (one year after Longwall 711) with quarterly stress periods.

4.1.4 System Stresses

This section presents a summary of the main model inputs to replicate system stresses that were varied as part of this study, including wells, streamflow, recharge and mining.

4.1.4.1 Wells

AGL held 137 bore licences for the Camden Gas Project gas production wells from two Water Access Licences (24856 and 24736) which have a combined allocation of 30 ML per year, with 15 ML allocated to the Sydney Basin Central Groundwater Source and 15 ML allocated to the Sydney Basin Nepean Groundwater Source, and are licensed for industrial purposes (AGL, 2018).

The MODFLOW Well (WELL) package has been used to present these Camden Gas Project production wells to replicate depressurisation within the Bulli Seam (Figure 27). Within the model the Camden Gas Project wells commenced operation based on the date of installation and were turned off at 2023 (AGL, 2018).

The WELL package was also used to capture the water take from 83 licensed registered water supply bores within the model domain. Four wells are screened in the Wianamatta Group, one in the Bulgo Sandstone with the remainder screened in the HBSS. The extraction rate has been assumed as 5 ML/year or if unknown the shared component volume. Within the model the wells were started based on information on the drilled date and remain active until the end of model prediction period.

4.1.4.2 Water Storages

Old underground workings at Appin are used for water storage. The measured water levels at water storages were provided by South32. MODFLOW-USG Time variant constant head package (CHD) was used to represent these water levels. Figure 28 shows the actual water levels measured for underground workings in Area 4 and White Panel compared to modelled levels.

No information was provided on water storage levels for Area 4 and White Panel prior to 2018. Therefore, a simplified approach was adopted where the water levels were set based on the short period of available data, and then extrapolated out for where no data was available as shown in Figure 28.

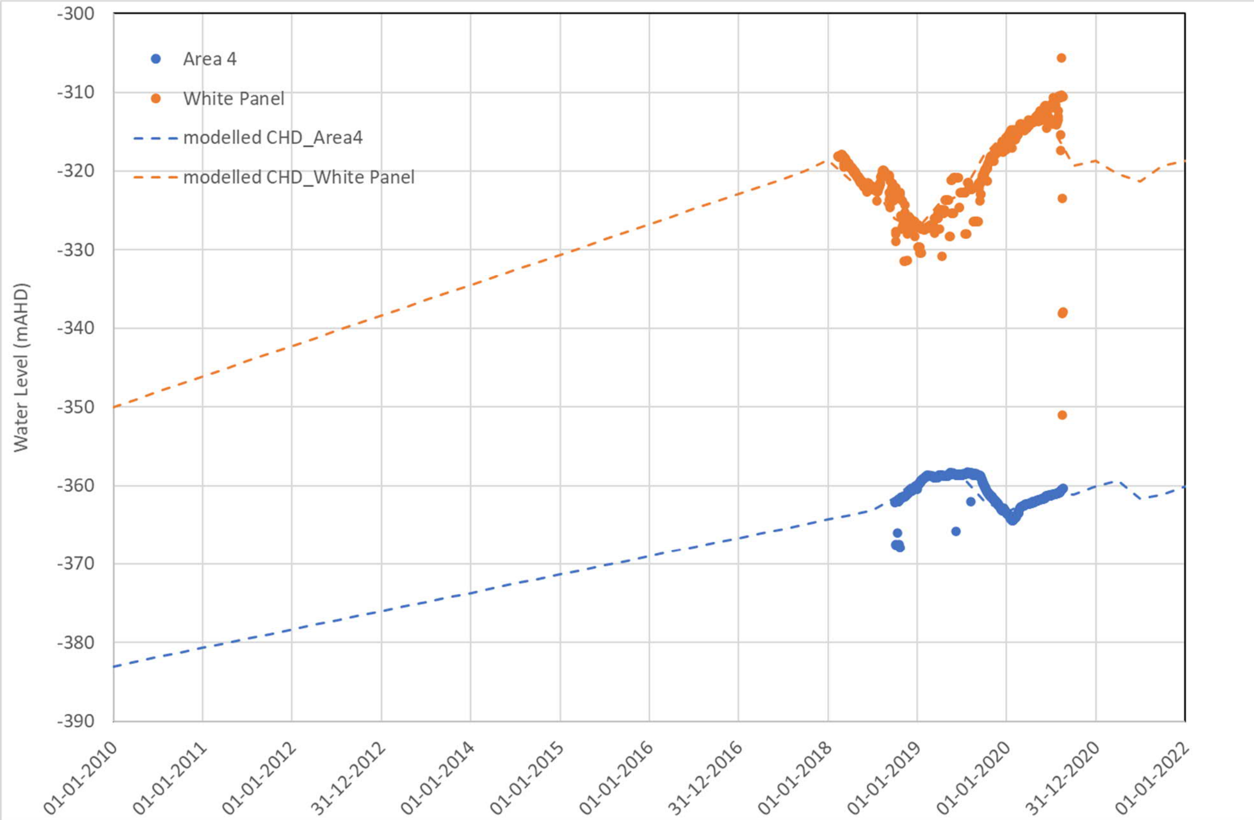


Figure 28 Underground Ponded Water Levels

4.1.4.3 Streamflow

All major watercourses are represented using the MODFLOW River (RIV) package. Figure 29 shows the modelled versus observed water levels at the three locations. The main streams (Nepean River, Cataract River and Stonequarry Creek) were replicated with a time-variant stage based on the observed levels from the stream gauging stations (212216, 212230 and 212053). Remaining third order streams with no observation data available were modelled with a constant 1 m stage. Forth order streams/ephemeral drainage lines were represented as ‘river’ boundary cells in the model, with the stage equal to the base of the riverbed to present the river only gaining water from the groundwater system.

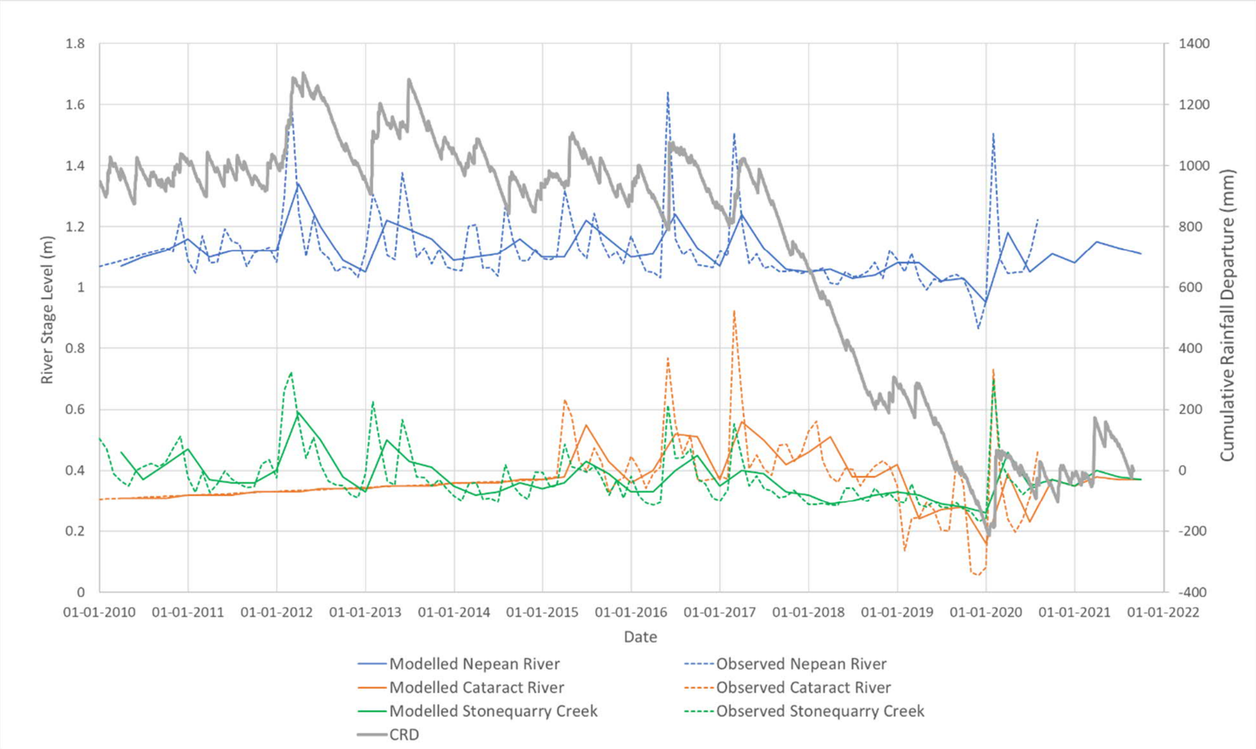


Figure 29 Modelled Stage Levels vs Cumulative Rainfall Departure (CRD)

4.1.4.4 Recharge and Evapotranspiration

Diffuse rainfall recharge is simulated using the recharge package (RCH). Recharge was distributed in laterally distinct zones within the model domain. In this study, the zones are based on outcropping geology (Figure 7) and observed rainfall from multiple rainfall stations. A portion of annual rainfall was assigned to each zone and varied to match historical observed quarterly rainfall. The final calibrated values for the percentage of rainfall is presented in Table 12.

For the predictive model, average quarterly rainfall was applied from July 2021 to December 2027. The modelled recharge for alluvium is presented in Figure 30.

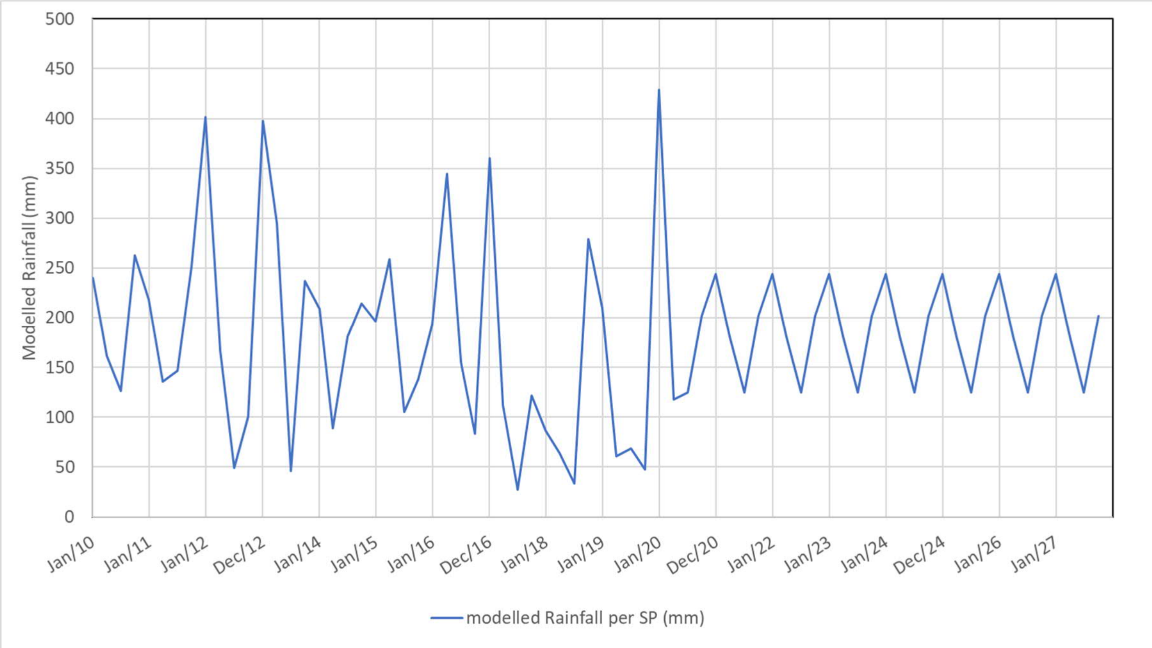


Figure 30 Modelled Rainfall Recharge to Alluvium and Outcrop Formations

Evapotranspiration (ET) from shallow water tables is simulated using the ET package and is represented in the upper most cells of the model domain down to an extinction depth of 3 m. A uniform ET rate of 1.4 mm/day was applied to the model.

4.1.4.5 Mining

The MODFLOW Drain (DRN) package is used to simulate mine dewatering in the model for the Project and the surrounding mines. Drain boundary conditions allow a one-way flow of water out of the model. When the computed head drops below the stage of the drain, the drain cells become inactive (Rumbaugh and Rumbaugh, 2011). This is an effective way of theoretically representing removal of water seeping into a mine over time, with the actual removal of water being via pumping and evaporation.

Longwall extraction drain cells are only applied to the layer representing the mined coal seam. A high drain conductance of 100 m^2/day was applied to the drain cells to simulate the effect of mining. The hydraulic properties were varied with time using the Time-Variant Materials (TVM) package of MODFLOW-USG. For the underground mines, the hydraulic properties were changed with time in the goaf and overlying fractured zone directly above each longwall panel. The DRN and TVM packages were updated for the study to align with the updated model timing.

4.1.5 Simulation of Goaf and Fracturing

As longwall mining progresses through the coal seam, the void left behind (goaf) fills with collapsed rock from the formations directly above the coal seam. There is a sag in the bedded formations above the goaf zone and the deformation causes generally vertical fractures to occur. These fractures reduce in size and frequency the higher up the profile they go. These cracks can provide new flow paths for groundwater and alter the permeability of the strata overlying longwall mining areas. Therefore, they are included in the groundwater model.

The hydraulic properties of overburden material above a mined coal seam will change in time due to the caving and subsidence above longwall panels. It is generally accepted that there will be a sequence of deformational zones consisting of the caved zone, the fracture zone (a lower zone of connective cracking and an upper zone of disconnected cracking), the constrained zone and the surface zone.

High permeability is expected in the caved zone where there is direct connectivity with the mined goaf. In the lower part of the fracture zone, the collapsed rocks will have a substantially higher vertical hydraulic conductivity than the undisturbed host rocks. In the disconnected-cracking fractured zone, the vertical hydraulic conductivity is not predicted to be significantly greater than under natural conditions. Depending on the width of the longwall panels and the depth of mining, and the presence of low permeability lithologies, some increase in horizontal hydraulic conductivity can be expected in the constrained zone. Near-surface fracturing can occur due to horizontal tension at the edges of a subsidence trough in the surface zone.

The groundwater model simulated the gradual changes to the hydrostratigraphic units in response to mining (e.g. longwall goafing) using the MODFLOW-USG TVM (time varying materials) package. Goafing and fracturing was simulated within the numerical groundwater model by changing the parameters within the coal seam and overlying strata as the longwall panel was progressed.

There are no specific measurements available at site on the height and properties of the fractured zone above the longwalls. Therefore, the height of fracturing in the model was calculated based on the Ditton and Merrick (2014) subsurface fracture height prediction model for longwall mines in NSW Coalfield.

The simplified ramp function used in the existing model was applied to vertical hydraulic conductivity (Kv), gradually decaying to the estimated maximum height of connective cracking. Specific yield (Sy) was increased in the mined coal seam layer to 10% to represent the void left in the mined seam.

Ditton and Merrick (2014) include the key fracture height driving parameters of panel width (W), cover depth (H), mining height (T) and local geology factors to estimate the A and B zone horizons above a given longwall panel. The A Zone corresponds with the connective-cracking part of the fracture zone, while the B Zone corresponds with the disconnected-cracking part of the fracture zone which is equivalent to the lower dilated part of the constrained zone.

Formula offered for the model is referred to as the Geology Model, which depends on W, H, T and t' (where t' is the effective thickness of the strata where the A Zone height occurs). The Geology Model formula for fracture zone height (A) for single-seam mining is:

- Geology Model: A = 1.52 W'0.4 H0.535 T0.464 t'-0.4 +/- (0.10 - 0.15) W'. Where W' is the minimum of the panel width (W) and the critical panel width (1.4 H).

Information on the panel width and extraction height was provided for historical mining at Appin to calculate the goaf and fracturing. For the predictive model the panel width and average extraction height was provided for Longwalls 709, 710A, 710B, 711 and 905 and the fracture zone height calculated, as presented in Figure 31.

The fractured height is highly sensitive to effective thickness of the strata (t'). As a part of the recent Appin Closure Study (SLR, 2021b), a sensitivity analysis was carried out with the aim of comparing the fracture zone height using different t' values. The sensitivity analysis included the following values:

- t'=20 m
- t'=15 m
- t'=10 m

The results of the sensitivity analysis are presented in Table 8 below. As shown in Table 8, in t'=10 m, the modelled fractured height reached the lower HBSS (Layer 5) in the model while in t'=20, the fracturing did not go beyond BGSS (Layer 7) in the model.

Table 8 Sensitivity of Ditton Geology Model Methods to Thickness of the strata (t').

Methods	Average Height (m)	Average Vertical Buffer (m)	Fractured into Model Layers
Ditton A t'=20m	198 – 286	306 – 536	7 [BGSS]
Ditton A t'=15m	223 – 321	280 – 501	6 [BACS]
Ditton A t'=10m	262 – 378	239 – 448	5 [Lower HBSS]

A study by Ditton and Merrick (2014) on longwall mines in the NSW coalfields indicated that t'=15 m to 20 m is considered appropriate for the Southern Coalfield (Table 9). The 2014 study considered t'=10 as an extreme value (i.e., worst case scenario).

Given that the depth of cover above the Appin longwalls varies between 430 and 750 m, the groundwater model used the Ditton method with a variable t' (between 15 to 20) to be used in calculation of fracture height for different depths of cover above the Appin longwalls.

Figure 31 shows the simulated fractured height for the Project (Longwalls 709, 710A, 710B, 711 and 905). As it is shown in the figure, the simulated is in the range of 221 m to 270 m above the roof of the Bulli Seam up to the Bulgo Sandstone comparing with the model layer elevations (model layers 7 and 8).

Table 9 Recommended Values for Effective Thickness of the Strata (t') for Longwall Mines in the NSW Coalfields (Ditton and Merrick, 2014)

Coal Field	Normal Condition t' (m)	Adverse Condition t'
Southern	40-20	15
Western	30-20	10
Newcastle	20-15	10
Hunter	20-15	10
Gunnedah	20-15	10

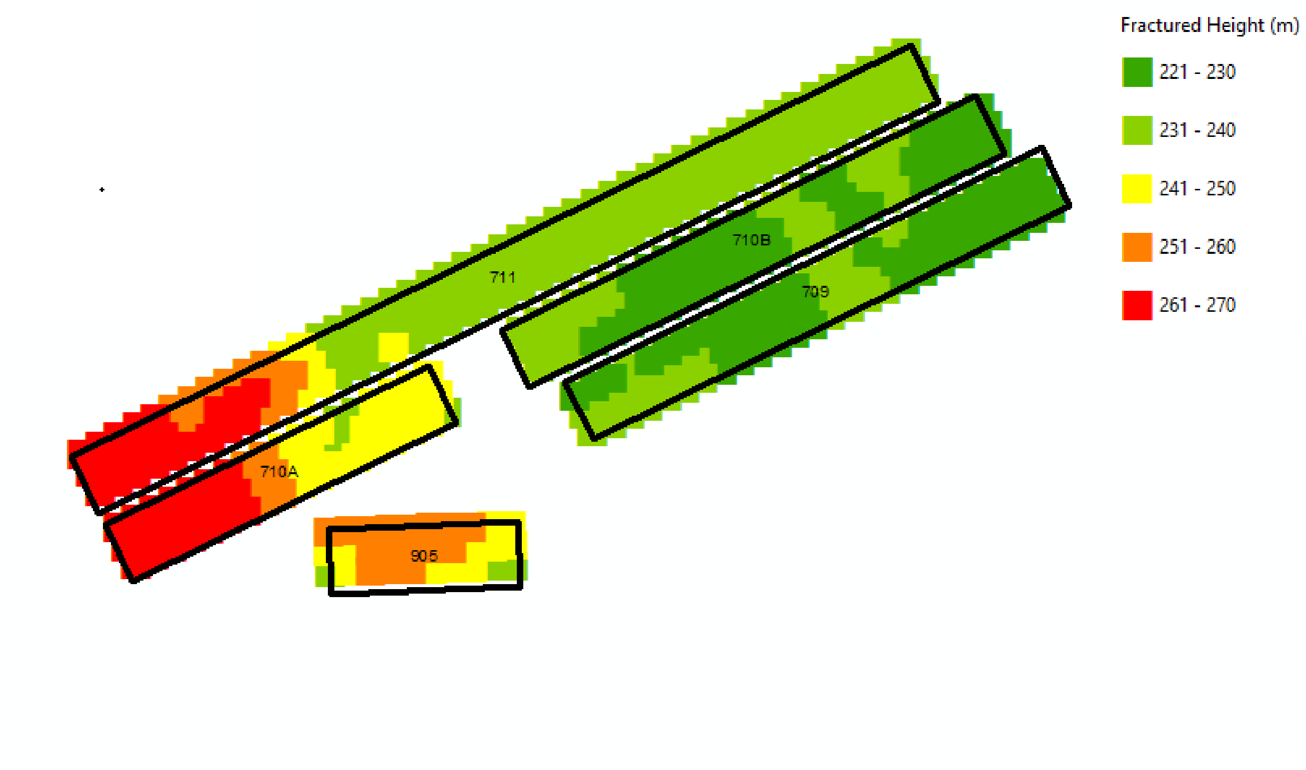


Figure 31 Simulated Fracture Zone Height (m) above workings

4.2 Model Calibration

Automated calibration utility PEST ++ (Doherty 2019) and manual calibration were used to match the available transient water level data. The groundwater levels recorded between January 2010 to June 2021 were used for the model calibration. In all, 19,386 target water levels were established for 318 bores from the following sites:

- Appin: included 250 groundwater level observations sites and VWPs;
- Tahmoor: included 44 groundwater level observations sites and VWPs: and
- Metropolitan: included 24 groundwater level observations sites and VWPs.

To ensure of the quality of the data used in the calibration, a filtering process is applied. The final dataset has a good distribution between lithologies. The calibration data are then given weights of 0.1 to 1 by a reviewing the data source, bore construction details, elevation source, coordinates source, and lithology. Details on each of the observation points and their residuals (measured subtract modelled) are presented in Appendix D of this report. The locations of these bores are shown in Figure 34.

The hydraulic properties (i.e., horizontal, vertical conductivity, specific yield and specific storage), recharge rates and pumping rates were adjusted during the calibration to provide best match between the measurements and model simulated water levels.

4.2.1 Calibration Performance

Figure 32 presents the observed and simulated groundwater levels graphically as a scattergram. The industry standard method to evaluate the performance of the model is to examine the error between the modelled and observed (measured) water levels in terms of the root mean square (RMS). A root mean square (RMS) expressed as:

$$RMS = \left[1/n \sum (h_o - h_m)_i^2 \right]^{0.5}$$

where: n = number of measurements

ho = observed water level

hm = simulated water level

RMS is considered to be the most suitable measure of error, if errors are normally distributed. The RMS error calculated for the calibrated model is 27.5 m. If the ratio of the RMS error to the total head change in the system is small, the errors are only a small part of the overall model response. The mean absolute residual across the model domain is 9.7 m; therefore, the ratio of RMS to the total head loss (SRMS) is 3.0 % with weighting applied to the values and a mass balance error of less than 0.01%. The SRMS is a useful guide on the measure of fit between observed and modelled data (Barnett et al., 2012).

Figure 33 shows the distribution of calibration residuals. As shown in the figure the calibration residuals in majority of the calibration data points are within ± 20 m. The model results further indicate that in general the model tends to overpredict the groundwater levels as the number of observations with the negative residuals is larger than the number of observations with the positive residuals.

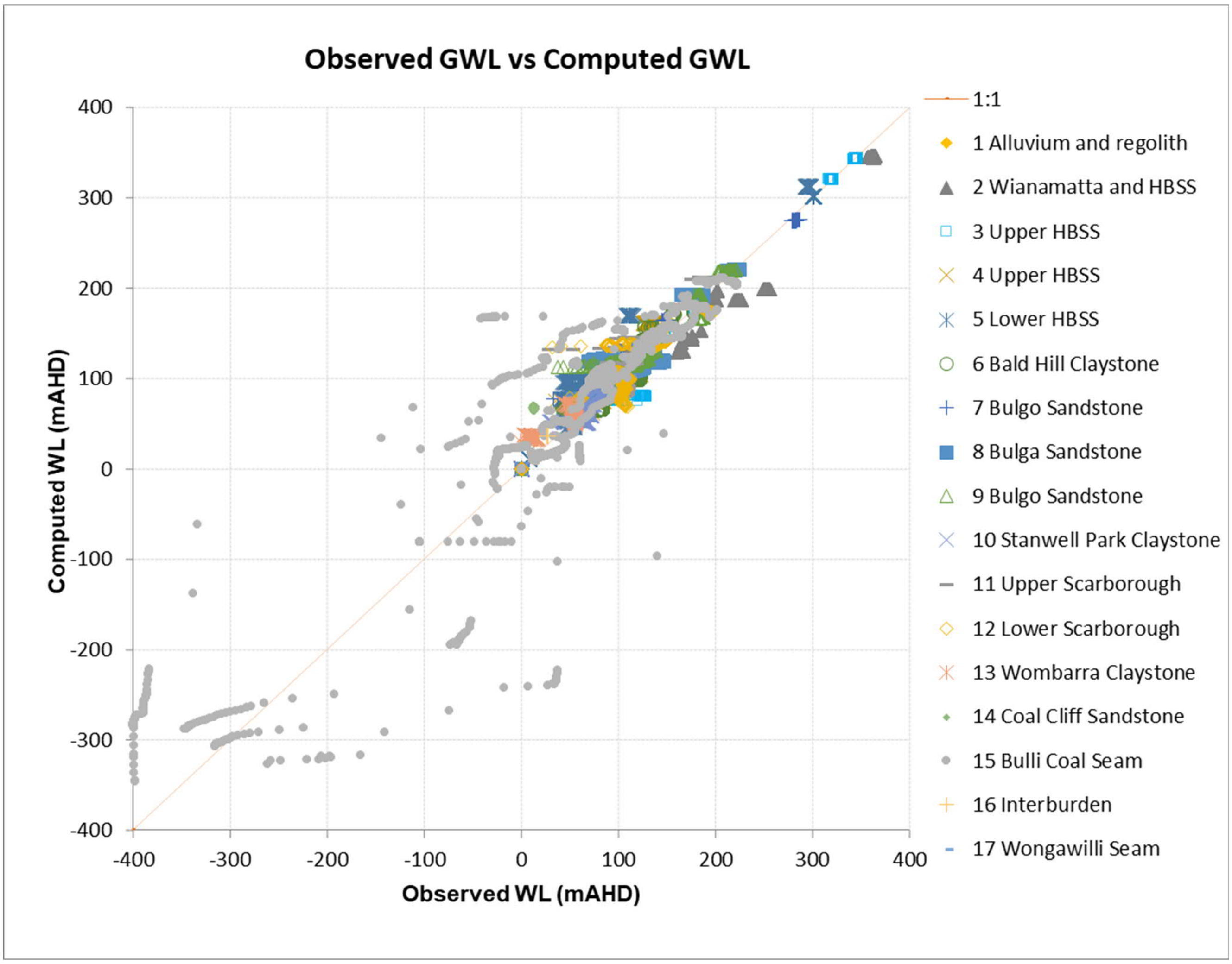


Figure 32 Modelled vs Observed Groundwater Levels

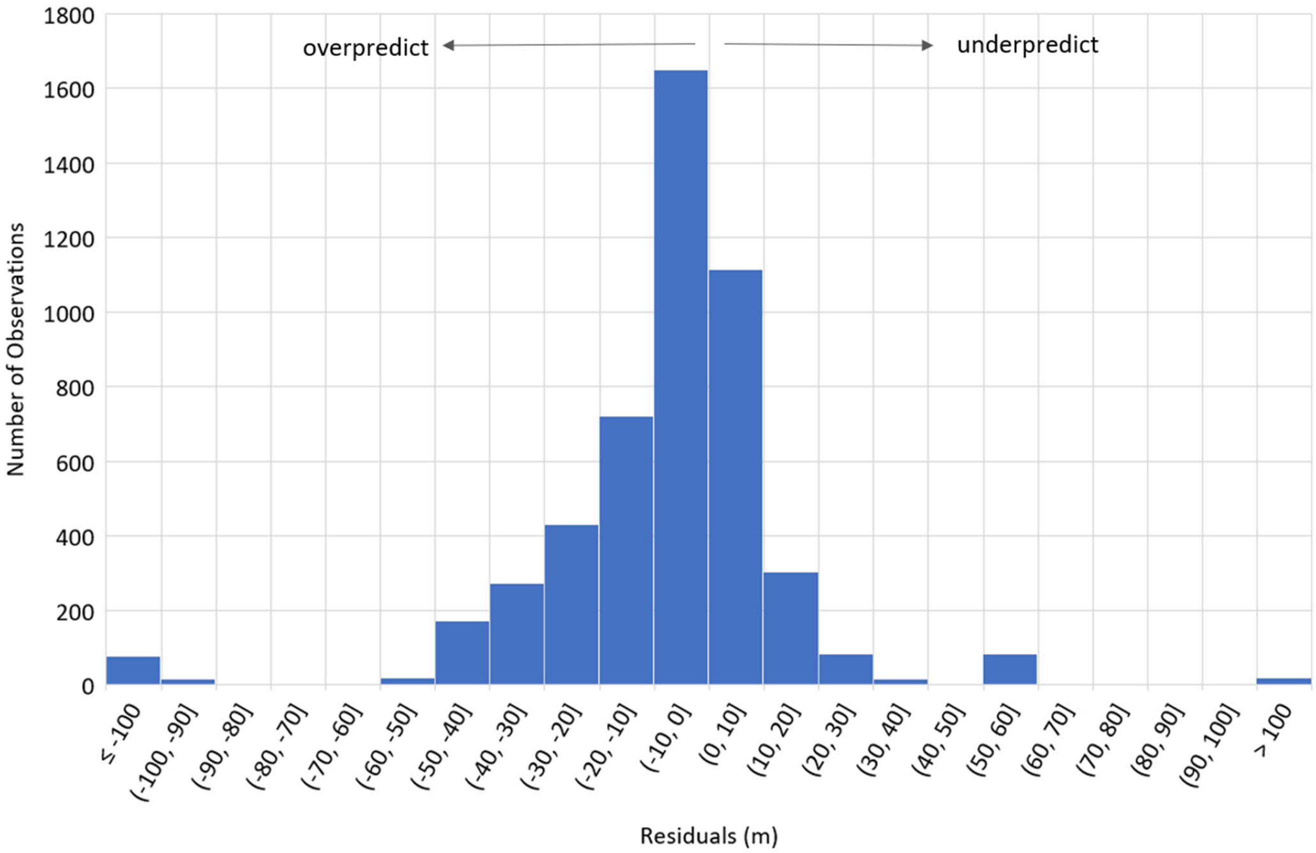


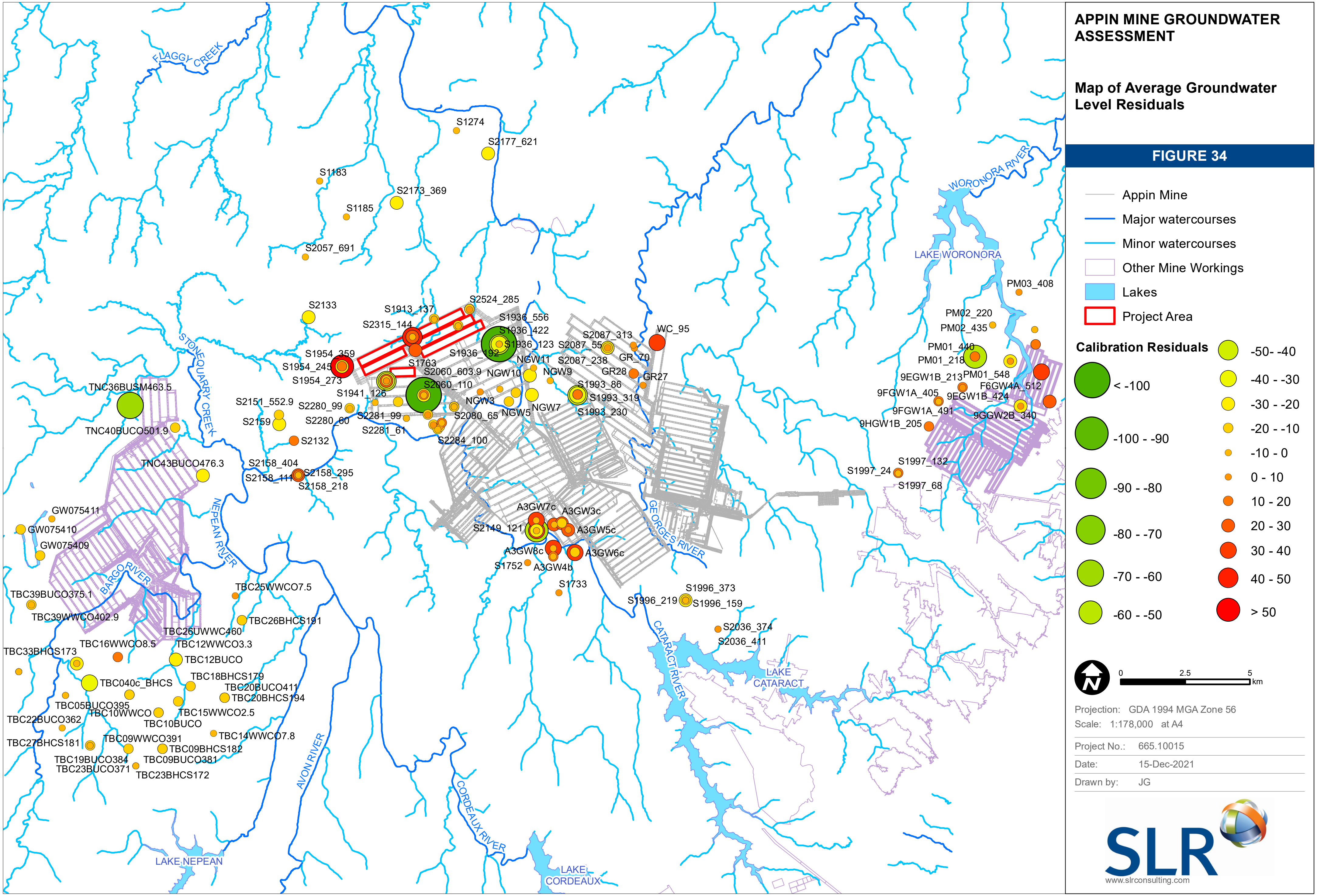
Figure 33 Calibration Residual Histogram Scattergram

Table 10 compares the calibration statistics to the previous versions of the model. The RMS error, SRMS, mean and absolute residual values for SLR model are all less than the results in the previous models (Heritage Computing, 2009 and HydroSimulations, 2018) indicating that the calibration model has been improved with the good fit between observed and modelled groundwater levels and is inside of the Australian guideline's indicator of 10% Scaled RMS (MDBC, 2001; Barnett et al., 2012).

Table 10 Transient Calibration Statistics

Calibration Statistics	Heritage Computing (2009)	HydroSimulations (2018)	SLR (2021)
Number of Data (n)	220	4275	9978
Root Mean Square (RMS) (m)	98.3	95	27.5
Scaled Root Mean Square (SRMS) (%)	9.6	33	3
Mean residual (m)	39.5	36.1	-3.0
Mean absolute residual (m)	117.9	56.1	9.7

The average residuals for points around the study area are also presented in Figure 34. The residuals were calculated as observed minus modelled, therefore a positive value indicates observed levels are higher than modelled and vice versa.



APPIN MINE GROUNDWATER ASSESSMENT
Map of Average Groundwater Level Residuals
FIGURE 34
Appin Mine
Major watercourses
Minor watercourses
Other Mine Workings
Lakes
Project Area
Calibration Residuals
< -100
-100 - -90
-90 - -80
-80 - -70
-70 - -60
-60 - -50
-50- -40
-40 - -30
-30 - -20
-20 - -10
-10 - 0
0 - 10
10 - 20
20 - 30
30 - 40
40 - 50
> 50
0
2.5
5
km
Projection: GDA 1994 MGA Zone 56
Scale: 1:178,000 at A4
Project No.: 665.10015
Date: 15-Dec-2021
Drawn by: JG
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FLAGGY CREEK
STONEQUARRY CREEK
NEPEAN RIVER
BARGO RIVER
AVON RIVER
CORDEAUX RIVER
CATARACT RIVER
GEORGES RIVER
WORONORA RIVER
LAKE WORONORA
LAKE CATARACT
LAKE CORDEAUX
LAKE NEPEAN
S1274
S2177_621
S1183
S2173_369
S1185
S2057_691
S2133
S1913_137
S2524_285
S2315_144
S1936_556
S1936_422
S1936_123
S1936_192
S1954_359
S1954_245
S1954_273
S1763
S2060_603.9
S2060_110
S1941_126
S2151_552.9
S2280_99
S2280_60
S2281_99
S2281_61
S2159
S2132
S2080_65
S2284_100
NGW10
NGW11
NGW9
NGW3
NGW5
NGW7
S2087_313
S2087_55
S2087_238
GR_70
GR28
GR27
WC_95
S1993_86
S1993_319
S1993_230
S2158_404
S2158_111
S2158_295
S2158_218
TNC36BUSM463.5
TNC40BUCO501.9
TNC43BUCO476.3
GW075411
GW075410
GW075409
A3GW7c
A3GW3c
A3GW5c
S2149_121
A3GW8c
A3GW6c
S1752
A3GW4b
S1733
S1996_373
S1996_219
S1996_159
S2036_374
S2036_411
PM03_408
PM02_220
PM02_435
PM01_440
PM01_218
PM01_548
9EGW1B_213
F6GW4A_512
9FGW1A_405
9EGW1B_424
9FGW1A_491
9GGW2B_340
9HGW1B_205
S1997_132
S1997_24
S1997_68
TBC25WWCO7.5
TBC39BUCO375.1
TBC39WWCO402.9
TBC26BHCS191
TBC26UWWC460
TBC16WWCO8.5
TBC12WWCO3.3
TBC33BHCS173
TBC12BUCO
TBC18BHCS179
TBC040c_BHCS
TBC20BUCO411
TBC20BHCS194
TBC05BUCO395
TBC10WWCO
TBC15WWCO2.5
TBC22BUCO362
TBC10BUCO
TBC14WWCO7.8
TBC09WWCO391
TBC27BHCS181
TBC09BHCS182
TBC19BUCO384
TBC09BUCO381
TBC23BUCO371
TBC23BHCS172

4.2.2 Calibration Fit

This section provides a discussion on the modelled to observed groundwater levels (calibration hydrographs) for key bores across the site. Calibration hydrographs for the full calibration dataset is presented as Appendix D.

The objective of the transient-state calibration was to replicate, as closely as possible, observed groundwater hydrographs for the period 2010 to 2021. Appendix D shows that the model, whilst not matching the absolute water level elevations at all bores, simulates the water level trends in most of the Appin Study area.

The hydrographs for most of the bores highlight the challenge in simulating groundwater levels in the complex groundwater system which has been subjected to significant historical stresses such as pumping from registered and unregistered bores, gas extraction and historical mining activities that could not be replicated in the model as there was no information available on the timing and magnitude of these stresses.

Across the entire model domain, the weighted average head difference between simulated and observed water levels are less than 5 m for in the Permian units. This average difference is considered a small variance in head for a regional-scale model.

4.2.2.1 Hawkesbury Sandstone (HBSS)

Figure 35 presents the fit between modelled and measured water levels for some key VWP bores (S1913_65, S1913_137, S1913_194, S2315_144, S2308_135, S2281_61, S2281_99 and S2282_60), located within or near Appin Mine, with their respective sensors in the HBSS.

The hydrographs for bore S1913 with sensor depths 65 mbgl, 137 mbgl and 194 mbgl, located 90 m north of Longwall 711, show the model underpredicts groundwater levels at sensor depth 65 mbgl by approximately 5 m, and overpredicts at sensor depth 137 mbgl and 194 mbgl by approximately 10 m. Although the model doesn’t predict the variability in the observed water levels, it captured the long-term groundwater trends in the HBSS.

Bore S2315_144 is located within Longwall 711. The hydrograph for S2315_144 shows that the model overpredicts the observed water levels at this bore by 10 m to 25 m. The reason for this poor match is the groundwater levels at this bore is likely impacted by extraction bores screened in the HBSS. Due to the lack of information for these extraction bores, the model used an assumption of the pumping rates and timing, which might differ from the actual extractions.

As shown in the hydrograph for S2308_135, located within Longwall 710, regionally there is a good match (with 5 m difference) between the modelled and measured groundwater levels in the HBSS.

The hydrographs for bore S2281 sensor depths 61 mbgl and 99 mbgl, located close to the Harris Creek and Longwall 901, show that the groundwater levels are underpredicted at sensor depth 61 mbgl by approximately 7 m and overpredicted at sensor depth 99 mbgl by approximately 7 m. The model is predicting stable groundwater levels with less correlation with the CRD than the observed, and also does not respond to the impact by mining or short-term extraction from bore (GW035033) in the HBSS.

There is an approximately 5 m difference between modelled and measured in the hydrograph for S2282_60, located on the edge of Longwall 901.

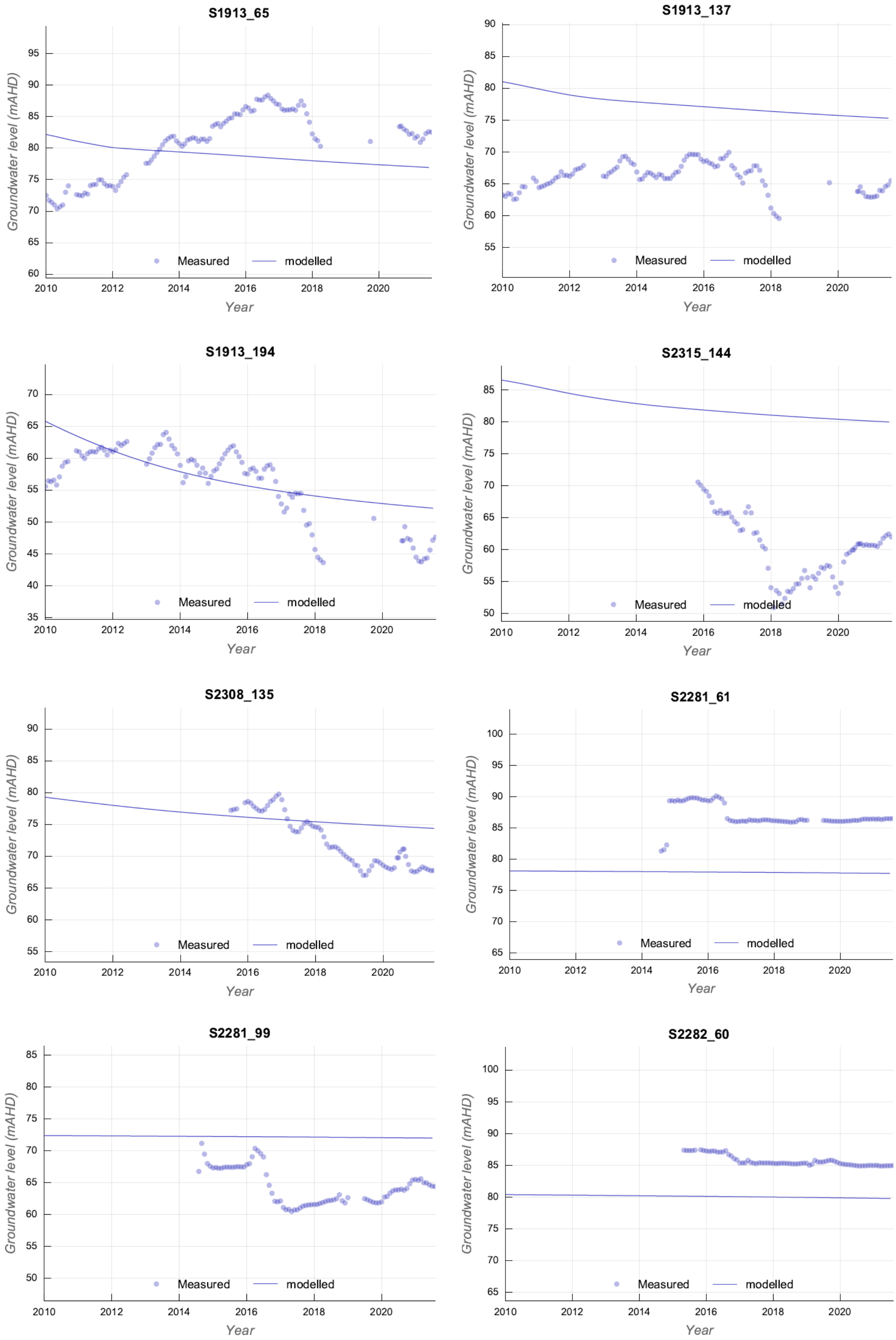


Figure 35 Modelled and Observed Hydrographs in key VWP in the HBSS

4.2.2.2 Wianamatta Group

Bore S1954 is located approximately 250 m west of Longwall 711 with seven sensors depths (36 mbgl, 85 mbgl, 100 mbgl, 138 mbgl, 145 mbgl, 181 mbgl and 205 mbgl) in the Wianamatta Group. Observed groundwater levels range from 130 mAHD to 230 mAHD (Figure 10). All seven sensors are all sitting in model layer 2, of those seven sensors, the middle the sensor S1954_138 has been selected to calibrate. As shown in the hydrograph for S1954_138 (Figure 36) model overpredicts groundwater levels at sensor depth 138 mbgl, but is in the range of the measured levels in Wianamatta Group.

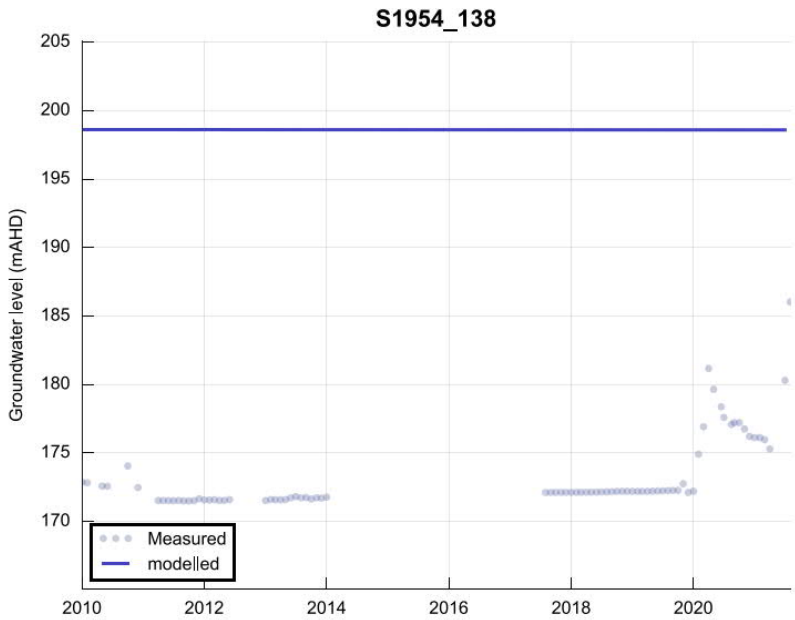


Figure 36 Modelled and Observed Hydrograph in S1954_138

4.2.2.3 Narrabeen Group

The hydrographs for VWP bores S1913_358, S2308_378, S2060_495 and S2315_460 screened in the Bulgo Sandstone (BGSS) and S2315_460 and S1941_487 screened in the Scarborough Sandstone (SBSS) are shown in Figure 37.

The modelled groundwater levels for S1913_358, S2060_495 and S2315_460 are well matched to the observed water levels with the difference of +/-5 m. The model underpredicts observed water levels at S2308_378, S2080_326 and S1941_487 with the difference up to 10 m, however the general trend in the water levels are matched well.

Although the model does not predict the variability in water levels over time due to using quarterly model stress periods to capture the mining progression, the overall trends are similar with measured levels. Further, the predicted maximum depressurisations match the measured maximum depressurisations in BGSS and SBSS during the mining period.

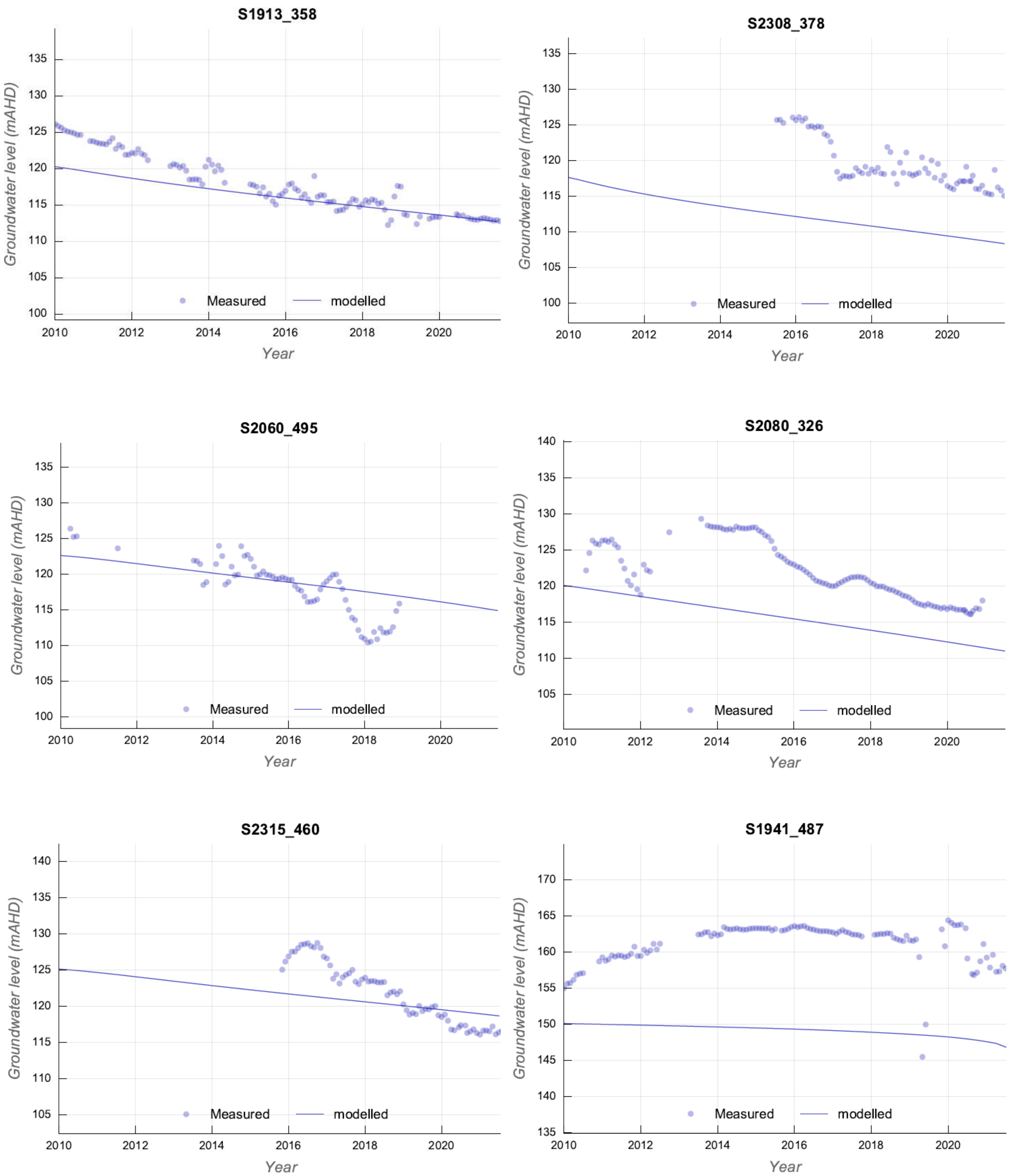


Figure 37 Modelled and Observed Hydrograph in S1913_358, S2308_378, S2060_495, S2315_460, S2308_378 and S1941_487

4.2.2.4 Illawarra Coal Measures

The VWP bores S1913_559, S1941_555, S2315_576, and S2060_603 are screened in the Bulli Coal Seam and located within the Appin Areas 7 and 9 mining footprints. Observed and modelled water levels for these VWP bores are shown in Figure 38. The hydrographs show a close match between observed and measured water levels with the depressurisation in Bulli Coal Seam effected by the mining.

The hydrograph for S1913_559 shows the modelled groundwater levels match the measured levels with the depressurisation once the mining is close to this bore.

The hydrograph for S1941_555 shows a good match between the modelled and measured groundwater levels in the Bulli Coal Seam.

The hydrograph for S2315_576 shows that the model overpredicts the groundwater levels during 2020 by approximately 5 m. The reason for this is that the modelled mining time does not match the actual mining progression exactly. This same reason is likely the cause for the modelled higher groundwater levels than the measured levels in the bore S2060_603.

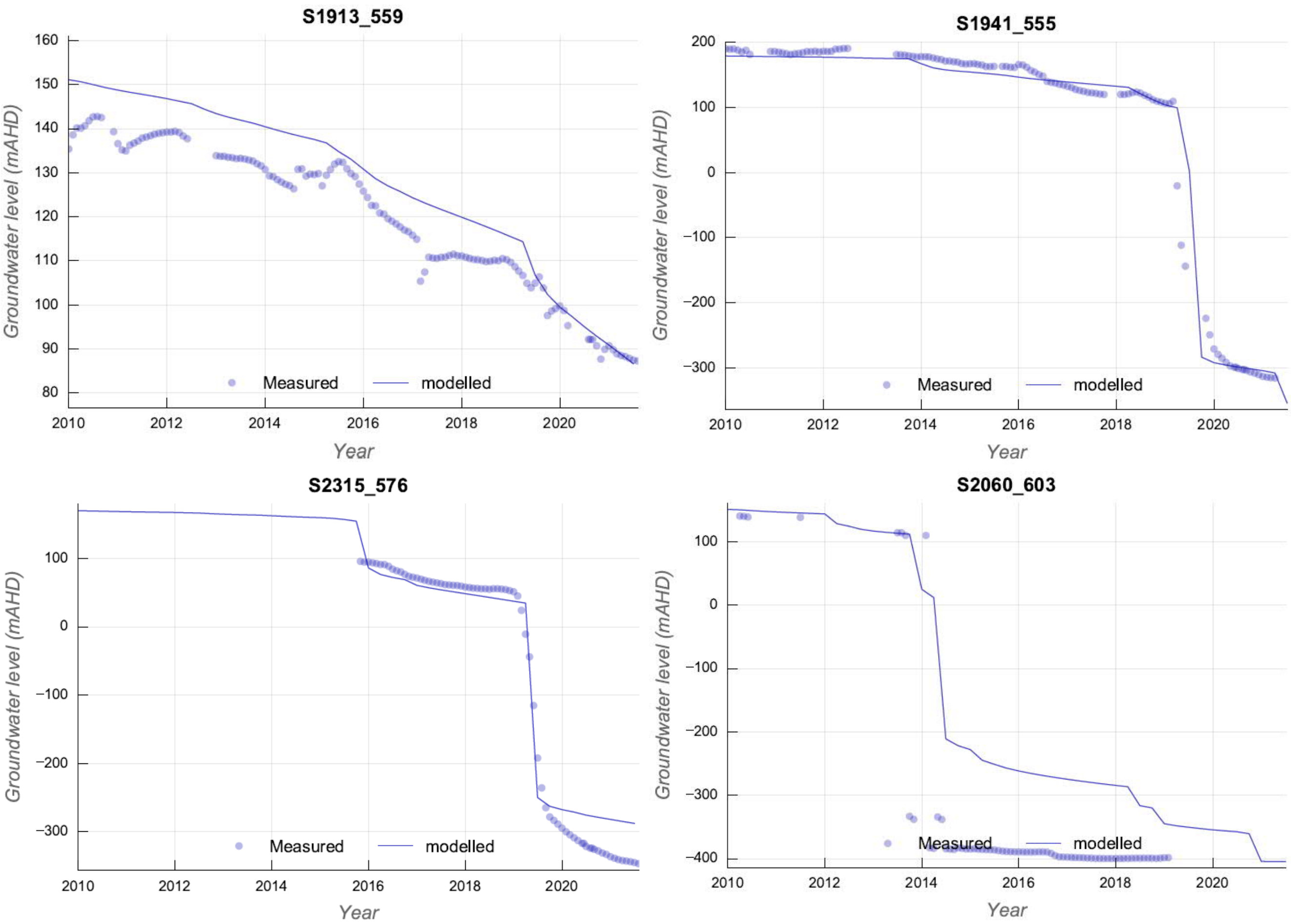


Figure 38 Modelled and Observed Hydrograph in S1913_559, S1941_555, S2315_576 and S2060_603

4.2.2.5 Vertical Gradient

Groundwater flow systems are strongly influenced by heterogeneity and anisotropy of hydraulic conductivity (K). Particularly in stratified sedimentary aquifers, the vertical hydraulic gradient is often very high, due to the low vertical hydraulic conductivity or high anisotropy (Kx/Kz).

Structural simplifications in the model, including the vertical discretization of the model and resulting 'coarse' representation of features and hydraulic gradients at scales of a model cell (or layer) or less. For example, strong vertical gradients may mean that a model, which predicts average water levels for a cell, will struggle to replicate an observed water level if that water level is from the upper or lower portion of that layer. For example, if a model layer that is 50 m thick and the vertical gradient is 1 in 10, this can lead to errors of +/- 5m.

The vertical gradient at project area is mainly the result of the aquifer system and properties rather than abstraction rate, which is too limited at depth to make an imprint.

Figure 39 to Figure 43 show the observed against simulated water levels at selected VWPs within or close to the project area. From each plot, the difference in water level between two sensors divided by the vertical distance of the two sensors can be interpreted as the vertical gradient. The observed vertical gradients were discussed in Section 3.2.4. For simplicity, a downward hydraulic gradient is defined as the shallower sensor showing the higher water level, which means water is migrating toward the lower sensor. Conversely, an upward hydraulic gradient is defined as the deeper sensor showing the higher water level, which means water is migrating toward the shallower sensor. Even if the model cannot always capture absolute water levels correctly, it is a sign of a well calibrated model if the gradients are captured correctly (i.e. which way the water is potentially going).

The model captures the observed upwards hydraulic gradients at S1913 (Figure 39) and S2315 (Figure 40) presenting higher water levels in Scarborough Sandstone than Bulgo Sandstone and HBSS.

The downwards hydraulic gradients from upper HBSS to lower HBSS at S2308 (Figure 41), S1941 (Figure 42), and S2060 (Figure 43) are also captured by the model.

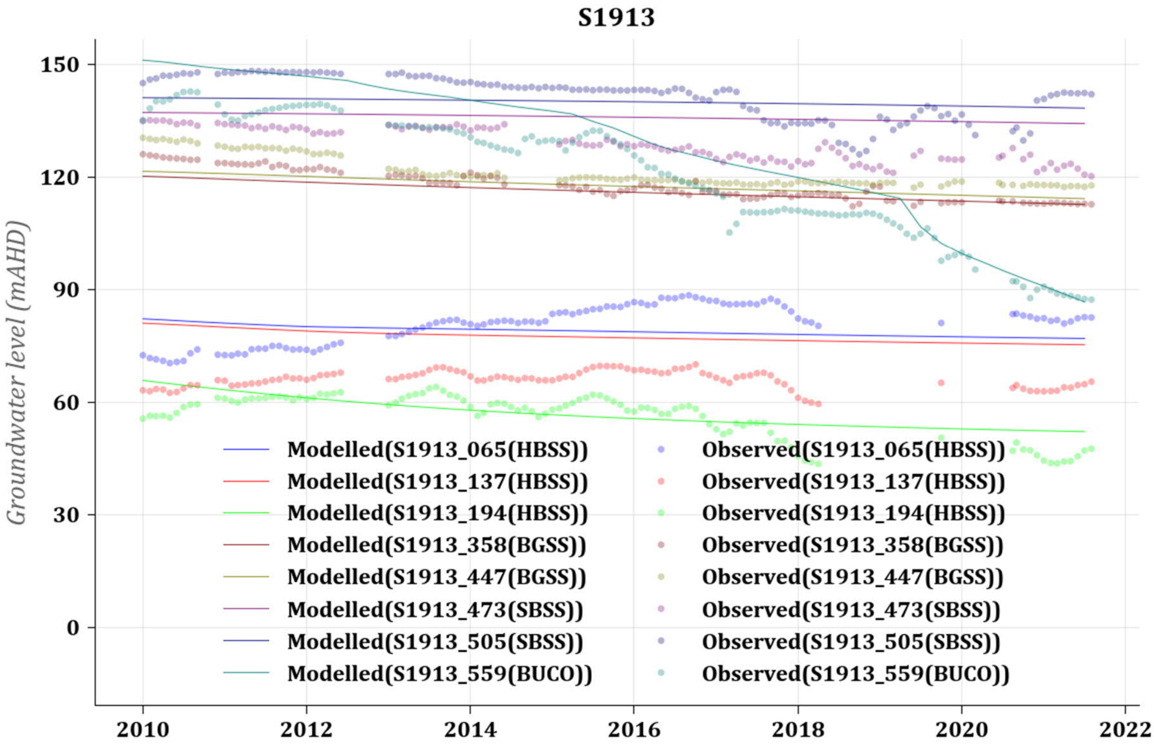


Figure 39 Modelled and Observed Hydrograph at S1913

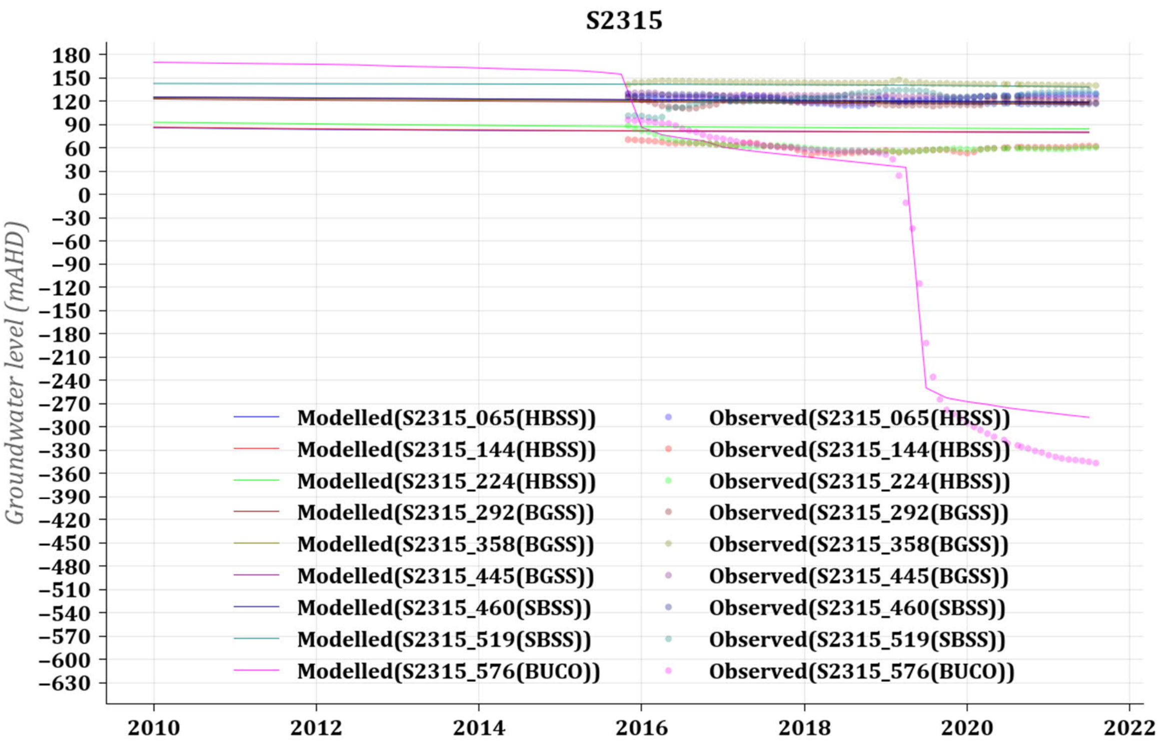


Figure 40 Modelled and Observed Hydrograph at S2315

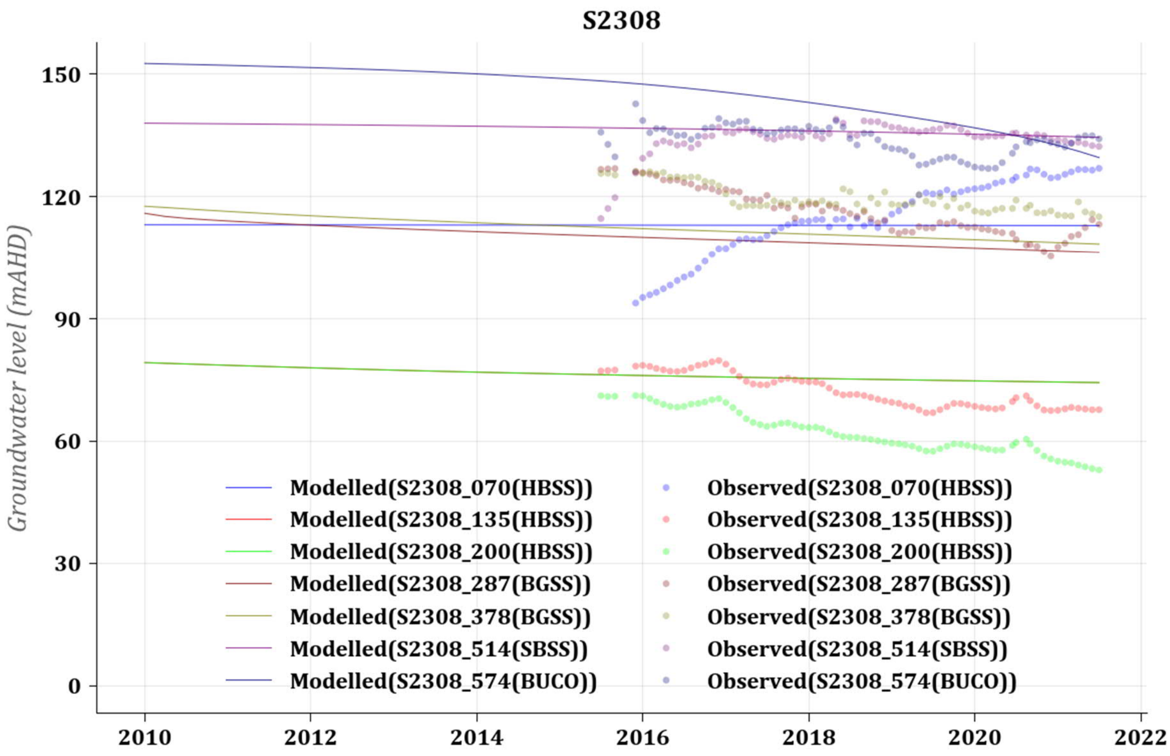


Figure 41 Modelled and Observed Hydrograph at S2308

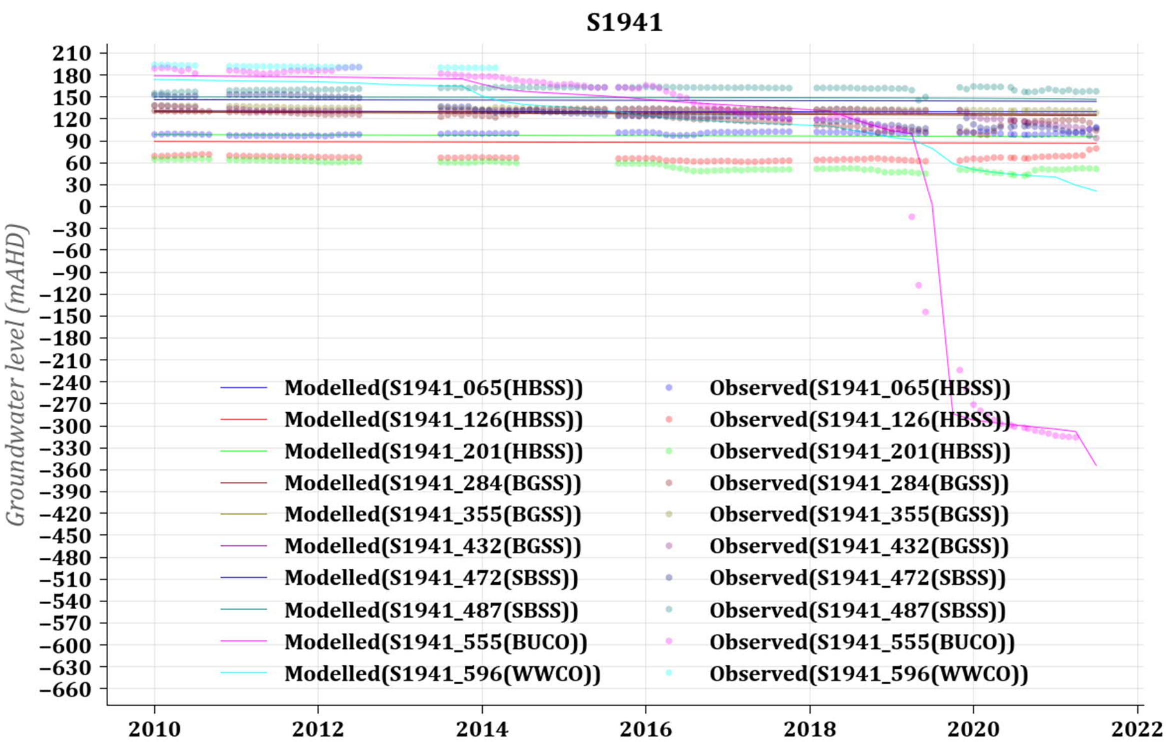


Figure 42 Modelled and Observed Hydrograph at S1941

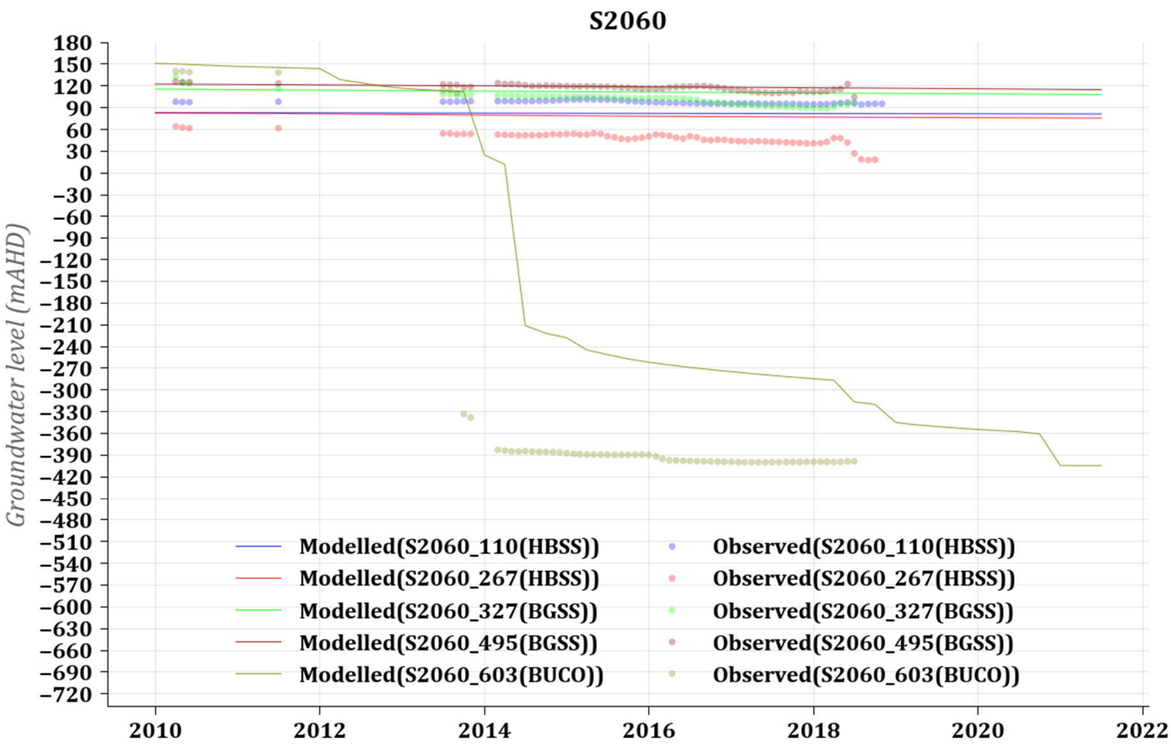


Figure 43 Modelled and Observed Hydrograph at S2060

4.2.3 Calibrated Parameters

Table 11 summarises the calibrated values for horizontal and vertical hydraulic conductivity as well as specific yield and specific storage. Both manual and automatic (Parameter ESTimation) calibration (PEST) were carried out. PEST was used to identify the most suitable hydraulic conductivity, specific yield, specific storage and percentage rainfall recharge in zones within the Appin, Tahmoor and Metropolitan mining areas.

Table 11 Calibrated Hydraulic Properties

Layer	Zone	Kx [m/d]	Kz [m/d]	Kx/Kz	Sy	Ss [m^{-1}]
1	Alluvium - 1	$4.2\times10^{+00}$	6.5×10^{-02}	1.5×10^{-02}	2.7×10^{-01}	3.0×10^{-05}
	Wianamatta Group - 19	1.0×10^{-03}	1.0×10^{-05}	1.0×10^{-02}	1.0×10^{-02}	1.0×10^{-07}
	HBSS - 20	1.0×10^{-02}	3.3×10^{-04}	3.0×10^{-02}	9.1×10^{-02}	1.0×10^{-07}
	Swamps - 21	$6.998\times10^{+00}$	5.9×10^{-01}	8.5×10^{-02}	1.0×10^{-01}	1.0×10^{-07}
	Lake and Bay - 22	$2.00\times10^{+02}$	$1.6\times10^{+02}$	8.0×10^{-01}	8.3×10^{-02}	1.0×10^{-07}
	Escarpment Zone -23	3.9×10^{-01}	3.9×10^{-01}	$1.0\times10^{+00}$	6.6×10^{-03}	1.0×10^{-07}
2	Wianamatta Group - 2	1.00×10^{-05}	3.2×10^{-07}	3.2×10^{-02}	2.5×10^{-03}	1.0×10^{-05}
	HBSS - 24	6.2×10^{-03}	6.2×10^{-03}	$1.0\times10^{+00}$	2.6×10^{-02}	1.5×10^{-05}
	HBSS under Wianamatta Group - 25	3.3×10^{-03}	3.3×10^{-03}	$1.0\times10^{+00}$	1.4×10^{-02}	9.8×10^{-06}
3	Upper HBSS	1.9×10^{-02}	6.5×10^{-04}	3.3×10^{-02}	4.3×10^{-02}	1.0×10^{-05}
4	Upper HBSS	1.0×10^{-03}	5.0×10^{-04}	5.0×10^{-01}	1.0×10^{-02}	2.6×10^{-05}

Layer	Zone	Kx [m/d]	Kz [m/d]	Kx/Kz	Sy	Ss [m^{-1}]
5	Lower HBSS	1.0×10^{-04}	1.2×10^{-06}	1.2×10^{-02}	1.2×10^{-02}	3.0×10^{-06}
6	Bald Hill Claystone	1.8×10^{-05}	6.1×10^{-07}	3.3×10^{-02}	9.4×10^{-03}	1.0×10^{-07}
7	Bulgo Sandstone	1.4×10^{-03}	1.7×10^{-05}	1.1×10^{-02}	8.1×10^{-02}	1.0×10^{-07}
8	Bulgo Sandstone	4.4×10^{-04}	1.8×10^{-05}	4.0×10^{-02}	1.3×10^{-02}	1.0×10^{-06}
9	Bulgo Sandstone	7.5×10^{-04}	9.9×10^{-06}	1.3×10^{-02}	1.6×10^{-02}	1.0×10^{-06}
10	Stanwell Park Claystone	$7.3\times10\text{-}^{07}$	7.8×10^{-08}	1.0×10^{-01}	4.5×10^{-03}	1.0×10^{-07}
11	Upper Scarborough	2.7×10^{-05}	2.7×10^{-07}	1.0×10^{-02}	1.3×10^{-02}	1.7×10^{-06}
12	Lower Scarborough	1.9×10^{-05}	1.9×10^{-07}	1.0×10^{-02}	9.1×10^{-03}	3.4×10^{-06}
13	Wombarra Claystone	3.3×10^{-06}	4.1×10^{-08}	1.2×10^{-02}	7.6×10^{-03}	1.0×10^{-07}
14	Coal Cliff Sandstone	1.1×10^{-04}	5.5×10^{-07}	4.8×10^{-03}	4.5×10^{-03}	5.0×10^{-06}
15	Bulli Coal Seam	1.0×10^{-03}	5.6×10^{-05}	5.6×10^{-02}	9.0×10^{-03}	1.0×10^{-07}
16	Interburden	3.5×10^{-05}	3.5×10^{-07}	1.0×10^{-02}	7.3×10^{-03}	1.0×10^{-07}
17	Wongawilli Seam	1.8×10^{-02}	2.9×10^{-03}	1.6×10^{-01}	4.8×10^{-03}	1.0×10^{-07}
18	Lower Permian Coal Measures	7.2×10^{-05}	2.6×10^{-06}	3.6×10^{-02}	2.1×10^{-03}	1.0×10^{-06}
7 - 18	Faults	1.1×10^{-02}	1.7×10^{-03}	1.5×10^{-01}	4.5×10^{-02}	1.7×10^{-07}

Table 12 presents the range in recharge values for the model domain, as a percentage of quarterly rainfall. The PEST calibration simulates an optimised rainfall recharge. The calibrated recharge rates are lower than the Heritage Computing (2009) model, which may relate to significantly greater calibration dataset and the increase in model time resolution to quarterly time steps and the use of observed streamflow data to better capture seasonality.

Table 12 Calibrated Rainfall Recharge

Zone	Calibrated Recharge (% Quarterly Rainfall)	Heritage Computing (2009) Recharge (% Annual Rainfall)
Alluvium/Swamps	5	20
Wianamatta Group	0.5	7.5
Western HBSSs	0.5	5
Eastern HBSSs	0.7	5
Centred HBSSs	1.7	5

As discussed in Section 4.2, the bore pumping rates were included in the calibration. The calibrated pumping rates were in a range of 0.001 L/s and 2.4 L/s. The average calibrated pumping rate was 0.18 L/s.

4.2.4 Water Balance

The water balance during the transient calibration period across the entire model area is summarised in Table 13. The average inflow (recharge) to the groundwater system is approximately 134.8 ML/d, comprising rainfall recharge (67%), leakage from streams to the groundwater system (6%) and constant head boundary inflow (3%).

The largest proportion of model outflows is the evapotranspiration (57%), followed by baseflow to rivers and streams (15%), constant head boundary outflow (5%), mine inflows (4%) and wells (<1%). There was a net gain in storage of approximately 4.3 megalitres per day (ML/d) over the calibration period.

Table 13 Groundwater Model - Water Budget/Balance (Jan 2010 -June 2021)

Component	Groundwater Inflow (Recharge) (ML/day)	Groundwater Outflow (Discharge) (ML/day)	Inflow – Outflow (ML/day)
Rainfall Recharge	51.1	-	51.1
Evapotranspiration	-	43.5	-43.5
Rivers/Creeks	4.8	11.7	-6.8
Constant Head (CHD)	2.5	4.1	-1.6
Mines	-	2.7	-2.7
Wells	-	0.8	-0.8
Storage	17.6	13.2	4.3
Total	76.0	76.0	0.0

4.3 Model Predictions

Transient predictive modelling was used to simulate the proposed mining at the Project as well as mining at other approved and foreseeable mines within the model domain. As discussed in Section 4.1.3, the predictive part of the model comprises quarterly stress periods starting from July 2021 until December 2027. Transient predictive models are developed for model scenarios:

- NULL Run – No mining in region;
- Basecase Run - All approved Appin Mine and all foreseeable neighbour mines, AGL CSG and registered borefields excluding mining of Longwalls 709 to 711 and 905;
- Cumulative Run - All approved Appin Mine and all foreseeable neighbour mines, AGL CSG and registered borefields including mining of Longwalls 709 to 711 and 905; and
- Null Appin Mine Run – All foreseeable neighbours' mines, AGL CSG and registered borefields, excluding the Appin Mine.

Timings of active drain cells at the Project were based on mine progression stage plans. As discussed in Section 4.1.5, MODFLOW Time Varying Materials (TVM) package was used to assign fractured properties to the cells above the longwall panels.

The model predictions include mine inflows, change in rivers base flow, groundwater depressurisation and depressurisation at landholder bores which are presented in the following sections.

4.3.1 Predicted Groundwater Interception

Mine inflow volumes have been calculated as time weighted averages of the outflow reported by Zone Budget software for the drain cells.

The predicted inflows due to the Project mining (i.e., Longwalls 709 to 711 and Longwall 905) and the total combined (Approved plus Project) for Appin are presented in Figure 44. The predicted average future total inflow rate over the duration of mining (Approved plus Project) is 189.38 ML/year (0.52 ML/day).

As shown in Figure 44, inflows due to the Project are predicted to reach a maximum peak in year 2025, with 157.37 ML inflow predicted for the year (0.43 ML/day). The average inflow rate due to the Project is 92.78 ML/year (0.25 ML/day).

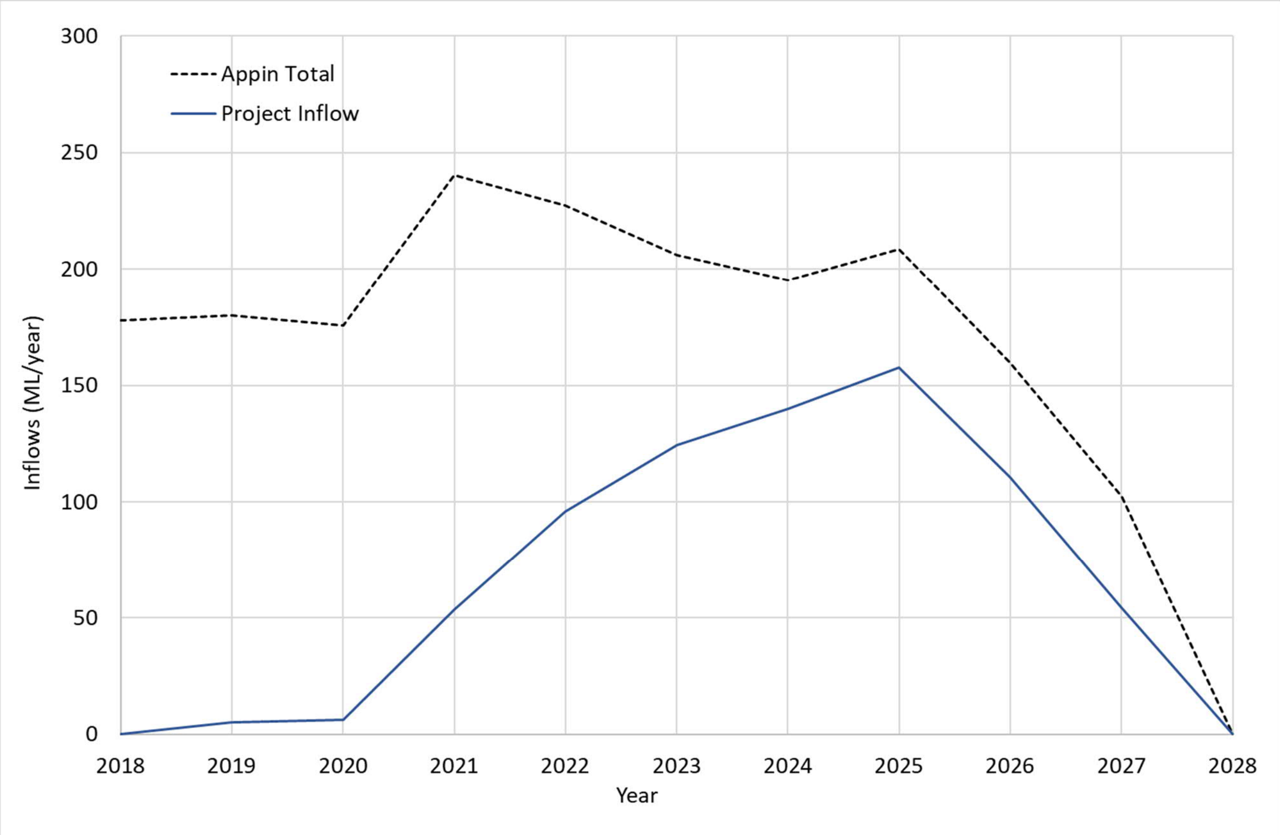


Figure 44 Predicted Mine Inflow for Appin Mine

4.3.2 Baseflow Change

The change in river leakage due to the Project was calculated by comparing the river flow budgets for Navigation Creek, Navigation Creek Tributary 1 and Foot Onslow Creek in the Approved plus Project Appin Mine scenario against the NULL Extension scenario. This calculation showed that over the life of the Project, the change in the baseflow is insignificant. This prediction is consistent with the predicted depressurisations shown in Section 4.3.3 where the model predicted no depressurisation along Nepean River, Cataract River and Stonequarry Creek.

4.3.3 Maximum Predicted Depressurisation

The process of mining directly removes water from the groundwater system and reduces water levels in surrounding groundwater units. The extent of the zone affected is dependent on the properties of the aquifers/aquitards and is referred to as the zone of depressurisation. Aquifer depressurisation is greatest at the working coal-face and decreases with distance from the mine.

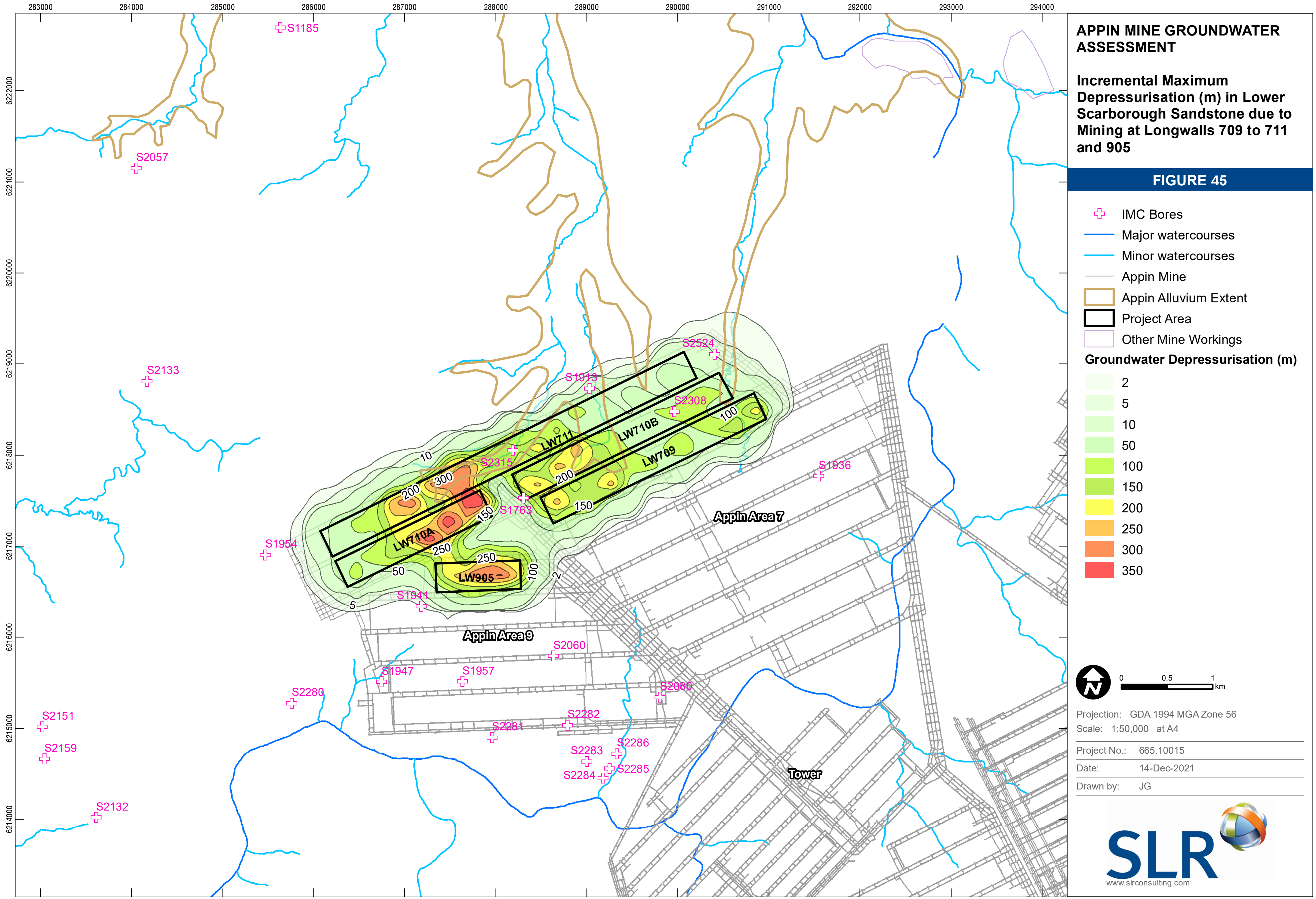
4.3.3.1 Maximum Incremental Depressurisations

Maximum incremental depressurisation refers to the depressurisation impact associated with mining of Longwalls 709 to 711 and 905 and is obtained by comparing the difference in predicted aquifer groundwater levels for the Approved plus Project Appin Mine scenario and NULL Extension scenario at matching times. The maximum depressurisation represents the maximum depressurisation values recorded at each model cell at any time over the model duration. Predicted depressurisation figures (Figure 45 and Figure 46) show where maximum depressurisation impacts are predicted to exceed 2 m. In areas within the 2 m depressurisation contour, the unit is considered impacted by depressurisation.

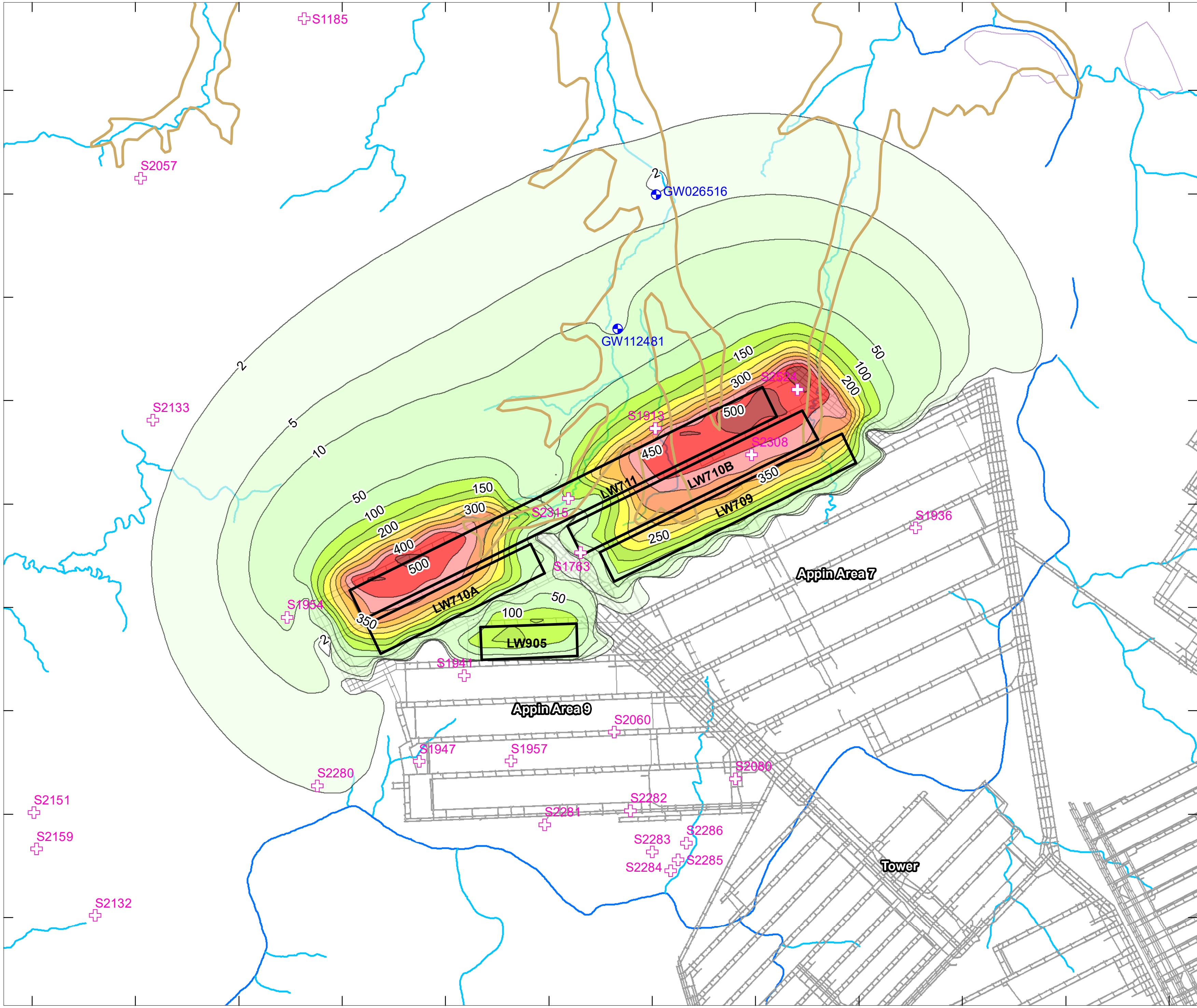
The predicted maximum incremental depressurisation in the Alluvium (Model Layer 1), Wianamatta Group (Model Layer 2), Upper HBSS (Model Layer 3), Lower HBSS (Model Layer 5), Upper Bulgo Sandstone (Model Layer 7), Lower Scarborough Sandstone (Model Layer 12) and Bulli Seam (Model Layer 15) have been conducted in this study.

The findings are:

- Negligible depressurisation is predicted in the Alluvium (Model Layer 1), Wianamatta Group (Model Layer 2), upper HBSS (Model Layer 3) and Lower HBSS (Model Layer 5) due to mining at Longwalls 709 to 711 and 905. The incremental depressurisation in the Upper Bulgo Sandstone (Model Layer 7) is predicted to be less than 1 m.
- The Lower Scarborough Sandstone (Model Layer 12) is predicted to experience significant depressurisation (up to 300 m) within the footprint of Longwalls 710, 711 and 905, 200 m on Longwall 709) due to mining at these longwalls and 2 m depressurisation contour extending approximately 300 m surrounding the Longwalls 710, 711 and 905 footprint (Figure 45).
- For the Bulli Coal Seam (Model Layer 15) there is significant depressurisation predicted due to mining at Longwalls 709 to 711 and 905 (Figure 46). As is to be expected, the area of greatest impact closely coincides with the mined area (about 500 m depressurisation at Longwall 711, 450 m on Longwall 710, 400 m on Longwall 709 and 150 m on Longwall 905 within the coal seam). The predicted 2 m depressurisation contour extending from Longwalls 710, 711 and 905 footprint extent up to approximately 2,200 – 2,700 m to the north and north east, 1,400 m to the west and 150 m to the south.



H:\Projects-SLR\620-BNE\665-WOL\665.10015 Illawarra Coal Closure - Water\CADGIS\ArcGIS\66510015 F51 Incremental Maximum Depressurisation (m) in Lower Scarborough Sandstone due to Mining at Longwalls 709 to 711 and 905.mxd



APPIN MINE GROUNDWATER ASSESSMENT

Incremental Maximum Depressurisation (m) in the Bulli Seam due Mining at Longwalls 709 to 711 and 905

FIGURE 46

Registered Bores
IMC Bores
Major watercourses
Minor watercourses
Appin Mine
Appin Alluvium Extent
Project Area
Other Mine Workings

Groundwater Depressurisation (m)

2
5
10
50
100
150
200
250
300
350
400
450
500

0 0.5 1 km

Projection: GDA 1994 MGA Zone 56
Scale: 1:50,000 at A4

Project No.: 665.10015
Date: 14-Dec-2021
Drawn by: JG

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H:\Projects-SLR\620-BNE\665-WOL\665.10015 Illawarra Coal Closure - Water\CADGIS\ArcGIS\66510015 F52 Incremental Maximum Depressurisation (m) in the Bulli Seam due Mining at Longwalls 709 to 711 and 905.mxd

4.3.3.2 Maximum Cumulative Depressurisations

Maximum Cumulative depressurisation impacts are shown in Figure 47 to Figure 53. These depressurisations represent the total impact of mining to model groundwater levels by comparing the maximum difference in aquifer groundwater levels for the Approved plus Project Appin Mine scenario with those in a theoretical “No Mining” or Null Run scenario, for all times during the predictive model period.

Figure 47 to Figure 53 present the predicted maximum cumulative depressurisation in the Alluvium (Model Layer 1), Wianamatta Group (Model Layer 2), Upper HBSS (Model Layer 3), Lower HBSS (Model Layer 5), Upper Bulgo Sandstone (Model Layer 7), Lower Scarborough Sandstone (Model Layer 12) and Bulli Seam (Model Layer 15), respectively.

The predicted depressurisations due to Appin Mine and due to groundwater abstraction are summarised in Table 14.

Table 14 Summary of Cumulative Depressurisation

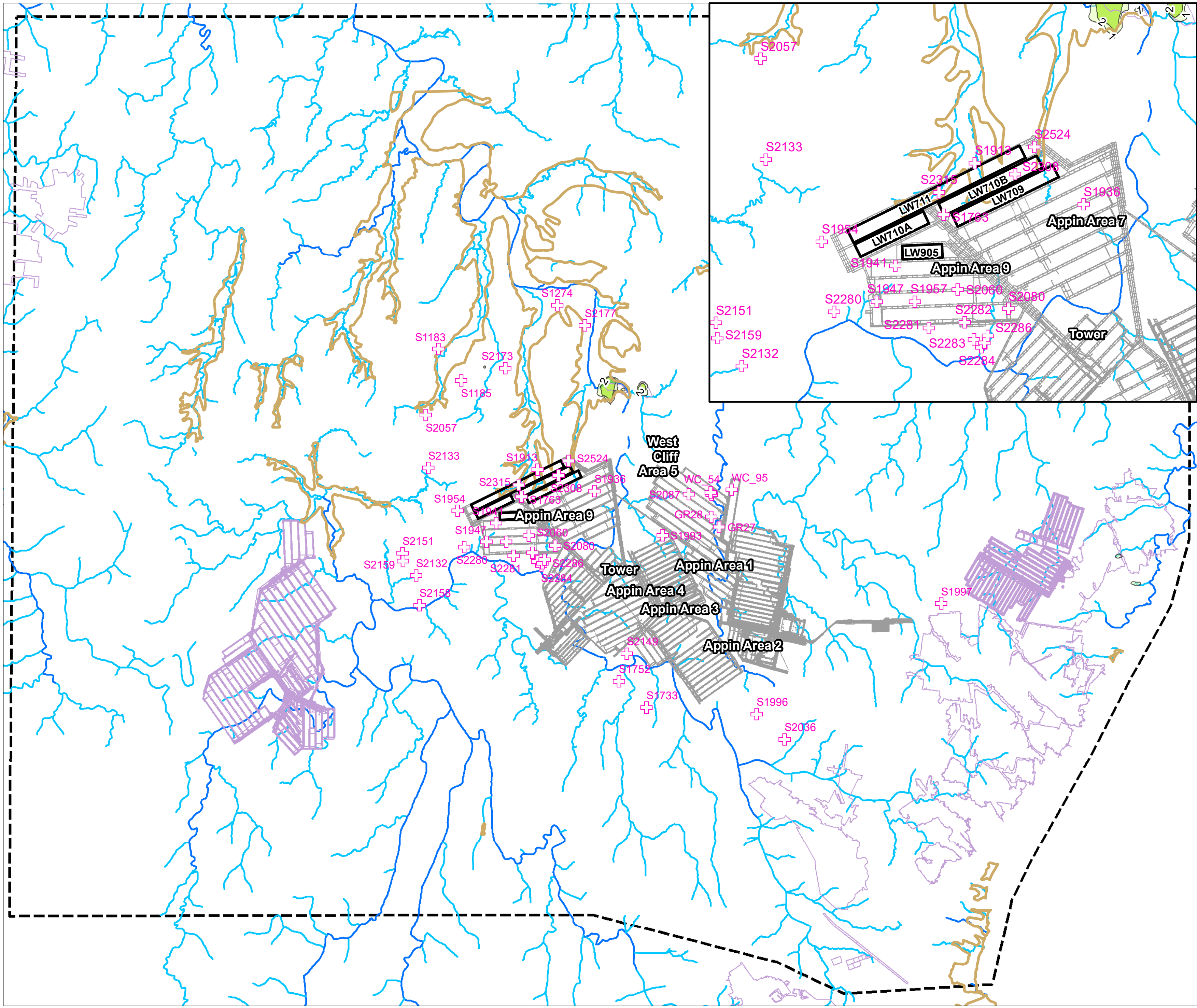
Hydrostratigraphic Unit	Maximum Predicted Depressurisation (m)			
	Appin Mine	Abstraction	Cumulative	Figure
Alluvium/Weathered	0	2*	2	Figure 47
Wianamatta Group	0	40	40	Figure 48
Upper HBSS	<0.1	20	20	Figure 49
Lower HBSS	3	97	100	Figure 50
Bulgo Sandstone	10	30	40	Figure 51
Lower Scarborough Sandstone	400	0	400	Figure 52
Bulli Seam	600	0	600	Figure 53

Note: * abstraction due to a sand quarry

The findings are:

- There is a 2 m depressurisation contour surrounding Menangle Quarry in the Alluvium (Model Layer 1) and no additional depressurisation due to Appin Mine.
- Up to 40 m depressurisation is predicted to at least 2,000 m away from Appin Mine in the Wianamatta Group around the registered bores.
- For the Upper HBSS there is 20 m predicted depressurisation around the central of Longwalls 710 and 711 surrounding the registered bores caused by the water supply extraction. The predicted 10 m depressurisation is extending from Longwalls 709 to 711 and 905 footprints to 6,000 m to the north and 700 m to the south caused by the cumulative extraction from the registered bores.
- Similar to the predicted depressurisation in the Upper HBSS, the Lower HBSS (Model Layer 5) is predicted to experience significant depressurisation (up to 100 m), located around the registered bores caused by the water supply extraction. The predicted 2 m depressurisation contours from Appin Mine and Metropolitan Mine join, which means that there is cumulative impact in those areas.

- There is up to 40 m predicted depressurisation in Bulgo Sandstone (Model Layer 7), which consists of 30 m depressurisation surrounding two registered bores caused by the regional extraction and 10 m depressurisation caused by the historical mining at Appin. The predicted 10 m depressurisation contour from Appin Mine and Metropolitan Mine join, as do the 2 m depressurisation contours from Appin Mine and Tahmoor Mine, which means that there is cumulative impact in those areas.
- The Lower Scarborough Sandstone (Model Layer 12) is predicted to experience significant depressurisation up to 400 m within the approved Appin Mine footprint and 350 m within the project area. The predicted 10 m depressurisation contour from Appin Mine and Metropolitan Mine join, which means that there is cumulative impact in those areas.
- For the Bulli Coal Seam (Model Layer 15) there is significant depressurisation predicted approximately 600 m within the project area and 500 m within the approved mining area. The 200 m predicted depressurisation contour from Appin Mine and Metropolitan old mining area overlap, which means that there is cumulative impact in those areas. All the predicted depressurisations outside the mine layout are all located around AGL CSG wells in response to CSG activities in the Bulli Coal Seam.



APPIN MINE GROUNDWATER ASSESSMENT

Cumulative Maximum Depressurisation (m) in Alluvium and Regolith

FIGURE 47

- IMC Bores
- Major watercourses
- Minor watercourses
- Appin Mine
- Appin Alluvium Extent
- Project Area
- Other Mine Workings
- Model Extent

Groundwater Depressurisation (m)

- 1
- 2

0 2.5 5 km

Projection: GDA 1994 MGA Zone 56
Scale: 1:230,000 at A4

Project No.: 665.10015
Date: 14-Dec-2021
Drawn by: JG

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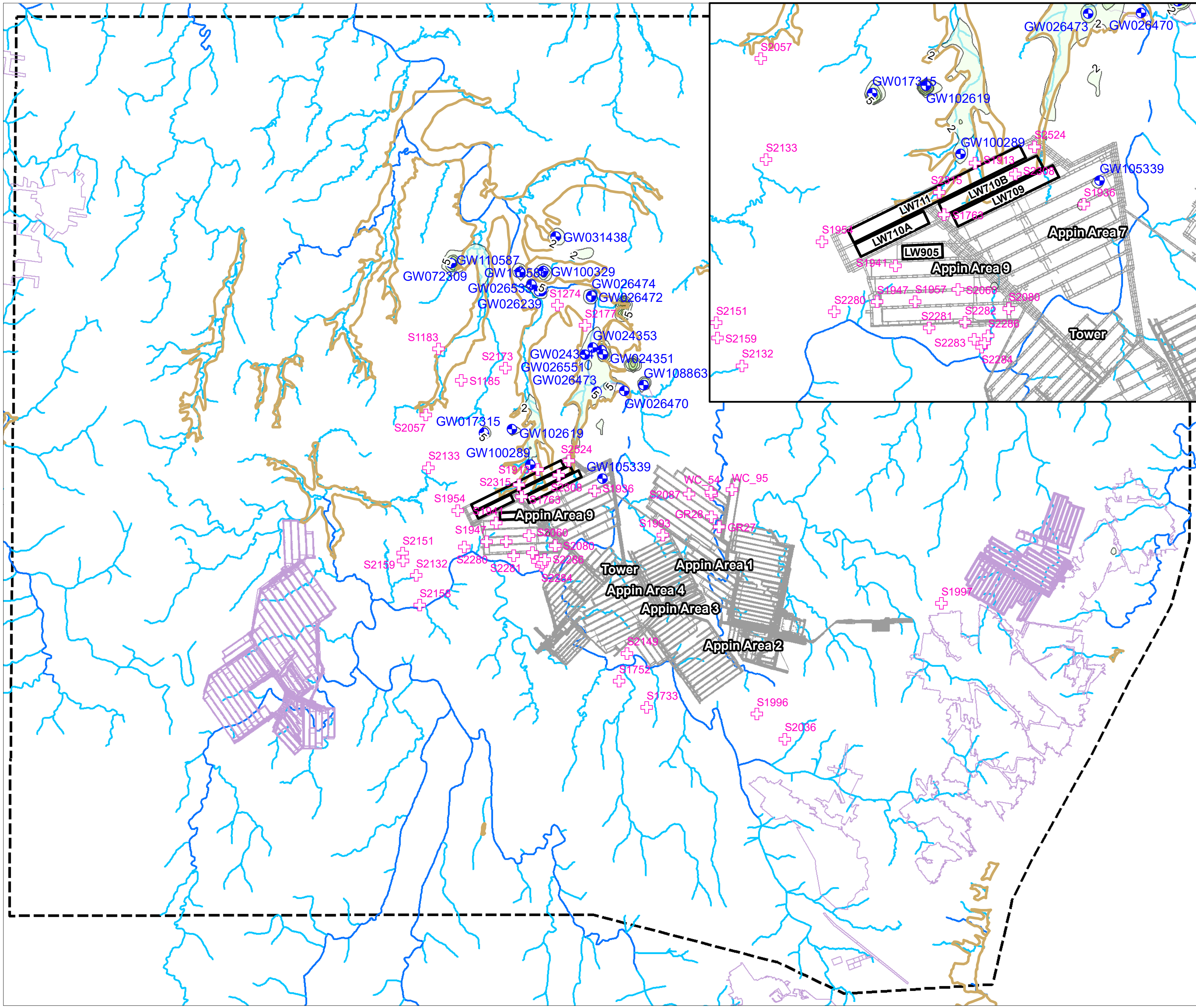

APPIN MINE GROUNDWATER ASSESSMENT

Cumulative Maximum Depressurisation (m) in Wianamatta Group

FIGURE 48

- Registered Bores
- IMC Bores
- Major watercourses
- Minor watercourses
- Appin Mine
- Appin Alluvium Extent
- Project Area
- Other Mine Workings
- Model Extent

Groundwater Depressurisation (m)

- 2
- 5
- 10
- 20
- 30
- 40

0 2.5 5 km

Projection: GDA 1994 MGA Zone 56
Scale: 1:230,000 at A4

Project No.: 665.10015
Date: 15-Dec-2021
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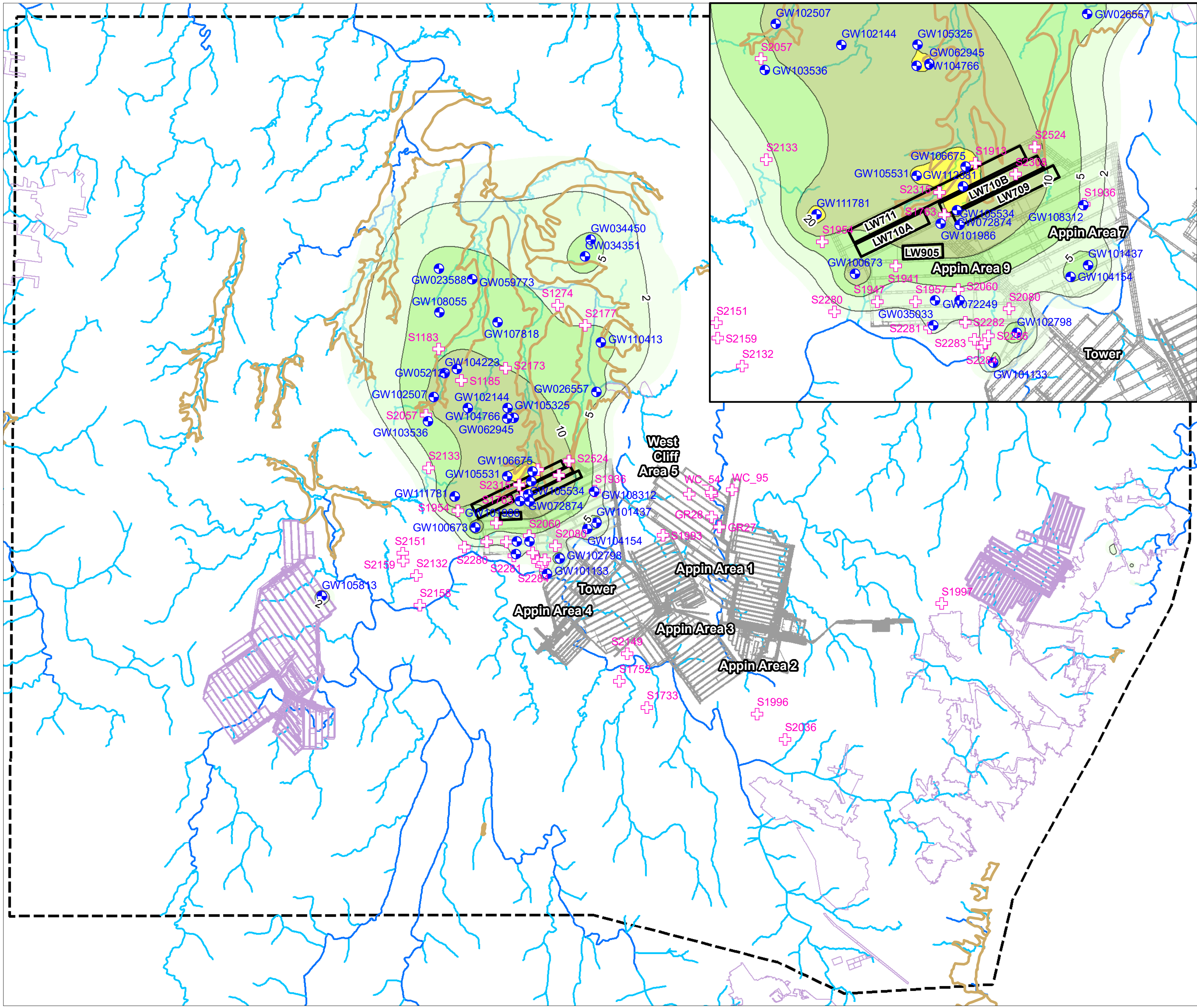
H:\Projects-SLR\620-BNE\665-WOL\665.10015 Illawarra Coal Closure - Water\CADGIS\ArcGIS\66510015 F54 Cumulative Maximum Depressurisation (m) in Wianamatta Group_v2.mxd



APPIN MINE GROUNDWATER ASSESSMENT

Cumulative Maximum Depressurisation (m) in Upper HBSS

FIGURE 49

- Registered Bores
- IMC Bores
- Major watercourses
- Minor watercourses
- Appin Mine
- Appin Alluvium Extent
- Project Area
- Other Mine Workings
- Model Extent

Groundwater Depressurisation (m)

- 1
- 2
- 5
- 10
- 20
- 30

0 2.5 5 km

Projection: GDA 1994 MGA Zone 56
Scale: 1:230,000 at A4

Project No.: 665.10015
Date: 14-Dec-2021
Drawn by: JG

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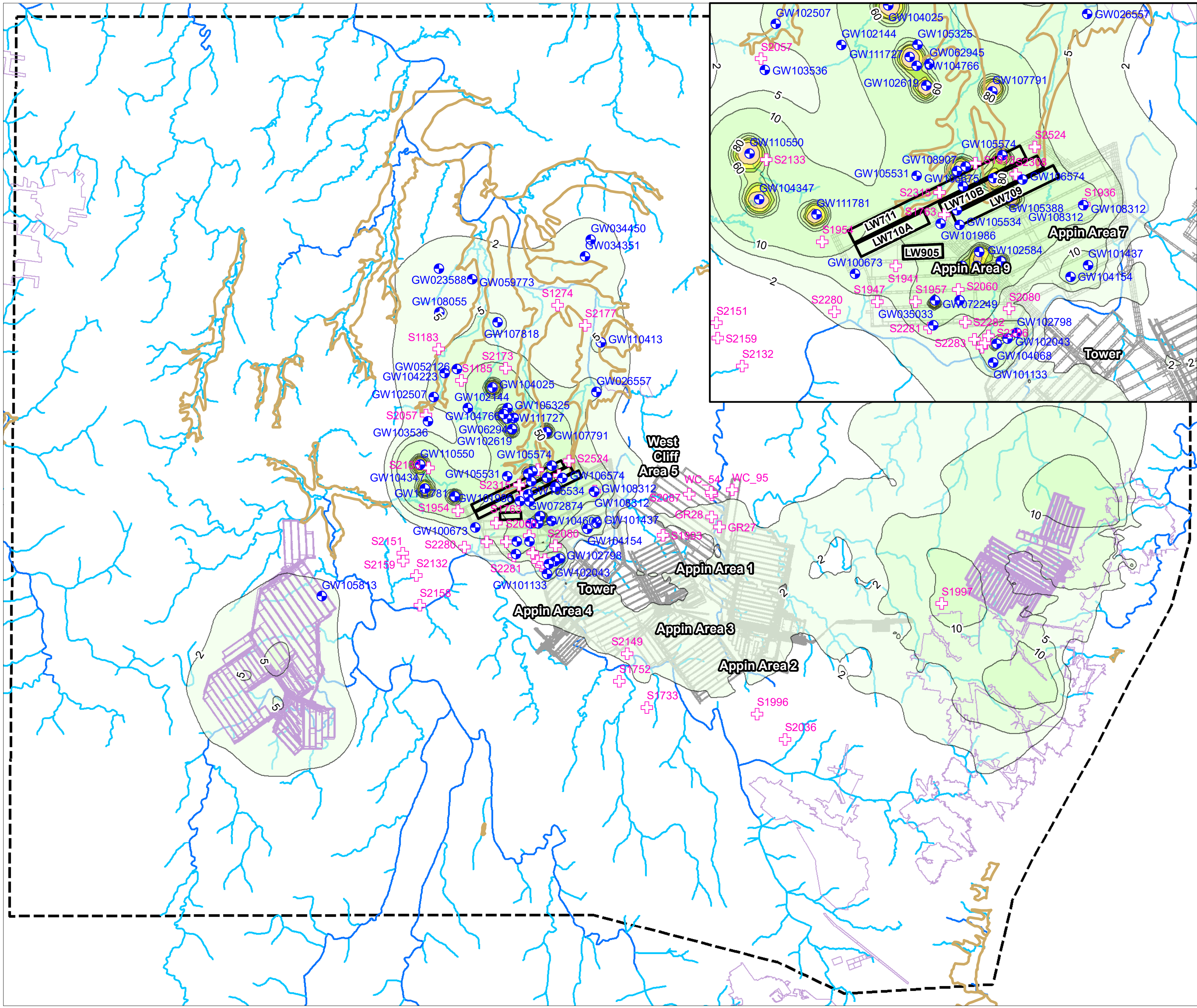
H:\Projects-SLR\620-BNE\665-WOL\665.10015 Illawarra Coal Closure - Water\CADGIS\ArcGIS\66510015 F55 Cumulative Maximum Depressurisation (m) in Upper HBSSCumulative Maximum Depressurisation (m) in Upper HBSS_v2.mxd



APPIN MINE GROUNDWATER ASSESSMENT

Cumulative Maximum Depressurisation (m) in Lower HBSS

FIGURE 50

- Registered Bores
- IMC Bores
- Major watercourses
- Minor watercourses
- Appin Mine
- Appin Alluvium Extent
- Project Area
- Other Mine Workings
- Model Extent

Groundwater Depressurisation (m)

- 2
- 5
- 10
- 50
- 60
- 70
- 80
- 100
- 150
- 200

0 2.5 5 km

Projection: GDA 1994 MGA Zone 56
Scale: 1:230,000 at A4

Project No.: 665.10015
Date: 14-Dec-2021
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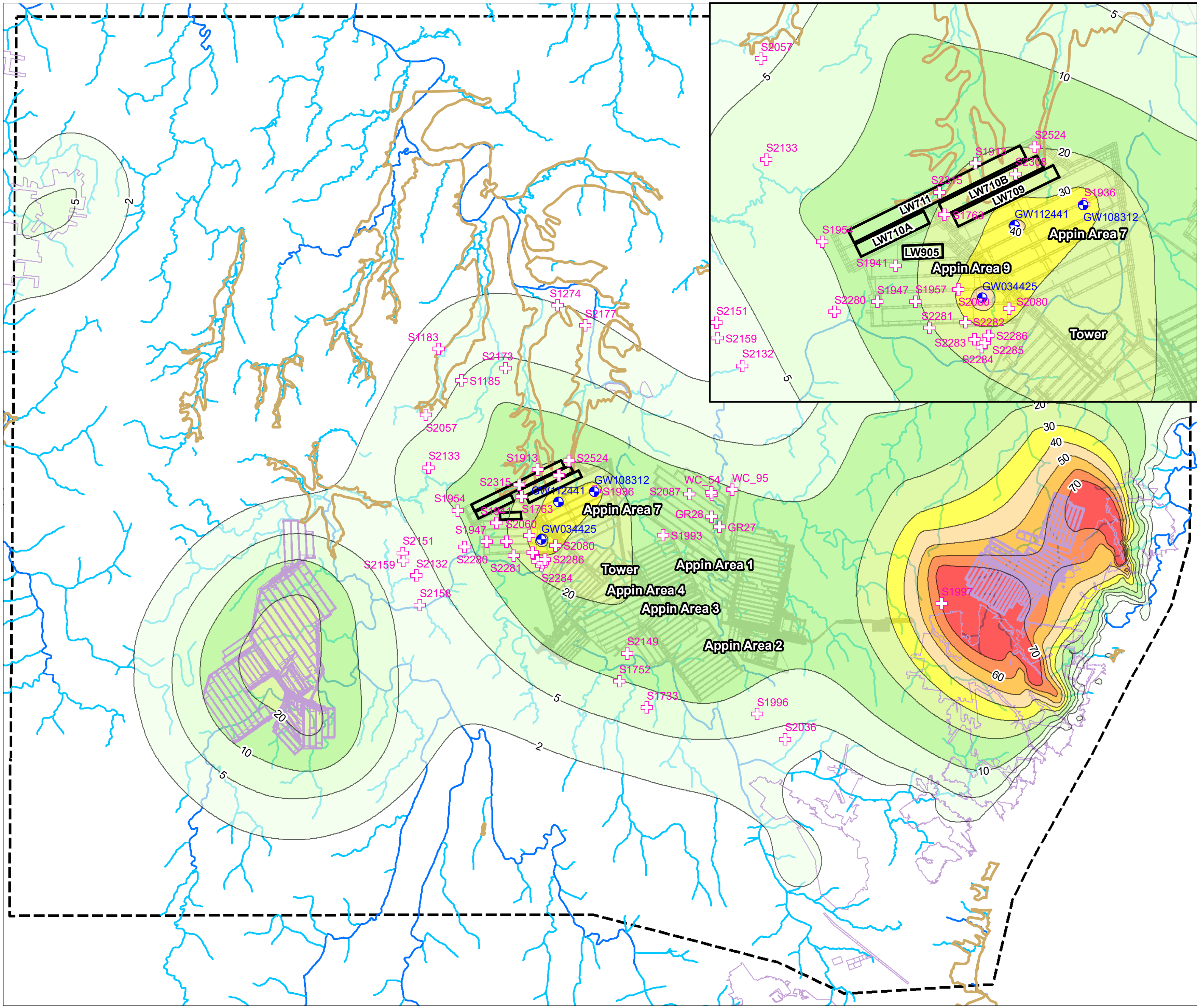
H:\Projects-SLR\620-BNE\665-WOL\665.10015 Illawarra Coal Closure - Water\CADGIS\ArcGIS\66510015 F56 Cumulative Maximum Depressurisation (m) in Lower HBSS_v2.mxd



APPIN MINE GROUNDWATER ASSESSMENT

Cumulative Maximum Depressurisation (m) in Upper Bulgo Sandstone

FIGURE 51

- Registered Bores
- IMC Bores
- Major watercourses
- Minor watercourses
- Appin Mine
- Appin Alluvium Extent
- Project Area
- Other Mine Workings
- Model Extent

Groundwater Depressurisation (m)

- 2
- 5
- 10
- 20
- 30
- 40
- 50
- 60
- 70

0 2.5 5 km

Projection: GDA 1994 MGA Zone 56
Scale: 1:230,000 at A4

Project No.: 665.10015
Date: 15-Dec-2021
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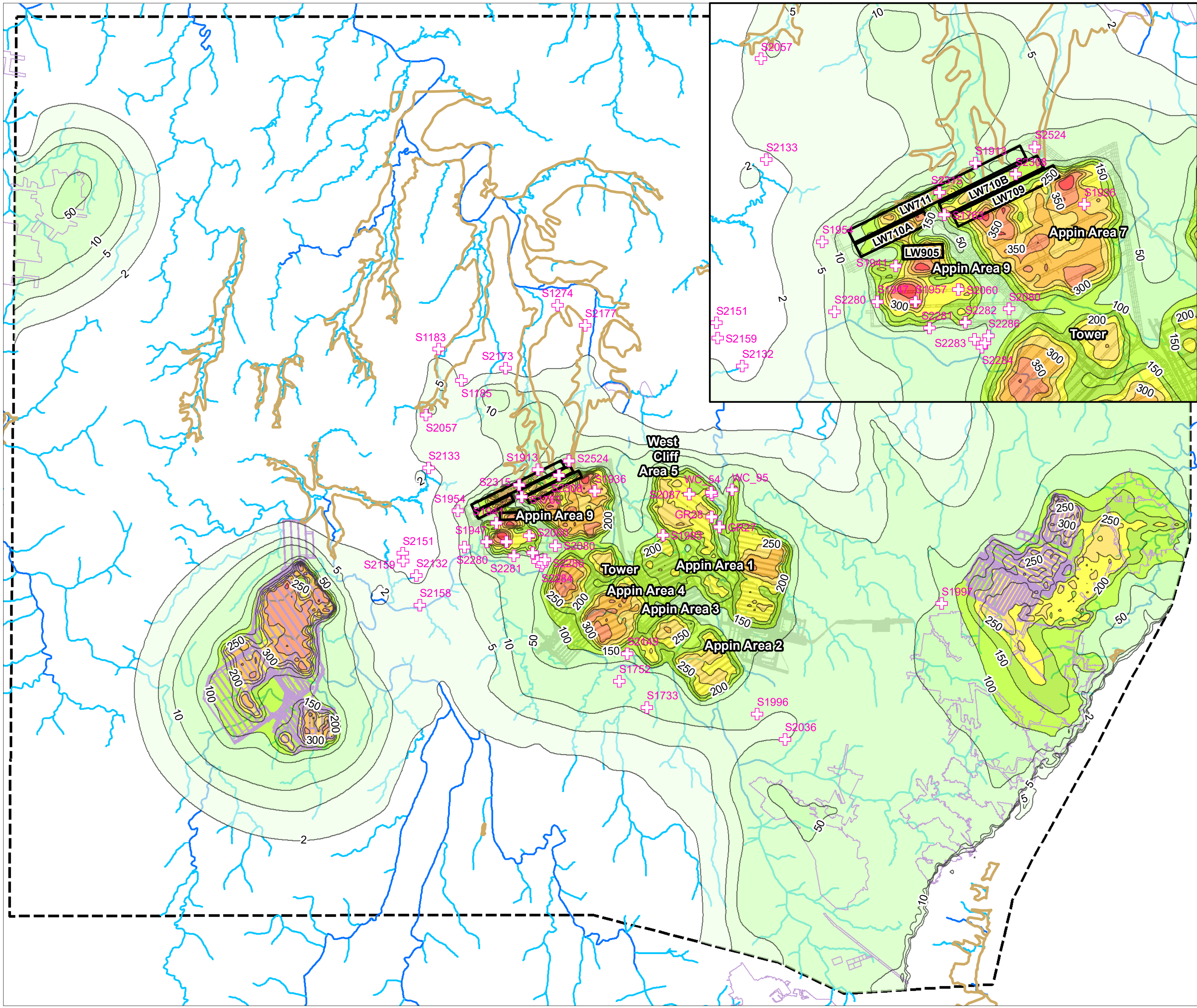
H:\Projects-SLR\620-BNE\665-WOL\665.10015 Illawarra Coal Closure - Water\CADGIS\ArcGIS\66510015 F57 Cumulative Maximum Depressurisation (m) in Upper Bulgo Sandstone_v2.mxd



APPIN MINE GROUNDWATER ASSESSMENT

Cumulative Maximum Depressurisation (m) in Lower Scarborough Sandstone

FIGURE 52

IMC Bores
Major watercourses
Minor watercourses
Appin Mine
Appin Alluvium Extent
Project Area
Other Mine Workings
Model Extent

Groundwater Depressurisation (m)

2
5
10
50
100
150
200
250
300
350
400

0 2.5 5 km

Projection: GDA 1994 MGA Zone 56
Scale: 1:230,000 at A4

Project No.: 665.10015
Date: 14-Dec-2021
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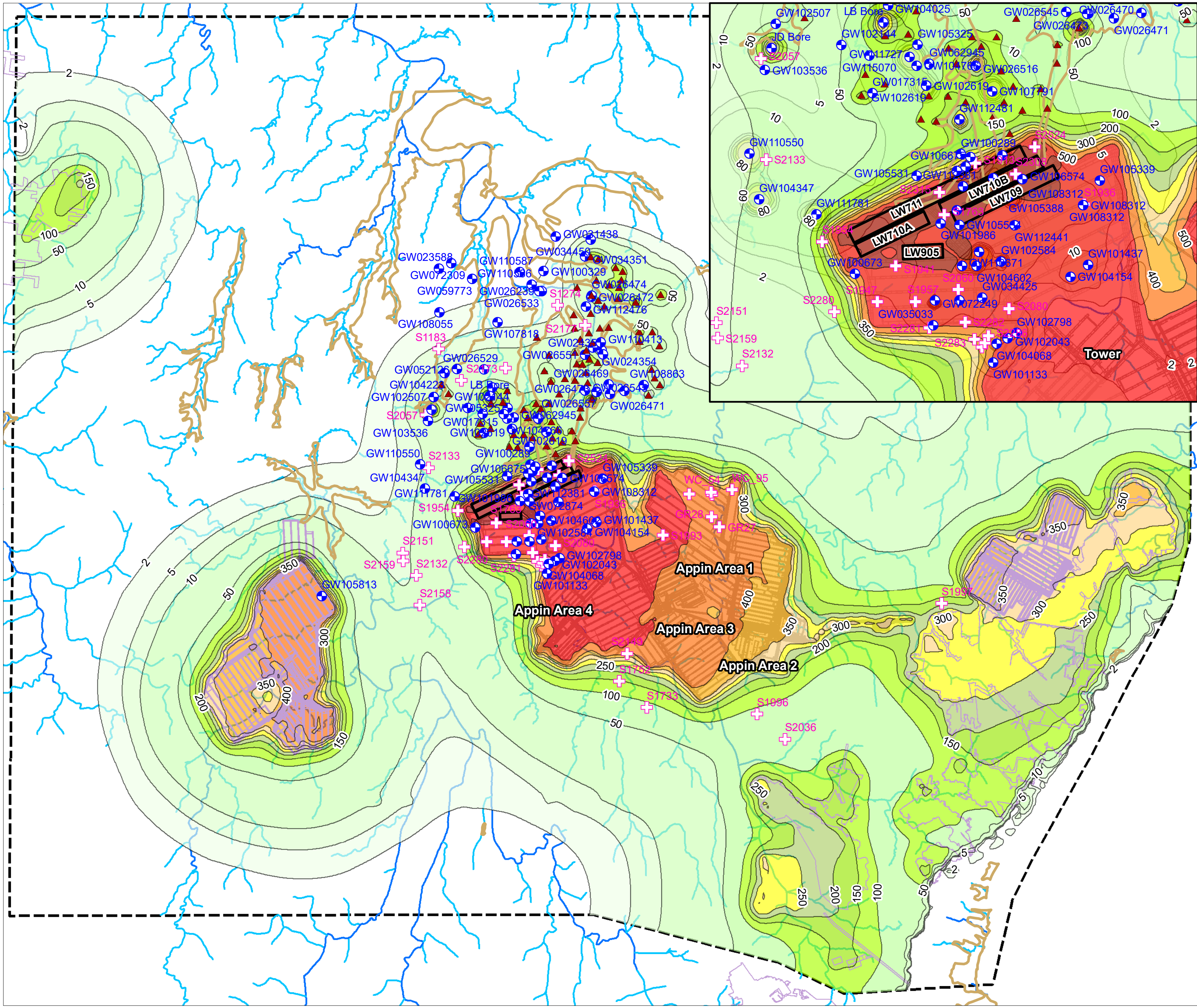
H:\Projects-SLR\620-BNE\665-WOL\665.10015 Illawarra Coal Closure - Water\CADGIS\ArcGIS\66510015 F58 Cumulative Maximum Depressurisation (m) in Lower Scarborough Sandstone_v2.mxd



APPIN MINE GROUNDWATER ASSESSMENT

Cumulative Maximum Depressurisation (m) in the Bulli Seam

FIGURE 53

- AGL CSG
- Registered Bores
- IMC Bores
- Major watercourses
- Minor watercourses
- Appin Mine
- Appin Alluvium Extent
- Project Area
- Other Mine Workings
- Model Extent

Groundwater Depressurisation (m)

2	250
5	300
10	350
50	400
100	450
150	500
200	600

0 2.5 5 km

Projection: GDA 1994 MGA Zone 56
Scale: 1:230,000 at A4

Project No.: 665.10015
Date: 15-Dec-2021
Drawn by: JG

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H:\Projects-SLR\620-BNE\665-WOL\665.10015 Illawarra Coal Closure - Water\CADGIS\ArcGIS\66510015 F59 Cumulative Maximum Depressurisation (m) in the Bulli Seam_v2.mxd

4.3.4 Depressurisation at Landholder Bores

As discussed in Section 3.4.2, there are 49 registered bores within 5 km of the Appin Mine/Project area. Within the BSO assessment by Heritage Computing (2009) it was concluded that:

- negligible drawdown was predicted for landholder bores within the shallow surficial strata (Alluvium/ Wianamatta Group / Weathered HBSS) (model layer 1);
- 3 m to 6 m of depressurisation at three bores within the upper HBSS;
- 3 m to 23 m of depressurisation at 35 bores within the lower HBSS; and
- 30 m to 85 m of depressurisation at nine bores within the Bulgo Sandstone.

Table 15 shows the maximum predicted depressurisation at privately owned bores. A conservative approach was taken where the predicted depressurisation at the bores was calculated based on maximum depressurisation across all layers representing the HBSS and Bulgo Sandstone.

As shown in Table 15 negligible depressurisation was predicted at all landholder bores due to mining at Longwalls 709 to 711 and 905.

The incremental depressurisation for privately owned bores due to Appin Mine was predicted by subtracting the Approved plus Project Appin Mine water levels from the NULL Appin Mine Run water levels shown in Table 15. Negligible depressurisation (less than 1 m) at all identified landholder bores due to Appin Mine.

For bores located directly above mined longwalls, there is a risk of damage to bore casing from subsidence related movement, as previously discussed by Heritage Computing (2009).

While no depressurisation is predicted within the surficial strata (Alluvium/ Wianamatta Group / Weathered HBSS) as part of the groundwater assessment, the subsidence assessment identified potential for surface cracking along Navigation Creek (refer to Section 2.4.1.3). This has the potential for localised impacts on Navigation Creek surface water flow, which may influence recharge to the alluvium in proximity to the Project and potentially landholder bores accessing alluvial groundwater in this particular area (i.e. GW100289). Local geological structures such as fracturing, and shearing could cause significantly greater depressurisation at individual bores. However, the groundwater model assumed fracturing height did not reach the surface and as such, the groundwater model is not able to predict those potential impacts.

Table 15 Predicted Change in Maximum Predicted Depressurisation (m) at Landholder Bores

Work ID	Bore Type / Role	Geology	Cumulative Maximum Depressurisation (m)	Incremental Maximum Depressurisation (m) due to Appin Mine	Incremental Maximum Depressurisation (m) due to Project
GW026516	Water Supply, Stock, Irrigation (BH Reg); IRAG (NGIS)	Unconsolidated Clay/Silt	677	0	0
GW112481*	Industrial (BH Reg); INDS (NGIS)	Bulli Coal Seam	653	0	0
GW072196	Domestic (BH Reg); HUSE (NGIS)	Unknown. Information on depth, likely HBSS	357	<1	0
GW110550	Stock, Domestic (BH Reg); HUSE (NGIS)	Sandstone and Shale from Open Hole to TD	323	<1	0
GW111727	Stock, Domestic (BH Reg); HUSE (NGIS)	-	298	0	0
GW104347	Stock, Domestic (BH Reg); HUSE (NGIS)	Sandstone from Open Hole to TD	290	0	0
GW107791	Stock, Domestic (BH Reg); HUSE (NGIS)	Sandstone from Open Hole to TD	263	0	0
GW105376	Stock, Domestic (BH Reg); HUSE (NGIS)	Sandstone from Open Hole to TD	213	0	0
GW105325	Stock, Domestic, Recreation (BH Reg); RECN (NGIS)	Sandstone and Shale from Open Hole to TD	66	<1	0
GW104661	Stock, Domestic (BH Reg); HUSE (NGIS)	Sandstone from Open Hole to TD	188	0	0
GW104766	Stock, Domestic (BH Reg); HUSE (NGIS)	Sandstone and Shale from Open Hole to TD	69	<1	0
GW062945	Stock, Domestic (BH Reg); HUSE (NGIS)	Sandstone from Open Hole to TD	69	<1	0

Work ID	Bore Type / Role	Geology	Cumulative Maximum Depressurisation (m)	Incremental Maximum Depressurisation (m) due to Appin Mine	Incremental Maximum Depressurisation (m) due to Project
GW102584	Stock, Domestic (BH Reg); HUSE (NGIS)	Sandstone from Open Hole to TD	180	0	0
GW110671	Stock, Domestic (BH Reg); HUSE (NGIS)	Sandstone, Shale and Granite from Open hole to TD	143	<1	0
GW101986	Stock, Domestic (BH Reg); HUSE (NGIS)	Sandstone in open hole section	64	<1	0
GW104602	Stock (BH Reg); STOK (NGIS)	Sandstone and Claystone from Open hole to TD	181	0	0
GW105574	Stock, Domestic (BH Reg); HUSE (NGIS)	Sandstone, Clay and Shale from Surface	201	0	0
GW105534	Stock, Domestic (BH Reg); HUSE (NGIS)	Sandstone and Slate from open hole to TD	22	<1	0
GW104154	Stock, Domestic (BH Reg); HUSE (NGIS)	Sandstone and Shale from Open Hole to TD	52	<1	0
GW072874	Stock, Domestic (BH Reg); HUSE (NGIS)	Sandstone, Siltstone and Shale from Open Hole to TD	24	<1	0
GW101437	Farming (BH Reg); IRAG (NGIS)	Sandstone and Shale from Open Hole to TD	92	<1	0
GW108907	Stock, Domestic (BH Reg); HUSE (NGIS)	Sandstone and Shale from Open Hole to TD	200	0	0
GW102144	Stock, Domestic (BH Reg); HUSE (NGIS)	Sandstone and Shale from Open Hole to TD	17	<1	0
GW112437	Stock, Domestic (BH Reg); HUSE (NGIS)	Sandstone and Shale from Open Hole to TD	30	<1	0

Work ID	Bore Type / Role	Geology	Cumulative Maximum Depressurisation (m)	Incremental Maximum Depressurisation (m) due to Appin Mine	Incremental Maximum Depressurisation (m) due to Project
GW108312	Test Bore (BH Reg); INDS (NGIS)	Sandstone from Slots and Open Hole to TD	21	<1	0
GW112381	Stock, Domestic (BH Reg); HUSE (NGIS)	Sandstone from Open Hole to TD	86	<1	0
GW102043	Stock, Domestic (BH Reg); HUSE (NGIS)	Sandstone, Siltstone and Clay from Open Hole to TD.	140	0	0
GW104068	Stock, Domestic (BH Reg); HUSE (NGIS)	Sandstone, Siltstone and Shale from Open Hole to TD	140	0	0
GW105531	Stock, Domestic (BH Reg); HUSE (NGIS)	Sandstone and Shale from Open Hole to TD	90	<1	0
GW111781	Domestic (BH Reg); HUSE (NGIS)	Sandstone from Open Hole to TD	28	<1	0
GW106675	Stock, Domestic (BH Reg); HUSE (NGIS)	Sandstone and Shale from Open Hole to TD	159	0	0
GW034425	Waste Disposal (BH Reg); WSUP, INDS (NGIS)	Sandstone from Open Hole to TD	158	<1	0
GW017315	Water Supply, Farming / General Purpose (BH Reg); WSUP (NGIS)	-	14	<1	0
GW035033	Stock (BH Reg); STOK (NGIS)	Sandstone and Shale from Open Hole to TD	29	<1	0
GW102619	Stock, Domestic, Irrigation (BH Reg); IRAG (NGIS)	Sandstone and Shale from Open Hole to TD	72	0	0

Work ID	Bore Type / Role	Geology	Cumulative Maximum Depressurisation (m)	Incremental Maximum Depressurisation (m) due to Appin Mine	Incremental Maximum Depressurisation (m) due to Project
GW101133	Stock, Domestic (BH Reg); HUSE (NGIS)	Sandstone, Siltstone and Ironstone from Open Hole to TD	94	0	0
GW102798	Stock, Domestic, Farming (BH Reg); IRAG (NGIS)	Sandstone from Open Hole to TD	88	<1	0
GW100673	Stock (BH Reg); STOK (NGIS)	-	32	<1	0
GW105339	Stock, Domestic, Irrigation (BH Reg); HUSE (NGIS)	Sandstone and Shale from Open Hole to TD	3	<1	0
GW100289	Stock, Domestic (BH Reg); HUSE (NGIS)	Bore is Screened in Gravel	30	0	0
GW108990	Test Bore (BH Reg); HUSE (NGIS)	-	10	<1	0
GW111637	Monitoring Bore (BH Reg); MON (NGIS)	-	1	<1	0
GW111638	Monitoring Bore (BH Reg); MON (NGIS)	-	1	<1	0
GW111636	Monitoring Bore (BH Reg); MON (NGIS)	-	5	<1	0
GW111634	Monitoring Bore (BH Reg); MON (NGIS)	-	3	<1	0
GW105942	Test Bore (BH Reg); MON (NGIS)	Shale and Clay from Open Hole to TD	0	0	0
GW108193	Test Bore (BH Reg); MON (NGIS)	Clay and Shale from Open Hole to TD	0	0	0

Note: * Water supply bore, part of the AGL Camden CSG project

NGIS naming convention: HUSE: household, INDS: industry, IRAG: irrigated agriculture, MON Monitoring, STOK: Water supply for livestock, WSUP Water supply

The above predictions from the Regional Groundwater Model relate to changes in groundwater levels and pressures due to regional depressurisation from the proposed mining. Local subsidence effects such as shear and localised fracturing of a bore can result in additional changes to groundwater level at that location.

4.3.5 Potential Impacts on Surface Water Bodies

There are no predicted incremental impacts on surface water bodies due to depressurisation of the coal measures as part of the Project. This is because the model predicted that the Project will not result in any depressurisation within the upper layers (Alluvium, Wianamatta Group and HBSS). These findings are consistent with the impact assessment conclusions for BSO by Heritage Computing (2009). However, a cumulative drawdown of up to 40 m is predicted in the Upper HBSS (refer to Figure 49).

Localised temporal changes in surface water flow and quality related to subsidence is discussed in the Surface Water Assessment report.

4.3.6 Impacts on Water Quality

The Project does not include any surface activities or direct abstraction or interaction with the HBSS groundwater source. Therefore, impacts on the water quality within the HBSS are unlikely.

The height of fracture calculations indicate longwall mining as part of the Project could result in fracturing from the Bulli Seam to the Scarborough Sandstone and in some localised areas the Bulgo Sandstone (lower). Increased iron staining has been observed and is attributed to groundwater becoming oxidised while in contact with fresh fractures or shears. Additional fracturing can also cause the liberation of formation gas particularly deeper bores such as these intersecting the Bulgo Sandstone. Post closure, this could create hydraulic connection between the confined Permian coal measures and overlying Narrabeen Group. As discussed in Section 3.3, the Bulgo Sandstone is generally moderately saline with sodium-bicarbonate type water and can be suitable for some stock water supply and short-term irrigation. However, the Bulgo Sandstone has limited usage within the region, with preferential use of the shallower HBSS.

There is limited data on water quality within the coal measures at Appin, but regionally it is characterised as moderately saline to saline. The impact on groundwater salinity within the hydrostratigraphic units above the Bulli Seam due to cracking is unknown since there is little water quality information available in these units including the Coalcliff Sandstone, Wombarra Claystone, Scarborough Sandstone and Stanwell Park Claystone. Water leakage from the upper units to the lower units will be partially restricted as the Stanwell Park Claystone and Wombarra Claystone units will continue to act as aquitards, which may be impacted by some minor cracking. Ongoing monitoring of site mine water representative of the Permian coal measures should be conducted and incorporated for ongoing mine closure planning and management.

5 Recommendations - Monitoring

5.1 Appin Mine Monitoring Network

Groundwater monitoring will be conducted in accordance with a Groundwater Monitoring Plan (GWMP) that will be prepared in consultation with the regulator. The GWMP will include full details on how, when and what groundwater parameters will be monitored across Appin Mine and surrounds. A groundwater management plan is to be prepared to describe the requirements for ongoing groundwater management at Appin. The groundwater management plan will be prepared in consultation with DPIE -Water and include the groundwater monitoring plan.

Table 16 presents the updated monitoring network and program for the Project, and Figure 54 shows the new and existing bore locations. In addition, it is recommended that monthly monitoring of mine water inflows (water quality) is conducted to monitor groundwater quality within the local Permian coal measures. Groundwater criteria have been developed and are discussed in Section 5.3.

Three exploration bores (S1913, S1941 and S1954) have been fitted with vibrating wire piezometers with 10 piezometers in bores S1913 and S1941 and 13 piezometers in S1954. Each piezometer monitors water pressure on an hourly interval and transmits data automatically via File Transfer Protocol (FTP). These bores are suitable for the early warning of the mining affect as part of the assessment criteria (Section 5.3).

Bore S1936 has only one remaining piezometer operational (65 m) as all other piezometers have sheared. This bore is not suitable for the early warning of mining impacts. Data from the remaining piezometer is captured manually via irregular site visits. Exploration bore S2157 has 10 piezometers, however their condition is unknown as the bore is not fitted with a FTP and access has not been possible since 2015. Renewed access to this site is currently being negotiated. This bore is not suitable for the early warning of mining impacts.

The existing monitoring bores are vibrating wire piezometers (VWP) each with multiple sensors monitoring water pressure at hourly intervals with data transmitted automatically to a FTP. Four new monitoring bores have been installed to monitor groundwater levels in the alluvium (S2536) and Hawkesbury Sandstone (S2536A, S2537 and S2538). These new bores are to be completed as VWPs installed to the depth and within the lithology as outlined in Table 16. S2537 is to be constructed as an open piezometer to calibrate the nearby VWPs and to collect groundwater quality samples.

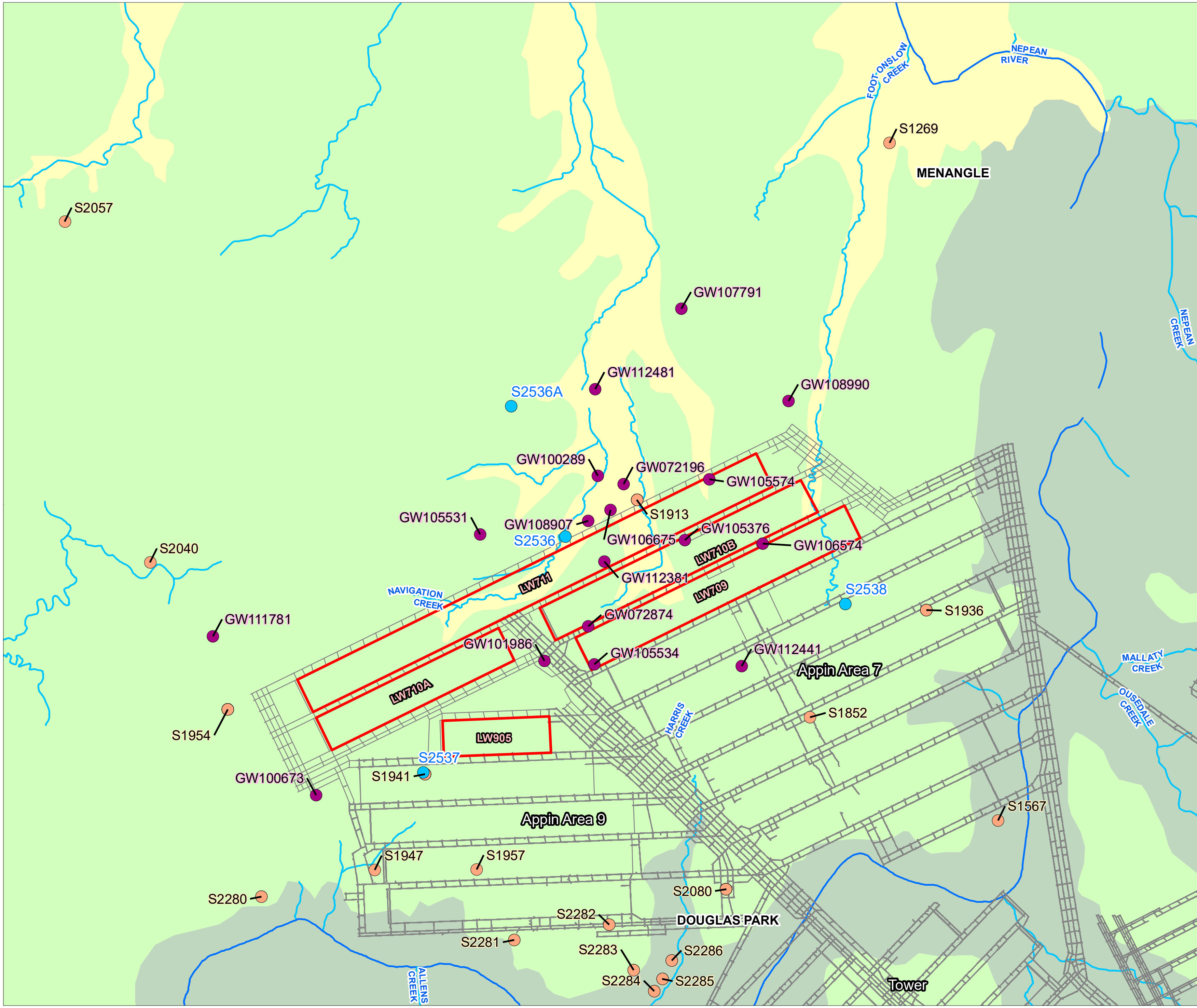
Table 16 Updated Project Monitoring Program

Bore ID	Type	Easting	Northing	Ground Level	Screen/ Sensor	Geology	Purpose	SWL (mAHD)		WQ	
								Frequency	Trigger	Frequency	Trigger
S1913	VWP (EX)	289028	6218729	117.04	65	HBSS	VWP immediately north of Project (LW711). Verify predicted water level impacts and early identification of adverse impacts not previously predicted.	Hourly	-	N/A	-
					137	HBSS		Hourly	74	N/A	-
					194	HBSS		Hourly	47	N/A	-
					274	BGSS		Hourly	-	N/A	-
					358	BGSS		Hourly	-	N/A	-
					447	BGSS		Hourly	112	N/A	-
					473	SBSS		Hourly	119	N/A	-
					486	SBSS		Hourly	-	N/A	-
					505	SBSS		Hourly	127	N/A	-
					559.5	BUCO		Hourly	70	N/A	-
S1936	VWP (AD)	291547	6217768	148.14	65	HBSS	VWP within 1 km of Project (LW709). Verify predicted water level impacts and early identification of adverse impacts not previously predicted	Irregular	85	N/A	-
					123.8	HBSS		Broken	-	N/A	-
					192	HBSS		Broken	36	N/A	-
					278	BGSS		Broken	-10	N/A	-
					347.8	BGSS		Broken	-10	N/A	-
					422.5	BGSS		Broken	-46	N/A	-
					456.2	SBSS		Broken	-50	N/A	-
					462.1	SBSS		Broken	-25	N/A	-
					468	SBSS		Broken	-	N/A	-
					556.1	BUCO		Broken	-400	N/A	-
S1941	VWP (EX)	287181	6216341	148.82	65	HBSS	VWP within 200 m of Project (LW905). Verify predicted water level impacts and early identification of adverse impacts not previously predicted	Hourly	108	N/A	-
					126.5	HBSS		Hourly	75	N/A	-
					201.6	HBSS		Hourly	40	N/A	-
					284.3	BGSS		Hourly	65	N/A	-
					355.7	BGSS		Hourly	85	N/A	-
					432	BGSS		Hourly	80	N/A	-
					463	SBSS		Hourly	-	N/A	-
					472.8	SBSS		Hourly	8.5	N/A	-
					487.5	SBSS		Hourly	-5	N/A	-
					555.4	BUCO		Hourly	-400	N/A	-

Bore ID	Type	Easting	Northing	Ground Level	Screen/ Sensor	Geology	Purpose	SWL (mAHD)		WQ	
					596	WWCO		Hourly	-242	N/A	-
S1954	VWP (EX)	285466	6216904	310	36	BrSh	VWP within 1 km of Project (LW711). Verify predicted water level impacts and early identification of adverse impacts not previously predicted	Hourly	-	N/A	-
					85	BrSh		Hourly	-	N/A	-
					100.5	BrSh		Hourly	-	N/A	-
					138.5	UnSS		Hourly	-	N/A	-
					145.3	UnSS		Hourly	-	N/A	-
					181	AsSh		Hourly	-	N/A	-
					205	AsSh		Hourly	-	N/A	-
					245	HBSS		Hourly	-	N/A	-
					273.1	HBSS		Hourly	-	N/A	-
					316.3	HBSS		Hourly	-	N/A	-
					359.4	HBSS		Hourly	67	N/A	-
					392.5	HBSS		Hourly	-	N/A	-
					742.9	BUCO		Hourly	-200	N/A	-
S2157	VWP (AD)	283212	6215968	224.45	82.5	WNSH	VWP approximately 3 km west of Project (LW711). Verify predicted water level impacts and early identification of adverse impacts not previously predicted	Currently not sampled	-	N/A	-
					135	HBSS			105*	N/A	-
					207	HBSS			-	N/A	-
					284	HBSS			90*	N/A	-
					368	BGSS			-	N/A	-
					418	BGSS			165*	N/A	-
					468	BGSS			160*	N/A	-
					518	SPCS			-	N/A	-
					568	SBSS			165*	N/A	-
					626.9	BUCO			160*	N/A	-
S2536^	MB NEW	288405	6218410	117	15.6	Qa	Near VWP S1913, to characterise alluvial groundwater conditions and monitor trends. Water level and water quality monitoring	Quarterly	TBC	Quarterly	EC, pH TBC
S2536A	MB NEW	287932.47	6219544.17	117	136.6	HBSS	1.2km north of the project, levels in HBSS and monitor groundwater quality.	Quarterly	-	Quarterly	EC, pH TBC
S2537	MB NEW	287168.90	6216357.00	148	129.5	HBSS	Near VWP S1941, to verify VWP levels in HBSS and monitor groundwater quality.	Quarterly	-	Quarterly	EC, pH TBC

Bore ID	Type	Easting	Northing	Ground Level	Screen/ Sensor	Geology	Purpose	SWL (mAHD)		WQ	
S2538	MB NEW	290840.83	6217822.03	148	129.5	HBSS	VWP within 400 m of Project (LW707). Verify predicted water level impacts and monitor groundwater quality.	Quarterly	-	Quarterly	EC, pH TBC

Note: MB – Monitoring bore (open standpipe) NEW – New bores (installed 05/Jul/21-27/Aug/21)
Q – Quarterly Daily – based on VWP sensor data
TBC – to be confirmed once sufficient data has been collected following bore installation
Coordinates in metres (GDA94 - MGA zone 56)
(*) Note: S2157 requires manual data pickup, but due to land access issues, data has not been picked up since 2015 and the status of the piezometers in this drill hole cannot be confirmed at this stage.
(^) Note: S2536 does not have surveyed coordinates yet..
Qa – Quaternary alluvium BrSh – Wianamatta Bringelly Shale UnSS – Wianamatta - Minchinbury Sandstone AsSh – Wianamatta – Ashfield Shale
HBSS – Hawkesbury Sandstone BGSS – Bulgo Sandstone
CCSS – Coal Cliff Sandstone SBSS – Scarborough Sandstone BUCO – Bulli Coal Seam
WWCO - Wongawilli Coal Seam LDSS – Loddon Sandstone



APPIN MINE GROUNDWATER ASSESSMENT

Updated Monitoring Network

FIGURE 54

Projection: GDA 1994 MGA Zone 56
Scale: 1:45,000 at A4

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5.2 Appin Monitoring Program

Manual groundwater level monitoring should be conducted for all monitoring bores, with data loggers installed within selected bores to gather temporal variations in water levels. Data should also continue to be downloaded from the existing VWPs, pressure readings recorded and converted to groundwater elevations within a central database.

Ongoing monitoring will enable natural groundwater level fluctuations (such as responses to rainfall) to be distinguished from potential groundwater level impacts due to depressurisation resulting from the Project. Ongoing monitoring of groundwater levels can also be used to assess the extent and rate of depressurisation against model predictions.

It is recommended that a monitoring program is conducted in accordance with a Groundwater Monitoring Plan (GWMP). The following actions are recommended to support on-going groundwater monitoring:

- Establishment of a central groundwater monitoring database;
- Water level and quality results from the monitoring network should be included in annual reviews;
- Monitoring data (groundwater levels, discharges and water quality) is reviewed and compared to targets (predicted) as described in the modelling actions above on a five yearly basis;
- Where access is available monitor landowner bores; and
- If a landowner bore is suitable, undertake the following:
    - Install a datalogger to automatically record water levels;
    - Install a flow meter on landowner water extraction bores to monitor usage;
    - Conduct an annual water quality analyses including pH and electrical conductivity (EC) as well as laboratory analysis as outlined below; and
    - Annual manual groundwater level monitoring with an electronic dip meter to calibrate the dataloggers where access is available.

Groundwater quality sampling should be conducted to detect any changes in groundwater quality during and post mining.

Water quality monitoring should include field analysis of pH and EC, as well as annual sampling for laboratory analysis of a full suite of analytes, including:

- physio-chemical indicators – pH, electrical conductivity, total dissolved solids;
- major ions – calcium, fluoride, magnesium, potassium, sodium, chloride, sulphate;
- total alkalinity as $CaCO_3$, HCO_3, CO_3; and
- dissolved and total metals – aluminium, arsenic, barium, boron, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, strontium, silver, vanadium and zinc.

5.3 Criteria Assessment

Proposed groundwater trigger criteria for the Project are presented in Table 17. Groundwater assessment levels at monitoring bores are based on the numerical model predicted change in groundwater levels, as outlined in Table 16. Investigation into groundwater level trends should be undertaken if there are three consecutive readings outside of the proposed trigger level. Investigation should include review of climate trends, the quality of the data/condition of the monitoring point, as well as water level and quality trends at other relevant bores to identify the cause for the change in levels beyond those predicted.

Water quality assessments are proposed for the four new bores, three within the HBSS and one within the alluvium. It is proposed that assessments of field pH and electrical conductivity (EC) be used for early detection of potential adverse changes in water quality. Indicative assessment levels for the HBSS bores have been included based on the 5th and 95th percentile for pH and 95th percentile for EC from site baseline data (Section 3.3). These assessment levels are indicative only and should be reviewed following bore installation and collection of data to ensure they are applicable and capable of early detection of potential impacts. The triggers for the new bores will be established once groundwater quality data is available.

Table 17 Proposed Appin Mine Assessment Criteria

Type	Proposed Assessment Criteria
Groundwater Levels	Three consecutive readings are outside of the proposed trigger levels for the individual bore/sensor as specified in Table 16.
Quaternary Alluvium Water Quality	Three consecutive readings for pH outside of the 5th and 95th percentile and EC outside of the 95th percentile of baseline data for Quaternary alluvium at Proposed Bore 1, to be determined from baseline data (2 years of data with a minimum of 18 samples).
Hawkesbury Sandstone Water Quality	Three consecutive readings for pH outside of the 5th and 95th percentile of baseline site data of 6.4 and 11.9 for Proposed Bore 2 to Proposed Bore 4. Three consecutive readings for EC outside the 95th percentile of baseline site data of 6,458 µS/cm for Proposed Bore 2 to Proposed Bore 4.

There is available baseline data for alluvial water quality from the Navigation Creek site (NAV1) that would be used to establish surface water quality assessment levels. Water level and quality results from the monitoring network should be included in an annual review. An assessment of water level and quality is undertaken in the relevant End of Panel Report. This information is summarised in the Annual Review. The reporting should include a review comparing predicted and observed levels and vertical head profiles to identify any potential adverse changes beyond those predicted. The review should include a comparison to climate trends and surface water monitoring results to identify any changes in the surface water and groundwater interactions, where relevant. The annual review or End of Panel Review should also identify if any additional monitoring sites are required, or if optimisation of the existing monitoring sites should be undertaken.

5.4 Landholder Bore Monitoring

If accessible, and landholder access is granted, it is recommended that landholder bores within the immediate vicinity of the Appin Mine are monitored for water levels, quality and details on bore usage be noted. Table 18 presents a summary of landholder bores above and in the vicinity of the Appin Mine, with available details on the bore construction, likely geology and recommended monitoring frequency. The location of the bores is shown in Figure 54. It should be noted that this is indicative only and would be dependent on landholder access.

It is recommended that the construction of bore GW100289 be verified to confirm if it is within alluvium or the Wianamatta Group. Currently, GW106574 has nested piezometers installed at depths of 65 m, 129 m and 190 m.

Table 18 Proposed Landholder Bore Monitoring

Bore ID	Easting	Northing	Elevation (mAHD)	Total Depth (mbgl)	Screen (mbgl)	Use	Geology	SWL	WQ
GW108990	290347	6219588	108.75		-	Domestic	Unknown (likely HBSS)	A	A
GW100289	288686	6218937	124.22	30	Slots (12 – 18)	Stock and Domestic	Wianamatta? Or alluvium?	D/Q	Q
GW072874	288601	6217630	140.9	189	OH (45 – TD)	Stock and Domestic	Upper HBSS	D/Q	Q
GW100673	286235	6216160	154.16	104	-	Stock	Upper HBSS	GS	A
GW101986	288223	6217328	174.71	210	OH (103 – TD)	Stock and Domestic	Upper HBSS	Q	A
GW105531	287664	6218430	150.51	210	OH (33 – TD)	Stock and Domestic	Upper HBSS	A	A
GW105534	288655	6217297	167.82		OH (72 – TD)	Stock and Domestic	Upper HBSS	D/Q	Q
GW106675	288797	6218642	124.43	183	OH (43 – TD)	Stock and Domestic	Upper HBSS	Q	A
GW111781	285334	6217542	-	305	OH (120 – TD)	Domestic	Upper HBSS	A	A
GW112381	288743	6218191	-	152	OH (72 – TD)	Stock and Domestic	Upper HBSS	D/Q	Q
GW105376	289443	6218380	151.54	218.5	OH (102 – TD)	Stock and Domestic	Lower HBSS	D/Q	Q
GW105574	289656	6218908	125.42	210	OH (Surface – TD)	Stock and Domestic	Lower HBSS	D/Q	Q
GW106574	290123	6218350	140.52	238	OH (6 – TD)	Domestic	Lower HBSS	D/Q	Q
GW107791	289415	6220392	114.32	OH (81 – 231)	-	-	Lower HBSS	A	A
GW108907	288602	6218547	125.78	210	OH (72 – TD)	Stock and Domestic	Lower HBSS	Q	A
GW108990	290347	6219588	108.75	-	-	-	NA	A	A
GW072196	288911	6218867	118.01	-	-	Domestic	HBSS?	A	A
GW110671	288717	6216340	141.86	240	OH (28 – TD)	Stock and Domestic	Lower HBSS	GS	A

Note: A – Annual Q - Quarterly
D – Daily water levels from datalogger if it can be installed within landholder bore
D/Q – Daily water levels and quarterly manual dipped water level readings to verify logger performance

GS – Bores are already monitored with piezometer data presented on the Geosensing website

Water levels at bores GW100673 and GW110671 are currently monitored with data loggers. Pending individual site evaluation, it is recommended that a datalogger be installed within the other 16 bores above the mine workings to monitor time series groundwater levels. In addition, quarterly manual groundwater level and quality monitoring should be conducted in these bores. As the registered bores are used for groundwater supply the water levels would be influenced by bore usage.

It is recommended that annual water quality analysis include field parameters of pH and electrical conductivity (EC) as well as laboratory analysis as outlined in Section 5.2.

6 Conclusions

IMC are proposing to continue extracting coal from Longwalls 709, 710A, 710B, 711 in Appin Area 7 and Longwall 905 in Area 9 and require EP approval prior to the commencement of secondary extraction. Groundwater modelling has been conducted to predict potential impacts to the local hydrogeological system to support the EP approval process.

The groundwater model was developed utilising existing numerical groundwater models developed by SLR (2021) and Hydrosimulations, 2018 and Heritage Computing, 2009. The model extends approximately 52 km from west to east and approximately 43 km from north to south, covering an area of approximately 2,070 km^2, centred on the Appin Mine. The model consists of 18 layers, simulating extraction from the Bulli Seam and potential impacts in the overlying hydrostratigraphy.

Based on the groundwater modelling, there is expected to be:

- Peak mine inflows are not predicted to change when compared to the approved mining plan. Predicted inflows from Longwalls 709 to 711 and 905 will result in up to 0.43 ML/day (157.37 ML/year) of groundwater inflows;
- Regional depressurisation of aquifers beneath the Bald Hill Claystone, including the Lower HBSS, Bulgo Sandstone and Scarborough Sandstone is likely to occur. Depressurisation is predicted to extend up to 1.7 km from the proposed longwall panels. The extent and magnitude of depressurisation is consistent with previous predictions by Heritage Computing (2009);
- There is negligible predicted impacts on surface water bodies including stream inflows due to depressurisation of the coal measures. This is because there is no predicted depressurisation within the upper layers, above the Bald Hill Claystone to induce downward seepage or reduce baseflow contributions;
- Within the 49 registered bores within a 5 km radius of the Project there will be some predicted depressurisation ranging from negligible depressurisation within the shallow strata up to 122 m of depressurisation predicted in a bore within the Bulgo Sandstone above Longwall 707. Depressurisation within the HBSS is predicted to range between 4 and 24 m depending on the distance from the longwall panels. The predicted impacts on landholder bores are consistent with previous predictions by Heritage Computing (2009) for BSO;
- The Project does not include any surface activities or direct abstraction or interaction with the HBSS groundwater source. Therefore, impacts on the water quality within the HBSS are unlikely. Although there is limited data on water quality within the coal measures at Appin, ongoing monitoring of site mine water representative of the Permian coal measures is recommended; and
- The groundwater data analysis, based on currently available records, has shown that there are no observed material impacts from longwall mining beyond what was foreseen for the cumulative impacts described in the BSO study by Heritage Computing (2009).

A groundwater monitoring program is recommended in accordance with a Groundwater Monitoring Plan (GWMP) that will be prepared in consultation with the regulator. The GWMP will include details on how, when and what groundwater parameters will be monitored across the Project area and surrounds. Monitoring will include groundwater level monitoring of mine bores and landowner bores (subject to gaining access), groundwater and surface water quality monitoring, with results compared to trigger levels to assist in recommending any additional management or mitigation measures.

7 References

AGL, 2013. Hydrogeological Summary of the Camden Gas Project area, January 2013.

AGL, 2018. Groundwater Management Plan for the Camden Gas Project report – version 5.0, DCS_CM_MP_HSE_023, July 2018.

Barnett, B., Townley, L.R., Post, V., Evans, R.E., Hunt, R.J., Peeters, L., Richardson, S., Werner, A.D., Knapton, A. and Boronkay, A., 2012. Australian Groundwater Modelling Guidelines. Waterlines Report Series No. 82, June 2012.

Bureau of Meteorology (BoM), 2013, Weather and Climate data, http://www.bom.gov.au/climate/data, Accessed March 2020.

BoM Drought Statement, Drought and Rainfall deficiencies, http://www.bom.gov.au/climate/drought/, issued 6 December 2021.

CSIRO, 2015; Soil and Landscape Grid National Soil Attribute Maps – Depth of Regolith. https://data.csiro.au/collections/collection/CIcsiro:11393v1#collection/CIcsiro:11393v006.

Ditton, S. and Merrick, N, 2014, A New Subsurface Fracture Height Prediction Model for Longwall Mines in the NSW Coalfields. Geological Society of Australia, 2014 Australian Earth Sciences Convention (AESC), Sustainable Australia. Abstract No 03EGE-03 of the 22nd Australian Geological Convention, Newcastle City Hall and Civic Theatre, Newcastle, New South Wales. July 7 - 10. Page 136.

Harries, 1997. Acid mine drainage in Australia: Its extent and potential future liability. Department of the Environment. 1997

Heritage Computing 2009, Bulli Seam Operations Groundwater Assessment, A Hydrogeological Assessment in support of the Bulli Seam Operations Environmental Assessment for Illawarra Coal Holdings Pty Ltd, HC2009/5, July 2009

HGEO,2019. Investigation into the height of fracturing above extracted longwalls in Area 3, Dendrobium. Report January 2020.

Holla and Barclay 2000, subsidence in the southern coalfield, NSW, Australia. New South Wales Dept. of Mineral Resources

HydroSimulations 2018; Appin Mine inflow report to estimate altered groundwater ingress into updated Appin Mine Area 7 and 9 mine plan proposed long walls. Report No HS2018/20, dated 10 April.

MSEC 2021; Subsidence Predictions and Impact Assessments, Subsidence Predictions and Impact Assessments for the Natural and Built Features due to the Extraction of the Proposed Longwalls 709, 710A, 710B, 711 and 905 at Appin Colliery, prepared for Illawarra Metallurgical Coal, dated July.

Moffitt, R.S., 1999. Southern Coalfield Regional Geology Map, 1:100,000, First Edition. Geological Survey of NSW, Sydney

Price and Wright, 2016. Water Quality Impact from the Discharge of Coal Mine Wastes to Receiving Streams: Comparison of Impacts from an Active Mine with a Closed Mine. Water, Air and Soil Pollution 2016.

Rumbaugh J.O and Rumbaugh D.B., 2011; Tutorial Manual for Groundwater Vistas, Version 6. Environmental Simulations.

SILO-Australian climate data from 1889 to yesterday, rainfall and Potential Evaporation, https://www.longpaddock.qld.gov.au/silo/point-data, Accessed June 2020.

SLR, 2021a, APPIN MINE EXTRACTION PLAN Groundwater Impact Assessment, Report reference 665.10015-R01 Version No: -v5.0 April 2021

SLR, 2021b, APPIN MINE CLOSURE PLAN Numerical Groundwater Modelling, report reference 665.10015.00002-R03 Version No: -v4.0, June 2021

South32, 2019, Lot 22 DP803255 110 McWilliam Drive, Douglas Park Illawarra Coal Post-Property Inspection June 2019.

State of Queensland, 2020. SILO (Scientific Information for Land Owners) database of Australian climate data. © The State of Queensland 1995 - 2020, https://silo.longpaddock.qld.gov.au, Accessed March 2020.

Wright I.A., Paciuszkiewicz K. and Belmer N.,2018. Increased Water Pollution After Closure of Australia's Longest Operating Underground Coal Mine: a 13-Month Study of Mine Drainage, Water Chemistry and River Ecology. Water, Air Soil Pollutant 229, 55.

APPENDIX A

Groundwater Monitoring Network

Mine Bore ID	Site ID	Type (Status)	Easting (m)	Northing (m)	Ground Level (mAHD)	Sensor/ Screen Depth (mbgl)	Stratigraphy	Data Range
S1913	Appin West (EAW5)	VWP (EX)	289028	6218729	117.04	65	HBSS	2008 – 2021
						137	HBSS	2008 – 2021
						194	HBSS	2008 – 2021
						274	BGSS	2008 – 2021
						358	BGSS	2008 – 2021
						447	BGSS	2008 – 2021
						473	SBSS	2008 – 2021
						486	SBSS	2008 – 2021
						505	SBSS	2008 – 2021
						559.5	BUCO	2008 – 2021
S1936	Appin West 07 (EAW7)	VWP (AD)	291547	6217768	148.14	65	HBSS	2008 - 2021
						123.8	HBSS	2008 - 2014
						192	HBSS	2008 - 2014
						278	BGSS	2008 - 2014
						347.8	BGSS	2008 - 2014
						422.5	BGSS	2008 - 2014
						456.2	SBSS	2008 - 2014
						462.1	SBSS	2008 - 2014
						468	SBSS	2008 - 2014
						556.1	BUCO	2008 - 2012
S1941	Appin West 09 (EAW9)	VWP (EX)	287181	6216341	148.82	65	HBSS	2009 - 2021
						126.5	HBSS	2009 - 2021
						201.6	HBSS	2009 - 2021
						284.3	BGSS	2009 - 2021
						355.7	BGSS	2009 - 2021
						432	BGSS	2009 - 2021
						463	SBSS	2009 - 2021
						472.8	SBSS	2009 - 2021
						487.5	SBSS	2009 - 2021
						555.4	BUCO	2009 - 2021
						596	WWCO	2009 - 2014
S1954	Appin West 18 (EAW18)	VWP (EX)	285466	6216904	310	36	BrSh	2009 - 2021
						85	BrSh	2009 - 2021
						100.5	BrSh	2009 - 2021
						138.5	UnSS	2009 - 2021
						145.3	UnSS	2009 - 2021
						181	AsSh	2009 - 2021
						205	AsSh	2009 - 2012
						245	HBSS	2009 - 2021
						273.1	HBSS	2009 - 2021
						316.3	HBSS	2009 - 2021
						359.4	HBSS	2009 - 2021
						392.5	HBSS	2009 - 2021
						742.9	BUCO	2009 - 2021
S1993	West Cliff	VWP (EX)	296778	6217610	164.39	35	HBSS	2009 - 2021
						86.5	HBSS	2009 - 2021
						168	HBSS	2009 - 2021
						230.9	BGSS	2009 - 2021
						319	BGSS	2009 - 2021
						412	BGSS	2009 - 2021
						435	SBSS	2009 - 2021
						441.5	SBSS	2009 - 2021
						448	SBSS	2009 - 2021
						508.2	BUCO	AD

Mine Bore ID	Site ID	Type (Status)	Easting (m)	Northing (m)	Ground Level (mAHD)	Sensor/ Screen Depth (mbgl)	Stratigraphy	Data Range
S1996	North to Cataract Lake	VWP (EX)	298772	6207843	381.65	82	HBSS	2010 - 2020
						159	HBSS	
						219	BGSS	
						274	BGSS	
						313	BGSS	
						355	SBSS	
						373	SBSS	
						380	SBSS	
						439	CCSS	
						478	BUCO	
S1997	West to Metropolitan Mine	VWP (EX)	306997	6212764	370.17	24	HBSS	2010 - 2021
						68.5	HBSS	
						132	HBSS	
						218	BGSS	
						292.5	BGSS	
						372	BGSS	
						429	SBSS	
						441.5	SBSS	
						454	SBSS	
						504.5	CCSS	
						511.63	BUCO	
S2036	North to Cataract Lake	VWP (EX)	300016	6206725.5	358.76	374.2	BUCO	2017 - 2021
						411.2	WWCO	
S2040	Appin Area 9	VWP (AD)	284789	6218183	251.45	773	BUCO	2009 - 2014
S2057	North to Appin Area 9	VWP (AD)	284047	6221149	137.4	691	LDSS	2010 - 2014
S2060	Appin West 51	VWP (EX)	288629.07	6215791.6	202.46	110	HBSS	2010 - 2019
						267	HBSS	2010 - 2019
						327	BGSS	2010 - 2019
						495	BGSS	2010 - 2019
						603.9	BUCO	2010 - 2019
						614.6	BACO	2010 - 2019
						626.7	CHCO	2010 - 2019
						645.7	WWCO_upper	2010 - 2014
						651.1	WWCO_Base	2010 - 2014
						663.1	ACCO	2010 - 2016
						668.5	ACFM	2010 - 2014
						706.3	TGCO	2010 - 2015
S2080	Appin West 58 (EAW58)	VWP (EX)	297111	6216174	125.9	65	HBSS	2010 - 2021
						95	HBSS	
						170	HBSS	
						241	BGSS	
						326.5	BGSS	
						417	BGSS	
						440	SBSS	
						447	SBSS	
						454	SBSS	
						499	CCSS	
S2087	West Cliff	VWP (AD)	295752	6217627.5	192.97	55	HBSS	2010 - 2021
						95	HBSS	2010 - 2021
						185	HBSS	2010
						238	BGSS	2010 - 2021
						313.5	BGSS	2010
						394	BGSS	2010

Mine Bore ID	Site ID	Type (Status)	Easting (m)	Northing (m)	Ground Level (mAHD)	Sensor/ Screen Depth (mbgl)	Stratigraphy	Data Range
						419	SBSS	2010
						440	SBSS	2010
S2149	Appin Area 8	VWP (EX)	282415	6215044	153.46	65	HBSS	2011 - 2021
						121.5	HBSS	
						203	HBSS	
						262	BGSS	
						326	BGSS	
						395	BGSS	
						429.5	SBSS	
						515.7	BUCO	
						525.4	BACO	
						541.4	CHCO	
S2157	Appin Area 8	VWP (AD)	283212	6215968	224.45	82.5	WNSH	2013 - 2021
						135	HBSS	
						207	HBSS	
						284	HBSS	
						368	BGSS	
						418	BGSS	
						468	BGSS	
						518	SPCS	
						568	SBSS	
						626.9	BUCO	
S2158	Appin Area 8	VWP (EX)	283778	6212690	138.92	44	HBSS	2012 - 2021
						65	HBSS	
						111.6	HBSS	
						158.2	HBSS	
						218.9	BGSS	
						295.4	BGSS	
						377	BGSS	
						404	SBSS	
						473	BUCO	
						511	UWWCO	
						516.5	LWWCO	
						528	ACCO	
S2160	Appin Area 8	VWP (AD)	284717	6213651	133.4	44	HBSS	2012 - 2021
						87	HBSS	
						164	HBSS	
						226	BGSS	
						273	BGSS	
						320.5	BGSS	
						367.8	SPCS	
						415	SBSS	
						479.6	BUCO	
						486	BACO	
S2165	North to Appin Area 7	VWP (EX)	288766	6226269	66.95	40	WNSH	2012 - 2021
						116	HBSS	
						112	HBSS	
						168.5	HBSS	
						257	HBSS	
						328	BGSS	
						414.2	BGSS	
						500.4	BGSS	
						586.5	SPCS	
						672.7	SBSS	

Mine Bore ID	Site ID	Type (Status)	Easting (m)	Northing (m)	Ground Level (mAHD)	Sensor/ Screen Depth (mbgl)	Stratigraphy	Data Range
						694.7	BUCO	
						713.6	BACO	
						765	WWCO	
S2173	North to Appin Area 7	VWP (EX)	287589	6223237	110.22	76	WNSH	2012 - 2020
						91.5	WNSH	
						116	HBSS	
						198	HBSS	
						285	HBSS	
						369	BGSS	
						451	BGSS	
						533	BGSS	
						554	SPCS	
						596.8	SBSS	
S2177	Appin Area 10	VWP (EX)	291122	6225144	70	44	HBSS	2013 - 2021
						80	HBSS	
						150.2	HBSS	
						220.3	HBSS	
						283.6	BGSS	
						358.9	BGSS	
						434.2	BGSS	
						462.1	SPCS	
						510	SBSS	
						621.1	BUCO	
S2280	Harris Creek 6	VWP (EX)	296752	6216617	129.86	60	HBSS	2014 - 2021
						99	HBSS	2014 - 2021
S2281	Harris Creek 7	VWP (EX)	289028	6218729	125.15	61	HBSS	2014 - 2021
						99	HBSS	2014 - 2021
S2282	Harris Creek	VWP (EX)	288787	6215032	133.01	60	HBSS	2014 - 2021
						100	HBSS	2014 - 2021
S2283	Harris Creek	VWP (EX)	288999	6214636	127.1	60	HBSS	2015 - 2021
						100	HBSS	2015 - 2021
S2284	Harris Creek	VWP (EX)	289176	6214454	110.45	60	HBSS	2015 - 2021
						100	HBSS	2015 - 2021
S2285	Harris Creek	VWP (EX)	289248	6214558	113.33	60	HBSS	2015 - 2021
						100	HBSS	2015 - 2021
S2286	Harris Creek	VWP (EX)	289329	6214721	114.55	60	HBSS	2015 - 2021
						100	HBSS	2015 - 2021
WC_54	West Cliff Area 5	MB (EX)	291547	6217768	206.49	46.8	HBSS	2014 - 2020
WC_95	West Cliff Area 5	MB (EX)	287181	6216341	228.68	20.24	HBSS	2014 - 2020
A3GW1	A3GW1a	MB (AD)	292997	6210540	209.4	62	HBSS	2006 - 2011
	A3GW1b					38.5	HBSS	2005 - 2012
	A3GW1c					9.9	HBSS	2005 - 2012
A3GW2	A3GW2a	MB (AD)	293674	6210776	215	59.6	HBSS	2006 - 2012
	A3GW2b					28.3	HBSS	2006 - 2012
	A3GW2c					9.9	HBSS	2006 - 2012
A3GW3	A3GW3a	MB (AD)	293974	6210832	219.7	70	HBSS	2006 - 2012
	A3GW3b					27	HBSS	2006 - 2010
	A3GW3c					9.9	HBSS	2006 - 2012
A3GW4	A3GW4a	MB (AD)	293640	6209537	236	84	HBSS	2005 - 2012
	A3GW4b					29.9	HBSS	2005 - 2012
A3GW5	A3GW5a	MB (AD)	294222	6210572	228.1	77	HBSS	2006 - 2010
	A3GW5b					50.75	HBSS	2006 - 2011

Mine Bore ID	Site ID	Type (Status)	Easting (m)	Northing (m)	Ground Level (mAHD)	Sensor/ Screen Depth (mbgl)	Stratigraphy	Data Range
	A3GW5c					10	HBSS	2006 - 2011
A3GW6	A3GW6a	MB (AD)	294482	6209688	240.9	74.5	HBSS	2006 - 2012
	A3GW6b					47.5	HBSS	2006 - 2012
	A3GW6c					9.85	HBSS	2006 - 2012
A3GW7	A3GW7a	MB (AD)	292988	6210942	226.6	75	HBSS	2006 - 2011
	A3GW7b					56.5	HBSS	2006 - 2011
	A3GW7c					25	HBSS	2006 - 2012
A3GW8	A3GW8a	MB (AD)	293646	6209862	228.5	53	HBSS	2005 - 2012
	A3GW8b					22.8	HBSS	2005 - 2012
	A3GW8c					8.3	HBSS	2005 - 2012
GR27	S1428	MB (AD)	297111	6216174	217.57	30.1	HBSS	2001 - 2020
GR28	S1429	MB (AD)	296752	6216617	206.9	24.31	HBSS	2001 - 2020
GR59	S1481	MB (AD)	296850	6213349	227.95	-	-	2002 - 2011
GR60	S1482	MB (AD)	296865	6213317	227.97	-	-	2002 - 2011
GR61	S1483	MB (AD)	296863	6213272	227.3	-	-	2002 - 2011
GR62	S1484	MB (AD)	296854	6213250	224.11	-	-	2002 - 2011
GR63	S1485	MB (AD)	296860	6213185	225.75	-	-	2002 - 2011
GR64	S1486	MB (AD)	296873	6213409	234.12	-	-	2002 - 2011
GR70	-	MB	296778	6217610	186.54	28.88	HBSS	2014 - 2019
NGW3	-	MB (AD)	6216750	275027	123.087	72.1	Shale / sandstone	2004 - 2015
NGW4	-	MB (AD)	6216826	275790	125.244	78.75	Sandstone	2004 - 2015
NGW5	-	MB (AD)	6216327	276124	110.85	66.45	Sandstone	2004 - 2015
NGW6	-	MB (AD)	6216681	276403	116.45	66.75	Sandstone	2004 - 2015
NGW7	-	MB (AD)	6216591	277027	124.333	69.18	Sandstone	2004 - 2013
NGW9	-	MB (AD)	6217131	277737	124.333	69.19	Sandstone	2004 - 2012
NGW10	-	MB (AD)	6217333	276952	123.252	69.5	Sandstone	2004 - 2013
NGW11	-	MB (AD)	6217625	277105	127.336	72.15	Sandstone	2004 - 2013

Coordinates in metres (GDA94 - MGA zone 56) monitoring bore/open standpipe
GW – Georges River Bores
HBSS – Hawkesbury Sandstone
BUCO – Bulli Coal Seam
UnSS – Wianamatta - Minchinbury Sandstone
LDSS – Loddon Sandstone

VWP – Vibrating Wire Piezometer
EX – Existing
AGW – Cataract River Bores
BGSS – Bulgo Sandstone
WWCO - Wongawilli Coal Seam
AsSh – Wianamatta – Ashfield Shale

MB – monitoring bore/open standpipe MB – AD – abandoned and destroyed
NGW – Nepean River Bores
SBSS – Scarborough Sandstone
BrSh – Wianamatta (WnSh)– Bringelly Shale
CCSS – Coal Cliff Sandstone

APPENDIX B

Water Quality Data

Analyte		NHMRC Drinking water	ANZECC (2000) Fresh Water Aquatic	ANZECC (2000) Short term irrigation	ANZECC (2000) Long term irrigation	ANZECC (2000) Stock Water	Nepean River (Surface water)	Wianamatta Group	Hawkesbury Sandstone	Bulgo Sandstone
pH (Field)	Av.						7.7	8.1	8.0	7.4
	Med.						7.7	7.9	7.5	7.2
	Min.	6.5 - 8.5b	6.5 – 8.5	6.0 - 8.5	6.0 - 8.5	-	5.6	7.1	4.8	4.2
	Max.						9.8	9.7	13.1	12.8
	Pop.						3561	19	205.0	48.0
EC (Field)	Av.						321	4354	2653	4379
	Med.						244	4750	2063	4950
	Min.	-	120 - 300	-	-	-	12	7	7	7
	Max.						5596	9310	15820	10070
	Pop.						3575	19	206	48
TDS	Av.						173	2917^	1778^	2934^
	Med.						135	3183^	1382^	3317^
	Min.	600b	-	-	-	3,000 - 13,000*	10	5^	5^	4^
	Max.						1460	6238^	10599^	6747^
	Pop.						1738	19	206	48
Chloride	Av.						41	979	548	114
	Med.						33	675	233	122
	Min.	250b	-	-	-	-	14	289	22	16
	Max.						724	2820	8530	332
	Pop.						1761	23	213	60
Calcium	Av.						5	42	76	60
	Med.						4	36	70	50
	Min.	-	-	-	-	1,000	1	7	1	1
	Max.						83	108	384	190
	Pop.						1763	23	212	60
Sodium	Av.						48	1018	336	1203
	Med.						34	1050	261	1300
	Min.	180b	-	-	-	-	11	162	20	63
	Max.						362	1930	1390	2230
	Pop.						1763	23	213	60
Magnesium	Av.						5	15	52	24
	Med.						4	14	30	22
	Min.	-	-	-	-	-	1	6	1	4
	Max.						112	34	332	48
	Pop.						1763	23	194	60

Analyte		NHMRC Drinking water	ANZECC (2000) Fresh Water Aquatic	ANZECC (2000) Short term irrigation	ANZECC (2000) Long term irrigation	ANZECC (2000) Stock Water	Nepean River (Surface water)	Wianamatta Group	Hawkesbury Sandstone	Bulgo Sandstone
Sulphate	Av.	500a / 250b	-	-	-	1,000 – 2,400 (pigs)	5	2	11	5
	Med.						4	1	5	3
	Min.						1	1	2	2
	Max.						100	4	38	9
	Pop.						252	3	13	3
Potassium	Av.	-	-	-	-	-	4	36	151	33
	Med.						3	23	16	29
	Min.						1	11	3	3
	Max.						17	318	7190	106
	Pop.						1763	23	213	60
Fluoride	Av.	1.5a	-	2	1	2	0.2	0.5	0.2	0.2
	Med.						0.1	0.5	0.2	0.2
	Min.						0.1	0.2	0.1	0.1
	Max.						0.3	0.9	1.3	0.6
	Pop.						201	7	68.0	24.0
Bicarbonate	Av.	-	-	-	-	-	81	1140	540	2834
	Med.						55	789	374	2900
	Min.						1	252	29	1360
	Max.						399	2810	2570	4430
	Pop.						1754	1140	540	2834
Iron (t)	Av.	0.3b	-	10	0.2	-	0.3	1.5	2.0	3.8
	Med.						0.3	1.4	1.1	1.9
	Min.						0.01	0.01	0.03	0.03
	Max.						12.2	4	19	12
	Pop.						1766	20	186	55
Aluminium (d)	Av.	0.2b c	0.055	20	5	5	0.1	0.1	0.4	0.01
	Med.						0.1	0.03	0.02	0.01
	Min.						0.01	0.01	0.01	0.01
	Max.						5.2	0.5	7.6	0.2
	Pop.						1766	14	101	50
Arsenic (d)	Av.	0.01a	As (III) 0.024 As (V) 0.013	2	0.1	0.5	0.003	0.004	0.007	0.004
	Med.						0.001	0.002	0.003	0.003
	Min.						0.001	0.001	0.001	0.001
	Max.						0.2	0.010	0.061	0.013
	Pop.						1764	18	173	60

Analyte		NHMRC Drinking water	ANZECC (2000) Fresh Water Aquatic	ANZECC (2000) Short term irrigation	ANZECC (2000) Long term irrigation	ANZECC (2000) Stock Water	Nepean River (Surface water)	Wianamatta Group	Hawkesbury Sandstone	Bulgo Sandstone
Barium (d)	Av.	2a	-	-	-	-	0.2	7.2	2.3	16.8
	Med.						0.2	6.0	1.08	15.50
	Min.						0.1	3.1	0.03	0.4
	Max.						0.2	17.0	14.5	38.8
	Pop.						5.0	19	205	58
Boron (d)	Av.	4a	0.37	refer to guideline	0.5	7 (cattle)	0.2	-	-	-
	Med.						0.8	-	-	-
	Min.						0.0	-	-	-
	Max.						4.9	-	-	-
	Pop.						45.0	-	-	-
Cadmium (d)	Av.	0.002a	0.0002	0.05	0.01	0.01	0.0001	-	-	-
	Med.						0.0001	-	-	-
	Min.						0.0001	-	-	-
	Max.						0.0001	-	-	-
	Pop.						2.0	-	-	-
Chromium (d)	Av.	0.05a	CrIII – ID Cr(VI) 0.001	1	0.1	1	0.001	-	-	-
	Med.						0.001	-	-	-
	Min.						0.001	-	-	-
	Max.						0.001	-	-	-
	Pop.						2	-	-	-
Copper (d)	Av.	2a / 1b	0.0014	5	0.2	1 (cattle)	0.001	0.001	0.002	0.007
	Med.						0.001	0.001	0.002	0.001
	Min.						0.001	0.001	0.001	0.001
	Max.						0.03	0.005	0.006	0.17
	Pop.						1764	16	18	31
Iron (d)	Av.	-	-	-	-	-	0.3	-	-	-
	Med.						0.3	-	-	-
	Min.						0.0	-	-	-
	Max.						12.2	-	-	-
	Pop.						1766	-	-	-
Lead (d)	Av.	0.01a	0.0034	5	2	0.1	0.001	0.04	0.24	0.7
	Med.						0.001	0.001	0.04	0.7
	Min.						0.001	0.001	0.001	0
	Max.						0.05	0.7	1.4	1.4
	Pop.						1764	16	7	2

Analyte		NHMRC Drinking water	ANZECC (2000) Fresh Water Aquatic	ANZECC (2000) Short term irrigation	ANZECC (2000) Long term irrigation	ANZECC (2000) Stock Water	Nepean River (Surface water)	Wianamatta Group	Hawkesbury Sandstone	Bulgo Sandstone
Manganese (d)	Av.	0.5a / 0.1b	1.9	10	0.2	-	0.04	0.1	0.1	0.04
	Med.						0.03	0.03	0.1	0.02
	Min.						0.001	0.01	0.001	0.001
	Max.						1.6	0.3	0.7	0.5
	Pop.						1766	18	145	45
Mercury (d)	Av.	-	0.0006	0.002	0.002	0.002	0.0001	-	-	-
	Med.						0.0001	-	-	-
	Min.						0.0001	-	-	-
	Max.						0.0001	-	-	-
	Pop.						2	-	-	-
Nickel (d)	Av.	0.02a	0.011	2	0.2	1	0.006	0.001	0.005	0.003
	Med.						0.003	0.001	0.002	0.002
	Min.						0.001	0.001	0.001	0.001
	Max.						0.1	0.002	0.09	0.02
	Pop.						1764	20	136	47
Selenium (d)	Av.	0.01a	Total – 0.011 SeIIV - ID	0.05	0.02	0.02	0.01	0.01	0.009	0.007
	Med.						0.01	0.01	0.01	0.009
	Min.						0.02	0.005	0.006	0.001
	Max.						0.1	0.01	0.01	0.01
	Pop.						1764	16	3	3
Zinc (d)	Av.	3b	0.008	2	2	20	0.01	0.14	0.044	0.058
	Med.						0.01	0.006	0.003	0.010
	Min.						0.004	0.003	0.003	0.001
	Max.						0.24	2.5	1.4	2.4
	Pop.						1764	20	116	54

Note Values below the limit of reporting were set at the limit for the calculations

* Maximum concentration at which good condition might be expected, with 13,000 mg/L for sheep, 5,000 mg/L for beef cattle, 4,000 mg/L for dairy cattle, 6,000 mg/L for horses and 3,000 mg/L for pigs and poultry.

a NHMRC Health Guidelines for Drinking Water (2015)

b NHMRC Aesthetic Guidelines for Drinking Water (2015)

c NHMRC acid-soluble aluminium concentrations (2015)

(d) dissolved metals

Av. Average; Med. Median

^ Calculated based on field EC

APPENDIX C

Registered Bores in the Appin Mine Area

Bore ID	Easting	Northing	Elevation (mAHD)	Year Drilled	Total Depth (mbgl)	Screen (mbgl)	SWL (mbgl)	EC/ Salinity	Status	Use	Geology	Comment
GW017315	286642	6220354	140.51	1938	36.5	OH (0.9 – TD)	-	3001-7000 ppm	Current	Farming – General Use	-	-
GW026516	289037	6220994	96.21	1965	10	-	-	-	Test Hole (Unknown)	Irrigation	Unconsolidated Clay, Silt and Shale	WBZ 4.5 m (Clay)
GW034425	289184	6215603	121	1972	70.1	OH (12 – TD)	-	Good	non-operational	Waste Disposal	Sandstone	WBZ (Sandstone) 9.1 - 10.6 m (SWL 4.7 m, Yield 0.03 L/s) WBZ (Sandstone) 21.3 - 24.3 m (SWL 14.6 m, Yield 0.04 L/s) WBZ (Sandstone) 64 - 69.4 m (SWL 14.6 m, Yield 0.63 L/s)
GW035033	288045	6214961	129.67	1973	131	OH (20.4 – TD)	-	-	Current	Stock	Sandstone and Shale	WBZ (Sandstone/Shale) 17.6 - 17.7 m (SWL 17.6 m, Yield 0.13 L/s) WBZ (Sandstone) 54.8 - 55.1 m (SWL 54.8 m, Yield 0.23 L/s)
GW062945	287960	6221031	115.28	1986	150	OH (86.9 – TD)	-	Fresh	Current	Stock, Domestic and Farming	Sandstone	WBZ (Fractured Shale) 29.6 - 30.8 m (SWL 15 m, Yield 1.2 L/s) WBZ (Sandstone) 101.3 - 101.7 m (SWL 85 m, Yield 0.2 L/s) WBZ (Sandstone) 144.8 - 145.9 m (SWL 40 m, Yield 0.7 L/s)
GW072196	288911	6218867	118.01	2006	-	-	-	-	Current	Domestic	-	Drilled in mapped alluvium (NGIS) potentially in HBSS
GW072874	288601	6217630	140.9	1992	189	OH (45 – TD)	-	Good	Current	Stock and Domestic	Sandstone, Shale and Siltstone	WBZ (Gravels) 6 - 7 m (Yield 0.2 L/s) WBZ (Shale) 30 - 36 m (Yield 0.1 L/s) WBZ (Sandstone) 80 - 85 m (Yield 0.3 L/s) WBZ (Siltstone) 98 - 104 m (Yield 0.1 L/s) WBZ (Sandstone) 164 - 170 m (Yield 0.2 L/s) WBZ (Sandstone) 176 - 189 m (Yield 1.4 L/s)

Bore ID	Easting	Northing	Elevation (mAHD)	Year Drilled	Total Depth (mbgl)	Screen (mbgl)	SWL (mbgl)	EC/ Salinity	Status	Use	Geology	Comment
GW100289	288686	6218937	124.22	1994	30	Slots (12 – 18) OH (18 - TD)	10	Good	Current	Stock and Domestic	Gravel (Slots) Shale (OH)	WBZ (Gravel) (Yield 0.3 L/s, SWL 10 m)
GW100673	286235	6216160	154.16	1995	104	-	49	Good	Current	Stock	-	Yield: 0.6 L/s (BH Reg), Work Summary (Unavailable)
GW101133	289443	6214100	117.02	1997	96	OH (5.5 – TD)	61	1100 mg/L	Current	Stock and Domestic	Sandstone, Ironstone and Siltstone	WBZ (Sandstone) 78.5 - 78.8 m (Yield 1.8 L/s, SWL 61 m)
GW101437	291642	6216361	135.89	1997	128	OH (6 – TD)	75	2500 mg/L	Current	Farming	Sandstone and Shale	WBZ (Sandstone and Shale) 119 – 121 m (Yield: 0.7 L/s, SWL 75 m, Salinity 2500 mg/L)
GW101986	288223	6217328	174.71	1998	210	OH (103 – TD)	82	-	Current	Stock and Domestic	Sandstone	WBZ (Sandstone) 119 - 120 m (SWL 82 m , Yield 0.25 L/s) WBZ (Sandstone) 132 - 133 m (SWL 82 m, Yield 0.31 L/s) WBZ (Sandstone) 146 - 148 m (SWL 82 m, Yield 0.05 L/s) WBZ (Sandstone) 173 - 179 m (SWL 82 m, Yield 0.05 L/s)
GW102043	289777	6214659	125.56	1999	192	OH (11.6 – TD)	104	260 mg/L	Current	Stock and Domestic	Sandstone, Siltstone and Clay	WBZ (Sandstone) 40 - 41 m (Yield 0.1 L/s, Salinity 291 mg/L) WBZ (Sandstone) 161.5 - 162 m (Yield 0.2 L/s, Salinity 260 mg/L)

Bore ID	Easting	Northing	Elevation (mAHD)	Year Drilled	Total Depth (mbgl)	Screen (mbgl)	SWL (mbgl)	EC/ Salinity	Status	Use	Geology	Comment
GW102144	285921	6221466	143.24	1992	182	OH (17 – TD)	6	-	Current	Stock and Domestic	Sandstone and Shale	NGIS reports northing as 6220466, BH Reg lists as 6221466 WBZ (Shale) 114 - 115 m (SWL 6 m, Yield 0.07 L/s) WBZ (Shale) 140 - 140.4 m (SWL 6 m, Yield 0.06 L/s) WBZ (Sandstone) 162 - 163 m (SWL 6 m, Yield 0.13 L/s) WBZ (Sandstone) 168 - 168.6 m (SWL 6 m, Yield 0.12 L/s)
GW102584	289626	6216445	136.76	1999	186	OH (29.5 – TD)	-	1300 mg/L	Grouted	Stock and Domestic	Sandstone	WBZ (Sandstone) 54 - 60 m (Yield 0.1 L/s, Salinity 1370 mg/L) WBZ (Sandstone) 64 - 70 m (Yield 0.1 L/s, Salinity 1190 mg/L) WBZ (Sandstone) 108 - 112 m (Yield 0.2 L/s, Salinity 1300 mg/L) WBZ (Sandstone) 144 - 150 m (Yield 0.2 L/s, Salinity 1300 mg/L, SWL 60 m) WBZ (Sandstone) 177 - 179 m (Yield 0.9 L/s, Salinity 1300 mg/L)
GW102619	287887	6220525	124.74	1999	224	OH (95 – TD)	95	-	Current	Stock, Domestic, Farming and Irrigation	Sandstone and Shale	WBZ (Sandstone) 38 - 39 m (Yield 0.13 L/s, SWL 24 m) WBZ (Sandstone) 81 - 83 m (Yield 0.75 L/s) WBZ (Shale) 145 - 150 m (Yield 0.25 L/s, SWL 95 m) WBZ (Sandstone) 165 - 200 m (Yield 0.75 L/s, SWL 95 m) WBZ (Sandstone) 200 - 225 m (Yield 0.75 L/s, SWL 95 m)
GW102798	289990	6214783	127.16	See comment	122	OH (3 – TD)	148	700 mg/L	Current	Farming, Stock and Domestic	Sandstone	WBZ (Sandstone) 95 - 96 m (Yield 0.25 L/s) WBZ (Sandstone) 103 - 104 m) (SWL 148 m, Yield 1 L/s, Salinity 700 mg/L)

Bore ID	Easting	Northing	Elevation (mAHD)	Year Drilled	Total Depth (mbgl)	Screen (mbgl)	SWL (mbgl)	EC/ Salinity	Status	Use	Geology	Comment
GW104068	289519	6214530	118.66	2001	180	OH (12 – TD)	62	1000 mg/L	Current	Stock and Domestic	Sandstone, Siltstone and Shale	WBZ (Sandstone) 95 - 118 m (Yield 0.52 L/s, Salinity 990 mg/L, SWL 62 m) WBZ (Sandstone) 152 - 153 m (Yield 0.26 L/s, Salinity 1000 mg/L, SWL 62 m) WBZ (Sandstone) 163 - 164 m (Yield 0.88 L/s, Salinity 1000 mg/L, SWL 62 m)
GW104154	291233	6216088	134.69	2000	165	OH (18 – TD)	74	-	Current	Stock and Domestic	Sandstone and Shale	WBZ (Sandstone) 116 - 117 m (Yield 0.7 L/s) WBZ (Sandstone) 134 - 135 m (Yield 0.9 L/s) WBZ (Sandstone) 160 - 161 m (Yield 1.3 L/s, SWL 74 m)
GW104347	284012	6217884	199.9	2002	298	OH (145 – TD)	110	Brackish	Current	Stock and Domestic	Sandstone	WBZ (Sandstone) 195 - 196 m (Yield 0.3 L/s, SWL 110 m) WBZ (Sandstone) 207 - 208 m (Yield 0.4 L/s, SWL 110 m) WBZ (Sandstone) 273 - 274 m (Yield 0.2 L/s, SWL 110 m)
GW104602	289054	6216338	133.52	Unknown	231	OH (101.5 – TD)	42	Fresh	Current	Stock	Sandstone and Clay	WBZ (Shale) 29.9 - 30 m (Yield 0.13 L/s, Salinity 2500 mg/L, SWL 27 m) WBZ (Sandstone) 161 - 161.5 m (Yield 0.75 L/s, SWL 42 m) WBZ (Sandstone) 213 - 213.15 m (Yield 0.75 L/s, SWL 42 m)
GW104661	289118	6216661	140.74	2003	219.3	OH (42 – TD)	68	Fresh	Grouted	Stock and Domestic	Sandstone	WBZ (Sandstone) 113 - 113.1 m (Yield 0.38 L/s, SWL 68 m) WBZ (Sandstone) 154 - 154.1 m (Yield 0.53 L/s, SWL 68 m) WBZ (Sandstone) 197 - 197.1 m (Yield 0.53 L/s, SWL 68 m) WBZ (Sandstone) 212 - 212.15 m (Yield 1.05 L/s, SWL 68 m)

Bore ID	Easting	Northing	Elevation (mAHD)	Year Drilled	Total Depth (mbgl)	Screen (mbgl)	SWL (mbgl)	EC/ Salinity	Status	Use	Geology	Comment
GW104766	287663	6220995	117.31	2002	192	OH (29.5 – TD)	82	662 mg/L	Current	Stock and Domestic	Sandstone and Shale	WBZ (Sandstone) 121.5 - 123 m (Yield 0.2 L/s, Salinity 860 mg/L) WBZ (Sandstone) 128.5 - 129 m (Yield 0.15 L/s, Salinity 850 mg/L) WBZ (Sandstone) 175 - 176 m (Yield 0.1 L/s, Salinity 740 mg/L) WBZ (Sandstone) 184 - 187 m (Yield 0.15 L/s, Salinity 662 mg/L, SWL 82 m)
GW105325	287685	6221474	111.02	2001	159	OH (122 - TD)	-	2000 mg/L	Current	Stock, Domestic and Recreation	Sandstone and Shale	WBZ (Shale) 72 - 73 m (Yield 0.3 L/s, Salinity 2000 mg/L) WBZ (Shale) 121 - 122 m (Yield 0.5 L/s, Salinity 1800 mg/L) WBZ (Sandstone) 130 - 137 m (Yield 1.2 L/s, Salinity 2000 mg/L)
GW105339	291919	6218356	129	2003	238	OH (30 – TD)	-	-	Grouted	Stock, Domestic and Recreation	Sandstone and Shale	WBZ (Sandstone) 139 - 140 m (Yield 0.25 L/s) WBZ (Sandstone) 183 - 184 m (Yield Unknown)
GW105376	289443	6218380	151.54	2002	218.5	OH (102 – TD)	76	Fresh	Current	Stock and Domestic	Sandstone	WBZ (Sandstone) 180 - 180.1 m (Yield 1.13 L/s, SWL 76 m) WBZ (Sandstone) 191 - 191.2 m (Yield 1.63 L/s, SWL 76 m) WBZ (Sandstone) 204 - 204.2 m (Yield 1.5 L/s, SWL 76 m)
GW105531	287664	6218430	150.51	2003	210	OH (33 – TD)	79	2070 mg/L	Current	Stock and Domestic	Sandstone and Shale	WBZ (Sandstone) 96.2 - 96.8 m (Yield 0.2 L/s, Salinity 2070 mg/L) WBZ (Sandstone) 110.5 - 113 m (Yield 0.20 L/s, Salinity 2450 mg/L) WBZ (Sandstone) 175.5 - 177 m (Yield 0.15 L/s, Salinity 2190 mg/L) WBZ (Sandstone) 188 - 188.2 m (Yield 0.15 L/s, Salinity 2070 mg/L)

Bore ID	Easting	Northing	Elevation (mAHD)	Year Drilled	Total Depth (mbgl)	Screen (mbgl)	SWL (mbgl)	EC/ Salinity	Status	Use	Geology	Comment
GW105534	288655	6217297	167.82	1905	See comment	OH (72 – TD)	92	Fresh	Current	Stock and Domestic	Sandstone and Slate	NGIS lists -total depth as 207, BH Reg lists as 201 WBZ (Sandstone) 113 - 113.1 m (Yield 0.1 L/s, SWL 92 m) WBZ (Sandstone) 161 - 161.1 m (Yield 0.5 L/s, SWL 92 m) WBZ (Sandstone) 188 - 188.1 m (Yield 0.68 L/s, SWL 92 m) WBZ (Sandstone) 197 - 197.1 m (Yield 0.42 L/s, SWL 92 m)
GW105574	289656	6218908	125.42	2003	210	OH (Surface – TD)	-	3630	Current	Stock and Domestic	Sandstone, Clay and Shale	WBZ (Shale) 27 - 28.5 m (Yield 0.5 L/s, Salinity 2960 mg/L) WBZ (Sandstone) 85 - 86 m (Yield 0.5 L/s, Salinity 2840 mg/L) WBZ (Shale) 145 - 147 m (Yield 0.45 L/s, Salinity 3630 mg/L)
GW105942	282545	6218791	307.01	2002	214	OH (Surface – TD)	11	Fresh	Unknown	Test Bore	Shale and Clay	WBZ (Shale) 18 - 18.1 m (Yield 0.03 L/s, SWL 11 m) WBZ (Shale) 64 - 64.1 m (Yield 0.13 L/s, SWL 11 m)
GW106574	290123	6218350	140.52	2002	238	OH (6 – TD)	-	3000 mg/L	Grouted	Domestic	Sandstone and Shale	WBZ (Sandstone) 115 - 116 m (Yield 0.2 L/s, Salinity 1400 mg/L) WBZ (Sandstone) 133 - 114 m (Yield 0.55 L/s, Salinity 3000 mg/L)
GW106675	288797	6218642	124.43	2003	183	OH (43 – TD)	20	Fresh	Current	Stock and Domestic	Sandstone and Shale	WBZ (Sandstone) 60 - 60.1 m (Yield 1 L/s, SWL 42 m) WBZ (Sandstone) 83 - 83.1 m (Yield 0.9 L/s, SWL 42 m) WBZ (Sandstone) 145 - 145.1 m (Yield 1.1 L/s, SWL 42 m) WBZ (Sandstone) 162 - 162.15 m (Yield 1.05 L/s, SWL 42 m)

Bore ID	Easting	Northing	Elevation (mAHD)	Year Drilled	Total Depth (mbgl)	Screen (mbgl)	SWL (mbgl)	EC/ Salinity	Status	Use	Geology	Comment
GW107791	289415	6220392	114.32	2003	231	OH (81 – TD)	37	Fresh	Current	Stock and Domestic	Sandstone	WBZ (Sandstone) 128 - 128.2 m (Yield 0.85 L/s, SWL 37 m) WBZ (Sandstone) 151 - 151.1 m (Yield 0.28 L/s, SWL 37 m) WBZ (Sandstone) 162 - 162.1 m (Yield 0.15 L/s, SWL 37 m) WBZ (Sandstone) 217 - 217.2 m (Yield 0.53 L/s, SWL 37 m) WBZ (Sandstone) 222 - 222.25 m (Yield 1.2 L/s, SWL 37 m)
GW108193	282555	6218724	308.35	2002	214	OH (Surface – TD)	16	2800 mg/L	Unknown	Test Bore	Clay and Shale	WBZ (Shale) 17.8 - 18 m (Yield 0.03 L/s, SWL 16 m) WBZ (Shale) 63.8 - 64 m (Yield 0.13 L/s, SWL 16 m, Salinity 2800 mg/L)
GW108312	291534	6217750	144.97	2004	175	Slots (78 – 84 - No WBZ listed at this depth) OH (85 – TD)	84	500 mg/L	Current	Industrial	Sandstone (Slots and OH to TD)	WBZ (Sandstone) 119 - 120 m (Yield 0.1 L/s, SWL 84 m, Salinity 1200 mg/L) WBZ (Sandstone) 156 - 157 m (Yield 0.16 L/s, Salinity 500 mg/L)
GW108907	288602	6218547	125.78	2007	210	OH (72 – TD)	40	1200 mg/L	Current	Stock and Domestic	Sandstone and Shale	WBZ (Sandstone/Shale) 62 - 64 (Yield 0.8 L/s, Salinity 3000 mg/L) WBZ (Sandstone) 126 - 130 m (Yield 1 L/s, SWL 40 , Salinity 1830 mg/L) WBZ (Sandstone) 186 - 188 m (Yield 1.4 L/s, SWL 40 m, Salinity 1300 mg/L) WBZ (Shale) 206 - 208 m (Yield 1.8 L/s, SWL 40 m, Salinity 1200 mg/L)
GW108990	290347	6219588	108.75	2008	See comment	-	-	-	Current	Domestic	-	NGIS lists total depth as 150 m, BH Reg lists as 0;

Bore ID	Easting	Northing	Elevation (mAHD)	Year Drilled	Total Depth (mbgl)	Screen (mbgl)	SWL (mbgl)	EC/ Salinity	Status	Use	Geology	Comment
GW110550	283788	6218949	249.41	2009	See comment	OH (2.5 – TD)	200	670 mg/L	Current	Stock and Domestic	Sandstone and Shale	NGIS lists total depth as 336 m; BH Reg lists as 339 m WBZ (Sandstone) 277 - 279 m (Yield 0.5 L/s, Salinity 800 mg/L) WBZ (Sandstone) 310 - 312 m (Yield 0.6 L/s, Salinity 616 mg/L) WBZ (Sandstone) 320 - 322 m (Yield 0.75 L/s, SWL 200 m, Salinity 670 mg/L)
GW110671	288717	6216340	141.86	2010	240	OH (28 – TD)	82	400 mg/L	Current	Stock and Domestic	Sandstone, Shale and Granite	WBZ (Sandstone) 72 - 72.2 m (Yield 0.05 L/s, SWL 82 m, Salinity 400 mg/L) WBZ (Sandstone) 150 - 150.3 m (Yield 0.1 L/s) WBZ (Sandstone) 166 - 166.2 m (Yield 0.9 L/s) WBZ (Sandstone) 211 - 211.1 m (Yield 0.15 L/s)
GW111634	290819	6215923	128.36	2004	72.14	-	-	-	Active	Monitoring Bore	-	No construction or geology information
GW111636	291580	6216015	125.72	2004	78.75	-	-	-	Active	Monitoring Bore	-	No construction or geology information
GW111637	291924	6215523	115.57	2004	78.75	-	-	-	-	Monitoring Bore	-	No construction or geology information
GW111638	292197	6215881	119.03	2004	78.75	-	-	-	-	Monitoring Bore	-	No construction or geology information
GW111727	287506	6221188	-	2004	261	OH (Surface – TD)	150	Salty	Current	Stock and Domestic	-	Yield: 1 L/s (BH Reg) No information on geology
GW111781	285334	6217542	-	2005	305	OH (120 – TD)	185	Fresh	Current	Domestic	Sandstone	Yield: 1 L/s (BH Reg) WBZ (Sandstone) 243 - 243.05 m (Yield 0.2 L/s, SWL 185 m) WBZ (Sandstone) 283 - 283.01 m (Yield 1 L/s, SWL 185 m)

Bore ID	Easting	Northing	Elevation (mAHD)	Year Drilled	Total Depth (mbgl)	Screen (mbgl)	SWL (mbgl)	EC/ Salinity	Status	Use	Geology	Comment
GW112381	288743	6218191	-	2010	152	OH (72 – TD)	70	Fresh	Current	Stock and Domestic	Sandstone	WBZ (Sandstone) 102 - 102.5 m (Yield 0.1 L/s, SWL 70 m) WBZ (Sandstone) 142 - 142.05 m (Yield 0.5 L/s)
GW112437	288659	6215538	-	2010	156	OH (72 – TD)	63	1500 mg/L	Current	Stock and Domestic	Sandstone and Shale	WBZ (Sandstone) 50 - 50.05 m (Yield 0.25 L/s, SWL 63 m, Salinity 3200 mg/L) WBZ (Sandstone) 62 - 62.05 m (Yield 0.19 L/s, SWL 63 m, Salinity 3200 mg/L) WBZ (Sandstone) 141 - 141.5 m (Yield 1.9 L/s, SWL 63 m, Salinity 1500 mg/L)
GW112441	289940	6217284	-	2010	294	OH (60 – TD)	70	400	Grouted	Stock and Domestic	Sandstone	WBZ (Sandstone) 113 - 113.05 m (Yield 0.1 L/s, SWL 70 m, Salinity 400 mg/L) WBZ (Sandstone) 136 - 136.05 m (Yield 0.2 L/s) WBZ (Sandstone) 140 - 140.05 m (Yield 0.2 L/s) WBZ (Sandstone) 225 - 225.01 m (Yield 0.1 L/s)
GW112481	288663	6219694	-	2007	633.2	-	-	-	-	Industrial	-	No construction or geology information

Datum: GDA94/MGA Zone 56

OH – Open Hole TD – Total Depth WBZ – Water Bearing Zone

APPENDIX D

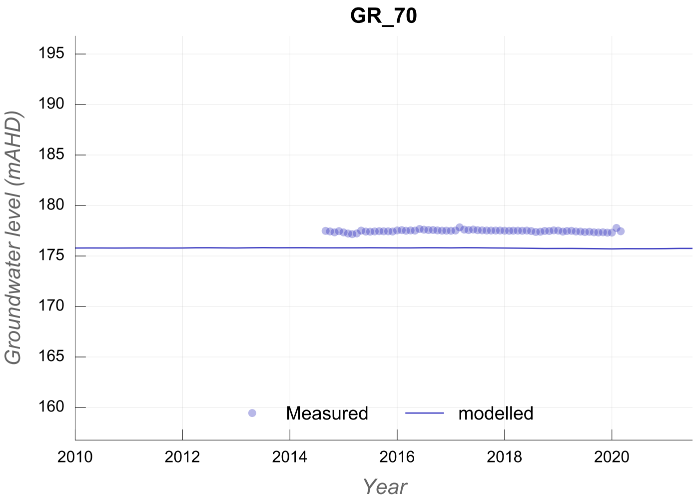
Calibration Hydrographs

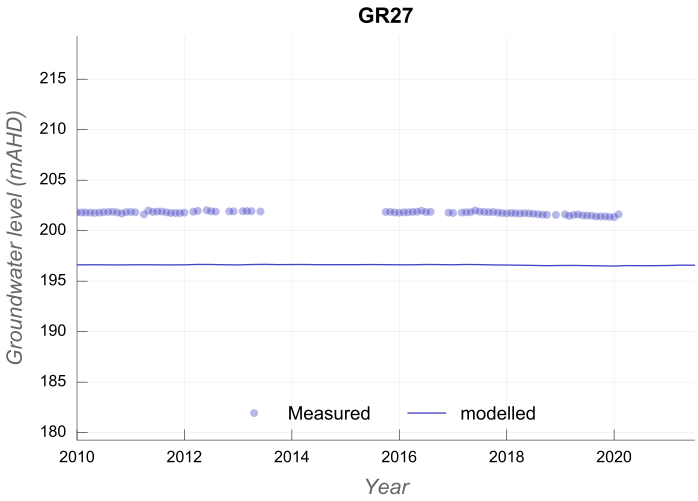
Bore	X	Y	Layer	Weight	Average Weighted Residual (m)
S2060_603.9	288629.067	6215791.598	15	1.0	-108.0
S1936_556	291547.29	6217767.82	15	1.0	-106.5
TNC36BUSM463.5	277268.6	6215382	15	0.5	-68.7
S2149_121	292995.4	6210539.6	5	1.0	-58.5
PM01_548	309971	6217271	14	0.5	-54.7
S1993_319	294585.041	6215806.125	8	0.8	-43.4
S1941_201	287180.737	6216340.979	5	1.0	-41.8
S1936_456	291547.29	6217767.82	11	1.0	-41.6
S1936_468	291547.29	6217767.82	12	1.0	-38.1
S1936_422	291547.29	6217767.82	9	1.0	-35.2
S1993_230	294585.041	6215806.125	7	0.8	-33.4
TBC040c_BHCS	275695.83	6204641.87	6	0.5	-31.5
S1941_65	287180.737	6216340.979	2	1.0	-30.7
9GGW2B_474	311734	6215359	15	0.5	-29.8
S2149_65	292997	6210539.5	4	1.0	-29.2
S2087_238	295752.14	6217627.53	7	0.5	-28.6
S2177_621	291122.95	6225144.48	15	0.5	-27.8
TNC43BUCO476.3	280076.55	6212671.35	15	0.5	-27.6
TBC12WWCO3.3	279039.5	6205549	17	0.5	-27.5
S2060_267	288629.067	6215791.598	5	0.9	-27.0
S1996_373	298772.256	6207843.316	11	0.8	-26.6
S2173_369	287589.99	6223237.03	7	1.0	-25.6
9GGW2B_437	311734	6215359	13	0.5	-24.5
NGW10	292733	6216545	3	1.0	-24.3
S2315_224	288186.55	6218050.77	5	1.0	-24.1
NGW7	292812	6215804	3	1.0	-23.8
TBC12BUCO	279039.5	6205549	15	0.5	-23.2
TBC33BHCS173	275193.79	6205394.75	6	0.5	-22.9
S1954_359	285466.001	6216903.707	5	1.0	-22.9
S2087_185	295752.14	6217627.53	5	0.5	-21.8
S1941_126	287180.737	6216340.979	4	1.0	-21.2
S2159	283040.28	6214662.99	15	1.0	-20.8
S2315_144	288186.55	6218050.77	4	1.0	-20.8
S2133	284168.39	6218809.75	15	1.0	-20.4
S2087_419	295752.14	6217627.53	11	0.5	-20.3
9EGW2A_557	311331	6217099	15	0.5	-20.2
S2087_313	295752.14	6217627.53	8	0.5	-20.1
S2087_440	295752.14	6217627.53	12	0.5	-19.2
S2087_394	295752.14	6217627.53	9	0.5	-18.3
TBC18BHCS179	279608.3	6204502	6	0.5	-18.0
S2284_100	289176.853	6214454.096	4	1.0	-17.9
S1941_472	287180.737	6216340.979	11	1.0	-17.9
TBC10BUCO	278363.7	6203479	15	0.5	-17.3
TBC05BUCO395	277242.08	6204183.04	15	0.5	-17.0
TBC20BHCS194	280926.2	6204067	6	0.5	-16.7
S2280_99	285758.067	6215274.781	4	1.0	-16.7
TNC40BUCO501.9	279003.56	6214520.88	15	0.5	-16.7
S1996_159	298772.256	6207843.316	5	1.0	-16.4
S2158_218	283778.66	6212690.01	7	1.0	-16.3
NGW6	292197	6215881	3	1.0	-16.0
TBC15WWCO2.5	279129.2	6203915.1	17	0.5	-15.6
S2524_285	290405.429	6219105.735	7	1.0	-15.5
TBC27BHCS181	275714.53	6202210.78	6	0.5	-15.4
TBC26UWWC460	281593.37	6207054.22	17	0.5	-14.9
S1954_245	285466.001	6216903.707	3	1.0	-14.7
S2524_361	290405.429	6219105.735	8	1.0	-14.7
S2285_100	289248.471	6214558.696	4	1.0	-14.4
TBC09BUCO381	278512.53	6202084.47	15	0.5	-13.8

Bore	X	Y	Layer	Weight	Average Weighted Residual (m)
TBC05WWCO416	277242.08	6204183.04	17	0.5	-13.7
NGW5	291924	6215523	3	1.0	-13.7
S1957_518.75	287631.89	6215512.94	15	0.7	-13.6
S2080_95	289803.46	6215341.7	4	0.8	-13.5
A3GW3a	293973.7	6210832	3	0.8	-13.4
TBC20WWCO439	280926.2	6204067	17	0.5	-13.3
TBC09BHCS182	278512.53	6202084.47	6	0.5	-13.3
TBC19BUCO384	277205.74	6202083.04	15	0.5	-13.3
S2524_323	290405.429	6219105.735	7	1.0	-13.2
S1993_86	294585.041	6215806.125	4	0.8	-13.1
S2308_200	289958.22	6218475.73	4	1.0	-13.0
S2283_100	288999.969	6214636.197	4	1.0	-12.5
S2282_100	288786.3	6215032.09	4	1.0	-12.4
S2080_241	289803.46	6215341.7	7	0.6	-12.2
TBC20BUCO411	280926.2	6204067	15	0.5	-12.1
GW075409	273772	6209569	1	0.5	-11.9
S2080_417	289803.46	6215341.7	9	0.7	-11.8
S2524_40	290405.429	6219105.735	2	1.0	-11.7
S1913_137	289027.67	6218729.28	4	1.0	-11.6
TBC09WWCO391	278512.53	6202084.47	17	0.5	-11.5
TBC39BUCO375.1	273439.26	6207667.3	15	0.5	-11.4
S2151_552.9	283018.883	6215016.65	15	0.9	-11.4
A3GW6a	294482.4	6209687.8	3	0.8	-11.2
TBC26BHCS191	281593.37	6207054.22	6	0.5	-11.1
S1993_35	294585.041	6215806.125	3	1.0	-10.8
TBC10WWCO	278363.7	6203479	17	0.5	-10.6
S2158_65	283778.66	6212690.01	4	1.0	-10.4
PM01_440	309971	6217271	10	0.5	-10.2
GW075410	273034	6210587	1	0.5	-10.1
S2057_691	284047.177	6221149.586	16	0.2	-9.9
TBC23BHCS172	277482.8	6201426.8	6	0.5	-9.8
TBC14WWCO7.8	280493.73	6202694.56	17	0.5	-9.7
A3GW4a	293640.4	6209536.8	3	0.8	-9.6
S2060_327	288629.067	6215791.598	7	1.0	-9.6
TBC24BUCO371	274762.6	6204162.8	15	0.5	-9.4
NGW11	292881	6216842	3	1.0	-9.3
S2149_262	292995.4	6210539.6	8	1.0	-8.8
S2149_326	292997	6210539.5	9	1.0	-8.5
S2315_576	288186.55	6218050.77	15	1.0	-8.3
TBC24WWCO384	274762.6	6204162.8	17	0.5	-8.0
S2281_99	287958.447	6214897.373	4	1.0	-7.7
TBC27BUCO384	275714.53	6202210.78	15	0.5	-7.7
9FGW1A_491	308556	6215537	13	0.5	-7.4
S1913_559	289027.67	6218729.28	15	1.0	-7.3
S2158_295	283778.66	6212690.01	8	0.8	-7.1
TBC22BUCO362	274630.7	6202893.1	15	0.5	-7.1
S2284_60	289176.853	6214454.096	3	1.0	-7.0
S2308_574	289958.22	6218475.73	15	1.0	-6.9
TBC27LWWC400	275714.53	6202210.78	17	0.5	-6.8
S2158_473	283778.66	6212690.01	15	1.0	-6.6
A3GW7a	292988.1	6210941.7	3	0.8	-6.2
GW075411	274232	6210996	1	0.5	-5.7
NGW9	293521	6216358	3	1.0	-5.4
PHGW1B_216	312281	6218335	6	0.5	-5.1
S1183	284603.24	6224088.4	15	0.1	-4.9
S2080_440	289803.46	6215341.7	11	0.8	-4.8
A3GW2a	293673.7	6210776.2	3	0.8	-4.7
TBC33BUCO384.3	275193.79	6205394.75	15	0.5	-4.7

Bore	X	Y	Layer	Weight	Average Weighted Residual (m)
TBC34BUCO364.9	272955	6205075	15	0.5	-4.4
PHGW1B_554	312281	6218335	15	0.5	-4.4
NGW4	291580	6216015	3	1.0	-4.1
S1996_313	298772.256	6207843.316	9	0.8	-4.0
S1913_473	289027.67	6218729.28	11	0.7	-3.8
S2286_100	289329.613	6214721.143	4	1.0	-3.5
TBC23WWCO381	277482.8	6201426.8	17	0.5	-3.4
TBC23BUCO371	277482.8	6201426.8	15	0.5	-3.3
S2158_111	283778.66	6212690.01	5	0.1	-2.9
9FGW1A_405	308556	6215537	10	0.5	-2.9
S2308_135	289958.22	6218475.73	4	1.0	-2.9
TBC39WWCO402.9	273439.26	6207667.3	17	0.5	-2.8
S1936_65	291547.29	6217767.82	2	1.0	-2.4
S1185	285630.15	6222694.42	15	0.1	-2.3
TBC34WWCO382	272955	6205075	17	0.5	-2.2
PM02_435	310650	6218509	10	0.5	-2.0
A3GW8a	293645.7	6209862.2	3	0.8	-1.6
S1936_278	291547.29	6217767.82	7	1.0	-1.4
S1996_274	298772.256	6207843.316	8	0.8	-1.3
S2280_60	285758.067	6215274.781	3	1.0	-1.3
S1913_194	289027.67	6218729.28	5	1.0	-1.1
S2060_495	288629.067	6215791.598	9	1.0	-0.9
S1274	289901.81	6226041.77	15	0.4	-0.9
S2308_514	289958.22	6218475.73	12	0.9	-0.5
S1996_82	298772.256	6207843.316	3	1.0	-0.4
S1997_132	306997.238	6212764.942	5	1.0	-0.4
S1936_123	291547.29	6217767.82	4	1.0	-0.2
S1947_502.45	286745.34	6215508.62	15	0.5	-0.1
S2285_60	289248.471	6214558.696	3	1.0	0.0
9EGW1B_424	309483	6216091	10	0.5	0.2
S2315_292	288186.55	6218050.77	7	1.0	0.4
S1941_555	287180.737	6216340.979	15	1.0	1.3
S1997_68	306997.238	6212764.942	3	1.0	1.7
GR_70	296778.03	6217609.61	3	1.0	1.7
S2524_87	290405.429	6219105.735	3	1.0	1.7
9EGW2A_212	311331	6217099	6	0.5	1.9
S2087_55	295752.14	6217627.53	3	0.5	2.1
TBC25WWCO7.5	281336.59	6208024.17	17	0.5	2.2
S2080_65	289803.46	6215341.7	3	0.6	2.3
S1941_432	287180.737	6216340.979	9	0.8	2.4
TBC33WWCO408.7	275193.79	6205394.75	17	0.5	2.6
S1752	292648.58	6209301.97	15	0.1	2.7
S1913_447	289027.67	6218729.28	9	1.0	3.4
WC_54	296738.42	6217720.16	3	1.0	3.6
S2080_326	289803.46	6215341.7	8	0.6	3.6
S1913_505	289027.67	6218729.28	12	0.8	3.8
S2036_374	300016.893	6206725.496	15	0.1	4.0
TBC34BHCS176	272955	6205075	6	0.5	4.2
S1936_347	291547.29	6217767.82	8	1.0	4.5

Bore	X	Y	Layer	Weight	Average Weighted Residual (m)
A3GW5b	294222.2	6210570.7	3	0.8	4.7
9EGW2A_433	311331	6217099	10	0.5	4.7
S1996_439	298772.256	6207843.316	15	0.1	4.9
GR27	297110.994	6216174.113	2	1.0	5.2
S2036_411	300016.893	6206725.496	17	0.1	5.3
9GGW2B_340	311734	6215359	10	0.5	5.3
S1936_192	291547.29	6217767.82	5	1.0	5.4
S2282_60	288786.3	6215032.09	3	1.0	5.7
S1941_355	287180.737	6216340.979	8	1.0	5.8
S1996_478	298772.256	6207843.316	17	0.1	5.9
S2315_445	288186.55	6218050.77	9	1.0	6.4
S2080_447	289803.46	6215341.7	12	0.6	6.6
S2158_44	283778.66	6212690.01	3	1.0	6.7
S1996_219	298772.256	6207843.316	7	1.0	6.7
S2283_60	288999.969	6214636.197	3	1.0	7.0
A3GW1b	292995.4	6210539.6	3	0.8	7.8
S1733	293864.5	6208136.2	15	0.3	7.9
S2308_287	289958.22	6218475.73	7	1.0	7.9
PM03_408	311664	6219773	10	0.5	8.4
S2281_61	287958.447	6214897.373	3	1.0	9.0
S2308_378	289958.22	6218475.73	8	1.0	9.1
PM02_220	310650	6218509	6	0.5	9.4
NGW3	290819	6215923	3	1.0	9.8
GR28	296751.925	6216617.276	2	1.0	10.3
S2286_60	289329.613	6214721.143	3	1.0	11.9
S1993_435	294585.041	6215806.125	11	1.0	12.1
9FGW1A_513	308556	6215537	15	0.5	12.3
S1993_441	294585.041	6215806.125	12	0.7	14.0
S1954_273	285466.001	6216903.707	4	1.0	15.0
A3GW4b	293640.8	6209532.1	2	0.8	15.1
PHGW2A_389	312322	6217752	10	0.5	15.3
PM01_218	309971	6217271	6	0.5	15.4
S2060_110	288629.067	6215791.598	3	1.0	15.4
S2132	283609.36	6214019.7	15	1.0	15.5
TBC16WWCO8.5	276781.8	6205632	17	0.5	15.7
S1997_24	306997.238	6212764.942	2	1.0	16.0
S2158_377	283778.66	6212690.01	9	1.0	16.1
S1763	288306.58	6217527.27	15	0.5	16.2
PHGW2A_182	312322	6217752	6	0.5	16.4
9HGW1B_205	308189	6214580	6	0.5	18.4
9EGW1B_213	309483	6216091	6	0.5	20.0
S2158_404	283778.66	6212690.01	12	1.0	22.1
S1941_596	287180.737	6216340.979	17	1.0	23.1
S2315_358	288186.55	6218050.77	8	1.0	24.3
A3GW2c	293672.4	6210776.3	2	0.8	25.4
A3GW3c	293973.5	6210833.5	2	0.8	26.4
F6GW3A_450	312855	6215539	15	0.5	27.9
A3GW5c	294222.5	6210569.4	2	0.8	29.9
A3GW1c	292994.7	6210541	2	0.8	31.9
A3GW6c	294484.2	6209686.2	2	0.8	32.5
A3GW8c	293644.9	6209864.4	2	0.8	33.7
F6GW4A_512	312531	6216694	15	0.5	34.8
A3GW7c	292987.7	6210944	2	0.8	35.6
WC_95	297658.4	6217832.58	2	1.0	36.5
S2315_65	288186.55	6218050.77	3	1.0	42.8
S1954_85	285466.001	6216903.707	2	1.0	53.6


GR_70
Groundwater level (mAHD)
195
190
185
180
175
170
165
160
Measured
modelled
2010
2012
2014
2016
2018
2020
Year


GR27
Groundwater level (mAHD)
215
210
205
200
195
190
185
180
Measured
modelled
2010
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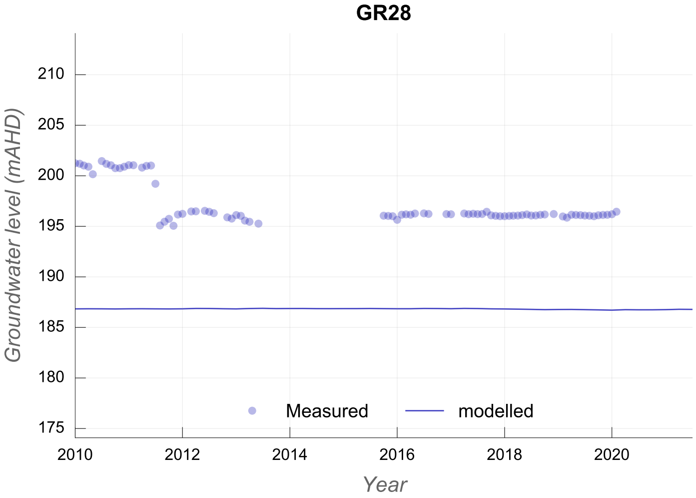
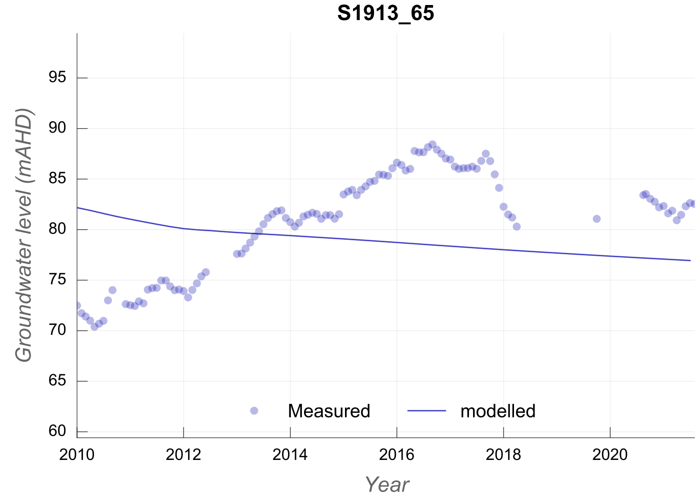
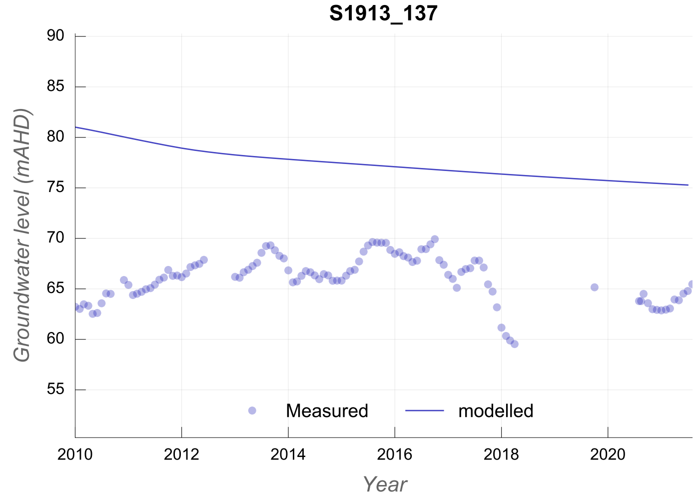
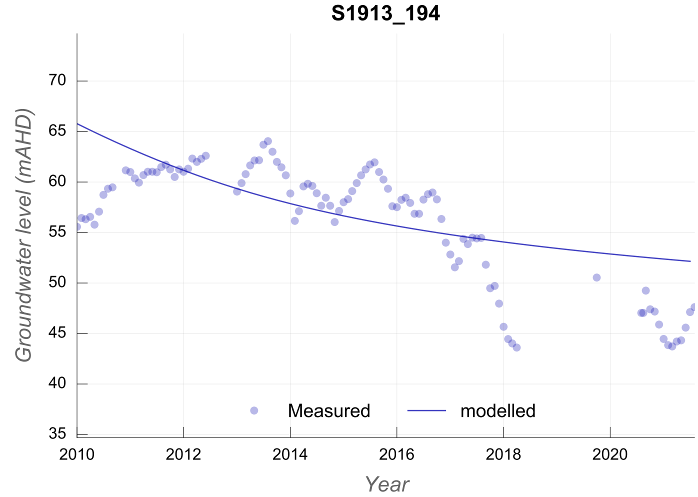
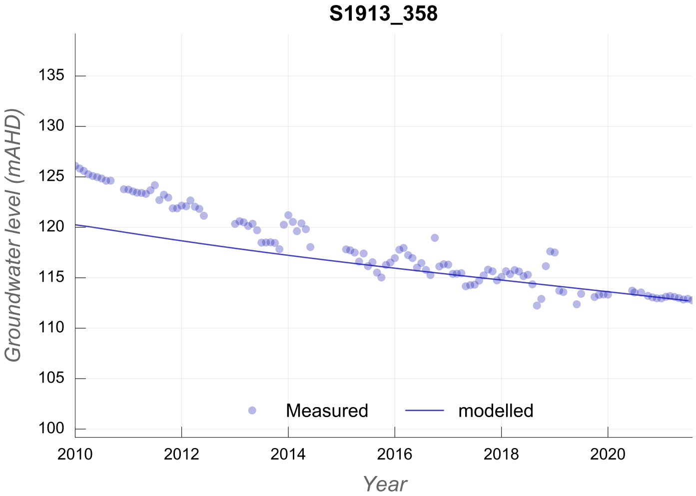
2014
2016
2018
2020
Year

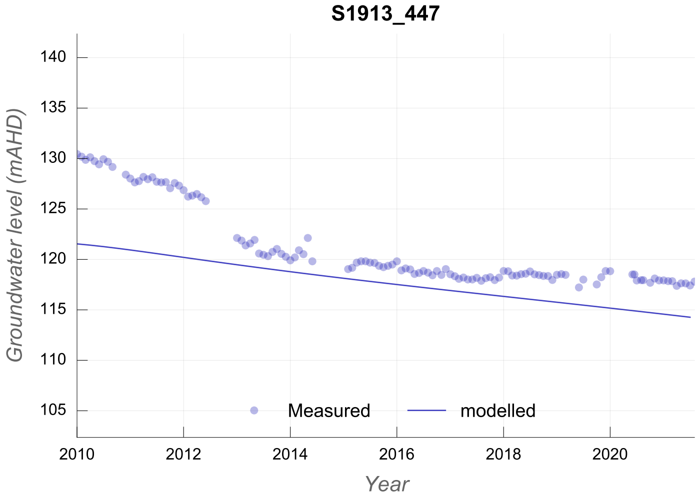

GR28
Groundwater level (mAHD)
210
205
200
195
190
185
180
175
Measured
modelled
2010
2012
2014
2016
2018
2020
Year

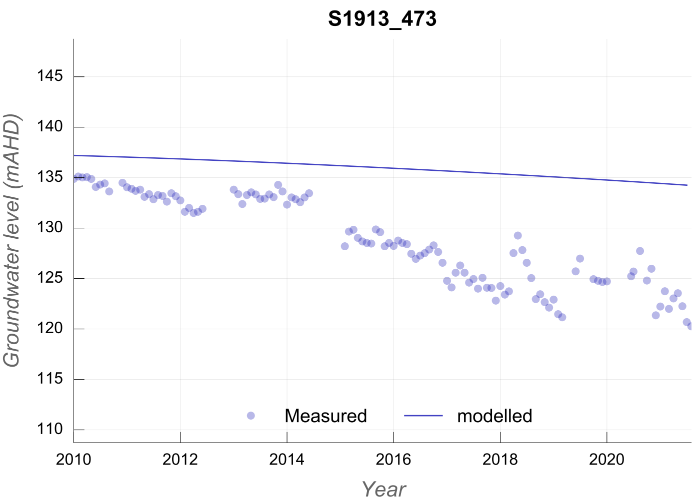

S1913_65
Groundwater level (mAHD)
95
90
85
80
75
70
65
60
Measured
modelled
2010
2012
2014
2016
2018
2020
Year

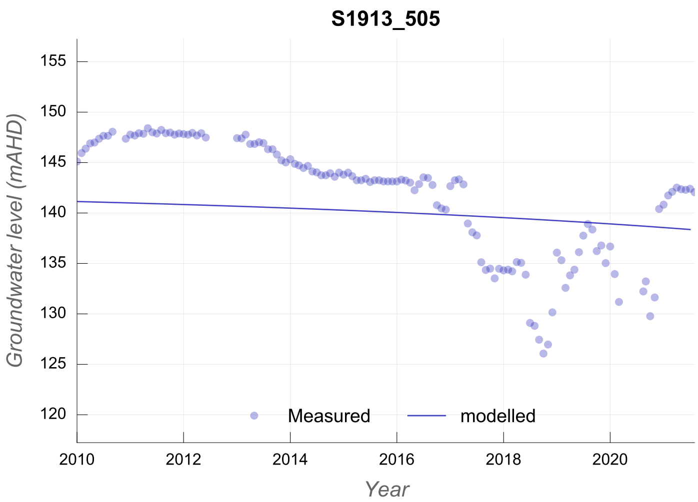

S1913_137
Groundwater level (mAHD)
90
85
80
75
70
65
60
55
Measured
modelled
2010
2012
2014
2016
2018
2020
Year


S1913_194
Groundwater level (mAHD)
70
65
60
55
50
45
40
35
Measured
modelled
2010
2012
2014
2016
2018
2020
Year


S1913_358
Groundwater level (mAHD)
135
130
125
120
115
110
105
100
Measured
modelled
2010
2012
2014
2016
2018
2020
Year


S1913_447
Groundwater level (mAHD)
140
135
130
125
120
115
110
105
Measured
modelled
2010
2012
2014
2016
2018
2020
Year


S1913_473
145
140
135
130
125
120
115
110
Groundwater level (mAHD)
Measured
modelled
2010
2012
2014
2016
2018
2020
Year


S1913_505
155
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145
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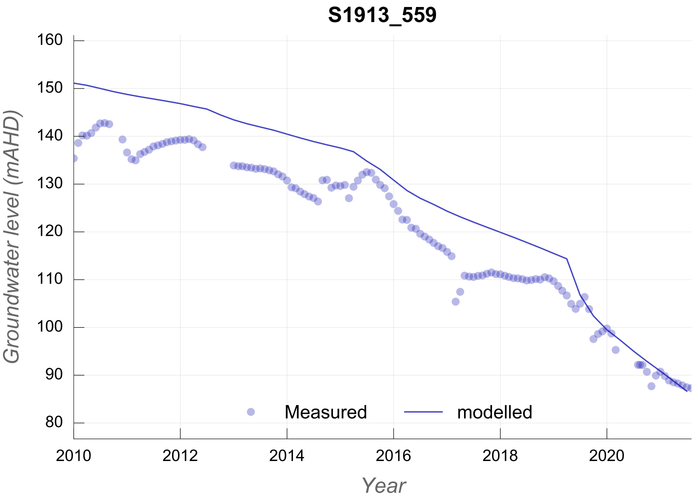
130
125
120
Groundwater level (mAHD)
Measured
modelled
2010
2012
2014
2016
2018
2020
Year


S1913_559
160
150
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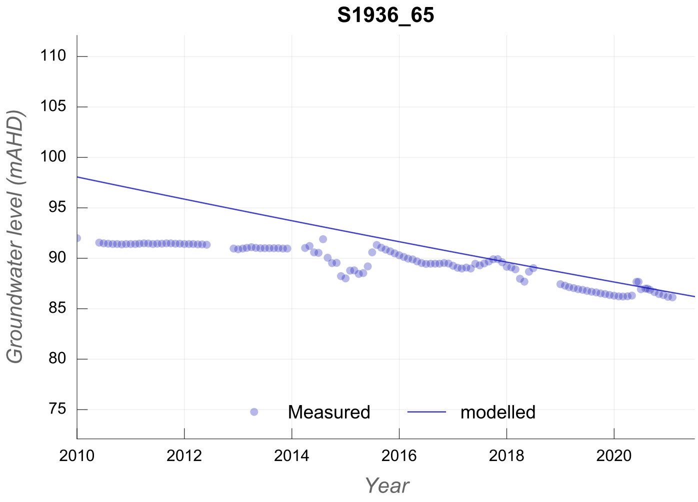
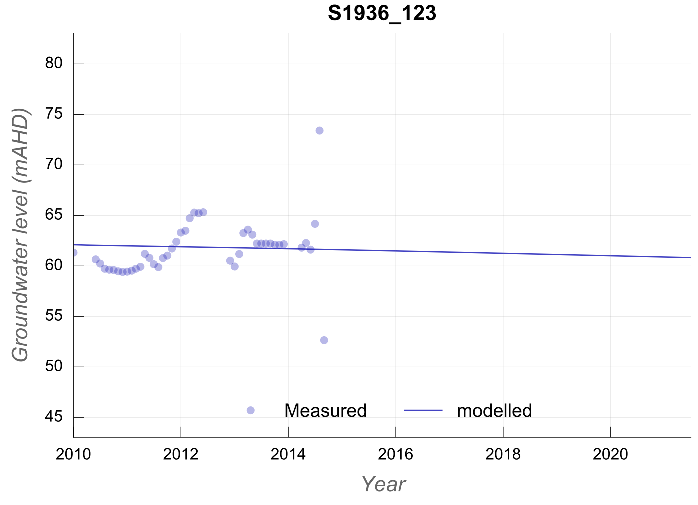
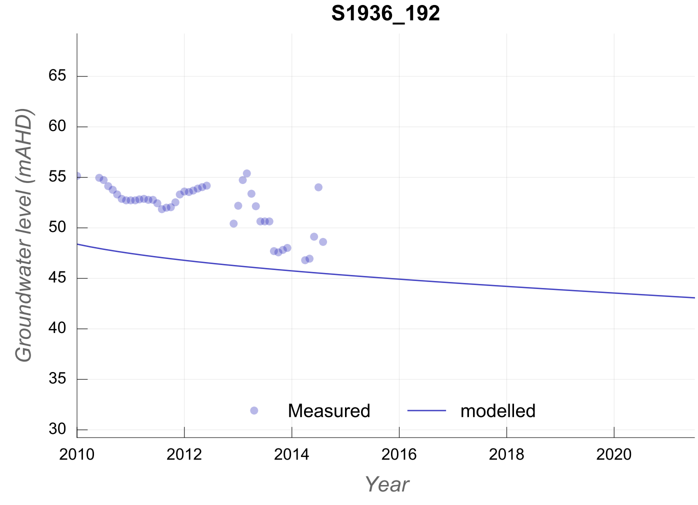
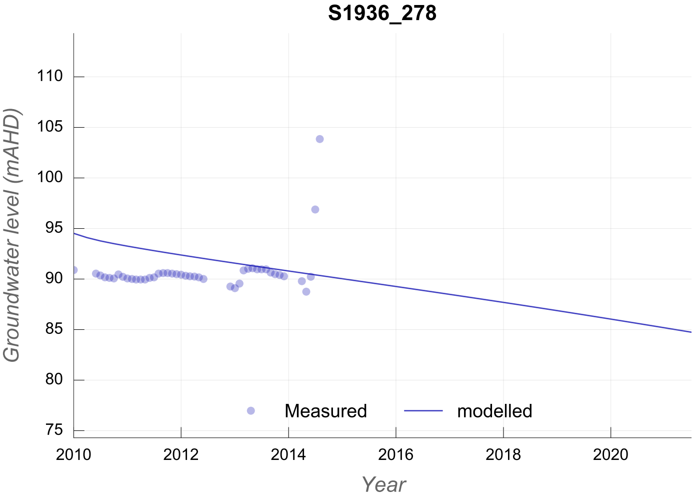
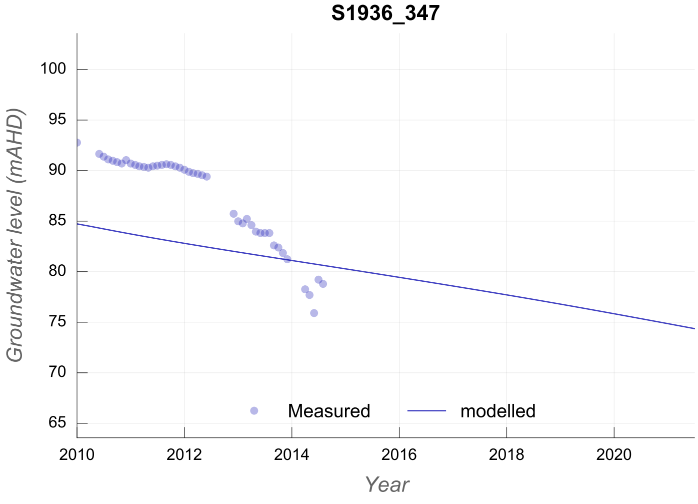
120
110
100
90
80
Groundwater level (mAHD)
Measured
modelled
2010
2012
2014
2016
2018
2020
Year

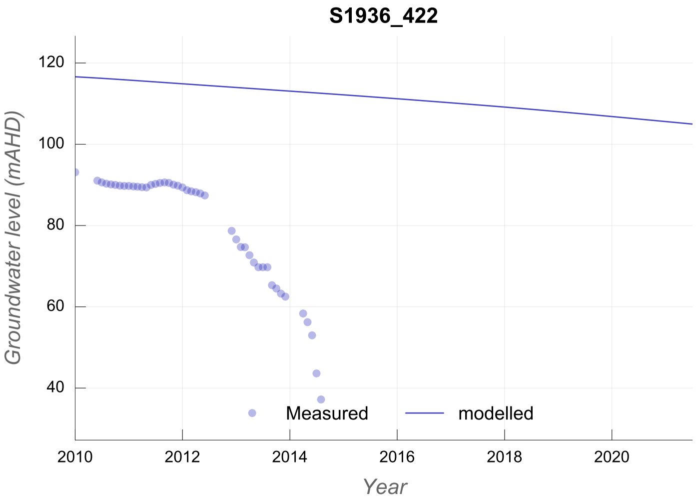

S1936_65
110
105
100
95
90
85
80
75
Groundwater level (mAHD)
Measured
modelled
2010
2012
2014
2016
2018
2020
Year

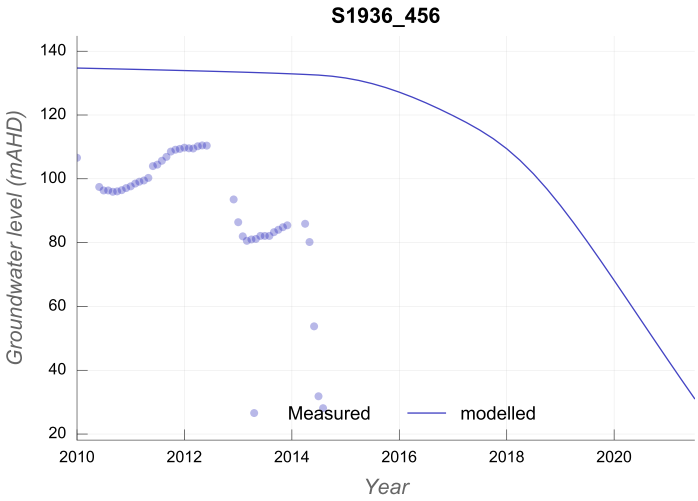

S1936_123
80
75
70
65
60
55
50
45
Groundwater level (mAHD)
Measured
modelled
2010
2012
2014
2016
2018
2020
Year

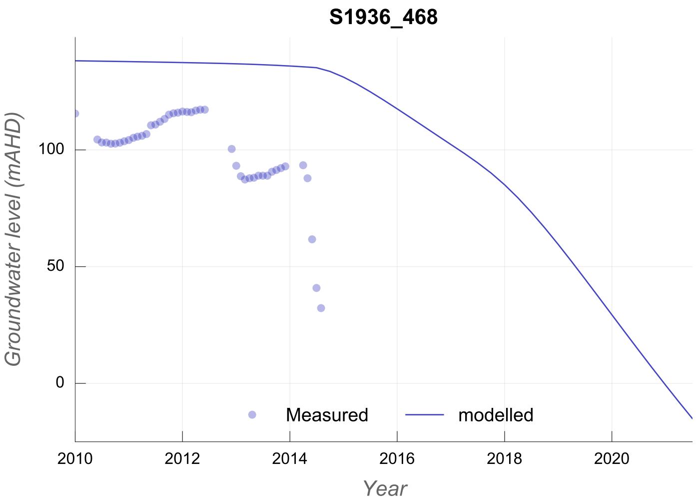

S1936_192
65
60
55
50
45
40
35
30
Groundwater level (mAHD)
Measured
modelled
2010
2012
2014
2016
2018
2020
Year

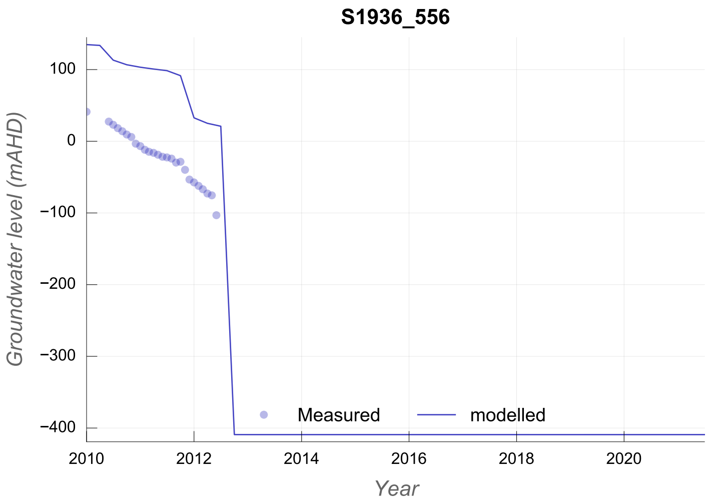

S1936_278
110
105
100
95
90
85
80
75
Groundwater level (mAHD)
Measured
modelled
2010
2012
2014
2016
2018
2020
Year

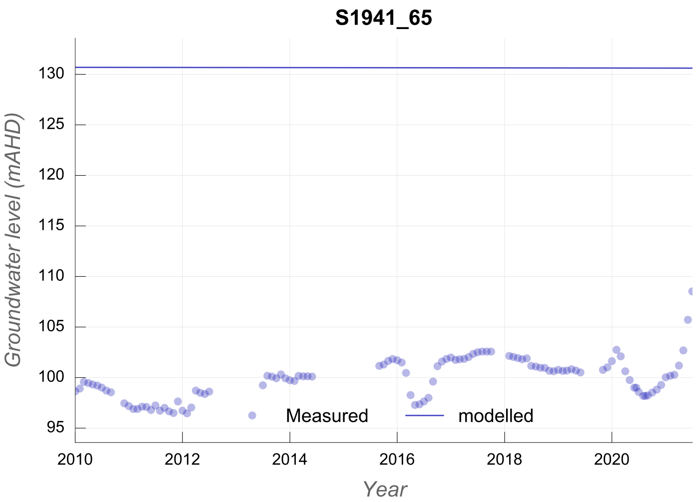

S1936_347
100
95
90
85
80
75
70
65
Groundwater level (mAHD)
Measured
modelled
2010
2012
2014
2016
2018
2020
Year

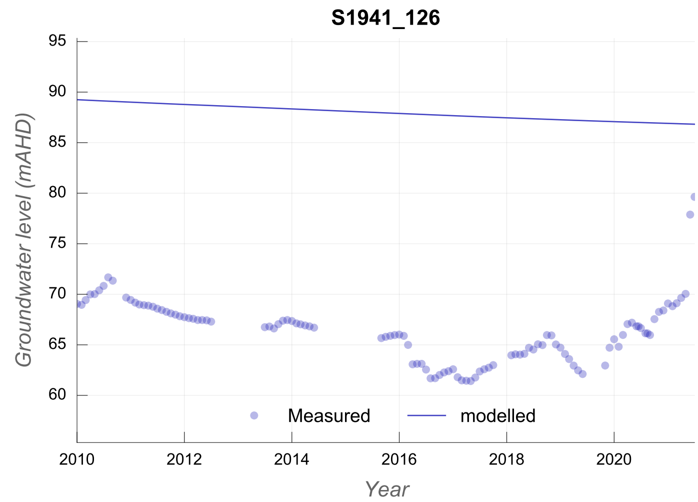

S1936_422
Groundwater level (mAHD)
Measured
modelled
Year

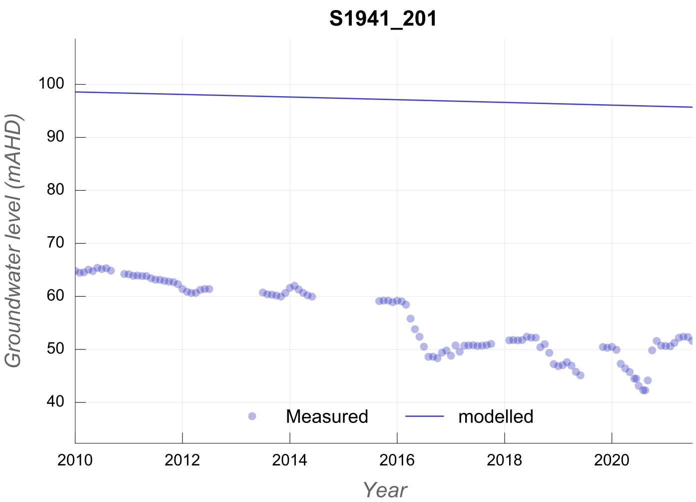

S1936_456
Groundwater level (mAHD)
Measured
modelled
Year

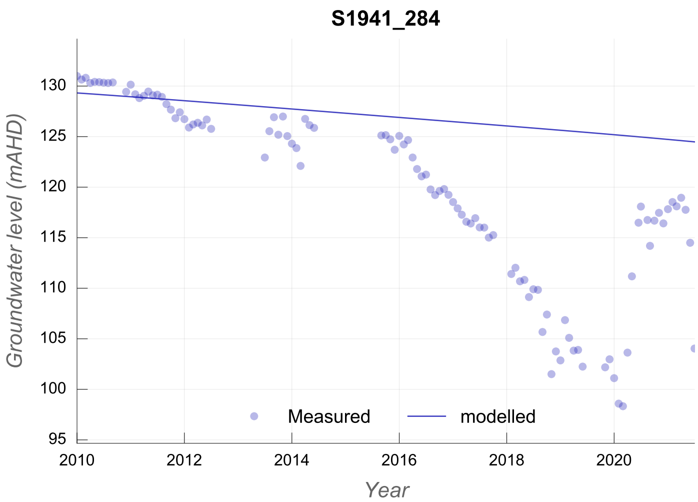

S1936_468
Groundwater level (mAHD)
Measured
modelled
Year

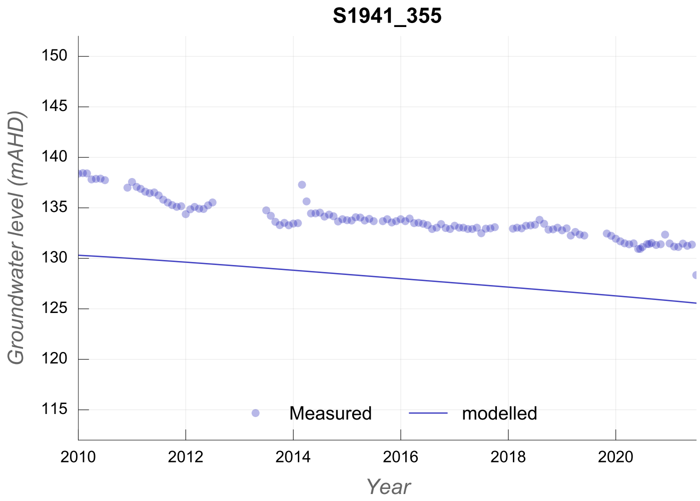

S1936_556
Groundwater level (mAHD)
Measured
modelled
Year

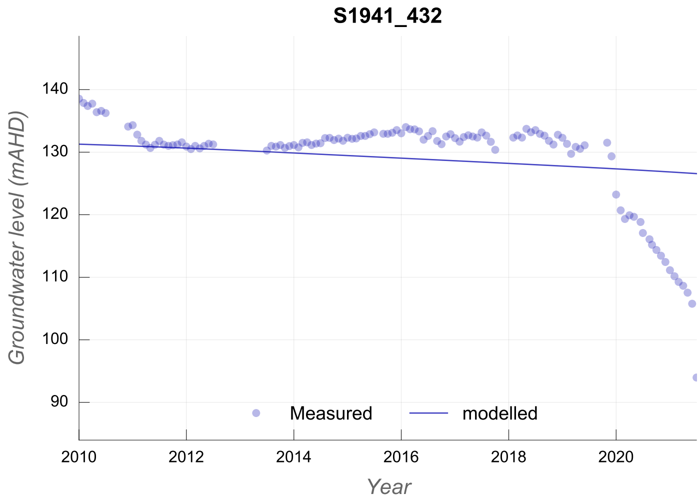

S1941_65
Groundwater level (mAHD)
Measured
modelled
Year

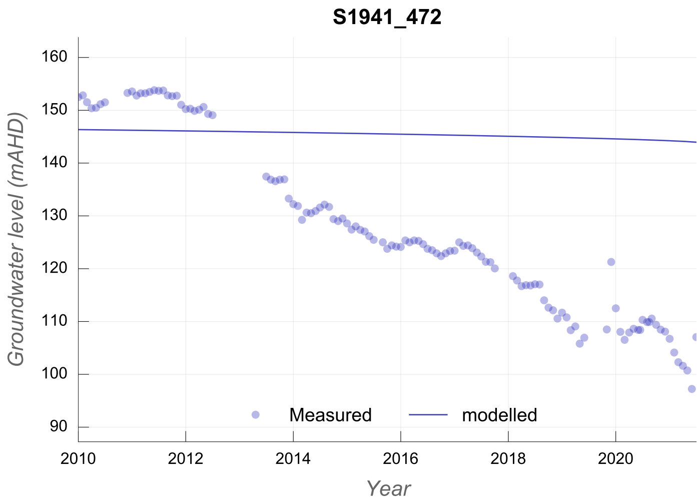

S1941_126
Groundwater level (mAHD)
Measured
modelled
Year

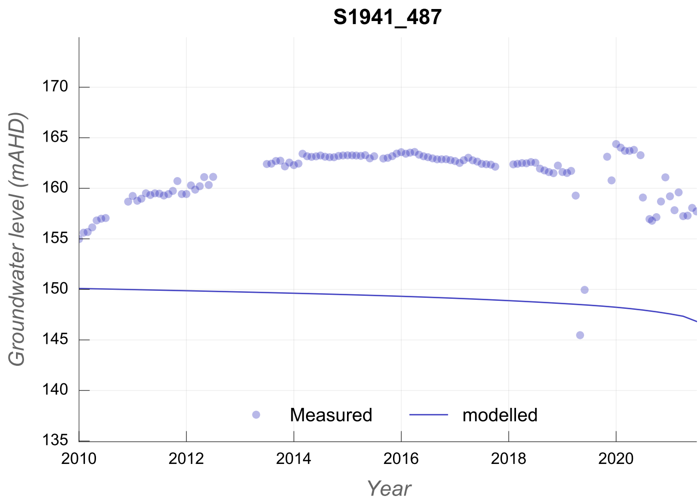

S1941_201
Groundwater level (mAHD)
Measured
modelled
Year

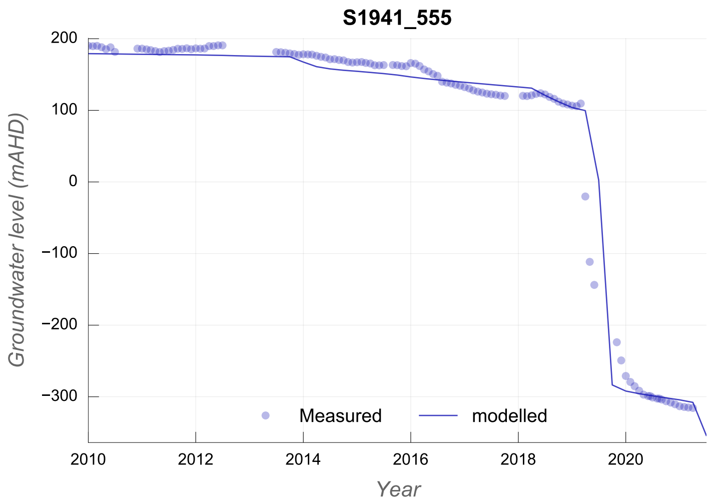

S1941_284
Groundwater level (mAHD)
Measured
modelled
Year

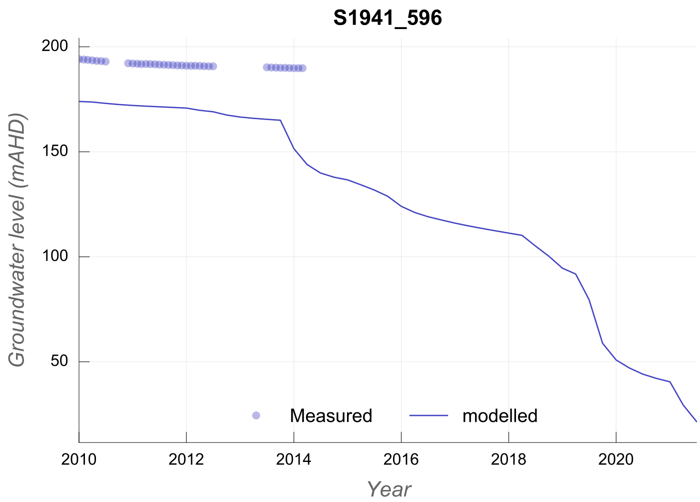

S1941_355
Groundwater level (mAHD)
150
145
140
135
130
125
120
115
Measured
modelled
2010
2012
2014
2016
2018
2020
Year

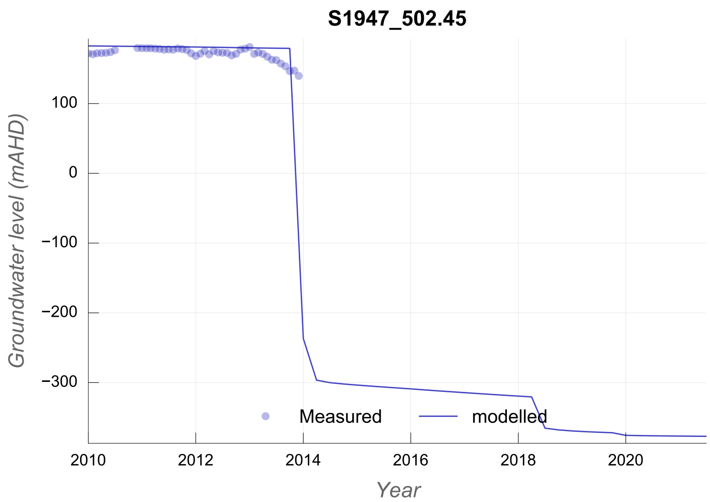

S1941_432
Groundwater level (mAHD)
140
130
120
110
100
90
Measured
modelled
2010
2012
2014
2016
2018
2020
Year

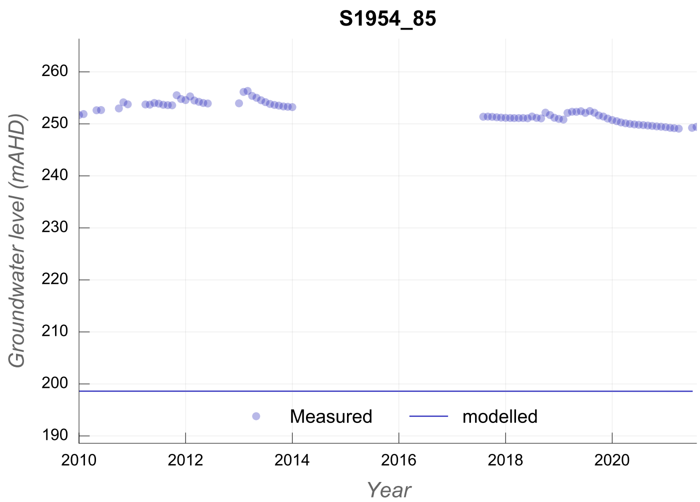

S1941_472
Groundwater level (mAHD)
160
150
140
130
120
110
100
90
Measured
modelled
2010
2012
2014
2016
2018
2020
Year


S1941_487
Groundwater level (mAHD)
170
165
160
155
150
145
140
135
Measured
modelled
2010
2012
2014
2016
2018
2020
Year


S1941_555
Groundwater level (mAHD)
200
100
0
−100
−200
−300
Measured
modelled
2010
2012
2014
2016
2018
2020
Year


S1941_596
Groundwater level (mAHD)
200
150
100
50
Measured
modelled
2010
2012
2014
2016
2018
2020
Year


S1947_502.45
Groundwater level (mAHD)
100
0
−100
−200
−300
Measured
modelled
2010
2012
2014
2016
2018
2020
Year


S1954_85
Groundwater level (mAHD)
260
250
240
230
220
210
200
190
Measured
modelled
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2012
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2016
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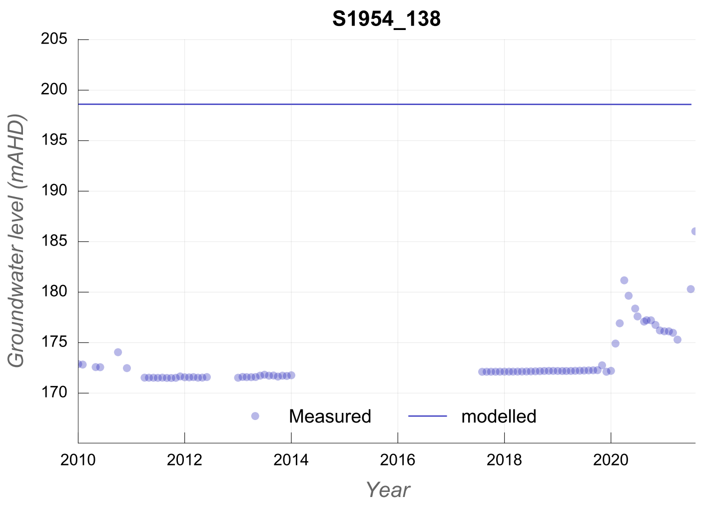
2020
Year


S1954_138
Groundwater level (mAHD)
205
200
195
190
185
180
175
170
Measured
modelled
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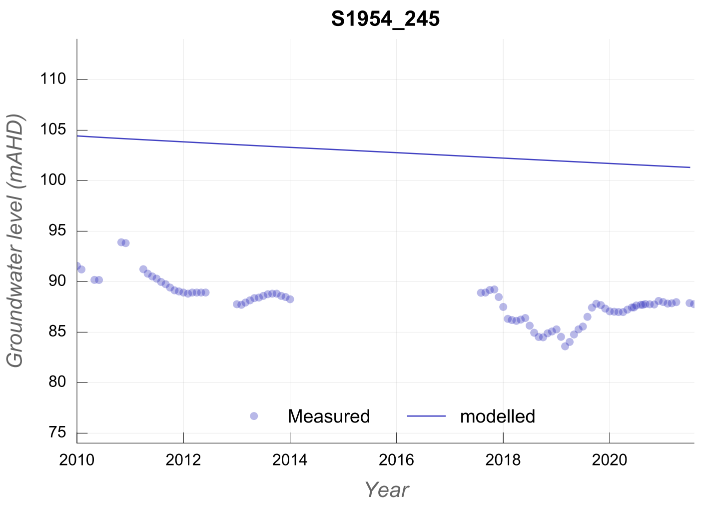
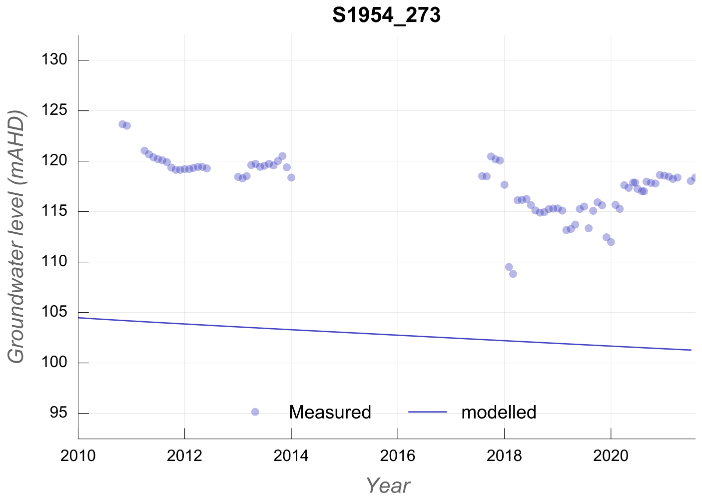
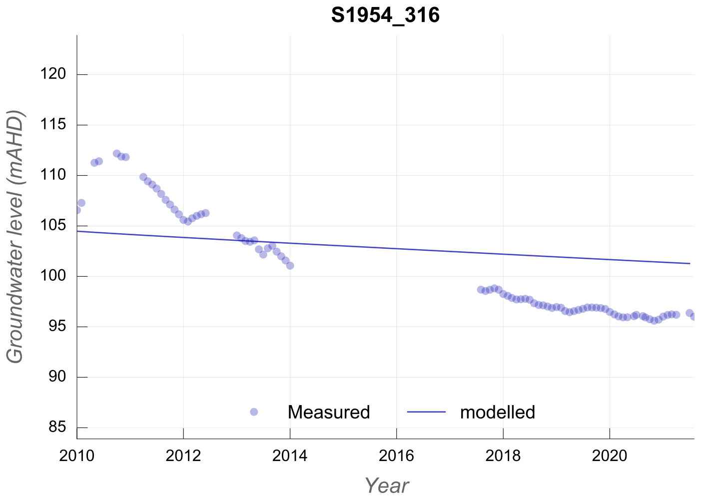
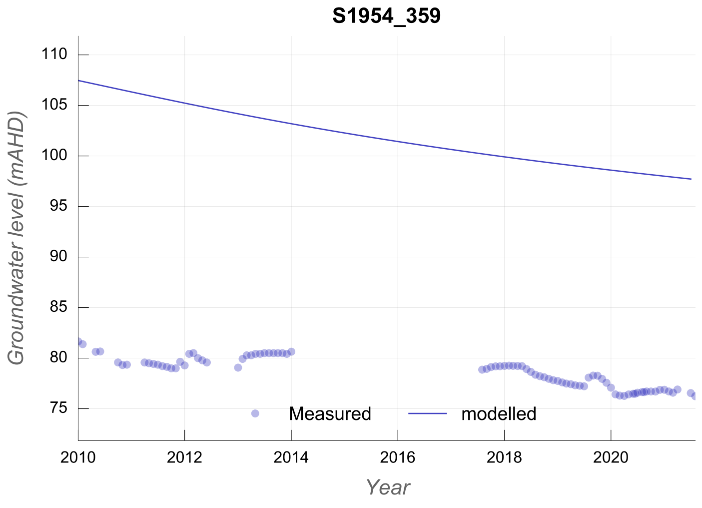
2020
Year


S1954_245
Groundwater level (mAHD)
110
105
100
95
90
85
80
75
Measured
modelled
2010
2012
2014
2016
2018
2020
Year


S1954_273
Groundwater level (mAHD)
130
125
120
115
110
105
100
95
Measured
modelled
2010
2012
2014
2016
2018
2020
Year


S1954_316
Groundwater level (mAHD)
120
115
110
105
100
95
90
85
Measured
modelled
2010
2012
2014
2016
2018
2020
Year


S1954_359
Groundwater level (mAHD)
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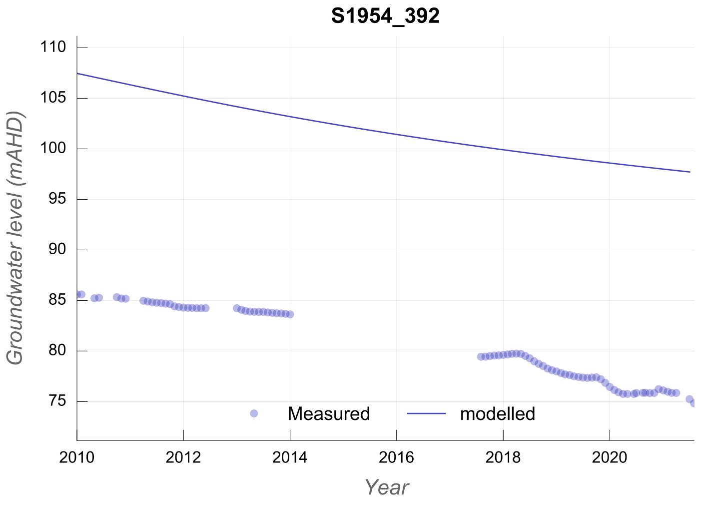
105
100
95
90
85
80
75
Measured
modelled
2010
2012
2014
2016
2018
2020
Year


S1954_392
Groundwater level (mAHD)
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105
100
95
90
85
80
75
Measured
modelled
2010
2012
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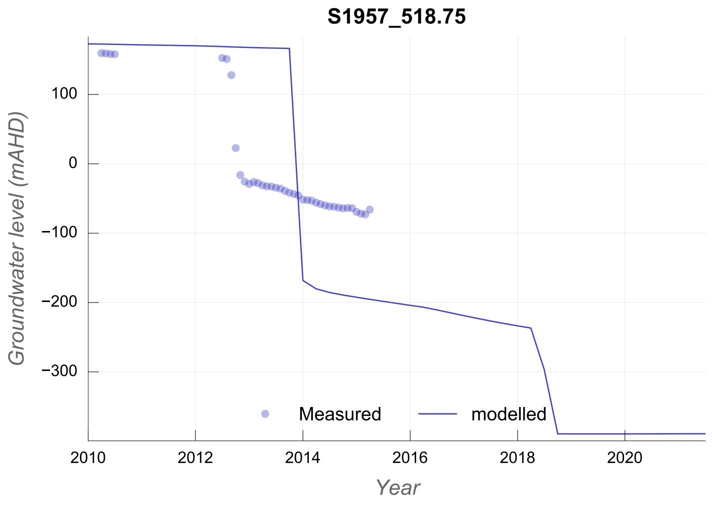
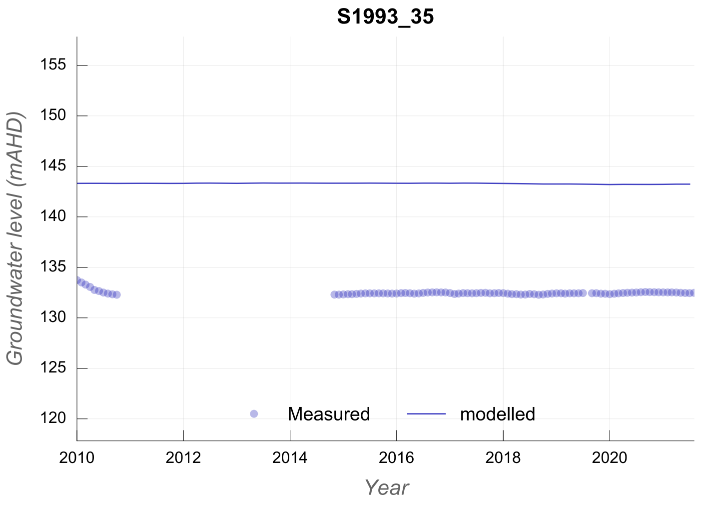
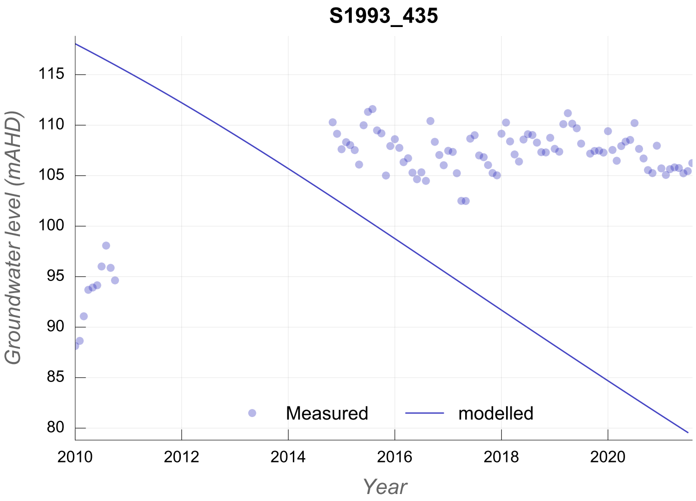
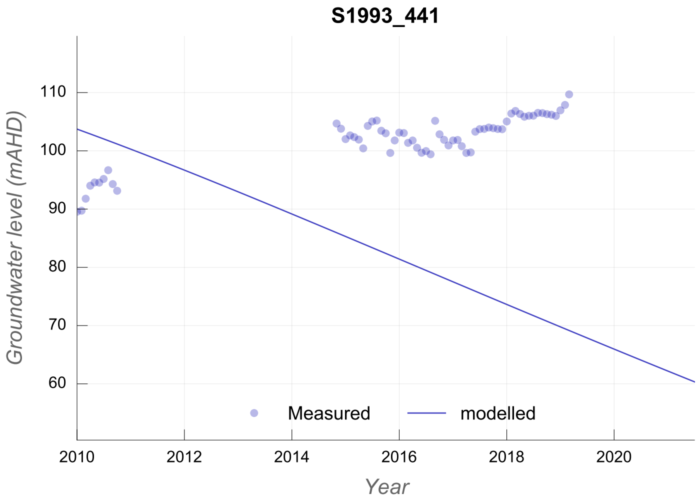
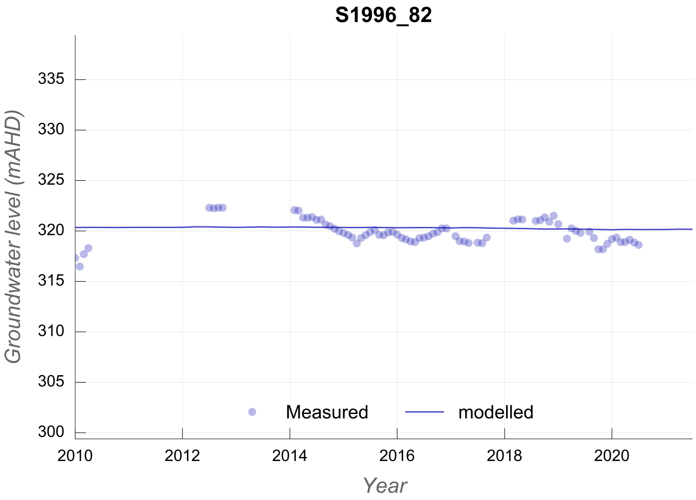
2016
2018
2020
Year

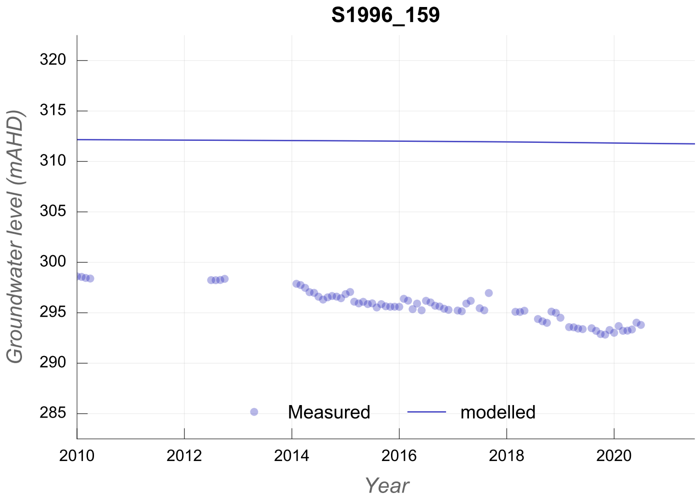

S1957_518.75
Groundwater level (mAHD)
100
0
−100
−200
−300
Measured
modelled
2010
2012
2014
2016
2018
2020
Year

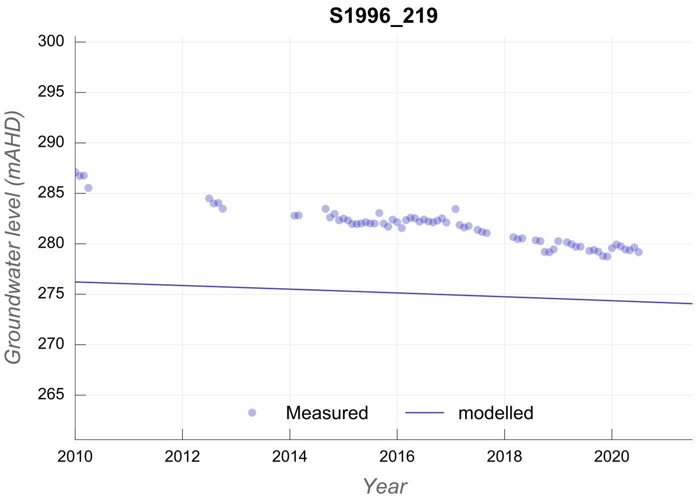

S1993_35
Groundwater level (mAHD)
155
150
145
140
135
130
125
120
Measured
modelled
2010
2012
2014
2016
2018
2020
Year

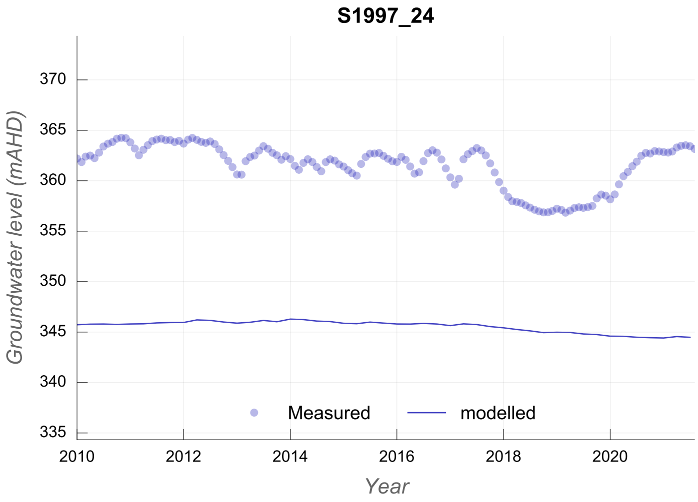

S1993_435
Groundwater level (mAHD)
Year
Measured
modelled

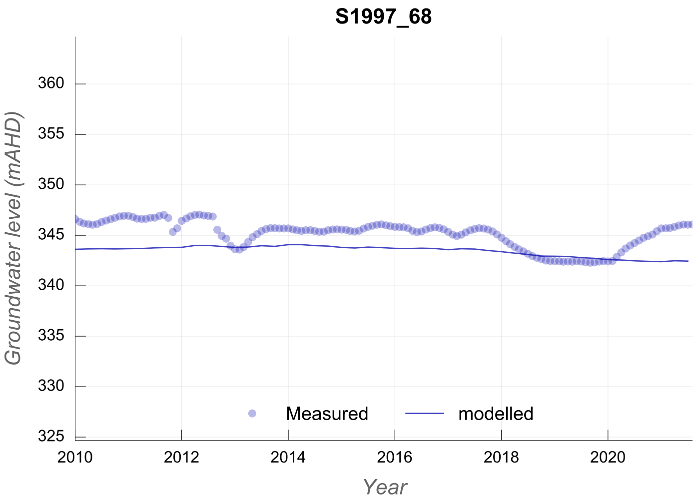

S1993_441
Groundwater level (mAHD)
Year
Measured
modelled

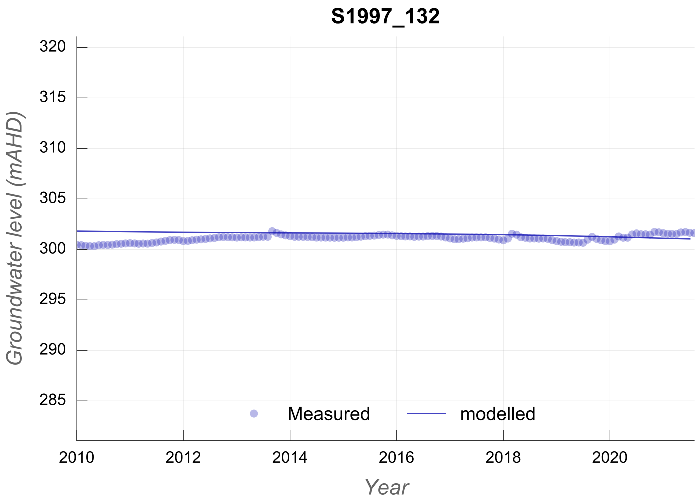

S1996_82
Groundwater level (mAHD)
Year
Measured
modelled

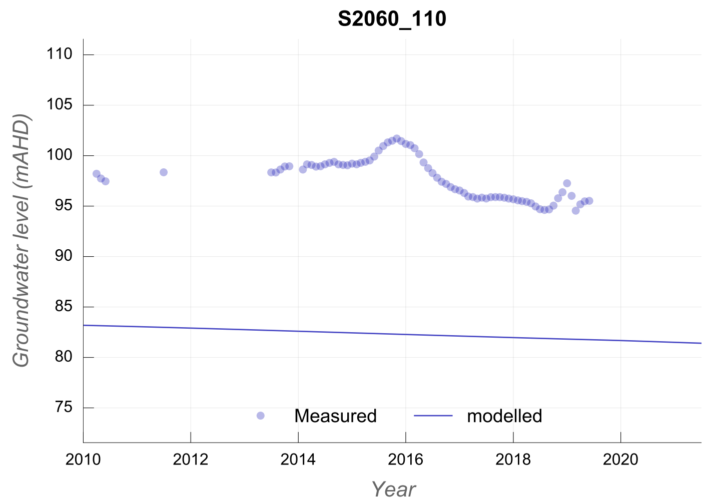

S1996_159
Groundwater level (mAHD)
Year
Measured
modelled

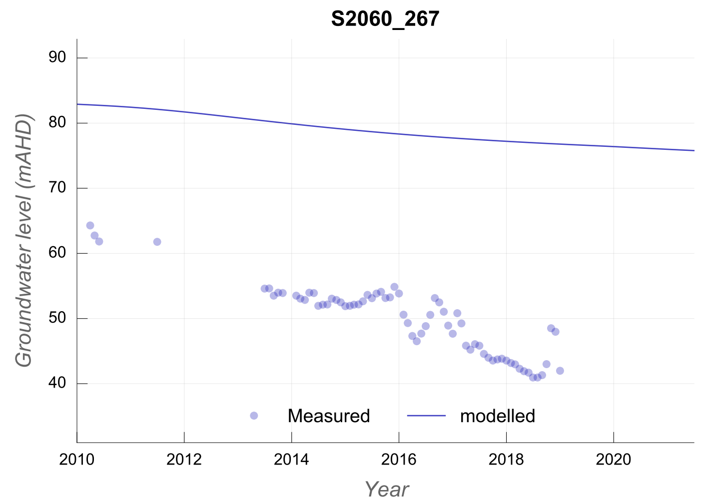

S1996_219
Groundwater level (mAHD)
Year
Measured
modelled

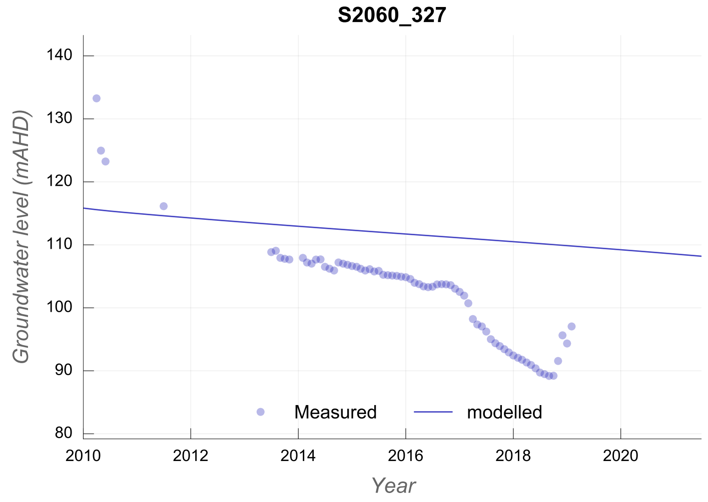

S1997_24
Groundwater level (mAHD)
Year
Measured
modelled

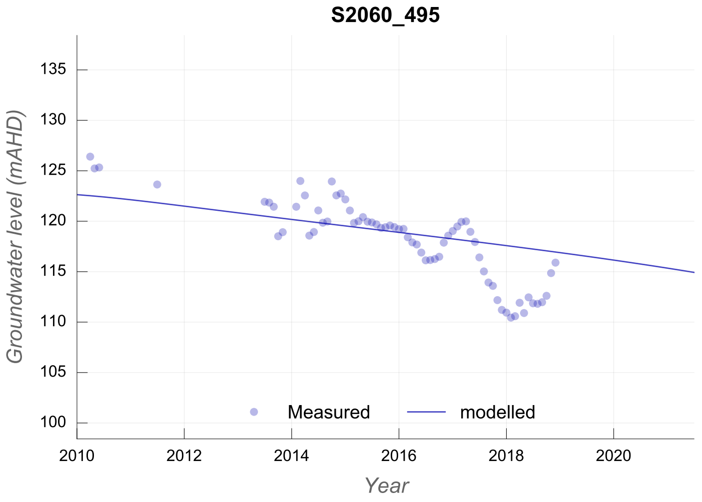

S1997_68
Groundwater level (mAHD)
Year
Measured
modelled

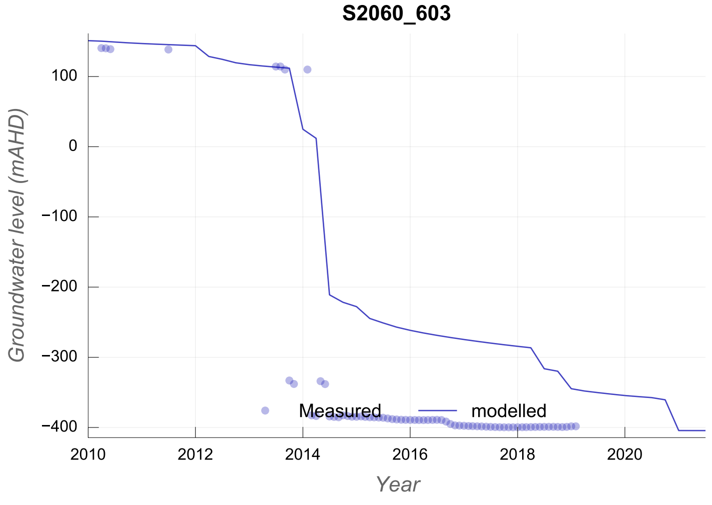

S1997_132
Groundwater level (mAHD)
Year
Measured
modelled

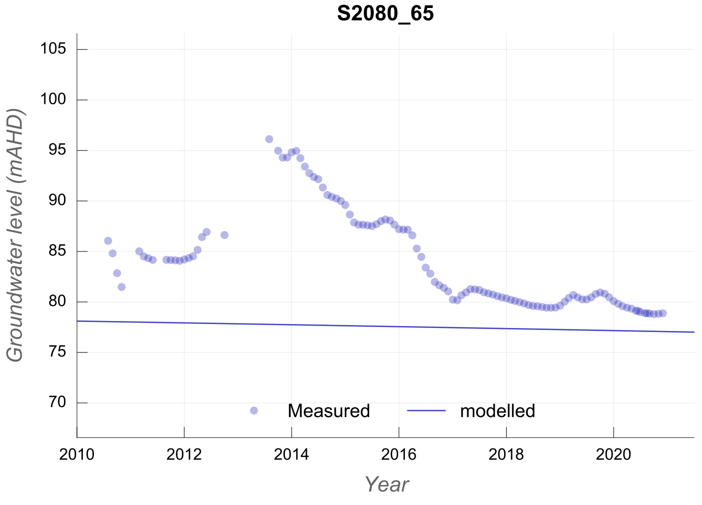

S2060_110
110
105
100
95
90
85
80
75
Groundwater level (mAHD)
Measured
modelled
2010
2012
2014
2016
2018
2020
Year

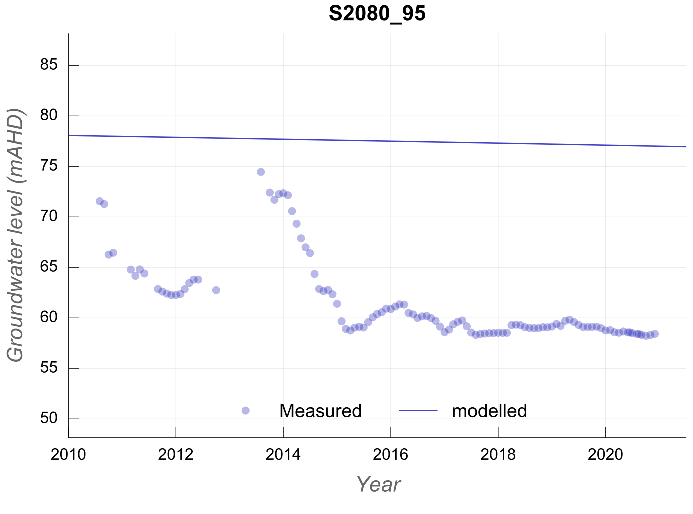

S2060_267
90
80
70
60
50
40
Groundwater level (mAHD)
Measured
modelled
2010
2012
2014
2016
2018
2020
Year

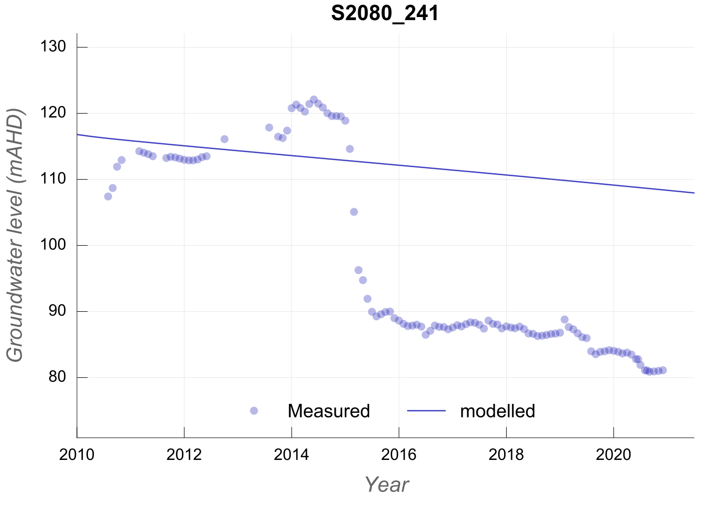

S2060_327
140
130
120
110
100
90
80
Groundwater level (mAHD)
Measured
modelled
2010
2012
2014
2016
2018
2020
Year

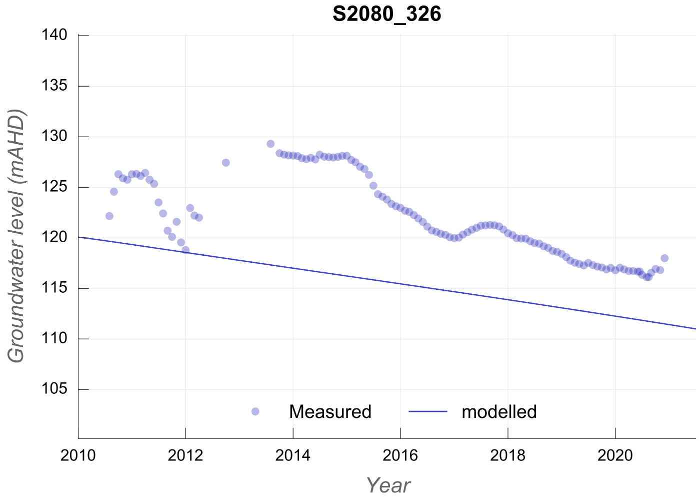

S2060_495
135
130
125
120
115
110
105
100
Groundwater level (mAHD)
Measured
modelled
2010
2012
2014
2016
2018
2020
Year

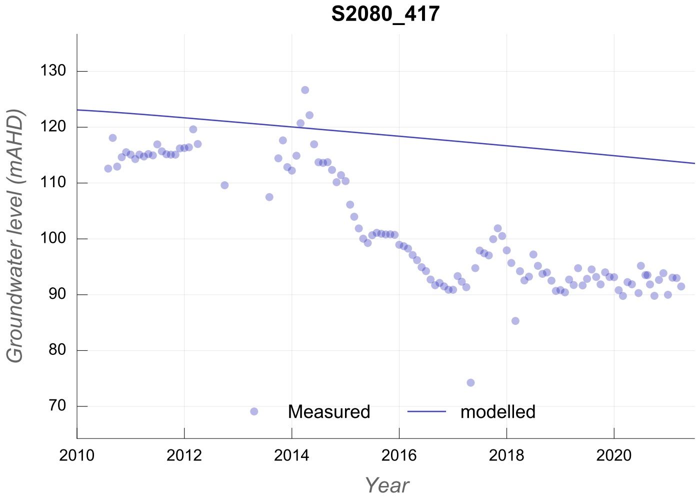

S2060_603
100
0
−100
−200
−300
−400
Groundwater level (mAHD)
Measured
modelled
2010
2012
2014
2016
2018
2020
Year

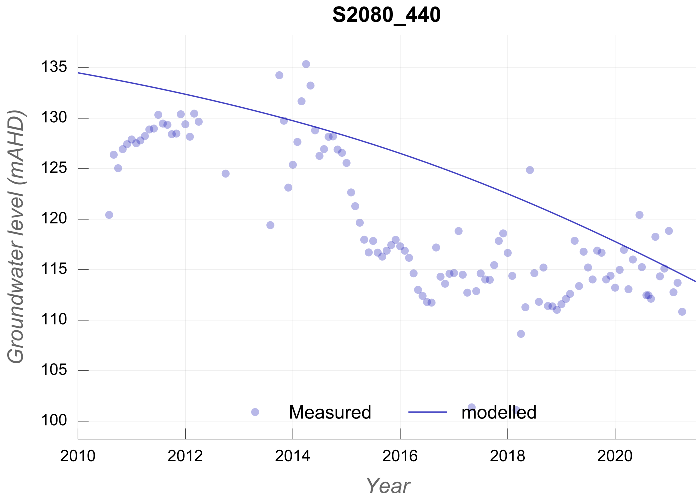

S2080_65
105
100
95
90
85
80
75
70
Groundwater level (mAHD)
Measured
modelled
2010
2012
2014
2016
2018
2020
Year

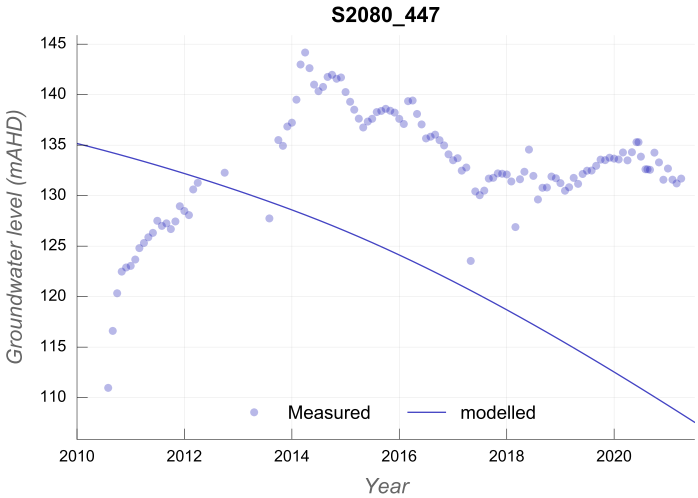

S2080_95
85
80
75
70
65
60
55
50
Groundwater level (mAHD)
Measured
modelled
2010
2012
2014
2016
2018
2020
Year

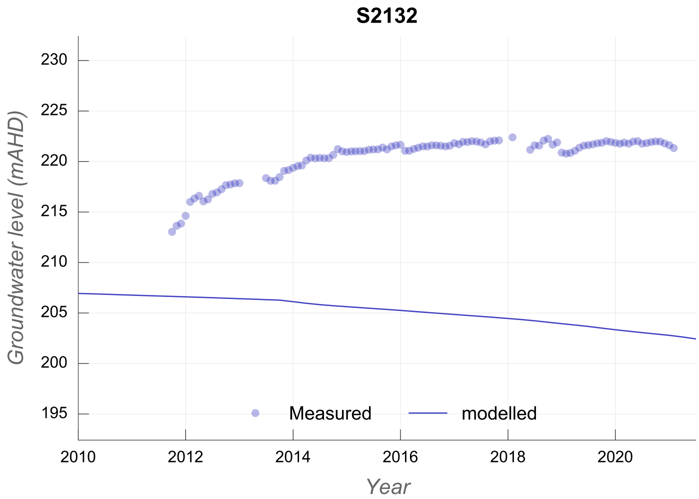

S2080_241
130
120
110
100
90
80
Groundwater level (mAHD)
Measured
modelled
2010
2012
2014
2016
2018
2020
Year

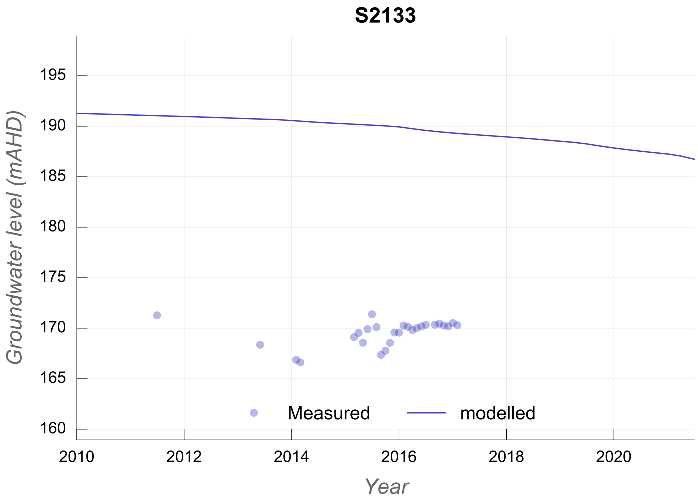

S2080_326
Groundwater level (mAHD)
Measured
modelled
Year

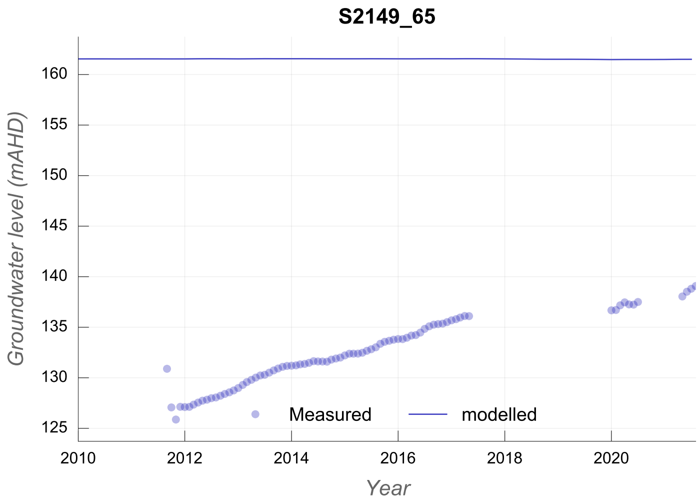

S2080_417
Groundwater level (mAHD)
Measured
modelled
Year

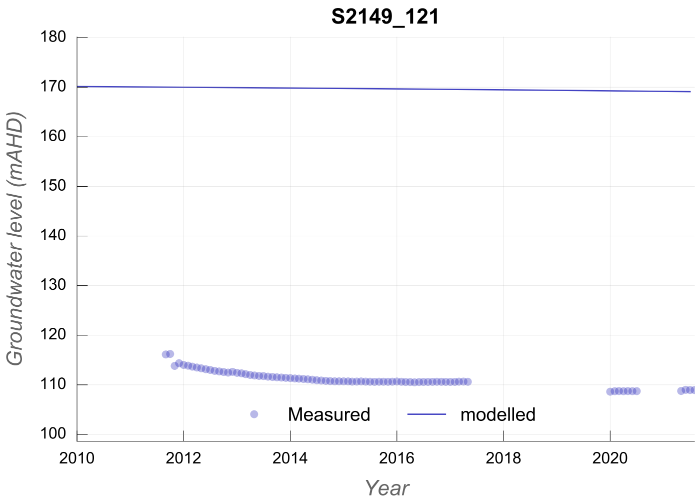

S2080_440
Groundwater level (mAHD)
Measured
modelled
Year


S2080_447
Groundwater level (mAHD)
Measured
modelled
Year

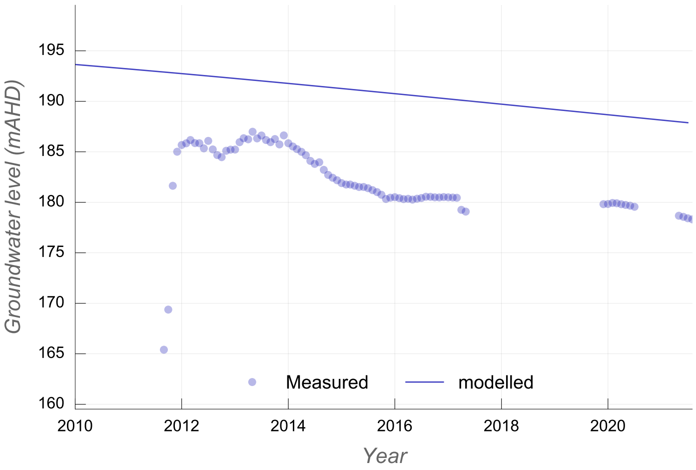

S2132
Groundwater level (mAHD)
Measured
modelled
Year


S2133
Groundwater level (mAHD)
Measured
modelled
Year

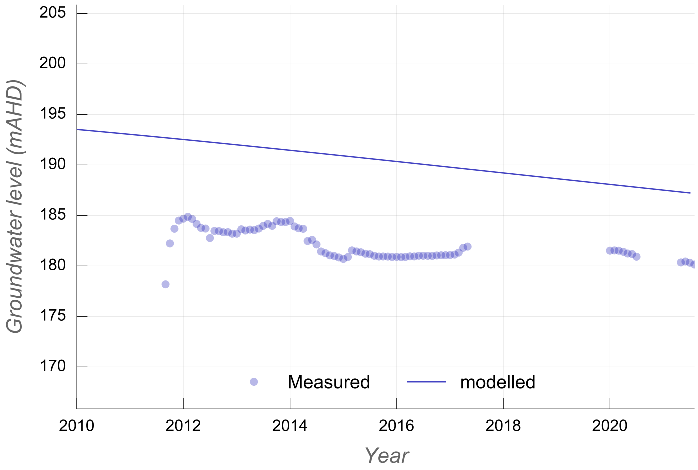

S2149_65
Groundwater level (mAHD)
Measured
modelled
Year


S2149_121
Groundwater level (mAHD)
Measured
modelled
Year

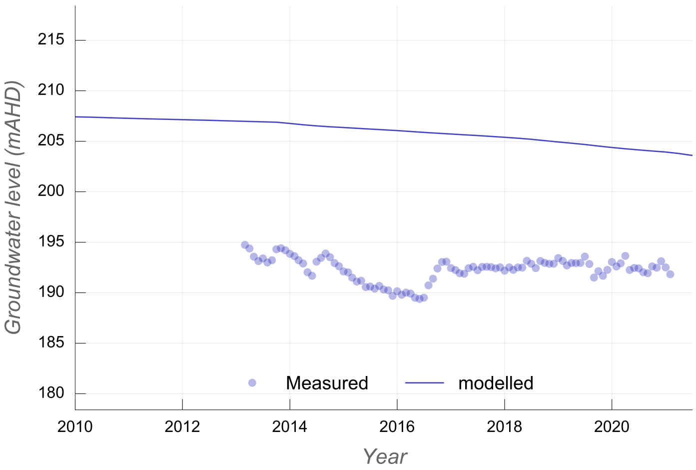
S2149_262



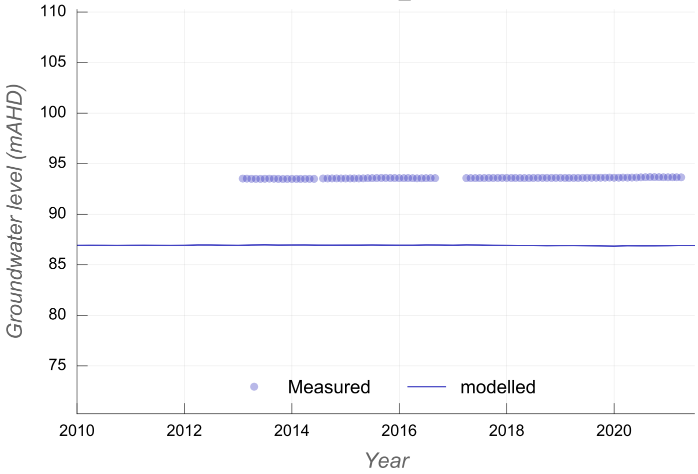
S2149_326



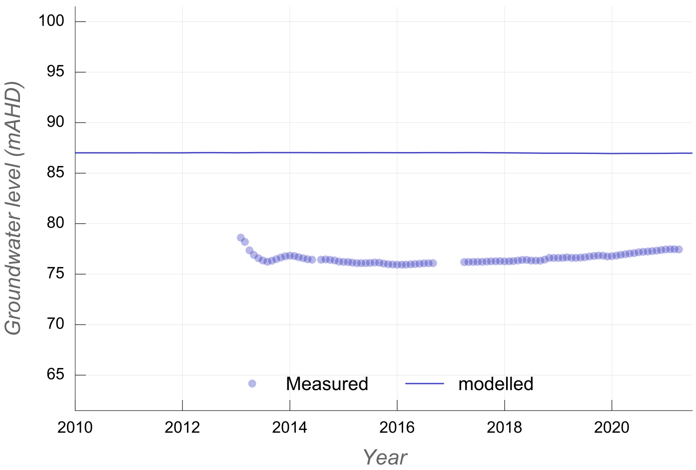
S2151_552.9



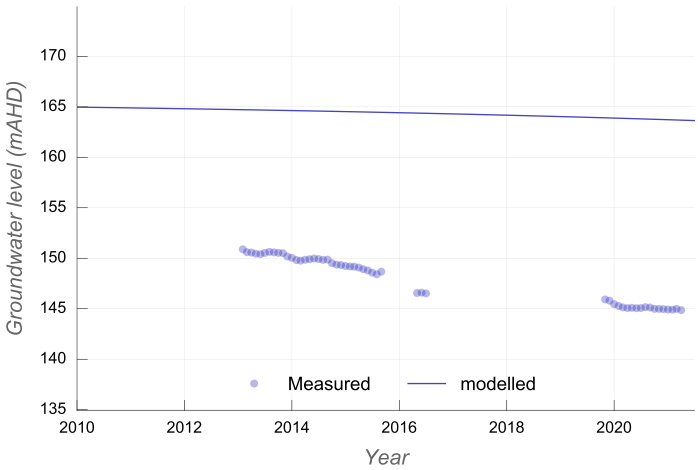
S2158_44



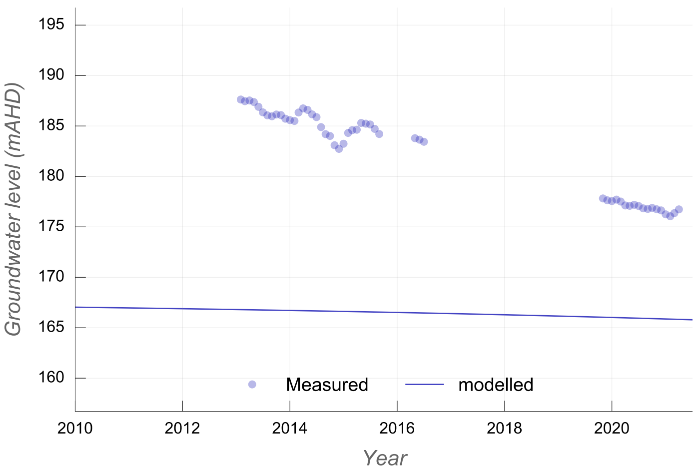
S2158_65



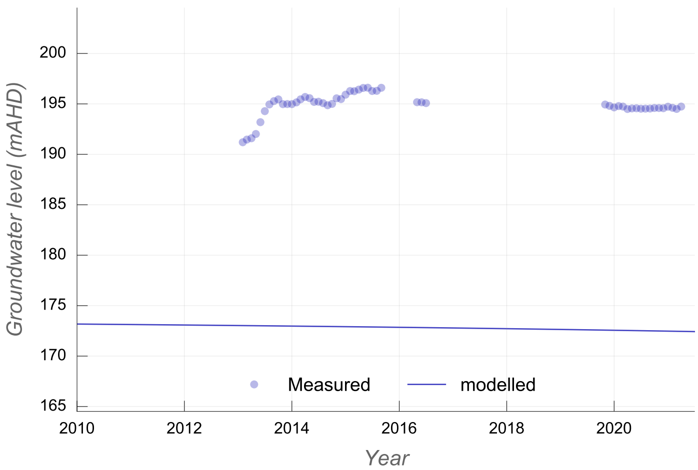
S2158_218

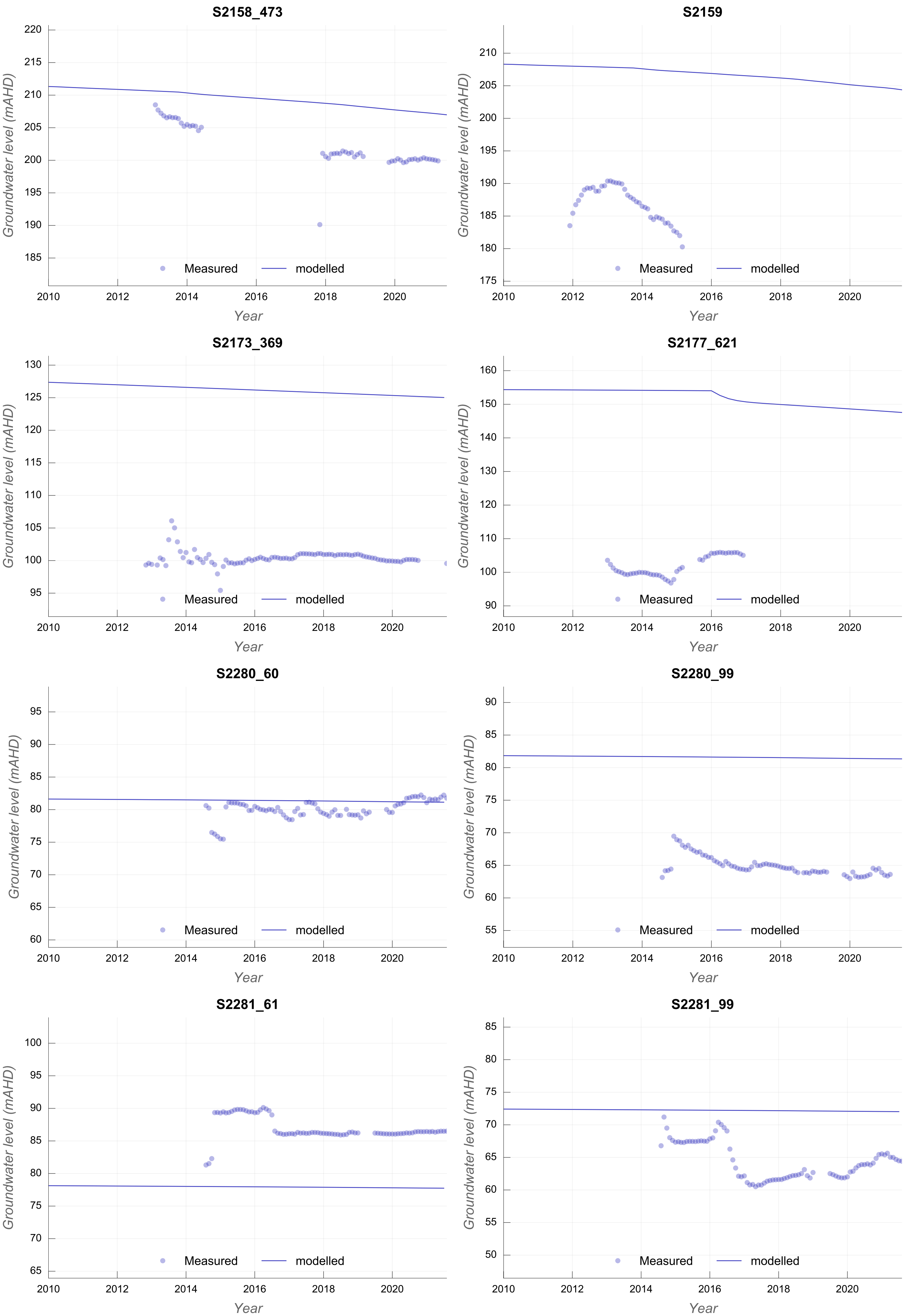


S2158_377

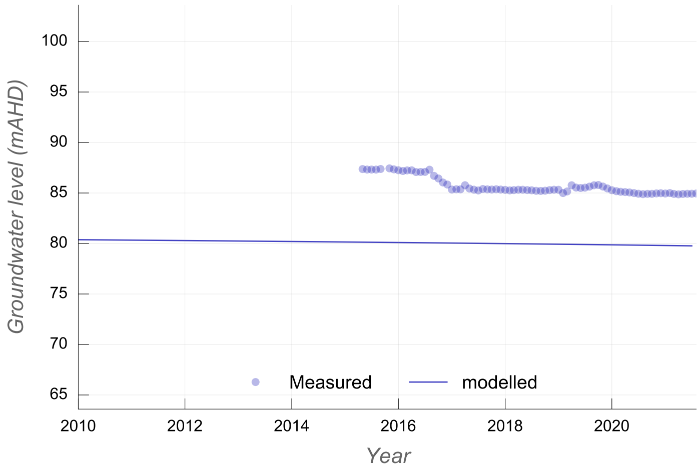


S2158_404

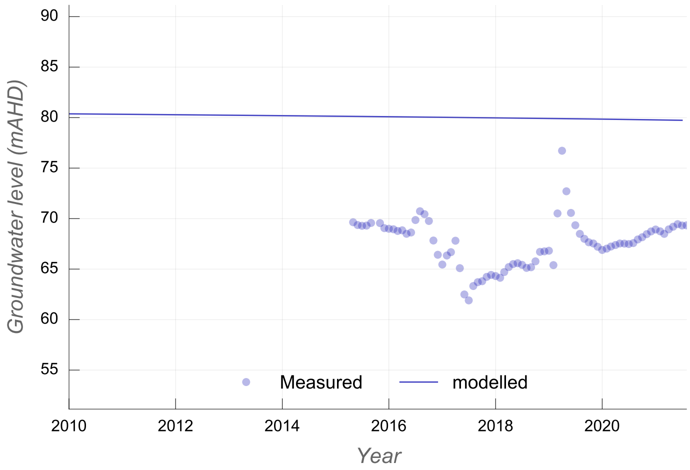



S2158_473
S2159
S2173_369
S2177_621
S2280_60
S2280_99
S2281_61
S2281_99
Groundwater level (mAHD)
Year
Measured
modelled

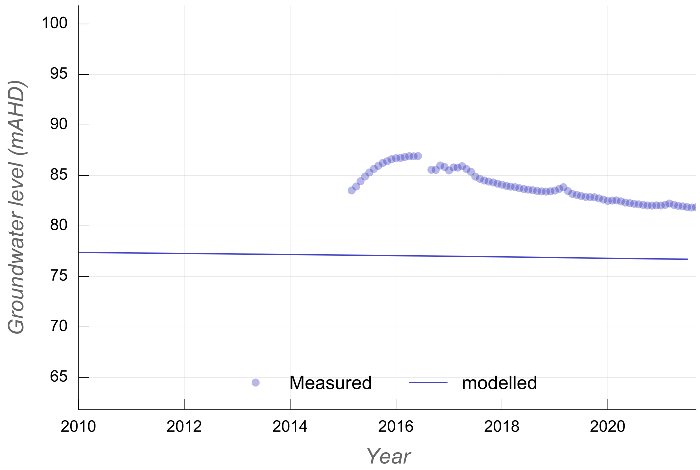
S2282_60



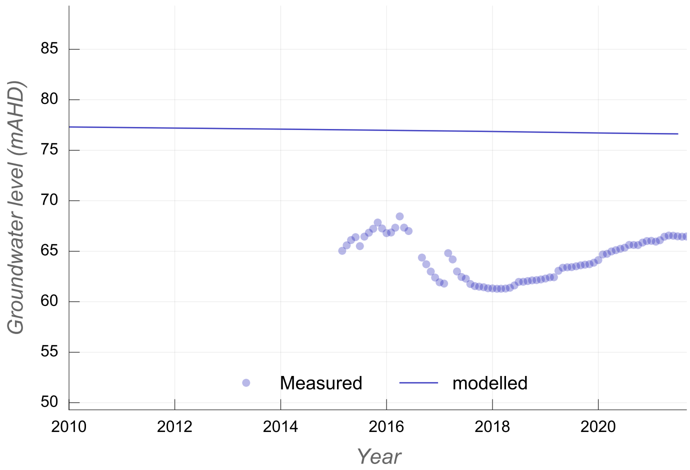
S2282_100



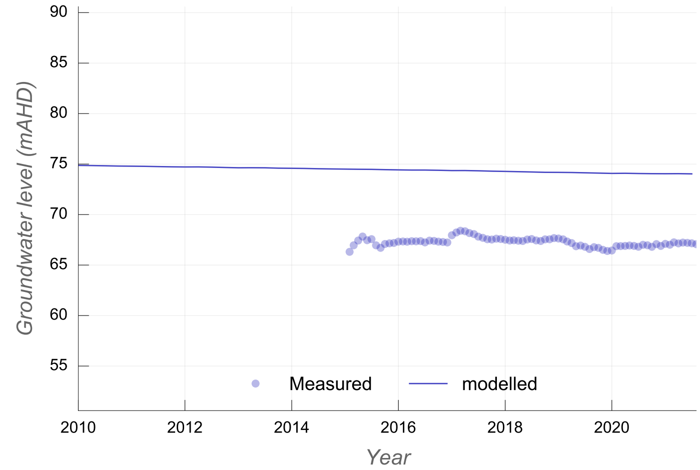
S2283_60



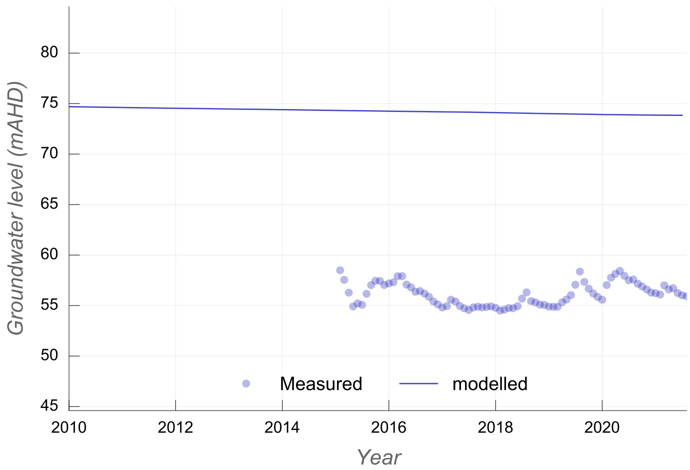
S2283_100



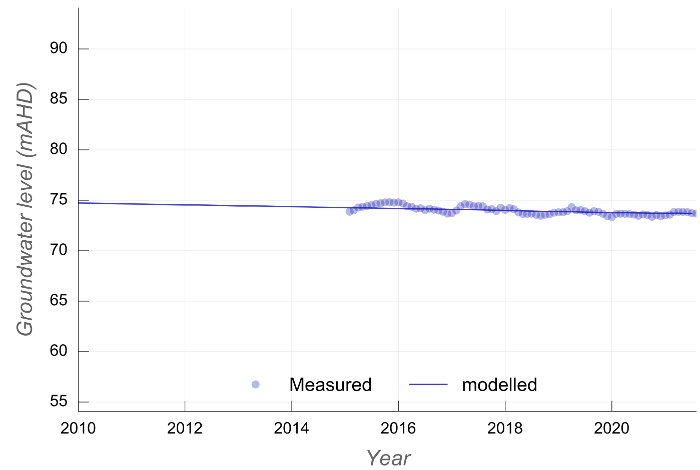
S2284_60



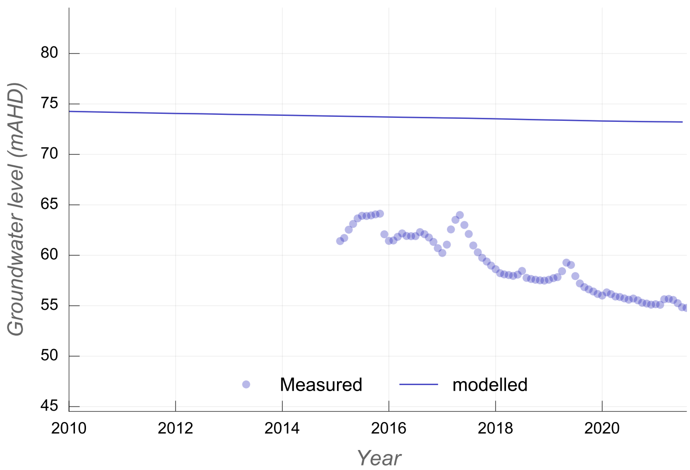
S2284_100



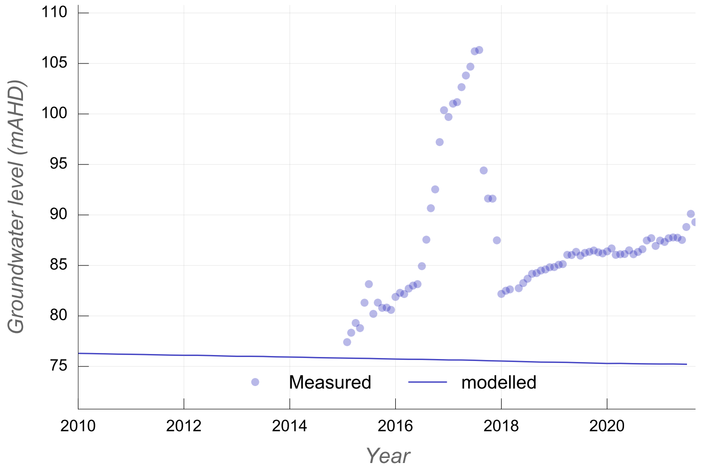
S2285_60



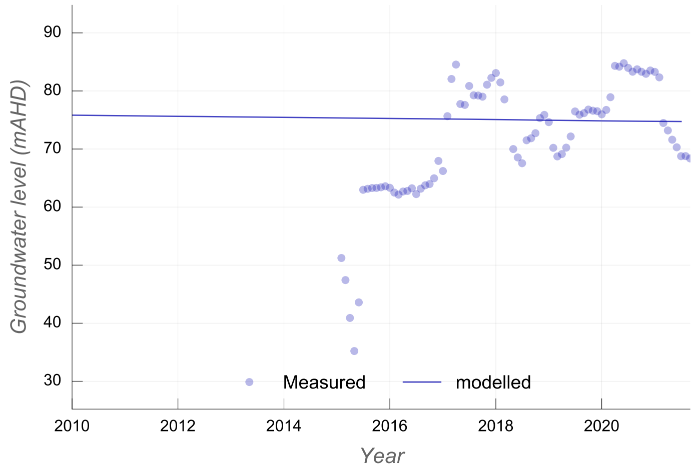
S2285_100



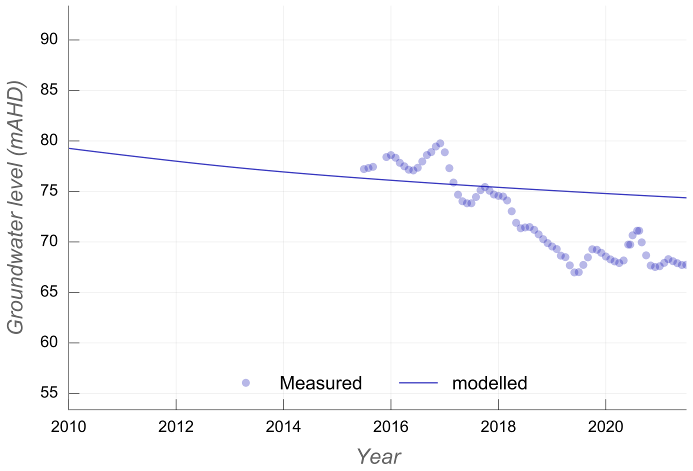
S2286_60



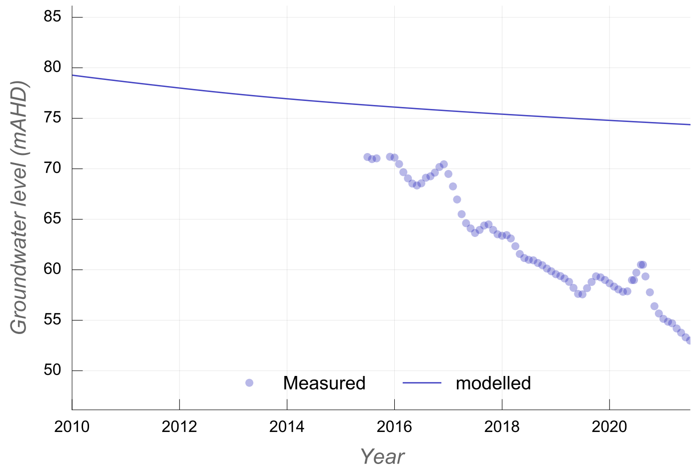
S2286_100



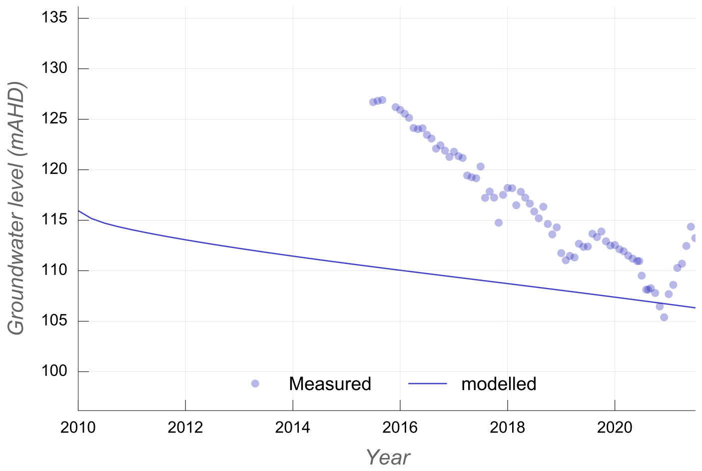
S2308_135



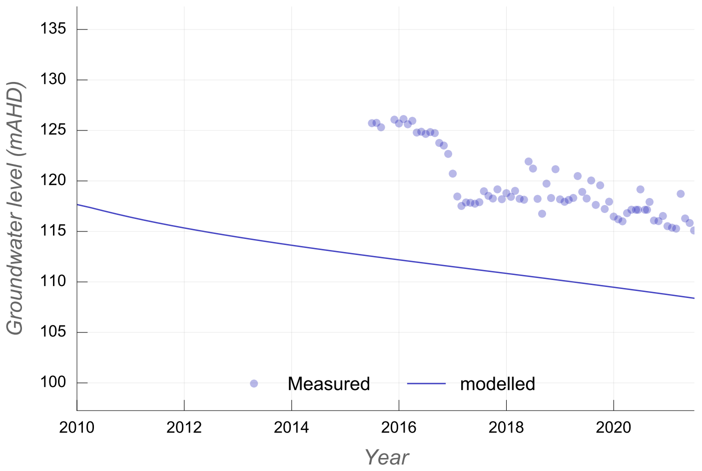
S2308_200



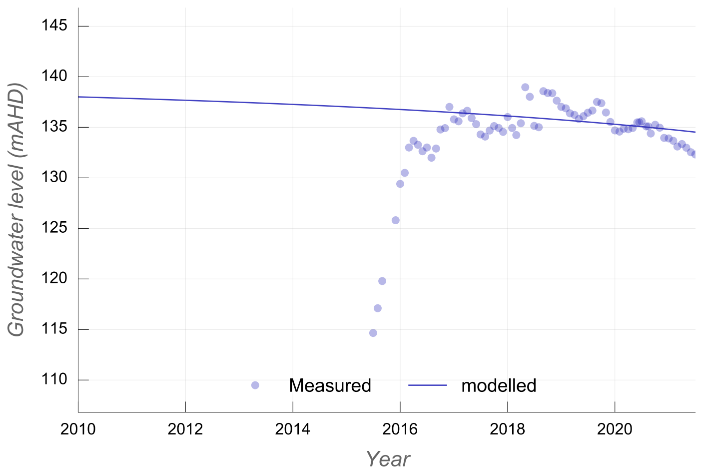
S2308_287



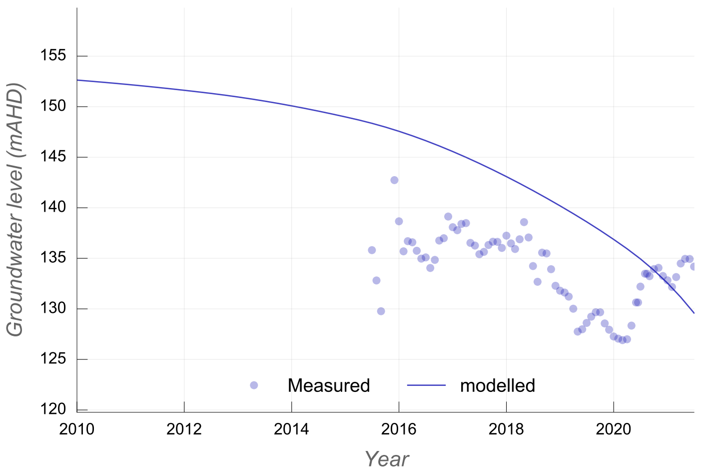
S2308_378

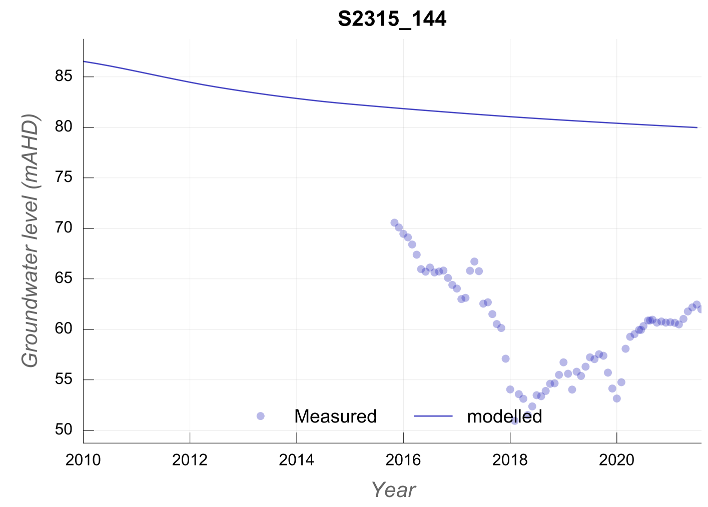


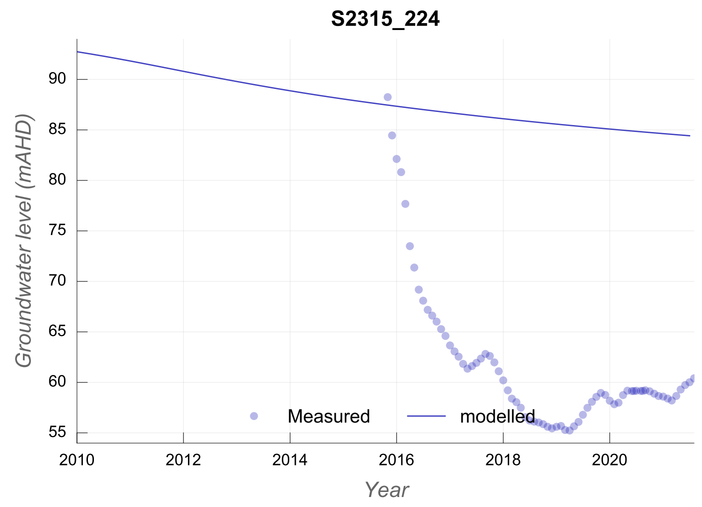
S2308_514

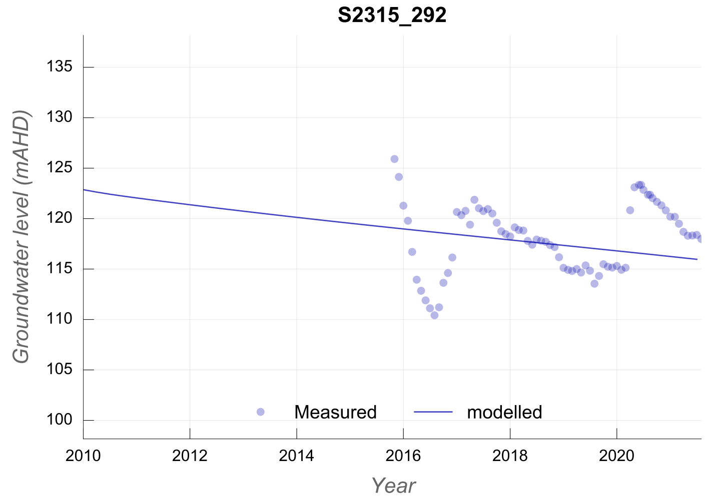


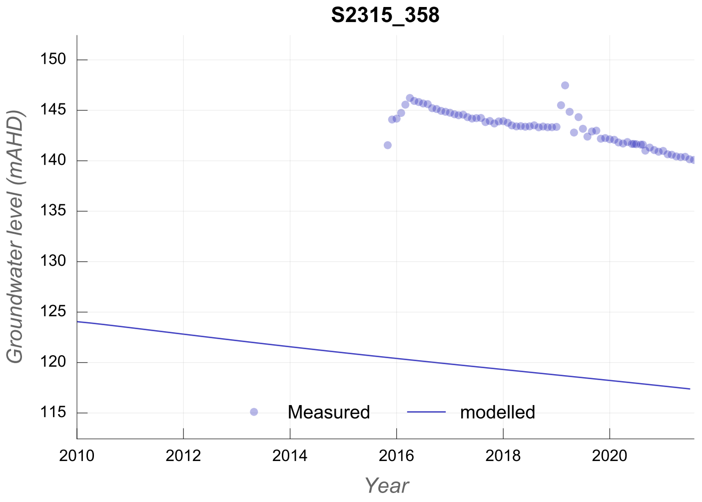
S2308_574

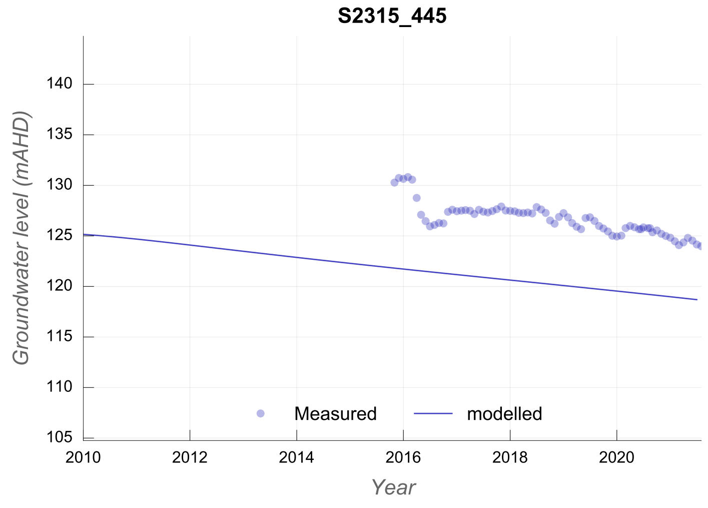


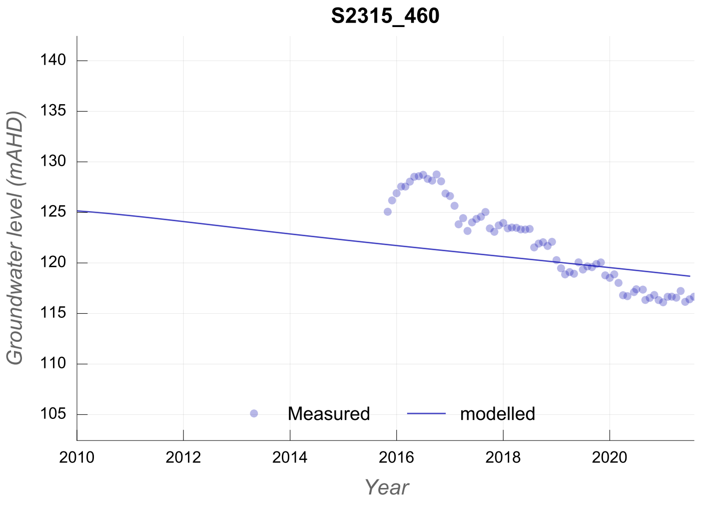

S2315_144
Groundwater level (mAHD)
Year
Measured
modelled

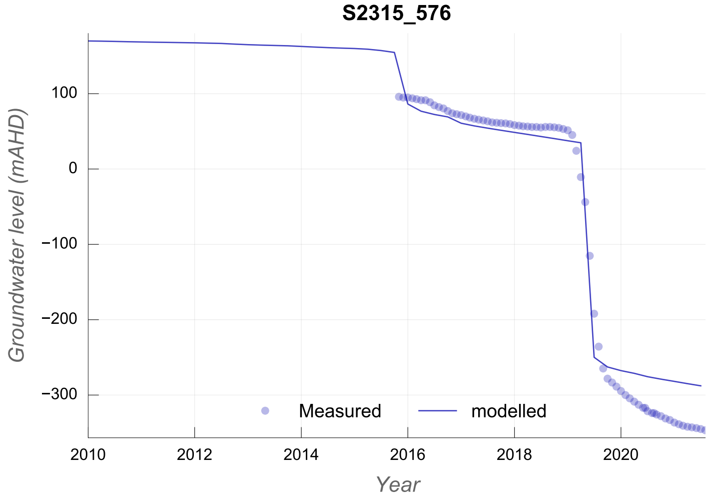

S2315_224
Groundwater level (mAHD)
Year
Measured
modelled

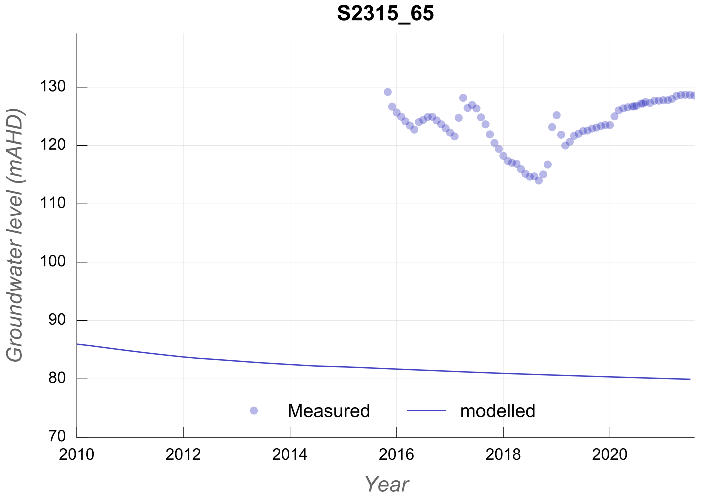

S2315_292
Groundwater level (mAHD)
Year
Measured
modelled


S2315_358
Groundwater level (mAHD)
Year
Measured
modelled

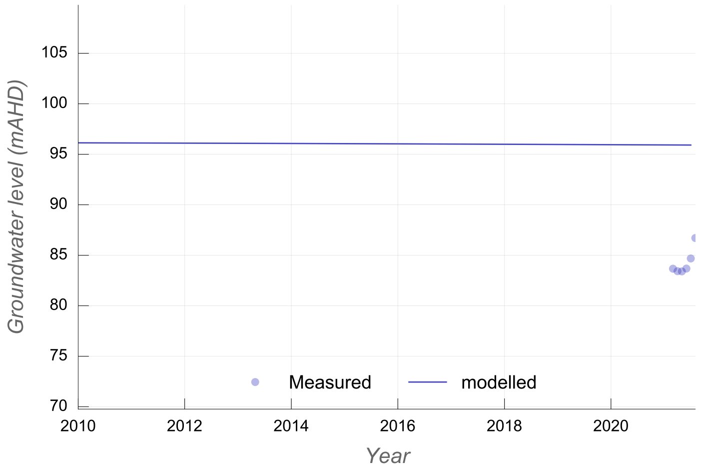

S2315_445
Groundwater level (mAHD)
Year
Measured
modelled


S2315_460
Groundwater level (mAHD)
Year
Measured
modelled

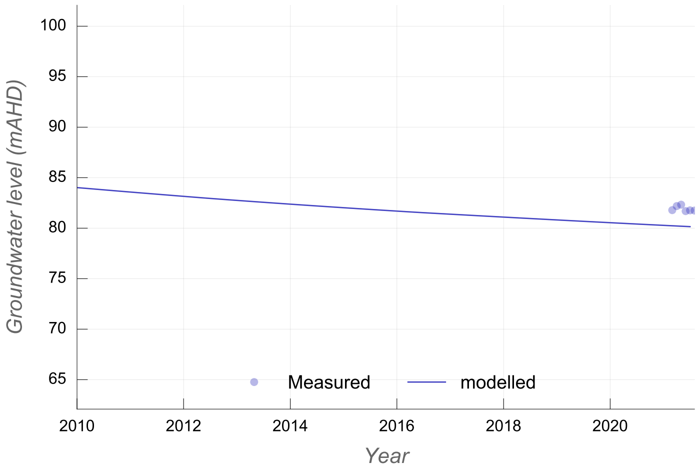

S2315_576
Groundwater level (mAHD)
Year
Measured
modelled


S2315_65
Groundwater level (mAHD)
Year
Measured
modelled

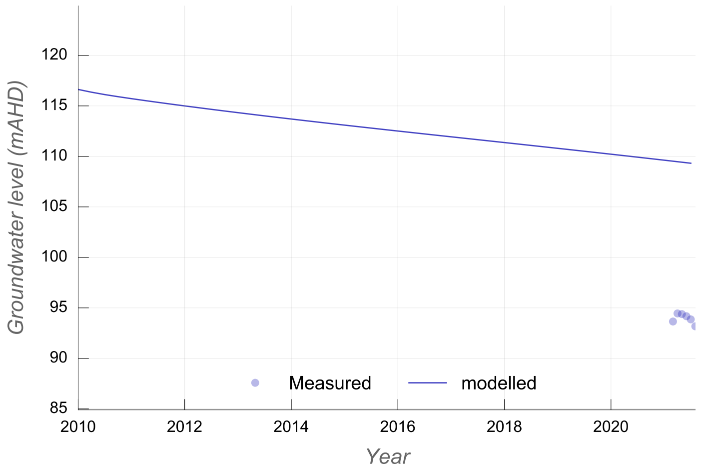
S2524_40



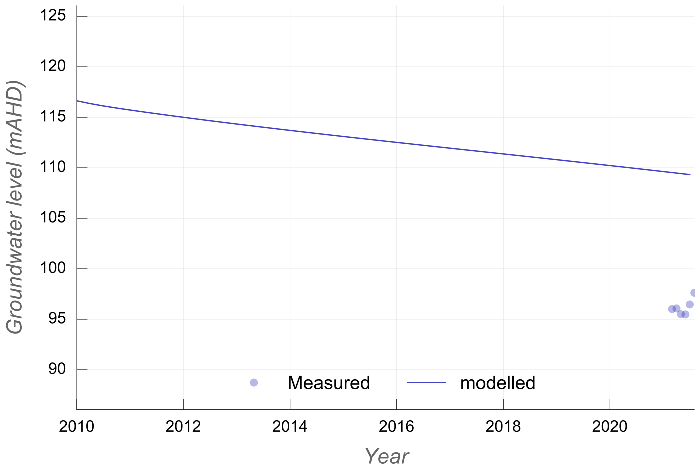
S2524_87



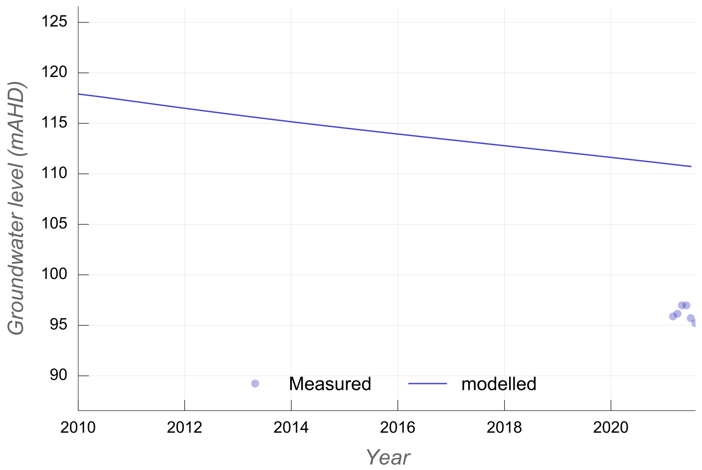
S2524_285



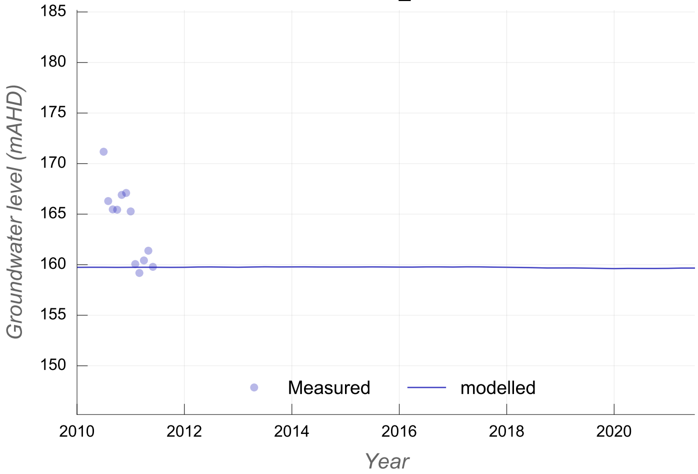
S2524_323



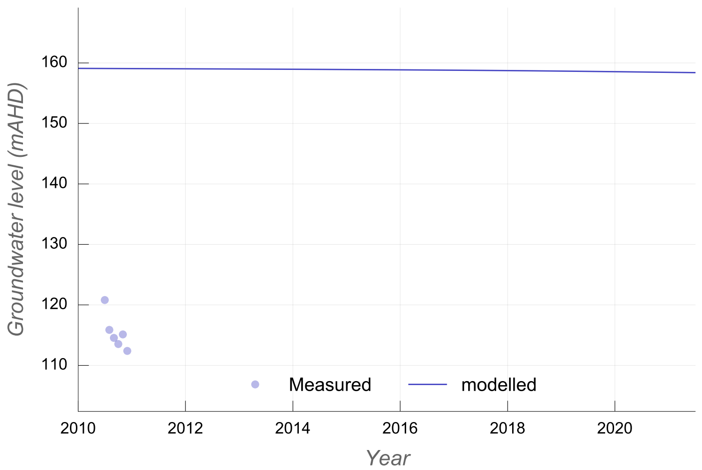
S2524_361



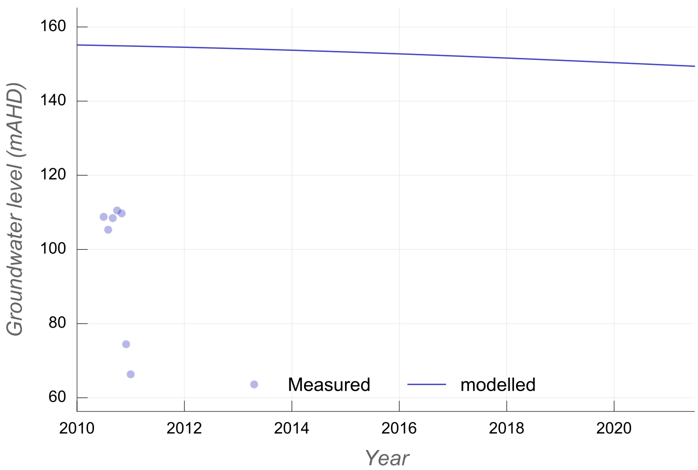
S2087_55

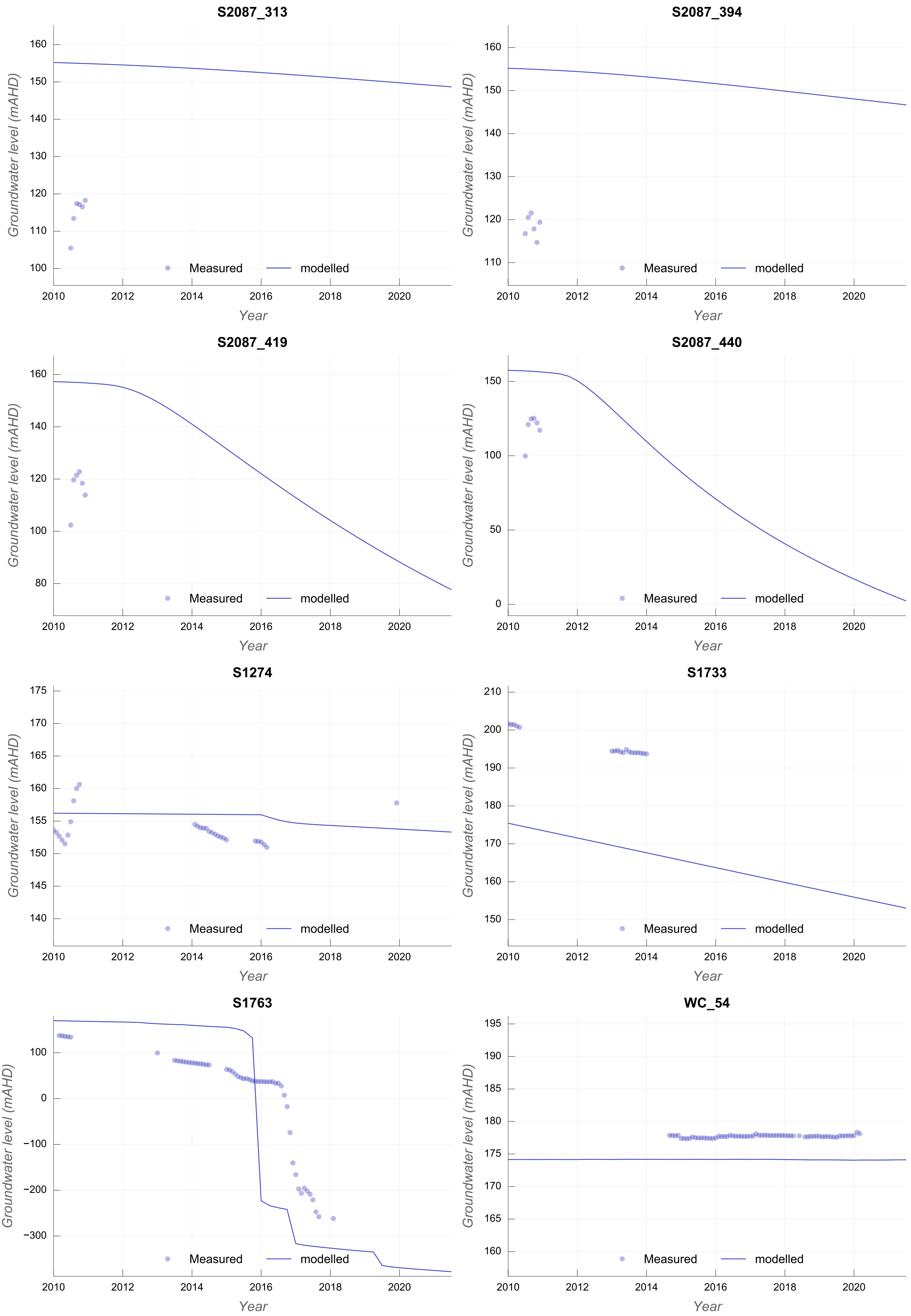


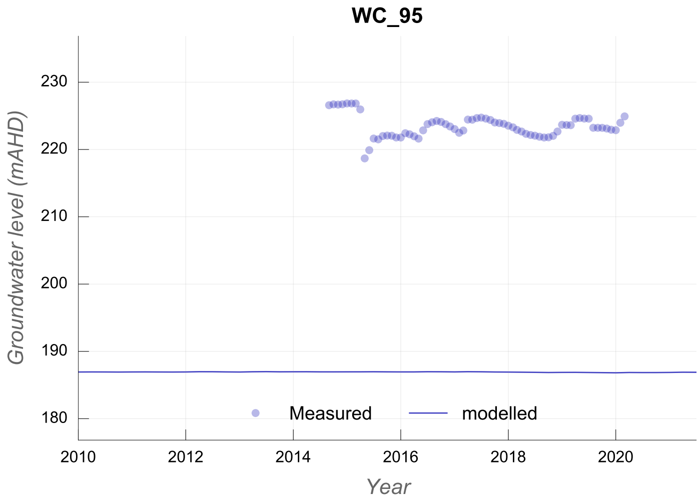
S2087_185

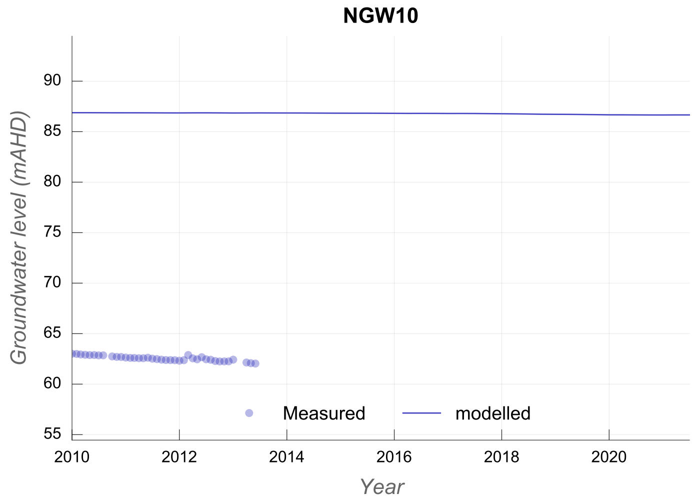


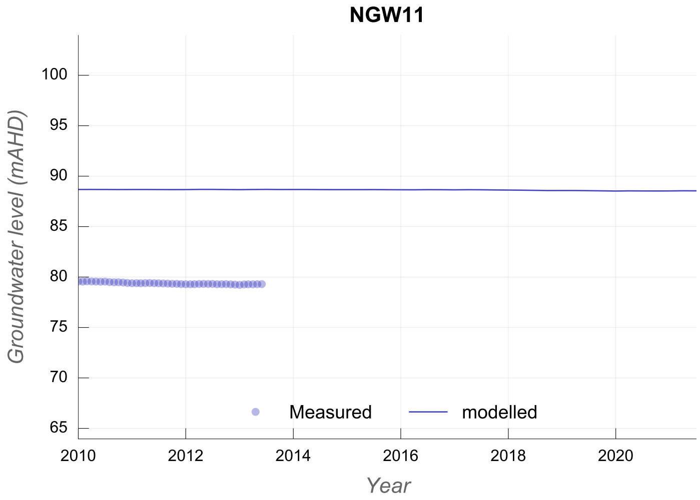
S2087_238

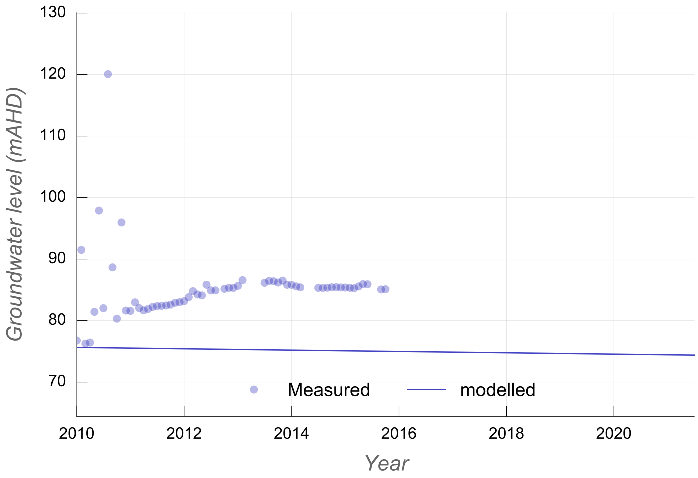


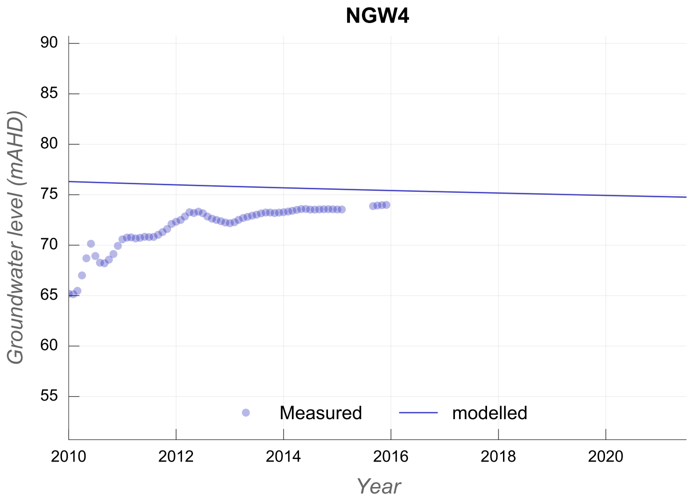

S2087_313
S2087_394
S2087_419
S2087_440
S1274
S1733
S1763
WC_54
Groundwater level (mAHD)
Year
Measured
modelled

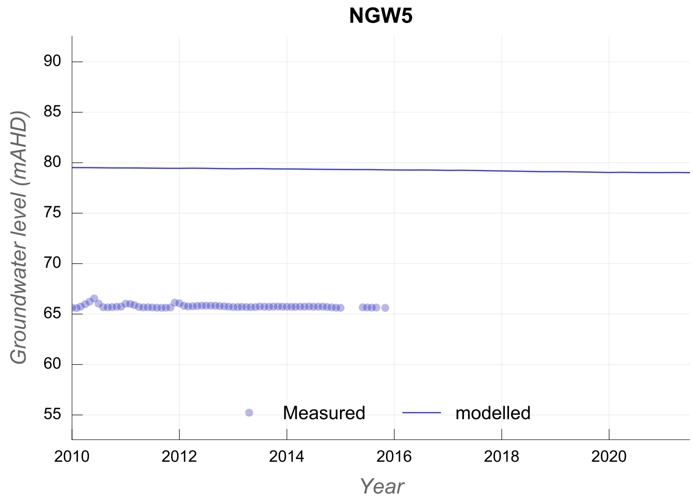

WC_95
Groundwater level (mAHD)
230
220
210
200
190
180
Measured
modelled
2010
2012
2014
2016
2018
2020
Year

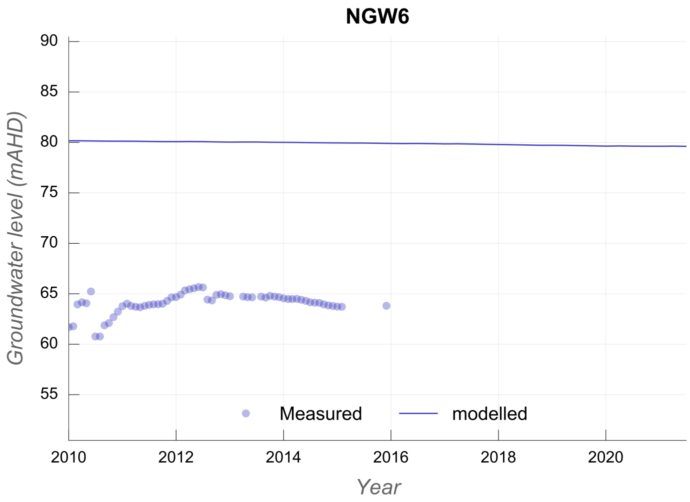

NGW10
Groundwater level (mAHD)
90
85
80
75
70
65
60
55
Measured
modelled
2010
2012
2014
2016
2018
2020
Year

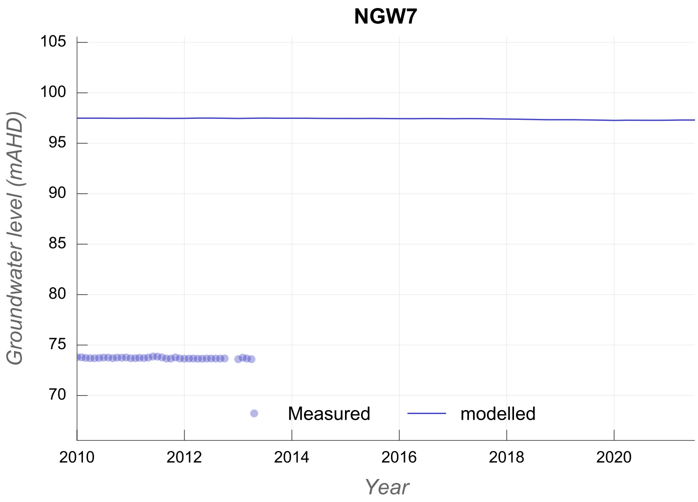

NGW11
Groundwater level (mAHD)
100
95
90
85
80
75
70
65
Measured
modelled
2010
2012
2014
2016
2018
2020
Year


NGW3
Groundwater level (mAHD)
130
120
110
100
90
80
70
Measured
modelled
2010
2012
2014
2016
2018
2020
Year

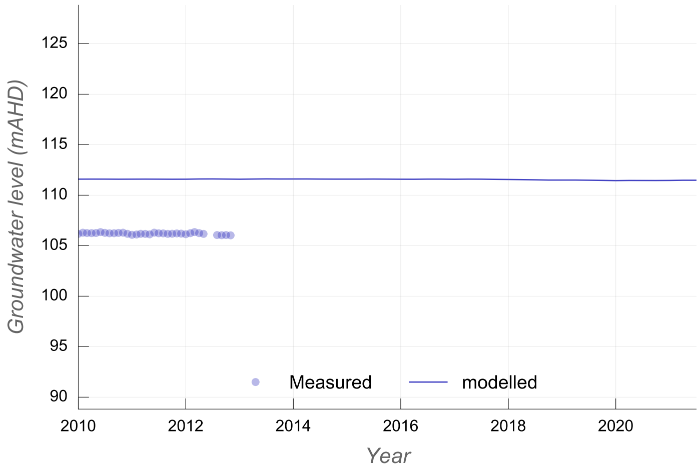

NGW4
Groundwater level (mAHD)
90
85
80
75
70
65
60
55
Measured
modelled
2010
2012
2014
2016
2018
2020
Year


NGW5
Groundwater level (mAHD)
90
85
80
75
70
65
60
55
Measured
modelled
2010
2012
2014
2016
2018
2020
Year

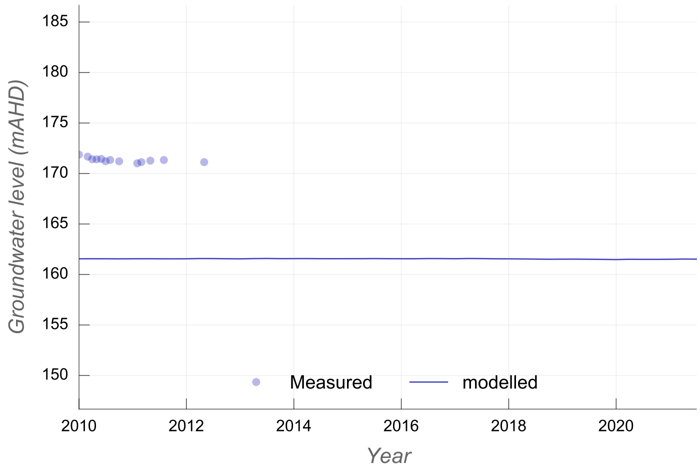

NGW6
Groundwater level (mAHD)
90
85
80
75
70
65
60
55
Measured
modelled
2010
2012
2014
2016
2018
2020
Year


NGW7
Groundwater level (mAHD)
105
100
95
90
85
80
75
70
Measured
modelled
2010
2012
2014
2016
2018
2020
Year

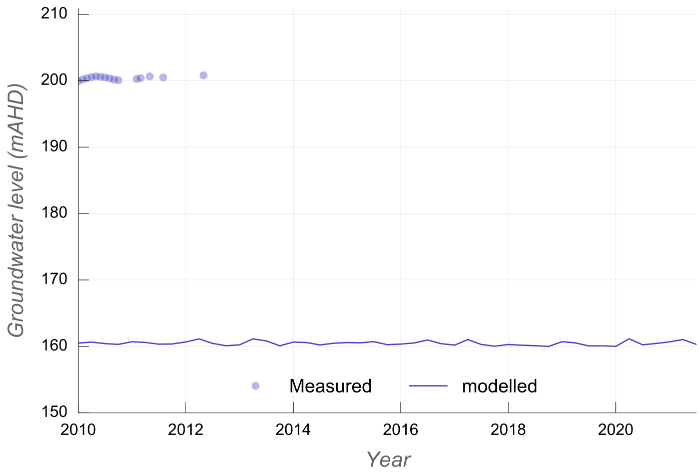
NGW9



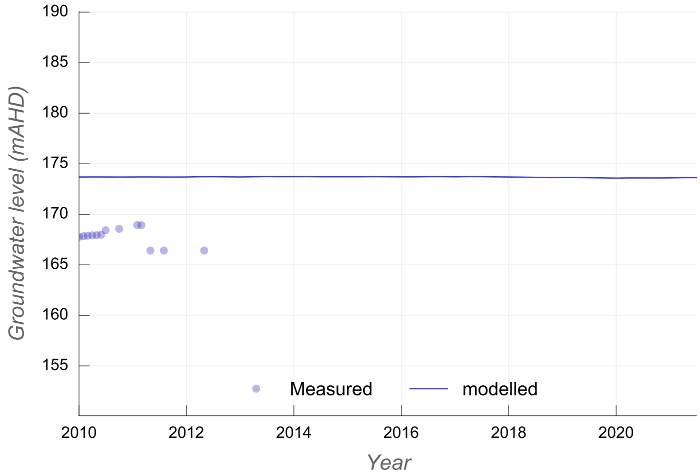
A3GW1B



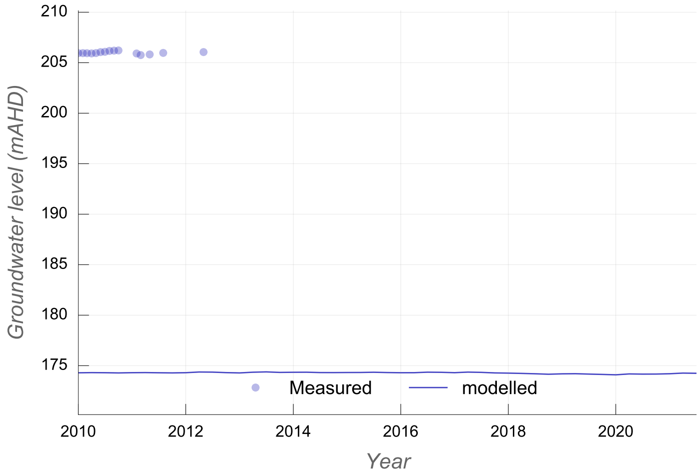
A3GW1C



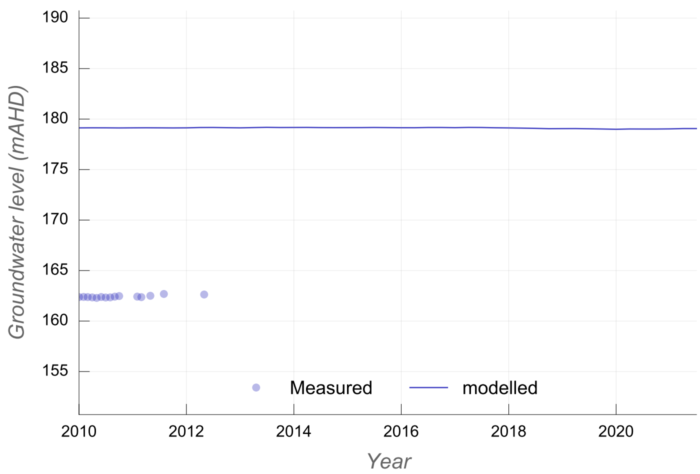
A3GW2A



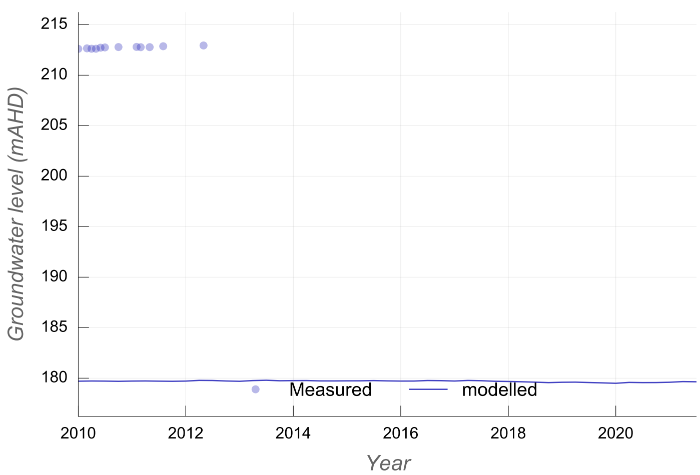
A3GW2C



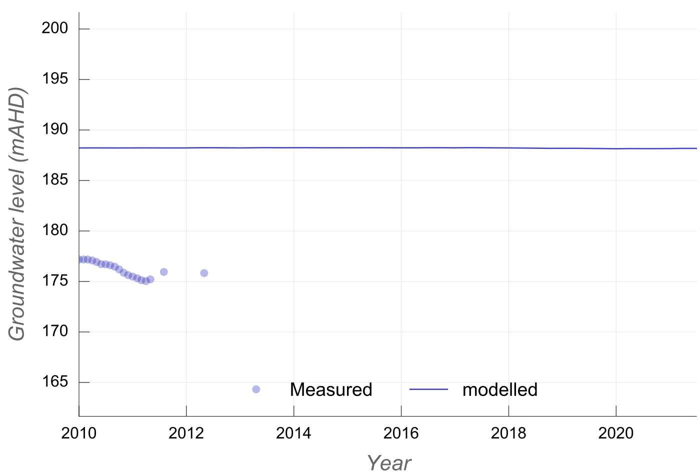
A3GW3A

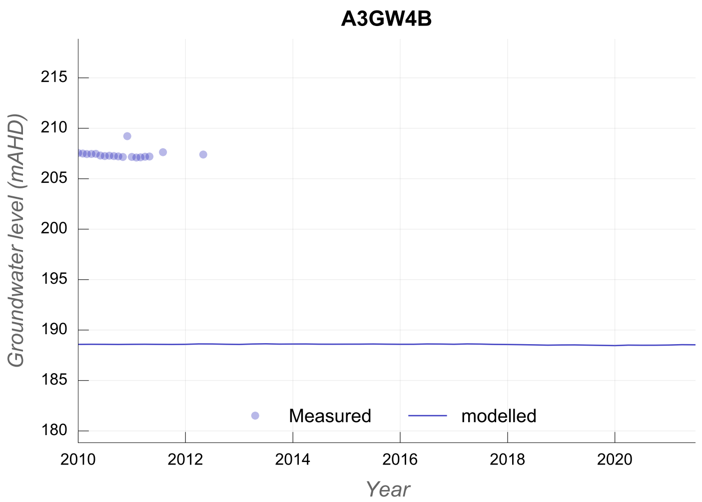


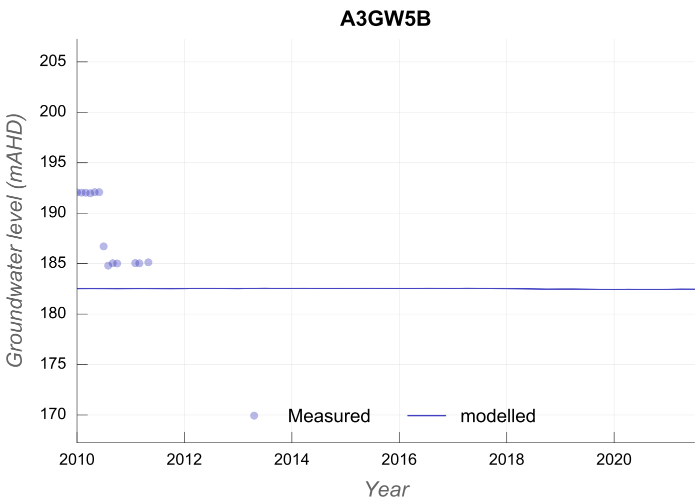
A3GW3C

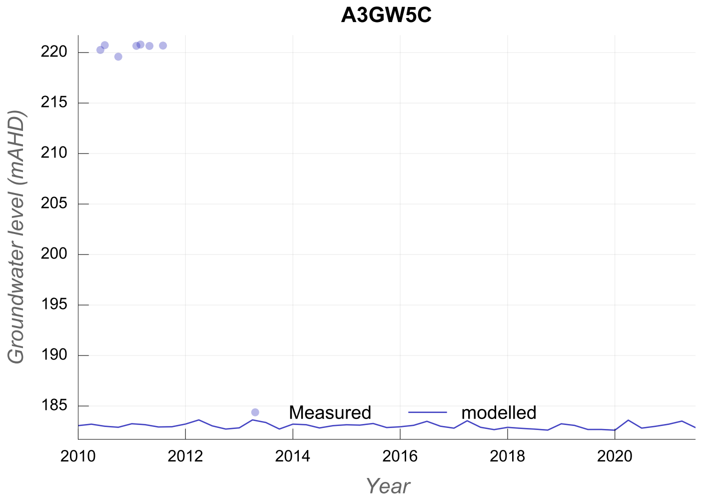


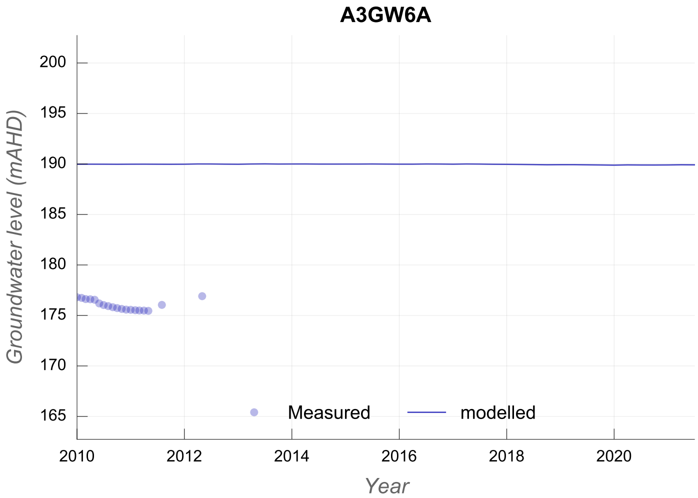
A3GW4A

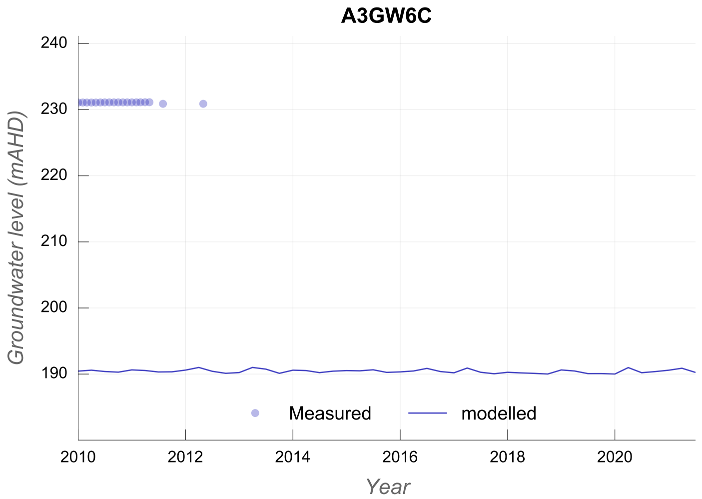


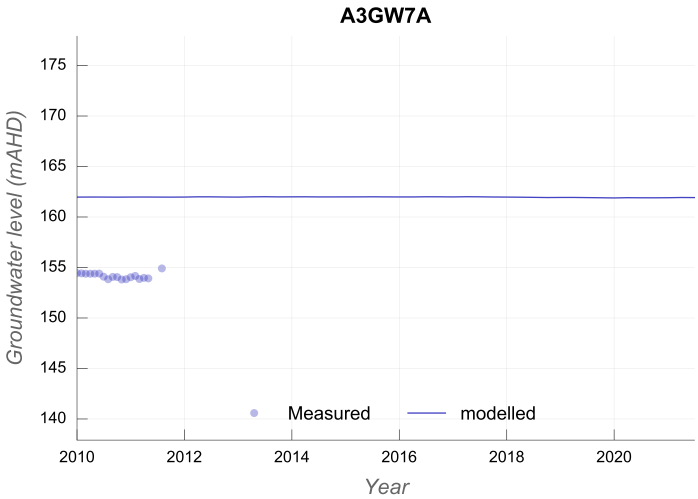

A3GW4B
215
210
205
200
195
190
185
180
Groundwater level (mAHD)
Measured
modelled
2010
2012
2014
2016
2018
2020
Year

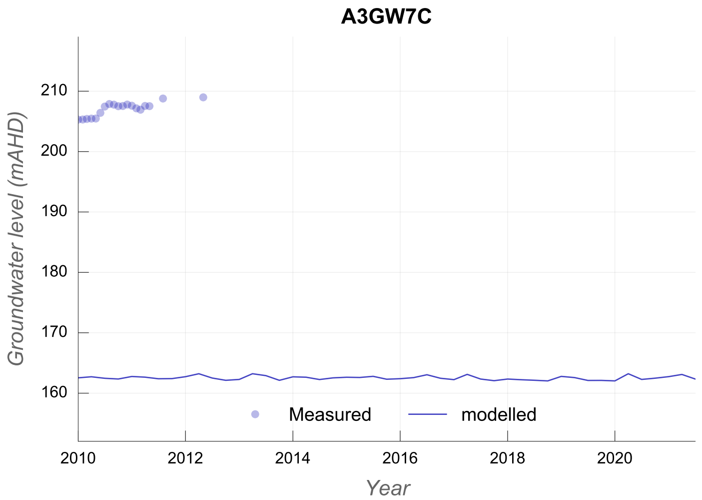

A3GW5B
205
200
195
190
185
180
175
170
Groundwater level (mAHD)
Measured
modelled
2010
2012
2014
2016
2018
2020
Year

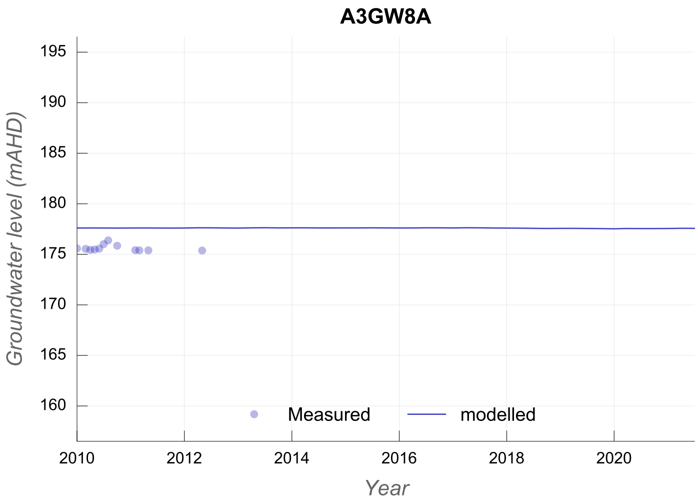

A3GW5C
220
215
210
205
200
195
190
185
Groundwater level (mAHD)
Measured
modelled
2010
2012
2014
2016
2018
2020
Year

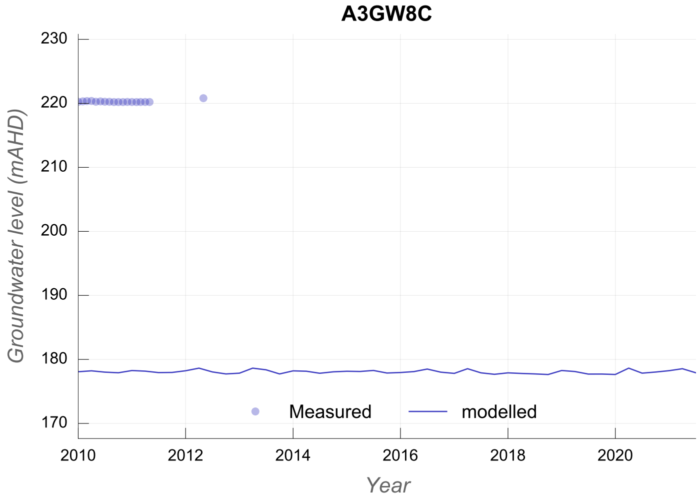

A3GW6A
200
195
190
185
180
175
170
165
Groundwater level (mAHD)
Measured
modelled
2010
2012
2014
2016
2018
2020
Year

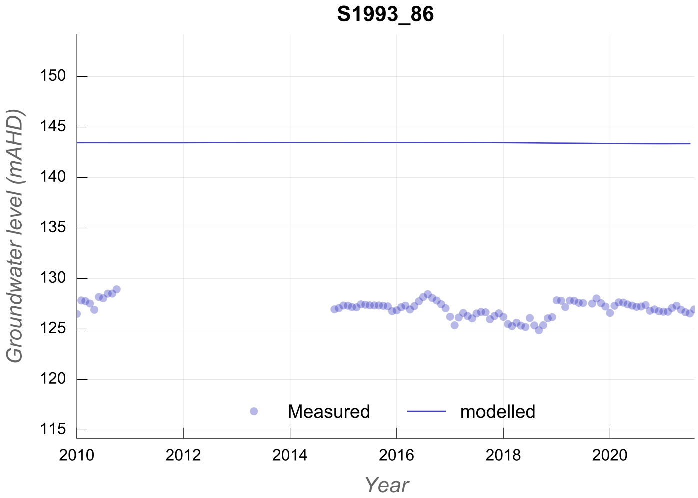

A3GW6C
240
230
220
210
200
190
Groundwater level (mAHD)
Measured
modelled
2010
2012
2014
2016
2018
2020
Year

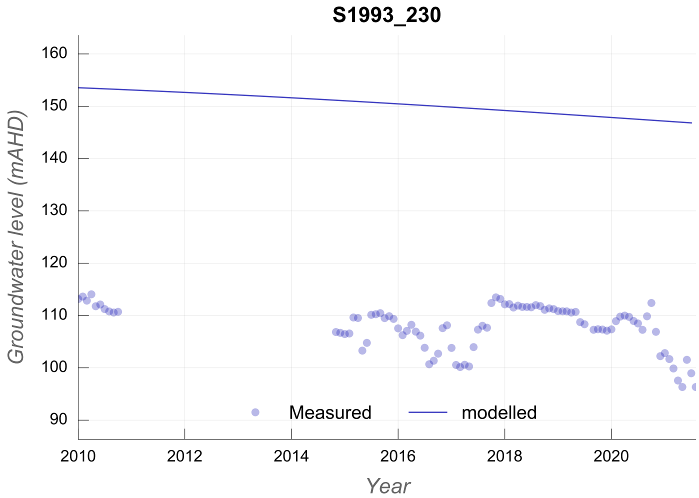

A3GW7A
175
170
165
160
155
150
145
140
Groundwater level (mAHD)
Measured
modelled
2010
2012
2014
2016
2018
2020
Year

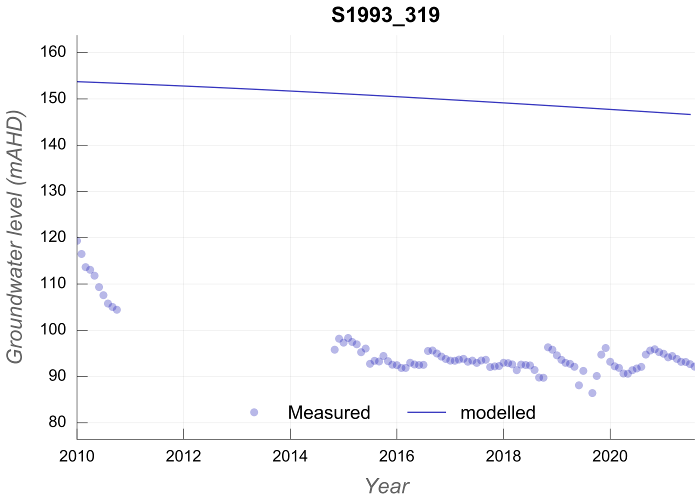

A3GW7C
210
200
190
180
170
160
Groundwater level (mAHD)
Measured
modelled
2010
2012
2014
2016
2018
2020
Year

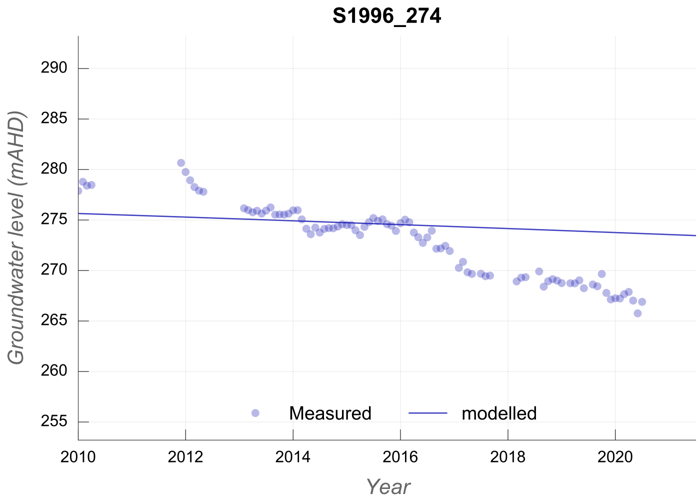

A3GW8A
195
190
185
180
175
170
165
160
Groundwater level (mAHD)
Measured
modelled
2010
2012
2014
2016
2018
2020
Year

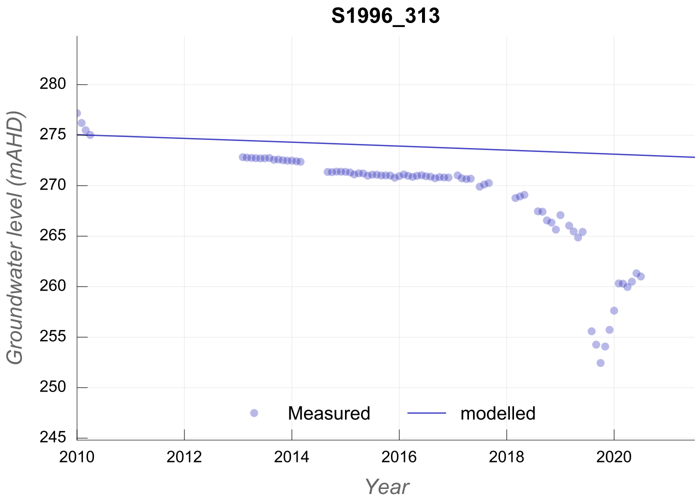

A3GW8C
Groundwater level (mAHD)
230
220
210
200
190
180
170
2010
2012
2014
2016
2018
2020
Year
Measured
modelled

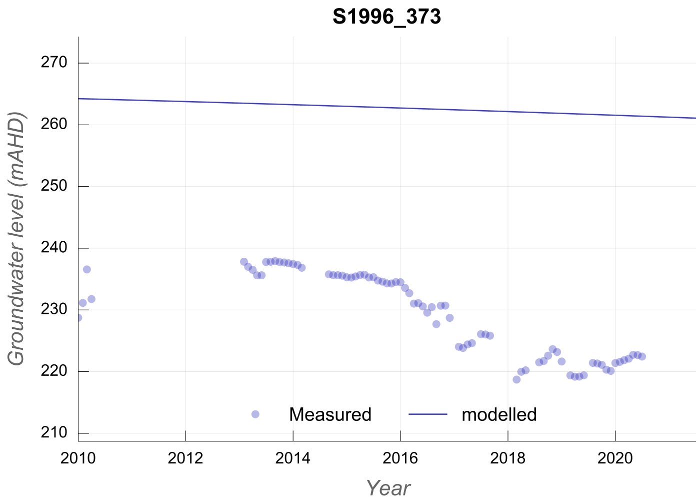

S1993_86
Groundwater level (mAHD)
150
145
140
135
130
125
120
115
2010
2012
2014
2016
2018
2020
Year
Measured
modelled

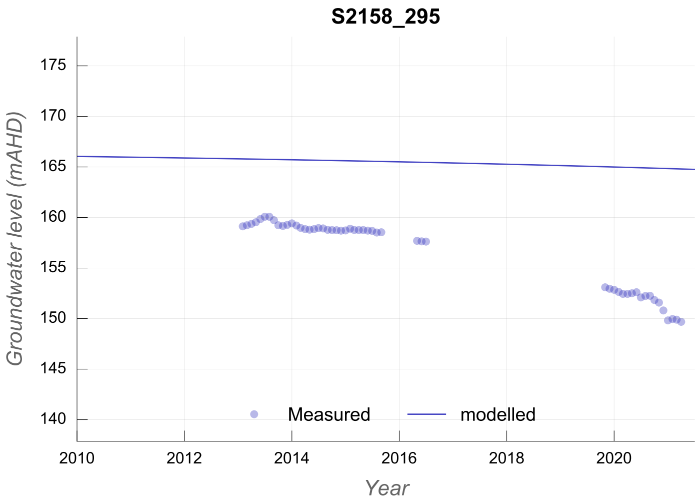

S1993_230
Groundwater level (mAHD)
160
150
140
130
120
110
100
90
2010
2012
2014
2016
2018
2020
Year
Measured
modelled

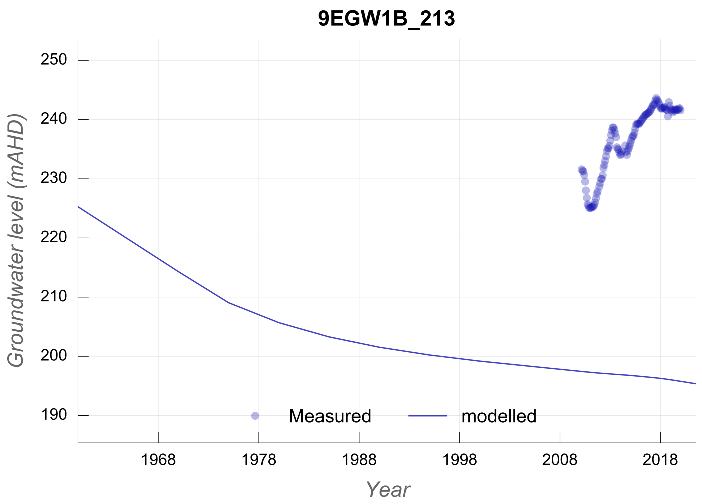

S1993_319
Groundwater level (mAHD)
160
150
140
130
120
110
100
90
80
2010
2012
2014
2016
2018
2020
Year
Measured
modelled

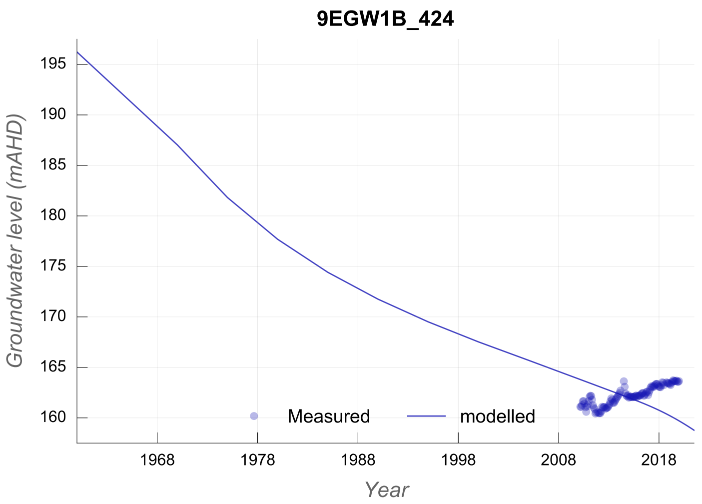

S1996_274
Groundwater level (mAHD)
290
285
280
275
270
265
260
255
2010
2012
2014
2016
2018
2020
Year
Measured
modelled

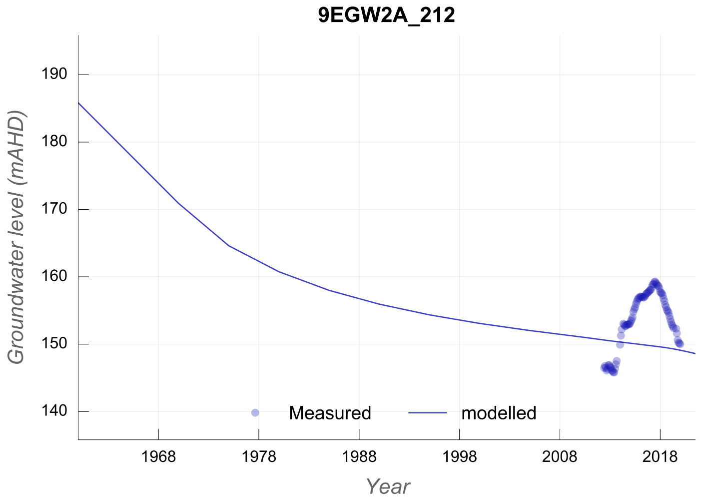

S1996_313
Groundwater level (mAHD)
280
275
270
265
260
255
250
245
2010
2012
2014
2016
2018
2020
Year
Measured
modelled

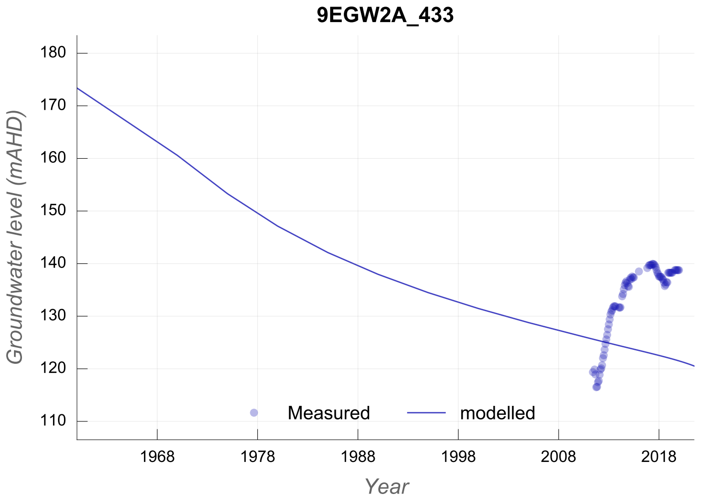

S1996_373
Groundwater level (mAHD)
270
260
250
240
230
220
210
2010
2012
2014
2016
2018
2020
Year
Measured
modelled

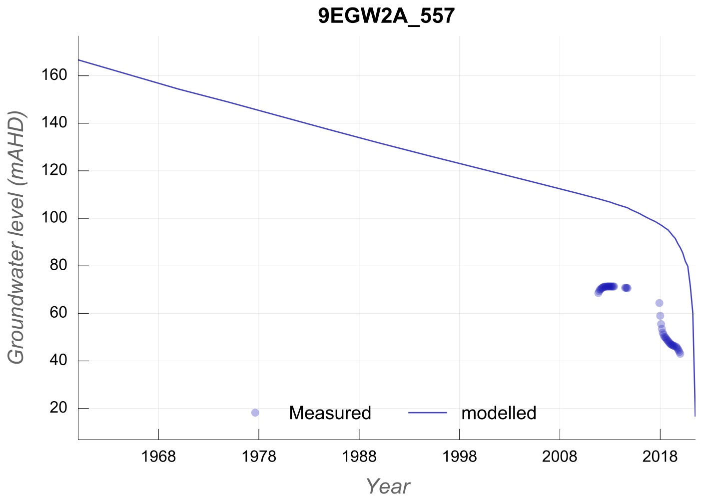

S2158_295
Groundwater level (mAHD)
175
170
165
160
155
150
145
140
2010
2012
2014
2016
2018
2020
Year
Measured
modelled

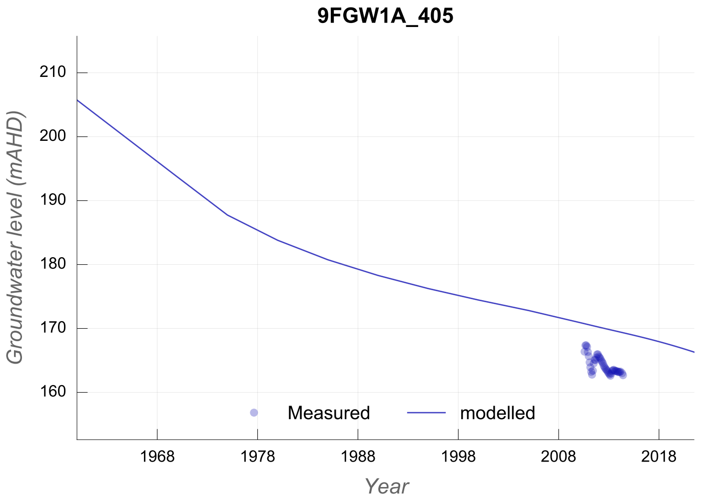

9EGW1B_213
Groundwater level (mAHD)
250
240
230
220
210
200
190
Measured
modelled
1968
1978
1988
1998
2008
2018
Year

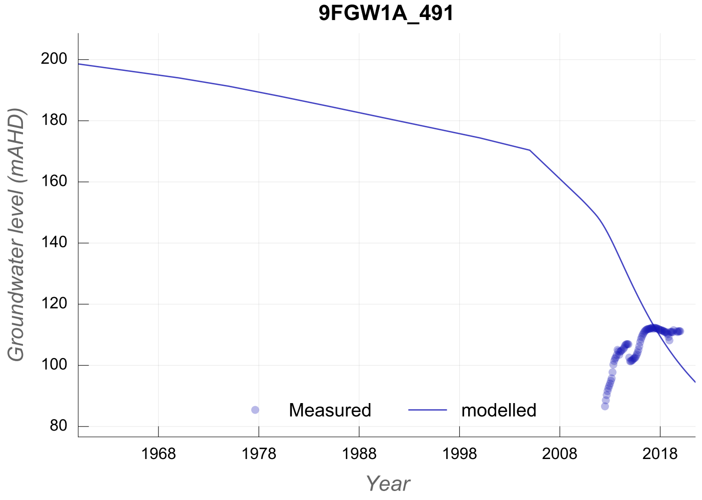

9EGW1B_424
Groundwater level (mAHD)
195
190
185
180
175
170
165
160
Measured
modelled
1968
1978
1988
1998
2008
2018
Year

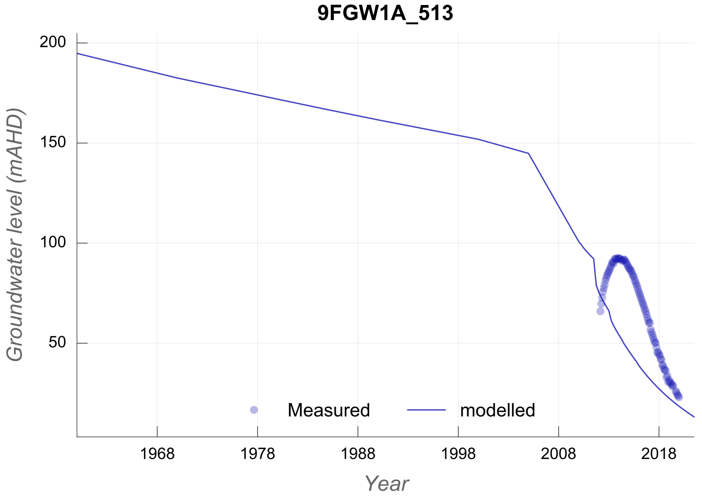

9EGW2A_212
Groundwater level (mAHD)
190
180
170
160
150
140
Measured
modelled
1968
1978
1988
1998
2008
2018
Year

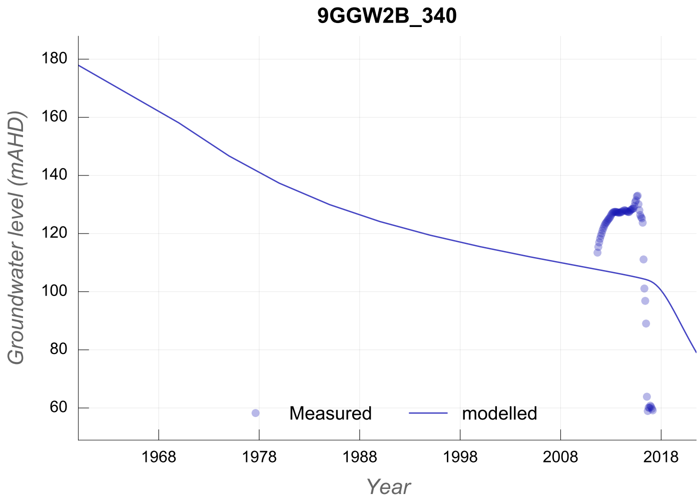

9EGW2A_433
Groundwater level (mAHD)
180
170
160
150
140
130
120
110
Measured
modelled
1968
1978
1988
1998
2008
2018
Year

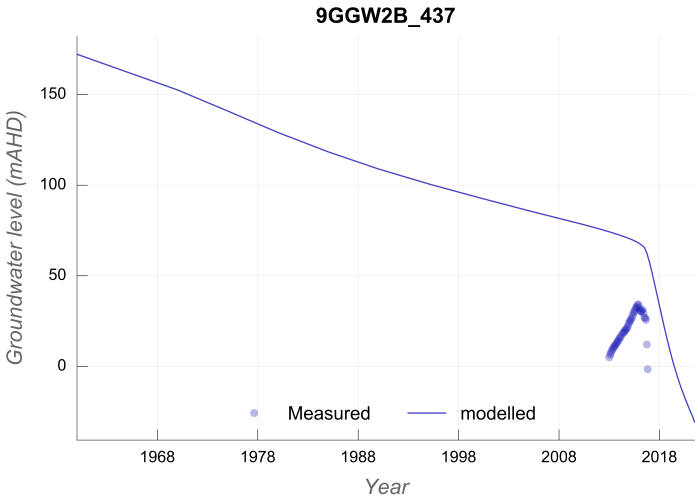

9EGW2A_557
Groundwater level (mAHD)
160
140
120
100
80
60
40
20
Measured
modelled
1968
1978
1988
1998
2008
2018
Year

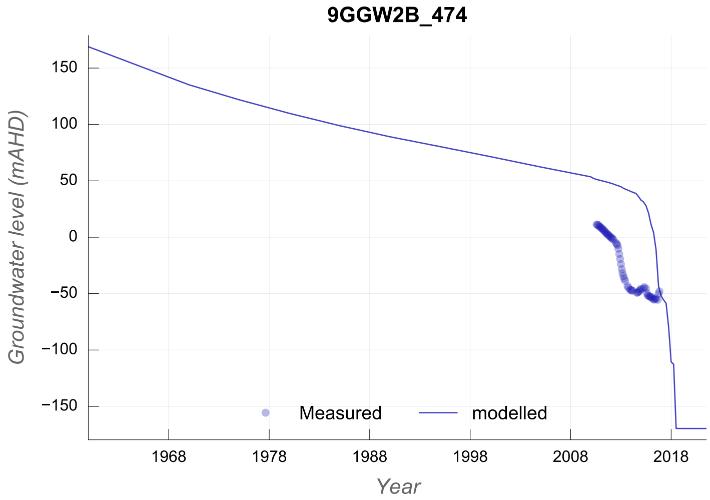

9FGW1A_405
Groundwater level (mAHD)
210
200
190
180
170
160
Measured
modelled
1968
1978
1988
1998
2008
2018
Year

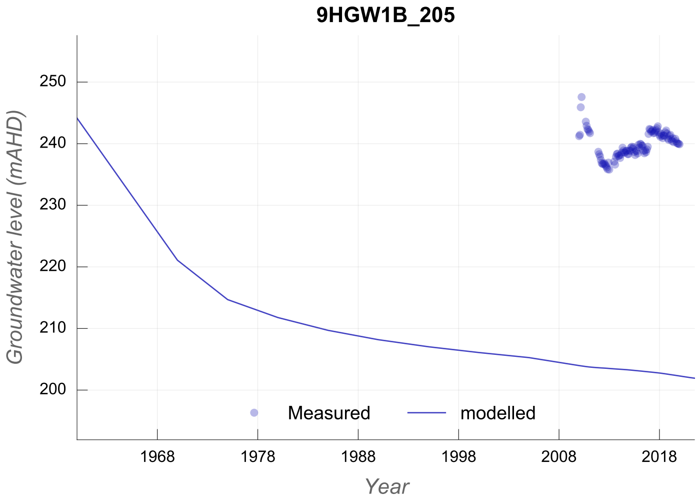

9FGW1A_491
Groundwater level (mAHD)
200
180
160
140
120
100
80
Measured
modelled
1968
1978
1988
1998
2008
2018
Year

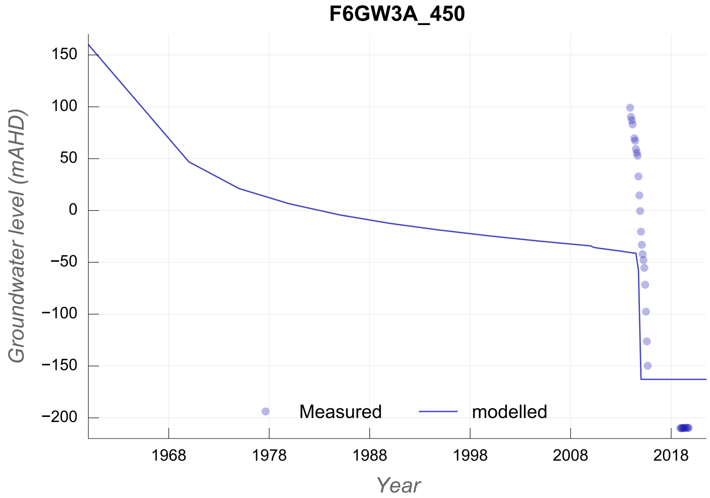

9FGW1A_513
Groundwater level (mAHD)
200
150
100
50
Measured
modelled
1968
1978
1988
1998
2008
2018
Year

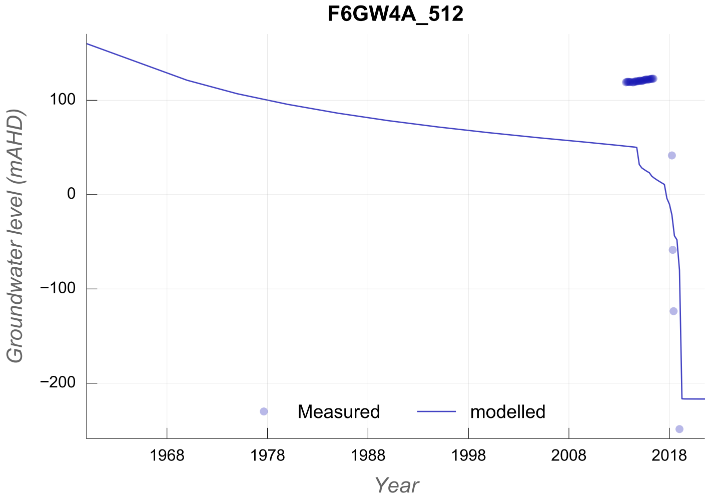

9GGW2B_340
Groundwater level (mAHD)
180
160
140
120
100
80
60
1968
1978
1988
1998
2008
2018
Year
Measured
modelled

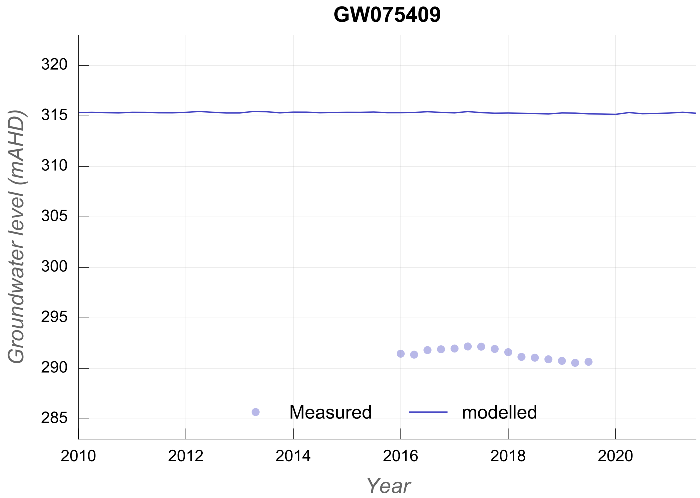

9GGW2B_437
Groundwater level (mAHD)
150
100
50
0
1968
1978
1988
1998
2008
2018
Year
Measured
modelled

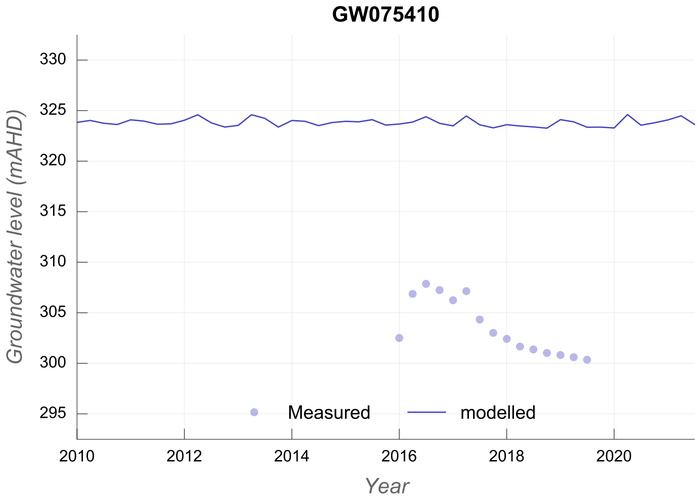

9GGW2B_474
Groundwater level (mAHD)
150
100
50
0
−50
−100
−150
1968
1978
1988
1998
2008
2018
Year
Measured
modelled

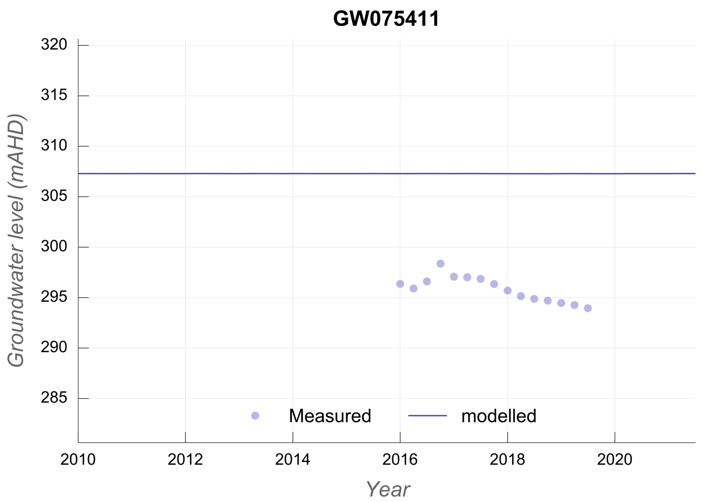

9HGW1B_205
Groundwater level (mAHD)
250
240
230
220
210
200
1968
1978
1988
1998
2008
2018
Year
Measured
modelled

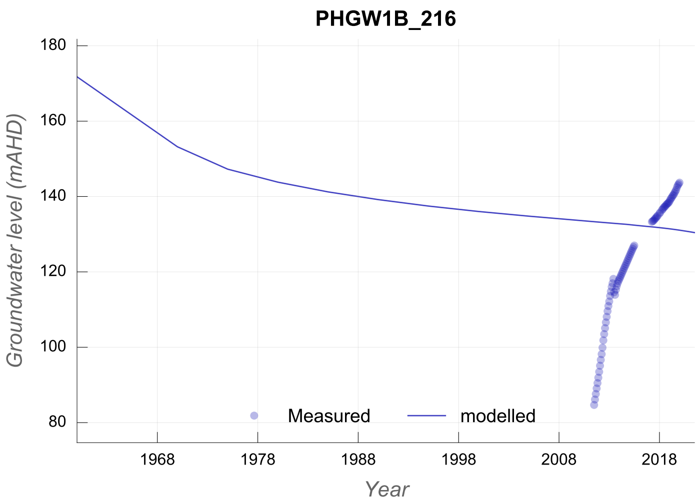

F6GW3A_450
Groundwater level (mAHD)
150
100
50
0
−50
−100
−150
−200
1968
1978
1988
1998
2008
2018
Year
Measured
modelled

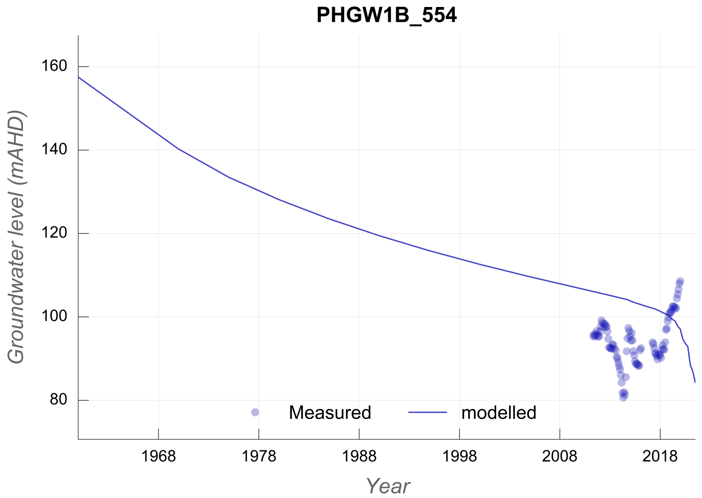

F6GW4A_512
Groundwater level (mAHD)
100
0
−100
−200
1968
1978
1988
1998
2008
2018
Year
Measured
modelled

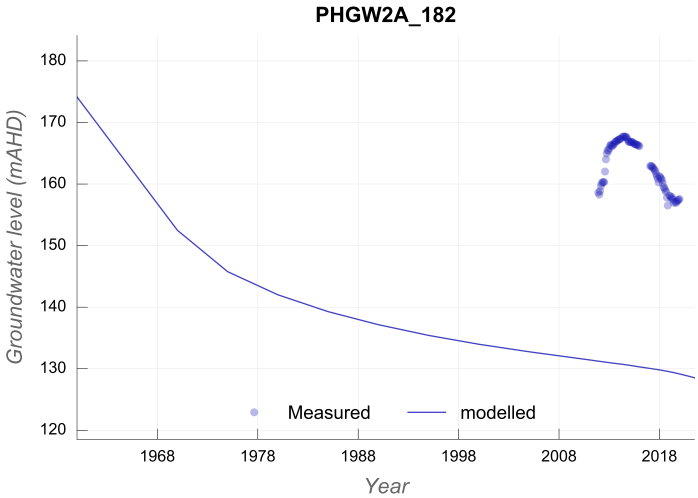

GW075409
Groundwater level (mAHD)
320
315
310
305
300
295
290
285
2010
2012
2014
2016
2018
2020
Year
Measured
modelled

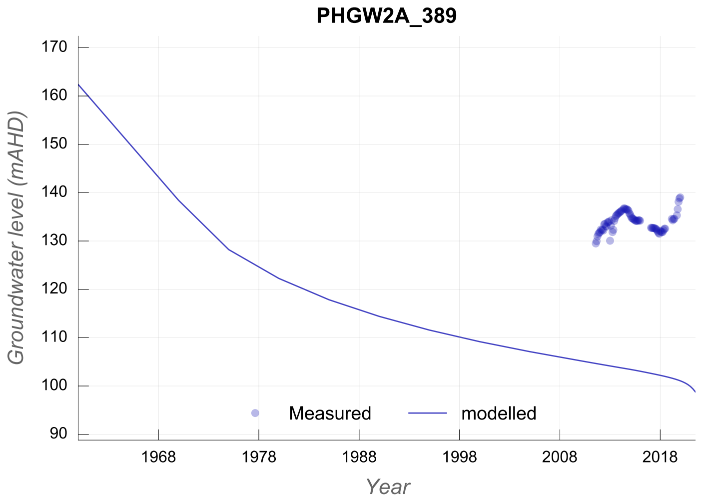

GW075410
Groundwater level (mAHD)
330
325
320
315
310
305
300
295
2010
2012
2014
2016
2018
2020
Year
Measured
modelled

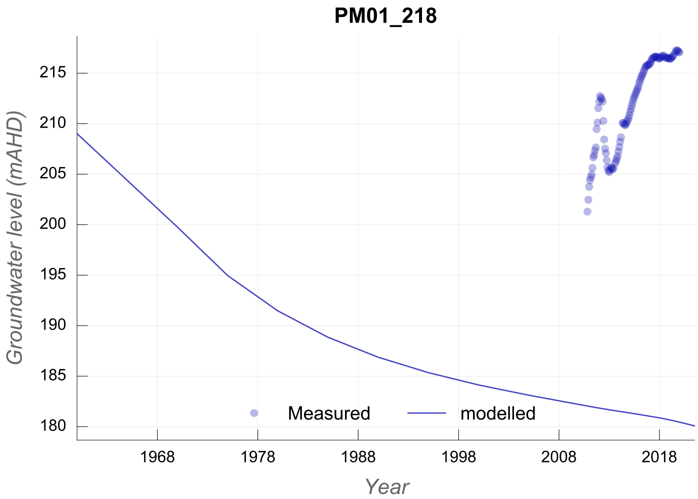

GW075411
Groundwater level (mAHD)
320
315
310
305
300
295
290
285
2010
2012
2014
2016
2018
2020
Year
Measured
modelled

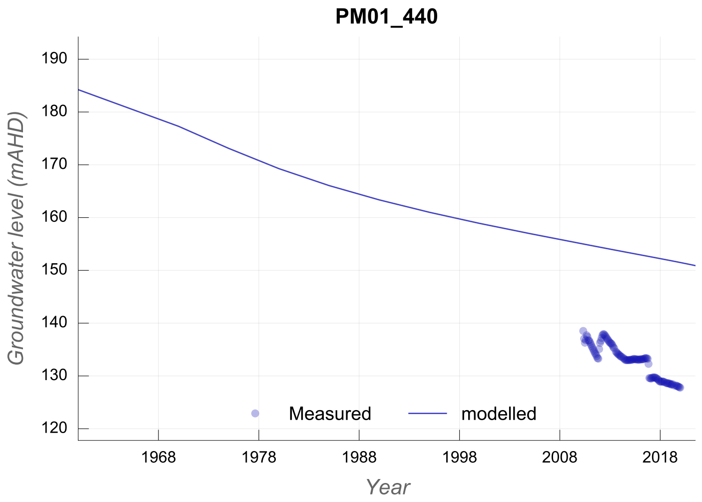

PHGW1B_216
Groundwater level (mAHD)
180
160
140
120
100
80
1968
1978
1988
1998
2008
2018
Year
Measured
modelled

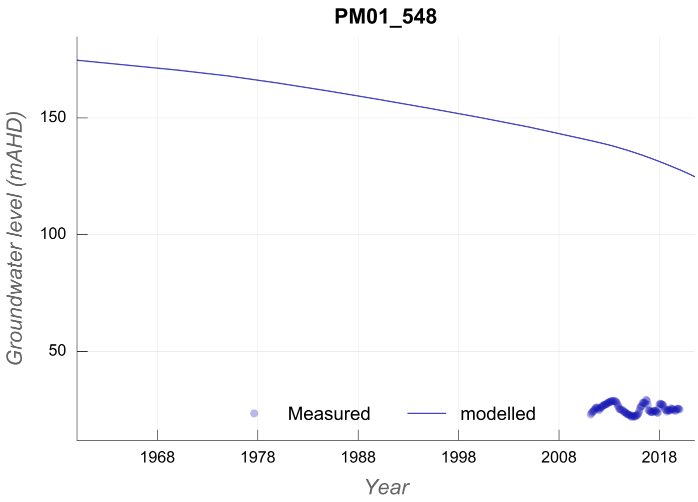

PHGW1B_554
Groundwater level (mAHD)
160
140
120
100
80
1968
1978
1988
1998
2008
2018
Year
Measured
modelled

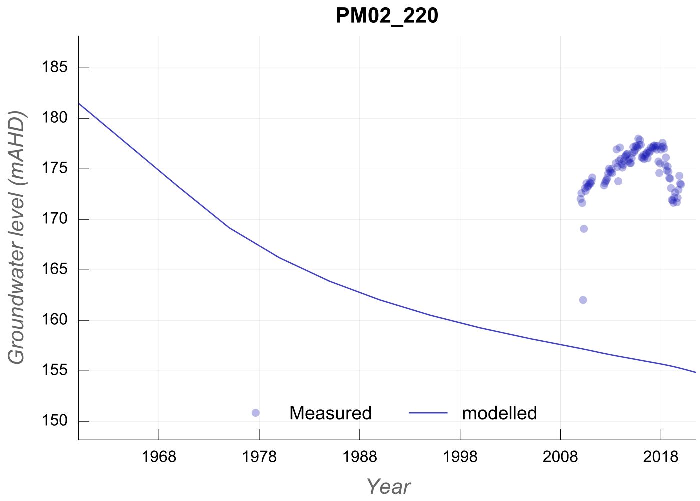

PHGW2A_182
Groundwater level (mAHD)
180
170
160
150
140
130
120
1968
1978
1988
1998
2008
2018
Year
Measured
modelled


PHGW2A_389
Groundwater level (mAHD)
170
160
150
140
130
120
110
100
90
1968
1978
1988
1998
2008
2018
Year
Measured
modelled


PM01_218
Groundwater level (mAHD)
215
210
205
200
195
190
185
180
1968
1978
1988
1998
2008
2018
Year
Measured
modelled


PM01_440
Groundwater level (mAHD)
190
180
170
160
150
140
130
120
1968
1978
1988
1998
2008
2018
Year
Measured
modelled


PM01_548
Groundwater level (mAHD)
150
100
50
1968
1978
1988
1998
2008
2018
Year
Measured
modelled


PM02_220
Groundwater level (mAHD)
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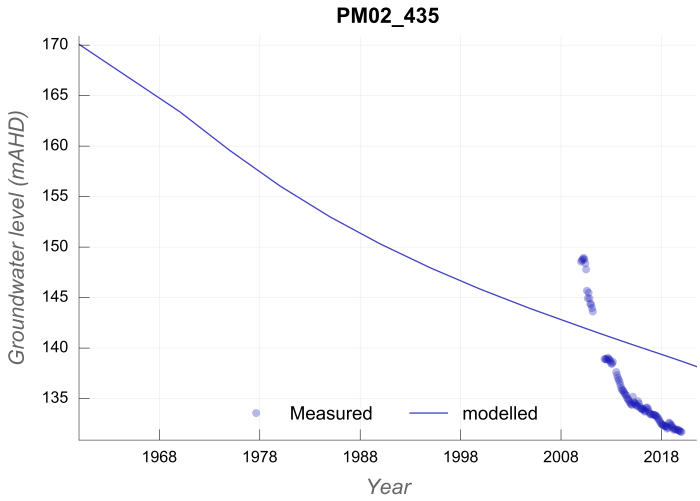
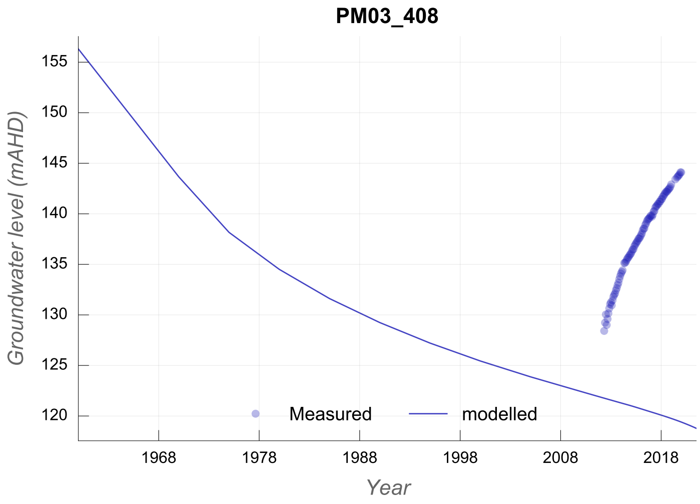
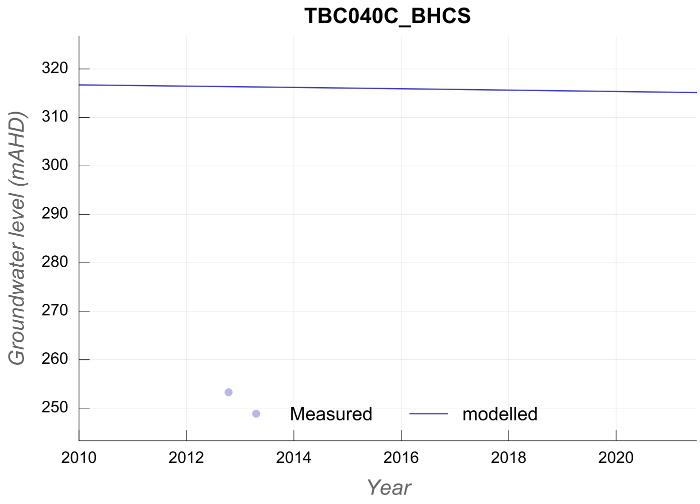
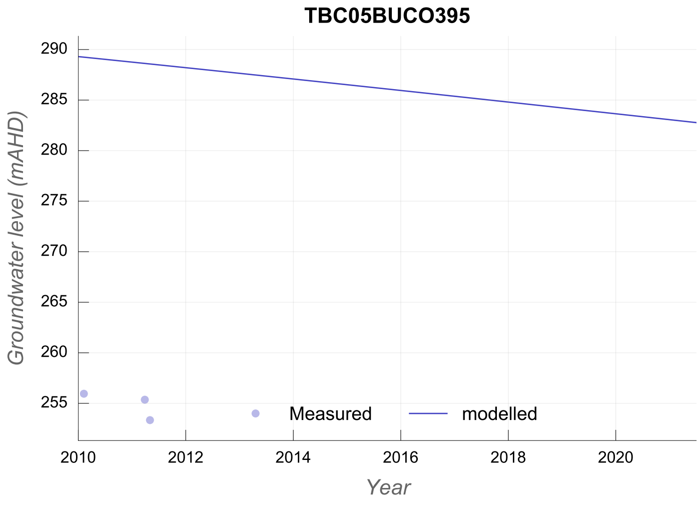
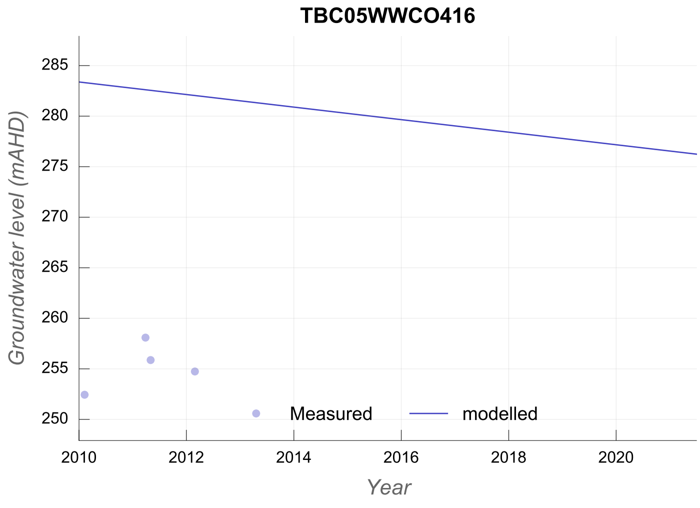
155
160
165
170
175
180
185
1968
1978
1988
1998
2008
2018
Year
Measured
modelled


PM02_435
Groundwater level (mAHD)
135
140
145
150
155
160
165
170
1968
1978
1988
1998
2008
2018
Year
Measured
modelled


PM03_408
Groundwater level (mAHD)
120
125
130
135
140
145
150
155
1968
1978
1988
1998
2008
2018
Year
Measured
modelled


TBC040C_BHCS
Groundwater level (mAHD)
250
260
270
280
290
300
310
320
2010
2012
2014
2016
2018
2020
Year
Measured
modelled


TBC05BUCO395
Groundwater level (mAHD)
255
260
265
270
275
280
285
290
2010
2012
2014
2016
2018
2020
Year
Measured
modelled


TBC05WWCO416
Groundwater level (mAHD)
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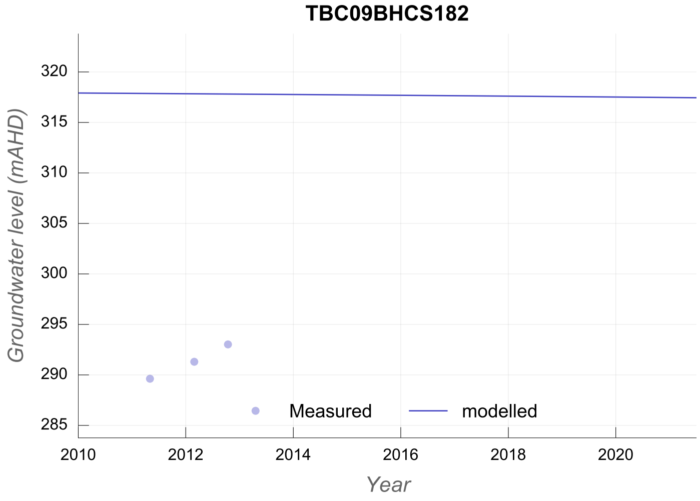
255
260
265
270
275
280
285
2010
2012
2014
2016
2018
2020
Year
Measured
modelled


TBC09BHCS182
Groundwater level (mAHD)
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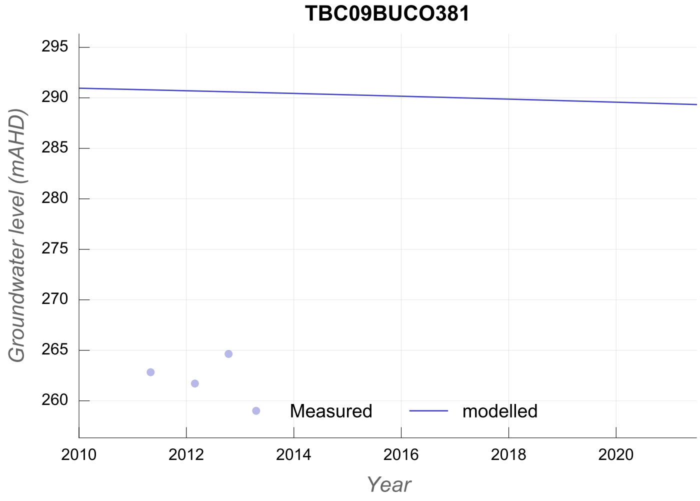
290
295
300
305
310
315
320
2010
2012
2014
2016
2018
2020
Year
Measured
modelled


TBC09BUCO381
Groundwater level (mAHD)
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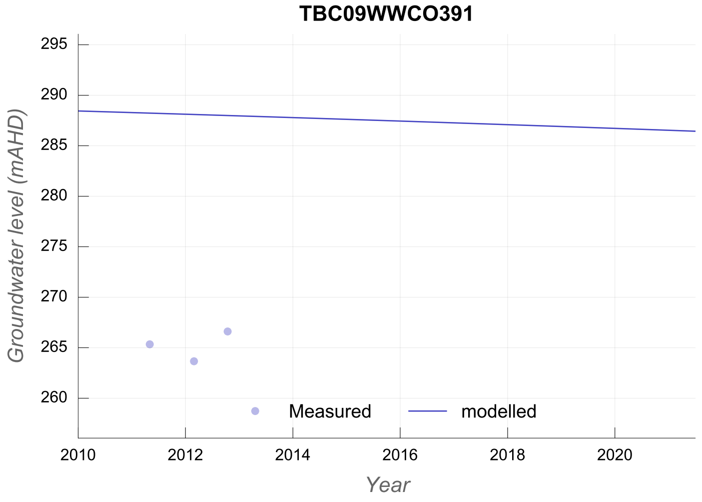
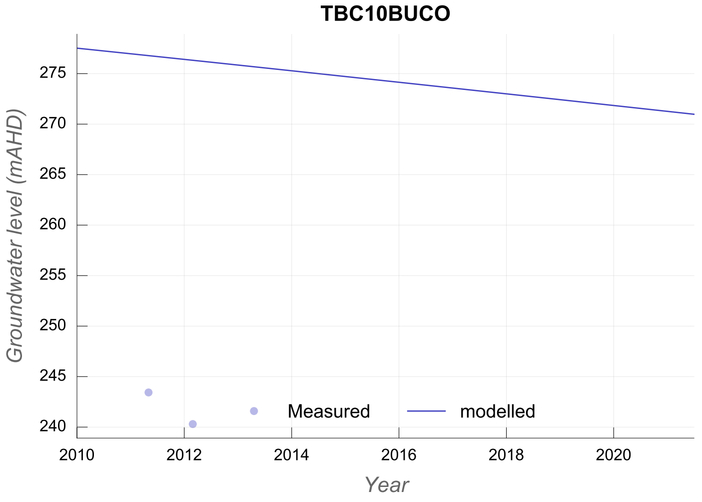
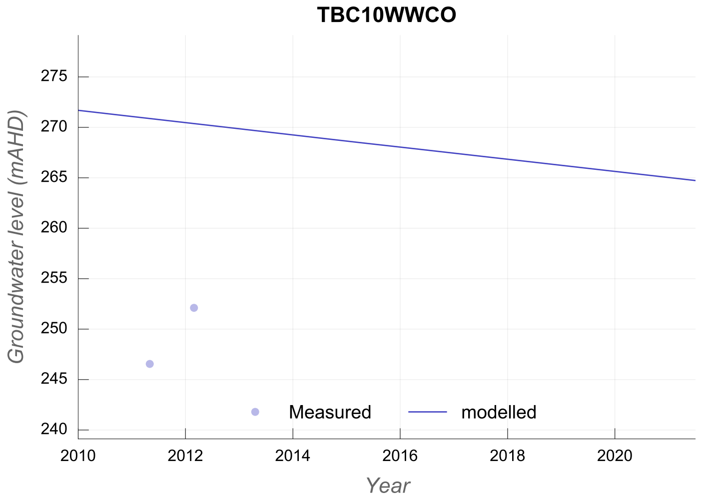
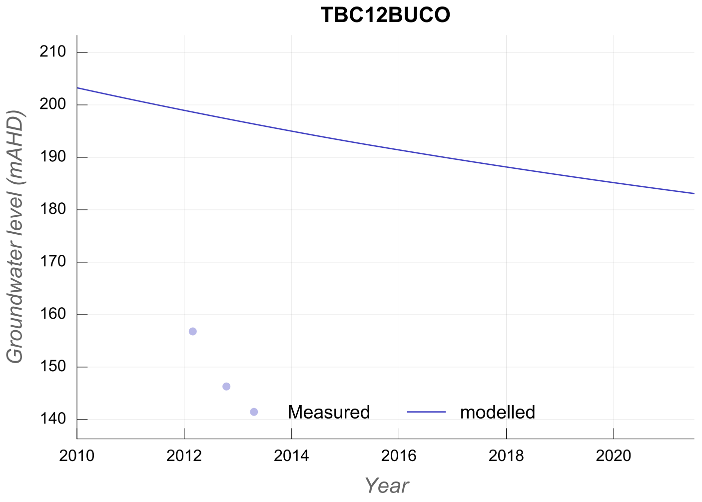
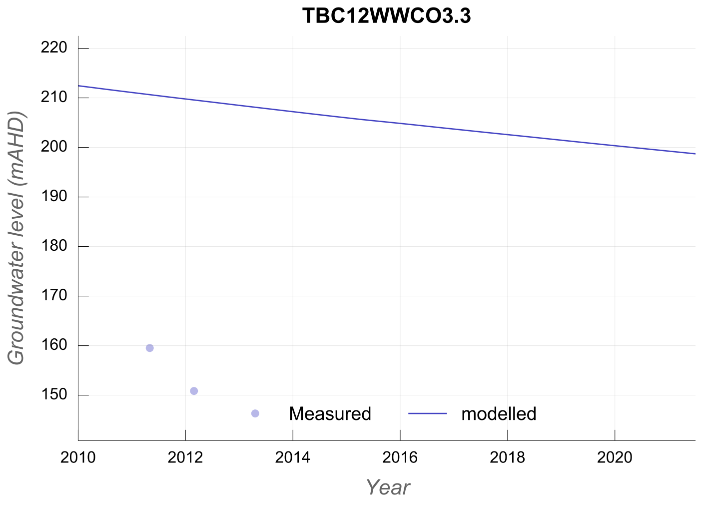
265
270
275
280
285
290
295
2010
2012
2014
2016
2018
2020
Year
Measured
modelled

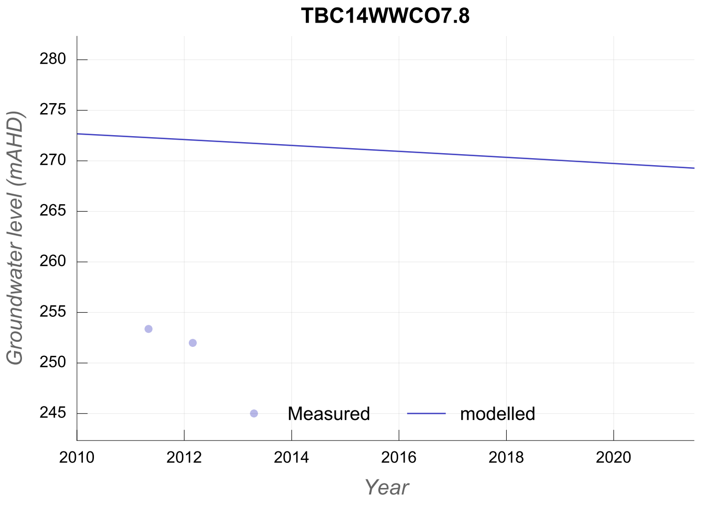

TBC09WWCO391
Groundwater level (mAHD)
Year
Measured
modelled

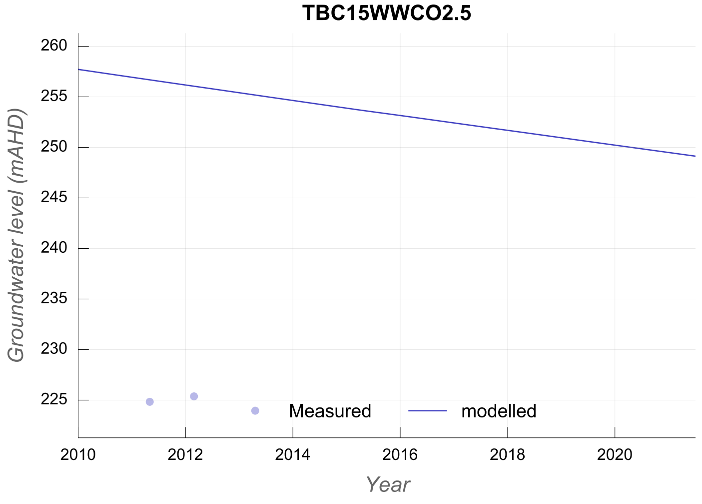

TBC10BUCO
Groundwater level (mAHD)
Year
Measured
modelled

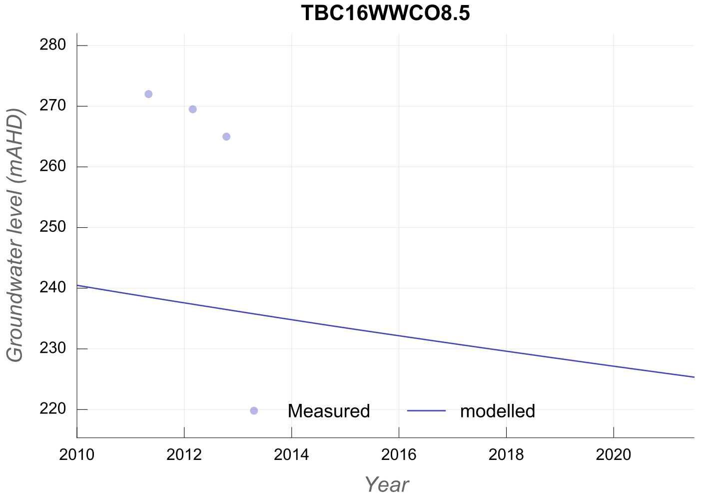

TBC10WWCO
Groundwater level (mAHD)
Year
Measured
modelled

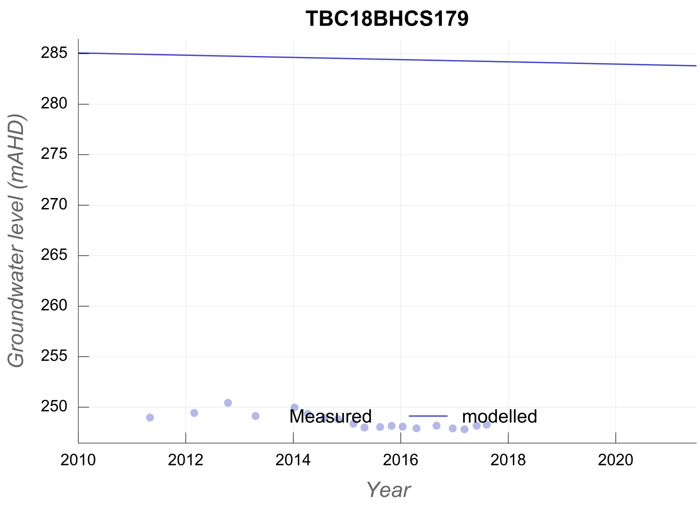

TBC12BUCO
Groundwater level (mAHD)
Year
Measured
modelled

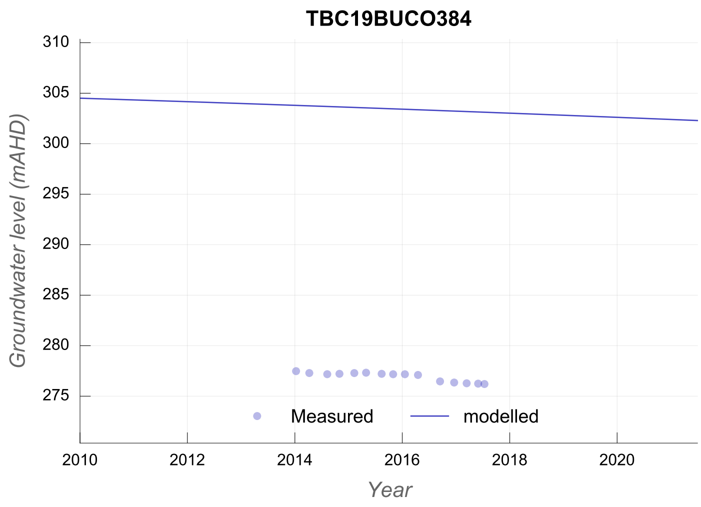

TBC12WWCO3.3
Groundwater level (mAHD)
Year
Measured
modelled

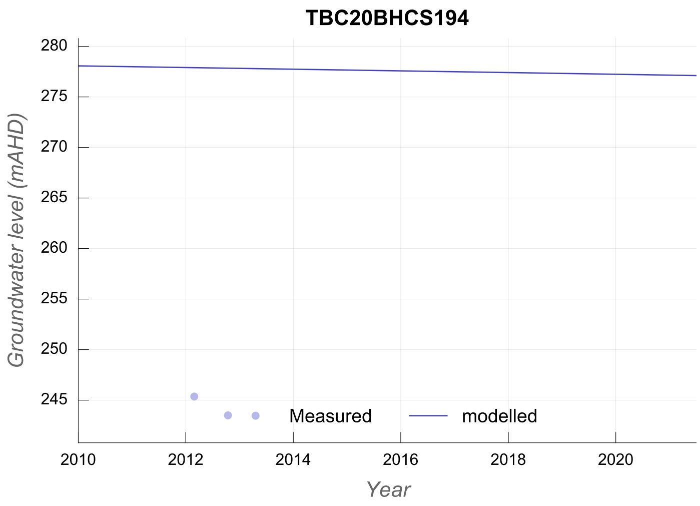

TBC14WWCO7.8
Groundwater level (mAHD)
Year
Measured
modelled

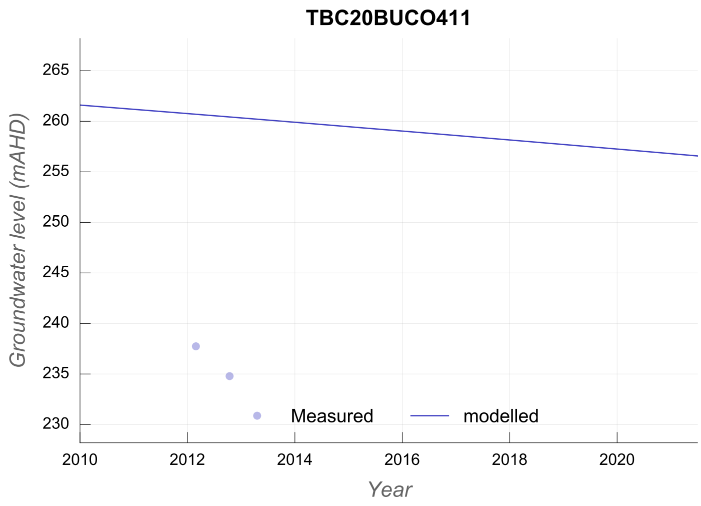

TBC15WWCO2.5
Groundwater level (mAHD)
Year
Measured
modelled

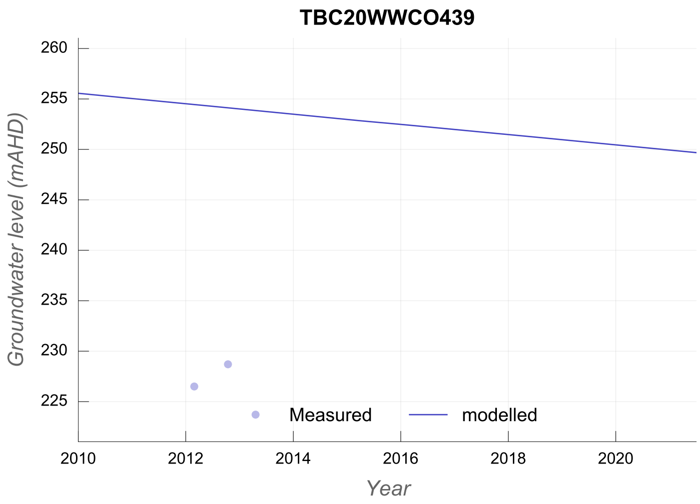

TBC16WWCO8.5
Groundwater level (mAHD)
Year
Measured
modelled

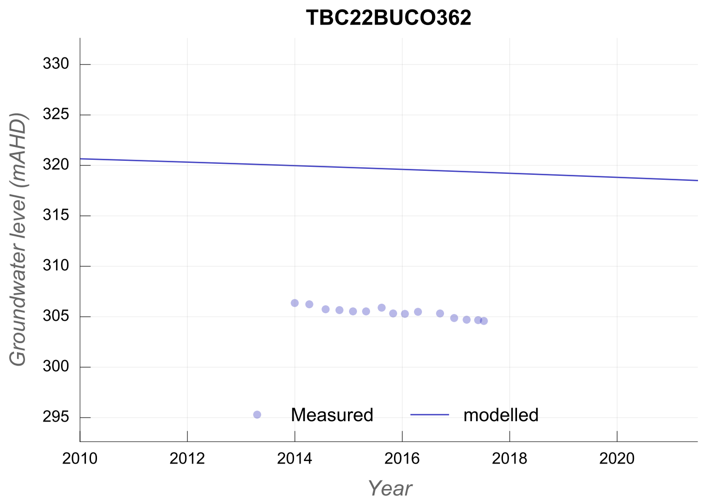

TBC18BHCS179
Groundwater level (mAHD)
285
280
275
270
265
260
255
250
Measured
modelled
2010
2012
2014
2016
2018
2020
Year

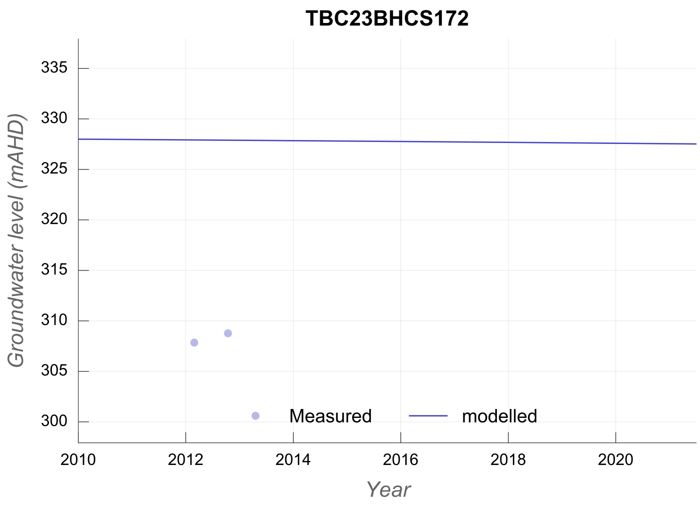

TBC19BUCO384
Groundwater level (mAHD)
310
305
300
295
290
285
280
275
Measured
modelled
2010
2012
2014
2016
2018
2020
Year

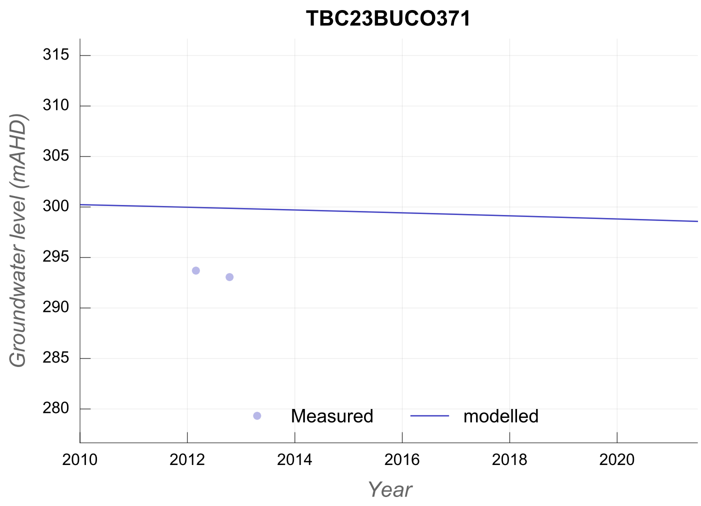

TBC20BHCS194
Groundwater level (mAHD)
280
275
270
265
260
255
250
245
Measured
modelled
2010
2012
2014
2016
2018
2020
Year


TBC20BUCO411
Groundwater level (mAHD)
265
260
255
250
245
240
235
230
Measured
modelled
2010
2012
2014
2016
2018
2020
Year

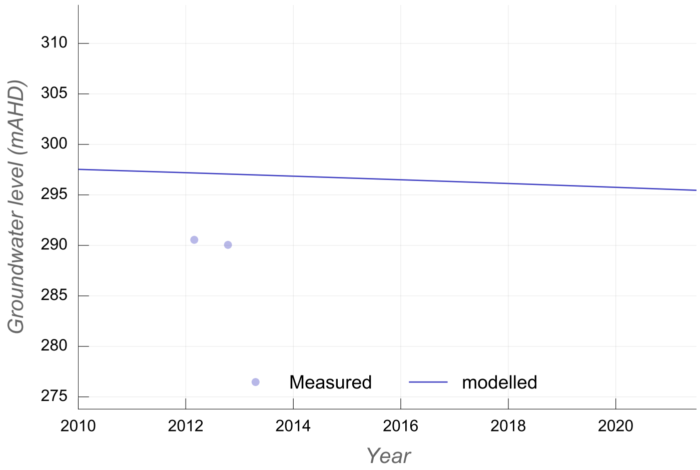

TBC20WWCO439
Groundwater level (mAHD)
260
255
250
245
240
235
230
225
Measured
modelled
2010
2012
2014
2016
2018
2020
Year


TBC22BUCO362
Groundwater level (mAHD)
330
325
320
315
310
305
300
295
Measured
modelled
2010
2012
2014
2016
2018
2020
Year


TBC23BHCS172
Groundwater level (mAHD)
335
330
325
320
315
310
305
300
Measured
modelled
2010
2012
2014
2016
2018
2020
Year


TBC23BUCO371
Groundwater level (mAHD)
315
310
305
300
295
290
285
280
Measured
modelled
2010
2012
2014
2016
2018
2020
Year

TBC23WWCO381



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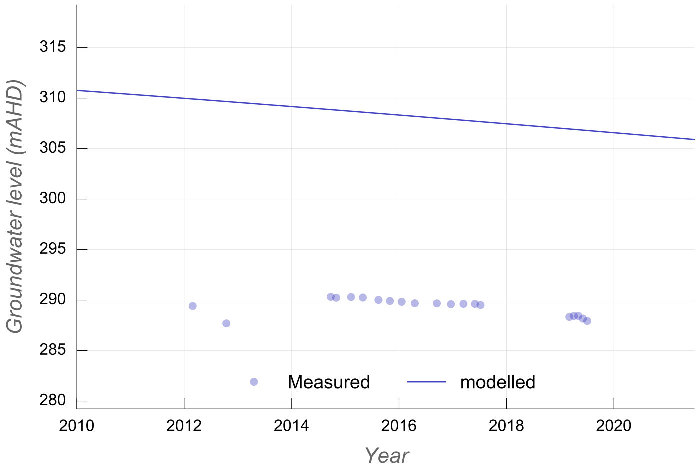

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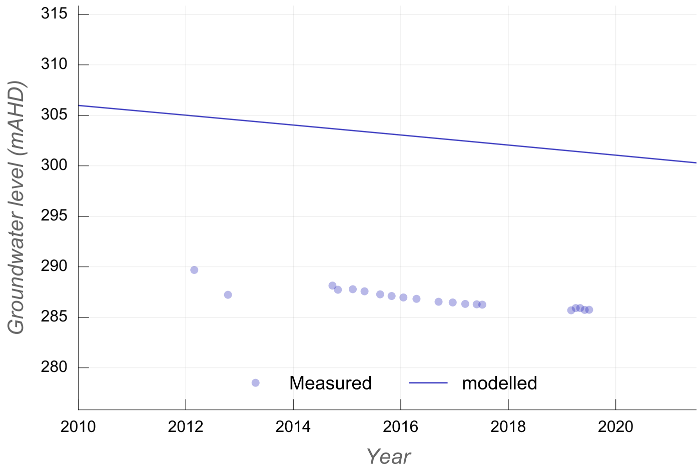

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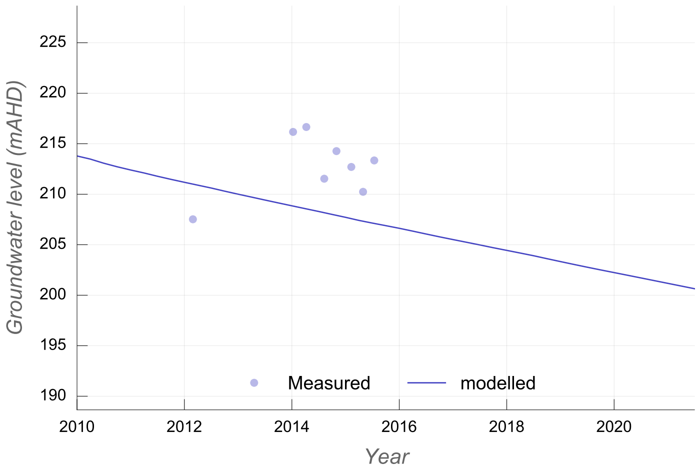

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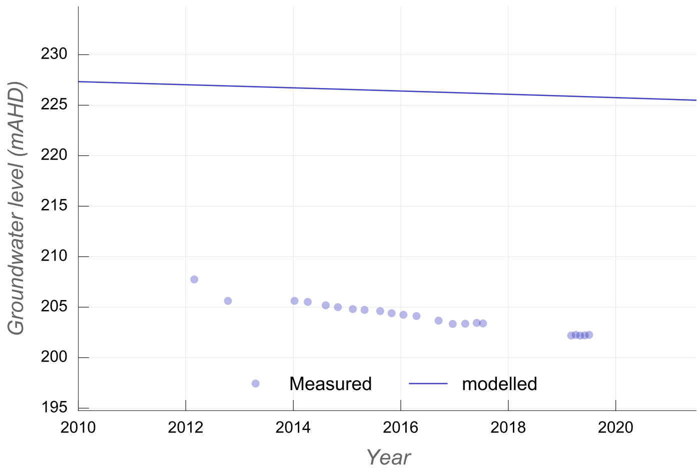
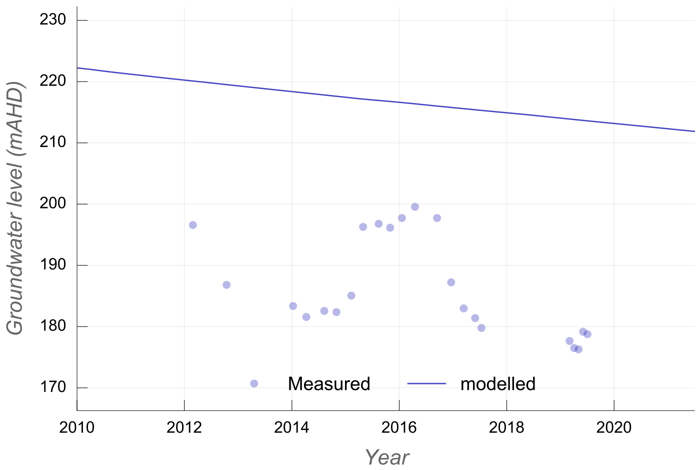


TBC26UWWC460



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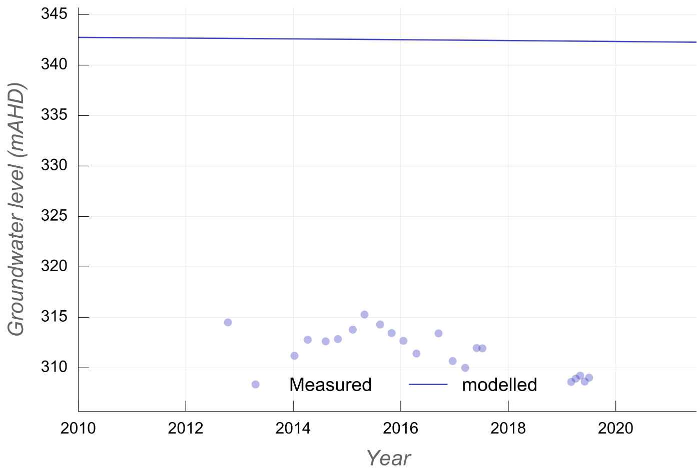

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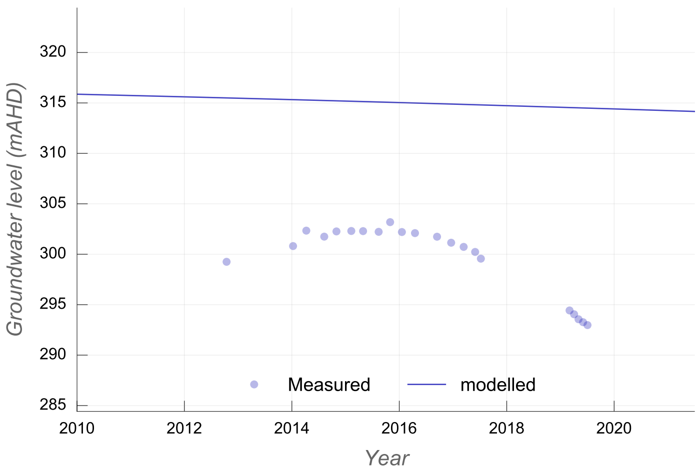

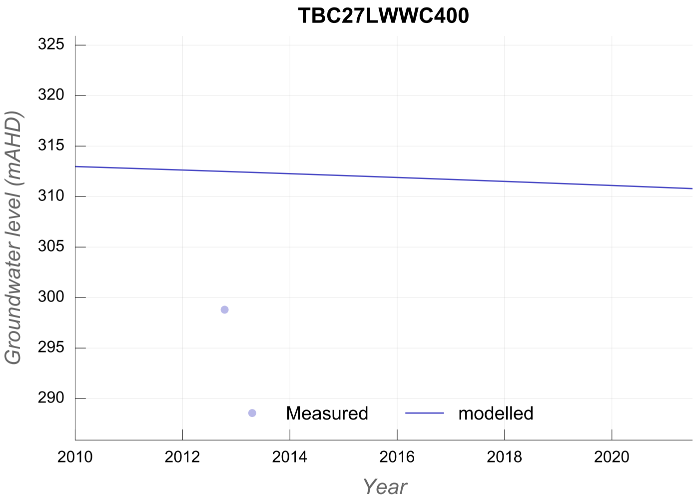
TBC27LWWC400
Groundwater level (mAHD)
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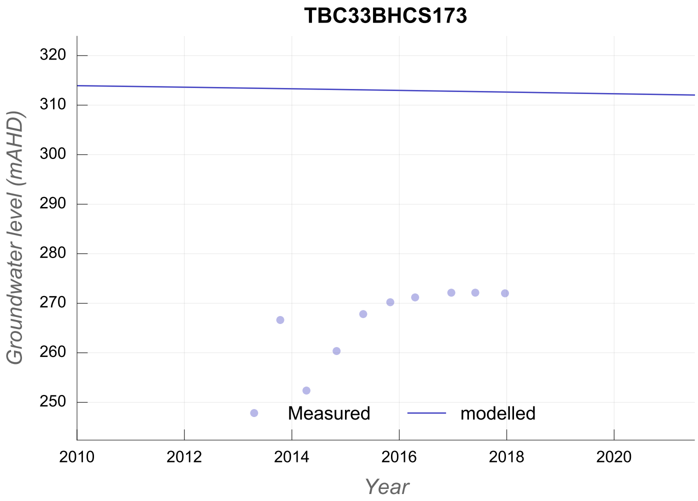
320
315
310
305
300
295
290
Measured
modelled
2010
2012
2014
2016
2018
2020
Year


TBC33BHCS173
Groundwater level (mAHD)
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310
300
290
280
270
260
250
Measured
modelled
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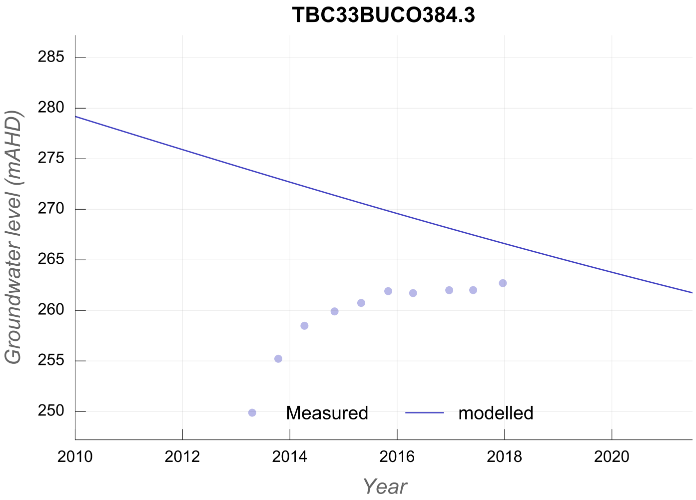
2016
2018
2020
Year


TBC33BUCO384.3
Groundwater level (mAHD)
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280
275
270
265
260
255
250
Measured
modelled
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2012
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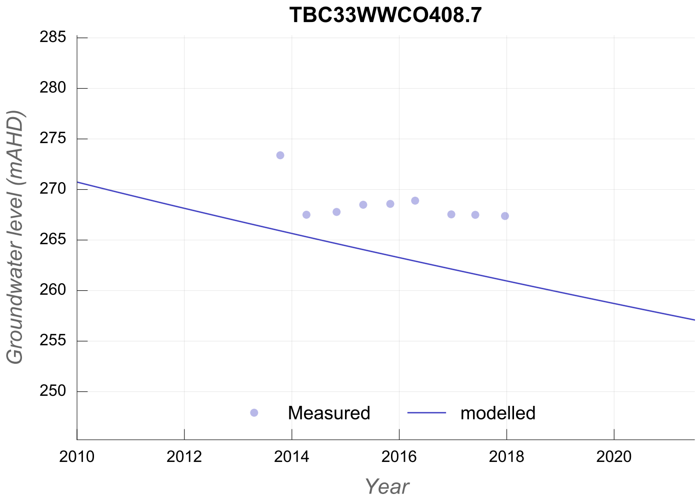
2016
2018
2020
Year


TBC33WWCO408.7
Groundwater level (mAHD)
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280
275
270
265
260
255
250
Measured
modelled
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2012
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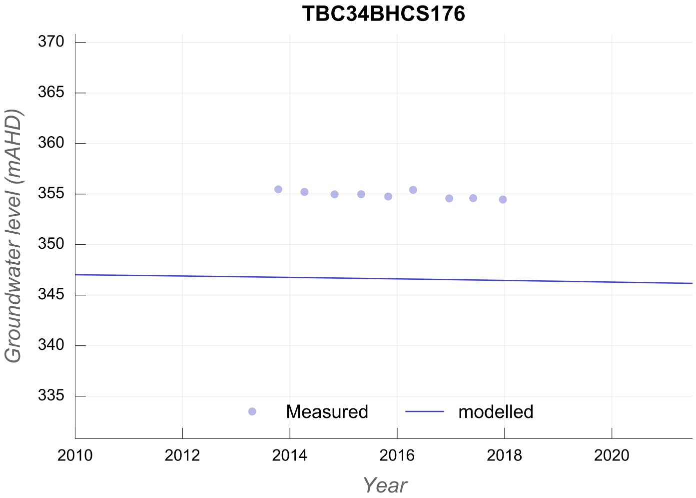
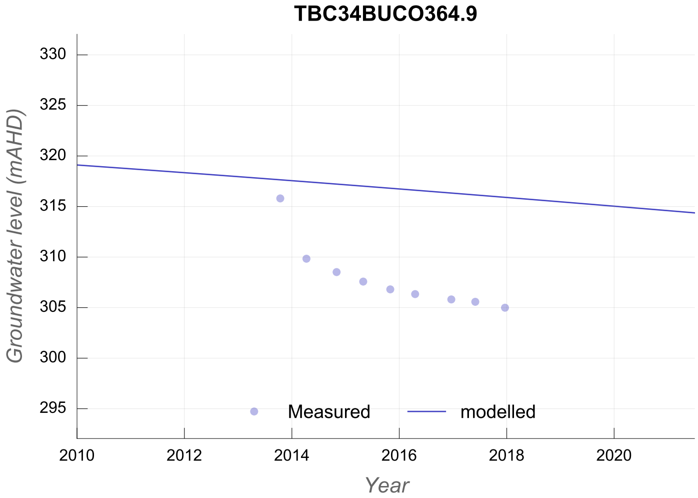
2016
2018
2020
Year


TBC34BHCS176
Groundwater level (mAHD)
370
365
360
355
350
345
340
335
Measured
modelled
2010
2012
2014
2016
2018
2020
Year


TBC34BUCO364.9
Groundwater level (mAHD)
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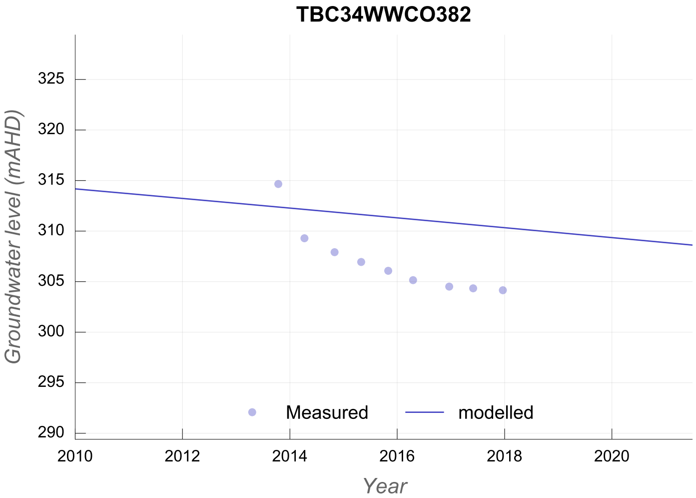
325
320
315
310
305
300
295
Measured
modelled
2010
2012
2014
2016
2018
2020
Year


TBC34WWCO382
Groundwater level (mAHD)
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320
315
310
305
300
295
290
Measured
modelled
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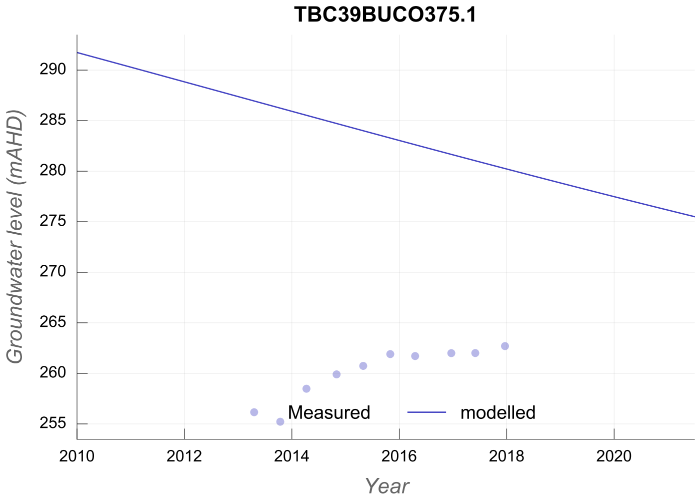
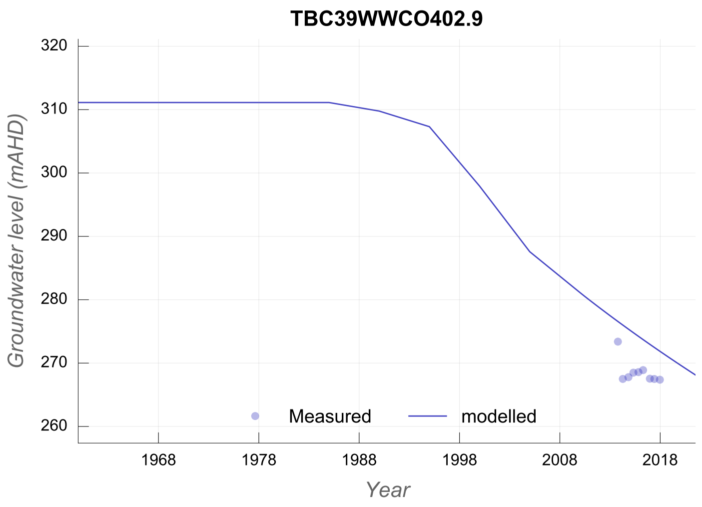
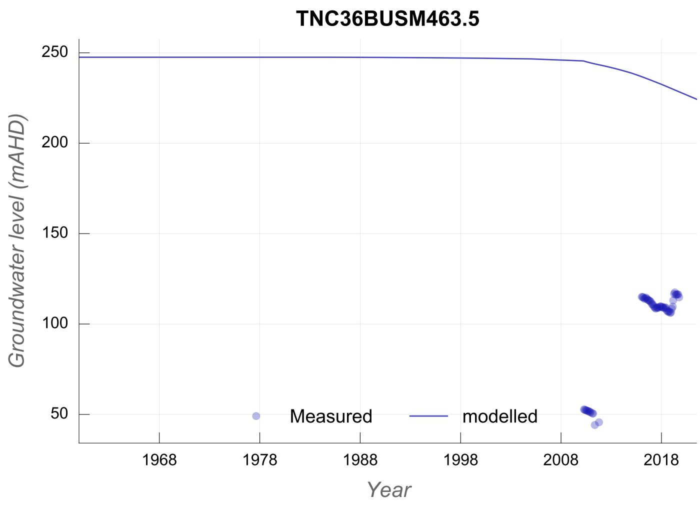
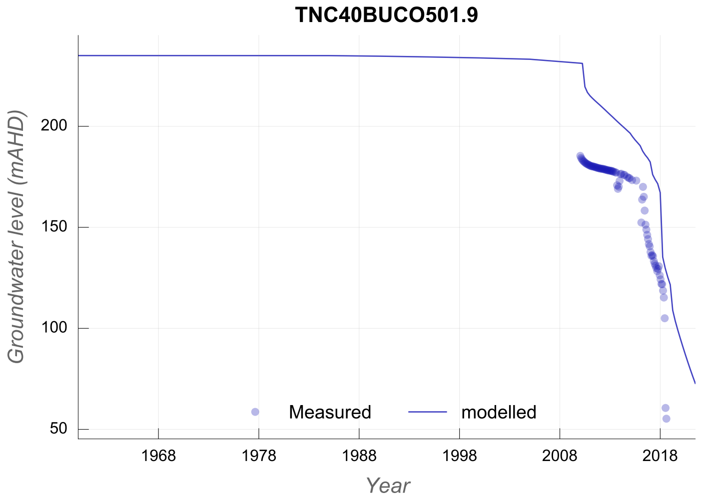
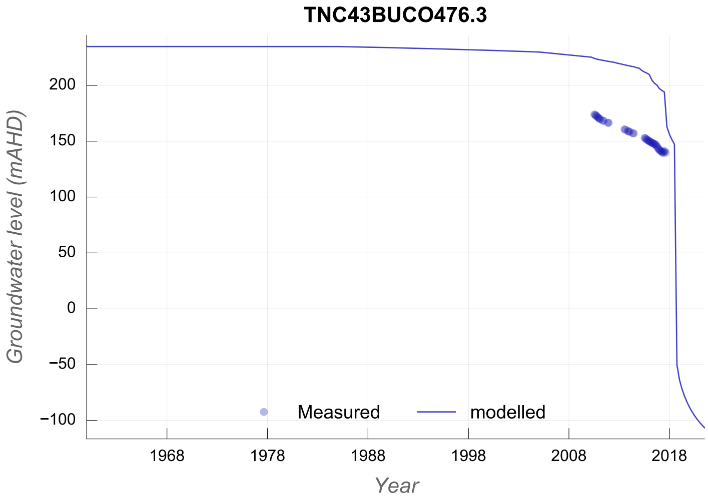
2012
2014
2016
2018
2020
Year


TBC39BUCO375.1
Groundwater level (mAHD)
290
285
280
275
270
265
260
255
Measured
modelled
2010
2012
2014
2016
2018
2020
Year


TBC39WWCO402.9
Groundwater level (mAHD)
Year
Measured
modelled


TNC36BUSM463.5
Groundwater level (mAHD)
Year
Measured
modelled


TNC40BUCO501.9
Groundwater level (mAHD)
Year
Measured
modelled


TNC43BUCO476.3
Groundwater level (mAHD)
Year
Measured
modelled

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