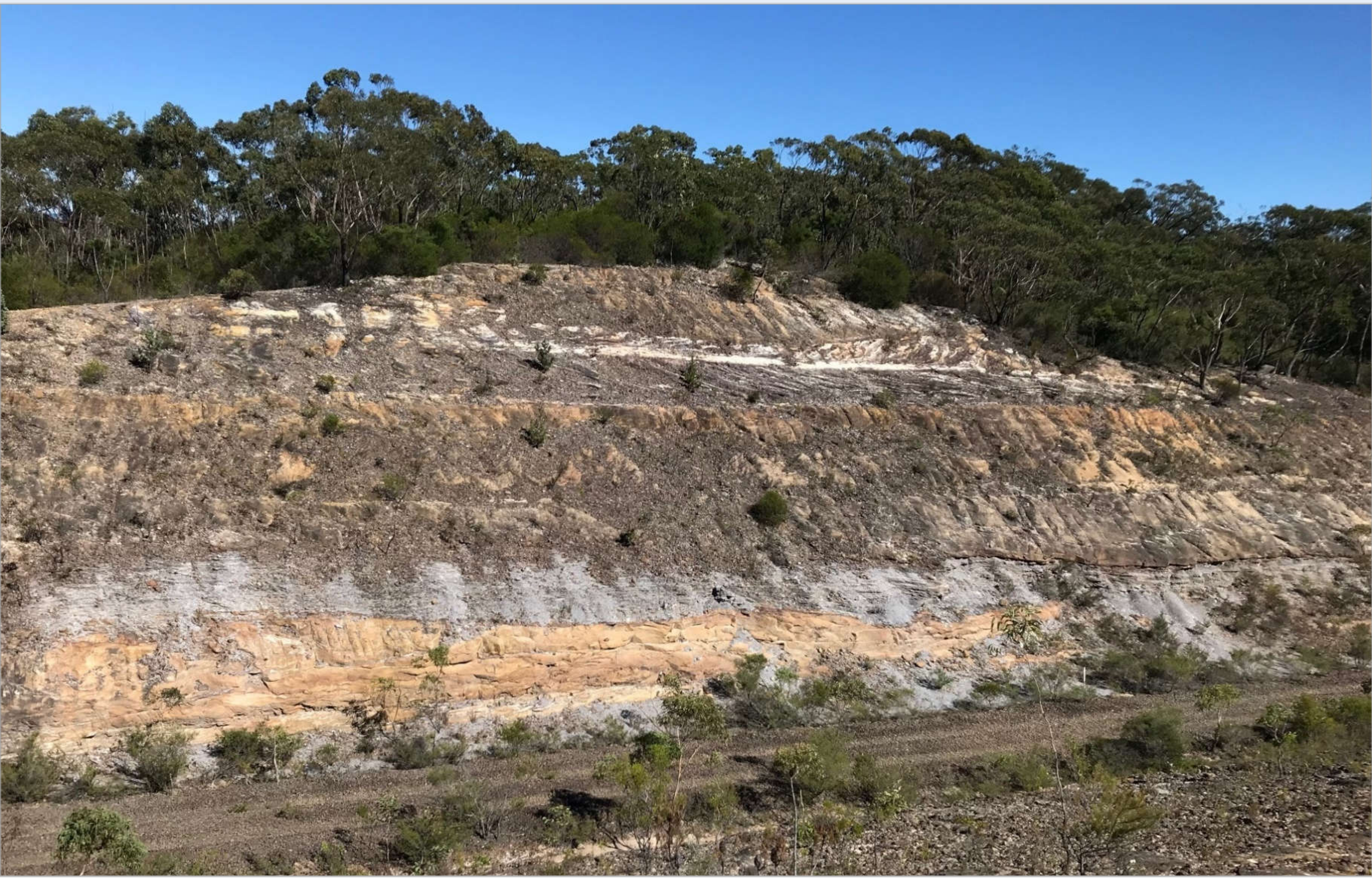
South32 - Illawarra Metallurgical Coal

DENDROBIUM MINE

End of Panel Groundwater Assessment for Longwall 21 (Area 3C)



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EXECUTIVE SUMMARY

This report provides an assessment of the hydrogeological effects of Longwall 21 extraction in Area 3C at Dendrobium Mine, as required under the conditions of mining approval. Mining in Area 3B was completed in May 2022, after which mining resumed in Area 3A with Longwall 19. Extraction of Longwall 21 in Area 3C commenced on 25/4/2023 and was completed on 6/8/2023. Longwall 21 has a total length of 863 m and a width of 305 m including first workings with a maximum cutting height of 3.9 m. The depth of cover ranges between 284 m and 384 m.

The mean total mine inflow during Longwall 21 extraction was 8.05 ML/day which represents a 28% decrease compared with the previous longwall (19). The high inflows observed during the previous longwall were related to very high rainfall recorded in 2022. The net mine water balance is dominated by pumping from Area 3B (83 % of total), with Area 3C (where Longwall 21 is located) representing only 9.5 % of inflows. No anomalous inflow due to intersecting water-bearing structures such as faults or dykes was reported during the extraction of Longwall 21.

Groundwater salinity (as indicated by electrical conductivity – EC) shows a general increase with depth below the surface. A declining trend in EC was previously reported in two monitoring bores (S2314_30m and S2001_63m). The trend at S2001 has reversed. Resampling of S2314_30m should be carried out in late 2023 and reviewed in the next EOP report.

Mining of Longwall 21 resulted in continued depressurisation of the target coal seam and overlying strata in line with numerical model predictions. Importantly, for piezometers adjacent to Lake Avon, observed head is similar to the numerical model prediction. Therefore, the model predictions are generally accurate as of Longwall 21.

Piezometers installed after longwall extraction indicate significant depressurisation throughout all strata and throughout the Hawkesbury Sandstone (HBSS) in most holes. Holes drilled above extracted longwalls provide evidence for groundwater perching and recovery in the years following mining. Drawdown in the HBSS reduces with distance and is typically negligible at distances greater than 1.2 km from the goaf footprint.

Although within prediction, piezometers installed along the barrier zone between Lake Avon and Area 3B indicate hydraulic gradients away from the lake within the zone of mining influence. Numerical model forecasts indicate seepage losses of ~ 0.12 ML/day from Lake Avon and ~0.10 ML/day from Lake Cordeaux at the end of Longwall 21. The estimates are within the tolerable loss limit of 1 ML/day prescribed by Dams Safety NSW.

Recommendations are made in relation to improvement of reporting of groundwater depressurisation above extracted longwalls, and acquisition of data for bores located near water storage reservoirs.

1. INTRODUCTION

Illawarra Metallurgical Coal (IMC) operates the Dendrobium underground coal mine, located approximately 12 km west of Wollongong (NSW) in the Southern Coalfield (Figure 1). IMC is required under the conditions of mining approval to submit regular reviews of the local hydrological data, including groundwater level and quality, and potential seepage losses from stored water.

IMC operates an extensive network of groundwater monitoring sensors (piezometers), groundwater sampling pumps and down-hole geotechnical instruments. Groundwater data from more than 950 active piezometers at 219 monitoring bores is updated monthly via telemetry or collected by IMC field teams.

This End of Panel (EoP) assessment reviews groundwater level and quality monitoring data up to one month after the completion of Longwall 21 (cumulative). Data are assessed against baseline and impact criteria defined in the Trigger Action Response Plan (TARP) which forms part of the Subsidence Management Plan for Area 3C (South32, 2023) and the Groundwater management plans contained therein.

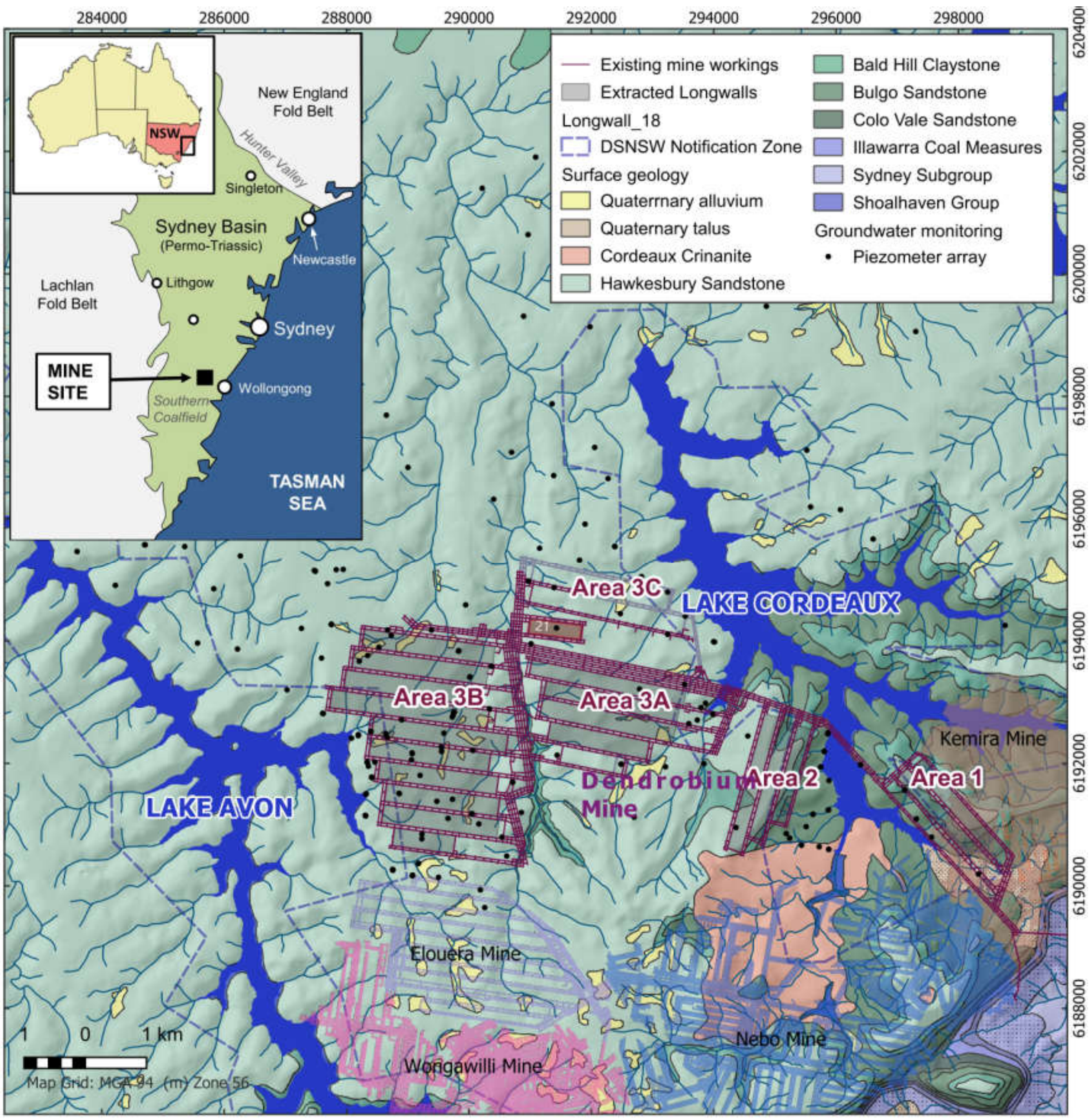

Figure 1. Location of Dendrobium Mine and surface geology

1.1 Longwall 21

Longwall mining at Dendrobium has been carried out in three designated areas: Area 1 (east of Lake Cordeaux), Area 2 (west of Lake Cordeaux), and Area 3 (between Lake Cordeaux and Lake Avon) which is divided into sub areas 3A, 3B and 3C.

Mining in Area 3B was completed in May 2022, after which mining resumed in Area 3A with Longwall 19. Extraction of Longwall 21 in Area 3C commenced on 25/4/2023 and was completed on 6/8/2023. Longwall 21 has a total length of 863 m and a width of 305 m including first workings with a maximum cutting height of 3.9 m. The depth of cover ranges between 284 m and 384 m.

At Dendrobium Mine, coal is extracted from the Wongawilli Seam. Previous workings in the Wongawilli Seam are located to the south at Elouera and Nebo, and to the east at Kemira. The overlying Bulli Seam was mined previously at Mt Kembla to the east of and partially overlapping Area 1.

1.2 Hydrogeology

Dendrobium Mine is located within the Southern Coalfield which is one of the five major coalfields that lie within the Sydney Geological Basin. The stratigraphy of the Southern Sydney Basin is shown in Figure 2. The Basin is primarily a Permo-Triassic sedimentary rock sequence, underlain by undifferentiated sediments of Carboniferous and Devonian age. The Bulli and Wongawilli Coal Seams are the primary target seams in the top part of the Illawarra Coal Measures. The Coal Measures are overlain by Triassic sandstones, siltstones and claystones of the Narrabeen Group and the Hawkesbury Sandstone (HBSS). The HBSS is the dominant outcropping formation across the mine area, but lower stratigraphic units (Bald Hill Claystone (BHCS), Narrabeen Group) are exposed in deeply incised parts of Wongawilli Creek and along the south-eastern shores of Lake Cordeaux.

The hydrogeology of the area is described in previous groundwater assessments associated with Dendrobium Mine (e.g. Coffey, 2012; HydroSimulations, 2016; Parsons Brinckerhoff, 2014), and summarised below.

Three main groundwater systems are recognised:

1. Perched groundwater systems associated with swamps and shallow sandstone. These may be ephemeral and/or disconnected from the deeper groundwater systems.
2. Shallow groundwater systems: layered water-bearing zones within the saturated HBSS; and
3. Deeper groundwater systems within the Narrabeen Group and the Illawarra Coal Measures.

Recharge to the aquifer systems is primarily from rainfall infiltration through outcropping formations, generally the HBSS in the western half of the Dendrobium mine area and the Bulgo Sandstone (BGSS) in the eastern half. There will be some recharge from the Reservoirs and streams to host formations at times of high-water level and creek flooding.

Strong topographic relief and recharge drive vertical groundwater flow near the ground surface, but at depth the alternation of aquifers and aquitards promotes horizontal groundwater flow at the base of permeable units. In general, groundwater flow in shallow systems is strongly influenced by local topographical features such as streams and lakes, whereas deeper groundwater systems are influenced by regional topographic and drainage patterns (Toth, 2009). Regional groundwater flow in the deeper sandstone units (pre-development) is predominantly northwest, towards the Nepean River system and away from the Illawarra escarpment.

Discharge from the (shallow) groundwater systems occurs naturally at the surface to creeks and to the reservoir as baseflow and seeps, and by evapotranspiration through vegetation. Along the escarpment to the south-east of Dendrobium Mine, groundwater discharge appears as seeps in cliff faces at the junction of formations with contrasting permeability.

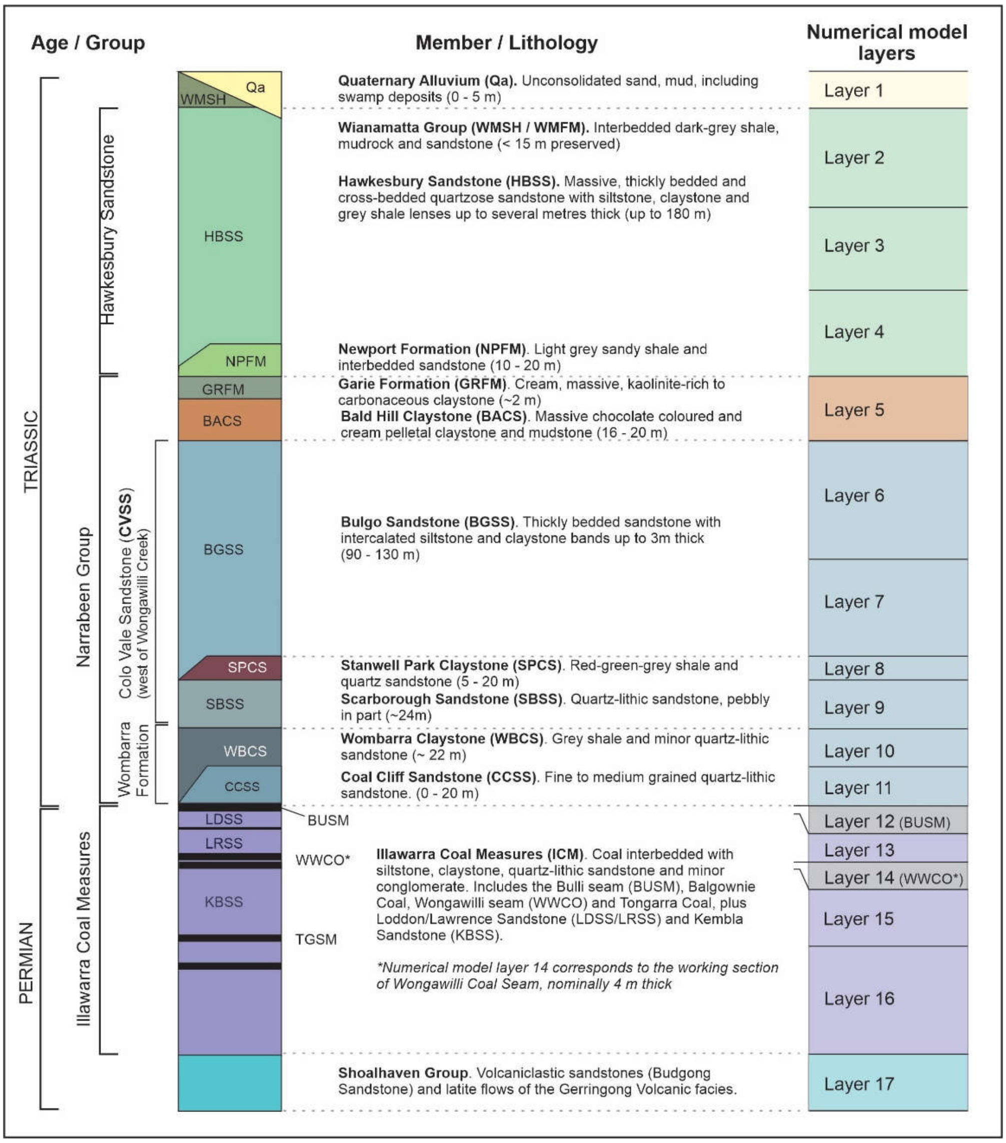

Figure 2. Generalised stratigraphy of the Southern Coalfield

1.3 Effects of mining

Extraction of coal using longwall methods commonly results in ground subsidence and associated deformation and fracturing of overlying strata (Peng and Chiang, 1984; Whittaker and Reddish, 1989). Fracturing is most intense and vertically connected immediately above the collapsed longwall (goaf), and grades upwards through zones of less fractured strata (Booth, 2002). Fracturing of the overburden can cause significant changes in aquifer characteristics such as permeability and storage, and potentially can provide pathways for vertical groundwater movement between shallow groundwater and surface water systems and underground mines (Advisian, 2016; McNally and Evans, 2007). The height to which vertically connected (and free-draining) fracture networks extend above the mined seam is therefore important in assessing potential impacts of longwall mining on groundwater and surface water systems.

Several authors have developed empirical approaches to estimating the height of connected fracturing or complete groundwater drainage above longwalls; for example, Forster 1995; Guo *et al.* 2007; Mills 2011; Tammetta 2013; Ditton & Merrick 2014. These methods have been used at numerous coal mines in NSW to provide guidance on the height of fracturing (or depressurisation) for the development of numerical groundwater impact models. It is important to note that the terms used by the authors are not equivalent; Tammetta refers to the "height of desaturation" (more precisely, complete depressurisation); Ditton and Merrick refer to a "zone of continuous cracking" (Zone A), and Mills refers to a zone of large downward movement (Zone 2).

The Independent Expert Panel for Mining in the Catchment (IEPMC) was established in 2018 to provide advice to government on impacts of mining activities in the Greater Sydney Water Catchment Special Areas, with a focus on risks to quantity of water (IEPMC, 2019a, 2019b). In relation to hydrogeological impacts and height of fracturing, the Panel considers that:

"*…changes in ground behaviour and fracturing, permeability and the lateral extent of affected areas occur gradationally rather than as step changes. The so-called 'fractured zone' is a misnomer. Fracturing still develops above this zone and may be connected. Due largely to the different interests and focus of geoscience and engineering disciplines, zones defining mining-induced rock deformation do not necessarily align with zones defining groundwater response to mining.*

Adhikary *et al.* (2020) reviewed strata-caving mechanics and the observations of Tammetta (2013) and developed empirical equations defining upper and lower bound estimates for the height of connected fracturing. The equations are functions of the effective panel width (W') and height of mining (t) only. The authors propose that the upper and lower bounds could be used to define possible ranges of fracturing heights in probabilistic modelling, and that the upper bound should be used as a conservative assumption in deterministic studies[1]. Modelling indicated that subsidence above wide or super-critical[2] panels would be accommodated by fracturing to the surface; however, the authors emphasise that the seam to surface fracturing does not imply direct seam to surface connection. In addition, rock mass dilation may result in sudden and complete piezometric pressure drops throughout overlying strata that are independent of (and beyond) the connected fracture network. Initial piezometric pressure loss may recover to various degrees depending on the fracture network, recharge rate, and aquitard integrity including the presence of self-healing clay-rich aquitards. Those conclusions are consistent with observations at Dendrobium as summarised in this report.

Since 2018 IMC has carried out targeted investigations into the height of fracturing and groundwater conditions above completed longwalls at Dendrobium Mine. Investigation holes have been drilled above existing Longwalls 12 to 18 in Area 3B and Longwalls 6 and 7 in Area 3A, allowing assessment of effects above longwalls of different width. The main findings of the investigation are summarised in Section 3.2.2.

1.4 Numerical groundwater impact model

The Area 3B Subsidence Management Plan (SMP) application and subsequent approval was based on numerical model estimates of groundwater drawdown and associated surface water impacts by Coffey (Coffey, 2012). The model has been revised and updated several times since 2012 to better represent subsidence fracturing and to allow assessment of shallow groundwater within swamps and

[1] Note that for Area 3B, the lower and upper bounds of Adhikary *et al.* (2020) are 199 – 387 m. Those values bracket or contain estimates based on Mills 2011 (305 m), Tammetta 2013 (351 – 377 m) and Ditton & Merrick 2014 (216 – 258 m; Geol-A95).

[2] Adhikary *et al.* (2020) define critical and super-critical width, in the absence of site-specific data, as W/d ≥ 1.2 and ≥1.4, where W is the effective panel width and d is the depth of cover (seam top to ground surface). For longwalls in Area 3B W/d ranges from 0.74 to 1.12 (sub-critical).

baseflow to streams. The current model was developed by Watershed Hydrogeo (2020) using the MODFLOW-USG modelling software. The model includes historical mining at Dendrobium and surrounding mines.

The Longwall 20 and 21 Subsidence Management Plan (South32, 2019) was based on estimates of groundwater drawdown and associated surface water impacts by HydroSimulations (2019). In this report, assessment is based on forecasts from the more recent numerical model developed by Watershed Hydrogeo (2020). This is because the recent model adopts an up-to-date mine plan and is considered to match past drawdown more closely).

Figure 2 shows a geological stratigraphic column for the Woronora Plateau and the vertical extent of layers used in the numerical groundwater model. An East-West cross section showing the modelled stratigraphy is presented in Figure 3.

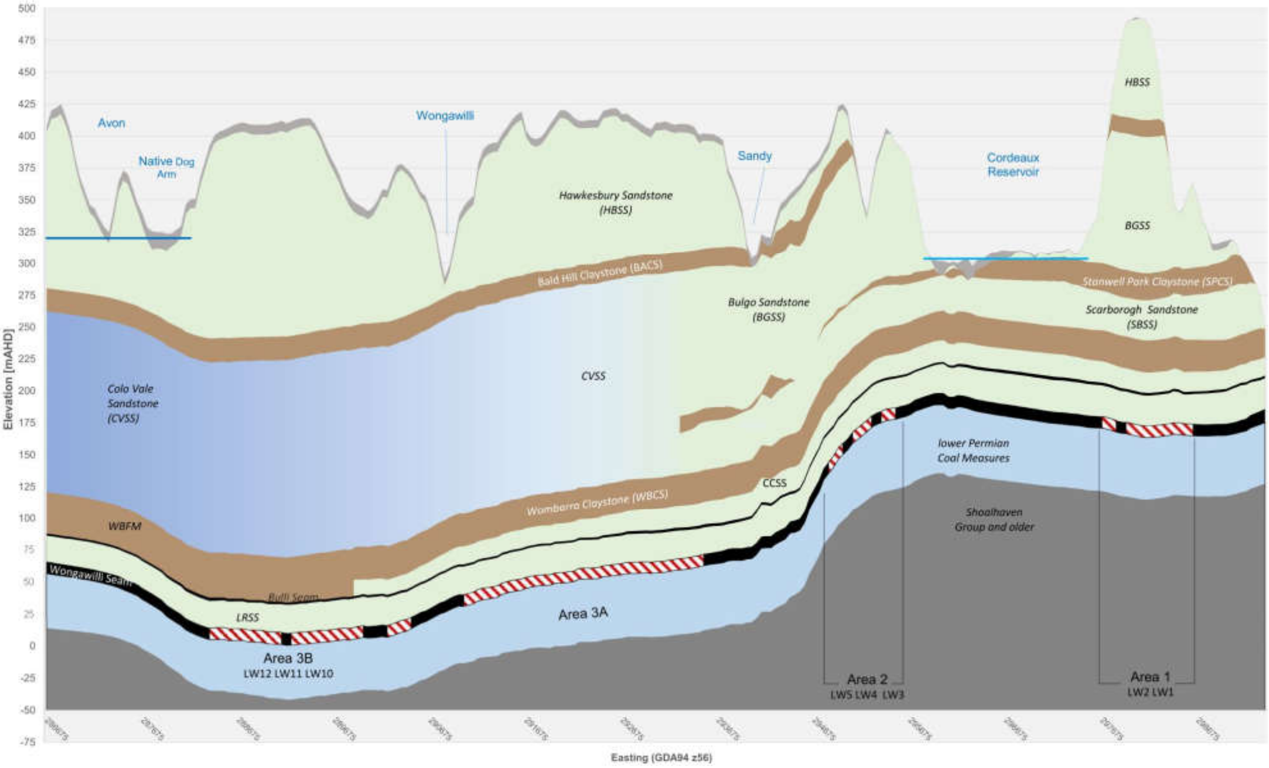

Figure 3. Geological cross-section (east-west) through Dendrobium Mine

2. MONITORING DATA

This section presents the monitoring data available for the groundwater assessment and supports the discussion of the observed hydrological behaviour presented in Section 3.

2.1 Management Plan

Groundwater monitoring at Dendrobium Mine is conducted in accordance with the Subsidence Management Plan for Area 3C (South32, 2023) and the Groundwater management plan contained therein. The aims of the Groundwater Management Plan are to:

- Monitor groundwater levels and quality, commencing at least one year prior to mining affecting the system.
- Project potential groundwater changes during mining (short term) and post-mining (long term) with particular attention to the effect of changes to groundwater regime, impact on the catchment yield and interaction with the stored waters.
- Identify hydraulic characteristics of overlying and intercepted groundwater systems and determine changes to groundwater systems due to coal extraction and dewatering operations.
- Report any pumping tests and groundwater/surface water simulation studies; and
- Collect water level data from relevant groundwater-monitoring locations.

2.2 Groundwater monitoring network

The groundwater-monitoring locations for Areas 3A, 3B and 3C are shown in Figure 4. A list of all monitoring bores installed at Dendrobium is included in Appendix A. There are approximately 220 monitoring bores located across the Dendrobium mine lease, containing over 950 piezometers, excluding those that are decommissioned or no longer monitored.

2.3 Deep groundwater levels

Deep groundwater levels are monitored using one or more piezometers installed within monitoring bores. Monitoring bores typically have an index number with an ‘S’ prefix such as S2314, within which piezometers may be installed at multiple depth levels (e.g., S2314_128m). In most cases, the piezometers are vibrating wire piezometers (VWP) that are fully grouted into the bore hole. The sensors contain a sensitive diaphragm that deforms in response to subtle changes in pore pressure that are transmitted through the connected pores of the grout from the adjacent geological strata. VWP sensors are commonly used in deep mining and geotechnical applications where the strata permeability is low and conventional (standpipe) piezometers are impractical (Contreras et al., 2008; Mikkelson and Green, 2003).

Standpipe piezometers, consisting of a slotted open casing, are best suited to monitoring of relatively shallow groundwater systems within moderate to high permeability strata (e.g., swamp sediments and shallow HBSS). Automated loggers record groundwater pressures each hour (typically). The recorded data are subsequently converted to fluid pressure head (m) and potentiometric head (mAHD).

Deep groundwater responses to mining are assessed primarily through the use of time-series hydrographs for multi-level piezometer sites (VWPs). Most VWPs at Dendrobium suffer from electromagnetic noise which causes spurious spikes in the data records. Noisy data are filtered and removed where practical. Hydrographs and analysis are presented in Section 3.1.

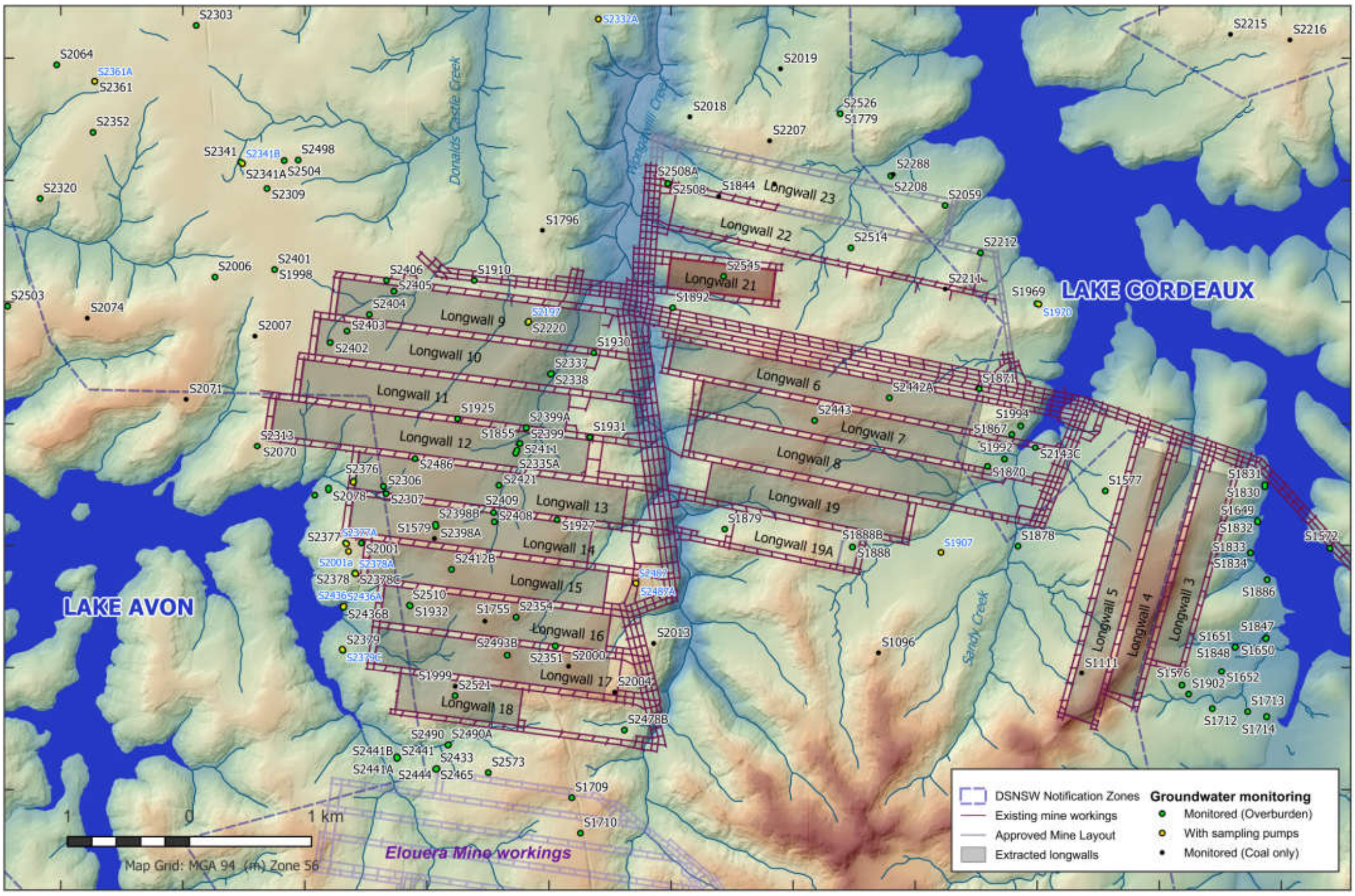

Figure 4. Dendrobium Mine deep groundwater monitoring network

Hydrographs are plotted in terms of ***piezometric head*** (mAHD) and ***pressure head*** (m H_2O). Piezometric head can be thought of as the theoretical level to which water would rise in a bore that is open to an aquifer at a given elevation and is calculated by adding the measured pore pressure (at the VWP, expressed in m of water) to the elevation of the sensor (in m AHD). The potentiometric head in a confined aquifer system can be (and often is) different to the water table elevation at the same location.

Hydrographs presented in this assessment include surface water hydrographs for the nearest water supply reservoir (Lake Cordeaux for Areas 3A and 3C and Lake Avon for Area 3B hydrographs). Note also that individual hydrograph traces are presented as dotted lines at times when the pressure head is below a threshold of 2 m. The ***pressure head*** is the absolute pore pressure at the sensor expressed in m of water. When the pressure head is below that threshold it is an indication that the rock matrix is approaching complete depressurisation at the location of the sensor and, given the uncertainty in pressure measurements, may be totally or partially desaturated. Both piezometric and pressure head hydrographs are presented in Appendix B.

Assessment of the spatial distribution of piezometric head and pressure drawdown over the reporting period is carried out using annotated and coloured symbols on a map. ***Drawdown*** (in metres) is simply the difference in potentiometric head between a reference date and the end of the current reporting period.

In this assessment the groundwater drawdown reference date is November 2009, immediately prior to the start of mining at Area 3A. This date was selected because very few piezometers were operational in Area 3B prior to 2009. The following procedure was used to calculate groundwater drawdown.

- Piezometric head and pressure head data were tabulated from the Dendrobium VWP database. Data were reduced to daily observations using a median of sub-daily data.
- The median head at each operational sensor was obtained for the last 3 months of the recently completed longwall and the last three months of Longwall 5 (ending in November 2009). This approach is used to capture sensors with records that fall slightly short of the end of panel.
- The average head was calculated for each of five subunits: middle HBSS, lower HBSS, upper BGSS, lower BGSS and SBSS. This allows piezometric heads to be compared at bore locations where sensors are set at inconsistent depths. The subunits also correspond to the subunits used in the regional numerical model, allowing direct comparison with model predictions.
- For bores that were installed after 2009, the piezometric head in 2009 was spatially interpolated from sensors within each subunit that were active at that time (using kriging).
- Drawdown was calculated for each subunit as the difference between median heads at the end of the recently completed longwall and the end of Longwall 5 (either observed or interpolated).
- Where one or more of the sensors in the subunit recorded less than 1 m of pressure head (assumed to be near desaturation), the drawdown is recorded as a minimum. Those locations are highlighted on the relevant spatial plots.
- Sensor data for decommissioned or damaged bores are not extrapolated. Locations that have been decommissioned, damaged or for which data are otherwise unavailable at the time of reporting are not included in analysis, although they are still shown on locations maps.

Spatial plots are presented and discussed in Section 3.3.

2.3.1 Proposed changes to assessment of drawdown

In response to comments from BCD regarding assessment of drawdown, it is recommended that the above procedure be revised in future End of Panel assessment to improve clarity, particularly in relation to bores located above extracted longwalls. The existing procedure (described above) was derived to allow comparison between locations where the number of sensors and length of baseline data were different. Calculations become problematic if there are one or more perched aquifers, or if the piezometric head drops below the piezometer in one or more sensors (the sensor records near-zero head). This is common in the HBSS above extracted longwalls. In such cases the calculated average drawdown is a minimum and can seem counterintuitive. In other cases, average drawdown may not be calculated if there is no recent data for one or more sensors, or if the bore is (spatially) outside the interpolated baseline data.

Previous EOP reports provide all hydrographs for bores located above extracted longwalls and describe depressurization of strata. In addition it is recommended that future EoP Groundwater assessments include:

1. A table that lists the most recent observed piezometric and pressure head for each VWP sensor, values for the reference date (Longwall 5 end), and estimated drawdown. The table should clearly indicate whether the calculations are based on observed or interpolated baseline, and if the VWP indicates near-zero pressure head.
2. Plots of pressure head above extracted longwalls versus height above the extracted seam (as is produced in this report at Figure 11). Such plots will clearly show the complexity of groundwater conditions above the goaf and supplement the hydrographs and maps already provided.

2.4 Mine water balance

All movements of water via pumping stations are monitored and controlled in real-time through the System Control and Data Acquisition (SCADA) system and used to calculate a daily mine Water Balance. The Water Balance is an accurate measure of all water that enters, circulates and leaves the mine, including via air moisture and coal moisture content. Mine water seepage (groundwater inflow), which cannot be directly measured, is determined by mass balance for each goaf and is therefore known to a reasonable accuracy. Key metrics of the Mine Water Balance are reported against Trigger Action Response Plan (TARP) levels to Dams Safety NSW monthly.

In this assessment, the estimated groundwater inflow component of the mass balance is presented as time-series hydrographs and compared with rainfall trends and model predictions. Analysis of water balance trends for the reporting period is presented in Section 3.

2.5 Groundwater chemistry

Groundwater chemistry sampling sites relevant to this assessment are shown in Figure 4 (yellow symbols). Currently there are eight sampling bores in Area 3B containing 20 individual sampling pumps screened within the Hawkesbury and Balgo Sandstone. Most sampling sites are located between the mined and planned longwalls of Area 3B and the eastern shore of Lake Avon. The SBSS is monitored at two locations: S1886 (Area 2) and S1870 (Area 3C).

In addition to samples collected from bores, groundwater samples are routinely collected from underground workings, inter-seam boreholes and flooded adjacent mine workings, as described in the *Underground Water Sampling and Analysis Procedure* (DENP0048). Water is analysed for chemistry (major and minor ions), and isotopes of carbon and hydrogen. Monthly water samples are taken from the main discharge points of the mine and from completed longwall panels. The results of the sampling are reviewed each month and reported to Dams Safety NSW. More than 1,900 underground mine water samples and >5,000 surface water samples have been collected and analysed at Dendrobium Mine since 2004 (including > 1,300 tritium analyses), providing an extensive database for ongoing assessment and a basis for chemically characterising waters from various sources.

In this assessment, average field electrical conductivity (EC), is used as a general indicator of water quality (salinity). Water salinity varies according to its source (see Figure 5) and, in general, groundwater salinity tends to increase with the depth below the surface; groundwater in the HBSS tends to be relatively fresh (average EC ~ 170 μS/cm) whereas mine seepage water is distinctly more brackish (average EC of seepage in Areas 3A and 3B ~ 2200 μS/cm). Beneficial water use categories based on the ANZECC water quality guidelines (ANZECC, 2000) are shown for reference only. Groundwater quality is assessed further in Section 3.5.

Samples collected from bores can sometimes be influenced by drilling water, residual grout or bentonite leachate from the construction of the piezometer. Typically, this is indicated by elevated or anomalous EC, pH, sulfate, or Ca/Na ratios. Samples that are highly affected by grout or bentonite are excluded from assessment; however, some samples may show subtle effects.

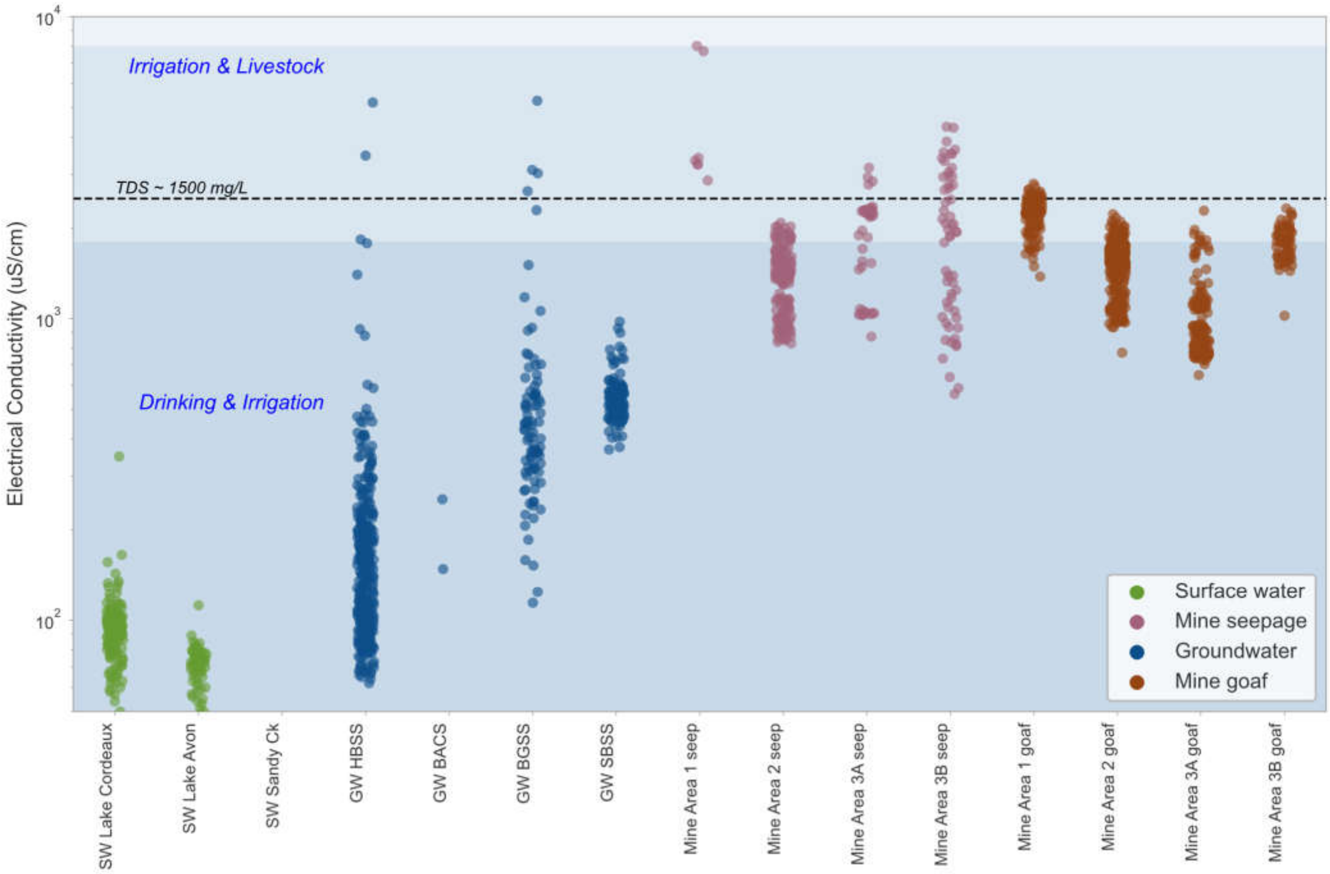

Figure 5. Electrical Conductivity of surface water, groundwater and mine inflow (as of Sept 2023).

3. ASSESSMENT OF GROUNDWATER RESPONSE TO MINING

3.1 Mine water balance

Table 1 presents mine inflow statistics as indicated from the net water balance for each Area for the period over which Longwall 21 was extracted (25/4/2023 to 6/8/2023). The water balance for each area over previous longwalls is shown in Figure 6. Continuous timeseries plots of mine inflow compared with the cumulative rainfall residual curve are shown in Figure 7. The cumulative rainfall residual is the cumulative deviation of observed daily rainfall from the daily rainfall mean (~3.1 mm per day). The curve trends downward during prolonged dry periods (e.g., during the severe 2017-2019 drought), and upward during prolonged wet periods (e.g., the 2020-2022 La Nina events). Groundwater recharge processes are often correlated with rainfall residual trends.

Table 1. Dendrobium Mine Inflow during the Extraction of Longwall 21 (in ML/day)

STATISTIC	AREA 1	AREA 2	AREA 3A	AREA 3B	AREA 3C	TOTAL
Longwall 21 (mean)	0.14	0.46	0.05	6.64	0.77	8.05
Longwall 21 (max)	0.75	1.13	0.21	8.22	2.46	9.88

The mean total mine inflow during Longwall 21 extraction was 8.05 ML/day which represents a 28% decrease compared with the previous longwall (19). The decrease brings the mean inflow back to a similar level the average observed during Longwalls 17 and 18, prior to the very high rainfall year in 2022. The net mine water balance is dominated by pumping from Area 3B (83 % of total), with Area 3C (where Longwall 21 is located) representing only 9.5 % of inflows. High inflows occurred in 2022 following the very high rainfall events. Those high inflows were managed by transferring water from Area 2 to Area 3A and Area 3B. No anomalous inflow due to intersecting water-bearing structures such as faults or dykes was reported during the extraction of Longwall 21.

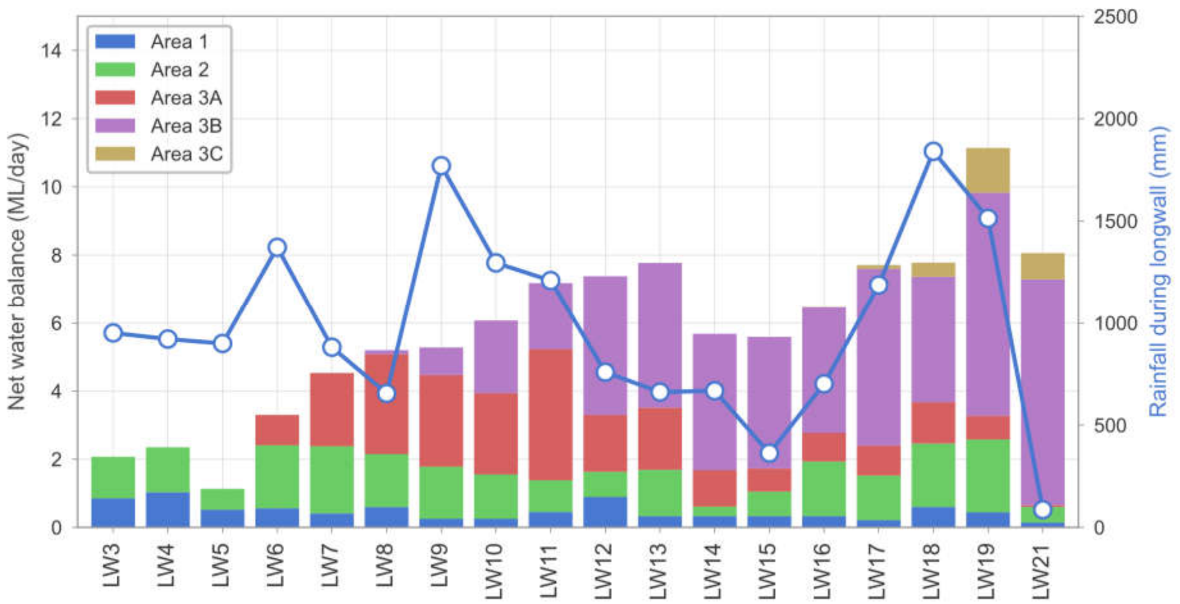

Figure 6. Net mine water balance during longwall extraction periods

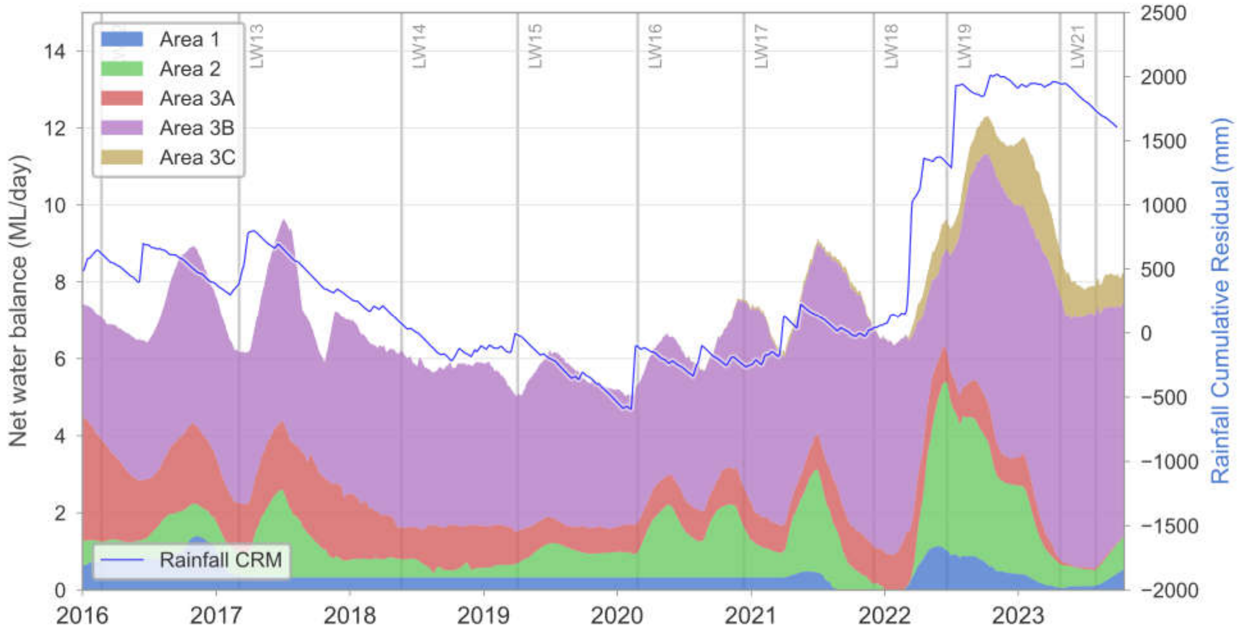

Figure 7. Groundwater inflow from water balance for all mine areas (ML/day)

3.1.1 Estimates of the surface water component of mine inflow

The correlation of inflow peaks with periods of high rainfall implies that there is a rainfall (or surface water) induced component to mine inflow. Two approaches are used to assess the proportion of mine inflow that may be attributed to rainfall or surface water:

1. Baseflow separation approach, whereby the volume related to the inflow peaks is estimated as a fraction of the total inflow for a given period. Baseflow is a concept from stream flow hydrology whereby the baseflow represents the groundwater discharge component of flow, as opposed to the ‘quick flow’ component of rainfall runoff represented by the hydrograph peaks (in this case peaks in mine inflow following rain events).

2. Isotopic tracer approach, whereby tracers of modern water (tritium and radiocarbon) are used to detect and estimate the proportion of rainfall or surface water in mine inflow samples.

The two approaches assess surface water input in different ways and will not necessarily yield similar results. The baseflow separation approach estimates the inflow component related to high rainfall events. Those events result in a rise in groundwater levels or piezometric head (within porous rock and fracture networks) which drive transient increases in mine inflow. However, the water itself may be largely derived from the release of (old) groundwater storage[3] unless there are direct and rapid pathways between the surface and the goaf.

[3] Note that the volume of groundwater storage above the longwall footprint alone is significant. Unconfined or drainable groundwater storage would be in the order of 7 GL per longwall (assuming an average longwall goaf area of 610,000 m2, a Specific Yield of 3% averaged over all strata and an average saturated thickness of 370 m). Confined or elastic storage would be small in comparison; in the order of 20 ML (assuming a Specific Storage coefficient of around 10^{-6} m^{-1}; David *et al.* 2017). At the average mine inflow rate per longwall, complete drainage of the column (ignoring lateral groundwater flow) would take in the order of 20 years. Old groundwater storage release is likely to dominate mine inflow for many years.

3.1.2 Water balance baseflow separation

An example of base-flow separation analysis is shown in Figure 8 for the total mine water balance data. The daily water balance data (grey circles) is highly variable due to the nature of pumping cycles in the underground mine and the trend is best represented as a 30-day moving average (the purple line). The moving average clearly defines peaks in net mine inflow following large rainfall events, with a two to three-month delay; the largest peak being that following the very high rainfall in 2022. Much of the rainfall response in the total mine water balance is driven by the Area 2 water balance which is known to be dominated by rainfall response; however, rainfall response signals are also evident in the Area 3B water balance.

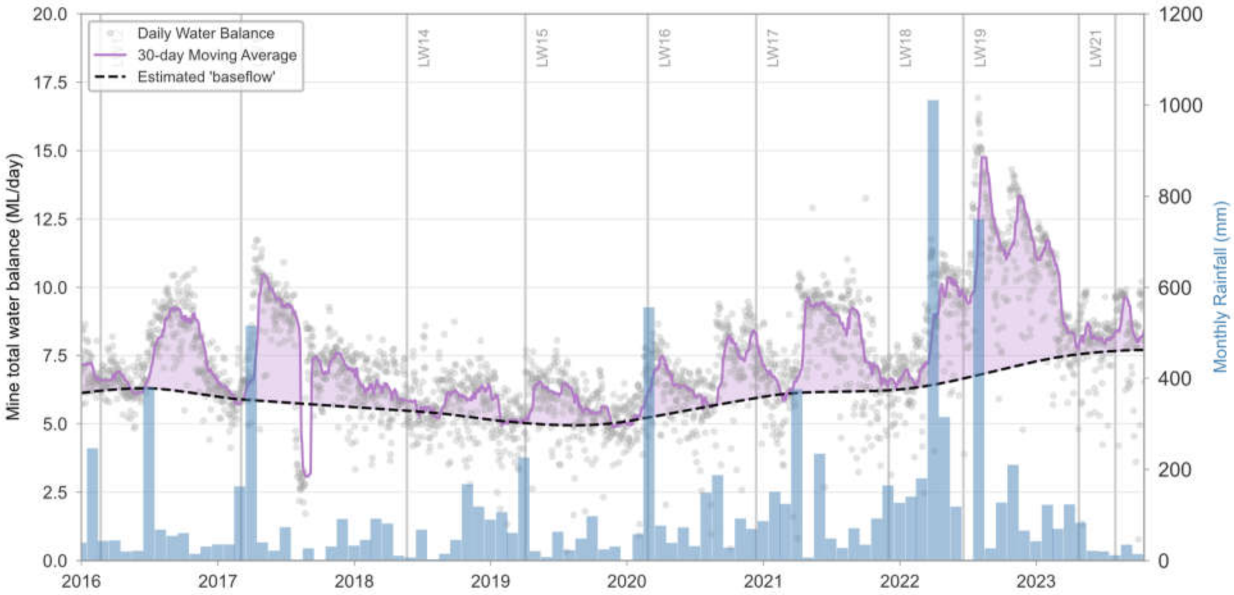

Figure 8. Estimate of potential surface water component of the total mine water balance

Applying digital stream baseflow separation filters to the water balance data is problematic due to the high variability of the data (including negative values) and significant lag times. Therefore, the baseflow component has been approximated by interpolating between troughs in the 30-day moving average water balance. The potential rainfall-induced inflow component is defined by the difference between the two curves (purple shading). Note that the estimate will include peaks caused by variations in pumping (for operational reasons) and therefore may over-estimate the rainfall-induced component.

Using this method, the rainfall-induced component of inflow for the whole mine has averaged 20% since the start of Longwall 12. The apparent contribution during Longwall 21 was 7 % (equating to ~0.5 ML/d), down from 38% for the previous longwall, again due to the high rainfall in 2022.

3.1.3 Tritium in mine inflow

The modern water component in mine inflow is monitored by analysing tritium in samples collected from goaf inflow and development seepage water samples. The results are reported monthly to Dams Safety NSW. Tritium is an isotope of hydrogen (^3H), generated in the atmosphere through interactions with cosmic rays and through past atmospheric nuclear weapons testing (Clark, 2015). Tritium is incorporated into water molecules in rainfall and enters groundwater systems through recharge (rainfall and stream-bed infiltration). Tritium decays exponentially according to its half-life (12.32 years) and is typically only detectable in surface water samples and in groundwater that recharged within 4 to 5 half-lives (50 to 70 years). Detection of tritium above deep groundwater baseline levels in mine inflow samples would indicate a component of modern water in the sample (as it does for samples from Area 2).

Tritium is widely assumed to be a conservative tracer in that it is not significantly sorbed or otherwise retarded during groundwater transport (e.g. Cendón et al., 2014; Štamberg et al., 2014). However, a review by ANSTO (2018), commissioned by South32, concluded that tritium may undergo diffusive exchange with (and therefore loss to) zones of older groundwater. While the effect has not been quantified in terms of typical groundwater pathways at Dendrobium, it is important to consider when assessing tritium results. Despite possible diffusive losses, tritium remains an important and unambiguous indicator of modern water when tritium is detected above baseline levels.

A timeseries plot of tritium in groundwater samples from the underground mine and Lake Avon is shown in Figure 9. Tritium in samples collected from the Area 3B goaf outflow is typically within or close to baseline concentrations in deep groundwater, as defined by the 95th percentile (P95) level for samples collected from the Scarborough Sandstone (shaded area below 0.2 TU in Figure 9). This implies a generally low contribution of modern water to mine inflow in Area 3B. The median tritium content in Area 3B has increased slightly since 2020 and, in 2022 trended above 0.2 TU, noting that tritium in rainfall samples shows an increasing trend over the same period. The trend likely reflects a higher proportion of surface water inflow to the mine as a result of high rainfall in 2022 (and the preceding 2 years). The increasing trend may also reflect the redirection of inflow from Areas 2 and 3A through Area 3B during periods of peak inflow (HGEO, 2023).

Samples from Areas 2 and 3A are typically slightly higher than in Area 3B, ranging up to approximately 0.6, implying a higher proportion of modern water, and again increasing during 2022. Estimates of modern water content based on simple binary mixing using the most recent 12 tritium samples for each mining area are ~ 11% for Area 3B, 28% for Area 3A, 27% for Area 2 and ~13% for Area 1. Those estimates imply a flow weighted mean for the whole mine of **~16%** modern water, which is broadly consistent with the long-term average of 20% calculated from the water balance by peak separation (noting that these statistics will be skewed by the high inflows in 2022). The tritium estimate of percent modern water should be regarded as an underestimate due to potential diffusive losses as discussed above.

As of the time of reporting, no analyses of tritium or carbon-14 for samples collected from Area 3C have been received from ANSTO.

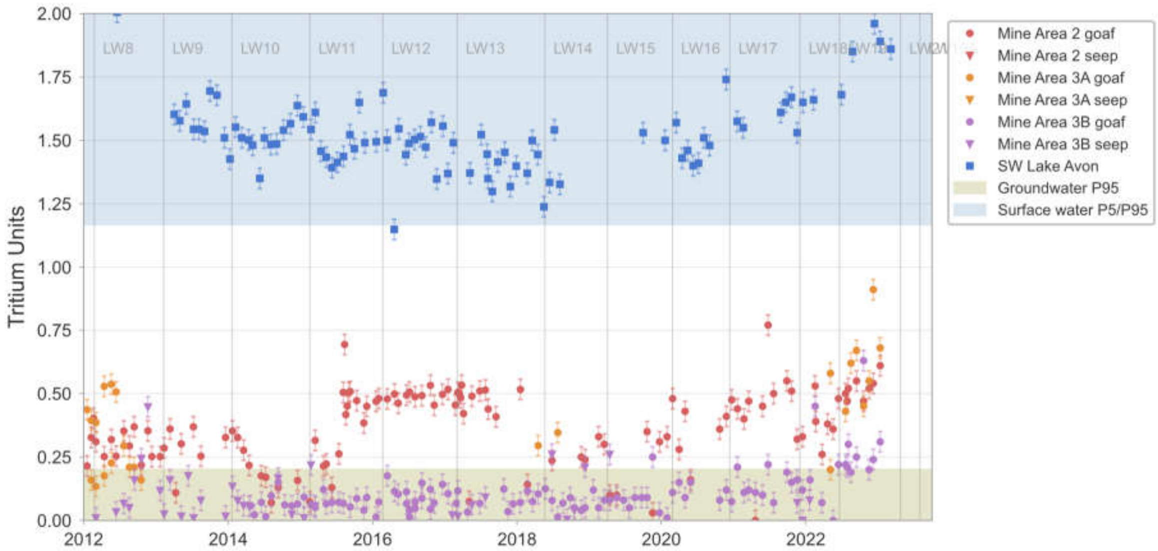

Figure 9. Tritium concentration in water samples from Area 3B

3.2 Deep groundwater levels – time-series hydrographs

Groundwater hydrographs for all active VWP arrays are presented in Appendix B (Piezometric head and pressure head hydrographs). Overall trends and notable observations are summarised in the following subsections according to their proximity to mine workings.

3.2.1 Near Longwall 21

Monitoring bore S2545 is located directly above Longwall 21. The bore contains an array of 8 VWP sensors ranging in depth from 13 m (HBSS) to 256 m (SBSS). A hydrograph for S2545 is shown in Figure 10. The upper two piezometers have recorded near-zero pressure head since installation in 2021. The sensor at 88 m depth (lower HBSS) shows relatively stable groundwater levels prior to Longwall 21 that were consistently above the level of Lake Avon (Full Supply Level = 320.2 m AHD) and Lake Cordeaux (FSL 303.7 m AHD). As Longwall 21 approached the monitoring bore, strata compression caused the groundwater pore pressure to increase, prior to the cables shearing due to subsidence movement, which is common for bores located directly above longwalls. The deeper sensors record relatively stable piezometric levels within the upper BGSS, prior to rapid depressurisation and cable failure as Longwall 21 passed beneath the bore.

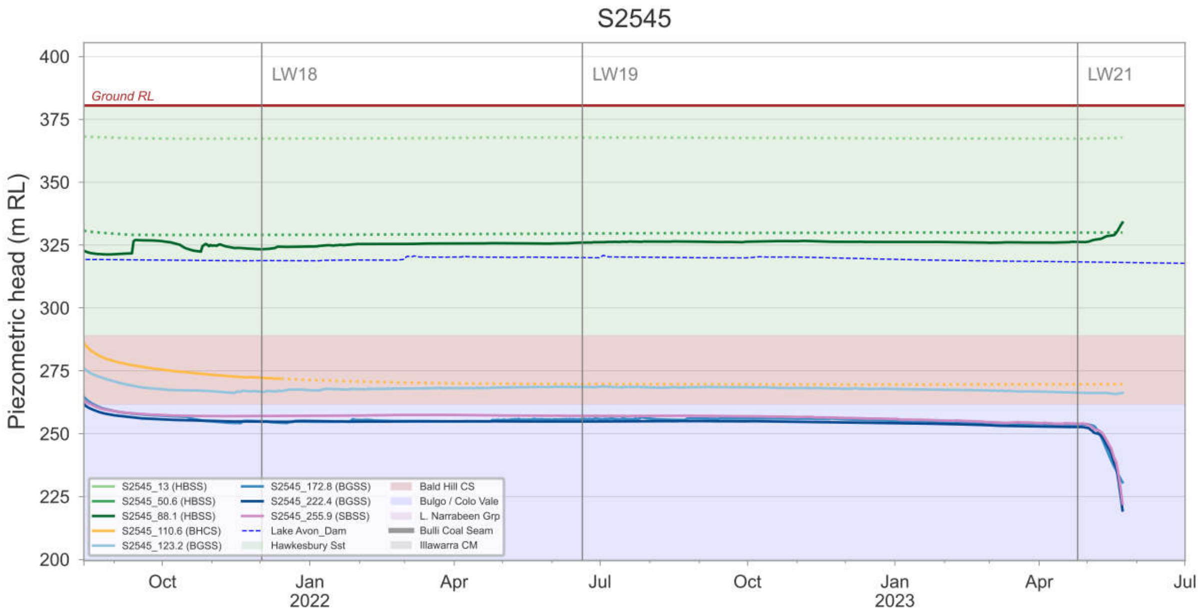

Figure 10. Hydrograph for VWP sensors in bore S2514 above Longwall 21

The next closest monitoring bores are S1892, located 153 m south of Longwall 21 and S2514 located 647 m to the east of Longwall 21. Hydrographs for those bores are provided in Appendix B.

S1892 which was installed in 2008 shows relatively stable groundwater level in the HBSS, prior to rapid depressurisation during Longwall 21. Deeper strata show depressurisation associated with previous mining in Areas 3A and 3B. Groundwater levels in the deeper strata recovered slightly as mining in Area 3B moved southward, away from the bore site, before experiencing slight depressurisation just prior to, and during, Longwall 21.

S2514 which was installed in 2020, shows minor drawdown in the HBSS during Longwall 21 with evidence for drawdown due to mining in Area 3A to the south, prior to Longwall 21.

The above effects are consistent with those observed near previous extracted longwalls and in line with expectations and numerical model predictions.

3.2.2 Strata above mined longwalls

Piezometer cables in bores located above the footprint of a longwall are usually sheared or the sensors rendered inoperable by ground movements associated with mining and there is rarely a continuous record of groundwater pressures after the longwall has passed the monitoring location. Therefore, it is useful to consider groundwater monitoring data from locations above longwalls in two groups:

1. Baseline monitoring of groundwater levels as the longwall approached the monitoring location (until the cables shear).
2. Monitoring established over the goaf following the passage of the longwall. Since 2018, new piezometer arrays have been installed over previously mined longwalls 6 and 7 in Area 3A and Longwalls 12 to 18 in Area 3B. In addition, piezometers have been installed above mined longwalls to monitor specific swamps and watercourses.

Prior to being mined beneath:

Review of hydrographs from piezometers installed above longwalls prior to being mined beneath show evidence of depressurisation at the coal seams before mining started at Area 3A and years before mining started in Area 3B (Appendix B). Depressurisation of most overlying strata is apparent from the start of mining at Area 3A, and the rate of depressurisation increased as mining moved to Area 3B, and with every successive longwall in Area 3B. Depressurisation is generally greater in the deeper formations. Transient pressure *increases* are also common as the longwall approaches or passes nearby the monitoring site and these reflect compression and relaxation of the strata as the subsidence wave passes (Booth, 2002). Piezometer cables typically shear when the longwall passes within 10 m of the location, but at some sites shearing has occurred when the longwall was up to 660 m away (e.g., S1929).

After being mined beneath:

IMC has carried out investigation drilling above extracted Longwalls in Areas 3A and 3B to assess the extent of fracturing and depressurisation above extracted longwalls (HGEO, 2021, 2020a, 2020b). Where practical, monitoring bores located above longwalls that are damaged by subsidence movement are re-drilled and replaced, allowing continued monitoring after longwall extraction. The most recent replacement was S2521 above Longwall 18. All hydrographs are provided in Appendix B.

VWPs installed after longwall extraction Areas 3A and 3B indicate significant depressurisation throughout all strata, with near-zero pressure heads recorded in most piezometers. Some bores in both areas show positive and increasing pressure heads in some sensors in the upper CVSS, BACS and HBSS, indicating localised perching and recovery of groundwater levels within those strata (e.g. S2403, S2220, S2411). This effect was particularly noticeable between 2020 and 2022 in response to higher-than-average rainfall which during which significant groundwater recharge occurred. In general groundwater levels above longwalls remains significantly below pre-mining levels.

The pressure head recorded at all VWP sensors located above extracted longwalls are plotted against the height of the sensor above the mined coal seam (Wongawilli Seam) as at the most recent longwall (Figure 11) and the end of the previous longwall (Figure 12). Note that recent data were not available for some bores at the time of reporting.

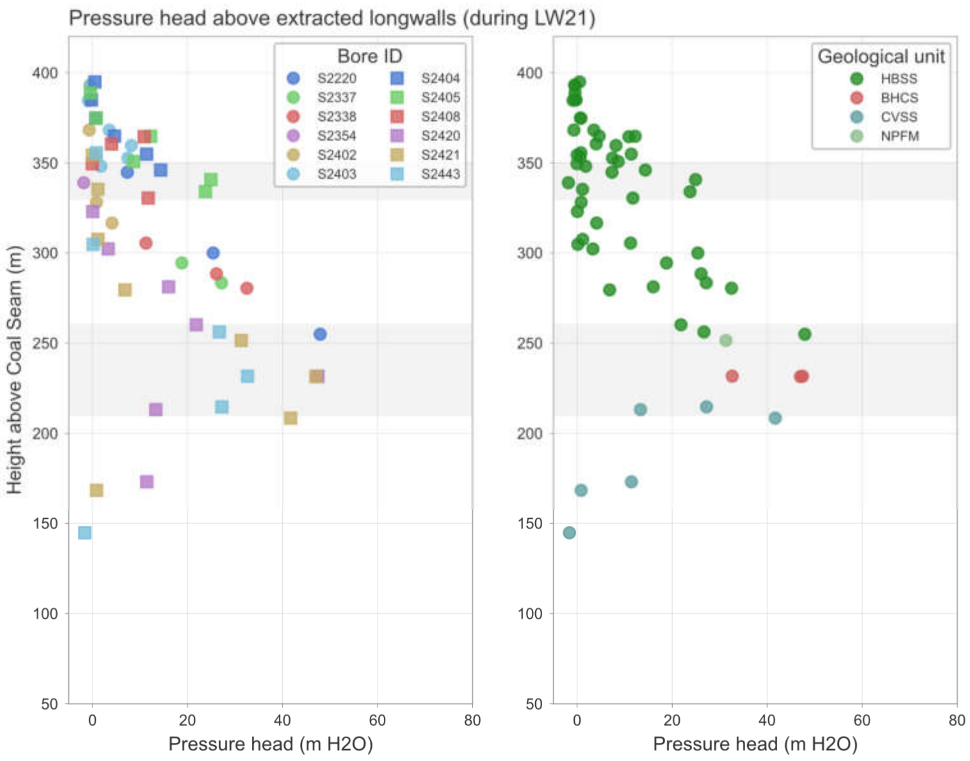

Figure 11. Pressure head in VWP sensors above extracted longwalls (during Longwall 21)

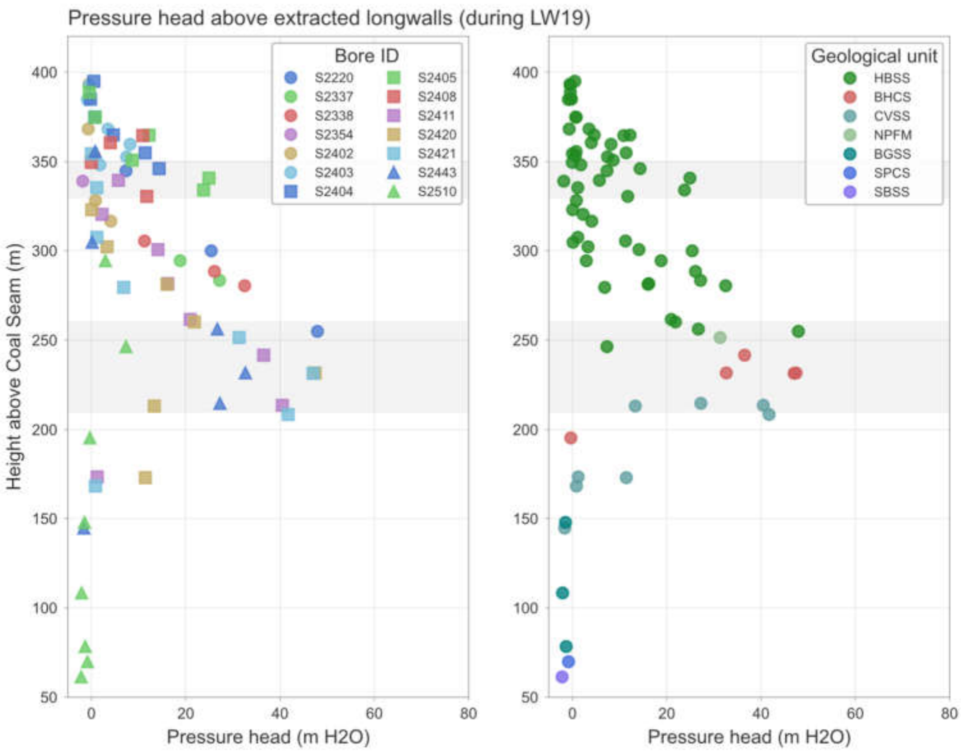

Figure 12. Pressure head in VWP sensors above extracted longwalls (during Longwall 19)

The plots of pressure head versus the height of the sensor above the mined coal seam in Figure 11 and Figure 12, illustrate the following:

- Complete depressurisation throughout mid- to upper HBSS in most bores located above longwalls, but also:
- Impedance of downward flow at two main horizons (shaded), causing perching above the following horizons:
    - around 330-350 m above the coal seam, corresponding to the mid-HBSS which contains some prominent claystone horizons.
    - around 210-260 m above the coal seam, corresponding to the BHCS and upper BGSS. This height also corresponds to the height where fracturing transitions from high-angled fractures to (dominantly) horizontal bedding plane fractures (based on the Height of Fracturing investigations (HGEO, 2020a)).

The overall pattern of groundwater depressurisation has not changed significantly from the previous longwall, although slight decreases in head due to dry conditions in 2023 are noted elsewhere in this report.

3.2.3 Area 3B: Strata outside mined longwalls

In this section, data from piezometers located outside the current mined longwall footprint are reviewed (excluding the Avon monitoring bores which are discussed below). These include bores installed north and northwest of Area 3. Refer to hydrographs in Appendix B.

Piezometers located to the north and west, and within 1 km of Area 3 (S1910, S1892, S1998 / S2401, S2006, S2007, S1969) show a gradual decline in groundwater pressures in most strata with the rate of decline increasing with depth and proximity to the longwall. Those observations are consistent with the gradual expansion of a drawdown cone away from the mine and are in line with numerical modelling predictions. The most strongly affected strata are within 500 m of extracted longwalls (S1910, S1892). At S2006 (1 km west of Longwall 9) piezometric head decreased to their lowest level in most strata towards the end of Longwall 14 and have shown recovery in within the HBSS and upper BGSS since Longwall 14 which continued during Longwall 21.

Monitoring bores installed northwest of Area 3B show that drawdown is minor at distances greater than 1.2 to 1.5 km from Area 3B. At S2341 (1.2 km), there is some evidence for depressurisation in the deeper sandstone strata; however, all sensors show piezometric head at an elevation corresponding to the HBSS. Similar piezometric levels are observed at S2352 (2.3 km), S2342 (2.6 km), S2345 (3.5 km) and S2340 (4.7 km). At those relatively distant locations, piezometric head within the HBSS is typically above 320 m AHD (and above the level of Lake Avon), whereas levels within the BGSS and SBSS have heads < 300 m AHD and display broadly hydrostatic profiles, with evidence for some depressurisation in deeper strata since Longwall 16 and during Longwall 19. This condition has not significantly changed during the extraction of Longwall 21.

3.2.4 Avon reservoir bores

A series of monitoring bores was installed along the barrier zone between Lake Avon reservoir and Area 3B to characterise the strata permeability before and/or after mining of adjacent longwall panels and to provide ongoing groundwater monitoring. Most holes were re-drilled and tested following extraction of the adjacent longwall(s). Those observations provide critical information to allow more accurate calculation and modelling of potential seepage losses from the reservoir(s) to the mine. Hydrographs for all Avon Dam series monitoring bores are included in Appendix B.

Piezometers in the Lake Avon barrier zone show widespread depressurisation of all strata in response to mining in Area 3B, as predicted in numerical groundwater models (Watershed HydroGeo, 2020). Groundwater levels at the base of the HBSS were likely near or just above the lake level prior to mining and have declined to be below the lake level. Several piezometers show evidence for recovery in piezometric level between 2020 and 2022 corresponding to the very high rainfall during that period (e.g., at S2313, S2314, S2379, S2435, S2436), with a slight decline during 2023 due to dryer conditions. The observed levels imply hydraulic gradients away from the lake and towards the mine adjacent to extracted longwalls (see also Figure 17); however, gradients remain towards the lake beyond the influence of the extracted longwalls. Perched aquifers are apparent in upper parts of the HBSS which can persist after mining.

At the time of reporting, recent data for some of the monitoring bores adjacent to lake Avon was not available. Those bores are S2377, S2378, S2379, and S2436. It is recommended that dataloggers from those bores are downloaded prior to the next EOP review.

A plot of model predicted piezometric head versus observed head at piezometers adjacent to Lake Avon as of the end of Longwall 21 is shown in Figure 13. The plot shows that piezometers located adjacent to Lake Avon show observed head that is similar to, or higher than, the numerical model prediction (plotting close to the 1:1 Model:Observed line). Therefore, the model predictions remain generally accurate as of Longwall 21.

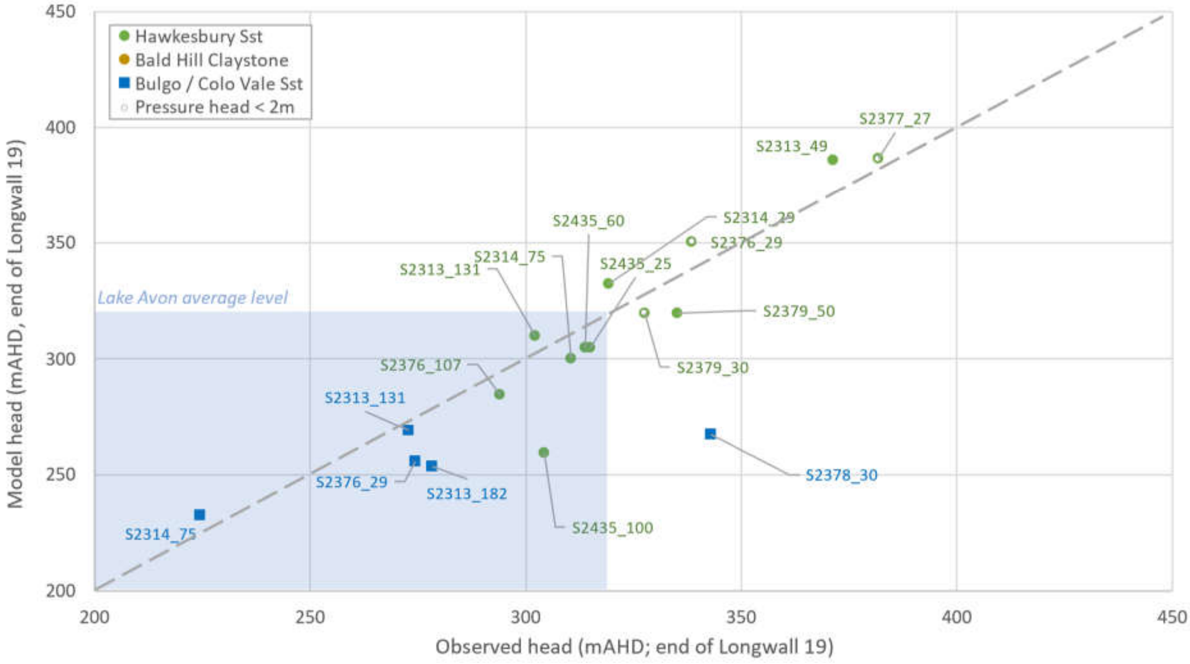

Figure 13. Modelled versus observed piezometric head for Avon Dam monitoring sites.

Hydraulic gradients away from the lake imply groundwater flow from the lake to the mine and seepage loss from the lake. The rate of seepage loss is governed by the hydraulic gradient and permeability (measured and expressed as hydraulic conductivity) of the intervening strata which has been tested prior to mining (at most sites) and following extraction of longwalls. Estimated seepage rates based on the most recent numerical groundwater model are provided in Section 3.4.3.

3.2.5 Potentially transmissive geological structures

Geological structures such as faults and fracture zones have the potential to form conduits for groundwater flow to the mine and transmit drawdown to receptors distant from the mine. The permeability structure of faults is related to the internal structure, rock type, the prevailing stress regime and post-movement mineralisation of the fault zone (Bense et al., 2013). A geological assessment, including mapped and potential structures was carried out prior to mining in Area 3B (BHP Billiton, 2013).

The geology of Area 3C was revised in 2022 as part of assessment for the Longwall 21A SMP application (South32, 2022). Figure 14 shows the revised geology on relation to the Longwall 21 footprint. The maps show outcrop lithology which is dominated by Hawkesbury sandstone (HBSS). The geological structures are mostly those mapped at seam level during first workings.

A dyke zone (DD9P and fault DF33) is located to the north of Longwall 21, trending east-west, but does not directly intersect the goaf. A minor fault and dyke (DF32, a continuation of DD7A) is inferred to traverse the north-eastern corner of the longwall. Two lineaments also traverse the longwall. During the extraction of Longwall 21 there were no anomalous inflows or changes in groundwater chemistry associated with mining through or beneath the mapped structural features (Section 3.1).

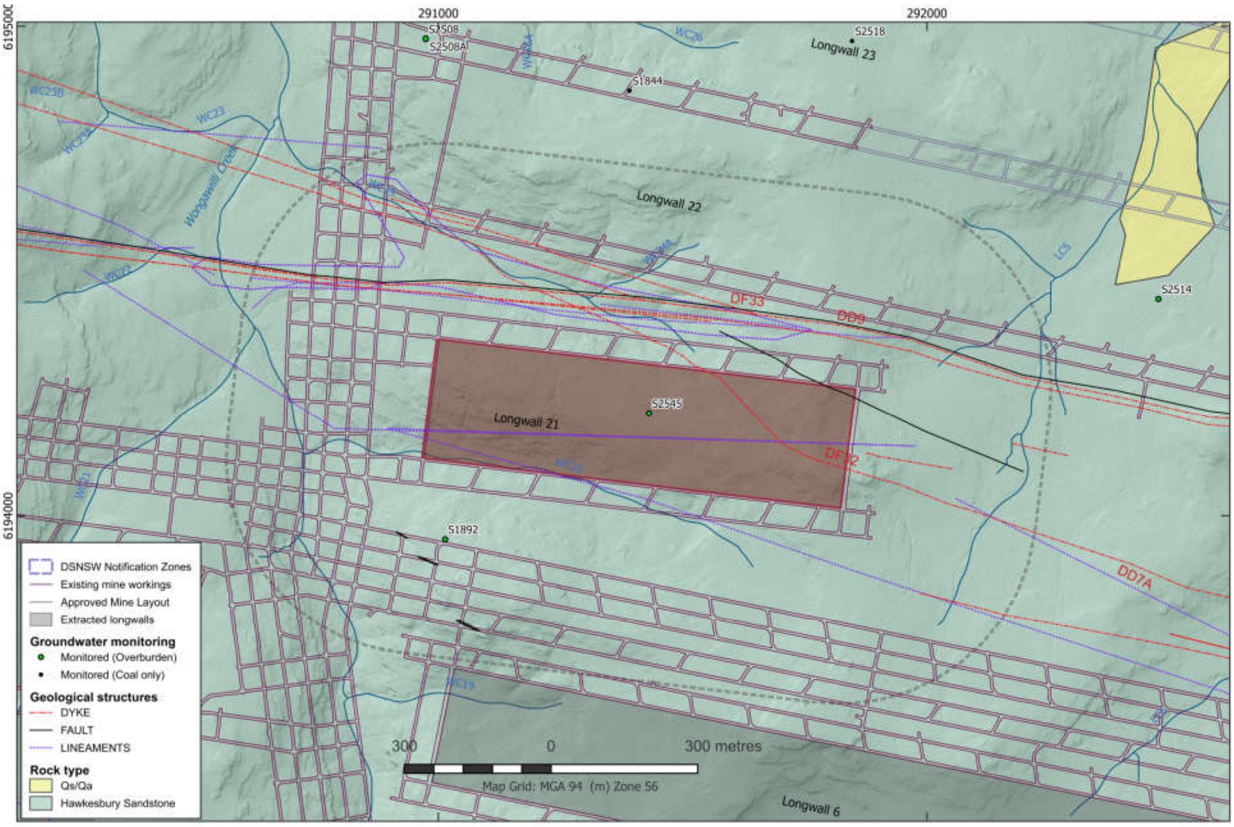

Figure 14. Surface geology and mapped structural features near Longwall 21

SRK (2020) assessed faults and surface lineaments above and around Dendrobium Mine, and their interaction with mine subsidence. The assessment included analysis of LiDAR elevation data to determine if surface subsidence is controlled by or reactivates mapped surface lineaments. The study identified several very minor linear anomalies directly above mined longwall panels in Area 3B, with none identified in Areas 2 or 3A. The study concluded that the potential for reactivation of lineaments extending outside the planned mining areas was assessed as low. A separate study HGEO (2020c) assessed of the spatial relationship between piezometric response in vibrating wire piezometers (anomalous drawdown compared with predictions) and proximity to known or inferred geological structures. The study concluded that anomalous drawdown responses are not correlated with mapped structural features. This is consistent with the observations in the underground mine that large inflows of groundwater are typically not associated with mapped linear features such as igneous dykes and faults, and with experience elsewhere in the Southern Coalfield (Doyle, 2007; Tonkin and Timms, 2015).

3.3 Deep groundwater levels – spatial patterns

The spatial distribution of piezometric heads and drawdown in piezometric head due to mining is shown in the following figures:

1. Bores where there are one or more sensors within the HBSS that record near-zero pressure head (assumed to be desaturated; Figure 15).
2. The change in average piezometric head (drawdown) between the end of Longwall 5 (November 2009) and the end of Longwall 21 (Figure 16 to Figure 20); and
3. The piezometric head in the lower HBSS relative to the Lake Avon FSL and recent lake levels as of the end of Longwall 21 (Figure 17).

Piezometers that are now inactive or have not been downloaded within 3 months of the end of panel are excluded from the plots. It should be noted that calculations of drawdown since 2009 are subject to uncertainty because of the inconsistency in the depths of sensors within each geological unit between monitoring bores.

3.3.1 Spatial distribution in groundwater drawdown

Maps of observed and estimated drawdown are shown for subunits within the HBSS, BGSS (and stratigraphic equivalent within the CVSS), and the SBSS. Analysis concentrates on the Triassic sandstone formations since those units are most relevant to connected surface water processes; drawdown in the Wongawilli and Bulli coal seams is shown in time series plots (hydrographs). The coal seams, being typically more permeable than the host coal measures and overlying Narrabeen Group, depressurise well in advance of mining, defining a broad zone of drawdown around current mining areas that overlaps with residual drawdown from neighbouring historic mines.

Analysis of drawdown in the HBSS focusses on the lower 70 m of the formation (lower HBSS). Comparison of drawdown in the upper and middle parts of the formation is problematic and potentially misleading (an underestimate) because of the number of sensors within desaturated strata. The number of sensors that record zero or near-zero (< 2 m H_2O pressure head) is shown in Figure 15. It is common for bores located above extracted longwalls to show near-zero pressure head conditions in multiple sensors implying drawdown of head below those sensors. The typical depth to water on the plateau areas prior to mining was in the order of 25 to 30 m. Therefore, sensors that are at less than 15 m depth are plotted separately (as green symbols) since it is more likely that those sensors would be desaturated under natural conditions.

Within the lower HBSS, maximum drawdown exceeding 45 m is observed in piezometer arrays above and immediately surrounding extracted longwalls. However, review of individual hydrographs (Appendix B) and pressure head for sensors above mined longwalls (Section 3.2.2) indicates that most strata above extracted longwalls are depressurised with evidence for perched aquifers forming above low-permeability horizons. Therefore, drawdown values above extracted longwalls should be considered as minima. Drawdown in the HBSS reduces rapidly away from the mined longwalls. Bores at which a groundwater increase is recorded relative to 2009 (“negative drawdown”) are shown as zero. Several piezometers record groundwater recovery relative to the baseline due to the high rainfall between 2020 and 2022, with many piezometers showing a slight decline in 2023 as a result of drier conditions.

Piezometric head in the lower HBSS compared with the water level in Lake Avon is shown in Figure 17. Several bores located between extracted longwalls in Area 3B and Lake Avon record piezometric heads that are below the current lake level, consistent with a gradient away from the reservoir as described previously. It should be noted that some bores contain sensors at higher stratigraphic levels that record piezometric head above the lake level (e.g., S2313_49 m) and therefore the hydraulic gradient within the barrier zone varies with both location and elevation. In addition, there is evidence for minor perched water tables persisting in some sensors. As noted in Section 3.2.4, bores at which no colour symbols are shown are those for which recent data were unavailable at the time of reporting (< 90 days before the end of the Longwall). It is recommended that all bores adjacent to Lake Avon and Lake Cordeaux be checked and data reviewed prior to the next EOP report.

Observations of piezometric head in the BGSS are mainly restricted to near the extracted and planned longwalls (Figure 18 and Figure 19). Drawdown exceeding 100 m is estimated at several bores (e.g., S2486, S2421). Drawdown decreases away from the mined areas such that less than 30 m of drawdown is estimated at distances of 1.2 km or more north of Area 3B (S2341, S2006). Significant depressurisation is expected above extracted longwalls in the BGSS (and units below) due to subsidence-related fracturing extending upwards from the goaf into these units.

The SBSS (Figure 20) is depressurised in the vicinity of the mined areas. As with the BGSS, estimated drawdown decreases to the northwest with distance from Area 3B; however, depressurisation of ~79 m is observed to the northeast (S2059) due to residual drawdown from neighbouring mines.

Hgeo
hgeo.com.au

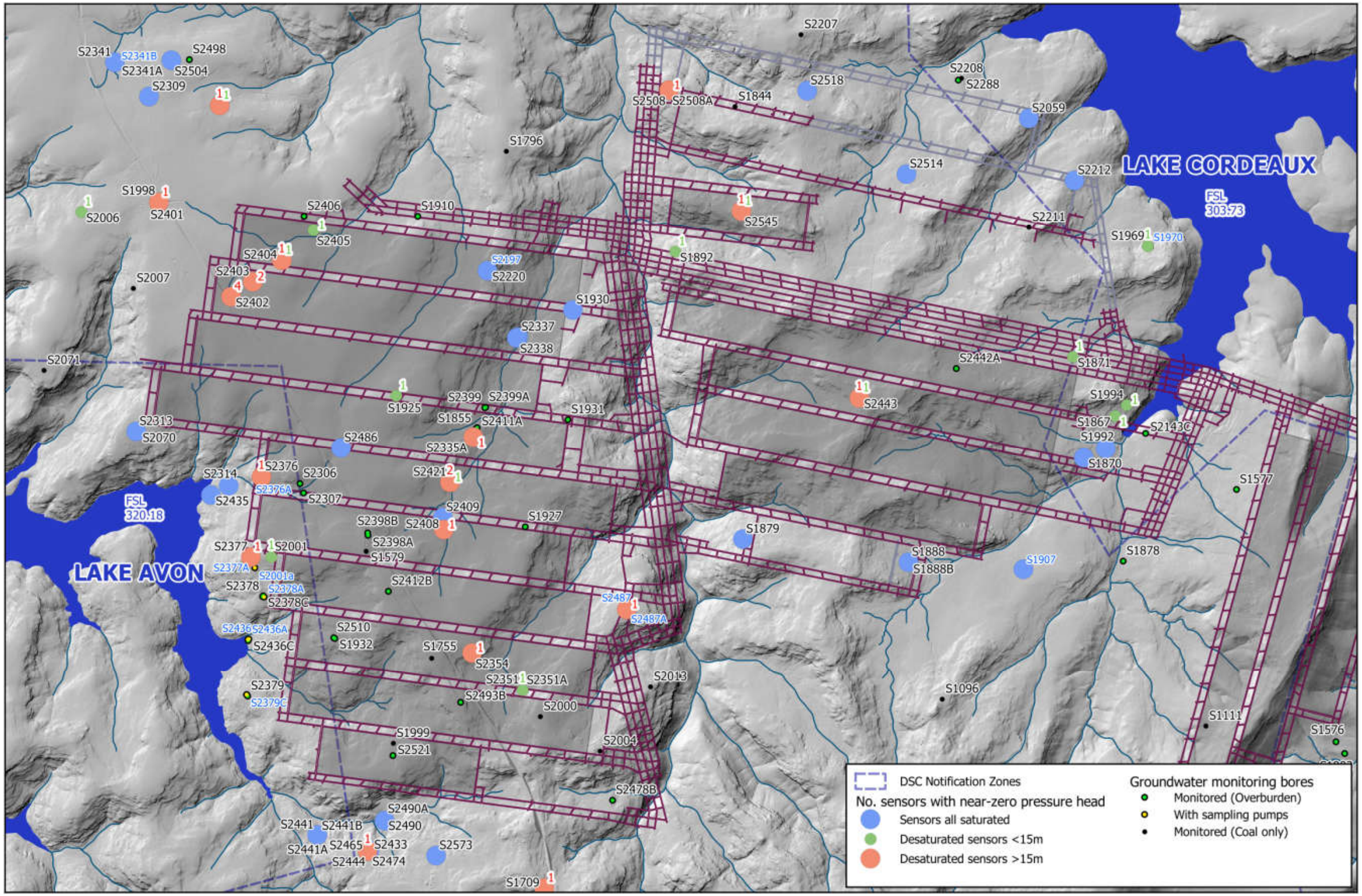

Figure 15. Sensors recording desaturated conditions in the Hawkesbury Sandstone (2023)

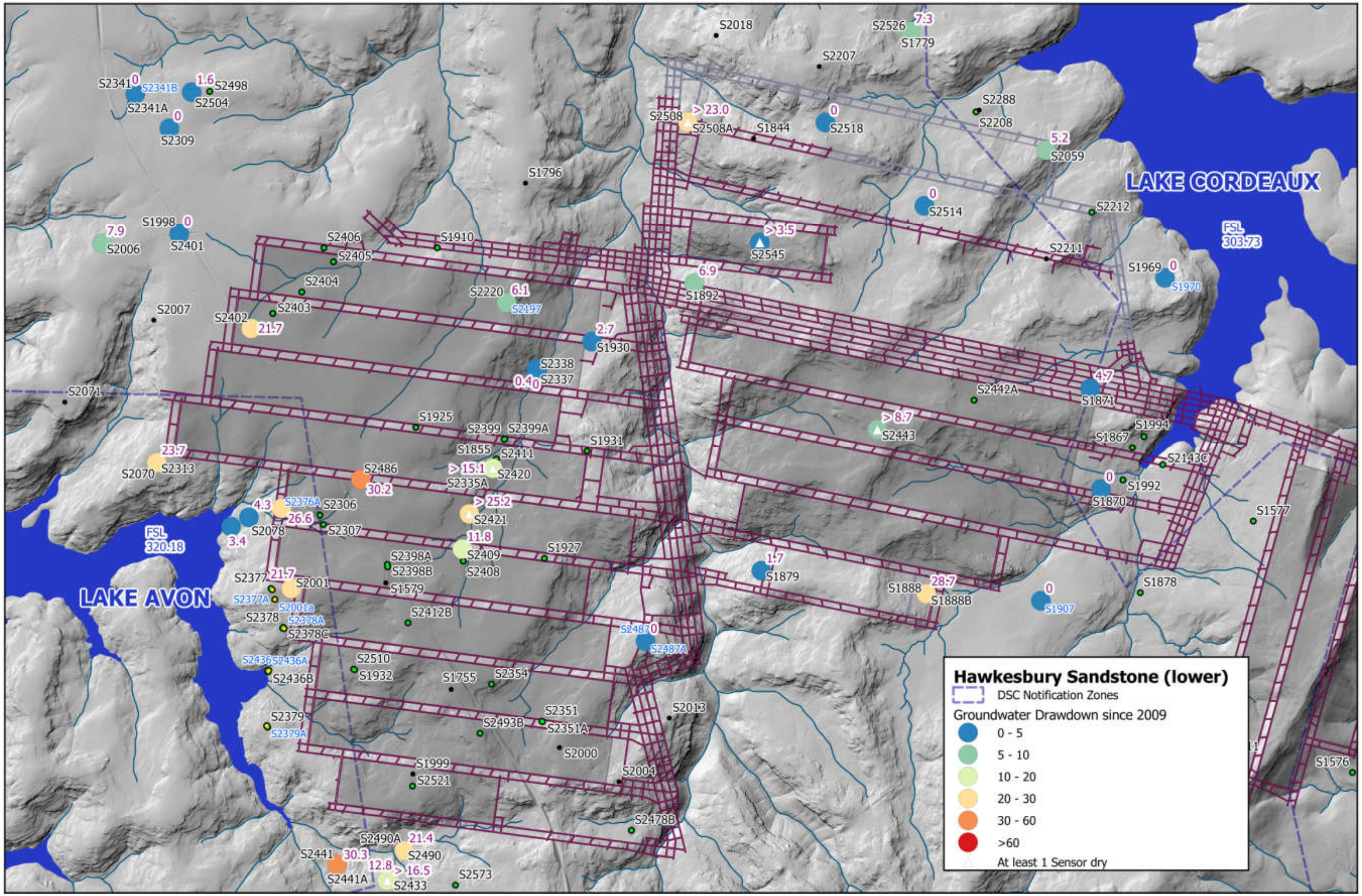

Figure 16. Drawdown in piezometric head in the lower Hawkesbury Sandstone (2009-2023)

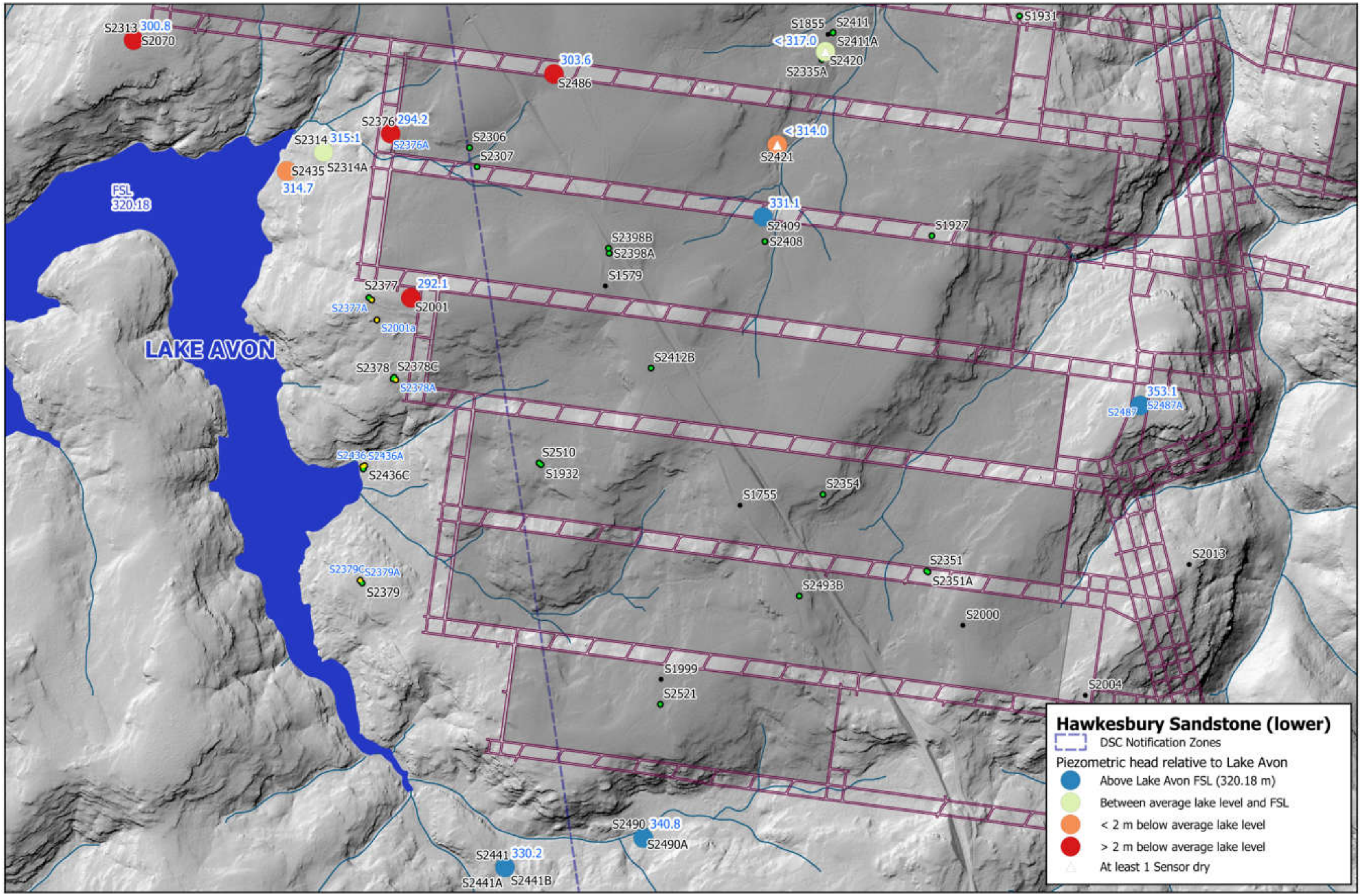

Figure 17. Piezometric head in the lower Hawkesbury Sandstone relative to Lake Avon (2023)

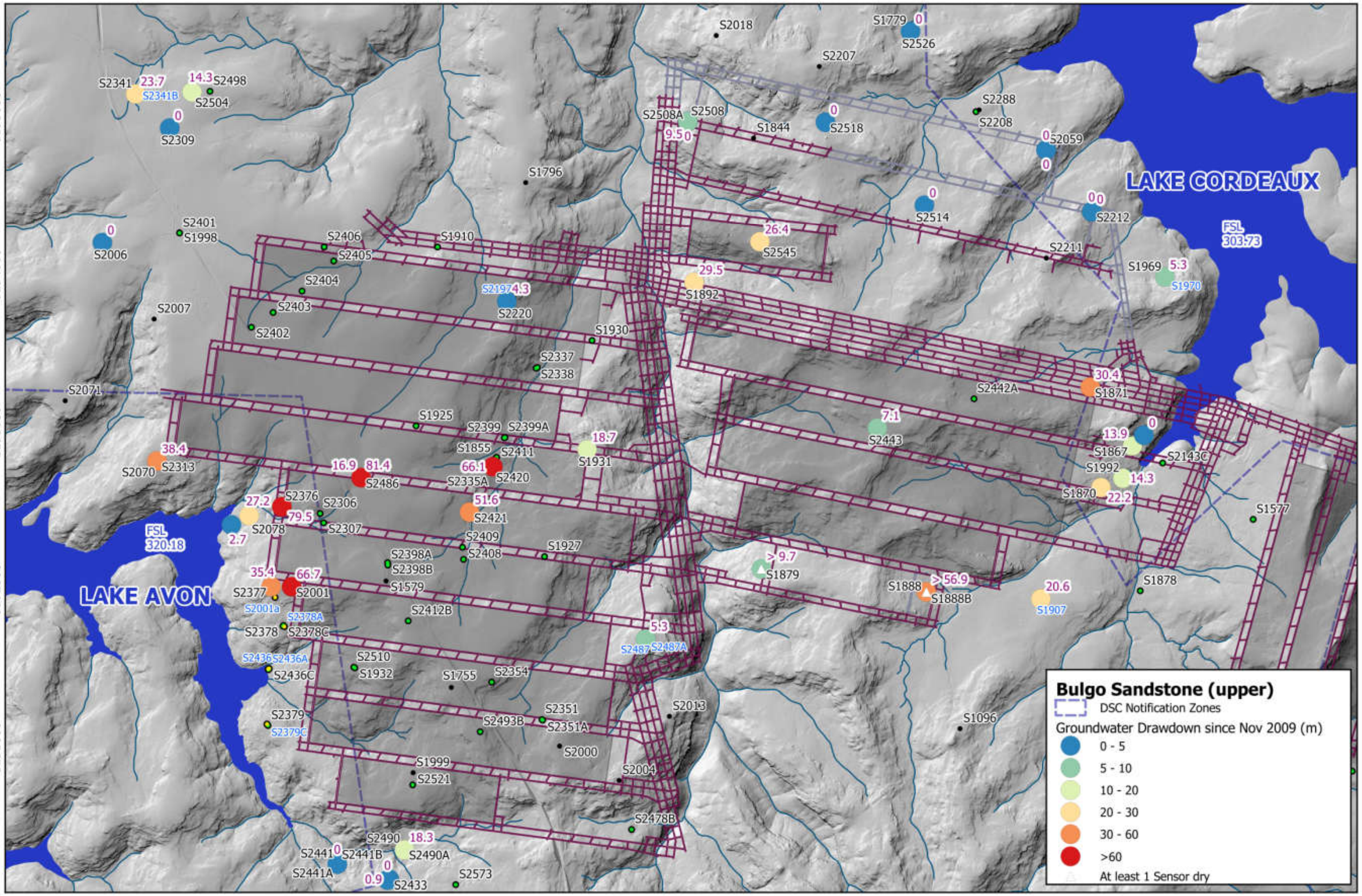

Figure 18. Drawdown in piezometric head in the upper Bulgo Sandstone (2009-2023)

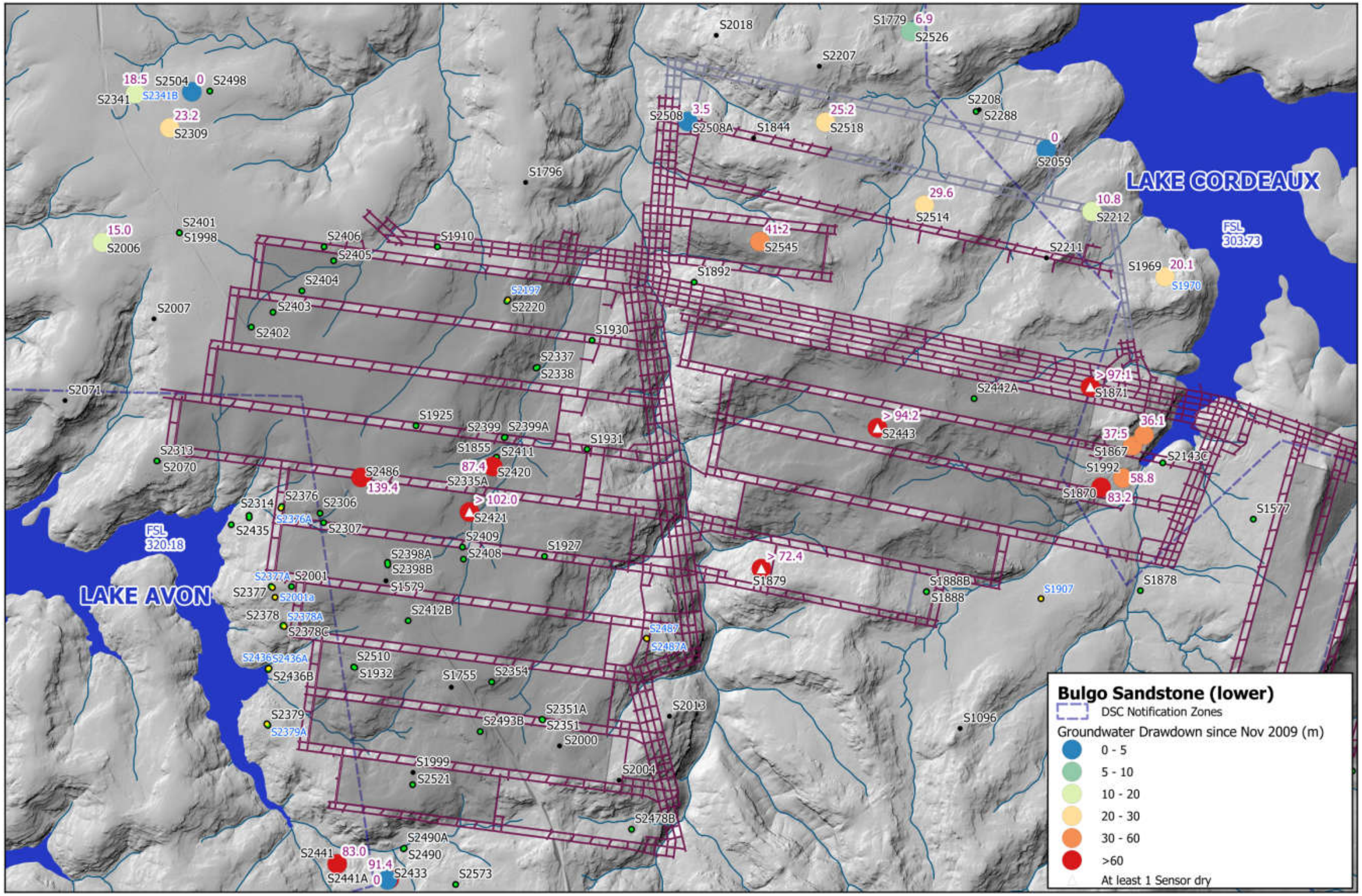

Figure 19. Drawdown in piezometric head in the lower Bulgo Sandstone (2009-2023)

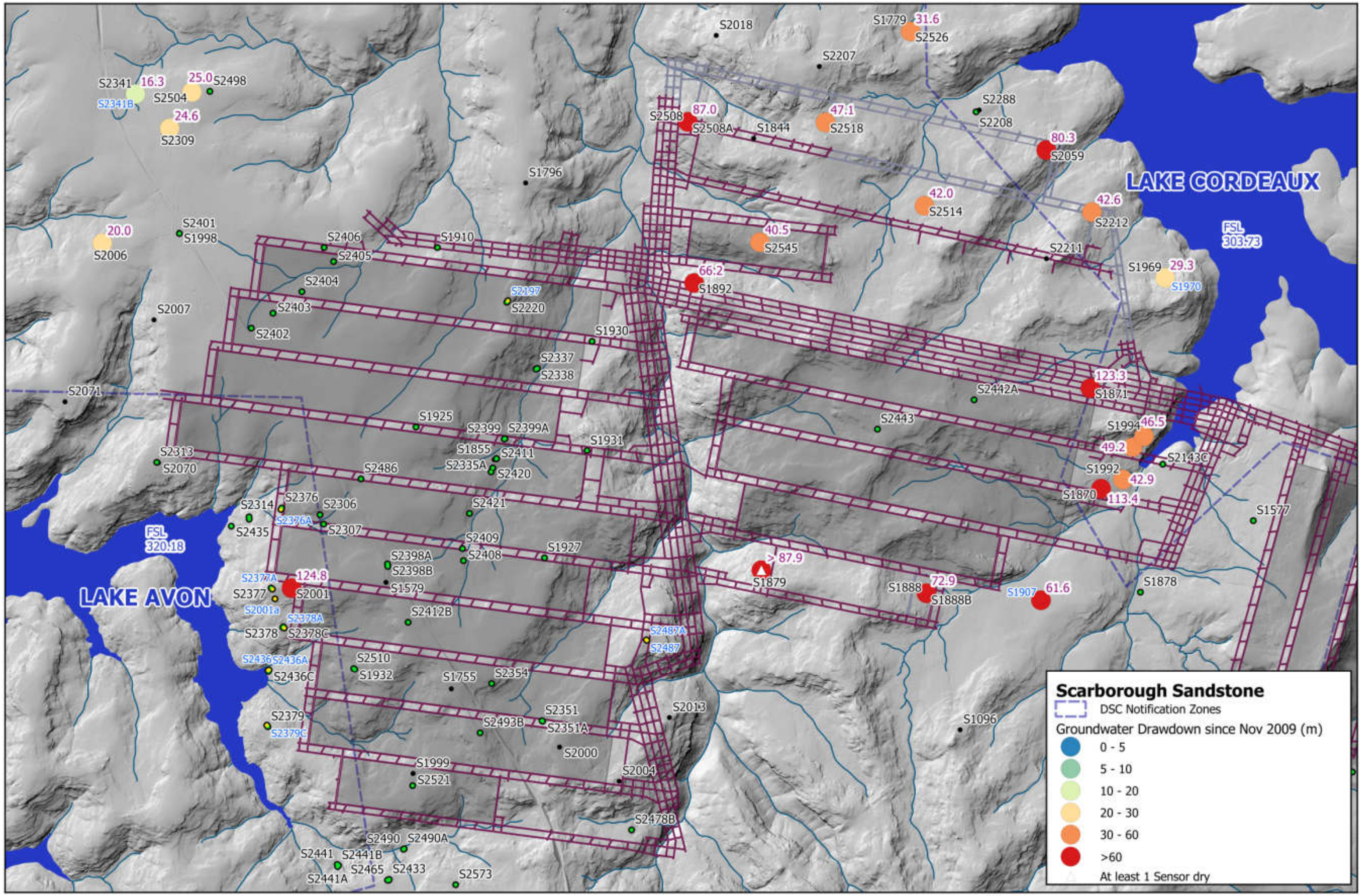

Figure 20. Drawdown in piezometric head in the Scarborough Sandstone (2009-2023)

3.4 Comparison with model predictions

3.4.1 Deep groundwater levels

In this section observed deep groundwater levels are compared with those predicted in the most recent groundwater impact model for Dendrobium Mine (Watershed HydroGeo, 2020). The comparison was carried out by extracting the predicted heads at representative sensors as of the end of Longwall 21 from the original model output files (provided to HGEO by Watershed Hydrogeo) and plotting those heads against the observed heads (as presented in Section 3.3). It is therefore an independent assessment of the ongoing accuracy of the groundwater model predictions.

Figure 21 is a plot of the modelled and observed heads as of the end of Longwall 21. The data are coloured according to the formation, and bores that are located adjacent to Lake Avon are highlighted with concentric circles (holes, S2313, S2314, S2376, S2377, S2378, S2379, S2435, S2436, and holes S2001, S2194). Data from an accurate and well-calibrated model should cluster along the diagonal 1:1 line. Points plotting below the line indicate that observed heads are higher than predicted (i.e., the model over-predicts drawdown and is conservative), while points that plot above the line indicate that the model under-predicts drawdown at those locations. Data for sensors with near-zero pressure head (< 2m) are plotted as hollow triangles.

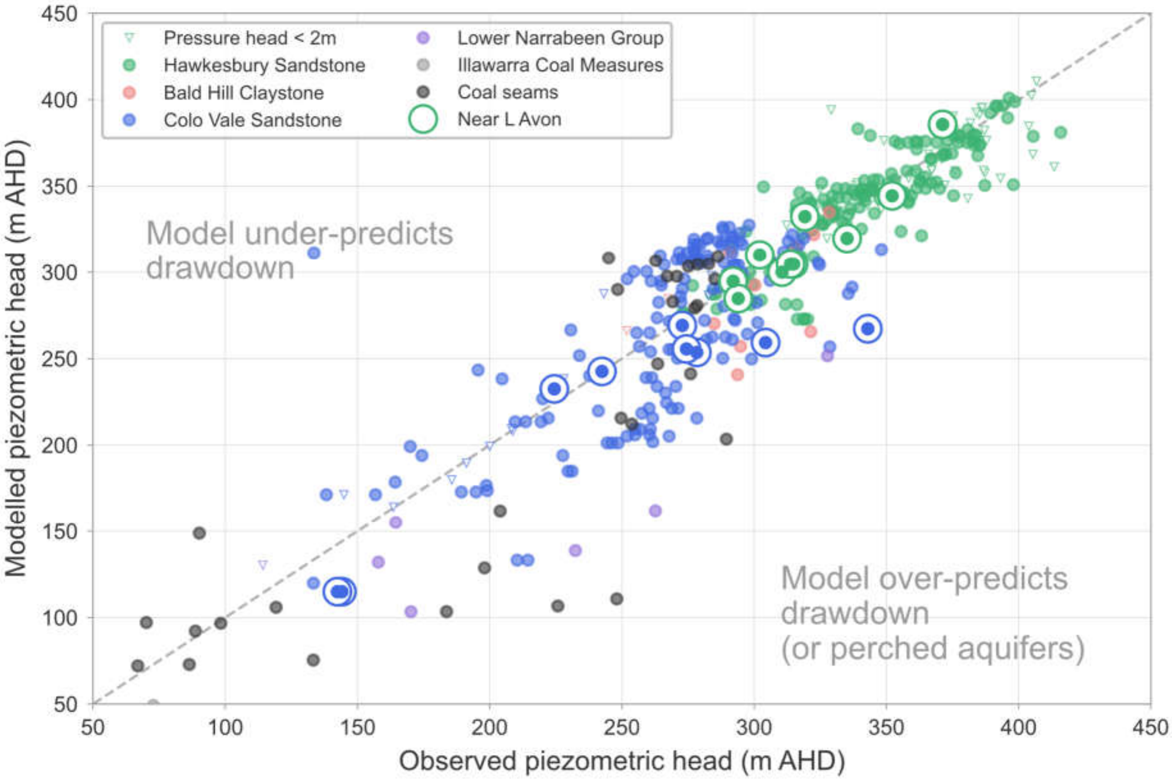

Figure 21. Observed versus model predicted heads at the end of Longwall 21

With reference to Figure 21:

- 50.4% of the observed-modelled piezometric head pairs plot below the 1:1 line and 49.6% are above the line, indicating that, on average, the model forecasts match observed drawdown well.
- Model predictions for piezometers in the HBSS plot close to the 1:1 line, particularly those in the range 280 to 350 m head, corresponding to the elevation range for watercourses in Area 3B.

- Model and observed heads for piezometers within the HBSS adjacent to Lake Avon plot close to the 1:1 line. Observed heads within this barrier zone are therefore generally in line with model predictions.

3.4.2 Mine water balance

Figure 22 is a plot of the modelled and observed groundwater inflow to the Dendrobium underground mine during the extraction of Longwalls 6 to 21. The numerical model is set up with stress periods corresponding to the originally planned longwall start and end dates and calibrated with groundwater monitoring and inflow data up to 2021. The plot shows that the model predictions match observed mine inflows closely over most of the timeseries and tends to slightly overestimate mine inflows from about 2018.

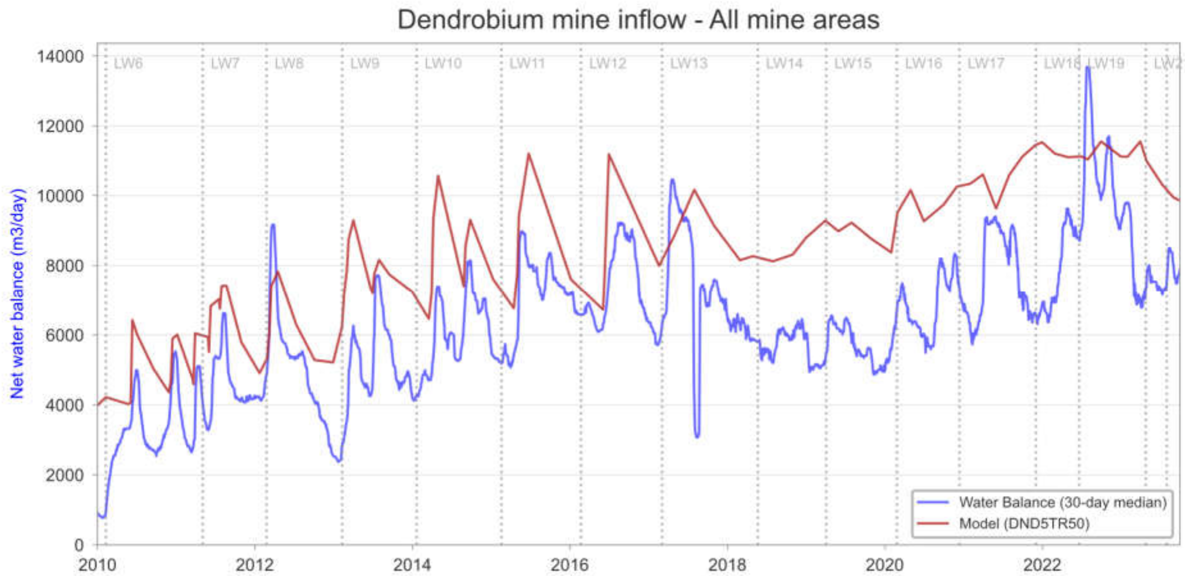

Figure 22. Observed versus model predicted mine groundwater inflow.

3.4.3 Seepage loss from Lake Avon

The actual rate of seepage loss from Lake Avon cannot be measured directly and can only be estimated by calculation (using for example, Darcy's Law) or by numerical modelling. All estimates rely on assumptions relating to the permeability and hydraulic head distribution within the sandstone barrier zone between the lake and the mine.

Forecast estimates of the net loss (seepage) from water storage reservoirs based on the regional groundwater model DND5TR55 (Watershed HydroGeo, 2020), as at the end of Longwall 21 are as follows:

- Lake Avon: **0.12 ML/day**
- Lake Cordeaux: **0.10 ML/day**

These estimates are within the tolerable loss limit of 1 ML/day prescribed by Dams Safety NSW (DSC, 2014).

3.5 Groundwater chemistry

Previous reviews have shown that there is no clear spatial pattern in the distribution of groundwater quality in HBSS and BGSS bores. Time series plots of groundwater salinity measured using electrical conductivity (EC) and pH for samples collected from monitoring bores are presented in Appendix C; the most recent results and trends are summarised in Table 2. Adverse trends are identified where recent samples define a consistent freshening trend (decreasing EC). Such trends in bores located adjacent to water storage reservoirs may indicate migration of fresh surface waters towards the mine. Despite efforts to avoid the use of drilling additives during the installation of sampling pumps, it is still common for samples collected in the first few months or years following installation to be tainted by bentonite, cement grout or other compounds. Influence from grout or bentonite typically manifests as high EC and anomalously high pH (>8.5 to 11), making it difficult to discern background groundwater trends (e.g., S1870_160m, S2436_90m).

Bore sampling pumps at which freshening trends are observed, or were observed in the previous review are as follows:

- S2314_30m: Declining EC noted in two consecutive samples although EC remains within the range of previous samples. No new samples reported during Longwall 21. As in the previous report, it is recommended the site is re-sampled in late 2023.
- S2001_63m: EC declined to below the previous range. A sample collected during Longwall 21 shows the trend has reversed.

Table 2. Summary of EC measurements at monitoring bores

Bore ID	Depth (m)	Unit	Samples	Last sample	EC (µS/cm)	pH	Comment / trends
S1870	10m	HBSS	5	21/07/2021	67	5.7	No adverse trends
S1870	16.5m	HBSS	5	21/07/2021	74	5.8	No adverse trends
S1879	10m	HBSS	2	15/10/2019	75	4.6	Insufficient data
S1879	58m	HBSS	2	15/10/2019	233	6.6	Insufficient data
S1888	7.3m	HBSS	4	**29/06/2023**	81	5.1	No adverse trends
S1888	10m	HBSS	1	16/10/2019	102	5.5	Insufficient data
S1907	10m	HBSS	2	**17/07/2023**	71	5.3	Insufficient data
S1907	23.5m	HBSS	2	**17/07/2023**	76	5.8	Insufficient data
S1934	55m	HBSS	13	12/09/2022	114	6.2	No adverse trends
S1970	43m	HBSS	15	21/04/2021	86	5.9	Sparse data since 2014
S2001	63m	HBSS	8	**05/09/2023**	151	6.4	Decreasing EC trend reversed
S2313	54m	HBSS	7	14/06/2022	80	5.2	No adverse trends
S2314	30m	HBSS	8	19/07/2021	121	6.0	Declining EC: no new data
S2314	75m	HBSS	15	**28/04/2023**	126	6.2	No adverse trends
S2361	70m	HBSS	3	01/07/2021	1830	6.9	Increasing EC
S2365	70m	HBSS	1	01/07/2021	292	6.9	Insufficient data
S2376	30m	HBSS	2	15/02/2022	506	7.3	Insufficient data
S2376	102m	HBSS	2	15/02/2022	147	6.6	Insufficient data
S2377	34m	HBSS	4	**05/09/2023**	93	4.5	No adverse trends
S2377	113m	HBSS	5	**05/09/2023**	91	5.1	No adverse trends
S2378	29m	HBSS	2	26/08/2022	97	6.0	Insufficient data
S2378	89m	HBSS	6	**05/09/2023**	129	6.3	No adverse trends
S2379	47m	HBSS	5	**10/05/2023**	82	5.2	No adverse trends
S1879	200m	BGSS	2	15/10/2019	639	8.7	Insufficient data
S1907	167m	BGSS	2	**17/07/2023**	899	11.3	Insufficient data
S1970	109m	BGSS	14	21/04/2021	309	9.0	Sparse data since 2014
S2313	138m	BGSS	7	14/06/2022	111	5.9	No adverse trends
S2313	194m	BGSS	7	14/06/2022	504	8.0	Initially high EC, no trend since
S2314	128m	BGSS	15	**28/04/2023**	348	7.5	Initially high EC, no trend since
S2341A	228m	BGSS	1	02/08/2018	1400	7.4	Insufficient data
S2376	169m	BGSS	2	15/02/2022	523	7.5	Insufficient data
S2379	128m	BGSS	5	**10/05/2023**	479	7.8	No adverse trends
S2436	35m	BGSS	10	**28/04/2023**	137	6.4	Sparse data since 2014
S2436	90m	BGSS	10	**28/04/2023**	476	7.8	Initially high EC, no trend since
S1870	160m	SBSS	5	21/07/2021	264	9.9	Declining EC: No new data
S1886	22m	SBSS	45	**11/07/2023**	478	7.4	No adverse trends
S1886	30m	SBSS	45	**11/07/2023**	476	7.4	No adverse trends
S1886	38m	SBSS	45	**11/07/2023**	554	7.7	No adverse trends

Note: * Grey shading = Results likely affected by bentonite pack near pump intake; Orange shading = declining EC trend. Dates in **BOLD** indicate new analyses since the last longwall end of panel report.

4. CONCLUSION

The following conclusions are made with respect to the assessment of groundwater conditions following the completion of Longwall 21:

- The mean total mine inflow during Longwall 21 extraction was 7.3 ML/day which represents a 26% decrease compared with the previous longwall (19) and brings the mean inflow back to a similar level the average observed during Longwalls 17 and 18. The net mine water balance is dominated by pumping from Area 3B (91 % of total), with Area 3C (where Longwall 21 is located) representing only 10.6 % of inflows. No anomalous inflow due to intersecting water-bearing structures such as faults or dykes was reported during the extraction of Longwall 21.

- Analysis of the underground mine water balance indicates that the component of mine inflow related to rainfall induced peaks has averaged ~20% since 2016 and was approximately 7% during Longwall 21. Analysis of the tritium in mine inflow water indicates that the contribution of modern water varies between mine areas and averages approximately 16% for the whole mine.

- Groundwater salinity (as indicated by electrical conductivity – EC) shows a general increase with depth below the surface. A declining trend in EC was previously reported in two monitoring bores (S2314_30m and S2001_63m). The trend at S2001 has reversed. Resampling of S2314_30m should be carried out in late 2023 and reviewed in the next EOP report.

- Mining of Longwall 21 resulted in continued depressurisation of the target coal seam and overlying strata in line with numerical model predictions. Importantly, for piezometers adjacent to Lake Avon, observed head is similar to the numerical model prediction. Therefore, the model predictions are generally accurate as of Longwall 21.

- Piezometers installed after longwall extraction indicate significant depressurisation throughout all strata and throughout the Hawkesbury Sandstone (HBSS) in most holes. Holes drilled above extracted longwalls provide evidence for groundwater perching and recovery in the years following mining. Drawdown in the HBSS reduces with distance and is typically negligible at distances greater than 1.2 km from the goaf footprint.

- Although within prediction, piezometers installed along the barrier zone between Lake Avon and Area 3B indicate hydraulic gradients away from the lake within the zone of mining influence. Numerical model forecasts indicate seepage losses of ~ 0.12 ML/day from Lake Avon and ~0.10 ML/day from Lake Cordeaux at the end of Longwall 21. The estimates are within the tolerable loss limit of 1 ML/day prescribed by Dams Safety NSW.

4.1 Recommendations

- At the time of reporting, recent data for some of the monitoring bores adjacent to lake Avon were not available. Those bores are S2377, S2378, S2379, and S2436. It is recommended that dataloggers from those bores are downloaded prior to the next EOP review.

- It is recommended that the procedure for assessment of groundwater drawdown be revised to improve clarity for future End of Panel assessments. It is recommended that: 1) Groundwater observations and drawdown calculations for each sensor are tabulated, and 2) Plots of pressure head versus height above the seam for all VWP sensors located above extracted longwalls should be included in future reports, as described in Section 2.3.1.

- The groundwater sampling pump at S2314_30m should be resampled in late 2023

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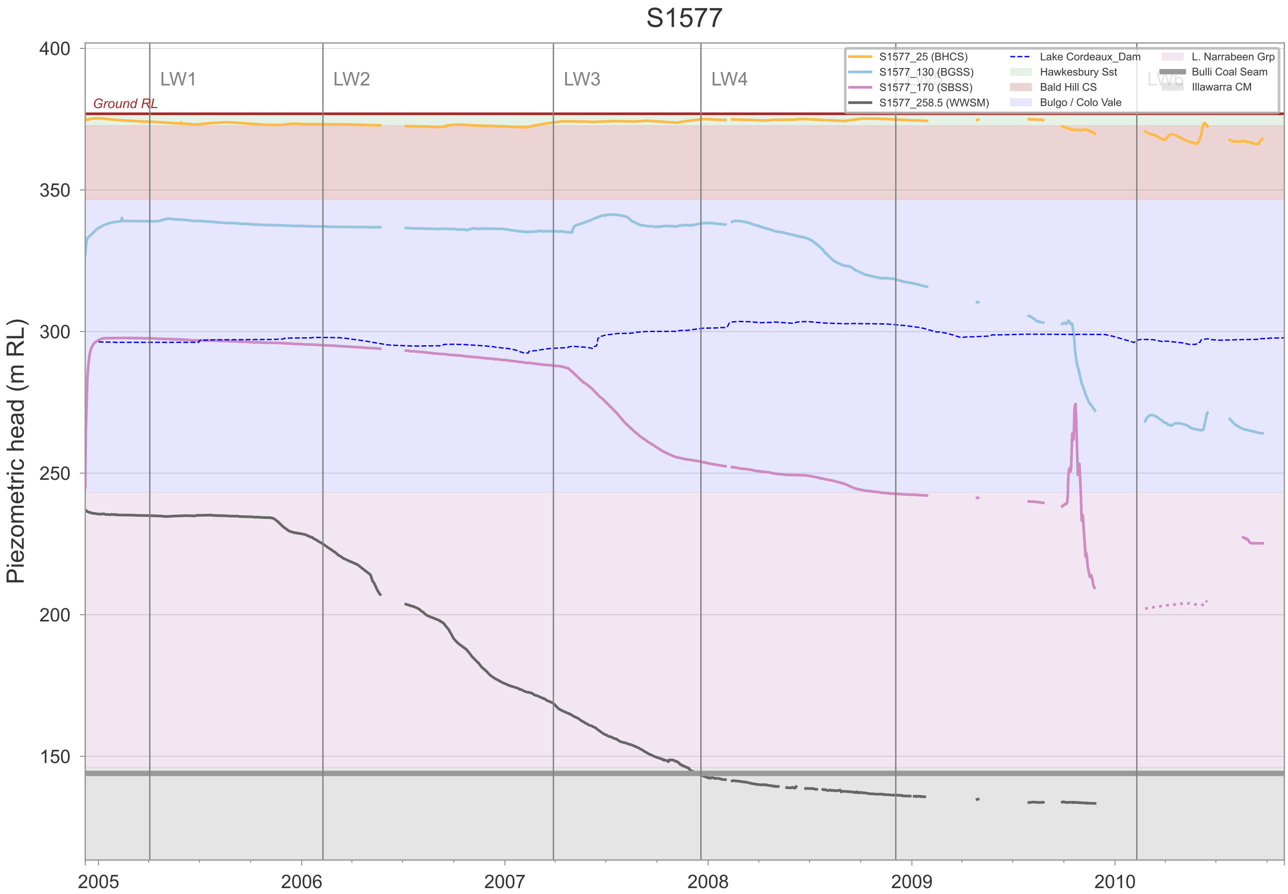
APPENDIX A: List of monitoring bores

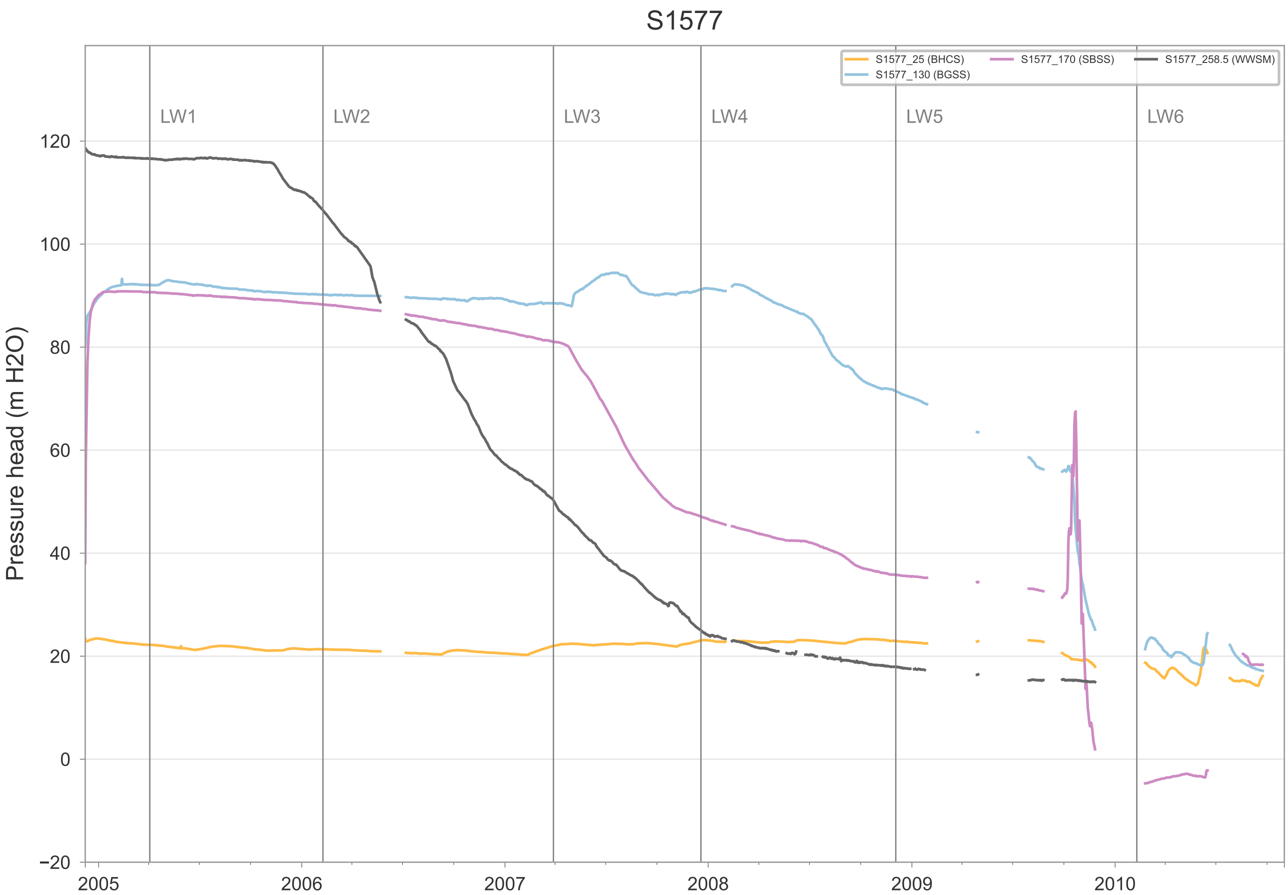
Bore ID	Alt_Name	MGA_mE	MGA_mN	Col_RL	Mine_Area	Sensors	First_record	Last_record	Years	%with_data
S1577	Dendrobium DDH 38	294558.0	6192446.6	376.9	Den 2	4	8/12/2004	23/09/2010	5.8	81.3
S1647B	Dendrobium 45 A to C	297312.3	6191093.7	360.1	Den 1	7	21/07/2005	21/02/2011	5.6	83.6
S1709	DC Elouera DDH 8	290186.4	6189934.4	434.3	Den Other	8	1/03/2005	6/09/2023	18.5	85.4
S1710	DC Elouera DDH 9	290258.0	6189645.7	432.5	Den Other	4	20/05/2005	6/09/2023	18.3	90.4
S1719	DC Dendrobium DDH 56	291202.0	6193277.0	413.6	Den 3A	1	16/06/2005	18/02/2010	4.7	91.9
S1739	DC Dendrobium DDH 62	289683.6	6191798.7	423.7	Den 3B	1	3/09/2005	19/01/2019	13.4	71.4
S1755	DC Dendrobium DDH64	289475.4	6191380.2	433.3	Den 3B	2	11/01/2006	24/04/2020	14.3	73.8
S1758	Dendrobium DDH 65	288586.6	6193106.9	408.8	Den 3B	2	27/01/2006	10/06/2014	8.4	72.1
S1796	Dendrobium DDH 69	289946.6	6194587.4	398.6	Den 3B	1	6/04/2006	20/03/2023	17	61.6
S1800	Dendrobium DDH 70	289933.4	6193996.5	392.5	Den 3B	2	26/04/2006	31/08/2011	5.3	90.4
S1844	Dendrobium DDH 76	291391.1	6194868.8	375.6	Den 3C	2	23/08/2006	1/07/2023	16.9	71.4
S1845	Dendrobium DDH 77	291464.0	6193770.0	399.7	Den 3A	2	29/11/2006	4/01/2010	3.1	90.6
S1848	Dendrobium DDH 79	295620.7	6191166.3	315.5	Den 2	6	6/09/2006	27/07/2023	16.9	100
S1855	Dendrobium DDH 82	289746.5	6192833.2	366.6	Den 3B	2	12/12/2006	27/07/2016	9.6	88.8
S1867	ED Dendrobium DDH 84	293792.6	6192912.5	346.0	Den 3A	11	21/03/2007	19/07/2023	16.3	94.3
S1870	ED Dendrobium DDH 85	293593.2	6192648.2	351.5	Den 3A	12	3/02/2007	31/08/2023	16.6	88
S1871	ED Dendrobium DDH 86	293525.0	6193287.1	375.6	Den 3A	12	18/02/2007	31/08/2023	16.5	92
S1878	ED Dendrobium DDH 91	293842.3	6191994.3	337.1	Den 3A	11	25/04/2007	7/02/2020	12.8	95.2
S1879	ED Dendrobium DDH 92	291440.3	6192133.4	379.7	Den 3A	12	8/06/2007	31/08/2023	16.2	83.3
S1885	ED Dendrobium DDH 93	291504.4	6192667.9	420.0	Den 3A	12	8/06/2007	17/05/2012	4.9	91
S1886	ED Dendrobium PDH 94	295883.8	6191719.6	307.5	Den 2	1	23/03/2007	11/07/2023	16.3	90.2
S1888	ED Dendrobium DDH 96	292486.5	6191987.4	381.3	Den 3A	8	1/06/2007	31/08/2023	16.3	75
S1889	ED Dendrobium DDH 97	292244.8	6192980.4	435.4	Den 3A	8	3/06/2007	10/08/2011	4.2	92
S1890	ED Dendrobium DDH 98	292637.3	6192490.5	407.1	Den 3A	8	1/08/2007	7/08/2012	5	100
S1892	ED Dendrobium DDH 99	291014.1	6193952.0	356.1	Den 3A	8	8/08/2008	28/06/2023	14.9	71.6
S1902	ED Dendrobium DDH 100	295241.3	6190779.8	343.1	Den 2	4	4/10/2007	27/07/2023	15.8	88
S1907	ED Dendrobium DDH 103	293212.2	6191943.1	371.9	Den 3A	8	26/01/2008	31/08/2023	15.6	89.3
S1908	ED Dendrobium DDH 104	288925.9	6193601.4	405.7	Den 3B	8	17/05/2008	1/05/2014	6	79.6
S1910	EDEN105	289387.4	6194176.3	377.2	Den 3B	8	30/08/2008	5/03/2019	10.5	76.5
S1911	EDEN106	288802.8	6192549.4	405.2	Den 3B	12	16/05/2008	24/05/2017	9	96.7
S1914	EDEN107	289370.0	6192511.9	414.5	Den 3B	7	30/04/2008	10/08/2017	9.3	79.4
S1925	ED Dendrobium DDH 108	289251.6	6193041.1	416.7	Den 3B	8	5/08/2008	15/05/2023	14.8	89.1
S1926	ED Dendrobium DDH 109	289660.4	6193444.9	409.0	Den 3B	8	28/08/2008	8/08/2014	5.9	96.3
S1927	ED Dendrobium DDH 110	290066.0	6192211.0	414.8	Den 3B	8	17/05/2008	23/01/2017	8.7	88.9
S1929	ED Dendrobium DDH 111	290010.6	6193398.1	337.7	Den 3B	8	28/08/2008	8/08/2014	5.9	97
S1930	ED Dendrobium DDH 112	290367.3	6193582.9	353.1	Den 3B	12	17/06/2008	16/05/2023	14.9	85.5
S1931	ED Dendrobium DDH 113	290335.6	6192889.9	396.4	Den 3B	9	12/08/2008	27/07/2023	15	80
S1932	ED Dendrobium DDH 114	288863.3	6191505.4	396.1	Den 3B	11	1/09/2008	10/03/2020	11.5	89.8
S1934	ED Dendrobium DDH 115	292128.0	6192398.0	427.5	Den 3A	4	31/07/2009	20/11/2022	13.3	91.5
S1969	EDEN118	293998.1	6193985.7	368.5	Den 3C	11	24/09/2009	31/08/2023	13.9	66.5
S1992	EDEN119	293732.1	6192706.8	339.1	Den 3A	8	11/05/2009	31/08/2023	14.3	95.2
S1994	EDEN120	293865.2	6192982.4	345.5	Den 3A	8	14/01/2009	26/06/2023	14.4	68.9
S1995	EDEN121	288212.4	6193662.3	404.5	Den 3B	2	12/06/2009	28/01/2014	4.6	65.6
S1998	EDEN122	287750.6	6194273.1	410.5	Den 3B	2	12/06/2009	15/01/2020	10.6	63.5
S1999	EDEN123	289232.8	6190843.7	406.4	Den 3B	2	11/07/2009	20/04/2021	11.8	83.9
S2000	EDEN124	290161.4	6191011.2	442.0	Den 3B	2	11/07/2009	9/06/2021	11.9	74.4
S2001	EDEN125	288462.6	6192020.0	413.9	Den 3B	10	7/08/2009	1/09/2023	14.1	96.7
S2002	EDEN126	288633.4	6194222.1	400.0	Den 3B	2	21/07/2009	19/02/2012	2.6	85.3
S2003	EDEN127	290571.1	6192478.0	409.4	Den 3B	2	4/08/2009	1/03/2014	4.6	10.8
S2004	EDEN128	290538.5	6190794.8	443.5	Den 3B	2	16/11/2011	22/07/2021	9.7	69.6
S2006	EDEN129	287263.2	6194204.3	409.1	Den 3B	10	25/07/2009	31/08/2023	14.1	76.2
S2007	EDEN130	287590.8	6193718.9	405.8	Den 3B	2	18/06/2009	17/08/2022	13.2	69.5
S2009	EDEN131	287828.2	6193092.0	402.5	Den 3B	10	10/08/2009	24/03/2016	6.6	24.1
S2013	EDEN134	290857.7	6191198.2	399.7	Den 3B	2	22/07/2009	16/08/2022	13.1	69.4
S2059	EDEN148	293245.7	6194795.1	380.8	Den 3C	11	17/08/2011	31/08/2023	12	65.3
S2070	EDEN150	287619.3	6192813.2	414.7	Den 3B	2	16/05/2013	30/05/2023	10	81.8
S2078	EDEN154	288190.0	6192451.9	342.0	Den 3B	2	21/06/2010	13/03/2017	6.7	96.7
S2192	S2192	289826.7	6193848.7	389.3	Den 3B	6	25/03/2013	18/11/2014	1.7	34.8
S2194	S2194	288514.9	6190978.8	371.1	Den 3B	11	14/04/2013	1/04/2018	5	98.8
S2208	S2208	292801.1	6195037.3	344.0	Den 3C	8	20/12/2014	31/10/2020	5.9	99.8
S2211	S2211	293247.0	6194106.0	397.7	Den 3C	2	3/10/2013	1/09/2023	9.9	94.7
S2212	S2212	293534.8	6194402.9	369.2	Den 3C	10	12/10/2013	31/08/2023	9.9	98.7
S2220	S2220 (AQ5)	289827.2	6193830.7	388.1	Den 3B	3	13/11/2014	31/08/2023	8.8	99.9
S2303	Dend S2303	287109.8	6196268.1	411.7	Den 3B	7	14/02/2016	31/08/2023	7.5	88.2
S2306	Swamp Bore 3 (adjacent)	288643.3	6192483.7	395.5	Den 3B	4	17/09/2015	19/06/2022	6.8	95.1
S2307	Swamp Bore 4	288665.9	6192424.6	394.5	Den 3B	4	16/09/2015	19/06/2022	6.8	95.6
S2309	Dendrobium S2309_R	287689.9	6194933.2	412.0	Den 3D	10	16/07/2015	31/08/2023	8.1	97.6

Bore ID	Alt_Name	MGA_mE	MGA_mN	Col_RL	Mine_Area	Sensors	First_record	Last_record	Years	%with_data
S2312	Dendrobium S2312	284450.1	6196150.7	409.4	Den 3D	10	13/08/2015	31/08/2023	8.1	83.8
S2313	Avon 1	287609.0	6192815.5	415.3	Den 3B	3	1/11/2015	31/08/2023	7.8	94.1
S2314	Avon 2	288193.5	6192470.3	342.4	Den 3B	3	14/11/2015	1/07/2023	7.6	95
S2321	Dend S2321	284710.0	6195575.5	411.0	Den 3D	2	13/08/2016	31/08/2023	7	98.7
S2325	Dend S2325	283596.2	6195466.7	433.5	Den 3D	8	6/09/2016	31/08/2023	7	96.6
S2333	Dend s2333 (D-A3C-14-12)	290697.1	6197087.4	310.9	Den 3C	10	9/10/2016	31/07/2023	6.8	96.5
S2335	WC21Project Hole1Site 2	289725.4	6192748.7	372.6	Den 3B	5	19/10/2016	12/11/2016	0.1	96
S2335A	WC21Project Hole1Site 2	289727.0	6192755.0	370.1	Den 3B	6	5/09/2017	31/08/2023	6	98
S2336	WC21Hole2,Site2	289721.9	6192758.1	372.4	Den 3B	2	21/10/2016	20/07/2017	0.7	81.3
S2337	WC21Project Hole1Site 5	290021.0	6193411.9	336.1	Den 3B	3	25/11/2016	23/05/2023	6.5	94.3
S2338	WC21Hole2,Site5	290012.2	6193406.7	336.1	Den 3B	3	25/11/2016	23/05/2023	6.5	94.3
S2340	D-A5-25	285468.1	6197978.9	396.9	Den 3D	9	8/12/2016	31/08/2023	6.7	90.4
S2341	D-A5-28	287473.5	6195149.8	401.6	Den 3D	10	8/12/2016	31/08/2023	6.7	99.9
S2341A	D-A5-28A	287489.0	6195138.2	402.6	Den 3C	4	22/12/2016	31/08/2023	6.7	96.6
S2342	D-A5-12	287953.2	6196755.8	403.2	Den 3D	10	24/12/2016	31/08/2023	6.7	98.6
S2345	D-A5-19	285356.8	6196094.9	402.0	Den 3D	12	30/04/2017	2/08/2023	6.3	94.9
S2348	D-A5-17	286450.5	6196461.9	396.3	Den 3D	13	12/08/2017	31/08/2023	6.1	73.1
S2351	S14-04	290049.6	6191178.2	402.8	Den 3B	2	1/09/2017	23/05/2023	5.7	79.1
S2352	D-A5-6	286264.6	6195393.3	408.8	Den 3C	10	27/04/2017	31/08/2023	6.3	71.7
S2354	S14_05	289730.9	6191413.7	424.6	Den 3B	1	6/09/2017	31/08/2023	6	95.7
S2355	A5_S85_DBH	288136.2	6194877.8	396.6	Den 3C	5	5/08/2017	8/09/2023	6.1	100
S2357	A5-S100_DBH	286809.6	6196991.8	394.0	Den 3C	4	29/07/2017	8/09/2023	6.1	71.7
S2359	D-A5-5	285354.6	6195547.7	403.6	Den 3C	10	12/08/2017	31/08/2023	6.1	69.5
S2361	A5_S109_DBH	286277.9	6195810.7	402.4	Den 3C	4	24/06/2017	11/09/2023	6.2	78.2
S2362	A5_S110_DBH	285772.9	6195823.0	399.9	Den 3C	4	24/06/2017	28/12/2022	5.5	88.4
S2364	A5_S103_DBH	285982.8	6196782.1	395.0	Den 3C	4	14/11/2017	18/06/2021	3.6	68.4
S2365	A5_101/102_DBH	286042.3	6196448.9	399.2	Den 3C	5	5/09/2017	10/09/2023	6	83.6
S2366	A6_S113_DBH	291865.1	6200199.1	358.6	Den 3D	4	23/05/2018	16/07/2021	3.2	100
S2367	A6_S117_DBH	291630.7	6199726.5	356.1	Den 3D	4	23/05/2018	16/07/2021	3.2	100
S2370	D-A5-2	285554.8	6196642.7	375.6	Den 3C	10	13/05/2018	25/06/2021	3.1	70.7
S2371	A6_S116_DBH	291977.5	6199135.2	351.2	Den 3C	4	23/05/2018	16/07/2021	3.2	100
S2372	A6_S115_DBH	291576.9	6198891.4	373.5	Den 3C	4	23/05/2018	16/07/2021	3.2	100
S2373	A6_S112_DBH	292043.2	6200899.2	359.0	Den 3C	4	7/10/2017	16/07/2021	3.8	100
S2374	A6_S83_DBH	291114.8	6201461.1	324.4	Den 3C	4	24/05/2018	16/07/2021	3.1	100
S2376	Avon 6	288400.4	6192527.0	367.8	Den 3B	3	6/10/2017	11/09/2023	5.9	88.7
S2377	Avon 3	288333.4	6192020.4	408.2	Den 3B	3	2/06/2018	1/09/2023	5.3	98.4
S2378	Avon 4	288407.4	6191770.9	379.3	Den 3B	4	15/11/2017	9/11/2022	5	55.7
S2379	Avon 5	288312.9	6191140.5	356.6	Den 3B	4	17/07/2018	21/04/2023	4.8	40.3
S2398	LW14_1	289073.2	6192164.3	420.2	Den 3B	8	11/05/2018	15/08/2018	0.3	100
S2398B	LW14-1 post extraction Redrill	289070.9	6192172.6	418.0	Den 3B	8	8/03/2019	31/07/2021	2.4	99.2
S2399	LW12_1	289810.5	6192965.1	355.1	Den 3B	8	4/05/2018	9/08/2022	4.3	68.6
S2401	Den01b_R1	287752.2	6194264.9	411.1	Den 3B	6	17/11/2018	10/09/2023	4.8	85.1
S2402	Den01b_R2	288207.8	6193666.6	403.4	Den 3B	6	7/07/2018	10/09/2023	5.2	84.7
S2403	Den01b_R3	288345.1	6193761.1	400.7	Den 3B	6	17/11/2018	11/09/2023	4.8	86.7
S2404	Den01b_R4	288528.6	6193896.8	396.2	Den 3B	6	23/11/2018	11/09/2023	4.8	86.7
S2405	Den01b_R5	288729.5	6194087.6	386.1	Den 3B	6	18/11/2018	11/09/2023	4.8	86.8
S2406	Den01b_R6	288669.1	6194176.5	396.6	Den 3B	6	18/11/2018	1/08/2022	3.7	82.9
S2408	GW14-2	289552.1	6192193.4	398.1	Den 3B	7	4/10/2018	13/07/2023	4.8	87.2
S2409	GW14-3	289546.1	6192269.7	394.6	Den 3B	6	4/10/2018	31/08/2023	4.9	94.6
S2411	LW12_2	289761.1	6192837.7	364.0	Den 3B	8	6/07/2018	21/03/2023	4.7	99.5
S2412	LW15-1	289201.1	6191807.4	427.3	Den 3B	8	13/05/2018	17/06/2019	1.1	97
S2412B	GW15-1	289201.6	6191803.7	425.2	Den 3B	8	19/12/2019	31/08/2023	3.7	94.7
S2420	LW12-3	289738.4	6192780.0	367.8	Den 3B	8	3/10/2018	31/08/2023	4.9	91.2
S2421	LW13-1	289590.4	6192492.2	381.8	Den 3B	8	9/02/2019	31/08/2023	4.6	85.8
S2433	Elouera 2-1	289082.0	6190172.9	375.7	Den 3B	10	19/12/2021	31/08/2023	1.7	95.5
S2435	AD7	288080.8	6192411.6	328.2	Den 3B	3	21/11/2018	31/08/2023	4.8	92.4
S2436	AD8	288313.8	6191499.7	320.3	Den 3B	5	4/12/2018	15/01/2023	4.1	87.2
S2438		287944.9	6197535.1	399.3	Den 3C	9	24/11/2018	31/08/2023	4.8	98.3
S2441	Elouera1-1	288752.5	6190268.4	347.6	Den 3B	9	18/12/2021	30/05/2023	1.4	94.7
S2441B	Elouera1-3	288760.7	6190260.9	348.4	Den 3B	10	24/10/2021	26/08/2023	1.8	99.9

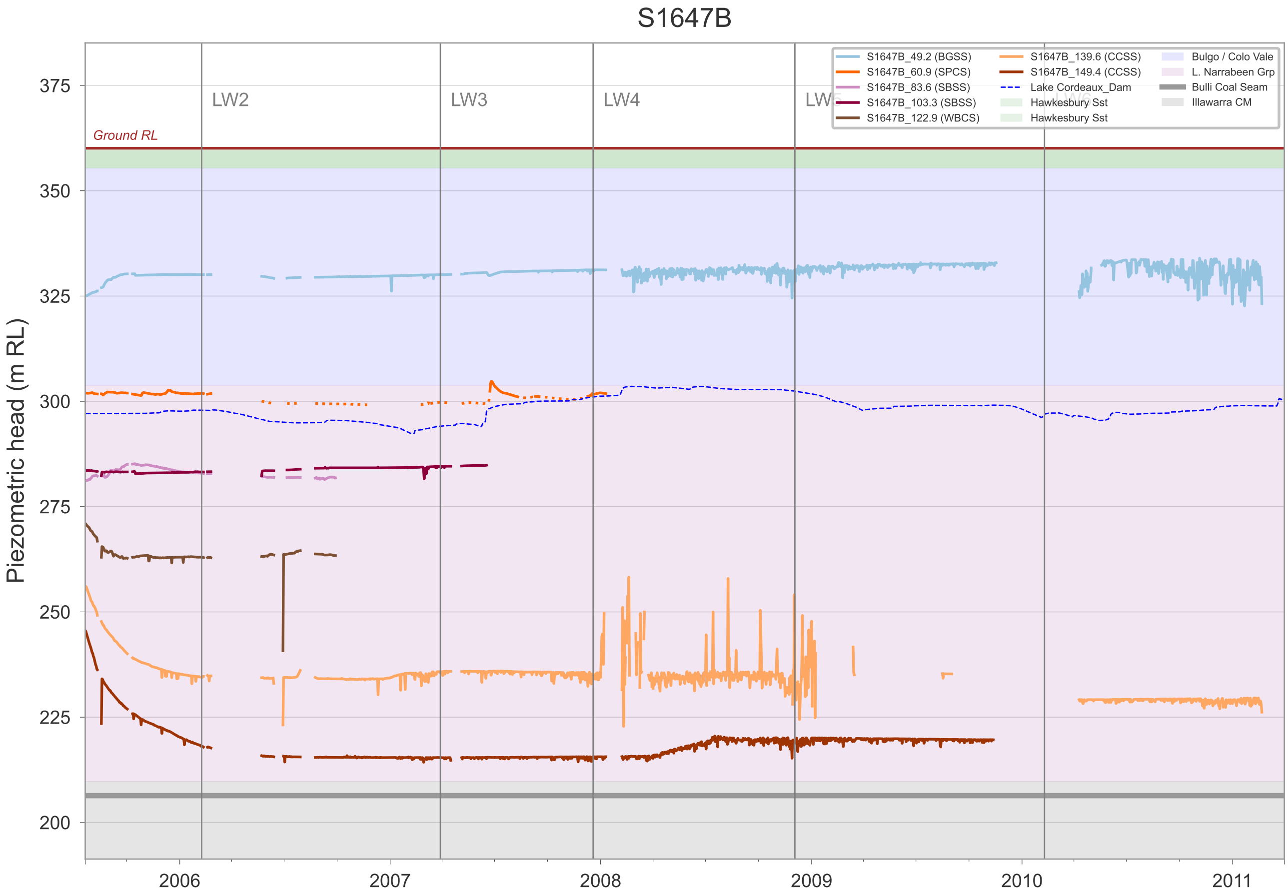
APPENDIX B: Groundwater hydrographs

Groundwater hydrographs

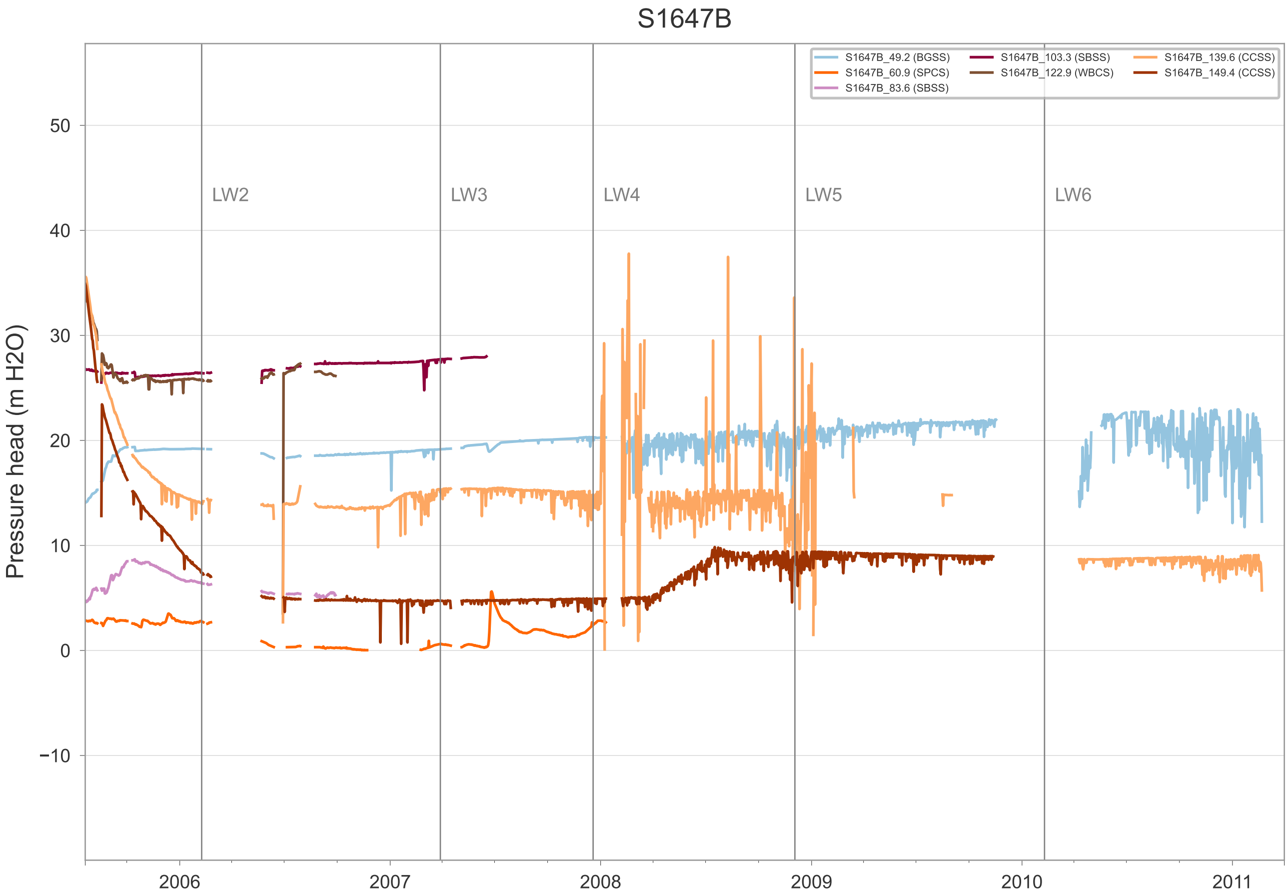


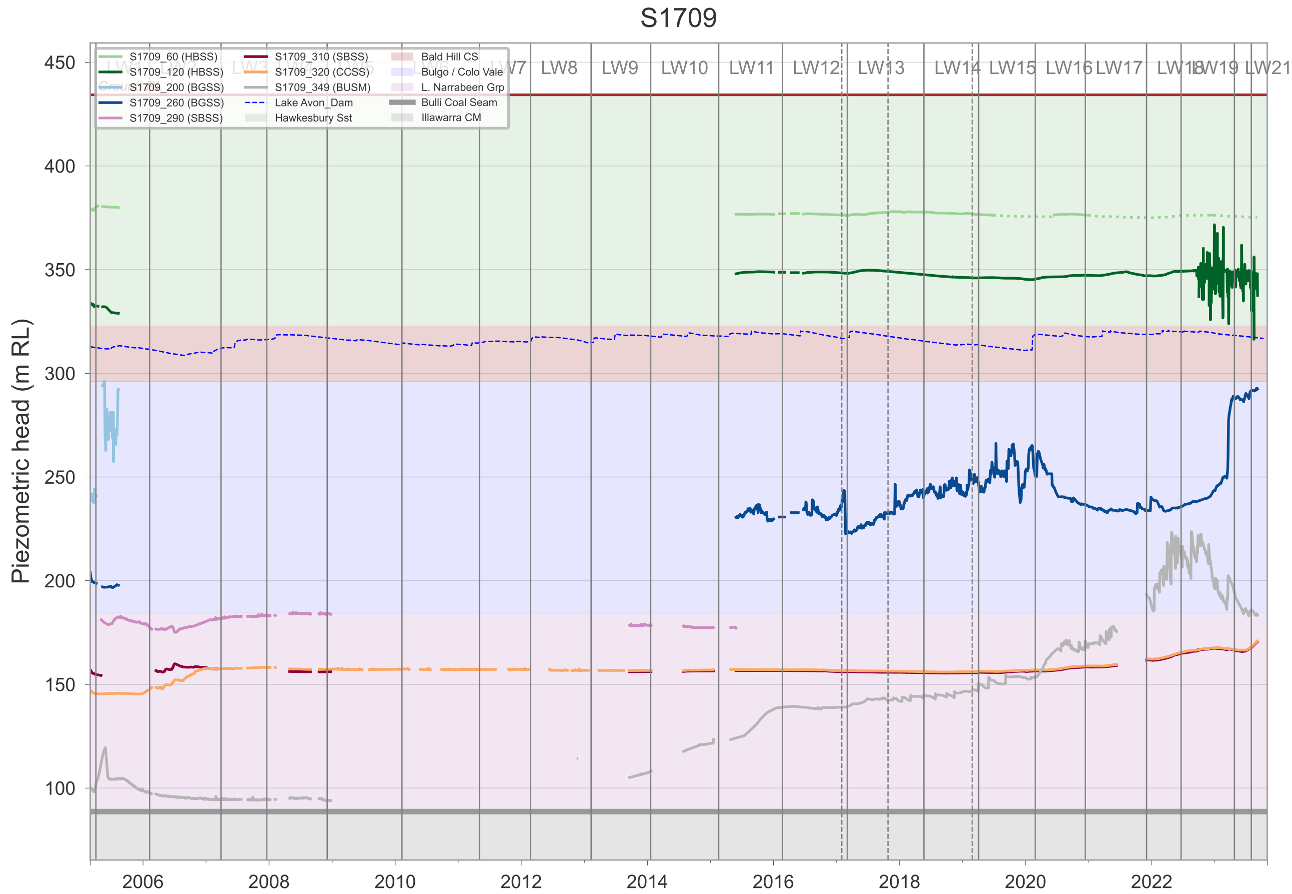


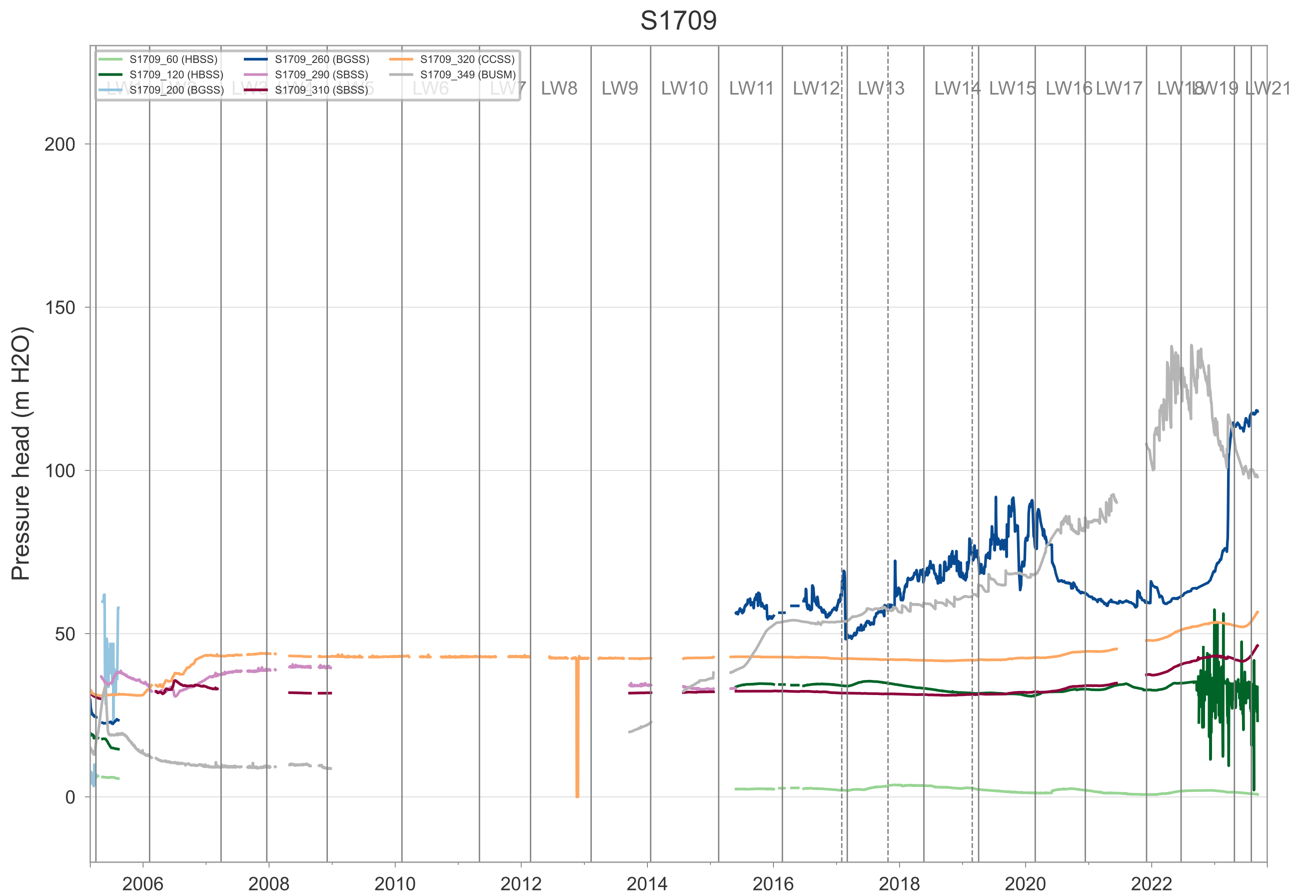
S1647B



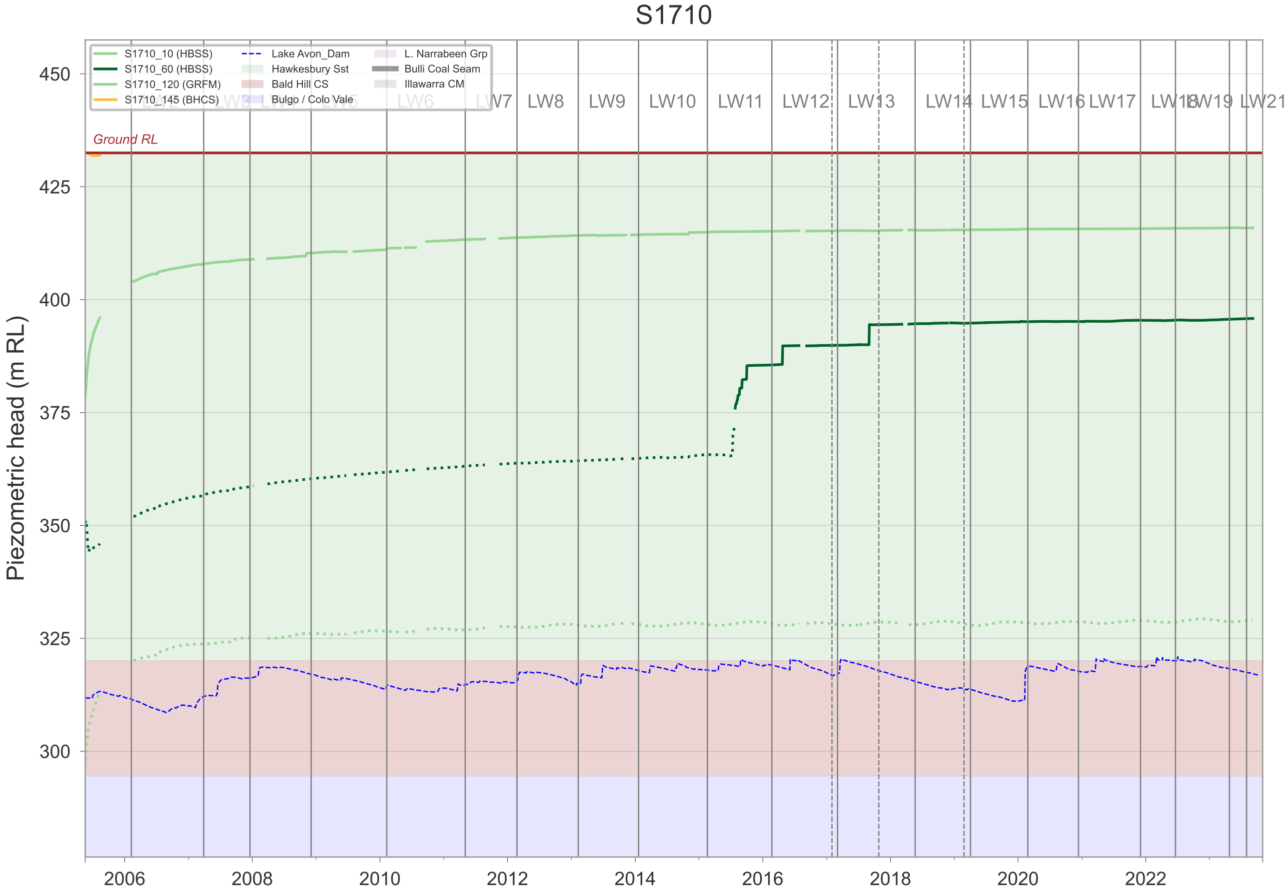
S1647B

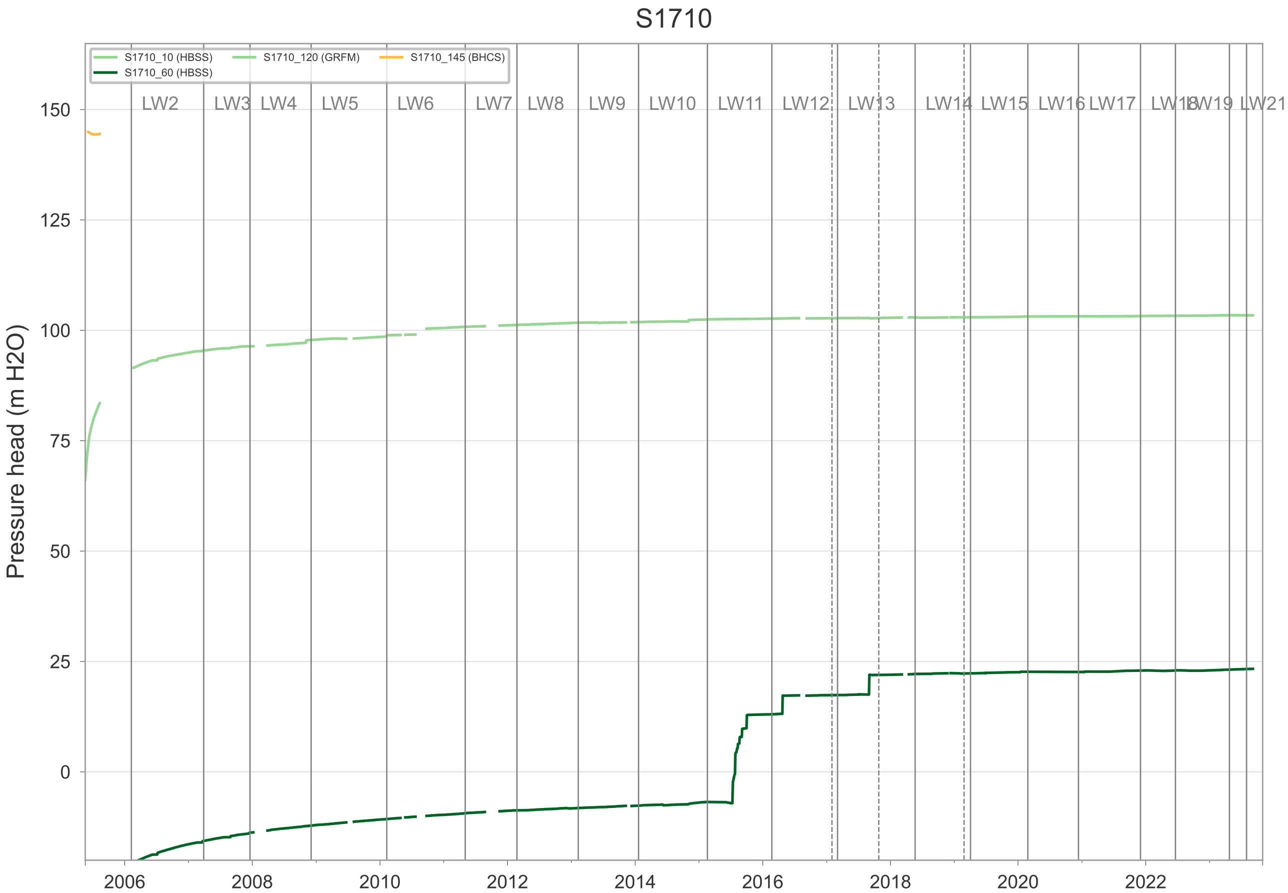



S1709
Piezometric head (m RL)
S1709_60 (HBSS)
S1709_120 (HBSS)
S1709_200 (BGSS)
S1709_260 (BGSS)
S1709_290 (SBSS)
S1709_310 (SBSS)
S1709_320 (CCSS)
S1709_349 (BUSM)
Lake Avon_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM
LW8 LW9 LW10 LW11 LW12 LW13 LW14 LW15 LW16 LW17 LW18 LW19 LW21
450 400 350 300 250 200 150 100
2006 2008 2010 2012 2014 2016 2018 2020 2022

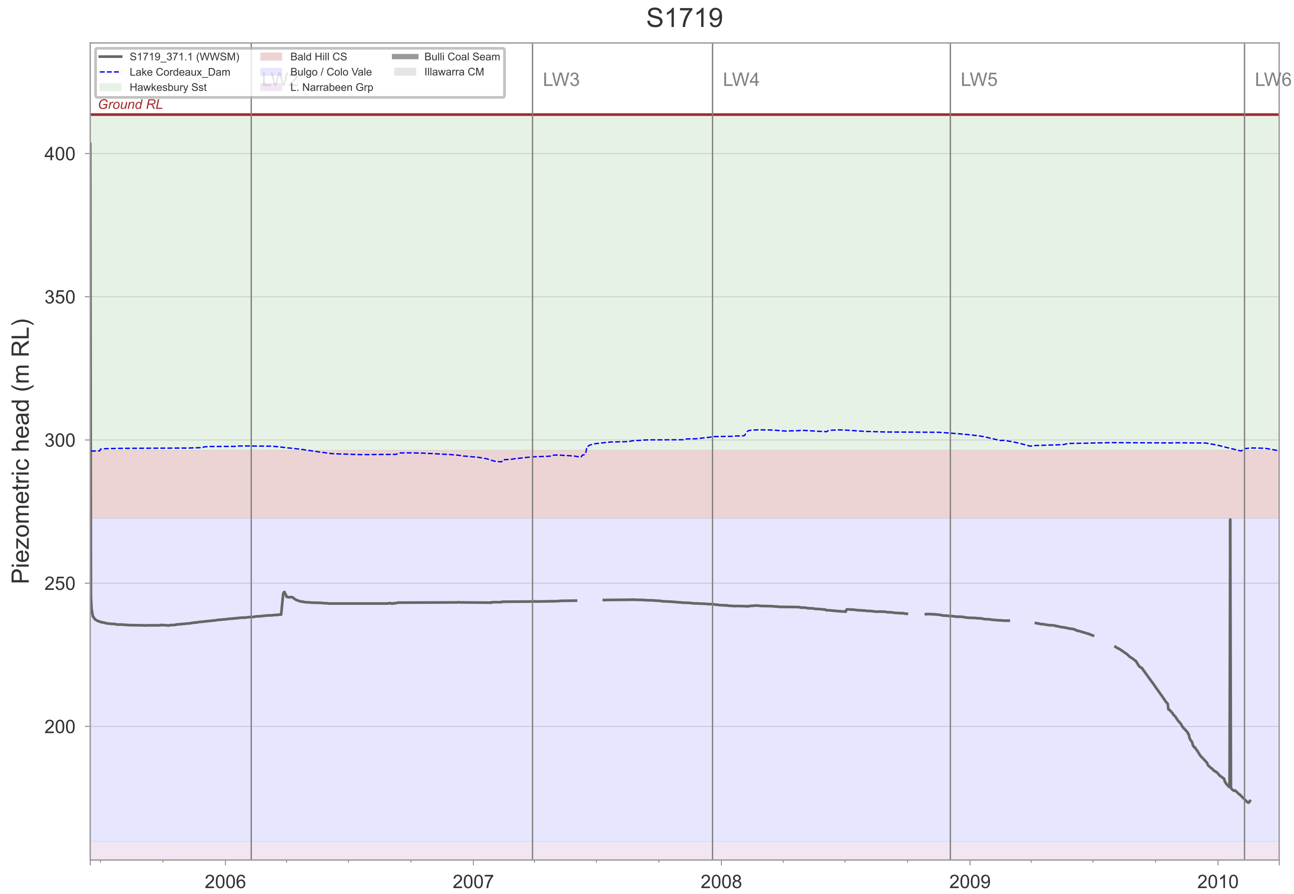

S1709
Pressure head (m H2O)
S1709_60 (HBSS)
S1709_120 (HBSS)
S1709_200 (BGSS)
S1709_260 (BGSS)
S1709_290 (SBSS)
S1709_310 (SBSS)
S1709_320 (CCSS)
S1709_349 (BUSM)
LW8 LW9 LW10 LW11 LW12 LW13 LW14 LW15 LW16 LW17 LW18 LW19 LW21
200 150 100 50 0
2006 2008 2010 2012 2014 2016 2018 2020 2022

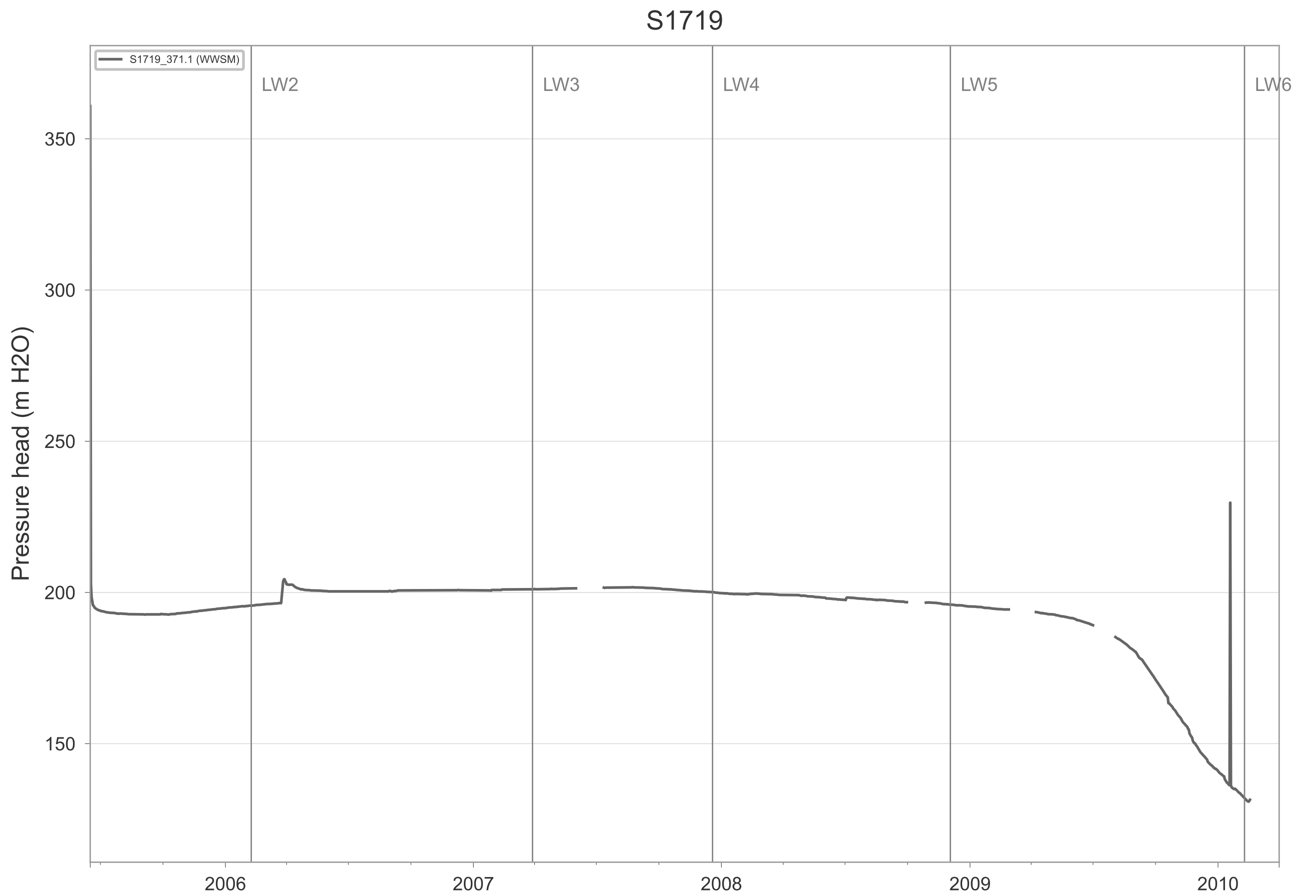
Groundwater hydrographs



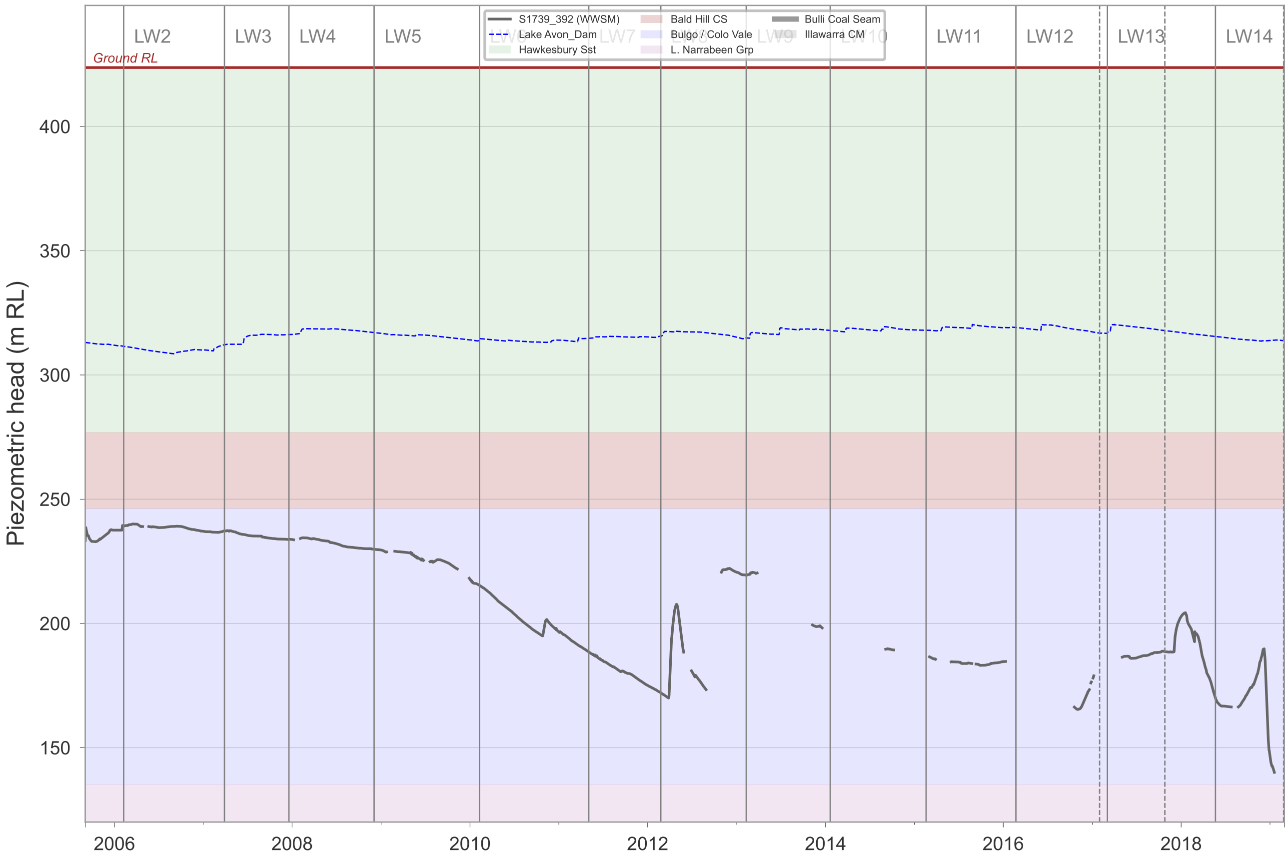


Hgeo
hgeo.com.au

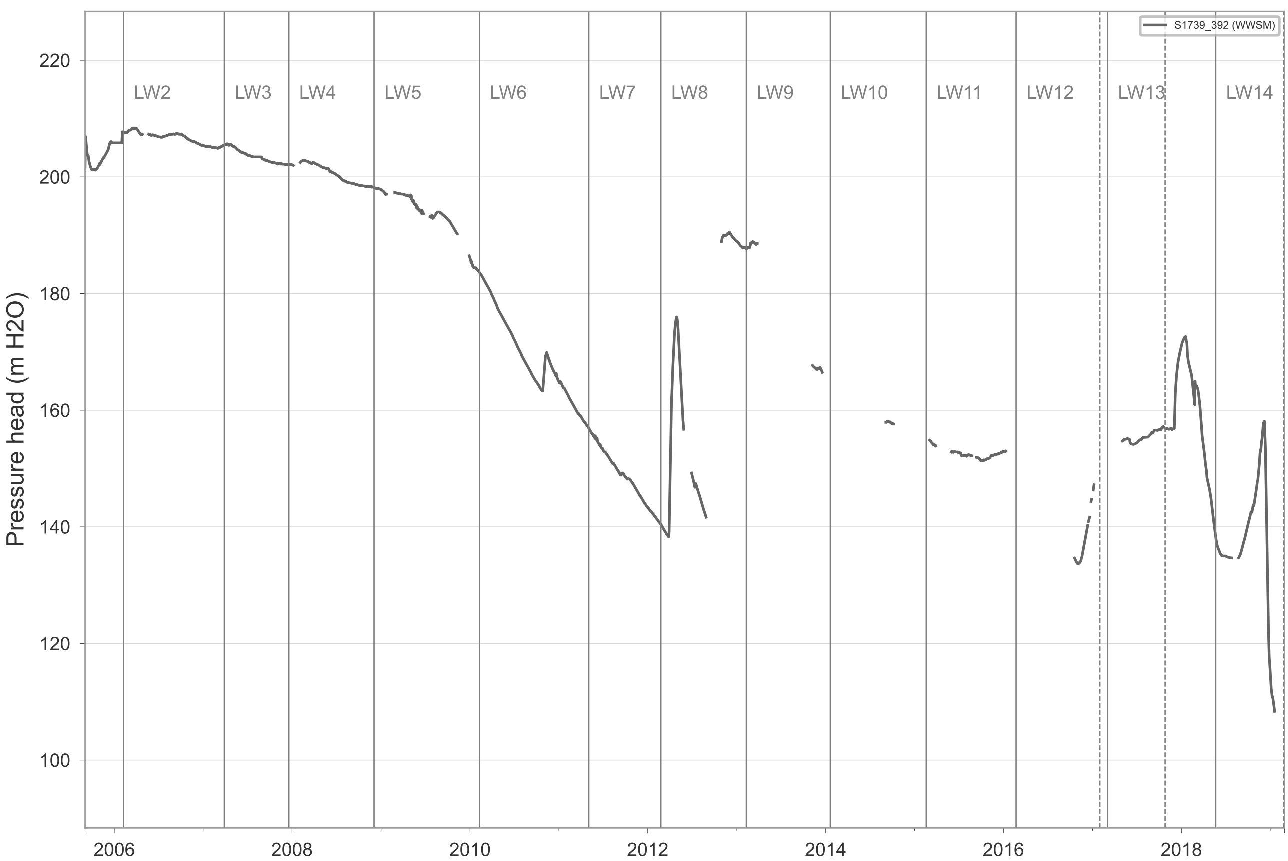


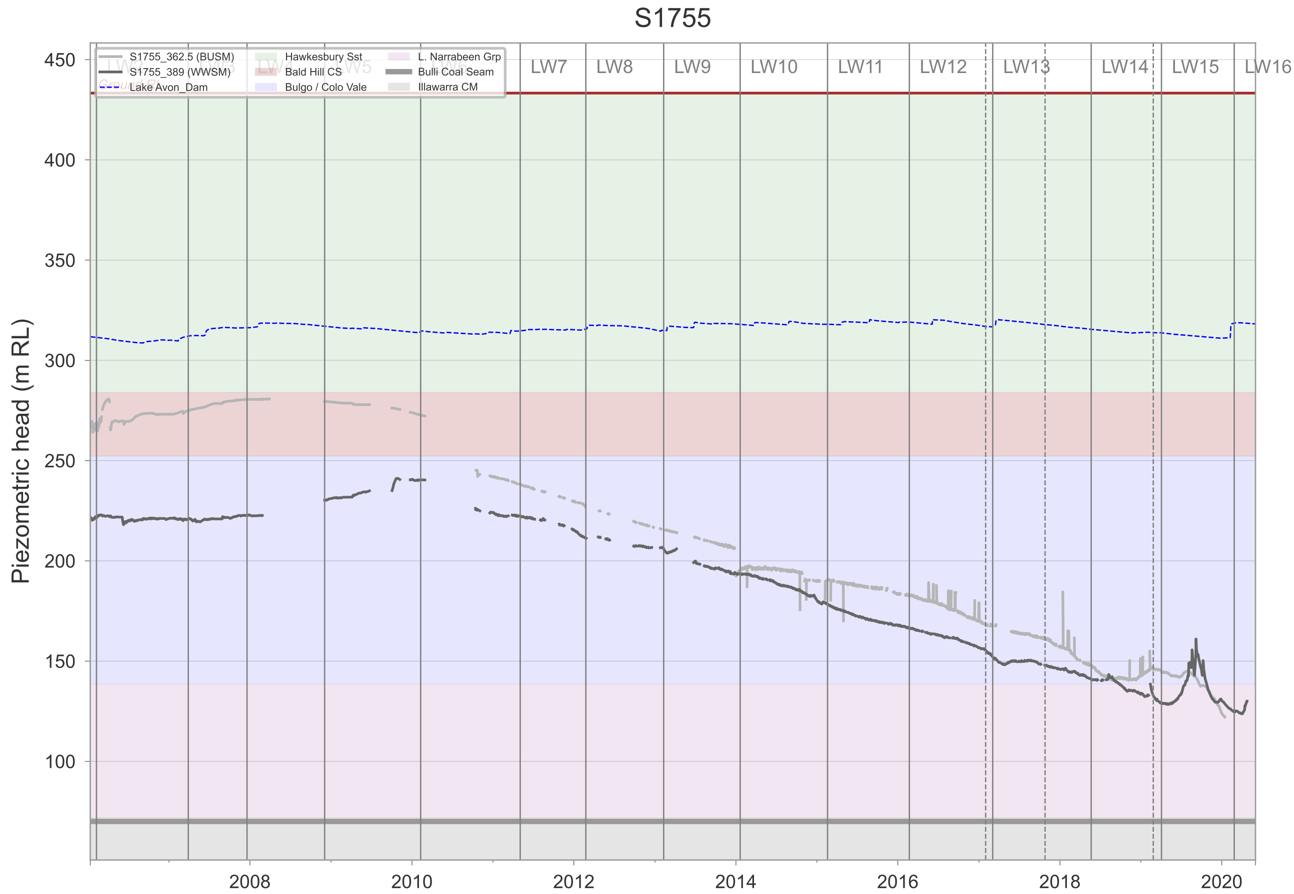


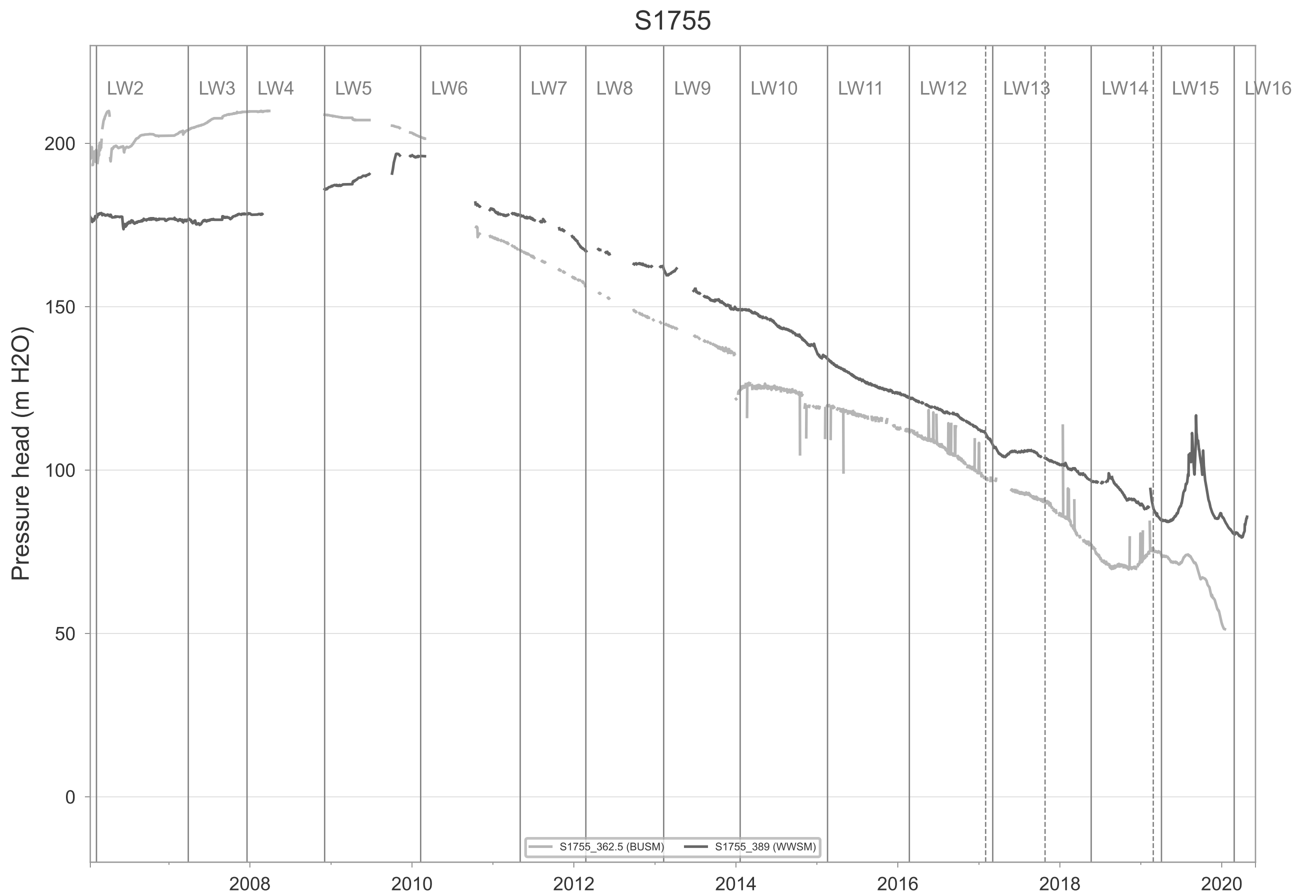
S1739

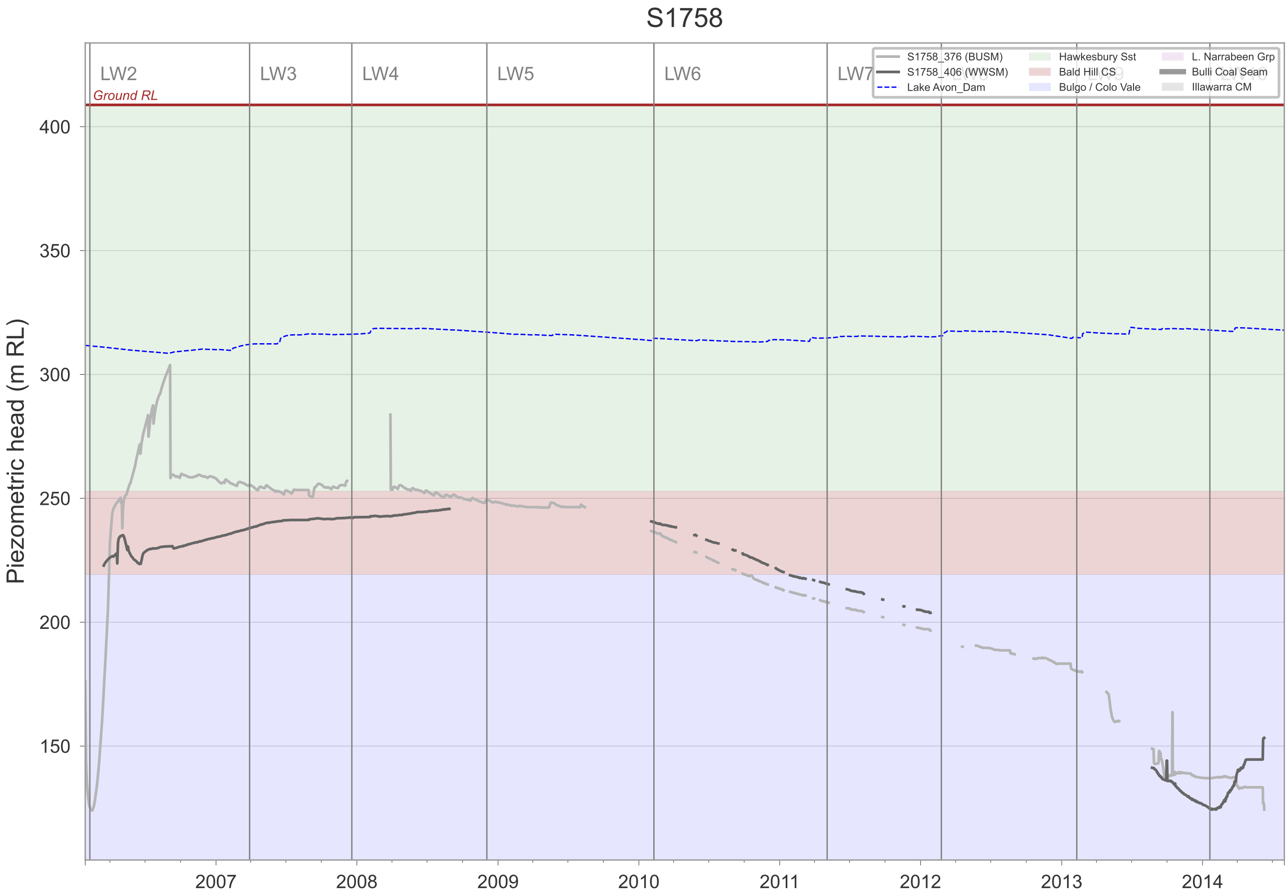

S1739_392 (WWSM)
Lake Avon_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM
LW2
LW3
LW4
LW5
LW11
LW12
LW13
LW14
Ground RL
Piezometric head (m RL)
400
350
300
250
200
150
2006
2008
2010
2012
2014
2016
2018

S1739

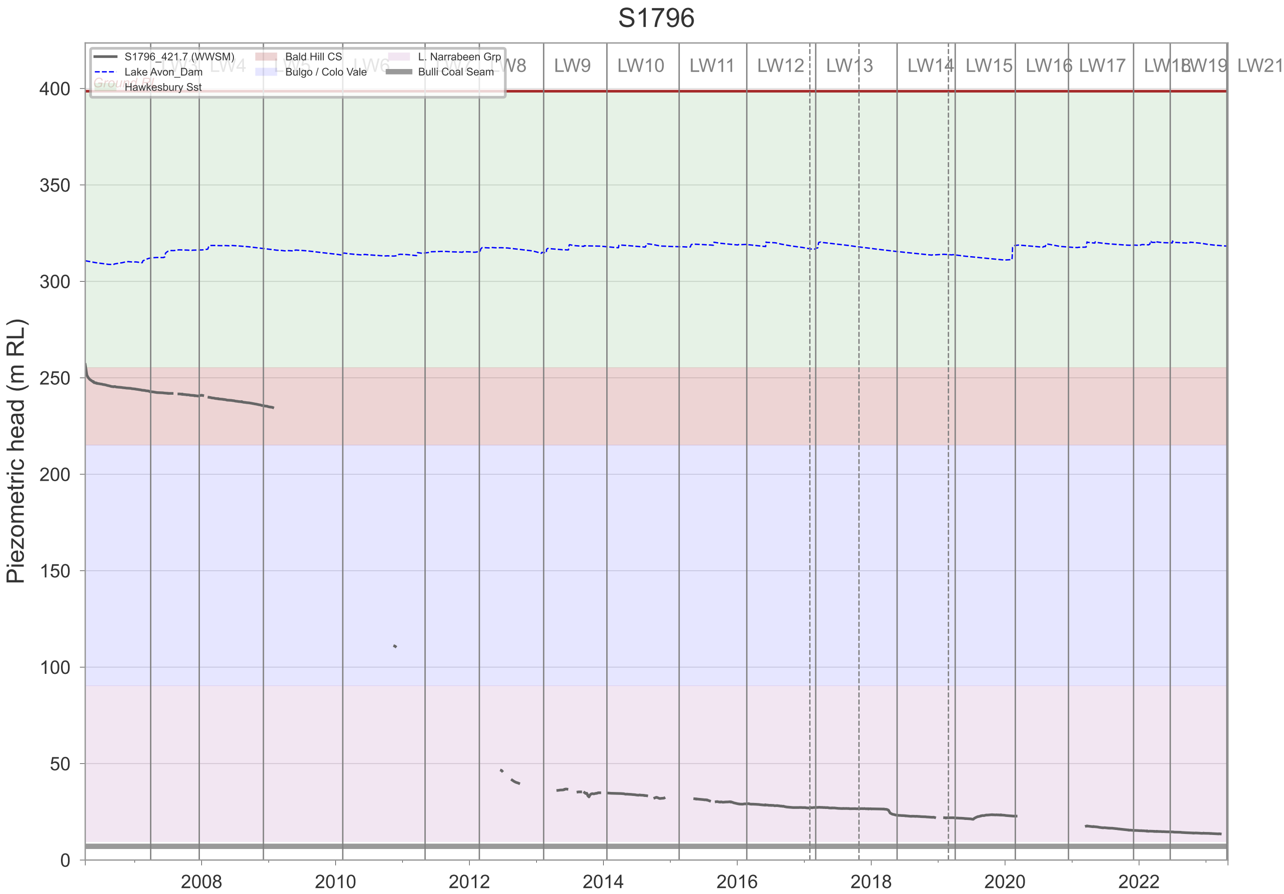

S1739_392 (WWSM)
LW2
LW3
LW4
LW5
LW6
LW7
LW8
LW9
LW10
LW11
LW12
LW13
LW14
Pressure head (m H2O)
220
200
180
160
140
120
100
2006
2008
2010
2012
2014
2016
2018

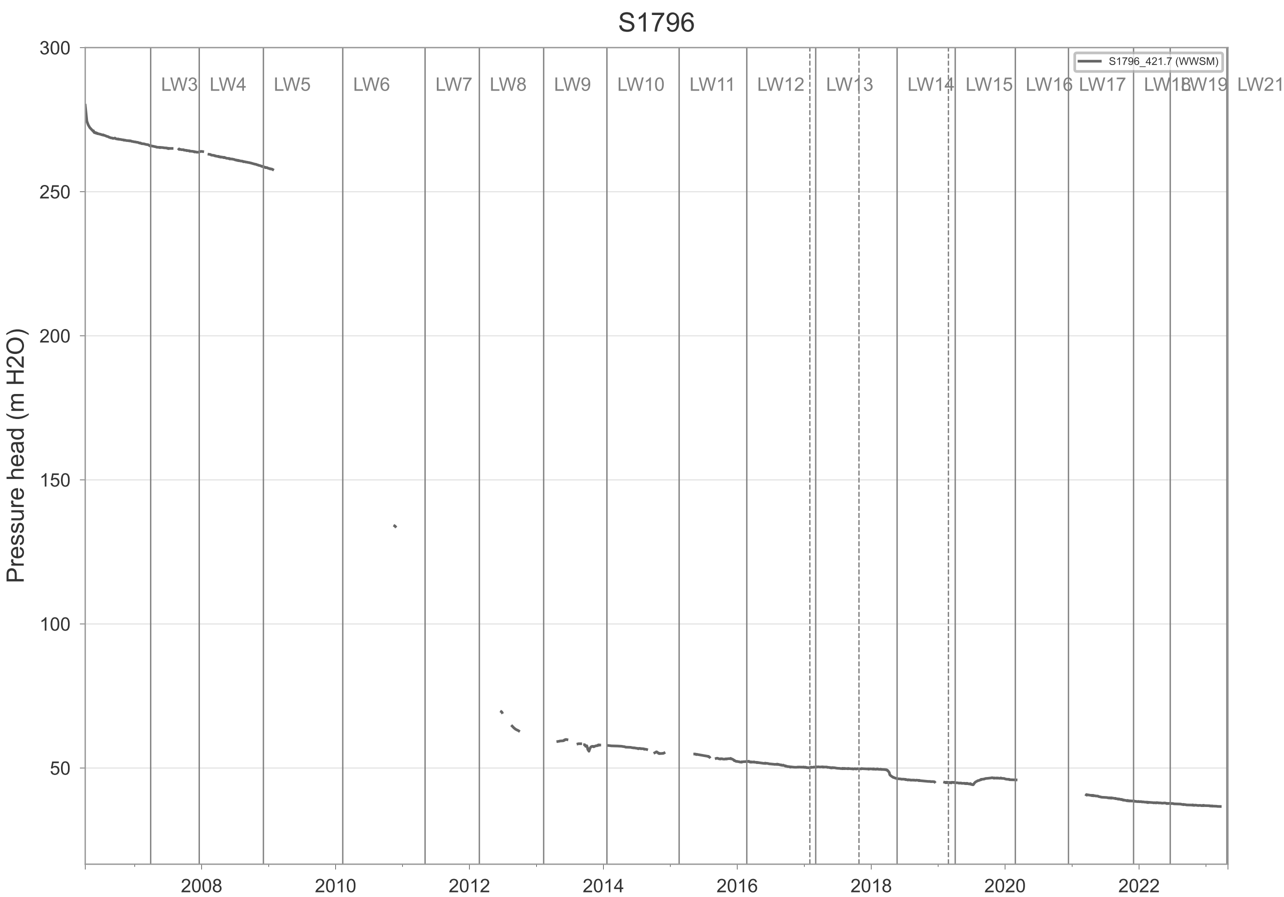

S1755
S1755_362.5 (BUSM)
S1755_389 (WWSM)
Lake Avon_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM
LW7
LW8
LW9
LW10
LW11
LW12
LW13
LW14
LW15
LW16
Piezometric head (m RL)
450
400
350
300
250
200
150
100
2008
2010
2012
2014
2016
2018
2020

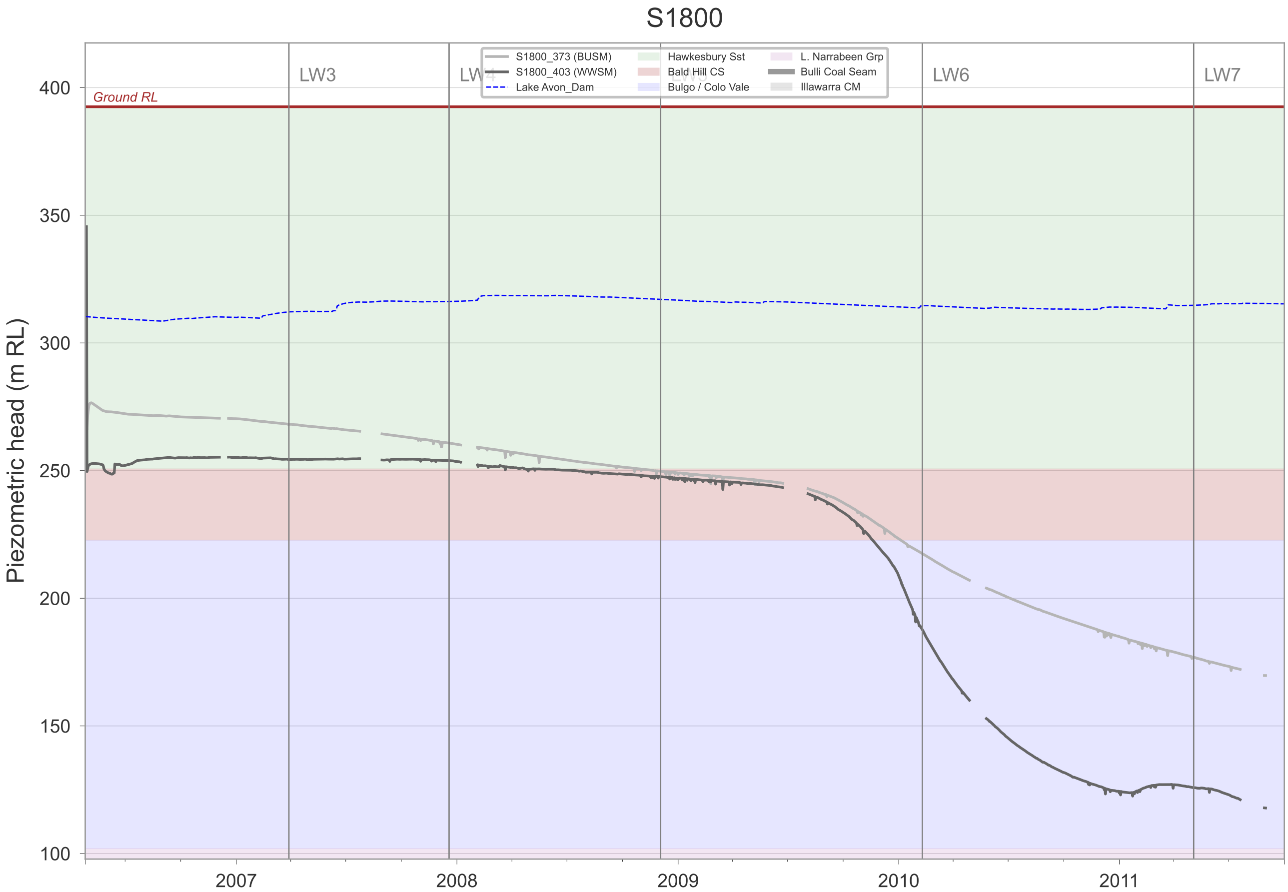

S1755
LW2
LW3
LW4
LW5
LW6
LW7
LW8
LW9
LW10
LW11
LW12
LW13
LW14
LW15
LW16
Pressure head (m H2O)
200
150
100
50
0
S1755_362.5 (BUSM)
S1755_389 (WWSM)
2008
2010
2012
2014
2016
2018
2020

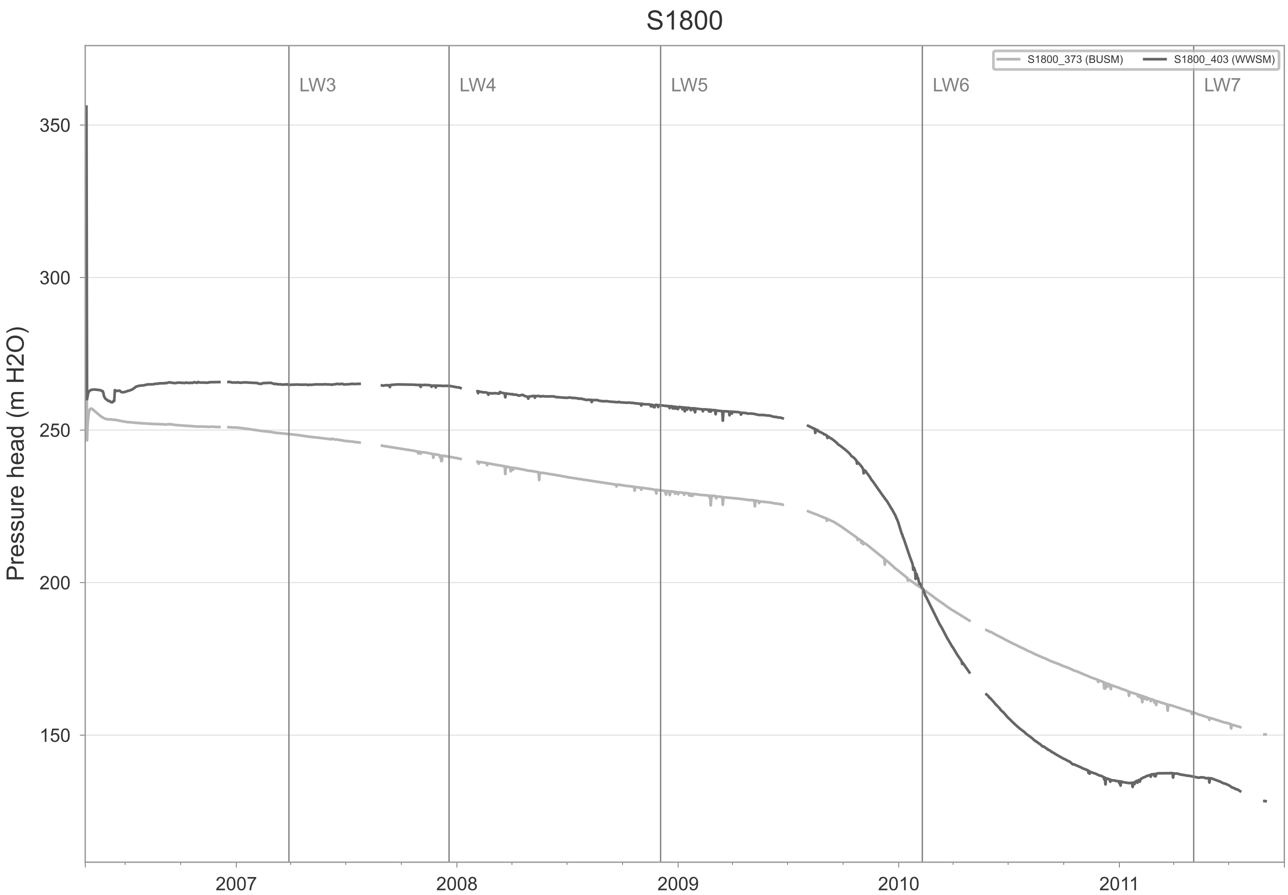

S1758
LW2
LW3
LW4
LW5
LW6
LW7
Ground RL
S1758_376 (BUSM)
S1758_406 (WWSM)
Lake Avon_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM
Piezometric head (m RL)
400
350
300
250
200
150
2007
2008
2009
2010
2011
2012
2013
2014

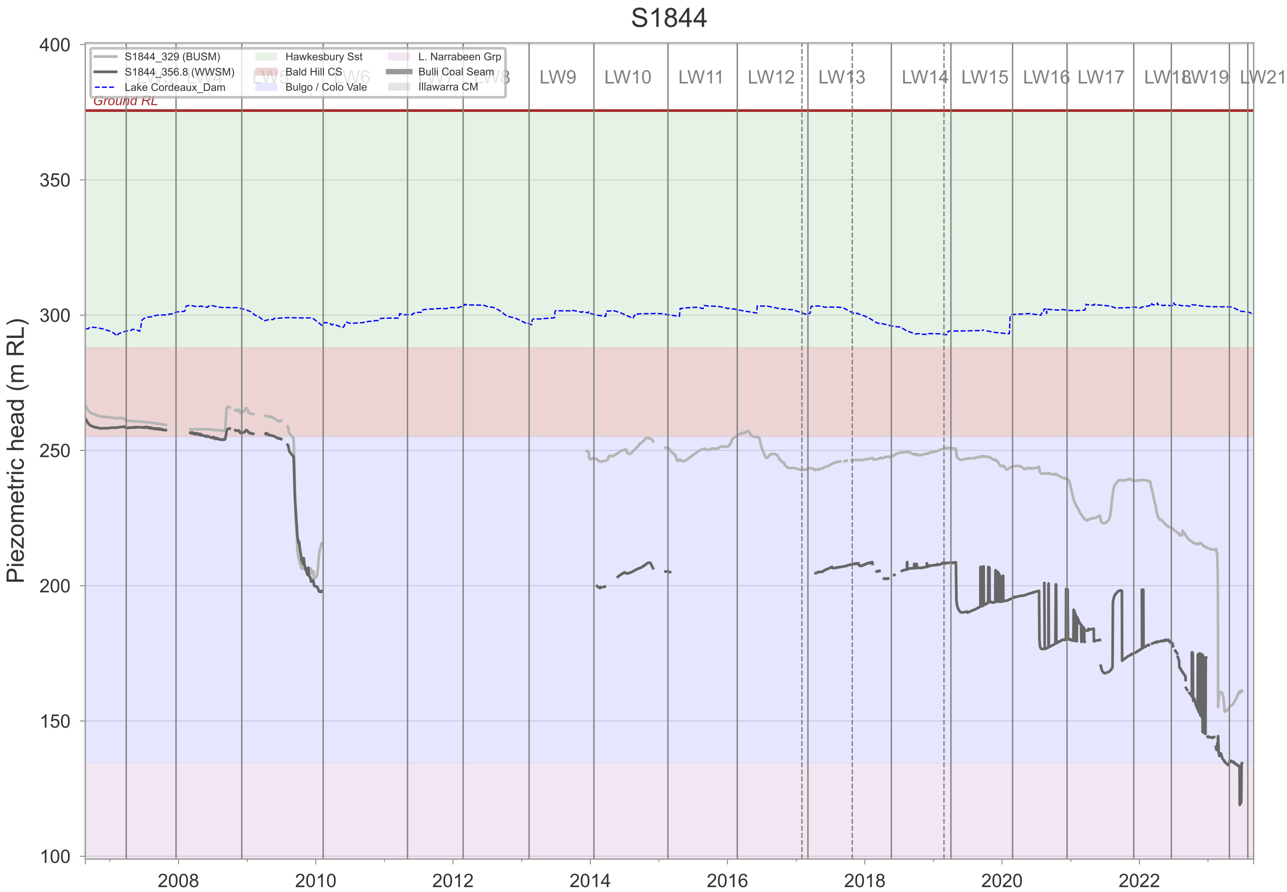

S1758
S1758_376 (BUSM)
S1758_406 (WWSM)
LW2
LW3
LW4
LW5
LW6
LW7
LW8
LW9
LW10
Pressure head (m H2O)
275
250
225
200
175
150
125
100
75
2007
2008
2009
2010
2011
2012
2013
2014

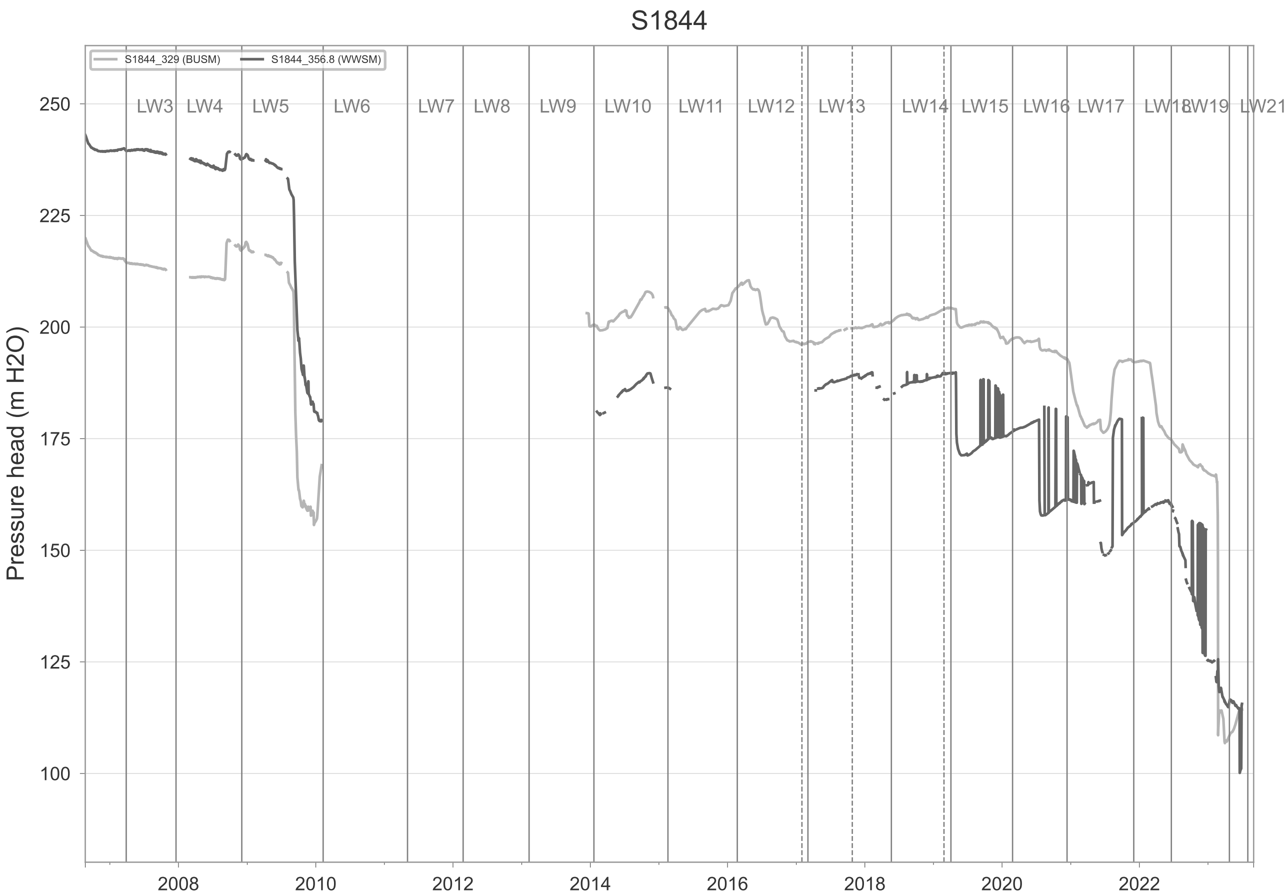

S1796
S1796_421.7 (WWSM)
Lake Avon_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
LW8
LW9
LW10
LW11
LW12
LW13
LW14
LW15
LW16
LW17
LW18
LW19
LW21
Piezometric head (m RL)
0
50
100
150
200
250
300
350
400
2008
2010
2012
2014
2016
2018
2020
2022


S1796
S1796_421.7 (WWSM)
LW3
LW4
LW5
LW6
LW7
LW8
LW9
LW10
LW11
LW12
LW13
LW14
LW15
LW16
LW17
LW18
LW19
LW21
Pressure head (m H2O)
50
100
150
200
250
300
2008
2010
2012
2014
2016
2018
2020
2022

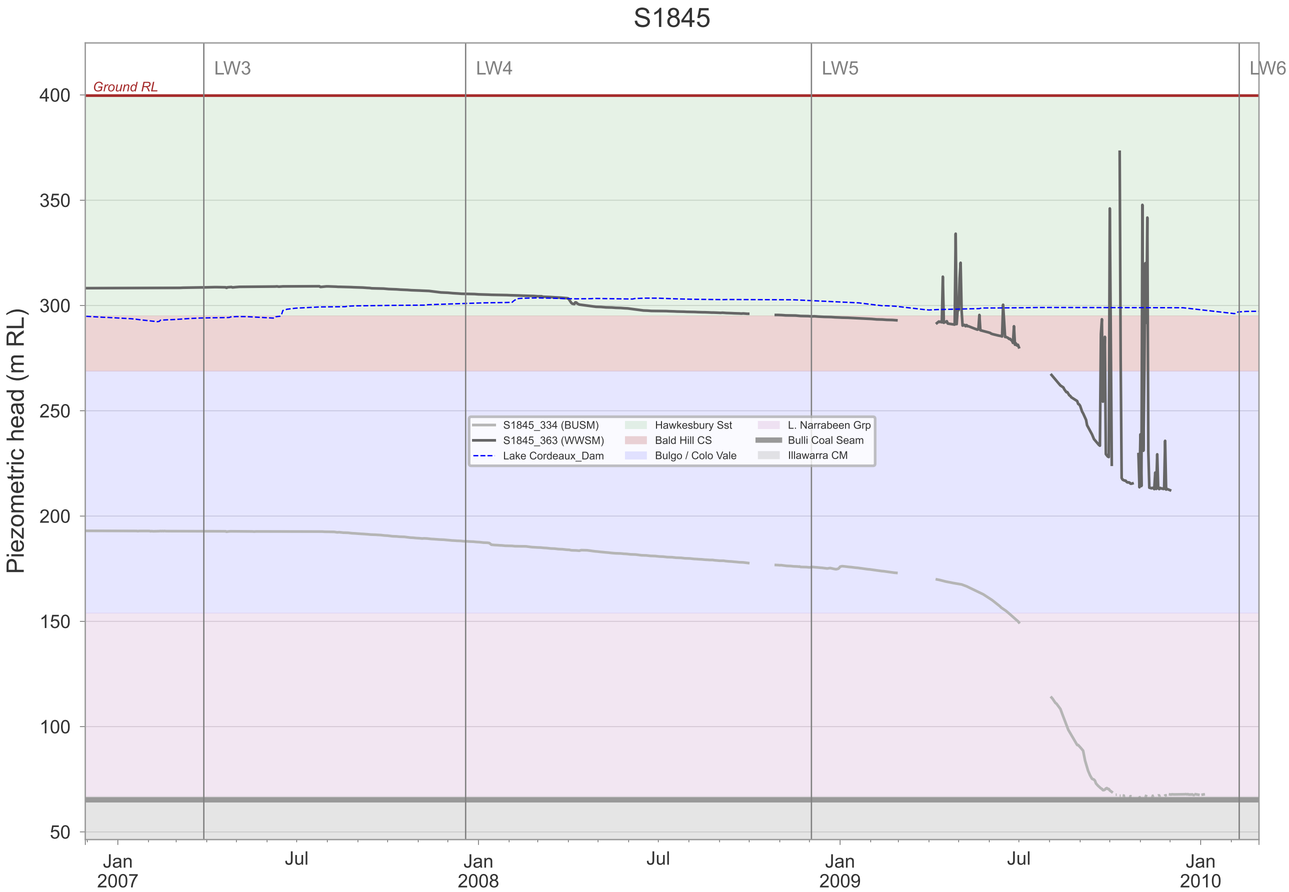

S1800
Ground RL
LW3
LW6
LW7
S1800_373 (BUSM)
S1800_403 (WWSM)
Lake Avon_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM
Piezometric head (m RL)
400
350
300
250
200
150
100
2007
2008
2009
2010
2011

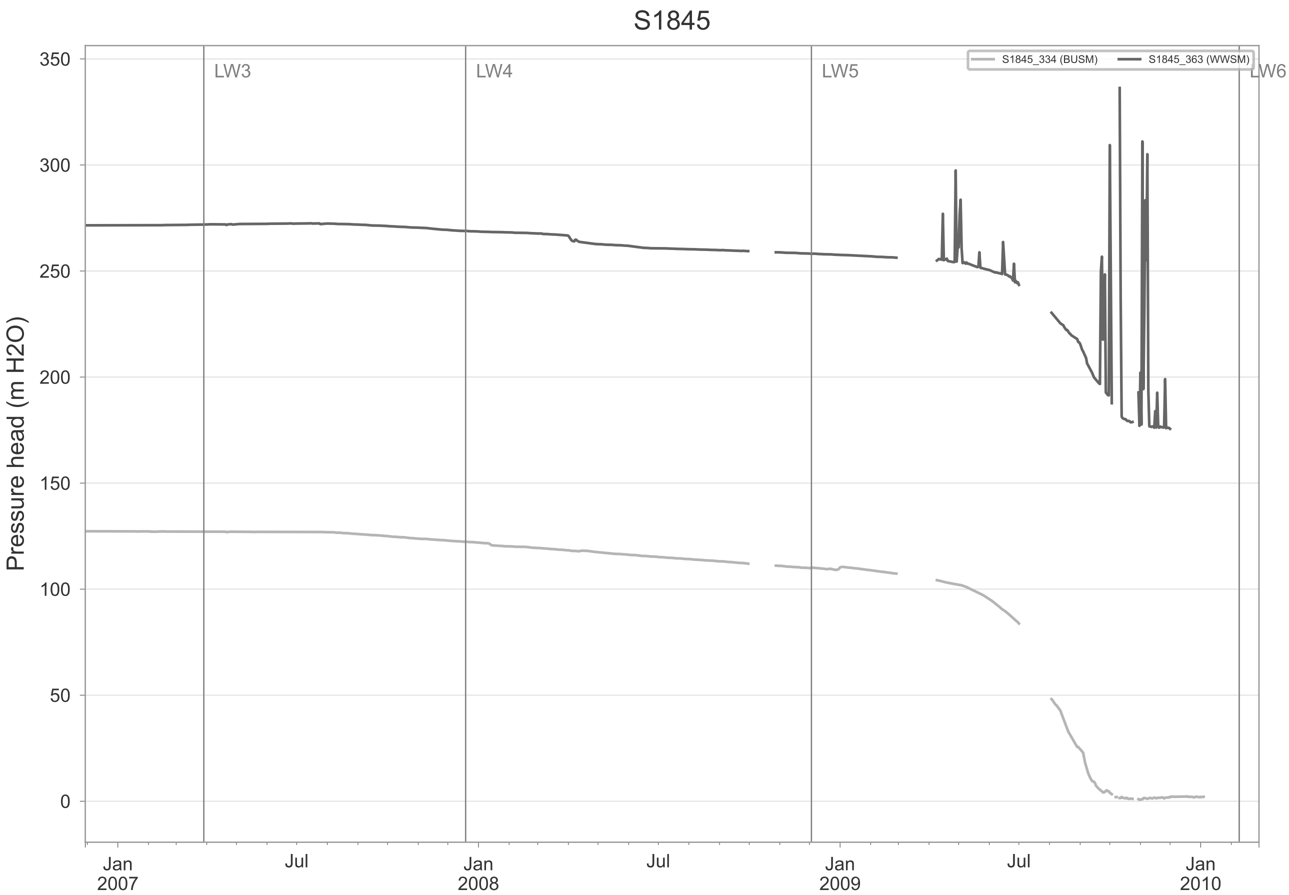

S1800
S1800_373 (BUSM)
S1800_403 (WWSM)
LW3
LW4
LW5
LW6
LW7
Pressure head (m H2O)
350
300
250
200
150
2007
2008
2009
2010
2011

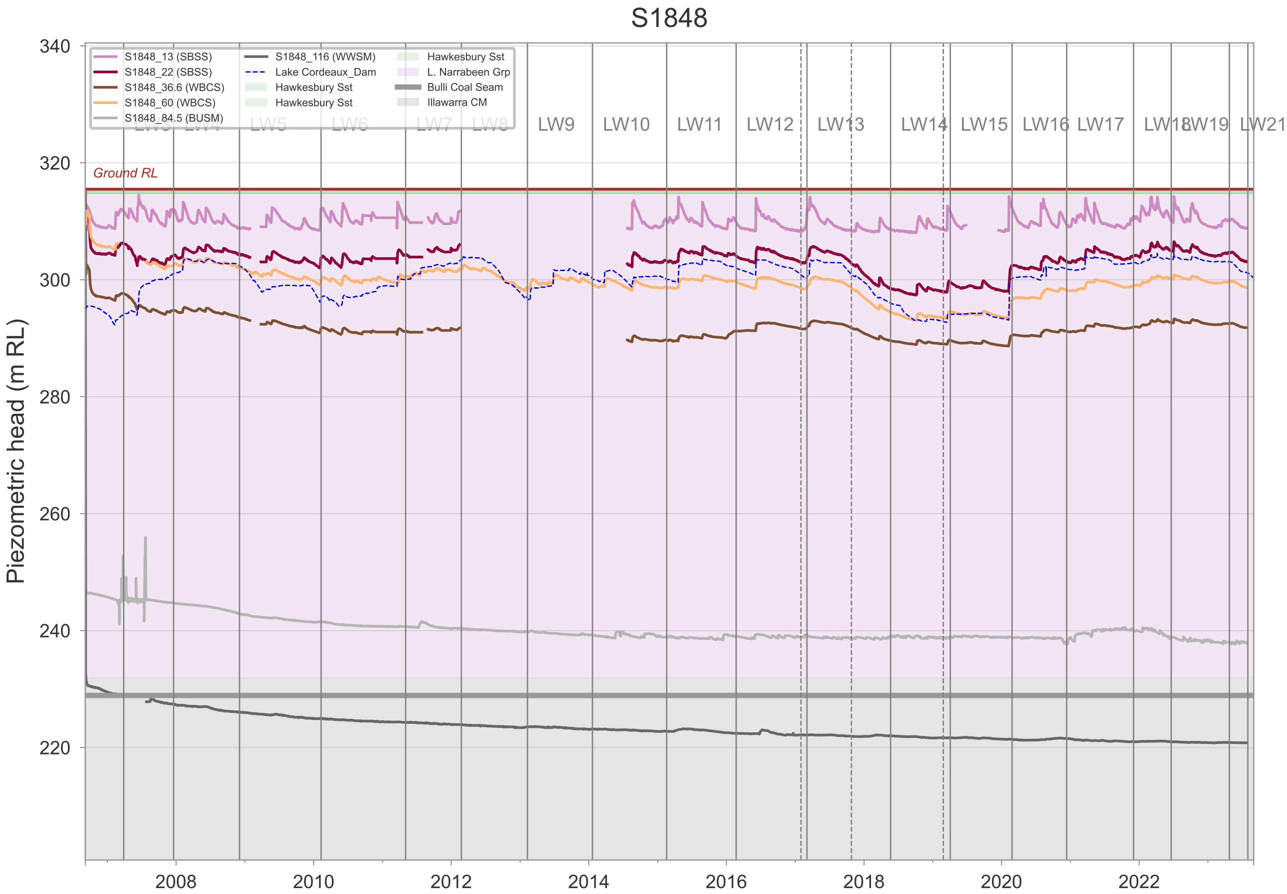

S1844
S1844_329 (BUSM)
S1844_356.8 (WWSM)
Lake Cordeaux_Dam
Ground RL
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM
LW9
LW10
LW11
LW12
LW13
LW14
LW15
LW16
LW17
LW18
LW19
LW21
Piezometric head (m RL)
400
350
300
250
200
150
100
2008
2010
2012
2014
2016
2018
2020
2022

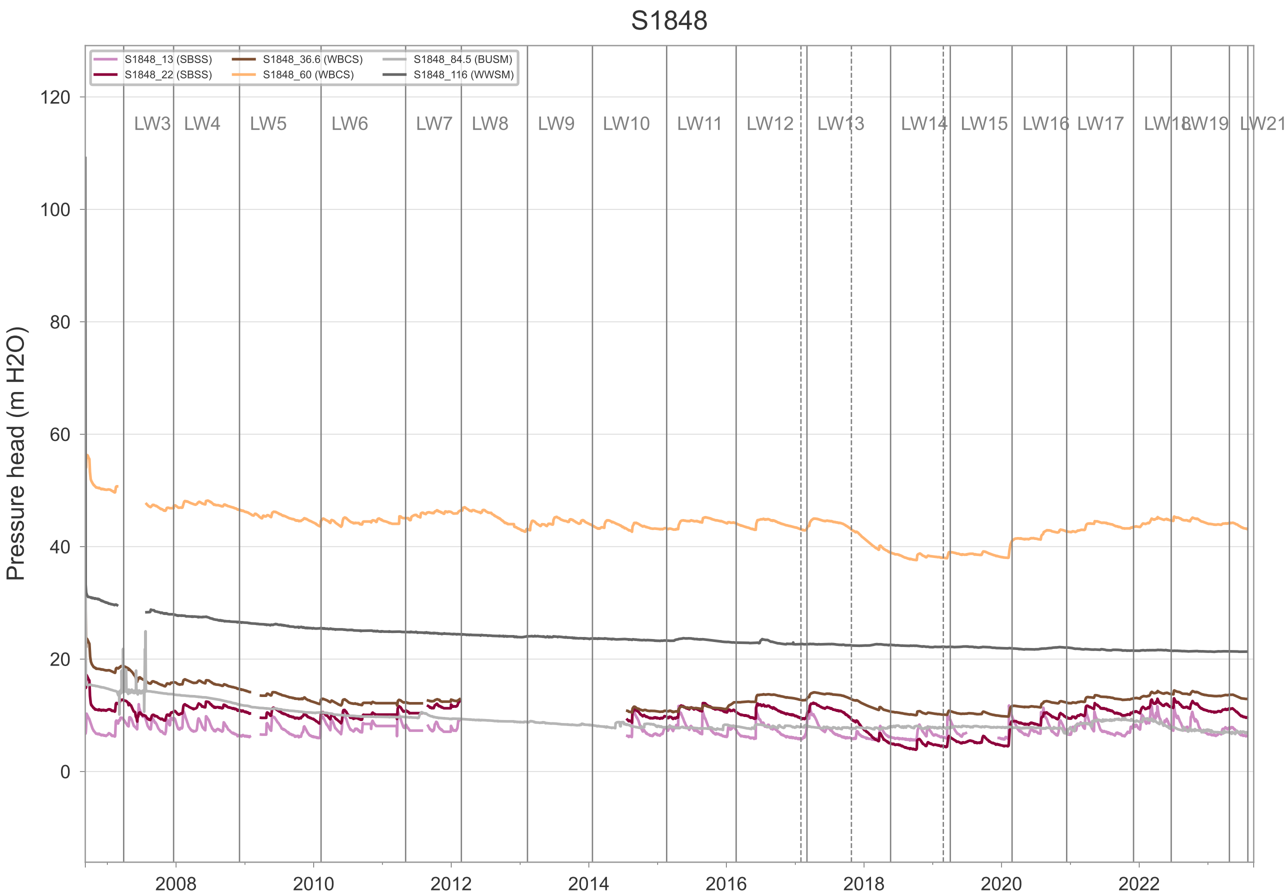

S1844
S1844_329 (BUSM)
S1844_356.8 (WWSM)
LW3
LW4
LW5
LW6
LW7
LW8
LW9
LW10
LW11
LW12
LW13
LW14
LW15
LW16
LW17
LW18
LW19
LW21
Pressure head (m H2O)
250
225
200
175
150
125
100
2008
2010
2012
2014
2016
2018
2020
2022

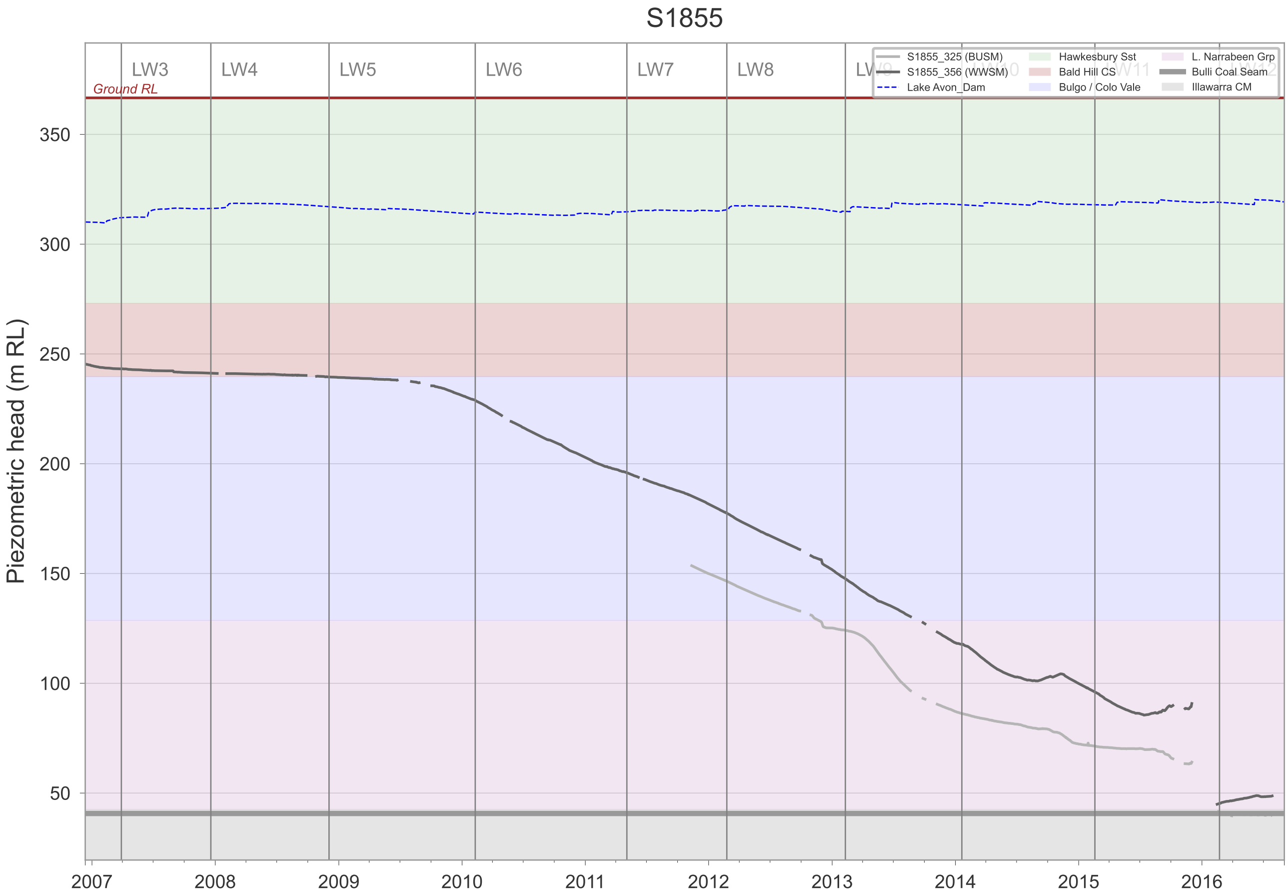
Groundwater hydrographs

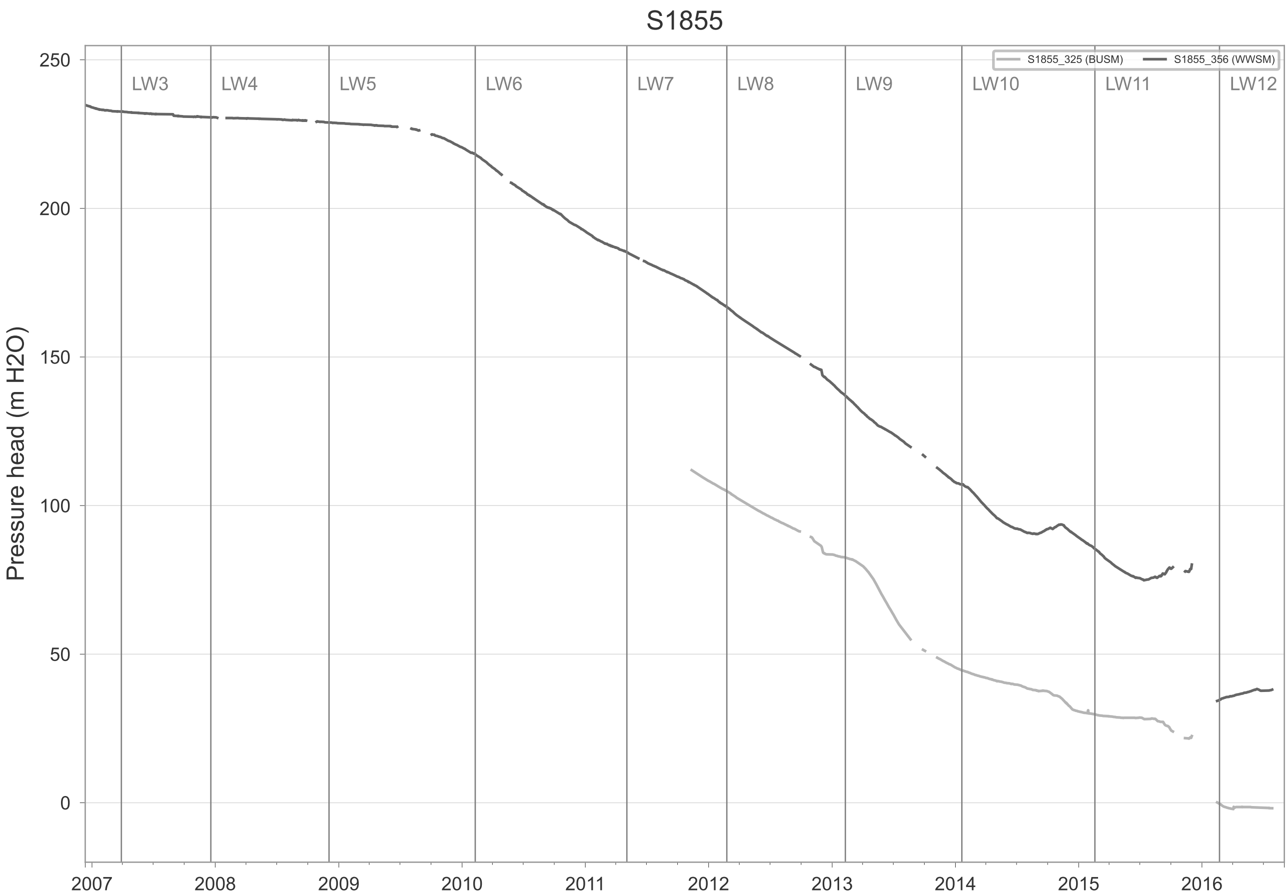


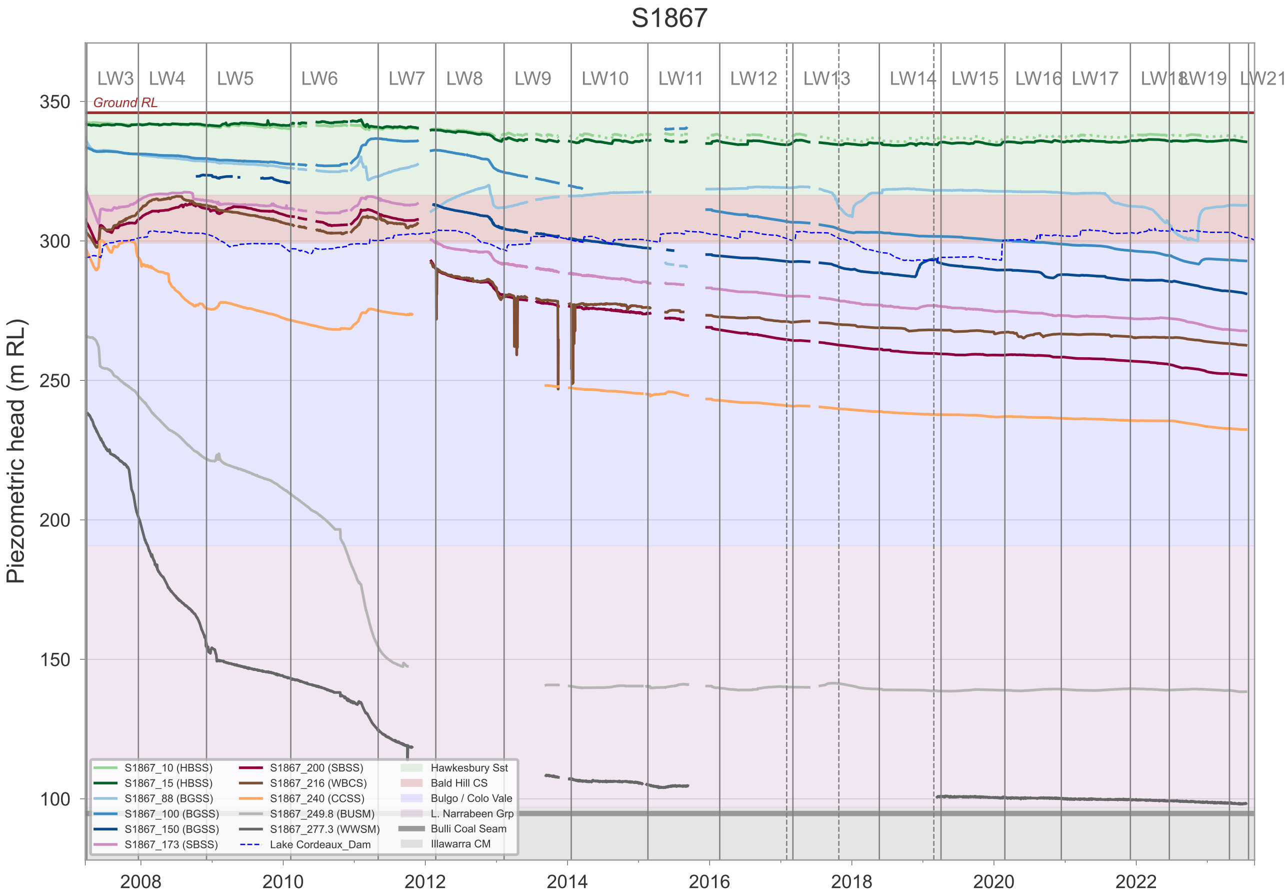


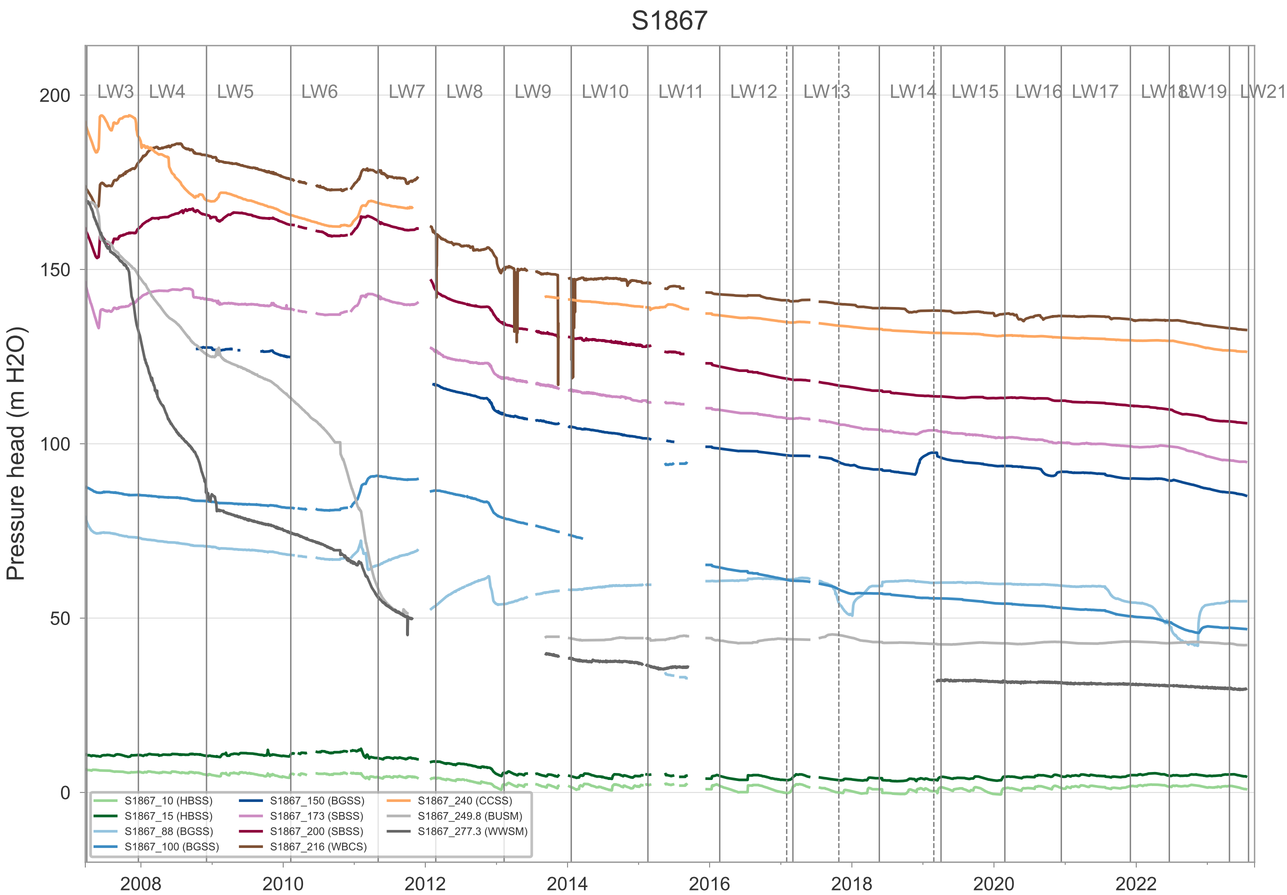

S1848
Piezometric head (m RL)
S1848_13 (SBSS)
S1848_22 (SBSS)
S1848_36.6 (WBCS)
S1848_60 (WBCS)
S1848_84.5 (BUSM)
S1848_116 (WWSM)
Lake Cordeaux_Dam
Hawkesbury Sst
Hawkesbury Sst
Hawkesbury Sst
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM
Ground RL
LW9
LW10
LW11
LW12
LW13
LW14
LW15
LW16
LW17
LW18
LW19
LW21
340
320
300
280
260
240
220
2008
2010
2012
2014
2016
2018
2020
2022

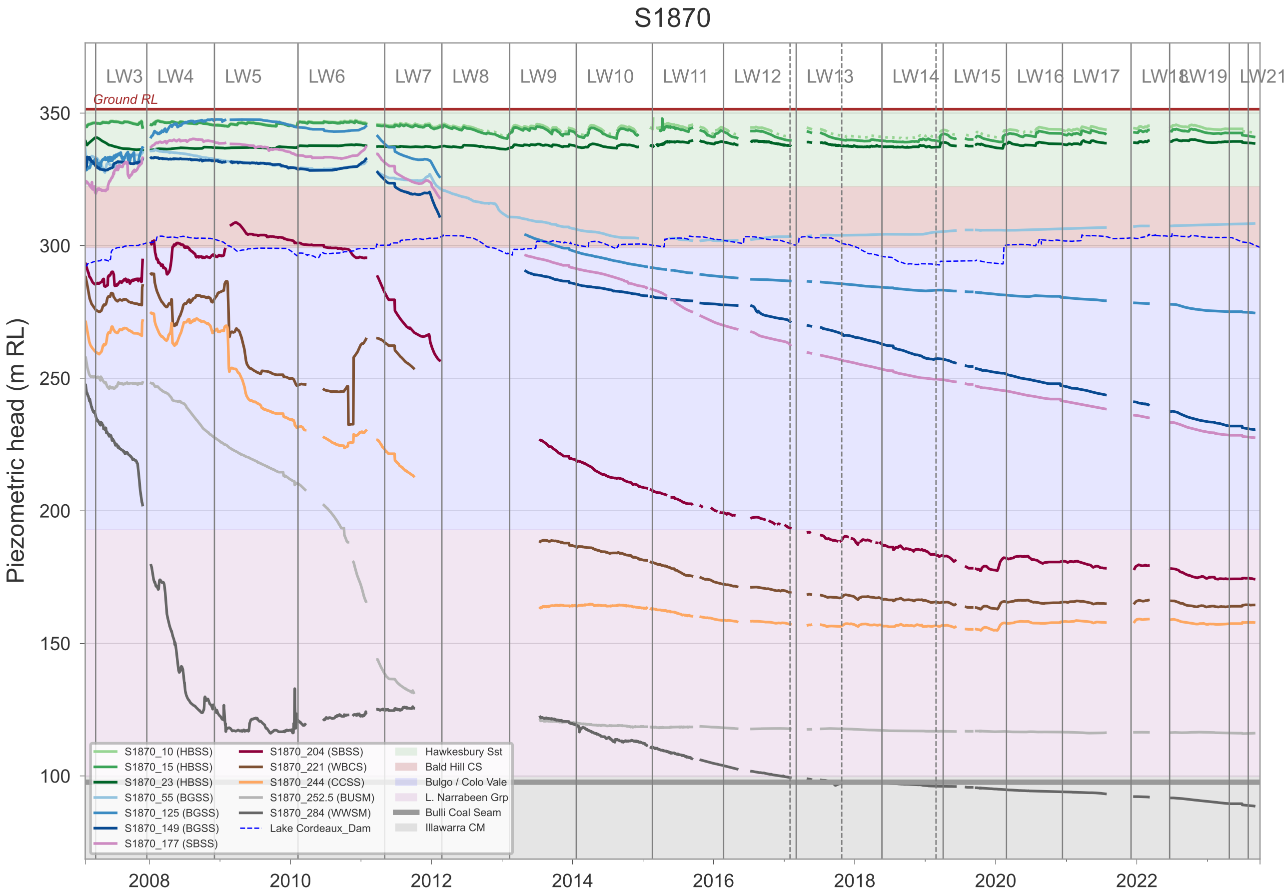

S1848
Pressure head (m H2O)
S1848_13 (SBSS)
S1848_22 (SBSS)
S1848_36.6 (WBCS)
S1848_60 (WBCS)
S1848_84.5 (BUSM)
S1848_116 (WWSM)
LW3
LW4
LW5
LW6
LW7
LW8
LW9
LW10
LW11
LW12
LW13
LW14
LW15
LW16
LW17
LW18
LW19
LW21
120
100
80
60
40
20
0
2008
2010
2012
2014
2016
2018
2020
2022

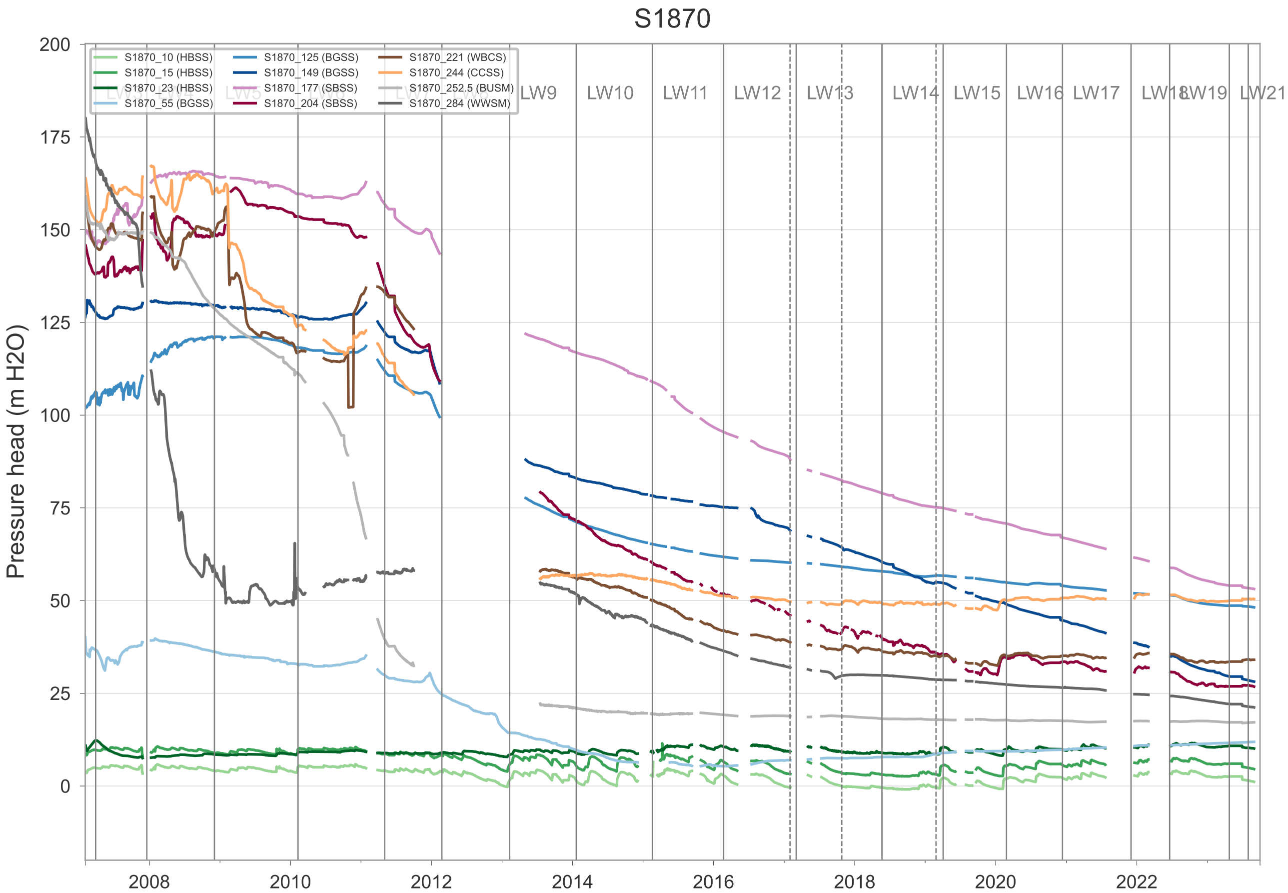

S1855
LW3
LW4
LW5
LW6
LW7
LW8
LW9
Ground RL
S1855_325 (BUSM)
S1855_356 (WWSM)
Lake Avon_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM
Piezometric head (m RL)
350
300
250
200
150
100
50
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016

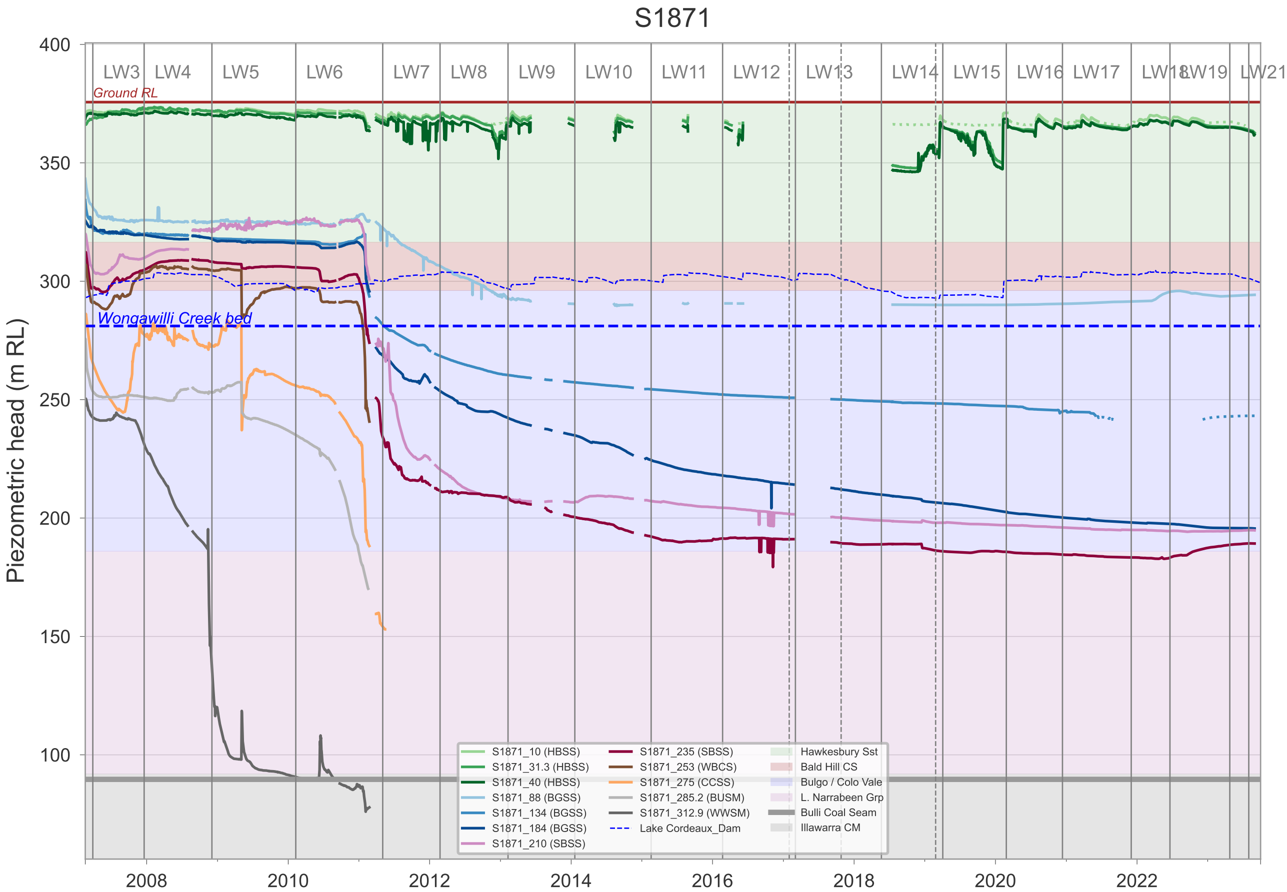

S1855
S1855_325 (BUSM)
S1855_356 (WWSM)
LW3
LW4
LW5
LW6
LW7
LW8
LW9
LW10
LW11
LW12
Pressure head (m H2O)
250
200
150
100
50
0
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016

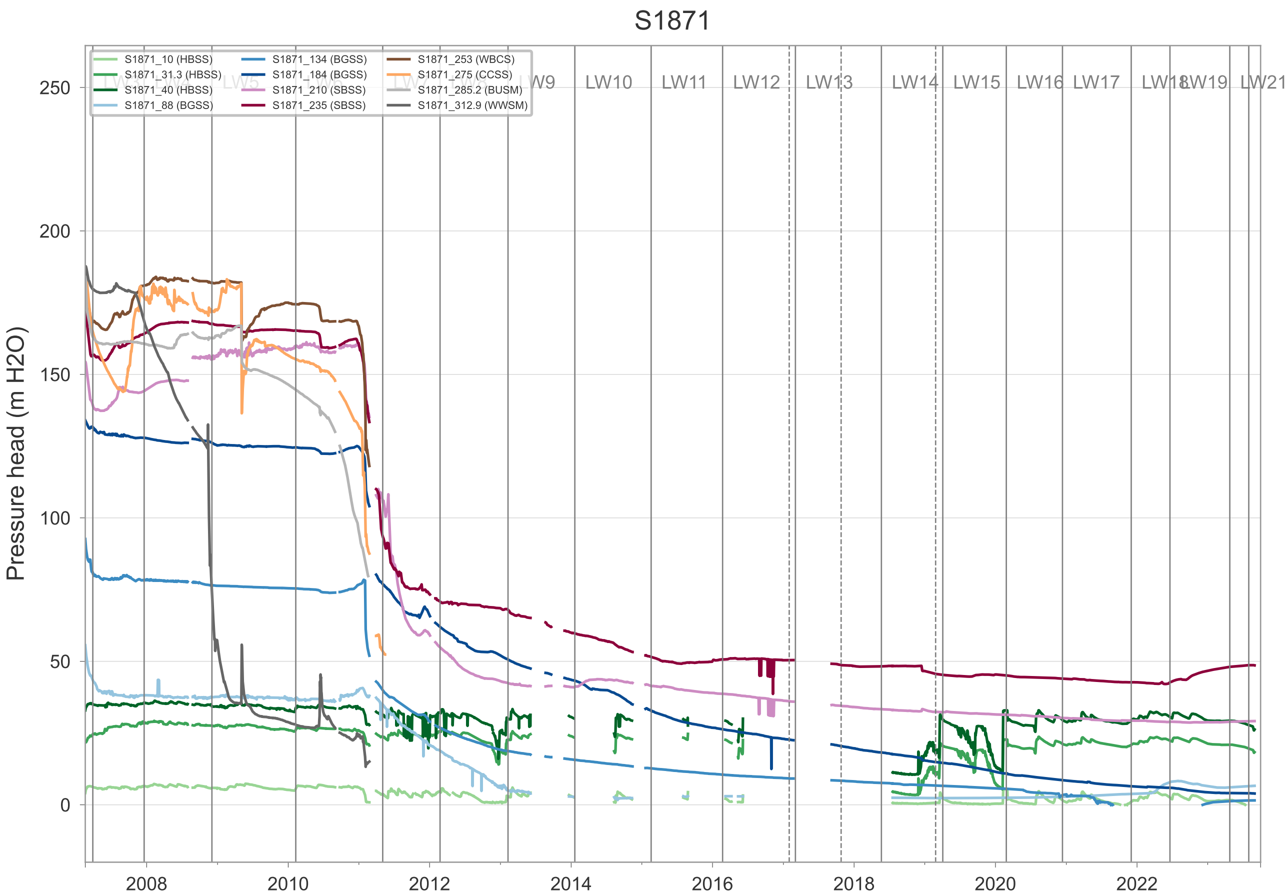

S1867
LW3
LW4
LW5
LW6
LW7
LW8
LW9
LW10
LW11
LW12
LW13
LW14
LW15
LW16
LW17
LW18
LW19
LW21
Ground RL
Piezometric head (m RL)
350
300
250
200
150
100
2008
2010
2012
2014
2016
2018
2020
2022
S1867_10 (HBSS)
S1867_15 (HBSS)
S1867_88 (BGSS)
S1867_100 (BGSS)
S1867_150 (BGSS)
S1867_173 (SBSS)
S1867_200 (SBSS)
S1867_216 (WBCS)
S1867_240 (CCSS)
S1867_249.8 (BUSM)
S1867_277.3 (WWSM)
Lake Cordeaux_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM

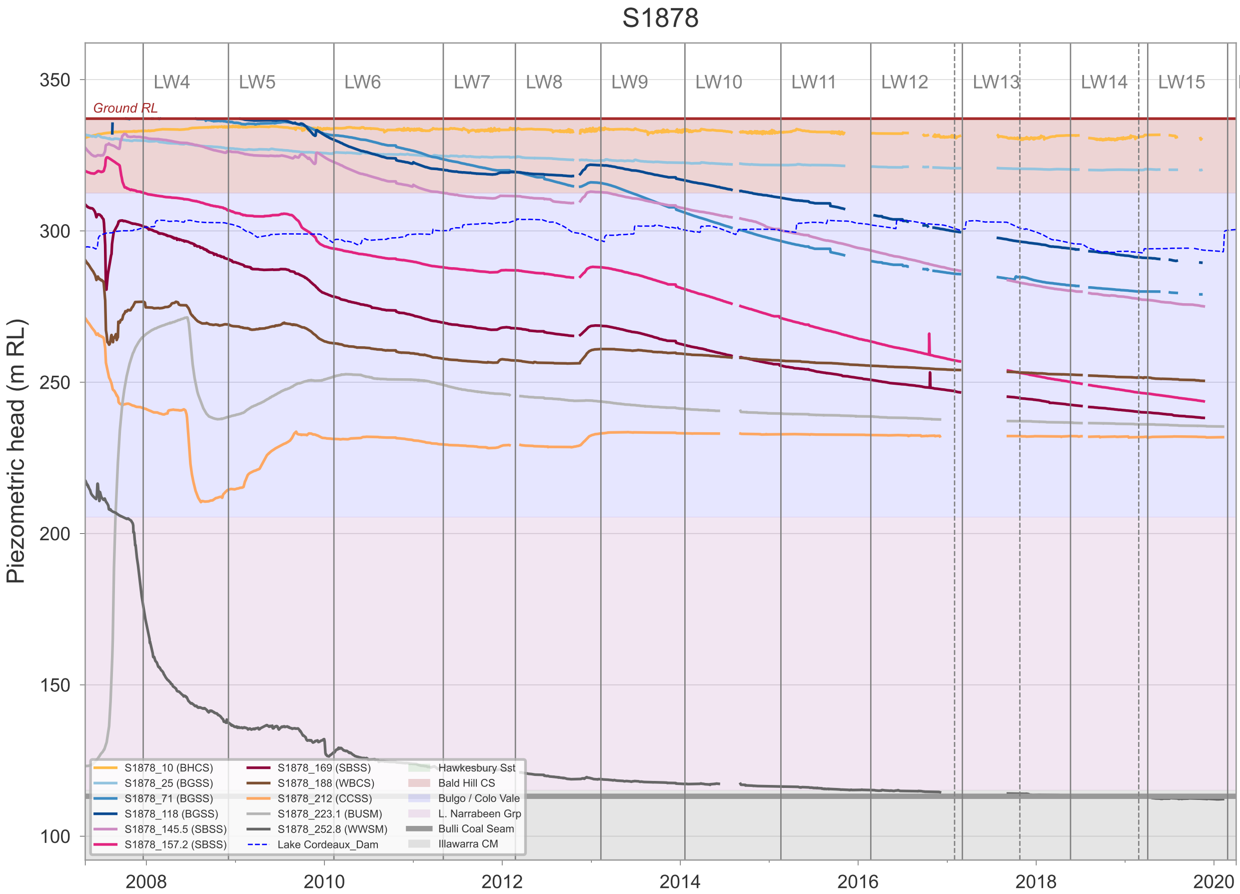

S1867
LW3
LW4
LW5
LW6
LW7
LW8
LW9
LW10
LW11
LW12
LW13
LW14
LW15
LW16
LW17
LW18
LW19
LW21
Pressure head (m H2O)
200
150
100
50
0
2008
2010
2012
2014
2016
2018
2020
2022
S1867_10 (HBSS)
S1867_15 (HBSS)
S1867_88 (BGSS)
S1867_100 (BGSS)
S1867_150 (BGSS)
S1867_173 (SBSS)
S1867_200 (SBSS)
S1867_216 (WBCS)
S1867_240 (CCSS)
S1867_249.8 (BUSM)
S1867_277.3 (WWSM)

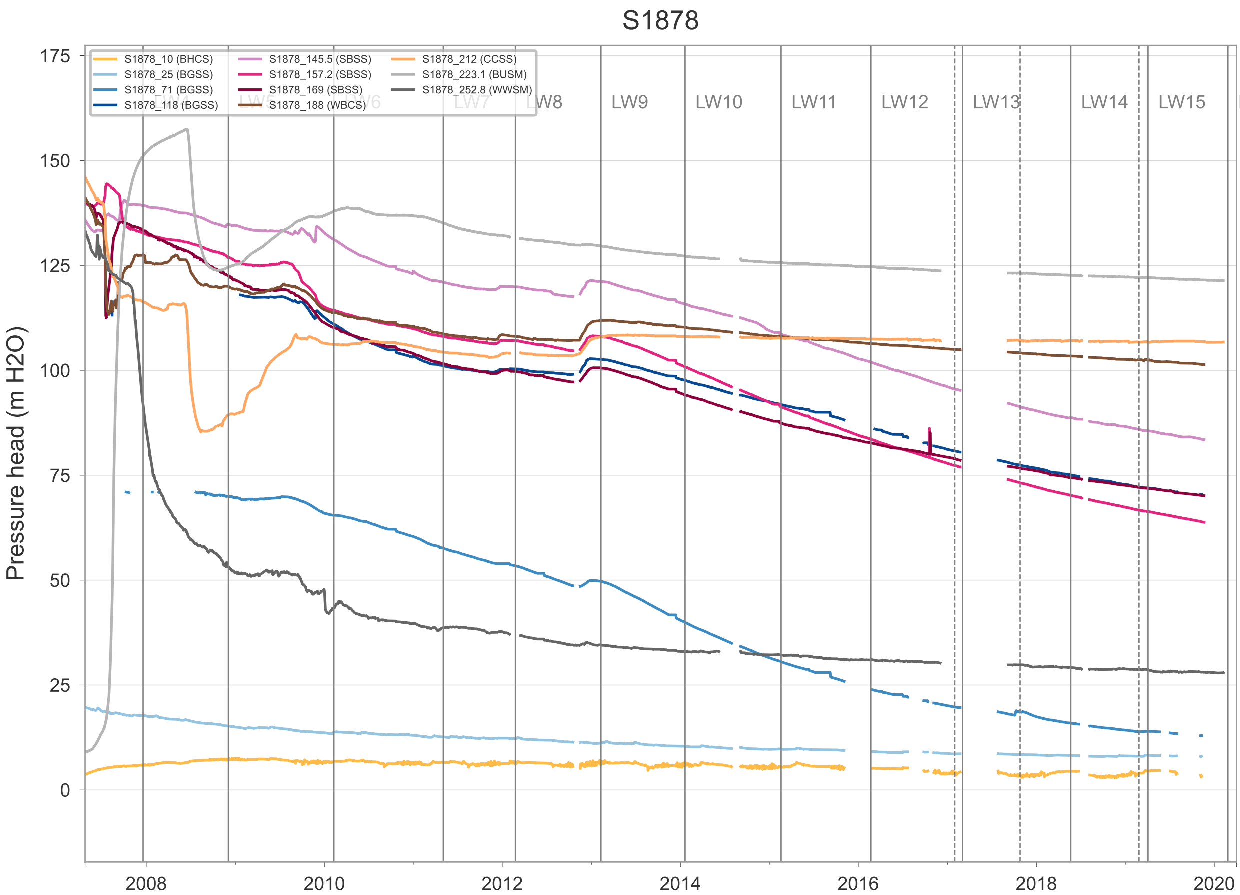

S1870
LW3
LW4
LW5
LW6
LW7
LW8
LW9
LW10
LW11
LW12
LW13
LW14
LW15
LW16
LW17
LW18
LW19
LW21
Ground RL
Piezometric head (m RL)
350
300
250
200
150
100
2008
2010
2012
2014
2016
2018
2020
2022
S1870_10 (HBSS)
S1870_15 (HBSS)
S1870_23 (HBSS)
S1870_55 (BGSS)
S1870_125 (BGSS)
S1870_149 (BGSS)
S1870_177 (SBSS)
S1870_204 (SBSS)
S1870_221 (WBCS)
S1870_244 (CCSS)
S1870_252.5 (BUSM)
S1870_284 (WWSM)
Lake Cordeaux_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM

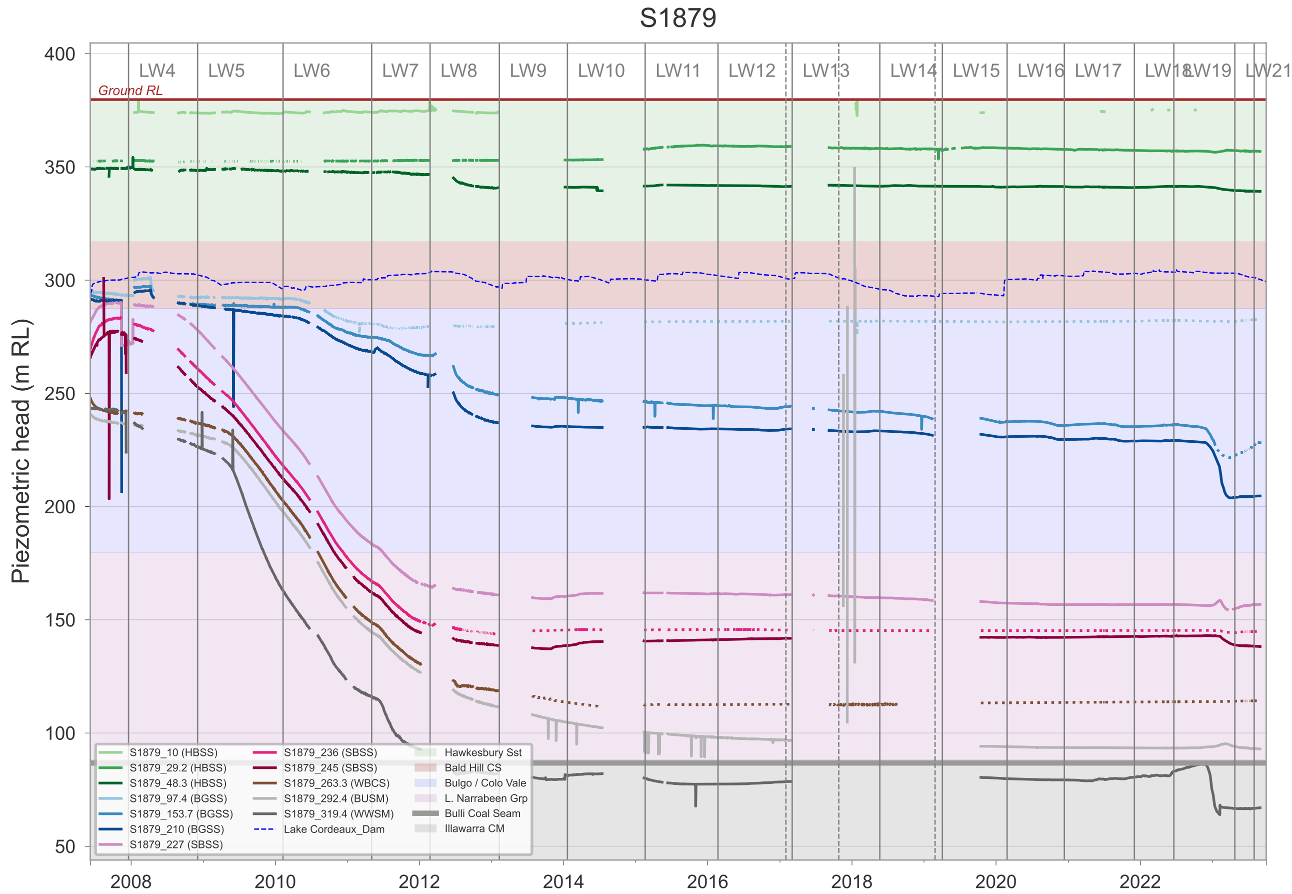

S1870
LW9
LW10
LW11
LW12
LW13
LW14
LW15
LW16
LW17
LW18
LW19
LW21
Pressure head (m H2O)
200
175
150
125
100
75
50
25
0
2008
2010
2012
2014
2016
2018
2020
2022
S1870_10 (HBSS)
S1870_15 (HBSS)
S1870_23 (HBSS)
S1870_55 (BGSS)
S1870_125 (BGSS)
S1870_149 (BGSS)
S1870_177 (SBSS)
S1870_204 (SBSS)
S1870_221 (WBCS)
S1870_244 (CCSS)
S1870_252.5 (BUSM)
S1870_284 (WWSM)

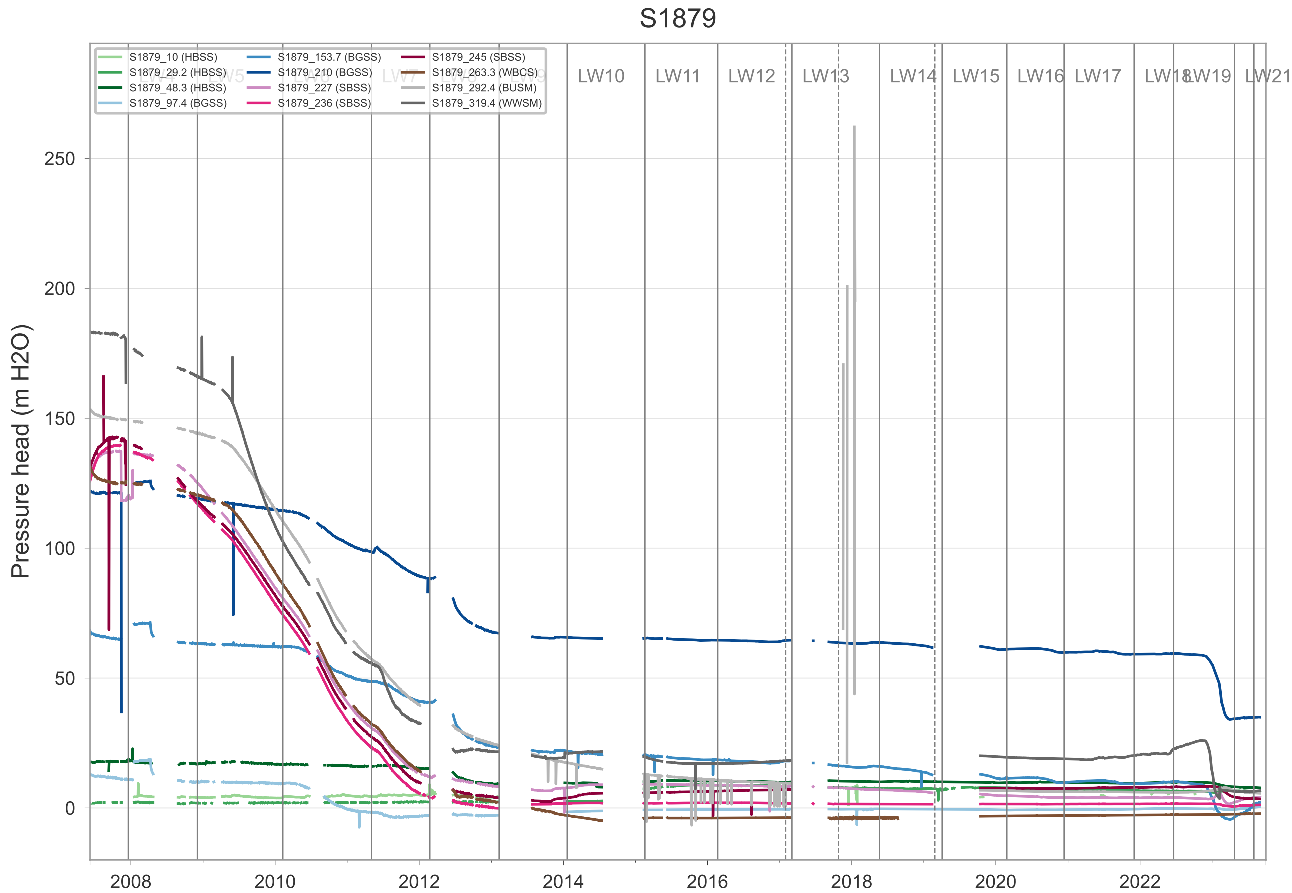

S1871
Piezometric head (m RL)
400
350
300
250
200
150
100
LW3
LW4
LW5
LW6
LW7
LW8
LW9
LW10
LW11
LW12
LW13
LW14
LW15
LW16
LW17
LW18
LW19
LW21
Ground RL
Wongawilli Creek bed
S1871_10 (HBSS)
S1871_31.3 (HBSS)
S1871_40 (HBSS)
S1871_88 (BGSS)
S1871_134 (BGSS)
S1871_184 (BGSS)
S1871_210 (SBSS)
S1871_235 (SBSS)
S1871_253 (WBCS)
S1871_275 (CCSS)
S1871_285.2 (BUSM)
S1871_312.9 (WWSM)
Lake Cordeaux_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM
2008
2010
2012
2014
2016
2018
2020
2022

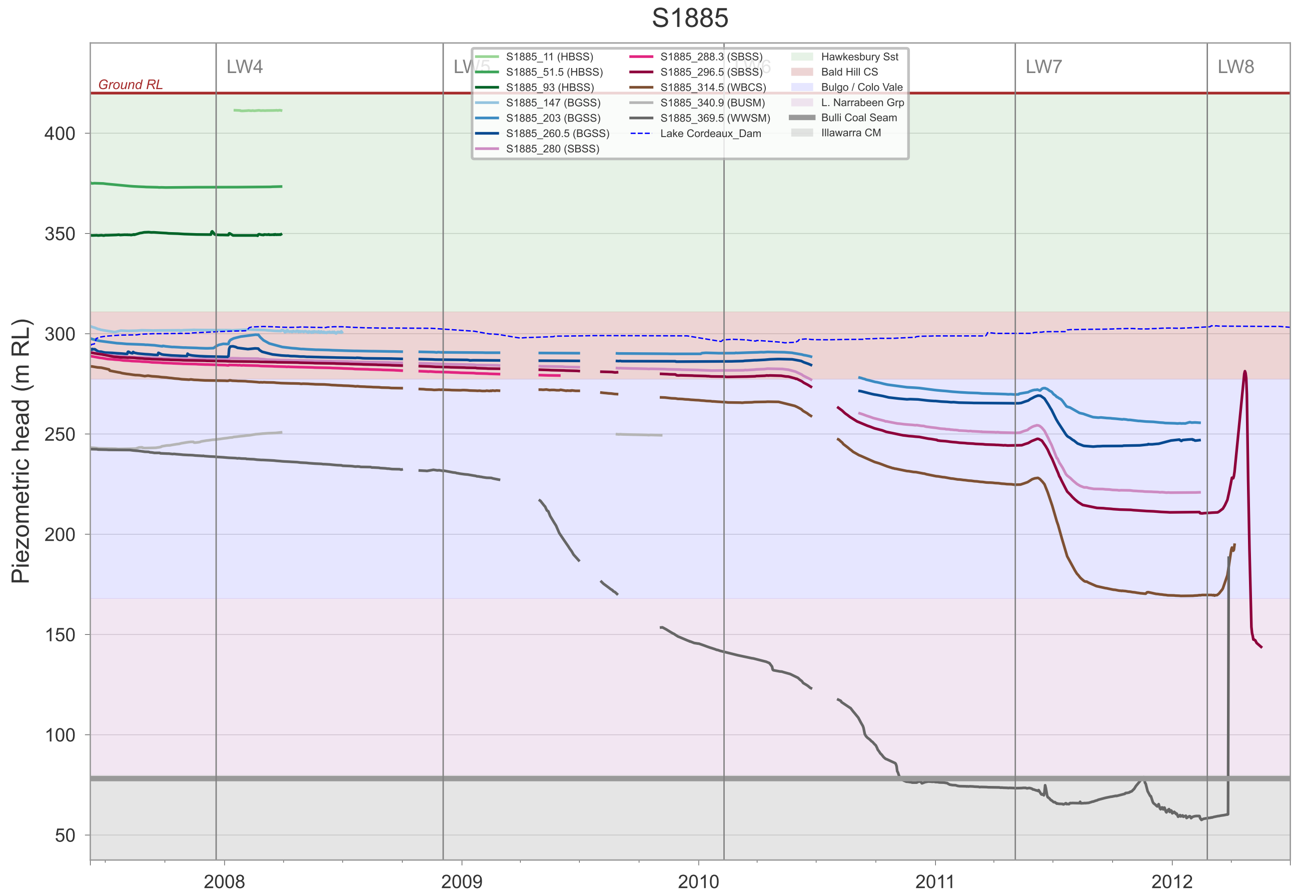

S1871
Pressure head (m H2O)
250
200
150
100
50
0
S1871_10 (HBSS)
S1871_31.3 (HBSS)
S1871_40 (HBSS)
S1871_88 (BGSS)
S1871_134 (BGSS)
S1871_184 (BGSS)
S1871_210 (SBSS)
S1871_235 (SBSS)
S1871_253 (WBCS)
S1871_275 (CCSS)
S1871_285.2 (BUSM)
S1871_312.9 (WWSM)
LW10
LW11
LW12
LW13
LW14
LW15
LW16
LW17
LW18
LW19
LW21
2008
2010
2012
2014
2016
2018
2020
2022

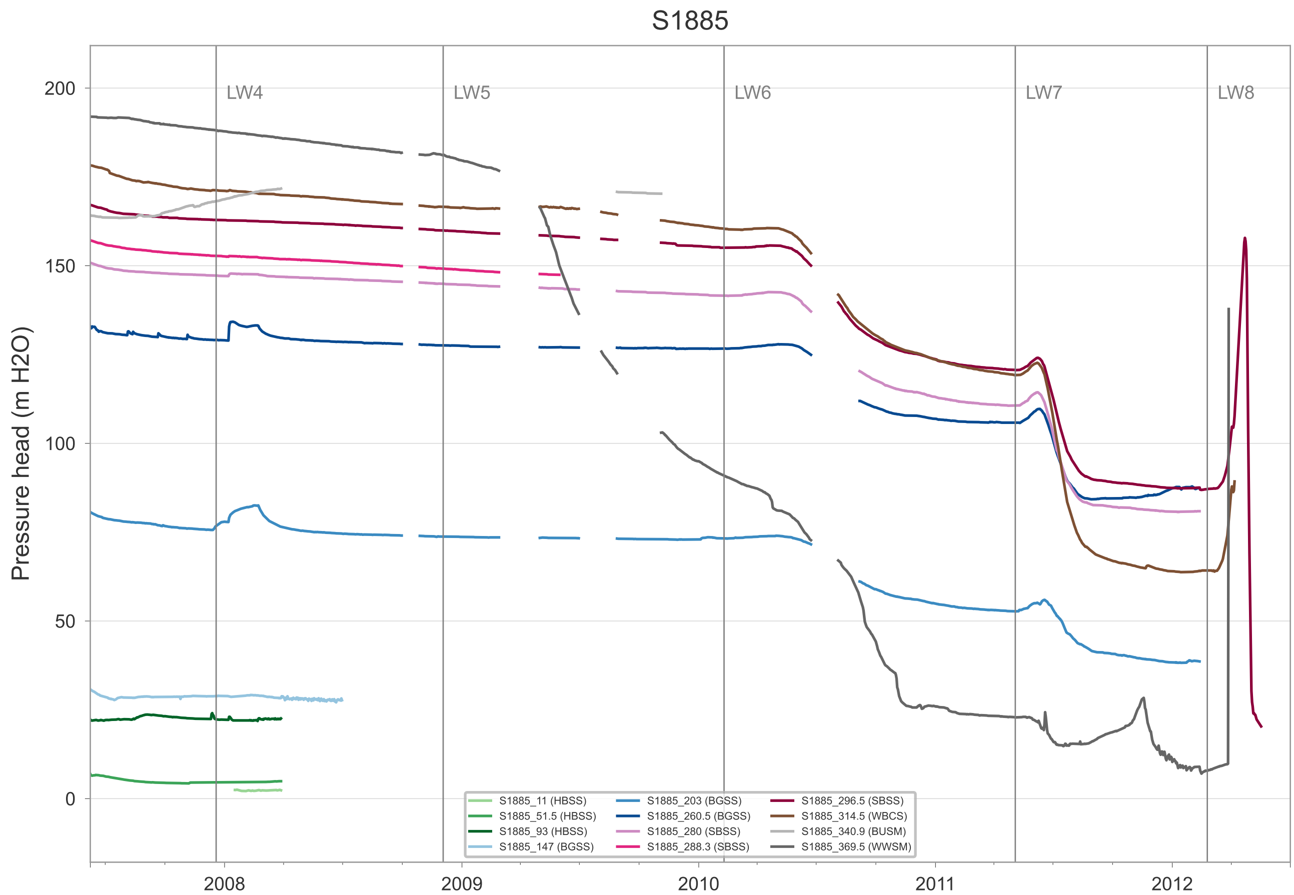

S1878
Piezometric head (m RL)
Ground RL
LW4
LW5
LW6
LW7
LW8
LW9
LW10
LW11
LW12
LW13
LW14
LW15
LW16
S1878_10 (BHCS)
S1878_25 (BGSS)
S1878_71 (BGSS)
S1878_118 (BGSS)
S1878_145.5 (SBSS)
S1878_157.2 (SBSS)
S1878_169 (SBSS)
S1878_188 (WBCS)
S1878_212 (CCSS)
S1878_223.1 (BUSM)
S1878_252.8 (WWSM)
Lake Cordeaux_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM
350
300
250
200
150
100
2008
2010
2012
2014
2016
2018
2020


S1878
Pressure head (m H2O)
S1878_10 (BHCS)
S1878_25 (BGSS)
S1878_71 (BGSS)
S1878_118 (BGSS)
S1878_145.5 (SBSS)
S1878_157.2 (SBSS)
S1878_169 (SBSS)
S1878_188 (WBCS)
S1878_212 (CCSS)
S1878_223.1 (BUSM)
S1878_252.8 (WWSM)
LW8
LW9
LW10
LW11
LW12
LW13
LW14
LW15
LW16
175
150
125
100
75
50
25
0
2008
2010
2012
2014
2016
2018
2020

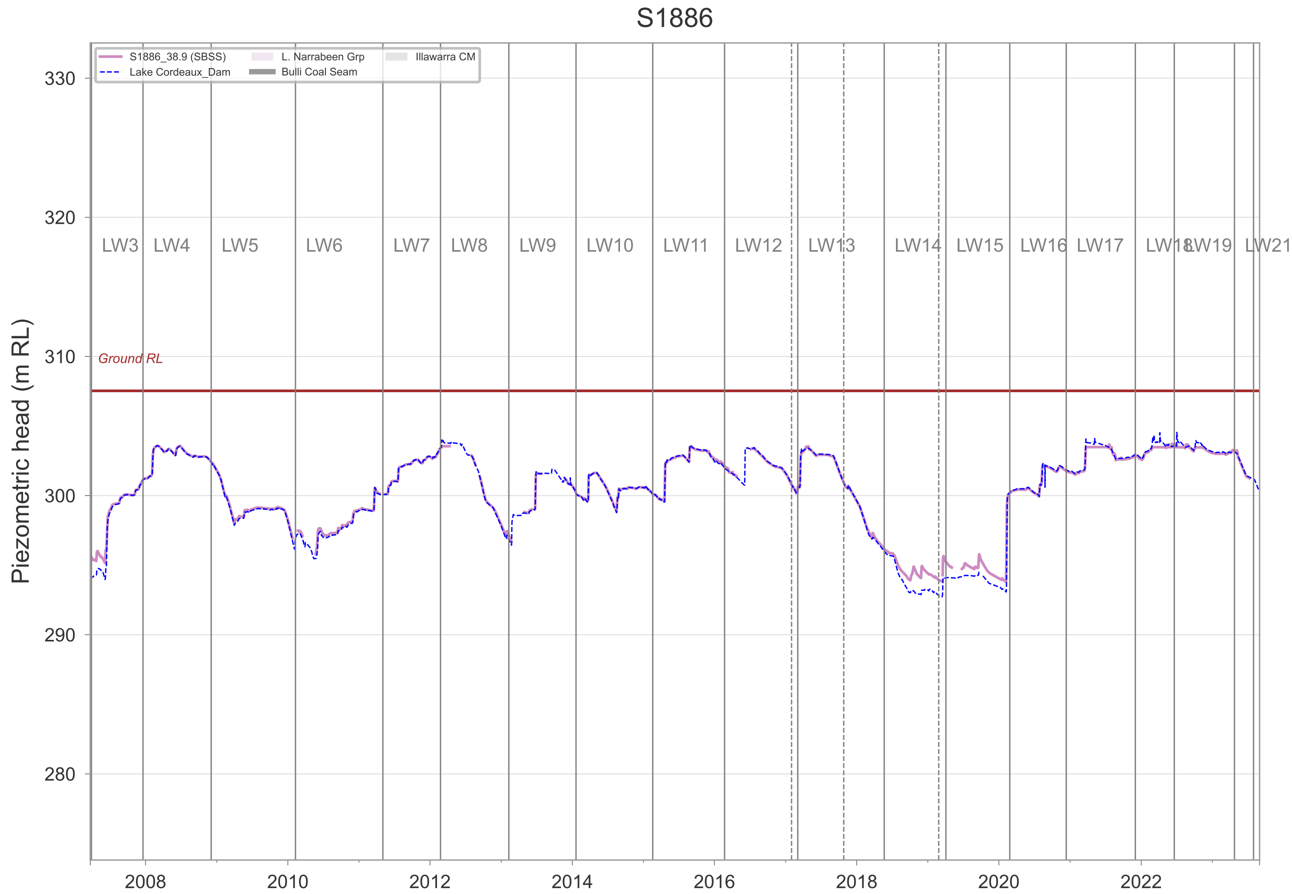

S1879
Piezometric head (m RL)
Ground RL
LW4
LW5
LW6
LW7
LW8
LW9
LW10
LW11
LW12
LW13
LW14
LW15
LW16
LW17
LW18
LW19
LW21
400
350
300
250
200
150
100
50
2008
2010
2012
2014
2016
2018
2020
2022
S1879_10 (HBSS)
S1879_29.2 (HBSS)
S1879_48.3 (HBSS)
S1879_97.4 (BGSS)
S1879_153.7 (BGSS)
S1879_210 (BGSS)
S1879_227 (SBSS)
S1879_236 (SBSS)
S1879_245 (SBSS)
S1879_263.3 (WBCS)
S1879_292.4 (BUSM)
S1879_319.4 (WWSM)
Lake Cordeaux_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM

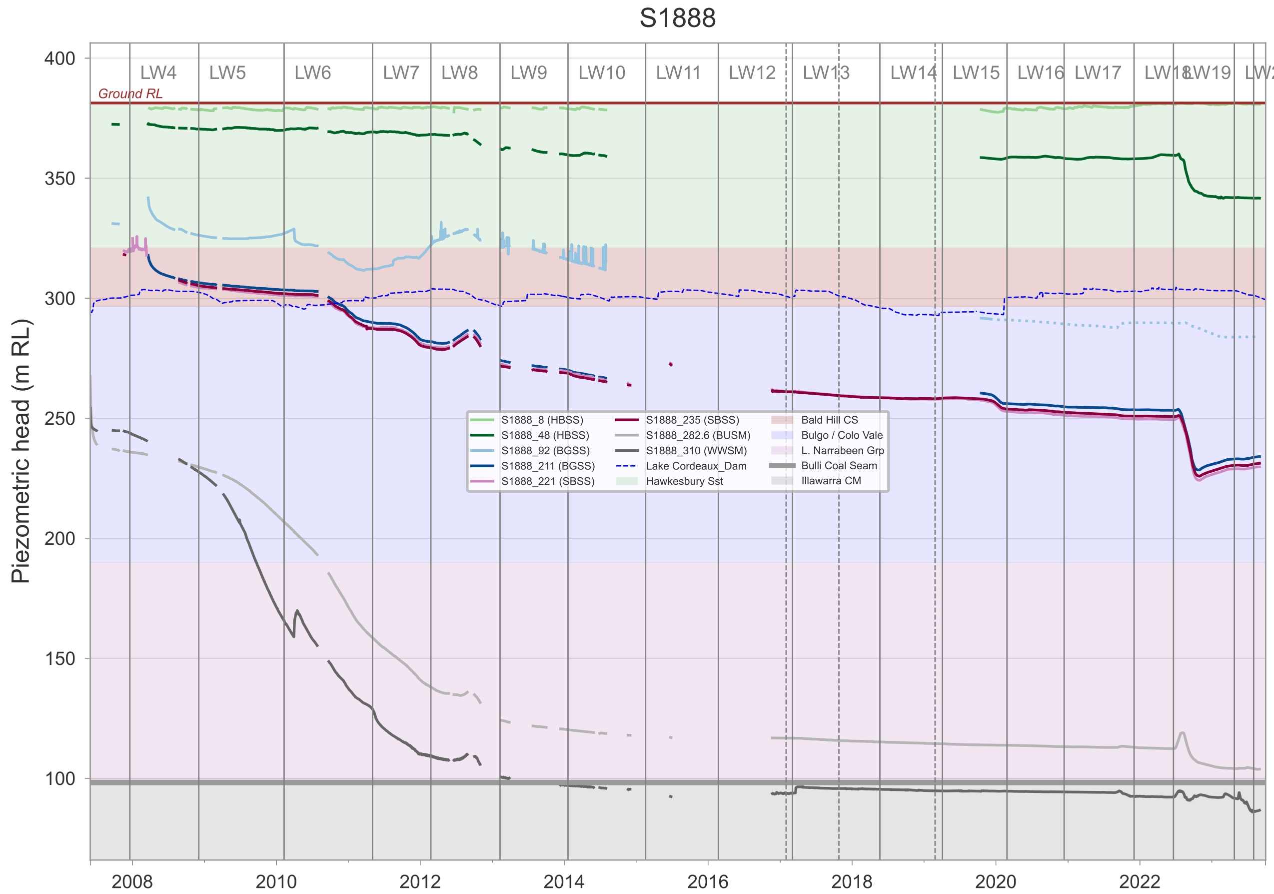

S1879
Pressure head (m H2O)
S1879_10 (HBSS)
S1879_29.2 (HBSS)
S1879_48.3 (HBSS)
S1879_97.4 (BGSS)
S1879_153.7 (BGSS)
S1879_210 (BGSS)
S1879_227 (SBSS)
S1879_236 (SBSS)
S1879_245 (SBSS)
S1879_263.3 (WBCS)
S1879_292.4 (BUSM)
S1879_319.4 (WWSM)
LW10
LW11
LW12
LW13
LW14
LW15
LW16
LW17
LW18
LW19
LW21
250
200
150
100
50
0
2008
2010
2012
2014
2016
2018
2020
2022

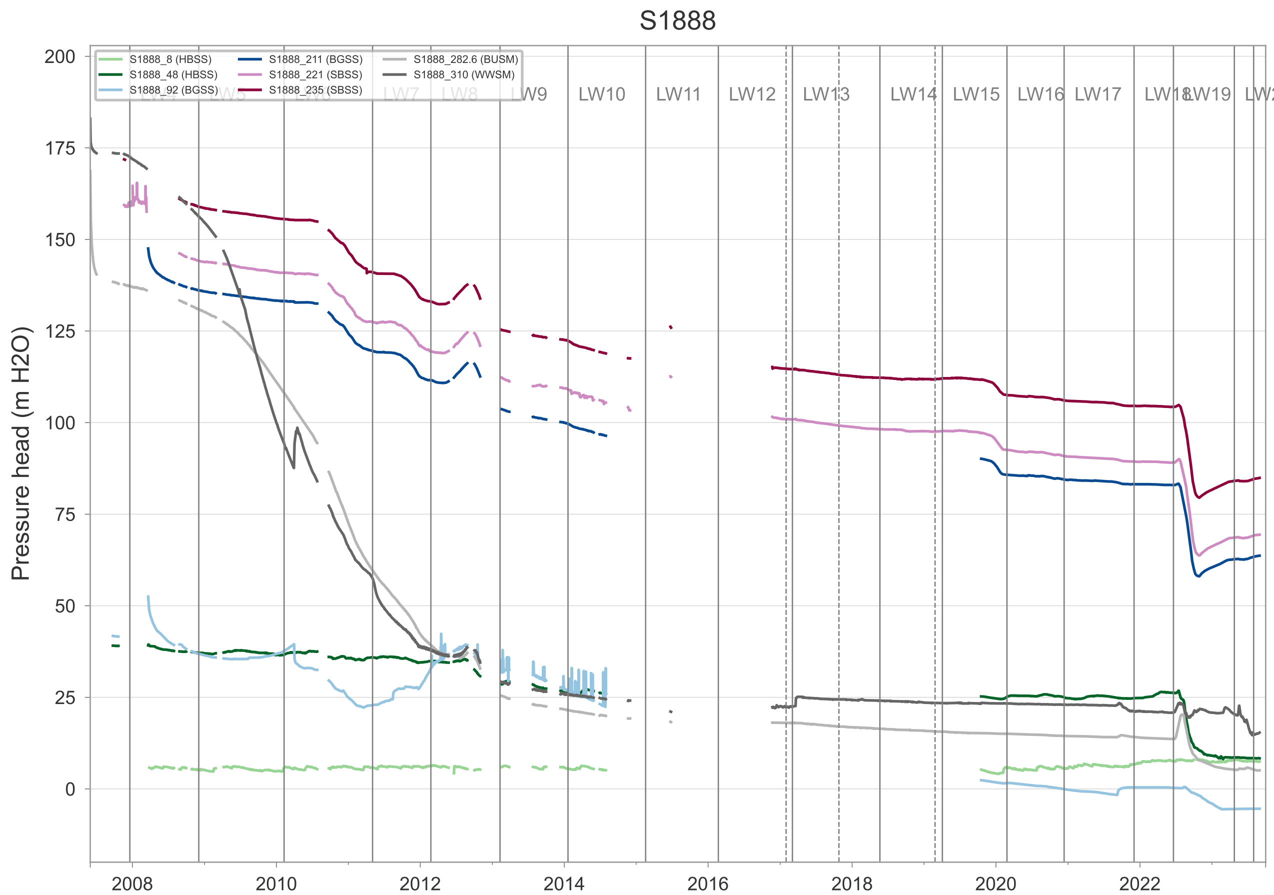

S1885
Ground RL
LW4
LW7
LW8
S1885_11 (HBSS)
S1885_51.5 (HBSS)
S1885_93 (HBSS)
S1885_147 (BGSS)
S1885_203 (BGSS)
S1885_260.5 (BGSS)
S1885_280 (SBSS)
S1885_288.3 (SBSS)
S1885_296.5 (SBSS)
S1885_314.5 (WBCS)
S1885_340.9 (BUSM)
S1885_369.5 (WWSM)
Lake Cordeaux_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM
Piezometric head (m RL)
2008
2009
2010
2011
2012


S1885
LW4
LW5
LW6
LW7
LW8
Pressure head (m H2O)
S1885_11 (HBSS)
S1885_51.5 (HBSS)
S1885_93 (HBSS)
S1885_147 (BGSS)
S1885_203 (BGSS)
S1885_260.5 (BGSS)
S1885_280 (SBSS)
S1885_288.3 (SBSS)
S1885_296.5 (SBSS)
S1885_314.5 (WBCS)
S1885_340.9 (BUSM)
S1885_369.5 (WWSM)
2008
2009
2010
2011
2012

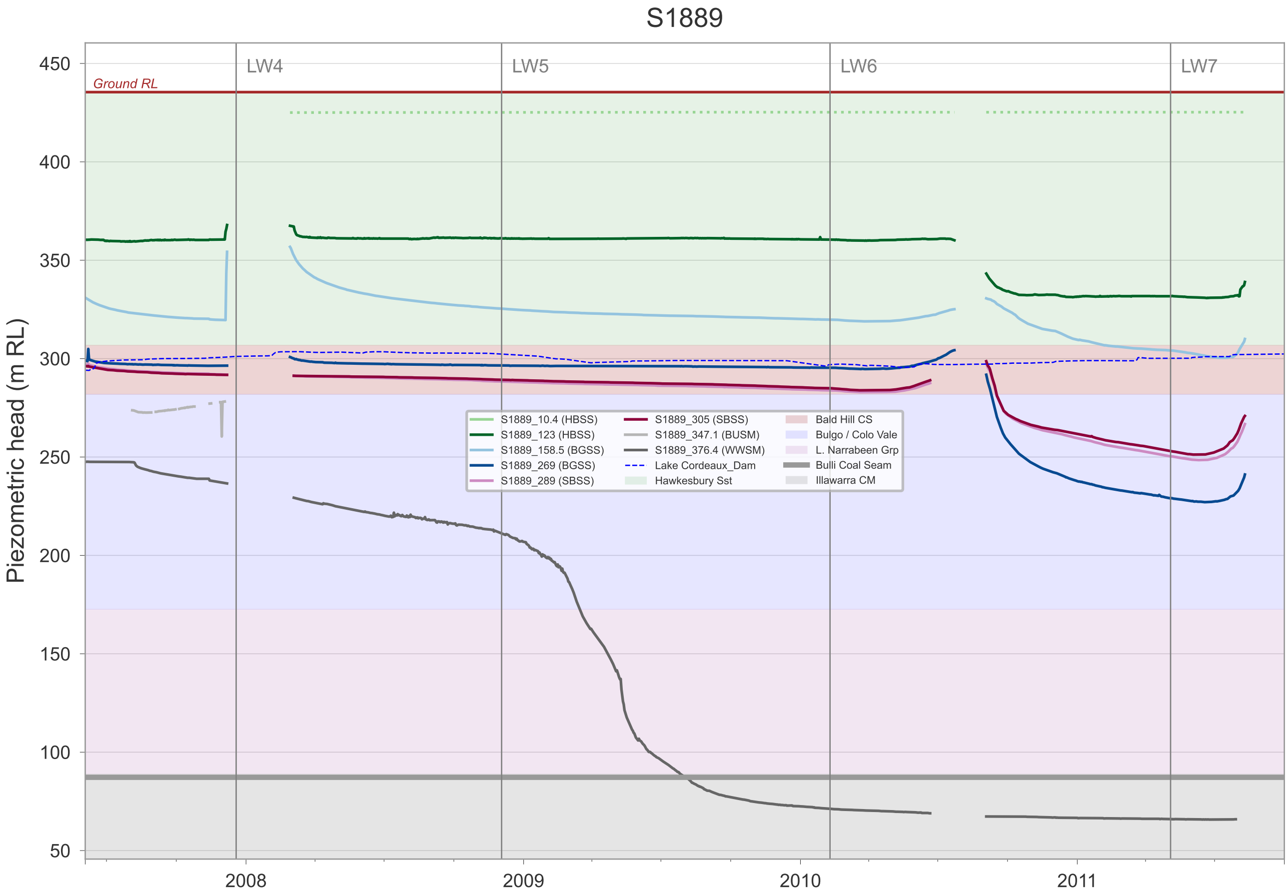
Groundwater hydrographs

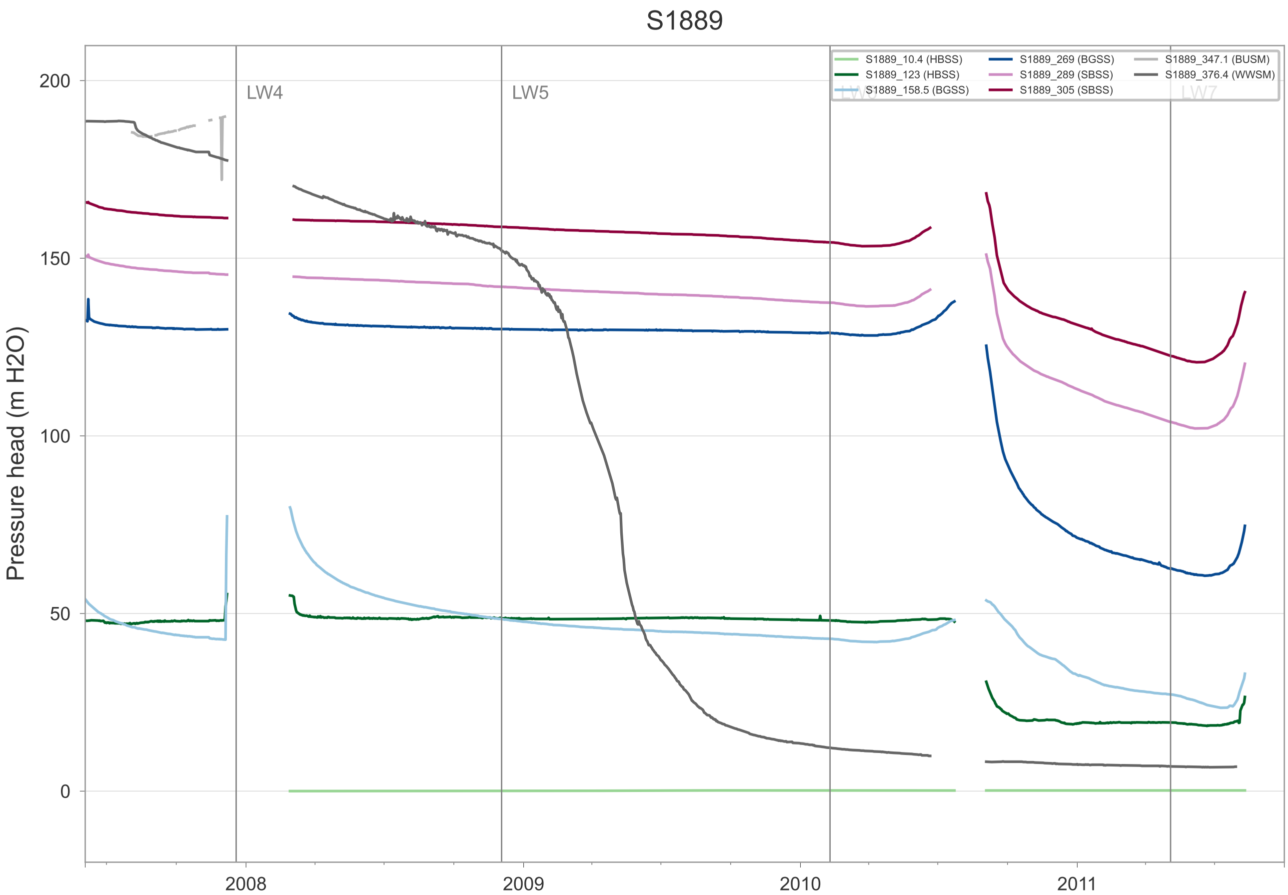


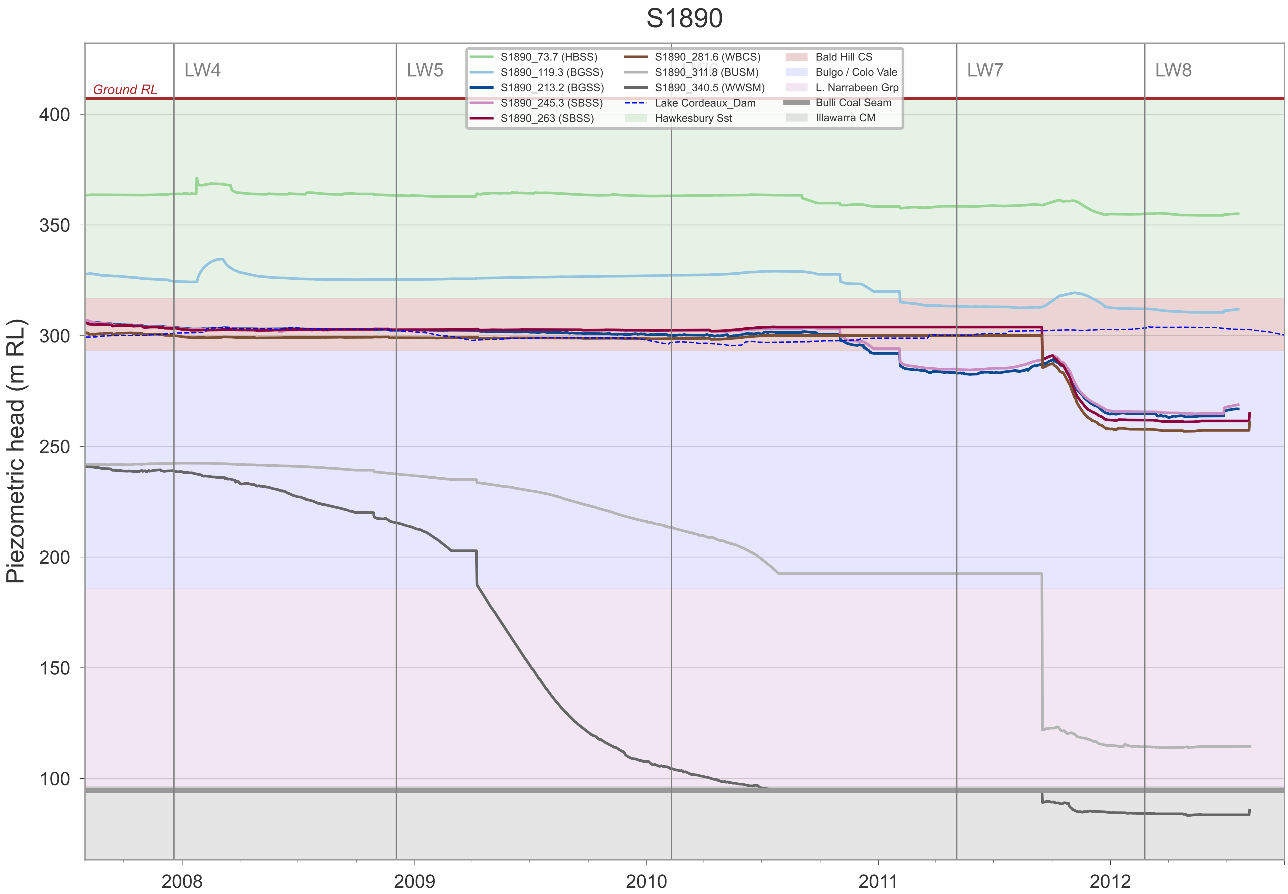

S1888
Piezometric head (m RL)
Ground RL
LW4
LW5
LW6
LW7
LW8
LW9
LW10
LW11
LW12
LW13
LW14
LW15
LW16
LW17
LW18
LW19
LW21
S1888_8 (HBSS)
S1888_48 (HBSS)
S1888_92 (BGSS)
S1888_211 (BGSS)
S1888_221 (SBSS)
S1888_235 (SBSS)
S1888_282.6 (BUSM)
S1888_310 (WWSM)
Lake Cordeaux_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM
400
350
300
250
200
150
100
2008
2010
2012
2014
2016
2018
2020
2022

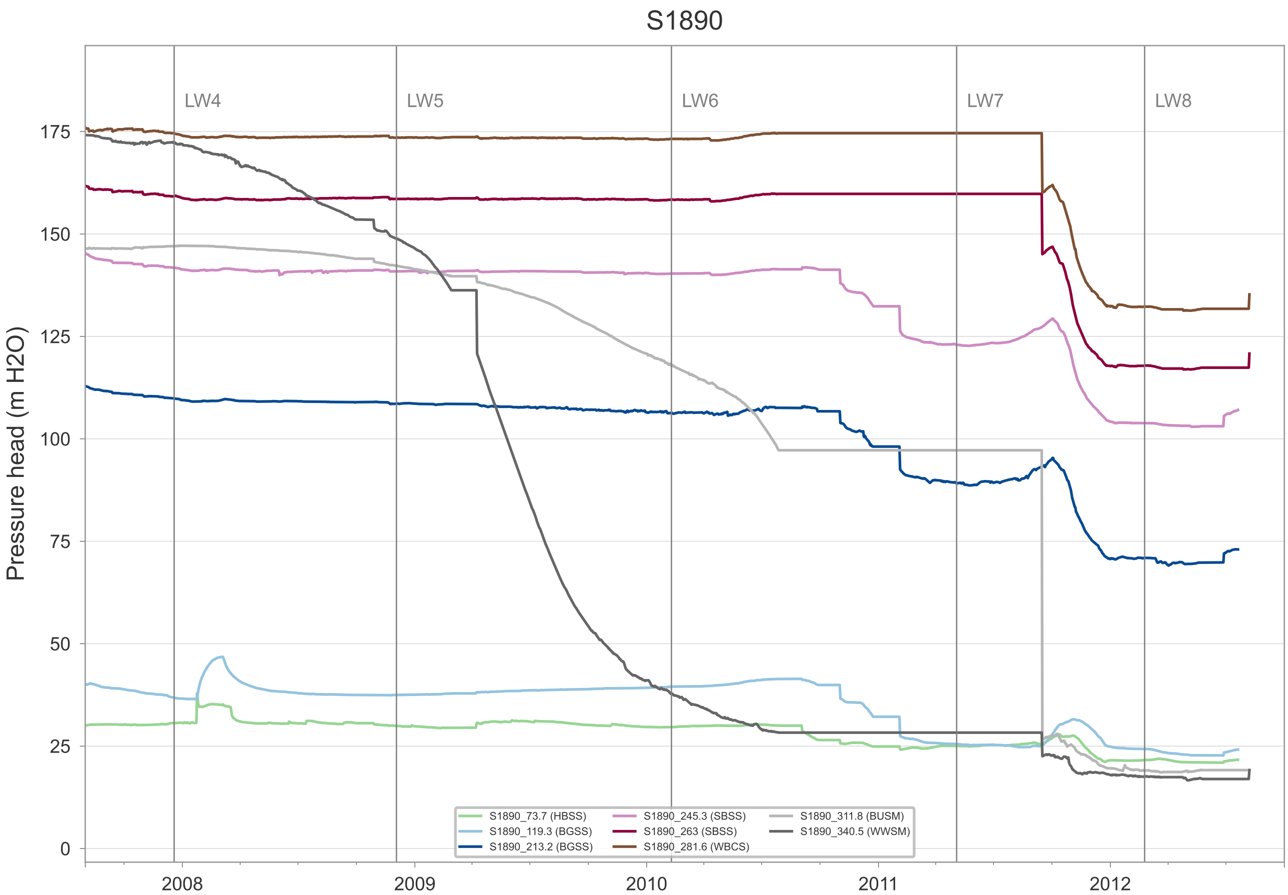

S1888
Pressure head (m H2O)
S1888_8 (HBSS)
S1888_48 (HBSS)
S1888_92 (BGSS)
S1888_211 (BGSS)
S1888_221 (SBSS)
S1888_235 (SBSS)
S1888_282.6 (BUSM)
S1888_310 (WWSM)
LW9
LW10
LW11
LW12
LW13
LW14
LW15
LW16
LW17
LW18
LW19
LW21
200
175
150
125
100
75
50
25
0
2008
2010
2012
2014
2016
2018
2020
2022

Groundwater hydrographs

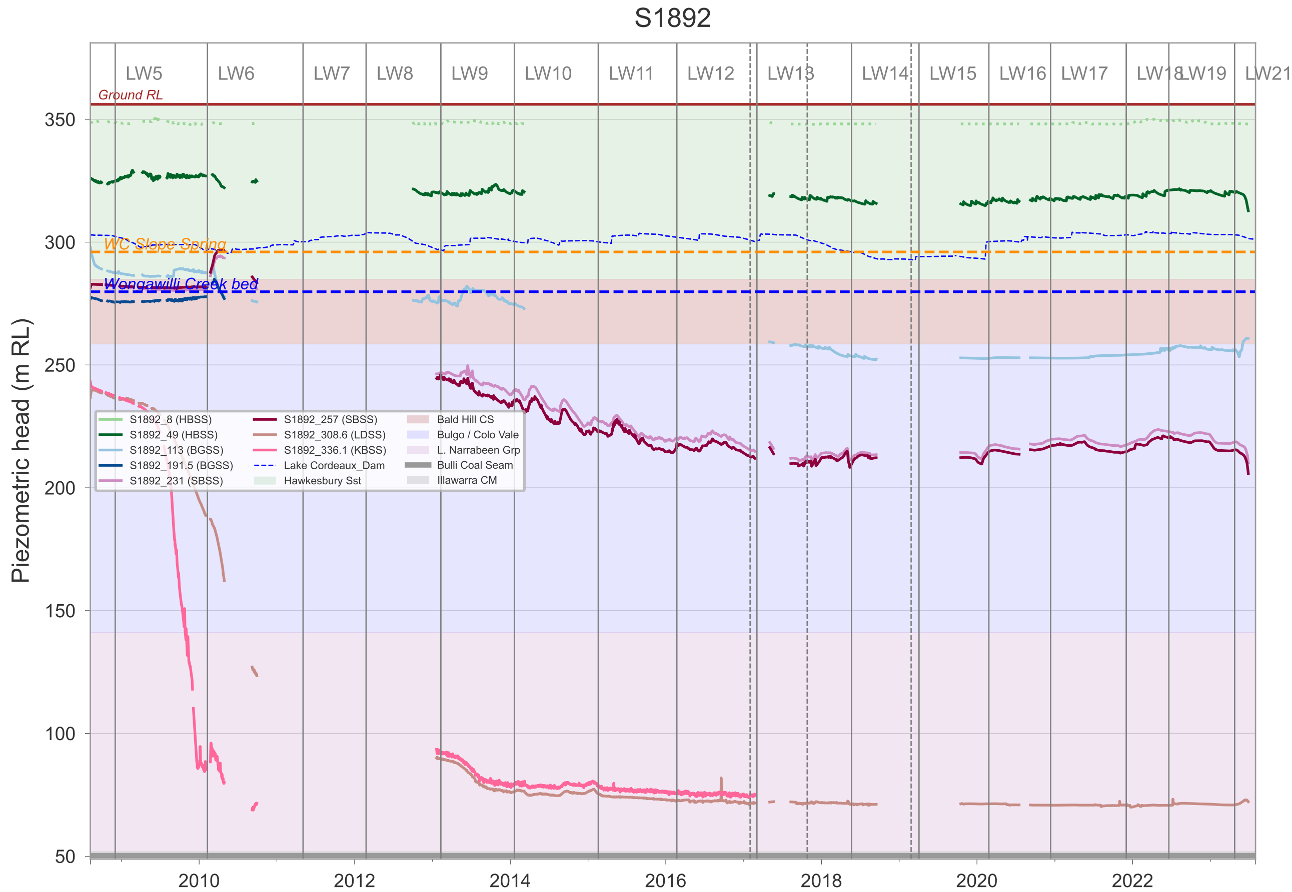


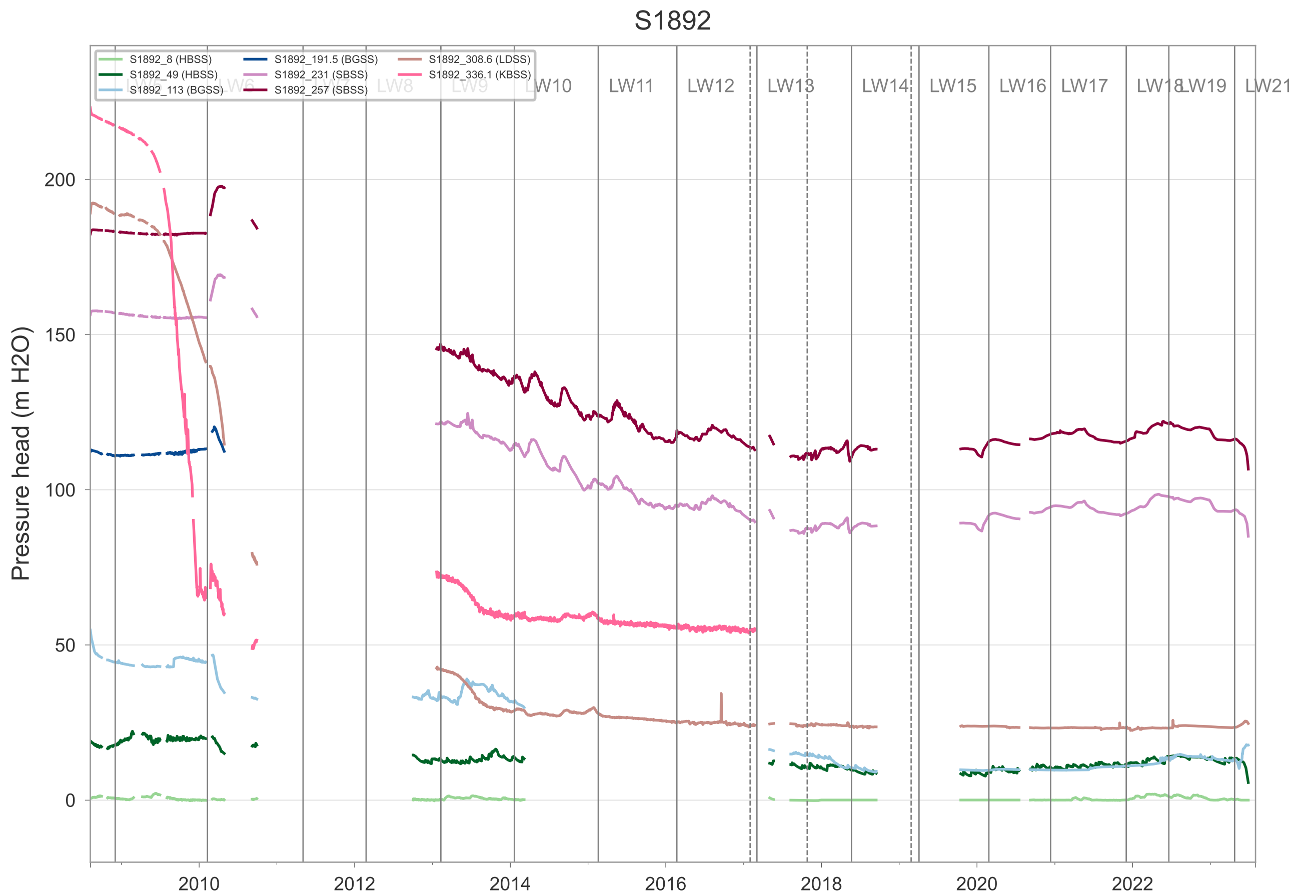



S1890
LW4
LW5
LW7
LW8
Ground RL
S1890_73.7 (HBSS)
S1890_119.3 (BGSS)
S1890_213.2 (BGSS)
S1890_245.3 (SBSS)
S1890_263 (SBSS)
S1890_281.6 (WBCS)
S1890_311.8 (BUSM)
S1890_340.5 (WWSM)
Lake Cordeaux_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM
Piezometric head (m RL)
400
350
300
250
200
150
100
2008
2009
2010
2011
2012

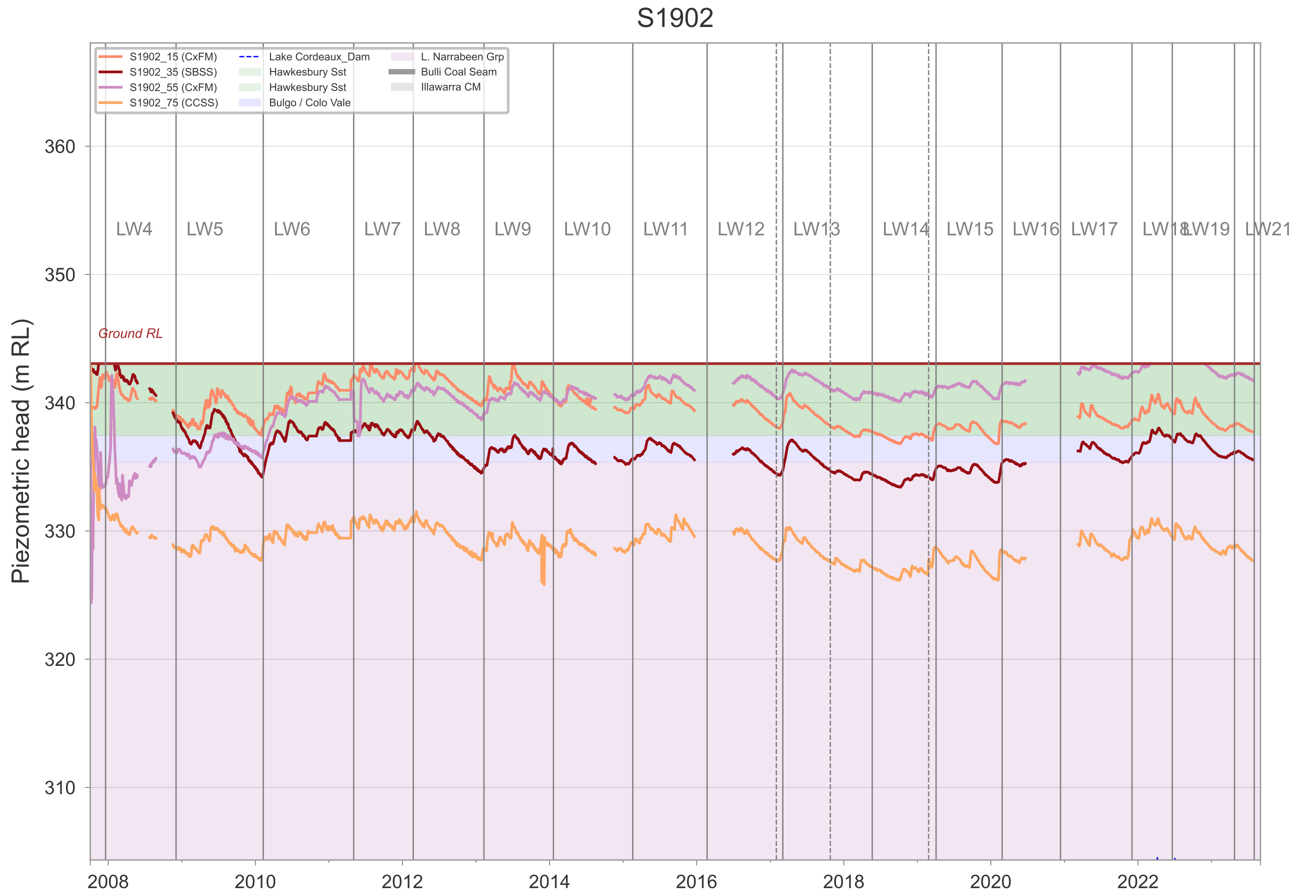

S1890
LW4
LW5
LW6
LW7
LW8
Pressure head (m H2O)
175
150
125
100
75
50
25
0
S1890_73.7 (HBSS)
S1890_119.3 (BGSS)
S1890_213.2 (BGSS)
S1890_245.3 (SBSS)
S1890_263 (SBSS)
S1890_281.6 (WBCS)
S1890_311.8 (BUSM)
S1890_340.5 (WWSM)
2008
2009
2010
2011
2012

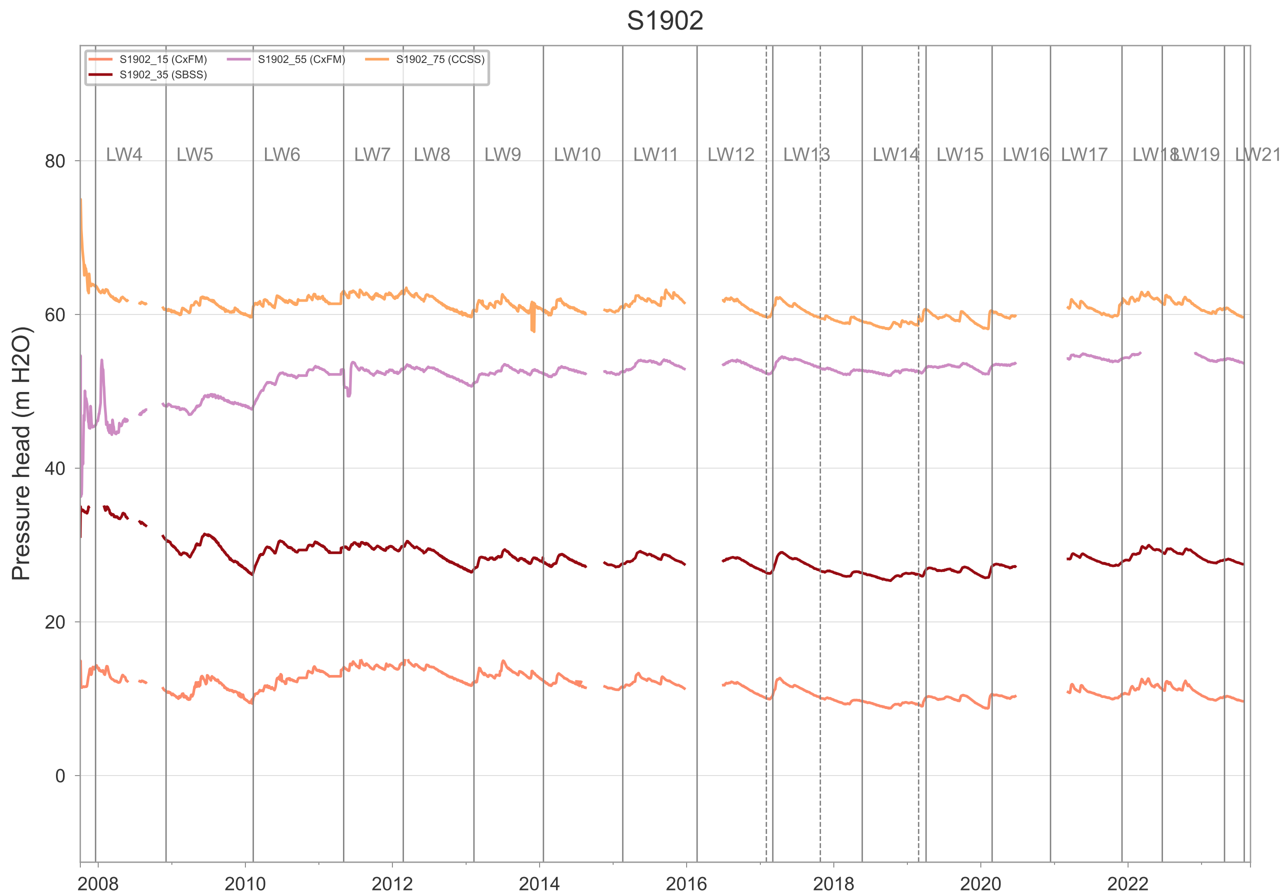
Groundwater hydrographs



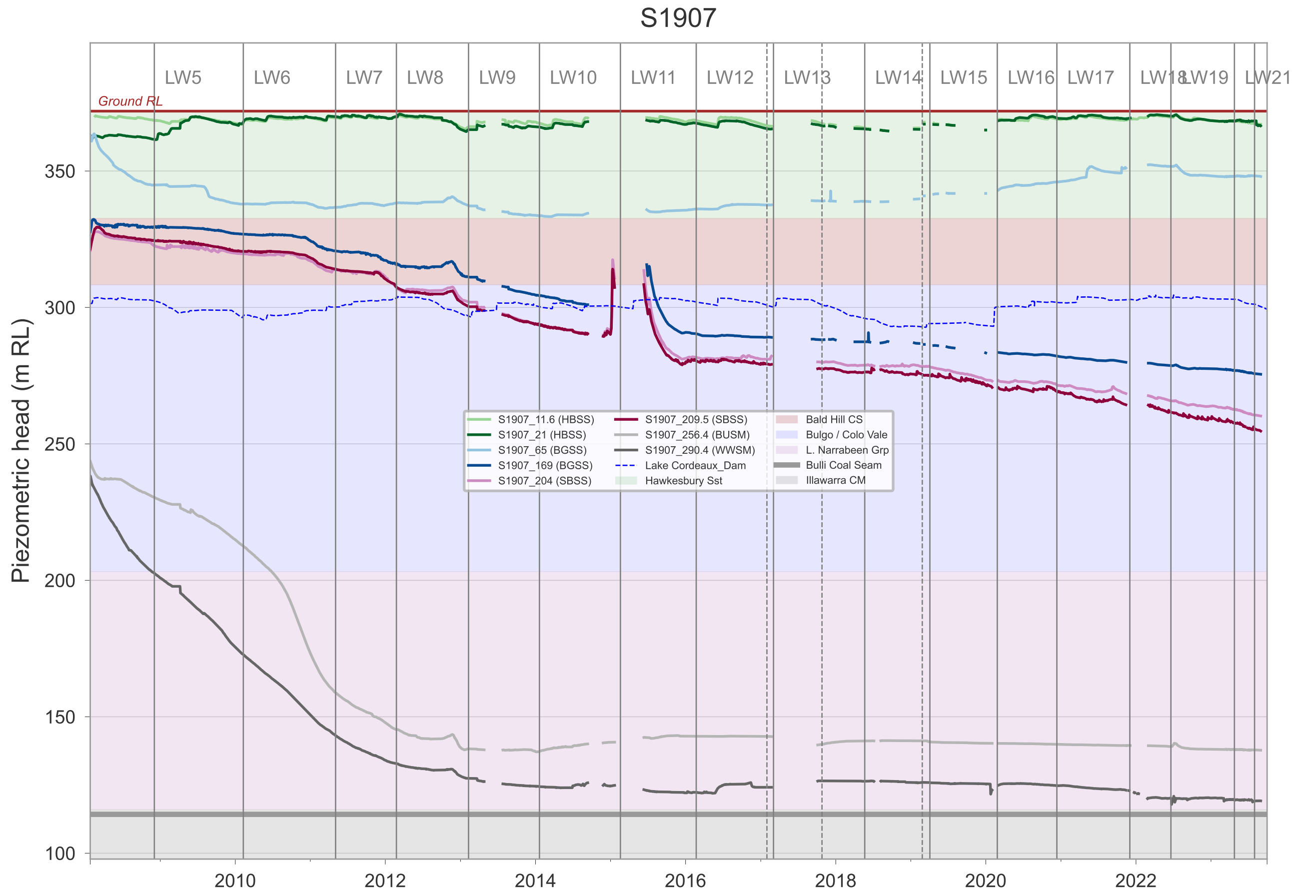


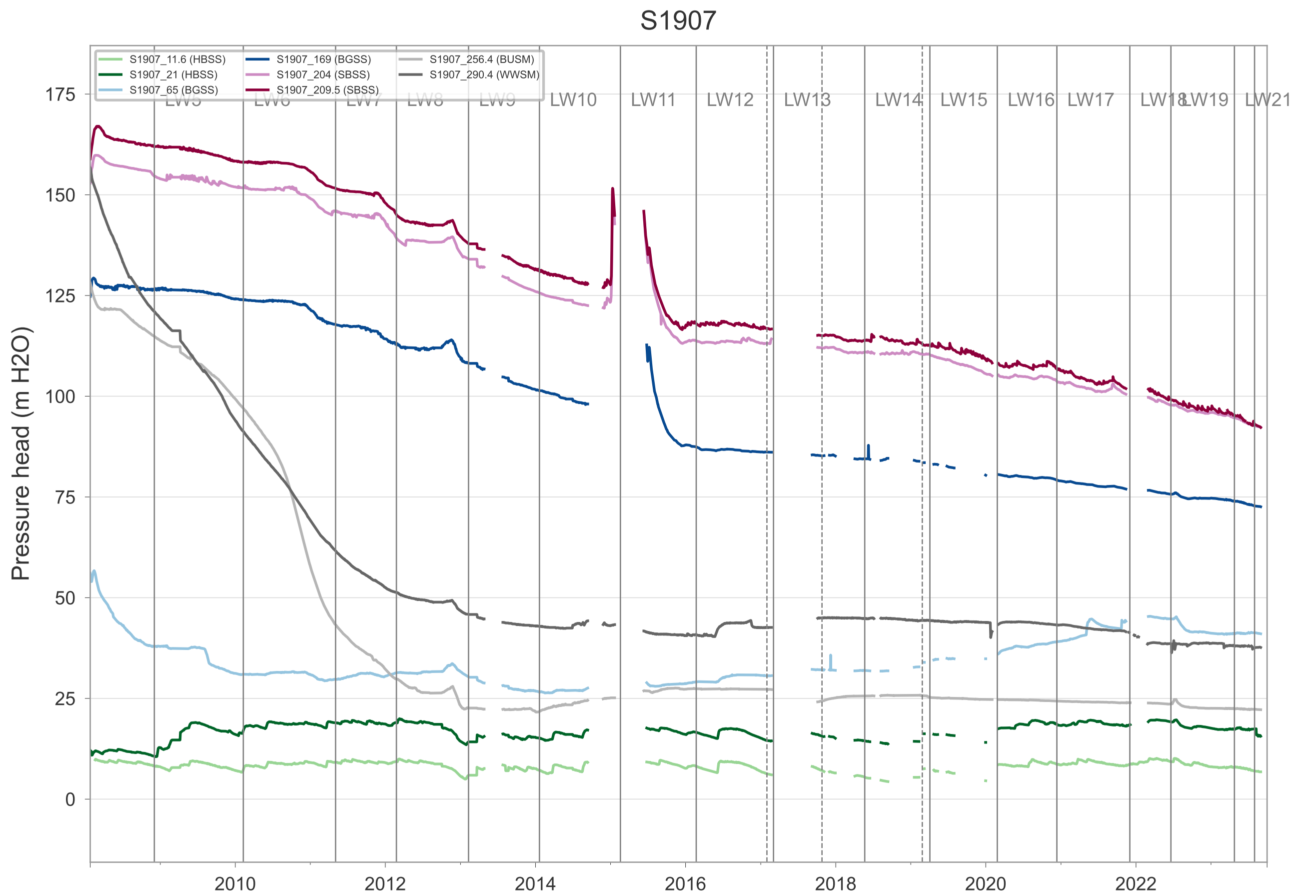
Groundwater hydrographs

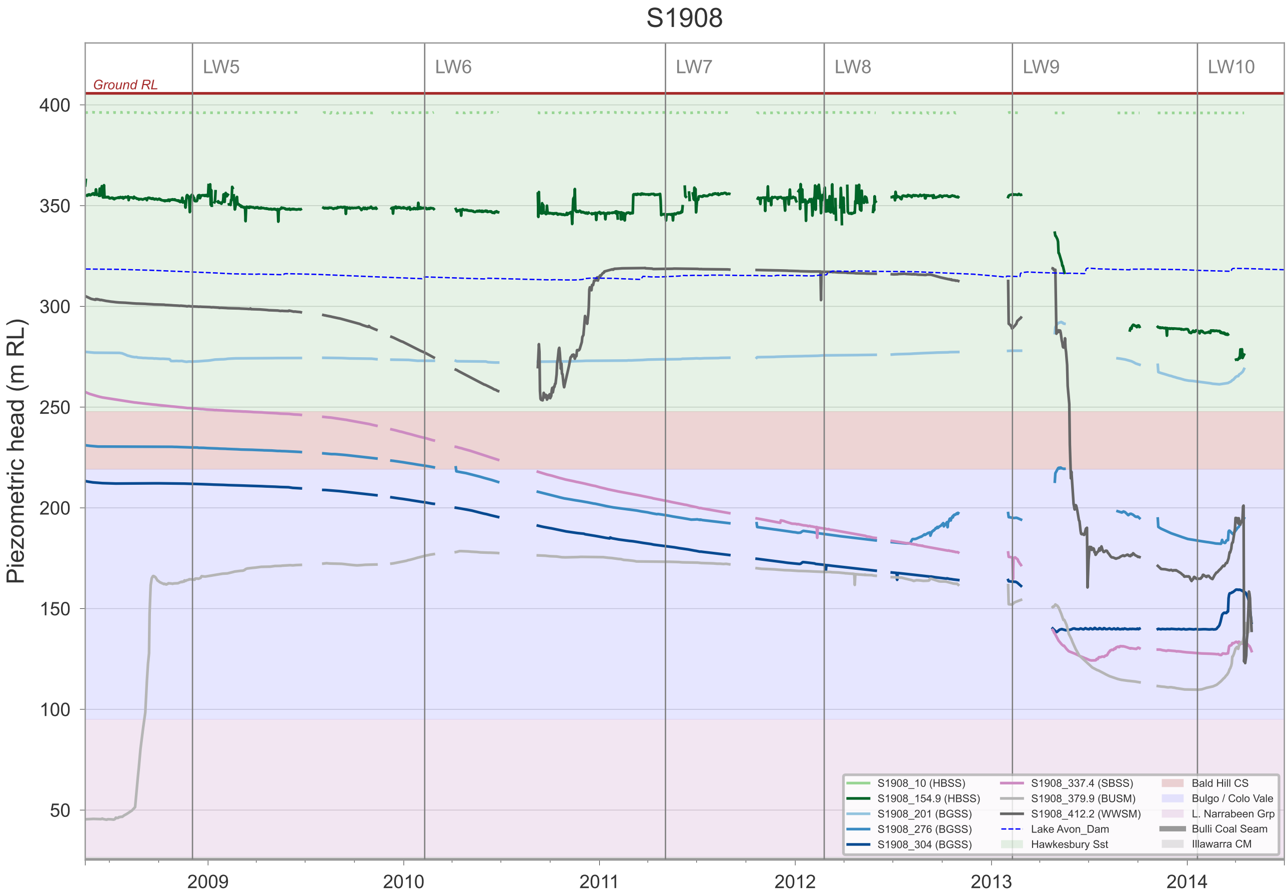


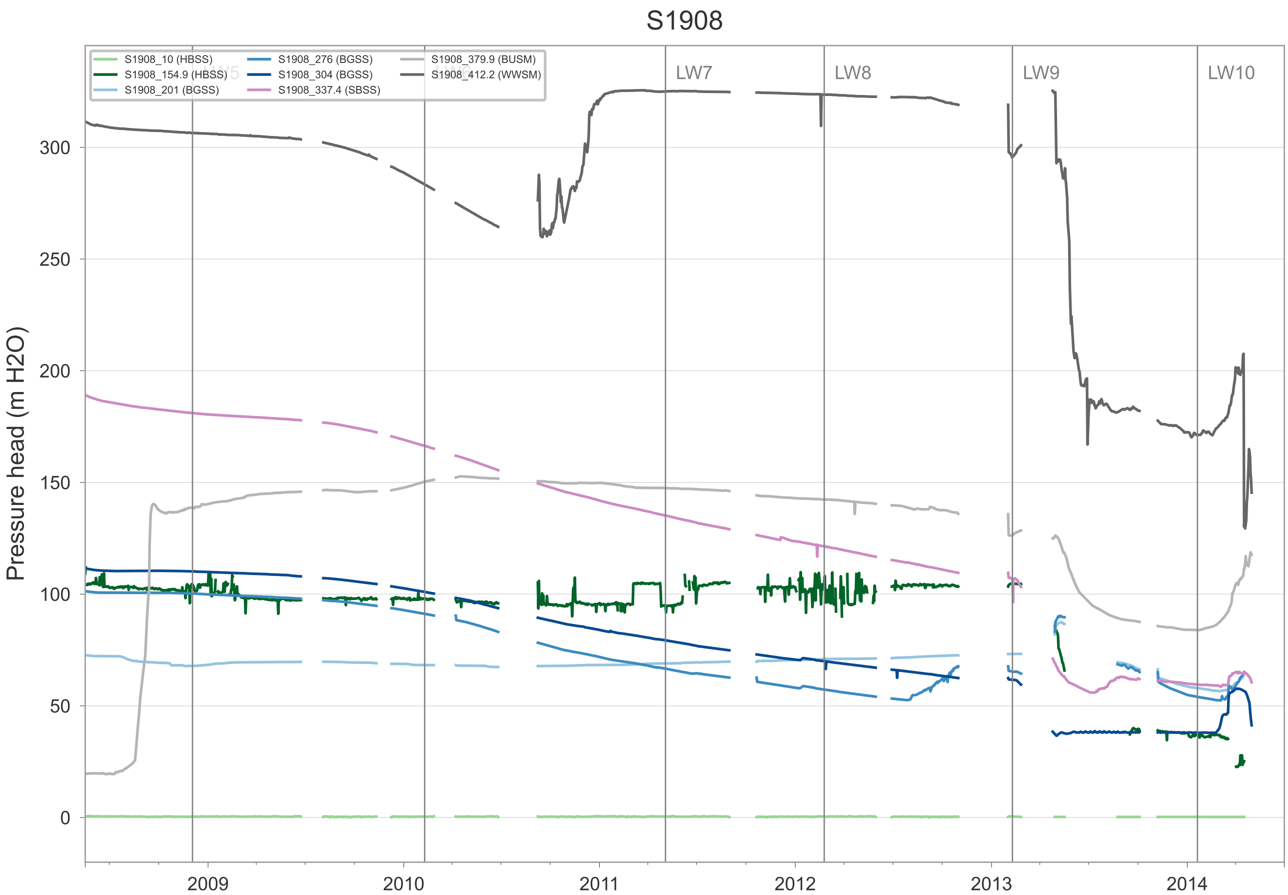


Groundwater hydrographs

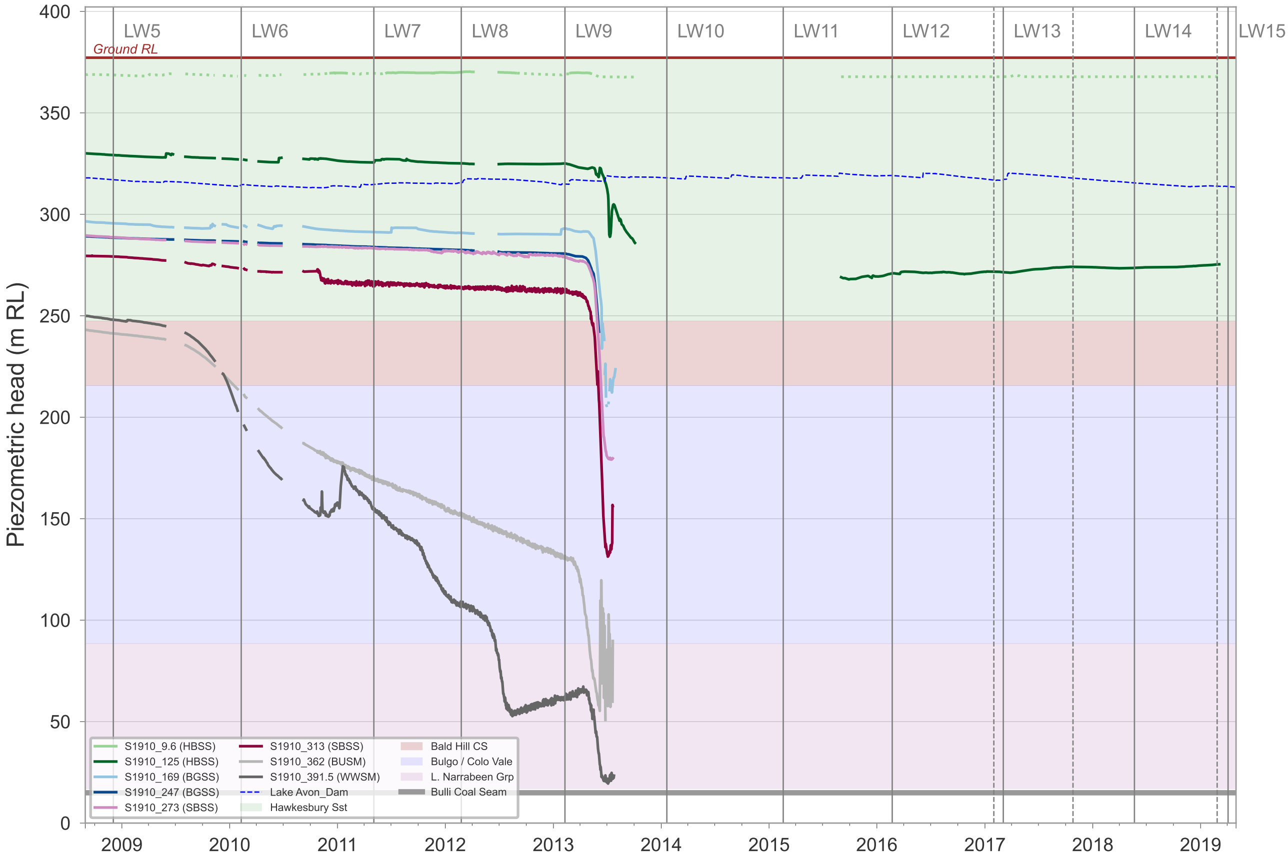





S1908
LW5
LW6
LW7
LW8
LW9
LW10
Ground RL
Piezometric head (m RL)
400
350
300
250
200
150
100
50
2009
2010
2011
2012
2013
2014
S1908_10 (HBSS)
S1908_154.9 (HBSS)
S1908_201 (BGSS)
S1908_276 (BGSS)
S1908_304 (BGSS)
S1908_337.4 (SBSS)
S1908_379.9 (BUSM)
S1908_412.2 (WWSM)
Lake Avon_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM

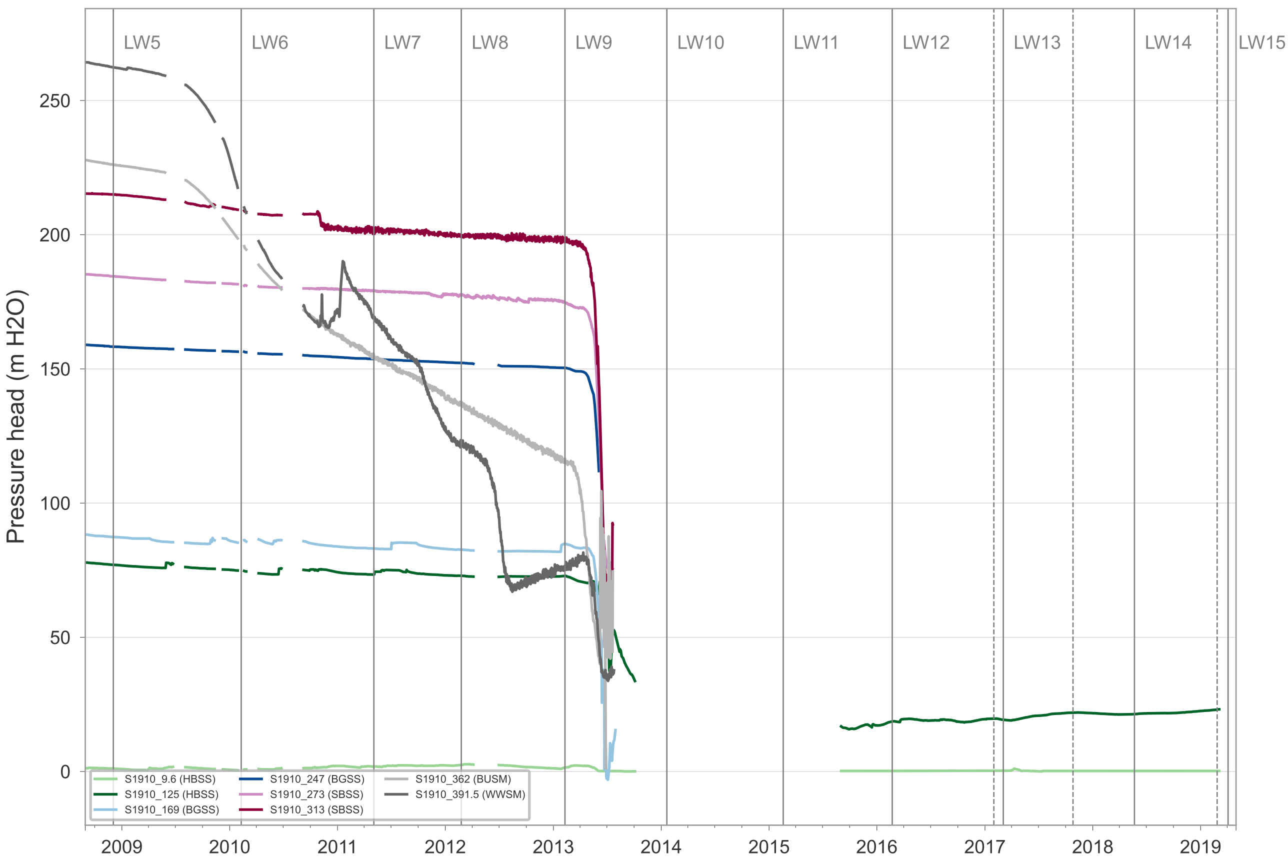

S1908
LW7
LW8
LW9
LW10
Pressure head (m H2O)
300
250
200
150
100
50
0
2009
2010
2011
2012
2013
2014
S1908_10 (HBSS)
S1908_154.9 (HBSS)
S1908_201 (BGSS)
S1908_276 (BGSS)
S1908_304 (BGSS)
S1908_337.4 (SBSS)
S1908_379.9 (BUSM)
S1908_412.2 (WWSM)

S1910

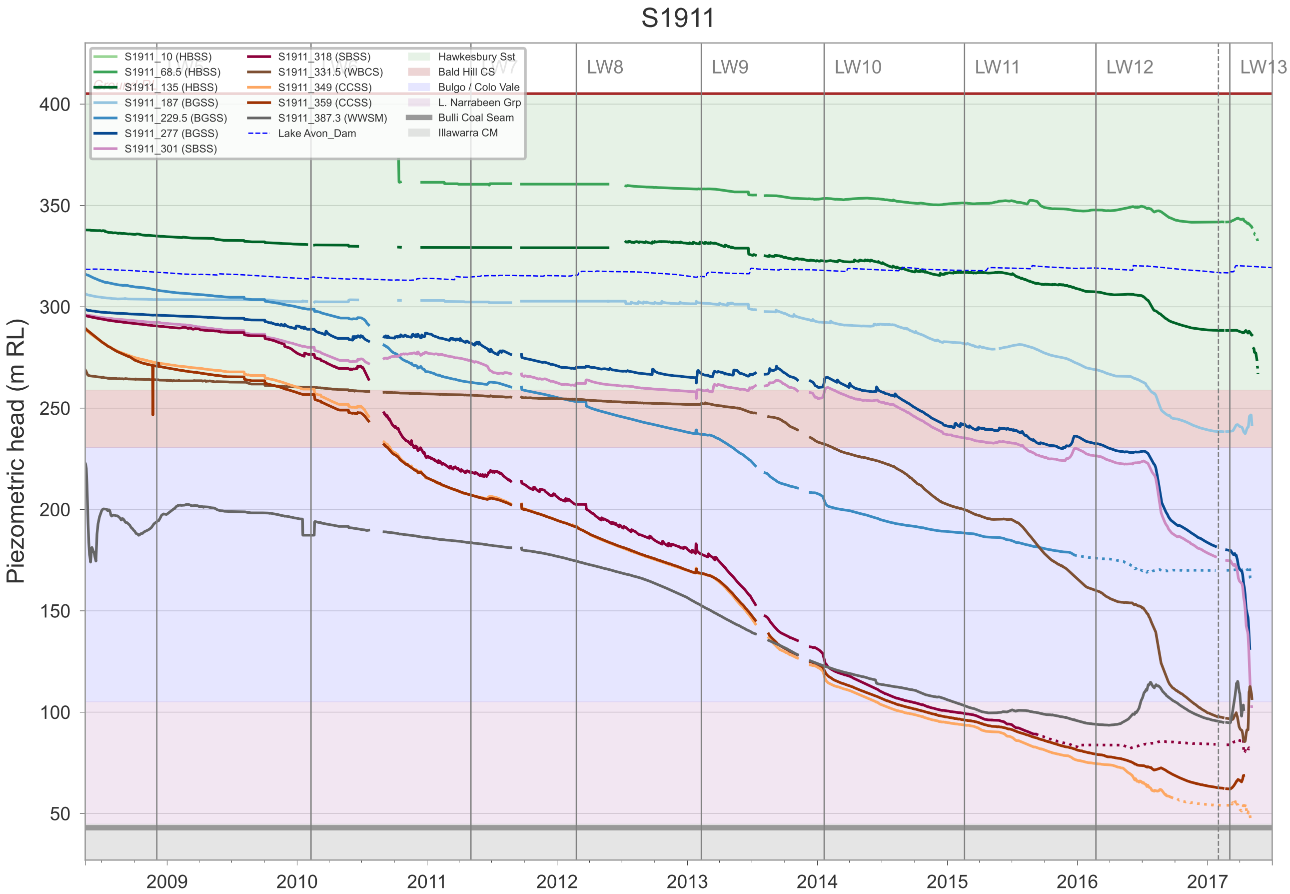


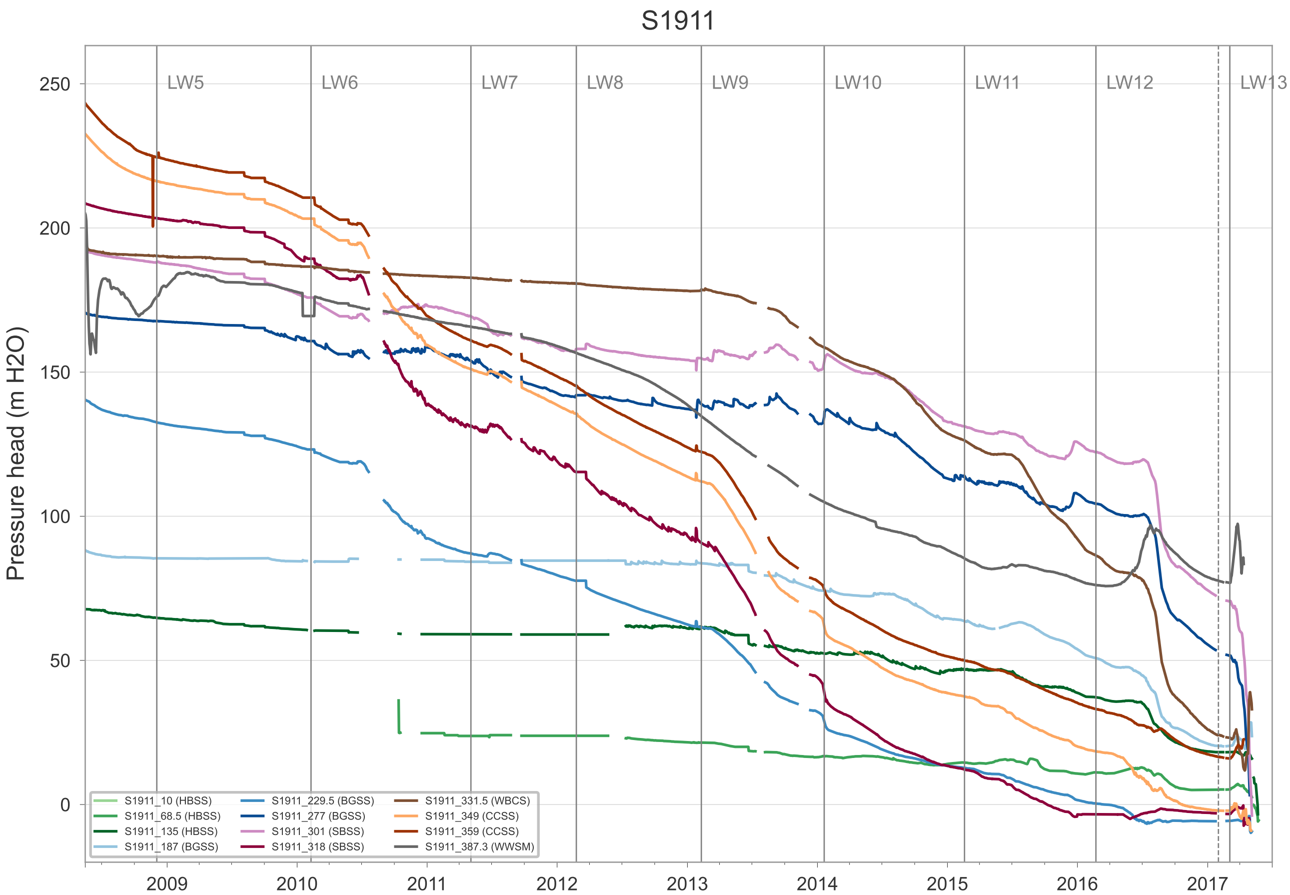
Piezometric head (m RL)
LW5
LW6
LW7
LW8
LW9
LW10
LW11
LW12
LW13
LW14
LW15
Ground RL
S1910_9.6 (HBSS)
S1910_125 (HBSS)
S1910_169 (BGSS)
S1910_247 (BGSS)
S1910_273 (SBSS)
S1910_313 (SBSS)
S1910_362 (BUSM)
S1910_391.5 (WWSM)
Lake Avon_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
0
50
100
150
200
250
300
350
400
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019

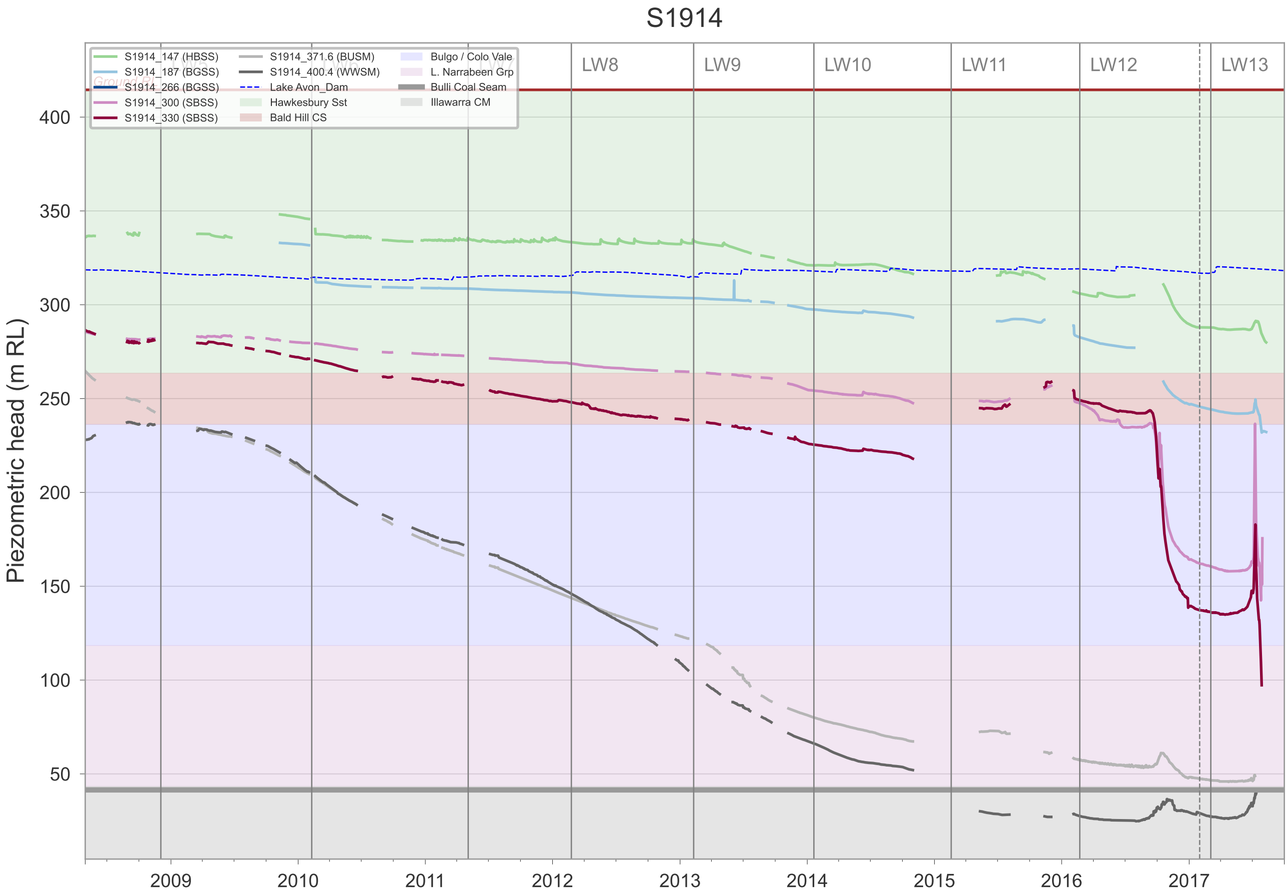
S1910

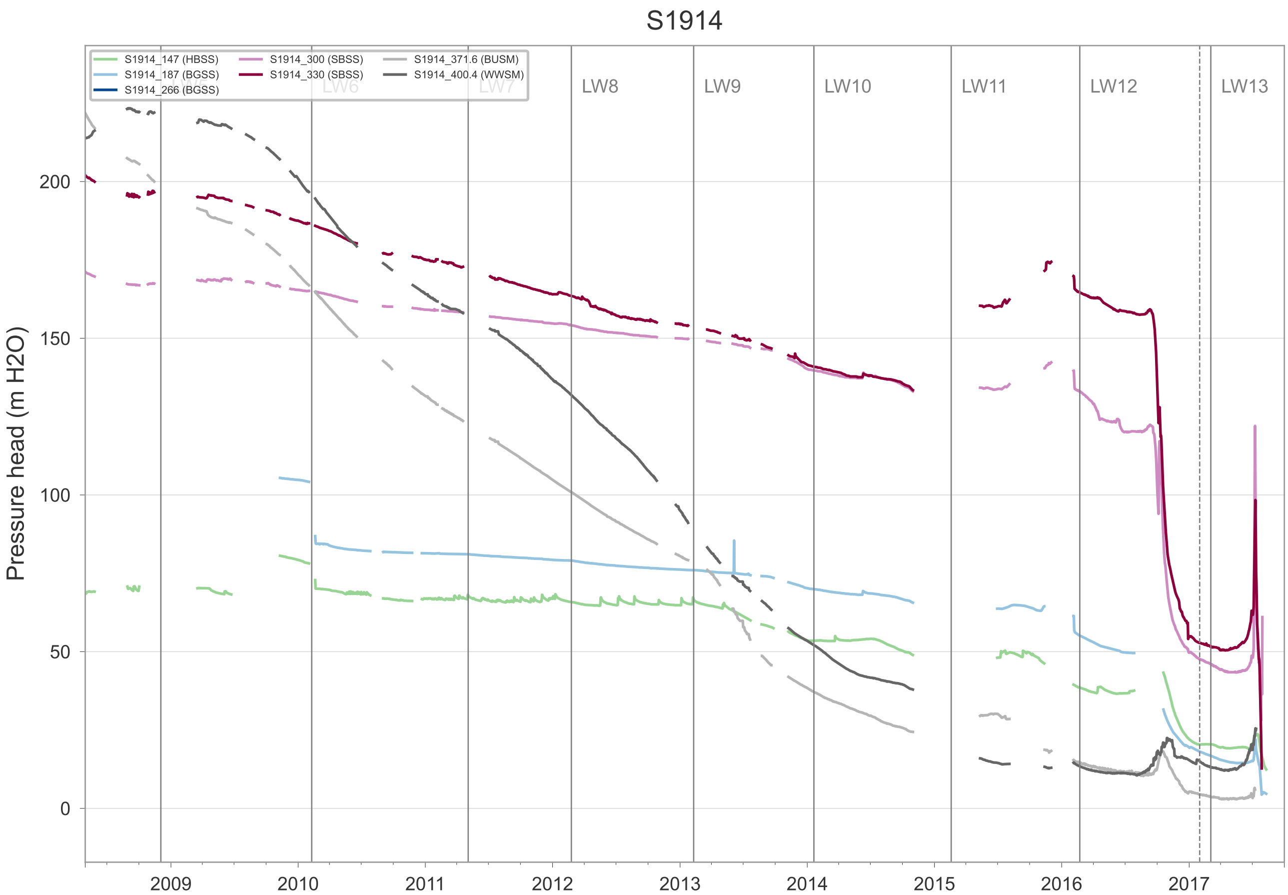


Pressure head (m H2O)
LW5
LW6
LW7
LW8
LW9
LW10
LW11
LW12
LW13
LW14
LW15
S1910_9.6 (HBSS)
S1910_125 (HBSS)
S1910_169 (BGSS)
S1910_247 (BGSS)
S1910_273 (SBSS)
S1910_313 (SBSS)
S1910_362 (BUSM)
S1910_391.5 (WWSM)
0
50
100
150
200
250
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019

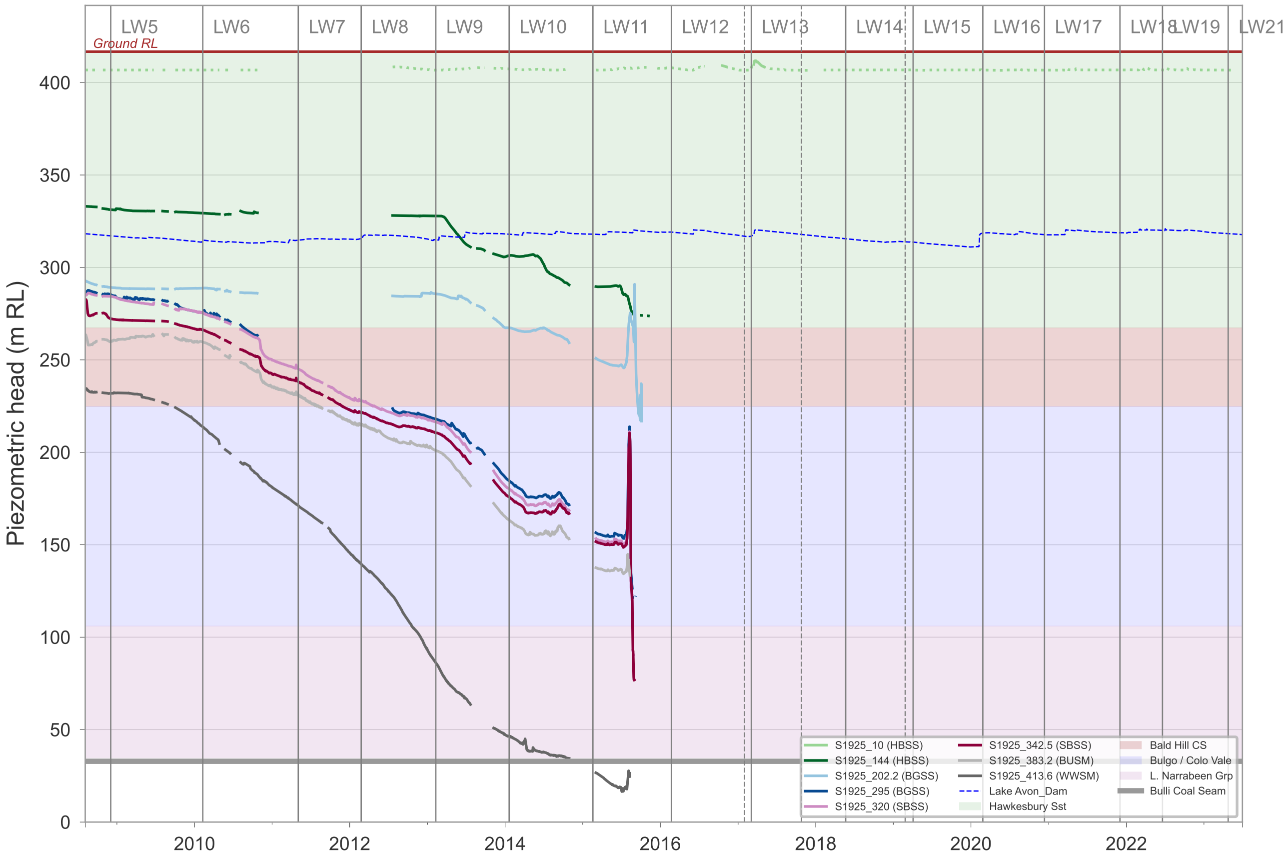

S1911
S1911_10 (HBSS)
S1911_68.5 (HBSS)
S1911_135 (HBSS)
S1911_187 (BGSS)
S1911_229.5 (BGSS)
S1911_277 (BGSS)
S1911_301 (SBSS)
S1911_318 (SBSS)
S1911_331.5 (WBCS)
S1911_349 (CCSS)
S1911_359 (CCSS)
S1911_387.3 (WWSM)
Lake Avon_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM
LW8
LW9
LW10
LW11
LW12
LW13
Piezometric head (m RL)
400
350
300
250
200
150
100
50
2009
2010
2011
2012
2013
2014
2015
2016
2017


S1911
LW5
LW6
LW7
LW8
LW9
LW10
LW11
LW12
LW13
Pressure head (m H2O)
250
200
150
100
50
0
S1911_10 (HBSS)
S1911_68.5 (HBSS)
S1911_135 (HBSS)
S1911_187 (BGSS)
S1911_229.5 (BGSS)
S1911_277 (BGSS)
S1911_301 (SBSS)
S1911_318 (SBSS)
S1911_331.5 (WBCS)
S1911_349 (CCSS)
S1911_359 (CCSS)
S1911_387.3 (WWSM)
2009
2010
2011
2012
2013
2014
2015
2016
2017


S1914
S1914_147 (HBSS)
S1914_187 (BGSS)
S1914_266 (BGSS)
S1914_300 (SBSS)
S1914_330 (SBSS)
S1914_371.6 (BUSM)
S1914_400.4 (WWSM)
Lake Avon_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM
LW8
LW9
LW10
LW11
LW12
LW13
Piezometric head (m RL)
400
350
300
250
200
150
100
50
2009
2010
2011
2012
2013
2014
2015
2016
2017

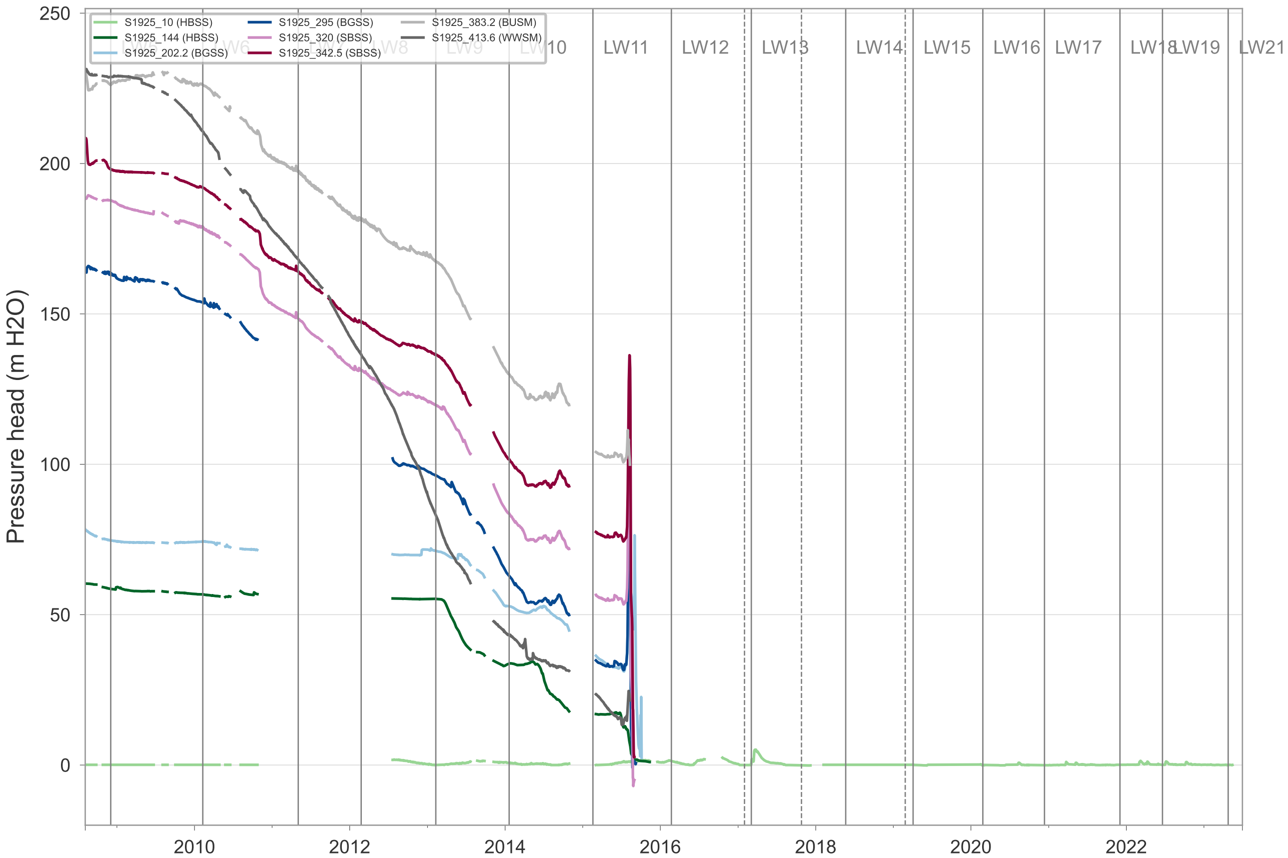

S1914
S1914_147 (HBSS)
S1914_187 (BGSS)
S1914_266 (BGSS)
S1914_300 (SBSS)
S1914_330 (SBSS)
S1914_371.6 (BUSM)
S1914_400.4 (WWSM)
LW6
LW7
LW8
LW9
LW10
LW11
LW12
LW13
Pressure head (m H2O)
200
150
100
50
0
2009
2010
2011
2012
2013
2014
2015
2016
2017

S1925

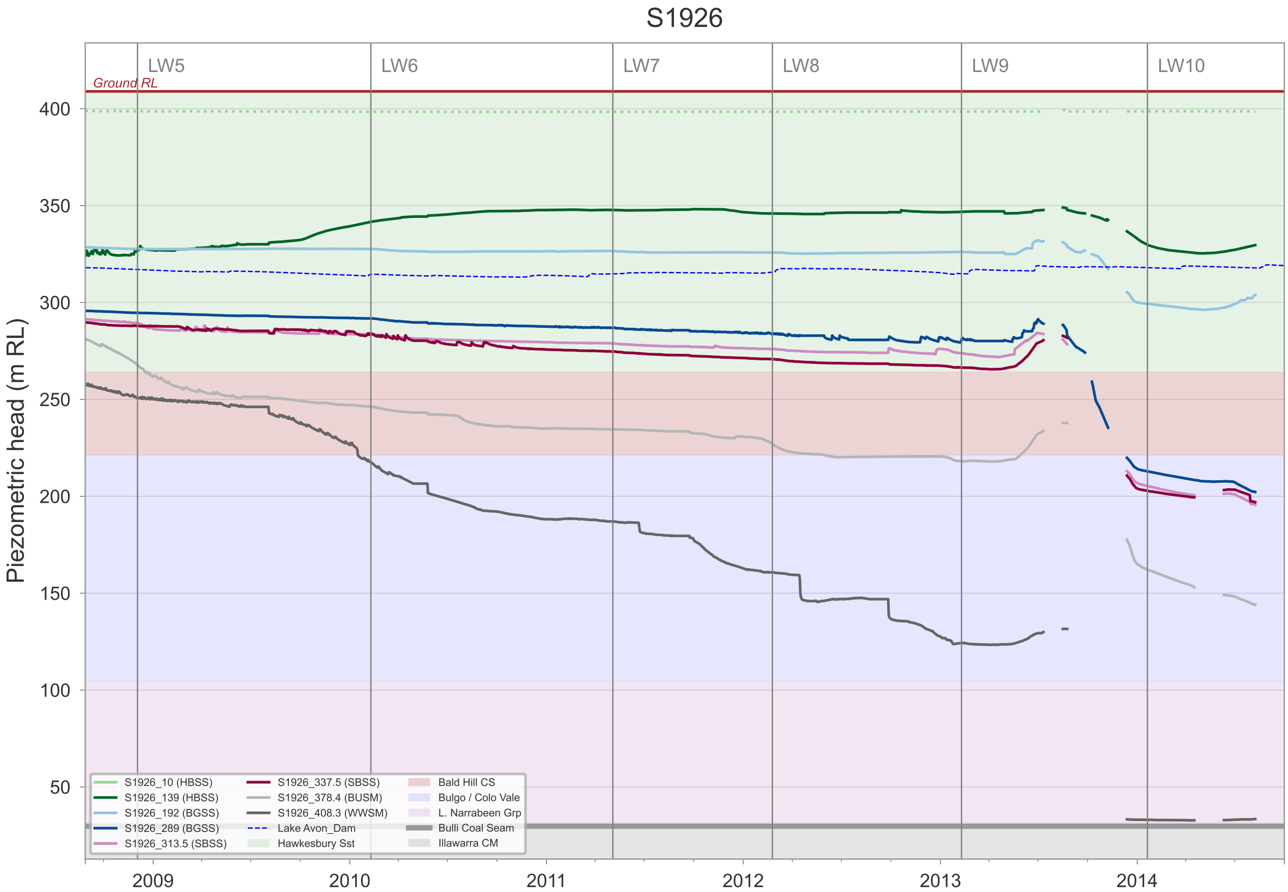


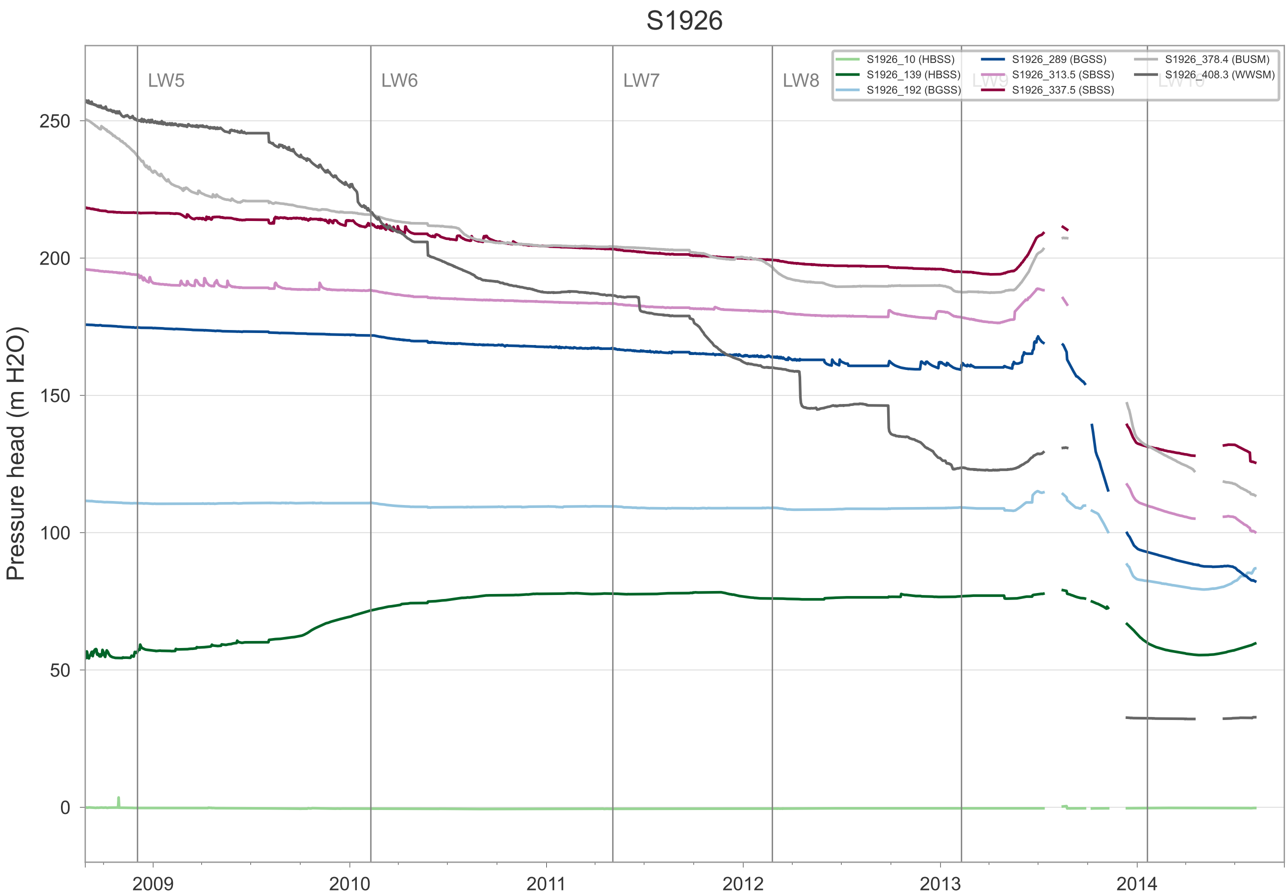
LW5
LW6
LW7
LW8
LW9
LW10
LW11
LW12
LW13
LW14
LW15
LW16
LW17
LW18
LW19
LW21
Ground RL
Piezometric head (m RL)
S1925_10 (HBSS)
S1925_144 (HBSS)
S1925_202.2 (BGSS)
S1925_295 (BGSS)
S1925_320 (SBSS)
S1925_342.5 (SBSS)
S1925_383.2 (BUSM)
S1925_413.6 (WWSM)
Lake Avon_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam

S1925

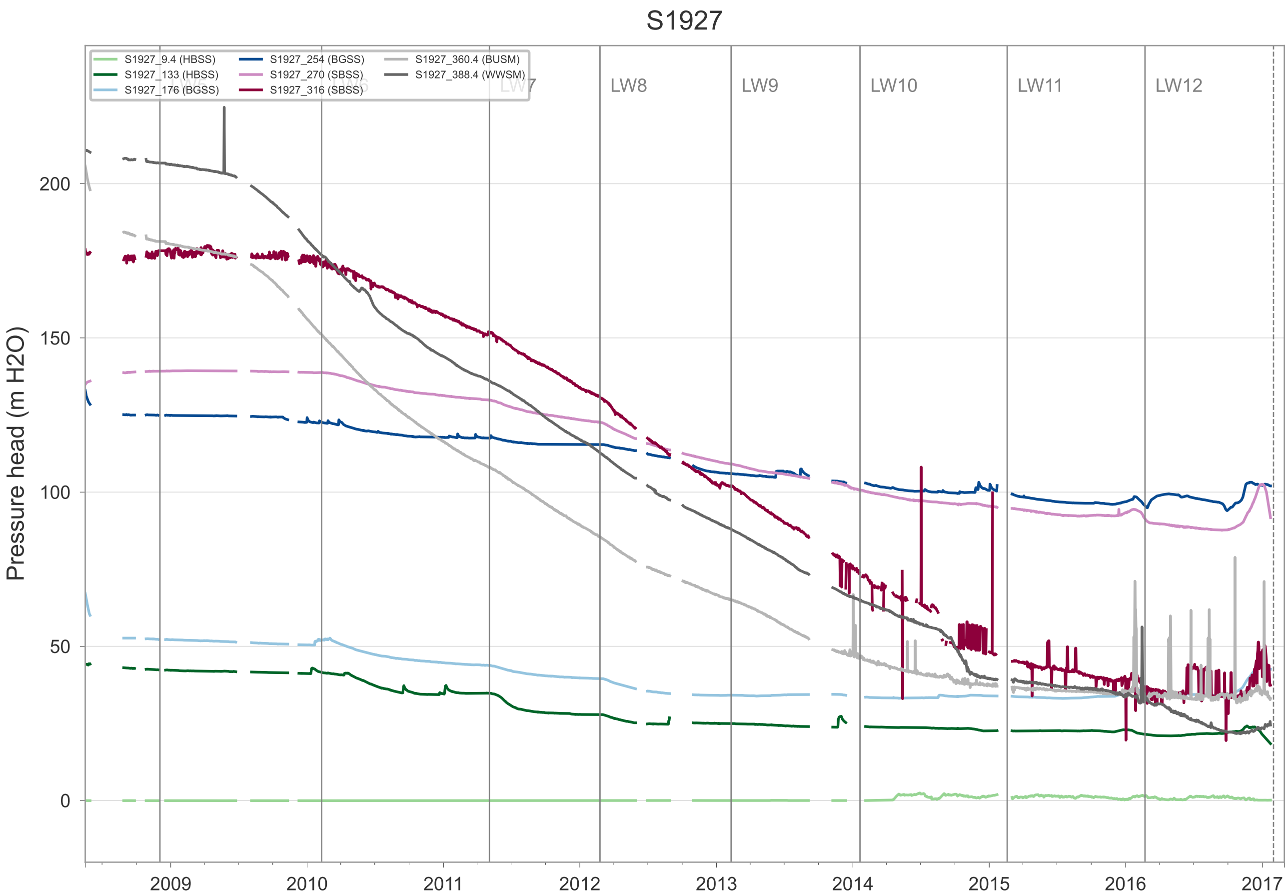


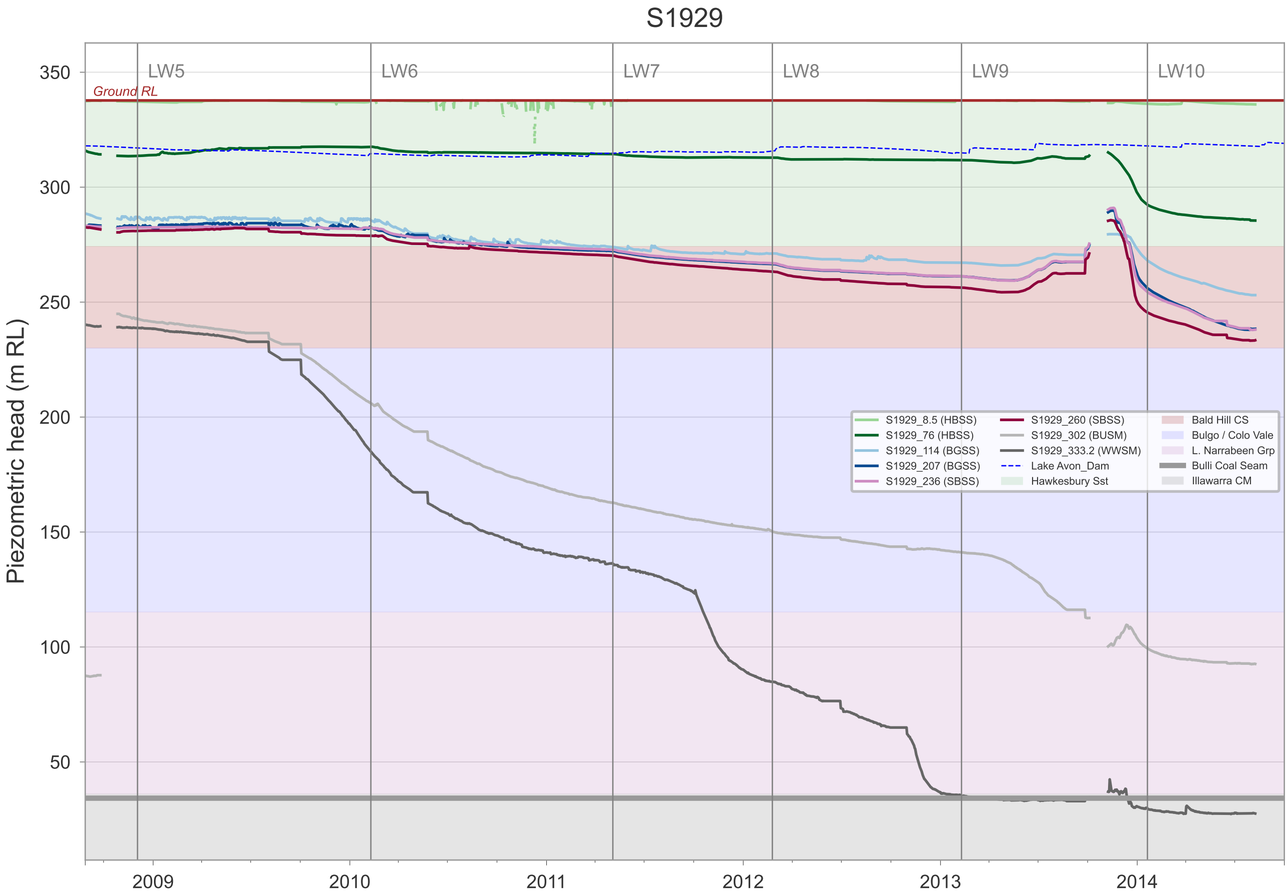
S1925_10 (HBSS)
S1925_144 (HBSS)
S1925_202.2 (BGSS)
S1925_295 (BGSS)
S1925_320 (SBSS)
S1925_342.5 (SBSS)
S1925_383.2 (BUSM)
S1925_413.6 (WWSM)
LW11
LW12
LW13
LW14
LW15
LW16
LW17
LW18
LW19
LW21
Pressure head (m H2O)

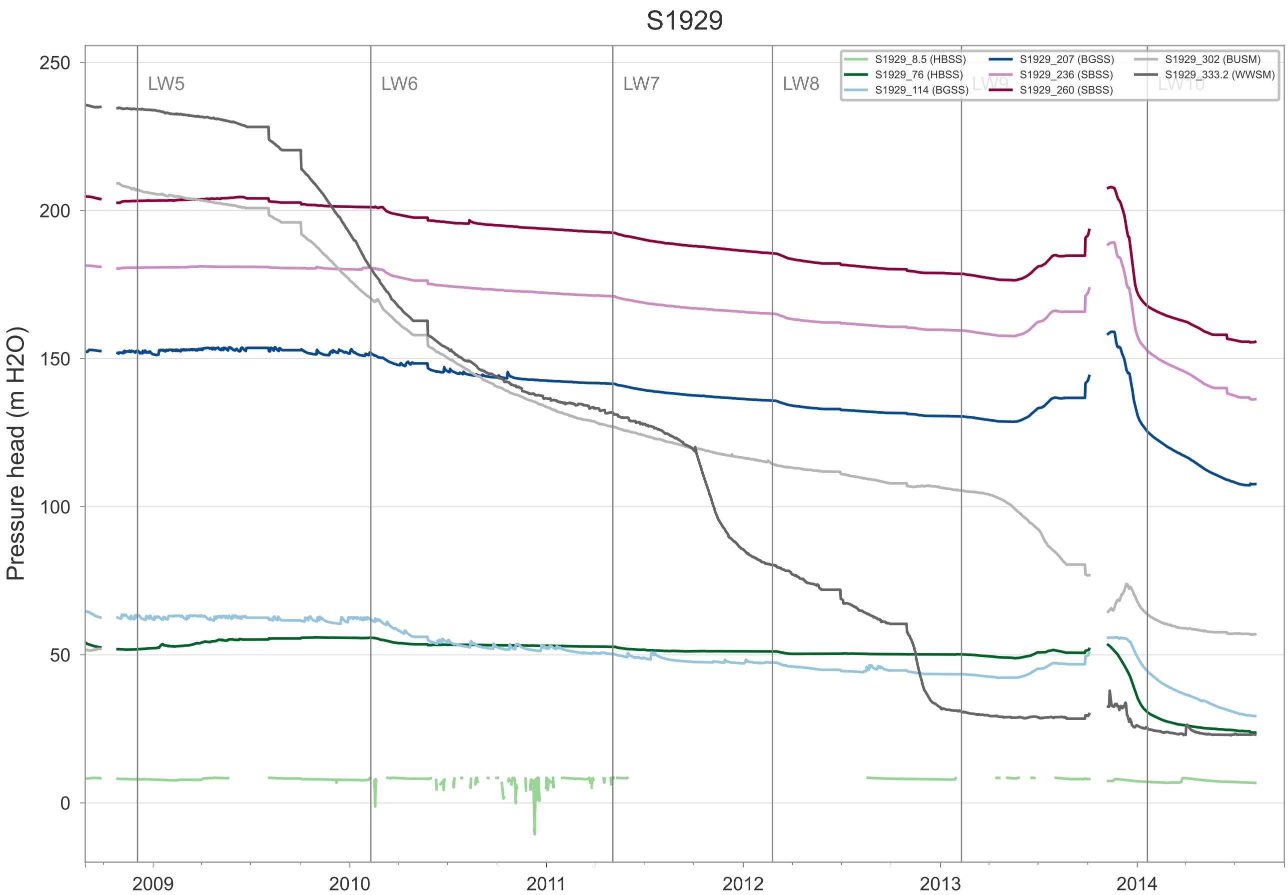

S1926
LW5
LW6
LW7
LW8
LW9
LW10
Ground RL
Piezometric head (m RL)
400
350
300
250
200
150
100
50
2009
2010
2011
2012
2013
2014
S1926_10 (HBSS)
S1926_139 (HBSS)
S1926_192 (BGSS)
S1926_289 (BGSS)
S1926_313.5 (SBSS)
S1926_337.5 (SBSS)
S1926_378.4 (BUSM)
S1926_408.3 (WWSM)
Lake Avon_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM


S1926
LW5
LW6
LW7
LW8
Pressure head (m H2O)
250
200
150
100
50
0
2009
2010
2011
2012
2013
2014
S1926_10 (HBSS)
S1926_139 (HBSS)
S1926_192 (BGSS)
S1926_289 (BGSS)
S1926_313.5 (SBSS)
S1926_337.5 (SBSS)
S1926_378.4 (BUSM)
S1926_408.3 (WWSM)

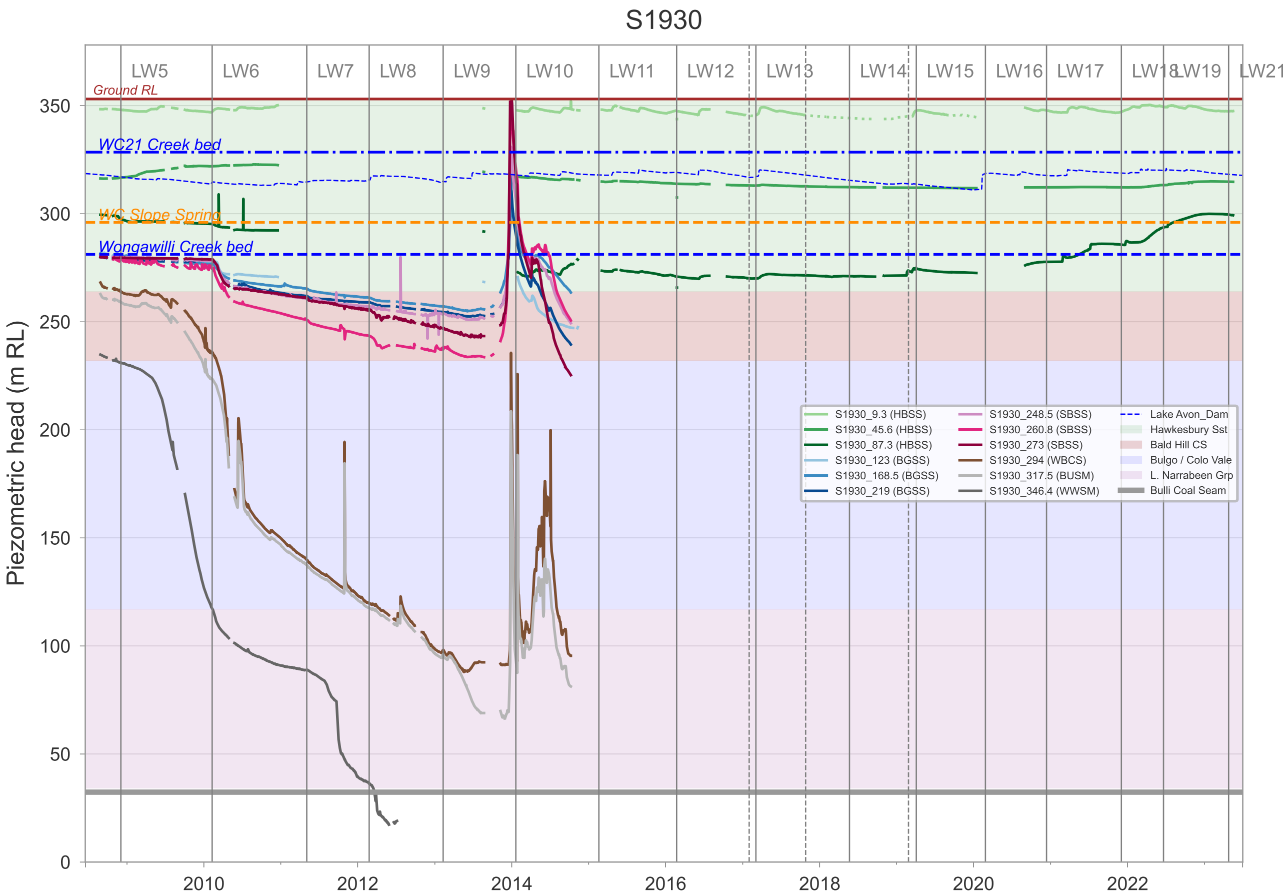

S1927
Ground RL
LW5
LW6
LW7
LW8
LW9
LW10
LW11
LW12
Piezometric head (m RL)
50
100
150
200
250
300
350
400
2009
2010
2011
2012
2013
2014
2015
2016
2017
S1927_9.4 (HBSS)
S1927_133 (HBSS)
S1927_176 (BGSS)
S1927_254 (BGSS)
S1927_270 (SBSS)
S1927_316 (SBSS)
S1927_360.4 (BUSM)
S1927_388.4 (WWSM)
Lake Avon_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM

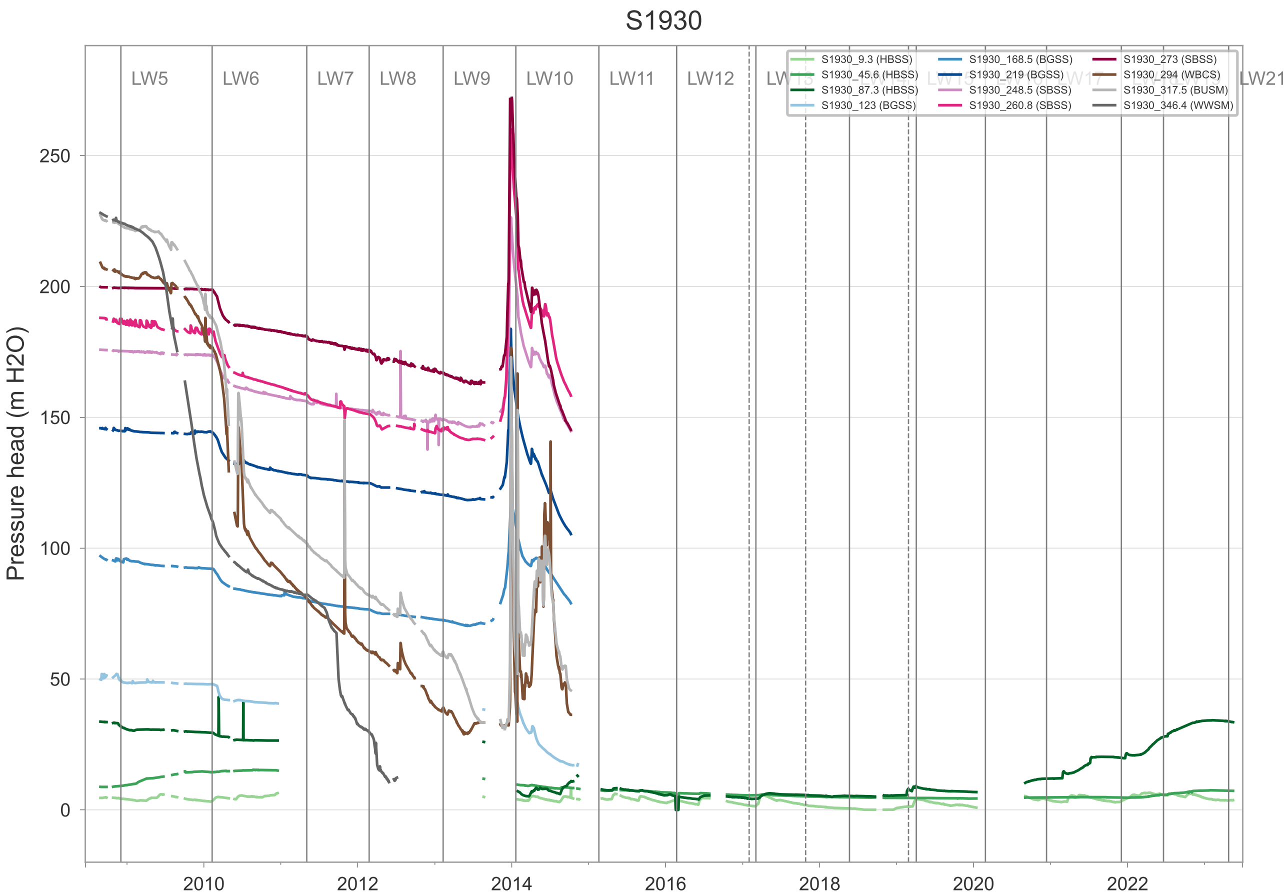

S1927
LW7
LW8
LW9
LW10
LW11
LW12
Pressure head (m H2O)
0
50
100
150
200
2009
2010
2011
2012
2013
2014
2015
2016
2017
S1927_9.4 (HBSS)
S1927_133 (HBSS)
S1927_176 (BGSS)
S1927_254 (BGSS)
S1927_270 (SBSS)
S1927_316 (SBSS)
S1927_360.4 (BUSM)
S1927_388.4 (WWSM)


S1929
Piezometric head (m RL)
Ground RL
LW5
LW6
LW7
LW8
LW9
LW10
350
300
250
200
150
100
50
2009
2010
2011
2012
2013
2014
S1929_8.5 (HBSS)
S1929_76 (HBSS)
S1929_114 (BGSS)
S1929_207 (BGSS)
S1929_236 (SBSS)
S1929_260 (SBSS)
S1929_302 (BUSM)
S1929_333.2 (WWSM)
Lake Avon_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM

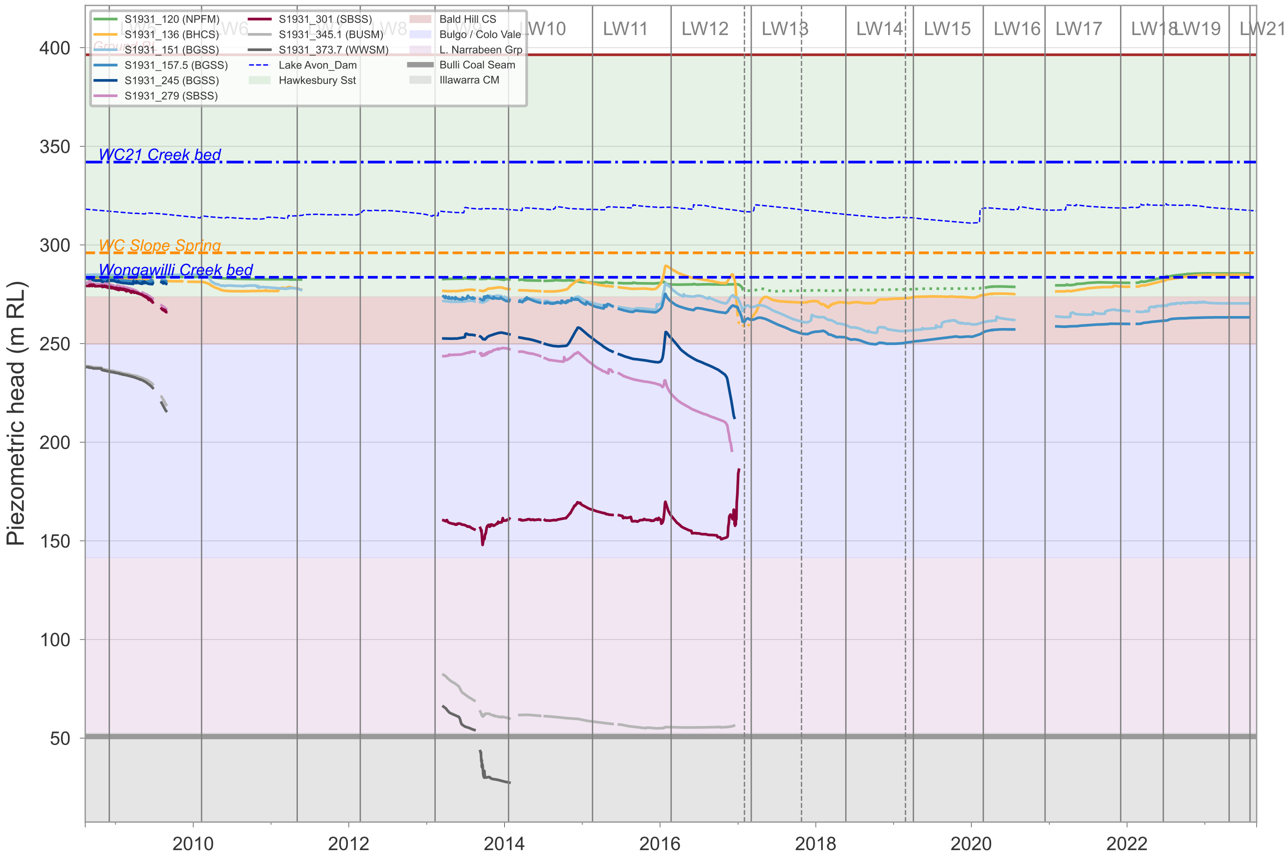

S1929
Pressure head (m H2O)
LW5
LW6
LW7
LW8
250
200
150
100
50
0
2009
2010
2011
2012
2013
2014
S1929_8.5 (HBSS)
S1929_76 (HBSS)
S1929_114 (BGSS)
S1929_207 (BGSS)
S1929_236 (SBSS)
S1929_260 (SBSS)
S1929_302 (BUSM)
S1929_333.2 (WWSM)

Groundwater hydrographs

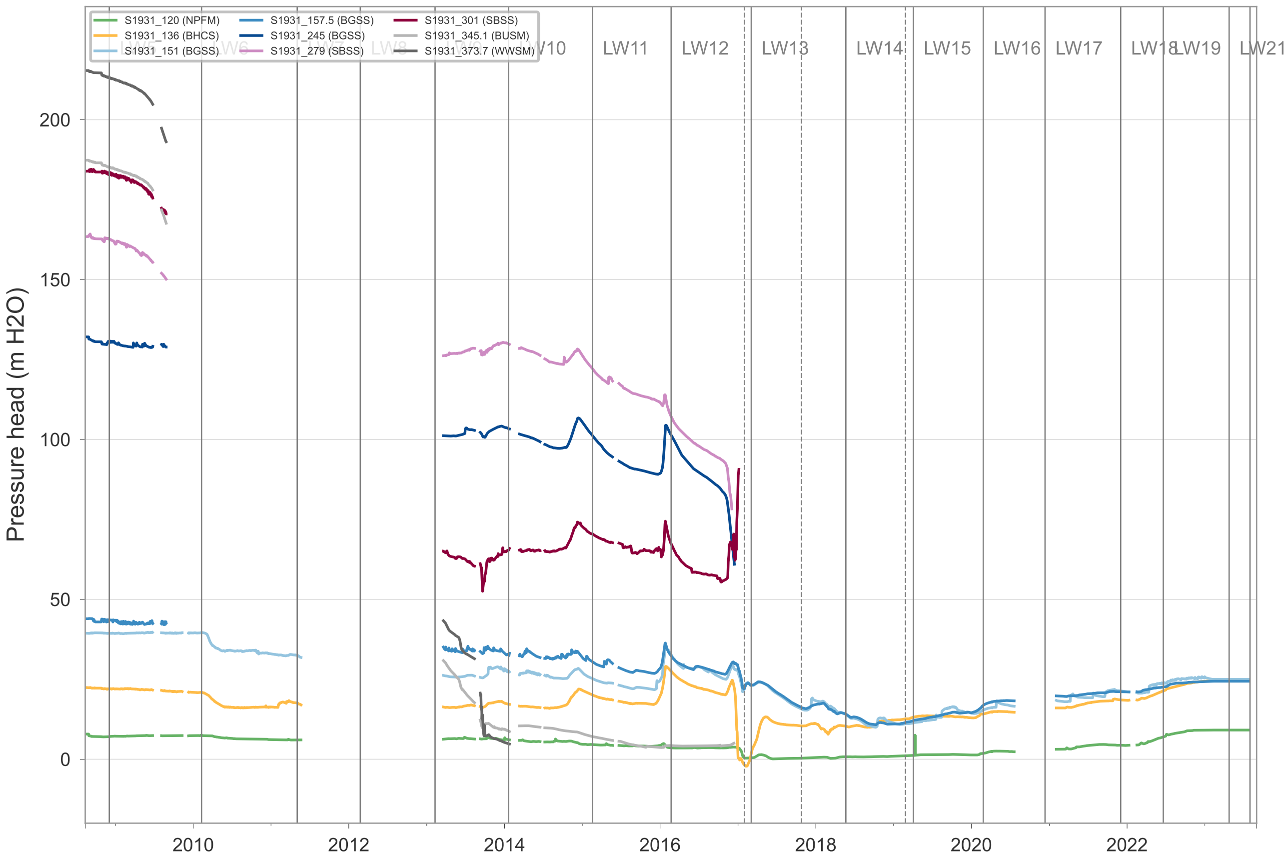




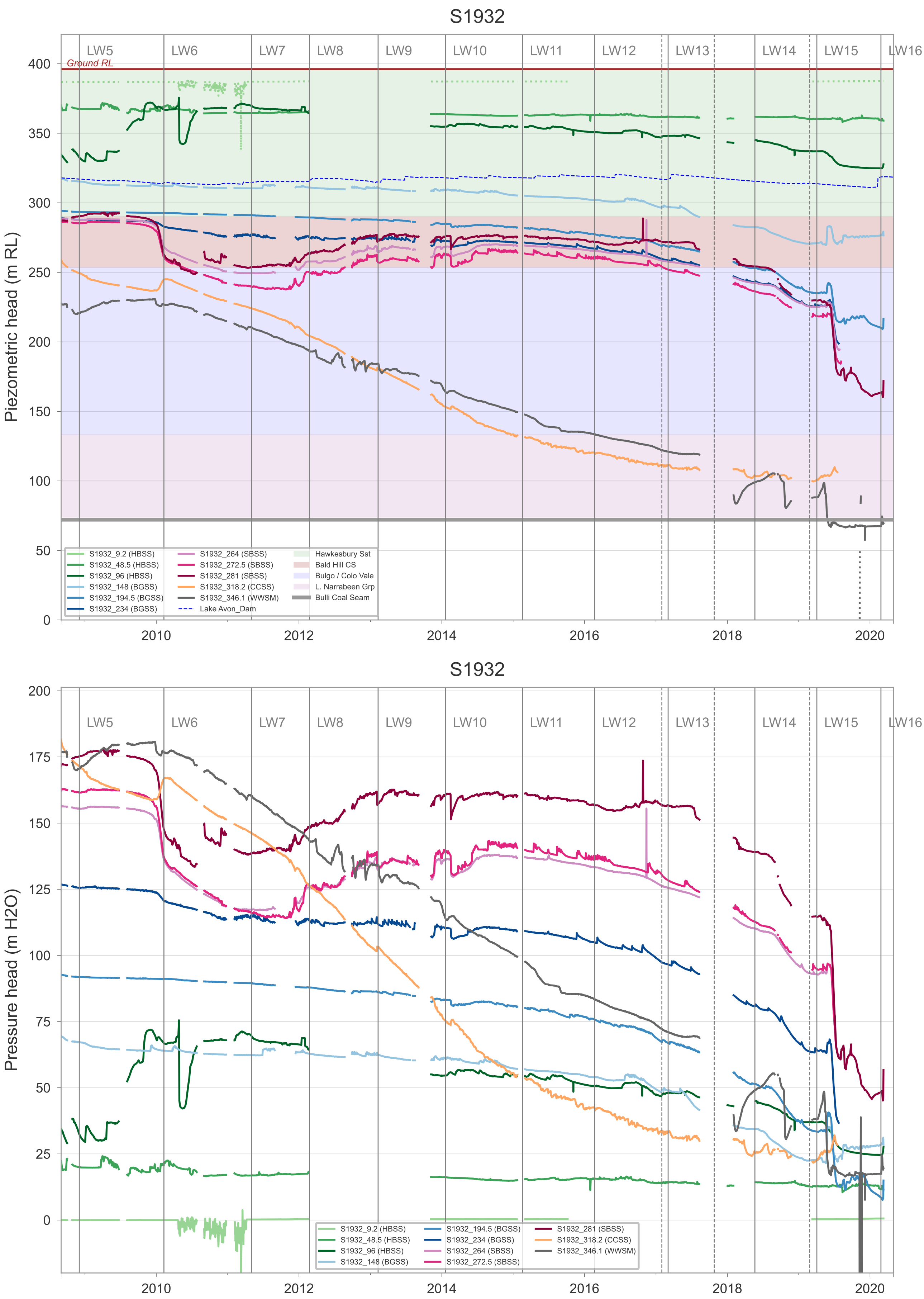
S1931


S1931_120 (NPFM)
S1931_136 (BHCS)
S1931_151 (BGSS)
S1931_157.5 (BGSS)
S1931_245 (BGSS)
S1931_279 (SBSS)
S1931_301 (SBSS)
S1931_345.1 (BUSM)
S1931_373.7 (WWSM)
Lake Avon_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM
LW10
LW11
LW12
LW13
LW14
LW15
LW16
LW17
LW18
LW19
LW21
WC21 Creek bed
WC Slope Spring
Wongawilli Creek bed
Piezometric head (m RL)
400
350
300
250
200
150
100
50
2010
2012
2014
2016
2018
2020
2022

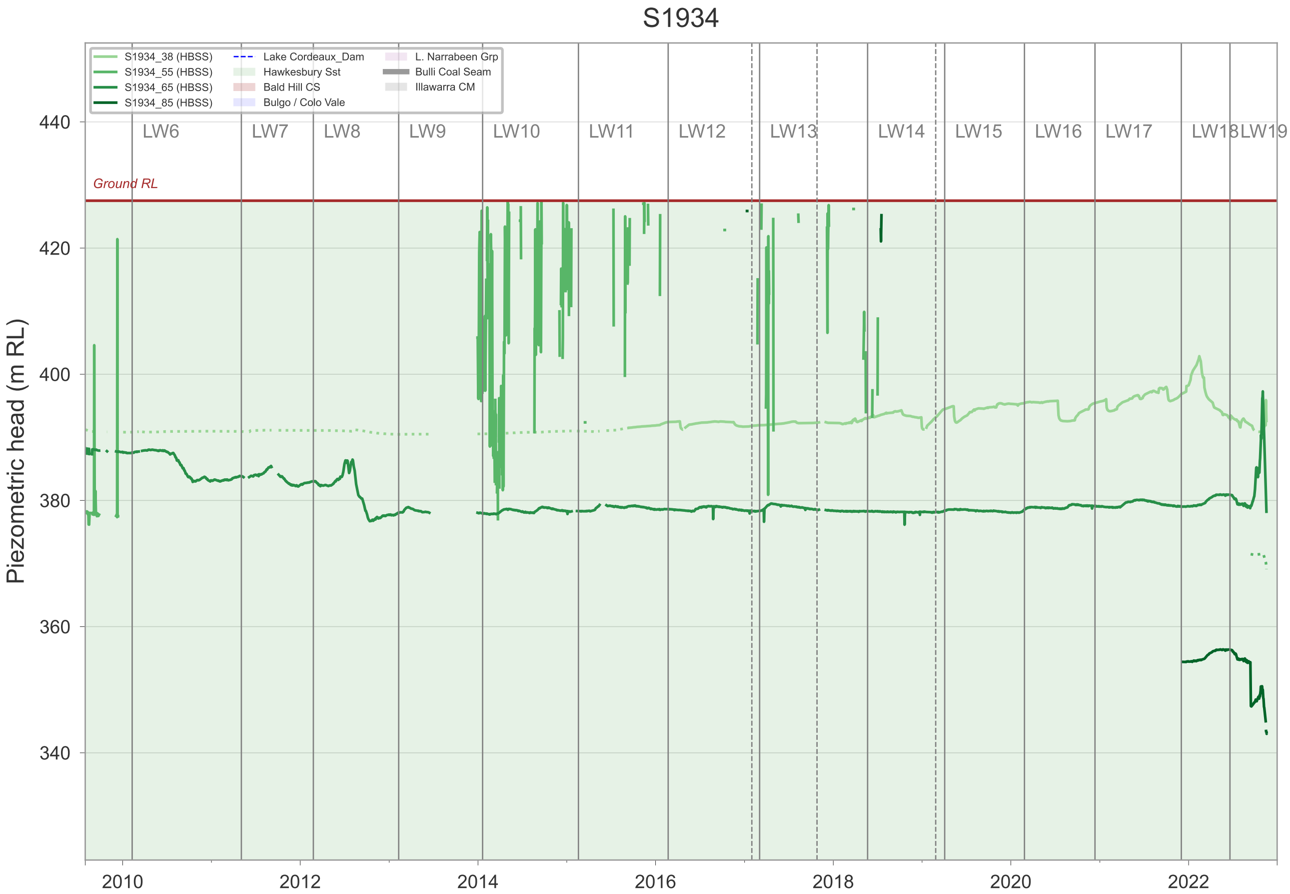
S1931

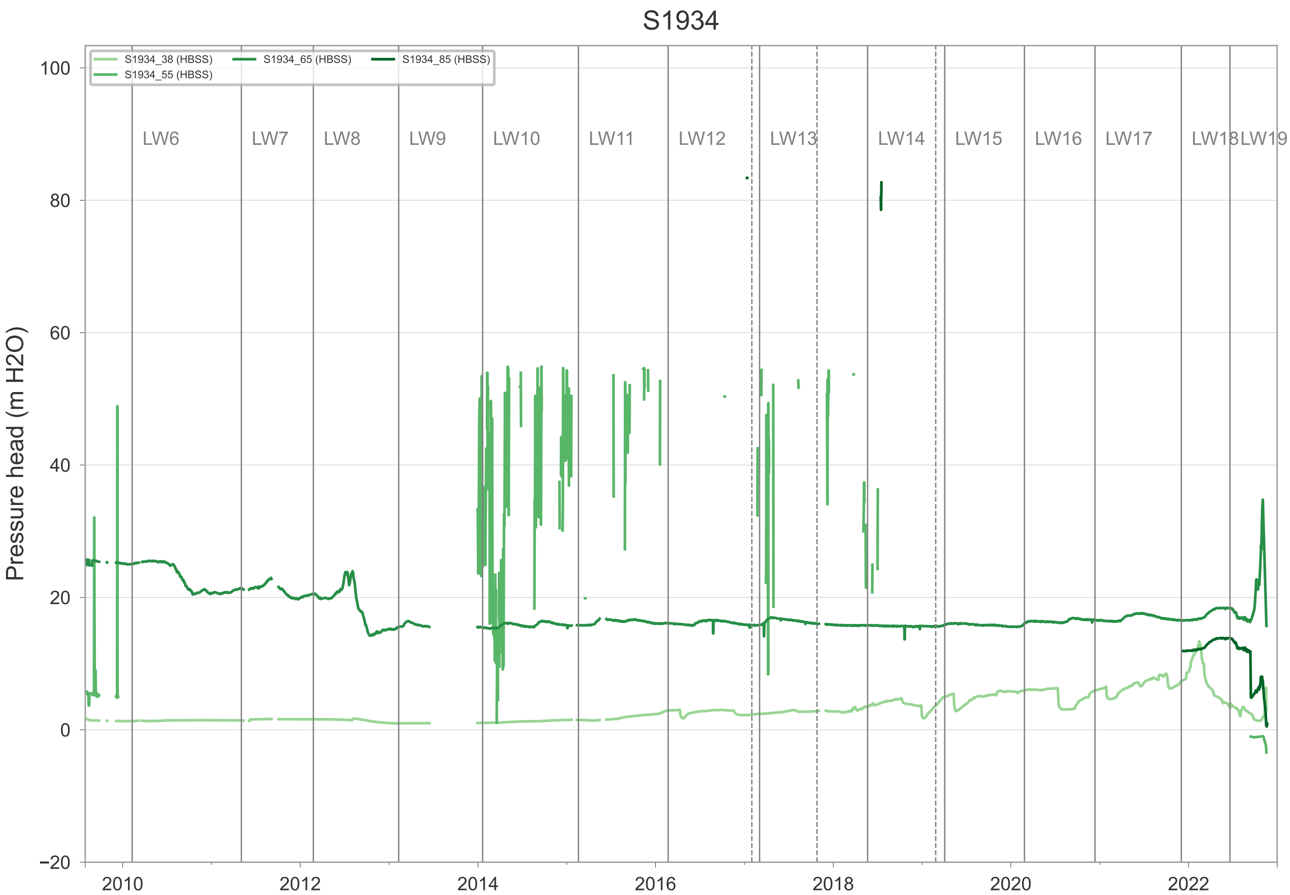

S1931_120 (NPFM)
S1931_136 (BHCS)
S1931_151 (BGSS)
S1931_157.5 (BGSS)
S1931_245 (BGSS)
S1931_279 (SBSS)
S1931_301 (SBSS)
S1931_345.1 (BUSM)
S1931_373.7 (WWSM)
LW10
LW11
LW12
LW13
LW14
LW15
LW16
LW17
LW18
LW19
LW21
Pressure head (m H2O)
200
150
100
50
0
2010
2012
2014
2016
2018
2020
2022

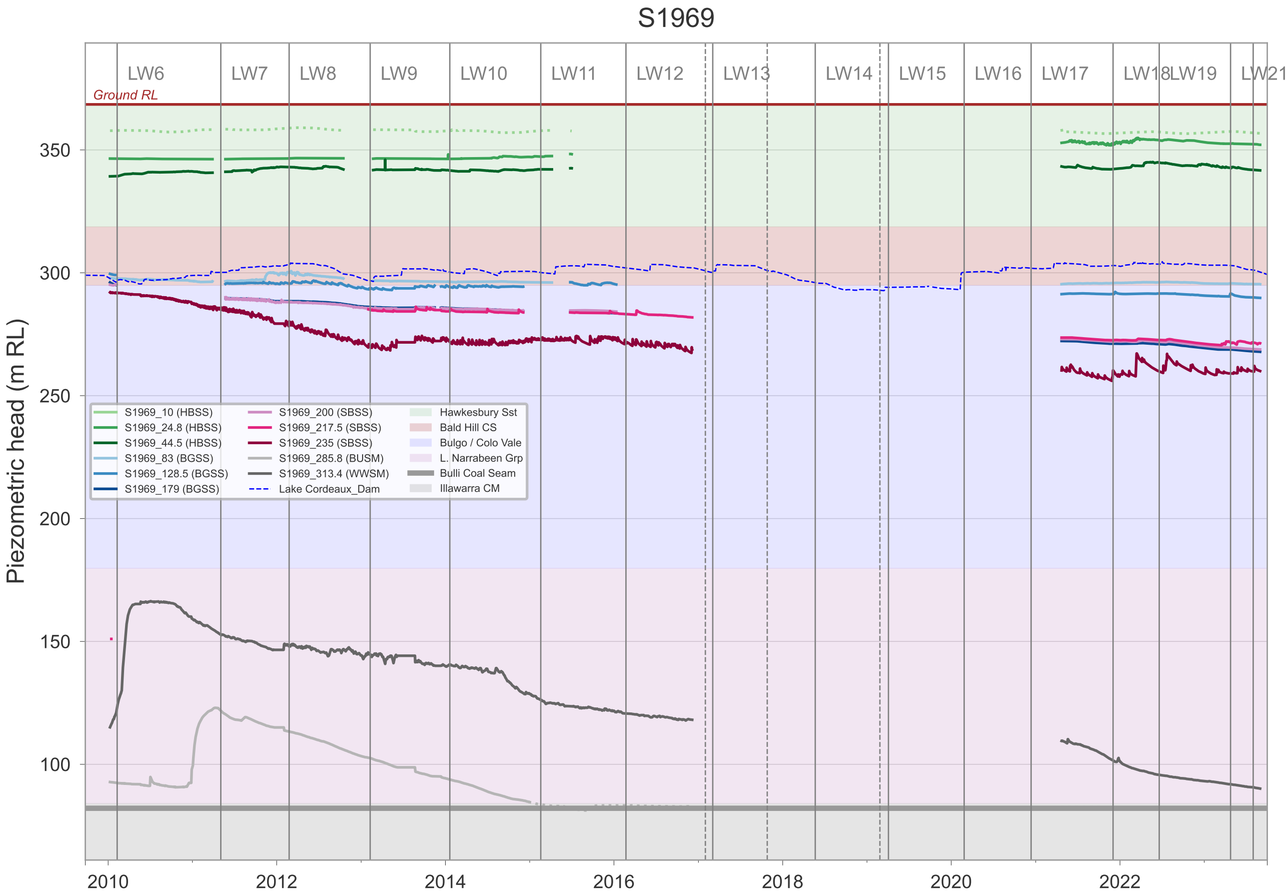
Groundwater hydrographs

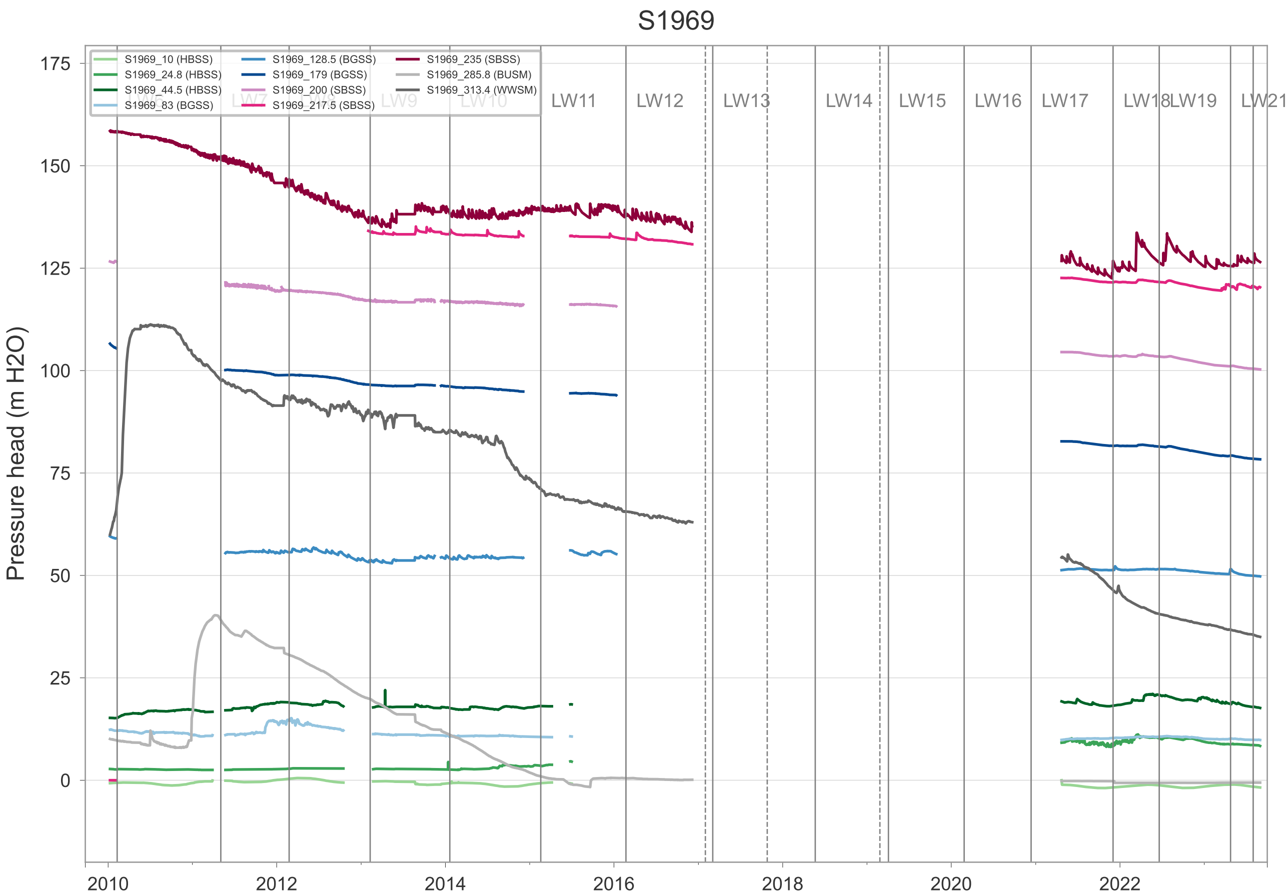


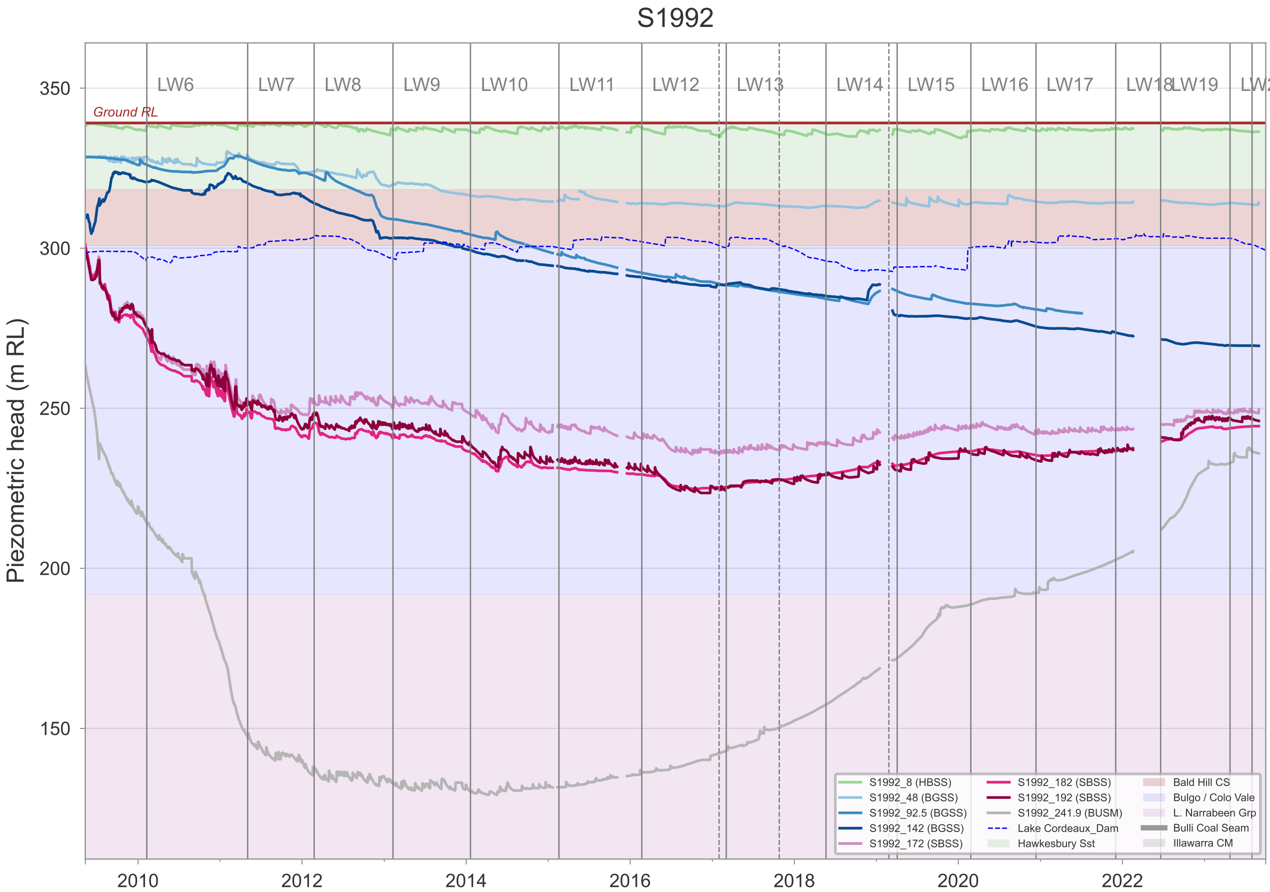
Groundwater hydrographs

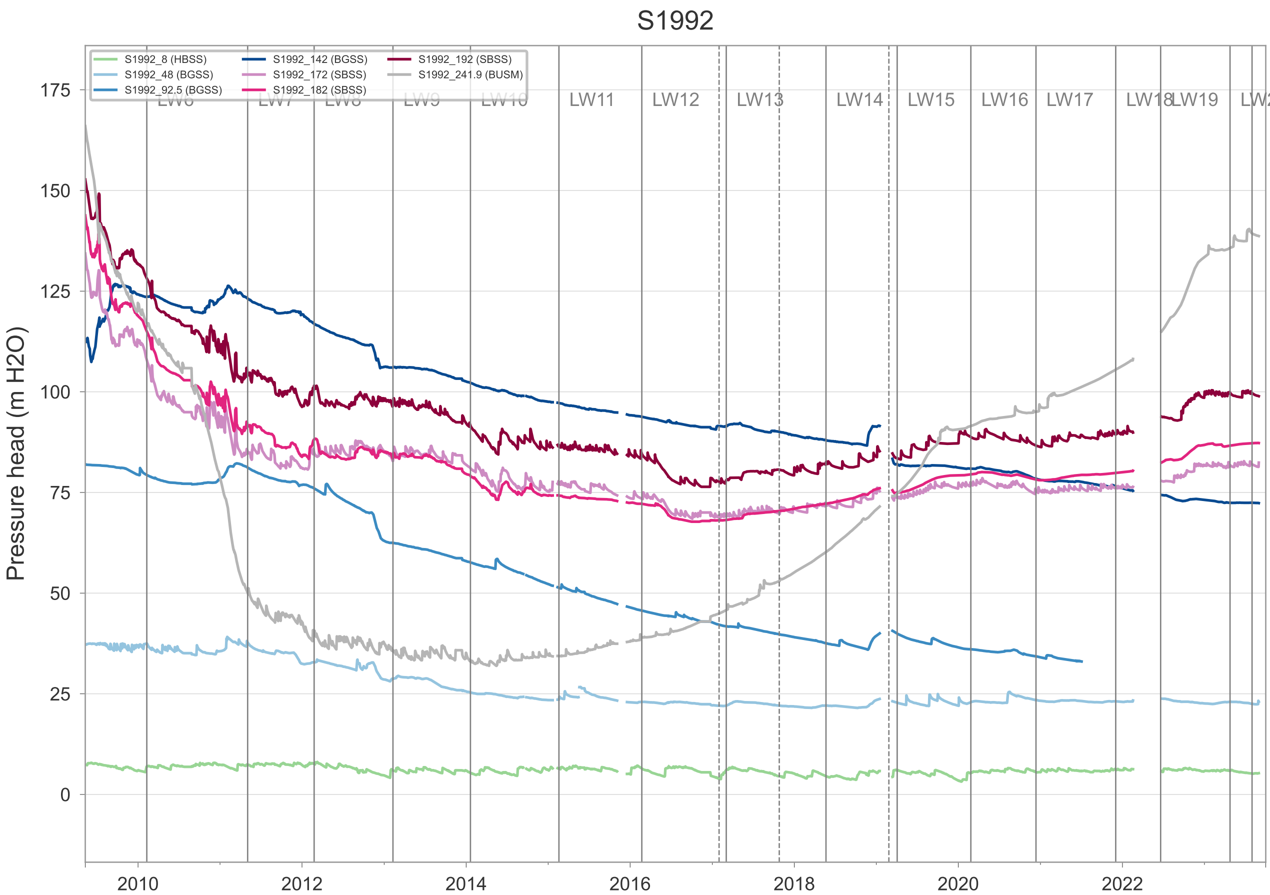


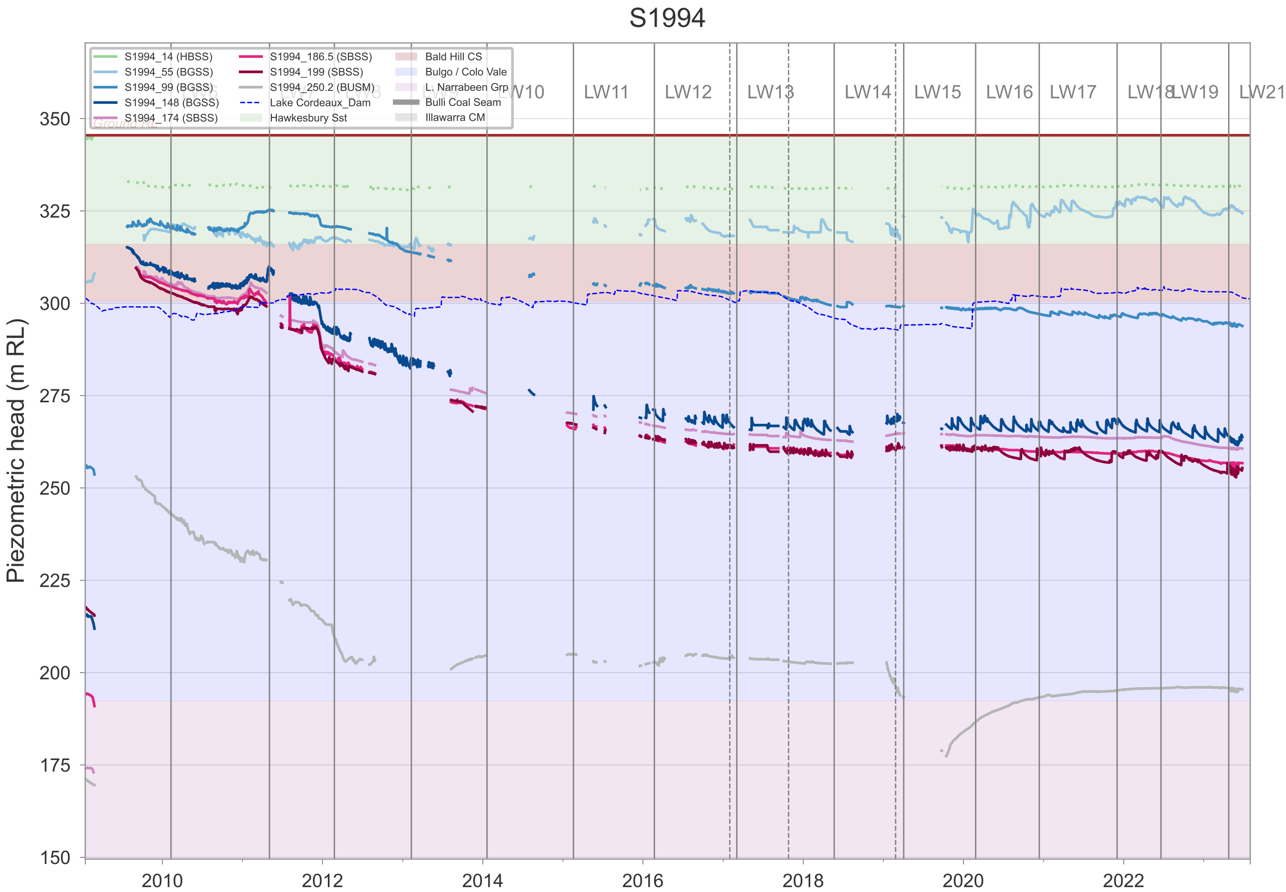


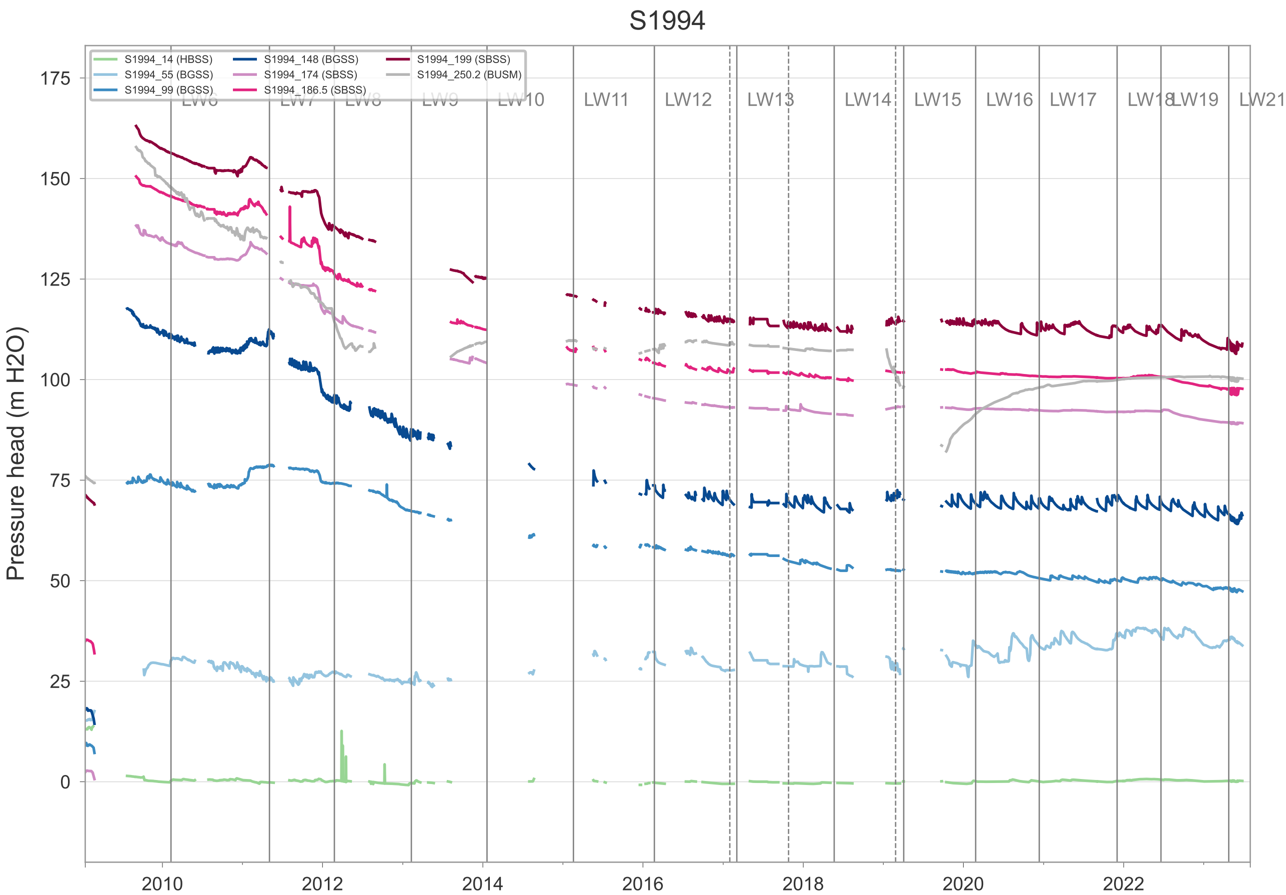

S1969
LW6
LW7
LW8
LW9
LW10
LW11
LW12
LW13
LW14
LW15
LW16
LW17
LW18
LW19
LW21
Ground RL
Piezometric head (m RL)
S1969_10 (HBSS)
S1969_24.8 (HBSS)
S1969_44.5 (HBSS)
S1969_83 (BGSS)
S1969_128.5 (BGSS)
S1969_179 (BGSS)
S1969_200 (SBSS)
S1969_217.5 (SBSS)
S1969_235 (SBSS)
S1969_285.8 (BUSM)
S1969_313.4 (WWSM)
Lake Cordeaux_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM


S1969
LW11
LW12
LW13
LW14
LW15
LW16
LW17
LW18
LW19
LW21
Pressure head (m H2O)
S1969_10 (HBSS)
S1969_24.8 (HBSS)
S1969_44.5 (HBSS)
S1969_83 (BGSS)
S1969_128.5 (BGSS)
S1969_179 (BGSS)
S1969_200 (SBSS)
S1969_217.5 (SBSS)
S1969_235 (SBSS)
S1969_285.8 (BUSM)
S1969_313.4 (WWSM)

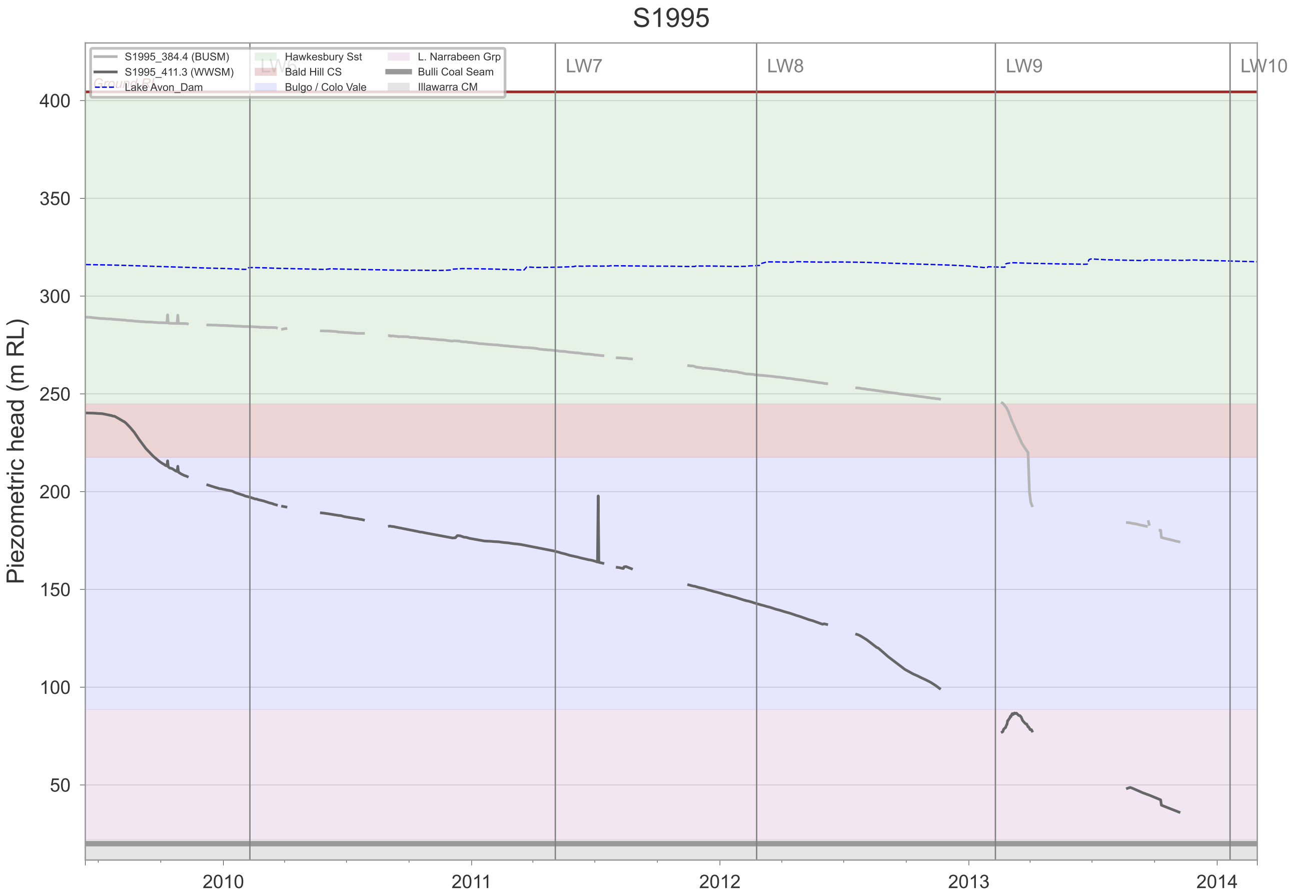

S1992
Piezometric head (m RL)
Ground RL
LW6
LW7
LW8
LW9
LW10
LW11
LW12
LW13
LW14
LW15
LW16
LW17
LW18
LW19
LW21
350
300
250
200
150
2010
2012
2014
2016
2018
2020
2022
S1992_8 (HBSS)
S1992_48 (BGSS)
S1992_92.5 (BGSS)
S1992_142 (BGSS)
S1992_172 (SBSS)
S1992_182 (SBSS)
S1992_192 (SBSS)
S1992_241.9 (BUSM)
Lake Cordeaux_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM

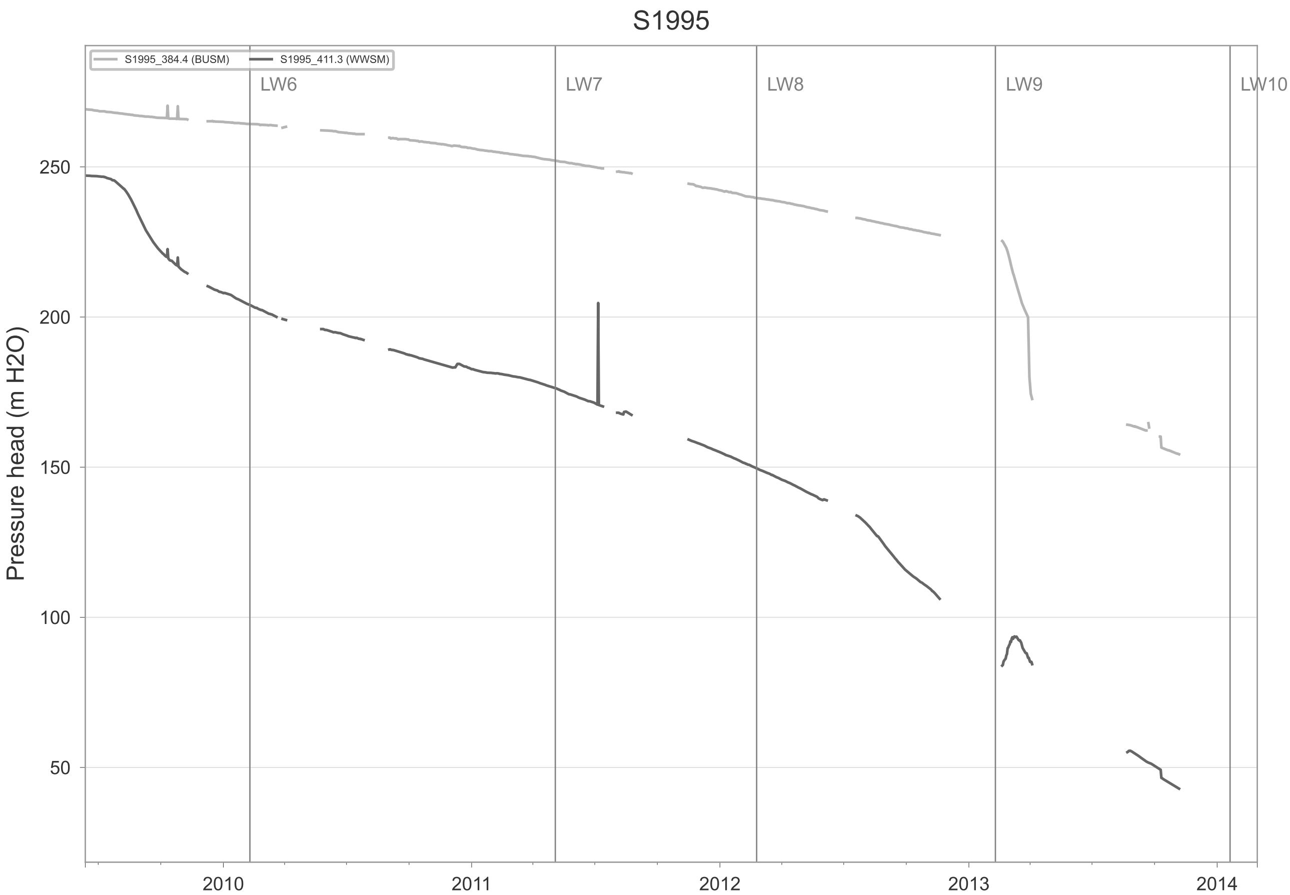

S1992
Pressure head (m H2O)
S1992_8 (HBSS)
S1992_48 (BGSS)
S1992_92.5 (BGSS)
S1992_142 (BGSS)
S1992_172 (SBSS)
S1992_182 (SBSS)
S1992_192 (SBSS)
S1992_241.9 (BUSM)
LW11
LW12
LW13
LW14
LW15
LW16
LW17
LW18
LW19
LW21
175
150
125
100
75
50
25
0
2010
2012
2014
2016
2018
2020
2022

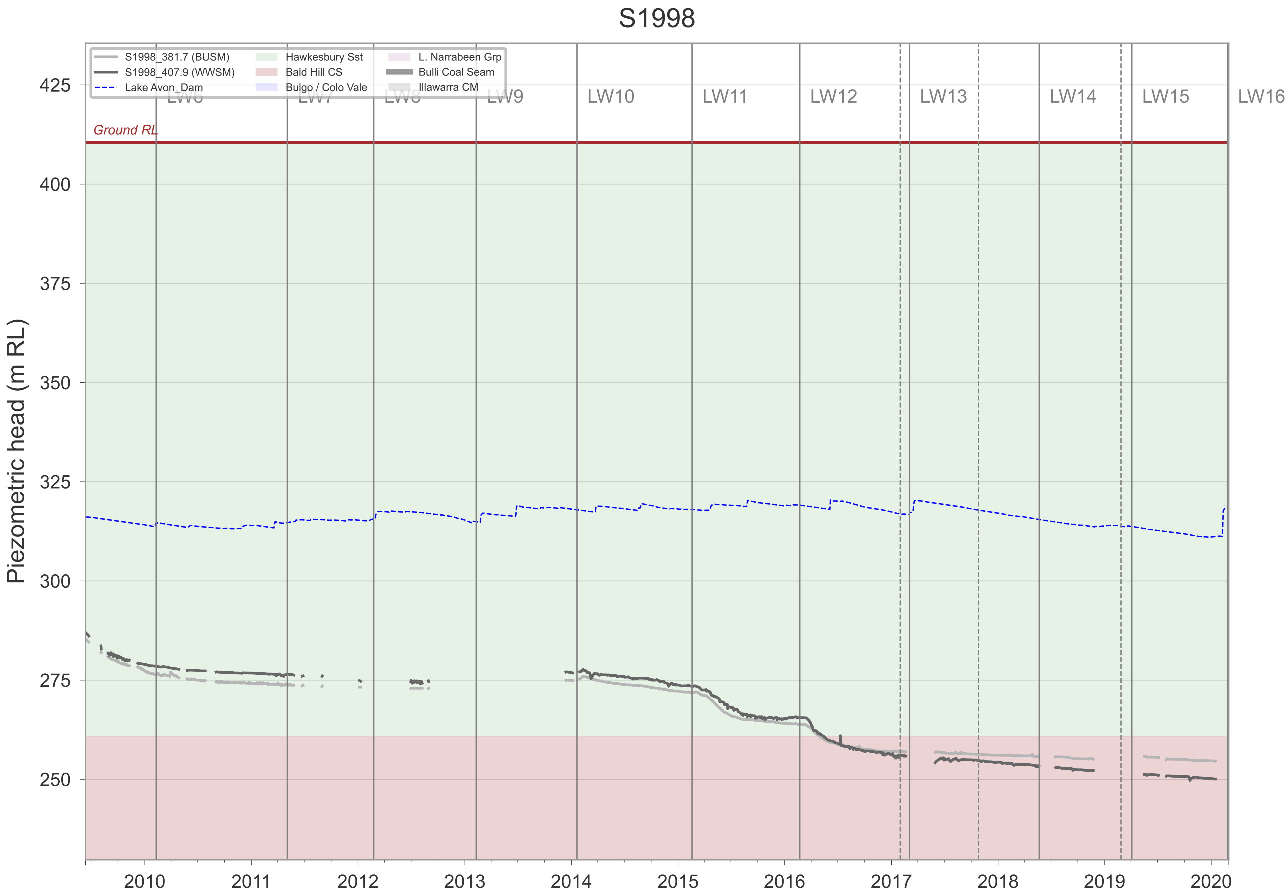

S1994
S1994_14 (HBSS)
S1994_55 (BGSS)
S1994_99 (BGSS)
S1994_148 (BGSS)
S1994_174 (SBSS)
S1994_186.5 (SBSS)
S1994_199 (SBSS)
S1994_250.2 (BUSM)
Lake Cordeaux_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM
LW10
LW11
LW12
LW13
LW14
LW15
LW16
LW17
LW18
LW19
LW21
Piezometric head (m RL)
350
325
300
275
250
225
200
175
150
2010
2012
2014
2016
2018
2020
2022


S1994
S1994_14 (HBSS)
S1994_55 (BGSS)
S1994_99 (BGSS)
S1994_148 (BGSS)
S1994_174 (SBSS)
S1994_186.5 (SBSS)
S1994_199 (SBSS)
S1994_250.2 (BUSM)
LW10
LW11
LW12
LW13
LW14
LW15
LW16
LW17
LW18
LW19
LW21
Pressure head (m H2O)
175
150
125
100
75
50
25
0
2010
2012
2014
2016
2018
2020
2022

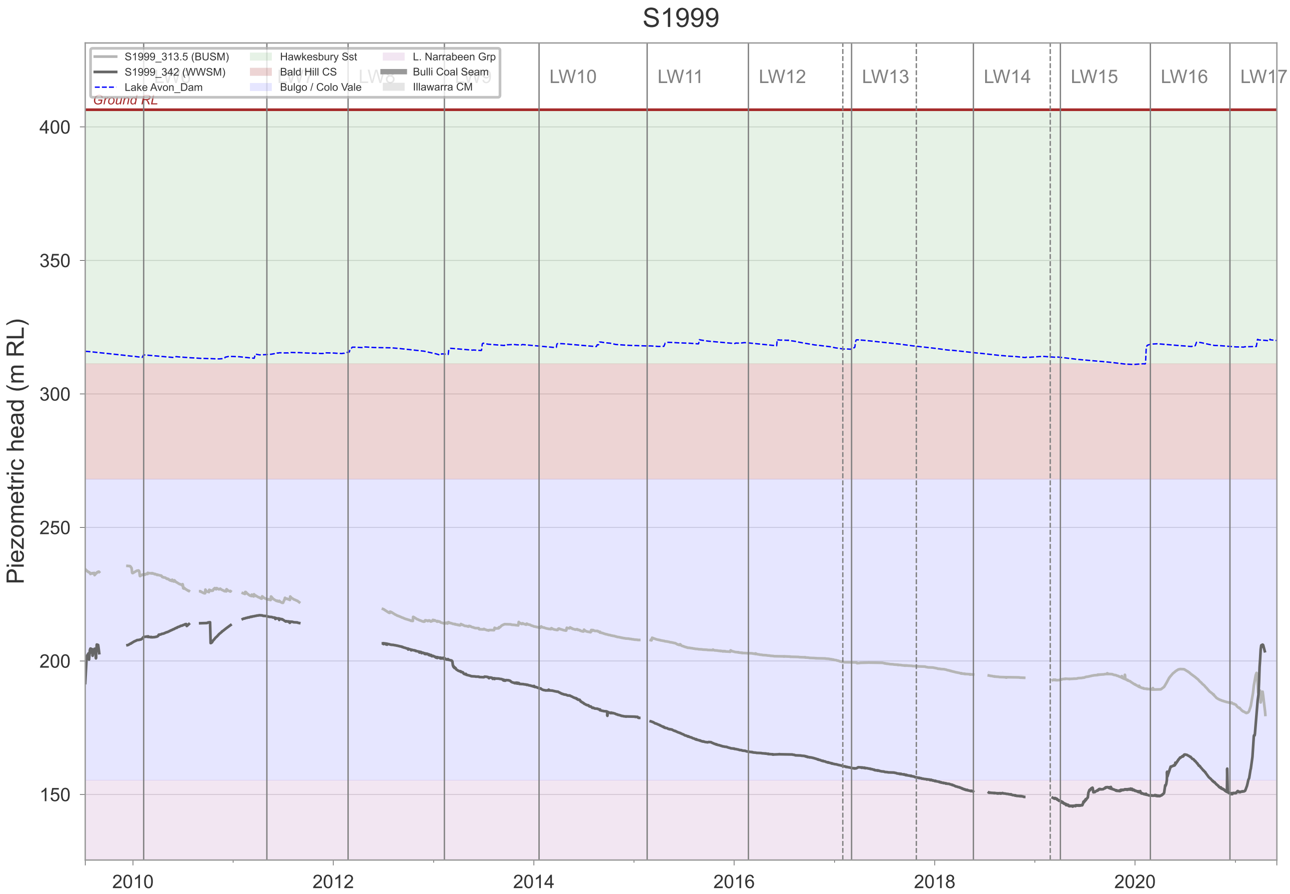
Groundwater hydrographs





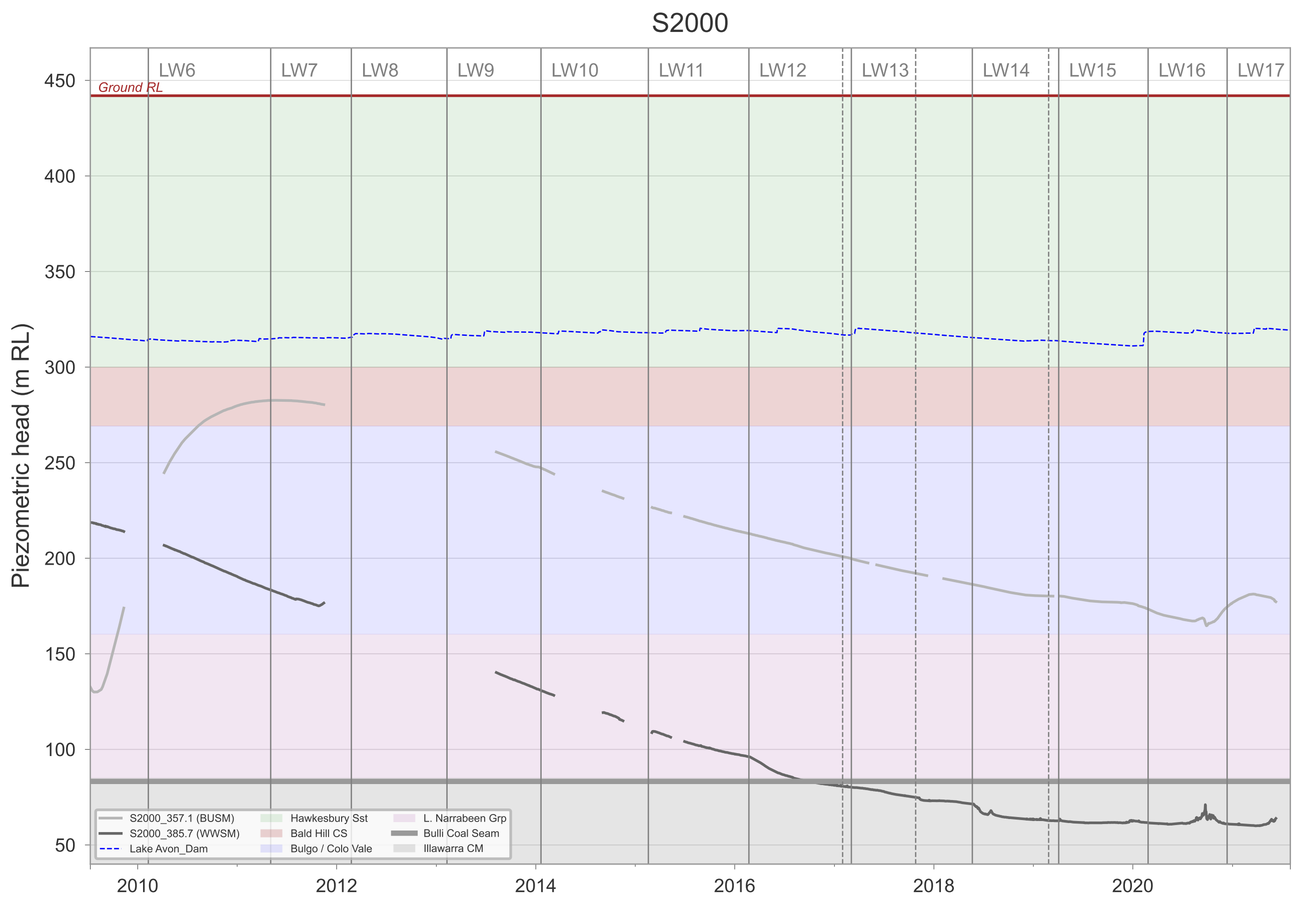

S1998
S1998_381.7 (BUSM)
S1998_407.9 (WWSM)
Lake Avon_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM
Ground RL
LW6
LW7
LW8
LW9
LW10
LW11
LW12
LW13
LW14
LW15
LW16
Piezometric head (m RL)
425
400
375
350
325
300
275
250
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020

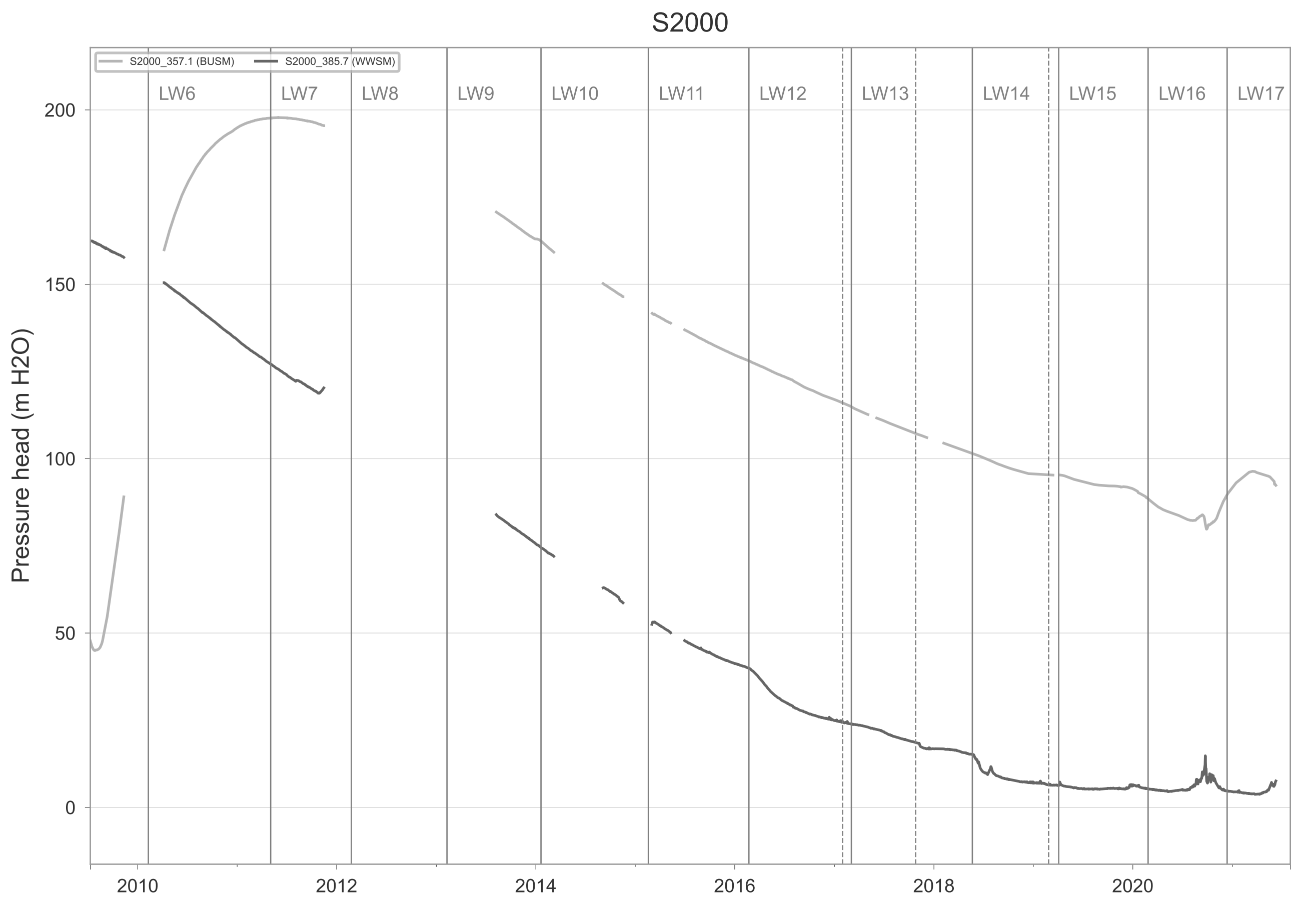

S1998
S1998_381.7 (BUSM)
S1998_407.9 (WWSM)
LW6
LW7
LW8
LW9
LW10
LW11
LW12
LW13
LW14
LW15
LW16
Pressure head (m H2O)
300
280
260
240
220
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020


S1999
S1999_313.5 (BUSM)
S1999_342 (WWSM)
Lake Avon_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM
Ground RL
LW10
LW11
LW12
LW13
LW14
LW15
LW16
LW17
Piezometric head (m RL)
400
350
300
250
200
150
2010
2012
2014
2016
2018
2020

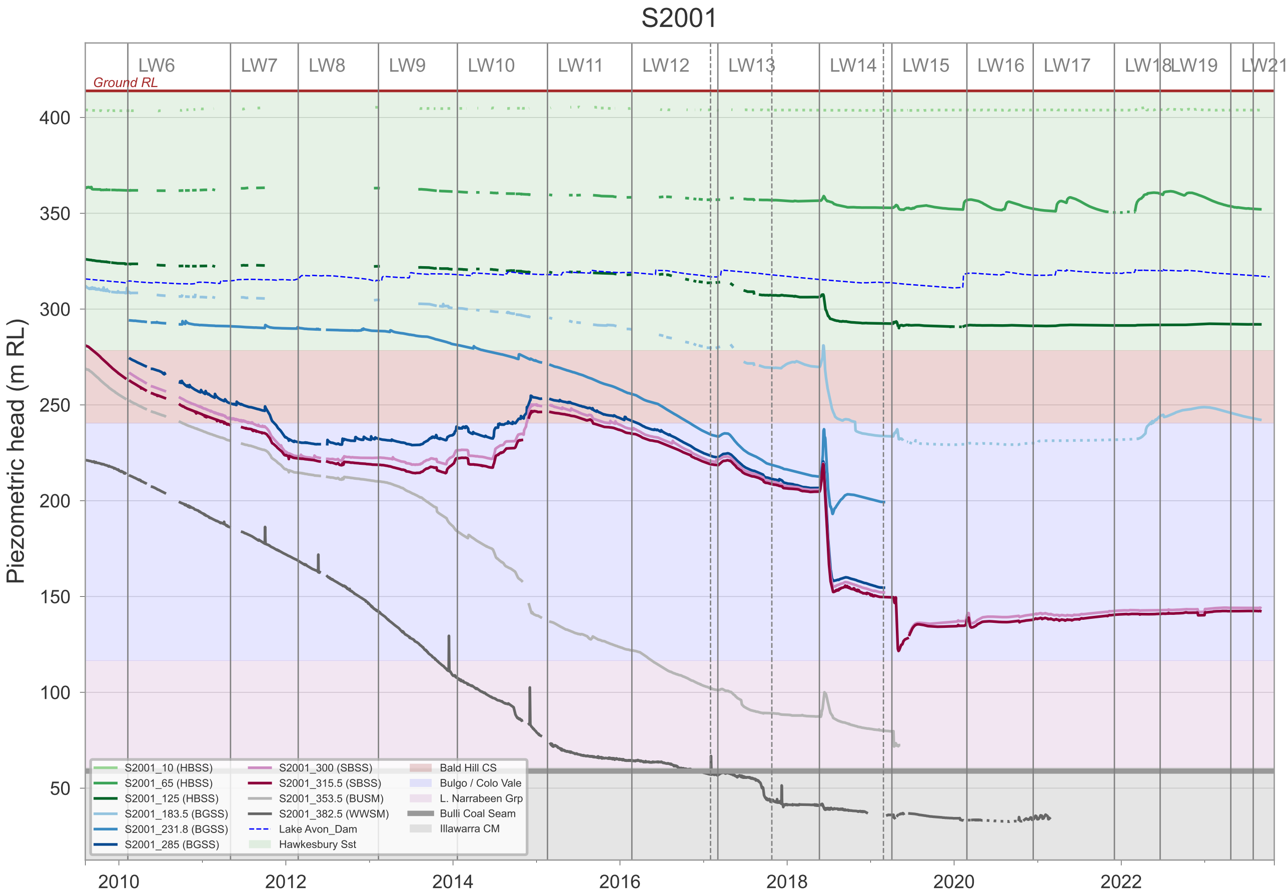

S1999
S1999_313.5 (BUSM)
S1999_342 (WWSM)
LW6
LW7
LW8
LW9
LW10
LW11
LW12
LW13
LW14
LW15
LW16
LW17
Pressure head (m H2O)
160
140
120
100
80
2010
2012
2014
2016
2018
2020

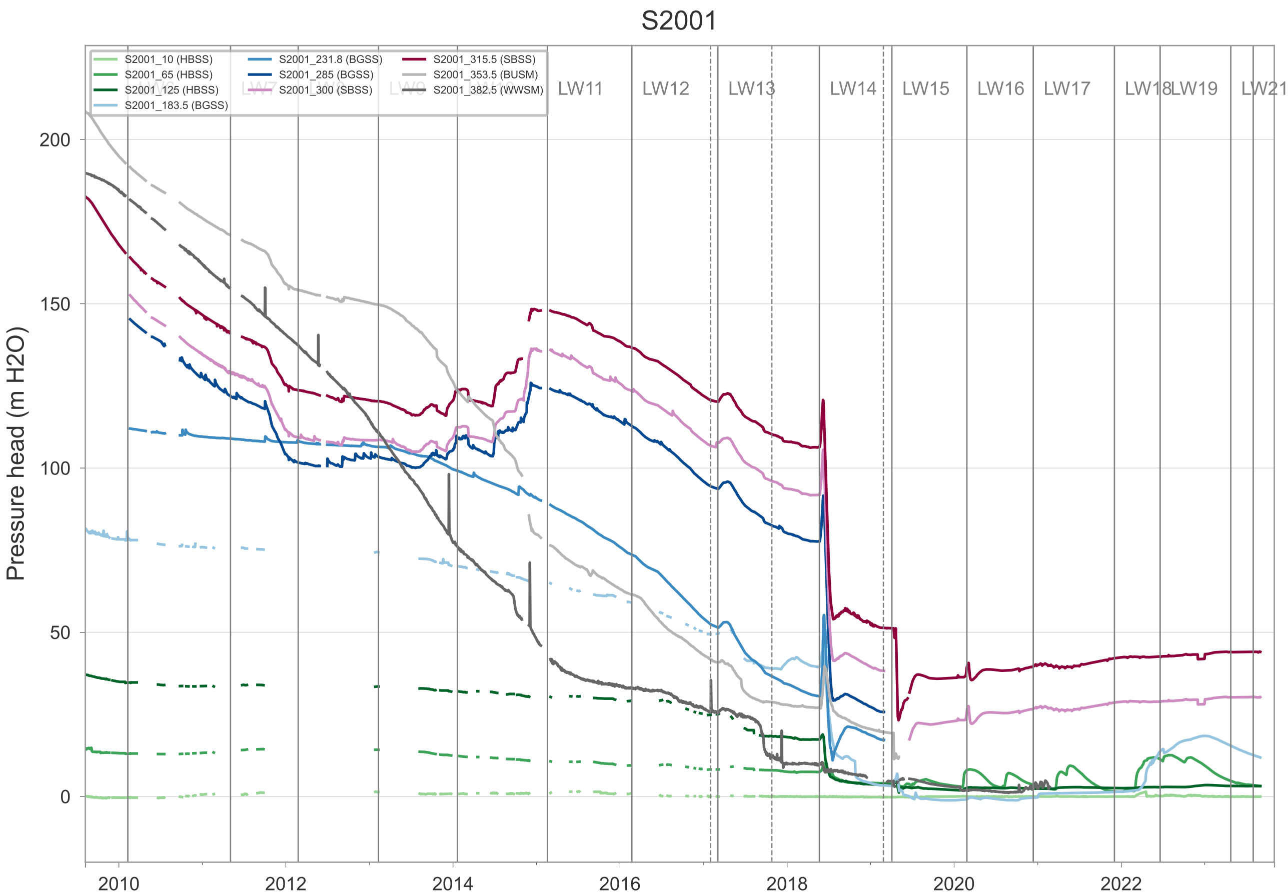
Groundwater hydrographs



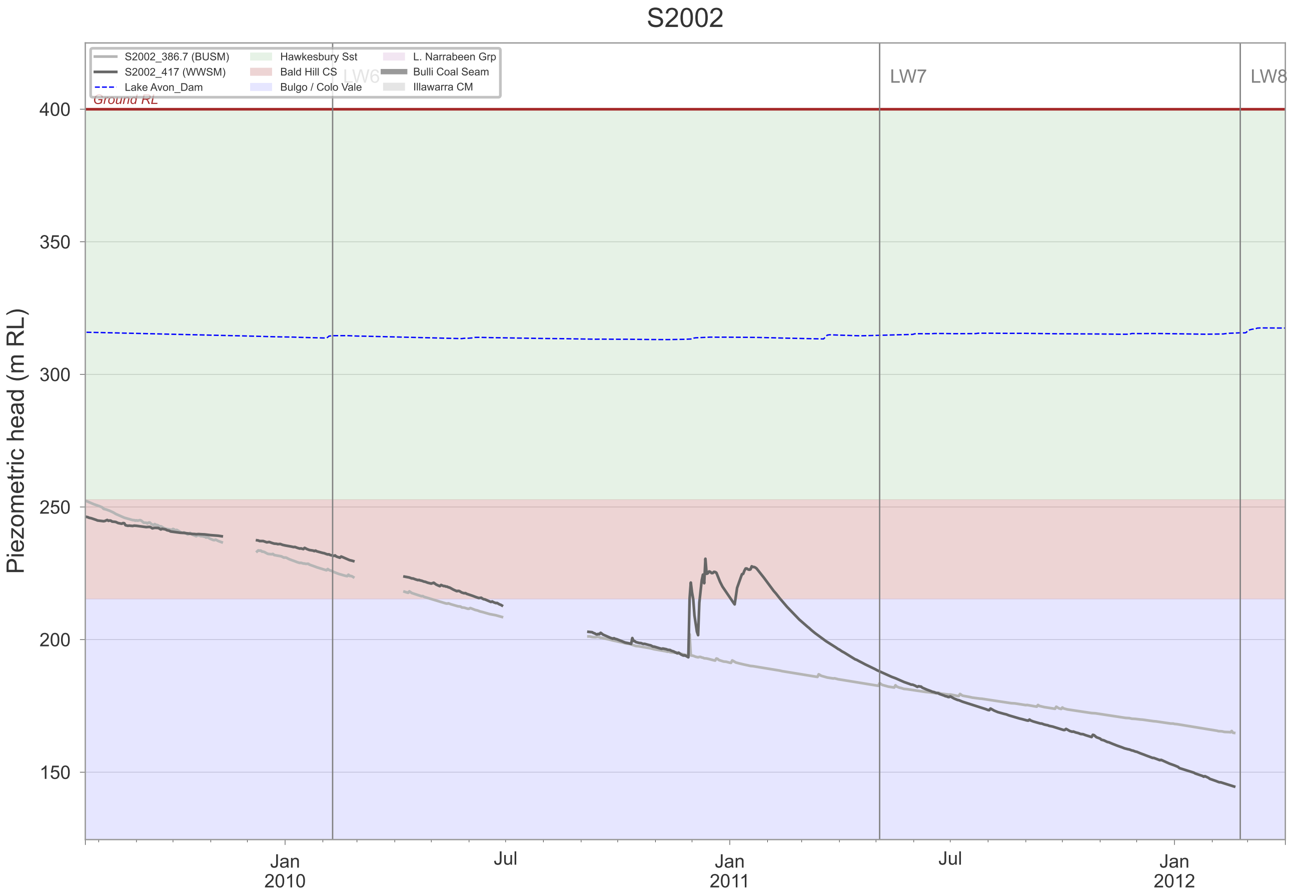


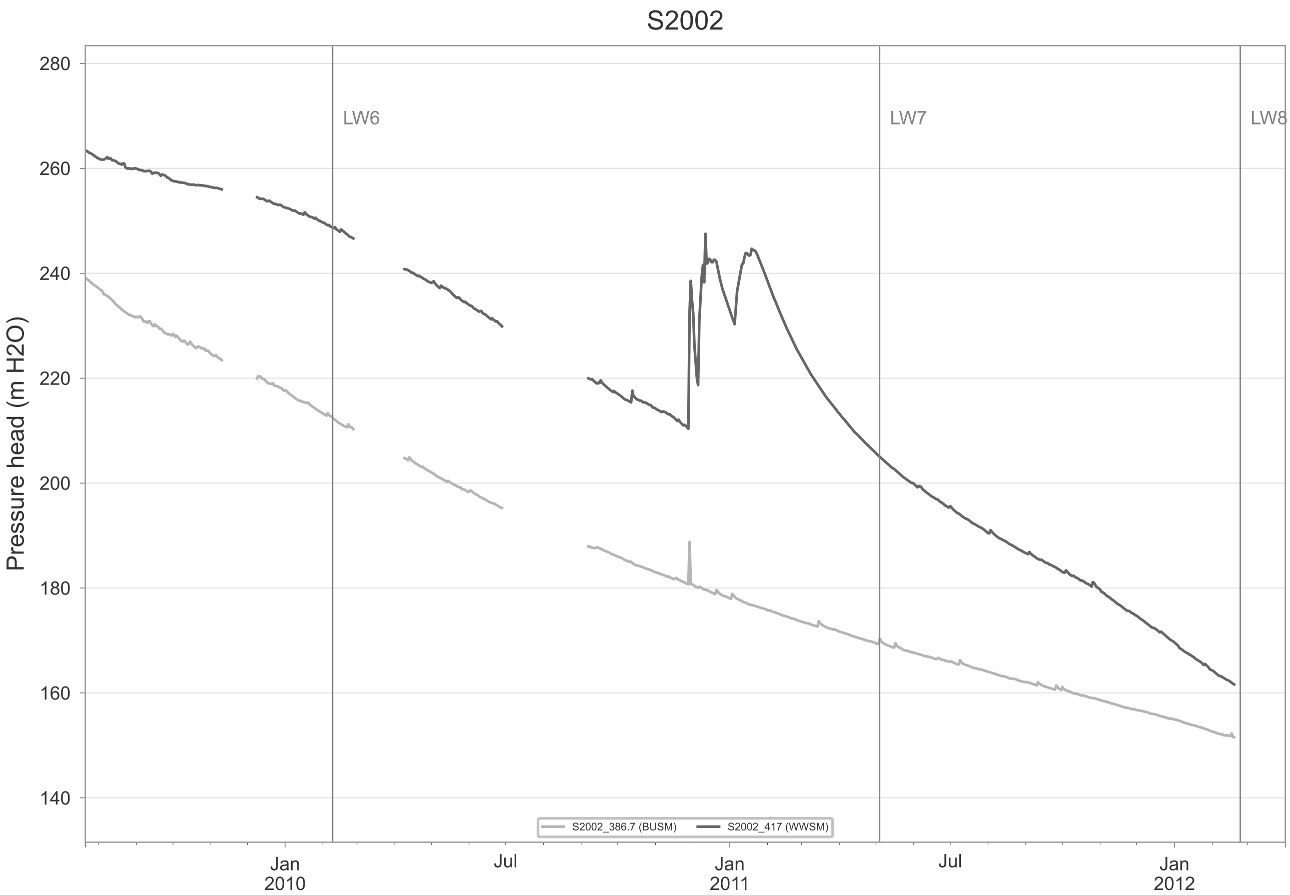
Groundwater hydrographs

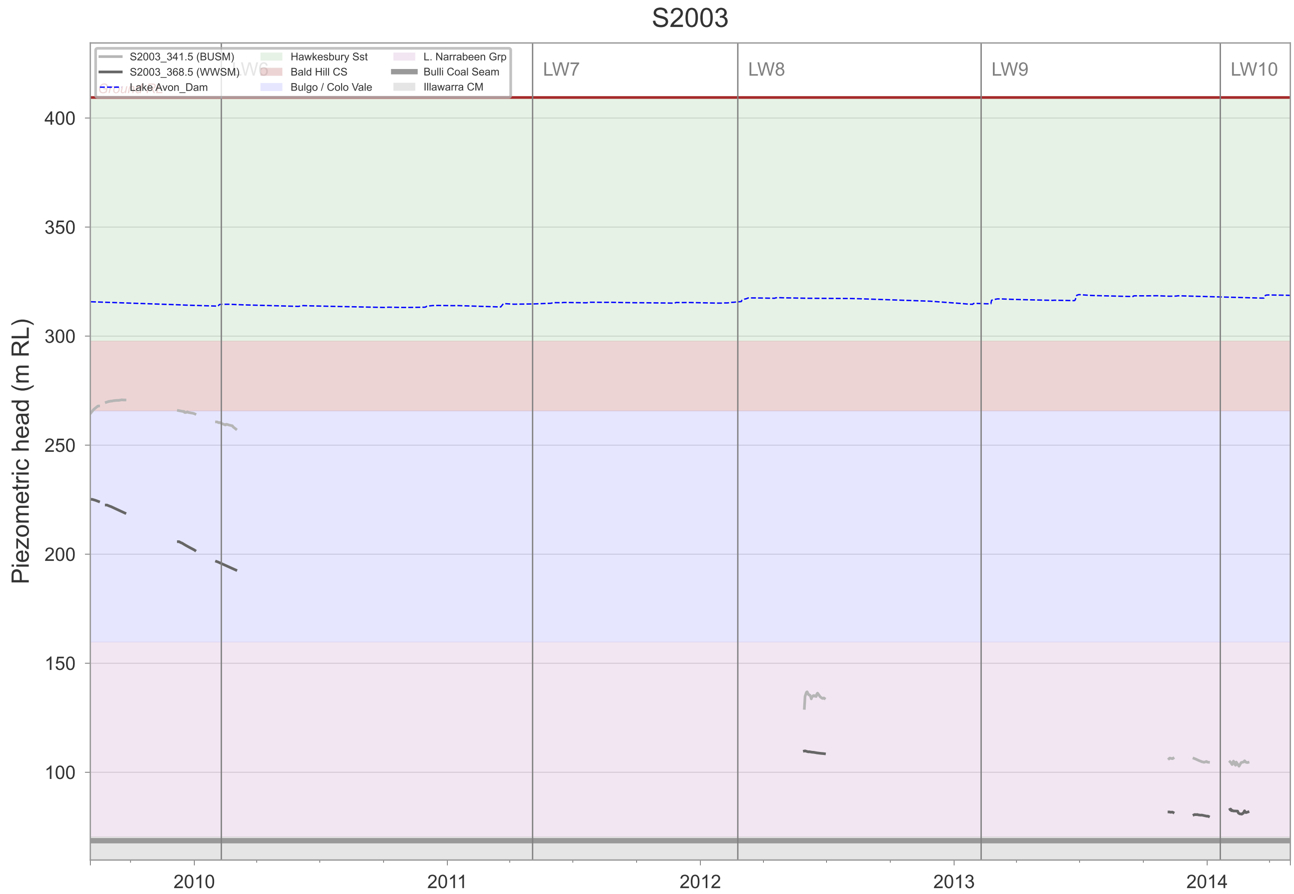


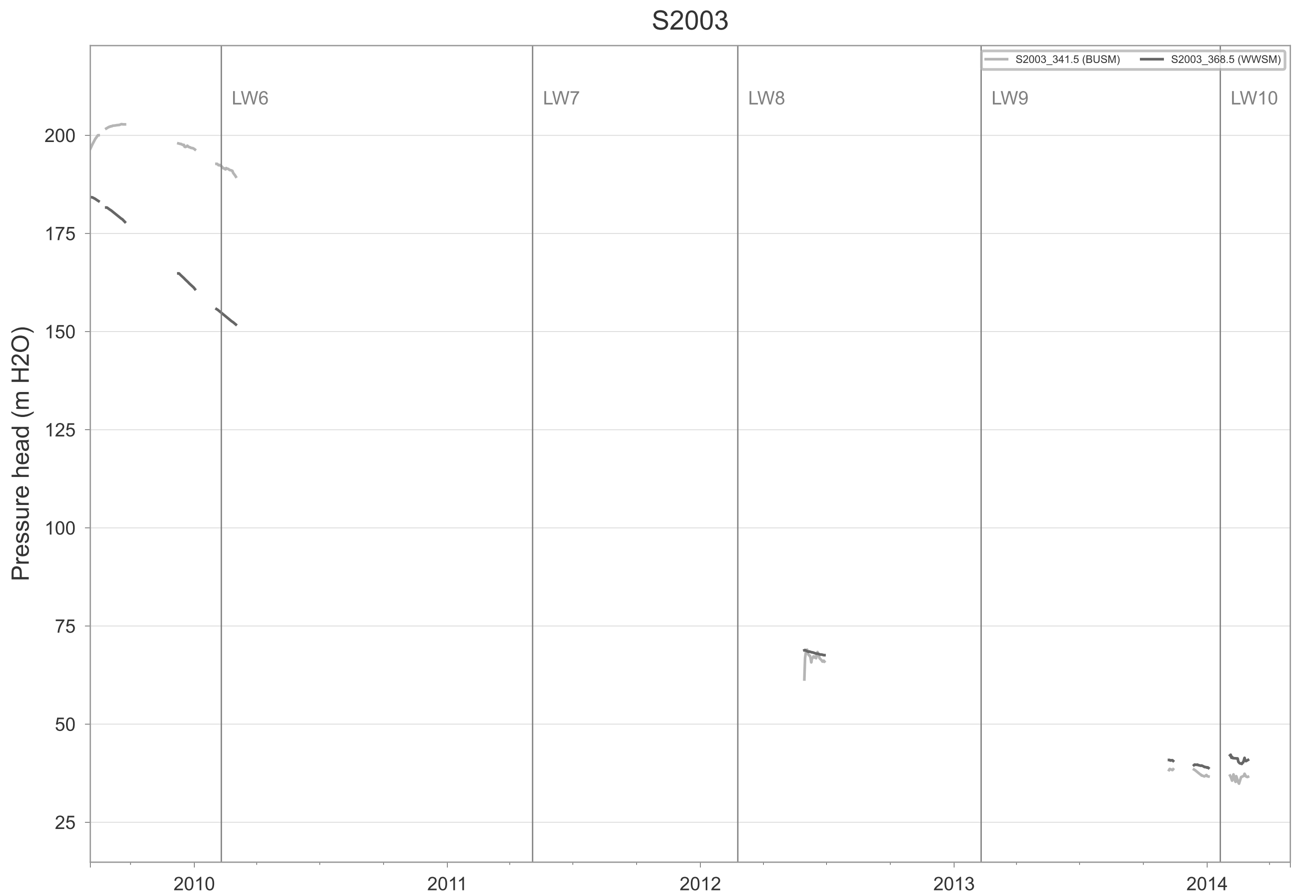


Groundwater hydrographs



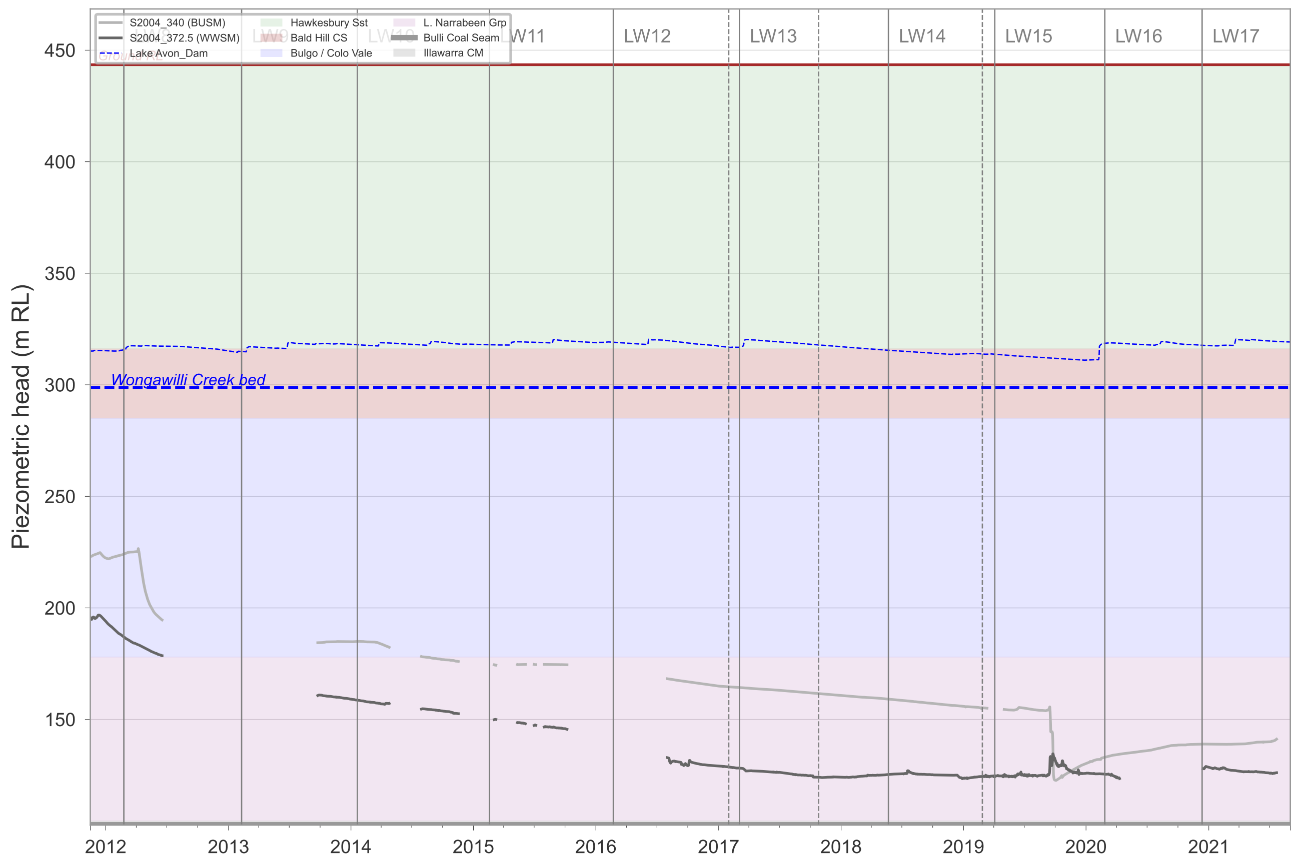



S2003
S2003_341.5 (BUSM)
S2003_368.5 (WWSM)
Lake Avon_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM
LW7
LW8
LW9
LW10
Piezometric head (m RL)
400
350
300
250
200
150
100
2010
2011
2012
2013
2014

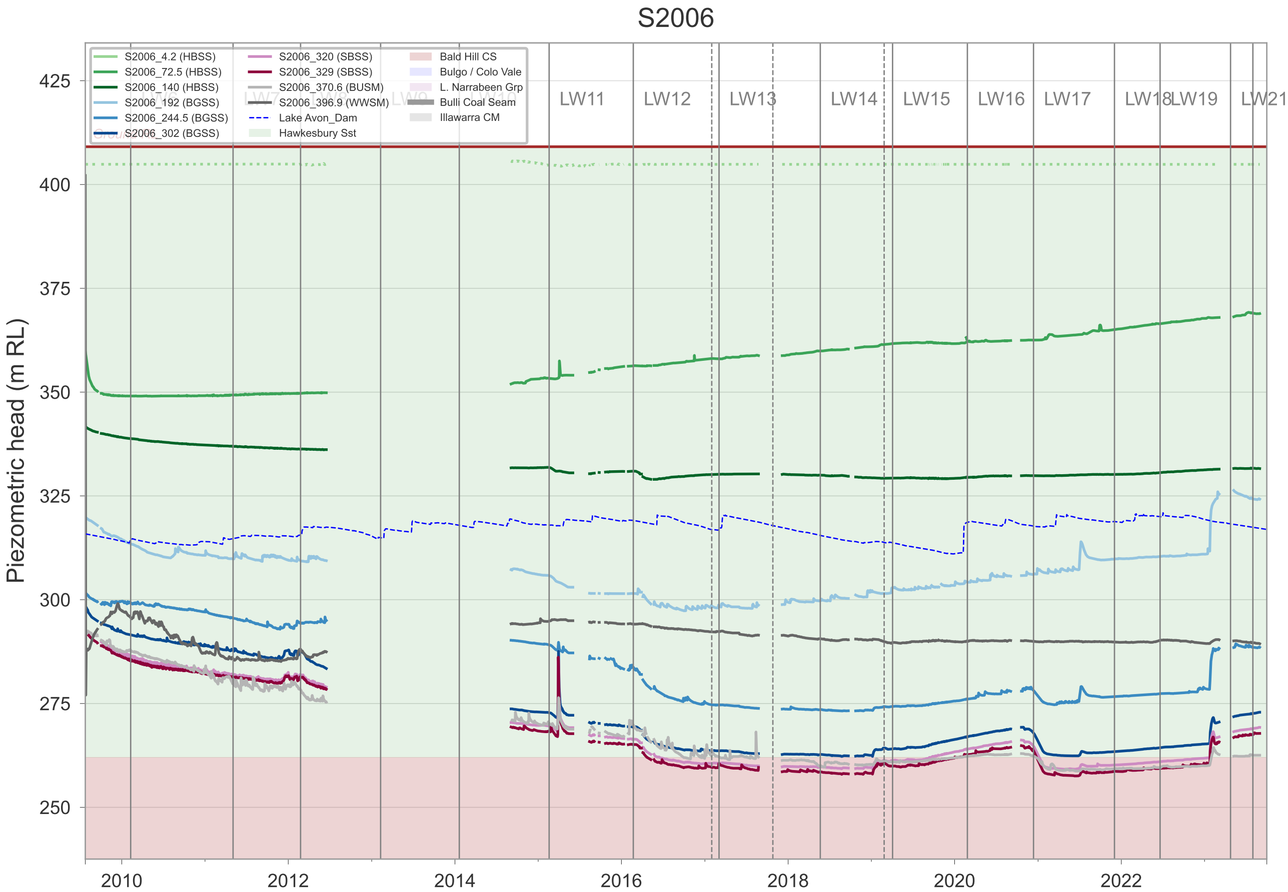

S2003
S2003_341.5 (BUSM)
S2003_368.5 (WWSM)
LW6
LW7
LW8
LW9
LW10
Pressure head (m H2O)
200
175
150
125
100
75
50
25
2010
2011
2012
2013
2014

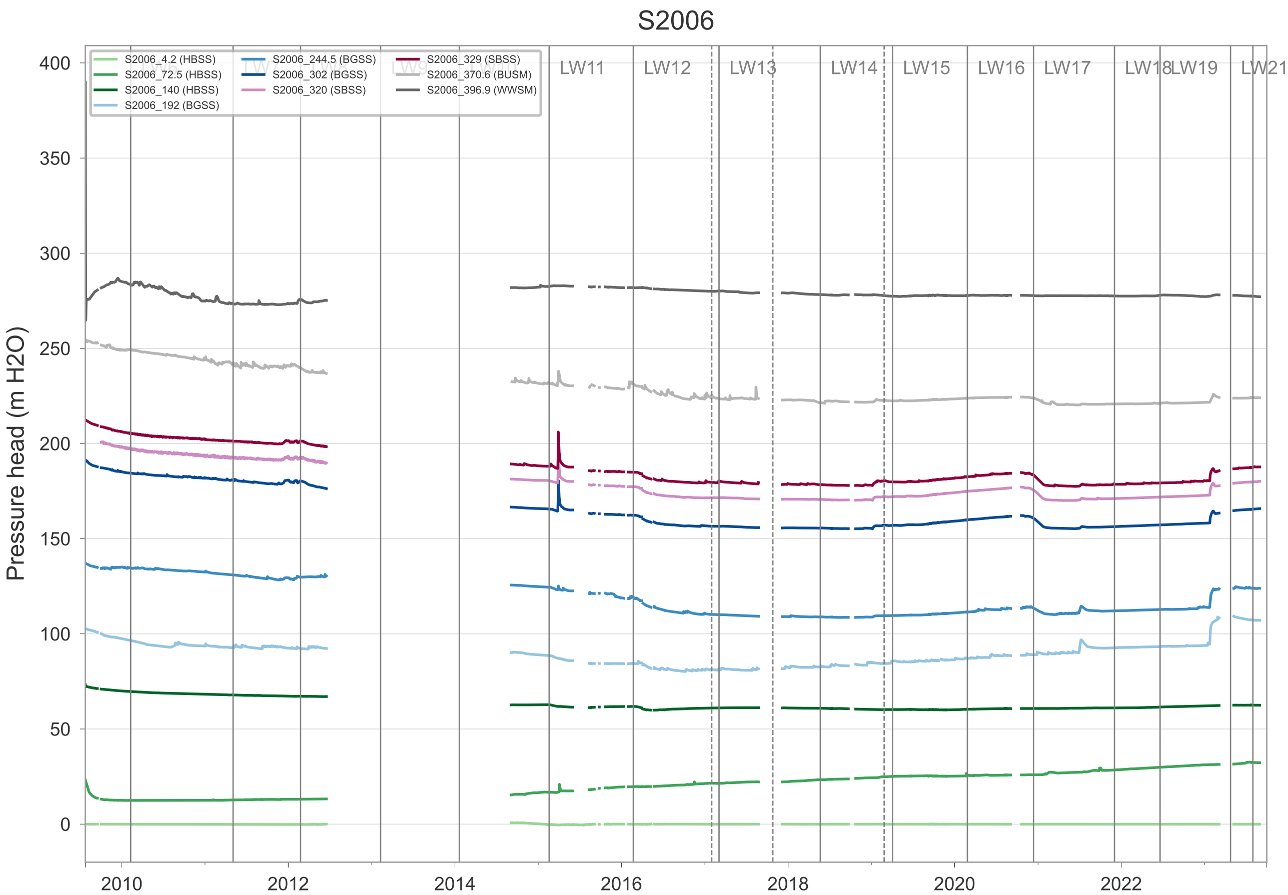
Groundwater hydrographs

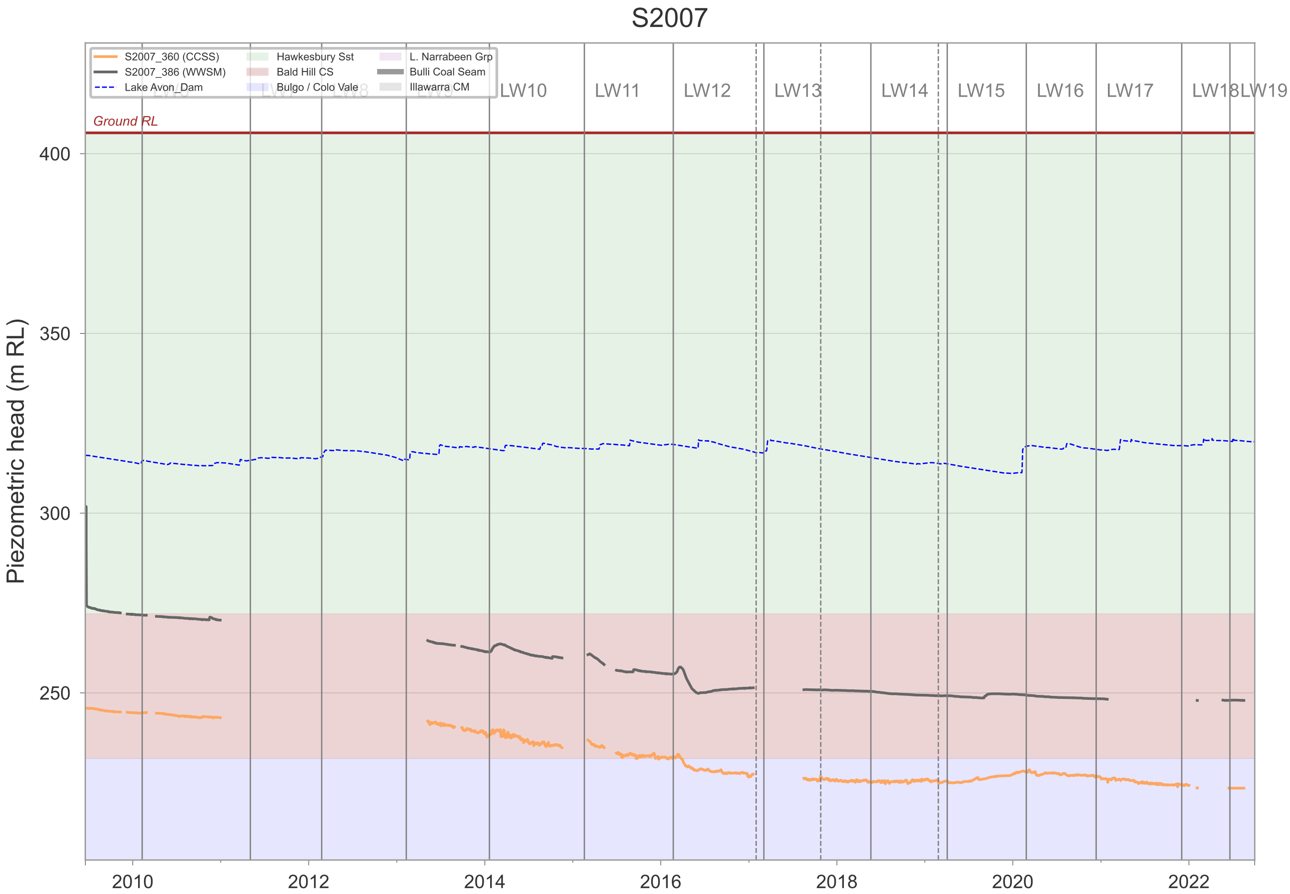
S2004

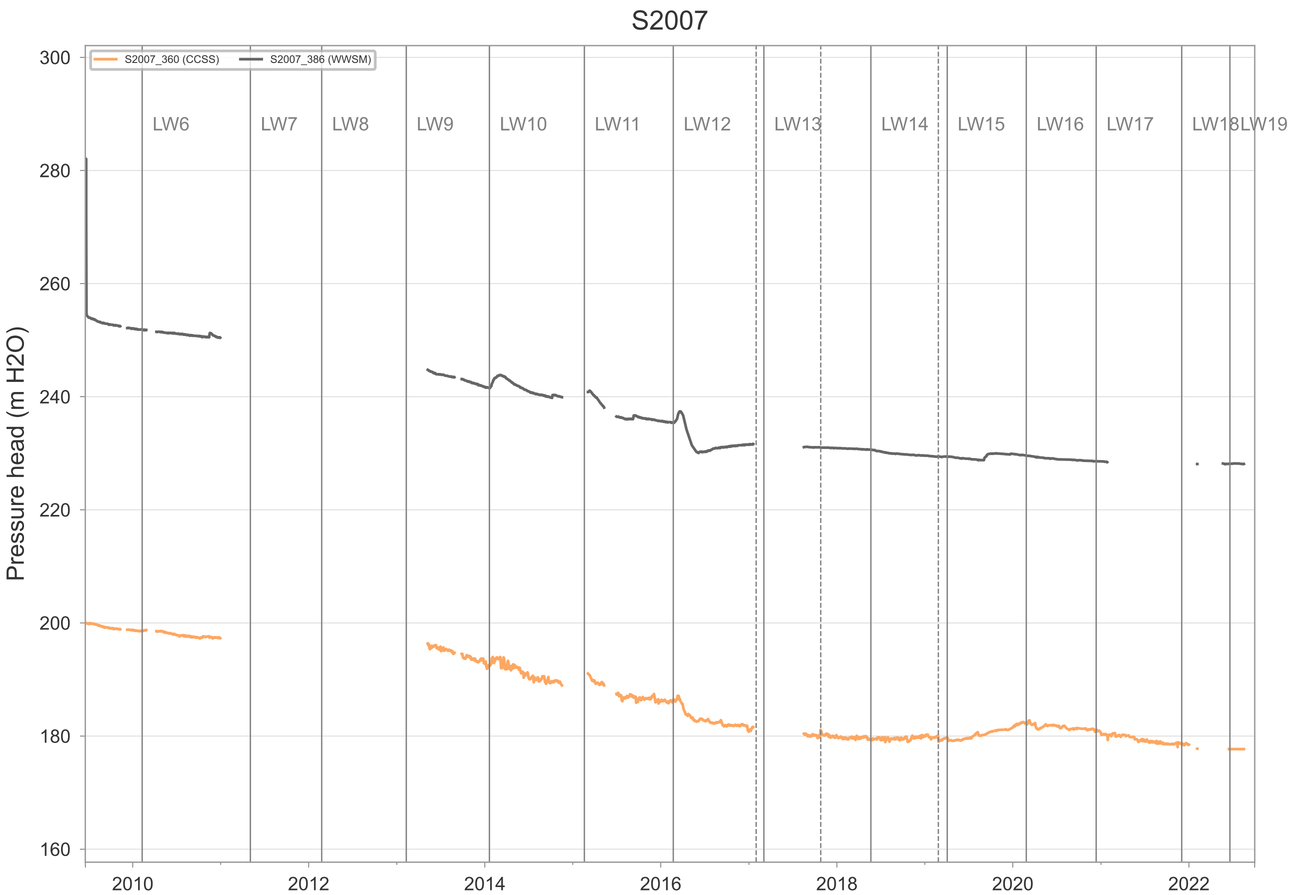


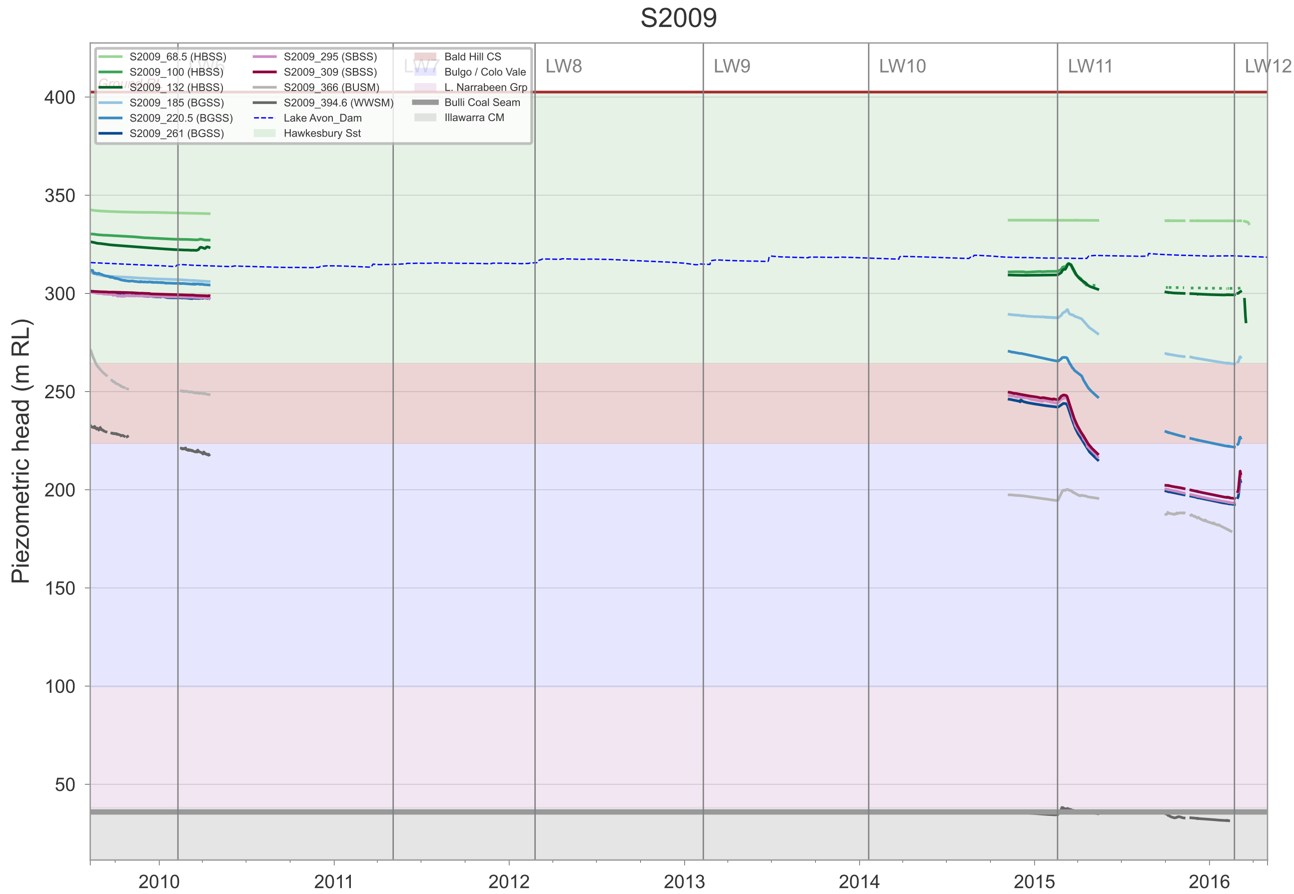
S2004

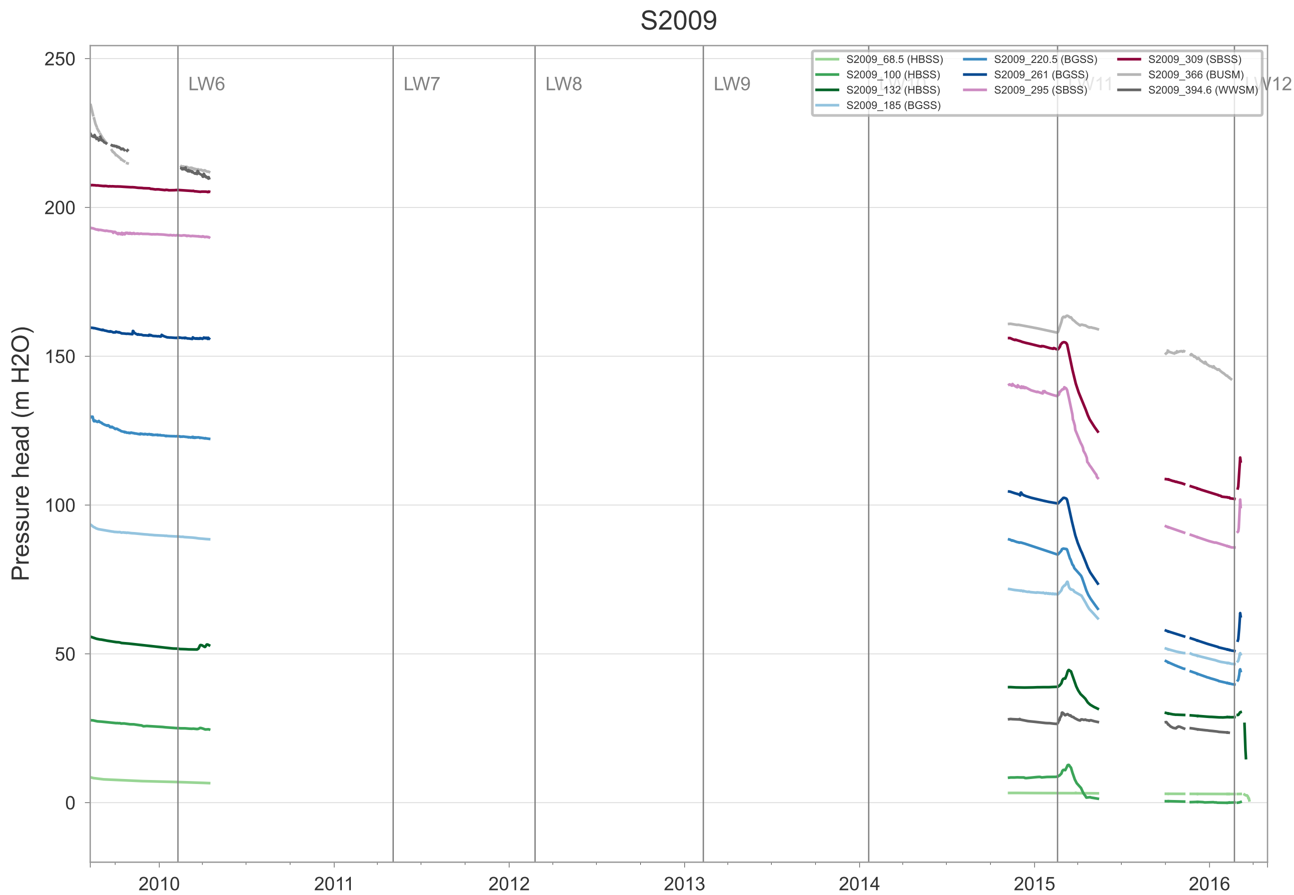

S2006
Piezometric head (m RL)
425
400
375
350
325
300
275
250
2010
2012
2014
2016
2018
2020
2022
LW11
LW12
LW13
LW14
LW15
LW16
LW17
LW18
LW19
LW21
S2006_4.2 (HBSS)
S2006_72.5 (HBSS)
S2006_140 (HBSS)
S2006_192 (BGSS)
S2006_244.5 (BGSS)
S2006_302 (BGSS)
S2006_320 (SBSS)
S2006_329 (SBSS)
S2006_370.6 (BUSM)
S2006_396.9 (WWSM)
Lake Avon_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM


S2006
Pressure head (m H2O)
400
350
300
250
200
150
100
50
0
2010
2012
2014
2016
2018
2020
2022
LW11
LW12
LW13
LW14
LW15
LW16
LW17
LW18
LW19
LW21
S2006_4.2 (HBSS)
S2006_72.5 (HBSS)
S2006_140 (HBSS)
S2006_192 (BGSS)
S2006_244.5 (BGSS)
S2006_302 (BGSS)
S2006_320 (SBSS)
S2006_329 (SBSS)
S2006_370.6 (BUSM)
S2006_396.9 (WWSM)

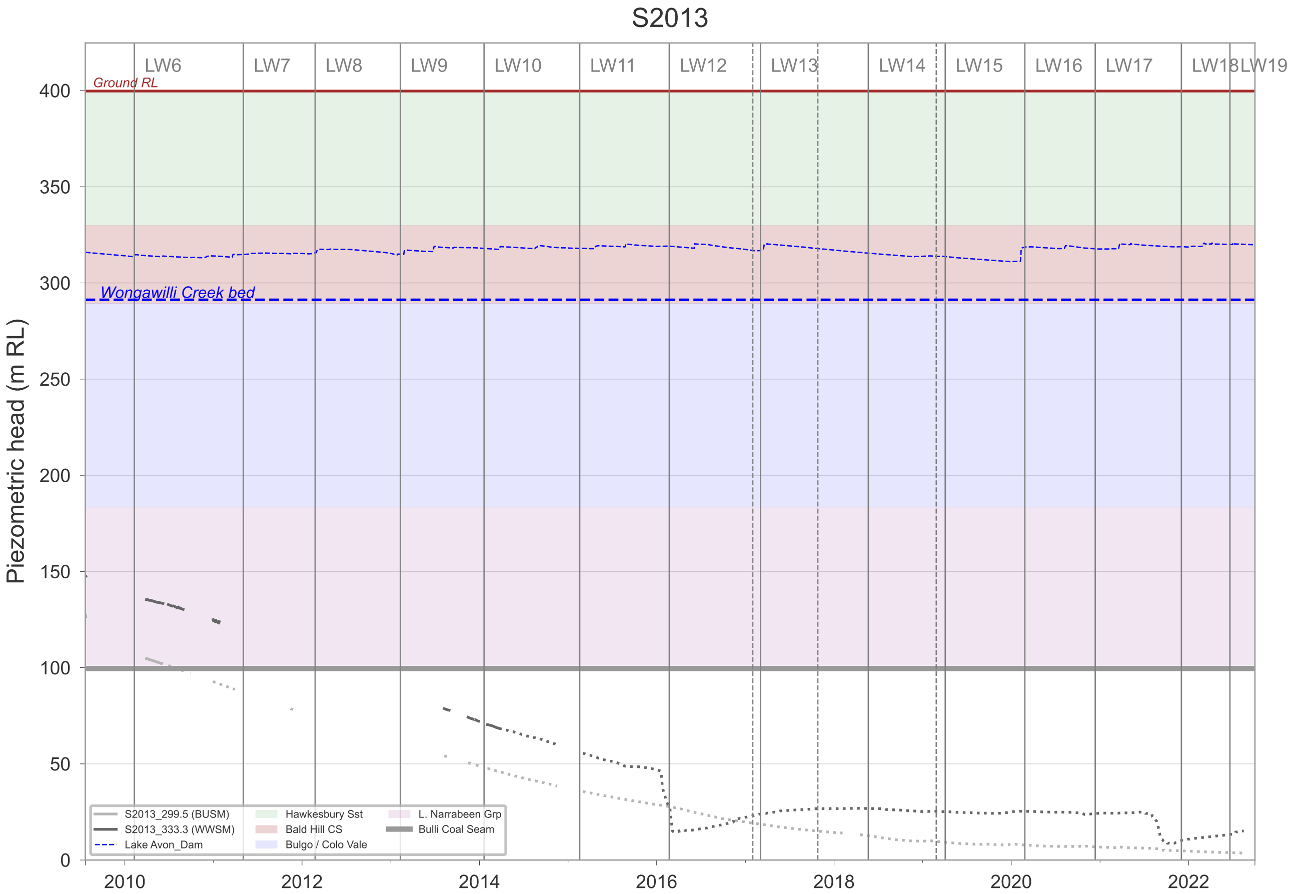

S2007
S2007_360 (CCSS)
S2007_386 (WWSM)
Lake Avon_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM
LW10
LW11
LW12
LW13
LW14
LW15
LW16
LW17
LW18
LW19
Ground RL
Piezometric head (m RL)
400
350
300
250
2010
2012
2014
2016
2018
2020
2022

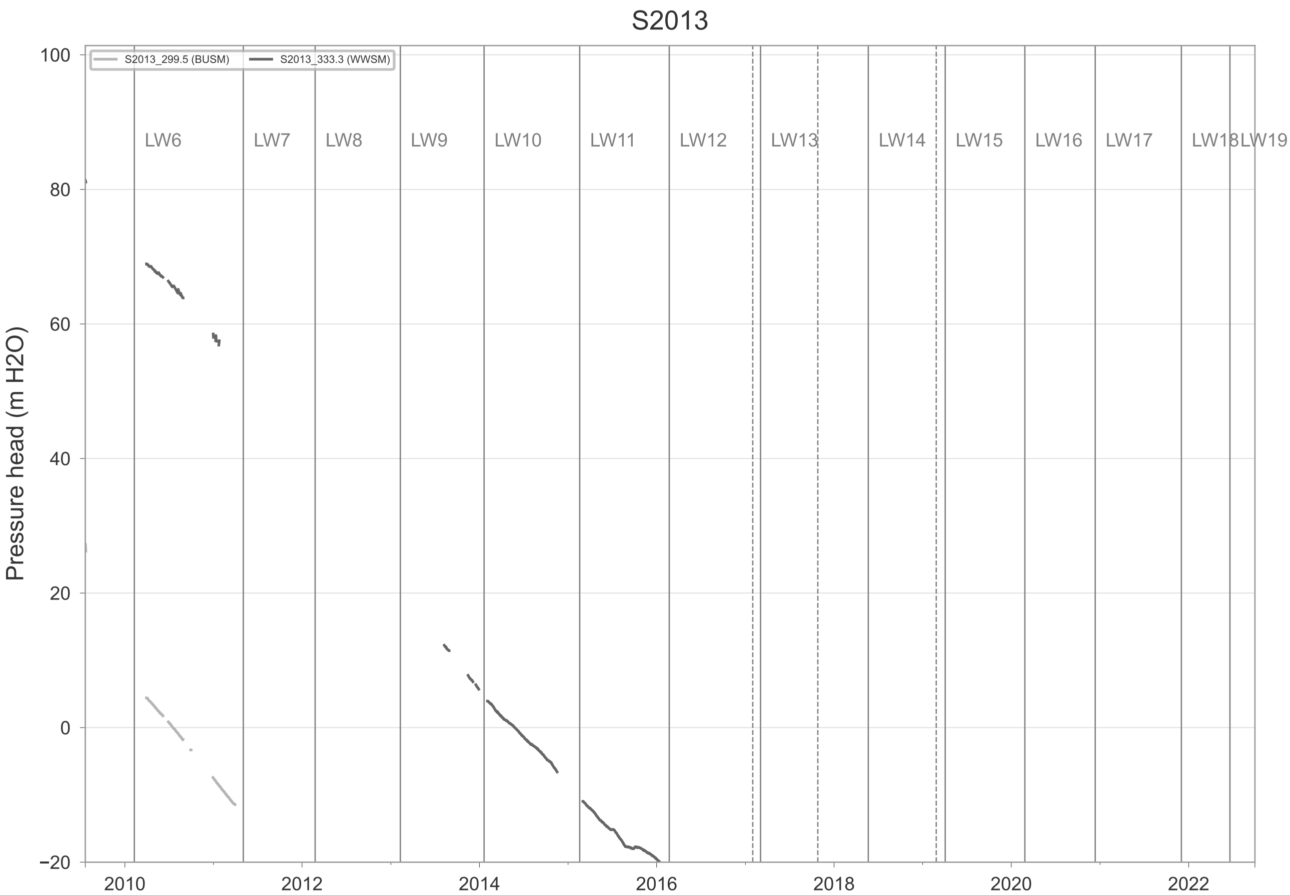

S2007
S2007_360 (CCSS)
S2007_386 (WWSM)
LW6
LW7
LW8
LW9
LW10
LW11
LW12
LW13
LW14
LW15
LW16
LW17
LW18
LW19
Pressure head (m H2O)
300
280
260
240
220
200
180
160
2010
2012
2014
2016
2018
2020
2022


S2009
Piezometric head (m RL)
S2009_68.5 (HBSS)
S2009_100 (HBSS)
S2009_132 (HBSS)
S2009_185 (BGSS)
S2009_220.5 (BGSS)
S2009_261 (BGSS)
S2009_295 (SBSS)
S2009_309 (SBSS)
S2009_366 (BUSM)
S2009_394.6 (WWSM)
Lake Avon_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM
LW8
LW9
LW10
LW11
LW12
400
350
300
250
200
150
100
50
2010
2011
2012
2013
2014
2015
2016

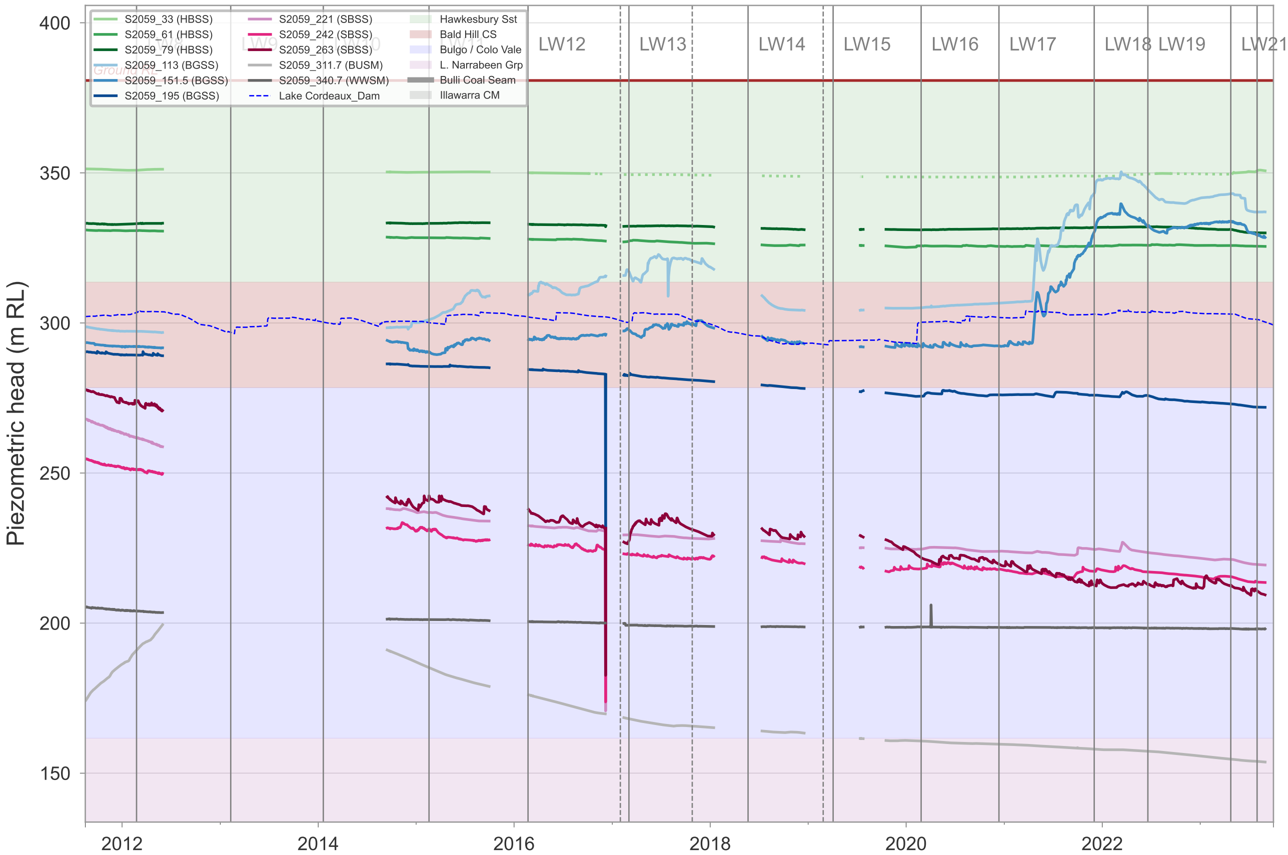

S2009
Pressure head (m H2O)
S2009_68.5 (HBSS)
S2009_100 (HBSS)
S2009_132 (HBSS)
S2009_185 (BGSS)
S2009_220.5 (BGSS)
S2009_261 (BGSS)
S2009_295 (SBSS)
S2009_309 (SBSS)
S2009_366 (BUSM)
S2009_394.6 (WWSM)
LW6
LW7
LW8
LW9
250
200
150
100
50
0
2010
2011
2012
2013
2014
2015
2016

Groundwater hydrographs

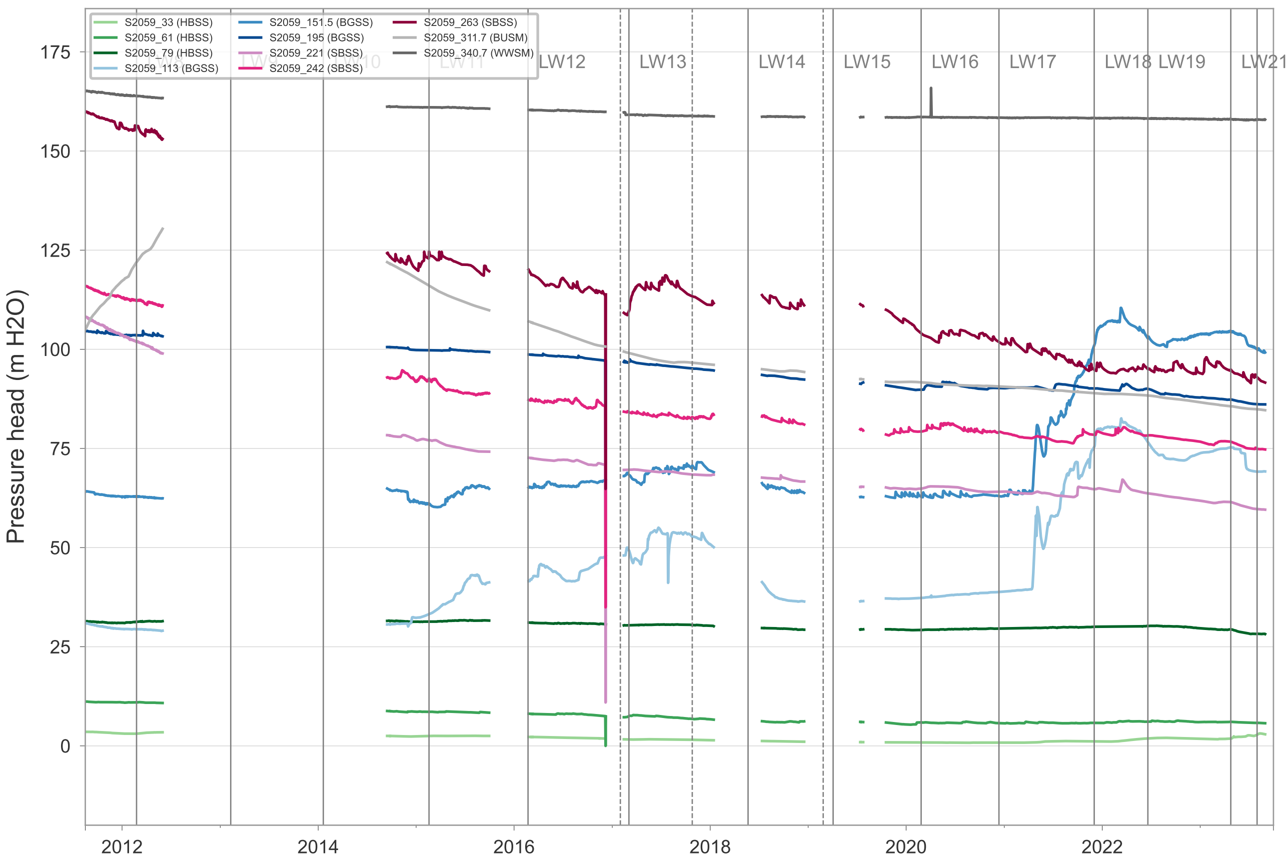


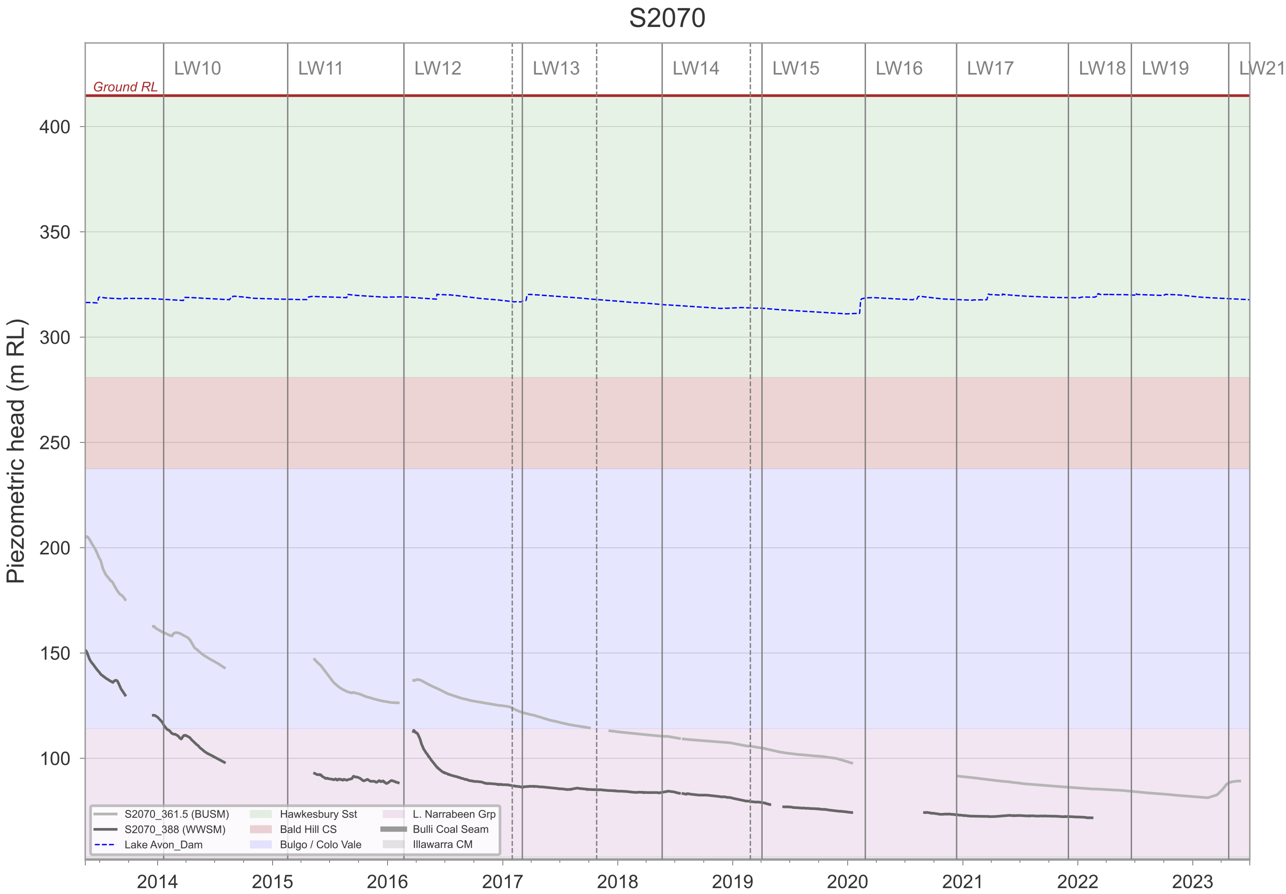


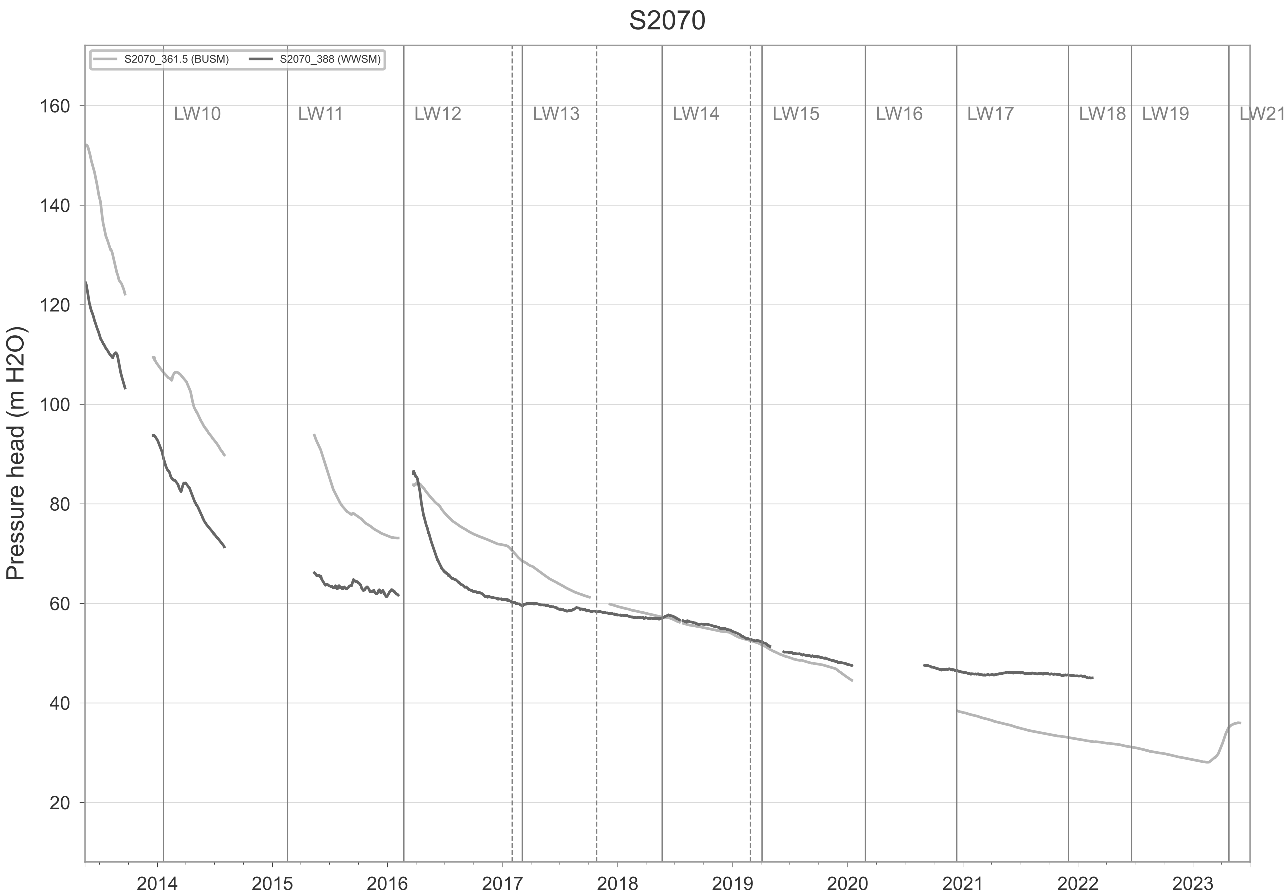
S2059

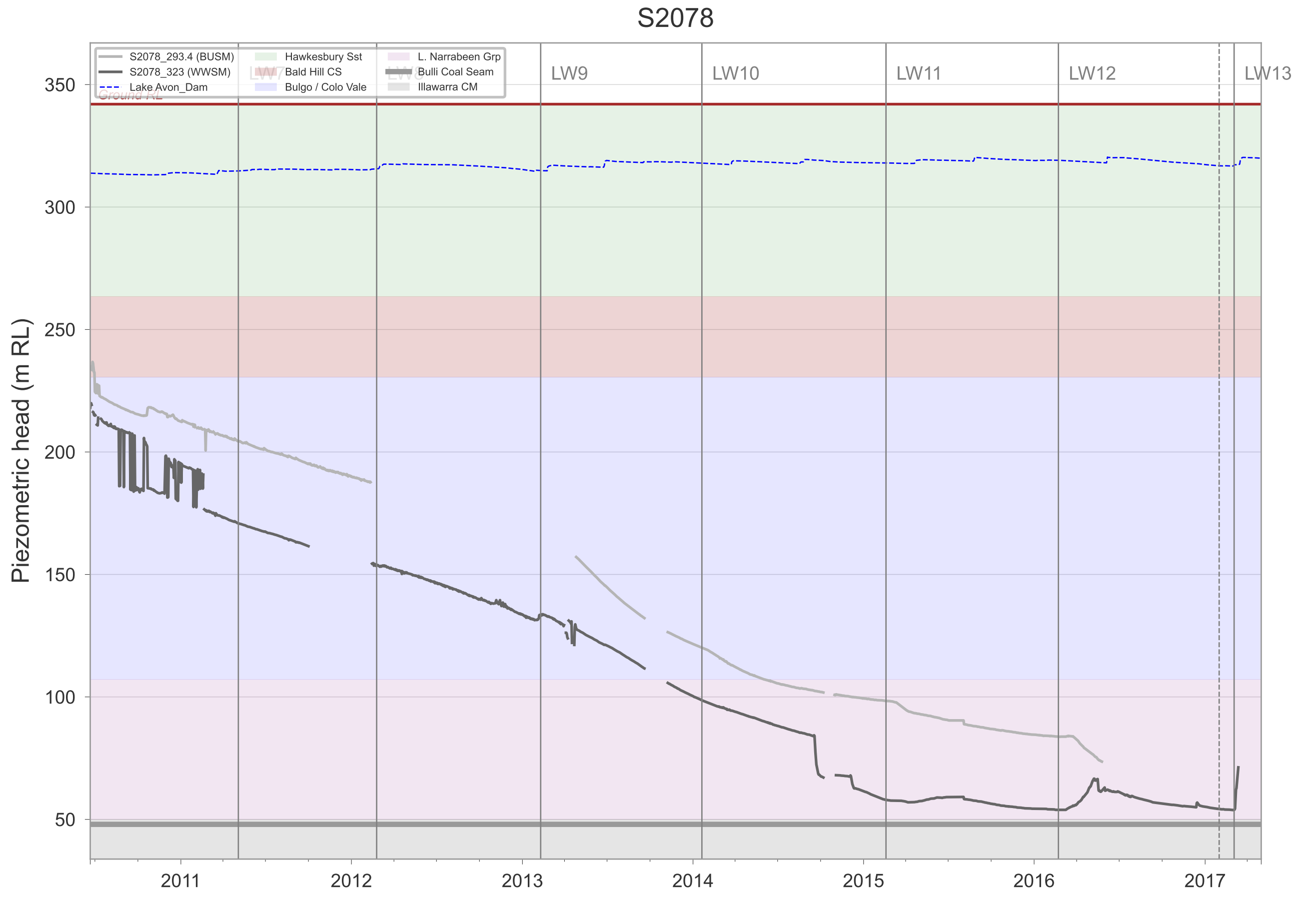

S2059_33 (HBSS)
S2059_61 (HBSS)
S2059_79 (HBSS)
S2059_113 (BGSS)
S2059_151.5 (BGSS)
S2059_195 (BGSS)
S2059_221 (SBSS)
S2059_242 (SBSS)
S2059_263 (SBSS)
S2059_311.7 (BUSM)
S2059_340.7 (WWSM)
Lake Cordeaux_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM
LW12
LW13
LW14
LW15
LW16
LW17
LW18
LW19
LW21
Piezometric head (m RL)
400
350
300
250
200
150
2012
2014
2016
2018
2020
2022

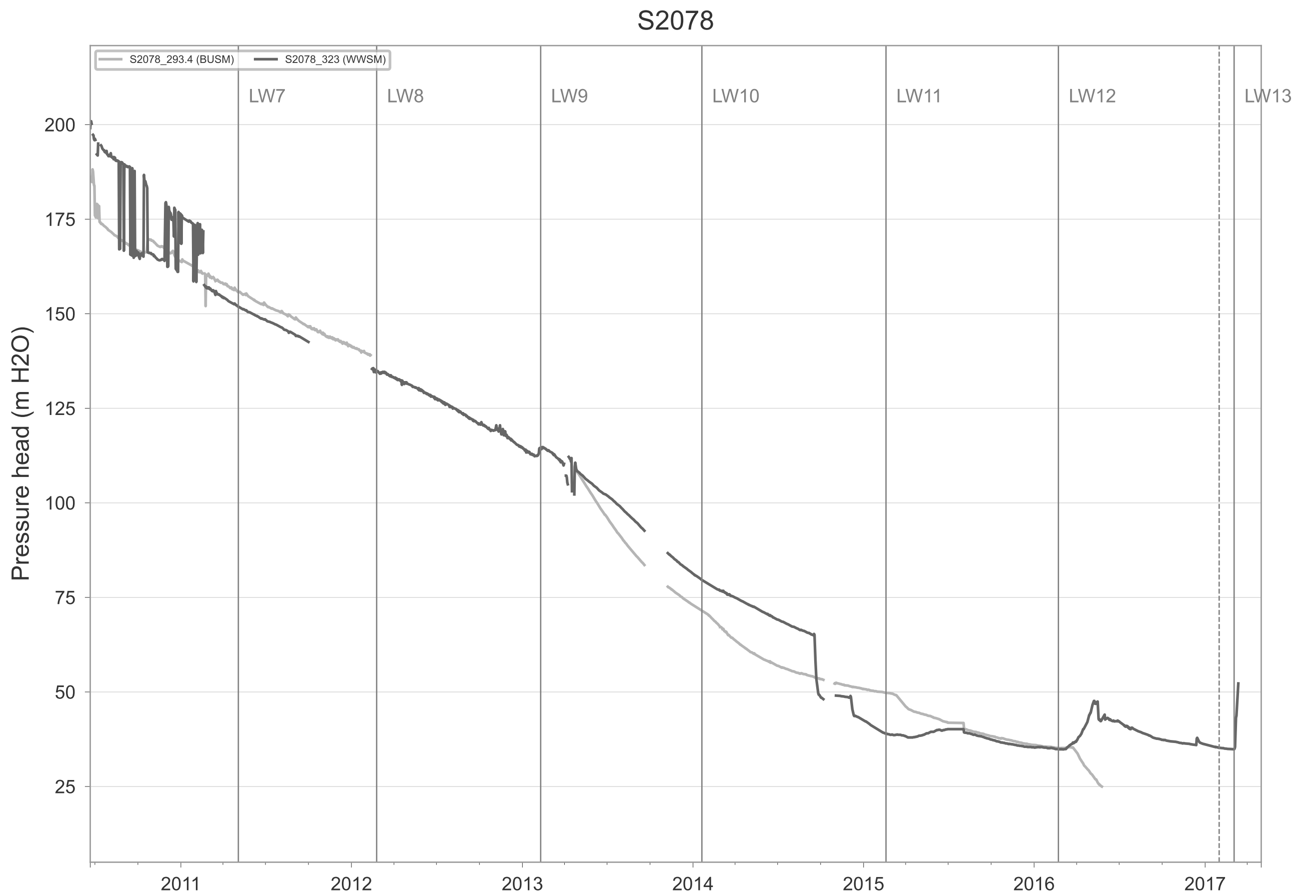
S2059


S2059_33 (HBSS)
S2059_61 (HBSS)
S2059_79 (HBSS)
S2059_113 (BGSS)
S2059_151.5 (BGSS)
S2059_195 (BGSS)
S2059_221 (SBSS)
S2059_242 (SBSS)
S2059_263 (SBSS)
S2059_311.7 (BUSM)
S2059_340.7 (WWSM)
LW12
LW13
LW14
LW15
LW16
LW17
LW18
LW19
LW21
Pressure head (m H2O)
175
150
125
100
75
50
25
0
2012
2014
2016
2018
2020
2022

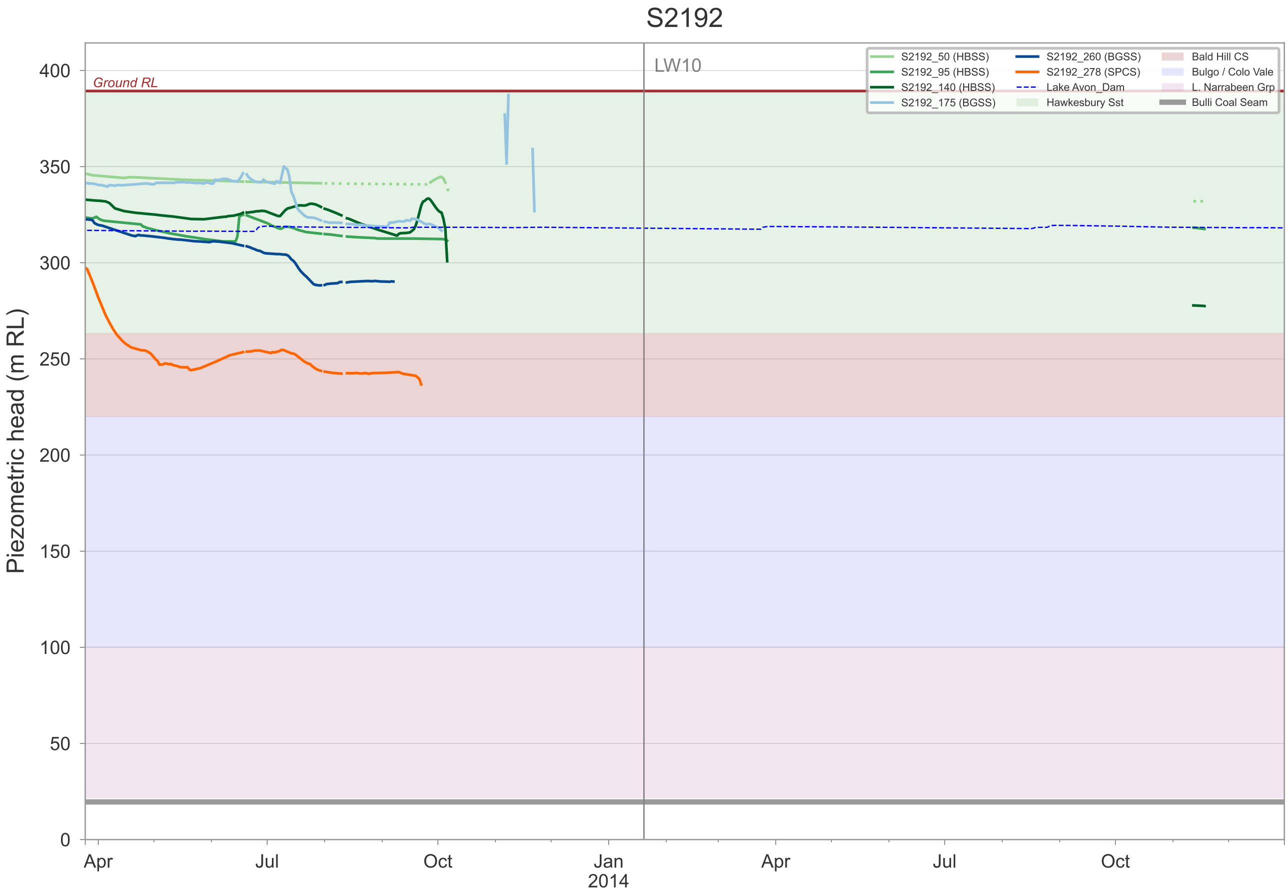

S2070
LW10
LW11
LW12
LW13
LW14
LW15
LW16
LW17
LW18
LW19
LW21
Ground RL
Piezometric head (m RL)
400
350
300
250
200
150
100
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
S2070_361.5 (BUSM)
S2070_388 (WWSM)
Lake Avon_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM

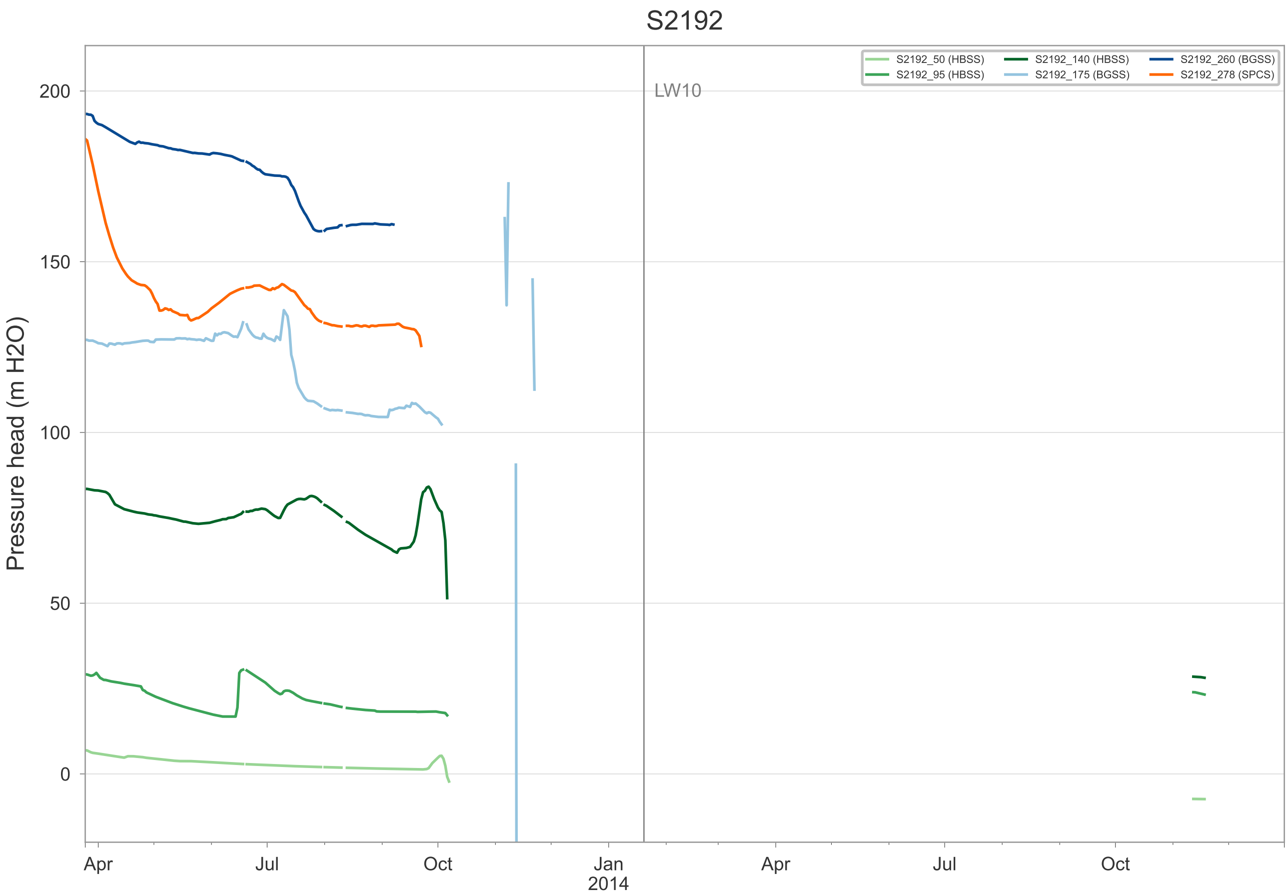

S2070
S2070_361.5 (BUSM)
S2070_388 (WWSM)
LW10
LW11
LW12
LW13
LW14
LW15
LW16
LW17
LW18
LW19
LW21
Pressure head (m H2O)
160
140
120
100
80
60
40
20
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023

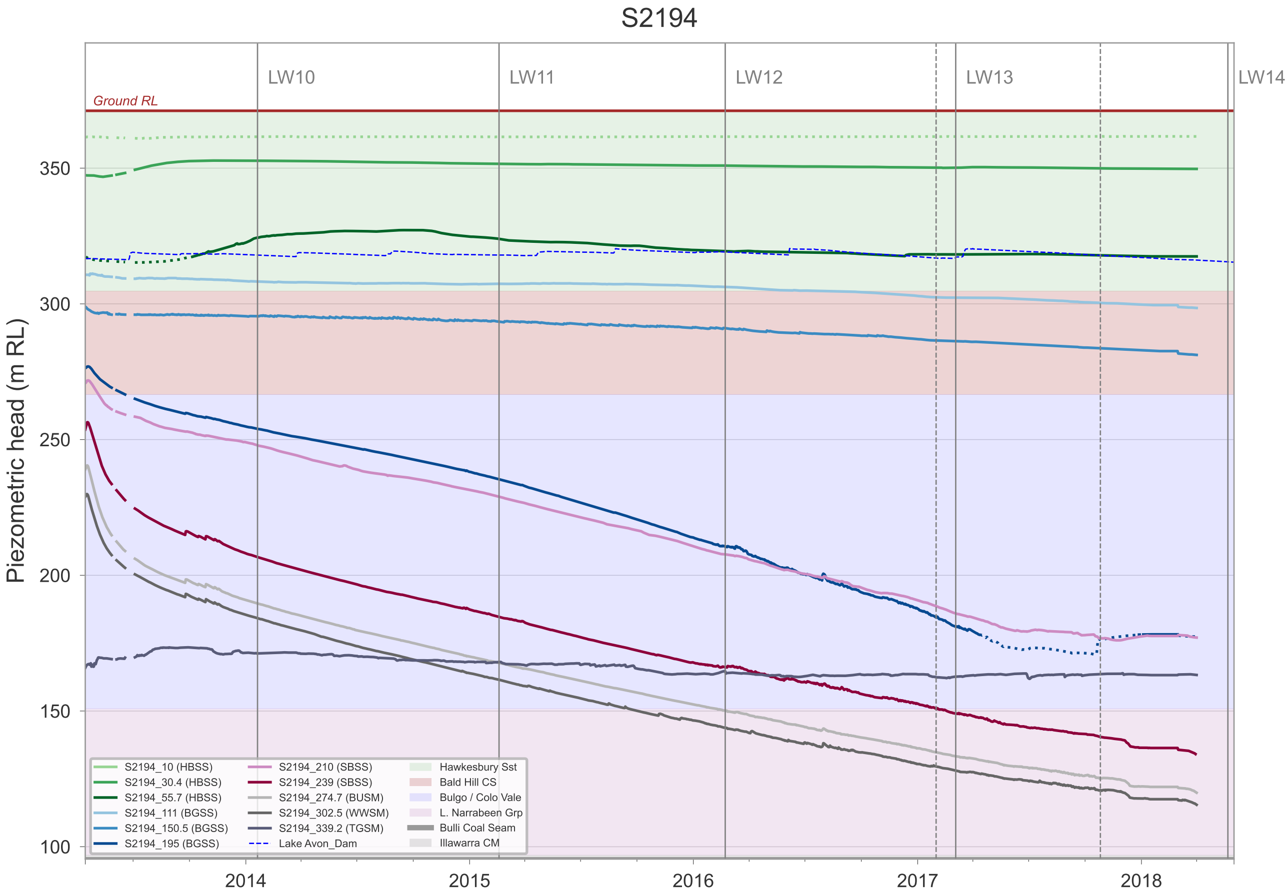

S2078
S2078_293.4 (BUSM)
S2078_323 (WWSM)
Lake Avon_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM
LW9
LW10
LW11
LW12
LW13
Piezometric head (m RL)
350
300
250
200
150
100
50
2011
2012
2013
2014
2015
2016
2017

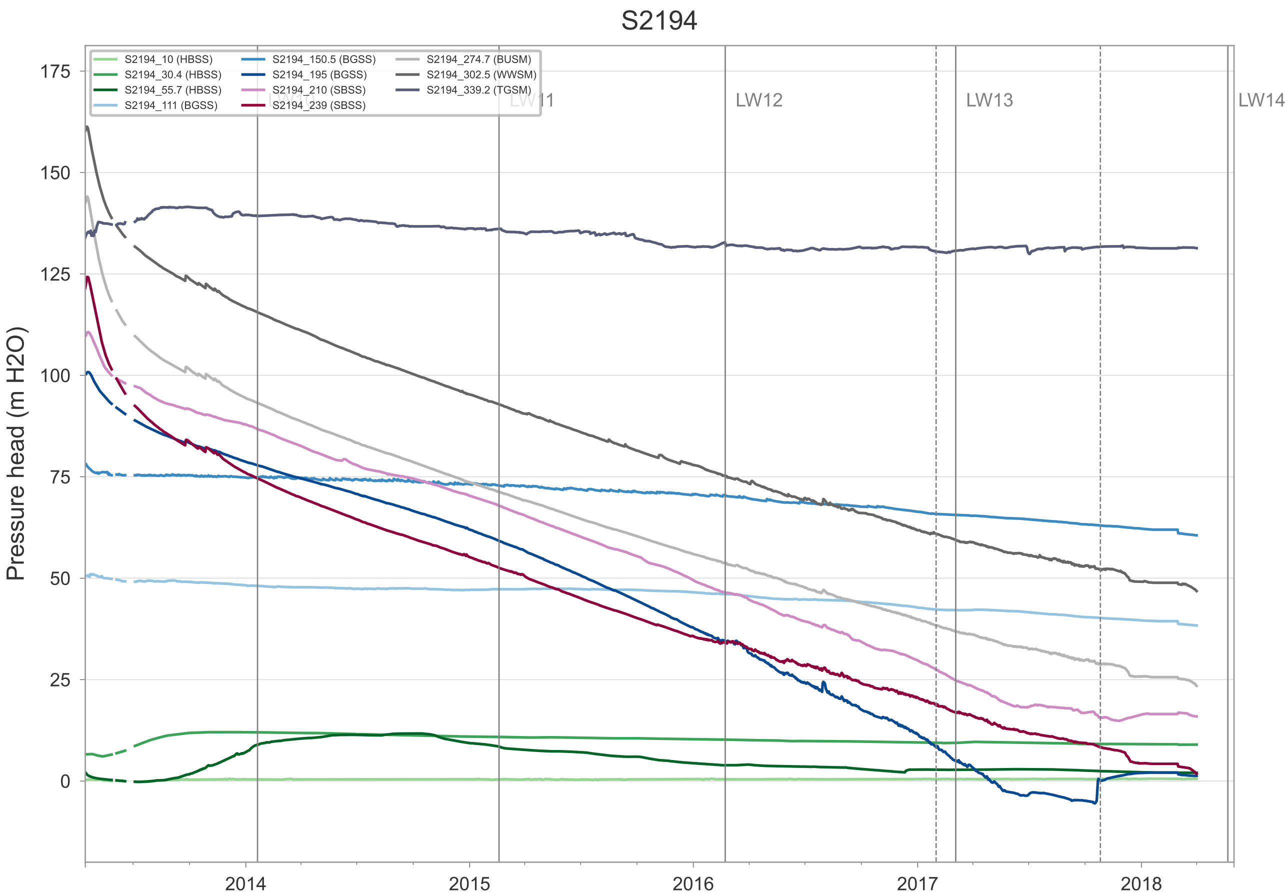

S2078
S2078_293.4 (BUSM)
S2078_323 (WWSM)
LW7
LW8
LW9
LW10
LW11
LW12
LW13
Pressure head (m H2O)
200
175
150
125
100
75
50
25
2011
2012
2013
2014
2015
2016
2017

Groundwater hydrographs

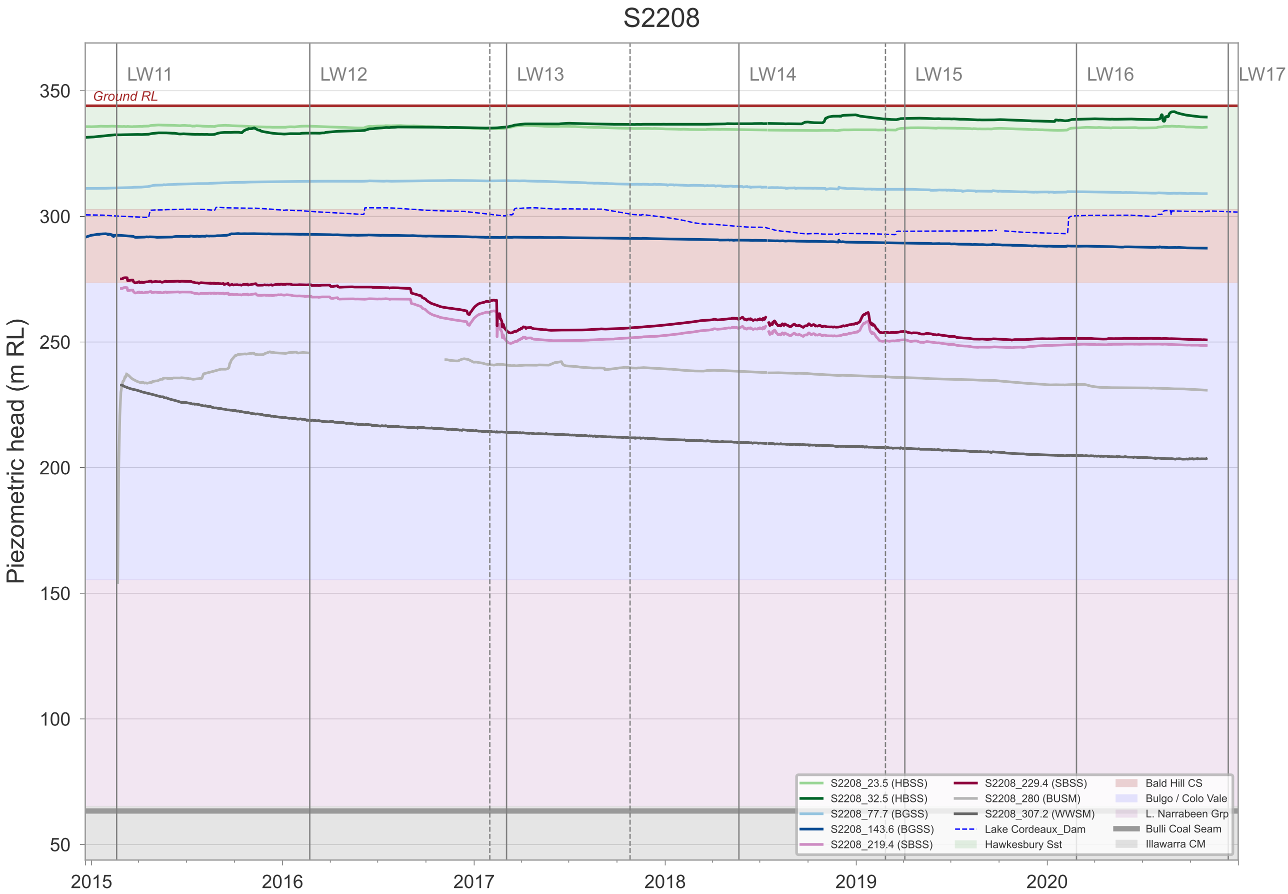


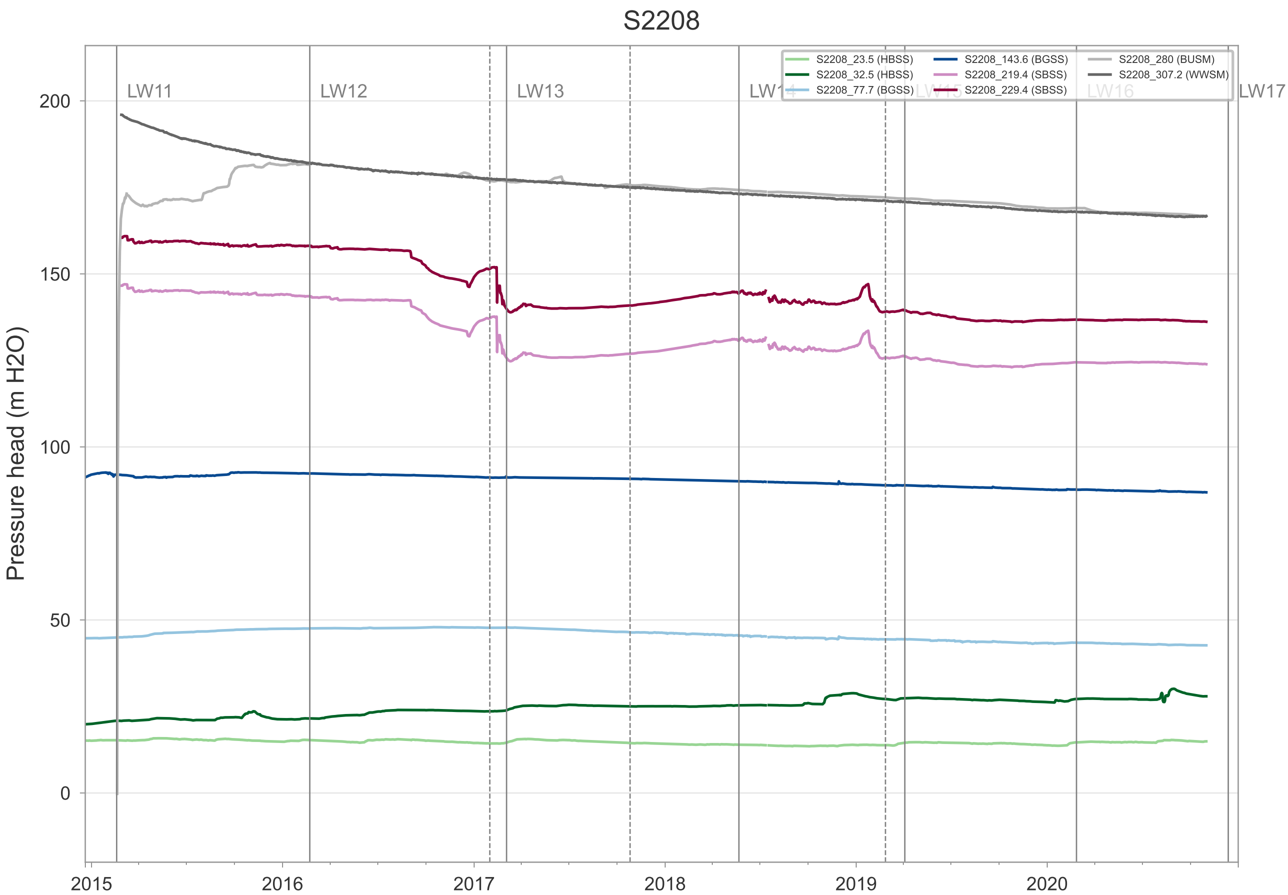



S2194
LW10
LW11
LW12
LW13
LW14
Ground RL
Piezometric head (m RL)
350
300
250
200
150
100
2014
2015
2016
2017
2018
S2194_10 (HBSS)
S2194_30.4 (HBSS)
S2194_55.7 (HBSS)
S2194_111 (BGSS)
S2194_150.5 (BGSS)
S2194_195 (BGSS)
S2194_210 (SBSS)
S2194_239 (SBSS)
S2194_274.7 (BUSM)
S2194_302.5 (WWSM)
S2194_339.2 (TGSM)
Lake Avon_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM

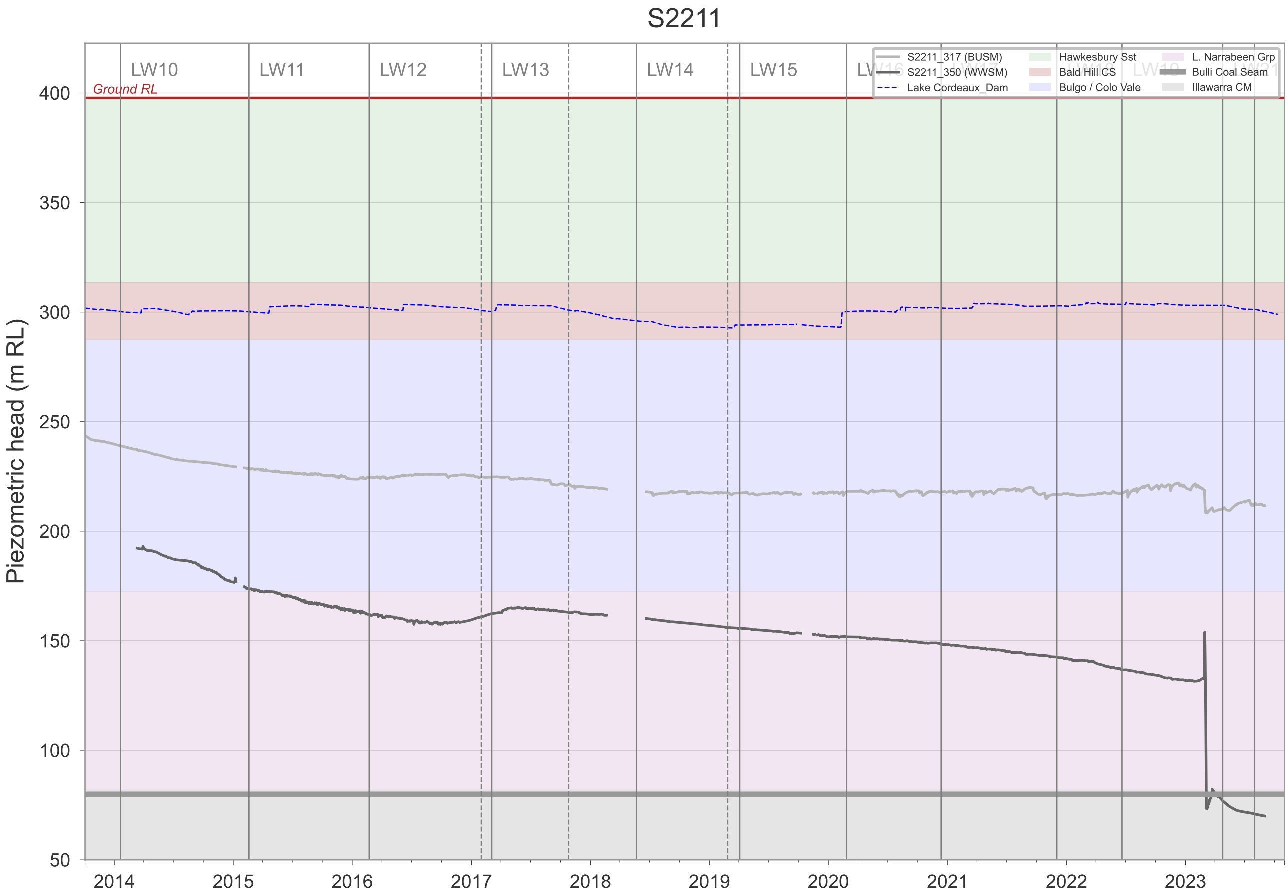

S2194
LW11
LW12
LW13
LW14
Pressure head (m H2O)
175
150
125
100
75
50
25
0
2014
2015
2016
2017
2018
S2194_10 (HBSS)
S2194_30.4 (HBSS)
S2194_55.7 (HBSS)
S2194_111 (BGSS)
S2194_150.5 (BGSS)
S2194_195 (BGSS)
S2194_210 (SBSS)
S2194_239 (SBSS)
S2194_274.7 (BUSM)
S2194_302.5 (WWSM)
S2194_339.2 (TGSM)

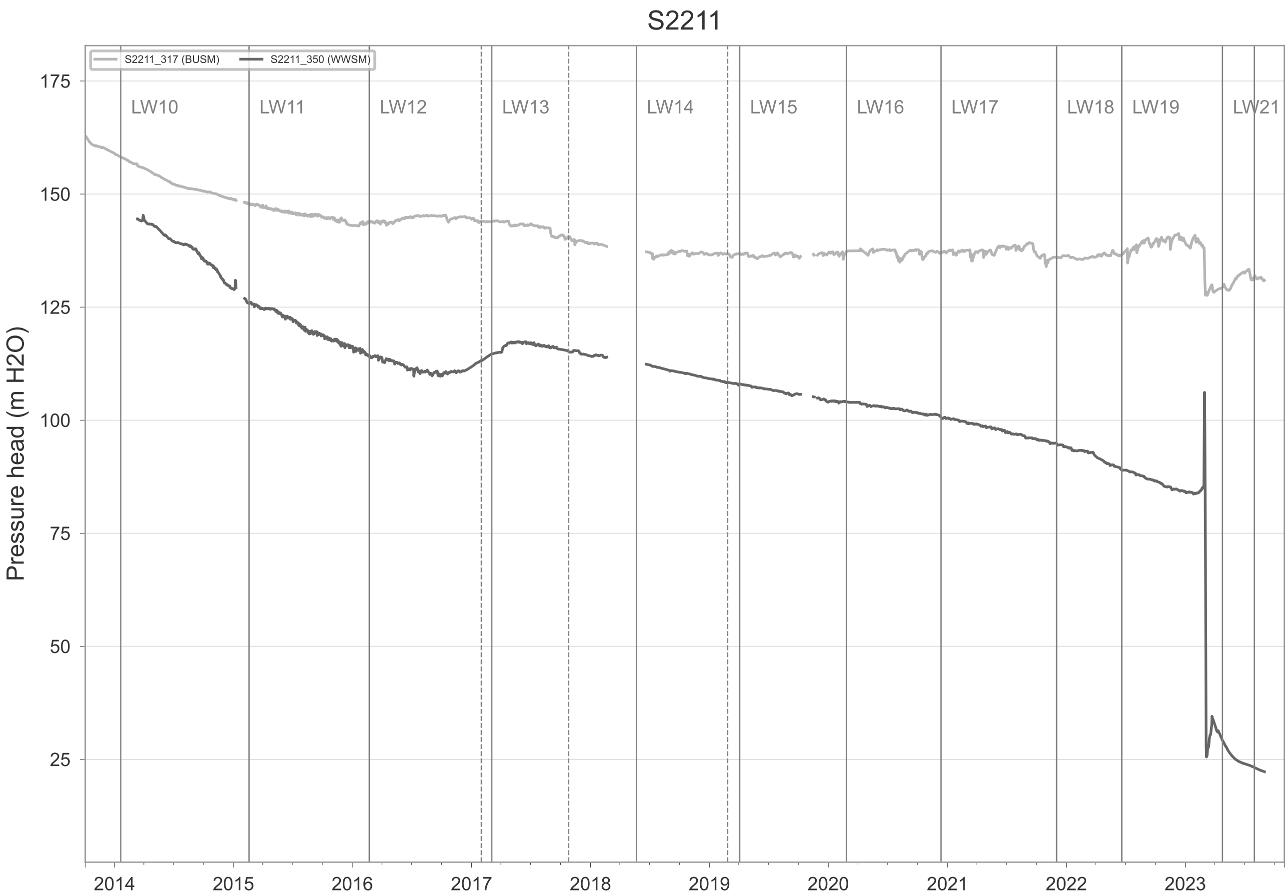
Groundwater hydrographs



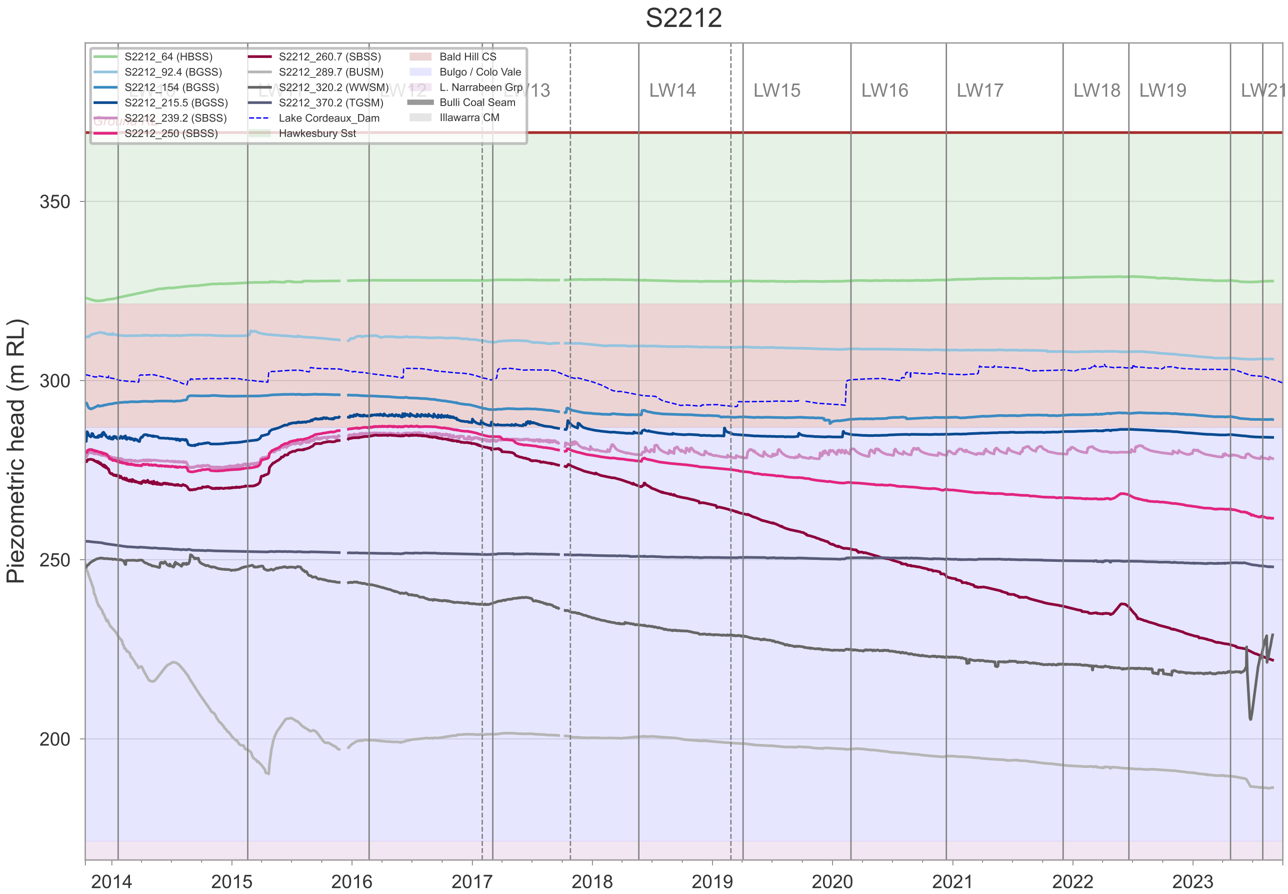


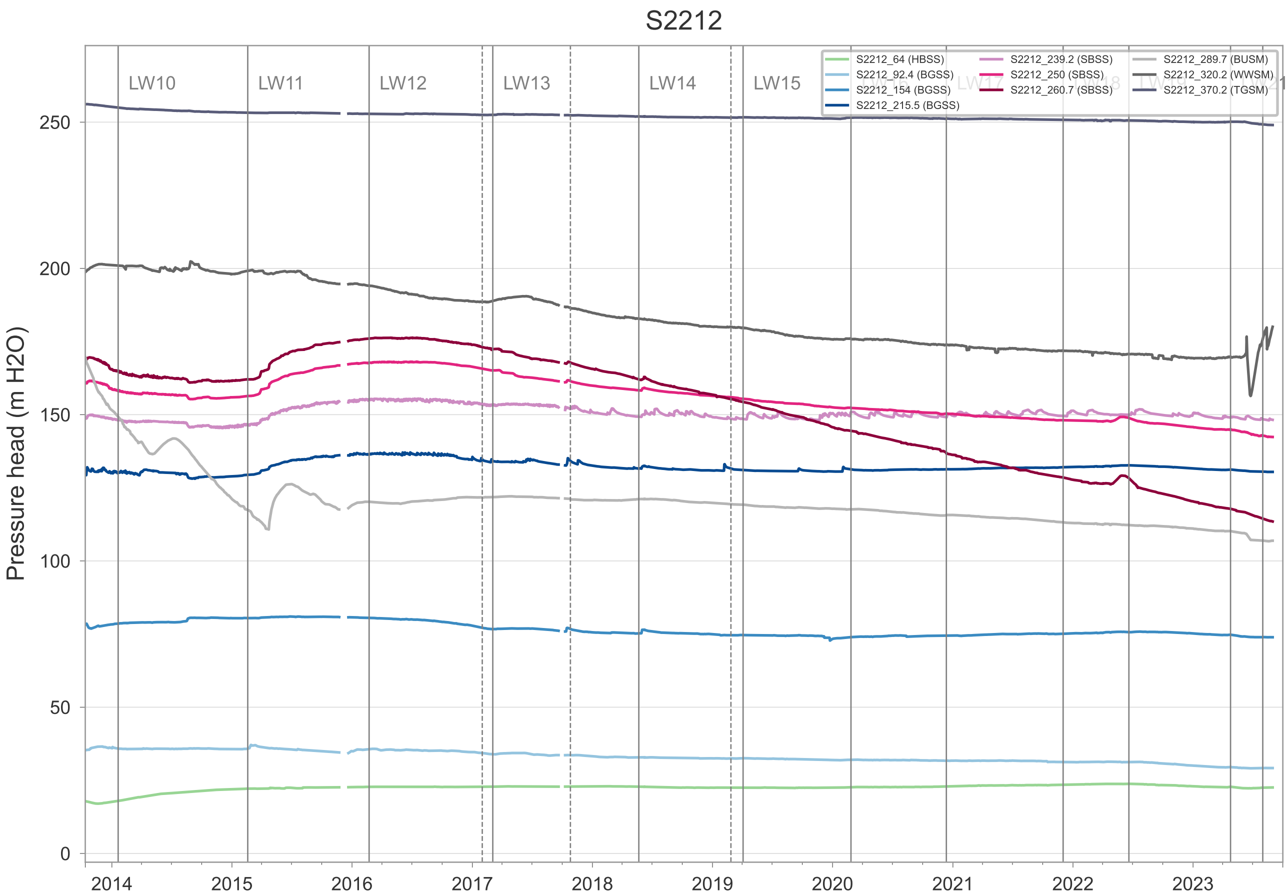
Groundwater hydrographs



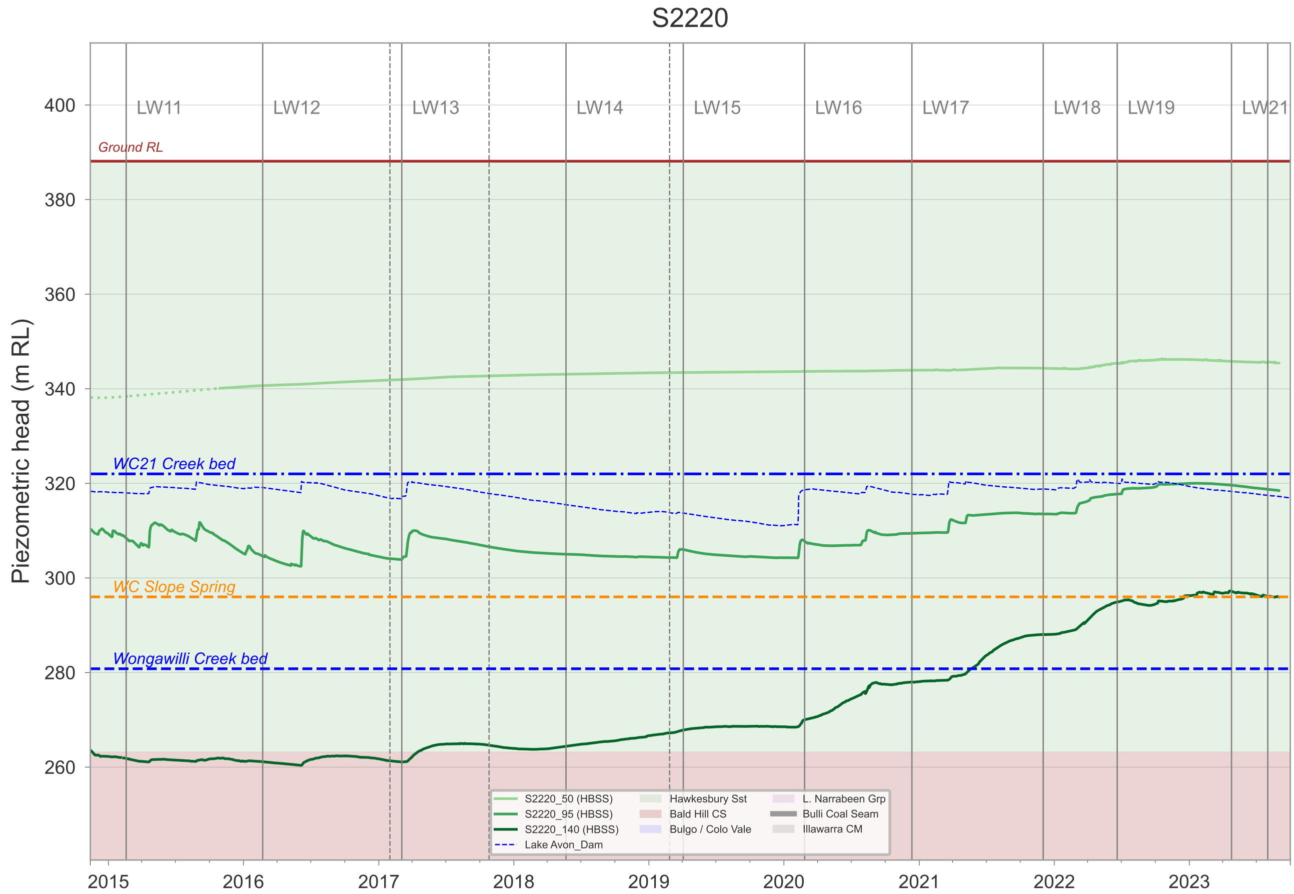


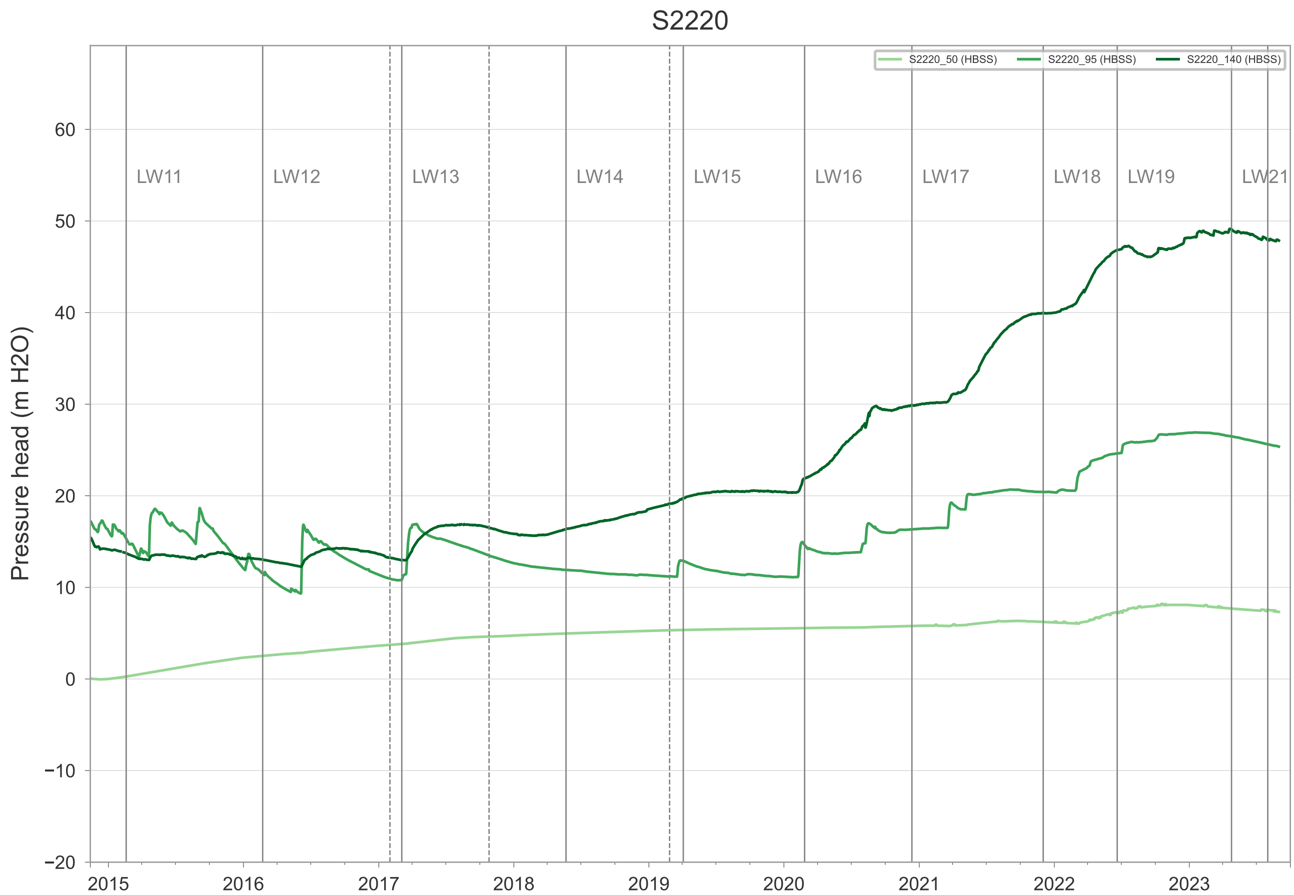
Groundwater hydrographs

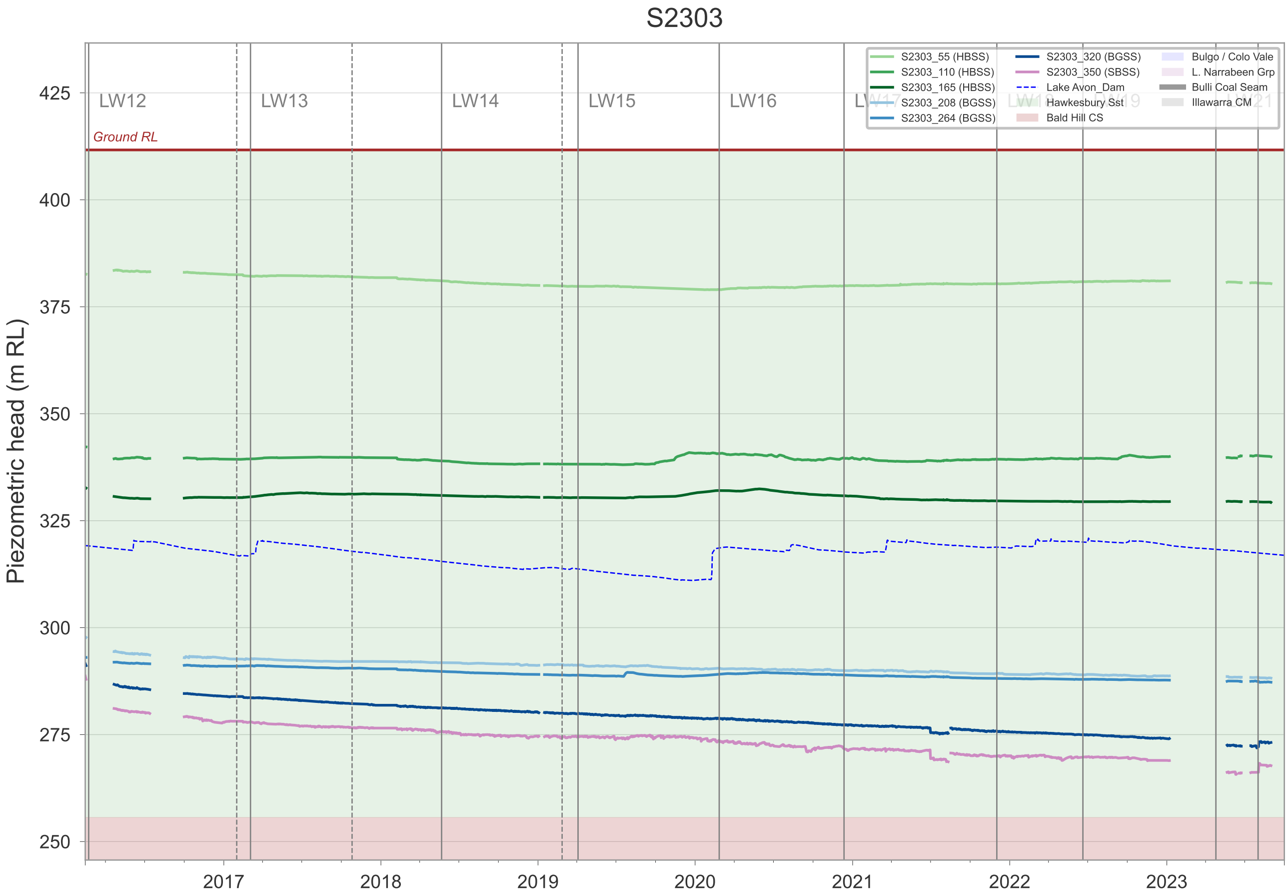


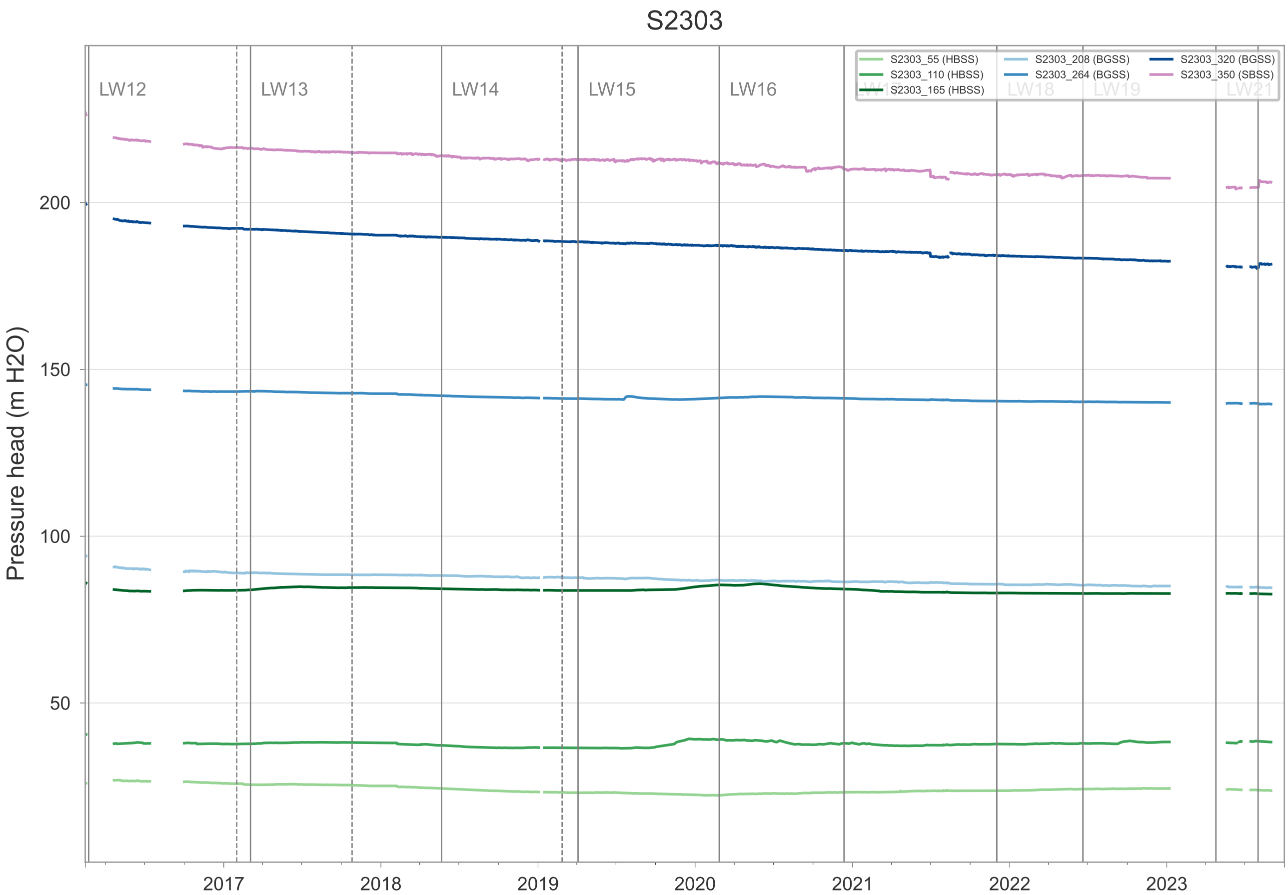


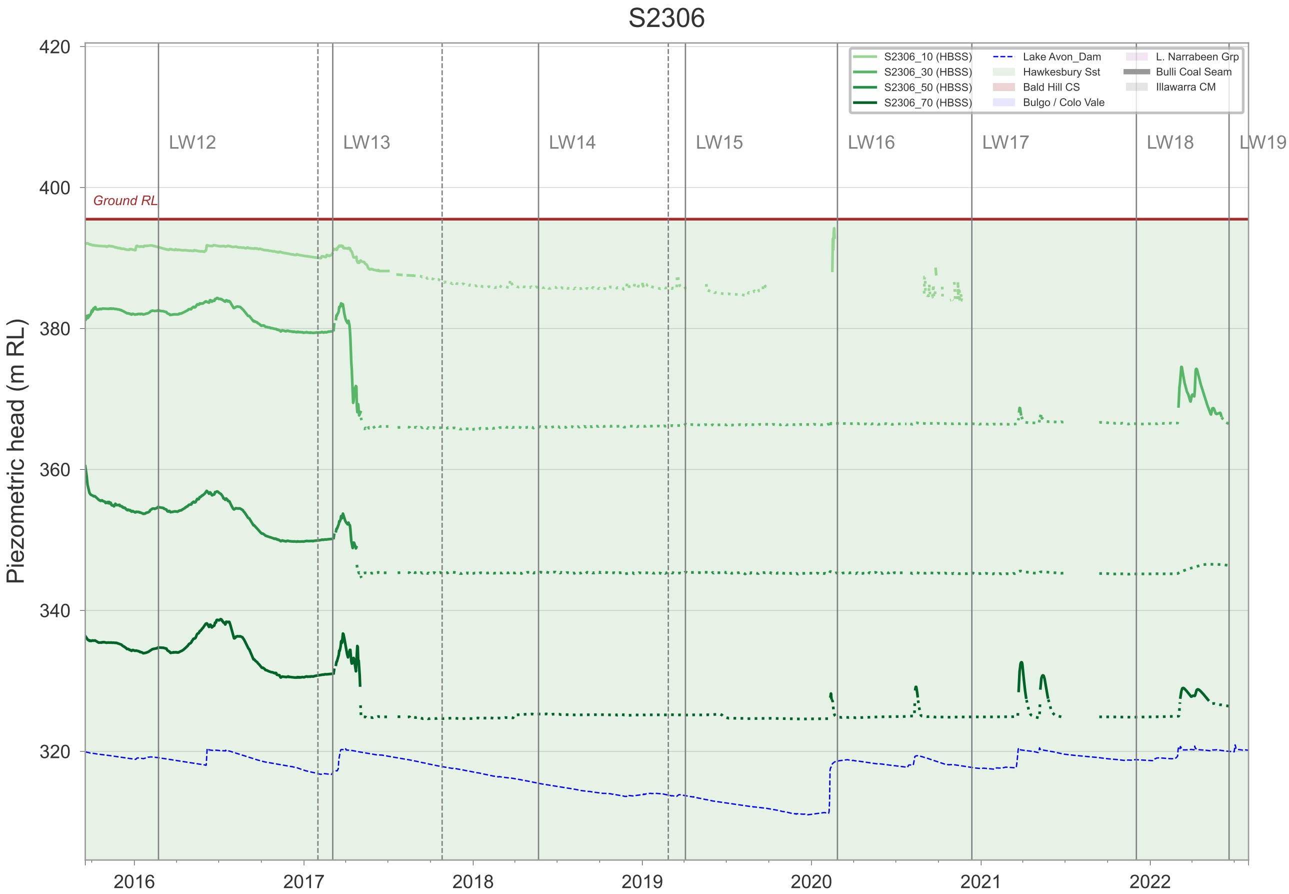
Groundwater hydrographs

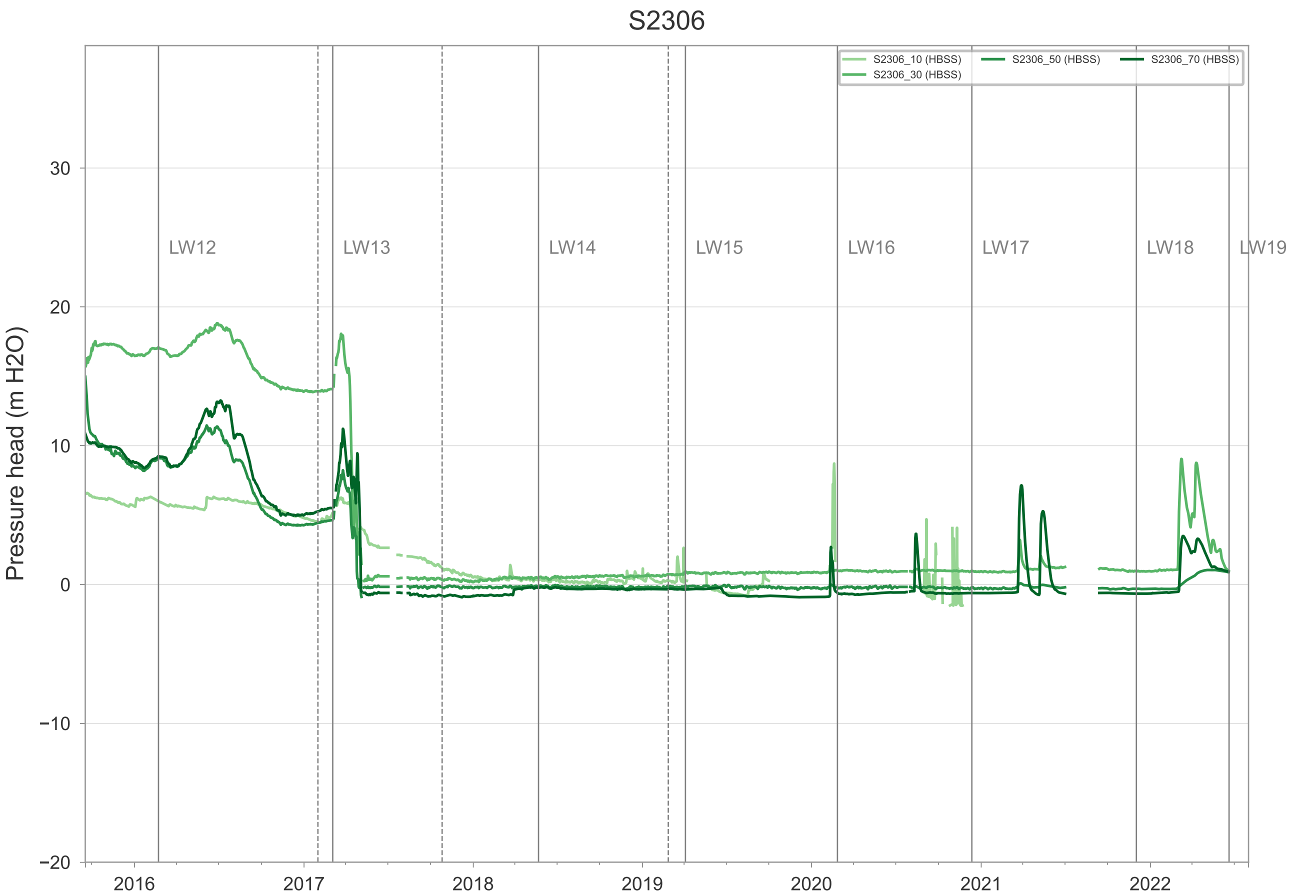




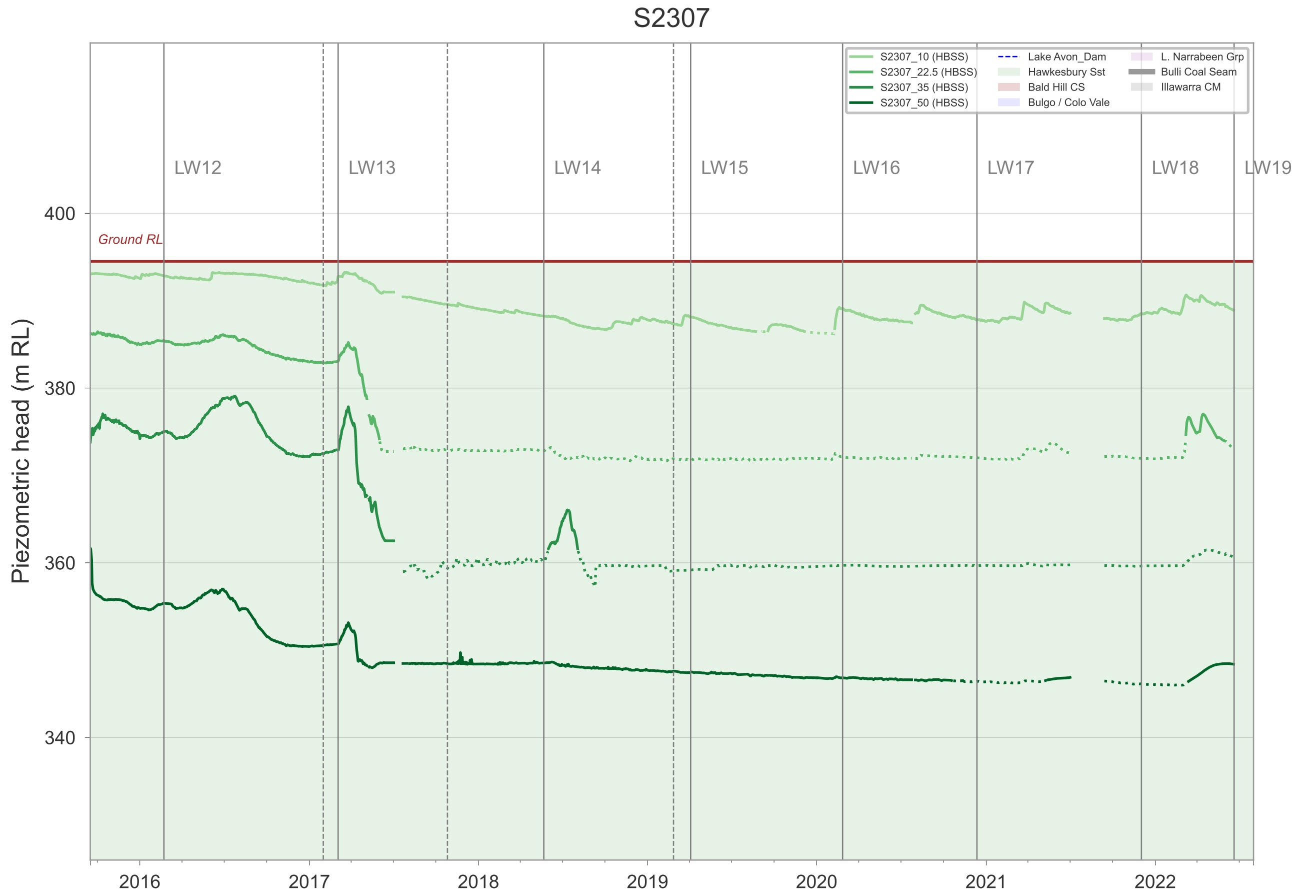

S2303
Piezometric head (m RL)
425
400
375
350
325
300
275
250
LW12
LW13
LW14
LW15
LW16
Ground RL
2017
2018
2019
2020
2021
2022
2023
S2303_55 (HBSS)
S2303_110 (HBSS)
S2303_165 (HBSS)
S2303_208 (BGSS)
S2303_264 (BGSS)
S2303_320 (BGSS)
S2303_350 (SBSS)
Lake Avon_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM

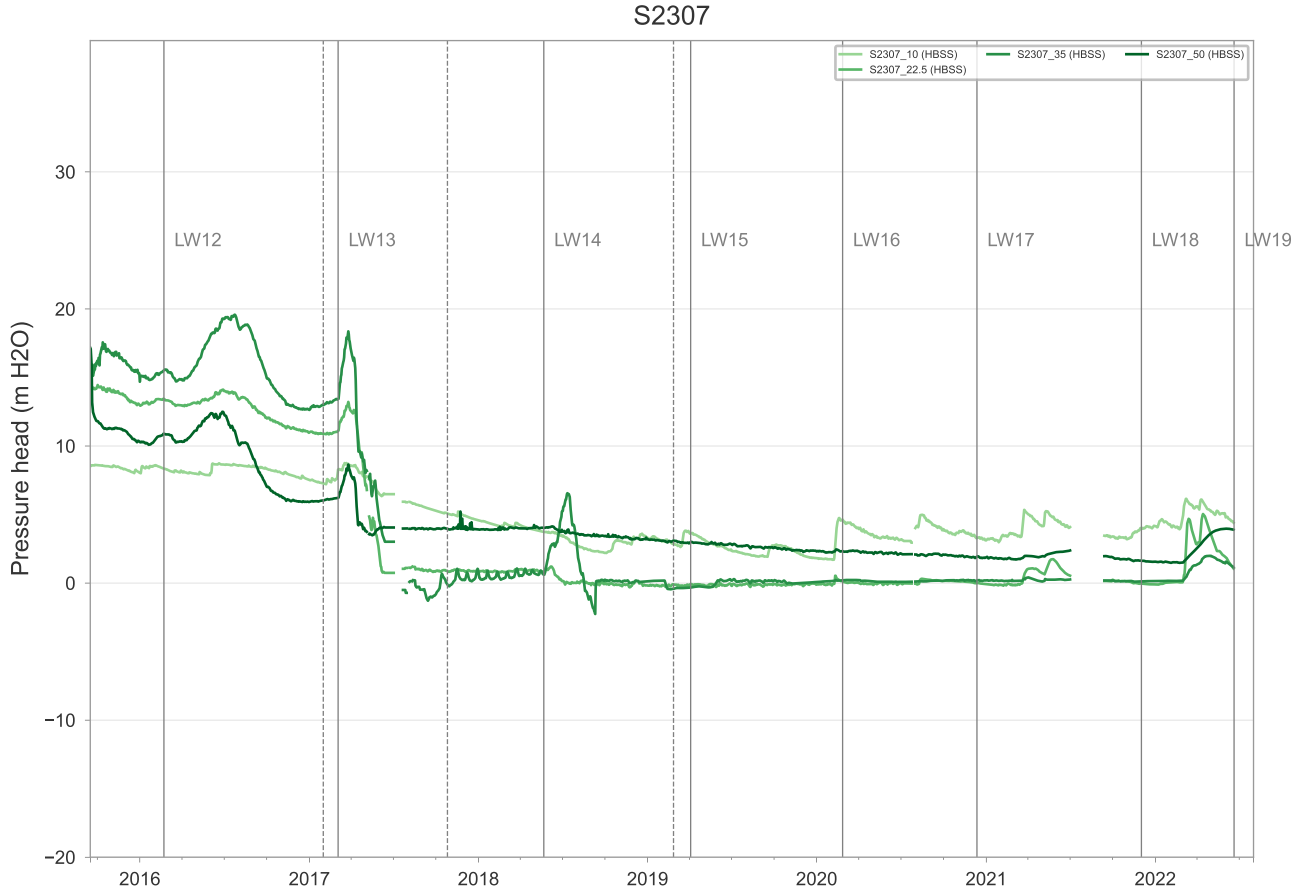

S2303
Pressure head (m H2O)
200
150
100
50
LW12
LW13
LW14
LW15
LW16
2017
2018
2019
2020
2021
2022
2023
S2303_55 (HBSS)
S2303_110 (HBSS)
S2303_165 (HBSS)
S2303_208 (BGSS)
S2303_264 (BGSS)
S2303_320 (BGSS)
S2303_350 (SBSS)

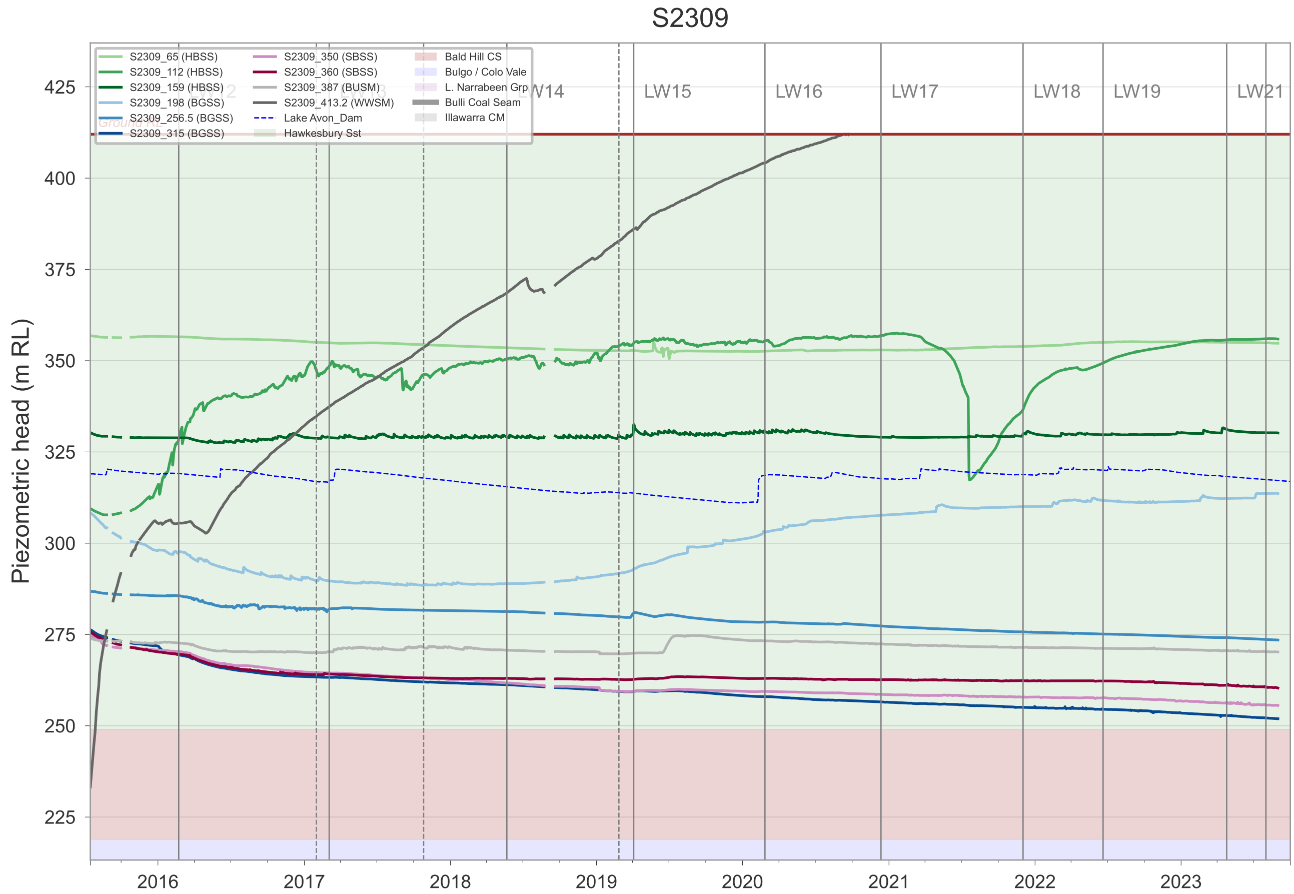

S2306
S2306_10 (HBSS)
S2306_30 (HBSS)
S2306_50 (HBSS)
S2306_70 (HBSS)
Lake Avon_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM
LW12
LW13
LW14
LW15
LW16
LW17
LW18
LW19
Ground RL
Piezometric head (m RL)
420
400
380
360
340
320
2016
2017
2018
2019
2020
2021
2022

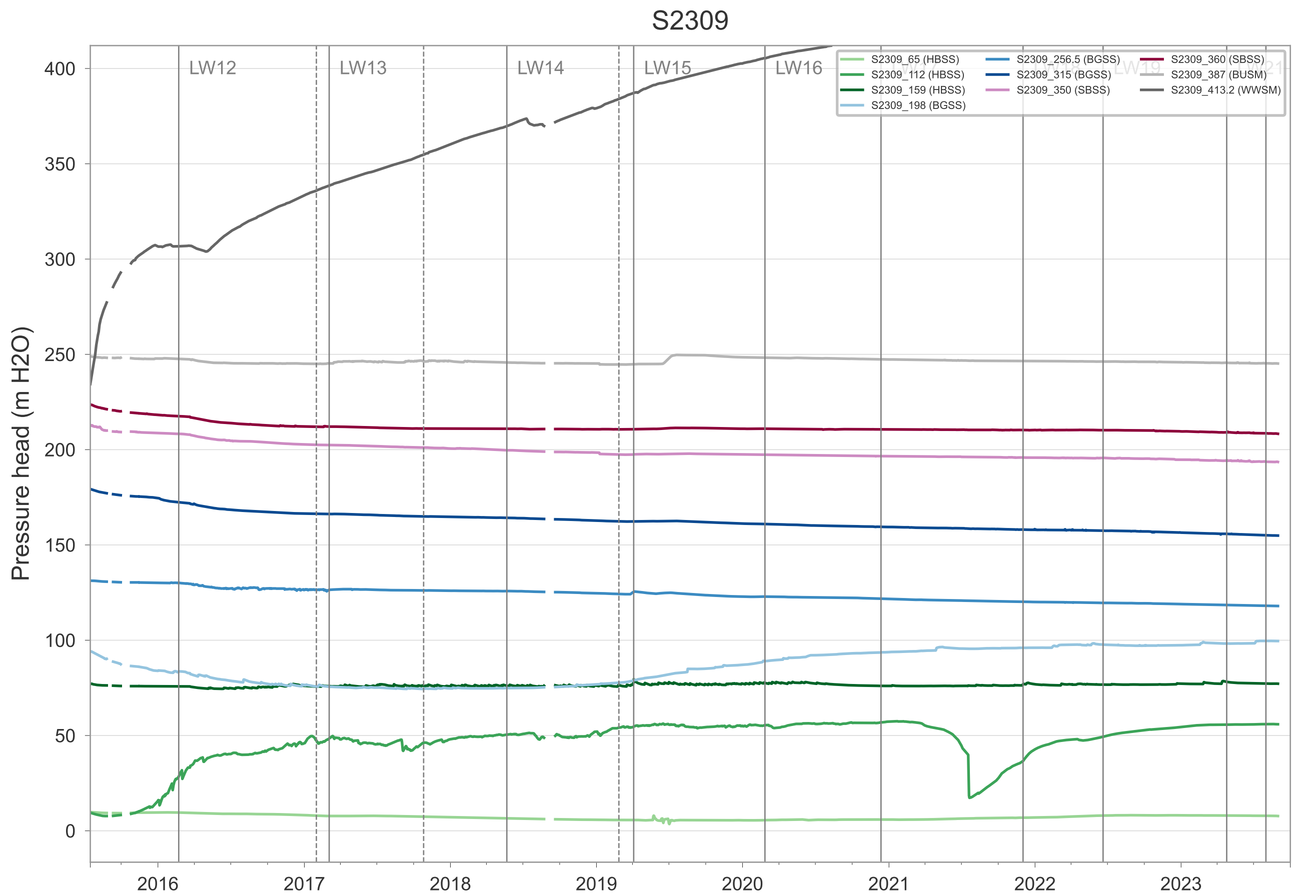

S2306
S2306_10 (HBSS)
S2306_30 (HBSS)
S2306_50 (HBSS)
S2306_70 (HBSS)
LW12
LW13
LW14
LW15
LW16
LW17
LW18
LW19
Pressure head (m H2O)
30
20
10
0
−10
−20
2016
2017
2018
2019
2020
2021
2022

Groundwater hydrographs

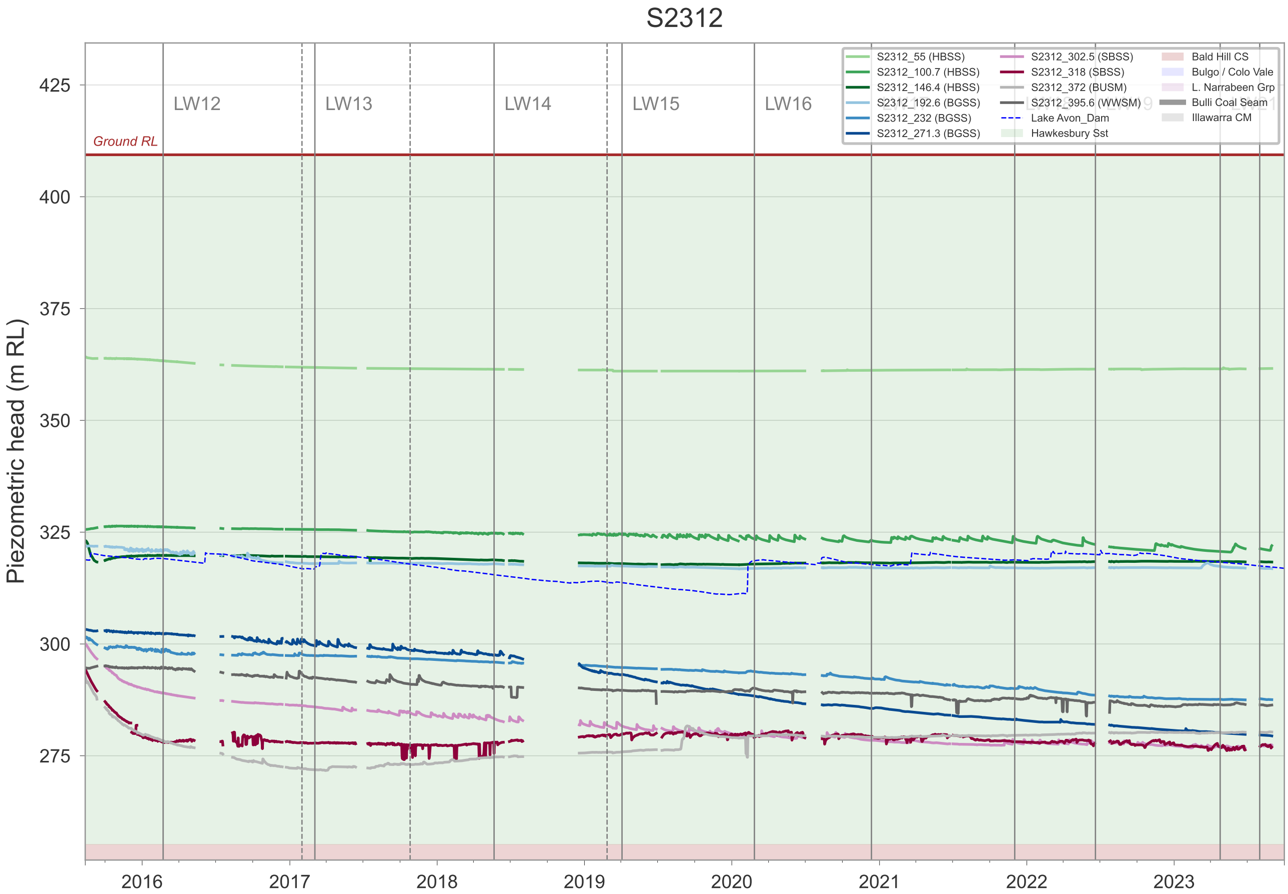




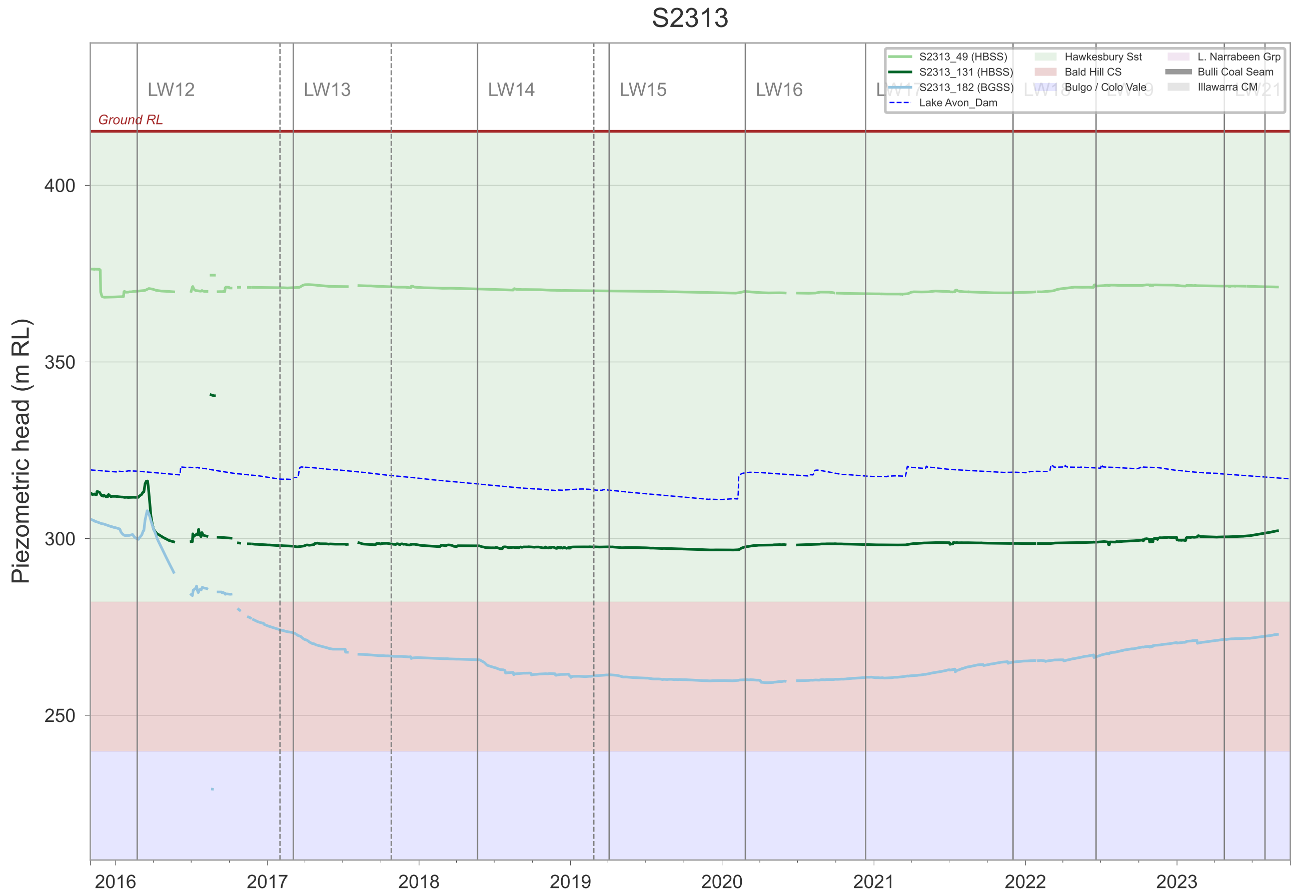

S2309
S2309_65 (HBSS)
S2309_112 (HBSS)
S2309_159 (HBSS)
S2309_198 (BGSS)
S2309_256.5 (BGSS)
S2309_315 (BGSS)
S2309_350 (SBSS)
S2309_360 (SBSS)
S2309_387 (BUSM)
S2309_413.2 (WWSM)
Lake Avon_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM
LW15
LW16
LW17
LW18
LW19
Piezometric head (m RL)
2016
2017
2018
2019
2020
2021
2022
2023

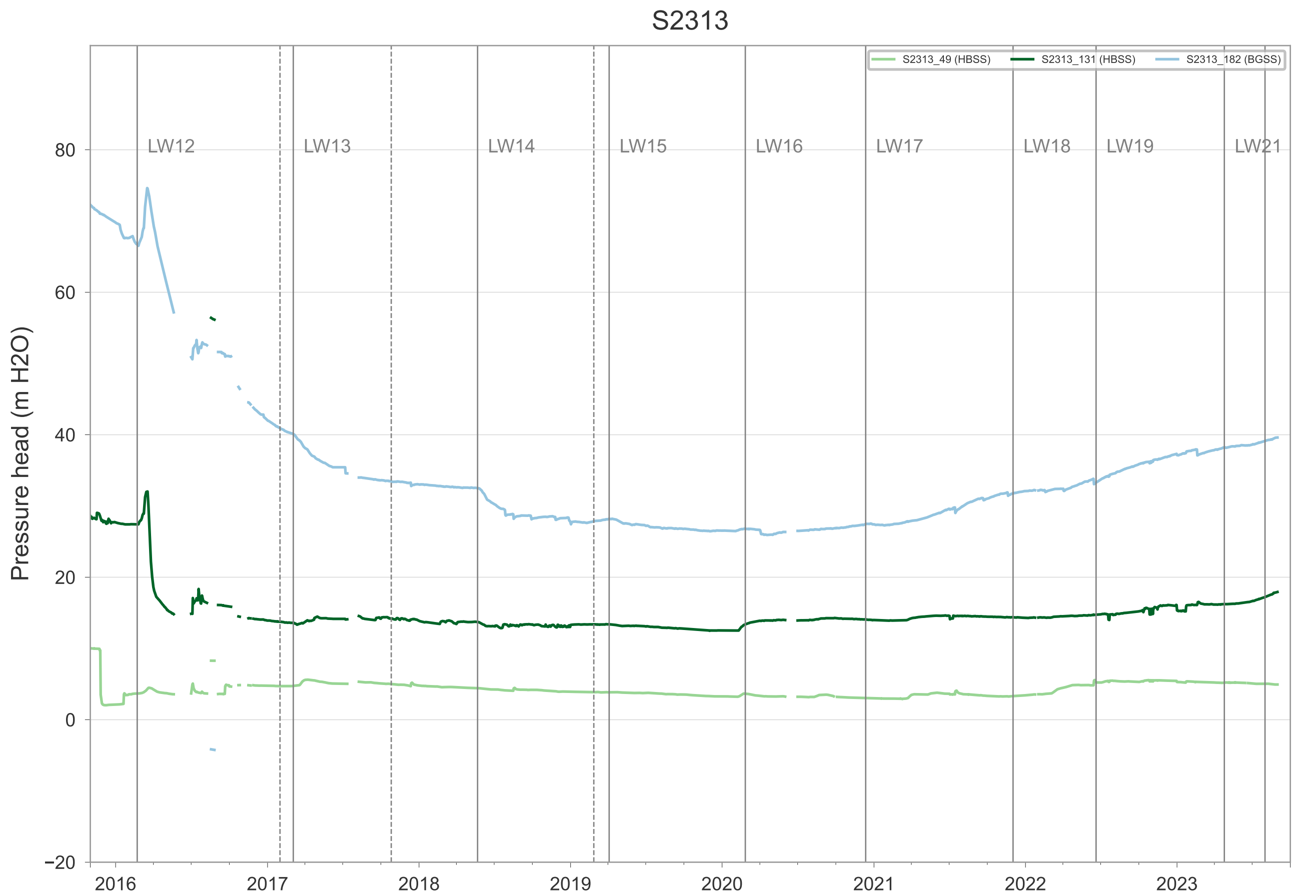

S2309
LW12
LW13
LW14
LW15
LW16
S2309_65 (HBSS)
S2309_112 (HBSS)
S2309_159 (HBSS)
S2309_198 (BGSS)
S2309_256.5 (BGSS)
S2309_315 (BGSS)
S2309_350 (SBSS)
S2309_360 (SBSS)
S2309_387 (BUSM)
S2309_413.2 (WWSM)
Pressure head (m H2O)
2016
2017
2018
2019
2020
2021
2022
2023

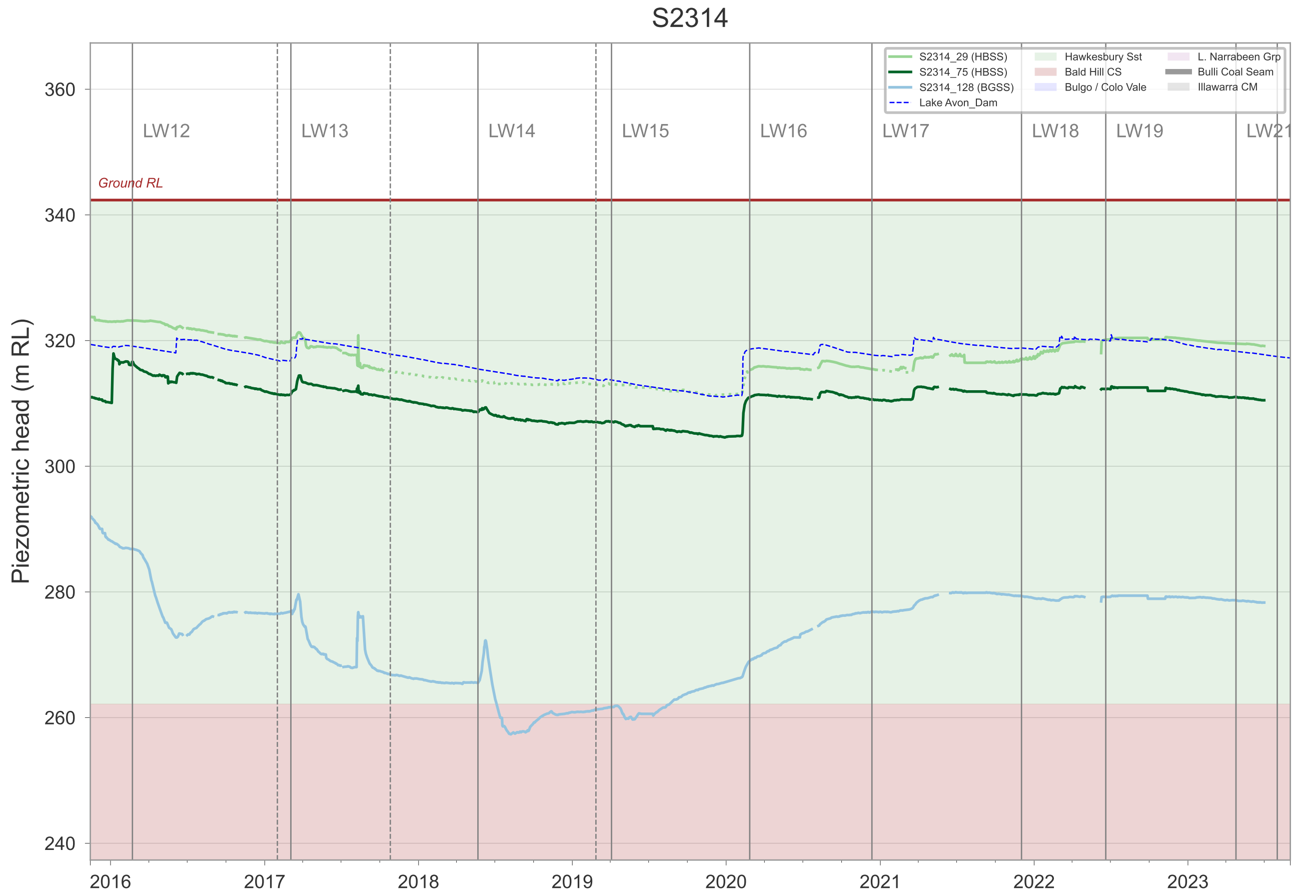
Groundwater hydrographs

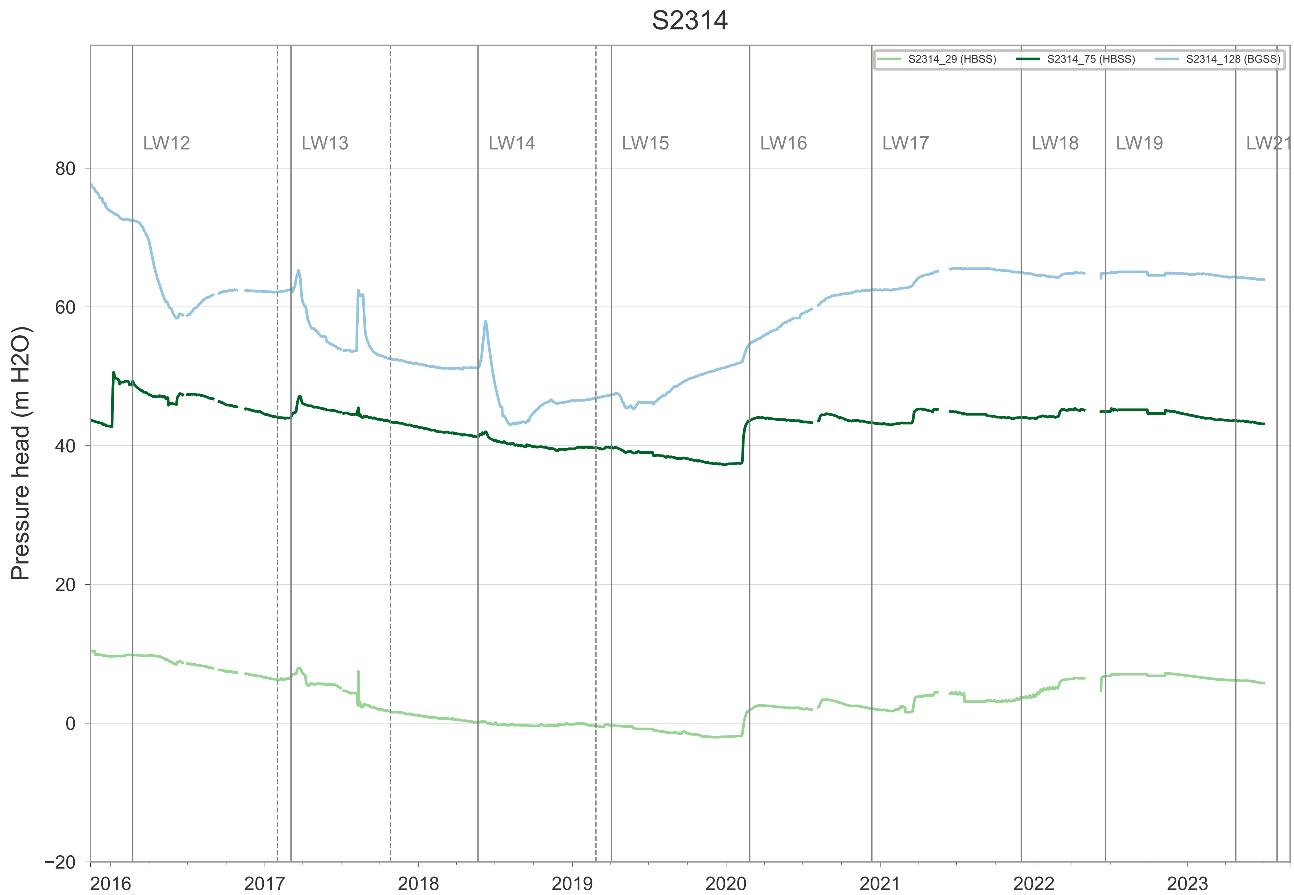


Groundwater hydrographs

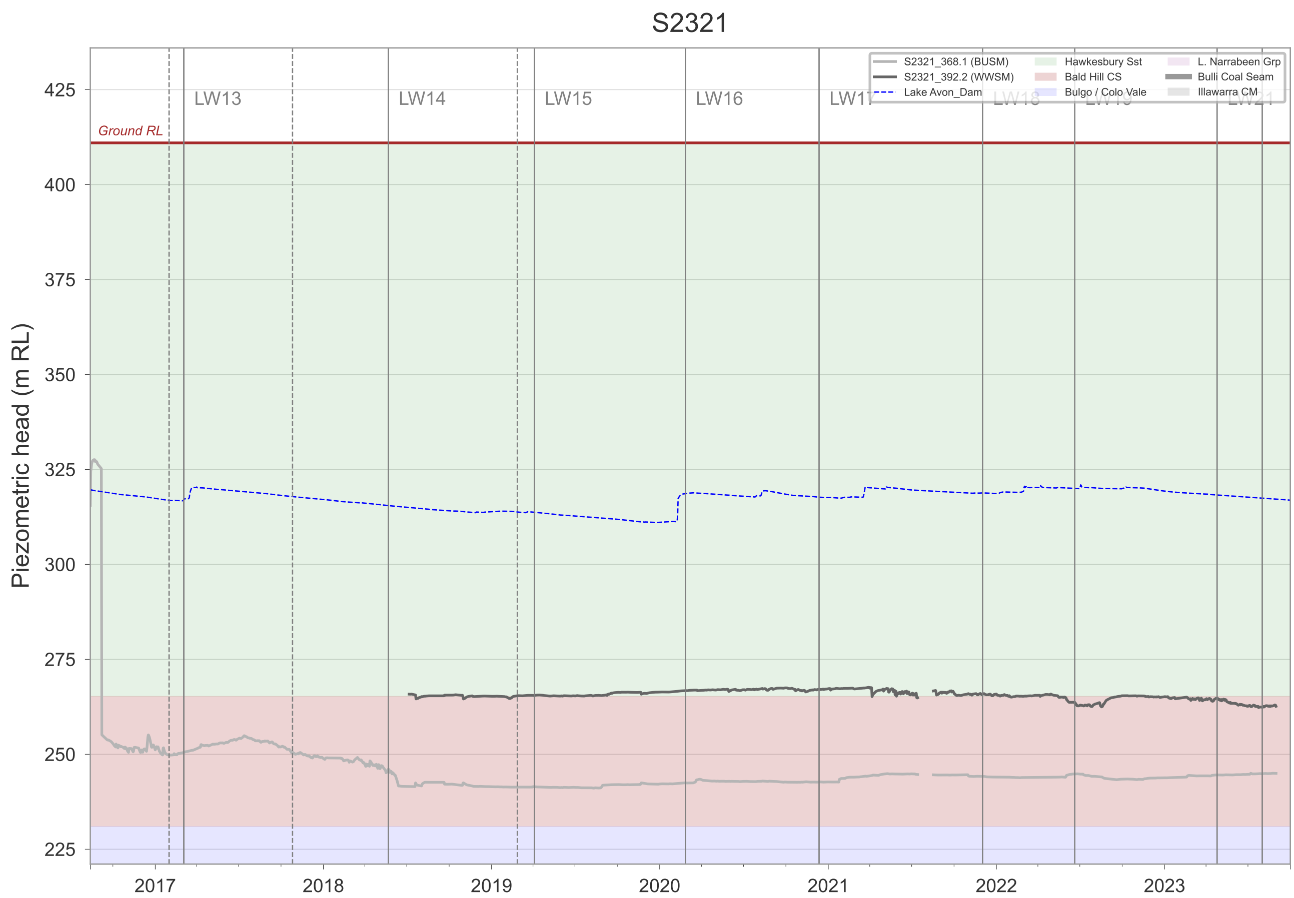


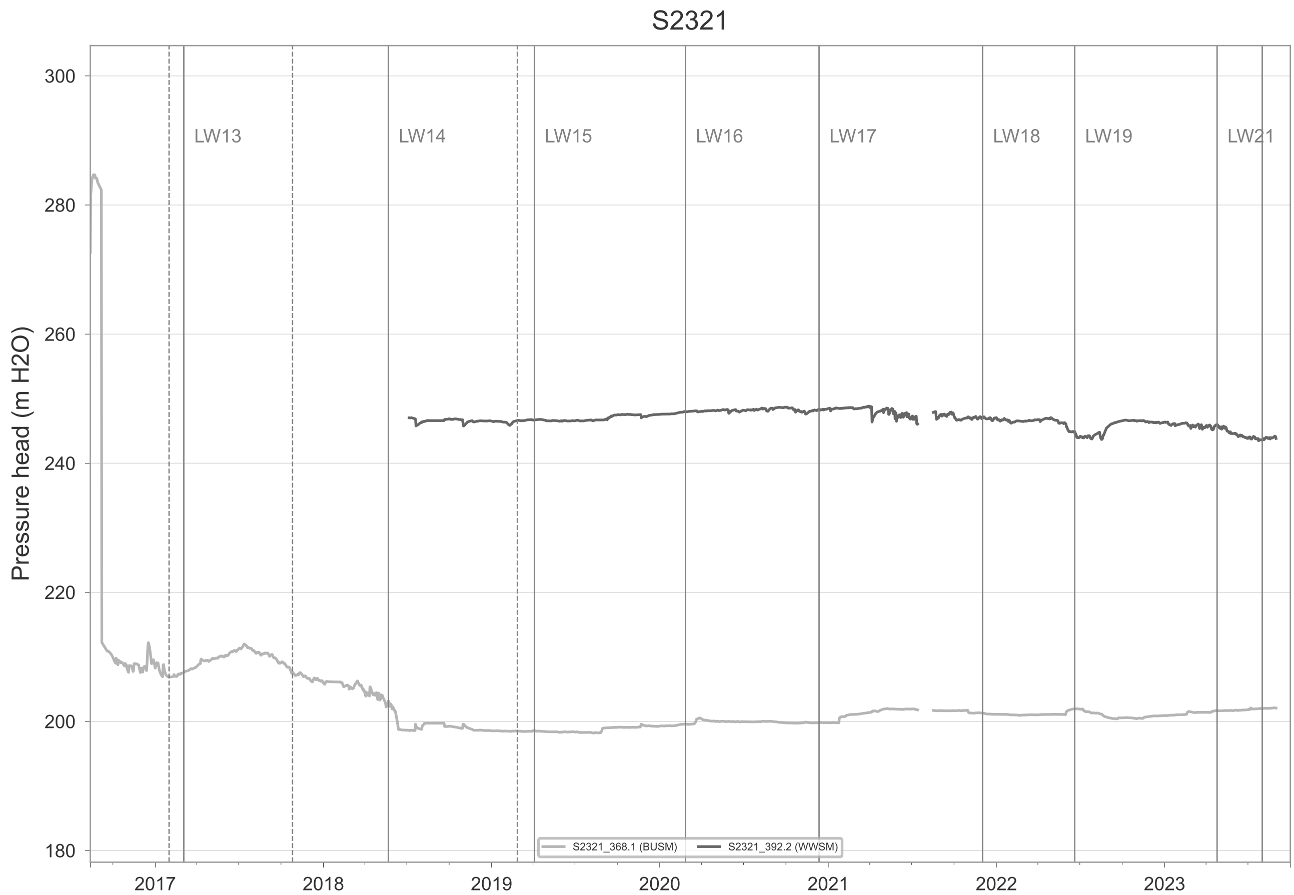



S2314
S2314_29 (HBSS)
S2314_75 (HBSS)
S2314_128 (BGSS)
Lake Avon_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM
LW12
LW13
LW14
LW15
LW16
LW17
LW18
LW19
LW21
Ground RL
Piezometric head (m RL)
360
340
320
300
280
260
240
2016
2017
2018
2019
2020
2021
2022
2023

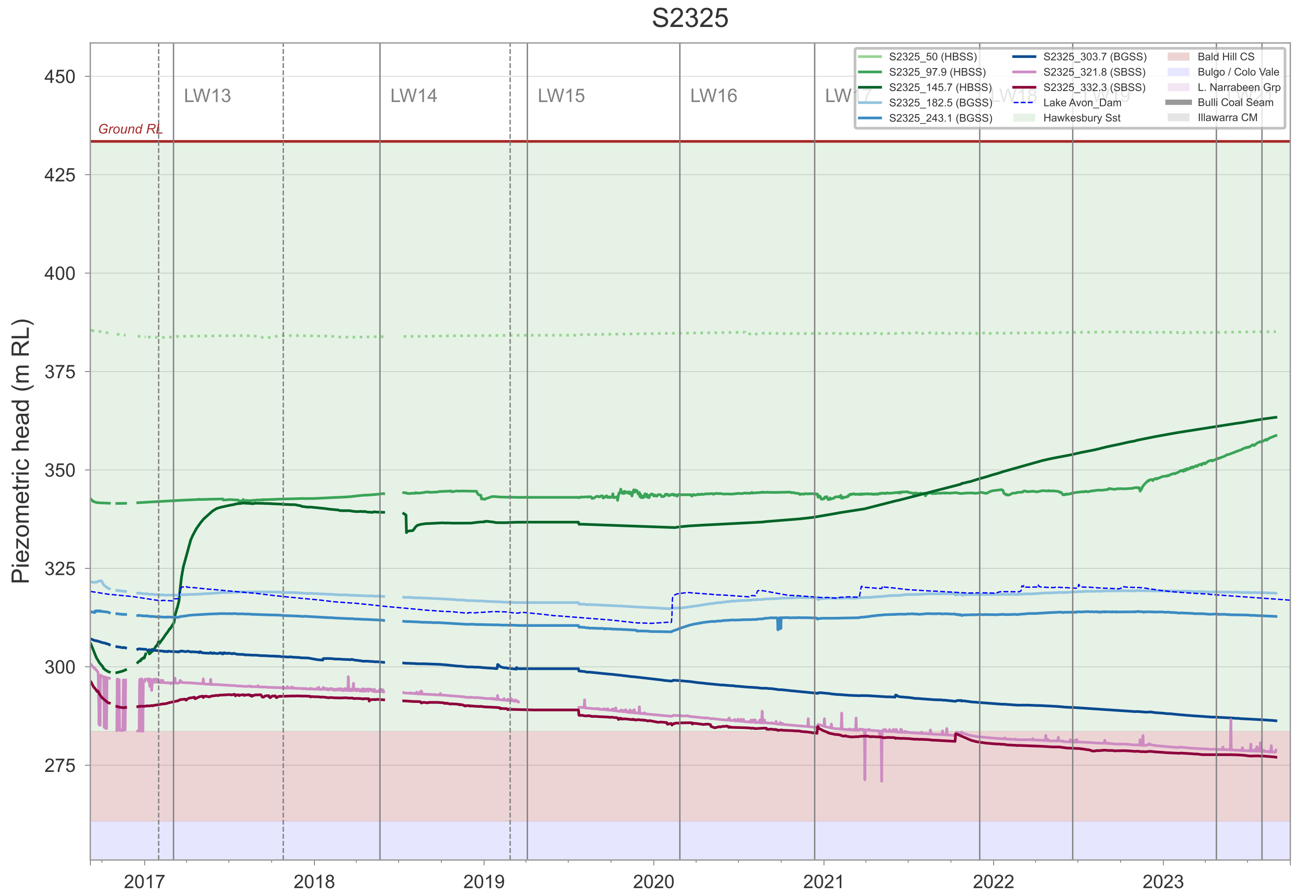

S2314
S2314_29 (HBSS)
S2314_75 (HBSS)
S2314_128 (BGSS)
LW12
LW13
LW14
LW15
LW16
LW17
LW18
LW19
LW21
Pressure head (m H2O)
80
60
40
20
0
−20
2016
2017
2018
2019
2020
2021
2022
2023

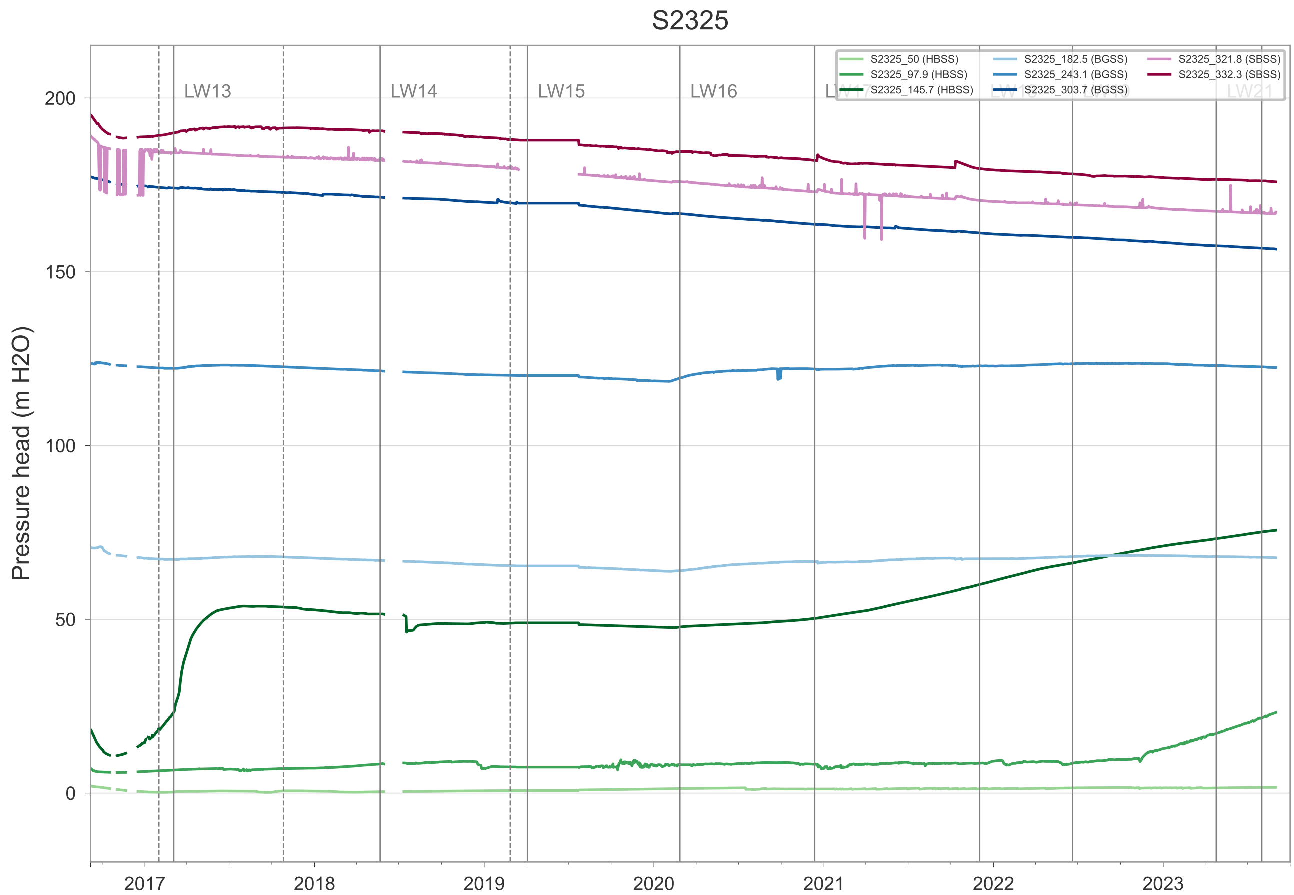
Groundwater hydrographs





Groundwater hydrographs





Groundwater hydrographs

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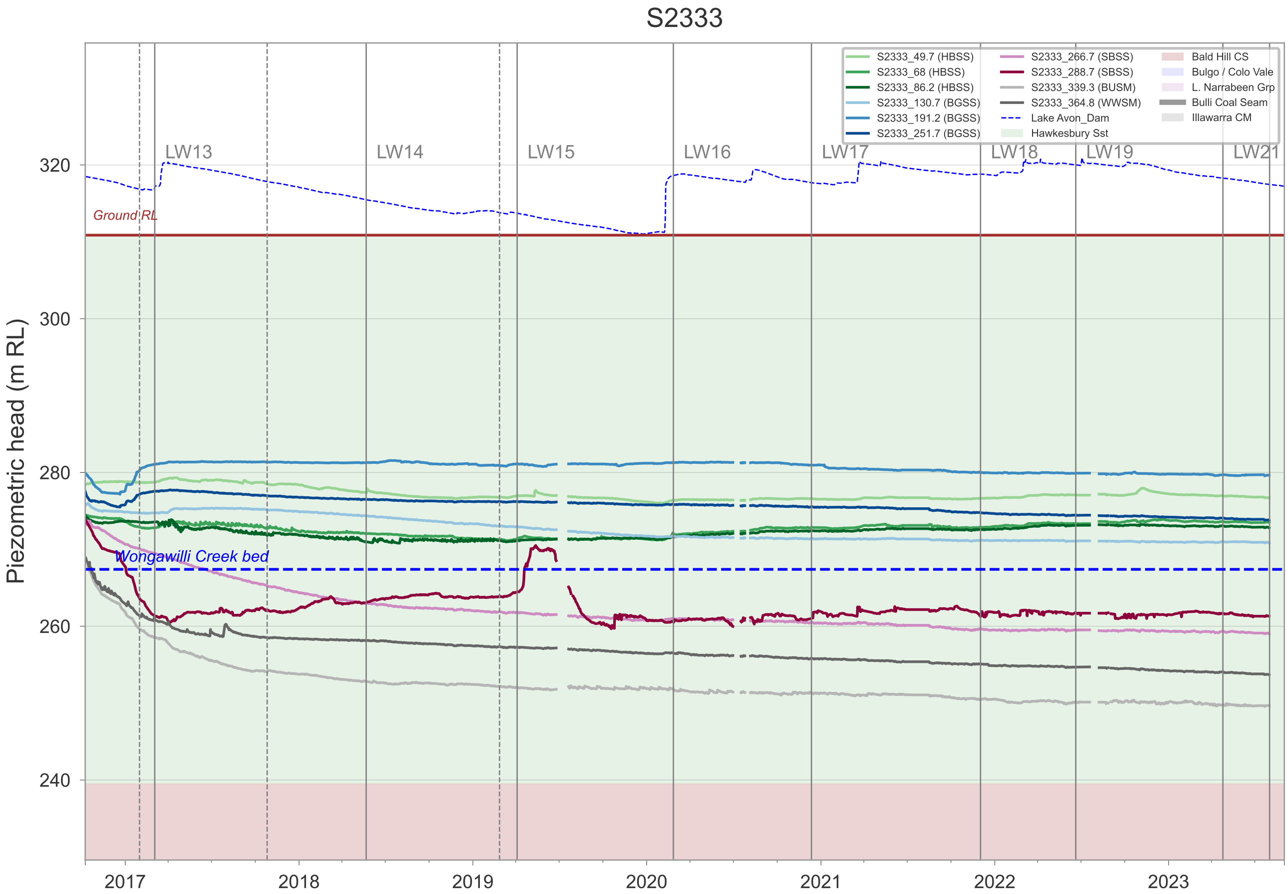
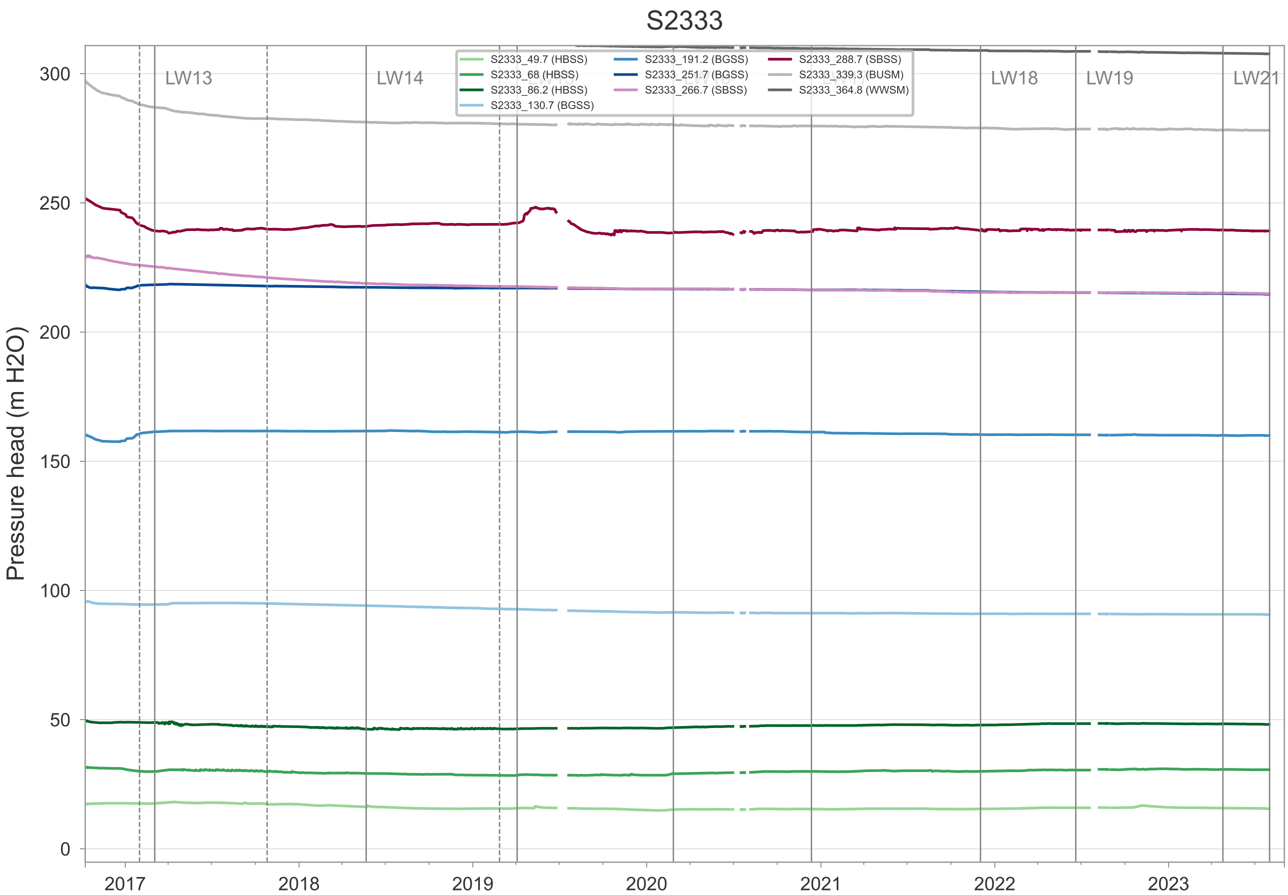
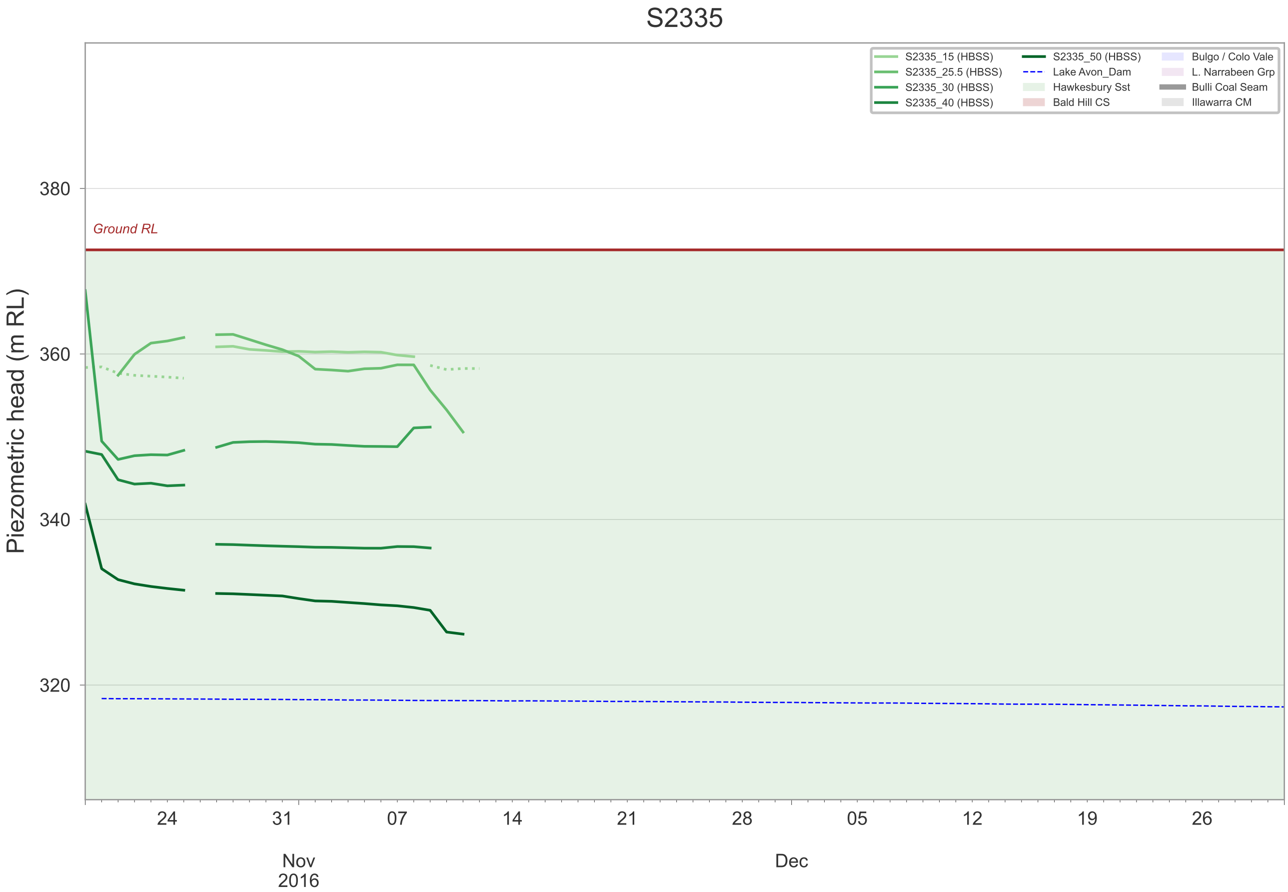
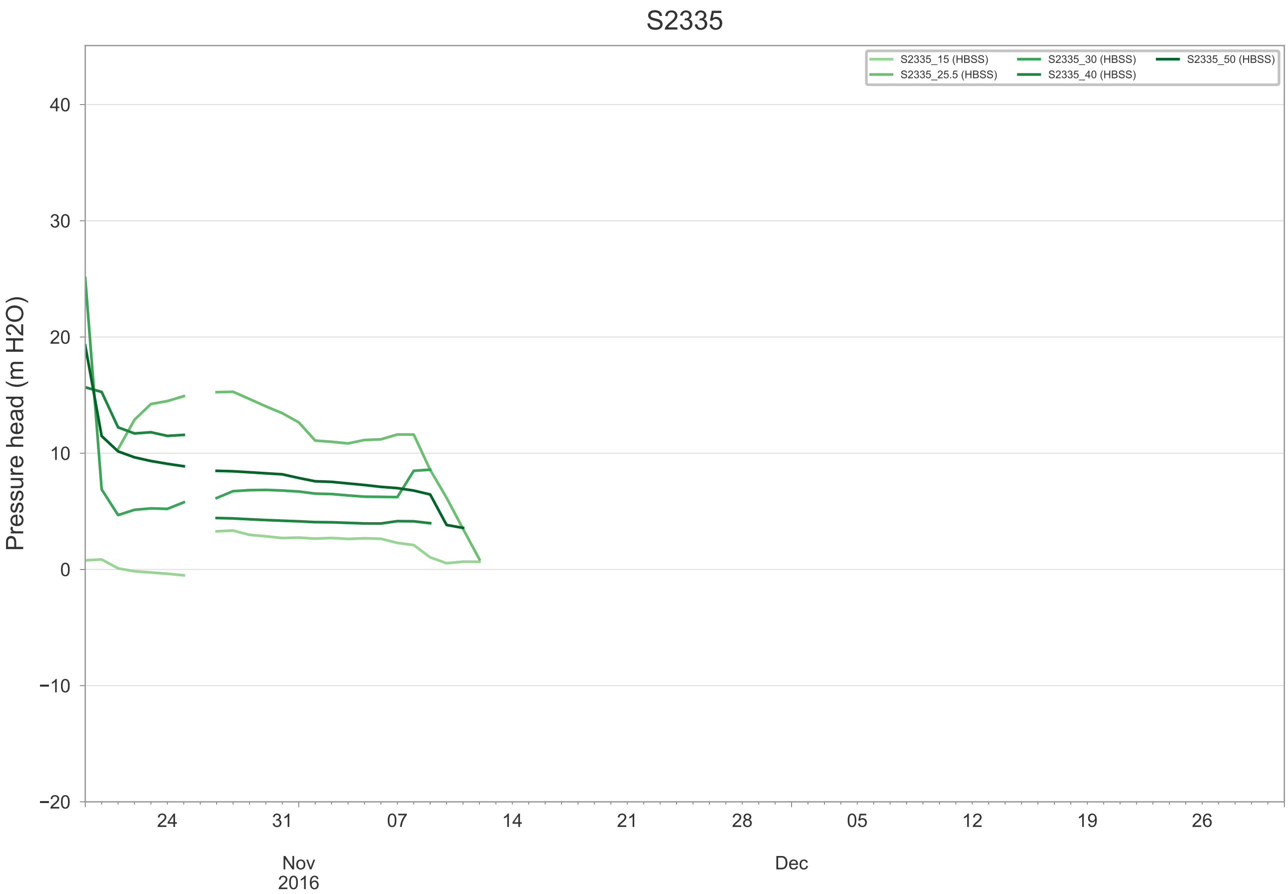


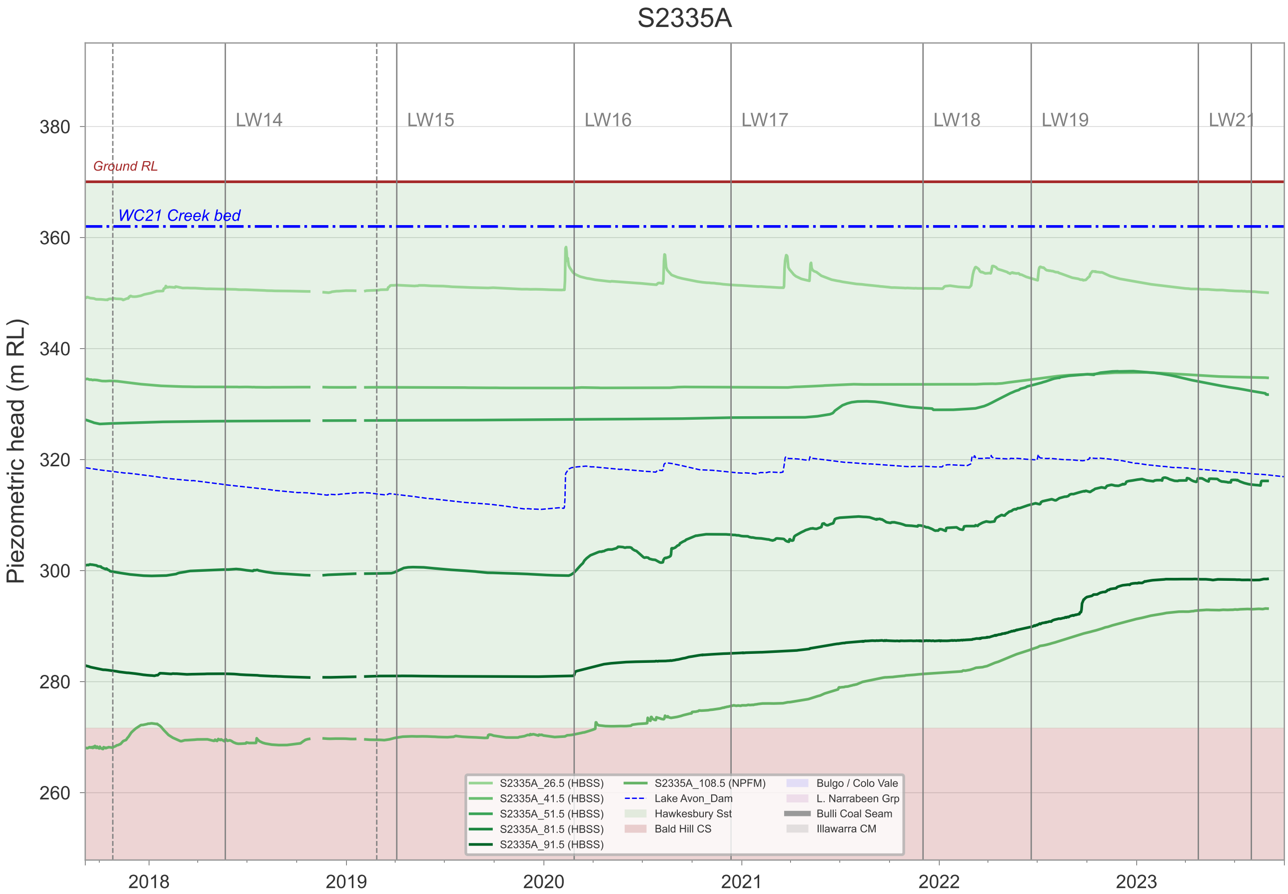


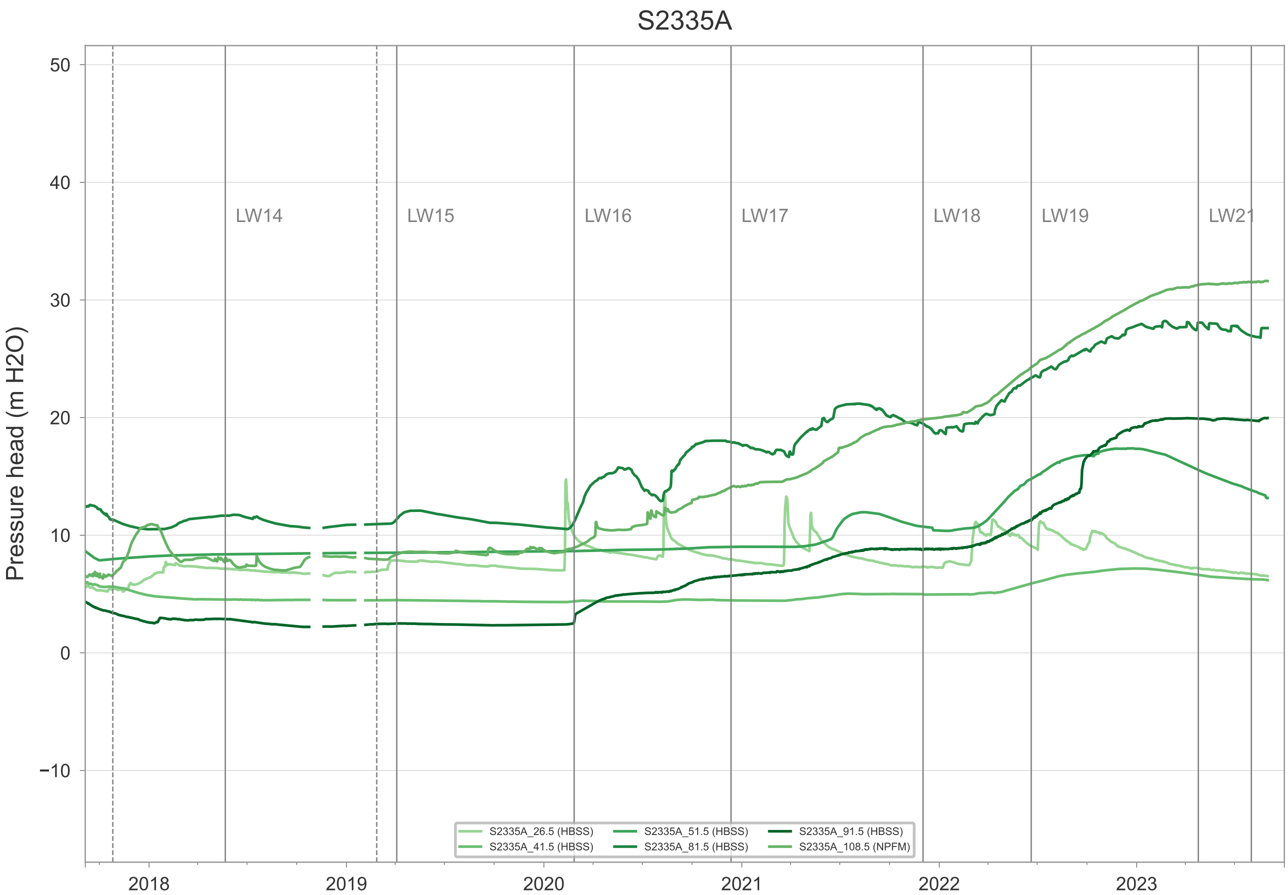
Groundwater hydrographs

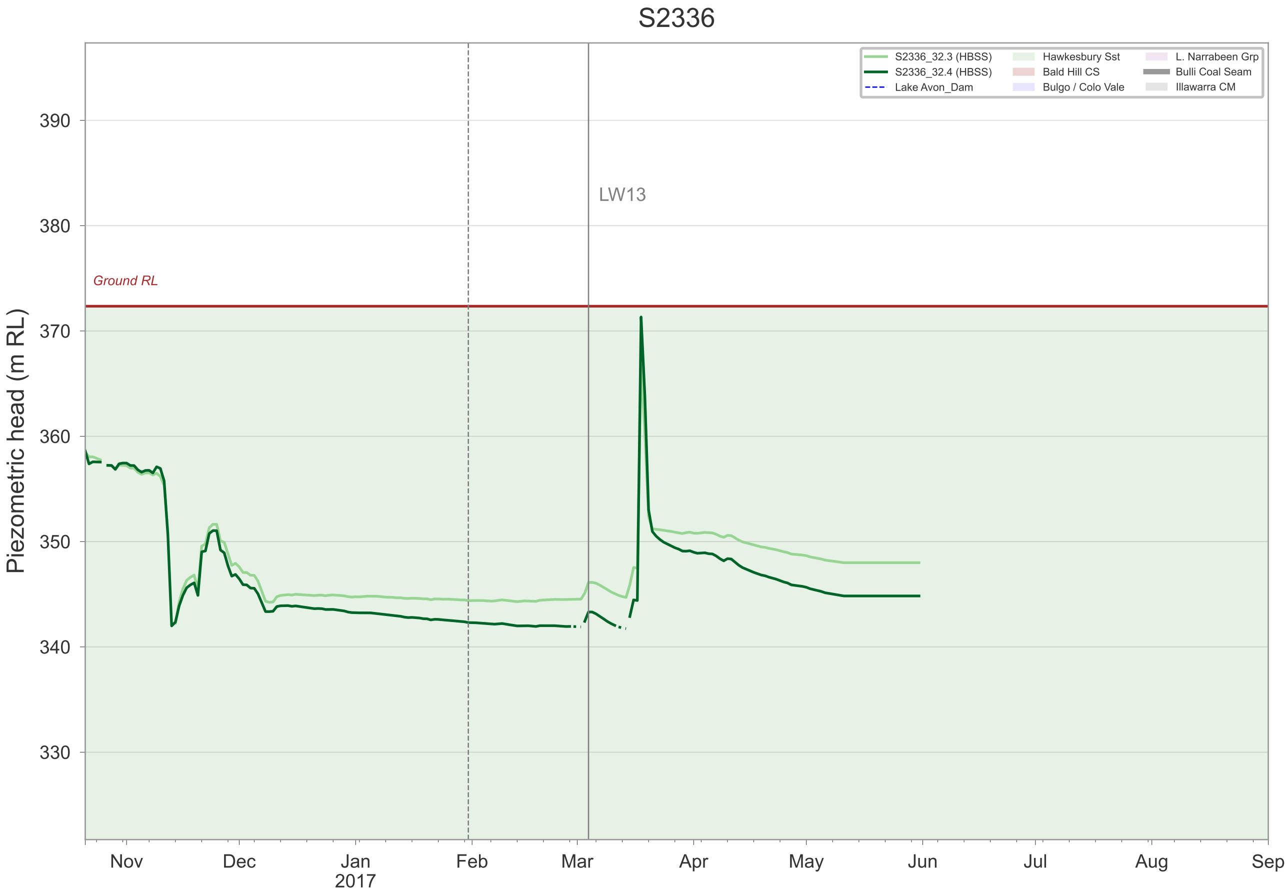


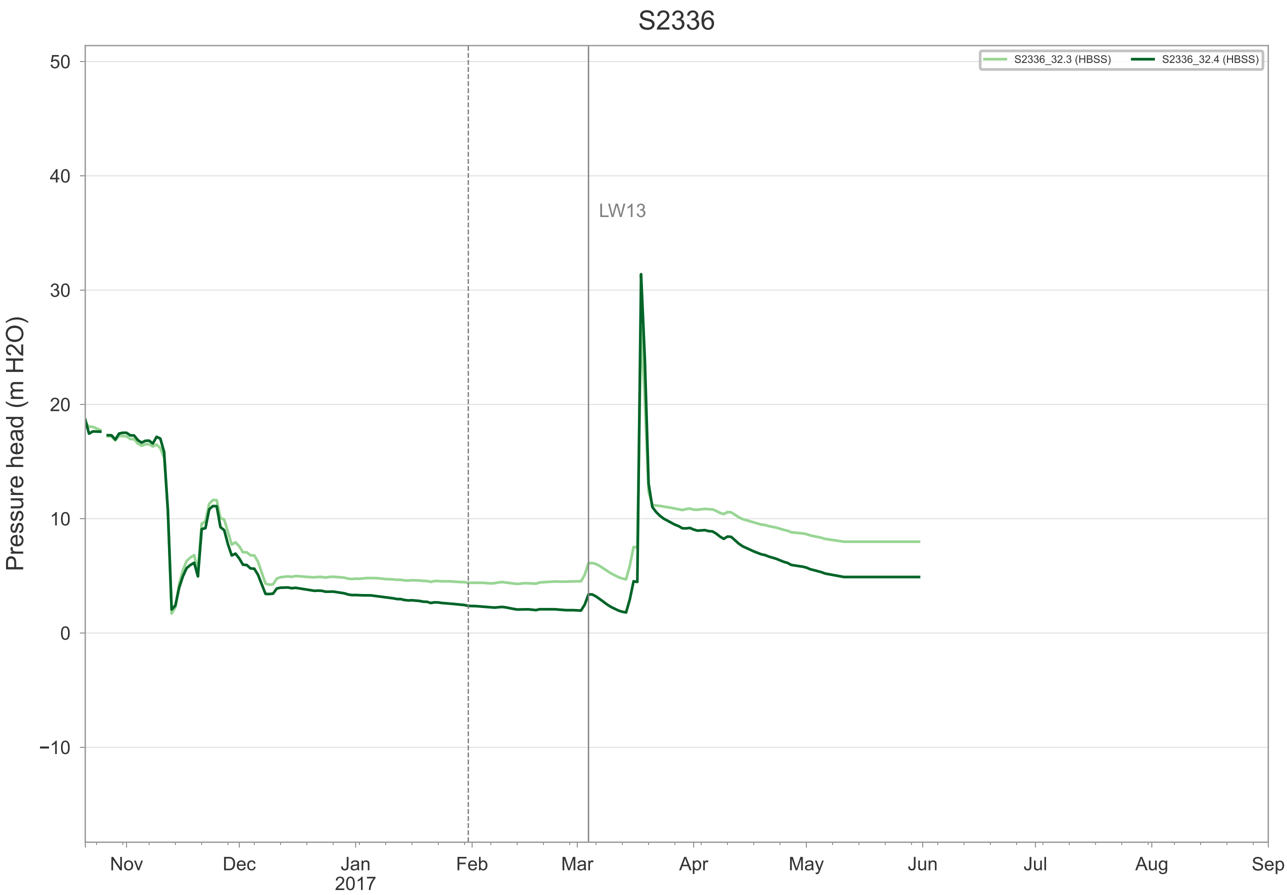


Groundwater hydrographs

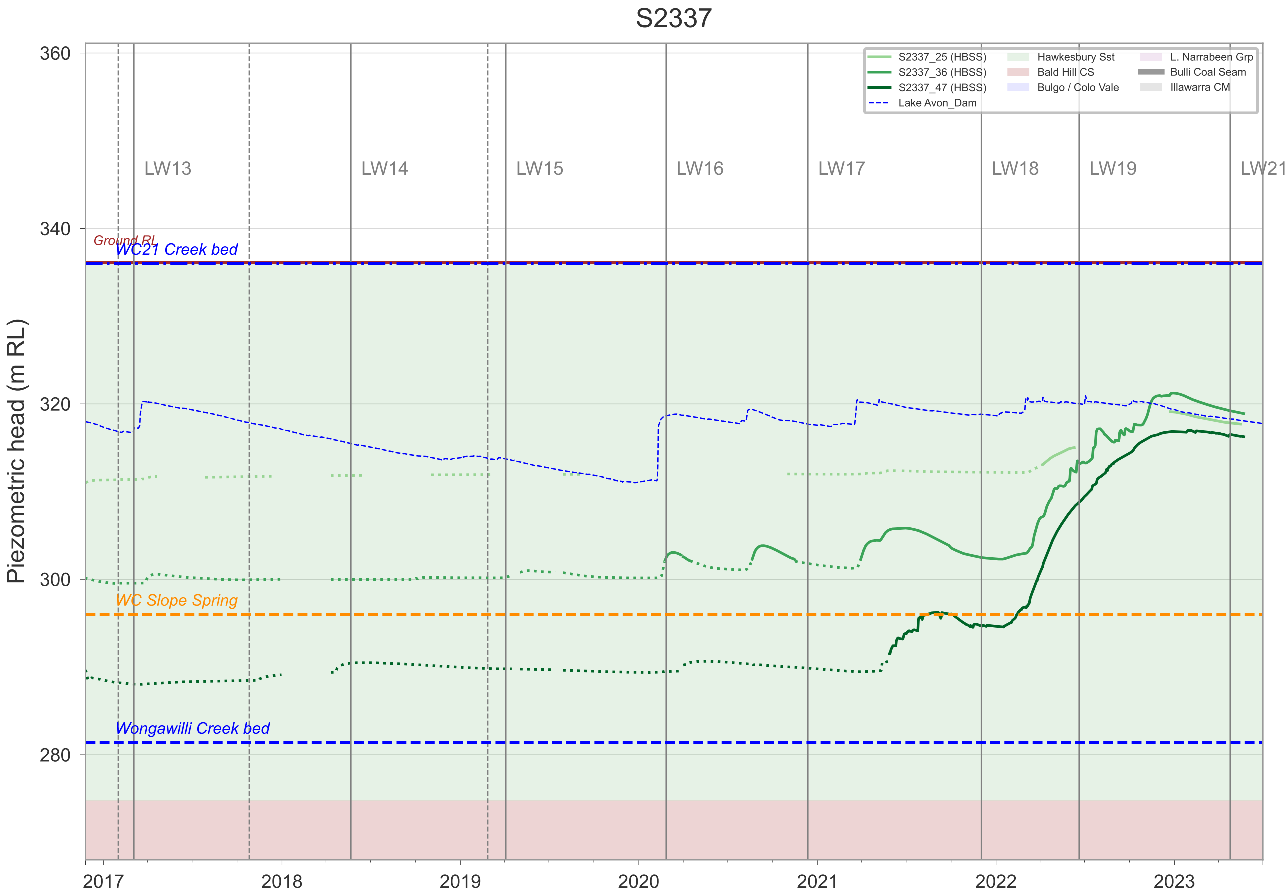


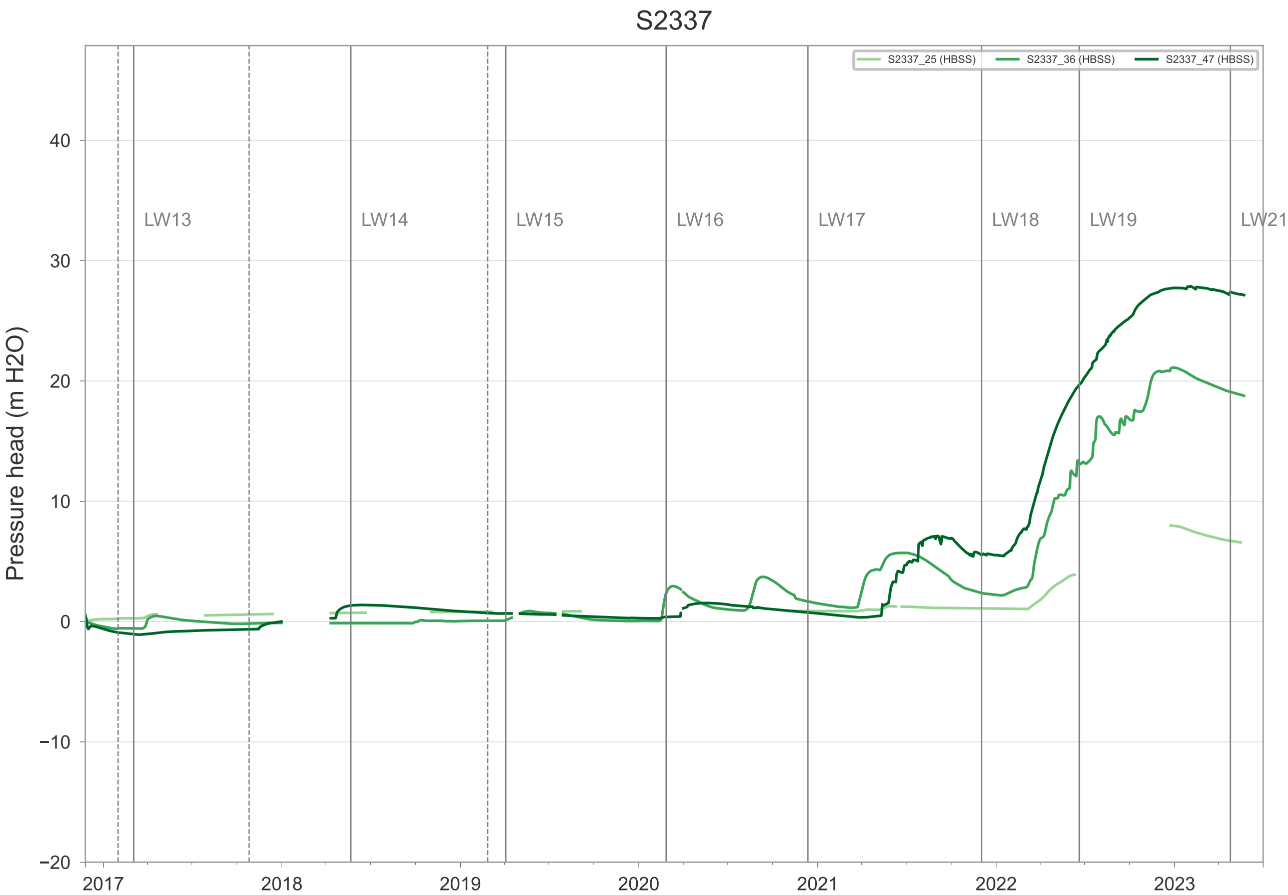


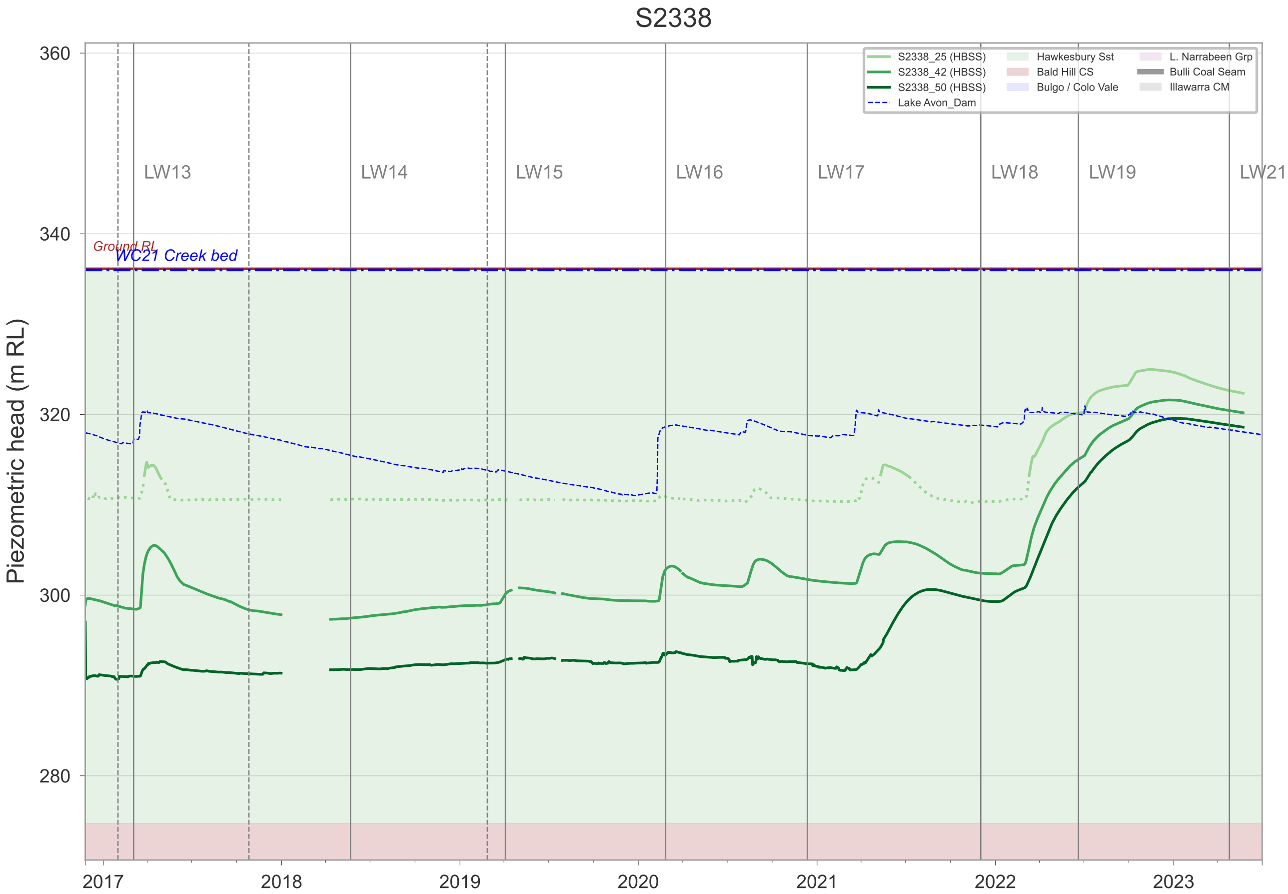

S2336
S2336_32.3 (HBSS)
S2336_32.4 (HBSS)
Lake Avon_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM
LW13
Ground RL
Piezometric head (m RL)
390
380
370
360
350
340
330
Nov
Dec
Jan
2017
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep

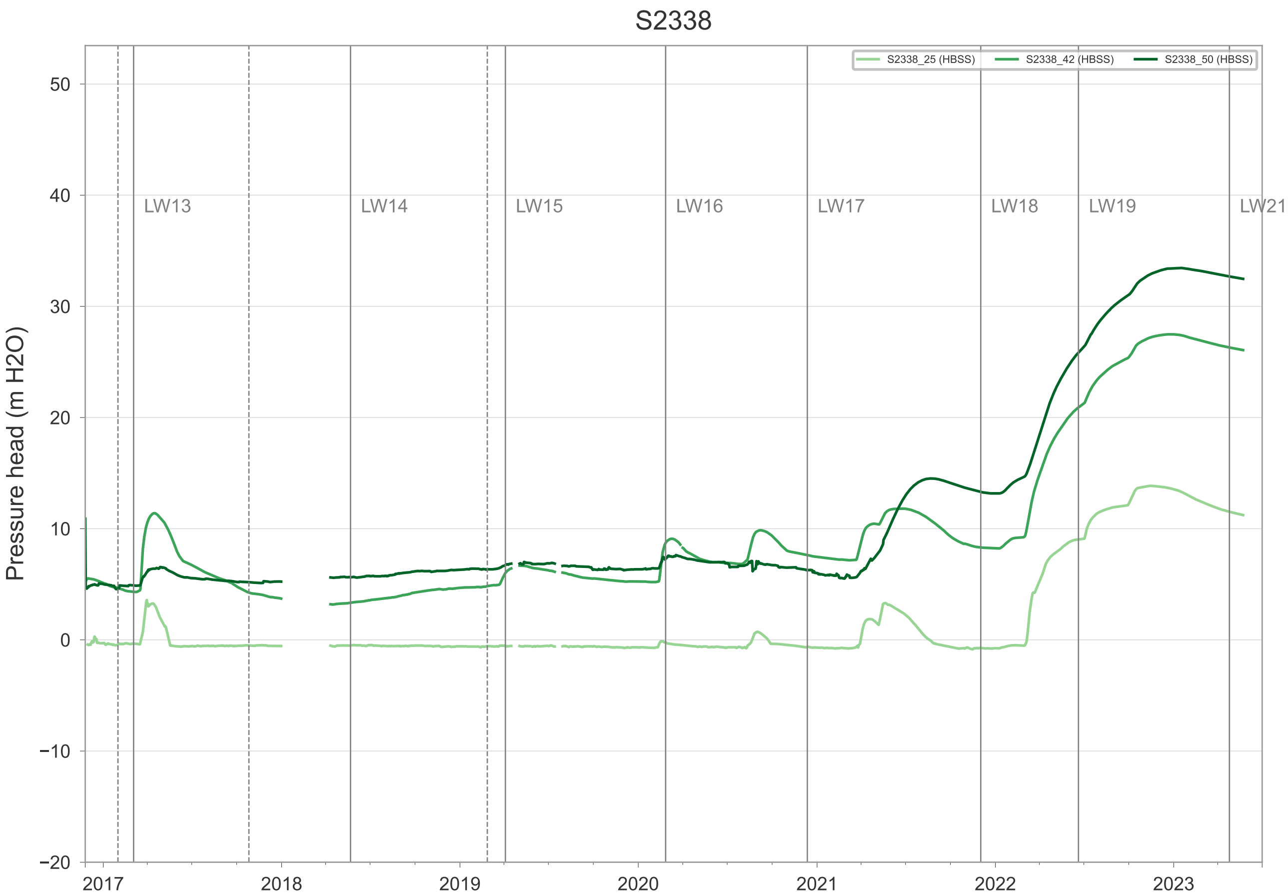

S2336
S2336_32.3 (HBSS)
S2336_32.4 (HBSS)
LW13
Pressure head (m H2O)
50
40
30
20
10
0
−10
Nov
Dec
Jan
2017
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep

Groundwater hydrographs

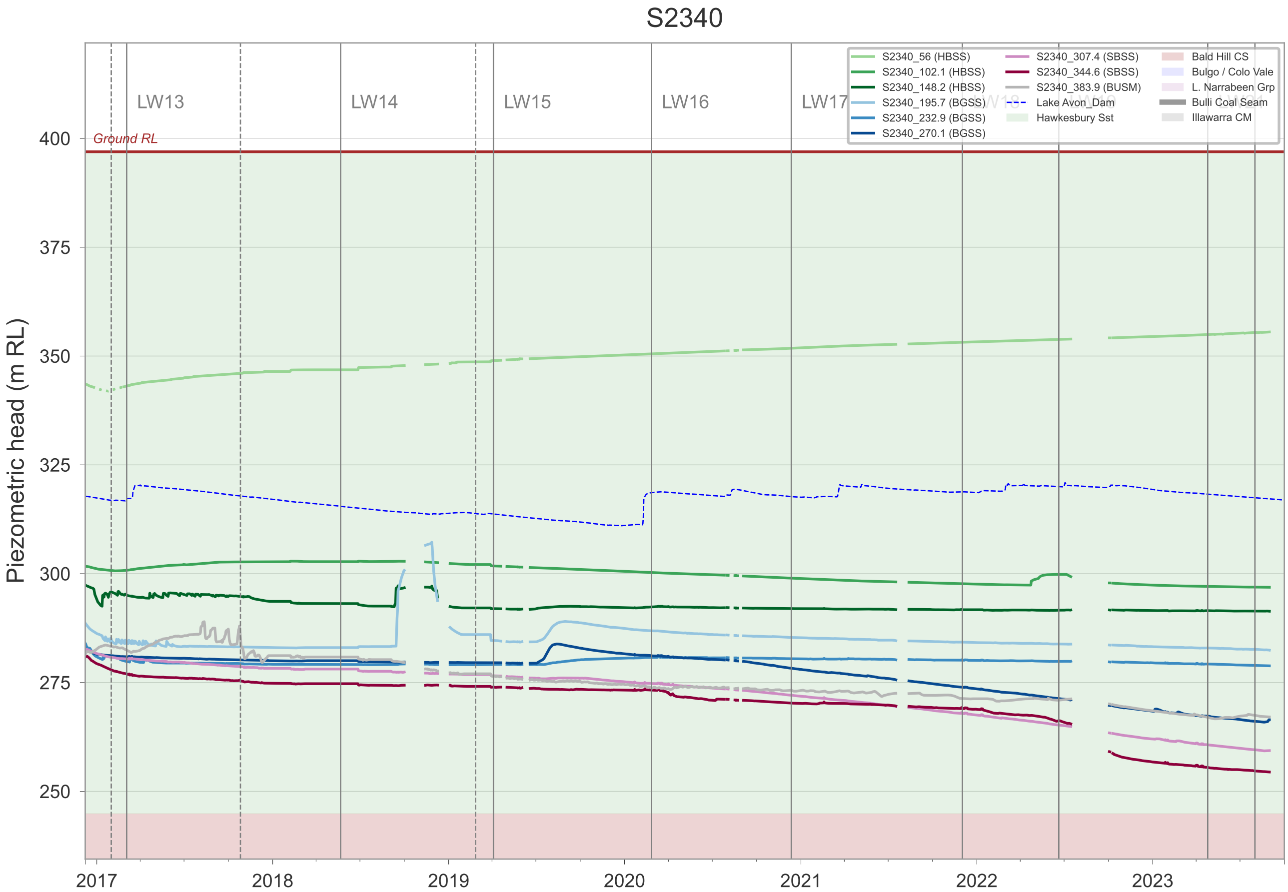


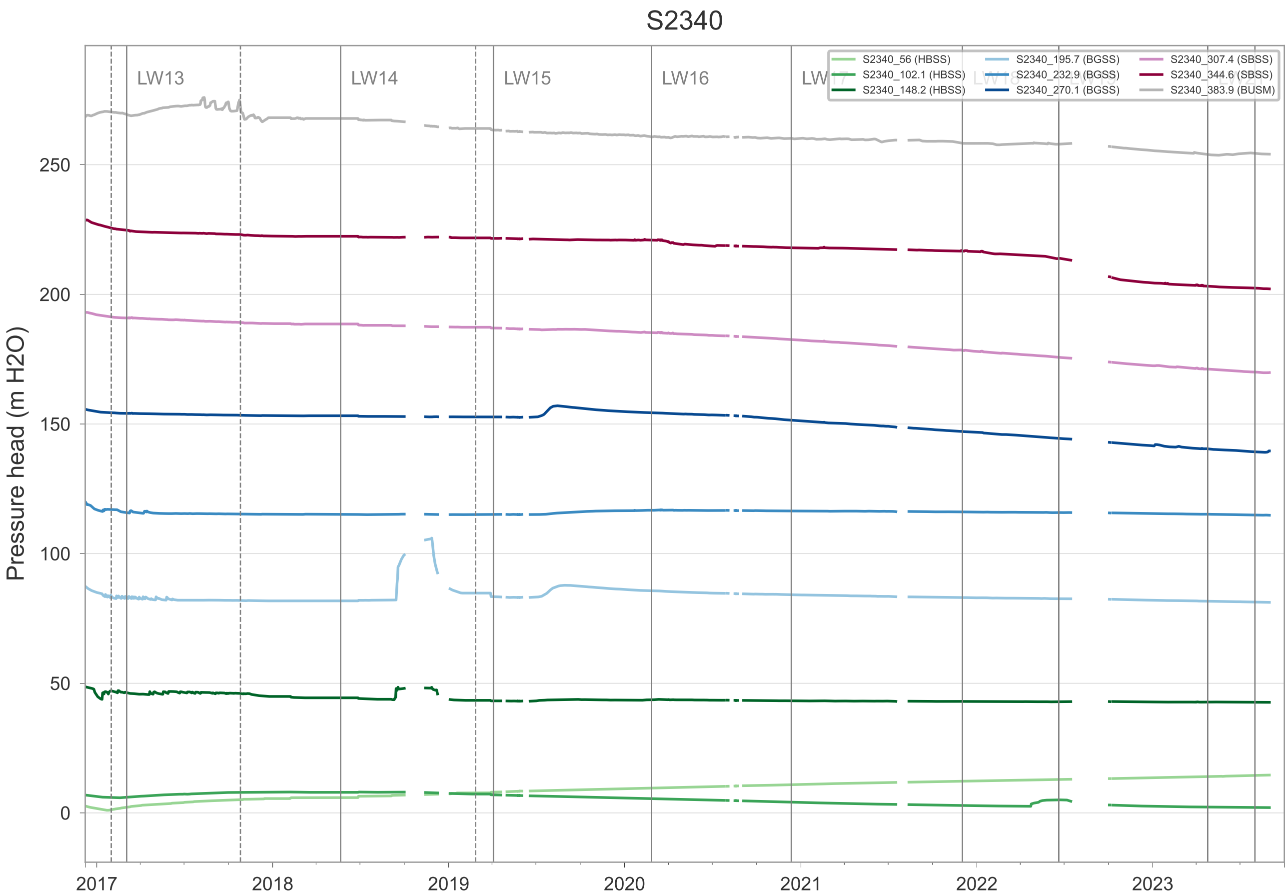



S2338
S2338_25 (HBSS)
S2338_42 (HBSS)
S2338_50 (HBSS)
Lake Avon_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM
LW13
LW14
LW15
LW16
LW17
LW18
LW19
LW21
Ground RL
WC21 Creek bed
Piezometric head (m RL)
360
340
320
300
280
2017
2018
2019
2020
2021
2022
2023

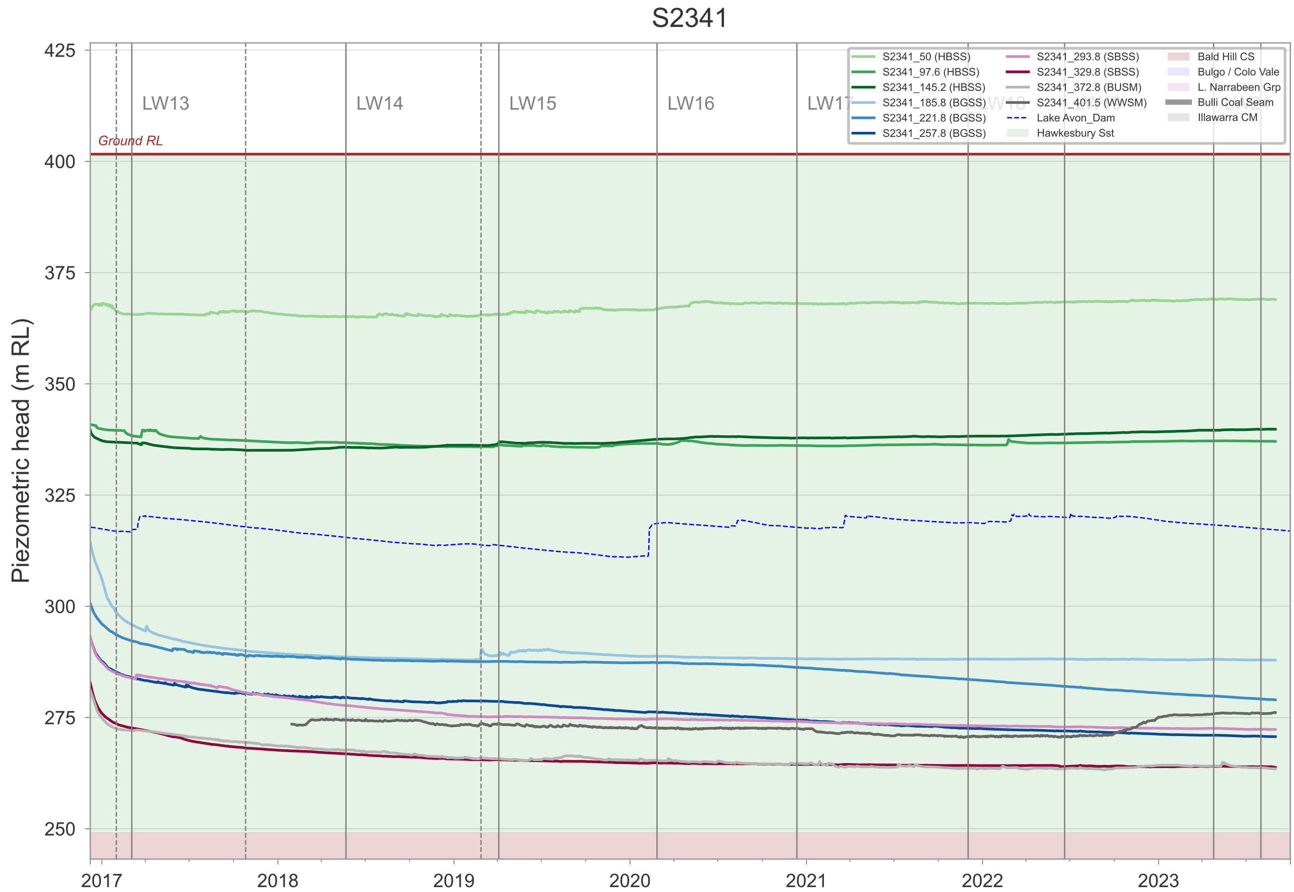

S2338
S2338_25 (HBSS)
S2338_42 (HBSS)
S2338_50 (HBSS)
LW13
LW14
LW15
LW16
LW17
LW18
LW19
LW21
Pressure head (m H2O)
50
40
30
20
10
0
−10
−20
2017
2018
2019
2020
2021
2022
2023

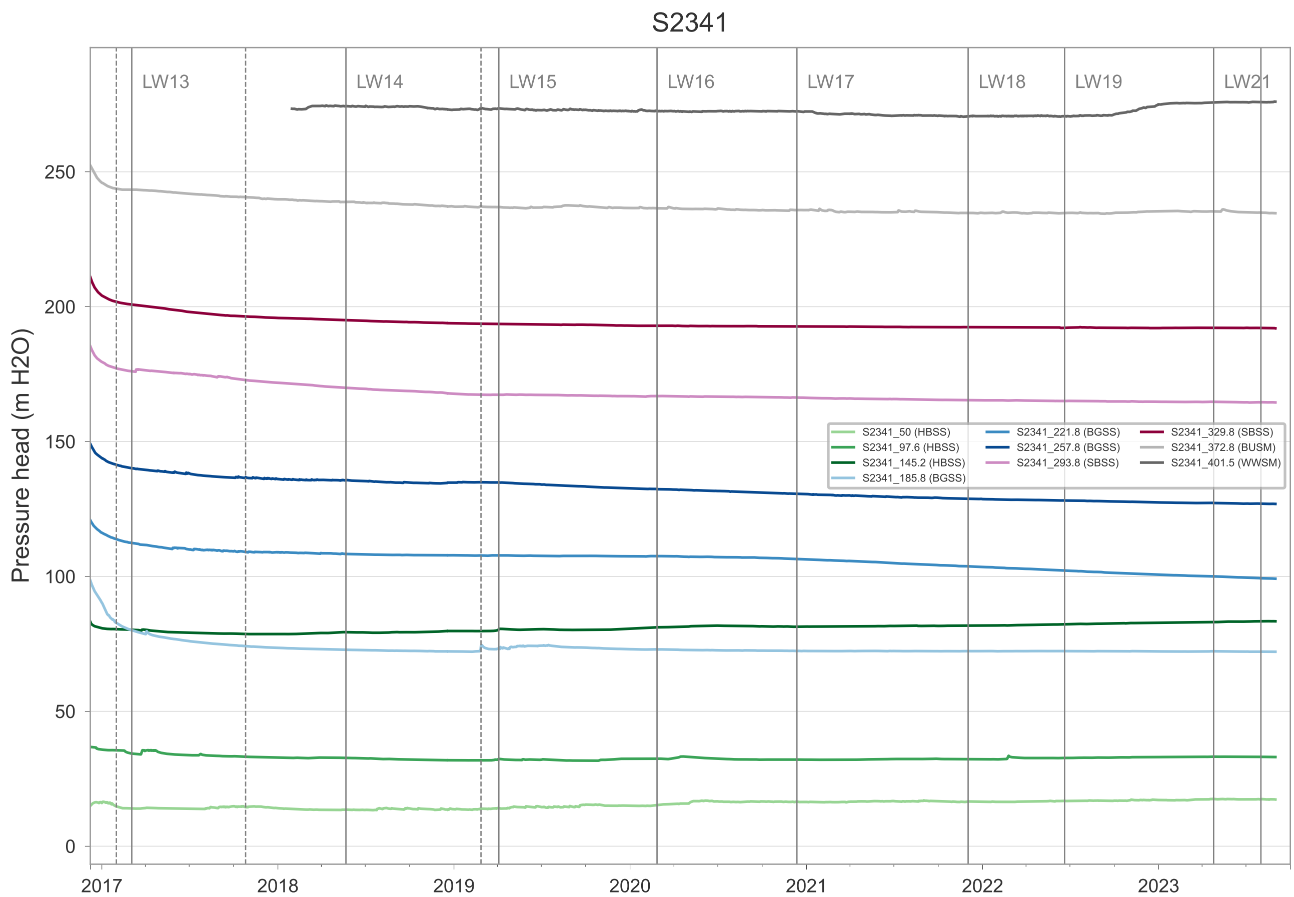
Groundwater hydrographs





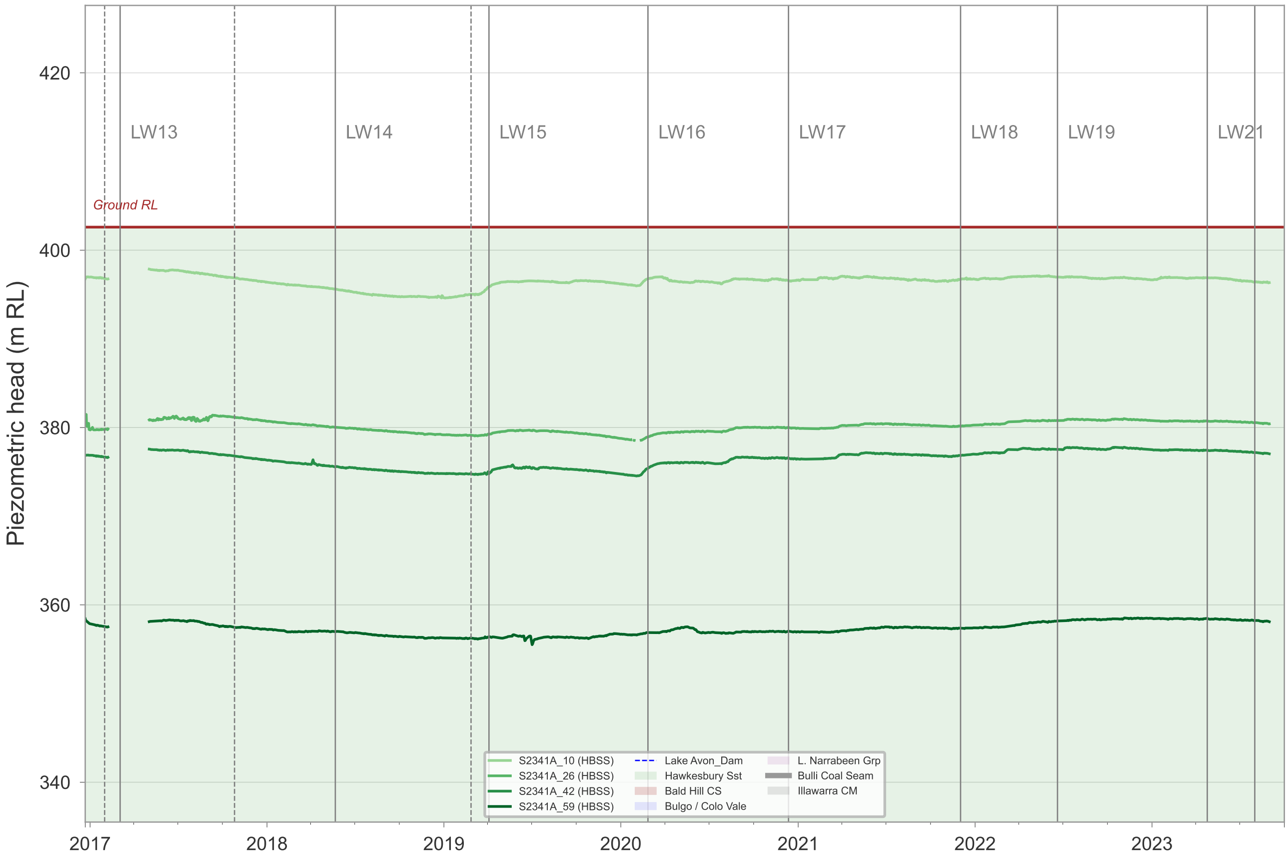
Groundwater hydrographs



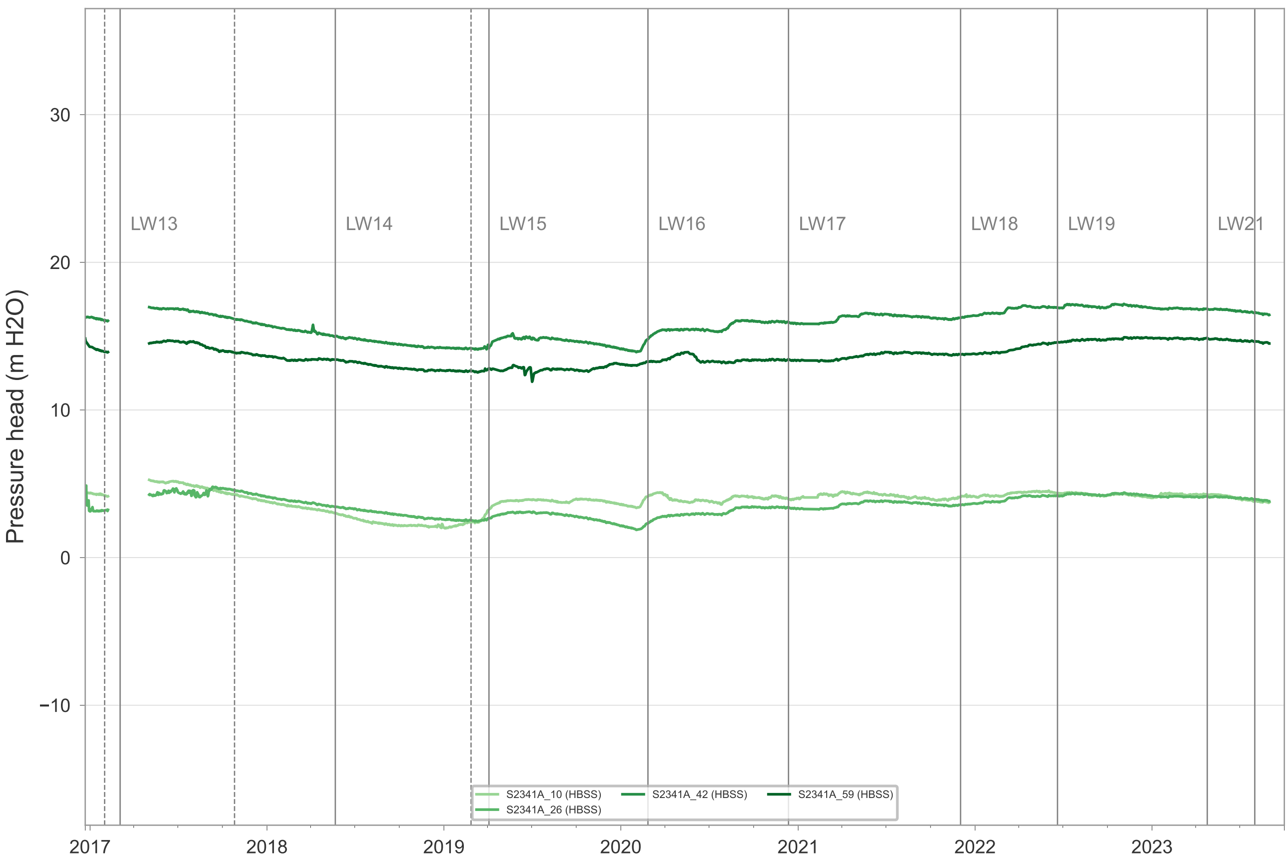


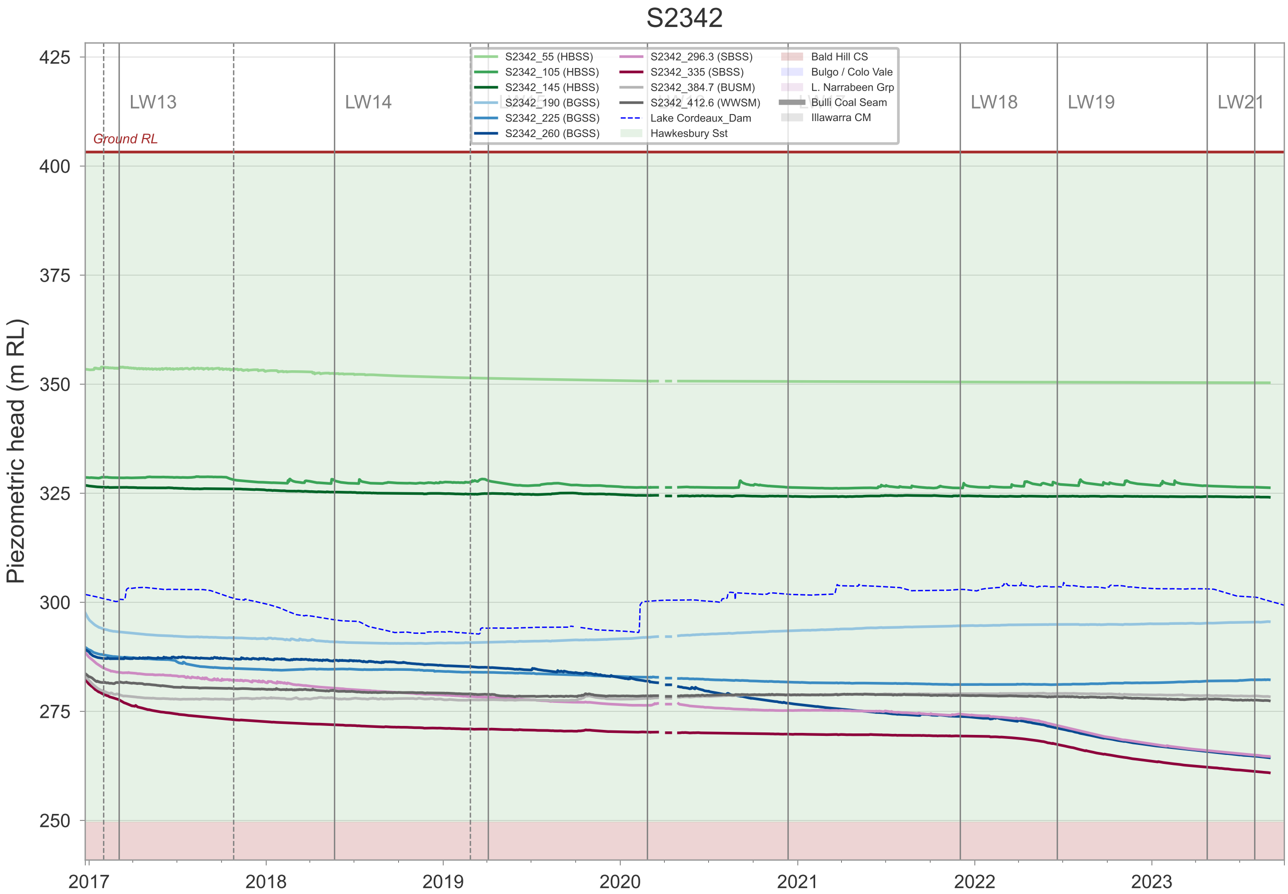
Groundwater hydrographs

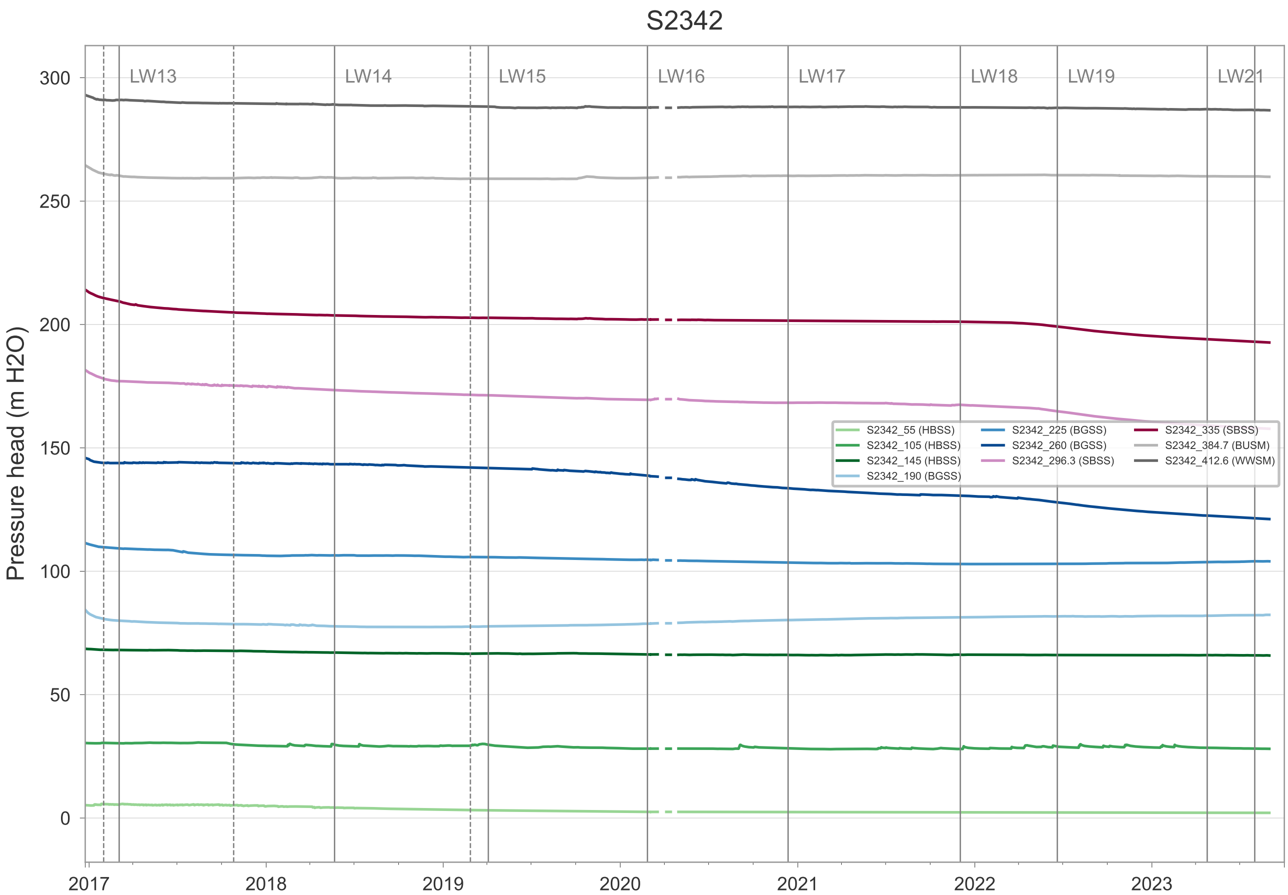
S2341A



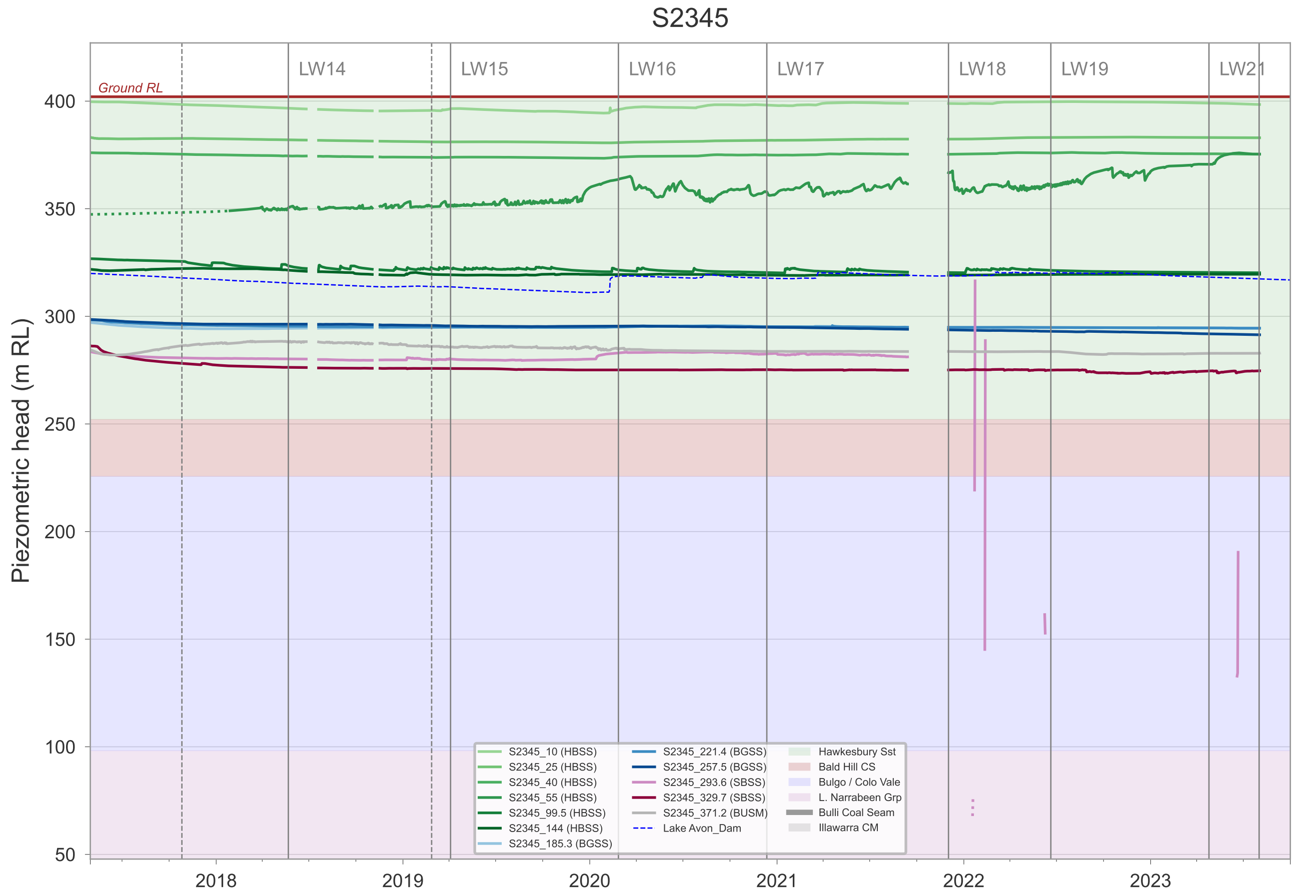
S2341A

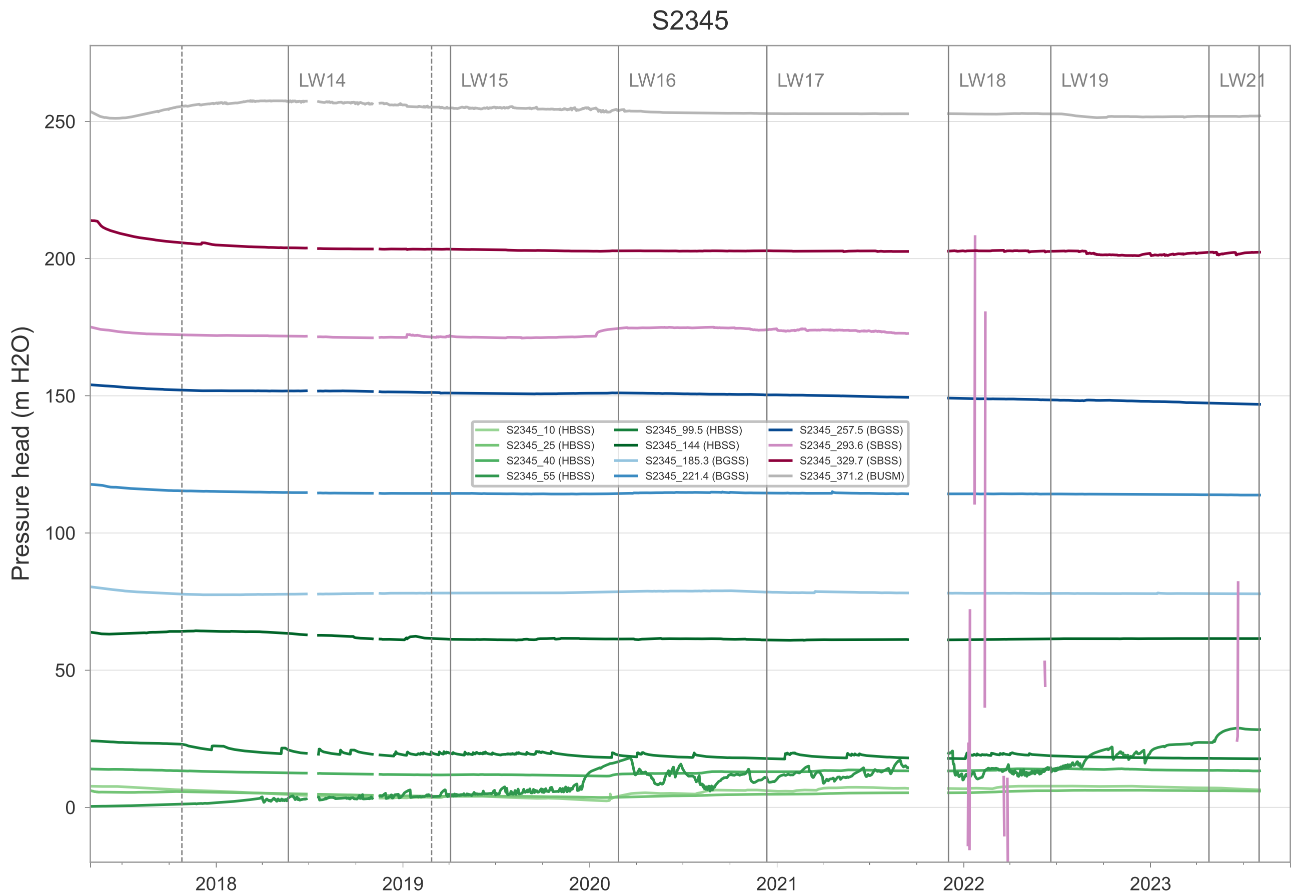



S2342
Piezometric head (m RL)
Ground RL
LW13
LW14
LW18
LW19
LW21
S2342_55 (HBSS)
S2342_105 (HBSS)
S2342_145 (HBSS)
S2342_190 (BGSS)
S2342_225 (BGSS)
S2342_260 (BGSS)
S2342_296.3 (SBSS)
S2342_335 (SBSS)
S2342_384.7 (BUSM)
S2342_412.6 (WWSM)
Lake Cordeaux_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM
425
400
375
350
325
300
275
250
2017
2018
2019
2020
2021
2022
2023

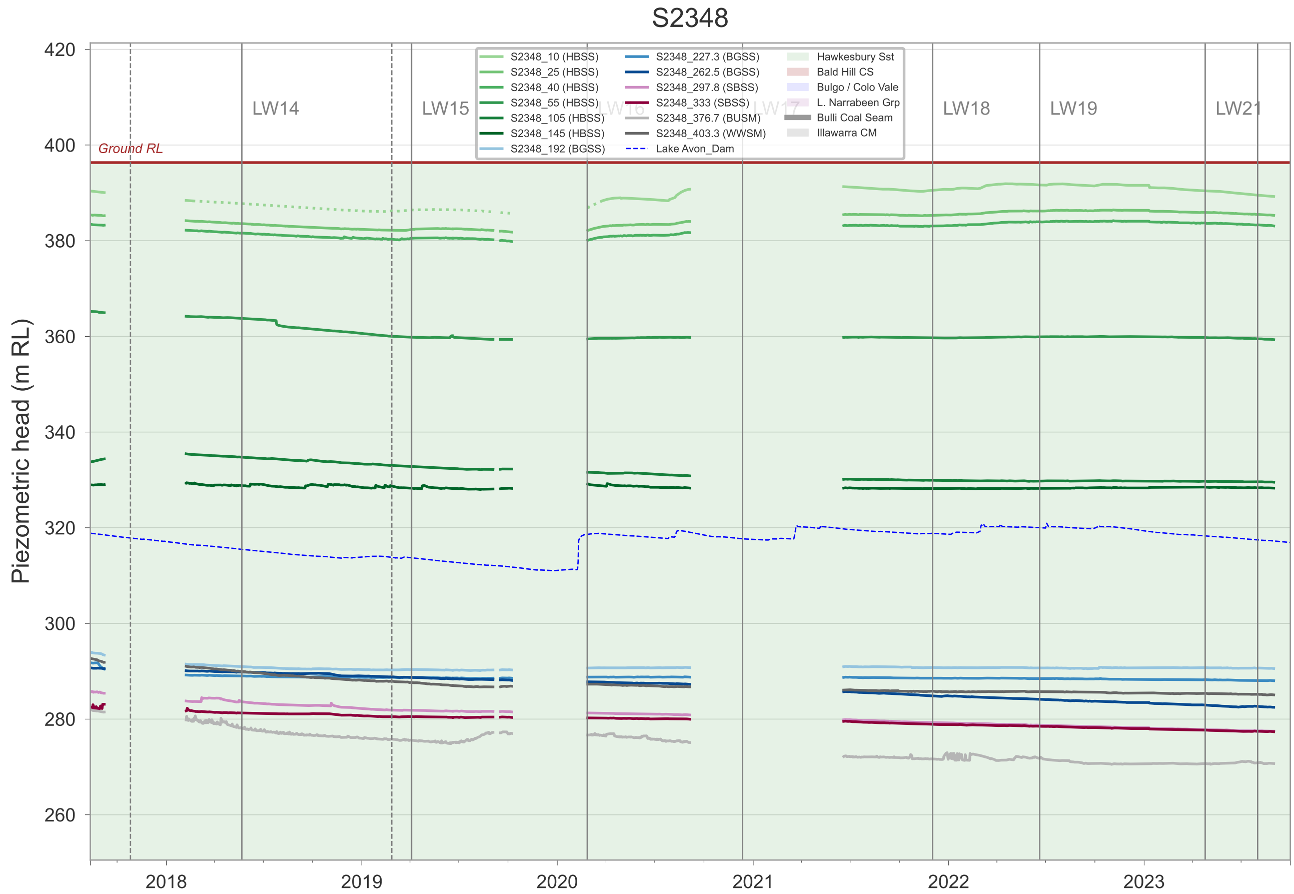

S2342
Pressure head (m H2O)
LW13
LW14
LW15
LW16
LW17
LW18
LW19
LW21
S2342_55 (HBSS)
S2342_105 (HBSS)
S2342_145 (HBSS)
S2342_190 (BGSS)
S2342_225 (BGSS)
S2342_260 (BGSS)
S2342_296.3 (SBSS)
S2342_335 (SBSS)
S2342_384.7 (BUSM)
S2342_412.6 (WWSM)
300
250
200
150
100
50
0
2017
2018
2019
2020
2021
2022
2023

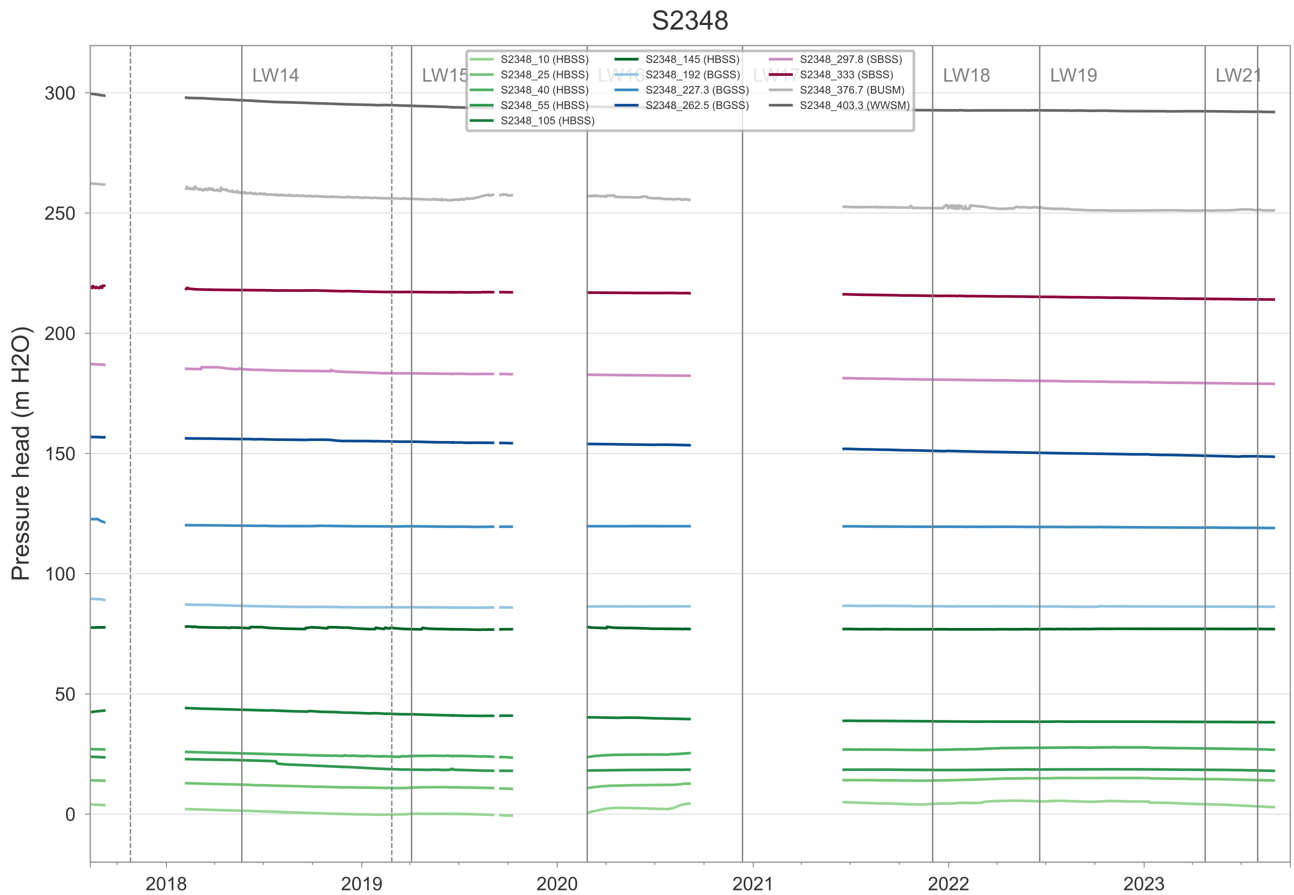
Groundwater hydrographs

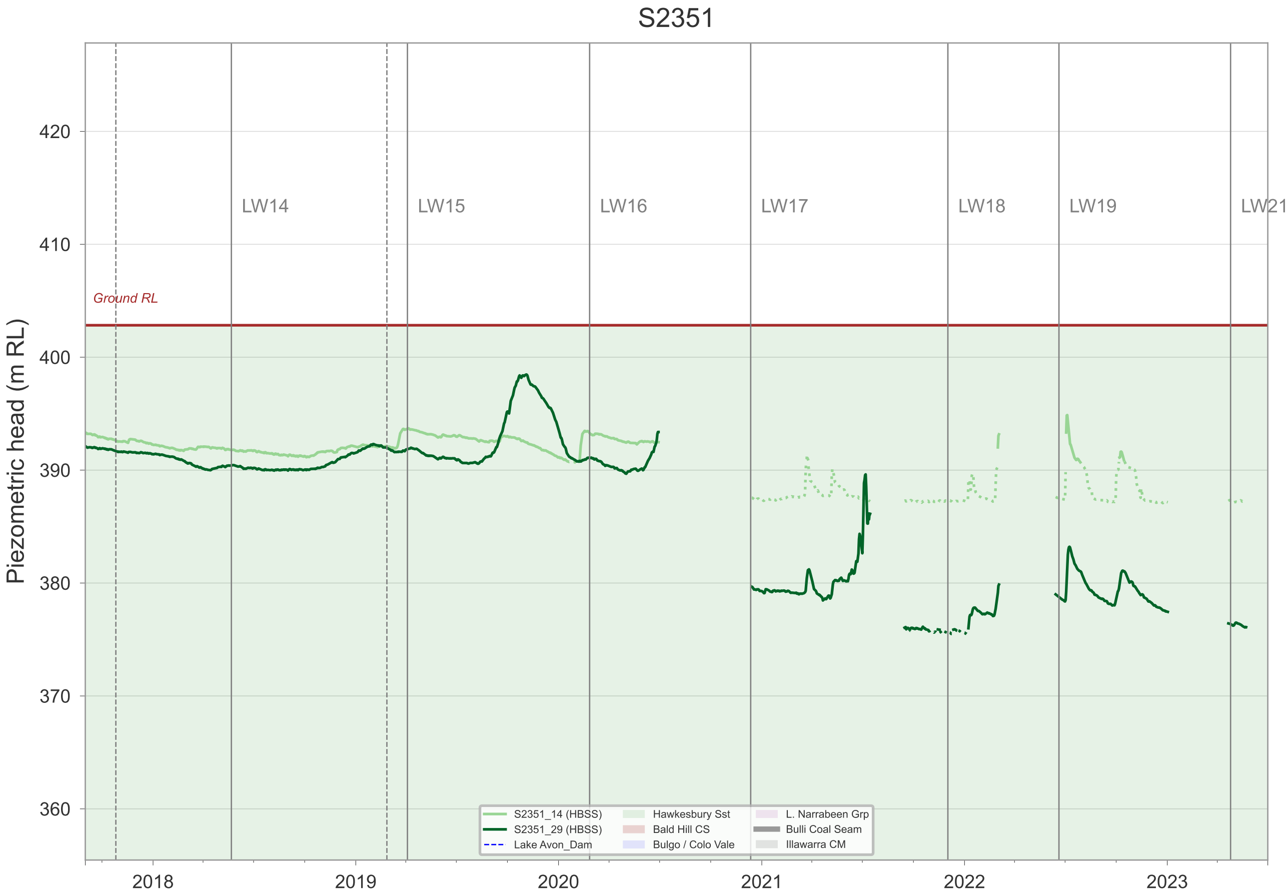


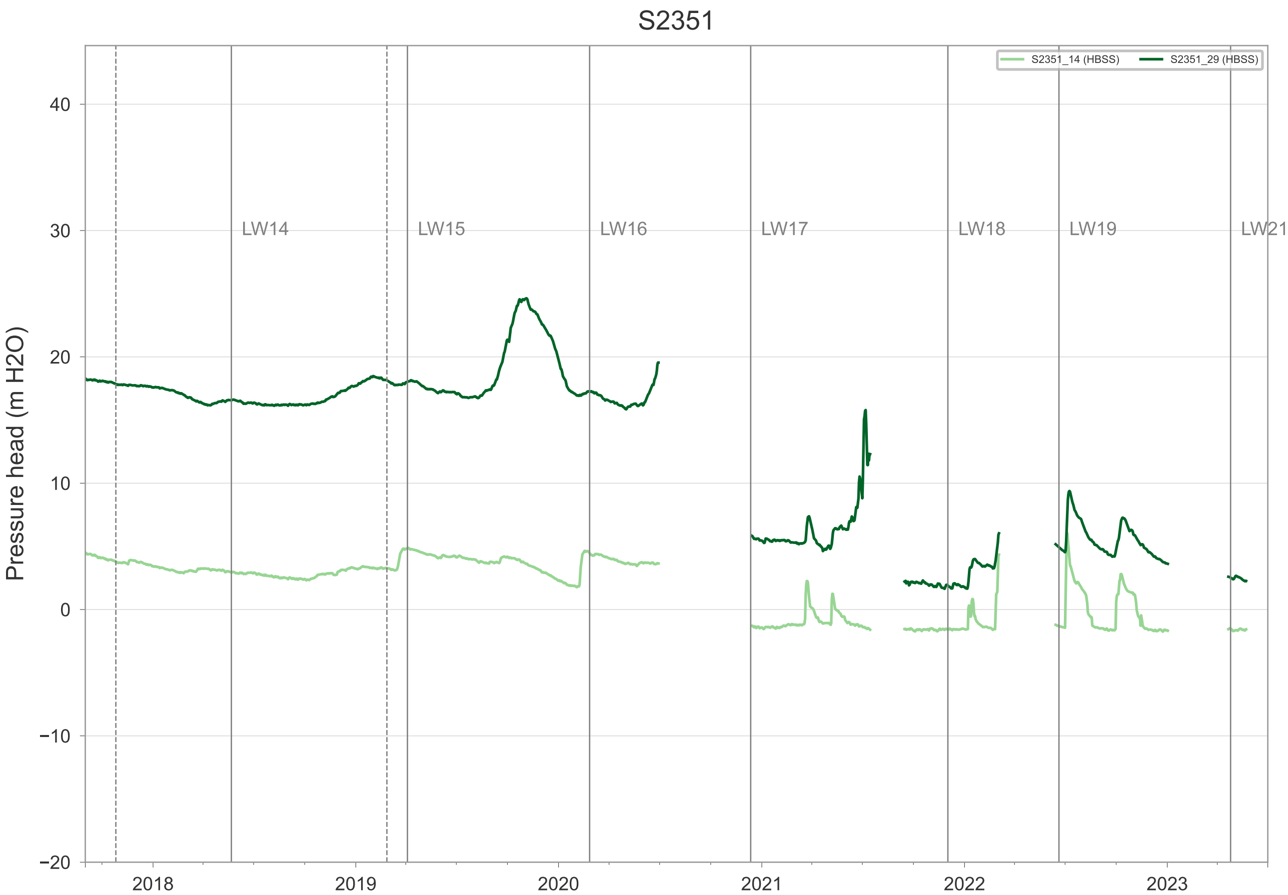


Groundwater hydrographs

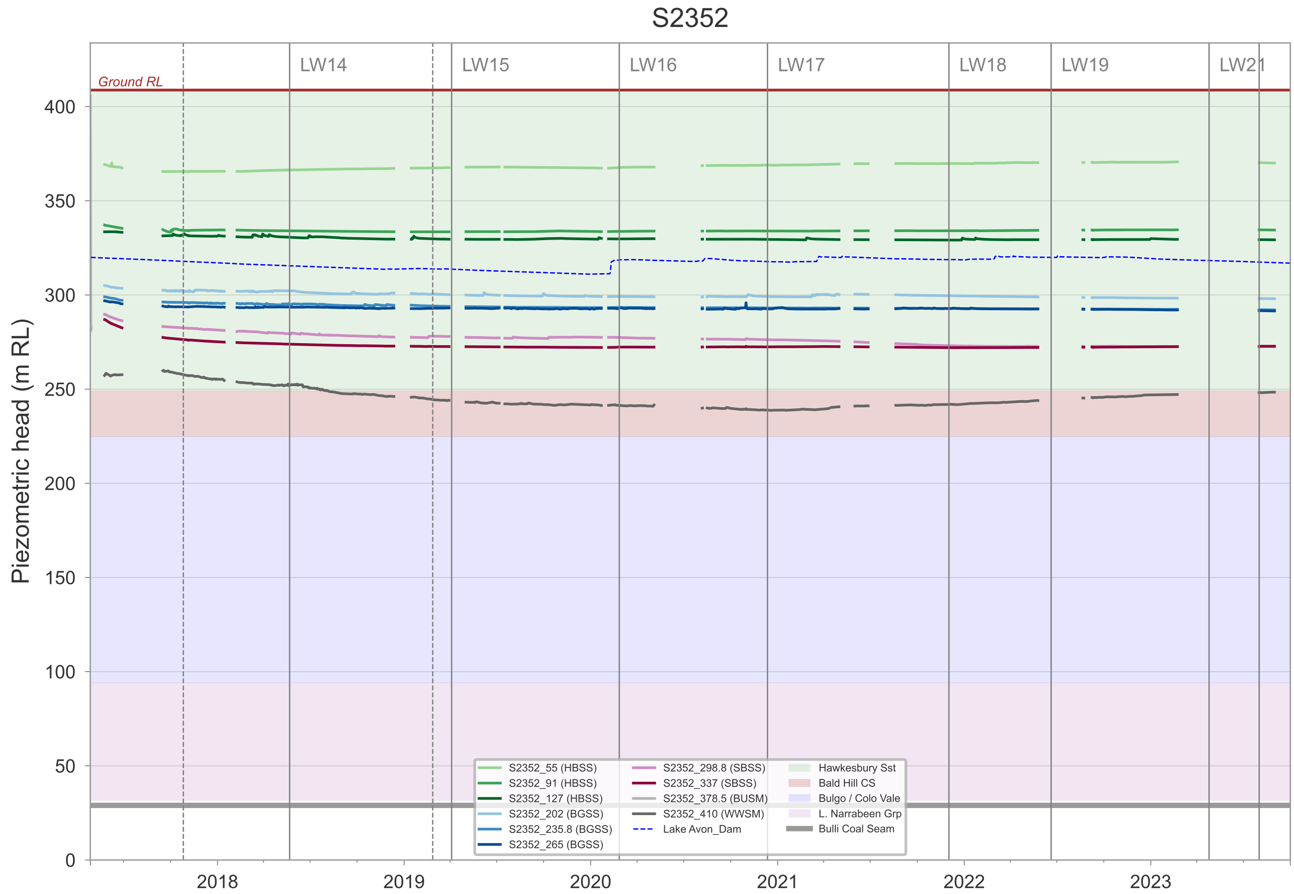


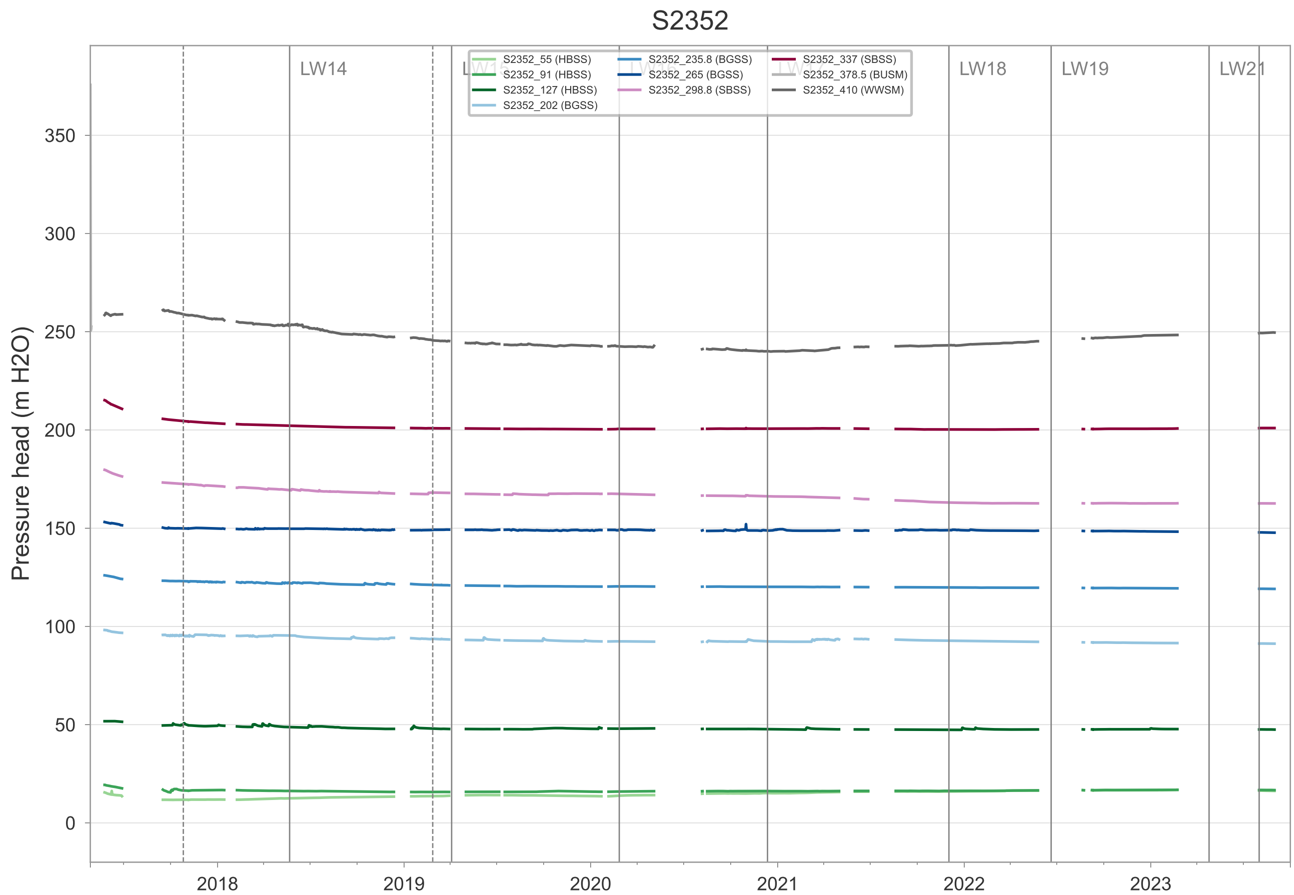


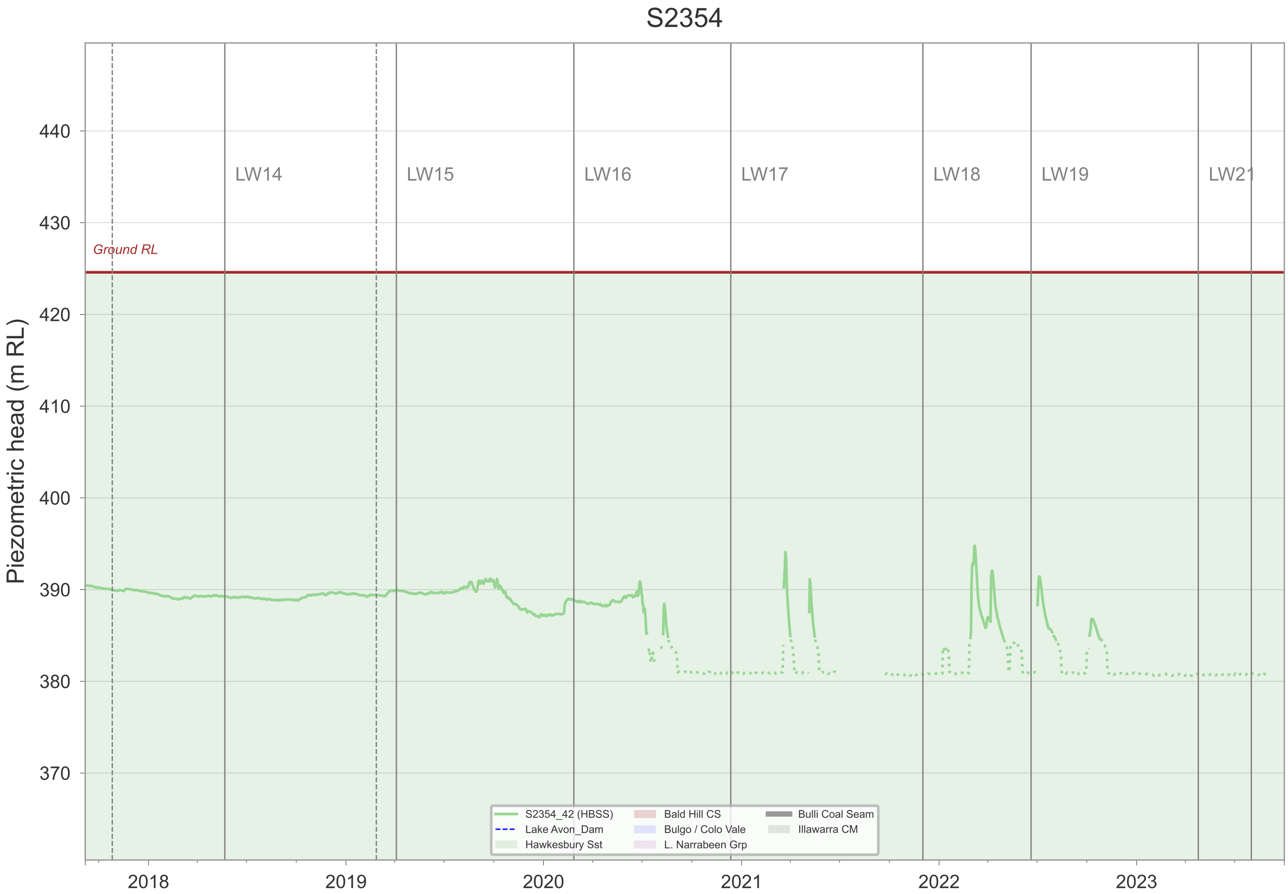

S2351
Piezometric head (m RL)
Ground RL
LW14
LW15
LW16
LW17
LW18
LW19
LW21
420
410
400
390
380
370
360
2018
2019
2020
2021
2022
2023
S2351_14 (HBSS)
S2351_29 (HBSS)
Lake Avon_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM

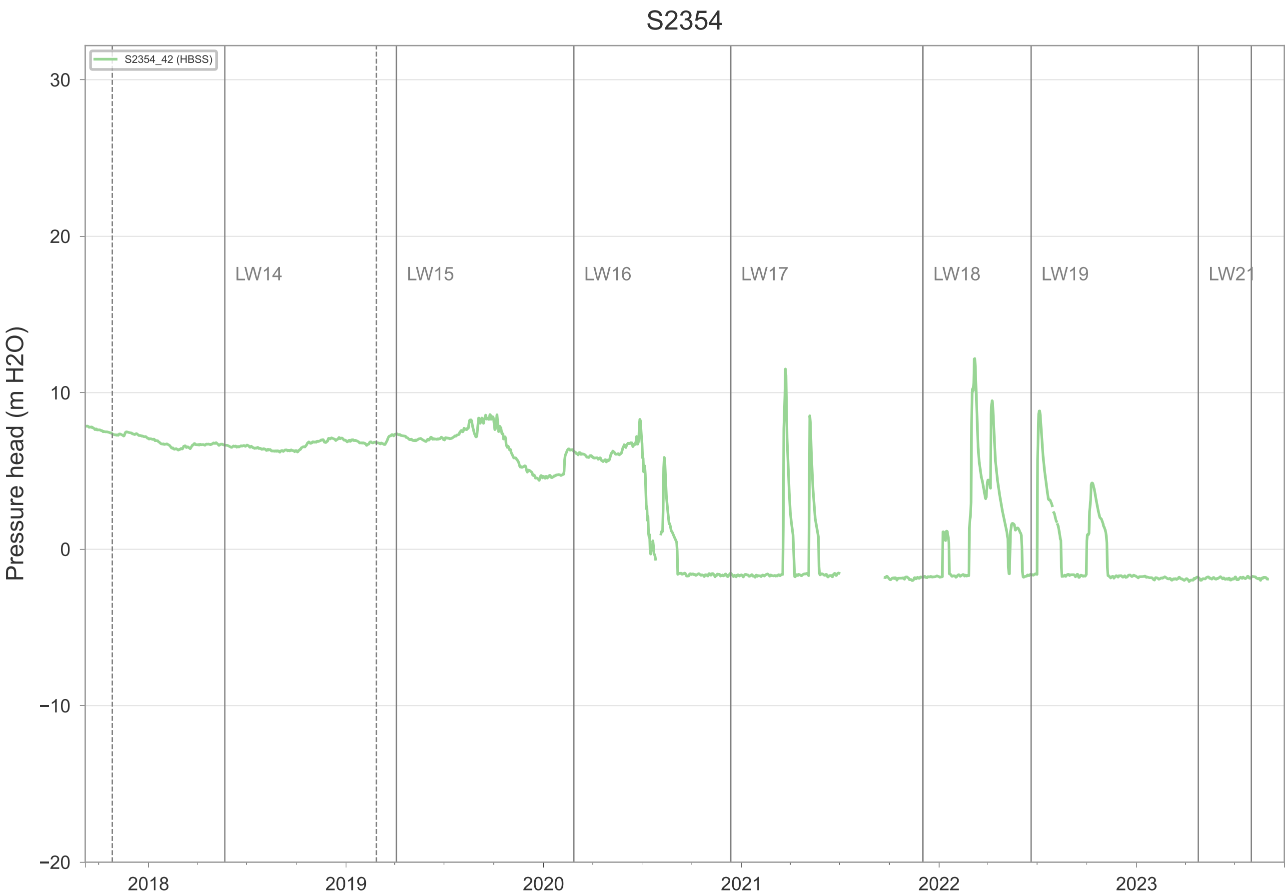

S2351
Pressure head (m H2O)
S2351_14 (HBSS)
S2351_29 (HBSS)
LW14
LW15
LW16
LW17
LW18
LW19
LW21
40
30
20
10
0
−10
−20
2018
2019
2020
2021
2022
2023

Groundwater hydrographs

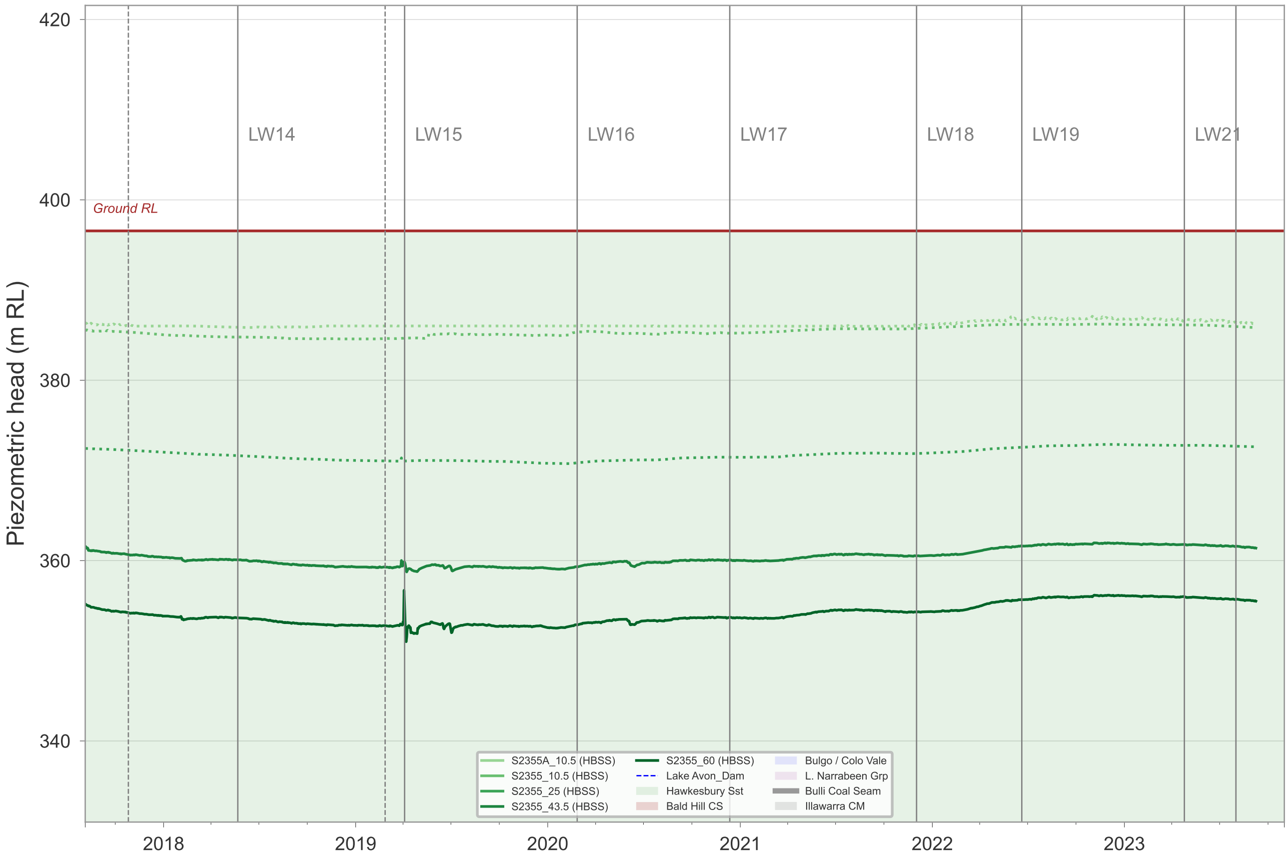




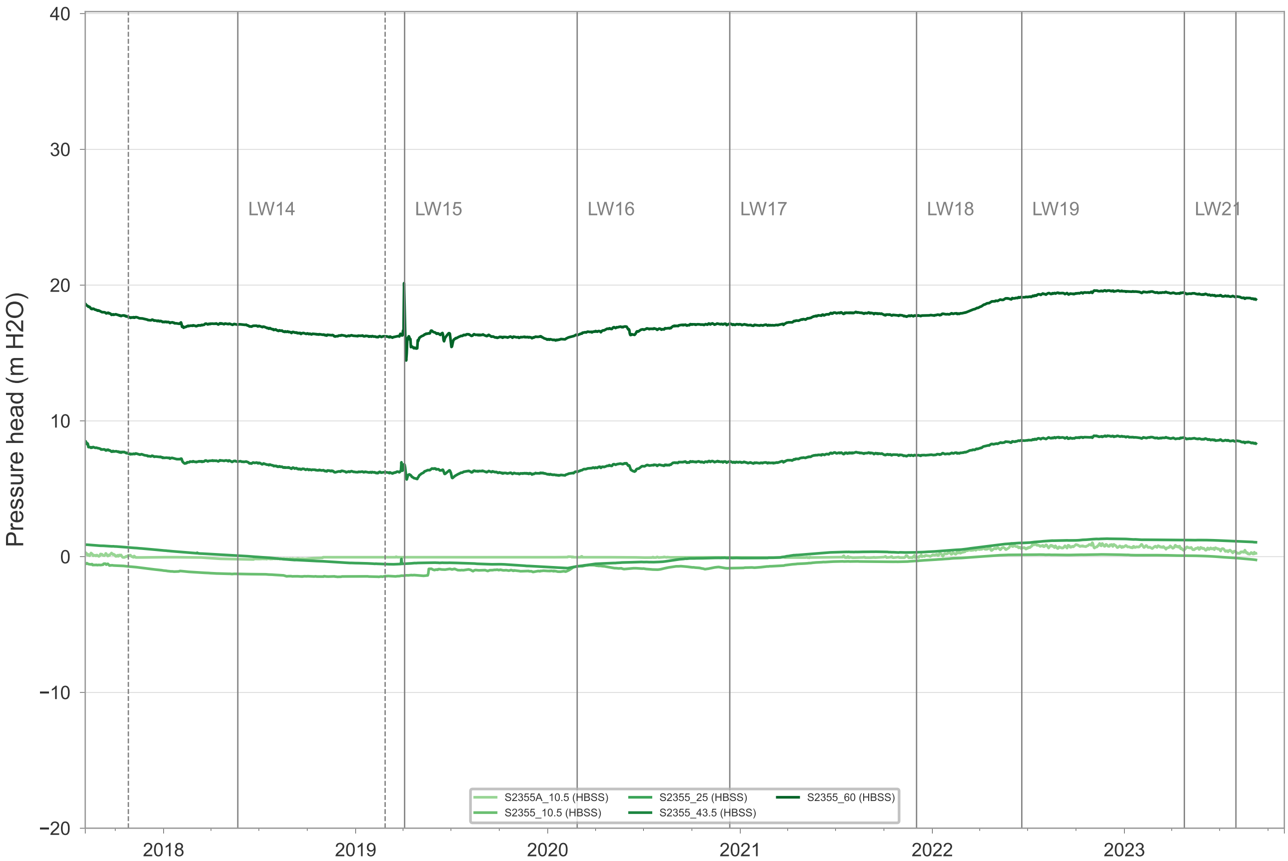

S2354
Piezometric head (m RL)
Ground RL
LW14
LW15
LW16
LW17
LW18
LW19
LW21
440
430
420
410
400
390
380
370
2018
2019
2020
2021
2022
2023
S2354_42 (HBSS)
Lake Avon_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM


S2354
Pressure head (m H2O)
S2354_42 (HBSS)
LW14
LW15
LW16
LW17
LW18
LW19
LW21
30
20
10
0
−10
−20
2018
2019
2020
2021
2022
2023

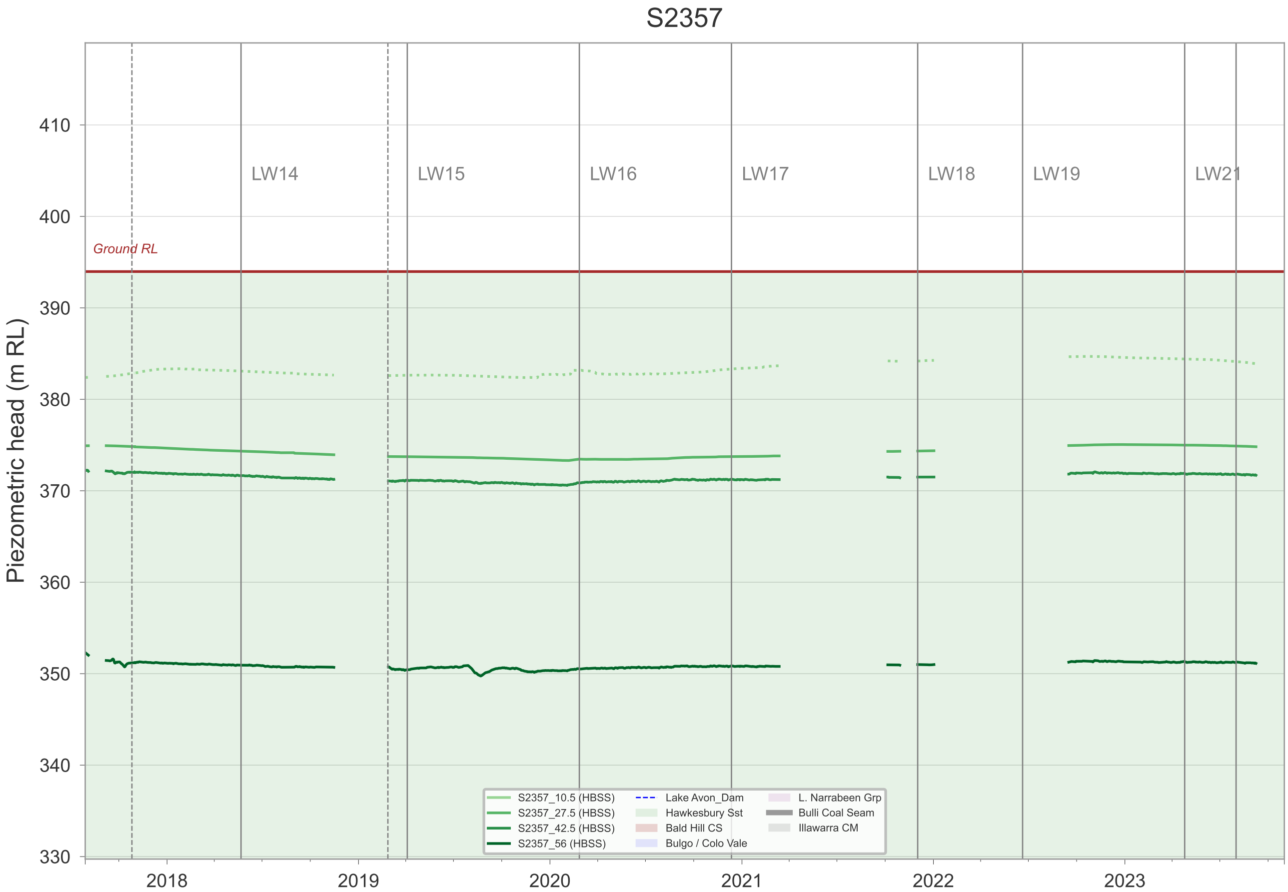
S2355

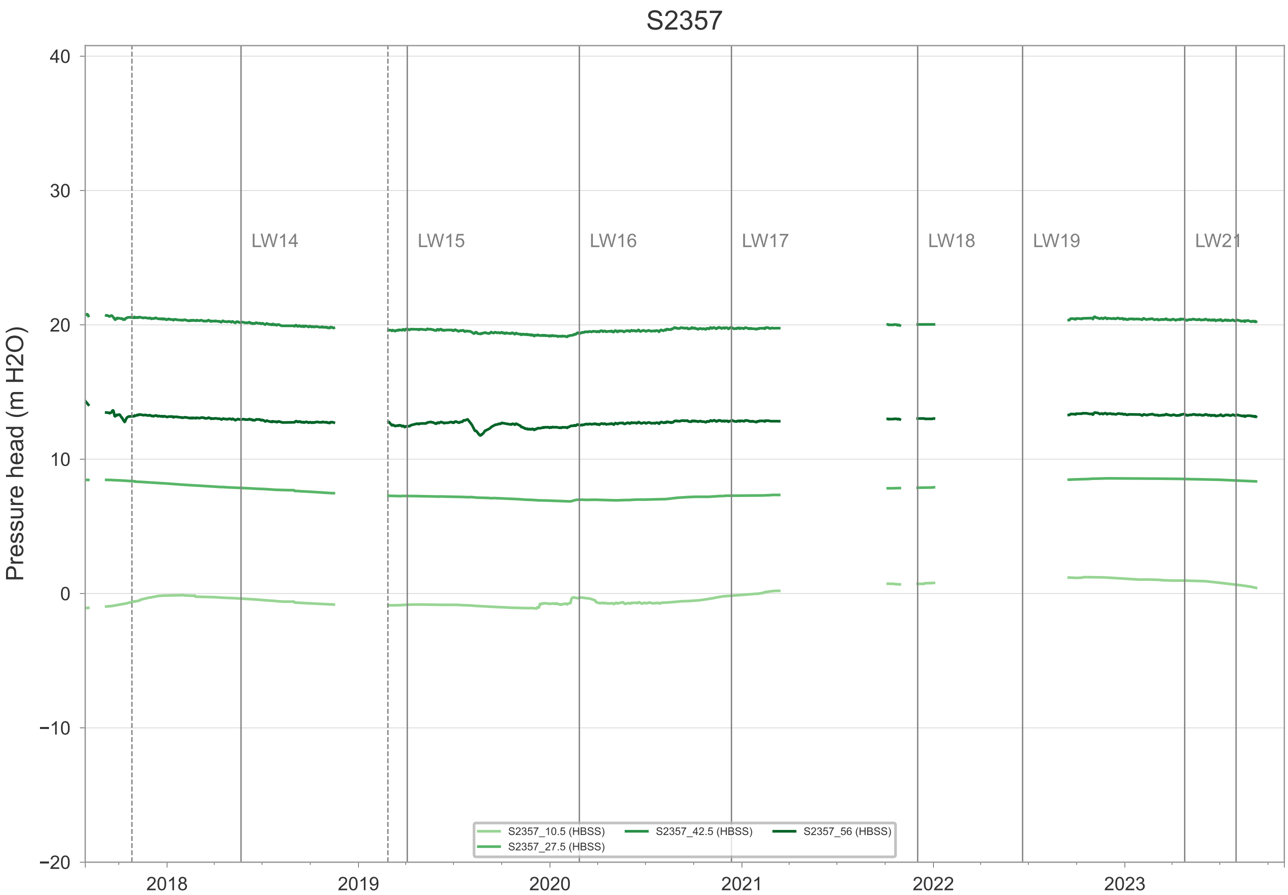

Piezometric head (m RL)
420
400
380
360
340
Ground RL
LW14
LW15
LW16
LW17
LW18
LW19
LW21
2018
2019
2020
2021
2022
2023
S2355A_10.5 (HBSS)
S2355_10.5 (HBSS)
S2355_25 (HBSS)
S2355_43.5 (HBSS)
S2355_60 (HBSS)
Lake Avon_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM

S2355


Pressure head (m H2O)
40
30
20
10
0
−10
−20
LW14
LW15
LW16
LW17
LW18
LW19
LW21
2018
2019
2020
2021
2022
2023
S2355A_10.5 (HBSS)
S2355_10.5 (HBSS)
S2355_25 (HBSS)
S2355_43.5 (HBSS)
S2355_60 (HBSS)

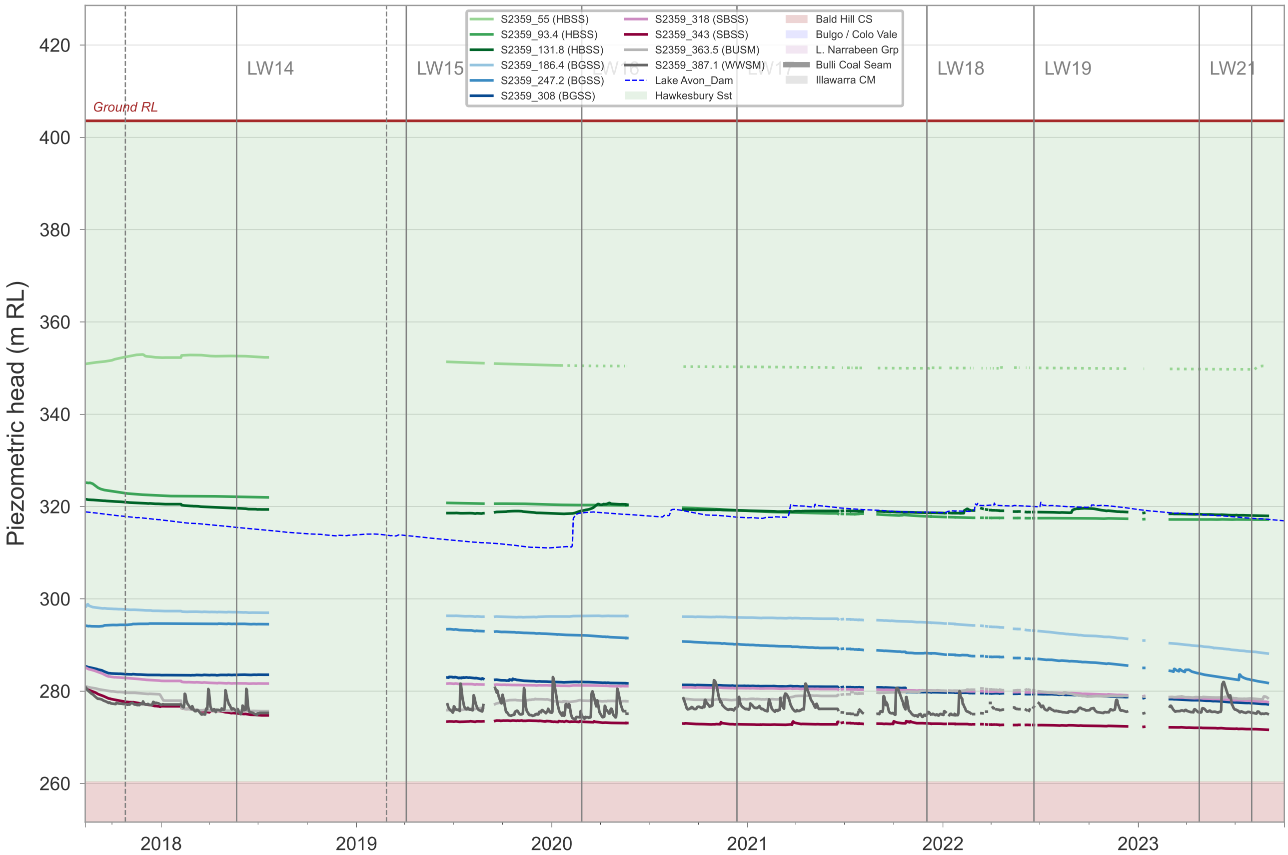
Groundwater hydrographs



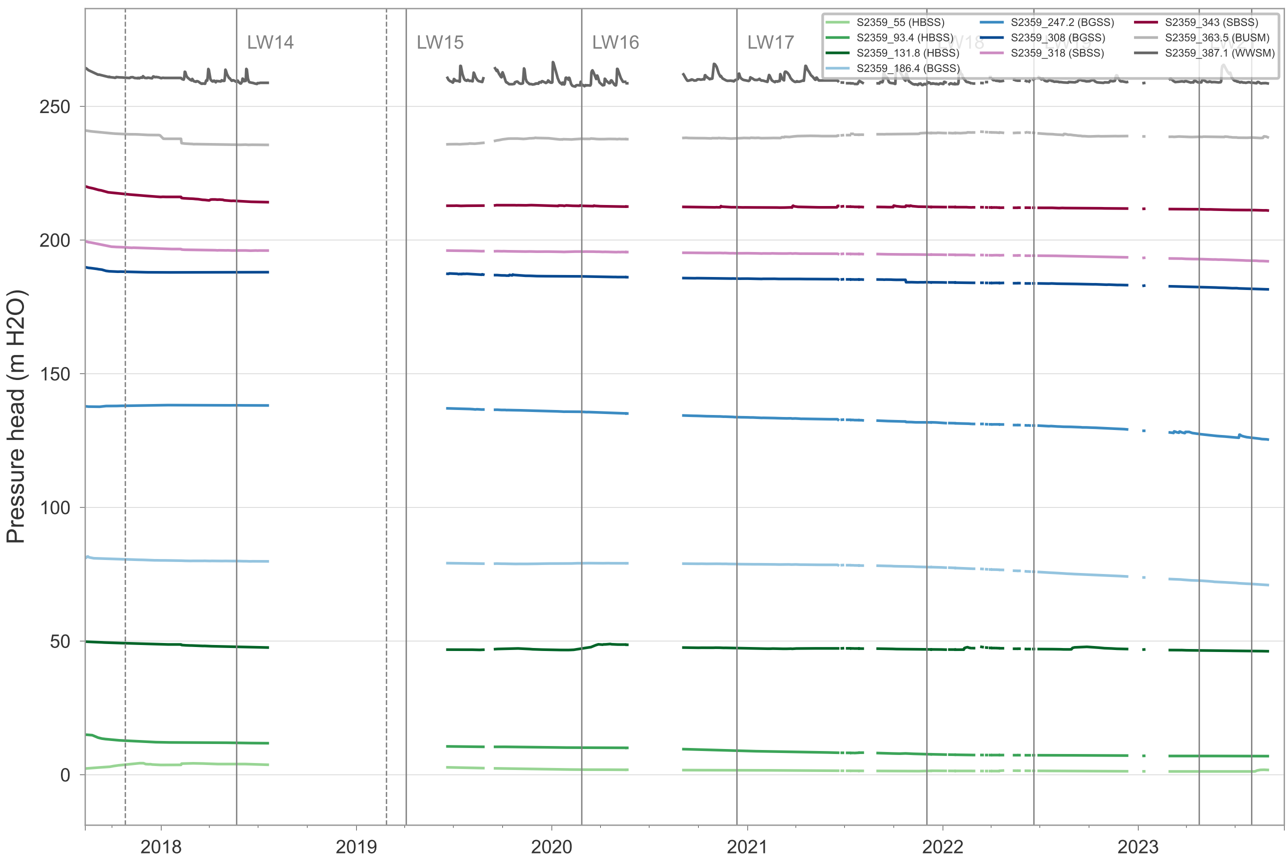


Groundwater hydrographs

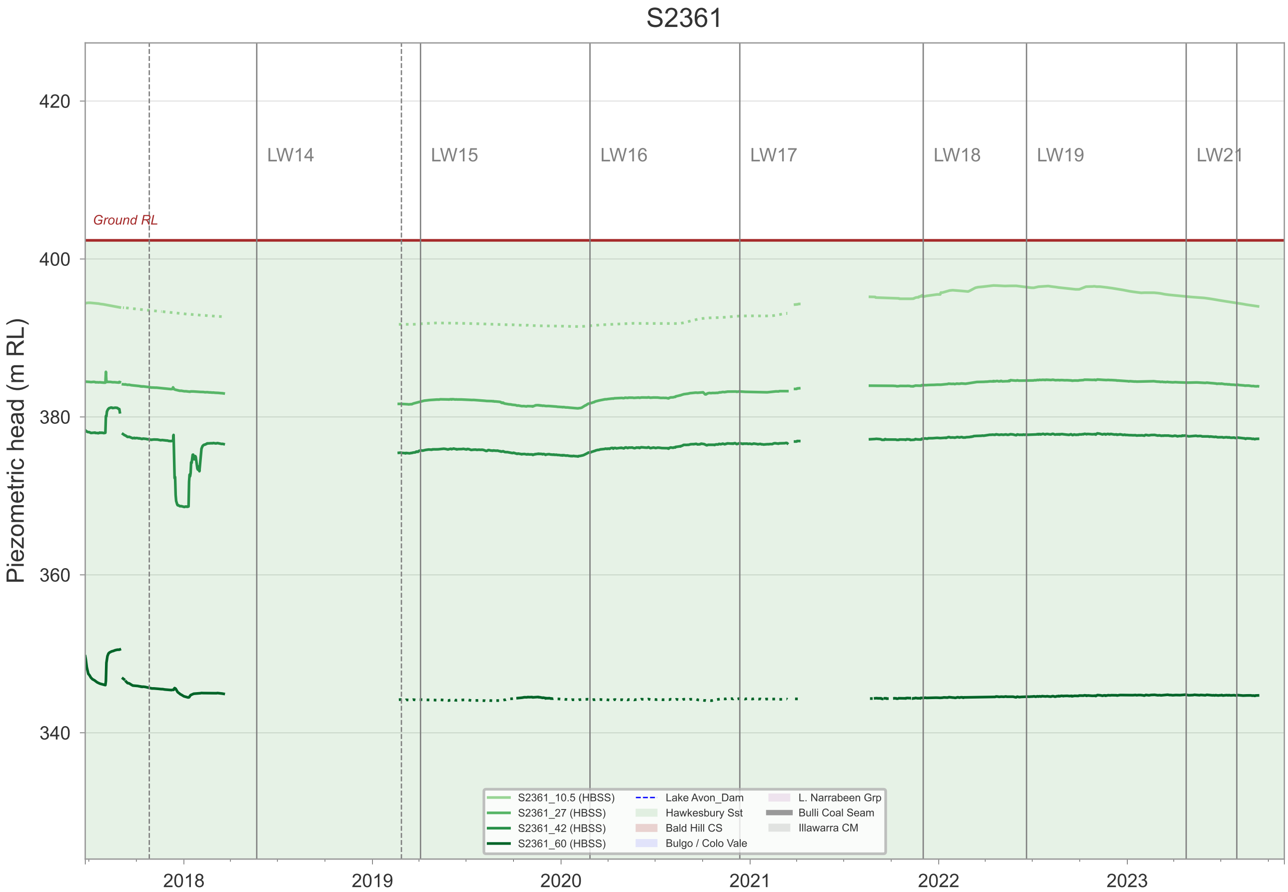
S2359

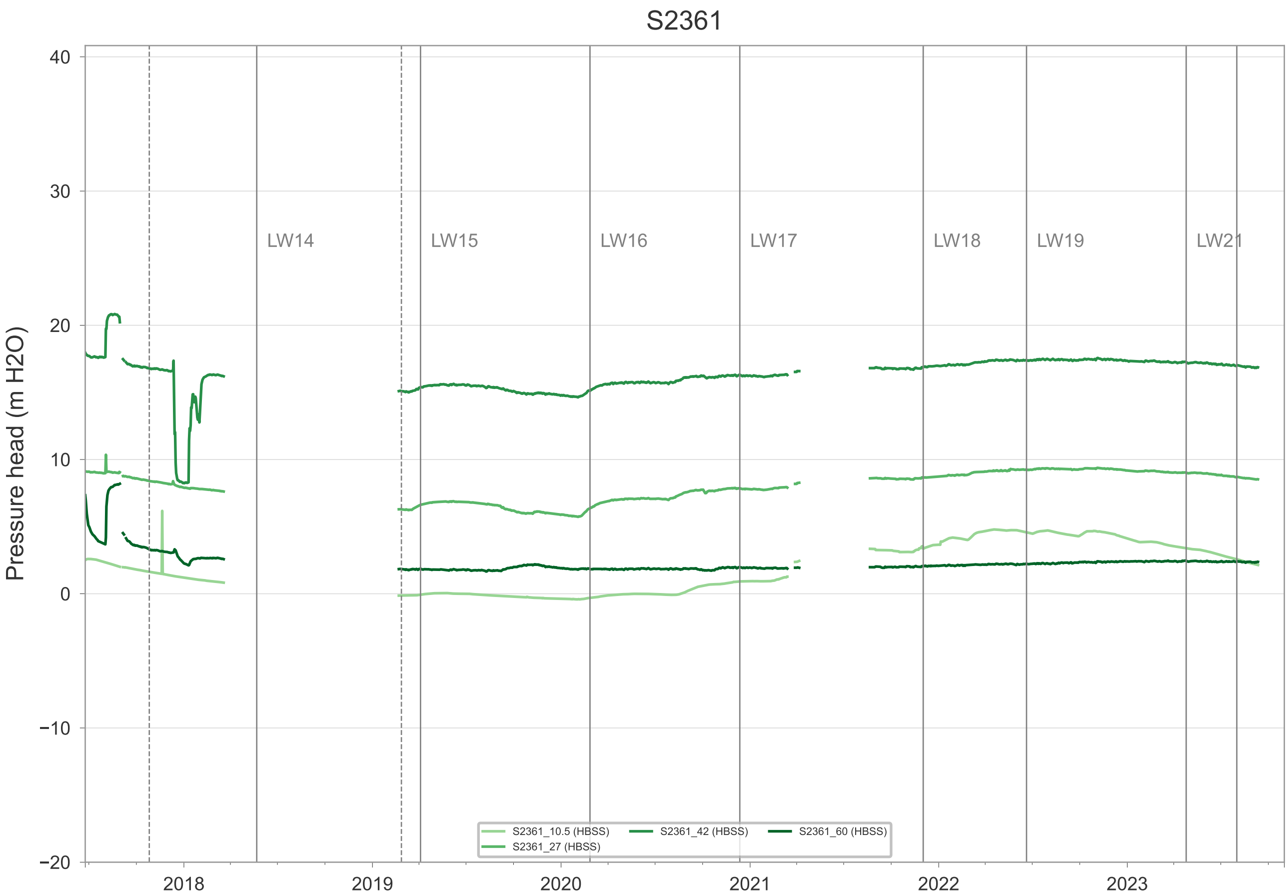


S2359

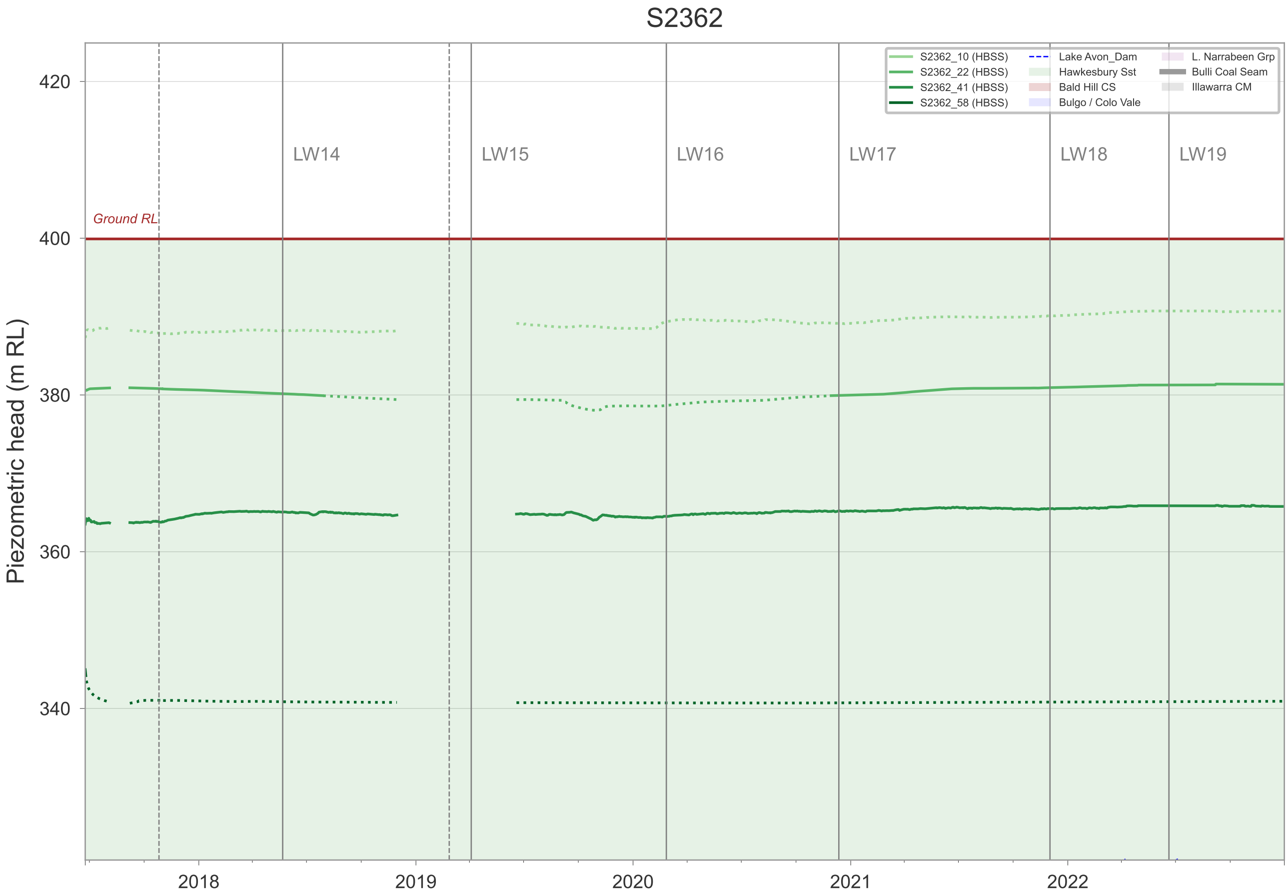


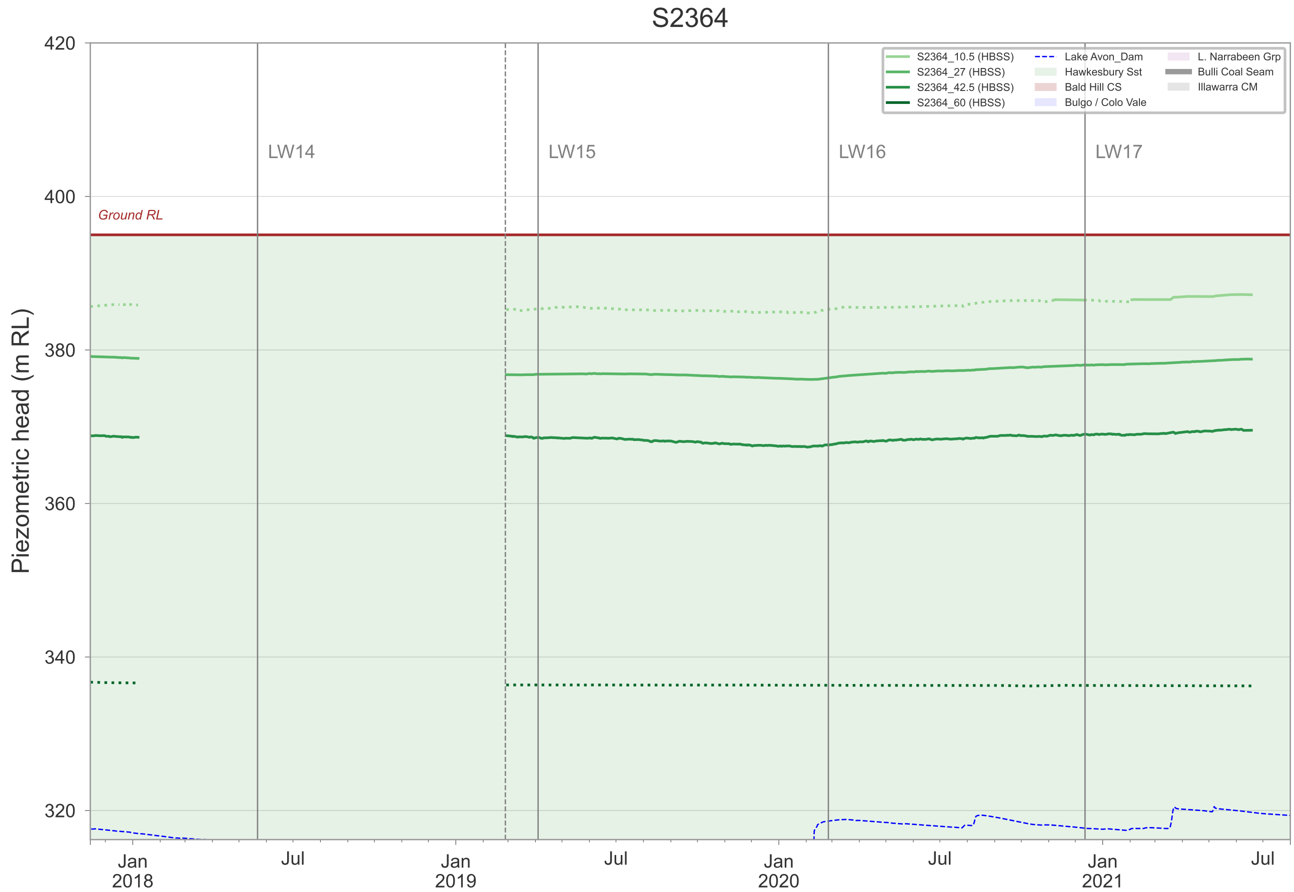
Groundwater hydrographs

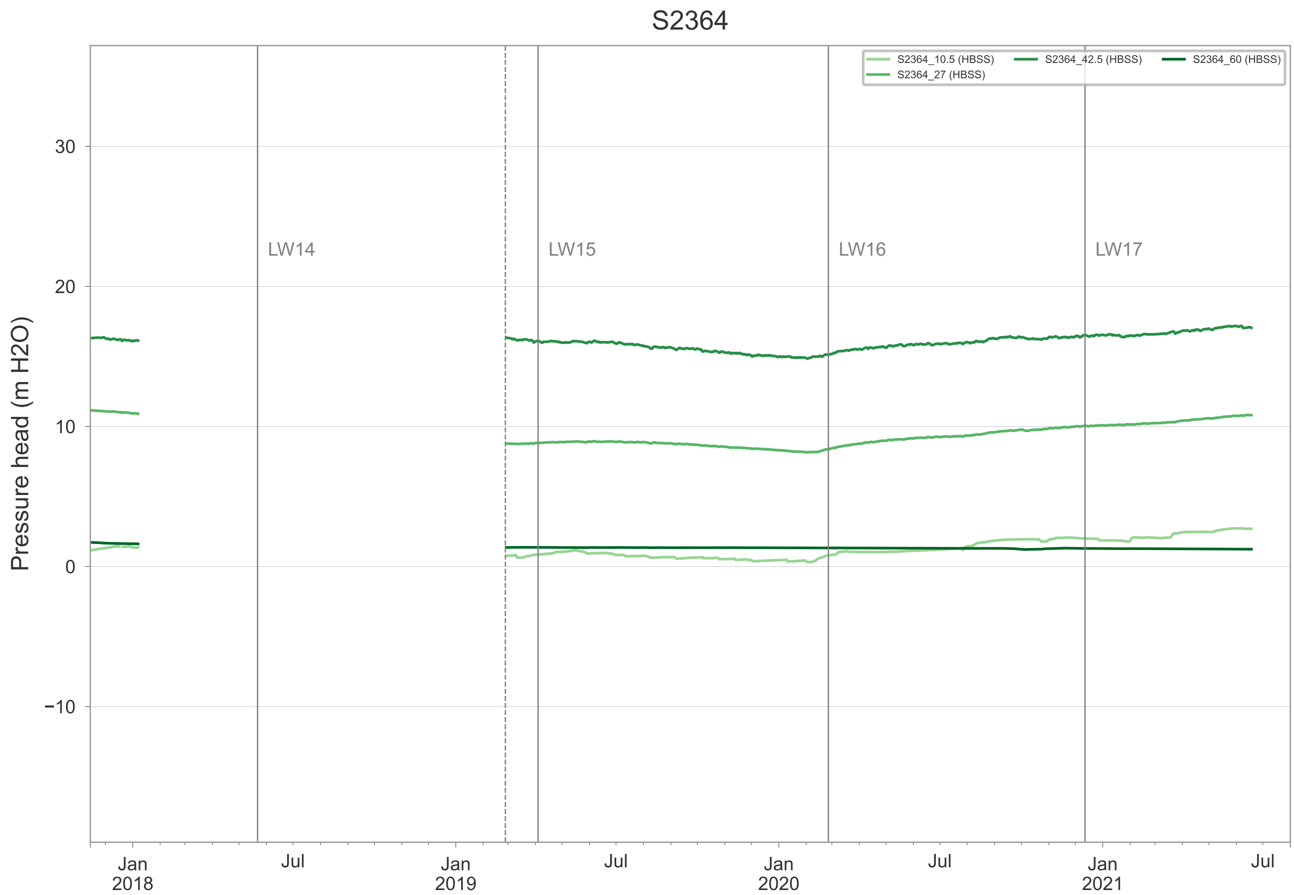




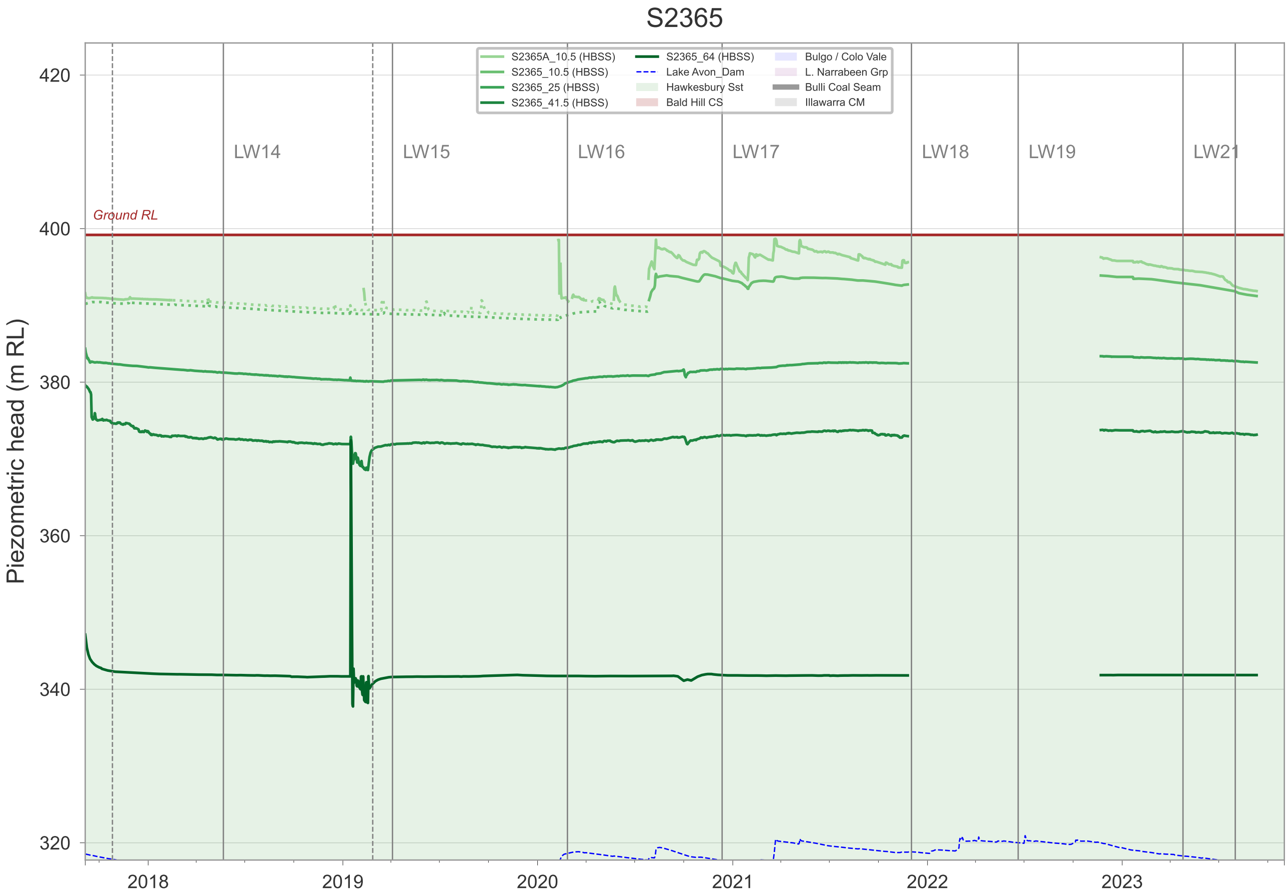
Groundwater hydrographs

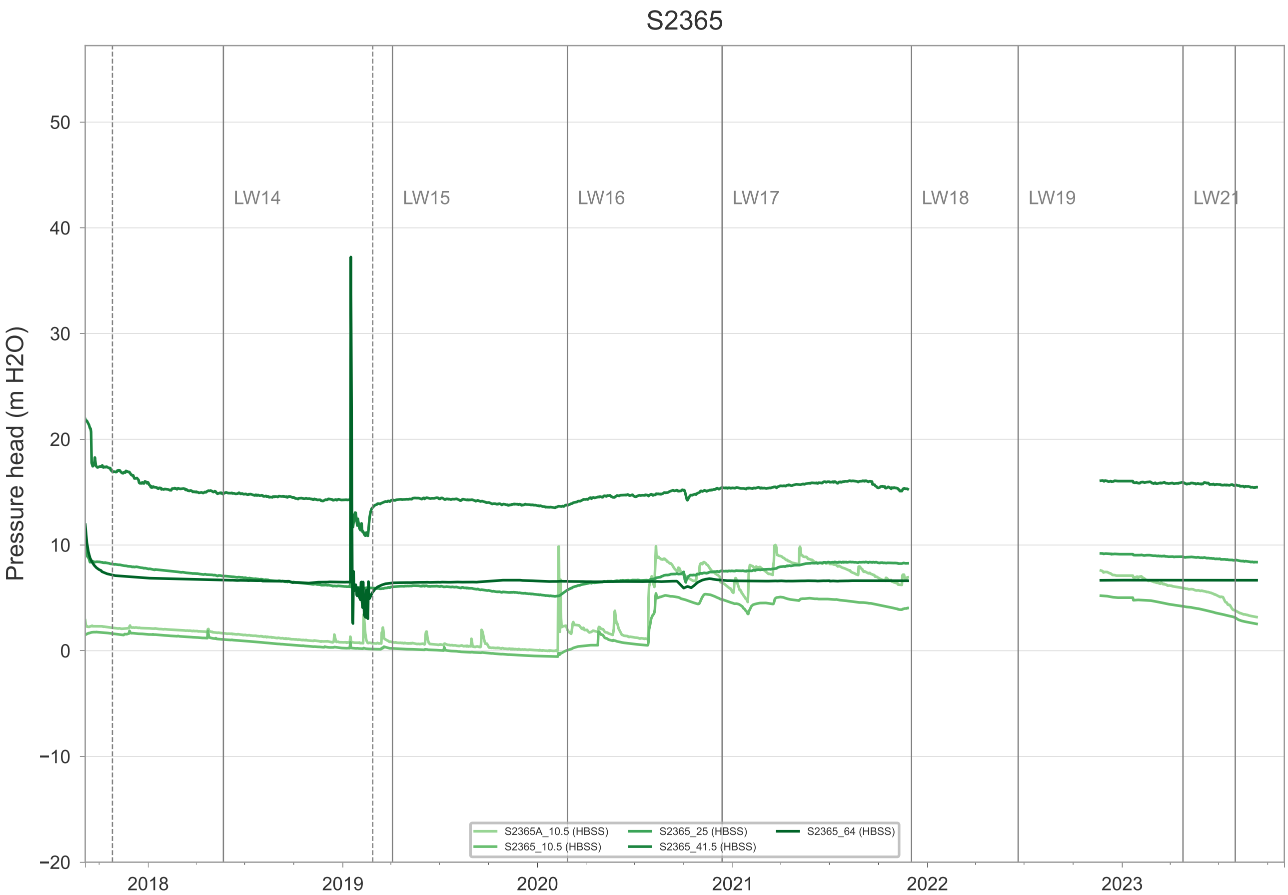


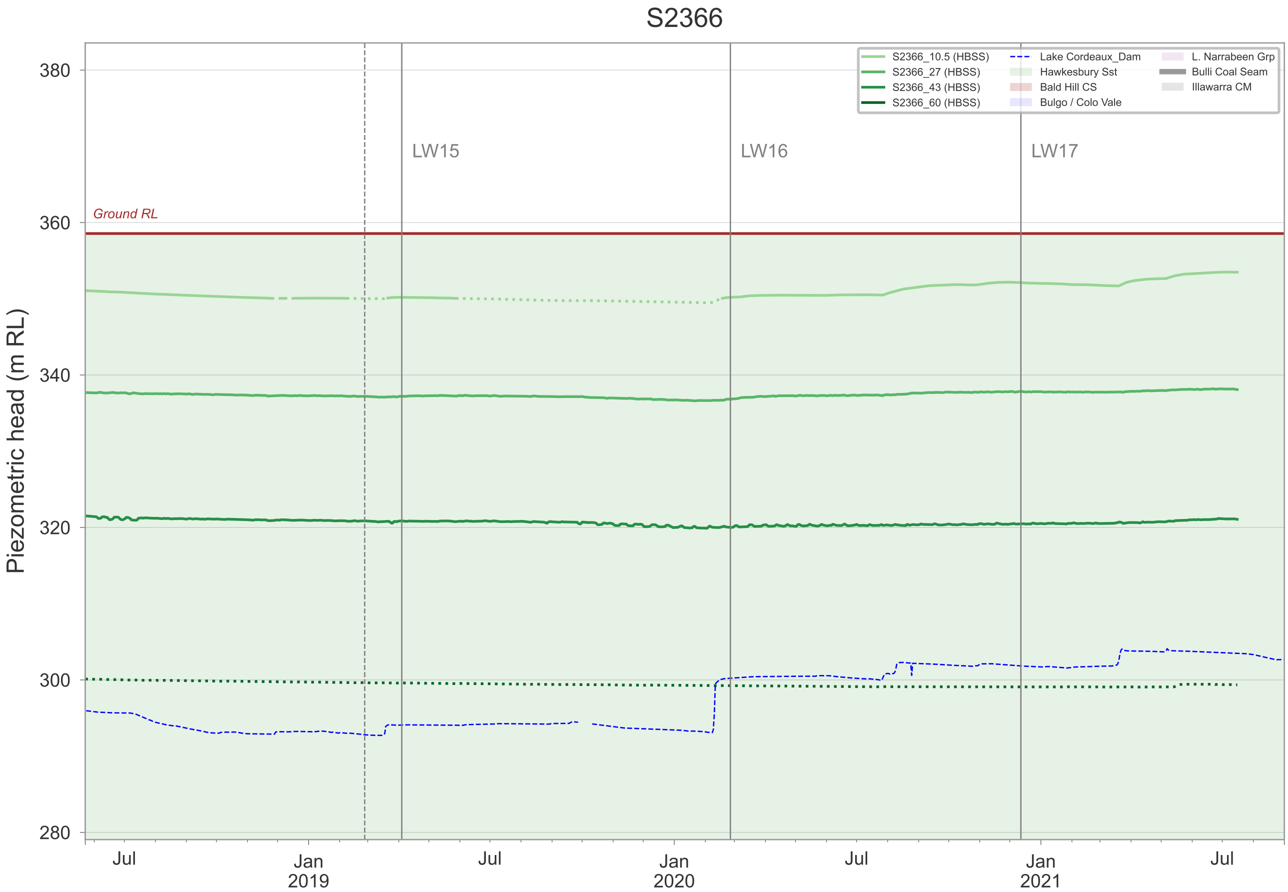

S2364
S2364_10.5 (HBSS)
S2364_27 (HBSS)
S2364_42.5 (HBSS)
S2364_60 (HBSS)
Lake Avon_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM
LW14
LW15
LW16
LW17
Ground RL
Piezometric head (m RL)
420
400
380
360
340
320
Jan 2018
Jul
Jan 2019
Jul
Jan 2020
Jul
Jan 2021
Jul

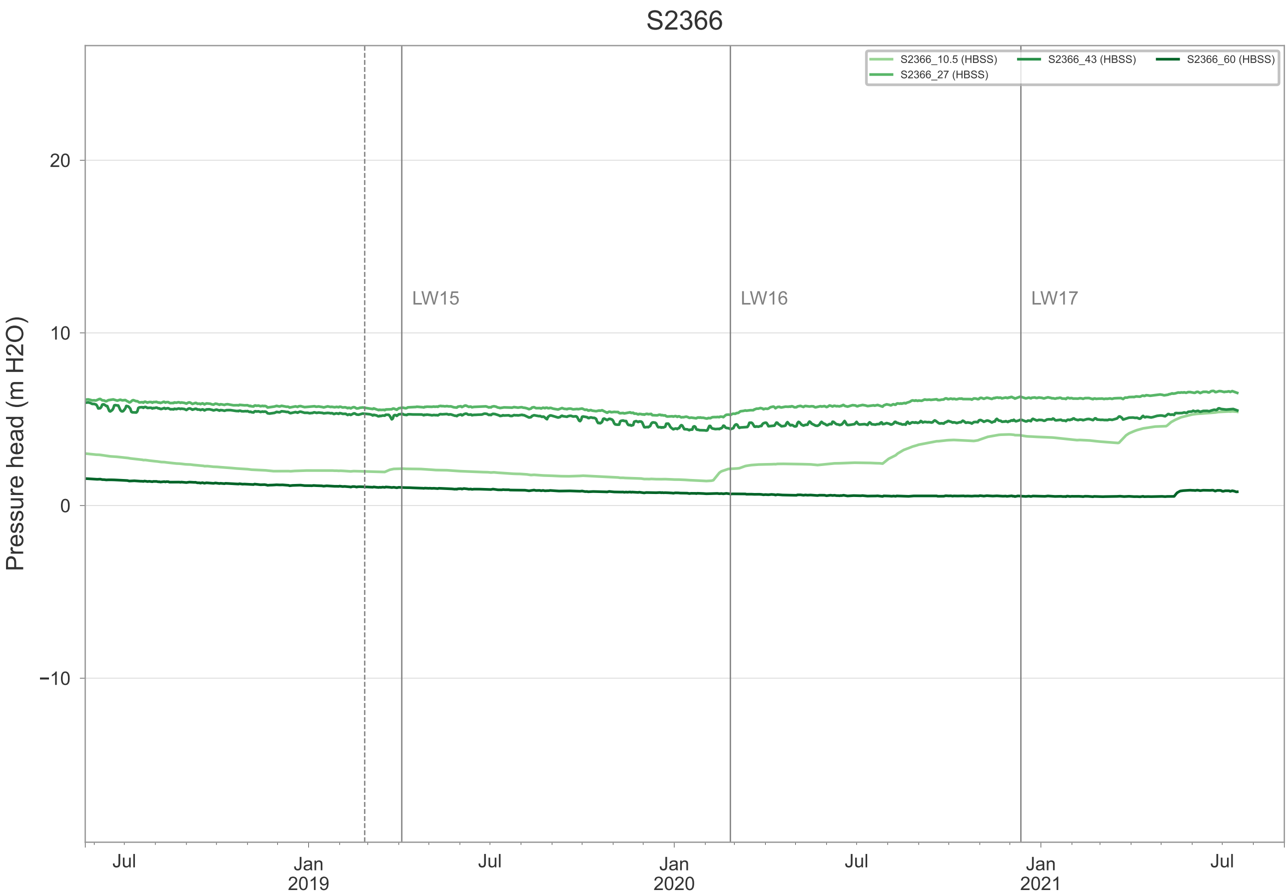

S2364
S2364_10.5 (HBSS)
S2364_27 (HBSS)
S2364_42.5 (HBSS)
S2364_60 (HBSS)
LW14
LW15
LW16
LW17
Pressure head (m H2O)
30
20
10
0
−10
Jan 2018
Jul
Jan 2019
Jul
Jan 2020
Jul
Jan 2021
Jul

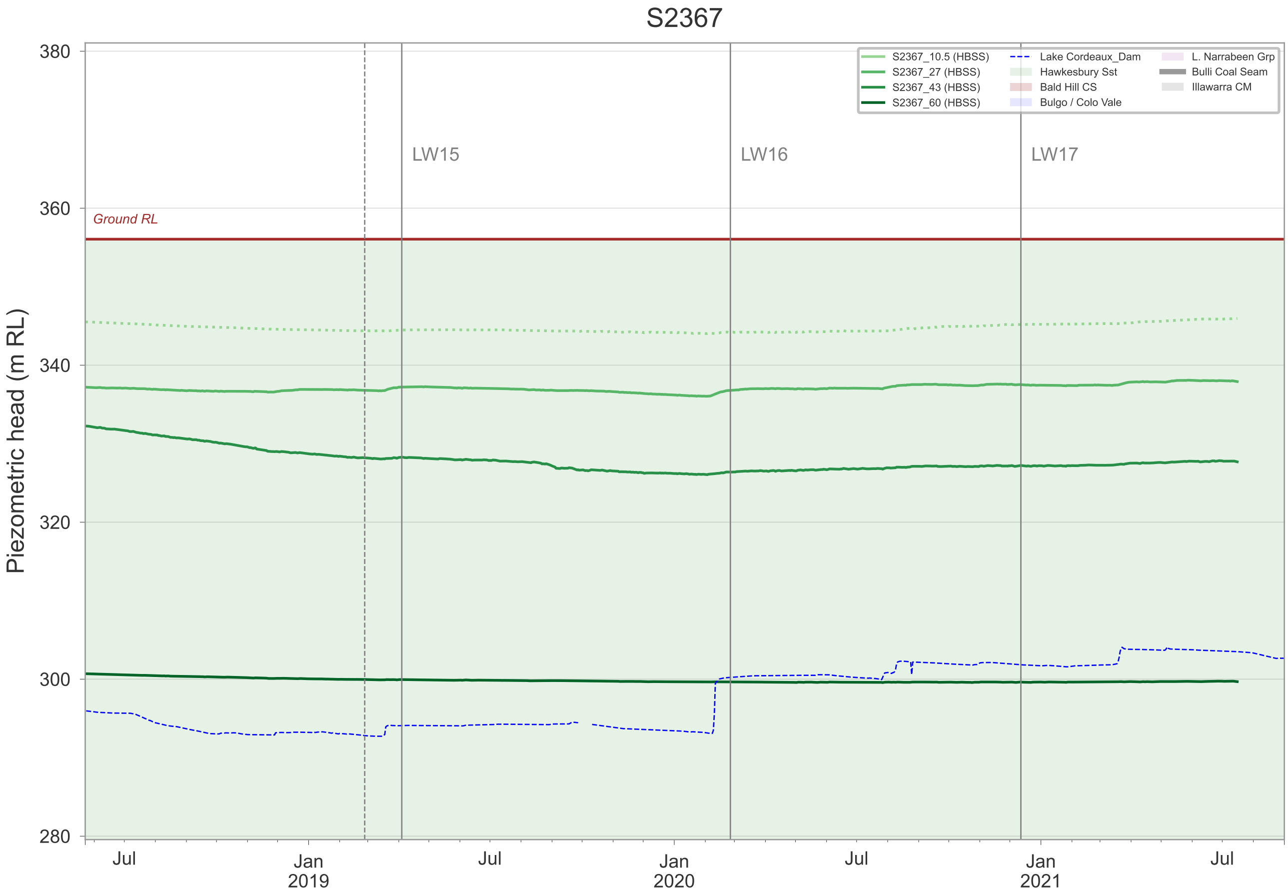
Groundwater hydrographs

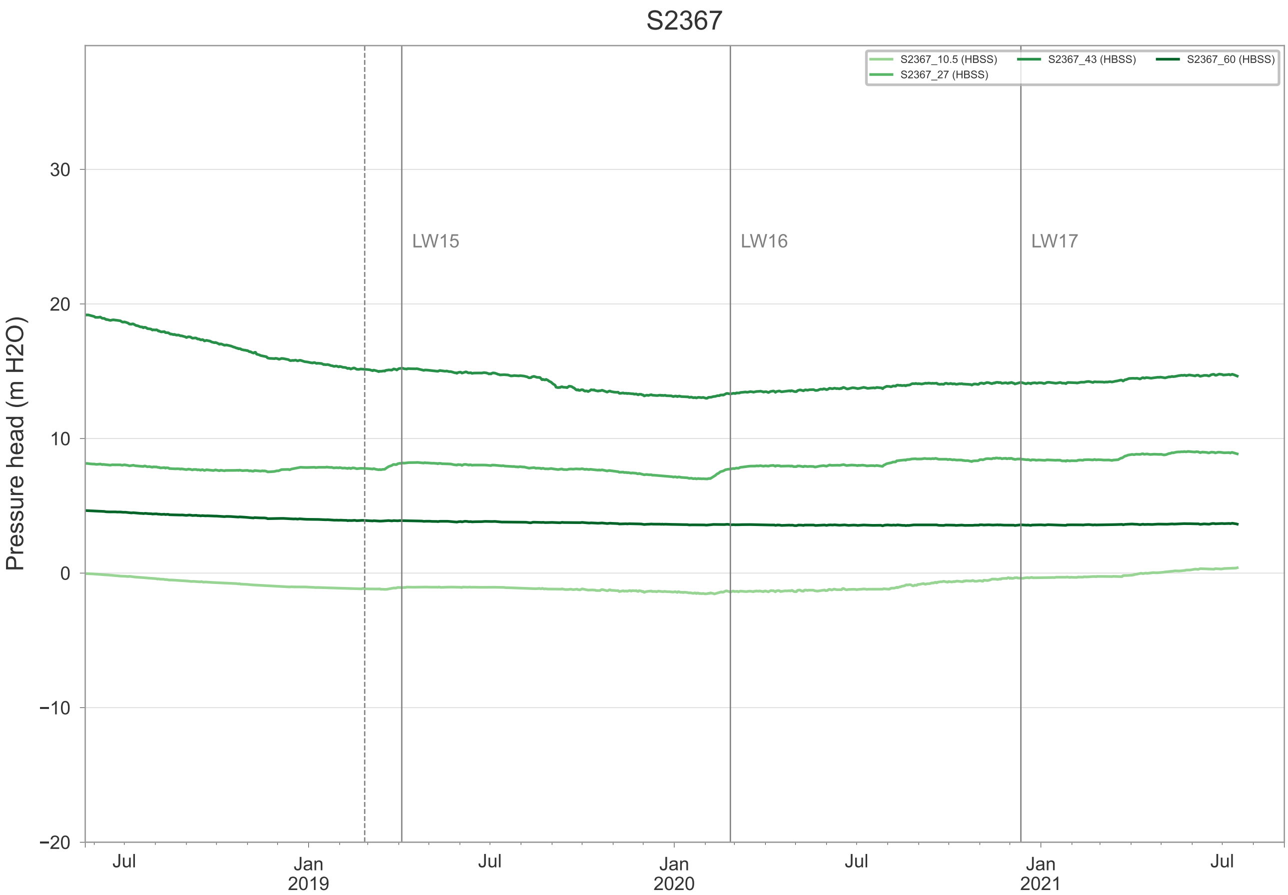




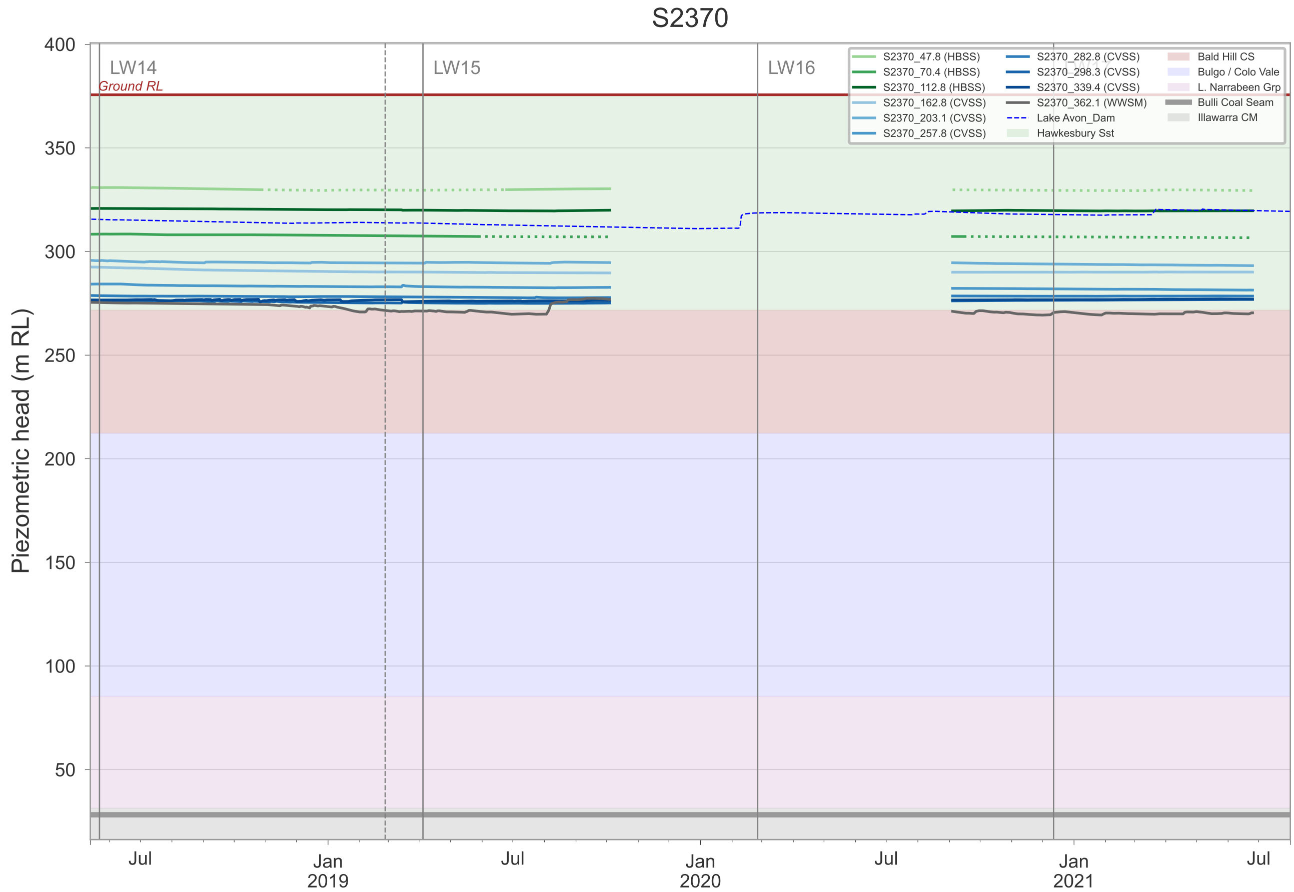

S2366
Piezometric head (m RL)
S2366_10.5 (HBSS)
S2366_27 (HBSS)
S2366_43 (HBSS)
S2366_60 (HBSS)
Lake Cordeaux_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM
LW15
LW16
LW17
Ground RL
380
360
340
320
300
280
Jul
Jan 2019
Jul
Jan 2020
Jul
Jan 2021
Jul

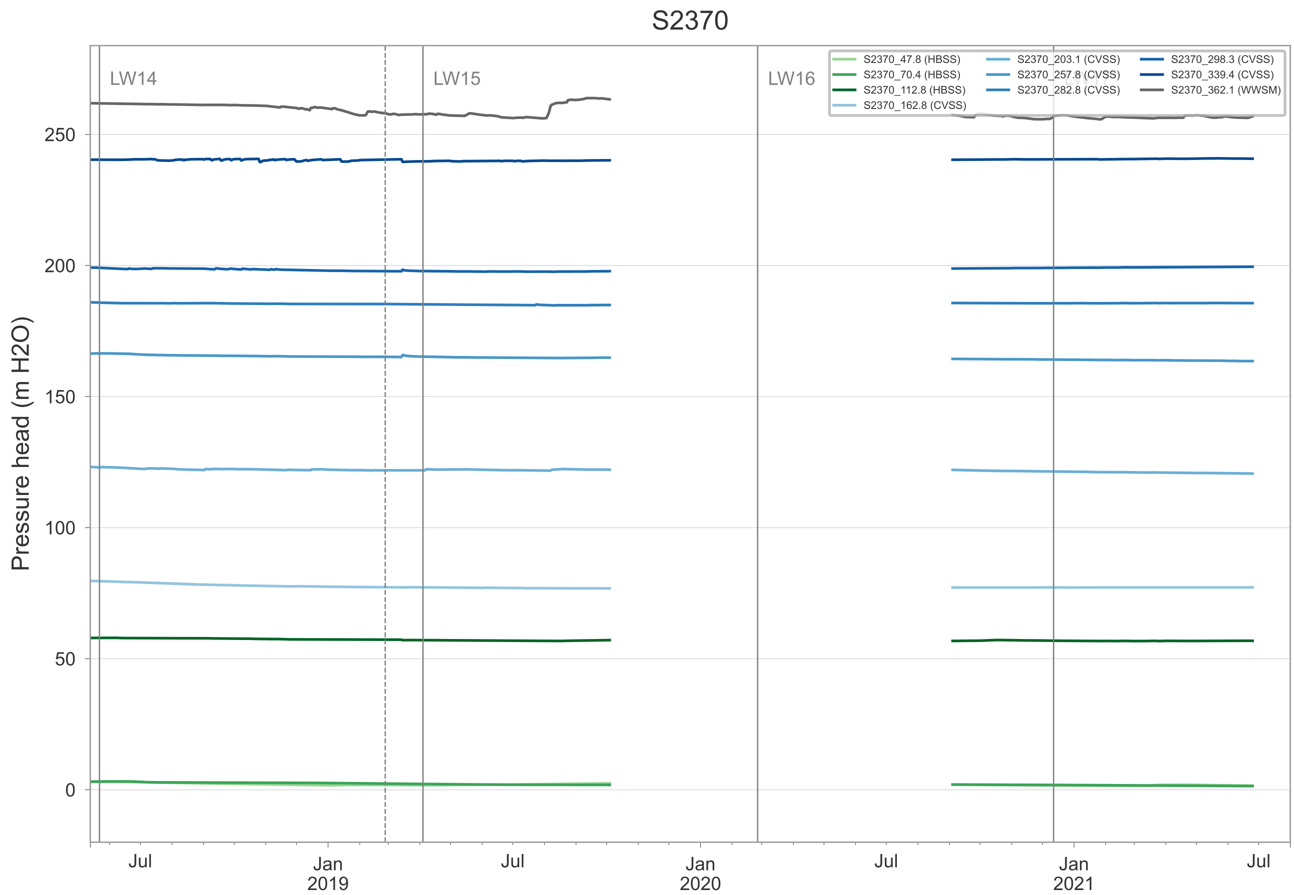

S2366
Pressure head (m H2O)
S2366_10.5 (HBSS)
S2366_27 (HBSS)
S2366_43 (HBSS)
S2366_60 (HBSS)
LW15
LW16
LW17
20
10
0
−10
Jul
Jan 2019
Jul
Jan 2020
Jul
Jan 2021
Jul


S2367
Piezometric head (m RL)
380
360
340
320
300
280
Jul
Jan 2019
Jul
Jan 2020
Jul
Jan 2021
Jul
LW15
LW16
LW17
Ground RL
S2367_10.5 (HBSS)
S2367_27 (HBSS)
S2367_43 (HBSS)
S2367_60 (HBSS)
Lake Cordeaux_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM

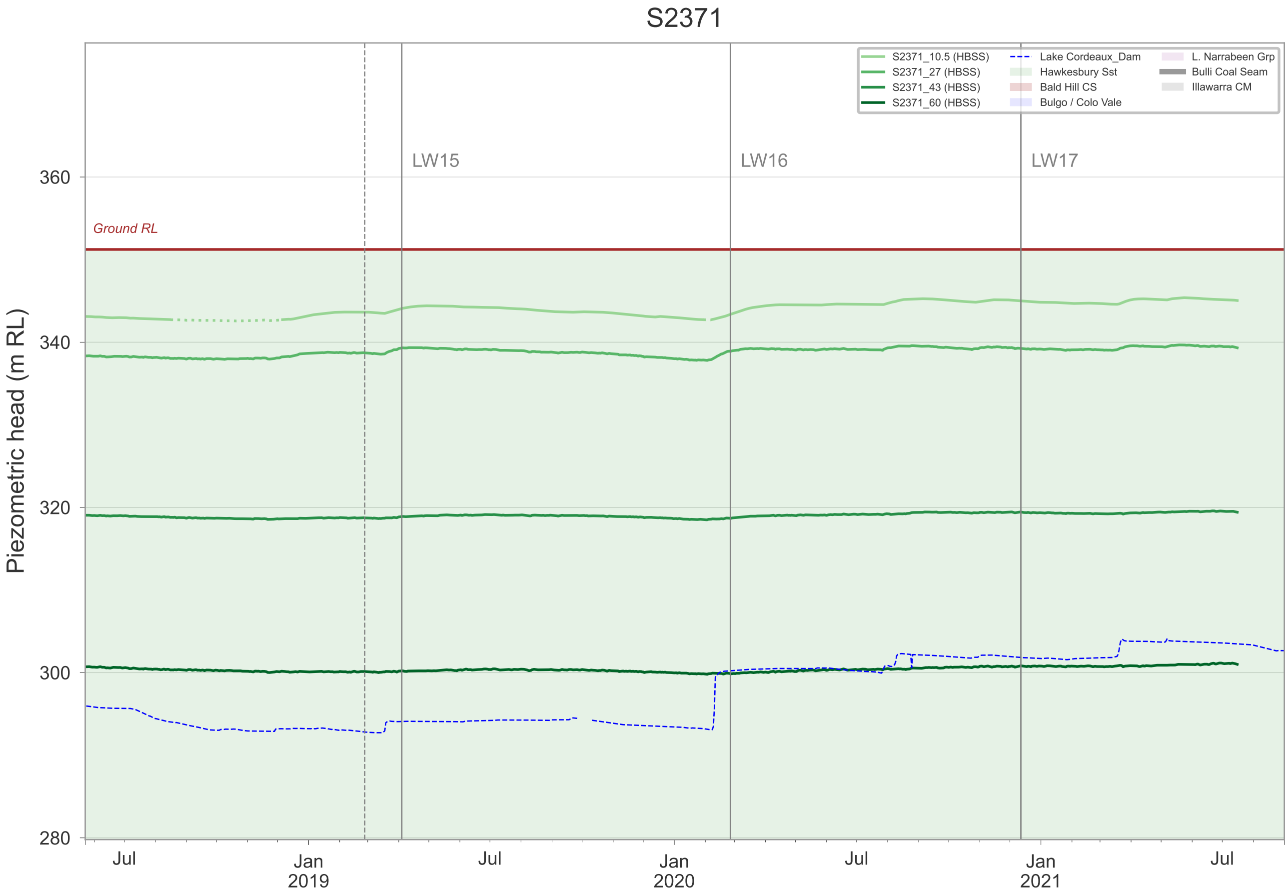

S2367
Pressure head (m H2O)
30
20
10
0
−10
−20
Jul
Jan 2019
Jul
Jan 2020
Jul
Jan 2021
Jul
LW15
LW16
LW17
S2367_10.5 (HBSS)
S2367_27 (HBSS)
S2367_43 (HBSS)
S2367_60 (HBSS)

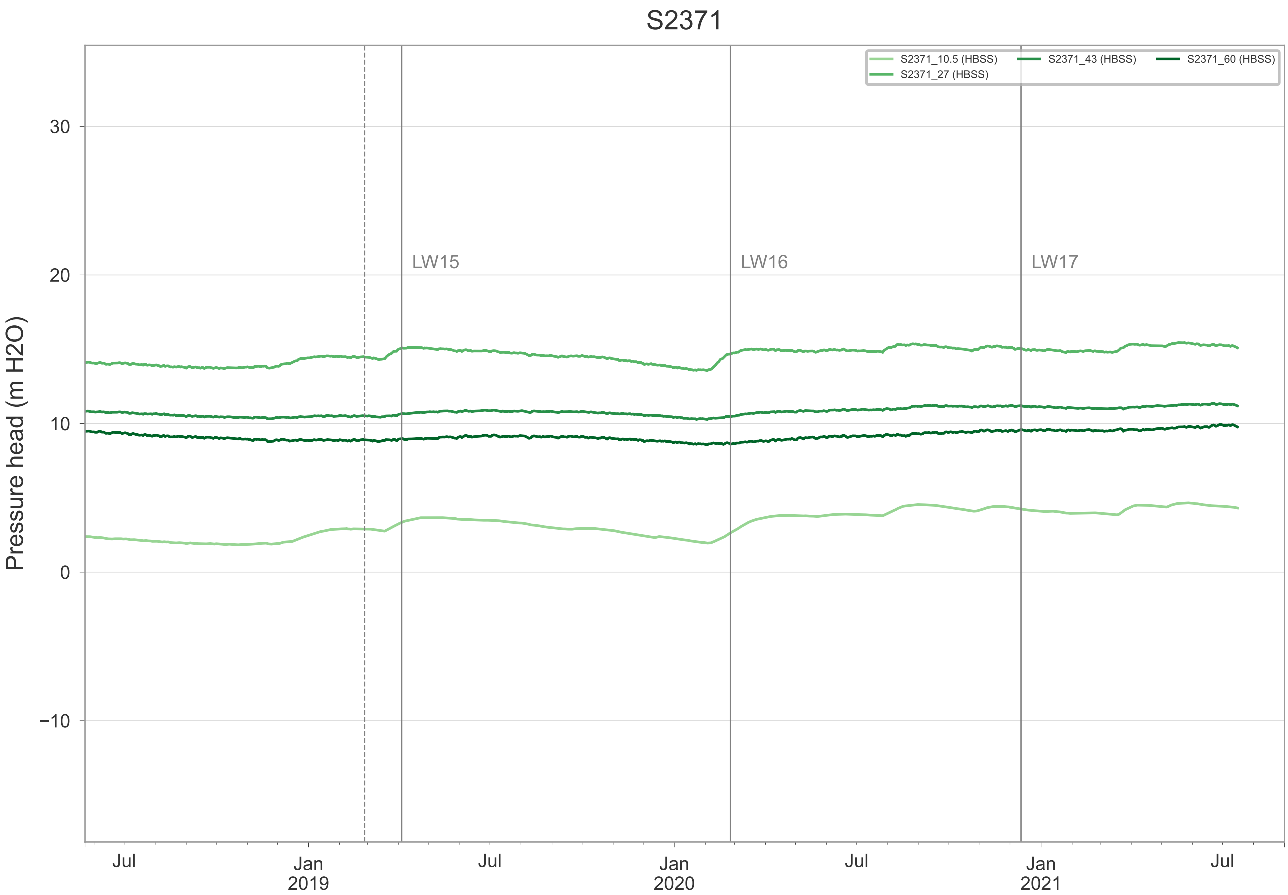
Groundwater hydrographs



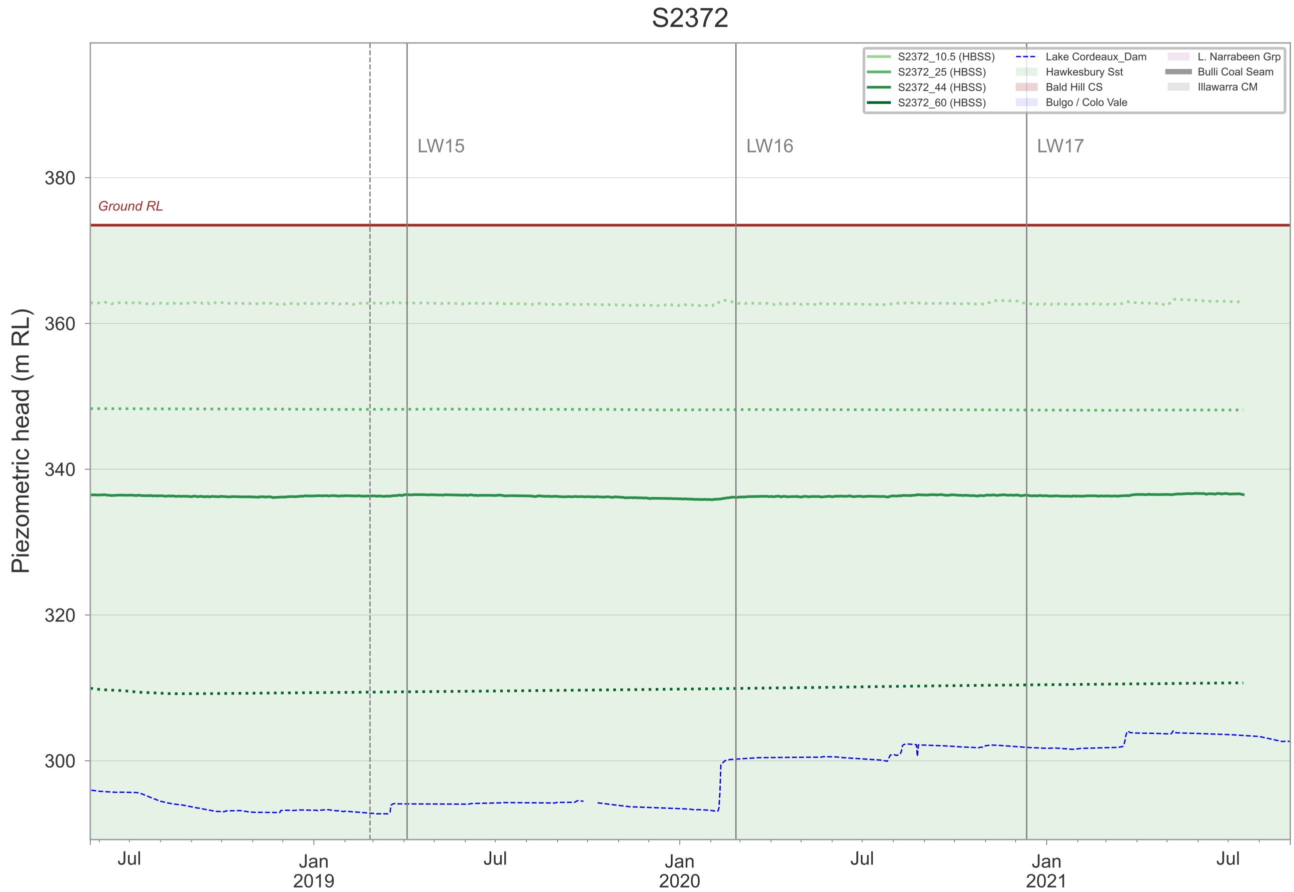


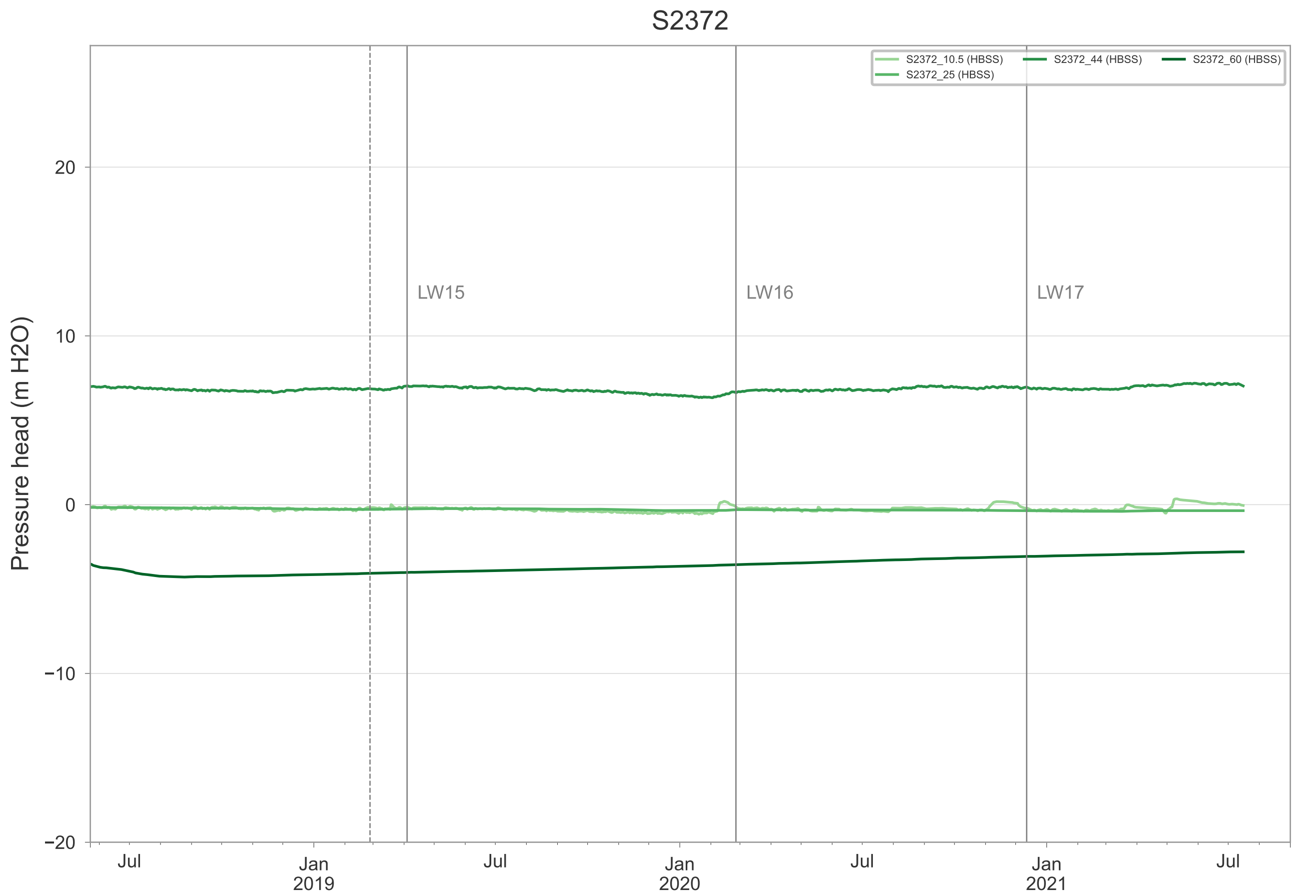
Groundwater hydrographs





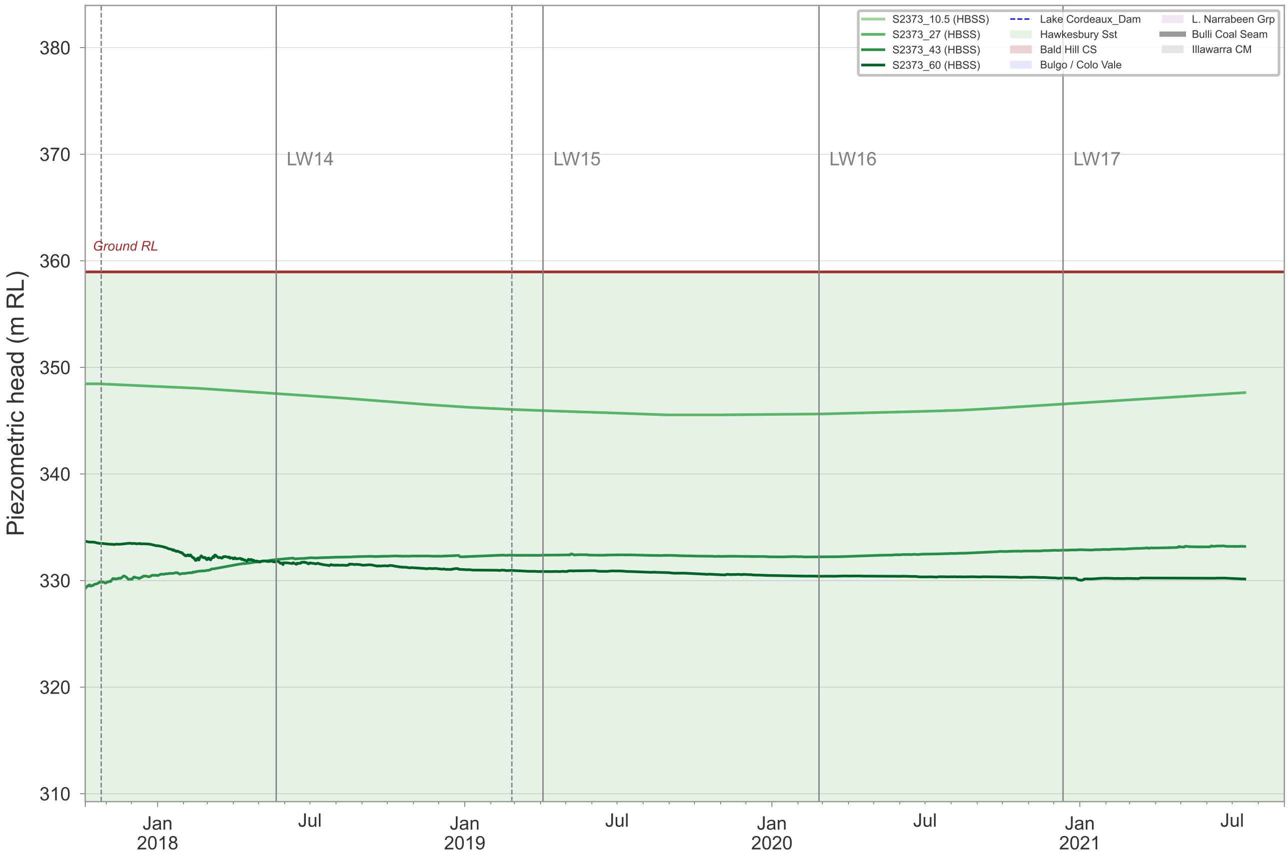
Groundwater hydrographs



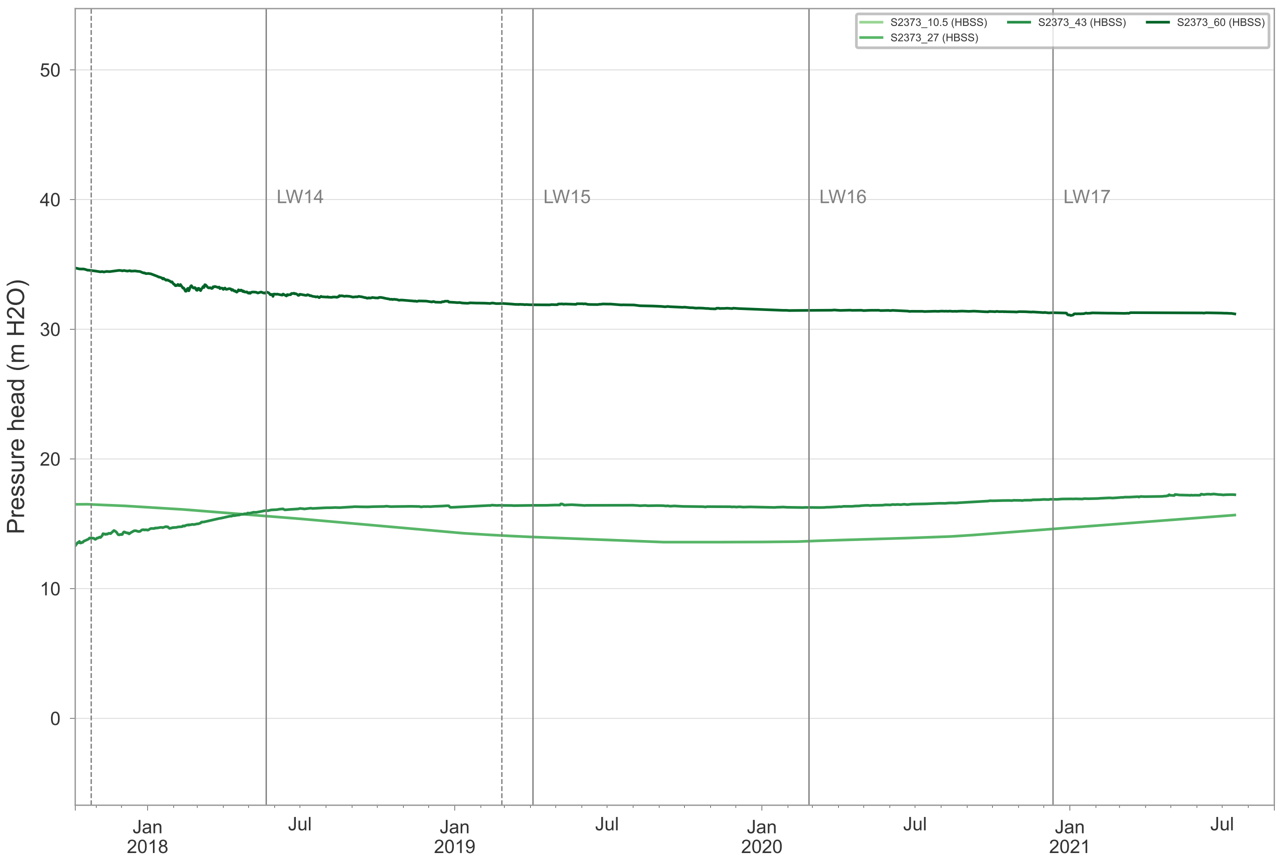


Groundwater hydrographs

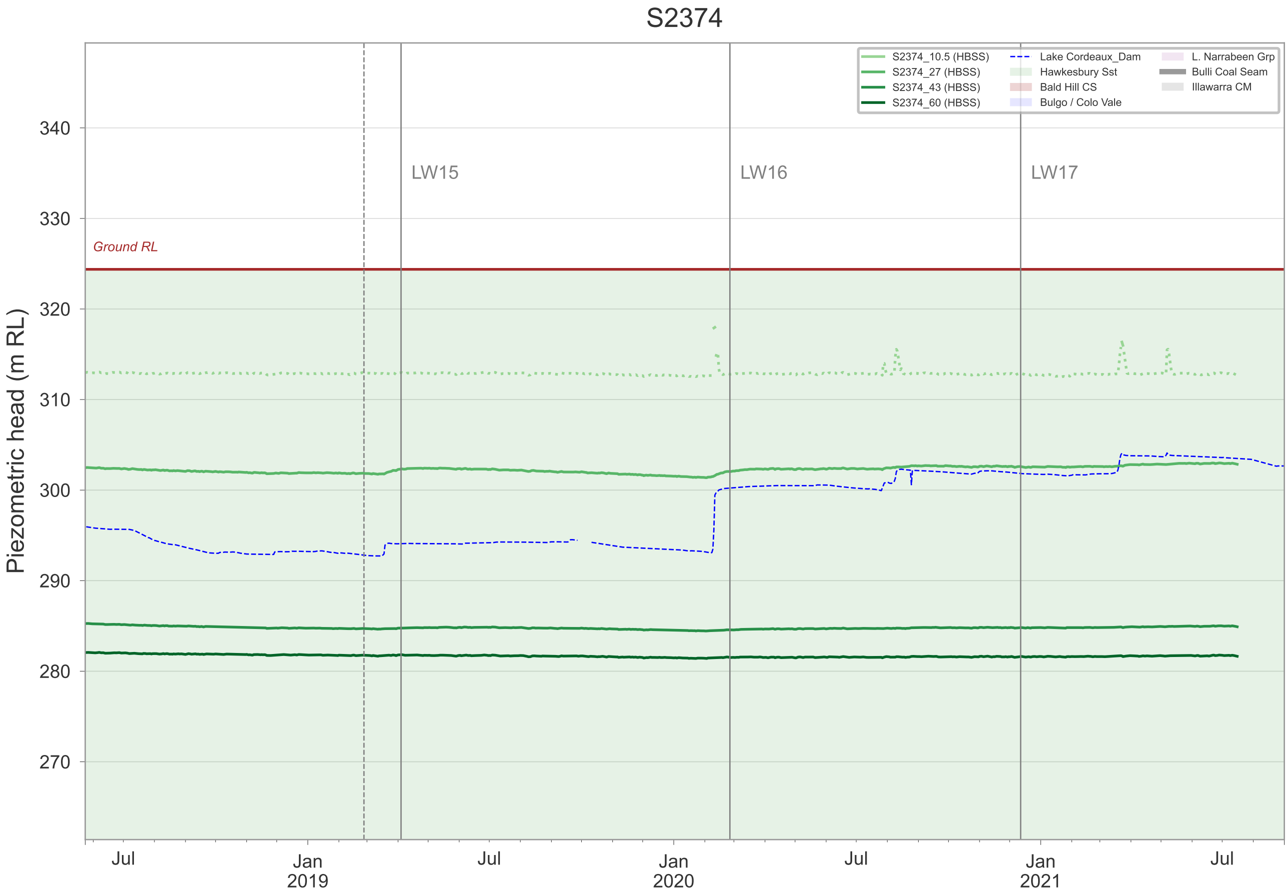
S2373

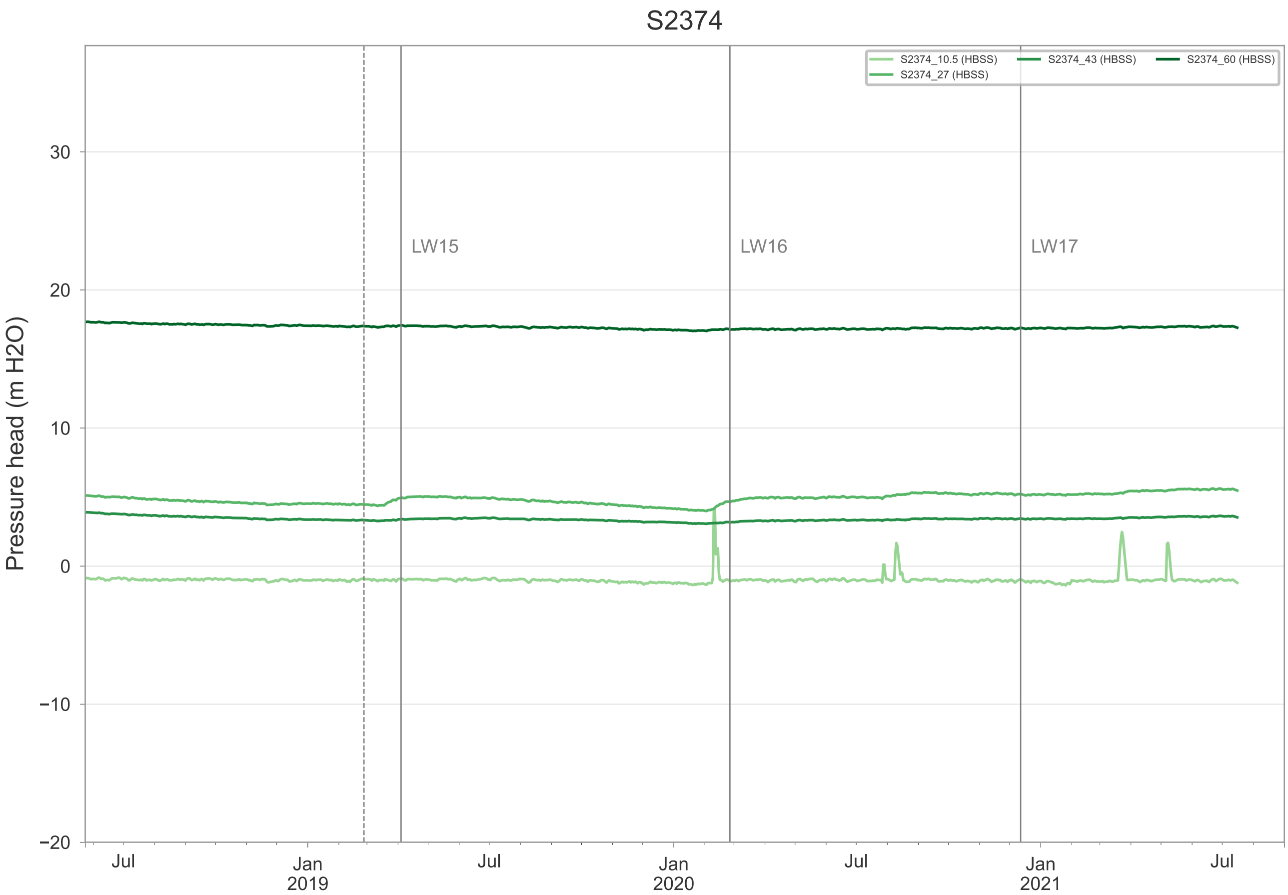


S2373



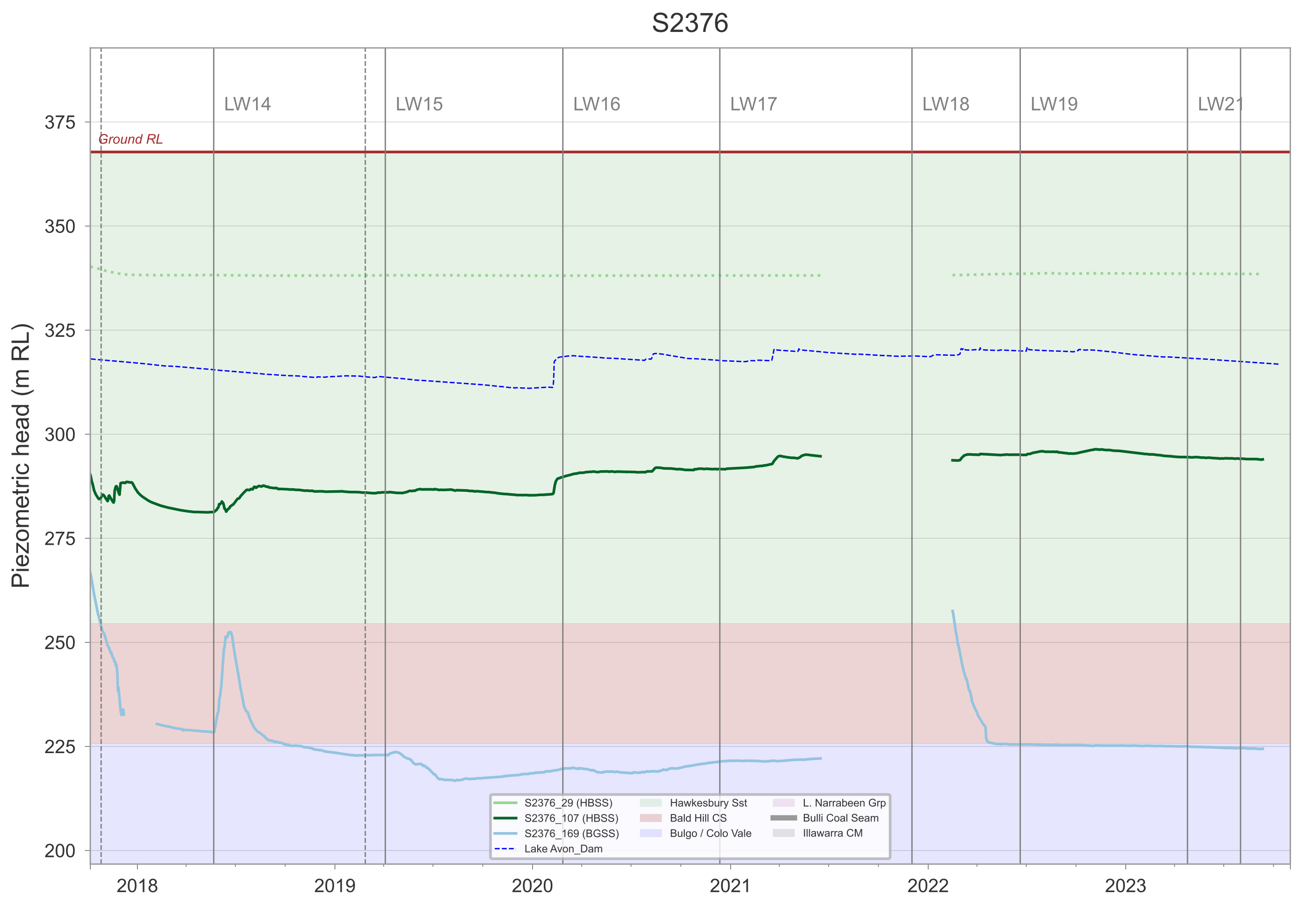
Groundwater hydrographs

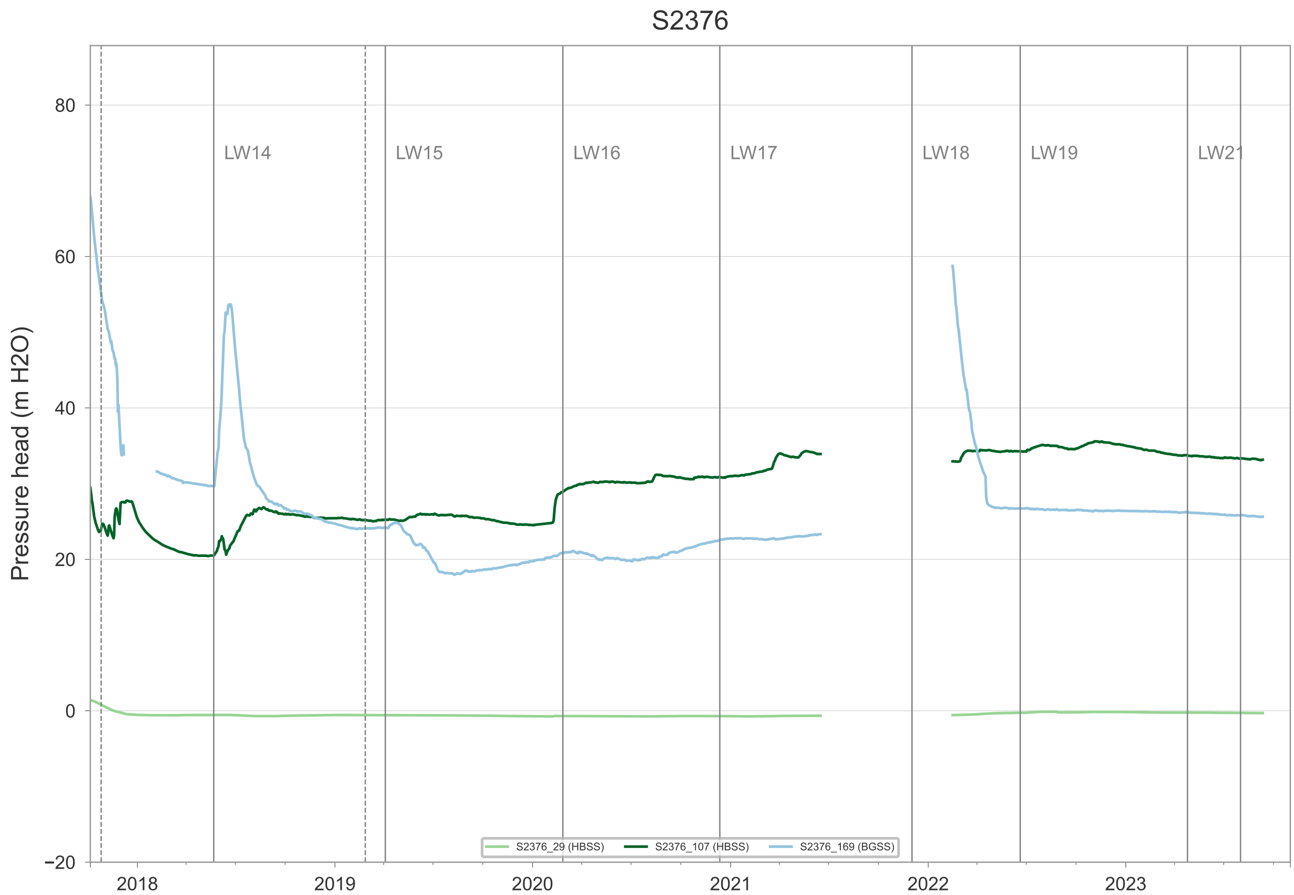




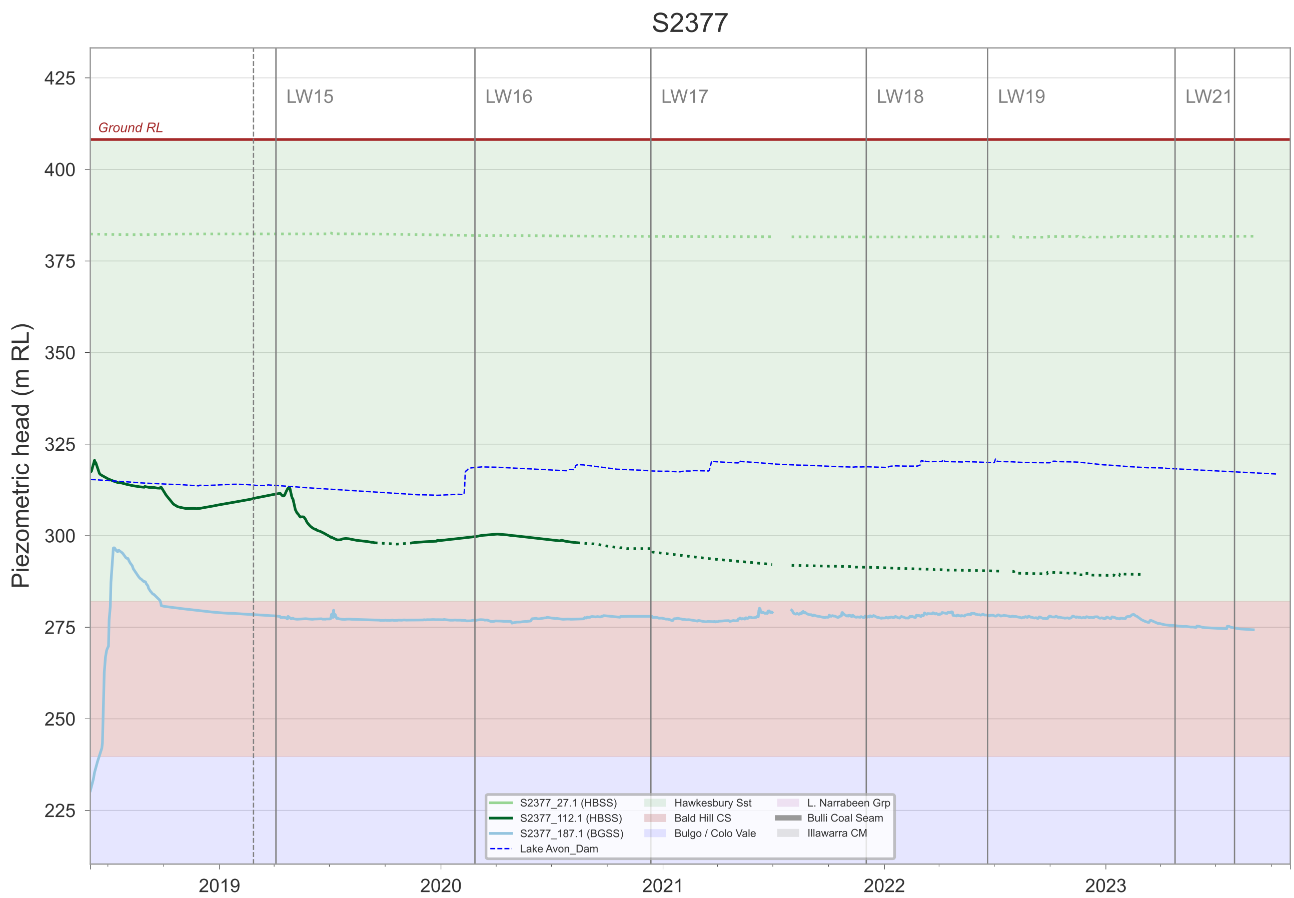
Groundwater hydrographs

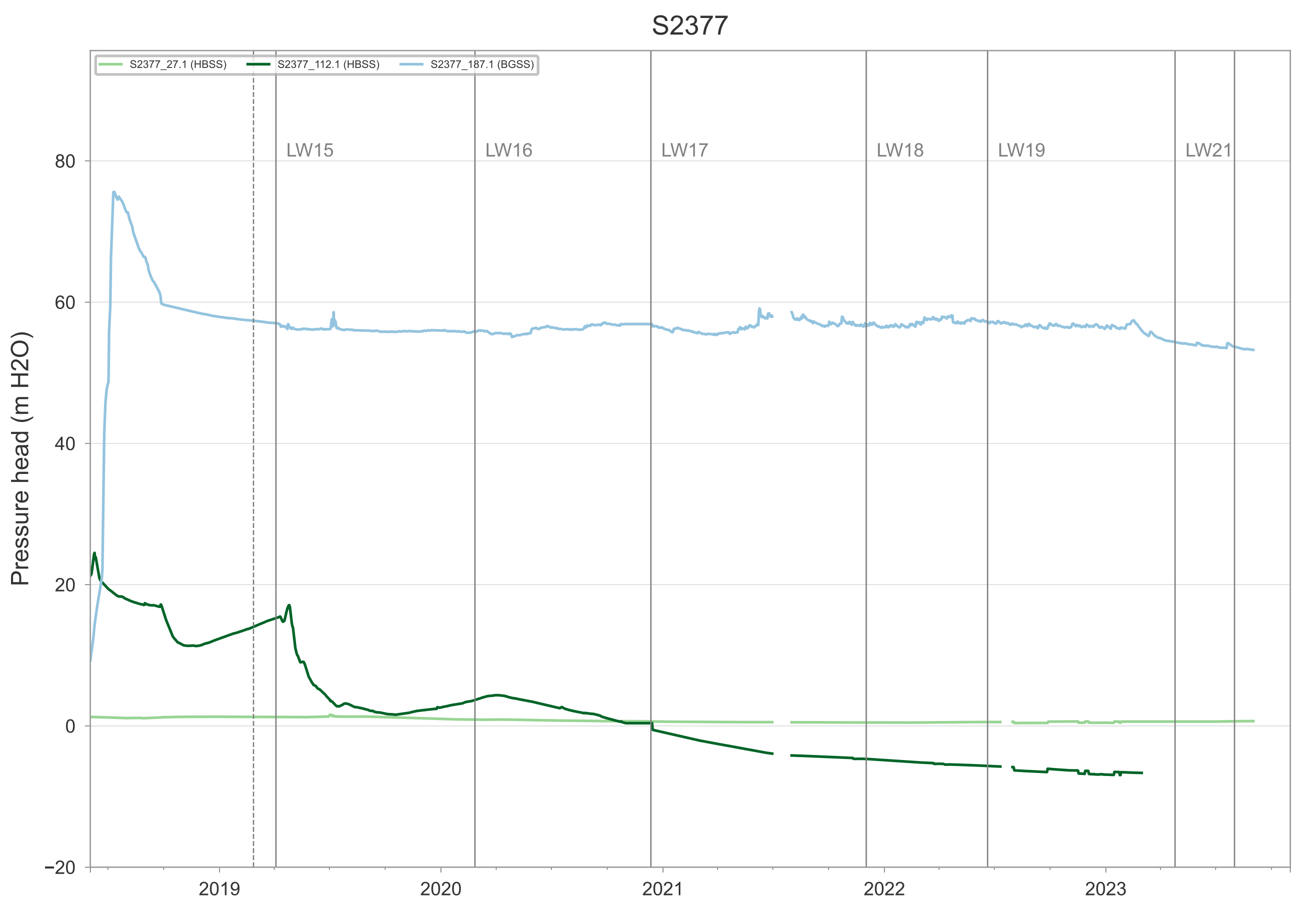
Hgeo hgeo.com.au



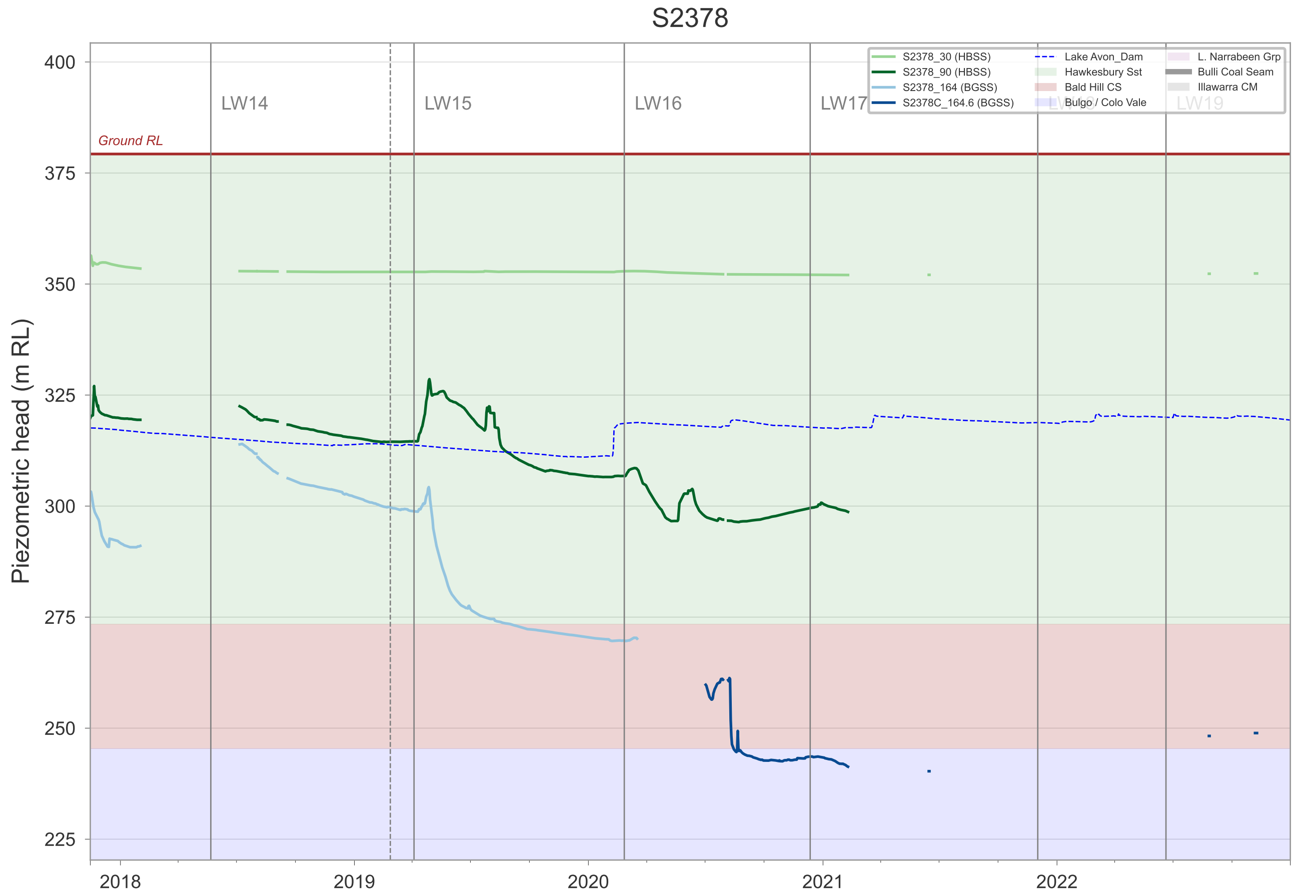


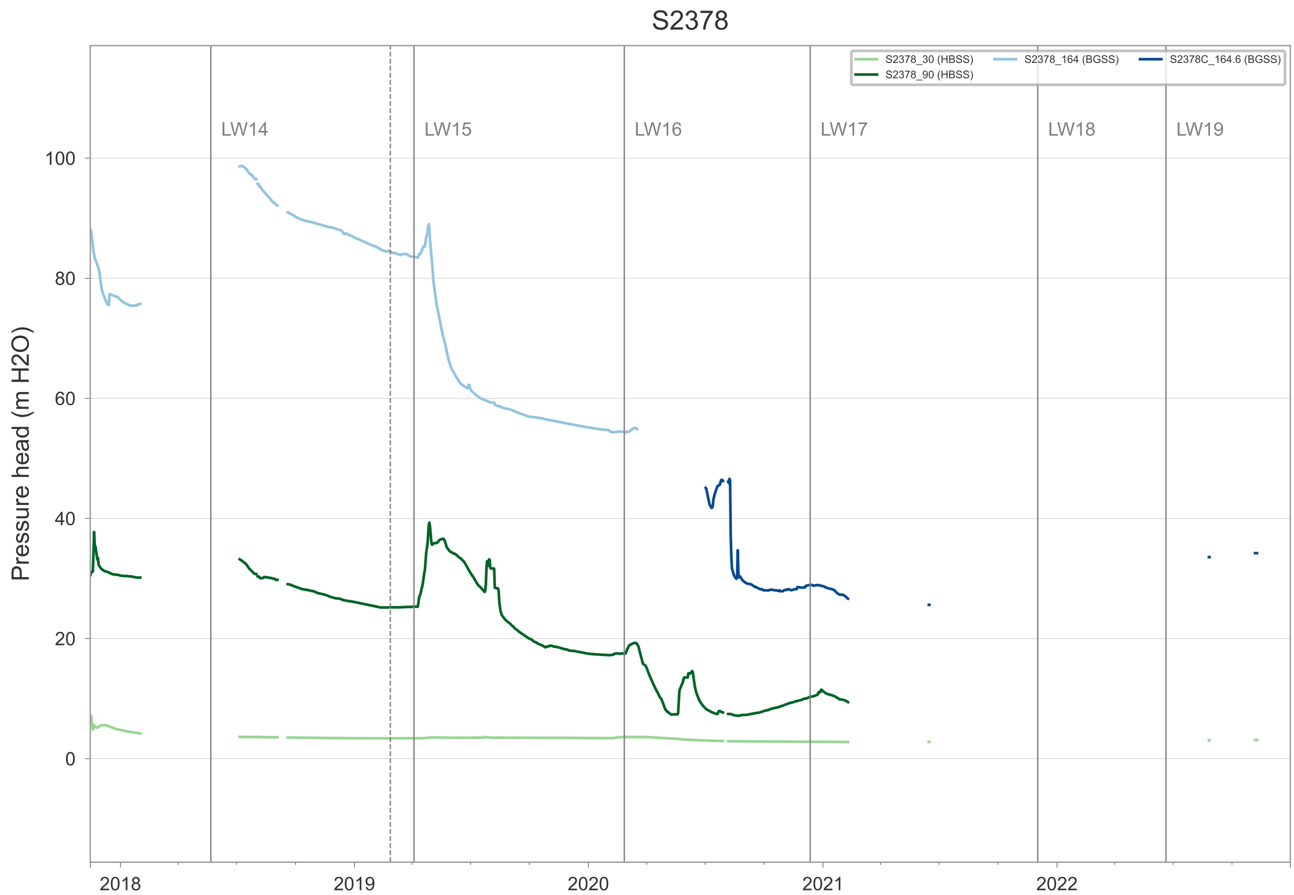
Groundwater hydrographs



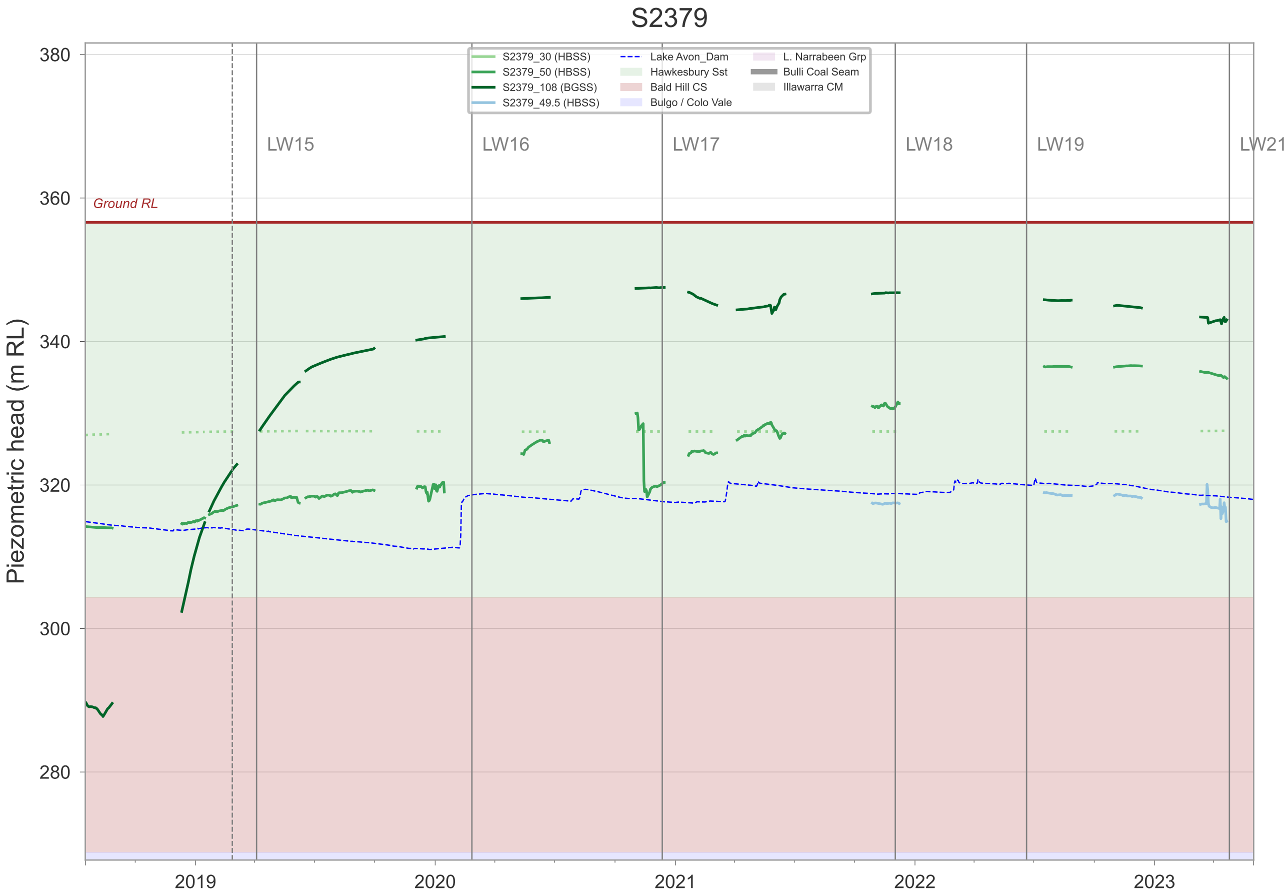


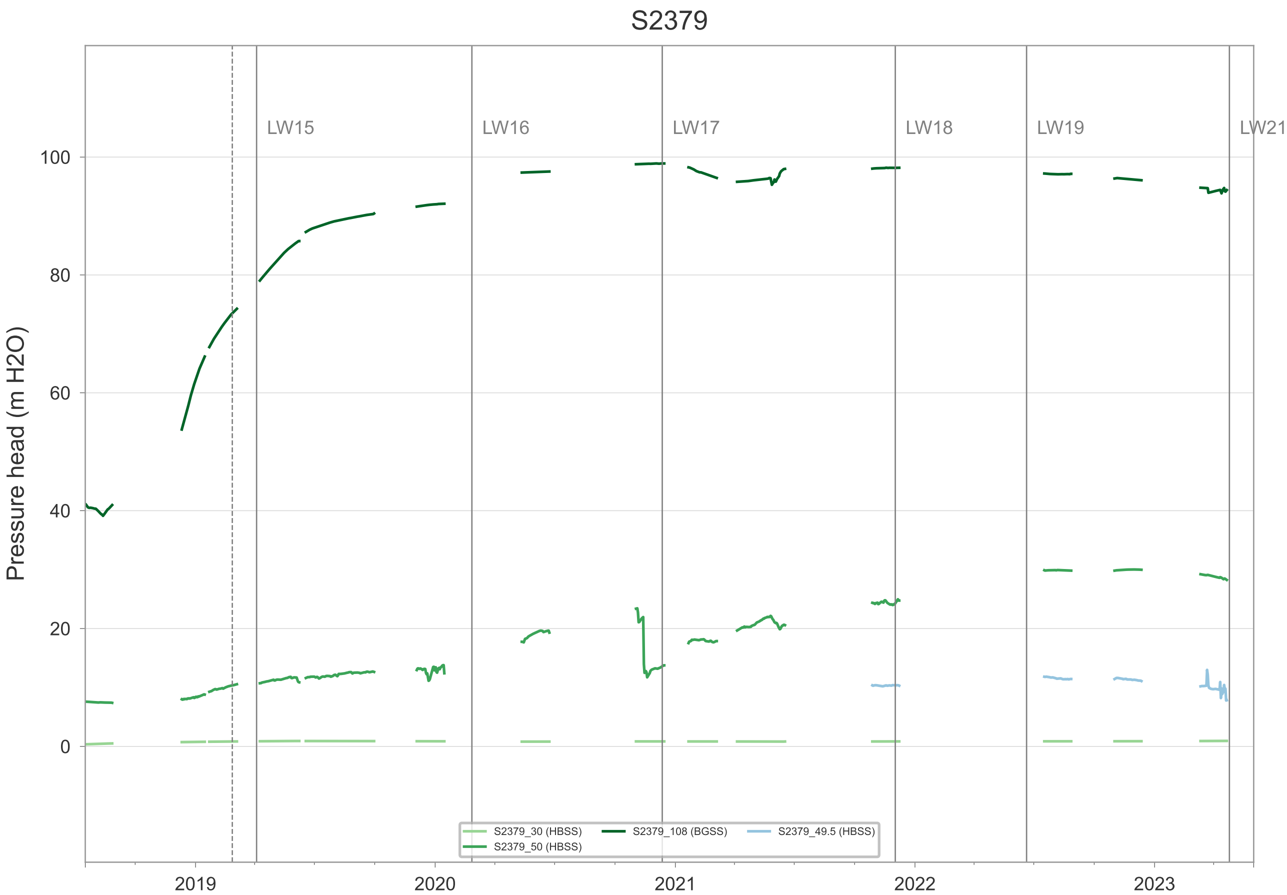
Groundwater hydrographs



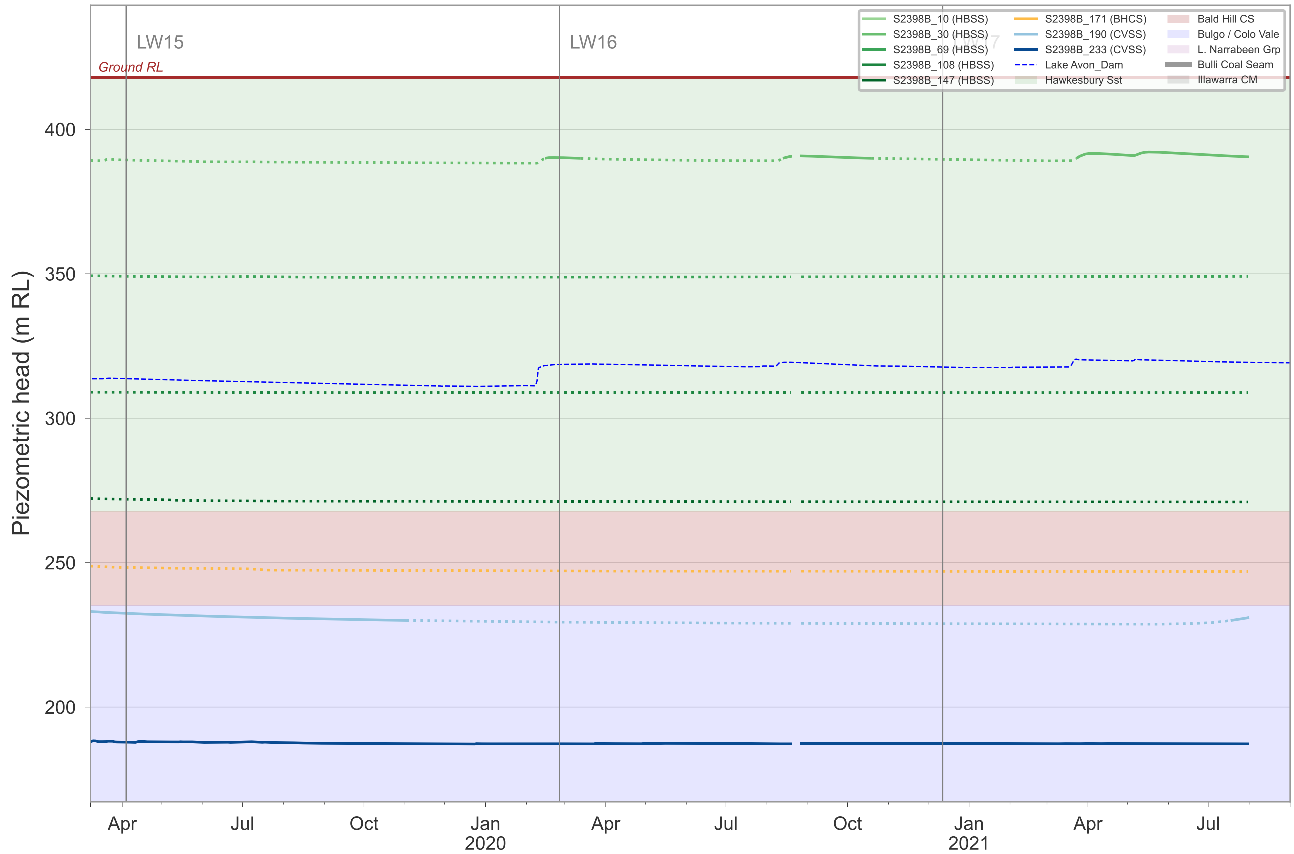


Groundwater hydrographs

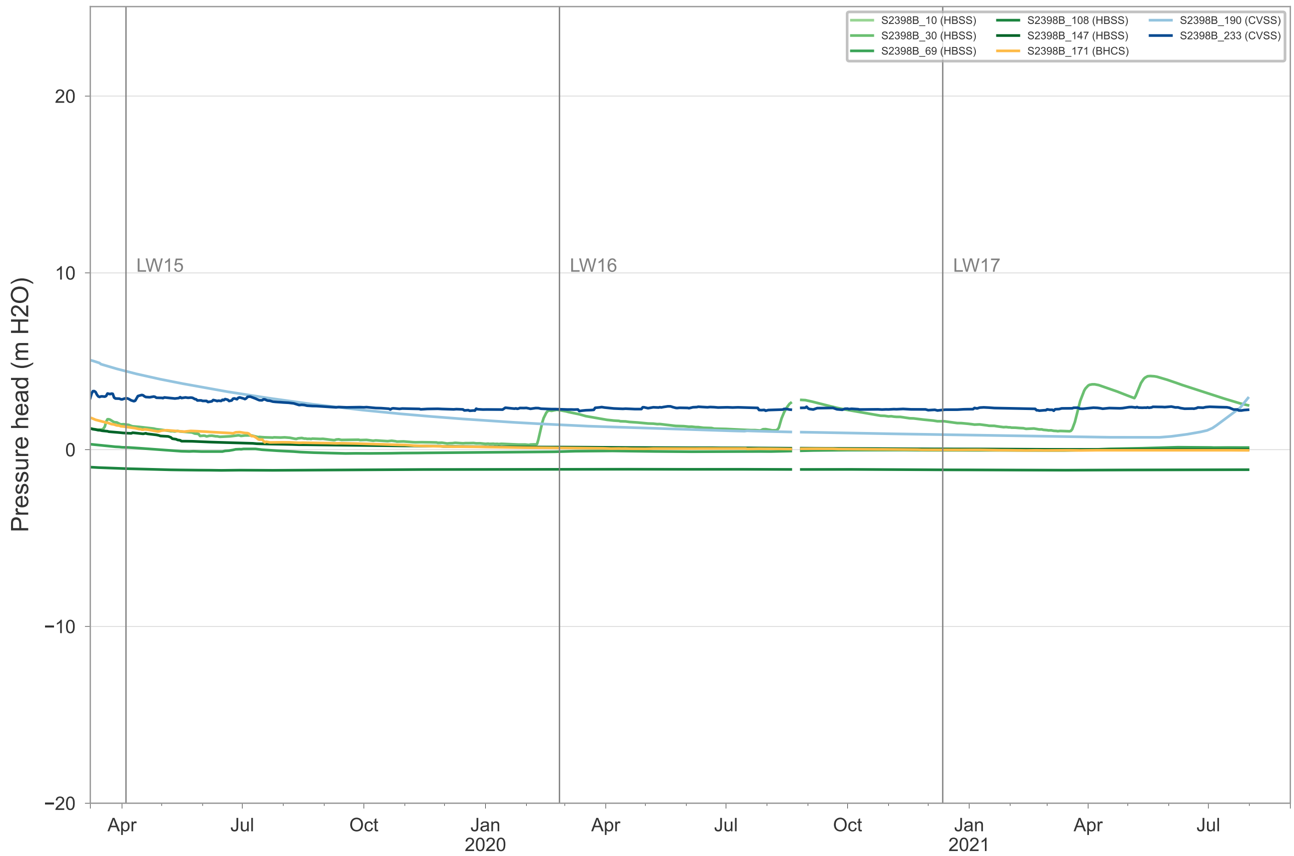




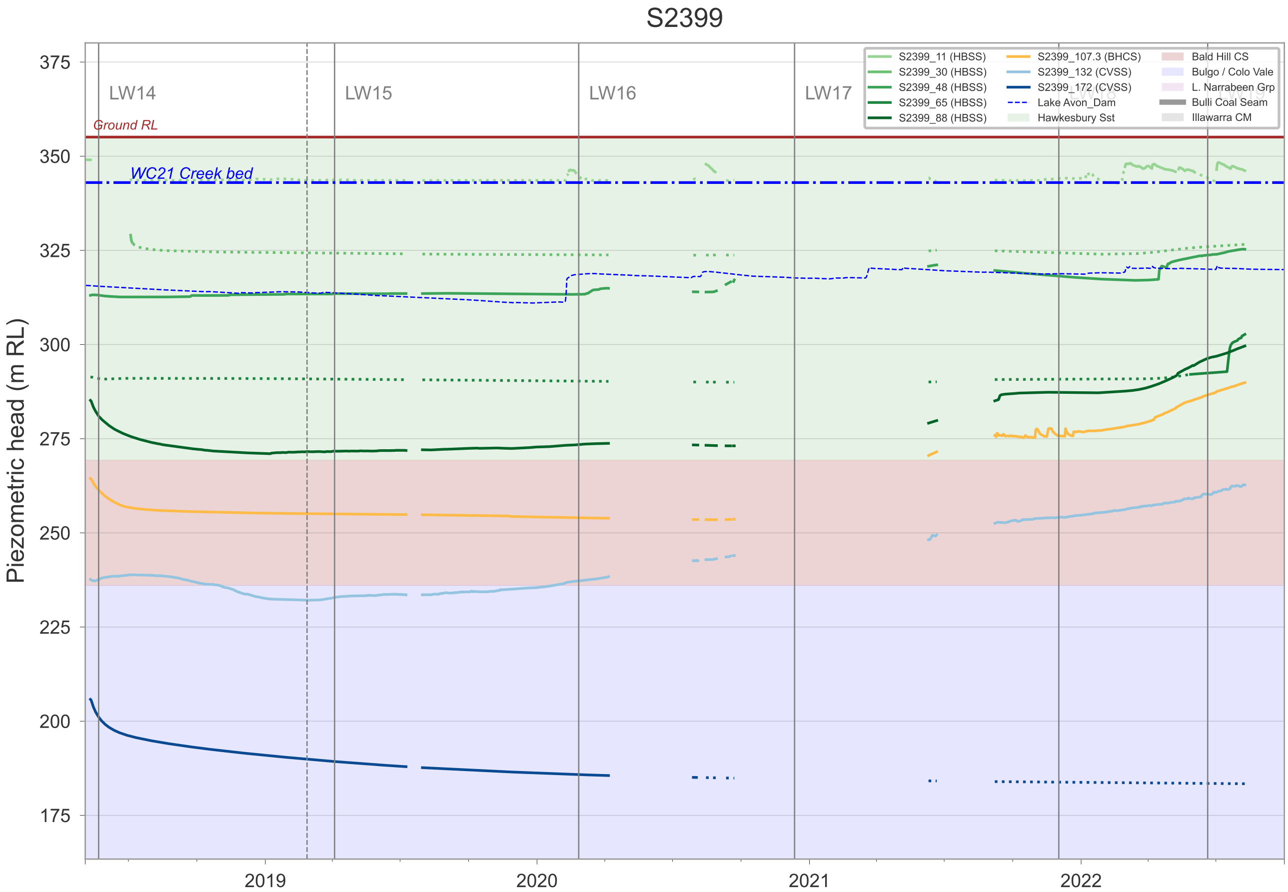
S2398B

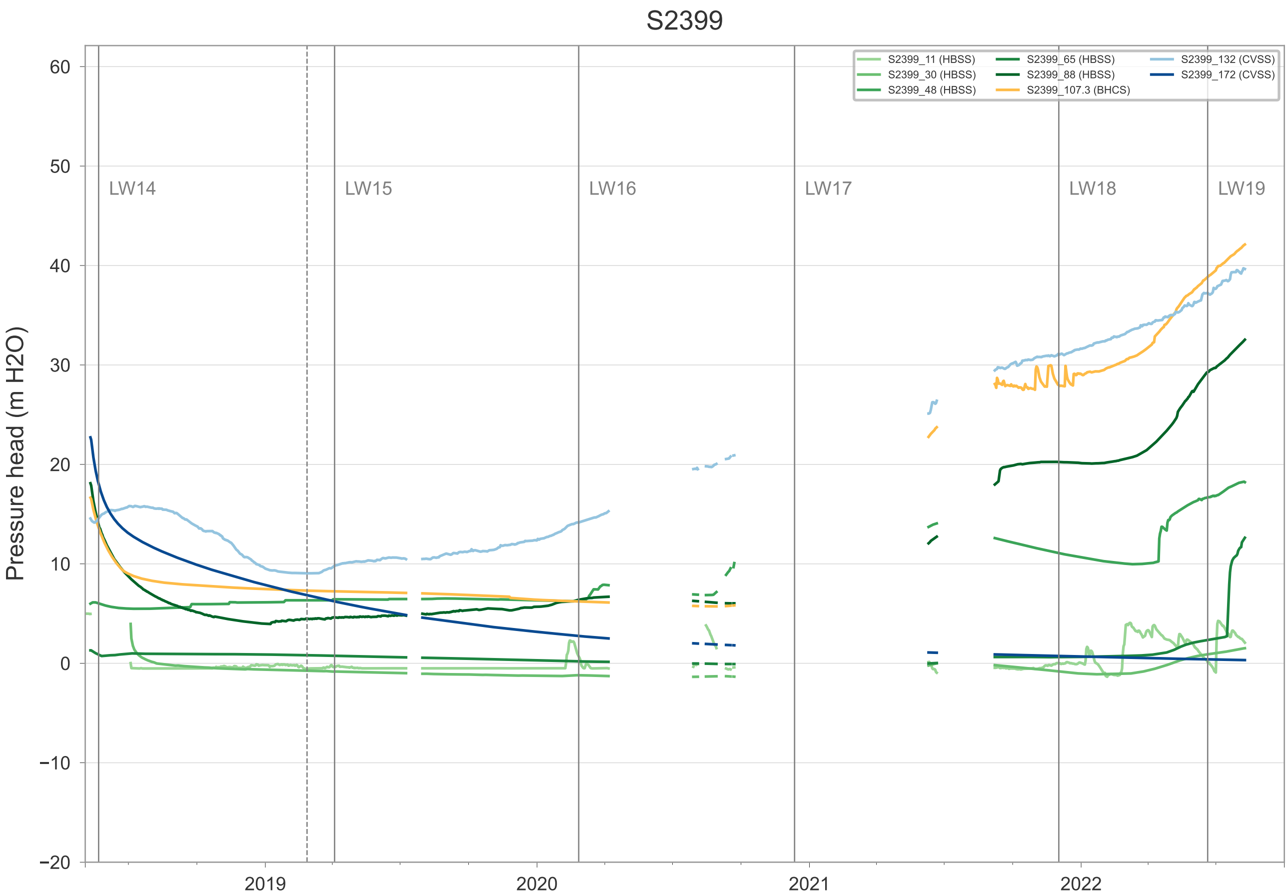


S2398B

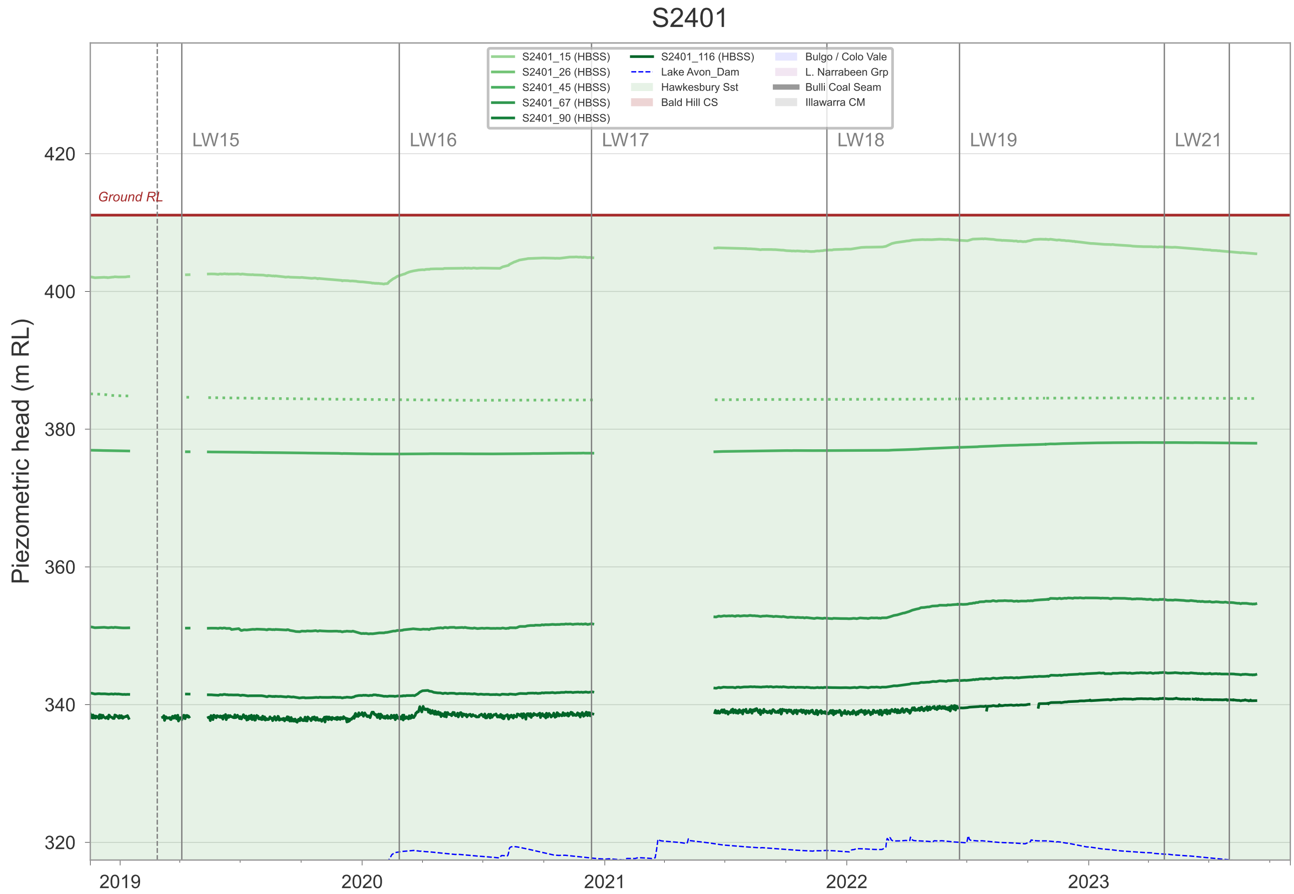


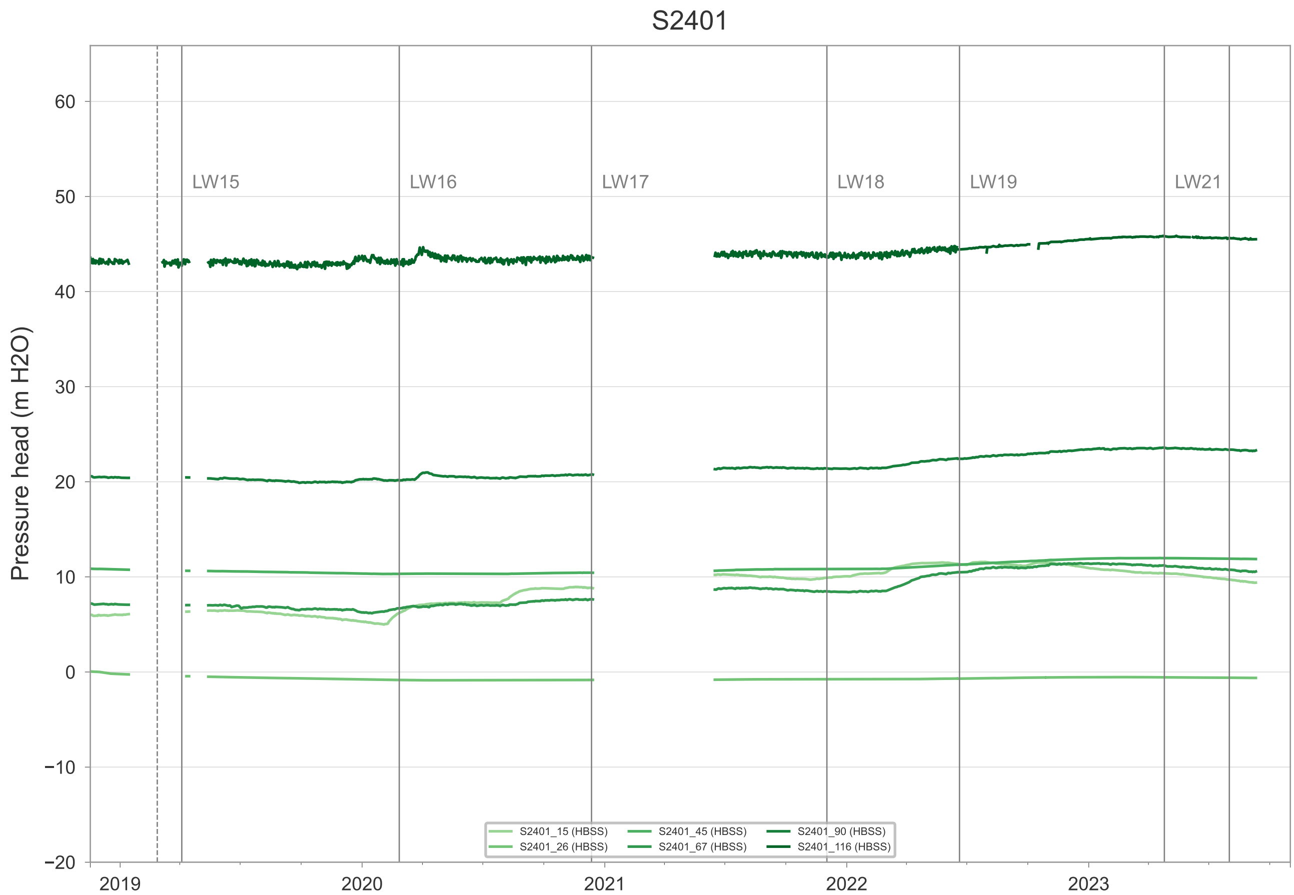
Groundwater hydrographs



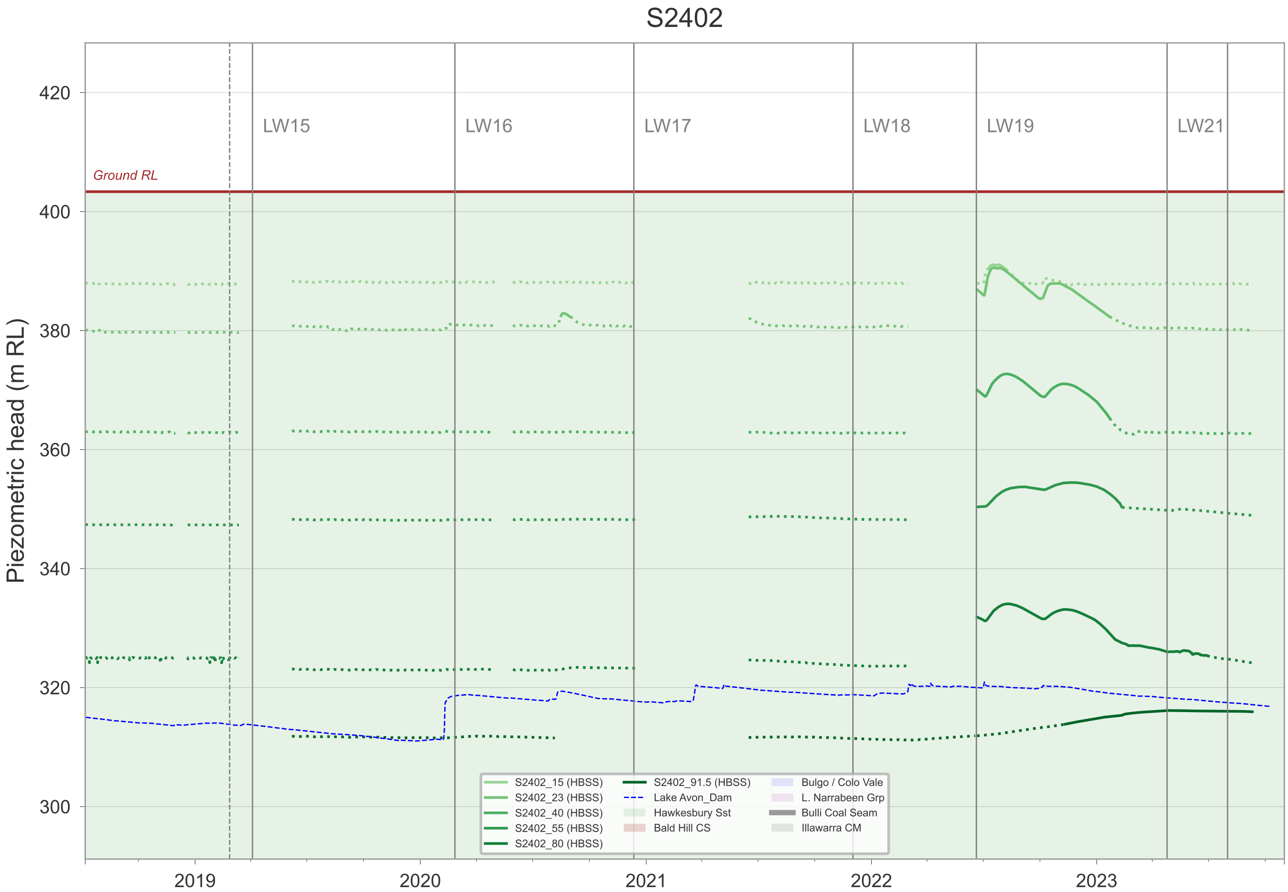


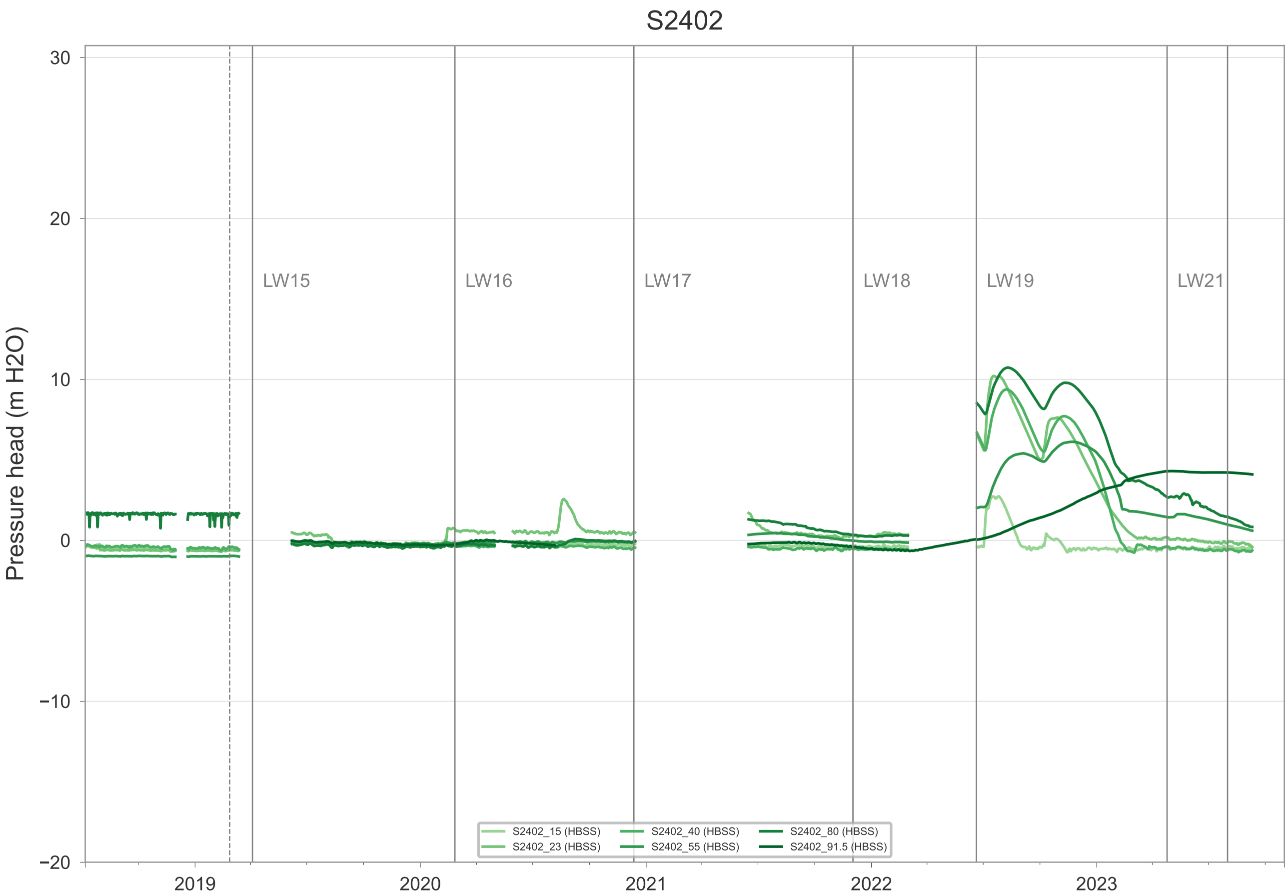
Groundwater hydrographs





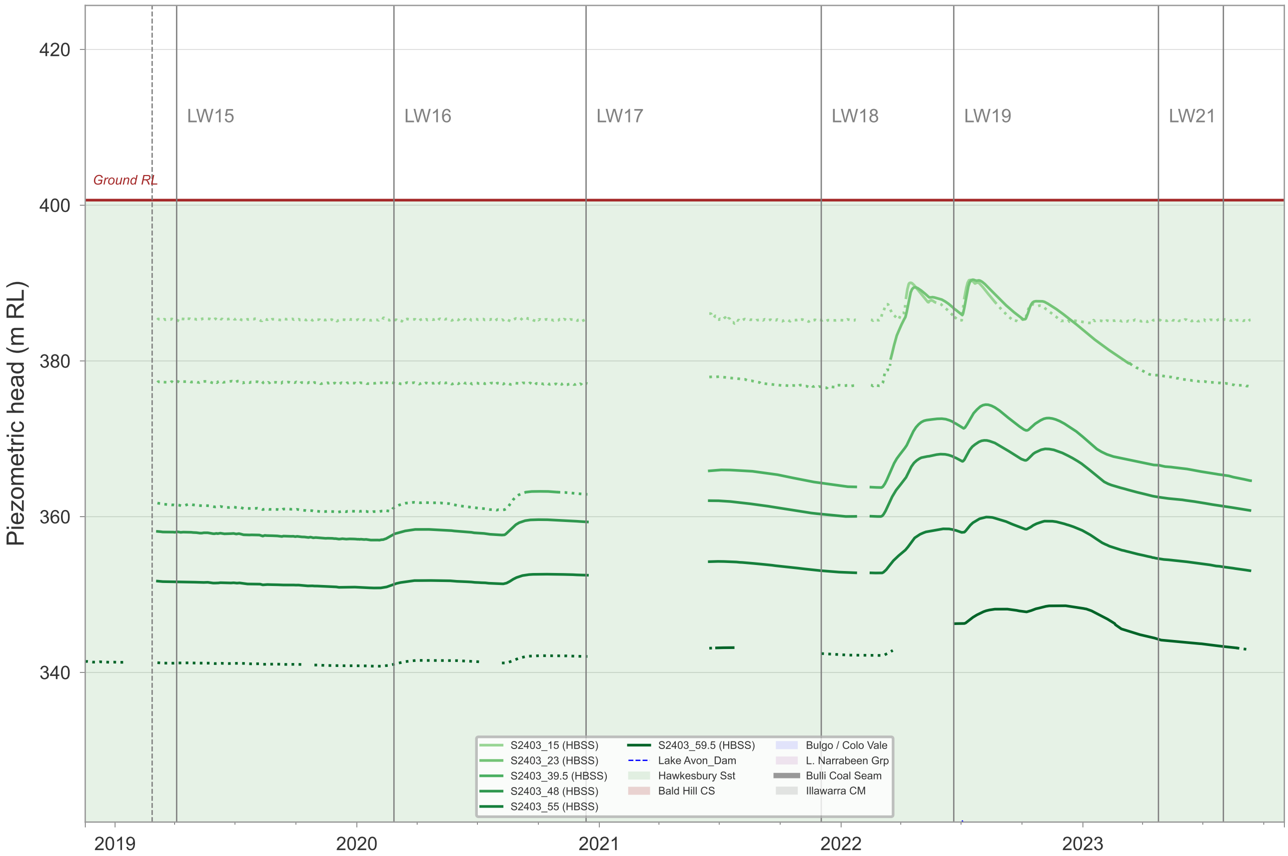
Groundwater hydrographs



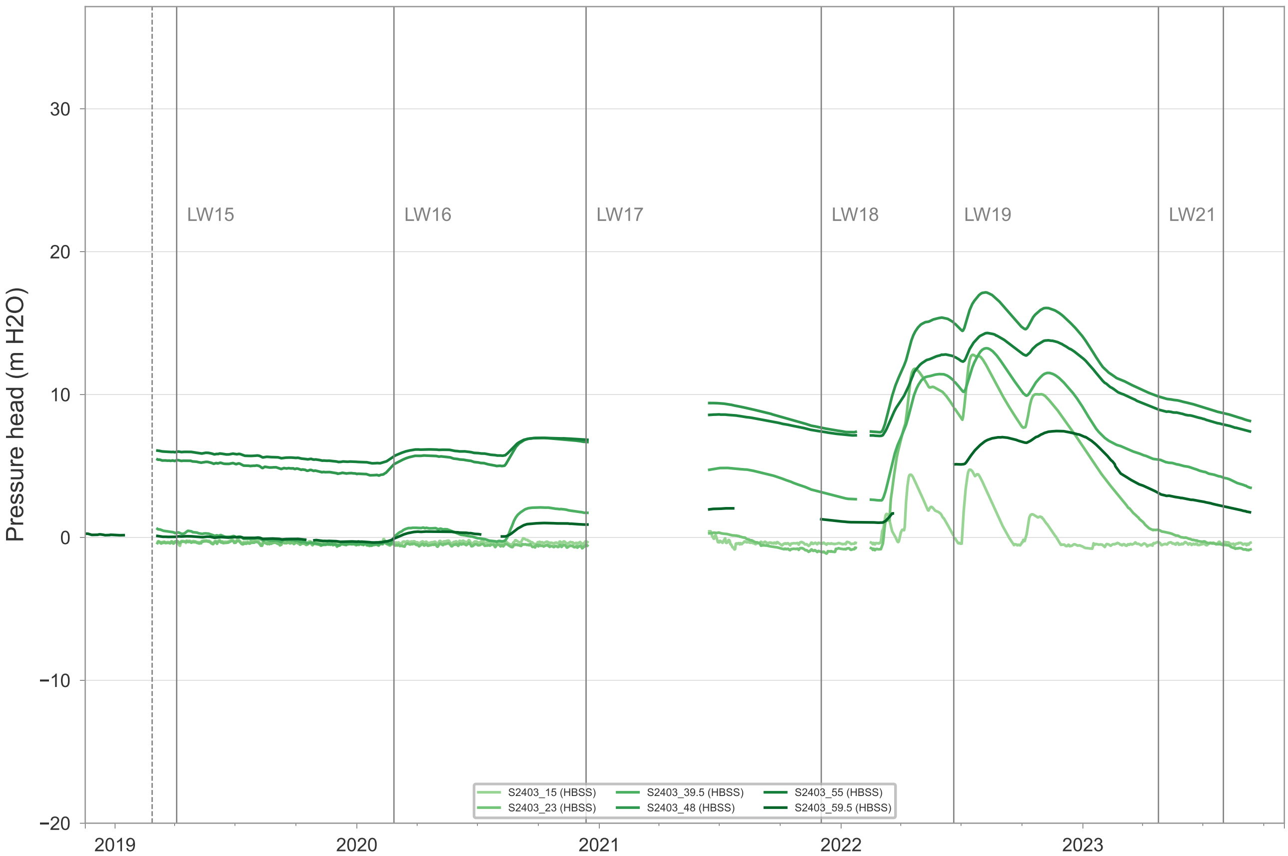


Groundwater hydrographs

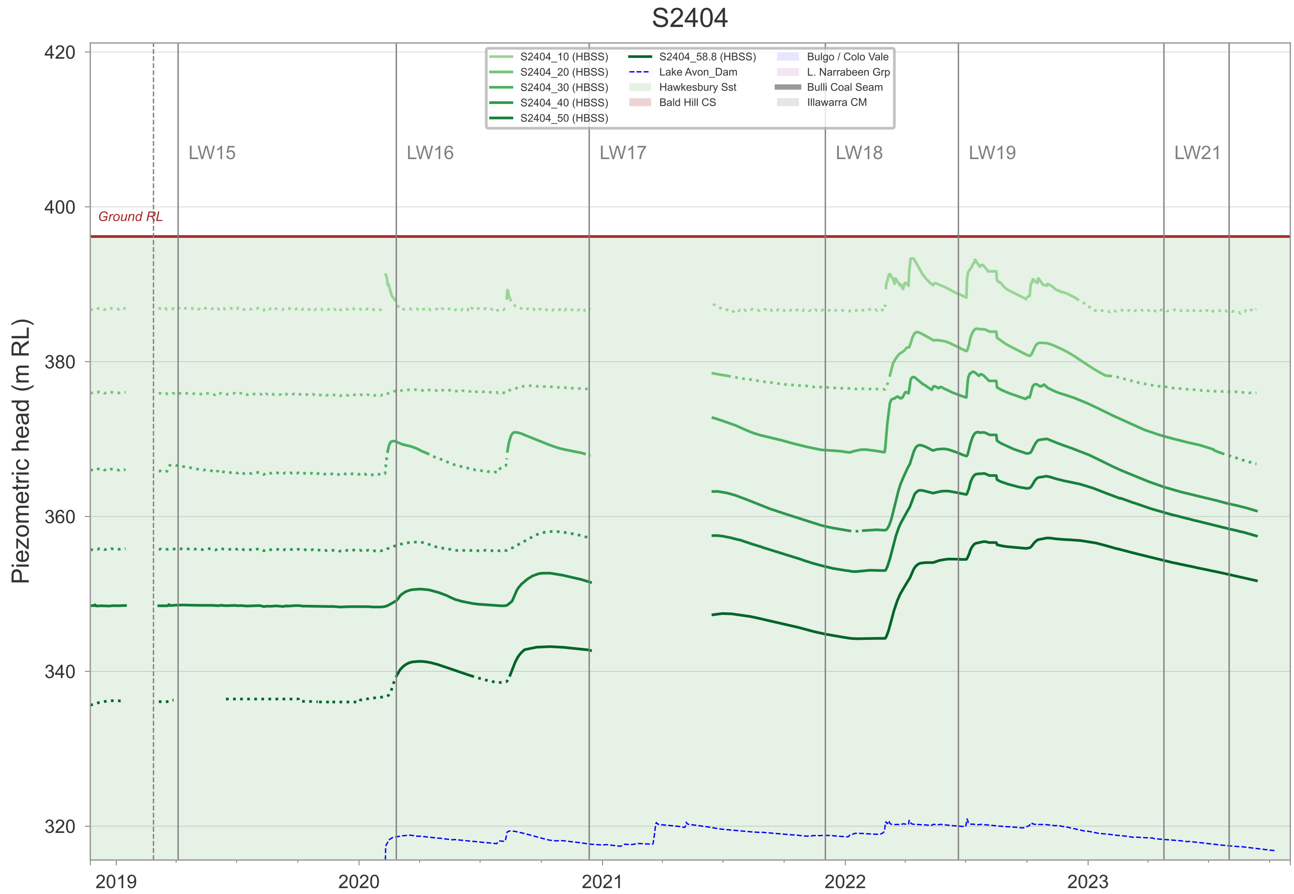
S2403

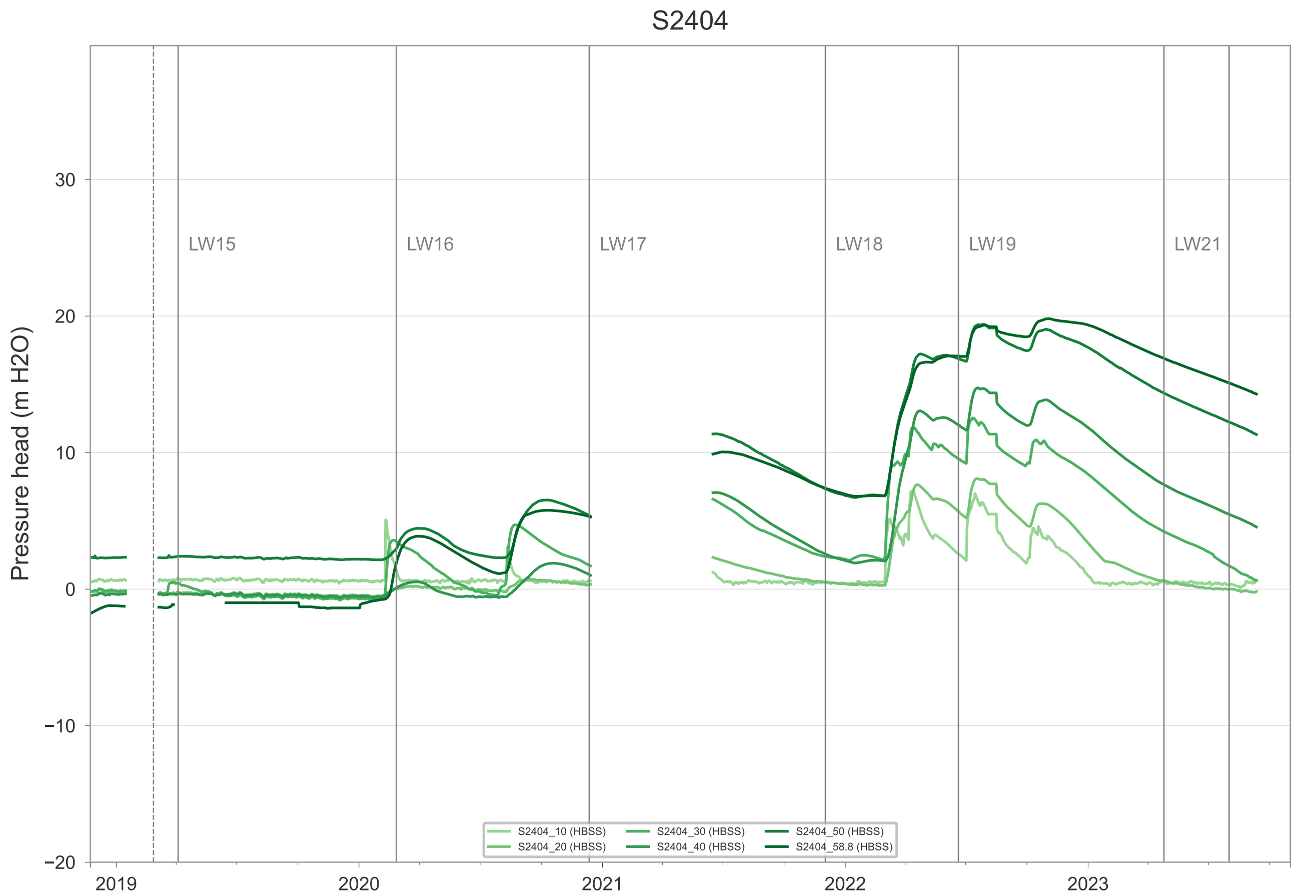


S2403



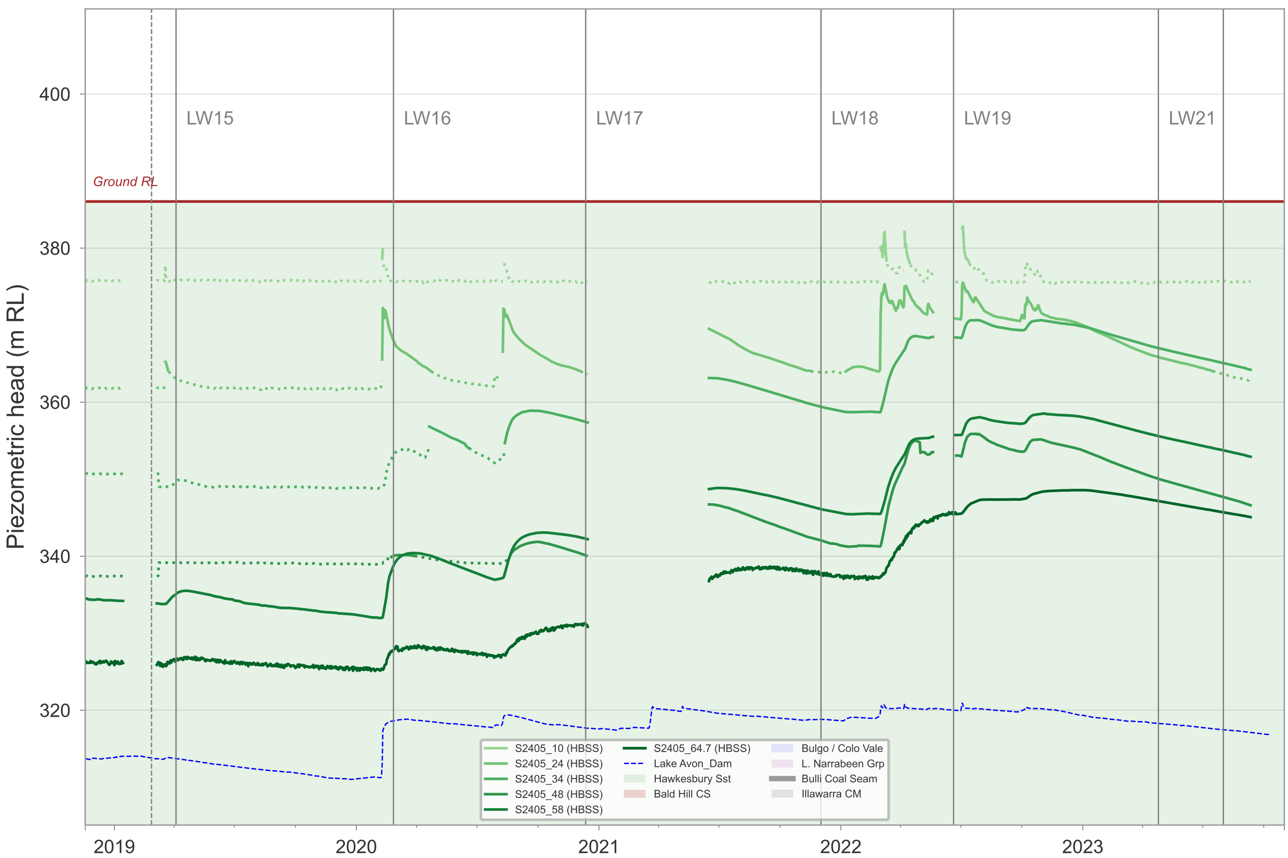
Groundwater hydrographs



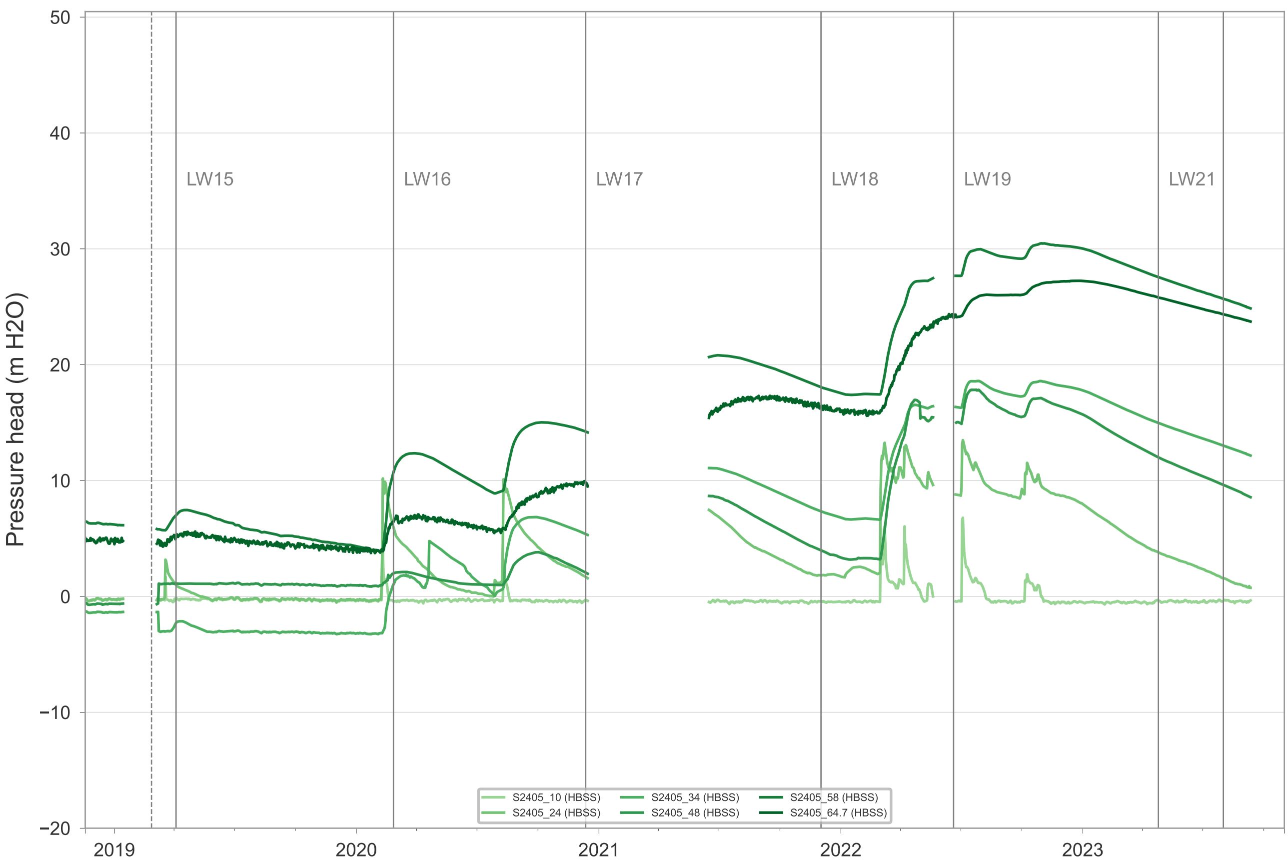


Groundwater hydrographs

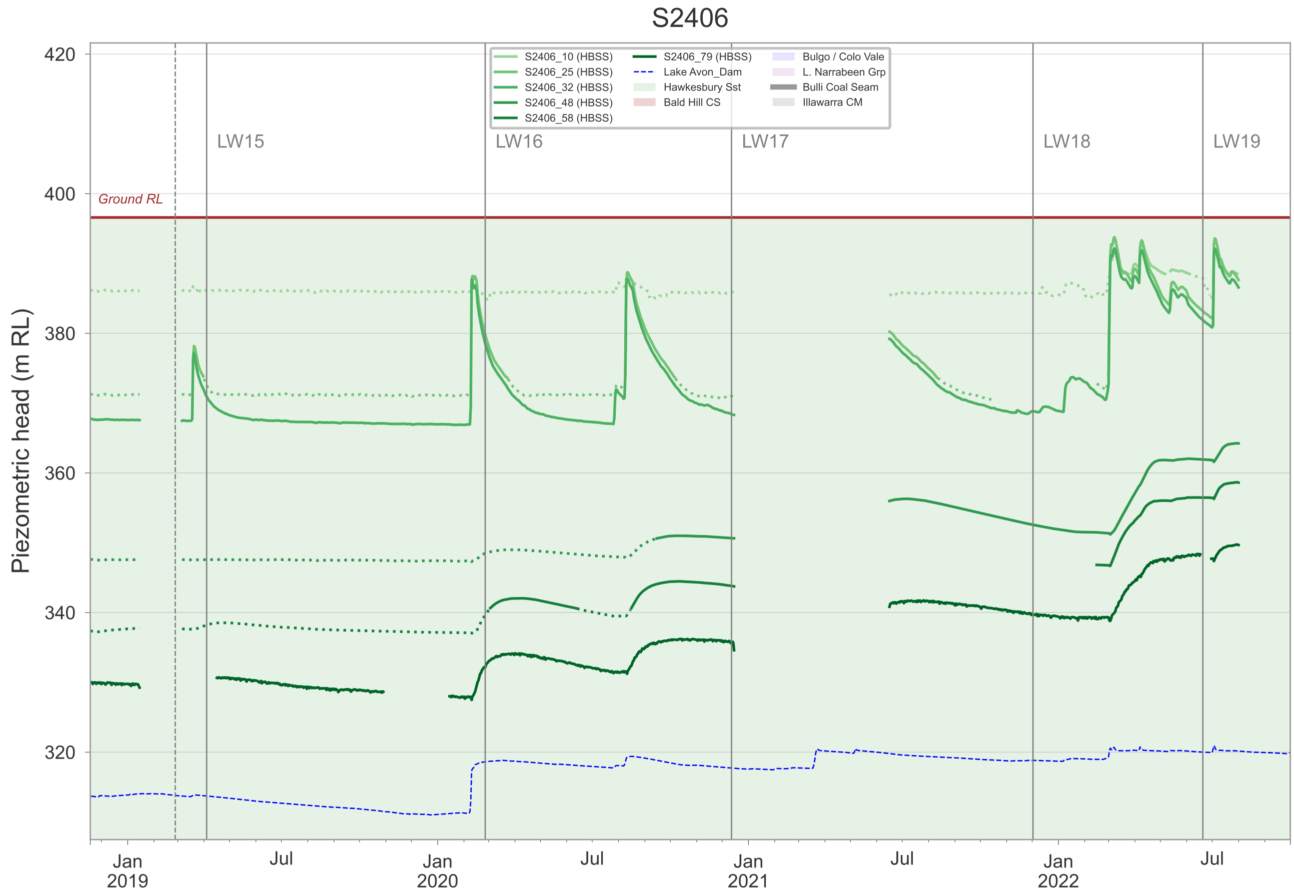
S2405

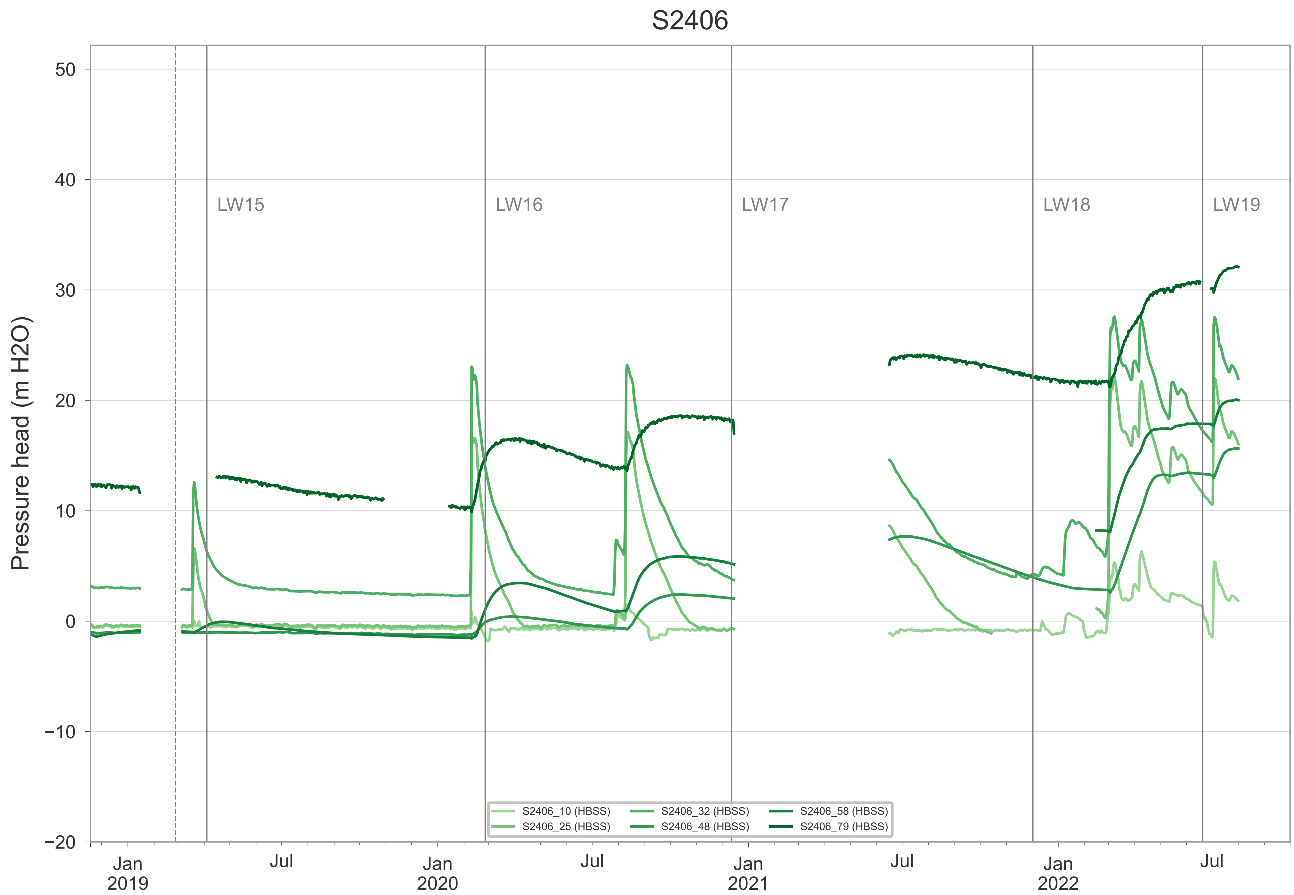


S2405

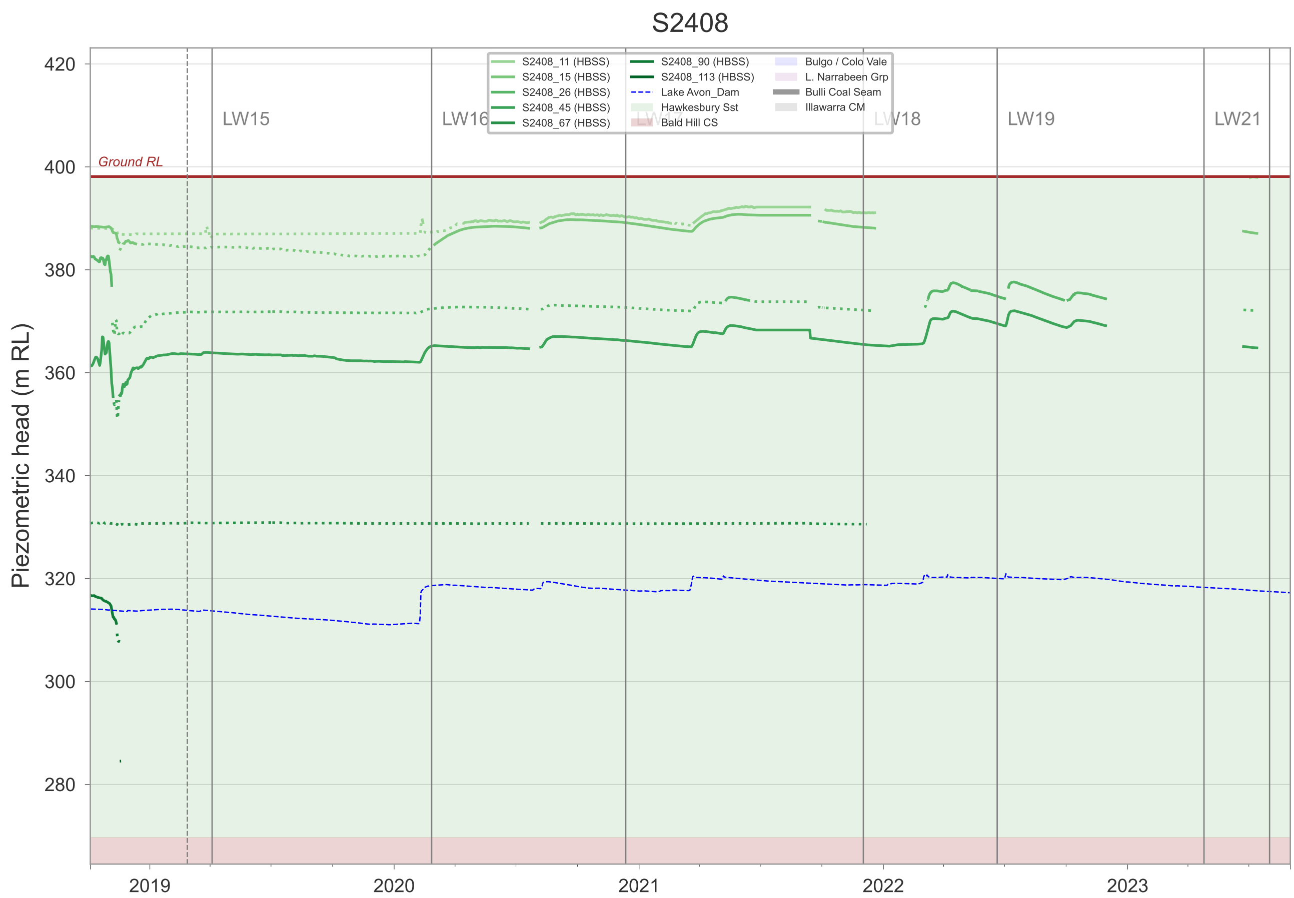


Groundwater hydrographs



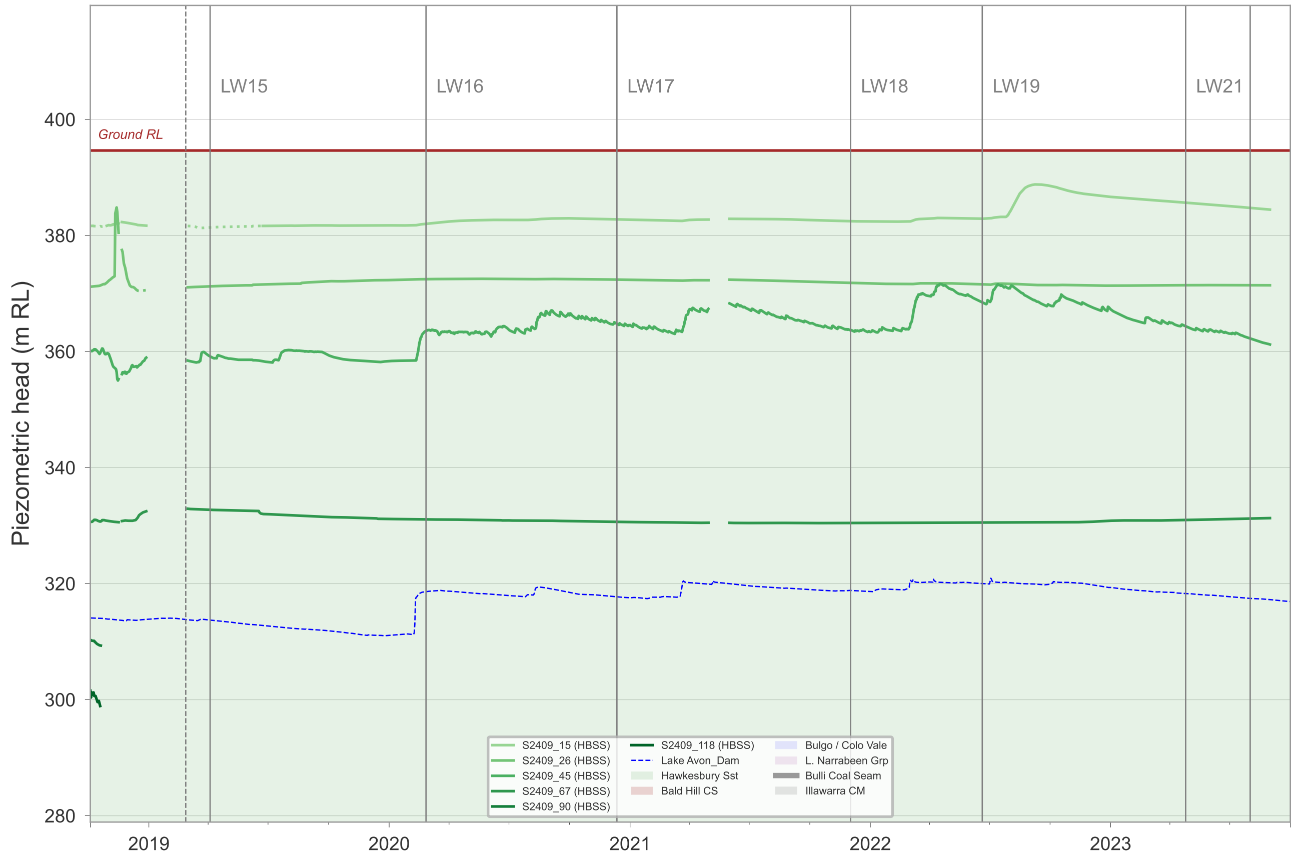


Groundwater hydrographs

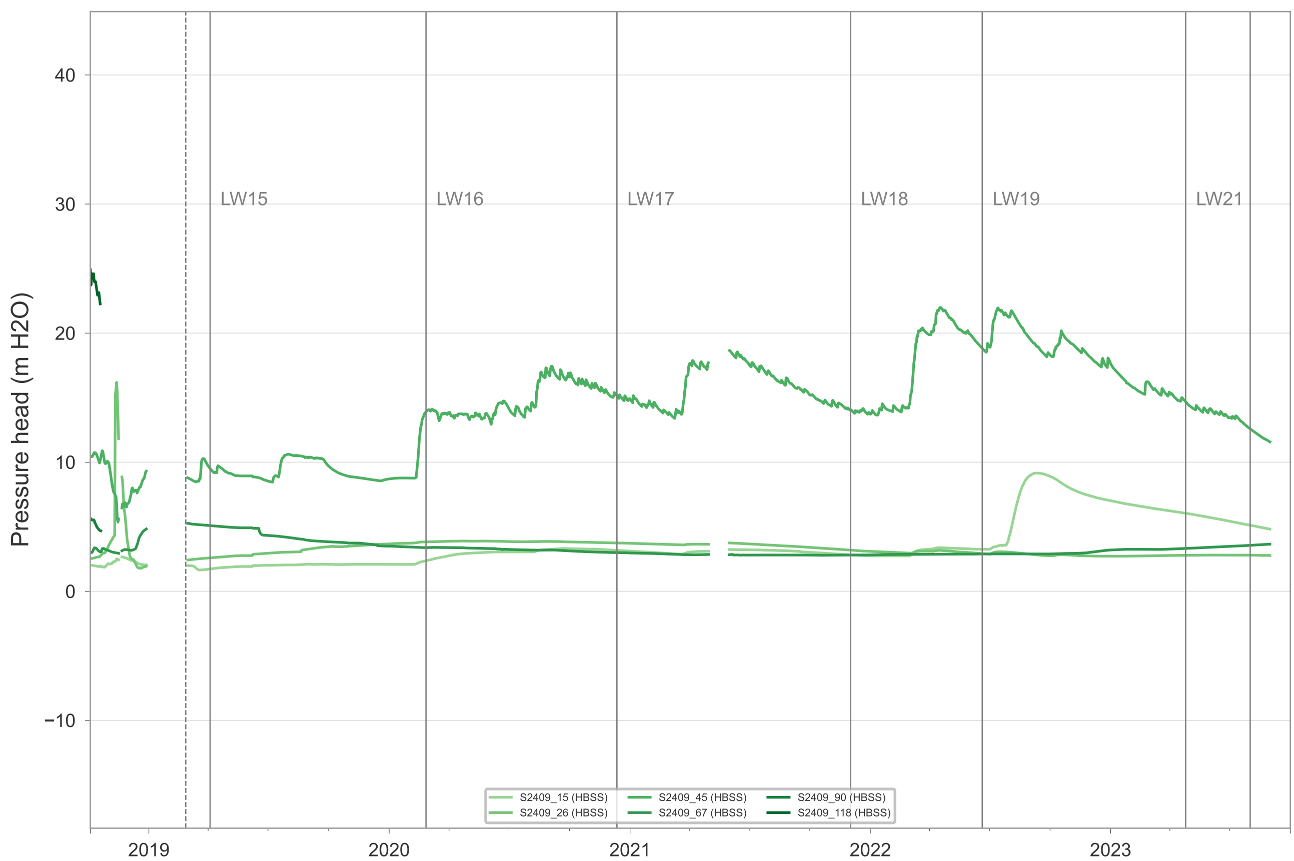


Groundwater hydrographs

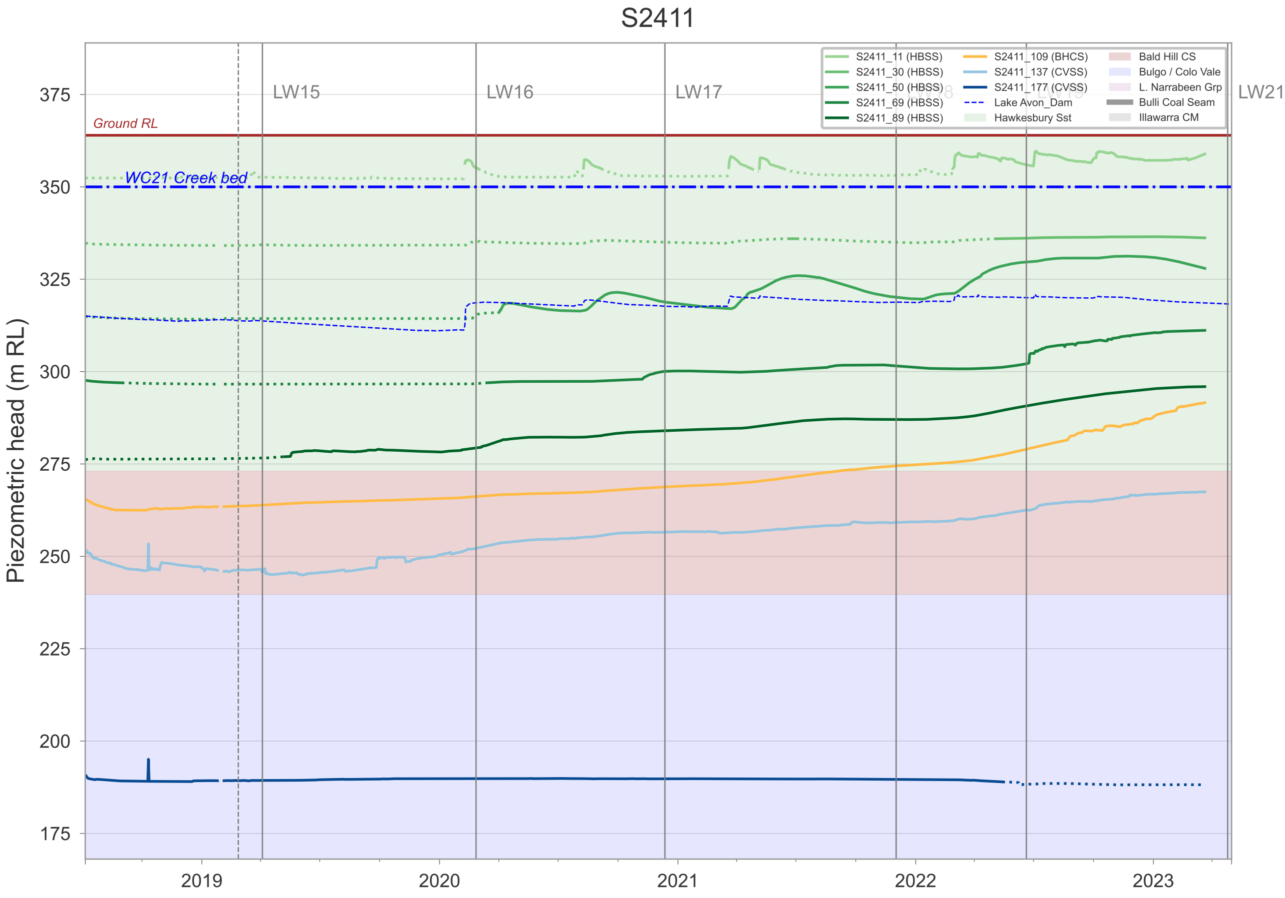
S2409

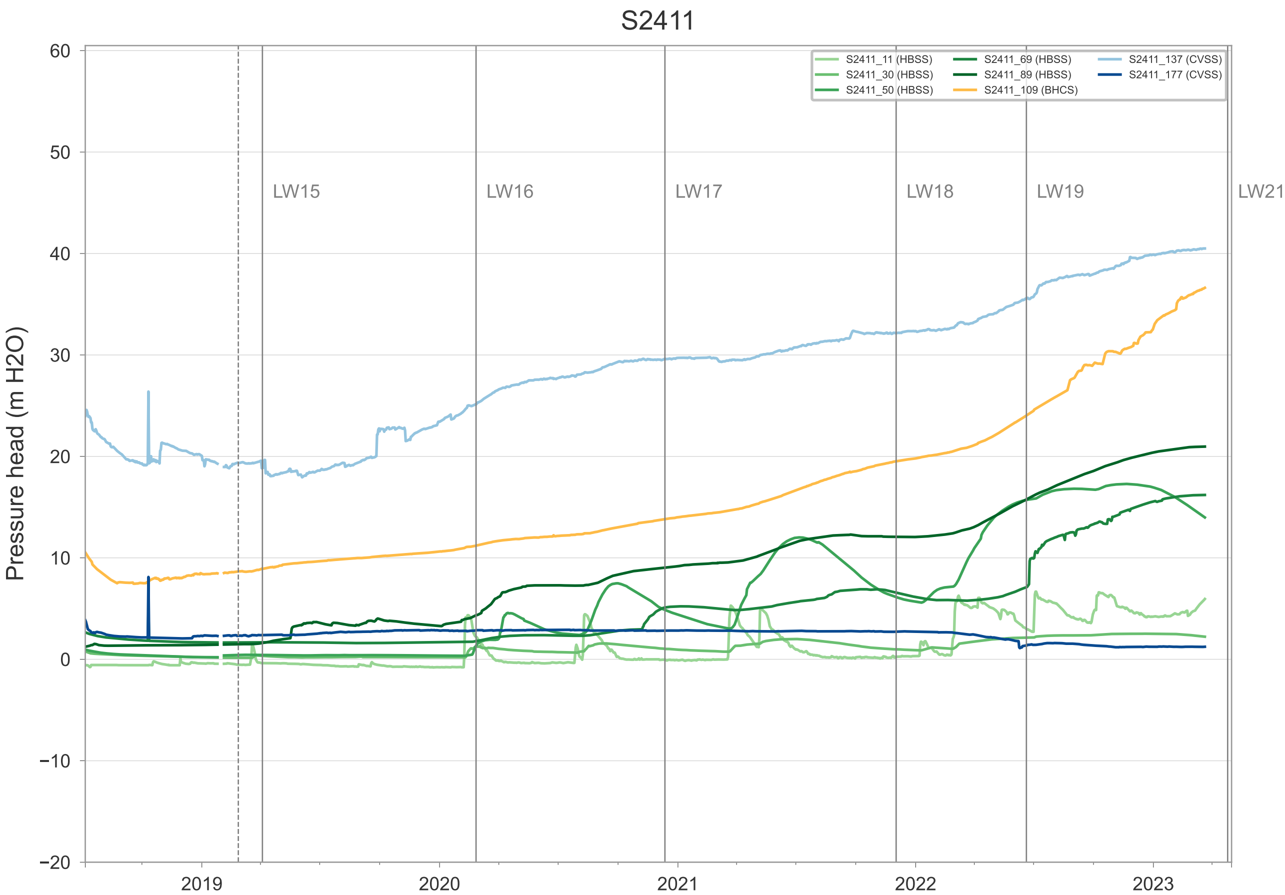


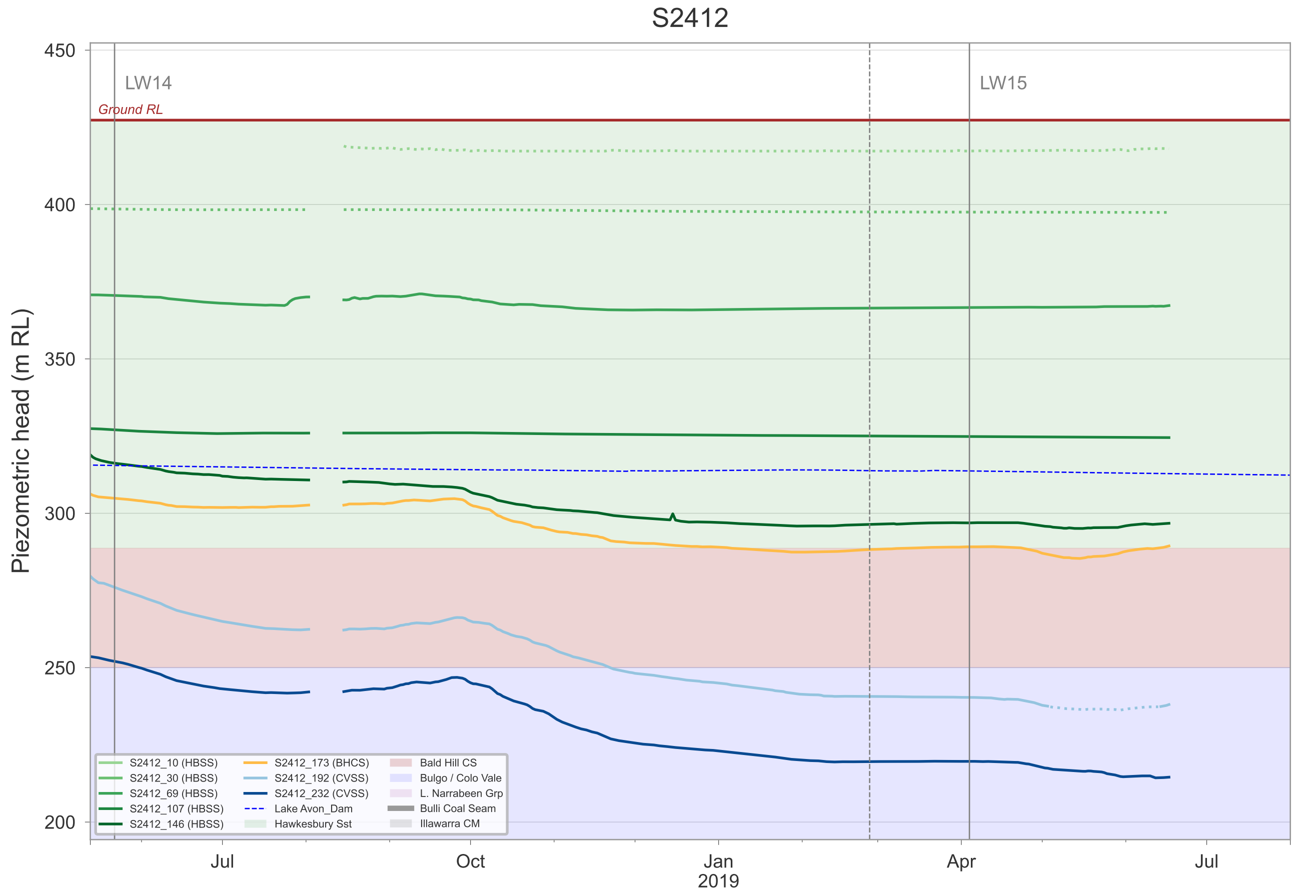
S2409

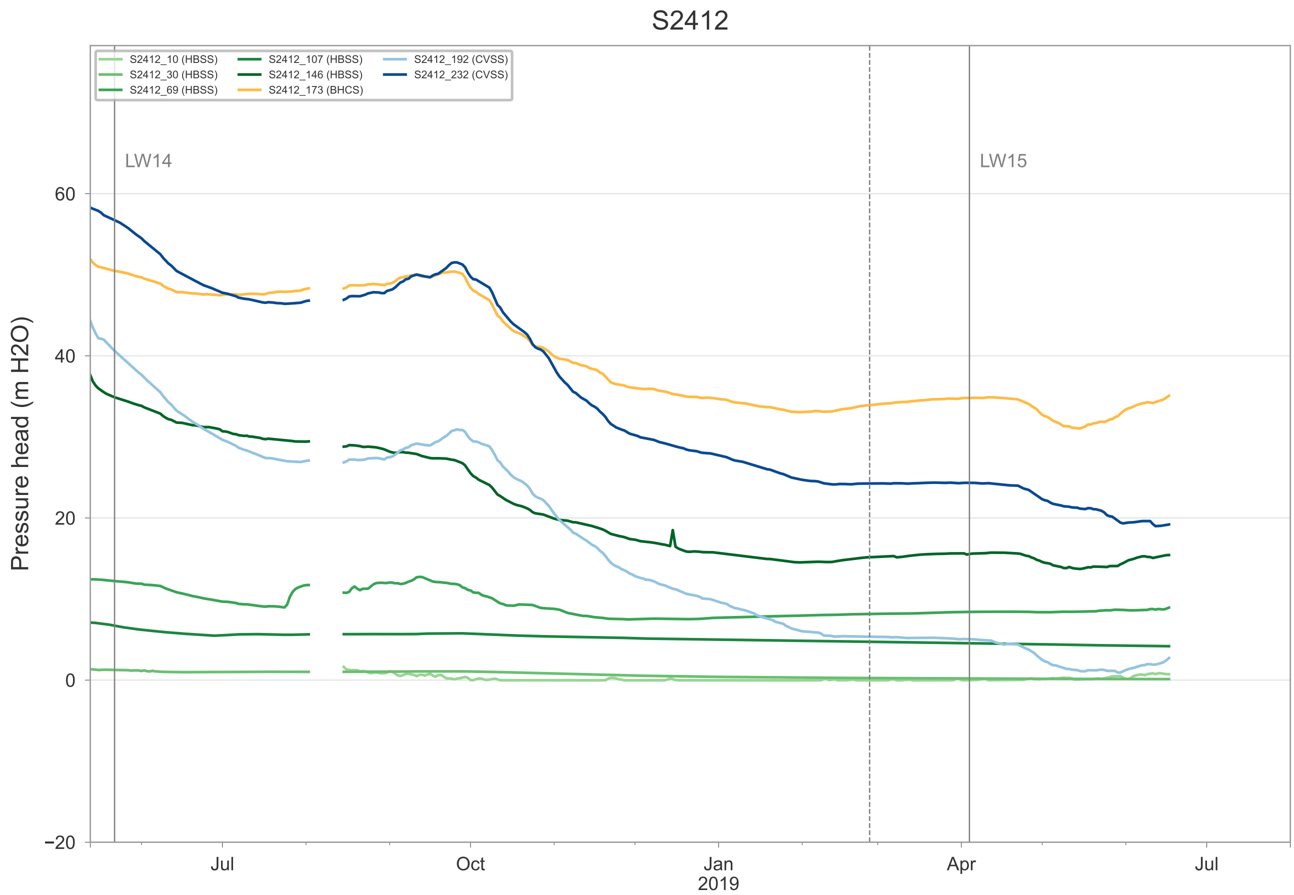


Groundwater hydrographs

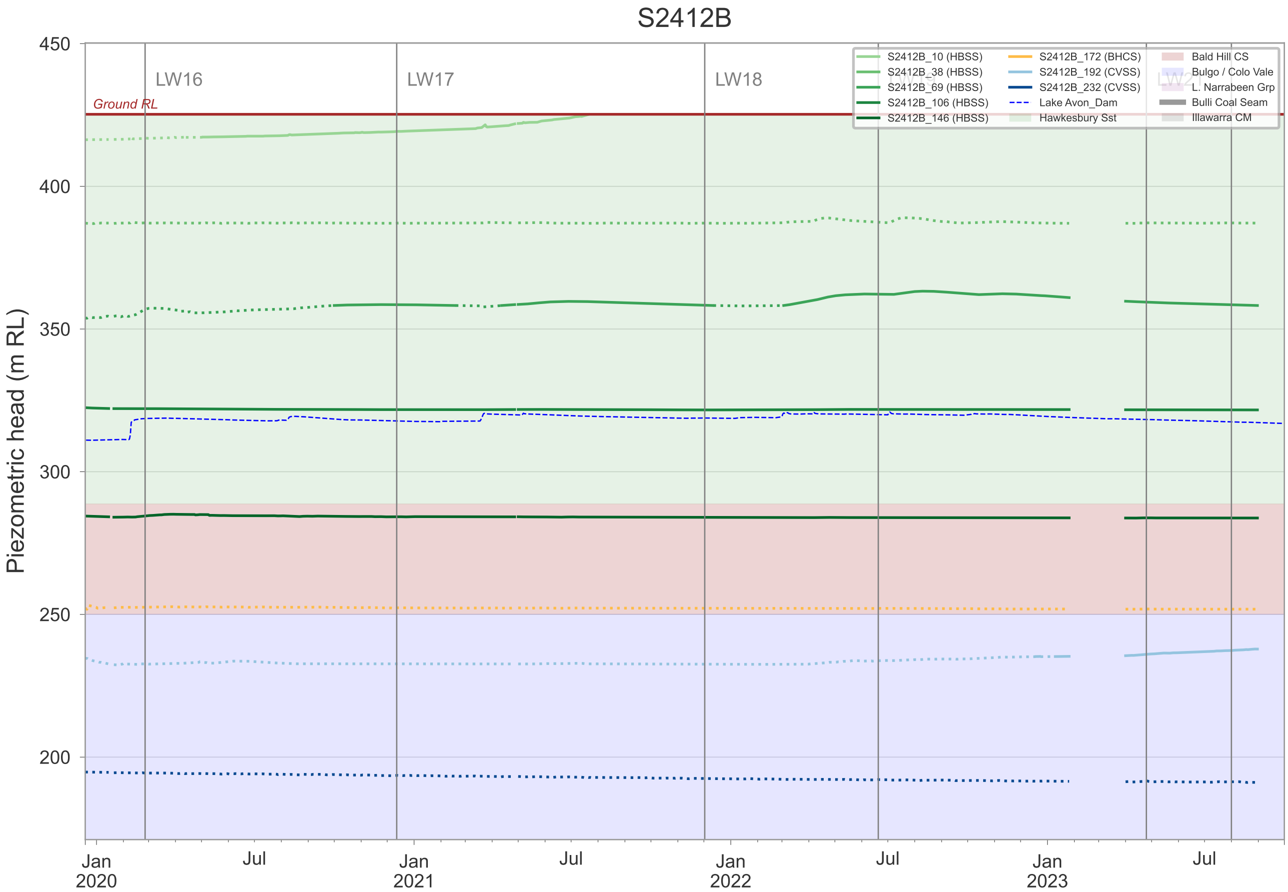


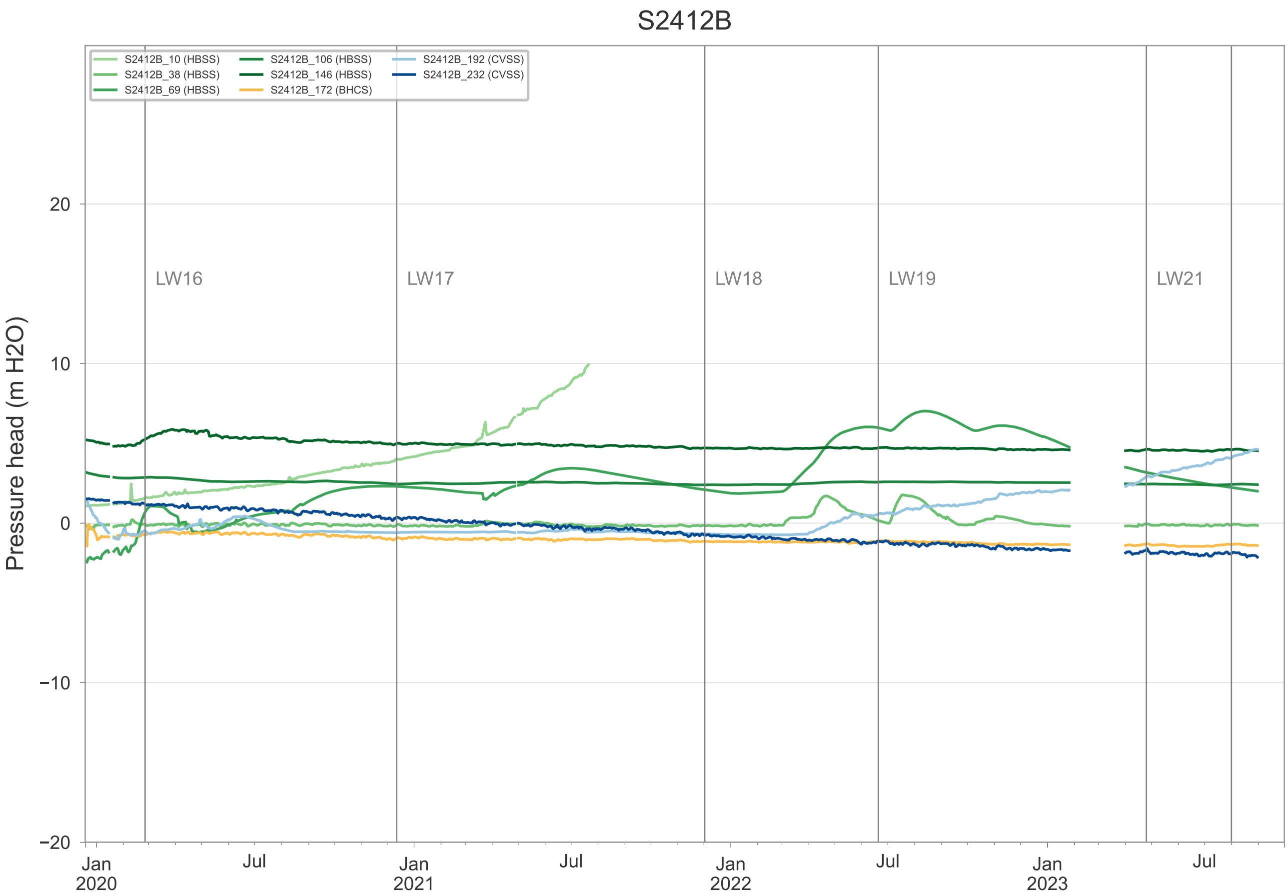



S2412
Piezometric head (m RL)
LW14
LW15
Ground RL
450
400
350
300
250
200
Jul
Oct
Jan
2019
Apr
Jul
S2412_10 (HBSS)
S2412_30 (HBSS)
S2412_69 (HBSS)
S2412_107 (HBSS)
S2412_146 (HBSS)
S2412_173 (BHCS)
S2412_192 (CVSS)
S2412_232 (CVSS)
Lake Avon_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM

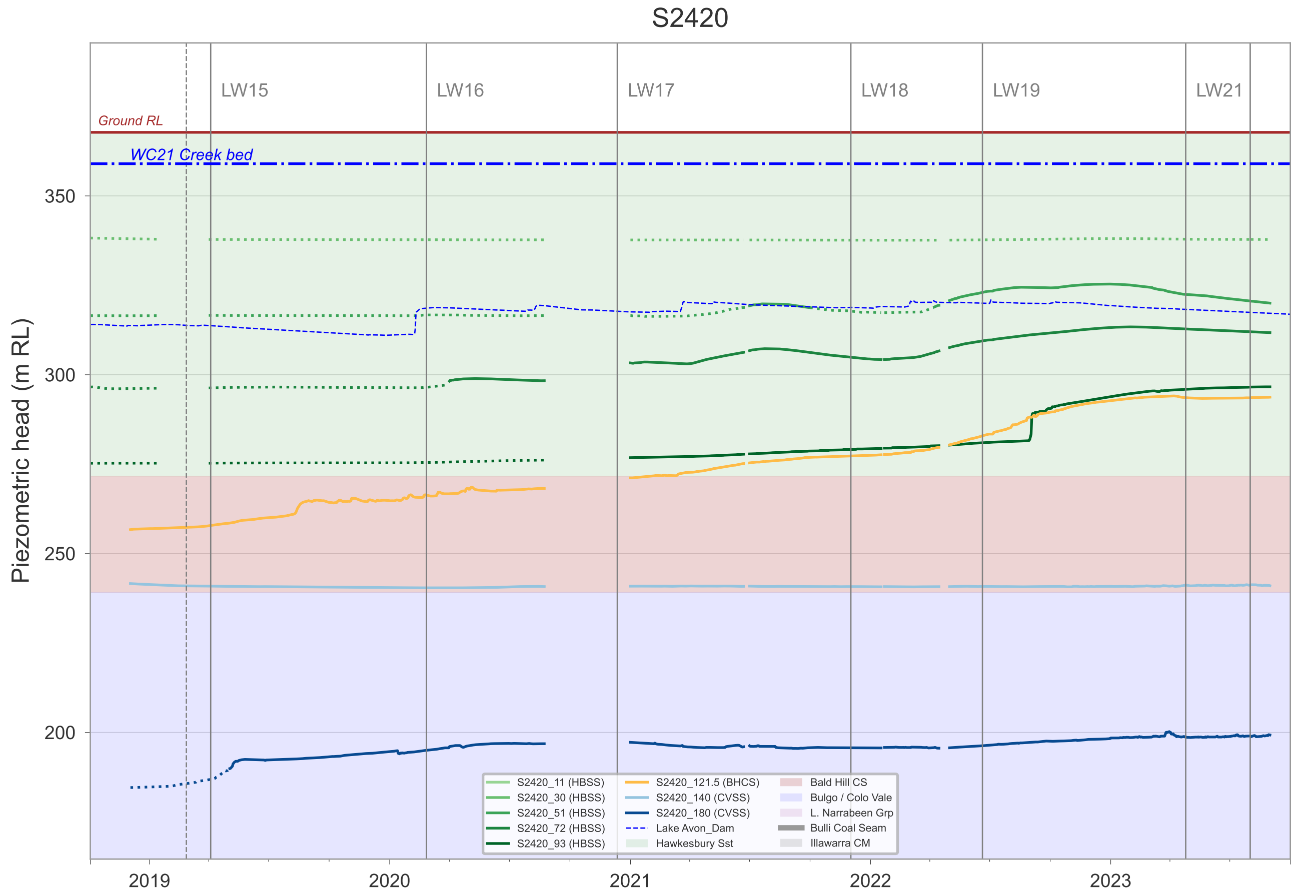

S2412
Pressure head (m H2O)
LW14
LW15
60
40
20
0
−20
Jul
Oct
Jan
2019
Apr
Jul
S2412_10 (HBSS)
S2412_30 (HBSS)
S2412_69 (HBSS)
S2412_107 (HBSS)
S2412_146 (HBSS)
S2412_173 (BHCS)
S2412_192 (CVSS)
S2412_232 (CVSS)

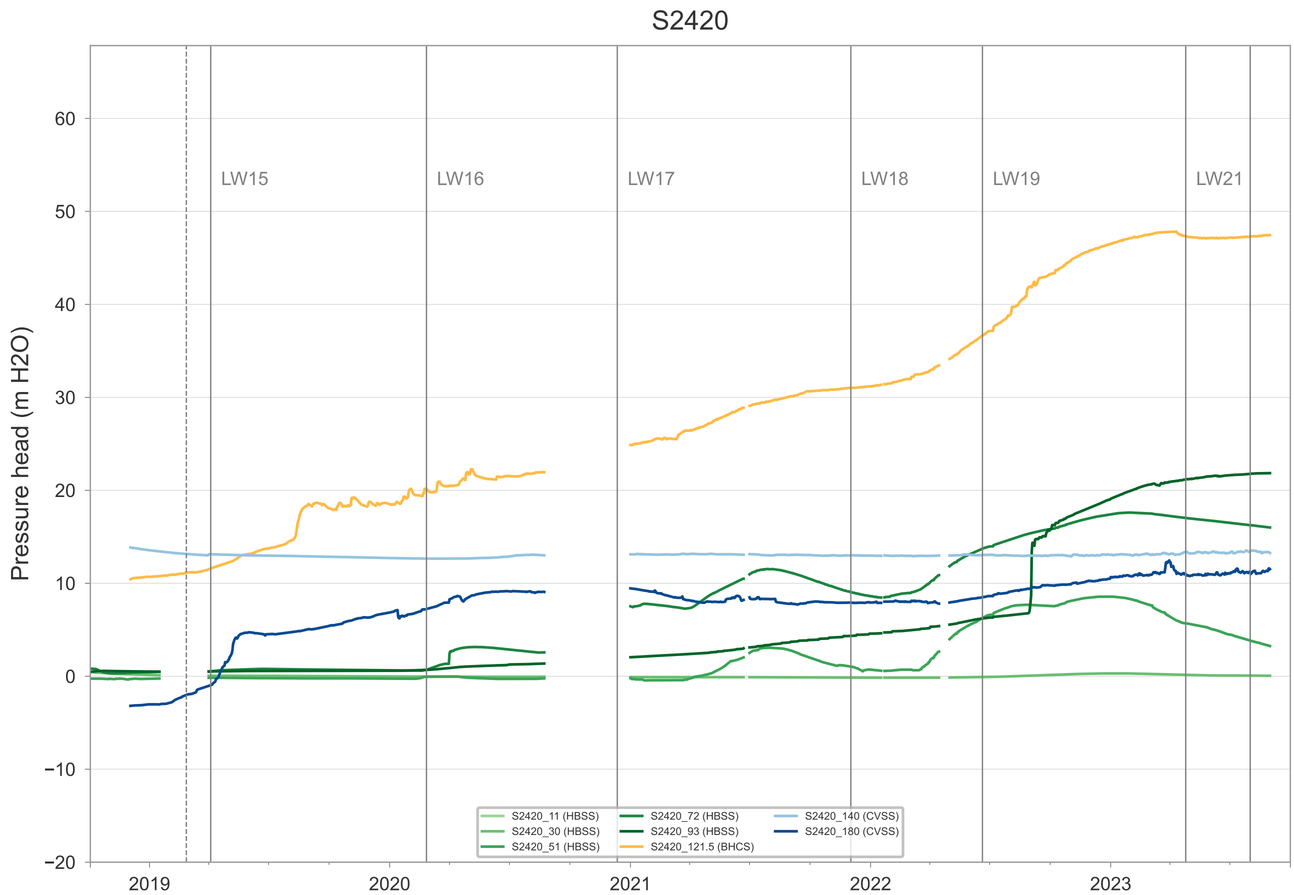
Groundwater hydrographs



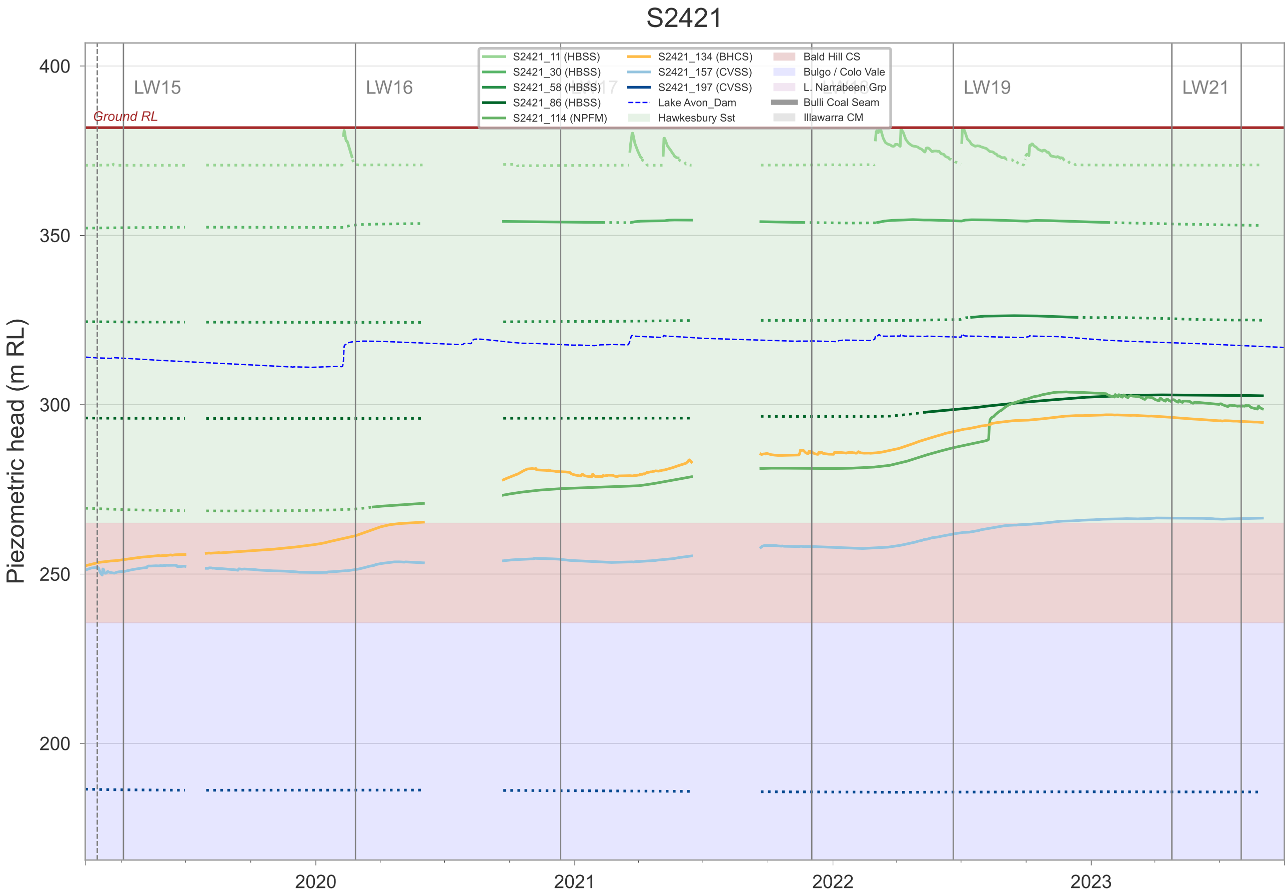


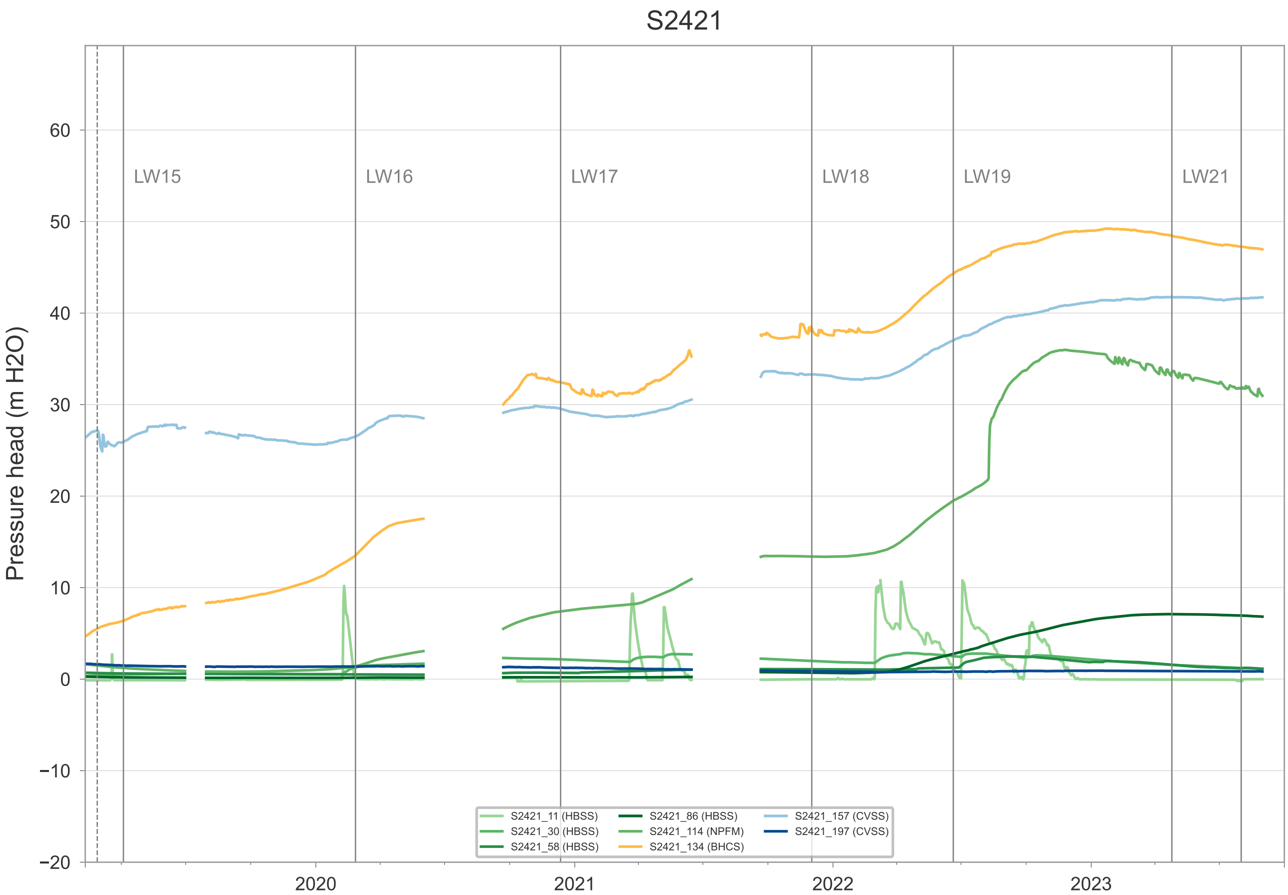
Groundwater hydrographs



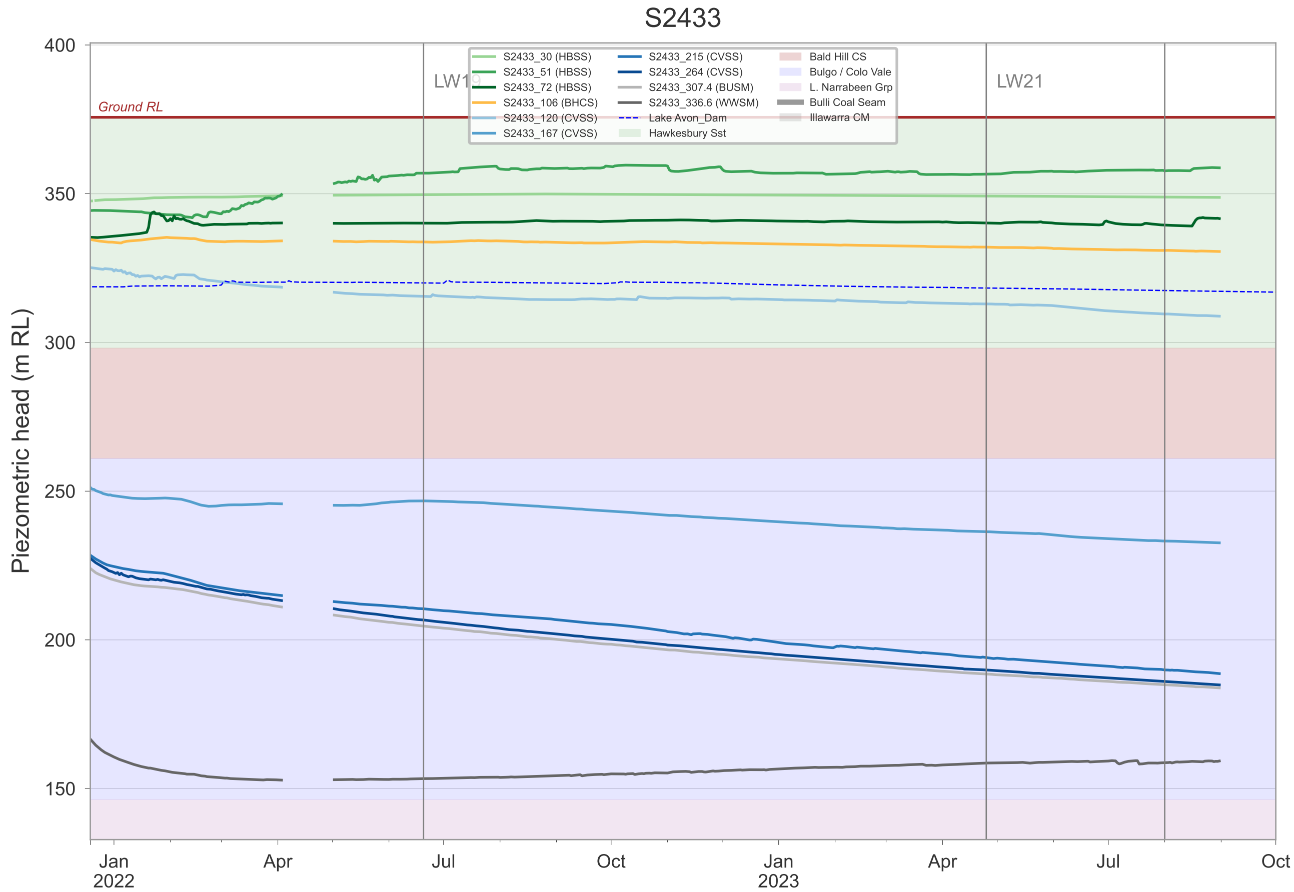


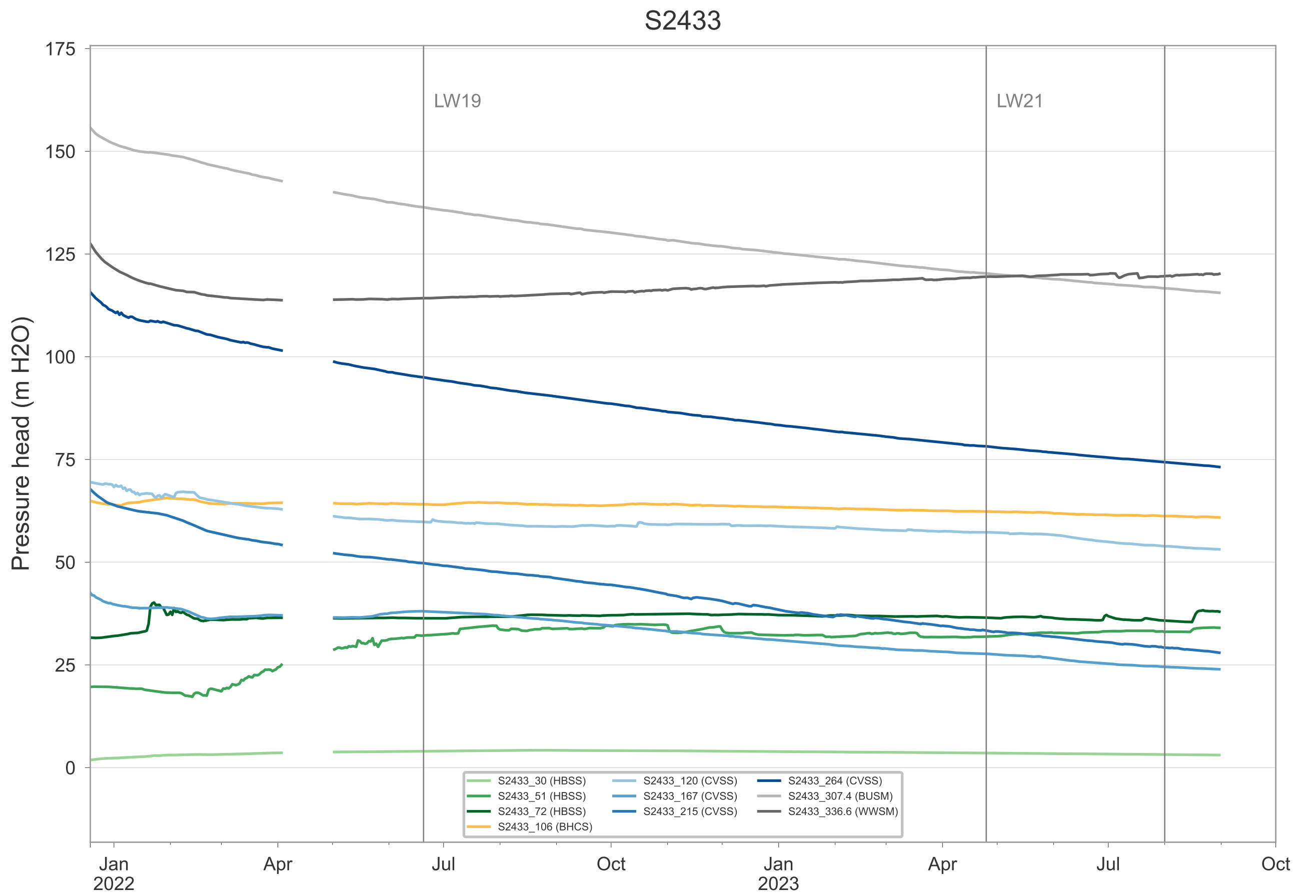
Groundwater hydrographs



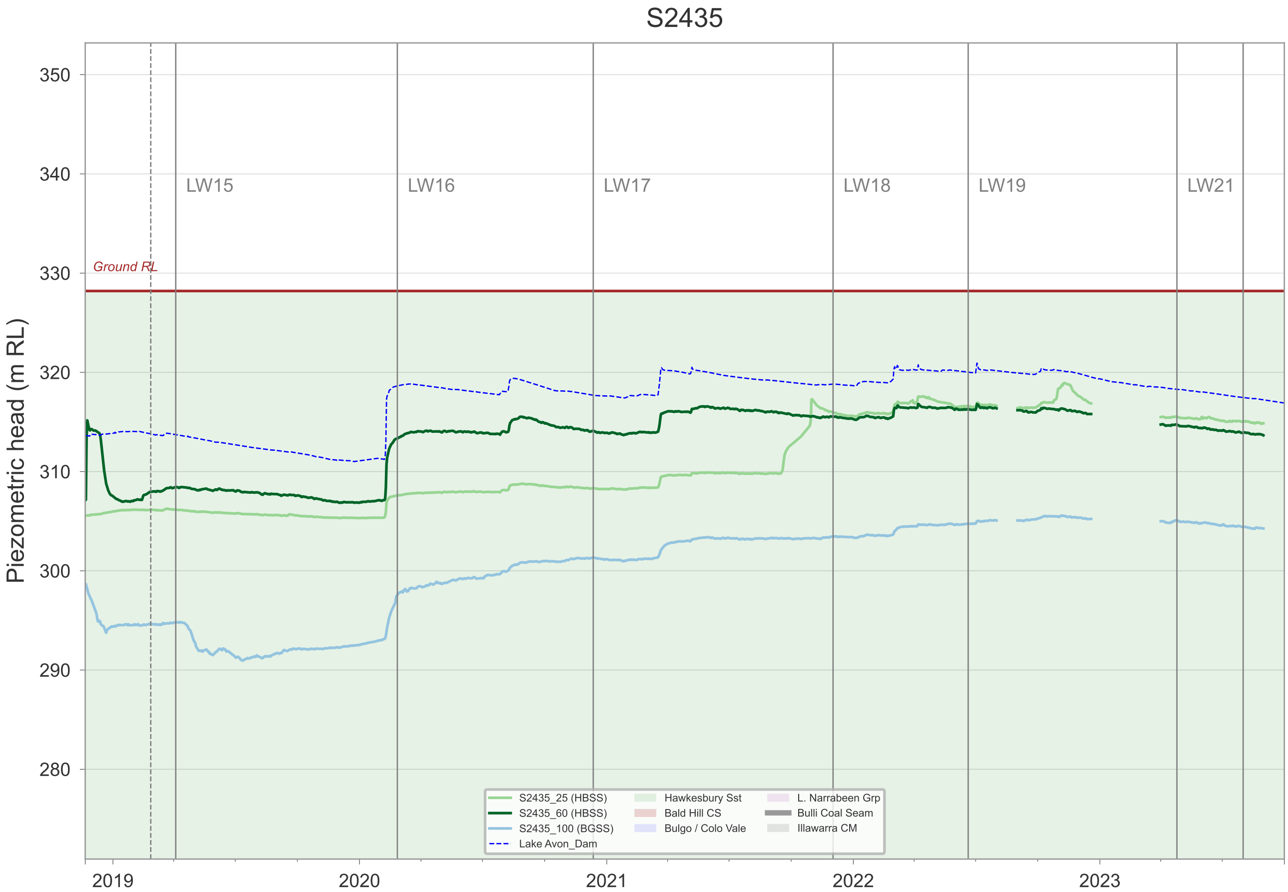


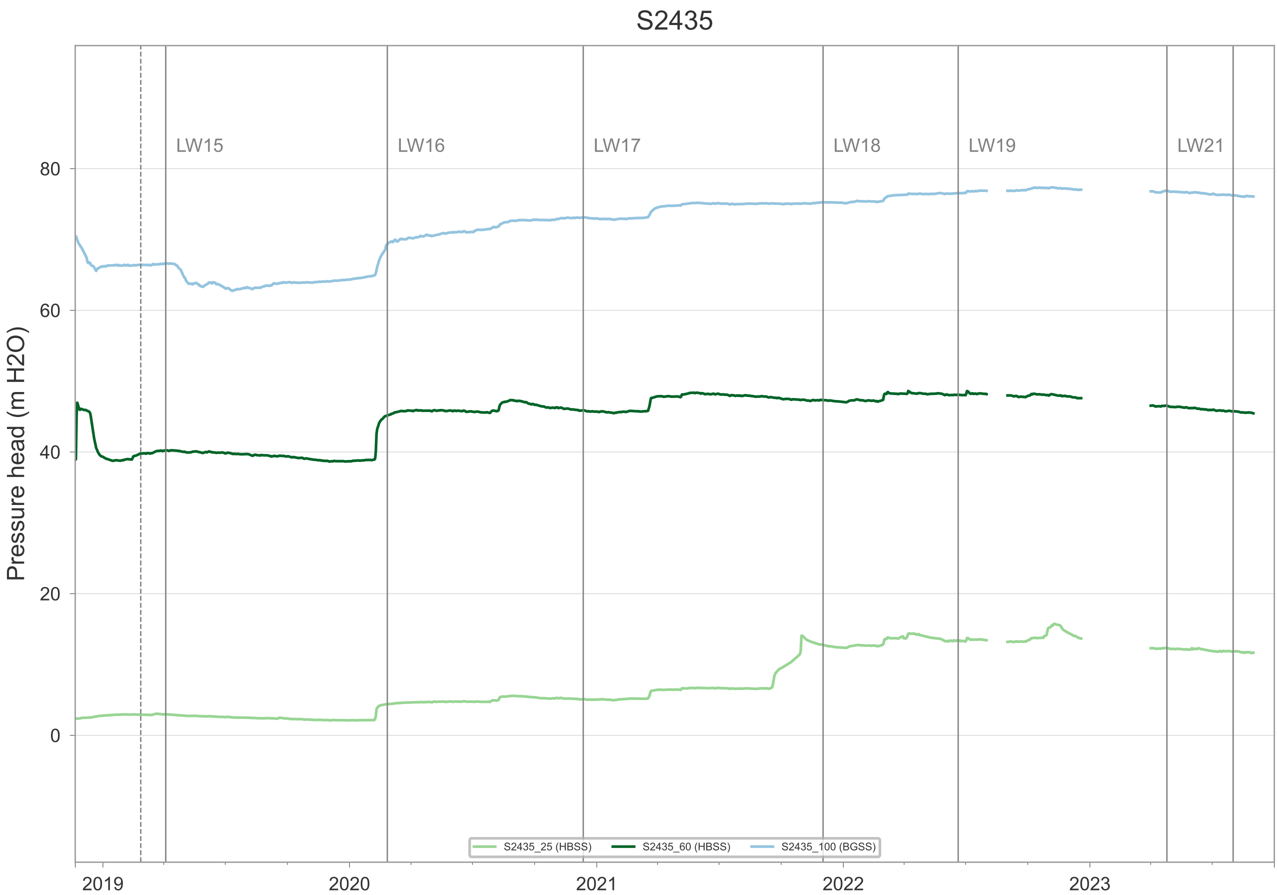
Groundwater hydrographs



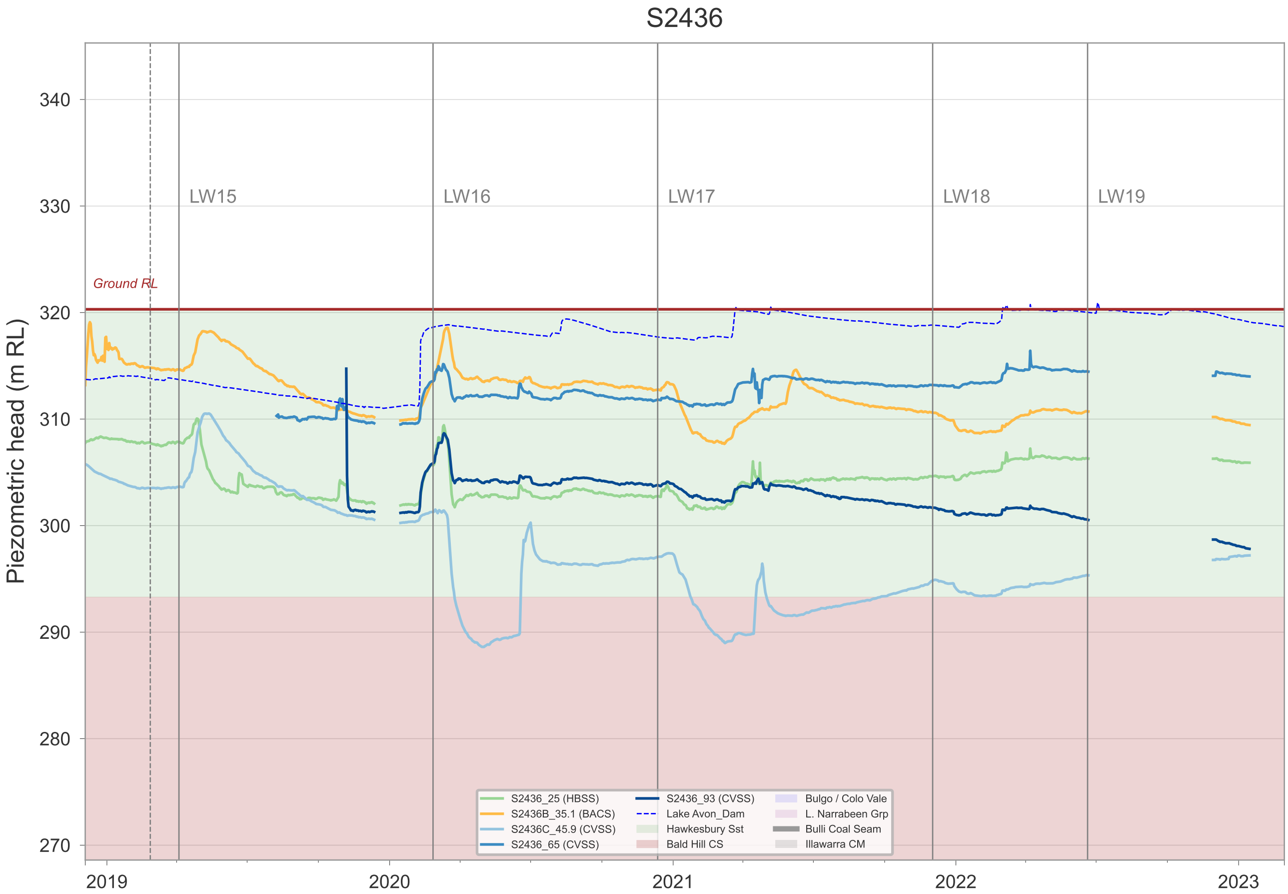


Groundwater hydrographs

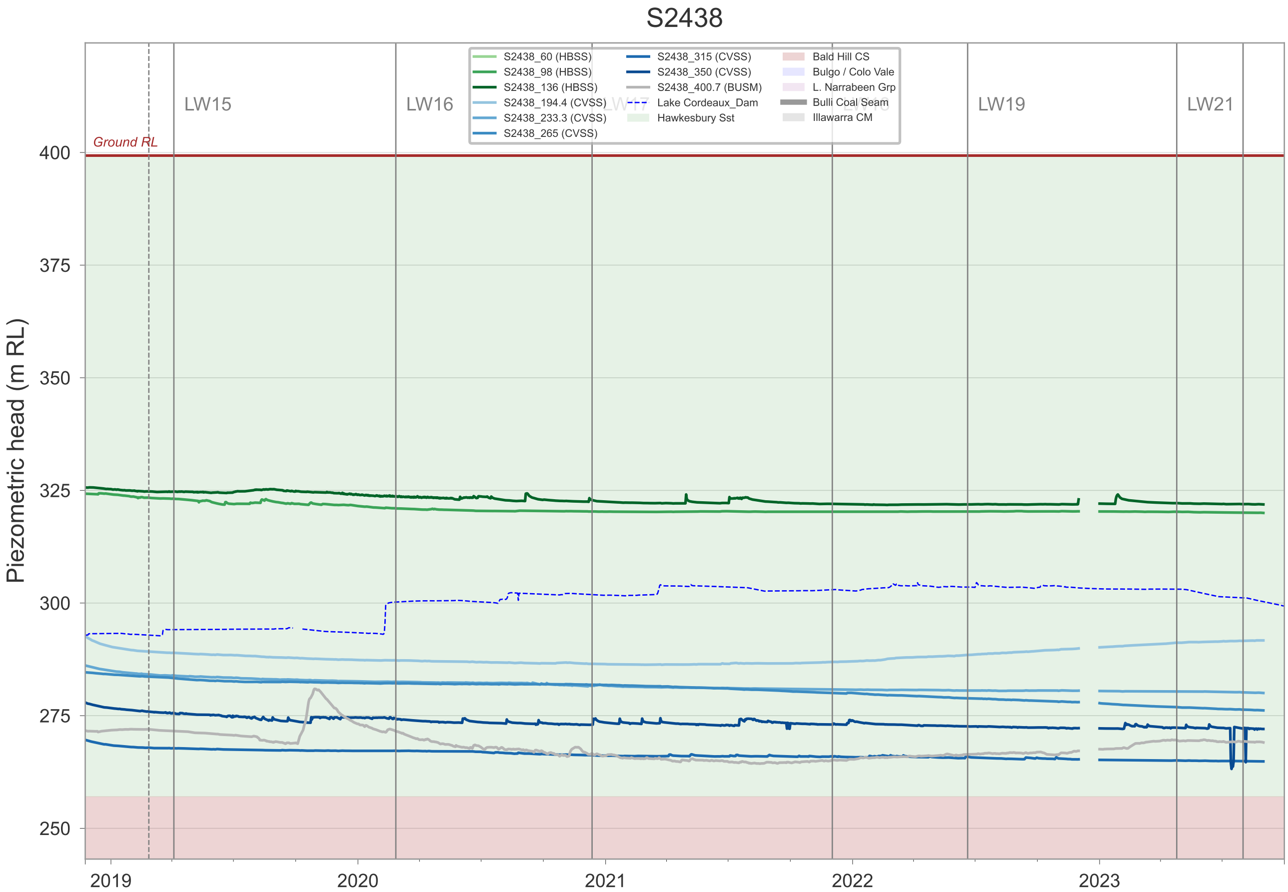


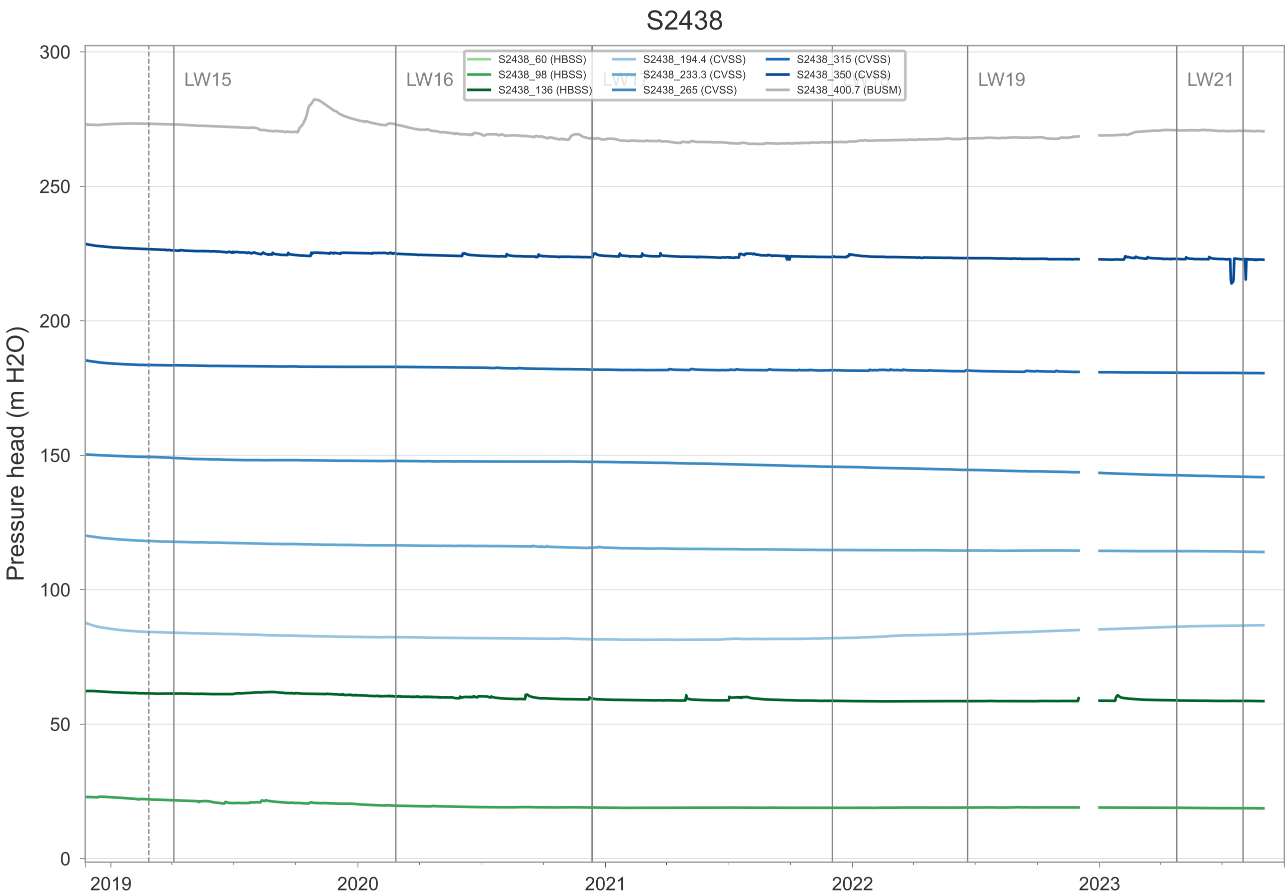


Groundwater hydrographs

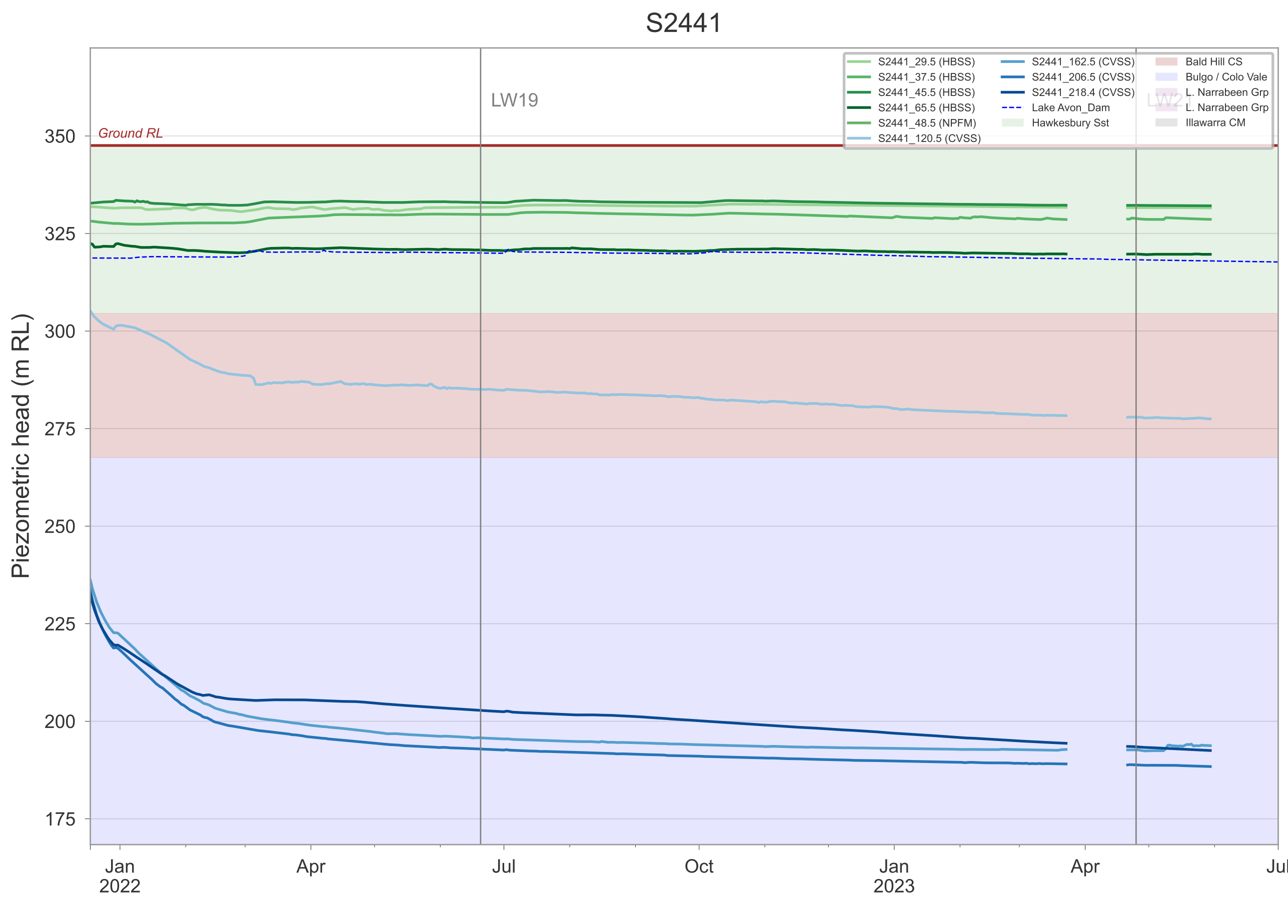


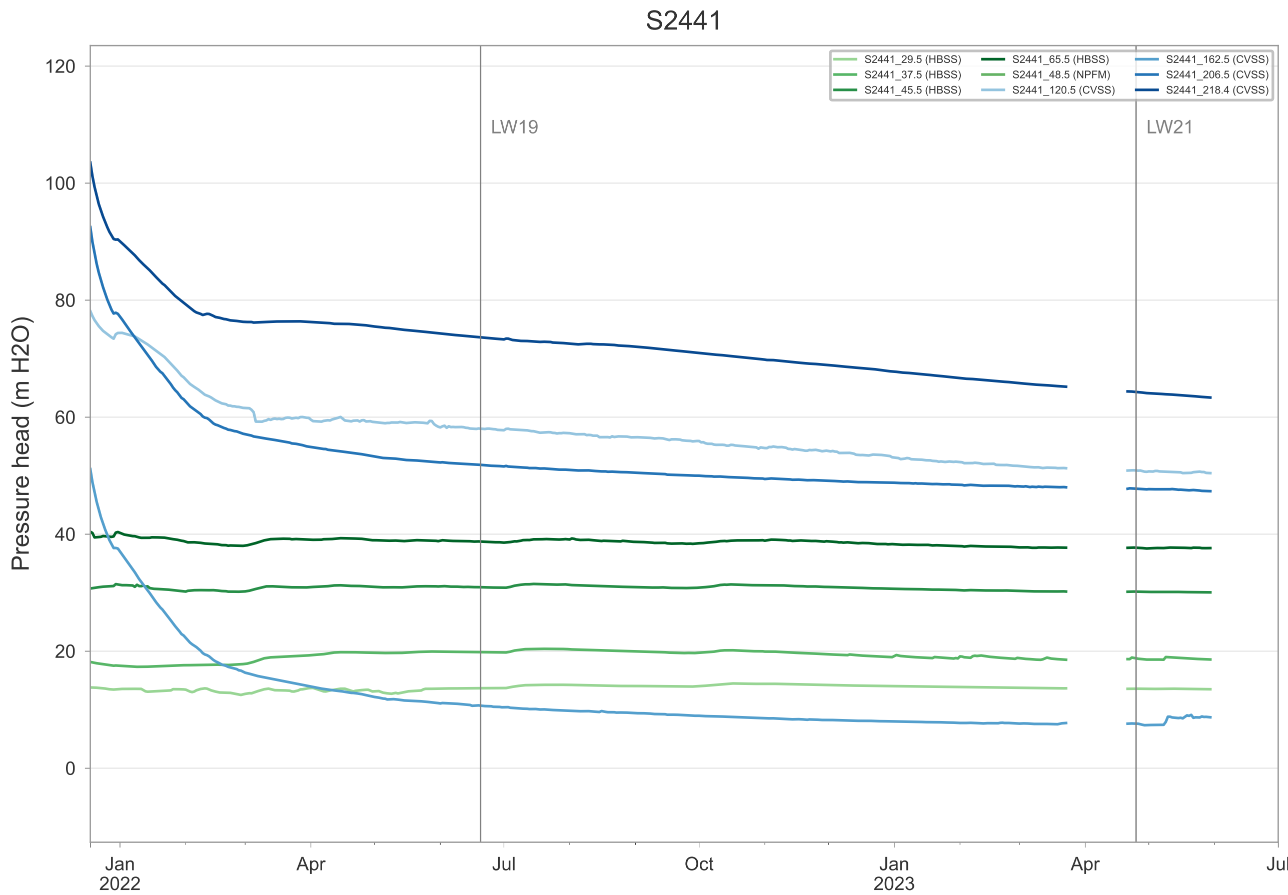
Groundwater hydrographs



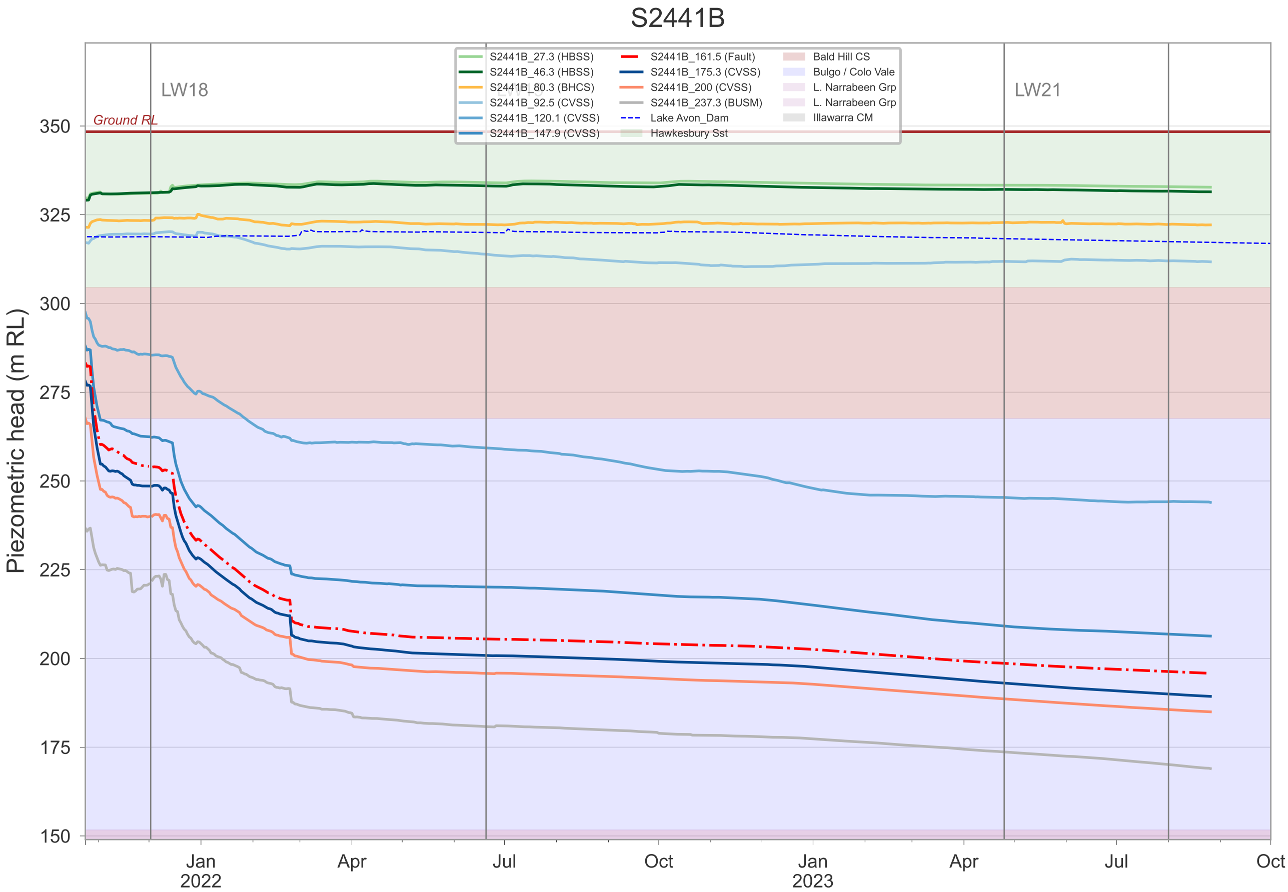


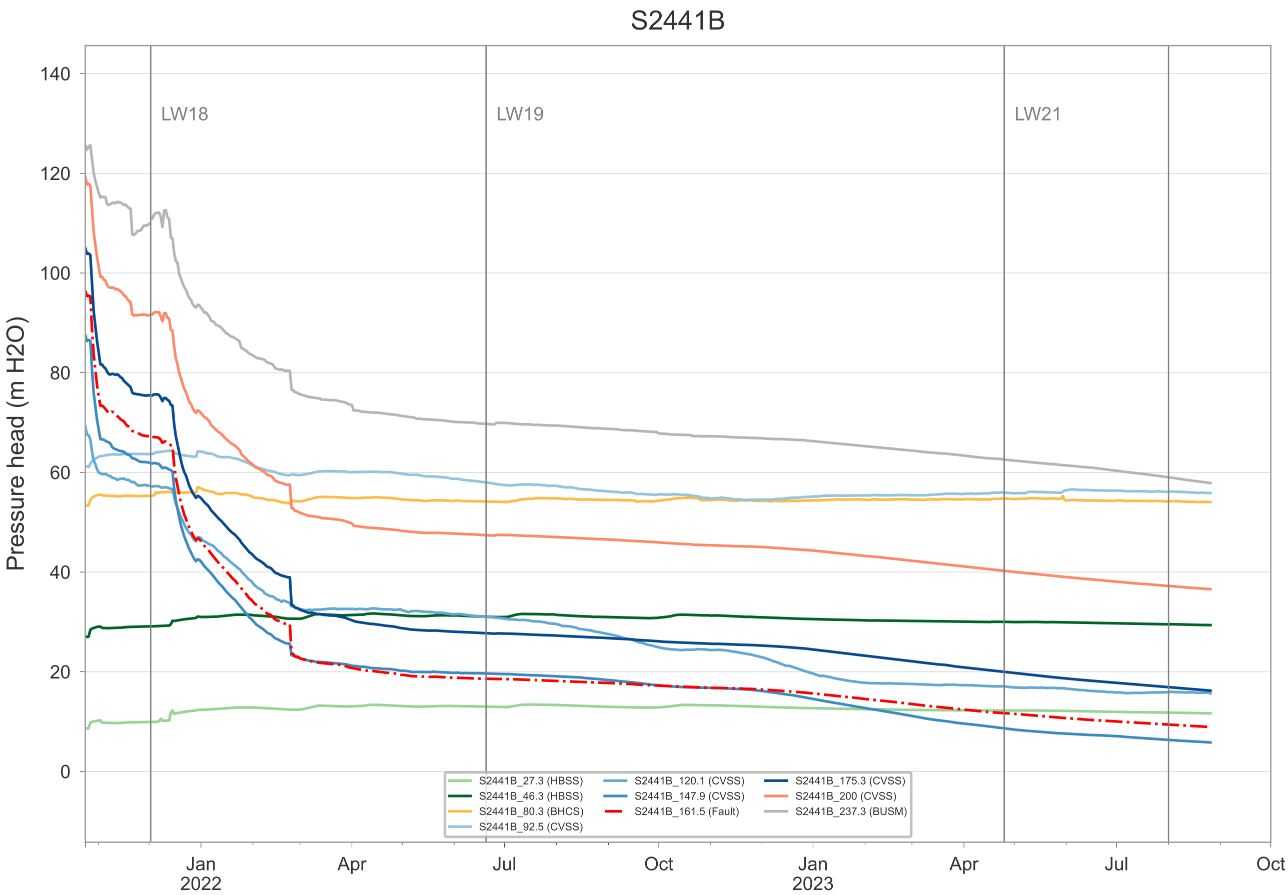
Groundwater hydrographs



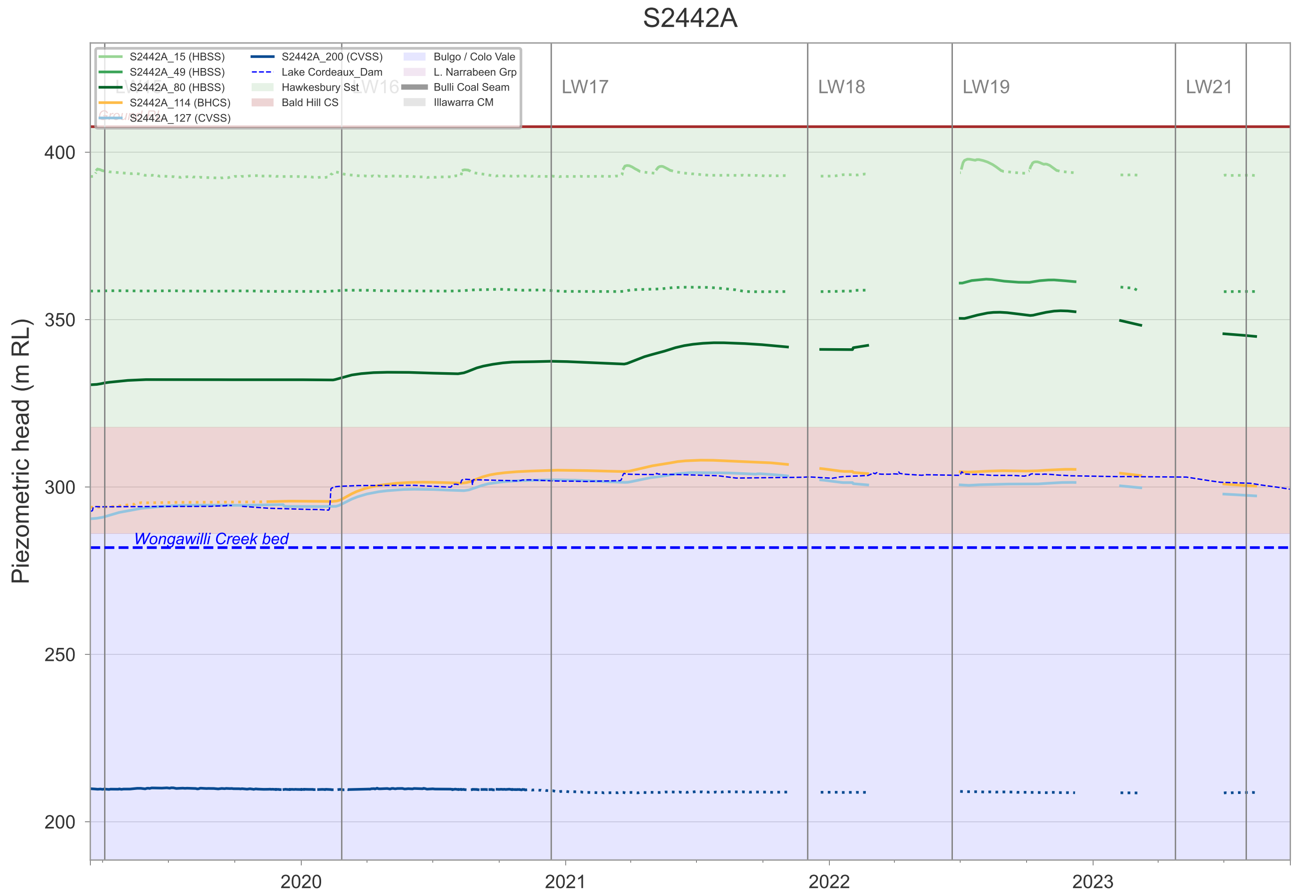


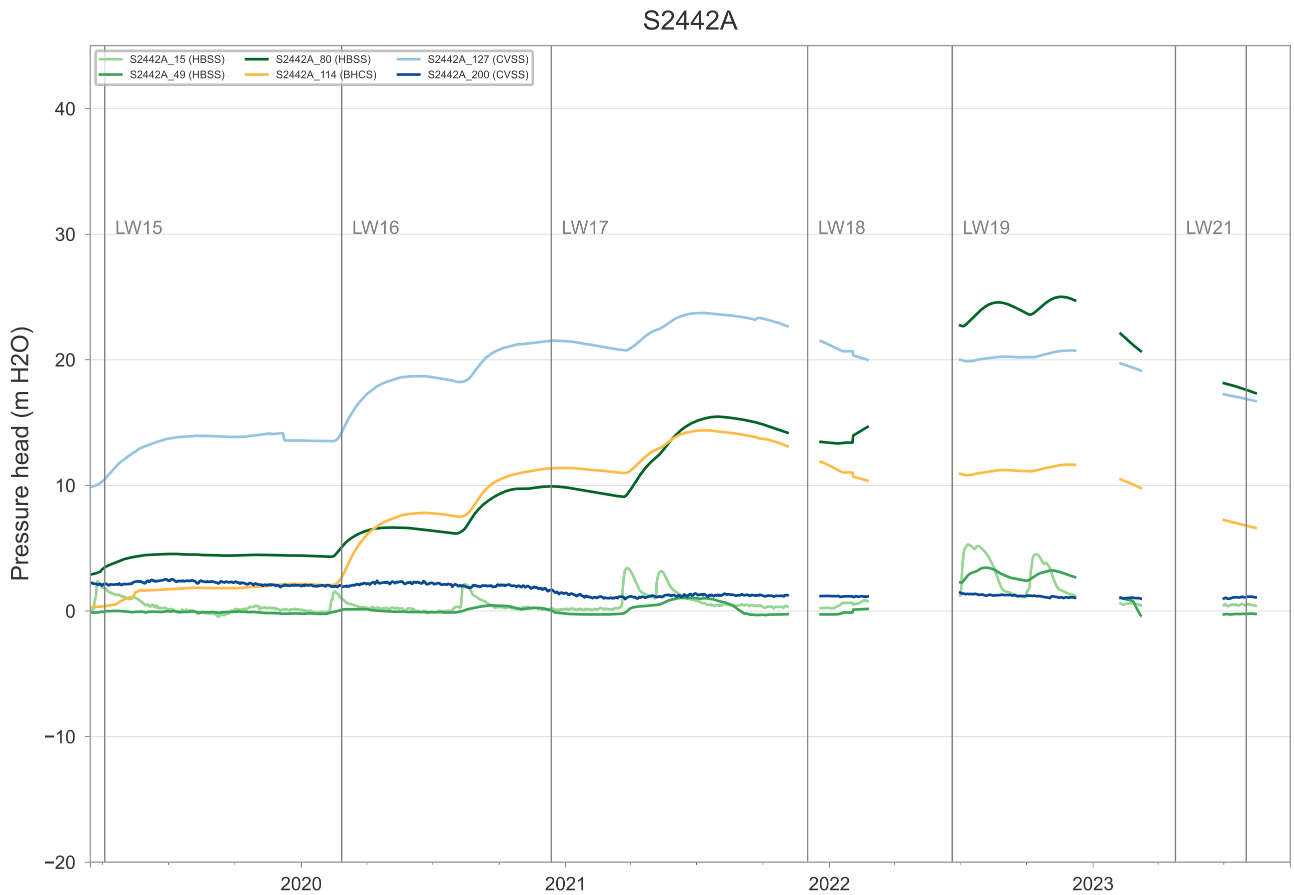
Groundwater hydrographs



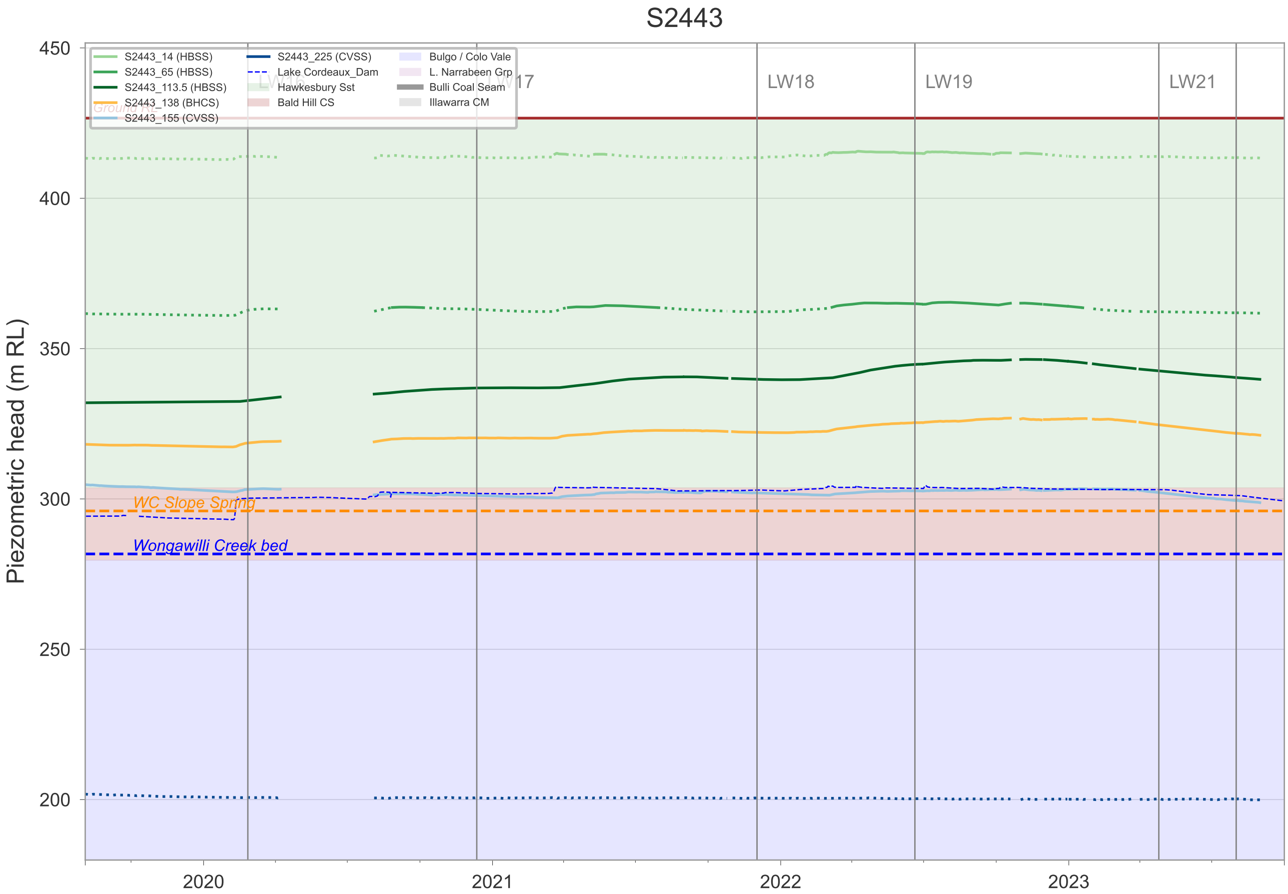


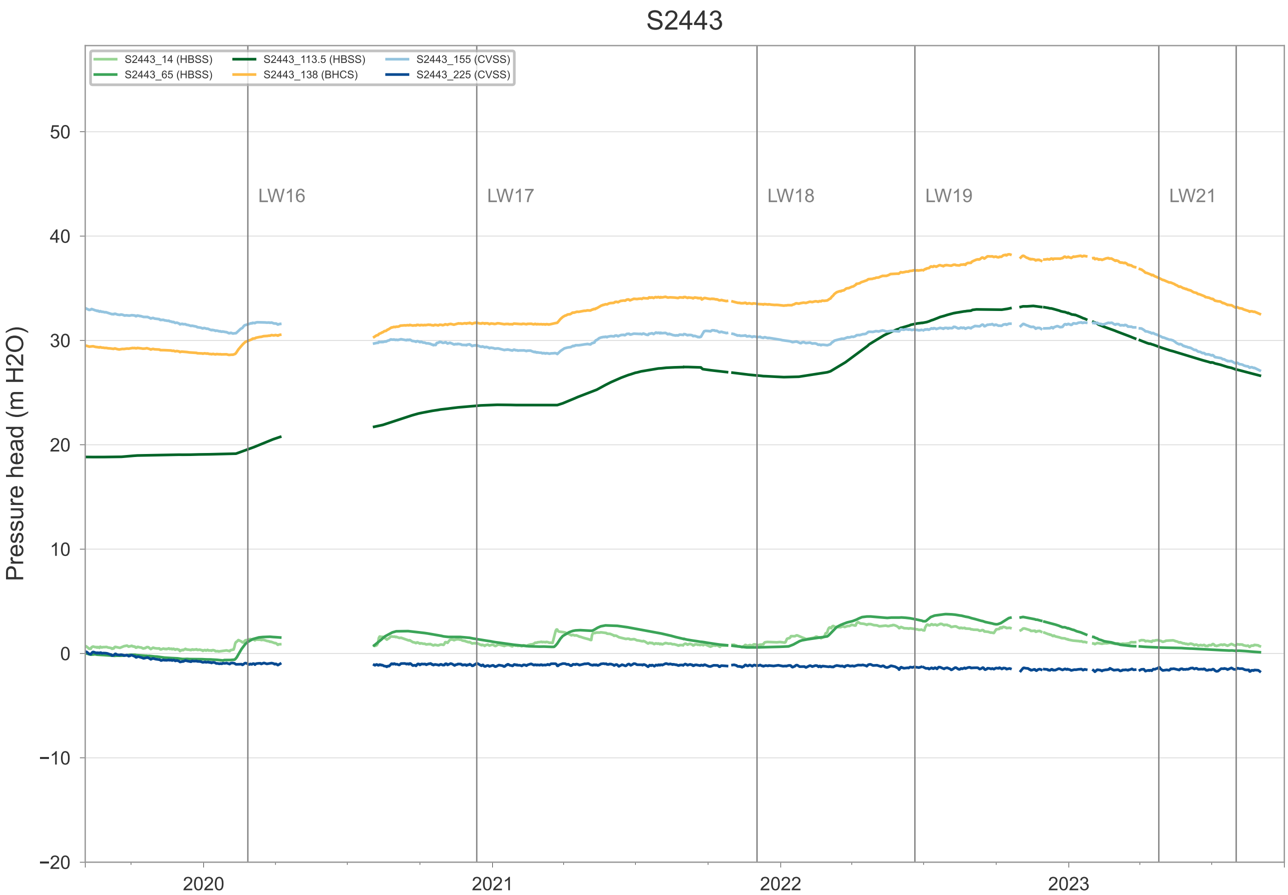
Groundwater hydrographs



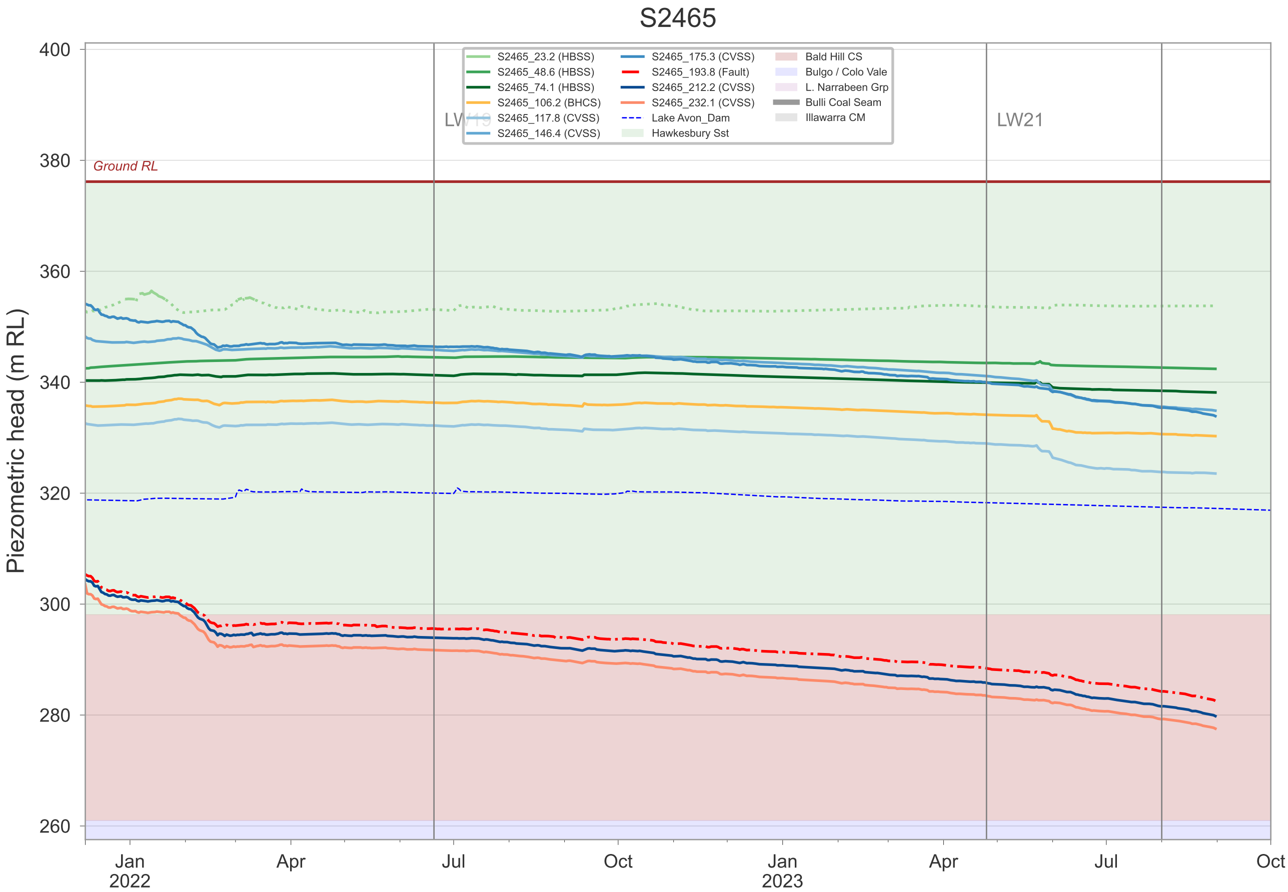


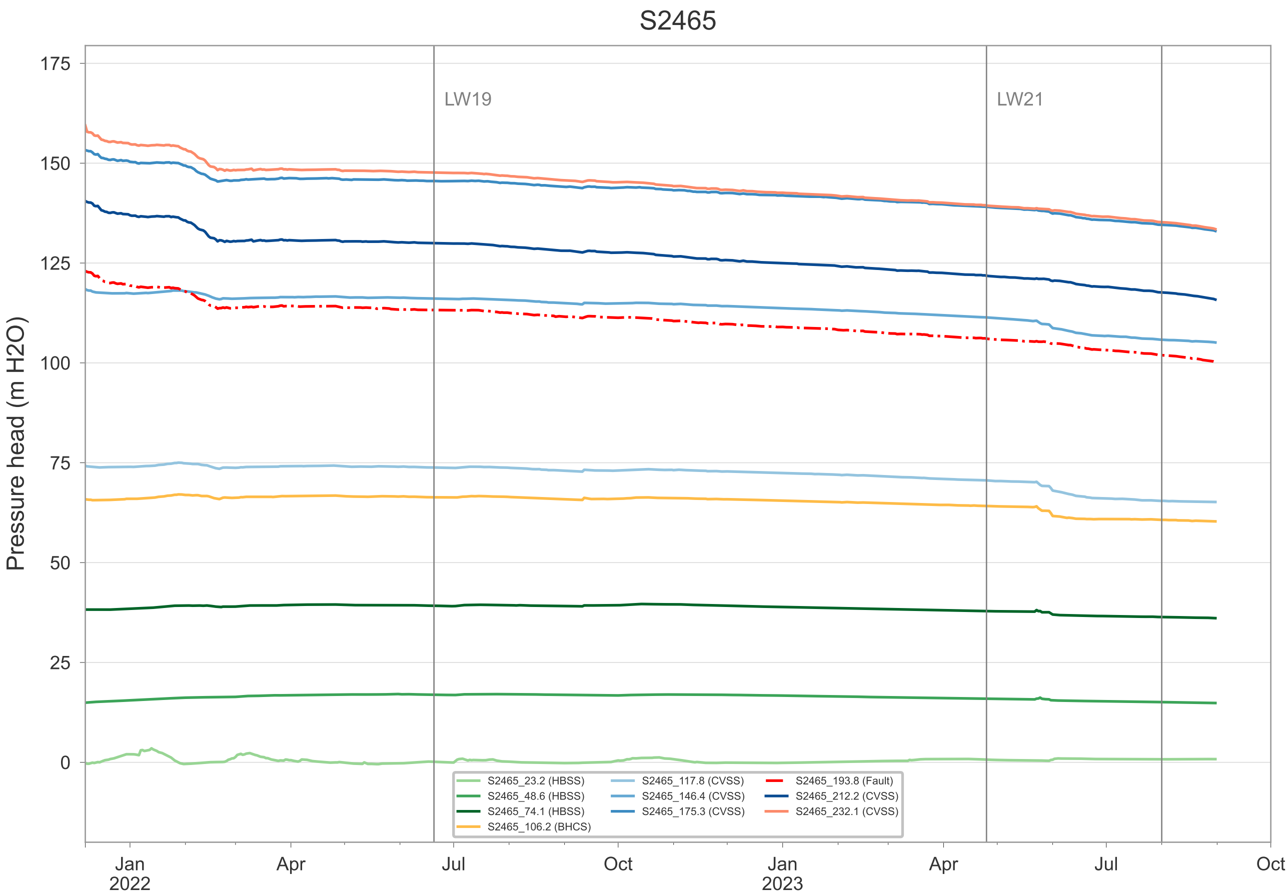
Groundwater hydrographs



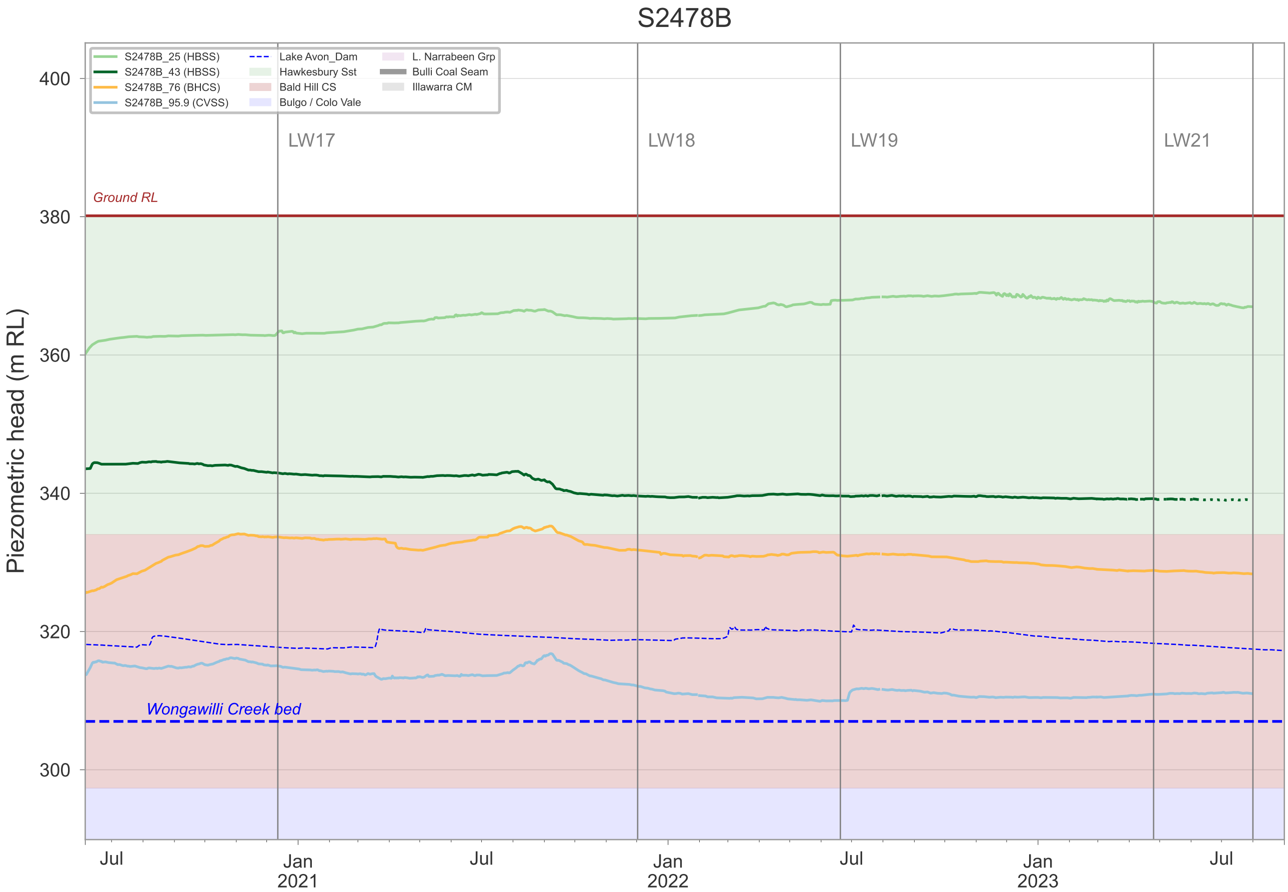


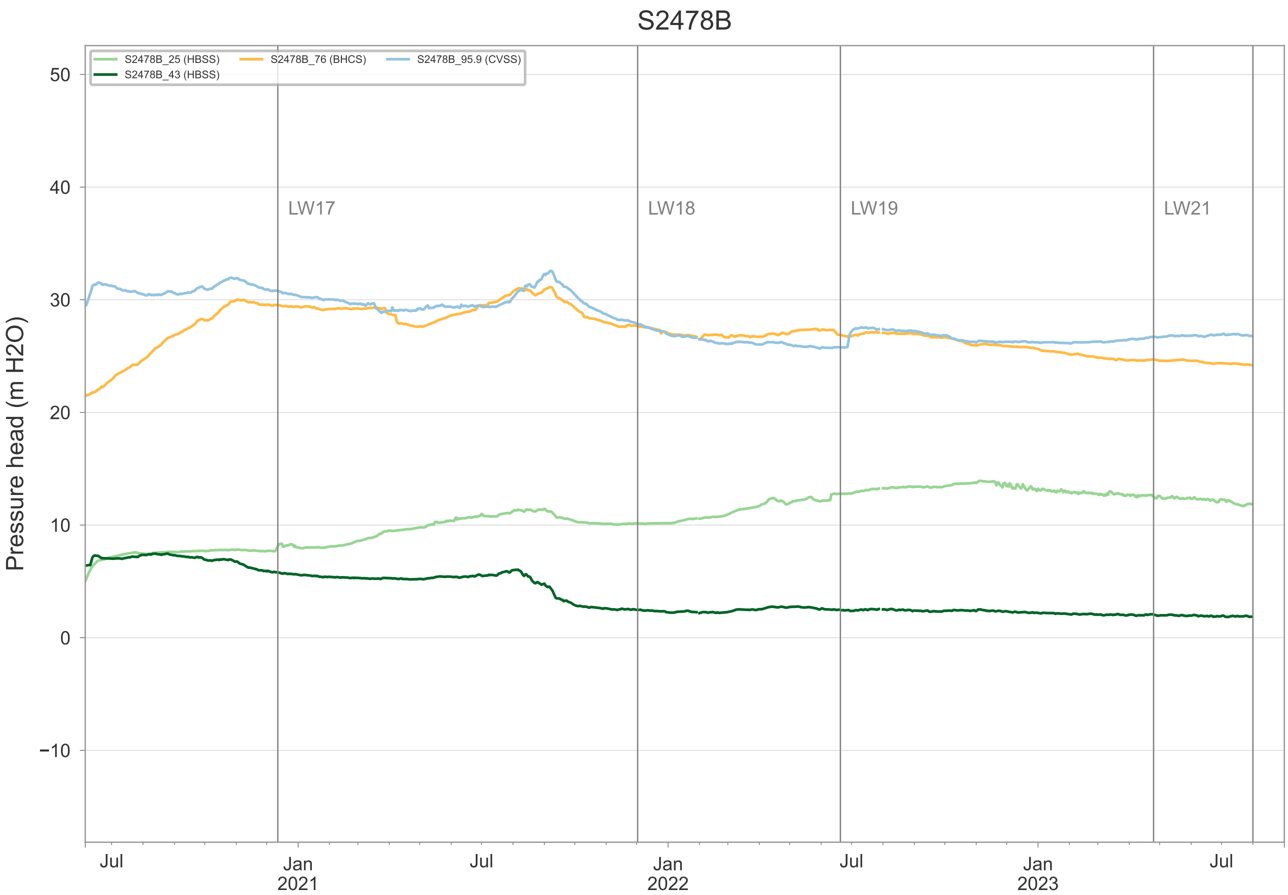
Groundwater hydrographs

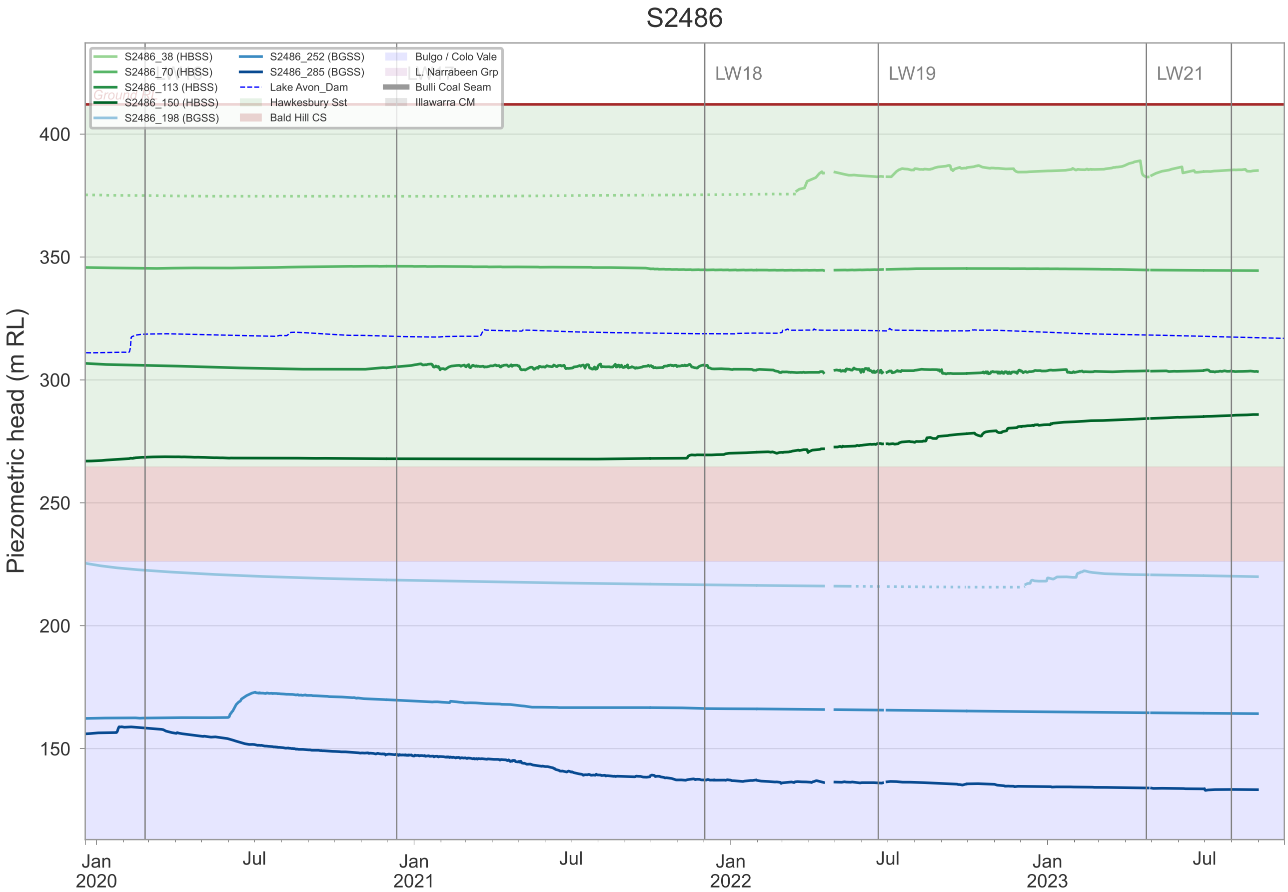


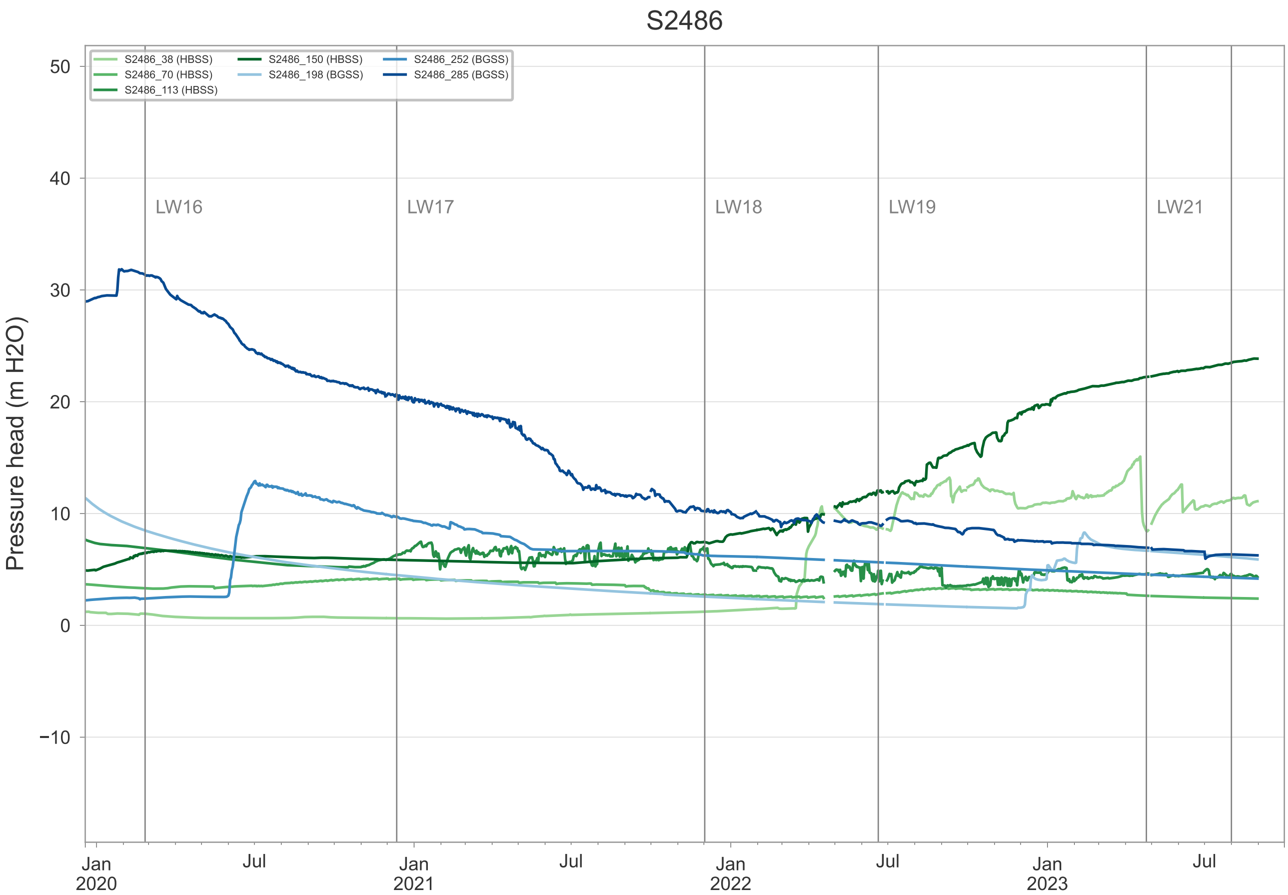


Groundwater hydrographs

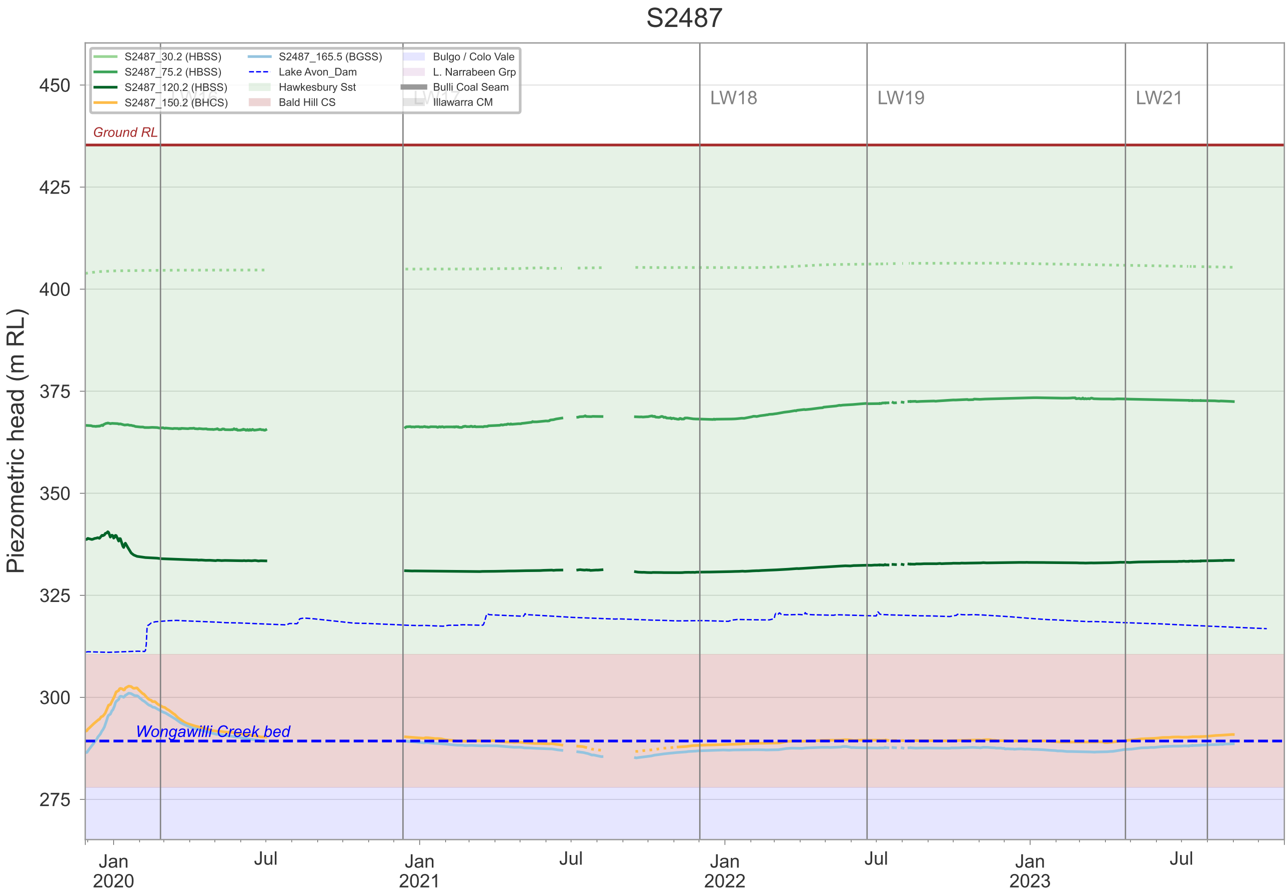


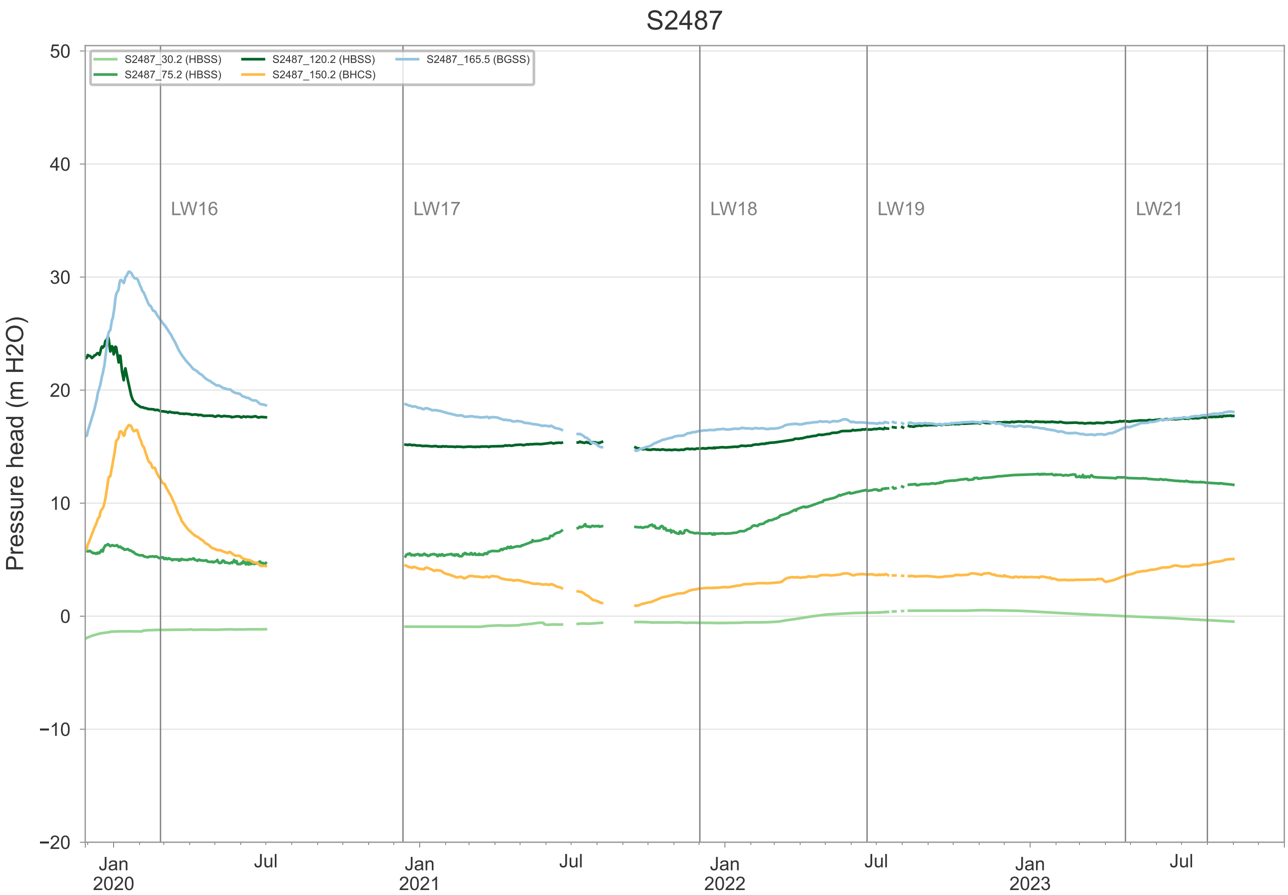



S2486
S2486_38 (HBSS)
S2486_70 (HBSS)
S2486_113 (HBSS)
S2486_150 (HBSS)
S2486_198 (BGSS)
S2486_252 (BGSS)
S2486_285 (BGSS)
Lake Avon_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM
LW18
LW19
LW21
Piezometric head (m RL)
400
350
300
250
200
150
Jan 2020
Jul
Jan 2021
Jul
Jan 2022
Jul
Jan 2023
Jul

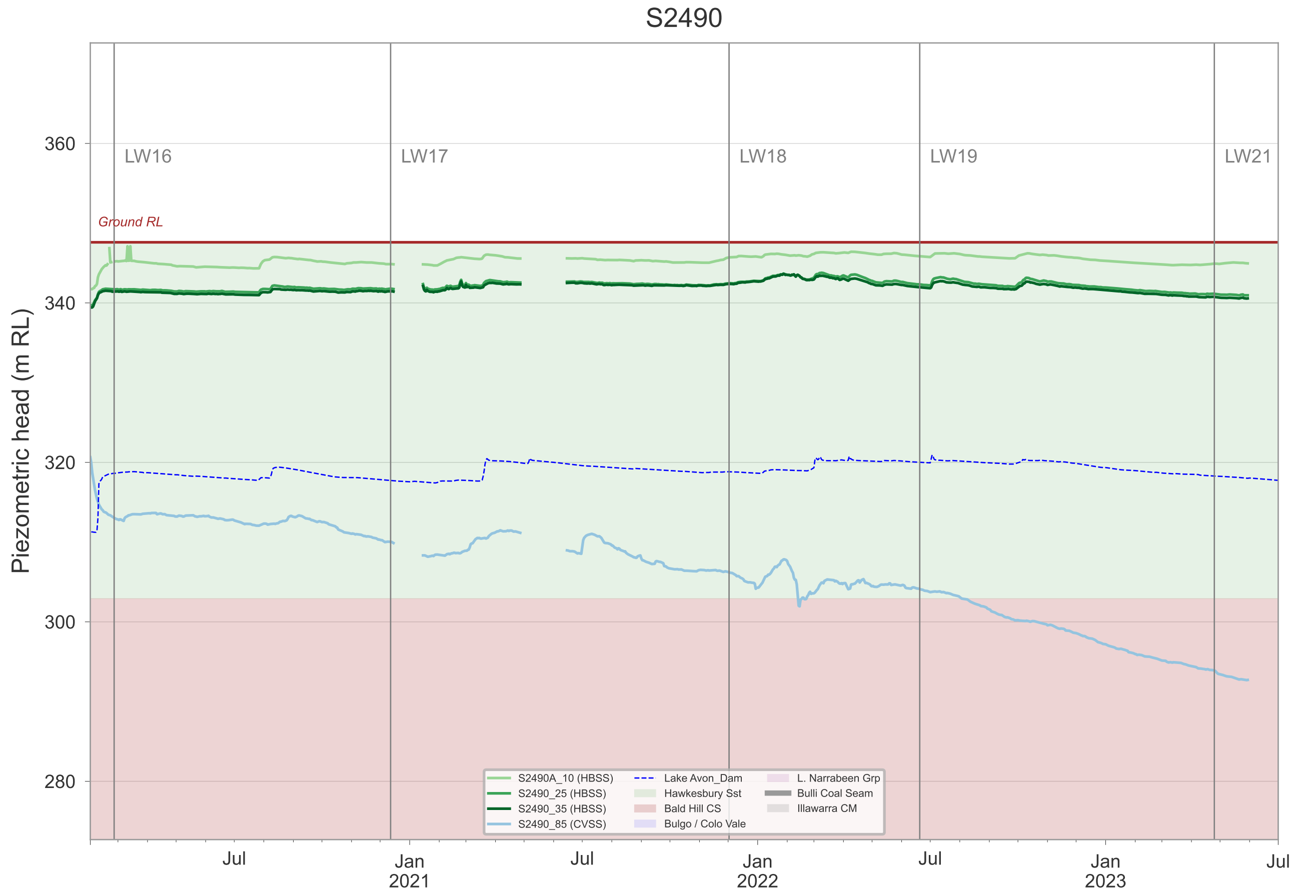

S2486
S2486_38 (HBSS)
S2486_70 (HBSS)
S2486_113 (HBSS)
S2486_150 (HBSS)
S2486_198 (BGSS)
S2486_252 (BGSS)
S2486_285 (BGSS)
LW16
LW17
LW18
LW19
LW21
Pressure head (m H2O)
50
40
30
20
10
0
−10
Jan 2020
Jul
Jan 2021
Jul
Jan 2022
Jul
Jan 2023
Jul

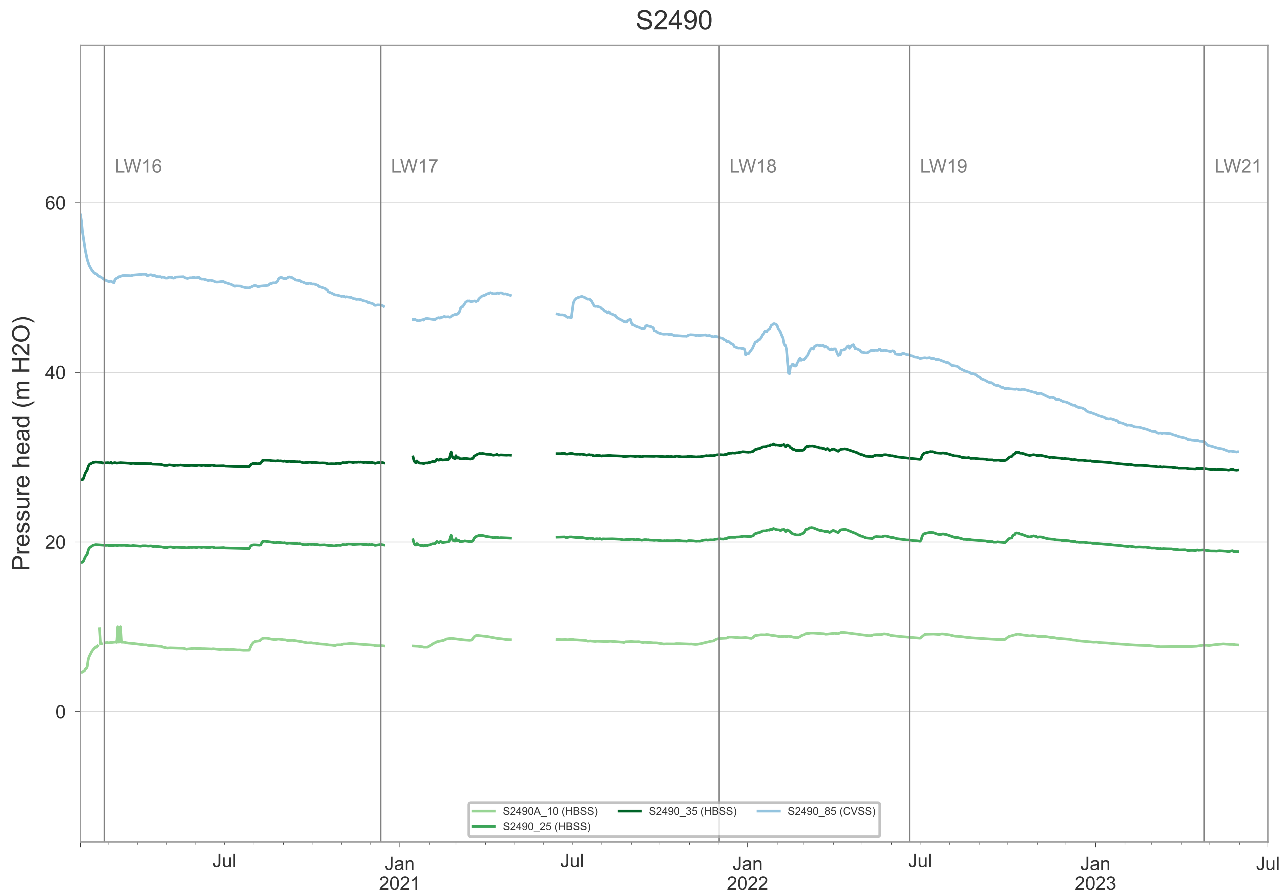
Groundwater hydrographs



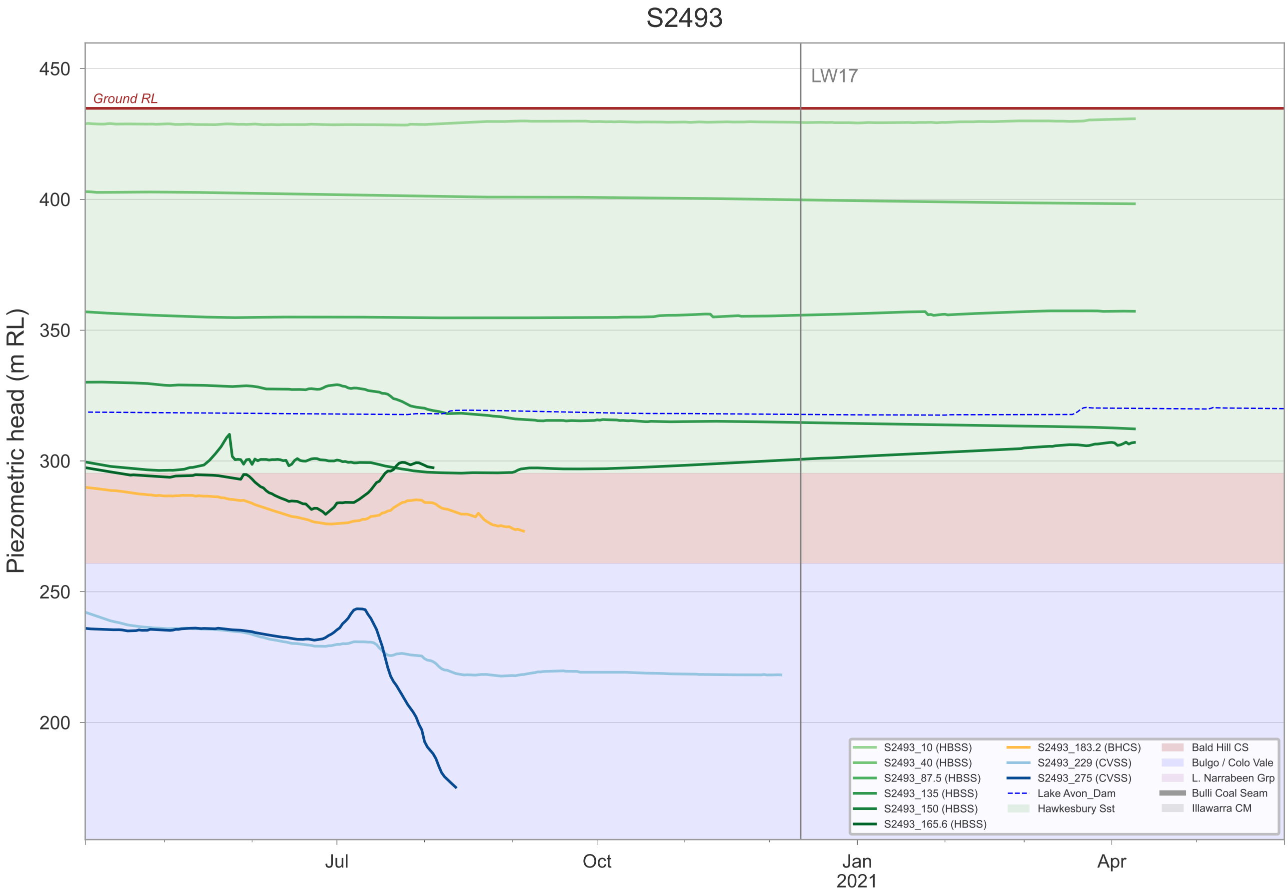


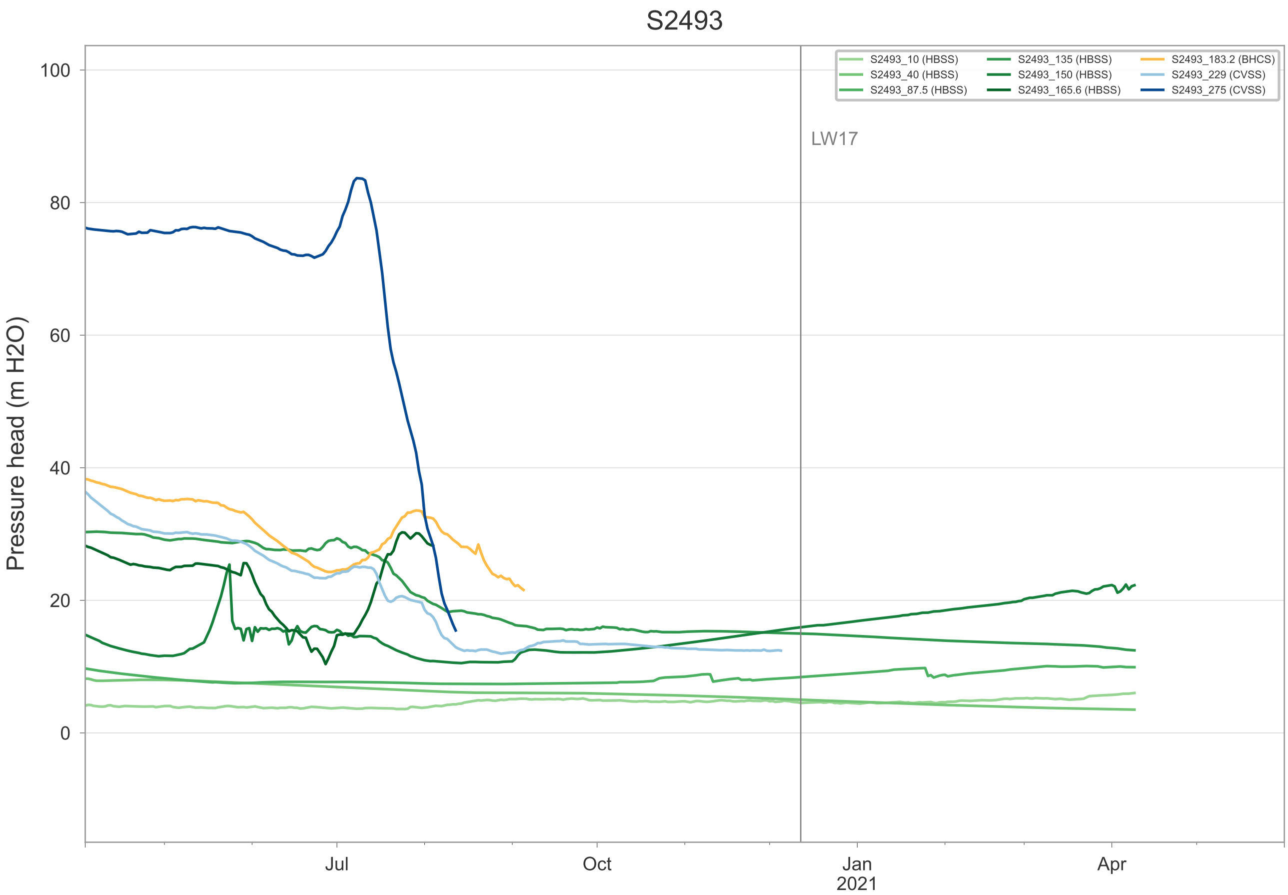
Groundwater hydrographs



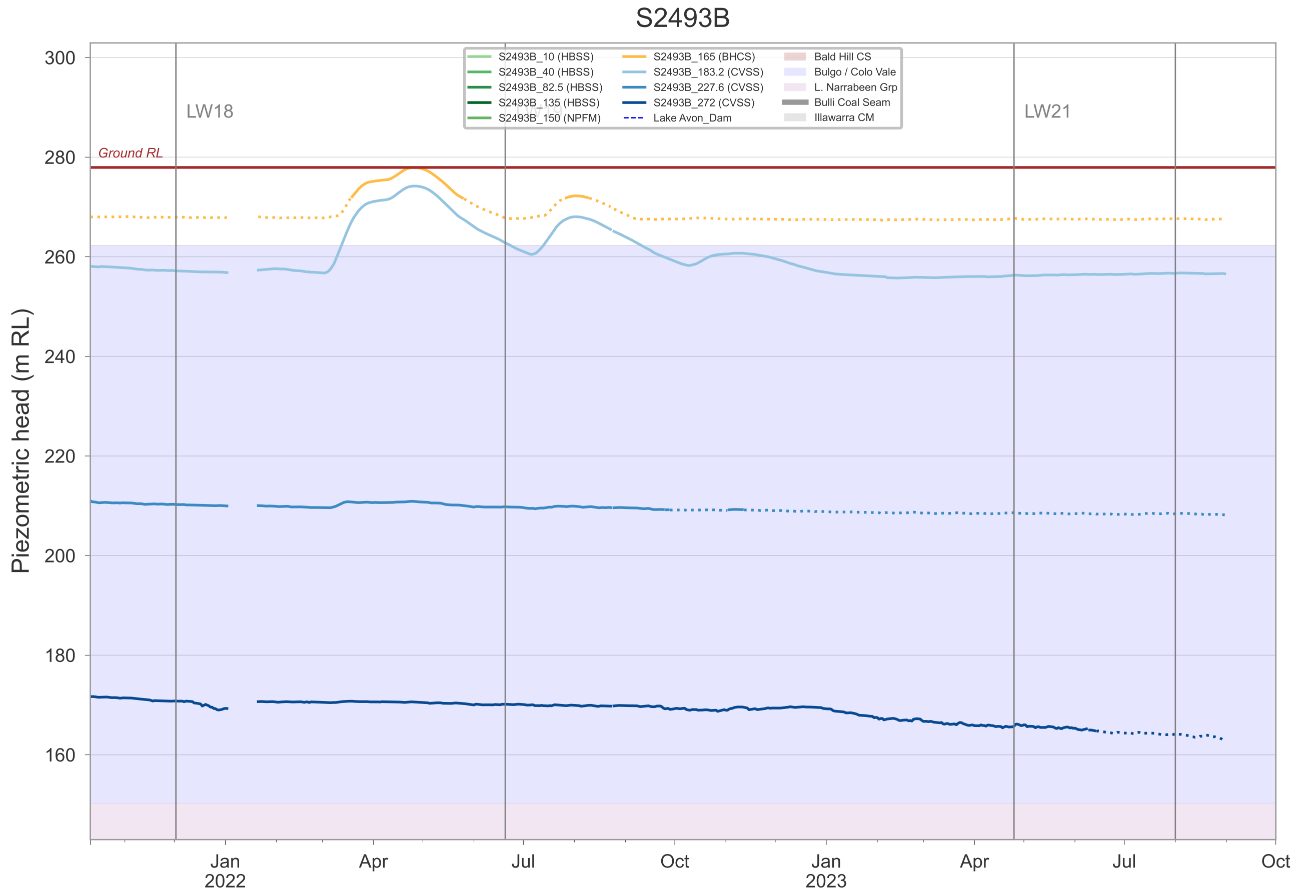


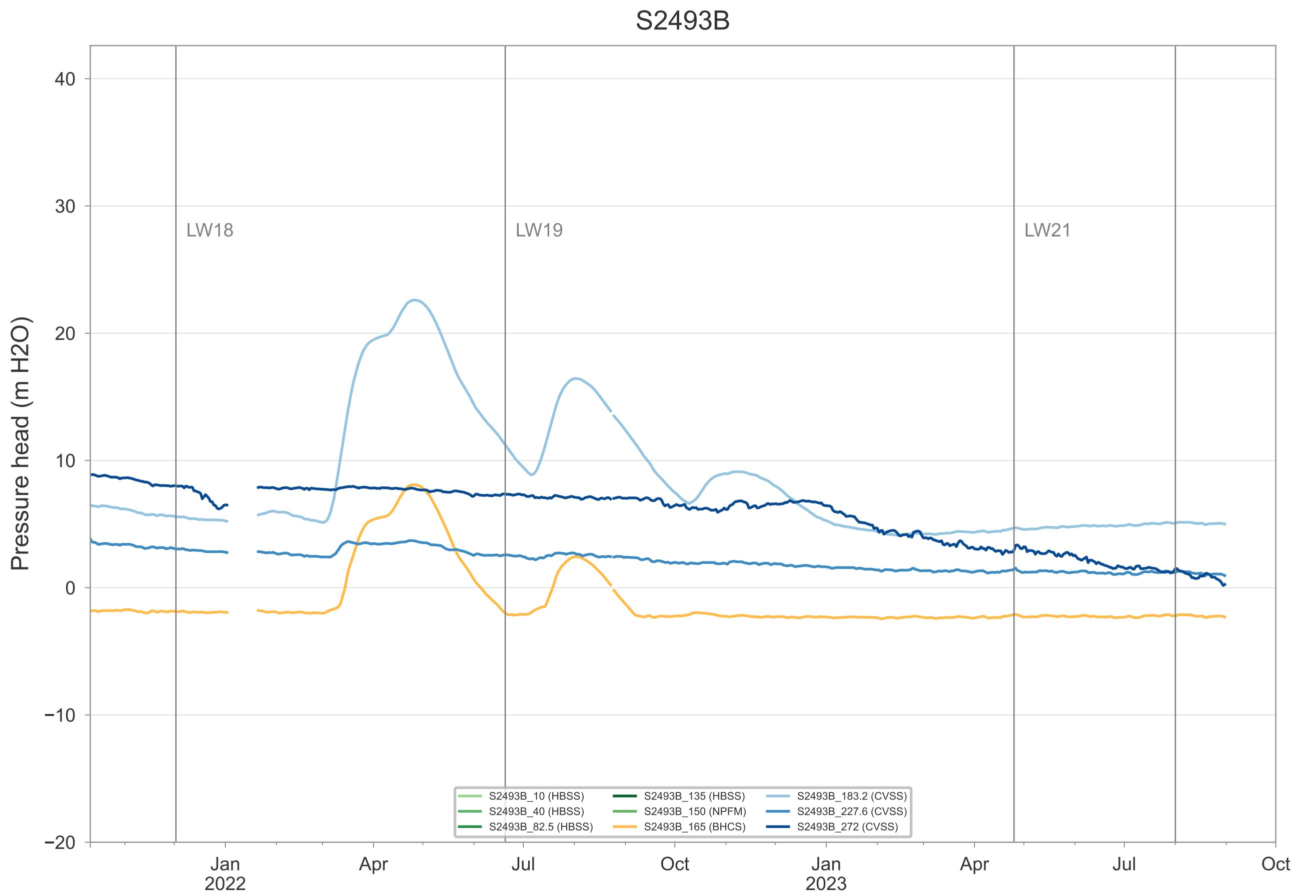
Groundwater hydrographs



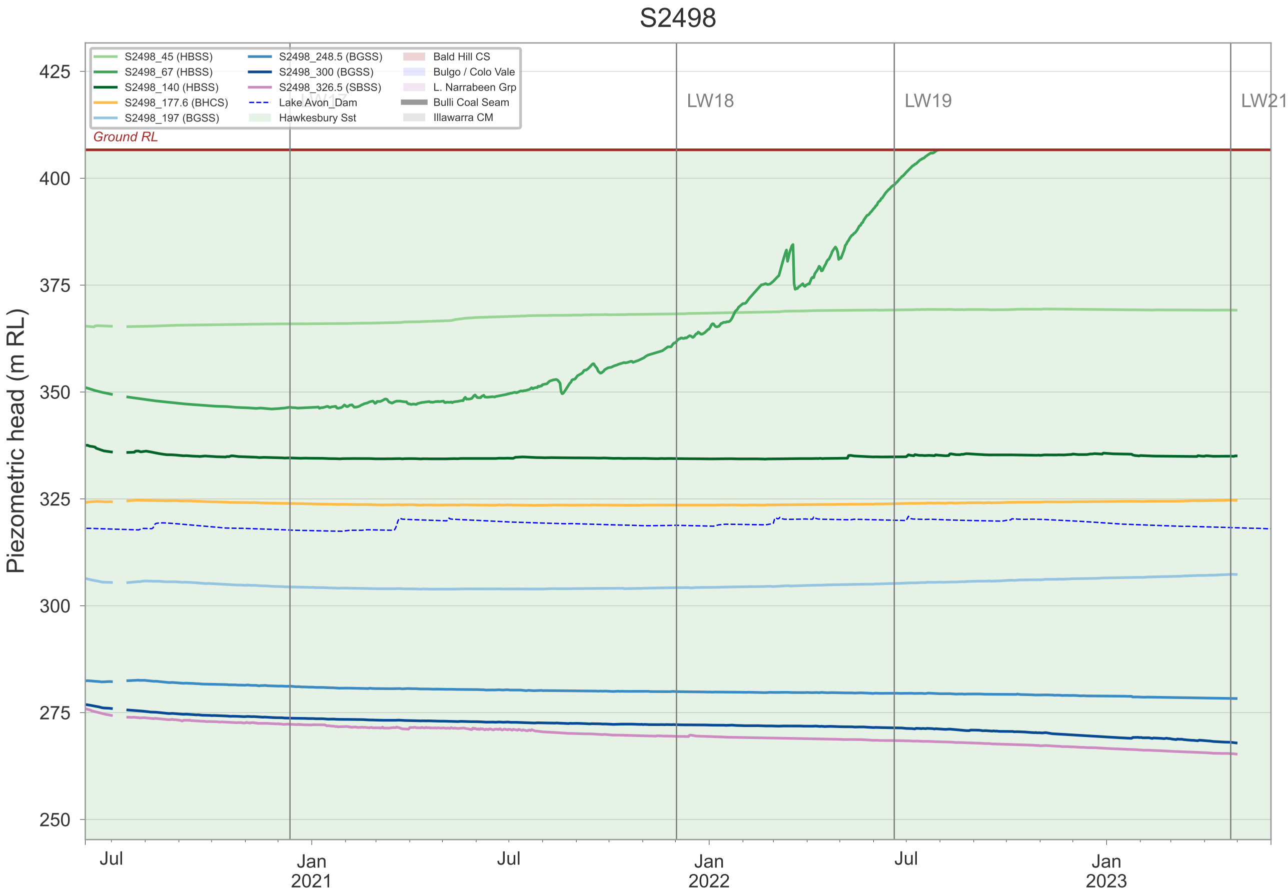


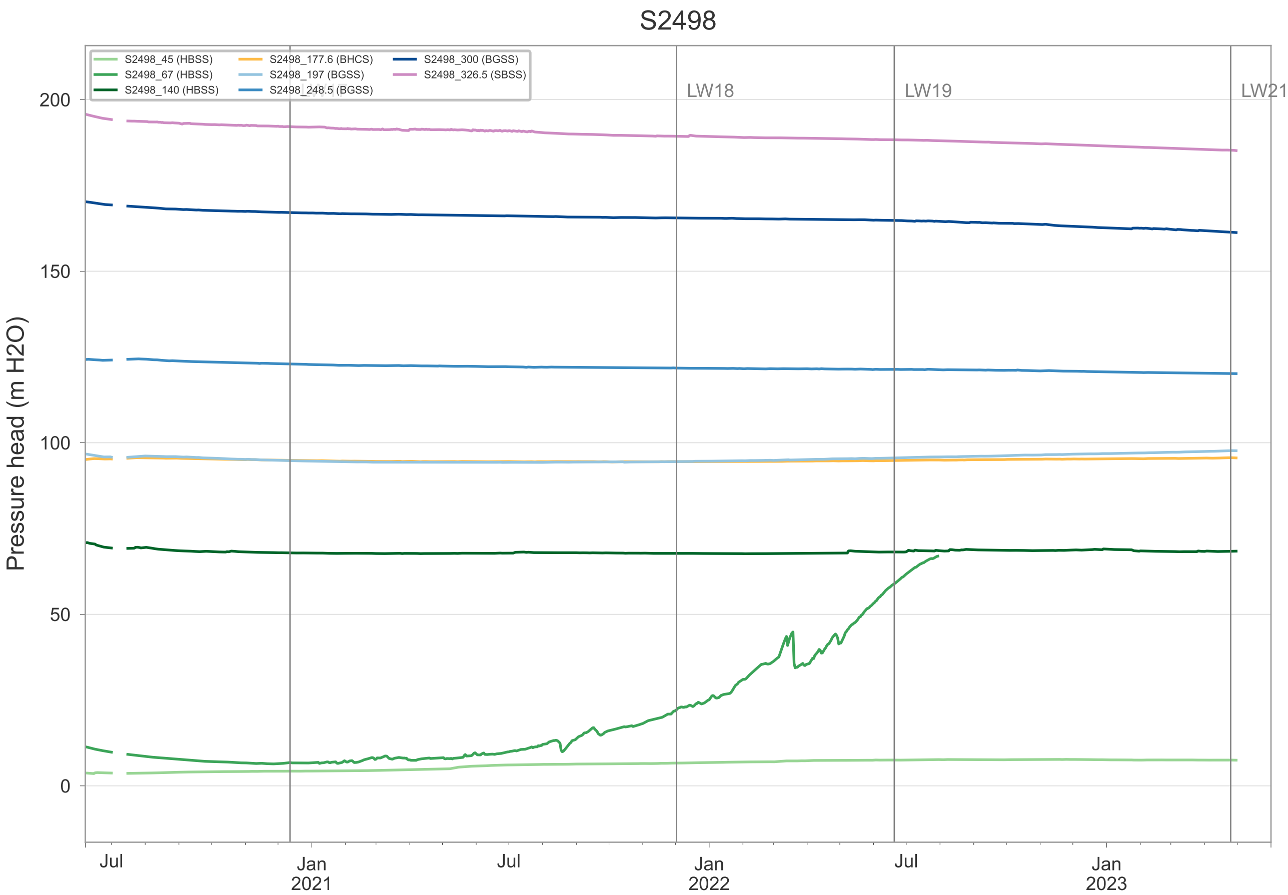
Groundwater hydrographs



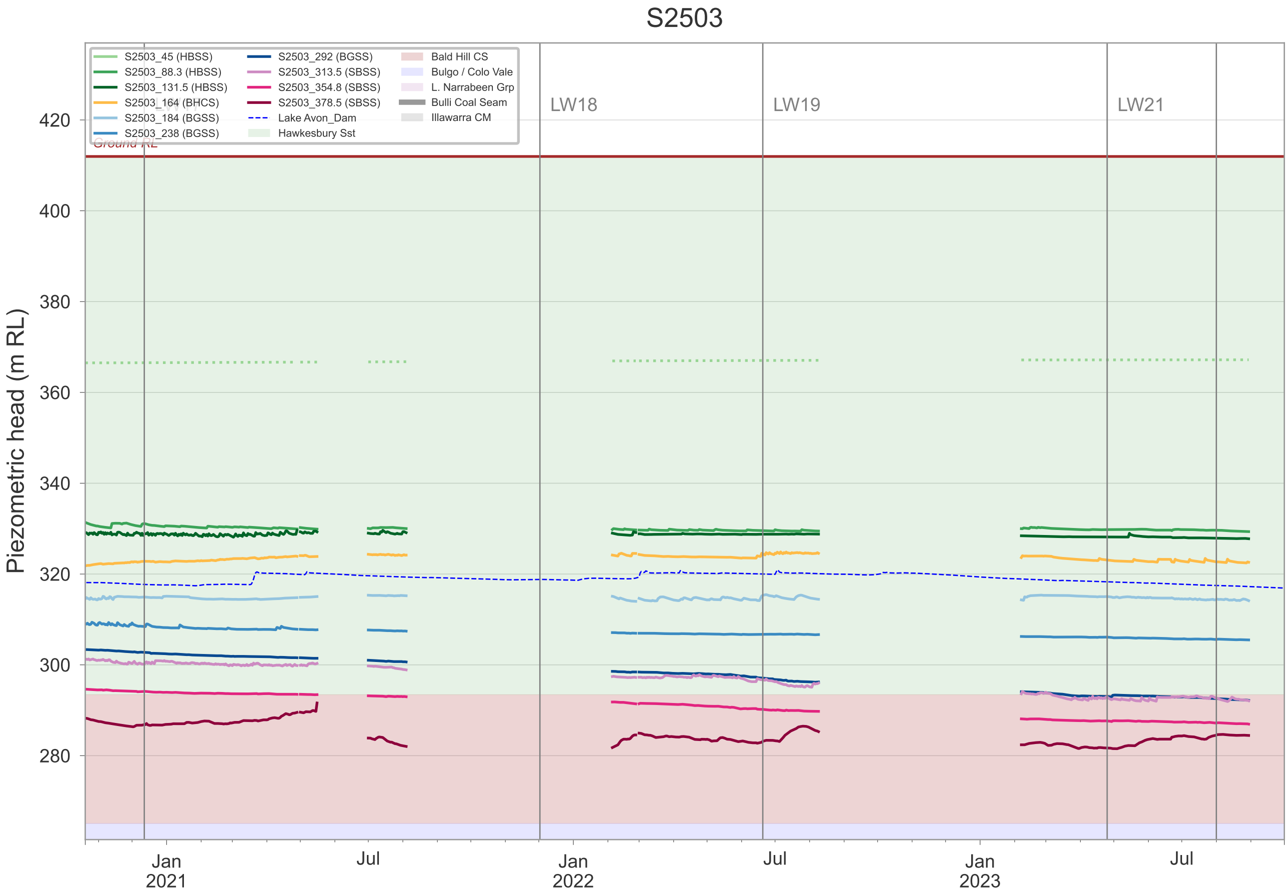


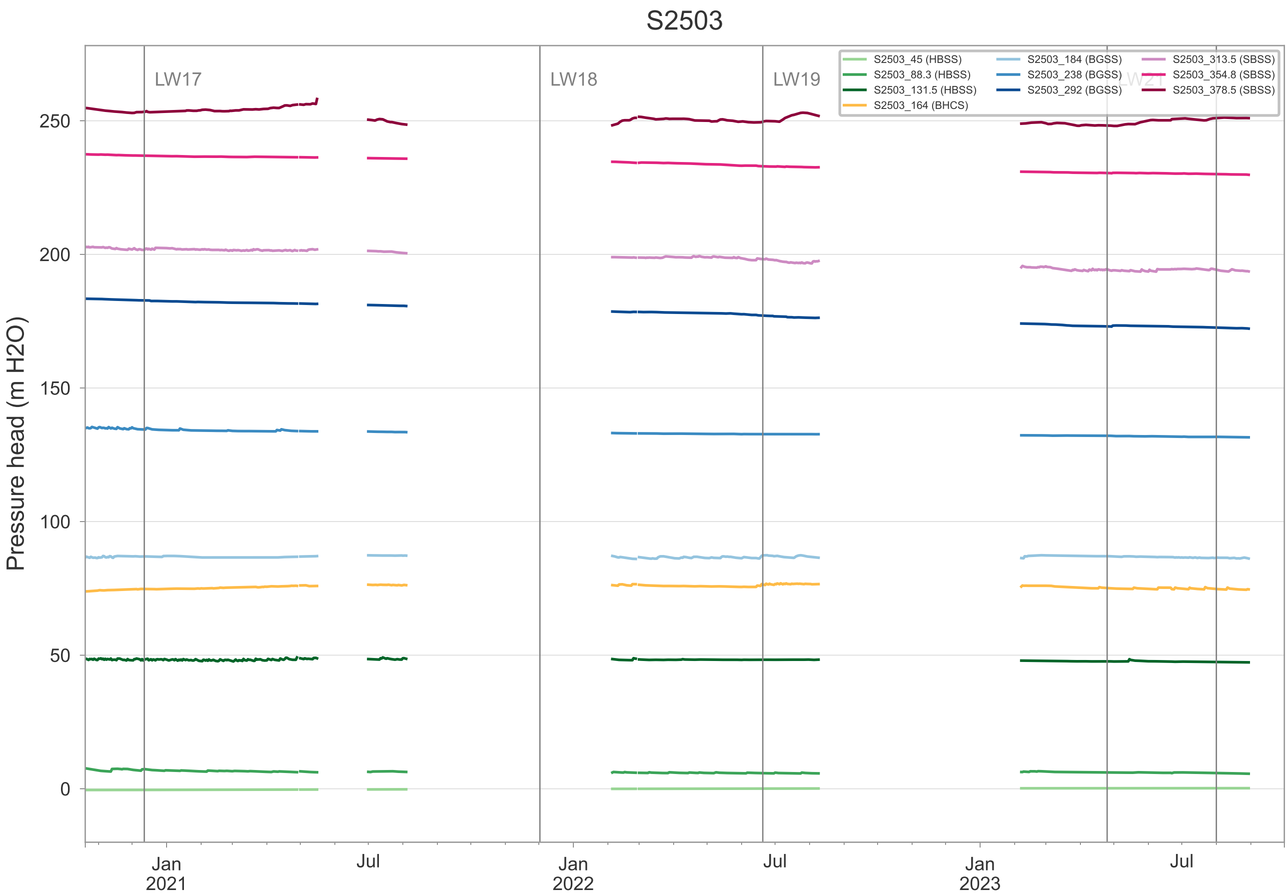
Groundwater hydrographs



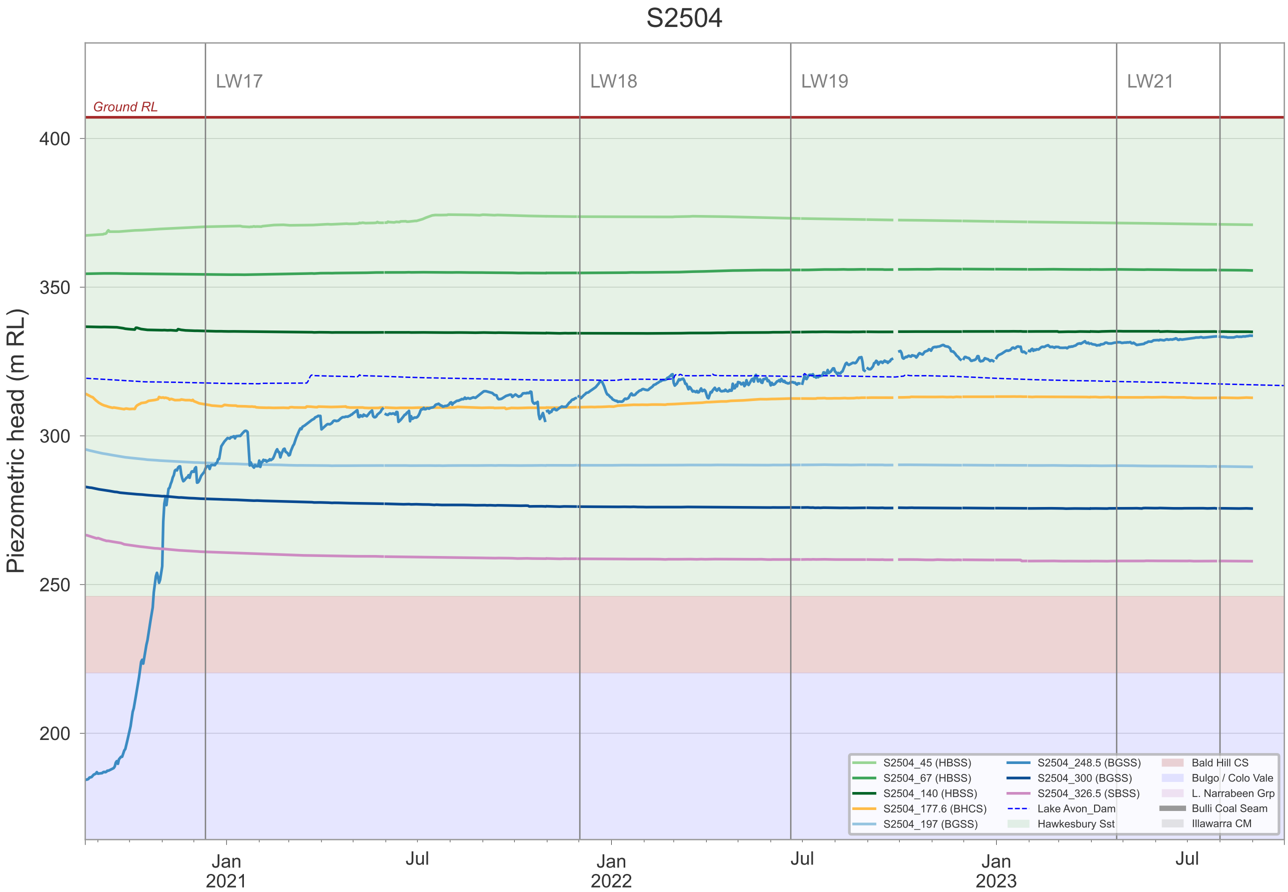


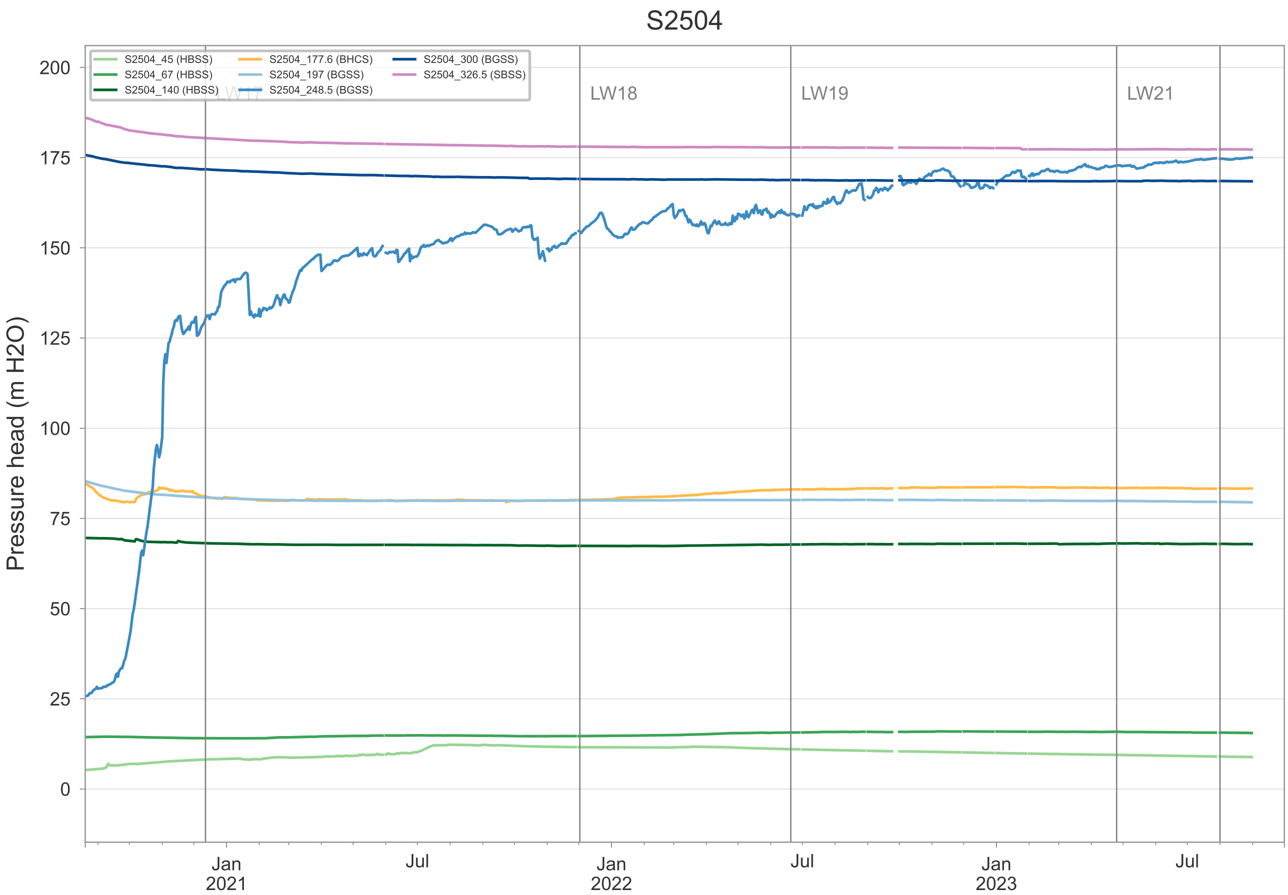
Groundwater hydrographs



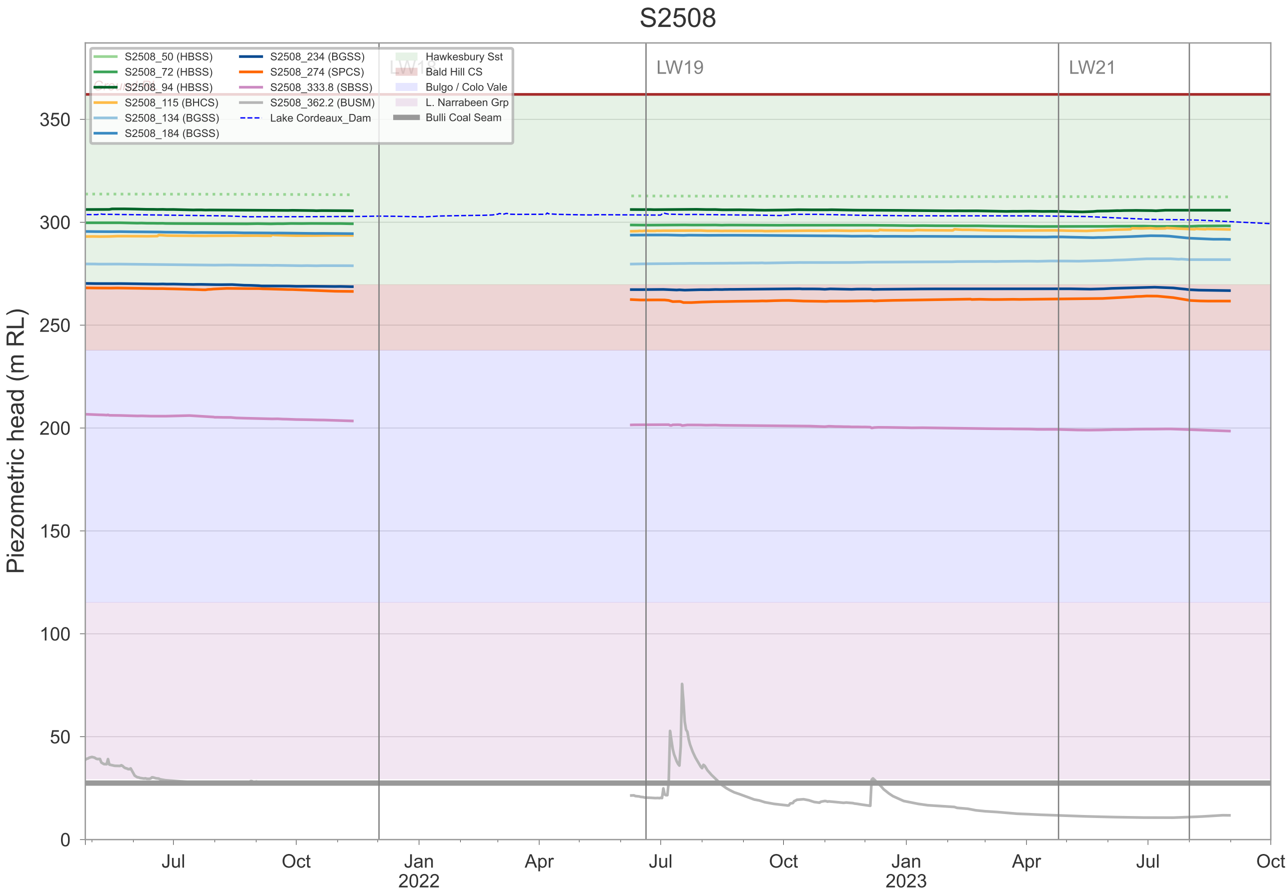


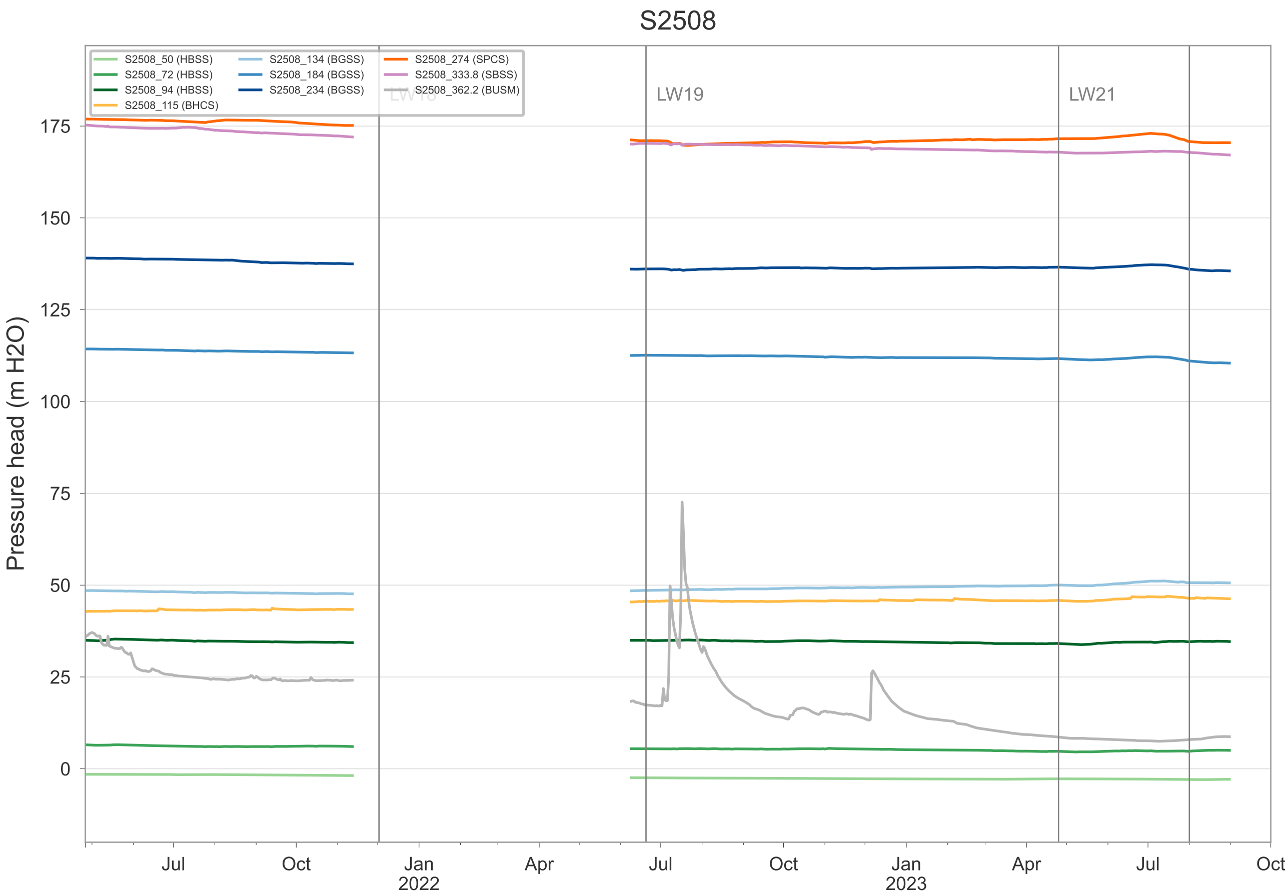
Groundwater hydrographs



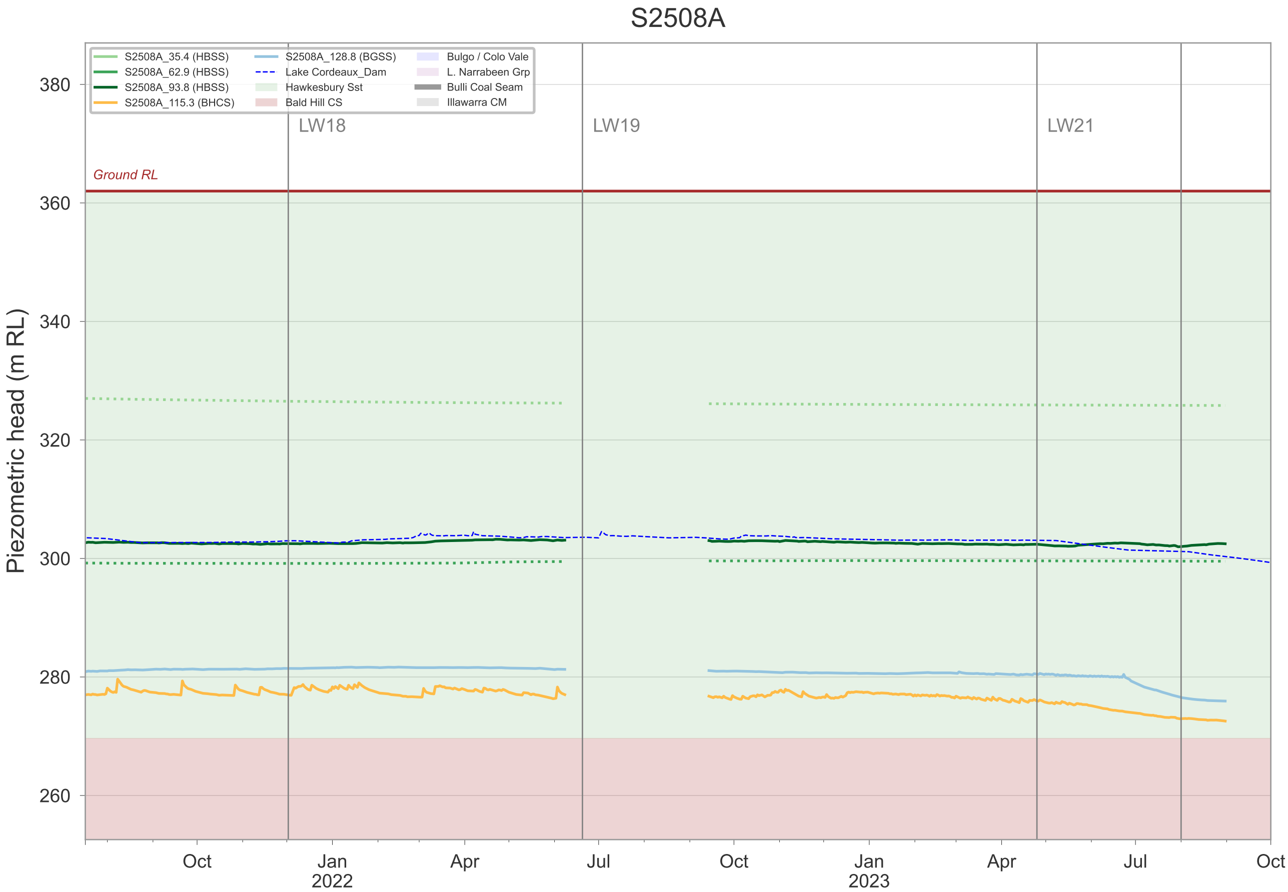


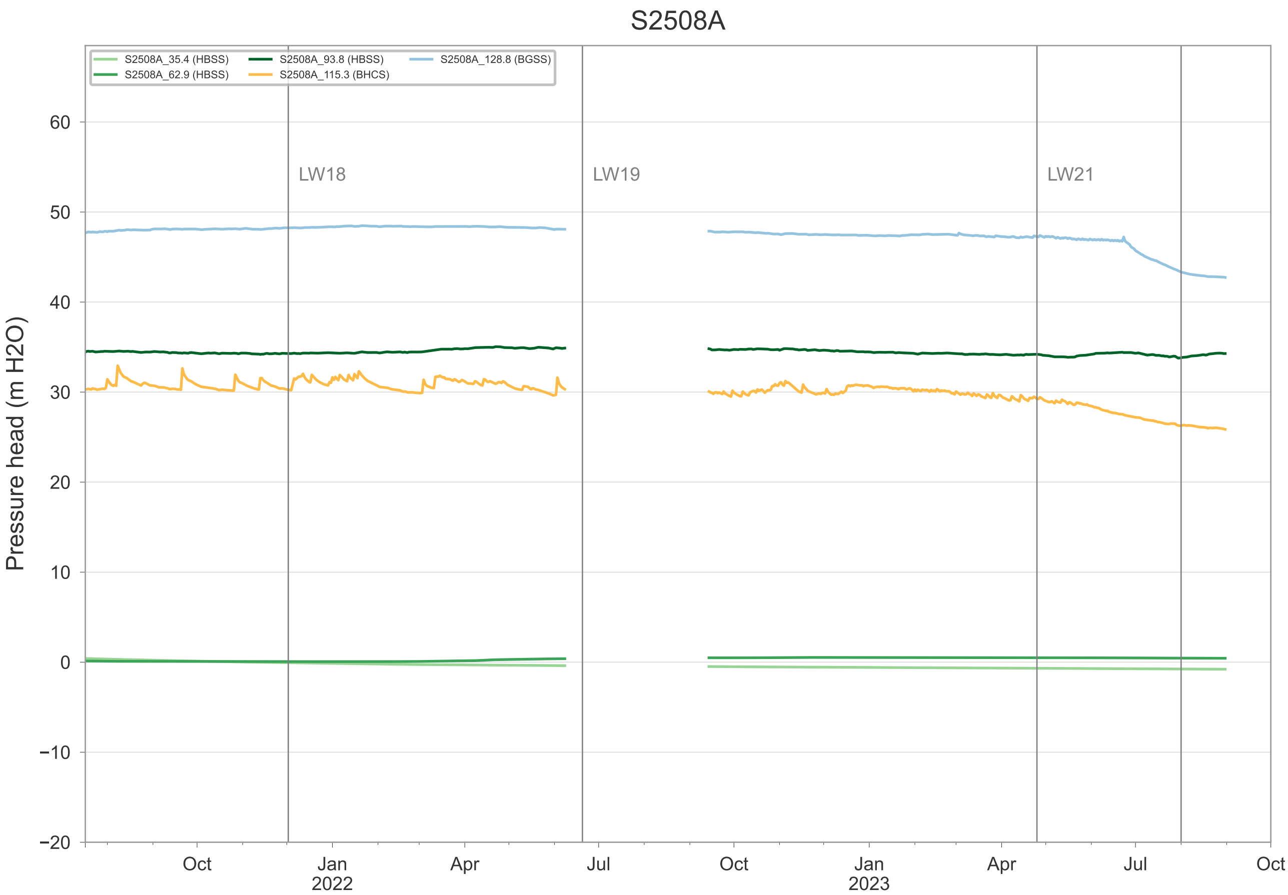
Groundwater hydrographs



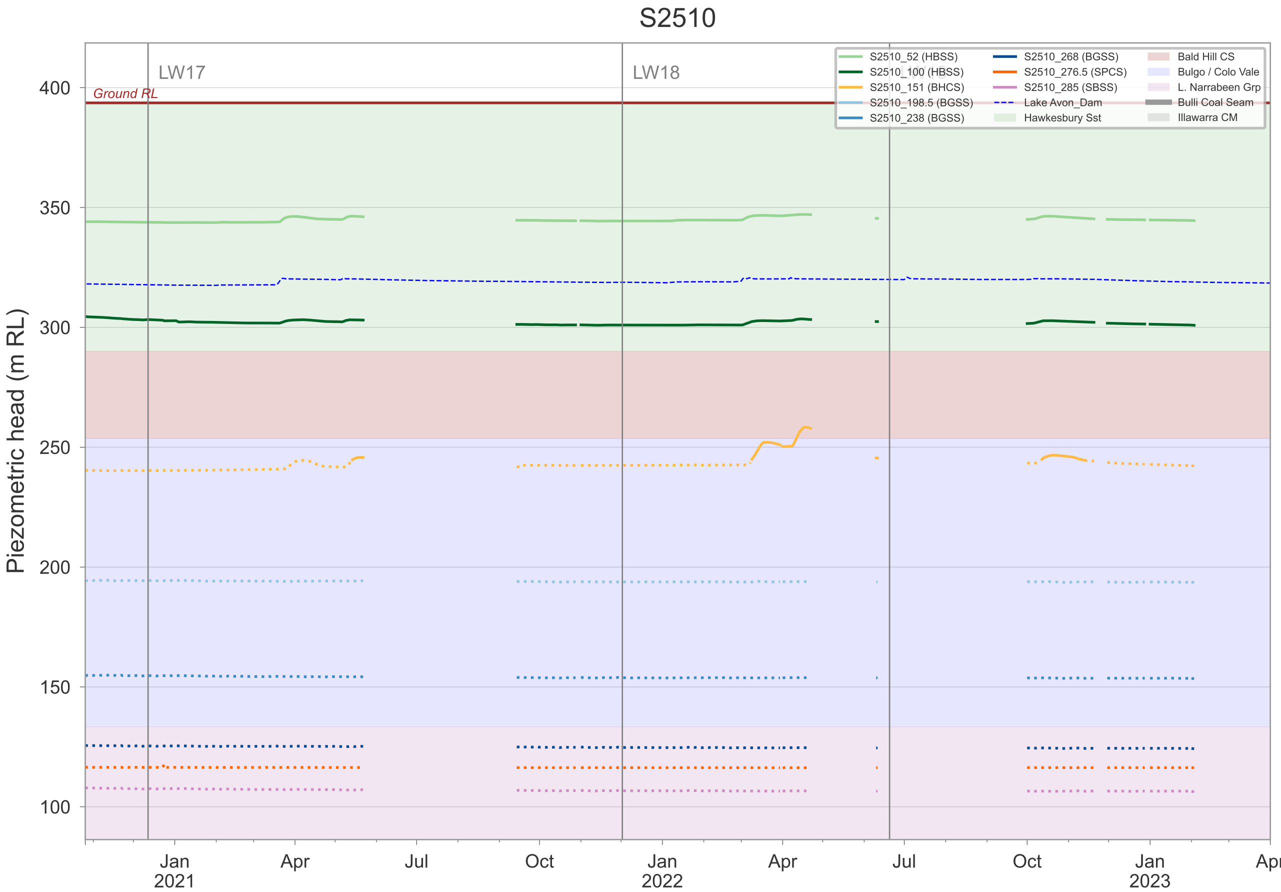


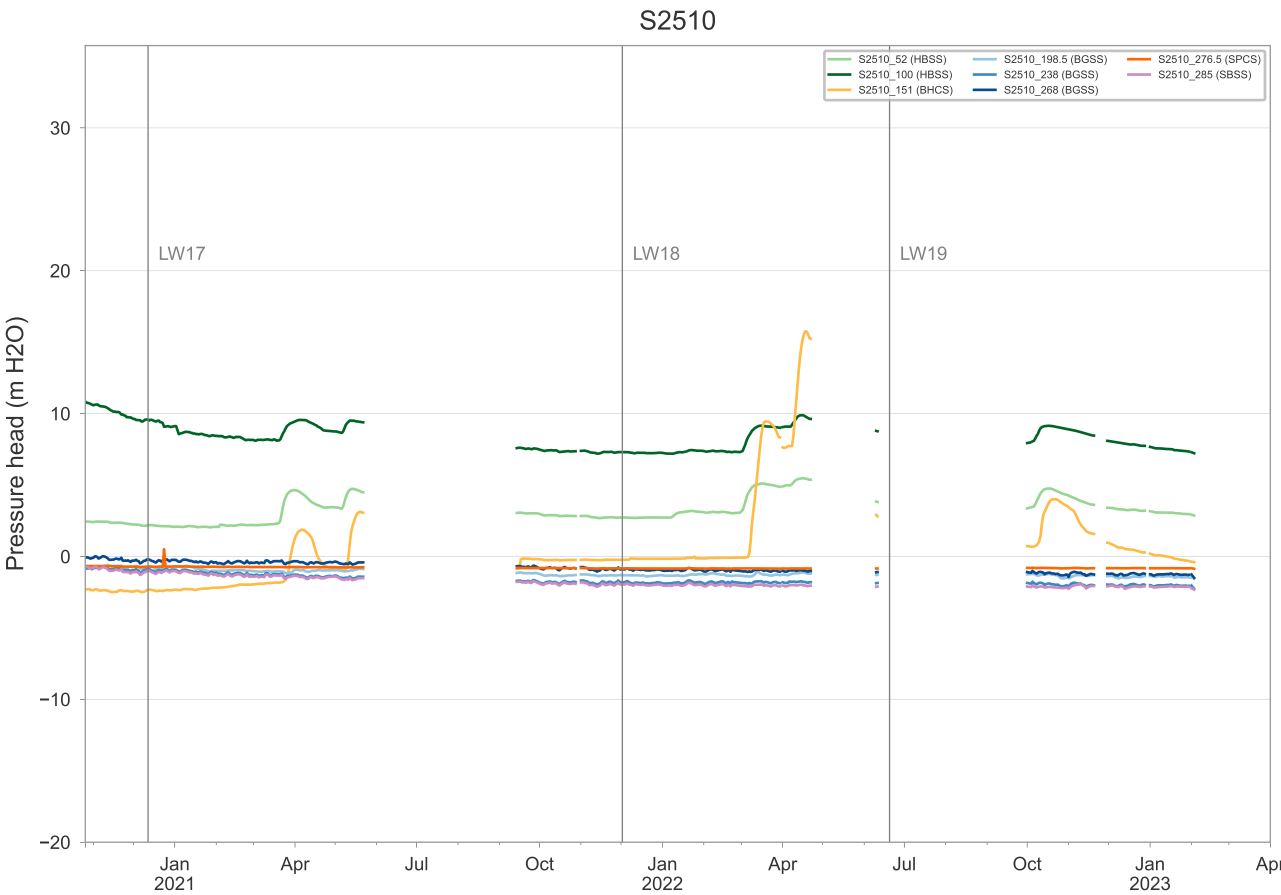
Groundwater hydrographs



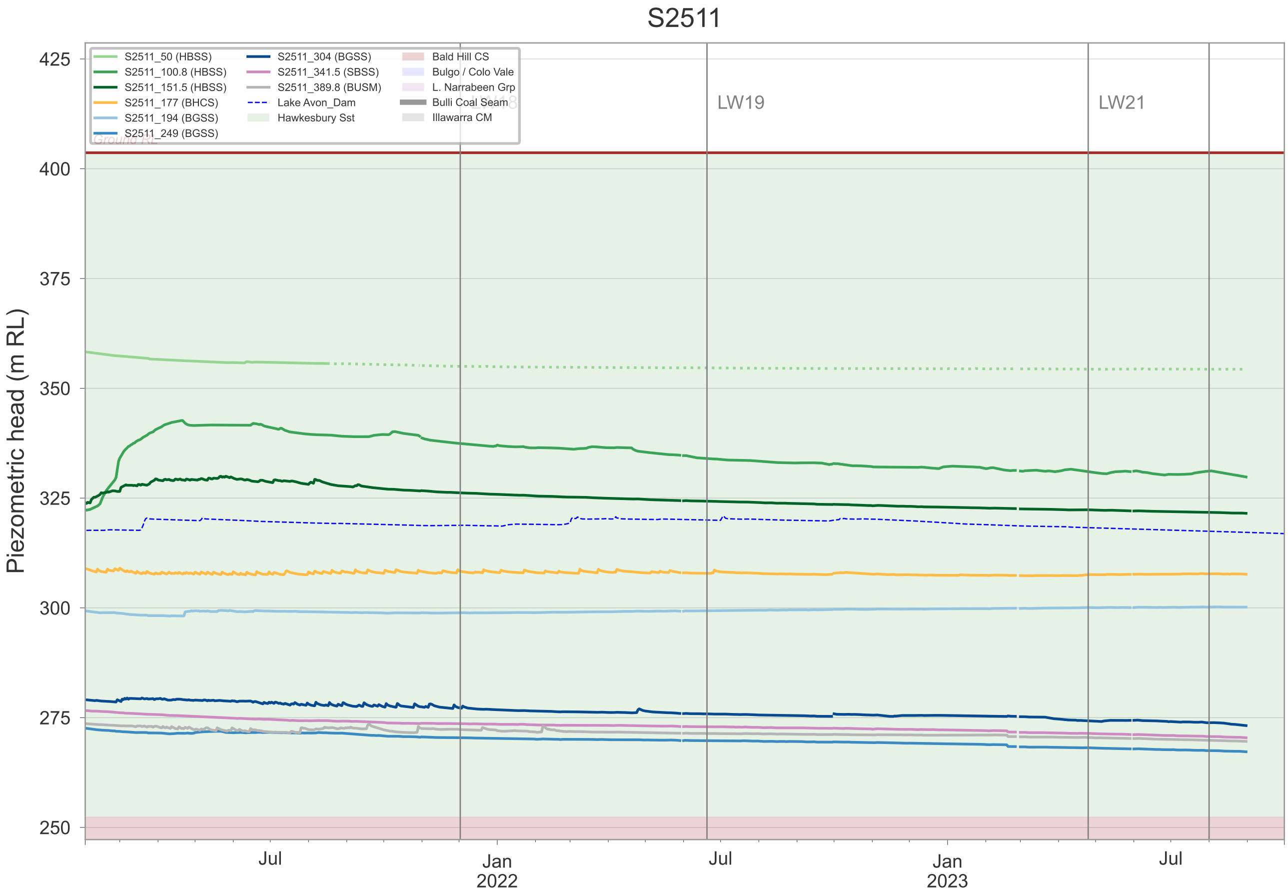


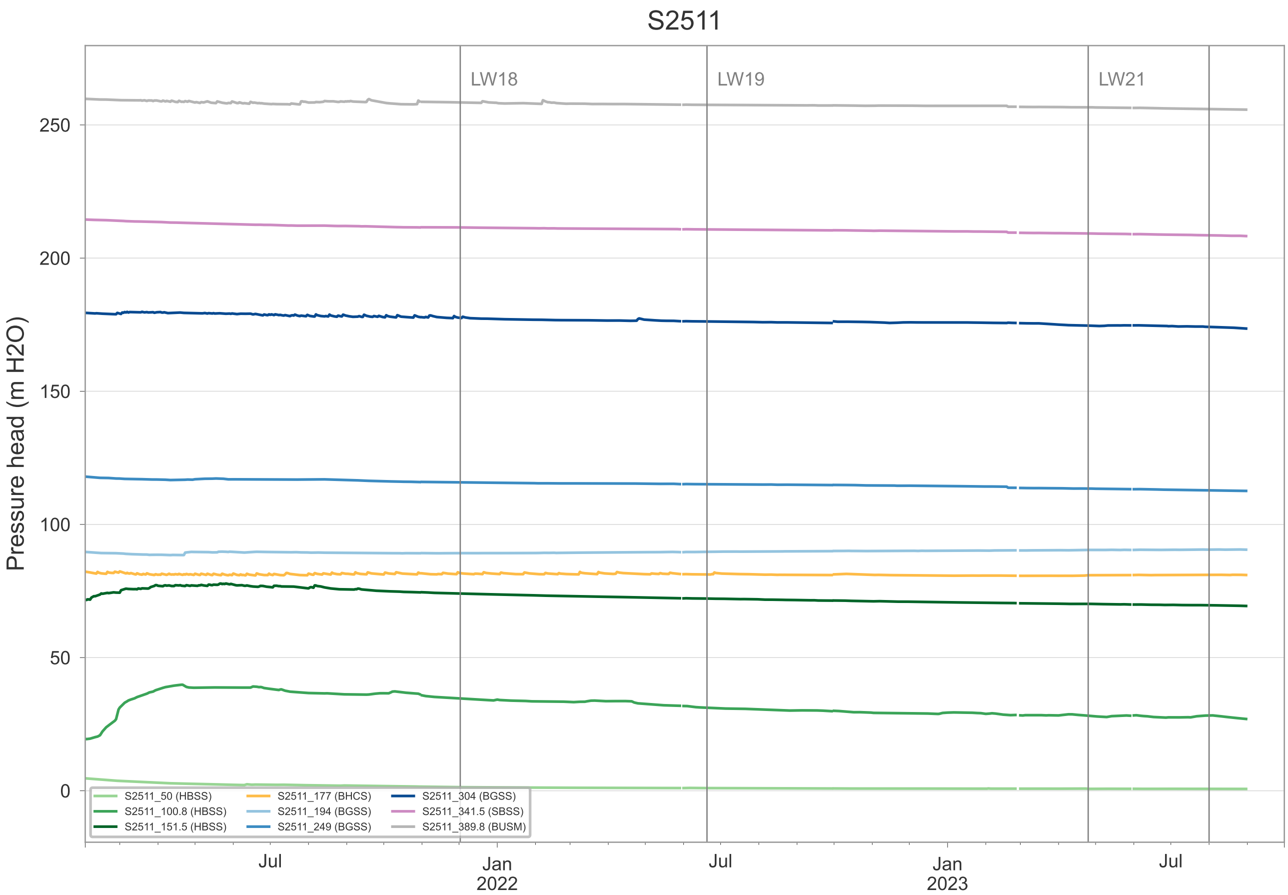
Groundwater hydrographs



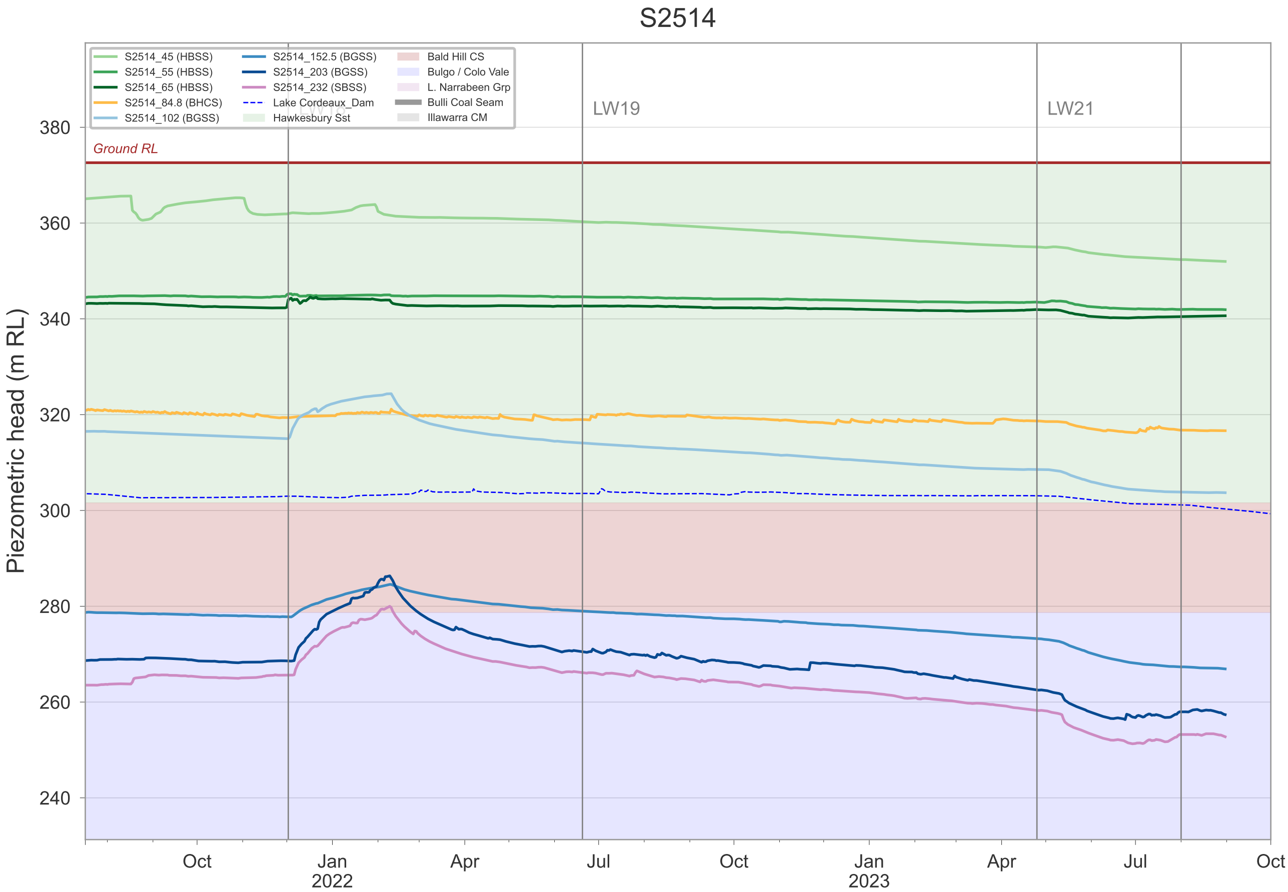


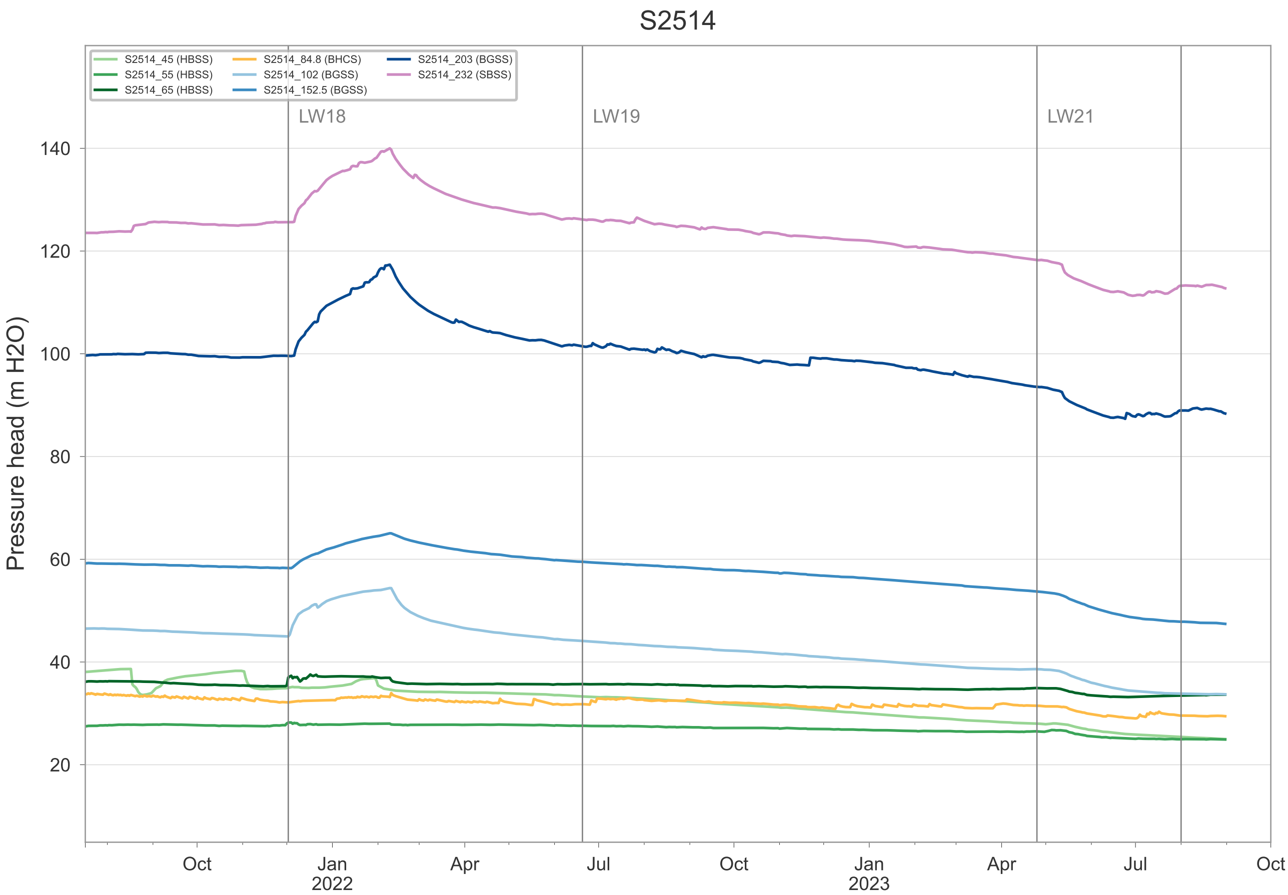
Groundwater hydrographs

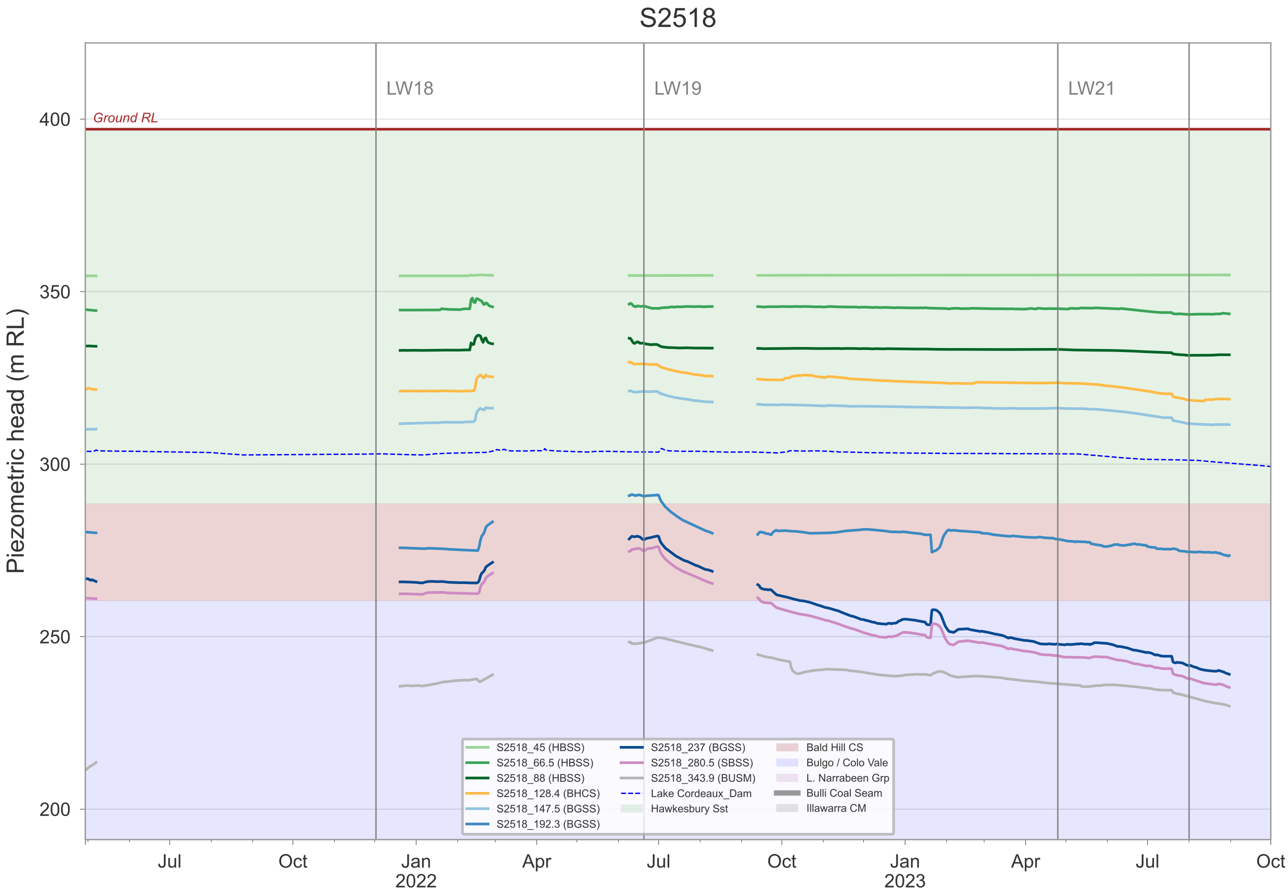


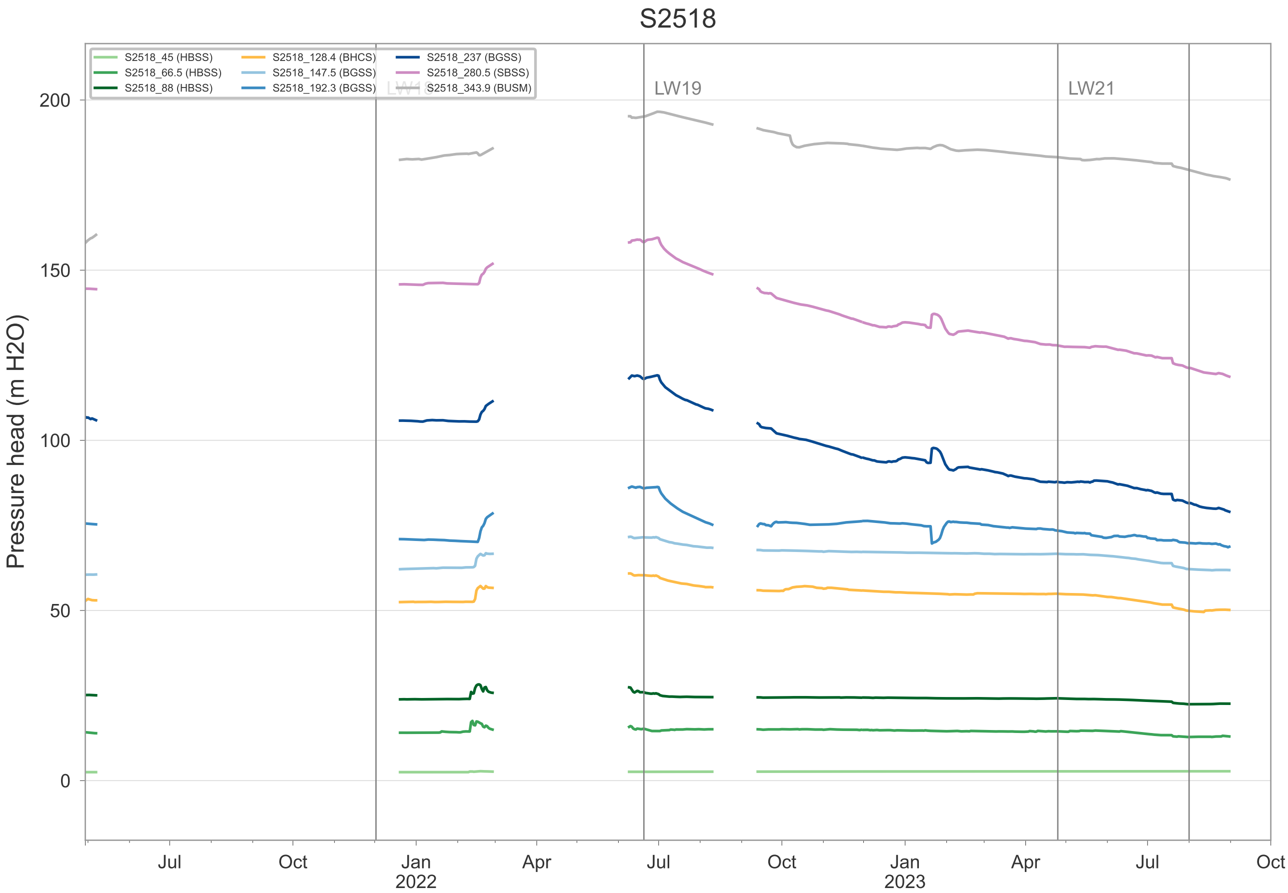


Groundwater hydrographs

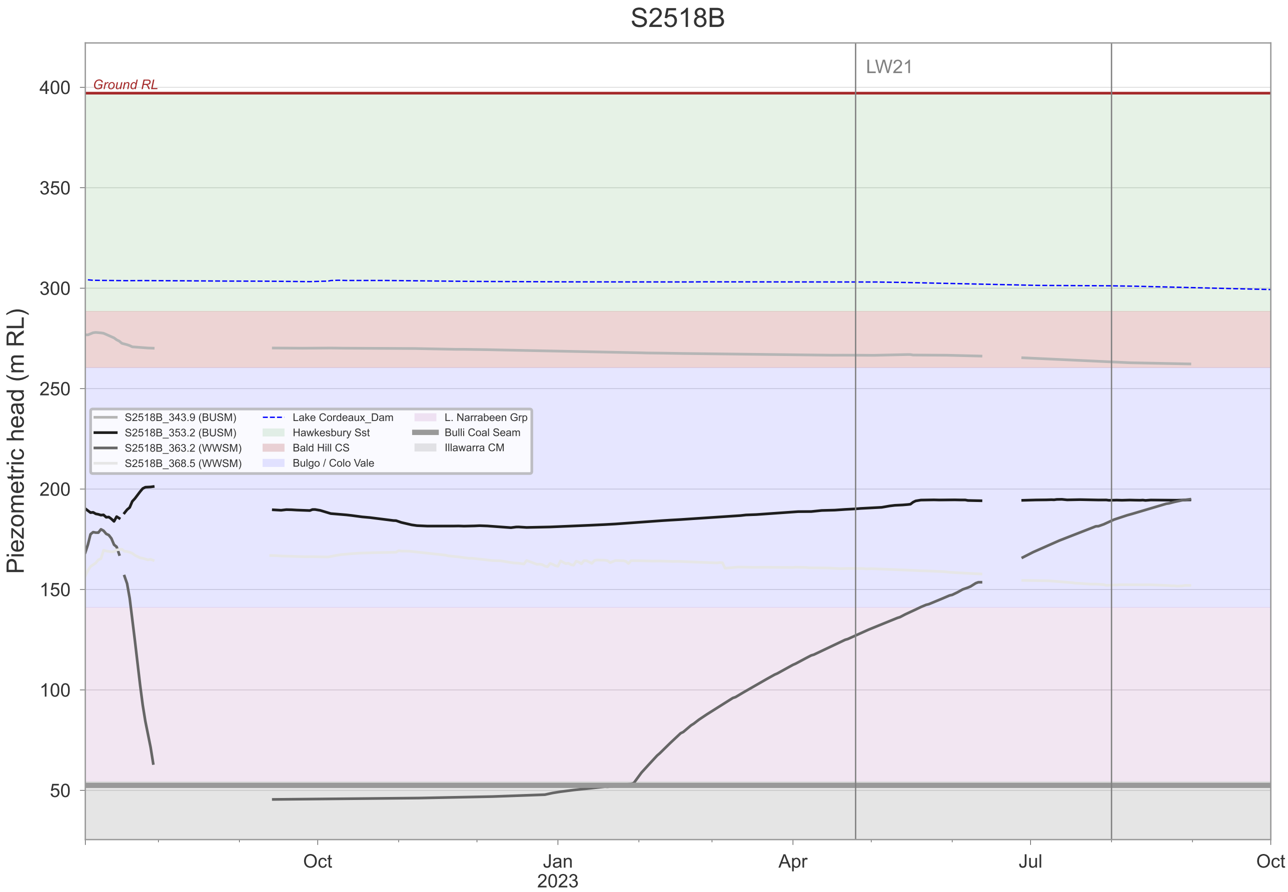


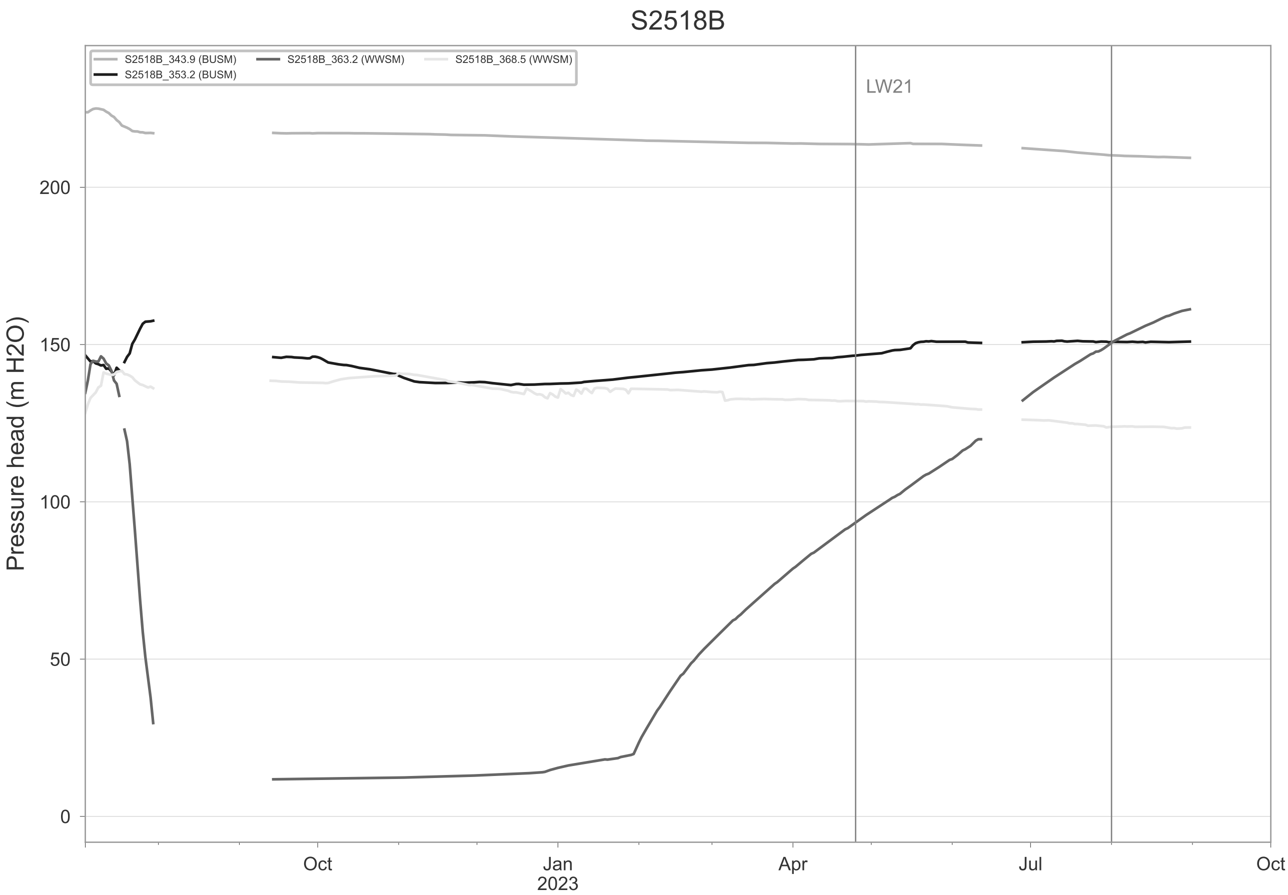



S2518
LW18
LW19
LW21
Ground RL
Piezometric head (m RL)
400
350
300
250
200
Jul
Oct
Jan
2022
Apr
Jul
Oct
Jan
2023
Apr
Jul
Oct
S2518_45 (HBSS)
S2518_66.5 (HBSS)
S2518_88 (HBSS)
S2518_128.4 (BHCS)
S2518_147.5 (BGSS)
S2518_192.3 (BGSS)
S2518_237 (BGSS)
S2518_280.5 (SBSS)
S2518_343.9 (BUSM)
Lake Cordeaux_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM

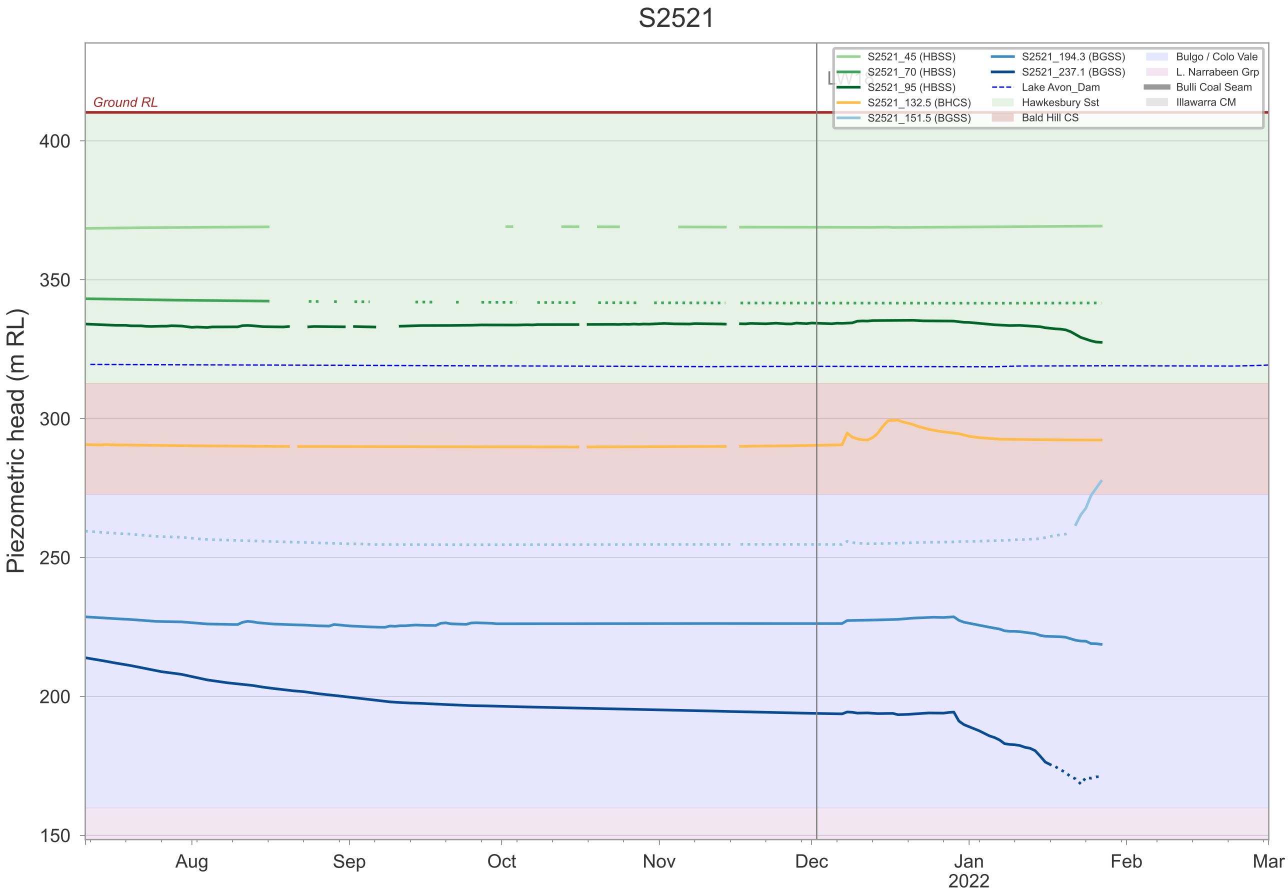

S2518
S2518_45 (HBSS)
S2518_66.5 (HBSS)
S2518_88 (HBSS)
S2518_128.4 (BHCS)
S2518_147.5 (BGSS)
S2518_192.3 (BGSS)
S2518_237 (BGSS)
S2518_280.5 (SBSS)
S2518_343.9 (BUSM)
LW19
LW21
Pressure head (m H2O)
200
150
100
50
0
Jul
Oct
Jan
2022
Apr
Jul
Oct
Jan
2023
Apr
Jul
Oct

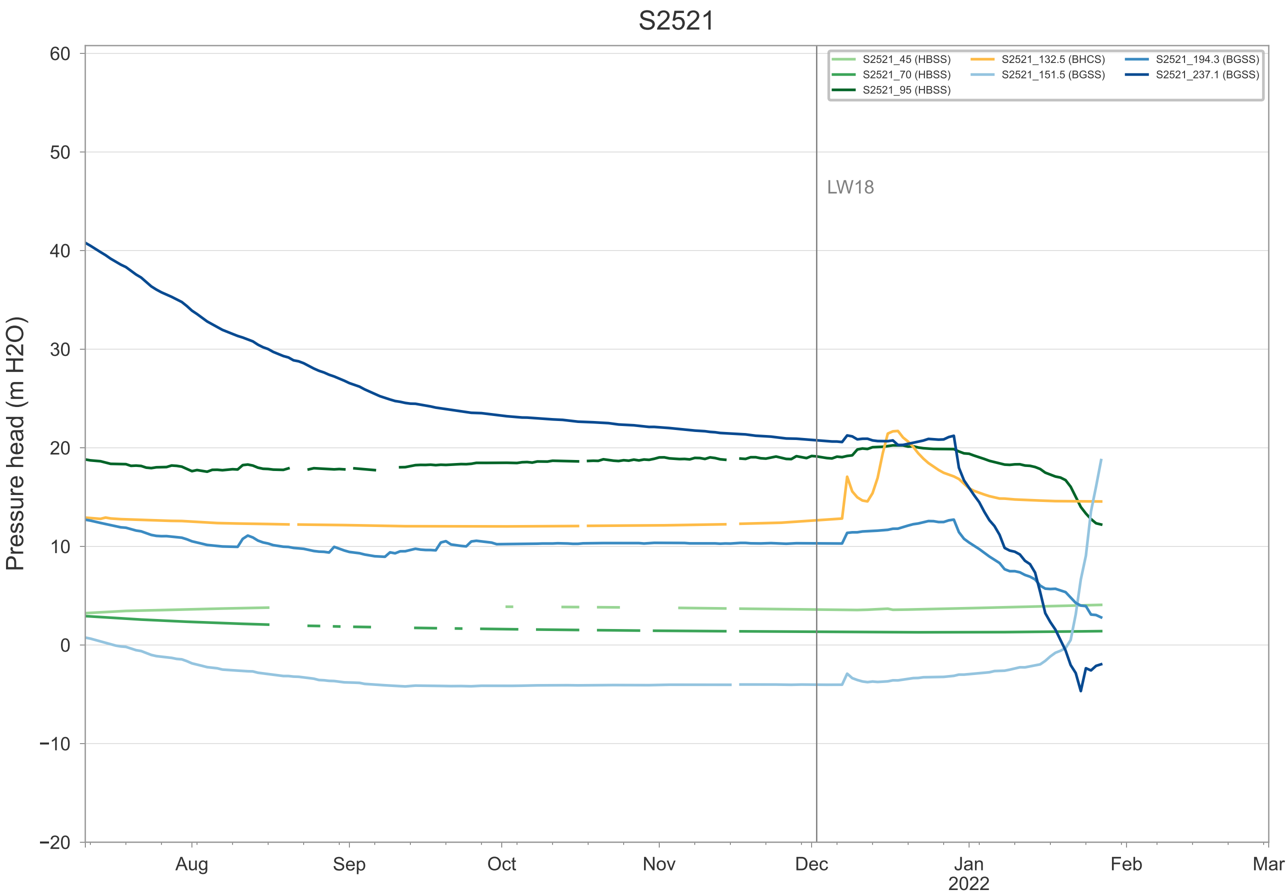
Groundwater hydrographs



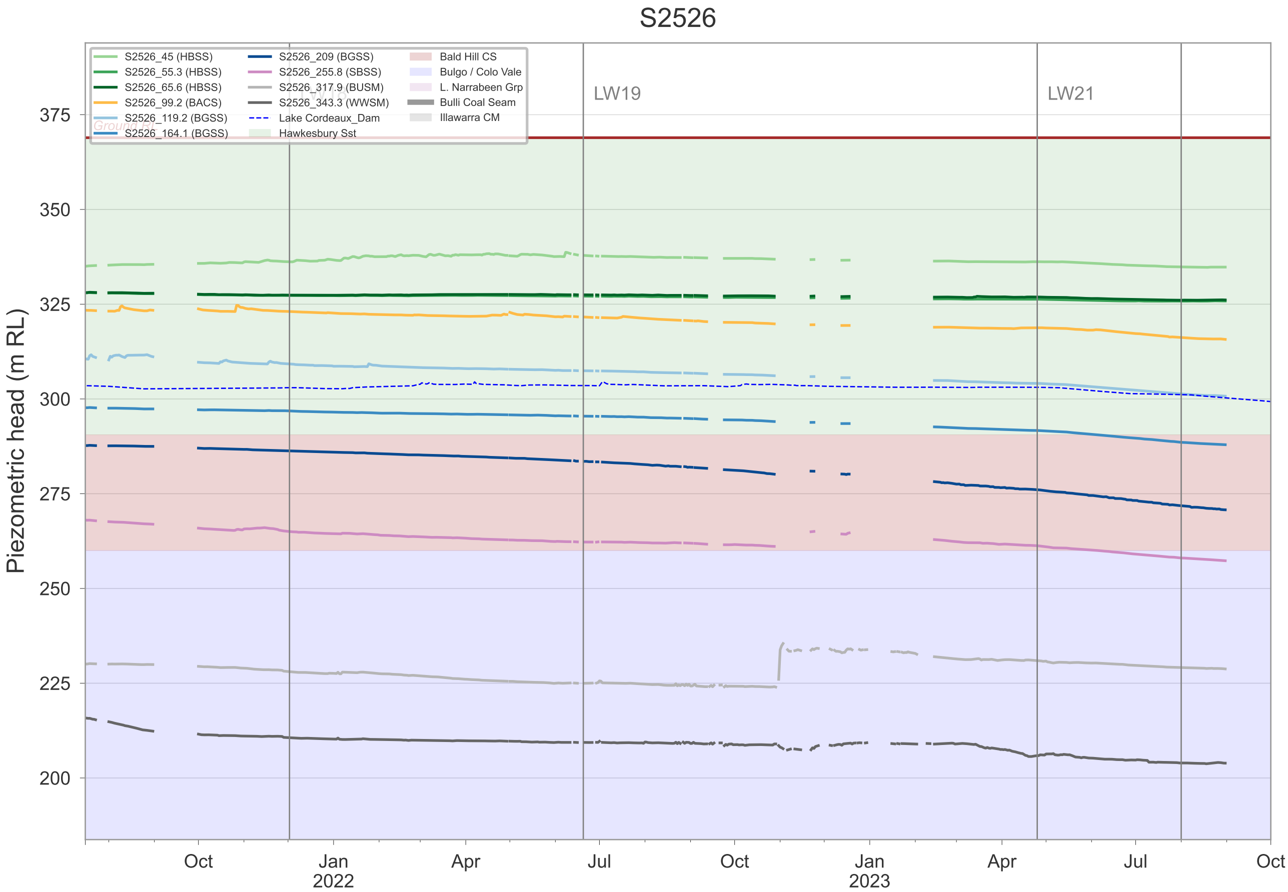


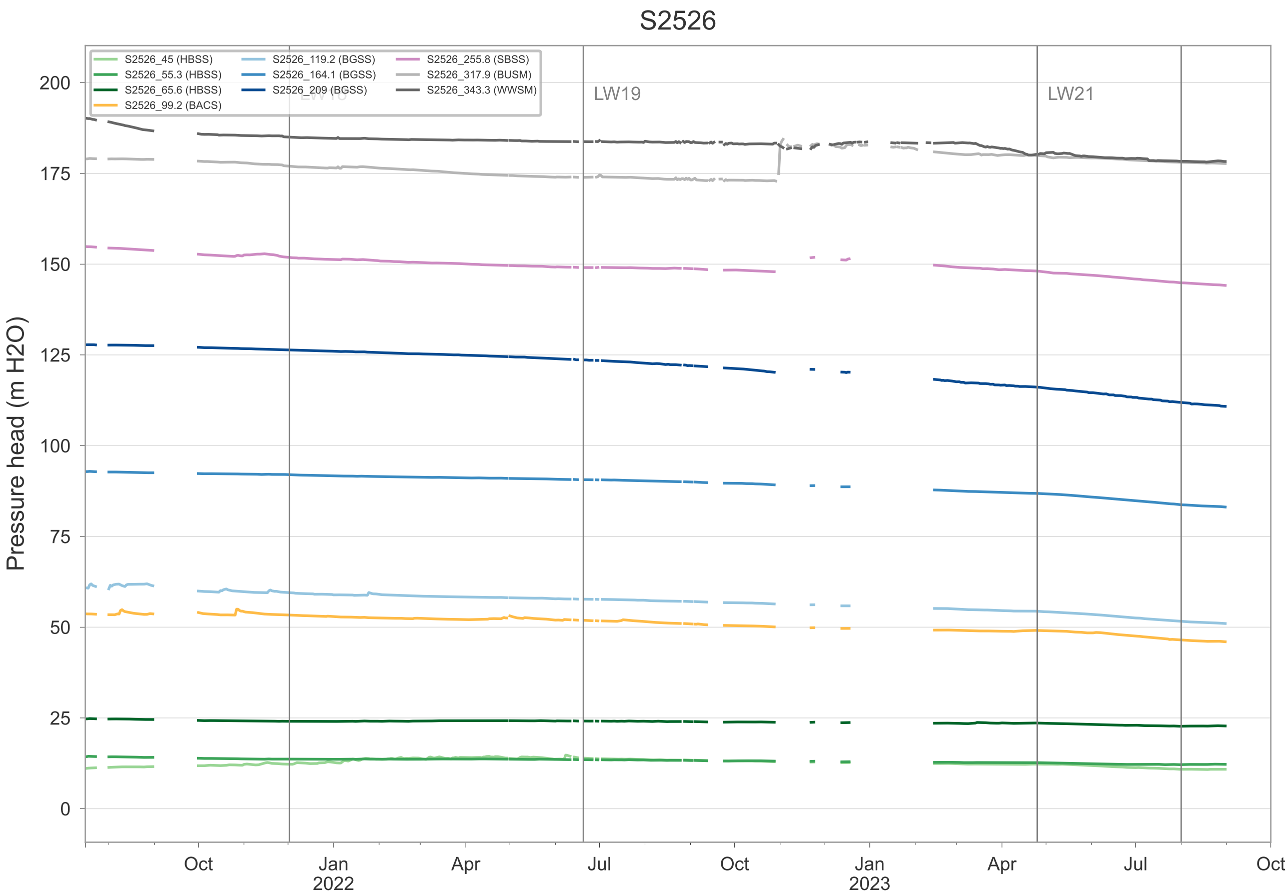
Groundwater hydrographs



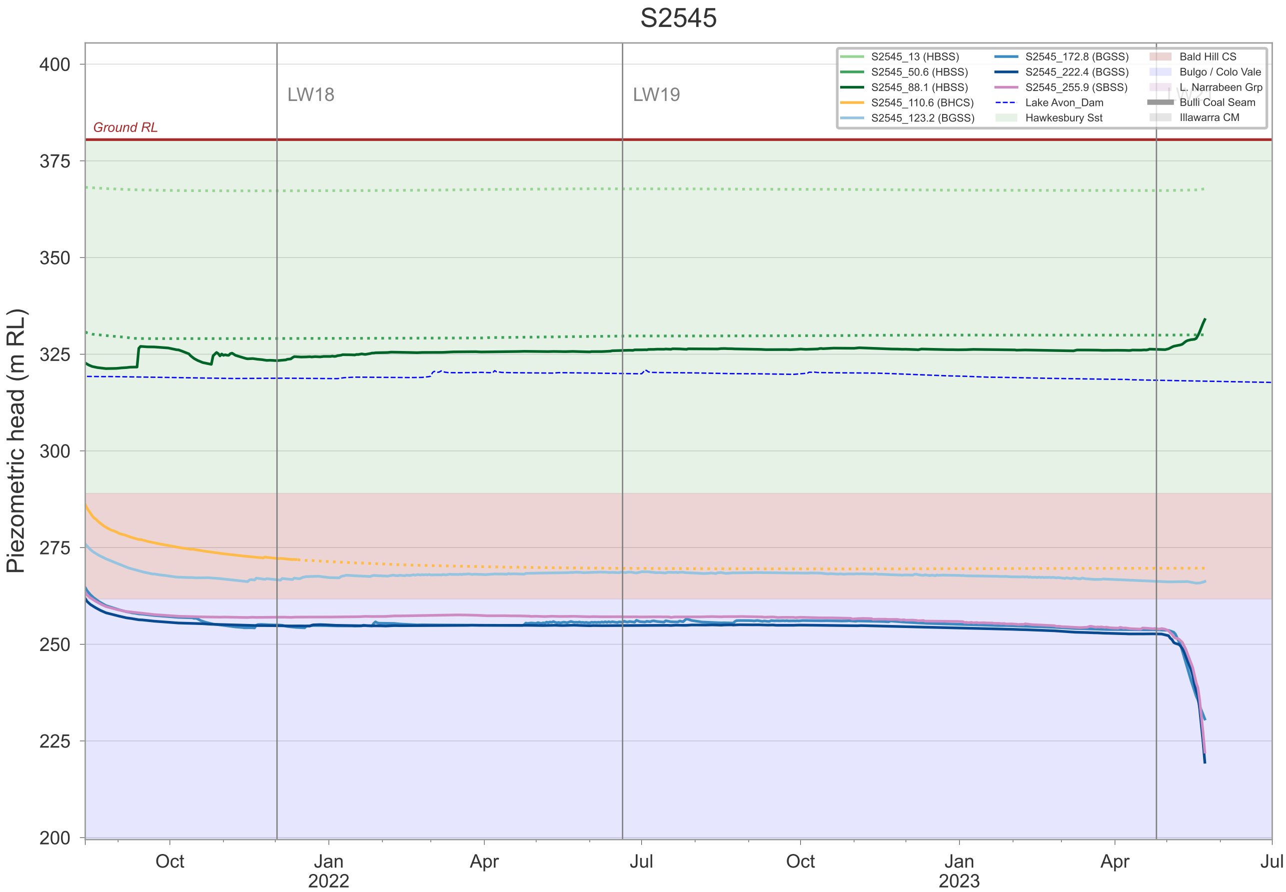


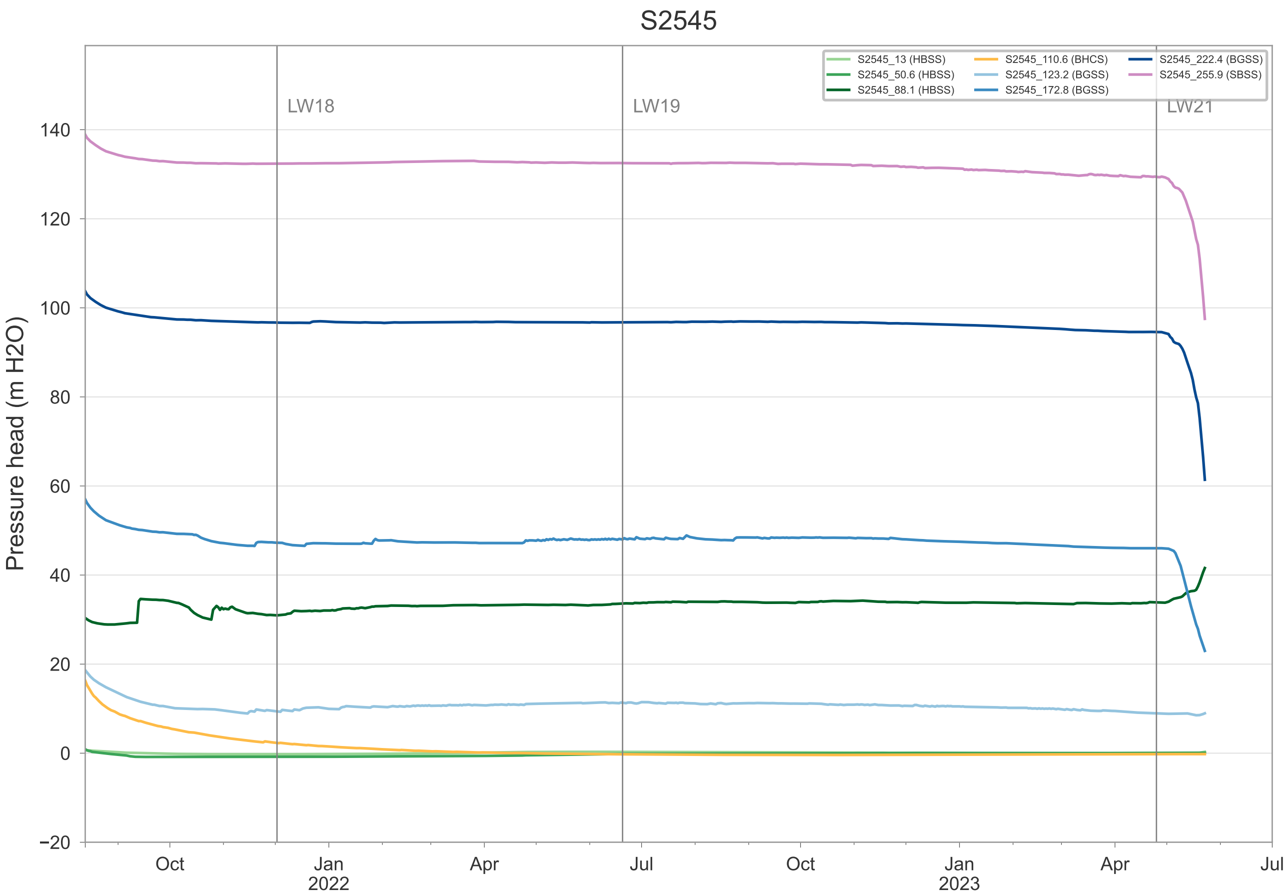
Groundwater hydrographs

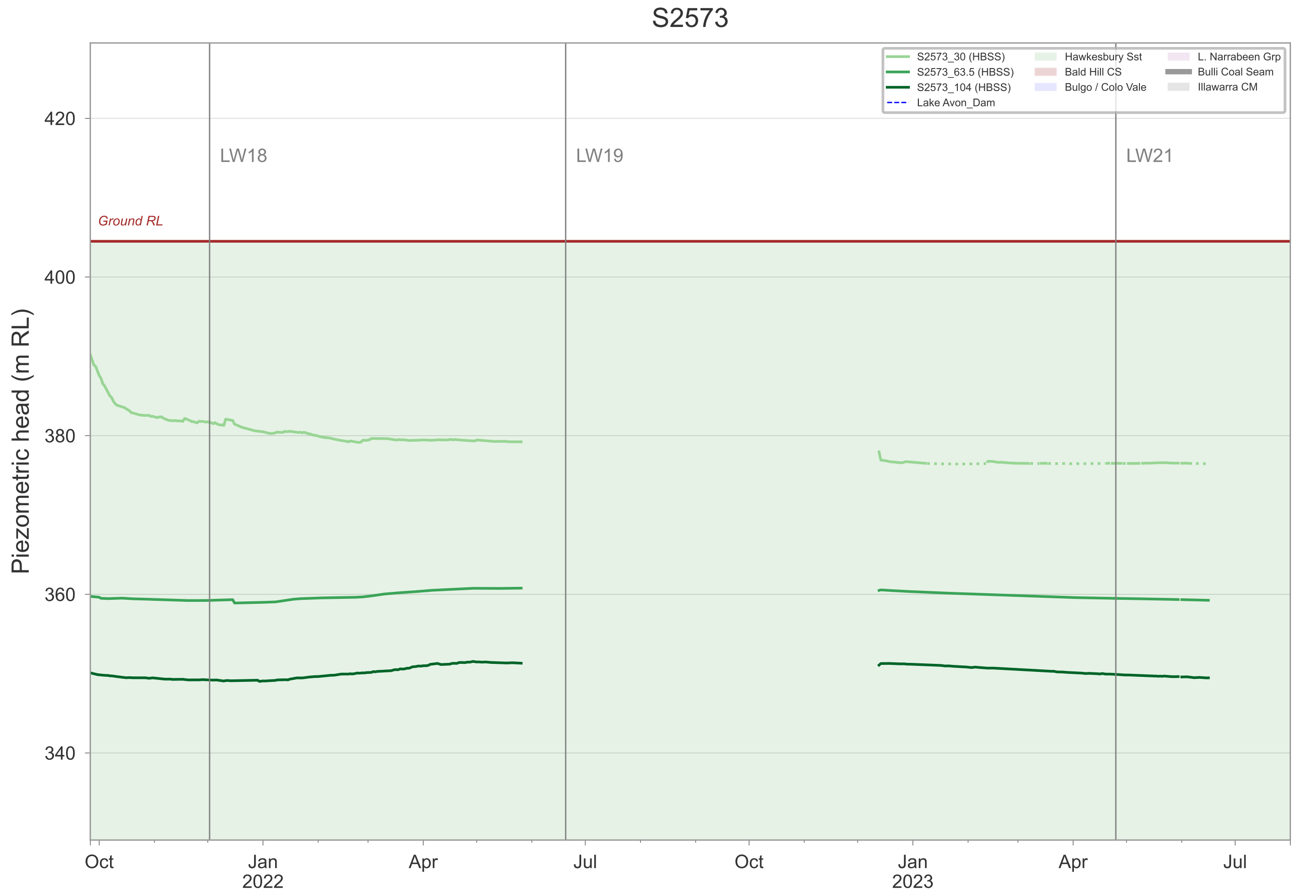


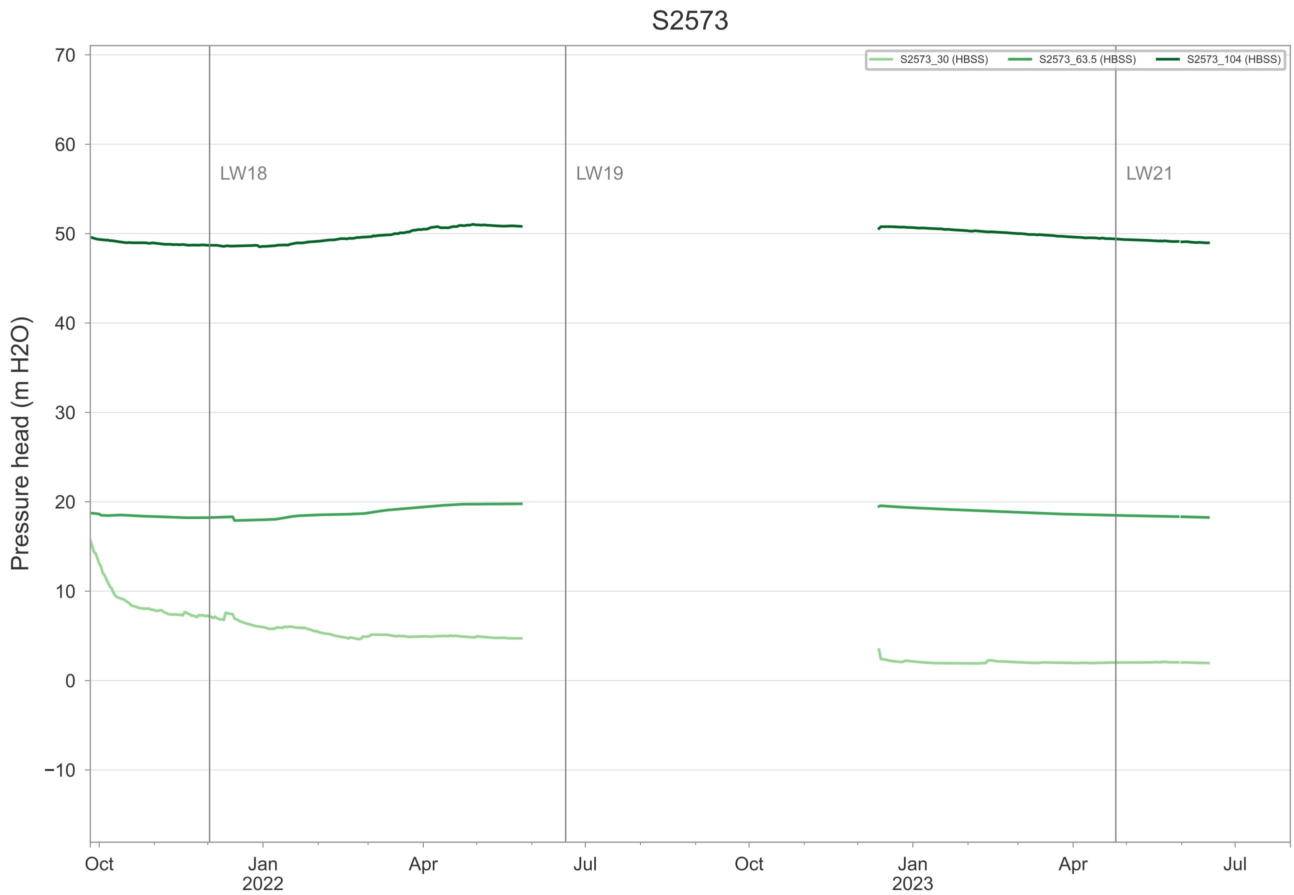


Groundwater hydrographs



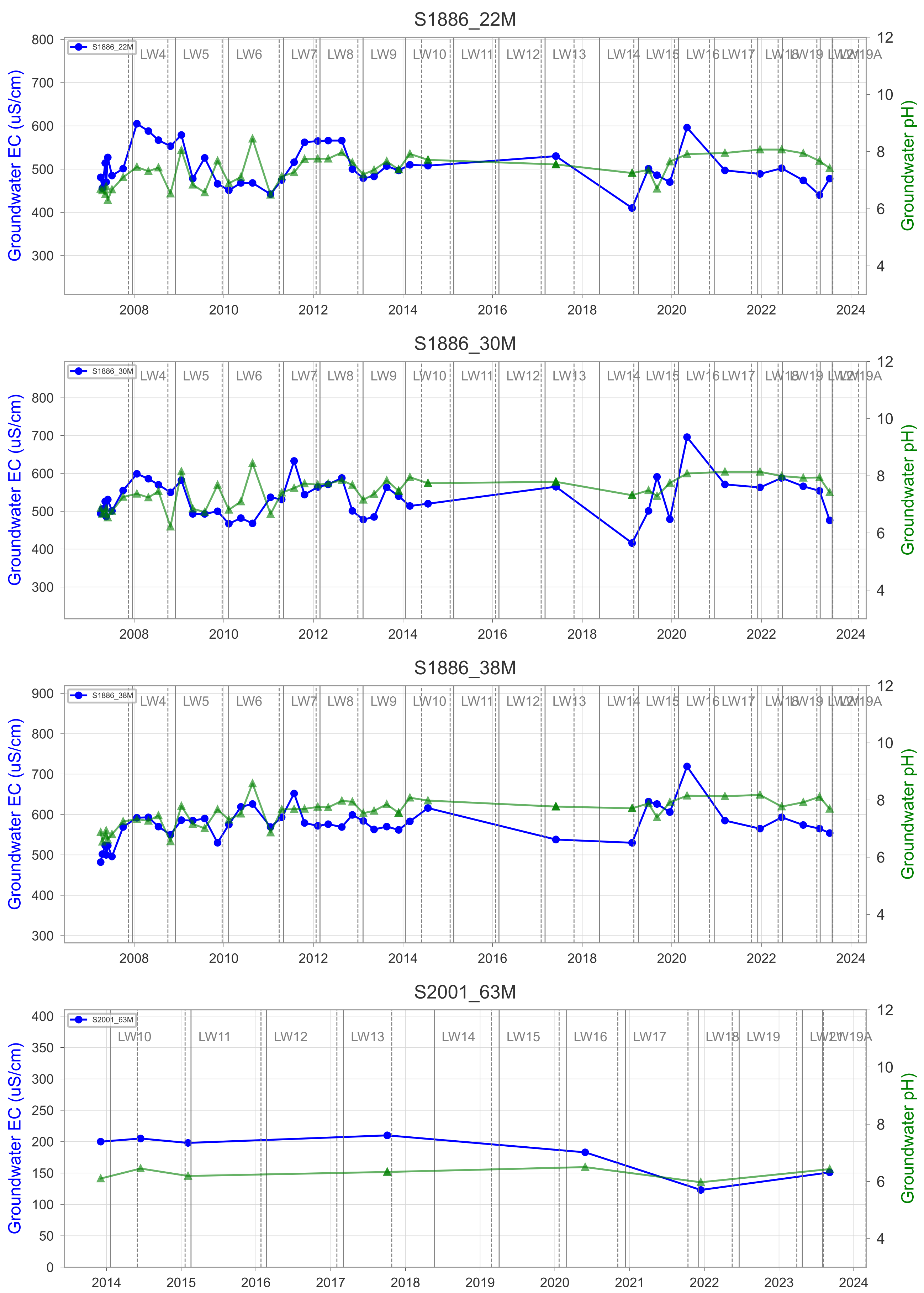



S2573
S2573_30 (HBSS)
S2573_63.5 (HBSS)
S2573_104 (HBSS)
Lake Avon_Dam
Hawkesbury Sst
Bald Hill CS
Bulgo / Colo Vale
L. Narrabeen Grp
Bulli Coal Seam
Illawarra CM
LW18
LW19
LW21
Ground RL
Piezometric head (m RL)
420
400
380
360
340
Oct
Jan
2022
Apr
Jul
Oct
Jan
2023
Apr
Jul

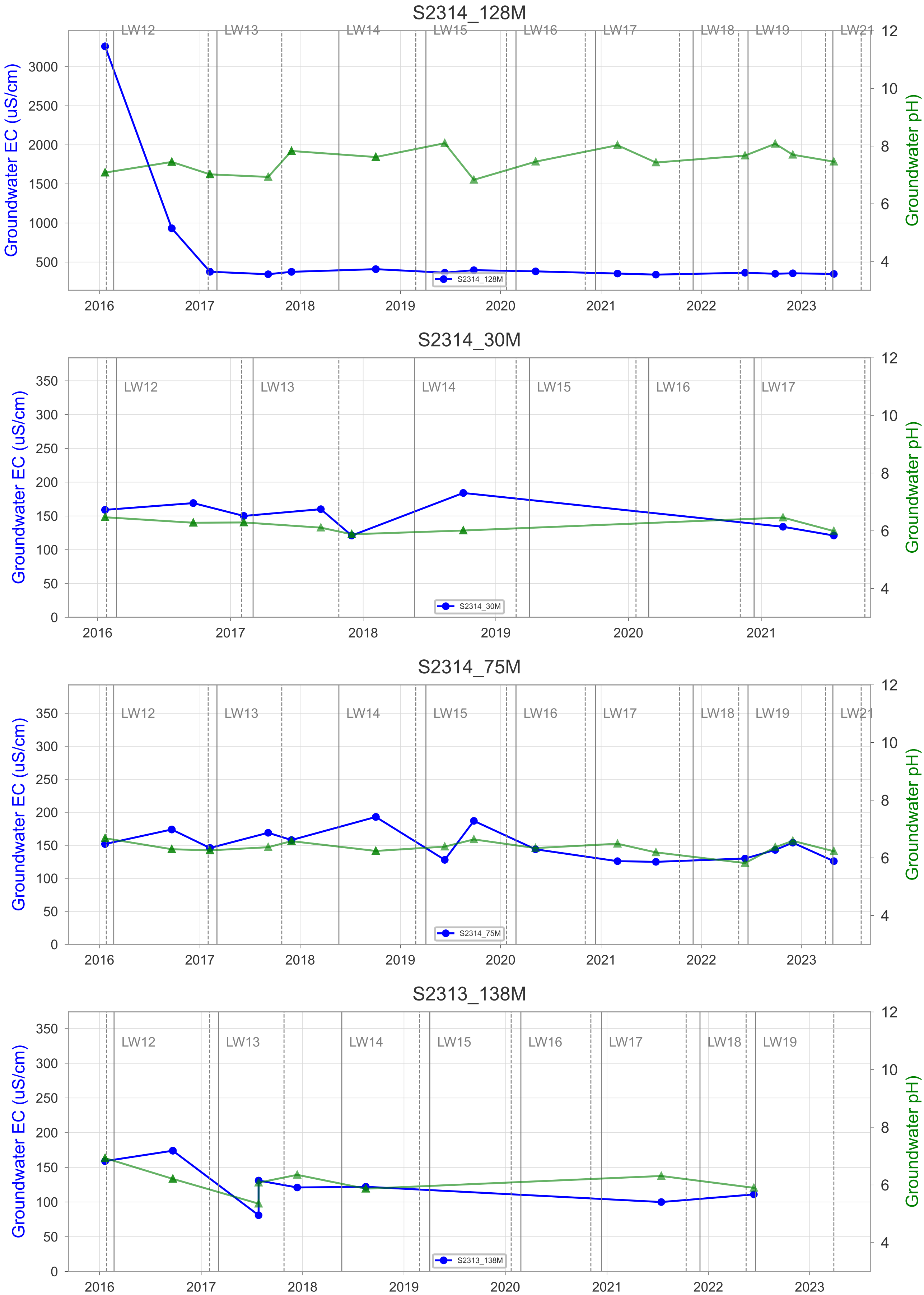

S2573
S2573_30 (HBSS)
S2573_63.5 (HBSS)
S2573_104 (HBSS)
LW18
LW19
LW21
Pressure head (m H2O)
70
60
50
40
30
20
10
0
−10
Oct
Jan
2022
Apr
Jul
Oct
Jan
2023
Apr
Jul

APPENDIX C: Groundwater quality timeseries

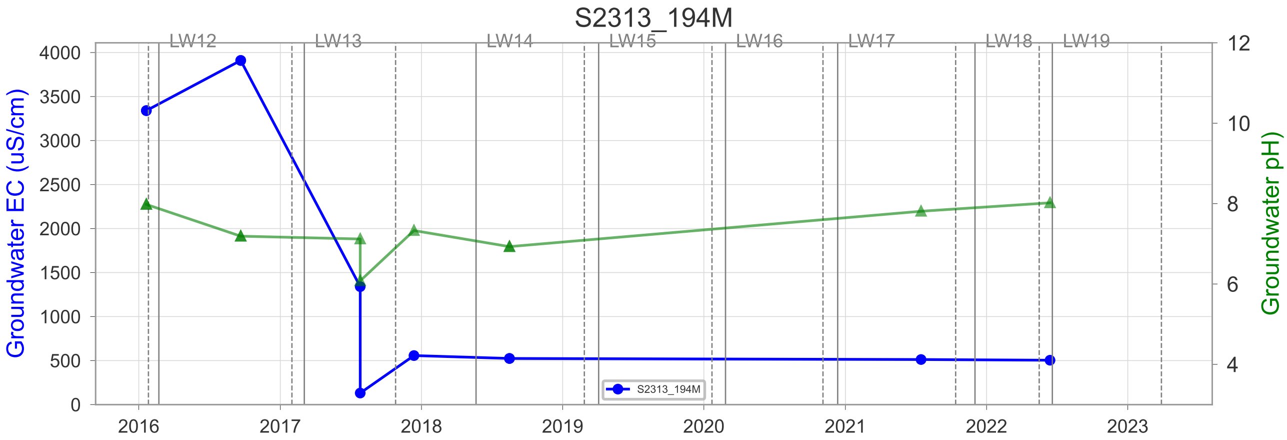
Groundwater EC timeseries

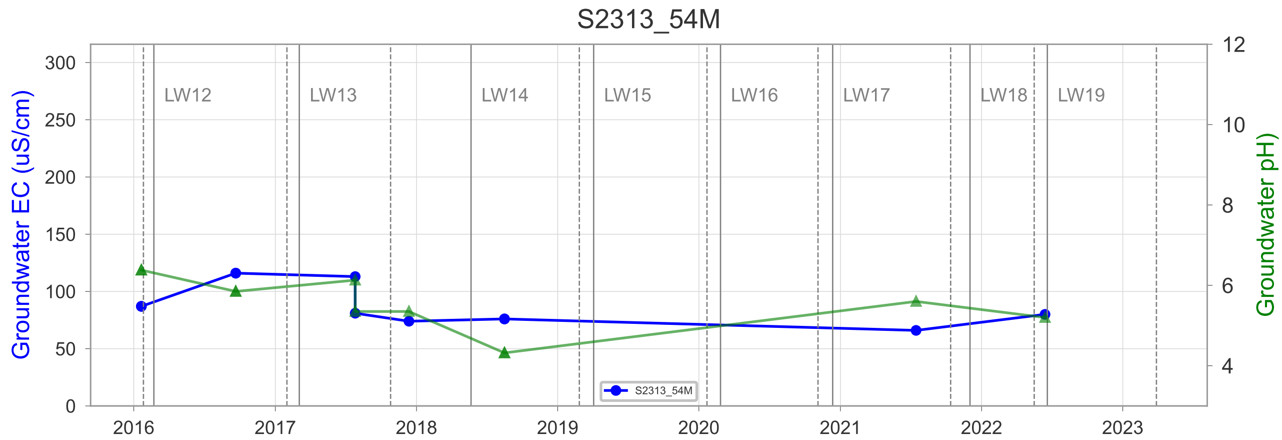


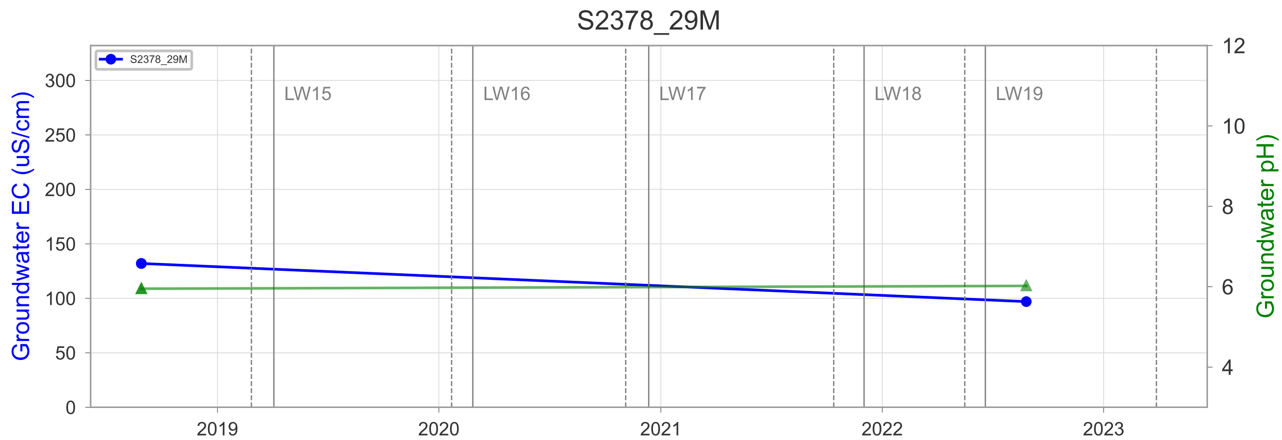
Groundwater EC timeseries

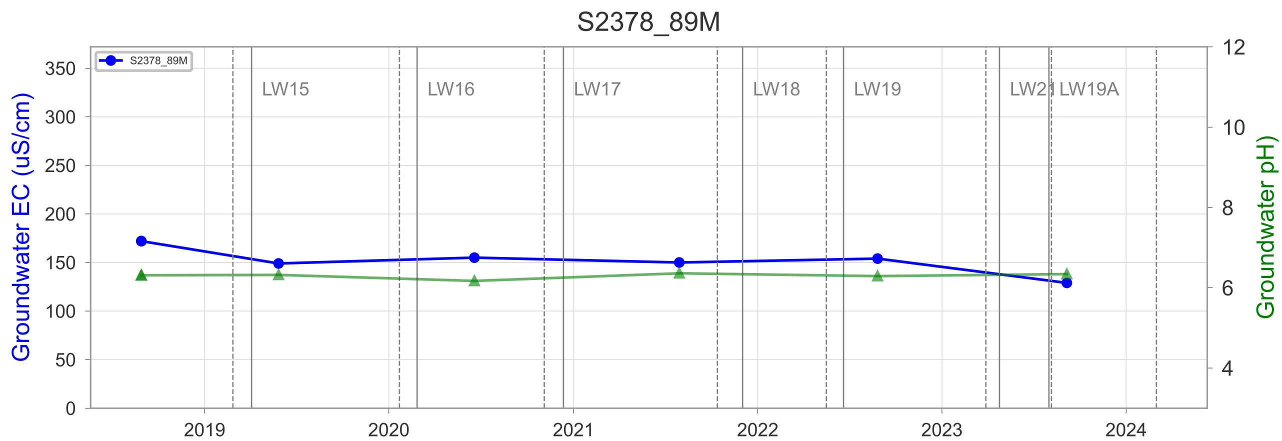


Groundwater EC timeseries



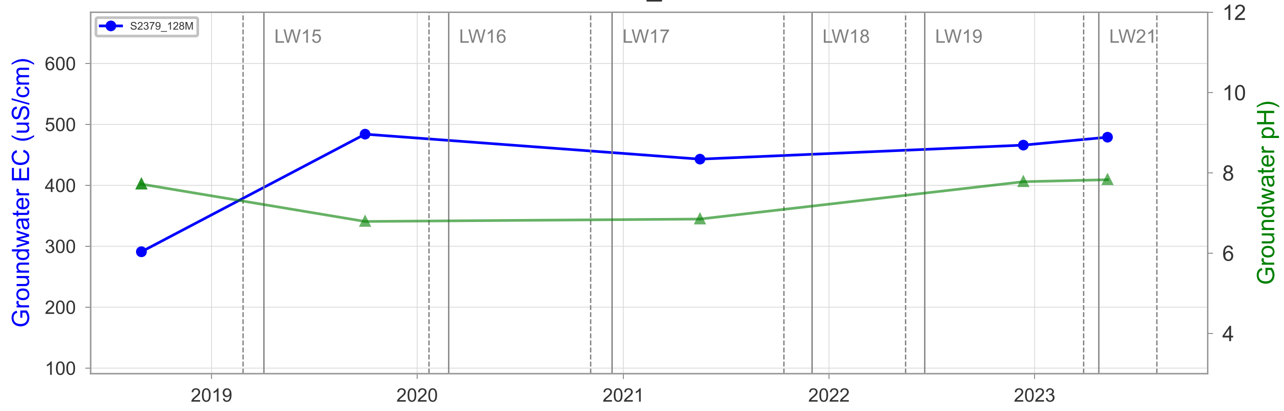




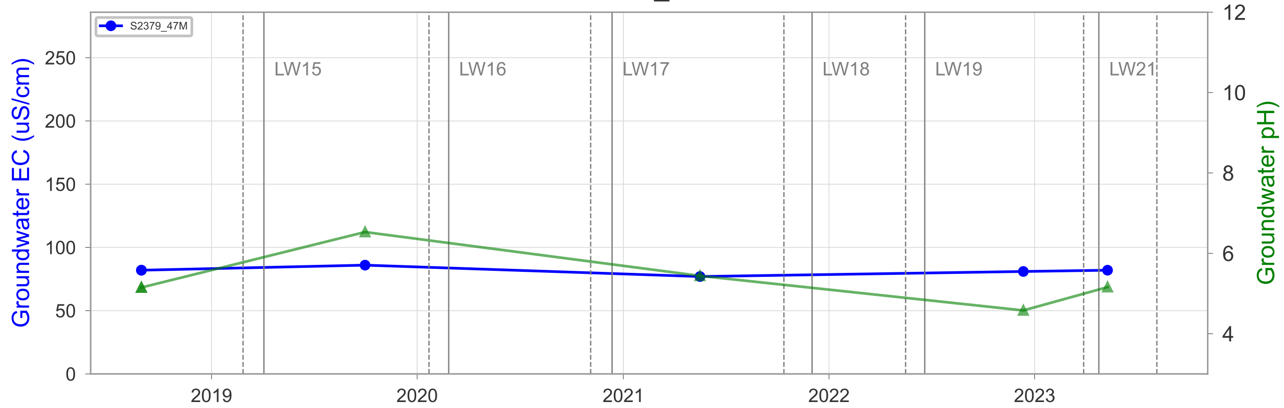


Groundwater EC timeseries

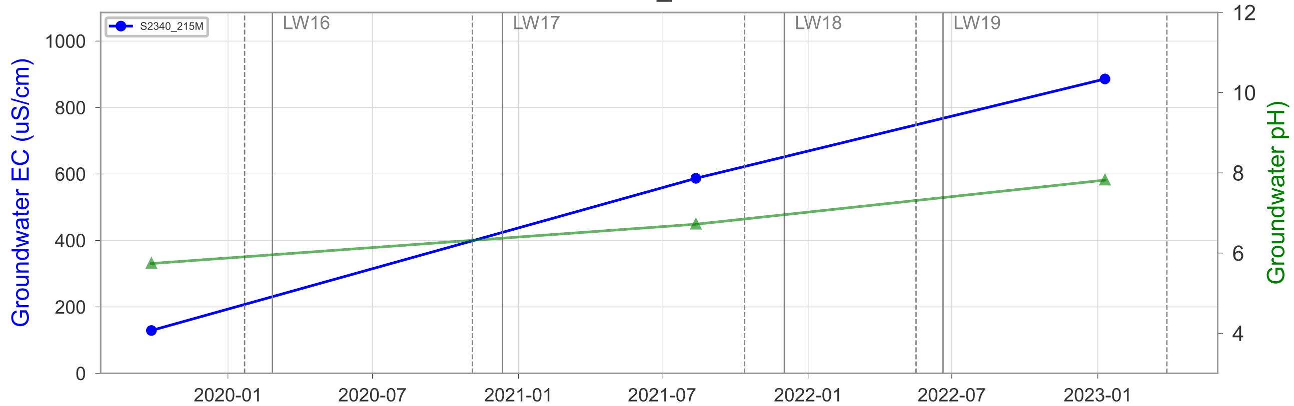
S2379_128M



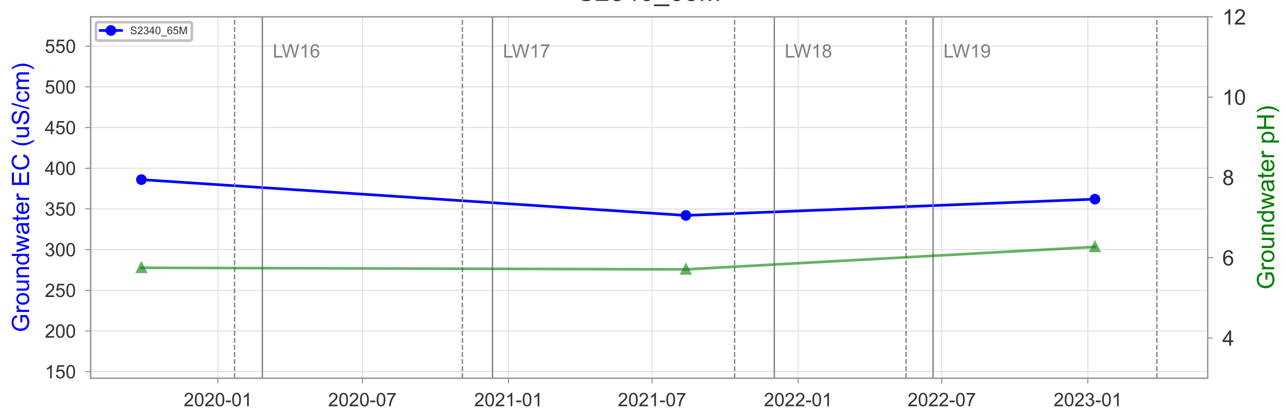
S2379_47M



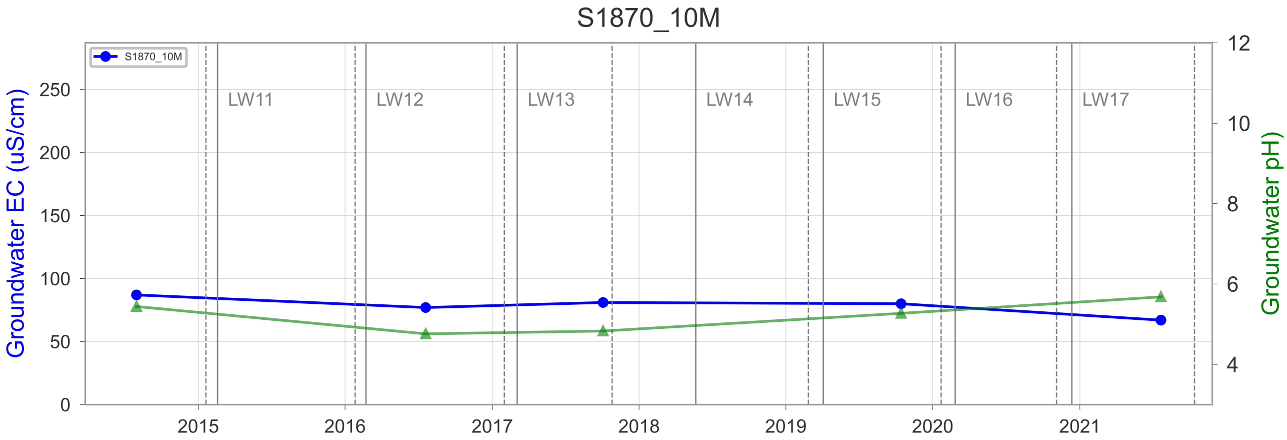
S2340_215M

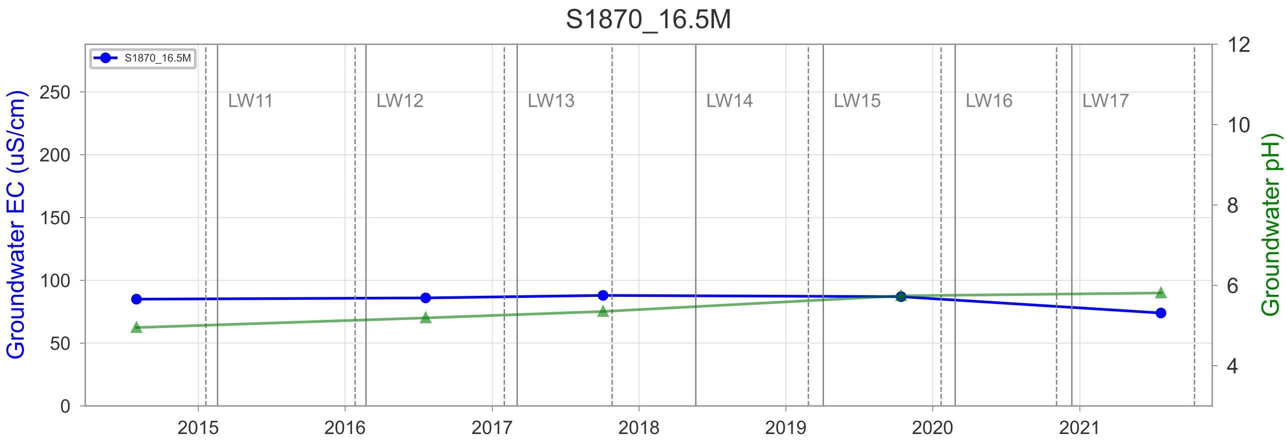


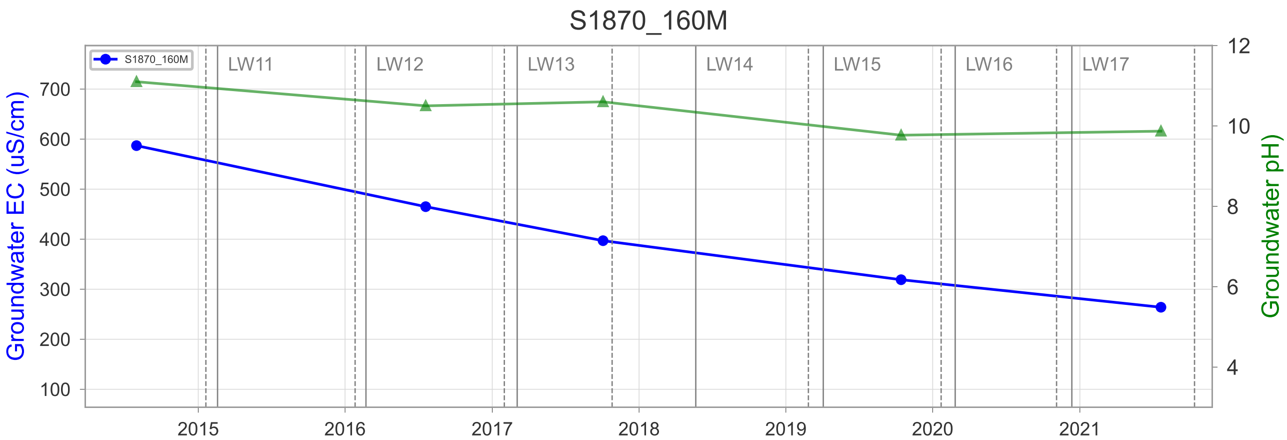
S2340_65M

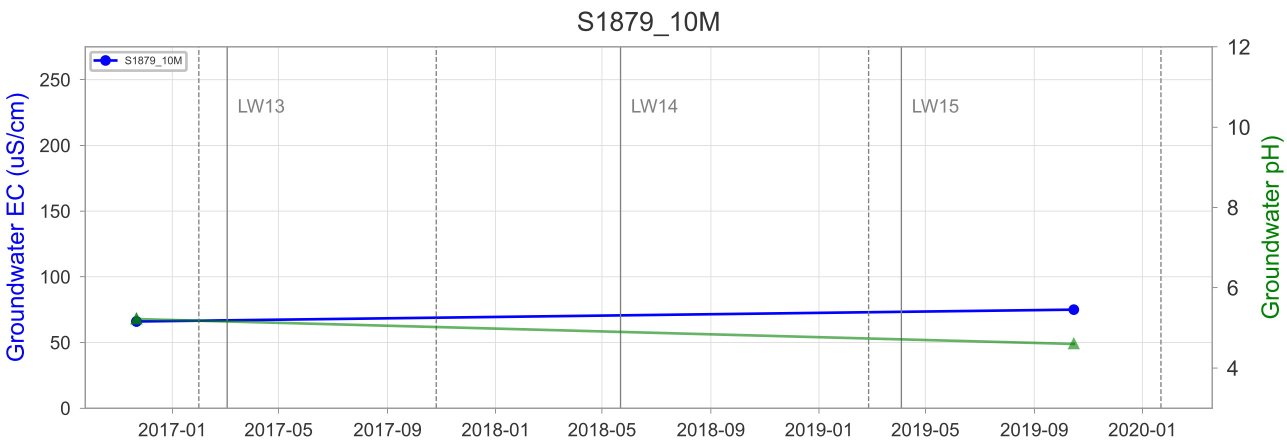


Groundwater EC timeseries

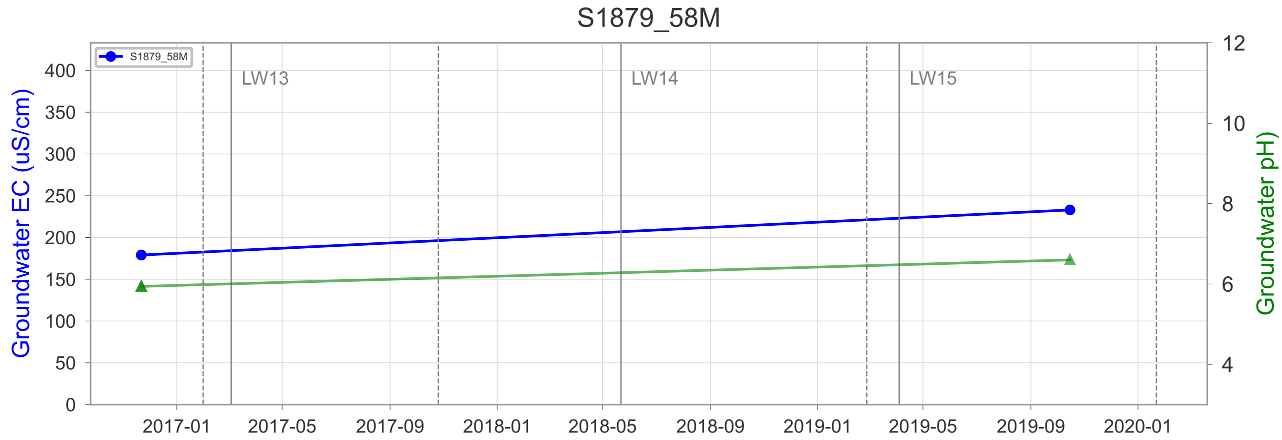


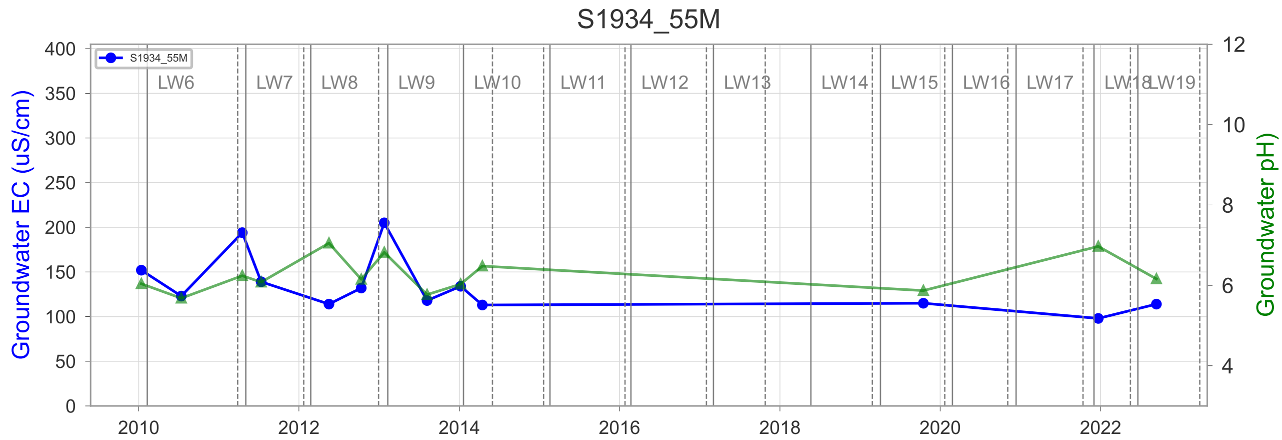


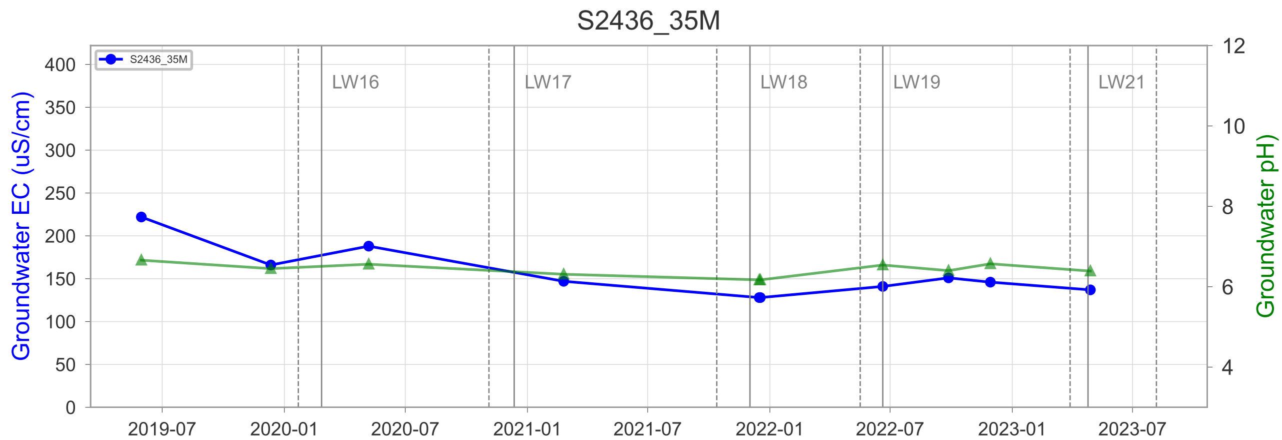


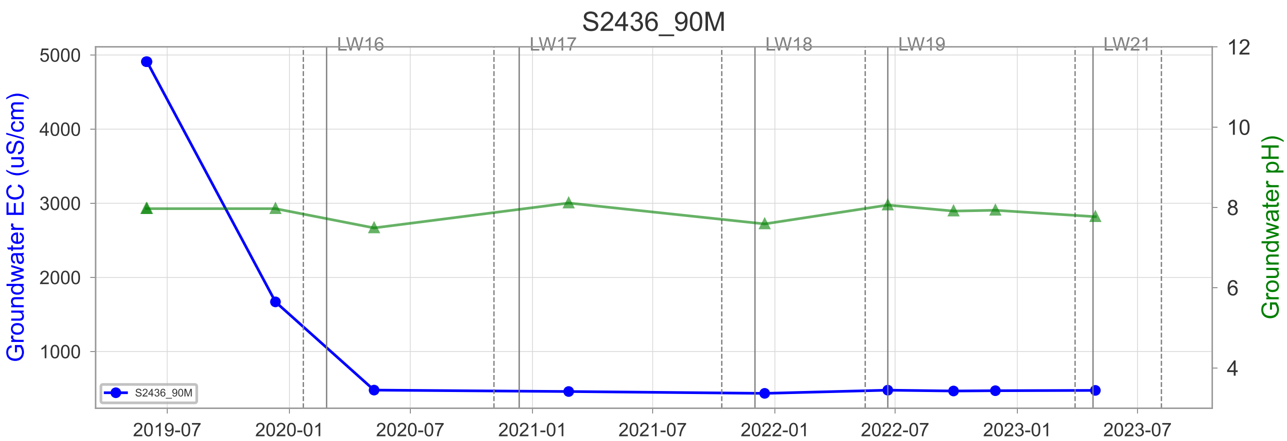


Groundwater EC timeseries



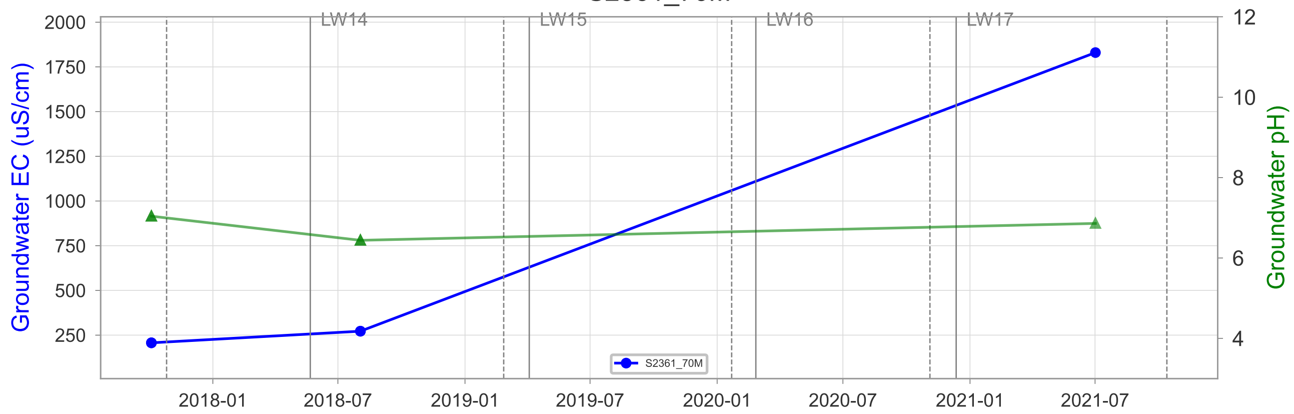




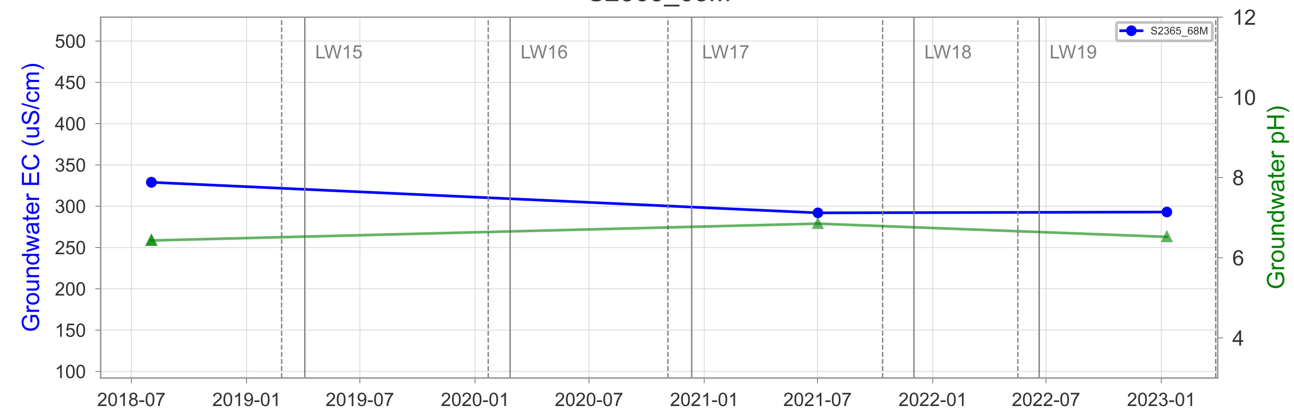


Groundwater EC timeseries

S2361_70M



S2365_68M



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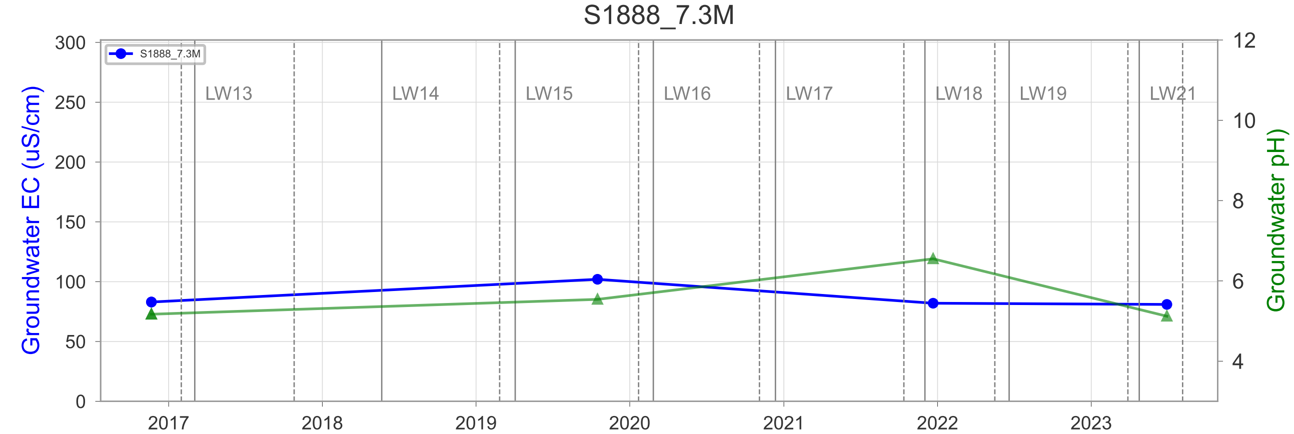

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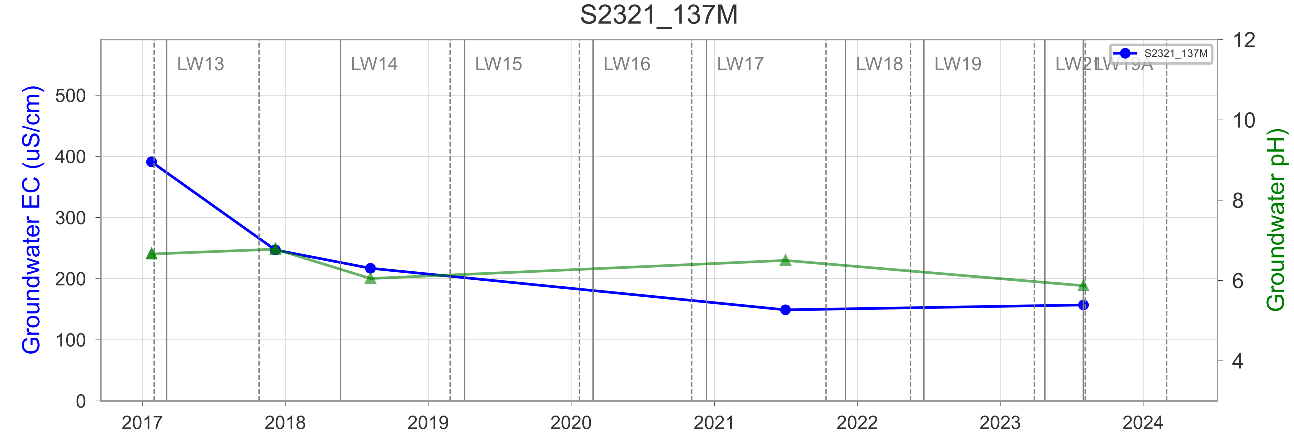
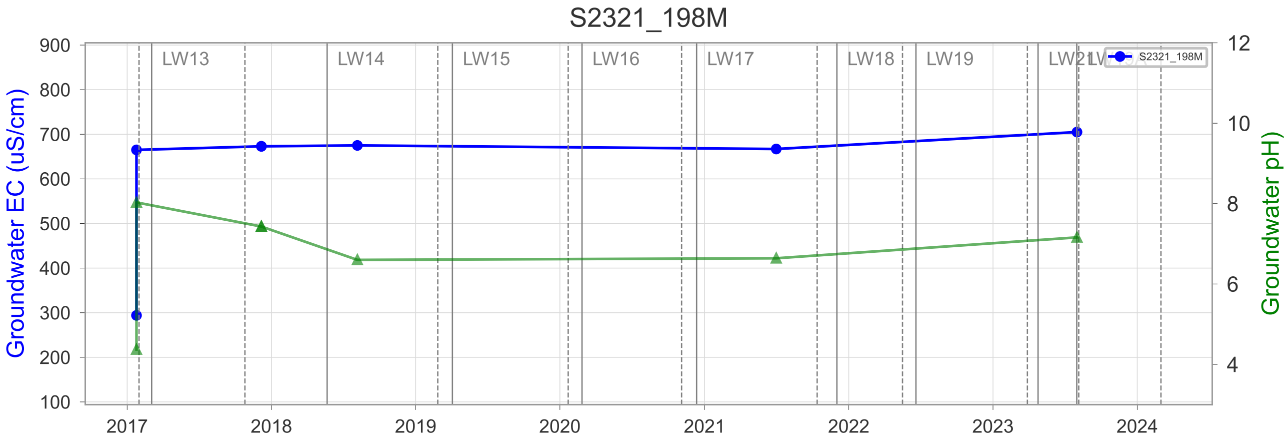
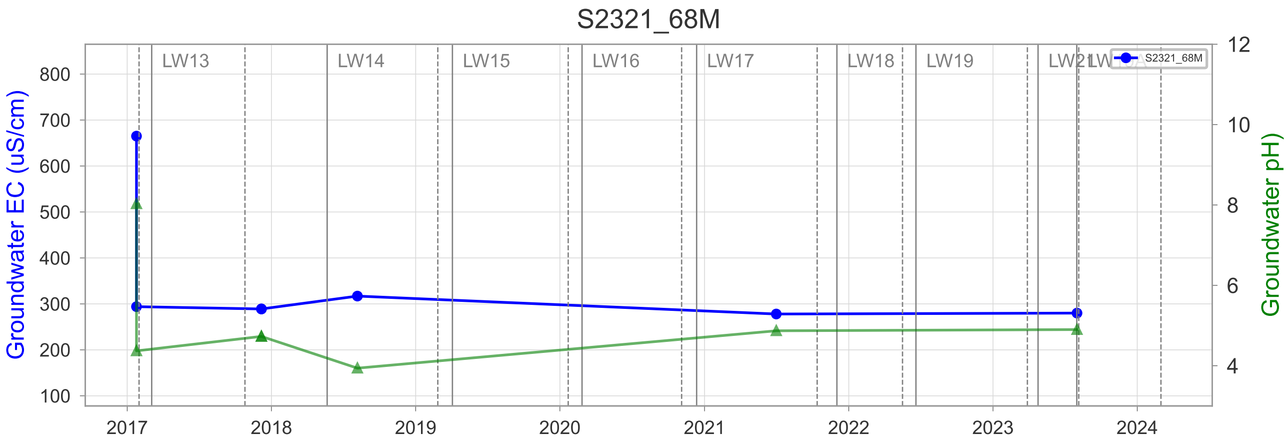
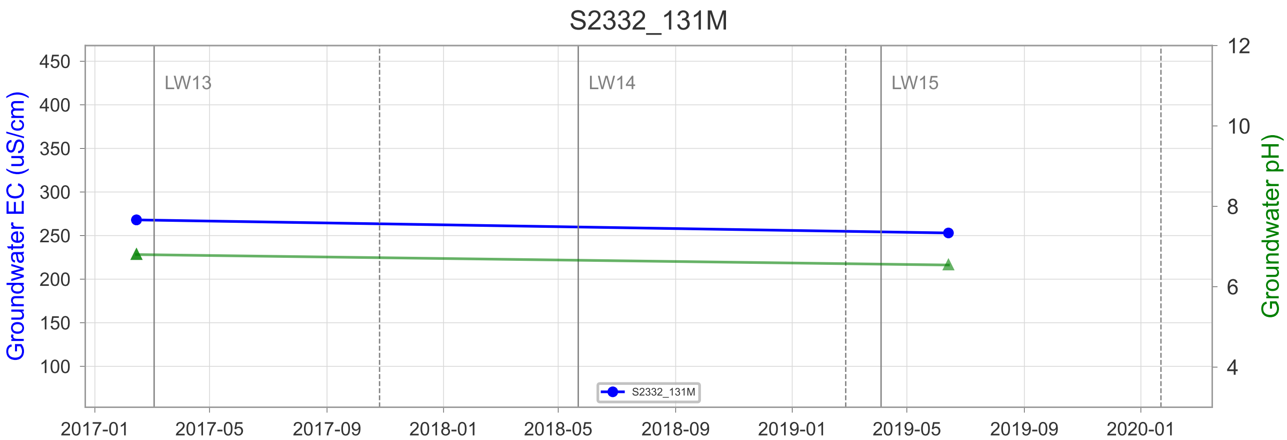
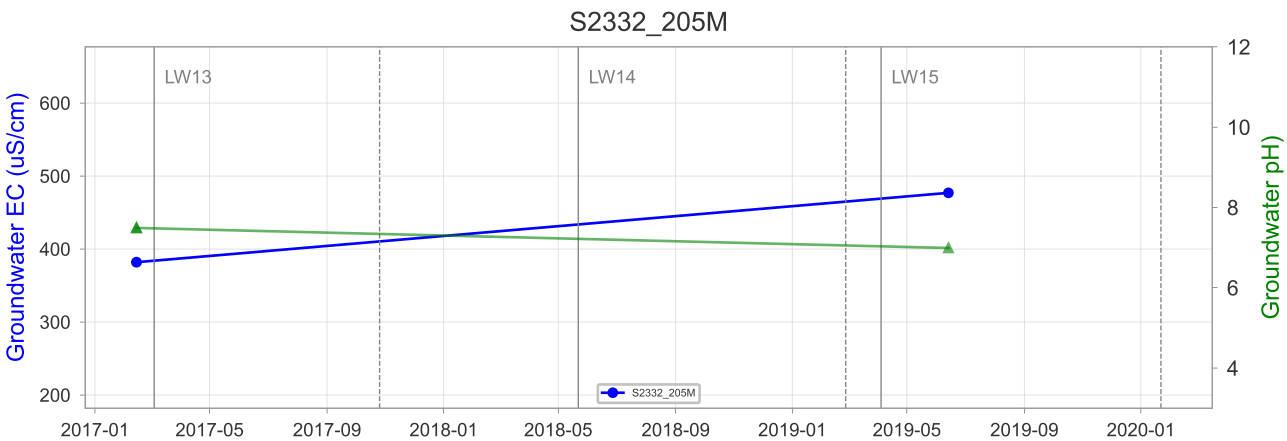


Groundwater EC timeseries

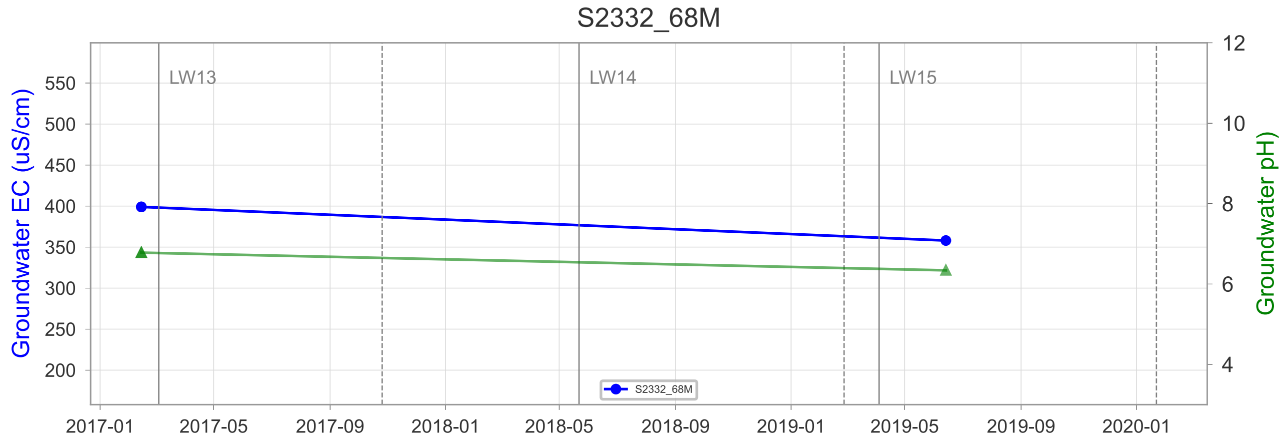


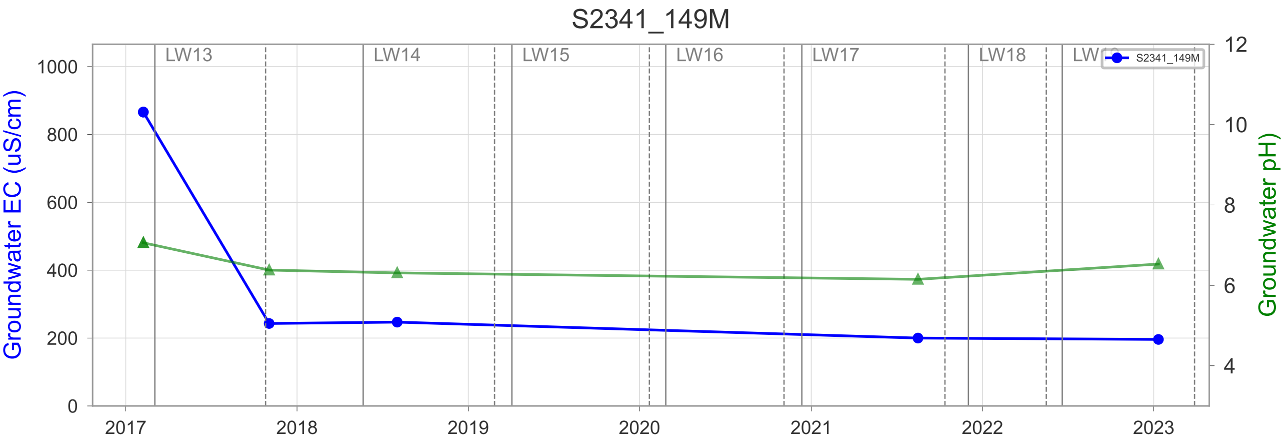


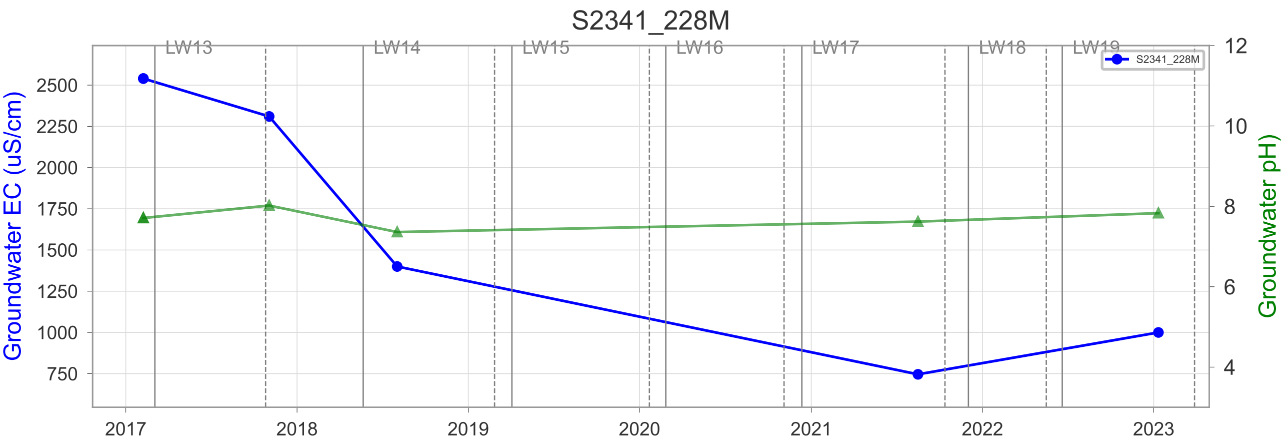


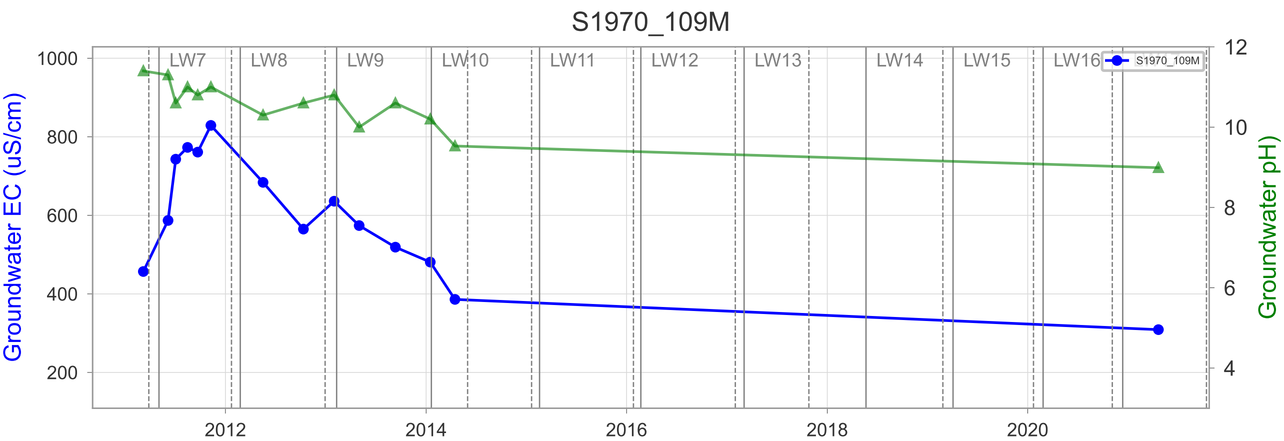


Groundwater EC timeseries









Groundwater EC timeseries