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WATER MANAGEMENT PLAN – TAHMOOR SOUTH DOMAIN – LONGWALLS SOUTH 1A – SOUTH 6A

Tahmoor Coal Pty Ltd

Document Control

Applicant:	Tahmoor Coal Pty Ltd
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1 Introduction

1.1 Background

Tahmoor Coal Pty Ltd (Tahmoor Coal) owns and operates the Tahmoor Mine, an existing underground coal mine located approximately 80 kilometres (km) south-west of Sydney in the Southern Coalfields of New South Wales (NSW). Tahmoor Mine surface facilities are situated between the towns of Tahmoor and Bargo within the Wollondilly Local Government Area (LGA). The mine has previously extracted longwalls to the north and west of the surface facilities and has been operating continuously since 1979 when coal was first mined using bord and pillar mining methods, followed by longwall mining methods since 1987.

The location of Tahmoor Mine in the regional context is shown in **Figure 1**.

Tahmoor Mine produces a primary hard coking coal product and a secondary higher ash coking coal product that are used predominantly for coke manufacture for steel production. Extracted coal is processed on site at the coal handling and preparation plant (CHPP) and coal clearance facilities prior to transportation via rail to Port Kembla and Newcastle for Australian domestic and export customers.

An Environmental Impact Statement (EIS) was exhibited in early 2019 to gain approval for the Tahmoor South Coal Project (the Project), which involves use of the existing surface infrastructure and the expansion of underground longwall mining to the south of the existing workings (referred to as the Tahmoor South Domain). Tahmoor Coal subsequently revised the proposed mine design and submitted amended development applications on two occasions (in February and August 2020). In April 2021, Tahmoor Coal received Development Application Approval (SSD 8445) for the extraction of up to 4 million tonnes per annum (Mtpa) of run-of-mine (ROM) coal, with a total of up to around 33 Mt of ROM coal proposed to be extracted over a 10-year period.

The Tahmoor South Domain is located south of the Bargo River and east of Remembrance Driveway and the township of Bargo. Longwall mining would be used to extract coal from the Bulli coal seam within the bounds of Consolidated Coal Lease (CCL) 716 and CCL 747. Twelve longwalls are proposed in this domain which are divided into a series of six northern (A series) and six southern (B series) longwalls. The A series, Longwalls South 1A to South 6A (LW S1A-S6A), are the focus of the current Extraction Plan application.

The location of LW S1A-S6A and associated Study Area are illustrated in **Figure 2**.

1.2 Purpose

This Water Management Plan has been prepared to support an Extraction Plan for the secondary extraction of coal from LW S1A-S6A.

The purpose of this Water Management Plan is to provide a framework for Tahmoor Coal personnel to ensure that compliance is achieved with relevant internal and external regulatory requirements related to surface water and groundwater monitoring and management within the Extraction Plan Study Area. The plan ensures that impacts on the environment and community are, given that secondary extraction is to proceed, minimised and managed within a structured framework.

This Water Management Plan complies with Development Consent (SDD 8445) (the Consent) Condition C8.

1.3 Scope

The Study Area applicable to this management plan consists of a combination of the predicted 20 millimetre (mm) total subsidence contour and the 35 degree angle of draw as shown in **Figure 2** (labelled Study Area).

Relevant environmental features within a 600 metre (m) buffer from extraction that could be susceptible to far-field or valley related movements have also been included for consideration.

1.4 Preparation of this Management Plan

This Water Management Plan has been prepared by ATC Williams on behalf of Tahmoor Coal.

Camilla West (ATC Williams – Associate Scientist (BSc (Hons) PhD) has been endorsed by the Department of Planning, Industry and Environment (DPIE, now the Department of Planning and Environment (DPE)) as a suitability qualified water scientist to prepare this management plan.

1.5 Plan and Structure

This Water Management Plan:

- Addresses specific requirements set by Development Consent SSD 8445, EIS Commitments, Leases, Licences, and regulatory requirements (refer to **Section 2**);
- Addresses comments received during stakeholder consultation (refer to **Section 2.4**);
- Provides an overview of the existing environment for surface water and groundwater resources (refer to **Section 3**);
- Provides details on the predicted subsidence impacts and environmental consequences to surface water and groundwater resources from the extraction of LW S1A-S6A (refer to **Section 4**);
- Outlines the monitoring program for potential subsidence-related impacts to surface water and groundwater resources (refer to **Section 5**);
- Outlines the management strategies for potential subsidence-related impacts to surface water and groundwater resources (refer to **Section 6**);
- Outlines the strategies for implementation, reporting, and review of this document (refer to **Section 7**);
- Provides document information (refer to **Section 8**); and
- Provides Trigger Action Response Plans (TARPs) to be implemented to manage and protect surface water and groundwater resources within the Study Area (refer to **Appendix A**).

This Water Management Plan has been prepared based on the contents of the following technical reports:

- Tahmoor South Project Environmental Impact Statement Technical Specialists Report – Geomorphology (Fluvial Systems, 2013) (Appendix H of the Tahmoor South Project EIS);
- Tahmoor South Amended Project Surface Water Impact Assessment (HEC, 2020);
- Groundwater Technical Report (SLR, 2022) (**Appendix E** of this Water Management Plan);
- LW S1A-S6A Biodiversity Management Plan; and
- Subsidence Predictions and Impact Assessments Report (MSEC, 2022) (Appendix A of the Extraction Plan Main Document).

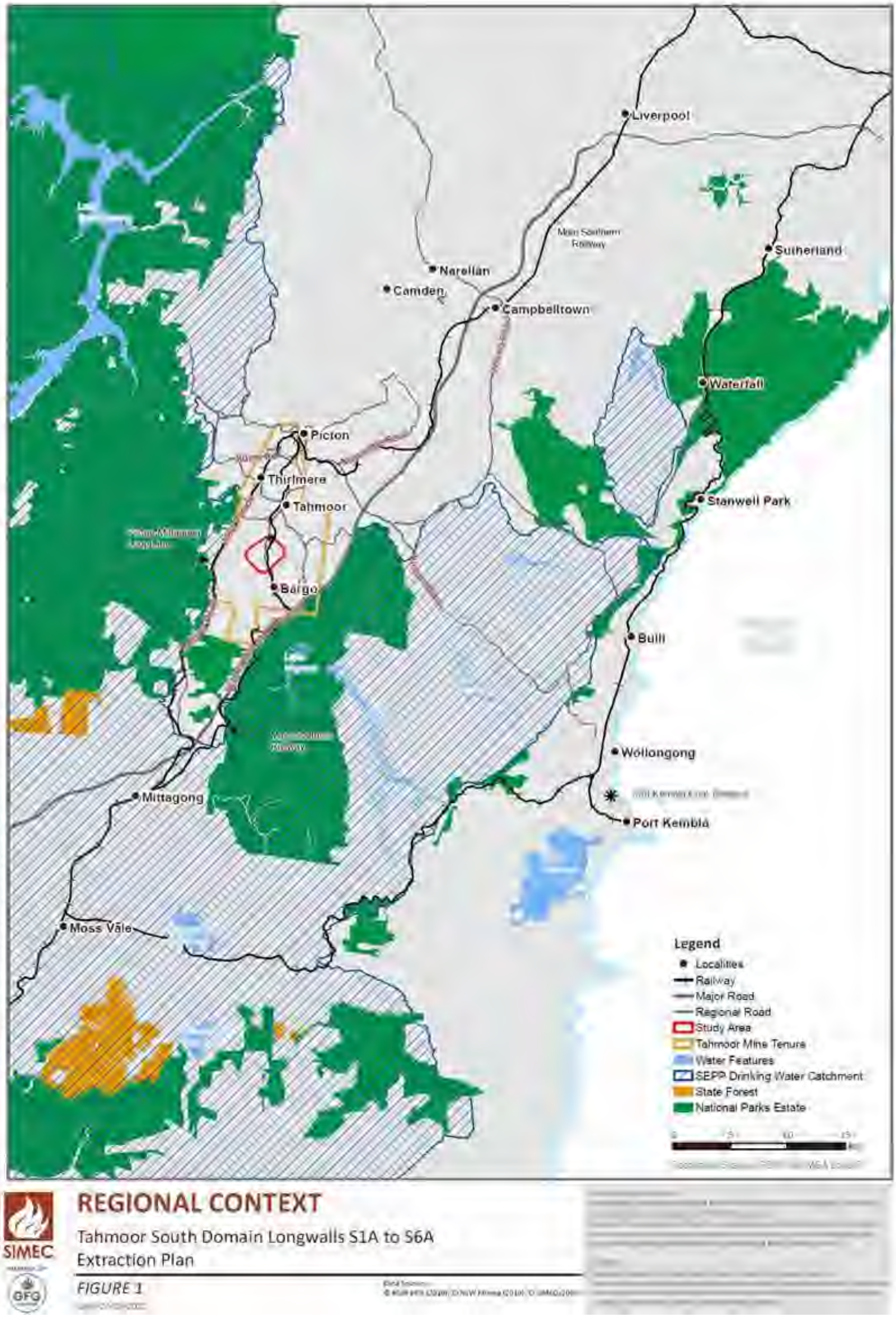

Figure 1 Regional Context

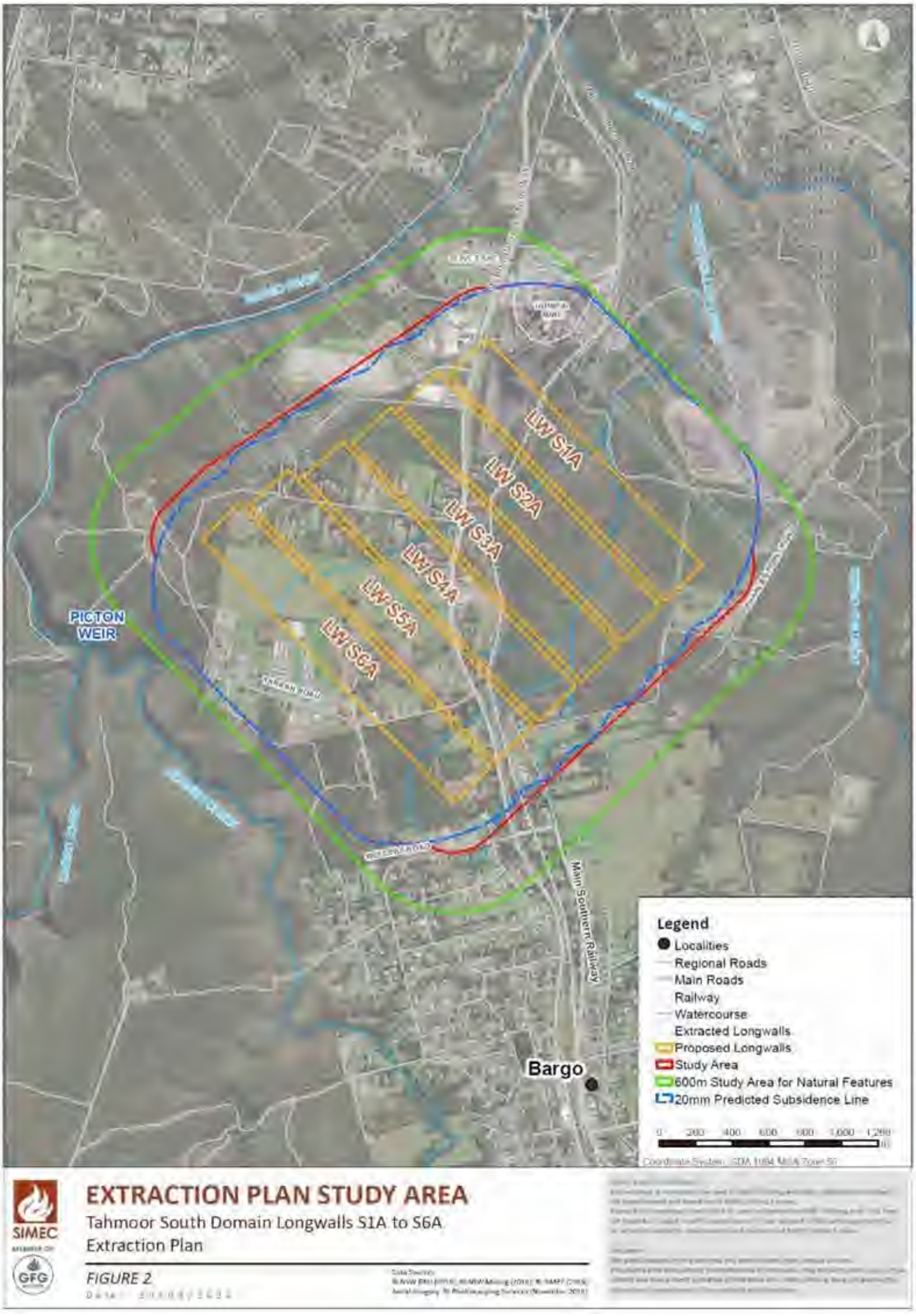

Figure 2 Water Management Plan Study Area

2 Regulatory Requirements

2.1 Project Approval

2.1.1 Development Consent Conditions

2.1.1.1 Extraction Plan Requirements

Tahmoor Coal's operations are conducted in accordance with applicable Commonwealth and State environmental, planning, mining safety, and natural resource legislation. A register of relevant environmental legislative and regulatory requirements is maintained by Tahmoor Coal in a compliance database.

LW S1A-S6A will be extracted in the Tahmoor South Domain under Development Consent SSD 8445 (as modified according to Modification 1 and Modification 2), as discussed further in Section 3.2.1 of the Extraction Plan Main Document. SSD 8445 provides the conditional planning approval framework for mining activities in the Tahmoor South Domain to be addressed within an Extraction Plan and supporting management plans. Conditions relevant to this management plan from SSD 8445 are detailed in **Table 1**.

Table 1 Key Conditions from SSD 8445 regarding Surface Water and Groundwater Resources

Condition Reference	Condition Requirement	Where Addressed
Compensatory Water Supply		
B25	Prior to the commencement of second workings under this consent, the Applicant must complete a bore census for all licensed privately-owned groundwater bores that are predicted to have a drawdown of greater than 2 metres as a result of the development.	**Section 3.7.6.3 and Appendix E**
B26	The Applicant must provide a compensatory water supply to any landowner of privately-owned land whose rightful water supply is adversely and directly impacted (other than an impact that is minor or negligible) as a result of the development, in consultation with NRAR and DPE Water, and to the satisfaction of the Planning Secretary	**Section 6.2.1.3**
B27	The compensatory water supply measures must provide an alternative long-term supply of water that is equivalent, in quality and volume, to the loss attributable to the development. Equivalent water supply should be provided (at least on an interim basis) as soon as practicable after the loss is identified, unless otherwise agreed with the landowner. The burden of proof that any loss of water supply is not due to mining impacts rests with the Applicant.	**Section 6.2.1.3**
SUBSIDENCE **Performance Measures – Natural and Heritage Features etc.**		
C1	The Applicant must ensure that the development does not cause any exceedances of the performance measures in Table 7.	**Section 5, Section 6, Appendix A**

Table 1 (Cont.) Key Conditions from SSD 8445 regarding Surface Water and Groundwater Resources

<table>
<tr><th>Condition Reference</th><th>Condition Requirement</th><th>Where Addressed</th></tr>
<tr><td>Excerpt from Table 7</td><td>Table 7: Subsidence impact performance measures - natural and heritage features etc
<table>
<tr><th>Feature</th><th>Performance Measures</th></tr>
<tr><td colspan="2">Water Resources</td></tr>
<tr><td>All watercourses within the Subsidence Area</td><td>- No greater subsidence impact or environmental consequences to water quality, water flows (including baseflow) or stream health (including riparian vegetation), than predicted in the EIS</td></tr>
<tr><td>Other watercourses</td><td>- Negligible environmental consequences including beyond those predicted in the EIS, including:
- negligible diversion of flows or changes in the natural drainage behaviour of pools;
- negligible decline in baseline channel stability;
- negligible gas releases and iron staining; and
- negligible increase in water turbidity</td></tr>
<tr><td>GDEs including Thirlmere Lakes</td><td>- Negligible impacts including:
- negligible change in groundwater levels; and
- negligible change in groundwater quality.</td></tr>
</table>
Notes for Table 7 (C1):
Notes:
• These performance measures apply to all mining taking place after the date of this consent.
• The Applicant is required to define more detailed performance indicators (including impact assessment criteria) for each of these performance measures in the various management plans that are required under this consent (see condition CB).</td><td>Section 5, Section 6, Appendix A</td></tr>
<tr><td>C2</td><td>Measurement and monitoring of compliance with performance measures and performance indicators in this consent is to be undertaken using generally accepted methods that are appropriate to the environment and circumstances in which the feature or characteristic is located. These methods are to be fully described in the relevant management plans and monitoring programs. In the event of a dispute over the appropriateness of proposed methods, the Planning Secretary will be the final arbiter.</td><td>Section 5, Appendix B</td></tr>
<tr><td colspan="3">Extraction Plan</td></tr>
<tr><td>C8</td><td>The Applicant must prepare an Extraction Plan for all second workings on the site of the development to the satisfaction of the Planning Secretary. Each Extraction Plan must:</td><td>Noted.
This management plan is part of the LW S1A-S6A Extraction Plan Application.</td></tr>
<tr><td>C8(e)</td><td>provide revised predictions of the potential subsidence effects, subsidence impacts and environmental consequences of the proposed mining covered by the Extraction Plan, incorporating any relevant information obtained since this consent;</td><td>Section 4</td></tr>
<tr><td>C8(f)</td><td>describe in detail the performance indicators to be implemented to ensure compliance with the performance measures in Table 7 and Table 8, and manage or remediate any impacts and/or environmental consequences to meet the rehabilitation objectives in condition B56;</td><td>Section 5.1, Section 5.2, Section 6</td></tr>
</table>

Table 1 (Cont.) Key Conditions from SSD 8445 regarding Surface Water and Groundwater Resources

Condition Reference	Condition Requirement	Where Addressed
C8(g)(iii)	Water Management Plan which has been prepared in consultation with DPE Water and BCD and is consistent with the Water Management Plan required under condition B34, which provides for the management of potential impacts and environmental consequences of the proposed underground workings on watercourses and aquifers, including:	This management plan. **Section 2.4**
	• detailed baseline data on: -surface water flows, quality and geomorphic conditions of watercourses and/or water bodies that could be affected by subsidence; and -groundwater levels, yield and quality in the region, including for privately-owned licensed bores;	**Section 3**
	• detailed surface and groundwater impact assessment criteria, including specific trigger levels for: -investigating any potentially adverse impacts on water resources or water quality; -active remediation of geomorphic and erosional impacts (including supporting justification for the selected triggers); and -providing compensatory water supply to affected water users under condition B26 of this Schedule;	**Section 3.3.3, Section 5.1, Section 6, Appendix A**
	• a surface water monitoring program to monitor and report on: -stream flows and quality; -stream and riparian vegetation; -channel and bank stability; and -the effectiveness of remediation measures in controlling geomorphic and erosional impacts;	**Section 5.2**
	• a groundwater monitoring program to monitor and report on: -groundwater inflows to the underground mining operations; -the height of groundwater depressurisation; -height of fracturing above indicative longwall panels following mining; -background changes in groundwater yield/quality against mine-induced changes, in particular, on privately-owned groundwater bores in the vicinity of the site; -permeability, hydraulic gradient, flow direction and connectivity of the deep and shallow groundwater aquifers; and • impacts of the development on GDEs (including Thirlmere Lakes);	**Section 5.2, Section 5.5**
	• a description of any adaptive management practices implemented to guide future mining activities in the event of greater than predicted impacts on aquatic habitat;	**Section 6.4**
	• a program to validate the surface water and groundwater models for the development and compare monitoring results with modelled predictions; and	**Section 6.2, Section 6.3, Appendix A**
	• a plan to respond to any exceedances of the surface water and groundwater assessment criteria, including a Watercourse Corrective Action Management Plan as detailed in Condition C12.	**Section 6.2, Appendix A**

Table 1 (Cont.) Key Conditions from SSD 8445 regarding Surface Water and Groundwater Resources

Condition Reference	Condition Requirement	Where Addressed
C8(g)(viii)	Trigger Action Response Plans addressing all features in Table 7 and Table 8, which contain:	**Section 6.3, Appendix A**
	• appropriate triggers to warn of increased risk of exceedance of any performance measure;	
	• specific actions to respond to high risk of exceedance of any performance measure to ensure that the measure is not exceeded;	
	• an assessment of remediation measures that may be required if exceedances occur and the capacity to implement the measures; and	
	• adaptive management where monitoring indicates that there has been an exceedance of any performance measures in Table 7 and/or Table 8, or where any such exceedance appears likely; and	**Section 6.5**
C8(g)(ix)	Contingency Plan that expressly provides for:	**Section 6.4, Appendix A**
	• adaptive management where monitoring indicates that there has been an exceedance of any performance measure in Table 7 and/or Table 8, or where any such exceedance appears likely;	**Section 6.5**
	• an assessment of remediation measures that may be required if exceedances occur and the capacity to implement those measures;	**Section 6.2, Section 6.5**
C8(i)	• include a program to collect sufficient baseline data for future Extraction Plans.	**Section 5.6** and **Appendix B**
Adaptive Management		
E4	The Applicant must assess and manage development-related risks to ensure that there are no exceedances of the criteria and performance measures in this consent. Any exceedance of these criteria or performance measures constitutes a breach of this consent and may be subject to offset or other provisions as specified in this consent and/or penalty or offence provisions under the EP&A Act or EP&A Regulation. Where any exceedance of these criteria or performance measures has occurred, the Applicant must, at the earliest opportunity: • take all reasonable and feasible steps to ensure that the exceedance ceases and does not recur; • consider all reasonable and feasible options for remediation (where relevant) and submit a report to the Department describing those options and any preferred remediation measures or other course of action; • within 14 days of the exceedance occurring (or other timeframe agreed by the Planning Secretary), submit a report to the Planning Secretary describing these remediation options and any preferred remediation measures or other course of action; and • implement reasonable remediation measures as directed by the Planning Secretary.	**Section 6.5**

In addition, this management plan includes relevant information from the Tahmoor South Site Water Management Plan, prepared in accordance with Condition B38, to ensure compliance with this document.

2.1.1.2 Management Plan Requirements

Condition E5 of the Consent outlines the general requirements for all management plans. **Table 2** outlines the requirements under this condition and identifies where these requirements have been addressed.

Table 2 Management Plan Requirements

Condition Reference	Condition Requirement	Where Addressed
E5	Management plans required under this consent must be prepared in accordance with relevant guidelines, and include:	Noted.
(a)	a summary of relevant background or baseline data;	**Section 3**
(b)	details of:	NA
(b)(i)	the relevant statutory requirements (including any relevant approval, licence or lease conditions);	**Sections 2.1, 2.2 and 2.3**
(b)(ii)	any relevant limits or performance measures and criteria; and	**Section 3.3.3, Section 5.1, Appendix A**
(b)(iii)	the specific performance indicators that are proposed to be used to judge the performance of, or guide the implementation of, the development or any management measures;	**Section 3.3.3, Section 5.1, Section 6.3, Appendix A**
(c)	any relevant commitments or recommendations identified in the document/s listed in condition A2(c);	**Section 2**
(d)	a description of the measures to be implemented to comply with the relevant statutory requirements, limits, or performance measures and criteria;	**Section 6**
(e)	a program to monitor and report on the:	NA
(e)(i)	impacts and environmental performance of the development; and	**Section 5**
(e)(ii)	effectiveness of the management measures set out pursuant to condition E5(d);	**Section 6.2**
(f)	a contingency plan to manage any unpredicted impacts and their consequences and to ensure that ongoing impacts reduce to levels below relevant impact assessment criteria as quickly as possible;	**Section 6.4, Appendix A**
(g)	a program to investigate and implement ways to improve the environmental performance of the development over time;	**Section 6.4, Section 6.5**
(h)	a protocol for managing and reporting any:	NA
(h)(i)	incident, non-compliance or exceedance of any impact assessment criterion or performance criterion;	**Section 7**
(h)(ii)	complaint; or	**Section 7**
(h)(iii)	failure to comply with other statutory requirements;	**Section 7**
(i)	public sources of information and data to assist stakeholders in understanding environmental impacts of the development; and	**Section 7**
(j)	a protocol for periodic review of the plan.	**Section 7**

2.1.2 EIS Commitments

Condition A2(g) of the Consent states that the development may only be carried out generally in accordance with the EIS. The relevant EIS documents include:

- Tahmoor South Project Environmental Impact Statement, Volumes 1 and 7, dated January 2019;
- Tahmoor South Project Amendment Report, including Appendices A to R and response to submissions, dated February 2020;
- Tahmoor South Project Second Amendment Report, Appendices A to O and response to submissions, dated August 2020; and
- Additional information responses dated 14 September 2020 (including Appendices A to L), 23 October 2020 and 4 November 2020.

EIS commitments relevant to this management plan are outlined in **Table 3**. These EIS commitments do not include commitments that are covered by the SSD 8445 Conditions of Consent.

Table 3 Relevant EIS Commitments

EIS Reference	Commitment	Where Addressed
GE-1	**Geomorphology** Potential impact: Impacts to geomorphological features in the Project Area from mining-induced subsidence Management and mitigation measures: • Pre, during and post-mining photographic surveys and visual inspections of geomorphological features for each longwall. Results would be documented in the Extraction Plan and Annual Review. • Annual catchment survey at 10 headwater photographic sampling locations to monitor mining-induced subsidence impacts of the Project over time. • A geomorphology survey (baseline and post mining) of waterways overlying each longwall to complement monitoring of subsidence at each longwall. • Installation of subsidence monitoring points before mining of secondary workings for all longwalls. The adaptive management plan for the Project would include re-evaluation of the monitoring techniques for subsidence and biodiversity after mining of each longwall. This would then inform monitoring for subsequent longwall panels. • Monitoring of knickpoint formation during mining of each longwall, and implementation of appropriate controls to prevent knickpoint formation. • Reporting of monitoring results within the Annual Review.	**Section 5, Section 7, Appendix A** of this document, **Appendix B** of this document and Appendix A of the Extraction Plan Main Document
SW-1	**Surface water** Potential impact: Impacts to surface water from mining-induced subsidence Management and mitigation measures: Monitoring would be undertaken before mining commences to assess the baseline conditions above each longwall, and would include: • Geomorphological conditions • Water quality • Stream flow Monitoring sites will include: • Ongoing streamflow monitoring at existing monitoring sites. • An additional stream flow gauging station would be installed at Teatree Hollow, downstream of the edge of the longwall and upstream of Licensed Discharge Point (LDP) 1. • Additional water level monitoring to establish baseline water level data to enable the assessment of potential impacts to pool water levels. • Streamflow gauging activities would be continued. Enhanced low flow control weirs would be established at the existing gauging station at Dogtrap Creek downstream and the proposed new gauging station at Teatree Hollow to support the generation of reliable continuous flow data (including reliable low flow data) at the stations. Routine water level and water quality monitoring at the stations would also be continued. Monitoring results would be reported in the Annual Review.	**Section 5, Section 7, Appendix A, Appendix B**

Table 3 (Cont.) Relevant EIS Commitments

EIS Reference	Commitment	Where Addressed
SW-2	**Surface water** Potential impact: Impacts to surface water from mining-induced subsidence Management and mitigation measures: Monitoring of waterways within 200m of active longwall mining, including monthly photographic recording and monthly water quality sampling upstream and downstream of potentially affected areas. Results would be analysed in relation to action response triggers, as detailed in the surface water management plan. Monitoring to be reported in the Annual Review and six-monthly subsidence impact reports.	**Section 5, Section 7, Appendix A, Appendix B**
SW-5	**Surface water** Potential impact: Impacts to surface water from mining-induced subsidence Management and mitigation measures: Update the monitoring and management plans and the groundwater/surface water model in relation to impacts to the Thirlmere Lakes as findings from the OEH research project become available to guide ongoing management of impacts.	**Section 5, Appendix A, Appendix B, Appendix E**
SW-7	**Surface water** Potential impact: Surface water entitlement Management and mitigation measures: Obtain the necessary authorised entitlement to account for the maximum take of water from both surface water and groundwater sources in accordance with the Aquifer Interference Policy.	**Section 3.6.1, Section 4.5**
PAR #6	**Surface water** • Prior to the commencement of longwall mining, an adaptive monitoring and TARP would be developed. The following surface water elements would be incorporated into the plan: - TARPs for water quality exceedances which incorporate both baseline and control monitoring data. - TARPs for unexpected flow loss based on analysis of baseline (i.e. pre-subsidence) streamflow data, post-subsidence streamflow data and contemporaneous data from control sites. Catchment flow modelling would also be used in the analysis. - TARPs for unexpected loss of pool water holding capacity based on analysis of baseline (i.e. pre-subsidence) pool water level data, post-subsidence pool water level data and contemporaneous data from control pool sites.	**Section 5, Section 6.3, Appendix A**
PAR #9	**Surface water** Monitoring of streamflow, pool water levels and water quality would continue for two years following cessation of longwall subsidence related movement in a watercourse or following completion of any stream/pool remediation.	**Section 5**

Table 3 (Cont.) Relevant EIS Commitments

EIS Reference	Commitment	Where Addressed
GW-3	**Groundwater** Potential impact: Impacts to groundwater as a result of mining induced subsidence Management and mitigation measures: Update and maintain regional groundwater monitoring network, with monitoring results reported annually within the Annual Review. This would include replacement of failed bores around Tahmoor North and Tahmoor South, as well as establishing new bores. Monitoring of groundwater levels would include: • A condition assessment of bores and monitoring equipment (VMPs) of new bores around Tahmoor South, with a specific update of the GWMP. • Geophysical logging of boreholes that allow changes in groundwater storage and fracture apertures to be quantified and depth of rock deformation to be identified (i.e. observations of non-deformed ground which could be at least 10- 30 m below surface). • Re-install at least one bore in the footprint of a Tahmoor North longwall (e.g. at TNC029) to monitor post-mining groundwater level and groundwater quality. • Monitoring in longwall centre-lines of pre- and post-mining conditions Tahmoor South. This would be undertaken for the longwall (101A), and then every two or three after that. Packer testing would also be undertaken, followed by installing VMPs at four elevations in the Hawkesbury Sandstone and then two in the Bulgo Sandstone to assist in defining a profile of fracturing and depressurisation above longwalls. Results from monitoring would be compared to those from groundwater monitoring of reference sites including upstream and outside the predicted subsidence impact zone where relevant	**Section 5, Appendix E**
GW-5	**Groundwater** Potential impact: Impacts to groundwater as a result of mining induced subsidence Management and mitigation measures: Revision of the groundwater model to: • Take further advantage of unstructured mesh capabilities; • Incorporate conceptual developments from the OEH Thirlmere Lakes Research Program (once complete); and • Incorporate the results of mine inflow monitoring; • Incorporate monitoring data from groundwater bores in the Western Domain of Tahmoor North.	**Appendix E**

2.1.3 EPBC Act Approval Conditions

Conditions relevant to this management plan from the approval (EPBC 2017/8084) granted by the NSW Department of Agriculture, Water and the Environment (DAWE) for the Project are outlined in **Table 4**.

Table 4 EPBC Act Approval Conditions

Condition	Condition Requirement	Where Addressed
3	For the protection of water resources, the approval holder must comply with State development consent conditions A7, B23, B24, B30, B31, B32, B33, B34, B35, B36, C1, C2, C8, C9 and C10	Relevant conditions applicable to this Extraction Plan are discussed in **Section 2.1.1** and the Extraction Plan Main Document. Condition A7 of SSD 8445 is not considered relevant to this Extraction Plan. Conditions B30, B31, B32, B33, B34, B35 and B36 of SSD 8445 are covered by the generic Water Management Plan for the Tahmoor South Domain, which has been approved by DPE. Conditions B23 and B24 of SSD 8445 will be reported on in the Annual Review.
4	The approval holder must ensure there is no adverse effect on the function of a water resource as a result of the action.	**Section 5**

2.1.4 Extraction Plan Guideline

This management plan has been prepared in accordance with the *Draft Guidelines for the Preparation of Extraction Plans V5* (DPE, 2015), as detailed in **Table 5**.

Table 5 Extraction Plan Guideline Requirements for Key Component Plans

Extraction Plan Guideline Content Requirements for Key Component Plans	Where Addressed
An overview of all landscape features, heritage sites, environmental values, built features or other values to be managed under the component plan.	**Section 3**
Setting out all performance measures included in the development consent relevant to the features or values to be managed under the component plan.	**Section 2.1.1, Section 5.1**
Setting out clear objectives to ensure the delivery of the performance measures and all other relevant statutory requirements (including relevant safety legislation).	**Section 2, Section 5.1, Section 6**
Proposing performance indicators to establish compliance with these performance measures and statutory requirements.	**Section 5.1, Appendix A**
Describe the landscape features, heritage sites and environmental values to be managed under the component plan, and their significance.	**Section 3**
Describe all currently predicted subsidence impacts and environmental consequences relevant to the features, sites and values to be managed under the component plan.	**Section 4**
Describe all measures planned to remediate these impacts and/or consequences, including any measures proposed to ensure that impacts and/or consequences comply with performance measures and/or the Applicant's commitments.	**Section 5, Section 6, Appendix A**
Describe the existing baseline monitoring network and the current baseline monitoring results, including pre-subsidence photographic surveys of key landscape features and key heritage sites which may be subject to significant subsidence impacts (such as significant watercourses, swamps and Aboriginal heritage sites).	**Section 3**
Fully describing the proposed monitoring of subsidence impacts and environmental consequences.	**Section 5**
Describe the proposed monitoring of the success of remediation measures following implementation.	**Section 6.2, Section 6.4, Appendix A**
Describe adaptive management proposed to avoid repetition of unpredicted subsidence impacts and/or environmental consequences.	**Section 6.5**

Table 5 (Cont.) Extraction Plan Guideline Requirements for Key Component Plans

Extraction Plan Guideline Content Requirements for Key Component Plans	Where Addressed
Describe contingency plans proposed to prevent, mitigate or remediate subsidence impacts and/or environmental consequences which substantially exceed predictions or which exceed performance measures.	**Section 6.4, Appendix A**
Listing responsibilities for implementation of the plan.	**Section 7**
An attached Trigger, Action, Response Plan (effectively a tabular summary of most of the above).	**Appendix A**

2.2 Relevant Legislation and Policies

The relevant acts and regulations protecting and managing surface water and groundwater resources in New South Wales are detailed in the subsections below.

2.2.1 Relevant Legislation

2.2.1.1 Protection of the Environment Operations Act 1997

The *Protection of the Environmental Operations Act 1997* and the *Protection of the Environment Operations (General) Regulation 2009* set out the general obligations for environmental protection in NSW. The Tahmoor Mine operates in accordance with Environment Protection Licence (EPL) 1389.

2.2.1.2 Water Management Act 2000

The objects of the *Water Management Act 2000* are to provide for the sustainable and integrated management of the water sources of the State for the benefit of both present and future generations.

The NSW Department of Planning and Environment (DPE) – Water (DPE – Water; formerly part of the NSW Department of Planning, Industry and Environment [DPIE]) develops, assesses and recommends changes to water sharing/water resources plans and water management rules for regional water in NSW in accordance with the *Water Management Act 2000*. A primary objective of DPE – Water is the sustainable management and use of water resources, balancing environmental, social and economic considerations. DPE – Water has developed Water Sharing Plans (WSPs) for much of the State and these establish rules for sharing and trading water between the environment, town water supplies, basic landholder rights and commercial uses. The NSW Department of Natural Resources Access Regulator (NRAR) is an independent regulatory body established by DPE – Water and is responsible for compliance with and enforcement of the regulatory framework.

2.2.1.3 Water Sharing Plans

The Study Area is regulated by the *Water Sharing Plan for Greater Metropolitan Region Unregulated River Water Sources 2023*. The Water Sources relevant to the Study Area, as defined in the *Water Sharing Plan for Greater Metropolitan Region Unregulated River Water Sources 2023*, are the:

- Stonequarry Creek Water Source; and
- Maldon Weir Water Source.

Water used in existing and on-going mining and coal processing operations will continue to be sourced from the underground operations (groundwater ingress and recycling of supply for mining operations) and from water captured within the existing pit top water management system – principally at the coal handling and processing plant and rejects emplacement area, which are partially located approximately within the Study Area. Some water is also supplied under agreement with Sydney Water.

The Study Area is also located within the *Greater Metropolitan Region Groundwater Sources Water Sharing Plan 2023*. The *Greater Metropolitan Region Groundwater Sources Water Sharing Plan 2023* is used to manage the average long-term annual volume of water extracted from relevant groundwater sources.

The Groundwater Source and associated Management Zone relevant to the Study Area is the Sydney Basin Nepean Groundwater Source and the Nepean Management Zone 2, respectively.

The Sydney Basin Nepean Groundwater Source has an annualised limit on entitlement (LTAAEL) of 64,785 megalitres (ML), while the current entitlement is 31,446 ML (based on the WaterNSW Water Register[1] 2023-2024 water year).

2.2.1.4 NSW Aquifer Interference Policy

The Project will include the dewatering of the geological strata proposed to be mined. In accordance with the *NSW Aquifer Interference Policy* (AIP), such activity is classified as an 'Aquifer Interference'. In order to meet the requirements of the 'minimal impact considerations' of the AIP, a groundwater assessment is required to be conducted.

The AIP was developed to provide a framework to guide the assessment of impacts that may result following the 'take' of water from an aquifer. It outlines the requirements for obtaining licences for approved aquifer interference activities, as well as considerations for the assessment of impacts.

The AIP specifies 'minimal harm considerations' for highly and less productive aquifers, while also defining thresholds for water table and groundwater pressure drawdown, and changes in groundwater and surface water quality. There are specific minimal impact considerations for:

- "Highly productive" groundwater;
- "Less productive" groundwater;
- "Water supply" works;
- "High Priority" Groundwater Dependent Ecosystems (GDEs); and
- "High Priority" Culturally significant sites.

The AIP categorises groundwater source productivity (highly productive or less productive) based on characteristics of salinity and aquifer yield. The Project proposes to mine the Bulli Coal Seam which is located at depth beneath the 'Highly Productive' Hawkesbury Sandstone aquifer (refer **Appendix E**).

2.3 Other Leases and Licences

All development consents, leases, licences, and other relevant approvals are stored in the Cority Compliance Management database, which is administered by both site and Liberty GFG Corporate. A summary of the relevant mining leases is provided in **Table 6**. A summary of other approvals and licences is provided in **Table 7**.

[1] https://waterregister.waternsw.com.au/water-register-frame

Table 6 Mining Lease

Lease	Title	Granted	Expires
CCL 716	Original Tahmoor Leases	15/06/1990	13/03/2021 (renewal documentation submitted and being assessed)
CCL 747	Bargo Mining Lease	23/05/1990	06/11/2025
ML 1376	Tahmoor North Lease	28/08/1995	28/08/2016 (renewal documentation submitted and being assessed)
ML 1308	Small Western Lease to west of CCL 716	2/3/1993	2/3/2035
ML 1539	Tahmoor North Extensions Lease	16/06/2003	16/06/2024
ML 1642	Pit-top and REA surface Mining Lease	27/08/2010	27/08/2031

Table 7 Environmental Approvals and Licences

Approval Title / Description	Date of Issue	Expiry Date
Environmental Protection Licence 1389	01/05/2012	No Expiry
WAL36442	6/12/2013	No Expiry
WAL25777	27/10/2014	No Expiry
WAL43572	7/5/2021	No Expiry
WAL43656	1/8/2022	No Expiry
WAL44608	8/2/2023	No Expiry
SWC839757	10/07/2023	No Expiry
XSTR200005 (Licence to store explosives)	02/02/2017	02/02/2027

2.4 Stakeholder Consultation

2.4.1 Consultation to Date

The following stakeholders were consulted during the preparation of this management plan:

- DPE Environment, Energy and Science Group (EES);
- DPE Water;
- WaterNSW;
- Crown Lands; and
- Wollondilly Shire Council.

The feedback provided by stakeholders is summarised within **Table 8** below. This consultation table does not include consultation completed during the Extraction Plan review stage post submission to DPE.

A summary of all consultation undertaken for the Extraction Plan is provided in **Section 2.1.2** of the Extraction Plan Main Document, and a copy of the incoming correspondence is also provided in **Appendix C** of the Extraction Plan Main Document.

Table 8 Consultation to Date

Consulted Stakeholder	Consultation Conducted	Outcomes of Consultation	Where Addressed
EES	3 February 2022	Consideration is to be given to subsidence impacts to Hornes Creek and the re-opening of fractures in the Bargo River associated with historical mining. This will require an appropriate water monitoring program and a clear commitment to undertake necessary remediation actions should impacts occur.	**Section 5** and **Appendix A**
		An update is to be provided on the progress of the remediation of Myrtle and Redbank Creek	**Appendix F**
DPE Water	19 January 2022	A record of pre- and post- subsidence state of key rock bars and pools should be maintained for review of impact predictions reporting.	**Section 5** and **Appendix A**
WaterNSW	10 January 2022	The Extraction Plan is to confirm that the potential impacts to the Sydney Drinking Water Catchment and Special Areas are as per that detailed in the EIS.	**Section 4**
		Monitoring and management measures relevant to the Sydney Drinking Water Catchment and Special Areas are to be detailed.	**Section 4** Impacts to the Sydney Drinking Water Catchment and Special Areas are not predicted to occur.
		The Extraction Plan is to consider WaterNSW Mining Principles and Water Monitoring Guidelines for Underground Mining Activities.	**Section 5**
Crown Lands	2 February 2022	Mitigation of impacts on the Bargo River and other watercourses, as a consequence of the longwall extraction works, will need to be addressed in the plan.	**Appendix A**
Wollondilly Shire Council	14 February 2022	An assessment of impacts to surface and groundwaters be consistent with all current scientific research that includes the Characterisation and Modelling of Geological Fault Zones Guideline publication	**Section 4** and **Appendix E**
		A detailed geological model that identifies the likely interaction of subsidence induced fractures with the modelled groundwater environment as part of complying with the above IESC publication.	**Appendix E**

Table 8 (Cont.) Consultation to Date

Consulted Stakeholder	Consultation Conducted	Outcomes of Consultation	Where Addressed
Wollondilly Shire Council	14 February 2022	An assessment of potential impacts of mining activities to the operation of private bores and mitigation measures to address any identified potential adverse implications.	**Section 4.3.3, Section 5, Section 6.2.1.3, Appendix A** and **Appendix E**
		Trigger Response Action Plans and related monitoring programs that are developed as part of the Extraction Plan and Water Plan are to be scientifically based, supported by commensurate data. They are requested in this regard to include appropriate ecological focussed indicators to monitor any impacts to the ecological health of waterways at a suitable timeframe that would restrict the need for Creek Management Action Plans.	**Appendix A**

3 Existing Environment

3.1 Surface Water Resources

Tahmoor Mine is located within the Bargo River catchment. From its headwaters near the townships of Hill Top and Yerrinbool, the Bargo River flows in a generally north-easterly direction through incised valleys and gorges to its confluence with the Nepean River (refer **Figure 3**). Flows in the Bargo River upstream of the Tahmoor Mine are unregulated.

The headwaters of the Nepean River rise in the coastal ranges to the south of Tahmoor Mine. Flows in the Nepean River near Tahmoor are highly regulated by the Upper Nepean Water Supply Scheme, operated by WaterNSW, which incorporates four major water supply dams on the Cataract, Cordeaux, Avon and Nepean Rivers. Releases from the Cordeaux, Avon and Nepean Dams are made to enable withdrawal for water supply purposes from the Pheasants Nest Weir located further downstream on the Nepean River. The Nepean Dam is situated some 18 km upstream of the Bargo River confluence, while the Pheasants Nest Weir is located approximately 7 km upstream of the confluence. The Nepean River, downstream of Pheasants Nest Weir and adjacent to and downstream of the Study Area, is not part of the Sydney Drinking Water Catchment or the Special Areas[2]. The Study Area is also located outside of the Sydney Drinking Water Catchment and the Special Areas. Cow Creek is the closest watercourse to LW S1A-S6A that is located in the Sydney Drinking Water Catchment – located approximately 4.7 km south-east of the Study Area boundary (refer **Figure 3)**.

The Nepean River flows into the Warragamba River near Wallacia at which point it is referred to as the Hawkesbury-Nepean River. The Hawkesbury-Nepean catchment is one of the largest coastal catchments in NSW with an area of some 21,400 square kilometres (km^2) from its mouth in Broken Bay on the northern side of the Sydney Metropolitan area.

The Study Area is located predominantly within the Teatree Hollow catchment which is a sub-catchment of the Bargo River. Small portions of the Study Area and 600 m buffer are also located within the Hornes Creek, Dogtrap Creek and Bargo River catchments (refer **Figure 3**). The lower reaches of Teatree Hollow, Dogtrap Creek and the Bargo River have, to varying degrees, experienced subsidence-related effects due to historical mining operations at the Tahmoor Mine.

3.1.1 Bargo River

The Bargo River catchment area is approximately 130 km^2 at its confluence with the Nepean River. The river consists of a sequence of pools, glides and rockbars across sandstone bedrock, with occasional boulder fields and cobblestone riffles. The Bargo River flows into the Nepean River approximately 9 km downstream of the Teatree Hollow confluence. The lower 4 km of the river pass through the Bargo River Gorge, which is characterized by steep rock faces up to 110 m high.

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[2] The Special Areas comprise undisturbed areas around WaterNSW Drinking Water storages and infrastructure. Public access and activities are restricted to protect water quality in these areas.

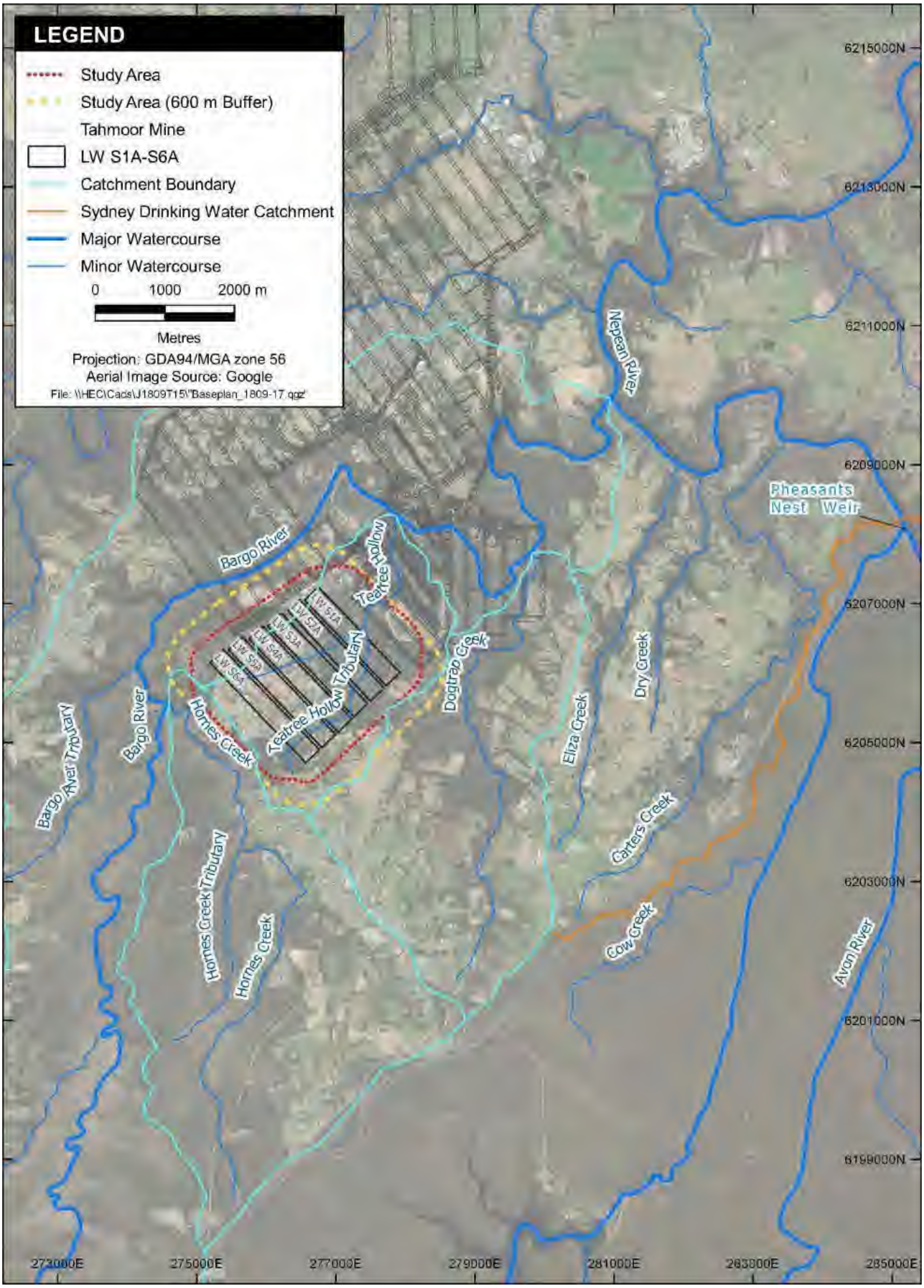

Figure 3 Study Area Surface Water Resources

The headwaters of a second order tributary of the Bargo River overlie the western edge of the approved LW S5A and LW S6A (refer **Figure 4**). Rock slabs and bedrock outcrop were mapped in the mid to lower reach of the tributary and a total of 6 pools were identified with the dominant pool control comprising boulders (Fluvial Systems, 2013). Predominantly hard (likely to be fixed) knickpoints[3] of varying dimensions were observed in the Bargo River tributary (Fluvial Systems, 2013). The baseline geomorphology survey identified that the Bargo River tributary was generally in good geomorphic condition (i.e. essentially natural with intact form and process). Sites where the redirection of surface flow to the subsurface was observed, presumed to be associated with historical mining-induced bed fracturing, were classified as having moderate geomorphic condition (Fluvial Systems, 2013).

3.1.2 Teatree Hollow

The mid to upper reaches of Teatree Hollow overlie the approved LW S1A-S6A. The headwaters of Teatree Hollow rise in the northern part of the Bargo Township with the main watercourse flowing generally north-northeast to the Bargo River. Downstream of the Bargo Township, Teatree Hollow predominantly traverses bushland to the confluence with the Bargo River.

Teatree Hollow is a third order stream from the eastern edge of the approved LW S1A to the confluence with the Bargo River and has a total catchment area of approximately 8 km^2. A third order tributary joins with Teatree Hollow at the eastern edge of the approved LW S1A (refer **Figure 4**). This tributary overlies the approved LW S1A-S6A but is a lower order stream (first or second order) upstream of LW S2A.

Teatree Hollow tributary and the headwaters of Teatree Hollow traverse the Australian Wildlife Sanctuary (refer **Figure 4**). The Australian Wildlife Sanctuary (the Sanctuary), formerly the Wirrimbirra Sanctuary, is a State heritage listed flora and fauna sanctuary, native plant nursery and education centre. The Sanctuary overlies approved LW S1A-S4A. Five pools were mapped within the Sanctuary boundary, two of which are of notable size – pool TT2 and pool TT3. Pool TT3 and pool TT11 are referred to as the Ockenden Pool by the Sanctuary and pool TT2 is referred to as the Big Pool.

The baseline geomorphology survey (Fluvial Systems, 2013) identified that the upper to mid reach of Teatree Hollow and the mid to lower reach of Teatree Hollow Tributary were predominantly in good geomorphic condition while the mid to lower reach of Teatree Hollow and the upper reach of Teatree Hollow Tributary were predominantly in moderate geomorphic condition. The sites of moderate geomorphic condition related to minor culvert or track crossings, low riparian vegetation cover or discharge from LDP1 (Fluvial Systems, 2013). The upper reaches of Teatree Hollow and Teatree Hollow Tributary were characterised by a low relief landscape, with a dominant bed material of mud (cohesive clay/silt/sand) and notable grass coverage (Fluvial Systems, 2013). In the mid to lower reaches, the landscape was characterised as high relief with dominant bed material of mud, sand, boulders and/or exposed bedrock and little low flow channel grass coverage.

Exposed bedrock comprising rock slabs, rock bars and bedrock outcrop, were mapped in the upper reaches of Teatree Hollow Tributary and in the mid to lower reaches of Teatree Hollow. A total of 15 pools were mapped in Teatree Hollow and Teatree Hollow Tributary with the dominant pool control comprising boulders or cohesive clay/silt/sand (Fluvial Systems, 2013). Of the 15 pools, 7 pools directly overlie LW S1A-S3A (refer **Figure 4**).

[3] A knickpoint is a part of a watercourse where there is a steep fall in channel bed elevation and, as such, may be susceptible to erosion and channel instability.

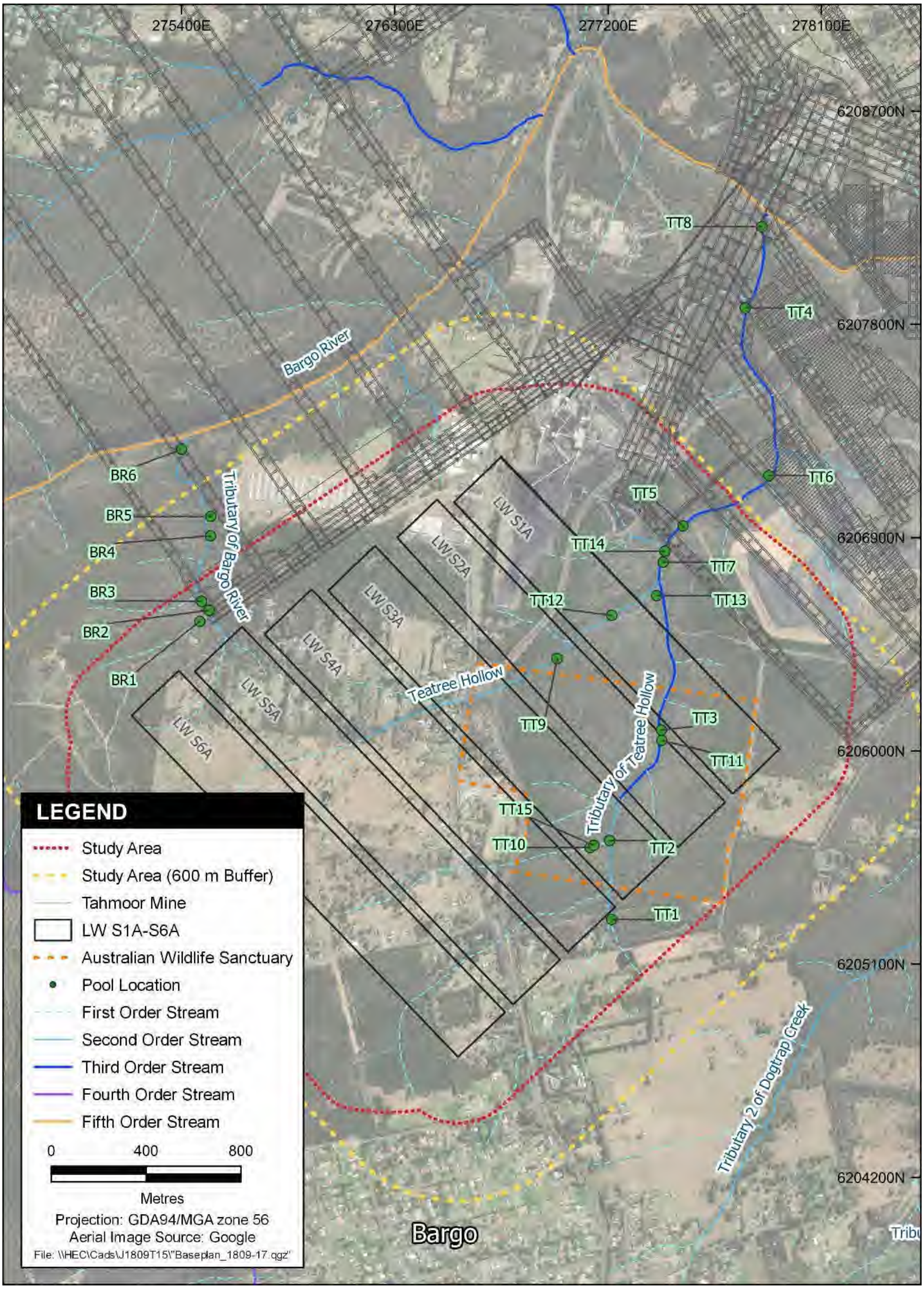

Figure 4 Teatree Hollow and Bargo River Tributary Stream Order and Pools

Hard (likely to be fixed) and soft (likely to be mobile) knickpoints of varying dimensions were mapped in Teatree Hollow and Teatree Hollow Tributary (Fluvial Systems, 2013). Soft knickpoints, with the potential to impact channel stability, were identified in the mid to lower reaches of Teatree Hollow and the upper to mid reach of Teatree Hollow Tributary. Two notable soft knickpoints were identified in Teatree Hollow, one located just downstream of pool TT13 and one located just downstream of pool TT5. The deeply incised section downstream of pool TT5 extended for 130 m and comprised a bed sand deposit which was identified as rare for the area surveyed (Fluvial Systems, 2013).

In accordance with EPL 1389, Tahmoor Coal is licensed to discharge to Teatree Hollow from one licenced discharge point (LDP) and three licenced overflow points (LOPs). The locations of LDP1 and the LOPs are shown in **Figure 6**.

3.1.3 Dogtrap Creek

Dogtrap Creek has a total catchment area of approximately 13.6 km^2 to its confluence with the Bargo River. A very small portion of the catchment area lies within the Study Area (600 m Buffer) (refer **Figure 3**). Dogtrap Creek is a third order stream from approved LW S4B to the confluence with the Bargo River.

3.1.4 Hornes Creek

Hornes Creek catchment is located to the south-southwest of LW S1A-S6A. The catchment area of Hornes Creek is approximately 19.3 km^2 which comprises predominantly bushland, rural-residential area and residential area associated with the Bargo township. Hornes Creek is a fourth order stream adjacent to the Study Area and at its confluence with the Bargo River (Fluvial Systems, 2013).

The baseline geomorphology survey (Fluvial Systems, 2013) identified that Hornes Creek was generally in good geomorphic condition. A total of 16 pools were mapped in Hornes Creek adjacent to the Study Area with the dominant pool control comprising boulders or bedrock outcrop (refer **Figure 5** for pool locations). Significant bedrock features comprised rock slabs and rockbars.

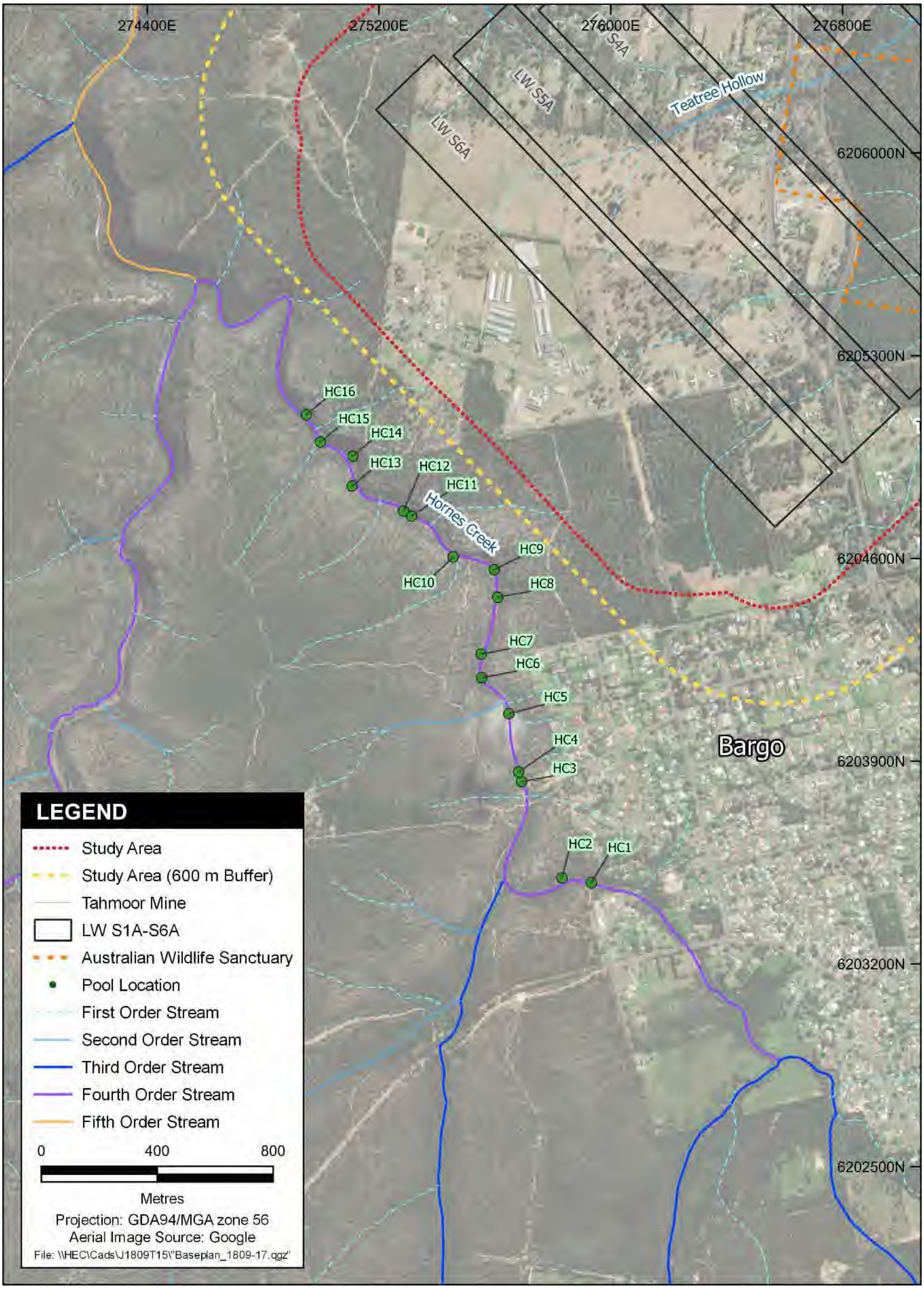

Figure 5 Hornes Creek Stream Order and Pools

3.2 Water Level and Streamflow

The Surface Water Monitoring Plan, which documents the historical, existing and proposed surface water monitoring associated with the Project, is included as **Appendix B**. The locations of the existing surface water monitoring sites are shown in **Figure 6**. The monitoring site nomenclature is associated with the watercourse and pool number (i.e. TT12 is pool 12 on Teatree Hollow) and the type of monitoring to be implemented: water quality (Q), automated (continuous) and manual water level monitoring (La), monthly manual water level measurements only (Lm), rating relationship derived streamflow (R) and streamflow gauging station (F).

A streamflow rating relationship (R) has been derived for specific sites on the Bargo River, Dogtrap Creek, Teatree Hollow and Hornes Creek. A streamflow rating is a relationship specific to each site which enables flow rate to be derived from recorded water level at that particular site location. A period of time is normally required following station establishment to develop a rating relationship. For specific sites, the ratings were extended to high flows by theoretical means using surveyed stream cross-sections. The streamflow rating relationship for BR13-QRLa and HC4-QRLa were recently updated following review of the streamflow rating relationship and incorporating additional manual streamflow gauging measurements.

A streamflow gauging station has been constructed on Teatree Hollow (TT-F1). The gauging station is comprised of a concrete and steel v-notch weir to enable accurate and continuous low flow monitoring from commissioning.

Monitoring of sites in the Dogtrap Creek catchment is undertaken to inform the Extraction Plan for LW S1B-S6B and, as such, monitoring results for the Dogtrap Creek catchment are not detailed in this Water Management Plan unless relevant.

Table 9 lists the relevant existing monitoring sites and the period of monitoring data record.

Appendix B presents plots of the water level monitored over the period of record at each existing monitoring site in Teatree Hollow, Hornes Creek and the Bargo River. For comparative purposes, rainfall data from SILO Point Data[4] for a point in close proximity to the watercourses and the cease to flow (CTF) level are also presented in the plots. The CTF level refers to the point at which surface water ceases to flow over the streamflow control i.e. the lowest point on a controlling rockbar or boulder field. In the event that streamflow over the rockbar or boulder field ceases, there may still be streamflow around, through or under the rockbar / boulder field control which reports downstream of the control.

[4] The SILO Point Data is a system which provides synthetic daily climate data sets for a specified point by interpolation between surrounding point records held by the Bureau of Meteorology – refer https://www.longpaddock.qld.gov.au/silo/point-data/.

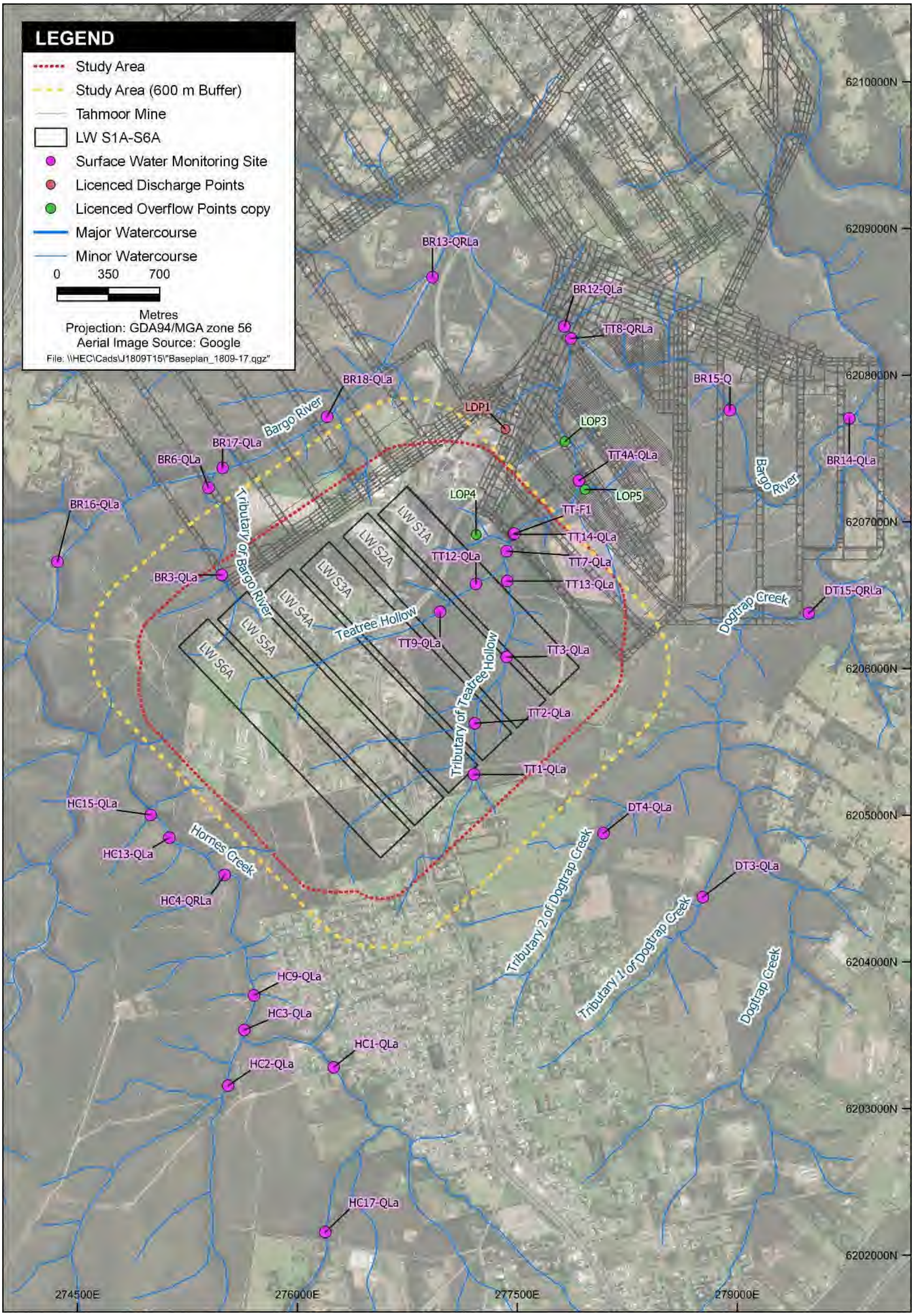

Figure 6 Study Area Surface Water Monitoring Sites

Table 9 Current Study Area Monitoring Sites - Period of Record

Site Name	Monitoring Type	Period of Record
Bargo River Catchment		
BR3-QLa	Water level and water quality	Oct 2022 – current (La) Sep 2022 – current (Q)
BR6-QLa	Water level and water quality	Dec 2022 – current (La) Sep 2022 – current (Q)
BR12-QLa	Water level and water quality	Jan 2019 – current (Q & La)
BR13-QRLa	Water level, streamflow and water quality	Apr 2012 – Jun 2015 (Q) Feb 2019 – current (Q) Mar 2013 – current (La & R)
BR14-QLa	Water level and water quality	Apr 2012 – Jun 2015 (Q) Feb 2019 – current (Q) Mar 2013 – current (La)
BR15-Q	Water quality	Sep 2022 – current (Q)
BR16-QLa	Water level and water quality	Oct 2022 – current (La) Sep 2022 – current (Q)
BR17-QLa	Water level and water quality	Oct 2022 – current (La) Sep 2022 – current (Q)
BR18-QLa	Water level and water quality	Oct 2022 – current (La) Sep 2022 – current (Q)
Teatree Hollow Catchment		
TT-F1	Streamflow gauging station	Mar 2021 – Aug 2022 (derived baseline flow data) Sep 2022 – current (F)
TT1-QLa	Water level and water quality	Aug 2019 – current (Q) Feb 2020 – current (La)
TT2-QLa	Water level and water quality	Aug 2019 - Mar 2020 (Q) Jan 2020 - Mar 2020 (La) July 2022 - current (Q & La)
TT3-QLa	Water level and water quality	Aug 2019 - Mar 2020 (Q) Feb 2020 - Mar 2020 (La) July 2022 - current (Q & La)
TT4A-QLa	Water level and water quality	May 2020 – current (Q & La)
TT7-QLa	Water level and water quality	Mar 2019 – current (Q) Jan 2020 – current (La)
TT8-QRLa	Water level, streamflow and water quality	Sep 2012 – Jun 2015 (Q) Apr 2019 – current (Q) Mar 2013 – current (La & R)
TT9-QLa	Water level and water quality	July 2022 - current (Q & La)
TT12-QLa	Water level and water quality	Sep 2021 – current (Q & La)
TT13-QLa	Water level and water quality	Oct 2021 – current (Q & La)
TT14-QLa	Water level and water quality	Sep 2021 – current (Q & La)
Hornes Creek Catchment		
HC1-QLa	Water level and water quality	Sep 2019 – current (Q & La)

Table 9 (Cont.) Current Study Area Monitoring Sites - Period of Record

Site Name	Monitoring Type	Period of Record
Hornes Creek Catchment		
HC9-QLa	Water level and water quality	May 2012 – Jun 2015 (Q) Oct 2020 – current (Q) Mar 2013 – Nov 2015 (La) Feb 2019 – current (La)
HC4-QRLa	Water level, streamflow and water quality	Sep 2019 – current (Q, La & R)
HC17-QLa	Water level and water quality	Mar 2019 – current (Q & La)
HC2-QLa	Water level and water quality	Mar 2020 – current (Q & La)
HC3-QLa	Water level and water quality	Sep 2019 – current (Q & La)

Field records of the presence of pooled and flowing water at monitoring sites in Teatree Hollow, Hornes Creek and the Bargo River tributary are collected during the monthly monitoring campaigns at each monitoring site. Due to data gaps[5] in the water level records for some sites, the field records have been used to calculate the frequency of days in which water was present at each monitoring site at the time of sampling. **Table 10** presents a summary of the field records. The summary is presented for the period August 2019 to March 2022 only as this was a common period of record for majority of sites and thereby enables direct comparison between sites. Only those sites which were monitored from August 2019 are presented.

Table 10 Frequency of Samples with Water Present

Site	Number of Sampling Days	Frequency of Sampling Days Pool was Dry	Frequency of Sampling Days with Pooled Water	Frequency of Sampling Days with Flowing Water
Bargo River Catchment				
BR12-QLa	31	0%	3%	97%
BR13-QRLa	30	0%	100%	100%
BR14-QLa	32	0%	100%	100%
Teatree Hollow Catchment				
TT1-QLa	31	13%	3%	84%
TT7-QLa	32	19%	0%	81%
TT4/TT4A-QLa*	30	87%	3%	10%
Hornes Creek Catchment				
HC1 -QLa**	32	6%	6%	88%
HC9-QLa	32	3%	9%	88%
HC4-QRLa	31	0%	13%	87%
HC17-QLa	32	9%	3%	88%
HC2-QLa	32	16%	3%	81%
HC3-QLa	32	0%	13%	88%

* Monitoring site TT4-QLa was moved immediately downstream in May 2020 and renamed TT4a-QLa.
** Monitoring site HC1-QLa water level sensor was relocated in January 2023 to approximately 20 m upstream of the original location.

[5] Data gaps occur due to site access restrictions, decommissioning of monitoring sites, sensor errors and dry periods.

The data presented in **Table 10** indicates that the monitoring sites on the Bargo River contained water at the time of each sampling event between August 2019 to March 2022. BR13-QRLa and BR14-QLa were flowing on all sampling occasions while BR12-QLa was flowing on 97% of sampling occasions. Based on the continuous water level records presented in **Appendix C**, in late 2019 and early 2020 during a drought period, connective streamflow in the Bargo River at monitoring sites BR13-QRLa and BR14-QLa ceased.

The presence of water at the monitoring sites in Teatree Hollow catchment varied from upstream to downstream with TT1-QLa (upstream Teatree Hollow tributary) recorded as dry on 13% of sampling occasions and TT4/TT4A-R (downstream Teatree Hollow) recorded as dry on 87% of sampling occasions. Based on the water level records for August 2019 to December 2021, Teatree Hollow tributary and Teatree Hollow have intermittent flow to monitoring site TT7-QLa and ephemeral flow at TT4/TT4A-QLa. As discharge from LDP1 reports to TT8-QRLa, the pool was recorded as holding water for the duration of monitoring (refer Chart C4, **Appendix C**).

The data presented in **Table 10** indicates that flowing water was recorded on at least 81% of sampling occasions at all monitoring sites in Hornes Creek. The number of sampling occasions in which the pools were recorded as dry declined from upstream to downstream with HC17-QLa (upstream) recorded as dry on 9% of sampling occasions and HC4-QRLa (downstream) holding water on all sampling occasions. Monitoring site HC2-QLa on Hornes Creek tributary was flowing on 81% of sampling occasions and dry on 16% of sampling occasions.

Streamflow ratings have been derived for specific sites on the Bargo River, Dogtrap Creek, Teatree Hollow and Hornes Creek. A streamflow rating is a relationship specific to each gauging station site which enables flow rate to be derived from recorded water level at that particular site location. A period of time is normally required following station establishment to develop a rating relationship. For specific sites, the ratings were extended to high flows by theoretical means using surveyed stream cross-sections and hydraulic modelling.

Table 11 presents summary statistics of streamflow recorded at select streamflow monitoring sites listed in **Table 9**. With the exception of TT-F1, the summary statistics have been derived for the full period of record at each site. The streamflow records for TT-F1 are presented for the baseline monitoring period to the commencement of mining of LW S1A in October 2022.

Table 11 Daily Streamflow Summary Statistics

Statistic	Derived Streamflow Rate (ML/d)				
	BR13-QRLa	TT-F1	TT8-QRLa	DT15-QRLa	HC4-QRLa
Min	0.14	0	0	0	0.5
Median	3.9	0.004	5.8	0.1	25
Mean	22	11	7	5	38
Max	8,513	854	980	732	497

It is noted that streamflow at monitoring site TT8-QRLa reflects discharge from LDP1. An average of 4.8 ML/d was released to Teatree Hollow at LDP1 between 2014 and 2021.

It should be noted that high flow rates for the above sites have been theoretically derived and may not be accurate. With the exception of TT-F1, the low flow rates for the above sites are also considered estimates due to the nature of the streamflow control (natural control) and the associated challenges in monitoring low flows at a natural control. .

3.3 Surface Water Quality

3.3.1 Default Guideline Values

For comparative purposes and to provide an indication of baseline water quality conditions within and adjacent to the Study Area, water quality data for the period of record has been compared to the ANZECC (2000) and ANZG (2018) default guideline values for the protection of aquatic ecosystems and recreational use in accordance with the perceived principal beneficial uses of the surface water resources in the area. The default guideline values are summarised in **Table 12**.

Table 12 Surface Water Default Guideline Values

Parameter	ANZECC (2000) & ANZG (2018) Default Guideline Values		
	Aquatic Ecosystems (95%ile level of species protection) †	Upland Rivers (NSW) ‡	Recreational Use‡
pH (pH units)	-	6–5 - 8	6–5 - 8.5
EC (µS/cm) and TDS (mg/L)	-	EC 350	TDS 1,000
Total Alkalinity as $CaCO_3$ (mg/L)	-	-	500
Chloride (mg/L)	-	-	400
Sulphate (mg/L)	-	-	400
Sodium (mg/L)	-	-	300
Aluminium (mg/L) pH > 6.5	0.055	-	-
Arsenic (mg/L) (As III)	0.024	-	-
Barium (mg/L)	-	-	1
Cadmium (mg/L)	0.0002	-	-
Copper (mg/L)	0.0014	-	1
Iron (mg/L)	-	-	0.3
Lead (mg/L)	0.0034	-	0.05
Manganese (mg/L)	1.9		0.1
Nickel (mg/L)	0.011	-	-
Selenium (mg/L)	0.011	-	0.01
Zinc (mg/L)	0.008	-	5
NOx (mg/L)	-	0.015	-
Total Phosphorous (mg/L)	-	0.02	-
Total Nitrogen (mg/L)	-	0.25	-

Note: EC = Electrical Conductivity; TDS = Total Dissolved Solids; - no relevant trigger value; † ANZG (2018); ‡ ANZECC (2000).

Water quality summary tables are presented in **Appendix D** for each monitoring site. Where default guideline values for aquatic ecosystems and/or upland rivers were available, the monitoring results were compared with these default guideline values and the percentage of exceedances reported. Where a default guideline value was available for recreational use only, the monitoring results were compared with the recreational use default guideline value and the percentage of exceedances reported. Where laboratory results have been recorded at below the limit of detection the result has been analysed assuming the concentration was equal to the limit of detection.

3.3.2 Baseline Water Quality Results

3.3.2.1 Bargo River

The field and laboratory pH records for monitoring sites on the Bargo River indicate slightly acidic to alkaline conditions, with some exceedances of the ANZECC (2000) default guideline value for pH recorded at all monitoring sites. The field EC records indicate that EC values have ranged between 64 µS/cm and 406 µS/cm at BR13-QRLa and between 99 µS/cm and 337 µS/cm at BR12-QLa. At BR14-QLa, field EC values have ranged between 181 µS/cm and 2,070 µS/cm due to the influence of higher EC water discharged at LDP1 in accordance with EPL 1389.

Exceedances of the default guideline values for aluminium, iron and zinc (dissolved and total) have been recorded historically at the monitoring sites on the Bargo River, including at BR13-QRLa which is located upstream of the confluence with Teatree Hollow and therefore upstream of releases from LDP1. This indicates that concentrations of aluminium and zinc are naturally elevated in the Bargo River. Exceedances of the ANZG (2018) default guideline value for dissolved and total copper at BR13-QRLa, BR14-QLa and BR12-QLa have also been recorded. Additionally, exceedances of the ANZECC (2000) default guideline values for total nitrogen and total phosphorus have been recorded historically at all monitoring sites.

Exceedances of the ANZG (2018) default guideline value for arsenic, barium and nickel have been recorded historically at BR14-QLa due to the influence of higher concentrations of these constituents discharged at LDP1. In accordance with EPL 1389, Tahmoor Coal propose to commission an upgraded wastewater treatment plant (WWTP) to reduce the concentration of constituents released to LDP1.

3.3.2.2 Teatree Hollow

The field and laboratory pH records for monitoring sites on Teatree Hollow and Teatree Hollow tributary indicate slightly acidic to alkaline conditions, with some exceedances of the ANZECC (2000) default guideline value range for pH recorded at all monitoring sites. Field and laboratory pH records for monitoring site TT8-QRLa consistently exceed the ANZECC (2000) default guideline value range due to the influence of higher pH water discharged at LDP1 in accordance with EPL 1389.

The field EC records for monitoring sites on Teatree Hollow and Teatree Hollow tributary, upstream of mining influences, indicate that maximum EC values have ranged from 218 µS/cm recorded at TT13-QLa to 663 µS/cm recorded at TT1-QLa. Within the area of potential mining influences, the field EC records indicated that maximum EC values have ranged from 384 µS/cm recorded at TT14-QLa to 2,490 µS/cm recorded at TT8-QRLa. It should be noted that TT8-QRLa on Teatree Hollow is influenced by higher EC water discharged at LDP1.

Exceedances of the default guideline values for aluminium, copper, iron and zinc (dissolved and total) have been recorded historically at TT1-QLa, TT2-QLa, TT7-QLa, TT12-QLa and TT13-QLa, located upstream of existing mining influences, indicating that these constituents are naturally elevated in the Teatree Hollow catchment. Additionally, exceedances of the ANZECC (2000) default guideline values for total nitrogen and total phosphorus have been recorded historically at all monitoring sites.

Exceedances of the ANZG (2018) default guideline value for arsenic, barium, cadmium and nickel have been recorded historically at TT8-QRLa due to the influence of higher concentrations of these constituents discharged at LDP1. The ANZG (2018) default guideline value for total lead was exceeded in one sample recorded at TT4A-QLa and 24% of samples recorded at TT8-QRLa, although the dissolved lead concentrations recorded at these sites did not exceed the ANZG (2018) default guideline value.

3.3.2.3 Hornes Creek

The field and laboratory pH records for monitoring sites on Hornes Creek indicate slightly acidic to alkaline conditions, with some exceedances of the ANZECC (2000) default guideline value range for pH recorded at all monitoring sites. The field EC records for monitoring sites on Hornes Creek indicate that maximum EC values have ranged from 306 µS/cm recorded at HC3-QLa to 694 µS/cm at HC9-QLa. Exceedances of the default guideline values for aluminium, copper, iron and zinc (dissolved and total) have been recorded at all monitoring sites. Exceedances of the ANZG (2018) default guideline value for dissolved manganese were recorded at HC4-QRLa (4% of samples) and HC9-QLa (9% of samples). Exceedances of the ANZG (2018) default guideline value for dissolved nickel were also recorded at HC9-QLa (15% of samples). Additionally, exceedances of the ANZECC (2000) default guideline values for total nitrogen and total phosphorus have been recorded at all monitoring sites.

The ANZG (2018) default guideline value for total lead was exceeded in one sample recorded at HC4-QRLa and two samples recorded at HC9-QLa, although the dissolved lead concentrations recorded at these sites did not exceed the ANZG (2018) default guideline value.

3.3.3 Site Specific Guideline Values

In order to reflect local conditions, ANZG (2018) recommend that site specific guideline values (SSGVs) should be derived for physical and chemical constituents monitored in surface water systems. ANZG (2018) recommend that the 80th percentile value of water quality monitoring data recorded over a period of 2 years should be adopted as the SSGV. The 20th percentile value of pH monitored over a period of 2 years is recommended to be adopted for the lower pH SSGV.

As constituent values may at times naturally exceed the 80th percentile value of the baseline water quality data, an exceedance of an SSGV is not considered as immediate evidence of an impact, rather an indication of potential changes in water quality characteristics which may result in impacts to aquatic ecosystems at monitored surface water sites.

As stated in **Section 3.3.2**, some constituents recorded at monitoring sites in the Bargo River, Teatree Hollow and Hornes Creek are naturally elevated above the default guideline values. As such, SSGVs have been derived for naturally elevated constituents where sufficient monitoring data is available. Where the baseline constituent values do not exceed the default guideline values, the default guideline values are proposed to be adopted in the assessment of a trigger exceedance (detailed in **Appendix A**). The SSGVs are only proposed for those constituents which are naturally elevated or which have the potential to be influenced by mining of LW S1A-S6A. The water quality monitoring data for all constituents would continue to be recorded and reviewed throughout the duration of the Project to identify any additional constituents which may need to be assessed against the surface water quality TARP (refer **Appendix A**).

The SSGVs have been derived from baseline data up to commencement of mining of LW S1A. As described in **Section 7.3**, the Water Management Plan would be reviewed on an annual basis as a minimum and revised as required. The SSGVs for monitoring sites located upstream of the active subsidence zone would be revised to reflect additional recorded baseline monitoring data. The revised SSGVs would be documented in the revised Water Management Plan.

Due to the influence of discharge from Tahmoor Mine, which is undertaken in accordance with EPL 1389, SSGVs have only been proposed for monitoring sites which are located outside of the influence of existing Tahmoor Mine activities.

Table 13 presents the SSGVs for relevant surface water monitoring sites. The values that were derived from baseline monitoring data are shown in bold. Where laboratory results have been recorded at below the limit of detection the result has been analysed assuming the concentration was equal to the limit of detection.

In accordance with the surface water quality TARP presented in **Appendix A**, the SSGVs would be compared against monitored data in order to identify exceedances of the trigger levels and initiate further action.

Table 13 Site Specific Guideline Values

Parameter	BR12-QLa	BR13-QRLa	HC9-QLa	HC4-QRLa	HC3-QLa
No. of Values[1]	37	37	35	29	31
pH (pH units)	6.5 - 8	6.5 - 8	**5.7 - 8**	6.5 - 8	6.5 - 8
EC (µS/cm)	350	350	**365**	350	350
Dissolved Aluminium (mg/L) pH > 6.5	**0.058**	0.055	**0.08**	**0.07**	**0.1**
Dissolved Copper (mg/L)	0.0014	0.0014	**0.002**	**0.002**	0.0014
Dissolved Iron (mg/L)	**0.52**	**0.61**	**4.2**	**0.61**	**0.5**
Dissolved Manganese (mg/L)	1.9	1.9	1.9	1.9	1.9
Dissolved Nickel (mg/L)	0.011	0.011	0.011	0.011	0.011
Dissolved Zinc (mg/L)	0.008	**0.009**	**0.03**	0.008	0.008

Parameter	TT1-QLa	TT2-QLa	TT7-QLa	TT12-QLa	TT13-QLa	TT14-QLa
No. of Values[1]	32	12[2]	35	13	13	13
pH (pH units)	6.5 – 8	**6 – 8**	6.5 – 8	6.5 – 8	6.5 – 8	6.5 – 8
EC (µS/cm)	**529**	350	**359**	350	350	350
Dissolved Aluminium (mg/L) pH > 6.5	**0.06**	**0.17**	**0.06**	**0.1**	0.092	**0.11**
Dissolved Copper (mg/L)	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014
Dissolved Iron (mg/L)	**0.75**	**0.55**	**0.81**	**0.64**	**0.47**	**0.57**
Dissolved Manganese (mg/L)	1.9	1.9	1.9	1.9	1.9	1.9
Dissolved Nickel (mg/L)	0.011	0.011	0.011	0.011	0.011	0.011
Dissolved Zinc (mg/L)	**0.03**	**0.02**	**0.031**	0.008	0.008	0.008

Notes:
[1] Minimum number of values used in SSGV derivation – for some constituents, a greater number of values were used.
[2] Number of values used to derive SSGV for TT2-QLa, prior to commencement of mining LWS3A, is expected to be greater than 24.
The values that were derived from baseline monitoring data are shown in bold.

3.4 Aquatic Habitat and Stream Health

Four seasons of aquatic ecology monitoring were undertaken between 2012 and 2013 on the Bargo River, Hornes Creek and Teatree Hollow. An additional five seasons of aquatic ecology monitoring were undertaken between 2019 and 2021. Details of the baseline monitoring is presented in the Biodiversity Management Plan and summarised as follows.

Monitoring undertaken during periods of below average rainfall identified that low streamflow rates placed natural stresses on the aquatic environment and the availability and quality of aquatic habitat. Regeneration was observed at sites that had been impacted by bushfires in late 2019. Overall, aquatic habitat quality was considered good at all sites with the exception of two sites in the Bargo River, located upstream of the confluence with Teatree Hollow, which were considered to be highly disturbed.

Stream health assessments, using the Australian River Assessment System (AUSRIVAS) methods, identified that Teatree Hollow had impaired stream health conditions when compared to reference site and control site data. The results indicated that Teatree Hollow was subject to environmental stress likely due to a combination of natural and anthropogenic factors including agriculture and road crossings. Niche (2021) note that this has likely been exacerbated by bushfire impacts and changes in climatic conditions varying between extended periods of below average rainfall and notable high rainfall events.

The majority of sites monitored in Hornes Creek and the Bargo River scored in Band B and Band C indicating significantly to severely impaired stream health. One site in the Bargo River scored in Band A on one occasion (indicating similar conditions to the reference sites) while one site in Teatree Hollow scored in Band D on one occasion (indicating extremely impaired stream health).

Macroinvertebrate assemblage results indicated large variability across the sites, with less dispersion observed at sites monitored in the Bargo River and Hornes Creek. A total of nine fish species were detected during the surveys with the most commonly encountered species being the Yabby (*Cherax destructor*), Common Freshwater Shrimp, (*Paratya australiensis*), Eastern Gambusia (*Gambusia holbrooki*) and Australian Smelt (*Retropinna semoni*). No threatened fish species were recorded during the surveys and are considered unlikely to be present in the Study Area. The Sydney Hawk Dragonfly (*Austrocordulia leonardi)*, listed as endangered, was not identified during the targeted surveys and the species is considered unlikely to be present in the Study Area.

3.5 Tahmoor Coal Water Access Licences

Tahmoor Coal holds a Water Access Licence (WAL) for the Sydney Basin Nepean Groundwater Source, in accordance with the *Greater Metropolitan Region Groundwater Sources Water Sharing Plan 2023*. Additionally, Tahmoor Coal holds WALs for the Stonequarry Creek Water Source and Maldon Weir Water Source, in accordance with the *Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources* 2023. The WALs currently held by Tahmoor Coal are detailed in **Table 14**.

Table 14 Tahmoor Coal Water Access Licences

WAL	Water Sharing Plan	Water Source	Management Zone	Entitlement	Category
36442	Greater Metropolitan Region Groundwater Sources WSP 2023	Sydney Basin Nepean Groundwater Source	Nepean Management Zone 2	1,642 units	Aquifer
25777	Greater Metropolitan Region Unregulated River Water Sources WSP 2023	Maldon Weir		5 ML	Unregulated river
43572		Stonequarry Creek		16 ML	
43656		Maldon Weir		25 ML	
44608		Stonequarry Creek		9 ML	
SWC839757		Maldon Weir		11 ML	

Note: WSP = Water Sharing Plan.

3.6 Other Water Users

3.6.1 Water Access Licences

As at June 2021, there were 22 WALs allocated for the Maldon Weir Water Source, excluding WALs held by Tahmoor Coal, with a corresponding total share component of 664 ML for the period July 2020 to June 2021 (inclusive)[6]. One WAL was associated with a property located within the Study Area boundary and one WAL was associated with a property located adjacent to the Bargo River downstream of the Study Area (refer **Figure 7** for locations). The remainder of WALs within the Maldon Weir Water Source were located outside of the potential zone of influence associated with mining of LW S1A-S6A.

3.6.2 Farm Dams

A total of 45 farm dams have been identified within the Study Area, the locations of which are shown in **Figure 8**. The farm dams have been identified as typically shallow (less than three metres deep), of earthen construction and established by localised cut and fill operations within natural watercourses (MSEC, 2022). Monitoring of farm dams, TARPs and proposed management measures are detailed in the Land Management Plan.

[6] https://waterregister.waternsw.com.au - accessed October 2021.

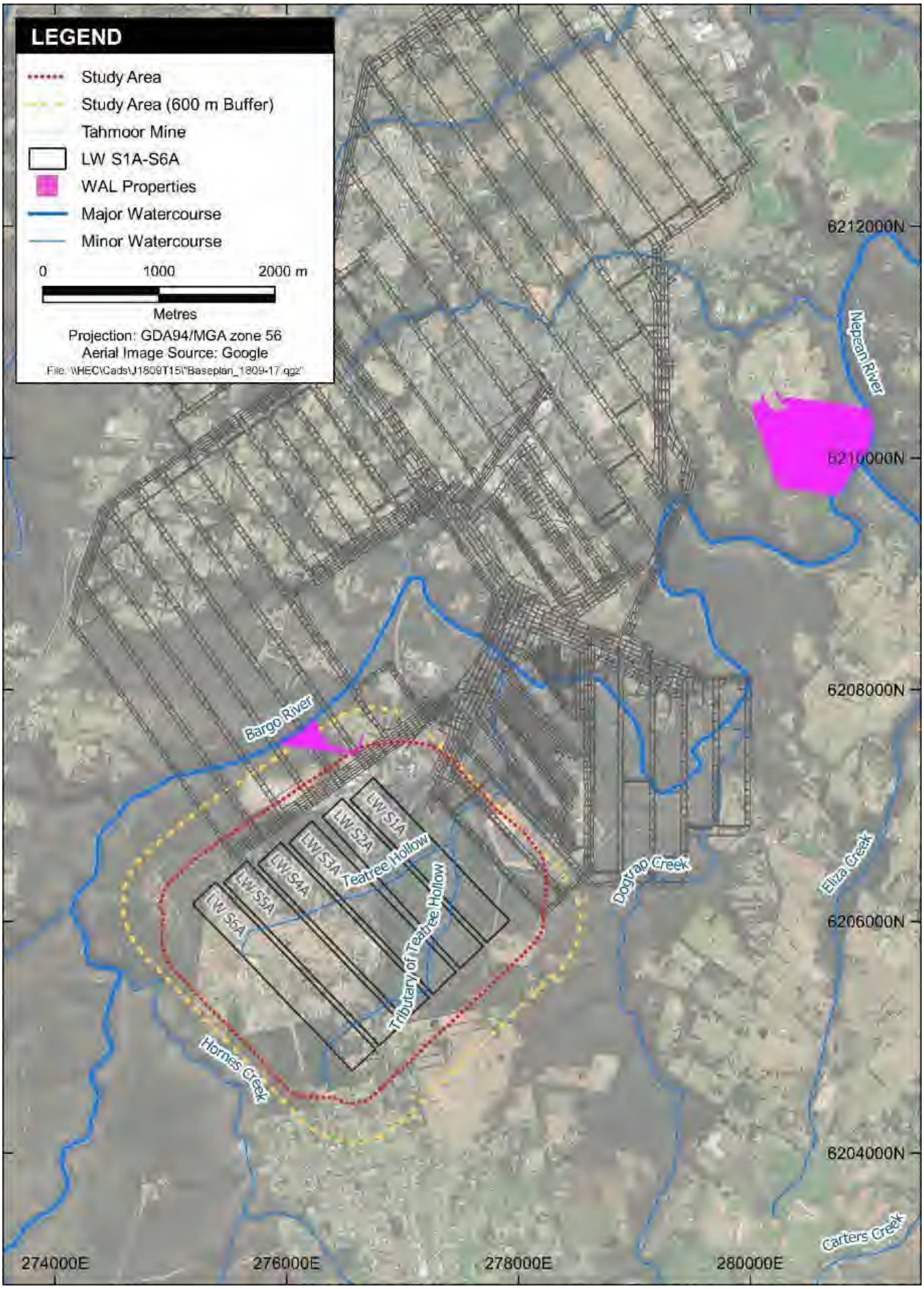

Figure 7 Study Area WAL Properties

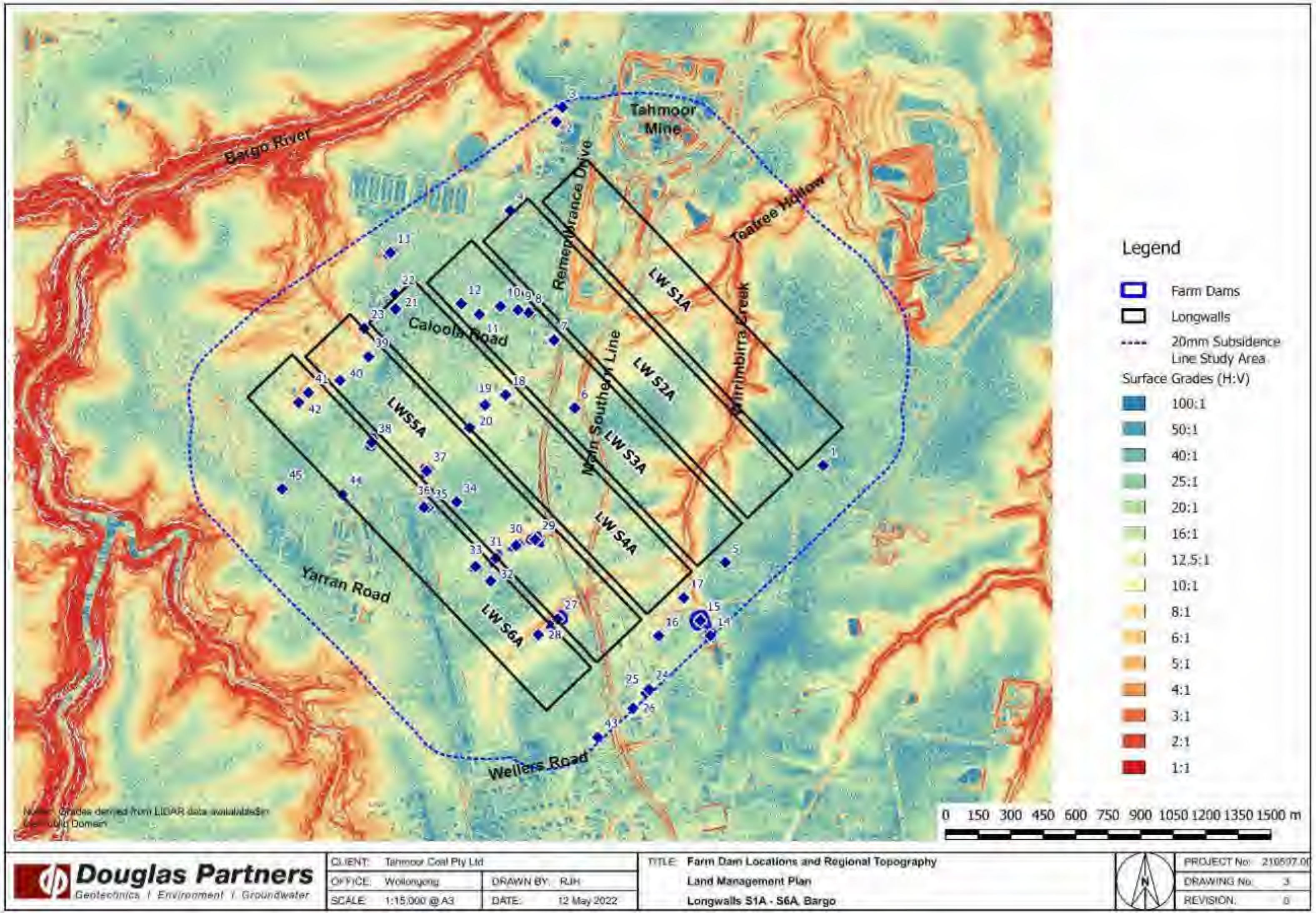

Figure 8 Study Area Farm Dams

3.7 Groundwater Resources

The groundwater resources within and adjacent to the Study Area are detailed in the Groundwater Technical Report (**Appendix E**) and summarised as follows.

3.7.1 Hydrogeological Units

The major hydrostratigraphic units that characterise the area around Tahmoor Mine are the Sydney Basin Triassic and Permian rock units, with the Hawkesbury Sandstone being the primary aquifer. These aquifers fall within the Sydney Basin Nepean Groundwater Source and have been classified as being 'Highly Productive' by the NSW Government based on considerations of bore yield and groundwater quality. The Bulgo Sandstone and Illawarra Coal Measures of the Triassic Narrabeen Group supply additional water to this system; however, contributions are substantially lower (SLR, 2022).

SLR (2022) note that limited surficial alluvium has been mapped in the Study Area. The shales of the Triassic Wianamatta Group are more extensive, predominantly to the north of the Tahmoor Mine, however have limited potential as a highly productive aquifer and are limited in the vicinity of LW S1A-S6A.

The key hydrogeological units relevant to the Study Area are summarised below (SLR, 2022):

- Alluvium – the Thirlmere Lakes alluvium comprising an upper peat sequence that grades into a distinct oxidised silty clay that underlies the entirety of the lakes. The oxidised silty clay layer acts as a local aquitard. The Thirlmere Lakes alluvium is mapped as being approximately 300 m west of the Tahmoor Mine and approximately 3,500 m west of LW S1A-S6A.
- Wianamatta Group – composed of the Liverpool Subgroup which includes the Bringelly Shale Formation, Minchinbury Sandstone and Ashfield Shale Formations. This formation is present as hill cappings overlying the Hawkesbury Sandstone formation, particularly in the northern region of the Tahmoor Coal leases. The formation predominantly comprises shales with low permeability and poor water quality, however can lead to the development of springs in areas in contact with the Hawkesbury Sandstone.
- Hawkesbury Sandstone – a porous rock aquifer of moderate resource potential, with higher resource potential in areas where secondary porosity has developed, such as the Nepean Fault zone. Over the Tahmoor Mine area, groundwater in this aquifer generally flows in an east to north-easterly direction. The water table is approximately 20 m below the ground surface in proximity to surface drainage lines, and 40-50 m below the ground surface in areas not associated with surface drainage lines. This formation is dominant across the Tahmoor Mine and beneath the alluvium and Wianamatta Group formation, except in eroded areas along valleys in the western region where the Narrabeen Group formation has been exposed.
- Narrabeen Group – composed of interbedded sandstone, claystone and siltstone with low permeability and low resource potential. This formation is present across the Tahmoor Mine site underlying the Hawkesbury Sandstone formation.
- Illawarra Coal Measures – composed of interbedded sandstones, shale, mudstones and coal seams including the Bulli Coal seam (2-4 m thick), the Eckersley Formation (8-38 m thick) which includes the Balgownie Seam, Loddon Sandstone and Lawrence Sandstone, the Wongawilli Seam (8-10 m thick) and the Kembla Sandstone. The poor water quality results in low resource potential. This formation is present across the Tahmoor Mine site underlying the Narrabeen Group formation.

3.7.2 Historic Groundwater Inflow

Since 2009, groundwater inflow to the Tahmoor Mine (Tahmoor North and Western Domain) has ranged from an estimated 2 ML/d to 6 ML/d. Calculated total groundwater inflow volumes to the Tahmoor Mine workings for water years 2019 to 2023 are presented in **Table 15**. The groundwater inflow to the Tahmoor Mine workings was calculated as described in SLR (2023)[7]. **Figure 9** presents the calculated total groundwater inflow volumes for water years 2016 to 2023 in comparison to the WAL36442 entitlement currently held by Tahmoor Coal for access to the Sydney Basin Nepean Groundwater Source.

Table 15 Calculated Groundwater Inflow to the Tahmoor Mine Workings

Water Year*	Average Daily Inflow (ML/day)	Total Inflow (ML)
2018 – 2019	3.4	1,225
2019 – 2020	3.3	1,207
2020 – 2021	4.5	1,641
2021 – 2022	4.3	1,577
2022 - 2023	2.9	1,068

* 1 July to 30 June.

Figure 9 Calculated Groundwater Inflow to the Tahmoor Mine Workings

As stated in **Section 3.5**, WAL36442 provides Tahmoor Coal with 1,642 units of entitlement to the Sydney Basin Nepean Groundwater Source, in accordance with the *Greater Metropolitan Region Groundwater Sources Water Sharing Plan 2023*. Based on the calculated groundwater inflow volumes to the Tahmoor Mine workings for each water year from 2016, as presented in **Figure 9**, the 1,642 units of entitlement held by Tahmoor Coal have not been exceeded to date.

3.7.3 Baseline Groundwater Levels

The locations of the existing groundwater monitoring bores within and adjacent to the Study Area are shown in **Figure 10**. Groundwater level monitoring data for the Tahmoor South reference sites, as detailed in the Groundwater Monitoring Plan (SLR, 2022), are presented and discussed in the sections which follow. Sites TBC024, TBC027, TBC034 and TBC038 are equipped with Vibrating Wire Piezometers (VWPs) with monitoring commencing between 2012 and 2013. Data loggers have also been installed in P51a, P51b, P52a, REA4, P53a, P53b, P53c, P55a, P55b and P55c. The depths of each VWP sensor and monitored strata are presented in **Appendix E** (SLR, 2022).

[7] Groundwater inflow to the Tahmoor Mine workings is calculated as the residual of water supplied to the underground workings (monitored flows), water re-circulated underground and water pumped from the underground workings to the surface (monitored flows).

Figure 10 **Existing Groundwater Monitoring Bores**

3.7.3.1 Site TBC024

TBC024 is located 1,700 m south of LWS6A and 440 m east of Bargo River. Groundwater pressure records are available for this site from April 2012, and have been recorded at various depths in the Hawkesbury Sandstone (HBSS), Bulgo Sandstone (BGSS), Bulli Coal Seam (BUCO), Wongawilli Coal Seam (WWCO), Bald Hill Claystone (BHCS) and the Wombarra Claystone (WBCS).

Figure 11 presents the water level records for TBC024 in comparison with the cumulative rainfall departure[8]. The data presented in **Figure 11** shows that a consistent decline in groundwater pressure of a similar magnitude was recorded in all units from 2012 to early 2020. Minor responses to rainfall recharge were recorded during the baseline monitoring period, with groundwater level increases ranging from 0.2-0.5 m during these periods.

Following above average rainfall in early 2020, groundwater levels stabilised in all units and increased by approximately 0.2-0.5 m. During and following above average rainfall in late May 2020, groundwater levels recorded in the Hawkesbury Sandstone unit increased by approximately 2 m.

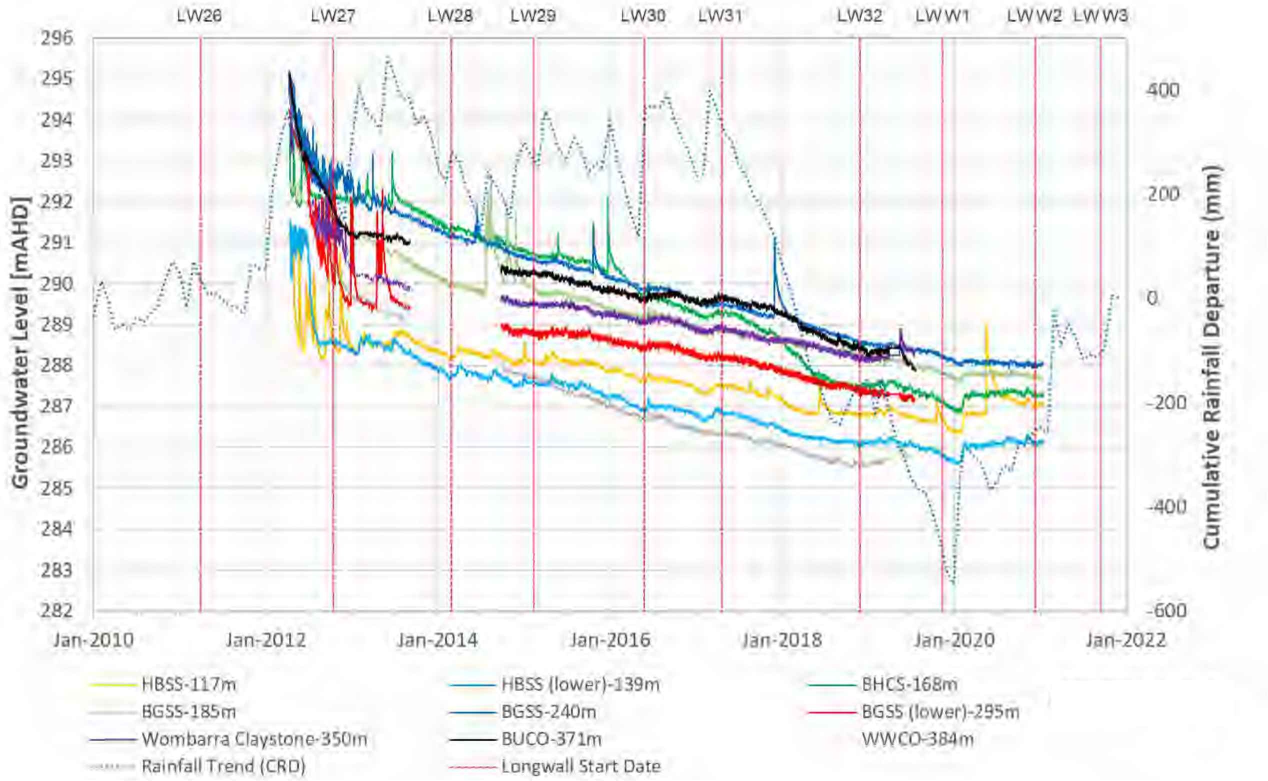

Figure 11 TBC024 Groundwater Level Monitoring Data and Cumulative Rainfall Departure (Source: SLR, 2022)

3.7.3.2 Site TBC027

TBC027 is located 2,700 m south-west of approved LWS6B and 500 m west of Hornes Creek. Groundwater level records are available for this site from April 2013 and have been recorded at various depths in the HBSS, BGSS, BUCO, WWCO, BHCS and the WBCS (refer **Figure 12**). The baseline monitoring data indicates that groundwater levels have generally increased by 1-2 m during periods of above average rainfall. Above average rainfall in early 2020 resulted in an increase in water levels of approximately 4-6 m.

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[8] The cumulative rainfall depature was calculated as the cumulative deviation from the average daily rainfall where positive (upward) slope in the plot indicates periods of above average rainfall and negative (downward) slope indicates periods of below average rainfall.

A pressure differential of approximately 6-7 m has been recorded in the upper (HBSS-95m) and lower (HBSS-132 m and HBSS-169m) Hawkesbury Sandstone units, with an evident downward vertical gradient. Groundwater levels in the upper Bulgo Sandstone unit (BGSS-198 m) appear less responsive to rainfall recharge with generally stable groundwater levels recorded since the commencement of monitoring. This suggests limited aquifer connectivity between the Hawkesbury Sandstone unit and the Bulgo Sandstone unit.

Groundwater depressurisation, likely due to regional mining (i.e. Tahmoor North), was recorded from mid-2016 to early 2020, with groundwater levels decreasing by approximately 10-12 m in the lower Bulgo Sandstone and coal seams. From early 2020, groundwater levels stabilised and had recovered by approximately 2 m as of January 2022.

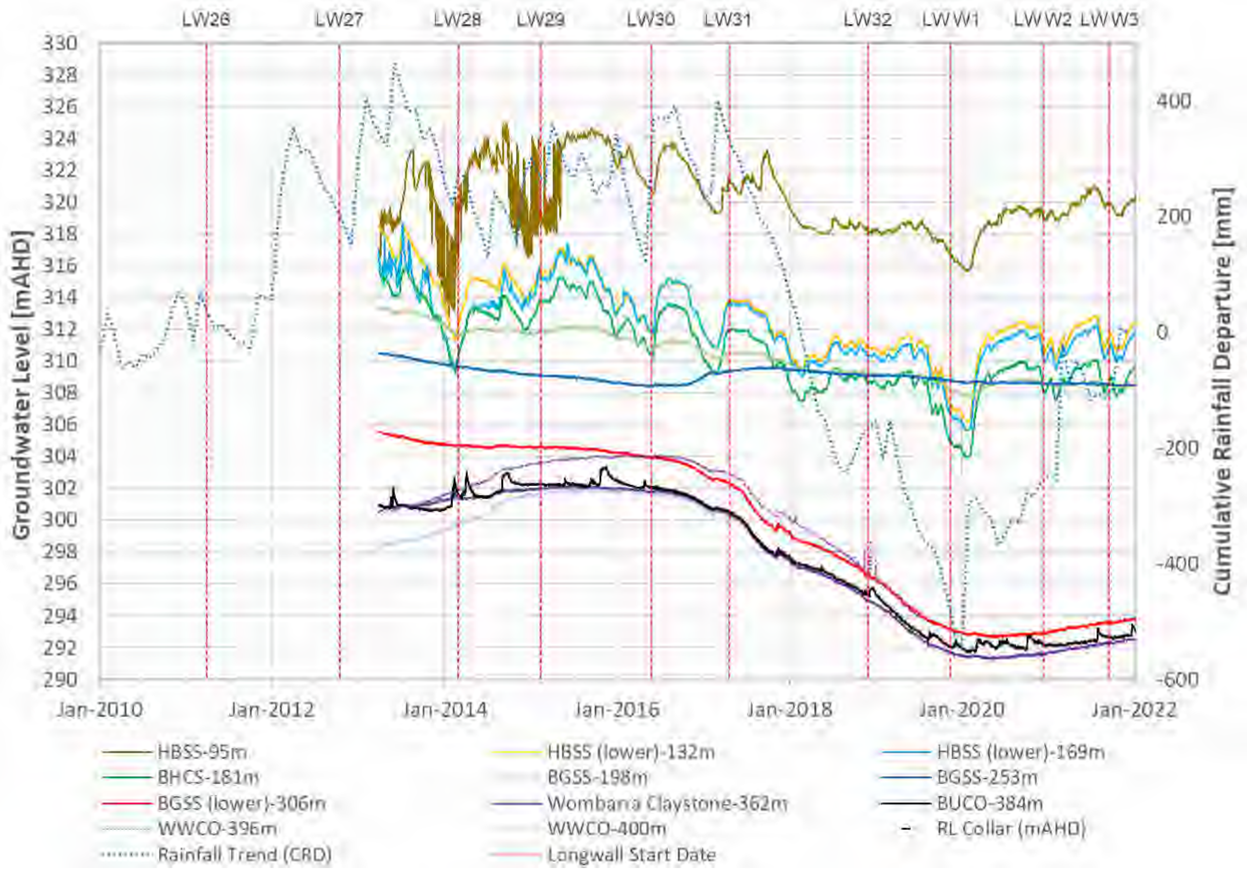

Figure 12 TBC027 Groundwater Level Monitoring Data and Cumulative Rainfall Departure (Source: SLR, 2022)

3.7.3.3 Site TBC034

TBC034 is located 2,500 m southwest of LWS6B and 1,500 m west of the Bargo River. Groundwater level records are available for this site from April 2013 and have been recorded at various depths in the HBSS, BGSS, BUCO, WWCO, BHCS and the WBCS (refer **Figure 13**). Groundwater levels recorded in all units were generally stable with only minor changes in groundwater level recorded in response to changes in climatic conditions.

An evident downward vertical gradient was recorded in the HBSS layers. Some degree of aquifer connectivity was recorded between the upper and mid BGSS (BGSS-196m to BGSS-294.3m) and the lower HBSS (HBSS-161m).

A pressure differential of 40-45 m between the lower (BGSS-343.5m) and upper (BGSS-196m) BGSS units was recorded indicating a strong downward vertical gradient in this unit. SLR (2021) note that this is likely reflective of the Western Domain fault.

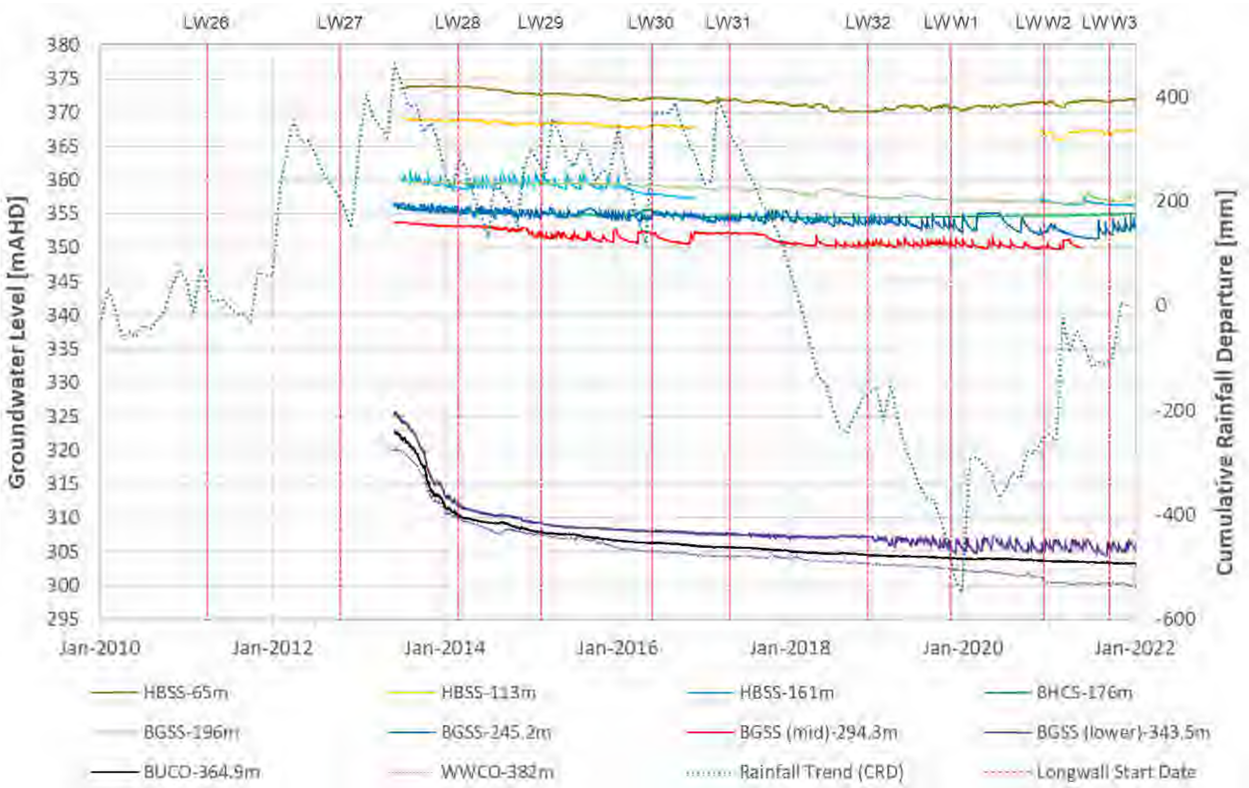

Figure 13 TBC034 Groundwater Level Monitoring Data and Cumulative Rainfall Departure (Source: SLR, 2022)

3.7.4 Baseline Groundwater Quality

Groundwater quality monitoring, conducted between January and March 2022, was undertaken at 31 private bores within the vicinity of the Study Area. Laboratory results of this sampling program are provided in the Private Bore Survey Summary Report (SLR, 2022) - Appendix D of **Appendix E**.

The median groundwater salinity monitored at the private bores was 810 µS/cm, with a minimum of 165 µS/cm and a maximum of 3,378 µS/cm recorded. There were no apparent trends between groundwater salinity and bore depth or location.

The groundwater monitoring bores listed in **Table 16** were installed in May 2022. A water quality monitoring program was implemented at this time with the monitoring results for May and June 2022 (average EC) summarised in **Table 16**.

Table 16 Tahmoor South Groundwater Monitoring Bore – Average Electrical Conductivity

Bore ID	Bore Depth (mbgl)	Average EC (µS/cm)
P51A	19.36	358
P51B	35.38	8106
P52	41.17	1250
P53A	41	814
P53B	60.55	1680
P53C	80.78	1708
P54C	35.99	1984
P55A	41.04	1656
P55B	59.36	1544
P55C	81.9	1327
P56A	20.9	1545
P56B	45.56	1090
P56C	80.4	3200
REA4	54.31	236

Notes: mbgl = metres below groundwater level; EC = electrical conductivity.
Source: SLR (2022).

Review of the local and regional data indicates that:

- Groundwater in the alluvium and Wianamatta Group is of mixed quality. It is likely that evaporative concentration of salts could occur in alluvial aquifers, especially in clay facies. The marine origin and low permeability of the Wianamatta Shales tends to lead to higher salinities in this unit;
- There is little data for the Narrabeen Group or Illawarra Coal Measures. Older units such as the Shoalhaven Group exhibit a range of salinities from fresh to saline; and
- The Hawkesbury Sandstone is the primary aquifer utilised and although shows variability in groundwater salinity it is overall suitable for stock and domestic purposes and most irrigation.

3.7.5 Groundwater Flow, Recharge and Discharge

The interpreted water table elevation in shallow groundwater aquifers within and adjacent to the Study Area is presented in **Figure 14.** The interpreted groundwater level contours, derived from data recorded between 2013 and 2020, indicates that groundwater generally flows in an east to north-easterly direction in the Tahmoor Mine region (SLR, 2022).

Where watercourses are present, groundwater levels tend to be higher indicating the potential for surface water recharge to the Hawkesbury Sandstone aquifer. In the vicinity of the Study Area, the water table elevation is generally 20 m below the ground surface in proximity to surface drainage lines, and 40-50 m below the ground surface in areas not associated with surface drainage lines.

The Bargo River is inferred to be a variably gaining (groundwater discharge to the surface water system) and losing system (surface water discharge to the groundwater system) (SLR, 2022).

In the Hawkesbury Sandstone, groundwater is inferred to flow in an eastward direction across LW S1A-S6A and in a northward direction from the south-west to north-east of LW S1B-S6B. In the lower Bulgo Sandstone and the Bulli Seam, groundwater is inferred to flow in a northward direction from the south-west to the north-east of the Study Area (SLR, 2022).

3.7.6 Groundwater Use

3.7.6.1 Groundwater Dependent Ecosystems

Thirlmere Lakes are the closest 'High Priority' groundwater dependent ecosystem to the Tahmoor Mine, being 650-700 m from historical Tahmoor longwalls at their closest points, but at least 3,500 m from LW S1A-S6A (refer **Figure 15**). The Thirlmere Lakes are of high conservation importance, gazetted as the Thirlmere Lakes National Park in 1972 and providing habitat for dependent aquatic species (Schädler & Kingsford, 2016). The nearest Tahmoor Mine longwall panels to the Thirlmere Lakes were mined between 1996 and 2002. Further information pertaining to the Thirlmere Lakes is provided in **Section 3.8.**

3.7.6.2 Springs

Relevant literature indicates that the Hawkesbury Sandstone may contain springs that have developed in saturated and perched aquifers of the formation (HydroSimulations, 2018). However, no significant springs or soaks have been mapped or located in the vicinity of the Study Area. Field investigations undertaken by Brienen Environment & Safety (2022) support this finding.

3.7.6.3 Anthropogenic Use

As stated in the EIS Groundwater Assessment (HydroSimulations, 2020), there are 982 registered bores and an associated 791 WALs within the immediate vicinity of the Study Area. The Hawkesbury Sandstone, surficial alluvium and basalt aquifers were the predominant target aquifers (89% of the total) with approximately 10% targeting the Bulgo Sandstone.

A total of 52 registered bores which had the potential to incur a Project related groundwater drawdown of greater than 2 metres, as identified in the EIS, were incorporated into the Private Bore Baseline Survey (refer **Appendix E**) as per the requirements of the Aquifer Interference Policy. During the survey process an additional six bores were incorporated into the survey at the request of individual landholders. The "heritage well", previously identified in the *Statement of Heritage Impact (SoHI)* for the Wirrimbirra Sanctuary (EMM, 2020) was also incorporated. Subsequently, a total of 59 private bores were proposed to be assessed, however, only 40 of these bores were inspected due to access restrictions. The baseline survey commenced on 15 January 2022 and was concluded by 15 March 2022. The summary report documenting the outcomes of the survey is provided in Appendix D of the Groundwater Technical Report (**Appendix E** of this Water Management Plan). The Groundwater Technical Report and updated groundwater model (post-EIS) reviewed the potential impacts to private bores, and identified three bores predicted to exceed greater than 2 metres of drawdown resulting from LW S1A – S6A extraction.

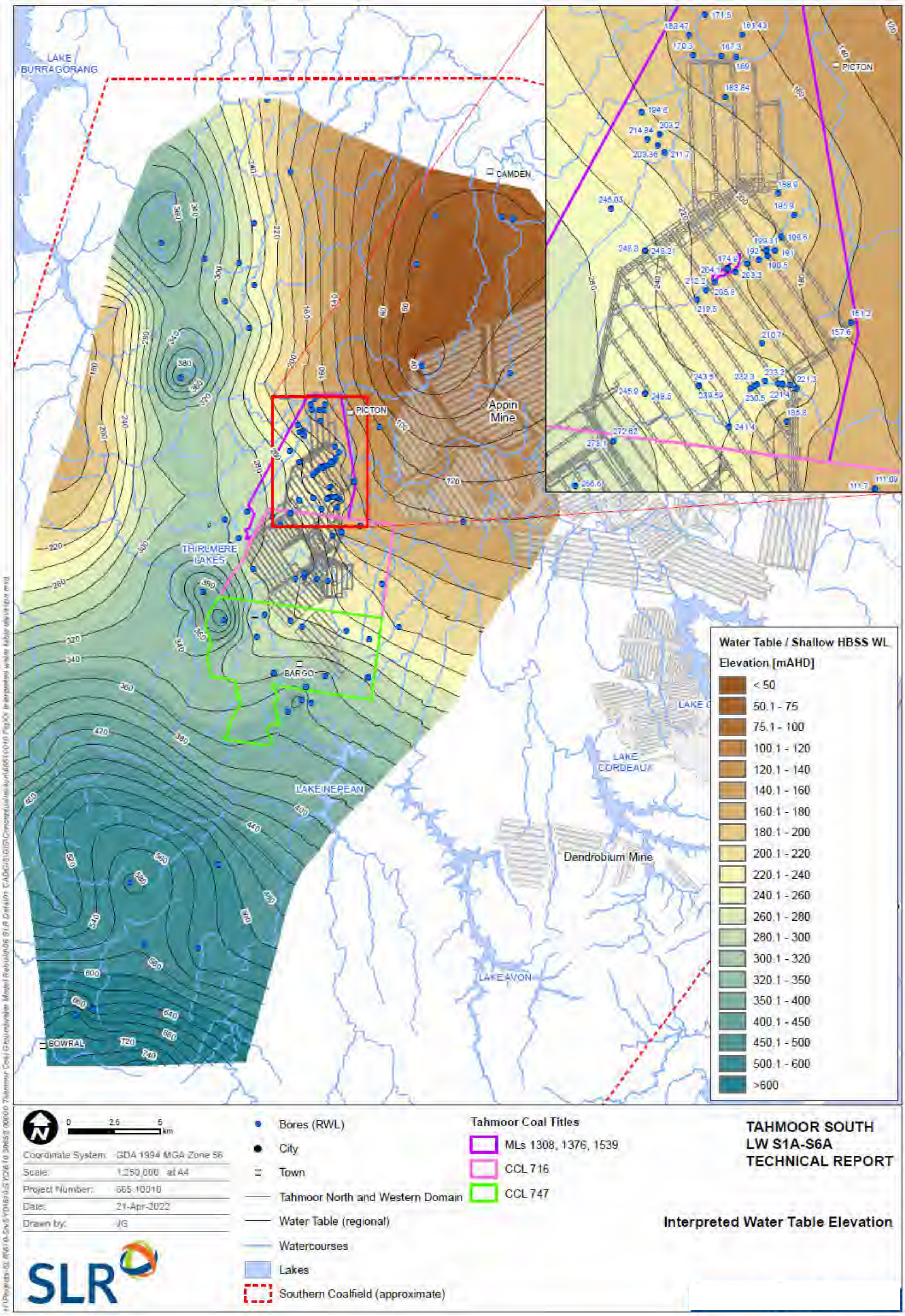

Figure 14 Interpreted Water Table Elevation (Shallow Hawkesbury Sandstone)

3.8 Thirlmere Lakes

The Thirlmere Lakes are situated in the upper reaches of Blue Gum Creek, which ultimately flows to Lake Burragorang (Warragamba Dam) – the main water supply storage of Sydney. The Thirlmere Lakes are a series of five interconnected Lakes (in order from most upstream to downstream): Gandangarra, Werri Berri, Couridjah, Baraba and Nerrigorang (refer **Figure 15**).

The water level of the Thirlmere Lakes has fluctuated over time, however, a notable decline in water level between 2017 and 2019 has initiated further research on the hydrological and hydrogeological characteristics of the lakes.

The Thirlmere Lakes Research Program identified that the lakes are a climate-sensitive wetland, with their water balance primarily driven by rainfall and evaporation (DPE, 2022). Input to the Thirlmere Lakes is primarily rainfall-runoff from small localised catchments, although the lakes can also receive water via infiltration[9] and interflow[10] processes from the surrounding catchment. Outflow from the lakes predominantly comprises evapotranspiration and streamflow, with a small component of outflow comprising groundwater discharge (DPE, 2022).

The water balance assessment identified that the primary influence on water level variation over the period of study (January 2014 to September 2020) was climatic, with the water balance accounting for approximately 83-98% of lake level variation during this period (DPE, 2022).

The geological investigations identified that there was no direct geological link between the Thirlmere Lakes and the Tahmoor Mine and there was no chemical or isotopic evidence of a correlation between groundwater in the mine and surface water in the lakes. DPE (2022) note that a lack of chemical or isotopic signature does not preclude the possibility of indirectly diminished groundwater discharge and/or runoff into to the lakes as a result of mining or other anthropogenic influences. However, the field and modelling results suggest that the recent water level declines are primarily associated with climate variability versus longwall mining.

9 The process by which water on the ground surface enters the soil (DPE, 2022).

10 The lateral movement of water in the unsaturated zone that returns to the surface prior to discharging to the groundwater system (DPE, 2022).

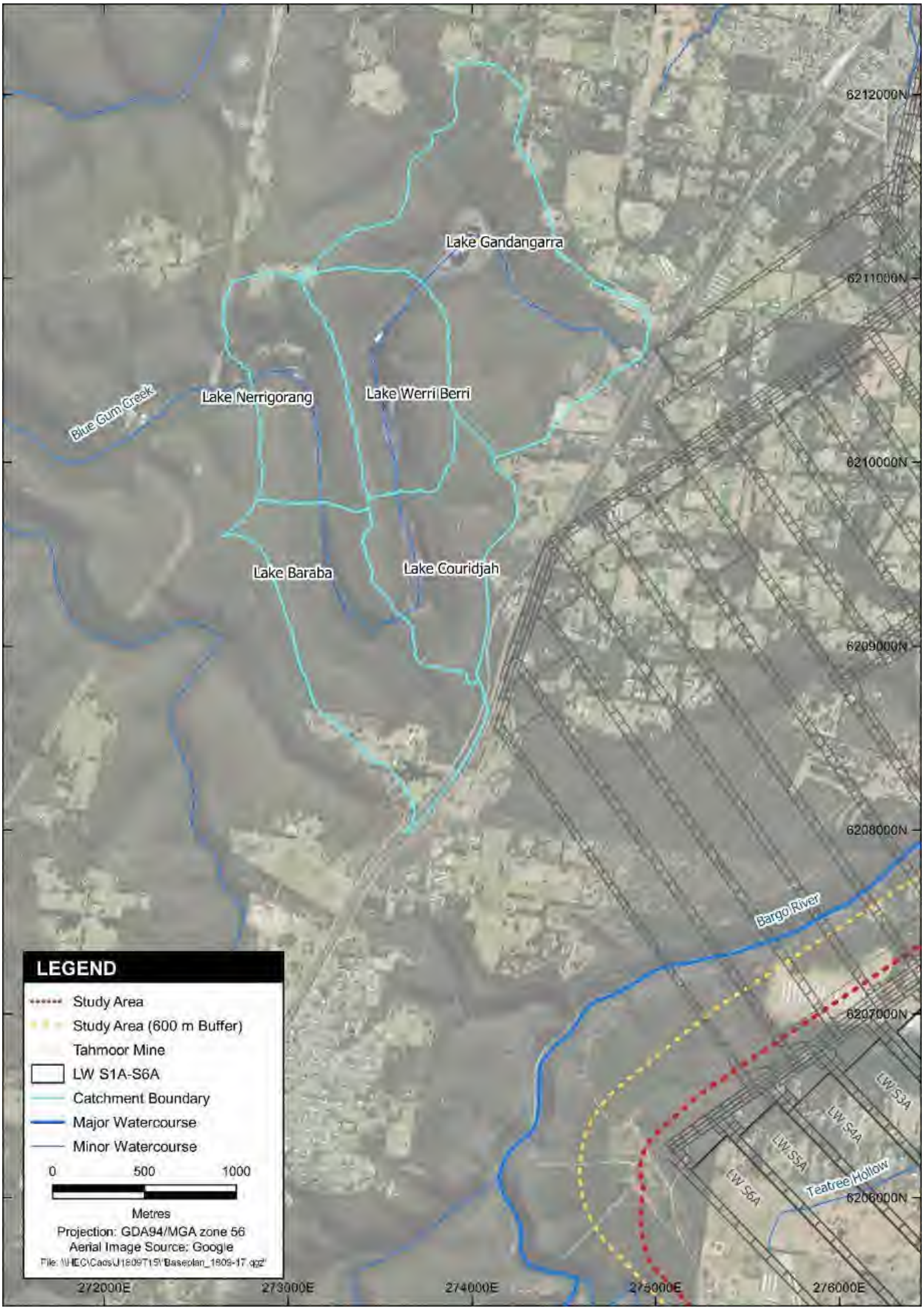

Figure 15 Thirlmere Lakes

4 Predicted Subsidence Impacts and Environmental Consequences

4.1 Subsidence Predictions

4.1.1 Predicted Subsidence Related Impacts to Watercourses

As detailed in Appendix A of the Extraction Plan, Tahmoor Mine has historically mined beneath or adjacent to the Bargo River. Impacts have previously been recorded due to direct undermining of the Bargo River, however, impacts have not occurred when secondary extraction has been undertaken more than 500 metres in plan distance from the River.

LW S1-S6A are located at a minimum distance of 690 metres plan distance from the Bargo River. Based on previous experience, at this distance subsidence related impacts to the Bargo River are not expected to occur. Additionally, subsidence related impacts to Hornes Creek, located a minimum plan distance of 650 m from LW S1-S6A, and to Dogtrap Creek, located a minimum plan distance of 1,800 m from the LW S1-S6A, are not expected to occur.

Notwithstanding, monitoring of the Bargo River and Hornes Creek would be conducted as detailed in **Section 5**, **Appendix B** and the Extraction Plan. Baseline monitoring of Dogtrap Creek would also be continued.

Watercourses which are located directly above LW S1-S6A may experience the full range of predicted subsidence movements detailed in Appendix A of the Extraction Plan. A summary of the maximum predicted values of total subsidence, upsidence and closure for Teatree Hollow and Teatree Hollow tributary are presented in **Table 17**. The predicted values based on the longwall layout presented in the EIS are included for comparative purposes.

Table 17 Maximum Total Subsidence, Upsidence and Closure Predictions for Watercourses

Location	Maximum Predicted Subsidence (mm)	Maximum Predicted Upsidence (mm)	Maximum Predicted Closure (mm)
Extraction Plan longwall layout			
Teatree Hollow	1,350	400	275
Teatree Hollow Tributary	1,300	450	375
EIS longwall layout			
Teatree Hollow	1,350	375	275
Teatree Hollow Tributary	1,250	400	350

As shown in **Table 17**, the maximum predicted values of total subsidence, upsidence and closure for Teatree Hollow and Teatree Hollow tributary based on the Extraction Plan longwall layout are slightly greater than that predicted based on the EIS longwall layout. This is due to very minor changes in the panel and chain pillar widths and in the extension of the commencing ends of LW S3A and LW S4A. Physical impacts including surface and rock fracturing are, however, dependent on differential movements which are described by curvature and strain rather than absolute vertical subsidence (MSEC, 2022).

The predicted upsidence and compressive strains due to valley closure based on both the Extraction Plan and EIS longwall layouts, are of sufficient magnitude to result in fracturing of bedrock in sections of Teatree Hollow and Teatree Hollow tributary which would directly overlie the longwall panels (MSEC, 2022). As noted by MSEC (2022), although the overall mining-induced movements are predicted to increase as a result of the Extraction Plan longwall layout, the potential for impacts to sections of streams proposed to be directly mined beneath is predicted to be of the same magnitude as that predicted based on the EIS longwall layout (refer **Section 4.2.1.2** for further discussion).

For streams which would not be directly mined beneath, the offset distance between the Extraction Plan longwalls would be of sufficient length such that the potential impacts to these streams are not expected to change significantly from that presented in the EIS. This includes the fourth and fifth order sections of Hornes Creek and the Bargo River which are located more than 670 m and 690 m plan distance respectively from the longwalls and therefore are not expected to experience subsidence related impacts.

Table 18 presents the predicted maximum change in grade and conventional curvature for Teatree Hollow and Teatree Hollow tributary based on the Extraction Plan and EIS longwall layouts.

Table 18 Maximum Predicted Change in Grade and Conventional Curvature

Location	Maximum Change in Grade (mm/m)		Maximum Conventional Curvature (km^{-1})	
	Increase	Decrease	Hogging	Sagging
Extraction Plan longwall layout				
Teatree Hollow	7	8	0.11	0.22
Teatree Hollow Tributary	6	6	0.1	0.21
EIS longwall layout				
Teatree Hollow	8	7.5	0.14	0.22
Teatree Hollow Tributary	7	4.5	0.1	0.21

As can be seen in **Table 18**, the maximum change in grade and maximum conventional curvature predicted for Teatree Hollow and Teatree Hollow tributary are similar for both the Extraction Plan and EIS longwall layouts.

4.2 Potential Impacts to Surface Water Resources

4.2.1 Water Quantity

Potential water quantity impacts associated with mining of LW S1-S6A, as addressed in the following sections, include:

- Reduction in baseflow rates and change in low flow regime;
- Change in pool water level and streamflow characteristics due to subsidence induced fracturing and tilt;
- Change in flood regime of watercourses and local tributary gullies;
- Change in overland flow behaviour; and
- Reduction in water supply to downstream surface water users.

4.2.1.1 Baseflow and Low Flow Regime

SLR (2022) describe baseflow reduction as '…the process of inducing leakage from a creek or river into the aquifer via a downward gradient or weakening an upward gradient from the aquifer into the watercourse and thereby reducing the rate at which baseflow occurs'.

The baseflow reduction associated with mining of LW S1A-S6A and cumulative mining activities[11] was predicted using an updated numerical groundwater model, as described in **Appendix E**. The predicted baseflow reduction rates for watercourses within the vicinity of the Study Area are listed in **Table 19**.

Table 19 Predicted Baseflow Reduction for Watercourses

Watercourse	Monitoring Site Location	Predicted Baseflow Reduction (ML/d)	
		LW S1A-S6A	Cumulative Mining
Dogtrap Creek	DT15-QRLa	0.002	0.039
Teatree Hollow	TT8-QRLa	0.001	0.053
Bargo River	BR13-QRLa	<0.001	0.026
Bargo River	BR14-QLa	<0.001	0.073
Hornes Creek	HC9-QLa	<0.001	0.004

Source: **Appendix E** (SLR, 2022).

Baseflow reduction was not predicted to occur in Cow Creek which is located to the south-east of the Study Area and within the Sydney Drinking Water Catchment (refer **Figure 3**).

In general, the updated numerical groundwater model predicted less reduction in baseflow in comparison with that predicted for the EIS (SLR, 2022).

Baseflow reduction is expected to be most noticeable during periods of low flow which would normally be dominated by baseflow. The effect on low flows can be seen by comparing the flow duration curves generated for the pre-mining and post-mining scenarios.

Figure 16 shows the effect of the predicted baseflow reduction rates on streamflow at monitoring site B13-QRLa in the Bargo River. **Figure 16** illustrates that there is expected to be negligible effect on streamflow rates in the Bargo River at monitoring site BR13-QRLa based on the predicted baseflow reduction rate associated with mining LW S1A-S6A or cumulative mining effects.

Figure 17 shows the effect of the predicted baseflow reduction rates on streamflow at monitoring site DT15-QRLa in Dogtrap Creek. **Figure 17** illustrates that there is expected to be negligible effect on streamflow rates in Dogtrap Creek at monitoring site DT15-QRLa based on the baseflow reduction predictions associated with mining LW S1A-S6A. The predicted baseflow reduction associated with cumulative mining may result in effects on flows in Dogtrap Creek when the flow rate is less than approximately 0.5 ML/d. The probability that the flow rate would exceed 0.1 ML/d would reduce from 58% of the time pre-mining to 53% of the time post-mining based on the predicted baseflow reduction rate associated with cumulative mining. This level of change would be low compared to natural variability in catchment conditions.

The effect on streamflow rates in Teatree Hollow at monitoring site TT8-QRLa, the Bargo River at monitoring site BR14-QLa and Hornes Creek at monitoring site HC9-QLa is expected to be negligible based on the predicted baseflow reduction rates for LW S1A-S6A and cumulative mining.

[11] Includes Appin, Dendrobium, Metropolitan, Russell Vale and Cordeaux mines

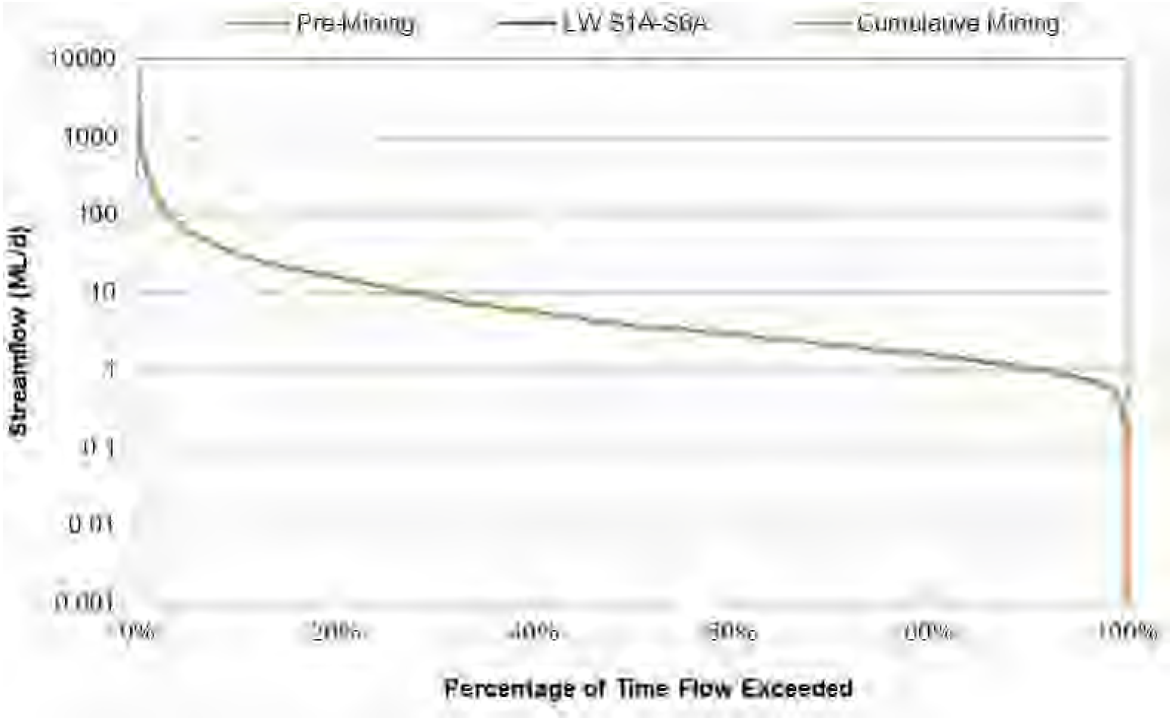

Figure 16 Flow Duration Curve – Bargo River (BR13-QRLa) Predicted Baseflow Reduction Effect

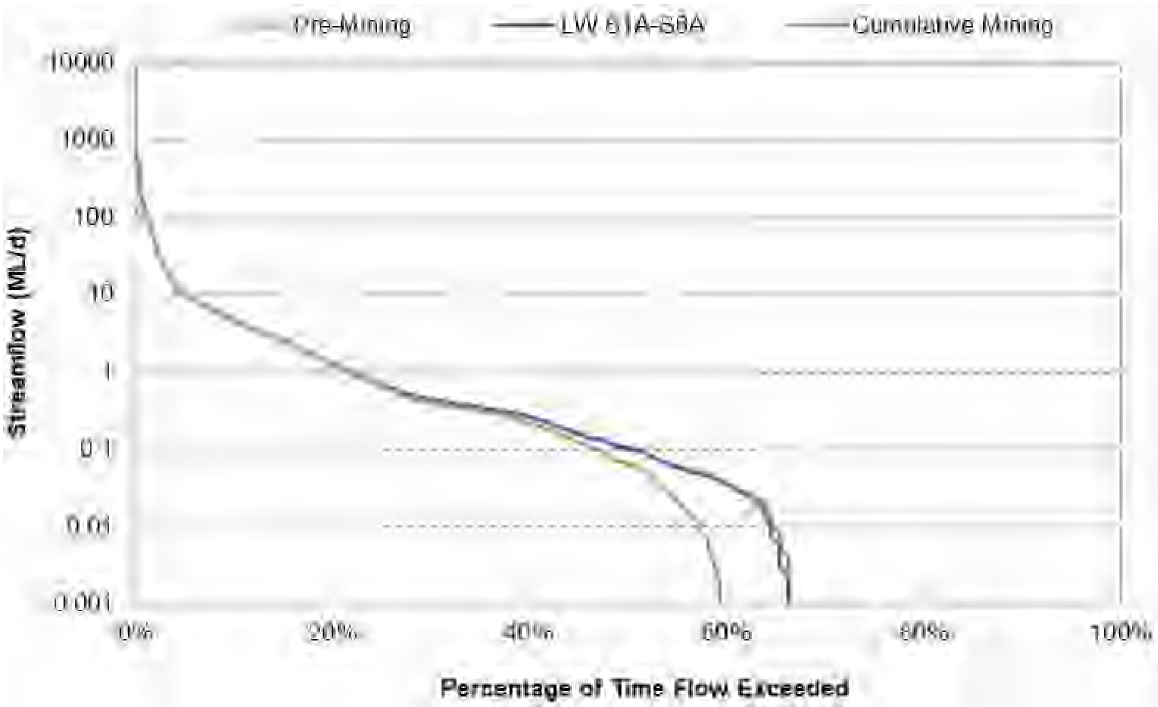

Figure 17 Flow Duration Curve – Dogtrap Creek (DT15-QRLa) Predicted Baseflow Reduction Effect

4.2.1.2 Pool Water Level and Streamflow

Where Teatree Hollow and Teatree Hollow tributary are directly mined beneath, upsidence and compressive strains due to valley closure are expected to be of sufficient magnitude to result in the buckling of underlying strata and associated surface fracturing at some locations. At these locations it is likely that water would be diverted from the watercourse into the underlying dilated strata. The diverted flow would be conveyed via the dilated strata and remerge further downstream in the watercourse as surface flow. As such, although Teatree Hollow and Teatree Hollow tributary are likely to incur localised reductions in pool water level and streamflow associated with fracturing in the vicinity of LW S1-S6A, the net reduction in streamflow conveyed from Teatree Hollow to the Bargo River is expected to be negligible.

This is consistent with that stated in the EIS and observed at historical Tahmoor Mine areas. Mining related impacts associated with Tahmoor North, including streambed and rockbar fracturing, occurred at a number of locations in Redbank Creek resulting in diversion of surface flow through the dilated strata and re-emergence of the flow further downstream in Redbank Creek. A recent study undertaken by Tammetta (2021), concluded that, although there was a statistically significant reduction in streamflow at sites in Redbank Creek which had been directly mined beneath, there was no evidence of a statistically significant reduction in streamflow at the downstream monitoring site in Redbank Creek beyond the extent of subsidence effects.

Surface water level and streamflow monitoring within and adjacent to the Study Area is proposed (refer **Section 5**) and TARPs have been developed to assess the need for a response which may include remediation (refer **Appendix A**).

4.2.1.3 Overland Flow and Flooding

The maximum predicted total conventional tilt ranges between 7 mm/m (LW S1A) and 9.5 mm/m (LW S6A) (MSEC, 2022). The natural gradient overlying the Study Area, excluding watercourses, ranges between approximately 2.5 mm/m and 50 mm/m. At locations of minimum natural gradient, the predicted subsidence may result in a very slight reduction in surface grade (i.e. 0.02%). This level of change is not expected to result in impacts to overland flow or to remnant ponding in the landscape (excluding the watercourses).

Above the approved longwalls, the natural gradient of Teatree Hollow varies between 20 mm/m and 50 mm/m and the natural gradient of Teatree Hollow tributary varies between 9 mm/m and 40 mm/m (MSEC, 2022). The predicted maximum tilts associated with mining LW S1A to LW S6A are notably less than the natural gradient of Teatree Hollow and Teatree Hollow tributary. There is potential that localised areas along the watercourses may experience a slight reduction in grade where the natural gradients are low. The predicted change in grade is typically less than 1% and, as such, any localised changes in ponding are expected to be negligible (MSEC, 2022).

As detailed in the EIS, subsidence related changes to the topography of the Study Area are not expected to result in detectable increases in the flood inundation extent associated with Teatree Hollow and Teatree Hollow tributary.

4.2.2 Water Quality

4.2.2.1 Elevated Constituents

Isolated, episodic pulses in salinity, iron, manganese, zinc and nickel may occur in Teatree Hollow and the Bargo River tributary due to subsidence induced changes in surface water runoff, underflow and baseflow discharging to these surface water systems. Localised and periodic increases in electrical conductivity and concentrations of dissolved iron, manganese, zinc, sulphate and nickel were recorded at monitoring sites in Redbank Creek overlying and downstream of longwall panels during and shortly following mining at Tahmoor North. While there were some periodic increases in constituents recorded at locations downstream of mining impacts, potentially due to re-emergence of upstream diverted flow, the increases were found to be temporary and decreased to baseline levels with time (HEC, 2020; HEC, 2021).

Water quality monitoring within and adjacent to the Study Area is proposed (refer **Section 5**) and TARPs have been developed to assess the need for a response which may include remediation (refer **Appendix A**).

4.2.2.2 Gas Emissions

Methane is naturally present in many shallow surface water and groundwater systems as a result of organic decomposition and redox-methanogenesis reactions (DoP, 2008). When sediments are disturbed by mining related subsidence effects, methane derived naturally may be released more rapidly in surface water systems (DoP, 2008). The generative fluxes and concentrations are generally low and inconsequential (DoP, 2008).

In areas where gas releases occur into the water column, there is insufficient time for substantial amounts of gas to dissolve into the water column (MSEC, 2022). As the majority of gas is released into the atmosphere, water quality impacts and dieback of riparian vegetation associated with gas emissions is rare.

Gas emissions were reported to have occurred at the Tahmoor Western Domain and at other mining areas in the Southern Coalfield. During mining of Longwalls West 1 and West 2 in the Tahmoor Western Domain, small although reasonably persistent gas bubbles were observed in a pool in Matthews Creek. Evidence of vegetation dieback associated with the observed gas emissions was not reported to have occurred (Niche, 2021). Additionally, impacts to water quality and aquatic ecology were not evident (HEC, 2021; Niche, 2021).

Based on findings from mining of the Tahmoor Western Domain and other mining areas in the Southern Coalfield, it is likely that gas emissions would occur as a result of mining activities associated with the Project. However, it is unlikely that gas emissions at the surface would result in long-term or extensive vegetation die-back. As the majority of gas is released into the atmosphere, water quality impacts are unlikely to occur.

4.2.3 Erosion and Sedimentation

Slight increases in the gradients of Teatree Hollow and Teatree Hollow tributary may occur where the watercourses flow into the predicted subsidence trough near the longwall edges (MSEC, 2022). However, the predicted maximum increase in grade is 1% which is relatively small compared with the natural watercourse gradients. As such, the potential for increased scouring and erosion is not expected to be substantial (MSEC, 2022).

Consistent with the EIS, localised areas of increased erosion may occur in watercourses where the streambed material is comprised predominantly of mud and/or sand or where soft knickpoints are present. Although the potential increase in erosion is expected to be negligible, knickpoints and watercourse stability will be monitored as summarised in **Section 5** and detailed in **Appendix B**.

4.2.4 Aquatic Biodiversity

Potential impacts to aquatic biodiversity associated with mining LW S1A-S6A are detailed in the Biodiversity Management Plan and summarised as follows.

In the event of fracturing, which is predicted to occur for the reaches of Teatree Hollow and Teatree Hollow tributary which directly overlie LW S1A-S6A, there is potential for a reduction in pool water level and associated reduction in available aquatic habitat and macroinvertebrate biomass. Additionally, a temporal reduction in fish passage may occur during periods of low flow. It is noted, however, that few fish species were observed during the aquatic ecology surveys and aquatic threatened species are considered unlikely to be present in the Study Area (refer **Section 3.4**).

For macroinvertebrates, while total biomass will likely be reduced, it is unlikely that a catchment scale change in overall assemblage and family richness will be measurable. The liberation of contaminants from subsidence induced fracturing in watercourses, with resulting localised and transient water quality impacts, has the potential to impact aquatic biota. This is particularly the case where increased iron precipitation occurs. Streams that are acidic and low in alkalinity are more likely to be impacted as these surface water systems have less buffering capacity against changes to pH. The surface water systems within the Study Area typically have low alkalinity and slightly acidic to near neutral pH conditions (refer **Section 3.3** and **Appendix D**). As such, changes to pH would have greater impact on these surface water systems and associated aquatic biota.

Where localised and transient pulses in metals are observed, the impacts to stream fauna are similarly expected to be localised, with fauna likely to recover from transient spikes in concentrations. Localised long-term changes to fauna may occur if metal concentrations are elevated for prolonged periods of time.

4.3 Potential Impacts to Groundwater Resources

The potential impacts to groundwater can be divided into two principal types:

- Impacts to groundwater level, i.e. drawdown and depressurisation, and associated changes in groundwater quantity due to groundwater discharge into the mine workings and changes to strata permeability and porosity; and
- Impacts to water quality characteristics due to enhanced aquifer connectivity/mixing.

Potential impacts have been assessed by SLR (2022) utilising an updated and comprehensive numerical groundwater model. Further information pertaining to recent model updates are provided in the Groundwater Technical Report (**Appendix E**)

4.3.1 Predicted Groundwater Inflow

Table 20 presents the predicted groundwater inflow to Tahmoor South for each water year to the end of the approved mine life (SLR,2023).

Table 20 Predicted Groundwater Inflow

Water Year*	Predicted Groundwater Inflow - Tahmoor South	
	Average Rate (ML/d)	Annual Volume (ML)
2023-2024	2.16	789
2024-2025	2.07	755
2025-2026	1.90	692
2026-2027	0.86	313
2027-2028	0.12	45
2028-2029	0.12	46
2029-2030	0.12	46
2030-2031	0.12	45
2031-2032	0.12	46

* 1 July to 30 June. Groundwater inflow to Tahmoor South is predicted to increase over the first half of the operational life of LW S1A-S6A, reaching a peak of approximately 789.3 ML (average of 2.16 ML/day) in water year 2024. Inflow rates are predicted to decline gradually from water year 2024 to 2032.

As stated in **Section 3.5**, WAL36442 provides Tahmoor Coal with 1,642 units of entitlement from the Sydney Basin Nepean Groundwater Source, in accordance with the *Greater Metropolitan Region Groundwater Sources Water Sharing Plan 2023*. The predicted groundwater inflow, as presented in **Table 20**, indicates that the 1,642 units of entitlement held by Tahmoor Coal is not expected to be exceeded over the duration of the approved mine life.

As historically required, groundwater 'take' associated with the Tahmoor Mine workings, i.e. the total groundwater inflow to the active and historical Tahmoor Mine workings that is subsequently transferred to the surface, has been predicted and is reported in Error! Reference source not found.**Table 20**.

The numerical groundwater model is currently in revision to predict the volume of groundwater inflow that would report to and remain in the void space following completion of longwall extraction (i.e. groundwater that becomes stored in the void space during the recovery / aquifer equilibration phase). Following completion of the model revision, the WMP would be revised to present the revised predictions of groundwater inflow with consideration to post-recovery stored volumes in the historical workings.

As stated above, Tahmoor Coal currently holds sufficient WAL entitlements to account for the groundwater inflow volumes predicted to be transferred from the Tahmoor Mine workings to the surface over the duration of the approved mine life. Tahmoor Coal is investigating the potential to obtain additional WAL entitlement to account for the volume of groundwater stored in the void space of the historical mine workings post-recovery, subject to the outcomes of the revised groundwater modelling.

4.3.2 Groundwater Levels

4.3.2.1 Predicted Drawdown

The predicted maximum drawdown associated with mining of LW S1A-S6A (incremental drawdown) is presented in **Figure 18** to **Figure 20**. **Figure 18** shows the predicted maximum water table drawdown associated with mining of LW S1A-S6A. The water table (shallow groundwater aquifers) has been featured as this reflects the highest level of connectivity with environmental (surface) features (refer **Appendix E**). The results presented in **Figure 18** indicate that the maximum predicted water table drawdown is generally less than 4 m within the Study Area, with the predicted drawdown extending approximately 0.5 km to the north and northeast, and approximately 0.5 km southwest towards Lake Nepean.

Figure 19 presents the predicted maximum drawdown in the lower Hawkesbury Sandstone which is the predominant source of local groundwater extraction. **Figure 19** shows that the maximum drawdown extends radially from LW S1A-S6A. The 1 m drawdown contour extends 1 km to the south towards Lake Nepean, and 1 km to the north and northeast.

Figure 20 shows that the maximum predicted depressurisation (1 metre contour) extends approximately 2 km to the south and 2 km to the east of from LW S1A-S6A. The cone of depression is predicted to be steepest around the extracted longwalls.

The extent of the maximum drawdown predicted by the updated numerical groundwater modelling is less than that presented in the EIS. The difference in drawdown extent is due to the updated model structure, the use of depth dependence functions and pilot points in the updated model.

The predicted cumulative mining effects are detailed in **Appendix E**.

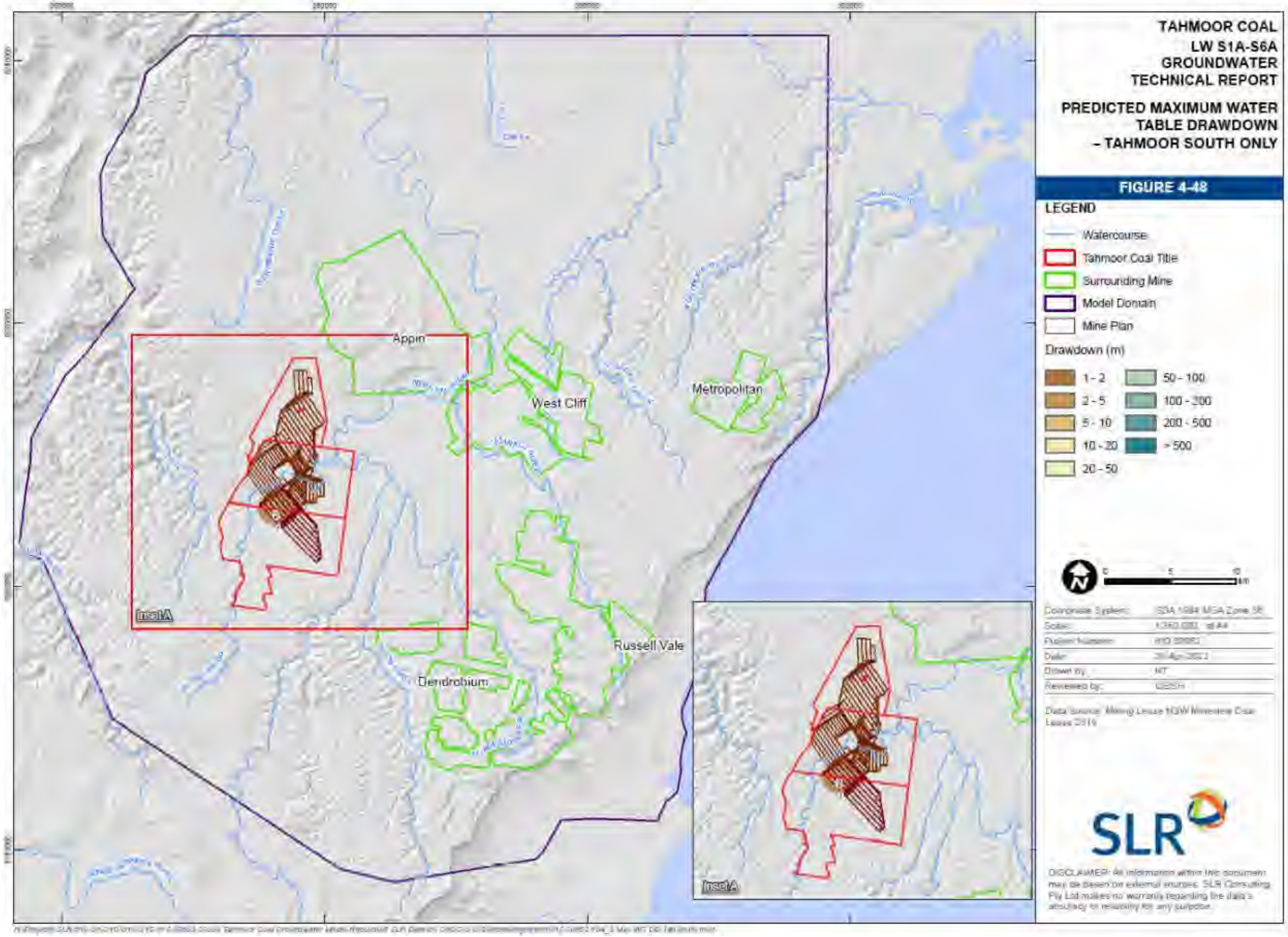

Figure 18 Predicted Maximum Water Table (Shallow Hawkesbury Sandstone) Drawdown – LW S1A-S6A Impact

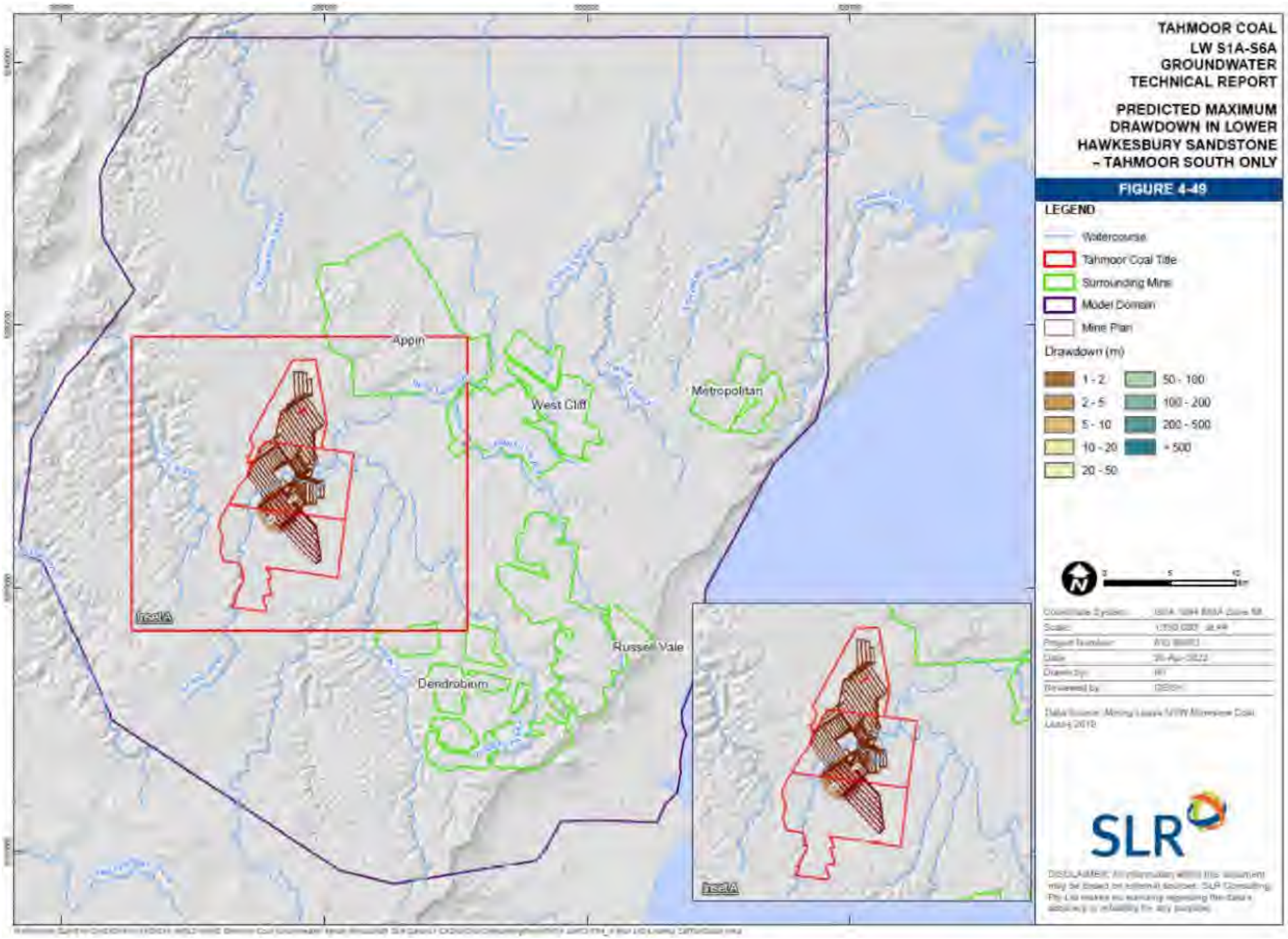

Figure 19 Predicted Maximum Drawdown in the Lower Hawkesbury Sandstone – LW S1A-S6A Impact

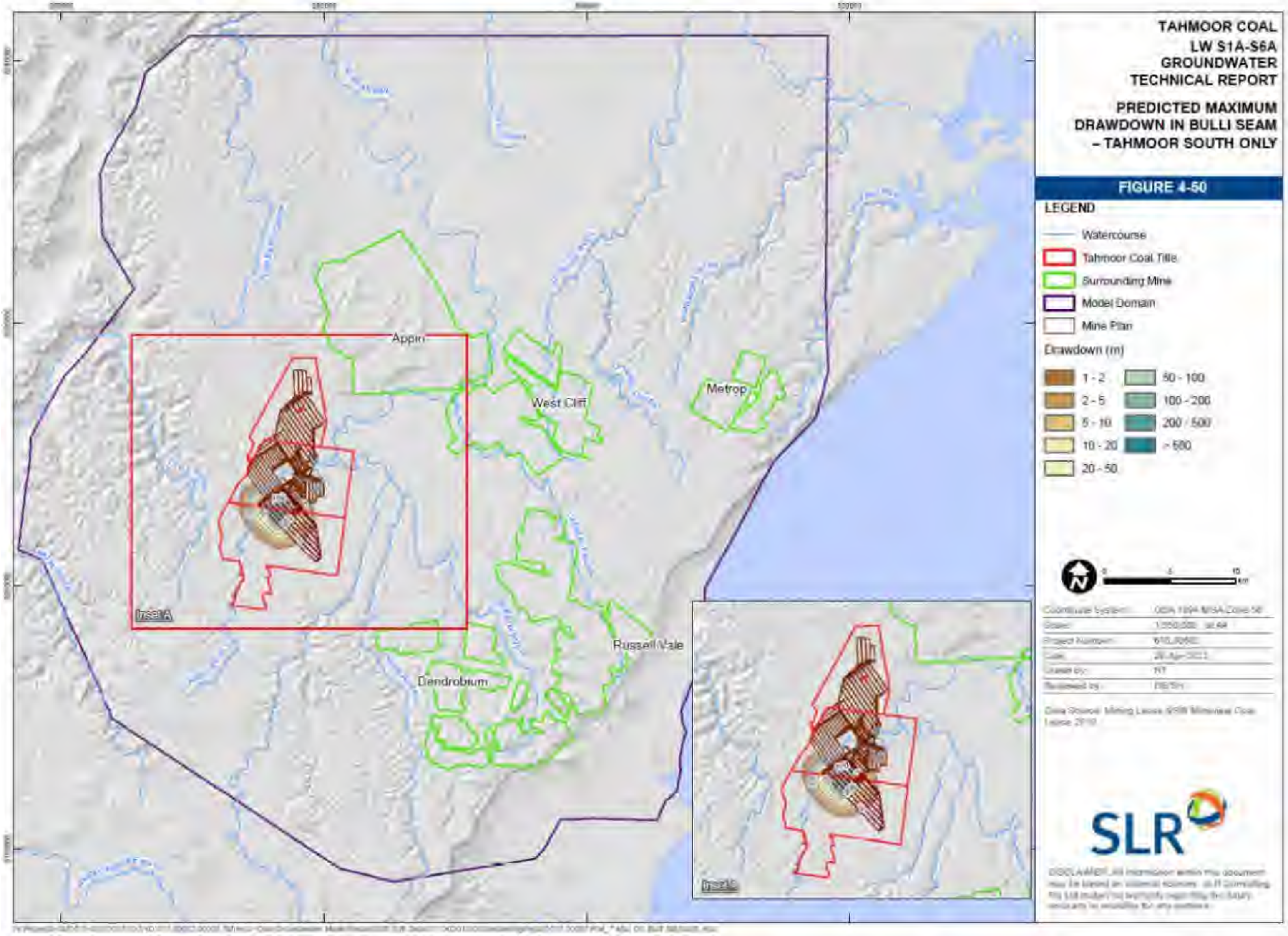

Figure 20 Predicted Maximum Drawdown in Bulli Seams – LW S1A-S6A Impact

4.3.3 Groundwater Levels – Private Bores

There are three private groundwater bores predicted to incur greater than 2 metres of drawdown resulting from mining of LW S1A-S6A. The highest drawdown of 2.4 m is predicted at GW032443 which is located above LW S3A (SLR, 2022).

Ongoing monitoring of seven private groundwater bores has been negotiated, as summarised in **Section 5** and detailed in **Appendix E**, and a TARP would be implemented, as detailed in **Appendix A**. Where a reduction in groundwater yield or groundwater quality occurs at private groundwater bores and investigation outcomes indicate a mining related effect, mitigation measures would be implemented as described in **Section 6.2.1.3.**

4.4 Potential Impacts to Thirlmere Lakes

The model drawdown predictions do not extend to the Thirlmere Lakes. As such, increased infiltration from the lakes to the groundwater system or a reduction in baseflow contribution from the alluvium to the lakes was not predicted. Notwithstanding, a cross-sectional monitoring network has been implemented as shown in **Figure 25** and detailed in **Appendix E** (SLR, 2022). A TARP has also been developed for Thirlmere Lakes to monitor for early warning signs of potential impacts and to initiate appropriate actions and responses.

4.5 Potential Impact to Water Supply and Other Water Users

As shown in **Table 19**, SLR (2022) predicted a baseflow reduction rate of less than 0.001 ML/d at BR14-QLa in the Bargo River associated with mining of LW S1A-S6A and a baseflow reduction of 0.073 ML/d associated with cumulative mining effects.

As stated in **Section 3.5**, Tahmoor Coal hold a total 41 ML entitlement for water access from the Maldon Weir Water Source, in accordance with the *Water Sharing Plan for Greater Metropolitan Region Unregulated River Water Sources 2023*. As such, Tahmoor Coal hold sufficient WALs to account for the predicted annual baseflow reduction in the Bargo River of 0.37 ML (0.001 ML/d) associated with mining of LW S1A-S6A.

5 Subsidence Monitoring Program

5.1 Performance Measures and Indicators

Performance measures for surface water and groundwater resources are provided in **Table 7** of Condition C1 of SSD 8445 and summarised in **Table 21**. The Biodiversity Management Plan and associated TARPs address potential impacts and proposed triggers, actions and responses in relation to aquatic and riparian ecosystems.

Table 21 Subsidence Performance Measures and Performance Indicators for Surface Water and Groundwater Resources

Feature	Subsidence Performance Measures	Subsidence Performance Indicators
All watercourses within the Subsidence Area	No greater subsidence impact or environmental consequences to water quality, water flows (including baseflow) or stream health (including riparian vegetation), than predicted in the EIS.	Exceedance of the impact assessment criteria, as defined in the relevant Level 1 to Level 3 trigger, where a Level 3 trigger denotes progression towards a potential exceedance of the performance measure. This performance measure and performance indicator have been incorporated into TARP WMP1, WMP3 and WMP5.
Other watercourses	Negligible environmental consequences including beyond those predicted in the EIS, including: • Negligible diversion of flows or changes in the natural drainage behaviour of pools; • Negligible decline in baseline channel stability; • Negligible gas releases and iron staining; and • Negligible increase in water turbidity.	The performance measure will be considered to be exceeded if a Level 3 TARP is triggered in relation to water level decline and/or water quality changes and the investigation outcomes indicate a mining related impact based on monitoring data for sites in Hornes Creek and the Bargo River. Performance indicators in relation to channel stability are not proposed as soft knickpoints have not been mapped in Hornes Creek or the Bargo River. This performance measure and performance indicator have been incorporated into TARP WMP2, WMP4 and WMP6.
GDEs including Thirlmere Lakes	Negligible impacts including: • Negligible change in groundwater levels; and • Negligible change in groundwater quality.	The performance measure will be considered to be exceeded if a Level 3 TARP is triggered and the investigation outcomes indicate a mining related impact based on monitoring data for the Thirlmere Lakes. This performance measure and performance indicator have been incorporated into TARP WMP13 (groundwater bores monitoring for Thirlmere Lakes).

For the purpose of this management plan, 'negligible' is defined as being 'so small and insignificant as to not be worth considering'. A negligible impact is viewed with regards to a long term context, causing little or no impact. If a short term impact causes a greater than negligible impact, the impact can still be considered negligible if the impacts are of a limited duration and are considered negligible when considered over the long term.

As detailed in **Section 4.2** and consistent with that presented in the EIS, where Teatree Hollow and Teatree Hollow tributary are directly mined beneath, surface fracturing and diversion of flow to the underlying dilated strata is predicted to occur. As such, TARPs have been designed to enable identification of potential impacts and to initiate appropriate actions and responses. Where mining related impacts occur to watercourses, remediation works are proposed to be implemented as documented in the TARPs. Where required, the remediation works would be guided by a Watercourse Corrective Management Action Plan (WCAMP) which would include performance indicators relating to the effectiveness of the proposed remediation works. Further discussion on remediation actions is provided in Section **4.2.1.2**.

Based on the predicted subsidence impacts (MSEC, 2022), it is considered that the performance measures for surface water and groundwater resources within the Study Area will be achieved during and after mining of LW S1A-S6A.

Regarding the performance measure for 'all watercourses within the Subsidence Area', the EIS concludes that where the longwalls directly mine beneath the streams, it is considered likely that fracturing would result in surface water flow diversion and that localised and transient increases in water quality constituents would occur. The performance measure will be considered to be exceeded if subsidence impacts cannot be repaired in a manner that restores pool water holding capacity and stream health. Remediation measures will be developed as required and detailed in the Watercourse Corrective Action Management Plan (C12 of the SSD 8445). These plans will contain relevant performance indicators specific to remediation performance measures.

5.2 Surface Water and Groundwater Monitoring Program

A subsidence monitoring program for surface water and groundwater resources will be implemented to monitor the impacts and consequences of subsidence effects during the extraction of LW S1A-S6A. The Surface Water Monitoring Plan is included as **Appendix B** and the Groundwater Monitoring Plan is detailed in **Appendix E**. Note that some sites have been commissioned following preparation of the reports included as **Appendix B** and **Appendix E** (refer **Section 3** and **Section 3.7.3**). The monitoring plans detail the proposed monitoring sites to be established, the timing of establishment and details of the proposed monitoring program. The surface water and groundwater monitoring program for the Project would be progressively developed based on the stage and scope of the Project development. It is noted that the number and location of proposed monitoring sites to be established will be dependent on:

- Gaining the necessary land access agreements; and
- The suitability of the site for the proposed monitoring.

The aim of the monitoring program is to identify where there is a risk of impact to surface water and groundwater resources as a result of extraction activities. The monitoring program provides for the opportunity to record the condition of each monitoring site during the following three phases:

- Prior to mining – baseline survey of the condition of the site before the commencement of mining;
- During mining – monitoring of the condition of the site during active subsidence to establish whether there has been any change to the site or if changes have occurred from the effects of subsidence; and

- Post mining – monitoring of the condition of the site after mining to identify whether there has been any change to the site in the period since mining, and to assess if the ground surface conditions have stabilised.

The TARP triggers have been designed to enable identification of potential impacts based on the before and after monitoring at reference and performance measure sites. If an impact is identified to have occurred or is likely to occur, the relevant TARP (refer to **Appendix A**) would then be referred to for the identification of appropriate mitigation strategies.

Access for features associated with the TARPs have been established with long-term Land Access Agreements covering a large proportion of Teatree Hollow, Teatree Hollow tributary, the Bargo River, the Bargo River tributary and Hornes Creek. Extensive consultation has occurred to reach agreement with as many landowners as possible associated with these watercourses. Tahmoor Coal will continue to consult with the community regarding Land Access Agreements.

5.2.1 Quality Assurance / Quality Control

A Before-After-Control-Impact (BACI) framework has been implemented, where feasible, for surface water and groundwater monitoring and has been incorporated in the design of the TARP triggers. The monitoring program aims to develop a baseline (before) dataset for a range of surface water and groundwater features and to assess operational and post-mining (after) impacts through the monitoring of reference (control) and performance measure (impact) sites.

Quality assurance and quality control (QA/QC) for water quality monitoring is and would continue to be undertaken in accordance with the *Australian and New Zealand Guidelines for Fresh & Marine Water Quality* (ANZG, 2018). The sample collection is and would continue to be undertaken by an experienced field technician. The sample analysis undertaken by a National Association of Testing Authorities (NATA) accredited laboratory and the data analysis undertaken by a specialist consultant. Where a data record is identified as potentially erroneous by the specialist consultant, the value is and would be queried with and reviewed by the field technician. The same process is and would be undertaken for pool water level records, with the records also verified through comparison of the manual field measurements and automatic water level logger records.

5.2.2 Monitoring Site Locations and Monitoring Program Summary

The monitoring site locations are shown in **Figure 21** to **Figure 25**. A summary of the monitoring program is provided in **Table 22**.

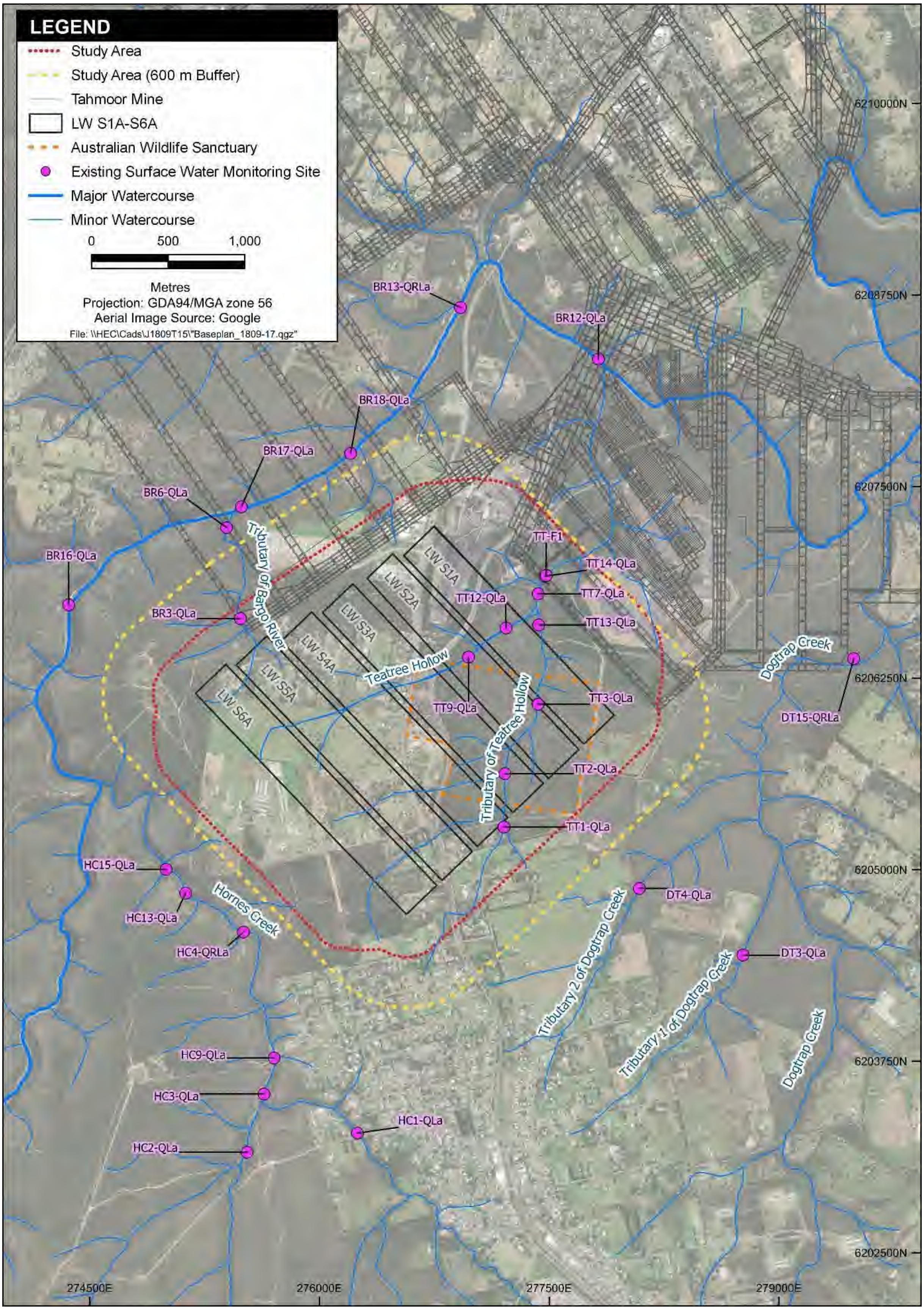

Figure 21 Existing Surface Water Monitoring Sites Specific to LWS1A-S6A

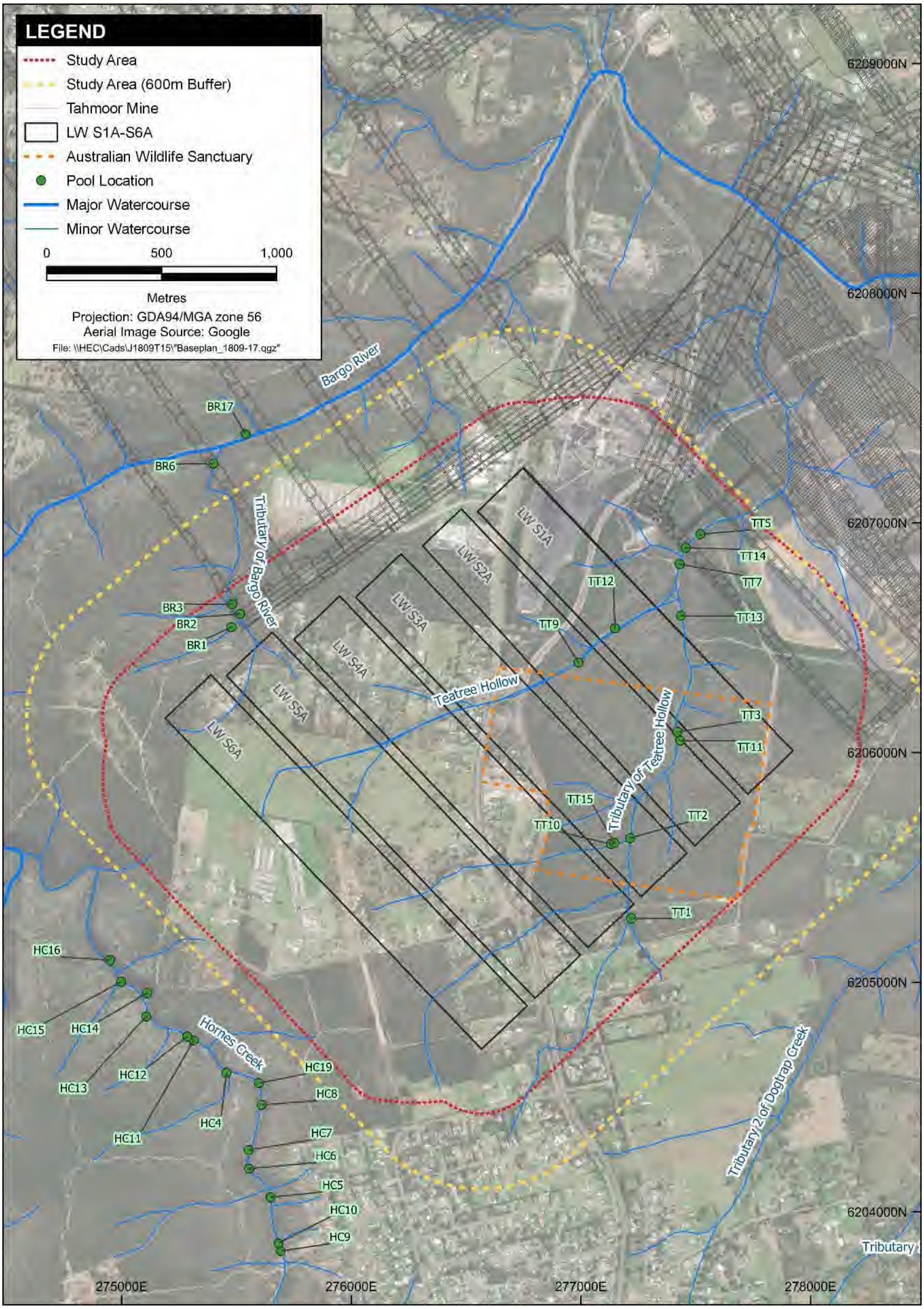

Figure 22 Pool Visual Inspection Sites

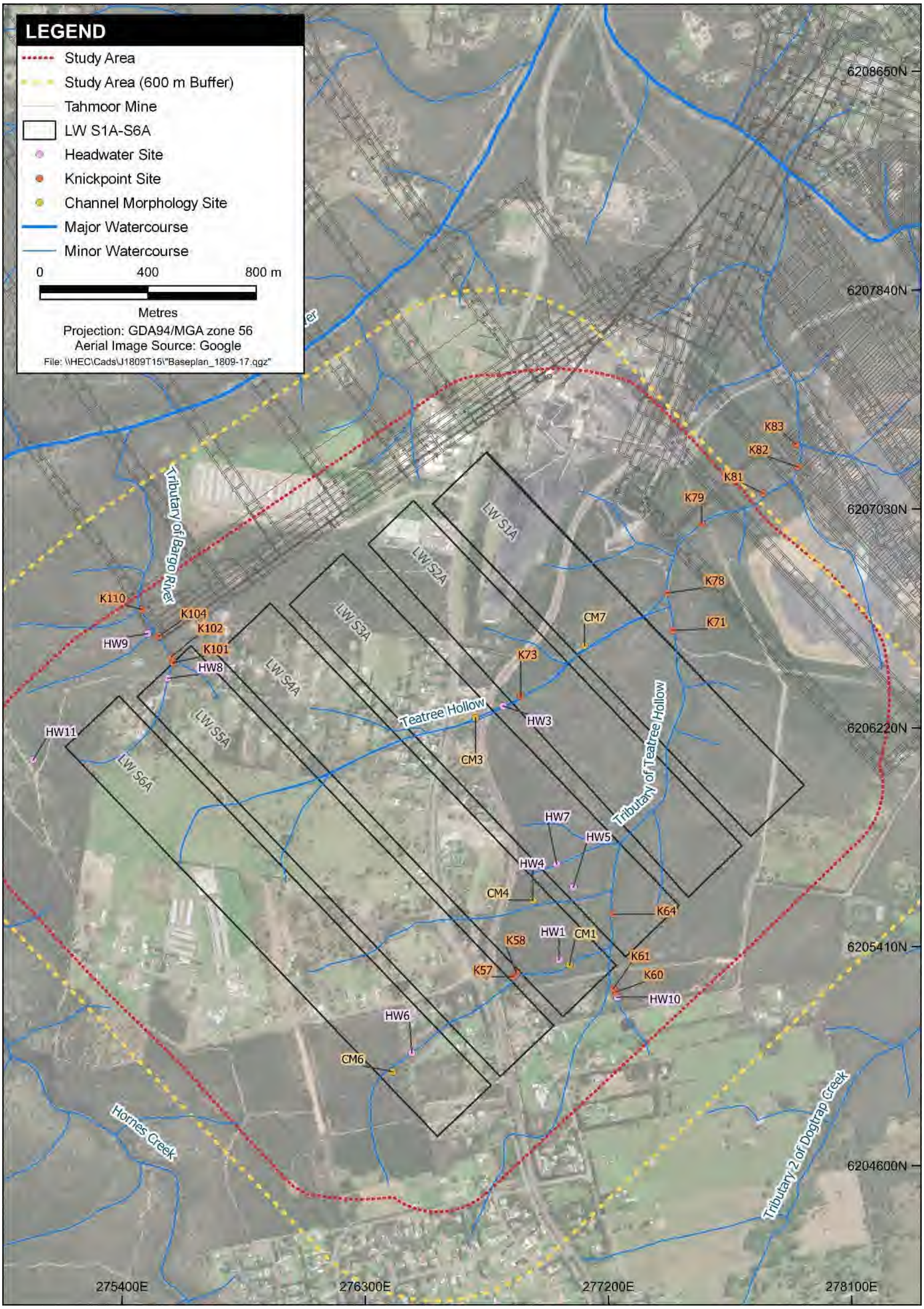

Figure 23 Morphology and Channel Stability Monitoring Sites

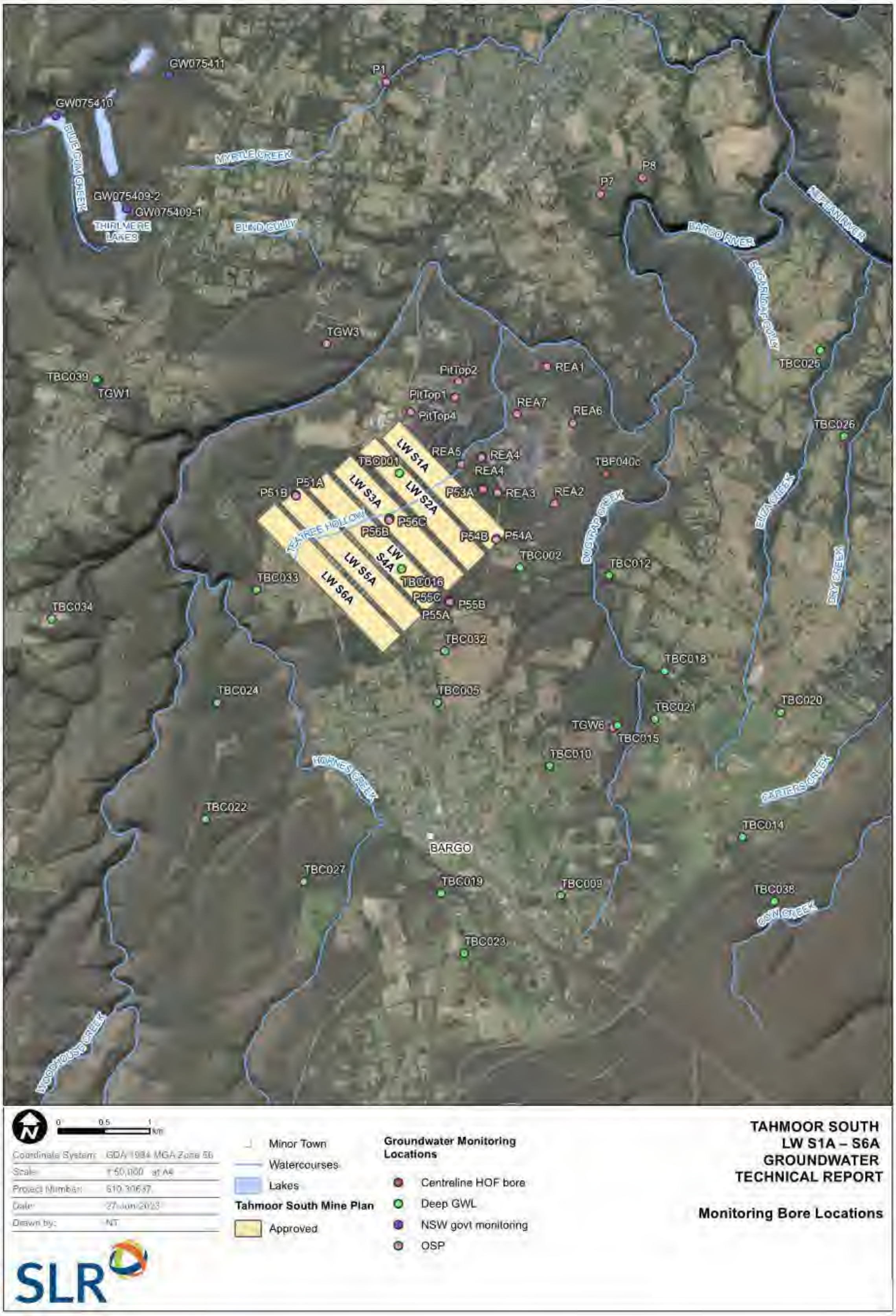

Figure 24 Existing and Proposed Groundwater Monitoring Sites

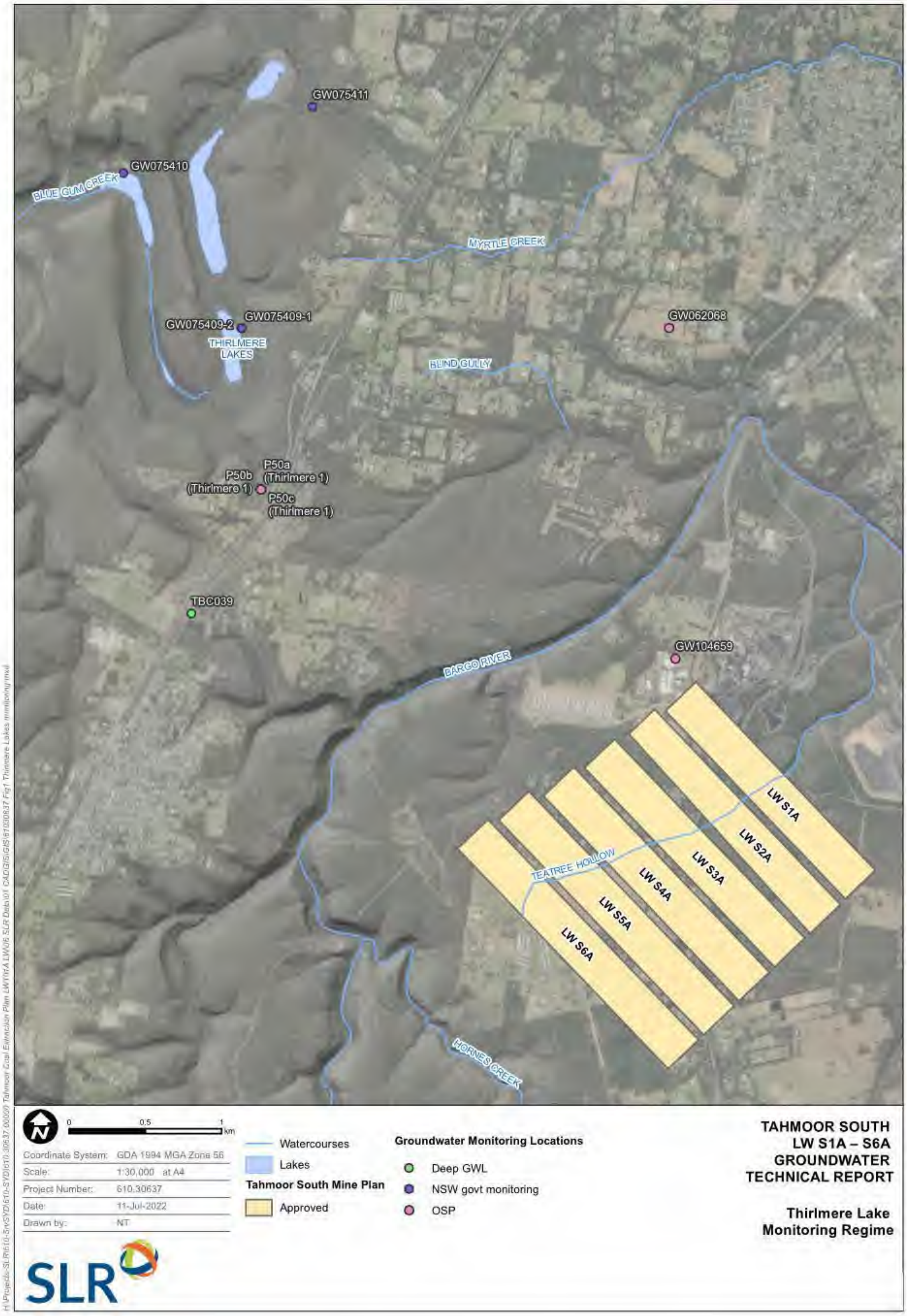

Figure 25 Thirlmere Lakes Monitoring Sites

Table 22 Monitoring Program for Surface Water and Groundwater Resources Relevant to LW S1A–S6A

Feature	Monitoring Component / Location	Pre-mining Monitoring	During Mining Monitoring	Post-mining Monitoring
Surface Water Monitoring				
Streamflow	Existing site: TT-F1	Continuous record. Data downloaded prior to the commencement of secondary extraction in relevant catchment.	Continuous record. Data downloaded and reviewed monthly.	Continuous record, data downloaded and reviewed quarterly for 12 months following the completion of LW S6A or as required in accordance with a Watercourse Corrective Action Management Plan.
Surface water quality	Existing sites: TT1-QLa, TT2-QLa, TT3-QLa, TT7-QLa, TT9-QLa, TT12-QLa, TT13-QLa, TT14-QLa, HC1-QLa, HC9-QLa, HC4-QRLa, HC3-QLa, HC13-QLa, HC15-QLa, BR3-QLa, BR6-QLa, BR13-QRLa, BR12-QLa, BR16-QLa, BR17-QLa, BR18-QLa	Monthly sampling prior to secondary extraction of the relevant longwall.	Monthly sampling and analysis or as required by a specified action relevant to a trigger level.	Monthly sampling and analysis for a minimum of 12 months following the completion of LW S6A or as required in accordance with a Watercourse Corrective Action Management Plan.
		Parameters: Field analysis: pH, electrical conductivity (EC) and dissolved oxygen (DO), temperature and oxygen reduction potential (ORP). Laboratory analysis for: pH, EC, total dissolved solids, total suspended solids, turbidity, major cations†, sulphate, alkalinity, chloride, dissolved and total metals‡, total kjeldahl nitrogen, total nitrogen, total phosphorus, total cations and total anions.		

† Calcium, magnesium, sodium and potassium.

‡ Aluminium, arsenic, barium, copper, iron, lead, lithium, manganese, nickel, selenium, strontium and zinc.

Table 22 (Cont.) Monitoring Program for Surface Water and Groundwater Resources Relevant to LW S1A–S6A

Feature	Monitoring Component / Location	Pre-mining Monitoring	During Mining Monitoring	Post-mining Monitoring
Surface Water Monitoring				
Pool water level	Existing sites: TT1-QLa, TT2-QLa, TT3-QLa, TT7-QLa, TT9-QLa, TT12-QLa, TT13-QLa, TT14-QLa, HC1-QLa, HC9-QLa, HC4-QRLa, HC3-QLa, HC13-QLa, HC15-QLa, BR3-QLa, BR6-QLa, BR12-QLa, BR13-QRLa, BR16-QLa, BR17-QLa, BR18-QLa	Continuous record and monthly manual measurements. Data downloaded prior to the commencement of secondary extraction of the relevant longwall.	Continuous record and monthly manual measurements. Data downloaded and reviewed monthly.	Continuous record and monthly manual measurements for a minimum of 12 months following the completion of LW S6A or as required in accordance with a Watercourse Corrective Action Management Plan.
Physical features and natural behaviour of pools and reaches	Teatree Hollow, Teatree Hollow tributary and the Bargo River tributary pools and reaches	One observation prior to mining using fixed location photo points.	Observations every month during the active subsidence period (after 200 m of secondary extraction of relevant longwall) for sites within the active subsidence zone^ using fixed location photo points.	Quarterly observations over 12 months for pools that are no longer within the active subsidence zone or as required in accordance with a Watercourse Corrective Action Management Plan.
Morphology and channel stability	Headwater and knickpoint sites in Teatree Hollow, Teatree Hollow tributary and the Bargo River tributary	One observation prior to mining using fixed location photo points. One catchment survey of 10 headwater sites.	Observations of knickpoint formation every month during the active subsidence period for sites within the active subsidence zone using fixed location photo points. Annual catchment survey of 10 headwater sites.	One observation of knickpoint formation at sites that are no longer within the active subsidence zone using fixed location photo points. One catchment survey of 10 headwater sites. Post-mining geomorphology survey following completion of mining LW S6A.

^ Survey area to include upstream, downstream and adjacent pools (to the extent of the potential impact) where a trigger exceedance has occurred at a potential impact site(s) in accordance with the TARPs

Table 22 (Cont.) Monitoring Program for Surface Water and Groundwater Resources Relevant to LW S1A–S6A

Feature	Monitoring Component / Location	Pre-mining Monitoring	During Mining Monitoring	Post-mining Monitoring
Groundwater Monitoring				
Groundwater level at all monitoring bores	Existing sites (VWPs): TBC009, TBC018, TBC019B, TBC020, TBC024, TBC026, TBC027, TBC032, TBC033, TBC034, TBC038, TBC039	VWPs recording pressure readings hourly. The system is telemetered so that data is transmitted continuously and can be accessed at any point in time.	VWPs recording pressure readings hourly. The system is telemetered so that data is transmitted continuously and can be accessed at any point in time.	Continuous record of water level/pressure for a minimum of 12 months following the completion of active dewatering or as deemed necessary in consideration to the status of aquifer recovery or as required for future extraction activities.
	Existing sites (OSP): REA4, P51a, P51b, P52a, P53a, P53b, P53c, P54a, P54b, P55a, P55b, P55c, P56a, P56b, P56c Private Bores (OSP): GW109257, GW104008, GW112473, GW104659, GW062068, GW105395, GW104323 Proposed sites (OSP): P57a, P57b, P57c, P50a, P50b, P50c	Continuous record and monthly manual measurements of water level. Data downloaded prior to the commencement of secondary extraction of the relevant longwall.	Continuous record and monthly manual measurements of water level. Data downloaded and reviewed monthly.	Continuous record (where loggers installed) and quarterly manual measurements of water level for a minimum of 12 months following the completion of active dewatering or as deemed necessary in consideration to the status of aquifer recovery or as required for future extraction activities.

OSP = open standpipe, VWP = vibrating wire piezometer

Table 22 (Cont.) Monitoring Program for Surface Water and Groundwater Resources Relevant to LW S1A–S6A

Feature	Monitoring Component / Location	Pre-mining Monitoring	During Mining Monitoring	Post-mining Monitoring
Groundwater Monitoring				
Groundwater level at Thirlmere Lakes	Existing VWP: TBC039 Existing OSP: GW062068, GW104659 Proposed OSPs: P50a, P50b, P50c NSW Government monitoring bores: GW075409–1, GW075409–2, GW075410, GW075411	Continuous record and monthly manual measurements of water level and water quality. Data downloaded prior to the commencement of secondary extraction of the relevant longwall.	Continuous record and monthly manual measurements of water level and water quality. Data downloaded and reviewed monthly.	Continuous record (where loggers installed) and quarterly manual measurements of water level for a minimum of 12 months following the completion of active dewatering or as deemed necessary in consideration to the status of aquifer recovery or as required for future extraction activities.
Groundwater quality at monitoring bores within and adjacent to the Study Area	Existing sites (OSP): REA4, P51a, P51b, P52a, P53a, P53b, P53c, P54a, P54b, P55a, P55b, P55c, P56a, P56b, P56c Existing sites (VWPs): TBC009, TBC018, TBC019B, TBC020, TBC024, TBC026, TBC027, TBC032, TBC033, TBC034, TBC038, TBC039 Private Bores (OSP): GW109257, GW104008, GW112473, GW104659, GW062068, GW105395, GW104323 Proposed sites (OSP): P57a, P57b, P57c, P50a, P50b, P50c	Monthly sampling.	Monthly sampling and analysis.	Quarterly sampling and analysis for a minimum of 12 months following the completion of active dewatering or as deemed necessary in consideration to the status of aquifer recovery or as required for future extraction activities.

OSP = open standpipe, VWP = vibrating wire piezometer

Table 22 (Cont.) Monitoring Program for Surface Water and Groundwater Resources Relevant to LW S1A–S6A

Feature	Monitoring Component / Location	Pre-mining Monitoring	During Mining Monitoring	Post-mining Monitoring
Groundwater Monitoring				
Groundwater quality at Thirlmere Lake monitoring bores	Existing OSPs: GW062068, GW104659 Proposed OSPs: P50a, P50b, P50c NSW Government monitoring bores: GW075409–1, GW075409–2, GW075410, GW075411	Monthly sampling. Data downloaded prior to the commencement of secondary extraction of the relevant longwall.	Monthly sampling and analysis. Downloaded and reviewed monthly.	Quarterly sampling and analysis for a minimum of 12 months following the completion of active dewatering or as deemed necessary in consideration to the status of aquifer recovery or as required for future extraction activities.

OSP = open standpipe, VWP = vibrating wire piezometer

5.3 Streamflow Gauging Stations

A streamflow gauging station has been constructed on Teatree Hollow (TT-F1 in **Figure 21**). Baseline streamflow data is available for this location from January 2020 to October 2022. As described in **Section 6.3.2.3,** the streamflow monitoring data recorded from commencement of mining will be assessed in comparison to the baseline streamflow data to identify potential reduction in Teatree Hollow streamflow volume following commencement of mining.

5.4 Groundwater Extraction Monitoring

Groundwater pumped from all sumps in the mine workings is currently, and will continue to be, monitored by means of flow meters fitted to pipelines recording pumping times and rates. This water reporting to the underground workings and sumps may include groundwater seepage inflows, supply inflows (potable supply and for operations) and some re-circulation.

5.5 Longwall Fracturing Investigations

TSC-1 is a fully cored borehole, with a full suite of geological, geotechnical and hydrogeological testing conducted through the sequence (refer **Figure 24** for location). The borehole was cored from surface to seam, with the Bulli Seam depth of 404.00 m. The location of this borehole (off the southern end of LW S1A) makes it suitable as a pre-mining Height of Fracturing (HoF) investigation borehole. A post-mining HoF borehole would be installed following completion of mining LW S1A.

A second fully cored pre-mining HoF borehole is proposed to be installed above LW S4A pending land access agreement. The borehole would be installed prior to commencement of mining the preceding longwall (e.g. prior to LW S3A if it is to be located over LW S4A). A post-mining HoF borehole would be installed following completion of the relevant longwall.

5.6 Baseline Monitoring to Support Future Extraction Plans

Monitoring data collected and analysed during the mining of LW S1A-S6A would be used to inform future Extraction Plans for the Project. The monitoring program for future Extraction Plans would build on the baseline monitoring undertaken to date, with additional monitoring sites implemented as required. The monitoring program would be adapted to changing priorities, mine design and/or include improvements to the overall design of the monitoring program.

The proposed surface water monitoring to be implemented for future Extraction Plans is detailed in **Appendix B** and includes monitoring of pool water level, water quality and streamflow in Dogtrap Creek in addition to monitoring of pool physical features and geomorphology. The monitoring program would be implemented at least two years in advance of mining the relevant longwall.

As indicated in **Table 22**, a period of post-mining monitoring is proposed for all groundwater monitoring bores of interest. These bores of interest would be established 12 months prior to completion of extraction of LW S6A and would be dependent on a review of historical data, bore suitability (i.e., bore condition, access agreements, etc) and suitability for purpose.

The intention of the post-mining monitoring is to allow ongoing review of potential impacts (i.e. depressurisation lags) and degree of recovery whilst also providing continued baseline data to support future Extraction Plans, both in terms of conceptual understanding of the effects of longwall mining and for improving confidence in the ability to simulate these in numerical models.

6 Subsidence Management Strategies

6.1 Mine Design Considerations

The Tahmoor South Domain mine plan has undergone a series of amendments since the issue of the first EIS for the Project in 2014. These mine plan revisions are summarised below:

- EIS Submission (2014): Original EIS submission, which was placed on hold and subsequently withdrawn in late 2015;
- EIS Submission (January 2019): Updated EIS submission based on revised Secretary's Environmental Assessment Requirements (SEARs) issued in June 2018;
- Project Amendment Report (February 2020): The mine design was modified to reduce potential environmental impacts of the Project through the reduction in the extent of longwall mining. This was achieved by the following modifications:
    i. Removal of LW 109, which was located directly beneath Dogtrap Creek. This would result in elimination of direct impacts to Aboriginal heritage items;
    ii. Configuration of the longwall layout to comprise two series of shorter longwall panels;
    iii. Reduction in the proposed longwall width, from approximately 305 m to approximately 285 m; and
    iv. Reduction in the height of extraction within the longwall panels from up to 2.85 m to up to 2.6 m.
- Second Amendment Report (August 2020): The mine design was again modified to further reduce potential environmental impacts. This included the removal of two longwalls in the southern part of the mine near the township of Bargo (LW 107B and LW108B), which would result in a reduction in magnitude of subsidence impacts.

The numerous modifications of the Tahmoor South Domain mine plan have resulted in a reduction of the magnitude and extent of subsidence impacts, as well as avoidance of significant impact to sensitive surface features of the environment, including Aboriginal heritage items.

The current mine plan proposes to complete underground mining with access to the Tahmoor South Domain provided from the existing pit top facilities. This mine design consideration minimises surface impacts from mining through the avoidance of establishing new surface facilities.

6.2 Management, Remediation and Verification Measures

6.2.1 Mitigation Measures and Corrective Management Actions

For watercourses which are affected by mining-induced subsidence effects but the effects do not extend as far as surface fracturing or flow diversion, corrective management actions (CMAs) would be implemented as described in the TARPs (refer **Appendix A**). The CMAs would be proposed and implemented based on the nature of non-fracture effects. The monitoring of and success of the CMAs would be reported in the Six Monthly Subsidence Impact Report and Annual Review.

In accordance with Consent Condition C12 and as described in the TARPs (refer **Appendix A**), a Watercourse Corrective Action Management Plan (WCAMP) will be prepared for watercourses damaged by subsidence impacts. 'Damage' of a watercourse is considered to relate to mining-induced fracturing of a watercourse and redirection of streamflow and/or localised and transient increases in water quality constituents.

6.2.1.1 Soft Knickpoints and Headwater Streams

If notable development of soft knickpoints and/or notable erosion and sedimentation of headwater streams was observed, the knickpoints and headwater streams would be professionally assessed in order to identify appropriate corrective management actions. The most reliable approach to erosion control comprises rock grade structures, however, the exact nature of the management measure would be assessed based on the nature of the erosion and sedimentation and site access restrictions.

6.2.1.2 Pool and Watercourses

As noted in **Section 4.2.1**, there is potential that, where directly undermined, Teatree Hollow and the Teatree Hollow tributary may experience the full range of subsidence related effects and, as such, a reduction in pool water holding capacity and connective streamflow may occur. Accordingly, surface water level and streamflow monitoring within and adjacent to the Study Area is proposed (refer **Section 5** and **Appendix B**) and TARPs have been developed to assess the need for a response which may include remediation (**Appendix A**).

Stream remediation measures, comprising grout curtains and grout pattern injection, have been successfully implemented in Redbank Creek and Myrtle Creek to remediate subsidence impacts associated with mining in Tahmoor North.

Appendix F presents a detailed assessment of the effectiveness of remediation works conducted to date in Redbank Creek and Myrtle Creek. The effectiveness of remediation works was assessed with respect to the improvement in pool water holding capacity, pool water level recession and aquatic habitat and stream health. The assessment outcomes identified that the effectiveness of the remediation works has been predominantly high at sites in Myrtle Creek and predominantly medium to high at sites in Redbank Creek.

A WCAMP would be developed where subsidence results in fracturing of the stream bed or controlling rockbars of watercourses. The WCAMP would be developed consistent with that developed and implemented for Myrtle Creek and Redbank Creek, incorporating learnings from these remediation works. It is envisaged that a staged approach to the remediation works would be adopted, with outcomes from each stage used to guide the approach adopted for the next stage.

The WCMAP would be developed in collaboration with relevant government agencies and would incorporate performance measures and indicators for assessing the effectiveness of the remediation works implemented. The performance measures and indicators would relate to the effectiveness of the remediation works for improving pool water holding capacity, pool water level recession and aquatic habitat and stream health.

6.2.1.3 Private Groundwater Bores

As detailed in **Appendix A** and **Appendix E**, where a mining related activity results in detrimental impact to private groundwater bores, Tahmoor Coal would implement make good provisions in consultation with the affected landholder and where applicable, Subsidence Advisory NSW.

Tahmoor Coal has been implementing this process during the life of Tahmoor/Tahmoor North. The process allows for bore owners to apply to Tahmoor Coal if they believe the level or quality of a bore has declined triggering an assessment into the potential cause (i.e. mining related). If it is identified from an independent investigation that the mine is responsible, then remedial action would be implemented.

The make good process would be staged by Tahmoor Coal in accordance with the proposed mining schedule and the results of predictive groundwater modelling. Contact has been made with landholders whose registered bores are predicted to experience a drawdown of greater than 2 m, as per the NSW Aquifer Interference Policy (AIP) criterion, or whose bores are at risk of subsidence related impacts. Following this initial contact with landholders and where access was granted, a baseline field survey has been completed to verify bore details – location, depth, condition of bore and pump, standing water levels, groundwater quality and usage (where possible). Survey findings have been provided to the landholder so that they have the same baseline information as Tahmoor Coal. This information has provided both parties with a thorough understanding of the current bore condition and a reference point for comparison with subsequent bore assessments as mining progresses. The verified bore data has also been included in the recent update of the groundwater model.

In the event that a mining-related impact to a private bore has been confirmed and any further potential impacts are understood (based on groundwater modelling), the landholder and Tahmoor Coal would develop a make good agreement. This agreement would include specific make good mitigation measures and would outline a potential timeframe for undertaking these measures in consultation with the landholder. The make good agreement would include and consider the conditions of any development consents, the provisions of the AIP and the NSW Coal Mine Subsidence Compensation Act 2017.

There are a number of make good options that may be adopted, based on the details and characteristics of an individual bore and the extent of mining-induced impacts. These mitigation measure options include:

- Bore maintenance where physical adjustments and regular maintenance of the bore(s) are required to return them to pre-mining conditions. This could include extending the depth of the bore(s), or lowering of the pump(s) to return yield to pre-mining conditions;
- Replacement of bore(s) to provide a yield at least equivalent to the yield of the affected bore prior to mining. This may be required where deepening of an existing bore is not possible (e.g. the bore has partially collapsed or the bore hole has sheared);
- Provision of access to an alternative source of water or compensatory water supply. This option may be offered while other measures are being undertaken and could include connection to the town water supply or the provision of on-site storage (e.g. dam or water tanks); and
- Compensation to reflect increased water extraction costs (e.g. due to lowering pumps or installation of additional or alternative pumping equipment).

The compensatory water supply measures must provide an alternative long-term supply of water that is equivalent, in quality and volume, to the loss attributable to the development. Equivalent water supply should be provided (at least on an interim basis) as soon as practicable after the loss is identified, unless otherwise agreed with the landowner. The burden of proof that any loss of water supply is not due to mining impacts rests with Tahmoor Coal, in accordance with Condition B27 of SSD 8445.

If there is a dispute as to whether the loss of water is to be attributed to the development or the measures to be implemented, or there is a dispute about the implementation of these measures, then either party may refer the matter to the Planning Secretary for resolution, in accordance with Condition B28 of SSD 8445. If Tahmoor Coal is unable to provide an alternative long-term supply of water, compensation will be provided to the affected landowner, to the satisfaction of the Planning Secretary.

6.2.2 Verification Methods

The groundwater model would be validated periodically via comparison of monitoring results with modelled predictions. Re-calibration would occur as necessary, and an independent review of the model would be undertaken every three years. Following each round of model re-calibration, trigger levels would be reviewed against the model predictions and revised as necessary. The revised trigger levels would be documented in an updated version of this Water Management Plan.

Operational water balance reviews would continue to be undertaken monthly collating groundwater extraction rates and on-site water supply and usage.

Where pool remediation works are required, monitoring of pool water level would continue for the duration of remediation works and for two years post-remediation in order to provide a suitable timeframe for assessment of the effectiveness of remediation works. Additionally, aquatic ecology surveys would continue for two years post-remediation.

6.3 Trigger Action Response Plan

A series of TARPs have been developed to address various components of surface water and groundwater resources relating to the performance indicators to be adopted during LW S1A-S6A mining, in accordance with Condition C8(g)(viii) of the Consent (refer to **Appendix A**).

The primary aims of the TARP are to:

- Define appropriate trigger levels for surface water and groundwater resources;
- Develop specific actions to respond to high risk of exceedance of any performance measure to ensure that the measure is not exceeded; and
- Present a plan in the event that a performance measure is exceeded or is likely to be exceeded and describe the management / corrective actions to be implemented (i.e. notifications to relevant agencies, groundwater reviews, revision in any WCMAP and/or Six Monthly Subsidence Impact Reports).

The 'Normal Condition' section of each TARP indicates that the environment is performing within normal levels or natural variability. Deviation from baseline or expected condition triggers an increased level of risk to the environment (Level 1 or higher based on escalating corresponding risk).

6.3.1 Implementation of Monitoring Program and TARP Requirements

Tahmoor Coal's standard approach for all monitoring, reporting, investigation and remediation is to commence all tasks as soon as practicable. The following sections provide more information on this standard approach to be adopted during the LW S1A-S6A pre-mining, mining and post-mining phases:

- All monitoring commitments will be tracked on a weekly basis so that tasks are completed as required, taking into consideration land access and environmental factors. Post-mining monitoring will typically be completed within one month of the completion of the relevant longwall and prior to the influence from the active subsidence zone on the feature from the next longwall.
- Following the receipt of monitoring data and laboratory results, specialist consultants will review the data against the relevant TARPs as soon as practicable. If any TARP trigger has occurred, specialist consultants will notify Tahmoor Coal as soon as practicable. Monitoring results and TARP triggers will also be discussed during the monthly Environmental Response Group meetings, and any relevant information from other disciplines will be shared within the group. It is noted that discussions amongst specialists from different disciplines will not be restricted to ERG meetings, and relevant specialists will be included at any time to discuss results and assist with the completion of required actions and responses, as required.
- In the event of a TARP trigger occurrence, Tahmoor Coal will initiate all requirements (actions and responses) in accordance with the relevant TARP (i.e. investigation, report, negotiation, CMA determination, or similar) as soon as practicable and endeavour to commence actions and responses within one month of the exceedance being recorded. This timeframe is noted to be subject to issues outside of Tahmoor Coal's control such as land access constraints, inclement weather, extended timeframes where further monitoring is required, and inability to communicate with a third party / landholder.

- Tahmoor Coal will complete the required actions and responses relating to the TARP trigger as soon as practicable and will endeavour to finalise these requirements, subject to issues outside of Tahmoor Coal's control, as follows:
    - Level 1 and Level 2 TARP trigger actions and responses within three months of the exceedance being recorded;
    - Level 3 and Level 4 TARP trigger actions and responses within six months of the exceedance being recorded; and
    - Exceeds Performance Measures actions and responses in accordance with the timeframes provided in the relevant TARPs.

The TARPs define levels of variation in environmental conditions following commencement of mining, as compared to normal (baseline) conditions, and the actions required to be implemented in response to each level of variation. The assessment and investigation action and responses have been designed accordingly:

- A Level 1 or Level 2 trigger would initiate an initial assessment,
- A Level 3 trigger would initiate a detailed investigation, incorporating findings from the initial assessment. A Level 3 trigger may also initiate development of a WCAMP (detailed further in **Section 6.3.3**).

6.3.2 Establishment of Trigger Levels

6.3.2.1 Water Quality (SSGVs)

The surface water quality SSGVs are listed in **Table 13** and **Appendix A**.

Based on a detailed analysis of the baseline water quality records for Teatree Hollow, Hornes Creek and the Bargo River, the SSGV (80th or 20th percentile baseline value) is regularly exceeded for two consecutive months under normal (non-mining) conditions. As such, it is considered that three consecutive months of SSGV exceedances would indicate a deviation from normal conditions and this forms the basis of the water quality TARP Level 1 trigger (refer WMP1 and WMP2).

The proposed trigger criteria in relation to groundwater resources are detailed in **Appendix E**.

6.3.2.2 Water Level

The water level TARPs (WMP3 and WMP4) define levels of variation in pool water level from normal conditions and the actions required to be implemented in response to each level of variation. Level 1 provides an early warning indication that there has been a change in water level characteristics at a given monitoring site. Level 2 provides an indication that this change is atypical with consideration to baseline conditions.

The 'greater than 10 cm decline' which forms a component of the Level 1 trigger definition indicates a deviation in excess of level sensor accuracy (i.e. greater than 10 mm) however is less than the deviation in water level under 'normal' climatic conditions. The Level 2 trigger definition refers to 'atypical' characteristics which is a deviation in water level in excess of natural variability.

The proposed trigger criteria in relation to groundwater resources are detailed in **Appendix E**.

6.3.2.3 Streamflow Reduction

An Australian Water Balance Model (AWBM) has been developed and calibrated to the baseline streamflow records for TT-F1 (Teatree Hollow). In accordance with the TARPs (WMP3 and WMP4) a streamflow reduction assessment will be conducted if a Level 1 trigger or above occurs in relation to pool water level decline. The streamflow reduction assessment will comprise comparison of simulated streamflow ('no mining scenario') with streamflow data recorded at TT-F1. Where there is a deviance in the modelled and recorded streamflow, the volumetric variance would be calculated and compared to the WAL volume held by Tahmoor Coal. The volumetric variance in streamflow would be reported as surface water take on an annual basis.

6.4 Contingency Plan

In accordance with Conditions C8(g)(ix) and E5(f) of the Consent, in the event that performance measures (in the form of pre-defined triggers) are considered to have been exceeded or are likely to be exceeded, a response will be undertaken in accordance with these TARPs (refer to **Appendix A**). This response is a contingency plan that describes the management / corrective management actions which would be implemented where required to remedy the exceedance.

If a WCMAP is required in accordance with the TARP, this plan will be prepared in accordance with Section 3.6.3 of the Extraction Plan Main Document.

The success of remediation measures that have been implemented for any TARP exceedance would be reviewed as part of any WCMAP, the Six Monthly Subsidence Impact Reports and the Annual Review.

6.4.1 Watercourse Corrective Action Management Plan

A WCAMP will be prepared for watercourses damaged by subsidence impacts. Further to this, the development of WCAMP is triggered in the following TARPs:

- Stream water quality for all watercourses within subsidence area;
- Stream water quality for other watercourses (Bargo River and Hornes Creek);
- Pool water level for all watercourses within subsidence area;
- Pool water level for other watercourses (Bargo River and Hornes Creek);
- Physical features and natural behaviour of watercourses within the subsidence area; and,
- Physical features and natural behaviour of pools for other watercourses (Bargo River and Hornes Creek).

In the event that a WCAMP is required, it may be appropriate to implement the WCAMP at a later date, e.g., at the conclusion of subsidence. The timeframe for implementation of remediation works would be detailed in the WCAMP.

6.5 Adaptive Management Strategies

6.5.1 Adaptive Management for Surface Water and Groundwater

There are no specific adaptive management strategies currently proposed for the management of surface water and groundwater resources in the Study Area. However, potential contingency measures in the event of unforeseen impacts or impacts in excess of those predicted could include:

- Providing a suitable offset(s) to compensate for the reduction in the quantity of water resources/flow, as discussed in **Section 6.2.1**; and/or
- Make good provisions, to be negotiated with an affected landholder, in the event that water supply from a surface water system (as designated by a Water Supply Works and Water Use Approval) is impacted, as discussed in **Section 6.2.1**.

6.5.2 Continuous Improvement

Tahmoor Coal have adopted the “Plan-Do-Check-Act” model as shown in **Figure 26**. This model will be applied to all aspects of Tahmoor Coal’s environmental management and is utilised to embed the continuous improvement process in all system documents.

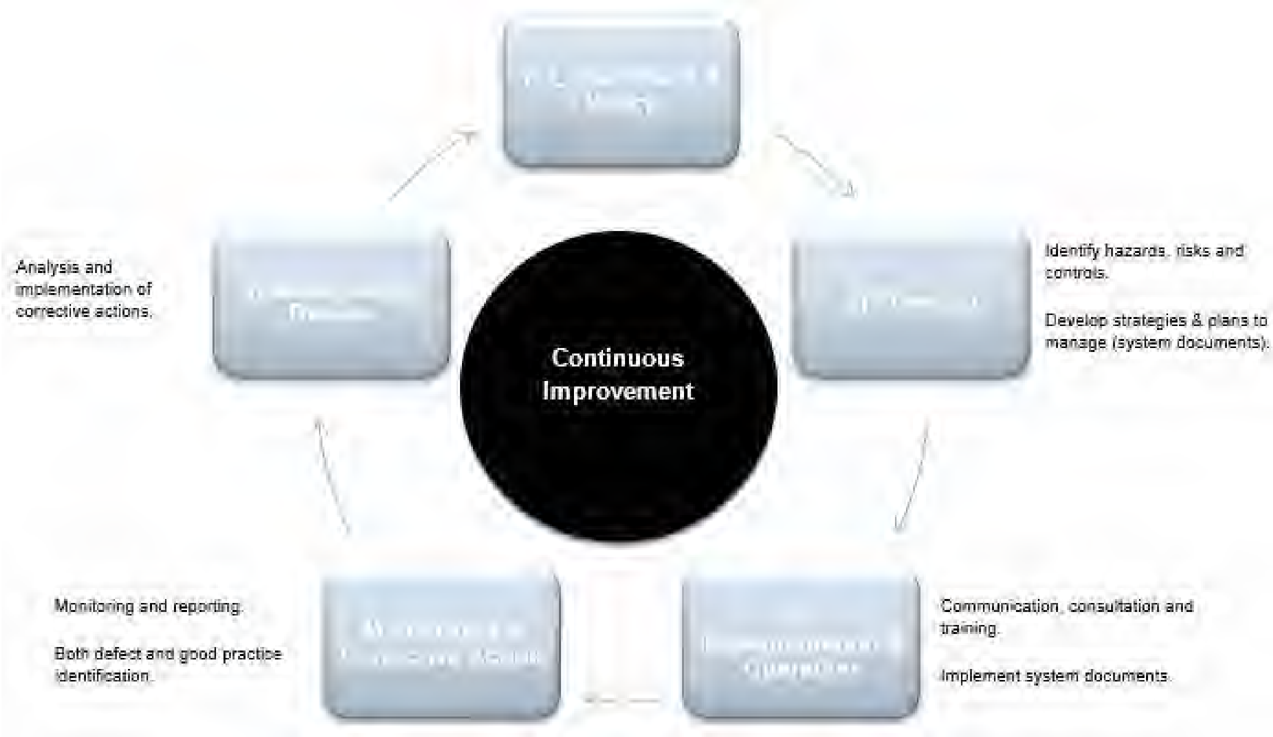

Figure 26 Continuous Improvement Model

7 Implementation and Reporting

7.1 General Requirements

This section of the management plan describes the key elements of implementation and reporting specific to the management of surface water and groundwater resources.

A description of requirements and procedures that are applicable to the extraction of LW S1A-S6A in general are provided in the Extraction Plan Main Document. This detail includes:

- Environmental Management System Framework;
- General reporting requirements, including details regarding the Six Monthly Subsidence Impact Report, Annual Review, and Annual Return;
- Incident management and reporting requirements;
- Non-compliance management and reporting requirements;
- Exceedances management and reporting requirements;
- Compliant and dispute management protocol;
- Audit and review requirements for general environmental performance, including internal audits and reviews, and independent environmental audits;
- General roles and responsibilities;
- Employee and contractor training requirements;
- Response groups to facilitate the review of monitoring data;
- Internal and External Stakeholder Communication Procedures;
- Access to information requirements, including Tahmoor Coal website and the Tahmoor Colliery Community Consultative Committee;
- Document control protocol; and
- Risk assessment for built and natural features and corresponding outcomes.

7.2 Reporting Requirements

7.2.1 Performance Measure Exceedance

In accordance with Condition E4 of the Consent, where any exceedance of the criteria or performance measures outlined within this document has occurred, Tahmoor Coal will:

- Take all reasonable and feasible steps to ensure that the exceedance ceases and does not recur;
- Consider all reasonable and feasible options for remediation (where relevant) and submit a report to the relevant government agency describing those options and any preferred remediation measures / corrective management actions or other course of action;
- Within 14 days of the exceedance occurring (or other timeframe agreed by the Planning Secretary), submit a report to the Planning Secretary describing these remediation options and any preferred remediation measures / corrective management actions or other course of action; and
- Implement reasonable remediation measures / corrective management actions as directed by the Planning Secretary.

7.2.2 Specific Reporting for Surface Water and Groundwater

Monitoring and management of surface water and groundwater resources relevant to extraction of LW S1A-S6A will be reported in the Six Monthly Subsidence Impact Report and Annual Review reports. The Six Monthly Subsidence Impact Report will also include review and reporting of the suitability of monitoring sites (including reference sites).

7.3 Review and Auditing

7.3.1 Plan Audit

Audits of the Water Management Plan are to be conducted in consultation with the Plan owner and nominated individuals and shall focus on the content and implementation.

Audits on the content shall consist of a determination of understanding of the Water Management Plan by the individual's allocated responsibility under this plan.

Audits on the implementation shall consist of reviews of the safe working procedures and risk assessments developed to ensure safe operation of this Water Management Plan, they may also involve discussions with personnel involved in the management plan to determine understanding and compliance.

Should an audit of this Water Management Plan determine that a deficiency is evident in the content or implementation, a corrective action must be developed and implemented. Actions will be assigned to a nominated individual and tracked in the Cority Compliance Management database.

Tahmoor Coal is responsible for verifying that the nominated corrective action has been implemented by way of a follow up audit.

Any changes to the Water Management Plan are to be managed and communicated to all personnel in line with the Change Management Process.

7.3.2 Plan Review

This Water Management Plan will be reviewed as follows:

Event based: in accordance with Condition E7 (a) of the Consent, a review will be required within 3 months of any incident, event or finding that identifies an inadequacy in the Water Management Plan risk assessment or associated documents to continue to effectively manage the identified hazard; a change to the workplace itself or any aspect of the work environment, a change to a system of work, a process or a procedure; or

Time based: in the absence of regular event-based reviews and in accordance with Condition E7 (b-e) of the Consent, this plan will be reviewed within three months of:

- the submission of an Annual Review under Condition E13;
- the submission of an Independent Environmental Audit under Condition E15;
- the approval of any modification of the conditions of this consent (unless the conditions require otherwise); or
- notification of a change in development phase under Condition A19.

If deemed appropriate, relevant stakeholders may be included in the review process. All reviews are to be documented. The process for review of this document will be in according to Tahmoor Coal's *Document and Record Control* (TAH-HSEC-00124).

Following changes (or as otherwise required above), a copy of the amended management plan will be forwarded to the Secretary of the DPE for approval.

7.4 Roles and Responsibilities

The implementation of surface water and groundwater monitoring and associated TARPs required in relation to mining of LW S1A-S6A is the responsibility of the Tahmoor Coal Environment and Community Group, particularly the Approvals Specialist.

8 Document Information

8.1 Referenced Documents

Reference information, listed in **Table 23** below, is information that is directly related to the development of this document or referenced from within this document.

Table 23 Reference Information

Title
ANZECC (2000). *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Canberra.
ANZG (2018). *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia. Available at www.waterquality.gov.au/anz-guidelines.
Brienen Environmental & Safety (2022). *Tahmoor South Springs Assessment.* Prepared for Tahmoor Coal Pty Ltd, August.
Douglas Partners (2022). *Report on Geotechnical Assessment Longwalls S1A to S6A, Bargo.* Prepared for Tahmoor Coal Pty Ltd, September.
DPE (2022). *Thirlmere Lakes – A Synthesis of Current Research*. Department of Planning and Environment – Environment, Energy and Science, March.
DoP (2008). *Impacts of underground coal mining on natural features in the Southern Coalfield: Strategic Review*. State of New South Wales through the NSW Department of Planning (DoP).
EMM (2020). *Tahmoor South Project: Wirrimbirra Sanctuary – Statement of Heritage Impact*. Prepared for Tahmoor Coal Pty Ltd.
Fluvial Systems (2013). *Tahmoor South Project Environmental Impact Statement Technical Specialists Report – Geomorphology*. Prepared for Tahmoor Coal, December.
HEC (2020). *Tahmoor South Amended Project Surface Water Impact Assessment*. Prepared for Tahmoor Coal Pty Ltd, February.
HEC (2021). *Tahmoor Mine Extraction Plan LW W3-W4 Surface Water Technical Report*. Prepared for Tahmoor Coal, September.
HydroSimulations (2018). *Tahmoor South Project EIS: Groundwater Assessment*. Report HS2018/52, December.
HydroSimulations (2020). *Tahmoor South – Amended Project Report: Groundwater Assessment*. Report HS2019/42 (v4), August.
MSEC (2022). *Tahmoor South Project – Extraction Plan for Longwalls S1A to S6A: Subsidence ground movement predictions and subsidence impact assessments for natural features and surface infrastructure*. Prepared for SIMEC Mining, May.
Niche (2019). *Aquatic Biodiversity Technical Report Tahmoor North – Western Domain Longwalls West 1 and West 2*. Prepared for Tahmoor Coking Coal Operations, June.
Schädler, S. and Kingsford, R.T. (2016). *Long-term changes to water levels in Thirlmere Lakes – drivers and consequences*. Centre for Ecosystem Science, UNSW, Australia.
Simec: • SIMEC (2019) Tahmoor South Project Environmental Impact Statement, Volumes 1 and 7, dated January 2019. • SIMEC (2020a) Tahmoor South Project Amendment Report, including Appendices A to R and response to submissions, dated February 2020. • SIMEC (2020b) Tahmoor South Project Second Amendment Report, Appendices A to O and response to submissions, dated August 2020.

Title
• SIMEC (2020c) Additional information responses dated 14 September 2020 (including Appendices A to L), 23 October 2020 and 4 November 2020.
SLR (2022). *LW S1A – S6A Extraction Plan Groundwater Technical Report*. Prepared for Tahmoor Coal, May.
SLR (2023). Tahmoor South Six-Monthly Compliance Report. Prepared for Tahmoor Coal, September.
Tahmoor Coal (2022). *Tahmoor South Site Surface Water Management Plan*.
Tammetta (2021). *Assessment of Surface Water Losses Redbank and Myrtle Creeks Tahmoor Coal Mine*. Prepared for the Natural Resources Access Regulator, July.

8.2 Related Documents

Related documents, listed in **Table 24** below, are internal documents directly related to or referenced from this document.

Table 24 Related Documents

Number	Title
TAH-HSEC-00124	Document and Record Control
TAH-HSEC-00365	LW S1A-S6A Extraction Plan Main Document
TAH-HSEC-00361	LW S1A-S6A Water Management Plan
TAH-HSEC-00362	LW S1A-S6A Land Management Plan
TAH-HSEC-00363	LW S1A-S6A Biodiversity Management Plan
TAH-HSEC-00364	LW S1A-S6A Heritage Management Plan
TAH-HSEC-00366	LW S1A-S6A Built Features Management Plan
TAH-HSEC-00365	LW S1A-S6A Public Safety Management Plan
TAH-HSEC-00367	LW S1A-S6A Subsidence Monitoring Plan

8.3 Glossary of Terms

Section 8.3 of the Extraction Plan Main Document provides a compiles Glossary of Terms.

8.4 Abbreviations

Abbreviations used in this document are provided below in **Table 25**.

Table 25 Abbreviations

Abbreviation	Definition
AIP	Aquifer Interference Policy
AWBM	Australian Water Balance Model
BACI	Before-After-Control-Impact
BGSS	Bulgo Sandstone
BHCS	Bald Hill Claystone
BUCO	Bulli Coal Seam
CCL	Consolidated Coal Lease
CMAP	Corrective Management Action Plan

Abbreviation	Definition
CTF	Cease to Flow
Crown Lands	NSW Department of Planning and Environment – Crown Lands
DAWE	NSW Department of Agriculture, Water and the Environment
DPE	Department of Environment and Planning
DPE – Water	NSW Department of Planning and Environment – Water
DPIE	Department of Planning, Industry and Environment (now DPE)
EIS	Environmental Impact Statement
EES	Environment, Energy and Science Group
LDP	Licensed Discharge Point
LGA	Local Government Area
LOP	Licensed Overflow Point
LW	Longwall
MZ	Management Zone
NATA	National Association of Testing Authorities
NRAR	Natural Resources Access Regulator
OSP	Open Standpipe
ROM	Run-of-mine
SSGV	Site Specific Guideline Value
TARP	Trigger Action Response Plan
VWP	Vibrating Wire Piezometer
WAL	Water Access Licence
WBCS	Wombarra Claystone
WWCO	Wongawilli Coal Seam

8.5 Change Information

Full details of the document history are recorded below in **Table 26**.

Table 26 Document History

Version	Date Reviewed	Reviewed By	Change Summary
1.0	May 2022	April Hudson, Charlie Wheatley, Zina Ainsworth, Malcolm Waterfall, Peter Vale	New Document.
2.0	September 2022	April Hudson, Charlie Wheatley, Zina Ainsworth	Updated document following consultation with DPE, government agencies and the Independent Advisory Panel for Underground Mining.
3.0	January 2023	April Hudson, Zina Ainsworth	Updated to reflect implemented monitoring program. Review in accordance with Condition E7(e) following the commencement of first and second workings (18

Version	Date Reviewed	Reviewed By	Change Summary
			October 2022) of the Consent SSD 8445.
4.0	June 2023	April Hudson, Zina Ainsworth	Reviewed in accordance with Condition E7(b) and (c) following the submission of an Annual Review (31st March 2023) and following the submission of an Independent Environmental Audit of the Consent SSD 8445.
4.1	October 2023	April Hudson, Zina Ainsworth	Updated in accordance with request for information received from DPE following submission of version 4.0.

APPENDIX A – Trigger Action Response Plans

WATER MANAGEMENT PLAN TARP – WMP1 STREAM WATER QUALITY FOR ALL WATERCOURSES WITHIN THE SUBSIDENCE AREA[1]

Performance Measure and Indicator, TARP Objective and Assessment Criteria

Performance Measure Feature
All watercourses within the Subsidence Area[1].

Performance Measure
No greater subsidence impact or environmental consequences to water quality, water flows (including baseflow) or stream health (including riparian vegetation), than predicted in the EIS.

The EIS concludes that where the longwalls directly mine beneath the streams, it is considered likely that fracturing would result in surface water flow diversion and that localised and transient increases in water quality constituents would occur[2]. The performance measure will be considered to be exceeded if subsidence impacts cannot be repaired in a manner that restores pool water holding capacity and stream health. Remediation measures will be developed as required and detailed in the Watercourse Corrective Action Management Plan (C12 of the SSD 8445). These plans will contain relevant performance indicators specific to remediation performance measures.

Performance Indicator
Exceedance of the site specific guideline values (SSGVs), as defined in the Level 1 to Level 3 trigger, where a Level 3 trigger denotes progression towards a potential exceedance of the performance measure.

TARP Objective
This TARP defines levels of variation in surface water quality from normal conditions[3] and the actions required to be implemented in response to each level of variation.

Assessment Criteria
SSGV as listed in table below.

Monitoring Program

Locations

Longwall	Potential Impact Sites	Reference Sites
LW S1A	TT7-QLa TT12-QLa TT13-QLa TT14-QLa	TT1-QLa
LW S2A	TT9-QLa[4] TT3-QLa[5] All sites above	
LW S3A	TT2-QLa All sites above	
LW S4A LW S5A LW S6A	BR3-QLa TT1-QLa All sites above	DT4-QLa DT3-QLa

All monitoring locations are shown in Figure 21 of the Water Management Plan.

Monitoring Frequency

Pre-mining
Monthly sampling prior to secondary extraction of relevant longwall.

During Mining
Monthly sampling and analysis or as required by a specified action relevant to a trigger level.

Post-mining
Monthly sampling and analysis for a minimum of 12 months following the completion of LW S6A or as required in accordance with a Watercourse Corrective Action Management Plan.

Management

Trigger	Action	Response
Normal Condition		
• Exceedance of an SSGV does not occur or occurs for less than three consecutive months.	• Continue monitoring and review of data as per monitoring program.	• No response required.
Level 1		
• Exceedance of an SSGV occurs at a given potential impact site in three consecutive months and the same has not occurred at the reference site(s).	• *Actions as required for Normal Condition.* • Assess if the trigger was exceeded during the baseline period prior to commencement of mining activities. • Review water quality trends along watercourse (upstream to downstream) to identify spatial changes with consideration to climatic conditions. • Discuss findings with and obtain other relevant information from key specialists (e.g. subsidence monitoring results, groundwater quality monitoring results) necessary to inform assessment. • Consider and decide on reasonable and feasible options for remediation as relevant (e.g. limestone cobbles for increasing pH level).	• Report trigger exceedance to DPE and key stakeholders. • Report trigger exceedance and investigation outcomes in Six Monthly Subsidence Impact Report and Annual Review. • Provide DPE and key stakeholders with proposed corrective management actions (CMAs) for consultation (e.g. limestone cobbles for increasing pH level). • Implement CMAs, subject to land access. • Monitor and report on success of CMAs in Six Monthly Subsidence Impact Report and Annual Review.
Level 2		
• Exceedance of an SSGV occurs at a given potential impact site in four or five consecutive months and the same has not occurred at the reference site(s).	• *Actions as stated in Level 1.* • Consider increasing monitoring and review of data frequency at sites where Level 2 has been reached or at other relevant sites, subject to land access, as follows: ○ Fortnightly, for sites within the active subsidence zone. ○ Monthly, outside of the active subsidence period. Reasons for not increasing monitoring frequency could include confident identification of causation (e.g. singular, anthropogenic, non-mining related change or confirmed as a mining-related impact that resulted in a water quality change). • If increased monitoring is adopted, undertake further analysis of water quality trends along creek (upstream to downstream) to identify spatial changes with consideration to climatic conditions. • Review CMAs in light of findings from further investigations and consider additional remediation options. • Review Water Management Plan and modify if necessary.	• *Responses as stated in Level 1.* • Advise DPE and key stakeholders of any required amendments to Water Management Plan. • Provide findings of CMA review to DPE and key stakeholders for consultation. • Implement additional CMAs, subject to land access.
Level 3		
• Exceedance of an SSGV occurs at a given potential impact site in six consecutive months and the same has not occurred at the reference site(s).	• *Actions as stated in Level 2.* • If mining related impact unconfirmed, increase monitoring and review of data frequency at sites where Level 3 has been reached or at other relevant sites, subject to land access, as follows: ○ Fortnightly, for sites within the active subsidence zone. ○ Monthly, outside of the active subsidence period. • Undertake a detailed investigation to assess if the change in behaviour is related to mining effects (e.g. whether there has been subsidence induced fracturing), other catchment changes, effects unrelated to mining or the prevailing climate.	• *Responses as stated in Level 2.* If it is concluded from the detailed investigation that watercourses have been damaged by subsidence impacts: • Offer site visit with DPE and other key stakeholders. • Develop Watercourse Corrective Action Management Plan (WCAMP) in consultation with the Resources Regulator, DPE and other key stakeholders (in accordance with C12 of SSD 8445). The stream remediation measures in the WCAMP could include grout curtain and grout pattern injection. Implement approved WCAMP, subject to land access.

Site Specific Guideline Value (SSGV)						
Parameter	**TT1-QLa**	**TT2-QLa**	**TT7-QLa**	**TT12-QLa**	**TT13-QLa**	**TT14-QLa**
No. of Values[6]	32	12(2)	35	13	13	13
pH (pH units)	6.5 – 8	6 – 8	6.5 – 8	6.5 – 8	6.5 – 8	6.5 – 8
EC (µS/cm)	529	350	359	350	350	350
Dissolved Aluminium (mg/L) pH > 6.5	0.06	0.17	0.06	0.1	0.092	0.11
Dissolved Copper (mg/L)	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014
Dissolved Iron (mg/L)	0.75	0.55	0.81	0.64	0.47	0.57
Dissolved Manganese (mg/L)	1.9	1.9	1.9	1.9	1.9	1.9
Dissolved Nickel (mg/L)	0.011	0.011	0.011	0.011	0.011	0.011
Dissolved Zinc (mg/L)	0.03	0.02	0.031	0.008	0.008	0.008

Notes:
[1] Subsidence Area is defined as the 'Subsidence Study Area' as illustrated in Figure 1 of Appendix 2 of SSD 8445.
[2] Due to the predicted surface fracturing of watercourses which directly overlie the longwall panels.
[3] As defined by the site specific guideline value (SSGV).
[4] Sites to be installed, subject to land access. The monitoring program relevant to this TARP has been designed to record at least 24 months of baseline data prior to commencement of mining of the relevant longwall (with the exception of TT12-Qla, TT13-Qla, TT14-Qla which will have 12 months of baseline data). Additional sites will be included prior to commencement of mining the relevant longwall. The derived SSGV for each relevant monitoring site would be included in the Water Management Plan and provided to the relevant government agencies for review and approval.
[5] SSGVs have not been derived for TT3-QLa as the pool was dry on five of eight sampling occasions.
[6] Minimum number of values used in SSGV derivation – for some constituents, a greater number of values were adopted.
[7] Number of values used to derive SSGV for TT2-QLa, prior to commencement of mining LWS3A, is expected to be greater than 24.
[8] TT12-QLa, TT13-QLa, TT14-QLa – a minimum of 12 samples (12 months) would be collected prior to secondary extraction.

WATER MANAGEMENT PLAN TARP – WMP2 STREAM WATER QUALITY FOR OTHER WATERCOURSES (BARGO RIVER AND HORNES CREEK)

Performance Measure and Indicator, TARP Objective and Assessment Criteria

Performance Measure Feature
Other watercourses.

Performance Measure
Negligible environmental consequences including beyond those predicted in the EIS.

Performance Indicator
The performance measure will be considered to be exceeded if a Level 3 TARP is triggered in relation to water quality changes and the investigation outcomes indicate a mining related impact based on monitoring data for sites in Hornes Creek and the Bargo River.

TARP Objective
This TARP defines levels of variation in surface water quality from normal conditions[1], indicators of exceedance of the performance measure and the actions required to be implemented in response to each level of variation or exceedance of the performance measure.

Assessment Criteria
SSGV as listed in table below.

Monitoring Program

Locations

Longwall	Potential Impact Sites	Reference Sites
LW S1A	BR12-QLa BR13-QRLa	BR16-QLa[2,3]
LW S2A	BR18-QLa[2] All sites above	
LW S3A	BR17-QLa[2] All sites above	
LW S4A LW S5A	BR6-QLa[2] All sites above	DT4-QLa DT3-QLa All sites above
LW S6A	HC13-QLa[2] HC16-QLa[2] HC4-QRLa HC9-QLa HC3-QLa All sites above	HC2-QLa HC17-QLa HC1-QLa All sites above

All monitoring locations are shown in Figure 21 of the Water Management Plan.

Monitoring Frequency

Pre-mining
Monthly sampling prior to secondary extraction or other relevant mining activity.

During Mining
Monthly sampling and analysis or as required by a specified action relevant to a trigger level.

Post-mining
Monthly sampling and analysis for a minimum of 12 months following the completion of LW S6A or as required in accordance with a Watercourse Corrective Action Management Plan.

Management

Trigger	Action	Response
Normal Condition		
• Exceedance of an SSGV does not occur or occurs for less than three consecutive months.	• Continue monitoring and review of data as per monitoring program.	• No response required.
Level 1		
• Exceedance of an SSGV occurs at a given potential impact site in three consecutive months and the same has not occurred at the reference site(s).	• *Actions as required for Normal Condition.* • Assess if the trigger was exceeded during the baseline period prior to commencement of mining activities. • Review water quality trends along watercourse (upstream to downstream) to identify spatial changes with consideration to climatic conditions. • Discuss findings and obtain other relevant information from key specialists (e.g. subsidence monitoring results, groundwater quality monitoring results) necessary to inform assessment. • Consider and decide on reasonable and feasible options for remediation as relevant (e.g. limestone cobbles for increasing pH level).	• Report trigger exceedance to DPE and key stakeholders. • Report trigger exceedance and investigation outcomes in Six Monthly Subsidence Impact Report and Annual Review. • Provide DPE and key stakeholders with proposed CMAs for consultation (e.g. limestone cobbles for increasing pH level). • Implement CMAs, subject to land access. • Monitor and report on success of CMAs in Six Monthly Subsidence Impact Report and Annual Review.
Level 2		
• Exceedance of an SSGV occurs at a given potential impact sites in four or five consecutive months and the same has not occurred at the reference site(s).	• *Actions as stated in Level 1.* • Consider increasing monitoring and review of data frequency at sites where Level 2 has been reached or at other relevant sites, subject to land access, as follows: ○ Fortnightly, for sites within the active subsidence zone. ○ Monthly, outside of the active subsidence period. Reasons for not increasing monitoring frequency could include confident identification of causation (e.g. singular, anthropogenic, non-mining related change or confirmed as a mining-related impact that resulted in a water quality change). • If increased monitoring is adopted, undertake further analysis of water quality trends along creek (upstream to downstream) to identify spatial changes with consideration to climatic conditions. • Review CMAs in light of findings from further investigations and consider additional remediation options. • Review Water Management Plan and modify if necessary.	• *Responses as stated in Level 1.* • Advise DPE and key stakeholders of any required amendments to Water Management Plan. • Provide findings of CMA review to DPE and key stakeholders for consultation. • Implement additional CMAs, subject to land access.
Level 3		
• Exceedance of an SSGV occurs at a given potential impact site in six consecutive months and the same has not occurred at the reference site(s).	• *Actions as stated in Level 2.* • If mining related impact unconfirmed, increase monitoring and review of data frequency at sites where Level 3 has been reached or at other relevant sites, subject to land access, as follows: ○ Fortnightly, for sites within the active subsidence zone. ○ Monthly, outside of the active subsidence period. • Undertake a detailed investigation to assess if the change in behaviour is related to mining effects (e.g. whether there has been subsidence induced fracturing), other catchment changes, effect unrelated to mining or the prevailing climate. • Undertake an investigation to determine if an exceedance of the performance measure is likely.	• *Responses as stated in Level 2.* • If relevant, notify DAWE of any predictions of an exceedance of a performance measure within two business days.
Exceeds Performance Measure		
• It is concluded from the Level 3 investigation that mining results in exceedance of an SSGV at a given potential impact site for six or more consecutive months.	• Investigate reasons for the performance measure exceedance. • Based on the outcomes of the investigation, review predictions of subsidence impacts and environmental consequences associated with future longwall extraction.	• Submit a report to DPE (in accordance with E4 of SSD 8445) within 14 days of the exceedance occurring (or other timeframe agreed by DPE). • Notify DAWE of any detection or predictions of an exceedance of a performance measure within two business days.

				• Submit an Impact Response Plan to DAWE (in accordance with Condition 11 of the DAWE Consent for the Tahmoor South Project). • Offer site visit with DPE and other key stakeholders. • Develop Watercourse Corrective Action Management Plan (WCAMP) in consultation with the Resources Regulator, DPE and other key stakeholders (in accordance with C12 of SSD 8445). The stream remediation measures in the WCAMP could include grout curtain and grout pattern injection. • Implement approved WCAMP, subject to land access.

Site Specific Guideline Value (SSGV)

Parameter	BR12-QLa	BR13-QRLa	HC9-QLa	HC4-QRLa	HC3-QLa
No. of Values[4]	37	37	35	29	31
pH (pH units)	6.5 - 8	6.5 - 8	5.7 - 8	6.5 - 8	6.5 - 8
EC (µS/cm)	350	350	365	350	350
Dissolved Aluminium (mg/L) pH > 6.5	0.058	0.055	0.08	0.07	0.1
Dissolved Copper (mg/L)	0.0014	0.0014	0.002	0.002	0.0014
Dissolved Iron (mg/L)	0.52	0.61	4.2	0.61	0.5
Dissolved Manganese (mg/L)	1.9	1.9	1.9	1.9	1.9
Dissolved Nickel (mg/L)	0.011	0.011	0.011	0.011	0.011
Dissolved Zinc (mg/L)	0.008	0.009	0.03	0.008	0.008

Notes:
[1] As defined by the SSGV.
[2] Sites to be installed, subject to land access. The monitoring program relevant to this TARP has been designed to record at least 24 months of baseline data prior to commencement of mining of the relevant longwall. Additional sites will be included prior to the commencement of mining the relevant longwall. The derived SSGV for each relevant monitoring site would be updated in the Water Management Plan and provided to the relevant government agencies for review and approval.
[3] Data collected from BR11-QLa (water quality data collected between 2012-2021 and water level data collected between 2013-2021) will be used in combination with data from BR16-QLa (once established) to provide a long-term baseline dataset for the Bargo River upstream of mining activities. [4] Minimum number of values used in SSGV derivation - for some constituents, a greater number of values were adopted.

WATER MANAGEMENT PLAN TARP – WMP3 POOL WATER LEVEL FOR ALL WATERCOURSES WITHIN THE SUBSIDENCE AREA[1]

Performance Measure and Indicator, TARP Objective and Assessment Criteria

Performance Measure Feature
All watercourses within the Subsidence Area[1].

Performance Measure
No greater subsidence impact or environmental consequences to water quality, water flows (including baseflow) or stream health (including riparian vegetation), than predicted in the EIS.

The EIS concludes that where the longwalls directly mine beneath the streams, it is considered likely that fracturing would result in surface water flow diversion and that localised and transient increases in water quality constituents would occur[2]. The performance measure will be considered to be exceeded if subsidence impacts cannot be repaired in a manner that restores pool water holding capacity and stream health. Remediation measures will be developed as required and detailed in the Watercourse Corrective Action Management Plan (C12 of the SSD 8445). These plans will contain relevant performance indicators specific to remediation performance measures.

Performance Indicator
Water level decline as defined in the Level 1 to Level 3 trigger, where a Level 3 trigger denotes progression towards a potential exceedance of the performance measure.

TARP Objective
This TARP defines levels of variation in pool water level from normal conditions[3] and the actions required to be implemented in response to each level of variation.

Assessment Criteria
- Comparison of baseline and operational recorded water level data (all levels).
- Water level recession analysis for Level 2 and above.

Monitoring Program

Locations

Longwall	Potential Impact Sites	Reference Sites
LW S1A	TT7-QLa TT12-QLa TT13-QLa TT14-QLa	TT1-QLa
LW S2A	TT9-QLa[4] TT3-QLa All sites above	TT1-QLa
LW S3A	TT2-QLa All sites above	TT1-QLa
LW S4A	BR3-QLa[4] TT1-QLa All sites above	DT4-QLa DT3-QLa

All monitoring locations are shown in Figure 21 of the Water Management Plan.

Monitoring Frequency

Pre-mining
Continuous record and monthly manual measurements. Data downloaded prior to the commencement of secondary extraction of the relevant longwall.

During Mining
Continuous record and monthly manual measurements. Data downloaded and reviewed monthly.

Post-mining
Continuous record and monthly manual measurements for a minimum of 12 months following the completion of LW S6A or as required in accordance with a Watercourse Corrective Action Management Plan.

Management

Trigger	Action	Response
Normal Condition		
• The recorded water level has not declined below the recorded baseline minimum level (for more than one 24 hour period for automated pool water level).	• Continue monitoring and review of data as per monitoring program.	• No response required.
Level 1		
• The recorded water level has declined by greater than 10 centimetres (cm) below the recorded baseline minimum level (for more than one 24 hour period for automated pool water level) and the same has not occurred at the reference site(s).	• *Actions as required for Normal Condition.* • Review water level trends along watercourse (upstream to downstream) to identify spatial changes with consideration to climatic conditions. • Review streamflow data recorded at TT-F1 and conduct streamflow reduction assessment. • Discuss findings and obtain other relevant information from key specialists (e.g. subsidence monitoring results, groundwater level monitoring results) necessary to inform assessment.	• Report trigger exceedance to DPE and key stakeholders. • Report trigger exceedance and investigation outcomes in Six Monthly Subsidence Impact Report and Annual Review.
Level 2		

• The recorded water level has declined atypically[5] below the recorded baseline minimum level for less than one month (as a consecutive period) and the same has not occurred at the reference site(s).	• *Actions as stated in Level 1.*
	• Consider increasing monitoring and review of data frequency at sites where Level 2 has been reached or at other relevant sites, subject to land access, as follows:
	  ○ Fortnightly, for sites within the active subsidence zone.
	  ○ Monthly, outside of the active subsidence period.
	• Reasons for not increasing monitoring frequency could include confident identification of causation (e.g. singular, anthropogenic, non-mining related change or confirmed as a mining-related impact that resulted in a water level change).
	• If increased monitoring is undertaken, conduct further analysis of water level trends along creek (upstream to downstream) to identify spatial changes with consideration to climatic conditions.
	• Review Water Management Plan and modify if necessary.
		• *Responses as stated in Level 1.*
		• Advise DPE and key stakeholders of any required amendments to Water Management Plan.

Level 3		

• The recorded water level has declined atypically[6] below the recorded baseline minimum level for greater than one month (as a consecutive period) and the same has not occurred at the reference site(s).	• *Actions as stated in Level 2.*
	• If mining related impact unconfirmed, increase monitoring and review of data frequency at sites where Level 3 has been reached or at other relevant sites, subject to land access, as follows:
	  ○ Fortnightly, for sites within the active subsidence zone.
	  ○ Monthly, outside of the active subsidence period.
	• Undertake a detailed investigation to assess if the change in behaviour is related to mining effects (e.g. whether there has been subsidence induced fracturing), other catchment changes, effect unrelated to mining or the prevailing climate.
		• *Responses as stated in Level 2.*
		If it is concluded from the detailed investigation that watercourses have been damaged by subsidence impacts:
		• Offer site visit with DPE and other key stakeholders.
		• Develop Watercourse Corrective Action Management Plan (WCAMP) in consultation with the Resources Regulator, DPE and other key stakeholders (in accordance with C12 of SSD 8445). The stream remediation measures in the WCAMP could include grout curtain and grout pattern injection.
		• Implement approved WCAMP, subject to land access.

Notes:
[1] Subsidence Area is defined as the 'Subsidence Study Area' as illustrated in Figure 1 of Appendix 2 of SSD 8445.
[2] Due to the predicted surface fracturing of watercourses which directly overlie the longwall panels.
[3] As indicated by the baseline water level and recession rate.
[4] Sites to be installed, subject to land access. The monitoring program relevant to this TARP has been designed to record at least 24 months of baseline data prior to commencement of mining of the relevant longwall. Additional sites will be included prior to the commencement of mining the relevant longwall. The pool water levels for each relevant monitoring site would be updated in the Water Management Plan and provided to the relevant government agencies for review and approval.
[5] 'Atypical' surface water characteristics relate to a notable and/or rapid water level decline or change in the slope of the falling limb of the hydrograph or the water level recessionary behaviour below the cease to flow level which is inconsistent with baseline conditions and cannot be attributed to climatic conditions

WATER MANAGEMENT PLAN TARP – WMP4 POOL WATER LEVEL FOR OTHER WATERCOURSES (BARGO RIVER AND HORNES CREEK)

Performance Measure and Indicator, TARP Objective and Assessment Criteria

Performance Measure Feature

Other watercourses.

Performance Measure

Negligible environmental consequences including beyond those predicted in the EIS, including:

- Negligible diversion of flows or changes in the natural drainage behaviour of pools.

Performance Indicator

The performance measure will be considered to be exceeded if a Level 3 TARP is triggered in relation to water level changes and the investigation outcomes indicate a mining related impact based on monitoring data for sites in Hornes Creek and the Bargo River.

TARP Objective

This TARP defines levels of variation in pool water level from normal conditions[1] and the actions required to be implemented in response to each level of variation.

Assessment Criteria

- Comparison of baseline and operational recorded water level data (all levels).
- Water level recession analysis for Level 2 and above.

Monitoring Program

Locations

Longwall	Potential Impact Sites	Reference Sites
LW S1A	BR12-QLa BR13-QRLa	BR16-QLa[2,3]
LW S2A	BR18-QLa[2] All sites above	
LW S3A	BR17-QLa[2] All sites above	
LW S4A LW S5A	BR6-QLa[2] All sites above	DT4-QLa DT3-QLa All sites above
LW S6A	HC13-QLa[2] HC16-QLa[2] HC4-QRLa HC9-QLa HC3-QLa All sites above	HC2-QLa HC17-QLa HC1-QLa All sites above

All monitoring locations are shown in Figure 21 of the Water Management Plan.

Monitoring Frequency

Pre-mining

Continuous record and monthly manual measurements. Data downloaded prior to the commencement of secondary extraction of the relevant longwall.

During Mining

Continuous record and monthly manual measurements. Data downloaded and reviewed monthly.

Post-mining

Continuous record and monthly manual measurements for a minimum of 12 months following the completion of LW S6A or as required in accordance with a Watercourse Corrective Action Management Plan.

Management

Trigger	Action	Response
Normal Condition		
• The recorded water level has not declined below the recorded baseline minimum level (for more than one 24 hour period for automated pool water level).	• Continue monitoring and review of data as per monitoring program.	• No response required.
Level 1		
• The recorded water level has declined by greater than 10 centimetres (cm) below the recorded baseline minimum level (for more than one 24 hour period for automated pool water level) and the same has not occurred at the reference site(s).	• *Actions as required for Normal Condition.* • Review water level trends along watercourse (upstream to downstream) to identify spatial changes with consideration to climatic conditions. • Discuss findings and obtain other relevant information from key specialists (e.g. subsidence monitoring results, groundwater level monitoring results) necessary to inform assessment.	• Report trigger exceedance to DPE and key stakeholders. • Report trigger exceedance and investigation outcomes in Six Monthly Subsidence Impact Report and Annual Review.
Level 2		
• The recorded water level has declined atypically[4] below the recorded baseline minimum level for less than one month (as a consecutive period) and the same has not occurred at the reference site(s).	• *Actions as stated in Level 1.* • Consider increasing monitoring and review of data frequency at sites where Level 2 has been reached or at other relevant sites, subject to land access, as follows: ○ Fortnightly, for sites within the active subsidence zone. ○ Monthly, outside of the active subsidence period. Reasons for not increasing monitoring frequency could include confident identification of causation (e.g. singular, anthropogenic, non-mining related change or confirmed as a mining-related impact that resulted in a water level change). • If increased monitoring is adopted, undertake further analysis of water level trends along creek (upstream to downstream) to identify spatial changes with consideration to climatic conditions. • Complete water level recession analysis for sites where Level 2 has been reached. • Review Water Management Plan and modify if necessary.	• *Responses as stated in Level 1.* • Advise DPE and key stakeholders of any required amendments to Water Management Plan.
Level 3		
• The recorded water level has declined atypically[4] below the recorded baseline minimum level for greater than one month (as a consecutive period) and the same has not occurred at the reference site(s).	• *Actions as stated in Level 2.* • If mining related impact unconfirmed, increase monitoring and review of data frequency at sites where Level 3 has been reached or at other relevant sites, subject to land access, as follows: ○ Fortnightly, for sites within the active subsidence zone. ○ Monthly, outside of the active subsidence period. • Undertake a detailed investigation to assess if the change in behaviour is related to mining effects (e.g. whether there has been subsidence induced fracturing), other catchment changes, effect unrelated to mining or the prevailing climate. • Undertake an investigation to determine if an exceedance of the performance measure is likely.	• *Responses as stated in Level 2.* • If relevant, notify DAWE of any predictions of an exceedance of a performance measure within two business days.
Exceeds Performance Measure		
• It is concluded from the detailed investigation that mining has resulted in an atypical[3] decline in water level for greater than one month (as a consecutive period).	• Investigate reasons for the performance measure exceedance. • Based on the outcomes of the investigation, review predictions of subsidence impacts and environmental consequences associated with further longwall extraction.	• Submit a report to DPE (in accordance with Condition E4 of SSD 8445) within 14 days of the exceedance occurring (or other timeframe agreed by DPE). • Notify DAWE of any detection or predictions of an exceedance of a performance measure within two business days. • Submit an Impact Response Plan to DAWE (in accordance with Condition 11 of the DAWE Consent for the Tahmoor South Project). • Offer site visit with DPE and other key stakeholders.

				• Develop Watercourse Corrective Action Management Plan (WCAMP) in consultation with the Resources Regulator, DPE and other key stakeholders (in accordance with C12 of SSD 8445). The stream remediation measures in the WCAMP could include grout curtain and grout pattern injection. • Implement approved WCAMP, subject to land access.

Notes:
[1] As indicated by the baseline water level and recession rate.
[2] Sites to be installed, subject to land access. The monitoring program relevant to this TARP has been designed to record at least 24 months of baseline data prior to commencement of mining of the relevant longwall. Additional sites will be included prior to the commencement of mining the relevant longwall. The derived SSGV for each relevant monitoring site would be updated in the Water Management Plan and provided to the relevant government agencies for review and approval.
[3] Data collected from BR11-QLa (water quality data collected between 2012-2021 and water level data collected between 2013-2021) will be used in combination with data from BR16-QLa (once established) to provide a long-term baseline dataset for the Bargo River upstream of mining activities.
[4] 'Atypical' surface water characteristics relate to a notable and/or rapid water level decline or change in the slope of the falling limb of the hydrograph or the water level recessionary behaviour below the cease to flow level which is inconsistent with baseline conditions and cannot be attributed to climatic conditions.

WATER MANAGEMENT PLAN TARP – WMP5 PHYSICAL FEATURES AND NATURAL BEHAVIOUR OF WATERCOURSES WITHIN THE SUBSIDENCE AREA[1]

<table>
<tr><th rowspan="2">Performance Measure and Indicator, TARP Objective and Assessment Criteria</th><th rowspan="2">Monitoring Program</th><th colspan="3">Management</th></tr>
<tr><th>Trigger</th><th>Action</th><th>Response</th></tr>
<tr><td rowspan="8"><u>Performance Measure Feature</u>
All watercourses within the Subsidence Area[1].

<u>Performance Measure</u>
No greater subsidence impact or environmental consequences to water quality, water flows (including baseflow) or stream health (including riparian vegetation), than predicted in the EIS.

The EIS concludes that where the longwalls directly mine beneath the streams, it is considered likely that fracturing would result in surface water flow diversion and that localised and transient increases in water quality constituents would occur[2]. The performance measure will be considered to be exceeded if subsidence impacts cannot be repaired in a manner that restores pool water holding capacity and stream health. Remediation measures will be developed as required and detailed in the Watercourse Corrective Action Management Plan (C12 of the SSD 8445). These plans will contain relevant performance indicators specific to remediation performance measures.

<u>Performance Indicator</u>
Variation in pool physical features and natural behaviour, as defined in the Level 1 to Level 3 trigger, where a Level 3 trigger denotes progression towards a potential exceedance of the performance measure.

<u>TARP Objective</u>
This TARP defines levels of variation in pool physical features and natural behaviour and the actions required to be implemented in response to each level of variation.

<u>Assessment Criteria</u>
Comparison of baseline and operational pool physical features and natural behaviour.</td><td rowspan="8"><u>Locations</u>
Accessible pools and reaches in Teatree Hollow, Teatree Hollow Tributary and Bargo River Tributary (subject to land access).

All monitoring locations are shown in Figure 22 of the Water Management Plan.

Channel morphology sites CM3 and CM7, refer Figure 23.

<u>Monitoring Frequency</u>
Pre-mining
One observation prior to mining using fixed location photo points.

During Mining
Observations every month during the active subsidence period (after 200 m of secondary extraction of relevant longwall) for sites within the active subsidence zone[3] using fixed location photo points.

Post-mining
Quarterly observations over 12 months for pools that are no longer within the active subsidence zone or as required in accordance with a Watercourse Corrective Action Management Plan.</td><td colspan="3">Normal Condition</td></tr>
<tr><td>• No observed impact to pool water level, overland connected flow, iron staining, gas release or turbidity - as compared with baseline conditions.</td><td>• Continue monitoring and review of data as per monitoring program.</td><td>• No response required.</td></tr>
<tr><td colspan="3">Level 1</td></tr>
<tr><td>• Visually observed anomalous change in water level, overland connected flow, iron staining, gas release or turbidity - as compared with baseline conditions - occurs in one month and the same has not occurred at the reference site(s)[3].
AND/OR
• Visual observation of fracturing.</td><td>• Actions as required for Normal Condition.
• Assess visual change along watercourse (upstream to downstream) to observe any spatial changes with consideration to climatic conditions.
• Discuss findings with and obtain other relevant information from key specialists (e.g. subsidence monitoring results, surface water monitoring results, groundwater monitoring results) necessary to inform assessment.
• Consider increasing monitoring and review of data frequency at sites where Level 1 has been reached or at other relevant sites, subject to land access, as follows:
  ○ Fortnightly, for sites within the active subsidence zone.
  ○ Monthly, outside of the active subsidence period.
Reasons for not increasing monitoring frequency could include confident identification of causation (e.g., surface fracturing of weathered bedrock that does not affect water holding capacity of rockbar control or pool base or confirmed as a mining-related impact).</td><td>• Report trigger exceedance to DPE and key stakeholders.
• Report trigger exceedance and investigation outcomes in Six Monthly Subsidence Impact Report and Annual Review.</td></tr>
<tr><td colspan="3">Level 2</td></tr>
<tr><td>• Visually observed anomalous change in water level, overland connected flow, iron staining, gas release or turbidity - as compared with baseline conditions - occurs for two consecutive months and the same has not occurred at the reference site(s).</td><td>• Actions as stated in Level 1.
• Undertake a detailed investigation to assess if the change in behaviour is related to mining effects (e.g. whether there has been subsidence induced fracturing other catchment changes, effect unrelated to mining or the prevailing climate).
• Review Water Management Plan and modify if necessary.
• If mining related impact unconfirmed, increase monitoring and review of data frequency at sites where Level 2 has been reached or at other relevant sites, subject to land access, as follows:
  ○ Fortnightly, for sites within the active subsidence zone.
  ○ Monthly, outside of the active subsidence period.</td><td>• Responses as stated in Level 1.
• Advise DPE and key stakeholders of any required amendments to Water Management Plan.</td></tr>
<tr><td colspan="3">Level 3</td></tr>
<tr><td>• Visually observed anomalous change in water level, overland connected flow, iron staining, gas release or turbidity - as compared with baseline conditions - occurs for three consecutive months and the same has not occurred at the reference site(s).
AND
• The change in behaviour has been investigated and confirmed to be related to mining effects.</td><td>• Actions as stated in Level 2.</td><td>• Responses as stated in Level 2.
• Offer site visit with DPE and other key stakeholders.
• Develop Watercourse Corrective Action Management Plan (WCAMP) in consultation with the Resources Regulator, DPE and other key stakeholders (in accordance with C12 of SSD 8445). The stream remediation measures in the WCAMP could include grout curtain and grout pattern injection.
• Implement approved WCAMP, subject to land access.</td></tr>
<tr><td colspan="5">Notes:
[1] Subsidence Area is defined as the ‘Subsidence Study Area’ as illustrated in Figure 1 of Appendix 2 of SSD 8445.
[2] Due to the predicted surface fracturing of watercourses which directly overlie the longwall panels.
[3] Survey area to include upstream, downstream and adjacent pools (to the extent of the potential impact) where a trigger exceedance has occurred at a potential impact site(s) in accordance with the TARPs.</td></tr>
</table>

WATER MANAGEMENT PLAN TARP – WMP6 PHYSICAL FEATURES AND NATURAL BEHAVIOUR OF POOLS FOR OTHER WATERCOURSES (BARGO RIVER AND HORNES CREEK)

Performance Measure and Indicator, TARP Objective and Assessment Criteria

Performance Measure Feature
Other watercourses.

Performance Measure
Negligible environmental consequences including beyond those predicted in the EIS, including:
- Negligible diversion of flows or changes in the natural drainage behaviour of pools;
- Negligible gas releases and iron staining; and
- Negligible increase in water turbidity.

Performance Indicator
The performance measure will be considered to be exceeded if changes in physical features and natural behaviour of pools occur for three consecutive months and the investigation outcomes indicate a mining related impact based on visual observation records for sites in Hornes Creek and the Bargo River.

TARP Objective
This TARP defines levels of variation in pool physical features and natural behaviour and the actions required to be implemented in response to each level of variation.

Assessment Criteria
Comparison of baseline and operational pool physical features and natural behaviour.

Monitoring Program

Locations

Longwall	Potential Impact Sites	Reference Sites
LW S1A	BR12-QLa BR13-QRLa	BR16-QLa[1,2]
LW S2A	BR18-QLa[1] All sites above	
LW S3A	BR17-QLa[1] All sites above	
LW S4A LW S5A	BR6-QLa[1] All sites above	DT4-QLa DT3-QLa All sites above
LW S6A	HC13-QLa[1] HC16-QLa[1] HC4-QRLa HC9-QLa HC3-QLa All sites above	HC2-QLa HC17-QLa HC1-QLa All sites above

All monitoring locations are shown in Figure 21 of the Water Management Plan.

Pre-mining
One observation prior to mining using fixed location photo points.

During Mining
Observations every month during the active subsidence period (after 200 m of secondary extraction of relevant longwall) for sites within the active subsidence zone using fixed location photo points.

Post-mining
Quarterly observations over 12 months for pools that are no longer within the active subsidence zone or as required in accordance with a Watercourse Corrective Action Management Plan.

Management

Trigger	Action	Response
Normal Condition		
• No observed impact to pool water level, overland connected flow, iron staining, gas release, turbidity or channel stability - as compared with baseline conditions.	• Continue monitoring and review of data as per monitoring program.	• No response required.
Level 1		
• Visually observed anomalous change in water level, overland connected flow, iron staining, gas release or turbidity - as compared with baseline conditions - occurs in one month and the same has not occurred at the reference site(s). AND/OR • Visual observation of fracturing.	• *Actions as required for Normal Condition.* • Assess visual change along watercourse (upstream to downstream) to observe any spatial changes with consideration to climatic conditions. • Discuss findings and obtain other relevant information from key specialists (e.g. subsidence monitoring results, surface water monitoring results, groundwater monitoring results) necessary to inform assessment. • Consider increasing monitoring and review of data frequency at sites where Level 1 has been reached or at other relevant sites, subject to land access, as follows: ○ Fortnightly, for sites within the active subsidence zone. ○ Monthly, outside of the active subsidence period. Reasons for not increasing monitoring frequency could include confident identification of causation (e.g. surface fracturing of weathered bedrock that does not affect water holding capacity of rockbar control or pool base or confirmed as a mining-related impact).	• Report trigger exceedance to DPE and key stakeholders. • Report trigger exceedance and investigation outcomes in Six Monthly Subsidence Impact Report and Annual Review.
Level 2		
• Visually observed anomalous change in water level, overland connected flow, iron staining, gas release or turbidity - as compared with baseline conditions - occurs for two consecutive months and the same has not occurred at the reference site(s).	• *Actions as stated in Level 1.* • Undertake a detailed investigation to assess if the change in behaviour is related to mining effects (e.g. whether there has been subsidence induced fracturing other catchment changes, effect unrelated to mining or the prevailing climate). • Review Water Management Plan and modify if necessary. • If mining related impact unconfirmed, increase monitoring and review of data frequency at sites where Level 2 has been reached or at other relevant sites, subject to land access, as follows: ○ Fortnightly, for sites within the active subsidence zone. ○ Monthly, outside of the active subsidence period. • Undertake an investigation to determine if an exceedance of the performance measure is likely.	• *Responses as stated in Level 1.* • Advise DPE and key stakeholders of any required amendments to Water Management Plan. • If relevant, notify DAWE of any predictions of an exceedance of a performance measure within two business days.
Exceeds Performance Measure		
• Visually observed anomalous change in water level, overland connected flow, iron staining, gas release or turbidity - as compared with baseline conditions - occurs for three consecutive months and the same has not occurred at the reference site(s). AND • The change in behaviour has been investigated and confirmed to be related to mining effects.	• *Actions as stated in Level 2.* • Investigate reasons for the performance measure exceedance. • Based on the outcomes of the investigation, review predictions of subsidence impacts and environmental consequences associated with further longwall extraction.	• *Responses as stated in Level 2.* • Submit a report to DPE (in accordance with Condition E4 of SSD 8445) within 14 days of the exceedance occurring (or other timeframe agreed by DPE). • Notify DAWE of any detection or predictions of an exceedance of a performance measure within two business days. • Submit an Impact Response Plan to DAWE (in accordance with Condition 11 of the DAWE Consent for the Tahmoor South Project). • Offer site visit with DPE and other key stakeholders. • Develop Watercourse Corrective Action Management Plan (WCAMP) in consultation with the Resources Regulator, DPE and other key stakeholders (in accordance with C12 of SSD 8445). The stream remediation measures in the WCAMP could include grout curtain and grout pattern injection.

Performance Measure and Indicator, TARP Objective and Assessment Criteria	Monitoring Program	Management		
		Trigger	**Action**	**Response**
				• Implement approved WCAMP, subject to land access.

[1] Sites to be installed, subject to land access. The monitoring program relevant to this TARP has been designed to record at least 24 months of baseline data prior to commencement of mining of the relevant longwall. Additional sites will be included prior to the commencement of mining the relevant longwall. The derived SSGV for each relevant monitoring site would be updated in the Water Management Plan and provided to the relevant government agencies for review and approval.
[2] Data collected from BR11-QLa (water quality data collected between 2012-2021 and water level data collected between 2013-2021) will be used in combination with data from BR16-QLa (once established) to provide a long-term baseline dataset for the Bargo River upstream of mining activities.

WATER MANAGEMENT PLAN TARP – WMP7 CHANNEL STABILITY, SEDIMENTATION AND EROSION

Performance Measure and Indicator, TARP Objective and Assessment Criteria	Monitoring Program	Management		
		Trigger	**Action**	**Response**
Performance Measure Feature No performance measure relevant[1,2,3]. **TARP Objective** This TARP defines levels of variation in channel stability, erosion and sedimentation and the actions required to be implemented in response to each level of variation. **Assessment Criteria** Comparison of baseline and operational condition of headwater streams and soft knickpoints.	**Locations** As shown in Figure 23 of the Water Management Plan: • 10 headwater sites • Channel morphology sites CM1, CM4 and CM6 • Soft knickpoints **Monitoring Frequency** **Pre-mining** • One observation prior to mining using fixed location photo points. • One inspection of 10 headwater sites. **During Mining** • Observations of knickpoint formation every month during the active subsidence period for sites within the active subsidence zone using fixed location photo points. • Annual inspection of 10 headwater sites. **Post-mining** • One observation of knickpoint formation at sites that are no longer within the active subsidence zone using fixed location photo points. • One inspection of 10 headwater sites. • Post-mining geomorphology survey following completion of mining.	**Normal Condition**		
		• No further development of soft knickpoints or increased erosion of headwater streams.	• Continue monitoring and review of data as per monitoring program.	• No response required.
		Level 1		

		• Visually observed minor increase in knickpoint development and/or minor erosion and sedimentation of headwater streams.	• *Actions as required for Normal Condition.*
			• Discuss findings and obtain other relevant information from key specialists (e.g. subsidence monitoring results, biodiversity monitoring results) necessary to inform assessment.
			• Consider increasing monitoring and review of data frequency at sites where Level 1 has been reached or at other relevant sites, subject to land access, as follows:
			  ○ Fortnightly, for sites within the active subsidence zone.
			  ○ Monthly, outside of the active subsidence period.
			Reasons for not increasing monitoring frequency could include confident identification of causation (e.g. singular, anthropogenic, non-mining related change or confirmed as a mining-related impact that resulted in increased erosion).
			• Consider and decide on reasonable and feasible options for remediation as relevant (e.g. enhanced vegetation establishment, rock armouring).
				• Report trigger exceedance to DPE and key stakeholders.
				• Report trigger exceedance and investigation outcomes in Six Monthly Subsidence Impact Report and Annual Review.
				• Provide DPE and key stakeholders with proposed corrective management actions (CMAs) for approval (e.g. enhanced vegetation establishment, rock armouring).
				• Implement CMAs, subject to land access.
				• Monitor and report on success of CMAs in Six Monthly Subsidence Impact Report and Annual Review.

		Level 2		

		• Visually observed moderate increase in knickpoint development and/or moderate or greater increase in erosion and sedimentation of headwater streams.	• *Actions as stated in Level 1.*
			• If mining related impact unconfirmed, increase monitoring and review of data frequency at sites where Level 2 has been reached or at other relevant sites, subject to land access, as follows:
			  ○ Fortnightly, for sites within the active subsidence zone.
			  ○ Monthly, outside of the active subsidence period.
			• Undertake an investigation to assess if the change in behaviour is related to mining effects (e.g. subsidence induced, other catchment changes, effect unrelated to mining or the prevailing climate).
			• Obtain specialist advice on further CMAs.
			• Review CMAs in light of findings from further investigations and consider additional remediation options.
			• Review Water Management Plan and modify if necessary.
				• *Responses as stated in Level 1.*
				• Advise DPE and key stakeholders of any required amendments to Water Management Plan.
				If it is concluded from the detailed investigation that watercourses have been damaged by subsidence impacts:
				• Offer site visit with DPE and other key stakeholders.
				• Provide findings of CMA review to DPE and key stakeholders for consultation.
				• Implement additional CMAs, subject to land access.

Notes:
[1] Subsidence Area is defined as the 'Subsidence Study Area' as illustrated in Figure 1 of Appendix 2 of SSD 8445.
[2] It is noted that SSD 8445 does not specify a performance measure in relation to channel stability, sedimentation and erosion for all watercourses within the Subsidence Area[1].
[3] It is noted that no soft knickpoints have been mapped in Hornes Creek or Bargo River. Therefore, assessment of 'decline in baseline channel stability' for these watercourses is not applicable.

WATER MANAGEMENT PLAN TARP – WMP8 SHALLOW GROUNDWATER LEVELS (OPEN STANDPIPES AND PRIVATE BORES)

Performance Measure and Indicator, TARP Objective and Assessment Criteria	Monitoring Program	Management – Trigger	Management – Action	Management – Response
Performance Measure Feature No performance measure relevant. **TARP Objective** This TARP defines levels of deviation in groundwater level from ‘normal’ or baseline conditions and the actions to be implemented in response to each level deviation. This TARP supports TARP WMP13, where groundwater levels as they pertain to groundwater dependent ecosystems (GDEs) (Thirlmere Lakes) are covered. **Assessment Criteria** Bore specific trigger values based on baselines data for each reporting level.	**Locations** **Open standpipes** Existing sites: P51a, P51b, P52, REA4, P53a, P53b, P53c, P54a, P54b, P54c, P55a, P55b, P55c, P56a, P56b, P56c Proposed sites: P50a, P50b, P50c, P57a, P57b **Private bores** GW109257, GW104008, GW112473, GW104659, GW062068, GW105395, GW104323 All monitoring locations are shown in Figure 24 of the Water Management Plan. **Monitoring Frequency** **Pre-mining** Continuous logger (hourly intervals) and monthly manual measurements of water level. **During Mining** Continuous logger (hourly intervals) and monthly manual measurements of water level. **Post-mining** Continuous record (where loggers installed) and quarterly manual measurements of water level for a minimum of 12 months following the completion of active dewatering or as deemed necessary in consideration to the status of aquifer recovery or as required for future extraction activities.	**Normal Condition**		
		• Groundwater level remains consistent with baseline variability and pre-mining trends with reductions in groundwater level less than two meters.	• Continue monitoring and review of data as per monitoring program.	• No response required.
		Level 1		
		• Greater than 2 m water level reduction[1] for a period of 6 months following the commencement of extraction.	For Private Bores and Open Standpipe Monitoring Bores • *Actions as required for Normal Condition.* • Undertake an investigation to assess cause and determine if mining related. • Undertake investigation to demonstrate if the decline will impact the long-term viability of the affected water supply works. • Discuss findings and obtain other relevant information from key specialists (e.g. subsidence monitoring results, surface water level results). The investigation will be commenced/completed as efficiently as practicable. If the changes have been confirmed to be related to mining effects: For Private Bores: • Initiate negotiations with impacts landowners as soon as practicable. Consider all reasonable and feasible options for remediation as relevant (e.g. extending the depth of the bore, establishment of additional bores, etc - as per Section 6.2.1.4 of the Water Management Plan). For Open Standpipe Monitoring Bores • For monitoring sites relevant to Thirlmere Lakes or associated with surface water monitoring sites, initiate groundwater – surface water interaction TARP.	For Private Bores and Open Standpipe Monitoring Bores: • Report trigger exceedance to DPE and key stakeholders. • Report trigger exceedance and investigation outcomes in Six Monthly Subsidence Impact Report and Annual Review. If the changes have been confirmed to be related to mining effects: For Private Bores: • Provide DPE and key stakeholders with proposed corrective management actions (CMAs) for consultation (e.g. extending the depth of the bore, establishment of additional bores, compensation to affected landowners as detailed in Section 6.2.1.4 of the Water Management Plan). • Implement CMAs, subject to land access (finalise negotiations and implement the agreed “make-good” arrangements) • Monitor and report on success of CMAs in Six Monthly Subsidence Impact Report and Annual Review.
		Level 2		
		• Water level declines below the average between the ‘maximum modelled drawdown’ (Level 3 trigger) and the ‘2 m drawdown’ (Level 1 trigger)[1] for a period of greater than 6 months following the commencement of extraction. AND • The reduction in water level is determined not to be controlled by climatic or external anthropogenic factors.	For Private Bores and Open Standpipe Monitoring Bores: • *Actions as stated in Level 1.* • Consider increasing monitoring and review of data at sites where Level 2 has been reached, subject to land access. Reasons for not increasing monitoring frequency could include solid identification causation that do not require further monitoring (e.g. singular anthropogenic impact resulting in water level change). • Compare against base case and deterministic model scenarios[2]. • Review Water Management Plan and modify if necessary. For Private Bores: • Review CMAs in light of findings from further investigations and consider additional reasonable and feasible options.	For Private Bores and Open Standpipe Monitoring Bores: • *Responses as stated in Level 1.* • Advise DPE and key stakeholders of any required amendments to Water Management Plan. For Private Bores: • Provide findings of CMA review to DPE and key stakeholders for consultation. • Implement additional CMAs, subject to land access.
		Level 3		
		• Water level reduction greater than the maximum modelled drawdown[1] for a period of 6 months following the commencement of extraction. AND • The reduction in water level is determined not to be controlled by climatic or external anthropogenic factors.	For Private Bores and Open Standpipe Monitoring Bores: • *Actions as stated in Level 2.* • Increase monitoring and review of data frequency for sites where Level 3 has been reached, subject to land access. • Undertake a detailed investigation to assess if the change in behaviour is related to mining effects (e.g. whether there has been subsidence induced fracturing, other catchment changes, effect unrelated to mining or the prevailing climate).	For Private Bores and Open Standpipe Monitoring Bores: • *Responses as stated in Level 2.* For Private Bores: • Develop a Rehabilitation Management Plan in consultation with DPE and key stakeholders. • Implement Rehabilitation Management Plan, subject to land access.

Notes:
[1] Level 1, 2 and 3 triggers for water level reduction is provided in Table 6-3 in Appendix E of the Water Management Plan.
[2] “Deterministic” model scenario refers to the predictive scenario modelling utilised to determine the trigger level.

WATER MANAGEMENT PLAN TARP – WMP9 SHALLOW GROUNDWATER PRESSURE (VWP SENSORS < 200 m DEPTH)

Performance Measure and Indicator, TARP Objective and Assessment Criteria	Monitoring Program	Management		
		Trigger	**Action**	**Response**
Performance Measure Feature No performance measure relevant. **TARP Objective** This TARP defines levels of deviation in groundwater level from 'normal' or baseline conditions and the actions to be implemented in response to each level deviation. **Assessment Criteria** Bore specific trigger values based on baselines data for each reporting level.	**Locations** TBC032, TBC033, TBC009, TBC018, TBC0039 Monitoring of all VWP < 200 m depth intakes. Reference Sites: TBC024, TBC027, TBC034, TBC038 All monitoring locations are shown in Figure 24 of the Water Management Plan. **Monitoring Frequency** **Pre-mining** VWPs recording pressure readings hourly. The system is telemetered so that data is transmitted continuously and can be accessed at any point in time. **During Mining** VWPs recording pressure readings hourly. The system is telemetered so that data is transmitted continuously and can be accessed at any point in time. **Post-mining** Continuous record of water level/pressure for a minimum of 12 months following the completion of active dewatering or as deemed necessary in consideration to the status of aquifer recovery or as required for future extraction activities.	**Normal Condition**		
		• No observable mining induced change at VWP intakes. • Up to 5 m water level reduction in VWP intakes[1] following the commencement of extraction for a period of less than six months.	• Continue monitoring and review of data as per monitoring program.	• No response required.
		Level 1		
		• Greater than 5 m water level reduction in VWP intakes[1] following the commencement of extraction for a period of greater than six months.	• *Actions as required for Normal Condition.* • Undertake an investigation to assess cause and determine if mining related, commence/complete as soon as practicable. • Discuss findings and obtain other relevant information from key specialists (e.g. subsidence monitoring results, surface water level results).	• Report trigger exceedance to DPE and key stakeholders. • Report trigger exceedance and investigation outcomes in Six Monthly Subsidence Impact Report and Annual Review.
		Level 2		
		• Water level declines below the calculated Level 2 trigger – being the average of Level 1 (the '5 m drawdown'[1]) and Level 3 (the 'maximum modelled drawdown') – following the commencement of extraction for a period of greater than six months. AND • The reduction in water level is determined not to be controlled by climatic or external anthropogenic factors.	• *Actions as stated in Level 1.* • Review deeper VWP data at monitored sites. Determine whether additional review of data is required. Determine if review of additional existing VWP sites is required. Reasons for not increasing frequency of data review could include solid identification causation that do not require further monitoring (e.g. singular anthropogenic impact resulting in water level change). • Compare against base case and deterministic model scenarios[2]. • Review Water Management Plan and modify if necessary.	• *Responses as stated in Level 1.* • Advise DPE and key stakeholders of any required amendments to Water Management Plan.
		Level 3		
		• Water level reduction greater than the maximum modelled drawdown[1] following the commencement of extraction for a period of greater than six months. AND • The reduction in water level is determined not to be controlled by climatic or external anthropogenic factors.	• *Actions as stated in Level 2.* • Increase review of data frequency for sites where Level 3 has been reached. • Undertake a detailed investigation to assess if the change in behaviour is related to mining effects (e.g. whether there has been subsidence induced fracturing, other catchment changes, effect unrelated to mining or the prevailing climate). Commence/complete as soon as practicable • Undertake investigative to review model results in conjunction with field data.	• *Responses as stated in Level 2.*

Notes:
[1] Level 1, 2 and 3 triggers for water level reduction is provided in Table 6-4 in Appendix E of the Water Management Plan).
[2] "Deterministic" model scenario refers to the predictive scenario modelling utilised to determine the trigger level.

WATER MANAGEMENT PLAN TARP – WMP10 GROUNDWATER LEVEL / PRESSURE DEEP VWPS (> 200 m DEPTH EXCLUDING MONITORING THE BULLI COAL SEAM)

Performance Measure and Indicator, TARP Objective and Assessment Criteria	Monitoring Program	Management: Trigger	Management: Action	Management: Response
Performance Measure Feature No performance measure relevant. **TARP Objective** This TARP defines levels of deviation in groundwater level from 'normal' or baseline conditions and the actions to be implemented in response to each level deviation. **Assessment Criteria** Bore specific trigger values based on modelled data for each reporting level. Model layers utilised to define predicted drawdown for each VWP logger provided in Table below.	**Locations** TBC009, TBC0018, TBC020, TBC026, TBC032, TBC033, TBC039 Reference sites: TBC024, TBC027, TBC034, TBC038 Monitoring of all VWP > 200 m depth intakes excluding those monitoring the Bulli Coal Seam. All monitoring locations are shown in Figure 24 of the Water Management Plan. **Monitoring Frequency** **Pre-mining** VWPs recording pressure readings hourly. The system is telemetered so that data is transmitted continuously and can be accessed at any point in time. **During Mining** VWPs recording pressure readings hourly. The system is telemetered so that data is transmitted continuously and can be accessed at any point in time. **Post-mining** Continuous record of water level/pressure for a minimum of 12 months following the completion of active dewatering or as deemed necessary in consideration to the status of aquifer recovery or as required for future extraction activities.			
		Normal Condition		
		• Observed data does not exceed modelled impacts predicted drawdown by greater than 30 metres[1]. • Observed drawdown exceeds the modelled predicted drawdown[1], by greater than 30 metres for less than three consecutive months	• Continue monitoring and review of data as per monitoring program.	• No response required.
		Level 1		
		• Observed drawdown exceeds the modelled predicted drawdown[1], by greater than 30 metres for greater than three consecutive months.	• *Actions as required for Normal Condition.* • Undertake an investigation to assess cause and determine if mining related to be commenced/completed as soon as practicable. • Discuss findings and obtain other relevant information from key specialists (e.g. subsidence monitoring results, surface water level monitoring results).	• Report trigger exceedance to DPE and key stakeholders. • Report trigger exceedance and investigation outcomes in Six Monthly Subsidence Impact Report and Annual Review.
		Level 2		
		• Observed drawdown exceeds modelled predicted drawdown[1] by more than 30 metres greater than 6 consecutive months.	• *Actions as stated in Level 1.* • Determine suitability of increasing frequency of data review at sites where Level 2 has been reached. Reasons for not increasing monitoring frequency could include solid identification causation that do not require further monitoring (e.g. singular anthropogenic impact resulting in water level change). • Review data in conjunction with VWP data from additional existing VWP sites. • Compare against base case and deterministic model scenarios[2]. • Review Water Management Plan and modify if necessary.	• *Responses as stated in Level 1.* • Inclusion of more regional VWPs into data review to determine likely extent and depth of depressurisation. • Advise DPE and key stakeholders of any required amendments to Water Management Plan.
		Level 3		
		• Observed drawdown exceeds modelled predicted drawdown[1] by 30 metres, for 12 consecutive months or more.	• *Actions as stated in Level 2.* • Increase review of data frequency for sites where Level 3 has been reached. • Undertake a detailed investigation to assess if the change in behaviour is related to mining effects (e.g. whether there has been subsidence induced fracturing, other catchment changes, effect unrelated to mining or the prevailing climate). To be commenced/completed as soon as practicable. • Review base case and deterministic model scenarios[2] in conjunction with water pressure data and report findings.	• *Responses as stated in Level 2.*

Notes:
[1] Predicted drawdown refers to the drawdown as generated by the groundwater model and varies over time as extraction progresses. Observed drawdown will be plotted on a monthly basis against the predicted drawdown to determine if a trigger has occurred. Therefore, as the predicted drawdown will be constantly changing according to extraction progression, it is not possible to set a specific trigger limit.
[2] "Deterministic" model scenario refers to the predictive scenario modelling utilised to assess the trigger level.

Sensor	Model Layer	Model Geology	Sensor	Model Layer	Model Geology
TBC09_322	8	BUSS Mid	TBC26_344	8	BUSS Mid
TBC09_343	8	BUSS Mid	TBC26_409	13	WBCS
TBC09_357	12	SBSS Lower	TBC26_432	15	Bulli Seam
TBC09_381	10	SPCS	TBC26_440	16	Eckersley
TBC09_391	15	Bulli Seam	TBC26_460	16	Eckersley
TBC09_397	17	Wongawilli	TBC32_200	8	BUSS Mid
TBC18_282	8	BUSS Mid	TBC32_237	8	BUSS Mid
TBC18_366	80..0	BUSS Mid	TBC32_257	8	BUSS Mid
TBC18_377	13	WBCS	TBC32_294	8	BUSS Mid

Performance Measure and Indicator, TARP Objective and Assessment Criteria	Monitoring Program	Management		
		Trigger	Action	Response

TBC18_404	15	Bulli Seam	TBC32_314	8	BUSS Mid
TBC18_426	17	Wongawilli	TBC33_247	8	BUSS Mid
TBC18_432	17	Wongawilli	TBC33_306	8	BUSS Mid
TBC20_211	8	BUSS Mid	TBC33_363	11	SBSS Upper
TBC20_293	8	BUSS Mid	TBC33_384	16	Eckersley
TBC20_375	8	BUSS Mid	TBC33_408	16	Eckersley
TBC20_397	13	WBCS	TBC39_243	8	BUSS Mid
TBC20_411	7	BUSS Upper	TBC39_299	8	BUSS Mid
TBC20_434	17	Wongawilli	TBC39_354	11	SBSS Upper
TBC20_439	4	HBSS Mid	TBC39_375	16	Eckersley
TBC26_211	8	BUSS Mid	TBC39_402	16	Eckersley
TBC26_278	8	BUSS Mid			

WATER MANAGEMENT PLAN TARP – WMP11 GROUNDWATER QUALITY (OPEN STANDPIPES AND PRIVATE BORES)

Performance Measure and Indicator, TARP Objective and Assessment Criteria	Monitoring Program	Management: Trigger	Management: Action	Management: Response
Performance Measure Feature No performance measure relevant. **TARP Objective** This TARP defines levels of deviation in groundwater level from 'normal' or baseline conditions and the actions to be implemented in response to each level deviation. This TARP supports TARP WMP13, where groundwater quality as it pertains to groundwater dependent ecosystems (GDEs) (Thirlmere Lakes) is covered. **Assessment Criteria** Bore specific trigger values based on baselines data for each reporting level.	**Locations** **Open standpipes** Existing sites: P51a, P51b, P52, REA4, P53a, P53b, P53c, P54a, P54b, P55a, P55b, P55c, P56a, P56b, P56c Proposed sites: P50a, P50b, P50c, P57a, P57b **Private bores** GW109257, GW104008, GW112473, GW104659, GW062068, GW105395, GW104323 All monitoring locations are shown in Figure 24 of the Water Management Plan. **Monitoring Frequency** **Pre-mining** Monthly water quality sampling. **During Mining** Monthly water quality sampling **Post-mining** Quarterly sampling and analysis for a minimum of 12 months following the completion of active dewatering or as deemed necessary in consideration to the status of aquifer recovery or as required for future extraction activities. Water Quality sample parameters: **Field Parameters** PH EC TDS DO **Laboratory Analysis** Total alkalinity as CaCO3, HCO3, CO3, DOC Dissolved Major Cations (Ca, K, Na, Mg, F, Cl, SO4) Dissolved Metals (Al, As, Ba, Co, Cu, Pb, Li, Mn, Ni, Se, Sr, Zn, Fe) Total Metals (Al, As, Ba, Co, Cu, Pb, Li, Mn, Ni, Se, Sr, Zn, Fe) Total Nitrogen Total Phosphorus Ionic Balance (Total Anions and Total Cations)	**Normal Condition**		
		• No observable changes in salinity, pH or metals outside of the baseline variability.	• Continue monitoring and review of data as per monitoring program.	• No response required.
		Level 1		
		• Observed salinity and/or metals or pH outside of defined trigger levels[1] for 3 consecutive months or more. The effect *does not persist* after a significant rainfall recharge event. AND • A similar trend or response is noted at other monitored bores or private groundwater bores.	For Private Bores and Open Standpipe Monitoring Bores • *Actions as required for Normal Condition.* • Undertake an investigation to assess cause and determine if mining related. • Undertake investigation to demonstrate if the change in quality will impact the long-term viability of the affected water supply works. • Discuss findings and obtain other relevant information from key specialists (e.g. subsidence monitoring results, surface water level results). If the changes have been confirmed to be related to mining effects: For Private Bores: • Initiate negotiations with impacted landholders as soon as practicable. Consider all reasonable and feasible options for remediation as relevant. This could include potential for implementation of make-good provisions as per Section 6.2.1.4 of the Water Management Plan for affected private bore owners (e.g. provision of access to an alternative source of water). For Open Standpipe Monitoring Bores • For monitoring sites relevant to Thirlmere Lakes or associated with surface water monitoring sites, initiate groundwater – surface water interaction TARP.	For Private Bores and Open Standpipe Monitoring Bores • Report trigger exceedance to DPE and key stakeholders. • Report trigger exceedance and investigation outcomes in Six Monthly Subsidence Impact Report and Annual Review. If the changes have been confirmed to be related to mining effects: For Private Bores: • Provide DPE and key stakeholders with proposed corrective management actions (CMAs) for consultation (e.g. provision of access to an alternative source of water as detailed in Section 6.2.1.4 of the Water Management Plan). • Implement CMAs, subject to land access. • Monitor and report on success of CMAs in Six Monthly Subsidence Impact Report and Annual Review.
		Level 2		
		• Observed salinity and/or metals or pH outside of defined trigger levels[1], for 3 consecutive months or more. The effect *persists* after a significant rainfall recharge event. AND • The change in water quality is determined not to be controlled by climatic or external anthropogenic factors.	For Private Bores and Open Standpipe Monitoring Bores • *Actions as stated in Level 1.* • Consider increasing monitoring and review of data at sites where Level 2 has been reached, subject to land access. Reasons for not increasing monitoring frequency could include solid identification causation that do not require further monitoring (e.g. singular anthropogenic impact resulting in water quality change). • Review Water Management Plan and modify if necessary. For Private Bores: • Review CMAs in light of findings from further investigations and consider additional reasonable and feasible options.	For Private Bores and Open Standpipe Monitoring Bores • *Responses as stated in Level 1.* • Advise DPE and key stakeholders of any required amendments to Water Management Plan. For Private Bores: • Provide findings of CMA review to DPE and key stakeholders for consultation. • Implement additional CMAs, subject to land access.
		Level 3		
		• Observed salinity and/or metals or pH outside of defined trigger levels[1], for greater than 6 consecutive months. AND • The change in water quality is determined not to be controlled by climatic or external anthropogenic factors.	For Private Bores and Open Standpipe Monitoring Bores • *Actions as stated in Level 2.* • Increase monitoring and review of data frequency for sites where Level 3 has been reached, subject to land access. • Undertake a detailed investigation to assess if the change in behaviour is related to mining effects (e.g. whether there has been subsidence induced fracturing, other catchment changes, effect unrelated to mining or the prevailing climate). • Undertake investigative report to demonstrate if the water quality change will impact the long-term viability of any affected water supply works.	For Private Bores and Open Standpipe Monitoring Bores • *Responses as stated in Level 2.* For Private Bores: If ascertained impact is due to mining activities and has potential to impact long-term viability of supply for private groundwater bores: • Develop a Rehabilitation Management Plan in consultation with DPE and landowner. • Implement Rehabilitation Management Plan, subject to land access.

Notes:
1 Defined trigger levels for groundwater quality are listed in Table 6-5 of Appendix E of the Water Management Plan.

WATER MANAGEMENT PLAN TARP – WMP12 GROUNDWATER - SURFACE WATER INTERACTION

<table>
<tr><th rowspan="2">Performance Measure and Indicator, TARP Objective and Assessment Criteria</th><th rowspan="2">Monitoring Program</th><th colspan="3">Management</th></tr>
<tr><th>Trigger</th><th>Action</th><th>Response</th></tr>
<tr><td rowspan="8"><u>Performance Measure Feature</u>
No performance measure relevant.

<u>TARP Objective</u>
This TARP defines levels of deviation in surface water - groundwater interactions from ‘normal’ conditions and the actions to be implemented in response to each level deviation.
The instigation of this TARP will be dictated by triggers exceedances in pertinent groundwater or surface water sites requiring further investigation of groundwater – surface water interactions.

Where groundwater – surface water connectivity indicates in a gaining stream, there is potential for groundwater supporting riparian vegetation. Consequently, Riparian vegetation in these situations could be a Groundwater Dependent Ecosystem (GDE), and the pertinent Performance Measure applicable:
Negligible impacts including:
• Negligible change in groundwater levels; and
• Negligible change in groundwater quality.

Riparian GDEs are addressed through the Riparian Vegetation TARP (BMP3). Consultation through the ERG will link this TARP (WMP12) to BMP3 via actions in BMP3 to consider groundwater – surface water relationships when pertinent.

<u>Assessment Criteria</u>
Bore specific trigger values based on baselines data for each reporting level. For this TARP, the aligned groundwater and surface water sites would be considered collectively to interpret potential changes/impacts to groundwater – surface water interaction.</td><td rowspan="8"><u>Locations</u>
Open standpipes
P51a, P51b, P52, REA4, P53a, P53b, P53c
P54a, P54b, P54c, P55a, P55b, P55c

The aligned surface water and groundwater sites are as follows:
• P51a, P51b with surface water site BR2-Qla
• P52, REA4 with surface water site-TT14-QLa
• P53a, P53b, P53c with surface water site-TT14-Qla
• P54a, P54b, P54c with surface water site TT3-QLa
• P55a, P55b, P55c with surface water site TT1-QLa

All monitoring locations are shown in Figure 24 of the Water Management Plan.

<u>Monitoring Frequency</u>
Pre-mining
Monthly manual measurements of water level and water quality.

During Mining
Monthly manual measurements of water level and water quality.

Post-mining
Continuous record (where loggers installed) and quarterly manual measurements of water level for a minimum of 12 months following the completion of active dewatering or as deemed necessary in consideration to the status of aquifer recovery or as required for future extraction activities.</td><td colspan="3">Normal Condition</td></tr>
<tr><td>• Observed (or inferred where not immediately neighbouring a surface water site) groundwater and surface water interaction remains consistent with baseline variability and/pre-mining trends, and decrease in groundwater inflow not persisting after significant rainfall recharge events.</td><td>• Continue monitoring and review of data as per monitoring program.</td><td>• No response required.</td></tr>
<tr><td colspan="3">Level 1</td></tr>
<tr><td>• Observed (or inferred where not immediately neighbouring a surface water site) groundwater levels at surface water monitoring site decline below Level 1 (in TARP WMP8) following the commencement of extraction.</td><td>• Actions as required for Normal Condition.
• Undertake an investigation to assess cause and determine if mining related.
• Discuss findings and obtain other relevant information from key specialists (e.g. subsidence monitoring results, surface water level results).</td><td>• Report trigger exceedance to DPE and key stakeholders.
• Report trigger exceedance and investigation outcomes in Six Monthly Subsidence Impact Report and Annual Review.
If the changes have been confirmed to be related to mining effects:
• Provide DPE and key stakeholders with proposed corrective management actions (CMAs) for consultation (e.g. extending the depth of the bore, establishment of additional bores, compensation to affected landowners as detailed in Section 6.2.1.4 of the Water Management Plan).
• Implement CMAs, subject to land access.
• Monitor and report on success of CMAs in Six Monthly Subsidence Impact Report and Annual Review.</td></tr>
<tr><td colspan="3">Level 2</td></tr>
<tr><td>• Observed (or inferred where not immediately neighbouring a surface water site) groundwater levels at aligned surface water monitoring site decline below Level 2 (in TARP WMP8) following the commencement of extraction.
AND
• The reduction in water level is determined not to be controlled by climatic or external anthropogenic factor.</td><td>• Actions as stated in Level 1.
• Increase frequency of data review to fortnightly at sites where Level 2 has been reached, subject to land access. Reasons for not increasing frequency could include solid identification causation that do not require further monitoring (e.g. singular anthropogenic impact resulting in water level change).
• Compare against base case and deterministic model scenarios[1].
• Review manual water level measurements for additional monitoring sites to identify potential spatial trends in water level decline.
• Review surface water data to assess for surface water level decline at relevant site.
• Review CMAs in light of findings from further investigations and consider additional reasonable and feasible options.
• Review Water Management Plan and modify if necessary.</td><td>• Responses as stated in Level 1.
• Provide findings of CMA review to DPE and key stakeholders for consultation.
• Implement additional CMAs, subject to land access.
• Advise DPE and key stakeholders of any required amendments to Water Management Plan, including reporting on relationship of observations to baseline and deterministic model scenarios, as necessary.</td></tr>
<tr><td colspan="3">Level 3</td></tr>
<tr><td>• Inferred groundwater levels at surface water monitoring site decline below Level 3 (in TARP WMP8) following the commencement of extraction.
AND
• The reduction in water level is determined not to be controlled by climatic or external anthropogenic factor.</td><td>• Actions as stated in Level 2.
• Increase frequency of data review for sites where Level 3 has been reached, subject to land access.
• Undertake a detailed investigation to assess if the change in behaviour is related to mining effects (e.g. whether there has been subsidence induced fracturing, other catchment changes, effect unrelated to mining or the prevailing climate). Report to be commenced and completed as soon as practicable.</td><td>• Responses as stated in Level 2.
• Develop a Rehabilitation Management Plan in consultation with DPE and key stakeholders.
• Implement Rehabilitation Management Plan, subject to land access.</td></tr>
<tr><td colspan="5">Notes:
1 [1]“Deterministic” model scenario refers to the predictive scenario modelling utilised to determine the trigger level.</td></tr>
</table>

Performance Measure and Indicator, TARP Objective and Assessment Criteria	Monitoring Program	Management – Trigger	Management – Action	Management – Response
Performance Measure Feature GDEs including Thirlmere Lakes[1]. **Performance Measure** Negligible impacts including: • Negligible change in groundwater levels; and • Negligible change in groundwater quality. **Performance Indicator** The performance measure will be considered to be exceeded if the groundwater levels or groundwater quality decline below Level 3 (in the relevant groundwater TARP triggers for water level and water quality – TARP WMP8 or WMP11) following the commencement of extraction, and the investigation outcomes indicate a mining related impact based on monitoring data for the Thirlmere Lakes. **TARP Objective** This TARP defines levels of deviation at Thirlmere Lakes from 'normal' conditions and the actions to be implemented in response to each level deviation. **Assessment Criteria** Bore specific trigger values based on baselines data for each reporting level.	**Locations** **"Early warning" bores** Existing sites: GW062068, GW104659, TBC039 (sensor at 65 metres in Hawkesbury Sandstone (HBSS)) Proposed sites: P50a, P50b, P50c **Thirlmere Lakes bores (not trigger bores)** Existing sites: GW075409–1, GW075409–2, GW075410, GW075411 (paired with gauging station 212066) All monitoring locations are shown in Figure 24 of the Water Management Plan. **Monitoring Frequency (for "early warning" bores)** **Pre-mining** Monthly manual measurements of water level and water quality. **During Mining** Monthly manual measurements of water level and water quality. **Post-mining** Continuous record (where loggers installed) and quarterly manual measurements of water level for a minimum of 12 months following the completion of active dewatering or as deemed necessary in consideration to the status of aquifer recovery or as required for future extraction activities. Water Quality sample parameters: **Field Parameters** PH EC TDS DO **Laboratory Analysis** Total alkalinity as CaCO3, HCO3, CO3, DOC Dissolved Major Cations (Ca, K, Na, Mg, F, Cl, SO4) Dissolved Metals (Al, As, Ba, Co, Cu, Pb, Li, Mn, Ni, Se, Sr, Zn, Fe) Total Metals (Al, As, Ba, Co, Cu, Pb, Li, Mn, Ni, Se, Sr, Zn, Fe) Total Nitrogen Total Phosphorus Ionic Balance (Total Anions and Total Cations)	**Normal Condition**		
		• Groundwater levels and quality remain consistent with baseline variability and/pre-mining trends, and changes in groundwater levels/quality not persisting after significant rainfall recharge events.	• Continue monitoring and review of data as per monitoring program.	• No response required.
		Level 1		
		• Level 1 trigger of TARP WMP8 for a minimum of two "early warning" bores. OR • Level 1 trigger of TARP WMP11 for a minimum of two "early warning" bores.	• *Actions as required for Normal Condition.* • Undertake an investigation to assess cause and determine if mining related. • Discuss findings and obtain other relevant information from key specialists (e.g. subsidence monitoring results, surface water level results). If the changes have been confirmed to be related to mining effects: • Consider all reasonable and feasible options for remediation as relevant (e.g. extending the depth of the bore, establishment of additional bores). This could include potential for implementation of make-good provisions as per Section 6.2.1.4 of the Water Management Plan for affected private bore owners. • For monitoring sites relevant to Thirlmere Lakes or associated with surface water monitoring sites, initiate groundwater – surface water interaction TARP.	• Report trigger exceedance to DPE and key stakeholders. • Report trigger exceedance and investigation outcomes in Six Monthly Subsidence Impact Report and Annual Review. If the changes have been confirmed to be related to mining effects: • Provide DPE and key stakeholders with proposed corrective management actions (CMAs) for consultation (e.g. extending the depth of the bore, establishment of additional bores, compensation to affected landowners as detailed in Section 6.2.1.4 of the Water Management Plan). • Implement CMAs, subject to land access. • Monitor and report on success of CMAs in Six Monthly Subsidence Impact Report and Annual Review.
		Level 2		
		• Level 2 trigger of TARP WMP8 for a minimum of three bores "early warning" bores OR • Level 2 trigger of TARP WMP11 for a minimum of three bores ("early warning" bores and Thirlmere Lakes bores).	• *Actions as stated in Level 1.* If the changes have been confirmed to be related to mining effects: • Consider increasing monitoring and review of data at sites where Level 2 has been reached, subject to land access. Reasons for not increasing monitoring frequency could include solid identification causation that do not require further monitoring (e.g. singular anthropogenic impact resulting in water level change). Review Thirlmere Lakes monitoring bore data • Compare against base case and deterministic model scenarios[2]. • Review manual water level measurements for additional monitoring sites to identify potential spatial trends in water level decline. • Review surface water data to assess for surface water level decline at relevant site. • Review CMAs in light of findings from further investigations and consider additional reasonable and feasible options. • Review Water Management Plan and modify if necessary. • Undertake an investigation to determine if an exceedance of the performance measure is likely. To be commenced/completed as soon as practicable.	• *Responses as stated in Level 1.* • Provide findings of CMA review to DPE and key stakeholders for consultation. • Implement additional CMAs, subject to land access. • Advise DPE and key stakeholders of any required amendments to Water Management Plan. • If relevant, notify DAWE of any predictions of an exceedance of a performance measure within two business days.
		Exceeds Performance Measure		
		• Level 3 trigger of TARPs WMP8 for a minimum of four bores "early warning" bores) OR • Level 3 trigger of TARPs WMP11 for a minimum of four bores ("early warning" bores and Thirlmere Lakes bores). AND • Review of Thirlmere Lakes bores indicated potential impacts resulting from extraction	• *Actions as stated in Level 2.* If the changes have been confirmed to be related to mining effects: • Increase monitoring and review of data frequency for sites where Level 3 has been reached, subject to land access. • Investigate reasons for the performance measure exceedance. To be commenced/completed as soon as practicable. • Review predictions of subsidence impacts and environmental consequences associated with further longwall extraction based on the outcomes of the investigation. • Consider modifying mine plan.	• *Responses as stated in Level 2.* • Submit a report to DPE (in accordance with Condition E4 of SSD 8445) within 14 days of the exceedance occurring (or other timeframe agreed by DPE) describing remediation options and any preferred remediation measures or other course of action. • Implement any reasonable remediation measures as directed by DPE, subject to land access. • Notify DAWE of any detection or predictions of an exceedance of a performance measure within two business days. • Submit an Impact Response Plan to DAWE (in accordance with Condition 11 of the DAWE Consent for the Tahmoor South Project). • Update numerical groundwater model and re-run predictive scenarios to determine the likely extent and depth of depressurisation in the vicinity

				of Thirlmere Lakes, and to determine whether any additional management actions are required such as modifying the mine plan
Notes: [1] It is noted that the only Groundwater Dependent Ecosystem (GDE) pertinent to the Tahmoor South Project is that of Thirlmere Lakes[2] "Deterministic" model scenario refers to the predictive scenario modelling utilised to determine the trigger level.				

APPENDIX B – Surface Water Monitoring Plan

HYDRO ENGINEERING & CONSULTING PTY LTD

REPORT

Tahmoor South Coal Project

Surface Water Monitoring Plan

Prepared for: Tahmoor Coal Pty Ltd

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Revision	Description	Author	Reviewer	Approved	Date
f	Final Rev 3	CAW	TSM	TSM	18/5/2022

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1.0 INTRODUCTION

1.1 BACKGROUND AND SCOPE OF WORK

Tahmoor Coal Pty Ltd (Tahmoor Coal) propose to develop the Tahmoor South Coal Project (the Project). The Project is to comprise mining of 12 longwalls over a 10-year mine life. Longwall South 1A (LW S1A) to LW S6A are to be mined in the first stage of Project development and LW S1B to LW S6B are to be mined in the second stage.

Prior to commencement of the Project, Tahmoor Coal is required to further develop the surface water monitoring program for the Project in accordance with the Development Consent SSD 8445 (the Consent), the commitments made in the Environmental Impact Statement (EIS) and additional government agency requests.

An extensive surface water monitoring program has been implemented within and adjacent to the Project comprising water level and water quality monitoring. Tahmoor Coal propose to expand the spatial representation of monitoring sites within and adjacent to the Project and to implement streamflow gauging stations. Further development of the surface water monitoring network will enable characterisation of surface water baseline conditions prior to Project commencement and facilitate the timely detection of potential impacts of the Project on surface water resources.

Hydro Engineering & Consulting Pty Ltd (HEC), a division of ATC Williams Pty Ltd, have developed a surface water monitoring plan to be implemented prior to, during and post Project development. This report describes the methodology for development of the surface water monitoring plan, the proposed monitoring program and the schedule for implementation of additional monitoring.

1.2 CONSENT CONDITIONS AND COMMITMENTS

The requirements of the Consent, EIS commitments and government agencies in relation to surface water monitoring are presented in Table 1 along with the section of this report in which the requirements have been addressed.

Table 1 Surface Water Monitoring Requirements

Requirement	Where Addressed
Development Consent	
Condition A8. If the Applicant decides to seek the Planning Secretary's approval to vary the commencement location of LW103B and LW104B set in Condition A7 of the Consent, then it must include the following information in the relevant Extraction Plan: a) significance assessment of key stream and riparian features including pool volumes and water holding capacity...	Section 3.0 describes the proposed pool water level monitoring (water holding capacity).
Condition C8(iii). A surface water monitoring program to monitor and report on: - stream flows and quality; ...	Section 3.0 describes the proposed streamflow and water quality monitoring program.
EIS Commitments	
A stream flow gauging station would be implemented at Teatree Hollow, downstream of the edge of the longwall and upstream of Licensed Discharge Point (LDP) 1.	Section 3.2.3 describes the proposed streamflow gauging station to be implemented at Teatree Hollow.

Table 1 (Cont.) Surface Water Monitoring Requirements

Requirement	Where Addressed
EIS Commitments	
Additional water level monitoring would be implemented to establish baseline water level data to enable the assessment of potential impacts to pool water levels.	Section 3.2.2 and Table 4 describe the proposed pool water level monitoring.
Enhanced low flow control weirs would be established at the existing gauging station at Dog Trap Creek and the proposed gauging station at Teatree Hollow to support the generation of reliable continuous flow data (including reliable low flow data) at these stations.	Section 3.2.3 and Table 4 describe the proposed streamflow gauging station to be implemented at Teatree Hollow and Dog Trap Creek.
A water quality monitoring site would be established on the Bargo River downstream of the confluence with Teatree Hollow and upstream of SW14 to increase the spatial representation of water quality sites downstream of LDP1.	Site BR15-Q in Table 3.
Monitoring of waterways within 200m of active longwall mining, including regular photographic recording and monthly water quality sampling upstream and downstream of potentially affected areas.	Section 3.2.1 and Table 4 describe the proposed monthly field and laboratory water quality monitoring. Section 3.2.4 and Table 4 describe the proposed monthly pool visual inspections.
A geomorphology survey (baseline and post mining) of waterways overlying each longwall.	Section 3.2.5 and Table 4 describes the proposed baseline and post mining geomorphology survey.
Pre, during and post-mining photographic surveys and visual inspections of geomorphological features for each longwall.	Section 3.2.4 and Table 4 describe the proposed monthly pool visual inspections. Section 3.2.5 and Table 4 describe the proposed monitoring of geomorphological features.
Annual catchment survey at 10 headwater photographic locations to monitor mining-induced subsidence impacts of the Project over time.	Section 3.2.5 and Table 4 describe the proposed monitoring of geomorphological features.
Monitoring of knickpoint formation during mining of each longwall and appropriate controls to prevent knickpoint formation.	Section 3.2.5 and Table 4 describe the proposed monitoring of knickpoint formation.
Department of Planning and Environment – Environment, Energy and Science Group Requirement	
Monitoring of Hornes Creek to identify potential subsidence impacts	Section 3.3 details the proposed Hornes Creek surface water monitoring sites.
Monitoring of Bargo River to identify potential re-opening of fractures associated with historical mining	Section 3.3 details the proposed Bargo River surface water monitoring sites.

2.0 HISTORICAL AND CURRENT SURFACE WATER MONITORING PROGRAM

Tahmoor Coal has implemented an extensive surface water monitoring program within and adjacent to the Project area. The Tahmoor Mine surface water monitoring program includes water level, water quality and streamflow monitoring and was developed generally in accordance with a Before-After-Control-Impact (BACI) framework. The monitoring program aims to develop a baseline (before) dataset for a range of surface water features and to assess operational and post-mining (after) impacts through the monitoring of reference (control) and potential impact sites (impact).

The monitoring sites are characterised as follows:

- Reference site: a site which is to provide reference data against which potential future impacts associated with the Project activities could be compared.
- Baseline/potential impact site: a site which is to be used to compare conditions before, during and after the Project activities.

Surface water monitoring sites are located on key watercourses within and adjacent to the Project area including Teatree Hollow, Teatree Hollow tributaries, Dog Trap Creek, Dog Trap Creek tributaries, Bargo River and Hornes Creek. The locations of the monitoring sites relevant to the Project and the Tahmoor Mine surface facilities are shown in Figure 1 and the site details summarised in Table 2.

The monitoring site nomenclature is associated with the watercourse and pool number (i.e. DT15 is pool 15 on Dog Trap Creek) and the type of monitoring to be implemented: water quality (Q), automated (continuous) and manual water level monitoring (La), monthly manual water level measurements only (Lm) and rating relationship derived streamflow (R).

2.1 WATER LEVEL MONITORING

Surface water level data has been monitored continuously and downloaded monthly during the monitoring periods specified in Table 2. Monthly manual water level measurements have also been recorded at each site at the time of data download. Additionally, visual inspection records of the presence of water at each monitoring site and flow at the monitoring site have been recorded monthly.

2.2 WATER QUALITY MONITORING

Water quality monitoring has been undertaken monthly at the sites listed in Table 2 and included the following:

- Field monitoring: pH, electrical conductivity (EC), temperature, dissolved oxygen (DO) and oxidation-reduction potential (ORP).
- Laboratory monitoring: pH, EC, total dissolved solids (TDS), major cations, sulphate, alkalinity, chloride, selected dissolved metals[1], selected total metals[2], total kjeldahl nitrogen, total nitrogen, total phosphorus, total anions and total cations.

2.3 STREAMFLOW MONITORING

Streamflow ratings have been derived for specific sites on the Bargo River, Dog Trap Creek, Teatree Hollow, Hornes Creek and Eliza Creek. A streamflow rating is a relationship specific to each gauging station site which enables flow rate to be derived from recorded water level at that particular site location. A period of time is normally required following station establishment to develop a rating

[1] Aluminium, arsenic, barium, copper, iron, lead, lithium, manganese, nickel, selenium, strontium and zinc.
[2] Aluminium, arsenic, barium, cadmium, copper, iron, lead, lithium, manganese, nickel, selenium, strontium and zinc.

relationship. Manual flow measurements (gaugings) were undertaken using an OSS-PC1 ‘Pygmy’ current meter which was calibrated annually and serviced weekly. All gaugings conformed to the relevant Australian Standard (AS 3778.3.1-2001). For specific sites, the ratings were extended to high flows by theoretical means using surveyed stream cross-sections and hydraulic modelling.

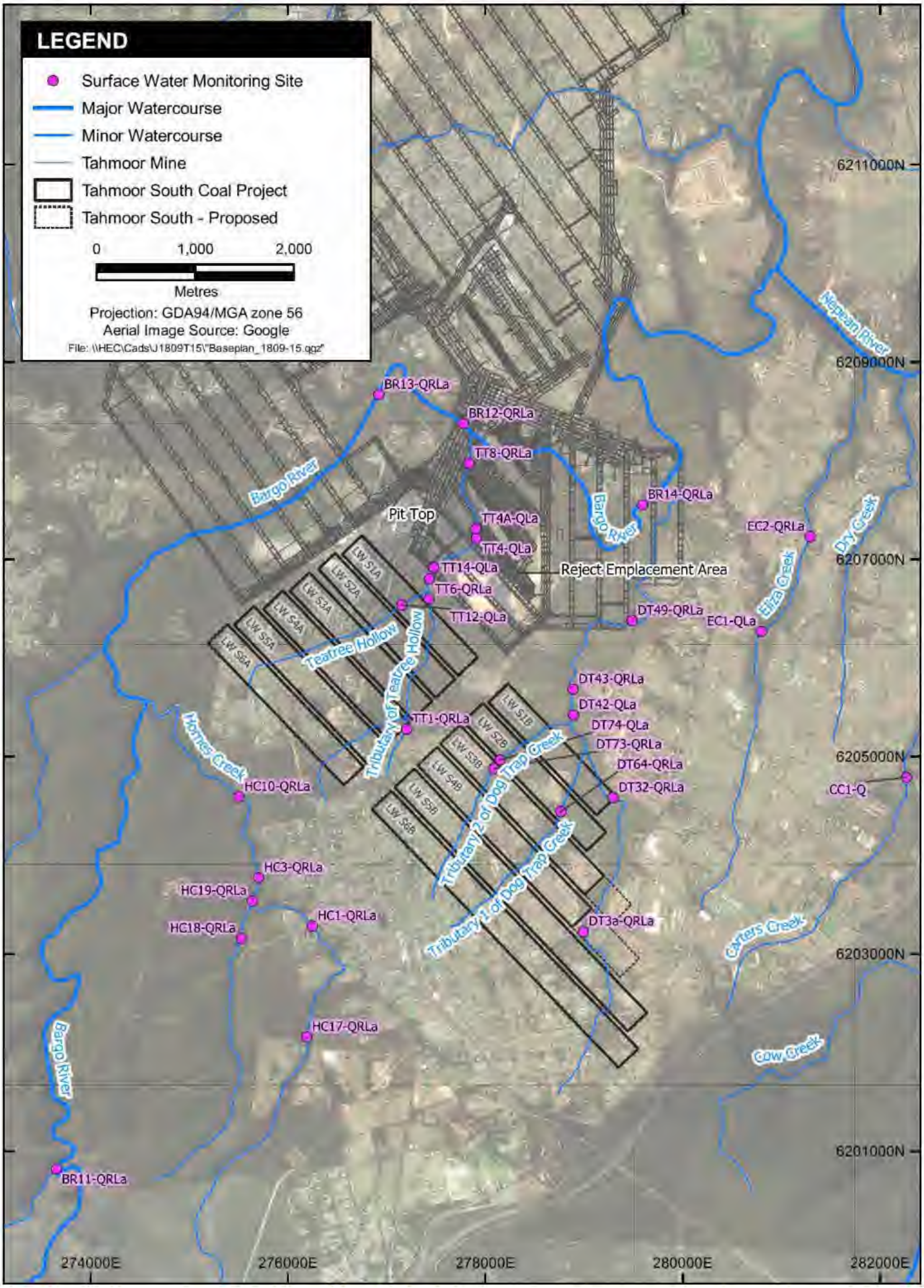

Figure 1 Historical and Current Surface Water Monitoring Sites

Table 2 Historical and Current Surface Water Monitoring Sites

Site Name	Previous Site Name	Location Description	Category	Monitoring Type	Period of Monitoring
Bargo River Catchment					
BR11-QRLa	Bargo River Upstream Site 1 (300061)	Upstream of mining influences	Reference site	Water level, streamflow and water quality	May 2012 – Jun 2015 (Q) Mar 2013 – Nov 2015 (La) Feb 2019 – Dec 2021 (Q, La & R)
BR13-QRLa	Bargo River Site 13 (300010A)	Downstream of historical mining areas, upstream of confluence with Teatree Hollow	Baseline/potential impact site	Water level, streamflow and water quality	Apr 2012 – Jun 2015 (Q) Feb 2019 – current (Q) Mar 2013 – current (La & R)
BR12-QRLa	Bargo River at Teatree Hollow (300012)	Above historical mining areas, upstream of confluence with Teatree Hollow	Baseline/potential impact site	Water level, streamflow and water quality	Jan 2019 – current (Q, La & R)
BR14-QRLa	Bargo River at Rockford Road Bridge Site 14 (300011A)	Above historical mining areas, downstream of confluence with Teatree Hollow, upstream of confluence with Dog Trap Creek	Baseline/potential impact site	Water level, streamflow and water quality	Apr 2012 – Jun 2015 (Q) Feb 2019 – current (Q) Mar 2013 – current (La & R)
Teatree Hollow Catchment					
TT1-QRLa	Teatree Site 1 (300132)	Above approved LW S4B workings, upstream of mine site facilities	Baseline/potential impact site	Water level, streamflow and water quality	Aug 2019 – current (Q) Feb 2020 – current (La & R)
TT6-QRLa	Teatree Hollow at REA (300089)	Adjacent to pit top, downstream of LOP4, upstream of REA	Baseline/potential impact site	Water level, streamflow and water quality	Mar 2019 – current (Q) Mar 2021 – current (La & R)
TT4-QLa	Teatree Site 4 (300135)	Above historical mining areas, adjacent to REA, upstream of LOP5	Baseline site	Water quality	Aug 2019 – May 2020 (Q)
TT4A-QRLa	Teatree Site 4A (300135A)	Above historical mining areas, adjacent to REA, downstream of LOP5	Baseline/potential impact site	Water level, streamflow and water quality	May 2020 – current (Q, La & R)
TT8-QRLa	Teatree Site 22 (300056)	Above historical mining areas, downstream of pit top, REA, LDP1 and LOP3	Baseline/potential impact site	Water level, streamflow and water quality	Sep 2012 – Jun 2015 (Q) Apr 2019 – current (Q) Mar 2013 – current (La & R)
TT12-QLa	Teatree Site 12 (300144)	Above approved LW S1A, adjacent to mine site facilities	Baseline/potential impact site	Water level and water quality	Sep 2021 – current (Q & La)

Q = water quality; La = automated and manual water level; R = rating relationship derived streamflow

Table 2 (Cont.) Historical and Current Surface Water Monitoring Sites

Site Name	Previous Site Name	Location Description	Category	Monitoring Type	Period of Monitoring
Teatree Hollow Catchment					
TT13-QLa	Teatree Site 13 (300146)	Above approved LW S1A workings, adjacent to mine site facilities	Baseline/potential impact site	Water level and water quality	Oct 2021 – current (Q & La)
TT14-QLa	Teatree Site 14 (300145)	Downstream of LW S1A workings, adjacent to mine site facilities	Baseline/potential impact site	Water level and water quality	Sep 2021 – current (Q & La)
Dog Trap Creek Catchment					
DT3a-QRLa	Dog Trap Site 1 (300128)	Above approved LW S4B, upstream of mine site facilities	Baseline/potential impact site	Water level, streamflow and water quality	Aug 2019 – current (Q) Jan 2019 – current (La & R)
DT32-QRLa	Dog Trap Site 2 (300129)	Above approved LW S1B, upstream of mine site facilities	Baseline/potential impact site	Water level, streamflow and water quality	Feb 2020 – current (Q) Jan 2020 – current (La & R)
DT64-QRLa	Dog Trap Site 3 (300130)	Above approved LW S2B, upstream of mine site facilities	Baseline/potential impact site	Water level, streamflow and water quality	Aug 2019 – current (Q) Feb 2020 – current (La & R)
DT74-QLa	Dog Trap Site 4 (300131)	Above approved LW S2B workings, upstream of mine site facilities	Baseline/potential impact site	Water level and water quality	Aug 2019 – Nov 2020 (Q) Feb 2020 – Nov 2020 (La)
DT73-QRLa	Dog Trap Site 4A (300131A)	Above approved LW S3B, upstream of mine site facilities	Baseline/potential impact site	Water level, streamflow and water quality	Nov 2020 – current (Q, La & R)
DT49-QRLa	Dog Trap Site 15 (300063)	Downstream of approved longwalls and ventilation shafts	Baseline/potential impact site	Water level, streamflow and water quality	Apr 2012 – Jun 2015 (Q) Mar 2013 – Nov 2015 (La &R) Feb 2019 - current (Q, La & R)
DT42-QLa	Dog Trap Site 16 (300064)	Downstream of approved longwalls and ventilation shafts	Baseline/potential impact site	Water level and water quality	Dec 2010 – Jun 2015 (Q & La) Feb 2019 – Mar 2021 (Q & La)
DT43-QRLa	Dog Trap Site 16A (300064A)	Downstream of approved longwalls and ventilation shafts	Baseline/potential impact site	Water level, streamflow and water quality	Mar 2021 – current (Q, La & R)

Q = water quality; La = automated and manual water level; R = rating relationship derived streamflow

Table 2 (Cont.) Historical and Current Surface Water Monitoring Sites

Site Name	Previous Site Name	Location Description	Category	Monitoring Type	Period of Monitoring
Hornes Creek Catchment					
HC17-QRLa	Hornes Creek Upstream (300113)	Outside of mining influences	Reference site	Water level, streamflow and water quality	Mar 2019 – current (Q, La & R)
HC1-QRLa	Hornes Site 1 (300124)	Outside of mining influences	Reference site	Water level, streamflow and water quality	Sep 2019 – current (Q, La & R)
H18-QRLa	Hornes Site 2 (300125)	Outside of mining influences	Reference site	Water level, streamflow and water quality	Mar 2020 – current (Q, La & R)
HC19-QRLa	Hornes Site 3 (300126)	Outside of mining influences	Reference site	Water level, streamflow and water quality	Sep 2019 – current (Q, La & R)
HC10-QRLa	Hornes Site 4 (3000127)	Outside of mining influences	Reference site	Water level, streamflow and water quality	Sep 2019 – current (Q, La & R)
HC3-QRLa	Hornes Site 9 (300062)	Outside of mining influences	Reference site	Water level, streamflow and water quality	May 2012 – Jun 2015 (Q) Oct 2020 – current (Q) Mar 2013 – Nov 2015 (La & R) Feb 2019 – current (La & R)
Eliza Creek and Carters Creek Catchment					
CC1-Q	Carters Site 24 (300076)	Outside of mining influences	Reference site	Water level, streamflow and water quality	Sep 2012 – Jun 2015 (Q) Feb 2019 – current (Q) Mar 2013 – Nov 2015 (La & R) Feb 2019 – Dec 2021 (La & R)
EC2-QRLa	Eliza Site 18 (300073A)	Outside of mining influences	Reference site	Water level, streamflow and water quality	Sep 2019 – current (Q) Feb 2019 – current (La & R)
EC1-QLa	Eliza Site 1 (300076A)	Outside of mining influences	Reference site	Water level and water quality	Feb 2019 – current (Q & La)

Q = water quality; La = automated and manual water level; R = rating relationship derived streamflow

3.0 PROPOSED SURFACE WATER MONITORING PROGRAM

3.1 MONITORING SITE SELECTION

In addition to consideration of existing monitoring site locations, the selection of proposed monitoring site locations was undertaken with consideration to the following key information:

- baseline geomorphology survey;
- proposed longwall layout and subsidence predictions;
- local landholders and areas of interest; and
- the proposed groundwater monitoring plan.

3.1.1 Baseline Geomorphology Survey

A baseline geomorphology survey of the Project area was undertaken by Fluvial Systems in 2013. The geomorphology survey was undertaken to characterise the physical environment of the Project area and to identify risk management zones from a geomorphological perspective. Field data collected during the survey included detail of fluvial features including, but not limited to, incisions, knickpoints, pools, bedrock features, hydraulic controls, riffles, bed material, feature dimensions and profiles, riparian zones, iron staining, alluvium and cliffs (Fluvial Systems, 2013).

Of specific relevance to the development of the surface water monitoring plan was the mapping of pools, pool hydraulic controls and pool dimensions and profiles. The locations of mapped pools in Teatree Hollow, Teatree Hollow tributary and Bargo River tributary are shown in Figure 2, the locations of mapped pools in Dog Trap Creek and tributaries are shown in Figure 3 and the locations of mapped pools in Hornes Creek area shown in Figure 4.

The proposed surface water monitoring site locations were selected to enable monitoring of a range of pools with varying hydraulic controls, dimensions and profiles. Monitoring of larger pools with presumed higher biodiversity and aesthetic value were prioritised.

The suitability of each selected pool for monitoring was confirmed through review of photographs taken during the baseline geomorphology survey.

3.1.2 Proposed Longwall Layout and Subsidence Predictions

Monitoring site locations were selected to ensure suitable spatial coverage across the Project area. Where pools were mapped, a minimum of one pool per longwall was selected for monitoring. Due to regulatory focus on the predicted subsidence effects on the third order section of Dog Trap Creek (the section downstream of LW S5B – refer Figure 3), additional monitoring sites were proposed above and adjacent to LW S1B to LW S4B. This will enable the baseline characteristics and significance of key stream features, namely pools, overlying LW S3B and LW S4B in particular to be assessed in accordance with the Consent Condition A8 (refer Table 1).

Although Bargo River and Hornes Creek are located outside of the predicted 20 millimetre (mm) total subsidence associated with mining of LW S1A-S6A (refer Figure 2 and Figure 4), the NSW Department of Planning and Environment – Environment, Energy and Science Group has requested that appropriate surface water monitoring is implemented in Bargo River and Hornes Creek in the event that mining related subsidence effects occur. Accordingly, additional surface water monitoring sites have been proposed to be instated in the Bargo River at locations overlying historical longwalls and in Hornes Creek adjacent to LW S6A.

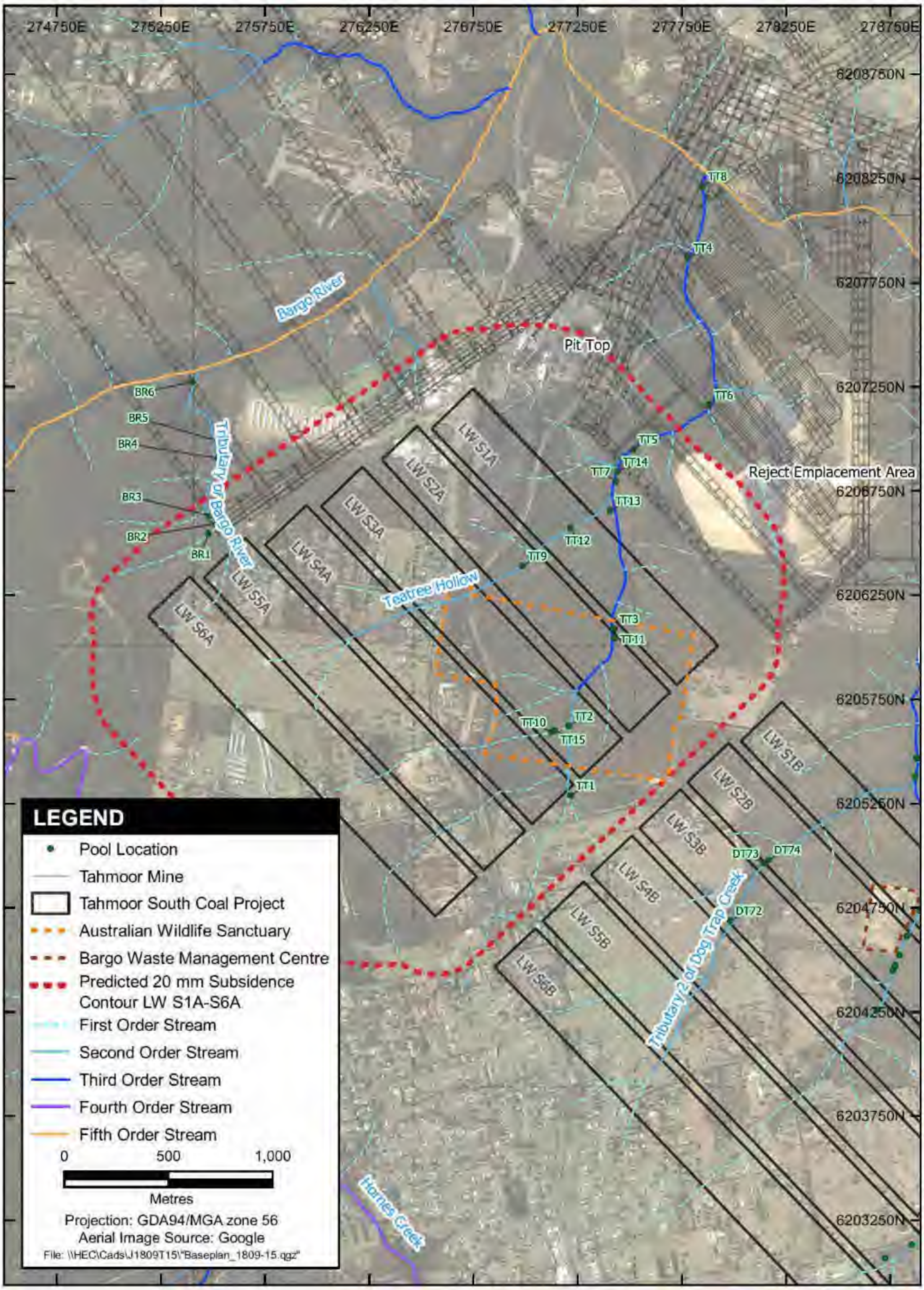

Figure 2 Teatree Hollow, Teatree Hollow Tributary and Bargo River Tributary Pool Locations

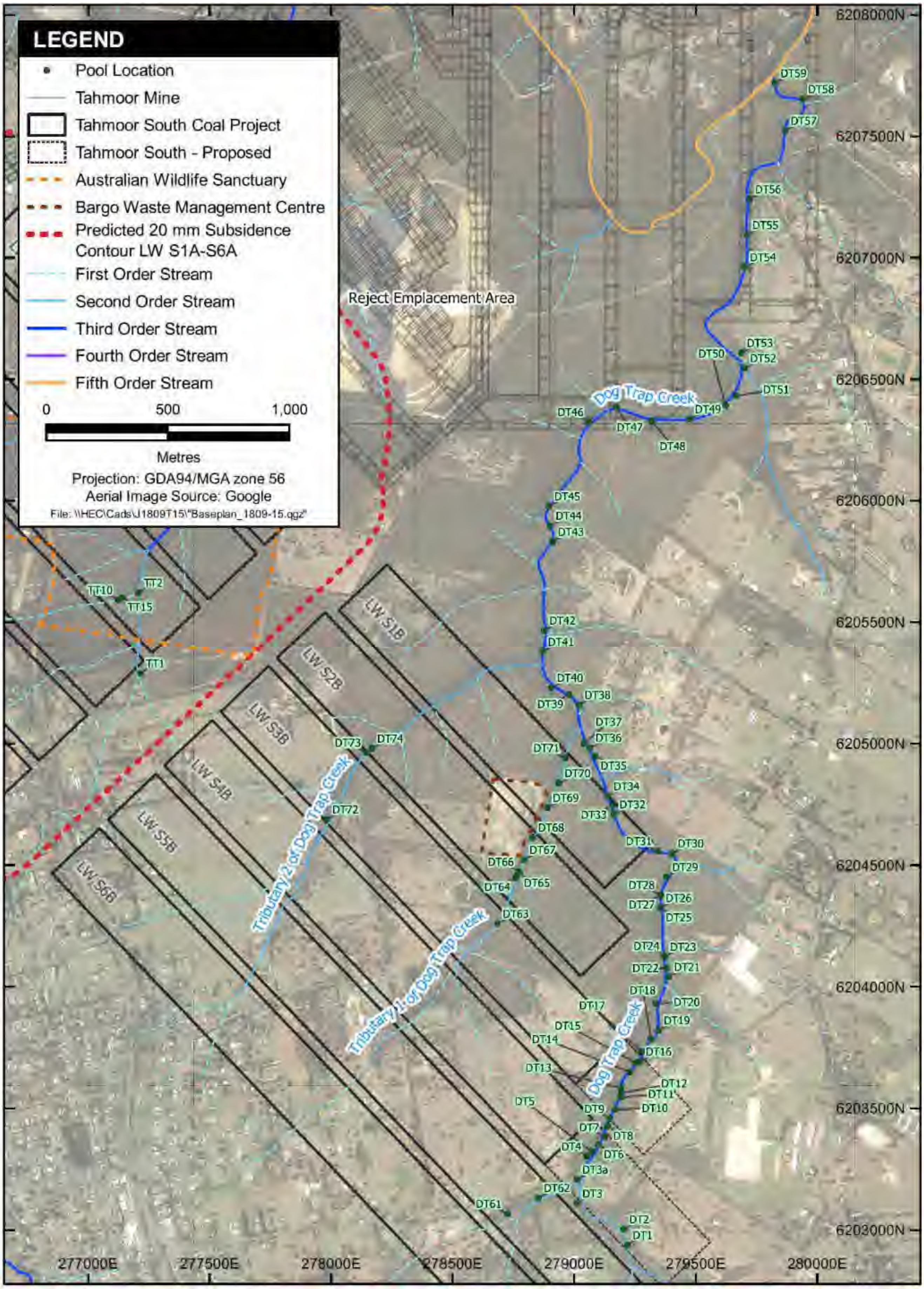

Figure 3 Dog Trap Creek and Dog Trap Creek Tributaries Pool Locations

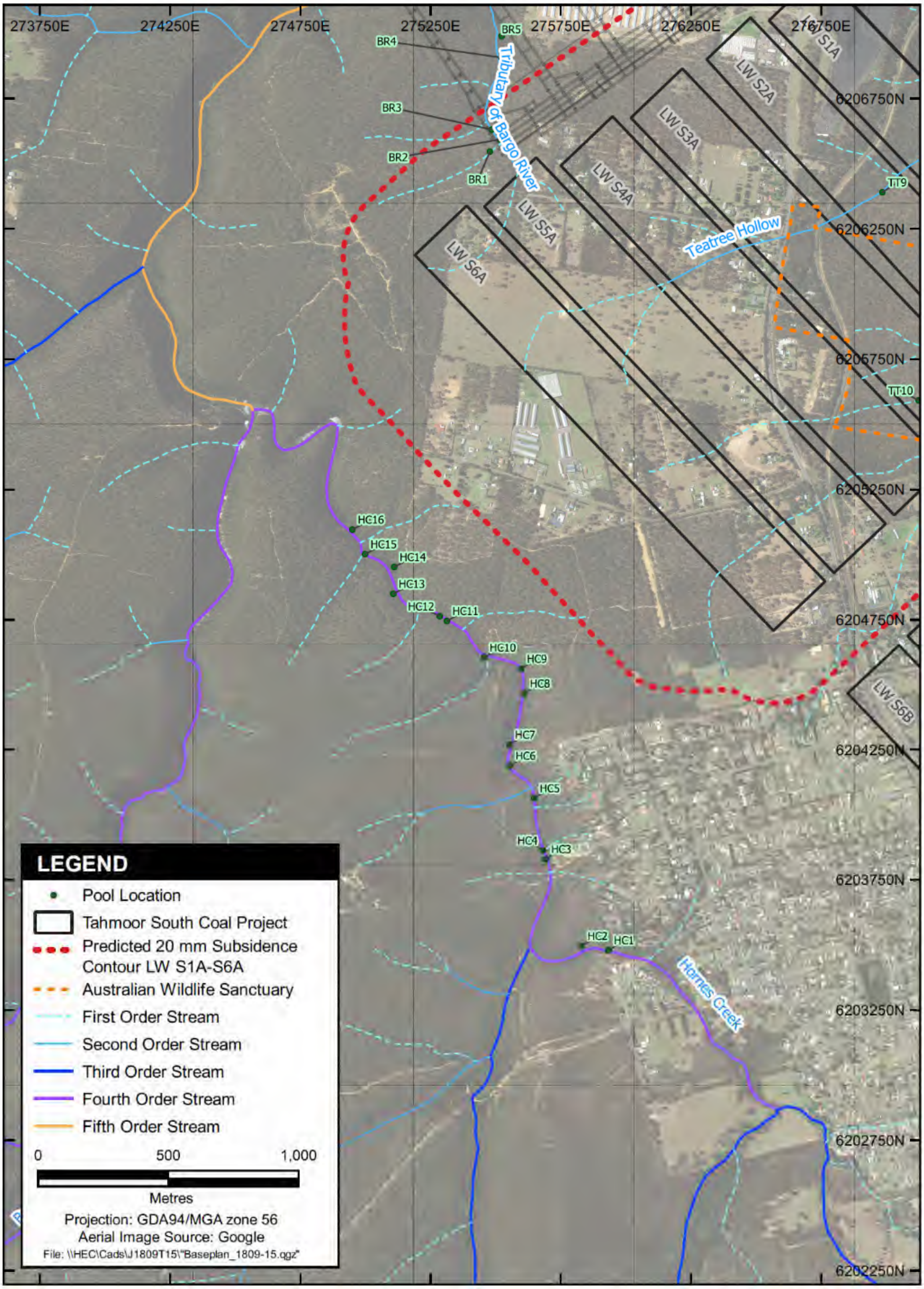

Figure 4 **Hornes Creek Pool Locations**

Streamflow gauging stations are proposed to be located downstream of predicted Project subsidence effects in order to limit or avoid potential subsidence related effects on the streamflow gauging infrastructure. As far as practically possible, the streamflow gauging stations were proposed to be located upstream of Tahmoor Mine surface facilities in order to avoid potential effects associated with Tahmoor Mine activities on the recorded streamflow rates.

3.1.3 Local Landholders and Areas of Interest

Two key areas of interest overlie the proposed Project longwalls – the Australian Wildlife Sanctuary and Bargo Waste Management Centre (refer Figure 2 and Figure 3).

The Australian Wildlife Sanctuary (the Sanctuary), formerly the Wirrimbirra Sanctuary, is a State heritage listed flora and fauna sanctuary, native plant nursery and education centre. The Sanctuary overlies proposed LW S1A-S4A and a small portion of LW S3B. Five pools were mapped within the Sanctuary boundary, two of which are of notable size – pool TT2 and pool TT3. Pool TT3 is referred to as the Ockenden Pool by the Sanctuary and pool TT2 is referred to as the Big Pool.

Surface water monitoring of pool TT2 and pool TT3 is proposed in order to enable characterisation of surface water baseline conditions prior to Project commencement and to facilitate the timely detection of potential impacts of the Project on these pools.

The Bargo Waste Management Centre overlies proposed LW S1B and LW S2B. Surface water monitoring sites have been proposed downstream of the Bargo Waste Management Centre in order to identify any current impacts of the Bargo Water Management Centre on the water quality of Dog Trap Creek tributary and to facilitate the timely detection of potential future impacts of the Project on these pools.

Further details of the proposed monitoring are provided in Section 3.3 and Section 3.4.

3.1.4 Proposed Groundwater Monitoring Plan

The proposed surface water monitoring site locations were selected with consideration to the proposed locations of groundwater monitoring sites as documented in SLR (2021). The aim was to develop an integrated monitoring network to enable assessment of baseline surface water-groundwater connectivity in the Project area and to assess the potential impacts of the Project on groundwater resources and associated effects on surface water resources.

3.1.5 Land Access

The equipping and operation of all monitoring sites are subject to access permission from relevant landholders. Where access is unable to be gained, the location of the proposed monitoring site(s) will be revised.

3.2 MONITORING PROGRAM DESIGN

3.2.1 Water Quality Monitoring

In accordance with the current monitoring program, water quality monitoring is proposed to be undertaken monthly at the existing and proposed monitoring sites (refer Section 3.3). The water quality monitoring is to comprise the following:

- Field monitoring: pH, EC, temperature, DO and ORP.
- Laboratory monitoring: pH, EC, TDS, major cations (calcium, magnesium, sodium and potassium), sulphate, alkalinity, chloride, selected dissolved metals (aluminium, arsenic, barium, copper, iron, lead, lithium, manganese, nickel, selenium, strontium and zinc), selected total metals (aluminium, arsenic, barium, cadmium, copper, iron, lead, lithium, manganese,

nickel, selenium, strontium and zinc), total kjeldahl nitrogen, total nitrogen, total phosphorus, total cations and total anions.

Monitoring at the proposed sites is proposed to commence a minimum of 12 months prior to the potential occurrence of mining related effects.

3.2.2 Water Level Monitoring

In accordance with the current monitoring program, automated and manual water level monitoring is proposed to be undertaken at select proposed monitoring sites (refer Section 3.3). The automated water level monitoring will comprise installation of a water pressure sensor that continuously records pressure measurements. Water level measurements will also be recorded manually on a monthly basis at sites with and without automated water level monitoring.

Monitoring at the proposed sites is proposed to commence a minimum of 12 months prior to the potential occurrence of mining related effects.

3.2.3 Streamflow Gauging Stations

Two streamflow gauging stations are proposed to be constructed – one on Teatree Hollow (TT-F1 in Figure 5) and one on Dog Trap Creek (DT-F1 in Figure 6). The streamflow gauging stations would be constructed with a concrete and steel v-notch weir to enable accurate and continuous low flow monitoring from commissioning. The specific design of the streamflow gauging stations is currently in development.

It is proposed that the streamflow gauging station at TT-F1 would be commissioned prior to the commencement of mining of LW S1A. Water level monitoring data recorded at monitoring site TT14-QLa will be used in conjunction with monitoring data recorded at the proposed streamflow gauging station to enable derivation of baseline flow data for Teatree Hollow downstream of the approved Project longwalls and, as far as practicable, upstream of the Tahmoor Mine surface facilities.

A similar structure will be constructed on Dog Trap Creek at DT-F1. The proposed location for DT-F1 would be at or adjacent to DT43-QRLa however this will be confirmed following site reconnaissance. It is proposed that the streamflow gauging station on Dog Trap Creek would be installed approximately four years prior to commencement of mining LW S1B to enable collection of a significant period of baseline flow data for Dog Trap Creek downstream of the approved LW S1B-S6B.

3.2.4 Monitoring of Pool Physical Features and Natural Behaviour

Visual inspections of the physical features and natural behaviour of pools will be undertaken prior to, during and following completion of the Project. A baseline inspection of mapped pools in Teatree Hollow, Teatree Hollow tributary, Bargo River tributary, Dog Trap Creek and Dog Trap Creek tributaries will be undertaken in stages prior to the commencement of secondary extraction from the Project (refer Figure 2 and Figure 3 for pool locations). Following commencement of secondary extraction, visual inspection of pools in the active subsidence zone will be undertaken monthly during the active subsidence period. Following completion of mining, visual inspections will be undertaken on a quarterly basis for a minimum of 12 months.

3.2.5 Geomorphology and Channel Stability Monitoring

Photographic surveys and visual inspections of geomorphological features will be undertaken prior to, during and post-mining activities. The photographic surveys and visual inspections will comprise:

- annual catchment survey at 10 headwater sites;
- monitoring of knickpoint formation prior to and during mining of each longwall; and

- geomorphology survey (post mining) of waterways overlying each longwall.

The annual catchment survey will be undertaken at a random selection of 10 headwater sites, as defined in Fluvial Systems (2013). The exact location of survey points will be dependent on acquiring land access agreements.

Visual inspection of headwater sites and knickpoints will be undertaken prior to the commencement of secondary extraction from the Project to confirm/revise the findings of the baseline geomorphology survey. Following commencement of secondary extraction, visual inspection of knickpoint formation in the active subsidence zone will be undertaken monthly during the active subsidence period (refer Figure 5 and Figure 6 for knickpoint locations). Following completion of mining, visual inspections will be undertaken on a quarterly basis for a minimum of 12 months.

3.3 MONITORING SITE LOCATIONS

The proposed monitoring sites to be instated in Teatree Hollow, Teatree Hollow tributary, Dog Trap Creek and its tributaries, Bargo River, Bargo River tributary and Hornes Creek are shown in Figure 5 and Figure 6, in addition to the location of knickpoints to be monitored. The monitoring site nomenclature is associated with the watercourse and pool number (i.e. DT15 is pool 15 on Dog Trap Creek) and the type of monitoring to be implemented: water quality (Q), automated (continuous) and manual water level monitoring (La), monthly manual water level measurements only (Lm) and streamflow gauging (F).

Monitoring of pool physical features and natural drainage behaviour will be undertaken at pools within the active subsidence zone. The locations of mapped pools within the Project area are shown in Figure 2 and Figure 3. The specific pools to be monitored for physical features and natural drainage behaviour will be defined in the Extraction Plan following confirmation of the subsidence zone.

Details of the proposed surface water monitoring sites are provided in Table 3.

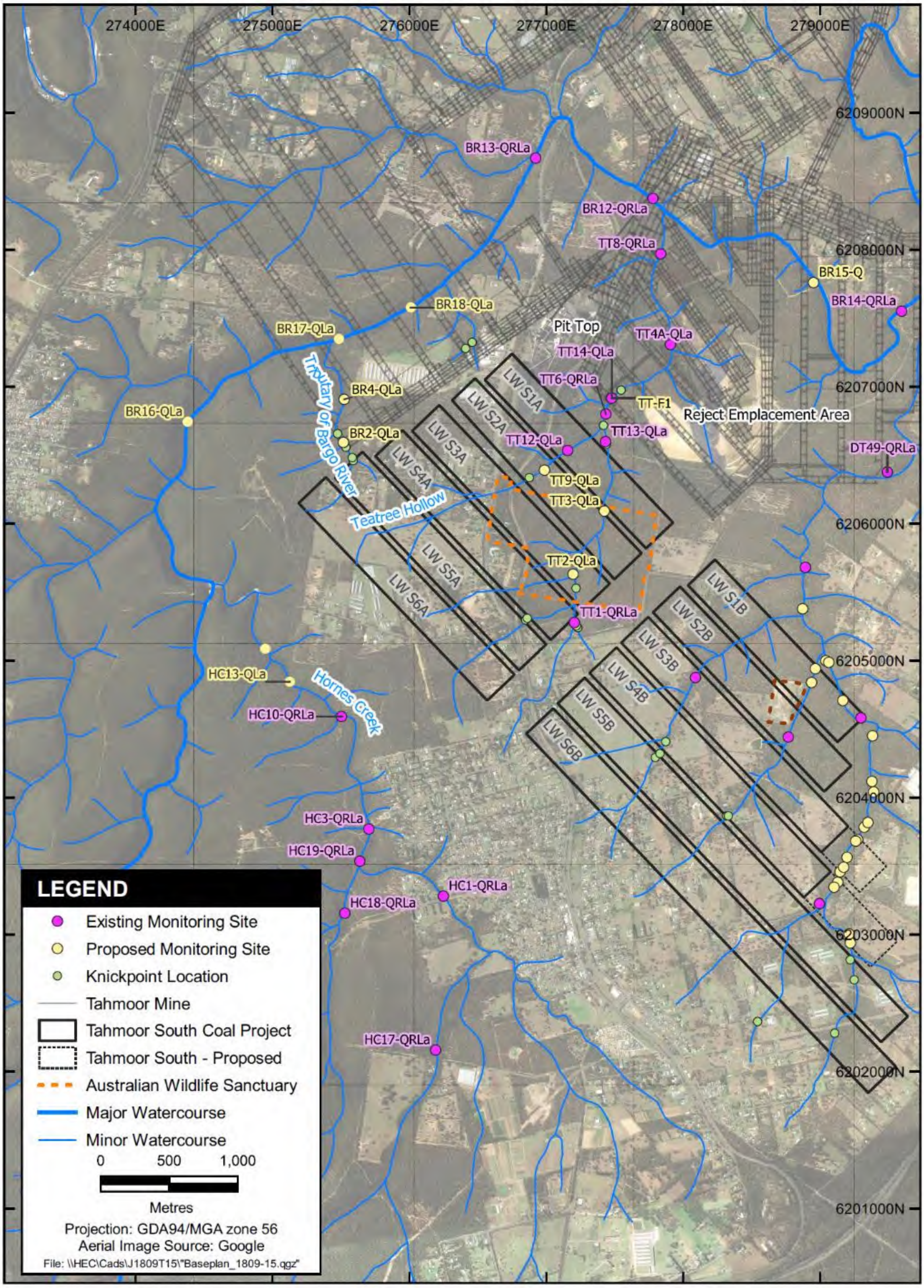

Figure 5 Proposed Monitoring Sites on Teatree Hollow, Teatree Hollow Tributary, Bargo River, Bargo River Tributary and Hornes Creek

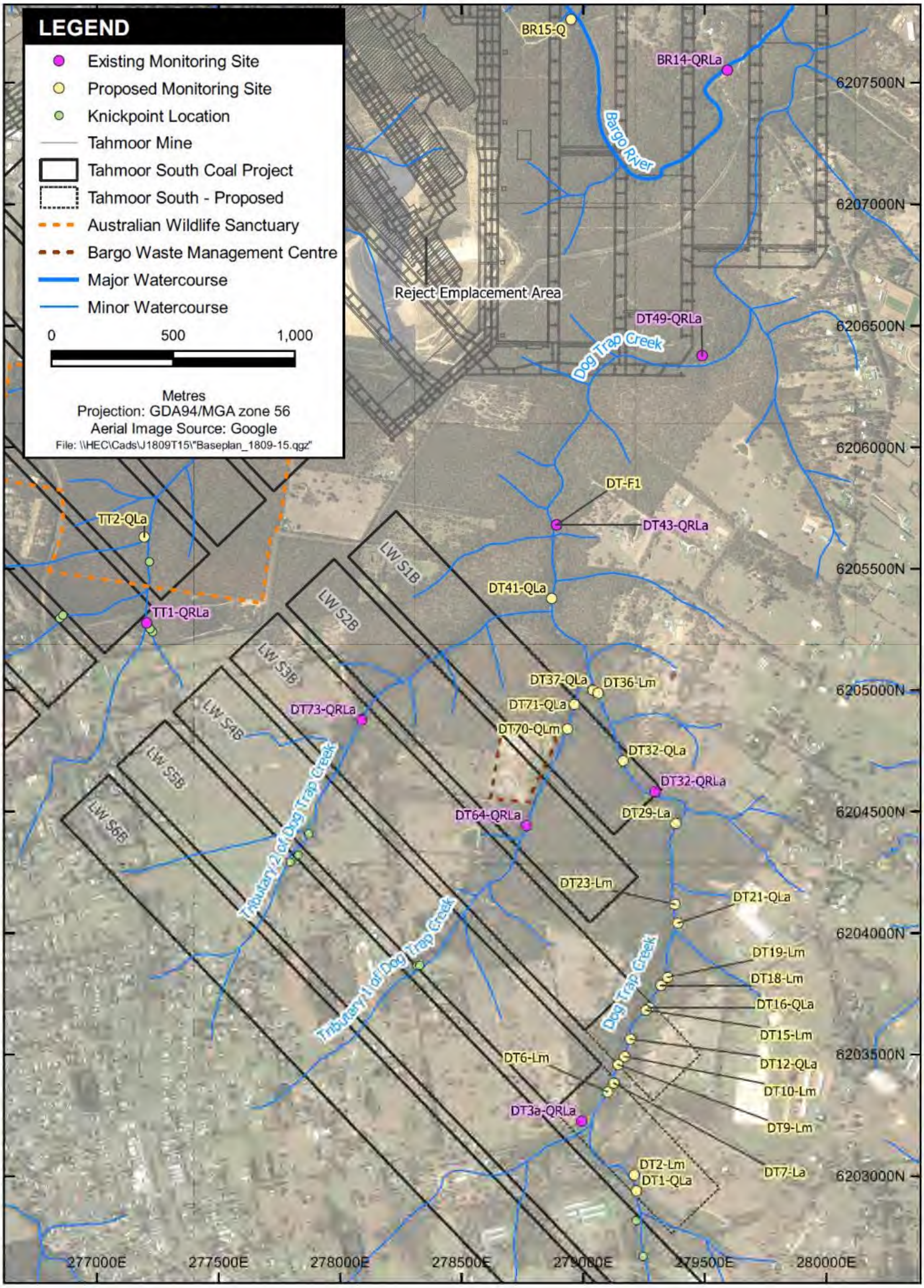

Figure 6 Proposed Monitoring Sites on Dog Trap Creek and Dog Trap Creek Tributaries

Table 3 Proposed Surface Water Monitoring Sites

Site	Purpose / Reason for Monitoring	Monitoring Type	Associated Reference Site(s)
Bargo River			
BR15-Q	Increase the spatial representation of water quality monitoring downstream of the Tahmoor Mine surface facilities and the Project	Water quality	BR13-QRLa BR12-QRLa
BR18-QLa	Baseline characterisation; monitoring of potential impacts to Bargo River outside of the predicted subsidence zone	Water level and water quality	BR16-QLa
BR17-QLa	Baseline characterisation; monitoring of potential impacts to Bargo River outside of the predicted subsidence zone	Water level and water quality	BR16-QLa
BR16-QLa	Baseline characterisation; reference site	Water level and water quality	N/A
Bargo River Tributary			
BR2-QLa	Baseline characterisation; monitoring of potential Project impacts to Bargo River tributary; surface water-groundwater connectivity monitoring†	Water level and water quality	DT64-QRLa DT73-QRLa
BR4-QLa	Monitoring of potential impacts to Bargo River tributary downstream of the predicted subsidence zone		
Teatree Hollow Catchment			
TT-F1	Monitoring of potential impacts to streamflow associated with mining of LW S1A-S6A	Streamflow gauging	DT49-QRLa DT43-QLa
TT2-QLa	Baseline characterisation; monitoring of potential Project impacts to Teatree Hollow tributary; Australian Wildlife Sanctuary pool; surface water-groundwater connectivity monitoring†	Water level and water quality	TT1-QRLa
TT3-QLa	Baseline characterisation; monitoring of potential Project impacts to Teatree Hollow tributary; Australian Wildlife Sanctuary pool; surface water-groundwater connectivity monitoring†		TT1-QRLa
TT9-QLa	Monitoring of potential Project impacts to Teatree Hollow		TT1-QRLa

† adjacent to proposed groundwater monitoring bore

Table 3 (Cont.) Proposed Surface Water Monitoring Sites

Site	Purpose / Reason for Monitoring	Monitoring Type	Associated Reference Site(s)
Dog Trap Creek Catchment			
DT-F1	Baseline characterisation; monitoring of potential impacts to streamflow associated with mining of LW S1B-S6B	Streamflow gauging	EC2-QRLa
DT1-QLa	Baseline characterisation; monitoring of potential Project impacts to Dog Trap Creek	Water level and water quality	EC2-QRLa EC1-QLa
DT2-Lm	Baseline characterisation; monitoring of potential Project impacts to Dog Trap Creek; surface water-groundwater connectivity monitoring†	Manual water level	
DT6-Lm	Baseline characterisation; monitoring of potential Project impacts to Dog Trap Creek	Manual water level	DT1-QLa
DT7-La	Baseline characterisation; monitoring of potential Project impacts to Dog Trap Creek; surface water-groundwater connectivity monitoring†	Water level	
DT9-Lm	Baseline characterisation; monitoring of potential Project impacts to Dog Trap Creek	Manual water level	Upstream monitoring sites on Dog Trap Creek
DT10-Lm		Manual water level	
DT12-QLa		Water level and water quality	
DT15-Lm		Manual water level	
DT16-QLa	Baseline characterisation; monitoring of potential Project impacts to Dog Trap Creek; surface water-groundwater connectivity monitoring†	Wwater level and water quality	
DT18-Lm	Baseline characterisation; monitoring of potential Project impacts to Dog Trap Creek	Manual water level	
DT19-Lm		Manual water level	
DT21-QLa	Baseline characterisation; monitoring of potential Project impacts to Dog Trap Creek; surface water-groundwater connectivity monitoring†	Water level and water quality	
DT23-Lm	Baseline characterisation; monitoring of potential Project impacts to Dog Trap Creek	Manual water level	
DT29-La		Water level	
DT32-QLa		Water level and water quality	
DT36-Lm		Manual water level	

† adjacent to proposed groundwater monitoring bore

Table 3 (Cont.) Proposed Surface Water Monitoring Sites

Site	Purpose / Reason for Monitoring	Monitoring Type	Associated Reference Site(s)
Dog Trap Creek Catchment			
DT37-QLa	Baseline characterisation; monitoring of potential Project impacts to Dog Trap Creek; surface water-groundwater connectivity monitoring†	Water level and water quality	Upstream monitoring sites on Dog Trap Creek
DT41-QLa	Baseline characterisation; monitoring of potential Project impacts to Dog Trap Creek	Water level and water quality	
DT70-QLm	Baseline characterisation; monitoring of potential impacts to Dog Trap Creek tributary associated with the Project and Bargo Waste Management Centre	Manual water level and water quality	DT64-QRLa
DT71-QLa		Water level and water quality	
Hornes Creek Catchment			
HC13-QLa	Baseline characterisation; monitoring of potential impacts to Hornes Creek outside of the predicted subsidence zone	Water level and water quality	Upstream monitoring sites on Hornes Creek
HC16-QLa	Baseline characterisation; monitoring of potential impacts to Hornes Creek outside of the predicted subsidence zone	Water level and water quality	

† adjacent to proposed groundwater monitoring bore

3.4 SURFACE WATER MONITORING PROGRAM

A summary of the proposed surface water monitoring program is presented in Table 4. The program, as it relates to surface water has been/will be undertaken in phases: prior to mining (secondary extraction), during secondary extraction and subsidence and following the end of mining and cessation of subsidence.

Table 4 Proposed Surface Water Monitoring Program

Feature	Locations	Monitoring		
		Prior to Mining	During Mining	Post Mining
Streamflow	Streamflow gauging stations: • TT-F1 • DT-F1	Continuous record. Data downloaded prior to the commencement of secondary extraction in relevant catchment.	Continuous record. Data downloaded and reviewed monthly.	Continuous record, data downloaded and reviewed quarterly for 12 months following the completion of relevant mining activities. This period may be extended as per decision by the Environmental Response Group*.
Surface Water Quality	Current and proposed water quality monitoring sites.	Monthly sampling for a minimum of 12 months prior to secondary extraction.	Monthly sampling and analysis.	Monthly sampling and analysis for 12 months following the completion of relevant mining activities. This period may be extended as per decision by the Environmental Response Group.
		Parameters: Field analysis: pH, EC and DO, temperature and ORP. Laboratory analysis for: pH, EC, total dissolved solids, total suspended solids, turbidity, major cations†, sulphate, alkalinity, chloride, dissolved metals‡, total metals≠, total kjeldahl nitrogen, total nitrogen, total phosphorus, total cations and total anions.		
Automated pool water level	Current and proposed water level monitoring sites.	Continuous record and monthly manual measurements for a minimum of 12 months prior to secondary extraction. Data downloaded prior to the commencement of secondary extraction in relevant catchment.	Continuous record and monthly manual measurements. Data downloaded and reviewed monthly.	Continuous record and monthly manual measurements. Data downloaded and reviewed quarterly for 12 months following the completion of relevant mining activities. This period may be extended as per decision by the Environmental Response Group.

* External technical specialists in subsidence, water resources, hydrogeology and aquatic ecology tasked with assessing the Project performance against the Trigger Action Response Plan defined in the Water Management Plan.

† Calcium, magnesium, sodium and potassium.

‡ Aluminium, arsenic, barium, copper, iron, lead, lithium, manganese, nickel, selenium, strontium and zinc.

≠ Aluminium, arsenic, barium, cadmium, copper, iron, lead, lithium, manganese, nickel, selenium, strontium and zinc.

Table 4 (Cont.) Proposed Surface Water Monitoring Program

Feature	Locations	Monitoring		
		Prior to Mining	During Mining	Post Mining
Manual water level	Current and proposed manual water level monitoring sites.	Monthly manual level measurements for a minimum of 12 months prior to secondary extraction.	Monthly manual level record.	Monthly manual level record for 12 months following the completion of relevant mining activities. This period may be extended as per decision by the Environmental Response Group.
Physical features and natural behaviour of pools	Stream reaches of Teatree Hollow, Teatree Hollow tributary, Dog Trap Creek, Dog Trap Creek tributary, Bargo River and Bargo River tributary.	One observation prior to mining using fixed location photo points.	Observations every month during the active subsidence period (after 200 m of secondary extraction of relevant longwall) for sites within the active subsidence zone^ using fixed location photo points.	Quarterly observations over 12 months for pools that are no longer within the active subsidence zone. This period may be extended as per decision by the Environmental Response Group.
Geomorphology and channel stability	Stream reaches of Teatree Hollow, Teatree Hollow tributary, Dog Trap Creek, Dog Trap Creek tributary and Bargo River tributary.	One observation prior to mining using fixed location photo points. One catchment survey of 10 headwater sites.	Observations of knickpoint formation every month during the active subsidence period for sites within the active subsidence zone using fixed location photo points. Annual catchment survey of 10 headwater sites.	One observation of knickpoint formation at sites that are no longer within the active subsidence zone using fixed location photo points. One catchment survey of 10 headwater sites. Post-mining geomorphology survey following completion of mining LW S6A.

^ Survey area to include upstream, downstream and adjacent pools (to the extent of the potential impact) where a trigger exceedance has occurred at a potential impact site(s) in accordance with the relevant Trigger Action Response Plan defined in the Water Management Plan.

° Locations to be specified in the Extraction Plan following confirmation of the subsidence zone.

3.5 MONITORING PROGRAM DEVELOPMENT SCHEDULE

The surface water monitoring program for the Project would be progressively developed based on the stage and scope of the Project development. The proposed schedule for implementation of the proposed surface water monitoring program is listed in Table 5.

Table 5 Proposed Schedule for Implementation of Surface Water Monitoring

Site	Implementation Schedule
Bargo River	
BR15-Q	As soon as possible
BR16-QLa	As soon as possible
BR17-QLa	Approximately two years prior to commencement of mining LW S3A
BR18-QLa	As soon as possible
Bargo River Tributary	
BR2-QLa, BR4-QLa	Approximately two years prior to commencement of mining LW S4A
Teatree Hollow Catchment	
TT-F1	As soon as possible
TT3-QLa, TT9-QLa	As soon as possible
TT2-QLa	Approximately two years prior to commencement of mining LW S4A
Dog Trap Creek Catchment	
DT-F1	Approximately four years prior to commencement of mining LW S1B
DT1-QLa, DT2-Lm, DT6-Lm, DT7-La, DT9-Lm, DT10-Lm, DT12-QLa, DT15-Lm, DT16-QLa, DT70-QLm, DT71-QLa	Minimum two years prior to the preparation of the Extraction Plan for LW S1B-S6B
DT18-Lm, DT19-Lm, DT21-QLa, DT23-Lm, DT29-La, DT32-QLa, DT36-Lm, DT37-QLa, DT41-QLa	Preferably approximately two years prior to the preparation of the Extraction Plan for LW S1B-S6B; minimum two years prior to commencement of mining underlying longwalls
Hornes Creek Catchment	
HC13-QLa	Approximately two years prior to commencement of mining LW S6A
HC16-QLa	Approximately two years prior to commencement of mining LW S6A

3.6 STREAMFLOW MONITORING APPROVALS PROCESS

The Project is classified as state significant development by the NSW Department of Planning, Industry and Environment (DPIE) and will be undertaken in accordance with the Consent. Conditions A2 and A4 of the Consent require the Project to be developed generally in accordance with the EIS. The construction of a streamflow gauging station on Teatree Hollow (proposed site TT-F1) and Dog Trap Creek (proposed site DT-F1) was recommended as a management and mitigation measure for the Project in the EIS. Accordingly, and as per legal advice provided to Tahmoor Coal, it is understood that Tahmoor Coal has development consent for the construction and implementation of a streamflow gauging station on Teatree Hollow and Dog Trap Creek. Legal advice provided to Tahmoor Coal has confirmed that no further approval under *the Water Management Act 2000* or the *Fisheries Management Act 1994* is required for the construction and implementation of the proposed streamflow gauging station.

REFERENCES

Fluvial Systems (2013). "Tahmoor South Project Environmental Impact Statement Technical Specialists Report – Geomorphology". Prepared for Tahmoor Coal, December.

OEH, 2016 (2016). "Guidelines for preparing a Review of Environmental Factors". NSW Office of Environment and Heritage (OEH).

SLR (2021). "Tahmoor South Groundwater Monitoring Plan". Prepared for Tahmoor Coal, October.

APPENDIX C – Surface Water Level Monitoring Data Plots

Teatree Hollow

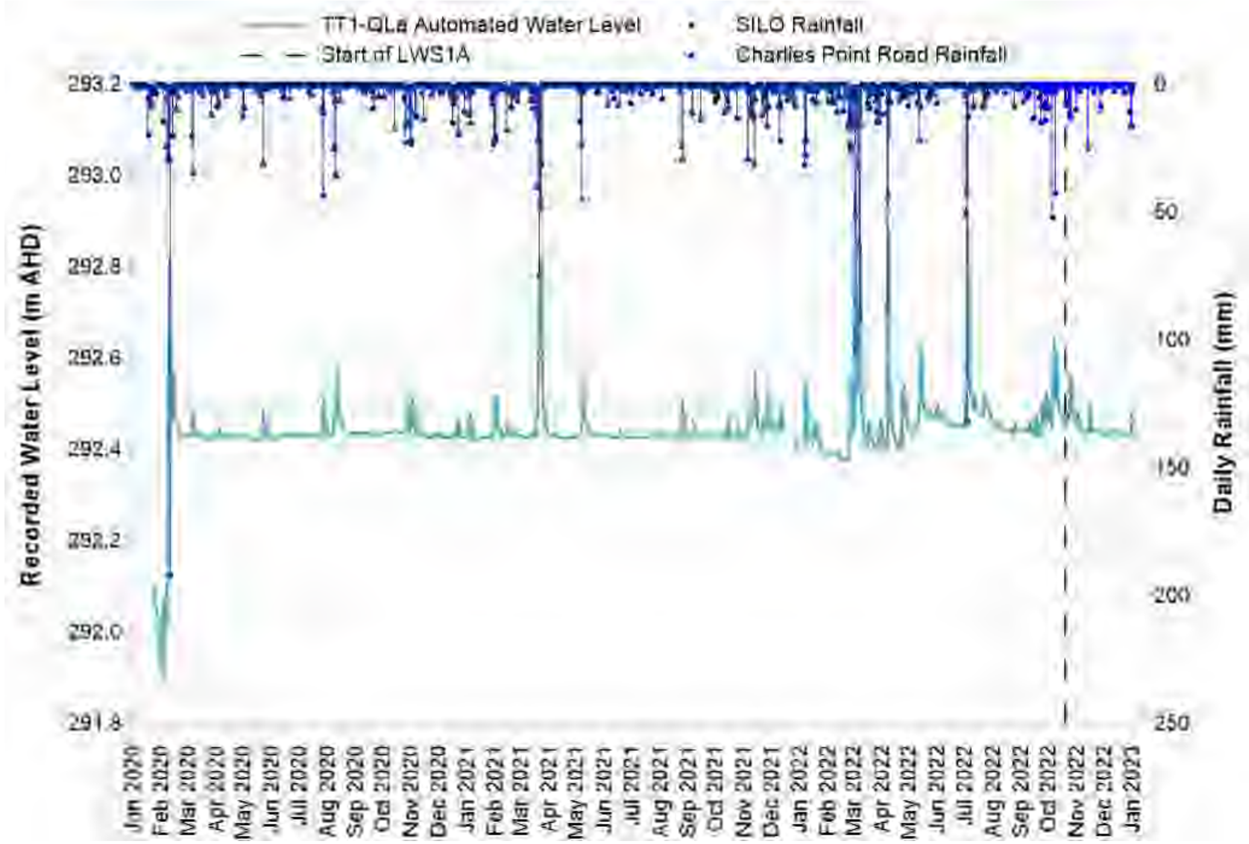

Chart C1: TT1-QLa Water Level Monitoring Data

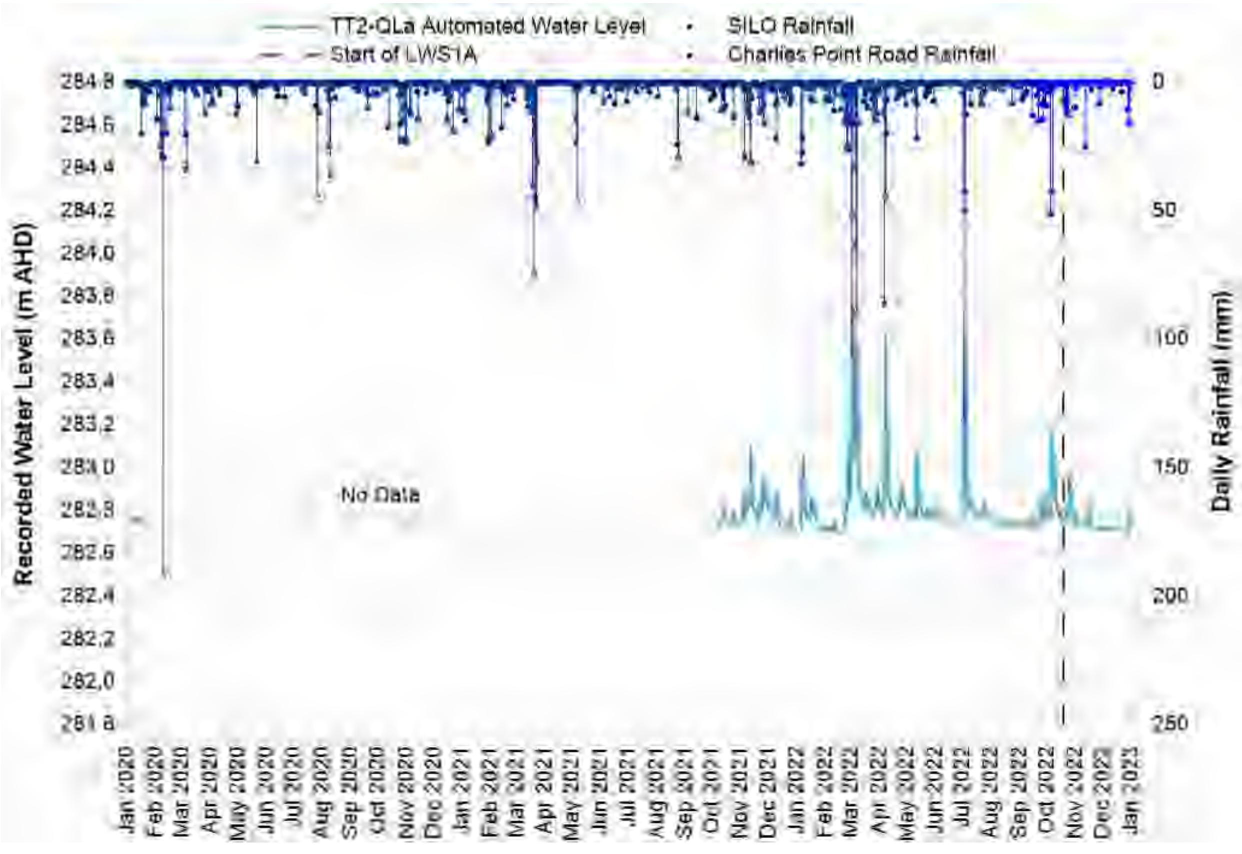

Chart C2: TT2-QLa Water Level Monitoring Data

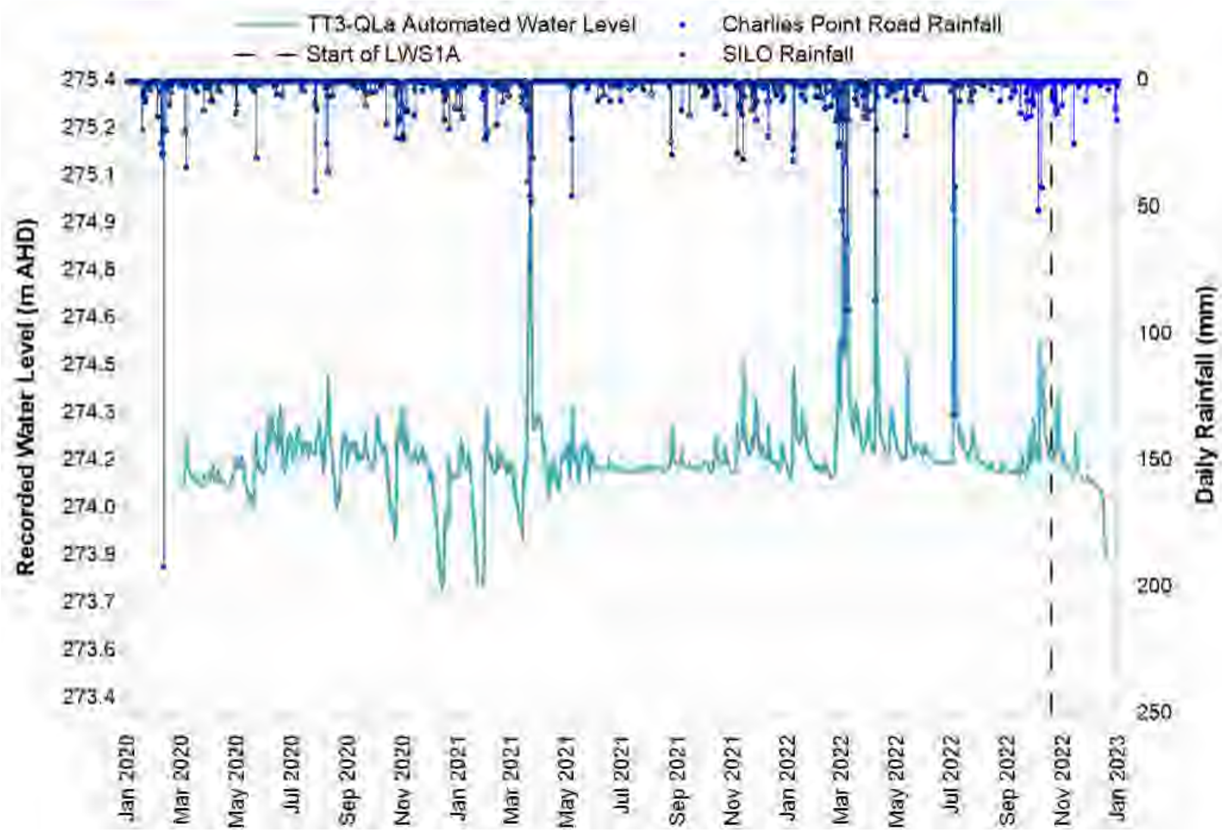

Chart C3: TT3-QLa Water Level Monitoring Data

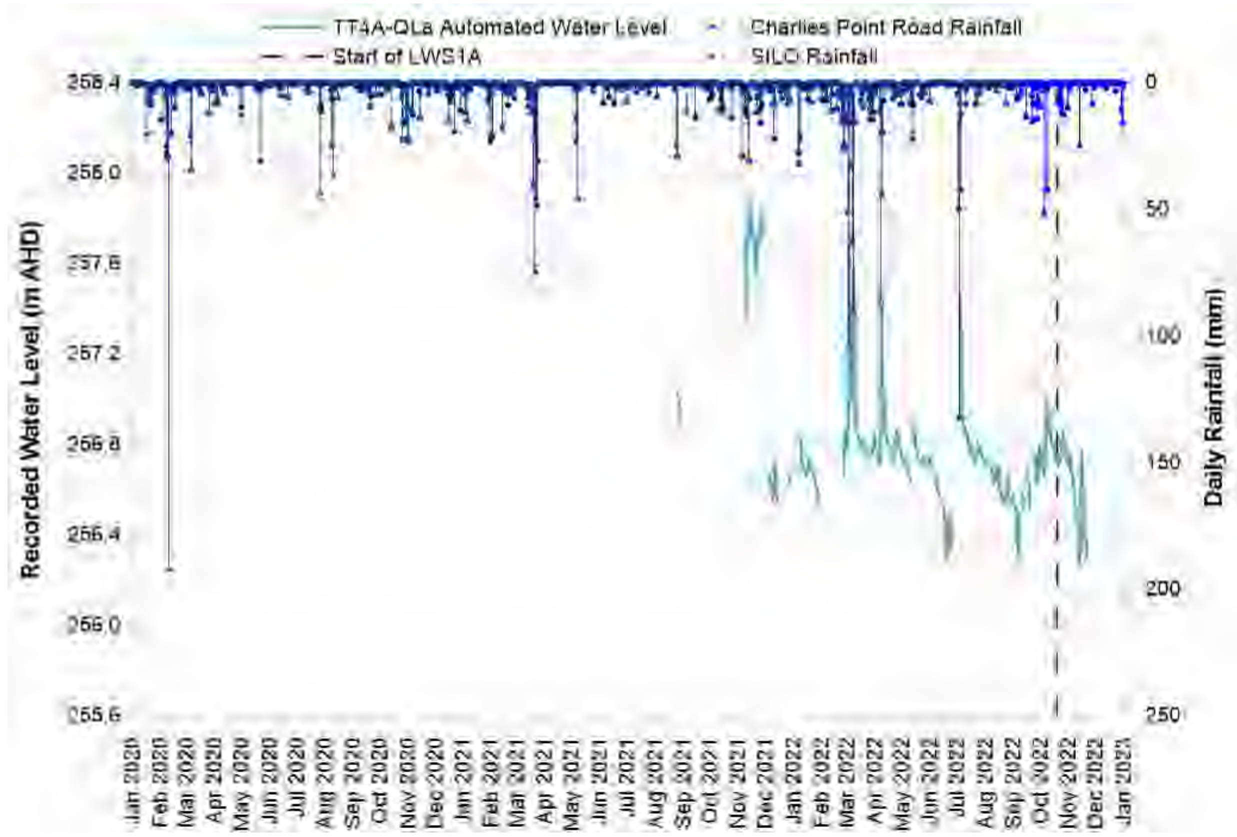

Chart C4: TT4A-QLa Water Level Monitoring Data

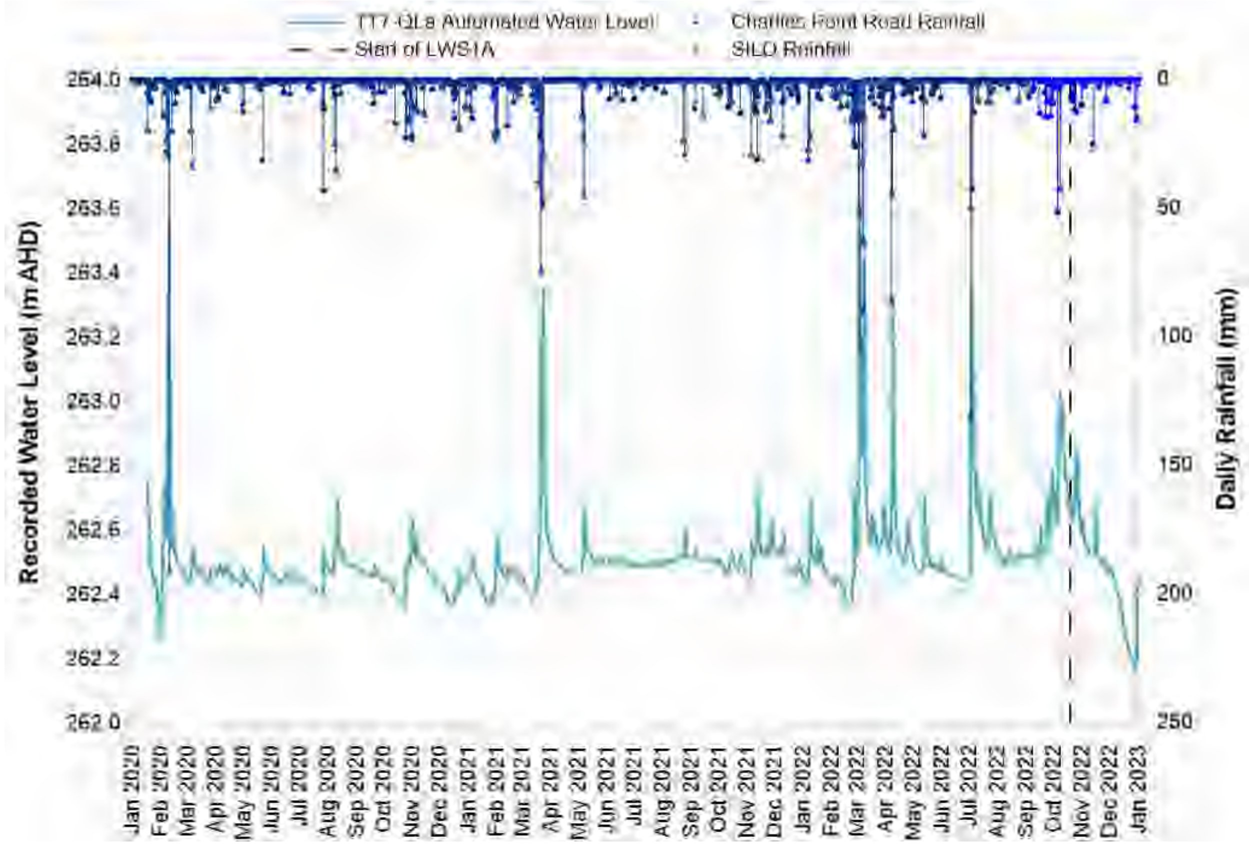

Chart C5: TT7-QLa Water Level Monitoring Data

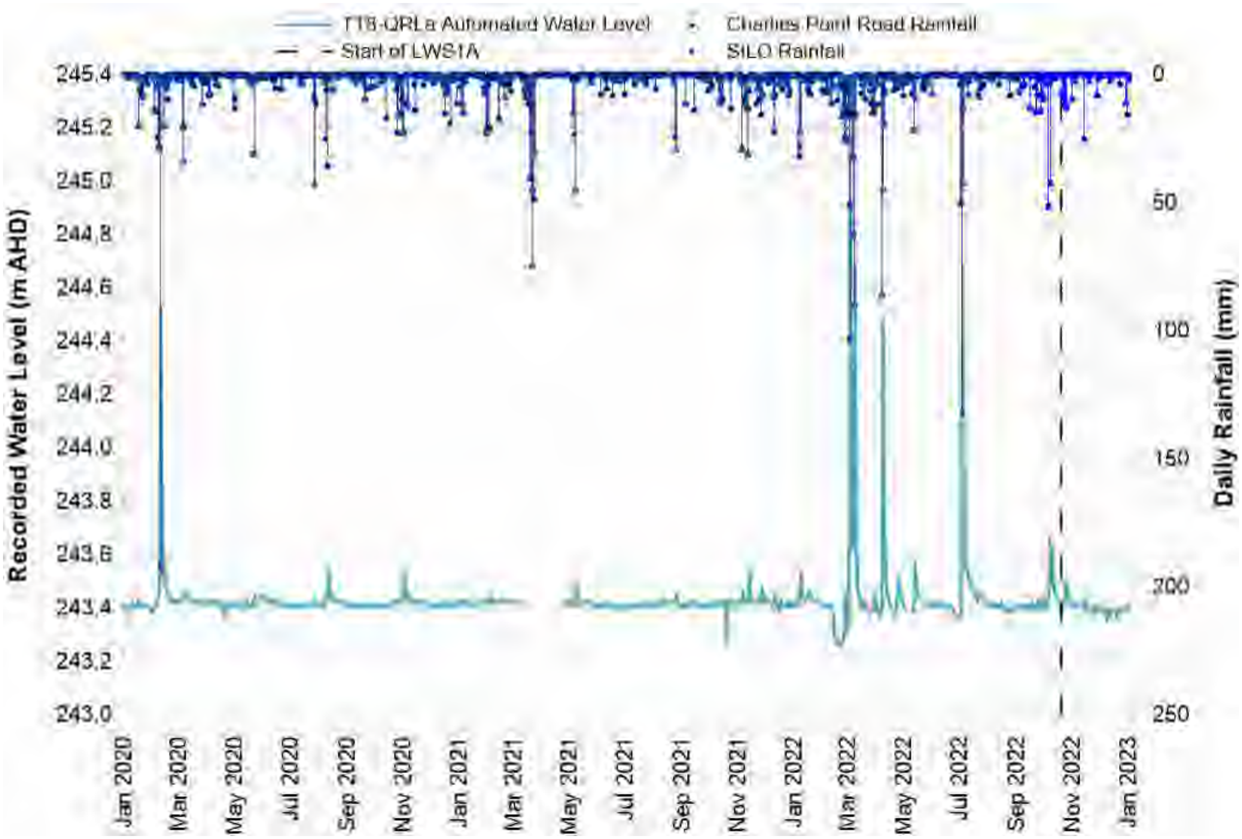

Chart C6: TT8-QRLa Water Level Monitoring Data

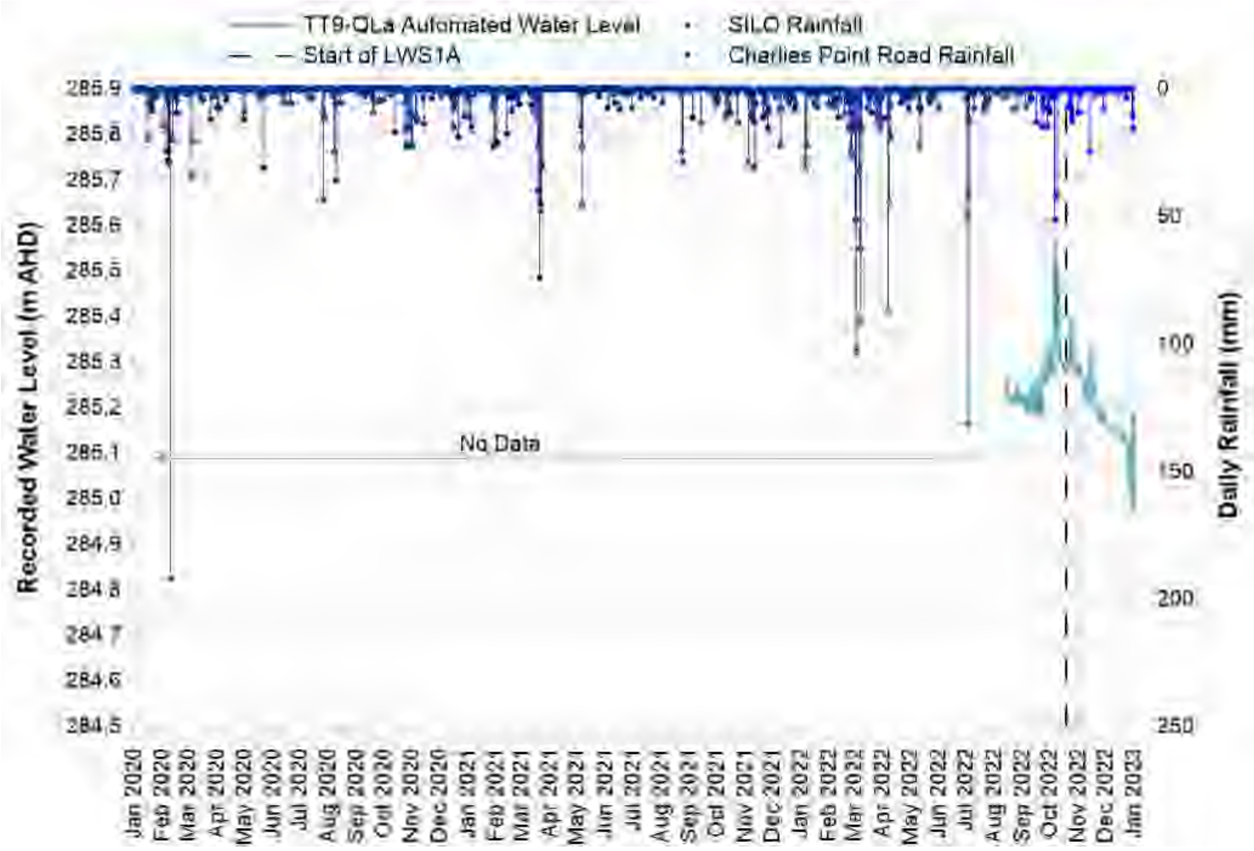

Chart C7: TT9-QLa Water Level Monitoring Data

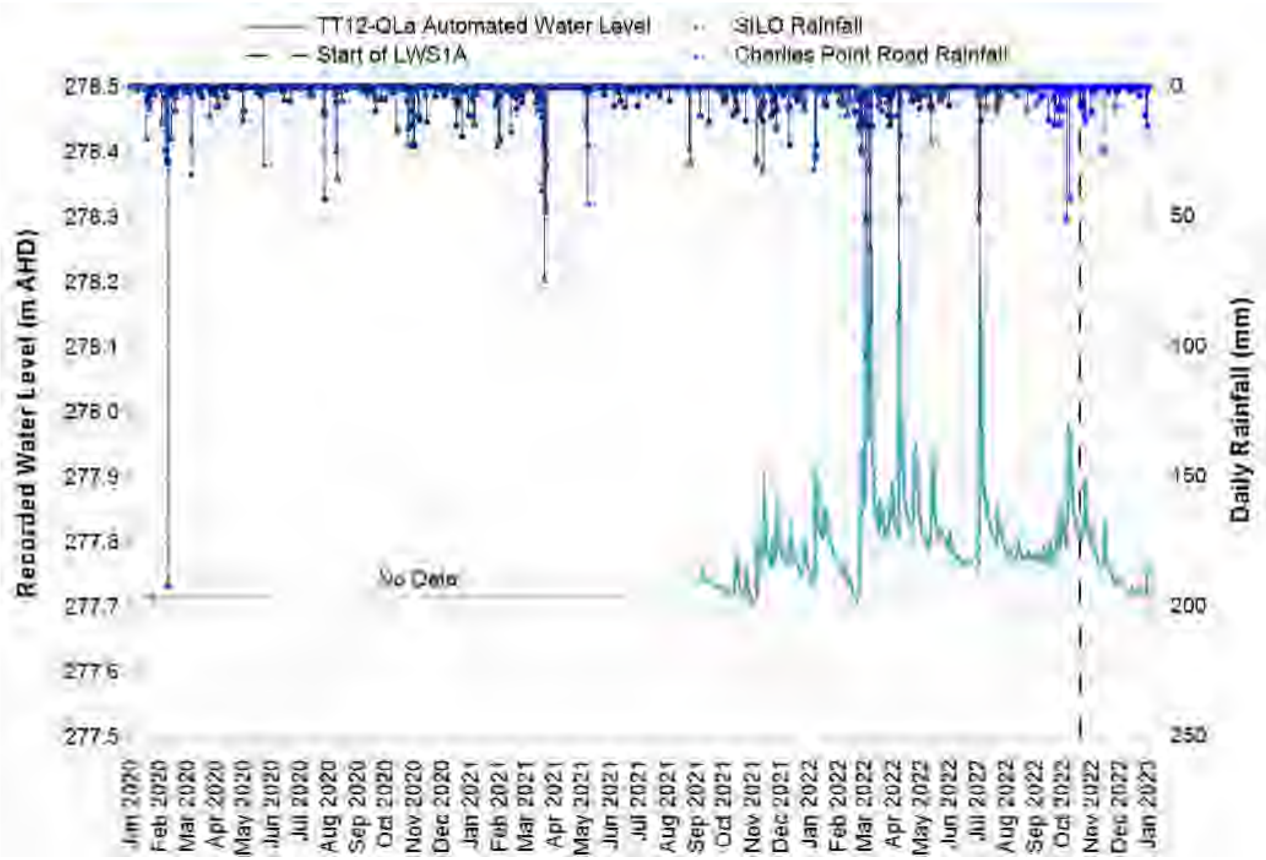

Chart C8: TT12-QLa Water Level Monitoring Data

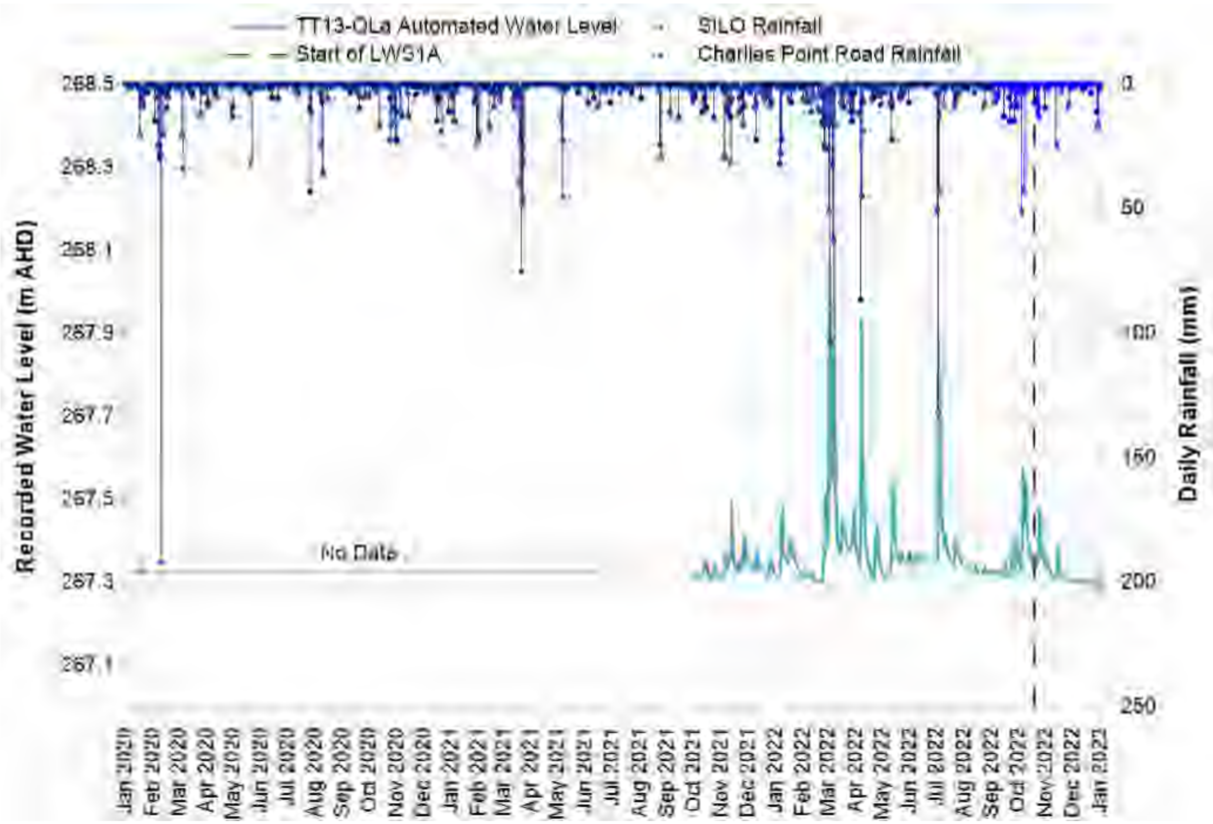

Chart C9: TT13-QLa Water Level Monitoring Data

Bargo River

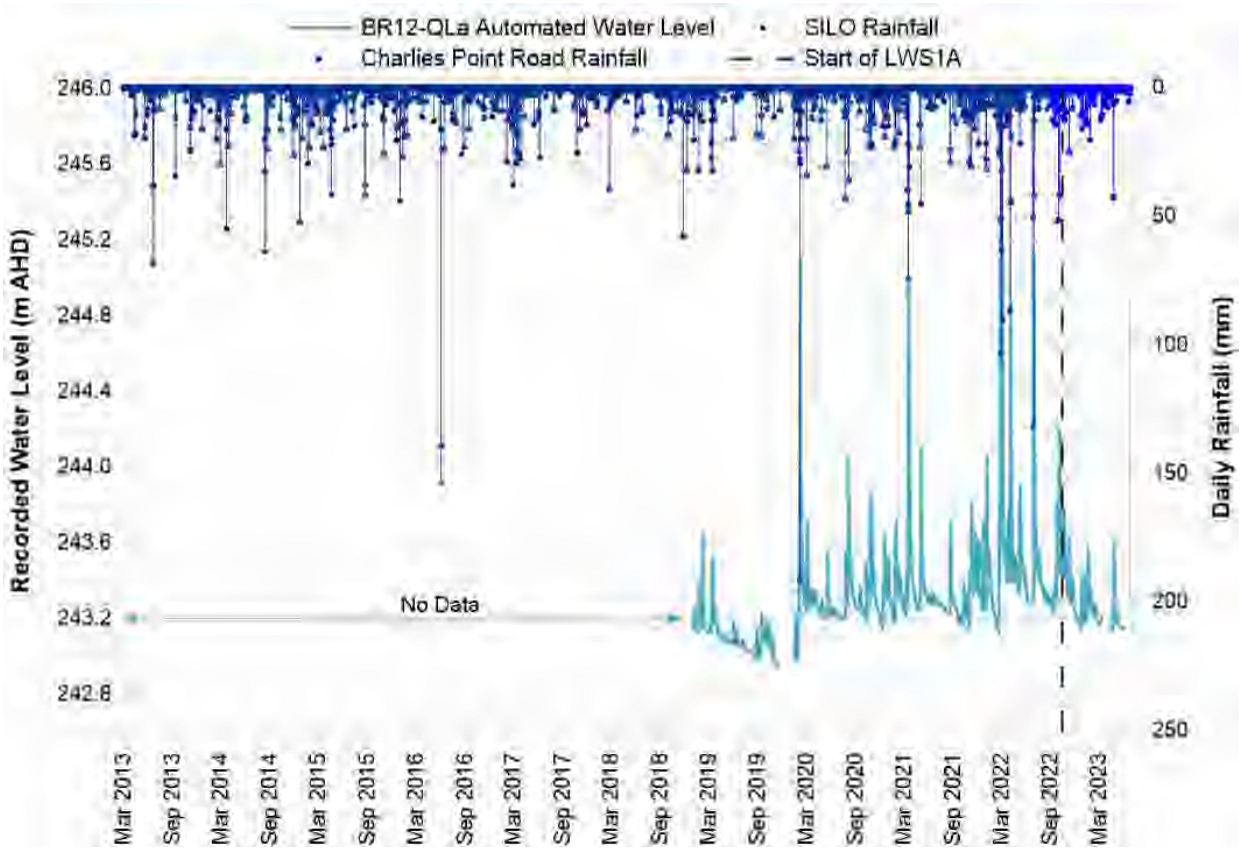

Chart C10: BR12-QLa Water Level Monitoring Data

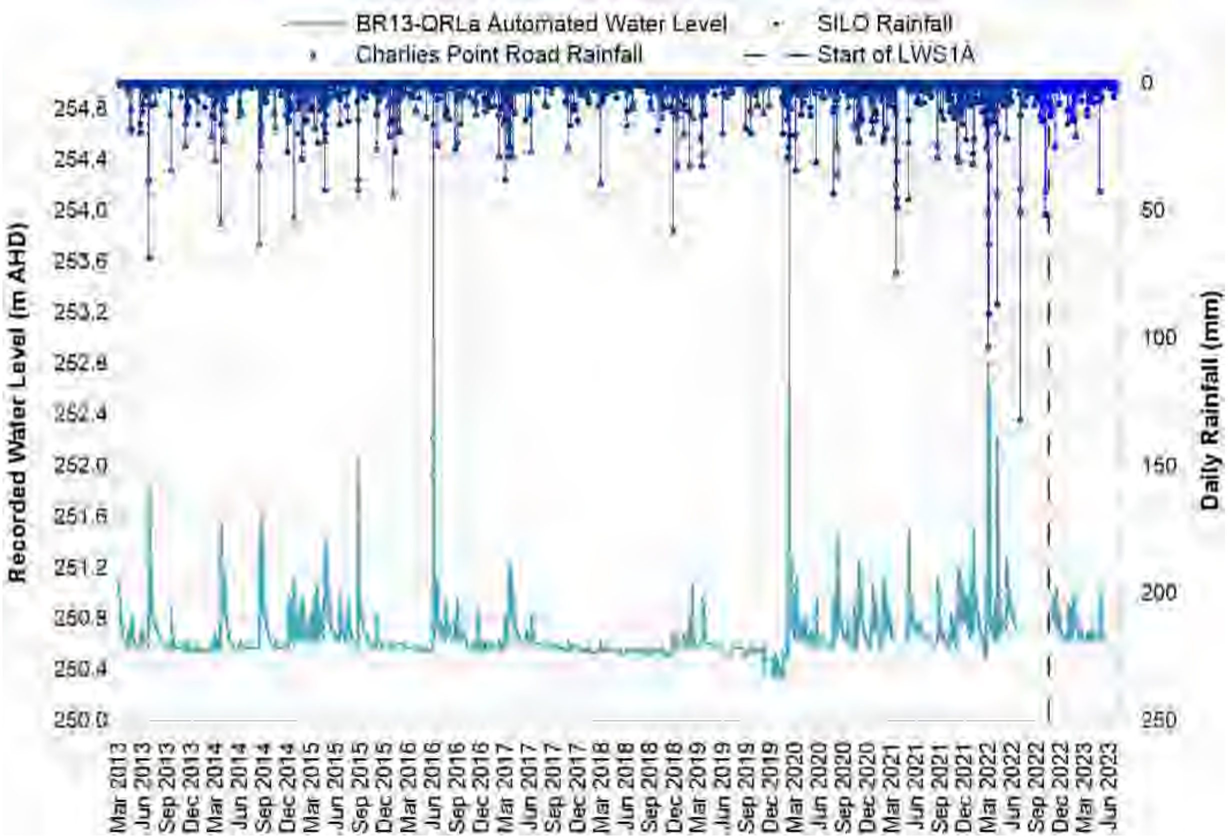

Chart C11: BR13-QRLa Water Level Monitoring Data

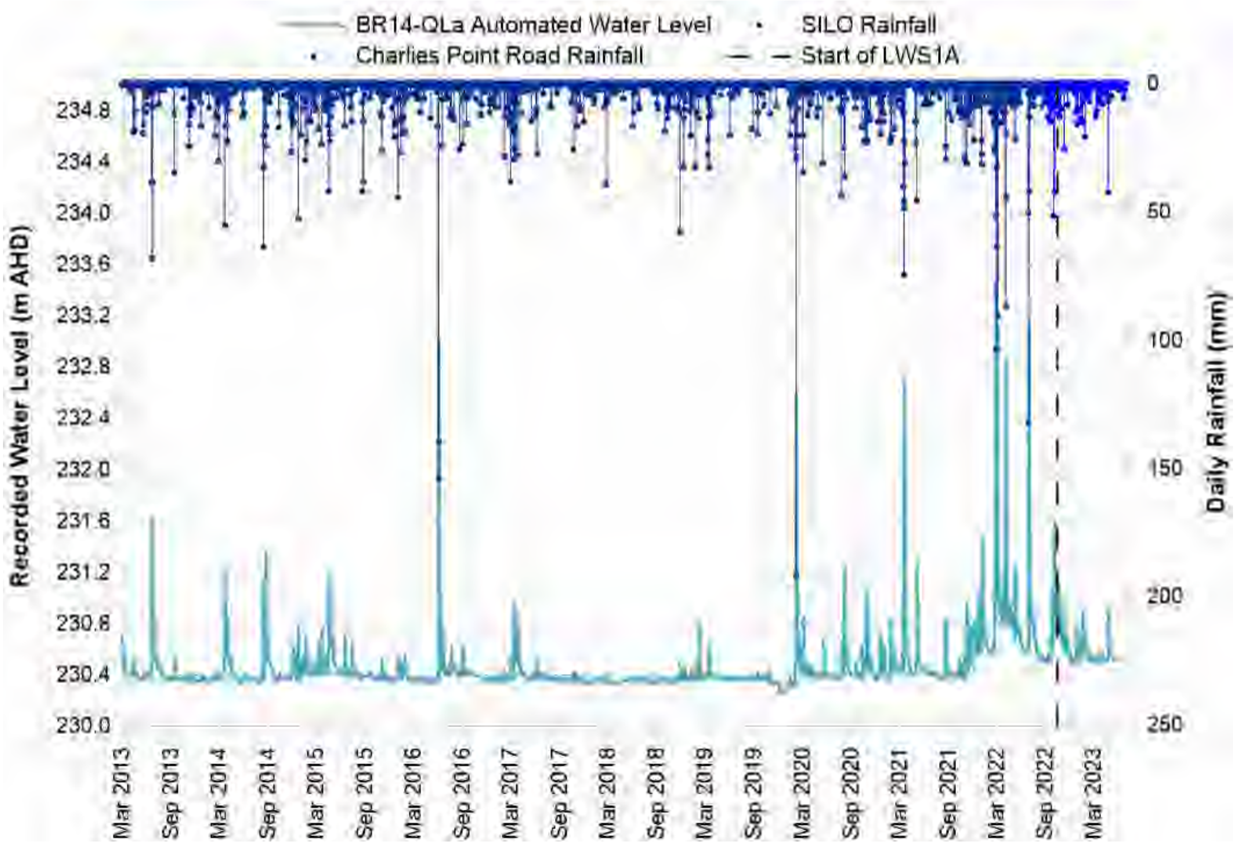

Chart C12: BR14-QLa Water Level Monitoring Data

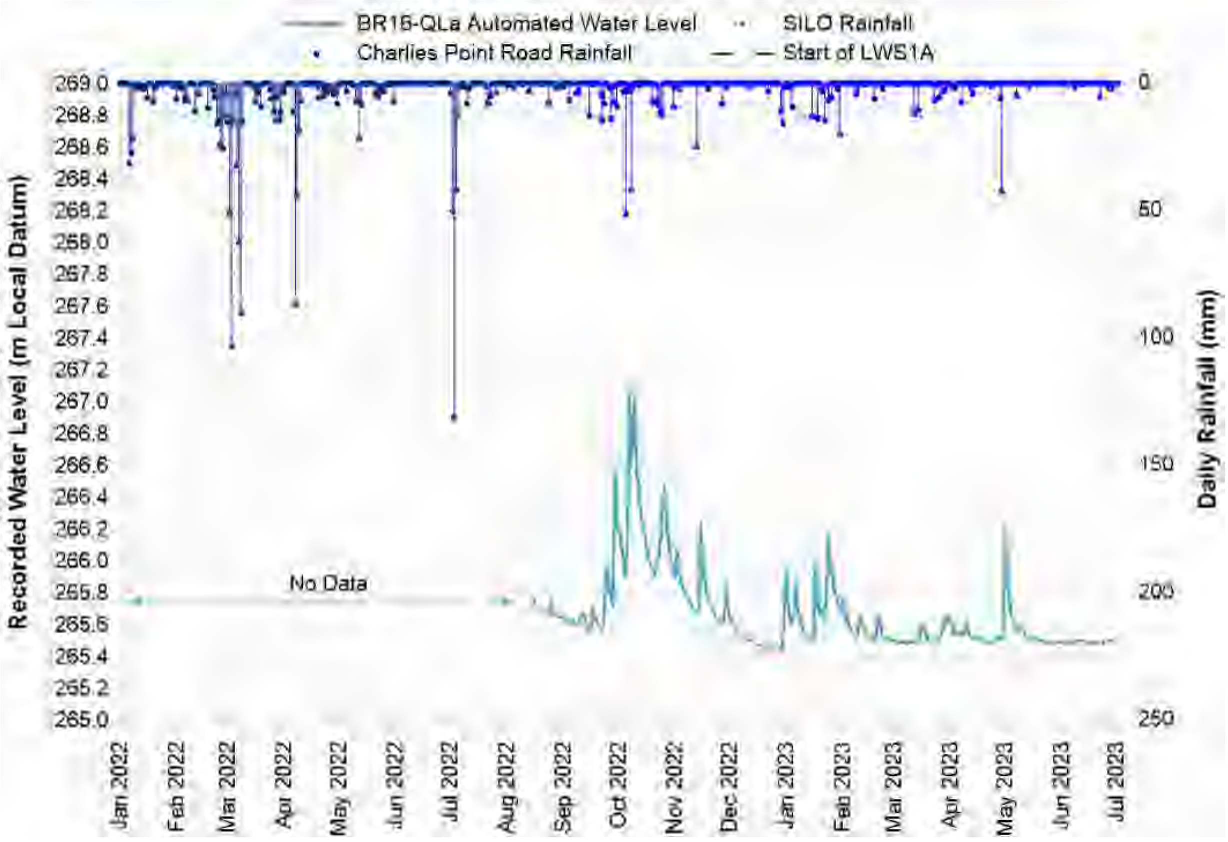

Chart C13: BR16-QLa Water Level Monitoring Data

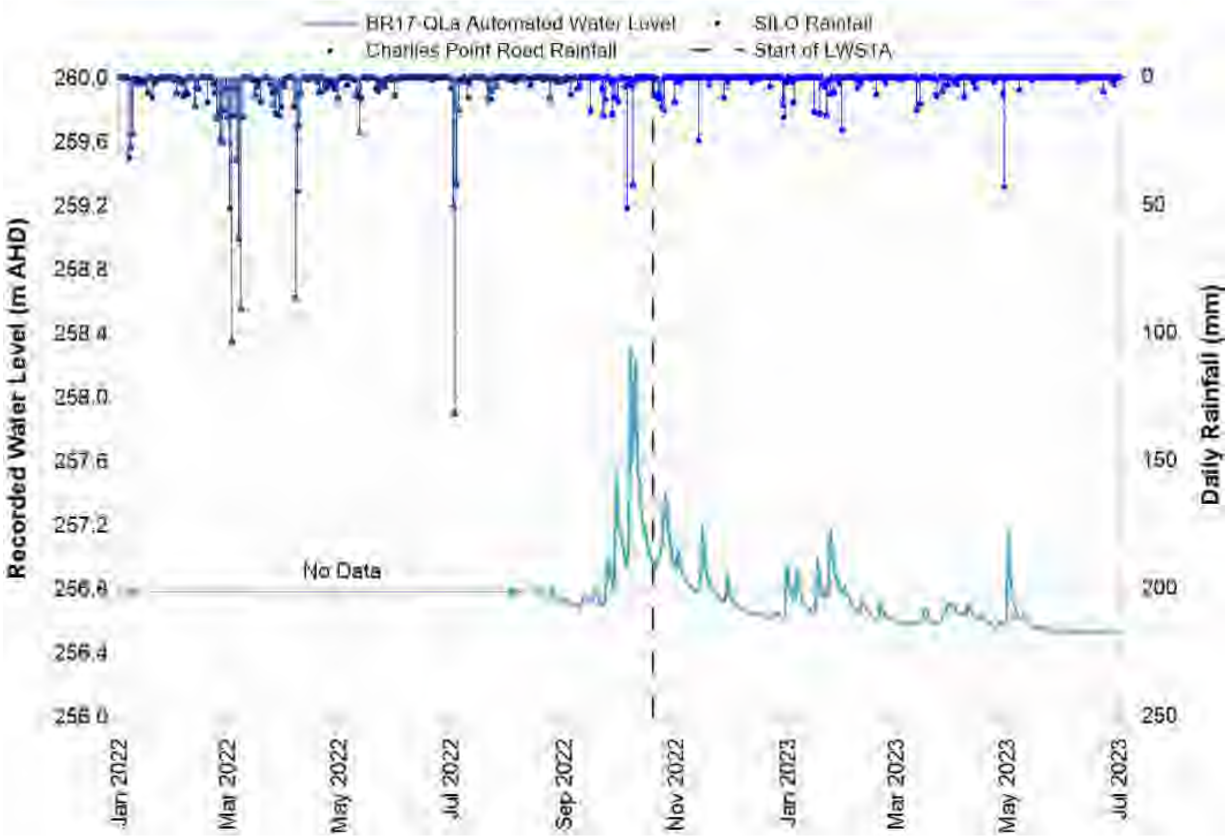

Chart C14: BR17-QLa Water Level Monitoring Data

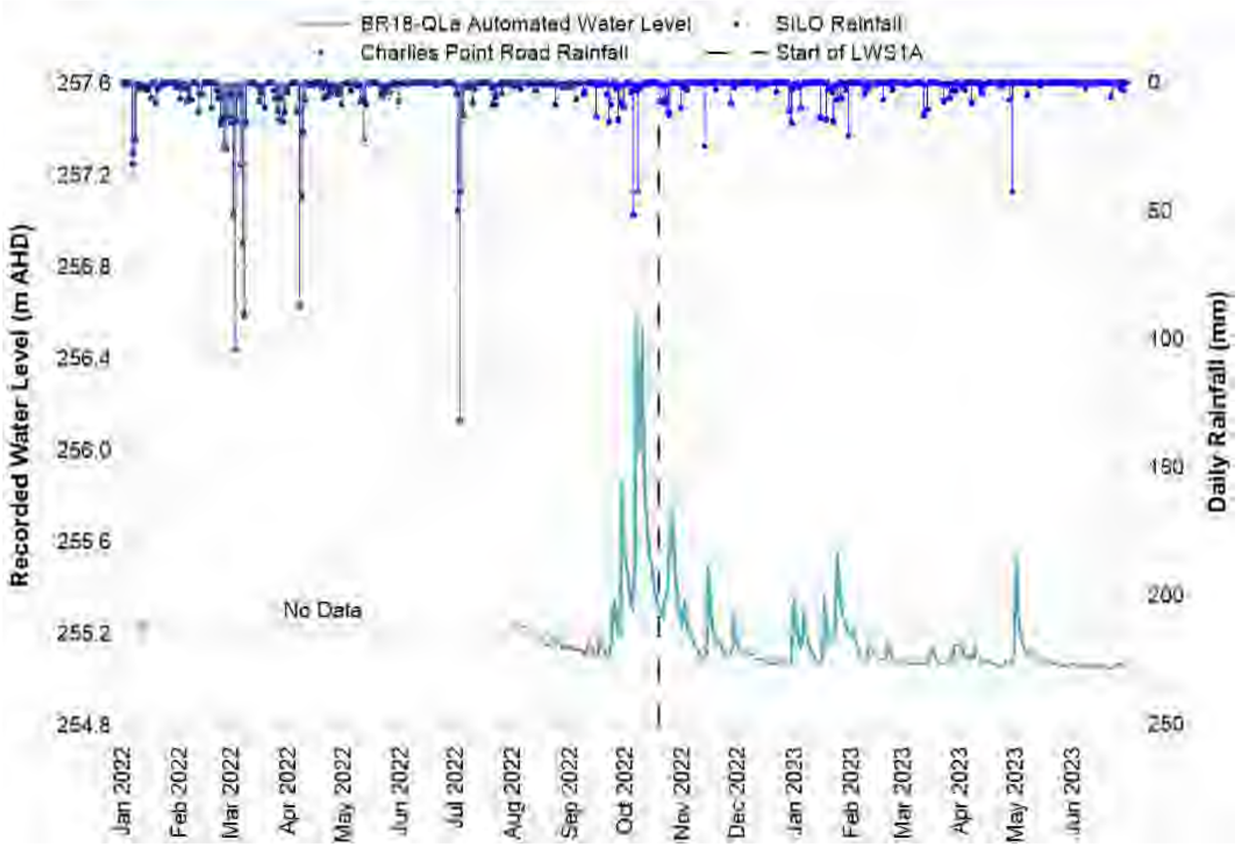

Chart C15: BR18-QLa Water Level Monitoring Data

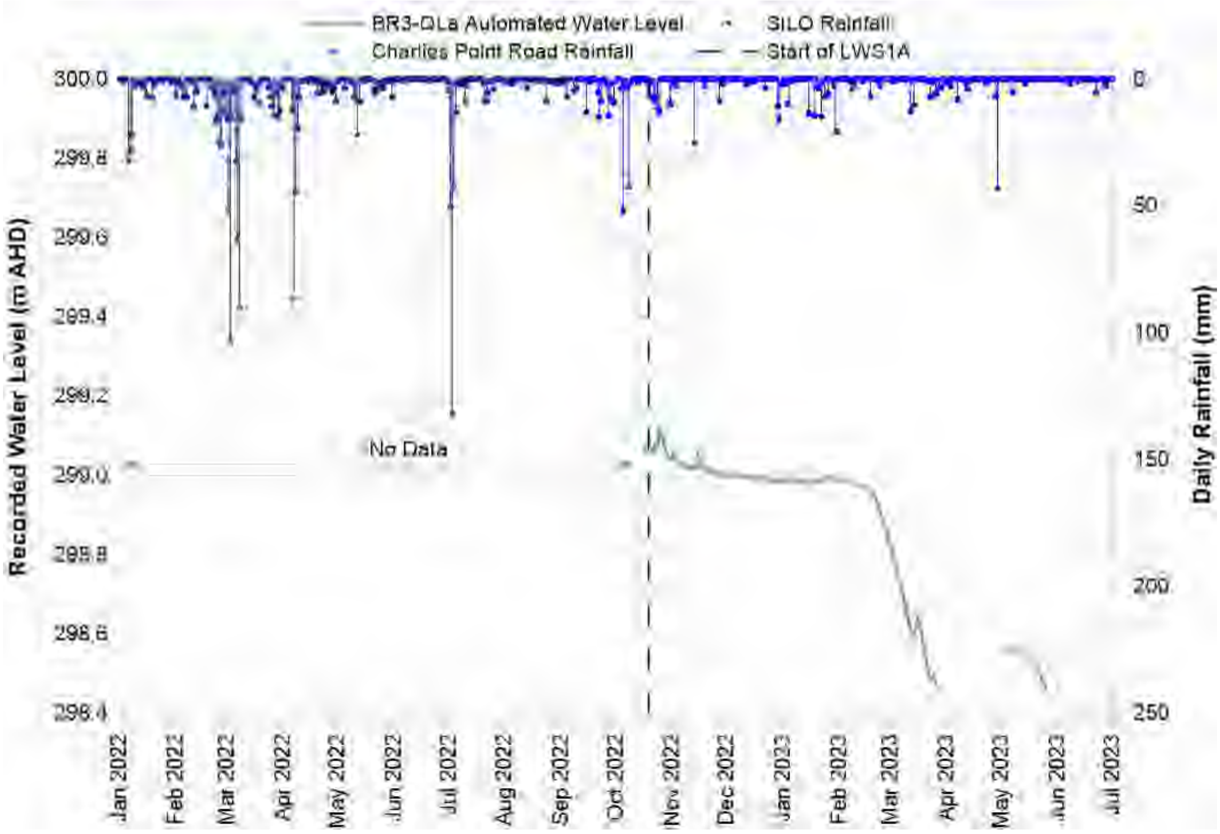

Chart C16: BR3-QLa Water Level Records

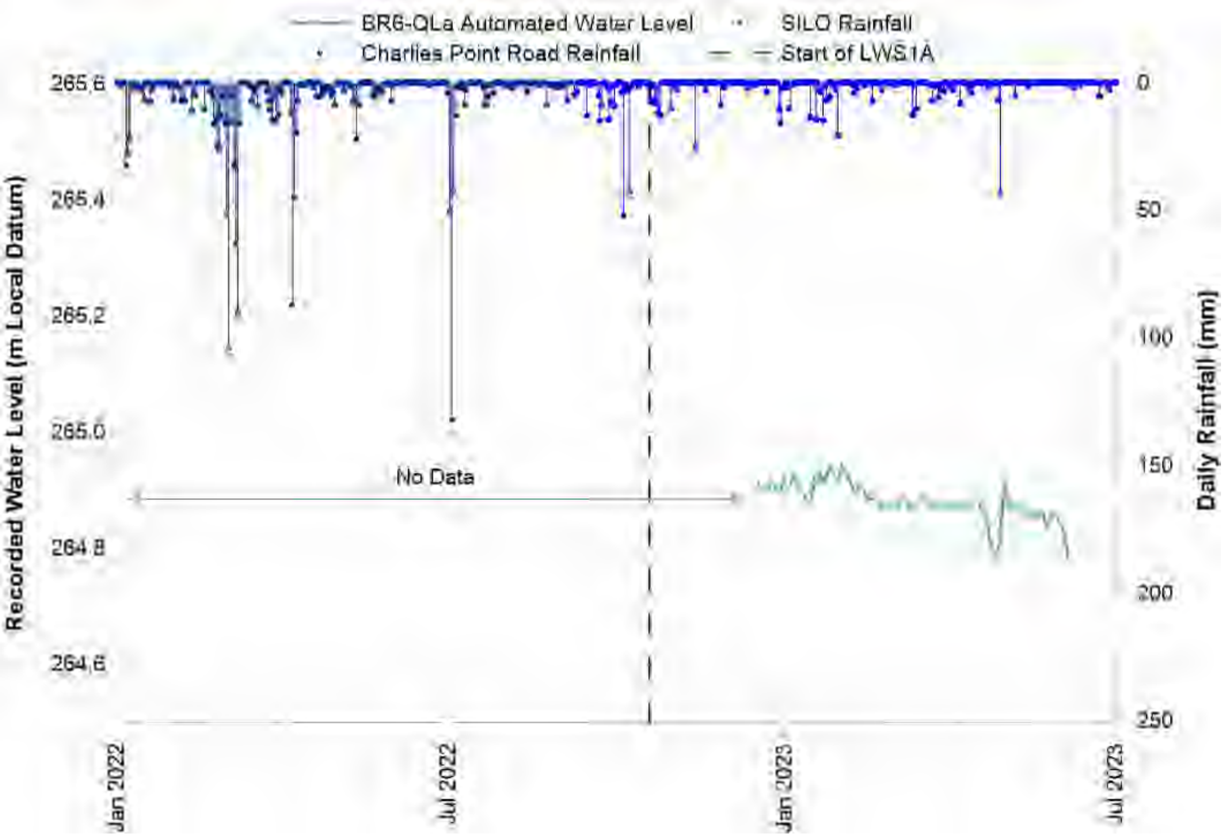

Chart C17: BR6-QLa Water Level Records

Hornes Creek

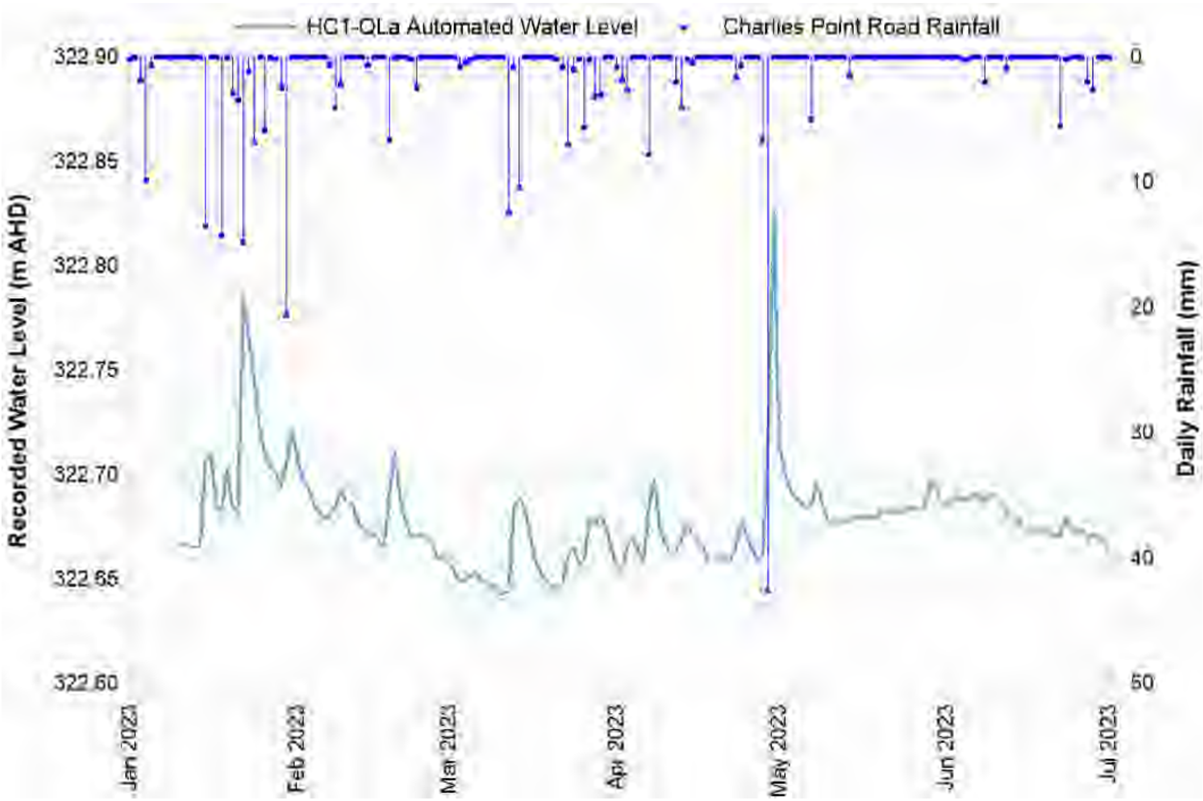

Chart C18: HC1-QLa Water Level Monitoring Data

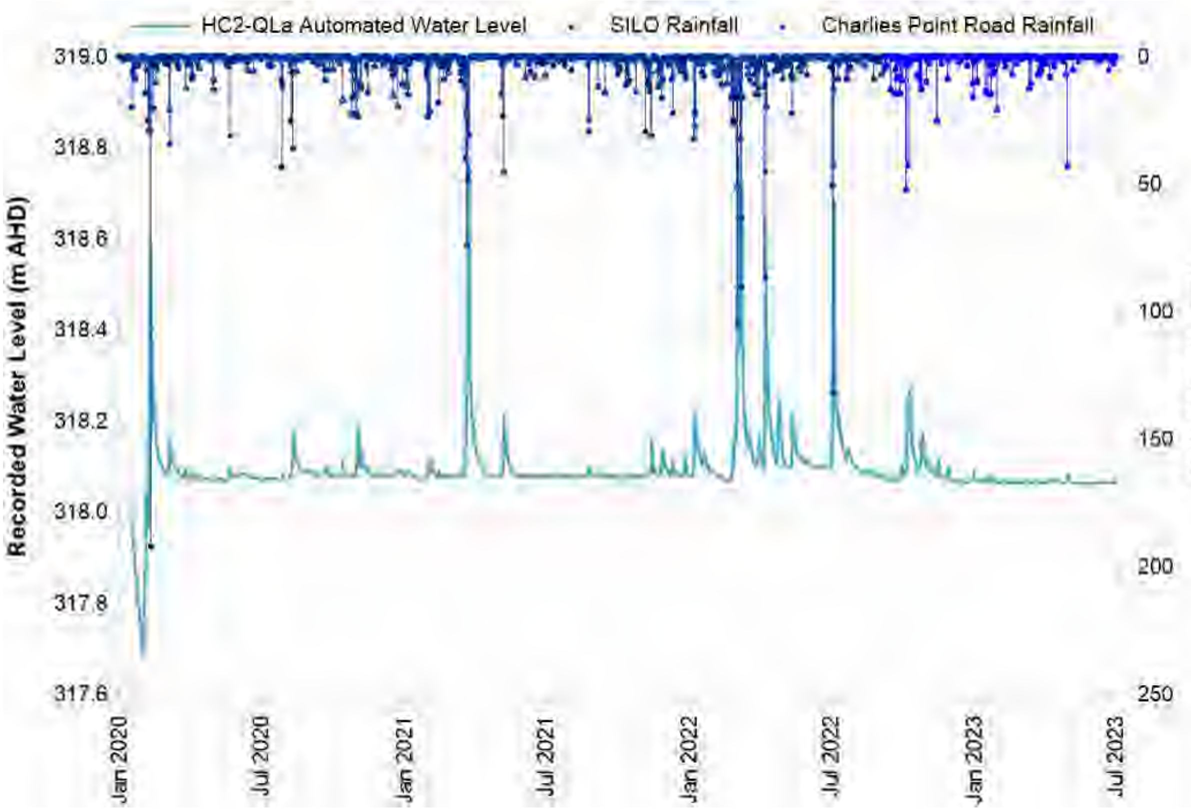

Chart C19: HC2-QLa Water Level Monitoring Data

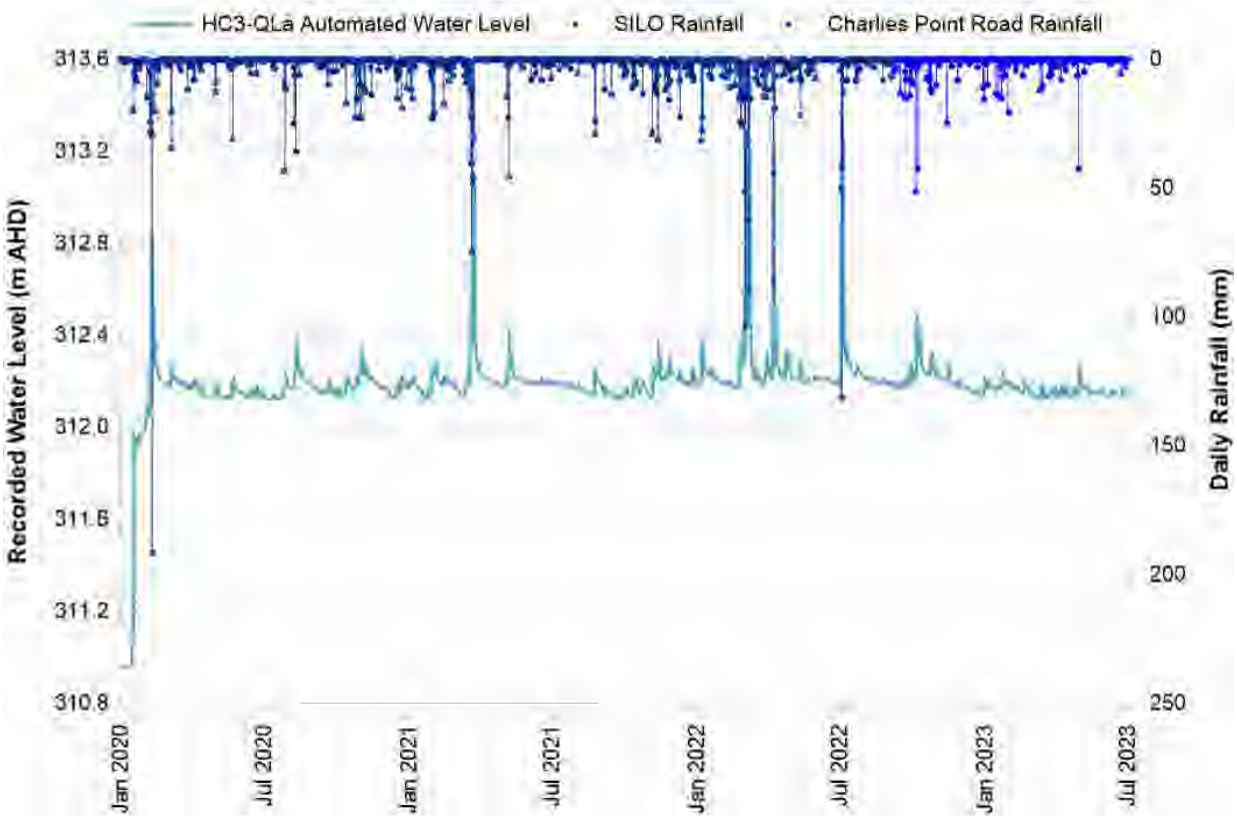

Chart C20: HC3-QLa Water Level Monitoring Data

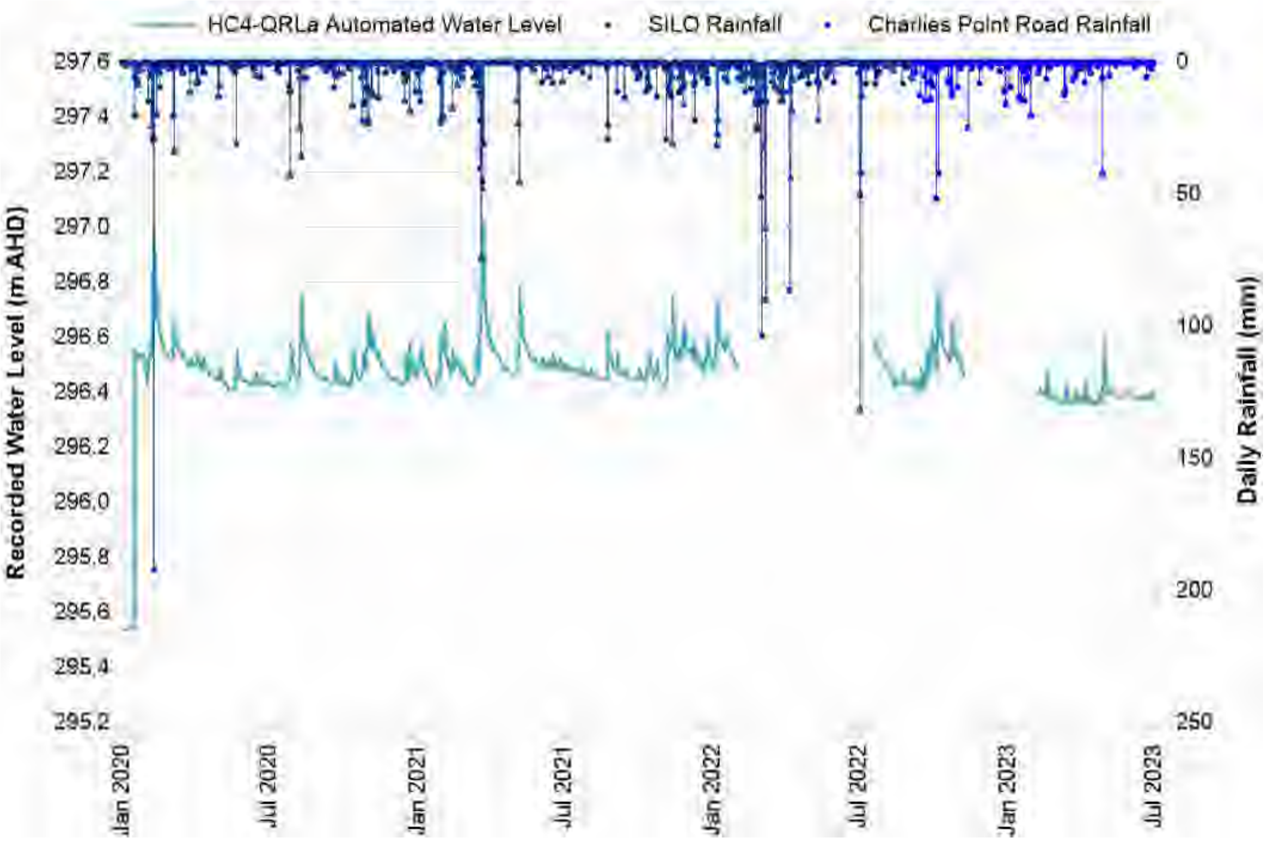

Chart C21: HC4-QRLa Water Level Monitoring Data

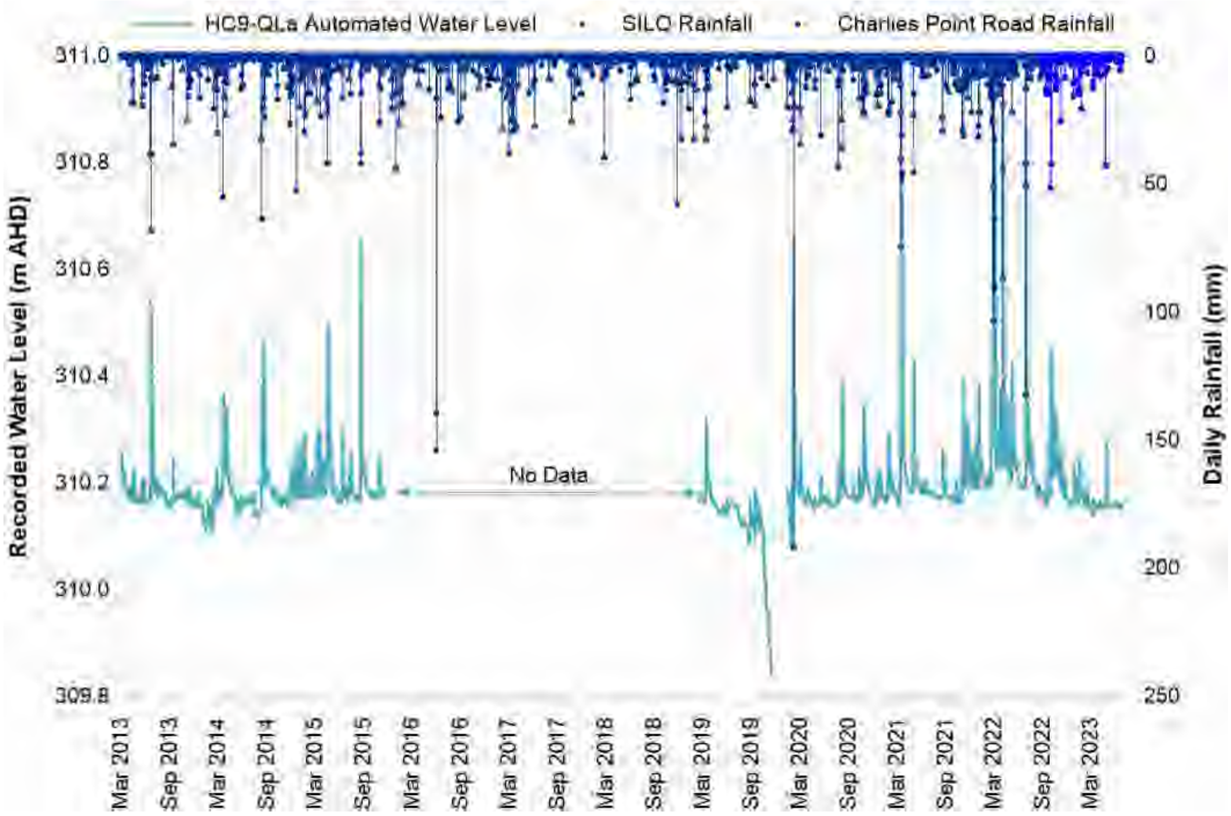

Chart C20: HC9-QLa Water Level Monitoring Data

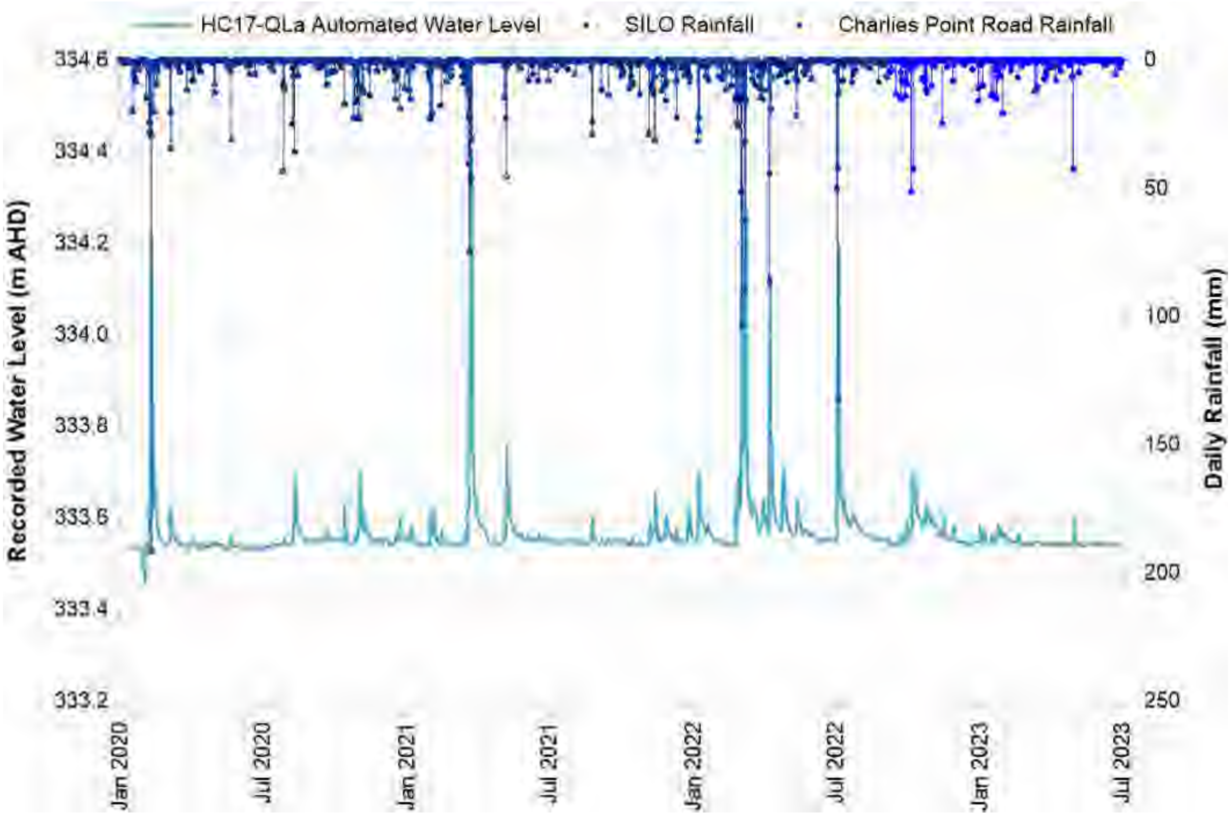

Chart C21: HC17-QLa Water Level Monitoring Data

APPENDIX D – Surface Water Quality Summary Tables

Bargo River (BR12-QLa and BR13-QRLa) Water Quality Summary

Parameter (mg/L unless otherwise stated)	Guideline Value	BR12-QLa					BR13-QRLa				
		No. Samples	Min	Median	Max	% Exceedance	No. Samples	Min	Median	Max	% Exceedance
Field pH	6.5 - 8‡	40	6.1	7.3	9.1	10%	41	0.3	7.0	9.1	15%
Lab pH	6.5 - 8‡	37	5.6	6.7	8.2	35%	39	4.1	6.6	7.8	46%
Field EC (µS/cm)	350‡	40	99.2	193	337	0%	41	64.1	190	406	5%
Lab EC (µS/cm)	350‡	37	98	194	404	3%	37	87	189	490	8%
Field DO	-	40	2.9	9.6	99.3	-	41	4.8	10.0	104.9	-
Sulphate as Turbidimetric SO_4	400*	37	<1	5	24	0%	64	3	5	18	0%
Total Alkalinity as $CaCO_3$	500*	37	4	11	72	0%	64	<1	8	57	0%
Chloride	400*	37	20	45	85	0%	64	16	46	119	0%
Dissolved Calcium	-	37	2	3	19	-	64	1	3	17	-
Dissolved Magnesium	-	37	2	5	13	-	64	1	5	14	-
Dissolved Potassium	-	37	12	23	38	-	64	10	23	50	-
Dissolved Sodium	-	37	2	2	8	-	64	1	2	13	-
Dissolved Aluminium	0.055†	37	<0.01	0.02	0.1	22%	37	<0.01	0.02	0.16	22%
Dissolved Arsenic	0.024†	37	<0.001	0.001	0.002	0%	37	<0.001	0.001	0.001	0%
Dissolved Barium	1*	37	0.01	0.01	0.09	0%	37	0.01	0.01	0.06	0%
Dissolved Copper	0.0014†	37	<0.001	0.001	0.002	3%	37	<0.001	0.001	0.004	3%
Dissolved Iron	0.3*	37	<0.05	0.30	1.56	49%	37	<0.05	0.32	1.52	51%
Dissolved Lead	0.0034†	37	<0.001	0.001	0.001	0%	37	<0.001	0.001	0.001	0%
Dissolved Lithium	-	8	<0.001	0.003	0.008	-	9	<0.001	0.001	0.001	-
Dissolved Manganese	1.9†	37	0.03	0.08	1.10	0%	37	0.03	0.14	0.64	0%

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – the default guideline value relates to the total concentration of a constituent although should also be compared with the dissolved concentration which represents the bioavailable fraction; ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; * ANZECC (2000) water quality guideline value for recreational purposes.

Bargo River (BR12-QLa and BR13-QRLa) Water Quality Summary

Parameter (mg/L unless otherwise stated)	Guideline Value	BR12-QLa					BR13-QRLa				
		No. Samples	Min	Median	Max	% Exceedance	No. Samples	Min	Median	Max	% Exceedance
Dissolved Nickel	0.011†	37	<0.001	0.001	0.006	0%	37	<0.001	0.001	0.006	0%
Dissolved Selenium	0.011†	37	<0.01	0.01	0.01	0%	37	<0.01	0.01	0.01	0%
Dissolved Strontium	-	37	0.01	0.03	0.14	-	37	0.01	0.03	0.13	-
Dissolved Zinc	0.008†	37	<0.005	0.005	0.021	8%	37	<0.005	0.005	0.036	22%
Total Aluminium	0.055†	37	<0.01	0.06	3.06	51%	64	<0.01	0.055	0.92	50%
Total Arsenic	0.024†	37	<0.001	0.001	0.004	0%	64	<0.001	0.001	0.006	0%
Total Barium	1*	37	0.01	0.01	0.10	0%	64	0.01	0.02	0.06	0%
Total Cadmium	0.0002†	0	-	-	-	-	30	<0	0.0001	0.0001	0%
Total Copper	0.0014†	37	<0.001	0.001	0.003	24%	64	<0.001	0.001	0.003	11%
Total Iron	0.3*	37	0.07	0.78	3.62	81%	64	0.12	1.06	3.28	86%
Total Lead	0.0034†	37	<0.001	0.001	0.003	0%	64	<0.001	0.001	0.003	0%
Total Lithium	-	37	<0.001	0.001	0.008	-	64	<0.001	0.001	0.004	-
Total Manganese	1.9†	37	0.04	0.08	1.02	0%	64	0.03	0.14	0.65	0%
Total Nickel	0.011†	37	<0	0.001	0.006	0%	64	<0.001	0.001	0.007	0%
Total Selenium	0.011†	37	<0.01	0.01	0.01	0%	64	<0.01	0.01	0.01	0%
Total Strontium	-	37	0.01	0.03	0.15	-	64	0.01	0.03	0.14	-
Total Zinc	0.008†	37	<0.005	0.006	0.05	24%	64	<0.005	0.006	0.04	33%
Nitrogen Oxides	0.015‡	37	<0.01	0.15	0.78	97%	64	<0.01	0.11	1.54	94%
Total Nitrogen	0.25‡	37	<0.1	0.40	1.4	73%	64	<0.10	0.40	1.9	78%
Total Phosphorus	0.02‡	37	<0.01	0.01	0.2	11%	64	<0.01	0.01	0.16	14%

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – the default guideline value relates to the total concentration of a constituent although should also be compared with the dissolved concentration which represents the bioavailable fraction; ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; * ANZECC (2000) water quality guideline value for recreational purposes.

Bargo River (BR14-QLa) Water Quality Summary

Parameter (mg/L unless otherwise stated)	Guideline Value	BR14-QRLa				
		No. Samples	Min	Median	Max	% Exceedance
Field pH	6.5 - 8‡	41	7.7	8.6	10.7	93%
Lab pH	6.5 - 8‡	35	6.3	8.4	8.9	74%
Field EC (µS/cm)	350‡	41	181.2	1004	2070	85%
Lab EC (µS/cm)	350‡	34	180	977	2260	85%
Field DO	-	41	5.6	9.7	100.0	-
Sulphate as Turbidimetric SO_4	400*	54	6	11	33	0%
Total Alkalinity as $CaCO_3$	500*	54	23	433.5	1100	39%
Chloride	400*	54	22	60	118	0%
Dissolved Calcium	-	54	1	9	20	-
Dissolved Magnesium	-	54	1	8	15	-
Dissolved Potassium	-	54	25	205	504	-
Dissolved Sodium	-	54	2	12	27	-
Dissolved Aluminium	0.055†	34	0.02	0.055	0.2	50%
Dissolved Arsenic	0.024†	34	0.002	0.011	0.051	21%
Dissolved Barium	1*	34	0.09	0.85	2.39	38%
Dissolved Copper	0.0014†	34	<0.001	0.001	0.002	3%
Dissolved Iron	0.3*	34	<0.05	0.16	0.45	32%
Dissolved Lead	0.0034†	34	<0.001	0.001	0.001	0%
Dissolved Lithium	-	8	0.041	0.1395	0.24	-
Dissolved Manganese	1.9†	34	0.004	0.02	0.10	0%

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – the default guideline value relates to the total concentration of a constituent although should also be compared with the dissolved concentration which represents the bioavailable fraction; ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; * ANZECC (2000) water quality guideline value for recreational purposes.

Bargo River (BR14-QLa) Water Quality Summary

Parameter (mg/L unless otherwise stated)	Guideline Value	BR14-QLa				
		No. Samples	Min	Median	Max	% Exceedance
Dissolved Nickel	0.011†	34	0.002	0.024	0.064	62%
Dissolved Selenium	0.011†	34	<0.01	0.01	0.01	0%
Dissolved Strontium	-	34	0.04	0.22	0.52	-
Dissolved Zinc	0.008†	34	<0.005	0.012	0.04	68%
Total Aluminium	0.055†	54	0.03	0.135	0.84	96%
Total Arsenic	0.024†	54	<0.001	0.017	0.086	31%
Total Barium	1*	54	0.1	1.07	4.56	54%
Total Cadmium	0.0002†	20	0.0001	0.0001	0.0001	0%
Total Copper	0.0014†	54	<0.001	0.001	0.006	22%
Total Iron	0.3*	54	<0.05	0.47	1.06	56%
Total Lead	0.0034†	54	<0.001	0.001	0.007	7%
Total Lithium	-	54	0.026	0.5025	1.39	-
Total Manganese	1.9†	54	0.02	0.03	0.11	0%
Total Nickel	0.011†	53	0.002	0.025	0.097	75%
Total Selenium	0.011†	54	<0.01	0.01	0.01	0%
Total Strontium	-	54	0.04	0.26	0.75	-
Total Zinc	0.008†	54	<0.005	0.019	0.11	89%
Nitrogen Oxides	0.015‡	54	0.03	0.93	2.92	100%
Total Nitrogen	0.25‡	54	0.4	1.30	3.3	100%
Total Phosphorus	0.02‡	54	<0.01	0.02	0.15	30%

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – the default guideline value relates to the total concentration of a constituent although should also be compared with the dissolved concentration which represents the bioavailable fraction; ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; * ANZECC (2000) water quality guideline value for recreational purposes.

Teatree Hollow (TT1-QLa and TT4-QLa/TT4A-QLa) Water Quality Summary

Parameter (mg/L unless otherwise stated)	Guideline Value	TT1-QLa					TT4-QLa/TT4A-QLa				
		No. Samples	Min	Median	Max	% Exceedance	No. Samples	Min	Median	Max	% Exceedance
Field pH	6.5 - 8‡	33	6.3	6.8	8.3	24%	11	6.6	7.6	8.3	27%
Lab pH	6.5 - 8‡	32	6.1	6.8	7.7	9%	10	6.5	7.1	8.2	30%
Field EC (µS/cm)	350‡	33	279	467	663	88%	11	157	232	1250	36%
Lab EC (µS/cm)	350‡	32	158	459.5	780	78%	10	170	207.5	1250	30%
Field DO	-	33	0.2	7.8	81.3	-	9	0.2	9.9	99.7	-
Sulphate as Turbidimetric SO_4	400*	32	9	23.5	126	0%	10	6	9	26	0%
Total Alkalinity as $CaCO_3$	500*	32	23	54.5	187	0%	10	35	48	712	10%
Chloride	400*	32	25	88	149	0%	10	12	28.5	109	0%
Dissolved Calcium	-	32	5	10	55	-	10	5	7	34	-
Dissolved Magnesium	-	32	5	13	37	-	10	3	5.5	19	-
Dissolved Potassium	-	32	22	52	72	-	10	22	25.5	234	-
Dissolved Sodium	-	32	3	8	31	-	10	3	4.5	14	-
Dissolved Aluminium	0.055†	32	<0.01	0.02	0.35	25%	10	0.02	0.075	0.66	70%
Dissolved Arsenic	0.024†	32	<0.001	0.001	0.003	0%	10	<0.001	0.001	0.001	0%
Dissolved Barium	1*	32	0.01	0.04	0.15	0%	10	0.04	0.05	0.51	0%
Dissolved Copper	0.0014†	32	<0.001	0.001	0.004	19%	10	<0.001	0.001	0.004	20%
Dissolved Iron	0.3*	31	<0.05	0.39	0.98	68%	9	<0.05	0.24	0.4	33%
Dissolved Lead	0.0034†	32	<0.001	0.001	0.001	0%	10	<0.001	0.001	0.001	0%
Dissolved Lithium	-	11	<0.001	0.001	0.001	-	10	<0.001	0.01	0.642	-
Dissolved Manganese	1.9†	32	0.01	0.10	3.00	3%	10	0.00	0.01	0.07	0%

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – the default guideline value relates to the total concentration of a constituent although should also be compared with the dissolved concentration which represents the bioavailable fraction; ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; * ANZECC (2000) water quality guideline value for recreational purposes.

Teatree Hollow (TT1-QLa and TT4-QLa/TT4A-QLa) Water Quality Summary

Parameter (mg/L unless otherwise stated)	Guideline Value	TT1-QLa					TT4-QLa/TT4A-QLa				
		No. Samples	Min	Median	Max	% Exceedance	No. Samples	Min	Median	Max	% Exceedance
Dissolved Nickel	0.011†	32	<0.001	0.001	0.003	0%	10	<0.001	0.001	0.007	0%
Dissolved Selenium	0.011†	32	<0.01	0.01	0.01	0%	10	<0.01	0.01	0.01	0%
Dissolved Strontium	-	32	0.03	0.09	0.70	-	10	0.04	0.06	0.52	-
Dissolved Zinc	0.008†	32	<0.005	0.017	0.215	75%	10	<0.005	0.005	0.034	30%
Total Aluminium	0.055†	32	0.06	0.17	1.31	100%	10	0.09	0.205	2.44	100%
Total Arsenic	0.024†	32	<0.001	0.001	0.003	0%	10	<0.001	0.001	0.002	0%
Total Barium	1*	32	0.01	0.05	0.16	0%	10	0.03	0.06	0.50	0%
Total Cadmium	0.0002†	0	-	-	-	-	0	-	-	-	-
Total Copper	0.0014†	32	<0.001	0.001	0.008	25%	10	<0.001	0.001	0.004	40%
Total Iron	0.3*	32	0.38	1.30	3.59	100%	10	0.16	0.61	1.3	90%
Total Lead	0.0034†	32	<0.001	0.001	0.003	0%	10	<0.001	0.001	0.006	10%
Total Lithium	-	32	<0.001	0.001	0.003	-	10	<0.001	0.0095	0.71	-
Total Manganese	1.9†	32	0.01	0.12	2.97	3%	10	0.004	0.01	0.13	0%
Total Nickel	0.011†	32	<0.001	0.001	0.01	0%	10	<0.001	0.0015	0.008	0%
Total Selenium	0.011†	32	<0.01	0.01	0.01	0%	10	<0.01	0.01	0.01	0%
Total Strontium	-	32	0.03	0.09	0.74	-	10	0.04	0.06	0.51	-
Total Zinc	0.008†	32	<0.005	0.0185	0.34	72%	10	<0.005	0.005	0.04	40%
Nitrogen Oxides	0.015‡	32	<0.01	0.04	0.57	78%	10	0.05	0.09	3.25	100%
Total Nitrogen	0.25‡	32	0.20	0.55	7.3	94%	10	0.2	0.35	4.0	90%
Total Phosphorus	0.02‡	32	<0.01	0.03	2.58	59%	10	<0.01	0.02	0.44	20%

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – the default guideline value relates to the total concentration of a constituent although should also be compared with the dissolved concentration which represents the bioavailable fraction; ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; * ANZECC (2000) water quality guideline value for recreational purposes.

Teatree Hollow (TT2-QLa and TT3-QLa) Water Quality Summary

Parameter (mg/L unless otherwise stated)	Guideline Value	TT2-QLa					TT3-QLa				
		No. Samples	Min	Median	Max	% Exceedance	No. Samples	Min	Median	Max	% Exceedance
Field pH	6.5 - 8‡	12	5.81	7.05	8.17	42%	7	6.31	6.90	7.4	14%
Lab pH	6.5 - 8‡	12	6.35	6.96	8.34	17%	5	6.2	6.58	7.33	40%
Field EC (µS/cm)	350‡	12	156.7	213	542	8%	7	138.5	183	240	0%
Lab EC (µS/cm)	350‡	12	148	242	542	17%	5	131	159	240	0%
Field DO	-	10	0.16	6.2	11.27	-	6	4.7	9.8	11	-
Sulphate as Turbidimetric SO_4	400*	12	7	11.5	27	0%	5	8	10	11	0%
Total Alkalinity as $CaCO_3$	500*	12	14	29	107	0%	5	21	25	33	0%
Chloride	400*	12	21	40	121	0%	5	23	30	52	0%
Dissolved Calcium	-	12	4	5.5	31	-	5	4	4	5	-
Dissolved Magnesium	-	12	4	5	15	-	5	4	5	5	-
Dissolved Potassium	-	12	10	25	66	-	5	16	19	33	-
Dissolved Sodium	-	12	3	5.5	14	-	5	2	3	4	-
Dissolved Aluminium	0.055†	12	0.02	0.07	0.47	58%	5	<0.01	0.03	0.18	40%
Dissolved Arsenic	0.024†	12	<0.001	0.001	0.006	0%	5	<0.001	0.001	0.001	0%
Dissolved Barium	1*	12	0.01	0.01	0.07	0%	5	0.01	0.01	0.02	0%
Dissolved Copper	0.0014†	12	<0.001	0.001	0.004	8%	5	<0.001	0.001	0.001	0%
Dissolved Iron	0.3*	11	<0.05	0.31	0.75	55%	4	0.18	-	0.51	50%
Dissolved Lead	0.0034†	12	<0.001	0.001	0.002	0%	5	<0.001	0.001	0.001	0%
Dissolved Lithium	-	12	<0.001	0.001	0.001	-	5	<0.001	0.001	0.001	-
Dissolved Manganese	1.9†	12	0.006	0.016	0.652	0%	5	0.007	0.010	0.040	0%

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – the default guideline value relates to the total concentration of a constituent although should also be compared with the dissolved concentration which represents the bioavailable fraction; ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; * ANZECC (2000) water quality guideline value for recreational purposes.

Teatree Hollow (TT2-QLa and TT3-QLa) Water Quality Summary

Parameter (mg/L unless otherwise stated)	Guideline Value	TT2-QLa					TT3-QLa				
		No. Samples	Min	Median	Max	% Exceedance	No. Samples	Min	Median	Max	% Exceedance
Dissolved Nickel	0.011†	12	<0.001	0.001	0.002	0%	5	<0.001	0.001	0.001	0%
Dissolved Selenium	0.011†	12	<0.01	0.01	0.01	0%	5	<0.01	0.01	0.01	0%
Dissolved Strontium	-	12	0.025	0.03	0.276	-	5	0.022	0.03	0.029	-
Dissolved Zinc	0.008†	12	<0.005	0.012	0.034	50%	5	<0.005	0.005	0.006	0%
Total Aluminium	0.055†	12	0.07	0.175	3.39	100%	5	0.08	0.12	0.52	100%
Total Arsenic	0.024†	12	<0.001	0.001	0.01	0%	5	<0.001	0.001	0.001	0%
Total Barium	1*	12	0.01	0.01	0.09	0%	5	0.01	0.01	0.02	0%
Total Cadmium	0.0002†	0	-	-	-	-	0	-	-	-	-
Total Copper	0.0014†	12	<0.001	0.001	0.012	17%	5	<0.001	0.001	0.001	0%
Total Iron	0.3*	12	0.22	0.48	1.95	83%	5	0.43	0.52	0.92	100%
Total Lead	0.0034†	12	<0.001	0.001	0.006	8%	5	<0.001	0.001	0.001	0%
Total Lithium	-	12	<0.001	0.001	0.001	-	5	<0.001	0.001	0.001	-
Total Manganese	1.9†	12	0.006	0.0165	0.779	0%	5	0.006	0.01	0.044	0%
Total Nickel	0.011†	12	<0.001	0.001	0.005	0%	5	<0.001	0.001	0.002	0%
Total Selenium	0.011†	12	<0.01	0.01	0.01	0%	5	<0.01	0.01	0.01	0%
Total Strontium	-	12	0.02	0.03	0.30	-	5	0.02	0.03	0.03	-
Total Zinc	0.008†	12	<0.005	0.014	0.05	67%	5	<0.005	0.005	0.012	20%
Nitrogen Oxides	0.015‡	12	<0.01	0.055	0.57	92%	5	<0.01	0.04	0.07	80%
Total Nitrogen	0.25‡	12	0.20	0.40	5.00	75%	5	0.20	0.20	0.40	40%
Total Phosphorus	0.02‡	12	<0.01	0.02	0.79	33%	5	<0.01	0.01	0.03	20%

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – the default guideline value relates to the total concentration of a constituent although should also be compared with the dissolved concentration which represents the bioavailable fraction; ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; * ANZECC (2000) water quality guideline value for recreational purposes.

Teatree Hollow (TT7-QLa and TT8-QRLa) Water Quality Summary

Parameter (mg/L unless otherwise stated)	Guideline Value	TT7-QLa					TT8-QRLa				
		No. Samples	Min	Median	Max	% Exceedance	No. Samples	Min	Median	Max	% Exceedance
Field pH	6.5 - 8‡	33	6.4	7.0	8.0	15%	29	6.8	8.7	8.9	97%
Lab pH	6.5 - 8‡	35	5.8	6.6	7.4	29%	30	8.5	8.7	8.8	100%
Field EC (µS/cm)	350‡	33	147.9	258	687	30%	29	147	2120	2490	93%
Lab EC (µS/cm)	350‡	35	137	246	703	34%	29	1250	2120	2490	100%
Field DO	-	33	0.7	9.6	98.2	-	7	9.3	11.3	102.8	-
Sulphate as Turbidimetric SO_4	400*	35	6	9	36	0%	51	11	19	40	0%
Total Alkalinity as $CaCO_3$	500*	35	11	33	126	0%	51	609	984	1320	100%
Chloride	400*	35	24	50	195	0%	51	50	80	122	0%
Dissolved Calcium	-	35	3	5	42	-	51	5	18	27	-
Dissolved Magnesium	-	35	4	6	15	-	51	9	14	21	-
Dissolved Potassium	-	35	17	34	81	-	51	250	468	651	-
Dissolved Sodium	-	35	3	4	12	-	51	14	24	40	-
Dissolved Aluminium	0.055†	35	<0.01	0.03	0.27	29%	29	<0.01	0.04	0.11	38%
Dissolved Arsenic	0.024†	35	<0.001	0.001	0.002	0%	29	0.022	0.057	0.094	86%
Dissolved Barium	1*	35	0.01	0.02	0.15	0%	29	1.28	2.50	5.36	100%
Dissolved Copper	0.0014†	35	<0.001	0.001	0.004	9%	29	<0.001	0.001	0.007	45%
Dissolved Iron	0.3*	34	0.07	0.52	1.54	82%	29	<0.05	0.05	0.48	3%
Dissolved Lead	0.0034†	35	<0.001	0.001	0.001	0%	29	<0.001	0.001	0.003	0%
Dissolved Lithium	-	11	<0.001	0.001	0.004	-	6	0.563	0.8885	1.09	-
Dissolved Manganese	1.9†	35	0.01	0.06	0.59	0%	29	0.004	0.02	0.06	0%

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – the default guideline value relates to the total concentration of a constituent although should also be compared with the dissolved concentration which represents the bioavailable fraction; ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; * ANZECC (2000) water quality guideline value for recreational purposes.

Teatree Hollow (TT7-QLa and TT8-QRLa) Water Quality Summary

Parameter (mg/L unless otherwise stated)	Guideline Value	TT7-QLa					TT8-QRLa				
		No. Samples	Min	Median	Max	% Exceedance	No. Samples	Min	Median	Max	% Exceedance
Dissolved Nickel	0.011†	35	<0.001	0.002	0.011	0%	29	0.019	0.053	0.081	100%
Dissolved Selenium	0.011†	35	<0.01	0.01	0.01	0%	29	<0.01	0.01	0.01	0%
Dissolved Strontium	-	35	0.02	0.03	0.18	-	29	0.34	0.54	0.90	-
Dissolved Zinc	0.008†	35	<0.005	0.011	0.091	60%	29	0.02	0.045	0.111	100%
Total Aluminium	0.055†	35	0.06	0.16	0.75	100%	51	0.02	0.11	0.70	86%
Total Arsenic	0.024†	35	<0.001	0.001	0.002	0%	51	0.023	0.069	0.162	92%
Total Barium	1*	35	0.01	0.03	0.13	0%	51	1.32	3.08	6.47	100%
Total Cadmium	0.0002†	0	-	-	-	-	22	0.0001	0.0001	0.0003	9%
Total Copper	0.0014†	35	<0.001	0.001	0.004	11%	51	<0.001	0.002	0.006	75%
Total Iron	0.3*	35	0.39	0.90	3.04	100%	51	<0.05	0.10	0.77	6%
Total Lead	0.0034†	35	<0.001	0.001	0.002	0%	51	<0.001	0.002	0.015	24%
Total Lithium	-	35	<0.001	0.001	0.005	-	51	0.625	1.22	1.82	-
Total Manganese	1.9†	35	0.01	0.07	0.67	0%	51	0.01	0.02	0.10	0%
Total Nickel	0.011†	35	<0.001	0.002	0.01	0%	50	0.019	0.059	0.111	100%
Total Selenium	0.011†	35	<0.01	0.01	0.01	0%	51	<0.01	0.01	0.01	0%
Total Strontium	-	35	0.02	0.03	0.18	-	50	0.35	0.67	1.12	-
Total Zinc	0.008†	35	<0.005	0.023	0.09	71%	51	0.017	0.067	0.32	100%
Nitrogen Oxides	0.015‡	35	<0.01	0.05	2.47	80%	51	0.20	1.82	12.50	100%
Total Nitrogen	0.25‡	35	<0.1	0.30	4.5	57%	51	1.60	2.80	13.5	100%
Total Phosphorus	0.02‡	35	<0.01	0.01	0.13	20%	51	<0.01	0.03	0.14	55%

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – the default guideline value relates to the total concentration of a constituent although should also be compared with the dissolved concentration which represents the bioavailable fraction; ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; * ANZECC (2000) water quality guideline value for recreational purposes.

Teatree Hollow (TT12-QLa and TT13-QLa) Water Quality Summary

Parameter (mg/L unless otherwise stated)	Guideline Value	TT12-QLa					TT13-QLa				
		No. Samples	Min	Median	Max	% Exceedance	No. Samples	Min	Median	Max	% Exceedance
Field pH	6.5 - 8‡	14	6.5	7.2	7.5	0%	13	6.3	6.8	7.2	23%
Lab pH	6.5 - 8‡	13	6.1	6.8	7.6	15%	13	5.7	6.5	7.4	62%
Field EC (µS/cm)	350‡	14	167.7	203	260	0%	13	130.8	163.9	218	0%
Lab EC (µS/cm)	350‡	13	165	187	250	0%	13	119	152	377	8%
Field DO	-	13	8.5	10.8	108.3	-	12	7.7	9.8	99.9	-
Sulphate as Turbidimetric SO_4	400*	13	<4	6	9	0%	13	7	9	15	0%
Total Alkalinity as $CaCO_3$	500*	13	34	43	54	0%	13	13	22	76	0%
Chloride	400*	13	24	32	44	0%	13	22	28	66	0%
Dissolved Calcium	-	13	4	5	6	-	13	2	3	15	-
Dissolved Magnesium	-	13	5	6	8	-	13	3	4	12	-
Dissolved Potassium	-	13	20	24	36	-	13	15	20	42	-
Dissolved Sodium	-	13	3	3	5	-	13	2	4	8	-
Dissolved Aluminium	0.055†	13	<0.01	0.06	0.23	54%	13	<0.01	0.02	0.21	23%
Dissolved Arsenic	0.024†	13	<0.001	0.001	0.001	0%	13	<0.001	0.001	0.001	0%
Dissolved Barium	1*	13	0.01	0.01	0.02	0%	13	0.01	0.01	0.04	0%
Dissolved Copper	0.0014†	13	<0.001	0.001	0.002	8%	13	<0.001	0.001	0.003	8%
Dissolved Iron	0.3*	12	0.13	0.33	0.82	58%	12	0.07	0.23	0.79	33%
Dissolved Lead	0.0034†	13	<0.001	0.001	0.001	0%	13	<0.001	0.001	0.001	0%
Dissolved Lithium	-	13	<0.001	0.001	0.005	-	13	<0.001	0.001	0.001	-
Dissolved Manganese	1.9†	13	0.01	0.02	0.02	0%	13	0.00	0.01	0.07	0%

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – the default guideline value relates to the total concentration of a constituent although should also be compared with the dissolved concentration which represents the bioavailable fraction; ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; * ANZECC (2000) water quality guideline value for recreational purposes.

Teatree Hollow (TT12-QLa and TT13-QLa) Water Quality Summary

Parameter (mg/L unless otherwise stated)	Guideline Value	TT12-QLa					TT13-QLa				
		No. Samples	Min	Median	Max	% Exceedance	No. Samples	Min	Median	Max	% Exceedance
Dissolved Nickel	0.011†	13	<0.001	0.001	0.001	0%	13	<0.001	0.001	0.001	0%
Dissolved Selenium	0.011†	13	<0.01	0.01	0.01	0%	13	<0.01	0.01	0.01	0%
Dissolved Strontium	-	13	0.03	0.03	0.05	-	13	0.02	0.02	0.09	-
Dissolved Zinc	0.008†	13	<0.005	0.005	0.012	8%	13	<0.005	0.005	0.007	0%
Total Aluminium	0.055†	13	0.08	0.14	0.39	100%	13	0.06	0.09	0.49	100%
Total Arsenic	0.024†	13	<0.001	0.001	0.001	0%	13	<0.001	0.001	0.001	0%
Total Barium	1*	13	0.01	0.01	0.02	0%	13	0.01	0.01	0.04	0%
Total Cadmium	0.0002†	0	-	-	-	-	0	-	-	-	-
Total Copper	0.0014†	13	<0.001	0.001	0.049	15%	13	<0.001	0.001	0.001	0%
Total Iron	0.3*	13	0.27	0.79	1.24	85%	13	0.22	0.48	1.3	77%
Total Lead	0.0034†	13	<0.001	0.001	0.003	0%	13	<0.001	0.001	0.001	0%
Total Lithium	-	13	<0.001	0.001	0.004	-	13	<0.001	0.001	0.001	-
Total Manganese	1.9†	13	0.01	0.01	0.03	0%	13	0.004	0.01	0.07	0%
Total Nickel	0.011†	13	<0.001	0.001	0.002	0%	13	<0.001	0.001	0.001	0%
Total Selenium	0.011†	13	<0.01	0.01	0.01	0%	13	<0.01	0.01	0.01	0%
Total Strontium	-	13	0.03	0.03	0.05	-	13	0.02	0.02	0.10	-
Total Zinc	0.008†	13	<0.005	0.005	0.04	15%	13	<0.005	0.005	0.01	8%
Nitrogen Oxides	0.015‡	13	<0.01	0.07	0.13	92%	13	<0.01	0.01	0.06	38%
Total Nitrogen	0.25‡	13	<0.10	0.40	0.8	85%	13	<0.1	0.20	0.7	23%
Total Phosphorus	0.02‡	13	<0.01	0.02	0.05	15%	13	<0.01	0.01	0.06	31%

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – the default guideline value relates to the total concentration of a constituent although should also be compared with the dissolved concentration which represents the bioavailable fraction; ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; * ANZECC (2000) water quality guideline value for recreational purposes.

Teatree Hollow (TT14-QLa) Water Quality Summary

Parameter (mg/L unless otherwise stated)	Guideline Value	TT14-QLa				
		No. Samples	Min	Median	Max	% Exceedance
Field pH	6.5 - 8‡	16	6.6	7.3	7.6	0%
Lab pH	6.5 - 8‡	15	6.1	6.9	7.9	20%
Field EC (µS/cm)	350‡	16	167	207	502	13%
Lab EC (µS/cm)	350‡	15	155	195	389	13%
Field DO	-	16	8.4	10.0	109.3	-
Sulphate as Turbidimetric SO_4	400*	15	18	24	52	0%
Total Alkalinity as $CaCO_3$	500*	15	3	4	6	0%
Chloride	400*	15	24	34	61	0%
Dissolved Calcium	-	15	<4	8	9	-
Dissolved Magnesium	-	15	27	43	152	-
Dissolved Potassium	-	15	4	5	23	-
Dissolved Sodium	-	15	5	5	10	-
Dissolved Aluminium	0.055†	15	<0.01	0.05	0.25	47%
Dissolved Arsenic	0.024†	15	<0.001	<0.001	<0.001	0%
Dissolved Barium	1*	15	0.01	0.02	0.14	0%
Dissolved Copper	0.0014†	15	<0.001	<0.001	<0.001	0%
Dissolved Iron	0.3*	14	0.1	0.39	0.61	71%
Dissolved Lead	0.0034†	15	<0.001	<0.001	<0.001	0%
Dissolved Lithium	-	15	<0.001	0.002	0.018	-
Dissolved Manganese	1.9†	15	0.01	0.02	0.34	0%

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – the default guideline value relates to the total concentration of a constituent although should also be compared with the dissolved concentration which represents the bioavailable fraction; ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; * ANZECC (2000) water quality guideline value for recreational purposes.

Teatree Hollow (TT14-QLa) Water Quality Summary

Parameter (mg/L unless otherwise stated)	Guideline Value	TT14-QLa				
		No. Samples	Min	Median	Max	% Exceedance
Dissolved Nickel	0.011†	15	<0.001	<0.001	0.002	0%
Dissolved Selenium	0.011†	15	<0.01	<0.01	<0.01	0%
Dissolved Strontium	-	15	0.02	0.03	0.14	-
Dissolved Zinc	0.008†	15	<0.005	<0.005	0.006	0%
Total Aluminium	0.055†	15	0.04	0.18	1.14	93%
Total Arsenic	0.024†	15	<0.001	<0.001	<0.001	0%
Total Barium	1*	15	0.01	0.02	0.18	0%
Total Cadmium	0.0002†	0	-	-	-	-
Total Copper	0.0014†	15	<0.001	<0.001	0.027	13%
Total Iron	0.3*	15	0.35	0.82	1.51	100%
Total Lead	0.0034†	15	<0.001	<0.001	<0.001	0%
Total Lithium	-	15	<0.001	<0.001	0.017	-
Total Manganese	1.9†	15	0.01	0.02	0.49	-
Total Nickel	0.011†	15	<0.001	<0.001	0.004	0%
Total Selenium	0.011†	15	<0.01	<0.01	<0.01	0%
Total Strontium	-	15	0.02	0.04	0.16	-
Total Zinc	0.008†	15	<0.005	<0.005	0.02	27%
Nitrogen Oxides	0.015‡	15	<0.01	0.04	0.06	60%
Total Nitrogen	0.25‡	15	<0.1	0.20	0.6	47%
Total Phosphorus	0.02‡	15	<0.01	<0.01	0.04	13%

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – the default guideline value relates to the total concentration of a constituent although should also be compared with the dissolved concentration which represents the bioavailable fraction; ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; * ANZECC (2000) water quality guideline value for recreational purposes.

Hornes Creek (HC1-QLa and HC2-QLa) Water Quality Summary

Parameter (mg/L unless otherwise stated)	Guideline Value	HC1-QLa					HC2-QLa				
		No. Samples	Min	Median	Max	% Exceedance	No. Samples	Min	Median	Max	% Exceedance
Field pH	6.5 - 8‡	36	6.27	6.92	8.14	14%	32	6.12	6.64	8.63	44%
Lab pH	6.5 - 8‡	31	5.80	6.58	7.19	29%	27	5.46	6.19	7.59	89%
Field EC (µS/cm)	350‡	36	137.9	228	350	0%	32	61.7	137.5	339	0%
Lab EC (µS/cm)	350‡	31	129	240	331	0%	27	62	153	449	4%
Field DO	-	36	1.34	8.15	97.2	-	32	0.17	10.05	99.8	-
Sulphate as Turbidimetric SO_4	400*	31	14	25	36	0%	27	10	19	35	0%
Total Alkalinity as $CaCO_3$	500*	31	2	4	7	0%	27	<1	2	12	0%
Chloride	400*	30	19	40	65	0%	26	14	34	70	0%
Dissolved Calcium	-	30	4	12	35	-	26	2	4	26	-
Dissolved Magnesium	-	31	15	30	56	-	27	4	7	148	-
Dissolved Potassium	-	31	4	7	18	-	27	1	2	37	-
Dissolved Sodium	-	31	3	5	9	-	27	1	3	20	-
Dissolved Aluminium	0.055†	31	<0.01	0.04	0.33	45%	27	<0.01	0.02	0.12	33%
Dissolved Arsenic	0.024†	31	<0.001	0.001	0.002	0%	27	<0.001	0.001	0.002	0%
Dissolved Barium	1*	30	0.01	0.02	0.07	0%	26	0.01	0.04	0.091	0%
Dissolved Copper	0.0014†	31	<0.001	0.001	0.003	23%	27	<0.001	0.001	0.003	4%
Dissolved Iron	0.3*	31	<0.05	0.36	2.22	71%	27	0.06	0.15	0.44	15%
Dissolved Lead	0.0034†	31	<0.001	0.001	0.001	0%	27	<0.001	0.001	0.001	0%
Dissolved Lithium	-	8	<0.001	0.001	0.001	-	7	<0.001	0.001	0.001	-
Dissolved Manganese	1.9†	31	0.02	0.13	1.30	0%	27	0.02	0.07	1.07	0%

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – the default guideline value relates to the total concentration of a constituent although should also be compared with the dissolved concentration which represents the bioavailable fraction; ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; * ANZECC (2000) water quality guideline value for recreational purposes.

Hornes Creek (HC1-QLa and HC2-QLa) Water Quality Summary

Parameter (mg/L unless otherwise stated)	Guideline Value	HC1-QLa					HC2-QLa				
		No. Samples	Min	Median	Max	% Exceedance	No. Samples	Min	Median	Max	% Exceedance
Dissolved Nickel	0.011†	31	<0.001	0.001	0.007	0%	27	<0.001	0.001	0.002	0%
Dissolved Selenium	0.011†	31	<0.01	0.01	0.01	0%	27	<0.01	0.01	0.01	0%
Dissolved Strontium	-	31	0.02	0.04	0.14	0%	27	0.00	0.01	0.47	0%
Dissolved Zinc	0.008†	31	<0.005	0.005	0.023	19%	27	<0.005	0.01	0.02	59%
Total Aluminium	0.055†	31	0.07	0.17	1.74	100%	27	0.05	0.1	1.1	93%
Total Arsenic	0.024†	31	<0.001	0.001	0.002	0%	27	<0.001	0.001	0.002	0%
Total Barium	1*	30	0.01	0.03	0.06	0%	26	0.008	0.04	0.09	0%
Total Cadmium	0.0002†	0	-	-	-	-	0	-	-	-	-
Total Copper	0.0014†	31	<0.001	0.001	0.009	32%	27	<0.001	0.001	0.002	7%
Total Iron	0.3*	31	0.46	1.43	5.64	100%	27	0.09	0.44	1.13	70%
Total Lead	0.0034†	31	<0.001	0.001	0.002	0%	27	<0.001	0.001	0.001	0%
Total Lithium	-	31	<0.001	0.001	0.001	0%	27	<0.001	0.001	0.001	0%
Total Manganese	1.9†	31	0.03	0.15	1.10	0%	27	0.02	0.07	1.25	0%
Total Nickel	0.011†	31	<0.001	0.001	0.007	0%	27	<0.001	0.001	0.003	0%
Total Selenium	0.011†	31	<0.01	0.01	0.01	0%	27	<0.01	0.01	0.01	0%
Total Strontium	-	31	0.02	0.04	0.14	0%	27	0.00	0.01	0.48	0%
Total Zinc	0.008†	31	<0.005	0.008	0.033	45%	27	<0.005	0.011	0.025	63%
Nitrogen Oxides	0.015‡	30	<0.01	0.10	1.98	80%	26	<0.01	0.04	0.38	77%
Total Nitrogen	0.25‡	31	<0.1	0.40	2.70	90%	27	<0.10	0.20	3.00	37%
Total Phosphorus	0.02‡	31	<0.01	0.03	0.34	58%	27	<0.01	0.01	0.18	11%

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – the default guideline value relates to the total concentration of a constituent although should also be compared with the dissolved concentration which represents the bioavailable fraction; ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; * ANZECC (2000) water quality guideline value for recreational purposes.

Hornes Creek (HC3-QLa and HC4-QRLa) Water Quality Summary

Parameter (mg/L unless otherwise stated)	Guideline Value	HC3-QRLa					HC4-QRLa				
		No. Samples	Min	Median	Max	% Exceedance	No. Samples	Min	Median	Max	% Exceedance
Field pH	6.5 - 8‡	37	6.57	7.15	8.22	5%	36	6.67	7.43	8.40	6%
Lab pH	6.5 - 8‡	31	5.73	6.56	7.25	45%	29	5.8	6.62	7.39	28%
Field EC (µS/cm)	350‡	37	102.2	211	306	0%	36	113.7	241.5	536	14%
Lab EC (µS/cm)	350‡	31	111	211	293	0%	29	109	254	436	10%
Field DO	-	37	0.69	9.83	102.7	-	36	1.25	10.345	102.1	-
Sulphate as Turbidimetric SO_4	400*	31	12	25	33	0%	29	14	30	47	0%
Total Alkalinity as $CaCO_3$	500*	31	<1	3	6	0%	29	<1	3	9	0%
Chloride	400*	30	16	39	62	0%	28	21	52.5	101	0%
Dissolved Calcium	-	30	5	8.5	20	-	28	1	9	31	-
Dissolved Magnesium	-	31	9	24	57	-	29	12	21	66	-
Dissolved Potassium	-	31	2	6	14	-	29	2	6	16	-
Dissolved Sodium	-	31	3	5	7	-	29	3	6	12	-
Dissolved Aluminium	0.055†	31	<0.01	0.05	0.45	42%	29	<0.01	0.03	0.22	31%
Dissolved Arsenic	0.024†	31	<0.001	0.001	0.001	0%	29	<0.001	0.001	0.002	0%
Dissolved Barium	1*	30	0.01	0.02	0.03	0%	28	0.01	0.02	0.07	0%
Dissolved Copper	0.0014†	31	<0.001	0.001	0.002	19%	29	<0.001	0.001	0.003	24%
Dissolved Iron	0.3*	31	0.06	0.28	1.36	48%	29	<0.05	0.32	2.78	52%
Dissolved Lead	0.0034†	31	<0.001	0.001	0.001	0%	29	<0.001	0.001	0.001	0%
Dissolved Lithium	-	7	<0.001	0.001	0.001	-	5	<0.001	0.001	0.001	-
Dissolved Manganese	1.9†	31	0.022	0.048	0.337	0%	29	0.02	0.05	2.57	3%

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – the default guideline value relates to the total concentration of a constituent although should also be compared with the dissolved concentration which represents the bioavailable fraction; ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; * ANZECC (2000) water quality guideline value for recreational purposes.

Hornes Creek (HC3-QLa and HC4-QRLa) Water Quality Summary

Parameter (mg/L unless otherwise stated)	Guideline Value	HC3-QLa					HC4-QRLa				
		No. Samples	Min	Median	Max	% Exceedance	No. Samples	Min	Median	Max	% Exceedance
Dissolved Nickel	0.011†	31	<0.001	0.001	0.001	0%	29	<0.001	0.001	0.003	0%
Dissolved Selenium	0.011†	31	<0.01	0.01	0.01	0%	29	<0.01	0.01	0.01	0%
Dissolved Strontium	-	31	0.014	0.03	0.105	0%	29	0.01	0.04	0.13	0%
Dissolved Zinc	0.008†	31	<0.005	0.005	0.01	10%	29	<0.005	0.005	0.019	14%
Total Aluminium	0.055†	31	0.07	0.14	1.45	100%	29	0.02	0.09	4.65	76%
Total Arsenic	0.024†	31	<0.001	0.001	0.001	0%	29	<0.001	0.001	0.002	0%
Total Barium	1*	30	0.01	0.02	0.04	0%	28	0.01	0.03	0.08	0%
Total Cadmium	0.0002†	0	-	-	-	-	0	-	-	-	-
Total Copper	0.0014†	31	<0.001	0.001	0.004	13%	29	<0.001	0.001	0.005	21%
Total Iron	0.3*	31	0.35	0.83	1.65	100%	29	0.28	1.01	5.01	97%
Total Lead	0.0034†	31	<0.001	0.001	0.003	0%	29	<0.001	0.001	0.005	3%
Total Lithium	-	31	<0.001	0.001	0.001	0%	29	<0.001	0.001	0.002	0%
Total Manganese	1.9†	31	0.027	0.056	0.311	0%	29	0.02	0.06	2.31	3%
Total Nickel	0.011†	31	<0.001	0.001	0.002	0%	29	<0.001	0.001	0.004	0%
Total Selenium	0.011†	31	<0.01	0.01	0.01	0%	29	<0.01	0.01	0.01	0%
Total Strontium	-	31	0.02	0.04	0.11	0%	29	0.02	0.04	0.14	0%
Total Zinc	0.008†	31	<0.005	0.005	0.028	16%	29	<0.005	0.005	0.022	28%
Nitrogen Oxides	0.015‡	30	<0.01	0.08	1.13	87%	28	<0.01	0.06	0.88	82%
Total Nitrogen	0.25‡	31	<0.1	0.50	3.80	81%	29	<0.1	0.40	2.20	76%
Total Phosphorus	0.02‡	31	<0.01	0.02	0.11	32%	29	<0.01	0.02	0.19	34%

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – the default guideline value relates to the total concentration of a constituent although should also be compared with the dissolved concentration which represents the bioavailable fraction; ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; * ANZECC (2000) water quality guideline value for recreational purposes.

Hornes Creek (HC9-QLa and HC17-QLa) Water Quality Summary

Parameter (mg/L unless otherwise stated)	Guideline Value	HC9-QLa					HC17-QLa				
		No. Samples	Min	Median	Max	% Exceedance	No. Samples	Min	Median	Max	% Exceedance
Field pH	6.5 - 8.‡	40	3.14	6.89	8.37	38%	39	5.67	6.91	8.47	21%
Lab pH	6.5 - 8‡	35	4.02	6.37	7.31	54%	37	5.58	6.5	7.2	46%
Field EC (µS/cm)	350‡	40	113.4	241.5	694	23%	39	85.9	169	401	10%
Lab EC (µS/cm)	350‡	35	111	251	767	20%	37	1	176	478	11%
Field DO	-	40	1.61	9.41	102.6	-	39	0.27	9.76	100	-
Sulphate as Turbidimetric SO_4	400*	54	13	32	96	0%	37	11	21	43	0%
Total Alkalinity as $CaCO_3$	500*	54	<1	3	8	0%	37	<1	3	15	0%
Chloride	400*	53	16	51	250	0%	36	15	38.5	109	0%
Dissolved Calcium	-	53	2	8	20	-	36	4	8	38	-
Dissolved Magnesium	-	54	1	20	65	-	37	6	13	82	-
Dissolved Potassium	-	54	2	5	17	-	37	2	4	23	-
Dissolved Sodium	-	54	2	6	17	-	37	2	3	16	-
Dissolved Aluminium	0.055†	35	<0.01	0.04	0.34	37%	37	<0.01	0.05	0.88	49%
Dissolved Arsenic	0.024†	35	<0.001	0.001	0.001	0%	37	<0.001	0.001	0.004	0%
Dissolved Barium	1*	34	0.01	0.03	0.23	0%	36	0.00	0.01	0.07	0%
Dissolved Copper	0.0014†	35	<0.001	0.001	0.004	29%	37	<0.001	0.001	0.006	16%
Dissolved Iron	0.3*	35	0.23	0.95	13.4	83%	37	0.07	0.26	1.84	38%
Dissolved Lead	0.0034†	35	<0.001	0.001	0.001	0%	36	<0.001	0.001	0.001	0%
Dissolved Lithium	-	7	<0.001	0.001	0.001	-	8	<0.001	0.001	0.001	-
Dissolved Manganese	1.9†	35	0.02	0.15	2.28	9%	37	0.02	0.06	1.61	0%

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – the default guideline value relates to the total concentration of a constituent although should also be compared with the dissolved concentration which represents the bioavailable fraction; ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; * ANZECC (2000) water quality guideline value for recreational purposes.

Hornes Creek (HC9-QLa and HC17-QLa) Water Quality Summary

Parameter (mg/L unless otherwise stated)	Guideline Value	HC9-QLa					HC17-QLa				
		No. Samples	Min	Median	Max	% Exceedance	No. Samples	Min	Median	Max	% Exceedance
Dissolved Nickel	0.011†	35	<0.001	0.001	0.02	14%	37	<0.001	0.001	0.005	0%
Dissolved Selenium	0.011†	35	<0.01	0.01	0.01	0%	37	<0.01	0.01	0.01	0%
Dissolved Strontium	-	35	0.01	0.04	0.14	-	37	0.01	0.03	0.21	-
Dissolved Zinc	0.008†	35	<0.005	0.009	0.083	54%	37	<0.005	0.005	0.253	41%
Total Aluminium	0.055†	54	<0.01	0.12	2.55	80%	37	0.09	0.2	2.51	100%
Total Arsenic	0.024†	54	<0.001	0.001	0.01	0%	37	<0.001	0.001	0.005	0%
Total Barium	1*	53	0.01	0.03	0.25	0%	36	0.01	0.01	0.07	0%
Total Cadmium	0.0002†	19	0.0001	0.0001	0.0001	0%	0	-	-	-	-
Total Copper	0.0014†	54	<0.001	0.001	0.017	35%	37	<0.001	0.001	0.011	19%
Total Iron	0.3*	54	0.4	1.79	25.80	100%	37	0.23	0.68	4.24	95%
Total Lead	0.0034†	54	<0.001	0.001	0.004	4%	37	<0.001	0.001	0.003	0%
Total Lithium	-	54	<0.001	0.001	0.009	-	37	<0.001	0.001	0.006	-
Total Manganese	1.9†	54	0.03	0.09	2.53	11%	37	0.02	0.06	1.53	0%
Total Nickel	0.011†	54	<0.001	0.002	0.023	22%	37	<0.001	0.001	0.006	0%
Total Selenium	0.011†	54	<0.01	0.01	0.01	0%	37	<0.01	0.01	0.01	0%
Total Strontium	-	54	0.02	0.04	0.13	-	37	0.01	0.03	0.22	-
Total Zinc	0.008†	54	<0.005	0.0115	0.172	63%	37	<0.005	0.008	0.263	38%
Nitrogen Oxides	0.015‡	53	<0.01	0.09	2.88	81%	36	<0.01	0.07	5.26	78%
Total Nitrogen	0.25‡	54	<0.1	0.40	3.60	72%	37	<0.1	0.40	6.60	65%
Total Phosphorus	0.02‡	54	<0.01	0.015	0.16	35%	37	<0.01	0.02	0.7	43%

† ANZG (2018) default guideline value for aquatic ecosystems (95% level of species protection for slightly to moderately disturbed ecosystems) – the default guideline value relates to the total concentration of a constituent although should also be compared with the dissolved concentration which represents the bioavailable fraction; ‡ ANZECC (2000) default guideline value for Upland Rivers in NSW; * ANZECC (2000) water quality guideline value for recreational purposes.

APPENDIX E – Groundwater Technical Report

LW S1A-S6A

Extraction Plan
Groundwater Technical Report

Prepared for:

Tahmoor Coal
2975 Remembrance Driveway
Tahmoor NSW 2574

SLR Ref: 610.30637.00000-R01
Version No: -v6.0
June 2023

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BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Tahmoor Coal (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
610.30637.00000-R01-v6.0	26 June 2023	Sharon Hulbert, Arash Mohajeri	Brian Rask	Brian Rask
610.30637.00000-R01-v5.1	20 June 2023	Sharon Hulbert, Arash Mohajeri	Brian Rask	Brian Rask
610.30637.00000-R01-v5.0	14 October 2022	Sharon Hulbert, Arash Mohajeri	Brian Rask	Brian Rask

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APPENDICES

1 Introduction

Tahmoor Coal Mine (Tahmoor Mine) is an underground coal mine located approximately 80 kilometres (km) south-west of Sydney between the towns of Tahmoor and Bargo, New South Wales (NSW) (refer to Figure 1-1). Tahmoor Mine produces up to three million tonnes of Run of Mine (ROM) coal per annum from the Bulli Coal Seam. Tahmoor Mine produces a primary hard coking coal product and a secondary higher ash coking coal product that are used predominantly for coke manufacture for steel production. Product coal is transported via rail to Port Kembla and Newcastle for Australian domestic customers and export customers.

Operations at Tahmoor Mine commenced in 1979 using bord and pillar mining methods, and via longwall mining methods since 1987. Tahmoor Coal has previously extracted 35 longwalls to the north and west of Tahmoor Mine's current pit top location (Figure 1-1). The current mining area, the 'Western Domain', is located north-west of the Main Southern Rail between the townships of Thirlmere and Picton. The Western Domain is within the Tahmoor Mine mining area and is within Mining Lease (ML) 1376 and ML 1539 (Figure 1-1).

The 'Tahmoor South' domain is an underground coal development targeting the Bulli Coal seam coal resource within Consolidated Coal Leases (CCL) 716 and 747. On the 23rd April 2021, Tahmoor Coal received Development Consent SSD 8445 (the Consent) for the Tahmoor South Project, enabling extension of underground longwall mining to the south of the existing workings. This enables an extension of mining operations at Tahmoor Colliery until 31 December 2033 or until 10 years from the commencement of second workings, whichever is the sooner. In accordance with SSD 8445, the key aspects of Tahmoor South include the following:

- Continued mining activities using the longwall mining method into the Tahmoor South project area in the Bulli Seam within CCL 747 and CCL 716
- Continued use of the surface and ancillary infrastructure and services at the surface facilities areas
- Extraction of up to 4 Mtpa of run of mine (ROM) coal with up to 33 Mt of ROM coal extracted over the life of the project
- Continued transportation by rail to the Port Kembla Coal Terminal (PKCT) and occasionally to Newcastle using the existing rail load out, rail loop and rail infrastructure
- Transportation of up to 200,000 tpa of either product coal or reject material via road
- An increase in the height of the final landform of the reject emplacement area (REA) from the approved height of RL 300 mAHD to RL 320 mAHD, to accommodate the additional rejects produced in Tahmoor South
- Construction of a new upcast ventilation shaft (TSC1) and downcast ventilation shaft (TSC2), south of the REA
- Upgrades to the existing surface facilities, amenities, equipment and infrastructure to accommodate the extension of mining
- Progressive rehabilitation and mine closure activities

SLR Consulting Australia Pty Ltd (SLR) have been engaged by Tahmoor Coal to prepare the Groundwater Technical Report which will inform, and be appended to, the Water Management Plan developed for Longwalls (LW) South 1A to South 6A (S1A–S6A). It exists to describe the likely environmental effects and compliance with relevant internal and external regulatory requirements related to groundwater management at LW S1A - S6A within the context of Tahmoor South as a whole. This report also presents an analysis of the available baseline data for the proposed monitoring bores, results from numerical groundwater model, and outlines trigger ranges to aid in the identification of adverse mining-related impacts to the groundwater system.

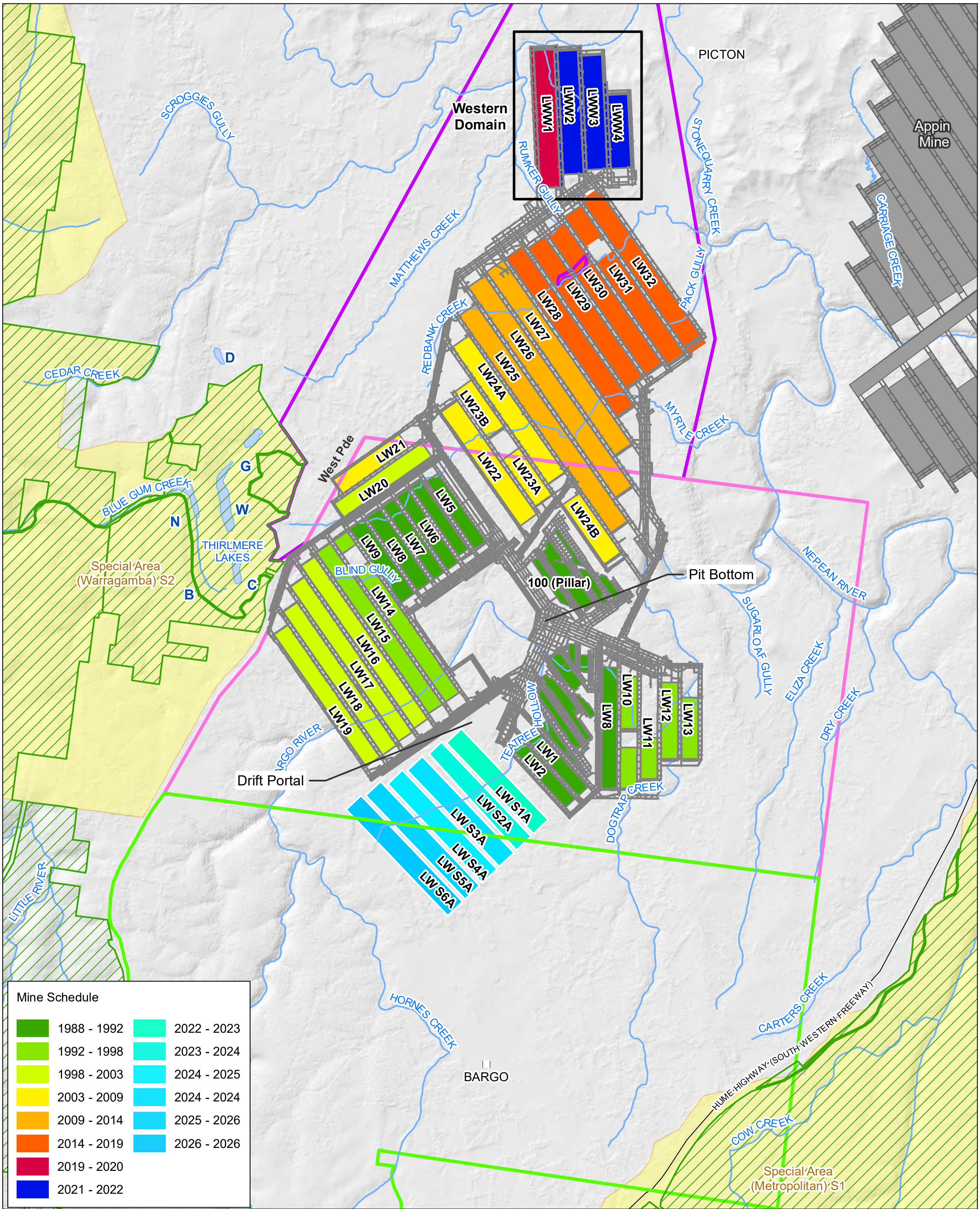
1.1 Extraction Plan Focus

LW S1A–S6A are oriented north-west to south-east, with each panel increasing slightly in length from LW S1A through to LW S6A as shown on Figure 1-2. Table 1-1 details the extraction parameters for LW S1A-S6A. Mining at Tahmoor South LW S1A commenced on 18th October 2022, with completion of mining at LW S6A predicted in December 2026 (essentially 7-9 months of extraction for each of the relevant longwall panels).

Table 1-1 LW S1A-S6A Proposed Timing

Longwall Panel	Proposed Start Date	Proposed Completion Date	Duration (days)	Panel Length (m)	Void Width (m)	Panel Width (m)
LW S1A	18-10-2022*	05-04-2023	194	1711	277.8	272.6
LW S2A	09-05-2023	12-12-2023	217	1768	279.8	274.6
LW S3A	15-01-2024	29-07-2024	196	1808	279.8	274.6
LW S4A	29-08-2024	21-03-2025	204	1860	279.8	274.6
LW S5A	23-04-2025	17-11-2025	208	1949	279.8	274.6
LW S6A	17-12-2025	25-07-2026	220	1999	279.8	274.6

*actual commencement date



0 1 2 km

Coordinate System:	GDA 1994 MGA Zone 56
Scale:	1:68,000 at A4
Project Number:	610.30652
Date:	22-Apr-2022
Drawn by:	JG

- Minor Town
- Tahmoor North and Western Domain
- Major Roads
- Watercourses
- Lakes
- National Park Estate
- NSW State Forest
- WaterNSW Special Area
- Existing Mine

Tahmoor Coal Titles

- MLs 1308, 1376, 1539
- CCL 716
- CCL 747

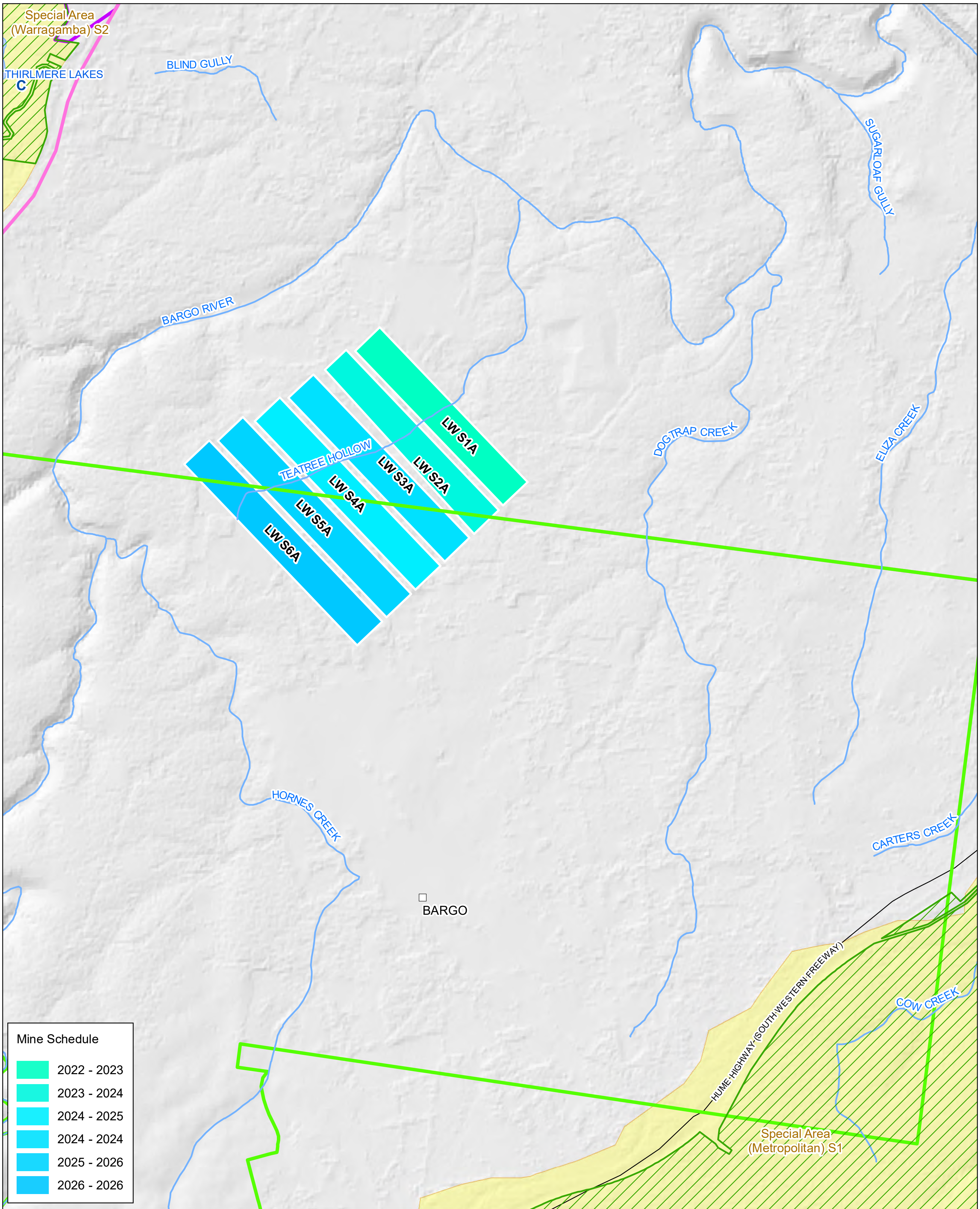
Lakes:
D = Dry Lake
G = Gandangarra
W = Werri Berri
C = Couridjah
B = Baraba
N = Nerrigorang

TAHMOOR SOUTH LW S1A – S6A GROUNDWATER TECHNICAL REPORT

Mine Plan and Extraction Schedule

FIGURE 1-1

H:\Projects-SLR\610-SrvSYD\610-SYD\610.30637.00000 Tahmoor Coal Extraction Plan LW101A LW06 SLR Data\01 CADGIS\GIS\61030637 Fig1_1 Mine plan and extraction schedule.mxd



0 0.5 1 km

Coordinate System:	GDA 1994 MGA Zone 56
Scale:	1:40,000 at A4
Project Number:	610.30637
Date:	22-Apr-2022
Drawn by:	NT

- Minor Town
- Major Roads
- Watercourses
- Lakes
- National Park Estate
- NSW State Forest
- WaterNSW Special
- Existing Mine

Tahmoor Coal Titles

- MLs 1308, 1376, 1539
- CCL 716
- CCL 747

TAHMOOR SOUTH LW S1A – S6A GROUNDWATER TECHNICAL REPORT

Tahmoor South Mine Plan and Extraction Schedule

FIGURE 1-1

H:\Projects-SLR\610-SrvSYD\610-SYD\610.30637.00000 Tahmoor Coal Extraction Plan LW101A LW06 SLR Data\01 CADGIS\GIS\61030637 Fig1_2 Tah SouthMine plan and extraction schedule.mxd

1.2 History of Tahmoor South

An Environmental Impact Statement (EIS) was exhibited in early 2019 seeking approval for the extraction of up to 48 million tonnes (Mt) of ROM coal over a 13-year mine life. Tahmoor Coal subsequently revised the proposed mine design and submitted amended development applications on two occasions (in February and August 2020). In April 2021, Tahmoor Coal received Development Consent SSD 8445.

The Tahmoor South Groundwater Management Plan (SLR, 2022) received Directors Approval from the NSW Department of Planning and Environment on the 14th April 2022.

1.2.1 Other Leases and Licences

All development consents, leases, licences, and other relevant approvals are stored in the Cority Compliance Management database, which is administered by both site and Liberty GFG Corporate. A summary of the relevant mining leases is provided in Table 1-2. A summary of other approvals and licences is provided in Table 1-3.

Table 1-2 Mining Leases

Lease	Title	Granted	Expires
CCL 716	Original Tahmoor Leases	15/06/1990	13/03/2021(renewal documentation submitted, being assessed)
CCL 747	Bargo Mining Lease	23/05/1990	06/11/2025
ML 1376	Tahmoor North Lease	28/08/1995	28/08/2016 (renewal documentation submitted, under assessment)
ML 1308	Small Western lease, west of CCL716	02/03/1993	02/03/2035
ML 1539	Tahmoor North Extensions Lease	16/06/2003	16/06/2024
ML1642	Pit-top and REA surface Mining Lease	27/08/2010	27/08/2031

Table 1-3 Approvals/Licences

Approval Title / Description	Date Granted	Expiry Date
Environmental Protection Licence 1389	01/05/2012	No Expiry
WAL36442 and WAL25777	6/12/2013	No Expiry
WAL 43572	07/05/2021	No Expiry
WAL43656	1/08/2022	No Expiry

1.3 Structure of this Document

The Groundwater Technical Report will support the LW S1A-S6A Extraction Plan and overarching Water Management Plan (WMP), and is structured as follows:

Section 1: Provides background to the site and details of the proposed operations

Section 2: Outlines the Statutory requirements applicable to the Groundwater Technical Report.

Section 3: Describes the existing environment pertinent to the LW S1A-S6A extraction with respect to groundwater and associated receptors

Section 4: Details the predicted subsidence impacts and consequences to groundwater resources within the Investigative Area.

Section 5: Describes the monitoring, mitigation, and management plan for LW S1A-S6A.

Section 6: Details the Trigger Action Response Plans (TARPs) and adaptive management measures

2 Statutory Requirements

This section provides background to the statutory requirements associated with the broader Tahmoor Mine and for LW S1A-S6A.

2.1 Relevant Legislation and Policy

2.1.1 Water Management Act 2000

The *Water Management Act 2000* is the regulatory framework for the management and control of water use within NSW. In conjunction with the *Water Act 1912*, it governs the licensing of water to users. Further, the *Water Management Act 2000* allows for the development and implementation of Water Sharing Plans (WSPs). WSPs regulate the trade and sharing of surface and groundwaters between competing needs and users throughout NSW.

2.1.1.1 Relevant Water Sharing Plans and Groundwater Management Areas

Tahmoor Mine currently extracts groundwater that drains into underground mine workings and pumps this water to the surface via three dewatering lines before treating the water and discharging it off site.

Tahmoor Mine falls within the 'Greater Metropolitan Region Groundwater Sources' WSP (NOW, 2011b), which commenced in 2011. Figure 2-1 indicates the extent of this WSP, along with the various groundwater sources in this region that are regulated by the WSP. A WSP is used to manage the average long-term annual volume of water extracted from a given groundwater source.

The relevant Groundwater Source for the Tahmoor Mine is:

- Sydney Basin Nepean Sandstone

Other relevant Groundwater Sources include:

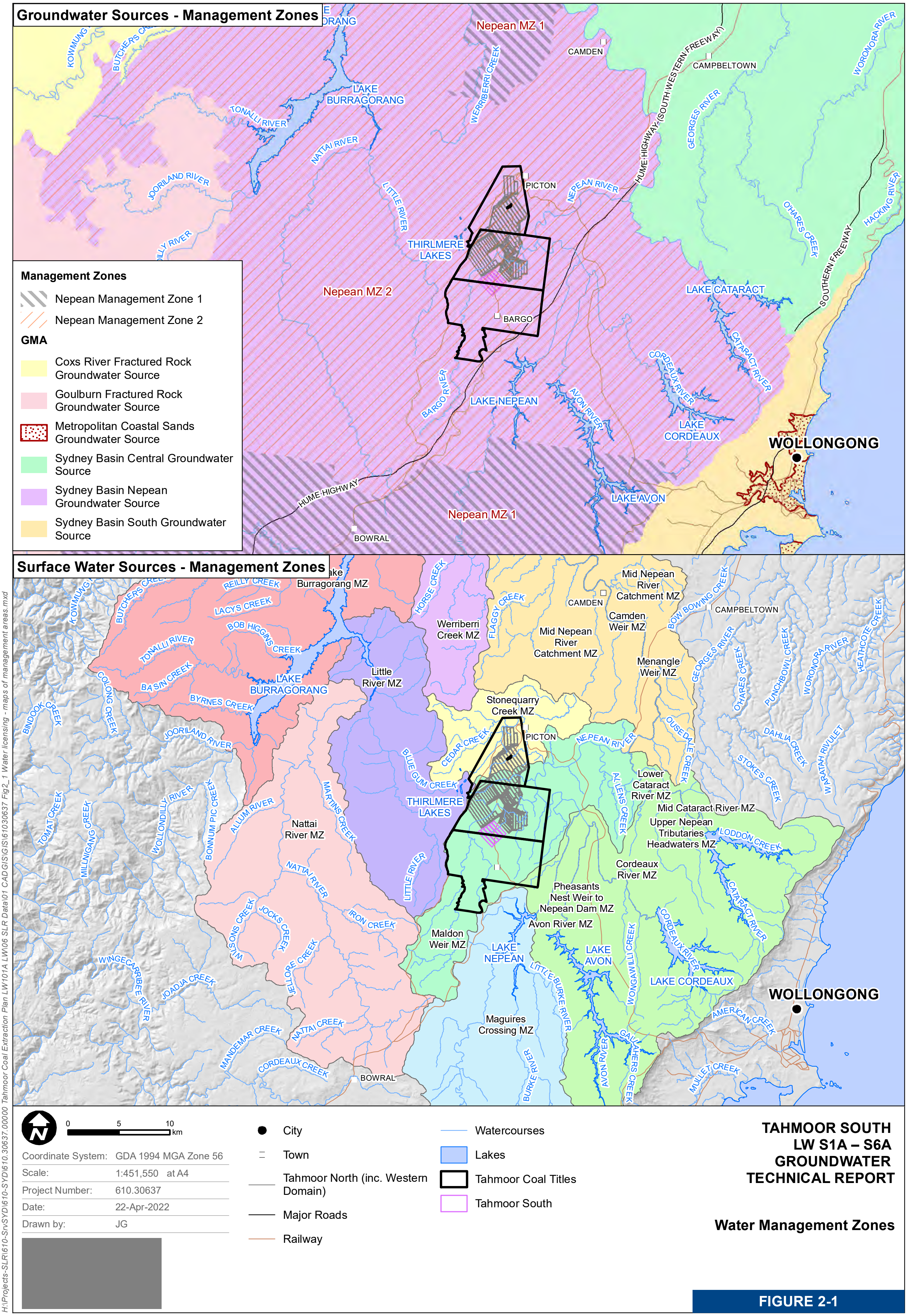
- Sydney Basin – Central, located 10 km to the east and north-east,
- Sydney Basin – South, located 15-20 km east and south-east, and
- Goulburn GMA – located over 25 km to the west and south.

The Sydney Basin Nepean Sandstone Groundwater Source is further subdivided into Management Zones (MZ), as shown using hatching on Figure 2-1. The LW S1A-S6A Study Area lies within Nepean Management Zone 2, while Zone 1 covers the southern 'third' of the Groundwater Source as well as a smaller area to the west of Camden. The Sydney Basin Nepean Sandstone Groundwater Source has an annualised limit on entitlement (LTAAEL) of 99,568 ML (NOW, 2011a), while current entitlement is 31,346 ML (based on the WaterNSW Water Register 2020-2021 water year).

The Greater Metropolitan Region Unregulated River Water Sources WSP (NOW, 2011c) is the relevant plan for surface waters for the LW S1A-S6A Study Area. Within this WSP the Upper Nepean River source is the relevant Water Source, of which the following MZ cover or adjacent to the project site:

- Pheasants Nest Weir to Nepean Dam MZ;
- Stonequarry Creek MZ; and

- Maldon Weir MZ.



TAHMOOR SOUTH
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Water Management Zones

FIGURE 2-1

2.1.2 NSW Aquifer Interference Policy

Underground mining generally requires the dewatering of the geological strata. In accordance with the NSW Aquifer Interference Policy (AIP), such activity is classified as an 'Aquifer Interference'. In order to meet the requirements of the 'minimal impact considerations' of the AIP, a groundwater assessment is conducted.

The AIP requires an estimation of "all quantities of water that are likely to be taken from any water source during and following cessation of the activity and all predicted impacts associated with that activity...". Water take and impact estimation is to be based on a "complex modelling platform" for any mining activity not subject to the Gateway process, where the model makes use of the "available baseline data that has been collected at an appropriate frequency and scale and over a sufficient period of time to incorporate typical temporal variations".

The AIP was developed to provide a framework to guide the assessment of impacts that may result following the 'take' of water from an aquifer. It outlines the requirements for obtaining licences for approved aquifer interference activities, as well as considerations for the assessment of impacts (NSW Government, 2012).

The AIP specifies 'minimal harm considerations' for highly and less productive aquifers, while also defining thresholds for water table and groundwater pressure drawdown, and changes in groundwater and surface water quality. There are separate minimal impact considerations for:

- "Highly productive" groundwater;
- "Less productive" groundwater;
- "Water supply" works;
- "High Priority" Groundwater Dependent Ecosystems (GDEs); and
- "High Priority" Culturally significant sites.

The AIP categorises groundwater source productivity (highly productive or less productive) based on characteristics of salinity and aquifer yield. Tahmoor Mine undermines the 'Highly Productive' Hawkesbury Sandstone aquifer (Figure 2-1). The Hawkesbury Sandstone aquifer is the most utilised aquifer in this region. Water sourced from the Narrabeen Group and Permian Coal Measures comprises the remaining portion of water sourced around Tahmoor Mine (HydroSimulations, 2018).

It should be noted that the categorisation of groundwater source productivity does not make any vertical distinction of aquifer productivity. This is relevant as the high yielding Hawkesbury Sandstone aquifer overlies the lower-yielding Narrabeen Group/Permian Coal Measures groundwater systems which are at greater depths.

2.1.3 Water Licensing

Water Access Licences (WAL) held by Tahmoor Coal for the Sydney Basin Nepean Groundwater Source which is regulated in accordance with the *Greater Metropolitan Region Groundwater Sources Water Sharing Plan* under the authority of the Water Management Act 2000 are listed in the Table 2-1.

Table 2-1 Tahmoor Coal Water Access Licences

WAL Title	Issued	Purpose	Share
WAL 36442	06/12/2013	Mining dewatering (groundwater) (Nepean Sandstone Groundwater MZ2)	1,642ML
WAL 25777	27/10/2014	Surface Water Take (Maldon Weir MZ)	5ML

WAL Title	Issued	Purpose	Share
WAL 43572	13/04/2021	Incidental Surface Water Take (Stonequarry Creek MZ)	16ML
WAL 44608	8/2/2023	Incidental Surface Water Take (Stonequarry Creek MZ)	9ML
WAL 43656	1/8/2022	Incidental Surface Water Take (Maldon Weir MZ)	25ML
SWC828767	19/8/2022	Incidental Surface Water Take (Maldon Weir MZ) – Lease	11ML
SWC828752	19/8/2022	Incidental Surface Water Take (Stonequarry Creek MZ) – Lease	24ML

2.1.4 Licensed Discharge Points

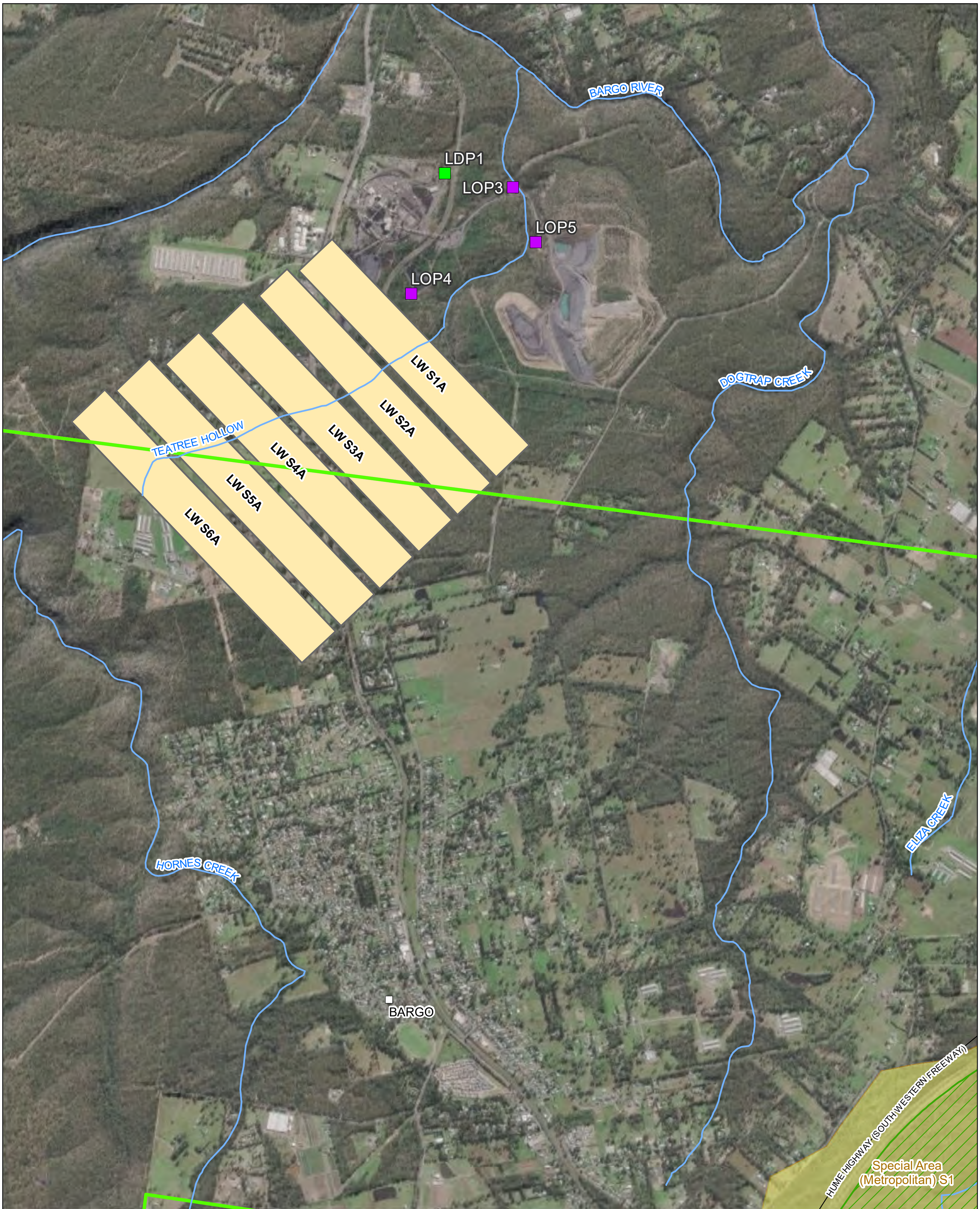
Tahmoor Coal also holds a discharge licence, issued by the NSW EPA. This licence, Environment Protection Licence (EPL) 1389, permits the discharge of wastewater and 'made water' from the underground mine to surface water.

In accordance with EPL 1389, Tahmoor Coal is licensed to discharge from one licenced discharge point (LDP) and three licenced overflow points (LOPs). The locations of the LDP and LOP's are shown on Figure 2-2, and described in Table 2-2.

Table 2-2 EPL 1389 Licenced Discharge Points

Discharge/Overflow Point	Type of Discharge Point	Location Description	Discharge Limit
LDP1	Discharge to waters Discharge quality monitoring Volume monitoring	Main water discharge – discharge drain located downstream of the final mine water treatment dam (dam M4)	15,500 kilolitres per day during low rainfall conditions Unlimited during wet weather conditions*†
LOP3	Discharge to waters	Overflow from sediment dam S9	Unlimited during wet weather conditions*†
LOP4		Overflow from sediment dam S4	
LOP5		Overflow from sediment dam S8	

* Defined as more than 10 millimetres (mm) rainfall within a 24 hour period.
† Provided that all practical measures are taken to reduce potential water quality impacts



0 0.5 1 km

Coordinate System: GDA 1994 MGA Zone 56
Scale: 1:30,000 at A4
Project Number: 610.30637
Date: 29-Apr-2022
Drawn by: NT

Discharge Point
Overflow Point
Minor Town
Major Roads
Watercourses
National Park Estate
WaterNSW Special Area

Tahmoor Coal Titles
CCL 716
CCL 747

Tahmoor South Mine Plan
Approved

TAHMOOR SOUTH LW S1A – S6A GROUNDWATER TECHNICAL REPORT

Licenced Discharge Points and Licenced Overflow Points

FIGURE 2-2

H:\Projects-SLR\610-SrvSYD\610-SYD\610.30637.00000 Tahmoor Coal Extraction Plan LW101A LW06 SLR Data\01 CADGIS\GIS\61030637 Fig2_2 Licened Discharge Points.mxd

2.2 Project Approval Conditions

This Groundwater Technical Report has been prepared as part of the Extraction Plan and overarching Water Management Plan (WMP), as prescribed under the Development Consent SSD 8445.

2.2.1 Water Management Plan

SSD 8445 provides the conditional planning approval framework for mining activities in the Tahmoor South Domain to be addressed within an Extraction Plan and supporting management plans. Conditions pertaining to groundwater are detailed in Table 2-3.

Table 2-3 Water Management Plan Requirements

Condition Reference	Condition Requirement	Where Addressed
B34	Prior to the commencement of construction activities, the Applicant must prepare a Water Management Plan for the development to the satisfaction of the Planning Secretary. This plan must: Groundwater Management Plan that includes:	
	• detailed baseline data regarding groundwater levels, yield and quality for privately-owned groundwater bores (as required under condition B25(a)) and the condition of GDEs (including Thirlmere Lakes) potentially impacted by the development;	Section 3
	• a program to periodically review and update data regarding groundwater levels, yield and quality at privately-owned groundwater bores in the vicinity of the development, including any bores potentially impacted by cumulative groundwater drawdown;	Section 5.1
	• a detailed description of the groundwater management system, including commitments to: o install an additional monitoring bore in the footprint of Tahmoor North to monitor post-mining groundwater level and quality;	Section 5.1.4
	o install additional monitoring bores (minimum of four) at or near the Thirlmere Lakes;	Section 5.1
	o install bores above the initial longwalls to define profile fracturing and depressurisation in the Hawkesbury Sandstone and Bulgo Sandstone;	Section 5.1.3
	o monitor shallow groundwater within the Hawkesbury Sandstone;	Section 5.1
	o monitor volumetric take (mine inflow), including inflows to the underground mine; and o regularly review the monitoring program to ensure robust and reliable monitoring is undertaken, including reviewing the performance of vibrating wire piezometers;	Section 5.1
	• groundwater performance criteria, including trigger levels for identifying and investigating any potentially adverse groundwater impacts (or trends) associated with the development, on: o regional and local aquifers (alluvial and hard rock); and o groundwater supply for other users such as licensed privately-owned groundwater bores;	Section 6
	• uncertainty analysis of the potential impacts of mining the proposed longwalls on the water levels in Thirlmere Lakes, based upon results from the current Thirlmere Lakes Research Program and other ongoing monitoring and investigations;	Section 4.4
	• a program to monitor and evaluate: o compliance with the relevant performance measures listed in Table 4 (of the commitments) and the performance criteria of this plan; o water loss/seepage from water storages into the groundwater system; o groundwater inflows, outflows and storage volumes, to inform the Site Water Balance; o impacts on water supply for other water users; o impacts on GDEs (including Thirlmere Lakes); o the hydrogeological setting of any nearby alluvial aquifers and the likelihood of any indirect impacts from the development; and o the effectiveness of the groundwater management system;	Section 5 and 6
	• reporting procedures for the results of the monitoring program, including notifying other water users, the NSW Office of Environment and Heritage and Thirlmere Lakes Research Program of any elevated results;	Section 6
	• a trigger action response plan to respond to any exceedances of the relevant performance measures and groundwater performance criteria, and repair, mitigate and/or offset any adverse groundwater impacts of the development, including impacts on Thirlmere Lakes;	Section 6
	• a Groundwater Modelling Plan that: o provides details for the future groundwater model re-build and recalibration which must be completed within 2 years of the commencement of development under this consent; o is independently third-party reviewed; o provides for the incorporation of the outcomes of the findings of the Thirlmere Lakes Research Program and other relevant research on the Thirlmere Lakes; o considers field data and the outcomes of subsidence monitoring; o provides for periodic validation and where necessary recalibration, of the groundwater model for the development, including an independent review of the model every 3 years, and comparison of monitoring results with modelled predictions; and	SLR, 2021, Appendix E
	a plan to respond to any exceedances of the performance measures in Table 4.	Section 6

Consent Condition E5 outlines the general requirements for all management plans. Table 2 outlines the requirements under this condition and identifies where these requirements have been addressed.

Table 2-4 Management Plan Requirements

Condition Reference	Condition	Where Addressed
E5	Management plans required under this consent must be prepared in accordance with relevant guidelines, and include:	
(a)	a summary of relevant background or baseline data;	Section 3
(b)	details of:	Section 2
(b) (i)	the relevant statutory requirements (including any relevant approval, licence or lease conditions);	
(b) (ii)	any relevant limits or performance measures and criteria; and	
(b) (iii)	the specific performance indicators that are proposed to be used to judge the performance of, or guide the implementation of, the development or any management measures;	
(c)	any relevant commitments or recommendations identified in the document/s listed in condition A2(c);	
(d)	a description of the measures to be implemented to comply with the relevant statutory requirements, limits, or performance measures and criteria;	
(e)	a program to monitor and report on the:	Section 4, 5 and 6
(e) (i)	impacts and environmental performance of the development; and	
(e) (ii)	effectiveness of the management measures set out pursuant to condition E5(d);	
(f)	a contingency plan to manage any unpredicted impacts and their consequences and to ensure that ongoing impacts reduce to levels below relevant impact assessment criteria as quickly as possible;	
(g)	a program to investigate and implement ways to improve the environmental performance of the development over time;	
(h)	a protocol for managing and reporting any:	
(h) (i)	incident, non-compliance or exceedance of any impact assessment criterion or performance criterion;	
(h) (ii)	complaint; or	
(h) (iii)	failure to comply with other statutory requirements;	
(i)	public sources of information and data to assist stakeholders in understanding environmental impacts of the development; and	
(j)	a protocol for periodic review of the plan.	

3 Existing Environment

This section provides an analysis of the natural characteristics of the Study Area, along with an assessment of available baseline data. This work builds on the previous conceptualisation completed for the Tahmoor South EIS (HydroSimulations, 2018) updated where additional information is available.

3.1 Climatic Conditions

Rainfall data in the area is available from numerous sources. Bureau of Meteorology (BoM) operate two rainfall stations, Picton Council Depot (68052) and Buxton (681660) located to the north and west of Tahmoor Mine operations respectively. Tahmoor Coal operate their own rainfall station, and the SILO climate data source provide interpolated and infilled records for 0.05°x0.05° latitude and longitude tiles.

Due to the occasional gaps in the data for the BoM sites, and the relatively short record of data held by Tahmoor (the mine's record has no gaps, but started in July 2006), the SILO record for the closest 0.05°x0.05° tile near the mine (Lat: -34.25, Long: 150.60) has been adopted for this report to understand long-term trends for the record since 1900. This record has been compared against the other data sources to verify its appropriateness for this task.

Average annual rainfall at Tahmoor is approximately 822 mm/year for the recorded period of January 1900 to May 2023). Areas with higher rainfall occur to the south and east, while areas to the north and west are typically drier. Monthly average rainfall is presented on Figure 3-1, alongside estimated actual evapotranspiration. Rainfall is generally consistent all year with the average total monthly rainfall ranging from 44mm to 95 mm. The highest monthly rainfall is typically in January, February and March (85, 95 and 85 mm respectively), while September is typically the driest month (averaging 44 mm) for the recorded period. Evaporation and evapotranspiration show similar trends with higher rates during the summer months and lower during the winter months. The average monthly potential evaporation is highest in December (188 mm).

Figure 3-2 shows the historical record of monthly rainfall and the calculated trend in rainfall (using cumulative residual departure from mean method). This trend (orange line) shows relatively wet periods as upward gradients, droughts as downward gradients, and average conditions as horizontal. Of note in recent times, there was a significant drought period from mid-2017 until January 2020, with extreme conditions in November 2019 to January 2020, producing notable bushfire conditions around Tahmoor and more widely across eastern NSW. Since then, conditions have been wetter than average, including high rainfall totals in March and November 2021 (304 and 168 mm respectively). To date, 2022 has experienced record high rainfalls, including 112 mm in January, 195 mm in February and 485 mm in March, associated with widespread flooding. In 2023, high rainfall was recorded in January (147 mm) and April (102 mm) while the remainder of months in the first half of the year have been relatively dry.

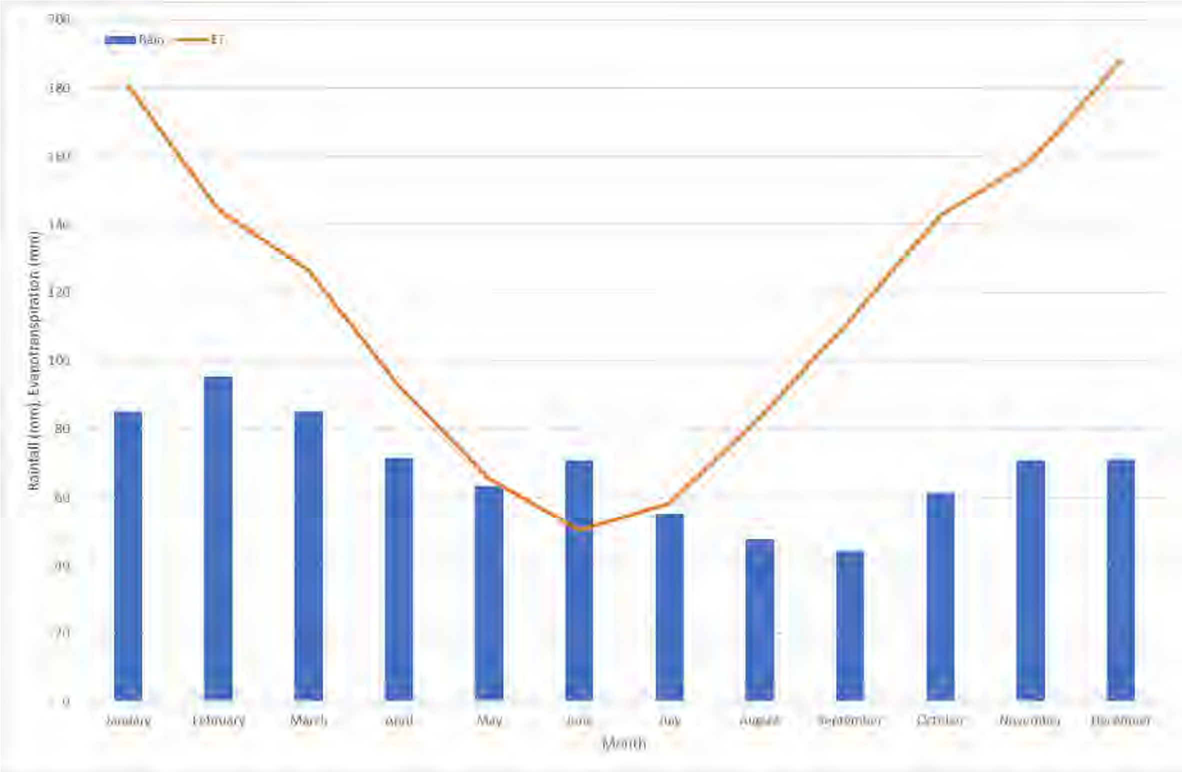


Figure 3-1 Average Monthly Rainfall and Evapotranspiration (ET)

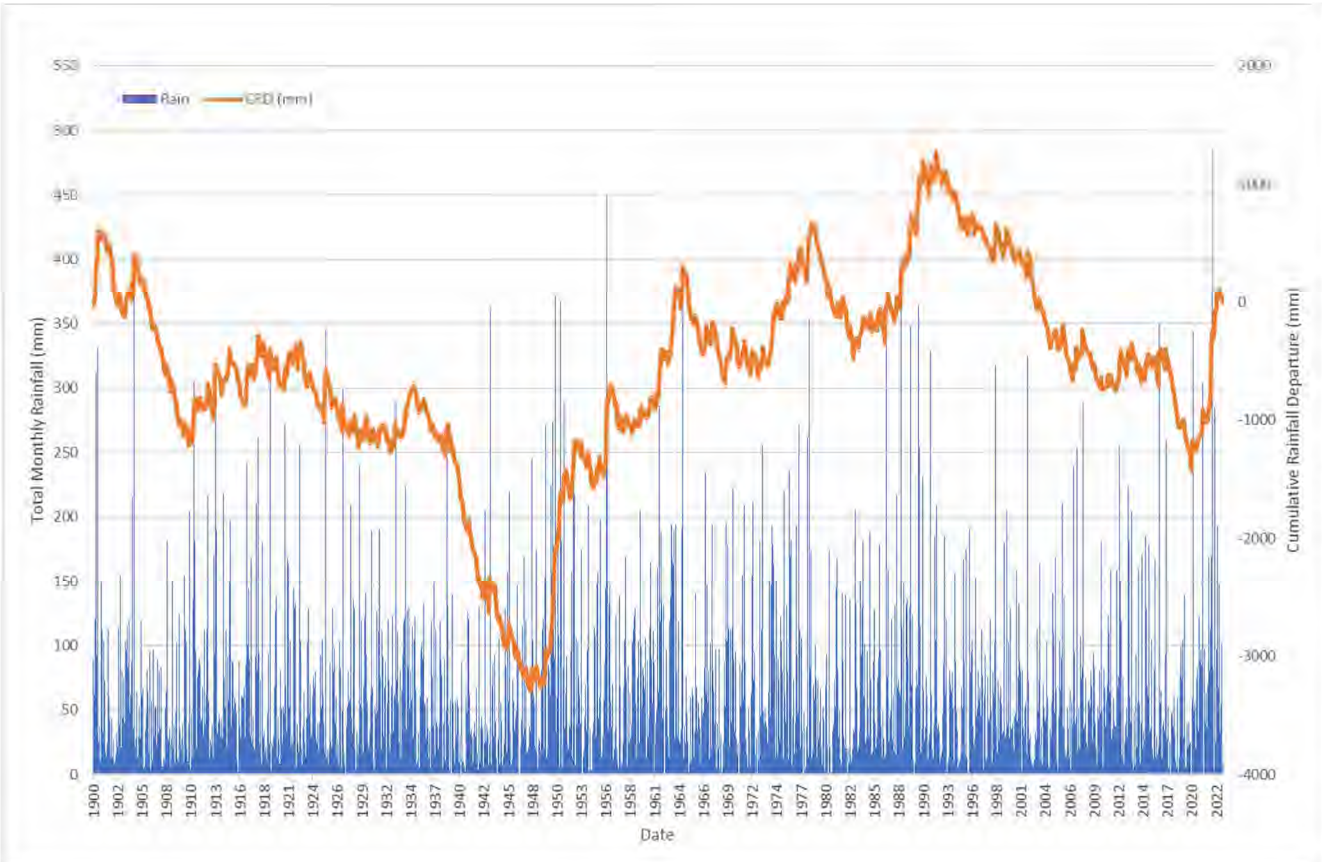
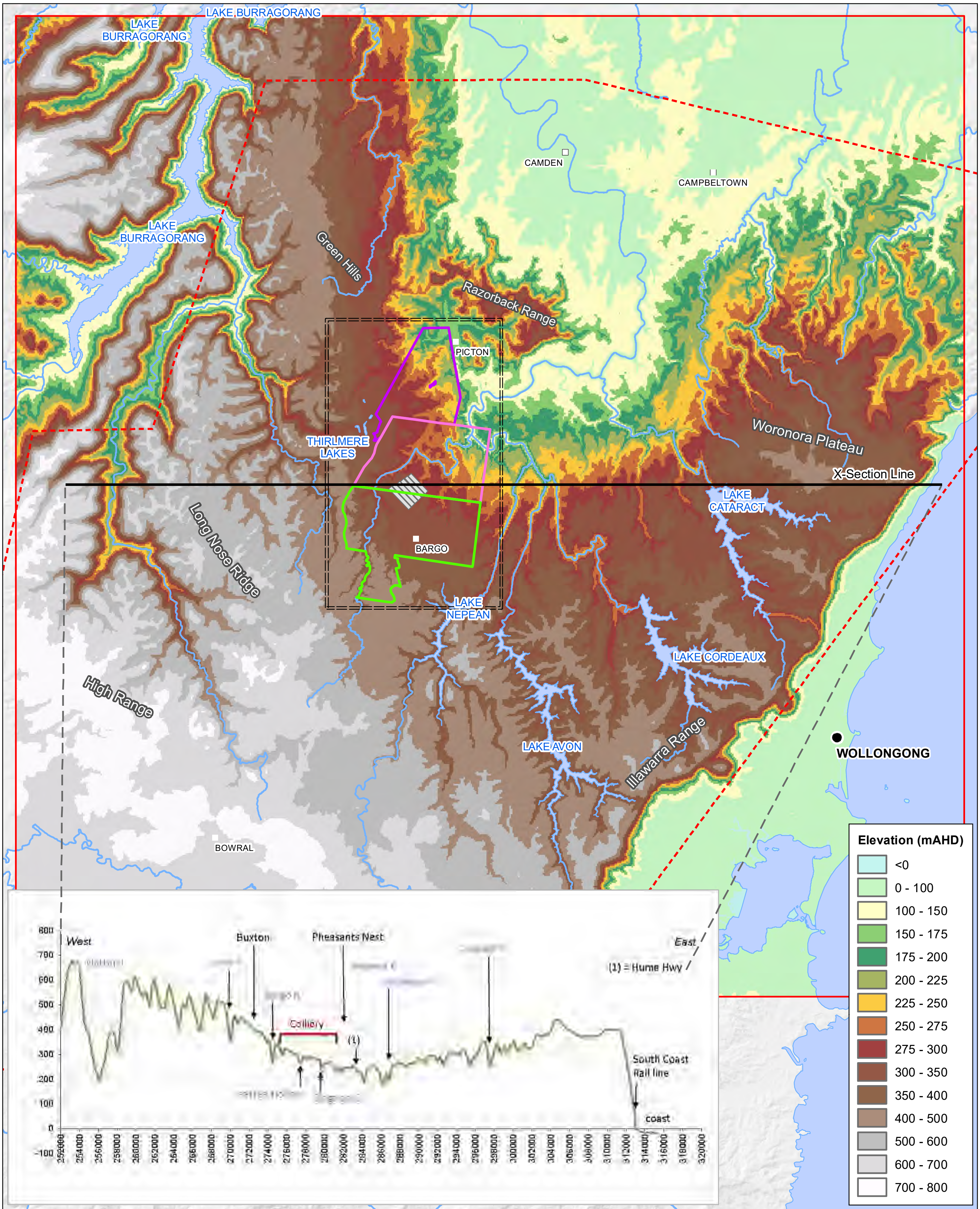


Figure 3-2 Cumulative Rainfall Departure and Total Monthly Rainfall

3.2 Topography

Tahmoor Mine is located approximately 20 km west of the Illawarra Escarpment (Figure 1-1)). It is surrounded by several deeply incised river valleys that flow in a predominantly northerly or north-easterly direction. Surface infrastructure at Tahmoor Mine lies at an elevation of approximately 280 mAHD, and the elevation of interfluves above LW S1A-S6A is typically 280-300 mAHD (Figure 3-3).



0 5 10 km

Coordinate System: GDA 1994 MGA Zone 56
Scale: 1:350,000 at A4
Project Number: 610.30637
Date: 22-Apr-2022
Drawn by: JG

City
Town
Watercourses
Lakes

Tahmoor Coal Titles
MLs 1308, 1376, 1539
CCL 716
CCL 747

Lidar Covarage
Southern Coalfield (approximate)
Study Area for Groundwater Assessment
Tahmoor South Mine Plan

TAHMOOR SOUTH LW S1A – S6A GROUNDWATER TECHNICAL REPORT

Topography

FIGURE 3-3

H:\Projects-SLR\610-SrvSYD\610-SYD\610.30637.00000 Tahmoor Coal Extraction Plan LW101A LW06 SLR Data\01 CADGIS\GIS\61030652 Fig3_3 Topography.mxd

3.3 Surface Water

The Tahmoor mining lease is located in the Upper Hawkesbury-Nepean Catchment. The Nepean River is the major watercourse in this catchment, flowing perennially from the south through Lake Nepean. The Bargo, Avon and Cordeaux are major tributaries to the Nepean River in this area. The Bargo River flows eastward through the lower portions of the Tahmoor mine plan. The Avon and Cordeaux Rivers are positioned to the south-east of the Tahmoor mining leases and flow northward before reaching their confluences with the Nepean River 4 km and 6 km, respectively, to the east of the mining leases. These watercourses are presented on Figure 3-4.

Tahmoor South is located predominantly within the Teatree Hollow and Dogtrap Creek sub-catchments of the Bargo River catchment. Teatree Hollow is a third order stream that overlies LW S1A-S6A while Dogtrap Creek and its tributaries overlie the approved LW S1B-S6B. Teatree Hollow and Dogtrap Creek flow generally north-northeast toward the Bargo River, with Teatree Hollow traversing bushland between the Tahmoor Mine surface facilities and the Reject Emplacement Area (REA) and Dogtrap Creek traversing predominantly bushland to the east of the REA. The lower reaches of Teatree Hollow, Dogtrap Creek and the Bargo River have, to varying degrees, experienced subsidence-related effects due to historical mining operations at the Tahmoor Mine.

3.3.1 Bargo River

The Bargo River catchment area is approximately 130 square kilometres (km^2) at its confluence with the Nepean River. The Bargo River has intermittent flow in its upstream reaches which, to some degree, are regulated by the Picton Weir located at the Hornes Creek confluence, approximately 14 kilometres (km) upstream of the Nepean River confluence. Downstream of the Tahmoor Mine pit top (i.e. downstream of the Teatree Hollow confluence) flow is perennial due to persistent licensed discharges from Tahmoor Mine.

The lower 4 km of the river pass through the Bargo River Gorge, which is characterized by steep rock faces up to 110 m high. The river consists of a sequence of pools, glides and rock bars across sandstone bedrock, with occasional boulder fields and cobblestone riffles. The Bargo River flows into the Nepean River approximately 9 km downstream of the Teatree Hollow confluence. The headwaters of a second order tributary of the Bargo River overlie the western edge of the approved LW S5A. The baseline geomorphology survey identified that the Bargo River tributary was generally in good geomorphic condition (i.e. essentially natural with intact form and process) (Fluvial Systems, 2013). Sites where the redirection of surface flow to the subsurface was observed, presumed to be associated with historical mining-induced bed fracturing, were classified as having moderate geomorphic condition (Fluvial Systems, 2013).

3.3.2 Teatree Hollow

Teatree Hollow has its headwaters in the northern part of the Bargo Township, above the approved LW S1A-S6A and between the existing Tahmoor Mine surface facilities and REA. Teatree Hollow is a third order stream present from the northern boundary of the approved LW S1A to the confluence with the Bargo River and has a total catchment area of approximately 6.8 km^2. A third order tributary joins with Teatree Hollow at the eastern edge of the LW S1A.

The baseline geomorphology survey (Fluvial Systems, 2013) identified that the upper to mid reach of Teatree Hollow and the mid to lower reach of Teatree Hollow Tributary were predominantly in good geomorphic condition while the mid to lower reach of Teatree Hollow and the upper reach of Teatree Hollow Tributary were predominantly in moderate geomorphic condition. The sites of moderate geomorphic condition related to minor culvert or track crossings, low riparian vegetation cover or discharge from the LDPs (Fluvial Systems, 2013). The upper reaches of Teatree Hollow and Teatree Hollow Tributary were characterised by a low relief landscape, with a dominant bed material of mud (cohesive clay/silt/sand) and notable grass coverage (Fluvial Systems, 2013). In the mid to lower reaches, the landscape was characterised as high relief with dominant bed material of mud, sand, boulders and/or exposed bedrock and little low flow channel grass coverage.

3.3.3 Dogtrap Creek

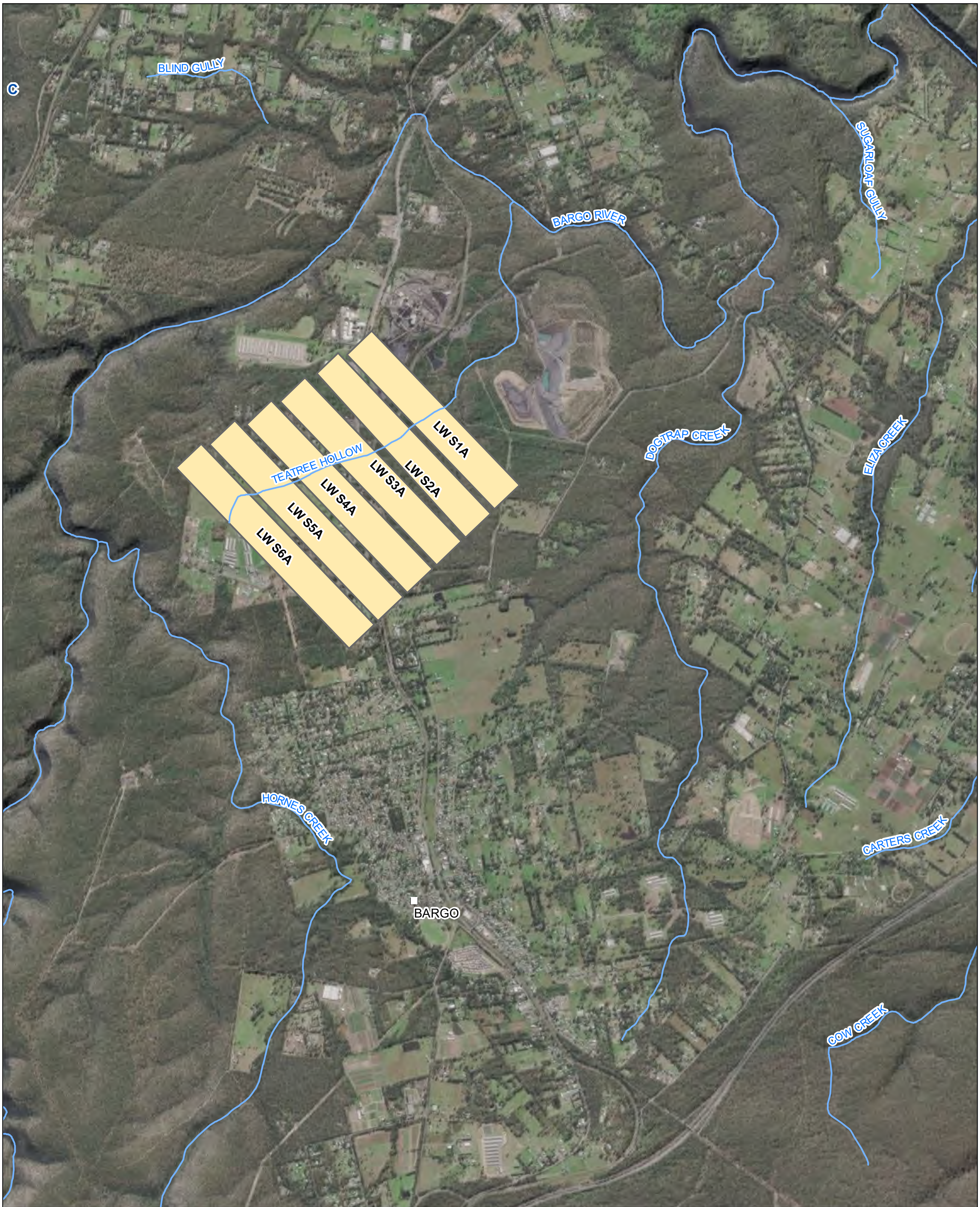
Dogtrap Creek has its headwaters in the southern part of the Bargo Township, above LW S1B-S6B and east of the REA to the Bargo River, and approximately 1 km east of the nearest part of LW S1A. Dogtrap Creek is a third order stream from approved LW S4B to the confluence with the Bargo River and has a total catchment area of approximately 13.6 km^2. Two second order tributaries join with Dogtrap Creek at the northern edge of approved LW S1B.

The outcomes of the geomorphology survey concluded that the majority of Dogtrap Creek and its tributaries were in good geomorphic condition with some sites in the upper reaches of Dogtrap Creek and its tributaries characterised as moderate geomorphic condition.

3.3.4 Thirlmere Lakes

Although spatially disparate to LW S1A-S6A, the five lakes of the Thirlmere Lakes are nominated High Priority Groundwater Dependent Ecosystems and within a World Heritage Area and consequently incorporated in this study. These lakes are formed in the alluvium along Blue Gum Creek, to the west of historical Tahmoor mine longwalls. The nearest of the Thirlmere Lakes is at least 3,500 m from LW S1A-S6A (Figure 3-4).

The Thirlmere Lakes Research Program (TLRP), a NSW government initiative, was commenced in 2018 and completed in 2022. This program aimed to provide a detailed understanding of the hydrological dynamics, water sources and water flow pathways. The summation report, “Thirlmere Lakes – A Synthesis of Current Research” was released in late March 2022, by DPE. Further information on Thirlmere Lakes is provided in Section 3.6.1.



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Coordinate System:	GDA 1994 MGA Zone 56
Scale:	1:40,000 at A4
Project Number:	610.30637
Date:	22-Apr-2022
Drawn by:	NT

□ Minor Town

Watercourses

Tahmoor South Mine Plan

Approved

TAHMOOR SOUTH
LW S1A – S6A
GROUNDWATER
TECHNICAL REPORT

Watercourses

FIGURE 3-4

H:\Projects-SLR\610-SrvSYD\610-SYD\610.30637.00000 Tahmoor Coal Extraction Plan LW101A LW06 SLR Data\01 CADGIS\GIS\61030637 Fig3_3 Watercourse.mxd

3.4 Geological Setting

3.4.1 Regional Stratigraphic Setting

Tahmoor Mine is situated within the Southern Coalfield in the sedimentary Sydney Basin (UOW, 2012). Figure 3-5 presents the outcropping geology at and around Tahmoor Mine. Locally, the underlying geology consists of interbedded Permo-Triassic strata, primarily sandstones, siltstones, claystones and coal seams. Table 3-1 describes the regional stratigraphic sequence.

In the vicinity of the mine the strata dips mainly towards the east and north. The fluvially-deposited Triassic Hawkesbury Sandstone (HBSS) is the dominant outcropping stratigraphic unit in this region. Its full thickness is approximately 150 m or more. The Wianamatta Group (WMFM), composed of carbonaceous shales, that overlie the Hawkesbury Sandstone and is more apparent to the north of the mine. Due to the high silica content of this sequence, the HBSS exhibits higher resistance to erosion than the WMFM. As such, soil production on the HBSS is low and the sandstone is the common bed material for the watercourses in this region (UOW, 2012), with the WMFM typically appearing as capping material at higher elevations.

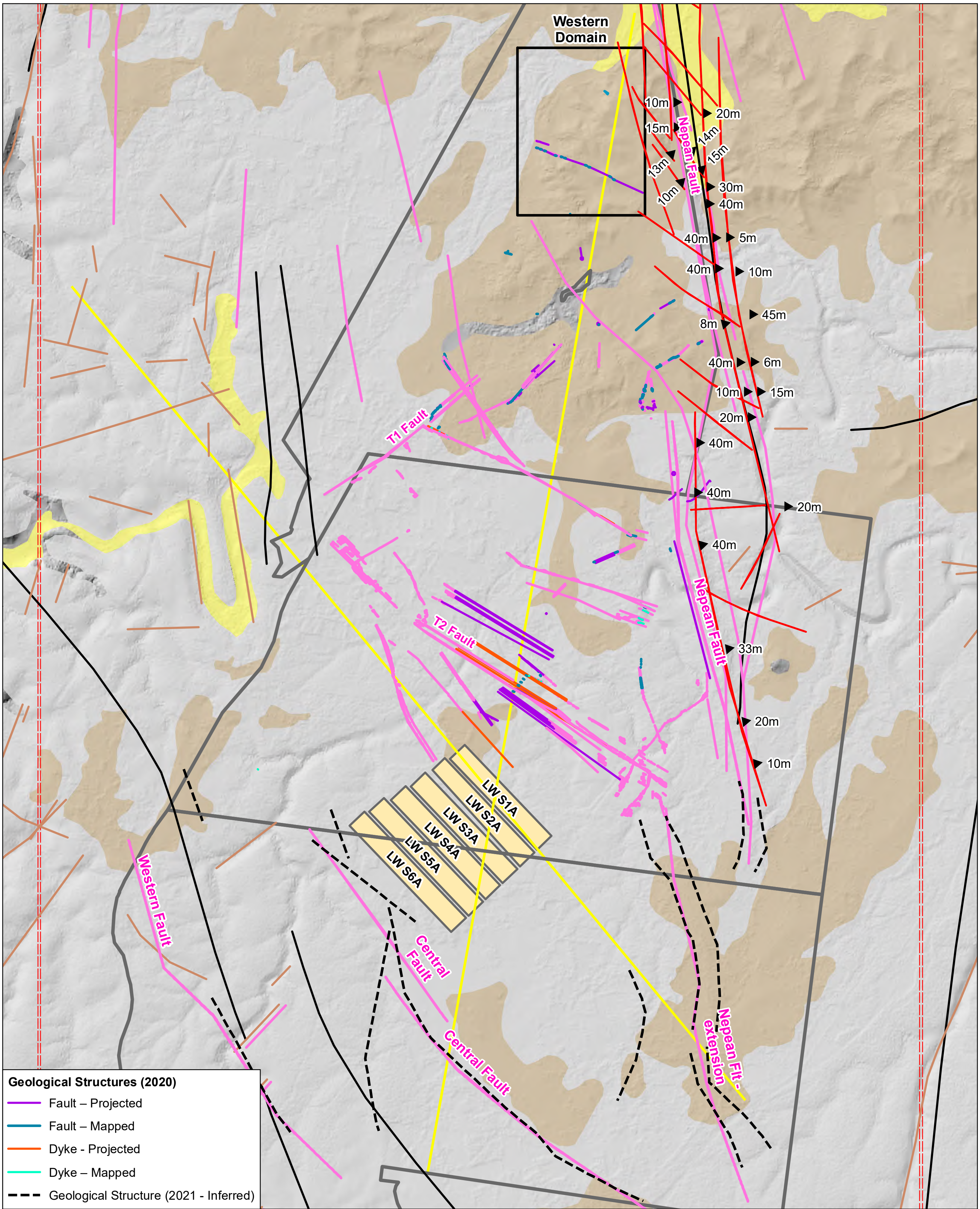
Below the HBSS are the Narrabeen Group formations, of which the main units are the Bald Hill Claystone (BHCS), which is considered to be a regional aquitard of approximately 10 m thick (varying from approximately 2-30m across the Tahmoor Mine lease), and the Bulgo Sandstone (BGSS) which is a thick (140-220 m) sandstone/siltstone sequence with minor aquifer potential.

The Bulli (BUCO) and Wongawilli Coal (WWCO) seams are the main deposits of economic significance in this region. As summarised in Table 3-1, these coal seams belong the Sydney Subgroup of the Permian-aged Illawarra Coal Measures (ICM) (UOW, 2012). The Bulli Coal Seam is the youngest coal seam of the ICM and is approximately 2-4 m thick. This is the seam targeted by Tahmoor Coal and the neighbouring Appin Mine.

Figure 3-6 and Figure 3-7 show regional south-north and west-east cross-sections respectively.

Table 3-1 Regional Stratigraphy

Period	Stratigraphic Unit		Description
Quaternary	Alluvium and colluvium and other sediments in floodplains, alluvial fans, and high terraces (Qal, Tal, Qs)		Alluvial and residual deposits comprising quartz and lithic fluvial sand, silt and clay.
Triassic	Wianamatta Group	Camden Sub-group	Shale with sporadic thin lithic sandstone.
		Liverpool Sub-group: Bringelly Shale (Rwb), Minchinbury Sandstone and Ashfield Shale (Rwa)	Dark green and black shales with thin graywacke-type sandstone lenses. Calcareous graywacke-type sandstone and black mudstones and silty shales with sideritic mudstone bands.
	Hawkesbury Sandstone (Rh)		Consists of thickly bedded or massive quartzose sandstone (with grey shale lenses up to several metres thick).
	Narrabeen Group	Newport Formation	Interbedded grey shales and sandstones
		Garie Formation	Cream to brown, massive, characteristically oolitic claystone
		Bald Hill Claystone	Brownish-red coloured “chocolate shale”, a lithologically stable unit
		Bulgo Sandstone	Strong, thickly bedded, medium to coarse-grained lithic sandstone with occasional beds of conglomerate or shale
		Stanwell Park Claystone	Greenish-grey mudstones and sandstones
		Scarborough Sandstone	Mainly of thickly bedded sandstone with shale and sandy shale lenses up to several metres thick
		Wombarra Claystone	Similar properties to the Stanwell Park Claystone
		Coal Cliff Sandstone	Basal shales and mudstones that are contiguous with the underlying Bulli Coal seam. Absent in much of the Tahmoor area.
Permian	Illawarra Coal Measures		Interbedded shales, mudstones, lithic sandstones and coals, including the:
			Bulli Coal seam (2-4 m thick);
			Eckersley Formation, including the Balgownie Seam (5-10 m below Bulli Seam), Loddon Sandstone and Lawrence Sandstone.
			Wongawilli Coal seam (8-10 m thick).
			Kembla Sandstone
	Shoalhaven Group		



0 0.5 1 km

Coordinate System:	GDA 1994 MGA Zone 56
Scale:	1:68,000 at A4
Project Number:	610.30637
Date:	22-Apr-2022
Drawn by:	JG

Faults (locally mapped)
Southern CF Structure
Southern CF Fold
Local Geological model Extent

Nepean Fault Complex (SCT, 2020)

Offset, Estimated
Surface Trace

Cross Section
Tahmoor Coal Titles
Alluvium
Wianamatta Formation
Hawkesbury Sandstone

Tahmoor South Mine Plan

Approved

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Outcropping Geology and Structural Features at Tahmoor

FIGURE 3-5

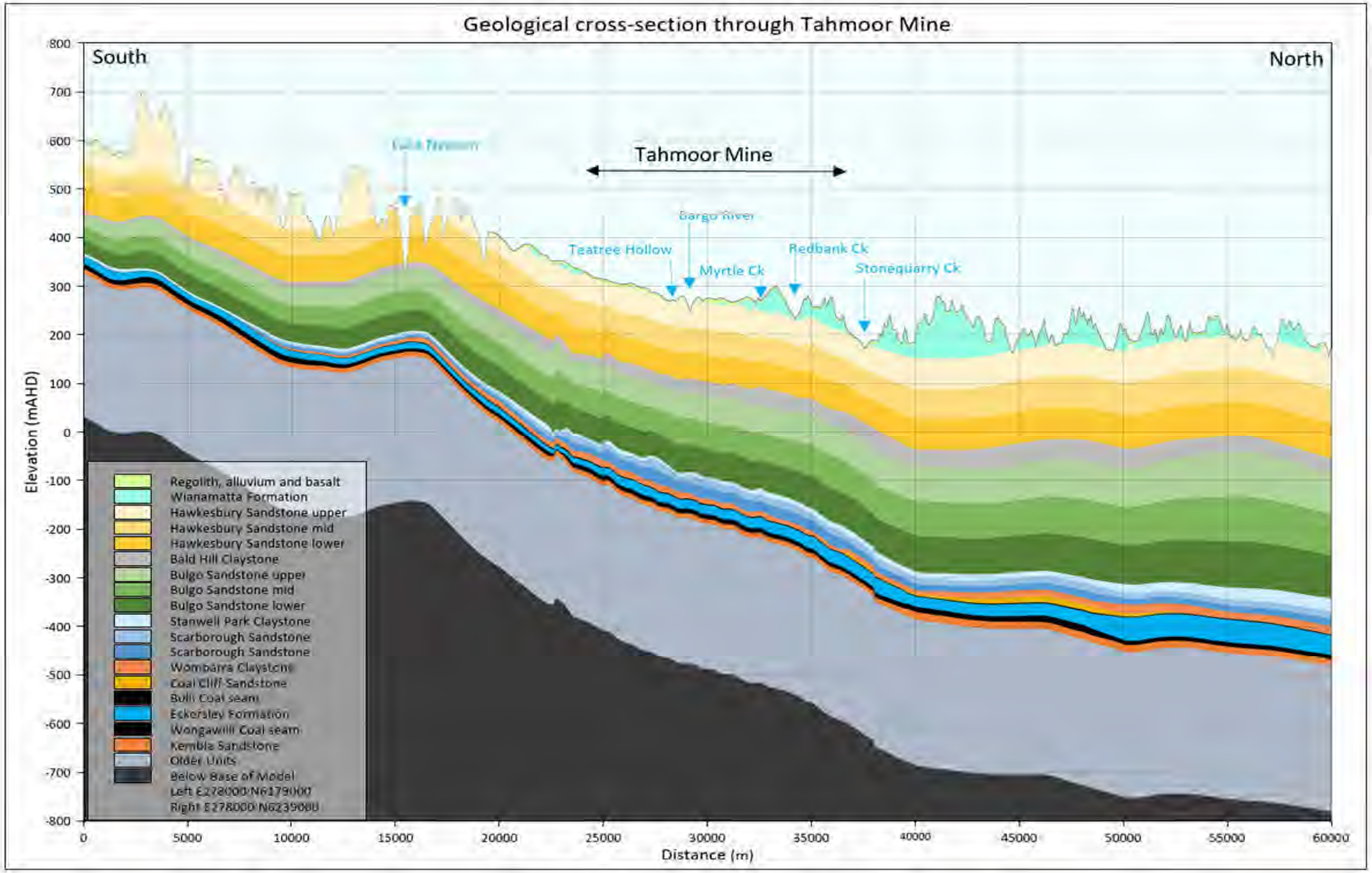


Figure 3-6 Geological Cross-Section: South to North

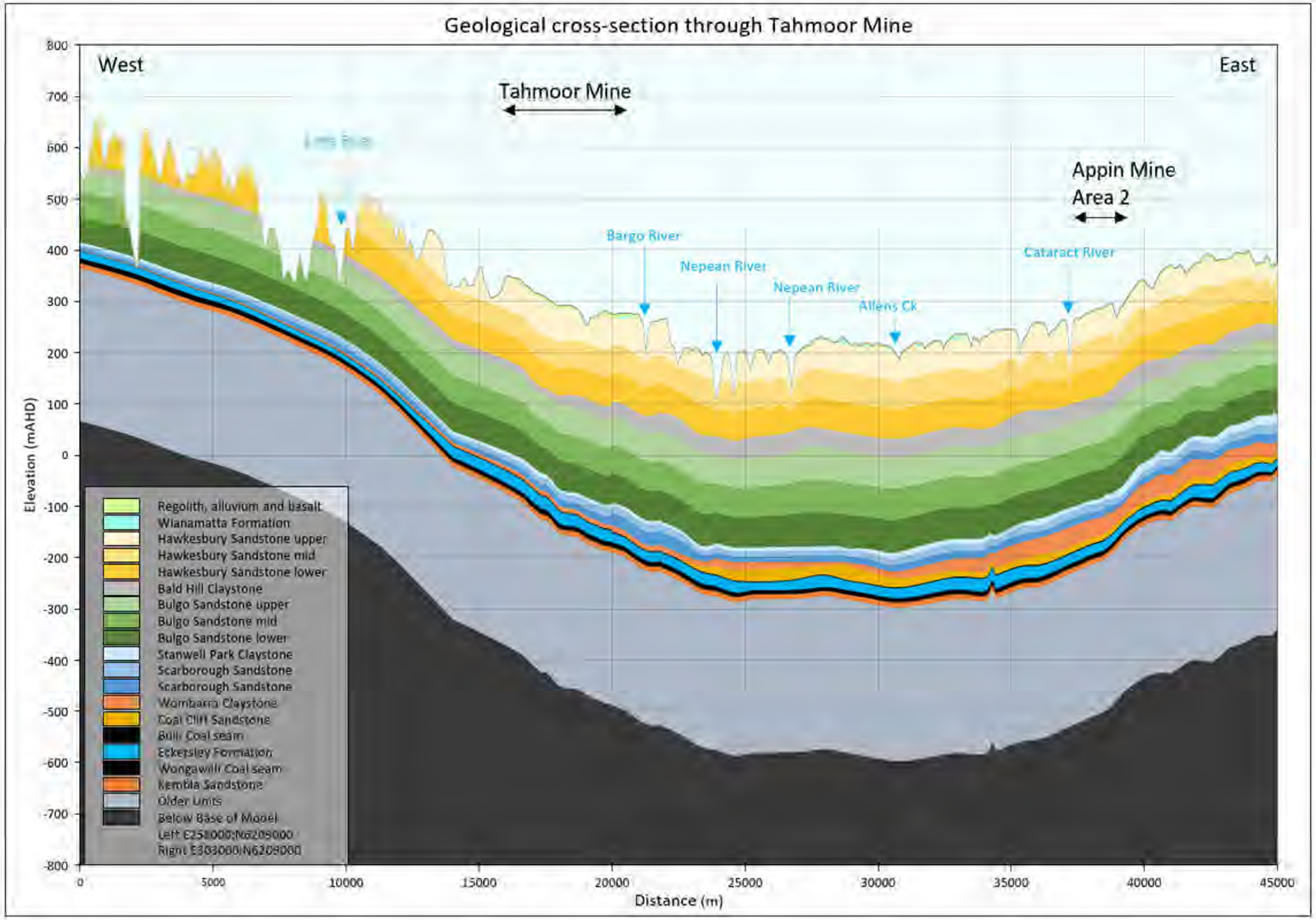


Figure 3-7 Geological Cross Section: West to East

3.4.2 Regional Structural Geology

As shown on Figure 3-5 the region is dissected by several faults, folds, and dykes of volcanic origin, varying in age from Jurassic to Tertiary. This figure presents the results of structural mapping carried out by Tahmoor Coal over the mine footprint.

The major structural feature of interest to Tahmoor Mine is the Nepean Fault. As noted in Tahmoor Coal (2019), "The Nepean Fault encountered at Tahmoor Mine is part of the regional Nepean Fault system. This system is the southern extension of the Lapstone Monocline, and at Tahmoor, it consists of closely spaced sub-vertical *en-echelon* faults in a zone up to 400 m wide." Mapping confirms that this fault extends 10 km along the eastern edge of the Tahmoor mine footprint, and extends still further north and south beyond the Tahmoor area (e.g. northward as part of the Lapstone Monocline).

This significant high angle structural feature is known to be transmissive and mine workings that intersect this zone can produce more water than areas that are located away from this zone. Tahmoor Coal (2019) described this as follows "The Nepean Fault zone is the only hydraulically charged geological structure encountered during mining to date".

Increases in inflow have been observed in mine workings as a result of intersection or proximity of the Nepean Fault zone, noting that previous workings at Tahmoor Mine have intersected or approached to within approximately 100 m of the secondary splays (typically oriented northwest-southeast), such as at Longwalls 31 and 32 in the north of the Tahmoor mining area. However, the main north-south trending faults have not been intersected by previous workings, and the closest approach by longwalls was at Longwall 32 (approximately 340 m west) and at Longwall 13 (approximately 480 m west) of such major faults. Available mapping of this structure indicates that it is 1.5 km east of LW S1A at its closest point, and further from the other "A" longwalls (LW S2A-S6A). This structural feature is closer to longwalls of the future "B" longwalls (LW S1B-S6B).

The 'T1' and 'T2' faults which are present at the western edge of the previously extracted Tahmoor longwalls between the mine and the Thirlmere Lakes. These faults lie essentially 900 m to the north of (and would not be intersected by) the Tahmoor South longwalls.

Other structural features of note include:

- The Camden Syncline, which plunges from south to north, is located approximately 3.3 km east of the eastern-most Tahmoor South longwall panels, and approximately coincident with the Nepean River at this point. At its nearest, this feature is approximately 3.3 km from LW S1A-S6A.
- Bargo Fault, heading predominantly west, which diverges from the Nepean Fault and crosses the mined area of Tahmoor North. At its nearest, this feature is approximately 1.5 km from LW S1A-S6A.
- The Central and Western Faults, which trends NW-SE, just outside the proposed southern limit of the Tahmoor South longwalls. The alignment of the Central Fault is essentially congruent with the course of Hornes Creek, suggesting that the creek might exist at this location due to the influence of this structural feature. At its nearest, the Central Fault is approximately 360 m from LW S6A, whilst the Western Fault is 3.1 km.
- Victoria Park Fault, located west of the Tahmoor North longwalls 26-31.
- Other smaller faults mapped within the extent of the historical Tahmoor workings

Dyke and sill intrusions identified from surface mapping and drilling records, include a large sill at the southern edge of the Tahmoor South domain. Tahmoor South geologists have conducted underground inseam drilling (UIS) within the Bulli Coal seam through the entire block of LW S1A, and drilling has commenced in LW S2A and LW S3A. No significant structural features have been identified. The main feature identified has been a small dyke, detailed as (J. Reid, personal communication, 26th April 2022):

- Indicative thickness (inseam drilling intersection) – 1m up to <6m
- Indicative length (inseam drilling intersection) – approx. 900m (System of potential sills and dyke)
- Dyke was soft and fullseam height
- Minimal water was reported when cutting through it

3.4.2.1 Structural Geology of the Thirlmere Lakes area

The conceptual geological model for the lakes (Section 3.3.4) environment involves a late Cretaceous to early Tertiary alluvium (clayey quartz sand) overlying Triassic Hawkesbury Sandstone (quartz sandstone having a clay matrix and sideritic cement). Beneath the Hawkesbury Sandstone the geology continues to be representative of the regional southern Sydney Basin.

Groundwater flow at shallow depths, up to approximately 200 metres below ground surface (mBGL) is suggested to be dominated by flow through fractures, while at greater depths groundwater flow is controlled mainly by the porosity of the rock matrix (Commonwealth of Australia, 2014). The Bald Hill Claystone was previously considered to be a significant low permeability formation separating Hawkesbury Sandstone from the deeper groundwater systems. The matrix permeability of the Bald Hill Claystone was suggested to be significantly lower when compared to hydraulic conductivities measured for sandstone formations. However, field packer test results indicate that the hydraulic conductivity of the Bald Hill Claystone can be quite similar to other strata (Reid, 1996; Pells & Pells, 2011) and research associated with the Thirlmere Lakes Research Program is now challenging previous theories regarding the nature and aquitard properties of the Bald Hill Claystone (DPE, 2022).

Only two structures, the Eastern and Western Fault Propagation folds (FPFs), were identified by TLRP that had demonstrable displacement and which could be classified as faults. Several other lineaments exist within the region that could not be given a more distinct classification with the available evidence. These lineaments may be either volcanic intrusions or small displacement faults, fault propagation folds, fault propagated joint swarms (see Och et al., 2009) or transfer features (DPE, 2022). The identified fracture patterns surrounding the FPFs effectively provide a much wider fault damage zone (100s rather than 10s of metres) when compared to traditional fault geometries.

Processes such as longwall mining would require a larger setback distance (i.e. wider buffer zone) to avoid the fault generated damage zone intersecting with the angle of draw that defines that area of ground movement above or adjacent to a longwall panel. In the case of Thirlmere Lakes, the Eastern FPF and the completed Tahmoor longwall panels, such a distance exists, and the identified FPFs were considered unlikely to have been directly affected by the mining.

It was hypothesised that the identified fracture patterns for the FPF zones, the Eastern and Western FPF fracture networks, are interconnected at the point of intersection between these two structures. It was therefore considered possible that any groundwater impacts experienced by the Western FPF could be transmitted along the Eastern FPF from the point of intersection between these two structures. As such, any significant groundwater abstraction along strike of the Eastern or Western FPFs (e.g. directly or indirectly related to mine dewatering or production bores) may influence the groundwater in the Hawkesbury Sandstone under the lake system through these highly transmissive, naturally produced fracture networks.

3.5 Groundwater

This section provides a summary of the hydrogeological units and groundwater use (environmental and anthropogenic) as it pertains to Tahmoor South.

3.5.1 Hydrogeological Units

The major hydrostratigraphic units that characterise the area around Tahmoor Mine are the Sydney Basin Triassic and Permian rock units, with the Hawkesbury Sandstone being the primary aquifer. These aquifers fall within the *Sydney Basin Nepean Sandstone Groundwater Source* and have been classified as being 'Highly Productive' by the NSW Government based on considerations of bore yield and groundwater quality. The Bulgo Sandstone and Illawarra Coal Measures of the Triassic Narrabeen Group supply additional water to this system; however, contributions are substantially lower. The extent of surficial geological units around Tahmoor Mine are presented on Figure 3-5. Geological cross sections have been prepared across the Tahmoor Mine area and are presented in Figure 3-6 and Figure 3-7, with the alignment of the sections shown on Figure 1-1.

Generally, there is limited extent of surficial alluvium in this region, with no notable occurrences in the vicinity of Tahmoor South LW S1A-S6A. Regionally, small areas of alluvium exist along Stonequarry Creek (located north of mining operations) and near Blue Gum Creek and Thirlmere Lakes (located west of the mine) (Figure 3-5). The shales of the Triassic Wianamatta Group are more extensive, especially to the north of Tahmoor Mine, but have limited potential as aquifers and very limited occurrence above or near LW S1A-S6A. A description of pertinent hydrogeological units is provided below.

3.5.1.1 Thirlmere Lakes Alluvium

The *Thirlmere Lakes Research Program* aimed to provide a detailed understanding of the hydrological dynamics, water sources and water flow pathways. The summation report, "Thirlmere Lakes – A Synthesis of Current Research" was released in late March 2022, by DPE.

The TLRP report (DPE, 2022) and associated specialist technical reports describe the general stratigraphy of the lakes system:

- The upper ~15 m across all surveyed lakes and sills is represented by unconsolidated alluvial/colluvial sediments.
- The upper 2–3 m of the sills are typically unsaturated sand, which generally overlay clay.
- Across the lakes, the upper 4–5 m horizon comprised saturated clay.
- In the areas to the north and east of the lakes system along the Boundary and Slades Road, the shallow dipping layers were observed to a depth of 5–6 m with a very gentle dip gradient to the south-west and north-east, typical of the Hawkesbury Sandstone constraining sediment depths (DPE, 2022).

The lake sediments are comprised of an upper peat sequence that has started to accumulate over the last 12,000 years. These organic-rich sediments represent the modern Thirlmere Lakes and this unit varies in thickness from up to 5 m in Lake Baraba to an average of ~2–3 m in the other lakes. This lithostratigraphic member has very low bulk density (0.174 ± 0.103 grams/cubic centimetre) and very high moisture content (83 ± 9%) and total organic carbon (TOC) contents of up to 40%.

This Holocene peat unit grades into a distinct oxidised silty clay that underlies all lakes. This unit represents a distinctive marker horizon in the lake sediment formation but also varies in thickness across and within any given lake. This unit has been dated in two lakes (Couridjah and Werri Berri) to be 21,000 to 12,000 years (the last glacial maximum [LGM] and the deglacial) and represents a massive hydrological change where Thirlmere Lakes dried and the lake sediments were sub-aerially exposed. This unit signifies catastrophic drying at Thirlmere Lakes and it also currently acts as a local aquitard based on the obvious saturated zone of sediment immediately overlying it.

At its closest point, the Thirlmere Lakes alluvium is mapped as being approximately 300 m west of Tahmoor Mine (Longwall 17, near Lake Couridjah) and approximately 3,500 m from LW S1A-S6A.

3.5.1.2 Wianamatta Group (WMFM)

The WMFM is composed of the Liverpool Subgroup which includes the Bringelly Shale Formation, Minchinbury Sandstone and Ashfield Shale Formations. Around the mine, the Wianamatta Group are present as hill cappings overlying the Hawkesbury Sandstone, particularly in the northern region of the Tahmoor Coal leases (Figure 3-6 and Figure 3-7). The formation predominantly comprises shales having poor permeability and water quality, and therefore is not considered a major groundwater resource in the area. The shales however, can lead to the development of springs in areas near the contact with the HBSS.

3.5.1.3 Hawkesbury Sandstone (HBSS)

The HBSS dominates the outcrop area around Tahmoor Mine, and is present beneath the WMFM and alluvium, except for where it may have been eroded away along valleys to expose the underlying Narrabeen Group (HydroSimulations, 2018) (Figure 3-5).

The unit is indicated to be greater than 150 m thick in the north of the mine, where recently drilled investigation bores show it to be up to 170 m thick (i.e. WD01; SCT, 2020). Above Tahmoor South, recent drilling shows thickness of 165 m (i.e. TSC01; SCT, 2020), as shown on Figure 3-6 and Figure 3-7.

The HBSS is a porous rock aquifer of moderate resource potential. In areas where secondary porosity has developed, such as in structural zones like the Nepean Fault zone, higher resource potential can be achieved.

3.5.1.4 Narrabeen Group

The Narrabeen Group is present across the Tahmoor Mine site beneath the HBSS. The unit consists of a sequence of interbedded sandstone, claystone, and siltstone. The main hydrostratigraphic units include the Bulgo Sandstone and Scarborough Sandstone, which have minor aquifer potential, and the BHCS, Stanwell Park Claystone and Wombarra Claystone which are considered aquitards. These units are shown, in stratigraphic order, in Figure 3-6 and Figure 3-7. Recent investigations into the structural integrity of the BHCS were conducted as part of the current Thirlmere Lakes enquiry. Findings from this investigation suggest that the BHCS is a poor aquitard that is likely to become leaky, or cease acting as an aquitard when fractured (either naturally or anthropogenically (UNSW, 2021; DPE, 2022). Recent drilling investigations completed as part of these studies (GW049046 and GW099003 nearer Dendrobium Mine and to the east of Tahmoor South), show the BHCS to have a thickness of around 6 m.

3.5.1.5 Illawarra Coal Measures

The Illawarra Coal Measures are present across Tahmoor beneath the Narrabeen Group. The formation contains the units of primary economic interest in the Sydney Basin, and consist of interbedded sandstones, shale and coal seams with a total thickness of approximately 200 m to 300 m.

The two main coal seams mined in the Southern Coalfield are the uppermost Bulli Coal seam and the Wongawilli Coal seam (Holla and Barclay, 2000). The coal seams outcrop to the east of Tahmoor Mine, where coal seams are truncated (eroded) along the Illawarra Escarpment, as well as being likely to outcrop approximately 20 km to the west of Tahmoor Mine along the Nattai River valley.

The thickness of the Bulli Coal seam is shown on Figure 3-6 and Figure 3-7. The Bulli seam is separated by approximately 8-38 m from the older Wongawilli Seam by the Eckersley Formation. The Wongawilli Seam is approximately 8-10 m thick around Tahmoor Mine (Figure 3-6 and Figure 3-7).

The Illawarra Coal Measures are not targeted for groundwater use as the water quality is poor (HydroSimulations, 2020). Publicly available data from AGL's Camden Gas Project indicated an average TDS of around 11,000 mg/L and a range of 3,200-27,500 mg/L (Parsons Brinckerhoff, 2013).

3.5.2 Hydraulic Properties

The following sub-sections describe pre-mining hydraulic properties (hydraulic conductivity and storage) for the geological units relevant to Tahmoor Mine. Subsidence due to longwall extraction can cause changes to both these properties. The changes to these are described, with some quantification, in Section 3.5.7.

3.5.2.1 Hydraulic Conductivity (K)

Geological formations are not homogenous in nature, and in this sedimentary environment are generally made up of layers of alternating sediments. This means that analysis of available permeability of hydraulic conductivity testing must take account of the influence of the different units and lithologies on horizontal and vertical flow.

Available data for hydraulic conductivities for the main lithological units relevant to Tahmoor are presented on Figure 3-8 and Figure 3-9, and summarised and tabulated in Table 3-2. Data has been sourced from packer testing with some available from core testing, conducted at Tahmoor, Appin and Dendrobium Mines. Packer testing primarily tests horizontal hydraulic conductivity (Kh), but can also be useful in characterising the likely vertical hydraulic conductivity (Kv) in sedimentary units
Data indicated that there is large range of values among formations, however it should be noted that there is limited core testing data (Kv), particularly outside of the Hawkesbury Sandstone (HBSS). Because of this, we have also added the harmonic mean from the packer testing as an estimate of 'representative' Kv to Table 3-2. Figure 3-8 shows that there is generally not a huge contrast between mean Kh for units termed as claystone and sandstone. The large range of observed Kh values are likely due to testing of more clay/sand rich layers. Figure 3-9 shows that these units termed claystone generally have lower Kv, however these units are on average less than 10 m thick and more difficult to characterise.

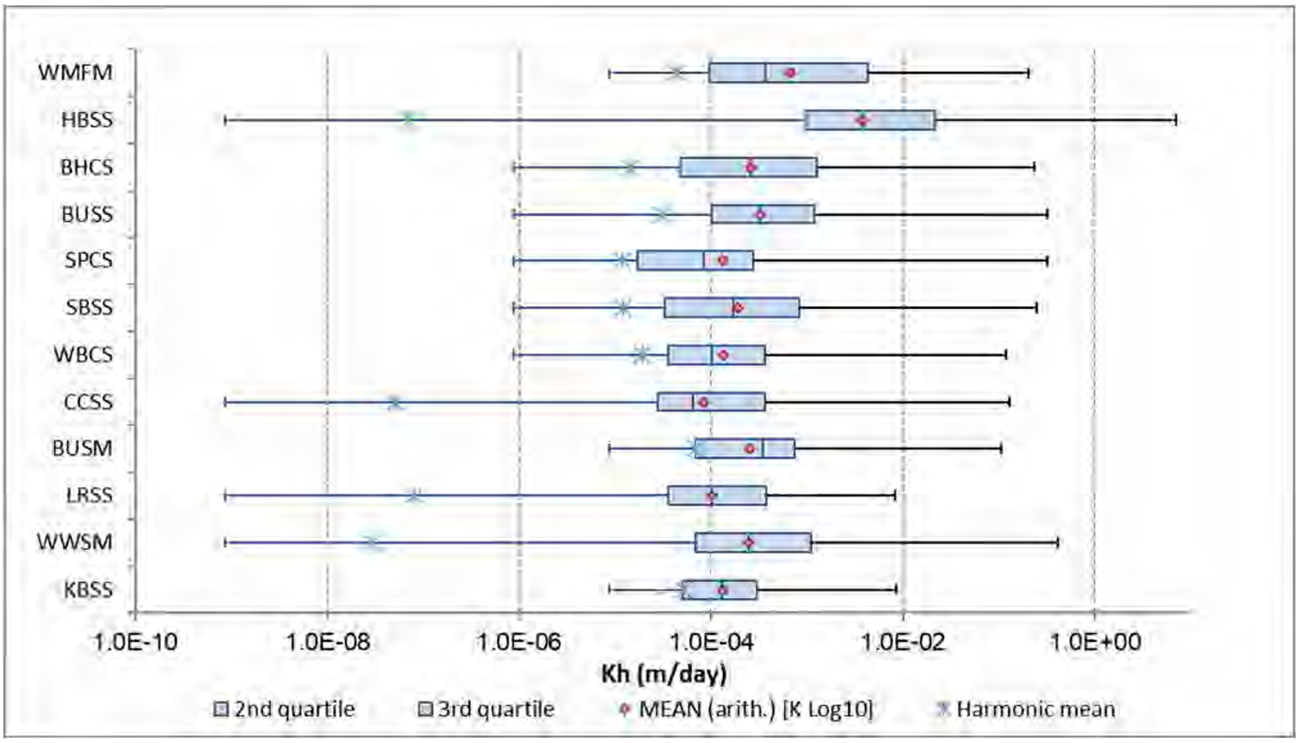


Figure 3-8 Box and whisker plot of horizontal hydraulic conductivity for each formation

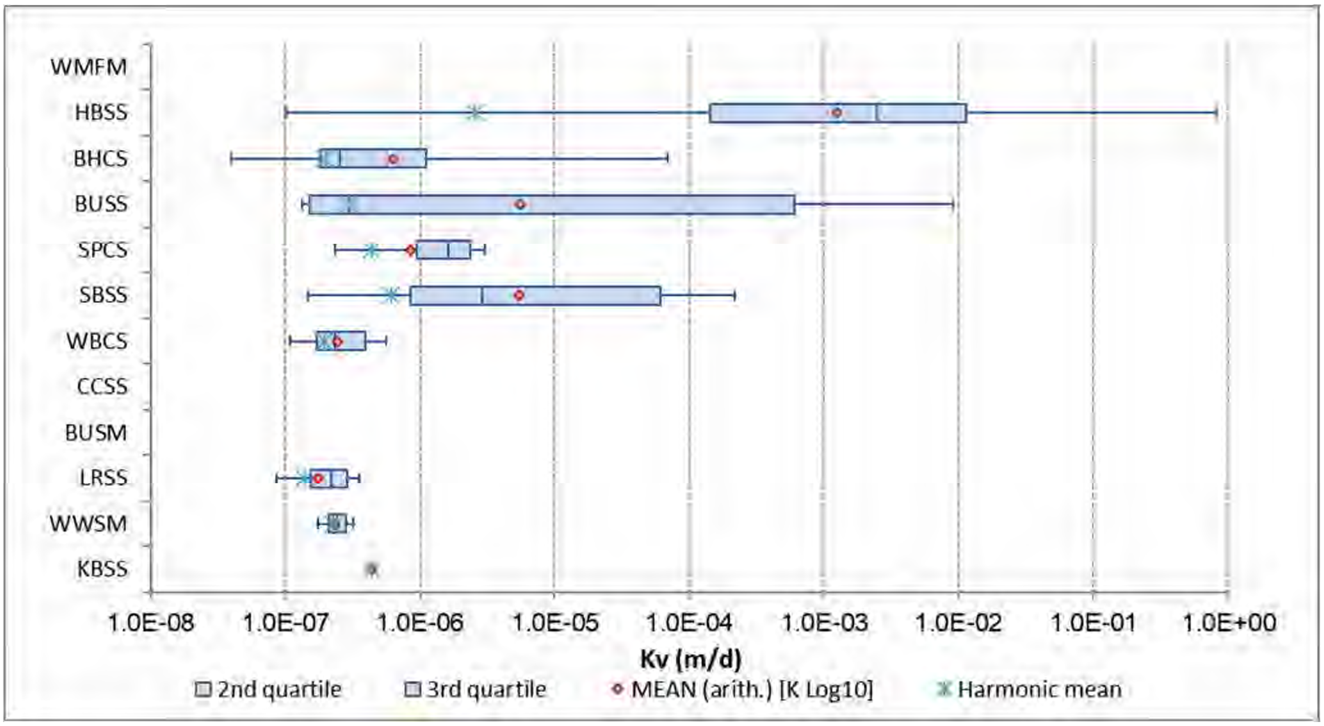


Figure 3-9 Box and whisker plot of vertical hydraulic conductivity for each formation

Table 3-2 Hydraulic conductivity data summary

Unit	Horizontal, Kh (m/d)				Vertical, Kv (m/d)				
	Packer, Arithmetic mean	Packer, 5th Perc.	Packer, Max	Packer, Population	Packer, Harmonic mean	Core testing, Arithmetic	Core, Min	Core, Max	Core, Population
WMFM	6.70E-04	8.64E-06	2.03E-01	18	4.44E-05	na	na	na	0
HBSS	3.73E-03	7.99E-05	7.07E+00	820	7.08E-08	1.25E-03	1.01E-07	0.817849	40
BHCS	2.64E-04	5.12E-06	2.33E-01	164	1.44E-05	6.34E-07	3.94E-08	6.85E-05	20
BUSS	3.30E-04	8.64E-06	3.20E-01	657	3.08E-05	5.54E-06	1.34E-07	0.00905	13
SPCS	1.34E-04	8.64E-06	3.20E-01	44	1.20E-05	8.42E-07	2.33E-07	3.04E-06	2
SBSS	1.90E-04	3.57E-06	2.51E-01	118	1.23E-05	5.47E-06	1.48E-07	0.000219	5
WBCS	1.36E-04	6.45E-06	1.21E-01	93	1.94E-05	2.41E-07	1.07E-07	5.57E-07	3
CCSS	8.40E-05	2.78E-06	1.30E-01	59	5.08E-08	na	na	na	0
BUSM	2.57E-04	1.26E-05	1.06E-01	52	6.83E-05	na	na	na	0
LRSS	1.02E-04	8.59E-06	8.29E-03	95	8.18E-08	1.74E-07	8.64E-08	3.51E-07	2
WWSM	2.48E-04	8.93E-06	4.15E-01	68	2.94E-08	2.34E-07	1.73E-07	3.17E-07	2
KBSS	1.33E-04	1.40E-05	8.55E-03	34	5.15E-05	4.34E-07	4.34E-07	4.34E-07	1

Arithmetic mean is best for describing 'average' Kh, noting that given the range in K over several orders of magnitude, average Log10 K is reported. Harmonic mean is best for estimating 'representative Kv (Domenico and Schwartz, 1998).

Hydraulic conductivity versus depth is presented in Figure 3-10 (horizontal) and Figure 3-11 (vertical). Both figures demonstrate that there is an overall decreasing trend of hydraulic conductivity with depth. Figure 3-10 shows that Kh decreases with depth both overall (pre- and post-mining) and for each formation. Figure 3-11 shows that Kv decreases with depth overall, however there is insufficient data to assess this trend for formations other than the Hawkesbury Sandstone and Bald Hill Claystone. Decreasing hydraulic conductivity with depth is expected due to overburden pressure reducing secondary porosity (essentially fracture or defect aperture) via compression.

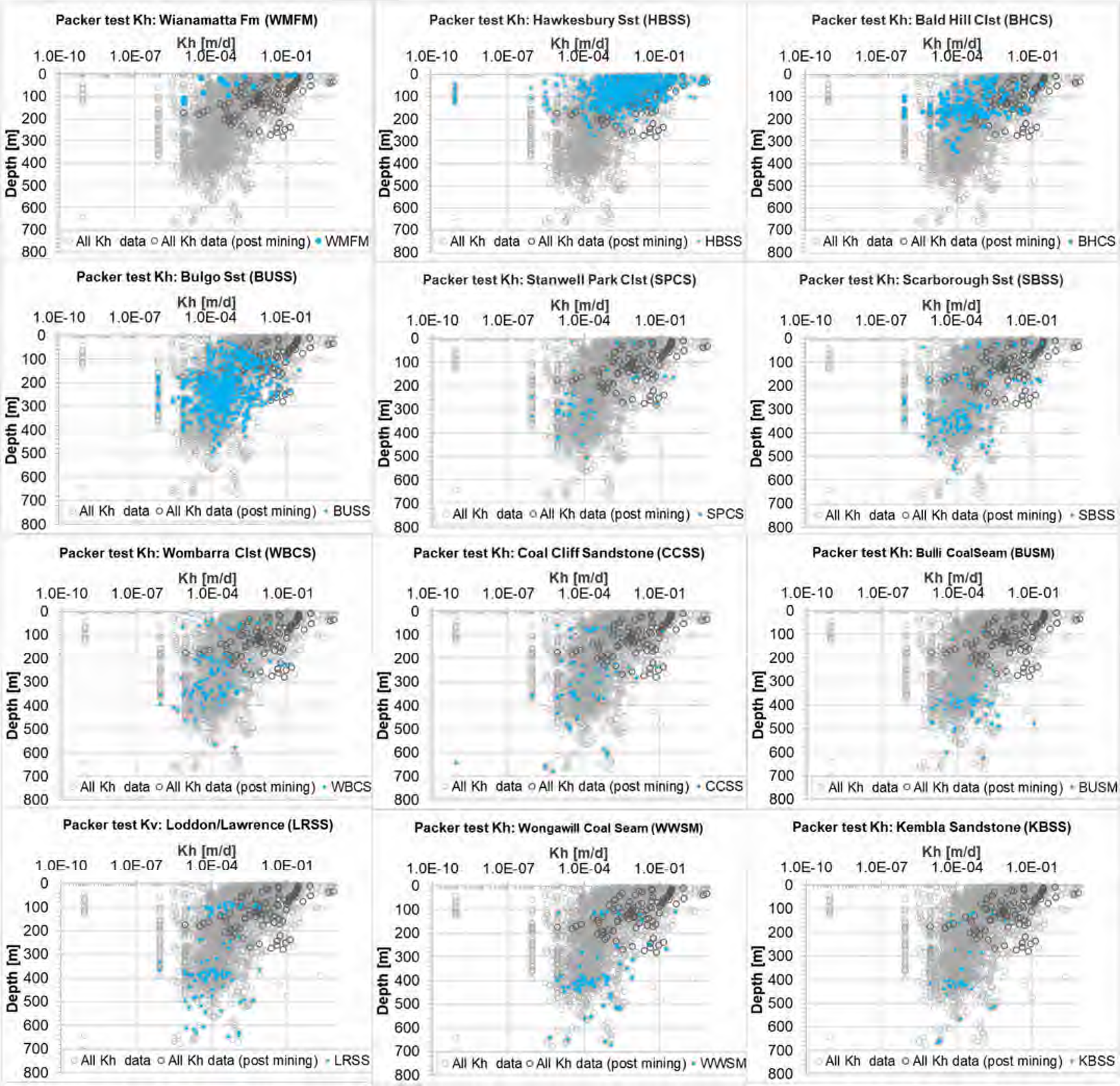


Figure 3-10 Horizontal hydraulic conductivity vs depth

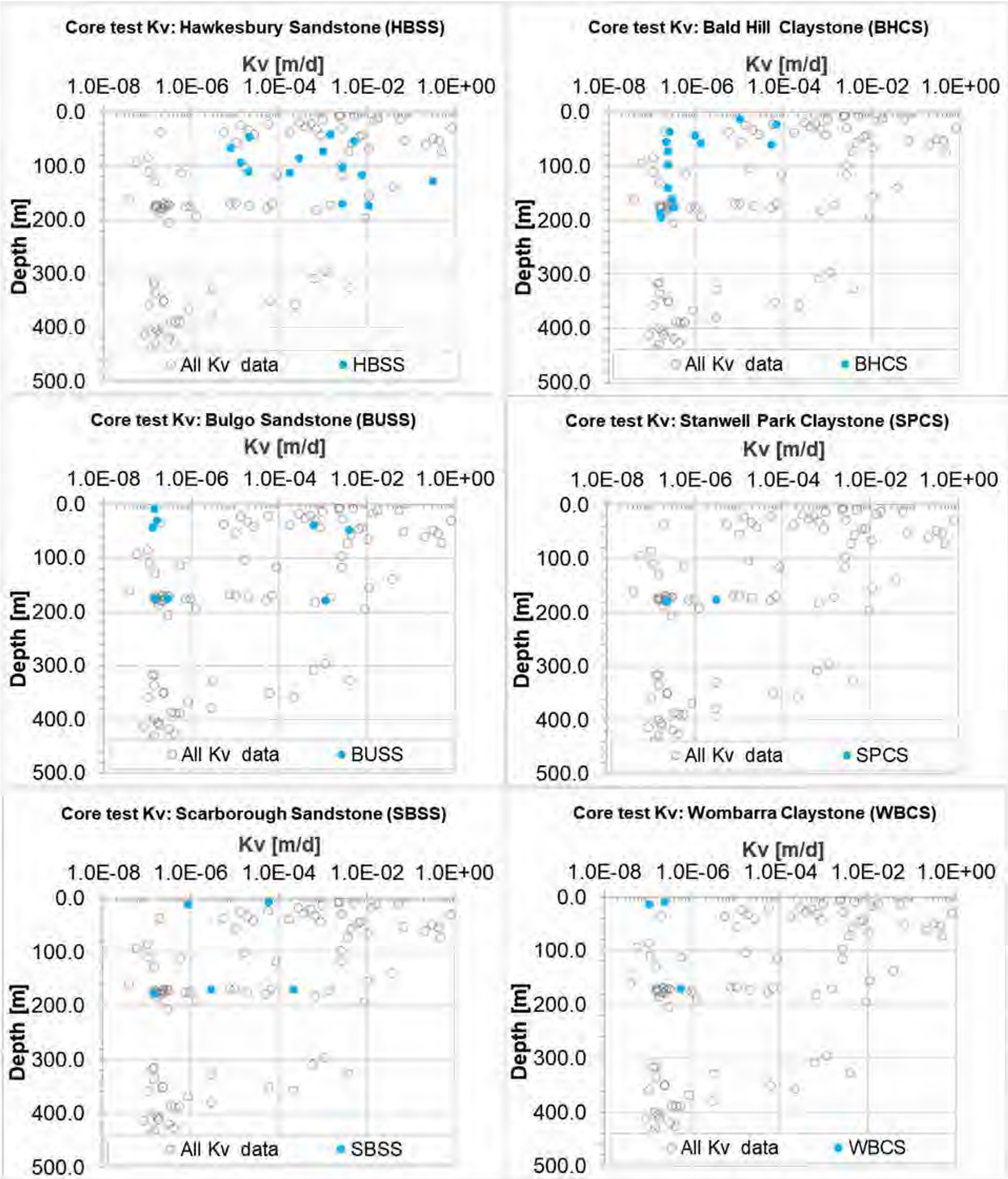


Figure 3-11 Vertical hydraulic conductivity vs depth

3.5.3 Storage Parameters

There is currently no field data concerning aquifer storage properties at Tahmoor Mine for specific yield (Sy) or specific storage (Ss), although these is some core testing of porosity. Groundwater specific storage varies by orders of magnitude, is difficult to quantify, and prone to significant uncertainty (Rau et al, 2018).

3.5.3.1 Storage Properties

HydroSimulations (2020) reports that there are three measurements of total porosity (n) (which would be the highest possible specific yield) available from core tests at bore TBC037 including:

- Two measurements from the HBSS, where n = 5.3% and 11%.
- One measurement from the BHCS, where n = 4%.

Data collected elsewhere in the Sydney Basin provides a Sy estimate of between 1 and 2% for the HBSS (Tammetta and Hewitt, 2004), appearing to confirm that Sy is lower than the total n stated above. Storage properties are expected to decrease depth due to a reduction in porosity from overburden pressure, as well as being influenced by strata lithology.

Alluvium is expected to possess a specific yield in the range of 0.03 to 0.2, i.e. 3-20% (HydroSimulations, 2020).

There is no site specific data available from Tahmoor mine to estimate specific storage. Pumping test data collected within the Sydney Basin, for intervals between ground surface and 300 m depth provide a specific storage estimate of 1.5E^{-6} m^{-1} (Commonwealth of Australia, 2014).

Useful estimates of specific storage can also be made based on Young's Modulus and porosity, based on calculations in Mackie (2009). Calculations for this site suggest that for coal, Ss generally lies in the range 5E^{-6} m^{-1} to 5E-5 m^{-1}, and interburden from 1.7E^{-6} (unfractured, fresh rock) to 8E^{-6} (fractured rock). These values are consistent with the appropriate range of Ss stated by Rau et al (2018).

Modelled storage properties from the most recent model at Tahmoor (HydroSimulations, 2020) are shown in Table 3-3.

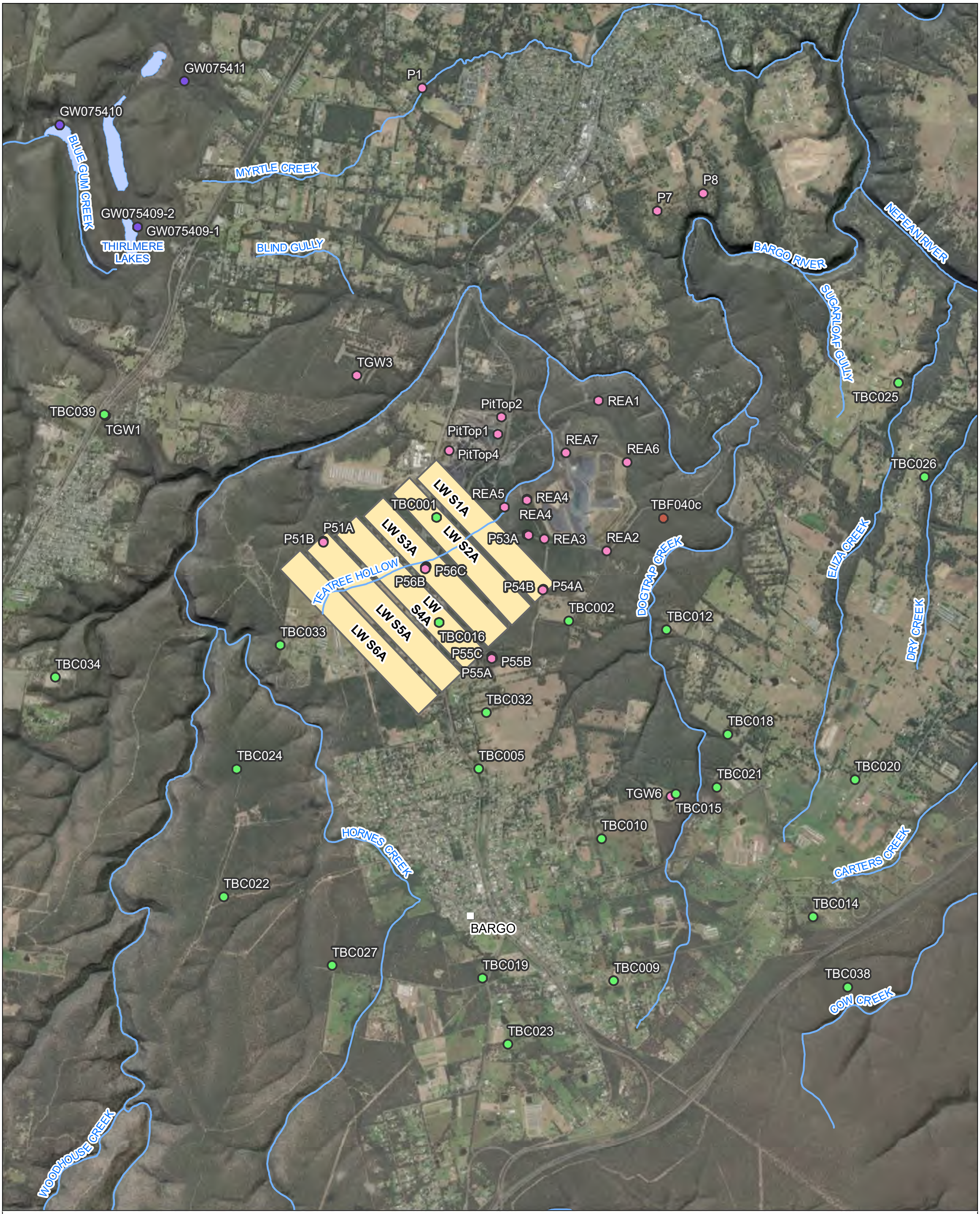
Table 3-3 Modelled storage properties (HydroSimulations, 2020)

Unit	Ss [m-1]	Sy
Alluvium	1.03E-04	1.14E-01
Alluvium – clay rich	1.03E-04	3.00E-02
Basalt	1.19E-05	2.00E-02
Wianamatta Formation	1.02E-06	1.06E-02
Hawkesbury Sandstone - upper	6.00E-06	1.60E-02
Hawkesbury Sandstone - mid	6.00E-06	1.10E-02
Hawkesbury Sandstone - lower	6.00E-06	1.10E-02
Bald Hill Claystone	6.00E-06	7.00E-03
Bulgo Sandstone - upper	6.00E-06	1.00E-02
Bulgo Sandstone - lower	7.00E-06	1.00E-02
Stanwell Park Claystone	6.00E-06	2.50E-03

Unit	Ss [m-1]	Sy
Scarborough Sandstone - upper	2.50E-06	6.00E-03
Scarborough Sandstone - lower	4.50E-06	7.50E-03
Wombarra Claystone	5.00E-06	2.00E-03
Coal Cliff Sandstone	4.00E-06	6.00E-03
Bulli Coal Seam	7.00E-06	8.00E-03
Loddon, Lawrence Sandstones	2.50E-06	5.00E-03
Wongawilli Seam	4.00E-06	5.00E-03
Kembla Sandstone	2.00E-06	5.00E-03
Lower Permian Coal Measures	1.00E-06	4.00E-03
Shoalhaven Group	3.06E-06	5.00E-03
Igneous intrusion / sill	1.02E-06	5.00E-03

3.5.4 Groundwater Levels

This Section described the current groundwater level observations for bores pertinent to Tahmoor South. Figure 3-12 shows the location of all the monitoring bores associated with LW S1A-S6A. Those with historical data records are discussed here.



N

0 0.5 1 km

Coordinate System:	GDA 1994 MGA Zone 56
Scale:	1:50,000 at A4
Project Number:	610.30637
Date:	27-Jun-2023
Drawn by:	NT

Minor Town

Watercourses

Lakes

Tahmoor South Mine Plan

Approved

Groundwater Monitoring Locations

Centreline HOF bore

Deep GWL

NSW govt monitoring

OSP

TAHMOOR SOUTH LW S1A – S6A GROUNDWATER TECHNICAL REPORT

Monitoring Bore Locations

FIGURE 3-12

H:\Projects-SLR\610-SrvSYD\610-SYD\610.30637.00000 Tahmoor Coal Extraction Plan LW101A LW06 SLR Data\01 CADGIS\GIS\61030637 Fig3_12 Monitoring Bore.mxd

3.5.4.1 Water Level Observations

3.5.4.1.1 Vibrating Wire Piezometers

Hydrographs for the groundwater Reference Sites identified in the Groundwater Monitoring Plan (SLR, 2021) for the Tahmoor South operations are shown on Figure 3-13, Figure 3-14, and Figure 3-15 with their locations displayed on Figure 3-12. Sites TBC024, TBC027, TBC034 and TBC038 are equipped with Vibrating Wire Piezometers and started recording groundwater levels in 2012-13. The depths of each VWP sensor and monitored strata are presented in Table 5-3.

Hydrographs for the other Tahmoor South VWP bores (not the Reference Sites) are provided in Appendix A.

Site TBC024

TBC024 is located 1,700 m south of LWS6A and 440 m east of Bargo River. It has a number of sensors placed in the Hawkesbury Sandstone and Bulgo Sandstone at various depths, as well as one in the Bulli Coal seam (BUCO) and Wongawilli Coal seam (WWCO). It also has one sensor in each of the two claystone units, the Bald Hill Claystone (BHCS) and Wombarra Claystone (WBCS). Groundwater pressure started to be recorded in April 2012 with data made available until January 2021. The uppermost sensor HBSS-95m was removed due to large fluctuation in pressure (Groundwater Exploration Services [GES], 2013) and removed from the dataset following a recent review of the data quality for VWP (GES, 2021). There is uncertainty in the position of the sensor in BHCS-168m as groundwater pressure appear higher than pressure recorded at other sensors from 2012 to 2016 (GES, 2013).

Hydrograph shown on Figure 3-13 presents a consistent decline in groundwater pressure of similar magnitude in all units from 2012 to early 2020. In the HBSS this decline ranges from 3.5-4.5 m in HBSS-117m and HBSS-139m respectively while it ranges from 3-5m in the BGSS (i.e. BGSS-185m, BGSS-240m and BGSS-295m). Minor responses to rainfall recharge is observed in the Hawkesbury Sandstone during the historical period, with responses in groundwater levels ranging from 0.2-0.5m. Groundwater pressure in the Bulli Coal seam and Wongawilli Coal seam followed the same declining trend before the sensors failed in July 2019.

Following the exceptional wetter condition in early 2020, groundwater levels stabilised in all units and increased by approximately 0.5 m in the HBSS and with a more subdued recovery in the BGSS (0.2-0.3 m rise). During late May 2020 – early June 2020, a spike in groundwater levels of approximately 2 m is observed in HBSS-117m, coincident withabove average rainfall.

A downward vertical gradient is observed in the HBSS between HBSS-117m and HBSS-139m with a head difference ranging from 1 m at the start of monitoring to 3 m in January 2021. The increase in head difference over time is due to water levels being more responsive to rainfall recharge in HBSS-117m than in HBSS-139m.

A minor upward vertical head differential from the BGSS to the HBSS is inferred at TBC024 with groundwater pressure in the BGSS being between 1 to 2 m above groundwater pressure in the HBSS. Similar groundwater pressures between the units suggests some degree of aquifer connectivity at site TBC024.

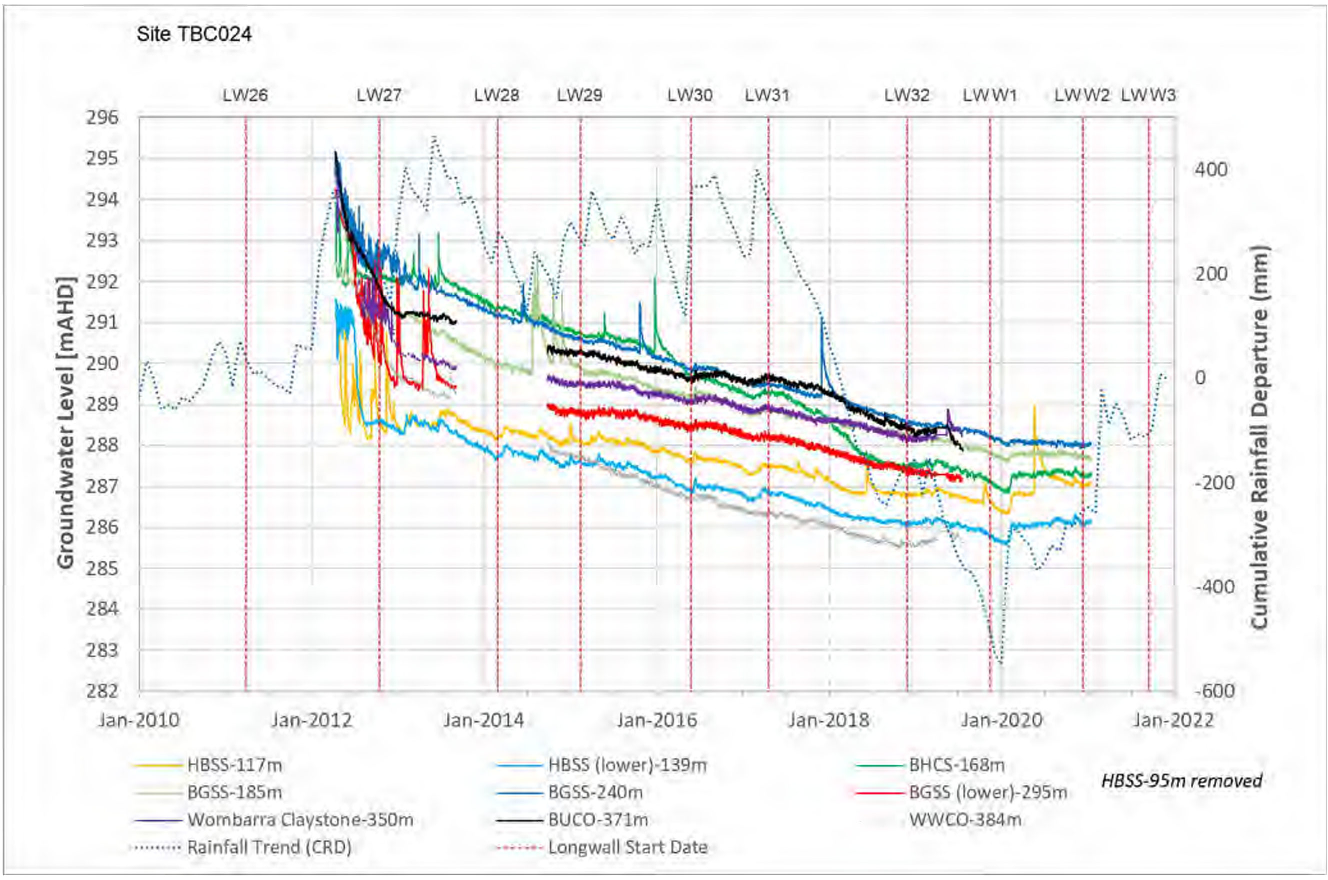


Figure 3-13 Hydrograph for TBC024

Site TBC027

TBC027 is located 2,400 m southwest of LWS6B and 500 m west of Hornes Creek. TBC027 is also located 2,200 m south of TBC024. TBC027 is equipped with three sensors in the HBSS (HBSS-95m, HBSS-132m and HBSS-169m), three sensors in the BGSS (BGSS-181m, BGSS-198m and BGSS-253m), one sensor in the Bald Hill and Wombarra claystones (BHCS-181m and WBCS-362m) as well as sensors in the Bulli Seam and Wongawilli Seam (BUCO-384m and WWCO-396m). Groundwater pressure started to be recorded in April 2013 and all sensors appear to be active as of January 2022. Groundwater levels in the HBSS have been responsive to historic rainfalls in the range of 1-2m, and more recently with the exceptional rainfalls in early 2020 showing a response in water levels of approximately 4-6m.

A head separation of approximately 6-7 m is observed between the upper (HBSS-95m) and the lower HBSS (HBSS-132m and HBSS-169m), with a clear downward vertical gradient.

Groundwater levels in upper Bulgo Sandstone are less responsive to rainfall recharge showing stable groundwater levels since the start of monitoring with water levels in BGSS-198m and BGSS-253m sitting at 308.5 mAHD in January 2022. This suggests limited aquifer connectivity between the HBSS and BGSS.

Groundwater pressures in the deeper strata are stable until mid-2016 before gradually declining by approximately 10-12 m in the lower Bulgo Sandstone and the coal seams. Depressurisation in the deeper units is likely due to regional mining (i.e. Tahmoor / Tahmoor North), although timing of the decline seems odd in the context of the location of mining in 2016-2018. From early 2020, groundwater pressure stabilised and started to recover by approximately 2 m in January 2022.

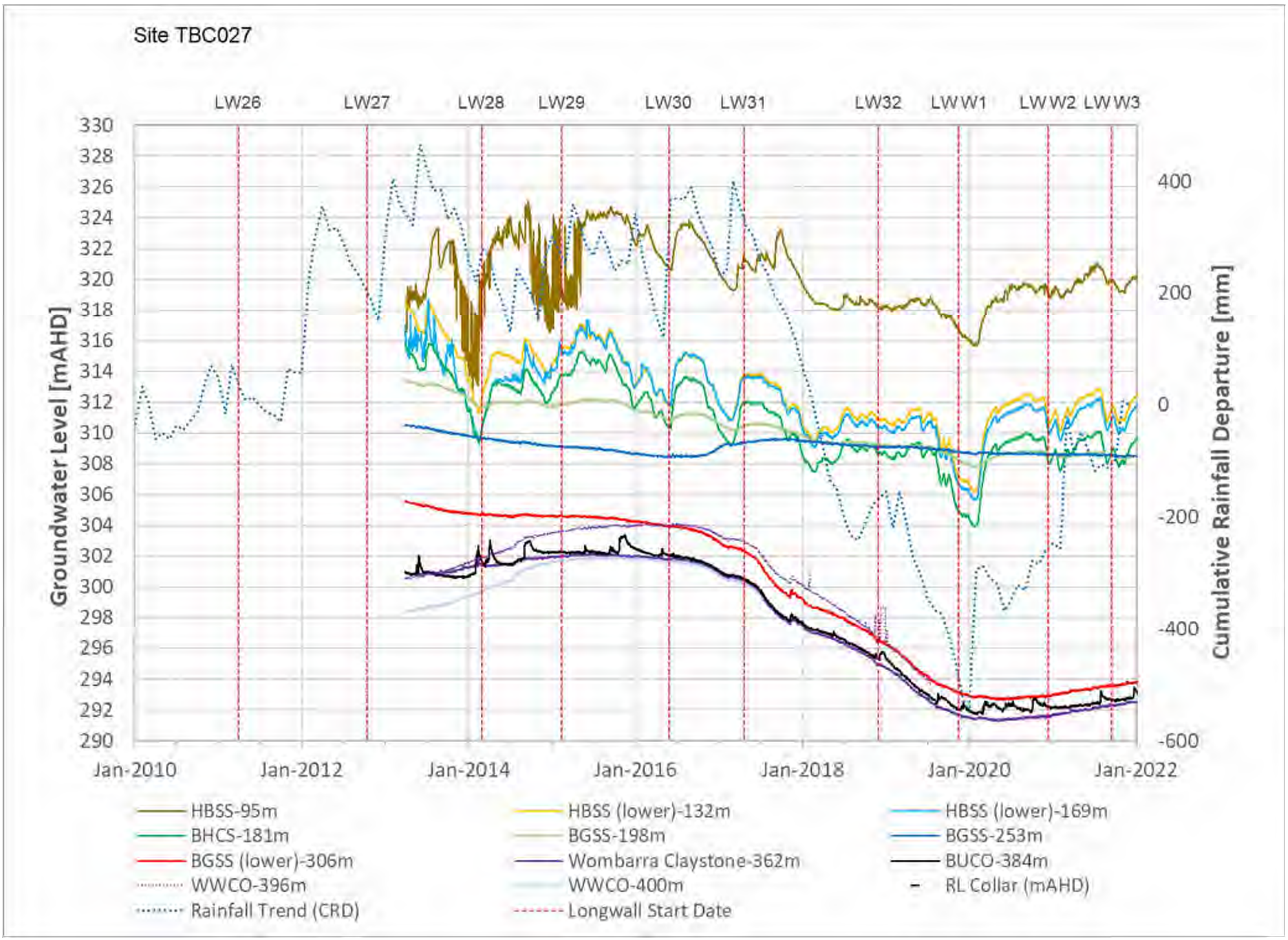


Figure 3-14 Hydrograph for TBC027

Site TBC034

TBC034 is located 2,500 m southwest of LWS6B and 1,500 m west of Bargo River. TBC034 is located to the east of the Western Fault. Similar to TBC027, TBC034 is equipped with three sensors in the Hawkesbury Sandstone (HBSS-65m, HBSS-113m and HBSS-161m), three sensors in the Bulgo Sandstone (BGSS-196m, BGSS-245m and BGSS-294m), one sensor in the Bald Hill (BHCS-176m) as well as sensors in the Bulli Seam and Wongawilli Seam (BUCO-365m and WWCO-382m). All sensors appear to be active and providing reasonable data as of January 2022 (i.e. latest available dataset) except for BGSS-294m which seemed to have failed in May 2021. Also, we note a gap in data for HBSS-113m and HBSS-161m between October 2016 and November 2020.

Figure 3-15 Hydrograph for TBC034

Groundwater levels in the Hawkesbury Sandstone are stable showing minor responses to rainfall recharge and drier periods. E.g. the shallow groundwater levels in HBSS-65 m show a minor decline of approximately 0.3 m during the recent drought (2017-2019 – Section 3.1). Groundwater levels in the Bulgo Sandstone also show limited responses to rainfall.

There is a clear downward vertical gradient observed from the upper to the lower Hawkesbury Sandstone with a consistent head separation of approximately 4 m between HBSS-65 m and HBSS- 113 m and 8 m between HBSS-113 m and HBSS-161 m. There is a smaller head gradient between the upper and mid Bulgo Sandstone, as well as a similar water level elevation as seen in HBSS-161 m. These observations suggest some degree of aquifer connectivity across the upper and mid Bulgo Sandstone and with the lower Hawkesbury Sandstone.

In the Bulgo Sandstone, there is a head separation of 40-45 m between the lowest sensor (BGSS-343.5 m) to BGSS- 294.3m showing evidence of a very strong downward vertical gradient likely to be an influence of the Western Domain fault. In the Bulli Coal and Wongawilli Coal seams a decline in groundwater pressure is observed with levels likely to be equilibrating over 2012-2014 following the installation of the VWPs. A gradual decline in groundwater pressure is observed during the monitoring period of approximately 5 m in the Bulli Seam and up to 7 m in the Wongawilli Seam between 2014 and 2020, before stabilising through 2021.

3.5.4.1.2 Reject Emplacement Area and Pit-top Bores

A series of piezometers at the pit-top and near the Reject Emplacement Area (REA). These are relatively close to the Tahmoor South domain, shown on Figure 3-12. The piezometers are not all associated with the regional aquifers (i.e. Hawkesbury sandstone) but rather some are constructed in shallow sediments and the REA and serve the following purposes:

- Pit Top piezometers (i.e.PT) are utilised to assess if the storage dams are leaking and
- REA piezometers are utilised to assess if there is any Acid Mine Drainage leaching the waste dumps.

Hydrographs for the Pit Top and REA bores are provided in Appendix B. Groundwater levels in PT1 and PT2 are highly responsive to climatic conditions (i.e. dry periods/rainfalls events) since monitoring started in November 2019. During 2020 and 2021, groundwater levels have increased by approximately 2 m at PT1. Short-term increases in water levels at PT2 are observed up to 1.5 m following rainfalls events with water levels sitting in mid-2021 approximately 1 m above the water levels observed at the end of the drought period (i.e late 2019). Groundwater levels at PT4 show less responses to rainfalls with fluctuations in the range of 0.1-0.15 m following rainfall events.

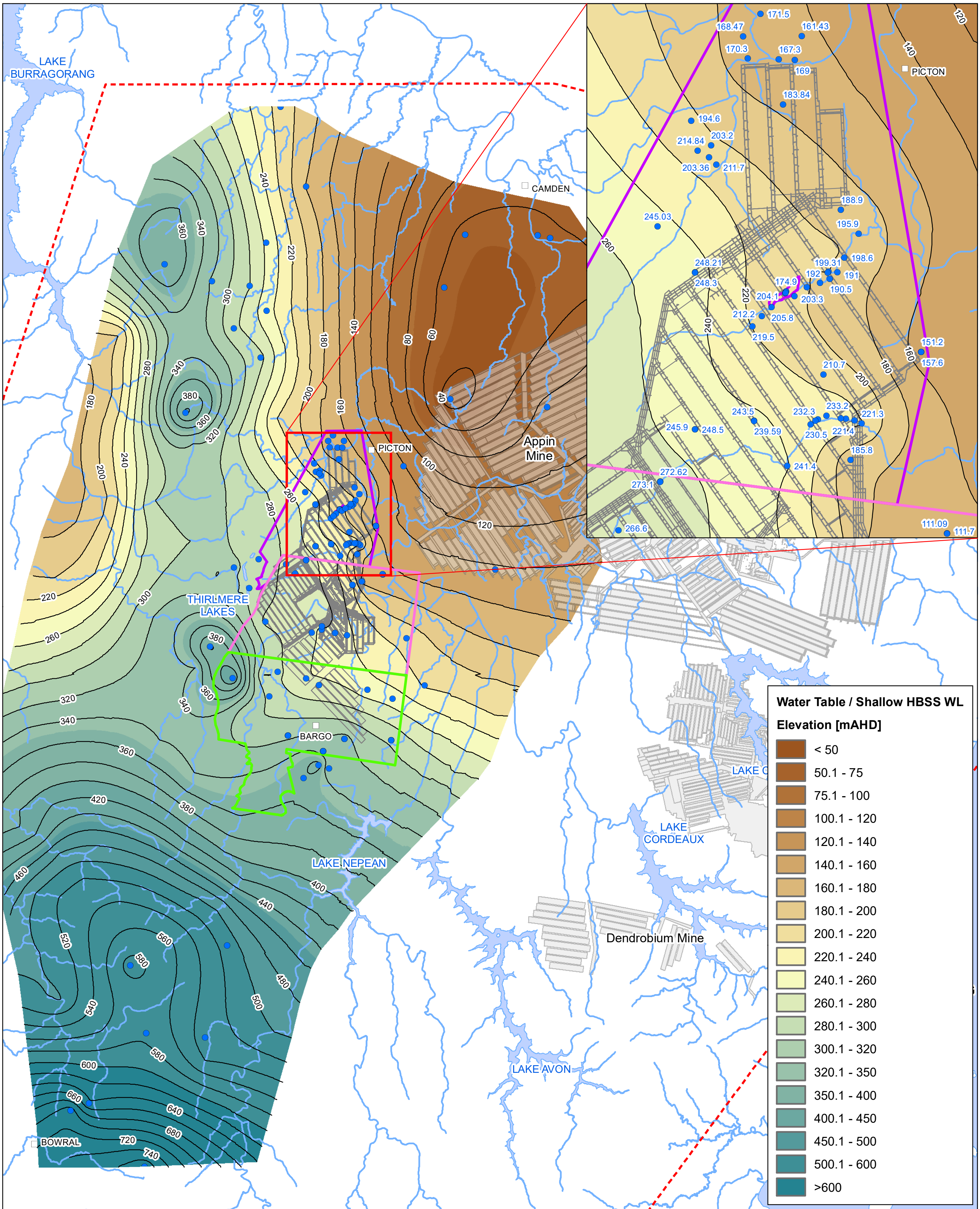
Following wet conditions in early 2020, groundwater levels at REA1, REA2, REA3, RE5, REA6 increased 0.5-0.7m. The increasing trend continued throughout 2020 at REA2 and RE3 while water levels at REA1, REA5 declined slightly (0.2-0.5 m). Throughout 2021, water levels continued to respond to rainfalls in the range of 0.2-0.5 m. At REA4 and REA7, the observed water level response to rainfall in early 2020 is larger with fluctuations in water levels of up to 7 m in REA7 while water levels in REA4 increased sharply by 1.5 m and continued to do so throughout 2021, rising by 1.5 m.

3.5.4.2 Flow, Recharge and Discharge

Interpreted water table elevations are shown on Figure 3-16 and the interpreted depth to the water table on Figure 3-17.

The interpreted groundwater conditions are based on recent available data, which ranges between 2013 and 2020. The contouring on Figure 3-16 shows that the groundwater gradient is generally flowing in an east to north-easterly direction in the area of Tahmoor Mine.

Figure 3-17 shows that groundwater levels are generally closer to the ground surface in areas where surface water drainage exists. This indicates the potential for surface drainage to contribute baseflow to the Hawkesbury Sandstone aquifer. Due to the number of watercourses surrounding Tahmoor Mine and the regional topography (see Section 3.3 and Error! Reference source not found.), the depth from the ground surface to the water table is shallower compared to the surrounding region. Over the mine, the water table is approximately 20 m below the ground surface. In areas not associated with surface drainage lines, such as that south-west of the mine, the depth to the water table is between 40 and 50 m.



0 2.5 5 km

Coordinate System:	GDA 1994 MGA Zone 56
Scale:	1:250,000 at A4
Project Number:	610.30652
Date:	22-Apr-2022
Drawn by:	JG

- Bores (RWL)
- City
- Town
- Tahmoor North and Western Domain
- Water Table (regional)
- Watercourses
- Lakes
- Southern Coalfield (approximate)

Tahmoor Coal Titles

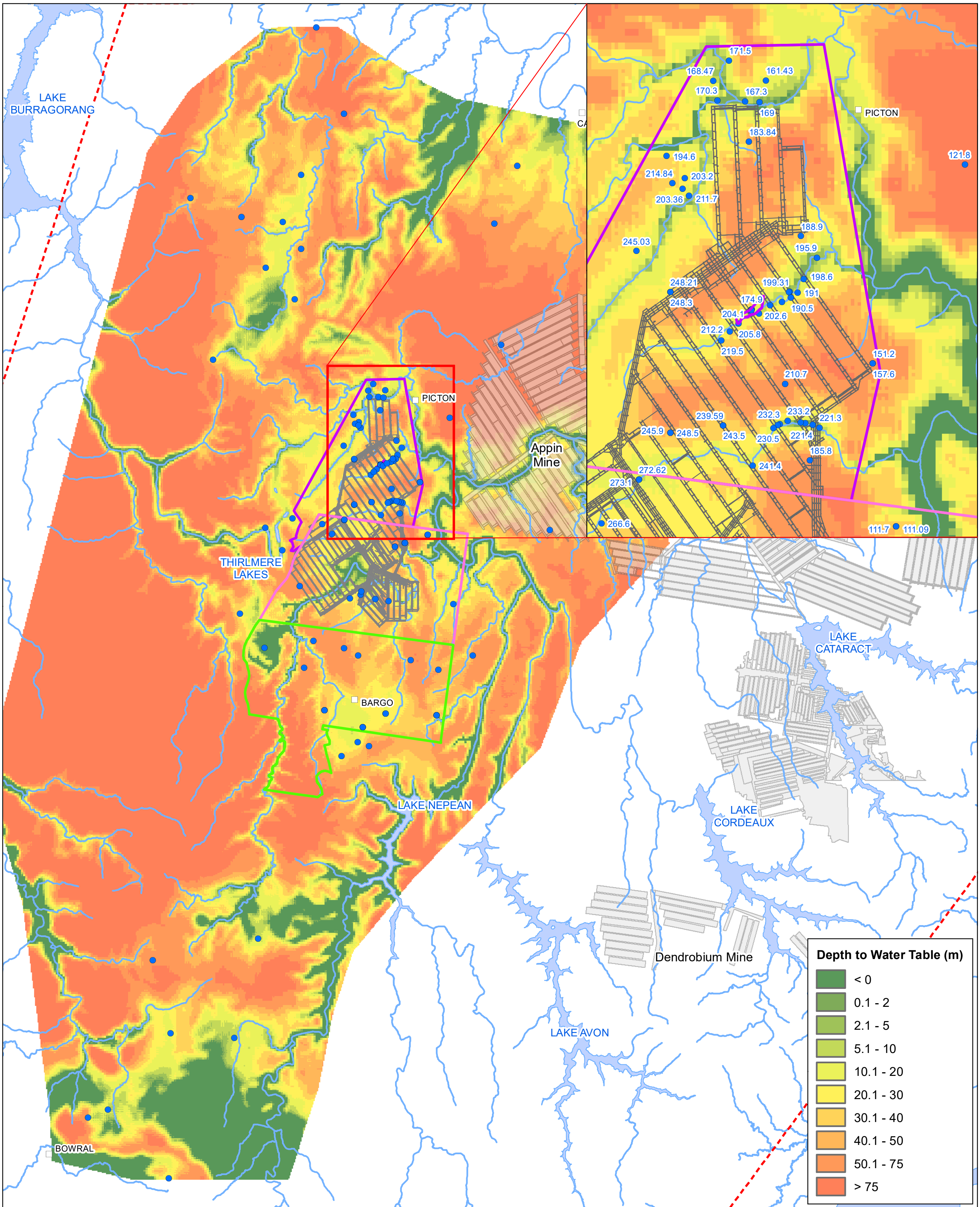
- MLs 1308, 1376, 1539
- CCL 716
- CCL 747

TAHMOOR COAL LW S1A-S6A GROUNDATER TECHNICAL REPORT

Interpreted Water Table Elevation

FIGURE 3-16

H:\Projects-SLR\610-SrvSYD\610-SYD\610.30652.00000 Tahmoor Coal Groundwater Model Rebuild\06 SLR Data\01 CADGIS\GIS\Conceptualisation\61030652 FigXX Interpreted water table elevation.mxd



N

0 2.5 5 km

Coordinate System:	GDA 1994 MGA Zone 56
Scale:	1:230,000 at A4
Project Number:	610.30652
Date:	22-Apr-2022
Drawn by:	JG

- Bore
- City
- Town
- Tahmoor North and Western Domain
- Watercourses
- Lakes
- Southern Coalfield (approximate)

Tahmoor Coal Titles

- MLs 1308, 1376, 1539
- CCL 716
- CCL 747

TAHMOOR COAL
LW S1A-S6A
GROUNDWATER TECHNICAL REPORT

Interpreted Depth to Water Table Elevation (Aug 2013)

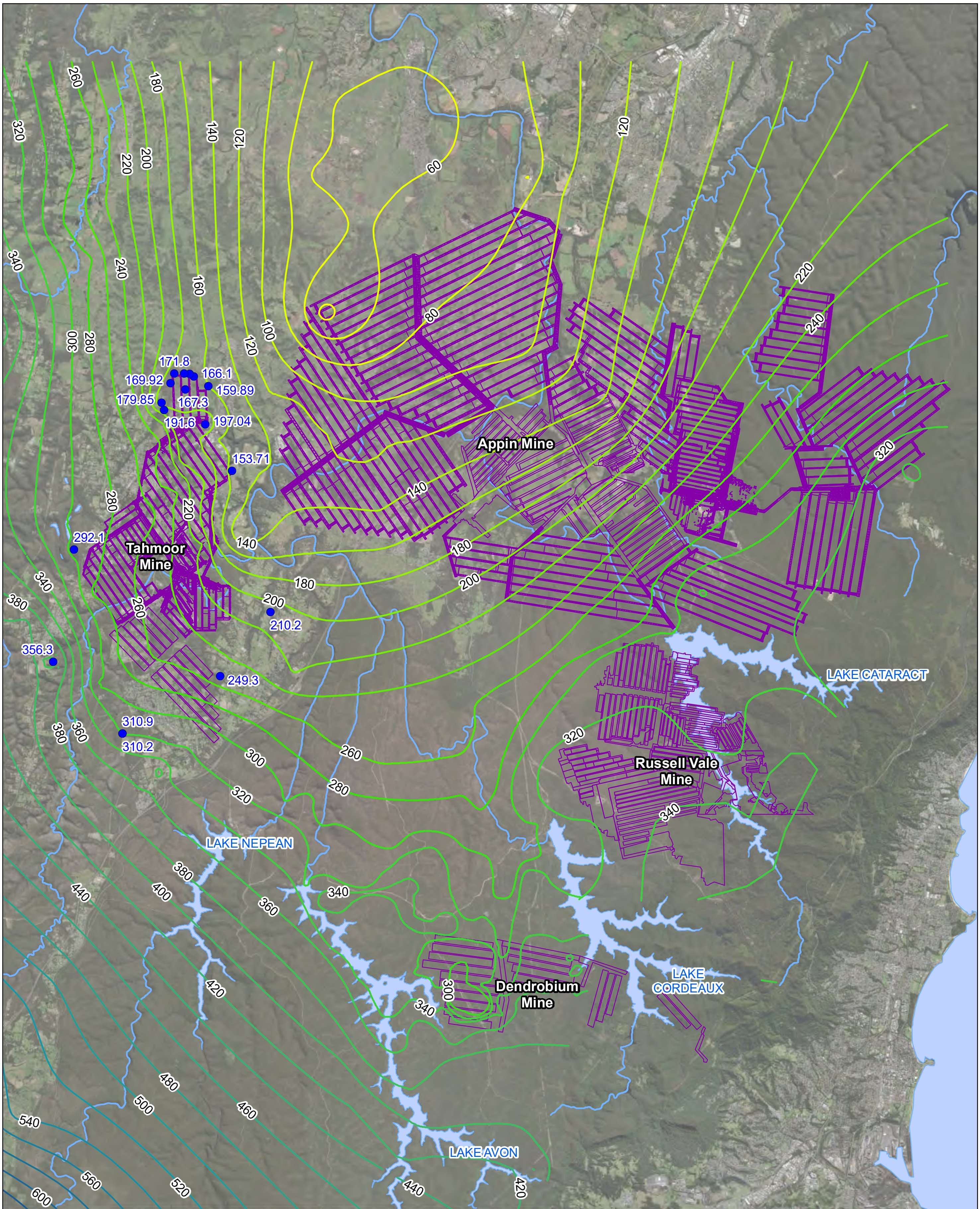
FIGURE 3-17

H:\Projects-SLR\610-SrvSYD\610-SYD\610.30652.00000 Tahmoor Coal Groundwater Model Rebuild\06 SLR Data\01 CADGIS\GIS\Conceptualisation\61030652 FigXX Interpreted depth to water table elevation (Aug 2013).mxd

Figure 3-18 presents the interpreted groundwater level elevation contours in the lower HBSS using groundwater level data from October 2021. To the east of Tahmoor South, groundwater levels in the lower HBSS range from 380-360 mAHD down to approximately 240 mAHD to the north of LW S1B. Figure 3-18 shows the groundwater gradient flows in an eastward direction across LW S1A-S6A and in a northward direction from the south-west to the north-east across the longwalls block B.

Figure 3-19 presents the interpreted groundwater level elevation contours in the lower BGSS using groundwater level data from October 2021. To the east of Tahmoor South, groundwater levels in the lower BGSS range from 340-320 mAHD down to around 230 mAHD to the north of LW S1B. Figure 3-18 shows the groundwater gradient flows in a northward direction from the south-west to the north-east across the longwalls block A and B.

Figure 3-20 presents the interpreted groundwater level elevation contours in the Bulli Seam using recent level data where available. To the east of Tahmoor South, groundwater levels in the Bulli Seam range from 300-280 mAHD down to around 180 mAHD to the north of LW S1B. Figure 3-18 shows the groundwater gradient flows in a northward direction from the south-west to the north-east across the longwalls block A and B. The cone of depression induced by mining at Tahmoor Mine (i.e. Tahmoor North and Western Domain) slightly developed across Tahmoor South and explain the observed historic depressurisation at bores relevant to Tahmoor South area.



0 2.5 5 km

Coordinate System:	GDA 1994 MGA Zone 56
Scale:	1:200,000 at A4
Project Number:	610.30652
Date:	21-Apr-2022
Drawn by:	JG

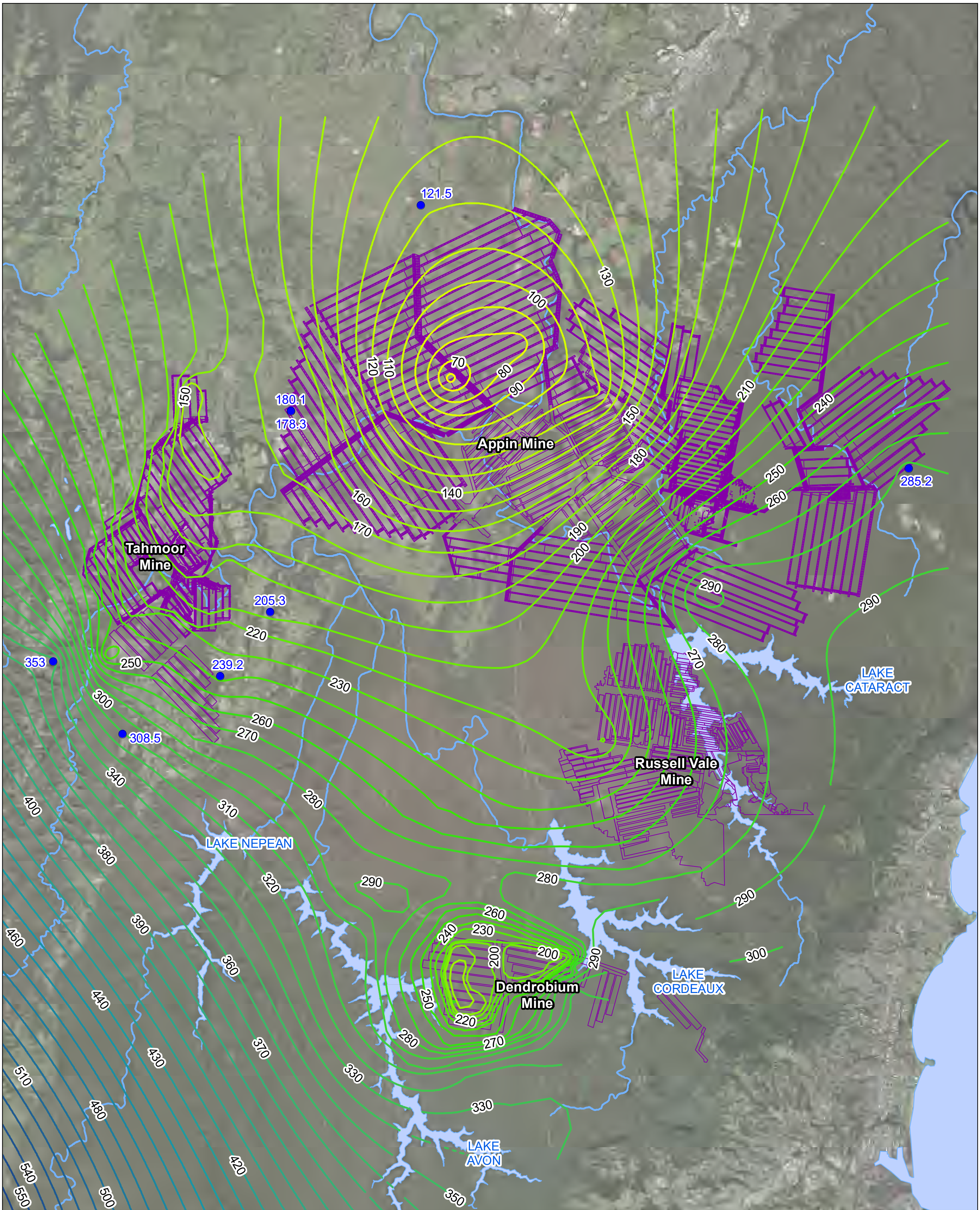
- Bore (RWL)
- Groundwater Level (mAHD)
- Existing Mine
- Watercourses
- Watercourse Area

TAHMOOR COAL
LW S1A - S6A
GROUNDWATER TECHNICAL REPORT

Interpreted Groundwater Level Elevation in the lower Hawkesbury Sandstone

FIGURE 3-18

H:\Projects-SLR\610-SrvSYD\610-SYD\610.30652.00000 Tahmoor Coal Groundwater Model Rebuild\06 SLR Data\01 CADGIS\GIS\Conceptualisation\61030652 FXX Groundwater Elevation - Hawkesbury Sandstone.mxd



0 2.5 5 km

Coordinate System:	GDA 1994 MGA Zone 56
Scale:	1:200,000 at A4
Project Number:	610.30652
Date:	21-Apr-2022
Drawn by:	JG

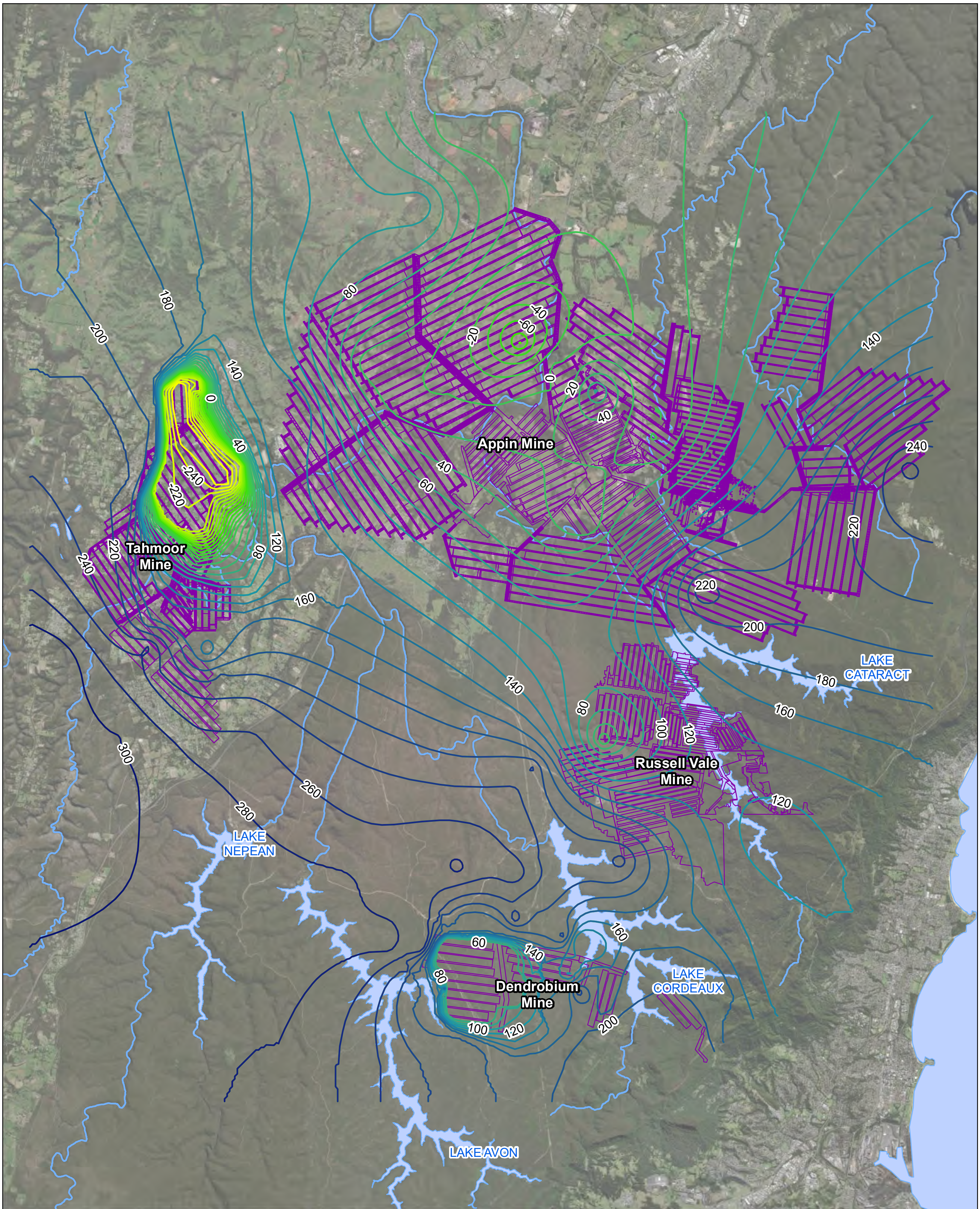
- Bore (RWL)
- Groundwater Level (mAHD)
- Existing Mine
- Watercourses
- Watercourse Area

TAHMOOR COAL
LW S1A - S6A
GROUNDWATER TECHNICAL REPORT

Interpreted Groundwater Level Elevation in the lower Bulgo Sandstone

FIGURE 3-19

H:\Projects-SLR\610-SrvSYD\610-SYD\610.30652.00000 Tahmoor Coal Groundwater Model Rebuild\06 SLR Data\01 CADGIS\GIS\Conceptualisation\61030652 FXX Groundwater Elevation - Bulgo Sandstone.mxd



0 2.5 5 km

Coordinate System:	GDA 1994 MGA Zone 56
Scale:	1:200,000 at A4
Project Number:	610.30652
Date:	21-Apr-2022
Drawn by:	JG

- Groundwater Level (mAHD)
- Existing Mine
- Watercourses
- Watercourse Area

TAHMOOR COAL
LW S1A - S6A
GROUNDWATER TECHNICAL REPORT

Interpreted Groundwater Level Elevation in the Bulli Seam

FIGURE 3-20

H:\Projects-SLR\610-SrvSYD\610-SYD\610.30652.00000 Tahmoor Coal Groundwater Model Rebuild\06 SLR Data\01 CADGIS\GIS\Conceptualisation\61030652 FXX Groundwater Elevation - Bulli Seam.mxd

3.5.5 Groundwater Quality

Water quality sampling is conducted at monitoring bores located within the Pit-Top area (Pit Top 1, 2, 4) and across the Reject Emplacement Area (REA1-7) since 2019 on a quarterly basis. Additionally, field water quality, inclusive of EC and pH, has been undertaken on a monthly basis since August 2019. Appendix C presents the baseline data (EC and pH) for the Pit Top and REA bores, with the rainfall residual mass included for comparison to climatic trends.

The Private Bore Survey, conducted between January – March 2022, completed groundwater quality sampling on a total of 31 private bores. Laboratory results of this sampling program are provided in the Private Bore Survey Summary Report (SLR, 2022), provided in Appendix D.

A summary of groundwater salinity and bore depth for the private bores is provided in Table 3-4. The median groundwater salinity is 810 µS/cm, with a minimum of 165 µS/cm and a maximum of 3,378 µS/cm. There are no apparent trends with groundwater salinity and bore depth or location.

Table 3-4 Summary of Private Bore groundwater salinity

Registered Number	Field Depth (mbgl)	Recorded Depth (mbgl)	EC (µS/cm)
10CA119328	NR	NA	1,472
115NTG	~160 – 170 m	NA	689
GW032443	10.71 (measured, likely blocked)	130.1	226.2
GW059618	122.71	117	2,396
GW062068	>100	150	165
GW070245	NR	97.5	949
GW102179	NR	153	1,849
GW102344	NR	110	801
GW102452	71.41	120.5	371.6
GW103023	51.43	165	3,378
GW103036	127.42	132.5	371.2
GW103559	NR	54	487
GW104008	>100	140	1,323
GW104323	79.8	109	1,025
GW104659	50.08	132	539
GW105262	NR	104	1,828
GW105395	53.1	90	3,341
GW105803	NR	140	1,108
GW105883	NR	NA	1,686
GW110669	NR	132	677
GW111518	28.32 (potential obstruction)	150	277
GW111669	NR	120	481
GW111810	NR	142	2058
GW112415	96.96	139	1059
GW112473	NR	138	515

Registered Number	Field Depth (mbgl)	Recorded Depth (mbgl)	EC (µS/cm)
GW115773	81.87	180	820
GW116897	51.2 (potential blockage)	160	776
Heritage Well	3.12	NA	684

NR = not recorded

Installation of a the Tahmoor South Monitoring Network, completed in May 2022, has allowed for a series of water quality sampling analysis prior to release of this report. Table 3-5 describes the salinity and pH of the monitoring bores, showing a range from approximately 230 µS/cm to 8,100 µS/cm, with a median salinity of approximately 1,500 µS/cm.

Table 3-5 Summary of Monitoring Bore groundwater salinity (June, 2022)

Bore ID	Bore Depth (mbgl)	EC (µS/cm)	pH
P51A	19.36	357.6	8.82
P51B	35.38	8106	12.66
P52	41.17	1250	5.69
P53A	41	814.25	6.15
P53B	60.55	1679.6	6.89
P53C	80.78	1708	6.9
P54C	35.99	1984	6.37
P55A	41.04	1656	5.68
P55B	59.36	1544.4	n/a
P55C	81.9	1327.3	6.99
P56A	20.9	1544.5	5.54
P56B	45.56	1090	7.06
P56C	80.4	3200.1	12.19
REA4	54.31	235.9	6.87

Review of the local and regional data indicates that:

- Groundwater in the Alluvium and Wianamatta Formation are of mixed quality. It is likely that evaporative concentration of salts could occur in alluvial aquifers, especially in clayey facies. The marine origin and low permeability of the Wianamatta Shales tends to lead to higher salinities in this unit.
- There is little data for the Narrabeen Group or Illawarra Coal Measures. Older units such as the Shoalhaven Group exhibit a range of salinities from fresh to saline.
- The Hawkesbury Sandston is the primary aquifer utilised and although shows variability in groundwater salinity it is overall suitable for stock and domestic purposes and most irrigation.

A full review of the baseline groundwater chemistry will be undertaken prior to commencement of extraction (September 2022), when minimum six months of data will be available for shallow monitoring bores and private bores.

3.5.6 Historical Groundwater inflows (Tahmoor North and Western Domain)

Groundwater pumped from all sumps in the mine workings is currently, and will continue to be, monitored by means of flow meters fitted to pipelines recording pumping times and rates. This water reporting to the underground workings and sumps may include groundwater seepage inflows, supply inflows (potable supply and for operations), and some re-circulation.

Operational water balance reviews will continue to be performed monthly collating groundwater extraction, as well as imported water to inform on-site water management. Such a system has been in operation at Tahmoor since 2009 (13 years) and will continue for the life of Tahmoor South. The volumetric flux monitoring will provide data on the total groundwater inflow to all workings, where dewatering of Tahmoor North/Western Domain workings will cease soon after LW W4 is completed (in 2022). This will mean that inflow to Tahmoor South workings will be the primary component of the measured dewatering volume.

Since 2009, inflows to the Tahmoor Mine have been within the range of 2 megalitres per day (ML/d) to 6 ML/d. Figure 3-21 presents a history of the calculated inflows ('water make') at Tahmoor Mine between 2016 and 2022. The average and total inflow for recent water years is presented in Table 3-6.

Table 3-6 Historic Mine Inflow

Water Year	Inflow, average (ML/day)	Inflow, total (ML)
2018 – 2019	3.4	1,234.4
2019 – 2020	3.3	1,206.6
2020 – 2021	4.5	1,640.6
2021 – 2022	4.4	1,290
2022 – 2023*	2.4	873.0

* For January to May 2023 only

It is noted, that pumping may cease for short periods (i.e. due to equipment failure and other reasons), the water balance may estimate zero inflow for short periods (i.e. an underestimate of true inflow). Conversely, if pumping is required to be increased to make up for earlier shortfalls in pumping, the water balance may estimate higher inflow for short periods (i.e. overestimate the true inflow). As a result, longer-term averages are more reliable than the short-term inflow estimates.

The period between mid-2020 shows an increase in inflows to greater than 5 ML/day at the end of July 2020 likely due to the extraction of LW W1. Inflow declined in late 2020, before rising in February 2021 (early in LW W2), with a peak at just over 6 ML/d in March and April 2021. Inflows to the Western Domain are not metered in isolation from other parts of Tahmoor North (they are metered along with all other pump-out) but were estimated to be greater than 2.5 ML/d at analysis between February – April 2021. Other than the minor fault observed in the southern 'half' of LW W1 and LW W2 and a small fault in the northern part of LW W3, no other obvious geological structures have been noted as intersecting current workings were observed by staff in the underground mine. As a result, no obvious relationship between higher inflow and geological structure could be determined (SLR, 2021).

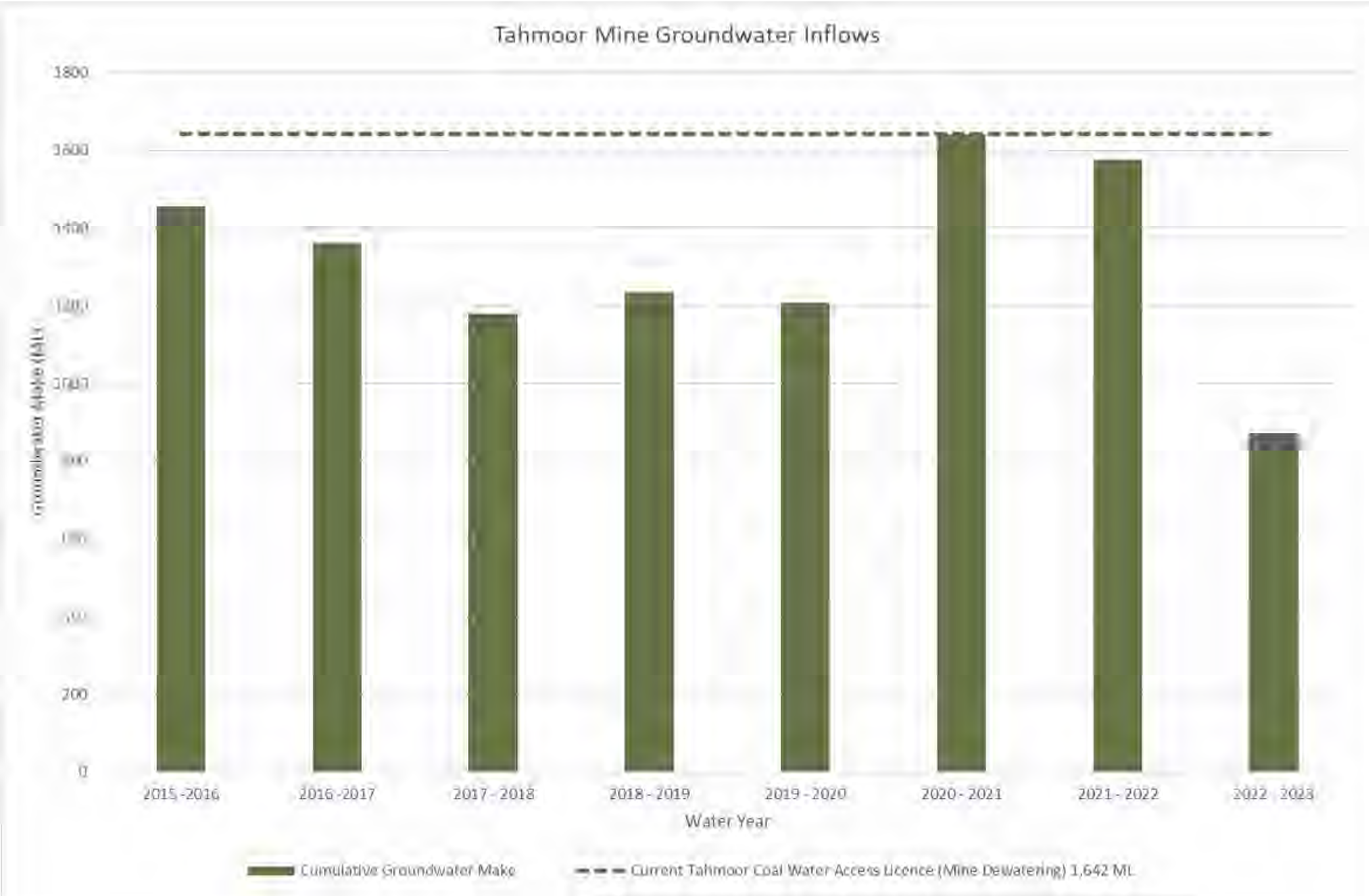


Figure 3-21 Historical Groundwater Inflow (measured) for the period July 2015 – May 2023

3.5.7 Investigation into Fracturing above Longwalls

Near-surface fracturing or "surface cracking" can occur due to horizontal tension at the edges of a subsidence trough. The depth of cracking from the surface will typically be less than 20 m; McNally and Evans (2007) stated this is usually but not always transitory. Water loss from surface features (e.g. watercourses, wetlands) into the cracks is unlikely to continue downwards towards the goaf and most will return to surface somewhere down-gradient. This has occurred in earlier mining at Tahmoor, e.g. along the Bargo River and Redbank Creek.

Investigations along Redbank Creek and Myrtle Creek have been carried out in boreholes to characterise the near surface-strata adjacent to the creeks impacted by the subsidence associated with longwall mining. These investigations involved the observations of borehole conditions and water flows, measurements of borehole diameter to identify voids and open fractures, and lugeon packer tests to measure hydraulic conductivity (SCT, 2020b).

These investigations along Redbank Creek concluded that the presence of open fractures in all boreholes coincided with intervals of increased hydraulic conductivities. Groundwater flow was observed out of these fractures in some bores (e.g. P10 and P19). However, no correlation or patterns were established between fracturing and depth below the creek bed at these targeted areas. Comparable findings were reported by SCT (2020a) along Myrtle Creek, with groundwater flows observed out of open fractures at P18, P21, P23 and P25 but no clear correlation between the zones of increased hydraulic conductivities and the depth below the creek bed was established.

Leakage of surface water into the surface cracking zone can result in the water quality of any re-emergent water being inferior to that of surface flow in an undisturbed environment (McNally and Evans, 2007). Effects of mining-induced subsidence have occurred at Tahmoor Mine, e.g. along Redbank (GeoTerra, 2019) and Myrtle Creeks.

An assessment conducted by Morrison *et al.* (2019) found that the quality of surface waters in areas directly above extracted longwall panels was degraded in the direct vicinity of surface cracking features along Redbank Creek, with higher salinity and metal concentrations measured compared to an unaffected reference site.

In many cases, metals concentrations decline downstream of the undermined sections, e.g. iron (Fe), nickel (Ni), cobalt (Co), but others remain at elevated levels, e.g. manganese (Mn), barium (Ba), strontium (Sr), noting that the sampling was conducted in dry conditions with minimal runoff present. The decline in some metals is attributed to oxidation and precipitation.

Future assessment of impacts of subsidence, will occur via monitoring and analysis of both ground and surface water levels and quality. Appropriately experienced consultants engaged by Tahmoor Coal will monitor for, analyse, and document effects on surface water levels and quality in watercourses adjacent to Tahmoor South longwalls inclusive of alterations to baseline groundwater – surface water interactions.

3.5.8 Groundwater Use

Groundwater use occurs via two predominant mechanisms; environmental and anthropogenic. Environmental groundwater use typically occurs via natural springs and Groundwater Dependent Ecosystems (GDEs). In the Tahmoor South project area, there are no identified springs (Brienen Environmental & Safety, 2022). Anthropogenic use is via specifically constructed groundwater bores, where private users extract groundwater for several purposes, primarily stock watering, domestic use and crop irrigation. Each of these methods of groundwater use is discussed in greater detail below.

3.5.8.1 Groundwater Dependent Ecosystems

The Thirlmere Lakes are the closest 'High Priority' Groundwater Dependent Ecosystem to Tahmoor Mine, being 650-700 m from historical Tahmoor longwalls at their closest points, but at least 3,500 m from LW S1A-S6A.

Thirlmere Lakes are of high conservation importance, gazetted as a National Park in 1972, and providing habitat for dependent aquatic species (Schädler & Kingsford, 2016). The Lakes are a group of waterbodies in the Greater Blue Mountains World Heritage Area that includes Lake Gandangarra, Lake Werri Berri, Lake Couridjah, Lake Baraba and Lake Nerrigorang.

The TLRP found that the lakes are a climate-sensitive wetland, primarily driven by rainfall and evaporation (DPE, 2022). Whilst the primary water input to Thirlmere Lakes and their surrounding catchments is rainfall precipitation, the lakes can also receive water via runoff, infiltration and interflow processes from their catchment. The major discharge processes (water outputs) from the lakes include evapotranspiration and streamflow. See Section 3.6.1 for further discussion on the groundwater – surface water interactions at Thirlmere Lakes.

3.5.8.2 Springs

Literature indicates that it is likely that the HBSS may contain springs that have developed in saturated and perched aquifers within the unit (HydroSimulations, 2018). However, no significant springs or soaks have been mapped or located in the vicinity of the Project. Field investigations carried out by Brienen Environment & Safety (2022) supported this finding.

3.5.8.3 Anthropogenic Use

The Groundwater Assessment in the initial EIS for Tahmoor South (HydroSimulations, 2021) presented a review of the NSW government's online database to identify registered groundwater bores within the original study or model domain. This resulted in 982 registered bores, 791 of which were matched with WALs. The HBSS, surficial alluvium and basalt aquifers were the predominant target aquifers (89% of the total) with approximately 10% from the Bulgo Sandstone.

Preliminary modelling simulated maximum drawdown impacts of the Tahmoor South Project to identify which bores may incur a drawdown resultant of mining activities of greater than 2 metres, as per the requirements of the Aquifer Interference Policy. A total of 52 bores were identified as fitting this criteria, and were subsequently incorporated into the Private Baseline Survey.

Tahmoor Coal Community Liaison Specialist attempted to contact all landholders with identified bores. Originally, 52 bores were identified that may experience greater than 2 metres drawdown due to proposed extraction operations, inclusive of both the A and B series longwalls. During the survey process an additional six bores were incorporated into the survey at the request of landholders. The "heritage well", previously identified in the *Statement of Heritage Impact* (SoHI) of the Wirrimbirra Sanctuary (EMM, 2020) was also incorporated. Consequently, a total of 59 bores are on the final baseline list, of which 40 bores were able to be surveyed, as summarised in Table 3-7. Access was unattainable for the remainder of the sites. Of these 40, it is considered likely that 20 will be affected beyond 2m drawdown by extraction of LW S1A-S6A, especially the 5 bores which directly overlie the panels of LW S1A-S6A and their chain pillars and are predicted to experience potentially greater than 10 metres of drawdown (see Section 4.4.4.1. The baseline survey was commenced on the 15th January 2022 and was concluded by 15th March 2022. The summary report documenting the outcomes of this survey is provided in Appendix D.

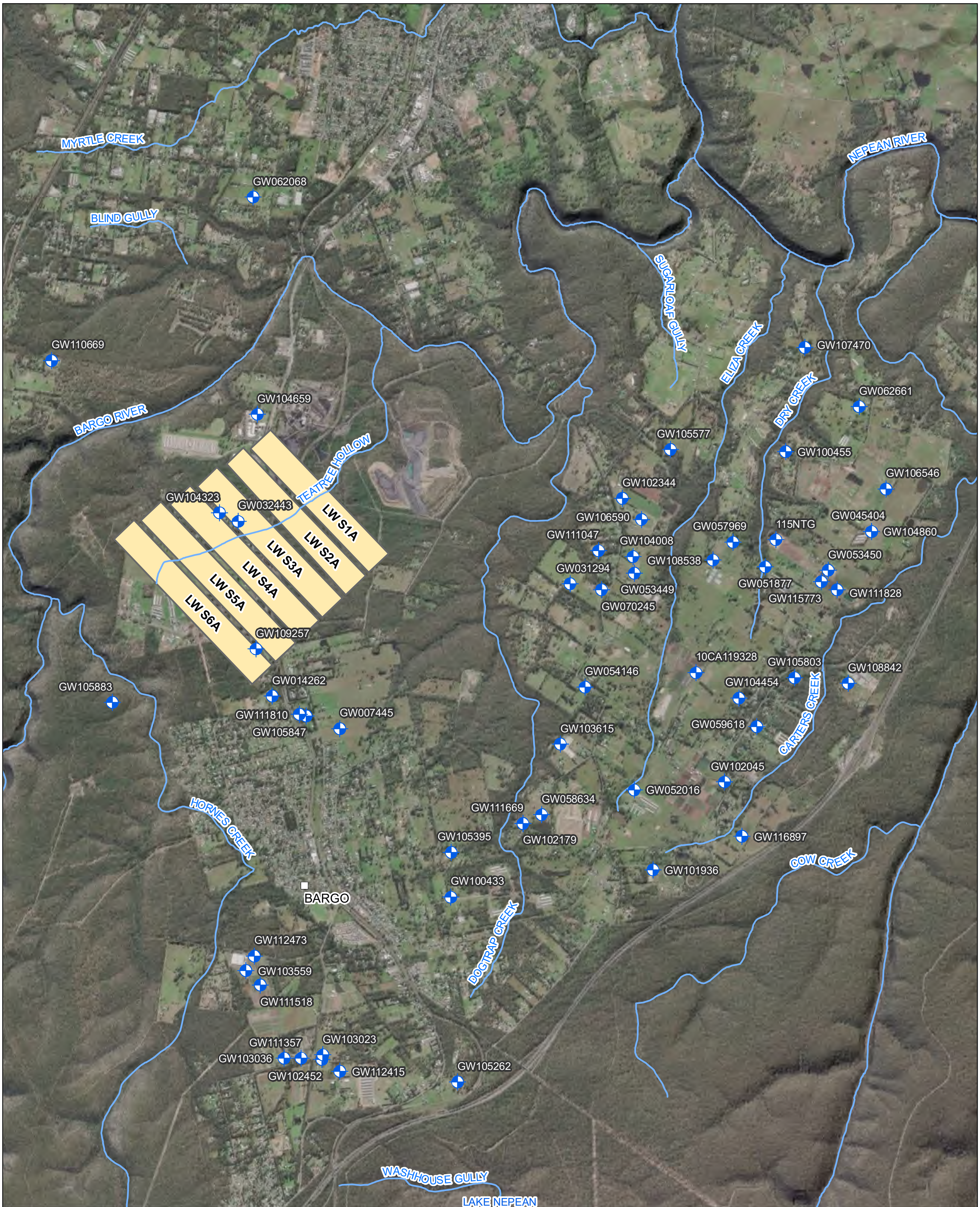
Table 3-7 Summary of Private Registered Bores predicated to have > 2m drawdown

Registered Number (RN) (if applicable)	Easting	Northing	Initial Survey Conducted	Predicted >2m Drawdown*
10CA119328	280984	6204822	yes	#N/A
115NTG	281781	6206145	yes	#N/A
GW007445	277437	6204264	no	bore with >2m DDN
GW014262	276764	6204587	no	bore with >2m DDN
GW031294	279732	6205706	no	bore with >2m DDN
GW032443	276427	6206329	yes	bore with >2m DDN
GW045404	282730	6206227	yes	bore with >2m DDN
GW051877	281673	6205875	no	bore with >2m DDN
GW052016	280369	6203655	no	bore with >2m DDN
GW053449	280369	6205813	no	bore with >2m DDN
GW053450	282301	6205841	yes	bore with >2m DDN
GW054146	279880	6204679	yes	bore with >2m DDN
GW057969	281351	6206122	yes	bore with >2m DDN
GW058634	279446	6203408	yes	bore with >2m DDN
GW059618	281589	6204282	yes	bore with >2m DDN
GW062068	276573	6209556	yes	bore with >2m DDN
GW062661	282609	6207469	no	bore with >2m DDN
GW070245	280043	6205645	yes	bore with >2m DDN
GW100433	278540	6202588	no	bore with >2m DDN
GW100455	281877	6207020	no	bore with >2m DDN
GW101936	280556	6202858	no	bore with >2m DDN
GW102045	281266	6203733	no	bore with >2m DDN
GW102179	279263	6203321	yes	bore with >2m DDN
GW102344	280251	6206554	yes	Bore with less than 2 m DDN
GW102452	277261	6200970	yes	bore with >2m DDN
GW103023	277266	6201016	yes	bore with >2m DDN
GW103036	276883	6200982	yes	bore with >2m DDN
GW103559	276504	6201854	yes	Bore with less than 2 m DDN
GW103615	279635	6204110	yes	bore with >2m DDN
GW104008	280359	6205978	yes	bore with >2m DDN
GW104323	276242	6206412	yes	bore with >2m DDN
GW104454	281410	6204568	no	bore with >2m DDN
GW104659	276616	6207392	yes	bore with >2m DDN
GW104860	282730	6206227	yes	bore with >2m DDN
GW105262	278611	6200745	yes	bore with >2m DDN
GW105395	278547	6203033	yes	bore with >2m DDN
GW105577	280728	6207041	no	bore with >2m DDN

Registered Number (RN) (if applicable)	Easting	Northing	Initial Survey Conducted	Predicted >2m Drawdown*
GW105803	281965	6204772	yes	bore with >2m DDN
GW105847	277103	6204390	no	bore with >2m DDN
GW105883	275176	6204523	yes	bore with >2m DDN
GW106546	282876	6206650	yes	bore with >2m DDN
GW106590	280442	6206344	no	bore with >2m DDN
GW107470	282069	6208057	no	bore with >2m DDN
GW108538	281155	6205941	no	bore with >2m DDN
GW108842	282500	6204716	no	bore with >2m DDN
GW109257	276604	6205057	yes	bore with >2m DDN
GW110669	274570	6207928	yes	bore with >2m DDN
GW111047	280015	6206037	no	bore with >2m DDN
GW111357	277051	6200982	no	bore with >2m DDN
GW111518	276648	6201710	yes	bore with >2m DDN
GW111669	279263	6203321	yes	bore with >2m DDN
GW111810	277035	6204405	yes	bore with >2m DDN
GW111828	282390	6205647	yes	bore with >2m DDN
GW111842	283187	6182673	yes	bore with >2m DDN
GW112415	277439	6200851	yes	bore with >2m DDN
GW112473	276586	6202000	yes	bore with >2m DDN
GW115773	282232	6205725	yes	#N/A
GW116897	281442	6203190	yes	#N/A

*Predicted drawdown from Tahmoor South EIS (HydroSimulations, 2018)

#NA not included in original assessment



0 0.5 1 km

Coordinate System:	GDA 1994 MGA Zone 56
Scale:	1:50,000 at A4
Project Number:	610.30637
Date:	03-May-2022
Drawn by:	NT

Private Bore
Minor Town
Watercourses
Lakes

Tahmoor South Mine Plan

Approved

TAHMOOR SOUTH LW S1A – S6A GROUNDWATER TECHNICAL REPORT

Private Bore Locations

FIGURE 3-22

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3.6 Groundwater – Surface Water Interaction

3.6.1 Groundwater – surface water interactions at Thirlmere Lakes

The *Thirlmere Lakes Research Program* (TLRP) aimed to provide a detailed understanding od the hydrological dynamics, water sources and water flow pathways. The summation report, "Thirlmere Lakes – A Synthesis of Current Research" was released in late March 2022, by DPE, which aligned with previous conceptualisation.

3.6.1.1 Thirlmere Lakes – A synthesis of Current Research (DPE, 2022)

The following provides redacted notes from the released report.

Ongoing monitoring of local groundwater bores showed:

- *Monitoring of these bores illustrates the sensitivity of shallow (~15 metres below ground level) groundwater levels to significant rainfall events.*
- *There was also a clear separation between the shallow bores (~15 metres depth) and the deeper bores (~100 metres depth) in terms of water level.*

During the dry period, hydraulic heads in the shallow piezometers (< ~ 4 metres depth below land surface) near the lakes were lower than the lake levels, but generally decreased at similar rates to the lake levels probably due to a combination of downward leakage and lateral transport driven by evapotranspiration. The relative proportion of each process is not known and difficult to determine. During the February 2020 recharge event, the shallow piezometers all responded synchronously with the rising lake levels and most measured hydraulic heads align to the lake levels of their adjacent lake during the wet period. This indicated that for most of the shallow piezometers a hydraulic connection to the lake's surface water does exist despite the heterogeneous shallow lithology across the Thirlmere Lakes and the presence of low-permeable peat and clay layers. However, due to the differences in the responses between each lake and their differing absolute surface water elevation it can be inferred that each lake is individually nested within its own shallow low-permeable sediments (DPE, 2022).

Deeper piezometers further from the lakes typically had lower water levels during the dry period and showed a delayed response to the February 2020 recharge event, but typically recharged to a higher hydraulic head than the adjacent lake levels. This is interpreted as diffuse recharge through the relatively small catchment rather than via leakage or overflow from the lakes. The hydraulic head in these deeper piezometers then declined faster than the shallower piezometers, likely due to vertical leakage or groundwater flow down the catchment. Several months after the February 2020 recharge event, groundwater levels were higher around the lowest lying lakes, Lake Nerrigorang and to some extend around Lake Gandangarra, and it is likely these lakes received some groundwater discharge during this period.

Groundwater input (i.e. discharge to the lakes and/or contributions to underlying sediments) is undoubtedly a critical factor for the lakes system. Even during this exceptionally dry period with lowered water tables, we have direct evidence of nearby discharge into Blue Gum Creek and inferred discharge into or flow below Lake Baraba. Every lake showed evidence of multiple loss mechanisms including recharge to groundwater.

Mine waters exhibit starkly different chemistry (Na-HCO3 type) from the lakes (Na-Cl and/or humic), exhibiting evolved groundwater beyond that typically found in the deep wells around the lakes that are in shallower strata. Mine samples also show no evidence of evaporated stable water isotopes found in lake signatures. There is no chemical or isotopic evidence linking groundwater in the mine directly to surface water in the lakes at present. It is unlikely that a measurable signature would arise in the near future due to apparent flow rates to depth.

A lack of chemical or isotopic signature does not preclude the possibility of indirectly diminished groundwater discharge and/or runoff into to the lakes. Mining and/or agricultural and/or other water abstraction in the region have lowered historical levels of shallow groundwater surrounding the lakes. Lowered groundwater levels could be the result of either direct pumping of water supply bores, or by pumping deeper mine water and increasing downward hydraulic gradients towards underlying strata. The field and modelling results suggest that the recent water level declines are primarily associated with climate variability versus the nearby longwall mining.

3.6.1.2 Historical Interpretations

The above conclusions summarised from the TLRP (DPE, 2022) are similar to interpretations previously submitted by HydroSimulations (2018), which are summarised below.
A hydrograph for Thirlmere Lakes is shown as Figure 3-23. The figure shows that Lake Baraba levels are much higher than the other lakes. Lake Baraba is suggested to be more like a swamp (e.g. Vorst, 1974), possibly with different hydrology and subsurface conditions (HydroSimulations, 2020).

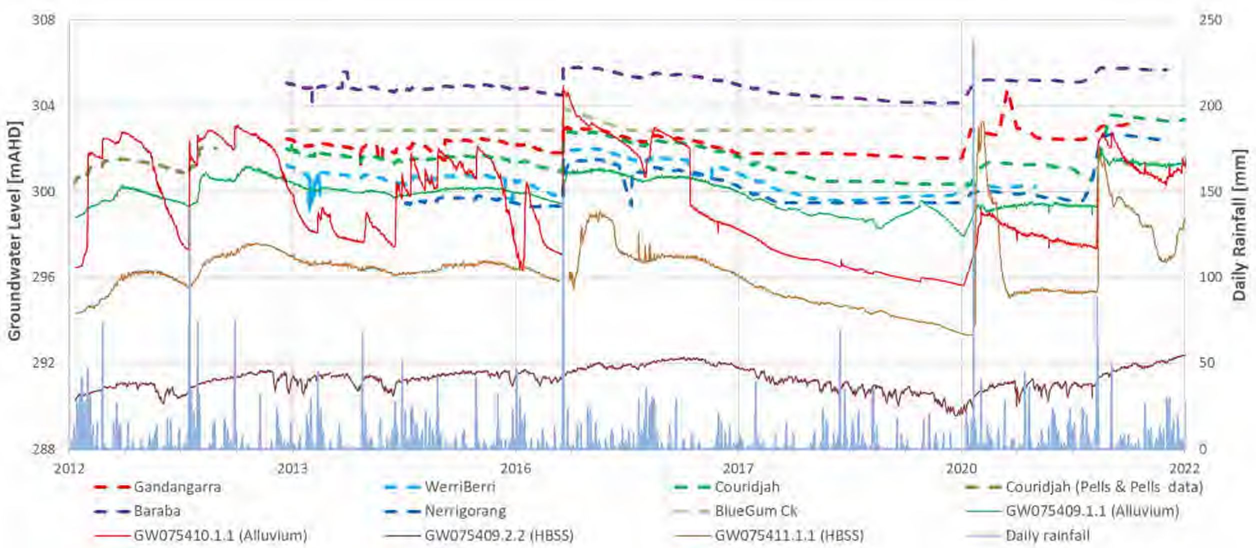


Figure 3-23 Thirlmere Lakes groundwater and lake levels

At GW075409 (near Lake Couridjah), groundwater levels in the alluvium have been consistently around 2 m below the lake level, showing that Lake Couridjah is a losing system (with the exception of during the major flood event in March 2021). At this site groundwater in the HBSS is around 10 m below the alluvium, indicating that the two aquifers are not connected, at least in regard to there being no pathway for groundwater flow from the HBSS to the alluvium, at this location.

Groundwater levels in GW075411 show that the HBSS at this location has historically not been connected to the surface, except for the high rainfall event in March 2020. This site does not monitor the alluvium, hence it is difficult to assess the connectivity to the underlying HBSS, however some connectivity is suggested during flood events. GW075411 does not show a sharp response to rainfall conditions, suggesting no direct connection with the surface.

Groundwater levels in GW075410 near Lake Nerrigorang, show that historically the lake has experienced both gaining and losing conditions, depending on rainfall conditions. Historically Lake Nerrigorang has remained wetter than the other lakes, suggesting that the lake is supported by groundwater baseflow and the others are less likely to be. This is consistent with findings from the TLRP regarding the limited connection between Thirlmere Lakes to groundwater (WRL, 2020 and Section 3.6.1).

3.6.2 Groundwater – surface water interactions adjacent to Tahmoor South

As discussed in HydroSimulations (2020) flow differentials can be used to infer losing or gaining conditions. Figure 3-24 displays daily flows and calculated differentials at Tahmoor South surface water locations Bargo River and Dogtrap Creek. The location of monitoring locations (i.e. SW-01, SW-13 and SW-15, SW-16) are shown on Figure 3-4. Because of the relatively small distances between gauges the differences are assumed to only represent any losses to and gains from groundwater between these combinations of gauges. This assumes that evaporation and surface water use and inflows from other sources (such as other ungauged tributaries) are negligible.

Figure 3-24 shows that while both Bargo River and Dogtrap Creek generally experience gaining conditions, they both lose water to the underlying HBSS aquifer for significant periods of time. This is supported by the fact flow losses are expected to be underestimated due to a lack of accounting for inflows from several small ungauged tributaries between gauging stations, particularly along the Bargo River between Site 1 (SW-01) and Site 13 (SW-13). There are few licensed groundwater abstractions along or near to this reach of the river (Figure 3-12), and hence unaccounted groundwater usage impacts on stream flows are not expected to compromise this water balance analysis. The loses could be natural, however are likely due to historical mining at Tahmoor.

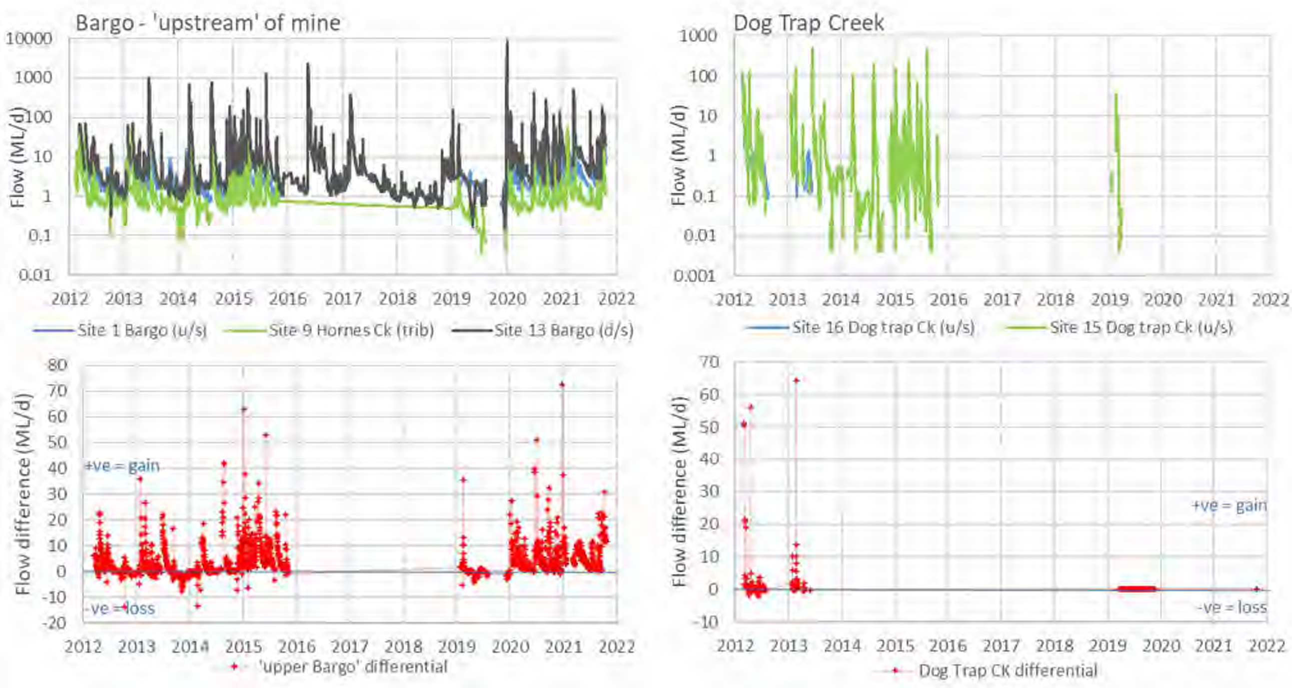


Figure 3-24 Flow differentials along Bargo River and Dogtrap Creek

3.6.3 Conceptual Model of Groundwater and Surface Water Impacts

Table 3-8 presents the anticipated mining-effects on water levels at Tahmoor South using observations across Tahmoor North and Western Domain. Details presented in Table 3-8 should remain as indicative due to limited data available for both the shallow groundwater level and surface water flow and level across Tahmoor South. Future baseline data collected from the proposed groundwater and surface water monitoring network will assist identifying any changes in surface and groundwater connectivity during mining / post mining and inferred estimates of surface water loss (if any) along relevant watercourses. As more data become available further analysis will be undertaken to understand groundwater and surface water interactions at Tahmoor South. The conceptual model will be updated to reflect those findings.

Table 3-8 Summary of anticipated mining effects on water levels at Tahmoor South

Water-course	Relevant Longwalls	Longwall distance to watercourses	Expected effects on shallow groundwater	Expected change to groundwater-surface water interaction and stream water levels
Teatree Hollow	LW S1A-S6A	Watercourse to be directly mined under	Effects are likely. Similar to shallow groundwater levels along Redbank Creek. No baseline data available over Redbank Creek to confirm magnitude of drawdown but recent response to groundwater recharge at bores along Redbank Creek typically show a groundwater recovery between 2-3 m and up to 5 m (i.e. possible historic drawdown).	Groundwater drawdown likely to reduce baseflow over under-mined reach. Expect similar observations as in Redbank Creek (i.e. loss of streamflow or re-emergence of diverted surface water downstream). A change in GW-SW condition is possible.
Bargo River	LW S1A-S6A	745 m	Minor effect is likely. Groundwater drawdown due to mining could be 0.5-1 m downstream the confluence with Hornes Creek, and to a lesser magnitude upstream of the Bargo River-Hornes Ck confluence.	Upstream of confluence with Hornes Creek – Possible reduction in baseflow during mining, with no discernible effect expected on SW post mining. Downstream of confluence with Hornes Creek –mined under by historical mining at Tahmoor, suggesting most of the mining-induced effect already occurred downstream. Cumulative mining-effect is possible, with reduction in baseflow during mining to be considered. SW-GW interaction expected to remain altered. Baseflow is likely to be reduced with surface water flow driven dominantly by surface run-off. Interactions could return to pre-mining condition if groundwater recovery is complete, otherwise medium-longer-terms impact to be considered downstream. Overall, LW S1A-S6A is not expected to cause significant change from current condition.
Hornes Creek	LW S6A; LW S6B (possibly LW S5A/B)	670 m	Minor effect is possible. Groundwater drawdown due to mining could be 0.5-1 m. Similar behaviour as observed along Cedar Creek near the Western Domain but effects are expected to be to a lesser degree due to distance; Hornes Creek is 670 m to the closest longwalls (LW S6A) while Cedar Creek is 60 m to LW W1.	Localised effect is possible during mining (i.e.as CB along Cedar Creek) but to a less degree due to distance to longwalls. Fracturing may play a role but has not been observed in Western Domain. Valley extension (opposite of closure) could occur. A change from gaining to losing condition is possible. Medium to long-terms impact to be considered.

4 Predicted Subsidence Impacts and Groundwater Impact Assessment

SLR was engaged by Tahmoor Coal to undertake a groundwater model rebuild for the Tahmoor Mine operations. Consent Condition B34 states that the Groundwater Management Plan includes;

- a Groundwater Modelling Plan that:
  - provides details for the future groundwater model re-build and recalibration which must be completed within 2 years of the commencement of development under this consent;
  - is independently third-party reviewed;
  - provides for the incorporation of the outcomes of the findings of the Thirlmere Lakes Research Program and other relevant research on the Thirlmere Lakes;
  - considers field data and the outcomes of subsidence monitoring; and
  - provides for periodic validation and where necessary recalibration, of the groundwater model for the development, including an independent review of the model every 3 years, and comparison of monitoring results with modelled predictions.

The Groundwater Modelling Plan (SLR, 2021) was completed and approved by the independent reviewer on the 23rd December 2021 (a copy of the memorandum is provided in Appendix E).

The Tahmoor Mine groundwater model is intended to inform the potential risk of environmental impacts associated with the historical, present, and future mining operations and meet Development Consent (SSD 8445) obligations as outlined in the B34 (v) and discussed above and presented in Section 2. The objectives of the groundwater model are to estimate:

- Mine inflows to the underground mine workings;
- Change in groundwater levels during and after mining, both within the Permo-Triassic strata and the alluvium associated with Thirlmere Lakes;
- Impacts on water supply for water users (i.e. private bores);
- Impacts on Groundwater Dependent Ecosystems (GDEs) including the Thirlmere Lakes;
- Change on baseflow and stream leakage to and from the Bargo and Nepean Rivers and their tributaries during and after mining;
- Estimate the storage capacity and groundwater recovery at Tahmoor Mine during and after the cessation of mining; and
- Inform possible changes in groundwater quality due to operations at Tahmoor Mine.

The numerical groundwater model builds on the previous groundwater models built for site. Tahmoor Coal recently established a data-sharing agreement with South32 who operate the nearby Dendrobium and Appin mines. This arrangement allows for the sharing of groundwater data, models and documentation. Under these agreements, the groundwater model extent is designed to incorporate both Dendrobium and Appin mines to allow for simulation of these mines as part of the cumulative impact assessment, as well as potentially allowing this numerical model to be used as a part of each mines' groundwater assessment process in the future. Of note, the current update of the groundwater model reported herein is the first iteration to include data and information from the Appin and Dendrobium sites.

A range of model updates were deemed required for the model to be considered fit for purpose. The updates to the model design from that reported in SLR (2020) included:

- Model extent and grid – adoption of an "unstructured" grid or mesh, revision of model extent and refinement of the mesh around mine areas;
- Model layers – update layers to include deepest mined seams at Tahmoor, update model layers to match Tahmoor, Dendrobium and Appin geological model surfaces, consider data from Sydney-Gunnedah Basin model in the layers, and update topography with the LiDAR data;
- Timing – extend calibration model period to December 2021 and refine timing to capture seasonality and mine progression changes;
- Boundary Conditions – update model boundary conditions with revised grid extent and regional flow; and
- Stresses – Maintain inputs, however updated with more recent and site-specific data.

A summary of updates to the model are discussed in Section 4.1, which presents how the conceptualisation has been developed as a numerical groundwater model, and Section 4.2 presents a summary of how well the model replicates observed data (calibration). A summary of how predicted groundwater impacts associated with LW S1A-S6A extraction is provided in Section 4.4. A more detailed description of the model and presentation of model results is provided in Appendix F.

4.1 Groundwater Model Design

4.1.1 Model Code

Numerical modelling was undertaken using Geographic Information Systems (GIS) in conjunction with MODFLOW-USG-Transport (Panday, 2021), which is distributed by the United States Geological Survey (USGS) and GSI Environmental. MODFLOW-USG is a relatively new version of the popular MODFLOW code (McDonald and Harbaugh, 1988) developed by the USGS. MODFLOW has been the most widely used code for groundwater modelling in the past and has long been considered an industry standard.

4.1.2 Model Extent and Mesh Design

To allow for numerically stable modelling of the large spatial area of the model domain, an unstructured grid mainly comprised of Voronoi cells of varying sizes was designed using AlgoMesh (HydroAlgorithmics, 2014). Varying Voronoi cell sizes allowed refinement around areas of interest, while utilising a coarser resolution elsewhere, reduced the total cell count to a manageable number. In addition, pinch-out option of MODFLOW-USG were used, which means model layering does not need to be continuous over the model domain, and layers can stop where geological units pinch out or outcrop. This is also particularly useful when simulating thin, discontinuous hydrostratigraphic units and faults.

The model domain is shown in Figure 4-1. The horizontal and vertical extent of the numerical model is approximately 65 km N-S and 56 km W-E, exceeding that of previous models. The model domain was designed large enough to allow the adjacent mines/projects (including Appin, Dendrobium, Metropolitan, Russell Vale and Cordeaux coal mines) to be assessed for potential cumulative impacts. Additionally, the domain is large enough to prevent any influence on modelled drawdowns due to the model edge. To the east, the model extends beyond the subcrop line of the deepest coal seam (i.e. the Wongawilli Coal seam) that is likely to be mined at any of the surrounding mines in the future.

The model domain was selected based on the following considerations:

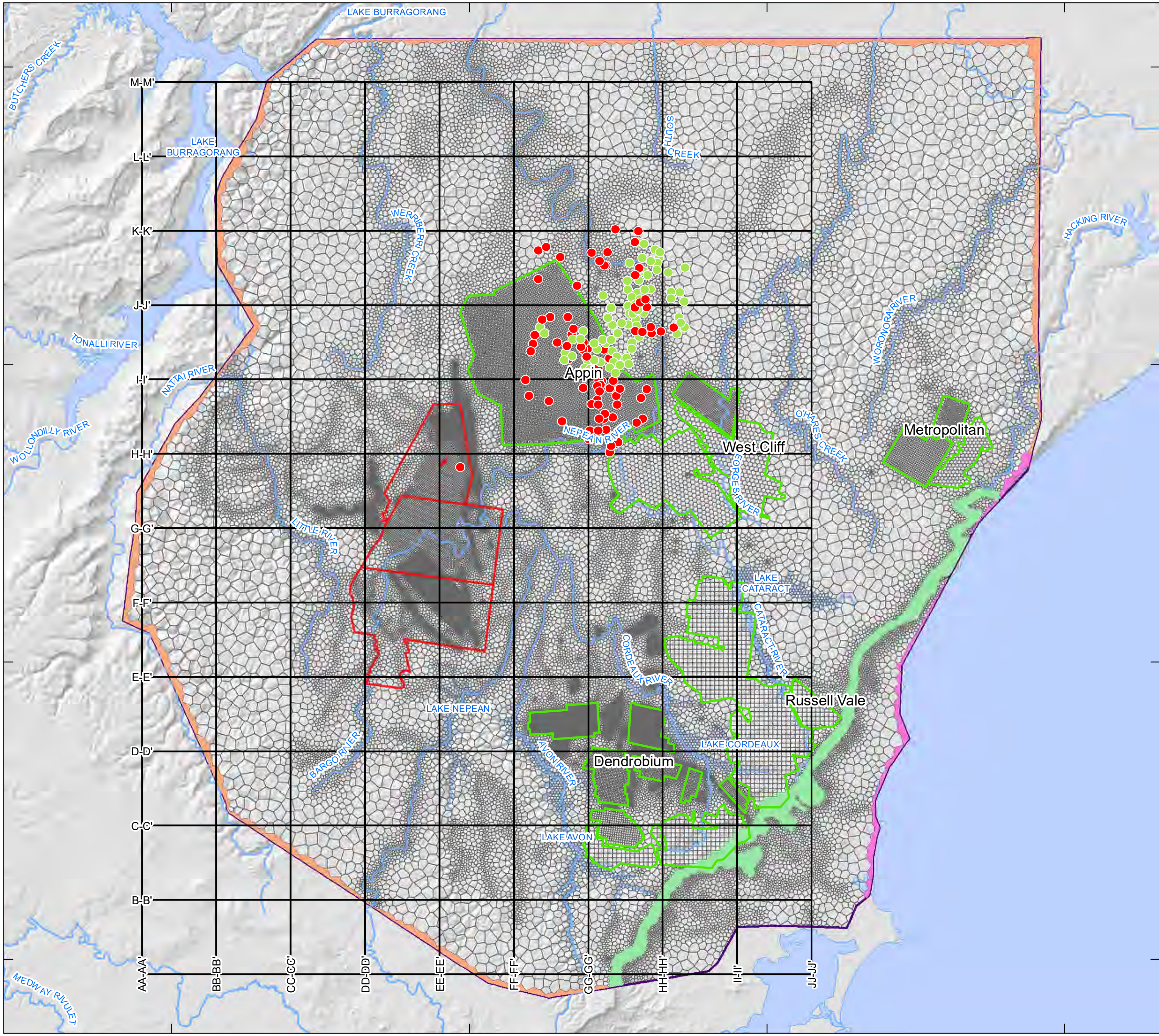
- The western and southern boundaries of the model is represented by the boundary of the Illawarra Coal Measures and Shoalhaven Group outcrops. The southern boundary of the model also follows the topographic high located approximately 21 km to the south of Tahmoor Mine;
- The eastern boundary of the model is set along the shoreline of the ocean near Wollongong and surrounding townships; and
- The northern model boundary is set approximately 25 km from the Project and is expected to be far outside the range of maximum predicted drawdown due to the Project.

The model domain was vertically discretised into 19 layers, each layer comprising up to 81,321 model cells. Areas in layers 2 to 18 were pinched out where the layer is not present based on the structural geology, resulting in a total of 1,340,263 cells in the model. In comparison to the SLR (2021) model which comprised 16 layers and 2,877,930 active model cells, the model grid provides improved discretisation of geological units and allows significantly reduced model run times, with less than half the number of active model cells.

TAHMOOR SOUTH LW S1A-S6A GROUNDWATER TECHNICAL REPORT

MODEL MESH AND BOUNDARY CONDITIONS

FIGURE 4-1



LEGEND

- Extraction Bore
- CSG Bore
- Cross Section
- Watercourse
- Tahmoor Coal Title
- Surrounding Mine
- Model Grid
- Drain Cell
- Fixed Head Cell
- General Head Boundary
- Model Domain
- Lake

0 5 10 km

Coordinate System:	GDA 1994 MGA Zone 56
Scale:	1:350,000 at A4
Project Number:	610.30652
Date:	28-Apr-2022
Drawn by:	NT
Reviewed by:	DE/SH

Data Source: Mining Lease NSW Mineview Coal Lease 2019

H:\Projects-SLR\610-SrvSYD\610-SYD\610.30652.00000 Tahmoor Coal Groundwater Model Rebuild\06 SLR Data\01 CADGIS\GIS\ModellingReport\610 30652 F02_1 Model Mesh.mxd

4.1.3 Layers and Features

Topography within the model domain has been defined using numerous sources. LiDAR data from the Tahmoor and the Dendrobium mine were used to define surface elevation. Outside the extents of the LiDAR dataset, public domain 25 m DEM data sourced from Geoscience Australia was used to define topography in the remainder of the model domain. Data extents of the sources used to construct model topography are shown in Figure 4-2.

The modelled strata is discretised into 19 layers, as listed in Table 4-1. Model layer extents (lateral and vertical) have been defined using data from the following sources:

- Tahmoor Coal, Tahmoor Mine Geology Model;
- South32, Dendrobium Mine Geology Model;
- South32, Appin Mine Geology Model;
- CSIRO Regolith mapping (CSIRO, 2015);
- Client/private/public bore logs;
- Geological Survey of NSW, Southern Coalfields Geological Model – Sydney Basin (herein referred to as the Sydney Basin Model); and
- NSW Government surface geology and basement geological maps.

Model Layer 1 is fully extensive across the model with an average thickness of 4.3 m. In the model domain extension, the base of Layer 1 was interpreted from the national CSIRO Depth to Regolith dataset. Subsequently the base of Layer 1 was then updated to align with bore logs available across the model domain including Tahmoor monitoring bores and publicly available bore logs.

Model Layer 2 represents the Triassic Wianamatta Formation and is not fully extensive across the model domain. The extent of Layer 2 is based on the outcrop (and assumed subcrop) extent of the Wianamatta Formation shown on the Wollongong-Port Hacking 1:100,000 geological map (Geological Survey of New South Wales, 1985). Where the Wianamatta Formation is present, Layer 2 has an average thickness of 67 m. The elevation of the base of this layer was interpreted from the Sydney Basin Geological Model and available bore logs.

The lower layers are largely present across the model domain except for the river valleys and on the seaward side of the escarpment to the east. The Hawkesbury Sandstone is split into 3 layers to reduce the overall thickness, and to improve the model's ability to represent vertical hydraulic gradients and subsidence fracturing effects within this unit. Similarly, the Bulgo Sandstone and Scarborough Sandstone layers were split into multiple layers to avoid having excessive thickness in the model layers and to provide enough vertical resolution to better represent the fracturing zone above longwalls.

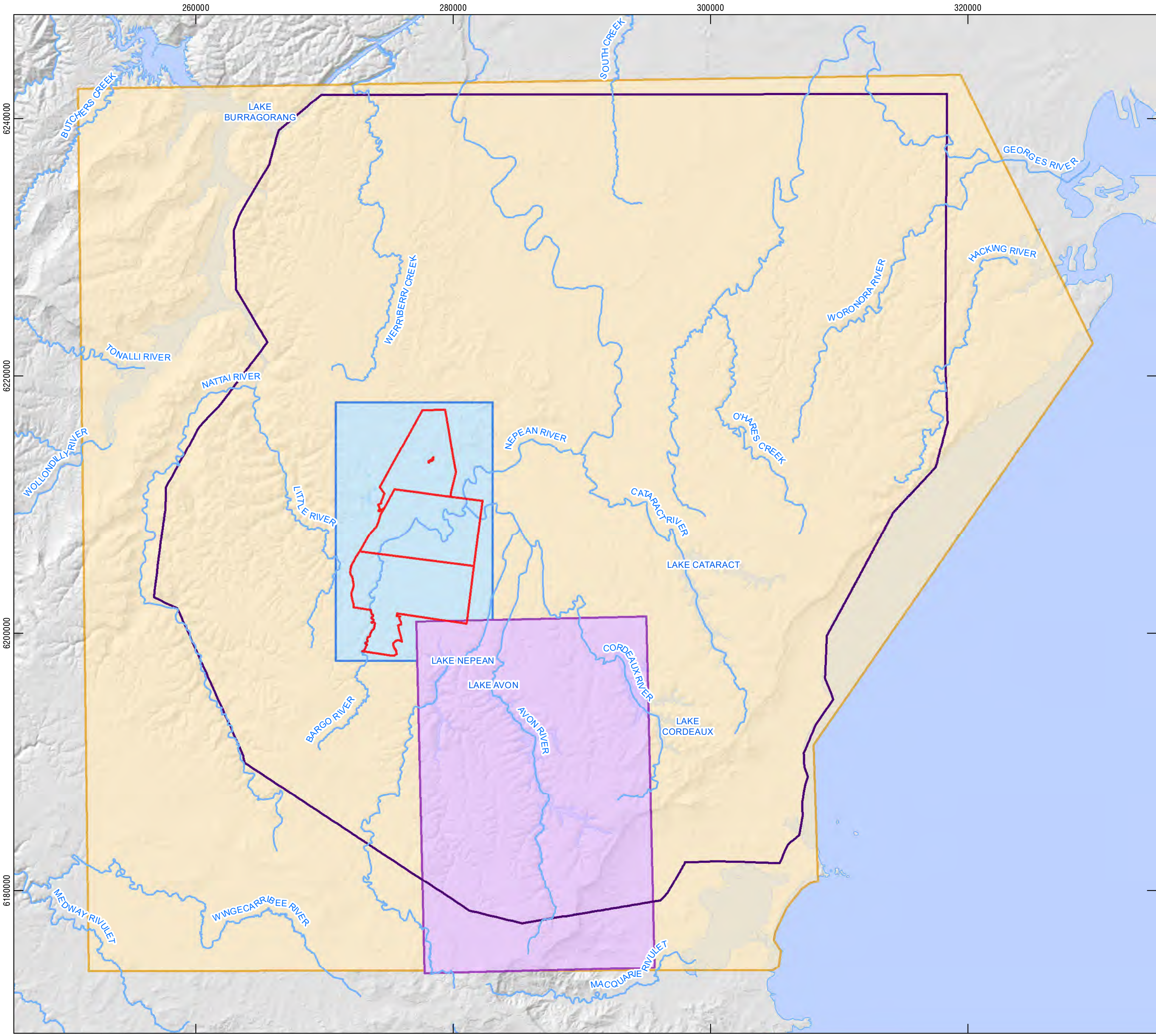
Within Tahmoor, Dendrobium and Appin mine areas, the layering from each mine's geology model has been adopted. Where overlap occurs between the different site geology models, the layers have either been averaged where appropriate or a specific site geology model has been given preference over another based on the proximity to the mine plan (with the assumption that the accuracy of a given site geology model is highest where the mine plans have been developed). Linear interpolation techniques were employed to achieve smooth transition between the site geology models provided.

Table 4-1 presents the average and maximum thicknesses across the model domain for each layer.

TAHMOOR SOUTH LW S1A-S6A GROUNDWATER TECHNICAL REPORT

EXTENT OF TOPOGRAPHY DATA

FIGURE 4-2



LEGEND

- Watercourse
- Tahmoor Coal Title
- Model Domain
- Lake

Topography Data Source

- Regional 25m DEM
- Dendrobium LiDAR
- Tahmoor Coal LiDAR

0 5 10 km

Coordinate System:	GDA 1994 MGA Zone 56
Scale:	1:400,000 at A4
Project Number:	610.30652
Date:	25-Mar-2022
Drawn by:	NT
Reviewed by:	DE/SH

Data Source: Mining Lease NSW Mineview Coal Lease 2019

Table 4-1 Model Layers

Layer	Lithology	Average Thickness (m) [1]	Maximum Thickness (m)	Source
1	Regolith, alluvium and basalt	4.3	25.8	CSIRO Depth of Regolith, Bore logs
2	Wianamatta Formation	67.0	307.1	Geo100k, Syd Basin Model, Bore Logs, Site Geo Models
3	Hawkesbury Sandstone - upper	49.3	182.6	Geo100k, Site Geo Models, Syd Basin Model
4	Hawkesbury Sandstone - middle	51.3	80.3	Site Geo Models, Syd Basin Model
5	Hawkesbury Sandstone - lower	54.8	82.7	Site Geo Models, Syd Basin Model
6	Bald Hill Claystone	35.1	153.8	Site Geo Models, Syd Basin Model
7	Bulgo Sandstone - upper	55.2	109.3	Site Geo Models, Syd Basin Model
8	Bulgo Sandstone - middle	55.1	109.3	Site Geo Models, Syd Basin Model
9	Bulgo Sandstone - lower	56.7	112.6	Site Geo Models, Syd Basin Model
10	Stanwell Park Claystone	10.1	106.9	Site Geo Models, Syd Basin Model
11	Scarborough Sandstone - upper	15.7	57.7	Site Geo Models, Syd Basin Model
12	Scarborough Sandstone - lower	16.4	57.7	Site Geo Models, Syd Basin Model
13	Wombarra Claystone	19.2	99.7	Site Geo Models, Syd Basin Model
14	Coal Cliff Sandstone	12.2	41.2	Site Geo Models, Syd Basin Model
15	Bulli Coal Seam	2.3	7.6	Site Geo Models, Syd Basin Model
16	Eckersley Formation	24.9	106.6	Site Geo Models, Syd Basin Model
17	Wongawilli Coal Seam	8.9	33.6	Site Geo Models, Syd Basin Model
18	Kembla Sandstone	11.5	41.3	Site Geo Models, Syd Basin Model
19	Older units (lower Permian Coal Measures and Shoalhaven Group)	293.8	369.0	300 m Below Kembla Sandstone Pre-eroded, minimum thickness of 15m

[1] Average value excludes pinched out cells/layers

Figure 4-3 and Figure 4-4 show the model layers in a horizontal and a vertical cross-section through Tahmoor Mine.

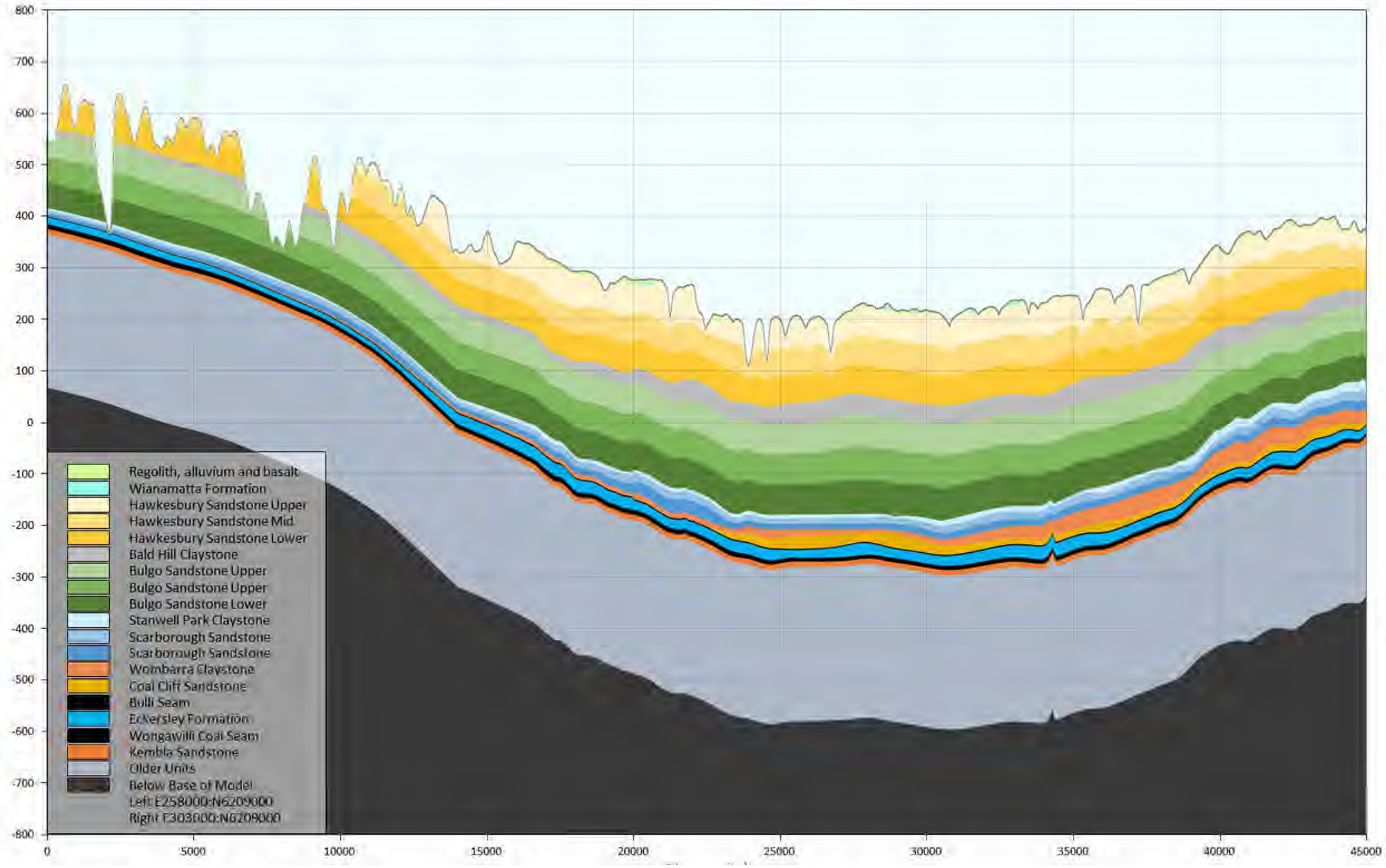


Figure 4-3 Model Layers Cross Section G-G’

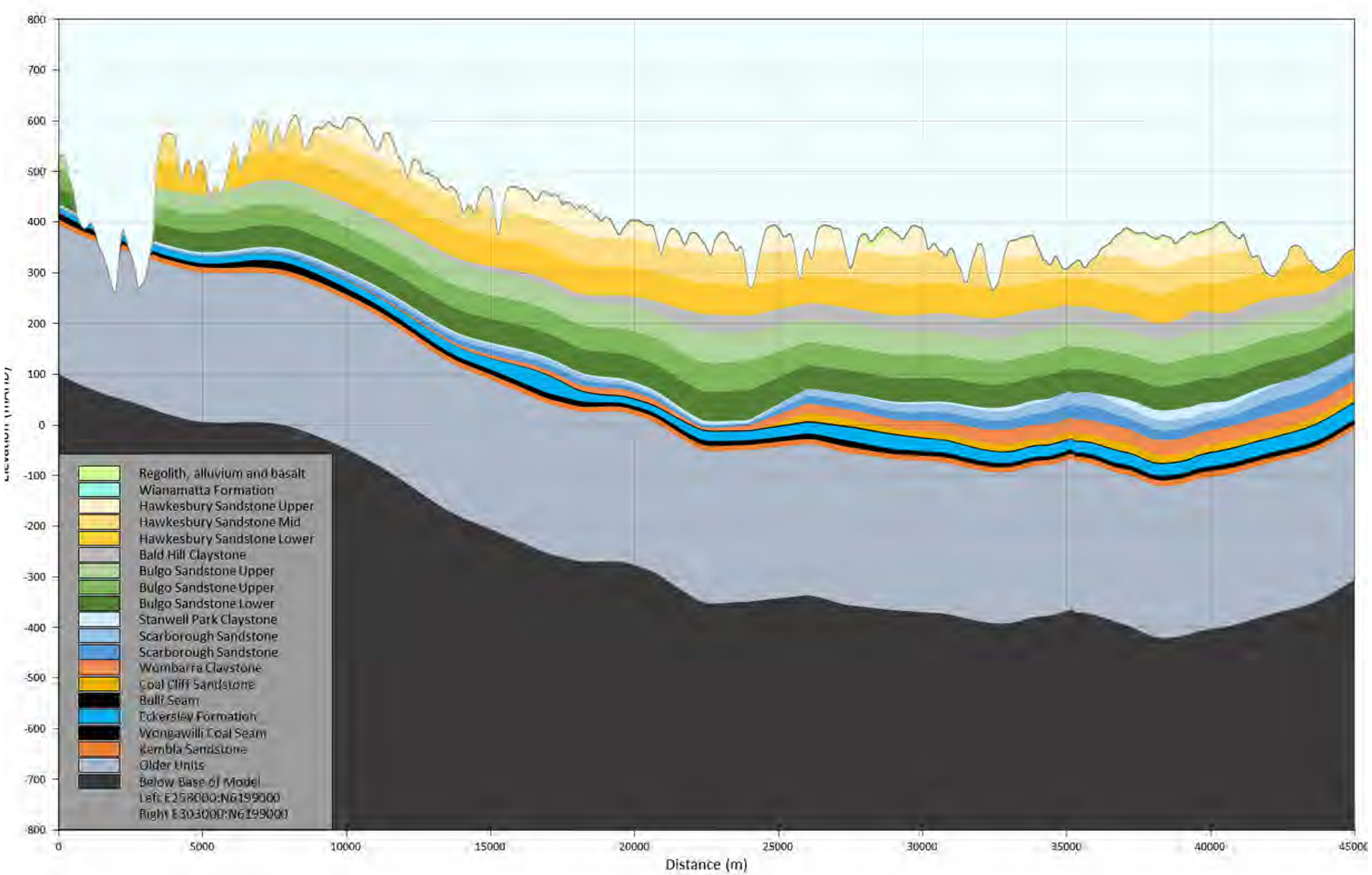
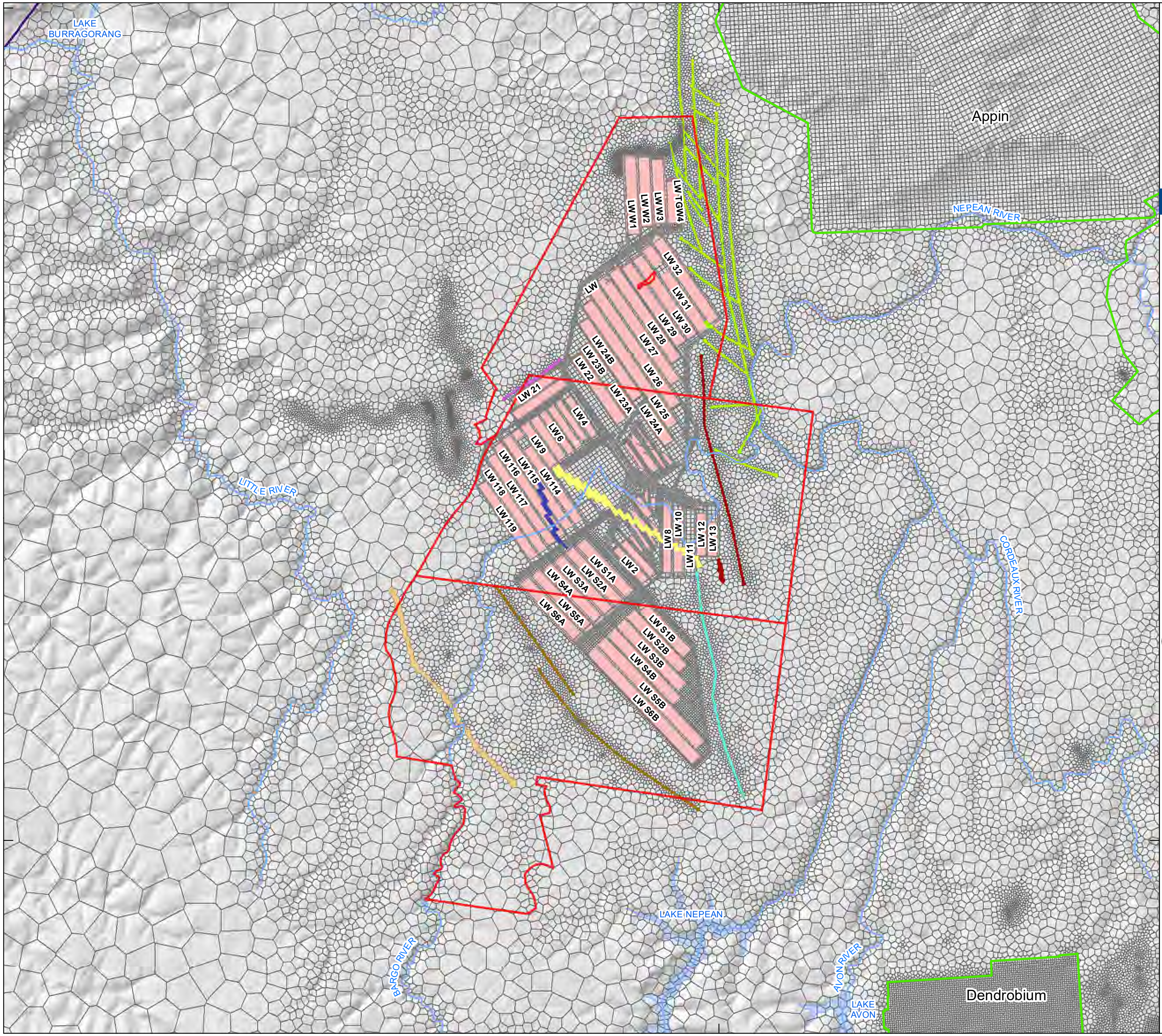


Figure 4-4 Model Layers Cross Section EE-EE'

4.1.4 Structural Geology

The structural geology at Tahmoor and surrounds is influenced by a series of folds and faults and dykes of volcanic origin, varying in age from Jurassic to Tertiary. The Nepean Fault is the major structural feature of interest to operations conducted by Tahmoor Coal. The other two major faults present at site are the 'T1' and 'T2' faults. These faults are mapped to the north and northwest of the Tahmoor South longwalls. The smaller faults near the site are the Central and Western Faults which trend NW-SE and are mapped just off the southern limit of the Tahmoor South longwalls. Further detail on structural geology was provided in Section 3.4.2.

The Nepean Fault, T1 and T2 Fault, and Central and Western Faults have been simulated in the groundwater model domain as separate hydraulic zones. The hydraulic properties of the fault zones were adjusted during the model calibration. Figure 4-5 shows the locations of geological fault zones represented in the model.



TAHMOOR COAL
LW S1A-S6A GROUNDWATER TECHNICAL REPORT

MODELLED FAULT ZONES

FIGURE 4-5

LEGEND

- Watercourse
- Tahmoor Coal Title
- Surrounding Mine
- Mine Plan
- Model Grid
- Lake

Modelled Fault

- Nepean Fault Complex
- T1 Fault
- Neapean Fault
- T2 East Fault
- T2 West Fault
- Southeastern Fault
- Central Fault
- Western Fault

0 2.5 5 km

Coordinate System:	GDA 1994 MGA Zone 56
Scale:	1:125,000 at A4
Project Number:	610.30652
Date:	13-Apr-2022
Drawn by:	NT
Reviewed by:	DE/SH

Data Source: Mining Lease NSW Mineview Coal Lease 2019

4.1.5 Timing

A combined steady state and transient model was developed, as follows:

- Steady state to replicate pre-mining conditions;
- Transient warm-up model for pre-2009 conditions to replicate influence of historical mining;
- Transient calibration model from January 2009 to December 2021 with quarterly time intervals; and
- Transient predictive model from December 2021 to December 2026 with quarterly time intervals.

The transient warm-up model period was built to incorporate pre-2001 mining activities and their impacts on groundwater levels around the Project Area. The transient warm up model covered a time period from 1969 to January 2009 and included 8 time slices each with a length of 5 years. The warm-up model was used to change model cell properties due to the underground mining within the model extent before 2009. This then provided appropriate starting conditions for the calibration model (i.e. starting heads and hydraulic properties).

To assist the model in overcoming the numerical difficulties, MODFLOW-USG Adaptive Time-Stepping (ATS) option was used. The ATS option of MODFLOW automatically decreases time-step size when the simulation becomes numerically difficult and increases it when the difficulty passes. The minimum time step size used in the simulations was 1 day.

The new numerical model ran in 3.5 hrs (from start of the calibration to end of prediction period), which is approximately 14% of the runtime from previous model (SLR, 2021). This facilitated automated calibration techniques (leading to uncertainty analysis), including the use of pilot points for assigning hydraulic properties to important strata.

4.1.6 Boundary Conditions and Stresses

4.1.6.1 Regional Groundwater Flow

The model boundary conditions are presented in Figure 4-1. At the edges of the model domain where it is expected that groundwater will be transmitted in or out of the model domain, primarily in the west, north and south, MODFLOW General Head Boundary condition (GHB) were assigned. A ’no flow’ boundary was applied to the western boundary of the model which represents the outcrop of the older units (lower Permian Coal Measures and Shoalhaven Group). Fixed head boundaries at 0 mAHD were assigned along the eastern boundary of model in all of layers 1 to 4 to represent the ocean.

Springs emanating from the Illawarra Escarpment along and inside the south-east margin of the model domain were simulated using the MODFLOW Drain package. The Drain boundary condition allows one-way flow of water out of the model. When the computed head drops below the stage elevation of the drain, the drain cells become inactive. These drains were simulated as occurring at the ground surface along the escarpment, placing them between model layers 3 and 15 depending on local stratigraphy. A high conductance was assigned to these model cells to represent ‘spring-like’ behaviour where groundwater flow can be discharged along the face of the escarpment. Having a drain elevation set at topography means that any groundwater contributed as ‘baseflow’ to these features is discharged from the system, removing the opportunity for these features to gain water and return flow to the system.

4.1.6.2 Surface Drainages

There are a significant number of surface water features that exist within the model extent. Creeks and Rivers throughout the model domain were modelled using MODFLOW's River (RIV) package. Use of the River package allows the surface drainage features (watercourses) to remain as potential source of water to the underlying porous rock aquifers.

River cells in the model are shown in Figure 4-6. As shown in the figure, major rivers and streams as well as minor creeks were built into the model. The major rivers within and around the Project area included in the RIV package are presented in Table 4-2.

To allow climate variability to be represented in the model, variable stage height is utilised to simulate watercourses within the model domain. Where possible, the variable stage height in the RIV package was calculated using the river level data recorded in the stations within the model domain. Data from 82 surface water monitoring stations within the model domain were included in the RIV package. The stations include 37 from the NSW Government monitoring sites, 19 from Tahmoor North Monitoring Sites, 12 from Western Domain Monitoring Sites and 14 from Tahmoor South Monitoring Sites.

Rivers with multiple stream level stations were split to a few zones in the RIV package to allow information from as many stations as possible to be captured in the model. The zonation can be seen for the Stonequarry Creek, Myrtle Creek, Nepean River and Bargo River in Figure 4-6.

As described in Table 4-2, historical quarterly average stage heights were used in both the calibration and prediction model. Using quarterly time slices is a simplified way to tie river stage height fluctuations to rainfall trends. It is important to note that the intent of modelling is to capture the long-term impacts of groundwater and surface water interaction. Due to the model time resolution (quarterly), the model is not set up or able to adequately capture the short-term (i.e. daily) climate response and interaction between groundwater and surface water.

The river stage height (water depth) in the minor tributaries or drainage lines was set to 0 m (i.e. modelled river stage elevation was equal to river bottom elevation). Therefore, the minor tributaries or drainage lines act as drains to the groundwater system, i.e. can receive baseflow, but do not result in any recharge from surface water to the underlying groundwater system.

Table 4-2 River and Surface Water Features in the Tahmoor Model

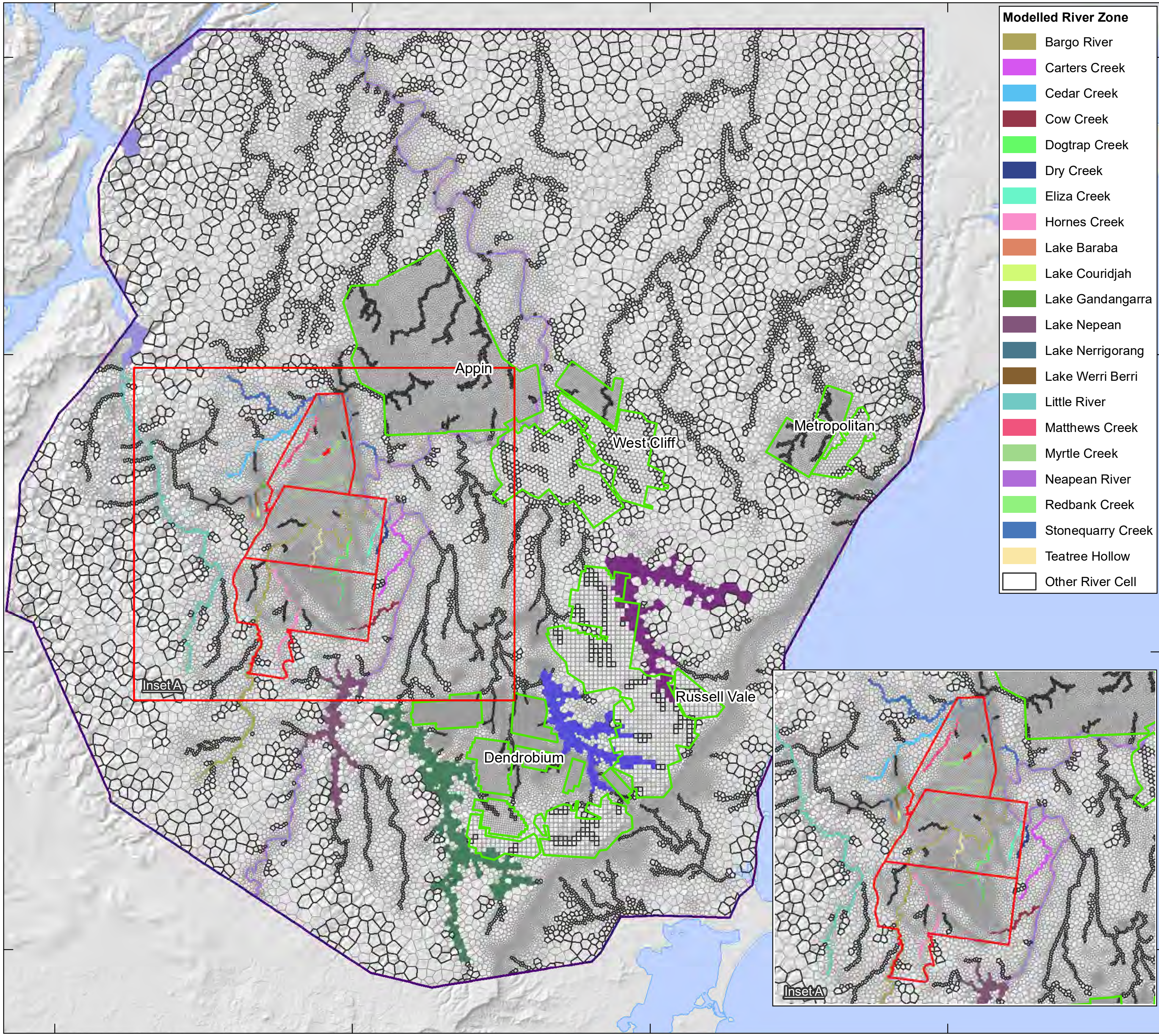
Boundary	River Stage (m)	River Bed Kz (m/day) (Initial value)
Nepean River	- SS simulation - Long-term Average - Calibration simulation - Historical Quarterly Average - Prediction simulation- Transient Stage Height- Long Term Quarterly Average	0.005
Bargo River, Avon River, Cordeaux River	- SS simulation - Long-term Average - Calibration simulation - Historical Quarterly Average - Prediction simulation- Transient Stage Height - Long Term Quarterly Average	$1x10^{-4}$ - 0.005

Boundary	River Stage (m)	River Bed Kz (m/day) (Initial value)
Stonequarry Creek	- SS simulation - Long-term Average - Calibration simulation - Historical Quarterly Average - Prediction simulation- Transient Stage Height- Long Term Quarterly Average	0.01
Cedar Creek, Redbank Creek, Matthews Creek, Myrtle Creek, Eliza Creek, Dogtrap Creek, Cow Creek, Hornes Creek, Teatree Hollow, Carters Creek, Dry Creek	- SS simulation - Long-term Average - Calibration simulation - Historical Quarterly Average - Prediction simulation - Transient Stage Height - Long Term Quarterly Average	0.005 - 0.1
Rumker Gully, Newlands Gully	- SS simulation - Long-term Average - Calibration simulation - Historical Quarterly Average - Prediction simulation - Transient Stage Height- Long Term Quarterly Average	0.005 - 0.01
Other minor creeks	- SS simulation - Long-term Average - Calibration simulation - Fixed Stage - Prediction simulation - Fixed Stage	$1x10^{-4}$ - 0.005

TAHMOOR COAL
LW S1A-S6A GROUNDWATER TECHNICAL REPORT

MODELLED RIVER ZONES

FIGURE 4-6



LEGEND

- Tahmoor Coal Title
- Surrounding Mine
- Model Domain
- Model Grid
- Lake

0 5 10 km

Coordinate System:	GDA 1994 MGA Zone 56
Scale:	1:350,000 at A4
Project Number:	610.30652
Date:	05-Apr-2022
Drawn by:	NT
Reviewed by:	DE/SH

Data Source: Mining Lease NSW Mineview Coal Lease 2019

4.1.6.3 Lakes and Reservoirs

The Thirlmere Lakes and the water supply reservoirs within the model domain were represented using the MODFLOW River Package. The lakes and reservoirs simulated in the model are presented in Figure 4-6. The following reservoirs were simulated in the model:

- Lake Burragorang (Warragamba Dam), 18 km northwest of Tahmoor South Domain;
- Lake Nepean 3 km south of the Tahmoor South Domain;
- Lake Avon, 6 km south-southeast of the Tahmoor South Domain;
- Lake Cordeaux, 14 km east-southeast of the Tahmoor Mine;
- Lake Cataract, 18 km east of the Tahmoor Mine; and
- Lake Woronora, 30 km east of the Tahmoor Mine.

For the calibration model, quarterly averages of the historical levels for the reservoirs were used. For the prediction period, long term quarterly averages of lakes levels were used in the model.

For the Thirlmere Lakes, bed elevations were defined based on the zero-gauge data from the government gauging stations (212063, 212065,212066,212067 and 212068) for the 2013 to 2021 period. Data is not available from the stations prior to 2013. Therefore, data from Pells (2011), HEC (2018), Schadler (2016) and Kingsford (2016) were also used to fill the gaps in lake level records prior to 2013.

For the prediction period, the lake stages were set at constant levels using the long-term historical average. The levels for the prediction model, were set as Gandangarra (302.4 mAHD), Werri Berri (302.0 mAHD), Couridjah (302.5 mAHD), Baraba (304.8 mAHD), and Nerrigorang (301 mAHD). The findings of the Thirlmere Lakes Research Program (TLRP) on the Thirlmere Lakes only became available after the groundwater model construction was complete. Therefore, the outcomes of the TLRP were not included in the model design and are considered a future improvement for the future versions of the model. However, comparing the simulated lake levels in the model against the levels presented in Table 3-1 of Research Report 268, "*Developing an integrated water balance budget for Thirlmere Lakes*" (Chen, et. al. 2020), shows a good alignment.

The initial values for riverbed conductance for all the lakes were adopted from the previous model (SLR, 2021). These values were subsequently varied during the calibration process.

4.1.6.4 Recharge

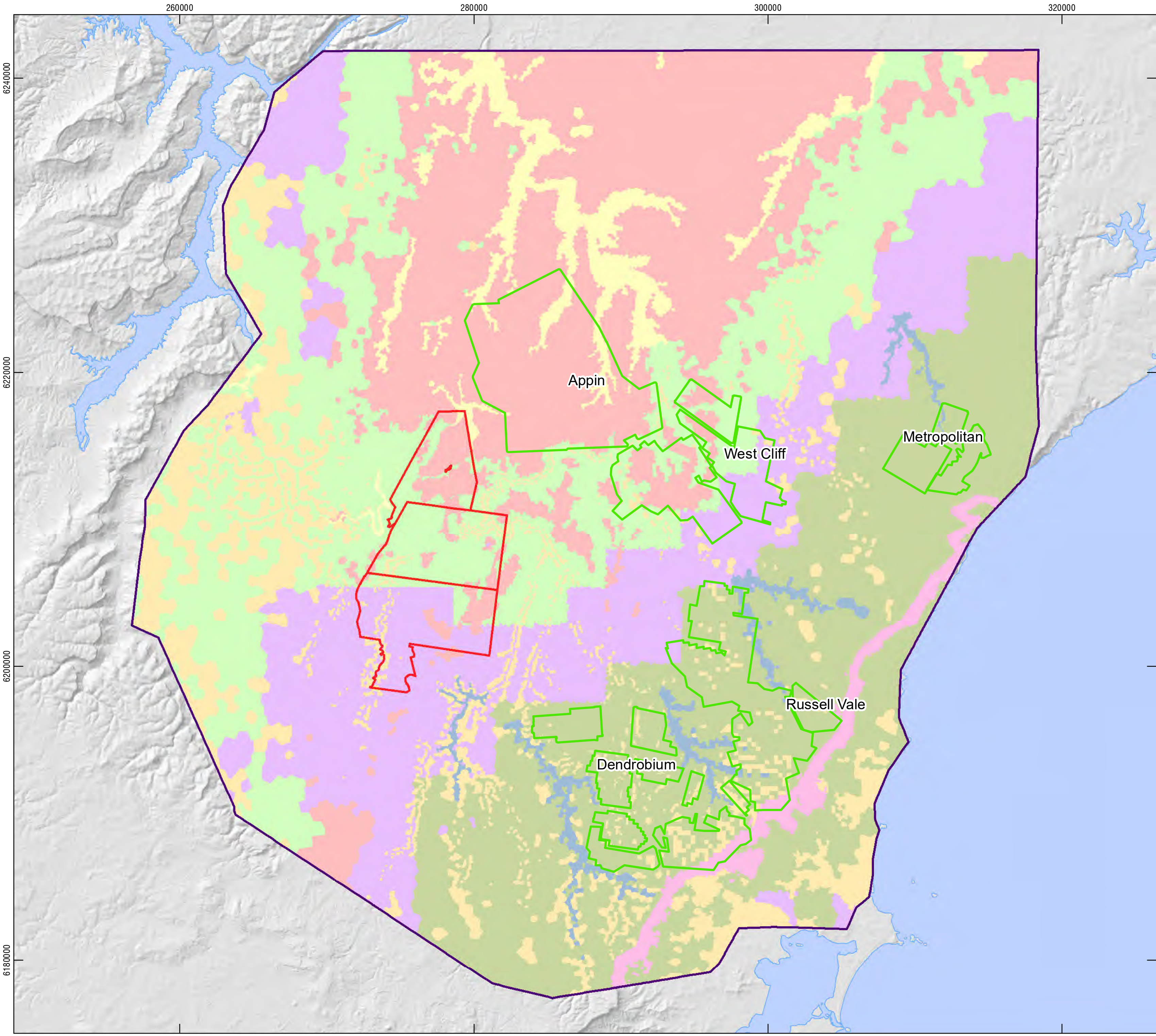
The dominant mechanism for recharge to the groundwater system is through diffuse infiltration of rainfall through the soil profile and subsequent deep drainage to underlying groundwater systems. Diffuse rainfall recharge to the model was represented using the MODFLOW-USG Recharge package (RCH).

Recharge zones have been established based on surface geology and rainfall spatial variation to simulate variation in local recharge due to these factors. Long-term precipitation data from BoM indicates higher annual rainfall in the east and south at the coast or near the escarpment, with rainfall declining inland to the north and west. Therefore, three main regions of rainfall (high, moderate, and low) have been considered in recharge zonation. The influence of outcrop geology on groundwater recharge in the Project area has previously been investigated (HydroSimulations, 2019) and is simulated using separate zones for Alluvium, Wianamatta Shale, and the Hawkesbury Sandstone (with which various other sandstones have been included).

The model included 8 recharge zones, as presented in Figure 4-7 and listed below:

- Alluvium – Zone 1;
- Alluvium – Zone 2;
- Wianamatta Formation – Low rainfall;
- Hawkesbury Sandstone – Zone 1;
- Hawkesbury Sandstone - Zone 2;
- Hawkesbury Sandstone– Zone 3;
- Coastal Escarpment; and
- Surface Water Bodies.

Recharge rates were established through the calibration process, with bounds based on the conceptual understanding of the system and comparing them with other groundwater models prepared for the region.



TAHMOOR COAL
LW S1A-S6A
GROUNDWATER
TECHNICAL REPORT

MODELLED RECHARGE ZONES

FIGURE 4-7

LEGEND

- Tahmoor Coal Title
- Surrounding Mine
- Model Domain
- Lake

Recharge Zone

- Alluvium, Low Rainfall
- Alluvium, High rainfall
- Wanamatta Formation, Low rainfall
- Hawkesbury Sandstone, Low rainfall
- Hawkesbury Sandstone, Moderate rainfall
- Hawkesbury Sandstone, High rainfall
- Escarpment
- Surface Water Bodies

0 5 10 km

Coordinate System:	GDA 1994 MGA Zone 56
Scale:	1:350,000 at A4
Project Number:	610.30652
Date:	13-Apr-2022
Drawn by:	NT
Reviewed by:	DE/SH

Data Source: Mining Lease NSW Mineview Coal Lease 2019

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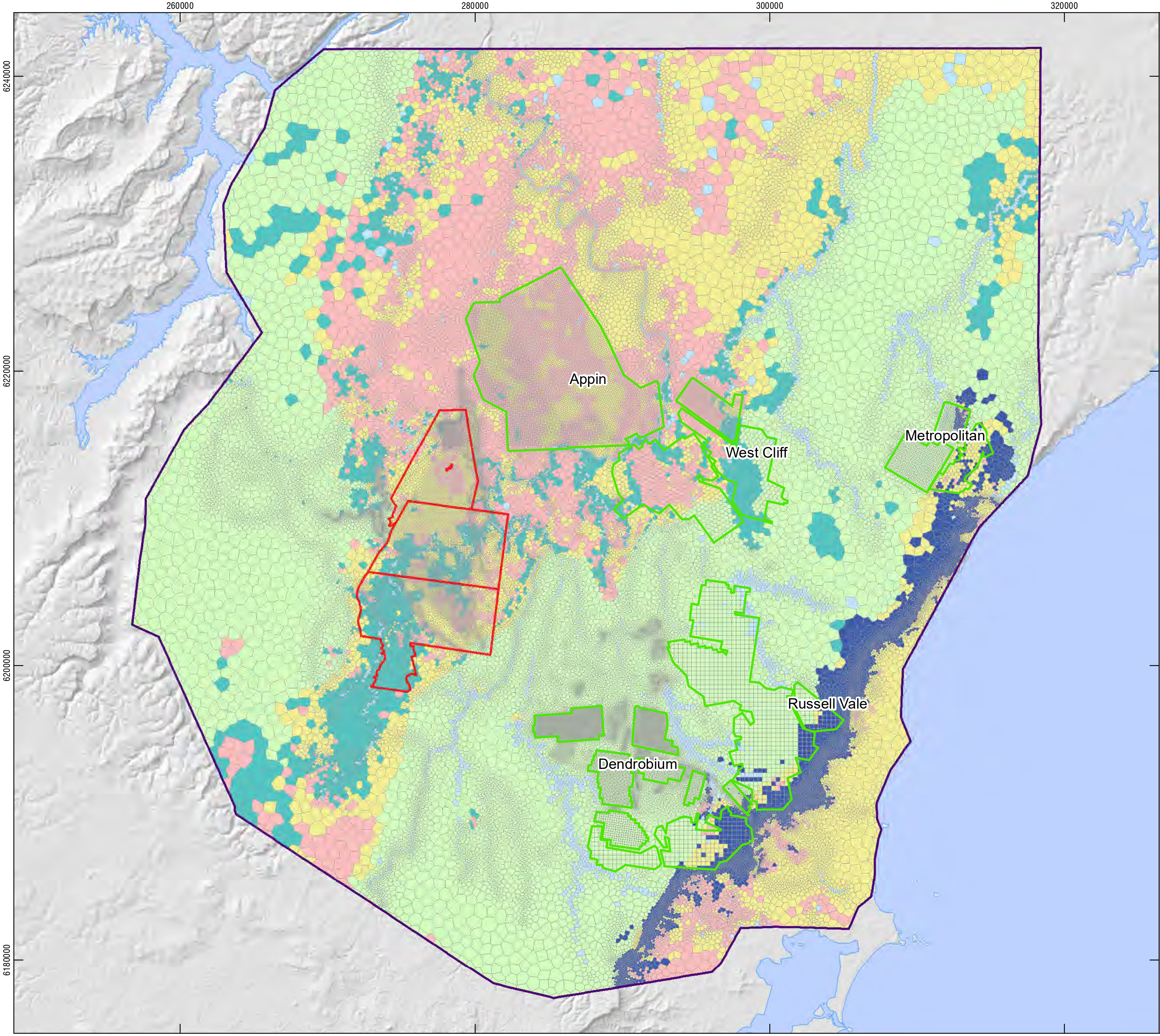
4.1.6.5 Evapotranspiration

Evapotranspiration from the shallow water table was simulated using the evapotranspiration package (EVT). Evapotranspiration zones (Figure 4-8) were established based on mapped land-use (ABARES), and land cover estimated through satellite imagery:

- Forest/Conservation;
- Grazing land;
- Rivers and drainage systems;
- Tree/shrub cover;
- Urban; and
- Escarpment.

Evapotranspiration was represented in the upper most cells of the model domain to an extinction depth up to 3 m, dependent on zone. A maximum rate of evapotranspiration was set based on the data from the SILO Grid Point observations for the closest location (Lat: -34.20, Long: 150.60).

The extinction depth applied to MODFLOW for the primary vegetation or land use zones has been estimated at 0.8-1 m for urban / grassed / pasture areas, and 3 m for trees. The spatial extent of these broad vegetation types as based on the National Scale v4 land use mapping by ABARES.



TAHMOOR COAL
LW S1A-S6A
GROUNDWATER TECHNICAL REPORT

MODELLED EVT ZONES

FIGURE 4-8

LEGEND

- Tahmoor Coal Title
- Surrounding Mine
- Model Domain
- Model Grid
- Lake

EVT Zone

- Forest/conservation
- Grazing
- River/drainage
- Tree/shrub cover
- Urban
- Escarpment

0 5 10 km

Coordinate System:	GDA 1994 MGA Zone 56
Scale:	1:350,000 at A4
Project Number:	610.30652
Date:	28-Apr-2022
Drawn by:	NT
Reviewed by:	DE/SH

Data Source: Mining Lease NSW Mineview Coal Lease 2019

4.1.6.6 Groundwater Use

As discussed in Section 3.5.8.3, a number of groundwater bores were identified as subject to potential impact via extraction in the Tahmoor South Domain during the EIS process (HydroSimulations, 2018). A bore census conducted between January and March of 2022 attempted to capture all 52 bores identified. Resultantly, 40 bores underwent a field survey to identify current bore condition (i.e. depth, status), groundwater conditions (i.e. depth to water, water quality) and use regime (i.e. currently used, disused). Current extraction from these bores was not included in the model because of the uncertainty associated with the actual extraction (rather than the entitlement). Consequently, the model does not account for bore pumping effects around LW S1A-S6A and the immediate surrounding area.

To the north, at and near to Appin Mine, 83 licensed registered water supply bores are located within the model domain. Majority of the groundwater usage in the area is from the Hawkesbury Sandstone or surficial alluvium and basalt aquifers. The MODFLOW-USG WELL package was used to capture the water take from 83 licensed registered water supply bores at Appin. The pumping rates for the water supply bores were adopted from the Appin Groundwater Impact Assessment (SLR, 2021).

The AGL Camden Gas Project is a located to the north of Appin Mine. The Camden Gas Project has been in operation since 2001. The Camden Gas Project comprises 137 wells (86 currently active) which target the Bulli and Balgownie seams approximately 14 km north of Tahmoor Mine. The gas extractions rates for the water supply bores were adopted from the Appin Groundwater Impact Assessment (SLR, 2021), and were derived from AGL (2013) study. The MODFLOW Well (WELL) package was used to present these Camden Gas Project production wells to replicate depressurisation within the Bulli Seam. Within the model the Camden Gas Project wells commenced operation based on the date of installation and were turned off at 2023 (AGL, 2018).

The pumping bores and the CSG wells included in the model are shown in Figure 4-1.

4.1.6.7 Mining

The MODFLOW Drain (DRN) package was used to simulate mine dewatering in the model for Tahmoor Coal operations and the surrounding mines. Drain boundary conditions allow a one-way flow of water out of the model. In both the calibration and prediction model, mining at Tahmoor (including Tahmoor North and South) was simulated based on the historical and future mine plan provided by Tahmoor Coal. The historical and proposed underground mining and dewatering activity at the following neighbouring mines were also included in the model:

- Bulli Seam Operations (BSO) and Appin Mine (historical and approved);
- Russell Vale (historical);
- Metropolitan Mine (historical and approved);
- Cordeaux Mine (historical);
- Dendrobium Mine (historical and approved domains); and
- Kemira, Mt Kembla, Nebo, Wongawilli, Elouera Mine (historical).

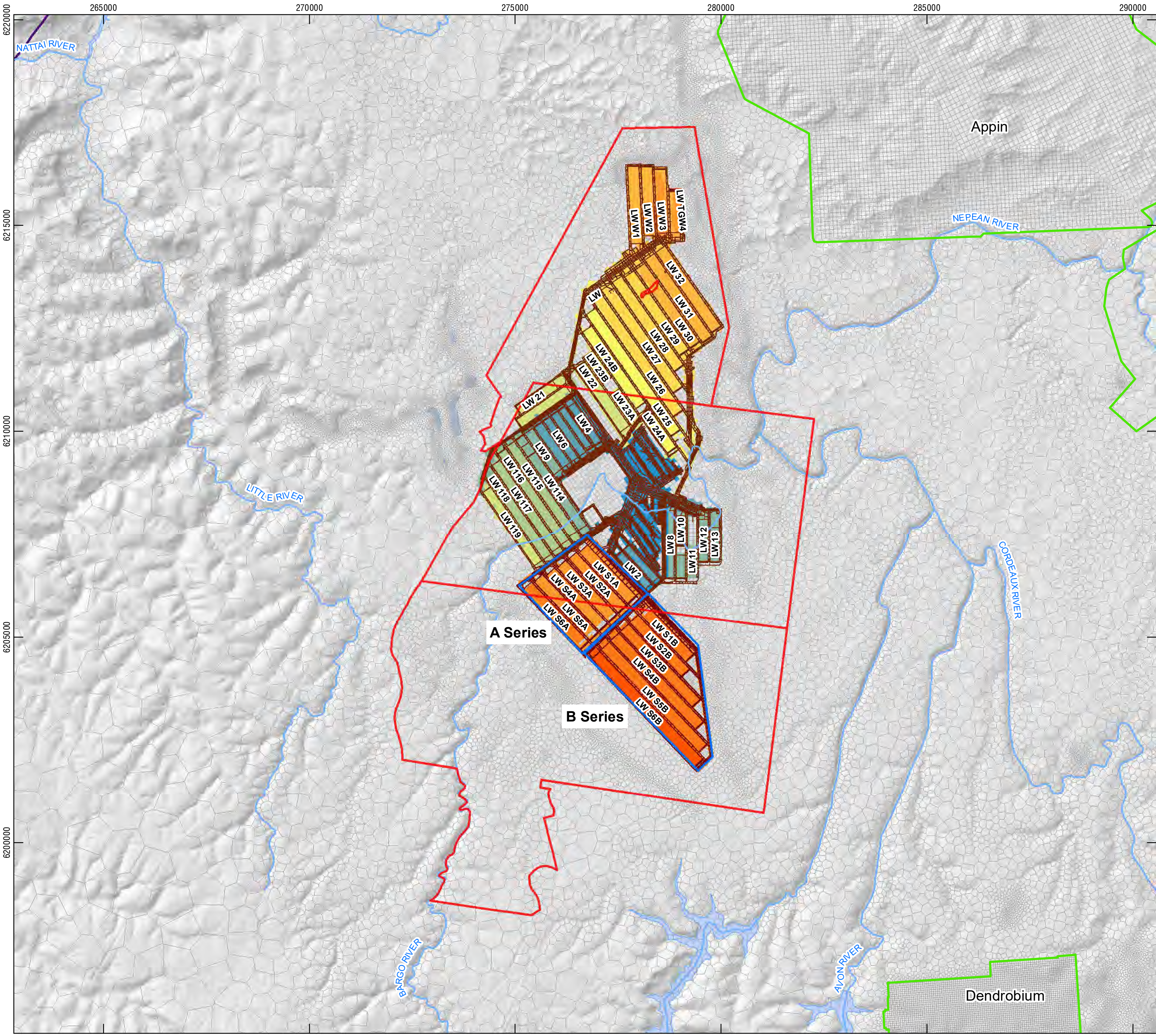
Historical mining at the Appin and Dendrobium operations was simulated using the model set-up from the SLR (2021) groundwater model. For other operations and periods, publicly available information was used to incorporate the mining activities. The modelled progression and timing of mining is presented in Figure 4-9.

The historical and proposed underground mining and dewatering activity at all the mines within the model domain target the Bulli Coal seam, except for parts of the Dendrobium domain, Kemira, Mt Kembla, Nebo, Wongawilli, Elouera Mine that target the Wongawilli Coal seam.

Drain cells were applied to each worked seam with drain elevations set to the base of the seam. These drain cells were applied wherever workings occur and were progressed through temporal increments in the transient model setup. A drain conductance value of 100 m^2/day was applied for all longwalls, roadways and development headings.

After goaf areas were mined out, the model Drains were inactivated in both the panel area and the neighbouring gate roads. Drains representing mains and roadways required for the continued operation of the mine were maintained as active until the end of their operational life, which could be as late as the end of the Tahmoor operation, until 2022 in Tahmoor North, or until around 2040 in Tahmoor South. The development headings were activated in advance of the active mining and subsequent subsidence, either one stress period ahead of active mining or based on a schedule provided by Tahmoor Coal.

MODFLOW-USG time varying materials (TVM) used to change the hydraulic properties of the model cells were with time to replicate the goaf and fractured zone above each longwall panel.



TAHMOOR COAL
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MODELLED MINE PROGRESSION

FIGURE 4-9

LEGEND

- Watercourse
- Tahmoor Coal Title
- Surrounding Mine
- Mine Plan
- Model Domain
- Model Grid
- Lake

Mine Progression (5 Years)

1981 - 1985	2011 - 2015
1986 - 1990	2016 - 2020
1991 - 1995	2021 - 2025
1996 - 2000	2026 - 2030
2001 - 2005	2031 - 2032
2006 - 2010	

0 2.5 5 km

Coordinate System:	GDA 1994 MGA Zone 56
Scale:	1:125,000 at A4
Project Number:	610.30652
Date:	28-Apr-2022
Drawn by:	NT
Reviewed by:	DE/SH

Data Source: Mining Lease NSW Mineview Coal Lease 2019

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4.1.6.8 Variation in Model Hydraulic Properties due to Longwall Mining

The Ditton method is the preferred method to represent the connected fractured zone (Zone A) as it is similar to, and in some instances, more conservative than the Tammetta (2013) method for longwall geometry at Tahmoor Mine. The Ditton A95 estimated fracture height is consistent with data collected by SCT (SCT, 2014 and 2021) at Tahmoor. Ditton (2014) also estimates the height of disconnected fracturing (Zone B).

The height of connected fracturing was estimated on a cell-by-cell basis using the method of Ditton A95 and the height of disconnected fracturing was estimated on a cell-by-cell basis using Ditton B95. Figure 4-10 shows the highest layer in the model that the height of Zone A and Zone B extend across the mine area. As shown in Figure 4-10, the connected fracturing primarily reaches Layers 7 and 8 of the model (Bulgo Sandstone middle and upper), except a small area within LW S1A and S2A where connected cracking reached Layer 6 (Bald Hill Claystone). Figure 4-10 shows the simulated disconnected fracturing reached Layer 4 and Layer 5 of the model which represent the middle and lower HBSS, respectively.

The fracture zones are represented in the groundwater model via an increase in the horizontal and vertical hydraulic conductivity, and the specific yield (only in disconnected fracturing zone) of the model layers above the seam in each extracted longwall panel using the Time-Varying Material properties (TVM) package of MODFLOW-USG-Transport.

Site-specific measurements of post-mining strata properties in the fracture profile are not available. However, data from boreholes S2398 and S2398A, which were used for pre- and post-mining investigations at Dendrobium Mine, is available (Watershed HydroGeo, 2020). The observed post-mining values at these bores were used to guide the updated post-mining properties simulated in groundwater model for Tahmoor Mine.

TAHMOOR COAL
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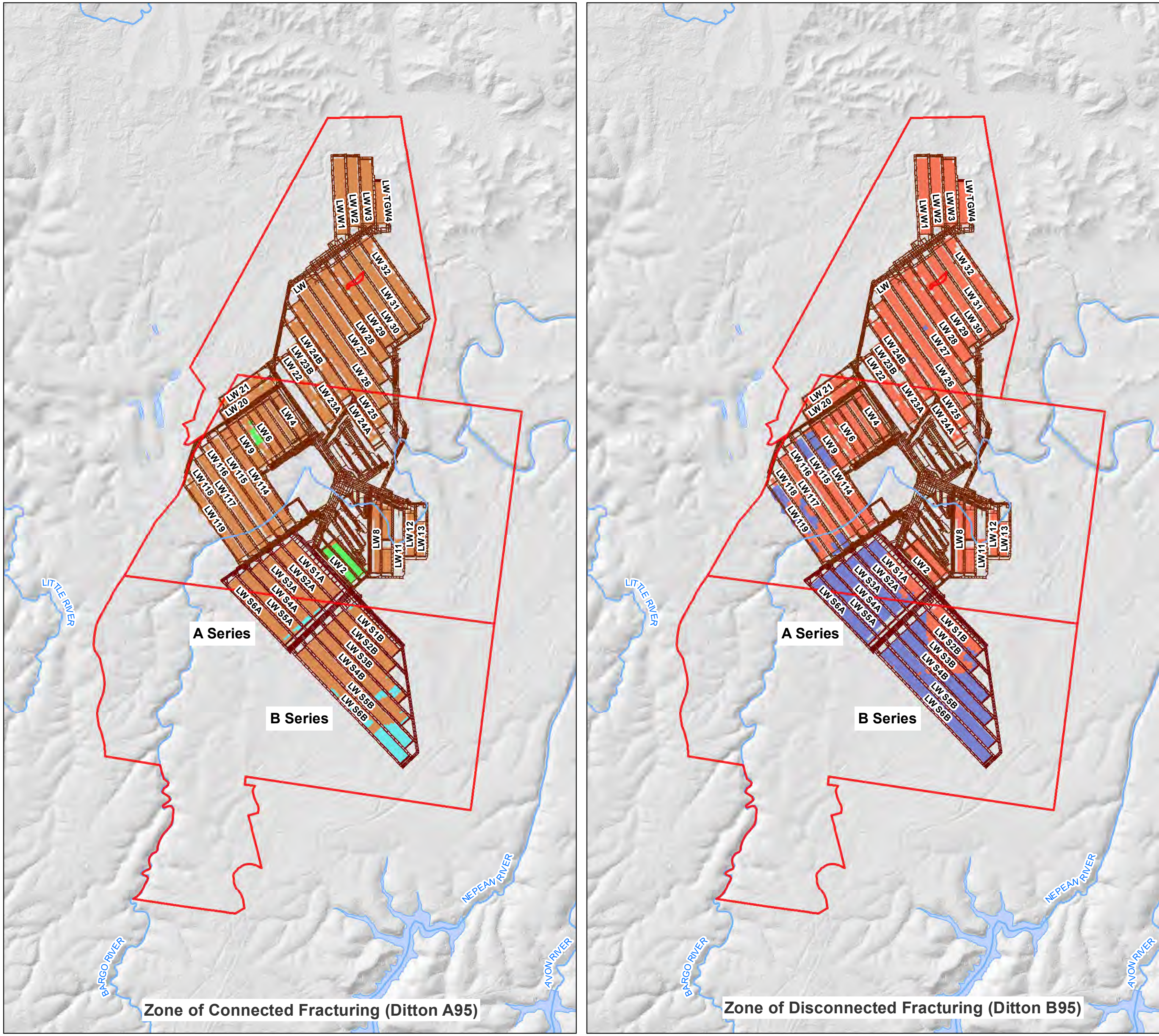
MODELLED ZONE OF CONNECTED FRACTURING (DITTON A95) AND DISCONNECTED FRACTURING (DITTON B95)

FIGURE 4-10



LEGEND

- Watercourse
- Tahmoor Coal Title
- Mine Plan
- Lake

Model Layer Intersected

- Layer 4 - Hawkesbury Sandstone, Middle
- Layer 5 - Hawkesbury Sandstone, Lower
- Layer 6 - Bald Hill Claystone
- Layer 7 - Bulgo Sandstone, Upper
- Layer 8 - Bulgo Sandstone, Middle

0 2.5 5 km

Coordinate System:	GDA 1994 MGA Zone 56
Scale:	1:125,000 at A4
Project Number:	610.30652
Date:	28-Apr-2022
Drawn by:	NT
Reviewed by:	DE/SH

Data Source: Mining Lease NSW Mineview Coal Lease 2019

Table 4-3 shows the changes in model properties in different zones of the fracturing profile adopted in the TVM package. Within the mined coal seam (goaf), the specific yield was modified to a value of 0.1 or 10%. This value provides for an increased storage capacity by removal of coal, but also accounts for reduced volume in the workings from collapse of overlying strata into the void space left by the removal of coal. The Caved Zone located immediately above the mined seam was simulated by increasing the horizontal and vertical conductivity of the cells within the Caved Zone. The enhanced horizontal and vertical conductivity of the cells within the Caved Zone were adjusted during the calibration process.

The hydraulic properties (horizonal and vertical conductivity) of the cells that fell within this connected fracturing zone, provided in Table 4-3, were modified from the 'host' or natural values using a 'log-linear function' which was calibrated to mine inflow and hydraulic heads at site.

For the disconnected fracturing zone, the horizontal conductivity in the model cells was increased up to 100 times the host values. The horizontal conductivity was capped at a maximum absolute of 0.01 m/d. This value was suggested from Dendrobium data (Watershed HydroGeo, 2020). The enhanced vertical conductivity in the disconnected fracturing zone was increased up to 3 times of the host properties. The Dendrobium data also suggested increases in porosity within the disconnected fracturing zone. This was adopted in the model by increasing the specific yield in the model cells. The modified values for the horizontal and vertical conductivity, and specific yield were adjusted during the calibration process.

To provide a more accurate representation of subsidence-induced impacts to the groundwater and surface water systems, changes in hydraulic properties that occur in areas where surface cracking occurs or is likely to occur were simulated. The horizontal and vertical hydraulic conductivity were increased in the model cells within the surface fracture zone. Evidence from borehole P11 suggests that surface cracking does not occur at distances outside the panel footprint. (SCT, 2020b). Therefore, in the numerical model, surface cracking parameters were only adopted in model cells overlying the longwall panel. As shown in Table 4-3, the depth below the surface to where surface cracking extends was calculated as ten times the extraction height of a given longwall. In areas estimated to be affected by surface cracking, the host horizontal and vertical hydraulic conductivity were both multiplied between 5 to 10 to represent the enhanced permeability of the fracture zone. The use of these multipliers is supported by a recent investigation into the changed hydraulic properties of sections of Redbank Creek that have experienced surface subsidence (SCT, 2018b and 2020b). The multiplier for the horizontal and vertical hydraulic conductivity in the surface fracture zone were adjusted in the calibration process.

Figure 4-11 presents a conceptual illustration of the deformation zones commonly observed above longwall panels, alongside a schematic of the numerical model representation of that conceptual model. The schematic simulated change in Kz in the groundwater model is also shown in Figure 4-11. This exemplifies the departure between the host Kz and post-mining Kz that extend from the coal seam to the height of fracturing. These changes decrease with vertical distance (height) above the coal seam to the upper limit of the estimated height of fracturing and surface fracturing.

Table 4-3 Changes in the Model Properties due to Longwall Mining

Conceptual Zone	Zone	Geometry	Change in the Model Properties
Surface Fracture Zone (i.e. surface cracking)	D-zone	Depth of increased surface fracturing (due to lower depth of cover/confinement) <=20 m, with enhanced horizontal and vertical hydraulic conductivity. 8 x T (extraction height)	High Kx, Higher Kz -Enhanced Kx was calibrated between 2 to 10 times the host value. -Enhanced Kz was calibrated between 2 to 10 times the host value.
Constrained Zone	C-zone		No change

Conceptual Zone		Zone	Geometry	Change in the Model Properties
Fractured Zone	upper zone of Disconnected Fracturing	B-zone	B95 – Ditton and Merrick (2014).	High Kx, Higher Kz, Higher Sy Enhanced Kx was calibrated between 10 to 100 times the host value (capped at maximum value of 0.01 M/day) Enhanced Kz was calibrated between 1 to 3 times the host value Enhanced Sy was calibrated between 0.01 to 0.1.
	lower zone of Connected Fracturing	A-zone	A95 – Ditton and Merrick (2014).	High Kx, Higher Kz. Kx and Kz changes used a logarithmic ramp function from a max value of at the top of caved zone to a value up to host VK at the top of the Ditton A95.
Caved Zone			5-10 x t (Forster & Enever, 1992; Guo et al., 2007).	High Kx, Higher Kz. Calibrated with the range between 2 to 10 times the host values.
Mined Zone (extracted seam)			Mined seam thickness (t)	Kx= 100 m/day, Kz=100m/day, Sy=0.1

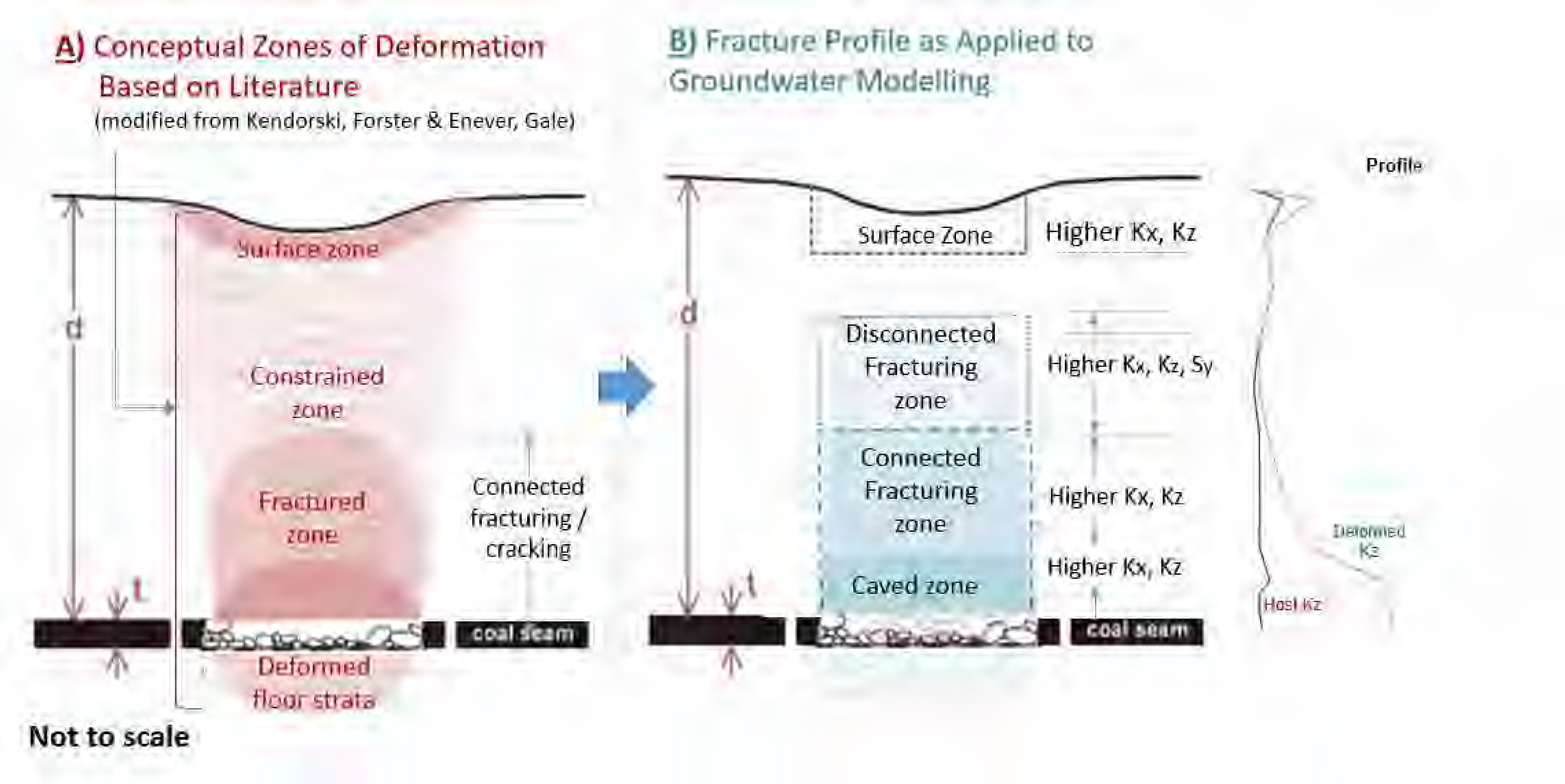


Figure 4-11 Application of Enhanced Permeability within the Groundwater Model

4.2 Model Performance

4.2.1 Calibration Dataset

The calibration dataset included a combination of targets as listed below:

- Groundwater elevation (mAHD);
- Changes in measured groundwater levels (i.e. drawdown\recovery, natural fluctuations); and
- Historic mine inflow rates at Tahmoor mine.

4.2.1.1 Groundwater Levels

Groundwater level data obtained within this model domain comprises standpipe piezometer data in conjunction with vibrating wire piezometer (VWP) data. The groundwater levels recorded between January 1979 to December 2021 were used for the model calibration. In all, 130,575 targets (heads and drawdowns combined) were established for 1,073 bores or monitoring instruments (e.g. VWPs) for calibration from the following sites:

- Tahmoor bores: 266 groundwater level sites and VWPs;
- Appin Mine bores: 241 bores or VWPs;
- Other mines including Dendrobium Mine Bores: 471 monitoring bores and VWPs; and
- Private and Government Bores: 95 other bores.

Groundwater targets were selected where valid information on bore construction or geology information was available for the site.

4.2.1.2 Change in Measure Groundwater Levels

To improve the match between simulated and observed drawdown in the bores included in the calibration, the model was also calibrated to change in groundwater levels. PEST OLPROC utility was used to extract simulated drawdowns in each observation bore. OLPROC reads model outputs (i.e. drawdowns) and then time-interpolates these outputs to approximate values at times which correspond to those at which field measurements were made.

4.2.1.3 Mine Inflows Measurements

Historical inflows (‘water make’) are available at Tahmoor Mine from 1995 until 2022. The calculation and measurement of the mine inflows was provided by Gilbert and Associates (now HEC / ATC Williams) and Tahmoor Coal. There was a period during which measurement of the inflows was not carried out (1977-2009). Inflow measurements from January 1977 until December 2021 were included as targets in the calibration process.

4.2.1.4 Calibration Weighting

Figure 4-12 shows the location of observation bores included in the calibration in conjunction with the locations for measured inflows at Tahmoor Mine. Figure 4-13 show the location of calibration bores at Tahmoor Mine.

Measured groundwater levels, drawdowns and flux observations included in the calibration had different units (mAHD, m, and m^3/day respectively). Therefore, it was expected the flux residuals be higher than water levels and drawdowns residual. The observation weighting was established so that it normalized the observations of different types in the model calibration. Lowest weights were assigned to the measured inflows to reduce the magnitude of flux errors and make them comparable to water level and drawdown errors.

Moreover, the observations at or near Tahmoor Mine were given greater priority compared to other areas in the model. Therefore, the observations at Tahmoor were weighted 5 times higher than the observations elsewhere in the model. Details on each of the observation points and their residuals are presented in the Modelling Technical Report (Appendix F).

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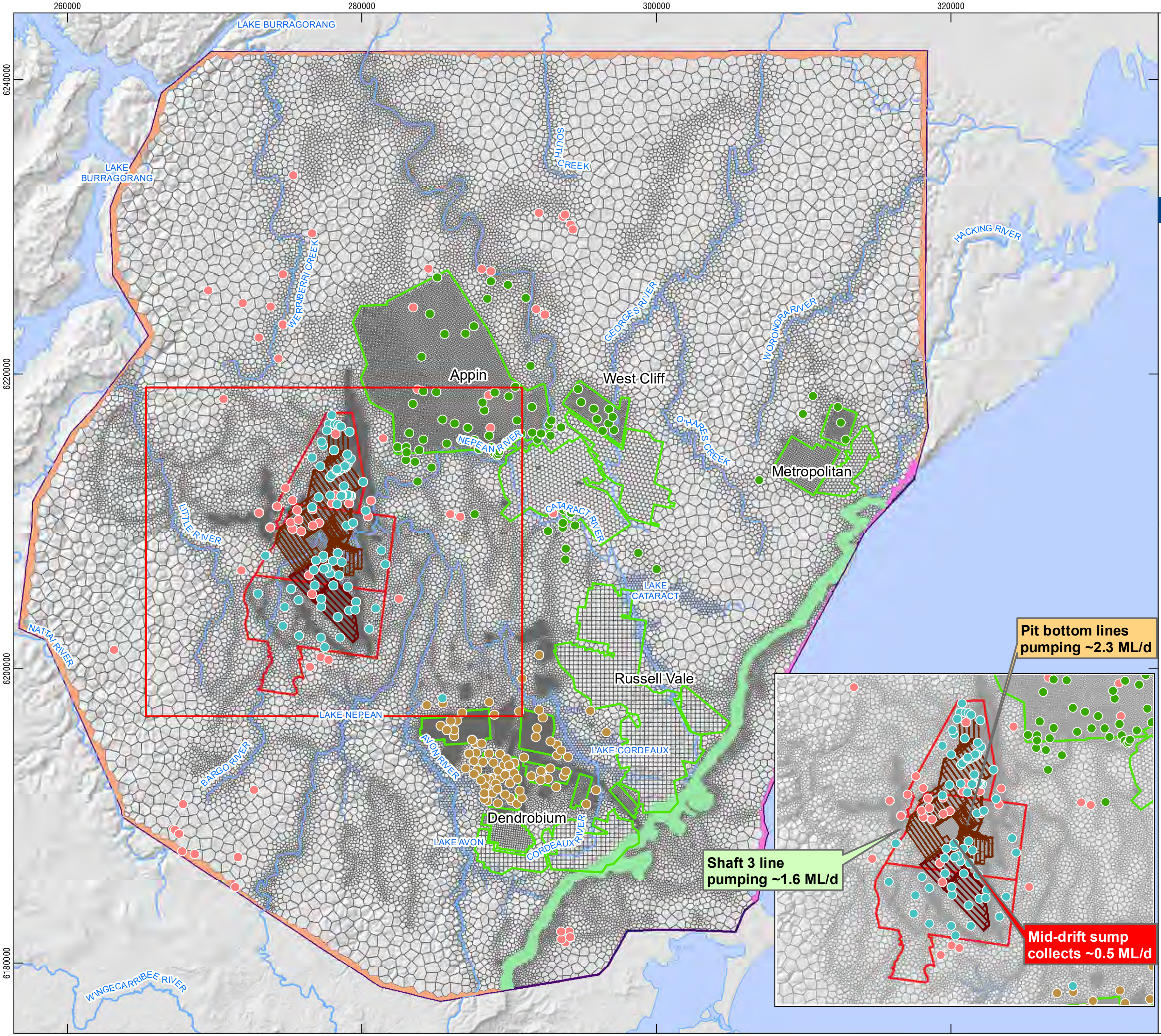
CALIBRATION BORE LOCATIONS AND LOCATION ON MEASURED INFLOWS

FIGURE 4-12



LEGEND

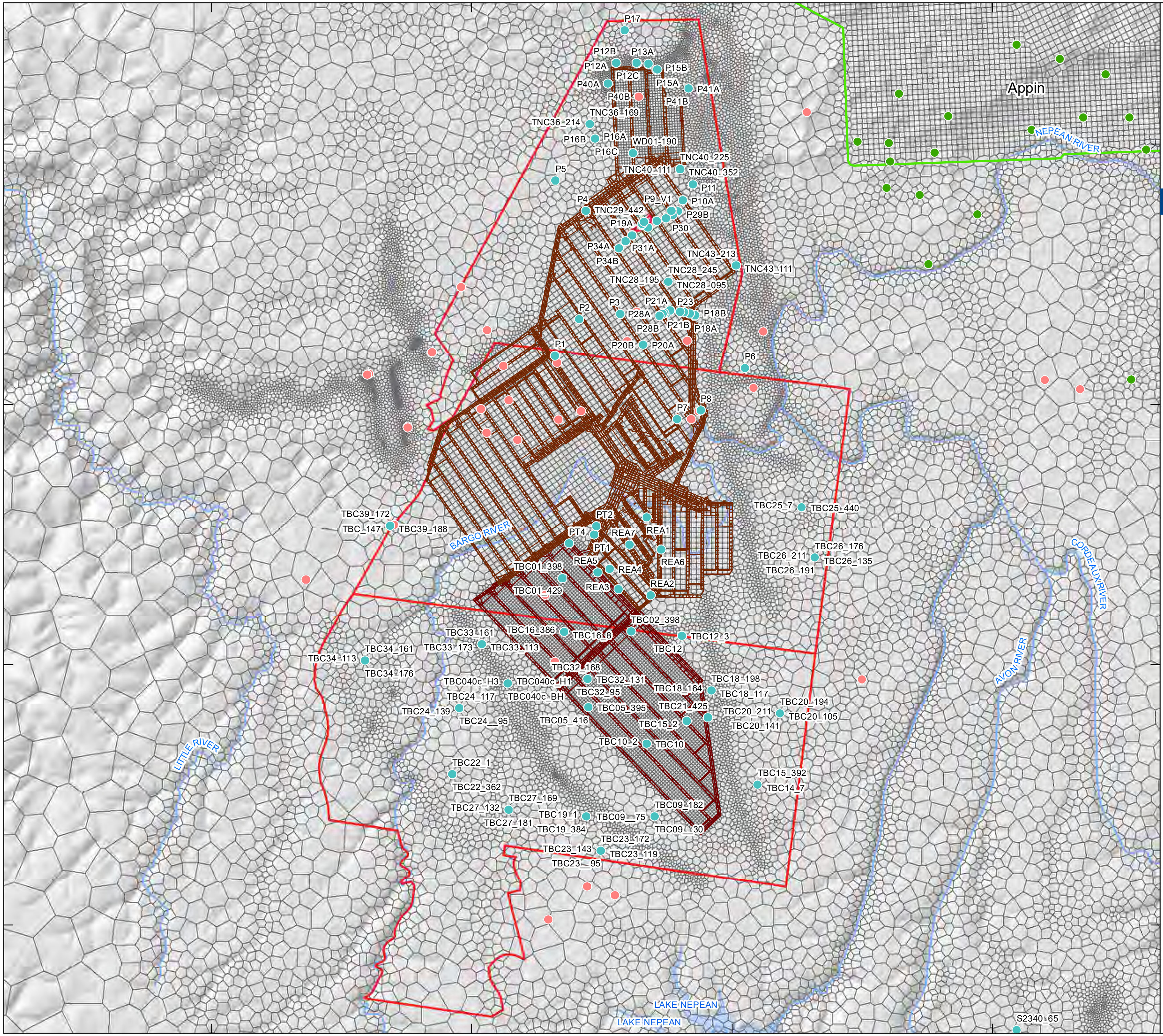
Calibration Bore - By Site

- Private Bore
- Appin
- Dendrobium
- Tahmoor
- Watercourse
- Tahmoor Coal Title
- Surrounding Mine
- Model Grid
- Drain Cell
- Fixed Head Cell
- General Head Boundary
- Model Domain
- Lake

0 5 10 km

Coordinate System:	GDA 1994 MGA Zone 56
Scale:	1:350,000 at A4
Project Number:	610.30652
Date:	28-Apr-2022
Drawn by:	NT
Reviewed by:	DE/SH

Data Source: Mining Lease NSW Mineview Coal Lease 2019



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TAHMOOR COAL
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GROUNDWATER
TECHNICAL REPORT

TAHMOOR CALIBRATION
BORE LOCATIONS

FIGURE 4-13

LEGEND

Calibration Bore - By Site

- Private Bore
- Appin
- Dendrobium
- Tahmoor
- Watercourse
- Tahmoor Coal Title
- Surrounding Mine
- Model Grid
- Model Domain
- Lake

Coordinate System:	GDA 1994 MGA Zone 56
Scale:	1:100,000 at A4
Project Number:	610.30652
Date:	29-Apr-2022
Drawn by:	NT
Reviewed by:	DE/SH

Data Source: Mining Lease NSW Mineview Coal Lease 2019

4.3 Model Calibration Strategy

Automated parameterisation software PEST++ (Doherty 2019) was used for the model calibration. PEST++ undertakes non-intrusive, highly parameterized inversion of an environmental model. PEST++ includes significant functionality that is absent from PEST including more efficient calibration algorithms that can accommodate large, highly parameterized groundwater models. PEST++ can conduct model runs in serial or in parallel. The model variables included in the calibration were:

- Aquifer parameters including horizontal and vertical hydraulic conductivity, specific storage and specific yield;
- All the fracture profile properties;
- Faults (including Nepean Fault Complex, Southern Faults, T1-T2) horizontal and vertical hydraulic conductivity, specific storage, and specific yield;
- Stresses including recharge rates and soil moisture model parameters, and pumping rates;
- Boundary conditions including evapotranspiration (EVT) rate, General Head Boundary (GHB), River (RIV) bed conductance for watercourses and for Thirlmere Lakes;
- Horizontal and vertical hydraulic conductivity, specific storage, and specific yield for pilot points; and
- For the layers with the depth dependent hydraulic conductivity function, PEST varied the hydraulic conductivity intercept (K_0) and the slope variable in the depth dependence functions adopted for the layers.

The starting values for all the variable listed above were adopted from the previous studies. To reduce the number of model parameters a 4-staged approach to model calibration was used. A schematic showing these calibration stages is presented in Figure 4-14.

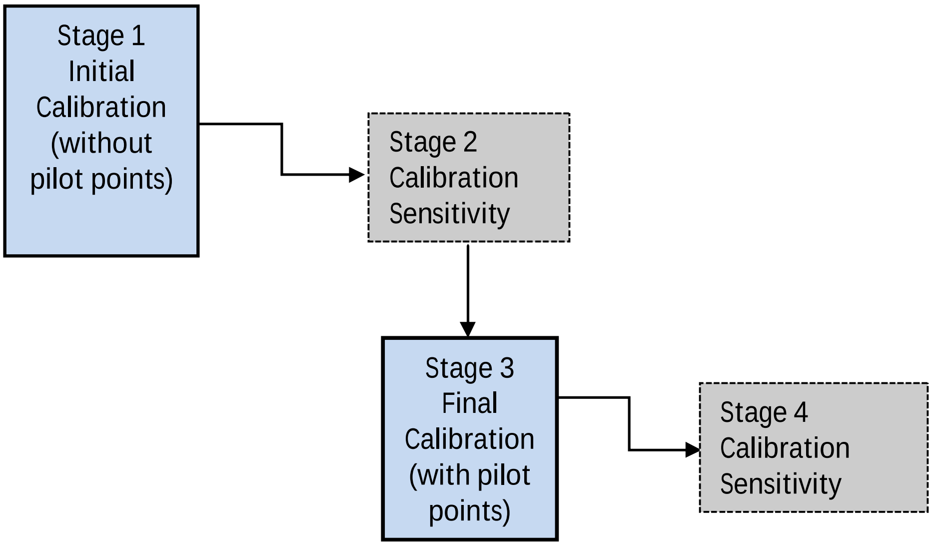


Figure 4-14 Calibration Stages

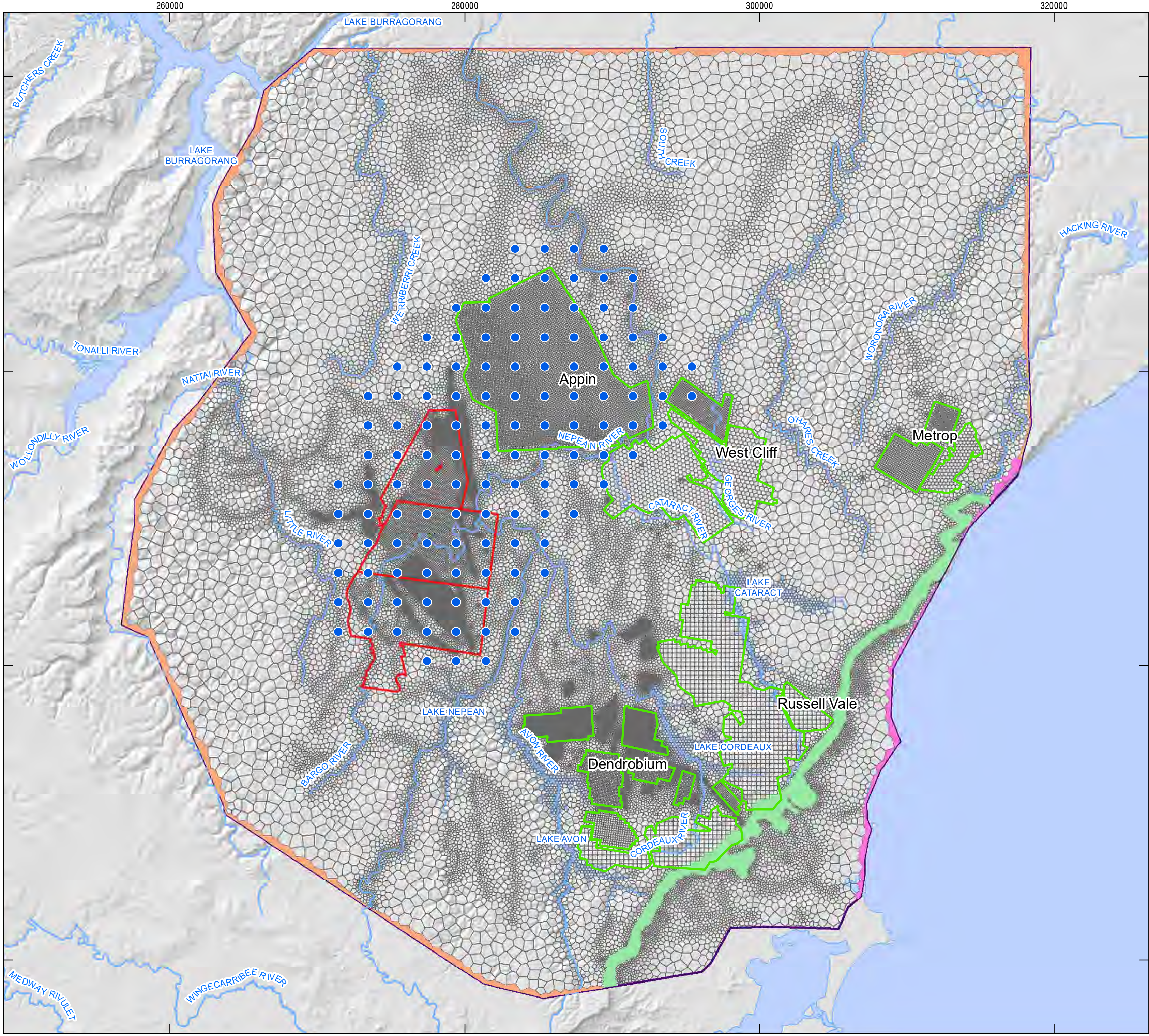
Stage 1: In the first stage the model calibration was run for two iterations using the initial values adopted. There were no pilot points included in the initial calibration.

Stage 2: Using the calibrated values from the initial calibration (Stage 1), an identifiability analysis was conducted on the initial calibration using PEST++. The identifiability analysis assesses the most sensitive properties of the model from a sensitivity (Jacobean) matrix. To calculate the Jacobian matrix, the model was run once for each variable included in the calibration. The results from the identifiability identified the most sensitive model parameters (with 0 representing not sensitive and 1 being the most sensitive) that can impact the match between measured and simulated values.

Stage 3: The final calibration was run using the parameters identified as sensitive from Stage 2. All the parameters with sensitivity of greater than 0.2 were allowed to change in the calibration and the remaining parameter values were kept unchanged. The results from Stage 2 showed very high sensitivity to HBSS Kx and Kz properties. As a part of the final calibration, pilot points were introduced in layers 3 to 5 of the model to allow more spatial variability in the HBSS Kx and Kz properties.

The location of the pilot points is shown in Figure 4-15. Pilot points were set within Tahmoor and Appin Mine operational areas and spaced uniformly. PEST++ used its PLPROC utility to interpolate between the pilot point values and creates a surface across the model domain for a targeted model parameter. This surface of model parameter values is then interrogated for values at the model cell centres to provide a value at each model cell. A total of 360 pilot points were used to assign the hydraulic parameters to layers 3 to 5 of the model. Due to the computational constraints and based upon the sensitivity results, the pilot points for horizontal conductivity in Layers 4 and 5 were tied to the pilot points in Layer 5. The pilot points for vertical conductivity were allowed to change independently in Layer 3, 4 and 5.

Stage 4: Using the calibrated values from the final calibration (Stage 3), the identifiability analysis was reconducted using calibration using PEST++. The results of the identifiability analysis are discussed in full in Appendix F.



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LOCAITON OF MODEL PILOT POINTS

FIGURE 4-15

LEGEND

- Pilot Point
- Watercourse
- Tahmoor Coal Title
- Surrounding Mine
- Model Grid
- Drain Cell
- Fixed Head Cell
- General Head Boundary
- Model Domain
- Lake

0 5 10 km

Coordinate System:	GDA 1994 MGA Zone 56
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Data Source: Mining Lease NSW Mineview Coal Lease 2019

4.3.1 Calibration Statistics

The full details of the calibration statistics and analyses on model calibration performance are provided in Appendix F. Below is a summary of the overall performance for calibration to Tahmoor Coal specific datasets.

One of the industry standard methods to evaluate the calibration of the model is to examine the statistical parameters associated with the calibration (as outlined in the Australian Groundwater Modelling Guidelines [AGMG]; Barnett et al, 2012). This is done by assessing the error between the modelled and observed (measured) water levels in terms of the root mean square (RMS). The RMS is defined as:

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

where: n = number of measurements
ho = observed water level
hm = simulated water level

RMS is considered to be the best measure of error if errors are normally distributed. The RMS error calculated for the observation sites at Tahmoor site only is 25.9 m.

The acceptable value for the calibration criterion depends on the magnitude of the change in heads over the model domain. If the ratio of the RMS error to the total head change in the system is small, the errors are considered small in relation to the overall model response(s). The ratio of RMS to the total head loss (SMRS) for entire dataset is 3.3% while SRMS for Tahmoor only is 2.6%. While there is no recommended universal SRMS error, the AGMG suggests that setting Scaled RMS targets such as 5% or 10% may be appropriate in some circumstances (Barnett et al, 2012).

The overall transient calibration statistics for Tahmoor only bores are presented in Table 4-4, which shows 85% (68,007 out of 79,474 calibration targets) are within ±20 m of the observed measurements. This provides an indication of reasonable fit for the large regional dataset.

Figure 4-16 presents the observed and simulated groundwater levels graphically as a scattergram for the initial and historic transient calibration (1977 to 2021) for the Tahmoor bores only.

Figure 4-17 shows the distribution of residuals for Tahmoor bores, which presents that the calibration residuals for the majority for data points are within ± 20 m for Tahmoor bores.

Table 4-4 Transient Calibration Statistics- Tahmoor Bores Only

Statistic	Value
Sum of Squares (m^2)	20,913,148.1
Mean of Squares (m)	263.6
Square Root of Mean of Squares (RMS) (m)	16.2
Scaled Root Mean Square (SRMS) (%)	2.6%
Sum of Residuals (m)	198,068.6
Mean Residual (m)	2.5
Scaled Mean Residual (%)	0.4%
Coefficient of Determination (tend to unity)	1.9
Targets within ±2m	9,981

Statistic	Value
Targets within ±5m	22,479
Targets within ±20	68,007

*RMFS represents the sample standard deviation of the differences between predicted values and observed values as a fraction of the observed value expressed as a percentage.
** SRMFS scales the RMFS error by the ratio of the mean observed value to the range of the observed values expressed as a percentage.

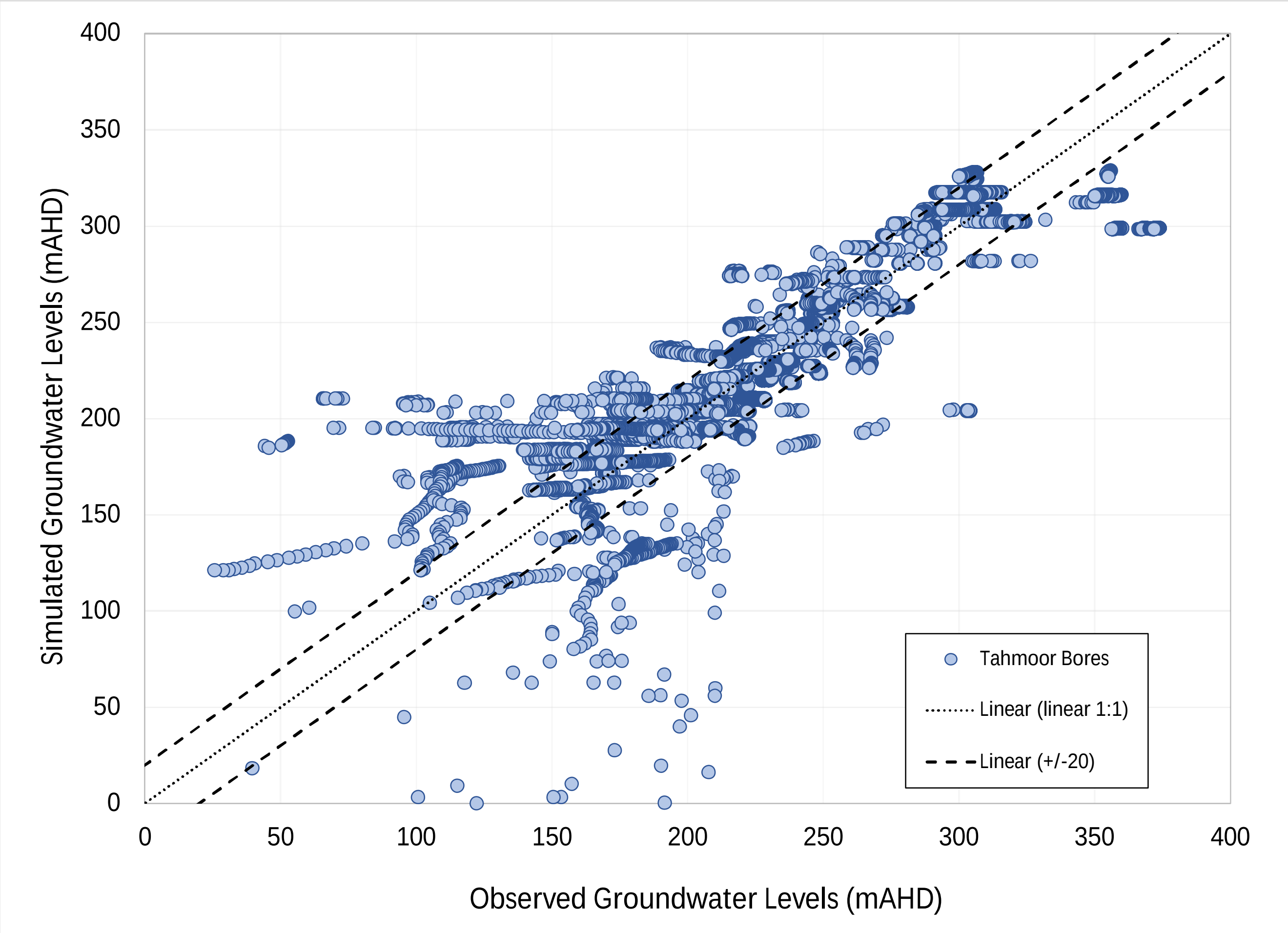


Figure 4-16 Calibration Scattergram – Modelled vs Observed Groundwater Levels for Tahmoor Bores

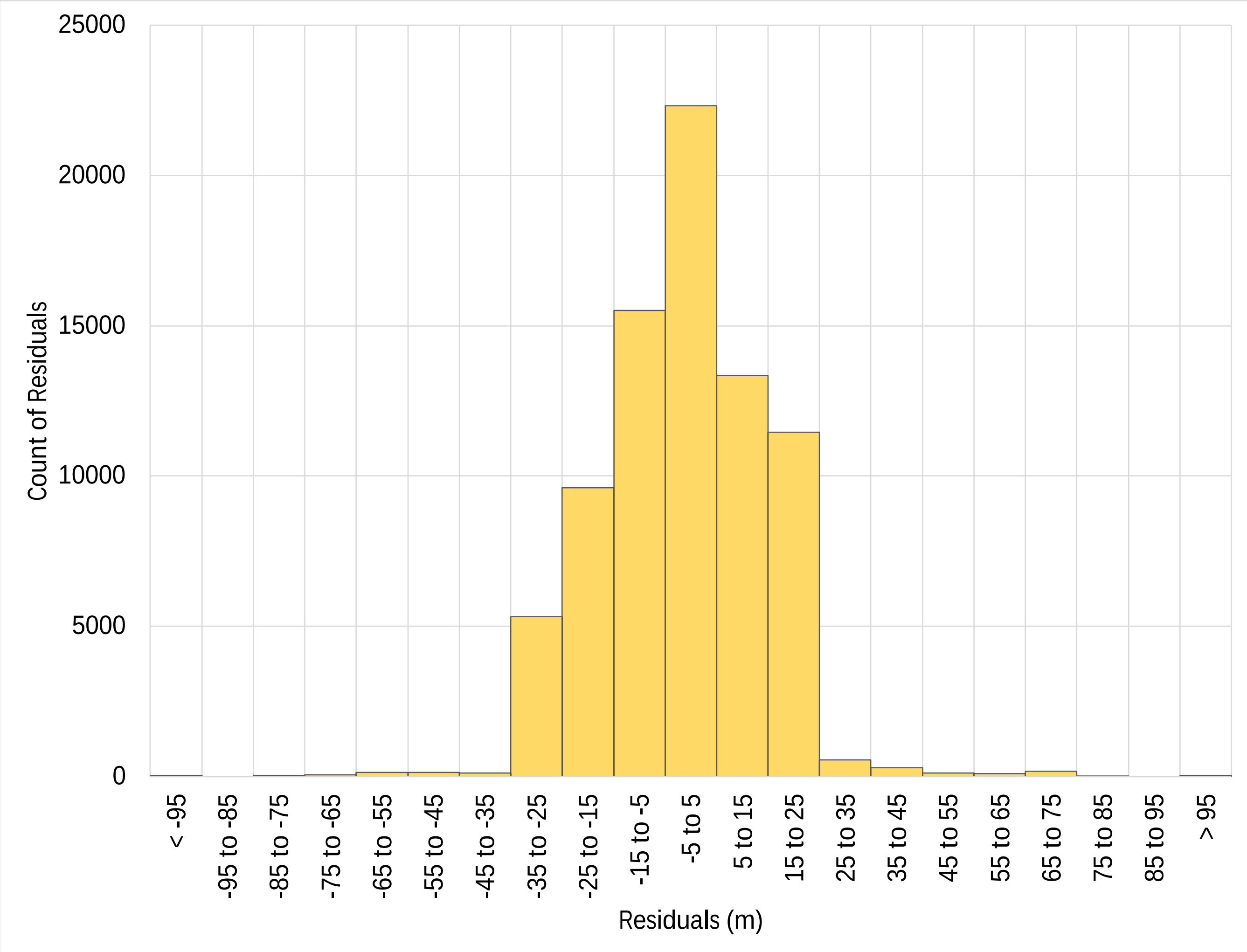


Figure 4-17 Calibration Residual Histogram – Tahmoor Bores

Table 4-5 shows a mix of over and underestimation of water levels in the model layers across the model domain. The table shows Layer 7 (Bulgo Sandstone – Upper) has the highest average and absolute average residual. Table 4-5 shows HBSS layers in the model have the highest number of observations while the average residuals in these layers are less than 9 m.

Table 4-6 shows the average calibration residual and absolute average residual per observation group. As indicated in the table, there is an overestimation of water levels in the Tahmoor bores. The table shows the Tahmoor site has the lowest average residuals.

Table 4-5 Average Residual by Model Layer

Model Layer	Formation	Average Residual (m)	Average Absolute Residual (m)	Number of Observation Targets	Number of bores
1	Regolith, alluvium and basalt	-1.2	6.2	9965	41
2	Wianamatta Formation	5.2	10.4	2211	22
3	Hawkesbury Sandstone - upper	-5.8	22.7	3839	61

Model Layer	Formation	Average Residual (m)	Average Absolute Residual (m)	Number of Observation Targets	Number of bores
4	Hawkesbury Sandstone - middle	10.0	24.6	74176	266
5	Hawkesbury Sandstone - lower	6.6	16.3	6319	114
6	Bald Hill Claystone	-10.4	28.0	289	24
7	Bulgo Sandstone - upper	-6.7	32.5	277	26
8	Bulgo Sandstone - middle	-1.6	27.2	9631	191
9	Bulgo Sandstone - lower	-8.4	37.5	748	22
10	Stanwell Park Claystone	19.9	32.3	615	10
11	Scarborough Sandstone – upper	8.9	33.5	571	19
12	Scarborough Sandstone - lower	-2.7	41.6	5789	105
13	Wombarra Claystone	-26.3	33.5	617	10
14	Coal Cliff Sandstone	-25.2	65.2	363	8
15	Bulli Coal seam	-14.7	49.5	3706	100
16	Eckersley Formation	22.6	35.9	9175	39
17	Wongawilli Coal seam	-29.7	45.9	2047	72
18	Kembla Sandstone	-92.7	92.7	43	3
19	Older units (lower Permian Coal Measures and Shoalhaven Group)	-27.1	27.1	43	1

Table 4-6 Average Residual by Site

Site	Average Residual (m)	Average Absolute Residual (m)	Number of Observation Targets	Number of Bores
Tahmoor	-1.4	12.2	79320	266
Dendrobium	-3.8	35.3	17701	471
Appin	21.0	39.4	14806	241
Private Bore	19.9	22.3	18379	84
Other	35.8	38.5	218	11

4.3.2 Calibration Fit

This section provides discussion on the modelled to observed groundwater level trends (calibration hydrographs) for key bores around the Tahmoor site. Calibration hydrographs for the full calibration dataset are presented as Appendix F.

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

The match in most of the private and government bores is good with errors of ± 5 m. Examples of this can be seen in the hydrographs for "GW" bores in Appendix F.

The hydrographs show better match in the Tahmoor bores compared to Appin and Dendrobium bores as the Tahmoor site bores were given priority in the calibration process. Comparing to the 2021 model, the hydrographs are generally consistent with the previous model.

Overall, across the model domain, there is a better match between simulated groundwater levels and observed levels in the shallow units (including the bores in alluvium and HBSS) which are connected to the surface water features and which host almost all the private bores. This is also shown through calibration residuals presented in Table 4-5. The hydrographs show increasing error in the deeper layers where there is greater, more severe drawdown and higher gradients around the mine. Potential sources of error when comparing simulated and observed water levels are:

- Imperfect simulation of mining operations, roadway development and advanced gas drainage (where present in the model). As an example, the discrepancy in observed and simulated groundwater levels between in Dendrobium mine borehole S1907 and Tahmoor bore TBC39. The hydrograph for the bores shown in Appendix F represent a timing influence, thought to be from the representation of the historical mine plan in this model compared to the actual progression of that mine;
- Structural simplifications in the model, including the vertical and horizontal discretization of the model and resulting 'coarse' representation of features and hydraulic gradients at scales of a model cell (or layer) or less. For example, strong vertical gradients may mean that a model, which predicts average water levels for a cell, will struggle to replicate an observed water level if that water level is from the upper or lower portion of that layer. For a layer that is 50 metres thick and where a gradient is 1 in 10, this leads to errors of ± 5m;
- Structural errors may also occur because of the discretisation of time in the model. In this case, stress period lengths are quarterly. Behaviour within this may significantly influence the observed water level, and the model may either not simulate the relevant stress or may smooth out the response to such a stress;
- High residuals but good match: examples are illustrated in the Bulli Coal seam piezometers in bores TN0C28 and TNC029, which show large residuals but also suggests that the model does a reasonable job of simulating groundwater levels and their response to mining;
- Processing / installation record errors: A lot of the bores with erroneous data were removed from the calibration dataset. However, given the number of bores and measurements available for the calibration, further review of the calibration data may identify more bores with erroneous that should be removed from the calibration. There were uncertainties about installation depth/formation (i.e. model layer) in some of the bores but the data from these bores were included in the calibration but were assigned lower weights; and
- Representation of fracture profile properties: It is evident that the bores screened within the fracture zone above the longwalls are impacted by post-mining properties of the fracture zone. The fracture zone properties are likely to be highly variable in different parts of the mine. However, the model uses one value across the site for the fracture zone which is a simplified representation of a highly complex stress system.

The following sections discuss the calibration hydrographs for shallow bores at Thirlmere Lakes, Tahmoor VWPs, and the Tahmoor open standpipe bores ("P" bores) around Tahmoor North and Western Domain.

4.3.2.1 Thirlmere Lakes Bores

Figure 4-18 to Figure 4-21 compares the simulated and observed groundwater levels for the shallow boreholes at Thirlmere Lakes. The hydrographs show the model simulated the groundwater levels in GW75409_1 and GW75410 are within 5 m of observed levels. The model underpredicts the groundwater levels in GW75409_1 and GW75411 by approximately 5 m. The trends and seasonal fluctuations in groundwater levels in all these bores is reasonably well replicated. The hydrographs presented show the new model was able to match in groundwater levels and trends in Thirlmere Lakes bores better comparing to the 2020 groundwater model.

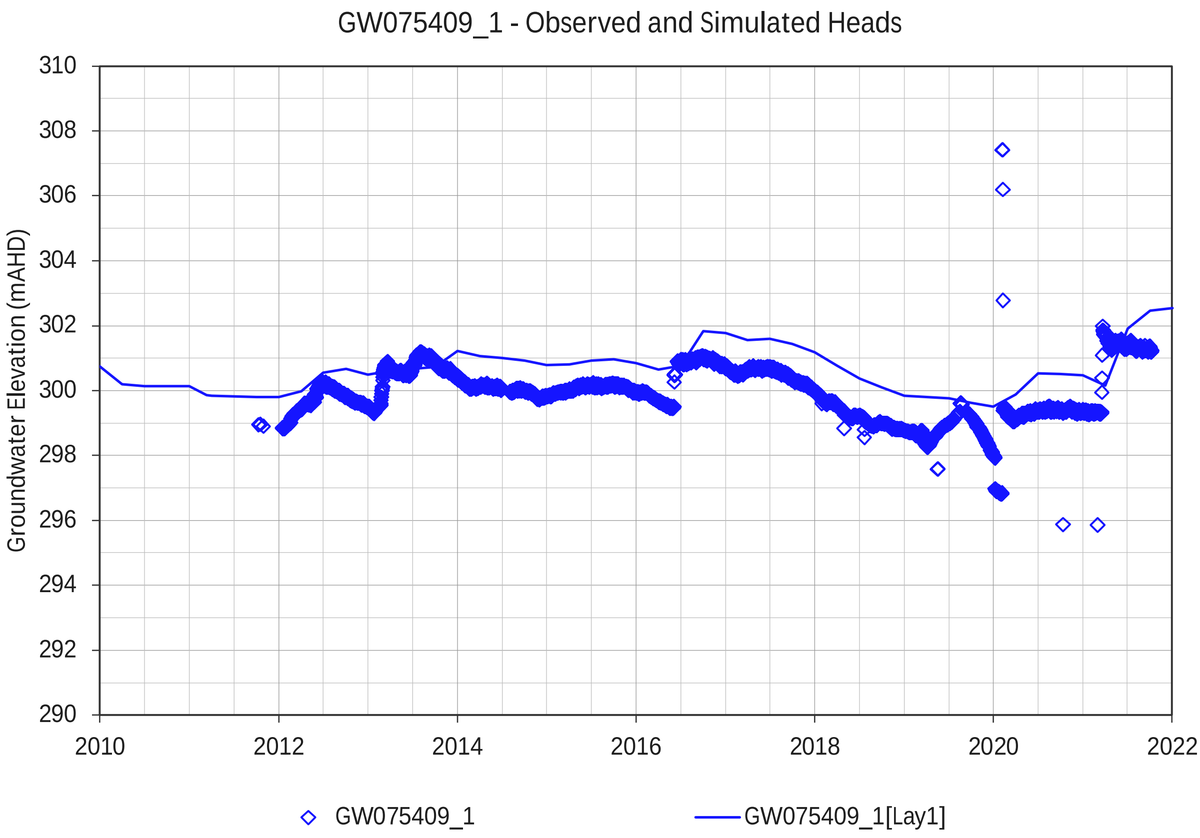


Figure 4-18 Hydrographs for Thirlmere Lakes Bore GW075409_1

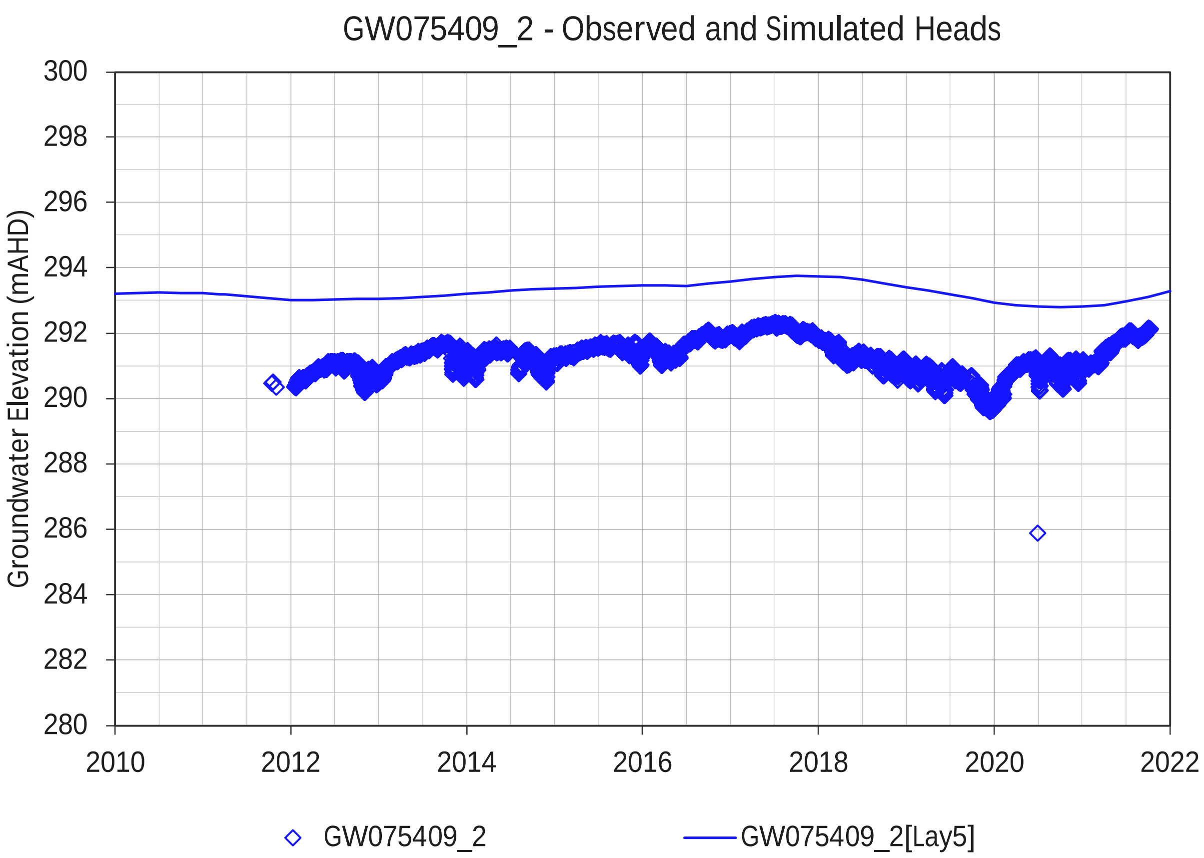


Figure 4-19 Hydrographs for Thirlmere Lakes Bore GW075409_2

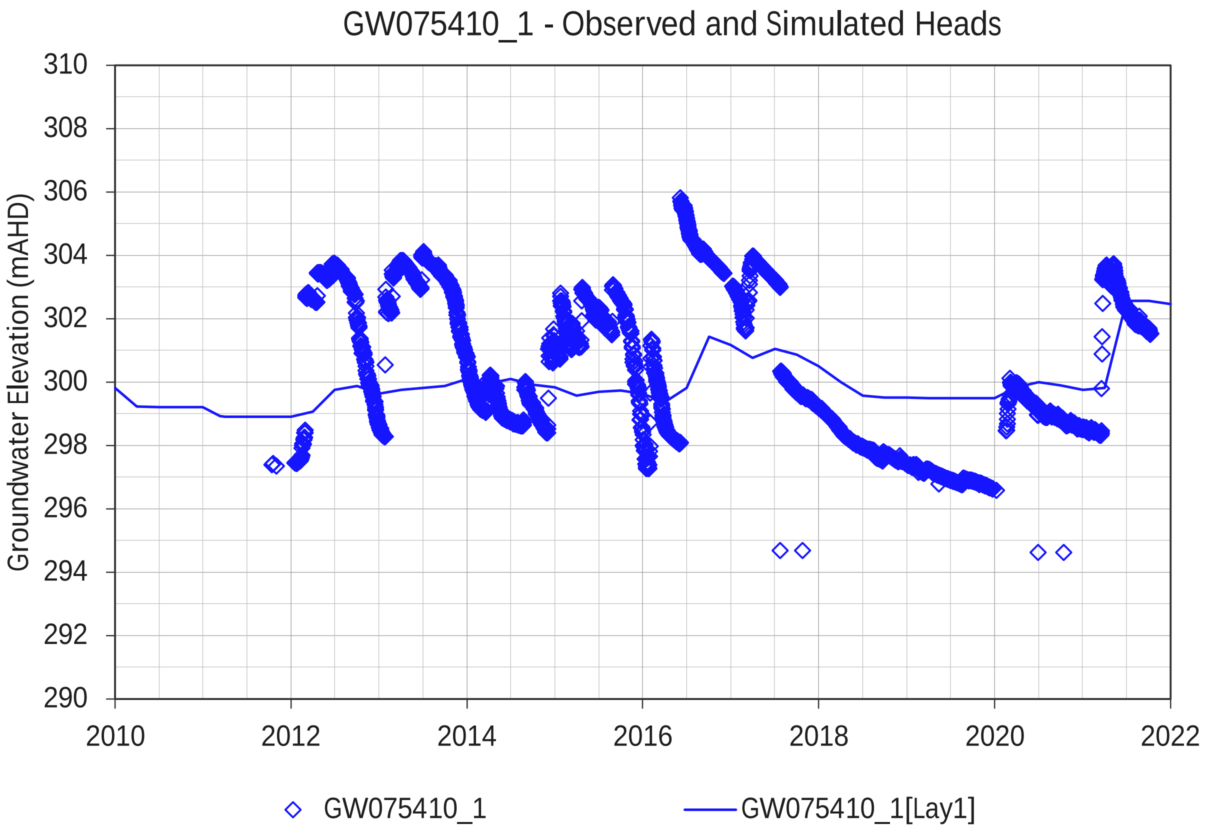


Figure 4-20 Hydrographs for Thirlmere Lakes Bore GW075410_1

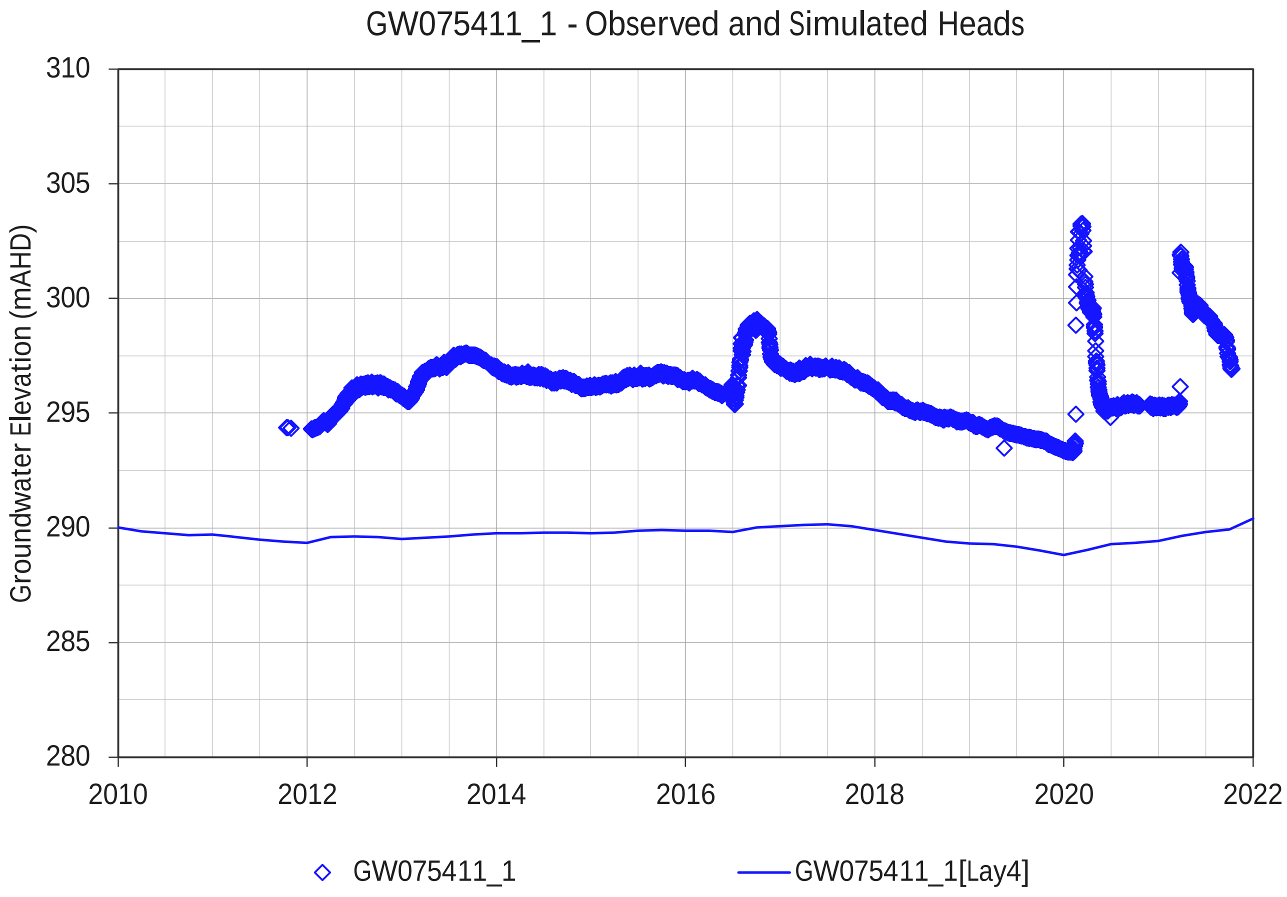


Figure 4-21 Hydrograph for Thirlmere Lakes Bore GW075411_1

4.3.2.2 Tahmoor VWPs

The following section presents the model performance at the VWPS in Tahmoor North and Western Domain bores (TNC040, TNC028, TNC029, WD01) and Tahmoor South (TBC032, TBC027, TBC039).

TNC040: TNC040 is a multi-VWP bore in Tahmoor North, located near LW32. Simulated water level profiles at bore TNC040 are shown in Figure 4-22. There is a good match between the simulated water levels and observations in most of the TNC040 sensors. The figure shows a good match down the profile, with modelled heads being a good match for those in the Hawkesbury Sandstone (both modelled and observed unaffected by mining) and the Bulgo Sandstone (both modelled and observed influenced by mining). The model tends to underpredict drawdown in the deeper units compared to the observed water levels. Overall, the model was able to simulate the depressurisation in deeper strata and minimal drawdown above the zone of connected fracturing.

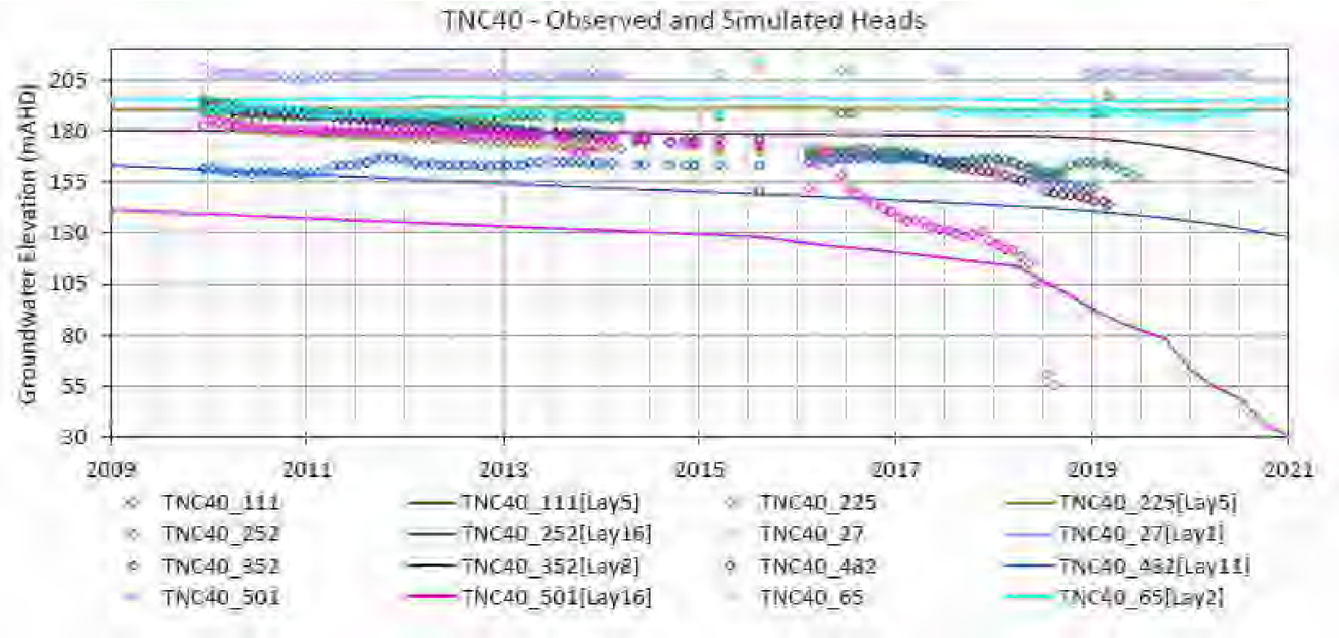


Figure 4-22 Hydrographs for VWP TNC040

TNC028 and TNC029: Figure 4-23 and Figure 4-24 show hydrographs comparing modelled and observed groundwater levels for TNC028 and TNC029 both located with the Tahmoor North mine footprint. The figures show the model was generally able to replicate the difference in heads observed at the sensors and was also able to closely simulate the drawdown due to mining at Tahmoor North. The model underpredicted the groundwater levels in the deepest VWP in TNC029.

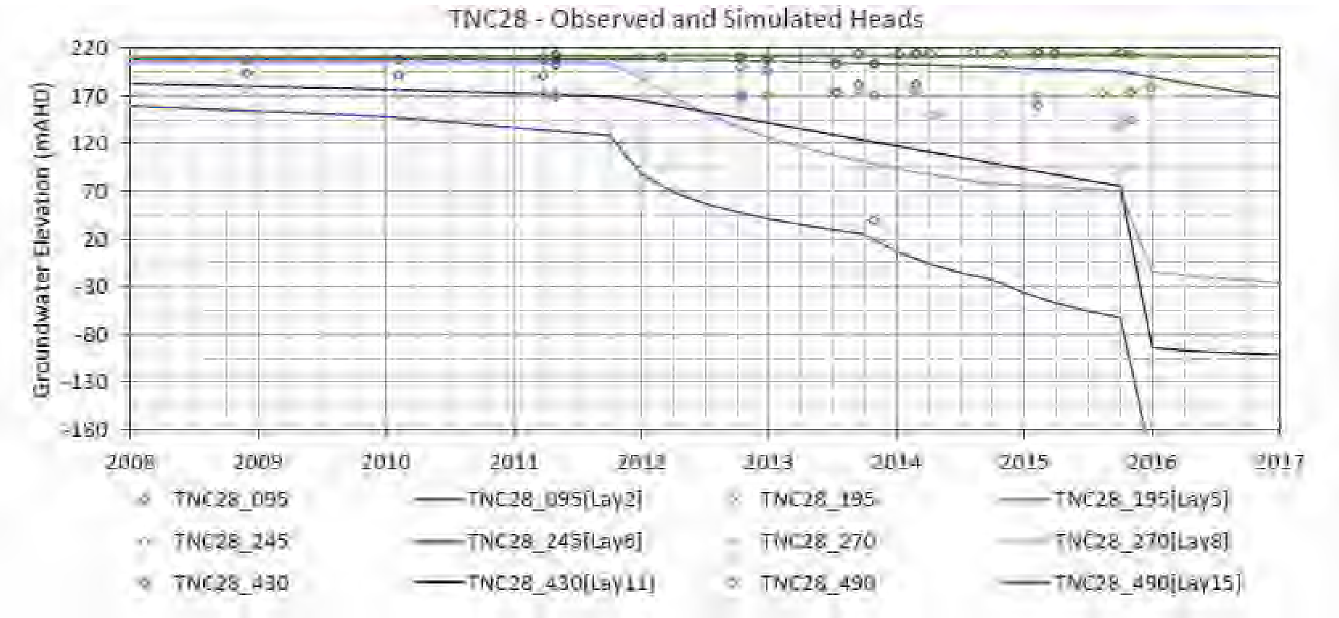


Figure 4-23 Hydrograph for VWP TNC028

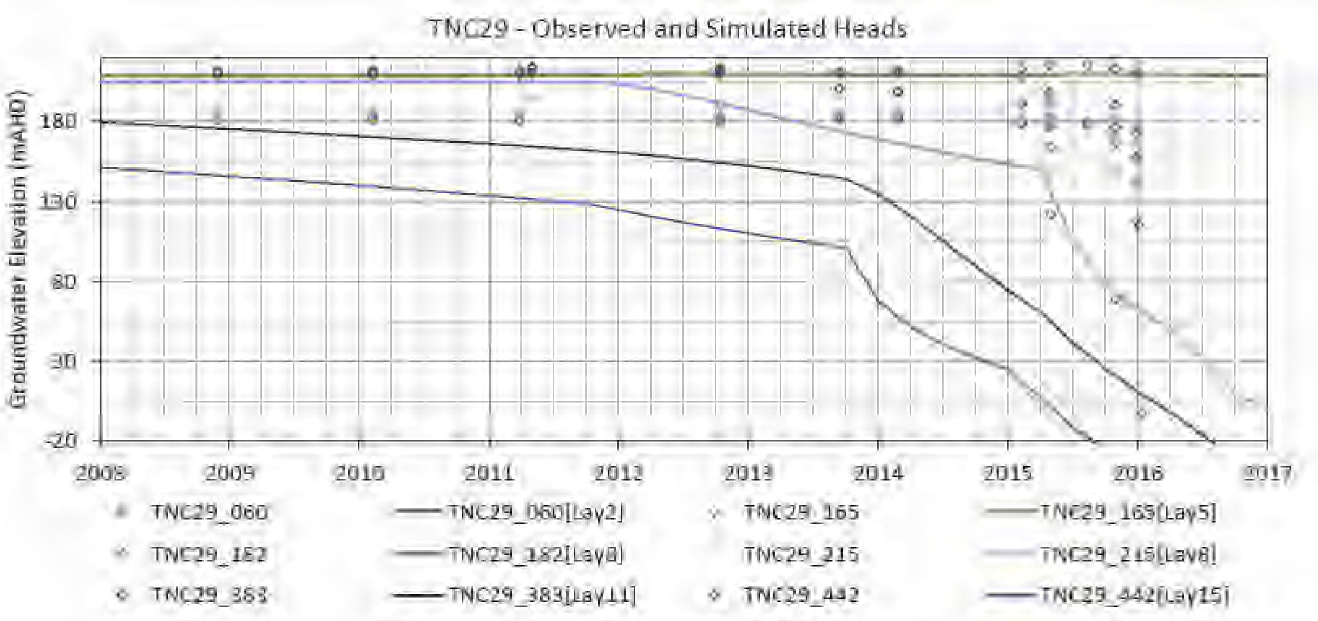


Figure 4-24 Hydrograph for VWP TNC029

WD01: Figure 4-25 compares the simulated and observed groundwater levels for sensors in WD01 which is located within Western Domain mine footprint. The figure show while the model replicated the shallow groundwater levels well, it was not able to capture the depressurisation in the lower Hawkesbury Sandstone (piezometer WD01-190m, WD01-210m and WD01-230m). The model overpredicted the groundwater levels in deeper units such as Bulgo Sandstone (piezometer WD01-300m) by between 20-50 m. Multiple piezometers in BGSS WD01-350m were simulated in the same model layer of the model due to vertical resolution of the model. This was a limitation in matching some of the groundwater levels recorded in the VWPs.

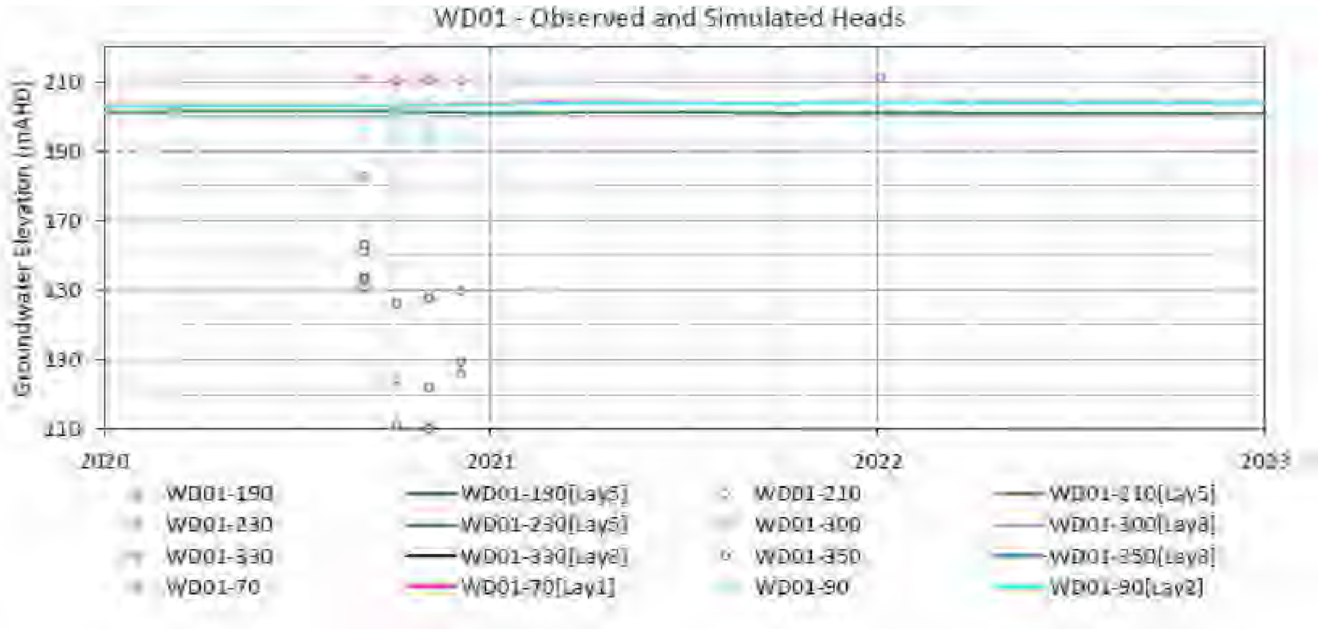


Figure 4-25 Hydrograph for VWP WD01

TBC018: Figure 4-26 shows the calibration hydrograph for TBC018 which is located to the southwest of Tahmoor South away from any historical mining. The model overpredicts the groundwater level in all the sensors at TBC018 but matches the observed trends well. In the case of the Bulli Coal piezometer (TBC18_404), the observed drawdowns are likely caused by equilibration of water levels after piezometer installation and therefore, the model was unable to replicate them.

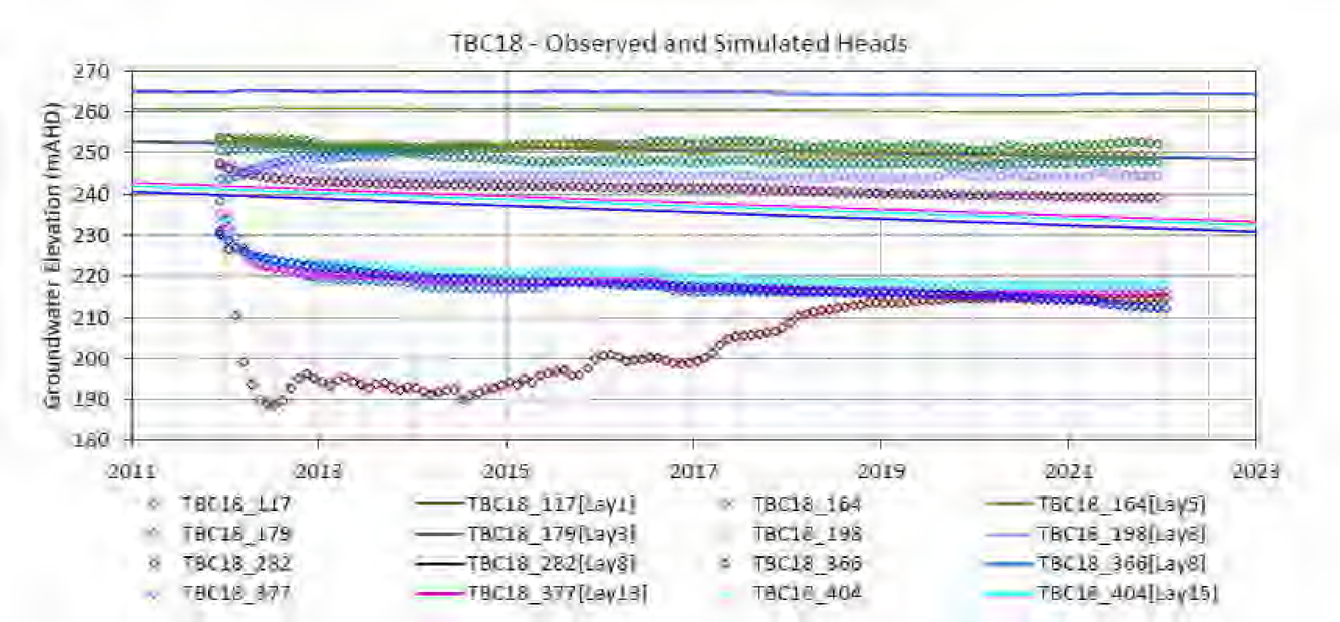


Figure 4-26 Hydrograph for VWP TB18

TBC034: TBC034 is also located to the east of Tahmoor South Panels. As shown in Figure 4-27, the model underpredicted the groundwater levels in most of the sensors. The drawdown observed in the deeper sensors in TBC034 appear to be a result of mining, but the model was not able to replicate this drawdown. The mismatch between observed in simulated and observed groundwater levels in this bore is likely due to the model structure (i.e. further away from the site resulting in a reduction of the geology model accuracy).

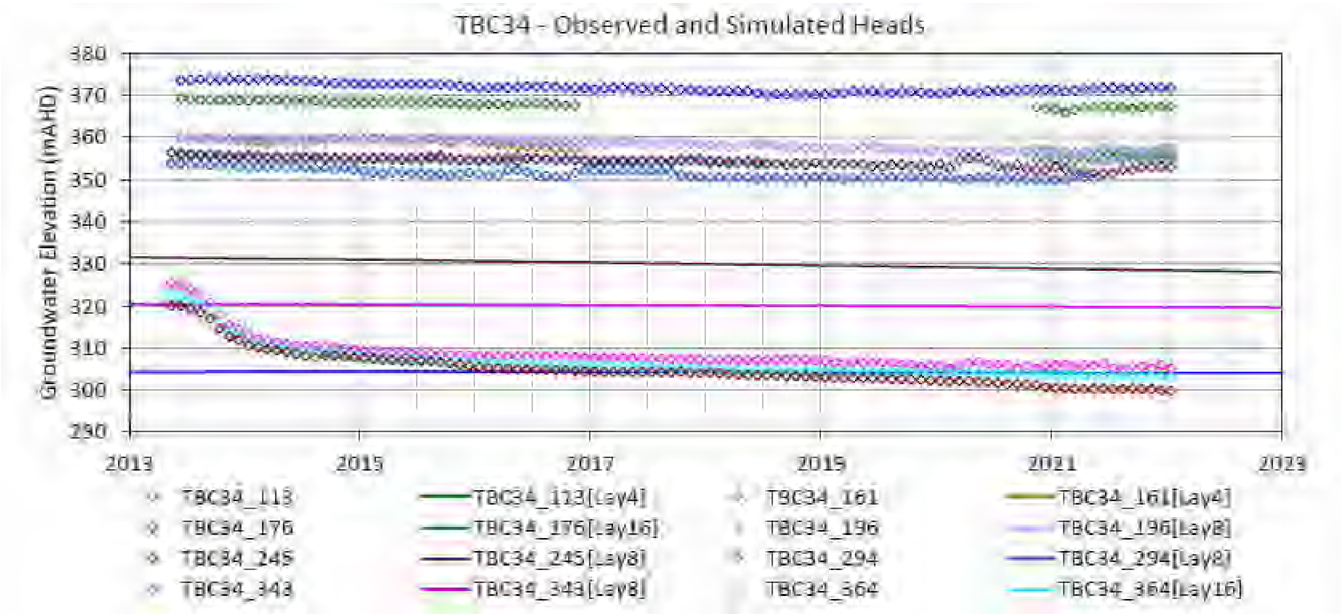


Figure 4-27 Hydrograph for VWP TBC34

TBC027: Figure 4-28 shows the hydrograph for TBC027 located to the south of Tahmoor South Panels. As shown in, the model overpredicted the groundwater levels in most of the deep VWPs in TBC027 (below HBSS). The drawdown observed in the deeper VWPs in TBC027 does not appear to be mining related and the model was not able to replicate this drawdown.

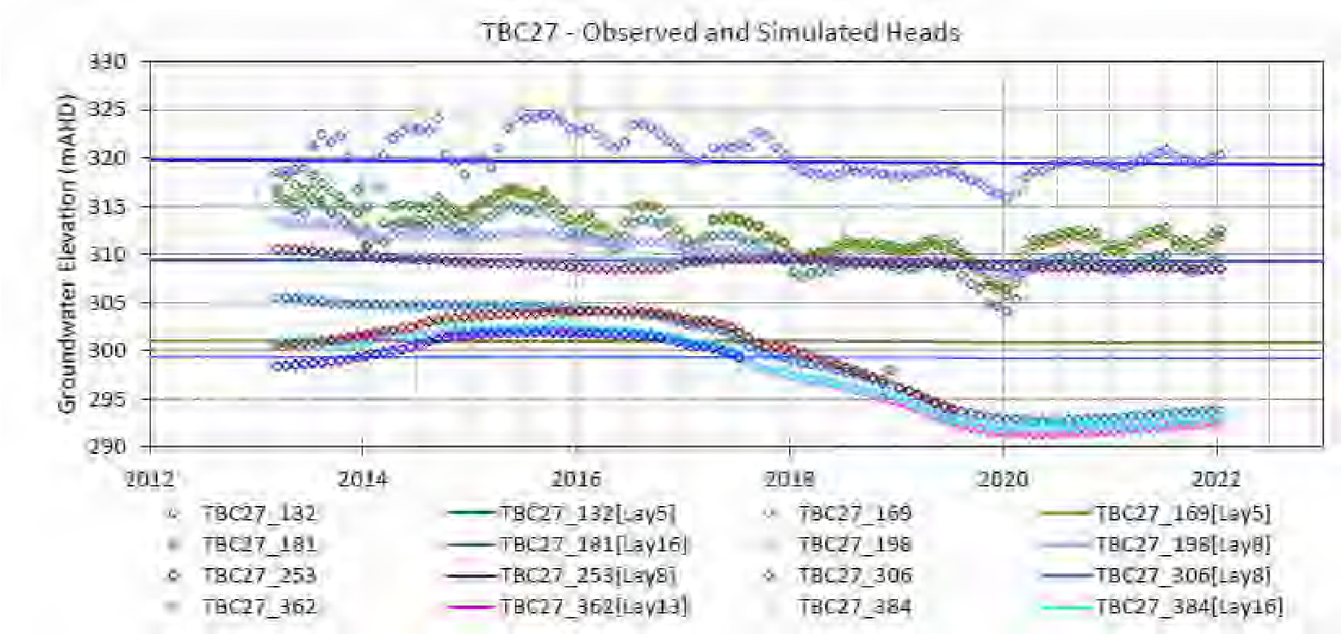


Figure 4-28 Hydrograph for VWP TB27

4.3.2.3 Tahmoor Open Standpipe Bores (P Bores)

4.3.2.3.1 Tahmoor North

This section presents hydrographs comparing modelled and observed groundwater levels for the existing groundwater monitoring bores located across Tahmoor North (P1-P8, P9) shown in Figure 4-29 to Figure 4-37, and along Redbank Creek (P10-P36) and Myrtle Creek (P18-P28) presented in Appendix F.

The comparison of modelled and historical observed groundwater levels for P1-P8 shows the model simulates a reasonable match to the trends at these bores but over or under predicts the groundwater levels between 5 to 20 m which is consistent with the previous model (SLR/HydroSimulations, 2021). P6 and P8 show the largest difference in observed and simulated groundwater levels.

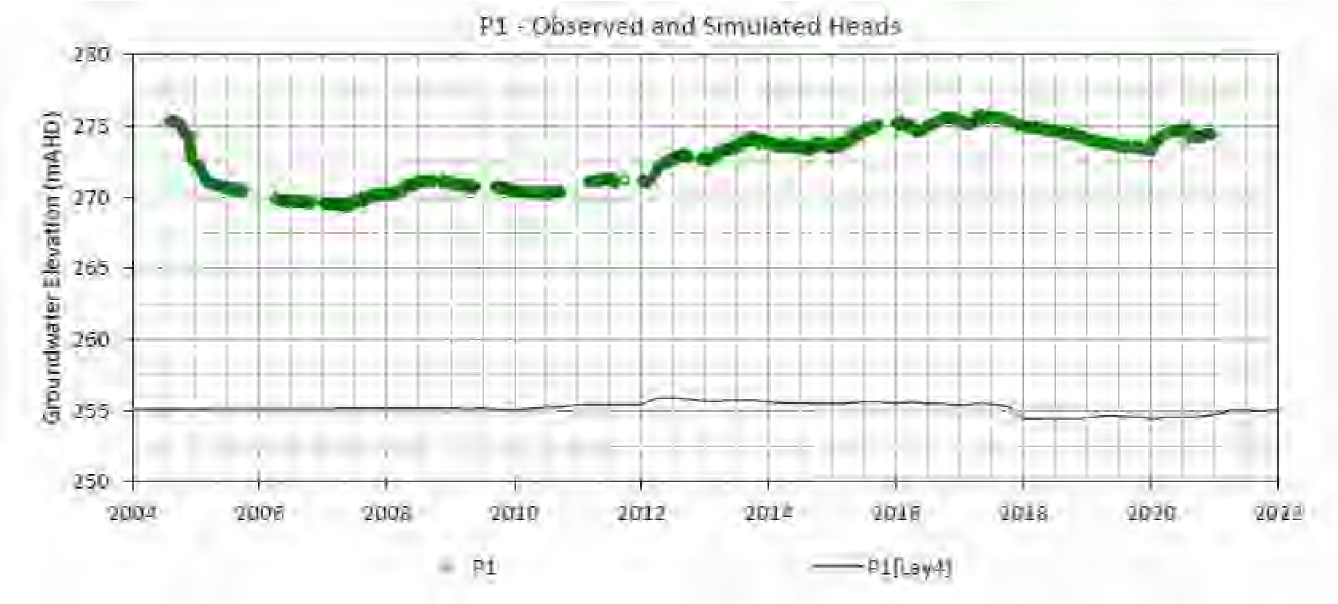


Figure 4-29 Hydrographs for P1- Tahmoor North

Figure 4-30 Hydrographs for P2- Tahmoor North

Figure 4-31 Hydrographs for P3- Tahmoor North

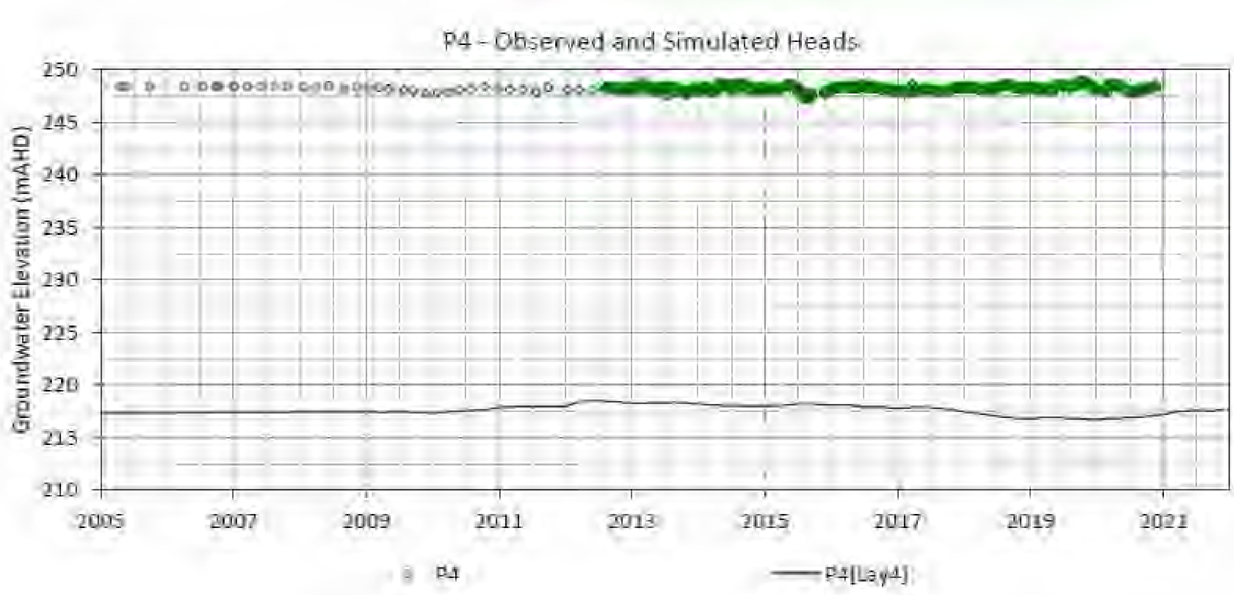


Figure 4-32 Hydrographs for P4- Tahmoor North

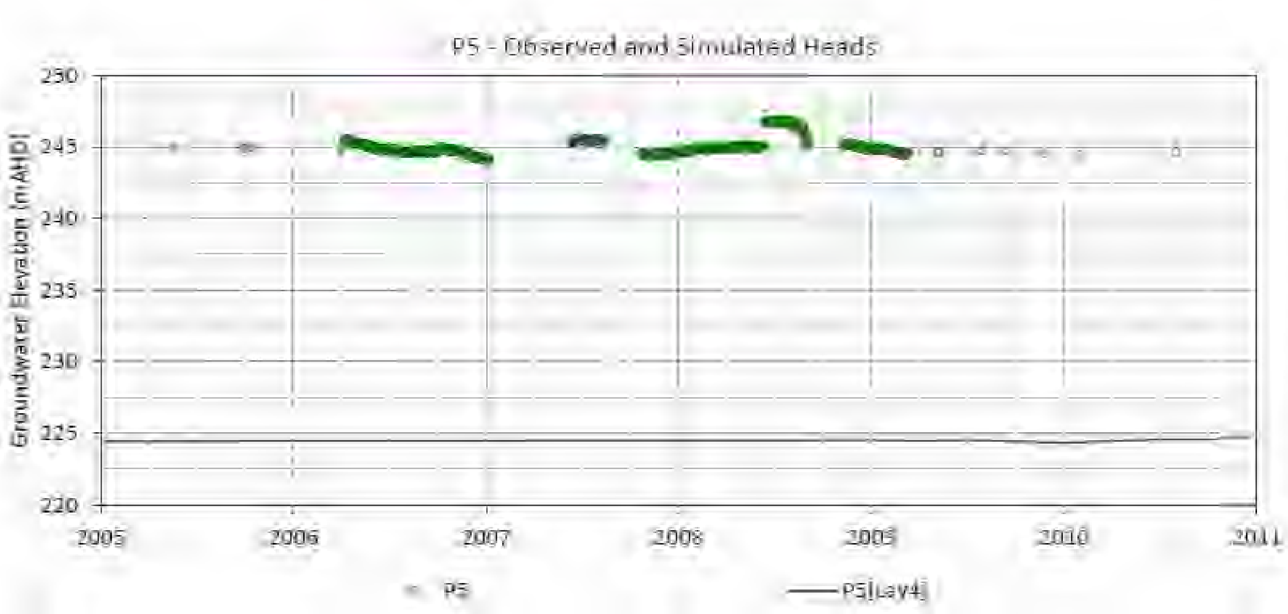


Figure 4-33 Hydrographs for P5- Tahmoor North

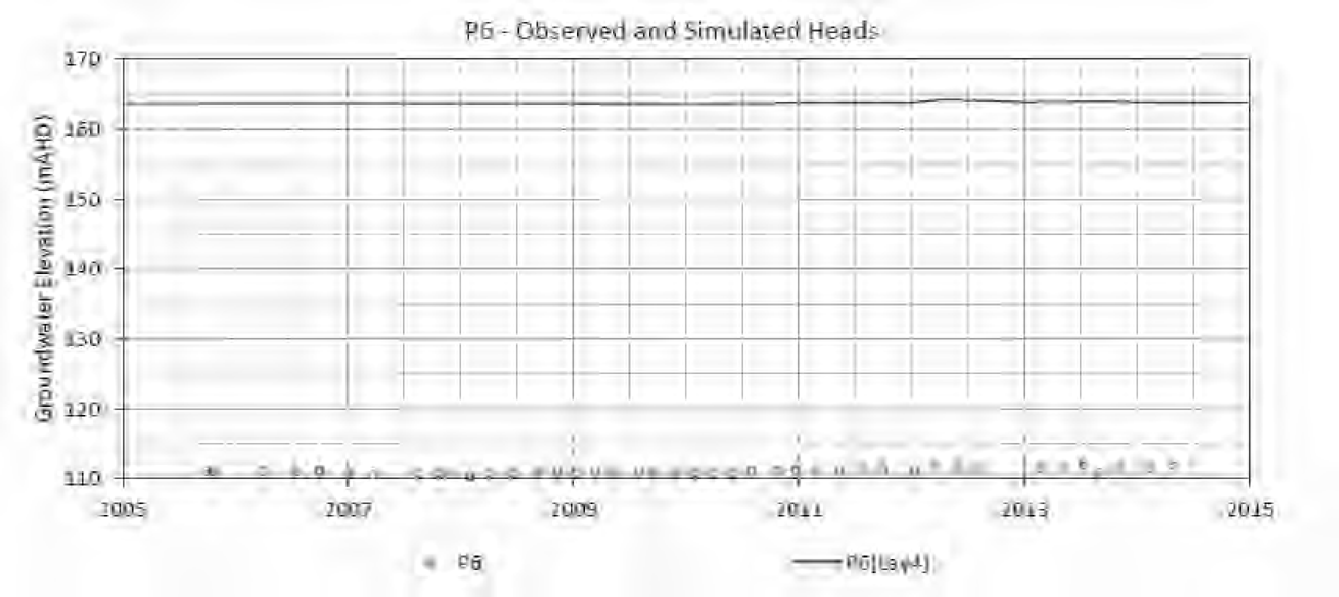


Figure 4-34 Hydrographs for P6- Tahmoor North

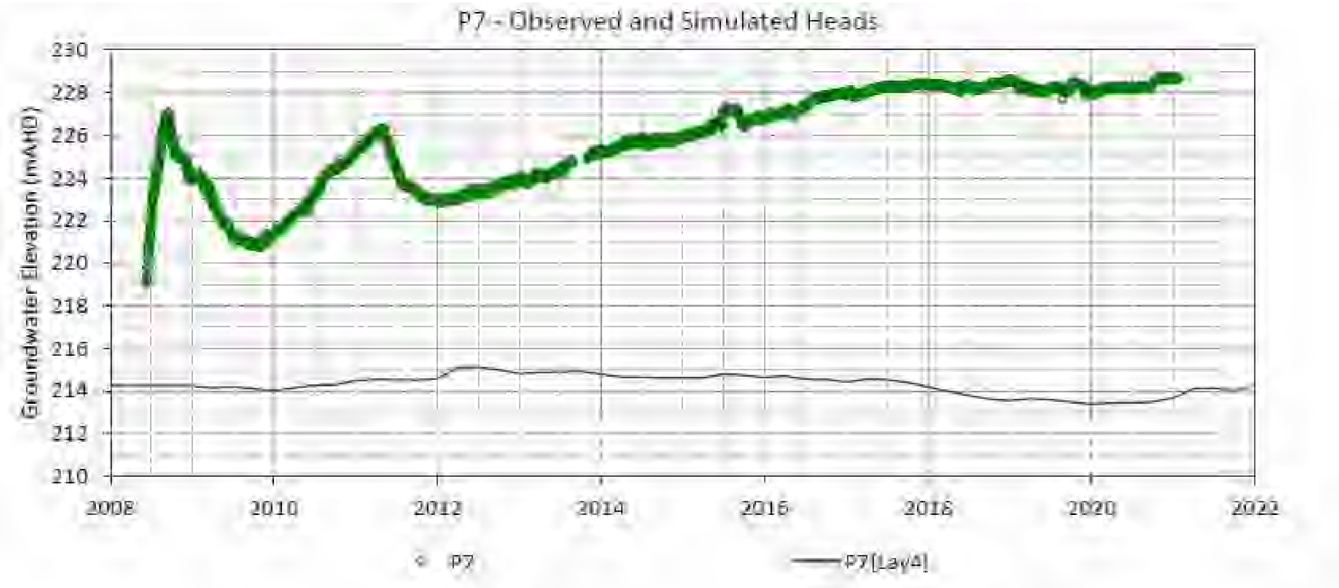


Figure 4-35 Hydrographs for P7- Tahmoor North

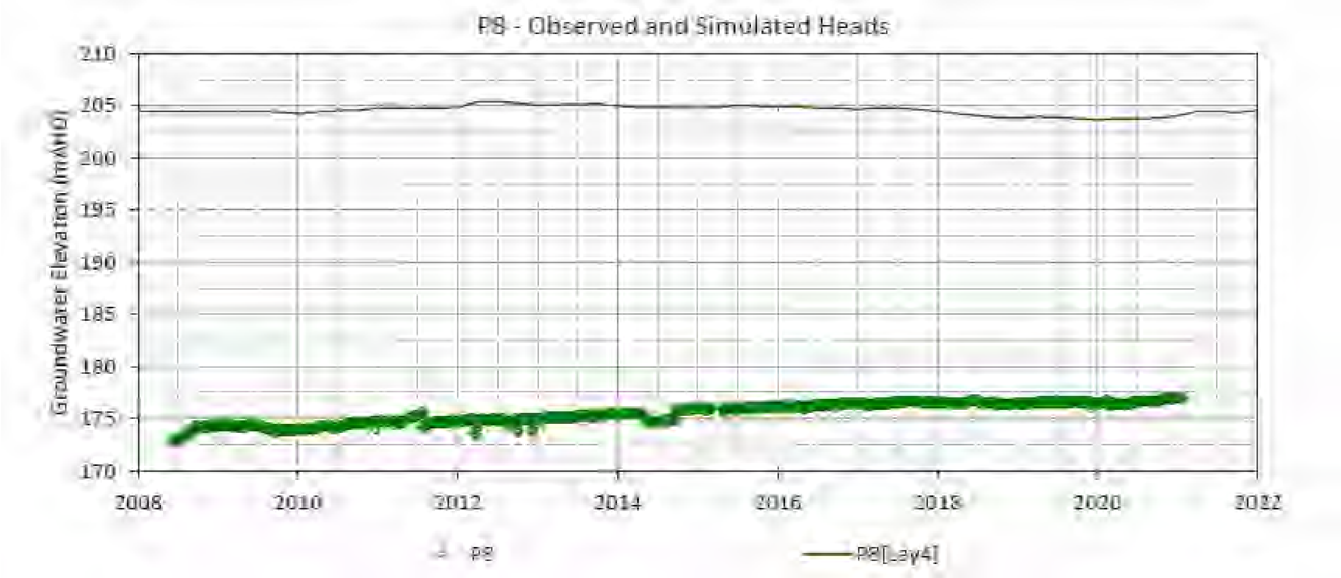
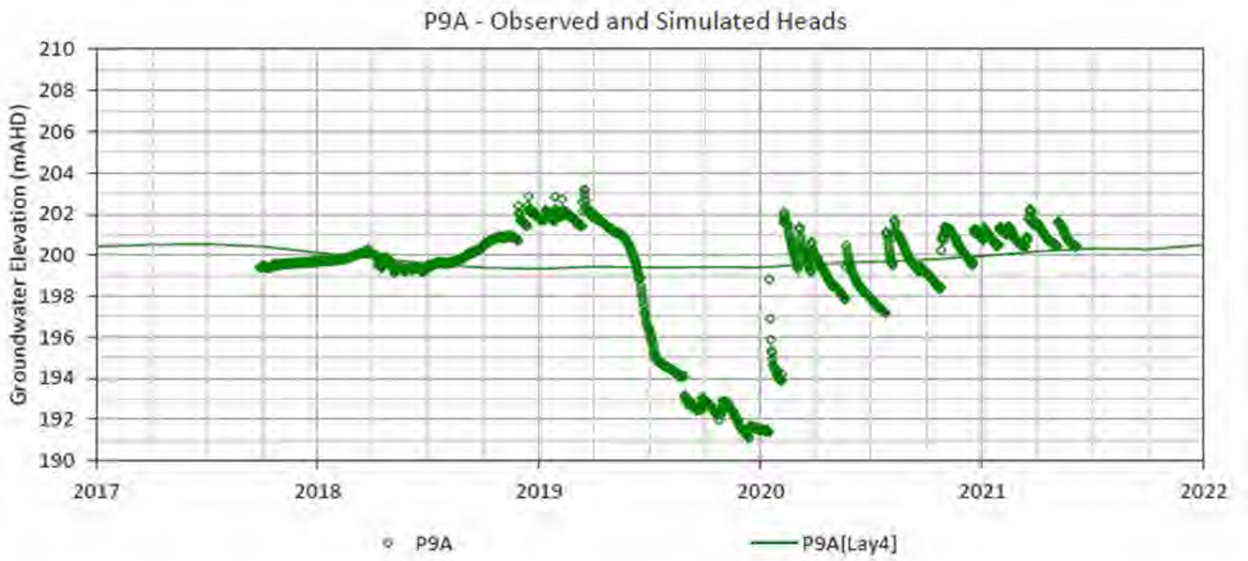


Figure 4-36 Hydrographs for P8- Tahmoor North

At bore P9 (Figure 4-37), the model replicates the LW31 and LW32 related drawdown observed in the shallow Hawkesbury Sandstones and the simulated water levels are within 5 m of observed levels (P9A, P9V1). The hydrograph for P9A shows the model was able to replicate the fluctuation in groundwater levels observed in Hawkesbury sandstone at this location. In the deeper section of the bore (P9_V3), the simulated drawdown is not as significant as the sharp decline in water levels observed after 2018. The mismatch in drawdown is likely due the properties of fractured zone and the timing of mining.



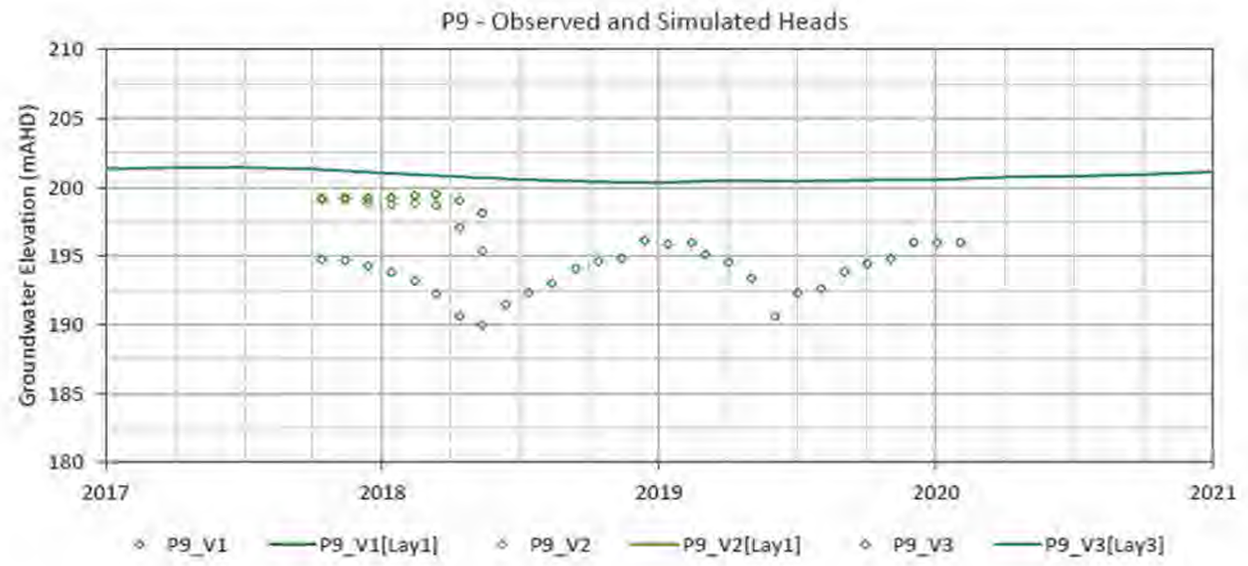


Figure 4-37 Hydrographs for P9 and P9A- Tahmoor North

Hydrographs for shallow bores along Redbank Creek (P10 A, P10) shown in Figure 4-38 indicate that in general, the model matches the groundwater levels along the creek. There is usually an offset of less than 5 m between observed and modelled. However, the simulated trends and seasonal fluctuation in the groundwater level in the Redbank Creek catchment are not significant as observed levels.

At bore P10, limited drawdown is simulated in the deep open standpipe bore (P10C) comparing to observed which is likely due to the timing of mining simulated in the model. Comparing to 2021 model, the match to observed levels in shallow bores P10 A and P10 has improved. As shown in Appendix F, overall, the match between simulated groundwater levels and observed for the bores along Redbank Creek is good and is within ± 10 m of the observed data (P11, P19, P29, P30, P32, P32, P33, P34). However, the model was not able to replicate the observed fluctuations in these bores. This can be seen in Figure 4-39 which shows the hydrographs for bores P30 and P32 along the Redbank creek.

Modelled water levels for bores along the Myrtle Creek catchment (P20B, P24A, P25, P26, P27 and P28A-B) are presented Appendix F. As shown the hydrographs, there is a consistent underprediction of groundwater levels at these bores. This underprediction of groundwater levels is likely due to the simulated mining in the model and simplifications in model layering. Although the modelled water levels do underpredict the observed levels, the model simulates the groundwater trend reasonably well.

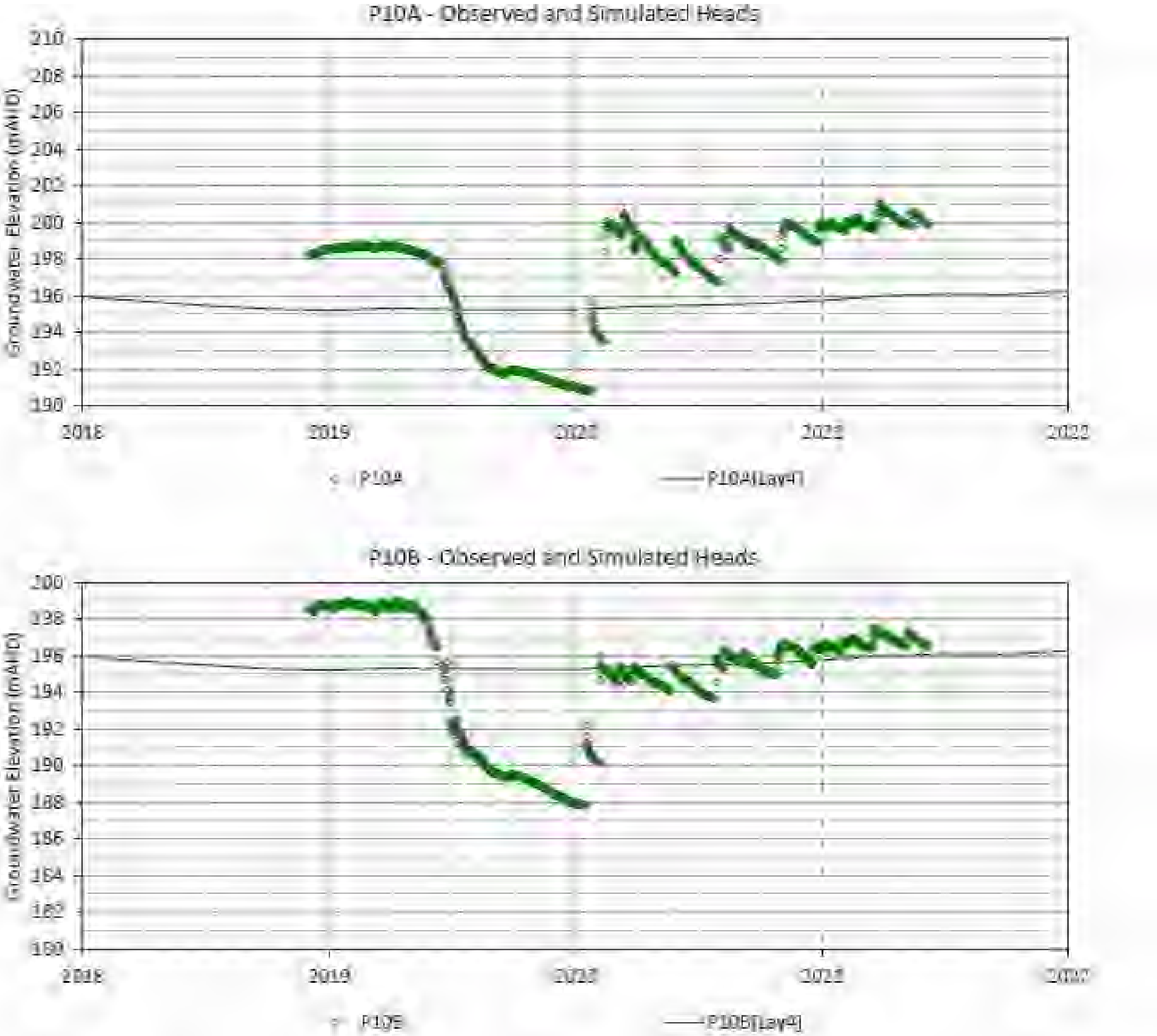


Figure 4-38 Hydrographs for P10A and P10B

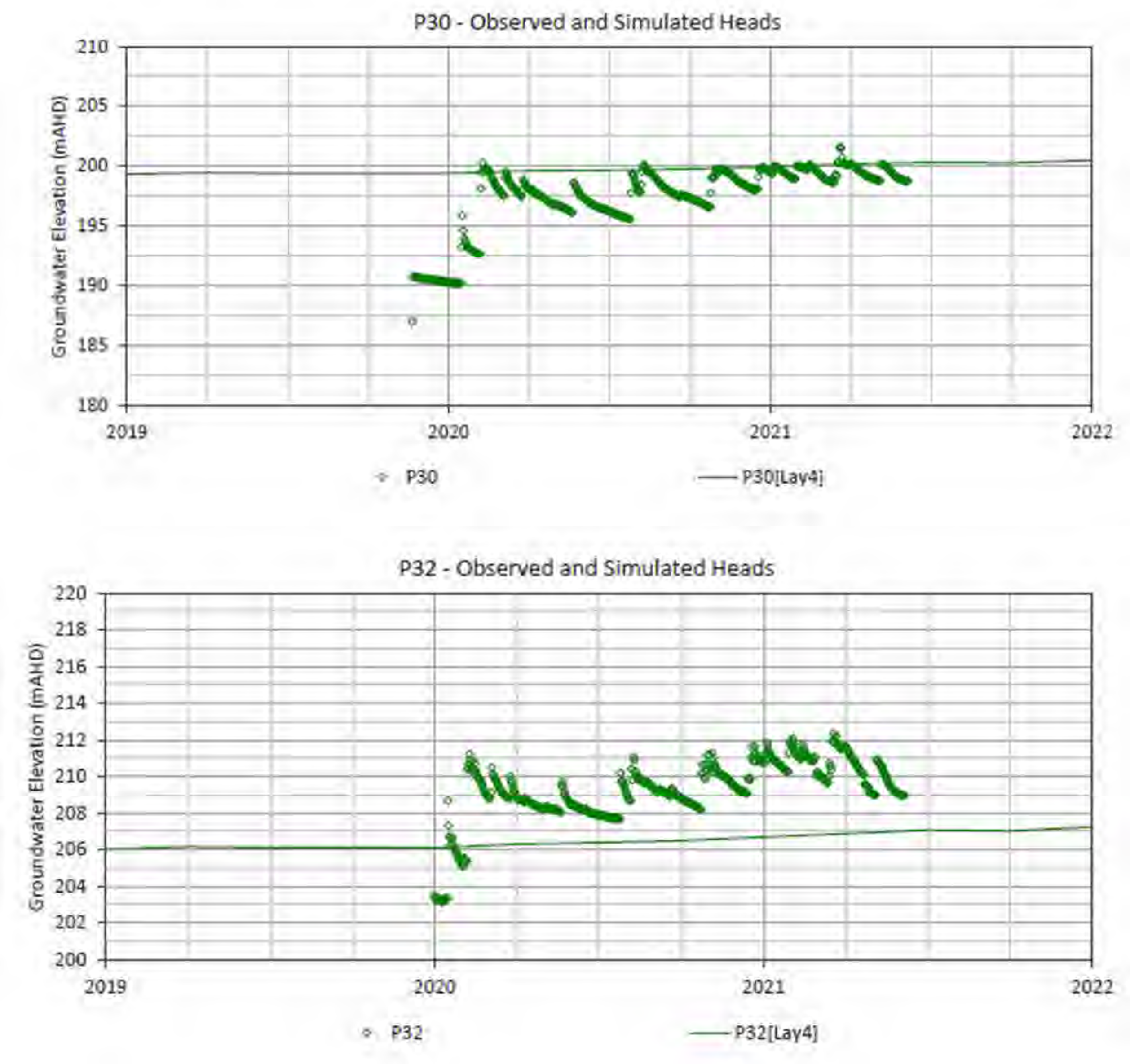


Figure 4-39 Hydrographs for P30 and P32

4.3.2.3.2 Western Domain

The hydrographs for the Western Domain Bores (P12-P17) are presented in Figure 4-40 to Figure 4-45 and in Appendix F. As shown in the figures, the model overpredicts the groundwater levels in P12 to P17 between 5 to 20 m. However, while modelled levels are offset, the trends and fluctuations are well matched. As shown in Figure 4-42, P14A that monitors the alluvium shows the model replicated the groundwater levels at this bore quite well but is not able to replicate the significant fluctuations at this bore. The over predictions of the groundwater levels in P14 to P17 is consistent with the SLR 2021 model.

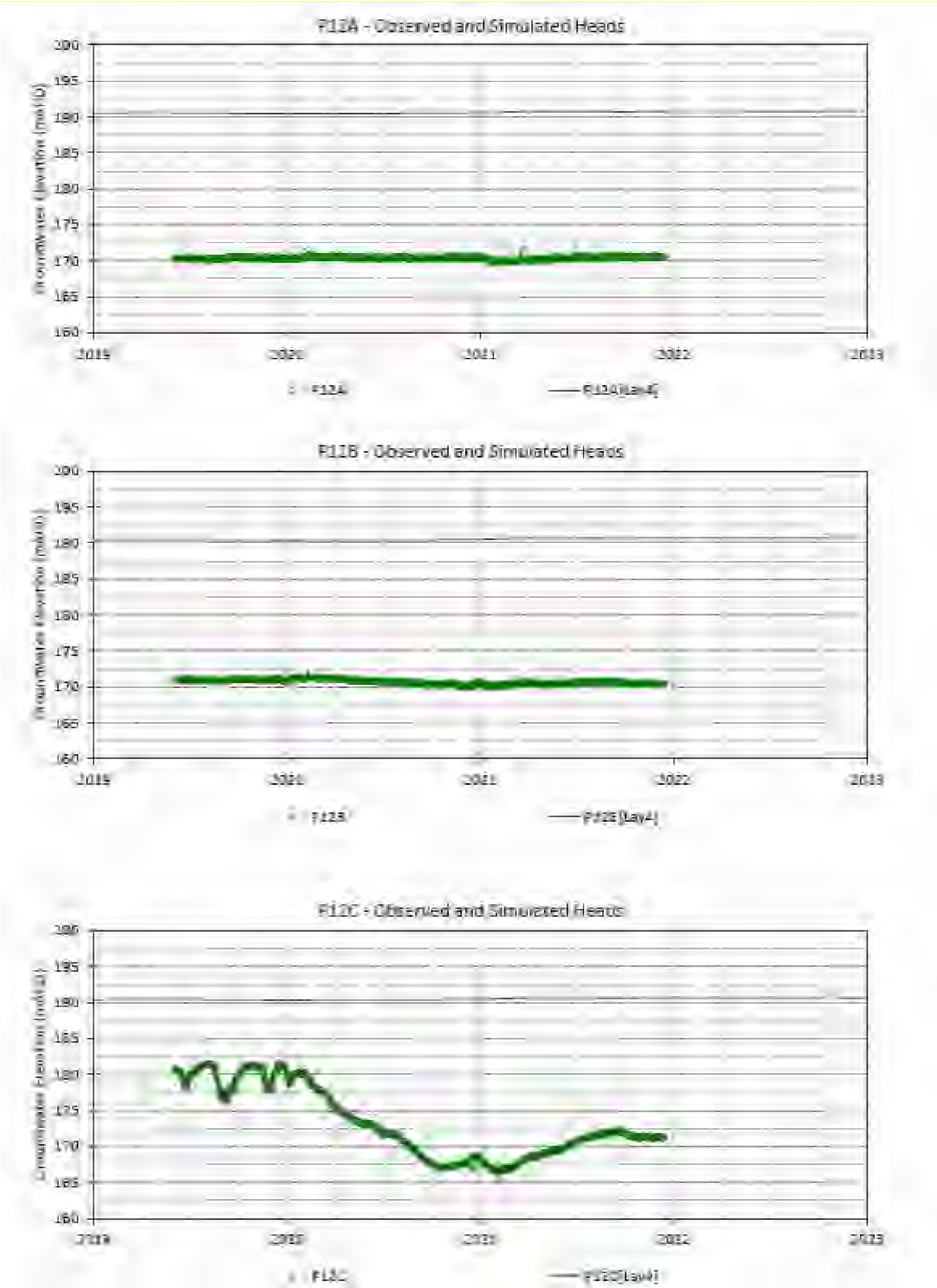


Figure 4-40 Hydrographs for P12- Western Domain

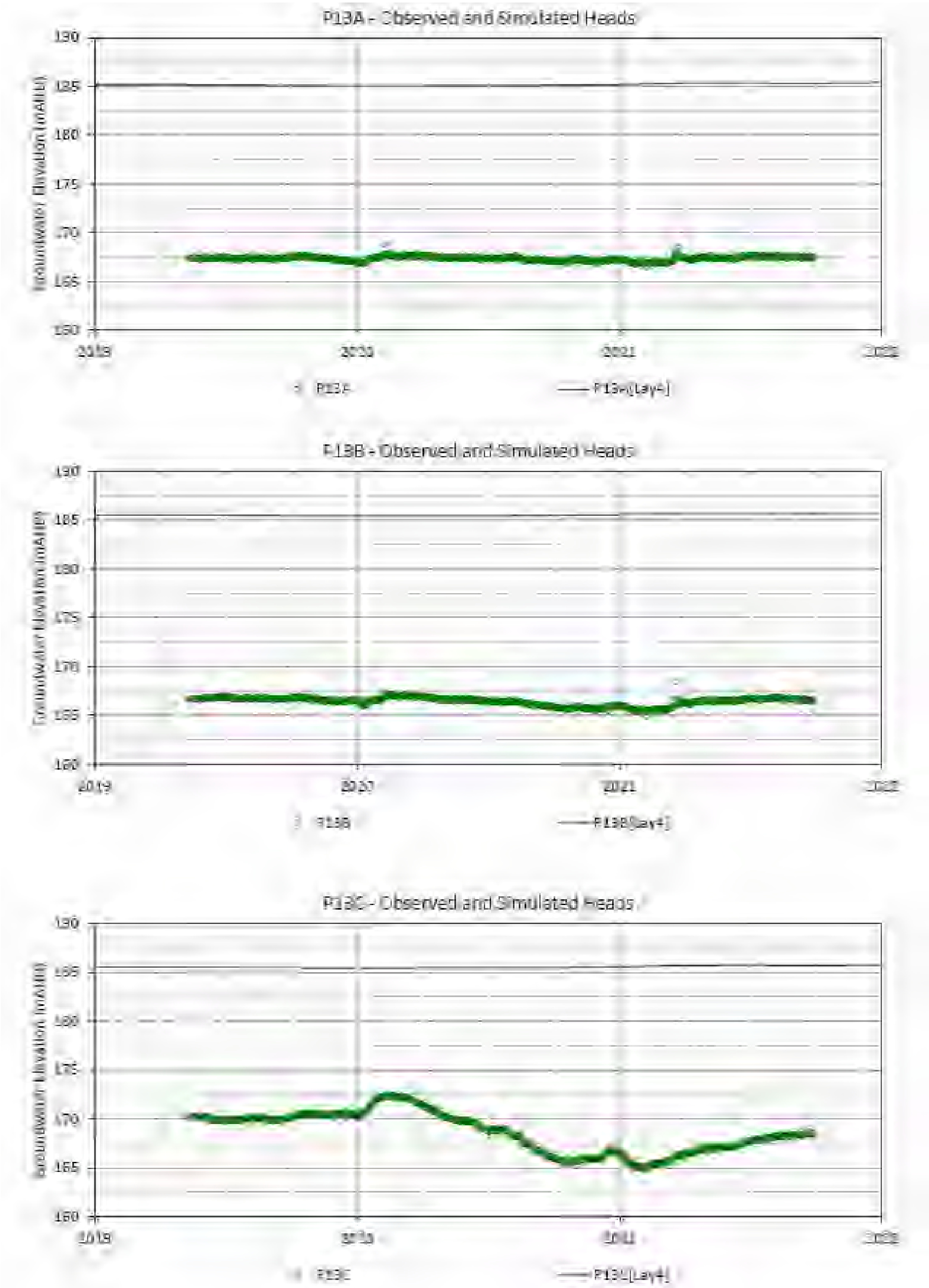


Figure 4-41 Hydrographs for P13- Western Domain

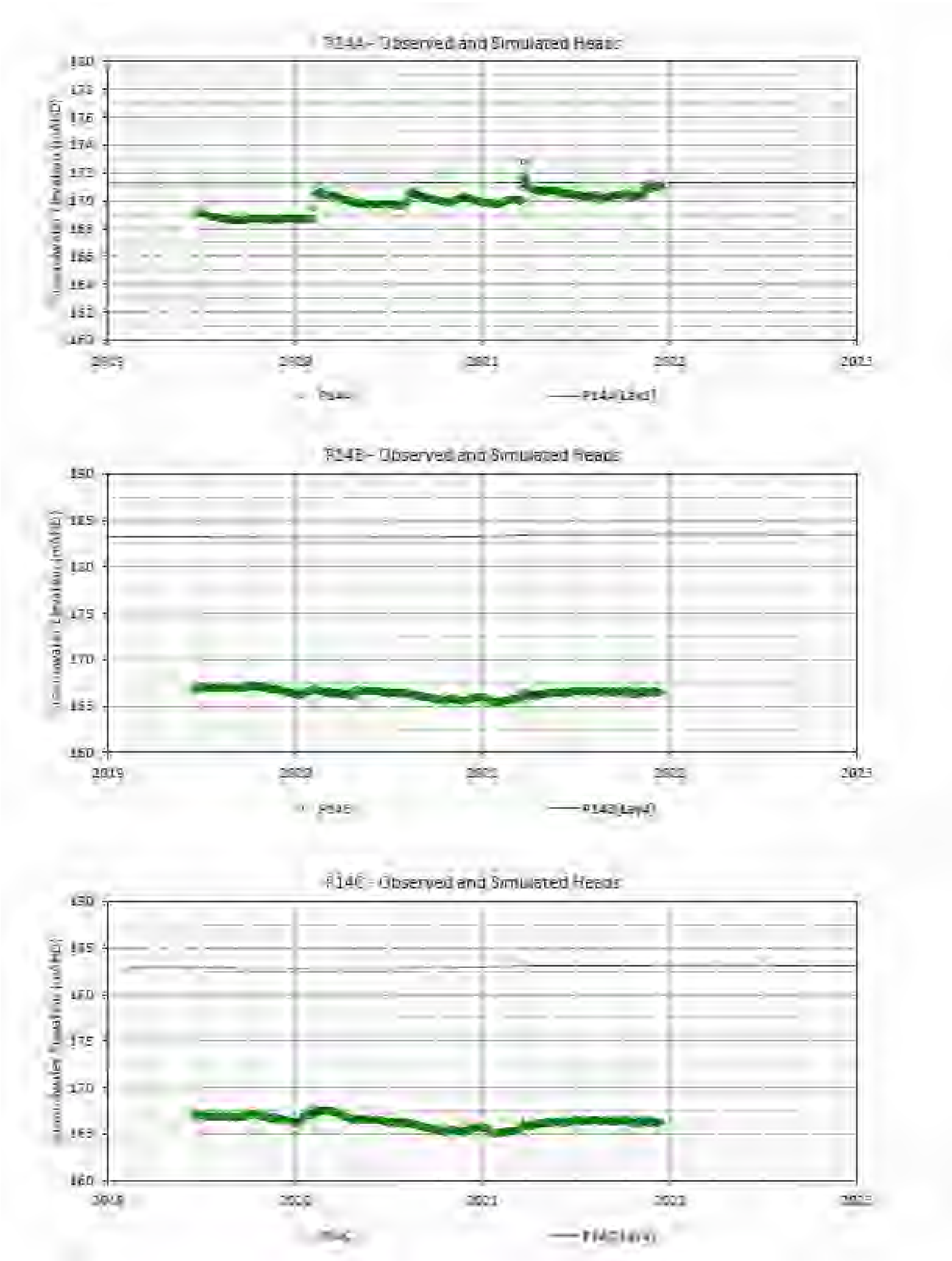


Figure 4-42 Hydrographs for P14- Western Domain

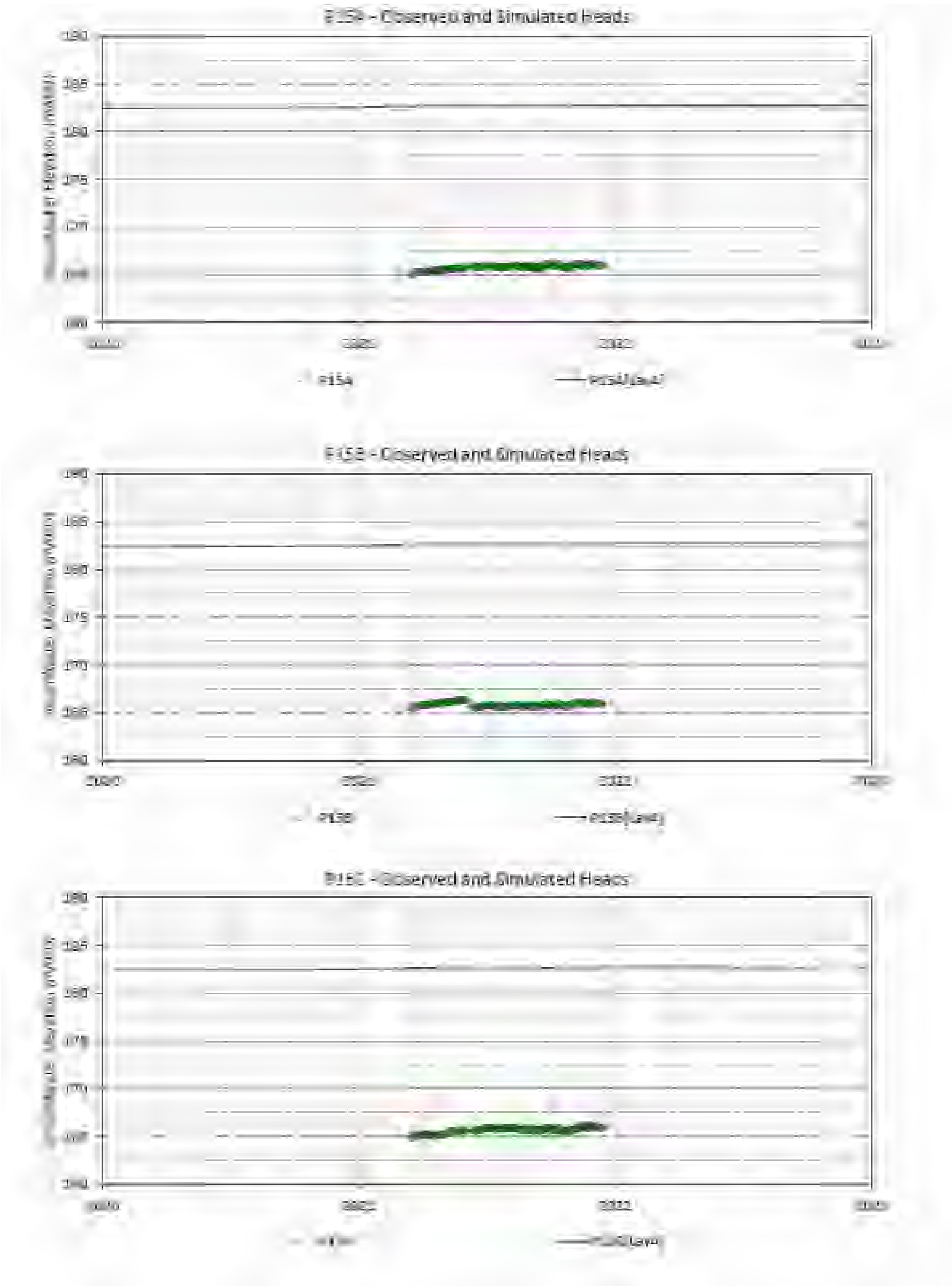


Figure 4-43 Hydrographs for P15- Western Domain

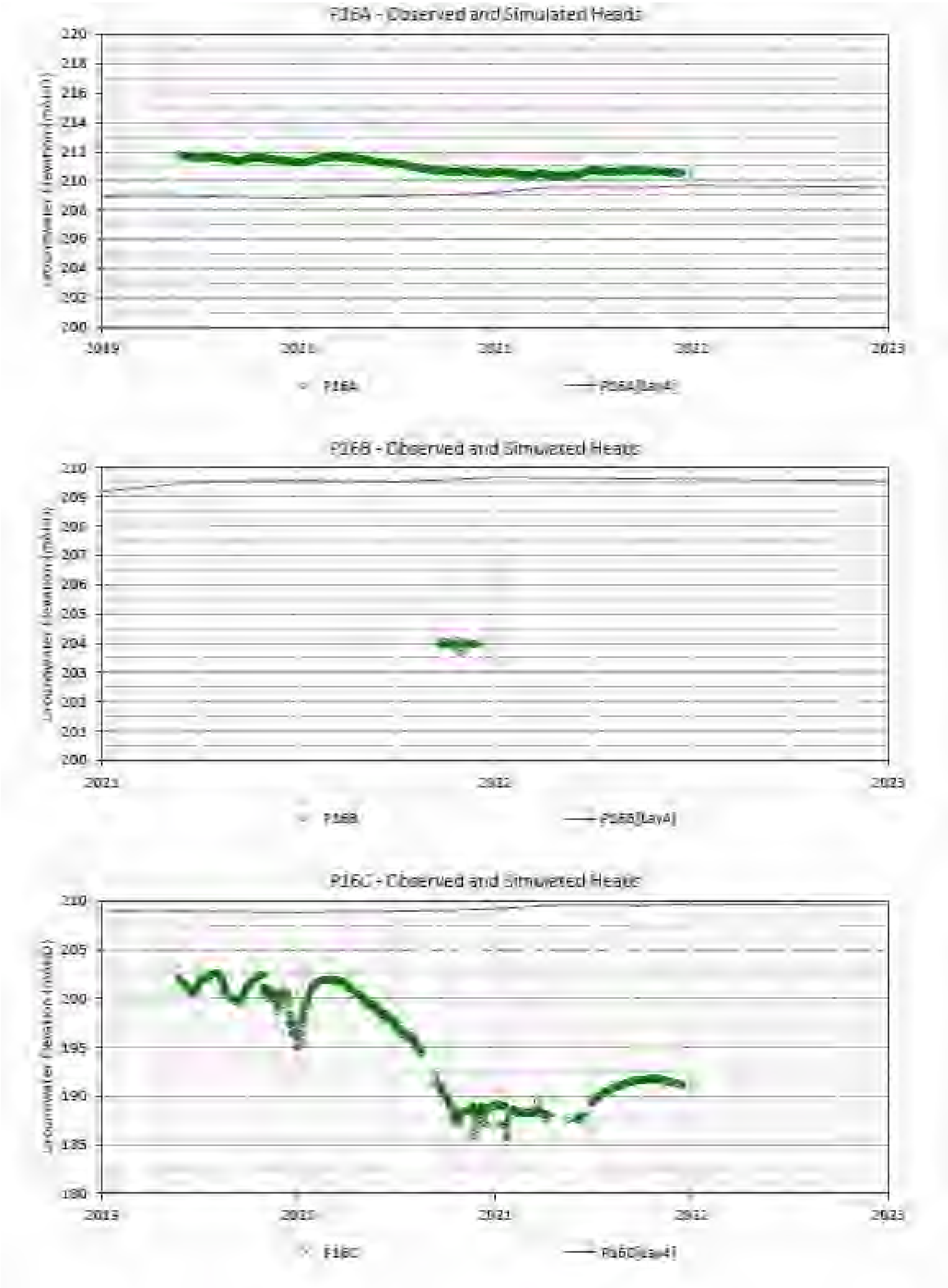


Figure 4-44 Hydrographs for P16- Western Domain

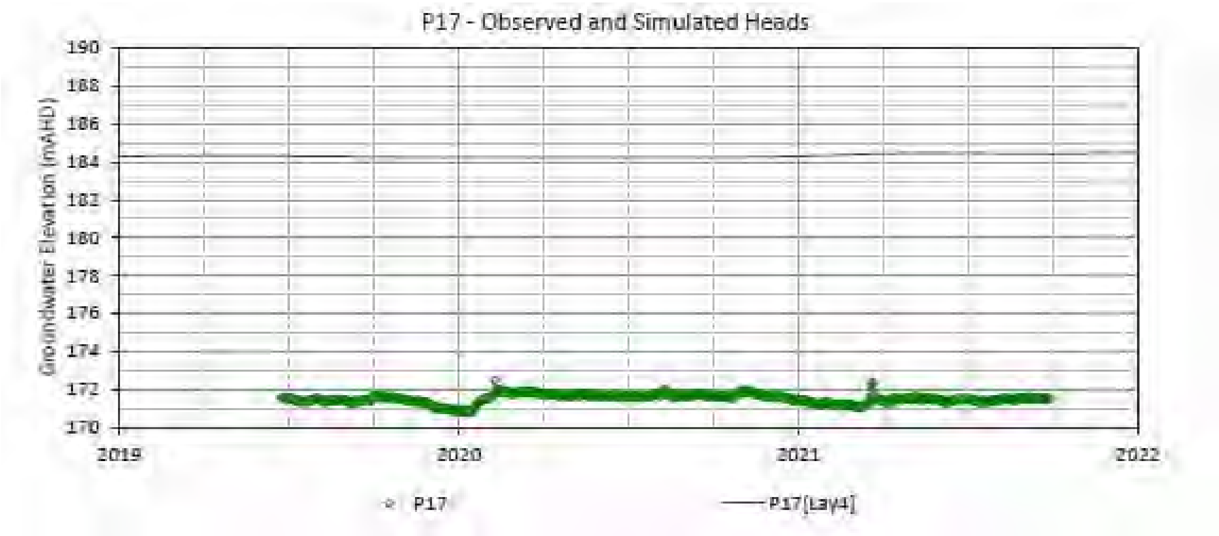


Figure 4-45 Hydrograph for P17- Western Domain

4.3.3 Inflows to Underground Mine Workings

Mine inflows were extracted from the groundwater model files using the MODFLOW-USG 'Zone Budget' utility. This was done on a zone-by-zone basis for the various mine areas within the model domain. For stress periods which were longer than 3 months, the groundwater model was setup to allow extraction of water budget information multiple times within each stress period, allowing the detail of the generally higher early-time inflows to be captured as well as the end-of-stress-period inflows.

Figure 4-46 compares the simulated mine inflows against the historical measurements at Tahmoor. The figure shows that while the model does not represent all peaks and troughs, it matches the magnitude of inflows and the general increasing trend after 2009. Figure 4-46 shows the model over predicts the historical pre-2009 inflows slightly.

For the recent period 2009-2021, the average historical measured inflows to the Tahmoor underground mine are 3.9 ML/d. The simulated average inflow for the same period is 4.1 ML/day. For the 1995-2002 period, the average measured inflows are 2.4 ML/day comparing to the modelled average inflow of 3.1 ML/day for the same period. Therefore, the model provides a more conservative estimate of inflows comparing to the measured inflows.

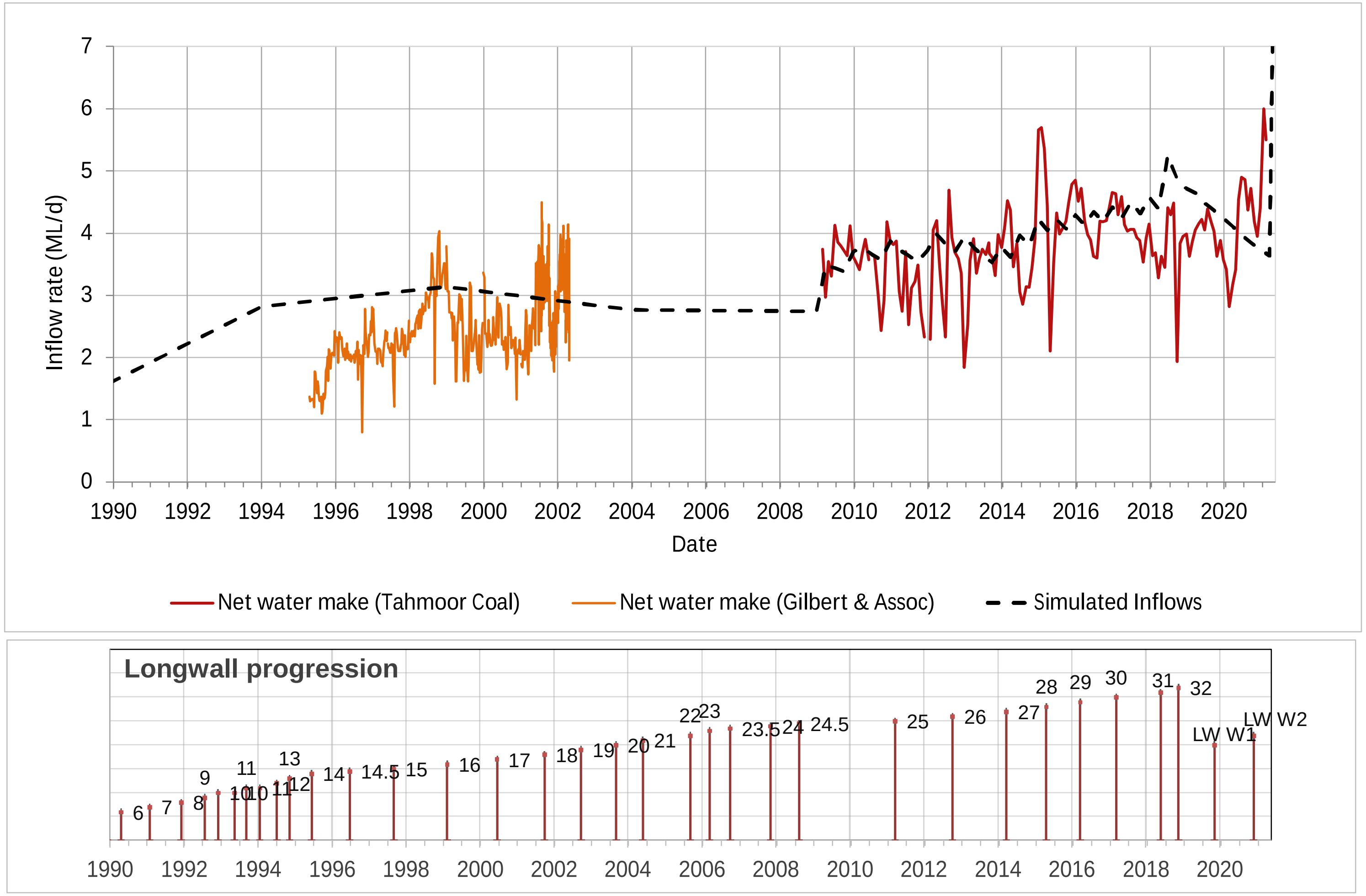


Figure 4-46 Comparison of Observed and Modelled Inflow at Tahmoor

4.4 Potential Groundwater Impacts

Predictive modelling presented herein has been conducted in support of the Extraction Plan for LW S1A-S6A. As such transient predictive modelling was used to simulate the proposed mining at LW S1A-S6A in conjunction with mining at other approved and foreseeable mines within the model domain. The predictive portion of the model comprises quarterly stress periods, starting from December 2021 to December 2026 (end of mining of LW S6A). The simulated predictive mine progression for the Project is presented Figure 4-9.

Transient predictive models have been developed for three model scenarios:

- Null run – no mining within region;
- Base case – all approved and foreseeable mining in region (including Tahmoor North), no proposed mining at Tahmoor South (LW S1A-S6A); and
- Full development of LW S1A-S6A – all approved and foreseeable mining in region plus proposed mining at LW S1A-S6A.

Mining is simulated as progressing quarterly, with MODFLOW Drain cells simulating the mining applied to the base of the target coal seam (i.e. the Bulli seam). After the Drains were removed, the MODFLOW Time Varying Materials (TVM) package was used to assign fracture properties to the cells above the longwalls.

4.4.1 Groundwater Take (mine inflow)

Predicted mine pit inflow volumes have been calculated as time weighted averages of the outflow reported by MODFLOW 'ZoneBudget' utility for model Drain cells. The inflows to the simulated LW S1A-S6A workings are presented in Figure 4-47. Inflows to the underground operations are predicted to increase over the first half of the operational life of LW S1A-S6A, reaching a maximum peak of approximately 2.5 ML/day at the beginning of 2025. Inflow rates decline gradually from 2025 until the cessation of mining in 2026, where inflows to LW S1A-S6A reach a steady rate of approximately 0.12 ML/day. The average inflow rate over the total duration of mining at LW S1A-S6A is calculated at 0.8 ML/day.

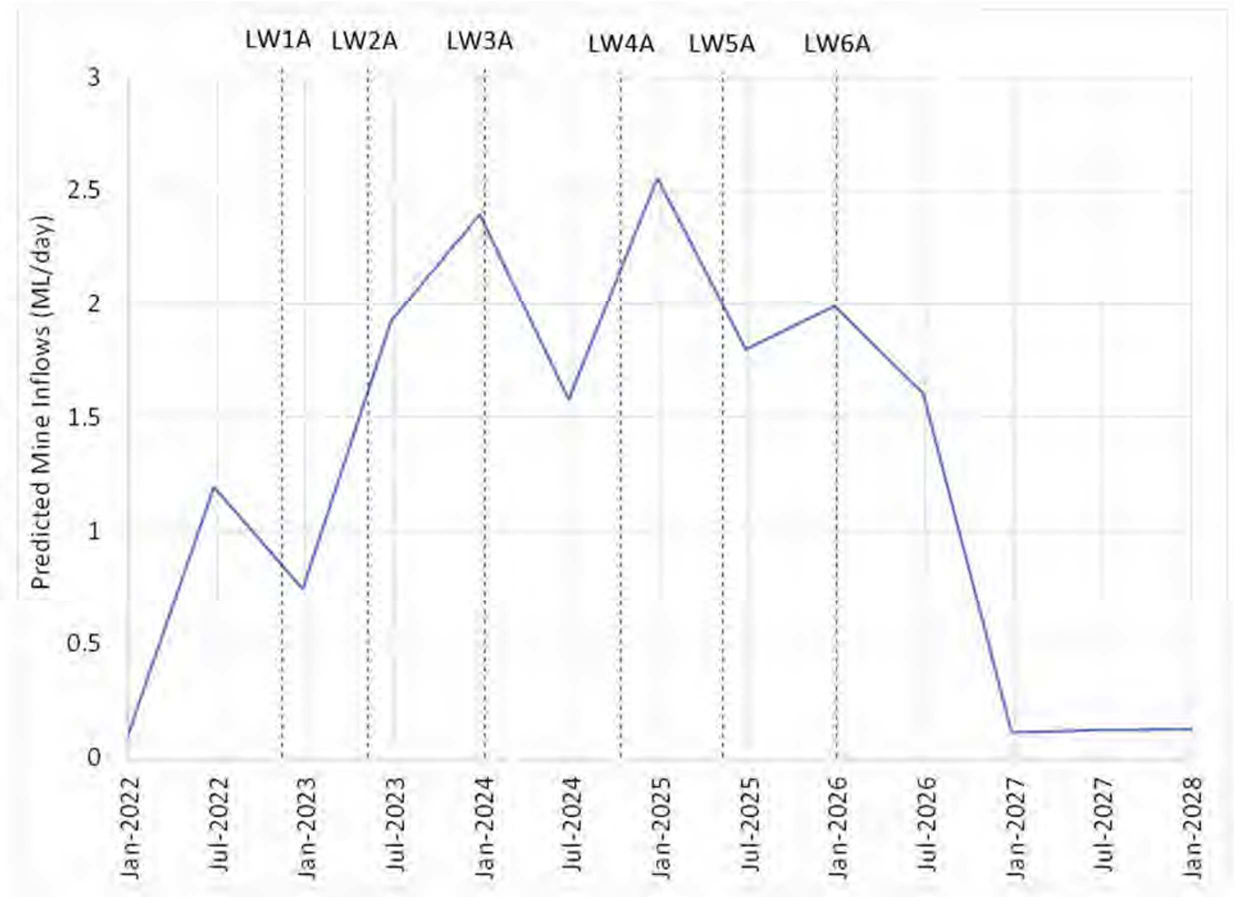


Figure 4-47 Modelled Mine Inflows

4.4.2 Loss of Flow in Streams

Estimates of predicted baseflow were calculated using the MODFLOW 'ZoneBudget' utility. The change in baseflow due LW S1A-S6A extraction was calculated by comparing the net river flow in the Full Development scenario against the Base Case scenario. The cumulative loss of baseflow was calculated by comparing the Full Development scenario against the Null scenario (i.e. no mining scenario).

Table 4-7 presents a summary of the predicted baseflow loss at several creeks directly related to LW S1A-S6A. The impact in ML/d represents the maximum baseflow impact from any time in the predictive run. The sub-catchments most affected by LW S1A-S6A are predicted to be Dogtrap Creek, and Bargo River between SW-1 and SW-13, which is consistent with the 2020 model predictions. The most recent estimation of baseflow loss was carried out by HEC (2022) which suggested a range of between 0.2 to 1.4 ML/day of inflow loss in Redbank Creek. Table 4-7 shows the predicted inflow loss from the groundwater model is close to the lower of bound of baseflow loss estimation for HEC (2022) study. In general, comparing to the 2020 EIS study, the current model predicts slightly less loss of baseflow in most of the creeks and rivers.

Table 4-7 Base Flow Impact in Local Watercourses

Watercourse	Site Used for Assessment	LW S1A-S6A Impact (ML/day)
Eliza Creek	SW-18	<0.001
Carters Creek	SW-23	<0.001
Blue Gum Creek		<0.001
Dogtrap Creek	SW-15	0.002
Teatree Hollow	SW-22	0.001
Cow Creek	SW-24	0.000
Stonequarry Creek	212053	<0.001
Bargo River	SW-1	<0.001
Bargo River	SW-13	<0.001
Bargo River	SW-14	<0.001
Hornes Creek	SW-9	<0.001
Nepean River	SW-21	<0.001
Matthews Creek		0.000
Cedar Creek		<0.001
Redbank Creek		<0.001
Avon River		<0.001
Cordeaux River		<0.001
Rumker Gully		<0.001
Newlands Gully		<0.001
Myrtle Creek		<0.001
Dry Creek		<0.001

The model did not predict drawdown to extend to the Thirlmere Lakes resultant of LW S1A-S6A extraction. Therefore, no changes in the lake leakages to the groundwater system or losses from the alluvium was predicted. This conclusion was confirmed by comparing water budgets for alluvial zones using the Base Case and Full Development scenarios.

4.4.3 Groundwater Drawdown

The process of mining reduces groundwater levels and pressures in surrounding geological units. The extent of the zone affected is dependent on the properties of the aquifers/aquitards and is referred to as the zone of depressurisation in a confined aquifer and zone of drawdown within unconfined aquifers, including the water table. Depressurisation and drawdown are greatest at the working coal-face, and reduces with distance from the mine. The predicted drawdowns due to LW S1A-S6A extraction and all the neighbouring mining operations (the 'Cumulative' mining effects) and due solely to LW S1A-S6A (incremental effects) are discussed in the following sections.

4.4.3.1 Incremental Drawdown

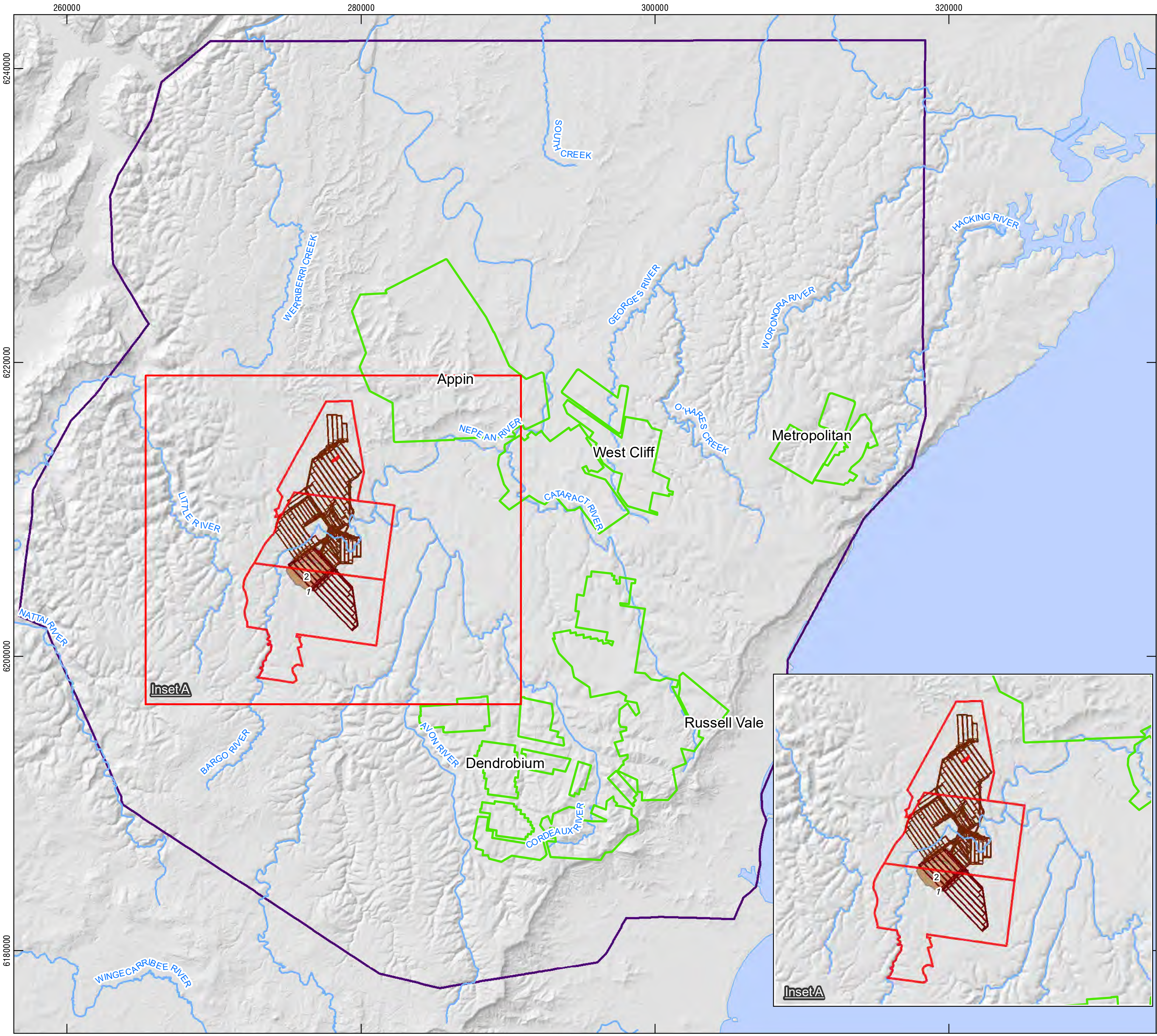
Maximum incremental drawdown due to the extraction of LW S1A-S6A was obtained by comparing the difference in groundwater levels for the Base Case scenario and the Full Development model scenario. The maximum drawdown is a combination of the maximum drawdown values recorded at each cell at any time from the start of the calibration period (January 2022) to end of mining of LW S6A (2026).

Predicted maximum drawdown due to LW S1A-S6A extraction (incremental drawdown) is presented from Figure 4-48 to Figure 4-50. Figure 4-48 shows the predicted maximum water table drawdown due to LW S1A-S6A extraction. The water table has been featured given it is the groundwater system with the highest level of connectivity to environmental (surface) features. Generally, maximum water table drawdown is <4 m across much of the Tahmoor South footprint, with the predicted drawdown extending approximately 0.5 km north or northeast, and 0.5 km southwest towards Lake Nepean.

Figure 4-49 shows the predicted maximum drawdown in lower Hawkesbury Sandstone which is the source of much of local groundwater extraction by bores. Figure 4-49 shows the maximum drawdown extends radially from the Tahmoor South longwall footprint. The 1 m contour extends to less than 1 km to the south towards Lake Nepean, and less than 1 km to the north and northeast .

Figure 4-50 shows the extent of maximum predicted depressurization (1 m contour) is approximately 2 km to the south and 2 km to the east LW S1A-S6A. The figure shows the maximum extents to the west of the panels through the faults present in that area. The cone of depression is predicted to be steepest around the mine area.

The shape of predicted drawdowns presented in the figures are similar to the predictions presented in the EIS report (SLR/HydroSimulations, 2020). However, the extent of maximum drawdown in this model is less than predicted in the EIS. The difference in drawdown extent is likely due to update in model structure, the use of depth dependence functions, and pilot points in the new model.



TAHMOOR COAL LW S1A-S6A GROUNDWATER TECHNICAL REPORT

PREDICTED MAXIMUM WATER TABLE DRAWDOWN – TAHMOOR SOUTH ONLY

FIGURE 4-48

LEGEND

- Watercourse
- Tahmoor Coal Title
- Surrounding Mine
- Model Domain
- Mine Plan

Drawdown (m)

- 1 - 2
- 2 - 5
- 5 - 10
- 10 - 20
- 20 - 50
- 50 - 100
- 100 - 200
- 200 - 500
- > 500

0 5 10 km

Coordinate System:	GDA 1994 MGA Zone 56
Scale:	1:350,000 at A4
Project Number:	610.30652
Date:	29-Apr-2022
Drawn by:	NT
Reviewed by:	DE/SH

Data Source: Mining Lease NSW Mineview Coal Lease 2019

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

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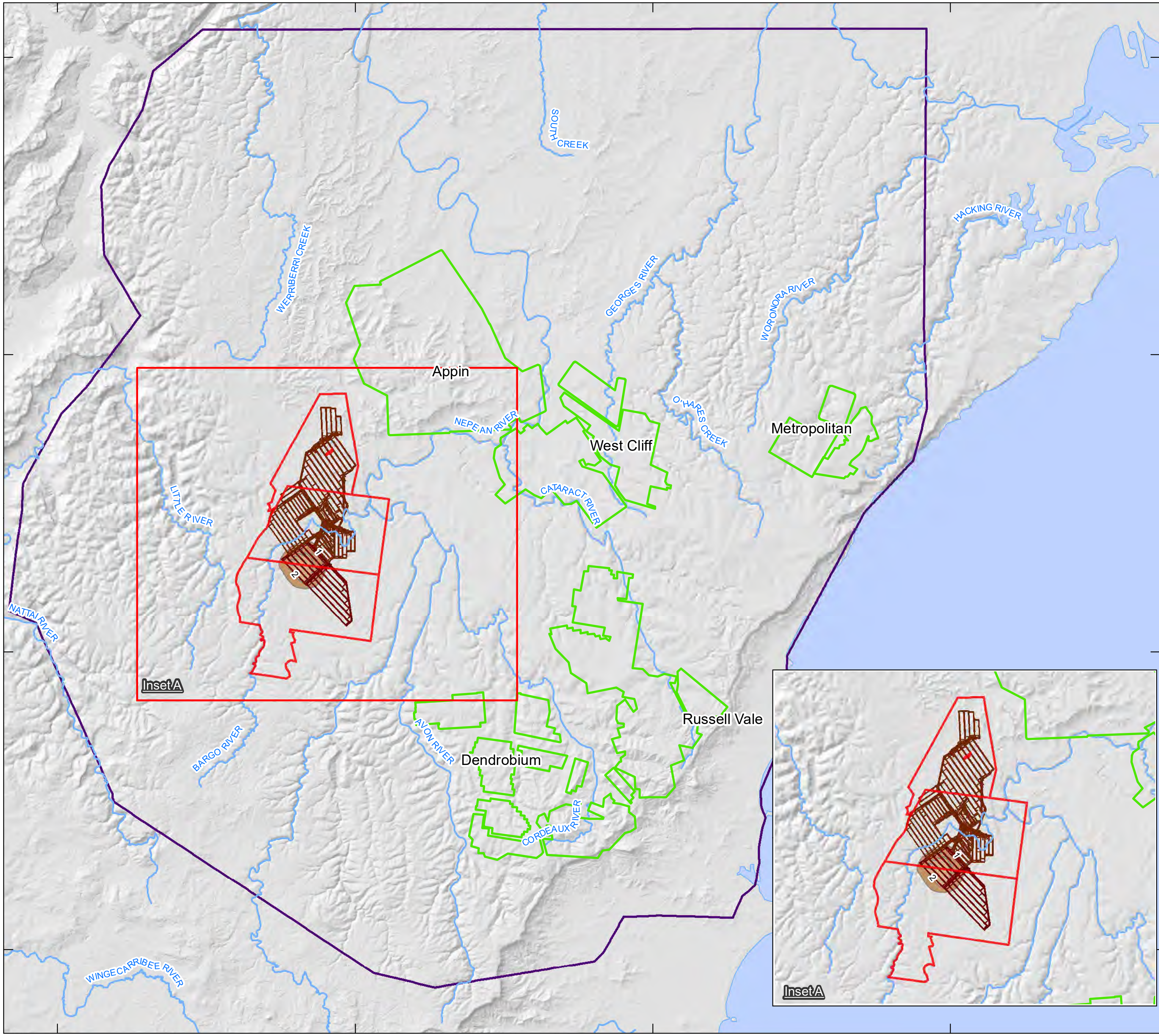


TAHMOOR COAL
LW S1A-S6A GROUNDWATER TECHNICAL REPORT

PREDICTED MAXIMUM DRAWDOWN IN LOWER HAWKESBURY SANDSTONE – TAHMOOR SOUTH ONLY

FIGURE 4-49

LEGEND

- Watercourse
- Tahmoor Coal Title
- Surrounding Mine
- Model Domain
- Mine Plan

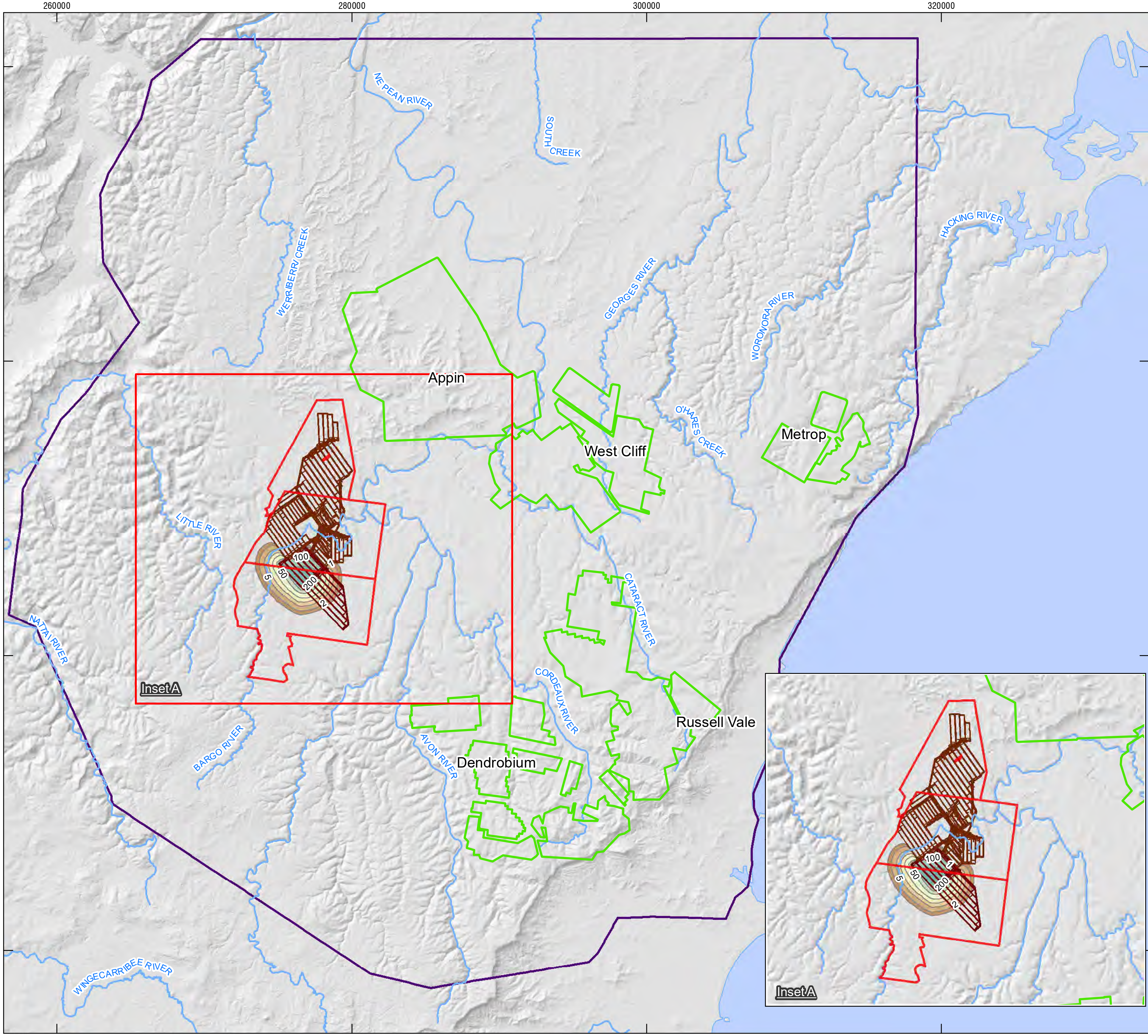
Drawdown (m)

- 1 - 2
- 2 - 5
- 5 - 10
- 10 - 20
- 20 - 50
- 50 - 100
- 100 - 200
- 200 - 500
- > 500

0 5 10 km

Coordinate System:	GDA 1994 MGA Zone 56
Scale:	1:350,000 at A4
Project Number:	610.30652
Date:	29-Apr-2022
Drawn by:	NT
Reviewed by:	DE/SH

Data Source: Mining Lease NSW Mineview Coal Lease 2019



TAHMOOR COAL
LW S1A-S6A GROUNDWATER TECHNICAL REPORT

PREDICTED MAXIMUM DRAWDOWN IN BULLI SEAM – TAHMOOR SOUTH ONLY

FIGURE 4-50

LEGEND

- Watercourse
- Tahmoor Coal Title
- Surrounding Mine
- Model Domain
- Mine Plan

Drawdown (m)

- 1 - 2
- 2 - 5
- 5 - 10
- 10 - 20
- 20 - 50
- 50 - 100
- 100 - 200
- 200 - 500
- > 500

0 5 10 km

Coordinate System:	GDA 1994 MGA Zone 56
Scale:	1:350,000 at A4
Project Number:	610.30652
Date:	29-Apr-2022
Drawn by:	NT
Reviewed by:	DE/SH

Data Source: Mining Lease NSW Mineview Coal Lease 2019

4.4.4 Cumulative Drawdown

The maximum cumulative drawdowns are obtained by the calculating the maximum difference in heads between the Full Development and Null Run model scenarios at each cell at any time, from the start of the calibration period (January 2022) to one year after end of extraction (completion of LW S6A).

Figure 4-51 through Figure 4-53 show the maximum predicted cumulative drawdown for the water table as well as depressurisation within Lower Hawkesbury Sandstone and the Bulli Seam.

Figure 4-51 shows the extent of 0.2 m cumulative water table drawdown at LW S1A-S6A connects with the zones of impact from Tahmoor North, Appin and Dendrobium mine. Generally, 0.2 m water table drawdown extends across the footprint of the longwall mines, including all domains at Tahmoor. This is driven by the surface cracking mechanism now simulated in the model.

Figure 4-52 shows the maximum cumulative drawdown in Lower Hawkesbury Sandstone due to LW S1A-S6A extraction connects with the neighbouring sites (Tahmoor North, Appin and Dendrobium) in a similar manner as shown in the cumulative water table drawdown.

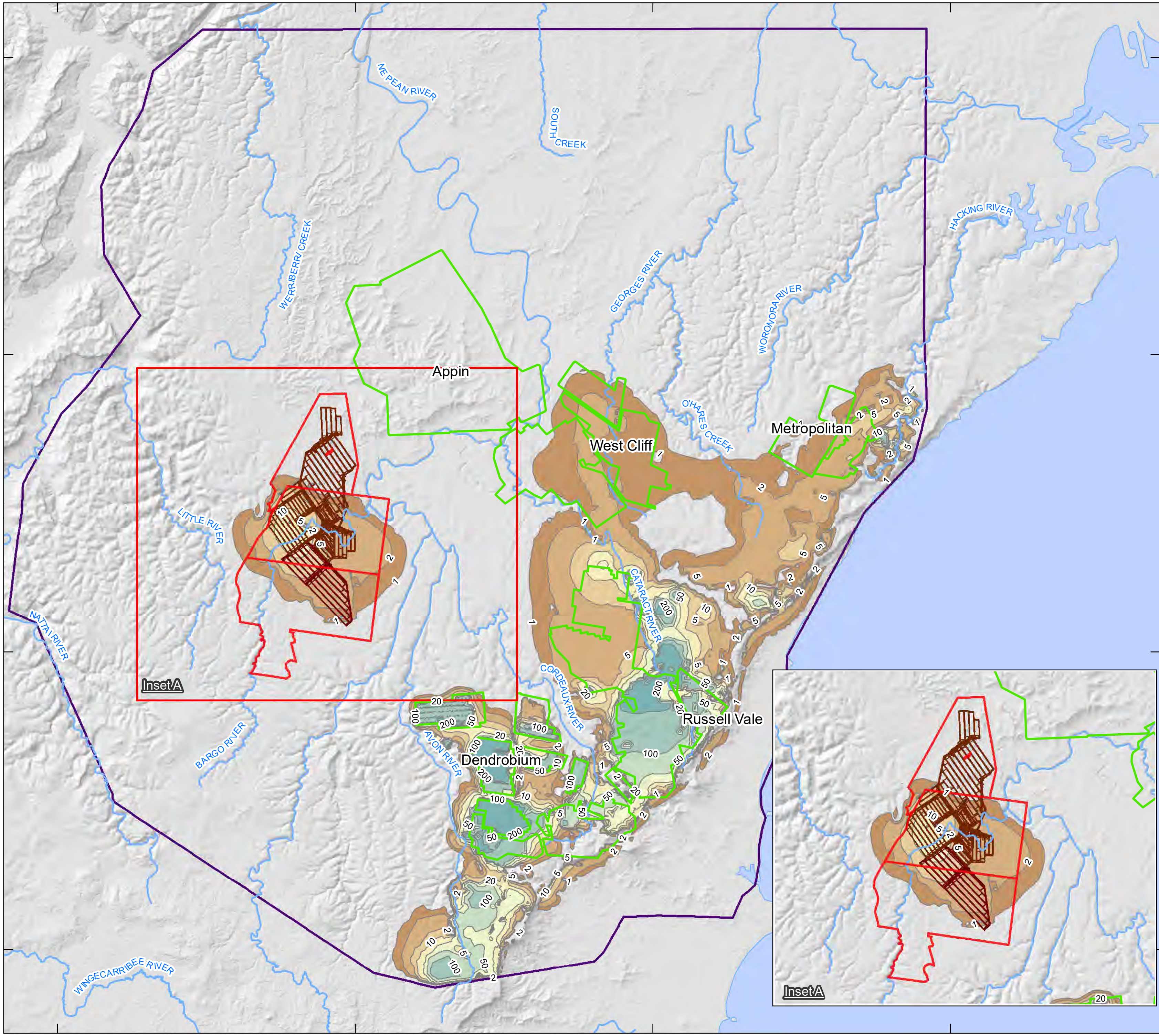
The extent of the predicted maximum cumulative drawdown shown in Figure 4-51 and Figure 4-52 are consistent with the predictions from the EIS (SLR/Hydrosimulations, 2020).

As shown in Figure 4-53, the greatest cumulative depressurisation occurs in the Bulli Seam, the extracted stratigraphic layer. Figure 4-53 shows drawdown in the Bulli Seam interacts with drawdown zone from Appin and Tahmoor North. However, the extent of depressurization due to LW S1A-S6A extraction does not interact with that from the Dendrobium Mine.

TAHMOOR COAL
LW S1A-S6A GROUNDWATER TECHNICAL REPORT

PREDICTED MAXIMUM WATER TABLE DRAWDOWN - CUMULATIVE

FIGURE 4-51



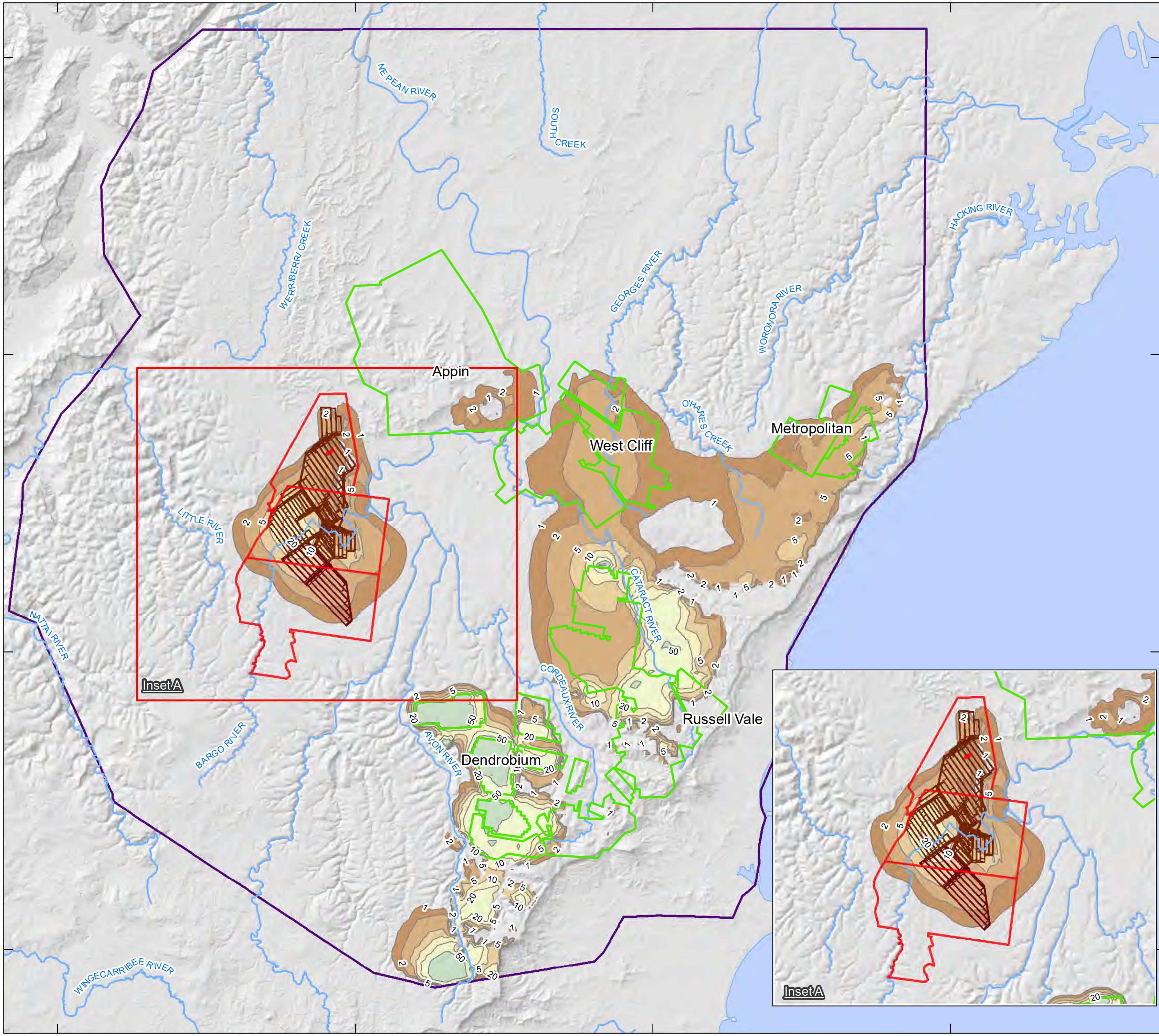
Coordinate System:	GDA 1994 MGA Zone 56
Scale:	1:350,000 at A4
Project Number:	610.30652
Date:	29-Apr-2022
Drawn by:	NT
Reviewed by:	DE/SH

Data Source: Mining Lease NSW Mineview Coal Lease 2019

TAHMOOR COAL
LW S1A-S6A GROUNDWATER TECHNICAL REPORT

PREDICTED MAXIMUM DRAWDOWN IN LOWER HAWKESBURY SANDSTONE - CUMULATIVE

FIGURE 4-52



LEGEND

- Watercourse
- Tahmoor Coal Title
- Surrounding Mine
- Model Domain
- Mine Plan

Drawdown (m)

- 1 - 2
- 2 - 5
- 5 - 10
- 10 - 20
- 20 - 50
- 50 - 100
- 100 - 200
- 200 - 500
- > 500

0 5 10 km

Coordinate System:	GDA 1994 MGA Zone 56
Scale:	1:350,000 at A4
Project Number:	610.30652
Date:	29-Apr-2022
Drawn by:	NT
Reviewed by:	DE/SH

Data Source: Mining Lease NSW Mineview Coal Lease 2019

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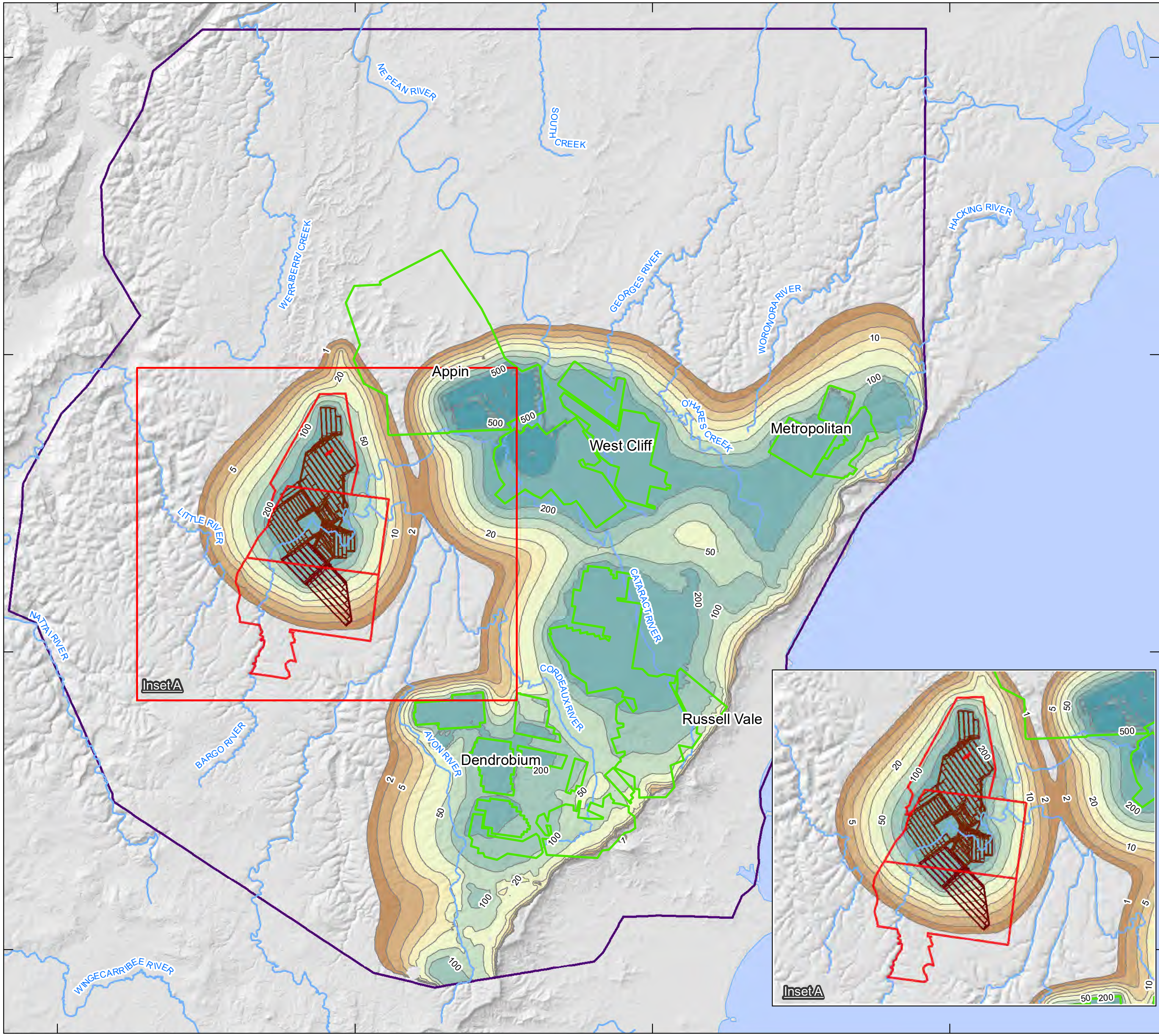
TAHMOOR COAL
LW S1A-S6A GROUNDWATER TECHNICAL REPORT

PREDICTED MAXIMUM DRAWDOWN IN BULLI SEAM - CUMULATIVE

FIGURE 4-53



LEGEND

- Watercourse
- Tahmoor Coal Title
- Surrounding Mine
- Model Domain
- Mine Plan

Drawdown (m)

- 1 - 2
- 2 - 5
- 5 - 10
- 10 - 20
- 20 - 50
- 50 - 100
- 100 - 200
- 200 - 500
- > 500

0 5 10 km

Coordinate System:	GDA 1994 MGA Zone 56
Scale:	1:350,000 at A4
Project Number:	610.30652
Date:	29-Apr-2022
Drawn by:	NT
Reviewed by:	DE/SH

Data Source: Mining Lease NSW Mineview Coal Lease 2019

4.4.4.1 Private Bores

The private bores incorporated in the impact assessment are discussed in detail in Section 3.5.8.3. Table 4-8 presents the simulated maximum drawdown experienced at any given point in time in the predictive model.

There are 3 bores identified with greater than 2 metres of drawdown resulting from LW S1A-S6A extraction. GW032443 is located above the longwalls and shows the largest drawdown (2.4 metres).

Table 4-8 Maximum Predicted drawdown at Private Bores due to LW S1A – S6A and cumulative mining

Bore ID	Easting	Northing	Bore Depth (m)	LW S1A-S6A Potential Impact (m)	Cumulative Mining Impact (m)
GW007445	277454	6204323	134.1	<1	3.6
GW014262	276764	6204587	48.8	1.6	4.6
GW031294	279732	6205706	90.2	<1	4.2
GW032443	276415	6206336	130.1	2.4	10.2
GW045404	282217	6206689	53.3	<1	2.2
GW051877	281673	6205875	92	<1	2.2
GW052016	280259	6203604	110	<1	1.4
GW053449	280369	6205813	105	<1	3.1
GW053450	282303	6205837	120	<1	1.8
GW054146	279886	6204676	104	<1	2.4
GW057969	281350	6206116	108	<1	2.5
GW058634	279479	6203419	122	<1	2.2
GW059618	281587	6204277	117	<1	1.2
GW062068	276581	6209579	150	<1	8.9
GW062661	282609	6207469	126.5	<1	1.6
GW070245	280090	6205714	97.5	<1	3.3
GW100433	278540	6202588	126	<1	1.5
GW100455	281877	6207020	96	<1	2.5
GW101936	280604	6202851	126	<1	1.0
GW102045	281266	6203733	120	<1	1.1
GW102179	280953	6203826	153	<1	1.3
GW102452	277234	6200992	120.5	<1	<1
GW103023	277261	6200993	165	<1	<1
GW103036	276840	6200964	132.5	<1	<1
GW103559	276504	6201854	190	<1	<1
GW103615	279720	6204034	103	<1	2.5
GW104008	280368	6205982	140	<1	3.5
GW104090	278208	6215913	150.5	<1	2.1
GW104323	279259	6203318	109	<1	2.1
GW104454	281410	6204568	66	<1	1.5
GW104659	276617	6207391	132	1.0	14.4

Bore ID	Easting	Northing	Bore Depth (m)	LW S1A-S6A Potential Impact (m)	Cumulative Mining Impact (m)
GW104860	282745	6206178	204.3	<1	1.6
GW105262	278609	6200731	104	<1	<1
GW105395	278543	6203037	90	<1	2.0
GW105577	280728	6207041	162	<1	3.5
GW105803	282278	6204644	140	<1	1.1
GW105847	277020	6204404	NA	1.1	3.9
GW105883	277040	6204629	NA	1.4	4.5
GW106546	282785	6206765	116	<1	1.6
GW106590	280442	6206344	150	<1	4.7
GW107470	282069	6208057	132	<1	1.7
GW108538	281155	6205941	66	<1	12.5
GW108842	282500	6204716	174	<1	1.0
GW109257	276603	6205052	120	2.2	6.0
GW110669	274565	6207896	132	<1	12.1
GW111047	280015	6206037	120	<1	4.6
GW111357	277051	6200982	144	<1	<1
GW111518	276882	6200987	150	<1	<1
GW111669	276232	6206450	120	2.2	10.8
GW111810	277034	6204407	142	1.1	3.9
GW111828	282391	6205638	205	<1	1.6
GW111842	282654	6205664	240	<1	1.4
GW112415	277479	6200865	139	<1	<1
GW112473	276577	6202010	138	<1	<1
GW115773	282232	6205725	81.87	<1	1.7
GW116897	281442	6203190	160	<1	<1

5 Management, Monitoring and Evaluation

In accordance with the requirements set out in Section 2.2, with the intention of monitoring the potential impacts to groundwater resulting from extraction of LW S1A-S6A, a Monitoring Program has been developed. The Groundwater Monitoring Plan (SLR, 2022) provided a review of current monitoring and outlined monitoring recommendations for pre-mining, during extraction and post-mining.

Implementation of the Groundwater Monitoring Plan is underway, with amendments made based on ongoing review of available data, the outcomes of the private bore survey and land access agreements. Provided here is the current proposed monitoring regime for LW S1A-S6A.

5.1 Groundwater Monitoring Plan

Described here are the proposed and operational monitoring regimes, aligned to the requirements outlined in Consent Condition B4, Table 2-3 and described in full in the Tahmoor South Groundwater Monitoring Plan (SLR, 2021). A summary of the monitoring pan is provided here.

The monitoring regime include monitoring of the following elements:

- Groundwater level and aquifer depressurisation;
- Groundwater quality;
- Impacts on surface water features;
- Impacts on groundwater dependent ecosystems (primarily Thirlmere Lakes, but also considering HEVAE (potential groundwater dependence) mapping by NSW government (DPIE, 2018)); and
- Potential effects on private bores.

To support the interpretation of groundwater monitoring data it is often considered in relation to the auxiliary monitoring networks, including:

- Surface water monitoring;
- Climatic monitoring; and
- Subsidence monitoring.

These monitoring plans were considered in development of the Groundwater Monitoring Plan. The monitoring network comprises both standpipe bores and multi-level VWP bores and cover major hydrogeological units and are broadly distributed across the project area. Negotiations for ongoing land access for routine monitoring of nine private registered bores is currently underway.

Table 5-1 shows how the proposed monitoring regime aligns with the groundwater receptors discussed in Section 3.5.8 and 3.6.

Table 5-1 Key Receptors and Associated Groundwater Monitoring

Receptor / Aspect	Parameter	Data Collection Frequency	Bore IDs
Teatree Hollow	Water Quality (field parameters)	Monthly	TBC032. P52, P53, P54, P55, P56
	Water Quality (speciation)	Quarterly	

Receptor / Aspect	Parameter	Data Collection Frequency	Bore IDs
	Water levels	Monthly (for manual dips and data downloads where loggers installed)	
	Water Quality (speciation)	Quarterly	
	Water levels	Monthly (for manual dips and data downloads where loggers installed)	
Other watercourses	Water Quality (field parameters)	Monthly	TBC026, TBC027, TBC033, TBC038. P51, P57
	Water Quality (speciation)	Quarterly	
	Water levels	Monthly (for manual dips and data downloads where loggers installed)	
Existing Users (bores)	Water levels / pressures	Monthly (for manual dips and data downloads where loggers installed)	TBC009, TBC018, TBC019B, TBC020, TBC027, TBC032, TBC039, P56 GW58634, GW109257, GW032443, GW104008, GW112473, GW106590, GW104659, GW062068, GW105395
	Water Quality (field parameters)	Quarterly	
	Water Quality (speciation)	Monthly/quarterly (dependent on land access agreements).	
Wirrimbirra Sanctuary (on Teatree Hollow)	Water Quality (field parameters)	Monthly	P55, P56
	Water Quality (speciation)	Quarterly	
	Water levels	Monthly (for manual dips and data downloads where loggers installed)	
Thirlmere Lakes	Water levels / pressures	Monthly (for manual dips and data downloads where loggers installed)	NSW govt: GW075409-1 & -2, GW075410, GW075411.
	Water levels / pressures	Monthly (for manual dips and data downloads where loggers installed)	TBC039.
	Water levels / pressures Water Quality (field parameters)	Monthly	P51 Proposed: P50
Cumulative effects (re: Bulli Seam Operations mine)	Water levels / pressures	Monthly (for manual dips and data downloads where loggers installed)	TBC026

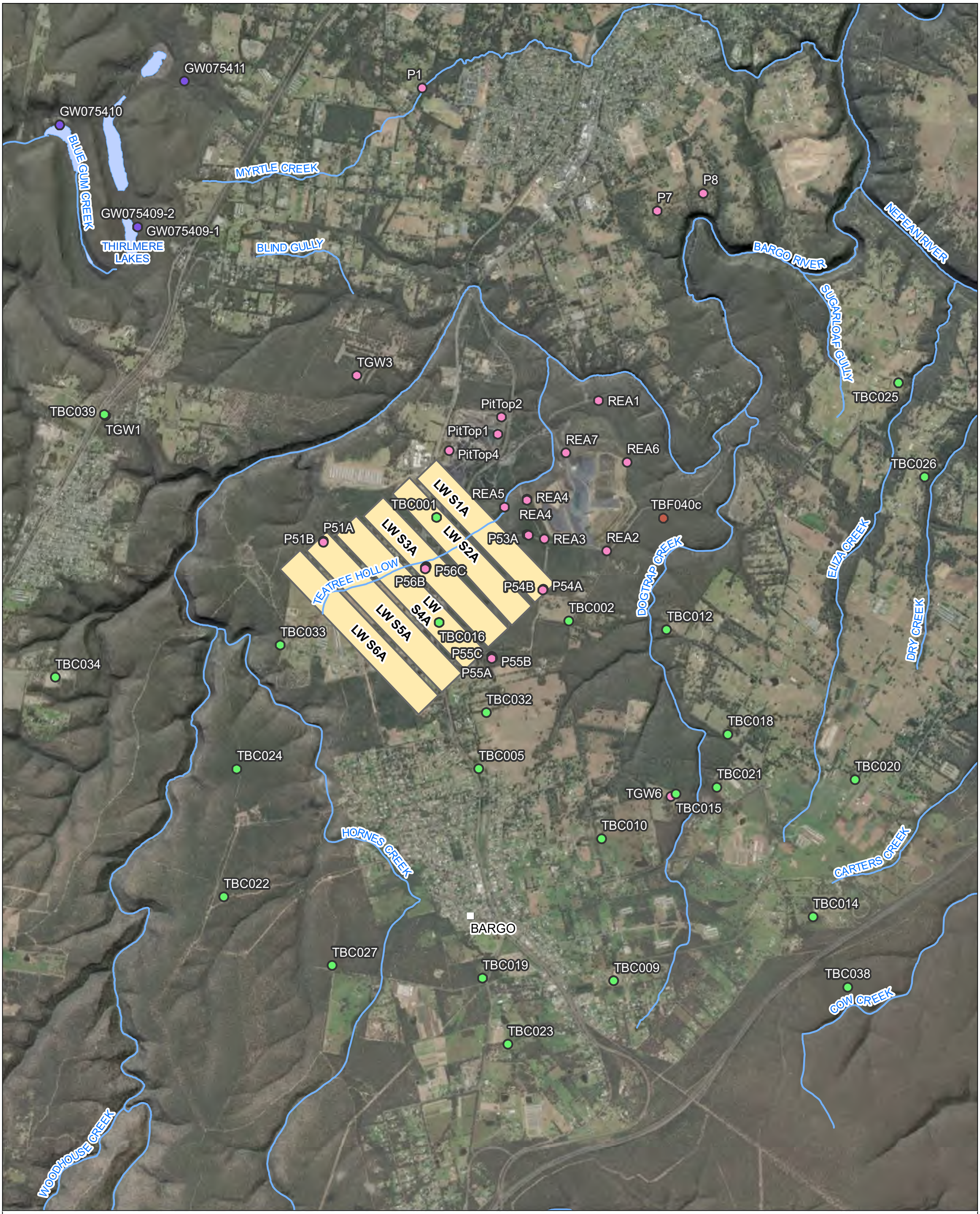
In addition to the monitoring bores described above are a series of piezometers at the pit-top and near the Reject Emplacement Area (REA) (Table 5-2). The piezometers are not associated with the regional aquifers (i.e. Hawkesbury sandstone) but rather constructed in shallow sediments and the REA and serve the following purposes:

- Pit Top piezometers are utilised to assess if the storage dams are leaking; and
- REA piezometers are utilised to assess if there is any acid mine drainage or general water quality impacts leaching the dumps.

The current network is considered adequate monitor these entities and consequently no additional monitoring bores are proposed here.

Table 5-2 Reject Emplacement Area (REA) Piezometers

Bore ID	Easting	Northing	Status	Targeted Aquifer	Type	Depth
REA1	278362.3	6207826.8	Active	REA	OSP	54.8
REA2	278441.2	6206332.2	Active	REA	OSP	58
REA3	277820.7	6206453.4	Active	REA	OSP	41
REA4	277650.8	6206835.2	Active	REA	OSP	57.5
REA5	277424.2	6206769.0	Active	REA	OSP	7.2
REA6	278643.3	6207214.8	Active	REA	OSP	46.3
REA7	278035.1	6207307.3	Active	REA	OSP	43
PitTop1	277357.6	6207494.9	Active	pit-top	OSP	55.04
PitTop2	277396.0	6207663.2	Active	pit-top	OSP	6.85
PitTop4	276872.2	6207331.6	Active	pit-top	OSP	33.7



N

0 0.5 1 km

Coordinate System:	GDA 1994 MGA Zone 56
Scale:	1:50,000 at A4
Project Number:	610.30637
Date:	27-Jun-2023
Drawn by:	NT

Minor Town
Watercourses
Lakes

Tahmoor South Mine Plan

Approved

Groundwater Monitoring Locations

Centreline HOF bore
Deep GWL
NSW govt monitoring
OSP

TAHMOOR SOUTH LW S1A – S6A GROUNDWATER TECHNICAL REPORT

Monitoring Bore Locations

FIGURE 5 -1

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5.1.1 Groundwater Levels

The Tahmoor South LW S1A-S6A shallow bore installation program is currently underway, with majority of bores installed by June 2022. A selection of seven private bores have established land access agreements for ongoing monthly water level monitoring. Additionally, the existing VWP network is installed and pertinent Tahmoor South sites upgraded to telemetry with continuous data streaming linked to trigger values and an associate alert system. The REA and Pit-top bores are operational and monthly monitoring will be continued.

A summary of the water level network is provided in Table 5-3.

Table 5-3 Summary Of Water Level Monitoring Bores

Bore ID	Status	Easting	Northing	Depth (mBNS)	Monitoring Regime
REA1	Active	278362.3	6207826.8	54.8	monthly
REA2	Active	278441.2	6206332.2	58	monthly
REA3	Active	277820.7	6206453.4	41	monthly
REA4	Active	277650.8	6206835.2	57.5	15 minute intervals
REA5	Active	277424.2	6206769	7.2	monthly
REA6	Active	278643.3	6207214.8	46.3	monthly
REA7	Active	278035.1	6207307.3	43	monthly
PitTop1	Active	277357.6	6207494.9	55.04	monthly
PitTop2	Active	277396	6207663.2	6.85	monthly
PitTop4	Active	276872.2	6207331.6	33.7	monthly
P50 a, b, c (Thirlmere1)	Approved	273900	6208500	Approx. 20, 35, 65	monthly
P51a	Active	275623.00	6206431.71	19.96	15 minute intervals
P51b	Active	275620.60	6206419.68	35.38	15 minute intervals
P57 a, b (Hornes1)	Approved	275500	6204600	Approx. 20, 35	monthly
P52a	Active	277649.84	6206848.30	41.17	15 minute intervals
P53 a	Active	277649.91	6206496.48	41	15 minute intervals
P53b	Active	277658.61	6206492.50	60.55	15 minute intervals
P53c	Active	277665.80	6206489.23	80.78	15 minute intervals
P54a	Active	277809.68	6205951.98	25	monthly
P54b	Active	277806.92	6205944.68	35.99	monthly
P55a	Active	277297.77	6205283.12	41.05	15 minute intervals
P55b	Active	277303.32	6205270.96	59.36	15 minute intervals
P55c	Active	277296.45	6205262.51	81.90	15 minute intervals
P56 a	Active	276645.55	6206175.36	20.9	15 minute intervals
P65b	Active	276639.18	6206166.92	45.56	15 minute intervals
P56c	Active	276637.06	6206154.37	80.4	15 minute intervals
GW109257	Active	276603.8	6205057	120	monthly
GW104008	Active	280359	6205978	140	monthly

Bore ID	Status	Easting	Northing	Depth (mBNS)	Monitoring Regime
GW112473	Active	276586	6202000	138	monthly
GW104659	Active	276616	6207392	132	monthly
GW062068	Active	276572.8	6209556	150	monthly
GW105395	Active	278546.8	6203033	90	monthly
GW104323	Active	276242	6206412	79.8	monthly
TBC001	Active	276749	6206665	VWPs: 398, 429 m	15 minute intervals
TBC009	Active	278511	6202058	VWPs: 30, 75, 140, 182, 192, 322, 343, 357, 381, 391, 397m	15 minute intervals
TBC018	Active	279645	6204509	VWPs: 70 (inactive), 11, 164, 179, 198, 282, 366, 377, 404, 426, 432m	15 minute intervals
TBC020	Active	280909	6204059	VWPs: 70, 105, 141, 194, 211, 293, 375, 397, 401, 434, 439m	15 minute intervals
TBC019B	Active	277200	6202080	to be drilled to mid-Bulgo (~250m)	15 minute intervals
TBC024	Active	274763	6204163	VWPs: 117, 139, 168, 185, 240, 295, 350, 371, 384, 391m	15 minute intervals
TBC026	Active	281603	6207068	VWPs: 95, 135, 176, 191, 211, 278, 344, 409, 432, 440, 460m	15 minute intervals
TBC027	Active	275708	6202210	VWPs: 95, 132, 169, 181, 198, 253, 306, 362, 384, 396, 400m	15 minute intervals
TBC032	Active	277244	6204725	VWPs: 95, 131, 168, 181, 200, 237, 294, 371, 397, 437m	15 minute intervals
TBC033	Active	275194	6205395	VWPs: 65, 113, 161, 173, 190, 247, 305, 363, 384, 408m	15 minute intervals
TBC034	Active	272956	6205076	VWPs: 65 (inactive), 113 (inactive), 161(inactive), 176, 196, 245, 294, 343, 364, 382m	15 minute intervals
TBC038	Active	280838	6201995	VWPs: 95, 129, 163, 175, 192, 249, 306, 364, 385, 408m	15 minute intervals
TBC039	Active	273445	6207688	VWPs: 65 (inactive), 106, 147, 172, 188, 243, 299, 354, 375, 402m	15 minute intervals

5.1.2 Groundwater Quality

The Tahmoor South LW S1A-S6A shallow bore installation program is currently underway, with majority of bores installed by June 2022. A selection of seven private bores have established land access agreements for ongoing monthly water level monitoring.

For the above-mentioned bores, the following suite of parameters will be analysed:

- Electrical conductivity (EC), Total Dissolved Solids (TDS), Dissolved Oxygen (DO);
- Nutrients (Total N, Total P);
- Major Ions (Ca, Cl, K, Na, SO_4, HCO_3, F);
- Total Alkalinity, Bicarbonate Alkalinity, Carbonate Alkalinity, Hydroxide Alkalinity; and
- Total (Fe, Mn) and dissolved metals (Fe, Mn, Cu, Pb, Zn, Ni, Al, As, Se, Li, Sr, Co).

EC is recorded at NSW government monitoring bores at Thirlmere Lakes since 2012.

Table 5-4 provides a summary of the water quality monitoring regime for LW S1A-S6A.

Table 5-4 Groundwater Quality Monitoring Network

Bore ID	Easting	Northing	Depth (mbgl)	Monitoring Regime
REA1	278362.3	6207826.8	54.8	quarterly
REA2	278441.2	6206332.2	58	quarterly
REA3	277820.7	6206453.4	41	quarterly
REA4	277650.8	6206835.2	57.5	monthly
REA5	277424.2	6206769	7.2	quarterly
REA6	278643.3	6207214.8	46.3	quarterly
REA7	278035.1	6207307.3	43	quarterly
PitTop1	277357.6	6207494.9	55.04	quarterly
PitTop2	277396	6207663.2	6.85	quarterly
PitTop4	276872.2	6207331.6	33.7	quarterly
P51a	275623.00	6206431.71	19.96	monthly
P51b	275620.60	6206419.68	35.38	monthly
P52a	277649.84	6206848.30	41.17	monthly
P53 a	277649.91	6206496.48	41	monthly
P53b	277658.61	6206492.50	60.55	monthly
P53c	277665.80	6206489.23	80.78	monthly
P54a	277809.68	6205951.98	25	monthly
P54b	277806.92	6205944.68	35.99	monthly
P55a	277297.77	6205283.12	41.05	monthly
P55b	277303.32	6205270.96	59.36	monthly
P55c	277296.45	6205262.51	81.90	monthly
P56 a	276645.55	6206175.36	20.9	monthly

Bore ID	Easting	Northing	Depth (mbgl)	Monitoring Regime
P65b	276639.18	6206166.92	45.56	monthly
GW109257	276603.8	6205057	120	monthly
GW104008	280359	6205978	140	monthly
GW112473	276586	6202000	138	monthly
GW104659	276616	6207392	132	monthly
GW062068	276572.8	6209556	150	monthly
GW105395	278546.8	6203033	90	monthly
GW104323	276242	6206412	79.8	monthly

5.1.2.1 Monitoring Standards

Groundwater monitoring will be undertaken in accordance with the relevant Australian Standards legislation and EPA approved methods for sampling, including (but not limited to):

- NSW DECC (2004) *Approved Methods for Sampling and Analysis of Water Pollutants in New South Wales*;
- AS/NZS 5667.1:1998 *Water Quality – Sampling – Guidance on the Design of Sampling Programs, Sampling Techniques, and the Preservation and Handling of Samples*; and
- AS/NZS 5667.11:1998 *Water Quality - Sampling - Guidance on Sampling of Groundwaters*.

5.1.3 Groundwater Extraction Monitoring

Groundwater pumped from all sumps in the mine workings is currently, and will continue to be, monitored by means of flow meters fitted to pipelines recording pumping times and rates. This water reporting to the underground workings and sumps may include groundwater seepage inflows, supply inflows (potable supply and for operations), and some re-circulation.

Operational water balance reviews will continue to be performed monthly collating groundwater extractions, as well as imported water to inform on-site water management. Such a system has been in operation at Tahmoor since 2009 (13 years) and will continue for the life of Tahmoor South. Advice from Tahmoor Coal is that the volume of groundwater extracted from Tahmoor South is monitored via “shaft 3”. The total volumetric flux monitoring provides data on the total groundwater inflow to all workings, where dewatering of Tahmoor North/Western Domain workings will cease soon after LW W4 is complete (in 2022). Consequently, inflow to Tahmoor South workings will be the primary component of all the groundwater inflow.

5.1.4 Longwall fracturing investigations

Pre-mining and post-mining investigation boreholes, which facilitate acquisition of geotechnical and groundwater-related data were proposed for LW S1A and one other location above the A-longwalls (likely to be LW S4A, but dependent on land access). It was planned that at each installation, the hole would be packer tested, run geophysical and downhole camera and have VWPs installed (proposed three sensors in the HBSS and three in the BGSS). The post-mining hole will be drilled following completion of the longwall it is located above.

TCS01 is a fully cored borehole, with a full suite of geological, geotechnical and hydrogeological testing conducted through the sequence. The borehole was cored from surface to seam, with the Bulli Seam depth of 404.00 m. The location of this borehole (off the southern end of LW 1SA make it a suitable proxy for the pre-mining investigation bore proposed. The second Height of Fracturing (HoF) hole will be installed prior to the preceding longwall (e.g. prior to LW S3A if it is to be located over LW S4A).

5.2 Verify Model Predictions

Groundwater monitoring results will be compared to groundwater model predictions on an annual basis to assess actual versus predicted groundwater levels and/or drawdown (i.e. height of depressurisation), and groundwater inflows to the mine. This analysis will be incorporated in regular groundwater compliance reporting, such as the Annual Review and/or Six-monthly Review.

For this task and for the TARP triggers, the relevant model predictions are those from the newly revised groundwater model (SLR, 2022).

Aligned with completion of model re-calibration, to occur every three years, the trigger levels dependent on modelling outputs will be reviewed and updated as necessary.

5.3 Groundwater Baseline Monitoring to support future Extraction Plans

As indicated in Section 5.1 a period of post-mining monitoring is to occur for all monitoring bores of interest. These bores of interest will be established 12 months prior to completion of extraction at LW S6A and be dependent on a review of historical data, bore suitability (i.e. bore condition, access agreements, etc) and suitability for purpose.

The intention of the post-mining monitoring is to allow ongoing review of potential impacts (i.e. depressurisation lags) and degree of recovery whilst also providing continued baseline data to support future groundwater extraction plans, both in terms of conceptual understanding of the effects of longwall mining and for improving confidence in the ability to simulate these in numerical models.

5.4 Private Bore Ameliorative Actions

The monitoring network described above, provides water level and quality data at an adequate spatial and temporal scale to undertake investigations into potential impacts to existing groundwater users.

In accordance with Condition B26 – B29 of the Tahmoor South Domain Consent (SSD 8445), where a mining related impact has occurred at a private bore, Tahmoor Coal will implement a make good process.

Tahmoor Coal has been implementing this process during the life of Tahmoor/Tahmoor North. The process allows for bore owners to apply to Tahmoor Coal if they believe their bore's level or water quality has declined triggering an assessment into the potential cause (i.e. mining related). If it is deemed that the mine is responsible, then remedial action would be implemented, potentially deepening and/or replacing bores and wells, and/or providing an alternative water source to affected users.

The make good process would be staged by Tahmoor Coal in accordance with the proposed mining schedule and the results of predictive groundwater modelling. Contact has been made with landholders whose registered bores are predicted to incur a drawdown of greater than 2 m, as per the NSW Aquifer Interference Policy (AIP) criterion, or whose bores are at risk of subsidence related impacts. Following this initial contact with landholders, where access was granted a baseline field survey has been completed to verify bore details – location, depth, condition of bore and pump, standing water levels, groundwater quality and usage (where possible). Survey findings have been provided to the landholder so that they have the same baseline information as Tahmoor Coal. This information has provided both parties with a thorough understanding of the current bore condition and a reference point for comparison with subsequent bore assessments as mining progresses. The verified bore data has also been included in the recent update of the groundwater model.

In the event that a mining-related impact to a private bore has been confirmed and any further potential impacts are understood (based on groundwater modelling), the landholder and Tahmoor Coal would negotiate a make good agreement. This agreement would include specific make good mitigation measures and outline a potential timeframe for undertaking these measures, if required. The make good agreement would include and consider the conditions of any development consents, the provisions of the AIP and the NSW Coal Mine Subsidence Compensation Act 2017.

There are a number of make good options that may be adopted, based on the details and characteristics of an individual bore and the extent of mining-induced impacts. These mitigation measure options include:

- Bore maintenance where physical adjustments and regular maintenance of the bore(s) are required to return them to pre-mining conditions. This could include re-establishment of saturated thickness in the affected bore(s) through extending the depth of the pump, or deepening of the bore(s) to return yield to pre-mining conditions;
- Replacement of bore(s) to provide a yield at least equivalent to the yield of the affected bore prior to mining. This may be required where deepening of an existing bore is not possible (e.g. the bore has partially collapsed or the bore hole is not straight or vertical);
- Provision of access to an alternative source of water or compensatory water supply. This option may be offered while other measures are being undertaken and could include connection to the town water supply or the provision of on-site storage (e.g. dam or water tanks); or
- Compensation to reflect increased water extraction costs (e.g. due to lowering pumps or installation of additional or alternative pumping equipment).

Equivalent water supply should be provided (at least on an interim basis) as soon as practicable after the loss is identified, unless otherwise agreed with the landowner. The burden of proof that any loss of water supply is not due to mining impacts rests with Tahmoor Coal, in accordance with Condition B27 of SSD 8445.

If there is a dispute as to whether the loss of water is to be attributed to the development or the measures to be implemented, or there is a dispute about the implementation of these measures, then either party may refer the matter to the Planning Secretary for resolution, in accordance with Condition B28 of SSD 8445. If Tahmoor Coal is unable to provide an alternative long-term supply of water, compensation will be provided to the affected landowner, to the satisfaction of the Planning Secretary.

6 Trigger Action Response Plan (TARP)

In accordance with Condition E5 (f) of the Consent, in the event that performance measures (in the form of pre-defined triggers) are considered to have been exceeded or are likely to be exceeded, a response will be undertaken in accordance with the Trigger Action Response Plans (TARP).

The primary actions of the TARP are to:

- Define appropriate trigger levels for 'shallow' and 'deep' groundwater levels, groundwater quality (pH, EC and metals) at monitoring bores and private bores that are useful for providing insight into potential impact from extraction or mining operations;
- Develop specific actions to respond to high risk of exceedance of any performance measure to ensure that the measure is not exceeded; and
- Present a plan in the event performance measures are exceeded or are likely to be exceeded and describe the management / corrective actions to be implemented (i.e. notifications to relevant agencies, groundwater monthly/quarterly reviews, revision in any Corrective Action Management Plan and/or Annual Reviews).

Each TARP has four levels of triggers – "Normal Conditions" - being where the environment is behaving or performing within normal or expected levels, through to Level 3 (L3) each with escalating risk to the environment via deviation from baseline or expected conditions.

The success of remediation measures that have been implemented for any TARP exceedance would be reviewed as part of any Corrective Action Management Plan and Six-monthly reporting, the latter which would provide an opportunity to review and update existing triggers if deemed necessary.

A total of six TARPS (TARP WMP8 to WMP13) are required to address various components of the groundwater system and these are discussed in greater detail below. The TARPS are provided to work in conjunction with not only each other, but also other TARPS within the overarching Water Management Plan to provide a holistic approach to the overall management of the water system.

6.1 Trigger Levels

6.1.1 Methodology Development

Trigger levels have been developed utilising baseline data in conjunction with modelled drawdown predictions and climate data. Additionally, consideration of existing TARPs utilised in the Western Domain will be made to inform the most reasonable and responsible approach to monitoring and managing potential impacts to groundwater resources and associated receptors.

Historical data indicates that significant mining-related drawdown or depressurisation (tens to hundreds of metres) is typical in strata deeper than 200 mbgl, and drawdown or depressurisation is less severe and less persistent in strata shallower than 200 mbgl. Consequently, trigger levels have been set independently for these depth profiles. The Bulli Coal Seam, being the target for coal extraction and being deliberately depressurised for that purpose, is excluded from trigger development, additional commentary regarding this provided below.

6.1.2 Groundwater Levels

6.1.2.1 Shallow Monitoring Bores and Private Bores (< 200 metres depth)

The shallow OSP monitoring bores for which groundwater triggers have been or will be developed are described in Table 6-1.

Monthly manual water level monitoring and water quality monitoring commenced at all installed wells in May 2022. Data loggers have been installed in 10 shallow monitoring observation bores (those sites associated with surface water monitoring sites).

Table 6-1 Shallow Monitoring Bore included in the TARPs

Bore Identification	Bore Depth (mbgl)	Status	Trigger Level Status
P50a	20	proposed	TBC
P50b	35	proposed	TBC
P50c	65	proposed	TBC
P51a	19.96	well installed, level and quality monitoring commenced	Trigger set
P51b	35.38	well installed, level and quality monitoring commenced	Trigger set
P57a	20	proposed	TBC
P57b	35	proposed	TBC
P52a	41.17	well installed, level and quality monitoring commenced	Trigger set
REA4	54.31	well installed, level and quality monitoring commenced	Trigger set
P53a	41	well installed, level and quality monitoring commenced	Trigger set
P53b	60.55	well installed, level and quality monitoring commenced	Trigger set
P53c	80.78	well installed, level and quality monitoring commenced	Trigger set
P54a	25	well installed, level and quality monitoring commenced	Trigger set
P54b	35.99	well installed, level and quality monitoring commenced	Trigger set
P55a	41.05	well installed, level and quality monitoring commenced	Trigger set
P55b	59.36	well installed, level and quality monitoring commenced	Trigger set
P55c	81.90	well installed, level and quality monitoring commenced	Trigger set
P56a	20.9	well installed, level and quality monitoring commenced	Trigger set
P56b	45.56	well installed, level and quality monitoring commenced	Trigger set
P56c	80.4	well installed, level and quality monitoring commenced	Trigger set
GW109257	120	existing site, level and quality monitoring commenced	Trigger set
GW104008	140	existing site, level and quality monitoring commenced	Trigger set
GW112473	138	existing site, level and quality monitoring commenced	Trigger set
GW104659	132	existing site, level and quality monitoring commenced	Trigger set
GW062068	150	existing site, level and quality monitoring commenced	Trigger set
GW105395	90	existing site, level and quality monitoring commenced	Trigger set
GW104323	109	existing site, level and quality monitoring commenced	Trigger set

In the Western Domain, climatic variations alone are not considered to have caused reductions in groundwater levels at shallow open-standpipe bores in excess of 2 m, although the cumulative effect of rainfall variability and groundwater pumping during dry periods is considered to have caused declines of >2 m (e.g. at bore P12C, P16B, P16C in the Western Domain). However, such declines related to groundwater extraction are relatively short-lived. Therefore, a water level reduction of greater than 2 m for shallow standpipe bores for a period beyond 6 months was considered to be a possible indicator of greater than predicted impacts to groundwater (even if greater drawdown was predicted, the concept is to use this magnitude of drawdown as an early warning).

The TARP Significance Levels (1, 2 and 3) will be assigned a trigger corresponding to a calculated groundwater elevation for each groundwater monitoring bores. For monitoring sites with short baseline periods (<6 months), the *maximum* groundwater level observed during pre-mining has been used as reference levels in the TARP level calculations. For bores with a longer baseline, the reference level has been defined following a review of the baseline data.

Table 6-2 presents the shallow groundwater level triggers.

Table 6-2 Shallow Monitoring Bore Trigger Levels

	Groundwater Level (mAHD)		
	TARP Level 1	TARP Level 2	TARP Level 3
Shallow OSP			
P51A	296.3	292.4	288.5
P51B	297.5	293.6	289.7
P52	246.7	244.6	242.5
P53A	255.8	253.7	251.6
P53B	255.8	253.7	251.6
P53C	253.6	251.4	249.1
P54A	260.7	259.0	257.4
P54B	259.9	258.2	256.6
P55A	271.1	269.7	268.2
P55B	266.0	264.4	262.9
P55C	259.7	258.2	256.6
P56A	288.2	284.8	281.4
P56B	278.9	275.5	272.1
P56C	257.4	254.1	250.7
REA4	248.3	246.2	244.1
Private Bores			
GW062068	274.0	270.5	267.1
GW104008	234.7	234.0	233.2
GW104323	256.9	256.8	256.8
GW104659	249.8	243.6	237.4

	Groundwater Level (mAHD)		
	TARP Level 1	TARP Level 2	TARP Level 3
GW105395	322.1	Modelled drawdown is equal to 2 m	Modelled drawdown is equal to 2 m
GW109257	280.9	278.9	276.9
GW112473	317.1	Modelled drawdown is equal to 1 m	Modelled drawdown is equal to 1 m

It is emphasised that trigger levels for bores/instruments with short records of pre-mining (baseline) data are less reliable or robust than those for sites with longer records. Given extraction activities will not likely impact shallow groundwater immediately, or for those spatially disparate from LW S1A for an extended period of time, trigger levels can be re-assessed after additional data is collected that can be considered baseline (not impacted).

6.1.2.2 Shallow VWPs (<200 m Depth)

Regionally, climatic variations have been observed to cause reductions in water levels of up to 5 m in shallow (< 200 m depth) VWPs. Therefore, a water level reduction of greater 5 m for shallow VWP loggers for a period beyond 6 months is considered to be a possible indicator of greater than predicted impacts to groundwater (even if greater drawdown was predicted, the concept is to use this magnitude of drawdown as an early warning).

A reference level has been generated for each VWP sensor, based on the average groundwater level observed prior to commencement of extraction. These are presented in Table 6-3.

At most sites the average groundwater levels sits at levels observed prior to the 2017-2019 NSW drought and in some cases to levels observed during the wetter conditions in 2021. This makes the groundwater level average a conservative reference level.

TARP Level 1 (L1) was then calculated as *Reference level (mAHD) minus 5 m* which is consistent with approaches adopted elsewhere at Tahmoor Mine (i.e. for the Western Domain).

Elsewhere at Tahmoor Mine, TARP Level 3 (L3) has been based on the maximum modelled drawdown and calculated as *Reference Level minus maximum modelled drawdown*. The maximum modelled drawdown at the reference sites ranges from 0 m to 3.3 m which is smaller than the adopted 5 m natural fluctuations to derive TARP L1. This results in some cases in the TARP L3 being higher than TARP L1.

Therefore, instead of calculating TARP L3 as “*Reference Level minus maximum modelled drawdown”,* TARP L3 is calculated as “*TARP L1 minus the maximum modelled drawdown”.* TARP L3 now lies below TARP L1.

TARP Level 2 (L2) is calculated as the average of L1 and L3.

Some VWP sensor are assigned model Layer 1 (i.e. TBC024 HBSS-117m; TBC027-HBSS-95m, TBC034-HBSS-65m). No drawdown is simulated in Layer 1 at those sites hence no TARP Level 2 and 3 can be derived here. The proposed trigger levels are plotted against the hydrographs for each sensor, and presented in Appendix G.

The hydrograph for TBC027 shows that the elevation of the three levels of triggers (L1/L2/L3) are within 1 meter, due to small modelled drawdown. The proposed trigger levels are provided in Table 6-4.

Table 6-3 Reference Level Utilised in Development of Shallow VWP Groundwater Level Triggers

Site/VWP	Strata	Reference GW Level (mAHD)	Reference Level Justification
Shallow VWPs (<200m)			
TBC024 - HBSS 117m	Hawkesbury Sandstone	287.6	Average groundwater levels, excluding data from April 2012 to Jan 2013 due to unstable VWP. Reference level of 287.6mAHD is similar to water level observed prior to the NSW drought 2017-2019.
TBC024 - HBSS 139m	Hawkesbury Sandstone	287.0	Average groundwater levels, excluding data from April 2012 to Aug 2012 due to unstable VWP. Reference level is similar to water levels observed prior to the NSW drought 2017-2019.
TBC024 - BHCSS 168m	Bald Hill Claystone	289.5	Average groundwater levels, excluding data from April 2012 to Aug 2012 due to unstable VWP. Reference level is similar to water levels observed prior to the NSW drought 2017-2019.
TBC024 - BGSS 185m	Bulgo Sandstone	289.3	Average groundwater levels for the baseline period. Reference level is similar to water levels observed prior to the NSW drought 2017-2019.
TBC027 - HBSS-95m	Hawkesbury Sandstone	320.1	Average groundwater levels for the baseline period. Natural fluctuation up to 10m in 2013. Reference level is similar to water levels observed prior to the NSW drought 2017-2019 and to water levels observed following exceptional wet conditions in 2020/2021.
TBC027 - HBSS-132m	Hawkesbury Sandstone	312.8	Average groundwater levels for the baseline period. Reference level is similar to water levels observed prior to the NSW drought 2017-2019 and to water levels observed following exceptional wet conditions in 2020/2021.
TBC027 - HBSS-169m	Hawkesbury Sandstone	312.2	Average groundwater levels for the baseline period. Reference level is similar to water levels observed prior to the NSW drought 2017-2019 and to water levels observed following exceptional wet conditions in 2020/2021.
TBC027 - BHCS-181m	Bald Hill Claystone	310.7	Average groundwater levels. Reference level is similar to water levels observed prior to the NSW drought 2017-2019 and to water levels observed following exceptional wet conditions in 2020/2021.
TBC027 - BGSS-198m	Bulgo Sandstone	310.3	Average groundwater levels for the baseline period. Reference level is similar to water levels observed prior to the NSW drought 2017-2019.
TBC034 - HBSS-65m	Hawkesbury Sandstone	371.8	Average groundwater levels for the baseline period.

Site/VWP	Strata	Reference GW Level (mAHD)	Reference Level Justification
TBC034 - HBSS-113m	Hawkesbury Sandstone	368.0	Average groundwater levels for the baseline period.
TBC034 – HBSS-161m	Hawkesbury Sandstone	358.4	Average groundwater levels for the baseline period.
TBC034 - BHCS-176m	Bald Hill Claystone	354.9	Average groundwater levels.
TBC034 - BGSS-196m	Bulgo Sandstone	358.3	Average groundwater levels.
TBC038 - XX*			
TBC09-HBSS-30m*	Hawkesbury Sandstone	Insufficient baseline data	No groundwater level available past Feb 2014. No trigger level developed.
TBC09-HBSS-75m	Hawkesbury Sandstone	309.4	Average groundwater levels between May 2012 and July 2021.
TBC09-BHCS-182m	Bald Hill Claystone	293.0	Average groundwater levels between May 2012 and July 2021.
TBC09-BGSS-192m	Bulgo Sandstone	290.4	Average groundwater levels between May 2012 and July 2021.
TBC018 - WWFM/HBSS-70m*	Hawkesbury Sandstone	Insufficient baseline data	Average groundwater levels between Dec 2011 and Oct 2013. No groundwater data past Oct 2013. No trigger level developed.
TBC018 - WWFM/HBSS-117m	Wianamatta Form/ Hawkesbury Sandstone	251.9	Average groundwater levels between Dec 2011 and Dec 2021.
TBC018 - HBSS (lower)-164m	Hawkesbury Sandstone	250.7	Average groundwater levels between Dec 2011 and Dec 2021.

Site/VWP	Strata	Reference GW Level (mAHD)	Reference Level Justification
TBC018 - BHCS-179m	Bald Hill Claystone	248.5	Average groundwater levels between Dec 2011 and Dec 2021.
TBC018 - BGSS-198m	Bulgo Sandstone	244.7	Average groundwater levels between Dec 2011 and Dec 2021.
TBC032 – HBSS – 95m	Hawkesbury Sandstone	262.3	Average groundwater levels between May 2013 and May 2021.
TBC032 – HBSS – 131m	Hawkesbury Sandstone	255.0	Average groundwater levels between May 2013 and May 2021.
TBC032 – HBSS – 168m	Hawkesbury Sandstone	266.9	VWP appears unstable. Average groundwater levels between May 2013 and May 2021.Trigger level developed but with the caveat that groundwater level may be erroneous.
TBC032 – BHCS – 181m	Bald Hill Claystone	242.8	Average groundwater levels between May 2013 and May 2021.
TBC032 – BGSS – 200m	Bulgo Sandstone	243.8	Average groundwater levels between May 2013 and May 2021.
TBC033 - HBSS-	Hawkesbury	284.9	Average groundwater levels between April 2013 and Dec 2020.
TBC033 - WWFM/HBSS-113m	Wianamatta Form/ Hawkesbury Sandstone	278.3	Average groundwater levels between April 2013 and Dec 2020.
TBC033 - HBSS (lower)-161m	Hawkesbury Sandstone	268.6	Average groundwater levels between April 2013 and Dec 2020.
TBC033 - BHCS-173m	Bald Hill Claystone	240.4	VWP appears unstable. Average groundwater levels between April 2013 and Dec 2020. Trigger level developed but with the caveat that groundwater level may be erroneous.
TBC033 - BGSS-	Bulgo	235.2	Average groundwater levels between April 2013 and Dec 2020.

*data unavailable at time of reporting

Table 6-4 Shallow VWP Groundwater Level Triggers

Bore	Groundwater Trigger Level (mAHD)			Model Layer
	TARP Level 1	TARP Level 2	TARP Level 3	
Shallow VWPs (<200m)				
TBC024 - HBSS 117m	282.6	-	-	1
TBC024 - HBSS 139m	282.0	281.5	281.0	5
TBC024 - BHCSS 168m	284.5	283.6	282.8	6
TBC024 - BGSS 185m	284.3	282.3	280.3	8
TBC027 - HBSS-95m	315.1	-	-	1
TBC027 - HBSS-132m	307.8	307.6	307.3	5
TBC027 - HBSS-169m	307.2	307.0	306.8	5
TBC027 - BHCS-181m	305.7	305.5	305.3	16
TBC027 - BGSS-198m	305.3	305.1	304.9	8
TBC034 - HBSS-65m	366.8	-	-	1
TBC034 - HBSS-113m	363.0	362.7	362.3	4
TBC034 - HBSS-161m	353.4	353.1	352.8	4
TBC034 - BHCS-176m	349.9	349.4	348.9	16
TBC034 - BGSS-196m	353.3	352.1	350.9	8
TBC038 – XXX*	tbc	tbc	tbc	
TBC09-HBSS-30m	tbc	tbc	tbc	1
TBC09-HBSS-75m	304.4	304.2	304.1	2
TBC09-BHCS-182m	288.0	287.4	286.8	15
TBC09-BGSS-192m	285.4	285.2	285.0	8
TBC018 - WWFM/HBSS-70m	tbc	tbc	tbc	1
TBC018 - WWFM/HBSS-117m	246.9	246.6	246.2	1
TBC018 - HBSS (lower)-164m	245.7	245.4	245.1	5
TBC018 - BHCS-179m	243.5	243.1	242.8	3
TBC018 - BGSS-198m	239.7	237.8	236.0	8
TBC032 - HBSS-95m	257.3	256.7	256.2	4
TBC032 - HBSS-131m	250.0	249.3	248.6	5
TBC032 - HBSS-168m^	261.9	261.1	260.4	5
TBC032 - BHCS-181m	237.8	228.7	219.5	6
TBC032 - BGSS-200m	238.8	208.7	178.7	8
TBC033 - HBSS-65m	279.9	279.2	278.6	3
TBC033 - WWFM/HBSS-113m	273.3	272.7	272.0	1
TBC033 - HBSS (lower)-161m	263.6	262.9	262.2	5
TBC033 - BHCS-173m^	235.4	213.8	192.3	16
TBC033 - BGSS-190m	230.2	217.7	205.2	8

* Data unavailable (tbc) tbc = to be confirmed ^potential issues with VWP stability but trigger levels still reported

6.1.2.3 Deep VWPs (> 200 metres depth)

For bores that monitor depths greater than 200 m groundwater level monitoring results will be compared to groundwater model predictions (Section 4.4) on an annual basis comparing actual groundwater levels with predictions. In the event that monitoring data suggests divergence from the predicted trends (i.e. from numerical groundwater modelling predictions), the TARP would be enacted.

Each trigger level is associated with level of deviation from modelled predicted drawdown and period of time for which this deviation is experienced:

- Normal Conditions – Observed drawdown does not exceed modelled impacts predicted drawdown by greater than 30 metres. Observed drawdown exceeds the modelled predicted drawdown by greater than 30 metres for less than three consecutive months;
- Level 1 (L1) – Observed drawdown exceeds the modelled predicted drawdown, by greater than 30 metres for greater than three consecutive months;
- Level 2 (L2) – Observed drawdown exceeds modelled predicted drawdown by more than 30 metres for a greater than 6 consecutive months; and
- Level 3 (L3) – Observed drawdown exceeds modelled predicted drawdown for 12 consecutive months or more.

Bores encompassed within this TARP, including the associated model layer, are provided in Table 6-5, with associated predicted drawdown hydrographs provided in Appendix H.

Table 6-5 Deep VWP sensors and associated model layers

Sensor	Model Layer	Model Geology
TBC09_322	8	BUSS Mid
TBC09_343	8	BUSS Mid
TBC09_357	12	SBSS Lower
TBC09_381	10	SPCS
TBC09_391	15	Bulli Seam
TBC09_397	17	Wongawilli
TBC18_282	8	BUSS Mid
TBC18_366	8	BUSS Mid
TBC18_377	13	WBCS
TBC18_404	15	Bulli Seam
TBC18_426	17	Wongawilli
TBC18_432	17	Wongawilli
TBC20_211	8	BUSS Mid
TBC20_293	8	BUSS Mid
TBC20_375	8	BUSS Mid
TBC20_397	13	WBCS

Sensor	Model Layer	Model Geology
TBC20_411	7	BUSS Upper
TBC20_434	17	Wongawilli
TBC20_439	4	HBSS Mid
TBC26_211	8	BUSS Mid
TBC26_278	8	BUSS Mid
TBC26_344	8	BUSS Mid
TBC26_409	13	WBCS
TBC26_432	15	Bulli Seam
TBC26_440	16	Eckersley
TBC26_460	16	Eckersley
TBC32_200	8	BUSS Mid
TBC32_237	8	BUSS Mid
TBC32_257	8	BUSS Mid
TBC32_294	8	BUSS Mid
TBC32_314	8	BUSS Mid
TBC33_247	8	BUSS Mid
TBC33_306	8	BUSS Mid
TBC33_363	11	SBSS Upper
TBC33_384	16	Eckersley
TBC33_408	16	Eckersley
TBC39_243	8	BUSS Mid
TBC39_299	8	BUSS Mid
TBC39_354	11	SBSS Upper
TBC39_375	16	Eckersley
TBC39_402	16	Eckersley

6.1.2.4 Bulli Coal Seam Monitoring Bores

It is expected that the TARP will exclude loggers located in the Bulli Coal Seam on the basis that as this is the target coal seam, significant depressurisation effects are expected due to dewatering of mine workings. Additionally, there are no other groundwater users of this aquifer (environmental or anthropogenic), other than mines, that warrant the need to investigate head changes in this unit. However, monitoring will be undertaken and undergo review alongside the loggers included in the TARP.

6.1.3 Groundwater Quality

As discussed in Section 5.1 the shallow monitoring program designed for LW S1A-S6A has commenced, with data being collected monthly.

Historical compliance reporting for the Tahmoor Western Domain, indicates that some groundwater quality analytes can have significant natural variation not attributable to mining activities that may not be captured in a discrete monitoring period. Consequently, it is recommended that groundwater quality triggers include regional water quality data where no impact from mining has been recorded. This provides a more comprehensive and representative assessment of baseline conditions. Prior to commencement of extraction, the available baseline data collected for these bores will be reviewed against the regional data to confirm the trigger developed. A data cleanse will be undertaken prior to development of triggers to exclude erroneous or unreliable data from the baseline dataset.

The methodology for groundwater quality parameters is based primarily on the method used for the Western Domain. However, in addition, further published literature will be consulted to assist in developing meaningful triggers. Table 1 of the NSW Aquifer Interference Policy [AIP] (NOW, 2012) sets out the minimal impact considerations for aquifer interference activities for Highly Productive Groundwater Sources (refer Section 2.1.2), including:

> *Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 m from the activity.*

The groundwater beneficial uses, alongside published water quality parameter guidelines (i.e. the 2018 Australian and New Zealand Guidelines [ANZG, 2018] for Fresh and Marine Water Quality) will be consulted to develop triggers that represent the natural variation and reference the ability to predict potential harm to the aquifer by impacting the groundwater quality beyond recommended concentrations.

All parameters will have an assigned upper trigger level, excluding pH which will be assigned both an upper and lower pH trigger level. Table 6-6 presents the bores, parameters and groundwater quality trigger levels developed. The trigger levels are defined as;

- Normal – No observable changes in salinity, pH or metals outside of the baseline variability.
- Level 1 – observed salinity and/or metals or pH outside of defined trigger levels for three consecutive months or more. The effect does not persist after a significant rainfall event. Additionally, a similar trend or response is noted at other monitored bores or private groundwater bores.
- Level 2 – observed salinity and/or metals or pH outside of defined trigger levels, for 3 consecutive months or more. The effect persists after a significant rainfall recharge event. In addition, the change in water quality is determined not to be controlled by climatic or external anthropogenic factors.
- Level 3 – observed salinity and/or metals or pH outside of defined trigger levels, for greater than six consecutive months. In addition, the change in water quality is assessed not to be controlled by climatic or external anthropogenic factors.

6.1.3.1 Salinity

Electrical Conductivity (EC) is the measure of salinity proposed to identify potential changes in groundwater salinity. The maximum observed EC during pre-mining (and in some cases during the early mining period before any likelihood of potential impact at that site) plus 10% has been adopted for the salinity trigger level. This will be reviewed upon collection of more extensive baseline data (prior to any extraction impacts incurred).

6.1.3.2 pH

An upper and lower pH trigger has been assigned for each shallow monitoring bore and private landholder bore. Triggers are based on the minimum and maximum pH values recorded in the available dataset minus/plus 1 pH unit if the max/min pH are within four pH units (otherwise, just max/min are utilised). Again, regional data will be taken into consideration.

6.1.3.3 Metals

A single level trigger for dissolved (not total) metals be applied to the monitoring and private bores. Given the limited baseline data available at this point, the pre-mining 95^{th} percentile for each parameter at each bore has been adopted. With collection of additional data, these trigger levels will be reviewed in conjunction with consideration of published literature on guidelines for concentrations associated with relevant beneficial uses.

Table 6-6 Groundwater Quality Triggers

Bore ID	Trigger Level			Trigger Level Concentrations (mg/L) for metals											
	EC (µS/cm)	pH lower	pH upper	Fe	Mn	Cu	Pb	Zn	Ni	Al	Li	Ba	Sr	Se	As
P50a	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	
P50b	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	
P50c	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	
P51a	299.000	5.230	12.660	0.026	0.135	0.031	0.001	0.051	0.014	0.466	0.204	0.284	1.866	0.005	0.002
P51b	3971.000	7.820	12.790	0.032	0.084	0.005	0.001	0.022	0.013	3.380	0.762	0.620	3.500	0.005	0.003
P57a	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	
P57b	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	
P52	1450.000	4.690	7.240	58.600	4.040	0.002	0.001	0.324	0.045	0.016	0.018	0.310	0.062	0.003	0.001
P53a	896.000	5.150	9.200	17.268	2.000	0.001	0.001	0.064	0.019	0.014	0.040	0.108	0.138	0.003	0.001
P53b	1848.000	5.560	8.370	11.908	2.252	0.001	0.001	0.039	0.013	0.014	0.474	0.194	0.652	0.003	0.001
P53c	1879.000	5.650	8.460	27.000	2.400	0.001	0.001	0.143	0.040	0.014	0.014	0.164	0.716	0.002	0.011
P54a	1951.000	5.000	7.620	33.800	3.100	0.400	0.400	0.024	0.043	4.001	0.067	0.568	0.310	0.400	0.003
P54b	2182.000	5.180	7.370	35.460	2.964	0.001	0.001	0.043	0.040	0.025	0.079	0.273	0.493	0.004	0.002
P55a	1822.000	4.260	8.070	37.400	3.900	0.001	0.001	0.221	0.062	0.024	0.020	0.351	0.372	0.002	0.003
P55b	1699.000	5.110	8.350	27.600	5.680	0.001	0.001	0.126	0.232	0.011	0.087	0.322	0.278	0.002	0.005
P55c	2663.000	5.090	8.420	38.000	2.780	0.001	0.001	0.007	0.141	0.014	0.256	0.296	0.644	0.002	0.001
P56a	1560.000	4.540	8.500	0.026	0.122	0.008	0.007	0.037	0.011	0.682	0.021	0.170	0.154	0.005	0.001
P56b	1526.000	7.060	11.870	0.076	1.676	0.001	0.001	0.005	0.032	0.016	0.830	0.254	1.036	0.005	0.001
P56c	3520.000	7.360	12.190	0.064	0.007	0.001	0.001	0.003	0.001	0.142	0.481	0.640	1.458	0.005	0.001
REA4	1126.000	4.200	8.010	0.050	0.005	0.003	0.002	0.058	0.002	0.040	0.005	0.011	0.110	0.002	0.002
GW109257	927.000	3.250	7.590	1.852	1.404	0.007	0.001	0.115	0.025	0.382	0.007	0.190	0.025	0.005	0.001

Bore ID	Trigger Level			Trigger Level Concentrations (mg/L) for metals											
	EC (µS/cm)	pH lower	pH upper	Fe	Mn	Cu	Pb	Zn	Ni	Al	Li	Ba	Sr	Se	As
GW104008	1983.000	4.590	7.110	32.600	2.100	0.001	0.001	0.017	0.018	0.016	0.066	0.160	0.097	0.001	0.001
GW112473	574.000	4.620	6.620	9.120	1.080	0.003	0.004	0.056	0.014	0.564	0.005	0.126	0.014	0.001	0.001
GW104659	685.000	4.320	7.050	28.600	1.660	0.009	0.001	0.038	0.010	0.014	0.015	0.152	0.028	0.001	0.001
GW062068	2070.000	2.590	6.100	0.090	2.980	0.030	0.015	0.142	0.024	7.520	0.011	0.218	0.019	0.001	0.002
GW105395	4635.000	4.660	8.240	37.800	1.880	0.001	0.001	0.038	0.040	0.014	0.077	0.081	0.176	0.001	0.001
GW104323	1541.000	2.760	6.950	0.068	2.660	2.320	0.182	4.540	0.069	3.320	0.010	0.290	0.013	0.001	0.002

6.1.4 Adaptive Management – Groundwater – Surface Water Interaction

Adaptive Management is the implementation of management strategies as required dependent on ongoing outcomes and impacts of mining. For example, if surface water losses are identified, additional management will be implemented to review this from a groundwater perspective (i.e. groundwater–surface water interaction study). Hence, adaptive management is responding to changing requirements for management based on ongoing review of data. Consequently, the two TARPs presented here have strong links to other primary TARPs and utilise the same network.

6.1.4.1 Groundwater – Surface Water Interaction

The Tahmoor South monitoring network has been developed to provide pertinent information on baseflow relationships with nested surface water and groundwater monitoring sites. Groundwater data would be reviewed alongside complementary monitoring.

This TARP defines levels of deviation in surface water - groundwater interactions from 'normal' conditions and the actions to be implemented in response to each level deviation. The instigation of this TARP will be dictated by triggers exceedances in pertinent groundwater or surface water sites requiring further investigation of groundwater – surface water interactions.

This TARP references Biodiversity Management Plan TARP – Riparian Vegetation (BMP3), which specifically defines levels of deviation in riparian vegetation condition from normal conditions and the actions required to be implemented in response to each level of deviation. The riparian vegetation can be considered a GDE with relevant Performance Measure, managed under the Riparian Vegetation TARP, supported by this TARP. TARP BMP3 will be enacted via this TARP as well as via its own specific criteria, to support investigations providing a holistic review of groundwater and surface water in relation to GDEs.

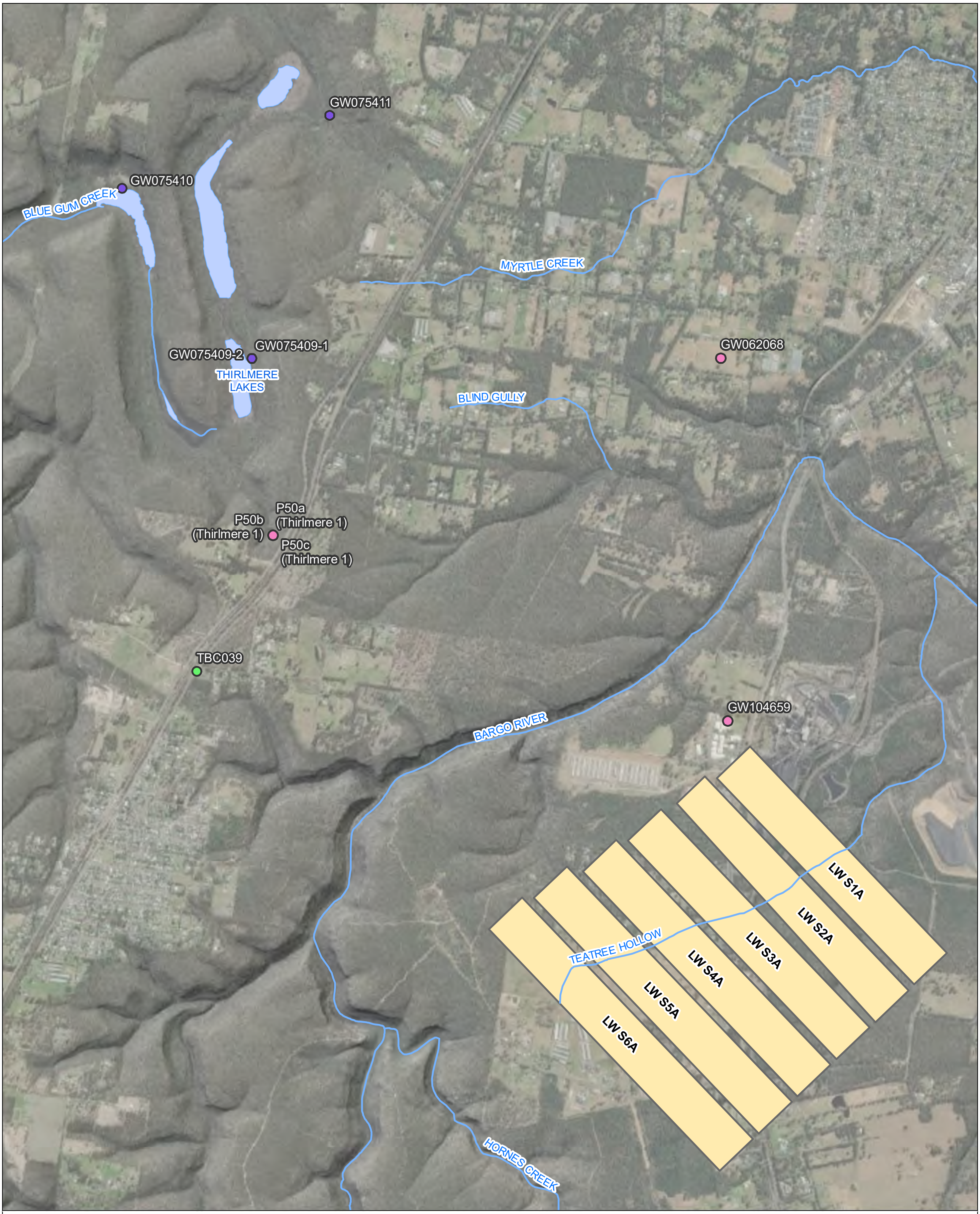
6.1.4.2 Groundwater Bores Monitoring for Thirlmere Lakes

The Thirlmere Lakes have a specific series of bores aimed at monitoring potential impacts on the Lakes resulting from longwall extraction. The network is designed to provide an early warning system of changes in groundwater conditions that may indicate a potential impact to Thirlmere Lakes, via a cross section of data between mine operations and the Lakes. Figure 6-1 shows the location of the specific network, including the following sites:

- "Early warning" bores: P51a, P51b, GW062068, GW104659, TBC039 (sensor at 65 metres in Hawkesbury Sandstone (HBSS))
- "Thirlmere Lakes" bores: GW075409–1, GW075409–2, GW075410, GW075411 (paired with gauging station 212066) and proposed sites: P50a, P50b, P50c

Trigger levels are linked to the shallow water level and water quality triggers defined in their specific TARPs. Given the Thirlmere Lakes are considered GDEs, the relevant Performance Measure is incorporated, being;

> *GDE Performance Measure: Negligible impacts including:*
>
> - *Negligible changes in groundwater levels; and*
> - *Negligible changes in groundwater quality.*



0 0.5 1 km

Coordinate System:	GDA 1994 MGA Zone 56
Scale:	1:30,000 at A4
Project Number:	610.30637
Date:	11-Jul-2022
Drawn by:	NT

Watercourses
Lakes

Tahmoor South Mine Plan

Approved

Groundwater Monitoring Locations

- Deep GWL
- NSW govt monitoring
- OSP

TAHMOOR SOUTH LW S1A – S6A GROUNDWATER TECHNICAL REPORT

Thirlmere Lake Monitoring Regime

FIGURE 6 -1

H:\Projects-SLR\610-SrvSYD\610-SYD\610.30637.00000 Tahmoor Coal Extraction Plan LW101A LW06 SLR Data\01 CADGIS\GIS\61030637 Fig1 Thirlmere Lakes monitoring.mxd

6.2 Trigger Action Response Plans

A Trigger Action Response Plan has been developed for each of the aforementioned categories, namely:

- Shallow Groundwater Levels (Open standpipes and private bores): Table 6-7;
- Shallow Groundwater Pressures (VWP < 200 m): Table 6-7;
- Deep Groundwater Pressures (VWP > 200 m): Table 6-9;
- Groundwater Quality (Open standpipes and private bores): Table 6-10;
- Groundwater – Surface-water interaction: Table 6-11; and
- Groundwater Bores Monitoring for Thirlmere Lakes: Table 6-11.

Table 6-7 Trigger Action Response Plan – WMP8 Shallow Groundwater Levels (Open standpipes and private bores)

Performance Measure and Indicator, TARP Objective and Assessment Criteria	Monitoring Program	Management: Trigger	Management: Action	Management: Response
Performance Measure Feature No performance measure relevant. TARP Objective This TARP defines levels of deviation in groundwater level from 'normal' or baseline conditions and the actions to be implemented in response to each level deviation. This TARP supports TARP WMP13, where groundwater levels as they pertain to groundwater dependent ecosystems (GDEs) (Thirlmere Lakes) are covered. Assessment Criteria Bore specific trigger values based on baselines data for each reporting level.	Locations Open standpipes Existing sites: P51a, P51b, P52, REA4, P53a, P53b, P53c, P54a, P54b, P54c, P55a, P55b, P55c, P56a, P56b, P56c Proposed sites: P50a, P50b, P50c, P57a, P57b Private bores GW109257, GW104008, GW112473, GW104659, GW062068, GW105395, GW104323 All monitoring locations are shown in Figure 23 of the Water Management Plan. Monitoring Frequency Pre-mining Monthly manual measurements of water level. During Mining Monthly manual measurements of water level. Post-mining Quarterly manual measurements of water level for 12 months following the completion of LW S6A, or as required in accordance with a Rehabilitation Management Plan.	**Normal Condition**		
		• Groundwater level remains consistent with baseline variability and pre-mining trends with reductions in groundwater level less than two meters.	• Continue monitoring and review of data as per monitoring program.	• No response required.
		Level 1		
		• Greater than 2 m water level reduction[1] for a period of 6 months following the commencement of extraction.	For Private Bores and Open Standpipe Monitoring Bores • *Actions as required for Normal Condition.* • Undertake an investigation to assess cause and determine if mining related. • Undertake investigation to demonstrate if the decline will impact the long-term viability of the affected water supply works. • Discuss findings and obtain other relevant information from key specialists (e.g. subsidence monitoring results, surface water level results). The investigation will be commenced/completed as efficiently as practicable. If the changes have been confirmed to be related to mining effects: For Private Bores: • Initiate negotiations with impacts landowners as soon as practicable. Consider all reasonable and feasible options for remediation as relevant (e.g. extending the depth of the bore, establishment of additional bores, etc - as per Section 6.2.1.4 of the Water Management Plan. " For Open Standpipe Monitoring Bores • For monitoring sites relevant to Thirlmere Lakes or associated with surface water monitoring sites, initiate groundwater – surface water interaction TARP.	For Private Bores and Open Standpipe Monitoring Bores • Report trigger exceedance to DPE and key stakeholders. • Report trigger exceedance and investigation outcomes in Six Monthly Subsidence Impact Report and Annual Review. If the changes have been confirmed to be related to mining effects: For Private Bores: • Provide DPE and key stakeholders with proposed corrective management actions (CMAs) for consultation (e.g. extending the depth of the bore, establishment of additional bores, compensation to affected landowners as detailed in Section 6.2.1.4 of the Water Management Plan). • Implement CMAs, subject to land access (finalise negotiations and implement the agreed "make-good" arrangements) • Monitor and report on success of CMAs in Six Monthly Subsidence Impact Report and Annual Review.
		Level 2		
		• Water level declines below the average between the 'maximum modelled drawdown' (Level 3 trigger) and the '2 m drawdown' (Level 1 trigger)[1] for a period of greater than 6 months following the commencement of extraction. AND • The reduction in water level is determined not to be controlled by climatic or external anthropogenic factors.	For Private Bores and Open Standpipe Monitoring Bores • *Actions as stated in Level 1.* • Consider increasing monitoring and review of data at sites where Level 2 has been reached, subject to land access. Reasons for not increasing monitoring frequency could include solid identification causation that do not require further monitoring (e.g. singular anthropogenic impact resulting in water level change). • Compare against base case and deterministic model scenarios[2]. • Review Water Management Plan and modify if necessary. For Private Bores: • Review CMAs in light of findings from further investigations and consider additional reasonable and feasible options.	For Private Bores and Open Standpipe Monitoring Bores • *Responses as stated in Level 1.* • Advise DPE and key stakeholders of any required amendments to Water Management Plan. For Private Bores: • Provide findings of CMA review to DPE and key stakeholders for consultation. • Implement additional CMAs, subject to land access.
		Level 3		
		• Water level reduction greater than the maximum modelled drawdown[1] for a period of 6 months following the commencement of extraction. AND • The reduction in water level is determined not to be controlled by climatic or external anthropogenic factors.	For Private Bores and Open Standpipe Monitoring Bores • *Actions as stated in Level 2.* • Increase monitoring and review of data frequency for sites where Level 3 has been reached, subject to land access. • Undertake a detailed investigation to assess if the change in behaviour is related to mining effects (e.g. whether there has been subsidence induced fracturing, other catchment changes, effect unrelated to mining or the prevailing climate).	For Private Bores and Open Standpipe Monitoring Bores • *Responses as stated in Level 2.* For Private Bores: • Develop a Rehabilitation Management Plan in consultation with DPE and key stakeholders. • Implement Rehabilitation Management Plan, subject to land access.

Notes:
[1] Level 1, 2 and 3 triggers for water level reduction is provided in Table 6-3 in Appendix E of the Water Management Plan.
[2] "Deterministic" model scenario refers to the predictive scenario modelling utilised to determine the trigger level.

Table 6-8 Trigger Action Response Plan – WMP9 Shallow Groundwater Pressures (VWP sensors < 200 m)

Performance Measure and Indicator, TARP Objective and Assessment Criteria	Monitoring Program	Management		
		Trigger	Action	Response
Performance Measure Feature No performance measure relevant. TARP Objective This TARP defines levels of deviation in groundwater level from 'normal' or baseline conditions and the actions to be implemented in response to each level deviation. Assessment Criteria Bore specific trigger values based on baselines data for each reporting level.	Locations TBC032, TBC033, TBC009, TBC018, TBC0039 Monitoring of all VWP < 200 m depth intakes. Reference Sites: TBC024, TBC027, TBC034, TBC038 All monitoring locations are shown in Figure 23 of the Water Management Plan. Monitoring Frequency Pre-mining VWPs sensors take pressure readings hourly. The system is now telemetered so data is streamed continuously and can be accessed at any point in time. During Mining VWPs sensors take pressure readings hourly. The system is now telemetered so data is streamed continuously and can be accessed at any point in time. Post-mining Monitoring of data (streamed continuously) for 12 months following the completion of LW S6A.	**Normal Condition**		
		• No observable mining induced change at VWP intakes. • Greater than 5 m water level reduction in VWP intakes[1] following the commencement of extraction for a period of less than six months	• Continue monitoring and review of data as per monitoring program.	• No response required.
		Level 1		
		• Greater than 5 m water level reduction in VWP intakes[1] following the commencement of extraction for a period of greater than six months	• *Actions as required for Normal Condition.* • Undertake an investigation to assess cause and determine if mining related, commence/complete as soon as practicable. • Discuss findings and obtain other relevant information from key specialists (e.g. subsidence monitoring results, surface water level results).	• Report trigger exceedance to DPE and key stakeholders. • Report trigger exceedance and investigation outcomes in Six Monthly Subsidence Impact Report and Annual Review.
		Level 2		
		• Water level declines below the calculated Level 2 trigger – being the average of Level 1 (the '5 m drawdown'[1]) and Level 3 (the 'maximum modelled drawdown') – following the commencement of extraction for a period of greater than six months. AND • The reduction in water level is determined not to be controlled by climatic or external anthropogenic factors.	• *Actions as stated in Level 1.* • Review deeper VWP data at monitored sites. Determine whether additional review of data is required. Determine if review of additional existing VWP sites is required. Reasons for not increasing frequency of data review could include solid identification causation that do not require further monitoring (e.g. singular anthropogenic impact resulting in water level change). • Compare against base case and deterministic model scenarios[2]. • Review Water Management Plan and modify if necessary.	• *Responses as stated in Level 1.* • Advise DPE and key stakeholders of any required amendments to Water Management Plan.
		Level 3		
		• Water level reduction greater than the maximum modelled drawdown[1] following the commencement of extraction for a period of greater than six months. AND • The reduction in water level is determined not to be controlled by climatic or external anthropogenic factors.	• *Actions as stated in Level 2.* • Increase review of data frequency for sites where Level 3 has been reached. • Undertake a detailed investigation to assess if the change in behaviour is related to mining effects (e.g. whether there has been subsidence induced fracturing, other catchment changes, effect unrelated to mining or the prevailing climate). Commence/complete as soon as practicable • Undertake investigative to review model results in conjunction with field data.	• *Responses as stated in Level 2.*

Notes:
[1] Level 1, 2 and 3 triggers for water level reduction is provided in Table 6-4 in Appendix E of the Water Management Plan).
[2] "Deterministic" model scenario refers to the predictive scenario modelling utilised to determine the trigger level.

Table 6-9 Trigger Action Response Plan – WMP10 Groundwater level/pressure Deep VWPs (> 200 m)

Performance Measure and Indicator, TARP Objective and Assessment Criteria	Monitoring Program	Management – Trigger	Management – Action	Management – Response
<u>Performance Measure Feature</u> No performance measure relevant. <u>TARP Objective</u> This TARP defines levels of deviation in groundwater level from 'normal' or baseline conditions and the actions to be implemented in response to each level deviation. <u>Assessment Criteria</u> Bore specific trigger values based on modelled data for each reporting level. Model layers utilised to define predicted drawdown for each VWP logger provided in Table below.	<u>Locations</u> TBC009, TBC0018, TBC020, TBC026, TBC032, TBC033, TBC039 Reference sites: TBC024, TBC027, TBC034, TBC038 Monitoring of all VWP > 200 m depth intakes excluding those monitoring the Bulli Coal Seam. All monitoring locations are shown in Figure 23 of the Water Management Plan. <u>Monitoring Frequency</u> Pre-mining VWPs sensors take pressure readings hourly. The system is now telemetered so data is streamed continuously and can be accessed at any point in time. During Mining VWPs sensors take pressure readings hourly. The system is now telemetered so data is streamed continuously and can be accessed at any point in time. Post-mining Monitoring of data (streamed continuously) for 12 months following the completion of LW S6A.	**Normal Condition**		
		• Observed data does not exceed modelled impacts predicted drawdown by greater than 30 metres[1]. • Observed drawdown exceeds the modelled predicted drawdown[1], by greater than 30 metres for of less than three consecutive months	• Continue monitoring and review of data as per monitoring program.	• No response required.
		Level 1		
		• Observed drawdown exceeds the modelled predicted drawdown[1], by greater than 30 metres for greater than three consecutive months.	• *Actions as required for Normal Condition.* • Undertake an investigation to assess cause and determine if mining related, to be commenced/completed as soon as practicable. • Discuss findings and obtain other relevant information from key specialists (e.g. subsidence monitoring results, surface water level results).	• Report trigger exceedance to DPE and key stakeholders. • Report trigger exceedance and investigation outcomes in Six Monthly Subsidence Impact Report and Annual Review.
		Level 2		
		• Observed drawdown is exceeds modelled predicted drawdown[1], by more than 30 metres greater than 6 consecutive months. •	• *Actions as stated in Level 1.* • Determine suitability of increasing frequency of data review at sites where Level 2 has been reached. Reasons for not increasing monitoring frequency could include solid identification causation that do not require further monitoring (e.g. singular anthropogenic impact resulting in water level change). • Review data in conjunction with VWP data from additional existing VWP sites. • Compare against base case and deterministic model scenarios[2]. • Review Water Management Plan and modify if necessary.	• *Responses as stated in Level 1.* • Inclusion of more regional VWPs into data review to determine likely extent and depth of depressurisation. • Advise DPE and key stakeholders of any required amendments to Water Management Plan.
		Level 3		
		• Observed drawdown exceeds modelled predicted drawdown[1] by 30 m, for 12 consecutive months or more.	• *Actions as stated in Level 2.* • Increase review of data frequency for sites where Level 3 has been reached. • Undertake a detailed investigation to assess if the change in behaviour is related to mining effects (e.g. whether there has been subsidence induced fracturing, other catchment changes, effect unrelated to mining or the prevailing climate). To be commenced/completed as soon as practicable. • Review base case and deterministic model scenarios[2] in conjunction with water pressure data and report findings.	• *Responses as stated in Level 2.*

Notes:
[1] Predicted drawdown refers to the drawdown as generated by the groundwater model and varies over time as extraction progresses. Observed drawdown will be plotted on a monthly basis against the predicted drawdown to determine if a trigger has occurred. Therefore, as the predicted drawdown will be constantly changing according to extraction progression, it is not possible to set a specific trigger limit.
[2] "Deterministic" model scenario refers to the predictive scenario modelling utilised to determine the trigger level.

Sensor	Model Layer	Model Geology
TBC09_322	8	BUSS Mid
TBC09_343	8	BUSS Mid
TBC09_357	12	SBSS Lower
TBC09_381	10	SPCS
TBC09_391	15	Bulli Seam
TBC09_397	17	Wongawilli
TBC18_282	8	BUSS Mid
TBC18_366	8	BUSS Mid

Sensor	Model Layer	Model Geology
TBC26_344	8	BUSS Mid
TBC26_409	13	WBCS
TBC26_432	15	Bulli Seam
TBC26_440	16	Eckersley
TBC26_460	16	Eckersley
TBC32_200	8	BUSS Mid
TBC32_237	8	BUSS Mid
TBC32_257	8	BUSS Mid

TBC18_377	13	WBCS		TBC32_294	8	BUSS Mid
TBC18_404	15	Bulli Seam		TBC32_314	8	BUSS Mid
TBC18_426	17	Wongawilli		TBC33_247	8	BUSS Mid
TBC18_432	17	Wongawilli		TBC33_306	8	BUSS Mid
TBC20_211	8	BUSS Mid		TBC33_363	11	SBSS Upper
TBC20_293	8	BUSS Mid		TBC33_384	16	Eckersley
TBC20_375	8	BUSS Mid		TBC33_408	16	Eckersley
TBC20_397	13	WBCS		TBC39_243	8	BUSS Mid
TBC20_411	7	BUSS Upper		TBC39_299	8	BUSS Mid
TBC20_434	17	Wongawilli		TBC39_354	11	SBSS Upper
TBC20_439	4	HBSS Mid		TBC39_375	16	Eckersley
TBC26_211	8	BUSS Mid		TBC39_402	16	Eckersley
TBC26_278	8	BUSS Mid				

Table 6-10 Trigger Action Response Plan – WMP11 Groundwater Quality (open standpipes and private bores)

<table>
<tr><th rowspan="2">Performance Measure and Indicator, TARP Objective and Assessment Criteria</th><th rowspan="2">Monitoring Program</th><th colspan="3">Management</th></tr>
<tr><th>Trigger</th><th>Action</th><th>Response</th></tr>
<tr><td rowspan="6">Performance Measure Feature
No performance measure relevant.

TARP Objective
This TARP defines levels of deviation in groundwater level from ‘normal’ or baseline conditions and the actions to be implemented in response to each level deviation.
This TARP supports TARP WMP13, where groundwater quality as it pertains to groundwater dependent ecosystems (GDEs) (Thirlmere Lakes) is covered.

Assessment Criteria
Bore specific trigger values based on baselines data for each reporting level.</td><td rowspan="6">Locations
Open standpipes
Existing sites:
P51a, P51b, P52, REA4, P53a, P53b, P53c, P54a, P54b, P55a, P55b, P55c, P56a, P56b, P56c

Proposed sites:
P50a, P50b, P50c, P57a, P57b

Private bores
GW109257, GW104008, GW112473, GW104659, GW062068, GW105395, GW104323

All monitoring locations are shown in Figure 23 of the Water Management Plan.

Monitoring Frequency
Pre-mining
Monthly water quality sampling.

During Mining
Monthly water quality sampling

Post-mining
Quarterly water quality sampling.

Water Quality sample parameters:
Field Parameters
PH
EC
TDS
DO
Laboratory Analysis</td><td colspan="3">Normal Condition</td></tr>
<tr><td>• No observable changes in salinity, pH or metals outside of the baseline variability.</td><td>• Continue monitoring and review of data as per monitoring program.</td><td>• No response required.</td></tr>
<tr><td colspan="3">Level 1</td></tr>
<tr><td>• Observed salinity and/or metals or pH outside of defined trigger levels[1] for 3 consecutive months or more. The effect does not persist after a significant rainfall recharge event.
AND
• A similar trend or response is noted at other monitored bores or private groundwater bores.</td><td>For Private Bores and Open Standpipe Monitoring Bores
• Actions as required for Normal Condition.
• Undertake an investigation to assess cause and determine if mining related.
• Undertake investigation to demonstrate if the change in quality will impact the long-term viability of the affected water supply works.
• Discuss findings and obtain other relevant information from key specialists (e.g. subsidence monitoring results, surface water level results).
If the changes have been confirmed to be related to mining effects:
For Private Bores:
• Initiate negotiations with impacted landholders as soon as practicable. Consider all reasonable and feasible options for remediation as relevant. This could include potential for implementation of make-good provisions as per Section 6.2.1.4 of the Water Management Plan for affected private bore owners (e.g. provision of access to an alternative source of water).
For Open Standpipe Monitoring Bores
• For monitoring sites relevant to Thirlmere Lakes or associated with surface water monitoring sites, initiate groundwater – surface water interaction TARP.</td><td>For Private Bores and Open Standpipe Monitoring Bores
• Report trigger exceedance to DPE and key stakeholders.
• Report trigger exceedance and investigation outcomes in Six Monthly Subsidence Impact Report and Annual Review.
If the changes have been confirmed to be related to mining effects:
For Private Bores:
• Provide DPE and key stakeholders with proposed corrective management actions (CMAs) for consultation (e.g. provision of access to an alternative source of water as detailed in Section 6.2.1.4 of the Water Management Plan).
• Implement CMAs, subject to land access.
• Monitor and report on success of CMAs in Six Monthly Subsidence Impact Report and Annual Review.</td></tr>
<tr><td colspan="3">Level 2</td></tr>
<tr><td>• Observed salinity and/or metals or pH outside of defined trigger levels[1], for 3 consecutive months or more. The effect persists after a significant rainfall recharge event.
AND
• The change in water quality is determined not to be controlled by climatic or external anthropogenic factors.</td><td>For Private Bores and Open Standpipe Monitoring Bores
• Actions as stated in Level 1.
• Consider increasing monitoring and review of data at sites where Level 2 has been reached, subject to land access. Reasons for not increasing monitoring frequency could include solid identification causation that do not require further monitoring (e.g. singular anthropogenic impact resulting in water quality change).
• Review Water Management Plan and modify if necessary.</td><td>For Private Bores and Open Standpipe Monitoring Bores
• Responses as stated in Level 1.
• Advise DPE and key stakeholders of any required amendments to Water Management Plan.
For Private Bores:
• Provide findings of CMA review to DPE and key stakeholders for consultation.
• Implement additional CMAs, subject to land access.</td></tr>
</table>

	Total alkalinity as CaCO3, HCO3, CO3, DOC Dissolved Major Cations (Ca, K, Na, Mg, F, Cl, SO4) Dissolved Metals (Al, As, Ba, Co, Cu, Pb, Li, Mn, Ni, Se, Sr, Zn, Fe) Total Metals (Al, As, Ba, Co, Cu, Pb, Li, Mn, Ni, Se, Sr, Zn, Fe) Total Nitrogen Total Phosphorus Ionic Balance (Total Anions and Total Cations)		For Private Bores: • Review CMAs in light of findings from further investigations and consider additional reasonable and feasible options.	
		Level 3		
		• Observed salinity and/or metals or pH outside of defined trigger levels[1], for greater than 6 consecutive months. AND • The change in water quality is determined not to be controlled by climatic or external anthropogenic factors.	For Private Bores and Open Standpipe Monitoring Bores • *Actions as stated in Level 2.* • Increase monitoring and review of data frequency for sites where Level 3 has been reached, subject to land access. • Undertake a detailed investigation to assess if the change in behaviour is related to mining effects (e.g. whether there has been subsidence induced fracturing, other catchment changes, effect unrelated to mining or the prevailing climate). • Undertake investigative report to demonstrate if the water quality change will impact the long-term viability of any affected water supply works.	Private Bores and Open Standpipe Monitoring Bores • *Responses as stated in Level 2.* For Private Bores: If ascertained impact is due to mining activities and has potential to impact long-term viability of supply for private groundwater bores: • Develop a Rehabilitation Management Plan in consultation with DPE and landowner. • Implement Rehabilitation Management Plan, subject to land access.
Notes: [1] Defined trigger levels for groundwater quality are listed in Table 6-5 of Appendix E of the Water Management Plan.				

Table 6-11 Trigger Action Response Plan – WMP12 Groundwater – surface water Interaction

Performance Measure and Indicator, TARP Objective and Assessment Criteria	Monitoring Program	Management		
		Trigger	Action	Response
<u>Performance Measure Feature</u> No performance measure relevant. <u>TARP Objective</u> This TARP defines levels of deviation in surface water - groundwater interactions from 'normal' conditions and the actions to be implemented in response to each level deviation. The instigation of this TARP will be dictated by triggers exceedances in pertinent groundwater or surface water sites requiring further investigation of groundwater – surface water interactions. Where groundwater – surface water connectivity indicates in a gaining stream, there is potential for groundwater supporting riparian vegetation. Consequently, Riparian vegetation in these situations could be a Groundwater Dependent Ecosystem (GDE), and the pertinent Performance Measure applicable: Negligible impacts including: • Negligible change in groundwater levels; and • Negligible change in groundwater quality. Riparian GDEs are addressed through the Riparian Vegetation TARP (BMP3). Consultation through the ERG will link this TARP (WMP12) to BMP3 via actions in BMP3 to consider groundwater – surface water relationships when pertinent. <u>Assessment Criteria</u>	<u>Locations</u> Open standpipes P51a, P51b, P52, REA4, P53a, P53b, P53c P54a, P54b, P54c, P55a, P55b, P55c The aligned surface water and groundwater sites are as follows: • P51a, P51b with surface water site BR2-Qla • P52, REA4 with surface water site-TT14-QLa • P53a, P53b, P53c with surface water site-TT14-Qla • P54a, P54b, P54c with surface water site TT3-QLa • P55a, P55b, P55c with surface water site TT1-QRLa All monitoring locations are shown in Figure 23 of the Water Management Plan. <u>Monitoring Frequency</u> Pre-mining Monthly manual measurements of water level and water quality. During Mining Monthly manual measurements of water level and water quality. Post-mining	**Normal Condition**		
		• Observed (or inferred where not immediately neighbouring a surface water site) groundwater and surface water interaction remains consistent with baseline variability and/pre-mining trends, and decrease in groundwater inflow not persisting after significant rainfall recharge events.	• Continue monitoring and review of data as per monitoring program.	• No response required.
		Level 1		
		• Observed (or inferred where not immediately neighbouring a surface water site) groundwater levels at surface water monitoring site decline below Level 1 (in TARP WMP8) following the commencement of extraction.	• *Actions as required for Normal Condition.* • Undertake an investigation to assess cause and determine if mining related. • Discuss findings and obtain other relevant information from key specialists (e.g. subsidence monitoring results, surface water level results).	• Report trigger exceedance to DPE and key stakeholders. • Report trigger exceedance and investigation outcomes in Six Monthly Subsidence Impact Report and Annual Review. If the changes have been confirmed to be related to mining effects: • Provide DPE and key stakeholders with proposed corrective management actions (CMAs) for consultation (e.g. extending the depth of the bore, establishment of additional bores, compensation to affected landowners as detailed in Section 6.2.1.4 of the Water Management Plan). • Implement CMAs, subject to land access. • Monitor and report on success of CMAs in Six Monthly Subsidence Impact Report and Annual Review.
		Level 2		
		• Observed (or inferred where not immediately neighbouring a surface water site) groundwater levels at aligned surface water monitoring site decline below Level 2 (in TARP WMP8) following the commencement of extraction. AND • The reduction in water level is determined not to be controlled by climatic or external anthropogenic factor.	• *Actions as stated in Level 1.* • Increase frequency of data review to fortnightly at sites where Level 2 has been reached, subject to land access. Reasons for not increasing frequency could include solid identification causation that do not require further monitoring (e.g. singular anthropogenic impact resulting in water level change). • Compare against base case and deterministic model scenarios[1]. • Review manual water level measurements for additional monitoring sites to identify potential spatial trends in water level decline. • Review surface water data to assess for surface water level decline at relevant site.	• *Responses as stated in Level 1.* • Provide findings of CMA review to DPE and key stakeholders for consultation. • Implement additional CMAs, subject to land access. • Advise DPE and key stakeholders of any required amendments to Water Management Plan, including reporting on relationship of observations to baseline and deterministic model scenarios, as necessary.

Bore specific trigger values based on baselines data for each reporting level. For this TARP, the aligned groundwater and surface water sites would be considered collectively to interpret potential changes/impacts to groundwater – surface water interaction.	Quarterly manual measurements of water level for 12 months following the completion of LW S6A, or as required in accordance with a Rehabilitation Management Plan.		• Review CMAs in light of findings from further investigations and consider additional reasonable and feasible options. • Review Water Management Plan and modify if necessary.	
		Level 3		
		• Inferred groundwater levels at surface water monitoring site decline below Level 3 (in TARP WMP8) following the commencement of extraction. AND • The reduction in water level is determined not to be controlled by climatic or external anthropogenic factor.	• *Actions as stated in Level 2.* • Increase frequency of data review for sites where Level 3 has been reached, subject to land access. • Undertake a detailed investigation to assess if the change in behaviour is related to mining effects (e.g. whether there has been subsidence induced fracturing, other catchment changes, effect unrelated to mining or the prevailing climate). Report to be commenced and completed as soon as practicable.	• *Responses as stated in Level 2.* • Develop a Rehabilitation Management Plan in consultation with DPE and key stakeholders. • Implement Rehabilitation Management Plan, subject to land access.

Notes:
[1] "Deterministic" model scenario refers to the predictive scenario modelling utilised to determine the trigger level.

Table 6-12 Trigger Action Response Plan – WMP13 Groundwater Bore Monitoring for Thirlmere Lakes

<table>
<tr><th rowspan="2">Performance Measure and Indicator, TARP Objective and Assessment Criteria</th><th rowspan="2">Monitoring Program</th><th colspan="3">Management</th></tr>
<tr><th>Trigger</th><th>Action</th><th>Response</th></tr>
<tr><td rowspan="8"><u>Performance Measure Feature</u>
GDEs including Thirlmere Lakes[1].

<u>Performance Measure</u>
Negligible impacts including:
• Negligible change in groundwater levels; and
• Negligible change in groundwater quality.

<u>Performance Indicator</u>
The performance measure will be considered to be exceeded if the groundwater levels or groundwater quality decline below Level 3 (in the relevant groundwater TARP triggers for water level and water quality – TARP WMP8 or WMP11) following the commencement of extraction, and the investigation outcomes indicate a mining related impact based on monitoring data for the Thirlmere Lakes.

<u>TARP Objective</u>
This TARP defines levels of deviation at Thirlmere Lakes from ‘normal’ conditions and the actions to be implemented in response to each level deviation.

<u>Assessment Criteria</u>
Bore specific trigger values based on baselines data for each reporting level.</td><td rowspan="8"><u>Locations</u>
“Early warning” bores
Existing sites:
GW062068, GW104659, TBC039 (sensor at 65 metres in Hawkesbury Sandstone (HBSS))
Proposed sites:
P50a, P50b, P50c

Thirlmere Lakes bores (not trigger bores)
Existing sites:
GW075409–1, GW075409–2, GW075410, GW075411 (paired with gauging station 212066)

All monitoring locations are shown in Figure 23 of the Water Management Plan.

<u>Monitoring Frequency (for “early warning” bores)</u>
Pre-mining
Monthly manual measurements of water level and water quality.

During Mining
Monthly manual measurements of water level and water quality.

Post-mining
Quarterly manual measurements of water level for 12 months following the completion of LW S6A, or as required in accordance with a Rehabilitation Management Plan.

Water Quality sample parameters:
Field Parameters
PH
EC
TDS
DO
Laboratory Analysis
Total alkalinity as CaCO3, HCO3, CO3, DOC
Dissolved Major Cations (Ca, K, Na, Mg, F, Cl, SO4)
Dissolved Metals (Al, As, Ba, Co, Cu, Pb, Li, Mn, Ni, Se, Sr, Zn, Fe)
Total Metals (Al, As, Ba, Co, Cu, Pb, Li, Mn, Ni, Se, Sr, Zn, Fe)
Total Nitrogen
Total Phosphorus
Ionic Balance (Total Anions and Total Cations)</td><td colspan="3">Normal Condition</td></tr>
<tr><td>• Groundwater levels and quality remain consistent with baseline variability and/pre-mining trends, and changes in groundwater levels/quality not persisting after significant rainfall recharge events.</td><td>• Continue monitoring and review of data as per monitoring program.</td><td>• No response required.</td></tr>
<tr><td colspan="3">Level 1</td></tr>
<tr><td>• Level 1 trigger of TARP WMP8 for a minimum of two “early warning” bores.
OR
• Level 1 trigger of TARP WMP11 for a minimum of two “early warning” bores.</td><td>• Actions as required for Normal Condition.
• Undertake an investigation to assess cause and determine if mining related.
• Discuss findings and obtain other relevant information from key specialists (e.g. subsidence monitoring results, surface water level results).
If the changes have been confirmed to be related to mining effects:
• Consider all reasonable and feasible options for remediation as relevant (e.g. extending the depth of the bore, establishment of additional bores). This could include potential for implementation of make-good provisions as per Section 6.2.1.4 of the Water Management Plan for affected private bore owners.
• For monitoring sites relevant to Thirlmere Lakes or associated with surface water monitoring sites, initiate groundwater – surface water interaction TARP.</td><td>• Report trigger exceedance to DPE and key stakeholders.
• Report trigger exceedance and investigation outcomes in Six Monthly Subsidence Impact Report and Annual Review.
If the changes have been confirmed to be related to mining effects:
• Provide DPE and key stakeholders with proposed corrective management actions (CMAs) for consultation (e.g. extending the depth of the bore, establishment of additional bores, compensation to affected landowners as detailed in Section 6.2.1.4 of the Water Management Plan).
• Implement CMAs, subject to land access.
• Monitor and report on success of CMAs in Six Monthly Subsidence Impact Report and Annual Review.</td></tr>
<tr><td colspan="3">Level 2</td></tr>
<tr><td>• Level 2 trigger of TARP WMP8 for a minimum of three bores “early warning” bores
OR
• Level 2 trigger of TARP WMP11 for a minimum of three bores (“early warning” bores and Thirlmere Lakes bores).</td><td>• Actions as stated in Level 1.
If the changes have been confirmed to be related to mining effects:
• Consider increasing monitoring and review of data at sites where Level 2 has been reached, subject to land access. Reasons for not increasing monitoring frequency could include solid identification causation that do not require further monitoring (e.g. singular anthropogenic impact resulting in water level change).
Review Thirlmere Lakes monitoring bore data
• Compare against base case and deterministic model scenarios[2].
• Review manual water level measurements for additional monitoring sites to identify potential spatial trends in water level decline.
• Review surface water data to assess for surface water level decline at relevant site.
• Review CMAs in light of findings from further investigations and consider additional reasonable and feasible options.
• Review Water Management Plan and modify if necessary.
• Undertake an investigation to determine if an exceedance of the performance measure is likely. To be commenced/completed as soon as practicable.</td><td>• Responses as stated in Level 1.
• Provide findings of CMA review to DPE and key stakeholders for consultation.
• Implement additional CMAs, subject to land access.
• Advise DPE and key stakeholders of any required amendments to Water Management Plan.
• If relevant, notify DAWE of any predictions of an exceedance of a performance measure within two business days.</td></tr>
<tr><td colspan="3">Exceeds Performance Measure</td></tr>
<tr><td>• Level 3 trigger of TARPs WMP8 for a minimum of four bores “early warning” bores)
OR
• Level 3 trigger of TARPs WMP11 for a minimum of four bores (“early warning” bores and Thirlmere Lakes bores).
AND
• Review of Thirlmere Lakes bores indicated potential impacts resulting from extraction</td><td>• Actions as stated in Level 2.
If the changes have been confirmed to be related to mining effects:
• Increase monitoring and review of data frequency for sites where Level 3 has been reached, subject to land access.
• Investigate reasons for the performance measure exceedance. To be commenced/completed as soon as practicable.
• Review predictions of subsidence impacts and environmental consequences associated with further longwall extraction based on the outcomes of the investigation.</td><td>• Responses as stated in Level 2.
• Submit a report to DPE (in accordance with Condition E4 of SSD 8445) within 14 days of the exceedance occurring (or other timeframe agreed by DPE) describing remediation options and any preferred remediation measures or other course of action.
• Implement any reasonable remediation measures as directed by DPE, subject to land access.
• Notify DAWE of any detection or predictions of an exceedance of a performance measure within two business days.</td></tr>
</table>

			• Consider modifying mine plan.	• Submit an Impact Response Plan to DAWE (in accordance with Condition 11 of the DAWE Consent for the Tahmoor South Project). • Update numerical groundwater model and re-run predictive scenarios to determine the likely extent and depth of depressurisation in the vicinity of Thirlmere Lakes, and to determine whether any additional management actions are required such as modifying the mine plan

Notes:
[1] It is noted that the only Groundwater Dependent Ecosystem (GDE) pertinent to the Tahmoor South Project is that of Thirlmere Lakes[2] "Deterministic" model scenario refers to the predictive scenario modelling utilised to determine the trigger level.

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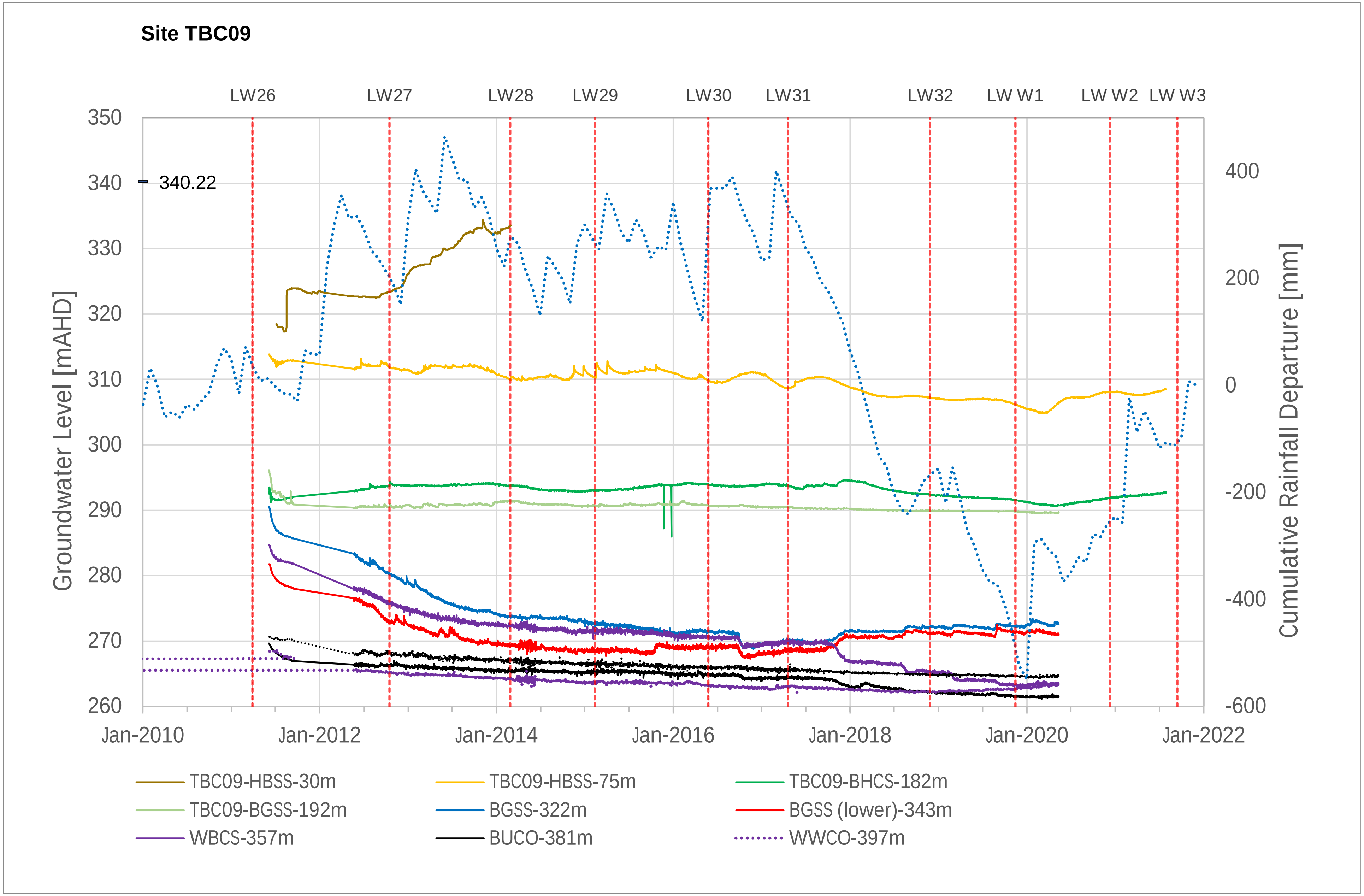
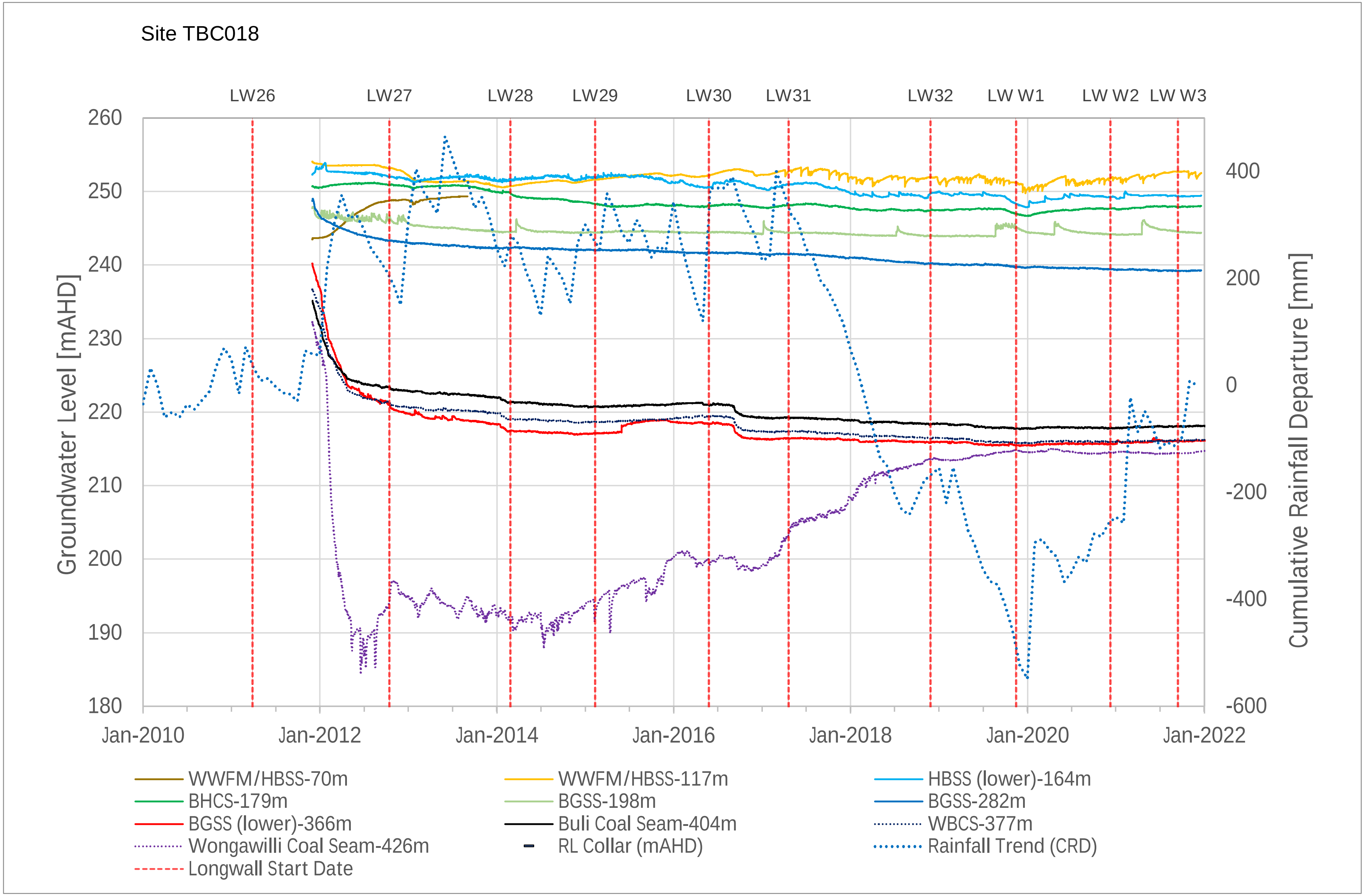
APPENDIX A

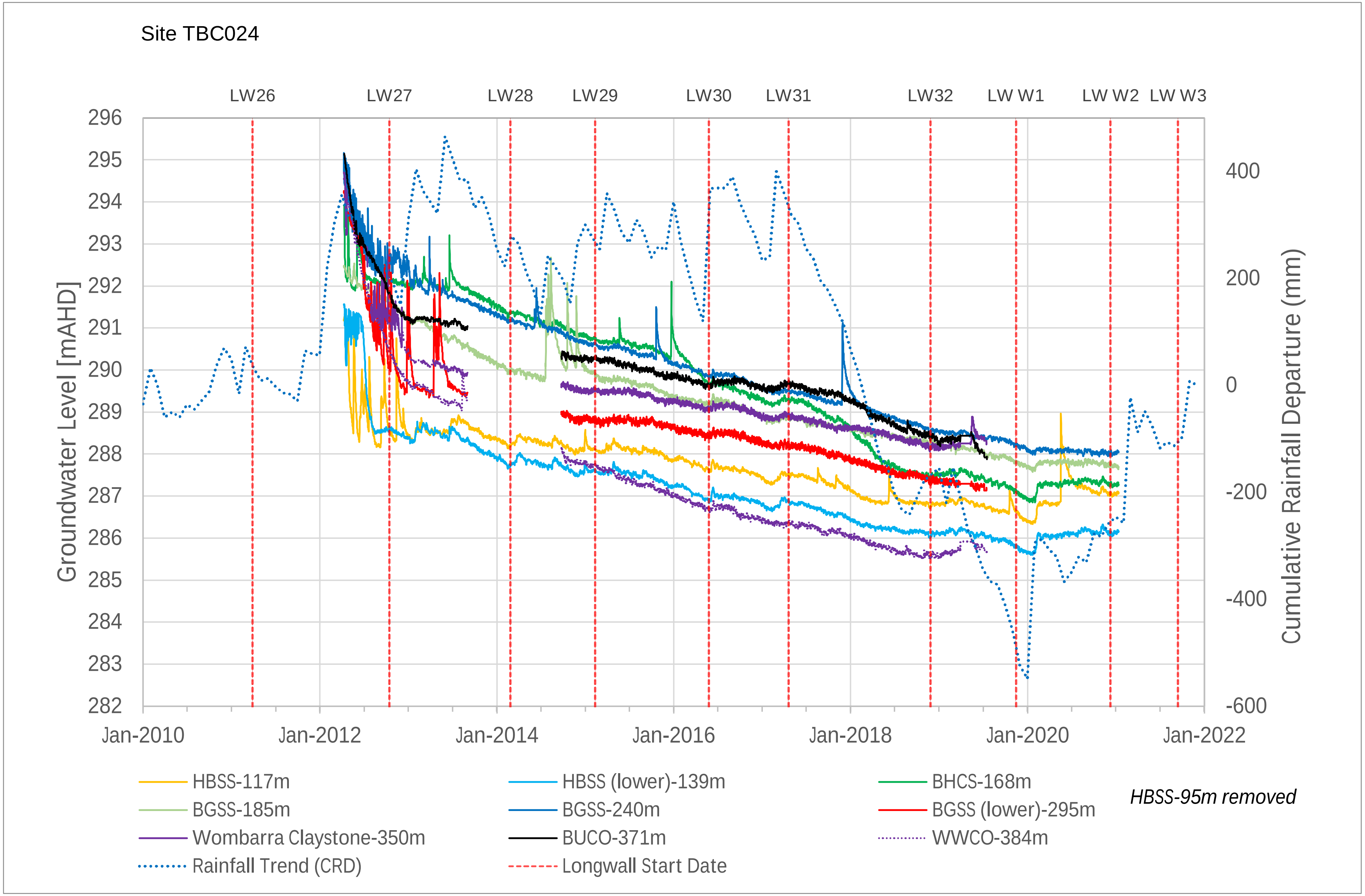
Vibrating Wire Piezometers Hydrographs



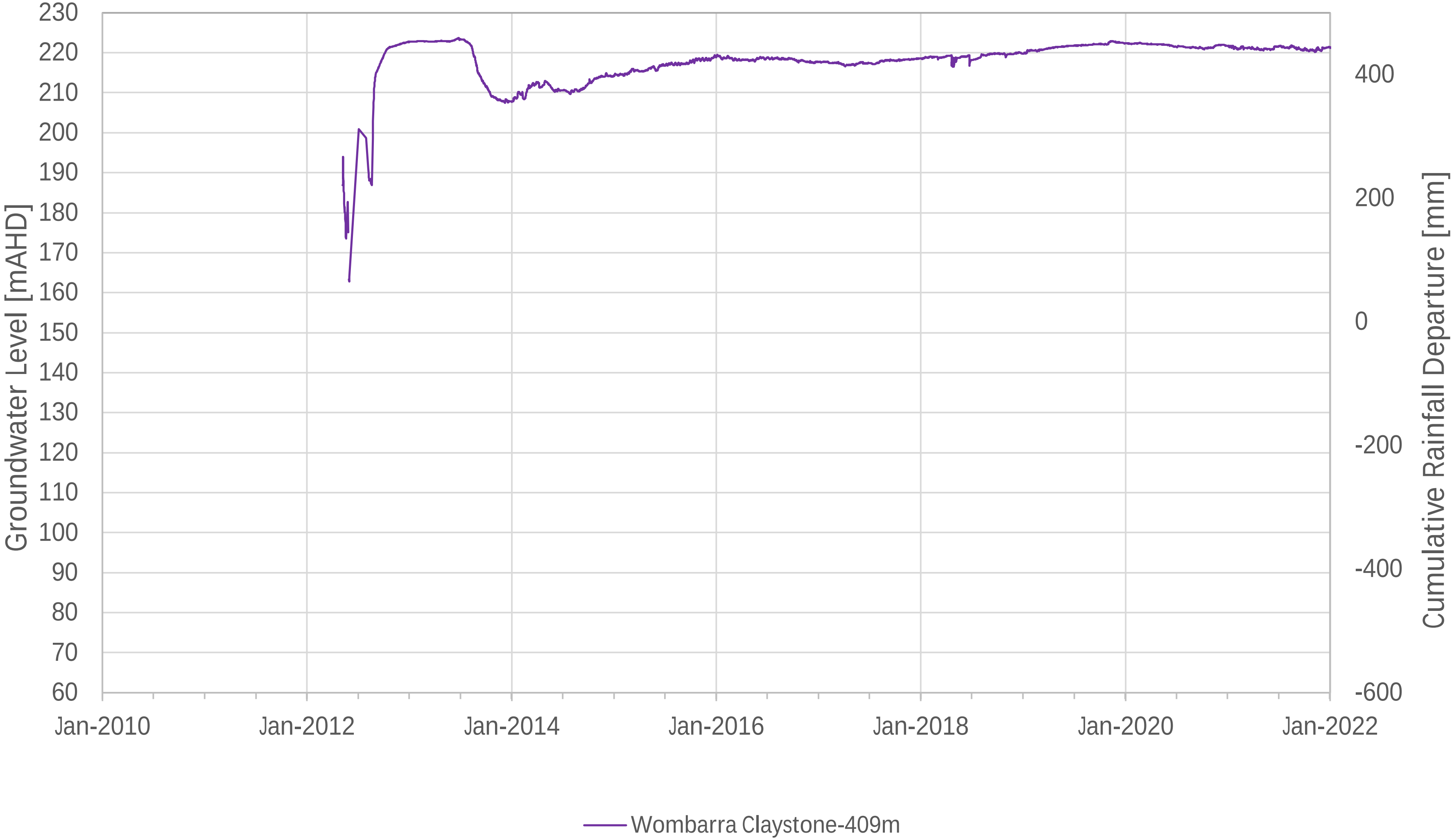
Site TBC09
LW26
LW27
LW28
LW29
LW30
LW31
LW32
LW W1
LW W2
LW W3
340.22
Groundwater Level [mAHD]
Cumulative Rainfall Departure [mm]
350
340
330
320
310
300
290
280
270
260
400
200
0
-200
-400
-600
Jan-2010
Jan-2012
Jan-2014
Jan-2016
Jan-2018
Jan-2020
Jan-2022
TBC09-HBSS-30m
TBC09-HBSS-75m
TBC09-BHCS-182m
TBC09-BGSS-192m
BGSS-322m
BGSS (lower)-343m
WBCS-357m
BUCO-381m
WWCO-397m



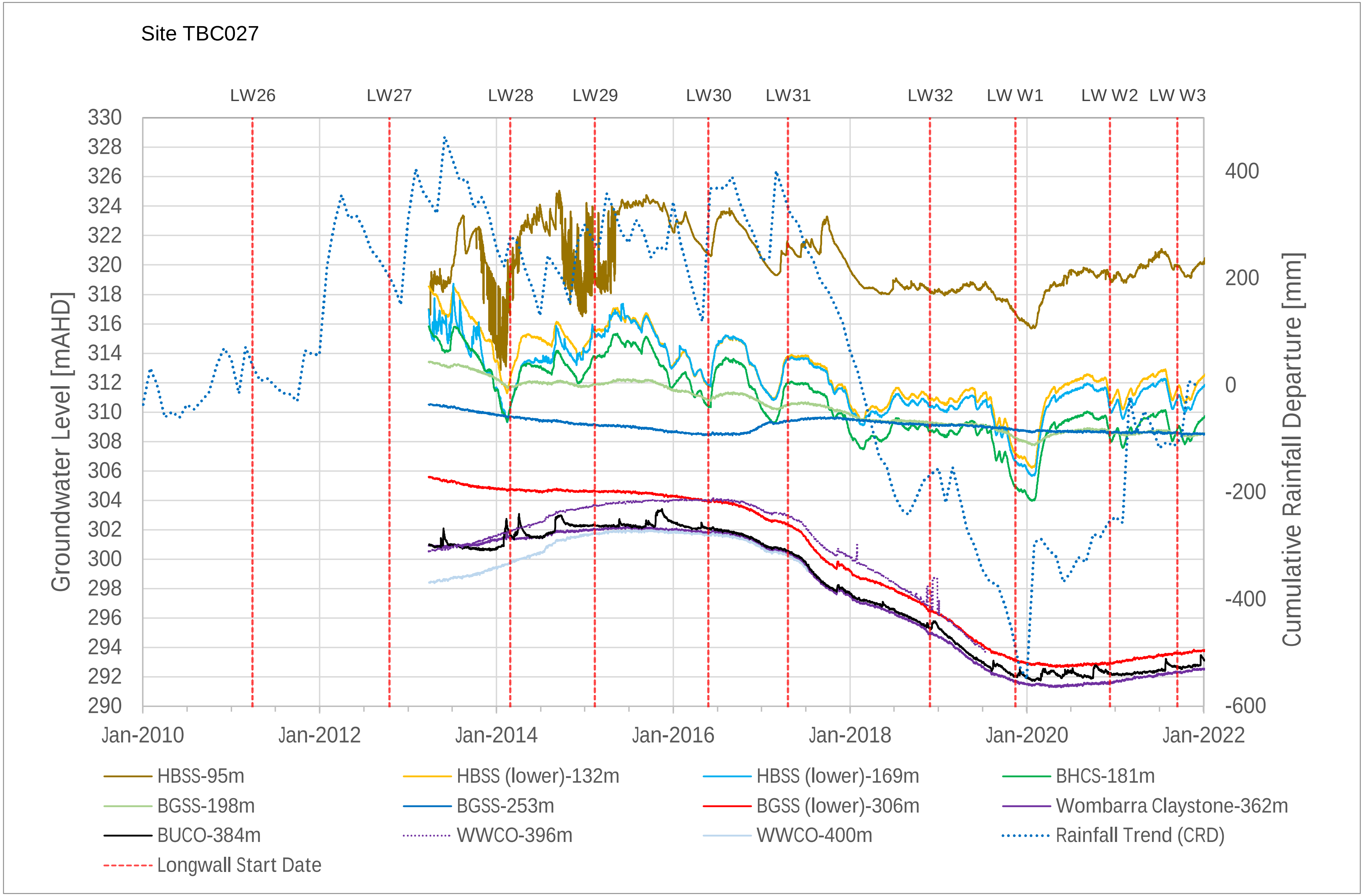
Site TBC018
LW26
LW27
LW28
LW29
LW30
LW31
LW32
LW W1
LW W2
LW W3
260
250
240
230
220
210
200
190
180
Groundwater Level [mAHD]
400
200
0
-200
-400
-600
Cumulative Rainfall Departure [mm]
Jan-2010
Jan-2012
Jan-2014
Jan-2016
Jan-2018
Jan-2020
Jan-2022
WWFM/HBSS-70m
WWFM/HBSS-117m
HBSS (lower)-164m
BHCS-179m
BGSS-198m
BGSS-282m
BGSS (lower)-366m
Buli Coal Seam-404m
WBCS-377m
Wongawilli Coal Seam-426m
RL Collar (mAHD)
Rainfall Trend (CRD)
Longwall Start Date

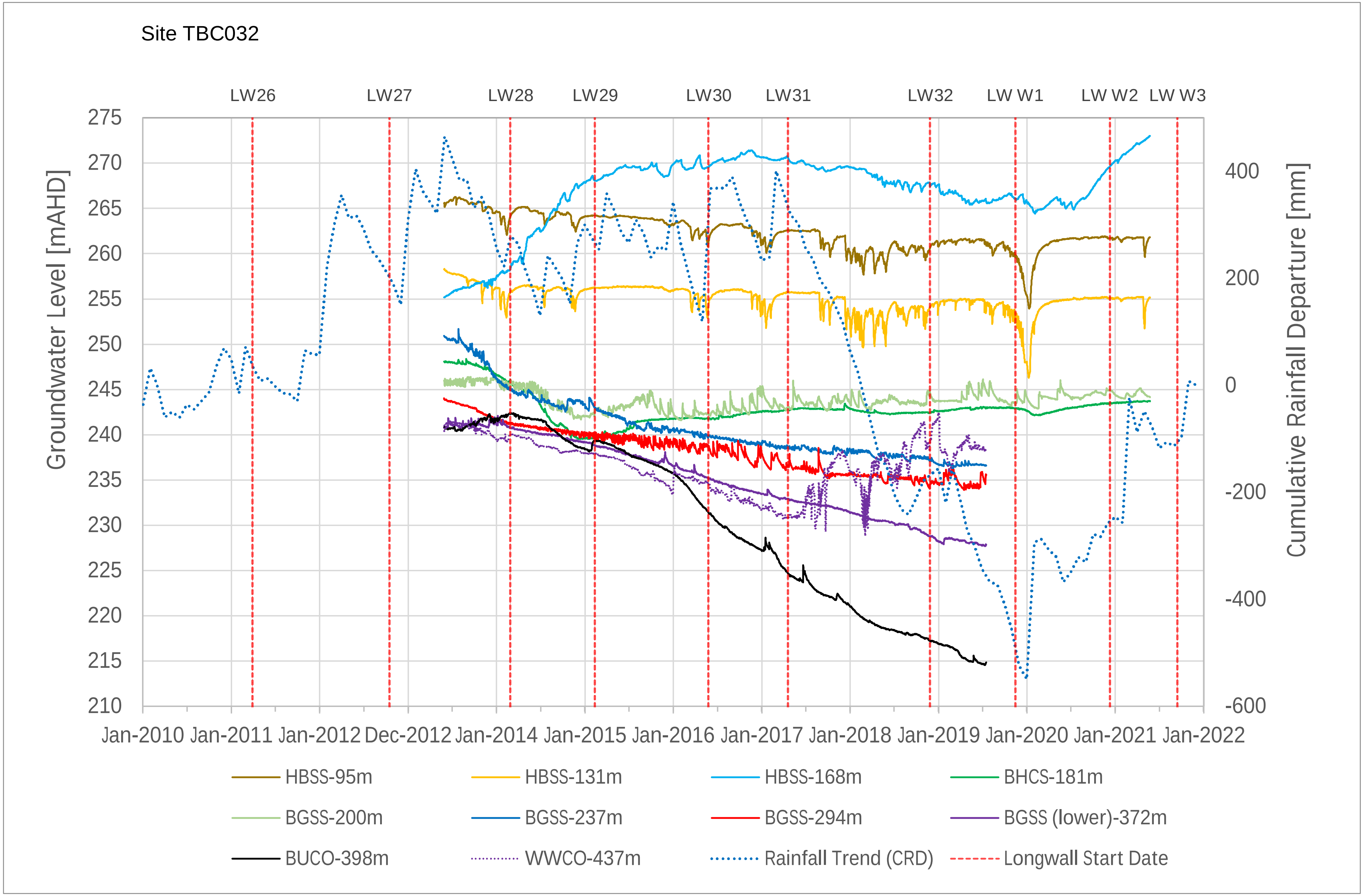

Site TBC024
LW26
LW27
LW28
LW29
LW30
LW31
LW32
LW W1
LW W2
LW W3
Groundwater Level [mAHD]
296
295
294
293
292
291
290
289
288
287
286
285
284
283
282
Cumulative Rainfall Departure (mm)
400
200
0
-200
-400
-600
Jan-2010
Jan-2012
Jan-2014
Jan-2016
Jan-2018
Jan-2020
Jan-2022
HBSS-117m
HBSS (lower)-139m
BHCS-168m
BGSS-185m
BGSS-240m
BGSS (lower)-295m
Wombarra Claystone-350m
BUCO-371m
WWCO-384m
Rainfall Trend (CRD)
Longwall Start Date
HBSS-95m removed

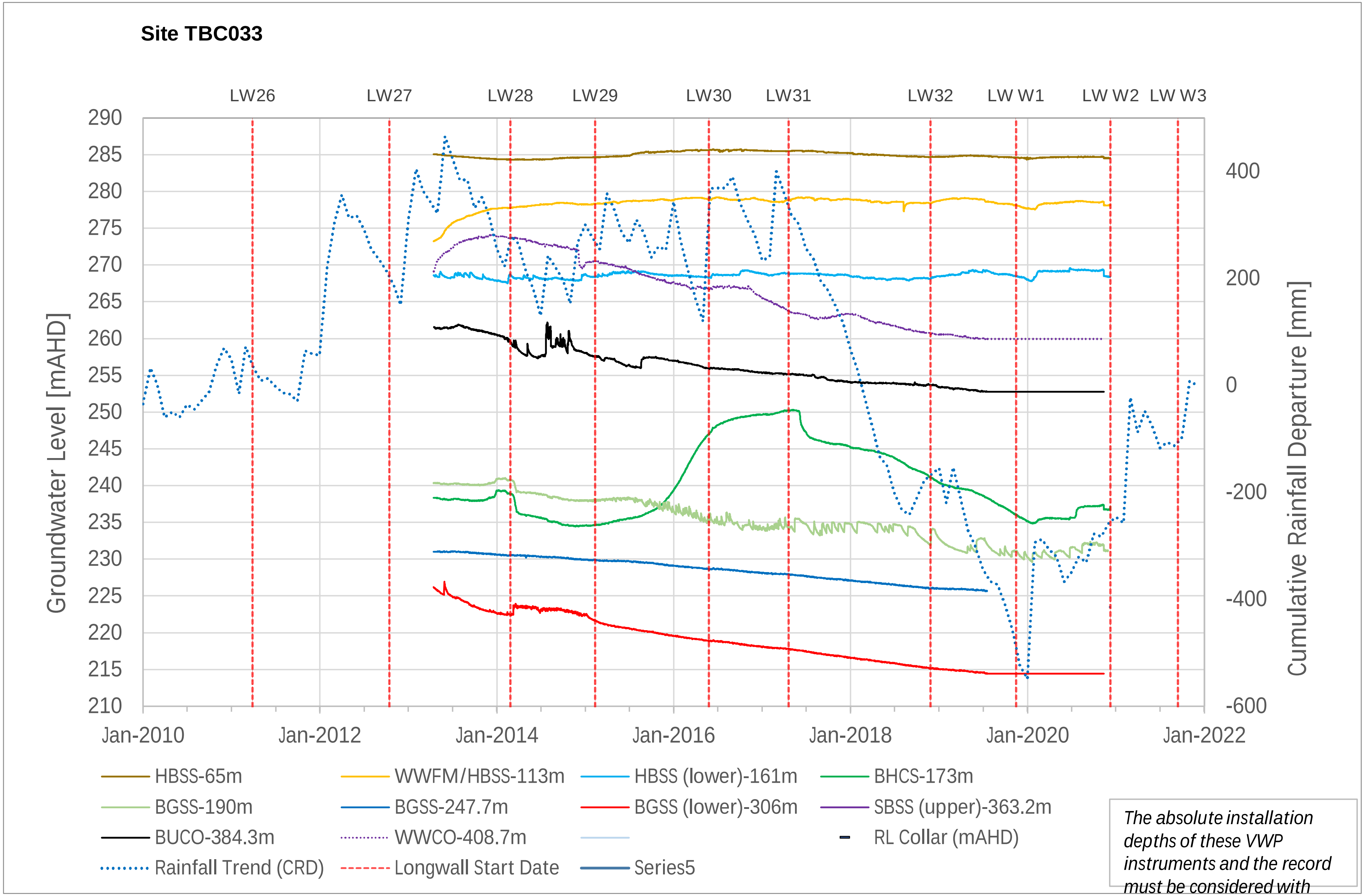
Site TBC026



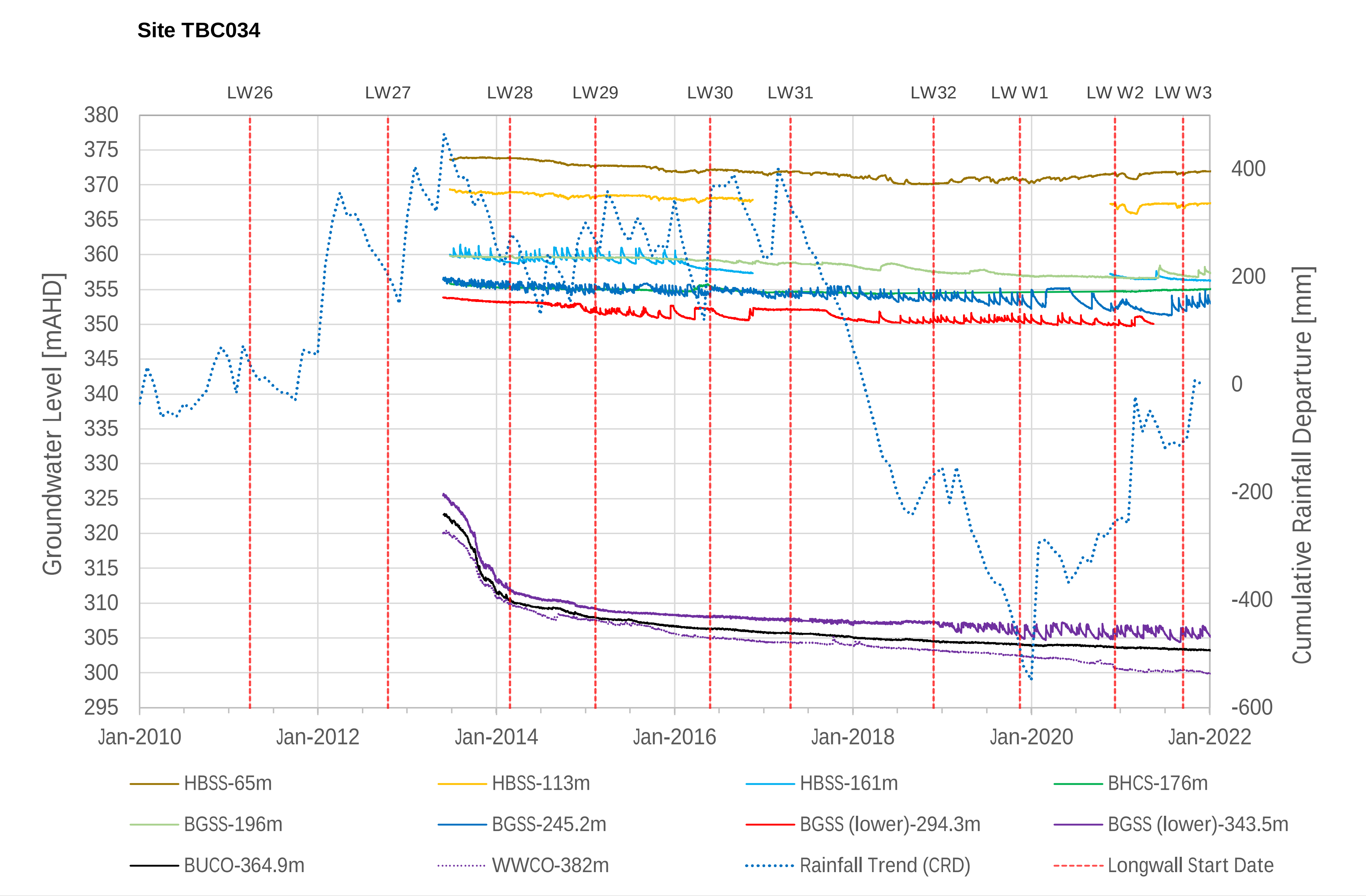
Groundwater Level [mAHD]
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
Cumulative Rainfall Departure [mm]
400
200
0
-200
-400
-600
Jan-2010
Jan-2012
Jan-2014
Jan-2016
Jan-2018
Jan-2020
Jan-2022
Wombarra Claystone-409m


Site TBC027
LW26
LW27
LW28
LW29
LW30
LW31
LW32
LW W1
LW W2
LW W3
Groundwater Level [mAHD]
Cumulative Rainfall Departure [mm]
330
328
326
324
322
320
318
316
314
312
310
308
306
304
302
300
298
296
294
292
290
400
200
0
-200
-400
-600
Jan-2010
Jan-2012
Jan-2014
Jan-2016
Jan-2018
Jan-2020
Jan-2022
HBSS-95m
HBSS (lower)-132m
HBSS (lower)-169m
BHCS-181m
BGSS-198m
BGSS-253m
BGSS (lower)-306m
Wombarra Claystone-362m
BUCO-384m
WWCO-396m
WWCO-400m
Rainfall Trend (CRD)
Longwall Start Date

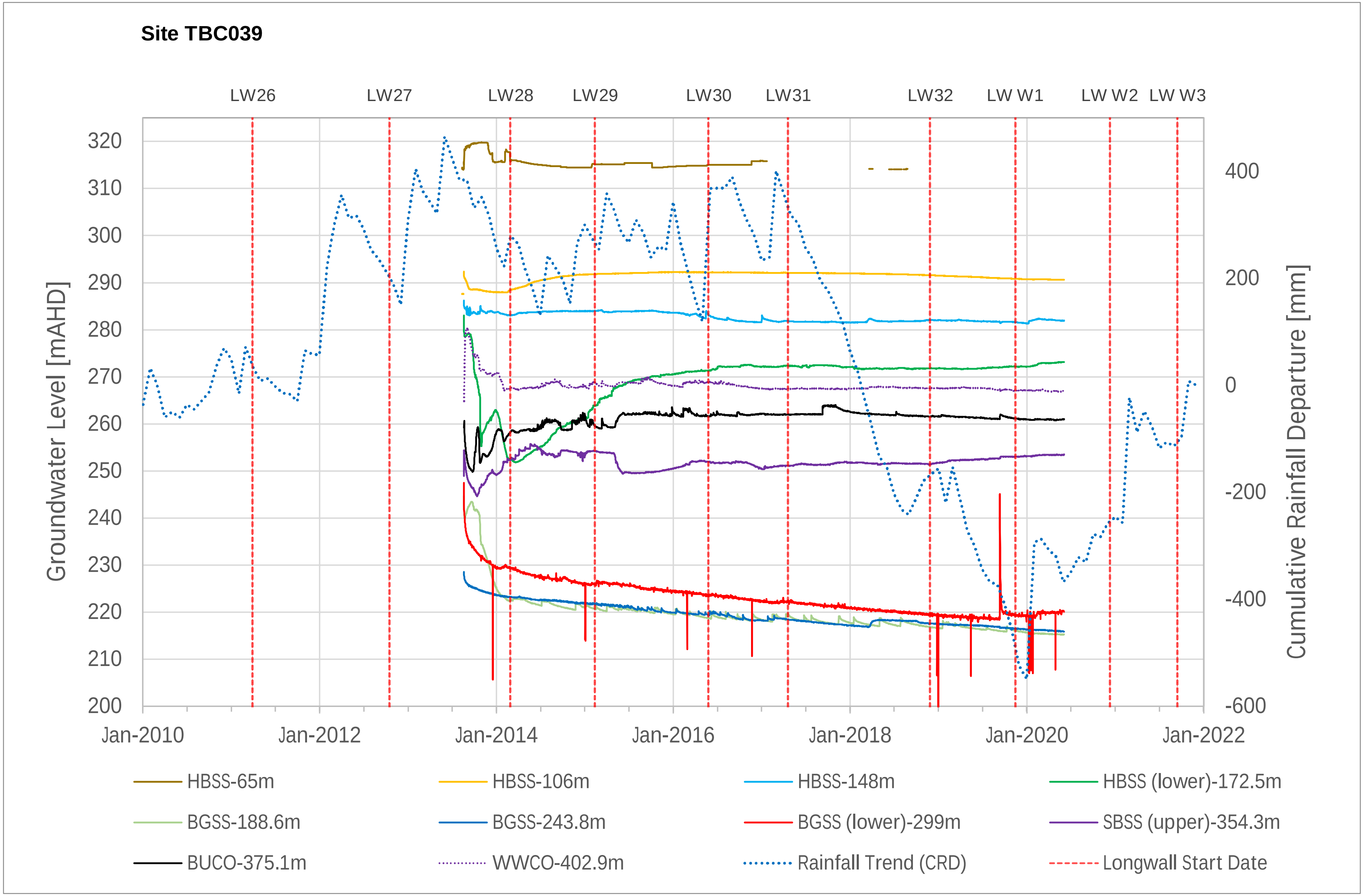

Site TBC032
LW26
LW27
LW28
LW29
LW30
LW31
LW32
LW W1
LW W2
LW W3
Groundwater Level [mAHD]
Cumulative Rainfall Departure [mm]
275
270
265
260
255
250
245
240
235
230
225
220
215
210
400
200
0
-200
-400
-600
Jan-2010
Jan-2011
Jan-2012
Dec-2012
Jan-2014
Jan-2015
Jan-2016
Jan-2017
Jan-2018
Jan-2019
Jan-2020
Jan-2021
Jan-2022
HBSS-95m
HBSS-131m
HBSS-168m
BHCS-181m
BGSS-200m
BGSS-237m
BGSS-294m
BGSS (lower)-372m
BUCO-398m
WWCO-437m
Rainfall Trend (CRD)
Longwall Start Date



Site TBC033
LW26
LW27
LW28
LW29
LW30
LW31
LW32
LW W1
LW W2
LW W3
Groundwater Level [mAHD]
Cumulative Rainfall Departure [mm]
290
285
280
275
270
265
260
255
250
245
240
235
230
225
220
215
210
400
200
0
-200
-400
-600
Jan-2010
Jan-2012
Jan-2014
Jan-2016
Jan-2018
Jan-2020
Jan-2022
HBSS-65m
WWFM/HBSS-113m
HBSS (lower)-161m
BHCS-173m
BGSS-190m
BGSS-247.7m
BGSS (lower)-306m
SBSS (upper)-363.2m
BUCO-384.3m
WWCO-408.7m
RL Collar (mAHD)
Rainfall Trend (CRD)
Longwall Start Date
Series5
The absolute installation depths of these VWP instruments and the record must be considered with

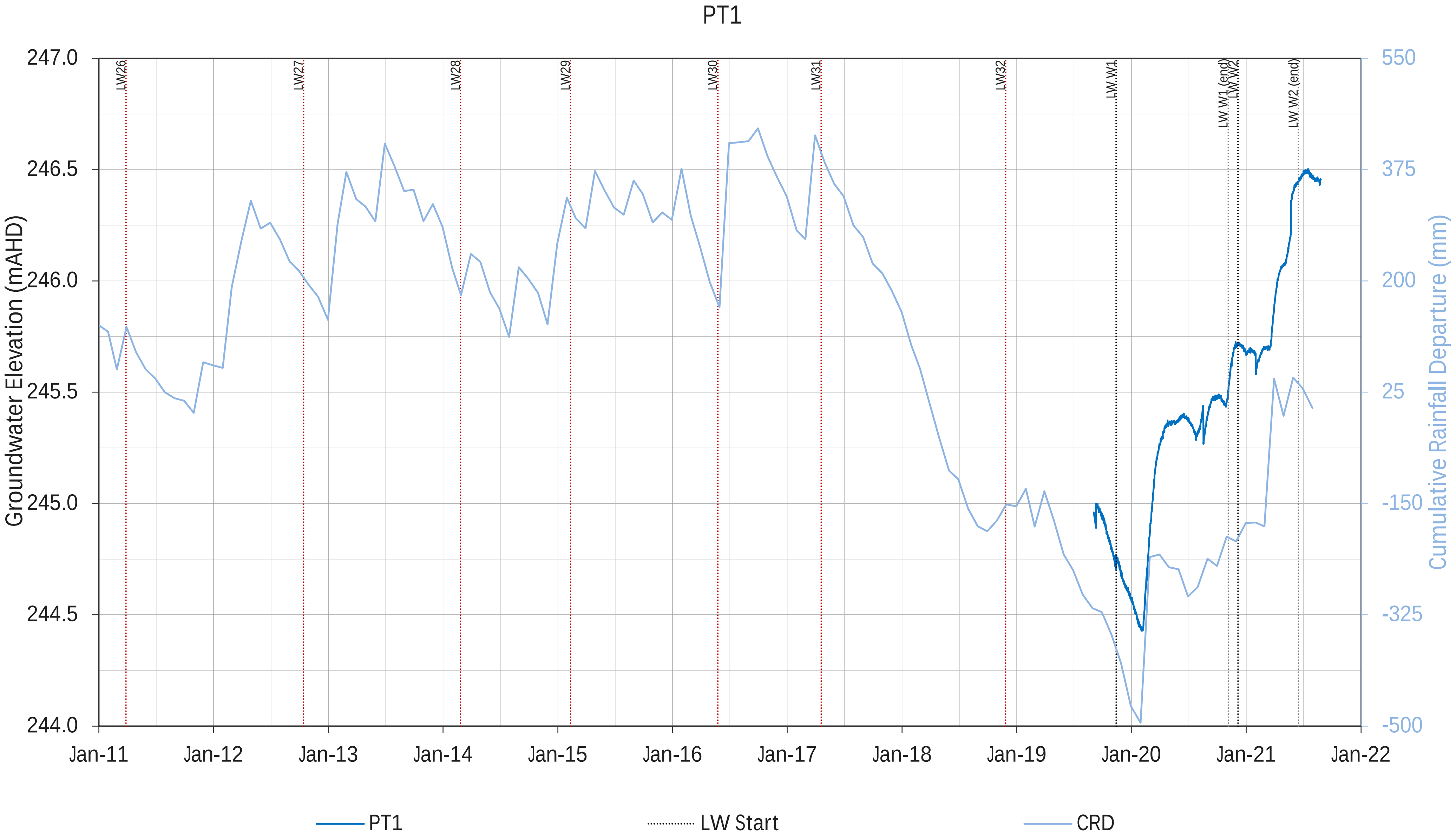


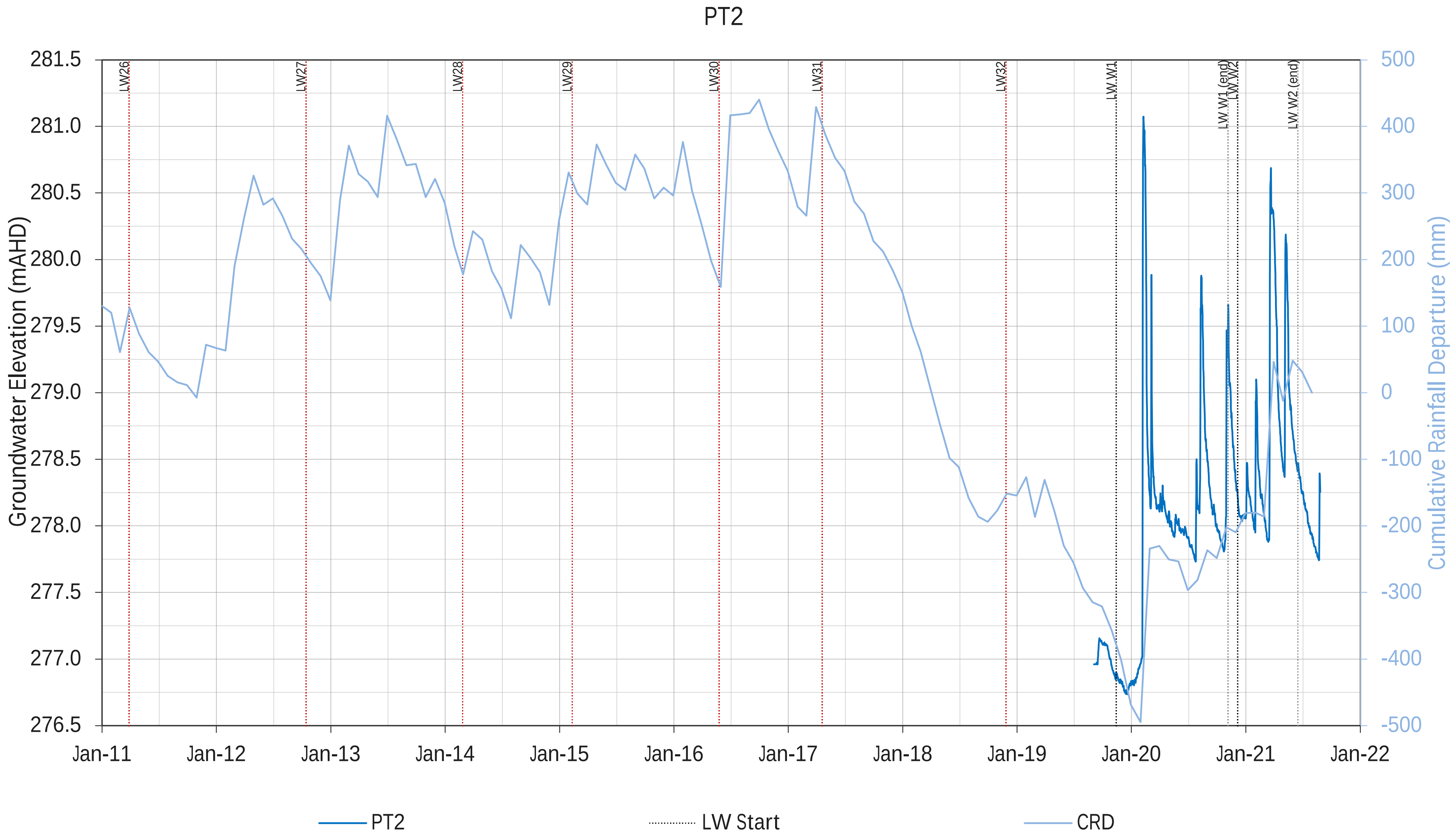
Site TBC034
LW26
LW27
LW28
LW29
LW30
LW31
LW32
LW W1
LW W2
LW W3
Groundwater Level [mAHD]
380
375
370
365
360
355
350
345
340
335
330
325
320
315
310
305
300
295
Cumulative Rainfall Departure [mm]
400
200
0
-200
-400
-600
Jan-2010
Jan-2012
Jan-2014
Jan-2016
Jan-2018
Jan-2020
Jan-2022
HBSS-65m
HBSS-113m
HBSS-161m
BHCS-176m
BGSS-196m
BGSS-245.2m
BGSS (lower)-294.3m
BGSS (lower)-343.5m
BUCO-364.9m
WWCO-382m
Rainfall Trend (CRD)
Longwall Start Date

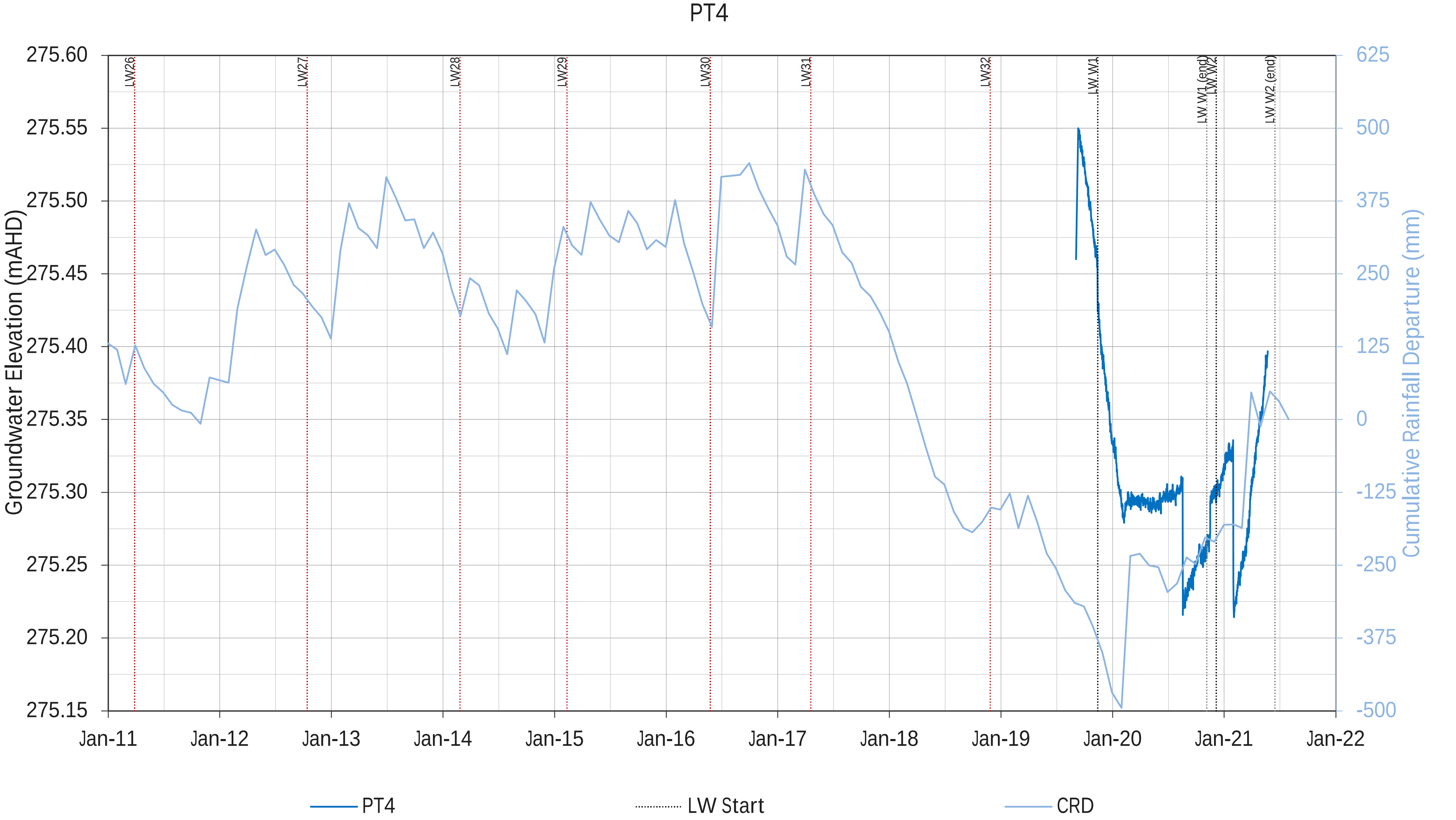

Site TBC039
LW26
LW27
LW28
LW29
LW30
LW31
LW32
LW W1
LW W2
LW W3
Groundwater Level [mAHD]
Cumulative Rainfall Departure [mm]
320
310
300
290
280
270
260
250
240
230
220
210
200
400
200
0
-200
-400
-600
Jan-2010
Jan-2012
Jan-2014
Jan-2016
Jan-2018
Jan-2020
Jan-2022
HBSS-65m
HBSS-106m
HBSS-148m
HBSS (lower)-172.5m
BGSS-188.6m
BGSS-243.8m
BGSS (lower)-299m
SBSS (upper)-354.3m
BUCO-375.1m
WWCO-402.9m
Rainfall Trend (CRD)
Longwall Start Date

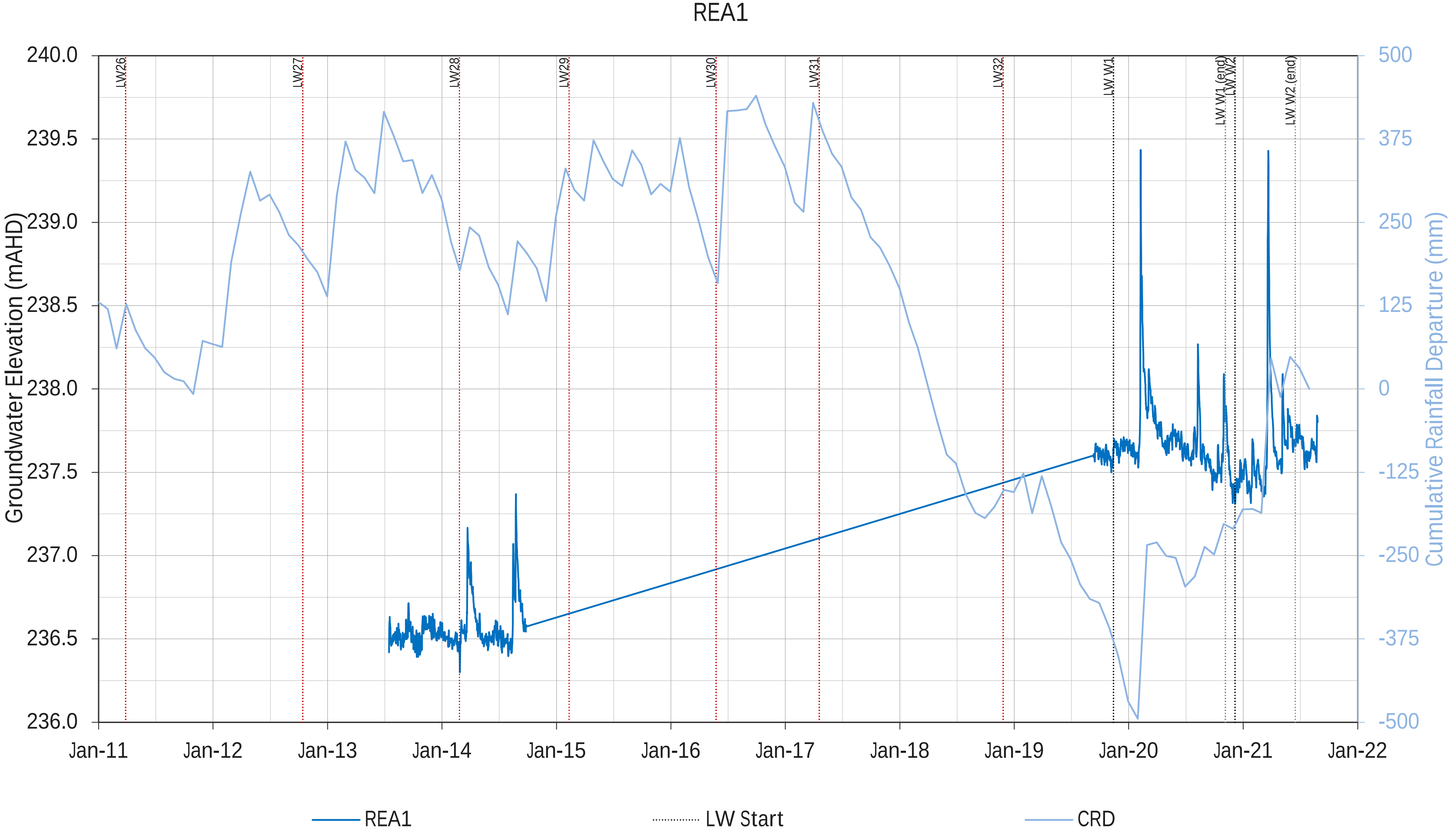
APPENDIX B

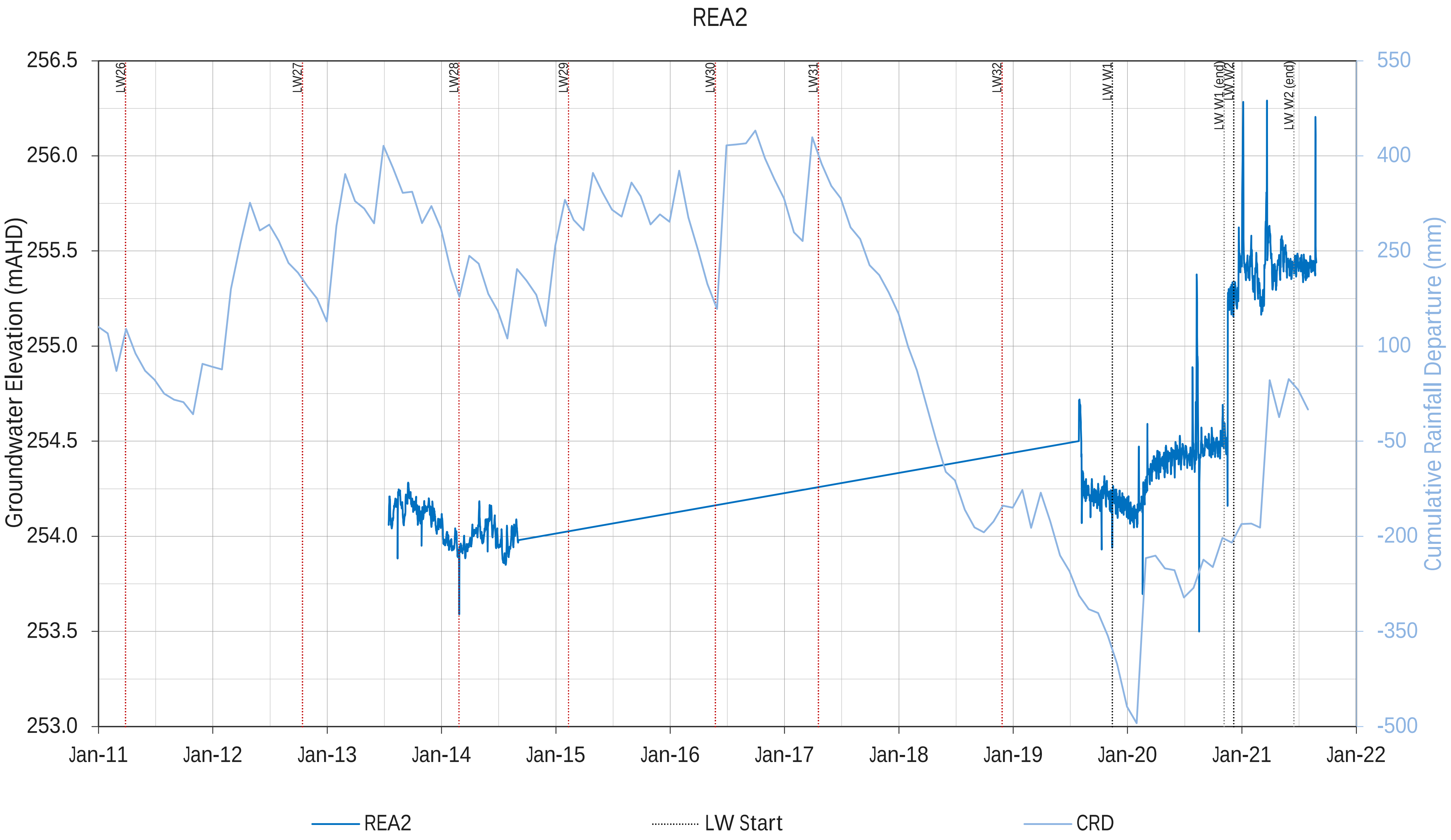
REA and Pit Top Bores Hydrographs


PT1
247.0
246.5
246.0
245.5
245.0
244.5
244.0
Groundwater Elevation (mAHD)
550
375
200
25
-150
-325
-500
Cumulative Rainfall Departure (mm)
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22
LW26
LW27
LW28
LW29
LW30
LW31
LW32
LW W1
LW W1 (end)
LW W2
LW W2 (end)
PT1
LW Start
CRD

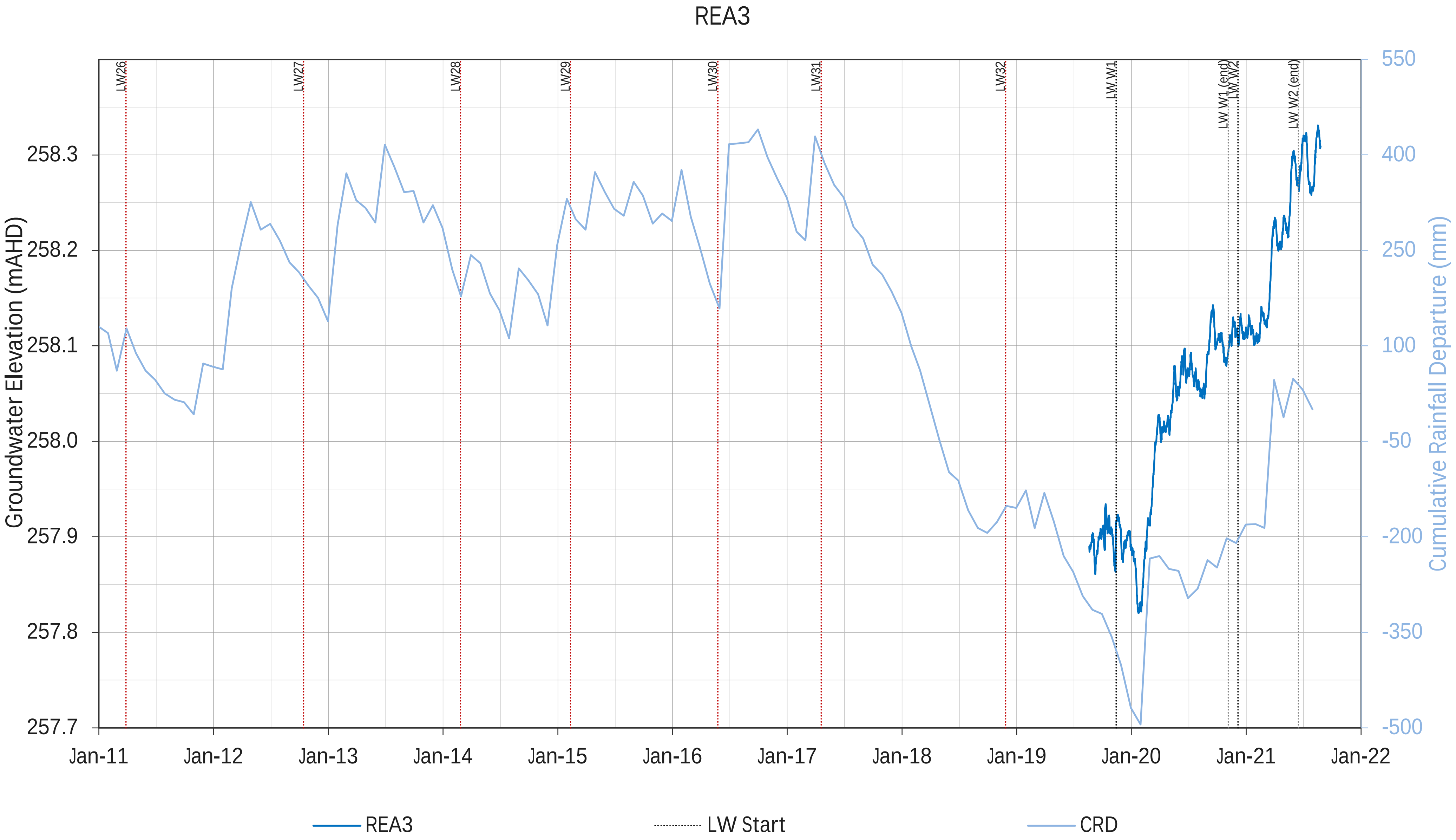

PT2
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
281.5
281.0
280.5
280.0
279.5
279.0
278.5
278.0
277.5
277.0
276.5
500
400
300
200
100
0
-100
-200
-300
-400
-500
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22
LW26
LW27
LW28
LW29
LW30
LW31
LW32
LW W1
LW W1 (end)
LW W2
LW W2 (end)
PT2
LW Start
CRD

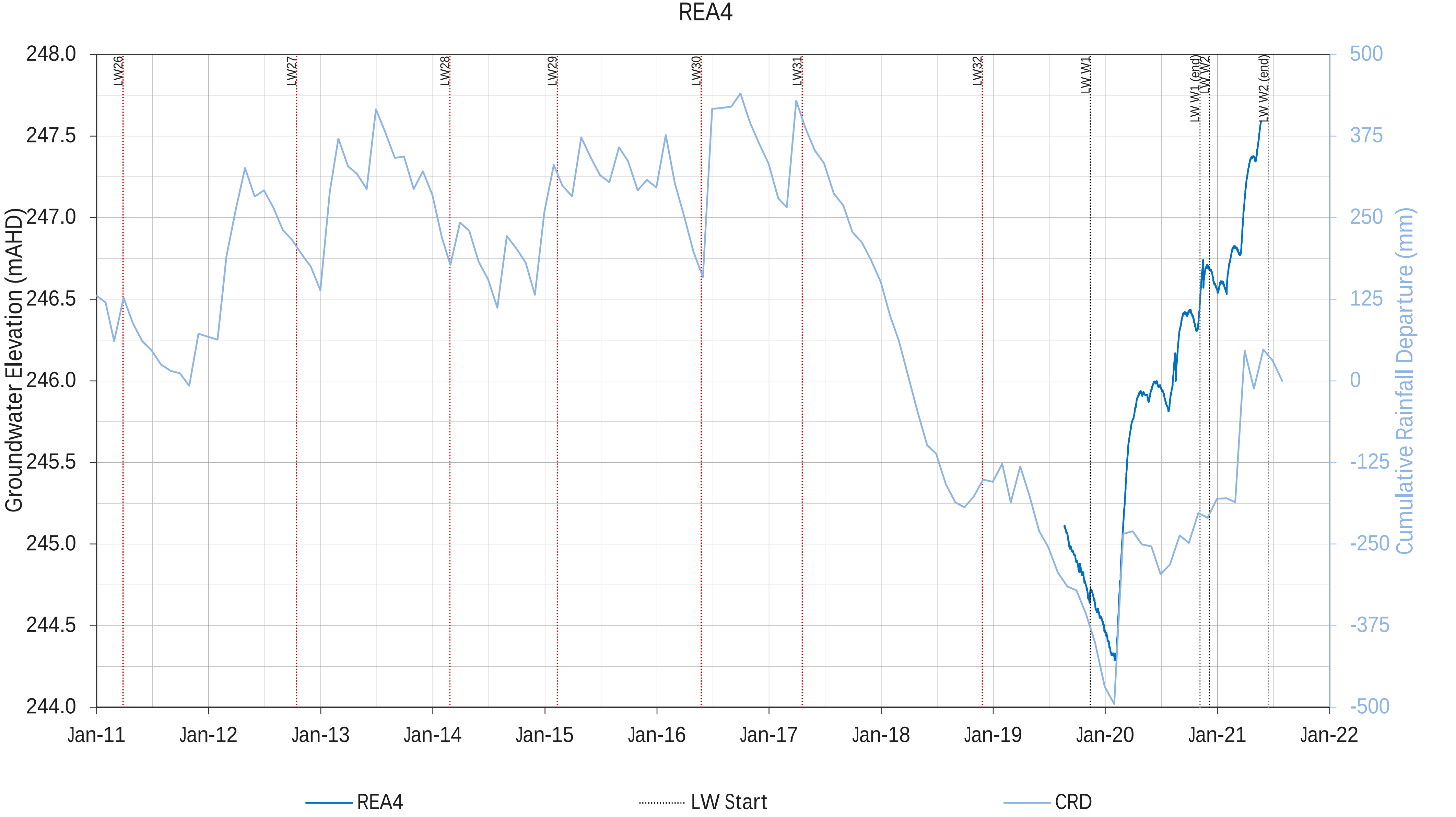

PT4
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
275.60
275.55
275.50
275.45
275.40
275.35
275.30
275.25
275.20
275.15
625
500
375
250
125
0
-125
-250
-375
-500
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22
LW26
LW27
LW28
LW29
LW30
LW31
LW32
LW W1
LW W1 (end)
LW W2
LW W2 (end)
PT4
LW Start
CRD

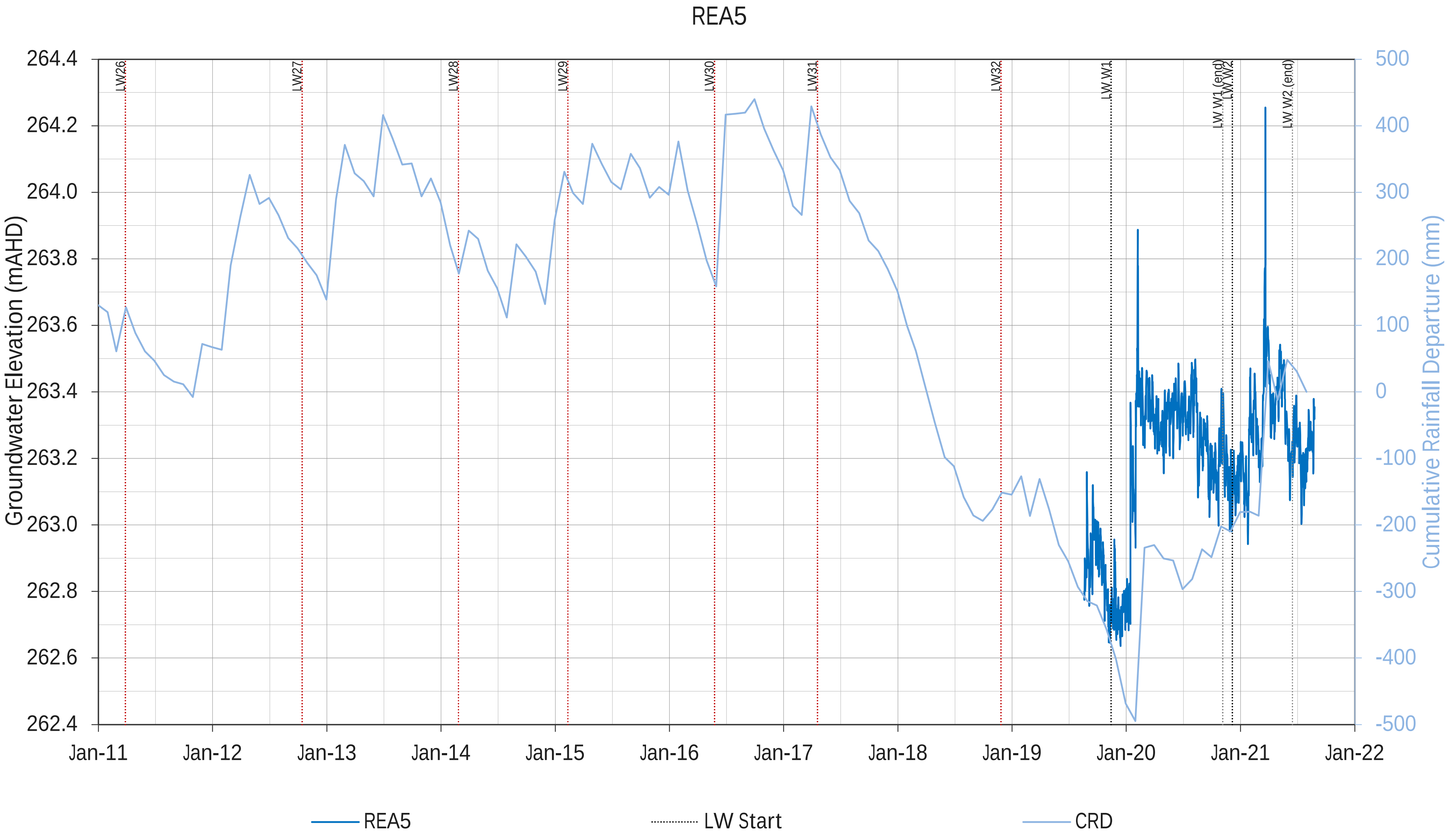

REA1
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
240.0
239.5
239.0
238.5
238.0
237.5
237.0
236.5
236.0
500
375
250
125
0
-125
-250
-375
-500
LW26
LW27
LW28
LW29
LW30
LW31
LW32
LW W1
LW W1 (end)
LW W2
LW W2 (end)
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22
REA1
LW Start
CRD



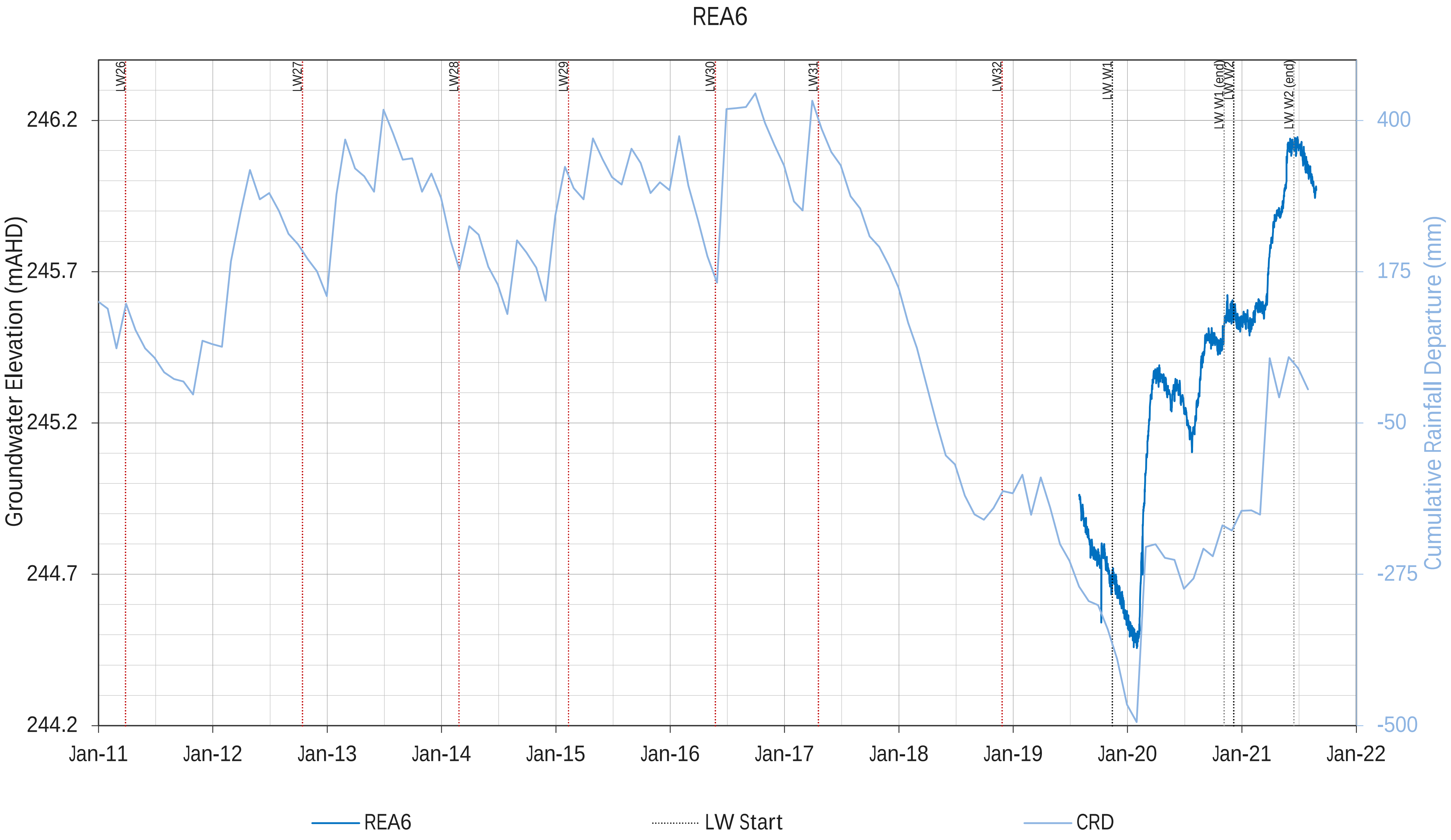
REA2
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
256.5
256.0
255.5
255.0
254.5
254.0
253.5
253.0
550
400
250
100
-50
-200
-350
-500
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22
LW26
LW27
LW28
LW29
LW30
LW31
LW32
LW W1
LW W1 (end)
LW W2
LW W2 (end)
REA2
LW Start
CRD

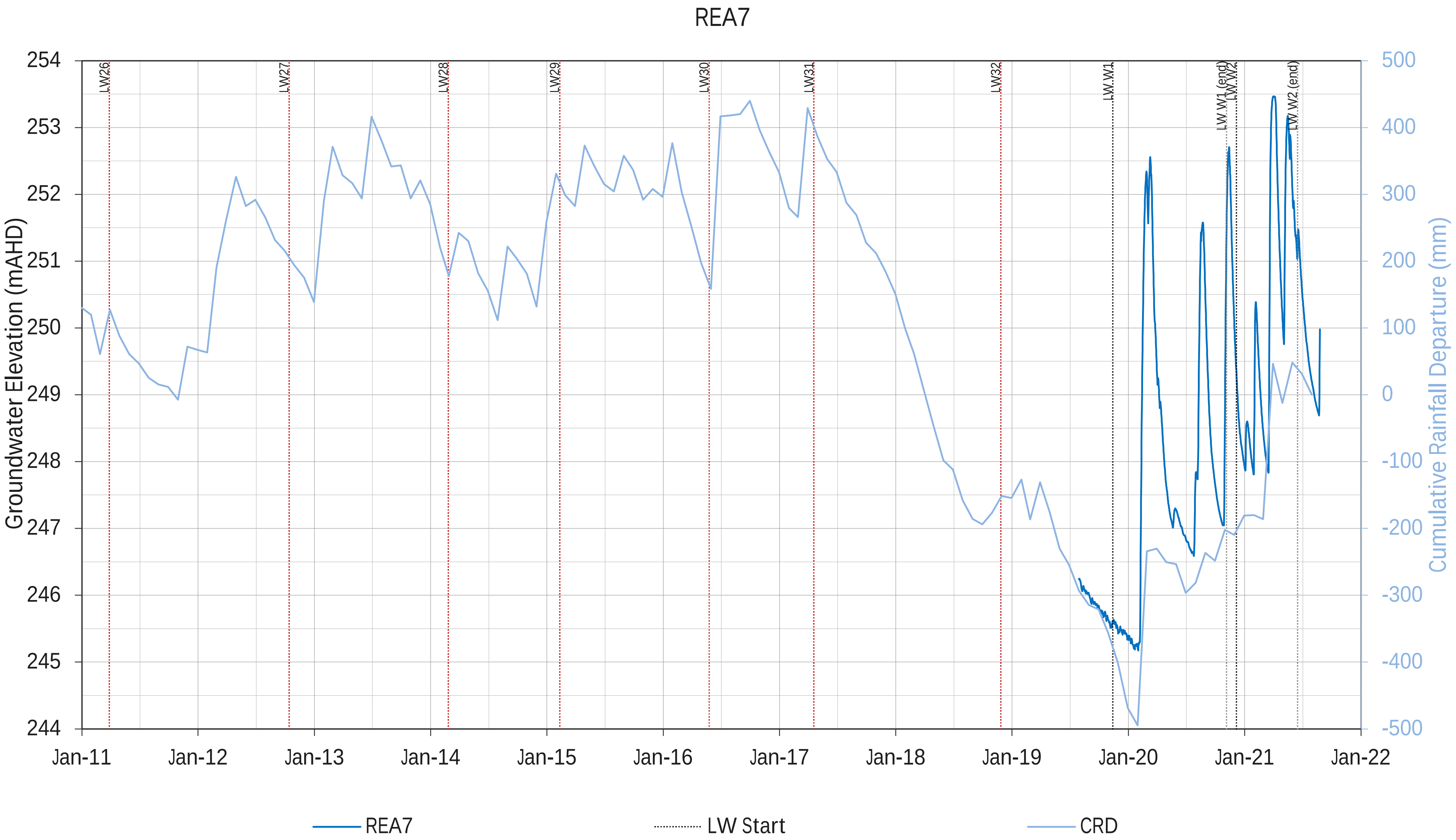

REA3
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
258.3
258.2
258.1
258.0
257.9
257.8
257.7
550
400
250
100
-50
-200
-350
-500
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22
LW26
LW27
LW28
LW29
LW30
LW31
LW32
LW W1
LW W1 (end)
LW W2
LW W2 (end)
REA3
LW Start
CRD


REA4
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
248.0
247.5
247.0
246.5
246.0
245.5
245.0
244.5
244.0
500
375
250
125
0
-125
-250
-375
-500
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22
LW26
LW27
LW28
LW29
LW30
LW31
LW32
LW W1
LW W1 (end)
LW W2
LW W2 (end)
REA4
LW Start
CRD



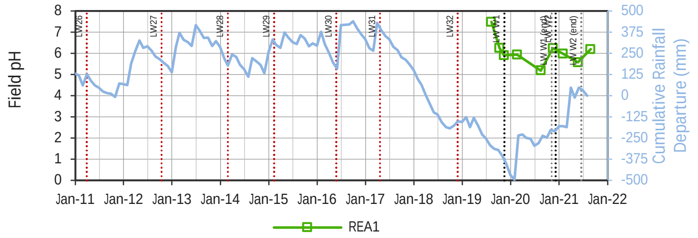
REA5
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
264.4
264.2
264.0
263.8
263.6
263.4
263.2
263.0
262.8
262.6
262.4
500
400
300
200
100
0
-100
-200
-300
-400
-500
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22
LW26
LW27
LW28
LW29
LW30
LW31
LW32
LW W1
LW W1 (end)
LW W2
LW W2 (end)
REA5
LW Start
CRD

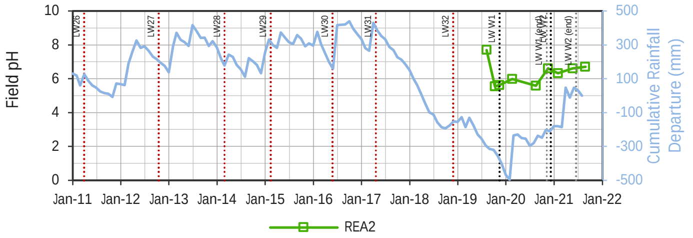

REA6
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
246.2
245.7
245.2
244.7
244.2
400
175
-50
-275
-500
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22
LW26
LW27
LW28
LW29
LW30
LW31
LW32
LW W1
LW W1 (end)
LW W2
LW W2 (end)
REA6
LW Start
CRD

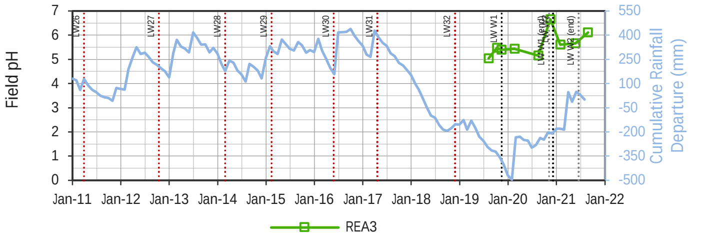

REA7
Groundwater Elevation (mAHD)
Cumulative Rainfall Departure (mm)
254
253
252
251
250
249
248
247
246
245
244
500
400
300
200
100
0
-100
-200
-300
-400
-500
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22
LW26
LW27
LW28
LW29
LW30
LW31
LW32
LW W1
LW W1 (end)
LW W2
LW W2 (end)
REA7
LW Start
CRD

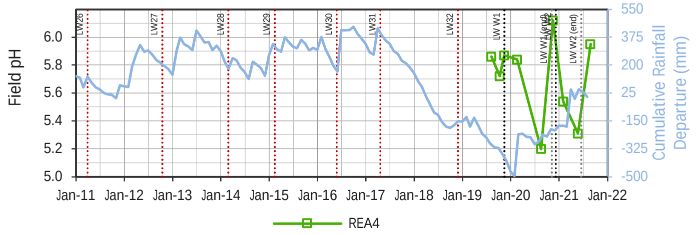
APPENDIX C

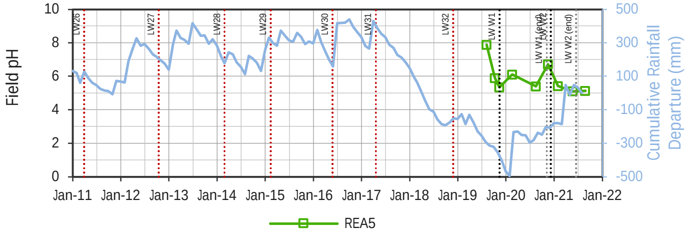
REA and Pit Top Bores Groundwater Quality

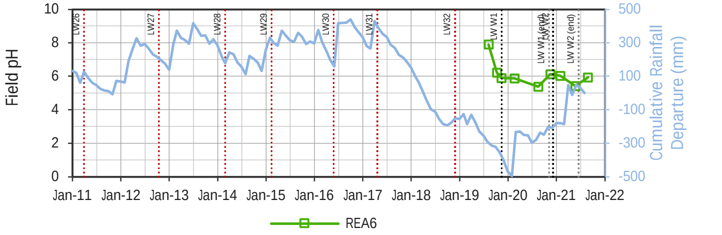

Field pH
Cumulative Rainfall Departure (mm)
REA1

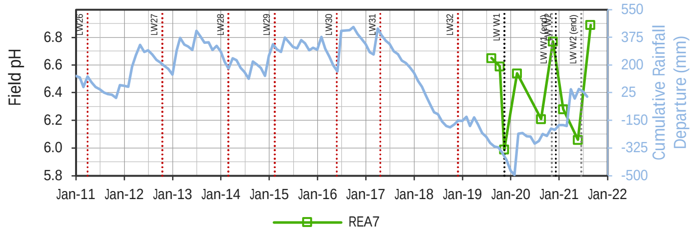

Field pH
Cumulative Rainfall Departure (mm)
REA2

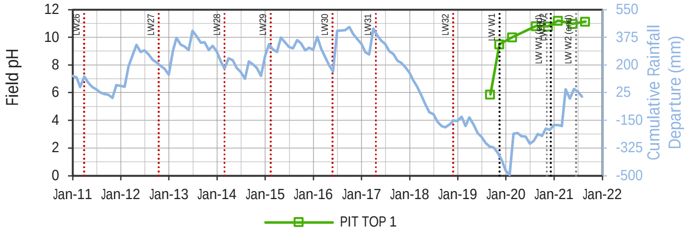

Field pH
Cumulative Rainfall Departure (mm)
REA3

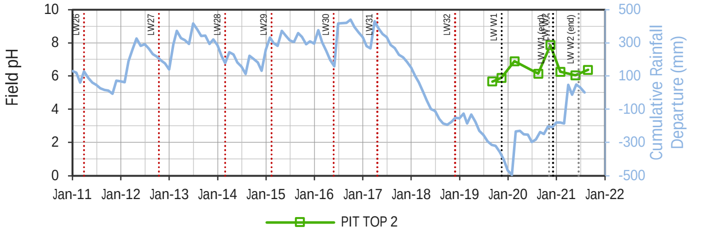

Field pH
Cumulative Rainfall Departure (mm)
REA4

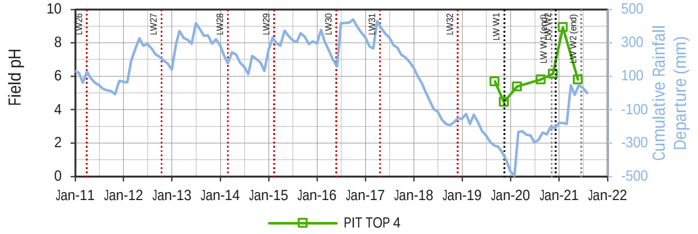

Field pH
Cumulative Rainfall Departure (mm)
REA5

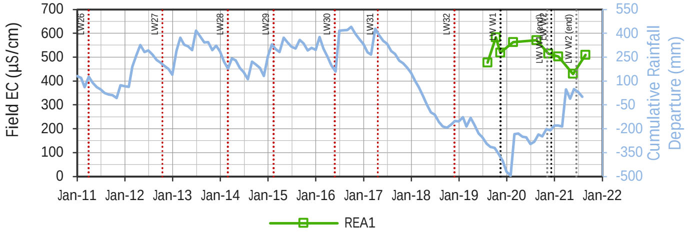

Field pH
Cumulative Rainfall Departure (mm)
REA6

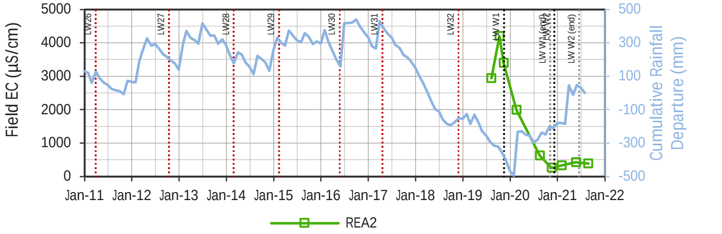

Field pH
Cumulative Rainfall Departure (mm)
REA7

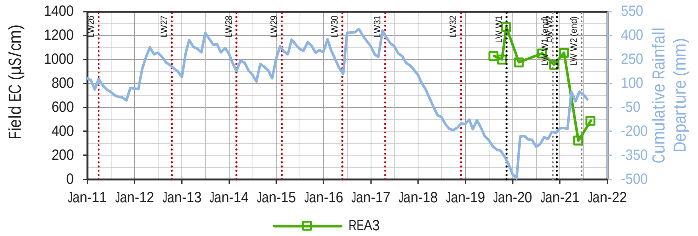

Field pH
Cumulative Rainfall Departure (mm)
PIT TOP 1

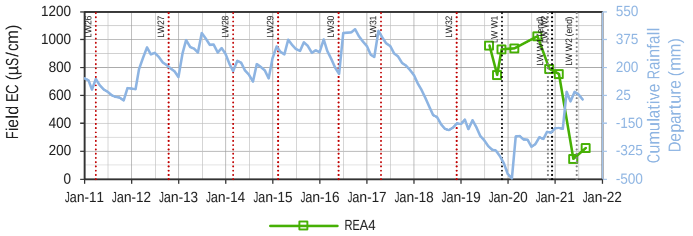

Field pH
Cumulative Rainfall Departure (mm)
PIT TOP 2

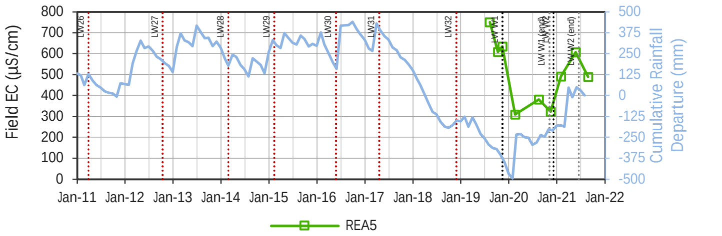

Field pH
Cumulative Rainfall Departure (mm)
PIT TOP 4

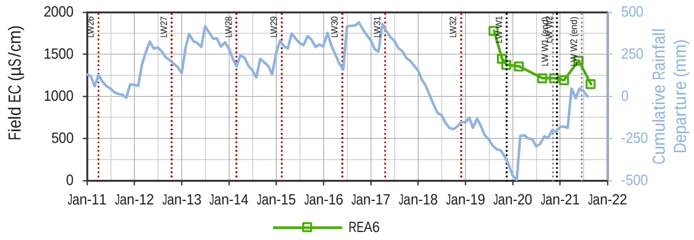

Field EC (µS/cm)
Cumulative Rainfall Departure (mm)
REA1

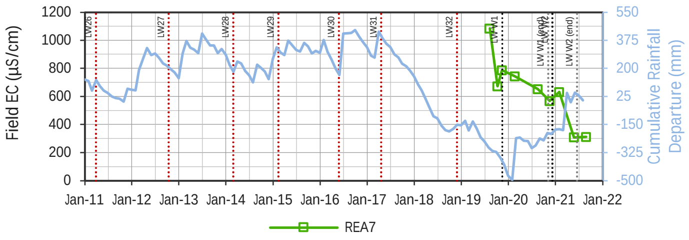

Field EC (µS/cm)
Cumulative Rainfall Departure (mm)
REA2

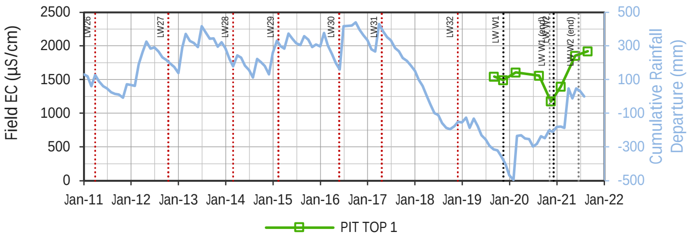

Field EC (µS/cm)
Cumulative Rainfall Departure (mm)
REA3

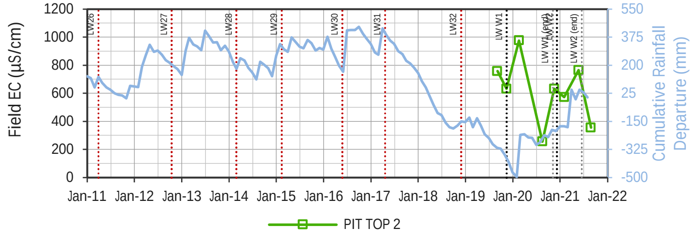

Field EC (µS/cm)
Cumulative Rainfall Departure (mm)
REA4

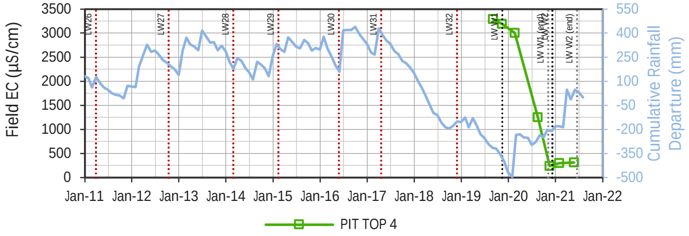

Field EC (µS/cm)
Cumulative Rainfall Departure (mm)
REA5

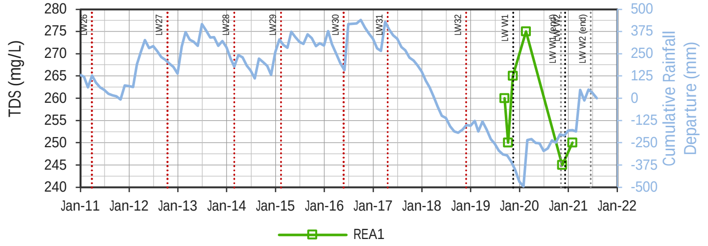

Field EC (µS/cm)
Cumulative Rainfall Departure (mm)
REA6

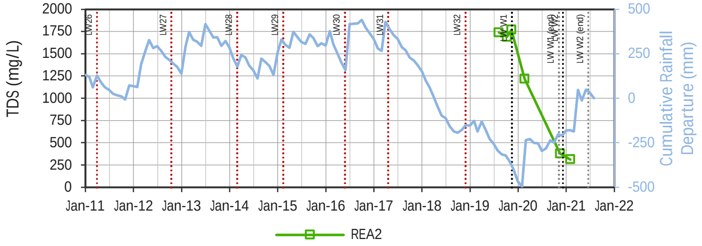

Field EC (µS/cm)
Cumulative Rainfall Departure (mm)
REA7

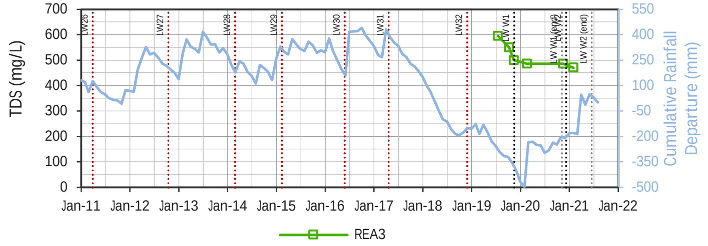

Field EC (µS/cm)
Cumulative Rainfall Departure (mm)
PIT TOP 1

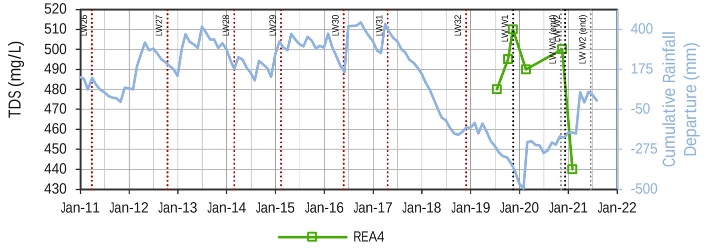

Field EC (µS/cm)
Cumulative Rainfall Departure (mm)
PIT TOP 2

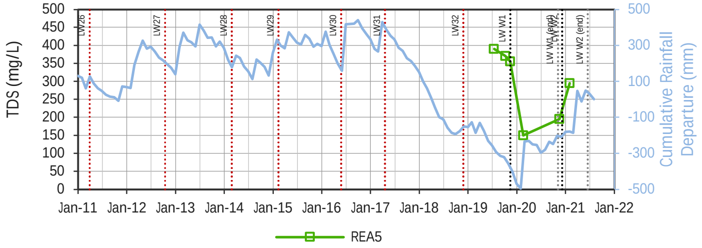

Field EC (µS/cm)
Cumulative Rainfall Departure (mm)
PIT TOP 4

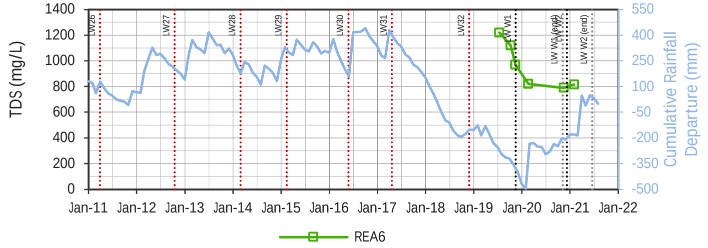

TDS (mg/L)
Cumulative Rainfall Departure (mm)
REA1

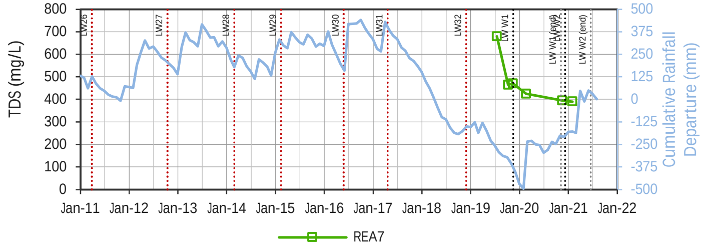

TDS (mg/L)
Cumulative Rainfall Departure (mm)
REA2

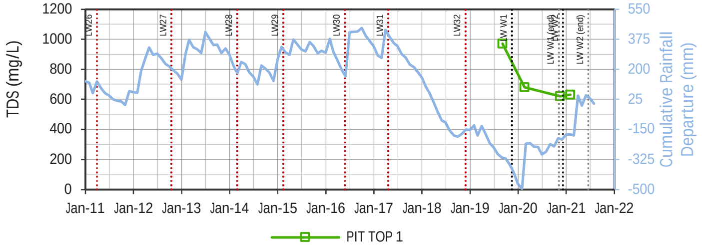

TDS (mg/L)
Cumulative Rainfall Departure (mm)
REA3

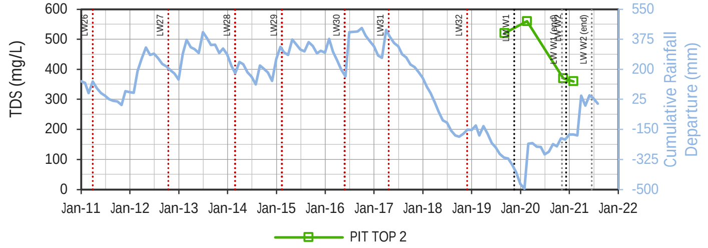

TDS (mg/L)
Cumulative Rainfall Departure (mm)
REA4

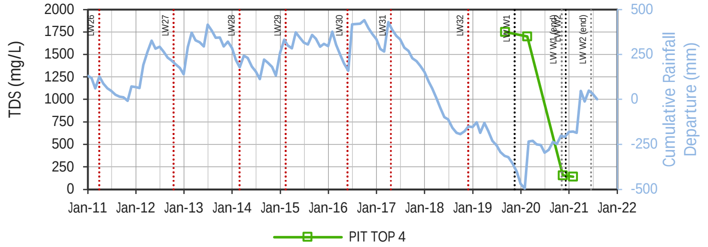

TDS (mg/L)
Cumulative Rainfall Departure (mm)
REA5

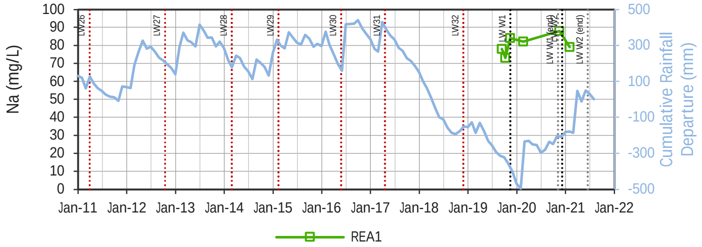

TDS (mg/L)
Cumulative Rainfall Departure (mm)
REA6

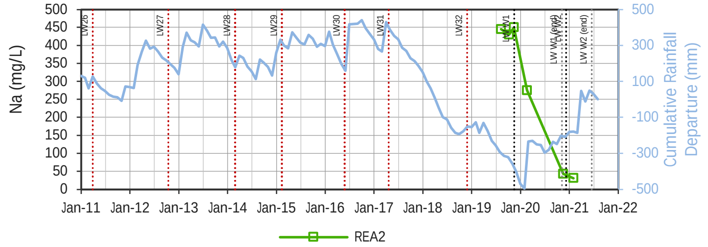

TDS (mg/L)
Cumulative Rainfall Departure (mm)
REA7

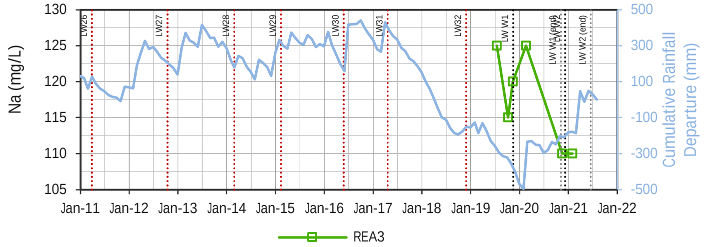

TDS (mg/L)
Cumulative Rainfall Departure (mm)
PIT TOP 1

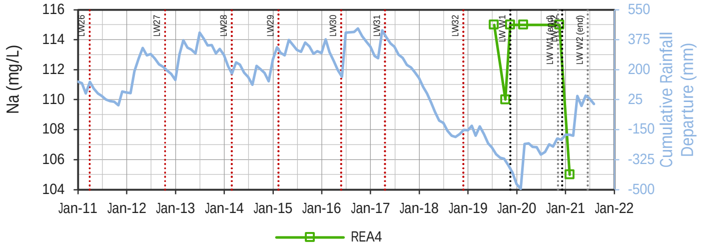

TDS (mg/L)
Cumulative Rainfall Departure (mm)
PIT TOP 2

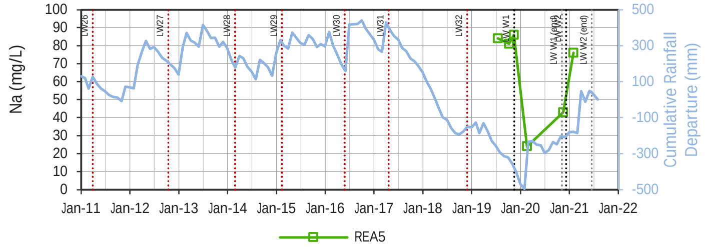

TDS (mg/L)
Cumulative Rainfall Departure (mm)
PIT TOP 4

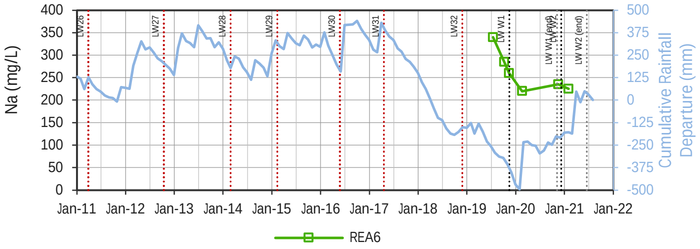

Na (mg/L)
Cumulative Rainfall Departure (mm)
REA1

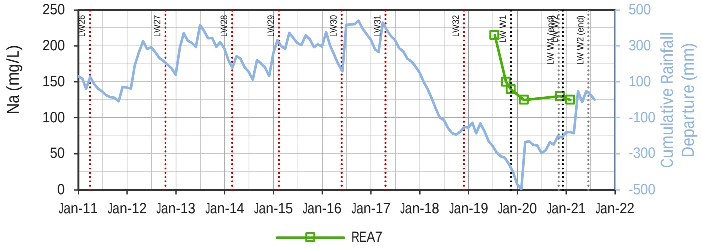

Na (mg/L)
Cumulative Rainfall Departure (mm)
REA2

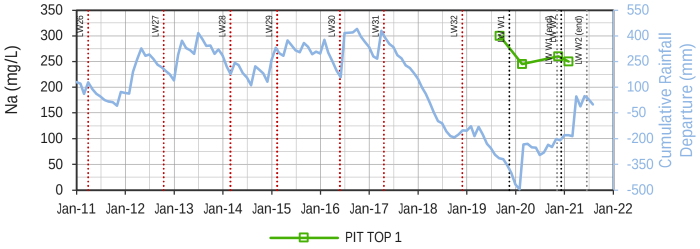

Na (mg/L)
Cumulative Rainfall Departure (mm)
REA3

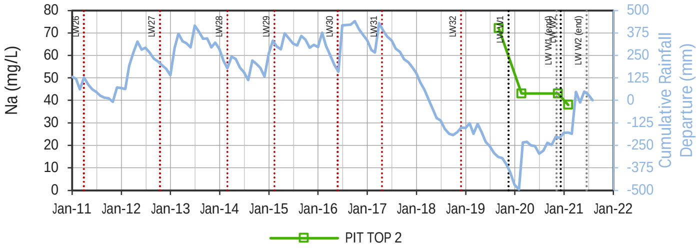

Na (mg/L)
Cumulative Rainfall Departure (mm)
REA4

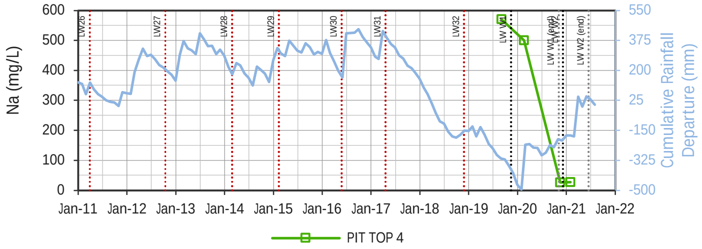

Na (mg/L)
Cumulative Rainfall Departure (mm)
REA5

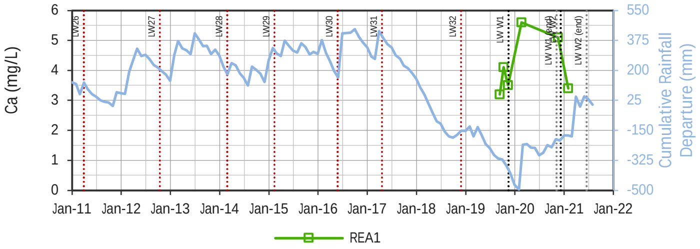

Na (mg/L)
Cumulative Rainfall Departure (mm)
REA6

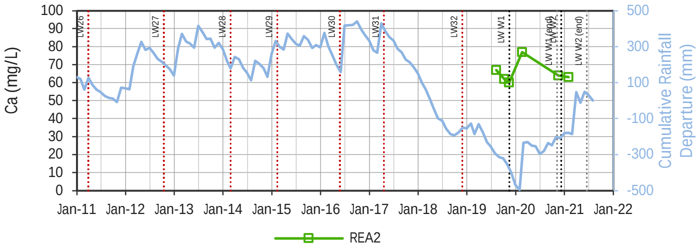

Na (mg/L)
Cumulative Rainfall Departure (mm)
REA7

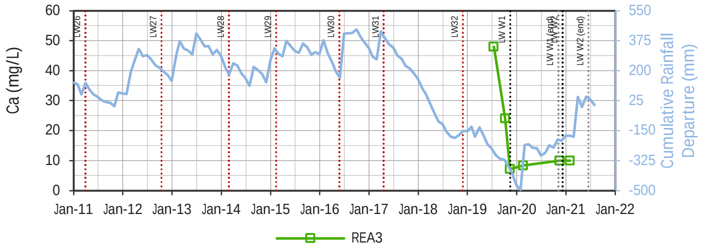

Na (mg/L)
Cumulative Rainfall Departure (mm)
PIT TOP 1

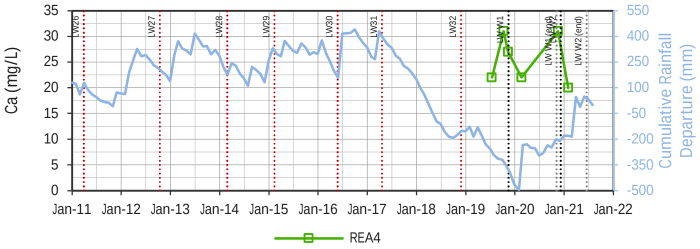

Na (mg/L)
Cumulative Rainfall Departure (mm)
PIT TOP 2

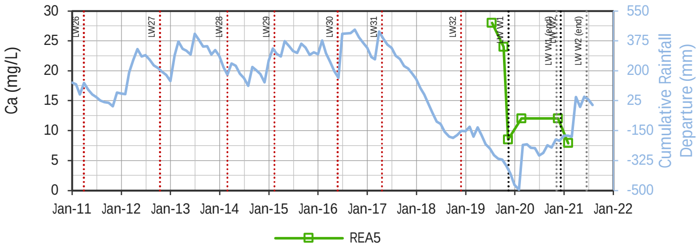

Na (mg/L)
Cumulative Rainfall Departure (mm)
PIT TOP 4

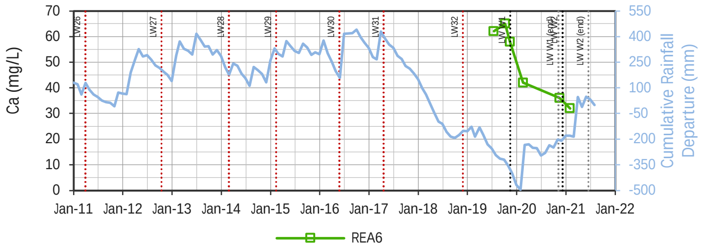

Ca (mg/L)
Cumulative Rainfall Departure (mm)
REA1

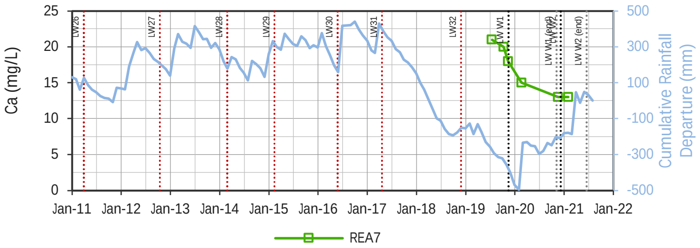

Ca (mg/L)
Cumulative Rainfall Departure (mm)
REA2

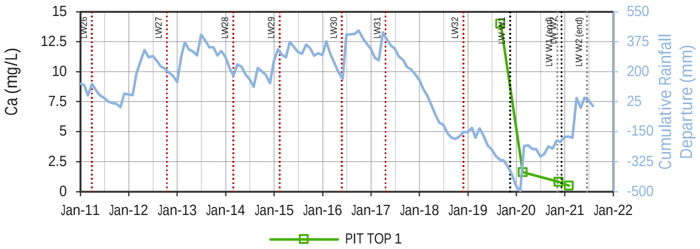

Ca (mg/L)
Cumulative Rainfall Departure (mm)
REA3

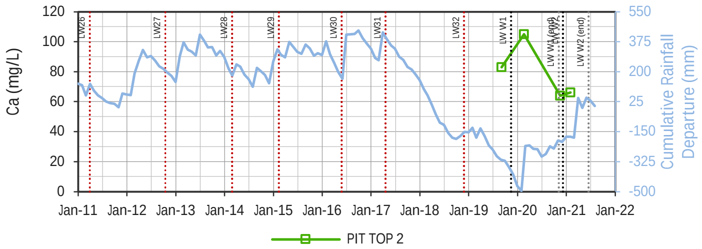

Ca (mg/L)
Cumulative Rainfall Departure (mm)
REA4

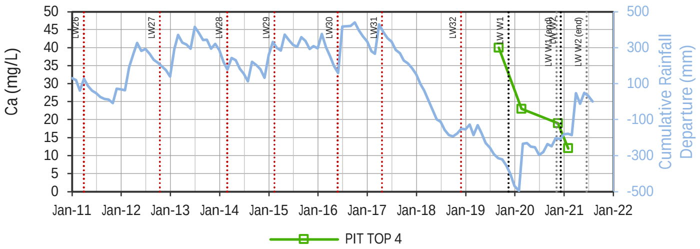

Ca (mg/L)
Cumulative Rainfall Departure (mm)
REA5

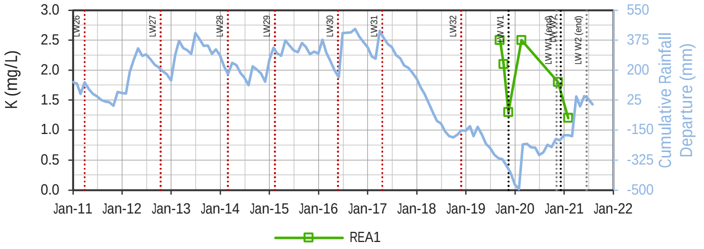

Ca (mg/L)
Cumulative Rainfall Departure (mm)
REA6

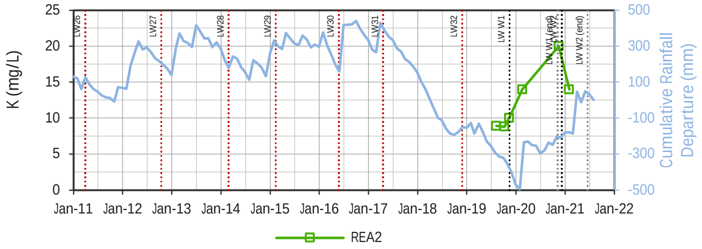

Ca (mg/L)
Cumulative Rainfall Departure (mm)
REA7

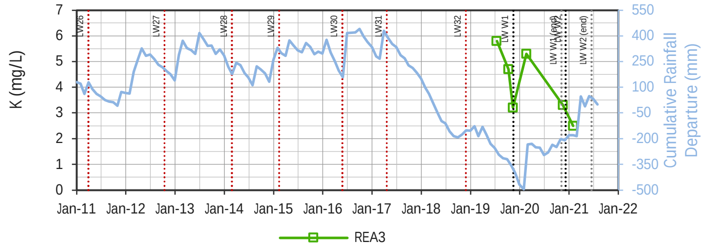

Ca (mg/L)
Cumulative Rainfall Departure (mm)
PIT TOP 1

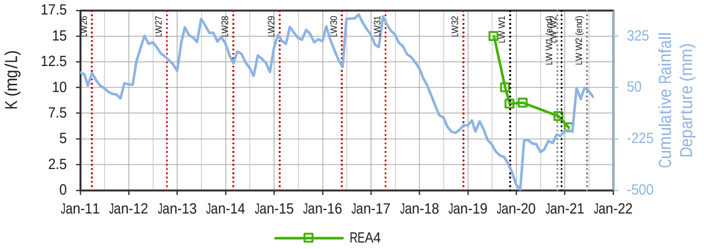

Ca (mg/L)
Cumulative Rainfall Departure (mm)
PIT TOP 2

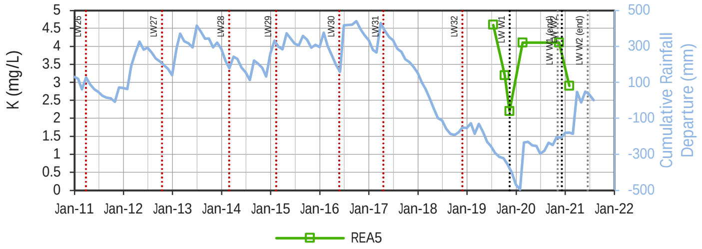

Ca (mg/L)
Cumulative Rainfall Departure (mm)
PIT TOP 4

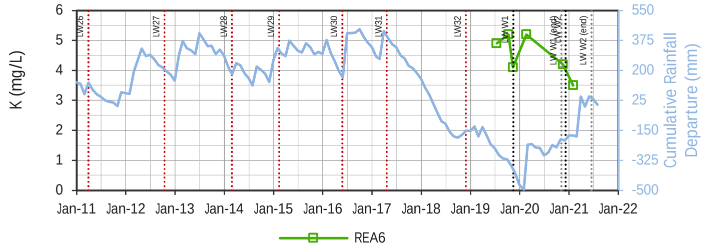

K (mg/L)
Cumulative Rainfall Departure (mm)
REA1

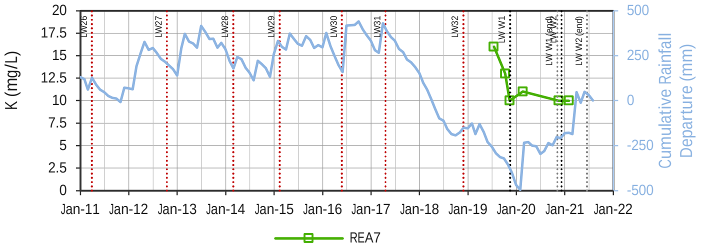

K (mg/L)
Cumulative Rainfall Departure (mm)
REA2

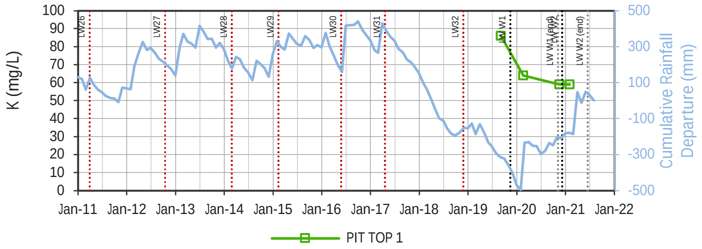

K (mg/L)
Cumulative Rainfall Departure (mm)
REA3

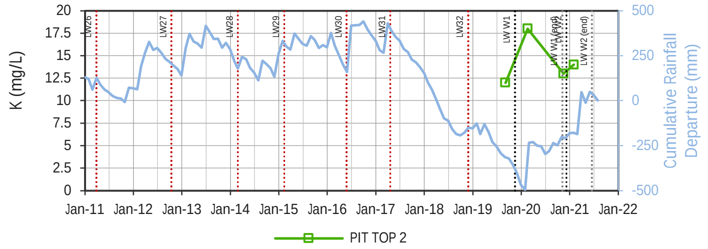

K (mg/L)
Cumulative Rainfall Departure (mm)
REA4

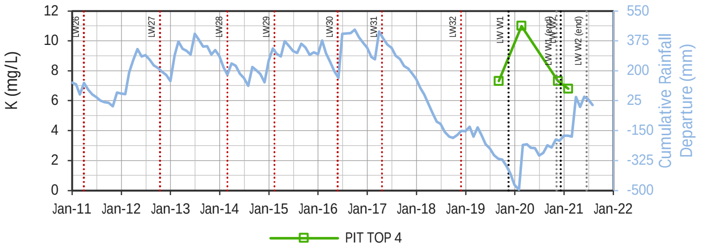

K (mg/L)
Cumulative Rainfall Departure (mm)
REA5

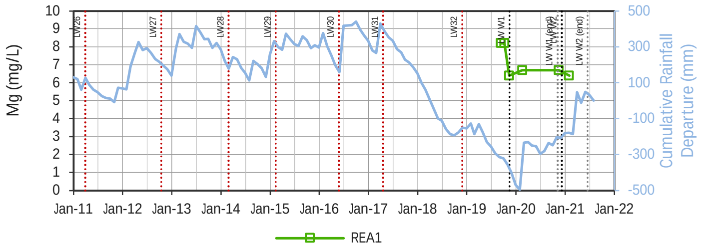

K (mg/L)
Cumulative Rainfall Departure (mm)
REA6

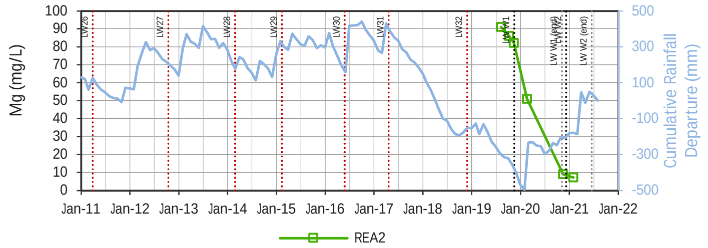

K (mg/L)
Cumulative Rainfall Departure (mm)
REA7

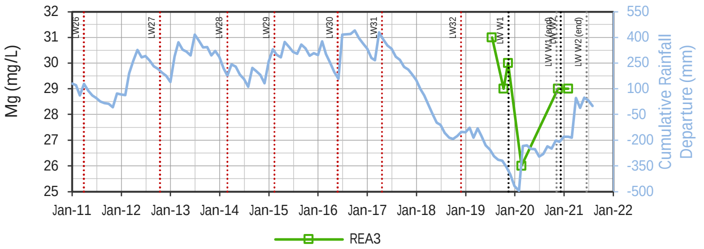

K (mg/L)
Cumulative Rainfall Departure (mm)
PIT TOP 1

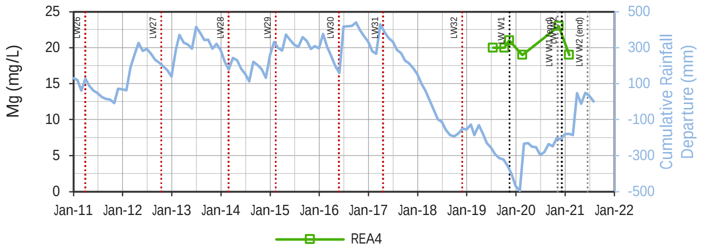

K (mg/L)
Cumulative Rainfall Departure (mm)
PIT TOP 2

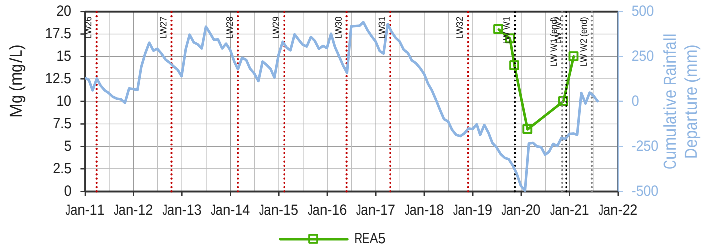

K (mg/L)
Cumulative Rainfall Departure (mm)
PIT TOP 4

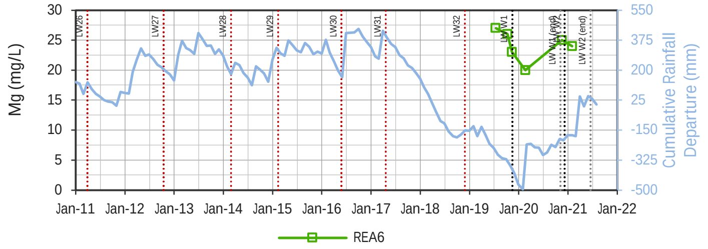

Mg (mg/L)
Cumulative Rainfall Departure (mm)
REA1

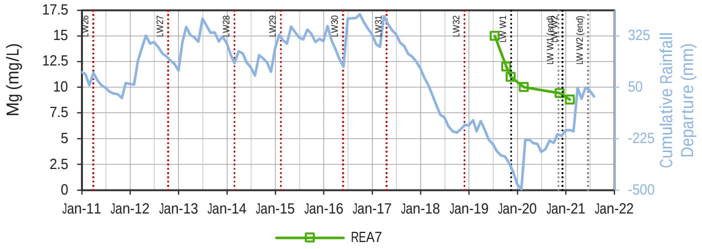

Mg (mg/L)
Cumulative Rainfall Departure (mm)
REA2

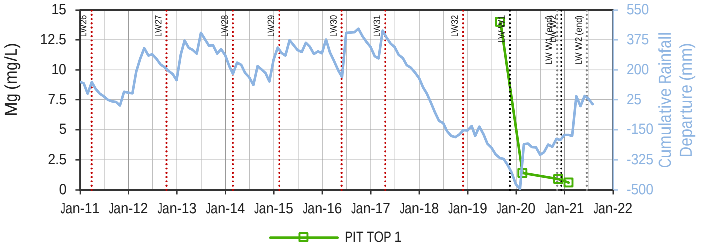

Mg (mg/L)
Cumulative Rainfall Departure (mm)
REA3

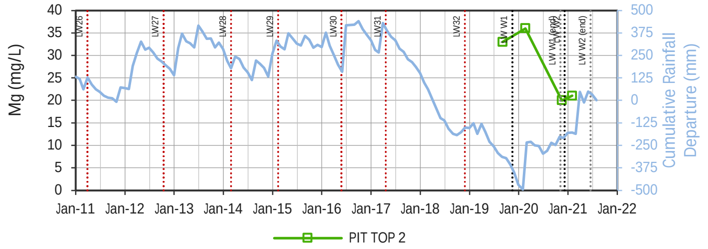

Mg (mg/L)
Cumulative Rainfall Departure (mm)
REA4

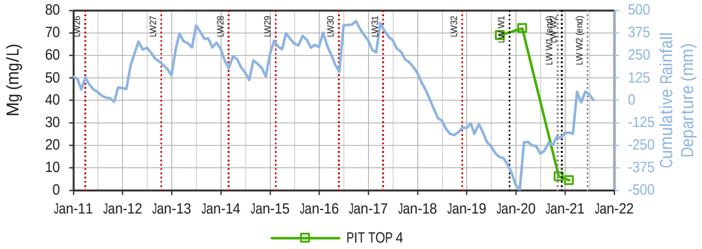

Mg (mg/L)
Cumulative Rainfall Departure (mm)
REA5

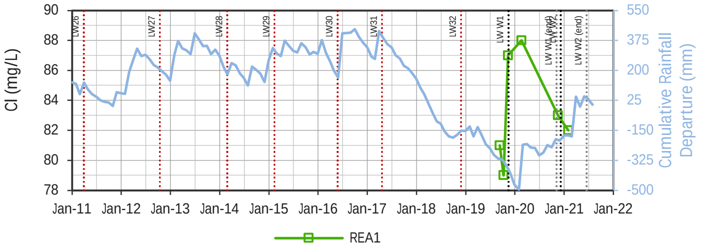

Mg (mg/L)
Cumulative Rainfall Departure (mm)
REA6

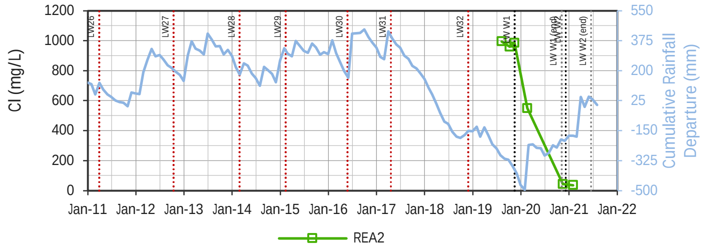

Mg (mg/L)
Cumulative Rainfall Departure (mm)
REA7

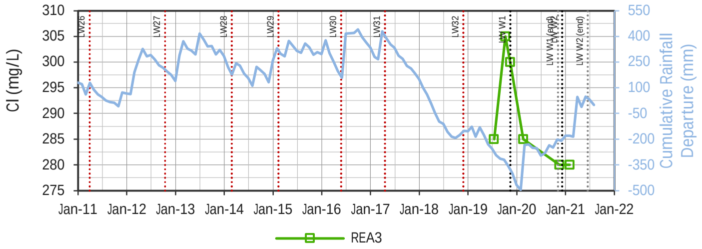

Mg (mg/L)
Cumulative Rainfall Departure (mm)
PIT TOP 1

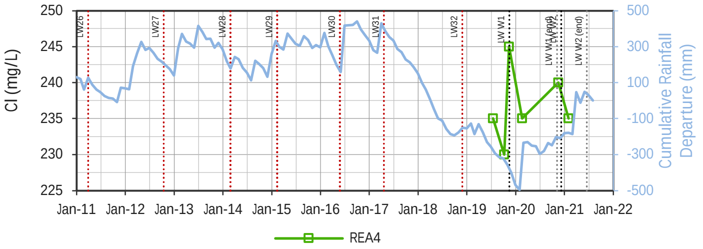

Mg (mg/L)
Cumulative Rainfall Departure (mm)
PIT TOP 2

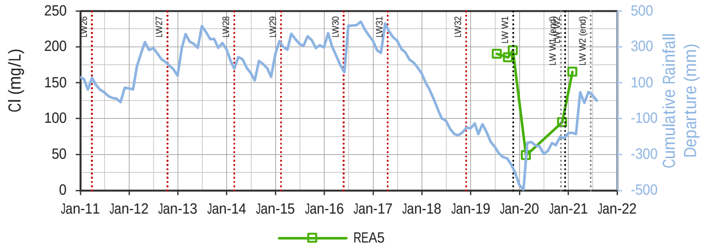

Mg (mg/L)
Cumulative Rainfall Departure (mm)
PIT TOP 4

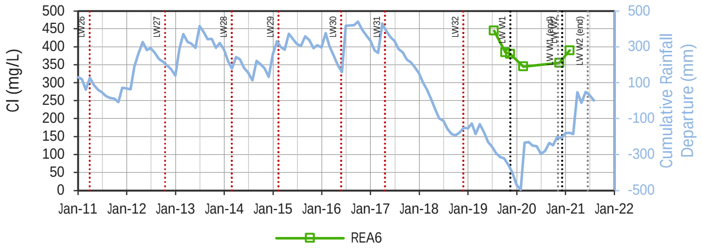

Cl (mg/L)
Cumulative Rainfall Departure (mm)
REA1

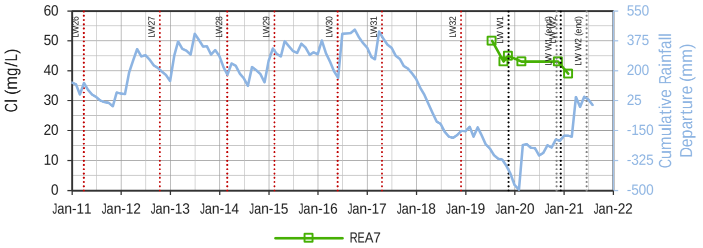

Cl (mg/L)
Cumulative Rainfall Departure (mm)
REA2

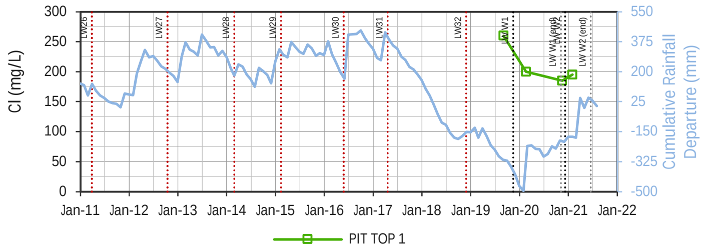

Cl (mg/L)
Cumulative Rainfall Departure (mm)
REA3

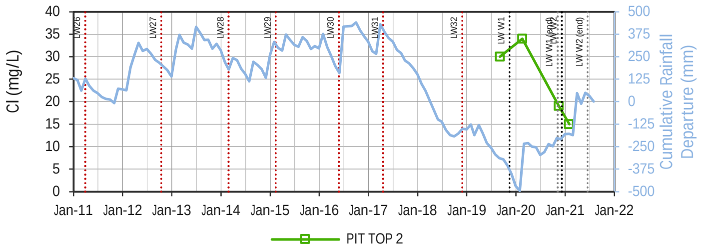

Cl (mg/L)
Cumulative Rainfall Departure (mm)
REA4

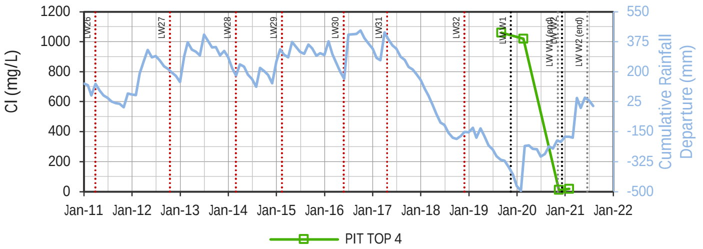

Cl (mg/L)
Cumulative Rainfall Departure (mm)
REA5

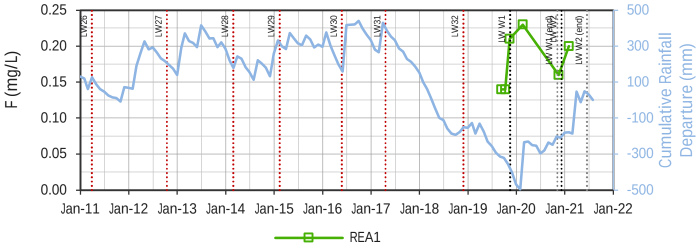

Cl (mg/L)
Cumulative Rainfall Departure (mm)
REA6

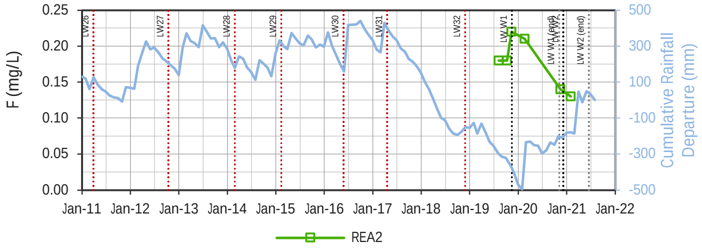

Cl (mg/L)
Cumulative Rainfall Departure (mm)
REA7

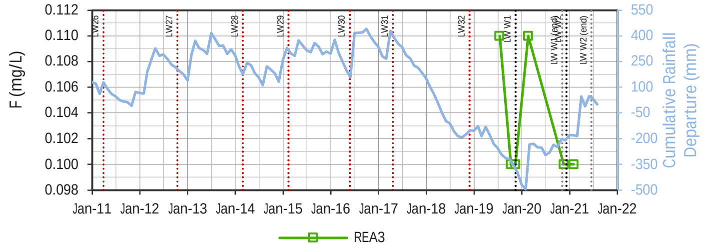

Cl (mg/L)
Cumulative Rainfall Departure (mm)
PIT TOP 1

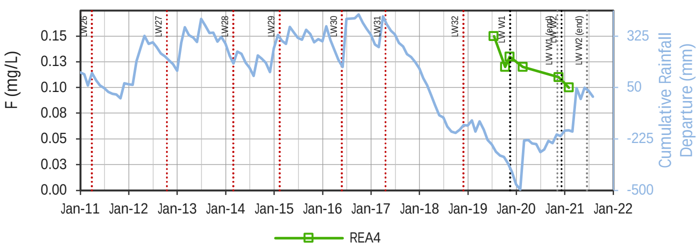

Cl (mg/L)
Cumulative Rainfall Departure (mm)
PIT TOP 2

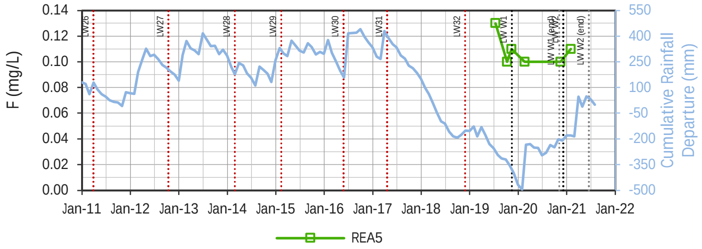

Cl (mg/L)
Cumulative Rainfall Departure (mm)
PIT TOP 4

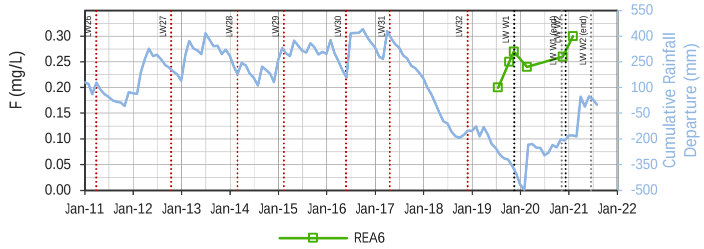

F (mg/L)
Cumulative Rainfall Departure (mm)
REA1

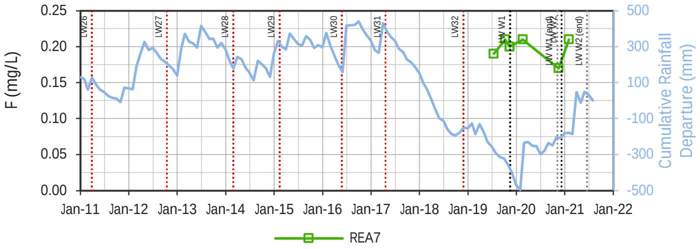

F (mg/L)
Cumulative Rainfall Departure (mm)
REA2

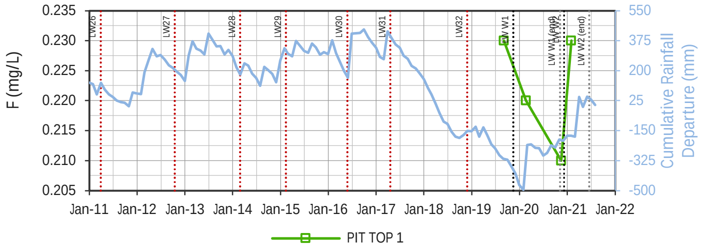

F (mg/L)
Cumulative Rainfall Departure (mm)
REA3

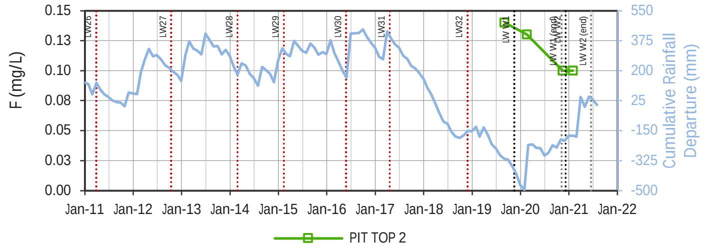

F (mg/L)
Cumulative Rainfall Departure (mm)
REA4

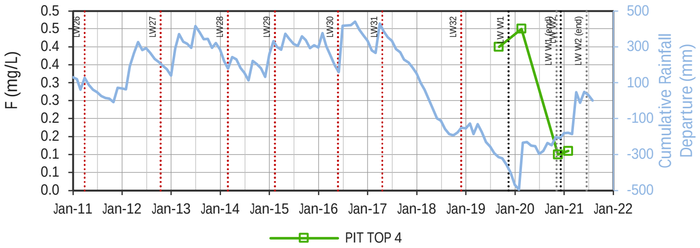

F (mg/L)
Cumulative Rainfall Departure (mm)
REA5

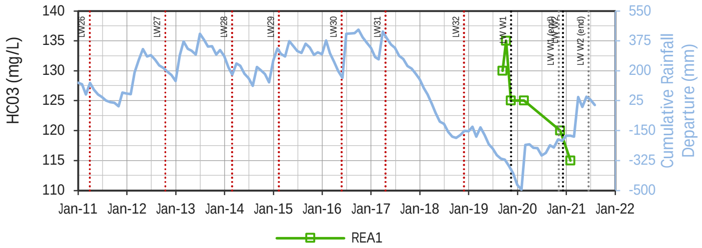

F (mg/L)
Cumulative Rainfall Departure (mm)
REA6

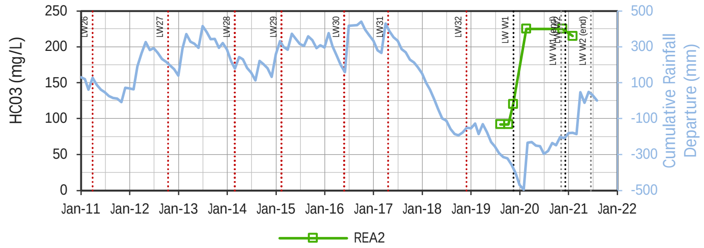

F (mg/L)
Cumulative Rainfall Departure (mm)
REA7

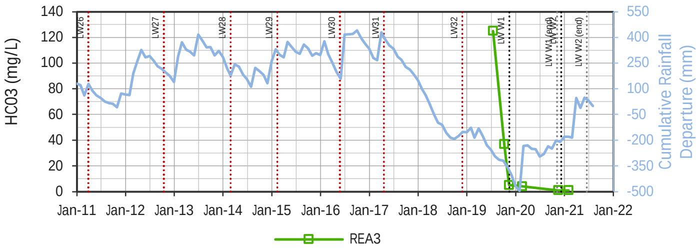

F (mg/L)
Cumulative Rainfall Departure (mm)
PIT TOP 1

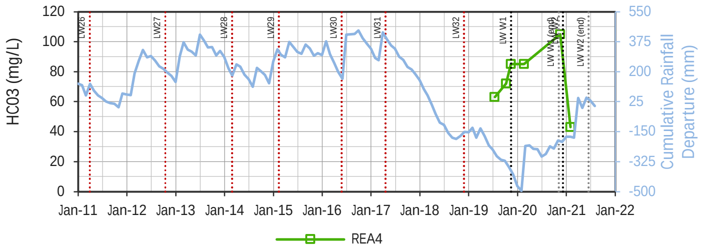

F (mg/L)
Cumulative Rainfall Departure (mm)
PIT TOP 2

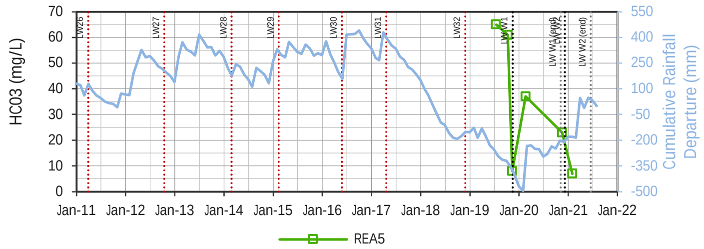

F (mg/L)
Cumulative Rainfall Departure (mm)
PIT TOP 4

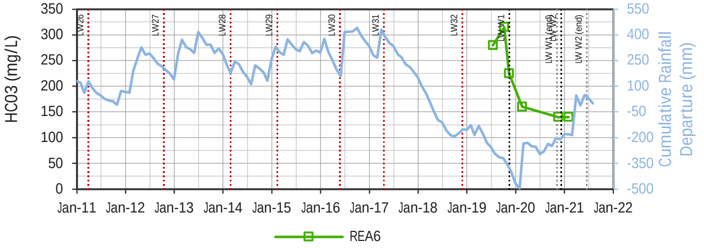

HC03 (mg/L)
Cumulative Rainfall Departure (mm)
REA1

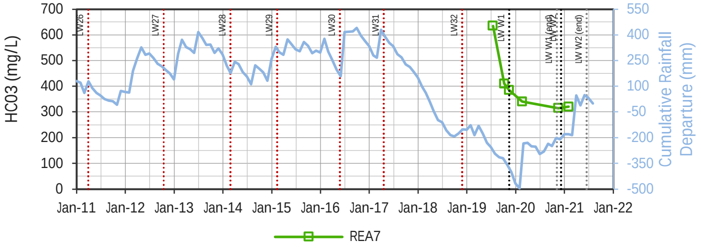

HC03 (mg/L)
Cumulative Rainfall Departure (mm)
REA2

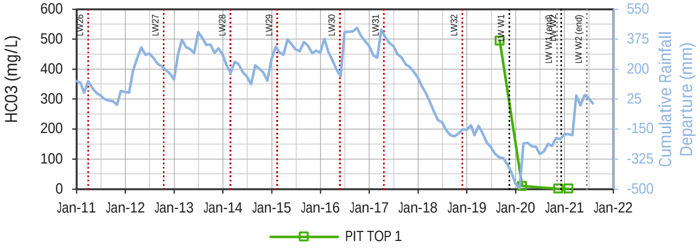

HC03 (mg/L)
Cumulative Rainfall Departure (mm)
REA3

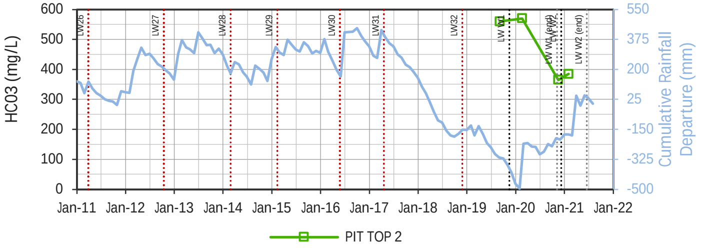

HC03 (mg/L)
Cumulative Rainfall Departure (mm)
REA4

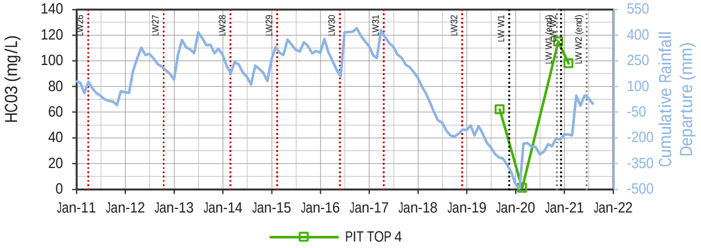

HC03 (mg/L)
Cumulative Rainfall Departure (mm)
REA5

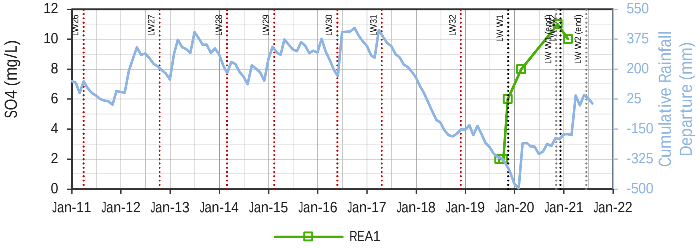

HC03 (mg/L)
Cumulative Rainfall Departure (mm)
REA6

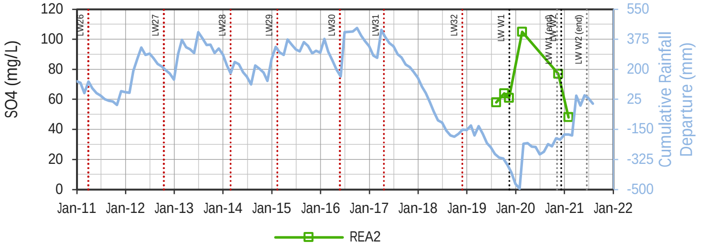

HC03 (mg/L)
Cumulative Rainfall Departure (mm)
REA7

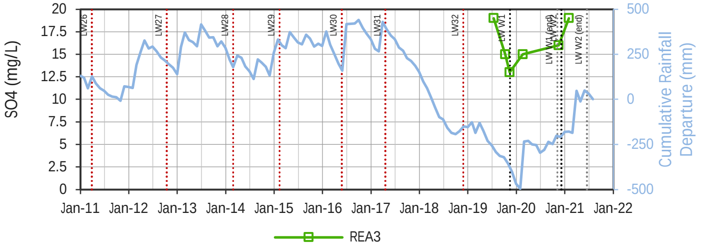

HC03 (mg/L)
Cumulative Rainfall Departure (mm)
PIT TOP 1

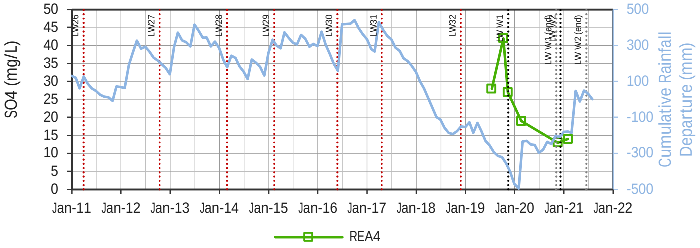

HC03 (mg/L)
Cumulative Rainfall Departure (mm)
PIT TOP 2

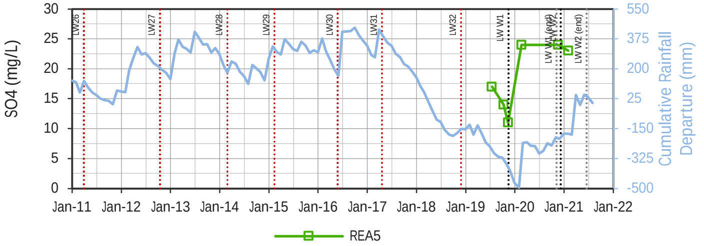

HC03 (mg/L)
Cumulative Rainfall Departure (mm)
PIT TOP 4

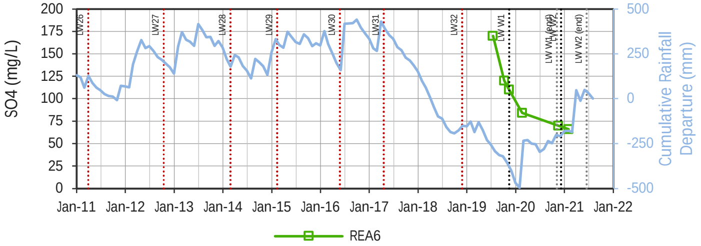

SO4 (mg/L)
Cumulative Rainfall Departure (mm)
REA1

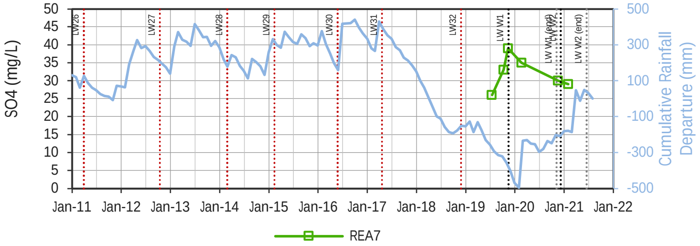

SO4 (mg/L)
Cumulative Rainfall Departure (mm)
REA2

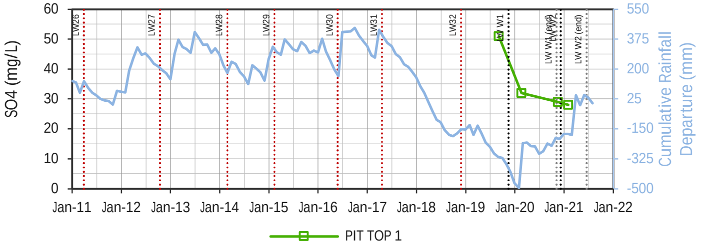

SO4 (mg/L)
Cumulative Rainfall Departure (mm)
REA3

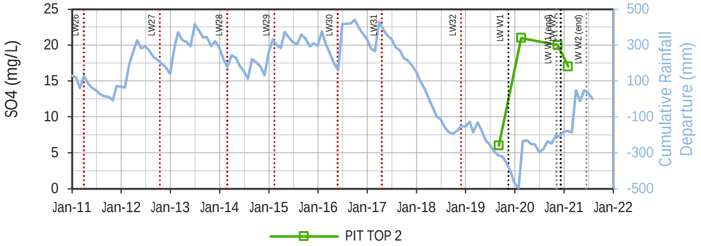

SO4 (mg/L)
Cumulative Rainfall Departure (mm)
REA4

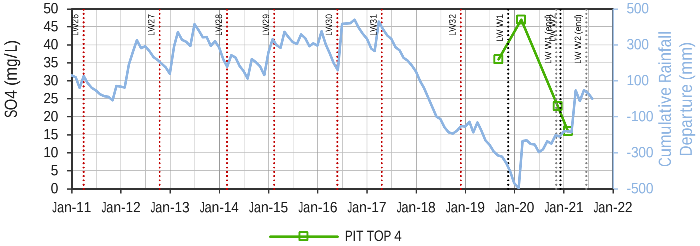

SO4 (mg/L)
Cumulative Rainfall Departure (mm)
REA5

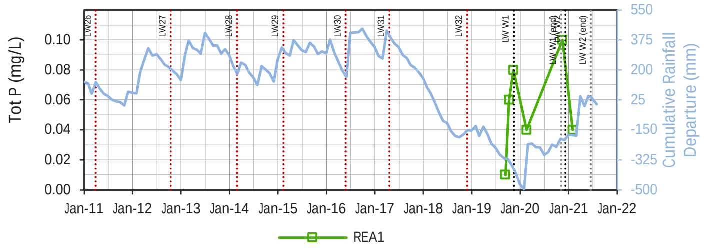

SO4 (mg/L)
Cumulative Rainfall Departure (mm)
REA6

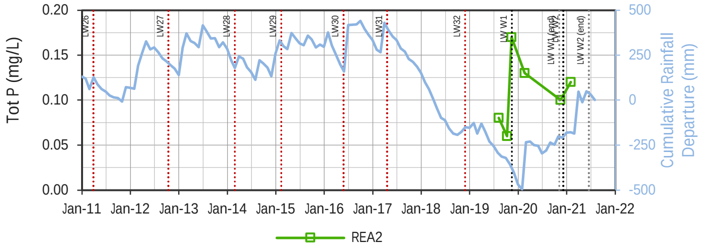

SO4 (mg/L)
Cumulative Rainfall Departure (mm)
REA7

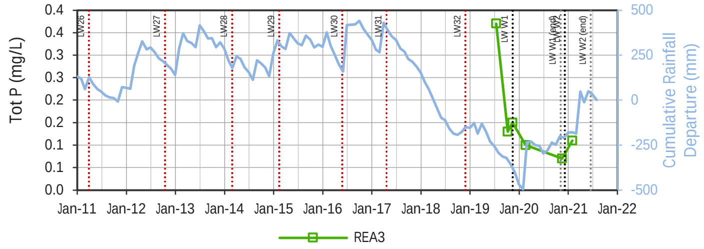

SO4 (mg/L)
Cumulative Rainfall Departure (mm)
PIT TOP 1

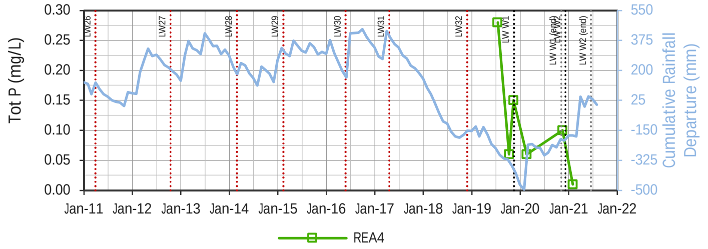

SO4 (mg/L)
Cumulative Rainfall Departure (mm)
PIT TOP 2

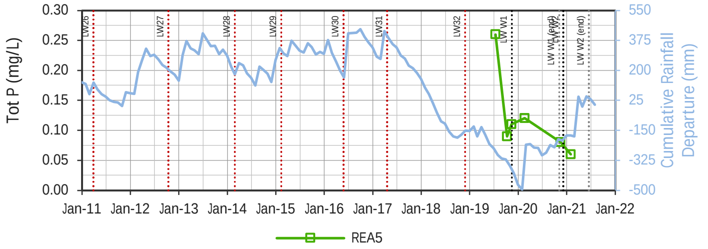

SO4 (mg/L)
Cumulative Rainfall Departure (mm)
PIT TOP 4

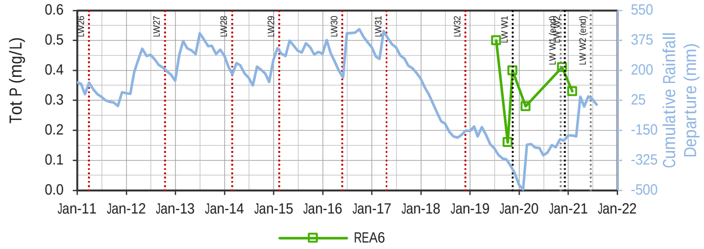

Tot P (mg/L)
Cumulative Rainfall Departure (mm)
REA1

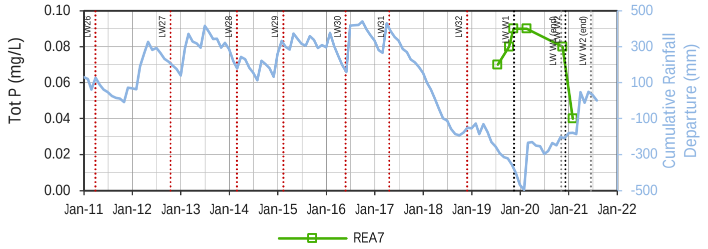

Tot P (mg/L)
Cumulative Rainfall Departure (mm)
REA2

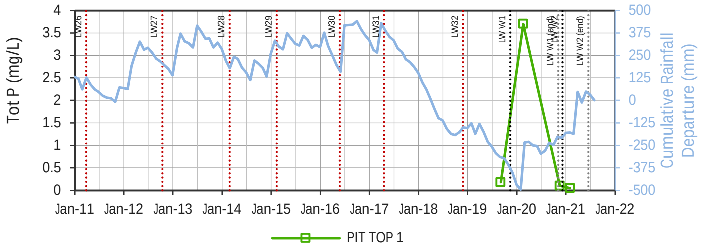

Tot P (mg/L)
Cumulative Rainfall Departure (mm)
REA3

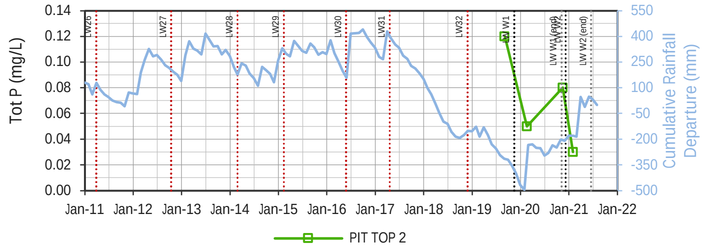

Tot P (mg/L)
Cumulative Rainfall Departure (mm)
REA4

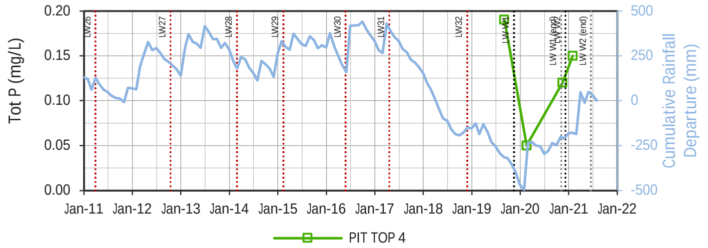

Tot P (mg/L)
Cumulative Rainfall Departure (mm)
REA5

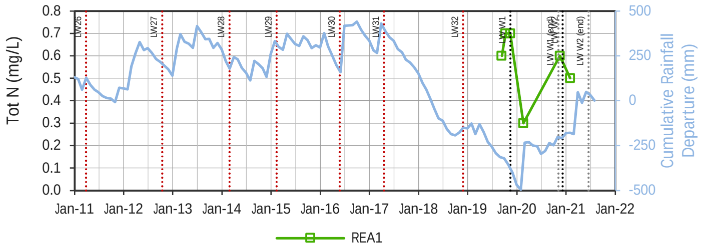

Tot P (mg/L)
Cumulative Rainfall Departure (mm)
REA6

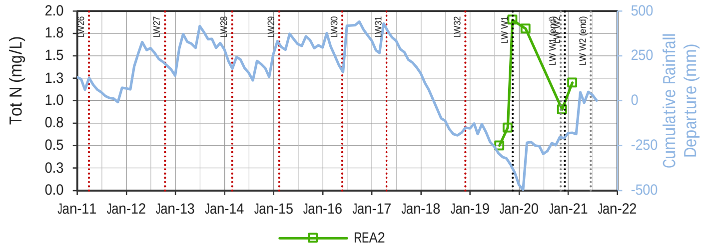

Tot P (mg/L)
Cumulative Rainfall Departure (mm)
REA7

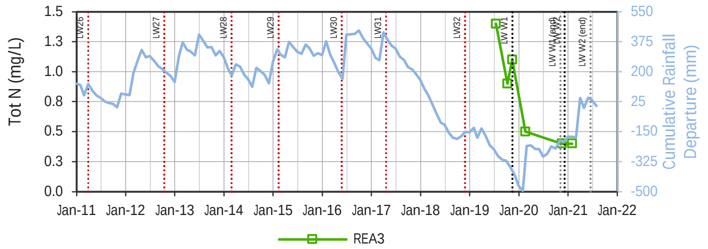

Tot P (mg/L)
Cumulative Rainfall Departure (mm)
PIT TOP 1

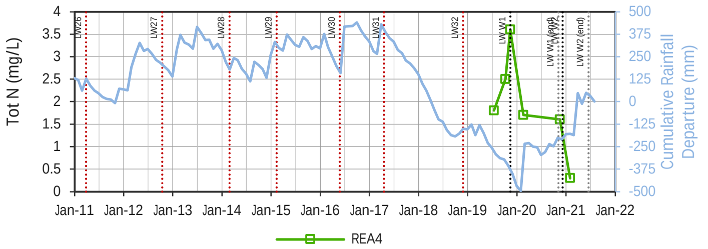

Tot P (mg/L)
Cumulative Rainfall Departure (mm)
PIT TOP 2

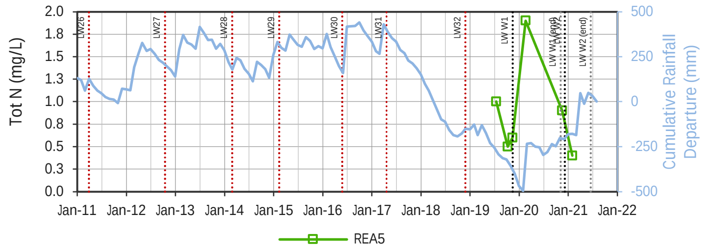

Tot P (mg/L)
Cumulative Rainfall Departure (mm)
PIT TOP 4

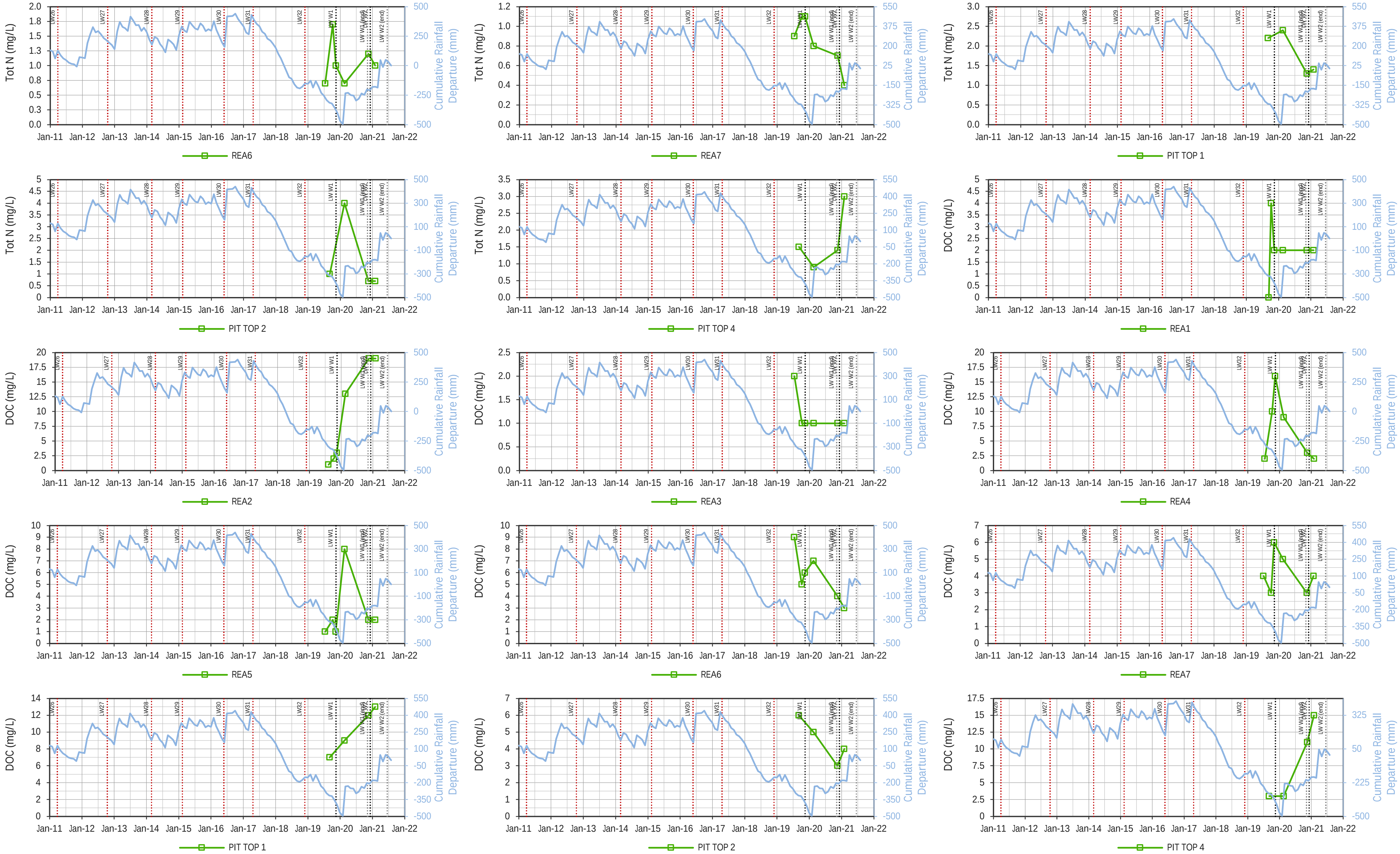

Tot N (mg/L)
Cumulative Rainfall Departure (mm)
REA1


Tot N (mg/L)
Cumulative Rainfall Departure (mm)
REA2

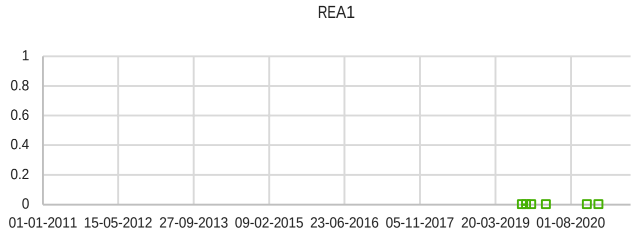

Tot N (mg/L)
Cumulative Rainfall Departure (mm)
REA3

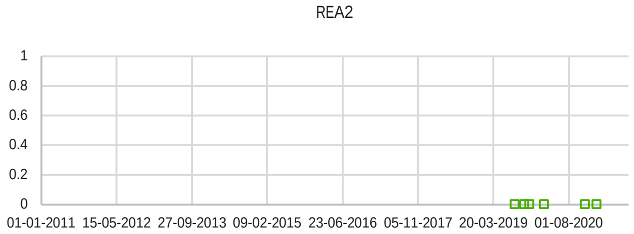

Tot N (mg/L)
Cumulative Rainfall Departure (mm)
REA4


Tot N (mg/L)
Cumulative Rainfall Departure (mm)
REA5



Tot N (mg/L)
DOC (mg/L)
Cumulative Rainfall Departure (mm)
REA6
REA7
PIT TOP 1
PIT TOP 2
PIT TOP 4
REA1
REA2
REA3
REA4
REA5
REA6
REA7
PIT TOP 1
PIT TOP 2
PIT TOP 4


REA1
1
0.8
0.6
0.4
0.2
0
01-01-2011 15-05-2012 27-09-2013 09-02-2015 23-06-2016 05-11-2017 20-03-2019 01-08-2020


REA2
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0.6
0.4
0.2
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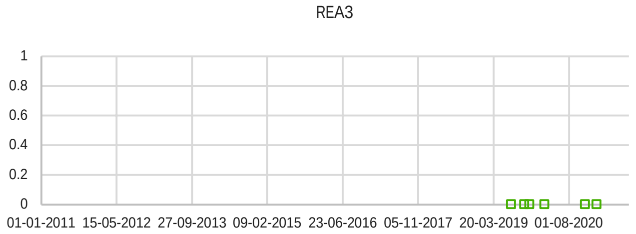
REA3
1
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0.6
0.4
0.2
0
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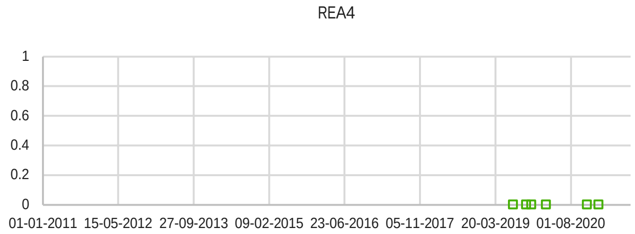
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0.4
0.2
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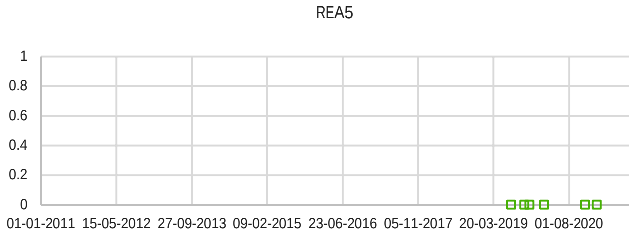
REA5
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0.6
0.4
0.2
0
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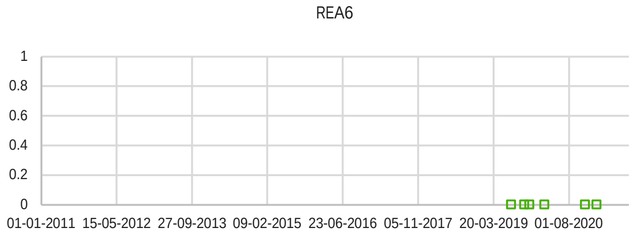
REA6
1
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0.6
0.4
0.2
0
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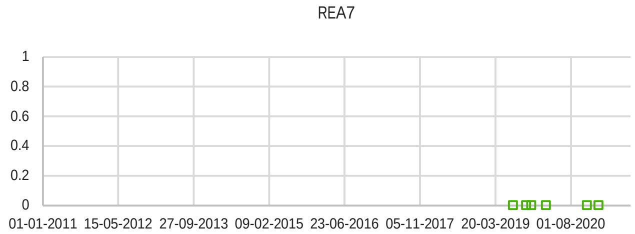
REA7
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0.2
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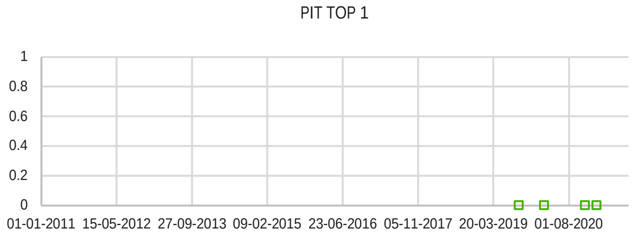
PIT TOP 1
1
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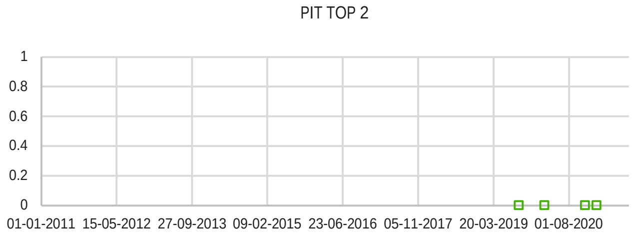
0.6
0.4
0.2
0
01-01-2011 15-05-2012 27-09-2013 09-02-2015 23-06-2016 05-11-2017 20-03-2019 01-08-2020


PIT TOP 2
1
0.8
0.6
0.4
0.2
0
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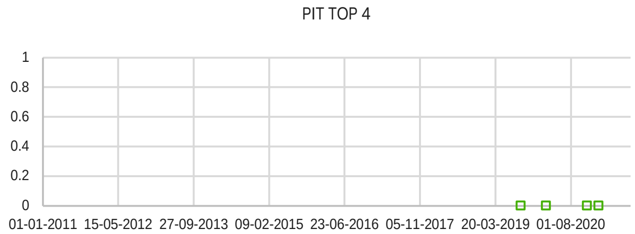
PIT TOP 4
1
0.8
0.6
0.4
0.2
0
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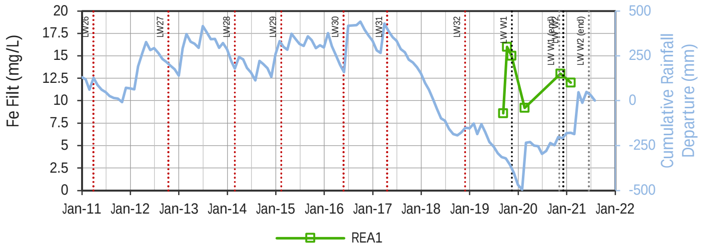
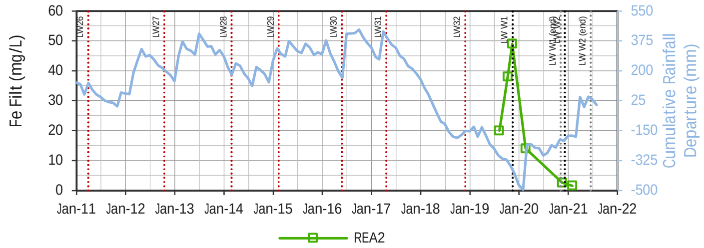
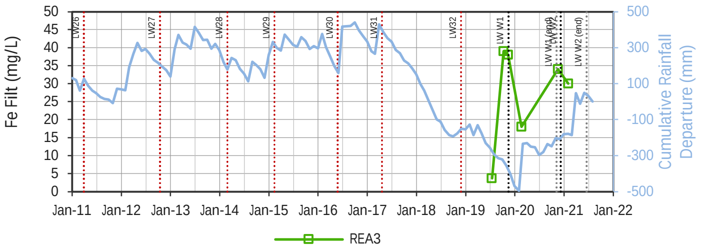
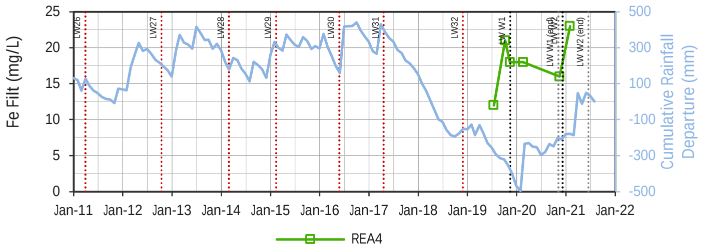
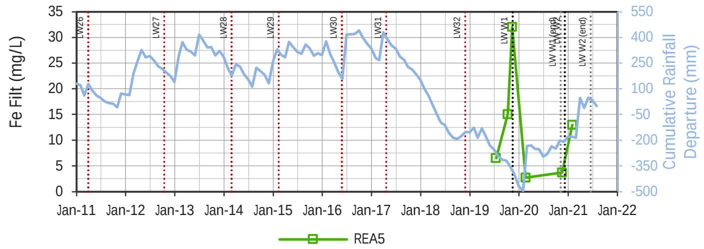
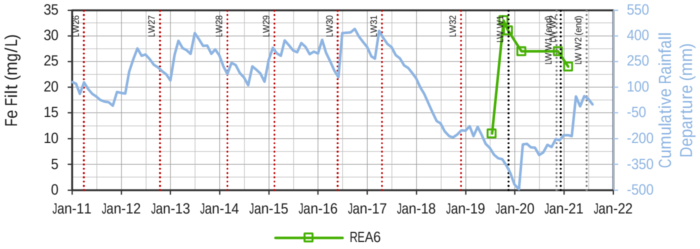

Fe Filt (mg/L)
20
17.5
15
12.5
10
7.5
5
2.5
0
LW26 LW27 LW28 LW29 LW30 LW31 LW32 LW W1 LW W1 (end) LW W2 LW W2 (end)
500
250
0
-250
-500
Cumulative Rainfall Departure (mm)
Jan-11 Jan-12 Jan-13 Jan-14 Jan-15 Jan-16 Jan-17 Jan-18 Jan-19 Jan-20 Jan-21 Jan-22
REA1

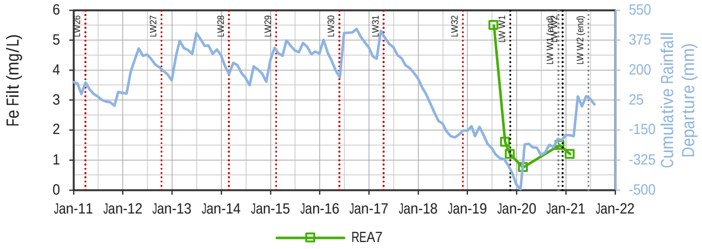

Fe Filt (mg/L)
60
50
40
30
20
10
0
LW26 LW27 LW28 LW29 LW30 LW31 LW32 LW W1 LW W1 (end) LW W2 LW W2 (end)
550
375
200
25
-150
-325
-500
Cumulative Rainfall Departure (mm)
Jan-11 Jan-12 Jan-13 Jan-14 Jan-15 Jan-16 Jan-17 Jan-18 Jan-19 Jan-20 Jan-21 Jan-22
REA2

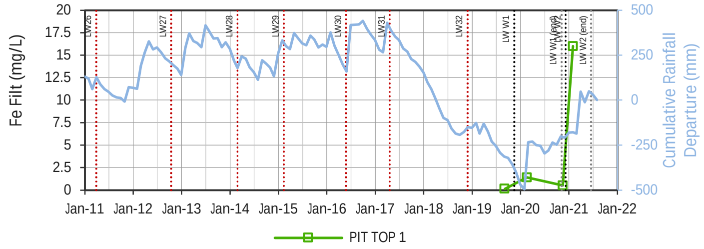

Fe Filt (mg/L)
50
45
40
35
30
25
20
15
10
5
0
LW26 LW27 LW28 LW29 LW30 LW31 LW32 LW W1 LW W1 (end) LW W2 LW W2 (end)
500
300
100
-100
-300
-500
Cumulative Rainfall Departure (mm)
Jan-11 Jan-12 Jan-13 Jan-14 Jan-15 Jan-16 Jan-17 Jan-18 Jan-19 Jan-20 Jan-21 Jan-22
REA3

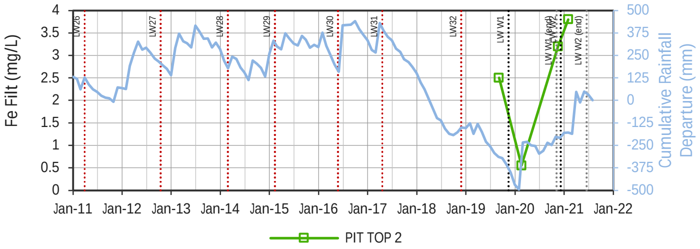

Fe Filt (mg/L)
25
20
15
10
5
0
LW26 LW27 LW28 LW29 LW30 LW31 LW32 LW W1 LW W1 (end) LW W2 LW W2 (end)
500
300
100
-100
-300
-500
Cumulative Rainfall Departure (mm)
Jan-11 Jan-12 Jan-13 Jan-14 Jan-15 Jan-16 Jan-17 Jan-18 Jan-19 Jan-20 Jan-21 Jan-22
REA4

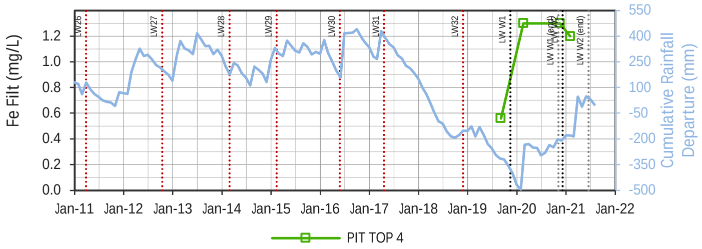

Fe Filt (mg/L)
35
30
25
20
15
10
5
0
LW26 LW27 LW28 LW29 LW30 LW31 LW32 LW W1 LW W1 (end) LW W2 LW W2 (end)
550
400
250
100
-50
-200
-350
-500
Cumulative Rainfall Departure (mm)
Jan-11 Jan-12 Jan-13 Jan-14 Jan-15 Jan-16 Jan-17 Jan-18 Jan-19 Jan-20 Jan-21 Jan-22
REA5



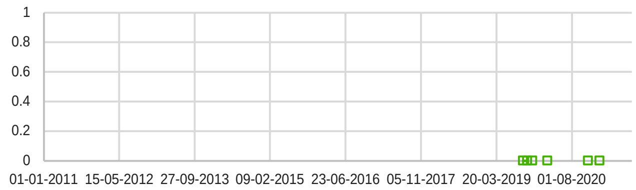




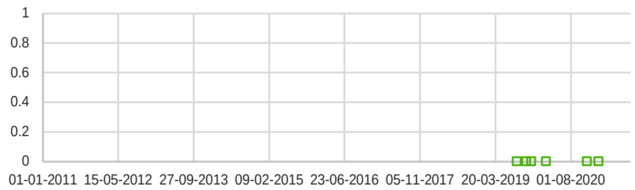




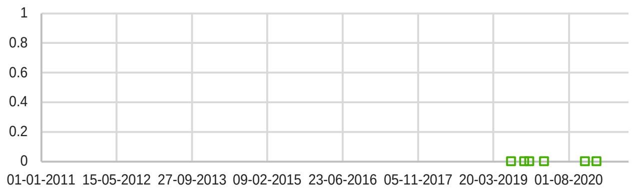
REA1



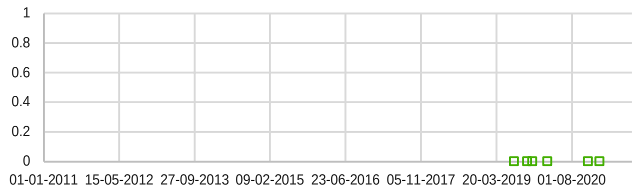
REA2



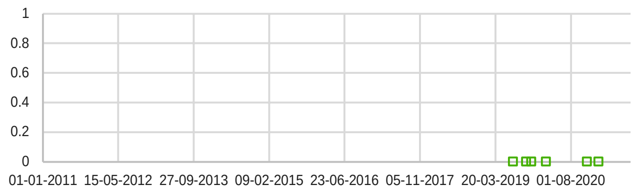
REA3



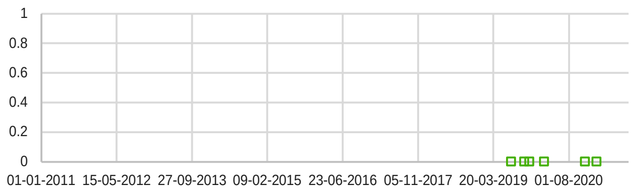
REA4



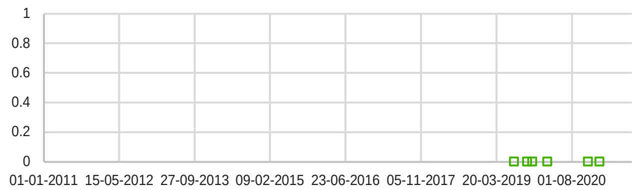
REA5



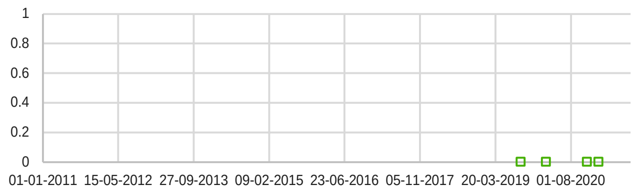
REA6



REA7



PIT TOP 1



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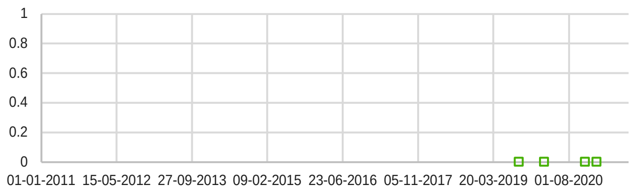
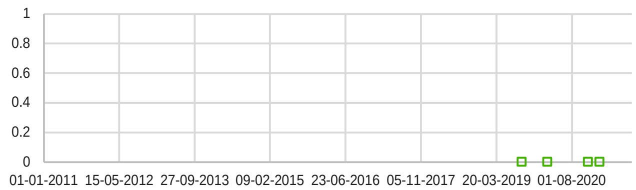
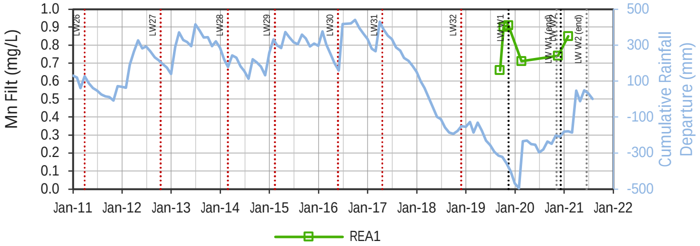
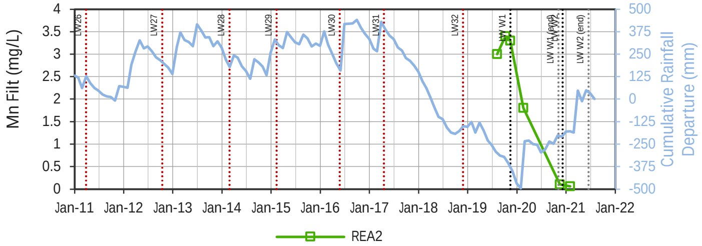
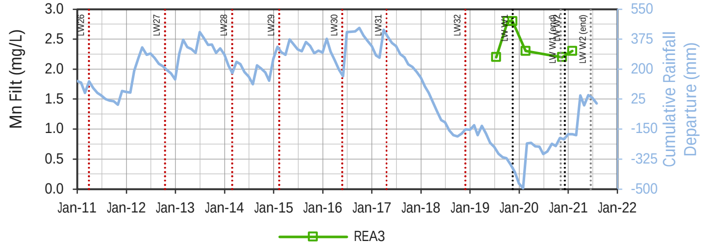


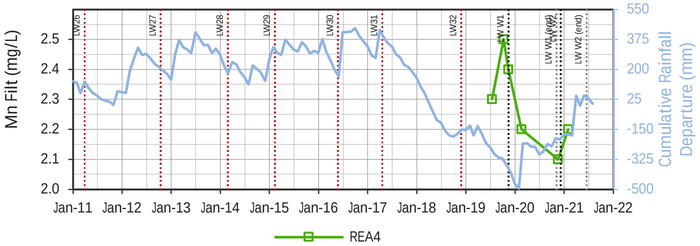
PIT TOP 4

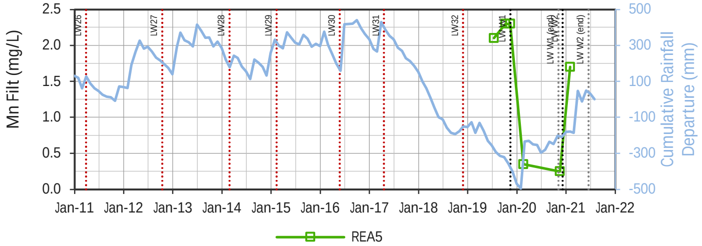


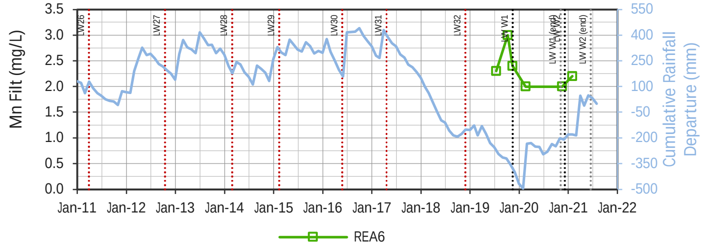

Mn Filt (mg/L)
Cumulative Rainfall Departure (mm)
REA1

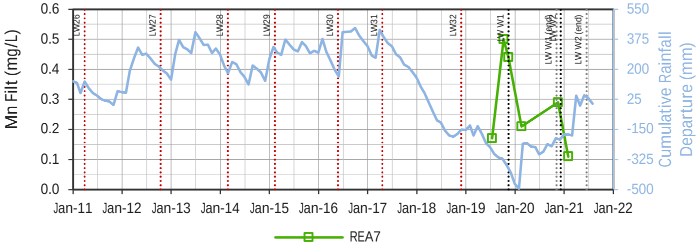

Mn Filt (mg/L)
Cumulative Rainfall Departure (mm)
REA2

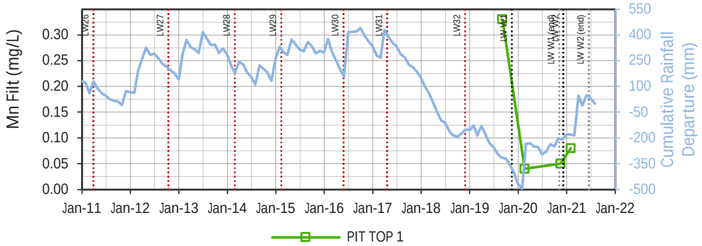

Mn Filt (mg/L)
Cumulative Rainfall Departure (mm)
REA3

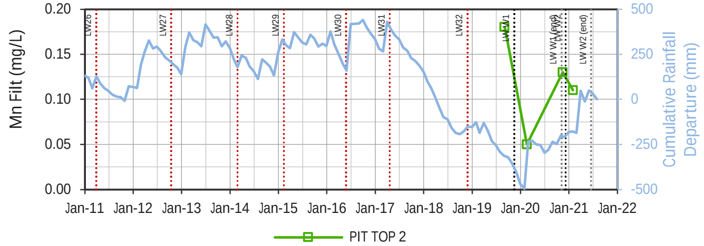

Mn Filt (mg/L)
Cumulative Rainfall Departure (mm)
REA4

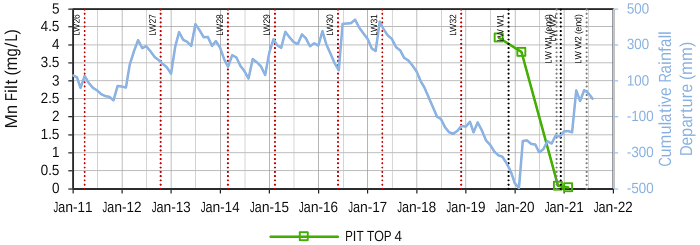

Mn Filt (mg/L)
Cumulative Rainfall Departure (mm)
REA5

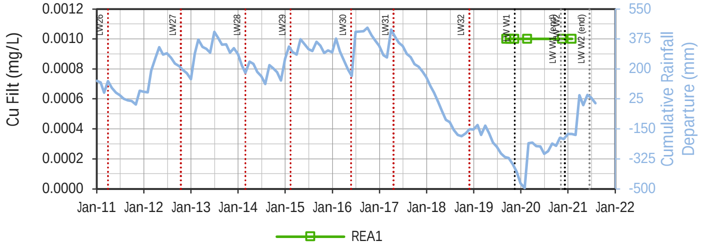

Mn Filt (mg/L)
Cumulative Rainfall Departure (mm)
REA6

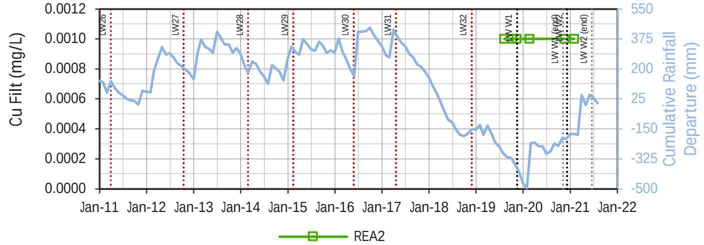

Mn Filt (mg/L)
Cumulative Rainfall Departure (mm)
REA7

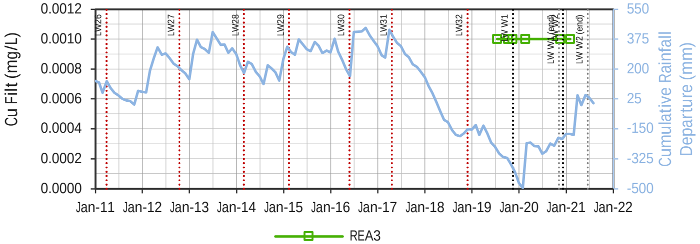

Mn Filt (mg/L)
Cumulative Rainfall Departure (mm)
PIT TOP 1

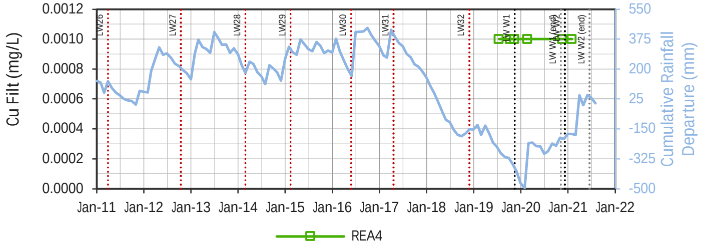

Mn Filt (mg/L)
Cumulative Rainfall Departure (mm)
PIT TOP 2


Mn Filt (mg/L)
Cumulative Rainfall Departure (mm)
PIT TOP 4


Cu Filt (mg/L)
Cumulative Rainfall Departure (mm)
REA1


Cu Filt (mg/L)
Cumulative Rainfall Departure (mm)
REA2


Cu Filt (mg/L)
Cumulative Rainfall Departure (mm)
REA3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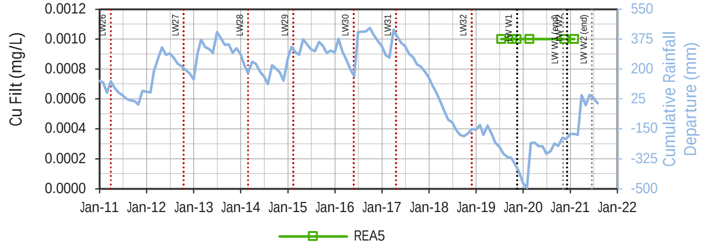
Cumulative Rainfall Departure (mm)
REA4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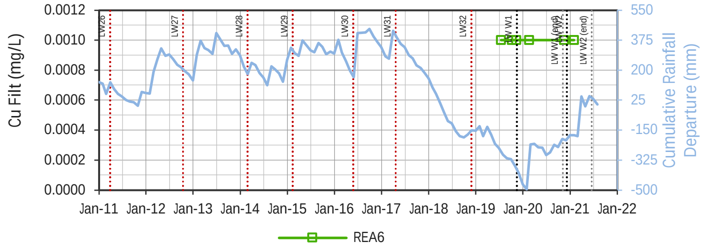
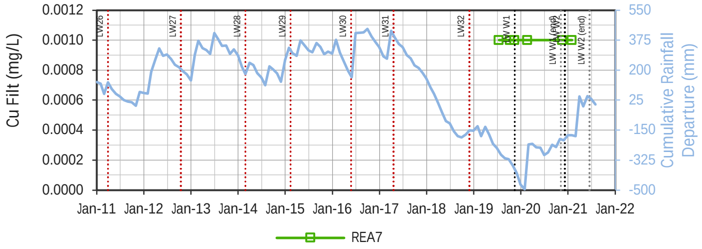
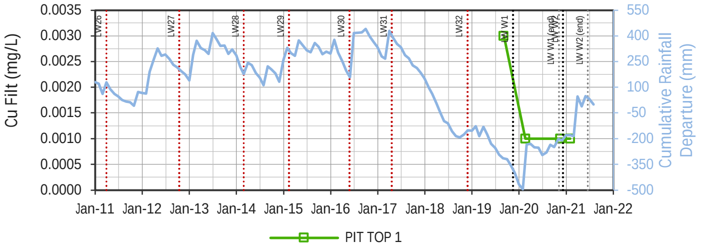
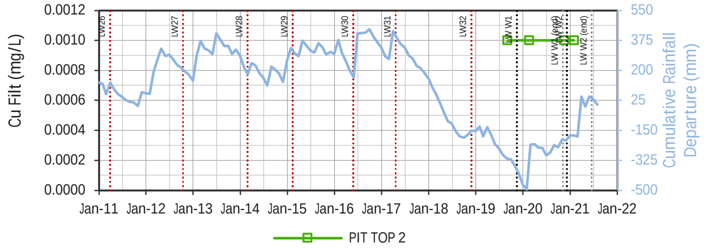
Cumulative Rainfall Departure (mm)
REA5


Cu Filt (mg/L)
Cumulative Rainfall Departure (mm)
Jan-11 – Jan-22
REA6


Cu Filt (mg/L)
Cumulative Rainfall Departure (mm)
Jan-11 – Jan-22
REA7


Cu Filt (mg/L)
Cumulative Rainfall Departure (mm)
Jan-11 – Jan-22
PIT TOP 1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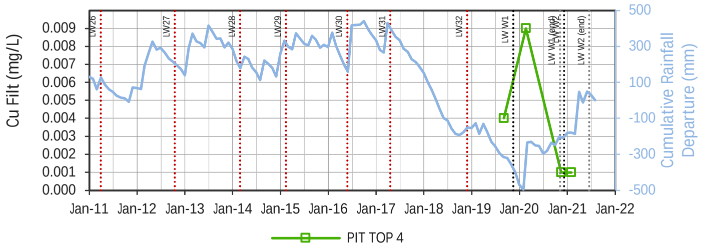
Cumulative Rainfall Departure (mm)
Jan-11 – Jan-22
PIT TOP 2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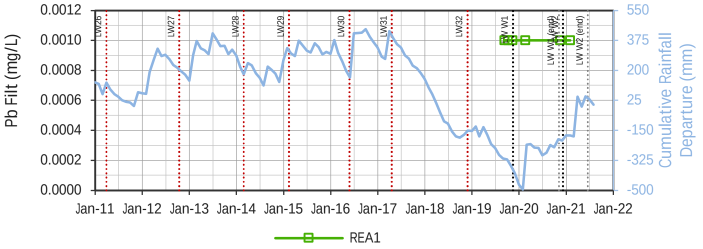
Cumulative Rainfall Departure (mm)
Jan-11 – Jan-22
PIT TOP 4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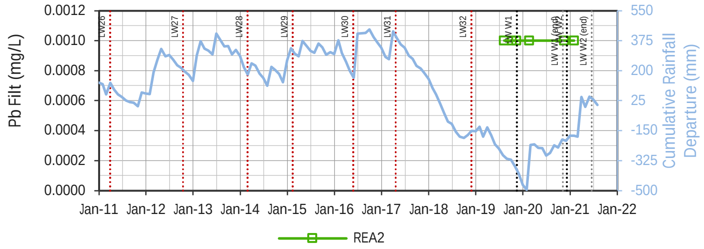
Cumulative Rainfall Departure (mm)
Jan-11 – Jan-22
REA1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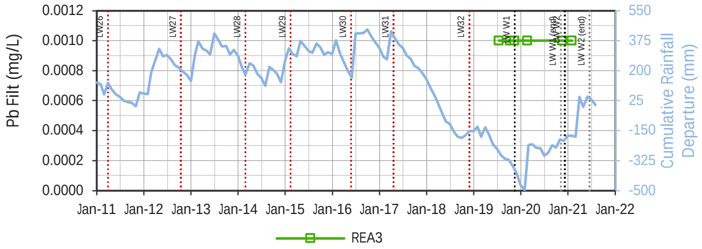
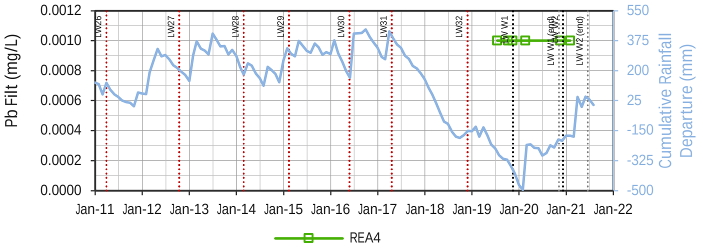
Cumulative Rainfall Departure (mm)
Jan-11 – Jan-22
REA2


Pb Filt (mg/L)
Cumulative Rainfall Departure (mm)
Jan-11 – Jan-22
REA3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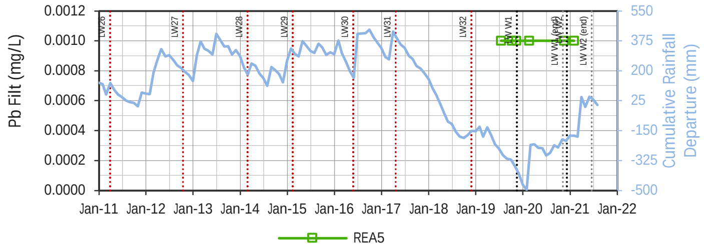
Cumulative Rainfall Departure (mm)
Jan-11 – Jan-22
REA4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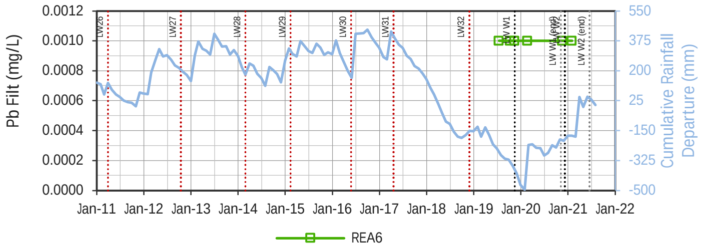
Cumulative Rainfall Departure (mm)
Jan-11 – Jan-22
REA5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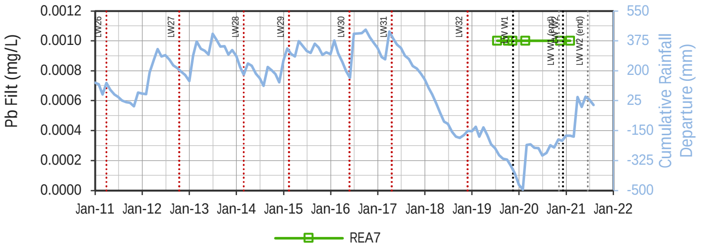
Cumulative Rainfall Departure (mm)
Jan-11 – Jan-22
REA6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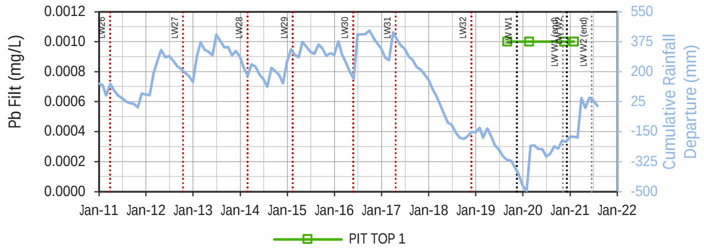
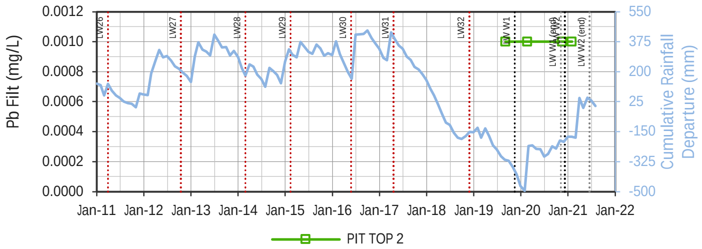
Cumulative Rainfall Departure (mm)
Jan-11 – Jan-22
REA7


Pb Filt (mg/L)
Cumulative Rainfall Departure (mm)
Jan-11 – Jan-22
PIT TOP 1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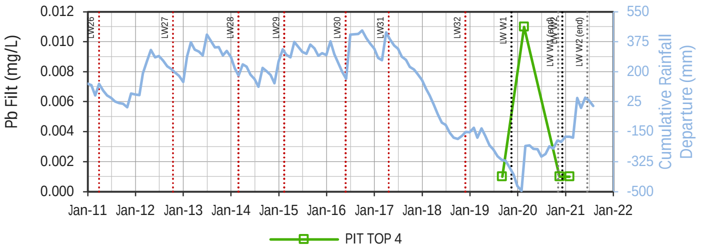
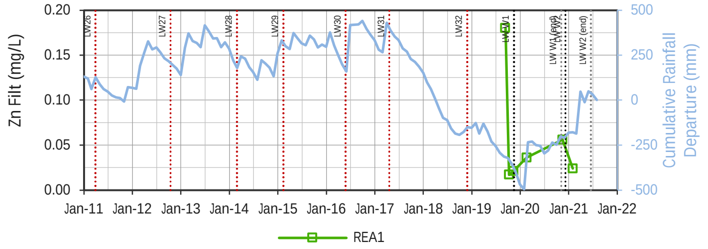
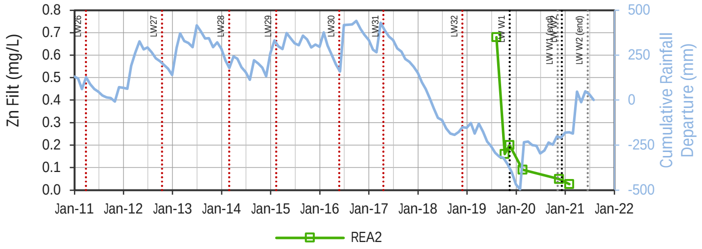
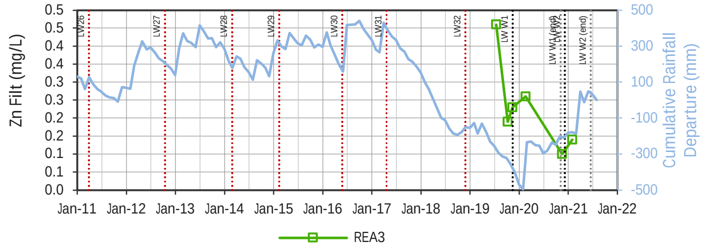
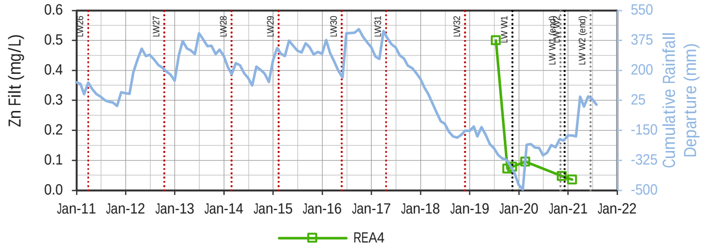
Cumulative Rainfall Departure (mm)
Jan-11 – Jan-22
PIT TOP 2

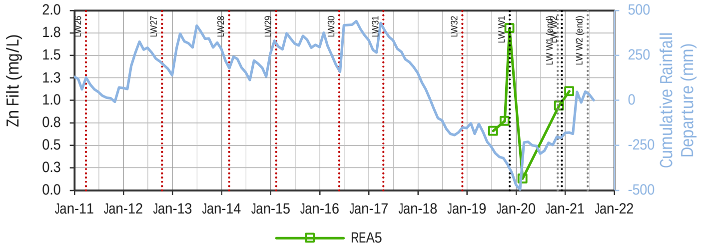

Pb Filt (mg/L)
Cumulative Rainfall Departure (mm)
Jan-11 – Jan-22
PIT TOP 4

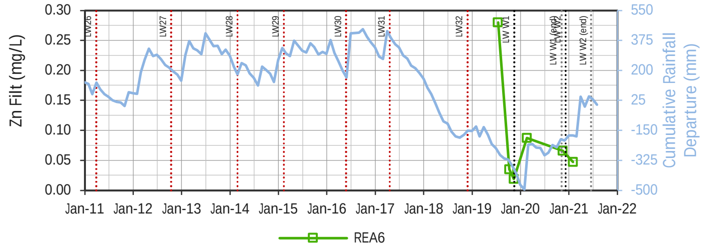

Zn Filt (mg/L)
Cumulative Rainfall Departure (mm)
REA1

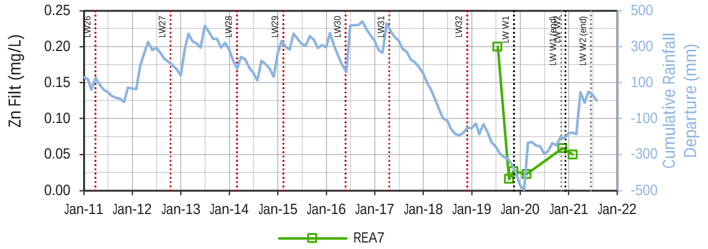

Zn Filt (mg/L)
Cumulative Rainfall Departure (mm)
REA2

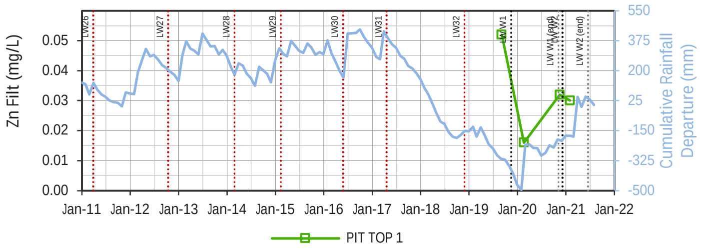

Zn Filt (mg/L)
Cumulative Rainfall Departure (mm)
REA3

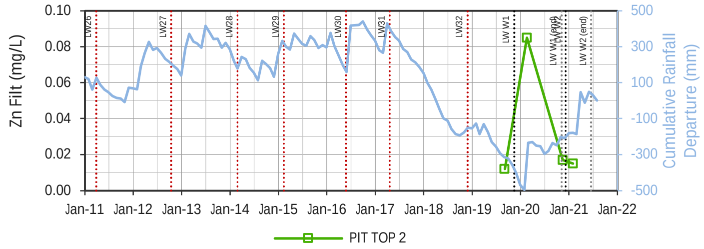

Zn Filt (mg/L)
Cumulative Rainfall Departure (mm)
REA4

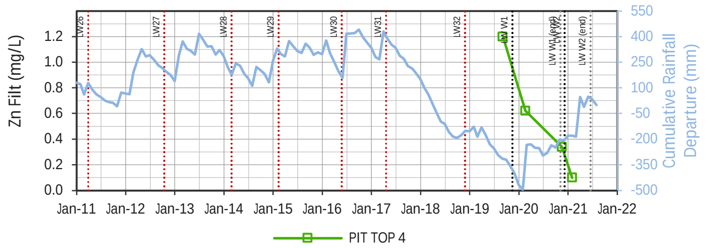

Zn Filt (mg/L)
Cumulative Rainfall Departure (mm)
REA5

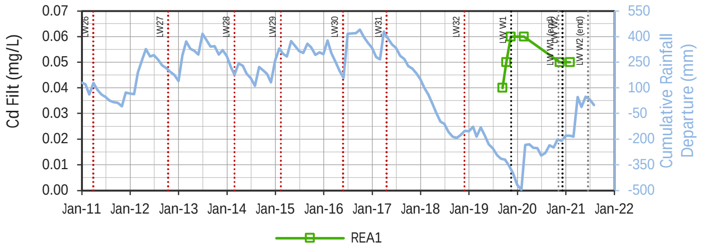

Zn Filt (mg/L)
Cumulative Rainfall Departure (mm)
REA6

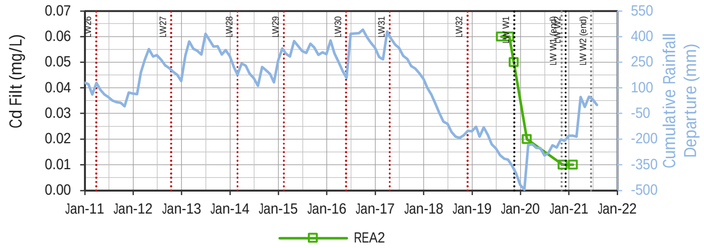

Zn Filt (mg/L)
Cumulative Rainfall Departure (mm)
REA7

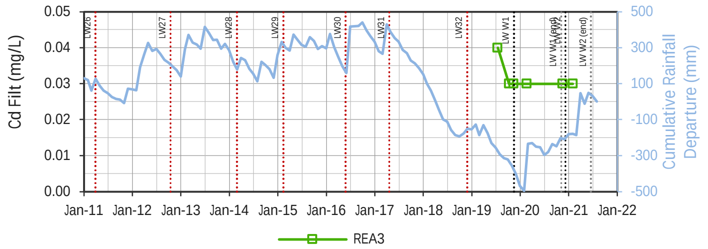

Zn Filt (mg/L)
Cumulative Rainfall Departure (mm)
PIT TOP 1

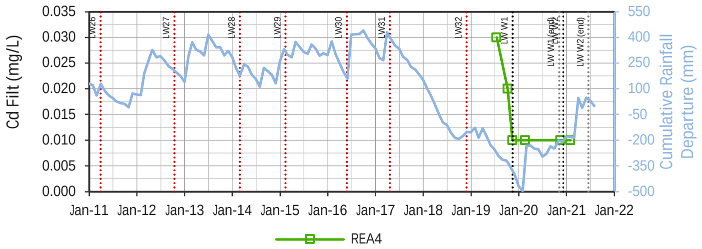

Zn Filt (mg/L)
Cumulative Rainfall Departure (mm)
PIT TOP 2

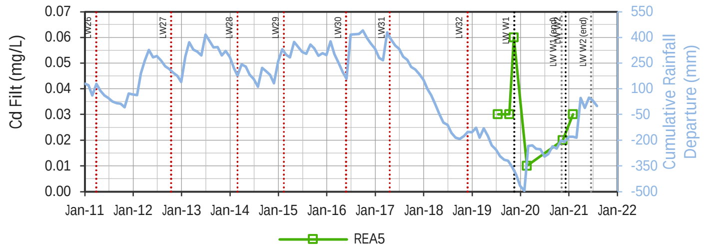

Zn Filt (mg/L)
Cumulative Rainfall Departure (mm)
PIT TOP 4

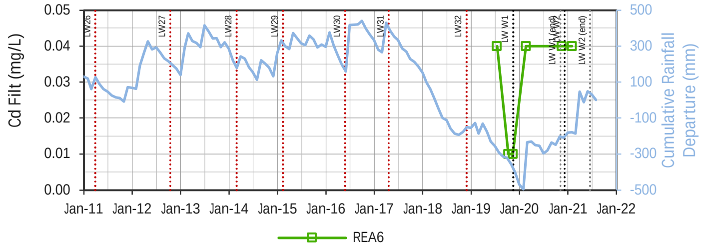

Cd Filt (mg/L)
Cumulative Rainfall Departure (mm)
REA1

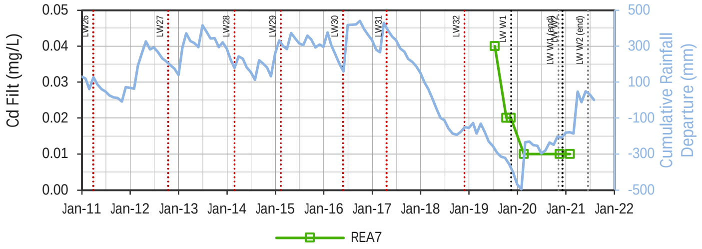

Cd Filt (mg/L)
Cumulative Rainfall Departure (mm)
REA2

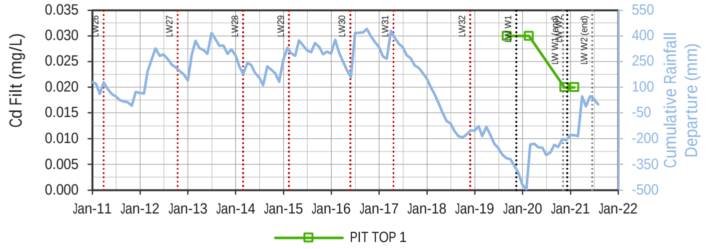

Cd Filt (mg/L)
Cumulative Rainfall Departure (mm)
REA3

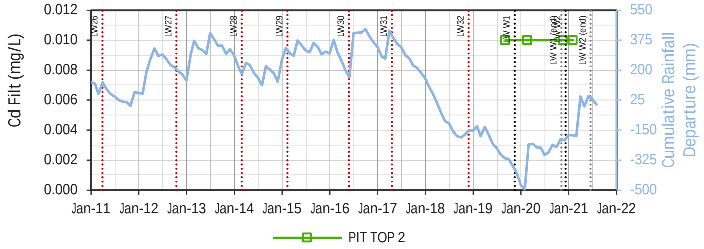

Cd Filt (mg/L)
Cumulative Rainfall Departure (mm)
REA4

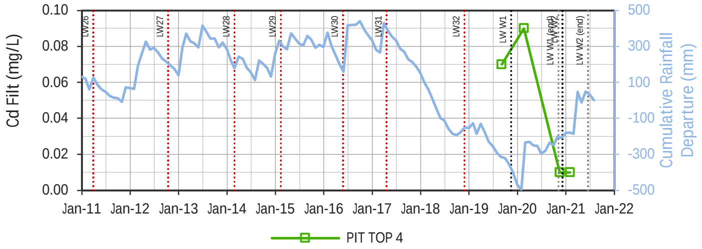

Cd Filt (mg/L)
Cumulative Rainfall Departure (mm)
REA5

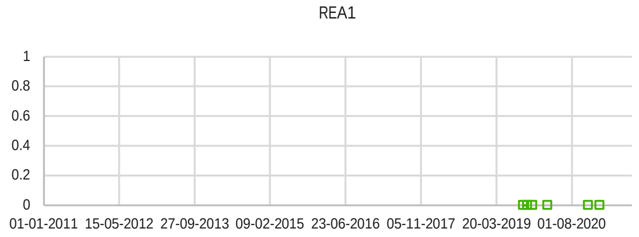

Cd Filt (mg/L)
Cumulative Rainfall Departure (mm)
LW26
LW27
LW28
LW29
LW30
LW31
LW32
LW W1
LW W1 (end)
LW W2
LW W2 (end)
0.05
0.04
0.03
0.02
0.01
0.00
500
300
100
-100
-300
-500
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22
REA6

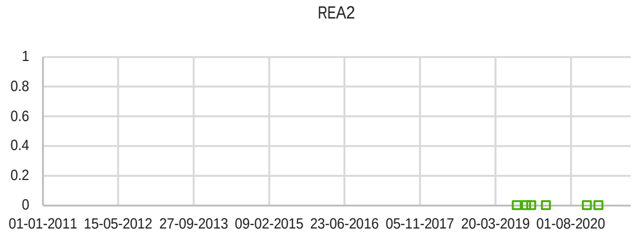

Cd Filt (mg/L)
Cumulative Rainfall Departure (mm)
LW26
LW27
LW28
LW29
LW30
LW31
LW32
LW W1
LW W1 (end)
LW W2
LW W2 (end)
0.05
0.04
0.03
0.02
0.01
0.00
500
300
100
-100
-300
-500
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22
REA7

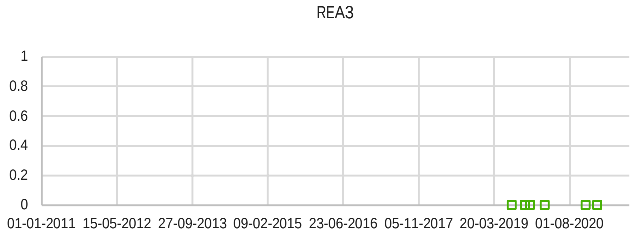

Cd Filt (mg/L)
Cumulative Rainfall Departure (mm)
LW26
LW27
LW28
LW29
LW30
LW31
LW32
LW W1
LW W1 (end)
LW W2
LW W2 (end)
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
550
400
250
100
-50
-200
-350
-500
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22
PIT TOP 1

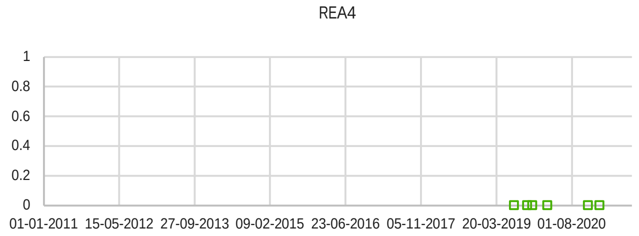

Cd Filt (mg/L)
Cumulative Rainfall Departure (mm)
LW26
LW27
LW28
LW29
LW30
LW31
LW32
LW W1
LW W1 (end)
LW W2
LW W2 (end)
0.012
0.010
0.008
0.006
0.004
0.002
0.000
550
375
200
25
-150
-325
-500
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22
PIT TOP 2

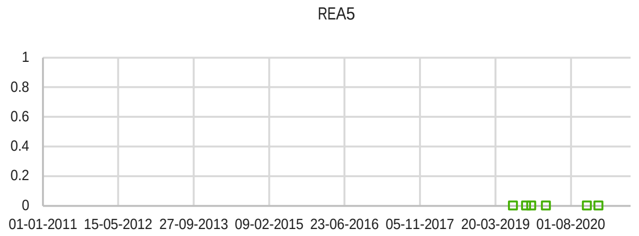

Cd Filt (mg/L)
Cumulative Rainfall Departure (mm)
LW26
LW27
LW28
LW29
LW30
LW31
LW32
LW W1
LW W1 (end)
LW W2
LW W2 (end)
0.10
0.08
0.06
0.04
0.02
0.00
500
300
100
-100
-300
-500
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22
PIT TOP 4

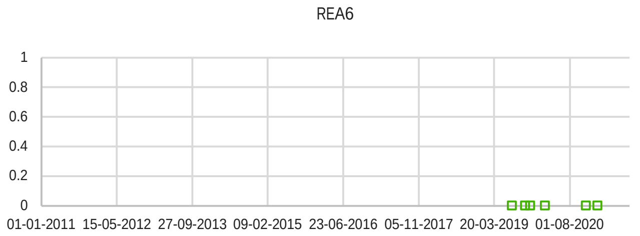

REA1
1
0.8
0.6
0.4
0.2
0
01-01-2011
15-05-2012
27-09-2013
09-02-2015
23-06-2016
05-11-2017
20-03-2019
01-08-2020


REA2
1
0.8
0.6
0.4
0.2
0
01-01-2011
15-05-2012
27-09-2013
09-02-2015
23-06-2016
05-11-2017
20-03-2019
01-08-2020


REA3
1
0.8
0.6
0.4
0.2
0
01-01-2011
15-05-2012
27-09-2013
09-02-2015
23-06-2016
05-11-2017
20-03-2019
01-08-2020


REA4
1
0.8
0.6
0.4
0.2
0
01-01-2011
15-05-2012
27-09-2013
09-02-2015
23-06-2016
05-11-2017
20-03-2019
01-08-2020


REA5
1
0.8
0.6
0.4
0.2
0
01-01-2011
15-05-2012
27-09-2013
09-02-2015
23-06-2016
05-11-2017
20-03-2019
01-08-2020


REA6
1
0.8
0.6
0.4
0.2
0
01-01-2011
15-05-2012
27-09-2013
09-02-2015
23-06-2016
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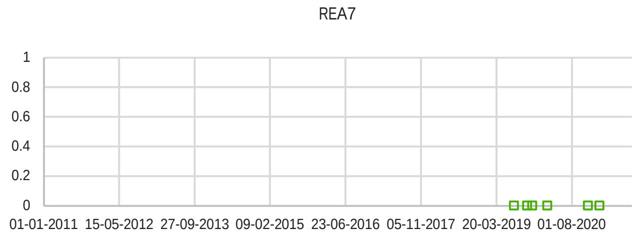
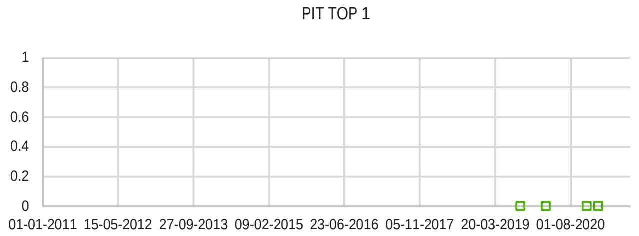
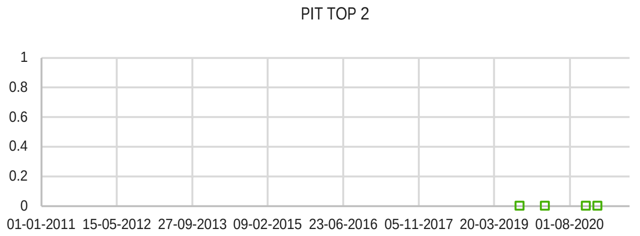
20-03-2019
01-08-2020


REA7
1
0.8
0.6
0.4
0.2
0
01-01-2011
15-05-2012
27-09-2013
09-02-2015
23-06-2016
05-11-2017
20-03-2019
01-08-2020


PIT TOP 1
1
0.8
0.6
0.4
0.2
0
01-01-2011
15-05-2012
27-09-2013
09-02-2015
23-06-2016
05-11-2017
20-03-2019
01-08-2020


PIT TOP 2
1
0.8
0.6
0.4
0.2
0
01-01-2011
15-05-2012
27-09-2013
09-02-2015
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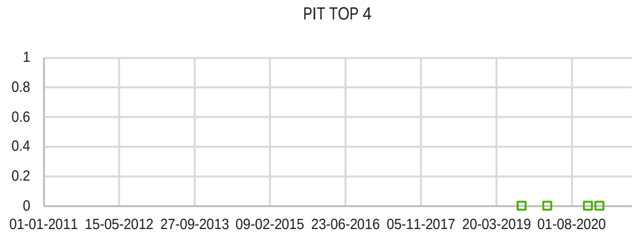
20-03-2019
01-08-2020


PIT TOP 4
1
0.8
0.6
0.4
0.2
0
01-01-2011
15-05-2012
27-09-2013
09-02-2015
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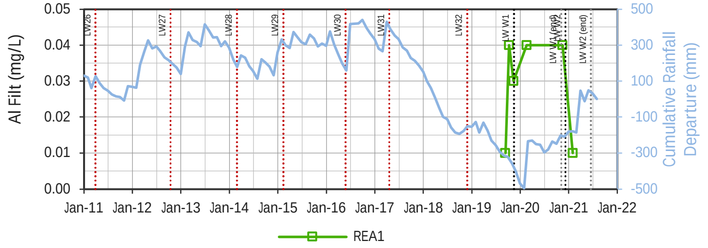
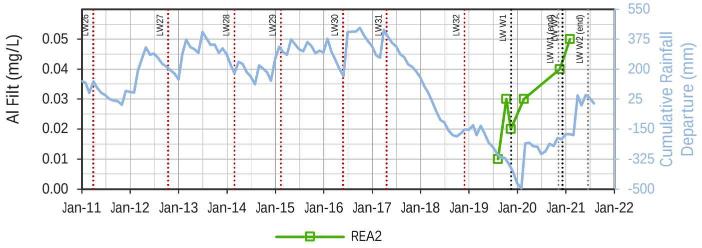
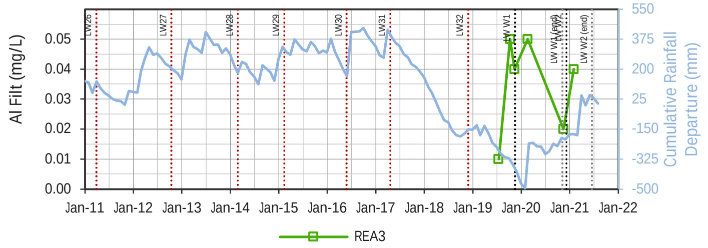
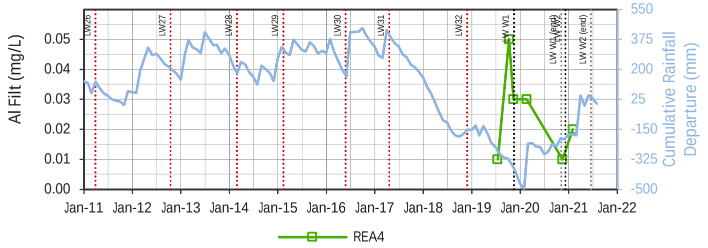
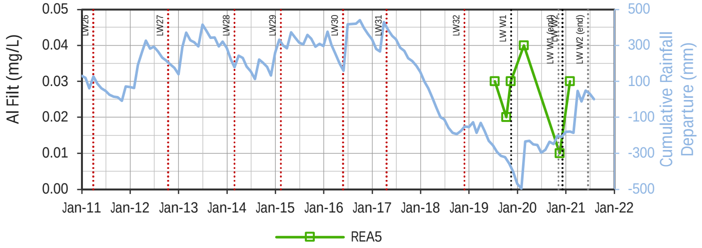
20-03-2019
01-08-2020

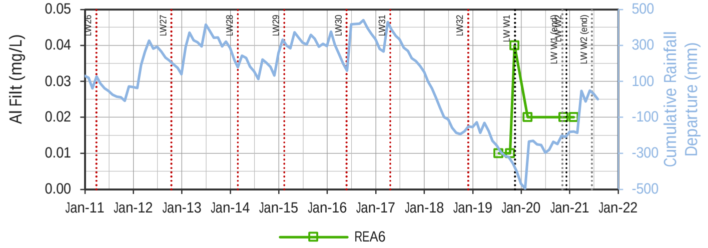

Al Filt (mg/L)
Cumulative Rainfall Departure (mm)
REA1

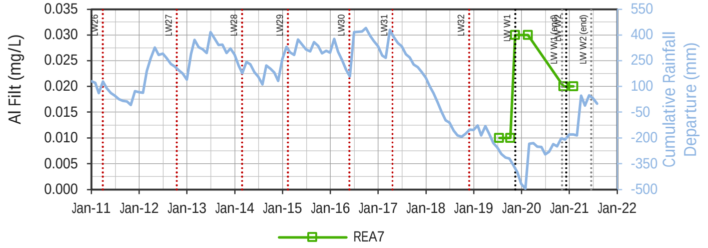

Al Filt (mg/L)
Cumulative Rainfall Departure (mm)
REA2

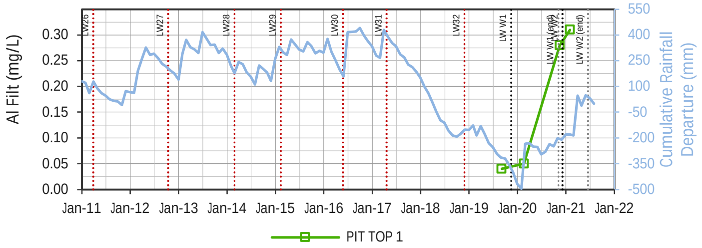

Al Filt (mg/L)
Cumulative Rainfall Departure (mm)
REA3

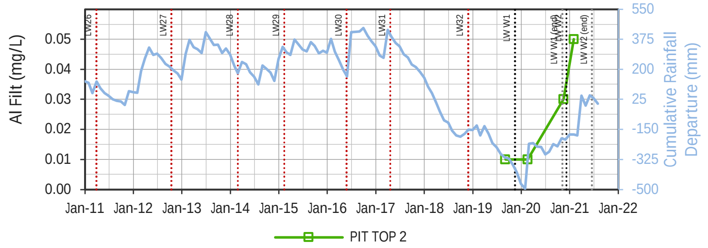

Al Filt (mg/L)
Cumulative Rainfall Departure (mm)
REA4

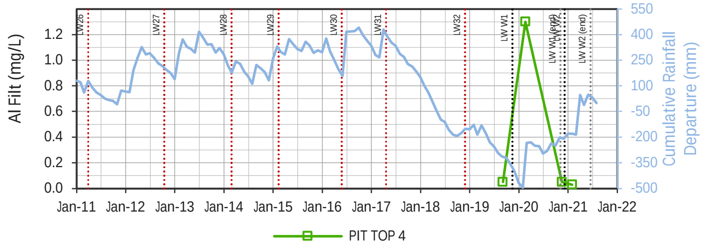

Al Filt (mg/L)
Cumulative Rainfall Departure (mm)
REA5

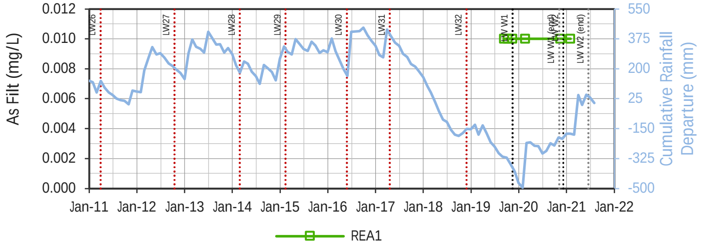

Al Filt (mg/L)
Cumulative Rainfall Departure (mm)
REA6

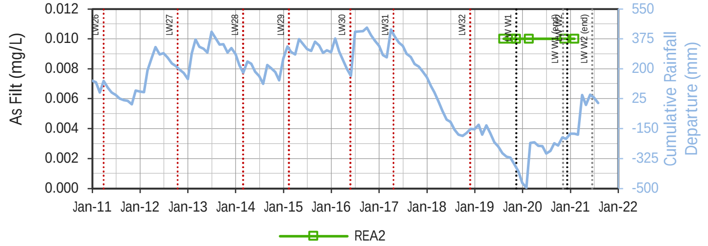

Al Filt (mg/L)
Cumulative Rainfall Departure (mm)
REA7

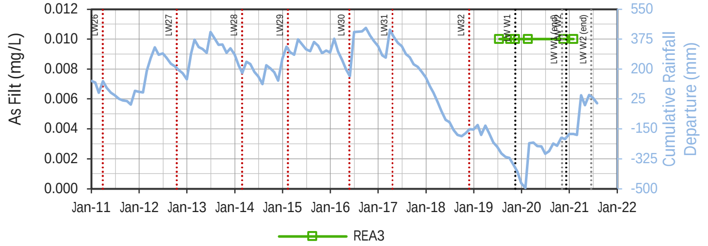

Al Filt (mg/L)
Cumulative Rainfall Departure (mm)
PIT TOP 1

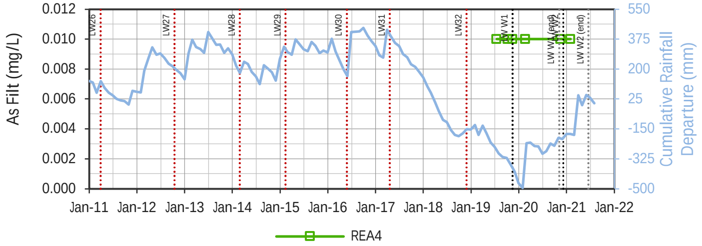

Al Filt (mg/L)
Cumulative Rainfall Departure (mm)
PIT TOP 2

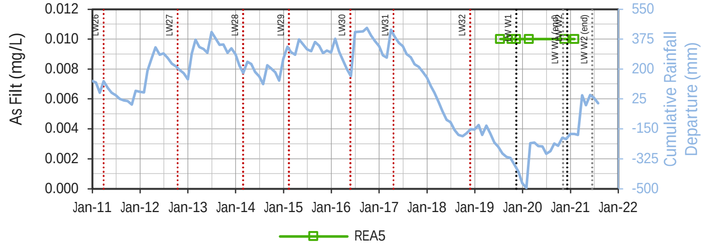

Al Filt (mg/L)
Cumulative Rainfall Departure (mm)
PIT TOP 4

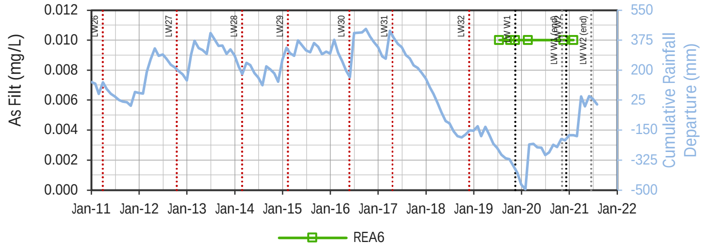

As Filt (mg/L)
Cumulative Rainfall Departure (mm)
REA1

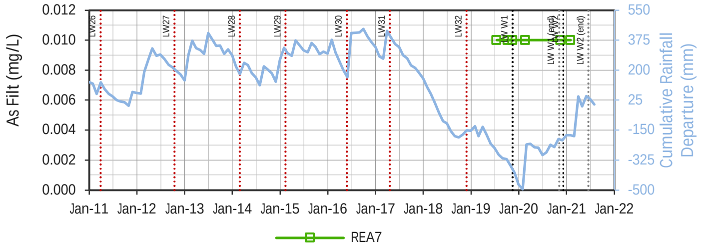

As Filt (mg/L)
Cumulative Rainfall Departure (mm)
REA2

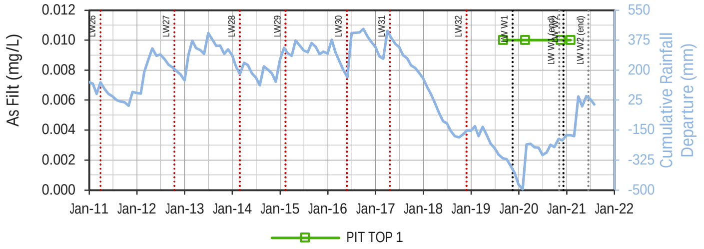

As Filt (mg/L)
Cumulative Rainfall Departure (mm)
REA3

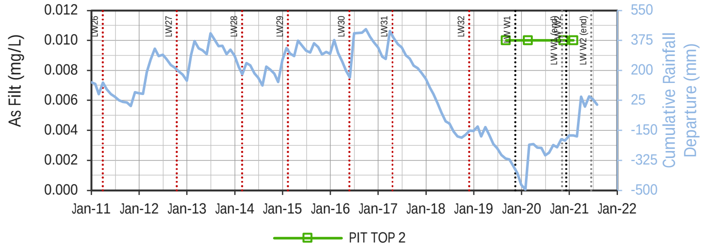

As Filt (mg/L)
Cumulative Rainfall Departure (mm)
REA4

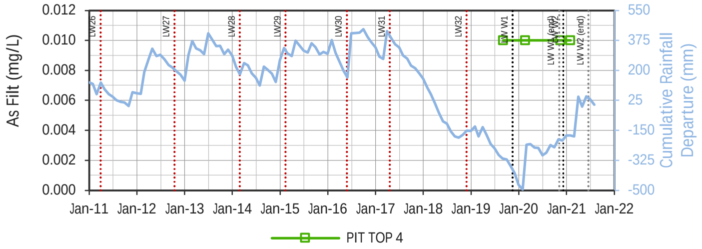

As Filt (mg/L)
Cumulative Rainfall Departure (mm)
REA5

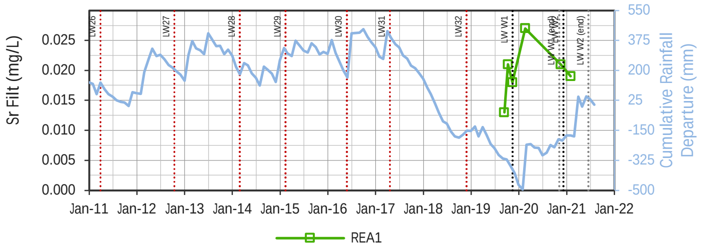

As Filt (mg/L)
Cumulative Rainfall Departure (mm)
REA6

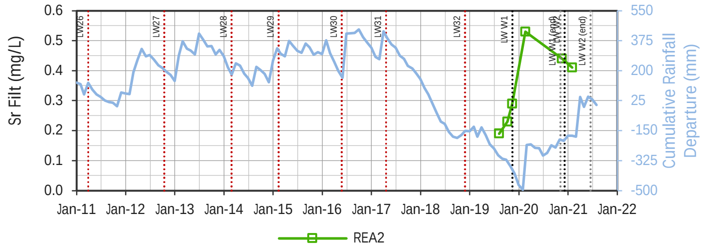

As Filt (mg/L)
Cumulative Rainfall Departure (mm)
REA7

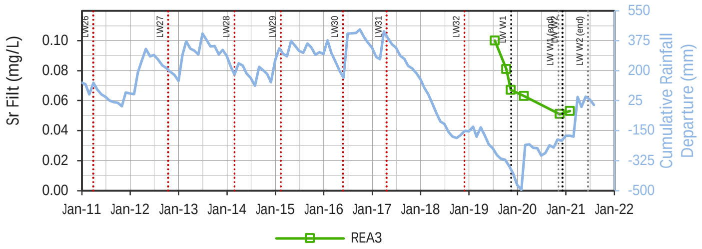

As Filt (mg/L)
Cumulative Rainfall Departure (mm)
PIT TOP 1

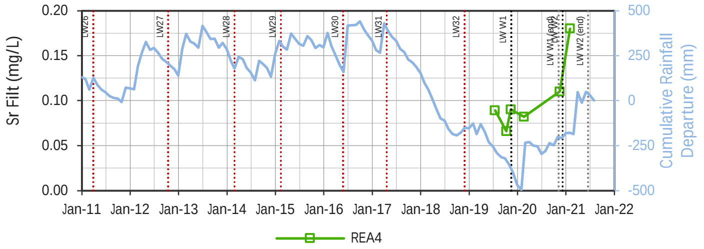

As Filt (mg/L)
Cumulative Rainfall Departure (mm)
PIT TOP 2

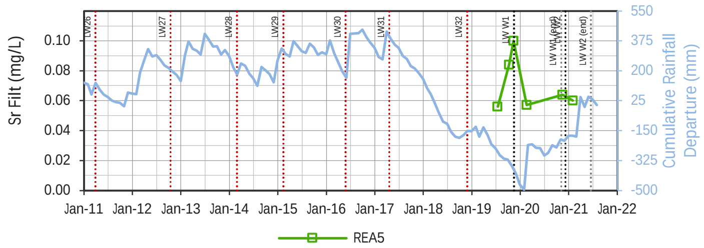

As Filt (mg/L)
Cumulative Rainfall Departure (mm)
PIT TOP 4

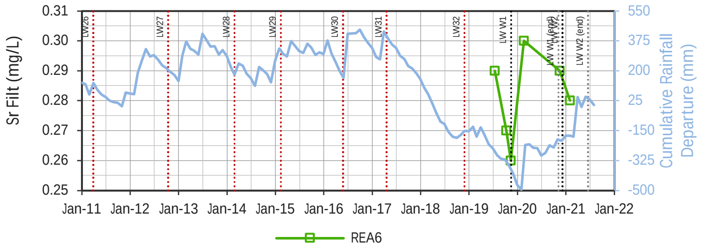

Sr Filt (mg/L)
Cumulative Rainfall Departure (mm)
REA1

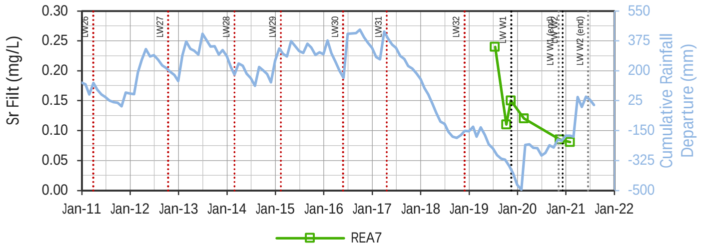

Sr Filt (mg/L)
Cumulative Rainfall Departure (mm)
REA2

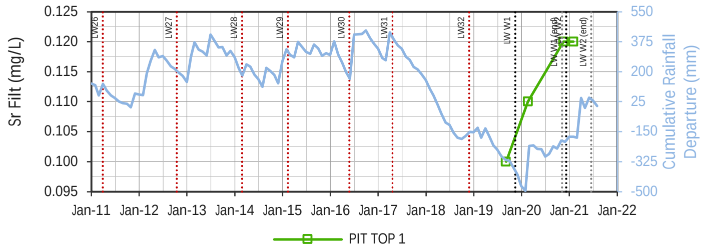

Sr Filt (mg/L)
Cumulative Rainfall Departure (mm)
REA3

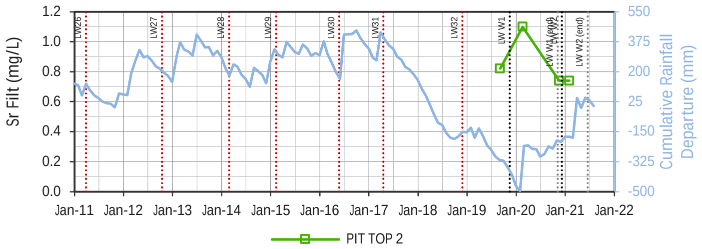

Sr Filt (mg/L)
Cumulative Rainfall Departure (mm)
REA4

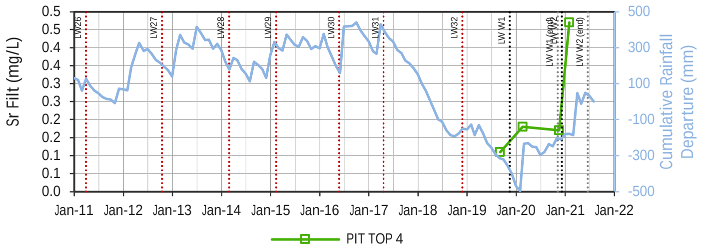

Sr Filt (mg/L)
Cumulative Rainfall Departure (mm)
REA5

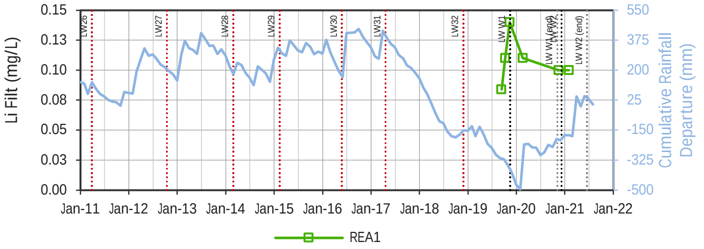

Sr Filt (mg/L)
Cumulative Rainfall Departure (mm)
REA6

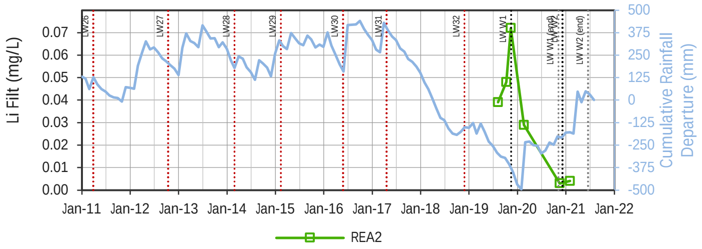

Sr Filt (mg/L)
Cumulative Rainfall Departure (mm)
REA7

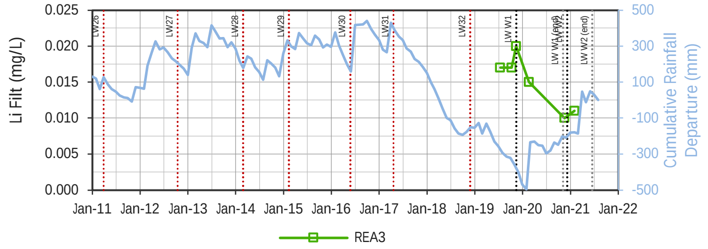

Sr Filt (mg/L)
Cumulative Rainfall Departure (mm)
PIT TOP 1

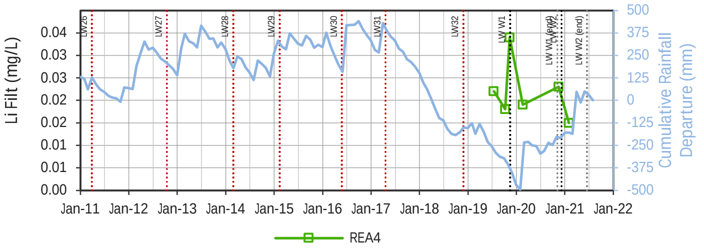

Sr Filt (mg/L)
Cumulative Rainfall Departure (mm)
PIT TOP 2

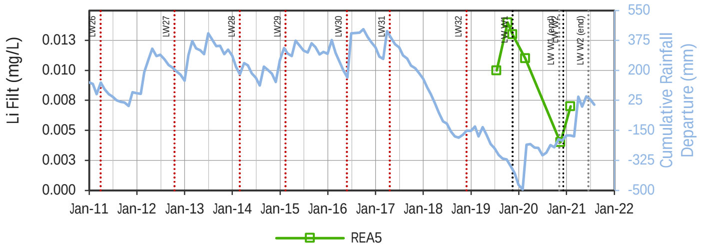

Sr Filt (mg/L)
Cumulative Rainfall Departure (mm)
PIT TOP 4

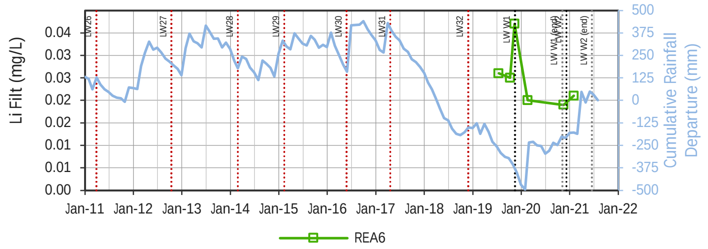

Li Filt (mg/L)
Cumulative Rainfall Departure (mm)
REA1


Li Filt (mg/L)
Cumulative Rainfall Departure (mm)
REA2


Li Filt (mg/L)
Cumulative Rainfall Departure (mm)
REA3


Li Filt (mg/L)
Cumulative Rainfall Departure (mm)
REA4


Li Filt (mg/L)
Cumulative Rainfall Departure (mm)
REA5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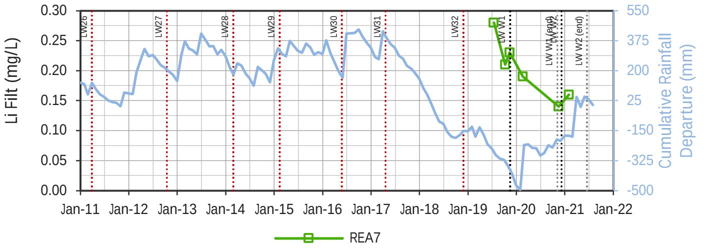
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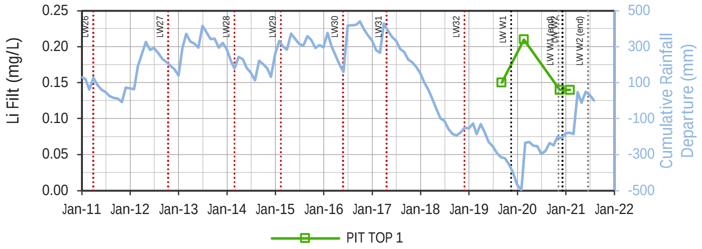
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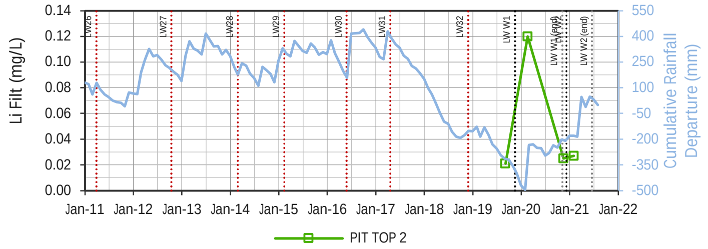
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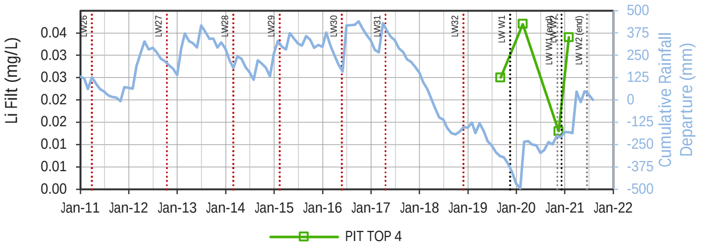
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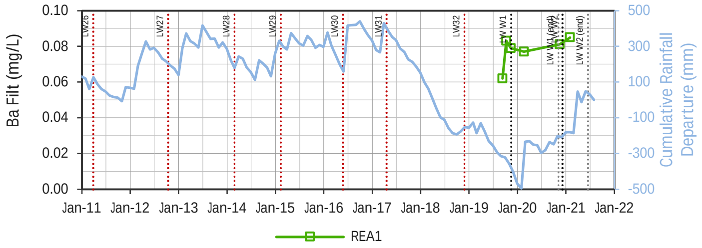
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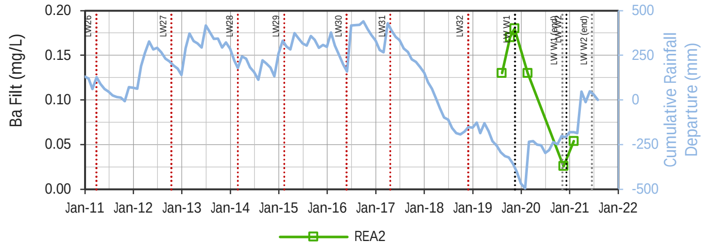
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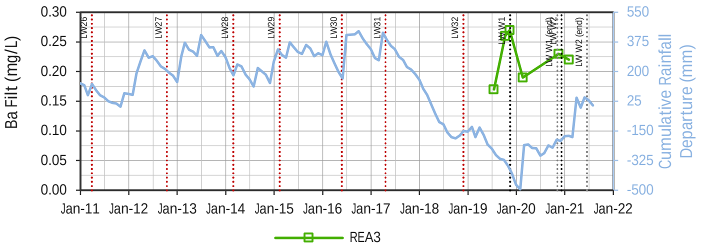
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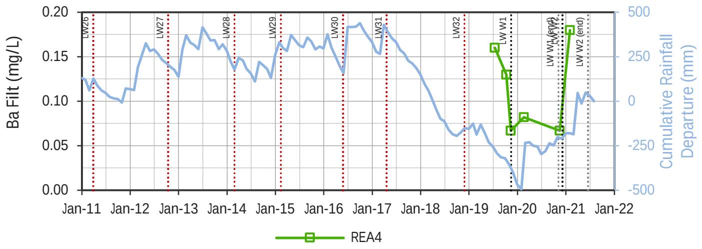
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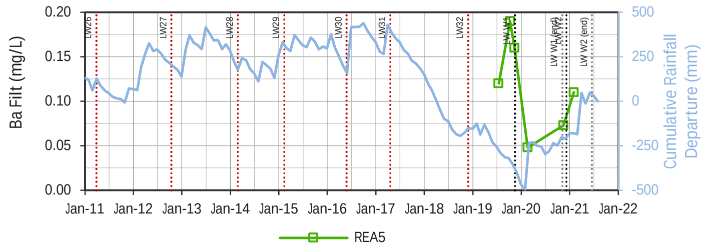
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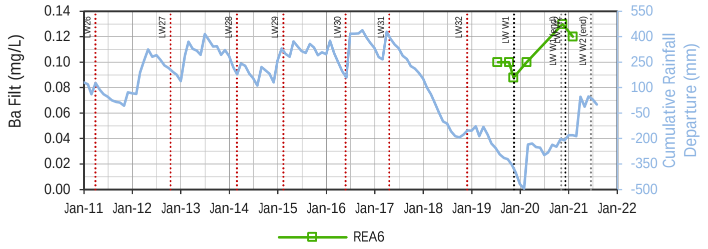
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LW27
LW28
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LW30
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LW W2 (end)
Jan-11
Jan-12
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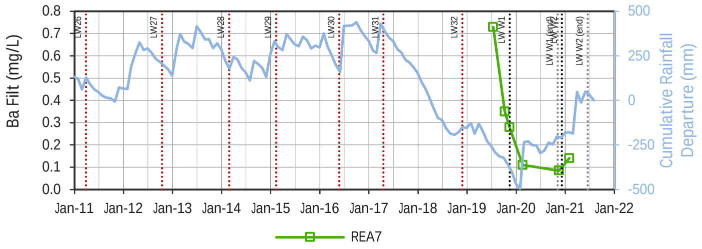
REA6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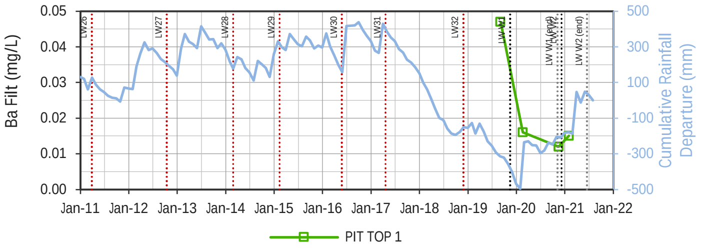
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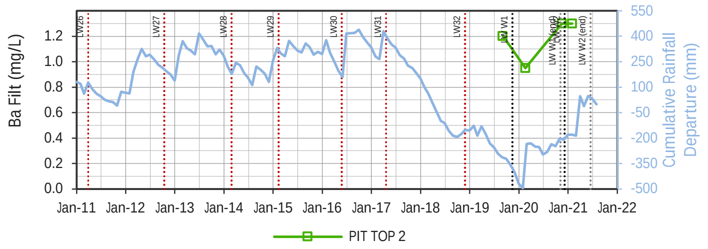
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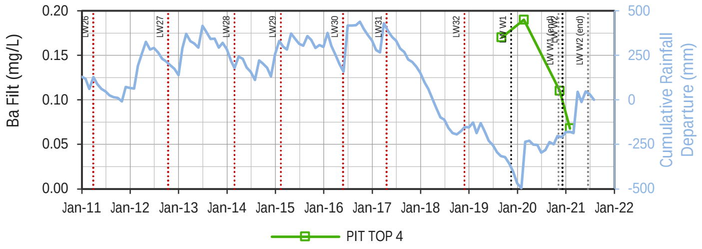
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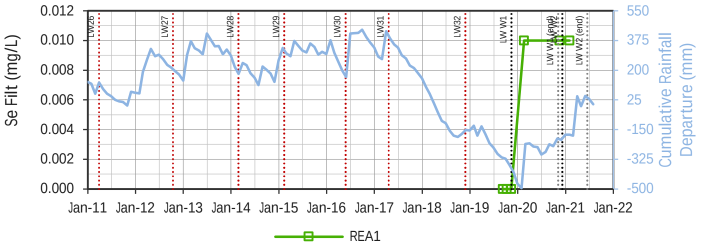
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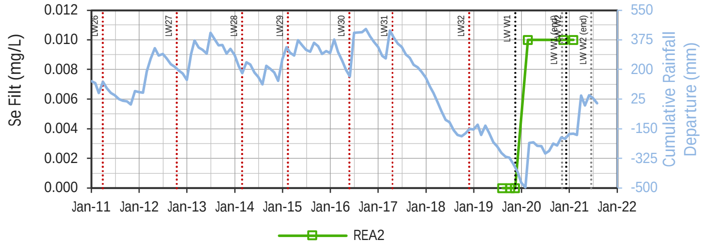
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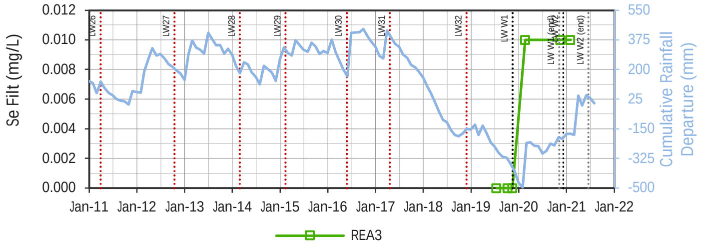
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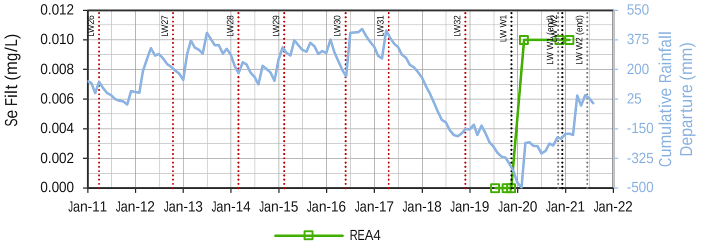
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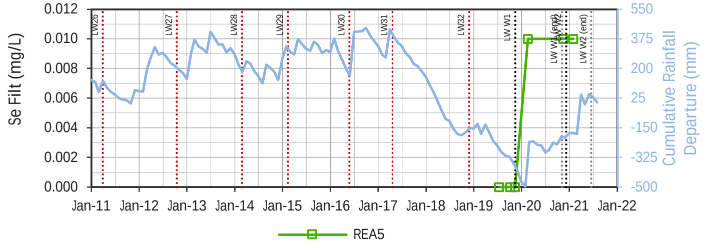
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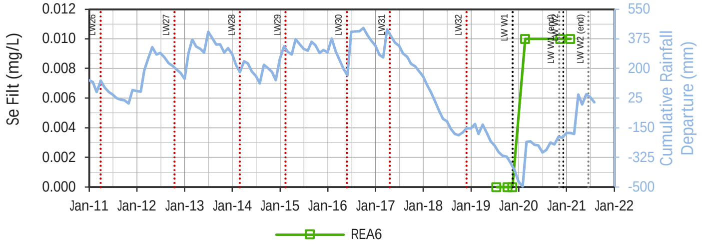
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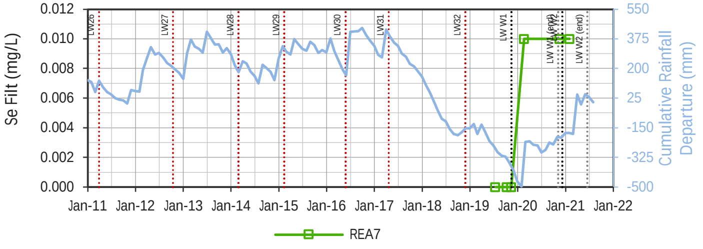
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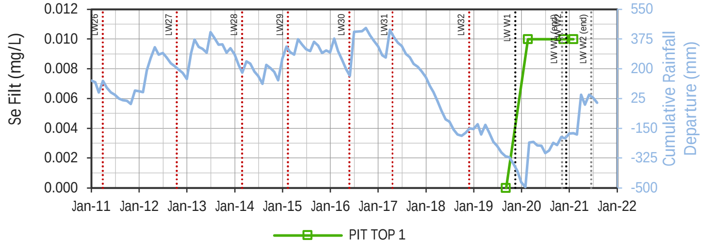
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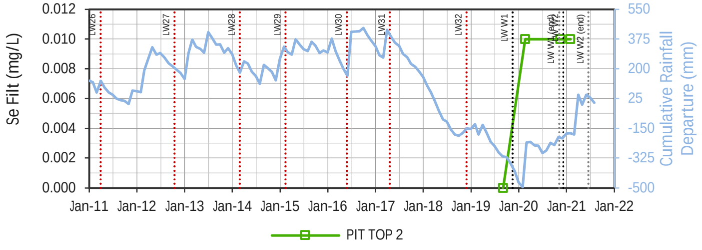
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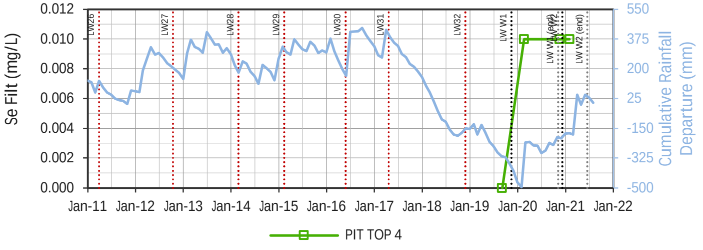
Se Filt (mg/L)
Cumulative Rainfall Departure (mm)
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APPENDIX D

Private Bore Survey Summary Report

TAHMOOR SOUTH

Baseline Private Bore Assessment Report

Prepared for:

Tahmoor Coal
2975 Remembrance Driveway
Tahmoor NSW 2574

SLR Ref: 610.30637.00000-R01
Version No: -v3.0
April 2022

PREPARED BY

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BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Tahmoor Coal (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
610.30637.00000-R01-v3.0	19 April 2022	Sharon Hulbert	Corinna De Castro	Corinna De Castro
610.30637.00000-R01-v2.1	13 April 2022	Sharon Hulbert	Corinna De Castro	
610.30637.00000-R01-v1.1	31 March 2022	Sharon Hulbert	Corinna De Castro	

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FIGURES

APPENDICES

1 Introduction

SLR Consulting Australia Pty Ltd (SLR) has been commissioned by Tahmoor Coal Pty Ltd (Tahmoor Coal) to prepare a Baseline Private Bore Assessment Report. Tahmoor Coal is seeking the approval of an Extraction Plan for Longwalls S1A to S6A (LW S1A-S6A) located in the Tahmoor South Domain. The Extraction Plan is required under condition C8 of the Development Consent (SSD 8445).

This Baseline Private Bore Assessment Report is a component of the overarching assessment undertaken to support the development of Tahmoor South Domain Extraction Plan for LW S1A-S6A.

Figure 1 shows the location of the private bores identified within the vicinity of Tahmoor Coal underground operations. Preliminary groundwater modelling indicated 52 private bores may experience a potential impact as a result of extraction operations, in the form of groundwater level drawdown exceeding 2 metres, as shown on Figure 1. A detailed survey of these private bores has been undertaken to ascertain details on the current bore condition (i.e. operational, not in use, destroyed, decommissioned, etc), and groundwater conditions (groundwater levels and quality).

The objectives of this report are to:

- Detail the current bore and groundwater conditions of the identified privately licenced bores in the region, including current use, groundwater levels, yield and quality
- To translate and review field survey data of these privately owned bores into “bore cards” and summarise in the form of this overarching report

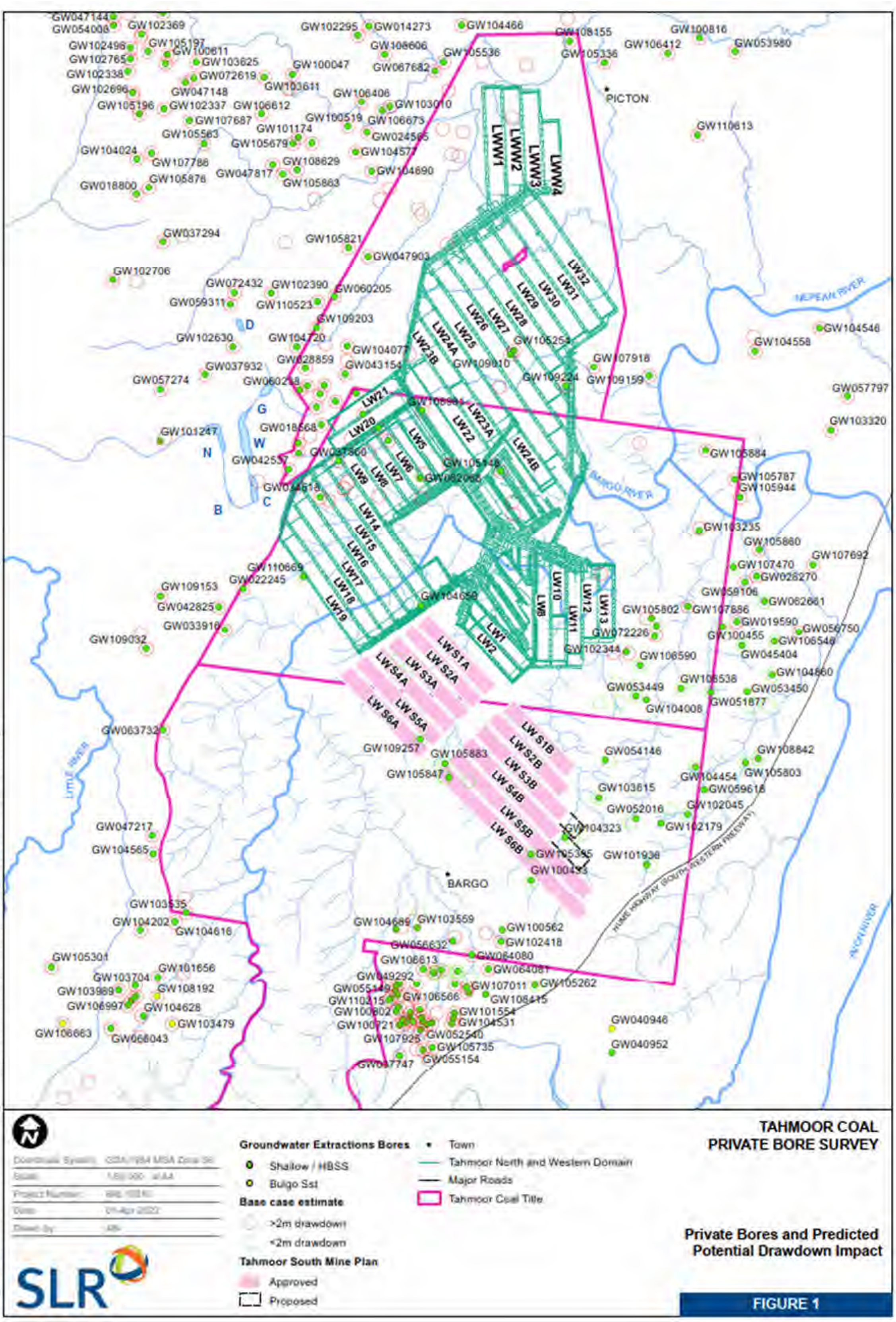

Figure 1 Private Users

2 Summary of Baseline Survey

Tahmoor Coal Community Liaison Specialist attempted to contact all landholders with identified bores. Originally, 52 bores were identified that may experience greater than 2 metres drawdown due to proposed extraction operations, inclusive of both the A and B series longwalls. During the survey process an additional six bores were incorporated into the survey at the request of landholders. The well previously identified at the Australian Wildlife Sanctuary, Wirrimbirra Sanctuary, was also included. Consequently, a total of 59 bores are on the final baseline list, of which 40 bores were able to be surveyed, as summarised in Table 1. The baseline survey was commenced on the 15th January 2022 and was concluded by 15th March 2022.

A bore card was generated for each site, to summarise the data recorded in the NSW database regarding the bore, and the findings of the field survey inclusive of laboratory results. These bore cards are provided to landholders for their information, and are presented in Appendix A.

Table 1 Summary table of bore survey

Registered bore number RN	Alternate Name	Easting[1]	Northing[1]	Locality Source	Property	Surveyed?
GW102452		277260.8	6200970	field survey	10 Bayan Pl, Bargo	Yes
GW103023		277266.3	6201016	field survey	10 Bayan Pl, Bargo	Yes
GW103036		276883	6200982	field survey	30 Carlisle St, Bargo	Yes
GW054146		279879.6	6204679	field survey	290 Arina Road	Yes
GW105262		278611.4	6200745	field survey	5 Lupton Rd, Bargo	Yes
GW111518		276648	6201710	field survey	30 Carlisle St, Bargo	Yes
GW059618		281588.5	6204282	field survey	50 Mockingbird Road, Pheasants Nest	Yes
GW032443		276427	6206329	field survey	10 Caloola Rd, Bargo	Yes
GW104659		276616	6207392	field survey	3000 Remembrance Driveway, Bargo	Yes
GW111810		277035.4	6204405	field survey	80 Great Southern Road, Bargo	Yes
GW112473		276586	6202000	field survey	115 Tylers Rd, Bargo	Yes
GW103559	GW2_175	276504.2	6201854	field survey	115 Tylers Rd, Bargo	Yes
GW116897		281442	6203190	field survey	39 David Pl	Yes
	GW10CA119328	280984	6204822	field survey	85 Dwyers RD	Yes
GW105803		281964.6	6204772	field survey	110 Mockingbird Rd, Pheasants Nest	Yes
GW103615		279634.6	6204110	field survey	275 Bargo Rd, Bargo	Yes
GW058634		279446.1	6203408	field survey	225 Bargo Rd, Bargo	Yes
GW105395		278546.8	6203033	field survey	130 Bargo Rd Bargo	Yes
GW104323		276241.6	6206412	field survey	225 Bargo Rd, Bargo	Yes
GW111669		279262.7	6203321	field survey	40 Caloola Rd, Bargo	Yes

Registered bore number RN	Alternate Name	Easting[1]	Northing[1]	Locality Source	Property	Surveyed?
GW102179		279262.7	6203321	field survey	130 Dwyer Rd Bargo	Yes
GW112415	GW1124152179	277439	6200851	field survey	129 Silica Rd, Yanderra	Yes
GW104008		280359	6205978	field survey	145 Arina Rd	Yes
GW057969		281351.1	6206122	field survey	45 Knox Rd, Pheasants Nest	Yes
GW110669		274570.4	6207928	field survey	45 Jumbunna Pl, Buxton	Yes
GW062068		276572.8	6209556	field survey	20 Stokes Rd, Tahmoor	Yes
	HERITAGEWELL	276604	6205057	field survey	3105 Remembrance Drive	Yes
GW070245		280043.3	6205645	field survey	190 Arina Rd, Bargo	Yes
GW102344	65ARINA	280250.8	6206554	field survey	65 Arina Rd, Bargo	Yes
GW111842		283187.3	6182673	field survey	130 Nightingale Road, Pheasants Nest	Yes
GW105883		275175.5	6204523	field survey	60 Great Southern Rd, Bargo	Yes
GW115773		282231.8	6205725	field survey	110 Nightingale Rd	Yes
	115NTG	277437	6204264	WaterNSW	115 Nightingale Rd	Yes
GW106546		282876.3	6206650	field survey	304 Pheasants Nest Rd, Pheasants Nest	Yes
GW053450		282301	6205841	field survey	110 Nightingale Road, Pheasants Nest	Yes
GW111828		282390.2	6205647	field survey	110 Nightingale Road, Pheasants Nest	Yes
GW104860		282730.3	6206227	field survey	170 Nightingale Rd Pheasants Nest	Yes
GW109257	3210REMEMBRANCEDVWY	276603.8	6205057	field survey	3210 Remembrance Drive, Bargo	Yes
GW031294		279732	6205706	WaterNSW	30 Glengarrie Rd, Bargo	No
GW111047		280015	6206037	WaterNSW	140 Arina Rd, Bargo	No
GW053449		280369	6205813	WaterNSW	155 Arina Rd, Bargo	No
GW106590		280442	6206344	WaterNSW	95 Arina Rd, Bargo	Yes

Registered bore number RN	Alternate Name	Easting[1]	Northing[1]	Locality Source	Property	Surveyed?
GW105577		280728	6207041	WaterNSW	100 Pheasants Nest Road, Pheasants Nest	No
GW014262		276764	6204587	WaterNSW	10 Wellers Road Bargo	No
GW105847		277103	6204390	WaterNSW	80 Great Southern Road, Bargo	No
GW007445		277437	6204264	WaterNSW	95 Great Southern Rd, Bargo	No
GW052016		280369	6203655	WaterNSW	15 Bidewell Drive, Pheasants Nest	No
GW101936		280556	6202858	WaterNSW	477 Arina Rd Bargo	No
GW102045		281266	6203733	WaterNSW	160 Dwyers Rd, Pheasants Nest	No
GW104454		281410	6204568	WaterNSW	63 Mockingbird Rd, Pheasants Nest	No
GW111357		277051	6200982	WaterNSW	10 Carlisle St, Bargo	No
GW108538		281155	6205941	WaterNSW	100 Knox Rd, Pheasants Nest	No
GW051877		281673	6205875	WaterNSW	75 Nightingale Road, Pheasants Nest	No
GW108842		282500	6204716	WaterNSW	180 Mockingbird Rd, Pheasants Nest	No
GW100455		281877	6207020	WaterNSW	260 Pheasants Nest Rd, Pheasants Nest	No
GW045404		282730.3	6206227	field survey	170 Nightingale Rd Pheasants Nest	Yes
GW062661		282609	6207469	WaterNSW	365 Pheasants Nest Rd, Pheasants Nest	No
GW107470		282069	6208057	WaterNSW	90 Lawson Rd, Pheasants Nest	No
GW100433		278540	6202588	WaterNSW	80 Johnston Rd, Bargo	No.

1 Coordinates for surveyed bores = surveyed location, coordinates for bores not surveyed = NSW database location

A summary of the recorded groundwater levels, salinities and current use regime is provided in Table 2.

Table 2 Recorded bore depth, salinity, and use regime

RN	Bore Depth (m)	Groundwater depth (m below ground level)	Electrical conductivity (EC) (µS/cm)	Bore use and frequency
10CA119328	NR	54.4	1472	Irrigation, daily (when onsite dam is low)
115NTG	~160 - 170 m	41.67	689	Not currently used, pump to be installed next month
GW032443	10.71 (measured, likely blocked)	0.71	226	Not currently used
GW053450	NR	NR	NR	Not currently used after pump ceased working two years ago
GW054146	NR	NR	NR	Not currently used
GW057969	32.33 (likely blockage)	NR	NR	Not currently used (not used for years)
GW058634	NR	NR	NR	Not currently used
GW059618	122.71	19.96	2396	No one onsite for comment, likely not in use as no infrastructure connected
GW062068	>100	21.93	165	Not used due to "part cave-in" 11 years ago
GW070245	NR	NR	949	When required to fill the dam
GW102179	NR	NR	1849	Moderate use for crop irrigation
GW102344	NR	NR	801	Daily use for irrigation
GW102452	71.41	36.41	371	Formerly used for aquaculture (~50,000L/day)
GW103023	51.43	17.68	3378	No current use. Formerly used for water extraction to supply aquaculture enterprise
GW103036	127.42	68.49	371	Daily, irrigation
GW103559	NR	NR	487	In use to fill irrigation dam
GW103615	73.1	65.36	NR	Not currently used
GW104008	>100	46.84	1323	When required to fill the dam and irrigate lawns
GW104323	79.8	68.6	1025	Daily use (on timer) for crop irrigation
GW104659	50.08	43.8	539	To replenish adjacent dam, regulated by timer
GW104860	NR	NR	NR	Not currently used
GW105262	NR	NR	1828	Infrequently used for crop irrigation
GW105395	53.1	0.5	3341	Not currently used
GW105803	80 (anecdotal, not measured)	17.05	1108	Not currently used
GW105883	NR	NR	1686	Used for filling adjacent water feature pond and garden irrigation

RN	Bore Depth (m)	Groundwater depth (m below ground level)	Electrical conductivity (EC) (µS/cm)	Bore use and frequency
GW106546	63.63 (likely blockage as installed to 116 metres)	41.67	NR	Once per week for stock watering
GW109257	NR	37.06	NR	Not used for two years, previously used to fill site dam
GW110669	NR, 111 metres install depth noted on bore	NR	677	When required to fill dam (not used for at least one year)
GW111518	28.3 (owner described depth of 28.3 so potential obstruction)	19.24	277	Frequent use when required, for crop irrigation
GW111669	NR	NR	481	Crop irrigation and small-scale poultry farm
GW111810	NR	NR	2058	Used frequently for irrigation via holding tanks
GW111828	60.7 (likely blocked as install depth recorded as 205 m)	Dry or blocked	NR	Not currently used, previously used intermittently when water not available from GW115773 as irrigation back-up
GW111842	69.4 (likely blocked as install depth recorded as 240 m)	Dry or blocked	NR	Not currently used
GW112415	96.96	42.86	1059	Daily use to fill dam and irrigate lawn
GW112473	NR	32.95	515	Daily use to fill dam
GW115773	81.87	75.85	820	Daily use for irrigation
GW116897	51.2 (potential blockage as install recorded to 160m)	19.9	776	Not currently used, waiting for pump install for future crop use
GW45404	72.73 (could be blocked)	Dry	NR	Not used in years
Heritage Well	3.12	1.15	684	Unused
GW106590	150 (Installed depth)	NR	842	Used to wet down horse track and fill dam when required

NR = not recorded

Laboratory results presenting groundwater quality at 31 sampled bores are provided in Appendix B.

3 Ongoing Monitoring Program

The ongoing monitoring of the private bores to establish baseline groundwater level and quality data was originally proposed for all existing bores, dependent on land access, suitability for sampling (i.e. in-situ operational pumps limiting ability to collect water levels deems bore unsuitable for ongoing monitoring), and pre-determined potential timing of impact. The private bores were grouped into two staged for ongoing works, dependent proximity to the active longwalls. The proposed monitoring program for the private bores identified as part of the A-series is summarised in Table 3. This will be finalised after confirmation of ongoing land access agreements.

Table 3 Proposed private bore monitoring program

Work Number	Easting	Northing	Preliminary Survey Undertaken	Staging for Works (A or B)	Monitoring Regime
GW058634	279479	6203419	yes	A	monthly WL/WQ
GW109257	276603	6205052	yes	A	monthly WL/WQ
GW032443	276415	6206336	yes	A	monthly WL/WQ
GW104008	280368	6205982	yes	A	monthly WL/WQ
GW112473	276577	6202010	yes	A	monthly WL/WQ
GW106590	280442	6206344	yes	A	monthly WL/WQ
GW104659	276617	6207391	yes	A	monthly WL/WQ
GW062068	276581	6209579	yes	A	monthly WL/WQ
GW105395	278543	6203037	yes	A	monthly WL/WQ

WL - groundwater level WQ - water quality

It is noted that landowners pumping from their own bores, as well as interference from other landholder groundwater use, can significantly affect groundwater levels in a bore without influence from mining or subsidence. Whilst all efforts have been made to monitor individual private bores, the monitoring network has been developed to capture regional groundwater conditions to assess potential impacts from mining.

3.1 Monitoring Standards

Groundwater monitoring will be undertaken in accordance with the relevant Australian Standards, legislation and EPA approved methods for sampling, including (but not limited to):

- NSW DECC (2004) *Approved Methods for Sampling and Analysis of Water Pollutants in New South Wales*.
- AS/NZS 5667.1:1998 *Water Quality – Sampling – Part 1 Guidance on the Design of Sampling Programs, Sampling Techniques, and the Preservation and Handling of Samples*.
- AS/NZS 5667.11:1998 *Water Quality - Sampling - Guidance on Sampling of Groundwaters*.

4 Summary

This baseline survey has been undertaken to:

- Understand private groundwater users and allow for assessment of potential impacts to inform make-good strategies (to be developed in the Groundwater Management Plan, informed by the monitoring network).
- Address the requirements of the Tahmoor South Commitments issued by regulators.

A total of 40 bores were visited, with varying levels of data collected.

APPENDIX A

Private Bore Cards

Bore: GW102452	Property: Tahmoor South
Bore Identification Information (NSW Real Time Water Data)	
Bore name	GW102452
NSW licence number	NA
NSW DNRME water licence number	NA
Datum	MGA Zone 56
Easting	277234
Northing	6200992
Elevation (mAHD)	NR
Intended Purpose	Aquaculture, farming
Bore Construction Details	
Drilling and construction records available	Yes
Date drilled/constructed	14/07/1999
Total depth of bore (m)	120.5 drilled, 29.6 cased
Geological Formation Screened	NR
Bore Casing	
Material	PVC Class 9, Steel
Diameter	140mm OD
Stick-up	0.4m, Steel casing 168mm OD
Hydrogeological info	
Screened lithology/formation	Sandstone
Standing water level (specify ref point)	NR
Water quality	Salinity 690 mg/L
Other bore log comments	Estimated yield 0.30 L/s
Data Collected While On Site	
Census Date	24/01/2022
Completed by	Chris Rotsider
Photographs (insert)	

Bore Details	
GPS Location datum	GDA94 Zone 56
Easting	277261
Northing	6200970

Bore: GW102452	Property: Tahmoor South
Elevation (mAHD) – specify survey method	NR
Drilling and construction records (Y/N)	Y
Stick-up (casing, monument etc.)	Metal casing stick up with metal cap
Total depth of bore (mbgl)	71.41
Depth to water (mbgl)	36.41
Pump status (if installed)	Formerly used for aquaculture (~50,000L/day)
Logger status/condition (if installed). Serial no., make, model etc.	NA
Fencing/barrier installed?	N
Sampling method	In-situ electric pump
Electrical Conductivity (µS/cm)	371.6
pH	5.73
Temperature (°C)	18.1
ORP (mV)	55.3
Dissolved Oxygen (mg/L)	1.12
Colour, odour, characteristics etc.	Moderate turbidity, 'Rusty' colour (high Fe), No odour, no sheen
Bore Pump Details (if relevant)	
Frequency of use	Formerly used for aquaculture (~50,000L/day)
Typical pumping rate	NA
Purpose / Use of Bore	NA
Comment:	
Headworks for this monitoring well were encountered to be in a reasonable working condition. Drawdown duration and recharge time: Extraction rate 1L/s Water extracted 10L. Recovery/Recharge time 2’20”.	

WaterNSW
Work Summary

GW102452

Licence:

Licence Status:

Authorised Purpose(s):
Intended Purpose(s): AQUACULTURE, FARMING

Work Type: Bore
Work Status:
Construct.Method: Rotary Air
Owner Type:

Commenced Date:
Completion Date: 14/07/1999

Final Depth: 120.50 m
Drilled Depth: 120.50 m

Contractor Name: INTERTEC DRILLING SERVICES
Driller: Dean John Milgate
Assistant Driller:

Property:
GWMA:
GW Zone:

Standing Water Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CAMDEN	BARGO	6 255425
Licensed:			

Region: 10 - Sydney South Coast

CMA Map:

River Basin: - Unknow n
Area/District:

Grid Zone:

Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknow n

Northing: 6200992.000
Easting: 277234.000

Latitude: 34°18'30.3"S
Longitude: 150°34'45.2"E

GS Map: -

MGA Zone: 56

Coordinate Source: Unknow n

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	5.40	210			Rotary Air
1		Hole	Hole	5.40	120.50	158			Rotary Air
1	1	Casing	Pvc Class 9	-0.40	29.60	140			Suspended in Clamps, Screw ed and Glued
1	1	Casing	Steel	-0.40	5.60	168	158		Driven into Hole
1	1	Opening	Slots - Vertical	27.00	29.50	140		0	Saw n, PVC Class 9, SL: 0.1mm, A: 4.00mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
27.50	28.00	0.50	Unknow n			0.30	30.00		690.00
44.00	44.50	0.50	Unknow n			0.20	48.00		550.00
96.50	97.00	0.50	Unknow n			0.90	102.00		394.00
108.00	109.00	1.00	Unknow n			0.60	114.00		300.00

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	1.50	1.50	CLAY GREY	Clay	
1.50	4.00	2.50	SANDSTONE WEATHERED	Sandstone	
4.00	24.00	20.00	SANDSTONE BROWN M.G	Sandstone	

24.00	27.50	3.50	SANDSTONE GREY M.G.	Sandstone	
27.50	28.00	0.50	SANDSTONE AND QUARTZ	Sandstone	
28.00	36.50	8.50	SANDSTONE WHITE M.G.	Sandstone	
36.50	44.00	7.50	SANDSTONE GREY M.G.	Sandstone	
44.00	44.50	0.50	SANDSTONE/QUARTZ FRACTURED	Sandstone	
44.50	74.00	29.50	SANDSTONE GREY M.G.	Sandstone	
74.00	74.50	0.50	SANDSTONE AND QUARTZ	Sandstone	
74.50	77.50	3.00	SANDSTONE WHITE M.G.	Sandstone	
77.50	80.00	2.50	SHALE BLACK	Shale	
80.00	96.50	16.50	SANDSTONE WHITE M.G.	Sandstone	
96.50	100.00	3.50	SANDSTONE AND QUARTZ FRACTURED	Sandstone	
100.00	108.00	8.00	SANDSTONE GREY M.G.	Sandstone	
108.00	109.00	1.00	SANDSTONE AND QUARTZ FRACTURED	Sandstone	
109.00	120.50	11.50	SANDSTONE WHITE M.G.	Sandstone	

***** End of GW102452 *****

Site GW102452 Values at Time of Drilling

Measure	Data Type	Hole	Pipe	Date	Value
Inst. Salinity (Total Dissolved Salts) (Milligrams/Litre)	Manual	1	1	14/07/1999 @ 00:00	300

Parameter	LOR	Unit	10 Bayan Pl
Registered Number			GW102452
Date			24-01-2022
Calcium - Dissolved	0.5	mg/L	2
Potassium - Dissolved	0.5	mg/L	0.9
Sodium - Dissolved	0.5	mg/L	36
Magnesium - Dissolved	0.5	mg/L	7.6
Hardness	3	mg/L	35
Hydroxide Alkalinity (OH-) as CaCO3	5	mg/L	<5
Bicarbonate Alkalinity as CaCO3	5	mg/L	36
Carbonate Alkalinity as CaCO3	5	mg/L	<5
Total Alkalinity as CaCO3	5	mg/L	36
Sulphate SO4	1	mg/L	2
Chloride Cl	1	mg/L	96
Ionic Balance	-	%	-20
Total Nitrogen in Water	0.1	mg/L	<0.1
Phosphorus Total	0.05	mg/L	1.5
Aluminium-Total	10	µg/L	30
Arsenic-Total	1	µg/L	1
Barium-Total	1	µg/L	100
Beryllium-Total	0.5	µg/L	9
Cadmium-Total	0.1	µg/L	<0.1
Chromium-Total	1	µg/L	<1
Cobalt-Total	1	µg/L	13
Copper-Total	1	µg/L	<1
Iron-Total	10	µg/L	47000
Lithium-Total	1	µg/L	8
Mercury-Total	0.05	µg/L	<0.05
Manganese-Total	5	µg/L	1800
Nickel-Total	1	µg/L	16
Lead-Total	1	µg/L	16
Selenium-Total	1	µg/L	<1
Strontium-Total	1	µg/L	19
Vanadium-Total	1	µg/L	<1
Zinc-Total	1	µg/L	65
Aluminium-Dissolved	10	µg/L	<10
Arsenic-Dissolved	1	µg/L	<1
Barium-Dissolved	1	µg/L	75
Beryllium-Dissolved	0.5	µg/L	0.5
Cadmium-Dissolved	0.1	µg/L	<0.1
Chromium-Dissolved	1	µg/L	<1
Cobalt-Dissolved	1	µg/L	13
Copper-Dissolved	1	µg/L	<1
Iron-Dissolved	10	µg/L	38000
Lithium-Dissolved	1	µg/L	8
Mercury-Dissolved	0.05	µg/L	<0.05
Manganese-Dissolved	5	µg/L	1900
Nickel-Dissolved	1	µg/L	15
Lead-Dissolved	1	µg/L	<1
Selenium-Dissolved	1	µg/L	<1
Strontium-Dissolved	1	µg/L	21
Vanadium-Dissolved	1	µg/L	<1
Zinc-Dissolved	1	µg/L	43

Bore: GW103023	Property: Tahmoor South
Bore Identification Information (NSW Real Time Water Data)	
Bore name	GW103023
Property	NOVASTAR 105 Silica Rd BARGO 2574 NSW
NSW licence number	10WA111958
NSW DNRME water licence number	NA
Datum	MGA Zone 56
Easting	277261
Northing	6200993
Elevation (mAHD)	NR
Purpose	Aquaculture
Bore Construction Details	
Drilling and construction records available	Yes
Date drilled/constructed	20/07/2000
Total depth of bore (m)	165.0
Geological Formation Screened	NR
Bore Casing	
Material	Stainless Steel
Diameter	209mm OD
Stick-up	0.5m, Stainless Steel
Hydrogeological info	
Screened lithology/formation	Sandstone
Standing water level (mbgl)	19.0
Water quality	Salinity description: Fresh
Other bore log comments	Yield : 10 l/s
Data Collected While On Site	
Census Date	24/01/2022
Completed by	Chris Rotsider, Consulting Earth Scientists Pty Ltd
Photographs (insert)	
	
Bore Details	
Site Address	10 Bayan Place, Bargo
GPS Location datum	GDA94 Zone 56

Bore: GW103023	Property: Tahmoor South
Easting	277266
Northing	6201016
Elevation (mAHD) – specify survey method	NR
Drilling and construction records (Y/N)	Y
Stick-up (casing, monument etc.)	Metal casing stick up with no cap
Total depth of bore (mbgl)	51.43
Depth to water (mbgl)	17.68
Pump status (if installed)	No pump installed
Logger status/condition (if installed). Serial no., make, model etc.	NA
Fencing/barrier installed?	N - Non-secure aluminium sheet
Sampling method	Micro purge/ No pump (geocontro used)
Electrical Conductivity (µS/cm)	3378
pH	3.54
Temperature (°C)	18.1
ORP (mV)	340.2
Dissolved Oxygen (mg/L)	1.97
Colour, odour, characteristics etc.	No odour, no turbidity
Bore Pump Details (if relevant)	
Frequency of use	No current use. Formerly used for water extraction to supply aquaculture enterprise
Typical pumping rate	NA
Purpose / Use of Bore	NA
Comment:	
Headworks for this well were encountered to be in a fair working condition. The steal casing had some seam rust and a fractured concrete base.	

WaterNSW
Work Summary

GW103023

Licence: 10WA111958

Licence Status: CURRENT

Authorised Purpose(s): AQUACULTURE
Intended Purpose(s): AQUACULTURE

Work Type: Bore
Work Status:
Construct.Method: Rotary
Owner Type:

Commenced Date:
Completion Date: 20/07/2000

Final Depth: 165.00 m
Drilled Depth: 166.00 m

Contractor Name: SOUTHERN TABLELANDS DRILLING
Driller: Roger Charles Ritchie
Assistant Driller:

Property: NOVASTAR 105 Silica Rd BARGO 2574 NSW
GWMA: -
GW Zone: -

Standing Water Level (m):
Salinity Description: Fresh
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CAMDEN	BARGO	6//255425
Licensed:	CAMDEN	BARGO	Whole Lot 6//255425

Region: 10 - Sydney South Coast
CMA Map:

River Basin: - Unknown
Area/District:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown
Northing: 6200993.000
Easting: 277261.000
Latitude: 34°18'30.3"S
Longitude: 150°34'46.3"E

GS Map: -
MGA Zone: 56
Coordinate Source: Unknown

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	59.30	250			Down Hole Hammer
1		Hole	Hole	59.30	166.00	205			Down Hole Hammer
1	1	Casing	Stainless Steel	-0.50	59.30	209			Seated on Bottom, Welded

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
28.00	31.00	3.00	Unknown	19.00		0.03	31.00		850.00
31.00	71.00	40.00	Unknown	25.00		1.32	91.00		280.00
97.00	116.00	19.00	Unknown	22.00		1.50	120.00		290.00
129.00	154.00	25.00	Unknown	33.00		10.00	165.00		200.00

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	32.20	32.20	INTERBEDDED SHALE AND SANDSTONE	Shale	
32.20	50.00	17.80	MEDIUM GRAINED SANDSTONE	Sandstone	
50.00	61.30	11.30	SHALE,SOME SANDY BANDS	Shale	
61.30	70.90	9.60	MEDIUM GRAINED SANDSTONE	Sandstone	
70.90	86.30	15.40	INTERBEDDED SHALE AND SANDSTONE	Sandstone	
86.30	110.00	23.70	MEDIUM GRAINED SANDSTONE	Sandstone	
110.00	112.60	2.60	SHALE	Shale	
112.60	128.00	15.40	MEDIUM GRAINED SANDSTONE	Sandstone	
128.00	147.40	19.40	MEDIUM TO COARSE SANDSTONE	Sandstone	
147.40	162.20	14.80	INTERBEDDED SHALE AND SANDSTONE	Shale	
162.20	166.00	3.80	DARK GREY SHALE	Shale	

Remarks

06/10/2000: PREVIOUS LIC. NO: 10BL159740

***** End of GW103023 *****

WaterNSW
Work Summary

GW103023

Licence: 10WA111958 **Licence Status:** CURRENT

Authorised Purpose(s): AQUACULTURE
Intended Purpose(s): AQUACULTURE

Work Type: Bore
Work Status:
Construct.Method: Rotary
Owner Type:

Commenced Date:
Completion Date: 20/07/2000

Final Depth: 165.00 m
Drilled Depth: 166.00 m

Contractor Name: SOUTHERN TABLELANDS DRILLING
Driller: Roger Charles Ritchie
Assistant Driller:

Property: NOVASTAR 105 Silica Rd BARGO 2574 NSW
GWMA: -
GW Zone: -

Standing Water Level (m):
Salinity Description: Fresh
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CAMDEN	BARGO	6//255425
Licensed:	CAMDEN	BARGO	Whole Lot 6//255425

Region: 10 - Sydney South Coast **CMA Map:**

River Basin: - Unknown **Grid Zone:** **Scale:**
Area/District:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown

Northing: 6200993.000
Easting: 277261.000

Latitude: 34°18'30.3"S
Longitude: 150°34'46.3"E

GS Map: - **MGA Zone:** 56 **Coordinate Source:** Unknown

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	59.30	250			Down Hole Hammer
1		Hole	Hole	59.30	166.00	205			Down Hole Hammer
1	1	Casing	Stainless Steel	-0.50	59.30	209			Seated on Bottom, Welded

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
28.00	31.00	3.00	Unknown	19.00		0.03	31.00		850.00
31.00	71.00	40.00	Unknown	25.00		1.32	91.00		280.00
97.00	116.00	19.00	Unknown	22.00		1.50	120.00		290.00
129.00	154.00	25.00	Unknown	33.00		10.00	165.00		200.00

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	32.20	32.20	INTERBEDDED SHALE AND SANDSTONE	Shale	
32.20	50.00	17.80	MEDIUM GRAINED SANDSTONE	Sandstone	
50.00	61.30	11.30	SHALE,SOME SANDY BANDS	Shale	
61.30	70.90	9.60	MEDIUM GRAINED SANDSTONE	Sandstone	
70.90	86.30	15.40	INTERBEDDED SHALE AND SANDSTONE	Sandstone	
86.30	110.00	23.70	MEDIUM GRAINED SANDSTONE	Sandstone	
110.00	112.60	2.60	SHALE	Shale	
112.60	128.00	15.40	MEDIUM GRAINED SANDSTONE	Sandstone	
128.00	147.40	19.40	MEDIUM TO COARSE SANDSTONE	Sandstone	
147.40	162.20	14.80	INTERBEDDED SHALE AND SANDSTONE	Shale	
162.20	166.00	3.80	DARK GREY SHALE	Shale	

Remarks

06/10/2000: PREVIOUS LIC. NO: 10BL159740

***** End of GW103023 *****

Parameter	LOR	Unit	10 Bayan Pl
Registered Number			GW103023
Date			24-01-2022
Calcium - Dissolved	0.5	mg/L	2
Potassium - Dissolved	0.5	mg/L	3
Sodium - Dissolved	0.5	mg/L	680
Magnesium - Dissolved	0.5	mg/L	78
Hardness	3	mg/L	330
Hydroxide Alkalinity (OH-) as CaCO3	5	mg/L	<5
Bicarbonate Alkalinity as CaCO3	5	mg/L	<5
Carbonate Alkalinity as CaCO3	5	mg/L	<5
Total Alkalinity as CaCO3	5	mg/L	<5
Sulphate SO4	1	mg/L	59
Chloride Cl	1	mg/L	1400
Ionic Balance	-	%	-4
Total Nitrogen in Water	0.1	mg/L	0.2
Phosphorus Total	0.05	mg/L	<0.05
Aluminium-Total	10	µg/L	20000
Arsenic-Total	1	µg/L	3
Barium-Total	1	µg/L	430
Beryllium-Total	0.5	µg/L	14
Cadmium-Total	0.1	µg/L	3.5
Chromium-Total	1	µg/L	<1
Cobalt-Total	1	µg/L	260
Copper-Total	1	µg/L	34
Iron-Total	10	µg/L	11000
Lithium-Total	1	µg/L	32
Mercury-Total	0.05	µg/L	0.15
Manganese-Total	5	µg/L	6800
Nickel-Total	1	µg/L	190
Lead-Total	1	µg/L	99
Selenium-Total	1	µg/L	<1
Strontium-Total	1	µg/L	65
Vanadium-Total	1	µg/L	<1
Zinc-Total	1	µg/L	1300
Aluminium-Dissolved	10	µg/L	20000
Arsenic-Dissolved	1	µg/L	2
Barium-Dissolved	1	µg/L	430
Beryllium-Dissolved	0.5	µg/L	14
Cadmium-Dissolved	0.1	µg/L	3.5
Chromium-Dissolved	1	µg/L	<1
Cobalt-Dissolved	1	µg/L	260
Copper-Dissolved	1	µg/L	45
Iron-Dissolved	10	µg/L	9500
Lithium-Dissolved	1	µg/L	33
Mercury-Dissolved	0.05	µg/L	<0.05
Manganese-Dissolved	5	µg/L	6600
Nickel-Dissolved	1	µg/L	180
Lead-Dissolved	1	µg/L	99
Selenium-Dissolved	1	µg/L	<1
Strontium-Dissolved	1	µg/L	62
Vanadium-Dissolved	1	µg/L	<1
Zinc-Dissolved	1	µg/L	1300

Bore: GW103036	Property: Tahmoor South
Bore Identification Information (NSW Real Time Water Data)	
Bore name/nickname	GW103036
Property	FARRUGIA 30 Carlisle St YANDERRA 2574 NSW
NSW licence number	10CA111872 (Current)
Datum	GDA94 Zone 56
Easting	276840
Northing	6200964
Elevation (mAHD)	NR
Purpose	Stock, domestic, irrigation
Bore Construction Details	
Drilling and construction records available	Yes
Date drilled/constructed	30/06/2000
Total depth of bore (m)	132.5
Geological Formation Screened	NR
Bore Casing	
Material	PVC Class 9
Diameter	PVC 140mm OD, Steel 168mm OD
Stick-up	0.5 m
Reference survey elevation (specify ref point, i.e. TOC, TOM, GL)	NA
Hydrogeological info	
Screened lithology/formation	Sandstone Quartz Fractured
Standing water level (mbgl)	24.3
Water quality	Salinity: 203mg/L
Other bore log comments	Yield (Ls): 1.3
Data Collected While On Site	
Census Date	27/01/2022
Completed by	Chris Rotsider, Consulting Earth Scientists Pty Ltd
Photographs (insert)	
	
Bore Details	
Site Address	30 Carlisle St YANDERRA 2574 NSW
GPS Location datum	GDA94 Zone 56
Easting	276883
Northing	6200982

Bore: GW103036	Property: Tahmoor South
Elevation (mAHD) – specify survey method	NR
Drilling and construction records (Y/N)	Y
Stick-up (casing, monument etc.)	Metal cap
Casing Diameter	150
Total depth of bore (mbgl)	127.42
Depth to water (mbgl)	68.49
Pump status (if installed)	NR
Logger status/condition (if installed). Serial no., make, model etc.	NA
Fencing/barrier installed?	NA
Sampling method	In-situ electric pump 4kW
Electrical Conductivity (µS/cm)	371.2
pH	5.58
Temperature (°C)	18.1
ORP (mV)	115.2
Dissolved Oxygen (mg/L)	4.68
Colour, odour, characteristics etc.	No odour, low turbidity, no signs of contamination
Bore Pump Details (if relevant)	
Frequency of use	Daily
Typical pumping rate	NR
Purpose / Use of Bore	Crop irrigation
Comment:	
Headworks for this monitoring well were encountered to be in a reasonable working condition. This included concrete support and PVC well casing. 1.0 L was extracted from well with recharge time of 3 min 35 seconds.	

WaterNSW
Work Summary

GW103036

Licence: 10CA111872

Licence Status: CURRENT

Authorised Purpose(s): STOCK,DOMESTIC,IRRIGATION
Intended Purpose(s): STOCK, DOMESTIC

Work Type: Bore
Work Status:
Construct.Method: Rotary Air
Owner Type:

Commenced Date:
Completion Date: 30/06/2000

Final Depth: 132.50 m
Drilled Depth: 132.50 m

Contractor Name: INTERTEC DRILLING SERVICES
Driller: William Crump
Assistant Driller:

Property: FARRUGIA 30 Carlisle St YANDERRA 2574 NSW
GWMA: -
GW Zone: -

Standing Water Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CAMDEN	BARGO	1 734564
Licensed:	CAMDEN	BARGO	Whole Lot 1//734564

Region: 10 - Sydney South Coast
CMA Map:
River Basin: - Unknown
Area/District:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown
Northing: 6200964.000
Easting: 276840.000
Latitude: 34°18'30.9"S
Longitude: 150°34'29.8"E

GS Map: -
MGA Zone: 56
Coordinate Source: Unknown

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	5.30	210			Down Hole Hammer
1		Hole	Hole	5.30	132.50	158			Down Hole Hammer
1	1	Casing	Pvc Class 9	-0.50	53.50	140			Suspended in Clamps, Screwed and Glued
1	1	Casing	Steel	-0.50	5.50	168	158		Driven into Hole

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
29.00	29.30	0.30	Unknown			0.10	30.00		258.00
57.00	62.00	5.00	Unknown			0.20	66.00		204.00
94.00	101.00	7.00	Unknown			0.20	102.00		204.00
113.30	120.00	6.70	Unknown			0.40	120.00		203.00
124.00	127.00	3.00	Unknown	24.30		1.30	132.50		203.00

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	1.00	1.00	SANDY LOAM	Loam	
1.00	11.00	10.00	WEATHERED SANDSTONE BROWN	Sandstone	
11.00	15.00	4.00	SANDSTONE BROWN M.G.	Sandstone	
15.00	20.00	5.00	SANDSTONE BROWN	Sandstone	
20.00	22.00	2.00	SANDSTONE AND QUARTZ	Sandstone	
22.00	26.00	4.00	SANDSTONE GREY	Sandstone	
26.00	27.00	1.00	IRONSTONE AND QUARTZ	Ironstone Gravel	
27.00	29.00	2.00	SANDSTONE WHITE	Sandstone	
29.00	29.30	0.30	QUARTZ	Quartz	
29.30	31.00	1.70	SANDSTONE WHITE	Sandstone	
31.00	36.00	5.00	SANDSTONE GREY	Sandstone	
36.00	43.00	7.00	SANDSTONE/IRONSTONE	Sandstone	
43.00	45.00	2.00	IRONSTONE FRACT.	Ironstone Gravel	
45.00	57.00	12.00	SANDSTONE GREY	Sandstone	
57.00	62.00	5.00	SANDSTONE QUARTZ	Sandstone	
62.00	75.00	13.00	SANDSTONE GREY	Sandstone	
75.00	77.00	2.00	SANDSTONE / SHALE	Sandstone	
77.00	94.00	17.00	SANDSTONE GREY	Sandstone	
94.00	101.00	7.00	SANDSTONE QUARTZ	Sandstone	
101.00	104.00	3.00	SANDSTONE GREY	Sandstone	
104.00	106.50	2.50	SANDSTONE QUARTZ	Sandstone	
106.50	110.00	3.50	SANDSTONE QUARTZ	Sandstone	
110.00	112.00	2.00	SANDSTONE AND SHALE	Sandstone	
112.00	113.50	1.50	SANDSTONE GREY	Sandstone	
113.50	120.00	6.50	SANDSTONE QUARTZ	Sandstone	
120.00	124.00	4.00	SANDSTONE WHITE	Sandstone	
124.00	127.00	3.00	SANDSTONE QUARTZ FRACTURED	Sandstone	
127.00	132.50	5.50	SANDSTONE GREY	Sandstone	

***** End of GW103036 *****

Site GW103036 Values at Time of Drilling

Measure	Data Type	Hole	Pipe	Date	Value
Inst. Salinity (Total Dissolved Salts) (Milligrams/Litre)	Manual	1	1	30/06/2000 @ 00:00	203

Parameter	LOR	Unit	30 Carlisle St
Registered Number			GW103036
Date			27-01-2022
Calcium - Dissolved	0.5	mg/L	2
Potassium - Dissolved	0.5	mg/L	0.8
Sodium - Dissolved	0.5	mg/L	47
Magnesium - Dissolved	0.5	mg/L	7.9
Hardness	3	mg/L	37
Hydroxide Alkalinity (OH-) as CaCO3	5	mg/L	<5
Bicarbonate Alkalinity as CaCO3	5	mg/L	24
Carbonate Alkalinity as CaCO3	5	mg/L	<5
Total Alkalinity as CaCO3	5	mg/L	24
Sulphate SO4	1	mg/L	3
Chloride Cl	1	mg/L	110
Ionic Balance	-	%	-14
Total Nitrogen in Water	0.1	mg/L	0.1
Phosphorus Total	0.05	mg/L	<0.05
Aluminium-Total	10	µg/L	310
Arsenic-Total	1	µg/L	<1
Barium-Total	1	µg/L	83
Beryllium-Total	0.5	µg/L	0.9
Cadmium-Total	0.1	µg/L	<0.1
Chromium-Total	1	µg/L	<1
Cobalt-Total	1	µg/L	16
Copper-Total	1	µg/L	<1
Iron-Total	10	µg/L	18000
Lithium-Total	1	µg/L	9
Mercury-Total	0.05	µg/L	<0.05
Manganese-Total	5	µg/L	1600
Nickel-Total	1	µg/L	33
Lead-Total	1	µg/L	2
Selenium-Total	1	µg/L	<1
Strontium-Total	1	µg/L	16
Vanadium-Total	1	µg/L	<1
Zinc-Total	1	µg/L	46
Aluminium-Dissolved	10	µg/L	210
Arsenic-Dissolved	1	µg/L	<1
Barium-Dissolved	1	µg/L	85
Beryllium-Dissolved	0.5	µg/L	0.7
Cadmium-Dissolved	0.1	µg/L	<0.1
Chromium-Dissolved	1	µg/L	<1
Cobalt-Dissolved	1	µg/L	16
Copper-Dissolved	1	µg/L	<1
Iron-Dissolved	10	µg/L	17000
Lithium-Dissolved	1	µg/L	7
Mercury-Dissolved	0.05	µg/L	<0.05
Manganese-Dissolved	5	µg/L	1400
Nickel-Dissolved	1	µg/L	16
Lead-Dissolved	1	µg/L	<1
Selenium-Dissolved	1	µg/L	<1
Strontium-Dissolved	1	µg/L	16
Vanadium-Dissolved	1	µg/L	<1
Zinc-Dissolved	1	µg/L	47

Bore: GW103559	Property: 115 TYLERS RD
Bore Identification Information (NSW Real Time Water Data)	
Bore name	GW103559
Property	Not listed
NSW licence number	NA
Datum	GDA 94 Zone 56
Easting	276543
Northing	6201786
Elevation (mAHD)	NR
Purpose	Irrigation
Bore Construction Details	
Drilling and construction records available	Yes
Date drilled/constructed	29/03/2000
Total depth of bore (m)	54
Geological Formation Screened	Sandstone/shale
Bore Casing	
Material	PVC
Diameter	PVC 125 mm OD
Stick-up	NR
Hydrogeological info	
Screened lithology/formation	Sandstone/shale
Standing water level (mbgl)	15
Water quality	NR
Other bore log comments	Yield (L/s): 3.40
Data Collected While On Site	
Census Date	04/02/2022
Completed by	Chris Rotsider, Consulting Earth Scientists Pty Ltd
Photographs (insert)	
	
Bore Details	
Site Address	115 TYLERS RD, BARGO, 2574 NSW
GPS Location datum	GDA 94 Zone 56
Easting	276504
Northing	6201854
Elevation (mAHD) – specify survey method	NR
Drilling and construction records (Y/N)	N

Bore: GW103559	Property: 115 TYLERS RD
Stick-up (casing, monument etc.)	PVC with metal cap
Casing Diameter	150 mm
Total depth of bore (mbgl)	190 (anecdotal, unable to be measured)
Depth to water (mbgl)	NR
Pump status (if installed)	In-situ electric pump disconnected and non operational
Logger status/condition (if installed). Serial no., make, model etc.	NA
Fencing/barrier installed?	No
Sampling method	Dam
Electrical Conductivity (µS/cm)	487
pH	5.7
Temperature (°C)	18.2
ORP (mV)	48.3
Dissolved Oxygen (mg/L)	1.17
Colour, odour, characteristics etc.	No odour, not turbid, likely high Fe+ due to layer of rust observed at bore water outlet into dam
Bore Pump Details (if relevant)	
Frequency of use	NR
Typical pumping rate	NR
Purpose / Use of Bore	Claimed to be in use by site contact to fill irrigation dam
Comment:	
PVC well head in fair/poor working condition	

WaterNSW
Work Summary

GW103559

Licence:

Licence Status:

Authorised Purpose(s):
Intended Purpose(s): IRRIGATION

Work Type: Bore
Work Status:
Construct.Method: Rotary
Owner Type:

Commenced Date:
Completion Date: 29/03/2000

Final Depth: 54.00 m
Drilled Depth: 54.00 m

Contractor Name: Slade Drilling
Driller: Paul Edwin Slade
Assistant Driller:

Property:
GWMA:
GW Zone:

Standing Water Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CAMDEN	BARGO	190 650138
Licensed:			

Region: 10 - Sydney South Coast
River Basin: - Unknown
Area/District:

CMA Map:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown

Northing: 6201786.000
Easting: 276543.000

Latitude: 34°18'04.0"S
Longitude: 150°34'19.0"E

GS Map: -
MGA Zone: 56
Coordinate Source: Unknown

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	54.00	145			Down Hole Hammer
1	1	Casing	P.V.C.	0.00	6.00	125			Driven into Hole

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
39.00	54.00	15.00	Unknown	15.00		3.40	54.00	02:00:00	

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.25	0.25	SOIL	Soil	

0.25	1.50	1.25	CLAY	Clay	
1.50	24.00	22.50	SANDSTONE	Sandstone	
24.00	30.00	6.00	SHALE	Shale	
30.00	36.00	6.00	SANDSTONE	Sandstone	
36.00	39.00	3.00	SHALE	Shale	
39.00	54.00	15.00	SANDSTONE	Sandstone	

***** End of GW103559 *****

Parameter	LOR	Unit	115 Tyler's Rd
Registered Number			GW2 -1757YLER
Date			04-02-2022
Calcium - Dissolved	0.5	mg/L	2
Potassium - Dissolved	0.5	mg/L	0.9
Sodium - Dissolved	0.5	mg/L	65
Magnesium - Dissolved	0.5	mg/L	9.8
Hardness	3	mg/L	44
Hydroxide Alkalinity (OH-) as CaCO3	5	mg/L	<5
Bicarbonate Alkalinity as CaCO3	5	mg/L	43
Carbonate Alkalinity as CaCO3	5	mg/L	<5
Total Alkalinity as CaCO3	5	mg/L	43
Sulphate SO4	1	mg/L	4
Chloride Cl	1	mg/L	150
Ionic Balance	-	%	-15
Total Nitrogen in Water	0.1	mg/L	<0.1
Phosphorus Total	0.05	mg/L	<0.05
Aluminium-Total	10	µg/L	10
Arsenic-Total	1	µg/L	<1
Barium-Total	1	µg/L	140
Beryllium-Total	0.5	µg/L	0.8
Cadmium-Total	0.1	µg/L	<0.1
Chromium-Total	1	µg/L	<1
Cobalt-Total	1	µg/L	21
Copper-Total	1	µg/L	<1
Iron-Total	10	µg/L	35000
Lithium-Total	1	µg/L	7
Mercury-Total	0.05	µg/L	<0.05
Manganese-Total	5	µg/L	2100
Nickel-Total	1	µg/L	19
Lead-Total	1	µg/L	<1
Selenium-Total	1	µg/L	<1
Strontium-Total	1	µg/L	17
Vanadium-Total	1	µg/L	<1
Zinc-Total	1	µg/L	60
Aluminium-Dissolved	10	µg/L	<10
Arsenic-Dissolved	1	µg/L	<1
Barium-Dissolved	1	µg/L	140
Beryllium-Dissolved	0.5	µg/L	0.7
Cadmium-Dissolved	0.1	µg/L	<0.1
Chromium-Dissolved	1	µg/L	<1
Cobalt-Dissolved	1	µg/L	21
Copper-Dissolved	1	µg/L	<1
Iron-Dissolved	10	µg/L	34000
Lithium-Dissolved	1	µg/L	8
Mercury-Dissolved	0.05	µg/L	<0.05
Manganese-Dissolved	5	µg/L	2100
Nickel-Dissolved	1	µg/L	19
Lead-Dissolved	1	µg/L	<1
Selenium-Dissolved	1	µg/L	1
Strontium-Dissolved	1	µg/L	18
Vanadium-Dissolved	1	µg/L	<1
Zinc-Dissolved	1	µg/L	62

Bore: GW103615	Property: 275 BARGO RD
Bore Identification Information (NSW Real Time Water Data)	
Bore name	GW103615
Property	ACERS 275 Bargo Rd BARGO 2574 NSW
NSW licence number	10WA110673 (current)
Datum	GDA 94 Zone 56
Easting	279720
Northing	6204034
Elevation (mAHD)	NR
Purpose	Stock, domestic
Bore Construction Details	
Drilling and construction records available	Yes
Date drilled/constructed	02/02/2001
Total depth of bore (m)	103
Geological Formation Screened	Sandstone
Bore Casing	
Material	PVC Class 9
Diameter	160 mm OD
Stick-up	NR
Hydrogeological info	
Screened lithology/formation	Coarse Sandstone
Standing water level (mbgl)	NR
Water quality	Salinity: 320 mg/L
Other bore log comments	
Data Collected While On Site	
Census Date	02/02/2022
Completed by	Chris Rotsider, Consulting Earth Scientists Pty Ltd
Photographs	
	
Bore Details	
Site Address	275 BARGO RD, BARGO, 2574 NSW
GPS Location datum	GDA 94 Zone 56
Easting	279635
Northing	6204110
Elevation (mAHD) – specify survey method	NR
Drilling and construction records (Y/N)	Y
Stick-up (casing, monument etc.)	Stick up with metal cap

Bore: GW103615	Property: 275 BARGO RD
Total depth of bore (mbgl)	73.1
Depth to water (mbgl)	65.36
Pump status (if installed)	In situ electric pump not currently operational and disconnected from power.
Logger status/condition (if installed). Serial no., make, model etc.	NA
Fencing/barrier installed?	Yes – Non enclosed shed like cover
Sampling method	Sample not collected as inadequate clearance for equipment
Electrical Conductivity (µS/cm)	NR
pH	NR
Temperature (°C)	NR
ORP (mV)	NR
Dissolved Oxygen (mg/L)	NR
Colour, odour, characteristics etc.	NR
Bore Pump Details (if relevant)	
Frequency of use	Not currently used
Typical pumping rate	NA
Purpose / Use of Bore	Not currently used
Comment:	
Headworks in fair condition with signs of disuse.	

WaterNSW
Work Summary

GW103615

Licence: 10WA110673

Licence Status: CURRENT

Authorised Purpose(s): STOCK,DOMESTIC
Intended Purpose(s): STOCK, DOMESTIC

Work Type: Bore
Work Status:
Construct.Method: Rotary
Owner Type:

Commenced Date:
Completion Date: 02/02/2001

Final Depth: 103.00 m
Drilled Depth: 103.00 m

Contractor Name: HIGHLAND DRILLING PTY LTD
Driller: Brett Delamont
Assistant Driller:

Property: ACERS 275 Bargo Rd BARGO 2574 NSW
GWMA: -
GW Zone: -

Standing Water Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CAMDEN	BARGO	1012//1067313
Licensed:	CAMDEN	BARGO	Whole Lot 1012//1067313

Region: 10 - Sydney South Coast

CMA Map:

River Basin: - Unknown
Area/District:

Grid Zone:

Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown

Northing: 6204034.000
Easting: 279720.000

Latitude: 34°16'53.6"S
Longitude: 150°36'25.2"E

GS Map: -

MGA Zone: 56

Coordinate Source: Unknown

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	103.00	200			Down Hole Hammer
1		Annulus	(Unknown)	0.00	0.00				Graded
1	1	Casing	Pvc Class 9	0.00	103.00	160			Seated on Bottom, Glued
1	1	Opening	Slots	85.00	103.00	160		0	Sawn, PVC Class 9, SL: 18.0mm, A: 3.00mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
71.00	72.00	1.00	Unknown			0.50	73.00		30.00
75.00	76.00	1.00	Unknown			0.60	76.00		30.00
96.00	97.00	1.00	Unknown			8.90	103.00		320.00

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	1.00	1.00	TOPSOIL	Topsoil	
1.00	37.50	36.50	FINE SANDSTONE	Sandstone	
37.50	39.00	1.50	SHALE	Shale	
39.00	61.50	22.50	OFF WHITE FINE SANDSTONE	Sandstone	
61.50	63.00	1.50	SHALE	Shale	
63.00	103.00	40.00	COARSE WHITE SANDSTONE	Sandstone	

***** End of GW103615 *****

Bore: GW104008	Property: 145 ARINA RD
Bore Identification Information (NSW Real Time Water Data)	
Bore name	GW104008
Property	DUFFY 145 Arina Rd BARGO 2574 NSW
NSW licence number	10WA110509 (current)
Datum	GDA 94 Zone 56
Easting	280554
Northing	6205744
Elevation (mAHD)	NR
Purpose	Stock, domestic
Bore Construction Details	
Drilling and construction records available	Yes
Date drilled/constructed	20/01/1999
Total depth of bore (m)	140
Geological Formation Screened	Sandstone
Bore Casing	
Material	PVC Class 9
Diameter	PVC 160 mm OD
Stick-up	NR
Hydrogeological info	
Screened lithology/formation	Sandstone
Standing water level (mbgl)	57
Water quality	NR
Other bore log comments	Yield (L/s): 2.50
Data Collected While On Site	
Census Date	01/02/2022
Completed by	Chris Rotsider, Consulting Earth Scientists Pty Ltd
Photographs	

Bore Details	
Site Address	145 ARINA RD BARGO 2574 NSW
GPS Location datum	GDA 94 Zone 56
Easting	280359
Northing	6205978

Bore: GW104008	Property: 145 ARINA RD
Elevation (mAHD) – specify survey method	NR
Drilling and construction records (Y/N)	Y
Stick-up (casing, monument etc.)	Cement footing with metal cap
Total depth of bore (mbgl)	>100
Depth to water (mbgl)	46.84
Pump status (if installed)	In-situ electric pump
Logger status/condition (if installed). Serial no., make, model etc.	NA
Fencing/barrier installed?	No
Sampling method	Pump (5 l purged)
Electrical Conductivity (µS/cm)	1323
pH	6.4
Temperature (°C)	18.8
ORP (mV)	-11.6
Dissolved Oxygen (mg/L)	0.79
Colour, odour, characteristics etc.	No odour, red colouring, high turbidity
Bore Pump Details (if relevant)	
Frequency of use	When required
Typical pumping rate	NR
Purpose / Use of Bore	Fill dam and irrigate lawn
Comment:	
Headworks in good condition with cement footing and plumbing into irrigation system Water removed: 5 l in 5 min Recovery time: >15 min	

WaterNSW
Work Summary

GW104008

Licence: 10WA110509

Licence Status: CURRENT

Authorised Purpose(s): STOCK,DOMESTIC
Intended Purpose(s): STOCK, DOMESTIC

Work Type: Bore
Work Status:
Construct.Method: Rotary
Owner Type:

Commenced Date:
Completion Date: 20/01/1999

Final Depth: 140.00 m
Drilled Depth: 140.00 m

Contractor Name: Ultra Drilling
Driller: Alan Marcus Dodd
Assistant Driller:

Property: DUFFY 145 Arinya Rd BARGO 2574 NSW
GWMA: -
GW Zone: -

Standing Water Level (m):
Salinity Description: Good
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CAMDEN	BARGO	22//803704
Licensed:	CAMDEN	BARGO	Whole Lot 22//803704

Region: 10 - Sydney South Coast
River Basin: - Unknown
Area/District:

CMA Map:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown

Northing: 6205744.000
Easting: 280554.000

Latitude: 34°15'58.7"S
Longitude: 150°36'59.4"E

GS Map: -
MGA Zone: 56
Coordinate Source: Unknown

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	9.00	201			Rotary Air
1		Hole	Hole	9.00	140.00	0			Rotary Air
1	1	Casing	Pvc Class 9	0.30	9.00	160			Seated on Bottom, Driven into Hole, Glued

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
84.00	85.00	1.00	Unknown		87.00	0.30	87.00		
100.00	110.00	10.00	Unknown		111.00	0.60	111.00	01:00:00	
135.00	136.00	1.00	Unknown	57.00		2.50	140.00	01:00:00	

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	1.00	1.00	RED CLAY	Clay	
1.00	8.00	7.00	SOFT SHALE	Shale	
8.00	106.00	98.00	SANDSTONE	Sandstone	
106.00	108.00	2.00	SHALE	Shale	
108.00	140.00	32.00	SANDSTONE/QUARTZITE	Sandstone	

***** End of GW104008 *****

Parameter	LOR	Unit	145 Arina Rd
Registered Number			GW104008
Date			10-02-2022
Calcium - Dissolved	0.5	mg/L	4
Potassium - Dissolved	0.5	mg/L	3
Sodium - Dissolved	0.5	mg/L	86
Magnesium - Dissolved	0.5	mg/L	18
Hardness	3	mg/L	84
Hydroxide Alkalinity (OH-) as CaCO3	5	mg/L	<5
Bicarbonate Alkalinity as CaCO3	5	mg/L	71
Carbonate Alkalinity as CaCO3	5	mg/L	<5
Total Alkalinity as CaCO3	5	mg/L	71
Sulphate SO4	1	mg/L	15
Chloride Cl	1	mg/L	200
Ionic Balance	-	%	-14
Total Nitrogen in Water	0.1	mg/L	1.7
Phosphorus Total	0.05	mg/L	9.4
Aluminium-Total	10	µg/L	130
Arsenic-Total	1	µg/L	130
Barium-Total	1	µg/L	6
Beryllium-Total	0.5	µg/L	500
Cadmium-Total	0.1	µg/L	35
Chromium-Total	1	µg/L	11
Cobalt-Total	1	µg/L	380000
Copper-Total	1	µg/L	62
Iron-Total	10	µg/L	380000
Lithium-Total	1	µg/L	62
Mercury-Total	0.05	µg/L	2200
Manganese-Total	5	µg/L	51
Nickel-Total	1	µg/L	15
Lead-Total	1	µg/L	<1
Selenium-Total	1	µg/L	<1
Strontium-Total	1	µg/L	100
Vanadium-Total	1	µg/L	100
Zinc-Total	1	µg/L	320
Aluminium-Dissolved	10	µg/L	<10
Arsenic-Dissolved	1	µg/L	<10
Barium-Dissolved	1	µg/L	<1
Beryllium-Dissolved	0.5	µg/L	140
Cadmium-Dissolved	0.1	µg/L	12
Chromium-Dissolved	1	µg/L	<1
Cobalt-Dissolved	1	µg/L	30
Copper-Dissolved	1	µg/L	1500
Iron-Dissolved	10	µg/L	15000
Lithium-Dissolved	1	µg/L	30
Mercury-Dissolved	0.05	µg/L	10
Manganese-Dissolved	5	µg/L	<1
Nickel-Dissolved	1	µg/L	<1
Lead-Dissolved	1	µg/L	54
Selenium-Dissolved	1	µg/L	<1
Strontium-Dissolved	1	µg/L	54
Vanadium-Dissolved	1	µg/L	130
Zinc-Dissolved	1	µg/L	15000

Bore: GW104323	Property: 225 BARGO RD
Bore Identification Information (NSW Real Time Water Data)	
Bore name	GW104323
Property	CONSTANTI 225 Bargo Rd BARGO 2574 NSW
NSW licence number	10WA110534 (current)
Datum	GDA 94 Zone 56
Easting	279131
Northing	6203333
Elevation (mAHD)	NR
Purpose	Stock, domestic
Bore Construction Details	
Drilling and construction records available	Yes
Date drilled/constructed	03/03/1999
Total depth of bore (m)	109
Geological Formation Screened	Sandstone
Bore Casing	
Material	PVC, Steel
Diameter	PVC 150 mm OD, Steel 200 mm OD
Stick-up	NR
Hydrogeological info	
Screened lithology/formation	Sandstone
Standing water level (mbgl)	60
Water quality	Salinity: 113 mg/L
Other bore log comments	Yield (L/s): 6.60
Data Collected While On Site	
Census Date	07/02/2022
Completed by	Chris Rotsider, Consulting Earth Scientists Pty Ltd
Photographs	
	
Bore Details	
Site Address	225 BARGO RD, BARGO, 2574 NSW
GPS Location datum	GDA 94 Zone 56
Easting	276242
Northing	6206412
Elevation (mAHD) – specify survey method	NR
Drilling and construction records (Y/N)	Y
Stick-up (casing, monument etc.)	Steel stick up with metal cap

Bore: GW104323	Property: 225 BARGO RD
Total depth of bore (mbgl)	79.8
Depth to water (mbgl)	68.6
Pump status (if installed)	In-situ electric pump 2120kW
Logger status/condition (if installed). Serial no., make, model etc.	NA
Fencing/barrier installed?	No
Sampling method	Tank (direct connection)
Electrical Conductivity (µS/cm)	1025
pH	4.3
Temperature (°C)	23.7
ORP (mV)	379.8
Dissolved Oxygen (mg/L)	1.55
Colour, odour, characteristics etc.	No odour, low turbidity
Bore Pump Details (if relevant)	
Frequency of use	Daily (use on timer)
Typical pumping rate	NR
Purpose / Use of Bore	Crop irrigation
Comment:	
Metal well head in good condition with no concrete footing.	

WaterNSW
Work Summary

GW104323

Licence: 10WA110534 **Licence Status:** CURRENT

Authorised Purpose(s): STOCK,DOMESTIC
Intended Purpose(s): STOCK, DOMESTIC

Work Type: Bore
Work Status: Supply Obtained
Construct.Method: Rotary
Owner Type: Private

Commenced Date: **Final Depth:** 109.00 m
Completion Date: 03/03/1999 **Drilled Depth:** 109.00 m

Contractor Name: Slade Drilling
Driller: Paul Edwin Slade
Assistant Driller:

Property: CONSTANTI 225 Bargo Rd BARGO 2574 NSW **Standing Water Level (m):** 60.000
GWMA: - **Salinity Description:**
GW Zone: - **Yield (L/s):** 6.600

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CAMDEN	BARGO	LT 2 DP 216449
Licensed:	CAMDEN	BARGO	Whole Lot 2//216449

Region: 10 - Sydney South Coast **CMA Map:**
River Basin: - Unknown **Grid Zone:** **Scale:**
Area/District:

Elevation: 0.00 m (A.H.D.) **Northing:** 6203333.000 **Latitude:** 34°17'15.9"S
Elevation Source: Unknown **Easting:** 279131.000 **Longitude:** 150°36'01.5"E

GS Map: - **MGA Zone:** 56 **Coordinate Source:** Map Interpre

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	109.00	200			Down Hole Hammer
1	1	Casing	P.V.C.	0.00	109.00	150			Seated on Bottom
1	1	Casing	Steel	0.00	1.30	200			Driven into Hole, Glued
1	1	Opening	Slots	94.00	109.00	150		0	Sawn, PVC Class 9, SL: 0.1mm, A: 3.00mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
102.00	105.00	3.00	Unknown	60.00		6.60	105.00	02:00:00	113.00

Drillers Log

From	To	Thickness	Drillers Description	Geological Material	Comments

(m)	(m)	(m)			
0.00	1.00	1.00	SANDY SOIL	Invalid Code	
1.00	24.00	23.00	SANDSTONE ORANGE	Sandstone	
24.00	27.00	3.00	SHALE	Shale	
27.00	109.00	82.00	SANDSTONE OFF WHITE	Sandstone	

***** End of GW104323 *****

Parameter	LOR	Unit	225 Bargo Rd
Registered Number			GW104323
Date			01-02-2022
Calcium - Dissolved	0.5	mg/L	<0.5
Potassium - Dissolved	0.5	mg/L	1
Sodium - Dissolved	0.5	mg/L	150
Magnesium - Dissolved	0.5	mg/L	20
Hardness	3	mg/L	81
Hydroxide Alkalinity (OH-) as CaCO3	5	mg/L	<5
Bicarbonate Alkalinity as CaCO3	5	mg/L	<5
Carbonate Alkalinity as CaCO3	5	mg/L	<5
Total Alkalinity as CaCO3	5	mg/L	<5
Sulphate SO4	1	mg/L	27
Chloride Cl	1	mg/L	310
Ionic Balance	-	%	-6
Total Nitrogen in Water	0.1	mg/L	0.5
Phosphorus Total	0.05	mg/L	<0.05
Aluminium-Total	10	µg/L	3700
Arsenic-Total	1	µg/L	<1
Barium-Total	1	µg/L	260
Beryllium-Total	0.5	µg/L	6
Cadmium-Total	0.1	µg/L	0.6
Chromium-Total	1	µg/L	<1
Cobalt-Total	1	µg/L	43
Copper-Total	1	µg/L	32
Iron-Total	10	µg/L	100
Lithium-Total	1	µg/L	11
Mercury-Total	0.05	µg/L	<0.05
Manganese-Total	5	µg/L	2300
Nickel-Total	1	µg/L	30
Lead-Total	1	µg/L	24
Selenium-Total	1	µg/L	<1
Strontium-Total	1	µg/L	12
Vanadium-Total	1	µg/L	<1
Zinc-Total	1	µg/L	220
Aluminium-Dissolved	10	µg/L	2300
Arsenic-Dissolved	1	µg/L	<1
Barium-Dissolved	1	µg/L	200
Beryllium-Dissolved	0.5	µg/L	4
Cadmium-Dissolved	0.1	µg/L	1
Chromium-Dissolved	1	µg/L	<1
Cobalt-Dissolved	1	µg/L	37
Copper-Dissolved	1	µg/L	140
Iron-Dissolved	10	µg/L	160
Lithium-Dissolved	1	µg/L	11
Mercury-Dissolved	0.05	µg/L	<0.05
Manganese-Dissolved	5	µg/L	1900
Nickel-Dissolved	1	µg/L	36
Lead-Dissolved	1	µg/L	46
Selenium-Dissolved	1	µg/L	<1
Strontium-Dissolved	1	µg/L	11
Vanadium-Dissolved	1	µg/L	<1
Zinc-Dissolved	1	µg/L	1800

Bore: GW104659	Property: Tahmoor South
Bore Identification Information (NSW Real Time Water Data)	
Bore name/nickname	GW104659
Property	SYDNEY ANGLICAN SCHOOLS 3000 Remembrance Dr BARGO 2574 NSW
NSW licence number	10CA112050 (current)
Datum	GDA94 Zone 56
Easting	276617
Northing	6207391
Elevation (mAHD)	NR
Purpose	Recreation – low security, Irrigation
Bore Construction Details	
Drilling and construction records available	Yes
Date drilled/constructed	14/02/2003
Total depth of bore (m)	132.0
Geological Formation Screened	Sandstone
Bore Casing	
Material	PVC Class 9, Steel
Diameter	PVC 140mm OD, 1 Steel 168mm OD
Stick-up	0.5 m
Hydrogeological info	
Screened lithology/formation	Sandstone
Standing water level (mbgl)	51.0
Water quality	Salinity: 248 mg/L
Other bore log comments	Yield (Ls): 0.8
Data Collected While On Site	
Census Date	24/01/2022
Completed by	Chris Rotsider, Consulting Earth Scientists Pty Ltd
Photographs (insert)	

Bore Details

Bore: GW104659	Property: Tahmoor South
Site Address	WOLLONDILLY ANGLICAN COLLEGE, 3000 REMEMBRANCE DR, TAHMOOR, 2574 NSW
GPS Location datum	GDA 94 Zone 56
Easting	276616
Northing	6207392
Elevation (mAHD) – specify survey method	NR
Drilling and construction records (Y/N)	Y
Stick-up (casing, monument etc.)	Metal casing stick up with metal cap
Total depth of bore (mbgl)	50.08
Depth to water (mbgl)	43.8
Pump status (if installed)	5.5kW 415L in-situ electric pump
Logger status/condition (if installed). Serial no., make, model etc.	NA
Fencing/barrier installed?	Yes - Secured within a fenced perimeter
Sampling method	In-situ electric 5.5 kW 415L Bore Pump
Electrical Conductivity (µS/cm)	539
pH	5.72
Temperature (°C)	18.5
ORP (mV)	34.7
Dissolved Oxygen (mg/L)	0.71
Colour, odour, characteristics etc.	Moderate turbidity, 'rusty' colour (Pressured high Fe), no odour, no sheen
Bore Pump Details (if relevant)	
Frequency of use	NR regulated by timer to replenish dam
Typical pumping rate	~1L/sec
Purpose / Use of Bore	To replenish adjacent dam
Comment:	
Headworks for this monitoring well were encountered to be in a good working condition. Water extracted: 10 l Recovery time: 4 min 54 s	

WaterNSW
Work Summary

GW104659

Licence: 10CA112050

Licence Status: CURRENT

Authorised Purpose(s): RECREATION - LOW SECURITY
Intended Purpose(s): IRRIGATION

Work Type: Bore
Work Status: Supply Obtained
Construct.Method: Rotary
Owner Type: Private

Commenced Date:
Completion Date: 14/02/2003

Final Depth: 132.00 m
Drilled Depth: 132.00 m

Contractor Name: INTERTEC DRILLING SERVICES
Driller: William Crump
Assistant Driller:

Property: SYDNEY ANGLICAN SCHOOLS 3000 Rememberance Dr BARGO 2574 NSW
GWMA: -
GW Zone: -

Standing Water Level (m): 51.000
Salinity Description:
Yield (L/s): 0.800

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CAMDEN	BARGO	1 536959
Licensed:	CAMDEN	BARGO	Whole Lot 12//1122904

Region: 10 - Sydney South Coast
CMA Map: 9029-3N

River Basin Area/District: 212 - HAWKESBURY RIVER
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: (Unknown)

Northing: 6207391.000
Easting: 276617.000

Latitude: 34°15'02.3"S
Longitude: 150°34'27.1"E

GS Map: -
MGA Zone: 56
Coordinate Source: Unknown

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	5.50	208			Down Hole Hammer
1		Hole	Hole	5.50	132.00	157			Down Hole Hammer
1	1	Casing	Pvc Class 9	-0.50	47.50	140			Suspended in Clamps, Screwed and Glued
1	1	Casing	Steel	-0.50	5.50	168	158		Driven into Hole

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
76.50	81.00	4.50	Unknown			0.60	84.00		380.00
92.50	95.50	3.00	Unknown			1.00	96.00		450.00
98.00	105.00	7.00	Unknown			0.60	108.00		320.00
109.50	110.00	0.50	Unknown	51.00		0.80	132.00		248.00

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	1.00	1.00	CLAY BROWN	Clay	
1.00	28.00	27.00	SANDSTONE LT BROWN	Sandstone	
28.00	33.00	5.00	SANDSTONE GREY	Sandstone	
33.00	34.00	1.00	SANDSTONE QUARTZ	Sandstone	
34.00	43.00	9.00	SANDSTONE GREY	Sandstone	
43.00	44.20	1.20	SHALE	Shale	
44.20	47.50	3.30	SANDSTONE GREY	Sandstone	
47.50	48.30	0.80	SANDSTONE QUARTZ FINE	Sandstone	
48.30	74.00	25.70	SANDSTONE GREY	Sandstone	
74.00	76.00	2.00	SANDSTONE QUARTZ	Sandstone	
76.00	76.50	0.50	SANDSTONE GREY	Sandstone	
76.50	81.00	4.50	SANDSTONE QUARTZ	Sandstone	
81.00	85.00	4.00	SANDSTONE GREY	Sandstone	
85.00	86.00	1.00	SANDSTONE QUARTZ	Sandstone	
86.00	92.50	6.50	SANDSTONE L/GREY	Sandstone	
92.50	95.50	3.00	SANDSTONE QUARTZ/SMALL SHALE	Sandstone	
95.50	98.00	2.50	SANDSTONE GREY	Sandstone	
98.00	105.00	7.00	SANDSTONE QUARTZ	Sandstone	
105.00	108.00	3.00	SANDSTONE GREY	Sandstone	
108.00	109.50	1.50	SANDSTONE QUARTZ	Sandstone	
109.50	110.00	0.50	SANDSTONE QUARTZ V.FRACTURED	Sandstone	
110.00	115.00	5.00	SANDSTONE L/GREY	Sandstone	
115.00	117.00	2.00	SANDSTONE QUARTZ	Sandstone	
117.00	121.00	4.00	SANDSTONE L/GREY	Sandstone	
121.00	121.20	0.20	SANDSTONE FRACTURED	Sandstone	
121.20	132.00	10.80	SANDSTONE GREY	Sandstone	

Remarks

22/09/2004: Previous Lic no: 10BL161293

***** End of GW104659 *****

Site GW104659 Values at Time of Drilling

Measure	Data Type	Hole	Pipe	Date	Value
Groundwater depth below surface level (Metres)	Manual	1	1	14/02/2003 @ 12:00	51.000
Meter Discharge (Kilolitres/Day)	Manual	1	1	14/02/2003 @ 00:00	0.800
Inst. Salinity (Total Dissolved Salts) (Milligrams/Litre)	Manual	1	1	14/02/2003 @ 00:00	248

Parameter	LOR	Unit	Wollondilly Anglican Church
Registered Number			GW104659
Date			24-01-2022
Calcium - Dissolved	0.5	mg/L	3
Potassium - Dissolved	0.5	mg/L	1
Sodium - Dissolved	0.5	mg/L	68
Magnesium - Dissolved	0.5	mg/L	12
Hardness	3	mg/L	55
Hydroxide Alkalinity (OH-) as CaCO3	5	mg/L	<5
Bicarbonate Alkalinity as CaCO3	5	mg/L	6
Carbonate Alkalinity as CaCO3	5	mg/L	<5
Total Alkalinity as CaCO3	5	mg/L	6
Sulphate SO4	1	mg/L	7
Chloride Cl	1	mg/L	150
Ionic Balance	-	%	-5
Total Nitrogen in Water	0.1	mg/L	<0.1
Phosphorus Total	0.05	mg/L	3.6
Aluminium-Total	10	µg/L	6800
Arsenic-Total	1	µg/L	6
Barium-Total	1	µg/L	200
Beryllium-Total	0.5	µg/L	15
Cadmium-Total	0.1	µg/L	<0.1
Chromium-Total	1	µg/L	2
Cobalt-Total	1	µg/L	10
Copper-Total	1	µg/L	20
Iron-Total	10	µg/L	410000
Lithium-Total	1	µg/L	16
Mercury-Total	0.05	µg/L	<0.05
Manganese-Total	5	µg/L	1600
Nickel-Total	1	µg/L	10
Lead-Total	1	µg/L	73
Selenium-Total	1	µg/L	<1
Strontium-Total	1	µg/L	29
Vanadium-Total	1	µg/L	<1
Zinc-Total	1	µg/L	54
Aluminium-Dissolved	10	µg/L	<10
Arsenic-Dissolved	1	µg/L	<1
Barium-Dissolved	1	µg/L	150
Beryllium-Dissolved	0.5	µg/L	<0.5
Cadmium-Dissolved	0.1	µg/L	<0.1
Chromium-Dissolved	1	µg/L	<1
Cobalt-Dissolved	1	µg/L	10
Copper-Dissolved	1	µg/L	<1
Iron-Dissolved	10	µg/L	24000
Lithium-Dissolved	1	µg/L	16
Mercury-Dissolved	0.05	µg/L	<0.05
Manganese-Dissolved	5	µg/L	1700
Nickel-Dissolved	1	µg/L	8
Lead-Dissolved	1	µg/L	<1
Selenium-Dissolved	1	µg/L	<1
Strontium-Dissolved	1	µg/L	30
Vanadium-Dissolved	1	µg/L	<1
Zinc-Dissolved	1	µg/L	20

Bore: GW104860	Property: 170 NIGHTINGALE RD
Bore Identification Information (NSW Real Time Water Data)	
Bore name	GW104860
Property	PIROVIC INVESTMENTS PTY LTD, 296 PHEASANTS NEST RD, PHEADANTS NEST, 2574 NSW
NSW licence number	10WA112038 (current)
Datum	GDA 94 Zone 56
Easting	282745
Northing	6206178
Elevation (mAHD)	NR
Purpose	Industrial
Bore Construction Details	
Drilling and construction records available	Yes
Date drilled/constructed	30/05/2003
Total depth of bore (m)	204.3
Geological Formation Screened	Sandstone/Quartz/Shale
Bore Casing	
Material	PVC Class 9, Steel
Diameter	PVC 140 mm OD, Steel 168 mm OD 158 mm ID
Stick-up	0.3 m
Hydrogeological info	
Screened lithology/formation	Sandstone/Quartz/Shale
Standing water level (mbgl)	81
Water quality	Salinity: 338 mg/L
Other bore log comments	Yield (L/s): 1.10
Data Collected While On Site	
Census Date	February 2022
Completed by	Chris Rotsider, Consulting Earth Scientists Pty Ltd
Photographs	

Bore Details

Bore: GW104860	Property: 170 NIGHTINGALE RD
Site Address	170 NIGHTINGALE RD, PHEASANTS NEST, 2574
GPS Location datum	GDA 94 Zone 56
Easting	282730
Northing	6206227
Elevation (mAHD) – specify survey method	NR
Drilling and construction records (Y/N)	Y
Stick-up (casing, monument etc.)	Concrete monument, metal casing stick up with metal cap
Total depth of bore (mbgl)	NR
Depth to water (mbgl)	NR
Pump status (if installed)	Pump installed but not operational
Logger status/condition (if installed). Serial no., make, model etc.	NA
Fencing/barrier installed?	No
Sampling method	No sample obtained as bore sealed shut
Electrical Conductivity (µS/cm)	NR
pH	NR
Temperature (°C)	NR
ORP (mV)	NR
Dissolved Oxygen (mg/L)	NR
Colour, odour, characteristics etc.	NR
Bore Pump Details (if relevant)	
Frequency of use	Not in use
Typical pumping rate	NR
Purpose / Use of Bore	Not in use
Comment:	
Metal well casing with rust but still in fair working order. Concrete base in good working order.	

WaterNSW
Work Summary

GW104860

Licence: 10WA112038

Licence Status: CURRENT

Authorised Purpose(s): INDUSTRIAL
Intended Purpose(s): INDUSTRIAL

Work Type: Bore
Work Status: Supply Obtained
Construct.Method: Rotary Air
Owner Type: Private

Commenced Date:
Completion Date: 30/05/2003

Final Depth: 204.30 m
Drilled Depth: 204.30 m

Contractor Name: INTERTEC DRILLING SERVICES
Driller: Colin Leslie Barden
Assistant Driller:

Property: PIROVIC INVESTMENTS PTY LTD 296 Pheasants Nest Rd PHEASENTS NEST 2574 NSW
GWMA: -
GW Zone: -

Standing Water Level (m): 81.000
Salinity Description:
Yield (L/s): 1.100

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CAMDEN	BARGO	511 1042242
Licensed:	CAMDEN	BARGO	Whole Lot 5//1214896

Region: 10 - Sydney South Coast
CMA Map: 9029-3N

River Basin: 212 - HAWKESBURY RIVER
Area/District:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: (Unknown)

Northing: 6206178.000
Easting: 282745.000

Latitude: 34°15'46.3"S
Longitude: 150°38'25.4"E

GS Map: -
MGA Zone: 56
Coordinate Source: Unknown

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	5.70	208			Down Hole Hammer
1		Hole	Hole	5.70	204.30	165			Down Hole Hammer
1	1	Casing	Steel	-0.30	5.70	168	158		Driven into Hole
1	1	Casing	Pvc Class 9	0.30	35.70	140			Suspended in Clamps, Screwed and Glued

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
91.00	96.30	5.30	Unknown			0.02	96.30		288.00
120.30	121.30	1.00	Unknown			0.02	126.30		550.00
130.30	131.30	1.00	Unknown			0.02	132.30		659.00
150.00	159.80	9.80	Unknown	81.00		1.10	162.30		365.00

193.00	194.00	1.00	Unknown			0.20	204.30		338.00

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.40	0.40	TOPSOIL	Topsoil	
0.40	8.30	7.90	SILTSTONE,FINE GRAIN	Siltstone	
8.30	34.30	26.00	SANDSTONE GREY BROWN SOFT	Sandstone	
34.30	41.30	7.00	QUARTZ	Quartz	
41.30	44.30	3.00	SANDSTONE LT/GREY	Sandstone	
44.30	47.80	3.50	QUARTZ	Quartz	
47.80	91.30	43.50	SANDSTONE GREY	Sandstone	
91.30	96.30	5.00	SANDSTONE QUARTZ (W)	Sandstone	
96.30	103.80	7.50	SANDSTONE GREY	Shale	
103.80	104.80	1.00	SHALE BLACK	Shale	
104.80	117.30	12.50	SANDSTONE GREY	Sandstone	
117.30	132.10	14.80	SANDSTONE & QUARTZ	Sandstone	
132.10	133.30	1.20	SHALE BLACK	Shale	
133.30	139.80	6.50	SANDSTONE GREY	Sandstone	
139.80	156.00	16.20	QUARTZ	Quartz	
156.00	175.80	19.80	SANDSTONE GREY AND QUARTZ	Sandstone	
175.80	179.00	3.20	QUARTZ	Quartz	
179.00	181.30	2.30	SANDSTONE GREY AND LT/GREY	Sandstone	
181.30	189.00	7.70	QUARTZ	Quartz	
189.00	204.00	15.00	SANDSTONE GREY/BROWN	Sandstone	
204.00	204.30	0.30	RED SHALE	Shale	

Remarks

11/04/2005: Previous Lic No: 10BL161834
05/11/2010: Karla Abbs, 5-Nov-2010; Update drillers log as required

***** End of GW104860 *****

Bore: GW105262	Property: Tahmoor South
Bore Identification Information (NSW Real Time Water Data)	
Bore name	GW105262
Property	JONES 5 Lupton Rd BARGO 2574 NSW
NSW licence number	10WA110736
NSW DNRME water licence number	NA
Datum	MGA Zone 56
Easting	278609
Northing	6200731
Elevation (mAHD)	NR
Purpose	Stock, Domestic
Bore Construction Details	
Drilling and construction records available	Yes
Date drilled/constructed	31/12/2001
Total depth of bore (m)	104.0
Geological Formation Screened	NR
Bore Casing	
Material	PVC Class 9
Diameter	140mm OD
Stick-up	NR
Hydrogeological info	
Screened lithology/formation	Sandstone
Standing water level (mbgl)	44.0
Water quality	NR
Other bore log comments	Yield (Ls): 0.56
Data Collected While On Site	
Census Date	28/01/2022
Completed by	Chris Rotsider, Consulting Earth Scientists Pty Ltd
Photographs (insert)	
	
Bore Details	
Site Address	10 Bayan Place, Bargo
GPS Location datum	GDA94 Zone 56
Easting	278611
Northing	6200745

Bore: GW105262	Property: Tahmoor South
Elevation (mAHD) – specify survey method	NR
Drilling and construction records (Y/N)	Y
Stick-up (casing, monument etc.)	Metal casing stick up with sealed metal cap
Total depth of bore (mbgl)	NA
Depth to water (mbgl)	NA
Pump status (if installed)	In-situ electric 6kv pump
Logger status/condition (if installed). Serial no., make, model etc.	NA
Fencing/barrier installed?	N
Sampling method	In-situ electric 6kV pump
Electrical Conductivity (µS/cm)	1828
pH	5.72
Temperature (°C)	17.9
ORP (mV)	55.6
Dissolved Oxygen (mg/L)	0.41
Colour, odour, characteristics etc.	No odour, no turbidity, no sign of contamination
Bore Pump Details (if relevant)	
Frequency of use	Infrequently used for crop irrigation.
Typical pumping rate	NA
Purpose / Use of Bore	NA
Comment:	
Current depth measurements were not achievable as the metal cap securing the bore was unmovable. Well depth and water level measurements can be taken from former data from 2001. Headworks for this monitoring well were encountered to be in a good working condition. This included concrete support with fracture and steal casing/cap.	

WaterNSW
Work Summary

GW105262

Licence: 10WA110736
Licence Status: CURRENT

Authorised Purpose(s): STOCK,DOMESTIC
Intended Purpose(s): STOCK, DOMESTIC

Work Type: Bore
Work Status:
Construct.Method: Rotary
Owner Type:

Commenced Date:
Completion Date: 31/12/2001
Final Depth: 104.00 m
Drilled Depth: 104.00 m

Contractor Name: Ultra Drilling
Driller: Alan Marcus Dodd
Assistant Driller:

Property: JONES 5 Lupton Rd BARGO 2574 NSW
GWMA: -
GW Zone: -
Standing Water Level (m): 44.000
Salinity Description: Good
Yield (L/s): 0.560

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CAMDEN	BARGO	3 847661
Licensed:	CAMDEN	BARGO	Whole Lot 3//847661

Region: 10 - Sydney South Coast
CMA Map: 9029-3N

River Basin: 212 - HAWKESBURY RIVER
Area/District:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: (Unknown)
Northing: 6200731.000
Easting: 278609.000
Latitude: 34°18'39.9"S
Longitude: 150°35'38.7"E

GS Map: -
MGA Zone: 56
Coordinate Source: Unknown

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	18.00	165			Down Hole Hammer
1		Hole	Hole	18.00	104.00	140			Down Hole Hammer
1	1	Casing	Pvc Class 9	0.30	18.00	140			Driven into Hole, Riveted and Glued

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
78.00	79.00	1.00	Unknown		80.00	0.18	80.00	01:00:00	
96.00	97.00	1.00	Unknown	44.00	104.00	0.56	104.00	01:00:00	

Drillers Log

From	To	Thickness	Drillers Description	Geological Material	Comments

(m)	(m)	(m)			
0.00	3.00	3.00	SOIL/BROWN SHALE	Soil	
3.00	13.00	10.00	SHALE GREY	Shale	
13.00	38.00	25.00	SANDSTONE	Sandstone	
38.00	41.00	3.00	SHALE	Shale	
41.00	48.00	7.00	SANDSTONE	Sandstone	
48.00	49.00	1.00	QUARTZITE	Quartzite	
49.00	104.00	55.00	SANDSTONE	Sandstone	

***** End of GW105262 *****

Site GW105262 Values at Time of Drilling

Measure	Data Type	Hole	Pipe	Date	Value
Groundwater depth below surface level (Metres)	Manual	1	1	31/12/2001 @ 12:00	44.000
Meter Discharge (Kilolitres/Day)	Manual	1	1	31/12/2001 @ 00:00	0.560

Parameter	LOR	Unit	5 Lupton Rd
Registered Number			GW105262
Date			28-01-2022
Calcium - Dissolved	0.5	mg/L	7.2
Potassium - Dissolved	0.5	mg/L	4
Sodium - Dissolved	0.5	mg/L	280
Magnesium - Dissolved	0.5	mg/L	73
Hardness	3	mg/L	320
Hydroxide Alkalinity (OH-) as CaCO3	5	mg/L	<5
Bicarbonate Alkalinity as CaCO3	5	mg/L	78
Carbonate Alkalinity as CaCO3	5	mg/L	<5
Total Alkalinity as CaCO3	5	mg/L	78
Sulphate SO4	1	mg/L	46
Chloride Cl	1	mg/L	680
Ionic Balance	-	%	-7
Total Nitrogen in Water	0.1	mg/L	<0.1
Phosphorus Total	0.05	mg/L	0.1
Aluminium-Total	10	µg/L	20
Arsenic-Total	1	µg/L	<1
Barium-Total	1	µg/L	810
Beryllium-Total	0.5	µg/L	7
Cadmium-Total	0.1	µg/L	<0.1
Chromium-Total	1	µg/L	22
Cobalt-Total	1	µg/L	120
Copper-Total	1	µg/L	10
Iron-Total	10	µg/L	45000
Lithium-Total	1	µg/L	56
Mercury-Total	0.05	µg/L	<0.05
Manganese-Total	5	µg/L	7100
Nickel-Total	1	µg/L	82
Lead-Total	1	µg/L	7
Selenium-Total	1	µg/L	<1
Strontium-Total	1	µg/L	110
Vanadium-Total	1	µg/L	3
Zinc-Total	1	µg/L	540
Aluminium-Dissolved	10	µg/L	<10
Arsenic-Dissolved	1	µg/L	<1
Barium-Dissolved	1	µg/L	200
Beryllium-Dissolved	0.5	µg/L	5
Cadmium-Dissolved	0.1	µg/L	<0.1
Chromium-Dissolved	1	µg/L	<1
Cobalt-Dissolved	1	µg/L	110
Copper-Dissolved	1	µg/L	<1
Iron-Dissolved	10	µg/L	36000
Lithium-Dissolved	1	µg/L	45
Mercury-Dissolved	0.05	µg/L	<0.05
Manganese-Dissolved	5	µg/L	6300
Nickel-Dissolved	1	µg/L	69
Lead-Dissolved	1	µg/L	<1
Selenium-Dissolved	1	µg/L	<1
Strontium-Dissolved	1	µg/L	96
Vanadium-Dissolved	1	µg/L	<1
Zinc-Dissolved	1	µg/L	260

Bore: GW105395	Property: 130 BARGO RD
Bore Identification Information (NSW Real Time Water Data)	
Bore name	GW105395
Property	WOODS 130 Bargo Rd BARGO 2574 NSW
NSW licence number	10WA111029 (current)
Datum	GDA 94 Zone 56
Easting	278543
Northing	6203037
Elevation (mAHD)	NR
Purpose	Stock, domestic
Bore Construction Details	
Drilling and construction records available	Yes
Date drilled/constructed	20/09/2003
Total depth of bore (m)	86
Geological Formation Screened	Sandstone/Shale
Bore Casing	
Material	Welded steel
Diameter	168 mm OD
Stick-up	NR
Hydrogeological info	
Screened lithology/formation	Sandstone/Shale
Standing water level (mbgl)	23
Water quality	Salinity: 600 mg/L
Other bore log comments	Yield (L/s): 2.0
Data Collected While On Site	
Census Date	01/02/2022
Completed by	Chris Rotsider, Consulting Earth Scientists Pty Ltd
Photographs	

Bore Details	
Site Address	130 BARGO RD, BARGO 2574 NSW
GPS Location datum	GDA 94 Zone 56
Easting	278547
Northing	6203033
Elevation (mAHD) – specify survey method	NR

Bore: GW105395	Property: 130 BARGO RD
Drilling and construction records (Y/N)	Y
Stick-up (casing, monument etc.)	Steel stick up with metal cap
Total depth of bore (mbgl)	53.1
Depth to water (mbgl)	0.5
Pump status (if installed)	In-situ electric pump
Logger status/condition (if installed). Serial no., make, model etc.	NA
Fencing/barrier installed?	No
Sampling method	Pump
Electrical Conductivity (µS/cm)	3342
pH	6.3
Temperature (°C)	19.1
ORP (mV)	22.7
Dissolved Oxygen (mg/L)	3.13
Colour, odour, characteristics etc.	Faint organic odour, low turbidity
Bore Pump Details (if relevant)	
Frequency of use	Not currently used
Typical pumping rate	NA
Purpose / Use of Bore	Previous use to fill dam, but not used lately since water quality too low for use
Comment:	
Metal well head in good condition. Water removed: 1 l Recovery time: 1 min 20 s	

WaterNSW
Work Summary

GW105395

Licence: 10WA111029

Licence Status: CURRENT

Authorised Purpose(s): STOCK,DOMESTIC
Intended Purpose(s): STOCK, DOMESTIC

Work Type: Bore
Work Status:
Construct.Method: Rotary
Owner Type:

Commenced Date:
Completion Date: 20/09/2003

Final Depth: 90.00 m
Drilled Depth: 90.00 m

Contractor Name: HIGHLAND DRILLING PTY LTD
Driller: Brett Delamont
Assistant Driller:

Property: WOODS 130 Bargo Rd BARGO 2574 NSW
GWMA: -
GW Zone: -

Standing Water Level (m): 23.000
Salinity Description:
Yield (L/s): 3.000

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CAMDEN	BARGO	1 212216
Licensed:	CAMDEN	BARGO	Whole Lot 1//212216

Region: 10 - Sydney South Coast
River Basin: - Unknown
Area/District:

CMA Map:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown

Northing: 6203037.000
Easting: 278543.000

Latitude: 34°17'25.0"S
Longitude: 150°35'38.3"E

GS Map: -
MGA Zone: 56
Coordinate Source: Unknown

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	90.00	200			Down Hole Hammer
1	1	Casing	Steel	0.00	18.00	168			Other, Welded

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
9.00	10.00	1.00	Unknown	23.00		3.00	12.00		1920.00
47.00	48.00	1.00	Unknown			2.00	50.00		1530.00
83.00	84.00	1.00	Unknown			2.00	86.00		600.00

Drillers Log

From	To	Thickness	Drillers Description	Geological Material	Comments

(m)	(m)	(m)			
0.00	1.00	1.00	TOPSOIL	Topsoil	
1.00	21.00	20.00	SANDSTONE	Sandstone	
21.00	21.50	0.50	SHALE	Shale	
21.50	61.50	40.00	SANDSTONE	Sandstone	
61.50	63.00	1.50	SHALE	Shale	
63.00	90.00	27.00	SANDSTONE	Sandstone	

***** End of GW105395 *****

Parameter	LOR	Unit	130 Bargo Rd
Registered Number			GW105395
Date			01-02-2022
Calcium - Dissolved	0.5	mg/L	12
Potassium - Dissolved	0.5	mg/L	10
Sodium - Dissolved	0.5	mg/L	620
Magnesium - Dissolved	0.5	mg/L	130
Hardness	3	mg/L	570
Hydroxide Alkalinity (OH-) as CaCO3	5	mg/L	<5
Bicarbonate Alkalinity as CaCO3	5	mg/L	130
Carbonate Alkalinity as CaCO3	5	mg/L	<5
Total Alkalinity as CaCO3	5	mg/L	130
Sulphate SO4	1	mg/L	75
Chloride Cl	1	mg/L	1300
Ionic Balance	-	%	-1
Total Nitrogen in Water	0.1	mg/L	0.2
Phosphorus Total	0.05	mg/L	0.07
Aluminium-Total	10	µg/L	90
Arsenic-Total	1	µg/L	3
Barium-Total	1	µg/L	110
Beryllium-Total	0.5	µg/L	3
Cadmium-Total	0.1	µg/L	0.2
Chromium-Total	1	µg/L	<1
Cobalt-Total	1	µg/L	210
Copper-Total	1	µg/L	540
Iron-Total	10	µg/L	91000
Lithium-Total	1	µg/L	110
Mercury-Total	0.05	µg/L	<0.05
Manganese-Total	5	µg/L	2900
Nickel-Total	1	µg/L	250
Lead-Total	1	µg/L	21
Selenium-Total	1	µg/L	<1
Strontium-Total	1	µg/L	240
Vanadium-Total	1	µg/L	<1
Zinc-Total	1	µg/L	680
Aluminium-Dissolved	10	µg/L	10
Arsenic-Dissolved	1	µg/L	<1
Barium-Dissolved	1	µg/L	73
Beryllium-Dissolved	0.5	µg/L	0.5
Cadmium-Dissolved	0.1	µg/L	<0.1
Chromium-Dissolved	1	µg/L	<1
Cobalt-Dissolved	1	µg/L	85
Copper-Dissolved	1	µg/L	<1
Iron-Dissolved	10	µg/L	40000
Lithium-Dissolved	1	µg/L	94
Mercury-Dissolved	0.05	µg/L	<0.05
Manganese-Dissolved	5	µg/L	2000
Nickel-Dissolved	1	µg/L	87
Lead-Dissolved	1	µg/L	<1
Selenium-Dissolved	1	µg/L	<1
Strontium-Dissolved	1	µg/L	200
Vanadium-Dissolved	1	µg/L	<1
Zinc-Dissolved	1	µg/L	98

Bore: GW105803	Property: 110 MOCKINGBIRD RD
Bore Identification Information (NSW Real Time Water Data)	
Bore name	GW105803
Property	Not listed
NSW licence number	10WA110819 (current)
Datum	GDA 94 Zone 56
Easting	282278
Northing	6204644
Elevation (mAHD)	NR
Purpose	Stock, domestic
Bore Construction Details	
Drilling and construction records available	Yes
Date drilled/constructed	20/08/2002
Total depth of bore (m)	140
Geological Formation Screened	Sandstone
Bore Casing	
Material	PVC Class 9
Diameter	140 mm OD
Stick-up	0.3 m
Hydrogeological info	
Screened lithology/formation	Sandstone
Standing water level (mbgl)	29
Water quality	NR
Other bore log comments	
Data Collected While On Site	
Census Date	03/02/2022
Completed by	Chris Rotsider, Consulting Earth Scientists Pty Ltd
Photographs	

Bore Details	
Site Address	110 MOCKINGBIRD RD, PHEASANTS NEST, NSW 2574
GPS Location datum	GDA 94 Zone 56
Easting	281965
Northing	6204772
Elevation (mAHD) – specify survey method	NR
Drilling and construction records (Y/N)	Y
Stick-up (casing, monument etc.)	Steel stick up with metal cap

Bore: GW105803	Property: 110 MOCKINGBIRD RD
Total depth of bore (mbgl)	80 m (anecdotal, not measured)
Depth to water (mbgl)	17.05
Pump status (if installed)	In situ electric pump not currently operational
Logger status/condition (if installed). Serial no., make, model etc.	NA
Fencing/barrier installed?	No
Sampling method	Bailer
Electrical Conductivity (µS/cm)	1108
pH	5.9
Temperature (°C)	17.2
ORP (mV)	74.3
Dissolved Oxygen (mg/L)	3.03
Colour, odour, characteristics etc.	Light rusty colour, no odour, low turbidity
Bore Pump Details (if relevant)	
Frequency of use	Not currently used
Typical pumping rate	NA
Purpose / Use of Bore	Used in past for small scale poultry production
Comment:	
Headworks in good working order with connection with PVC piping	

WaterNSW
Work Summary

GW105803

Licence: 10WA110819

Licence Status: CURRENT

Authorised Purpose(s): STOCK,DOMESTIC
Intended Purpose(s): STOCK, DOMESTIC

Work Type: Bore
Work Status: Supply Obtained
Construct.Method: Down Hole Hamm
Owner Type: Private

Commenced Date:
Completion Date: 20/08/2002

Final Depth: 140.00 m
Drilled Depth: 140.00 m

Contractor Name: Ultra Drilling
Driller: Bradley Alan Dodd
Assistant Driller:

Property: N/A NSW

Standing Water Level (m): 29.000

GWMA: -
GW Zone: -

Salinity Description:
Yield (L/s): 2.300

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CAMDEN	BARGO	25//255689
Licensed:	CAMDEN	BARGO	Whole Lot 25//255689

Region: 10 - Sydney South Coast
CMA Map: 9029-3N

River Basin: 212 - HAWKESBURY RIVER
Area/District:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: (Unknown)

Northing: 6204644.000
Easting: 282278.000

Latitude: 34°16'35.7"S
Longitude: 150°38'05.7"E

GS Map: -
MGA Zone: 56
Coordinate Source: GIS - Geogra

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	24.00	165			Down Hole Hammer
1		Hole	Hole	24.00	140.00	140			Down Hole Hammer
1	1	Casing	Pvc Class 9	-0.30	24.00	140			Driven into Hole, Riveted and Glued

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
42.00	43.00	1.00	Unknown			0.05		01:00:00	
133.00	134.00	1.00	Unknown	29.00		1.80		01:00:00	

Drillers Log

From	To	Thickness	Drillers Description	Geological Material	Comments

(m)	(m)	(m)			
0.00	3.00	3.00	CLAY	Clay	
3.00	21.00	18.00	SHALE	Shale	
21.00	115.00	94.00	SANDSTONE, SHALE SEAMS	Sandstone	
115.00	140.00	25.00	SANDSTONE, QUARTZ	Sandstone	

Remarks

16/11/2009: updated from original form A

***** End of GW105803 *****

Parameter	LOR	Unit	Mockingbird Rd
Registered Number			GW105803
Date			02-02-2022
Calcium - Dissolved	0.5	mg/L	15
Potassium - Dissolved	0.5	mg/L	5.7
Sodium - Dissolved	0.5	mg/L	200
Magnesium - Dissolved	0.5	mg/L	46
Hardness	3	mg/L	220
Hydroxide Alkalinity (OH-) as CaCO3	5	mg/L	<5
Bicarbonate Alkalinity as CaCO3	5	mg/L	55
Carbonate Alkalinity as CaCO3	5	mg/L	<5
Total Alkalinity as CaCO3	5	mg/L	55
Sulphate SO4	1	mg/L	18
Chloride Cl	1	mg/L	450
Ionic Balance	-	%	-3
Total Nitrogen in Water	0.1	mg/L	1.3
Phosphorus Total	0.05	mg/L	0.4
Aluminium-Total	10	µg/L	60
Arsenic-Total	1	µg/L	1
Barium-Total	1	µg/L	72
Beryllium-Total	0.5	µg/L	4
Cadmium-Total	0.1	µg/L	0.1
Chromium-Total	1	µg/L	<1
Cobalt-Total	1	µg/L	15
Copper-Total	1	µg/L	3
Iron-Total	10	µg/L	22000
Lithium-Total	1	µg/L	26
Mercury-Total	0.05	µg/L	<0.05
Manganese-Total	5	µg/L	950
Nickel-Total	1	µg/L	19
Lead-Total	1	µg/L	2
Selenium-Total	1	µg/L	<1
Strontium-Total	1	µg/L	90
Vanadium-Total	1	µg/L	<1
Zinc-Total	1	µg/L	3700
Aluminium-Dissolved	10	µg/L	<10
Arsenic-Dissolved	1	µg/L	<1
Barium-Dissolved	1	µg/L	76
Beryllium-Dissolved	0.5	µg/L	<0.5
Cadmium-Dissolved	0.1	µg/L	<0.1
Chromium-Dissolved	1	µg/L	<1
Cobalt-Dissolved	1	µg/L	17
Copper-Dissolved	1	µg/L	<1
Iron-Dissolved	10	µg/L	<10
Lithium-Dissolved	1	µg/L	35
Mercury-Dissolved	0.05	µg/L	<0.05
Manganese-Dissolved	5	µg/L	1100
Nickel-Dissolved	1	µg/L	18
Lead-Dissolved	1	µg/L	<1
Selenium-Dissolved	1	µg/L	<1
Strontium-Dissolved	1	µg/L	100
Vanadium-Dissolved	1	µg/L	<1
Zinc-Dissolved	1	µg/L	3000

Bore: GW105883	Property: 60 GREAT SOUTHERN RD
Bore Identification Information (NSW Real Time Water Data)	
Bore name	GW105883
Property	Not listed
NSW licence number	10WA110852 (Current)
Datum	GDA 94 Zone 56
Easting	277040
Northing	6204629
Elevation (mAHD)	NR
Purpose	Domestic
Bore Construction Details	
Drilling and construction records available	No
Date drilled/constructed	09/05/2005
Total depth of bore (m)	NR
Geological Formation Screened	NR
Bore Casing	
Material	NR
Diameter	NR
Stick-up	NR
Hydrogeological info	
Screened lithology/formation	NR
Standing water level (mbgl)	NR
Water quality	NR
Other bore log comments	NR

Data Collected While On Site	
Census Date	February 2022
Completed by	Chris Rotsider, Consulting Earth Scientists Pty Ltd
Photographs	

Bore Details	
Site Address	60 GREAT SOUTHERN RD, BARGO, 2574 NSW
GPS Location datum	GDA 94 Zone 56
Easting	275176
Northing	6204523

Bore: GW105883	Property: 60 GREAT SOUTHERN RD
Elevation (mAHD) – specify survey method	NR
Drilling and construction records (Y/N)	N
Stick-up (casing, monument etc.)	PVC stick up with metal cap
Total depth of bore (mbgl)	NR (no access for depth measuring equipment)
Depth to water (mbgl)	NR (no access for depth measuring equipment)
Pump status (if installed)	In situ electric Grundfos pump
Logger status/condition (if installed). Serial no., make, model etc.	NA
Fencing/barrier installed?	No
Sampling method	In situ pump, 25 l water purged
Electrical Conductivity (µS/cm)	1686
pH	6.3
Temperature (°C)	18.5
ORP (mV)	-9.0
Dissolved Oxygen (mg/L)	0.83
Colour, odour, characteristics etc.	Clear, no odour, low turbidity
Bore Pump Details (if relevant)	
Frequency of use	NR
Typical pumping rate	NR
Purpose / Use of Bore	Used as a water feature filling adjacent pond and garden irrigation
Comment:	
PVC casing in good working order.	

WaterNSW
Work Summary

GW105883

Licence: 10WA110852

Licence Status: CURRENT

Authorised Purpose(s): DOMESTIC
Intended Purpose(s):

Work Type: Bore
Work Status:
Construct.Method:
Owner Type:

Commenced Date:
Completion Date: 09/05/2005

Final Depth:
Drilled Depth:

Contractor Name: (None)
Driller:
Assistant Driller:

Property: N/A NSW

GWMA: -
GW Zone: -

Standing Water Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CAMDEN	BARGO	3 9803
Licensed:	CAMDEN	BARGO	Whole Lot 3//9803

Region: 10 - Sydney South Coast

CMA Map: 9029-3N

River Basin: 212 - HAWKESBURY RIVER
Area/District:

Grid Zone:

Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: (Unknown)

Northing: 6204629.000
Easting: 277040.000

Latitude: 34°16'32.2"S
Longitude: 150°34'41.0"E

GS Map: -

MGA Zone: 56

Coordinate Source: Unknown

***** End of GW105883 *****

Parameter	LOR	Unit	60 Great Sourthern Rd
Registered Number			GW105883
Date			15-02-2022
Calcium - Dissolved	0.5	mg/L	13
Potassium - Dissolved	0.5	mg/L	4
Sodium - Dissolved	0.5	mg/L	280
Magnesium - Dissolved	0.5	mg/L	61
Hardness	3	mg/L	280
Hydroxide Alkalinity (OH-) as CaCO3	5	mg/L	<5
Bicarbonate Alkalinity as CaCO3	5	mg/L	78
Carbonate Alkalinity as CaCO3	5	mg/L	<5
Total Alkalinity as CaCO3	5	mg/L	78
Sulphate SO4	1	mg/L	32
Chloride Cl	1	mg/L	600
Ionic Balance	-	%	-3
Total Nitrogen in Water	0.1	mg/L	<0.1
Phosphorus Total	0.05	mg/L	<0.05
Aluminium-Total	10	µg/L	<10
Arsenic-Total	1	µg/L	<10
Barium-Total	1	µg/L	<1
Beryllium-Total	0.5	µg/L	190
Cadmium-Total	0.1	µg/L	13
Chromium-Total	1	µg/L	<1
Cobalt-Total	1	µg/L	33000
Copper-Total	1	µg/L	52
Iron-Total	10	µg/L	33000
Lithium-Total	1	µg/L	52
Mercury-Total	0.05	µg/L	2200
Manganese-Total	5	µg/L	13
Nickel-Total	1	µg/L	<1
Lead-Total	1	µg/L	3
Selenium-Total	1	µg/L	3
Strontium-Total	1	µg/L	140
Vanadium-Total	1	µg/L	140
Zinc-Total	1	µg/L	41
Aluminium-Dissolved	10	µg/L	<10
Arsenic-Dissolved	1	µg/L	<10
Barium-Dissolved	1	µg/L	<1
Beryllium-Dissolved	0.5	µg/L	200
Cadmium-Dissolved	0.1	µg/L	12
Chromium-Dissolved	1	µg/L	<1
Cobalt-Dissolved	1	µg/L	53
Copper-Dissolved	1	µg/L	2400
Iron-Dissolved	10	µg/L	28000
Lithium-Dissolved	1	µg/L	53
Mercury-Dissolved	0.05	µg/L	15
Manganese-Dissolved	5	µg/L	<1
Nickel-Dissolved	1	µg/L	<1
Lead-Dissolved	1	µg/L	150
Selenium-Dissolved	1	µg/L	<1
Strontium-Dissolved	1	µg/L	150
Vanadium-Dissolved	1	µg/L	44
Zinc-Dissolved	1	µg/L	28000

Bore: GW106546	Property: 304 PHEASANTS RD
Bore Identification Information (NSW Real Time Water Data)	
Bore name	GW106546
Property	Not listed
NSW licence number	10WA110902 (current)
Datum	GDA 94 Zone 56
Easting	282785
Northing	6206765
Elevation (mAHD)	NR
Purpose	Stock, domestic
Bore Construction Details	
Drilling and construction records available	Yes
Date drilled/constructed	13/11/2002
Total depth of bore (m)	116
Geological Formation Screened	Sandstone/Shale
Bore Casing	
Material	PVC Class 9, Steel
Diameter	PVC 168 mm OD, Steel 140 mm OD
Stick-up	0.3 m
Hydrogeological info	
Screened lithology/formation	Sandstone/Shale
Standing water level (mbgl)	49
Water quality	NR
Other bore log comments	Yield (L/s): 0.68
Data Collected While On Site	
Census Date	25/02/ 2022
Completed by	Chris Rotsider, Consulting Earth Scientists Pty Ltd
Photographs	

Bore Details	
Site Address	304 PHEASANTS RD, PHEASANTS NEST, 2574
GPS Location datum	GDA 94 Zone 56
Easting	282876

Bore: GW106546	Property: 304 PHEASANTS RD
Northing	6206650
Elevation (mAHD) – specify survey method	NR
Drilling and construction records (Y/N)	Y
Stick-up (casing, monument etc.)	Metal casing stick up with steel cap
Total depth of bore (mbgl)	63.63 (likely blockage as installed to 116 m)
Depth to water (mbgl)	41.67
Pump status (if installed)	In situ electric pump
Logger status/condition (if installed). Serial no., make, model etc.	NA
Fencing/barrier installed?	No
Sampling method	In situ pump, 15 l water purged
Electrical Conductivity (µS/cm)	NR
pH	6.5
Temperature (°C)	18.4
ORP (mV)	-30.7
Dissolved Oxygen (mg/L)	1.38
Colour, odour, characteristics etc.	Orange, no odour, moderate turbidity
Bore Pump Details (if relevant)	
Frequency of use	Once per week
Typical pumping rate	NR
Purpose / Use of Bore	Stock watering (cattle)
Comment:	
Metal well casing with some surface rust but still in fair/good working order. Plumbed into irrigation system. Discharged out of adjacent valve used for sampling. Discharge duration: 10 min Recharge time: <4 min	

WaterNSW
Work Summary

GW106546

Licence: 10WA110902

Licence Status: CURRENT

Authorised Purpose(s): STOCK,DOMESTIC
Intended Purpose(s): STOCK, DOMESTIC

Work Type: Bore
Work Status: Supply Obtained
Construct.Method: Down Hole Hamm
Owner Type: Private

Commenced Date:
Completion Date: 13/11/2002

Final Depth: 116.00 m
Drilled Depth: 116.00 m

Contractor Name: Ultra Drilling
Driller: Bradley Alan Dodd
Assistant Driller:

Property: N/A NSW

GWMA: -
GW Zone: -

Standing Water Level (m): 49.000
Salinity Description: Good
Yield (L/s): 0.710

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CAMDEN	BARGO	5311 881038
Licensed:	CAMDEN	BARGO	Whole Lot 5311//881038

Region: 10 - Sydney South Coast

CMA Map: 9029-3N

River Basin: 212 - HAWKESBURY RIVER
Area/District:

Grid Zone:

Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: (Unknown)

Northing: 6206765.000
Easting: 282785.000

Latitude: 34°15'27.3"S
Longitude: 150°38'27.5"E

GS Map: -

MGA Zone: 56

Coordinate Source: GIS - Geogra

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	18.00	171			Down Hole Hammer
1		Hole	Hole	18.00	116.00	140			Down Hole Hammer
1	1	Casing	Pvc Class 9	-0.30	18.00	140			Driven into Hole, Glued
1	1	Casing	Steel	-0.30	2.00	168			Driven into Hole, Glued

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
73.00	74.00	1.00	Unknown			0.30		01:00:00	
110.00	111.00	1.00	Unknown	49.00		0.68		01:00:00	

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	2.00	2.00	clay, dirt	Clay	
2.00	17.00	15.00	shale	Shale	
17.00	91.00	74.00	sandstone	Sandstone	
91.00	103.00	12.00	shale	Shale	
103.00	116.00	13.00	sandstone, shale	Sandstone	

Remarks

15/01/2010: updated from originl form A

***** End of GW106546 *****

Parameter	LOR	Unit	304 Pheasants Rd
Registered Number			GW106546
Date			25-02-2022
Calcium - Dissolved	0.5	mg/L	14
Potassium - Dissolved	0.5	mg/L	9.4
Sodium - Dissolved	0.5	mg/L	390
Magnesium - Dissolved	0.5	mg/L	87
Hardness	3	mg/L	390
Hydroxide Alkalinity (OH-) as CaCO3	5	mg/L	<5
Bicarbonate Alkalinity as CaCO3	5	mg/L	120
Carbonate Alkalinity as CaCO3	5	mg/L	<5
Total Alkalinity as CaCO3	5	mg/L	120
Sulphate SO4	1	mg/L	69
Chloride Cl	1	mg/L	750
Ionic Balance	-	%	0
Total Nitrogen in Water	0.1	mg/L	<0.1
Phosphorus Total	0.05	mg/L	0.8
Aluminium-Total	10	µg/L	30
Arsenic-Total	1	µg/L	1
Barium-Total	1	µg/L	92
Beryllium-Total	0.5	µg/L	
Cadmium-Total	0.1	µg/L	
Chromium-Total	1	µg/L	
Cobalt-Total	1	µg/L	5
Copper-Total	1	µg/L	4
Iron-Total	10	µg/L	39000
Lithium-Total	1	µg/L	92
Mercury-Total	0.05	µg/L	
Manganese-Total	5	µg/L	1400
Nickel-Total	1	µg/L	8
Lead-Total	1	µg/L	<1
Selenium-Total	1	µg/L	<1
Strontium-Total	1	µg/L	330
Vanadium-Total	1	µg/L	
Zinc-Total	1	µg/L	47
Aluminium-Dissolved	10	µg/L	<10
Arsenic-Dissolved	1	µg/L	<1
Barium-Dissolved	1	µg/L	67
Beryllium-Dissolved	0.5	µg/L	
Cadmium-Dissolved	0.1	µg/L	
Chromium-Dissolved	1	µg/L	
Cobalt-Dissolved	1	µg/L	3
Copper-Dissolved	1	µg/L	<1
Iron-Dissolved	10	µg/L	79
Lithium-Dissolved	1	µg/L	1000
Mercury-Dissolved	0.05	µg/L	
Manganese-Dissolved	5	µg/L	5
Nickel-Dissolved	1	µg/L	<1
Lead-Dissolved	1	µg/L	<1
Selenium-Dissolved	1	µg/L	220
Strontium-Dissolved	1	µg/L	27
Vanadium-Dissolved	1	µg/L	
Zinc-Dissolved	1	µg/L	<10

Bore: GW109257	Property: 3210 REMEMBRANCE DRIVEWAY
Bore Identification Information (NSW Real Time Water Data)	
Bore name	GW109257
Property	3210 REMEMBRANCE DR, BARGO 2574 NSW
NSW licence number	10WA111194 (current)
Datum	GDA 94 Zone 56
Easting	276603
Northing	6205052
Elevation (mAHD)	NR
Purpose	Stock, domestic
Bore Construction Details	
Drilling and construction records available	No
Date drilled/constructed	21/08/2008
Total depth of bore (m)	120
Geological Formation Screened	NR
Bore Casing	
Material	NR
Diameter	NR
Stick-up	NR
Hydrogeological info	
Screened lithology/formation	Sandstone
Standing water level (mbgl)	NR
Water quality	NR
Other bore log comments	Yield (L/s): 2.50
Data Collected While On Site	
Census Date	28/02/2022
Completed by	Chris Rotsider, Consulting Earth Scientists Pty Ltd
Photographs	
	
Bore Details	
Site Address	3210 REMEMBRANCE DR, BARGO 2574, NSW
GPS Location datum	GDA 94 Zone 56
Easting	276604

Bore: GW109257	Property: 3210 REMEMBRANCE DRIVEWAY
Northing	6205057
Elevation (mAHD) – specify survey method	NR
Drilling and construction records (Y/N)	N
Stick-up (casing, monument etc.)	PVC stick up with no cap
Total depth of bore (mbgl)	Not measured
Depth to water (mbgl)	37.06
Pump status (if installed)	No pump currently installed
Logger status/condition (if installed). Serial no., make, model etc.	NA
Fencing/barrier installed?	No
Sampling method	Micro-purging, 17 l water purged
Electrical Conductivity (µS/cm)	NR
pH	5.5
Temperature (°C)	18.0
ORP (mV)	201.0
Dissolved Oxygen (mg/L)	9.90
Colour, odour, characteristics etc.	Clear, earthy odour, low turbidity
Bore Pump Details (if relevant)	
Frequency of use	Not used for the last 2 years
Typical pumping rate	NR
Purpose / Use of Bore	Previously used to fill site dam
Comment:	
PVC casing is good working condition Pumping time: 15 min Recharge time: >10 min	

WaterNSW
Work Summary

GW109257

Licence: 10WA111194

Licence Status: CURRENT

Authorised Purpose(s): STOCK,DOMESTIC
Intended Purpose(s): STOCK, DOMESTIC

Work Type: Bore
Work Status:
Construct.Method:
Owner Type: Private

Commenced Date:
Completion Date: 21/08/2008

Final Depth: 120.00 m
Drilled Depth:

Contractor Name: JH ISELT PTY LTD
Driller: John Hans Iselt
Assistant Driller:

Property: DEN 3210 Rememberance Dr BARGO 2574 NSW
GWMA: -
GW Zone: -

Standing Water Level (m): 54.000
Salinity Description:
Yield (L/s): 2.500

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CAMDEN	BARGO	11 130182
Licensed:	CAMDEN	BARGO	Whole Lot 11//130182

Region: 10 - Sydney South Coast
River Basin: - Unknown
Area/District:

CMA Map:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown

Northing: 6205052.000
Easting: 276603.000

Latitude: 34°16'18.2"S
Longitude: 150°34'24.4"E

GS Map: -
MGA Zone: 56
Coordinate Source: Unknown

Remarks

21/08/2008: Previous Lic No:10BL154262

***** End of GW109257 *****

Parameter	LOR	Unit	3210 Remembrance Dvwy
Registered Number			GW109257
Date			28-02-2022
Calcium - Dissolved	0.5	mg/L	2
Potassium - Dissolved	0.5	mg/L	1
Sodium - Dissolved	0.5	mg/L	110
Magnesium - Dissolved	0.5	mg/L	20
Hardness	3	mg/L	88
Hydroxide Alkalinity (OH-) as CaCO3	5	mg/L	<5
Bicarbonate Alkalinity as CaCO3	5	mg/L	<5
Carbonate Alkalinity as CaCO3	5	mg/L	<5
Total Alkalinity as CaCO3	5	mg/L	<5
Sulphate SO4	1	mg/L	2
Chloride Cl	1	mg/L	220
Ionic Balance	-	%	2
Total Nitrogen in Water	0.1	mg/L	0.1
Phosphorus Total	0.05	mg/L	<0.05
Aluminium-Total	10	µg/L	450
Arsenic-Total	1	µg/L	<1
Barium-Total	1	µg/L	210
Beryllium-Total	0.5	µg/L	
Cadmium-Total	0.1	µg/L	
Chromium-Total	1	µg/L	
Cobalt-Total	1	µg/L	38
Copper-Total	1	µg/L	18
Iron-Total	10	µg/L	2800
Lithium-Total	1	µg/L	8
Mercury-Total	0.05	µg/L	
Manganese-Total	5	µg/L	1100
Nickel-Total	1	µg/L	26
Lead-Total	1	µg/L	3
Selenium-Total	1	µg/L	<1
Strontium-Total	1	µg/L	30
Vanadium-Total	1	µg/L	
Zinc-Total	1	µg/L	340
Aluminium-Dissolved	10	µg/L	350
Arsenic-Dissolved	1	µg/L	<1
Barium-Dissolved	1	µg/L	190
Beryllium-Dissolved	0.5	µg/L	
Cadmium-Dissolved	0.1	µg/L	
Chromium-Dissolved	1	µg/L	
Cobalt-Dissolved	1	µg/L	37
Copper-Dissolved	1	µg/L	17
Iron-Dissolved	10	µg/L	130
Lithium-Dissolved	1	µg/L	7
Mercury-Dissolved	0.05	µg/L	
Manganese-Dissolved	5	µg/L	1000
Nickel-Dissolved	1	µg/L	27
Lead-Dissolved	1	µg/L	1
Selenium-Dissolved	1	µg/L	1
Strontium-Dissolved	1	µg/L	30
Vanadium-Dissolved	1	µg/L	
Zinc-Dissolved	1	µg/L	320

Bore: GW110669	Property: 45 JUNBURRA PL
Bore Identification Information (NSW Real Time Water Data)	
Bore name	GW110669
Property	SALIBA 45 JUMBUNNA PLACE BUXTON 2571 NSW
NSW licence number	10WA111534 (current)
Datum	GDA 94 Zone 56
Easting	274565
Northing	6207896
Elevation (mAHD)	NR
Purpose	Stock, domestic
Bore Construction Details	
Drilling and construction records available	Yes
Date drilled/constructed	29/01/2010
Total depth of bore (m)	98
Geological Formation Screened	Sandstone
Bore Casing	
Material	PVC Class 9, PVC Class 12
Diameter	PVC Class 9 60 mm OD, PVC Class 12 60 mm OD
Stick-up	NR
Hydrogeological info	
Screened lithology/formation	Sandstone
Standing water level (mbgl)	66
Water quality	Salinity: 300 mg/L
Other bore log comments	Yield (L/s): 0.60
Data Collected While On Site	
Census Date	11/02/2022
Completed by	Chris Rotsider, Consulting Earth Scientists Pty Ltd
Photographs	

Bore: GW110669	Property: 45 JUNBURRA PL
Bore Details	
Site Address	45 JUMBUNNA PLACE, BUXTON, 2571 NSW
GPS Location datum	GDA 94 Zone 56
Easting	274570
Northing	6207928
Elevation (mAHD) – specify survey method	NR
Drilling and construction records (Y/N)	Y
Stick-up (casing, monument etc.)	PVC stick up with metal cap
Total depth of bore (mbgl)	Not measured, 111 m install depth noted on well
Depth to water (mbgl)	NR
Pump status (if installed)	In-situ electric pump SD2-20 Southern cross with 1.8m^3/hr flow capacity
Logger status/condition (if installed). Serial no., make, model etc.	NA
Fencing/barrier installed?	No
Sampling method	Pump, 5 l water purged
Electrical Conductivity (µS/cm)	677
pH	6.5
Temperature (°C)	18.5
ORP (mV)	21.3
Dissolved Oxygen (mg/L)	0.76
Colour, odour, characteristics etc.	Red coloured, earthy odour, moderate turbidity
Bore Pump Details (if relevant)	
Frequency of use	When required to fill dam (has not occurred for at least 1 year)
Typical pumping rate	NR
Purpose / Use of Bore	To fill dam
Comment:	
PVC with steal cap in good working order. Plumbed directly into dam filling piping.	

WaterNSW
Work Summary

GW110669

Licence: 10WA111534

Licence Status: CURRENT

Authorised Purpose(s): DOMESTIC,STOCK
Intended Purpose(s): STOCK, DOMESTIC

Work Type: Bore
Work Status:
Construct.Method: Rotary Air
Owner Type: Private

Commenced Date:
Completion Date: 29/01/2010

Final Depth: 132.00 m
Drilled Depth: 132.00 m

Contractor Name: Britt's Water Solutions
Driller: Darren James Britt
Assistant Driller:

Property: SALIBA 45 JUMBUNNA PLACE BUXTON 2571 NSW
GWMA: -
GW Zone: -

Standing Water Level (m): 66.000
Salinity Description:
Yield (L/s): 0.600

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CAMDEN	COURIDJAH	3//746989
Licensed:	CAMDEN	COURIDJAH	Whole Lot 3//746989

Region: 10 - Sydney South Coast
CMA Map:
River Basin: - Unknown
Area/District:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown
Northing: 6207896.000
Easting: 274565.000
Latitude: 34°14'44.3"S
Longitude: 150°33'07.4"E

GS Map: -
MGA Zone: 56
Coordinate Source: Unknown

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	36.00	200			Rotary Air
1		Hole	Hole	36.00	132.00	159			Rotary Air
1	1	Casing	Pvc Class 9	-0.30	33.00	60			Driven into Hole, Glued
1	1	Casing	Pvc Class 12	33.00	39.00	60			

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
108.00	108.10	0.10	Unknown	66.00		0.15			300.00
114.00	114.20	0.20	Unknown			0.45			
120.00	120.30	0.30	Unknown			0.60		01:00:00	

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.10	0.10	TOPSOIL	Topsoil	
0.10	2.00	1.90	WEATHERED SHALE	Shale	
2.00	34.00	32.00	COLOURED SANDSTONE	Sandstone	
34.00	132.00	98.00	WHITE SANDSTONE	Sandstone	

***** End of GW110669 *****

Parameter	LOR	Unit	45 Junburra Pl
Registered Number			GW110669
Date			11-02-2022
Calcium - Dissolved	0.5	mg/L	1
Potassium - Dissolved	0.5	mg/L	1
Sodium - Dissolved	0.5	mg/L	44
Magnesium - Dissolved	0.5	mg/L	8.2
Hardness	3	mg/L	37
Hydroxide Alkalinity (OH-) as CaCO3	5	mg/L	<5
Bicarbonate Alkalinity as CaCO3	5	mg/L	42
Carbonate Alkalinity as CaCO3	5	mg/L	<5
Total Alkalinity as CaCO3	5	mg/L	42
Sulphate SO4	1	mg/L	6
Chloride Cl	1	mg/L	100
Ionic Balance	-	%	-18
Total Nitrogen in Water	0.1	mg/L	0.5
Phosphorus Total	0.05	mg/L	20
Aluminium-Total	10	µg/L	430
Arsenic-Total	1	µg/L	430
Barium-Total	1	µg/L	16
Beryllium-Total	0.5	µg/L	130
Cadmium-Total	0.1	µg/L	18
Chromium-Total	1	µg/L	<1
Cobalt-Total	1	µg/L	290000
Copper-Total	1	µg/L	5
Iron-Total	10	µg/L	290000
Lithium-Total	1	µg/L	5
Mercury-Total	0.05	µg/L	1800
Manganese-Total	5	µg/L	21
Nickel-Total	1	µg/L	11
Lead-Total	1	µg/L	<1
Selenium-Total	1	µg/L	<1
Strontium-Total	1	µg/L	13
Vanadium-Total	1	µg/L	13
Zinc-Total	1	µg/L	73
Aluminium-Dissolved	10	µg/L	<10
Arsenic-Dissolved	1	µg/L	<10
Barium-Dissolved	1	µg/L	<1
Beryllium-Dissolved	0.5	µg/L	80
Cadmium-Dissolved	0.1	µg/L	16
Chromium-Dissolved	1	µg/L	<1
Cobalt-Dissolved	1	µg/L	6
Copper-Dissolved	1	µg/L	1900
Iron-Dissolved	10	µg/L	12000
Lithium-Dissolved	1	µg/L	6
Mercury-Dissolved	0.05	µg/L	14
Manganese-Dissolved	5	µg/L	<1
Nickel-Dissolved	1	µg/L	<1
Lead-Dissolved	1	µg/L	15
Selenium-Dissolved	1	µg/L	<1
Strontium-Dissolved	1	µg/L	15
Vanadium-Dissolved	1	µg/L	49
Zinc-Dissolved	1	µg/L	12000

Bore: GW111518	Property: Tahmoor South
Bore Identification Information (NSW Real Time Water Data)	
Bore name/nickname	GW111518
Property	FARRUGIA 30 Carlisle St YANDERRA 2574 NSW
NSW licence number	10WA111496
Datum	GDA 94 Zone 56
Easting	276882
Northing	6200987
Elevation (mAHD)	NR
Bore Status	Current – Stock, domestic
Bore Construction Details	
Drilling and construction records available	Yes
Date drilled/constructed	01/01/2009
Total depth of bore (m)	150.0
Geological Formation Screened	NR
Bore Casing	
Material	PVC Class 9
Diameter	160mm OD
Stick-up	NR
Hydrogeological info	
Screened lithology/formation	Sandstone
Standing water level (mbgl)	48
Water quality	Salinity: NA (values reported appear erroneous)
Other bore log comments	Yield (Ls): 2.0
Data Collected While On Site	
Census Date	27/01/2022
Completed by	Chris Rotsider, Consulting Earth Scientists Pty Ltd
Photographs (insert)	
	
Bore Details	
Site Address	FARRUGIA 30 Carlisle St YANDERRA 2574 NSW
GPS Location datum	GDA 94 Zone 56
Easting	276648
Northing	6201710
Elevation (mAHD) – specify survey method	NR
Drilling and construction records (Y/N)	Y

Bore: GW111518	Property: Tahmoor South
Stick-up (casing, monument etc.)	Metal cap
Total depth of bore (mbgl)	28.32*
Depth to water (mbgl)	19.24
Pump status (if installed)	In-situ electric pump which could not be operated by site contact.
Logger status/condition (if installed). Serial no., make, model etc.	NA
Fencing/barrier installed?	No
Sampling method	Tank water used
Electrical Conductivity (µS/cm)	277
pH	4.8
Temperature (°C)	21.8
ORP (mV)	316.5
Dissolved Oxygen (mg/L)	5.43
Colour, odour, characteristics etc.	No odour, slightly 'rusty' colour (Fe), low turbidity
Bore Pump Details (if relevant)	
Frequency of use	Frequent use when required for crop irrigation
Typical pumping rate	NR
Purpose / Use of Bore	Crop irrigation
Comment:	
*David (owner/ tenant) mentioned the well is ~160m. Potential obstruction? David unable to operate pump. He advised that water from this well led directly into a holding tank, situated ~70m NW of the bore location. As such, water samples were collected from the tank via attached tap Headworks for this monitoring well were encountered to be in fair condition. Included PVC casing above ground.	

WaterNSW
Work Summary

GW111518

Licence: 10WA111496

Licence Status: CURRENT

Authorised Purpose(s): DOMESTIC,STOCK
Intended Purpose(s): STOCK, DOMESTIC

Work Type: Bore
Work Status: Supply Obtained
Construct.Method: Down Hole Hamm
Owner Type: Private

Commenced Date:
Completion Date: 01/01/2009

Final Depth: 150.00 m
Drilled Depth: 150.00 m

Contractor Name: HIGHLAND DRILLING PTY LTD
Driller: Brett Delamont
Assistant Driller:

Property: FARRUGIA 30 Carlisle St YANDERRA 2574 NSW
GWMA: -
GW Zone: -

Standing Water Level (m): 48.000
Salinity Description:
Yield (L/s): 2.000

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CAMDEN	BARGO	1//734564
Licensed:	CAMDEN	BARGO	Whole Lot 1//734564

Region: 10 - Sydney South Coast
CMA Map:

River Basin: - Unknown
Area/District:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown

Northing: 6200987.000
Easting: 276882.000

Latitude: 34°18'30.2"S
Longitude: 150°34'31.5"E

GS Map: -
MGA Zone: 56
Coordinate Source: Unknown

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	55.00	200			Down Hole Hammer
1		Hole	Hole	55.00	150.00	165			Down Hole Hammer
1		Annulus	Waterworn/Rounded	0.00	0.00				Graded
1	1	Casing	Pvc Class 9	0.00	55.00	160			Driven into Hole, Screwed and Glued
1	1	Opening	Slots - Diagonal	52.00	55.00	160		0	Sawn, PVC Class 9, SL: 3.0mm, A: 2.00mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
19.00	20.00	1.00	Unknown	48.00		0.40			0.77
35.00	36.00	1.00	Unknown			0.35			0.66
47.00	48.00	1.00	Unknown			0.25			0.52
95.00	96.00	1.00	Unknown			0.40			0.34

113.00	114.00	1.00	Unknown			1.10			0.42
119.00	120.00	1.00	Unknown			0.80			0.42
131.00	132.00	1.00	Unknown			1.70			0.40
137.00	138.00	1.00	Unknown			2.00			0.38

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	110.00	110.00	SANDSTONE FINE	Sandstone	
110.00	150.00	40.00	SANDSTONE COARSE	Sandstone	

Remarks

01/01/2009: Form A Remarks:
Pump test recommended.

***** End of GW111518 *****

Site GW111518 Values at Time of Drilling

Measure	Data Type	Hole	Pipe	Date	Value
Groundwater depth below surface level (Metres)	Manual	1	1	01/01/2009 @ 12:00	48.000
Meter Discharge (Kilolitres/Day)	Manual	1	1	01/01/2009 @ 00:00	2.000

Parameter	LOR	Unit	30 Carlisle St
Registered Number			GW111518
Date			27-01-2022
Calcium - Dissolved	0.5	mg/L	1
Potassium - Dissolved	0.5	mg/L	0.7
Sodium - Dissolved	0.5	mg/L	34
Magnesium - Dissolved	0.5	mg/L	6
Hardness	3	mg/L	27
Hydroxide Alkalinity (OH-) as CaCO3	5	mg/L	<5
Bicarbonate Alkalinity as CaCO3	5	mg/L	<5
Carbonate Alkalinity as CaCO3	5	mg/L	<5
Total Alkalinity as CaCO3	5	mg/L	<5
Sulphate SO4	1	mg/L	<1
Chloride Cl	1	mg/L	82
Ionic Balance	-	%	-6
Total Nitrogen in Water	0.1	mg/L	<0.1
Phosphorus Total	0.05	mg/L	<0.05
Aluminium-Total	10	µg/L	<10
Arsenic-Total	1	µg/L	<1
Barium-Total	1	µg/L	57
Beryllium-Total	0.5	µg/L	<0.5
Cadmium-Total	0.1	µg/L	<0.1
Chromium-Total	1	µg/L	<1
Cobalt-Total	1	µg/L	12
Copper-Total	1	µg/L	<1
Iron-Total	10	µg/L	15000
Lithium-Total	1	µg/L	6
Mercury-Total	0.05	µg/L	<0.05
Manganese-Total	5	µg/L	1800
Nickel-Total	1	µg/L	29
Lead-Total	1	µg/L	<1
Selenium-Total	1	µg/L	<1
Strontium-Total	1	µg/L	14
Vanadium-Total	1	µg/L	2
Zinc-Total	1	µg/L	21
Aluminium-Dissolved	10	µg/L	<10
Arsenic-Dissolved	1	µg/L	<1
Barium-Dissolved	1	µg/L	61
Beryllium-Dissolved	0.5	µg/L	<0.5
Cadmium-Dissolved	0.1	µg/L	<0.1
Chromium-Dissolved	1	µg/L	<1
Cobalt-Dissolved	1	µg/L	12
Copper-Dissolved	1	µg/L	<1
Iron-Dissolved	10	µg/L	60
Lithium-Dissolved	1	µg/L	5
Mercury-Dissolved	0.05	µg/L	<0.05
Manganese-Dissolved	5	µg/L	1500
Nickel-Dissolved	1	µg/L	12
Lead-Dissolved	1	µg/L	<1
Selenium-Dissolved	1	µg/L	<1
Strontium-Dissolved	1	µg/L	14
Vanadium-Dissolved	1	µg/L	<1
Zinc-Dissolved	1	µg/L	25

Bore: GW111669	Property: 40 CALOOLA RD
Bore Identification Information (NSW Real Time Water Data)	
Bore name	GW111669
Property	KRILIC 40 Caloola Rd BARGO 2574 NSW
NSW licence number	10WA111489 (current)
Datum	GDA 94 Zone 56
Easting	276232
Northing	6206450
Elevation (mAHD)	NR
Purpose	Stock, domestic
Bore Construction Details	
Drilling and construction records available	Yes
Date drilled/constructed	25/11/2008
Total depth of bore (m)	120
Geological Formation Screened	Sandstone
Bore Casing	
Material	PVC Class 9
Diameter	PVC 175 mm OD
Stick-up	NR
Hydrogeological info	
Screened lithology/formation	Sandstone
Standing water level (mbgl)	84
Water quality	Salinity: 200 mg/L
Other bore log comments	Yield (L/s): 2.0
Data Collected While On Site	
Census Date	31/01/2022
Completed by	Chris Rotsider, Consulting Earth Scientists Pty Ltd
Photographs	
	
Bore Details	
Site Address	40 CALOOLA RD BARGO 2574 NSW
GPS Location datum	GDA 94 Zone 56
Easting	279263
Northing	6203321
Elevation (mAHD) – specify survey method	NR
Drilling and construction records (Y/N)	Y
Stick-up (casing, monument etc.)	Stick up with metal cap

Bore: GW111669	Property: 40 CALOOLA RD
Total depth of bore (mbgl)	NR
Depth to water (mbgl)	NR
Pump status (if installed)	In-situ electric pump 2120kW
Logger status/condition (if installed). Serial no., make, model etc.	NA
Fencing/barrier installed?	No
Sampling method	Tank
Electrical Conductivity (µS/cm)	481
pH	4.1
Temperature (°C)	26.2
ORP (mV)	370.3
Dissolved Oxygen (mg/L)	0.81
Colour, odour, characteristics etc.	No odour, low turbidity
Bore Pump Details (if relevant)	
Frequency of use	Daily
Typical pumping rate	NR
Purpose / Use of Bore	Crop irrigation and small-scale poultry farm
Comment:	
Headworks in good condition.	

WaterNSW
Work Summary

GW111669

Licence: 10WA111489

Licence Status: CURRENT

Authorised Purpose(s): DOMESTIC,STOCK
Intended Purpose(s): STOCK, DOMESTIC

Work Type: Bore
Work Status: Supply Obtained
Construct.Method: Rotary Air
Owner Type: Private

Commenced Date:
Completion Date: 25/11/2008

Final Depth: 120.00 m
Drilled Depth: 120.00 m

Contractor Name: Ultra Drilling
Driller: Peter Edward Davidson
Assistant Driller:

Property: KRILIC 40 Caloola Rd BARGO 2574 NSW
GWMA: -
GW Zone: -

Standing Water Level (m): 84.000
Salinity Description:
Yield (L/s): 2.000

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CAMDEN	BARGO	9//25735
Licensed:	CAMDEN	BARGO	Whole Lot 9//25735

Region: 10 - Sydney South Coast
River Basin: - Unknown
Area/District:

CMA Map:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown

Northing: 6206450.000
Easting: 276232.000

Latitude: 34°15'32.5"S
Longitude: 150°34'11.2"E

GS Map: -
MGA Zone: 56
Coordinate Source: Unknown

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	3.00	220			Rotary Air
1		Hole	Hole	3.00	120.00	173			Down Hole Hammer
1	1	Casing	Pvc Class 9	0.00	3.00	175			Driven into Hole

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
91.00	95.00	4.00	Unknown		96.00	0.75			200.00
104.00	106.00	2.00	Unknown		107.00	1.20			200.00
111.00	114.00	3.00	Unknown			1.40			200.00
114.00	118.00	4.00	Unknown	84.00		2.00		01:00:00	200.00

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	2.00	2.00	CLAY	Clay	
2.00	79.00	77.00	SANDSTONE	Sandstone	
79.00	91.00	12.00	SANDSTONE/SHALE	Sandstone	
91.00	106.00	15.00	SANDSTONE/QUARTZITE	Sandstone	
106.00	111.00	5.00	SHALE	Shale	
111.00	120.00	9.00	SANDSTONE/QUARTZITE	Sandstone	

***** End of GW111669 *****

Parameter	LOR	Unit	40 Caloola Rd
Registered Number			GW111669
Date			31-01-2022
Calcium - Dissolved	0.5	mg/L	1
Potassium - Dissolved	0.5	mg/L	3
Sodium - Dissolved	0.5	mg/L	65
Magnesium - Dissolved	0.5	mg/L	9.6
Hardness	3	mg/L	42
Hydroxide Alkalinity (OH-) as CaCO3	5	mg/L	<5
Bicarbonate Alkalinity as CaCO3	5	mg/L	<5
Carbonate Alkalinity as CaCO3	5	mg/L	<5
Total Alkalinity as CaCO3	5	mg/L	<5
Sulphate SO4	1	mg/L	26
Chloride Cl	1	mg/L	130
Ionic Balance	-	%	-7
Total Nitrogen in Water	0.1	mg/L	1.9
Phosphorus Total	0.05	mg/L	<0.05
Aluminium-Total	10	µg/L	930
Arsenic-Total	1	µg/L	<1
Barium-Total	1	µg/L	210
Beryllium-Total	0.5	µg/L	0.8
Cadmium-Total	0.1	µg/L	0.2
Chromium-Total	1	µg/L	<1
Cobalt-Total	1	µg/L	9
Copper-Total	1	µg/L	8
Iron-Total	10	µg/L	100
Lithium-Total	1	µg/L	6
Mercury-Total	0.05	µg/L	<0.05
Manganese-Total	5	µg/L	480
Nickel-Total	1	µg/L	7
Lead-Total	1	µg/L	8
Selenium-Total	1	µg/L	<1
Strontium-Total	1	µg/L	14
Vanadium-Total	1	µg/L	<1
Zinc-Total	1	µg/L	50
Aluminium-Dissolved	10	µg/L	930
Arsenic-Dissolved	1	µg/L	<1
Barium-Dissolved	1	µg/L	210
Beryllium-Dissolved	0.5	µg/L	0.7
Cadmium-Dissolved	0.1	µg/L	0.2
Chromium-Dissolved	1	µg/L	<1
Cobalt-Dissolved	1	µg/L	9
Copper-Dissolved	1	µg/L	8
Iron-Dissolved	10	µg/L	80
Lithium-Dissolved	1	µg/L	5
Mercury-Dissolved	0.05	µg/L	<0.05
Manganese-Dissolved	5	µg/L	470
Nickel-Dissolved	1	µg/L	7
Lead-Dissolved	1	µg/L	8
Selenium-Dissolved	1	µg/L	<1
Strontium-Dissolved	1	µg/L	14
Vanadium-Dissolved	1	µg/L	<1
Zinc-Dissolved	1	µg/L	50

Bore: GW111810	Property: 80 GREAT SOUTHERN RD
Bore Identification Information (NSW Real Time Water Data)	
Bore name	GW111810
Property	CHILCOTT 80 Great Southern Rd BARGO 2574 NSW
NSW licence number	10WA11272 (current)
Datum	GDA 94 Zone 56
Easting	277034
Northing	6204407
Elevation (mAHD)	NR
Purpose	Domestic, stock
Bore Construction Details	
Drilling and construction records available	Yes
Date drilled/constructed	30/08/2005
Total depth of bore (m)	142.0
Geological Formation Screened	Sandstone
Bore Casing	
Material	PVC
Diameter	PVC 161 mm OD, 148 mm ID
Stick-up	0.3 m
Hydrogeological info	
Screened lithology/formation	Sandstone
Standing water level (mbgl)	60.0
Water quality	Salinity: NR
Other bore log comments	Yield (Ls): 1.2
Data Collected While On Site	
Census Date	04/02/2022
Completed by	Chris Rotsider, Consulting Earth Scientists Pty Ltd
Photographs (insert)	
	
Bore Details	
Site Address	80 GREAT SOUTHERN RD BARGO 2574 NSW
GPS Location datum	GDA 94 Zone 56
Easting	277035
Northing	6204405
Elevation (mAHD) – specify survey method	NR
Drilling and construction records (Y/N)	Y

Bore: GW111810	Property: 80 GREAT SOUTHERN RD
Stick-up (casing, monument etc.)	PVC casing stick up with metal cap
Total depth of bore (mbgl)	NR
Depth to water (mbgl)	NR
Pump status (if installed)	In-situ electric pump
Logger status/condition (if installed). Serial no., make, model etc.	NA
Fencing/barrier installed?	No
Sampling method	Tank water
Electrical Conductivity (µS/cm)	2058
pH	6.8
Temperature (°C)	16.8
ORP (mV)	236.2
Dissolved Oxygen (mg/L)	4.4
Colour, odour, characteristics etc.	No odour, not turbid.
Bore Pump Details (if relevant)	
Frequency of use	Used frequently
Typical pumping rate	NR
Purpose / Use of Bore	Irrigation with holding tanks
Comment:	
Depth measuring equipment was not able to be inserted due to limited space at well head. Concrete footing and PVC well head both in good condition.	

WaterNSW
Work Summary

GW111810

Licence: 10WA111272

Licence Status: CURRENT

Authorised Purpose(s): DOMESTIC,STOCK
Intended Purpose(s): STOCK, DOMESTIC

Work Type: Bore
Work Status: Supply Obtained
Construct.Method: Down Hole Hamm
Owner Type: Private

Commenced Date:
Completion Date: 30/08/2005

Final Depth: 142.00 m
Drilled Depth: 142.00 m

Contractor Name: J.H. ISELT
Driller: John Hans Iselt
Assistant Driller:

Property: CHILCOTT 80 Great Southern Rd BARGO 2574 NSW
GWMA: -
GW Zone: -

Standing Water Level (m): 60.000
Salinity Description:
Yield (L/s): 1.200

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CAMDEN	BARGO	64//736032
Licensed:	CAMDEN	BARGO	Whole Lot 64//736032

Region: 10 - Sydney South Coast

CMA Map:

River Basin: - Unknown
Area/District:

Grid Zone:

Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown

Northing: 6204407.000
Easting: 277034.000

Latitude: 34°16'39.4"S
Longitude: 150°34'40.6"E

GS Map: -

MGA Zone: 56

Coordinate Source: Unknown

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	12.00	225			Down Hole Hammer
1		Hole	Hole	12.00	142.00	150			Down Hole Hammer
1		Annulus	Concrete	-0.10	12.00	225	161		
1	1	Casing	P.V.C.	-0.30	11.70	161	148		Seated on Bottom

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
79.90	80.40	0.50	Unknown	60.00	84.00	0.10			
137.70	138.30	0.60	Unknown	60.00	142.00	1.20		02:00:00	

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.10	0.10	TOPSOIL	Topsoil	
0.10	1.30	1.20	CLAY BROWN	Clay	
1.30	8.50	7.20	SHALE	Shale	
8.50	18.20	9.70	SANDSTONE CG GREY LT	Sandstone	
18.20	40.10	21.90	SANDSTONE CG YELLOW DK	Sandstone	
40.10	79.90	39.80	SANDSTONE CG GREY LT	Sandstone	
79.90	80.40	0.50	SANDSTONE CG GREY LT WB	Sandstone	
80.40	137.70	57.30	SANDSTONE CG GREY LT	Sandstone	
137.70	138.30	0.60	SANDSTONE CG GREY LT WB	Sandstone	
138.30	142.00	3.70	SANDSTONE CG GREY LT	Sandstone	

***** End of GW111810 *****

Parameter	LOR	Unit	80 Great Sourthern Rd
Registered Number			GW111810
Date			04-02-2022
Calcium - Dissolved	0.5	mg/L	18
Potassium - Dissolved	0.5	mg/L	7.6
Sodium - Dissolved	0.5	mg/L	330
Magnesium - Dissolved	0.5	mg/L	100
Hardness	3	mg/L	460
Hydroxide Alkalinity (OH-) as CaCO3	5	mg/L	<5
Bicarbonate Alkalinity as CaCO3	5	mg/L	110
Carbonate Alkalinity as CaCO3	5	mg/L	<5
Total Alkalinity as CaCO3	5	mg/L	110
Sulphate SO4	1	mg/L	57
Chloride Cl	1	mg/L	750
Ionic Balance	-	%	-2
Total Nitrogen in Water	0.1	mg/L	<0.1
Phosphorus Total	0.05	mg/L	<0.05
Aluminium-Total	10	µg/L	<10
Arsenic-Total	1	µg/L	<1
Barium-Total	1	µg/L	35
Beryllium-Total	0.5	µg/L	<0.5
Cadmium-Total	0.1	µg/L	<0.1
Chromium-Total	1	µg/L	<1
Cobalt-Total	1	µg/L	1
Copper-Total	1	µg/L	3
Iron-Total	10	µg/L	2300
Lithium-Total	1	µg/L	77
Mercury-Total	0.05	µg/L	<0.05
Manganese-Total	5	µg/L	350
Nickel-Total	1	µg/L	4
Lead-Total	1	µg/L	2
Selenium-Total	1	µg/L	<1
Strontium-Total	1	µg/L	180
Vanadium-Total	1	µg/L	<1
Zinc-Total	1	µg/L	75
Aluminium-Dissolved	10	µg/L	<10
Arsenic-Dissolved	1	µg/L	<1
Barium-Dissolved	1	µg/L	35
Beryllium-Dissolved	0.5	µg/L	<0.5
Cadmium-Dissolved	0.1	µg/L	<0.1
Chromium-Dissolved	1	µg/L	<1
Cobalt-Dissolved	1	µg/L	1
Copper-Dissolved	1	µg/L	7
Iron-Dissolved	10	µg/L	390
Lithium-Dissolved	1	µg/L	82
Mercury-Dissolved	0.05	µg/L	<0.05
Manganese-Dissolved	5	µg/L	330
Nickel-Dissolved	1	µg/L	3
Lead-Dissolved	1	µg/L	2
Selenium-Dissolved	1	µg/L	1
Strontium-Dissolved	1	µg/L	180
Vanadium-Dissolved	1	µg/L	<1
Zinc-Dissolved	1	µg/L	66

Bore: GW111828	Property: 110 NIGHTINGALE RD
Bore Identification Information (NSW Real Time Water Data)	
Bore name	GW111828
Property	VELLA 110 NIGHTINGALE RD PHEASANTS NEST NSW 2574
NSW licence number	10CA117935
Datum	GDA 94 Zone 56
Easting	282391
Northing	6205638
Elevation (mAHD)	NR
Purpose	Irrigation
Bore Construction Details	
Drilling and construction records available	Yes
Date drilled/constructed	25/04/2012
Total depth of bore (m)	205
Geological Formation Screened	Sandstone
Bore Casing	
Material	Steel
Diameter	Steel 219 mm OD, 209 mm ID
Stick-up	NR
Hydrogeological info	
Screened lithology/formation	Sandstone
Standing water level (mbgl)	79
Water quality	Salinity: 670 mg/L
Other bore log comments	Yield (L/s): 1.20
Data Collected While On Site	
Census Date	21/02/2022
Completed by	Chris Rotsider, Consulting Earth Scientists Pty Ltd
Photographs	

Bore Details

Bore: GW111828	Property: 110 NIGHTINGALE RD
Site Address	110 NIGHTINGALE RD, PHEASANTS NEST, NSW 2574
GPS Location datum	GDA 94 Zone 56
Easting	282390
Northing	6205647
Elevation (mAHD) – specify survey method	NR
Drilling and construction records (Y/N)	Y
Stick-up (casing, monument etc.)	Stick up with PVC cap
Total depth of bore (mbgl)	60.7 (likely blockage as installed to 205 m)
Depth to water (mbgl)	Dry or blockage
Pump status (if installed)	No pump installed
Logger status/condition (if installed). Serial no., make, model etc.	NA
Fencing/barrier installed?	No
Sampling method	No sample obtained as no water detected
Electrical Conductivity (µS/cm)	NR
pH	NR
Temperature (°C)	NR
ORP (mV)	NR
Dissolved Oxygen (mg/L)	NR
Colour, odour, characteristics etc.	NR
Bore Pump Details (if relevant)	
Frequency of use	Previously used intermittently when water was not available from GW115773
Typical pumping rate	NR
Purpose / Use of Bore	Previously used for irrigation back up
Comment:	
Metal well casing in fair/good working order.	

WaterNSW
Work Summary

GW111828

Licence: 10CA117935

Licence Status: CURRENT

Authorised Purpose(s): IRRIGATION
Intended Purpose(s): IRRIGATION

Work Type: Bore
Work Status: Supply Obtained
Construct.Method: Rotary Air
Owner Type: Private

Commenced Date:
Completion Date: 25/04/2012

Final Depth: 205.00 m
Drilled Depth: 205.00 m

Contractor Name: Ultradrilling
Driller: Peter Edward Davidson
Assistant Driller:

Property: VELLA 110 Nightingale Rd PHEASANTS NEST 2574 NSW
GWMA: -
GW Zone: -

Standing Water Level (m): 79.000
Salinity Description:
Yield (L/s): 1.200

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CAMDEN	BARGO	30//255689
Licensed:	CAMDEN	BARGO	Whole Lot 30//255689

Region: 10 - Sydney South Coast
CMA Map:

River Basin: - Unknown
Area/District:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown

Northing: 6205638.000
Easting: 282391.000

Latitude: 34°16'03.6"S
Longitude: 150°38'11.0"E

GS Map: -
MGA Zone: 56
Coordinate Source: Unknown

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	3.00	270			Rotary Air
1		Hole	Hole	3.00	205.00	167			Down Hole Hammer
1	1	Casing	Steel	0.00	3.00	219	209		Seated on Bottom

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
133.00	138.00	5.00	Unknown			0.45		01:00:00	780.00
142.00	144.00	2.00	Unknown			0.60		01:00:00	780.00
144.00	150.00	6.00	Unknown			1.00		01:00:00	720.00
165.00	168.00	3.00	Unknown	79.00		1.20		01:00:00	670.00

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	2.00	2.00	SOIL	Soil	
2.00	2.80	0.80	SHALE	Shale	
2.80	5.00	2.20	SANDSTONE PINK	Sandstone	
5.00	54.00	49.00	SANDSTONE YELLOW	Sandstone	
54.00	133.00	79.00	SANDSTONE/SHALE	Sandstone	
133.00	176.00	43.00	SANDSTONE / QUARTZ	Sandstone	
176.00	178.00	2.00	SANDSTONE / SHALE	Sandstone	
178.00	188.00	10.00	SANDSTONE / QUARTZ	Sandstone	
188.00	205.00	17.00	SANDSTONE / SILTSTONE	Sandstone	

***** End of GW111828 *****

Bore: GW111842	Property: 130 NIGHTINGALE RD
Bore Identification Information (NSW Real Time Water Data)	
Bore name	GW111842
Property	ZAHRA 130 NIGHTINGALE RD PHEASANTS NEST 2574 NSW
NSW licence number	10CA117931 (Current)
Datum	GDA 94 Zone 56
Easting	282654
Northing	6205664
Elevation (mAHD)	NR
Purpose	Irrigation
Bore Construction Details	
Drilling and construction records available	Yes
Date drilled/constructed	11/04/2012
Total depth of bore (m)	240
Geological Formation Screened	Sandstone
Bore Casing	
Material	Steel
Diameter	Steel 219 mm OD 209 mm ID
Stick-up	NR
Hydrogeological info	
Screened lithology/formation	Sandstone
Standing water level (mbgl)	75
Water quality	Salinity: 780 mg/L
Other bore log comments	Yield (L/s): 2.20
Data Collected While On Site	
Census Date	February 2022
Completed by	Chris Rotsider, Consulting Earth Scientists Pty Ltd
Photographs	

Bore Details	
Site Address	130 NIGHTINGALE RD, PHEASANTS NEST, 2574 NSW

Bore: GW111842	Property: 130 NIGHTINGALE RD
GPS Location datum	GDA 94 Zone 56
Easting	283187
Northing	6182673
Elevation (mAHD) – specify survey method	NR
Drilling and construction records (Y/N)	Y
Stick-up (casing, monument etc.)	Steel casing with metal sheet cover
Total depth of bore (mbgl)	69.4 (likely blockage as installation depth 240 m)
Depth to water (mbgl)	Dry (or blockage)
Pump status (if installed)	No pump installed
Logger status/condition (if installed). Serial no., make, model etc.	NA
Fencing/barrier installed?	No
Sampling method	No sample obtained as dry or blockage
Electrical Conductivity (µS/cm)	NR
pH	NR
Temperature (°C)	NR
ORP (mV)	NR
Dissolved Oxygen (mg/L)	NR
Colour, odour, characteristics etc.	NR
Bore Pump Details (if relevant)	
Frequency of use	Unused
Typical pumping rate	NR
Purpose / Use of Bore	Unused
Comment:	
Metal casing in fair working order.	

WaterNSW
Work Summary

GW111842

Licence: 10CA117931

Licence Status: CURRENT

Authorised Purpose(s): IRRIGATION
Intended Purpose(s): IRRIGATION

Work Type: Bore
Work Status: Supply Obtained
Construct.Method: Rotary Air
Owner Type: Private

Commenced Date:
Completion Date: 11/04/2012

Final Depth: 240.00 m
Drilled Depth: 240.00 m

Contractor Name: Ultradrilling
Driller: Peter Edward Davidson
Assistant Driller:

Property: ZAHRA 130 Nightingale Rd PHEASANTS NEST 2574 NSW
GWMA: -
GW Zone: -

Standing Water Level (m): 75.000
Salinity Description:
Yield (L/s): 2.200

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CAMDEN	BARGO	311//618097
Licensed:	CAMDEN	BARGO	Whole Lot 311//618097

Region: 10 - Sydney South Coast
River Basin: - Unknown
Area/District:

CMA Map:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown

Northing: 6205664.000
Easting: 282654.000

Latitude: 34°16'02.9"S
Longitude: 150°38'21.3"E

GS Map: -
MGA Zone: 56
Coordinate Source: Unknown

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	2.00	270			Rotary Air
1		Hole	Hole	2.00	240.00	170			Down Hole Hammer
1	1	Casing	Steel	0.00	2.00	219	209		Driven into Hole

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
105.00	108.00	3.00	Unknown			0.20		01:00:00	1200.00
116.00	118.00	2.00	Unknown			0.45		01:00:00	980.00
122.00	125.00	3.00	Unknown			0.75		01:00:00	880.00
163.00	168.00	5.00	Unknown	75.00		2.20		01:00:00	780.00

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	1.50	1.50	CLAY RED	Clay	
1.50	32.00	30.50	SANDSTONE YELLOW	Sandstone	
32.00	34.00	2.00	SHALE	Shale	
34.00	57.00	23.00	SANDSTONE WHITE	Sandstone	
57.00	105.00	48.00	SANDSTONE/SHALE	Sandstone	
105.00	149.00	44.00	SANDSTONE /QUARTZ	Sandstone	
149.00	163.00	14.00	SANDSTONE/SHALE	Sandstone	
163.00	175.00	12.00	SANDSTONE/QUARTZ	Sandstone	
175.00	189.00	14.00	SHALE	Shale	
189.00	190.00	1.00	SANDSDTONE GREY	Sandstone	
190.00	208.00	18.00	SANDSTONE WHITE	Sandstone	
208.00	240.00	32.00	SANDSTONE WHITE FINE GRAIN	Sandstone	

***** End of GW111842 *****

Bore: GW112415	Property: 129 SILLICA RD
Bore Identification Information (NSW Real Time Water Data)	
Bore name	GW11415
Property	ANNIS 129 Silica Rd YANDERRA 2574 NSW
NSW licence number	10WA111558 (current)
Datum	GDA 94 Zone 56
Easting	277479
Northing	6200865
Elevation (mAHD)	NR
Purpose	Stock, domestic
Bore Construction Details	
Drilling and construction records available	Yes
Date drilled/constructed	01/12/2009
Total depth of bore (m)	132
Geological Formation Screened	Sandstone/Shale
Bore Casing	
Material	PVC Class 9
Diameter	PVC 160 mm OD
Stick-up	NR
Hydrogeological info	
Screened lithology/formation	Sandstone/Shale
Standing water level (mbgl)	60
Water quality	NA (recorded salinity appears erroneous)
Other bore log comments	Yield (L/s): 2.75

Data Collected While On Site	
Census Date	01/02/2022
Completed by	Chris Rotsider, Consulting Earth Scientists Pty Ltd
Photographs	

Bore Details	
Site Address	ANNIS 129, SILICA RD, YANDERRA 2574 NSW
GPS Location datum	GDA 94 Zone 56
Easting	277439

Bore: GW112415	Property: 129 SILLICA RD
Northing	6200851
Elevation (mAHD) – specify survey method	NR
Drilling and construction records (Y/N)	Y
Stick-up (casing, monument etc.)	Concrete monument with metal cap
Total depth of bore (mbgl)	96.96
Depth to water (mbgl)	42.86
Pump status (if installed)	In-situ electric pump plumbed into dam filling and irrigation system
Logger status/condition (if installed). Serial no., make, model etc.	NA
Fencing/barrier installed?	Box with lid around bore
Sampling method	Sample taken from removed join at dam filling pipe work
Electrical Conductivity (µS/cm)	1059
pH	5.8
Temperature (°C)	20.9
ORP (mV)	-8.6
Dissolved Oxygen (mg/L)	15.9
Colour, odour, characteristics etc.	Clear, slight organic odour, low turbidity
Bore Pump Details (if relevant)	
Frequency of use	Daily
Typical pumping rate	NR
Purpose / Use of Bore	Fill dam and irrigate lawn
Comment:	
Headworks in good working condition. Pumping: 3 min Recovery time: 20 s	

WaterNSW
Work Summary

GW112415

Licence: 10WA111558

Licence Status: CURRENT

Authorised Purpose(s): DOMESTIC,STOCK
Intended Purpose(s): STOCK, DOMESTIC

Work Type: Bore
Work Status: Supply Obtained
Construct.Method: Down Hole Hamm
Owner Type: Private

Commenced Date:
Completion Date: 01/12/2009

Final Depth: 139.00 m
Drilled Depth: 139.00 m

Contractor Name: HIGHLAND DRILLING
Driller: Brett Delamont
Assistant Driller:

Property: ANNIS 129 Silica Rd YANDERRA 2574 NSW
GWMA: -
GW Zone: -

Standing Water Level (m): 60.000
Salinity Description:
Yield (L/s): 2.750

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CAMDEN	BARGO	2//1016431
Licensed:	CAMDEN	BARGO	Whole Lot 2//1016431

Region: 10 - Sydney South Coast
River Basin: - Unknown
Area/District:

CMA Map:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown

Northing: 6200865.000
Easting: 277479.000

Latitude: 34°18'34.6"S
Longitude: 150°34'54.7"E

GS Map: -
MGA Zone: 56
Coordinate Source: Unknown

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	88.00	200			Down Hole Hammer
1		Hole	Hole	88.00	139.00	165			Down Hole Hammer
1	1	Casing	Pvc Class 9	0.00	85.00	160			Driven into Hole, Screwed and Glued
1	1	Opening	Slots - Diagonal	79.00	85.00	160		0	Sawn, PVC Class 9, SL: 6.0mm, A: 2.00mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
35.00	36.00	1.00	Unknown			0.30	36.00		0.28
41.00	42.00	1.00	Unknown			0.20	42.00		0.29
107.00	108.00	1.00	Unknown			0.40	108.00		0.38
113.00	114.00	1.00	Unknown			0.35	114.00		0.38
131.00	132.00	1.00	Unknown	60.00		2.75	132.00		0.35

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	1.00	1.00	TOPSOIL / CLAY	Topsoil	
1.00	18.00	17.00	SANDSTONE ORANGE	Sandstone	
18.00	90.00	72.00	SANDSTONE OFF WHITE	Sandstone	
90.00	131.00	41.00	SHAKE	Shale	
131.00	139.00	8.00	SANDSTONE WHITE	Sandstone	

Remarks

01/12/2009: Form A Remarks:
Pump test recommended.
Aquifers: No attached schedule.

***** End of GW112415 *****

Parameter	LOR	Unit	129 Sillica Rd
Registered Number			GW112415
Date			01-02-2022
Calcium - Dissolved	0.5	mg/L	2
Potassium - Dissolved	0.5	mg/L	1
Sodium - Dissolved	0.5	mg/L	110
Magnesium - Dissolved	0.5	mg/L	17
Hardness	3	mg/L	75
Hydroxide Alkalinity (OH-) as CaCO3	5	mg/L	<5
Bicarbonate Alkalinity as CaCO3	5	mg/L	44
Carbonate Alkalinity as CaCO3	5	mg/L	<5
Total Alkalinity as CaCO3	5	mg/L	44
Sulphate SO4	1	mg/L	4
Chloride Cl	1	mg/L	270
Ionic Balance	-	%	-14
Total Nitrogen in Water	0.1	mg/L	<0.1
Phosphorus Total	0.05	mg/L	<0.05
Aluminium-Total	10	µg/L	50
Arsenic-Total	1	µg/L	<1
Barium-Total	1	µg/L	230
Beryllium-Total	0.5	µg/L	2
Cadmium-Total	0.1	µg/L	<0.1
Chromium-Total	1	µg/L	<1
Cobalt-Total	1	µg/L	40
Copper-Total	1	µg/L	<1
Iron-Total	10	µg/L	52000
Lithium-Total	1	µg/L	13
Mercury-Total	0.05	µg/L	<0.05
Manganese-Total	5	µg/L	4600
Nickel-Total	1	µg/L	33
Lead-Total	1	µg/L	<1
Selenium-Total	1	µg/L	1
Strontium-Total	1	µg/L	31
Vanadium-Total	1	µg/L	<1
Zinc-Total	1	µg/L	93
Aluminium-Dissolved	10	µg/L	<10
Arsenic-Dissolved	1	µg/L	<1
Barium-Dissolved	1	µg/L	240
Beryllium-Dissolved	0.5	µg/L	1
Cadmium-Dissolved	0.1	µg/L	<0.1
Chromium-Dissolved	1	µg/L	<1
Cobalt-Dissolved	1	µg/L	42
Copper-Dissolved	1	µg/L	<1
Iron-Dissolved	10	µg/L	43000
Lithium-Dissolved	1	µg/L	14
Mercury-Dissolved	0.05	µg/L	<0.05
Manganese-Dissolved	5	µg/L	4600
Nickel-Dissolved	1	µg/L	34
Lead-Dissolved	1	µg/L	<1
Selenium-Dissolved	1	µg/L	<1
Strontium-Dissolved	1	µg/L	34
Vanadium-Dissolved	1	µg/L	<1
Zinc-Dissolved	1	µg/L	90

Bore: GW112473	Property: 115 TYLERS RD
Bore Identification Information (NSW Real Time Water Data)	
Bore name	GW112473
Property	Not listed
NSW licence number	NA
Datum	GDA 94 Zone 56
Easting	276577
Northing	6202010
Elevation (mAHD)	NR
Purpose	Irrigation
Bore Construction Details	
Drilling and construction records available	Yes
Date drilled/constructed	18/12/2012
Total depth of bore (m)	138
Geological Formation Screened	Sandstone
Bore Casing	
Material	PVC Class 9
Diameter	PVC 203 mm OD, PVC 142 mm OD
Stick-up	0.3 m
Hydrogeological info	
Screened lithology/formation	Sandstone
Standing water level (mbgl)	42
Water quality	Salinity: 138 mg/L
Other bore log comments	Yield (Ls): 6.5
Data Collected While On Site	
Census Date	04/02/2022
Completed by	Chris Rotsider, Consulting Earth Scientists Pty Ltd
Photographs (insert)	

Bore Details	
Site Address	115 TYLERS RD, BARGO, 2574 NSW
GPS Location datum	GDA 94 Zone 56
Easting	276586
Northing	6202000
Elevation (mAHD) – specify survey method	NR
Drilling and construction records (Y/N)	Y

Bore: GW112473	Property: 115 TYLERS RD
Stick-up (casing, monument etc.)	PVC/Steel stick up with metal cap
Total depth of bore (mbgl)	NR
Depth to water (mbgl)	32.95
Pump status (if installed)	In-situ electric pump
Logger status/condition (if installed). Serial no., make, model etc.	NA
Fencing/barrier installed?	Yes – enclosed within shed
Sampling method	Dam outlet
Electrical Conductivity (µS/cm)	515
pH	4.9
Temperature (°C)	18.8
ORP (mV)	204.6
Dissolved Oxygen (mg/L)	2.6
Colour, odour, characteristics etc.	Rusty colour (Fe+), no odour, low turbidity
Bore Pump Details (if relevant)	
Frequency of use	Daily
Typical pumping rate	NR
Purpose / Use of Bore	To fill property dam
Comment:	
Head works in good working condition.	

WaterNSW
Work Summary

GW112473

Licence:

Licence Status:

Authorised Purpose(s):
Intended Purpose(s): IRRIGATION

Work Type: Bore
Work Status: Supply Obtained
Construct.Method: Rotary Air
Owner Type: Private

Commenced Date:
Completion Date: 18/12/2012

Final Depth: 138.00 m
Drilled Depth: 138.00 m

Contractor Name: Ultradrilling
Driller: Peter Edward Davidson
Assistant Driller:

Property:
GWMA:
GW Zone:

Standing Water Level (m): 42.000
Salinity Description:
Yield (L/s): 6.500

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CAMDEN	BARGO	190 650138
Licensed:			

Region: 10 - Sydney South Coast
River Basin: - Unknown
Area/District:

CMA Map:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown

Northing: 6202010.000
Easting: 276577.000

Latitude: 34°17'56.8"S
Longitude: 150°34'20.5"E

GS Map: -
MGA Zone: 56
Coordinate Source: Unknown

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	60.00	203			Rotary Air
1		Hole	Hole	60.00	138.00	173			Down Hole Hammer
1		Annulus	Concrete	0.00	6.00	203	203		
1	1	Casing	Pvc Class 9	-0.30	50.00	142			Driven into Hole, Riveted and Glued
1	1	Casing	Pvc Class 9	-0.30	6.00	203			Seated on Bottom

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
42.00	44.00	2.00	Unknown		44.00	0.50			350.00
51.00	60.00	9.00	Unknown		60.00	1.30			220.00
111.00	114.00	3.00	Unknown			3.00			150.00
132.00	138.00	6.00	Unknown	42.00		6.50			138.00

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	2.00	2.00	SOIL / CLAY	Soil	
2.00	43.00	41.00	SANDSTONE YELLOW	Sandstone	
43.00	104.00	61.00	SANDSTONE WHITE	Sandstone	
104.00	110.00	6.00	SANDSTONE QUARTZ	Sandstone	
110.00	111.00	1.00	SHALE	Sandstone	
111.00	138.00	27.00	SANDSTONE / QUARTZ	Sandstone	

***** End of GW112473 *****

Parameter	LOR	Unit	115 Tyler's Rd
Registered Number			GW112473
Date			04-02-2022
Calcium - Dissolved	0.5	mg/L	0.8
Potassium - Dissolved	0.5	mg/L	0.6
Sodium - Dissolved	0.5	mg/L	74
Magnesium - Dissolved	0.5	mg/L	11
Hardness	3	mg/L	47
Hydroxide Alkalinity (OH-) as CaCO3	5	mg/L	<5
Bicarbonate Alkalinity as CaCO3	5	mg/L	<5
Carbonate Alkalinity as CaCO3	5	mg/L	<5
Total Alkalinity as CaCO3	5	mg/L	<5
Sulphate SO4	1	mg/L	6
Chloride Cl	1	mg/L	170
Ionic Balance	-	%	-8
Total Nitrogen in Water	0.1	mg/L	0.5
Phosphorus Total	0.05	mg/L	0.2
Aluminium-Total	10	µg/L	1900
Arsenic-Total	1	µg/L	2
Barium-Total	1	µg/L	120
Beryllium-Total	0.5	µg/L	2
Cadmium-Total	0.1	µg/L	<0.1
Chromium-Total	1	µg/L	<1
Cobalt-Total	1	µg/L	14
Copper-Total	1	µg/L	<1
Iron-Total	10	µg/L	45000
Lithium-Total	1	µg/L	4
Mercury-Total	0.05	µg/L	0.27
Manganese-Total	5	µg/L	730
Nickel-Total	1	µg/L	12
Lead-Total	1	µg/L	39
Selenium-Total	1	µg/L	<1
Strontium-Total	1	µg/L	11
Vanadium-Total	1	µg/L	4
Zinc-Total	1	µg/L	60
Aluminium-Dissolved	10	µg/L	460
Arsenic-Dissolved	1	µg/L	<1
Barium-Dissolved	1	µg/L	120
Beryllium-Dissolved	0.5	µg/L	1
Cadmium-Dissolved	0.1	µg/L	<0.1
Chromium-Dissolved	1	µg/L	<1
Cobalt-Dissolved	1	µg/L	14
Copper-Dissolved	1	µg/L	<1
Iron-Dissolved	10	µg/L	7400
Lithium-Dissolved	1	µg/L	7
Mercury-Dissolved	0.05	µg/L	<0.05
Manganese-Dissolved	5	µg/L	730
Nickel-Dissolved	1	µg/L	12
Lead-Dissolved	1	µg/L	22
Selenium-Dissolved	1	µg/L	1
Strontium-Dissolved	1	µg/L	12
Vanadium-Dissolved	1	µg/L	<1
Zinc-Dissolved	1	µg/L	50

Bore: GW115773	Property: 110 NIGHTINGALE RD
Bore Identification Information (NSW Real Time Water Data)	
Bore name	GW115773
Property	VELLA 110 NIGHTINGALE ROAD PHEASANTS NEST NSW 2574
NSW licence number	10CA119303 (Current)
Datum	GDA 94 Zone 56
Easting	282233.7
Northing	6205723.7
Elevation (mAHD)	NR
Purpose	Stock, irrigation, domestic
Bore Construction Details	
Drilling and construction records available	Yes
Date drilled/constructed	19/08/2016
Total depth of bore (m)	180
Geological Formation Screened	Sandstone
Bore Casing	
Material	NR
Diameter	200 mm OD 188 mm ID, 141 mm OD 129 mm ID
Stick-up	NR
Hydrogeological info	
Screened lithology/formation	Sandstone
Standing water level (mbgl)	35
Water quality	Salinity: 395 mg/L
Other bore log comments	Yield (L/s): 1.0
Data Collected While On Site	
Census Date	21/02/ 2022
Completed by	Chris Rotsider, Consulting Earth Scientists Pty Ltd
Photographs	
	
Bore Details	
Site Address	110 NIGHTINGALE ROAD, PHEASANTS NEST, NSW 2574

Bore: GW115773	Property: 110 NIGHTINGALE RD
GPS Location datum	GDA 94 Zone 56
Easting	282232
Northing	6205725
Elevation (mAHD) – specify survey method	NR
Drilling and construction records (Y/N)	N
Stick-up (casing, monument etc.)	Concrete monument, PVC stick up with steel cap
Total depth of bore (mbgl)	81.87
Depth to water (mbgl)	75.85
Pump status (if installed)	In situ electric pump
Logger status/condition (if installed). Serial no., make, model etc.	NA
Fencing/barrier installed?	No
Sampling method	In situ pump, 10 l water purged
Electrical Conductivity (µS/cm)	820
pH	6.0
Temperature (°C)	19.6
ORP (mV)	-10.8
Dissolved Oxygen (mg/L)	0.62
Colour, odour, characteristics etc.	Clear, no odour, low turbidity
Bore Pump Details (if relevant)	
Frequency of use	Daily
Typical pumping rate	NR
Purpose / Use of Bore	Irrigation
Comment:	
PVC casing and concrete base in good working order with plumbing into irrigation system.	

WaterNSW
Work Summary

GW115773

Licence: 10CA119303
Licence Status: CURRENT

Authorised Purpose(s): STOCK,IRRIGATION,DOMESTIC
Intended Purpose(s): STOCK, DOMESTIC

Work Type: Bore
Work Status: Supply Obtained
Construct.Method:
Owner Type: Private

Commenced Date:
Completion Date: 19/08/2016
Final Depth: 180.00 m
Drilled Depth: 180.00 m

Contractor Name: Ultra Drilling
Driller: Bradley Alan Dodd
Assistant Driller: RON JONES

Property: VELLA 110 NIGHTINGALE ROAD PHEASANT'S NEST N S W 2574
GWMA: -
GW Zone: -
Standing Water Level (m): 35.000
Salinity Description:
Yield (L/s): 2.500

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CAMDEN	BARGO	30//255689
Licensed:	CAMDEN	BARGO	Whole Lot 30//255689

Region: - (Not set)
CMA Map:

River Basin: - Unknown
Area/District:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown
Northing: 6205723.700
Easting: 282233.700
Latitude: 34°16'00.7"S
Longitude: 150°38'05.0"E

GS Map: -
MGA Zone: 56
Coordinate Source: Map Interpre

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	5.50	250			Rotary - Percussion (Down Hole H
1		Hole	Hole	5.50	35.00	171			Rotary - Percussion (Down Hole H
1		Hole	Hole	35.00	180.00	141			Rotary - Percussion (Down Hole H
1	1			0.00	36.00	141	129	0	
1	1			0.00	5.50	200	188	0	

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
55.00	56.00	1.00	Unknown			0.20		00:00:30	1360.00
120.00	132.00	12.00	Unknown			1.30		00:00:30	513.00
150.00	160.00	10.00	Unknown	35.00		1.00		00:01:00	395.00

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	3.00	3.00	CLAY	Clay	
3.00	20.00	17.00	SANDSTONE	Sandstone	
20.00	25.00	5.00	SHALE	Shale	
25.00	55.00	30.00	SANDSTONE, WHITE	Sandstone	
55.00	60.00	5.00	SANDSTONE, SHALE	Sandstone	
60.00	102.00	42.00	SANDSTONE, WHITE	Sandstone	
102.00	160.00	58.00	SANDSTONE, WHITE / QUARTZ	Sandstone	
160.00	165.00	5.00	SHALE	Shale	
165.00	180.00	15.00	SANDSTONE, - GREY SHALE	Sandstone	

Remarks

19/08/2016: FORM ENTERED BY DIANA SMITH 19/4/2018

***** End of GW115773 *****

Parameter	LOR	Unit	Nightinglae Rd
Registered Number			GW115773
Date			21-02-2022
Calcium - Dissolved	0.5	mg/L	10
Potassium - Dissolved	0.5	mg/L	4
Sodium - Dissolved	0.5	mg/L	110
Magnesium - Dissolved	0.5	mg/L	25
Hardness	3	mg/L	130
Hydroxide Alkalinity (OH-) as CaCO3	5	mg/L	<5
Bicarbonate Alkalinity as CaCO3	5	mg/L	<5
Carbonate Alkalinity as CaCO3	5	mg/L	<5
Total Alkalinity as CaCO3	5	mg/L	<5
Sulphate SO4	1	mg/L	86
Chloride Cl	1	mg/L	230
Ionic Balance	-	%	-6
Total Nitrogen in Water	0.1	mg/L	<0.1
Phosphorus Total	0.05	mg/L	0.4
Aluminium-Total	10	µg/L	<10
Arsenic-Total	1	µg/L	<10
Barium-Total	1	µg/L	<1
Beryllium-Total	0.5	µg/L	150
Cadmium-Total	0.1	µg/L	5
Chromium-Total	1	µg/L	<1
Cobalt-Total	1	µg/L	20000
Copper-Total	1	µg/L	33
Iron-Total	10	µg/L	20000
Lithium-Total	1	µg/L	33
Mercury-Total	0.05	µg/L	1100
Manganese-Total	5	µg/L	5
Nickel-Total	1	µg/L	<1
Lead-Total	1	µg/L	<1
Selenium-Total	1	µg/L	<1
Strontium-Total	1	µg/L	69
Vanadium-Total	1	µg/L	69
Zinc-Total	1	µg/L	3
Aluminium-Dissolved	10	µg/L	<10
Arsenic-Dissolved	1	µg/L	<10
Barium-Dissolved	1	µg/L	<1
Beryllium-Dissolved	0.5	µg/L	140
Cadmium-Dissolved	0.1	µg/L	5
Chromium-Dissolved	1	µg/L	<1
Cobalt-Dissolved	1	µg/L	34
Copper-Dissolved	1	µg/L	1200
Iron-Dissolved	10	µg/L	20000
Lithium-Dissolved	1	µg/L	34
Mercury-Dissolved	0.05	µg/L	6
Manganese-Dissolved	5	µg/L	<1
Nickel-Dissolved	1	µg/L	<1
Lead-Dissolved	1	µg/L	74
Selenium-Dissolved	1	µg/L	<1
Strontium-Dissolved	1	µg/L	74
Vanadium-Dissolved	1	µg/L	4
Zinc-Dissolved	1	µg/L	20000

Bore: GW116897	Property: 39 DAVID PL
Bore Identification Information (NSW Real Time Water Data)	
Bore name	GW116897
Property	Not listed
NSW licence number	NA
Datum	GDA 94 Zone 56
Easting	281442
Northing	6203190
Elevation (mAHD)	NR
Purpose	Stock, domestic
Bore Construction Details	
Drilling and construction records available	No
Date drilled/constructed	17/08/2018
Total depth of bore (m)	174
Geological Formation Screened	NR
Bore Casing	
Material	NR
Diameter	NR
Stick-up	NR
Hydrogeological info	
Screened lithology/formation	NR
Standing water level (mbgl)	NR
Water quality	NR
Other bore log comments	NR
Data Collected While On Site	
Census Date	03/02/2022
Completed by	Chris Rotsider, Consulting Earth Scientists Pty Ltd
Photographs (insert)	
	
Bore Details	
Site Address	39 DAVID PL, PHEASANTS NEST, 2574 NSW
GPS Location datum	GDA 94 Zone 56
Easting	281442
Northing	6203190
Elevation (mAHD) – specify survey method	NR
Drilling and construction records (Y/N)	N

Bore: GW116897	Property: 39 DAVID PL
Stick-up (casing, monument etc.)	Bore opening was covered by 30 cm of soil, metal sheeting cap
Total depth of bore (mbgl)	51.2 (potential blockage as installed to 160 m)
Depth to water (mbgl)	19.9
Pump status (if installed)	No pump installed
Logger status/condition (if installed). Serial no., make, model etc.	NA
Fencing/barrier installed?	Metal sheeting cap with chicken wire surrounding well
Sampling method	Micro-purging
Electrical Conductivity (µS/cm)	776
pH	4.2
Temperature (°C)	17.7
ORP (mV)	381.0
Dissolved Oxygen (mg/L)	4.28
Colour, odour, characteristics etc.	No odour, low turbidity
Bore Pump Details (if relevant)	
Frequency of use	Not currently used
Typical pumping rate	NA
Purpose / Use of Bore	Waiting for pump install for future crop irrigation
Comment:	
Water extracted: 1 l Recovery time: 3 min 40 s	

Parameter	LOR	Unit	39 David Pl
Registered Number			GW116897
Date			03-02-2022
Calcium - Dissolved	0.5	mg/L	<0.5
Potassium - Dissolved	0.5	mg/L	0.9
Sodium - Dissolved	0.5	mg/L	120
Magnesium - Dissolved	0.5	mg/L	16
Hardness	3	mg/L	65
Hydroxide Alkalinity (OH-) as CaCO3	5	mg/L	<5
Bicarbonate Alkalinity as CaCO3	5	mg/L	<5
Carbonate Alkalinity as CaCO3	5	mg/L	<5
Total Alkalinity as CaCO3	5	mg/L	<5
Sulphate SO4	1	mg/L	41
Chloride Cl	1	mg/L	250
Ionic Balance	-	%	-9
Total Nitrogen in Water	0.1	mg/L	0.7
Phosphorus Total	0.05	mg/L	<0.05
Aluminium-Total	10	µg/L	1900
Arsenic-Total	1	µg/L	1900
Barium-Total	1	µg/L	<1
Beryllium-Total	0.5	µg/L	110
Cadmium-Total	0.1	µg/L	5
Chromium-Total	1	µg/L	6
Cobalt-Total	1	µg/L	730
Copper-Total	1	µg/L	7
Iron-Total	10	µg/L	730
Lithium-Total	1	µg/L	7
Mercury-Total	0.05	µg/L	79
Manganese-Total	5	µg/L	3
Nickel-Total	1	µg/L	23
Lead-Total	1	µg/L	<1
Selenium-Total	1	µg/L	<1
Strontium-Total	1	µg/L	5.5
Vanadium-Total	1	µg/L	5.5
Zinc-Total	1	µg/L	49
Aluminium-Dissolved	10	µg/L	2000
Arsenic-Dissolved	1	µg/L	2000
Barium-Dissolved	1	µg/L	<1
Beryllium-Dissolved	0.5	µg/L	110
Cadmium-Dissolved	0.1	µg/L	5
Chromium-Dissolved	1	µg/L	5
Cobalt-Dissolved	1	µg/L	5
Copper-Dissolved	1	µg/L	88
Iron-Dissolved	10	µg/L	30
Lithium-Dissolved	1	µg/L	5
Mercury-Dissolved	0.05	µg/L	4
Manganese-Dissolved	5	µg/L	18
Nickel-Dissolved	1	µg/L	<1
Lead-Dissolved	1	µg/L	6
Selenium-Dissolved	1	µg/L	<1
Strontium-Dissolved	1	µg/L	6
Vanadium-Dissolved	1	µg/L	44
Zinc-Dissolved	1	µg/L	30

Bore: HERITAGE WELL	Property: 3105 REMEMBRANCE DR
Bore Identification Information (NSW Real Time Water Data)	
Bore name	Site not found in NSW database.
Property	
NSW licence number	
Datum	
Easting	
Northing	
Elevation (mAHD)	
Purpose	
Bore Construction Details	
Drilling and construction records available	
Date drilled/constructed	
Total depth of bore (m)	
Geological Formation Screened	
Bore Casing	
Material	
Diameter	
Stick-up	
Hydrogeological info	
Screened lithology/formation	
Standing water level (mbgl)	
Water quality	
Other bore log comments	

Data Collected While On Site	
Census Date	10/02/2022
Completed by	Chris Rotsider, Consulting Earth Scientists Pty Ltd
Photographs	

Bore Details

Bore: HERITAGE WELL	Property: 3105 REMEMBRANCE DR
Site Address	3105 REMEMBRANCE DR TAHMOOR 2573 NSW
GPS Location datum	GDA 94 Zone 56
Easting	276604
Northing	6205057
Elevation (mAHD) – specify survey method	NR
Drilling and construction records (Y/N)	N
Stick-up (casing, monument etc.)	Well open to air and flush to ground ~ 2 m wide
Total depth of bore (mbgl)	3.12
Depth to water (mbgl)	1.15
Pump status (if installed)	No pump
Logger status/condition (if installed). Serial no., make, model etc.	NA
Fencing/barrier installed?	No
Sampling method	Bailer
Electrical Conductivity (µS/cm)	684
pH	6.79
Temperature (°C)	23.7
ORP (mV)	98.2
Dissolved Oxygen (mg/L)	10.29
Colour, odour, characteristics etc.	Black colour, no odour, moderate turbidity
Bore Pump Details (if relevant)	
Frequency of use	Unused in recent history
Typical pumping rate	NA
Purpose / Use of Bore	Not used
Comment:	
Approximately 2 m wide flush to ground and open to air.	

Parameter	LOR	Unit	3105 Remembrance Rd
Registered Number			Heritage Well
Date			10-02-2022
Calcium - Dissolved	0.5	mg/L	<0.5
Potassium - Dissolved	0.5	mg/L	4
Sodium - Dissolved	0.5	mg/L	5.8
Magnesium - Dissolved	0.5	mg/L	<0.5
Hardness	3	mg/L	<3
Hydroxide Alkalinity (OH-) as CaCO3	5	mg/L	<5
Bicarbonate Alkalinity as CaCO3	5	mg/L	14
Carbonate Alkalinity as CaCO3	5	mg/L	<5
Total Alkalinity as CaCO3	5	mg/L	14
Sulphate SO4	1	mg/L	<1
Chloride Cl	1	mg/L	9
Ionic Balance	-	%	-21
Total Nitrogen in Water	0.1	mg/L	2.4
Phosphorus Total	0.05	mg/L	0.09
Aluminium-Total	10	µg/L	470
Arsenic-Total	1	µg/L	470
Barium-Total	1	µg/L	2
Beryllium-Total	0.5	µg/L	7
Cadmium-Total	0.1	µg/L	<1
Chromium-Total	1	µg/L	<1
Cobalt-Total	1	µg/L	10000
Copper-Total	1	µg/L	<1
Iron-Total	10	µg/L	10000
Lithium-Total	1	µg/L	<1
Mercury-Total	0.05	µg/L	95
Manganese-Total	5	µg/L	4
Nickel-Total	1	µg/L	2
Lead-Total	1	µg/L	<1
Selenium-Total	1	µg/L	<1
Strontium-Total	1	µg/L	37
Vanadium-Total	1	µg/L	37
Zinc-Total	1	µg/L	5
Aluminium-Dissolved	10	µg/L	230
Arsenic-Dissolved	1	µg/L	230
Barium-Dissolved	1	µg/L	1
Beryllium-Dissolved	0.5	µg/L	6
Cadmium-Dissolved	0.1	µg/L	<1
Chromium-Dissolved	1	µg/L	<1
Cobalt-Dissolved	1	µg/L	<1
Copper-Dissolved	1	µg/L	29
Iron-Dissolved	10	µg/L	3200
Lithium-Dissolved	1	µg/L	<1
Mercury-Dissolved	0.05	µg/L	<1
Manganese-Dissolved	5	µg/L	1
Nickel-Dissolved	1	µg/L	<1
Lead-Dissolved	1	µg/L	32
Selenium-Dissolved	1	µg/L	<1
Strontium-Dissolved	1	µg/L	32
Vanadium-Dissolved	1	µg/L	4
Zinc-Dissolved	1	µg/L	3200

Bore: 115 NTG	Property: 115 NIGHTINGALE RD
Bore Identification Information (NSW Real Time Water Data)	
Bore name	Bore not found in NSW database.
Property	
NSW licence number	
Datum	
Easting	
Northing	
Elevation (mAHD)	
Purpose	
Bore Construction Details	
Drilling and construction records available	
Date drilled/constructed	
Total depth of bore (m)	
Geological Formation Screened	
Bore Casing	
Material	
Diameter	
Stick-up	
Hydrogeological info	
Screened lithology/formation	
Standing water level (mbgl)	
Water quality	
Other bore log comments	

Data Collected While On Site

Census Date	22/02/ 2022
Completed by	Chris Rotsider, Consulting Earth Scientists Pty Ltd
Photographs	

Bore Details	
Site Address	115 NIGHTINGALE RD, PHEASANTS NEST, 2574

Bore: 115 NTG	Property: 115 NIGHTINGALE RD
GPS Location datum	GDA 94 Zone 56
Easting	281781
Northing	6206145
Elevation (mAHD) – specify survey method	NR
Drilling and construction records (Y/N)	N
Stick-up (casing, monument etc.)	PVC stick up
Total depth of bore (mbgl)	Not measured, 160 – 170 m reported install depth
Depth to water (mbgl)	41.67
Pump status (if installed)	No pump installed, soon to be installed
Logger status/condition (if installed). Serial no., make, model etc.	NA
Fencing/barrier installed?	No
Sampling method	Micro-purging, 7 l water purged
Electrical Conductivity (µS/cm)	689
pH	5.74
Temperature (°C)	19.4
ORP (mV)	109.0
Dissolved Oxygen (mg/L)	0.97
Colour, odour, characteristics etc.	Brown colour, metallic odour, turbid
Bore Pump Details (if relevant)	
Frequency of use	Not currently used until pump installed in next few months
Typical pumping rate	NA
Purpose / Use of Bore	Not currently used until pump installed in next few months
Comment:	
PVC casing in good working order, no concrete on base. Well diameter 150mm 10 min discharge duration, < 4min recharge	

Parameter	LOR	Unit	115 Nightinggale Rd
Registered Number			115NTG
Date			23-02-2022
Calcium - Dissolved	0.5	mg/L	11
Potassium - Dissolved	0.5	mg/L	7.5
Sodium - Dissolved	0.5	mg/L	270
Magnesium - Dissolved	0.5	mg/L	62
Hardness	3	mg/L	280
Hydroxide Alkalinity (OH-) as CaCO3	5	mg/L	<5
Bicarbonate Alkalinity as CaCO3	5	mg/L	73
Carbonate Alkalinity as CaCO3	5	mg/L	<5
Total Alkalinity as CaCO3	5	mg/L	73
Sulphate SO4	1	mg/L	41
Chloride Cl	1	mg/L	570
Ionic Balance	-	%	-2
Total Nitrogen in Water	0.1	mg/L	0.2
Phosphorus Total	0.05	mg/L	1.3
Aluminium-Total	10	µg/L	130
Arsenic-Total	1	µg/L	130
Barium-Total	1	µg/L	9
Beryllium-Total	0.5	µg/L	210
Cadmium-Total	0.1	µg/L	35
Chromium-Total	1	µg/L	54
Cobalt-Total	1	µg/L	580000
Copper-Total	1	µg/L	54
Iron-Total	10	µg/L	580000
Lithium-Total	1	µg/L	54
Mercury-Total	0.05	µg/L	1600
Manganese-Total	5	µg/L	35
Nickel-Total	1	µg/L	22
Lead-Total	1	µg/L	<1
Selenium-Total	1	µg/L	<1
Strontium-Total	1	µg/L	130
Vanadium-Total	1	µg/L	130
Zinc-Total	1	µg/L	590
Aluminium-Dissolved	10	µg/L	10
Arsenic-Dissolved	1	µg/L	10
Barium-Dissolved	1	µg/L	<1
Beryllium-Dissolved	0.5	µg/L	130
Cadmium-Dissolved	0.1	µg/L	24
Chromium-Dissolved	1	µg/L	6
Cobalt-Dissolved	1	µg/L	54
Copper-Dissolved	1	µg/L	1600
Iron-Dissolved	10	µg/L	610
Lithium-Dissolved	1	µg/L	54
Mercury-Dissolved	0.05	µg/L	27
Manganese-Dissolved	5	µg/L	<1
Nickel-Dissolved	1	µg/L	<1
Lead-Dissolved	1	µg/L	140
Selenium-Dissolved	1	µg/L	<1
Strontium-Dissolved	1	µg/L	140
Vanadium-Dissolved	1	µg/L	610
Zinc-Dissolved	1	µg/L	6100

Bore: GW10CA119328	Property: 85 DWYERS RD
Bore Identification Information (NSW Real Time Water Data)	
Bore name	The bore was not found in the NSW database. There are no registered bores within a 500 m radius of the coordinates provided by the bore census.
Property	
NSW licence number	
Datum	
Easting	
Northing	
Elevation (mAHD)	
Purpose	
Bore Construction Details	
Drilling and construction records available	
Date drilled/constructed	
Total depth of bore (m)	
Geological Formation Screened	
Bore Casing	
Material	
Diameter	
Stick-up	
Hydrogeological info	
Screened lithology/formation	
Standing water level (mbgl)	
Water quality	
Other bore log comments	

Data Collected While On Site	
Census Date	03/02/2022
Completed by	Chris Rotsider, Consulting Earth Scientists Pty Ltd
Photographs	

Bore Details	
Site Address	85 DWYERS RD, PHEASANTS NEST, 2574 NSW
GPS Location datum	GDA 94 Zone 56
Easting	280984
Northing	6204822
Elevation (mAHD) – specify survey method	NR

Bore: GW10CA119328	Property: 85 DWYERS RD
Drilling and construction records (Y/N)	N
Stick-up (casing, monument etc.)	Concrete monument, steel stick up with metal cap
Total depth of bore (mbgl)	180 (anecdotal, not measured)
Depth to water (mbgl)	54.4
Pump status (if installed)	In situ electric pump
Logger status/condition (if installed). Serial no., make, model etc.	NA
Fencing/barrier installed?	Chicken wire surrounding bore
Sampling method	In situ pump
Electrical Conductivity (µS/cm)	1472
pH	5.7
Temperature (°C)	19.3
ORP (mV)	43.2
Dissolved Oxygen (mg/L)	0.49
Colour, odour, characteristics etc.	No odour, low turbidity
Bore Pump Details (if relevant)	
Frequency of use	Daily (when onsite dam is low)
Typical pumping rate	NR
Purpose / Use of Bore	Irrigation
Comment:	
Concrete footing in fair/good condition, metal head and piping in good condition. Bore water is channelled via PVC piping to a dam located approximately 200 m east.	

Parameter	LOR	Unit	85 Dwyers Rd
Registered Number			10CA119328
Date			03-02-2022
Calcium - Dissolved	0.5	mg/L	8.9
Potassium - Dissolved	0.5	mg/L	5.8
Sodium - Dissolved	0.5	mg/L	210
Magnesium - Dissolved	0.5	mg/L	47
Hardness	3	mg/L	210
Hydroxide Alkalinity (OH-) as CaCO3	5	mg/L	<5
Bicarbonate Alkalinity as CaCO3	5	mg/L	72
Carbonate Alkalinity as CaCO3	5	mg/L	<5
Total Alkalinity as CaCO3	5	mg/L	72
Sulphate SO4	1	mg/L	29
Chloride Cl	1	mg/L	490
Ionic Balance	-	%	-8
Total Nitrogen in Water	0.1	mg/L	<0.1
Phosphorus Total	0.05	mg/L	<0.05
Aluminium-Total	10	µg/L	60
Arsenic-Total	1	µg/L	60
Barium-Total	1	µg/L	<1
Beryllium-Total	0.5	µg/L	160
Cadmium-Total	0.1	µg/L	26
Chromium-Total	1	µg/L	<1
Cobalt-Total	1	µg/L	41000
Copper-Total	1	µg/L	48
Iron-Total	10	µg/L	41000
Lithium-Total	1	µg/L	48
Mercury-Total	0.05	µg/L	2300
Manganese-Total	5	µg/L	23
Nickel-Total	1	µg/L	<1
Lead-Total	1	µg/L	<1
Selenium-Total	1	µg/L	<1
Strontium-Total	1	µg/L	98
Vanadium-Total	1	µg/L	98
Zinc-Total	1	µg/L	36
Aluminium-Dissolved	10	µg/L	10
Arsenic-Dissolved	1	µg/L	10
Barium-Dissolved	1	µg/L	<1
Beryllium-Dissolved	0.5	µg/L	170
Cadmium-Dissolved	0.1	µg/L	26
Chromium-Dissolved	1	µg/L	<1
Cobalt-Dissolved	1	µg/L	47
Copper-Dissolved	1	µg/L	2500
Iron-Dissolved	10	µg/L	20000
Lithium-Dissolved	1	µg/L	47
Mercury-Dissolved	0.05	µg/L	22
Manganese-Dissolved	5	µg/L	<1
Nickel-Dissolved	1	µg/L	<1
Lead-Dissolved	1	µg/L	98
Selenium-Dissolved	1	µg/L	<1
Strontium-Dissolved	1	µg/L	98
Vanadium-Dissolved	1	µg/L	8
Zinc-Dissolved	1	µg/L	20000

Bore: GW032443	Property: Tahmoor South
Bore Identification Information (NSW Real Time Water Data)	
Bore name/nickname	GW032443
Property	Not listed
NSW licence number	10BL023692 (cancelled)
Datum	GDA94 Zone 56
Easting	276415
Northing	6206336
Elevation (mAHD)	NR
Bore Status	Irrigation, domestic
Bore Construction Details	
Drilling and construction records available	Yes
Date drilled/constructed	01/02/1966
Total depth of bore (m)	130.1
Geological Formation Screened	Sandstone
Bore Casing	
Material	Cemented
Diameter	152 mm OD
Stick-up	0.3 m
Hydrogeological info	
Screened lithology/formation	Sandstone
Standing water level (mbgl)	26.2
Water quality	Salinity: NR
Other bore log comments	Yield (Ls): 1.26
Data Collected While On Site	
Census Date	25/01/2022
Completed by	Chris Rotsider, Consulting Earth Scientists Pty Ltd
Photographs (insert)	

Bore Details	
Site Address	10 CALOOLA RD, BARGO, 2574 NSW
GPS Location datum	GDA 94 Zone 56
Easting	276427
Northing	6206329
Elevation (mAHD) – specify survey method	NR
Drilling and construction records (Y/N)	Y

Bore: GW032443	Property: Tahmoor South
Stick-up (casing, monument etc.)	Concrete flooring, bore at ground level, Iron cap
Casing Diameter	200mm
Total depth of bore (mbgl)	10.71 measured (likely blocked)
Depth to water (mbgl)	0.71
Pump status (if installed)	No pump
Logger status/condition (if installed). Serial no., make, model etc.	NA
Fencing/barrier installed?	No
Sampling method	Micro purge
Electrical Conductivity (µS/cm)	226.2
pH	5.96
Temperature (°C)	19.6
ORP (mV)	13.2
Dissolved Oxygen (mg/L)	8.42
Colour, odour, characteristics etc.	No odour, low turbidity, no signs of contamination
Bore Pump Details (if relevant)	
Frequency of use	Not currently used
Typical pumping rate	NA
Purpose / Use of Bore	Not currently used
Comment:	
Well head at ground level. Property formerly used as an apple orchard. Tenant estimates that the well base has been in place for 50+ years. Owner wasn't aware that there was water in the well.	

WaterNSW
Work Summary

GW032443

Licence: 10BL023692

Licence Status: CANCELLED

Authorised Purpose(s): IRRIGATION,DOMESTIC
Intended Purpose(s): IRRIGATION

Work Type: Bore open thru rock
Work Status: Needs Reconditioning
Construct.Method: Rotary
Owner Type: Private

Commenced Date:
Completion Date: 01/02/1966

Final Depth: 130.10 m
Drilled Depth: 130.10 m

Contractor Name: (None)
Driller:
Assistant Driller:

Property: N/A NSW

GWMA: -
GW Zone: -

Standing Water Level (m):
Salinity Description: invalid code
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CAMDEN	BARGO	9
Licensed:	CAMDEN	BARGO	Whole Lot //

Region: 10 - Sydney South Coast
River Basin: 212 - HAWKESBURY RIVER
Area/District:

CMA Map: 9029-3N
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: (Unknown)

Northing: 6206336.000
Easting: 276415.000

Latitude: 34°15'36.3"S
Longitude: 150°34'18.2"E

GS Map: -
MGA Zone: 56
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing		-0.30	2.70	152			Cemented

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
13.40	14.00	0.60	Consolidated			0.04			
26.20	26.20	0.00	Consolidated						
60.90	60.90	0.00	Consolidated						
67.60	85.20	17.60	Consolidated						
87.10	87.10	0.00	Consolidated			0.91			
97.80	98.70	0.90	Consolidated	26.20		1.26			

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.60	0.60	Soil	Soil	
0.60	1.82	1.22	Clay	Clay	
1.82	2.74	0.92	Sandstone Broken	Sandstone	
2.74	3.65	0.91	Sandstone Fine	Sandstone	
3.65	4.57	0.92	Sandstone Light Khaki	Sandstone	
4.57	5.48	0.91	Sandstone White	Sandstone	
5.48	5.79	0.31	Sandstone	Sandstone	
5.79	6.09	0.30	Sandstone White	Sandstone	
6.09	6.40	0.31	Shale Grey	Shale	
6.40	7.92	1.52	Sandstone	Sandstone	
7.92	9.75	1.83	Sandstone Cream	Sandstone	
9.75	10.36	0.61	Sandstone	Sandstone	
10.36	10.66	0.30	Sandstone Cream	Sandstone	
10.66	11.58	0.92	Sandstone Light Khaki	Sandstone	
11.58	12.19	0.61	Shale Grey	Shale	
12.19	13.41	1.22	Sandstone Cream	Sandstone	
13.41	14.02	0.61	Sandstone Soft Water Supply	Sandstone	
14.02	15.54	1.52	Sandstone Cream	Sandstone	
15.54	16.76	1.22	Sandstone Reddish	Sandstone	
16.76	18.28	1.52	Sandstone Grey Shaley	Sandstone	
18.28	20.72	2.44	Sandstone Grey	Sandstone	
20.72	21.94	1.22	Sandstone Light Brown	Sandstone	
21.94	26.21	4.27	Sandstone Cream Water Supply	Sandstone	
26.21	26.51	0.30	Sandstone Grey Cream	Sandstone	
26.51	27.43	0.92	Sandstone Light Brown	Sandstone	
27.43	28.34	0.91	Sandstone Yellow	Sandstone	
28.34	32.91	4.57	Sandstone Cream	Sandstone	
32.91	34.74	1.83	Sandstone Yellow	Sandstone	
34.74	35.05	0.31	Sandstone	Sandstone	
35.05	36.27	1.22	Sandstone Grey Cream	Sandstone	
36.27	36.57	0.30	Shale Grey	Shale	
36.57	37.79	1.22	Sandstone Grey Cream	Sandstone	
37.79	40.84	3.05	Sandstone White	Sandstone	
40.84	41.75	0.91	Sandstone Grey	Sandstone	
41.75	52.12	10.37	Sandstone Grey Cream	Sandstone	
52.12	52.73	0.61	Sandstone Dark Grey	Sandstone	
52.73	57.91	5.18	Sandstone Grey Cream	Sandstone	
57.91	61.56	3.65	Sandstone Cream Water Supply	Sandstone	
61.56	62.48	0.92	Sandstone Grey	Sandstone	
62.48	67.66	5.18	Sandstone Grey Cream	Sandstone	
67.66	86.56	18.90	Sandstone Cream Water Supply	Sandstone	
86.56	87.17	0.61	Sandstone Cream Coarse Water Supply	Sandstone	
87.17	90.52	3.35	Sandstone Cream	Sandstone	
90.52	99.36	8.84	Sandstone White Water Supply	Sandstone	
99.36	109.11	9.75	Shale Grey	Shale	
109.11	130.14	21.03	Sandstone White	Sandstone	

Remarks

19/02/1975: Changed from 90.53m to 130.15m on 22/07/69 ORIGINAL CASING RETAINED

***** End of GW032443 *****

Site GW032443 Latest Values

Measure	Data Type	Hole	Pipe	Date	Value
Bore Water Level below Measuring Point (Metres)	Manual	1	1	22/02/1978 @ 00:00	10.240

Parameter	LOR	Unit	10 Caloola Rd
Registered Number			GW032443
Date			25-01-2022
Calcium - Dissolved	0.5	mg/L	13
Potassium - Dissolved	0.5	mg/L	<0.5
Sodium - Dissolved	0.5	mg/L	21
Magnesium - Dissolved	0.5	mg/L	3
Hardness	3	mg/L	45
Hydroxide Alkalinity (OH-) as CaCO3	5	mg/L	<5
Bicarbonate Alkalinity as CaCO3	5	mg/L	66
Carbonate Alkalinity as CaCO3	5	mg/L	<5
Total Alkalinity as CaCO3	5	mg/L	66
Sulphate SO4	1	mg/L	4
Chloride Cl	1	mg/L	36
Ionic Balance	-	%	-14
Total Nitrogen in Water	0.1	mg/L	0.1
Phosphorus Total	0.05	mg/L	<0.05
Aluminium-Total	10	µg/L	490
Arsenic-Total	1	µg/L	<1
Barium-Total	1	µg/L	13
Beryllium-Total	0.5	µg/L	<0.5
Cadmium-Total	0.1	µg/L	2.2
Chromium-Total	1	µg/L	<1
Cobalt-Total	1	µg/L	<1
Copper-Total	1	µg/L	<1
Iron-Total	10	µg/L	22000
Lithium-Total	1	µg/L	1
Mercury-Total	0.05	µg/L	<0.05
Manganese-Total	5	µg/L	77
Nickel-Total	1	µg/L	4
Lead-Total	1	µg/L	12
Selenium-Total	1	µg/L	<1
Strontium-Total	1	µg/L	17
Vanadium-Total	1	µg/L	<1
Zinc-Total	1	µg/L	1200
Aluminium-Dissolved	10	µg/L	<10
Arsenic-Dissolved	1	µg/L	<1
Barium-Dissolved	1	µg/L	12
Beryllium-Dissolved	0.5	µg/L	<0.5
Cadmium-Dissolved	0.1	µg/L	0.4
Chromium-Dissolved	1	µg/L	<1
Cobalt-Dissolved	1	µg/L	<1
Copper-Dissolved	1	µg/L	3
Iron-Dissolved	10	µg/L	14000
Lithium-Dissolved	1	µg/L	1
Mercury-Dissolved	0.05	µg/L	<0.05
Manganese-Dissolved	5	µg/L	74
Nickel-Dissolved	1	µg/L	2
Lead-Dissolved	1	µg/L	<1
Selenium-Dissolved	1	µg/L	<1
Strontium-Dissolved	1	µg/L	18
Vanadium-Dissolved	1	µg/L	<1
Zinc-Dissolved	1	µg/L	1300

Bore: GW045404	Property: 170 NIGHTINGALE RD
Bore Identification Information (NSW Real Time Water Data)	
Bore name	GW045404
Property	Not listed
NSW licence number	10WA109772 (current)
Datum	GDA 94 Zone 56
Easting	282217
Northing	6206689
Elevation (mAHD)	NR
Purpose	Domestic, stock, general use
Bore Construction Details	
Drilling and construction records available	Yes
Date drilled/constructed	01/01/1952
Total depth of bore (m)	53.3
Geological Formation Screened	Sandstone
Bore Casing	
Material	NR
Diameter	NR
Stick-up	NR
Hydrogeological info	
Screened lithology/formation	Sandstone
Standing water level (mbgl)	NR
Water quality	Salinity description: Hard
Other bore log comments	NA
Data Collected While On Site	
Census Date	February 2022
Completed by	Chris Rotsider, Consulting Earth Scientists Pty Ltd
Photographs	

Bore Details

Bore: GW045404	Property: 170 NIGHTINGALE RD
Site Address	170 NIGHTINGALE RD, PHEASANTS NEST, 2574
GPS Location datum	GDA 94 Zone 56
Easting	282730
Northing	6206227
Elevation (mAHD) – specify survey method	NR
Drilling and construction records (Y/N)	Y
Stick-up (casing, monument etc.)	Concrete base, steel stick up with steel cap
Total depth of bore (mbgl)	72.73 could be blocked*
Depth to water (mbgl)	Dry or blocked
Pump status (if installed)	Pump installed but not operational
Logger status/condition (if installed). Serial no., make, model etc.	NA
Fencing/barrier installed?	No
Sampling method	No sample obtained as no water detected.
Electrical Conductivity (µS/cm)	NR
pH	NR
Temperature (°C)	NR
ORP (mV)	NR
Dissolved Oxygen (mg/L)	NR
Colour, odour, characteristics etc.	NR
Bore Pump Details (if relevant)	
Frequency of use	Not used for years
Typical pumping rate	NR
Purpose / Use of Bore	Not in use
Comment:	
Metal well casing with rust but still in fair working order. Concrete base in good working order. *Measured depth greater than recorded bore depth	

WaterNSW
Work Summary

GW045404

Licence: 10WA109772

Licence Status: CURRENT

Authorised Purpose(s): DOMESTIC,STOCK
Intended Purpose(s): GENERAL USE

Work Type: Bore open thru rock
Work Status:
Construct.Method: Cable Tool
Owner Type: Private

Commenced Date:
Completion Date: 01/01/1952

Final Depth: 53.30 m
Drilled Depth: 53.30 m

Contractor Name: (None)
Driller:
Assistant Driller:

Property: NARRINGA NSW
GWMA: -
GW Zone: -

Standing Water Level (m):
Salinity Description: Hard
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CAMDEN	BARGO	92
Licensed:	CAMDEN	BARGO	Whole Lot //

Region: 10 - Sydney South Coast
River Basin: 212 - HAWKESBURY RIVER
Area/District:

CMA Map: 9029-3N
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: (Unknown)

Northing: 6206689.000
Easting: 282217.000

Latitude: 34°15'29.3"S
Longitude: 150°38'05.2"E

GS Map: -
MGA Zone: 56
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing		0.00	0.60				

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.46	0.46	Nominal	(Unknown)	
0.46	53.34	52.88	Sandstone Or Rock Water Supply	Sandstone	

***** End of GW045404 *****

Bore: GW053450	Property: 110 NIGHTINGALE RD
Bore Identification Information (NSW Real Time Water Data)	
Bore name	GW053450
Property	Not listed
NSW licence number	NA
Datum	GDA 94 Zone 56
Easting	282313
Northing	66205890
Elevation (mAHD)	NR
Purpose	Irrigation
Bore Construction Details	
Drilling and construction records available	Yes
Date drilled/constructed	01/09/1981
Total depth of bore (m)	120
Geological Formation Screened	Sandstone
Bore Casing	
Material	Welded steel, pressure cemented
Diameter	Steel 168 mm OD
Stick-up	0.2 m
Hydrogeological info	
Screened lithology/formation	Sandstone
Standing water level (mbgl)	73
Water quality	Salinity description: Fresh
Other bore log comments	Yield (L/s): 0.50
Data Collected While On Site	
Census Date	February 2022
Completed by	Chris Rotsider, Consulting Earth Scientists Pty Ltd
Photographs	

Bore Details

Bore: GW053450	Property: 110 NIGHTINGALE RD
Site Address	110 NIGHTINGALE RD, PHEASANTS NEST, 2574
GPS Location datum	GDA 94 Zone 56
Easting	282301
Northing	6205841
Elevation (mAHD) – specify survey method	NR
Drilling and construction records (Y/N)	Y
Stick-up (casing, monument etc.)	Metal casing stick up with steel cap
Total depth of bore (mbgl)	NR
Depth to water (mbgl)	NR
Pump status (if installed)	In situ electric pump (non-operational)
Logger status/condition (if installed). Serial no., make, model etc.	NA
Fencing/barrier installed?	No
Sampling method	No sample obtained as bore sealed shut
Electrical Conductivity (µS/cm)	NR
pH	NR
Temperature (°C)	NR
ORP (mV)	NR
Dissolved Oxygen (mg/L)	NR
Colour, odour, characteristics etc.	NR
Bore Pump Details (if relevant)	
Frequency of use	Not currently used after pump ceased working 2 years ago
Typical pumping rate	NR
Purpose / Use of Bore	Not currently used
Comment:	
Metal well casing in fair/good working order.	

WaterNSW
Work Summary

GW053450

Licence:

Licence Status:

Authorised Purpose(s):
Intended Purpose(s): IRRIGATION

Work Type: Bore open thru rock
Work Status:
Construct.Method: Cable Tool
Owner Type: Private

Commenced Date:
Completion Date: 01/09/1981

Final Depth: 120.00 m
Drilled Depth: 120.00 m

Contractor Name: (None)
Driller: John Hans Iselt
Assistant Driller:

Property:
GWMA:
GW Zone:

Standing Water Level (m):
Salinity Description: Fresh
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CAMDEN	BARGO	L30 DP255689 (79)
Licensed:			

Region: 10 - Sydney South Coast
River Basin: 212 - HAWKESBURY RIVER
Area/District:

CMA Map: 9029-3N
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: (Unknown)

Northing: 6205890.000
Easting: 282313.000

Latitude: 34°15'55.3"S
Longitude: 150°38'08.2"E

GS Map: -
MGA Zone: 56
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Welded Steel	-0.20	20.00	168			Cemented
1	1	Casing	Pressure Cemented Casing	0.00	20.00				

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
82.10	82.40	0.30	Consolidated	66.00		0.25			
106.10	107.00	0.90	Consolidated	73.00		0.50			

Drillers Log

From	To	Thickness	Drillers Description	Geological Material	Comments

(m)	(m)	(m)			
0.00	0.40	0.40	Topsoil	Topsoil	
0.40	17.60	17.20	Shale Clay	Shale	
17.60	46.50	28.90	Sandstone Grey	Sandstone	
46.50	47.30	0.80	Sandstone Yellow	Sandstone	
47.30	48.00	0.70	Shale	Shale	
48.00	82.10	34.10	Sandstone Grey	Sandstone	
82.10	82.40	0.30	Sandstone Grey Open Water Supply	Sandstone	
82.40	101.50	19.10	Sandstone Grey	Sandstone	
101.50	102.00	0.50	Shale	Shale	
102.00	106.20	4.20	Sandstone Grey	Sandstone	
106.20	107.00	0.80	Sandstone Grey Open Water Supply	Sandstone	
107.00	120.00	13.00	Sandstone Grey	Sandstone	

***** End of GW053450 *****

Bore: GW054146	Property: Tahmoor South
Bore Identification Information (NSW Real Time Water Data)	
Bore name	GW054146
Property	NR
NSW licence number	NR
Datum	GDA94 Zone 56
Easting	279833
Northing	6204691
Elevation (mAHD)	NR
Purpose	Stock, domestic
Bore Construction Details	
Drilling and construction records available	Yes
Date drilled/constructed	01/10/1981
Total depth of bore (m)	104
Geological Formation Screened	NR
Bore Casing	
Material	Welded Steel
Diameter	168mm OD
Stick-up	0.3 m
Hydrogeological info	
Screened lithology/formation	Sandstone
Standing water level (mbgl)	70
Water quality	NR
Other bore log comments	Yield (Ls): 0.9
Data Collected While On Site	
Census Date	January 2022
Completed by	Chris Rotsider, Consulting Earth Scientists Pty Ltd
Photographs (insert)	

Bore Details

Bore: GW054146	Property: Tahmoor South
Site Address	290 ARINA RD BARGO 2574 NSW
GPS Location datum	GDA94 Zone 56
Easting	279880
Northing	6204679
Elevation (mAHD) – specify survey method	NR
Drilling and construction records (Y/N)	Y
Stick-up (casing, monument etc.)	Concrete pad flush with ground, metal stick up with metal cap
Total depth of bore (mbgl)	NR
Depth to water (mbgl)	NR
Pump status (if installed)	NR
Logger status/condition (if installed). Serial no., make, model etc.	NA
Fencing/barrier installed?	NA
Sampling method	In-situ electric pump non-operational
Electrical Conductivity (µS/cm)	NR
pH	NR
Temperature (°C)	NR
ORP (mV)	NR
Dissolved Oxygen (mg/L)	NR
Colour, odour, characteristics etc.	NR
Bore Pump Details (if relevant)	
Frequency of use	Not currently in use
Typical pumping rate	NA
Purpose / Use of Bore	Not currently in use
Comment:	
No sample was able to be obtained due to bolted cap and non functional in-situ pump. Headworks for this monitoring well were encountered to be in a reasonable working condition.	

WaterNSW
Work Summary

GW054146

Licence:

Licence Status:

Authorised Purpose(s):
Intended Purpose(s): STOCK, DOMESTIC

Work Type: Bore open thru rock
Work Status:
Construct.Method: Cable Tool
Owner Type: Private

Commenced Date:
Completion Date: 01/10/1981

Final Depth: 104.00 m
Drilled Depth: 104.00 m

Contractor Name: (None)
Driller: John Hans Iselt
Assistant Driller:

Property:
GWMA:
GW Zone:

Standing Water Level (m):
Salinity Description: Fresh
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CAMDEN	BARGO	22
Licensed:			

Region: 10 - Sydney South Coast
River Basin: 212 - HAWKESBURY RIVER
Area/District:

CMA Map: 9029-3N
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: (Unknown)

Northing: 6204691.000
Easting: 279833.000

Latitude: 34°16'32.3"S
Longitude: 150°36'30.2"E

GS Map: -
MGA Zone: 56
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Welded Steel	-0.30	3.70	168			Driven into Hole

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
86.00	87.20	1.20	Consolidated	70.00		0.90			

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.40	0.40	Soil	Soil	
0.40	2.40	2.00	Shale Clay	Shale	

2.40	72.10	69.70	Sandstone Yellow	Sandstone	
72.10	86.00	13.90	Sandstone Grey	Sandstone	
86.00	87.20	1.20	Sandstone Grey Open Water Supply	Sandstone	
87.20	94.60	7.40	Sandstone Grey	Sandstone	
94.60	94.90	0.30	Shale	Shale	
94.90	104.00	9.10	Sandstone Grey	Sandstone	

***** End of GW054146 *****

Parameter	LOR	Unit	5 Lupton Rd
Registered Number			GW105262
Date			28-01-2022
Calcium - Dissolved	0.5	mg/L	7.2
Potassium - Dissolved	0.5	mg/L	4
Sodium - Dissolved	0.5	mg/L	280
Magnesium - Dissolved	0.5	mg/L	73
Hardness	3	mg/L	320
Hydroxide Alkalinity (OH-) as CaCO3	5	mg/L	<5
Bicarbonate Alkalinity as CaCO3	5	mg/L	78
Carbonate Alkalinity as CaCO3	5	mg/L	<5
Total Alkalinity as CaCO3	5	mg/L	78
Sulphate SO4	1	mg/L	46
Chloride Cl	1	mg/L	680
Ionic Balance	-	%	-7
Total Nitrogen in Water	0.1	mg/L	<0.1
Phosphorus Total	0.05	mg/L	0.1
Aluminium-Total	10	µg/L	20
Arsenic-Total	1	µg/L	<1
Barium-Total	1	µg/L	810
Beryllium-Total	0.5	µg/L	7
Cadmium-Total	0.1	µg/L	<0.1
Chromium-Total	1	µg/L	22
Cobalt-Total	1	µg/L	120
Copper-Total	1	µg/L	10
Iron-Total	10	µg/L	45000
Lithium-Total	1	µg/L	56
Mercury-Total	0.05	µg/L	<0.05
Manganese-Total	5	µg/L	7100
Nickel-Total	1	µg/L	82
Lead-Total	1	µg/L	7
Selenium-Total	1	µg/L	<1
Strontium-Total	1	µg/L	110
Vanadium-Total	1	µg/L	3
Zinc-Total	1	µg/L	540
Aluminium-Dissolved	10	µg/L	<10
Arsenic-Dissolved	1	µg/L	<1
Barium-Dissolved	1	µg/L	200
Beryllium-Dissolved	0.5	µg/L	5
Cadmium-Dissolved	0.1	µg/L	<0.1
Chromium-Dissolved	1	µg/L	<1
Cobalt-Dissolved	1	µg/L	110
Copper-Dissolved	1	µg/L	<1
Iron-Dissolved	10	µg/L	36000
Lithium-Dissolved	1	µg/L	45
Mercury-Dissolved	0.05	µg/L	<0.05
Manganese-Dissolved	5	µg/L	6300
Nickel-Dissolved	1	µg/L	69
Lead-Dissolved	1	µg/L	<1
Selenium-Dissolved	1	µg/L	<1
Strontium-Dissolved	1	µg/L	96
Vanadium-Dissolved	1	µg/L	<1
Zinc-Dissolved	1	µg/L	260

Bore: GW057969	Property: 45 KNOX RD
Bore Identification Information (NSW Real Time Water Data)	
Bore name	GW057969
Property	Not listed
NSW licence number	NA
Datum	GDA 94 Zone 56
Easting	281360
Northing	6206145
Elevation (mAHD)	NR
Purpose	Irrigation
Bore Construction Details	
Drilling and construction records available	Yes
Date drilled/constructed	01/06/1983
Total depth of bore (m)	108
Geological Formation Screened	Sandstone
Bore Casing	
Material	Welded Steel, pressure cemented
Diameter	Steel 168 mm OD
Stick-up	0.3 m
Hydrogeological info	
Screened lithology/formation	Sandstone
Standing water level (mbgl)	33
Water quality	NR
Other bore log comments	Yield (L/s): 1.20
Data Collected While On Site	
Census Date	11/02/2022
Completed by	Chris Rotsider, Consulting Earth Scientists Pty Ltd
Photographs	

Bore Details

Bore: GW057969	Property: 45 KNOX RD
Site Address	45 KNOX RD 2574 NSW
GPS Location datum	GDA 94 Zone 56
Easting	281351
Northing	6206122
Elevation (mAHD) – specify survey method	NR
Drilling and construction records (Y/N)	Y
Stick-up (casing, monument etc.)	Concrete base
Total depth of bore (mbgl)	32.33 (likely blockage)
Depth to water (mbgl)	Bore dry or blocked
Pump status (if installed)	No pump
Logger status/condition (if installed). Serial no., make, model etc.	NA
Fencing/barrier installed?	Yes – fencing to prevent vehicle access
Sampling method	No water detected therefore sample could not be taken
Electrical Conductivity (µS/cm)	NR
pH	NR
Temperature (°C)	NR
ORP (mV)	NR
Dissolved Oxygen (mg/L)	NR
Colour, odour, characteristics etc.	NR
Bore Pump Details (if relevant)	
Frequency of use	Not used for years
Typical pumping rate	NR
Purpose / Use of Bore	Not currently used
Comment:	
Concrete base only, no extension above ground.	

WaterNSW
Work Summary

GW057969

Licence:

Licence Status:

Authorised Purpose(s):
Intended Purpose(s): IRRIGATION

Work Type: Bore open thru rock
Work Status:
Construct.Method: Cable Tool
Owner Type: Private

Commenced Date:
Completion Date: 01/06/1983

Final Depth: 108.00 m
Drilled Depth: 108.00 m

Contractor Name: (None)
Driller: John Hans Iselt
Assistant Driller:

Property:
GWMA:
GW Zone:

Standing Water Level (m):
Salinity Description: Fresh
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CAMDEN	BARGO	LA DP384722 (79)
Licensed:			

Region: 10 - Sydney South Coast
River Basin: 212 - HAWKESBURY RIVER
Area/District:

CMA Map: 9029-3N
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: (Unknown)

Northing: 6206145.000
Easting: 281360.000

Latitude: 34°15'46.3"S
Longitude: 150°37'31.2"E

GS Map: -
MGA Zone: 56
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Welded Steel	-0.30	6.30	168			Driven into Hole
1	1	Casing	Pressure Cemented	0.00	6.30				

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
61.30	61.60	0.30	Consolidated	42.00		0.20			
97.50	98.10	0.60	Consolidated	33.00		0.90			
102.40	102.70	0.30	Consolidated	33.00		1.20			

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.60	0.60	Topsoil Dark	Topsoil	
0.60	4.80	4.20	Shale Clay	Shale	
4.80	61.30	56.50	Sandstone Grey	Sandstone	
61.30	61.60	0.30	Sandstone Grey Open Water Supply	Sandstone	
61.60	93.50	31.90	Sandstone Grey	Sandstone	
93.50	93.80	0.30	Shale	Shale	
93.80	97.50	3.70	Sandstone Grey	Sandstone	
97.50	98.10	0.60	Sandstone Grey Open Water Supply	Sandstone	
98.10	102.40	4.30	Sandstone Grey	Sandstone	
102.40	102.70	0.30	Sandstone Grey Open Water Supply	Sandstone	
102.70	108.00	5.30	Sandstone Grey	Sandstone	

***** End of GW057969 *****

Bore: GW058634	Property: 225 BARGO RD
Bore Identification Information (NSW Real Time Water Data)	
Bore name	GW058634
Property	Not listed
NSW licence number	NA
Datum	GDA 94 Zone 56
Easting	279479
Northing	6203419
Elevation (mAHD)	NR
Purpose	Stock, domestic
Bore Construction Details	
Drilling and construction records available	Yes
Date drilled/constructed	01/01/1983
Total depth of bore (m)	122
Geological Formation Screened	Sandstone
Bore Casing	
Material	Welded steel
Diameter	168 mm OD
Stick-up	NR
Hydrogeological info	
Screened lithology/formation	Sandstone
Standing water level (mbgl)	NR
Water quality	NR
Other bore log comments	Yield (L/s): 0.64
Data Collected While On Site	
Census Date	01/02/2022
Completed by	Chris Rotsider, Consulting Earth Scientists Pty Ltd
Photographs	

Bore Details	
Site Address	225 BARGO RD, BARGO, 2574 NSW
GPS Location datum	GDA 94 Zone 56
Easting	279446

Bore: GW058634	Property: 225 BARGO RD
Northing	6203408
Elevation (mAHD) – specify survey method	NR
Drilling and construction records (Y/N)	Y
Stick-up (casing, monument etc.)	Steel stick up with metal cap
Total depth of bore (mbgl)	NR
Depth to water (mbgl)	NR
Pump status (if installed)	Potentially in-situ pump since infrastructure present, but not in use
Logger status/condition (if installed). Serial no., make, model etc.	NA
Fencing/barrier installed?	Yes – in locked shed
Sampling method	Sample not collected as bore was sealed shut
Electrical Conductivity (µS/cm)	NR
pH	NR
Temperature (°C)	NR
ORP (mV)	NR
Dissolved Oxygen (mg/L)	NR
Colour, odour, characteristics etc.	NR
Bore Pump Details (if relevant)	
Frequency of use	Not currently used
Typical pumping rate	NA
Purpose / Use of Bore	Not currently used
Comment:	
Metal well head in fair condition.	

WaterNSW
Work Summary

GW058634

Licence:

Licence Status:

Authorised Purpose(s):
Intended Purpose(s): STOCK, DOMESTIC

Work Type: Bore open thru rock
Work Status:
Construct.Method: Rotary Air
Owner Type: Private

Commenced Date:
Completion Date: 01/10/1983

Final Depth: 122.00 m
Drilled Depth: 122.00 m

Contractor Name: (None)
Driller:
Assistant Driller:

Property:
GWMA:
GW Zone:

Standing Water Level (m):
Salinity Description: Good
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CAMDEN	BARGO	L2 DP216449 (23)
Licensed:			

Region: 10 - Sydney South Coast
CMA Map: 9029-3N
River Basin: 212 - HAWKESBURY RIVER
Area/District:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: (Unknown)
Northing: 6203419.000
Easting: 279479.000
Latitude: 34°17'13.3"S
Longitude: 150°36'15.2"E

GS Map: -
MGA Zone: 56
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Welded Steel	0.00	7.60	168			Driven into Hole

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
83.00	86.00	3.00	(Unknown)			0.10			
96.00	99.00	3.00	(Unknown)			0.40			
108.00	115.00	7.00	(Unknown)			0.64			
115.00	122.00	7.00	(Unknown)			0.36			

Drillers Log

From	To	Thickness	Drillers Description	Geological Material	Comments

(m)	(m)	(m)			
0.00	4.00	4.00	Soil Clay	Soil	
4.00	122.00	118.00	Sandstone Multicoloured Water Supply	Sandstone	

***** End of GW058634 *****

Bore: GW059618	Property: Tahmoor South
Bore Identification Information (NSW Real Time Water Data)	
Bore name/nickname	GW059618
Property	NR
NSW licence number	10WA109901 (current)
Datum	GDA94 Zone 56
Easting	281559
Northing	6204177
Elevation (mAHD)	NR
Purpose	Stock, domestic
Bore Construction Details	
Drilling and construction records available	Yes
Date drilled/constructed	01/06/1984
Total depth of bore (m)	117.0
Geological Formation Screened	Sandstone
Bore Casing	
Material	Welded Steel, Pressure Cemented
Diameter	168 mm OD
Stick-up	0.2 m
Hydrogeological info	
Screened lithology/formation	Sandstone
Standing water level (mbgl)	22.0
Water quality	NR
Other bore log comments	Yield (Ls): 0.62
Data Collected While On Site	
Census Date	25/01/2022
Completed by	Chris Rotsider, Consulting Earth Scientists Pty Ltd
Photographs (insert)	
	
Bore Details	
Site Address	FARRUGIA 30 Carlisle St YANDERRA 2574 NSW
GPS Location datum	GDA 94 Zone 56
Easting	281589
Northing	6204282
Elevation (mAHD) – specify survey method	NR
Drilling and construction records (Y/N)	Y

Bore: GW059618	Property: Tahmoor South
Stick-up (casing, monument etc.)	Bore opening at ground level, iron cap
Total depth of bore (mbgl)	122.71
Depth to water (mbgl)	19.96
Pump status (if installed)	No in-situ pump
Logger status/condition (if installed). Serial no., make, model etc.	NA
Fencing/barrier installed?	No
Sampling method	Micro purge
Electrical Conductivity (µS/cm)	2396
pH	5.53
Temperature (°C)	18.2
ORP (mV)	55.2
Dissolved Oxygen (mg/L)	2.41
Colour, odour, characteristics etc.	No odour, low turbidity, light 'rusty' colour (Fe)
Bore Pump Details (if relevant)	
Frequency of use	Not disclosed
Typical pumping rate	NA
Purpose / Use of Bore	Likely not in use as no infrastructure connected
Comment:	
No damage to headworks was recorded, well head was at ground level. Water extracted = 0.3L. Recovery time = 1min 55 sec	

WaterNSW
Work Summary

GW059618

Licence: 10WA109901

Licence Status: CURRENT

Authorised Purpose(s): STOCK,DOMESTIC
Intended Purpose(s): STOCK, DOMESTIC

Work Type: Bore open thru rock
Work Status:
Construct.Method: Cable Tool
Owner Type: Private

Commenced Date:
Completion Date: 01/06/1984

Final Depth: 117.00 m
Drilled Depth: 117.00 m

Contractor Name: (None)
Driller: John Hans Iselt
Assistant Driller:

Property: N/A NSW

Standing Water Level (m):

GWMA: -
GW Zone: -

Salinity Description: Fresh
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CAMDEN	BARGO	L21 DP250498 (80)
Licensed:	CAMDEN	BARGO	Whole Lot 21//250498

Region: 10 - Sydney South Coast
CMA Map: 9029-3N

River Basin: 212 - HAWKESBURY RIVER
Area/District:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: (Unknown)

Northing: 6204177.000
Easting: 281559.000

Latitude: 34°16'50.3"S
Longitude: 150°37'37.2"E

GS Map: -
MGA Zone: 56
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Welded Steel	-0.20	6.20	168			Cemented
1	1	Casing	Pressure Cemented	0.00	6.20	168			

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
22.00	22.20	0.20	Consolidated	22.00		0.06			
69.30	69.70	0.40	Consolidated	22.00		0.37			
111.80	112.30	0.50	Consolidated	22.00		0.62			

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.40	0.40	Topsoil Dark	Topsoil	
0.40	2.60	2.20	Shale Clay	Shale	
2.60	9.30	6.70	Sandstone Yellow	Sandstone	
9.30	58.50	49.20	Sandstone Grey Water Supply	Sandstone	
58.50	66.30	7.80	Sandstone Grey Some Shale	Sandstone	
66.30	69.30	3.00	Sandstone Grey	Sandstone	
69.30	69.70	0.40	Sandstone Grey Open Water Supply	Sandstone	
69.70	111.80	42.10	Sandstone Grey	Sandstone	
111.80	112.30	0.50	Sandstone Grey Open Water Supply	Sandstone	
112.30	117.00	4.70	Sandstone Grey	Sandstone	

***** End of GW059618 *****

Parameter	LOR	Unit	50 Mockingbird Rd
Registered Number			GW059618
Date			25-01-2022
Calcium - Dissolved	0.5	mg/L	5
Potassium - Dissolved	0.5	mg/L	5
Sodium - Dissolved	0.5	mg/L	360
Magnesium - Dissolved	0.5	mg/L	57
Hardness	3	mg/L	250
Hydroxide Alkalinity (OH-) as CaCO3	5	mg/L	<5
Bicarbonate Alkalinity as CaCO3	5	mg/L	63
Carbonate Alkalinity as CaCO3	5	mg/L	<5
Total Alkalinity as CaCO3	5	mg/L	63
Sulphate SO4	1	mg/L	44
Chloride Cl	1	mg/L	760
Ionic Balance	-	%	-6
Total Nitrogen in Water	0.1	mg/L	<0.1
Phosphorus Total	0.05	mg/L	<0.05
Aluminium-Total	10	µg/L	50
Arsenic-Total	1	µg/L	<1
Barium-Total	1	µg/L	120
Beryllium-Total	0.5	µg/L	3
Cadmium-Total	0.1	µg/L	<0.1
Chromium-Total	1	µg/L	<1
Cobalt-Total	1	µg/L	86
Copper-Total	1	µg/L	<1
Iron-Total	10	µg/L	60000
Lithium-Total	1	µg/L	24
Mercury-Total	0.05	µg/L	<0.05
Manganese-Total	5	µg/L	3000
Nickel-Total	1	µg/L	54
Lead-Total	1	µg/L	2
Selenium-Total	1	µg/L	<1
Strontium-Total	1	µg/L	71
Vanadium-Total	1	µg/L	<1
Zinc-Total	1	µg/L	180
Aluminium-Dissolved	10	µg/L	<10
Arsenic-Dissolved	1	µg/L	<1
Barium-Dissolved	1	µg/L	120
Beryllium-Dissolved	0.5	µg/L	2
Cadmium-Dissolved	0.1	µg/L	<0.1
Chromium-Dissolved	1	µg/L	<1
Cobalt-Dissolved	1	µg/L	78
Copper-Dissolved	1	µg/L	<1
Iron-Dissolved	10	µg/L	47000
Lithium-Dissolved	1	µg/L	26
Mercury-Dissolved	0.05	µg/L	<0.05
Manganese-Dissolved	5	µg/L	2800
Nickel-Dissolved	1	µg/L	47
Lead-Dissolved	1	µg/L	<1
Selenium-Dissolved	1	µg/L	<1
Strontium-Dissolved	1	µg/L	66
Vanadium-Dissolved	1	µg/L	<1
Zinc-Dissolved	1	µg/L	160

Bore: GW062068	Property: 20 STOKES RD
Bore Identification Information (NSW Real Time Water Data)	
Bore name	GW062068
Property	PULIC 20 Stokes Rd TAHMOOR 2573 NSW
NSW licence number	10WA111522 (current)
Datum	GDA 94 Zone 56
Easting	276597
Northing	6209616
Elevation (mAHD)	NR
Purpose	Stock, domestic
Bore Construction Details	
Drilling and construction records available	Yes
Date drilled/constructed	01/12/1986
Total depth of bore (m)	Drilled depth 451 m, total depth 150 m
Geological Formation Screened	Sandstone
Bore Casing	
Material	Drilled, NR
Diameter	NR 150 mm OD, Drilled 125 mm OD, Drilled 63 mm OD
Stick-up	NR
Hydrogeological info	
Screened lithology/formation	Sandstone
Standing water level (mbgl)	NR
Water quality	NR
Other bore log comments	NR
Data Collected While On Site	
Census Date	07/02/2022
Completed by	Chris Rotsider, Consulting Earth Scientists Pty Ltd
Photographs	
	
Bore Details	
Site Address	20 STOKES RD TAHMOOR 2573 NSW
GPS Location datum	GDA 94 Zone 56

Bore: GW062068	Property: 20 STOKES RD
Easting	276573
Northing	6209556
Elevation (mAHD) – specify survey method	NR
Drilling and construction records (Y/N)	Y
Stick-up (casing, monument etc.)	Concrete base with metal cap
Total depth of bore (mbgl)	> 100
Depth to water (mbgl)	21.93
Pump status (if installed)	In-situ electric pump installed but not connected to piping or electricity.
Logger status/condition (if installed). Serial no., make, model etc.	NA
Fencing/barrier installed?	Yes - Covered with sheet steel box, one side protected from vehicles with surrounding infrastructure
Sampling method	Micro-purging, 7 l water purged
Electrical Conductivity (µS/cm)	165
pH	6.4
Temperature (°C)	20.7
ORP (mV)	-51.8
Dissolved Oxygen (mg/L)	6.42
Colour, odour, characteristics etc.	Clear, organic odour, low turbidity
Bore Pump Details (if relevant)	
Frequency of use	Not used to part cave in 11 years ago
Typical pumping rate	NA
Purpose / Use of Bore	Not used
Comment:	
Water extracted: 7 l in 20 min Recovery time: < 1 min	

WaterNSW
Work Summary

GW062068

Licence: 10WA111522

Licence Status: CURRENT

Authorised Purpose(s): DOMESTIC,STOCK
Intended Purpose(s): STOCK, DOMESTIC

Work Type: Bore
Work Status:
Construct.Method: Rotary
Owner Type: Private

Commenced Date:
Completion Date: 01/12/1986

Final Depth: 150.00 m
Drilled Depth: 451.30 m

Contractor Name: (None)
Driller:
Assistant Driller:

Property: PULIC 20 Stokes Rd TAHMOOR 2573 NSW
GWMA: -
GW Zone: -

Standing Water Level (m):
Salinity Description: 1001-3000 ppm
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CAMDEN	COURIDJAH	1//403638
Licensed:	CAMDEN	COURIDJAH	Whole Lot 1//403638

Region: 10 - Sydney South Coast
River Basin: 212 - HAWKESBURY RIVER
Area/District:

CMA Map: 9029-4S
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: (Unknown)

Northing: 6209616.000
Easting: 276597.000

Latitude: 34°13'50.1"S
Longitude: 150°34'28.4"E

GS Map: -
MGA Zone: 56
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Backfill	Concrete	150.00	451.30				
1	1	Casing		0.00	6.00	150			
1	1	Casing	Drilled	6.00	100.00	125			
1	1	Casing	Drilled	100.00	451.30	63			

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	3.00	3.00	Clay Sand	Clay	
3.00	54.00	51.00	Sandstone	Sandstone	
54.00	69.00	15.00	Sandstone Some Mudstone	Sandstone	
69.00	87.00	18.00	Sandstone	Sandstone	
87.00	123.00	36.00	Sandstone Some Siltstone	Sandstone	
123.00	132.00	9.00	Sandstone Some Mudstone	Sandstone	

132.00	144.00	12.00	Sandstone	Sandstone	
144.00	156.00	12.00	Mudstone Sandstone	Mudstone	
156.00	177.00	21.00	Sandstone Some Mudstone	Sandstone	
177.00	198.00	21.00	Shale Reddish Claystone	Shale	
198.00	375.00	177.00	Sandstone Some Mudstone, Siltstone	Sandstone	
375.00	390.70	15.70	Sandstone Some Mudstone	Sandstone	
390.70	398.30	7.60	Sandstone	Sandstone	
398.30	412.20	13.90	Siltstone Laminated	Siltstone	
412.20	414.90	2.70	Coal	Coal	
414.90	419.40	4.50	Mudstone Some Sandstone	Mudstone	
419.40	419.90	0.50	Coal	Coal	
419.90	427.30	7.40	Claystone	Claystone	
427.30	439.00	11.70	Coal Claystone, Shale Carbonaceous	Coal	
439.00	441.20	2.20	Claystone Carbonaceous, Shale Some Coal	Claystone	
441.20	444.10	2.90	Coal Some Clay	Coal	
444.10	451.30	7.20	Sandstone Siltstone	Sandstone	
412.20	414.90	2.70	Shale Carbonaceous	Shale	

Remarks

18/08/1988: BACKFILL IS CEMENT.
20/08/2009: Previous Lic No:10BL135700.
20/11/2012: Nat Carling, 20-Nov-2012; Removed duplicate rows in driller's log.

***** End of GW062068 *****

Parameter	LOR	Unit	20 Stokes Rd
Registered Number			GW062068
Date			07-02-2022
Calcium - Dissolved	0.5	mg/L	5.6
Potassium - Dissolved	0.5	mg/L	16
Sodium - Dissolved	0.5	mg/L	8.5
Magnesium - Dissolved	0.5	mg/L	5
Hardness	3	mg/L	34
Hydroxide Alkalinity (OH-) as CaCO3	5	mg/L	<5
Bicarbonate Alkalinity as CaCO3	5	mg/L	32
Carbonate Alkalinity as CaCO3	5	mg/L	<5
Total Alkalinity as CaCO3	5	mg/L	32
Sulphate SO4	1	mg/L	11
Chloride Cl	1	mg/L	19
Ionic Balance	-	%	1
Total Nitrogen in Water	0.1	mg/L	2.2
Phosphorus Total	0.05	mg/L	0.5
Aluminium-Total	10	µg/L	450
Arsenic-Total	1	µg/L	450
Barium-Total	1	µg/L	<1
Beryllium-Total	0.5	µg/L	15
Cadmium-Total	0.1	µg/L	<1
Chromium-Total	1	µg/L	4
Cobalt-Total	1	µg/L	3700
Copper-Total	1	µg/L	<1
Iron-Total	10	µg/L	3700
Lithium-Total	1	µg/L	<1
Mercury-Total	0.05	µg/L	29
Manganese-Total	5	µg/L	4
Nickel-Total	1	µg/L	1
Lead-Total	1	µg/L	<1
Selenium-Total	1	µg/L	<1
Strontium-Total	1	µg/L	27
Vanadium-Total	1	µg/L	27
Zinc-Total	1	µg/L	16
Aluminium-Dissolved	10	µg/L	280
Arsenic-Dissolved	1	µg/L	280
Barium-Dissolved	1	µg/L	<1
Beryllium-Dissolved	0.5	µg/L	14
Cadmium-Dissolved	0.1	µg/L	<1
Chromium-Dissolved	1	µg/L	<1
Cobalt-Dissolved	1	µg/L	<1
Copper-Dissolved	1	µg/L	29
Iron-Dissolved	10	µg/L	2600
Lithium-Dissolved	1	µg/L	<1
Mercury-Dissolved	0.05	µg/L	4
Manganese-Dissolved	5	µg/L	<1
Nickel-Dissolved	1	µg/L	<1
Lead-Dissolved	1	µg/L	27
Selenium-Dissolved	1	µg/L	<1
Strontium-Dissolved	1	µg/L	27
Vanadium-Dissolved	1	µg/L	18
Zinc-Dissolved	1	µg/L	2600

Bore: GW070245	Property: 190 ARINA RD
Bore Identification Information (NSW Real Time Water Data)	
Bore name	GW070245
Property	Not listed
NSW licence number	NA
Datum	GDA 94 Zone 56
Easting	280090
Northing	6205714
Elevation (mAHD)	NR
Purpose	Stock, domestic
Bore Construction Details	
Drilling and construction records available	Yes
Date drilled/constructed	01/05/1992
Total depth of bore (m)	95
Geological Formation Screened	Consolidated
Bore Casing	
Material	PVC
Diameter	PVC 160 mm OD
Stick-up	NR
Hydrogeological info	
Screened lithology/formation	NR
Standing water level (mbgl)	NR
Water quality	NR
Other bore log comments	Yield (L/s): 1.90
Data Collected While On Site	
Census Date	08/02/2022
Completed by	Chris Rotsider, Consulting Earth Scientists Pty Ltd
Photographs	
	

Bore: GW070245	Property: 190 ARINA RD
Bore Details	
Site Address	190 ARINA RD, BARGO, 2574 NSW
GPS Location datum	GDA 94 Zone 56
Easting	280043
Northing	6205645
Elevation (mAHD) – specify survey method	NR
Drilling and construction records (Y/N)	Y
Stick-up (casing, monument etc.)	Concrete base with metal cap
Total depth of bore (mbgl)	NR (no access for depth measuring equipment)
Depth to water (mbgl)	NR (no access for depth measuring equipment)
Pump status (if installed)	In-situ electric Grundfos pump
Logger status/condition (if installed). Serial no., make, model etc.	NA
Fencing/barrier installed?	No
Sampling method	Pump, 5 l water purged *
Electrical Conductivity (µS/cm)	949
pH	6.2
Temperature (°C)	16.4
ORP (mV)	-13.6
Dissolved Oxygen (mg/L)	38.6
Colour, odour, characteristics etc.	Clear, no odour, low turbidity
Bore Pump Details (if relevant)	
Frequency of use	When required
Typical pumping rate	NR
Purpose / Use of Bore	Fill dam
Comment:	
Steal Cover on top of concrete plinth. The headworks in good working condition. * Directly plumbed into piping system with valve used for sampling point.	

WaterNSW
Work Summary

GW070245

Licence:

Licence Status:

Authorised Purpose(s):
Intended Purpose(s): STOCK, DOMESTIC

Work Type: Bore open thru rock
Work Status:
Construct.Method: Rotary Air
Owner Type: Private

Commenced Date:
Completion Date: 01/05/1992

Final Depth: 97.50 m
Drilled Depth:

Contractor Name: (None)
Driller: Alan Marcus Dodd
Assistant Driller:

Property:
GWMA:
GW Zone:

Standing Water Level (m):
Salinity Description: 0-500 ppm
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CAMDEN	BARGO	94
Licensed:			

Region: 10 - Sydney South Coast
River Basin: 212 - HAWKESBURY RIVER
Area/District:

CMA Map: 9029-3N
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown

Northing: 6205714.000
Easting: 280090.000

Latitude: 34°15'59.3"S
Longitude: 150°36'41.2"E

GS Map: -
MGA Zone: 56
Coordinate Source: Unknown

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	P.V.C.	-0.30	2.20	160			Seated on Bottom

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
75.70	77.00	1.30	Consolidated			0.45			
90.50	92.50	2.00	Consolidated			0.60			
93.00	95.00	2.00	Consolidated			1.90			

***** End of GW070245 *****

Parameter	LOR	Unit	190 Arina Rd
Registered Number			GW070245
Date			08-02-2022
Calcium - Dissolved	0.5	mg/L	5
Potassium - Dissolved	0.5	mg/L	2
Sodium - Dissolved	0.5	mg/L	91
Magnesium - Dissolved	0.5	mg/L	21
Hardness	3	mg/L	97
Hydroxide Alkalinity (OH-) as CaCO3	5	mg/L	<5
Bicarbonate Alkalinity as CaCO3	5	mg/L	61
Carbonate Alkalinity as CaCO3	5	mg/L	<5
Total Alkalinity as CaCO3	5	mg/L	61
Sulphate SO4	1	mg/L	11
Chloride Cl	1	mg/L	230
Ionic Balance	-	%	-14
Total Nitrogen in Water	0.1	mg/L	<0.1
Phosphorus Total	0.05	mg/L	0.09
Aluminium-Total	10	µg/L	10
Arsenic-Total	1	µg/L	10
Barium-Total	1	µg/L	<1
Beryllium-Total	0.5	µg/L	190
Cadmium-Total	0.1	µg/L	26
Chromium-Total	1	µg/L	6
Cobalt-Total	1	µg/L	39000
Copper-Total	1	µg/L	22
Iron-Total	10	µg/L	39000
Lithium-Total	1	µg/L	22
Mercury-Total	0.05	µg/L	2400
Manganese-Total	5	µg/L	23
Nickel-Total	1	µg/L	1
Lead-Total	1	µg/L	<1
Selenium-Total	1	µg/L	<1
Strontium-Total	1	µg/L	55
Vanadium-Total	1	µg/L	55
Zinc-Total	1	µg/L	53
Aluminium-Dissolved	10	µg/L	<10
Arsenic-Dissolved	1	µg/L	<10
Barium-Dissolved	1	µg/L	<1
Beryllium-Dissolved	0.5	µg/L	190
Cadmium-Dissolved	0.1	µg/L	27
Chromium-Dissolved	1	µg/L	<1
Cobalt-Dissolved	1	µg/L	22
Copper-Dissolved	1	µg/L	2400
Iron-Dissolved	10	µg/L	32000
Lithium-Dissolved	1	µg/L	22
Mercury-Dissolved	0.05	µg/L	22
Manganese-Dissolved	5	µg/L	<1
Nickel-Dissolved	1	µg/L	<1
Lead-Dissolved	1	µg/L	59
Selenium-Dissolved	1	µg/L	<1
Strontium-Dissolved	1	µg/L	59
Vanadium-Dissolved	1	µg/L	48
Zinc-Dissolved	1	µg/L	32000

Bore: GW102179	Property: 130 DWYERS RD
Bore Identification Information (NSW Real Time Water Data)	
Bore name	GW102179
Property	ZAHRA 130 Dwyers Rd PHEASANTS NEST 2574 NSW
NSW licence number	10CA111796 (current)
Datum	GDA 94 Zone 56
Easting	280811
Northing	6203573
Elevation (mAHD)	NR
Purpose	Irrigation
Bore Construction Details	
Drilling and construction records available	Yes
Date drilled/constructed	15/07/1998
Total depth of bore (m)	153
Geological Formation Screened	Sandstone/Shale
Bore Casing	
Material	PVC Class 9
Diameter	PVC 142 mm OD
Stick-up	NR
Hydrogeological info	
Screened lithology/formation	Sandstone/Shale
Standing water level (mbgl)	61
Water quality	Salinity: 700 mg/L
Other bore log comments	Yield (L/s): 1.50
Data Collected While On Site	
Census Date	31/01/2022
Completed by	Chris Rotsider, Consulting Earth Scientists Pty Ltd
Photographs	
	
Bore Details	
Site Address	130 DWYERS RD, PHEASANTS NEST, 2574 NSW
GPS Location datum	GDA 94 Zone 56
Easting	279263
Northing	6203321
Elevation (mAHD) – specify survey method	NR
Drilling and construction records (Y/N)	Y
Stick-up (casing, monument etc.)	Steel stick up with metal cap

Bore: GW102179	Property: 130 DWYERS RD
Total depth of bore (mbgl)	Blockage at 39 m
Depth to water (mbgl)	NR
Pump status (if installed)	In-situ electric pump
Logger status/condition (if installed). Serial no., make, model etc.	NA
Fencing/barrier installed?	No
Sampling method	Pump
Electrical Conductivity (µS/cm)	1849
pH	6.0
Temperature (°C)	21.3
ORP (mV)	24.6
Dissolved Oxygen (mg/L)	2.54
Colour, odour, characteristics etc.	No odour, low turbidity, faint discolouration, high Fe+ during first 3 min of pump operation
Bore Pump Details (if relevant)	
Frequency of use	Moderate
Typical pumping rate	NR
Purpose / Use of Bore	Crop irrigation
Comment:	
Headworks in good condition.	

WaterNSW
Work Summary

GW102179

Licence: 10CA111796

Licence Status: CURRENT

Authorised Purpose(s): IRRIGATION
Intended Purpose(s): IRRIGATION

Work Type: Bore
Work Status: Supply Obtained
Construct.Method: Rotary Air
Owner Type: Private

Commenced Date:
Completion Date: 15/07/1998

Final Depth: 153.00 m
Drilled Depth: 153.00 m

Contractor Name: Ultra Drilling
Driller: Alan Marcus Dodd
Assistant Driller:

Property: ZAHRA 130 Dwyers Rd PHEASANTS NEST 2574 NSW
GWMA: -
GW Zone: -

Standing Water Level (m): 61.000
Salinity Description:
Yield (L/s): 2.700

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CAMDEN	BARGO	4//243562
Licensed:	CAMDEN	BARGO	Whole Lot 4//243562

Region: 10 - Sydney South Coast
CMA Map:

River Basin: - Unknown
Area/District:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown

Northing: 6203573.000
Easting: 280811.000

Latitude: 34°17'09.4"S
Longitude: 150°37'07.4"E

GS Map: -
MGA Zone: 56
Coordinate Source: Unknown

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	122.00	203			Percussion
1		Hole	Hole	122.00	153.00	165			Percussion
1	1	Casing	Pvc Class 9	0.30	122.00	142			Suspended in Clamps, Glued
1	1	Casing	Steel	0.30	2.00	200	192		Seated on Bottom

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
100.00	102.00	2.00	Unknown		103.00	0.40	103.00	01:00:00	600.00
115.00	117.00	2.00	Unknown		119.00	0.80	119.00	01:00:00	700.00
140.00	142.00	2.00	Unknown	61.00	152.00	1.50	152.00	02:00:00	700.00

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.30	0.30	SOIL	Soil	
0.30	10.00	9.70	SHALE, GREY	Shale	
10.00	61.00	51.00	SANDSTONE	Sandstone	
61.00	92.00	31.00	SHALE/SANDSTONE	Shale	
92.00	121.00	29.00	SANDSTONE	Sandstone	
121.00	128.00	7.00	SHALE/SANDSTONE	Shale	
128.00	153.00	25.00	SANDSTONE/QUARTZITE	Sandstone	

***** End of GW102179 *****

Parameter	LOR	Unit	130 Dwyers Rd
Registered Number			GW102179
Date			31-01-2022
Calcium - Dissolved	0.5	mg/L	20
Potassium - Dissolved	0.5	mg/L	9.7
Sodium - Dissolved	0.5	mg/L	240
Magnesium - Dissolved	0.5	mg/L	55
Hardness	3	mg/L	280
Hydroxide Alkalinity (OH-) as CaCO3	5	mg/L	<5
Bicarbonate Alkalinity as CaCO3	5	mg/L	79
Carbonate Alkalinity as CaCO3	5	mg/L	<5
Total Alkalinity as CaCO3	5	mg/L	79
Sulphate SO4	1	mg/L	79
Chloride Cl	1	mg/L	530
Ionic Balance	-	%	-5
Total Nitrogen in Water	0.1	mg/L	2
Phosphorus Total	0.05	mg/L	0.08
Aluminium-Total	10	µg/L	60
Arsenic-Total	1	µg/L	<1
Barium-Total	1	µg/L	100
Beryllium-Total	0.5	µg/L	2
Cadmium-Total	0.1	µg/L	<0.1
Chromium-Total	1	µg/L	<1
Cobalt-Total	1	µg/L	41
Copper-Total	1	µg/L	1
Iron-Total	10	µg/L	27000
Lithium-Total	1	µg/L	54
Mercury-Total	0.05	µg/L	<0.05
Manganese-Total	5	µg/L	2000
Nickel-Total	1	µg/L	31
Lead-Total	1	µg/L	2
Selenium-Total	1	µg/L	<1
Strontium-Total	1	µg/L	200
Vanadium-Total	1	µg/L	<1
Zinc-Total	1	µg/L	59
Aluminium-Dissolved	10	µg/L	160
Arsenic-Dissolved	1	µg/L	<1
Barium-Dissolved	1	µg/L	93
Beryllium-Dissolved	0.5	µg/L	2
Cadmium-Dissolved	0.1	µg/L	<0.1
Chromium-Dissolved	1	µg/L	<1
Cobalt-Dissolved	1	µg/L	36
Copper-Dissolved	1	µg/L	<1
Iron-Dissolved	10	µg/L	24000
Lithium-Dissolved	1	µg/L	49
Mercury-Dissolved	0.05	µg/L	<0.05
Manganese-Dissolved	5	µg/L	1800
Nickel-Dissolved	1	µg/L	27
Lead-Dissolved	1	µg/L	<1
Selenium-Dissolved	1	µg/L	<1
Strontium-Dissolved	1	µg/L	180
Vanadium-Dissolved	1	µg/L	<1
Zinc-Dissolved	1	µg/L	52

Bore: GW102344	Property: 65 ARINA
Bore Identification Information (NSW Real Time Water Data)	
Bore name	GW102344
Property	Not listed
NSW licence number	NR
Datum	GDA 94 Zone 56
Easting	280198
Northing	6206580
Elevation (mAHD)	NR
Purpose	Irrigation
Bore Construction Details	
Drilling and construction records available	No (bore is registered but no bore report available)
Date drilled/constructed	NR
Total depth of bore (m)	110
Geological Formation Screened	NR
Bore Casing	
Material	NR
Diameter	NR
Stick-up	NR
Hydrogeological info	
Screened lithology/formation	NR
Standing water level (mbgl)	NR
Water quality	NR
Other bore log comments	NR
Data Collected While On Site	
Census Date	22/02/ 2022
Completed by	Chris Rotsider, Consulting Earth Scientists Pty Ltd
Photographs	

Bore Details

Bore: GW102344	Property: 65 ARINA
Site Address	65 ARINA RD, BARGO 2574
GPS Location datum	GDA 94 Zone 56
Easting	280251
Northing	6206554
Elevation (mAHD) – specify survey method	NR
Drilling and construction records (Y/N)	N
Stick-up (casing, monument etc.)	Concrete base with metal casing
Total depth of bore (mbgl)	NR (unable to be measured, no space for depth measuring equipment)
Depth to water (mbgl)	NR (unable to be measured, no space for depth measuring equipment)
Pump status (if installed)	In situ electric pump
Logger status/condition (if installed). Serial no., make, model etc.	NA
Fencing/barrier installed?	No
Sampling method	In situ pump, 16 l water purged
Electrical Conductivity (µS/cm)	801
pH	6.3
Temperature (°C)	18.2
ORP (mV)	7.9
Dissolved Oxygen (mg/L)	0.32
Colour, odour, characteristics etc.	Clear, no odour, low turbidity
Bore Pump Details (if relevant)	
Frequency of use	Daily
Typical pumping rate	NR
Purpose / Use of Bore	Irrigation
Comment:	
Metal casing and concrete base in good working order with plumbing into irrigation system	

Parameter	LOR	Unit	65 Arina Rd
Registered Number			GW102344
Date			23-02-2022
Calcium - Dissolved	0.5	mg/L	5
Potassium - Dissolved	0.5	mg/L	2
Sodium - Dissolved	0.5	mg/L	100
Magnesium - Dissolved	0.5	mg/L	23
Hardness	3	mg/L	110
Hydroxide Alkalinity (OH-) as CaCO3	5	mg/L	<5
Bicarbonate Alkalinity as CaCO3	5	mg/L	51
Carbonate Alkalinity as CaCO3	5	mg/L	<5
Total Alkalinity as CaCO3	5	mg/L	51
Sulphate SO4	1	mg/L	25
Chloride Cl	1	mg/L	240
Ionic Balance	-	%	-10
Total Nitrogen in Water	0.1	mg/L	<0.1
Phosphorus Total	0.05	mg/L	<0.05
Aluminium-Total	10	µg/L	<10
Arsenic-Total	1	µg/L	<10
Barium-Total	1	µg/L	<1
Beryllium-Total	0.5	µg/L	150
Cadmium-Total	0.1	µg/L	25
Chromium-Total	1	µg/L	<1
Cobalt-Total	1	µg/L	27000
Copper-Total	1	µg/L	20
Iron-Total	10	µg/L	27000
Lithium-Total	1	µg/L	20
Mercury-Total	0.05	µg/L	2000
Manganese-Total	5	µg/L	19
Nickel-Total	1	µg/L	<1
Lead-Total	1	µg/L	<1
Selenium-Total	1	µg/L	<1
Strontium-Total	1	µg/L	46
Vanadium-Total	1	µg/L	46
Zinc-Total	1	µg/L	33
Aluminium-Dissolved	10	µg/L	10
Arsenic-Dissolved	1	µg/L	10
Barium-Dissolved	1	µg/L	<1
Beryllium-Dissolved	0.5	µg/L	150
Cadmium-Dissolved	0.1	µg/L	25
Chromium-Dissolved	1	µg/L	<1
Cobalt-Dissolved	1	µg/L	21
Copper-Dissolved	1	µg/L	2000
Iron-Dissolved	10	µg/L	22000
Lithium-Dissolved	1	µg/L	21
Mercury-Dissolved	0.05	µg/L	19
Manganese-Dissolved	5	µg/L	<1
Nickel-Dissolved	1	µg/L	1
Lead-Dissolved	1	µg/L	47
Selenium-Dissolved	1	µg/L	1
Strontium-Dissolved	1	µg/L	47
Vanadium-Dissolved	1	µg/L	29
Zinc-Dissolved	1	µg/L	22000

Bore: GW106590	Property: 95 Arina Rd Pheasants Nest
Bore Identification Information (NSW Real Time Water Data)	
Bore name	GW106590
Property	Rixon
NSW licence number	10WA111109 (current)
Datum	GDA 94 Zone 56
Easting	280442
Northing	6206344
Elevation (mAHD)	NR
Purpose	Stock, Domestic
Bore Construction Details	
Drilling and construction records available	Yes
Date drilled/constructed	01/10/2004
Total depth of bore (m)	150m
Geological Formation Screened	Sandstone
Bore Casing	
Material	PVC
Diameter	130mm
Stick-up	NR
Hydrogeological info	
Screened lithology/formation	Sandstone
Standing water level (mbgl)	60m
Water quality	Salinity Description: Good
Other bore log comments	Yield: 5.6L/s
Data Collected While On Site	
Census Date	March 2022
Completed by	Consulting Earth Scientists Pty Ltd
Photographs	
	
Bore Details	
Site Address	Rixon 95 Arina RD, PHESANTS NEST, 2574, NSW
GPS Location datum	GDA 94 Zone 56
Easting	280442

Bore: GW106590	Property: 95 Arina Rd Pheasants Nest
Northing	6206344
Elevation (mAHD) – specify survey method	NR
Drilling and construction records (Y/N)	Y
Stick-up (casing, monument etc.)	Steel cap and corrugated shed. No opening to insert depth measuring equipment
Total depth of bore (mbgl)	N/A
Depth to water (mbgl)	N/A
Pump status (if installed)	In-situ Pump installed and Operational
Logger status/condition (if installed). Serial no., make, model etc.	NA
Fencing/barrier installed?	No
Sampling method	Pump
Electrical Conductivity (µS/cm)	842
pH	5.52
Temperature (°C)	20.1
ORP (mV)	78.5
Dissolved Oxygen (mg/L)	2.71
Colour, odour, characteristics etc.	Clear, Low turb, Organic Odour
Bore Pump Details (if relevant)	
Frequency of use	NR
Typical pumping rate	NR
Purpose / Use of Bore	Used to wet down horse track and fill dam when required
Comment:	
Headworks for this monitoring well were encountered to be in a reasonable working condition. This included concrete support and PVC well casing. 10 L was extracted from well with recharge time not assessable.	

WaterNSW
Work Summary

GW106590

Licence: 10WA111109

Licence Status: CURRENT

Authorised Purpose(s): STOCK,DOMESTIC
Intended Purpose(s): STOCK, DOMESTIC

Work Type: Bore
Work Status: Supply Obtained
Construct.Method: Down Hole Hamm
Owner Type: Private

Commenced Date:
Completion Date: 01/10/2004

Final Depth: 150.00 m
Drilled Depth: 150.00 m

Contractor Name: Ultra Drilling
Driller: Bradley Alan Dodd
Assistant Driller:

Property: RIXON 95 Arina Rd PHEASANT NEST 2574 NSW
GWMA: -
GW Zone: -

Standing Water Level (m): 60.000
Salinity Description: Good
Yield (L/s): 5.600

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CAMDEN	BARGO	5//243112
Licensed:	CAMDEN	BARGO	Whole Lot 5//243112

Region: 10 - Sydney South Coast
River Basin: 212 - HAWKESBURY RIVER
Area/District:

CMA Map: 9029-3N
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown

Northing: 6206344.000
Easting: 280442.000

Latitude: 34°15'39.2"S
Longitude: 150°36'55.5"E

GS Map: -
MGA Zone: 56
Coordinate Source: GIS - Geogra

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	20.00	170			Down Hole Hammer
1		Hole	Hole	20.00	150.00	140			Down Hole Hammer
1	1	Casing	P.V.C.	0.00	30.00	130			Driven into Hole, Glued

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
77.00	78.00	1.00	Unknown			0.30		00:15:00	
84.00	102.00	18.00	Unknown			1.30		00:15:00	
112.00	113.00	1.00	Unknown			1.80		00:15:00	
135.00	137.00	2.00	Unknown	60.00		2.20		00:15:00	

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	20.00	20.00	sandstone, yellow clay	Sandstone	
20.00	54.00	34.00	sandstone, white	Sandstone	
54.00	75.00	21.00	sandstone, shale	Sandstone	
75.00	150.00	75.00	sandstone, quartz	Sandstone	

Remarks

19/01/2010: updated from original form A

***** End of GW106590 *****

Parameter	LOR	Unit	95 Arina RD
Registered Number			GW106590
Date			24-03-2022
Calcium - Dissolved	0.5	mg/L	5.3
Potassium - Dissolved	0.5	mg/L	2
Sodium - Dissolved	0.5	mg/L	110
Magnesium - Dissolved	0.5	mg/L	21
Hardness	3	mg/L	100
Hydroxide Alkalinity (OH-) as CaCO3	5	mg/L	<5
Bicarbonate Alkalinity as CaCO3	5	mg/L	41
Carbonate Alkalinity as CaCO3	5	mg/L	<5
Total Alkalinity as CaCO3	5	mg/L	41
Sulphate SO4	1	mg/L	10
Chloride Cl	1	mg/L	240
Ionic Balance	-	%	-5
Total Nitrogen in Water	0.1	mg/L	<0.1
Phosphorus Total	0.05	mg/L	<0.05
Aluminium-Total	10	µg/L	<10
Arsenic-Total	1	µg/L	<1
Barium-Total	1	µg/L	170
Beryllium-Total	0.5	µg/L	
Cadmium-Total	0.1	µg/L	
Chromium-Total	1	µg/L	
Cobalt-Total	1	µg/L	21
Copper-Total	1	µg/L	5
Iron-Total	10	µg/L	15000
Lithium-Total	1	µg/L	21
Mercury-Total	0.05	µg/L	
Manganese-Total	5	µg/L	2000
Nickel-Total	1	µg/L	16
Lead-Total	1	µg/L	<1
Selenium-Total	1	µg/L	1
Strontium-Total	1	µg/L	52
Vanadium-Total	1	µg/L	
Zinc-Total	1	µg/L	27
Aluminium-Dissolved	10	µg/L	<10
Arsenic-Dissolved	1	µg/L	<1
Barium-Dissolved	1	µg/L	180
Beryllium-Dissolved	0.5	µg/L	
Cadmium-Dissolved	0.1	µg/L	
Chromium-Dissolved	1	µg/L	
Cobalt-Dissolved	1	µg/L	20
Copper-Dissolved	1	µg/L	<1
Iron-Dissolved	10	µg/L	15000
Lithium-Dissolved	1	µg/L	22
Mercury-Dissolved	0.05	µg/L	
Manganese-Dissolved	5	µg/L	2000
Nickel-Dissolved	1	µg/L	16
Lead-Dissolved	1	µg/L	<1
Selenium-Dissolved	1	µg/L	<1
Strontium-Dissolved	1	µg/L	50
Vanadium-Dissolved	1	µg/L	
Zinc-Dissolved	1	µg/L	20

APPENDIX B

Laboratory Results

Parameter	LOR	Unit	10 Bayan Pl	10 Bayan Pl	30 Carlisle St	5 Lupton Rd	30 Carlisle St	50 Mockingbird Rd
Registered Number			GW102452	GW103023	GW103036	GW105262	GW111518	GW059618
Date			24-01-2022	24-01-2022	27-01-2022	28-01-2022	27-01-2022	25-01-2022
Calcium - Dissolved	0.5	mg/L	2	2	2	7.2	1	5
Potassium - Dissolved	0.5	mg/L	0.9	3	0.8	4	0.7	5
Sodium - Dissolved	0.5	mg/L	36	680	47	280	34	360
Magnesium - Dissolved	0.5	mg/L	7.6	78	7.9	73	6	57
Hardness	3	mg/L	35	330	37	320	27	250
Hydroxide Alkalinity (OH-) as CaCO3	5	mg/L	<5	<5	<5	<5	<5	<5
Bicarbonate Alkalinity as CaCO3	5	mg/L	36	<5	24	78	<5	63
Carbonate Alkalinity as CaCO3	5	mg/L	<5	<5	<5	<5	<5	<5
Total Alkalinity as CaCO3	5	mg/L	36	<5	24	78	<5	63
Sulphate SO4	1	mg/L	2	59	3	46	<1	44
Chloride Cl	1	mg/L	96	1400	110	680	82	760
Ionic Balance	-	%	-20	-4	-14	-7	-6	-6
Total Nitrogen in Water	0.1	mg/L	<0.1	0.2	0.1	<0.1	<0.1	<0.1
Phosphorus Total	0.05	mg/L	1.5	<0.05	<0.05	0.1	<0.05	<0.05
Aluminium-Total	10	µg/L	30	20000	310	20	<10	50
Arsenic-Total	1	µg/L	1	3	<1	<1	<1	<1
Barium-Total	1	µg/L	100	430	83	810	57	120
Beryllium-Total	0.5	µg/L	9	14	0.9	7	<0.5	3
Cadmium-Total	0.1	µg/L	<0.1	3.5	<0.1	<0.1	<0.1	<0.1
Chromium-Total	1	µg/L	<1	<1	<1	22	<1	<1
Cobalt-Total	1	µg/L	13	260	16	120	12	86
Copper-Total	1	µg/L	<1	34	<1	10	<1	<1
Iron-Total	10	µg/L	47000	11000	18000	45000	15000	60000
Lithium-Total	1	µg/L	8	32	9	56	6	24
Mercury-Total	0.05	µg/L	<0.05	0.15	<0.05	<0.05	<0.05	<0.05
Manganese-Total	5	µg/L	1800	6800	1600	7100	1800	3000
Nickel-Total	1	µg/L	16	190	33	82	29	54
Lead-Total	1	µg/L	16	99	2	7	<1	2
Selenium-Total	1	µg/L	<1	<1	<1	<1	<1	<1
Strontium-Total	1	µg/L	19	65	16	110	14	71
Vanadium-Total	1	µg/L	<1	<1	<1	3	2	<1
Zinc-Total	1	µg/L	65	1300	46	540	21	180
Aluminium-Dissolved	10	µg/L	<10	20000	210	<10	<10	<10
Arsenic-Dissolved	1	µg/L	<1	2	<1	<1	<1	<1
Barium-Dissolved	1	µg/L	75	430	85	200	61	120
Beryllium-Dissolved	0.5	µg/L	0.5	14	0.7	5	<0.5	2
Cadmium-Dissolved	0.1	µg/L	<0.1	3.5	<0.1	<0.1	<0.1	<0.1
Chromium-Dissolved	1	µg/L	<1	<1	<1	<1	<1	<1
Cobalt-Dissolved	1	µg/L	13	260	16	110	12	78
Copper-Dissolved	1	µg/L	<1	45	<1	<1	<1	<1
Iron-Dissolved	10	µg/L	38000	9500	17000	36000	60	47000
Lithium-Dissolved	1	µg/L	8	33	7	45	5	26
Mercury-Dissolved	0.05	µg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Manganese-Dissolved	5	µg/L	1900	6600	1400	6300	1500	2800
Nickel-Dissolved	1	µg/L	15	180	16	69	12	47
Lead-Dissolved	1	µg/L	<1	99	<1	<1	<1	<1
Selenium-Dissolved	1	µg/L	<1	<1	<1	<1	<1	<1
Strontium-Dissolved	1	µg/L	21	62	16	96	14	66
Vanadium-Dissolved	1	µg/L	<1	<1	<1	<1	<1	<1
Zinc-Dissolved	1	µg/L	43	1300	47	260	25	160

Parameter	LOR	Unit	10 Caloola Rd	Wollondilly Anglican Church	80 Great Southern Rd	115 Tyler's Rd	115 Tyler's Rd	39 David Pl
Registered Number			GW032443	GW104659	GW111810	GW112473	GW2 -1757YLER	GW116897
Date			25-01-2022	24-01-2022	04-02-2022	04-02-2022	04-02-2022	03-02-2022
Calcium - Dissolved	0.5	mg/L	13	3	18	0.8	2	<0.5
Potassium - Dissolved	0.5	mg/L	<0.5	1	7.6	0.6	0.9	0.9
Sodium - Dissolved	0.5	mg/L	21	68	330	74	65	120
Magnesium - Dissolved	0.5	mg/L	3	12	100	11	9.8	16
Hardness	3	mg/L	45	55	460	47	44	65
Hydroxide Alkalinity (OH-) as CaCO3	5	mg/L	<5	<5	<5	<5	<5	<5
Bicarbonate Alkalinity as CaCO3	5	mg/L	66	6	110	<5	43	<5
Carbonate Alkalinity as CaCO3	5	mg/L	<5	<5	<5	<5	<5	<5
Total Alkalinity as CaCO3	5	mg/L	66	6	110	<5	43	<5
Sulphate SO4	1	mg/L	4	7	57	6	4	41
Chloride Cl	1	mg/L	36	150	750	170	150	250
Ionic Balance	-	%	-14	-5	-2	-8	-15	-9
Total Nitrogen in Water	0.1	mg/L	0.1	<0.1	<0.1	0.5	<0.1	0.7
Phosphorus Total	0.05	mg/L	<0.05	3.6	<0.05	0.2	<0.05	<0.05
Aluminium-Total	10	µg/L	490	6800	<10	1900	10	1900
Arsenic-Total	1	µg/L	<1	6	<1	2	<1	1900
Barium-Total	1	µg/L	13	200	35	120	140	<1
Beryllium-Total	0.5	µg/L	<0.5	15	<0.5	2	0.8	110
Cadmium-Total	0.1	µg/L	2.2	<0.1	<0.1	<0.1	<0.1	5
Chromium-Total	1	µg/L	<1	2	<1	<1	<1	6
Cobalt-Total	1	µg/L	<1	10	1	14	21	730
Copper-Total	1	µg/L	<1	20	3	<1	<1	7
Iron-Total	10	µg/L	22000	410000	2300	45000	35000	730
Lithium-Total	1	µg/L	1	16	77	4	7	7
Mercury-Total	0.05	µg/L	<0.05	<0.05	<0.05	0.27	<0.05	79
Manganese-Total	5	µg/L	77	1600	350	730	2100	3
Nickel-Total	1	µg/L	4	10	4	12	19	23
Lead-Total	1	µg/L	12	73	2	39	<1	<1
Selenium-Total	1	µg/L	<1	<1	<1	<1	<1	<1
Strontium-Total	1	µg/L	17	29	180	11	17	5.5
Vanadium-Total	1	µg/L	<1	<1	<1	4	<1	5.5
Zinc-Total	1	µg/L	1200	54	75	60	60	49
Aluminium-Dissolved	10	µg/L	<10	<10	<10	460	<10	2000
Arsenic-Dissolved	1	µg/L	<1	<1	<1	<1	<1	2000
Barium-Dissolved	1	µg/L	12	150	35	120	140	<1
Beryllium-Dissolved	0.5	µg/L	<0.5	<0.5	<0.5	1	0.7	110
Cadmium-Dissolved	0.1	µg/L	0.4	<0.1	<0.1	<0.1	<0.1	5
Chromium-Dissolved	1	µg/L	<1	<1	<1	<1	<1	5
Cobalt-Dissolved	1	µg/L	<1	10	1	14	21	5
Copper-Dissolved	1	µg/L	3	<1	7	<1	<1	88
Iron-Dissolved	10	µg/L	14000	24000	390	7400	34000	30
Lithium-Dissolved	1	µg/L	1	16	82	7	8	5
Mercury-Dissolved	0.05	µg/L	<0.05	<0.05	<0.05	<0.05	<0.05	4
Manganese-Dissolved	5	µg/L	74	1700	330	730	2100	18
Nickel-Dissolved	1	µg/L	2	8	3	12	19	<1
Lead-Dissolved	1	µg/L	<1	<1	2	22	<1	6
Selenium-Dissolved	1	µg/L	<1	<1	1	1	1	<1
Strontium-Dissolved	1	µg/L	18	30	180	12	18	6
Vanadium-Dissolved	1	µg/L	<1	<1	<1	<1	<1	44
Zinc-Dissolved	1	µg/L	1300	20	66	50	62	30

Parameter	LOR	Unit	85 Dwyers Rd	Mockingbird Rd	130 Bargo Rd	225 Bargo Rd	40 Caloola Rd	130 Dwyers Rd
Registered Number			10CA119328	GW105803	GW105395	GW104323	GW111669	GW102179
Date			03-02-2022	02-02-2022	01-02-2022	01-02-2022	31-01-2022	31-01-2022
Calcium - Dissolved	0.5	mg/L	8.9	15	12	<0.5	1	20
Potassium - Dissolved	0.5	mg/L	5.8	5.7	10	1	3	9.7
Sodium - Dissolved	0.5	mg/L	210	200	620	150	65	240
Magnesium - Dissolved	0.5	mg/L	47	46	130	20	9.6	55
Hardness	3	mg/L	210	220	570	81	42	280
Hydroxide Alkalinity (OH-) as CaCO3	5	mg/L	<5	<5	<5	<5	<5	<5
Bicarbonate Alkalinity as CaCO3	5	mg/L	72	55	130	<5	<5	79
Carbonate Alkalinity as CaCO3	5	mg/L	<5	<5	<5	<5	<5	<5
Total Alkalinity as CaCO3	5	mg/L	72	55	130	<5	<5	79
Sulphate SO4	1	mg/L	29	18	75	27	26	79
Chloride Cl	1	mg/L	490	450	1300	310	130	530
Ionic Balance	-	%	-8	-3	-1	-6	-7	-5
Total Nitrogen in Water	0.1	mg/L	<0.1	1.3	0.2	0.5	1.9	2
Phosphorus Total	0.05	mg/L	<0.05	0.4	0.07	<0.05	<0.05	0.08
Aluminium-Total	10	µg/L	60	60	90	3700	930	60
Arsenic-Total	1	µg/L	60	1	3	<1	<1	<1
Barium-Total	1	µg/L	<1	72	110	260	210	100
Beryllium-Total	0.5	µg/L	160	4	3	6	0.8	2
Cadmium-Total	0.1	µg/L	26	0.1	0.2	0.6	0.2	<0.1
Chromium-Total	1	µg/L	<1	<1	<1	<1	<1	<1
Cobalt-Total	1	µg/L	41000	15	210	43	9	41
Copper-Total	1	µg/L	48	3	540	32	8	1
Iron-Total	10	µg/L	41000	22000	91000	100	100	27000
Lithium-Total	1	µg/L	48	26	110	11	6	54
Mercury-Total	0.05	µg/L	2300	<0.05	<0.05	<0.05	<0.05	<0.05
Manganese-Total	5	µg/L	23	950	2900	2300	480	2000
Nickel-Total	1	µg/L	<1	19	250	30	7	31
Lead-Total	1	µg/L	<1	2	21	24	8	2
Selenium-Total	1	µg/L	<1	<1	<1	<1	<1	<1
Strontium-Total	1	µg/L	98	90	240	12	14	200
Vanadium-Total	1	µg/L	98	<1	<1	<1	<1	<1
Zinc-Total	1	µg/L	36	3700	680	220	50	59
Aluminium-Dissolved	10	µg/L	10	<10	10	2300	930	160
Arsenic-Dissolved	1	µg/L	10	<1	<1	<1	<1	<1
Barium-Dissolved	1	µg/L	<1	76	73	200	210	93
Beryllium-Dissolved	0.5	µg/L	170	<0.5	0.5	4	0.7	2
Cadmium-Dissolved	0.1	µg/L	26	<0.1	<0.1	1	0.2	<0.1
Chromium-Dissolved	1	µg/L	<1	<1	<1	<1	<1	<1
Cobalt-Dissolved	1	µg/L	47	17	85	37	9	36
Copper-Dissolved	1	µg/L	2500	<1	<1	140	8	<1
Iron-Dissolved	10	µg/L	20000	<10	40000	160	80	24000
Lithium-Dissolved	1	µg/L	47	35	94	11	5	49
Mercury-Dissolved	0.05	µg/L	22	<0.05	<0.05	<0.05	<0.05	<0.05
Manganese-Dissolved	5	µg/L	<1	1100	2000	1900	470	1800
Nickel-Dissolved	1	µg/L	<1	18	87	36	7	27
Lead-Dissolved	1	µg/L	98	<1	<1	46	8	<1
Selenium-Dissolved	1	µg/L	<1	<1	<1	<1	<1	<1
Strontium-Dissolved	1	µg/L	98	100	200	11	14	180
Vanadium-Dissolved	1	µg/L	8	<1	<1	<1	<1	<1
Zinc-Dissolved	1	µg/L	20000	3000	98	1800	50	52

Parameter	LOR	Unit	129 Sillica Rd	145 Arina Rd	45 Junburra Pl	20 Stokes Rd	3105 Remembrance Rd	190 Arina Rd
Registered Number			GW112415	GW104008	GW110669	GW062068	Heritage Well	GW070245
Date			01-02-2022	10-02-2022	11-02-2022	07-02-2022	10-02-2022	08-02-2022
Calcium - Dissolved	0.5	mg/L	2	4	1	5.6	<0.5	5
Potassium - Dissolved	0.5	mg/L	1	3	1	16	4	2
Sodium - Dissolved	0.5	mg/L	110	86	44	8.5	5.8	91
Magnesium - Dissolved	0.5	mg/L	17	18	8.2	5	<0.5	21
Hardness	3	mg/L	75	84	37	34	<3	97
Hydroxide Alkalinity (OH-) as CaCO3	5	mg/L	<5	<5	<5	<5	<5	<5
Bicarbonate Alkalinity as CaCO3	5	mg/L	44	71	42	32	14	61
Carbonate Alkalinity as CaCO3	5	mg/L	<5	<5	<5	<5	<5	<5
Total Alkalinity as CaCO3	5	mg/L	44	71	42	32	14	61
Sulphate SO4	1	mg/L	4	15	6	11	<1	11
Chloride Cl	1	mg/L	270	200	100	19	9	230
Ionic Balance	-	%	-14	-14	-18	1	-21	-14
Total Nitrogen in Water	0.1	mg/L	<0.1	1.7	0.5	2.2	2.4	<0.1
Phosphorus Total	0.05	mg/L	<0.05	9.4	20	0.5	0.09	0.09
Aluminium-Total	10	µg/L	50	130	430	450	470	10
Arsenic-Total	1	µg/L	<1	130	430	450	470	10
Barium-Total	1	µg/L	230	6	16	<1	2	<1
Beryllium-Total	0.5	µg/L	2	500	130	15	7	190
Cadmium-Total	0.1	µg/L	<0.1	35	18	<1	<1	26
Chromium-Total	1	µg/L	<1	11	<1	4	<1	6
Cobalt-Total	1	µg/L	40	380000	290000	3700	10000	39000
Copper-Total	1	µg/L	<1	62	5	<1	<1	22
Iron-Total	10	µg/L	52000	380000	290000	3700	10000	39000
Lithium-Total	1	µg/L	13	62	5	<1	<1	22
Mercury-Total	0.05	µg/L	<0.05	2200	1800	29	95	2400
Manganese-Total	5	µg/L	4600	51	21	4	4	23
Nickel-Total	1	µg/L	33	15	11	1	2	1
Lead-Total	1	µg/L	<1	<1	<1	<1	<1	<1
Selenium-Total	1	µg/L	1	<1	<1	<1	<1	<1
Strontium-Total	1	µg/L	31	100	13	27	37	55
Vanadium-Total	1	µg/L	<1	100	13	27	37	55
Zinc-Total	1	µg/L	93	320	73	16	5	53
Aluminium-Dissolved	10	µg/L	<10	<10	<10	280	230	<10
Arsenic-Dissolved	1	µg/L	<1	<10	<10	280	230	<10
Barium-Dissolved	1	µg/L	240	<1	<1	<1	1	<1
Beryllium-Dissolved	0.5	µg/L	1	140	80	14	6	190
Cadmium-Dissolved	0.1	µg/L	<0.1	12	16	<1	<1	27
Chromium-Dissolved	1	µg/L	<1	<1	<1	<1	<1	<1
Cobalt-Dissolved	1	µg/L	42	30	6	<1	<1	22
Copper-Dissolved	1	µg/L	<1	1500	1900	29	29	2400
Iron-Dissolved	10	µg/L	43000	15000	12000	2600	3200	32000
Lithium-Dissolved	1	µg/L	14	30	6	<1	<1	22
Mercury-Dissolved	0.05	µg/L	<0.05	10	14	4	<1	22
Manganese-Dissolved	5	µg/L	4600	<1	<1	<1	1	<1
Nickel-Dissolved	1	µg/L	34	<1	<1	<1	<1	<1
Lead-Dissolved	1	µg/L	<1	54	15	27	32	59
Selenium-Dissolved	1	µg/L	<1	<1	<1	<1	<1	<1
Strontium-Dissolved	1	µg/L	34	54	15	27	32	59
Vanadium-Dissolved	1	µg/L	<1	130	49	18	4	48
Zinc-Dissolved	1	µg/L	90	15000	12000	2600	3200	32000

Parameter	LOR	Unit	65 Arina Rd	60 Great Sourthern Rd	Nightinglae Rd	115 Nightinggale Rd	304 Pheasants Rd	3210 Remembrance Dvwy
Registered Number			GW102344	GW105883	GW115773	115NTG	GW106546	GW109257
Date			23-02-2022	15-02-2022	21-02-2022	23-02-2022	25-02-2022	28-02-2022
Calcium - Dissolved	0.5	mg/L	5	13	10	11	14	2
Potassium - Dissolved	0.5	mg/L	2	4	4	7.5	9.4	1
Sodium - Dissolved	0.5	mg/L	100	280	110	270	390	110
Magnesium - Dissolved	0.5	mg/L	23	61	25	62	87	20
Hardness	3	mg/L	110	280	130	280	390	88
Hydroxide Alkalinity (OH-) as CaCO3	5	mg/L	<5	<5	<5	<5	<5	<5
Bicarbonate Alkalinity as CaCO3	5	mg/L	51	78	<5	73	120	<5
Carbonate Alkalinity as CaCO3	5	mg/L	<5	<5	<5	<5	<5	<5
Total Alkalinity as CaCO3	5	mg/L	51	78	<5	73	120	<5
Sulphate SO4	1	mg/L	25	32	86	41	69	2
Chloride Cl	1	mg/L	240	600	230	570	750	220
Ionic Balance	-	%	-10	-3	-6	-2	0	2
Total Nitrogen in Water	0.1	mg/L	<0.1	<0.1	<0.1	0.2	<0.1	0.1
Phosphorus Total	0.05	mg/L	<0.05	<0.05	0.4	1.3	0.8	<0.05
Aluminium-Total	10	µg/L	<10	<10	<10	130	30	450
Arsenic-Total	1	µg/L	<10	<10	<10	130	1	<1
Barium-Total	1	µg/L	<1	<1	<1	9	92	210
Beryllium-Total	0.5	µg/L	150	190	150	210		
Cadmium-Total	0.1	µg/L	25	13	5	35		
Chromium-Total	1	µg/L	<1	<1	<1	54		
Cobalt-Total	1	µg/L	27000	33000	20000	580000	5	38
Copper-Total	1	µg/L	20	52	33	54	4	18
Iron-Total	10	µg/L	27000	33000	20000	580000	39000	2800
Lithium-Total	1	µg/L	20	52	33	54	92	8
Mercury-Total	0.05	µg/L	2000	2200	1100	1600		
Manganese-Total	5	µg/L	19	13	5	35	1400	1100
Nickel-Total	1	µg/L	<1	<1	<1	22	8	26
Lead-Total	1	µg/L	<1	3	<1	<1	<1	3
Selenium-Total	1	µg/L	<1	3	<1	<1	<1	<1
Strontium-Total	1	µg/L	46	140	69	130	330	30
Vanadium-Total	1	µg/L	46	140	69	130		
Zinc-Total	1	µg/L	33	41	3	590	47	340
Aluminium-Dissolved	10	µg/L	10	<10	<10	10	<10	350
Arsenic-Dissolved	1	µg/L	10	<10	<10	10	<1	<1
Barium-Dissolved	1	µg/L	<1	<1	<1	<1	67	190
Beryllium-Dissolved	0.5	µg/L	150	200	140	130		
Cadmium-Dissolved	0.1	µg/L	25	12	5	24		
Chromium-Dissolved	1	µg/L	<1	<1	<1	6		
Cobalt-Dissolved	1	µg/L	21	53	34	54	3	37
Copper-Dissolved	1	µg/L	2000	2400	1200	1600	<1	17
Iron-Dissolved	10	µg/L	22000	28000	20000	610	79	130
Lithium-Dissolved	1	µg/L	21	53	34	54	1000	7
Mercury-Dissolved	0.05	µg/L	19	15	6	27		
Manganese-Dissolved	5	µg/L	<1	<1	<1	<1	5	1000
Nickel-Dissolved	1	µg/L	1	<1	<1	<1	<1	27
Lead-Dissolved	1	µg/L	47	150	74	140	<1	1
Selenium-Dissolved	1	µg/L	1	<1	<1	<1	220	1
Strontium-Dissolved	1	µg/L	47	150	74	140	27	30
Vanadium-Dissolved	1	µg/L	29	44	4	610		
Zinc-Dissolved	1	µg/L	22000	28000	20000	6100	<10	320

Parameter	LOR	Unit	95 Arina RD
Registered Number			GW106590
Date			24-03-2022
Calcium - Dissolved	0.5	mg/L	5.3
Potassium - Dissolved	0.5	mg/L	2
Sodium - Dissolved	0.5	mg/L	110
Magnesium - Dissolved	0.5	mg/L	21
Hardness	3	mg/L	100
Hydroxide Alkalinity (OH-) as CaCO3	5	mg/L	<5
Bicarbonate Alkalinity as CaCO3	5	mg/L	41
Carbonate Alkalinity as CaCO3	5	mg/L	<5
Total Alkalinity as CaCO3	5	mg/L	41
Sulphate SO4	1	mg/L	10
Chloride Cl	1	mg/L	240
Ionic Balance	-	%	-5
Total Nitrogen in Water	0.1	mg/L	<0.1
Phosphorus Total	0.05	mg/L	<0.05
Aluminium-Total	10	µg/L	<10
Arsenic-Total	1	µg/L	<1
Barium-Total	1	µg/L	170
Beryllium-Total	0.5	µg/L	
Cadmium-Total	0.1	µg/L	
Chromium-Total	1	µg/L	
Cobalt-Total	1	µg/L	21
Copper-Total	1	µg/L	5
Iron-Total	10	µg/L	15000
Lithium-Total	1	µg/L	21
Mercury-Total	0.05	µg/L	
Manganese-Total	5	µg/L	2000
Nickel-Total	1	µg/L	16
Lead-Total	1	µg/L	<1
Selenium-Total	1	µg/L	1
Strontium-Total	1	µg/L	52
Vanadium-Total	1	µg/L	
Zinc-Total	1	µg/L	27
Aluminium-Dissolved	10	µg/L	<10
Arsenic-Dissolved	1	µg/L	<1
Barium-Dissolved	1	µg/L	180
Beryllium-Dissolved	0.5	µg/L	
Cadmium-Dissolved	0.1	µg/L	
Chromium-Dissolved	1	µg/L	
Cobalt-Dissolved	1	µg/L	20
Copper-Dissolved	1	µg/L	<1
Iron-Dissolved	10	µg/L	15000
Lithium-Dissolved	1	µg/L	22
Mercury-Dissolved	0.05	µg/L	
Manganese-Dissolved	5	µg/L	2000
Nickel-Dissolved	1	µg/L	16
Lead-Dissolved	1	µg/L	<1
Selenium-Dissolved	1	µg/L	<1
Strontium-Dissolved	1	µg/L	50
Vanadium-Dissolved	1	µg/L	
Zinc-Dissolved	1	µg/L	20

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APPENDIX E

Model Plan Independent Review Endorsement

Jacobs

Memorandum

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Subject	**Review**	**Project Name**	Tahmoor Coal Groundwater Model Plan
Attention	April Hudson	**Project No.**	IA267800
From	Brian Barnett		
Date	23 December, 2021		
Copies to	Sharon Hulbert		

1. Introduction

This document provides peer review comments on the Groundwater Modelling Plan for Tahmoor Coal, prepared by SLR Consulting Pty, Ltd. (the Report) of December, 2021. I was also provided a copy of a letter from New South Wales Department of Planning, Industry and Environment (DPIE) to Tahmoor Coal that includes review comments from DPIE to an earlier version of the Groundwater Modelling Plan (Groundwater Assessment, Appendix C, dated August 2020) (the DPIE Review).

I am a hydrogeologist and groundwater modeller with more than forty years of consulting industry experience. My qualifications and experience are summarised in Appendix A: Curriculum Vitae.

I believe I am suitably independent as I:

- Have no pecuniary interest in the project.
- Have never worked for the proponent either as an employee or consultant.
- Have never worked or collaborated with the proponent's specialists (SLR Consulting), other than in a peer review capacity.
- Have never worked on another nearby project that may have material cumulative impacts with the Tahmoor Coal Mine, other than in a peer review capacity.

My review is aimed at assessing whether the groundwater modelling plan provides a rational basis for the development and use of numerical groundwater models of the Tahmoor Coal Mine. I have noted DPIE suggestions that the model plan should adhere to the Australian Groundwater Modelling Guidelines[1] (AGMG). Accordingly, I have focussed on those aspects of the guidelines that are relevant to the proposed modelling plan.

[1] Barnett B, Townley LR, Post V, Evans RE, Hunt RJ, Peeters L, Richardson S, Werner AD, Knapton A and Boronkay A. 2012, *Australian Groundwater Modelling Guidelines.* Waterlines Report #82. National Water Commission, Canberra.

As a result of my review of earlier versions of the Report I provided a number of comments and suggestions on how the document could be improved. My comments pertained to the following:

- Adding context as to why the model is being updated and how it will be used.
- Adding a map of the mine showing the key environmental assets and a summary of the environmental features at risk of impact from future mining.
- The proposed approach to determine an appropriate size of the model domain.
- The proposed approach to defining model layers.
- The proposed approach to implementing the fracturing expected to occur above the longwall panels.
- The use of Zone Budgets approach to quantify changes in groundwater exchange fluxes with individual river reaches and alluvial aquifers.
- Clarification of how the model will be used to assess potential groundwater quality impacts.
- The use of groundwater evapotranspiration as an indicator of impacts on GDE's.
- The inclusion of a verification of the existing model predictions.
- Inclusion of stakeholder consultation in the progressive reporting and review process.
- Adding model limitations and exclusions.
- Whether the plan has adequately addressed the DPIE review comments.
- Whether the model plan adheres to the AGMG.

2. Peer Review Findings

My review comments have been addressed by SLR Consulting through a number of report revisions. The current version of the report dated 23rd December, 2021 (665.10010.00407-R02-v3.1-20121223.docx) includes the revisions that have been made in response to my review comments. I consider this document to provide a sound plan for the modelling programme for the coming months. It appears to be aligned with relevant Guiding Principles defined in the AGMG and with recommendations on uncertainty analysis included in Middlemis and Peeters, 2018[2].

The model is primarily being used to assess potential environmental impacts that may arise during and after future mining. Accordingly, my reviews have and will focus on ensuring that the model is designed, constructed and used to obtain confident estimates of future impacts to environmental assets including existing groundwater users and potential diversion of groundwater from shallow aquifers that are accessed by other users including GDE's.

---

[2] Middlemis, H and Peeters, LJM, 2018. *Uncertainty Analysis – Guidance for groundwater modelling within a risk management framework*. A report prepared by the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development through the Department of the Environment and Energy, Commonwealth of Australia 2018.

Appendix A: Curriculum Vitae

Brian Barnett

Qualifications:

Bachelor of Engineering (Civil), University of Auckland, 1980

Relevant Experience:

Jacobs Group (Australia) Pty Ltd. (Prior to December 2013 SINCLAIR KNIGHT MERZ, AUSTRALIA)

May 2000 to present

Senior Hydrogeologist and Geothermal Reservoir Engineer SKM, Melbourne, Australia.

Responsible for groundwater modelling and geothermal studies. Major projects include:

- ***Australian Groundwater Modelling Guidelines. National Water Commission.*** Project manager and principal contributor to an Australian Groundwater Modelling Guideline that is planned to supersede the current Murray Darling Basin Commission guidelines. The project was completed in March 2012 and the document was published in June 2012.
- ***Frieda River Mine Dewatering Investigations. Xstrata Copper.*** Groundwater modelling of a proposed copper mine in Papua New Guinea. Groundwater models were used to estimate the dewatering pumping requirement for the mine and to provide an assessment of the environmental impacts that may accompany mine dewatering.
- ***New Acland Coal Mine***. ***New Hope Group.*** Developed a groundwater model of the New Acland Coal Mine to assist with gaining environmental and industry approvals for expanding coal mining operations. The model was used to predict the likely future inflows to the mining pits and to assess potential impacts that may arise from the inflows and associated drawdown in groundwater

heads. The work has included expert witness appearance in recent Queensland Land Court proceedings.

- ***Wards Well Coal Mine. BMA***. Supervising the modelling of an underground coal mine in Queensland. The model includes time varying material properties that represent deformation of formations above long wall mine panels.
- ***Kulwin Mineral Sands Mine Dewatering Investigations. Iluka Resources Ltd.*** Detailed numerical groundwater models were developed to help design the mine dewatering system. Investigations were aimed at depressuring the local groundwater system to expose the mineral sand deposits to allow dry mining of the resource. The models paid particular attention to vertical flow processes in and around the deposit and hence incorporated multiple (27 layers in total) horizontal layers.
- ***Pardoo Iron Ore Mine Dewatering Investigations. Atlas Iron.*** Groundwater models were developed in the FEFLOW numerical modelling code to estimate the mine dewatering requirements of an iron ore mine in the Pilbara region of Western Australia.
- ***Northern Murray Basin Environmental Effects Statement. Iluka Resources Ltd.*** Preparation of a water management report that formed part of the EES for the Kulwin and WRP deposits in the Northern Murray Basin Project. Work included the development of regional groundwater flow models to assess environmental impacts of dewatering and water disposal.
- ***Mine dewatering for Murray Basin Titanium Ltd for the Wemen Mineral Sand Mine.*** Numerical groundwater models were formulated and calibrated in order to help optimise a dewatering plan for a mineral sand deposit in Northern Victoria. The models were also used to assess the likely impacts of dewatering and associated water disposal on the Murray River.
- ***Mine water management consultant for Murray Basin Titanium Ltd for the Prungle Mineral Sand Mine.*** Responsibilities included the development of numerical groundwater models to assist in designing a groundwater supply scheme to provide water for a dredge mining operation in Northern Victoria. Investigations also included the assessment of groundwater extraction and disposal on local and regional surface water and groundwater resources.
- ***Murray Darling Basin Sustainable Yields Project. CSIRO.*** Groundwater modelling team leader for a major project covering groundwater resources in Queensland, New South Wales, Victoria and South Australia. SKM was contracted by CSIRO in 2007 to undertake the groundwater resource assessment for the entire Murray Darling Basin. The project involved the numerical modelling of all major fresh water aquifers in the basin. Twelve finite difference numerical models were run for the study. Results were used to quantify the available groundwater resources of the basin and to assess the impacts of future climate change and impacts of groundwater development on river flows.
- ***Northern Sewer Project, Groundwater Models.*** Groundwater flow models were developed for the NSP1 and NSP2 sewer tunnels in north Melbourne. The models were used to assess inflows into the tunnels and to determine the likely impacts of groundwater drawdown on the aquifer and on

the associated loss of base flow to local streams and rivers. Models were constructed to assess both the construction and operational phases.

- ***Lindsay River Groundwater Modelling. DNRE Victoria.*** Development of a three dimensional finite element groundwater model of the aquifers within the Lindsay River Anabranch of the Murray River. The model was developed in the FEFLOW modelling code and is being used to design a salt interception scheme.
- ***Numerical Water Trade Models. Mallee CMA Victoria.*** Project manager and leader of modelling team to develop, calibrate and run predictive scenario models for the Nangiloc Colignan and Wemen irrigation areas in northern Victoria. Models were aimed at quantifying the impact on salinity in the River Murray associated with the trading of irrigation water.
- ***South East Queensland Effluent Reuse Study – Darling Downs.*** Brisbane City Council. The impacts associated with future use of treated effluent for irrigation in the Darling Downs was investigated through the development and calibration of large scale three dimensional groundwater flow and solute transport models. Impacts under investigation included changes in groundwater head, changes in the groundwater interaction with rivers and streams and the water quality changes in the aquifer.
- ***Lake Toolibin Groundwater Modelling. CALM WA.*** A three dimensional finite difference groundwater model was formulated to assess the dewatering performance of a network of pumping bores designed to reduce groundwater heads beneath Lake Toolibin. The project is aimed at minimising salinisation of the lake by reducing groundwater discharge through the lake bed.
- ***Barwon Downs Groundwater Modelling. Barwon Water, VIC.*** This project involved the development and calibration of a large three dimensional finite difference groundwater flow model to assess the safe long term yield from the Barwon Downs borefield. Models were calibrated over a thirty year period of observation and were run in predictive mode for 100 years.

KINGSTON MORRISON LIMITED, AUCKLAND

1997 to May 2000

In July 1999, Kingston Morrison Ltd joined the Sinclair Knight Merz Group.

- **Senior Geothermal Reservoir Engineer.** Responsible for all aspects of geothermal reservoir assessment and well testing. Also responsible for all hydrogeological investigations and groundwater modelling.

SUMIKO CONSULTANTS COMPANY LIMITED, TOKYO, JAPAN

1991 to 1997:

Geothermal Reservoir Engineering Manager. Responsible for the enhancement of geothermal reservoir engineering and mineral resource evaluation capabilities in Sumiko Consultants through the acquisition of reservoir and well bore simulation codes and the application of geostatistical methods and software.

GEOTHERMAL ENERGY NEW ZEALAND LIMITED (GENZL), AUCKLAND

1981 to 1991:

Reservoir Engineer. Responsible for all geothermal reservoir engineering studies including extended assignments in Indonesia, Kenya and Japan.

HAWKES BAY REGIONAL WATER BOARD

1979 to 1981:

Groundwater Engineer. Duties included the investigation of hydraulic and chemical characteristics of aquifers in the Hawkes Bay region and the preparation of resource management plans.

APPENDIX F

Tahmoor Groundwater Model Rebuild Report

TAHMOOR GROUNDWATER MODEL REBUILD

Groundwater Modelling Technical Report

Prepared for:
Tahmoor Coal
2975 Remembrance Driveway
Tahmoor, NSW 2574

SLR Ref: 610.30652-R01
Version No: -v2.0
May 2022

PREPARED BY

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BASIS OF REPORT

DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
610.30652-R01. v0.4	13 May 2022	Arash Mohajeri	Brian Rask	Brian Rask
610.30652-R01. v0.4	29 April 2022	Arash Mohajeri	Brian Rask, Will Minchin	
610.30652-R01. v.4	3 May 2022	Arash Mohajeri	Brian Rask	Brian Rask

TABLES

FIGURES

APPENDICES

1 Introduction

Tahmoor Coal Mine (Tahmoor Mine) is an underground coal mine located approximately 80 kilometres (km) south-west of Sydney between the towns of Tahmoor and Bargo, New South Wales (NSW) (refer to Figure 1-1 of the conceptual report). Tahmoor Mine produces up to three million tonnes of Run of Mine (ROM) coal per annum from the Bulli Coal Seam. Tahmoor Mine produces a primary hard coking coal product and a secondary higher ash coking coal product that are used predominantly for coke manufacture for steel production. Product coal is transported via rail to Port Kembla and Newcastle for Australian domestic customers and export customers.

Operations at Tahmoor Mine commenced in 1979 using bord and pillar mining methods, and via longwall mining methods since 1987.

Tahmoor Coal has previously extracted 35 longwalls to the north and west of Tahmoor Mine's current pit top location (Figure 1-1 of the conceptual report). The current mining area, the 'Western Domain', is located north-west of the Main Southern Rail between the townships of Thirlmere and Picton. The Western Domain is within the Tahmoor Mine mining area and is within Mining Lease (ML) 1376 and ML 1539 (Figure 1-1 of the conceptual report).

The 'Tahmoor South' domain is an underground coal development targeting the Bulli Coal seam coal resource within Consolidated Coal Leases (CCL) 716 and 747. On the 23rd April 2021, Tahmoor Coal received Development Consent SSD 8445 (the Consent) for the Tahmoor South Project, enabling extension of underground longwall mining to the south of the existing workings. This enables an extension of mining operations at Tahmoor Colliery until 31 December 2033 or until 10 years from the commencement of second workings, whichever is the sooner.

The Tahmoor South Project (the Project) is an underground coal development project targeting the Bulli Coal seam coal resource within Consolidated Coal Leases (CCL) 716 and 747 in the Southern Coalfield, 80 km southwest of Sydney. The Tahmoor South EIS received approval for extraction of LW S1A-S6A (the A-series), the focus of the impact assessment provided here, and also LW S1B-S6B (the B-series) which are not the focus of any modelling at this point.

SLR Consulting Australia Pty Ltd (SLR) has been engaged by Tahmoor Coal to undertake a groundwater model rebuild for the Tahmoor Mine operations, as a part of the requirements in the Tahmoor South Groundwater Management Plan (GMP). The Tahmoor Mine groundwater model is intended to inform the potential risk of environmental impacts associated with the historical, present, and future mining operations and meet Development Consent (SSD 8445) obligations as outlined in the B34 (v) and discussed in Section 1.2. The objectives of the groundwater model are to estimate:

- Mine inflows to the underground mine workings;
- Change in groundwater levels during and after extraction, both within the Permo-Triassic strata and the alluvium associated with Thirlmere Lakes;
- Impacts on water supply for water users (i.e. private bores);
- Impacts on Groundwater Dependent Ecosystems (GDEs) including the Thirlmere Lakes;
- Changes to baseflow and stream leakage to and from the Bargo and Nepean Rivers and their tributaries during and after mining;

- Estimate the storage capacity and groundwater recovery at Tahmoor Mine during and after the cessation of mining; and
- Inform possible changes in groundwater quality due to Tahmoor Mine operations.

The predictions are required for mining at Tahmoor South Project, namely LWS1A-S6A, to inform post-mining management and licensing across the Tahmoor Mine domain, and also for cumulative impacts from the Project and approved and foreseeable mines in the area.

The groundwater model will assist with decision-making and planning of the following components:

- Management of mine water (i.e. incorporate predicted mine inflows in the Site Water Balance);
- Licensable takes of water (i.e. groundwater and surface water licensing); and
- Quantify the level risk of risk associated with management options (i.e. Adaptive Management options).

The model will be used as a decision-making tool that can be utilised for current and future studies and to inform the Long-term Water Management Strategy for the Tahmoor mining complex.

Conceptualisation of the groundwater regime and the calibration of the model against observed data are key to achieving a reliable numerical model. Conceptualisation is a simplified overview of the groundwater regime (i.e. the distribution and flow of groundwater) based on available data and experience. Consistency between numerical model results and the conceptual understanding of the groundwater regime increases the credibility of the numerical model predictions. The conceptualisation of the groundwater regime was carried out by SLR in 2022 and is reported in the Conceptual Report (SLR, 2022) of which this groundwater modelling technical report forms an appendix.

Confidence in the numerical model is increased by calibration of numerical model results against observed data. A well calibrated model has demonstrated the ability to simulate groundwater levels that approximate observed levels at specific locations.

The numerical groundwater model for the Project builds on the existing the Tahmoor Western Domain LW W3-W4 Project (SLR, 2021). Tahmoor recently established groundwater a data-sharing agreement with South32 who operate the nearby Dendrobium and Appin mines. This arrangement allows for the sharing of groundwater data, models and documentation. Under these agreements, the groundwater model extent is designed to cover both Dendrobium and Appin mines to simulate these mines forming part of the cumulative impact assessment, as well as potentially allowing this numerical model to be used as a part of each mines' groundwater assessment process in the future. Of note, the current update of the groundwater model reported herein is the first iteration to include data and information from the Appin and Dendrobium sites.

The Tahmoor Western Domain LW W3-W4 model (SLR, 2021) is a MODFLOW-USG model built on the site geological model and reported on the model calibration, predicted mine inflows, predicted drawdown extents. Where possible, the results from this modelling work are compared against the Tahmoor South EIS model (SLR/HydroSimulations, 2020) in Section 3 and Section 4.

A range of model updates were deemed required for the model to be considered fit for purpose for the Project. The updates to the model design from that reported in SLR (2020) included:

- Model extent and grid – adoption of an "unstructured" grid or mesh, revision of model extent and refinement of the mesh around mine areas;

- Model layers – update layers to include deepest mined seams at Tahmoor, update model layers to match Tahmoor, Dendrobium and Appin geological model surfaces, consider data from Sydney-Gunnedah Basin model in the layers, and update topography with the LiDAR data;
- Timing – extend calibration model period to December 2021 and refine timing to capture seasonality and mine progression changes;
- Boundary Conditions – update model boundary conditions with revised grid extent and regional flows; and
- Stresses – Maintain inputs, but with updates from more recent and site-specific data.

Further details on the updates are discussed in Section 2 of this modelling report which presents how the conceptualisation has been developed as a numerical groundwater model, and Section 3.3 presents how well the model replicates observed data (calibration). Details on how the model represents extraction of LW S1A-S6A and other future approved and foreseeable activities within the region is outlined within Section 4 of this report.

2 Model Design

2.1 Previous Groundwater Models

The numerical groundwater model was first developed by HydroSimulations in 2013 using the MODFLOW-SURFACT code. The model investigated the potential impacts of mining on the groundwater regime. The 2013 groundwater model was then updated by HydroSimulations (2018) and converted to MODFLOW-USG code.

The 2018 model was further revised by SLR/HydroSimulations in 2020 to assess potential groundwater related impacts for the purpose of Tahmoor South Project EIS (SLR/HydroSimulations, 2020). The 2020 model covered an area of 3,237 km^2 and comprised 16 layers. The model was calibrated in steady state and transient modes, with the transient calibration run from 1980 to 2019. Model timing was varied based on mine progression, with most stress periods around 180 days (6 months) in length but varied from 20 days to over a year. The latest update to the model (SLR, 2021) was carried out in 2021 as a part the Extraction Plan developed for Longwall W3-W4 in Tahmoor Western Domain.

2.2 Model Code

Numerical modelling was undertaken using Geographic Information Systems (GIS) in conjunction with MODFLOW-USG-Transport (Panday, 2021), which is distributed by the United States Geological Survey (USGS) and GSI Environmental. MODFLOW-USG is a relatively new version of the popular MODFLOW code (McDonald and Harbaugh, 1988) developed by the USGS. MODFLOW has been the most widely used code for groundwater modelling in the past and has long been considered an industry standard.

2.3 Model Extent and Mesh Design

To allow numerically stable modelling of the large spatial area of the model domain, an unstructured grid mainly comprised of Voronoi cells of varying sizes was designed using AlgoMesh (HydroAlgorithmics, 2014). Varying Voronoi cell sizes allowed refinement around areas of interest, while a coarser resolution elsewhere reduced the total cell count to a manageable size. In addition, pinch-out option of MODFLOW-USG will be used, which means model layering does not need to be continuous over the model domain, and layers can stop where geological units pinch out or outcrop. This is also particularly useful when simulating thin, discontinuous hydrostratigraphic units and faults.

The model domain is shown in Figure 2-1. The model extent was designed to be large enough to incorporate surrounding mines and to prevent any influence on modelled drawdowns due to the model boundary.

The horizontal and vertical extent of the numerical model is approximately 65 km N-S and 56 km W-E, exceeding that of the SLR (2021) model. The model domain was designed large enough to allow the adjacent mines/projects (including Appin, Dendrobium, Metropolitan, Russell Vale and Cordeaux coal mines) to be assessed for potential cumulative impacts. To the east, the model extends beyond the subcrop line of the deepest coal seam (i.e. the Wongawilli Coal seam) that is likely to be mined at any of the surrounding mines in the future.

The model domain was selected based on the following considerations:

- The western and southern boundaries of the model is represented by the boundary of the Illawarra Coal Measures and Shoalhaven Group outcrops. The southern boundary of the model also follows the topographic high located approximately 21 km to the south of Tahmoor Mine;
- The eastern boundary of the model is set along the shoreline of the ocean near Wollongong and surrounding townships; and
- The northern model boundary is set approximately 25 km from the Project and is expected to be far outside the range of maximum predicted drawdown due to the Project. (This has been reviewed in Section 4.3).

The model domain was vertically discretised into 19 layers, each layer comprising a up to 81,321 model cells. Areas in layers 2 to 18 were pinched out where a layer is not present based on the structural geology, resulting in a total of 1,340,263 cells in the model. In comparison to the SLR (2021) model which comprised 16 layers and 2,877,930 active model cells, the model grid provides improved discretisation of geological units and allows significantly reduced model run times, with less than half the number of active model cells.

Grid refinement represented the following features:

- 50 to 100 m square shaped cells are used in the Tahmoor South, Tahmoor North and Western Domains respectively. The cells in each area were rotated to be consistent with the alignment of the longwalls;
- 50 to 100 m square shaped cells are used for the Dendrobium Mine. The cells in each area were rotated to be consistent with the alignment of the longwalls;
- 100 m square shaped cells are used to represent current and future mining at Appin and Metropolitan mines. 300 m by 300 m hexagonal cells are used to for historical mining in these two mines;
- 300 to 800 m irregular shaped Voronoi cells used to represent the historical underground mining at the neighbouring mines;

- 50 m by 50 m hexagonal cells represent the mapped faults within the model domain (i.e. Nepean Fault Complex, Bargo Fault, Victoria Park Fault, Central Fault, Western Fault);
- Drainage lines within the model domain are represented by Voronoi cells of different sizes depending on the location and priority rankings of the rivers:
  - 100 m cells are used along the mapped extents of the Nepean River;
  - 100 to 150 m cells along Bargo River;
  - 30 to 100 m along Stonequarry Creek, and
  - 300 m cells were assigned along minor creeks within the model domain.
- 25 m by 25 m hexagonal cells use to represent Thirlmere Lakes and the associated alluvium including the upper reach of Blue Gum Creek;
- For other lakes such as Lake Nepean, Lake Avon, Lake Woronora and Lake Cordeaux and Lake Cataract, 200 m Voronoi cells are used;
- Mapped alluvium, other than around Thirlmere Lakes, is represented by irregular shaped Voronoi cells with resolution in a range of 200 m and 400 m;
- Escarpment along the eastern boundary of the model is represented by 50 m by 50 m hexagonal cells; and
- Coal seam gas wells are represented with irregular shaped Voronoi cells with resolutions of approximately 15 m.

Figure 2-1 Model Mesh and Boundary Conditions

2.4 Layers and Features

Topography within the model domain has been defined using numerous sources. Data extents of the sources used to construct model topography are shown in Figure 2-2.

LiDAR data from the Tahmoor and the Dendrobium mine were used to define surface elevation. Outside the extents of the LiDAR dataset, public domain 25 m DEM data sourced from Geoscience Australia was used to define topography in the remainder of the model domain.

The modelled strata is discretised into 19 layers, as listed in Table 2-1. Model layer extents (lateral and vertical) have been defined using data from the following sources:

- Tahmoor Coal, Tahmoor Mine Geology Model;
- South32, Dendrobium Mine Geology Model;
- South32, Appin Mine Geology Model;
- CSIRO Regolith mapping (CSIRO, 2015);
- Client/private/public bore logs;
- Geological Survey of NSW, Southern Coalfields Geological Model – Sydney Basin (herein referred to as the Sydney Basin Model); and
- NSW Government surface geology and basement geological maps.

Model Layer 1 is fully extensive across the model with an average thickness of 4.3 m. In the model domain extension, the base of Layer 1 was interpreted from the national CSIRO Depth to Regolith dataset. Subsequently the base of Layer 1 was then updated to align with bore logs available across the model domain including Tahmoor monitoring bores and publicly available bore logs.

Model Layer 2 represents the Triassic Wianamatta Formation and is not fully extensive across the model domain. The extent of Layer 2 is based on the outcrop (and assumed subcrop) extent of the Wianamatta Formation shown on the Wollongong-Port Hacking 1:100,000 geological map (Geological Survey of New South Wales, 1985). Where the Wianamatta Formation is present, Layer 2 has an average thickness of 67 m. The elevation of the base of this layer was interpreted from the Sydney Basin Geological Model and available bore logs.

The lower layers are largely present across the model domain except for the river valleys and on the seaward side of the escarpment to the east. The Hawkesbury Sandstone is split into 3 layers to reduce the overall thickness, and to improve the model's ability to represent vertical hydraulic gradients and subsidence fracturing effects within this unit. Similarly, the Bulgo Sandstone and Scarborough Sandstone layers were split into multiple layers to avoid having excessive thickness in the model layers and to provide enough vertical resolution to better represent the fracturing zone above longwalls.

Within Tahmoor, Dendrobium and Appin mine areas, the layering from each mine's geology model has been adopted. Where overlap occurs between the different site geology models, the layers have either been averaged where appropriate or a specific site geology model has been given preference over another based on the proximity to the mine plan (with the assumption that the accuracy of a given site geology model is highest where the mine plans have been developed). Linear interpolation techniques were employed to achieve smooth transition between the site geology models provided.

Figure 2-2 Extent of Topography Data

At the exterior edge of the provided site geology models, the Sydney Basin Model layering was used. The Sydney Basin Layers were generally lowered to conform smoothly to the site geology models with an average drop in elevation of 8.8 m. The greatest change occurred on the Stanwell Park Claystone (Layer 10) where the overall elevation was dropped 16.08 m before merging with the site geology models. Linear interpolation techniques were employed to achieve smooth transition between the provided merged site geology models and the Sydney Basin Layers. The Sydney Basin model layers covered the model domain and therefore no additional extrapolation was required.

Table 2-1 presents the average and maximum thicknesses across the model domain for each layer.

Table 2-1 Model Layers

Layer	Lithology	Average Thickness (m) [1]	Maximum Thickness (m)	Source
1	Regolith, alluvium and basalt	4.3	25.8	CSIRO Depth of Regolith, Bore logs
2	Wianamatta Formation	67.0	307.1	Geo100k, Syd Basin Model, Bore Logs, Site Geo Models
3	Hawkesbury Sandstone - upper	49.3	182.6	Geo100k, Site Geo Models, Syd Basin Model
4	Hawkesbury Sandstone - middle	51.3	80.3	Site Geo Models, Syd Basin Model
5	Hawkesbury Sandstone - lower	54.8	82.7	Site Geo Models, Syd Basin Model
6	Bald Hill Claystone	35.1	153.8	Site Geo Models, Syd Basin Model
7	Bulgo Sandstone - upper	55.2	109.3	Site Geo Models, Syd Basin Model
8	Bulgo Sandstone - middle	55.1	109.3	Site Geo Models, Syd Basin Model
9	Bulgo Sandstone - lower	56.7	112.6	Site Geo Models, Syd Basin Model
10	Stanwell Park Claystone	10.1	106.9	Site Geo Models, Syd Basin Model
11	Scarborough Sandstone - upper	15.7	57.7	Site Geo Models, Syd Basin Model
12	Scarborough Sandstone - lower	16.4	57.7	Site Geo Models, Syd Basin Model
13	Wombarra Claystone	19.2	99.7	Site Geo Models, Syd Basin Model
14	Coal Cliff Sandstone	12.2	41.2	Site Geo Models, Syd Basin Model
15	Bulli Coal Seam	2.3	7.6	Site Geo Models, Syd Basin Model
16	Eckersley Formation	24.9	106.6	Site Geo Models, Syd Basin Model
17	Wongawilli Coal Seam	8.9	33.6	Site Geo Models, Syd Basin Model
18	Kembla Sandstone	11.5	41.3	Site Geo Models, Syd Basin Model
19	Older units (lower Permian Coal Measures and Shoalhaven Group)	293.8	369.0	300 m Below Kembla Sandstone Pre-eroded, minimum thickness of 15m

[1] Average value excludes pinched out cells/layers

Figure 2-3 and Figure 2-4 show the model layers in a horizontal and a vertical cross-section through Tahmoor Mine. The location of the cross-sections is shown in in Figure 2-1. Appendix A includes cross-section through the model for all the cross-section lines shown in Figure 2-1.

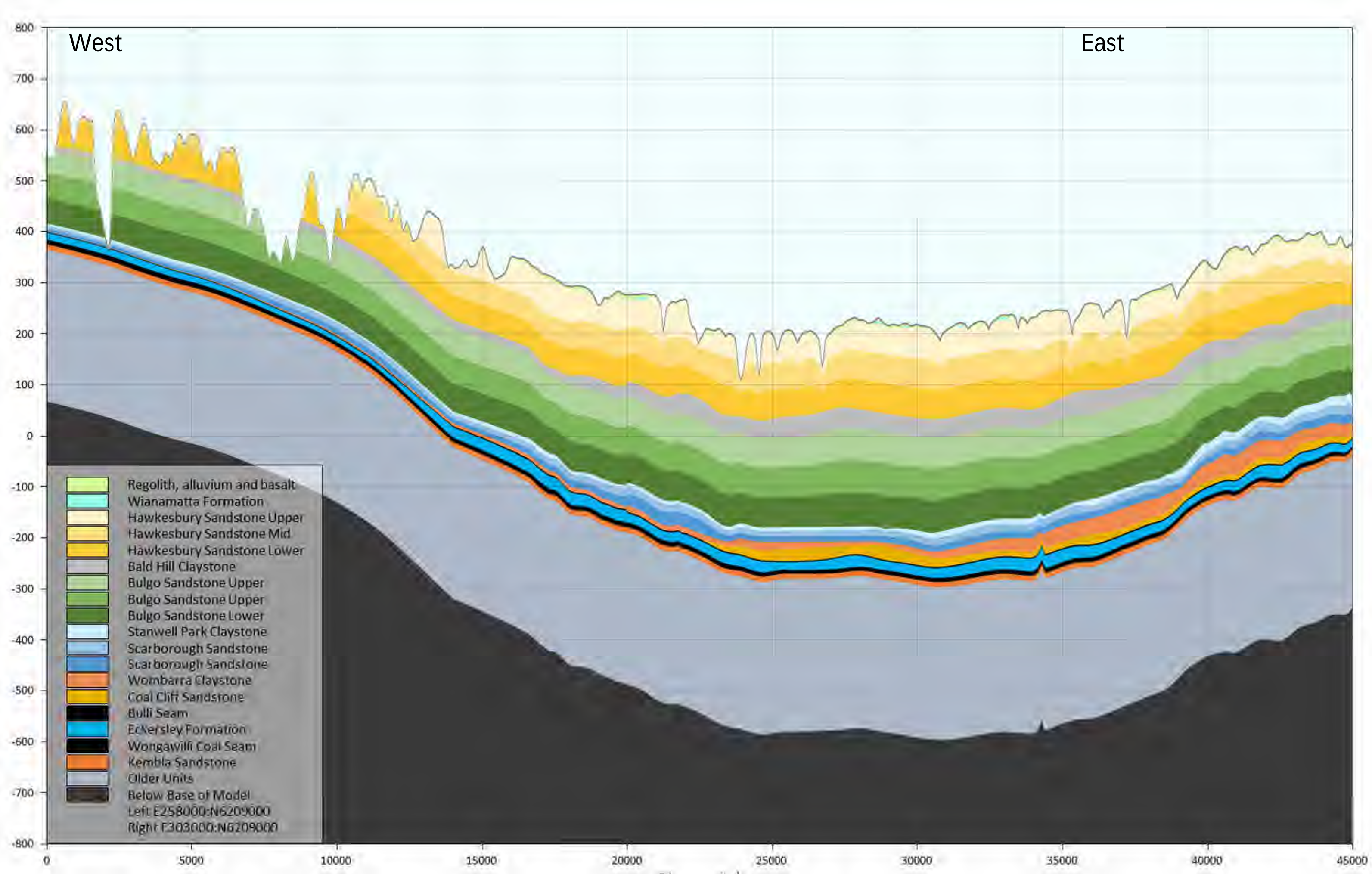


Figure 2-3 Model Layers Cross-section G-G’

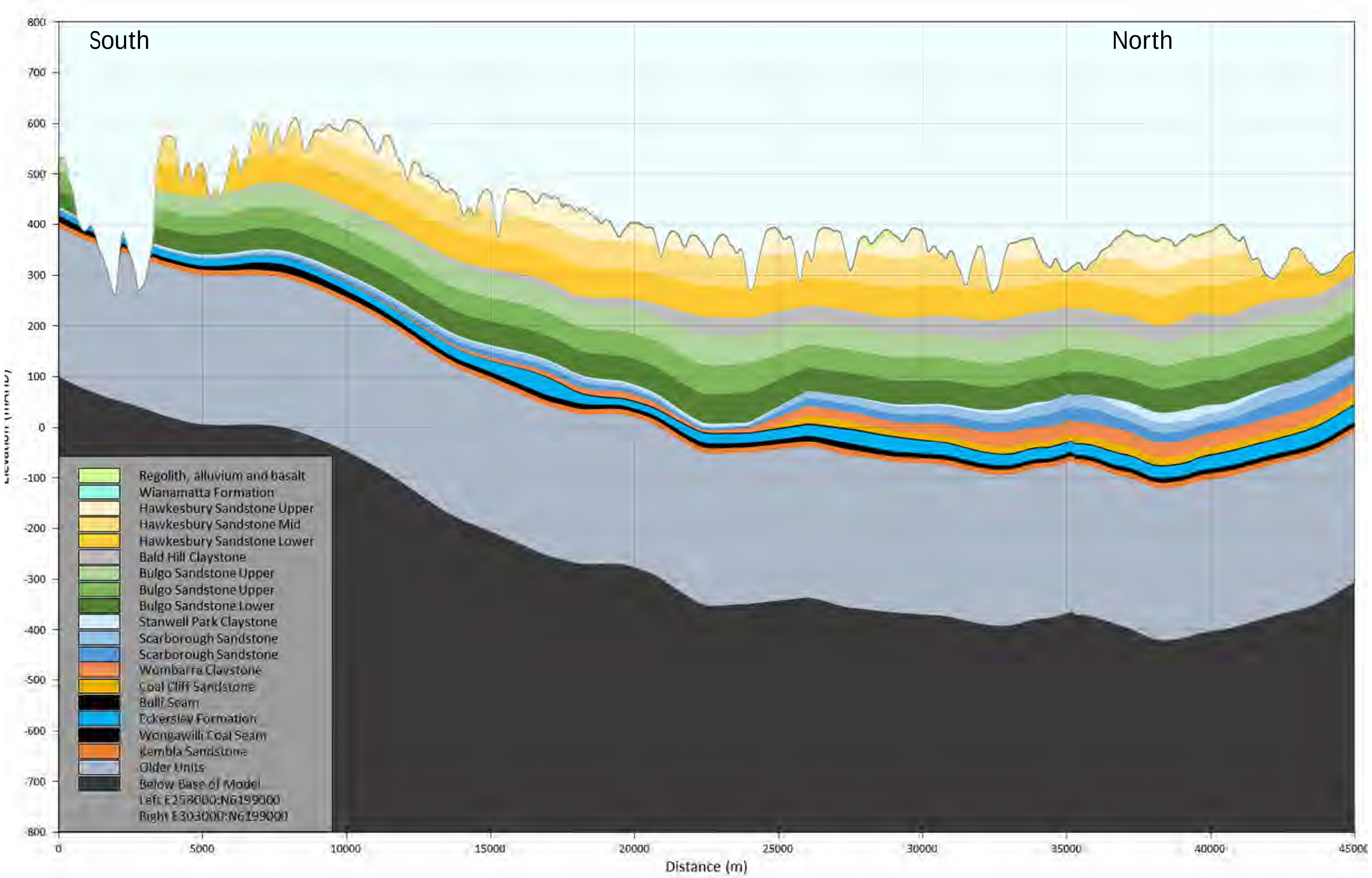


Figure 2-4 Model Layers Cross-section EE-EE'

2.5 Hydraulic Property Zones

The modelled hydraulic zones and values are reflective of the conceptual (and geological) model. The Conceptual Model (SLR, 2022) describes the hydraulic conductivity (K) data sources and the horizontal (Kx) and vertical (Kz) hydraulic conductivity parameter ranges for each stratigraphic unit as derived from field data. That document includes discussion the concept of broadly declining K with depth for most of the stratigraphic units.

The distributions of hydraulic properties in each model layer are shown in Appendix C. The model included 5 zones in Layer 1 (Alluvium, Weathered Sandstone, Shoalhaven/Illawarra outcrop, Wianamatta Formation and escarpment). The faults are represented in all the layers as separate zones. Further details on inclusion of the faults in the model is discussed in the next section.

2.6 Structural Geology

The structural geology at Tahmoor and surrounds is influenced by a series of folds and faults and dykes of volcanic origin, varying in age from Jurassic to Tertiary.

The Nepean Fault is the major structural feature of interest to operations conducted by Tahmoor Coal. Recent mapping by SCT (2018a) indicates that this fault extends along the full length of the eastern edge of the Tahmoor North mine footprint and is approximately 10 km in length. The Nepean Fault is known to be transmissive, and mine workings that intersect this zone can produce more water, i.e. be wetter than, areas that are located away from this zone. LW W4, which is the nearer of the two panels, is located between 500 and 600 m at least, and more typically 1000 m, from the fault and disturbed zone, and are therefore likely to be influenced by that structural feature.

The other two major faults present at site are the ‘T1’ and ‘T2’ faults. These faults are mapped to the north and northwest of the Tahmoor South longwalls. These faults are reported by Pells Consulting (2011) to be more permeable than the host rock. HydroSimulations (2020) suggested there is no evidence that supports the concept of these faults acting as a barrier as there is only a small gradient between the nearest bores lying on either side of the T1 fault, where an enhanced gradient would have suggested the fault acts as a barrier. Nor does the data provide evidence to support the role of either fault being conductive.

The smaller faults near the site are the Central and Western Faults which trend NW-SE and are mapped just off the southern limit of the Tahmoor South longwalls.

The Nepean Fault, T1 and T2 Fault, and Central and Western Faults have been simulated in the groundwater model domain as separate hydraulic zones. The hydraulic properties of the fault zones were adjusted during the model calibration. Figure 2-5 shows the locations of geological fault zones represented in the model.

Figure 2-5 Modelled Fault Zones

2.7 Timing

A combined steady state and transient model was developed, as follows:

- Steady state to replicate pre-mining conditions;
- Transient warm-up model for pre-2009 conditions to replicate influence of historical mining;
- Transient calibration model from January 2009 to December 2021 with quarterly time intervals; and
- Transient predictive model from December 2021 to December 2026 with quarterly time intervals.

The transient warm-up model period was built to incorporate pre-2001 mining activities and their impacts on groundwater levels around the Project Area. The transient warm up model covered a time period from 1969 to January 2009 and included 8 time slices each with a length of 5 years. The warm-up model was used to change model cell properties due to the underground mining within the model extent before 2009. This then provided appropriate starting conditions for the calibration model (i.e. starting heads and hydraulic properties).

To assist the model in overcoming the numerical difficulties, MODFLOW-USG Adaptive Time-Stepping (ATS) option was used. The ATS option of MODFLOW automatically decreases time-step size when the simulation becomes numerically difficult and increases it when the difficulty passes. The minimum time step size used in the simulations was 1 day.

The new numerical model ran in 3.5 hrs (from start of the calibration to end of prediction period), which is approximately 14% of the runtime from previous model (SLR, 2021). This facilitated automated calibration techniques (leading to uncertainty analysis), including the use of pilot points for assigning hydraulic properties to important strata.

2.8 Boundary Conditions and Stresses

2.8.1 Regional Groundwater Flow

The model boundary conditions are presented in Figure 2-1. As shown in Figure 2-1, the edges of the model domain where it is expected that groundwater will be transmitted in or out of the model domain, primarily in the west, north and south, were assigned as MODFLOW General Head Boundary condition (GHB).

GHB simulate groundwater flow into and/or out of the model domain according to a specified head and conductance. Groundwater enters the model where the head set in the GHB is higher than the modelled head in the adjacent cell and leaves the model when the water level is lower in the GHB. The GHB heads were assigned based on the most recently recorded water levels at monitoring and NSW government bores. GHB Conductance is variable which was adjusted during the model calibration process. The assigned heads are constant throughout the model simulation. Being far enough from the Project area, any variation in heads at these boundaries is expected to have insignificant impact on the model predictions.

A 'no flow' boundary was applied to the western boundary of the model which represents the outcrop of the older units (lower Permian Coal Measures and Shoalhaven Group).

Fixed head boundaries at 0 mAHD were assigned along the eastern boundary of model in all of layers 1 to 4 to represent the ocean.

Springs emanating from the Illawarra Escarpment along and inside the south-east margin of the model domain were simulated using the MODFLOW Drain package. The Drain boundary condition allows one-way flow of water out of the model. When the computed head drops below the elevation of the drain, the drain cells become inactive. These drains were simulated as occurring at the ground surface along the escarpment, placing them between model layers 3 and 15 depending on local stratigraphy. A high conductance was provided to these model cells to represent 'spring-like' behaviour where groundwater flow can be discharged along the face of the escarpment. Having a drain elevation set at topography means that any groundwater contributed as 'baseflow' to these features is discharged from the system, removing the opportunity for these features to gain water and return flow to the system.

2.8.2 Surface Drainages

There are a significant number of surface water features that exist within the model extent. Creeks and rivers throughout the model domain were modelled using MODFLOW's River (RIV) package. Use of the River package allows the creeks and rivers to remain as potential source of water to the underlying porous rock aquifers, which agrees with the data analysis and conceptualisation presented in Section 3.2.2 of the conceptual report (SLR, 2022). This package allows a stage (or depth of water) to be set and varied through time based on the inferred behaviour of each watercourse.

River cells in the model are shown in Figure 2-6. As shown in the figure, major rivers and streams as well as minor creeks were built into the model. The major rivers within and around the Project area included in the RIV package are presented in

Table 2-1.

River and creek widths were adopted from the SLR (2021) model. The river conductance was calculated using river width, river length, riverbed thickness, and the vertical hydraulic conductivity of river bed material (Kz). Therefore, the river conductance is variable due to the non-constant spatial discretisation in each of the model river cells. The initial values of river bed vertical hydraulic conductivity (Kz) were adopted from the previous model and adjusted during the calibration process.

River channel widths were set using geomorphological survey of the Tahmoor South area by Gippel (2013), aerial photos and GIS mapping of Thirlmere Lakes, and field inspection of a small number of sites. Where no specific data was not available, the river widths were estimated and assigned based on Google Satellite imagery data.

To allow climate variability to be represented in the model, variable stage height is utilised to simulate watercourses within the model domain. Where possible, the variable stage height in the RIV package was calculated using the river level data recorded in the stations within the model domain. Data from 82 surface water monitoring stations within the model domain were included in the RIV package. The stations include 37 from the NSW Government monitoring sites, 19 from Tahmoor North Monitoring Sites, 12 from Western Domain Monitoring Sites and 14 from Tahmoor South Monitoring Sites.

Rivers with multiple stream level stations were split to a few zones in the RIV package to allow information from as many stations as possible to be captured in the model. The zonation can be seen for the Stonequarry Creek, Myrtle Creek, Nepean River and Bargo River in Figure 2-6.

The river stage elevations for the transient warm-up model were calculated for the zones along Stonequarry Creek and Nepean River based on the average annual levels pre-2001 from surface water monitoring stations along these two rivers. For the transient simulation, river stage levels were varied quarterly based on the historical quarterly average levels from these stations. The river stage captured in the model for the Stonequarry Creek (Station 212053) and Nepean River at Maldon Weir (Station 212208) are shown in Figure 2-7 and Figure 2-8.

The river stage elevations in the transient warm-up model were calculated for the zones along Myrtle Creek, located in Tahmoor North area, based on the average annual levels pre 2001 from surface water monitoring stations (MYC1, MYC2, M3, M4, M5/Pool 23, M6, M20). For the transient simulation, river stage levels were varied quarterly based on the historical quarterly average levels from these stations. The change in river stage captured in the model for the Myrtle Creek (M5/Pool 23) is shown in Figure 2-9.

For the transient warm-up model the river stage elevation for Bargo River followed the long-term average from the historical monitoring gauge station located on Tahmoor South (SW-1 Bargo River Upstream, SW-13, Bargo River at Teatree Hollow, SW-14 Bargo River at Rockford Road Bridge). During historical transient simulation, Bargo River stage height was varied based on the available historical quarterly average levels. Where data was limited to a short period of time, a simplified approach was adopted where the stage height was set based on the short period of available data, and then extrapolated out for where no data was available, as presented for Bargo River at Teatree Hollow in Figure 2-10.

As described in

Table 2-1, historical quarterly average stage heights were used in both the calibration and prediction model. Using quarterly time slices is a simplified way to tie river stage height fluctuations to rainfall trends. It is important to note that the intent of modelling is to capture the long-term impacts of groundwater and surface water interaction. Due to the model time resolution (quarterly), the model is not set up or able to adequately capture the short-term (i.e. daily) climate response and interaction between groundwater and surface water.

The river stage height (water depth) in the minor tributaries or drainage lines was set to 0 m (i.e. modelled river stage elevation was equal to river bottom elevation). Therefore, the minor tributaries or drainage lines act as drains to the groundwater system, i.e. can receive baseflow, but do not result in any recharge from surface water to the underlying groundwater system.

Figure 2-6 Modelled River Zones

Table 2-1 River and Surface Water Features in the Tahmoor Model

Boundary	River Stage (m)	River Bed Kz (m/day) (Initial value)
Nepean River	• SS simulation - Long-term Average • Calibration simulation - Historical Quarterly Average • Prediction simulation- Transient Stage Height- Long Term Quarterly Average	0.005
Bargo River, Avon River, Cordeaux River	• SS simulation - Long-term Average • Calibration simulation - Historical Quarterly Average • Prediction simulation- Transient Stage Height - Long Term Quarterly Average	$1x10^{-4}$ - 0.005
Stonequarry Creek	• SS simulation - Long-term Average • Calibration simulation - Historical Quarterly Average • Prediction simulation- Transient Stage Height- Long Term Quarterly Average	0.01
Cedar Creek, Redbank Creek, Matthews Creek, Myrtle Creek, Eliza Creek, Dogtrap Creek, Cow Creek, Hornes Creek, Teatree Hollow, Carters Creek, Dry Creek	• SS simulation - Long-term Average • Calibration simulation - Historical Quarterly Average • Prediction simulation - Transient Stage Height - Long Term Quarterly Average	0.005 - 0.1
Rumker Gully, Newlands Gully	• SS simulation - Long-term Average • Calibration simulation - Historical Quarterly Average • Prediction simulation - Transient Stage Height- Long Term Quarterly Average	0.005 - 0.01
Other minor creeks	• SS simulation - Long-term Average • Calibration simulation - Fixed Stage • Prediction simulation - Fixed Stage	$1x10^{-4}$ - 0.005

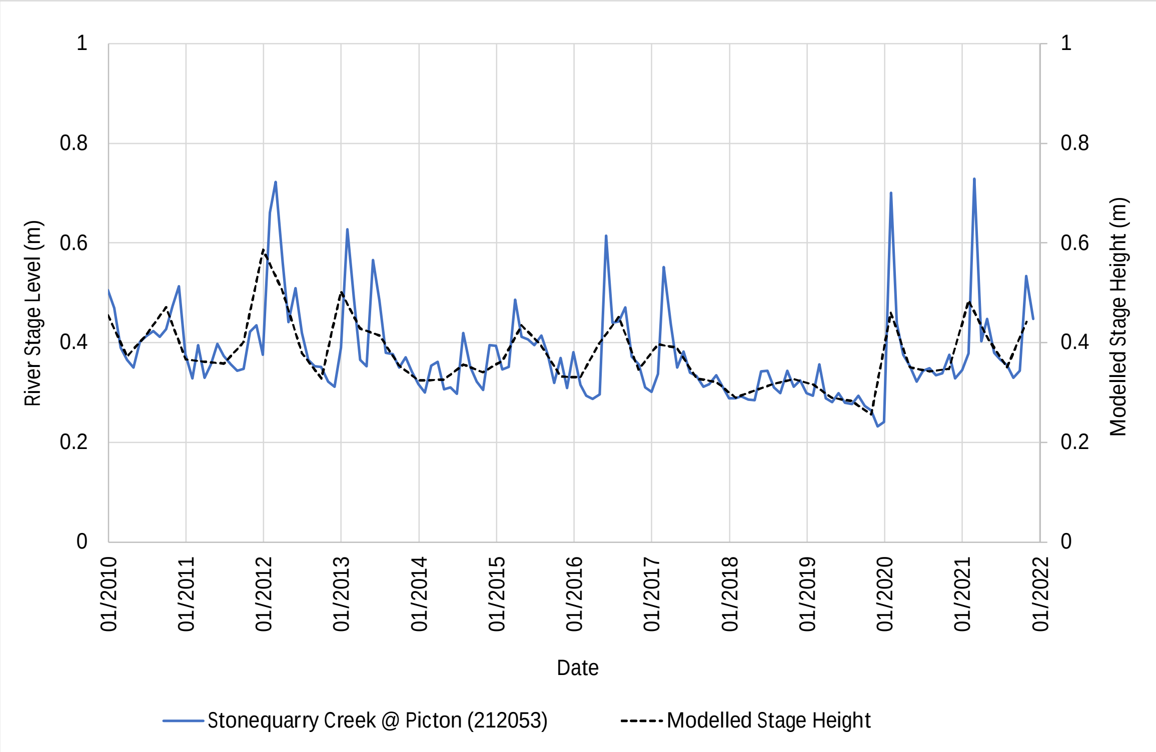


Figure 2-7 Stonequarry Creek @ Picton (212053) -Observed and Modelled River Stage

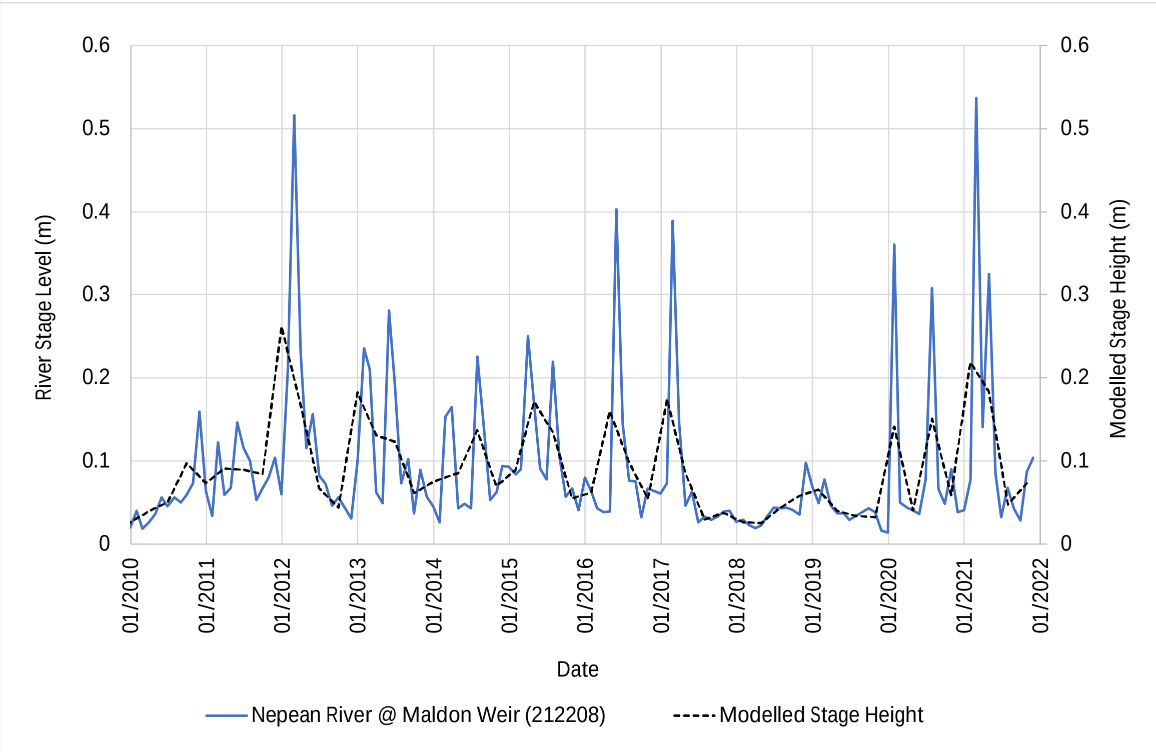


Figure 2-8 Nepean River at Maldon Weir (212208)- Observed and Modelled River Stage

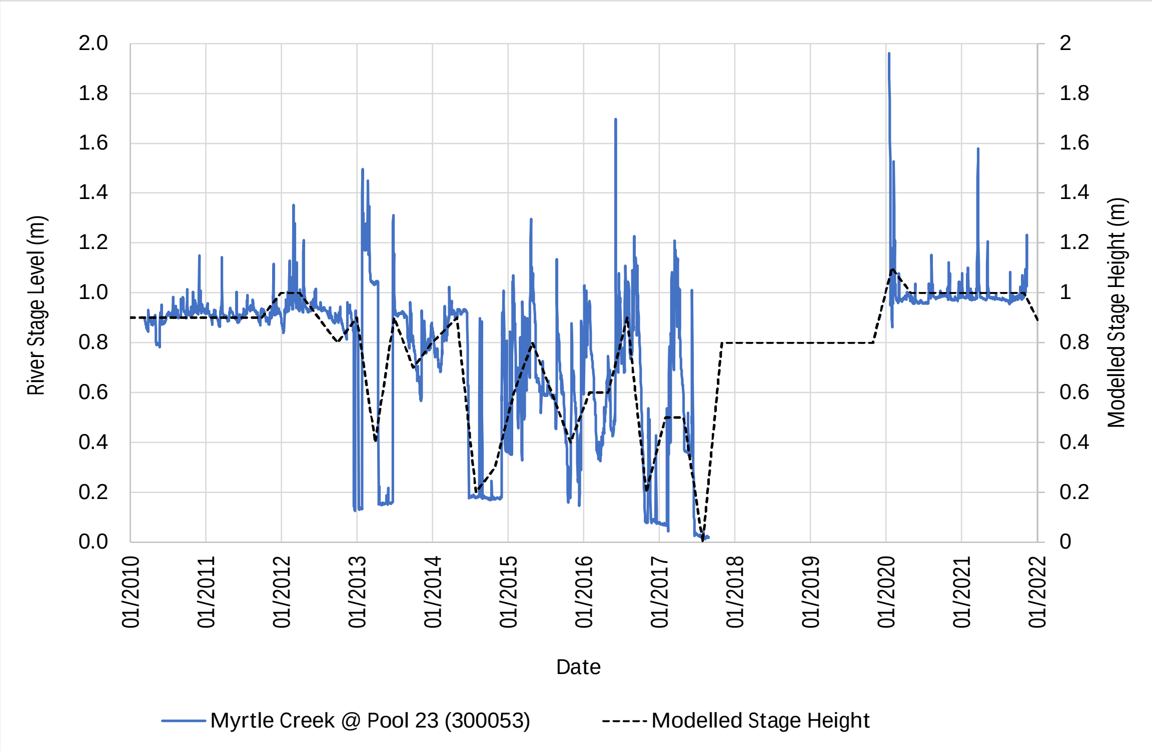


Figure 2-9 Myrtle Creek @ Pool 23 (300053) -Observed and Modelled River Stage

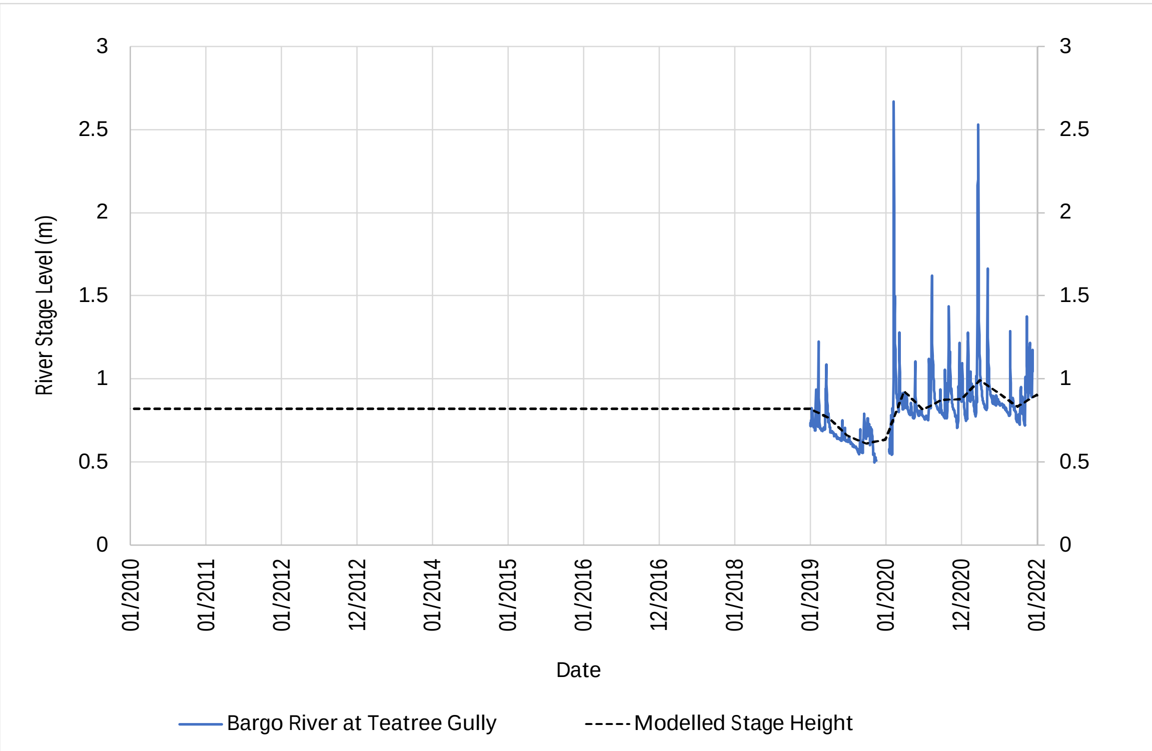


Figure 2-10 Bargo River @ Teatree Gully -Observed and Modelled River Stage

2.8.3 Lakes and Reservoirs

The Thirlmere Lakes and the water supply reservoirs within the model domain were represented using the MODFLOW River Package. The lakes and reservoirs simulated in the model are presented in Figure 2-6. The following reservoirs were simulated in the model:

- Lake Burragorang (Warragamba Dam), 18 km northwest of Tahmoor South Domain;
- Lake Nepean 3 km south of the Tahmoor South Domain;
- Lake Avon, 6 km south-southeast of the Tahmoor South Domain;
- Lake Cordeaux, 14 km east-southeast of the Tahmoor Mine;
- Lake Cataract, 18 km east of the Tahmoor Mine; and
- Lake Woronora, 30 km east of the Tahmoor Mine.

These reservoirs are operated by the NSW Government (WaterNSW) and are designed to capture and store water for Sydney's drinking water supply. The reservoirs were set with time-variant stage elevations based on the observed water levels at dams from the NSW Government gauging stations. For the calibration model, quarterly averages of the historical levels for the reservoirs were used. For the prediction period, long term quarterly averages of lakes levels were used in the model. Figure 2-11 shows the actual stage levels measured for Lake Nepean (Station 202215) compared to modelled levels.

For the Thirlmere Lakes, bed elevations were defined based on the zero-gauge data from the government gauging stations (212063, 212065,212066,212067 and 212068) for the 2013 to 2021 period. Data is not available from the stations prior to 2013. Therefore, data from Pells (2011), HEC (2018), Schadler (2016) and Kingsford (2016) were also used to fill the gaps in lake level records prior to 2013. Figure 2-12 and Figure 2-13 compared the measured levels and modelled levels for at Lake Nerrigorang (212066) and Lake Couridjah (212063).

For the prediction period, the lake stages were set at constant levels using the long-term historical average. The levels for the prediction model, were set as Gandangarra (302.4 mAHD), Werri Berri (302.0 mAHD), Couridjah (302.5 mAHD), Baraba (304.8 mAHD), and Nerrigorang (301 mAHD). The findings of the Thirlmere Lakes Research Program (TLRP) on the Thirlmere Lakes only became available after the groundwater model construction was completed. Therefore, the outcome of the TLRP were not included in the model design and are considered a future improvement for the future versions of the model. However, comparing the simulated lake levels in the model against the levels presented in Table 3-1 of WRL research report indicates the simulated levels in the model aligned with the values presented in the research report (WRL Research Report, 2020).

The initial values for riverbed conductance for all the lakes were adopted from the previous model (SLR, 2021). These values were subsequently varied during the calibration process.

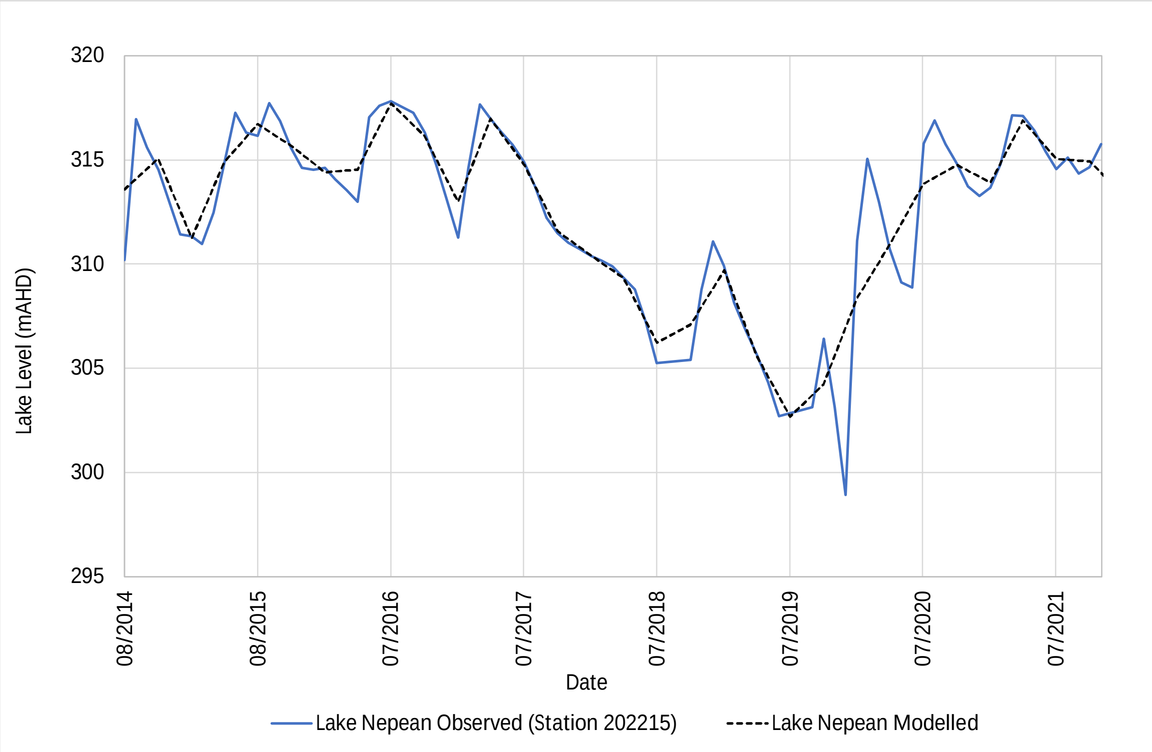


Figure 2-11 Lake Nepean Modelled Level

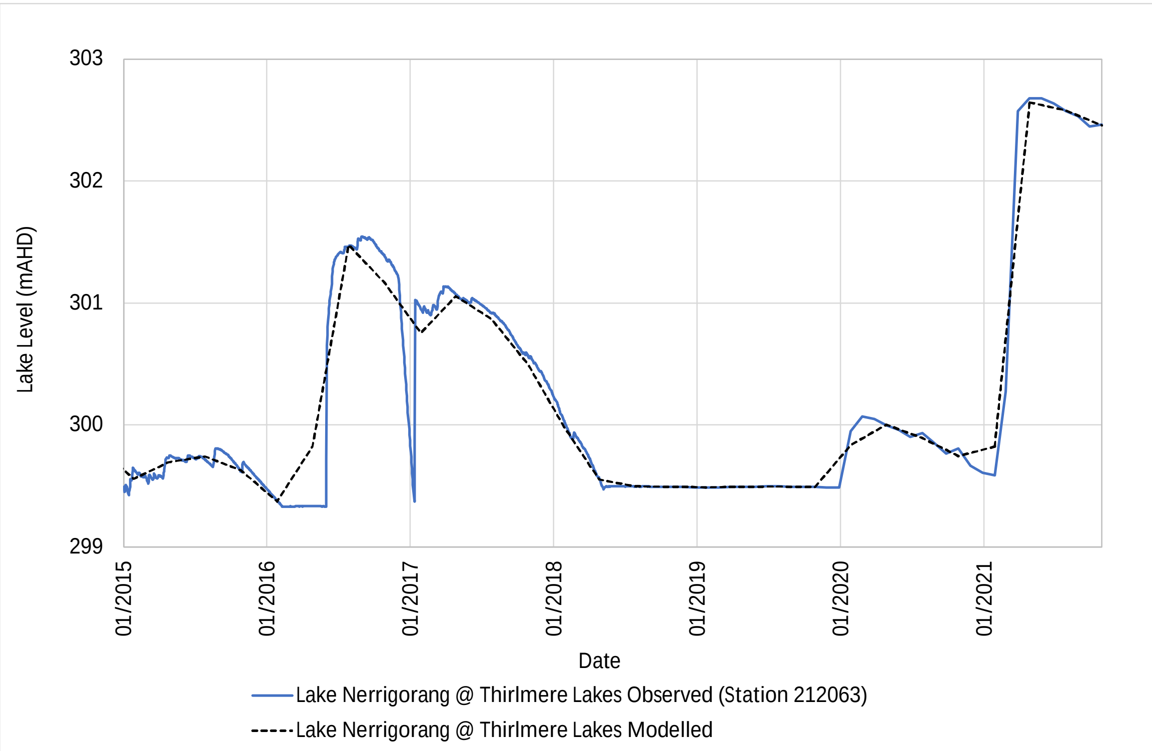


Figure 2-12 Lake Nerrigorang (at Thirlmere Lakes) Modelled Level

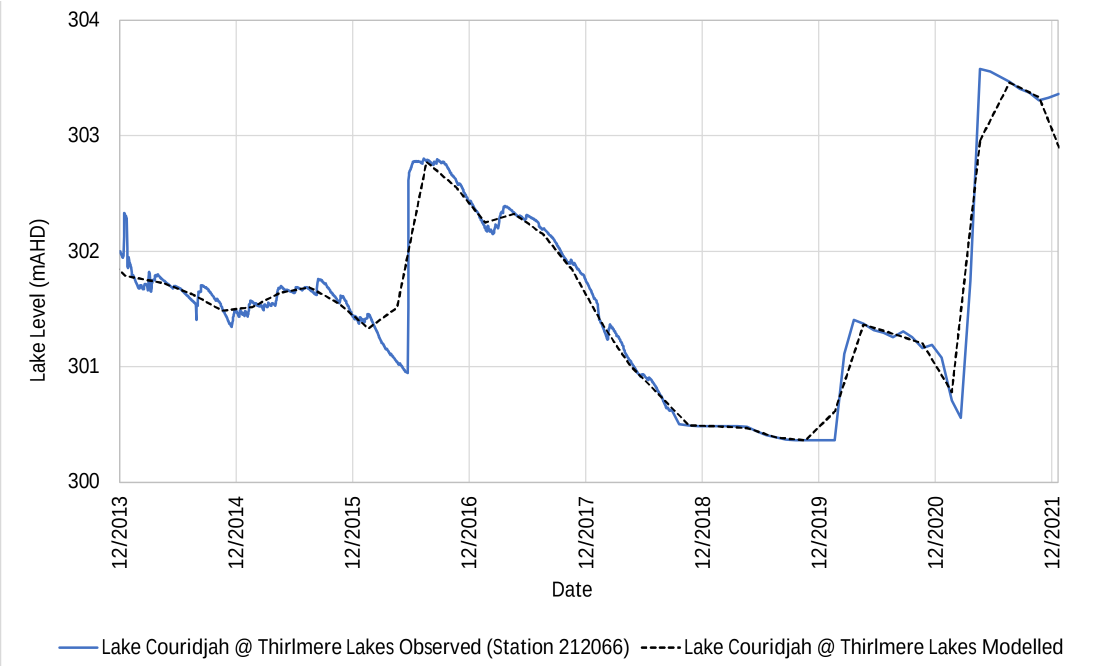


Figure 2-13 Lake Couridjah (at Thirlmere Lakes) Modelled Level

2.8.4 Recharge

The dominant mechanism for recharge to the groundwater system is through diffuse infiltration of rainfall through the soil profile and subsequent deep drainage to underlying groundwater systems. Diffuse rainfall recharge to the model was represented using the MODFLOW-USG Recharge package (RCH).

Recharge zones have been established based on surface geology and rainfall spatial variation to simulate variation in local recharge due to these factors. Long-term precipitation data from BoM indicates higher annual rainfall in the east and south at the coast or near the escarpment, with rainfall declining inland to the north and west. Therefore, three main regions of rainfall (high, moderate, and low) have been considered in recharge zonation. The influence of outcrop geology on groundwater recharge in the Project area has previously been investigated (HydroSimulations, 2019) and is simulated using separate zones for Alluvium, Wianamatta Shale, and the Hawkesbury Sandstone (with which various other sandstones have been included).

The model included 8 recharge zones, as presented in Figure 2-14 and listed below:

- Alluvium –Low Rainfall;
- Alluvium – High Rainfall;
- Wianamatta Formation – Low rainfall;
- Hawkesbury Sandstone – Low rainfall;
- Hawkesbury Sandstone - Medium rainfall;
- Hawkesbury Sandstone– High Rainfall;
- Coastal Escarpment; and
- Surface Water Bodies.

Figure 2-14 Modelled Recharge Zones

Recharge rates were established through the calibration process, with bounds based on the conceptual understanding of the system and comparing them with other groundwater models prepared for the region. The starting values adopted in the calibration process were derived using LUMPREM2, which is a soil moisture store model developed by Watermark Numerical Computing (2021). LUMPREM2 was built to complement a groundwater model. It uses daily rainfall as its input and supplying groundwater recharge as its output. Recharge is accumulated over user-defined lengths of time (i.e. groundwater model stress periods).

LUMPREM provides basic simulation of water balance within the unsaturated zone, with inputs and outputs that include rainfall, irrigation, evapotranspiration, runoff, recharge and macropore recharge. For this work, the LUMPREM model used daily rainfall and potential evaporation to simulate water movement in the unsaturated zone and generated a time series of recharge rates. Daily rainfall and evaporation data were obtained from the Scientific Information for Land Owners (SILO[1]) point data using the location (Lat: -34.20, Long: 150.60).

Figure 2-15 shows the conceptual model on which the LUMPREM2 numerical model is based on. As shown in Figure 2-15, LUMPREM2 has two stores. The upper store simulates processes in the plant root zone. It receives water from rainfall and loses water through the vegetation extraction and drainage to the lower store and micropore drainage, the latter only occurring when the store is full. The lower store simulates processes below the plant root zone and above the water table. The groundwater recharge is calculated as the sum of drainage from the lower store, overflow from the lower store and macropore recharge from the upper store (Watermark Numerical Computing, 2021).

Two equations are included in the LUMPREM2 model to determine the relationship between the evaporation and drainage rate and the volume of water stored within the soil moisture store. Further details about the LUMPREM2 model and the equations used are provided in the manual (Watermark Numerical Computing, 2021).

To provide the best fit between observed water levels and simulated heads, the parameters of LUMPREM2 and MODFLOW model were combined and adjusted during a joint calibration. The LUMPREM2 and MODFLOW parameters were updated and simulated consecutively when the parameter changes occur during the calibration (see discussion of calibrated values in Section 3). Table 2-2 details LUMPREM parameters and their definition that were adjusted in the calibration process.

[1] https://www.longpaddock.qld.gov.au/silo/point-data/

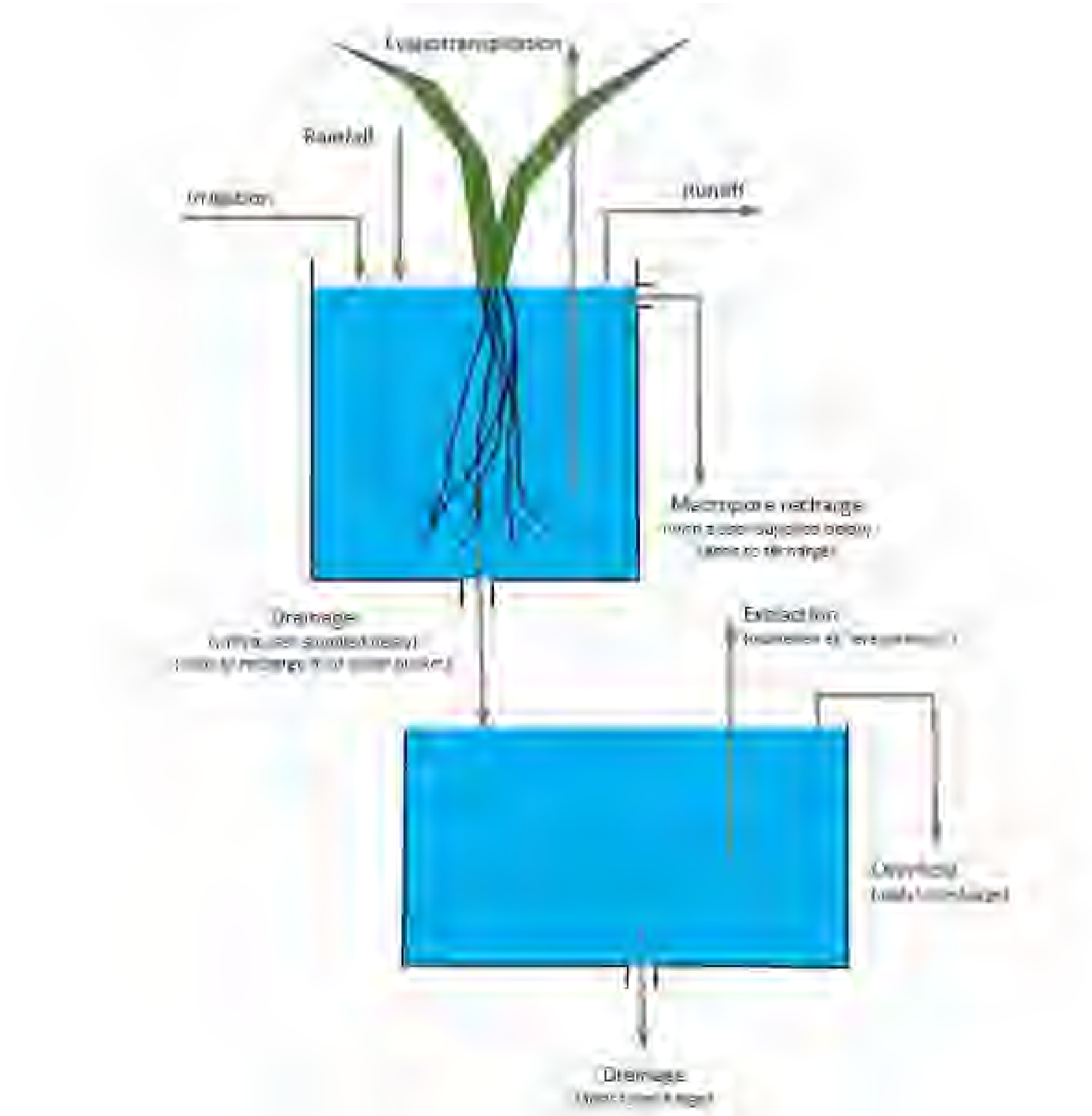


Figure 2-15 The LUMPREM2 Conceptual Model (from LUMPREM2 Manual, 2021)

Table 2-2 LUMPREM2 Model Parameters

Parameter	Unit	Description
maxvol_br	mm	The volume of the lower soil moisture store.
gamma_br	-	Parameter determining the rate of evaporate versus stored water relationship (Lower soil moisture store)
m_br	-	Parameter determining the rate of drainage versus stored water relationship (Lower soil moisture store)
l_br	-	Pore-connectivity parameter (Lower soil moisture store)
ks_br	m/day	Saturated hydraulic conductivity (Lower soil moisture store)
maxvol	mm	The volume of the upper soil moisture store.
gamma	-	Parameter determining the rate of evaporate versus stored water relationship (Upper soil moisture store)
m	-	Parameter determining the rate of drainage versus stored water relationship (Upper soil moisture store)
l	-	Pore-connectivity parameter (Upper soil moisture store)
ks	m/day	Saturated hydraulic conductivity (Upper soil moisture store)

2.8.5 Evapotranspiration

Evapotranspiration from the shallow water table was simulated using the evapotranspiration package (EVT). Evapotranspiration zones were established based on mapped land-use (ABARES), and land cover estimated through satellite imagery.

- Forest/Conservation;
- Grazing land;
- Rivers and drainage systems;
- Tree/shrub cover;
- Urban; and
- Escarpment.

Evapotranspiration was represented in the upper most cells of the model domain to an extinction depth up to 3 m, dependent on zone. A maximum rate of evapotranspiration was set based on the data from the SILO Grid Point observations for the closest location (Lat:-34.20, Long: 150.60).

The extinction depth applied to MODFLOW for the primary vegetation or land use zones has been estimated at 0.8-1 m for urban / grassed / pasture areas, and 3 m for trees. The spatial extent of these broad vegetation types was based on the National Scale v4 land use mapping by ABARES.

To avoid “short circuiting” between EVT and RIV boundary conditions, evapotranspiration was turned off in the river cells and in the cells simulating the lakes and reservoirs within the model domain. Further discussion of calibrated values is presented in Section 3.

Figure 2-16 Modelled EVT Zones

2.8.6 Groundwater Use

The most recent bore census by CES (CES, 2022) identified 57 groundwater extraction bores near to the Tahmoor South Domain (specifically, the 'A' block of longwalls – Figure 2-17). The pumping from these bores was not included in the model because of the uncertainty around the actual extraction (rather than the entitlement). This means that the model does not account for bore pumping effects at the Tahmoor South Domain and the immediate surrounding area. The landowner bores near the site are discussed in Section 3.5 of the Conceptual Report (SLR, 2022).

To the north, at and near to Appin Mine, 83 licensed registered water supply bores are located within the model domain. Most of the groundwater usage in the area is from the Hawkesbury Sandstone or from surficial alluvium and basalt aquifers. The MODFLOW-USG WELL package was used to capture the water take from 83 licensed registered water supply bores at Appin. The pumping rates for the water supply bores were adopted from the Appin Groundwater Impact Assessment (SLR, 2021).

The AGL Camden Gas Project is a located to the north of Appin Mine. The Camden Gas Project has been in operation since 2001. The Camden Gas Project comprises 137 wells (86 currently active) which target the Bulli and Balgownie seams approximately 14 km north of Tahmoor Mine. The gas extraction rates for the water supply bores were adopted from the Appin Groundwater Impact Assessment (SLR, 2021), and were derived from AGL (2013) study.

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

The pumping bores and the CSG wells included in the model are shown in Figure 2-1.

2.8.7 Mining

The MODFLOW Drain (DRN) package was used to simulate mine dewatering in the model for Tahmoor and the surrounding mines. As discussed in Section 2.8.2, Drain boundary conditions allow a one-way flow of water out of the model. In both the calibration and prediction model, mining at Tahmoor (including Tahmoor North and South) was simulated based on the historical and future mine plan provided by Tahmoor Coal. The historical and proposed underground mining and dewatering activity at the following neighbouring mines were also included in the model:

- Bulli Seam Operations (BSO) and Appin Mine (historical and approved);
- Russell Vale (historical);
- Metropolitan Mine (historical and approved);
- Cordeaux Mine (historical);
- Dendrobium Mine (historical and approved domains); and
- Kemira, Mt Kembla, Nebo, Wongawilli, Elouera Mine (historical).

Historical mining at the Appin and Dendrobium operations was simulated using the model set-up from the SLR (2021) groundwater model. For other operations and periods, publicly available information was used to incorporate the mining activities. The modelled progression and timing of mining is presented in Figure 2-17.

The historical and proposed underground mining and dewatering activity at all the mines within the model domain target the Bulli Coal seam, except for parts of the Dendrobium domain, Kemira, Mt Kembla, Nebo, Wongawilli, Elouera Mine that target the Wongawilli Coal seam.

Drain cells were applied to each worked seam with drain elevations set to the base of the seam. These drain cells were applied wherever workings occur and were progressed through temporal increments in the transient model setup. A drain conductance value of 100 m^2/day was applied for all longwalls, roadways and development headings.

After goaf areas were mined out, the model Drains were inactivated in both the panel area and the neighbouring gate roads. Drains representing mains and roadways required for the continued operation of the mine were maintained as active until the end of their operational life, which could be as late as the end of the Tahmoor operation, until 2022 in Tahmoor North, or until around 2040 in Tahmoor South. The development headings were activated in advance of the active mining and subsequent subsidence, either one stress period ahead of active mining or based on a schedule provided by Tahmoor Coal.

MODFLOW-USG time varying materials (TVM) used to change the hydraulic properties of the model cells were with time to replicate the goaf and fractured zone above each longwall panel (see Section 2.8.8 for details).

Figure 2-17 Modelled Mine Progression

2.8.8 Variation in Model Hydraulic Properties due to Longwall Mining

As discussed in Section 5.7 of the conceptual report, the Ditton method is the preferred method to represent the connected fractured zone (Zone A) as it is similar to, and in some instances, more conservative than the Tammetta (2013) method for longwall geometry at Tahmoor Mine. The Ditton A95 estimated fracture height is consistent with data collected by SCT (SCT, 2014 and 2021) at Tahmoor. Ditton (2014) also estimates the height of disconnected fracturing' (Zone B).

The height of connected fracturing was estimated on a cell-by-cell basis using the method of Ditton A95 and the height of disconnected fracturing was estimated on a cell-by-cell basis using Ditton B95.

The estimated height of connected and discounted fracturing zones using Ditton A95 and Ditton B95 are shown in Figure 5-10 of the conceptual report. Figure 2-18 shows the highest layer in the model the height of Zone A and Zone B extend to across the mine area. As shown in Figure 2-18, the connected fracturing primarily reaches Layers 7 and 8 of the model (Bulgo Sandstone middle and upper), except a small area within Longwalls 1 and 2 where connected cracking reached Layer 6 (Bald Hill Claystone). Figure 2-18 shows the simulated disconnected fracturing reached Layer 4 and Layer 5 of the model which represent the middle and lower HBSS, respectively.

The fracture zones are represented in the groundwater model via an increase in the horizontal and vertical hydraulic conductivity, and the specific yield (only in disconnected fracturing zone) of the model layers above the seam in each extracted longwall panel using the Time-Varying Material properties (TVM) package of MODFLOW-USG-Transport.

As discussed in Section 5.7.5 of the conceptual report, there site-specific measurements of post-mining strata properties in the fracture profile are not available. However, data from boreholes S2398 and S2398A, which were used for pre- and post-mining investigations at Dendrobium Mine, is available (Watershed HydroGeoC 2020). The observed post-mining values at these bores were used to guide the some of the updated post-mining properties simulated in groundwater model for Tahmoor Mine.

Figure 2-18 Modelled Zone of Connected Fracturing (Ditton A95) and Disconnected Fracturing (Ditton B95)

Table 2-3 show the changes in model properties in different zones of the fracturing profile adopted in the TVM package. As shown on the table, within the mined coal seam (goaf), the specific yield was modified to a value of 0.1 or 10%. This value provides for an increased storage capacity by removal of coal, but also accounts for reduced volume in the workings from collapse of overlying strata into the void space left by the removal of coal. The Caved Zone located immediately above the mined seam was simulated by increasing the horizontal and vertical conductivity of the cells within the Caved Zone. The enhanced horizontal and vertical conductivity of the cells within the Caved Zone were adjusted during the calibration process.

As listed in Table 2-3, the hydraulic properties (horizonal and vertical conductivity) of the cells that fell within this connected fracturing zone were modified from the 'host' or natural values using a 'log-linear function' which was calibrated to mine inflow and hydraulic heads at site.

For the disconnected fracturing zone, the horizontal conductivity in the model cells was increased up to 100 times the host values. The horizontal conductivity was capped at a maximum absolute of 0.01 m/d. This value was suggested from Dendrobium data (Watershed HydroGeo, 2020). The enhanced vertical conductivity in the disconnected fracturing zone were increased up to 3 times of the host properties. The Dendrobium data also suggested increased in porosity within the disconnected fracturing zone. This was adopted in the model by increasing the specific yield in the model cells. The modified values for the horizontal and vertical conductivity, and specific yield were adjusted during the calibration process.

To provide a more accurate representation of subsidence-induced impacts to the groundwater and surface water systems, changes in hydraulic properties that occur in areas where surface cracking occurs or is likely to occur were simulated. The horizontal and vertical hydraulic conductivity were increased in the model cells within the surface fracture zone. Evidence from borehole P11 at Tahmoor North suggests that surface cracking does not occur at distances outside the panel footprint. (SCT, 2020b). Therefore, in the numerical model, surface cracking parameters were only adopted in model cells overlying the longwall panel. As shown in Table 2-3, the depth below the surface to where surface cracking extends was calculated as ten times the extraction height of a given longwall. In areas estimated to be affected by surface cracking, the host horizontal and vertical hydraulic conductivity were both multiplied between 5 to 10 to represent the enhanced permeability of the fracture zone. The use of these multipliers is supported by a recent investigation into the changed hydraulic properties of sections of Redbank Creek that have experienced surface subsidence (SCT, 2018b and 2020b). The multiplier for the horizontal and vertical hydraulic conductivity in the surface fracture zone were adjusted in the calibration process.

Figure 2-19 presents a conceptual illustration of the deformation zones commonly observed above longwall panels, alongside a schematic of the numerical model representation of that conceptual model in Figure 2-19 (B). The schematic simulated change in Kz in the groundwater model is also shown in Figure 2-19. This exemplifies the departure between the host Kz and post-mining Kz that extend from the coal seam to the height of fracturing. These changes decrease with vertical distance (height) above the coal seam to the upper limit of the estimated height of fracturing and surface fracturing.

Table 2-3 Change in the Model Properties due to Longwall Mining

Conceptual Zone		Zone	Geometry	Change in the Model Properties
Surface Fracture Zone (i.e. surface cracking)		D-zone	Depth of increased surface fracturing (due to lower depth of cover/confinement) <=20 m, with enhanced horizontal and vertical hydraulic conductivity. • 8 x T (extraction height)	• High Kx, Higher Kz • Enhanced Kx was calibrated between 2 to 10 times the host value. • Enhanced Kz was calibrated between 2 to 10 times the host value.
Constrained Zone		C-zone		• No change
Fractured Zone	upper zone of Disconnected Fracturing	B-zone	• B95 – Ditton and Merrick (2014).	• High Kx, Higher Kz, Higher Sy • Enhanced Kx was calibrated between 10 to 100 times the host value (capped at maximum value of 0.01 M/day) • Enhanced Kz was calibrated between 1 to 3 times the host value • Enhanced Sy was calibrated between 0.01 to 0.1.
	lower zone of Connected Fracturing	A-zone	• A95 – Ditton and Merrick (2014).	• High Kx, Higher Kz. • Kx and Kz changes used a logarithmic ramp function from a max value of at the top of caved zone to a value up to host VK at the top of the Ditton A95.
Caved Zone			• 5-10 x t (Forster & Enever, 1992; Guo et al., 2007).	• High Kx, Higher Kz. • Calibrated with the range between 2 to 10 times the host values.
Mined Zone (extracted seam)			Mined seam thickness (t)	Kx= 100 m/day, Kz=100m/day, Sy=0.1

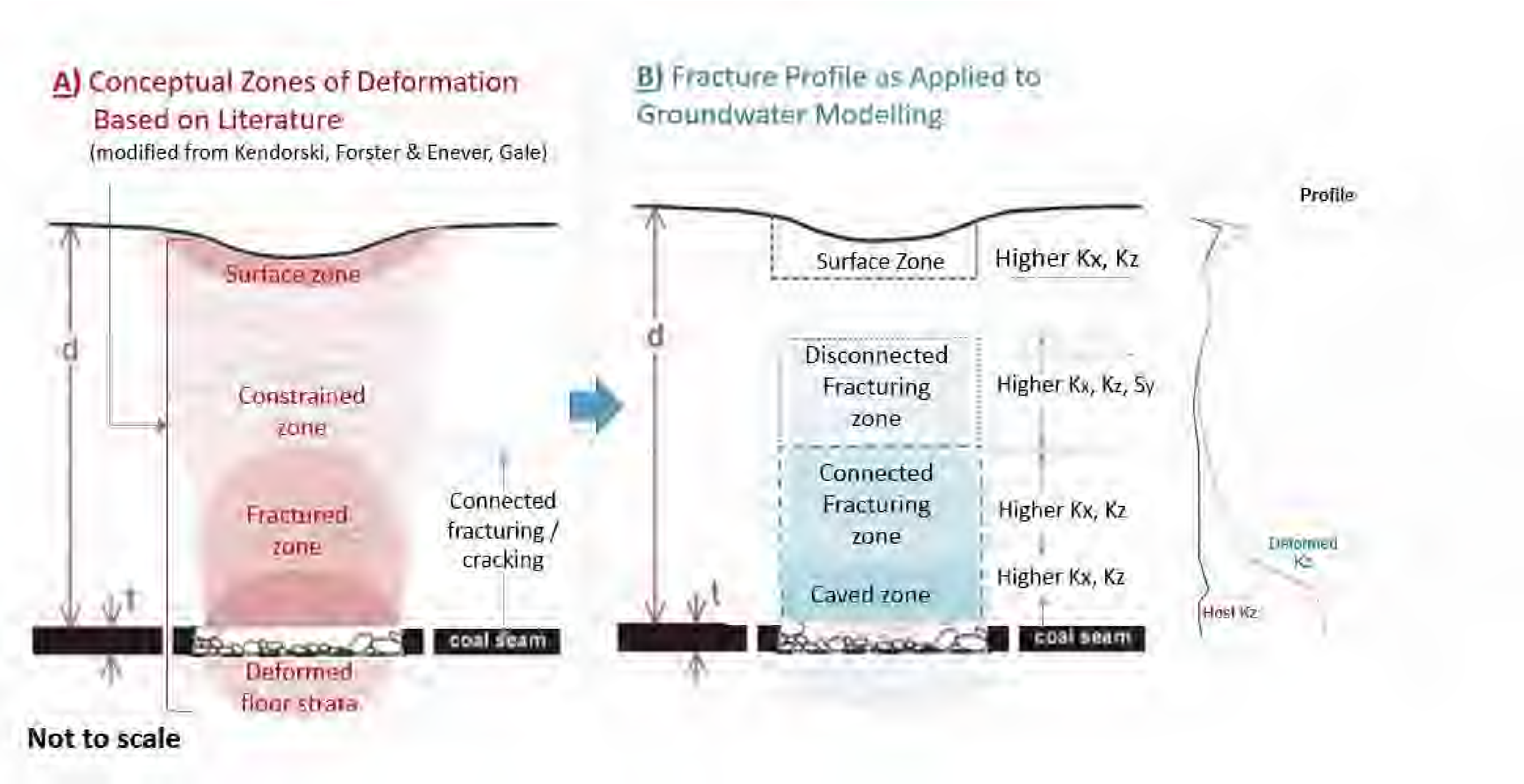


Figure 2-19 Application of Enhanced Permeability within the Groundwater Model

3 Model Calibration

3.1 Calibration Dataset

The calibration dataset included a combination of targets as listed below:

- Groundwater elevation (mAHD);
- Changes in measured groundwater levels (i.e. drawdown\recovery, natural fluctuations); and
- Historic mine inflow rates at Tahmoor.

3.1.1 Groundwater Levels

Groundwater level data obtained within this model domain comprises standpipe piezometer data as well as vibrating wire piezometer (VWP) data. The groundwater levels recorded between January 1979 to December 2021 were used for the model calibration. In all, 130,424 targets (heads and drawdowns combined) were established for 1,073 bores or monitoring instruments (e.g. VWPs) from the following sites:

- Tahmoor bores: calibration included 266 groundwater level sites and VWPs;
- Appin Mine bores: 241 bores or VWPs;
- Other mines including Dendrobium Mine Bores: 471 monitoring bores and VWPs; and
- Private and Government Bores: 95 other bores.

Groundwater targets were selected where valid information on bore construction or geology information was available for the site.

3.1.2 Change in Measured Groundwater Levels

To improve the match between simulated and observed drawdown in the bores included in the calibration, the model was also calibrated to change in groundwater levels. PEST OLPROC utility provided was used to extract simulated drawdowns in each observation bore. OLPROC reads model outputs (i.e. drawdowns) and then time-interpolates these outputs to approximate values at times which correspond to those at which field measurements were made.

3.1.3 Mine Inflows Measurements

Historical inflows ('water make') are available at Tahmoor Mine from 1995 until 2022. The calculation and measurement of the mine inflows was provided by Gilbert and Associates (now HEC) and Tahmoor Coal. There was a period during which measurement of the inflows was not carried out (1977-2009). Inflow measurements from January 1977 until December 2021 were included as targets in the calibration process.

3.1.4 Calibration Weighting

Figure 3-1 shows the location of observation bores included in the calibration and also the locations for measured inflows at Tahmoor Mine. Figure 3-2 show the location of calibration bores at Tahmoor Mine.

Measured groundwater levels and drawdowns and flux observations included in the calibration had different units (mAHD, m and m^3/day respectively). Therefore, it was expected the flux residuals to be much higher than water levels and drawdowns residual. The observation weighting was set up in a way that it normalized the observations of different types in the model calibration. Lowest weights were assigned to the measured inflows to reduce the magnitude of flux errors and make them comparable to water level and drawdown errors.

Moreover, the observations at or near Tahmoor Mine were given greater priority comparing to the other areas in the model. Therefore, the observations at Tahmoor were weighted 5 times higher than the observations elsewhere in the model. Details on each of the observation points and their residuals are presented in Appendix B.

Figure 3-1 Calibration Bore Locations and Location on Measured Inflows

Figure 3-2 Tahmoor Calibration Bore Locations

3.2 Model Calibration Strategy

Automated parameterisation software PEST ++ (Doherty 2019) was used for the model calibration. PEST++ undertakes non-intrusive, highly parameterized inversion of an environmental model. PEST++ includes significant functionality that is absent from PEST including more efficient calibration algorithms that can accommodate large, highly parameterized groundwater models. PEST++ can conduct model runs in serial or in parallel. The model variables included in the calibration were:

- Aquifer parameters including horizontal and vertical hydraulic conductivity, specific storage and specific yield;
- All the fracture profile properties;
- Faults (including Nepean Fault Complex, Southern Faults, T1-T2) horizontal and vertical hydraulic conductivity, specific storage, and specific yield;
- Stresses including recharge rates and soil moisture model parameters, and pumping rates;
- Boundary conditions including evapotranspiration (EVT) rate, General Head Boundary (GHB), River (RIV) bed conductance for watercourses and for Thirlmere Lakes;
- Horizontal and vertical hydraulic conductivity, specific storage, and specific yield for pilot points; and
- For the layers with the depth dependent hydraulic conductivity function (Section 3.7), PEST varied the hydraulic conductivity intercept (K_0) and the slope variable in the depth dependence functions adopted for the layers.

As discussed in Section 2, the starting values for all the variable listed above were adopted from the previous studies. To reduce the number of model parameters a 4-staged approach to model calibration was used. A schematic showing these calibration stages is presented in Figure 3-3.

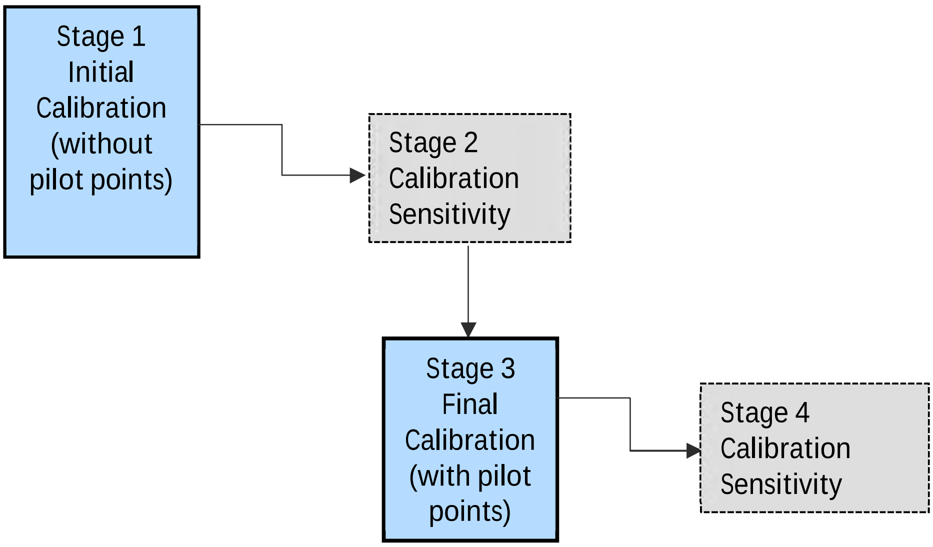


Figure 3-3 Calibration Stages

Stage 1: In the first stage the model calibration was ran for two iterations using the initial values adopted. There were no pilot points included in this initial calibration.

Stage 2: Using the calibrated values from the initial calibration (Stage 1), an identifiability analysis was conducted on the initial calibration using PEST++. The identifiability analysis assesses the most sensitive properties of the model from a sensitivity (Jacobean) matrix. To calculate the Jacobian matrix, the model was run once for each variable included in the calibration. The results from the identifiability identified the most sensitive model parameters (0 is not sensitive and 1 is most sensitive) that can impact the match between measured and simulated values.

Stage 3: The final calibration was run using the parameters identified as sensitive from Stage 2. All the parameters with sensitivity of more than 0.2 were allowed to change in the calibration and the remaining parameter values were kept unchanged. The results from Stage 2 showed very high sensitivity to HBSS Kx and Kz properties. As a part of the final calibration, pilot points were introduced in layers 3 to 5 of the model to allow more spatially variability in the HBSS Kx and Kz properties.

The location of the pilot points is shown in Figure 3-4. As shown in the figure, pilot points were set within Tahmoor and Appin Mine areas and spaced uniformly. PEST++ used its PLPROC utility to interpolate between the pilot point values and creates a surface across the model domain for a targeted model parameter. This surface of model parameter values is then interrogated for values at the model cell centres to provide a value at each model cell. A total of 360 pilot points were used to assign the hydraulic parameters to layers 3 to 5 of the model. Due to the computational constraints and based upon the sensitivity results, the pilot points for horizontal conductivity in Layers 4 and 5 were tied to the pilot points in Layer 5. The pilot points for vertical conductivity were allowed to change independently in Layer 3, 4 and 5.

Stage 4: Using the calibrated values from the final calibration (Stage 3), the identifiability analysis was reconducted using calibration using PEST++. The results of the identifiability analysis are discussed in Section 5.

Figure 3-4 Location of Model Pilot Points

3.3 Calibration Statistics

One of the industry standard methods to evaluate the calibration of the model is to examine the statistical parameters associated with the calibration (as outlined in the Australian Groundwater Modelling Guidelines [AGMG]; Barnett et al, 2012). This is done by assessing the error between the modelled and observed (measured) water levels in terms of the root mean square (RMS). The RMS is defined as:

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

where: n = number of measurements

h_o = observed water level

h_m = simulated water level

RMS is considered to be the best measure of error if errors are normally distributed. The RMS error calculated for the entire model is 33.2 m. The RMS error calculated for the observation sites at Tahmoor site only is 16.2 m.

The acceptable value for the calibration criterion depends on the magnitude of the change in heads over the model domain. If the ratio of the RMS error to the total head change in the system is small, the errors are considered small in relation to the overall model response(s). The ratio of RMS to the total head loss (SMRS) for entire dataset is 3.3% while SRMS for Tahmoor only is 2.6%. While there is no recommended universal SRMS error, The AGMG suggests that setting Scaled RMS targets such as 5% or 10% may be appropriate in some circumstances (Barnett et al, 2012). The SLR (2021) model calibration which showed the calibration statistics for the calibrated transient model are 2.8% SRMS and an absolute residual mean of 10.7 m. It should be noted that the previous model did not include all the Tahmoor bores or most of the bores in the neighbouring sites.

The overall transient calibration statistics for Tahmoor only bores and all the bores are presented in Table 3-1 and Table 3-2, respectively. As shown in Table 3-1, for the Tahmoor bores, 85 % (68,007 out of 79,474 calibration targets) are within ±20 m of the observed measurements. This provides an indication of reasonable fit for the large calibration dataset; however, further discussion on the fit between modelled and observed trends is included in Section 3.4.

Figure 3-5 and Figure 3-6 present the observed and simulated groundwater levels graphically as a scattergram for the initial and historic transient calibration (1977 to 2021) for the Tahmoor bores only and all the bores included in the calibration. As it can been in the figures, Tahmoor bores have the best fit comparing to the other sites within the model domain as they were given priority and therefore higher weights in the calibration process. The figures show the worst fit is to the Dendrobium site data which is considered an area for improvement for the next version of the model.

Figure 3-7 and Figure 3-8 shows the distribution of residuals for Tahmoor bores and all the bore respectively. As shown in the figure the calibration residuals for the majority for data points are within ± 20 m for Tahmoor bores and ± 35 m for all the bores in the calibration.

The spatial distribution of average residuals for each bore from the transient calibration is shown in Figure 3-9 and Appendix C. The size of the bore symbol in Figure 3-9 is proportional to the residual (i.e., larger residual has a larger symbol size. Figure 3-9 shows regionally there is a good match between the observed and simulated groundwater levels.

Table 3-1 Transient Calibration Statistics- Tahmoor Bores Only

Statistic	Value
Sum of Squares (m^2)	20,913,148.1
Mean of Squares (m)	263.6
Square Root of Mean of Squares (RMS) (m)	16.2
Scaled Root Mean Square (SRMS) (%)	2.6%
Sum of Residuals (m)	198,068.6
Mean Residual (m)	2.5
Scaled Mean Residual (%)	0.4%
Coefficient of Determination (tend to unity)	1.9
Targets within ±2m	9,981
Targets within ±5m	22,479
Targets within ±20	68,007

*

Table 3-2 Transient Calibration Statistics- All Bores

Statistic	Value
Sum of Squares (m^2)	143,769,116.1
Mean of Squares (m)	1,103.0
Square Root of Mean of Squares (RMS) (m)	33.2
Scaled Root Mean Square (SRMS) (%)	3.3%
Sum of Residuals (m)	2,583,354.0
Mean Residual (m)	18.
Scaled Mean Residual (%)	1.8%
Coefficient of Determination (tend to unity)	1.1
Targets within ±2m	16,489
Targets within ±5m	35,912
Targets within ±20	93,831

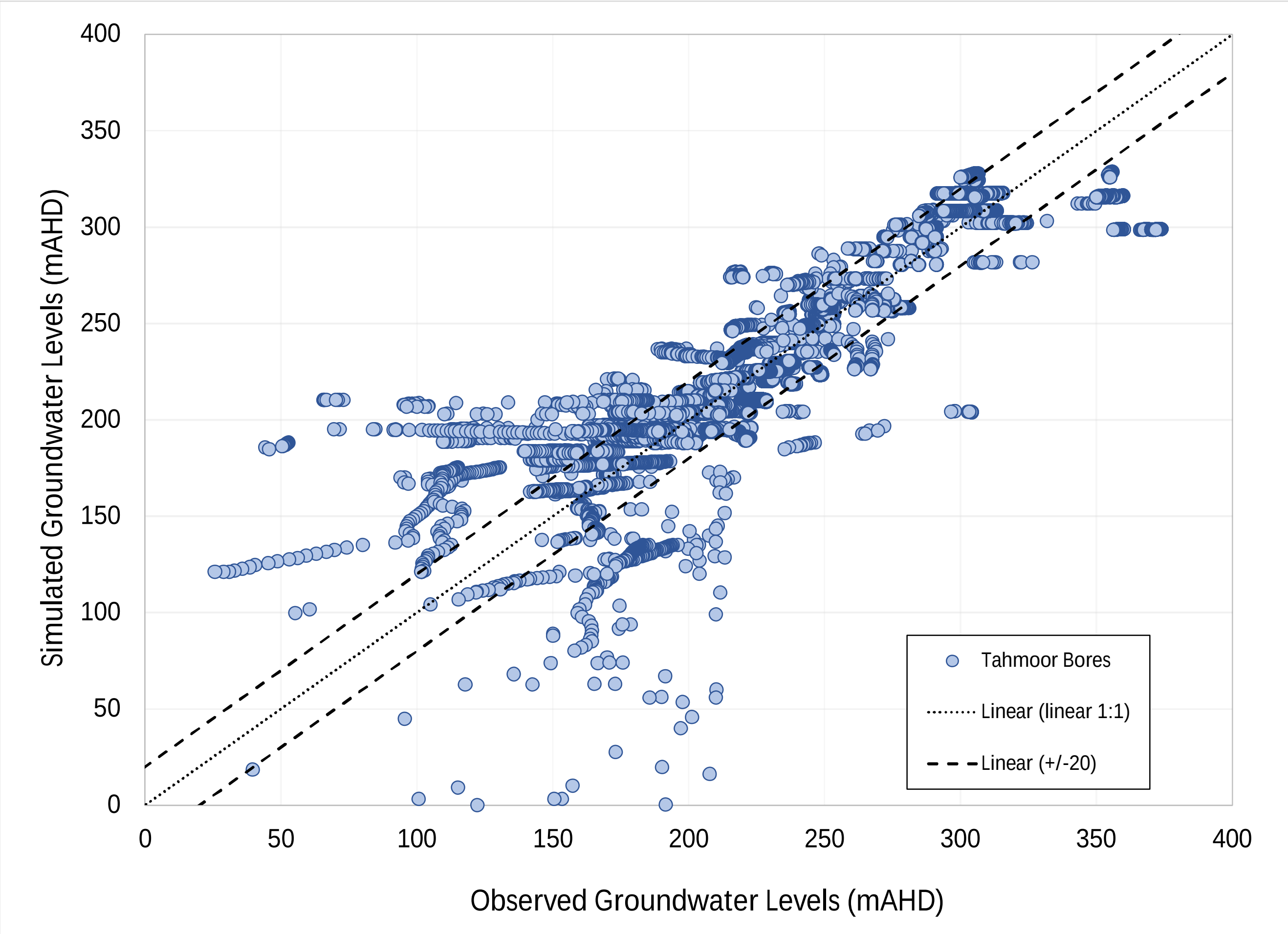


Figure 3-5 Calibration Scattergram– Modelled vs Observed Groundwater Levels for Tahmoor Bores

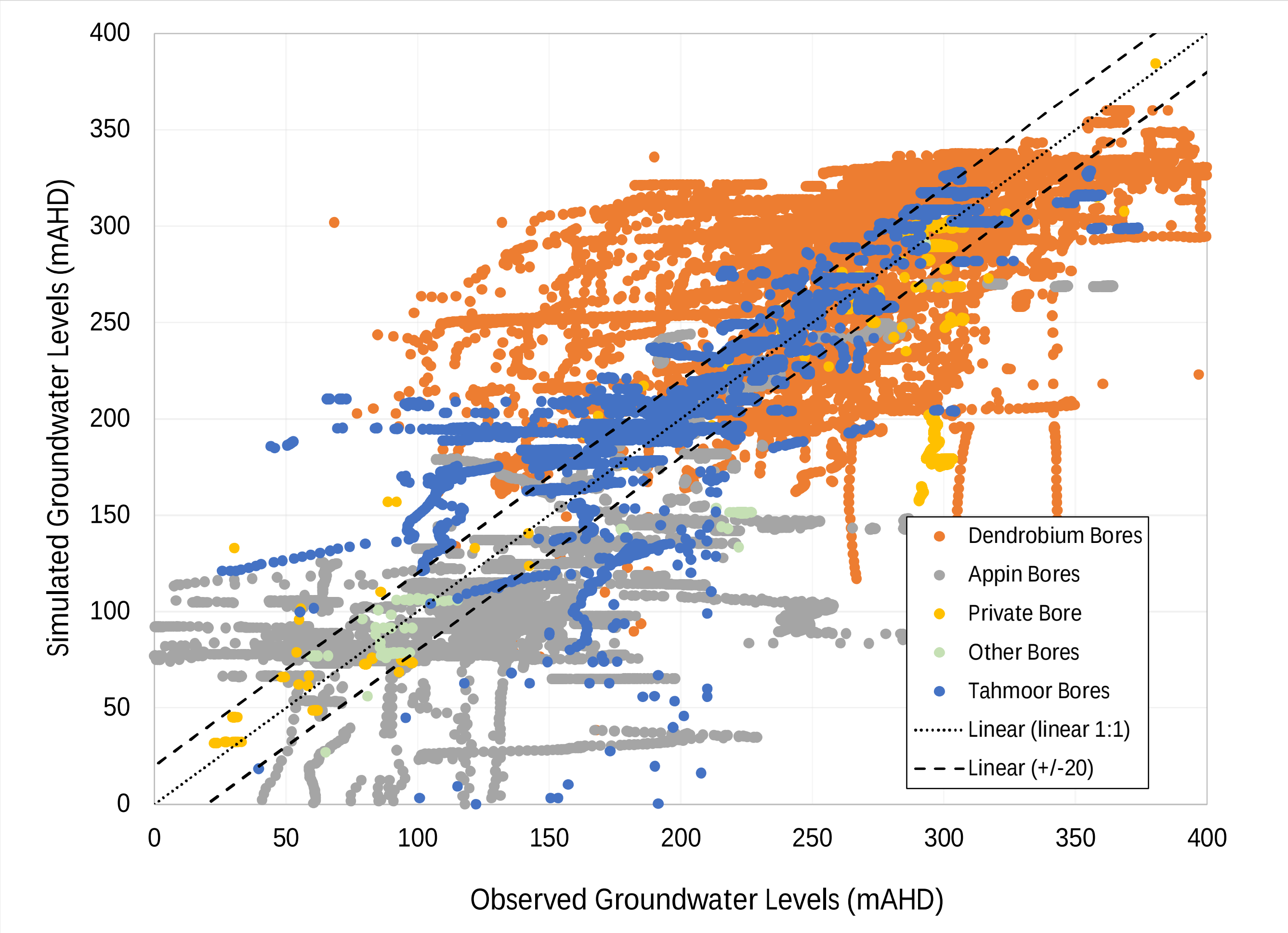


Figure 3-6 Calibration Scattergram– Modelled vs Observed Groundwater Levels for All Bores

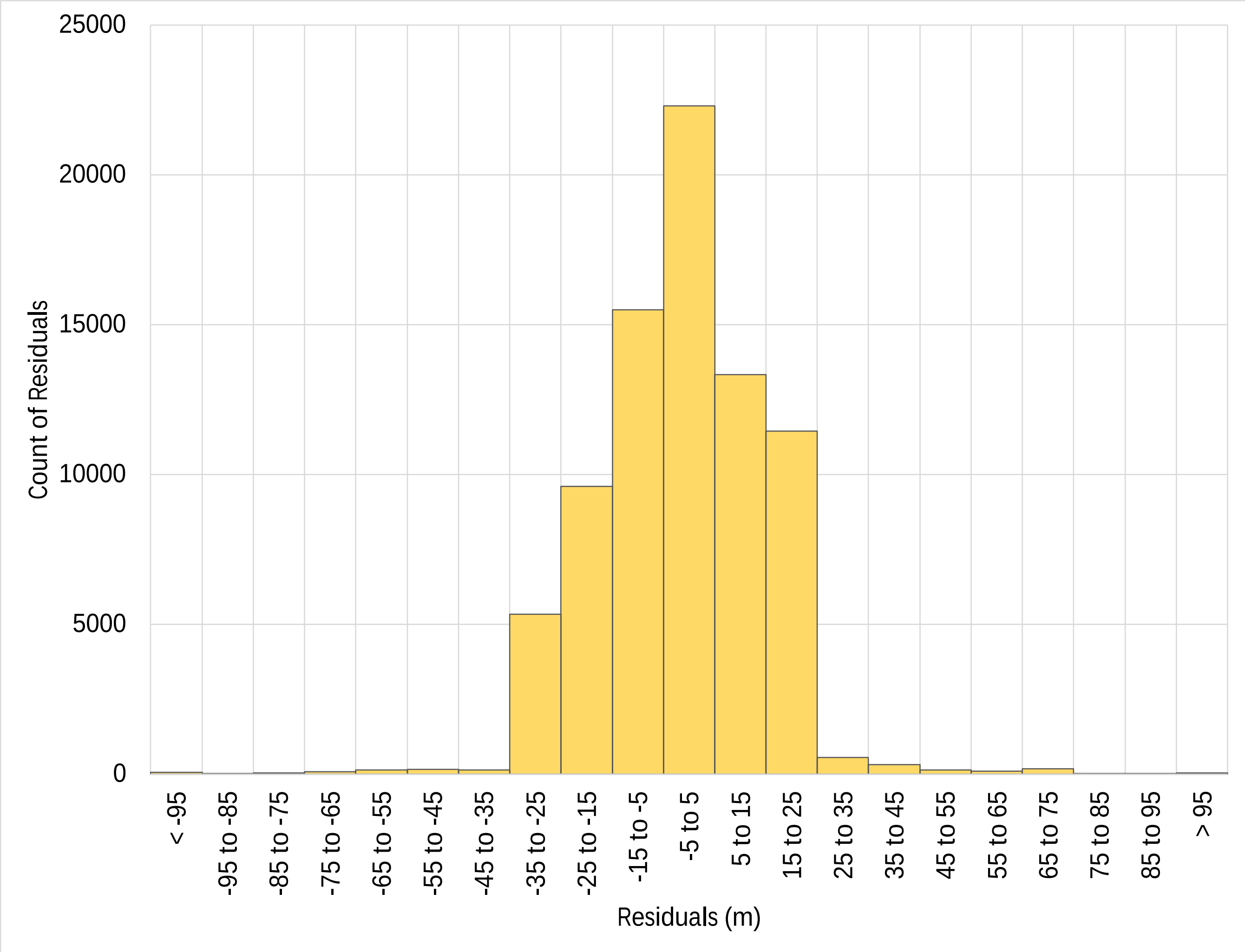


Figure 3-7 Calibration Residual Histogram Scattergram - Tahmoor Bores

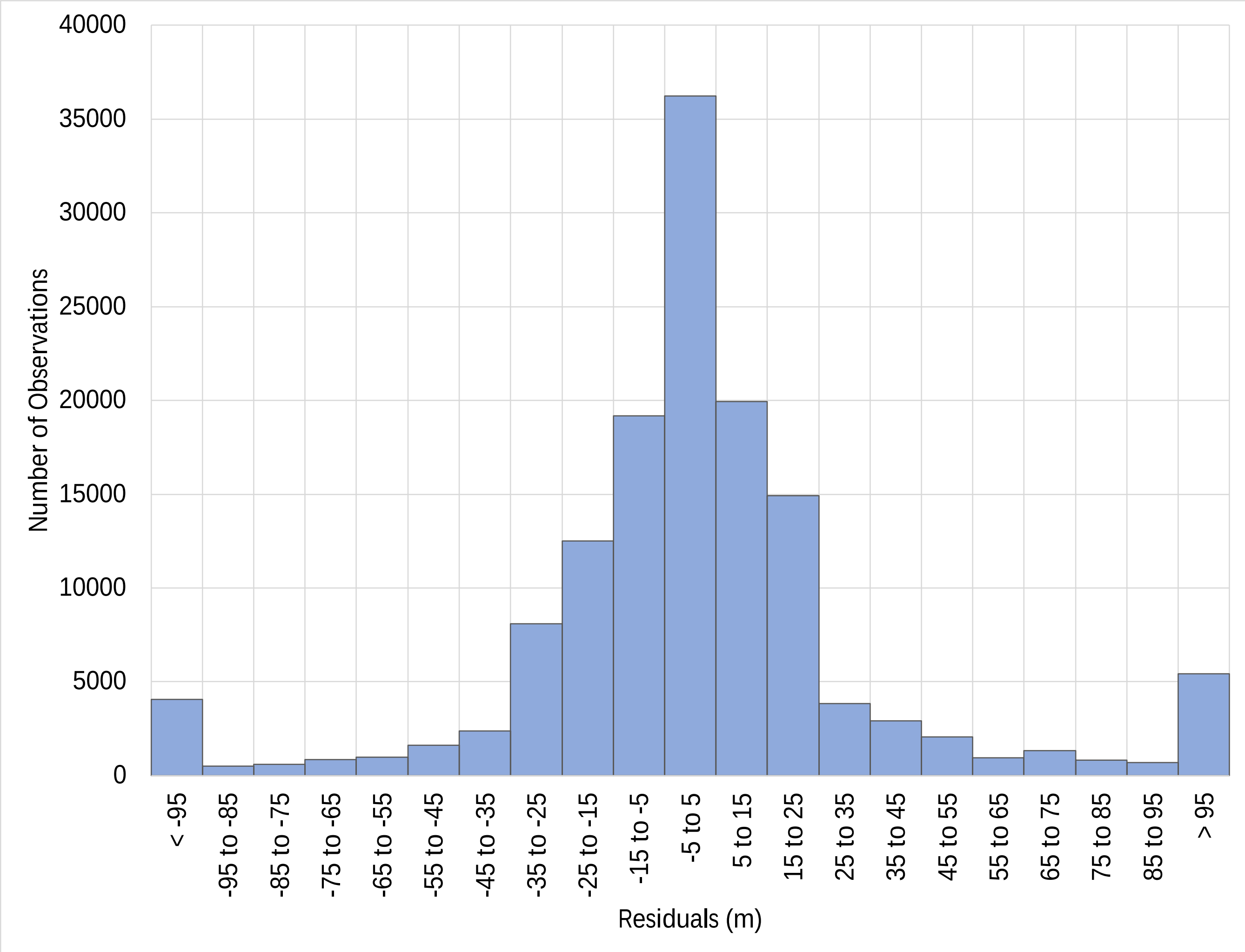


Figure 3-8 Calibration Residual Histogram Scattergram - All Bores

Figure 3-9 Transient Calibration Average Head Residuals

Table 3-3 shows a mix of over and underestimation of water levels in the model layers across the model domain. The table shows Layer 18 (Kembla Sandstone) has the highest average and absolute average residual. Table 3-3 shows Hawkesbury Sandstone layers in the model have the highest number of observations while the average residuals in these layers are less than 10.5 m.

Table 3-4 shows the average calibration residual and absolute average residual per observation group. As indicated in the table, there is an overestimation of water levels in the Tahmoor bores. The table shows the Tahmoor have the lowest average residuals.

Table 3-3 Average Residual by Model Layer

Model Layer	Formation	Average Residual (m)	Average Absolute Residual (m)	Number of Observation Targets	Number of bores
1	Regolith, alluvium and basalt	-1.2	6.2	9,965	41
2	Wianamatta Formation	5.2	10.4	2,211	22
3	Hawkesbury Sandstone - upper	-5.8	22.7	3,839	61
4	Hawkesbury Sandstone - middle	10.0	24.6	74,176	266
5	Hawkesbury Sandstone - lower	6.6	16.3	6,319	114
6	Bald Hill Claystone	-10.4	28.0	289	24
7	Bulgo Sandstone - upper	-6.7	32.5	277	26
8	Bulgo Sandstone - middle	-1.6	27.2	9,631	191
9	Bulgo Sandstone - lower	-8.4	37.5	748	22
10	Stanwell Park Claystone	19.9	32.3	615	10
11	Scarborough Sandstone – upper	8.9	33.5	571	19
12	Scarborough Sandstone - lower	-2.7	41.6	5,789	105
13	Wombarra Claystone	-26.3	33.5	617	10
14	Coal Cliff Sandstone	-25.2	65.2	363	8
15	Bulli Coal seam	-14.7	49.5	3,706	100
16	Eckersley Formation	22.6	35.9	9,175	39
17	Wongawilli Coal seam	-29.7	45.9	2,047	72
18	Kembla Sandstone	-92.7	92.7	43	3
19	Older units (lower Permian Coal Measures and Shoalhaven Group)	-27.1	27.1	43	1

Table 3-4 Average Residual by Site

Site	Average Residual (m)	Average Absolute Residual (m)	Number of Observation Targets	Number of Bores
Tahmoor	-1.4	12.2	79,320	266
Dendrobium	-3.8	35.3	17,701	471
Appin	21.0	39.4	14,806	241
Private Bore	19.9	22.3	18,379	84
Other	35.8	38.5	218	11

3.4 Calibration Fit

This section provides discussion on the modelled to observed groundwater level trends (calibration hydrographs) for key bores around the Tahmoor site. Calibration hydrographs for the full calibration dataset are presented as Appendix D.

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

The match in most of the private and government bores is good with errors of ± 5m. Examples of this can be seen in the hydrographs for "GW" bores in Appendix D.

The hydrographs show better match in the Tahmoor bores compared to Appin and Dendrobium bores as the Tahmoor site bores were given priority in the calibration process. Comparing to the 2021 model, the hydrographs are generally consistent with the previous model.

Overall, across the model domain, there is a better match between simulated groundwater levels and observed levels in the shallow units (including the bores in alluvium and HBSS) which are connected to the surface water features and which host almost all the private bores. This is also shown through calibration residuals presented in Table 3-3. The hydrographs show increasing error in the deeper layers where there is greater, more severe drawdown and higher gradients around the mine. Potential sources of error when comparing simulated and observed water levels are:

- Imperfect simulation of mining operations, roadway development and advanced gas drainage (where present in the model). As an example, the discrepancy in observed and simulated groundwater levels between in Dendrobium mine borehole S1907 and Tahmoor bore TBC39. The hydrograph for the bores shown in Appendix D represent a timing influence, thought to be from the representation of the historical mine plan in this model compared to the actual progression of that mine;
- Structural simplifications in the model, including the vertical and horizontal discretization of the model and resulting 'coarse' representation of features and hydraulic gradients at scales of a model cell (or layer) or less. For example, strong vertical gradients may mean that a model, which predicts average water levels for a cell, will struggle to replicate an observed water level if that water level is from the upper or lower portion of that layer. For a layer that is 50 metres thick and where a gradient is 1 in 10, this leads to errors of ± 5m;
- Structural errors may also occur because of the discretisation of time in the model. In this case, stress period lengths are quarterly. Behaviour within this may significantly influence the observed water level, and the model may either not simulate the relevant stress or may smooth out the response to such a stress;
- High residuals but good match: examples are illustrated in the Bulli Coal seam piezometers in bores TNC28 and TNC29, which show large residuals but also suggests that the model does a reasonable job of simulating groundwater levels and their response to mining;

- Processing / installation record errors: A lot of the bores with erroneous data were removed from the calibration dataset. However, given the number of bores and measurements available for the calibration, further review of the calibration data may identify more bores with erroneous that should be removed from the calibration. There were uncertainties about installation depth/formation (i.e. model layer) in some of the bores but the data from these bores were included in the calibration but were assigned lower weights; and
- Representation of fracture profile properties: It is evident that the bores screened within the fracture zone above the longwalls are impacted by post-mining properties of the fracture zone. The fracture zone properties are likely to be highly variable in different parts of the mine. However, the model uses one value across the site for the fracture zone which is a simplified representation of a highly complex stress system.

The following sections discuss the calibration hydrographs for shallow bores at Thirlmere Lakes, Tahmoor VWPs, and the Tahmoor open standpipe bores ("P" bores) around Tahmoor North and Western Domain.

3.4.1 Thirlmere Lakes Bores

Figure 3-10 to Figure 3-13 compares the simulated and observed groundwater levels for the shallow boreholes at Thirlmere Lakes. The hydrographs show the model simulated the groundwater levels in GW75409_1 and GW75410 are within 5 m of observed levels. The model underpredicts the groundwater levels in GW75409_1 and GW75411 by approximately 5 m. The trends and seasonal fluctuations in groundwater levels in all these bores is reasonably well replicated. The hydrographs presented show the new model was able to match in groundwater levels and trends in Thirlmere Lakes bores better comparing to the 2020 groundwater model.

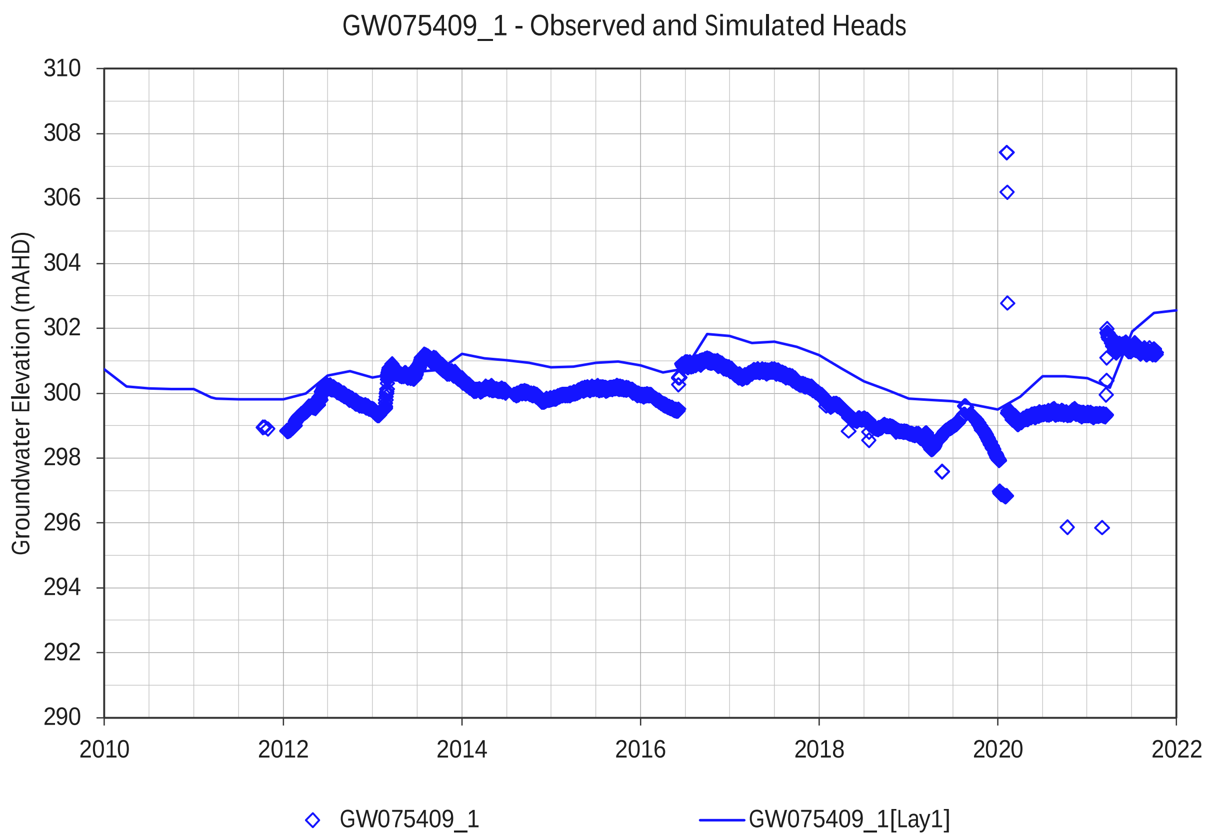


Figure 3-10 Hydrographs for Thirlmere Lakes Bores- GW075409_1

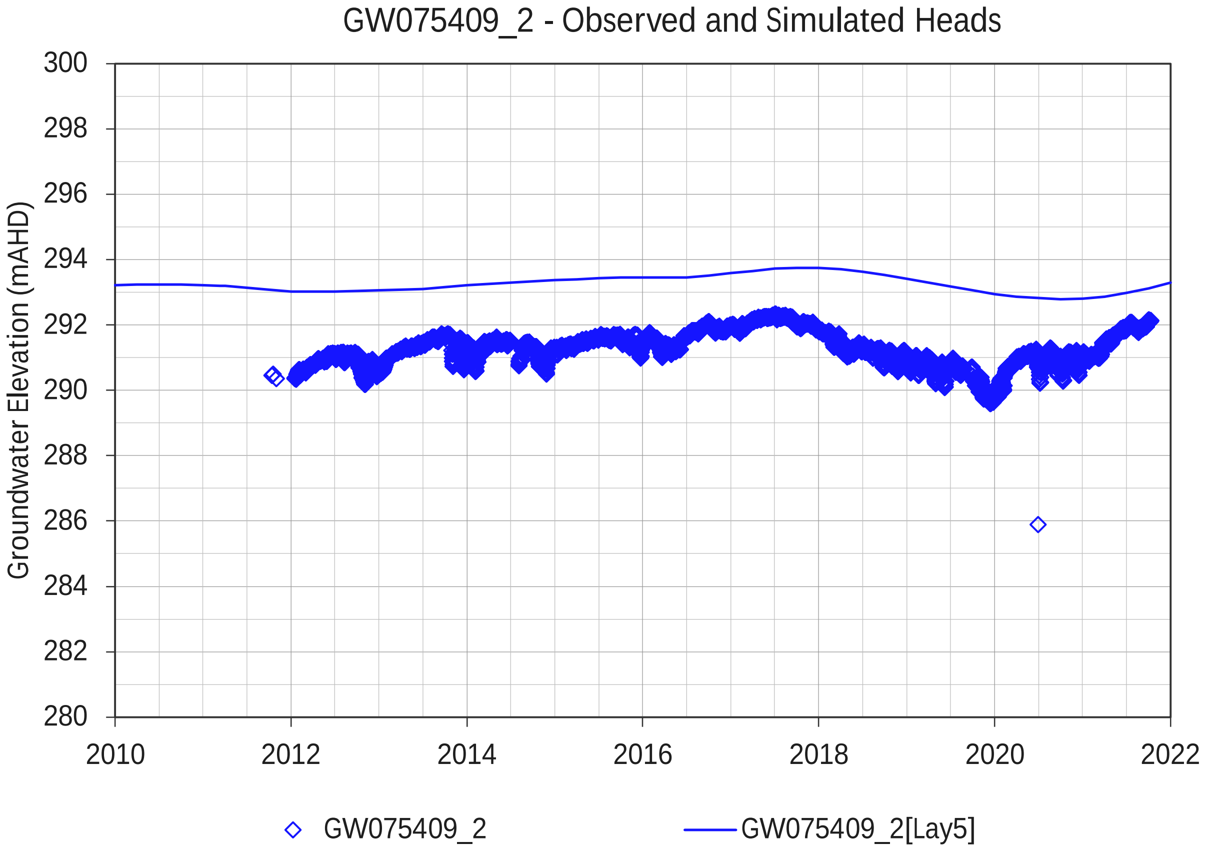


Figure 3-11 Hydrographs for Thirlmere Lakes Bores- GW075409_2

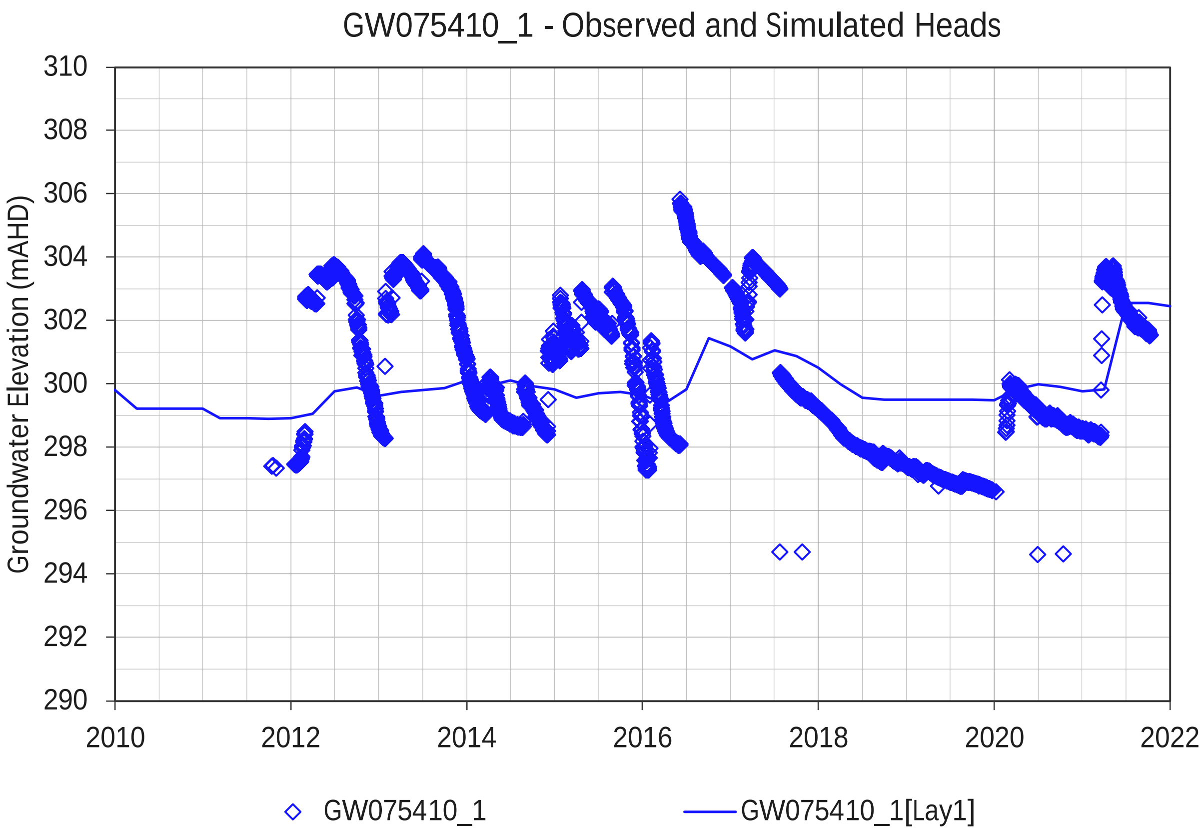


Figure 3-12 Hydrographs for Thirlmere Lakes Bores- GW075410_1

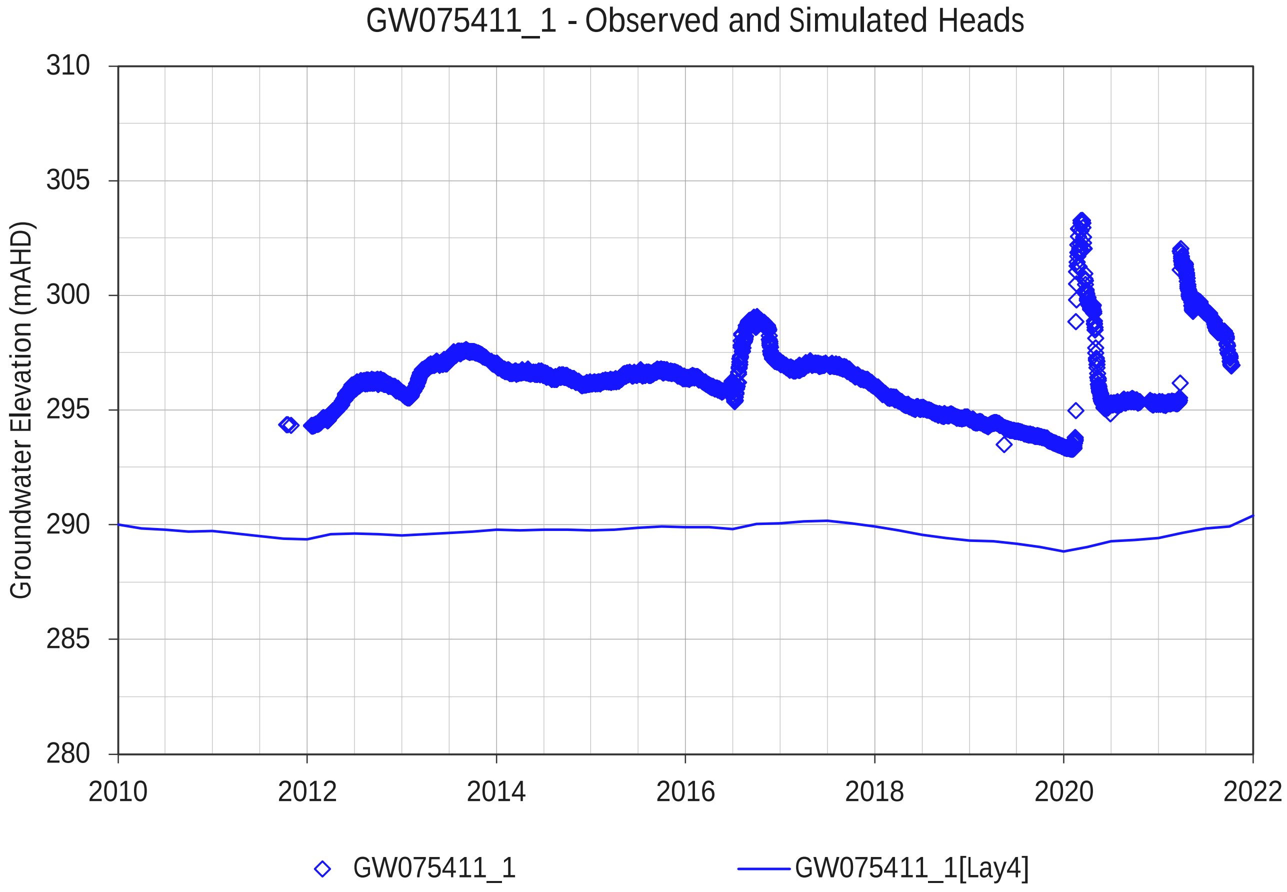


Figure 3-13 Hydrographs for Thirlmere Lakes Bores- GW075411_1

3.4.2 Tahmoor Vibrating Wire Piezometers (VWPs)

The following section presents the model performance at the VWPS in Tahmoor North and Western Domain bores (TNC040, TNC028, TNC029, WD01) and Tahmoor South (TBC032, TBC027, TBC039).

TNC040: TNC040 is a multi-VWP bore in Tahmoor North, located near LW32. Simulated water level profiles at bore TNC040 is show in Figure 3-14 .As shown in the figure there is a good match between the simulated water levels and observations in most of the TNC040 VWPs. The figure shows a good match down the profile, with modelled heads being a good match for those in the Hawkesbury Sandstone (both modelled and observed unaffected by mining) and the Bulgo Sandstone (both modelled and observed influenced by mining). The model tends to underpredict drawdown in the deeper units compared to the observed water levels. Overall, the model was able to simulate the depressurisation in deeper strata and minimal drawdown above the zone of connected fracturing.

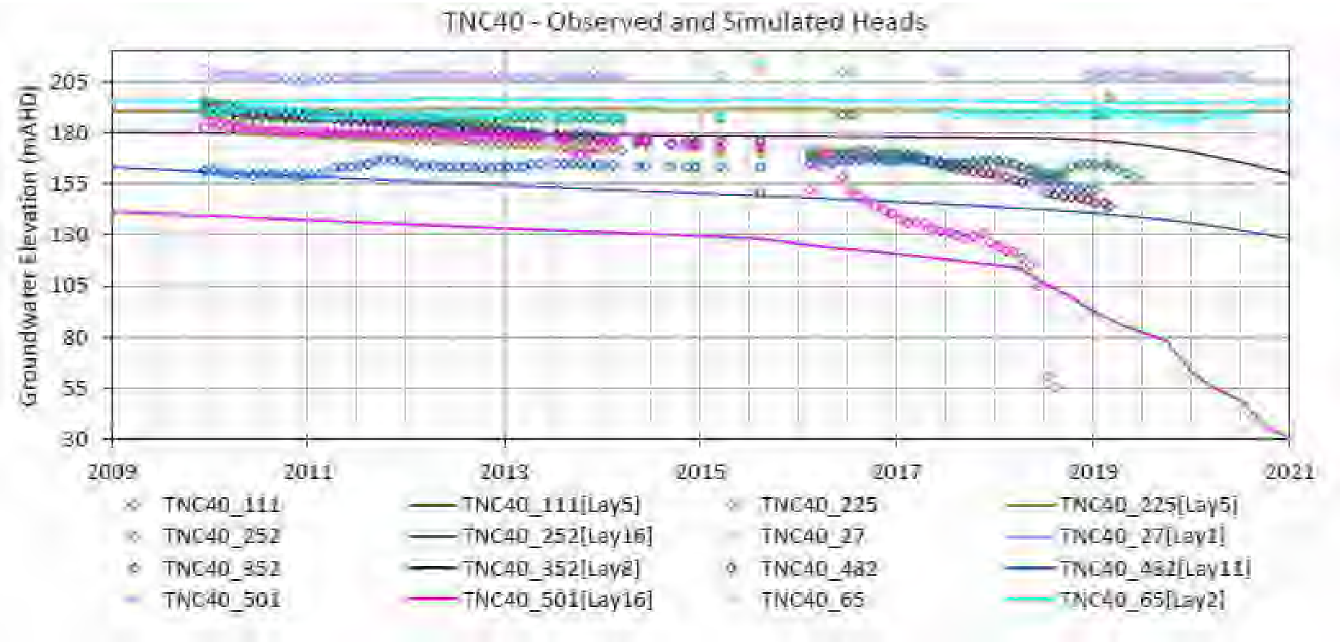


Figure 3-14 Hydrographs for VWPs- TNC40

TNC028 and TNC029: Figure 3-15 and Figure 3-16 show hydrographs comparing modelled and observed groundwater levels for TNC028 and TNC029 both located with the Tahmoor North mine footprint. The figures show the model was generally able to replicate the difference in heads observed at the VWPs and was also able to closely simulate the drawdown due to mining at Tahmoor North. The model underpredicted the groundwater levels in the deepest VWP in TNC029.

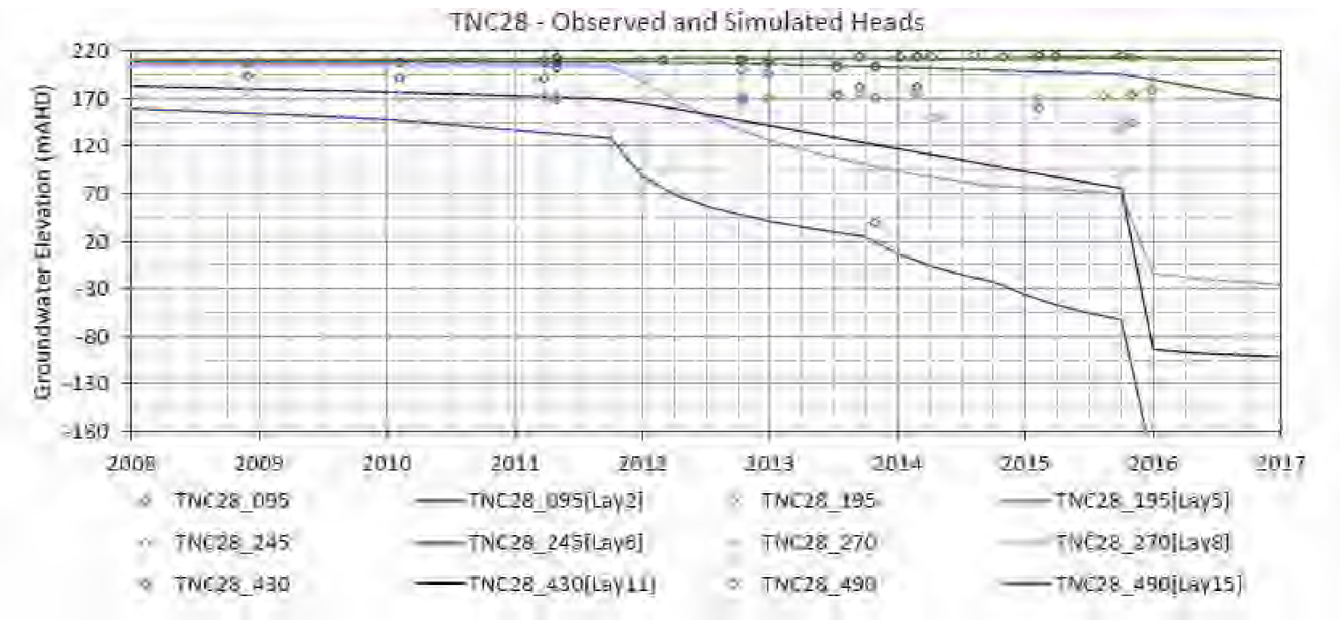


Figure 3-15 Hydrographs for VWPs- TNC028

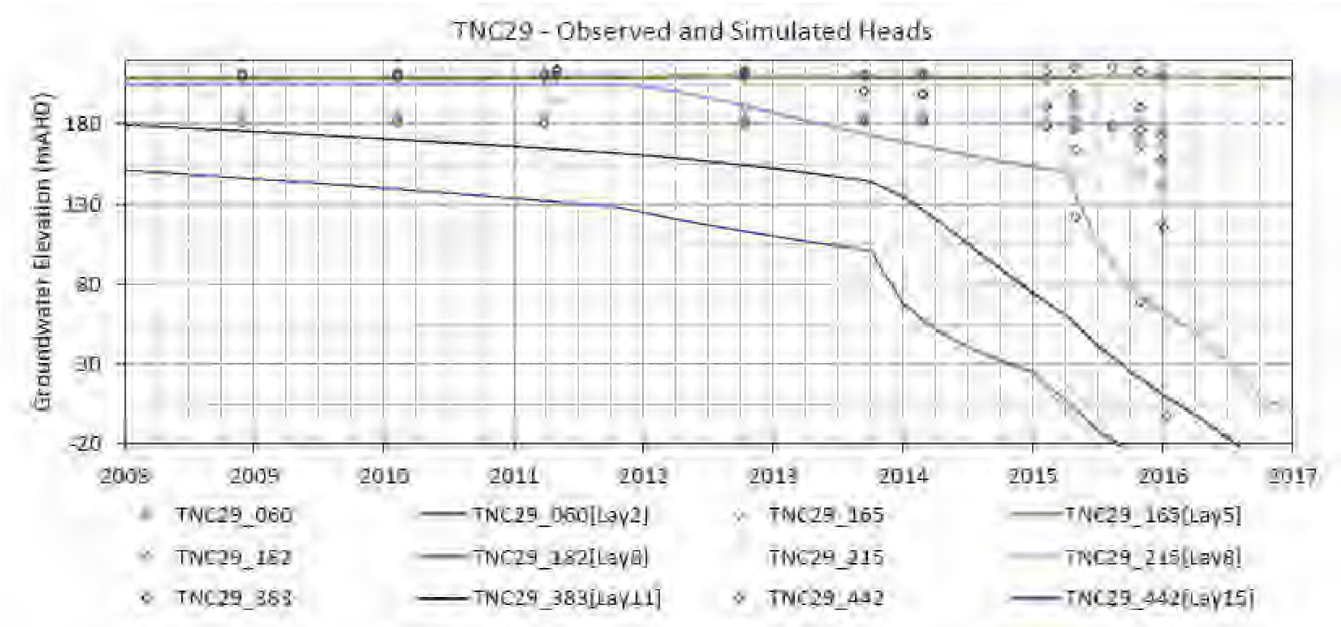


Figure 3-16 Hydrographs for VWPs- TNC029

WD01: Figure 3-17 compare the simulated and observed groundwater levels for VWPs in WD01 which is located within Western Domain mine footprint. The figure shows while the model replicated the shallow groundwater levels well (piezometer WD01-190m, WD01-210m and WD01-230m), the model overpredicted the groundwater levels in deeper units such as Bulgo Sandstone (piezometer WD01-300m) by between 20-50 m. Multiple piezometers in BGSS WD01-350m were simulated in the same model layer of the model due to vertical resolution of the model. This was a limitation in matching some of the groundwater levels recorded in the VWPs.

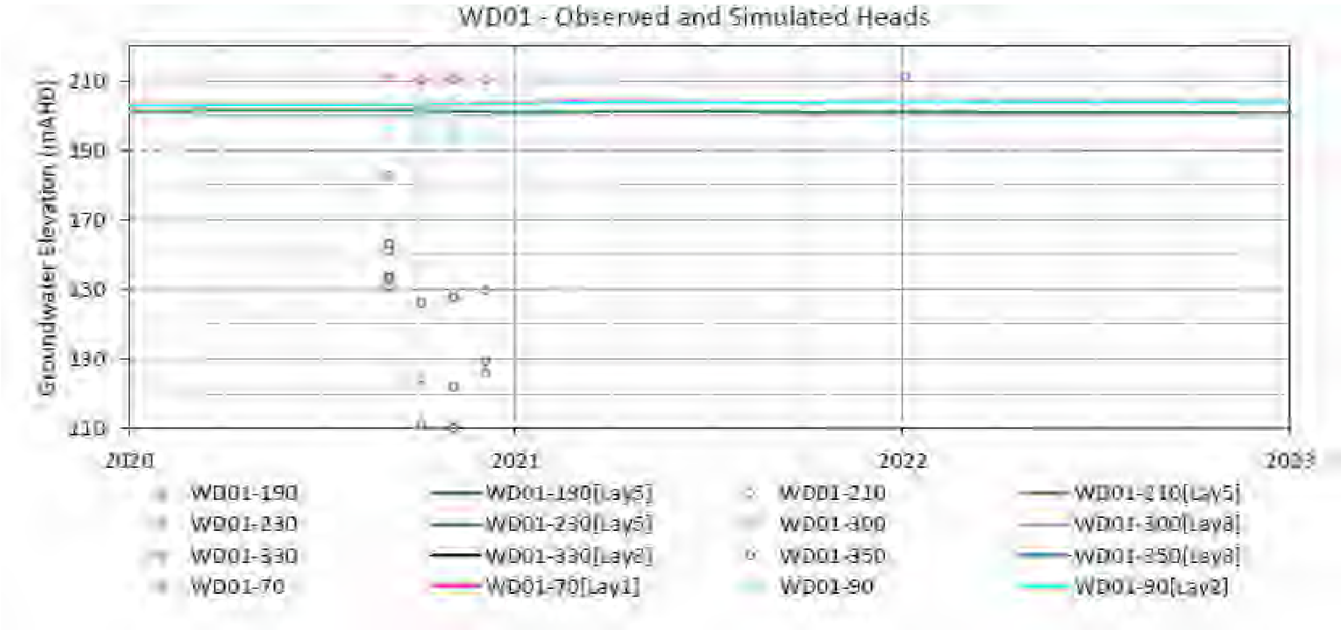


Figure 3-17 Hydrographs for VWPs-WD01

TBC018: Figure 3-18 show the calibration hydrograph for TBC18 which is located to the southwest of Tahmoor South away from any historical mining. The model overpredicts the groundwater level in all the VWPs at TBC18 but matching the observed trends well. In the case of the Bulli Coal piezometer (TBC18_404), the observed drawdowns are likely caused by equilibration of water levels after piezometer installation and therefore, the model was unable to replicate them.

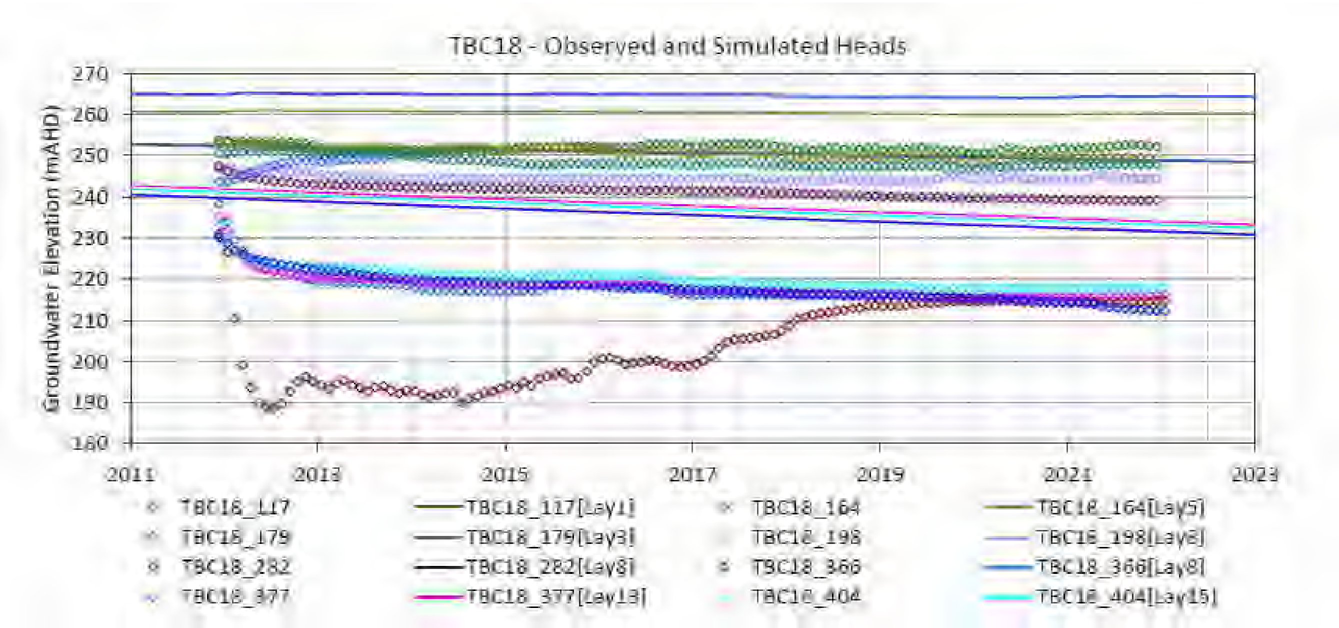


Figure 3-18 Hydrographs for VWPs-TB18

TBC034: TBC034 is also located to the east of Tahmoor South Panels. As shown in Figure 3-19, the model underpredicted the groundwater levels in most of the VWPs. The drawdown observed in the deeper VWPs in TBC034appear to be a result of mining, but the model was not able to replicate this drawdown. The mismatch between observed in simulated and observed groundwater levels in this bore is likely due to the model structure (i.e. further away from the site, the accuracy of the geology model reduced).

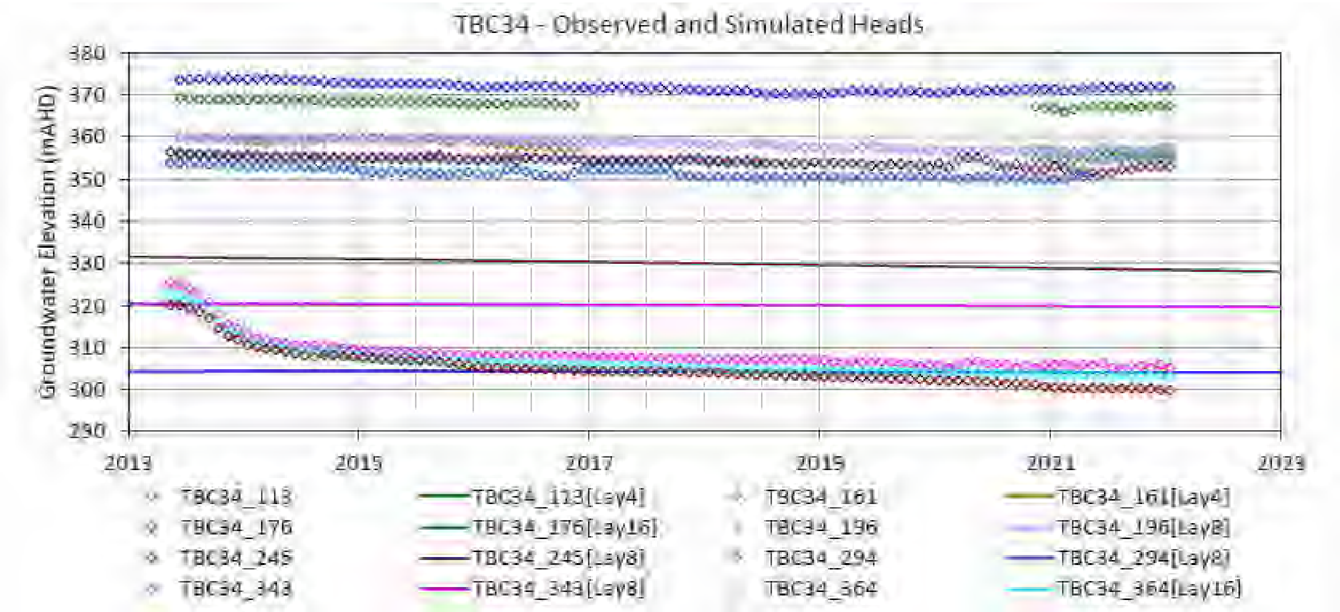


Figure 3-19 Hydrographs for VWPs-TBC34

TBC027: Figure 3-20 shows the hydrograph for TBC027 located to the south of Tahmoor South Panels. As shown in, the model overpredicted the groundwater levels in most of the deep VWPs in TBC027 (below HBSS). The drawdown observed in the deeper VWPs in TBC027 does not appear to be mining related and the model was not able to replicate this drawdown.

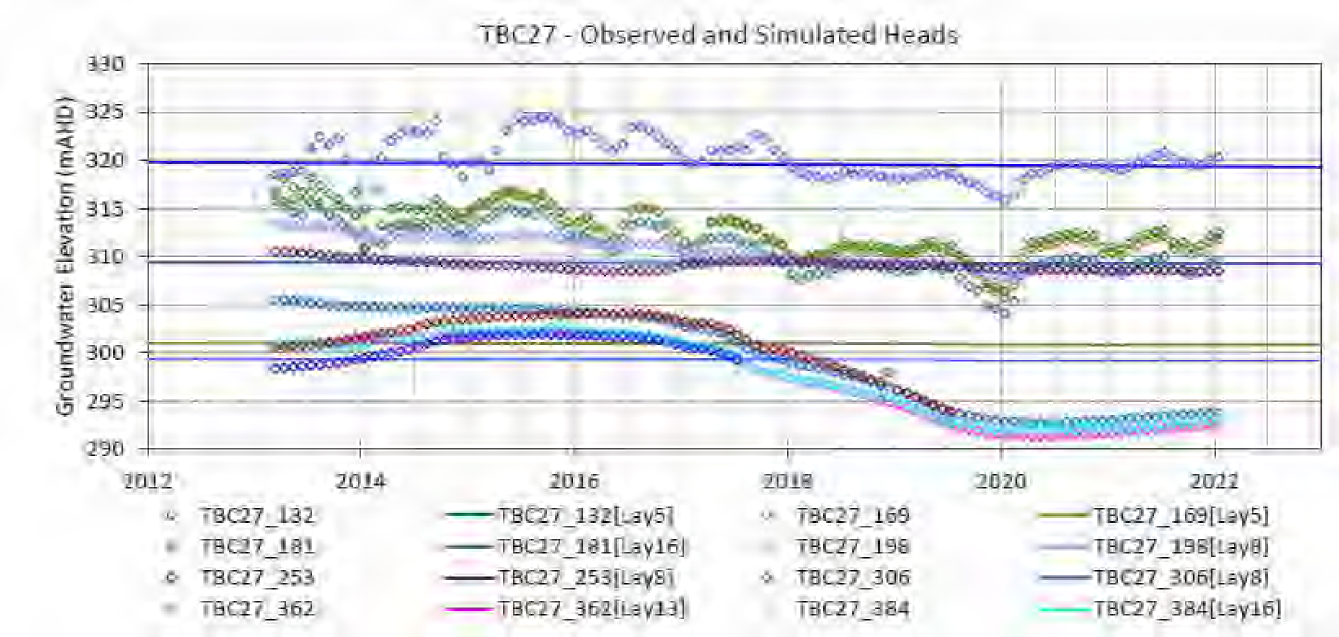


Figure 3-20 Hydrographs for VWPs-TB27

3.4.3 Tahmoor Open Standpipe Bores (P Bores)

3.4.3.1 Tahmoor North

This section presents hydrographs comparing modelled and observed groundwater levels for the existing groundwater monitoring bores located across Tahmoor North (P1-P8, P9) shown in Figure 3-21 to Figure 3-29, and along Redbank Creek (P10-P36) and Myrtle Creek (P18-P28) presented in Appendix D.

The comparison of modelled and historical observed groundwater levels for P1-P8 (Figure 3-21 and Figure 3-28) shows the model simulate a reasonable match to the trends at these bores but over or under predicts the groundwater levels between 5 to 20 m which are consistent with the previous model (SLR/HydroSimulations, 2021). P6 and P8 show the largest difference in observed and simulated groundwater levels.

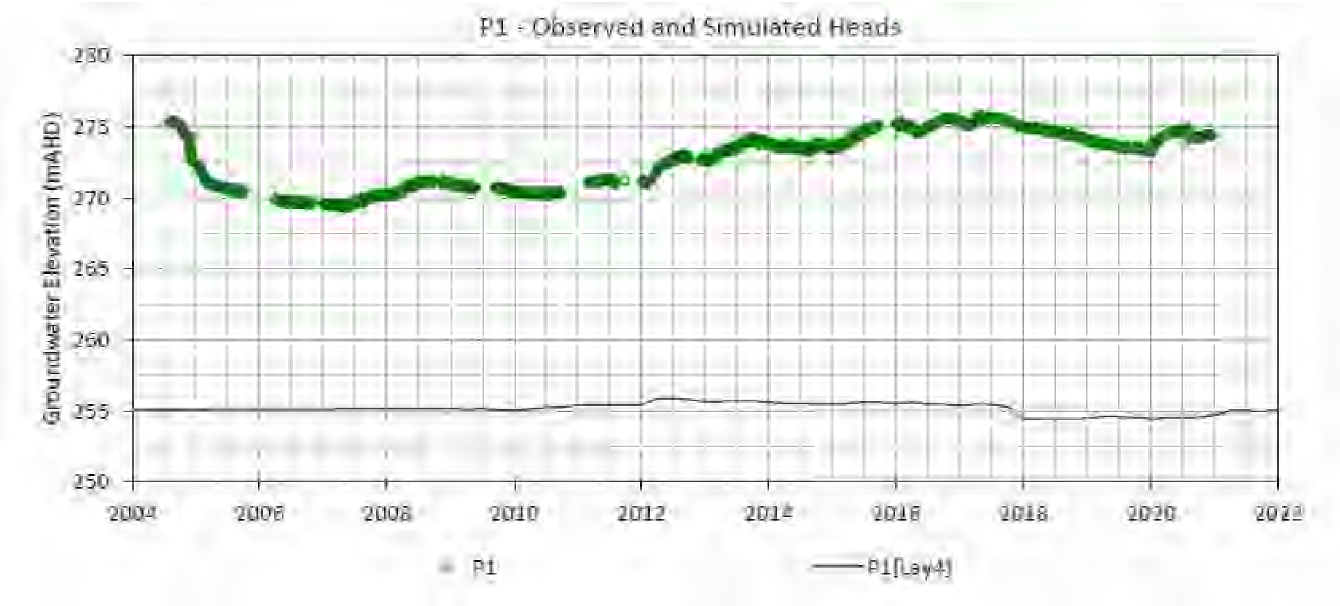


Figure 3-21 Hydrographs for P1- Tahmoor North

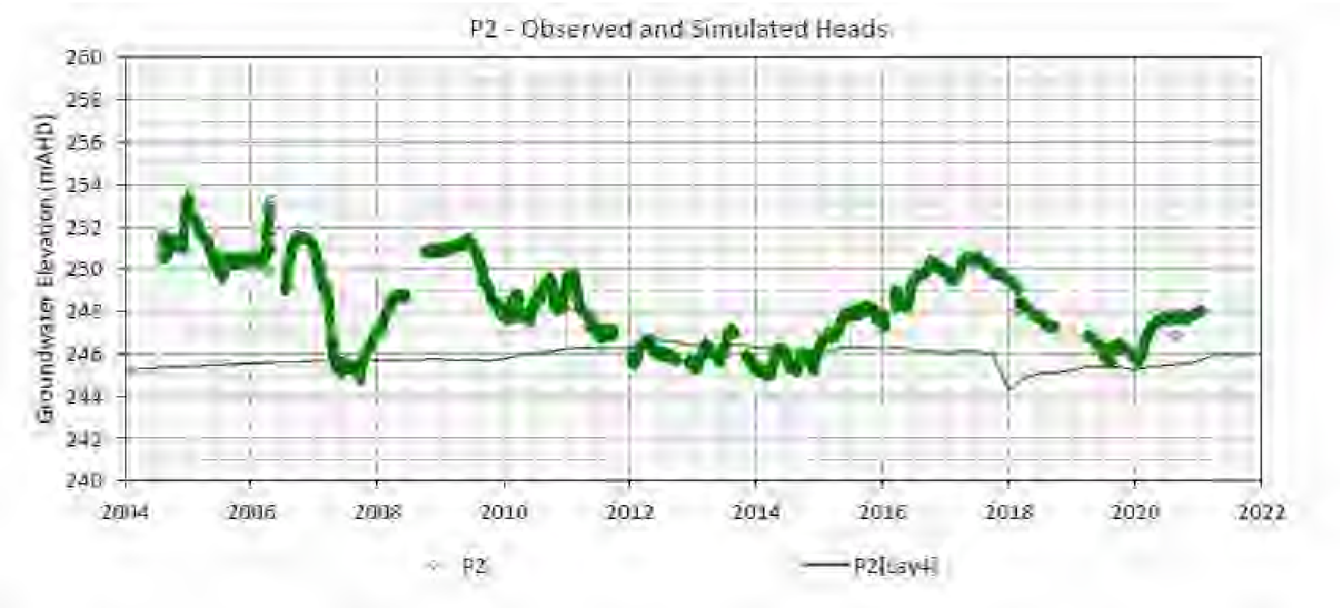


Figure 3-22 Hydrographs for P2- Tahmoor North

Figure 3-23 Hydrographs for P3- Tahmoor North

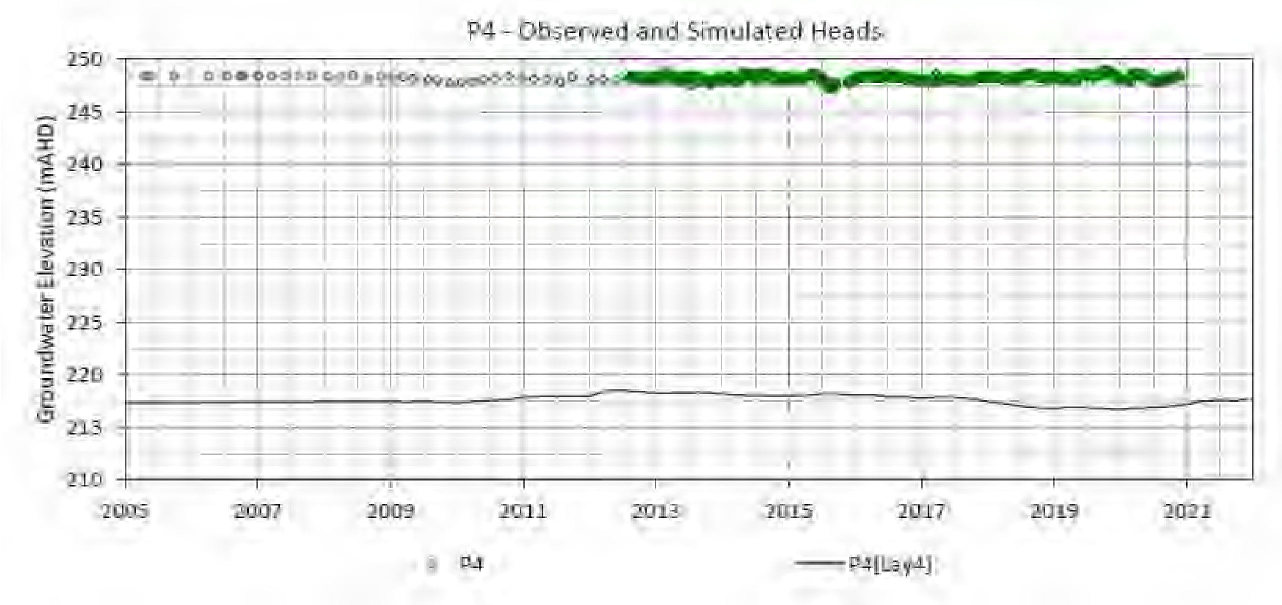


Figure 3-24 Hydrographs for P4- Tahmoor North

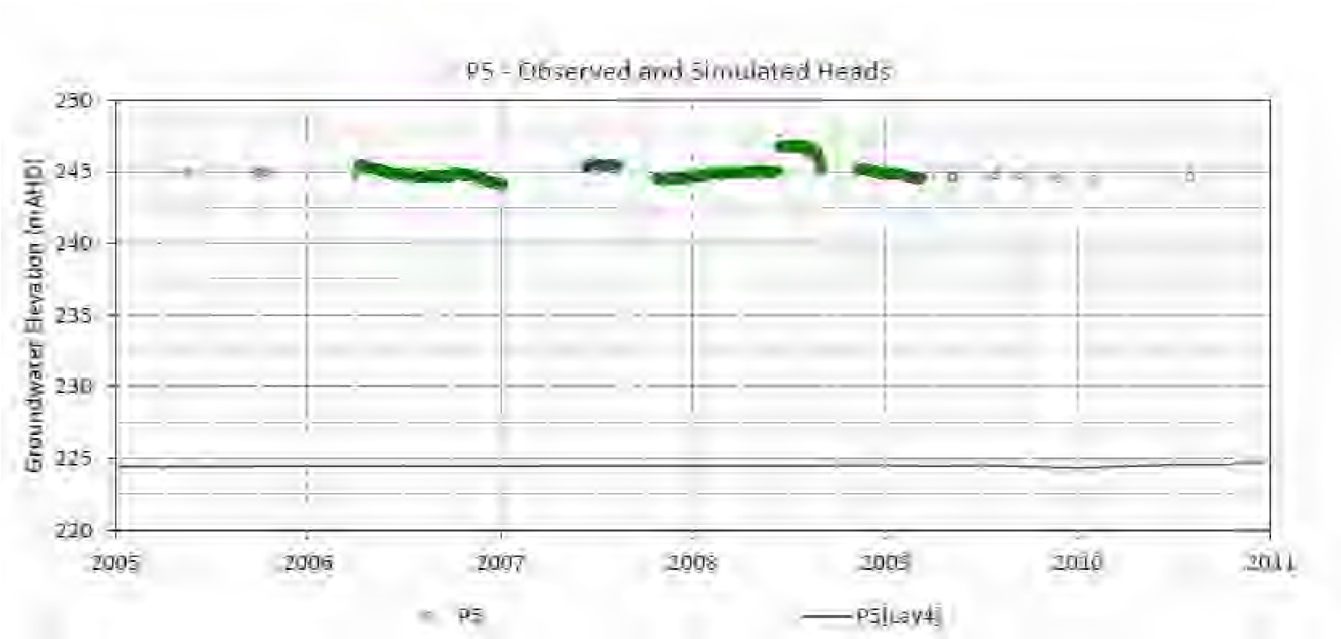


Figure 3-25 Hydrographs for P5- Tahmoor North

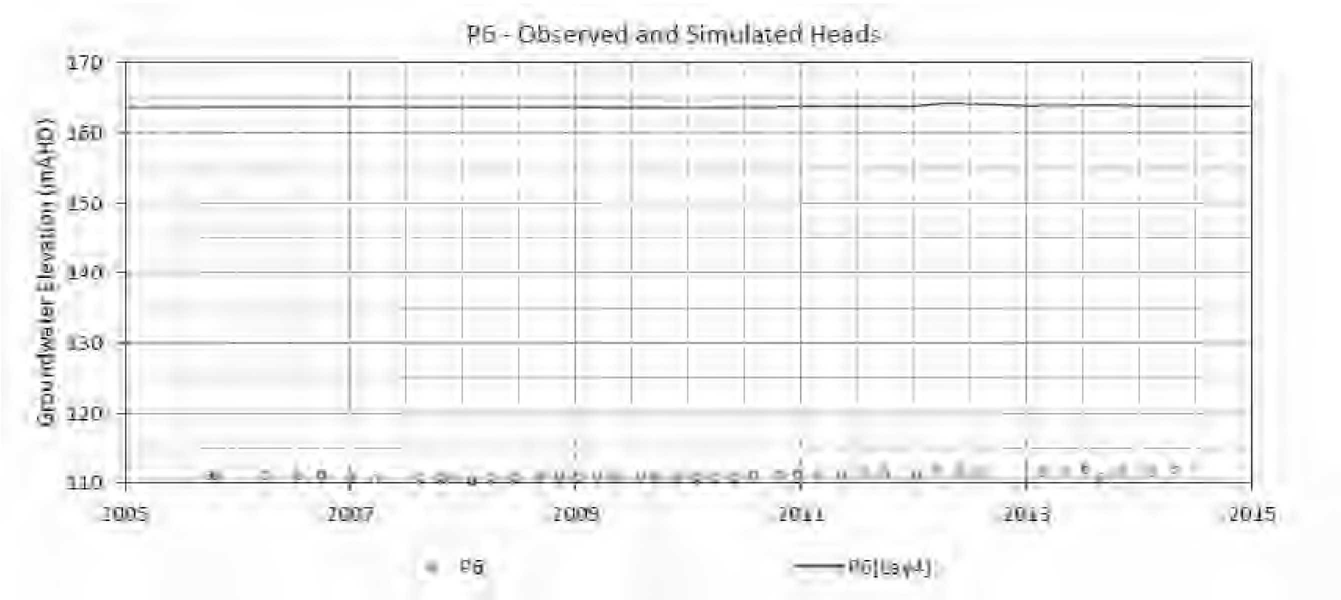


Figure 3-26 Hydrographs for P6- Tahmoor North

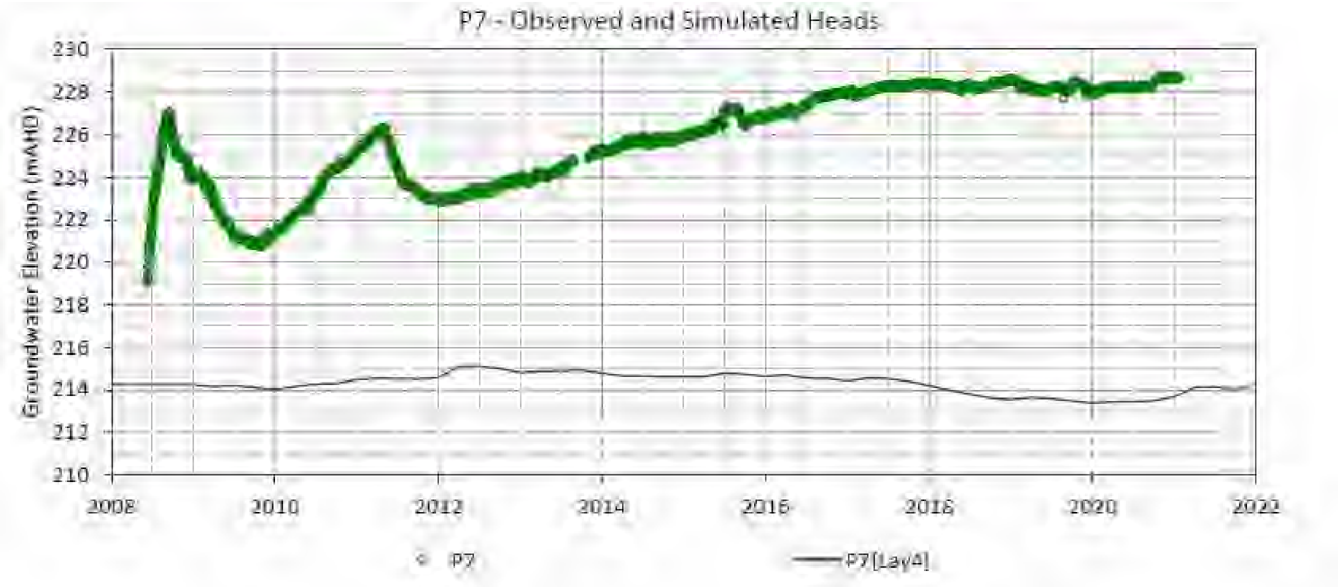


Figure 3-27 Hydrographs for P7- Tahmoor North

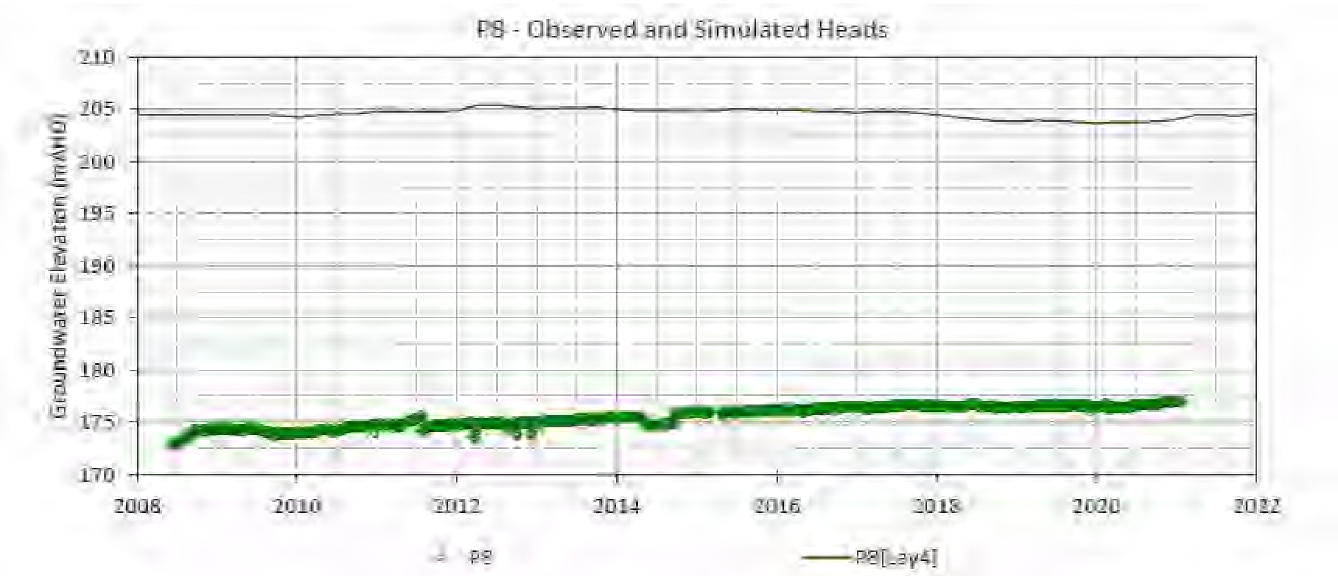
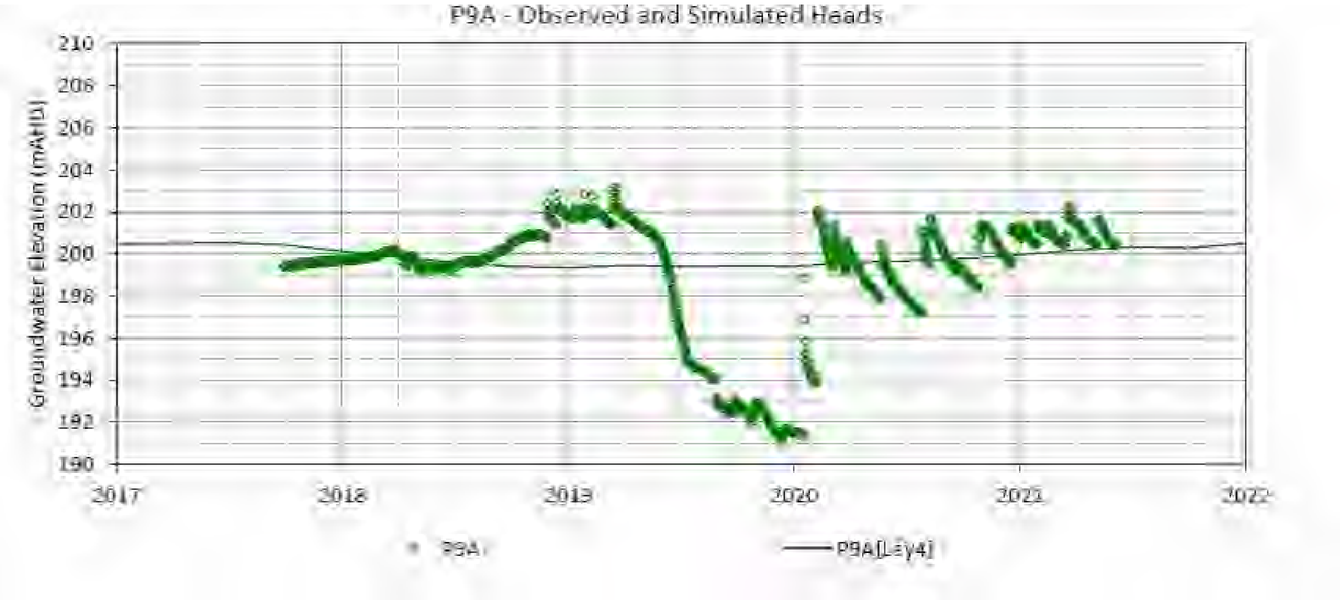


Figure 3-28 Hydrographs for P8- Tahmoor North

At bore P9 (Figure 3-29), the model replicates the LW31 and LW32 related drawdown observed in the shallow Hawkesbury Sandstones and the simulated water levels are within 5 m of observed levels (P9A, P9V1). The hydrograph for P9A shows the model was able to replicate the fluctuation in groundwater levels observed in Hawkesbury sandstone at this location. In the deeper section of the bore (P9_V3), the simulated drawdown is not as significant as the sharp decline in water levels observed after 2018. The mismatch in drawdown is likely due the properties of fractured zone and the timing of mining.



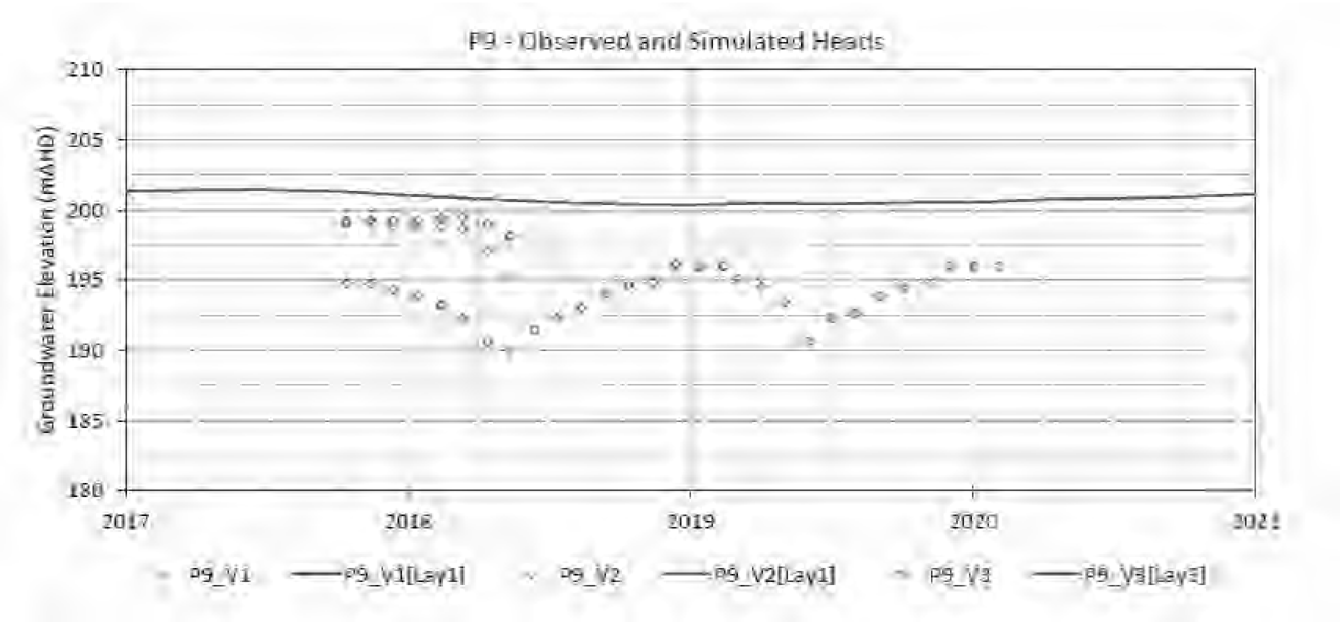


Figure 3-29 Hydrographs for P9A and P9- Tahmoor North

Hydrographs for shallow bores along Redbank Creek (P10 A, P10) shown in Figure 3-30 indicate that in general, the model match the groundwater levels along the creek. There is usually an offset of less than 5 m between observed and modelled. However, the simulated trends and seasonal fluctuation in groundwater level in the Redbank Creek catchment are not significant as observed levels.

At bore P10, limited drawdown is simulated in the deep open standpipe bore (P10C) comparing to observed which is likely due to the timing of mining simulated in the model. Comparing to 2021 model, the match to observed levels in shallow bores P10 A and P10 has improved. As shown in Appendix D, overall, the match between simulated groundwater levels and observed for the bores along Redbank Creek is good and is within ± 10 m of the observed data (P11, P19, P29, P30, P32, P32, P33, P34). However, the model was not able to replicate the observed drawdowns in these bores. This can be seen in Figure 3-31 which shows the hydrographs for bores P30 and P32 along the Redbank creek.

Modelled water levels for bores along the Myrtle Creek catchment (P20B, P24A, P25, P26, P27 and P28A-B) are presented Appendix D. As shown the hydrographs, there is a consistent underprediction of groundwater levels at these bores. This underprediction of groundwater levels is likely due to the simulated mining in the model and simplifications in model layering. Although the modelled water levels do underpredict the observed levels, the model simulates the groundwater trend reasonably well.

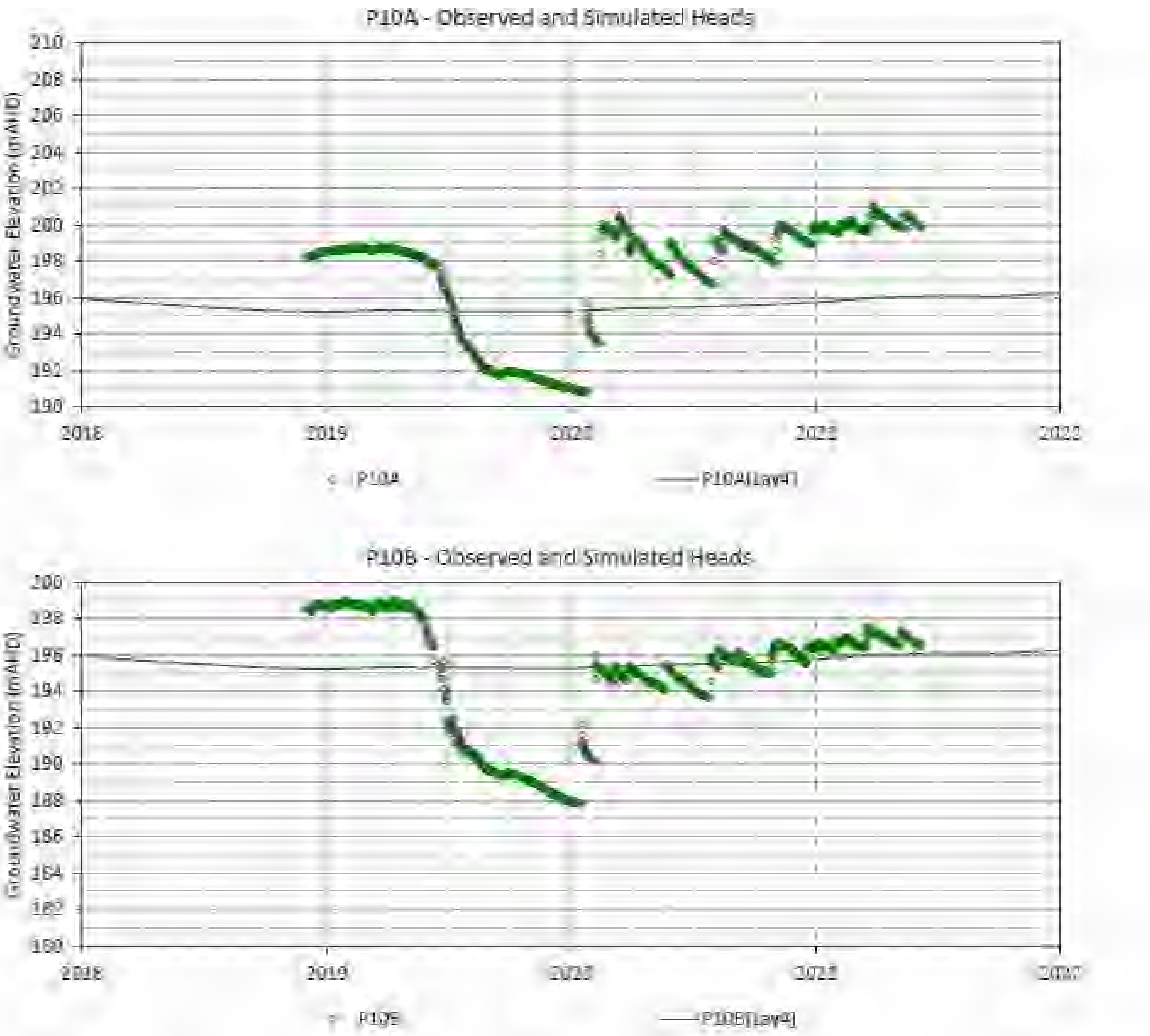
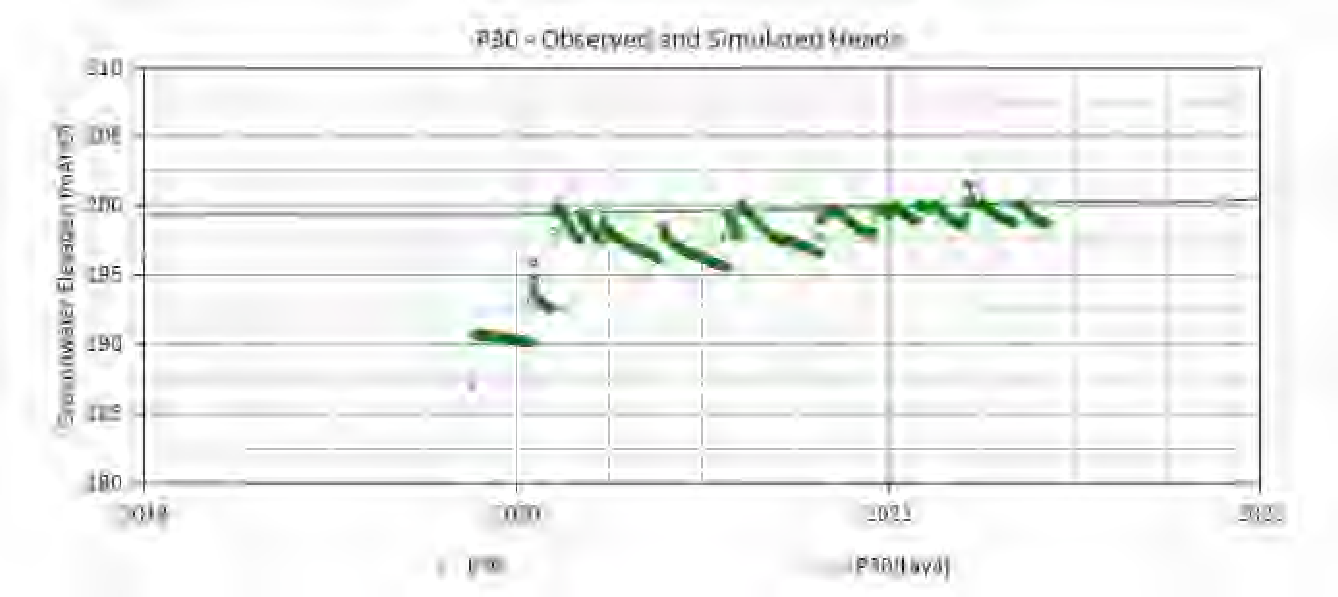


Figure 3-30 Hydrographs for P10A and P10B- Tahmoor North



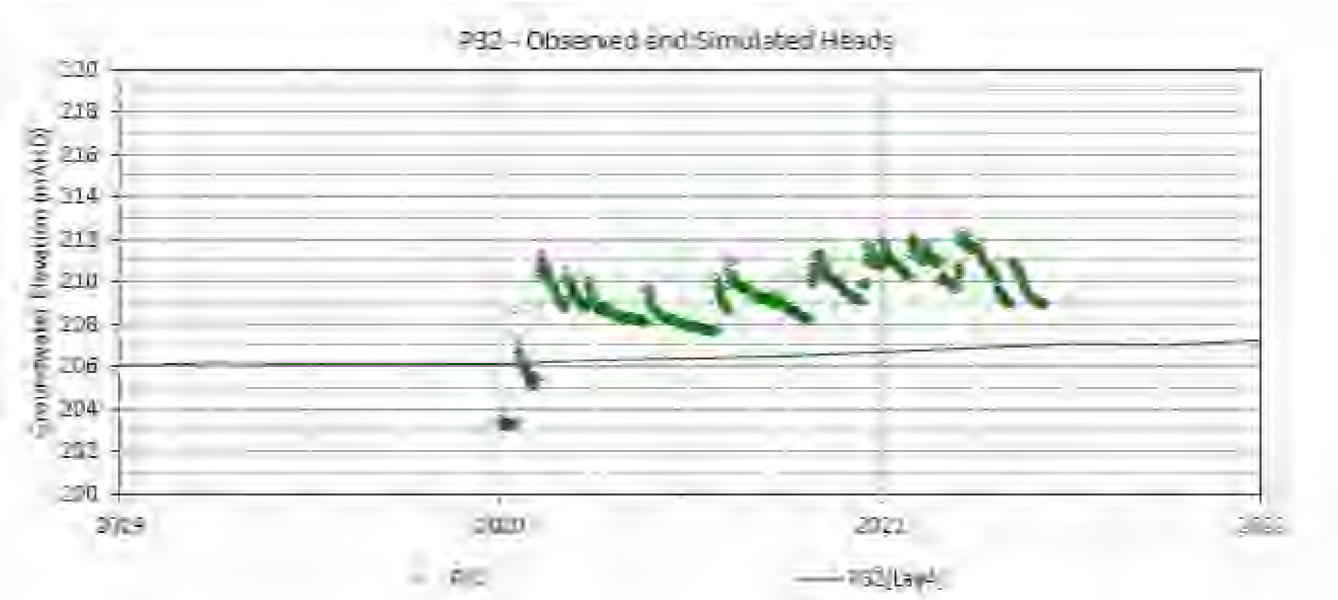


Figure 3-31 Hydrographs for P30 and P32- Tahmoor North

3.4.3.2 Western Domain

The hydrographs for the Western Domain Bores (P12-P17) are presented in Figure 3-32 to Figure 3-37 and in Appendix D. As shown in the figures, the model overpredicts the groundwater levels in P12 to P17 between 5 to 20 m. However, while modelled levels are offset, the trends and fluctuations are well matched. As shown in Figure 3-34, P14A that monitors the alluvium shows the model replicated the groundwater levels at this bore quite well but is not able to replicate the significant fluctuations at this bore. The over predictions of the groundwater levels in P14 to P17 is consistent with the SLR 2021 model.

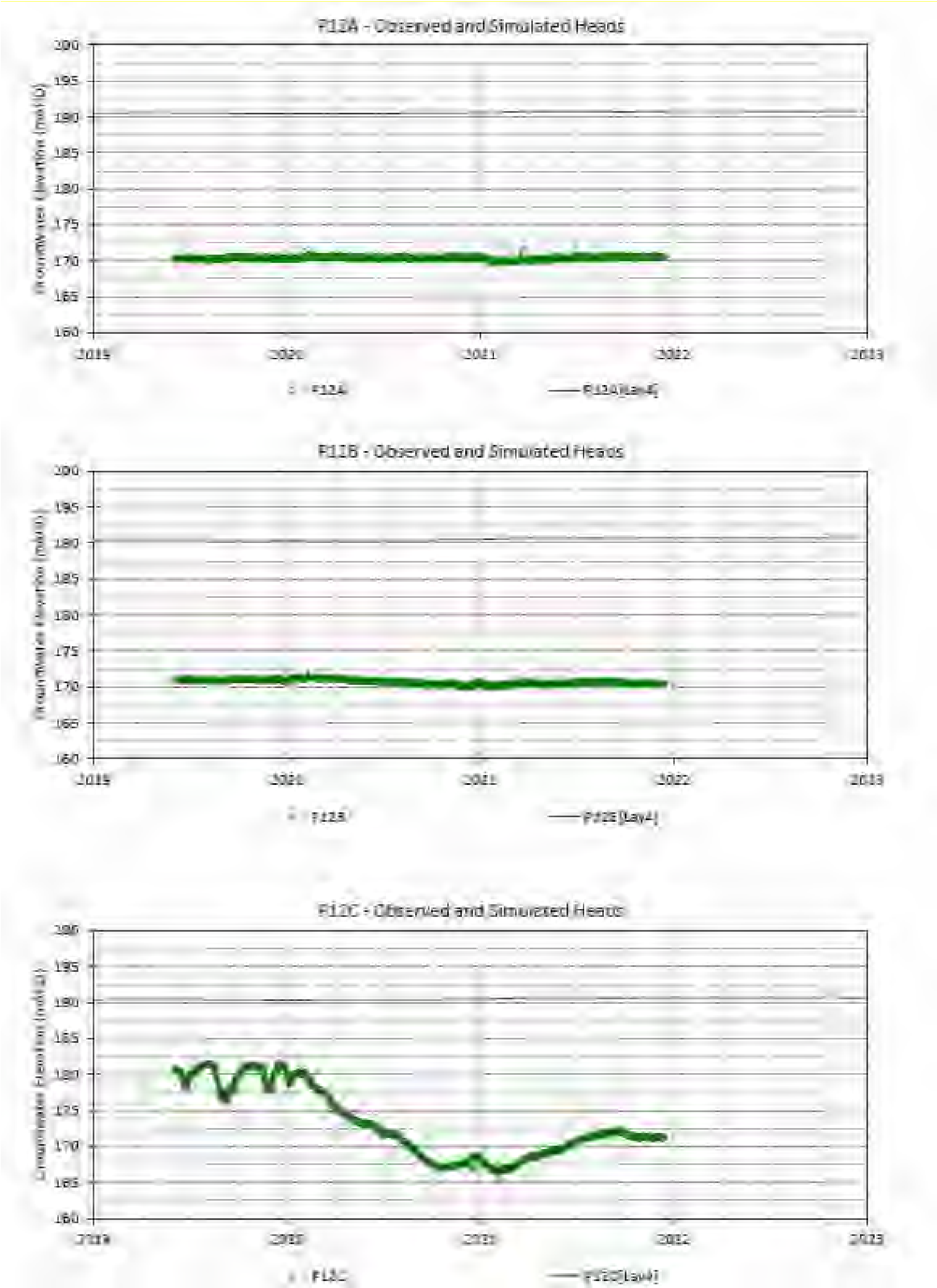


Figure 3-32 Hydrographs for P12- Western Domain

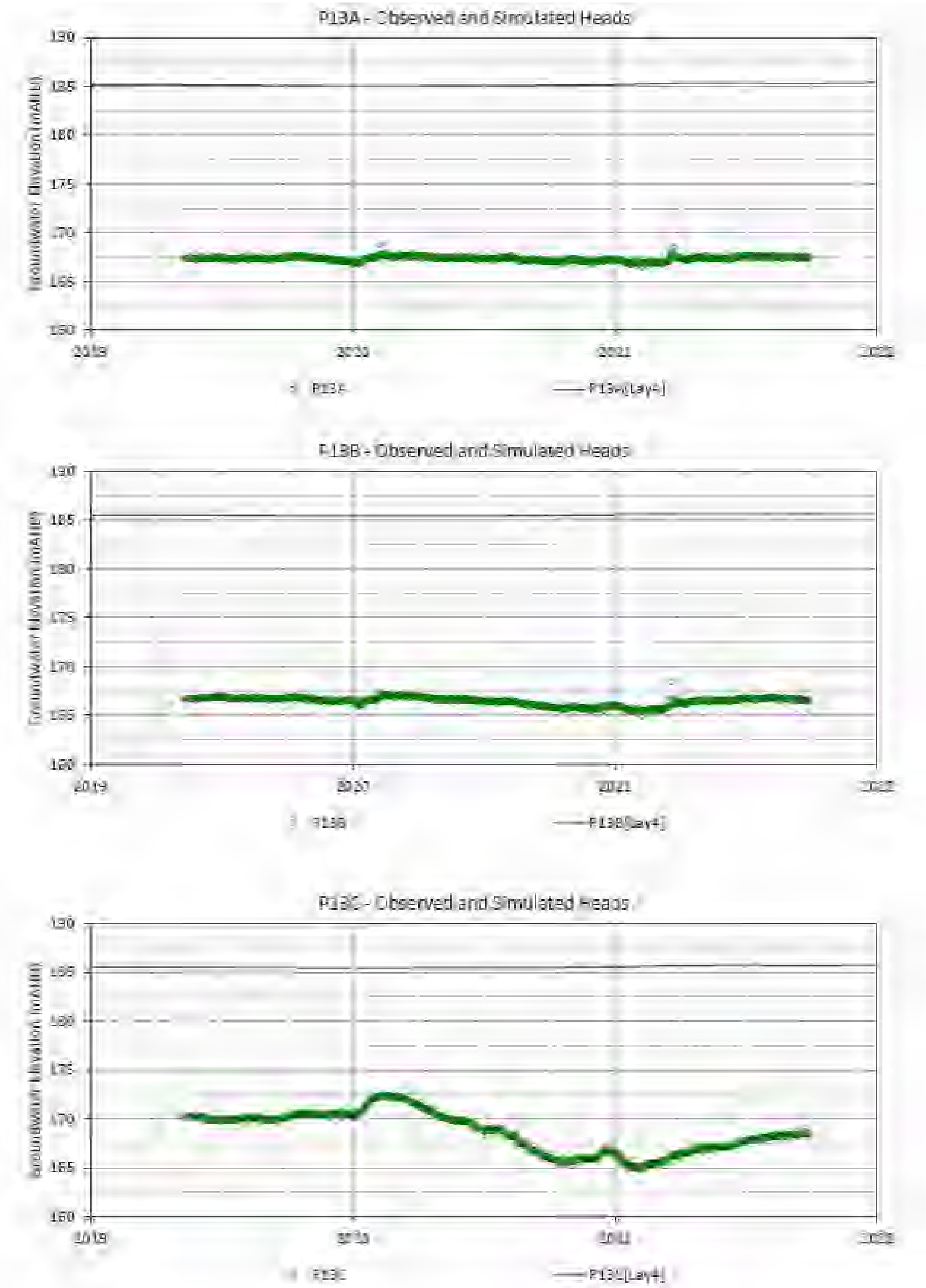


Figure 3-33 Hydrographs for P13- Western Domain

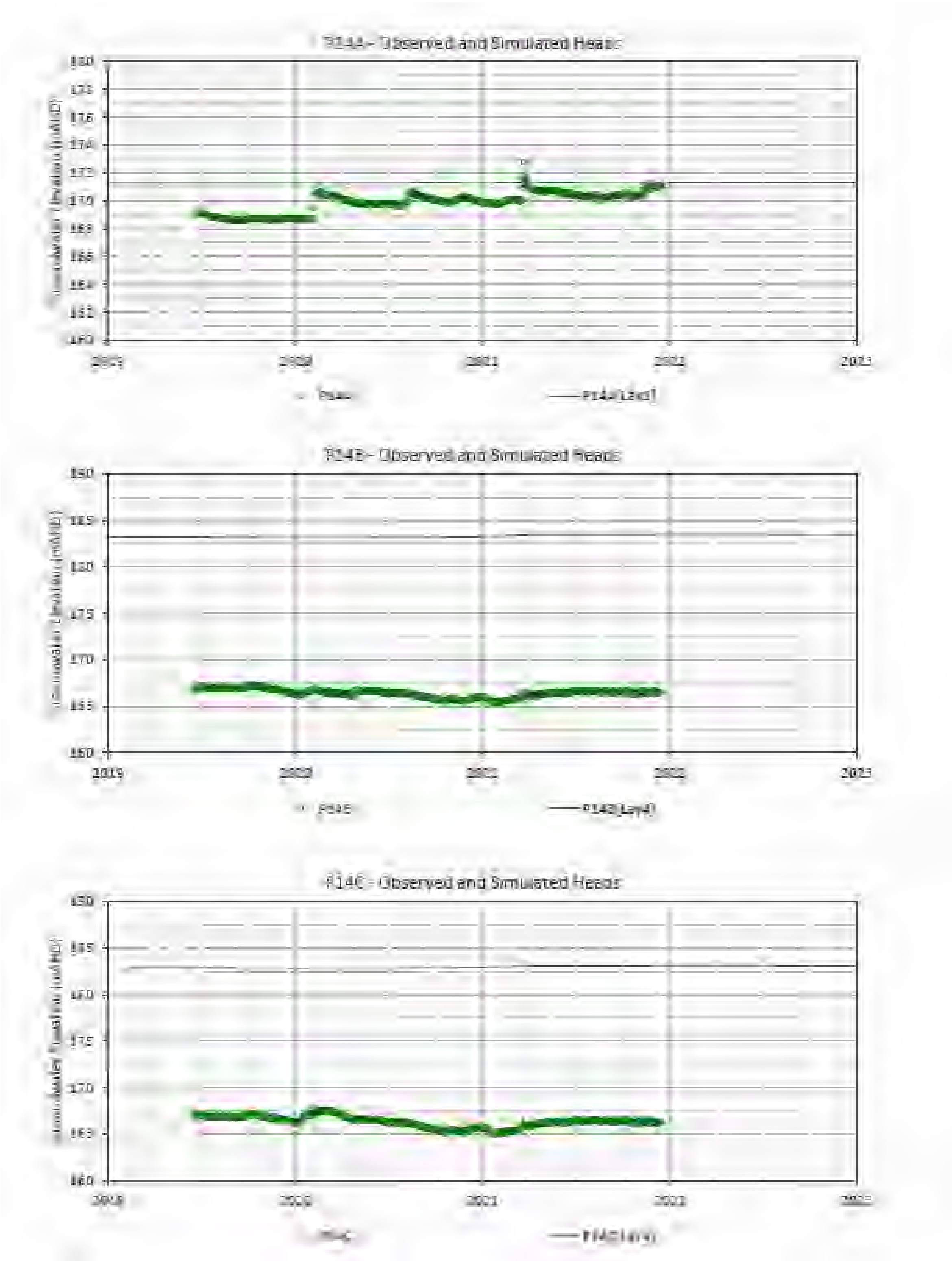


Figure 3-34 Hydrographs for P14- Western Domain

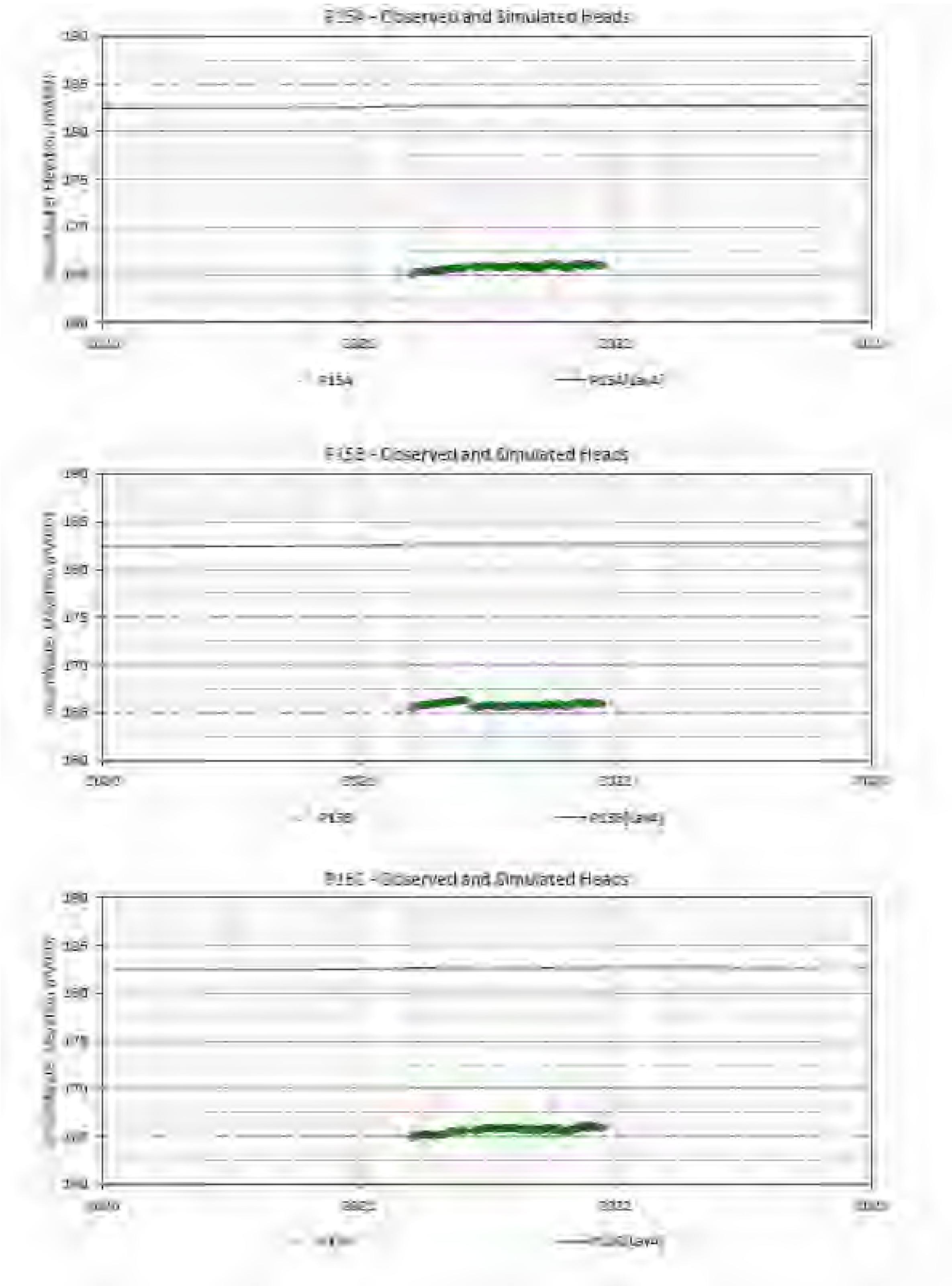


Figure 3-35 Hydrographs for P15- Western Domain

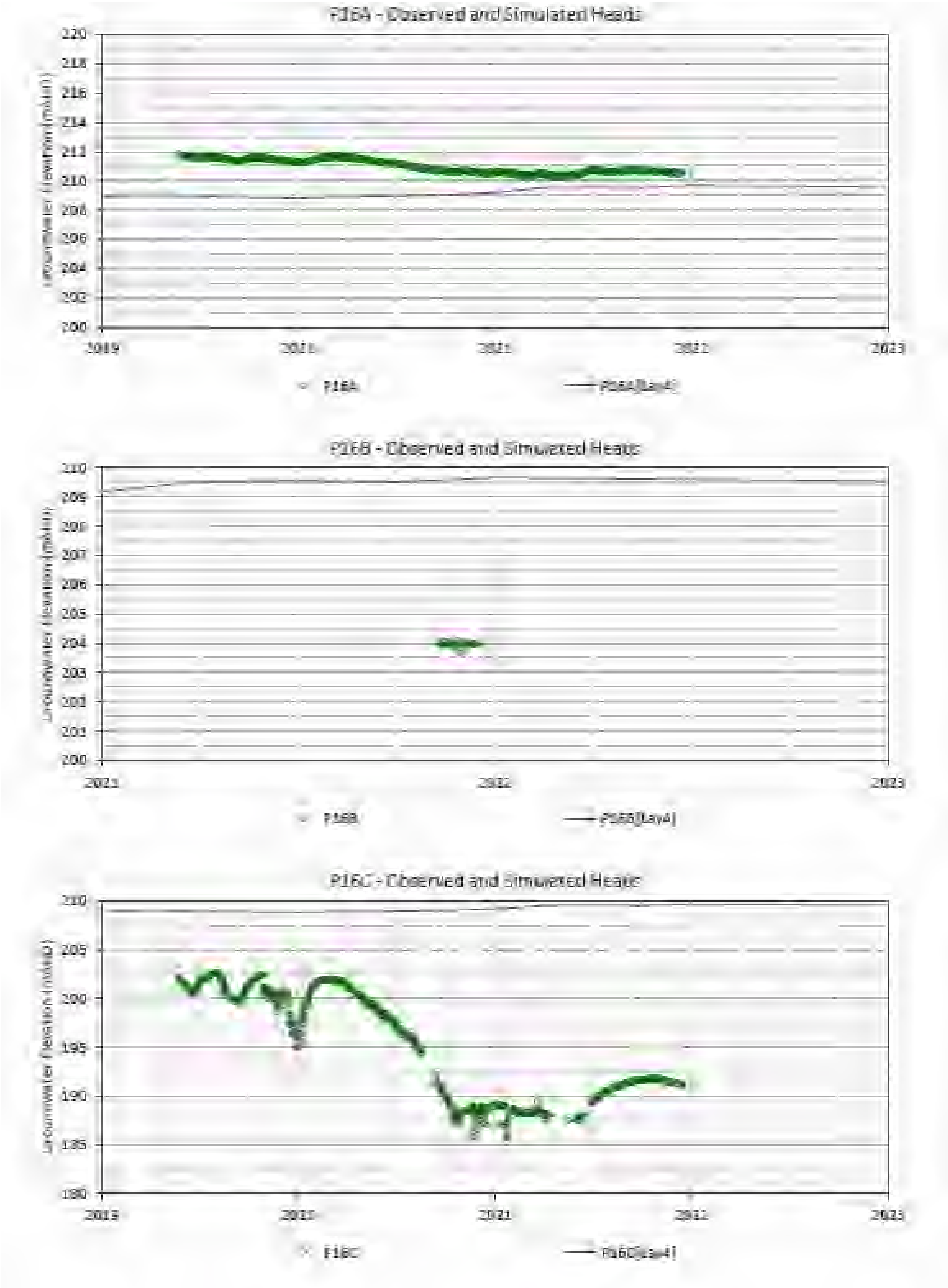


Figure 3-36 Hydrographs for P16- Western Domain

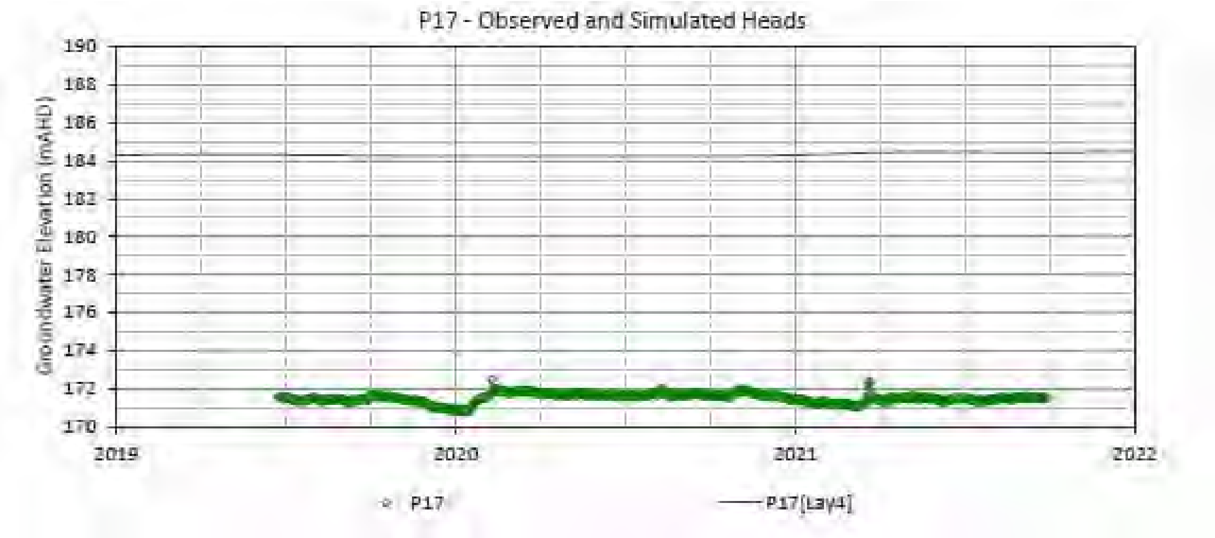


Figure 3-37 Hydrograph for P17- Western Domain

3.4.4 Inflows to Underground Mine Workings

Mine inflows were extracted from the groundwater model files using the MODFLOW-USG 'Zone Budget' utility. This was done on a zone-by-zone basis for the various mine areas within the model domain. For stress periods which were longer than 3 months, the groundwater model was setup to allow extraction of water budget information multiple times within each stress period, allowing the detail of the generally higher early-time inflows to be captured as well as the end-of-stress-period inflows.

Figure 3-38 compares the simulated mine inflows against the historical measurements at Tahmoor. The figure shows that while the model does not represent all peaks and troughs, it matches the magnitude of inflows and the general increasing trend after 2009. Figure 3-38 shows the model over predicts the historical pre-2009 inflows slightly.

For the recent period 2009-2021, the average historical measured inflows to the Tahmoor underground mine are 3.9 ML/d. The simulated average inflow for the same period is 4.1 ML/day. For the 1995-2002 period, the average measured inflows are 2.4 ML/day comparing to the modelled average inflow of 3.1 ML/day for the same period. Therefore, the model provides a more conservative estimate of inflows comparing to the measured inflows.

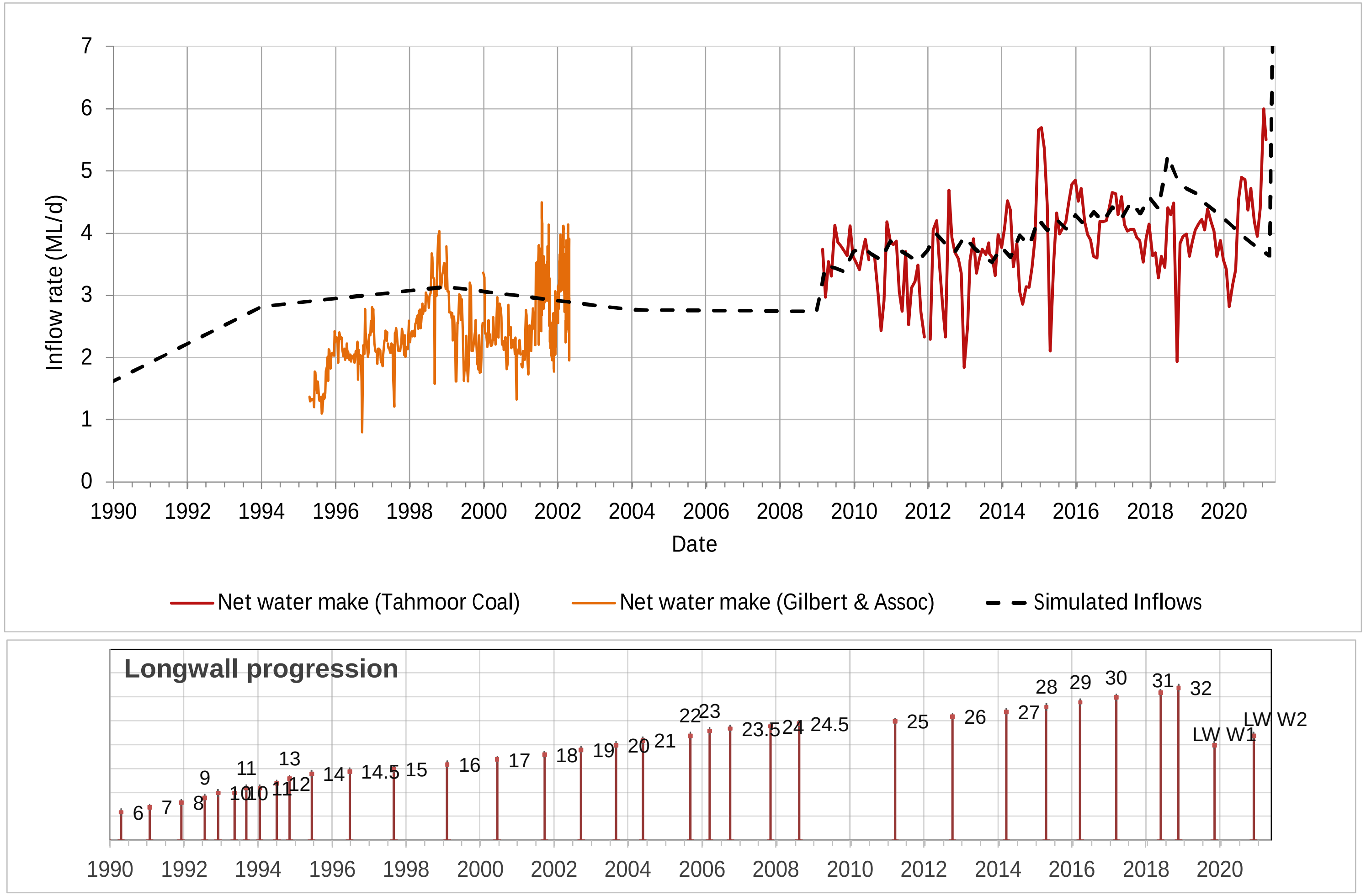


Figure 3-38 Comparison of Observed and Modelled Inflow at Tahmoor

3.5 Calibrated Water Levels

Figure 3-39 presents the simulated depth to groundwater table at the end of the transient calibration (2021). Figure 3-40 shows the modelled water levels for the Bulli seam, for the same time periods as described above.

As it is shown in the figures, the general south to north/northeast pattern of flow, seen in the observed data (Section 5 of the conceptual report) is shown in the model results. Stronger gradients are simulated around the large watercourses, such as the Nepean River and Bargo River (both of which flow to the north) and Lake Burragorang (west of Tahmoor).

Figure 3-40 shows the groundwater flow is currently locally influenced by depressurisation from active mining in Tahmoor Mine and Tahmoor North, as well as from recent workings at Appin and Dendrobium.

Figure 3-39 Simulated Depth to Water Table - End of Calibration (2021)

Figure 3-40 Simulated Groundwater Levels in Bulli Seam- End of Calibration (2021)

3.6 Water Balance

3.6.1.1 Steady State Calibration

The water balance for the steady state model calibration is shown in Table 3-5. The water balance for the steady-state model indicates that recharge was the largest net inflow contributor to the model (24.05 ML/d). Regional groundwater inflow and outflow are 16.83 and 5.77 ML/day respectively, indicating that groundwater leaves the model domain through this boundary. The Drain boundary condition that represents the groundwater discharge along the escarpment in the steady state model has an outflow of 0.99 ML/day.

A net outflow of 20.15 ML/d from the model occurs due to baseflow seepage. This is the largest component of outflow from the model during steady state calibration. The other process that contributes significantly to outflow from the groundwater system is evapotranspiration (13.65 ML/d outflow).

The mass balance error for the steady state calibration is 0.00 %, within the error threshold recommended by the AGMG (Barnett et al., 2012), and indicating the model is stable and achieves an accurate numerical solution.

Table 3-5 Steady-State Water Balance

Component	Inflow (ML/d)	Percent of Total Inflow (%)	Outflow (ML/d)	Percent of Total Inflow (%)	Net flux (ML/d)
Rainfall Recharge (RCH)	24.05	36.51	0.00	0.00	24.05
Evapotranspiration (EVT)	-	0.00	13.65	20.72	-13.65
Rivers/Creeks/Lakes (RIV)	24.71	37.51	44.86	68.10	-20.15
Escarpment (DRN)	0.00	0	0.99	1.50	-0.99
Ocean Constant Head (CHD)	0.28	0.43	0.60	0.91	-0.32
Wells (WEL)	0.00	0.00	0	0.00	0.00
Regional GW Flow (GHB)	16.83	25.55	5.77	8.77	11.06

3.6.1.2 Transient Calibration

The water balance during the transient calibration period across the entire model area is summarised in Table 3-6. The water balance indicates that recharge to the groundwater system within the model averages 23.97 ML/day. Approximately 44.26 ML/day is discharged via surface drainage and lakes, and 14.22 ML/day lost to evapotranspiration in areas where the water table is within a few metres of the land surface.

The net flux from the GHB component is 18.55 ML/day indicating that water entering the model domain through this boundary. 55.19 ML/day is removed from the model is by Drain boundary condition that represents mining (54.19 ML/day) and groundwater discharge at the escarpment (1.31 ML/day) in the model.

The mass balance error, that is, the difference between calculated model inflows and outflows at the completion of the transient calibration was 0.0%. This value indicates that the model is stable and achieves an accurate numerical solution.

Table 3-6 Transient Model Water Balance (Jan 1979 -December 2021)

Component	Inflow (ML/d)	Percent of Total Inflow (%)	Outflow (ML/d)	Percent of Total Inflow (%)	Net flux (ML/d)
Rainfall Recharge (RCH)	23.97	16.43	0.00	0.00	23.97
Evapotranspiration (EVT)	-	0.00	14.22	9.74	-14.22
Rivers/Creeks/Lakes (RIV)	45.79	31.38	44.26	30.33	1.53
Escarpment (DRN)	0.00	0.00	1.31	0.91	-1.31
Mining (DRN)	0.00	0.00	53.88	36.92	-53.88
Ocean Constant Head (CHD)	0.29	0.20	0.57	0.39	-0.28
Wells (WEL)	0.00	0.00	0.55	0.38	-0.55
Regional GW Flow (GHB)	24.91	17.07	6.36	4.36	18.55
Storage	50.95	34.92	24.76	16.97	26.19

3.7 Calibrated Hydraulic Parameters

Table 3-7 summarises the calibrated values for horizontal hydraulic conductivity (Kx) and vertical to horizontal hydraulic conductivity ratio (Kz/Kx), Specific Storage (Ss) and Specific Yield (Sy). The hydraulic conductivity of the coal seam and some of the sandstone and claystone layers in the model reduces with depth in order to reflect field observations.

The hydraulic conductivity of the sandstone and claystone units and coal seam layers decreases with depth according to Equations 1 and 2:

- Bulli and Wongawilli Seams: $Kx = Kx_0^{\,(slope \times depth)}$ (Eq. 1)
- Sandstone and Claystone units: $Kx = Kx_0 \times e^{(slope \times depth)}$ (Eq.2)

where: Kx is horizontal hydraulic conductivity at specific depth;
depth is depth of the floor of the layer (thickness of the cover material);
slope is a term representing slope of the formula (steepness of the curve).
Kx_0 is horizontal hydraulic conductivity at depth of 0.

The slope and Kx_0 for each equation were estimated in the calibration. The values were allowed to vary for different layer of the model during the calibration process. Figure 3-40 and Figure 3-41 present the calibrated horizontal conductivity against depth relationships for Bulli and Wongawilli seams, and Figure 3-42 shows the average calibrated horizontal conductivity against depth for Bulgo Sandstone and Scarborough Sandstone estimated during the calibration.

Table 3-7 Average Calibrated Hydraulic Parameters

Layer- Geology Unit	Kx (m/day)	Kz/Kx (ratio)	Sy	Ss (1/m)
L01 (Alluvium)	$30.28 \times 10^{+00}$	9.52×10^{-01}	1.07×10^{-01}	8.91×10^{-05}
L01 (Weathered Sandstone)	1.50×10^{-02}	1.25×10^{-01}	4.74×10^{-03}	1.64×10^{-06}
L01 (Shoalhaven/Illawarra)	1.20×10^{-04}	1.65×10^{-02}	5.00×10^{-03}	2.37×10^{-06}
L01 (Wianamatta)	2.50×10^{-01}	1.47×10^{-03}	8.87×10^{-03}	3.68×10^{-07}

Layer- Geology Unit	Kx (m/day)	Kz/Kx (ratio)	Sy	Ss (1/m)
L01 (Escarpment)	$1.40x10^{-02}$	$3.54X10^{-03}$	$1.60X10^{-02}$	$6.00X10^{-06}$
L01 (Basalts)	$1.60x10^{-02}$	$1.00X10^{-04}$	$2.31X10^{-02}$	$1.18X10^{-07}$
L02 (Wianamatta Formation)	$3.81x10^{-03}$	$4.89X10^{-01}$	$6.73X10^{-03}$	$1.21X10^{-06}$
L03 (Hawkesbury Sandstone Upper)	$1.40X10^{-02}$ - $1.60X10^{+00}$	$2.47X10^{-01}$	$3.86X10^{-03}$	$8.70X10^{-06}$
L04 (Hawkesbury Sandstone Middle)	$9.50X10^{-02}$ - $9.50X10^{-02}$	$1.11X10^{-02}$	$2.46X10^{-02}$	$1.64X10^{-06}$
L05 (Hawkesbury Sandstone Lower)	$3.80X10^{-03}$ - $3.80X10^{-03}$	$7.49X10^{-02}$	$1.79X10^{-02}$	$1.86X10^{-06}$
L06 (Bald Hill Claystone) *	$5.00X10^{-07}$ - $8.70X10^{-02}$	$3.22X10^{-01}$	$1.47X10^{-02}$	$4.90X10^{-06}$
L07 (Bulgo Sandstone upper) *	$5.00X10^{-07}$ - $1.40X10^{-02}$	$2.86X10^{-04}$	$2.05X10^{-02}$	$2.05X10^{-06}$
L08 (Bulgo Sandstone Middle) *	$5.00X10^{-07}$ - $1.30X10^{-01}$	$1.29X10^{-04}$	$1.71X10^{-03}$	$3.47X10^{-06}$
L09 (Bulgo Sandstone lower) *	$5.00X10^{-07}$ - $4.60X10^{-01}$	$3.89X10^{-04}$	$1.17X10^{-03}$	$1.10X10^{-06}$
L10 (Stanwell Park Claystone) *	$5.00X10^{-07}$ - $6.10X10^{-03}$	$1.09X10^{-01}$	$2.50X10^{-03}$	$6.01X10^{-06}$
L11 (Scarborough Sandstone upper) *	$5.00X10^{-07}$ - $4.60X10^{-02}$	$1.50X10^{-04}$	$6.00X10^{-03}$	$1.00X10^{-06}$
L12 (Scarborough Sandstone lower) *	$5.00X10^{-07}$ - $2.70X10^{-02}$	$3.08X10^{-04}$	$1.92X10^{-03}$	$6.84X10^{-06}$
L13 (Wombarra Claystone) *	$5.00X10^{-07}$ - $1.50X10^{-02}$	$1.59X10^{-01}$	$2.00X10^{-03}$	$4.21X10^{-06}$
L14 (Coal Cliff Sandstone) *	$5.00X10^{-07}$ - $5.00X10^{-03}$	$2.02X10^{-01}$	$1.00X10^{-03}$	$3.42X10^{-07}$
L15 (Bulli Seam) *	$1.00X10^{-04}$ - $6.00X10^{-01}$	$6.48X10^{-04}$	$5.43X10^{-03}$	$2.90X10^{-06}$
L16 (Eckersley Formation) *	$1.80X10^{-04}$ - $1.00X10^{+01}$	$1.93X10^{-04}$	$5.00X10^{-03}$	$2.56X10^{-07}$
L17 (Wongawilli Coal Seam) *	$1.00X10^{-04}$ - $1.10X10^{+00}$	$1.44X10^{-02}$	$3.21X10^{-03}$	$3.73X10^{-06}$
L18 (Kembla Sandstone) *	$1.00X10^{-04}$ - $5.80X10^{-02}$	$3.47X10^{-01}$	$5.00X10^{-03}$	$5.89X10^{-06}$
L19 (lower Permian/Shoalhaven) *	$1.00X10^{-04}$ - $1.20X10^{-02}$	$5.56X10^{-01}$	$4.00X10^{-03}$	$3.16X10^{-07}$
Fault (T1)	$2.24X10^{-04}$	$2.25X10^{-03}$	$2.68X10^{-03}$	$8.10X10^{-06}$
Fault (Nepean)	$2.43X10^{-03}$	$1.84X10^{-01}$	$6.00X10^{-03}$	$5.26X10^{-06}$
Fault (T2 East)	$1.00X10^{-03}$	$7.67X10^{-03}$	$2.79X10^{-03}$	$3.77X10^{-06}$
Fault (T2 West)	$5.00X10^{-03}$	$4.73X10^{-02}$	$5.62X10^{-03}$	$3.77X10^{-06}$
Fault (Nepean Extension)	$1.86X10^{-03}$	$9.62X10^{-02}$	$6.00X10^{-03}$	$3.77X10^{-06}$
Fault (Central)	$3.14X10^{-03}$	$2.20X10^{-02}$	$8.05X10^{-03}$	$3.77X10^{-06}$
Fault (Western)	$2.46X10^{-04}$	$2.10X10^{-01}$	$6.00X10^{-03}$	$6.03X10^{-06}$
Fault (Nepean Fault Complex)	$2.69X10^{-02}$	$2.54X10^{-03}$	$6.00X10^{-03}$	$6.17X10^{-06}$

*depth dependence equation was applied.

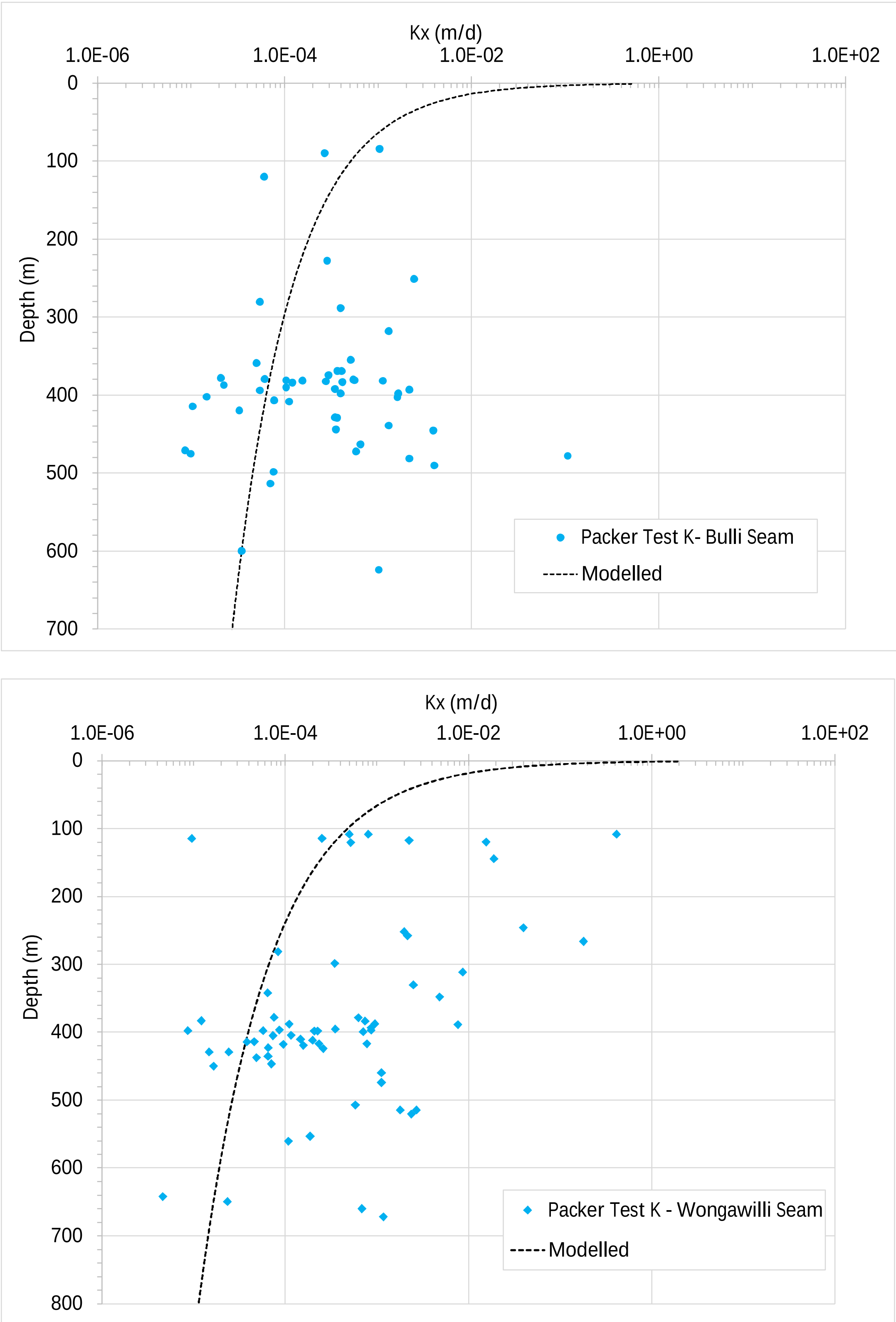


Figure 3-41 Hydraulic Conductivity against Depth – Bulli Seam and Wongawilli Seam

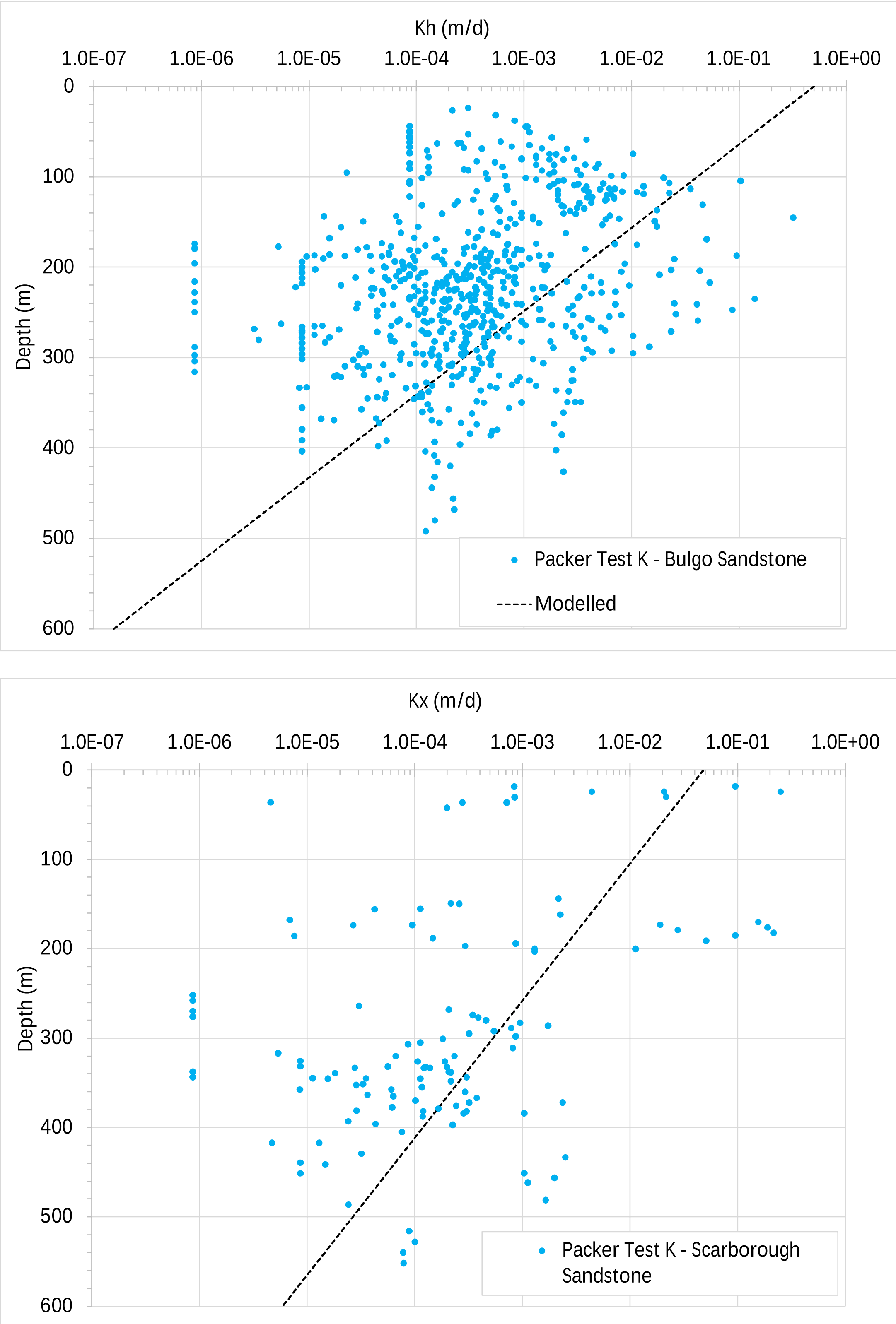


Figure 3-42 Hydraulic Conductivity against Depth – Bulgo Sandstone and Scarborough Sandstone

The calibrated parameters are compared to measured horizontal (packer test) and vertical (core test) results on Figure 3-43. For layers with depth dependence equation, the average values are presented in the figure. Figure 3-43 shows that the calibrated horizontal and vertical conductivities are mostly within the range of the observed dataset. The calibrated vertical conductivities for the units below Scarborough Sandstone are higher than the upper range of the core testing results.

The calibrated horizontal conductivity values for the HBSS are close to the upper ranges of site measurements. For Bald Hills Claystone and Bulgo Sandstone, the calibrated horizontal and vertical conductivity values are within the site measurements. For Coal Cliff Sandstone, the calibrated vertical conductivity is higher than the maximum value of core testing recorded while the horizontal conductivity of this unit is within the site conductivity tests.

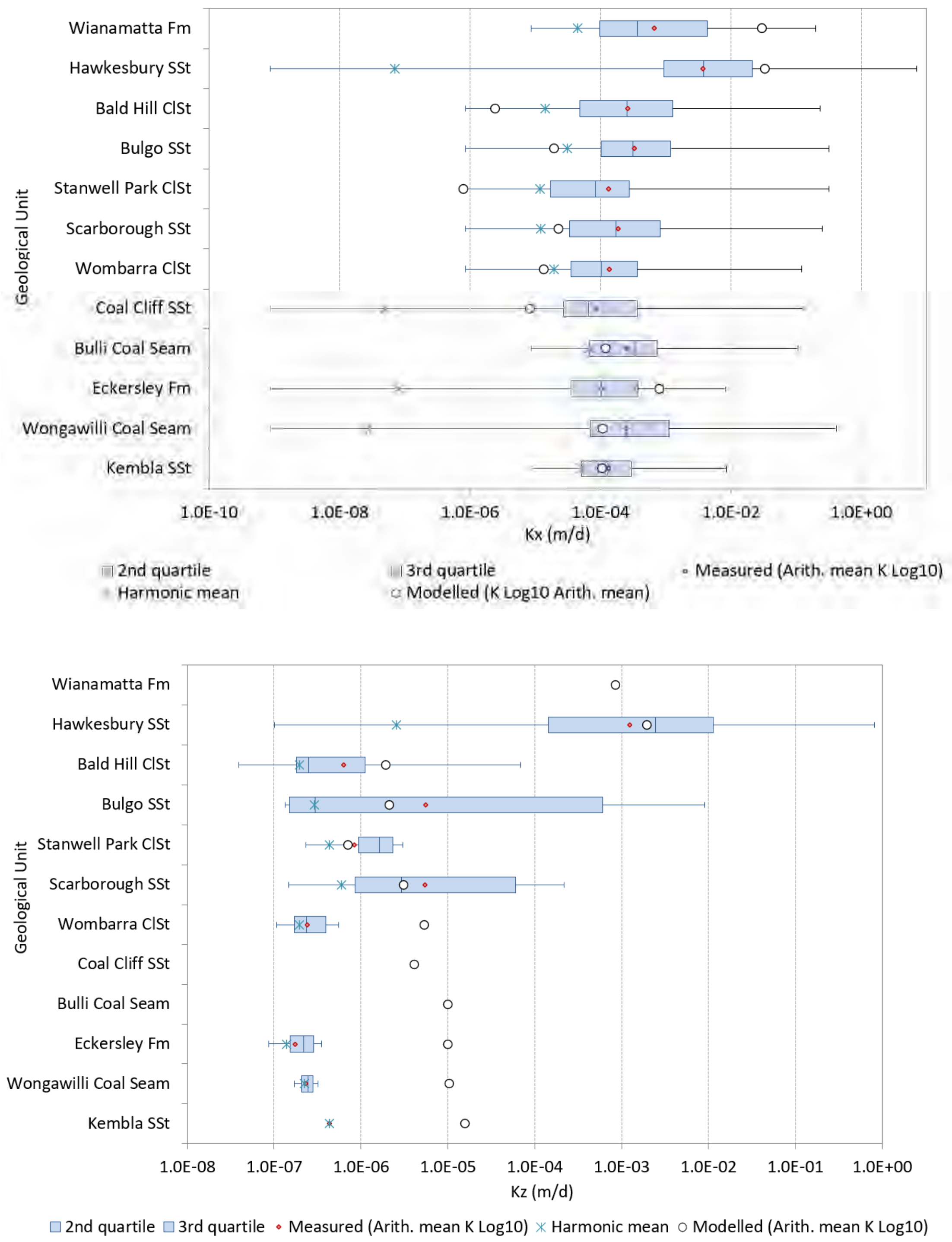


Figure 3-43 Modelled vs Measured Horizontal and Vertical Conductivity

Diffuse infiltration of rainfall through the soil profile and subsequent drainage to underlying hydrostratigraphic units is the primary method of groundwater recharge. In alluvial zones, river leakage can also provide recharge to groundwater systems, as detailed in Section 2.8.4. Model recharge zones and their corresponding annual recharge rates are summarised in Table 3-8. As shown in Table 3-8, the calibrated recharge rates for the alluvium AND Hawkesbury Sandstone are lower compared to those in SLR (2021), but consistent with parameters for Wianamatta Formation. Table 3-9 shows the LUMPREM2 model calibrated parameter values and Table 3-10 shows the calibrated EVT rates for different zones in the model. As discussed in Section 2.8.5, the annual EVT was set based on the data from the SILO Grid Point observations for the closest location to site.

Table 3-8 Calibrated Recharge Rates

Unit	Average Rainfall (mm/year)	% of average rainfall	SLR/HydroSimulations (2021) Calibrated Value (%)
Alluvium	7.1 - 40.1	1 - 5	8 - 14
Wianamatta Formation	15.8	2	2.1 - 2.7
Hawkesbury Sandstone	4.0 – 15.5	0.5 – 1.9	3.7 - 5.7
Coastal Escarpment	27.2	3.3	-
Surface Water Bodies	8.1	1	-

Table 3-9 LUMPREM2 Model Calibrated Parameters

Parameter	Unit	Calibrated Value	Description
maxvol_br	mm	230	The volume of the lower soil moisture store.
gamma_br	-	1.5	Parameter determining the rate of evaporate versus stored water relationship (Lower soil moisture store)
m_br	-	0.3	Parameter determining the rate of drainage versus stored water relationship (Lower soil moisture store)
l_br	-	0.6	Pore-connectivity parameter (Lower soil moisture store)
ks_br	m/day	1.7	Saturated hydraulic conductivity (Lower soil moisture store)
maxvol	mm	17	The volume of the upper soil moisture store.
gamma	-	1.5	Parameter determining the rate of evaporate versus stored water relationship (Upper soil moisture store)
m	-	0.4	Parameter determining the rate of drainage versus stored water relationship (Upper soil moisture store)
l	-	0.6	Pore-connectivity parameter (Upper soil moisture store)
ks	m/day	12	Saturated hydraulic conductivity (Upper soil moisture store)

Table 3-10 Calibrated EVT Rates

Unit	% of Annual EVT	Average Evapotranspiration (mm/Year)
Forest/Conservation	42	472.5
Grazing land	52	585.0
Rivers and drainage systems	0*	0
Tree/shrub cover	12	157.5
Urban	50	562.5
Escarpment	30	337.5

*EVT inactivated in cells containing River boundary conditions.

3.8 Calibrated Fracture Profile Properties

Table 3-11 shows the calibrated values for different zones in the fracture profile for Tahmoor.

Table 3-11 Calibrated Model Fracture Profile Properties

Conceptual Zone		Zone	Geometry	Change in the Model Properties
Surface Fracture Zone (i.e. surface cracking)		D-zone	Depth of increased surface fracturing (due to lower depth of cover/confinement) <=20 m, with enhanced horizontal and vertical hydraulic conductivity. • 8 x T (extraction height).	• Kx = 9.6 × host value. • Kz = 5 × host value.
Constrained Zone		C-zone		No change
Fractured Zone	upper zone of Disconnected Fracturing	B-zone	• B95 – Ditton and Merrick (2014).	• Kx = 30 × host value (capped at maximum 0.01 M/day). • Kz = 3 × host value. • Sy = 0.01.
	lower zone of Connected Fracturing	A-zone	• A95 – Ditton and Merrick (2014).	• Kx = 0.01-0.15 m/day, • Kz = 0.001 m/day.
Caved Zone			• 5-10 x t (Forster & Enever, 1992; Guo et al., 2007).	• Kx = 6 m/day, • Kz = 0.01 m/day.
Mined Zone (extracted seam)			Mined seam thickness (t)	Kx = 100 m/day, Kz=100m/day, Sy = 0.1.

3.9 Model Confidence Level Classification

The groundwater modelling was conducted in accordance with the AGMG (Barnett *et al.* 2012), the MDBC Groundwater Flow Modelling Guideline (MDBC, 2001) and the released IESC Explanatory Note for Uncertainty Analysis (IESC, 2018). These are mostly generic guides and do not include specific guidelines on special applications, such as underground coal mine modelling.

The AGMG has replaced the model complexity classification of the previous guideline by a "model confidence level" (Class 1, Class 2 or Class 3 in order of increasing confidence) typically depending on:

- Available data (and the accuracy of that data) for the conceptualisation, design and construction;
- Calibration procedures that are undertaken during model development;
- Consistency between the calibration and predictive analysis; and
- Level of stresses applied in predictive models.

Table 3-12 (based on Table 2.1, Barnett *et al.* 2012) summarises the classification criteria and shows a scoring system allowing model classification. Based on Table 3-12, the groundwater model developed for this Groundwater Assessment may be classified as primarily Class 2 (effectively "medium confidence") with some items meeting Class 3 criteria, which is considered an appropriate level.

Table 3-12 Groundwater Model Classification Table

Class	Data	Calibration	Prediction	Indicators	Total
1	Not much. Spares. Not metered usage. Remote climate data.	Not Possible. Large error statistics. Inadequate data spread. Targets incompatible with model purpose.	Timeframe>>calibration. Long stress periods. Transient prediction but steady state calibration. Bad verification.	Timeframe>10x. Stresses>5x. Mass balance>1% (or single 5%). Properties<>Field. Bad discretisation. No review.	
Count	1	0	0	0	1
2	Some. Poor coverage. Some usage info. Baseflow estimates.	Partial performance. Long-term trends wrong. Short time record. Weak seasonal replication. No use of targets compatible with model purpose.	Timeframe>calibration. Long stress periods. New stresses not in calibration. Poor verification.	Timeframe=3-10x. Stresses=2-5x. Mass balance<1%. Properties<>Field measurements. Some key coarse discretisation. Reviewed by hydrogeologist.	
Count	2	2	2	6	12
3	Lots. Good aquifer geometry. Good usage info. Local climate info. K measurements Hi –res DEM.	Good performance stats. Long-term trends replicated. Seasonal fluctuations OK. Present day data targets. Head and flux targets.	Timeframe~calibration. Similar stress periods. Similar stresses to those in calibration. Steady state prediction consistent with steady state calibration. Good verification.	Timeframe<3x. Stresses<2x. Mass balance<0.5% Properties~Field measurements. Some key coarse discretisation. Reviewed by modeller.	
Count	3	1	0	2	7

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Table 3-13 Groundwater Model and Data Limitations

Type	Part	Status	Comment
Structural/ Conceptual	Grid and Model Extent	Fit for purpose	The model used an unstructured Voronoi grid that includes detailed cell refinement around site, neighbouring mines and along drainage features (e.g. Thirlmere Lakes and upper reach of Blue Gum Creek). The mode extent has been revised to cover neighbouring mines (i.e. Appin Mine and Dendrobium Mine)
		Fit for purpose	The model layers are not fully extensive. Use of the MODFLOW-USG 'pinch-out' functionality was employed to reduce overall cell count. This process allowed to remove the need to have a minimum thickness and layer continuity where a stratigraphic unit is absent. The model cell count reduced from more than 2 million cells in the previous model to 1,340,263. This allowed much faster model run times.
	Layers / geometry	Fit for purpose	Top of layer 1 incorporates site LiDAR data for Tahmoor Mine, Appin Mine and Dendrobium Mine.
		Fit for purpose	The structure of the geology is based on detailed data at site (Tahmoor, Appin and Dendrobium) but regional model geometry (outside of site) interpolated based on the latest available Southern Coalfields Geological Model (July 2018) (herein referred to as the Sydney Basin Model).
		Fit for purpose	Thirlmere Lakes geometry – The model uses the latest Tahmoor site geological models and data covering the Thilmere Lakes area. Model layer elevations (i.e. upper most layers) updated to reflect latest available information (i.e. drill holes) in proximity to the Thirlmere Lakes.
		Fir for purpose,	Model layer elevations have been updated using the latest site geology model and Sydney Basin Model The layering was updated using the latest site geological drill holes data made available by Tahmoor and NSW government.
	Conceptualisation – Geological Structure	Fit for purpose, with future improvements possible, with review of future geological investigations	On-going and geological investigations conducted across Tahmoor South have been reviewed and findings incorporated in the model conceptualisation. No new potential causal pathways were identified with no significant changes implemented in the conceptual model. Future field studies can improve representation of all zones of fracturing (especially disconnected/dilated zone).

Type	Part	Status	Comment
	Conceptualisation – Surface Water Groundwater Interactions	Fit for purpose, future improvements possible where new data collected	The understanding of interaction between surface and groundwater (i.e. along Bargo River, Dog Trap Creek) was strengthen in the conceptual model using latest observations and findings across the Western Domain and Tahmoor North. On-going upgrade of the surface water and groundwater (shallow) monitoring network across Tahmoor South will improve the conceptualisation of surface Water groundwater Interactions.
	Conceptualisation – GDEs	Fit for purpose,	The NSW government TLPR – “Thirlmere Lakes – A synthesis of Current Research” (DPE, 2022) has been reviewed and incorporated in the conceptual model.
	Conceptualisation – Saturated Extent of Alluvium and Regolith/Hawkesbury Sandstone	Fit for purpose, with improvements possible where new data collected.	The conceptual model has presented all the existing groundwater monitoring data and recent data collected since the last conceptualisation work in 2020. Future groundwater monitoring sites will be presented in future work. There is still limited groundwater levels/quality data for the shallow groundwater monitoring network across Tahmoor South but on-going drilling occurs across Tahmoor South at the time of writing. Future improvement includes additional coverage of data around the Thirlmere Lakes with the installation of new monitoring sites to be installed. Data collected at the future groundwater monitoring bores within the shallow aquifers of Tahmoor South will better inform the conceptual model.
Parameterisation	Hydraulic Conductivity – Depth Dependence	Fit for purpose, with improvements possible where additional site data become available	The existing hydraulic conductivity database has been updated with the latest field testing of hydraulic conductivity (horizontal and to a lesser extent vertical) at Tahmoor Mine and Dendrobium Mine. The data shows a general decline in hydraulic conductivity with depth that is replicated in the model. Field program is planned to test the change in hydraulic conductivity with depth at the post mining hole WD02 across the Western Domain and will be considered in future model updates.
	Hydraulic Conductivity - Heterogeneity	Fit for purpose	Zones have been used to delineate hydraulic properties (K and S). Depth dependence functions for coal seams and some of the sandstone and claystone units were adopted in the model. The full suite of geological, geotechnical and hydrogeological testing data conducted at TS01 (off the southern end of LW S1A through the sequence) was used to define the modelled hydraulic property. Pilot points were used to represent heterogeneity in the Hawksbury Sandstone.

Type	Part	Status	Comment
	Goaf Effects	Fit for purpose, with improvements possible where new data collected	The existing hydraulic conductivity database was used - Site specific data is available but remains limited on the change in properties with longwall mining at Tahmoor (e.g. site TBF040c). Pre-mining and post-mining investigation boreholes, which facilitate acquisition of geotechnical and groundwater-related data were proposed for LW S1A and one other location above the A-longwalls (likely to be LW S4A, but dependent on land access). The second Height of Fracturing (HoF) hole will be installed prior to the preceding longwall (e.g. prior to LW S3A if it is to be located over LW S4A). Across the Western Domain, a post-mining investigation borehole WD02 is planned after the completion of LW W4 in late 2022. A full fracture profile including Ditton Zone A, Ditton Zone B, Cave Zone, and surface fracturing was included in the model. The parameters for all these zones were adjusted in the model calibration process.
	Rivers	Fit for purpose, with improvements possible where new data collected	River stage heights are changed temporally in the historical calibration model based on observed levels from government stream gauges, and average quarterly levels assumed in the predictive model. No site-specific information on surface water discharge, flow monitoring has been included in the model but could be included in future. No measurement of bed-conductance and hydraulic properties was conducted but if available, they could be included in the future version of the model.
	Lakes	Fit for purpose, with improvements possible	The model replicates water storage in Lake Burragorang, Lake Nepean, Lake Avon, Lake Cordeaux, Lake Cataract using RIV boundary condition. These features have been maintained in the model, and new information on fill levels have been considered and updated. The outcomes of the TLPR study were not incorporated in the groundwater model as they were made available after the model design and calibration had finished. While the current lake levels are consistent with the TLPR report, the TLPR research outcomes should be included in the future versions on the numerical model.

Type	Part	Status	Comment
	Recharge	Fit for purpose, Future improvements possible	Recharge zonation is based on mapped surface geology and recharge rates calibrated against independent estimates derived from chloride mass balance (Crosbie, 2015). Soil mapping and site water quality data could be further utilised to base recharge rates. LUMPREM2 was used to calculate the recharge. LUMPREM2 is a soil moisture store model developed by Watermark Numerical Computing (2021). Recharge rates and LUMPREM2 parameters were adjusted during the calibration process. Using pilot points for recharge could provide better special variability for recharge entering the groundwater model.
	Evapotranspiration	Fit for purpose	Simulated as a constant potential EVT rate from groundwater. The EVT rates in the model were included in the calibration.
	Drains (mine operations)	Fit for purpose with future improvements possible	Historical and approved mine plan data has been sought by Tahmoor Coal (with assistance from agencies) and used to simulate up-to-date mine plans. Future improvement includes updating the mine progression in the neighbouring mines to match with the actual historical underground mining.
	Groundwater pumping	Fit for purpose, with improvements possible where reliable data is available.	Groundwater pumping by third party bores users is highly uncertain (in terms of rates)., Bore use (i.e. across Appin Mine) were included in the model. Groundwater pumping via MODFLOW Wells have been included in calibration and prediction. If more reliable data is available from WaterNSW/DPIE-Water (although review of the Water Register suggests that it is not), this will be incorporated into future work.

Type	Part	Status	Comment
Data Sources	Observation Data Quality	Fit for purpose, with improvements possible where new data is collected.	Recent Groundwater observations ending in 2021 have been incorporated for the observation bore file prior to calibration. This includes observation data across the Western Domain, Tahmoor North, and Tahmoor South but could in the future also include new monitoring sites installed during the model re-build as part of the Groundwater Monitoring Plan.
	Landholder Bore Data Quality	Fit for purpose, but potentially review in future.	Impacts on registered landholder bores are influenced by the assumptions of the bore design, target geology and use. A bore census was conducted as part of the Groundwater Monitoring Plan. Verification of landholder bore details in the model will be undertaken.
	Temporal spread	Fit for purpose	Timeseries water level data from the site as well as the neighbouring mines were available for the shallow and deep aquifers and were included in the model. SLR incorporated all data for Tahmoor up to late 2021 Additional data for Appin and Dendrobium mine were also included in the calibration dataset.
Measurement Error	Settings	Fit for purpose	The model has 'solver' settings where the head close (HCLOSE) criteria is currently set to 0.01 m. Model stability should be emphasised during the attempt to reduce the HCLOSE criteria.
Scenario Uncertainties Future stresses/ conditions	Calibration	Fit for purpose	A combined steady state and transient calibration was carried out with data available between 1977 to 2021. Automated (PEST++) was used to calibrate the model. The model was calibration to observed water levels, historical mine inflows and observed drawdowns. The calibration was carried out using stage approach and included the hydraulic conductivity depth-dependence, pilot points in HBSS, boundary conditions (e.g. EVT, RIV, recharge), and peripheral boundary conditions (e.g. General Head Boundary conductance) and fracture zone properties. Limited verification against baseflow estimates along local watercourses, this needs to be improved if sufficient data is available.
	Predictive	Fit for purpose	Latest mine plan for Tahmoor mine was incorporated in the model

Type	Part	Status	Comment
	Sensitivity and uncertainty	To be completed	Sensitivity analysis was carried out on all aquifer property parameters (e.g. hydraulic conductivity and storativity parameters), boundary conditions (e.g. recharge), and peripheral boundary conditions (e.g. General Head Boundary conductance) and fracture zone properties. The primary outcome of sensitivity was that prediction for drawdowns and inflows are highly constrained by calibration. An Uncertainty analysis is being carried out using the outcome of the sensitivity analysis.

4 Predictive Modelling

Predictive modelling presented herein has been conducted in support of the Extraction Plan for LW S1A-S6A. As such transient predictive modelling was used to simulate the proposed LWS1A-S6A extraction as well as mining at other approved and foreseeable mines within the model domain. The predictive portion of the model comprises quarterly stress periods, starting from December 2021 to December 2026 (conclusion of extraction at LW S1A-S6A). The simulated predictive mine progression for the A series (LW S1A-S6A) is presented Figure 2-17.

Transient predictive models have been developed for three model scenarios:

- Null run – no mining within region;
- Base case – all approved and foreseeable mining in region (including Tahmoor North), no proposed mining at Tahmoor South (LW S1A-S6A); and
- Full development – all approved and foreseeable mining in region plus proposed LW S1A-S6A extraction.

Extraction is simulated as progressing quarterly, with MODFLOW Drain cells simulating the mining applied to the base of the target coal seam (i.e. the Bulli seam). After the Drains were removed, the MODFLOW Time Varying Materials (TVM) package was used to assign fracture properties to the cells above the longwalls (see Section 2.8.8 for more details).

4.1 Water Balance

Table 4-1 to Table 4-3 provide average flow rates for water transfer into and out of the predictive model (January 2022 until December 2026 period) for the three predictive scenarios. The mass balance error for all three scenarios was 0.0 %. All scenarios maintained mass balance errors below 0.1 % for all time steps throughout the simulations. The low error achieved indicates that the predictive model is stable, and the solution achieved is accurate (Barnett *et al*., 2012).

The tables show there was no change in recharge and EVT in the all the scenarios. Groundwater outflow from the model mostly occurs via drain cells, used to simulate Escarpment and underground mining activity in the model. Table 4-1 and Table 4-2 show that LW S1A-S6A extraction resulted in an increase in the average drain outflow to 17.73 ML/day in Full Development scenario from 16.99 ML/day in Base Case scenario.

Table 4-1 to Table 4-3 show in all the three predictive scenarios, groundwater leaves the model through regional groundwater flow (GHB). The net flux into the model increased from an average of 11.09 ML/day in the Null scenario to 14.30 ML/day in both the Base Case and Full Development scenarios. This difference is likely due to presence of mining near the boundaries of the model and the resulting drawdown from those mining activities.

Table 4-1 to Table 4-3 show the flow from Escarpment reduced from -0.99 ML/day in the Null Run to -1.81 ML/day in both the Base Case and Full Development scenarios. This reduction in flow is due to the mining simulated in the model.

Table 4-3 shows a net negative River flux (-19.2 ML/day) in the Null Run indicating flow from the groundwater system to rivers. However, Table 4-2 shows that in the Base Case Run the net river exchange flux (RIV) is 9.3 ML/day, which indicates the additional mining in the Full Development scenario results in less flux from the groundwater system to watercourses.

Table 4-1 shows the net negative River flux in the Full Development scenario is like the Base Case scenario which indicates there is insignificant change in baseflows due to addition of the LW S1A-S6A extraction in the Full Development scenario.

Table 4-1 Average Simulated Water Balance over the Prediction Period – Full Development

Component	Inflow (ML/d)	Percent of Total Inflow (%)	Outflow (ML/d)	Percent of Total Inflow (%)	Net flux (ML/d)
Rainfall Recharge (RCH)	24.52	22.41	0.00	0.00	24.52
Evapotranspiration (EVT)	-	0.00	14.54	13.29	-14.54
Rivers/Creeks/Lakes (RIV)	34.04	31.12	43.35	39.63	-9.31
Escarpment (DRN)	0.00	0.00	1.81	1.84	-1.81
Mining (DRN)	0.00	0.00	15.92	14.37	-15.92
Ocean Constant Head (CHD)	0.29	0.27	0.55	0.51	-0.26
Wells (WEL)	0.00	0.00	1.05	0.96	-1.05
Regional GW Flow (GHB)	21.37	19.54	7.07	6.46	14.30
Storage	29.16	26.66	25.09	22.94	4.07

Table 4-2 Average Simulated Water Balance over the Prediction Period – Base Case

Component	Inflow (ML/d)	Percent of Total Inflow (%)	Outflow (ML/d)	Percent of Total Inflow (%)	Net flux (ML/d)
Rainfall Recharge (RCH)	24.52	22.7	0.00	0.00	24.52
Evapotranspiration (EVT)	-	0.00	14.54	17.09	-14.54
Rivers/Creeks/Lakes (RIV)	34.04	31.52	43.35	47.34	-9.31
Escarpment (DRN)	0.00	0.00	1.81	0.80	-1.81
Mining (DRN)	0.00	0.00	15.18	7.17	-15.18
Ocean Constant Head (CHD)	0.29	0.27	0.55	0.31	-0.26
Wells (WEL)	0.00	0.00	1.04	0.46	-1.04
Regional GW Flow (GHB)	21.37	19.79	7.07	7.58	14.30
Storage	27.77	25.72	24.45	19.25	3.32

Table 4-3 Average Simulated Water Balance over the Prediction Period – Null Run

Component	Inflow (ML/d)	Percent of Total Inflow (%)	Outflow (ML/d)	Percent of Total Inflow (%)	Net flux (ML/d)
Rainfall Recharge (RCH)	24.52	36.57	0.00	0.00	24.52
Evapotranspiration (EVT)	-	0.00	13.3	19.84	-13.3
Rivers/Creeks/Lakes (RIV)	24.89	37.12	44.09	65.76	-19.2
Escarpment (DRN)	0.00	0.00	0.99	1.48	-0.99
Mining (DRN	0.00	0.00	0.00	0.00	0.00
Ocean Constant Head (CHD)	0.27	0.41	0.6	0.89	-0.33
Wells (WEL)	0.00	0.00	1.03	1.54	-1.03
Regional GW Flow (GHB)	16.84	25.12	5.75	8.58	11.09
Storage	0.52	0.78	1.28	1.91	-0.76

4.2 Predicted Groundwater Levels

Predicted depth to groundwater table at the end of mining for the Base Case scenario is presented in Figure 4-1. The figure shows the depth to groundwater varies between -40 m to more than 150 m and varies spatially, like results for the current calibrated groundwater conditions presented in Figure 3-39. The depth to water is generally greatest within the active or historical mine areas.

Figure 4-2 show the predicted groundwater elevation within the Bulli Seam at the end of LW S1A-S6A extraction (December 2026) for the Base Case scenario. The figure shows the general groundwater within the Bulli Seam will remain toward north and northeast. However, groundwater flow is locally influenced by depressurisation from active mining compared to existing conditions

Figure 4-3 shows modelled depth to ground (the water table) at the end of mining for the Full Development scenario. Figure 4-4 show the predicted groundwater elevations within the Bulli Seam at the end of LW S1A-S6A extraction (December 2026) for the Full Development scenario. The difference between these two maps is the zone depression created by LW S1A-S6A extraction in the Full Development run.

Figure 4-1 Predicted Depth to Water Table at End of Mining (2026) – Base Case

Figure 4-2 Predicted Groundwater Levels in Bulli Seam at End of Mining (2021) – Base Case

Figure 4-3 Predicted Depth to Water Table at End of LW S6A (2026) – Full Development

Figure 4-4 Predicted Groundwater Levels in Bulli Seam at End of LW S6A (2026) – Full Development

4.3 Predicted Maximum Drawdowns

The process of mining reduces groundwater levels and pressures in surrounding geological units. The extent of the zone affected is dependent on the properties of the aquifers/aquitards and is referred to as the zone of depressurisation in a confined aquifer and zone of drawdown within unconfined aquifers, including the water table. Depressurisation and drawdown is greatest at the working coal-face, and reduces with distance from the mine. The predicted drawdowns due to LW S1A-S6A extraction and all the neighbouring mining operations (the 'Cumulative' mining effects) and due to LW S1A-S6A extraction only (incremental effects) are discussed in the following sections.

4.3.1 Incremental Drawdown

Maximum incremental drawdown due to LW S1A-S6A extraction was obtained by comparing the difference in groundwater levels for the Base Case scenario and the Full Development model scenario. The maximum drawdown is a combination of the maximum drawdown values recorded at each cell at any time from the start of the calibration period (January 2022) to conclusion of extraction at LW S6A (December 2026).

Predicted maximum drawdown due to LW S1A-S6A extraction (incremental drawdown) is presented from Figure 4-5 to Figure 4-7. Figure 4-5 shows the predicted maximum water table drawdown due to LW S1A-S6A extraction. The water table has been selected because it is the groundwater system that is connected to most environmental (surface) features. Maximum water table drawdown is <4 m across much of the Tahmoor South footprint, with the predicted maximum water table drawdown extending approximately 0.5 km southwest, and 0.5 km southwest towards Lake Nepean.

Figure 4-6 show the predicted maximum drawdown in lower Hawkesbury Sandstone which is the source of much of local groundwater extraction by bores. Figure 4-6 show the maximum drawdown extends radially from the LW S1A-S6A footprint. The 1 m contour extends to less than 1 km to the south towards Lake Nepean, and less than 1 km to the north and northeast.

Figure 4-7 shows the extent of maximum predicted depressurization (1 m contour) is approximately 2 km to the south and 2 km to the east LW S1A-S6A. The figure shows the maximum extents to the west of the panels through the faults present in that area. The cone of depression is predicted to be steepest around the mine area.

The shape of predicted drawdowns presented in the figures are similar to the predictions presented in the EIS report (SLR/HydroSimulations, 2020). However, the extent of maximum drawdown in this model is less than predicted in the EIS. The difference in drawdown extent is likely due to update in model structure, the use of depth dependence functions, and pilot points in the new model.

Figure 4-5 Predicted Maximum Water Table Drawdown – LW S1A-S6A extraction Only

Figure 4-6 Predicted Maximum Drawdown in Lower Hawkesbury Sandstone - LW S1A-S6A extraction Only

Figure 4-7 Predicted Maximum Drawdown in Bulli Seam – LW S1A-S6A extraction Only

4.3.2 Cumulative Drawdowns

The maximum cumulative drawdowns are obtained by the calculating the maximum difference in heads between the Full Development and Null Run model scenarios at each cell at any time, from the start of the calibration period (January 2022) to one year after end of the extraction at LW S6A (December 2026).

Figure 4-8 and Figure 4-10 show the maximum predicted cumulative drawdown for the water table as well as depressurisation within Lower Hawkesbury Sandstone and the Bulli Seam.

Figure 4-8 shows the extent of 0.2 m cumulative water table drawdown at Tahmoor South connects with the zones of impact from Tahmoor North, Appin and Dendrobium mine. Generally, 0.2 m water table drawdown extends across the footprint of the longwall mines, including all domains at Tahmoor. This is driven by the surface cracking mechanism now simulated in the model.

Figure 4-9 shows the maximum cumulative drawdown in Lower Hawkesbury Sandstone due to LW S1A-S6A extraction connects with the neighbouring sites (Tahmoor North, Appin and Dendrobium) in a similar manner as shown in the cumulative water table drawdown.

The extent of the predicted maximum cumulative drawdown shown in Figure 4-8 and Figure 4-9 are consistent with the predictions from the EIS (SLR/Hydrosimulations, 2020).

As shown in Figure 4-10, the greatest cumulative depressurisation occurs in the Bulli Seam that are mined at the mining areas. Figure 4-10 shows drawdown in the Bulli Seam interacts with drawdown zone from Appin and Tahmoor North. However, the extent of depressurization from LW S1A-S6A extraction does not interact with that from the Dendrobium Mine.

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Figure 4-8 Predicted Maximum Water Table Drawdown - Cumulative

Figure 4-9 Predicted Maximum Drawdown in lower Hawkesbury Sandstone - Cumulative

Figure 4-10 Predicted Maximum Drawdown in Bulli Seam - Cumulative

4.4 Predicted Groundwater Interception

Predicted mine pit inflow volumes have been calculated as time weighted averages of the outflow reported by MODFLOW 'ZoneBudget' utility for model Drain cells. The inflows to the simulated Tahmoor South workings are presented in Figure 4-11. As shown, inflows to the underground operations are predicted to increase over the first half of the operational life at LW S1A-S6A, reaching a maximum peak of approximately 2.5 ML/day at the beginning of 2025. Inflow rates decline gradually from 2025 until the cessation of mining in July 2026, where inflows to Tahmoor South reach a steady rate of approximately 0.12 ML/day. The average inflow rate over the total duration of mining at Tahmoor South is calculated at 0.8 ML/day.

The predicted inflows are lower than the simulated inflow rates of 7.5 to 8 ML/day predicted by HydroSimulations/SLR (2020). The difference in the predicted inflows may relate to updates to the model structure from site geological information, the updates to the calibrated hydraulic properties based on more recent observation data and the implementation of the coal depth dependence functions in the current model (see Section 3.7).

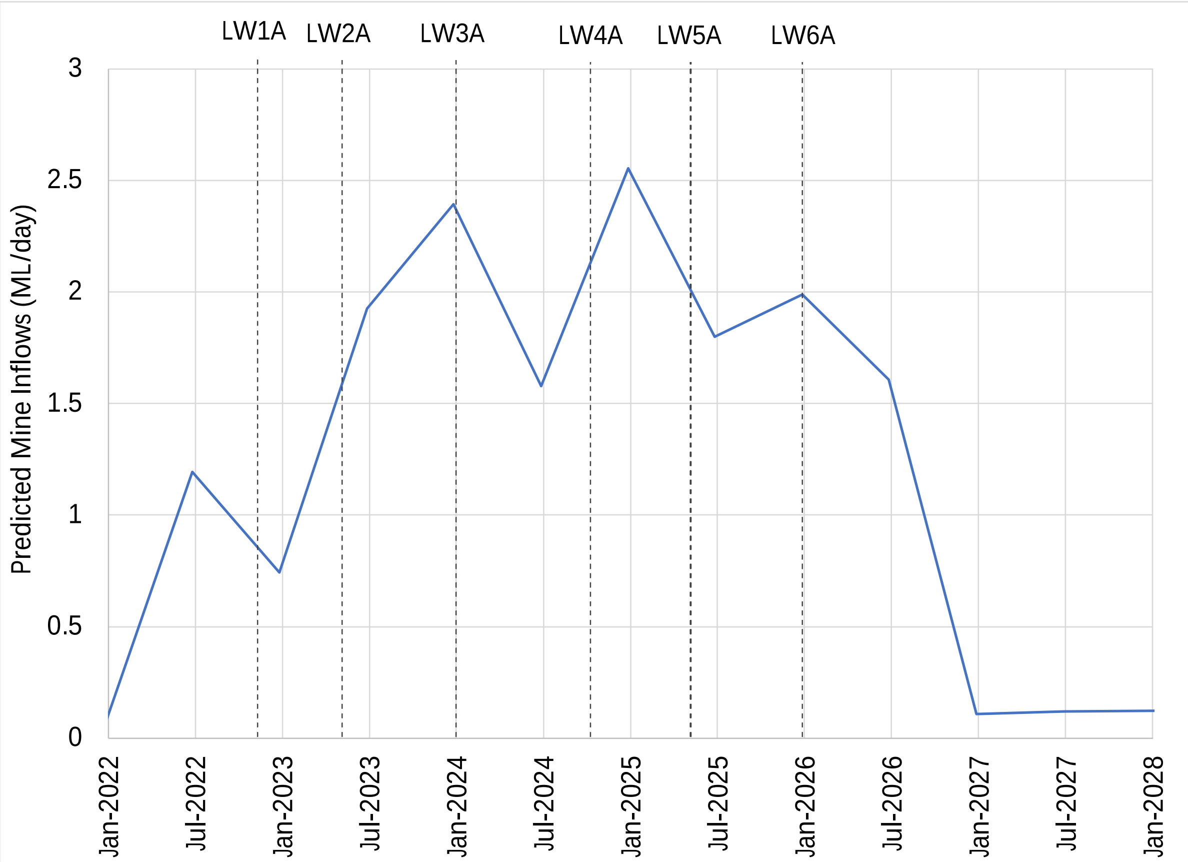

Figure 4-11 Predicted Mine Pit Inflows to LW S1A-S6A

4.5 Incidental Water Impacts

4.5.1 Loss of Flow in Streams

Mining activities can result in change in gradient from the aquifer into the watercourse and thereby reducing the rate at which baseflow occurs. This effect can be amplified in areas above longwall panels, where surface cracking may increase the permeability of the stream bed and the near-surface strata, as is evident around Tahmoor North (e.g. Redbank Creek).

Estimates of predicted baseflow were calculated using the MODFLOW 'ZoneBudget' utility. The change in baseflow due to LW S1A-S6A extraction was calculated by comparing the net river flow in the Full Development scenario against the Base Case scenario. The cumulative loss of baseflow was calculated by comparing the Full Development scenario against the Null scenario (i.e. no mining scenario).

Table 4-4 presents a summary of the predicted maximum baseflow loss at several creeks directly related to the LW S1A-S6A extraction. Overall, the model predicts insignificant change in baseflow due to LW S1A-S6A extraction. The impact in ML/d represents the maximum baseflow impact from any time in the predictive run. The sub-catchments most affected by the Tahmoor South mining operation were predicted to be Dogtrap Creek (0.001 ML/day loss in baseflow).

Table 4-4 shows cumulative baseflow losses due to mining are much greater with Bargo River, Myrtle Creek Nepean River, Dog Trap Creek and Tea Tree Hollow Creek predicted to experience the largest loss in baseflow (between 0.03 to 0.22 ML/day). The most recent estimation of baseflow loss was carried out by HEC (2022) which suggested a range of between 0.2 to 1.4 ML/day of inflow loss in Redbank Creek. Table 4-4 shows the predicted inflow loss from the groundwater model is close to the lower of bound of baseflow loss estimation for HEC (2022) study. Comparing to the 2020 EIS study, the current model predicts less loss of baseflow in most of the creeks and rivers.

Table 4-4 Base Flow Impacts in Local Watercourses

Watercourse	Site Used for Assessment	LW S1A-S6A extraction Impact (ML/day)	Cumulative Impact (ML/day)
Eliza Creek	SW-18	<0.001	0.002
Carters Creek	SW-23	<0.001	0.064
Blue Gum Creek		<0.001	0.001
Dogtrap Creek	SW-15	0.002	0.039
Teatree Hollow	SW-22	0.001	0.053
Cow Creek	SW-24	0.000	0.000
Stonequarry Creek	212053	<0.001	<0.001
Bargo River	SW-1	<0.001	0.001
Bargo River	SW-13	<0.001	0.026
Bargo River	SW-14	<0.001	0.073
Hornes Creek	SW-9	<0.001	0.004
Nepean River	SW-21	<0.001	0.072
Matthews Creek		0.000	<0.001
Cedar Creek		<0.001	0.003
Redbank Creek		<0.001	0.013

Watercourse	Site Used for Assessment	LW S1A-S6A extraction Impact (ML/day)	Cumulative Impact (ML/day)
Avon River		<0.001	0.100
Cordeaux River		<0.001	0.120
Rumker Gully		<0.001	<0.001
Newlands Gully		<0.001	<0.001
Myrtle Creek		<0.001	0.210
Dry Creek		<0.001	0.008

4.5.2 Change in Lake-Aquifer Interaction at Thirlmere Lakes

The connection between shallow groundwater (water table aquifers) and surface water features is governed by the permeability of the aquifer material and of any surficial sediments (lake-bed materials), and any head separation between the water body and the underlying aquifer. Declines in groundwater levels due to mining can results in changes in the groundwater-surface water interaction between the lake system and the local groundwater system.

As discussed in Section 4.3, the model did not predict drawdown to extend to the Thirlmere Lakes as a result of LW S1A-S6A extraction. Therefore, no changes in the lake leakages to the groundwater system was predicted. This is consistent with recent findings from the NSW Government Thirlmere Lakes Research Program (TLRP) that found that the historical mining at Tahmoor North (which are much closer to the lakes than LW S1A-S6A) had likely had only a negligible to very minor effect on lake water balance, and consistent with the conclusions of the Tahmoor South EIS.

For the cumulative mining, the model predicted loss of leakage at the Thirlmere Lakes. Table 4-5 shows the maximum reduction in leakage at the Thirlmere Lakes from any time in the predictive run. A shown in the table the largest loss of leakage was predicted for Lake Werri Berri (0.027 ML/day) while the model predicted leakages loss less than 0.1 ML/day for the other Thirlmere Lakes.

Table 4-5 Change in Lake Leakage due to Cumulative mining

Lake	LW S1A-S6A extraction Impact (ML/day)	Cumulative Impact (ML/day)
Gandangarra	<0.001	0.020
Baraba	<0.001	0.005
Nerrigorang	<0.001	0.018
Werri Berri	<0.001	0.027
Couridjah	<0.001	0.015

4.5.3 Influence on Alluvium

The main alluvial resources in the area include alluvium associated with Thirlmere Lakes. There were no drawdowns predicted in the Thirlmere Lakes alluvium in response to LW S1A-S6A extraction. Therefore, there was no change in alluvial water resources due to LW S1A-S6A extraction.

The loss in alluvium due to the cumulative mining was calculated by comparing the alluvial flows between the Null scenario and Full Development scenario. The maximum loss of flow in the Thirlmere Lakes alluvium was 0.02 ML/day which is likely to due to the mining activities in Tahmoor North and Western Domain.

4.6 Drawdown at Water Supply Bores

Table 4-6 presents a list of the bores identified in the project bore census (CES, 2022) and presents the simulated drawdown impact at each. The location of the bore investigated in the bore census are shown in Figure 3-9 of the conceptual report (SLR, 2022). It should be noted that the drawdown values in Table 4-6 are the maximum impact at any given point in time in the predictive model. These tables are restricted to listing those bores that were modelled in the 2020 ESI study as being potentially impacted upon (cumulative or otherwise) more than the AIP criterion of 2 m maximum cumulative drawdown.

As shown in Table 4-6, there are 2 bores with drawdowns more than 2 m due to LW S1A-S6A extraction. GW032443 and GW109257 are located within the Tahmoor South footprint and show drawdown impact more than 2 m due to the LW S1A-S6A extraction.

Table 4-6 Modelled Impacts on Groundwater Bores from the Project Bore Census

Bore	Easting	Northing	Model Layer	LW S1A-S6A extraction Impact (m)	Cumulative Mining Impact (m)
GW109257	276603.8	6205057.0	5	2.35	6.17
GW032443	276427.0	6206329.0	5	2.32	10.28
GW104323	276241.6	6206412.0	4	<2	10.09
GW014262	276764.0	6204587.0	3	<2	4.23
GW111810	277035.4	6204405.0	5	<2	3.84
GW104659	276616.0	6207392.0	5	<2	14.32
GW007445	277437.0	6204264.0	5	<2	3.46
GW103615	279634.6	6204110.0	4	<2	2.56
GW110669	274570.4	6207928.0	5	<2	13.21
GW058634	279446.1	6203408.0	4	<2	2.20
GW111669	279262.7	6203321.0	4	<2	2.16
GW102179	279262.7	6203321.0	5	<2	2.15
GW105395	278546.8	6203033.0	4	<2	2.01
GW111047	280015.0	6206037.0	5	<2	4.59
GW031294	279732.0	6205706.0	4	<2	2.91
GW070245	280043.3	6205645.0	4	<2	2.88
GW102344	280250.8	6206554.0	4	<2	3.33
GW053449	280369.0	6205813.0	4	<2	2.98
GW104008	280359.0	6205978.0	5	<2	3.56
GW106590	280442.0	6206344.0	5	<2	4.58
GW054146	279879.6	6204679.0	4	<2	2.03
GW105577	280728.0	6207041.0	5	<2	3.64
GW108538	281155.0	6205941.0	4	<2	2.55
GW062068	276572.8	6209556.0	5	<2	8.84
GW057969	281351.1	6206122.0	4	<2	2.47
GW051877	281673.0	6205875.0	4	<2	2.23
GW100455	281877.0	6207020.0	4	<2	2.53

5 Sensitivity Analysis

5.1.1 Identifiability

Calibration identifiability describes a parameters capability to be constrained by the model calibration. Identifiability values range from zero to one. As identifiability approaches one, the parameter is increasingly able to be constrained. Likewise, as values approach zero the parameter is increasingly unable to be constrained by the calibration and uncertainty of model results is not reduced through calibration.

Prediction identifiability describes parameters capability on impacting the model predictions. To calculate the prediction identifiability the groundwater model is run once per each parameter. As identifiability approaches one, the parameter is increasingly able to change model predictions. On the contrary, as values approach zero the parameter is increasingly unable to change model predictions. The predictions included in the analysis were the project only inflows, maximum cumulative drawdown, and changes to baseflows to the main river and creeks near the Tahmoor Mine as listed in Section 4.5.1.

The PEST utility GENLINPRED was used to provide an estimate of parameter identifiability for each of the model parameters. Estimated identifiability values for all parameters tested are summarised in Figure 5-1 through Figure 5-8 for both calibration and predictions.

Figure 5-1 indicates that in general the calibration process was successful in constraining the horizonal conductivity. Notably, the conductivity of units such as HBSS, Bulgo Sandstone, Scarborough Sandstone, Alluvium, Wongawilli Seam and Bulli Seam are well constrained by calibration (high identifiability values above 0.70). The calibration process was also able to constrain the horizontal hydraulic conductivity of most of the faults around the site.

Identifiability of hydraulic conductivity anisotropy for model zones is presented in Figure 5-2. Anisotropy in the in most of the units simulated such as HBSS, Bulgo Sandstone, Scarborough Sandstone, Alluvium, Wongawilli Seam, Bulli Seam and some of the faults have high identifiability values indicating these can be constrained and contribute to reducing model uncertainty. All other zones feature low values (equal to and below 0.40) and are less constrained by calibration.

In general, specific yield and specific storage of other zones in the model domain has low identifiability with the exception of HBSS, Bulgo Sandstone, Scarborough Sandstone (Figure 5-3 and Figure 5-4).

The recharge rates for all the zone except are highly constrained by the calibration while EVT rate had low identifiability and were not constrained well by the calibration (Figure 5-5). Figure 5-4 shows the calibration was able to constrain depth dependence function in layers representing Bulgo Sandstone, Scarborough Sandstone and Coal Cliff Sandstone. The calibration was not able to constrain this variable in the other layers. Figure 5-7 shows that with the exception of Stonequarry Creek, the calibration was not able to constrain the riverbed conductance in the other rivers. Figure 5-8 shows the identifiability for the other parameters in the much as soil moisture model properties and fracture zone properties.

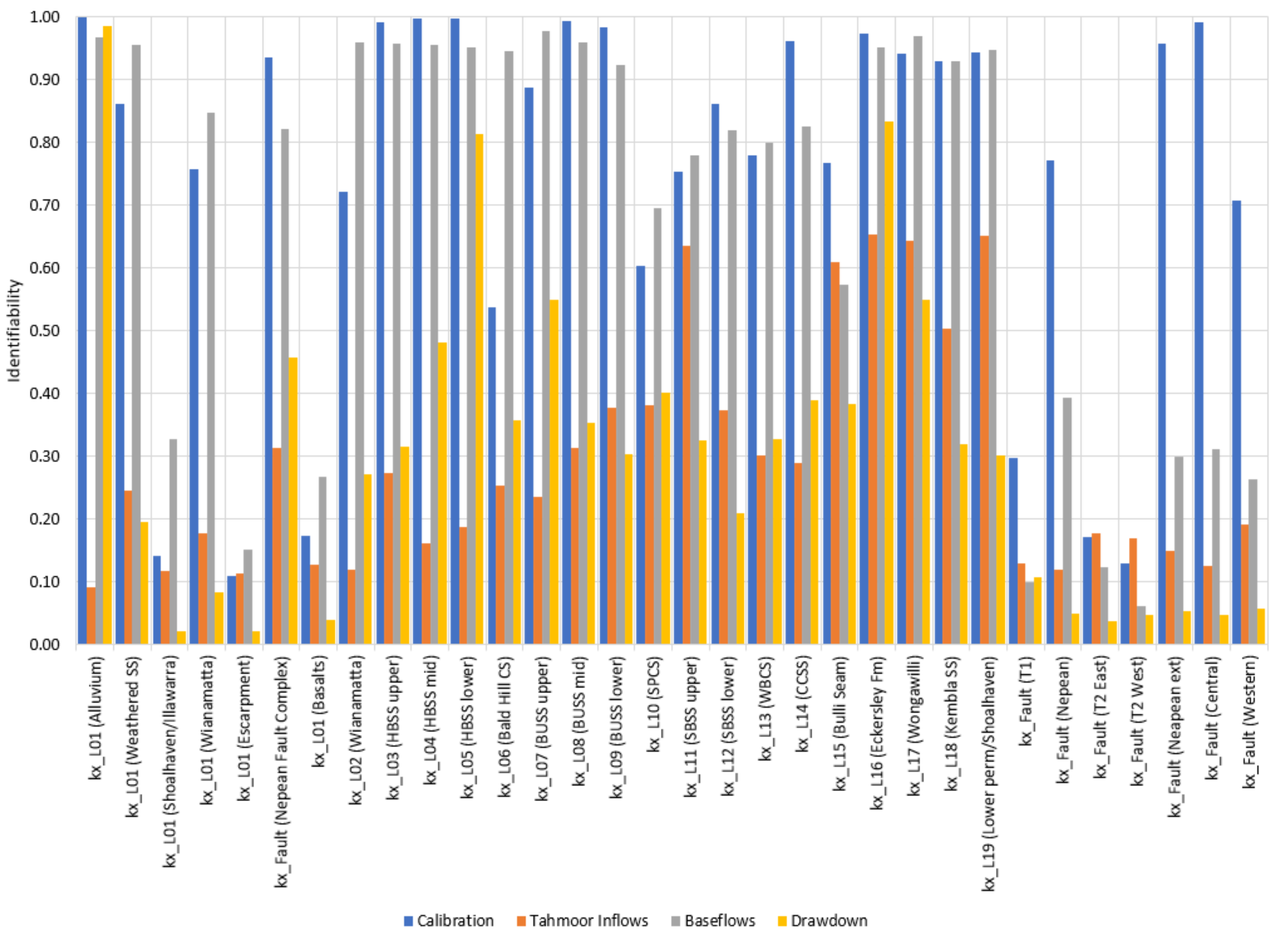

Figure 5-1 Identifiability – Horizontal Hydraulic Conductivity (Kx)

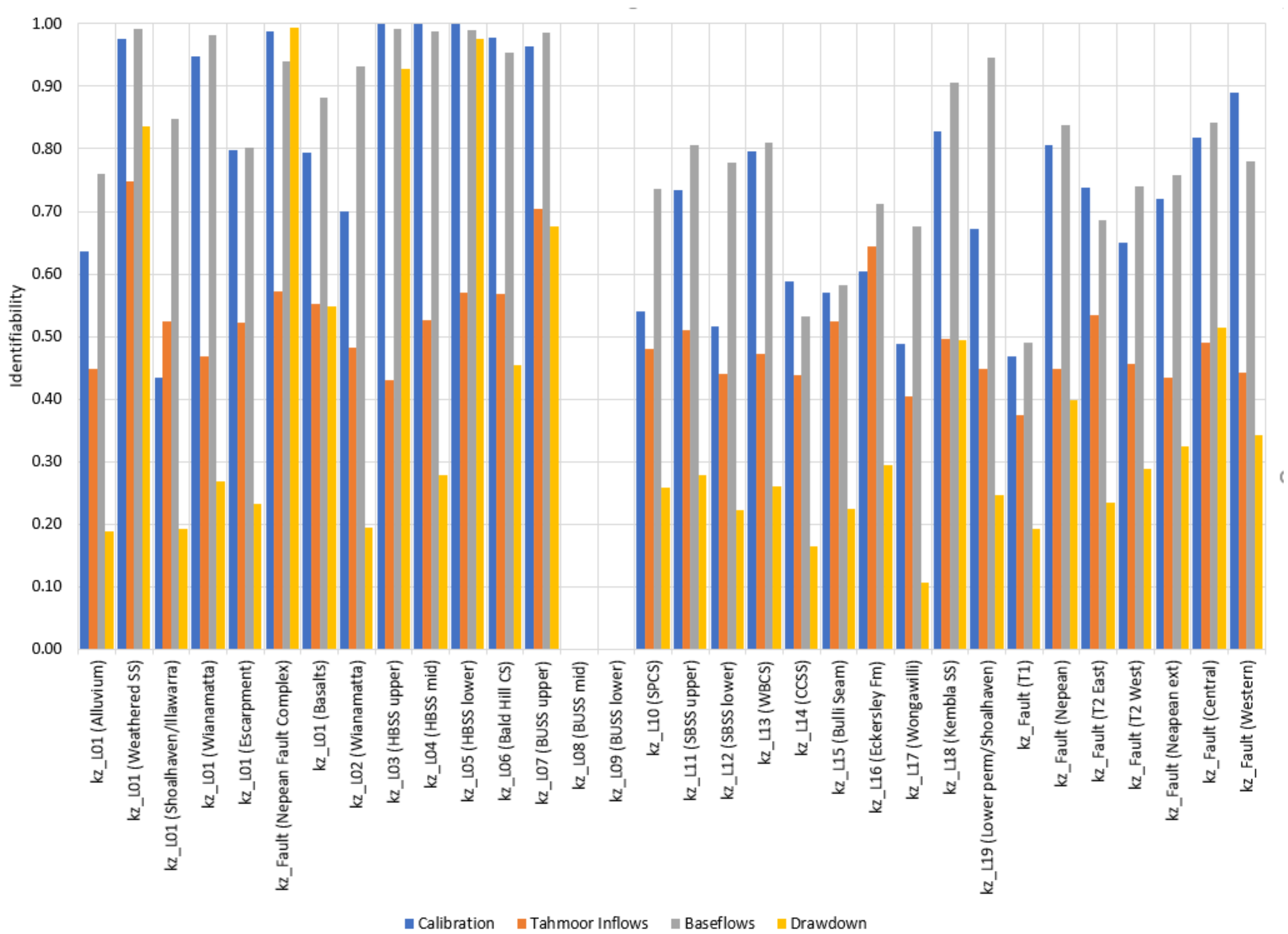

Figure 5-2 Identifiability – Anisotropy (Kz/Kx)

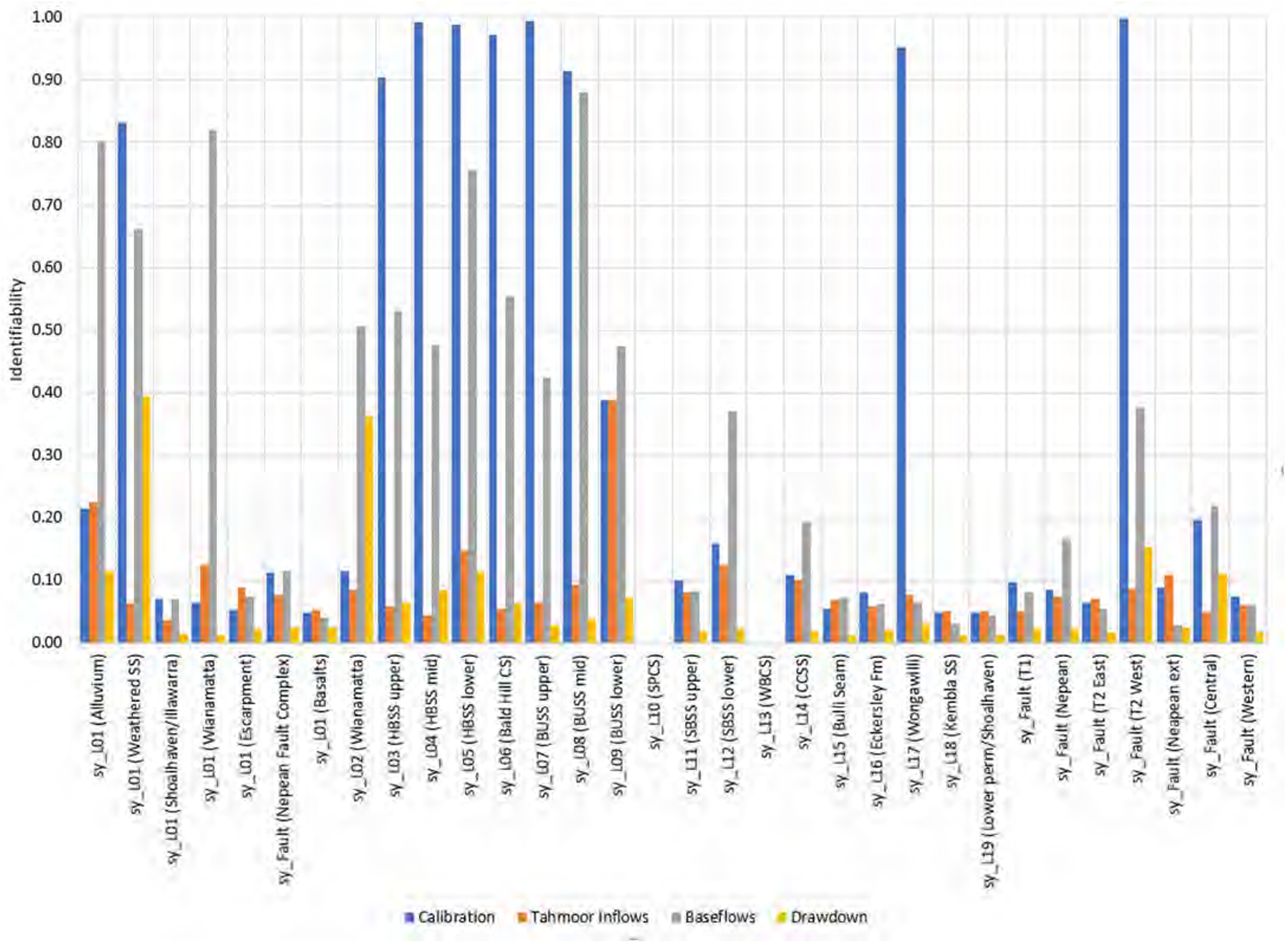

Figure 5-3 Identifiability – Specific Yield (Sy)

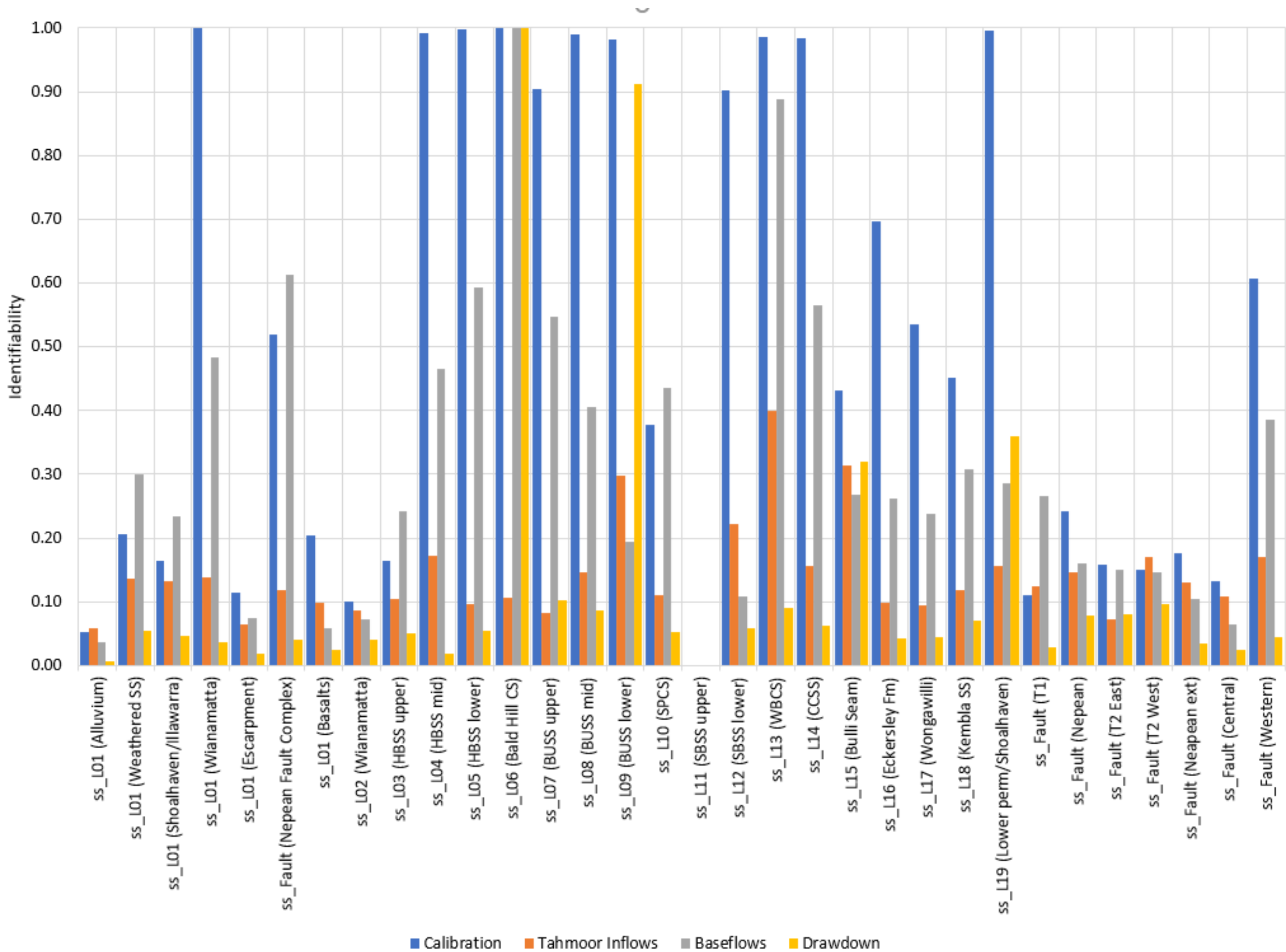

Figure 5-4 Identifiability – Specific Storage (Ss)

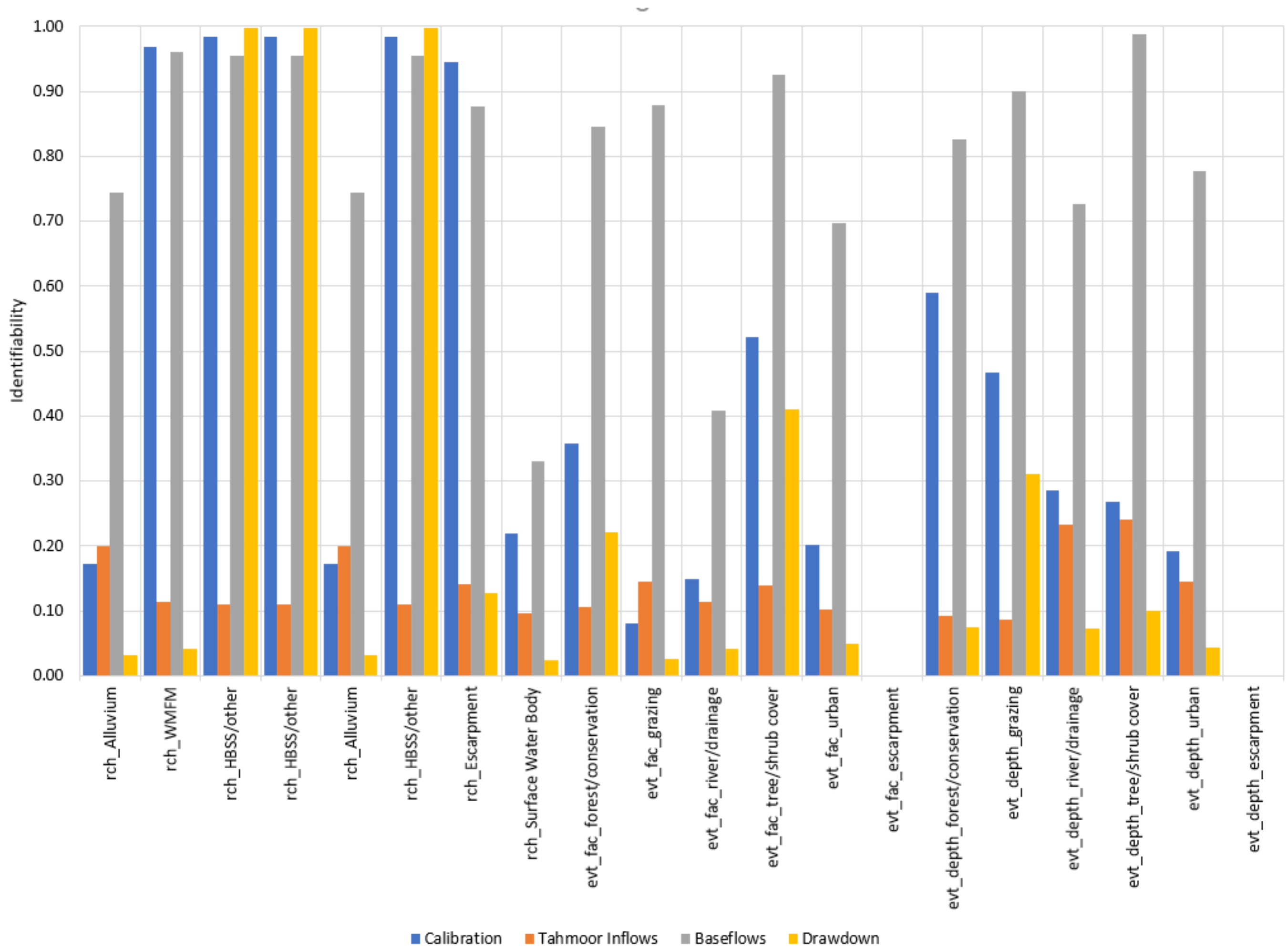

Figure 5-5 Identifiability – Recharge (RCH) and Evapotranspiration (EVT)

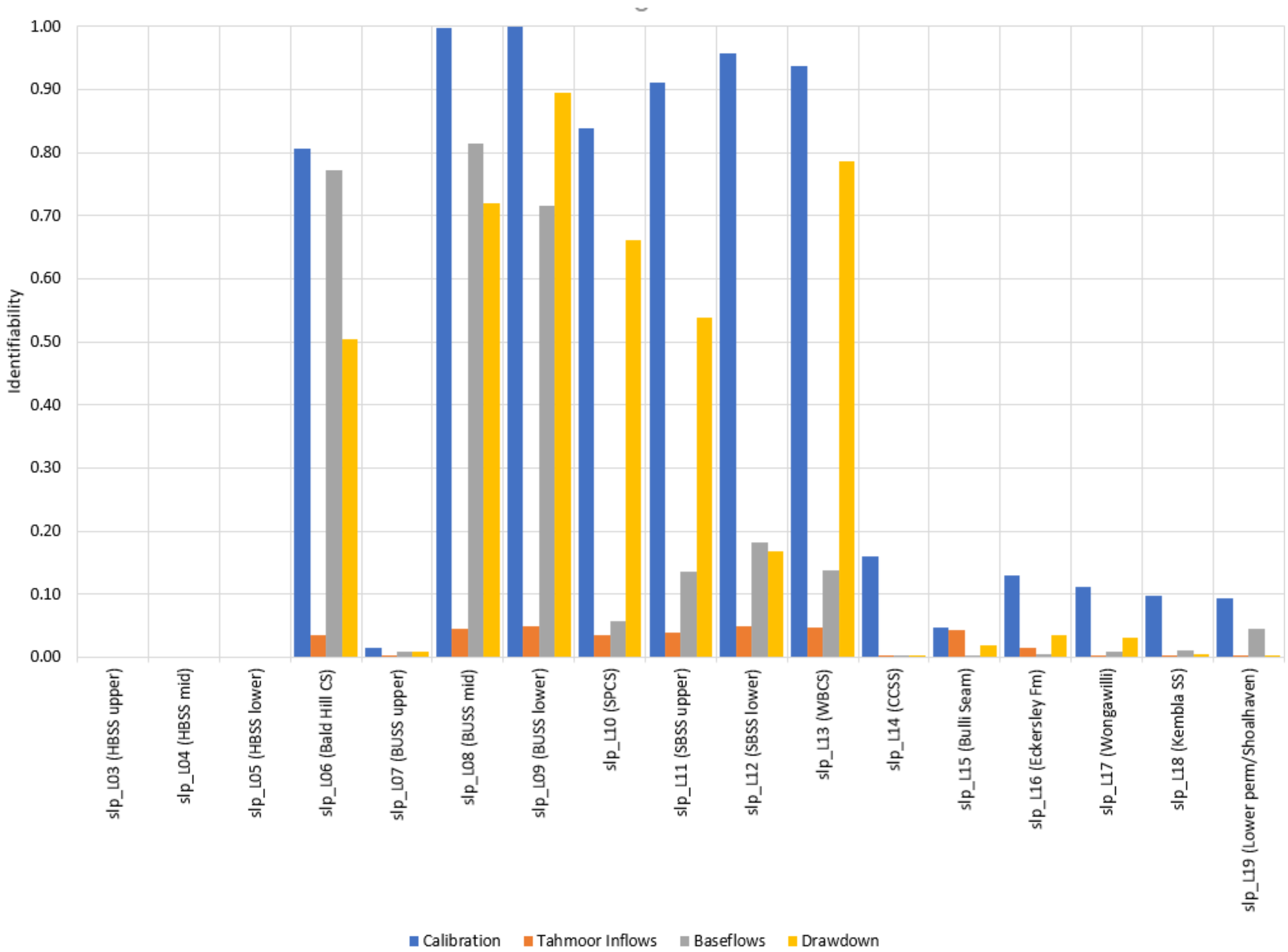

Figure 5-6 Identifiability – Depth Dependence Slope Function (slp)

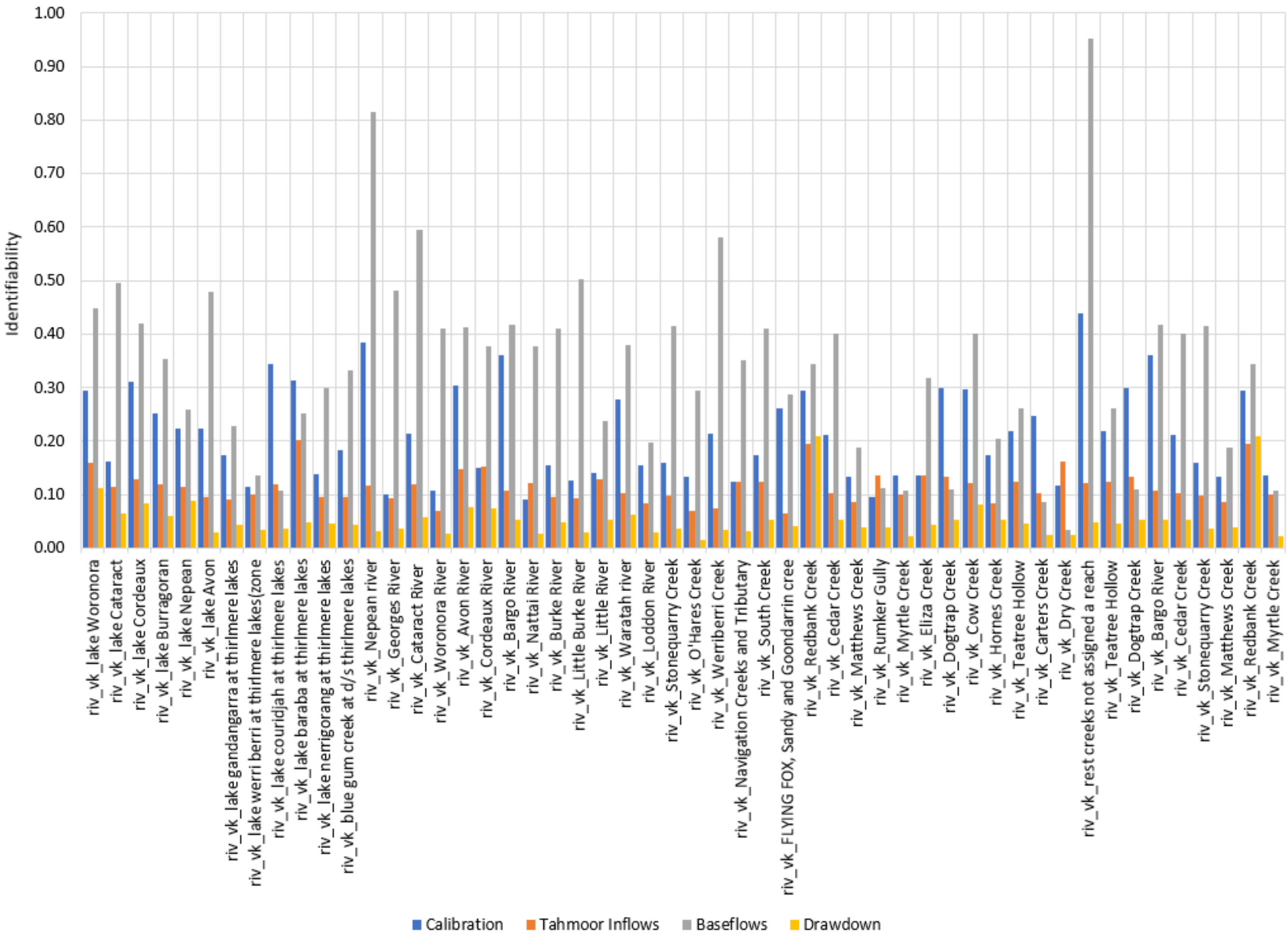

Figure 5-7 Identifiability – River Boundary Condition Conductance

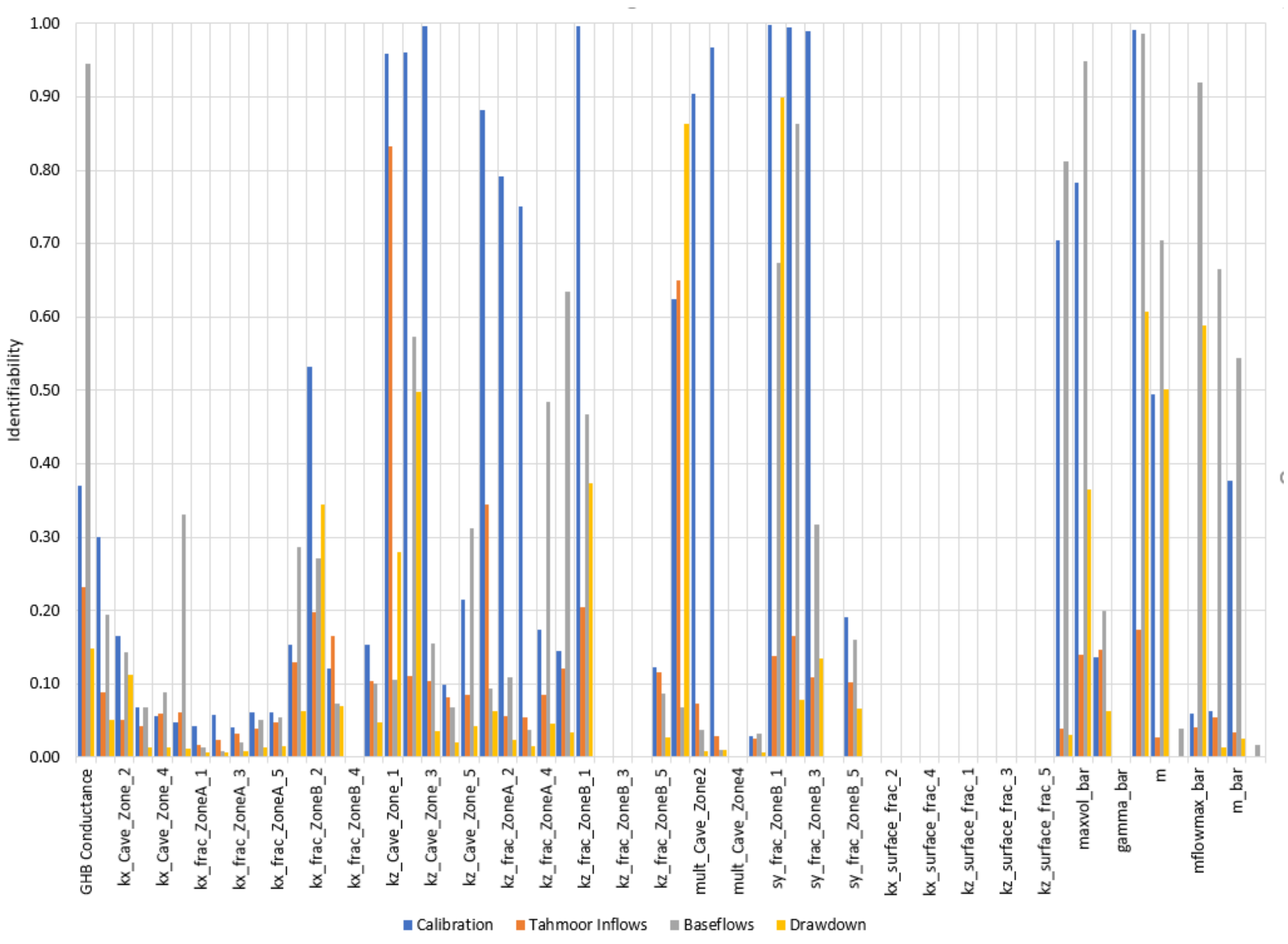

Figure 5-8 Identifiability – Other Parameters

5.1.2 Type I-IV Analysis (Identifiability)

The Murray Darling Basin Modelling Guidelines (MDBC, 2000) recommends classifying sensitivity by the resultant changes (or contribution) to the model calibration and predictions. According to this process models can be classified as one of the four main types:

- Type I: Insignificant changes to calibration (low identifiability) and prediction (low uncertainty contribution);
- Type II: Significant changes to calibration (high identifiability) – insignificant changes to predictions (low uncertainty contribution);
- Type III: Significant changes to calibration (high identifiability) –significant changes to predictions (high uncertainty contribution); and
- Type IV: Insignificant changes to calibration (low identifiability) –significant changes to predictions (high uncertainty contribution).

Types I-III are of less concern, as these Types have an insignificant impact on model predictions or constrained by calibration. Type IV is classed as 'a cause for concern' as non-uniqueness in a model input might allow a range of valid calibrations but the choice of value impacts significantly on a prediction (MDBC, 2000).

To classify the sensitivity contribution to the model calibration and predictions for each model parameter, the calibration and prediction Identifiability were compared against each other for each parameter.

Figure 5-9 presents the relationship between the identifiability of the predicted Project only inflow and the identifiability of the calibration. Sensitivity classifications for the sensitivity types have been assigned using judgement based on the range of the identifiability. The results show that the identifiability from calibration is greater than that for predictions for the vast majority of parameters, in particular for those to which predictions are sensitive, as indicated by points plotted above the line of equality (red dashed line). As such it can be inferred that the uncertainty in model predictions for inflows are highly constrained by calibration. Only three river boundary conductance values (Lake Gandangarra, Little Burke River, and Little River) were identified as Type IV parameters.

Figure 5-10 presents the relationship between identifiability of the maximum predicted drawdown and the identifiability of the calibration. The results show that the identifiability from calibration is greater than that for predictions for the vast majority of parameters, in particular for those to which predictions are sensitive, as indicated by points plotted above the line of equality (red dashed line). As such it can be inferred that the uncertainty in model predictions for drawdown is highly constrained by calibration. Only two parameters (Specific yield – L02 Wianamatta, and the lower soil moisture store parameter in LUMPREM2 model (i.e. mflowmac_bar)) were identified as Type IV parameters.

Figure 5-11 presents the relationship between identifiability of the change in baseflow to the main river and creeks near the Tahmoor Mine boundary conditions and the identifiability of the calibration. The results show that the prediction of changes to baseflow as a result of mining activities is sensitive to most parameters tested. However, most of these parameters are also considered sensitive to calibration (i.e. Type III) and therefore at least partially constrained. The difference in level of constraints between change in baseflow when compared to the results for mine inflows and drawdown is a direct result of data being available to which calibration could constrain drawdown and mine inflows, and a lack of calibration data for baseflow and baseflow losses. Thirty-three Type I-V parameters were identified (Table 5-1).

Table 5-1 Type I-IV Parameters – Change in Baseflow

Parameter	
kx_L01 (Shoalhaven/Illawarra)	mflowmax_bar
kx_L01 (Basalts)	ks_bar
sy_L01 (Wianamatta)	Lake Cataract
sy_L02 (Wianamatta)	Lake Gandangarra at Thirlmere Lakes
sy_L12 (SBSS lower)	Blue Gum Creek at d/s Thirlmere Lakes
sy_Fault (Central)	Georges River
ss_L01 (Shoalhaven/Illawarra)	Woronora River
ss_L03 (HBSS upper)	Cordeaux River
ss_Fault (T1)	Burke River
rch_Alluvium	Little Burke River
evt_fac_grazing	Little River
evt_fac_river/drainage	Loddon River
evt_depth_urban	O'Hares Creek
hk_c5	Navigation Creeks and Tributary
hk_d1	South Creek
vk_f4	Rumker Gully
vk_f5	

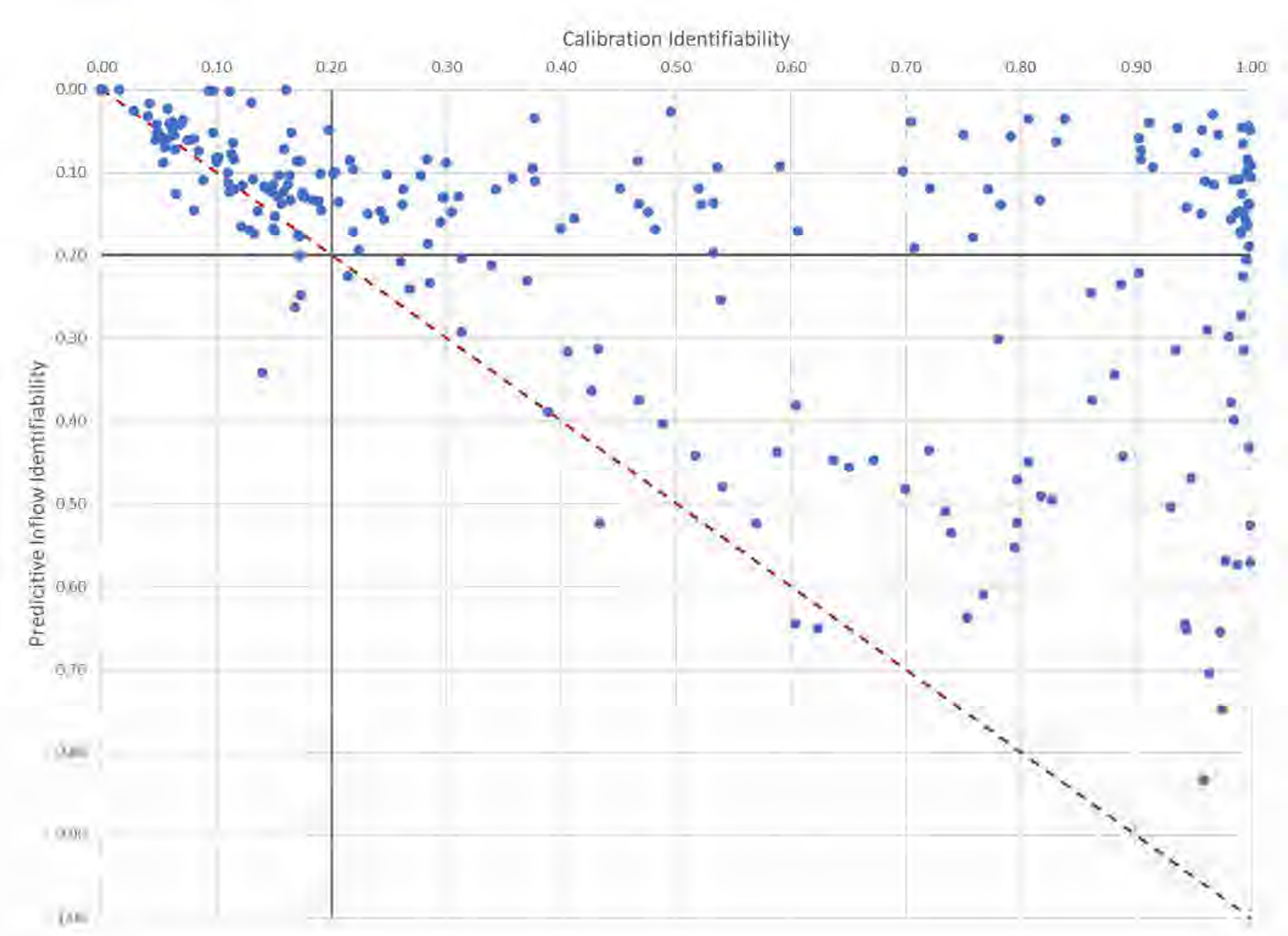

Figure 5-9 Uncertainty Contribution (Predicted Mine Inflow) versus Identifiability

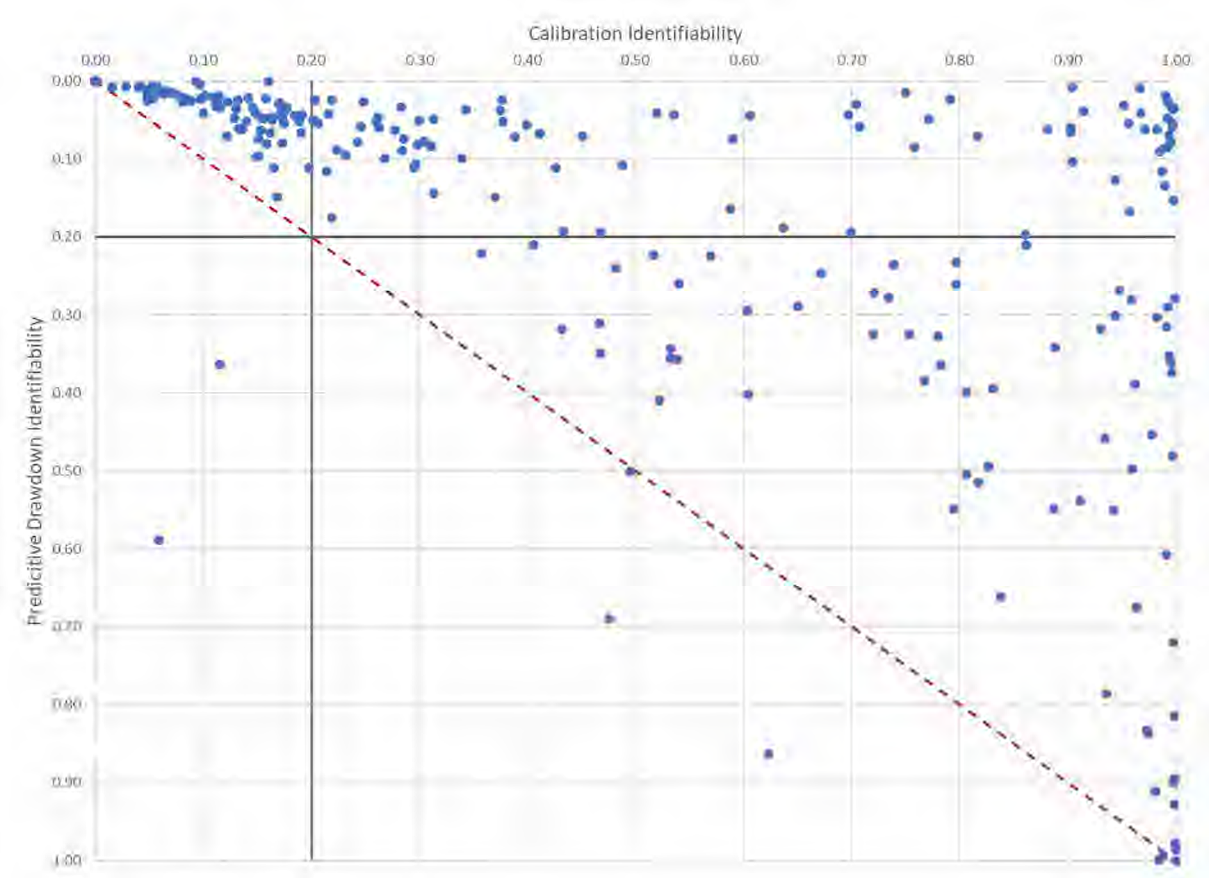

Figure 5-10 Uncertainty Contribution (Maximum Cumulative Drawdown) versus Identifiability

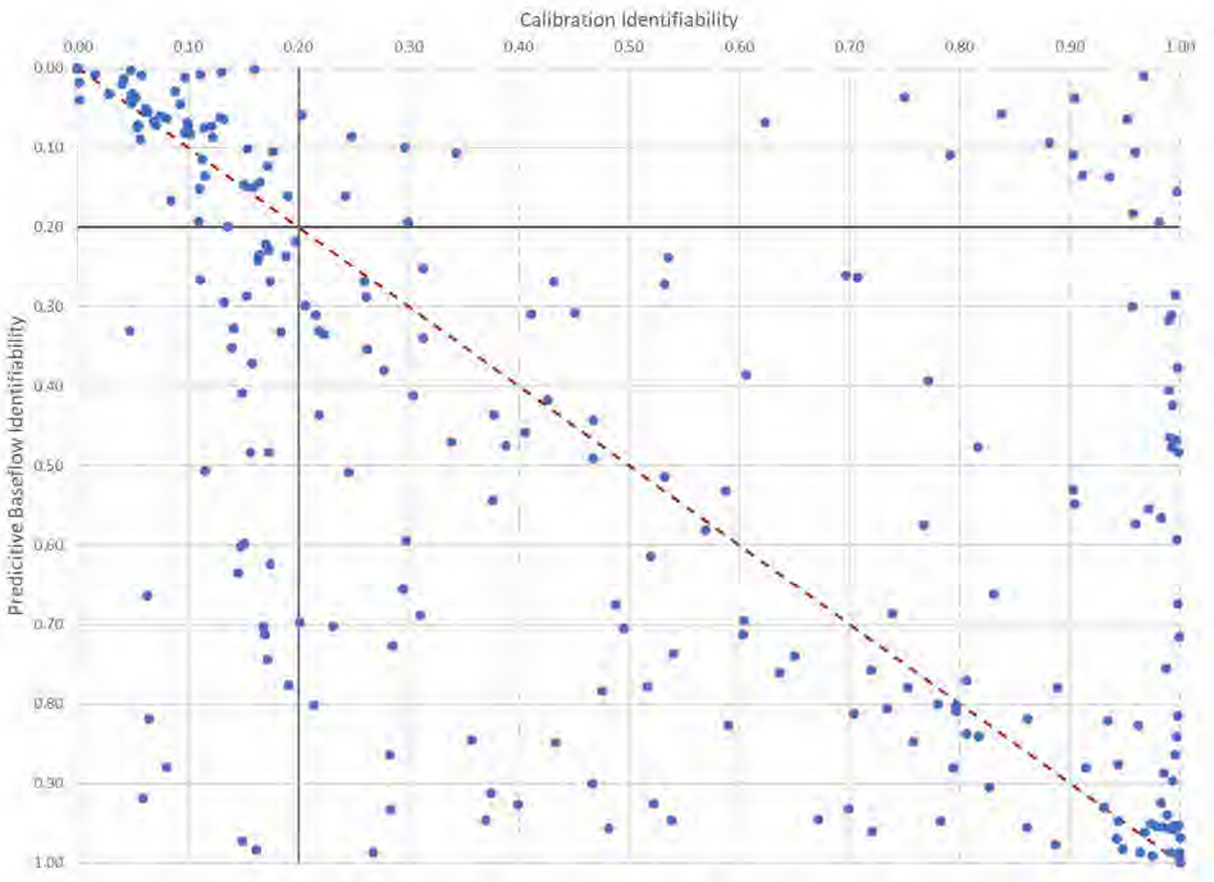

Figure 5-11 Uncertainty Contribution (Baseflows) versus Identifiability

6 Conclusion

This report describes the groundwater related impacts associated with approved mining at Tahmoor South Operations to address consent conditions outlined in the Consent SSD 8445 (the Consent).

As discussed in Section 2.1, previous groundwater assessments have been conducted for the Tahmoor Mine. This groundwater assessment builds upon the knowledge and data presented in these previous studies with the most recent data and information used to construct the model. A numerical groundwater model was developed from the conceptual model to represent the local geological and hydrogeological regime, which are described in Section 2 and Conceptual Model Report (SLR, 2022). The numerical groundwater model covers a large domain due to extensive historic and approved mining within the region. Existing and approved mines represented in the model include Tahmoor and Tahmoor North, Tahmoor Western Domain, Tahmoor South, Bulli Seam Operations (BSO) and Appin Mine, Russell Vale, Dendrobium, Metropolitan and Cordeaux.

The model mesh has been revised to take advantage of advances in software since the last major model revision. The ‘unstructured’ mesh maintains a focus on representing mining areas in detail, with coarser representation (larger cell sizes) in areas of lesser interest. The result is a numerical model that runs in 3.5 hrs, which is approximately 14% of the runtime from previous model. This then facilitates automated calibration techniques (leading to uncertainty analysis), including the use of pilot points for assigning hydraulic properties to important strata.

As discussed in Section 3, transient model calibration was carried out via PEST++ to match observed groundwater level fluctuation data, observed groundwater drawdowns and against calculated groundwater inflows to the existing Tahmoor Mine. Constraint of the hydraulic conductivities by the permeability dataset based on packer and core tests at Tahmoor Mine. In general, the model calibration provided a reasonable match with observed water levels and historical inflows. Sensitivity analysis was carried out on all aquifer property parameters (e.g. hydraulic conductivity and storativity parameters), boundary conditions (e.g. recharge), and peripheral boundary conditions (e.g. General Head Boundary conductance) and fracture zone properties. The primary outcome of sensitivity was that prediction for drawdowns and inflows are highly constrained by calibration.

Transient prediction included 3 different model scenarios to simulate the impacts from workings within the Tahmoor South Domain (LW S1A-S6A extraction) and the cumulative impacts from existing and approved parts of Tahmoor Mine and neighbouring mines. The model predictions were generally consistent with the predictions from the 2020 EIS report (SLR/HydroSimulations, 2020). The difference in prediction between the current model and the SLR/HydroSimulations (2020) are likely due to update in model structure, change in vertical resolution, updates to the fracture profile and additional information and details captured in the stresses of the current model including a horizontal hydraulic conductivity depth dependence function and the use of pilot points in the HBSS.

The key conclusion from the groundwater assessment is summarised as follows:

- The predicted total annual take of groundwater from the Permo-Triassic rock aquifer as mine inflows to LW S1A-S6A is approximately 0.8 ML/day on average, peaking at an annualised rate of 2.5 ML/day (or up to 913.1 ML for a 12-month period) at commencement of extraction at LW S1A. The predicted inflow is typically less than the predicted average inflows by SLR/HydroSimulations (2020), which ranged between 3 ML/day to 5 ML/day (up to 1825 ML/year) for LW S1A-S6A, noting that the proposed sequencing of longwalls has changed since the Tahmoor South EIS;

- Negligible groundwater drawdown in the alluvium associated with the Thirlmere Lakes due to LW S1A-S6A extraction;
- The nearby Thirlmere Lakes are predicted to experience no groundwater drawdown due to the LW S1A-S6A extraction. Therefore, the model did not predict any change in leakage from the Thirlmere Lakes as a result of LW S1A-S6A extraction. This is consistent with recent findings from the NSW Government Thirlmere Lakes Research Program (TLRP) that found that the historical mining at Tahmoor North (which are much closer to the lakes than the Tahmoor South longwalls) had likely had only a negligible to very minor effect on lake water balance, and consistent with the conclusions of the Tahmoor South EIS;
- The predicted water table drawdown of up to 4 m due to the extraction of LW S1A-S6A. The extent of predicted water table drawdown remains primarily within the mine footprint and is less compared to the previous predictions for approved operations by SLR/HydroSimulations (2020);
- Substantial decrease in potentiometric head in the fractured and porous rock groundwater sources comparing to pre-mining conditions in the near vicinity of LW S1A-S6A are predicted to result in drawdown of up to 90 m in HBSS with the predicted 1 m and 2 m drawdown contours extending radially approximately 1.5 and 2 km from the longwalls respectively;
- The predicted maximum loss of baseflow due to LW S1A-S6A extraction was largest for sub-catchments Dogtrap Creek and Bargo River between SW-1 and SW-13 (all less than <0.1 ML/day). The predicted maximum loss of baseflow due to LW S1A-S6A in Teatree Creek was less 0.001 ML/day; and
- The Type I-IV analysis indicates that uncertainty in predictions for drawdown and inflows are highly constrained by calibration, thus indicating confidence in model predictions and that the model is fit for purpose.

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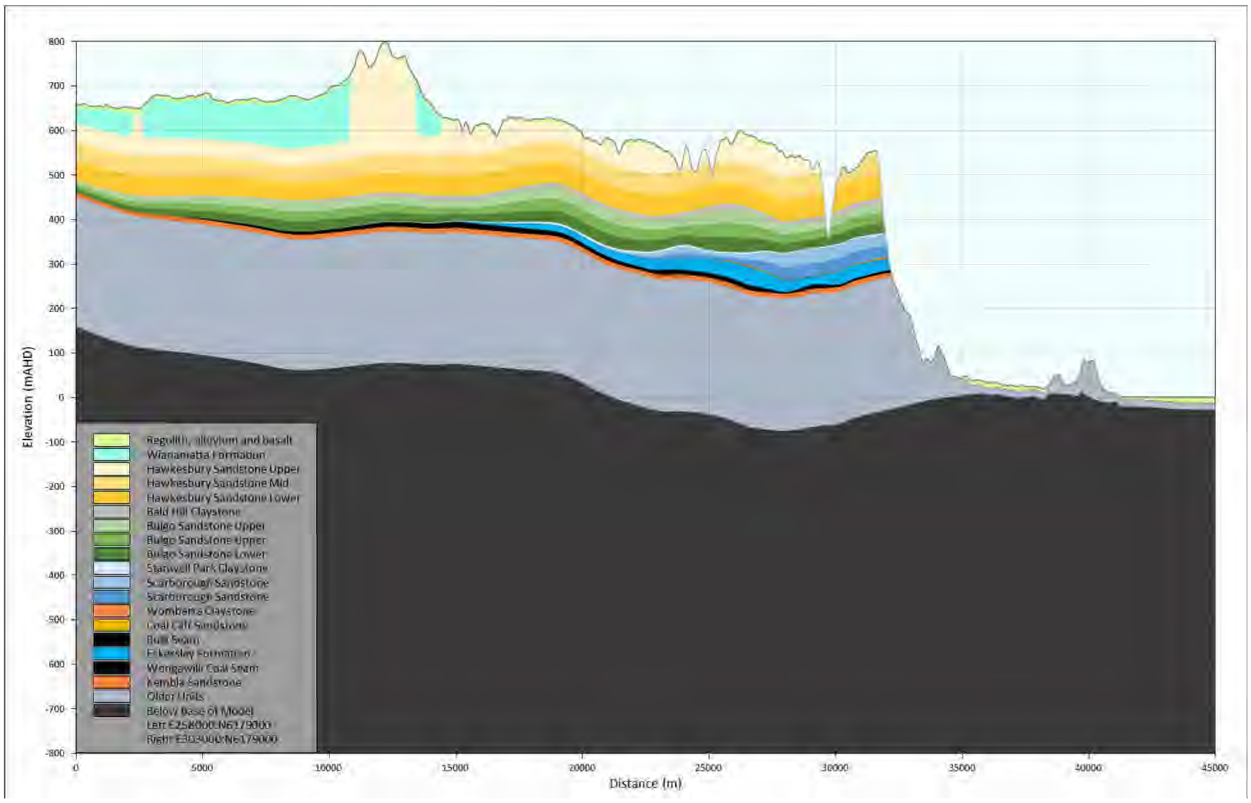
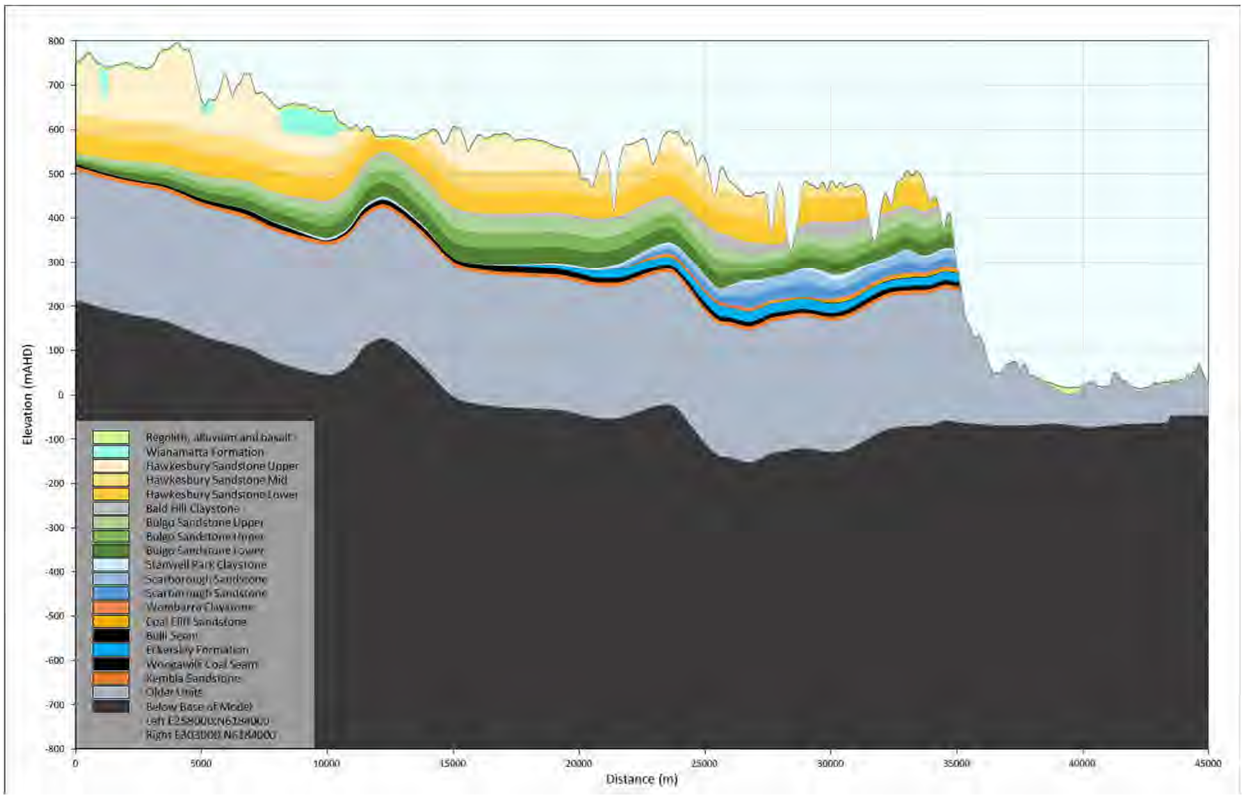
APPENDIX A

Model Layers Cross Sections



Cross-Section A-A'



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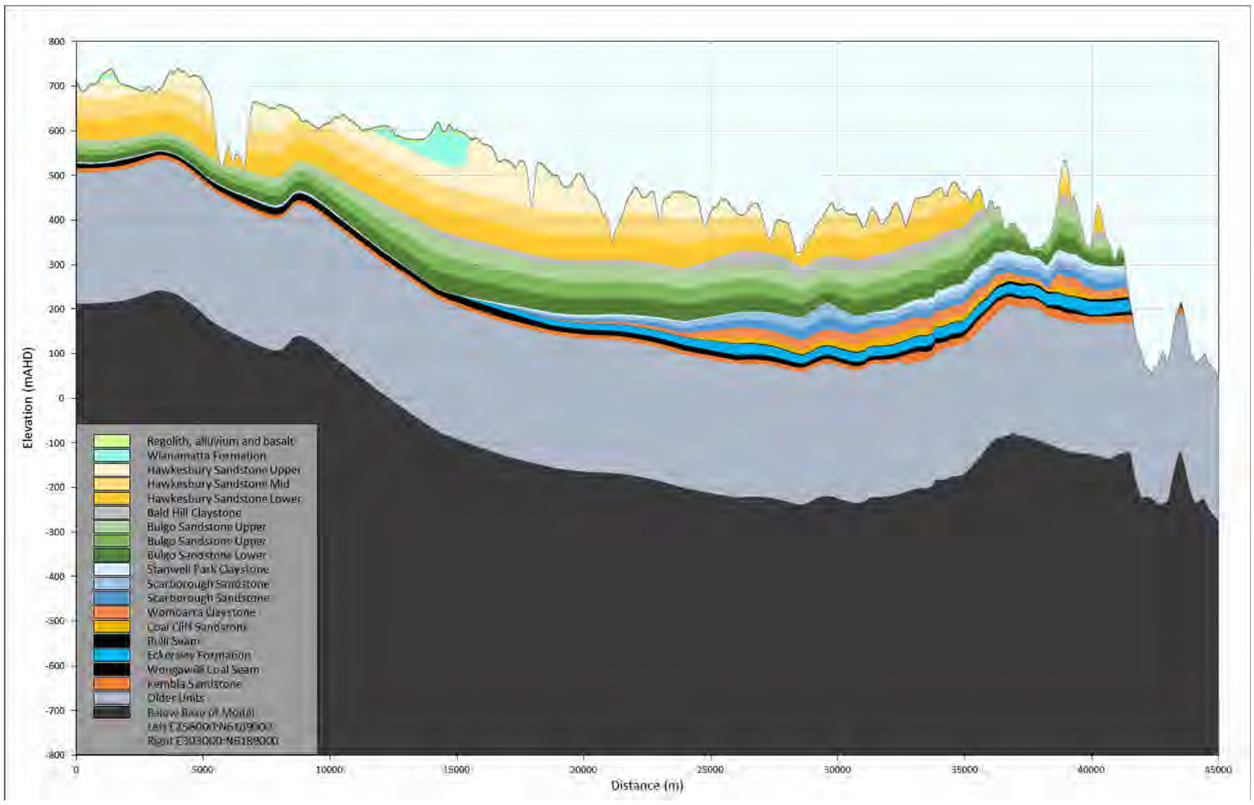

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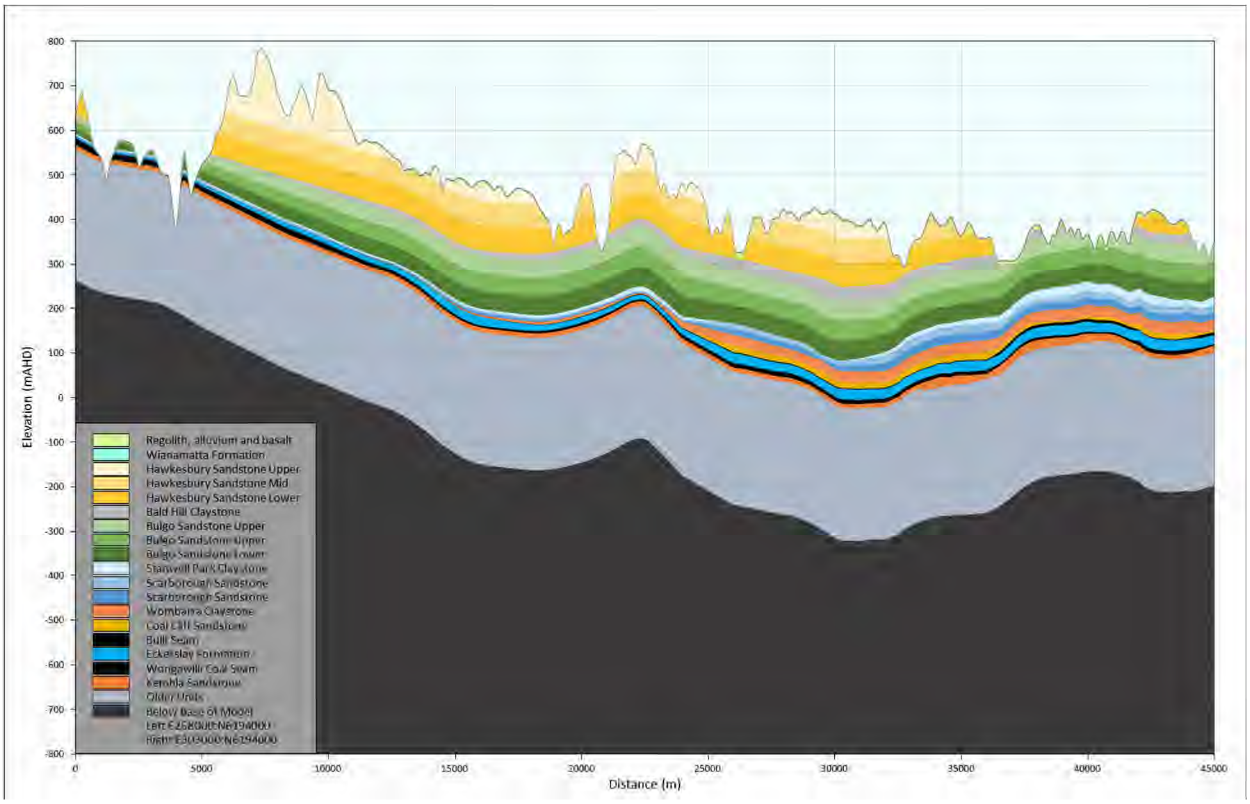

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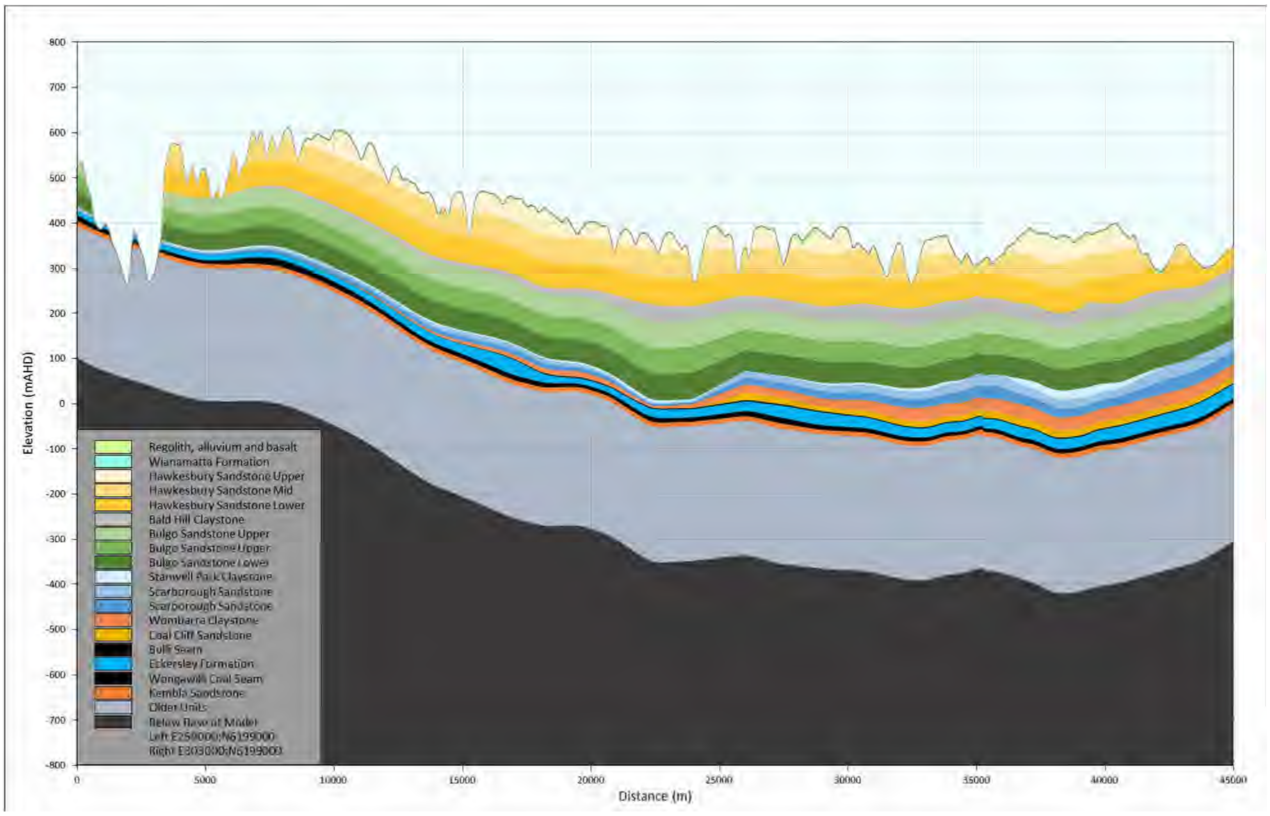

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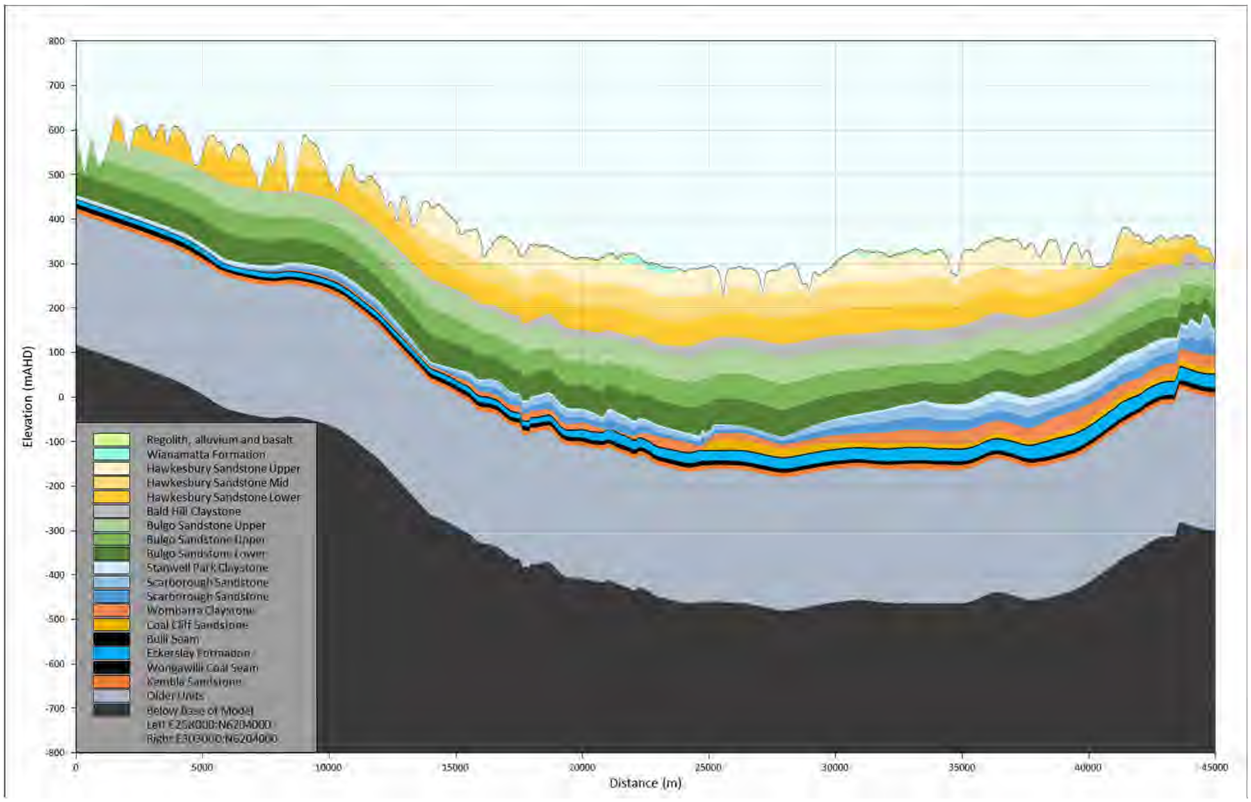

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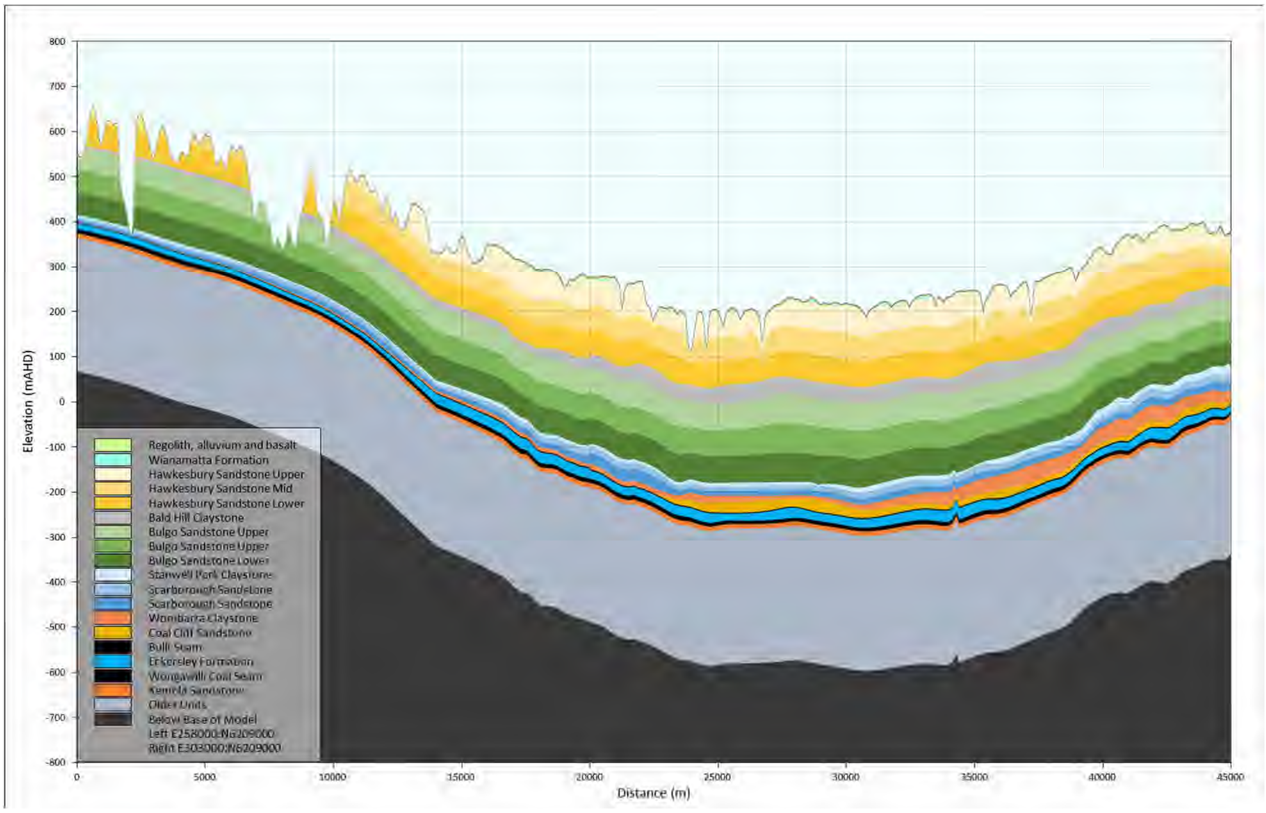

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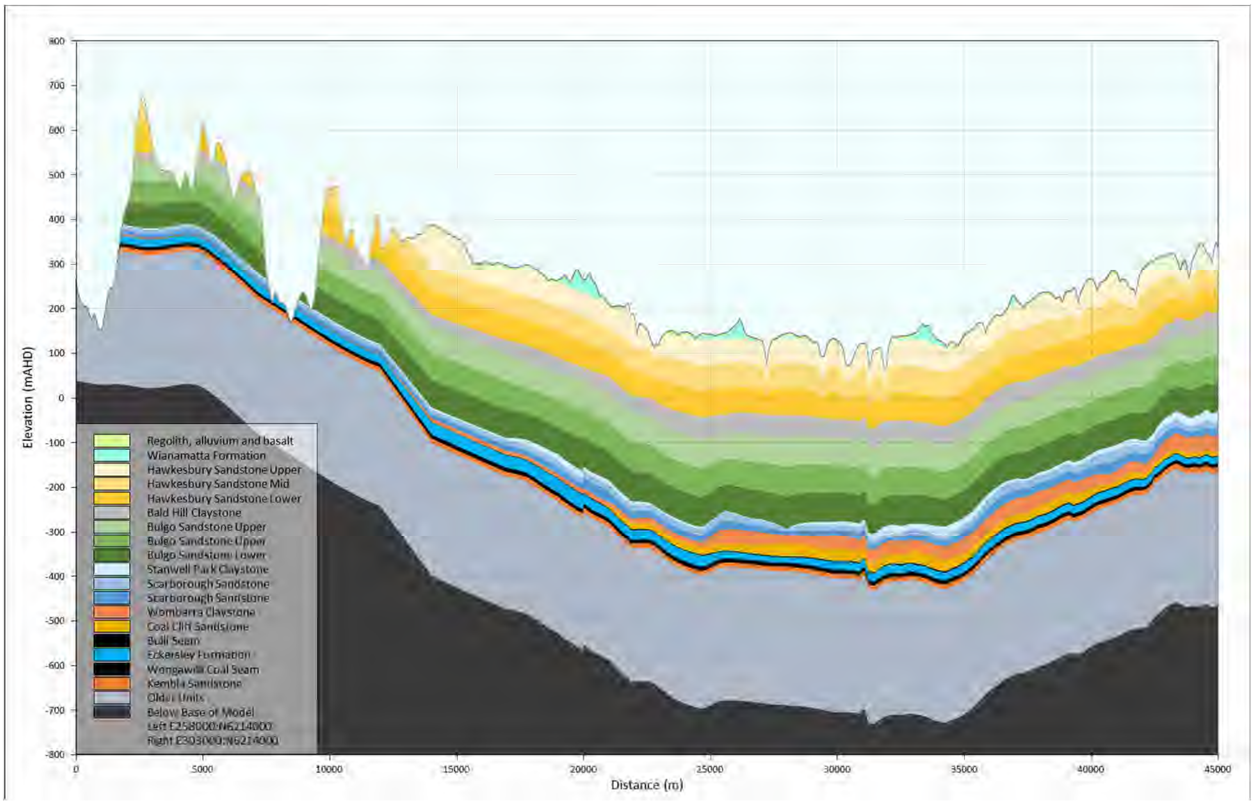

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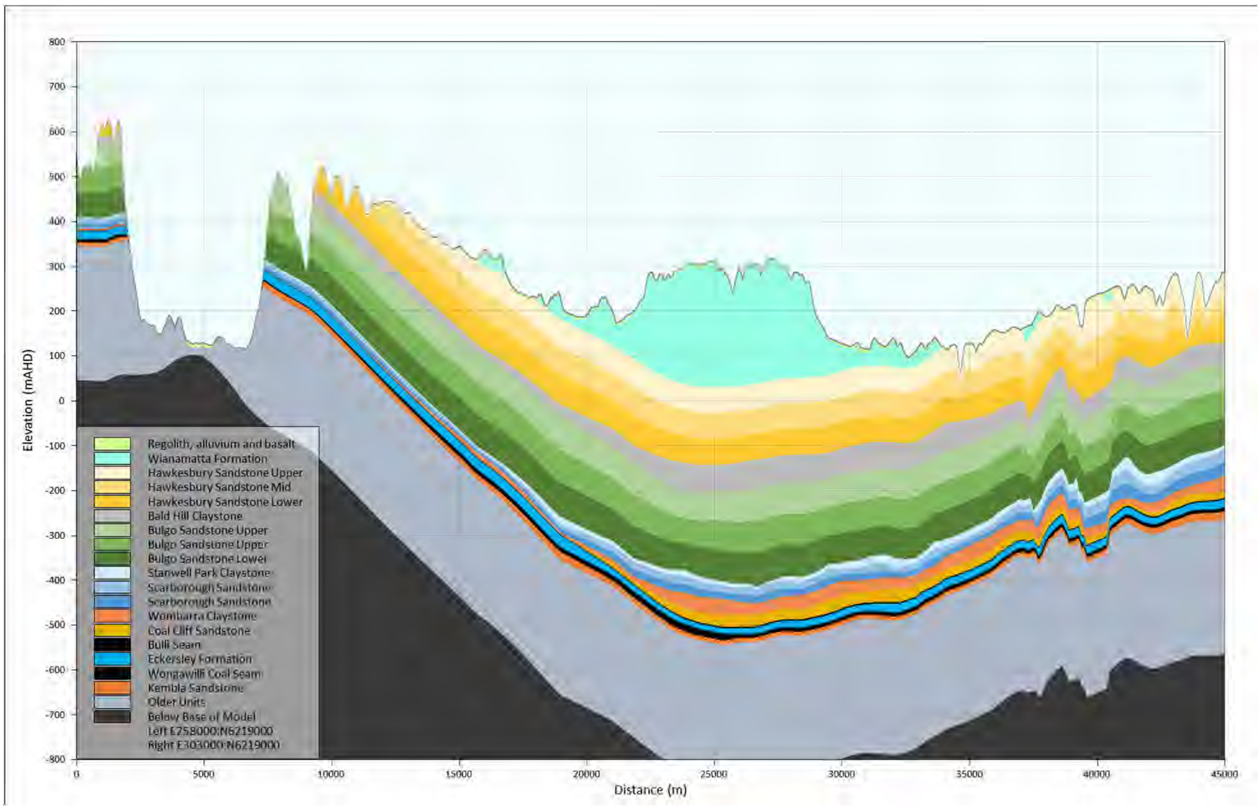
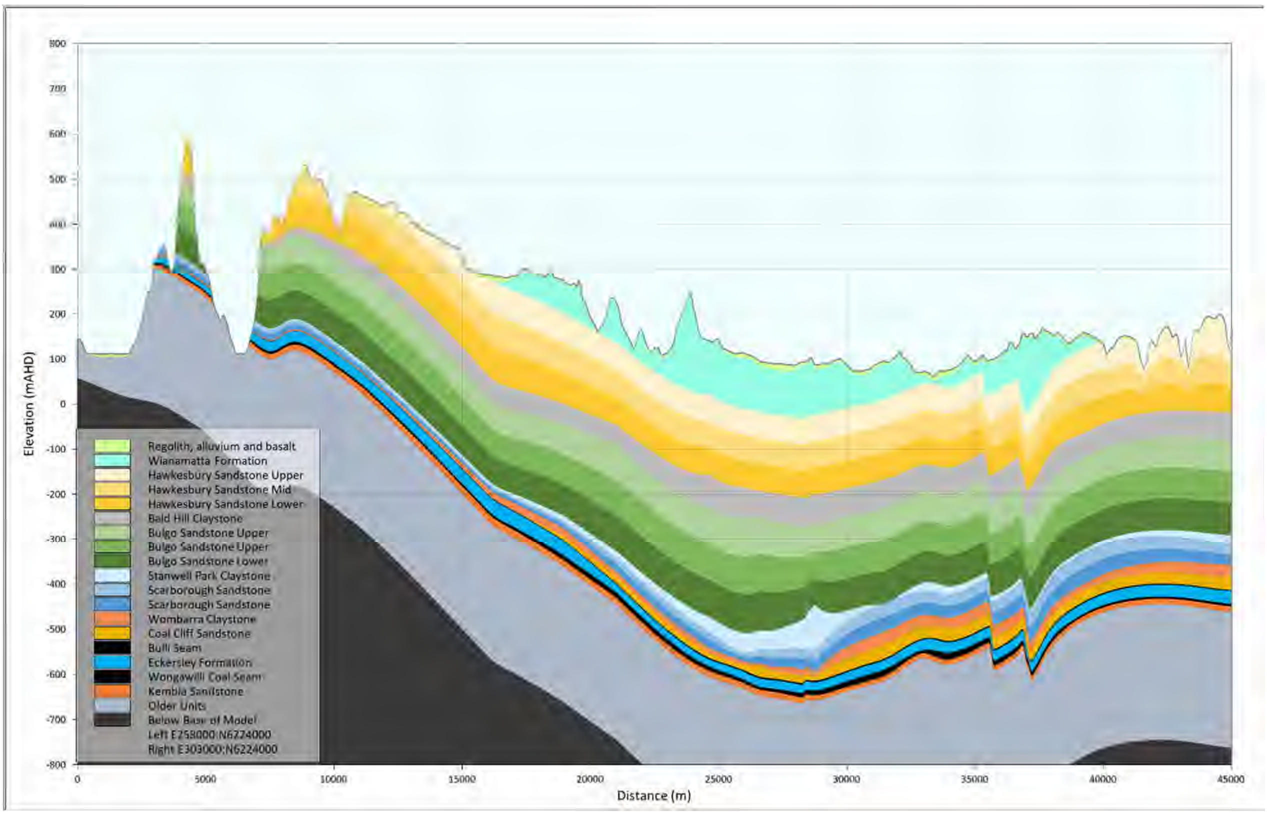
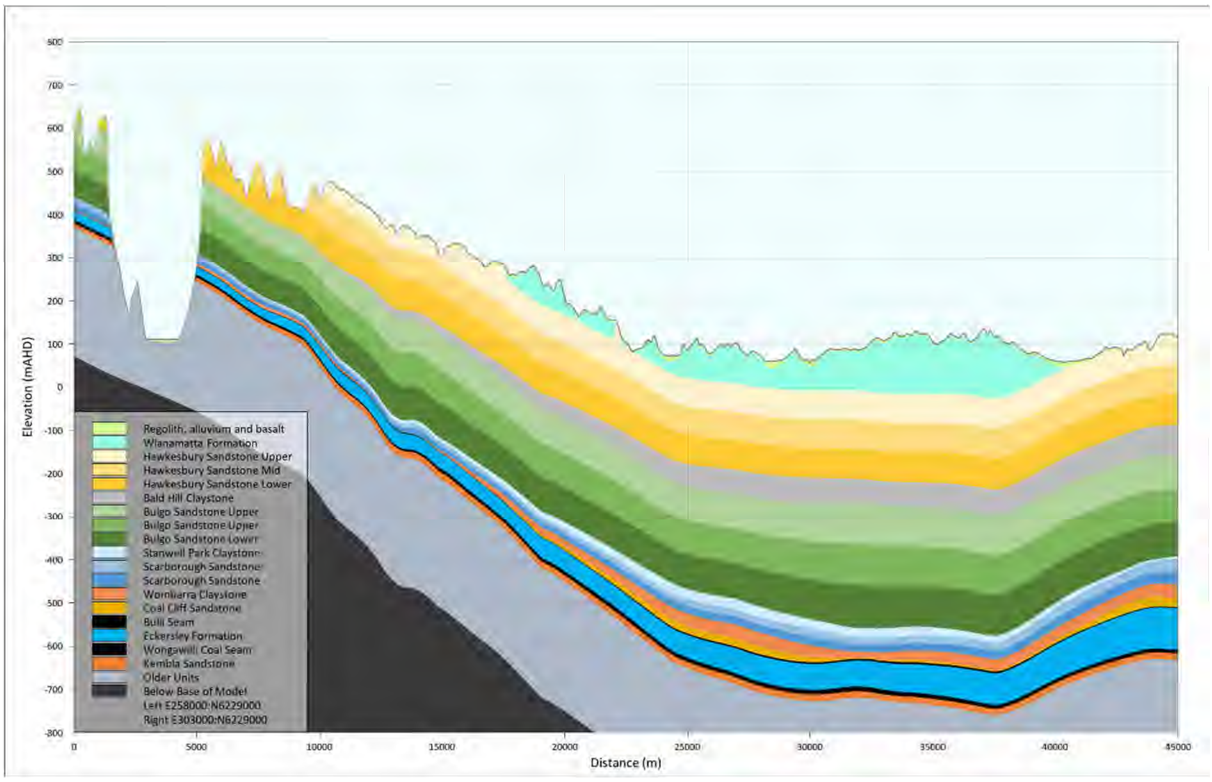


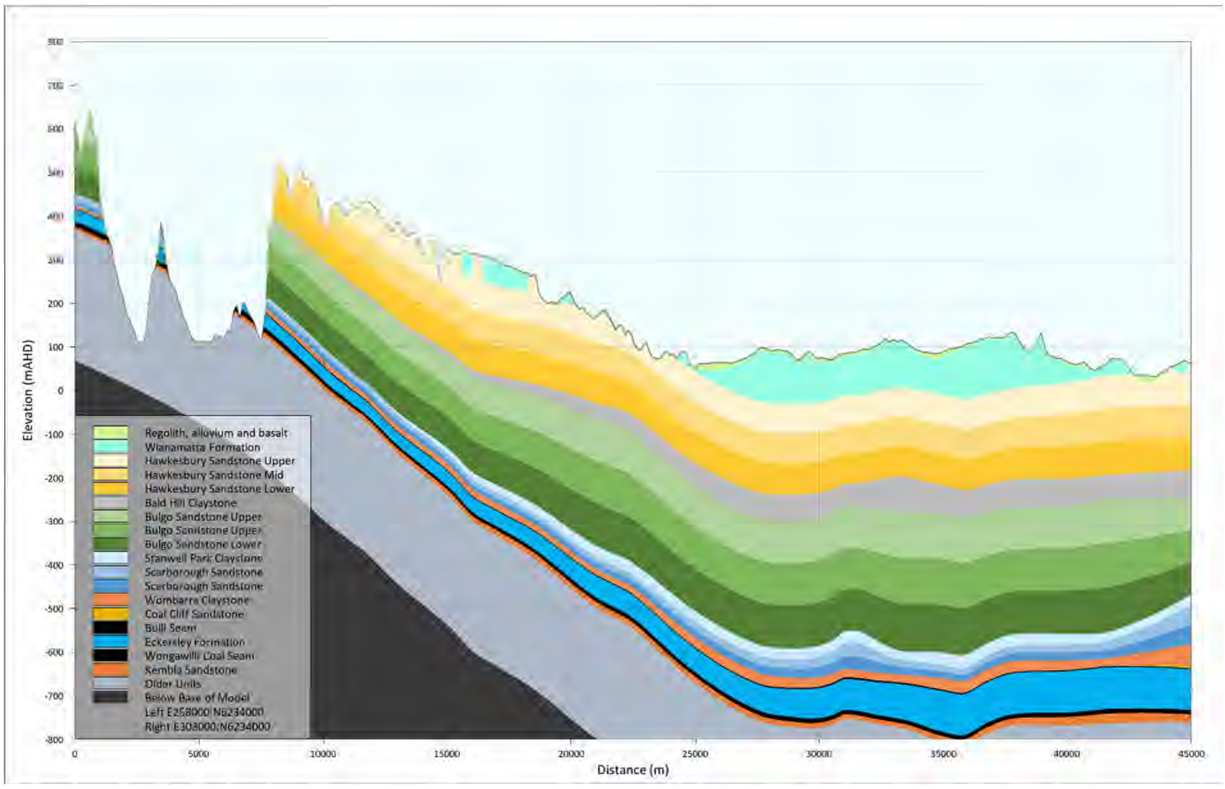
Cross-Section I-I’



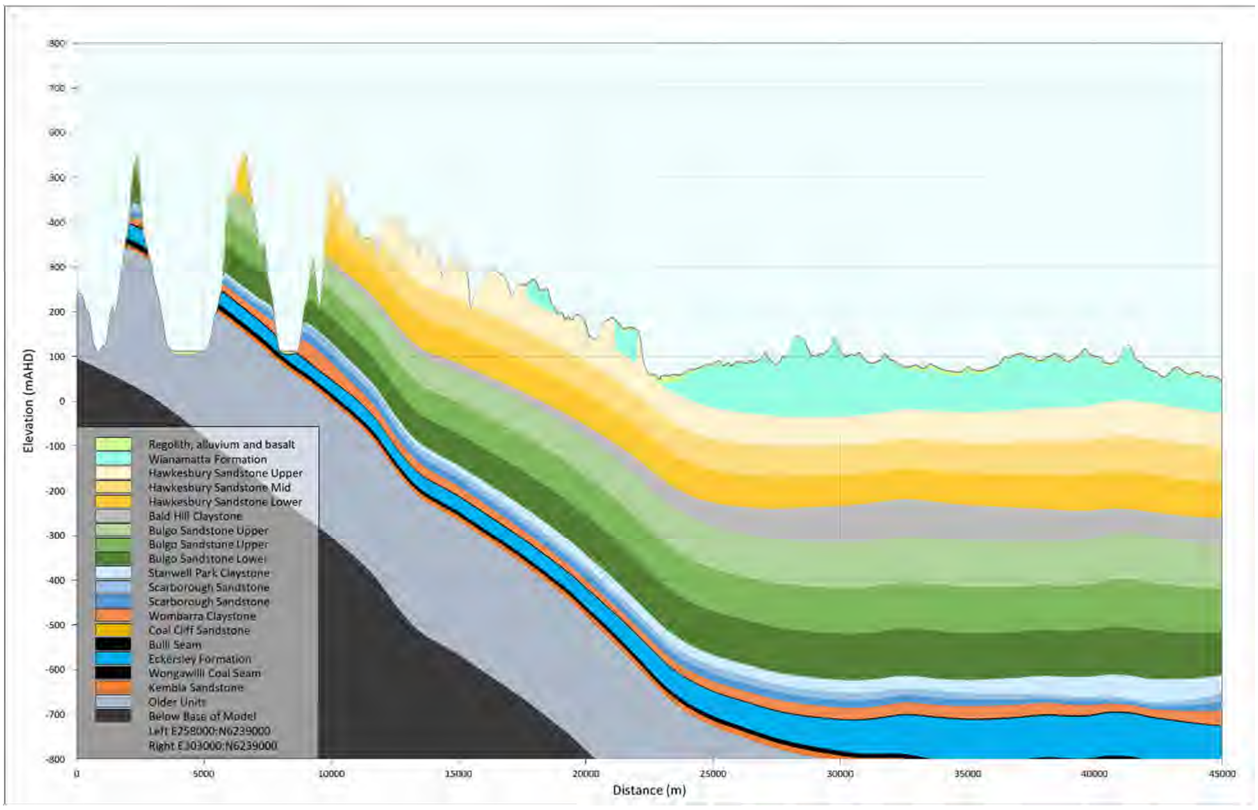
Cross-Section J-J’



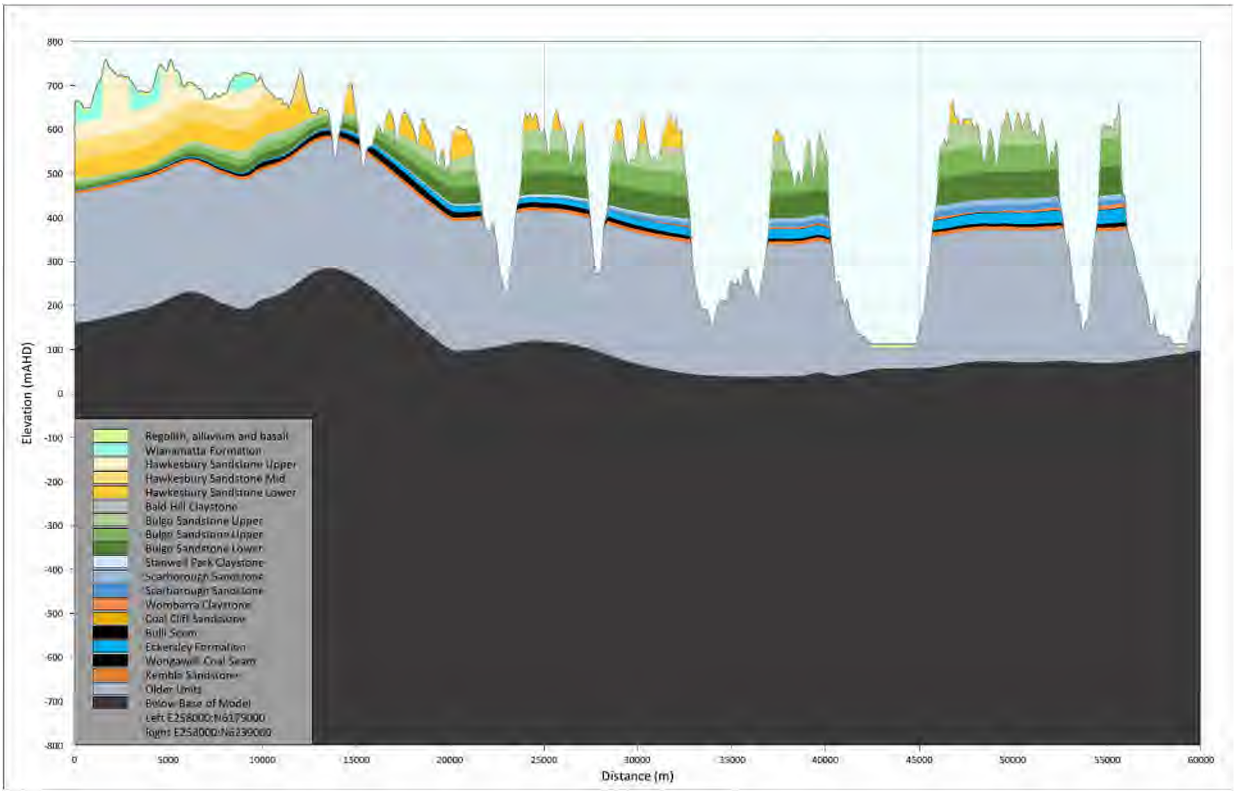
Cross-Section K-K’



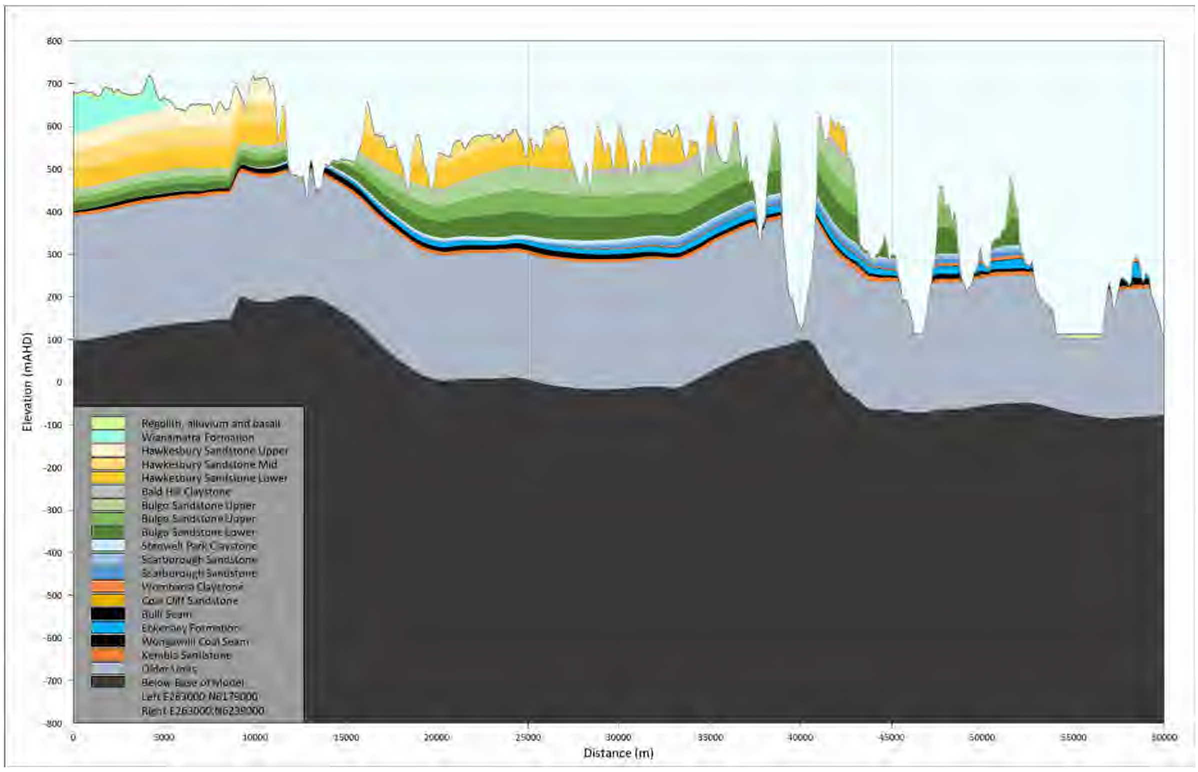
Cross-Section L-L’



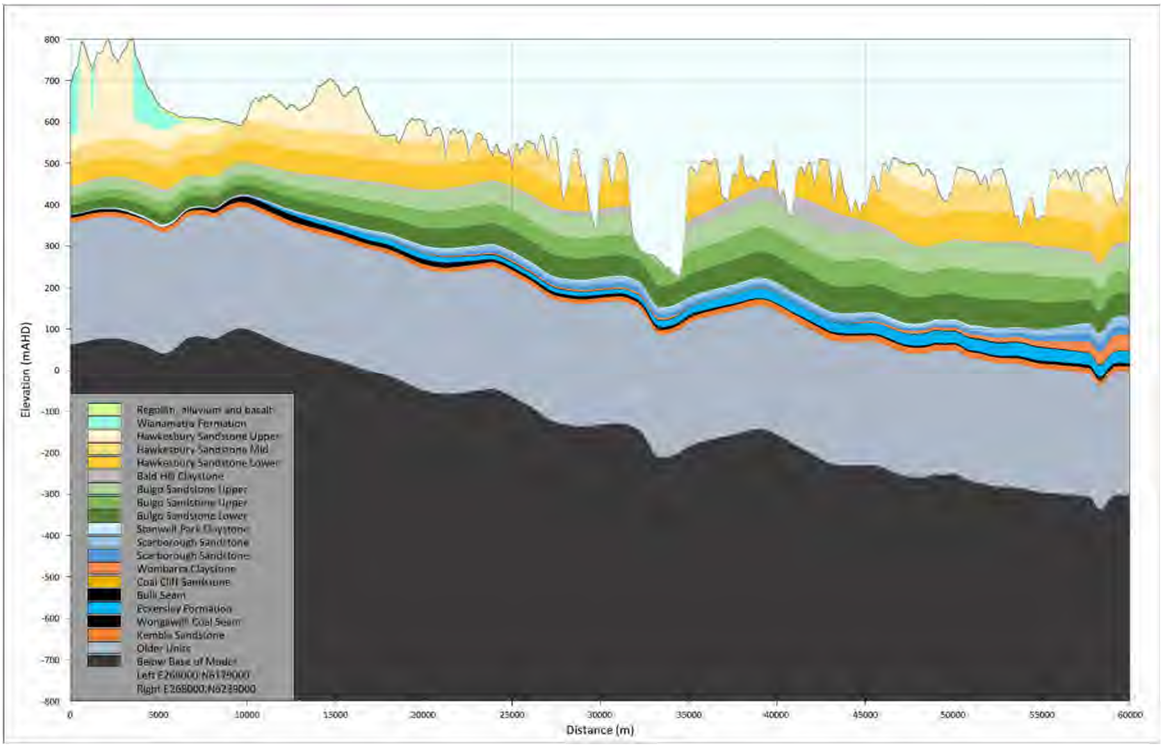
Cross-Section M-M’



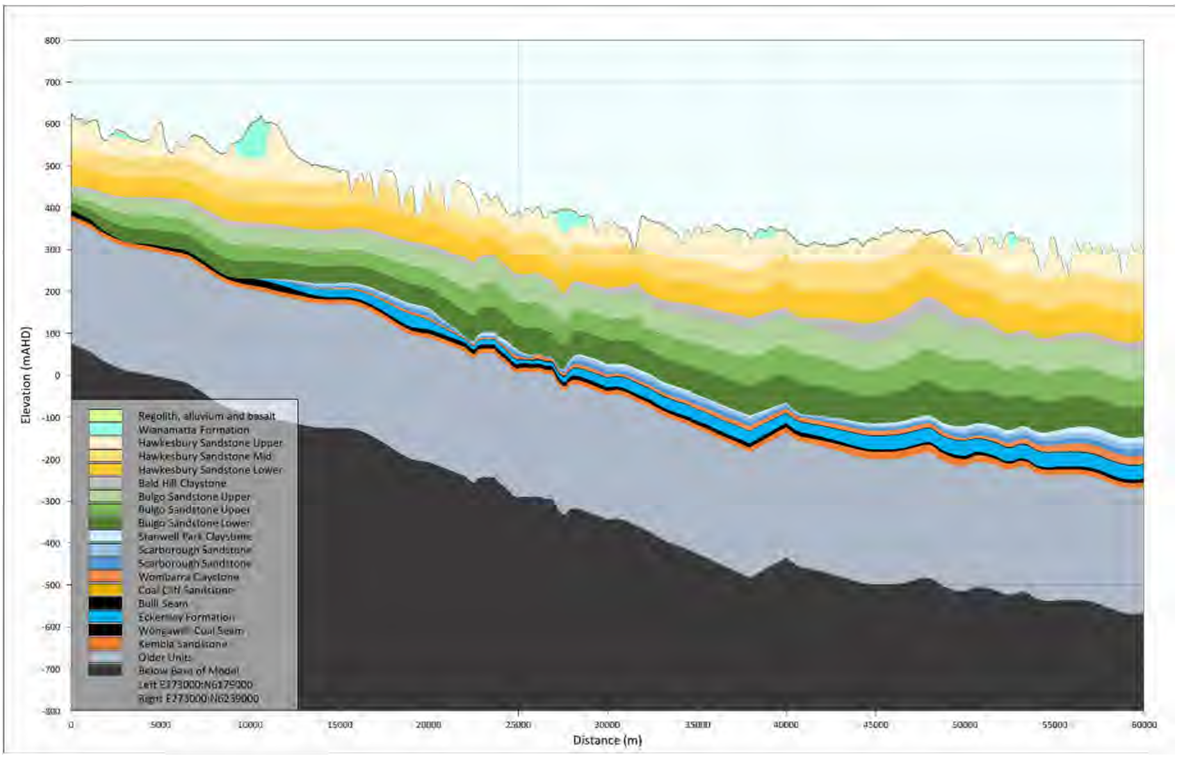
Cross-Section AA-AA'



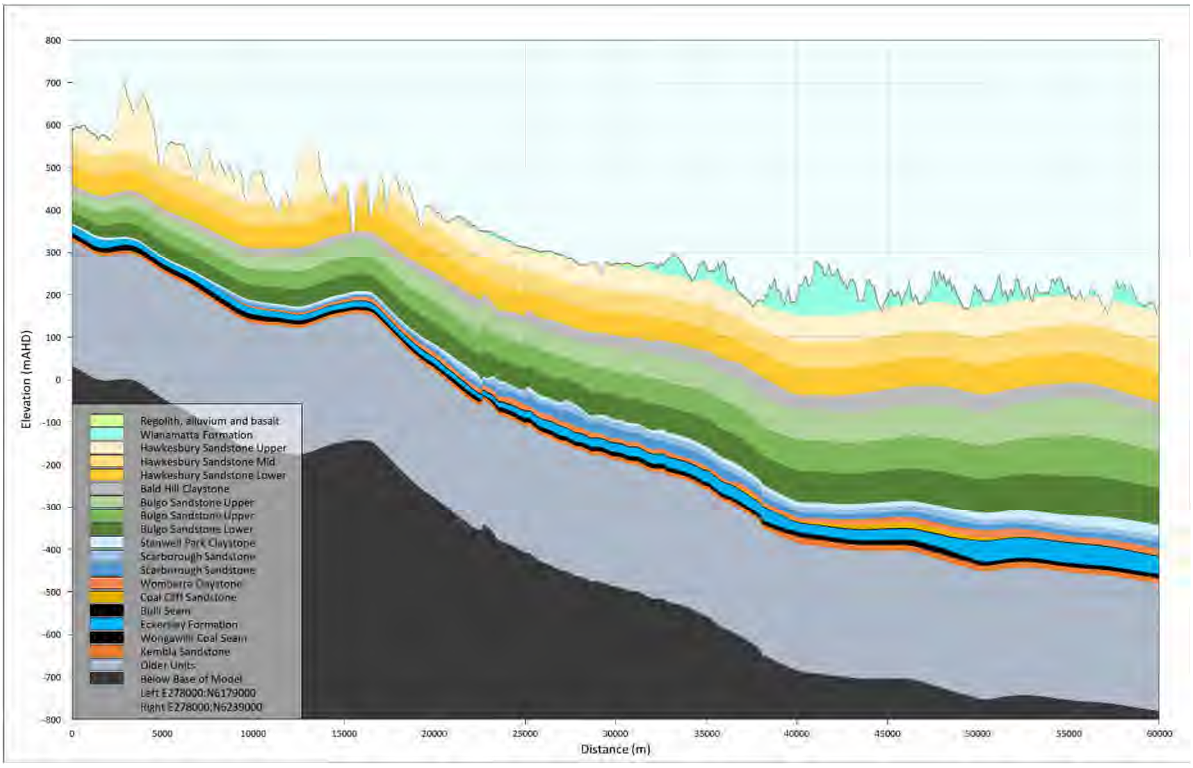
Cross-Section BB-BB'



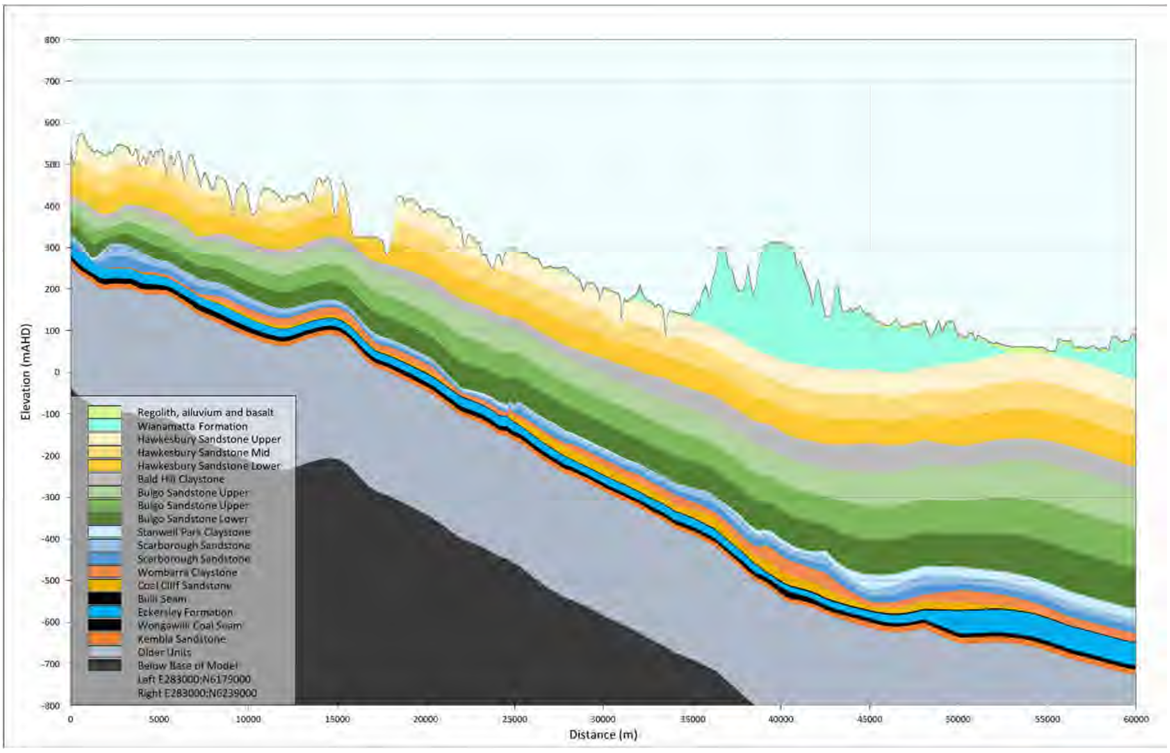
Cross-Section CC-CC'



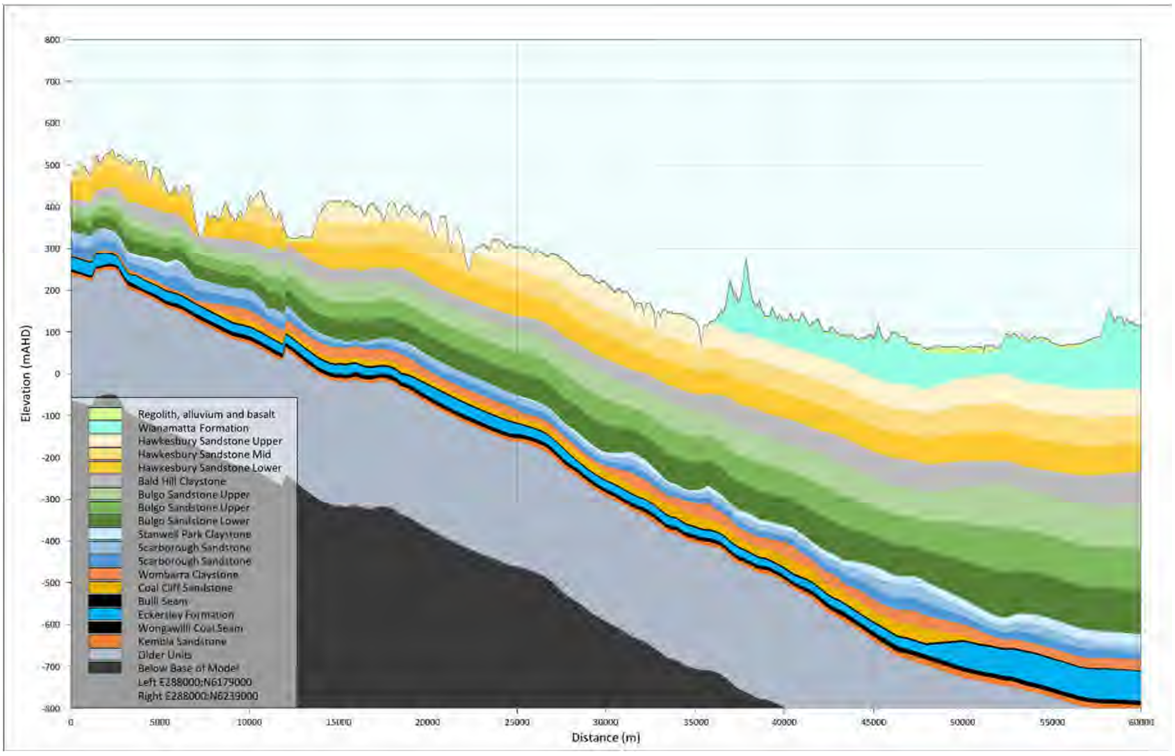
Cross-Section DD-DD'



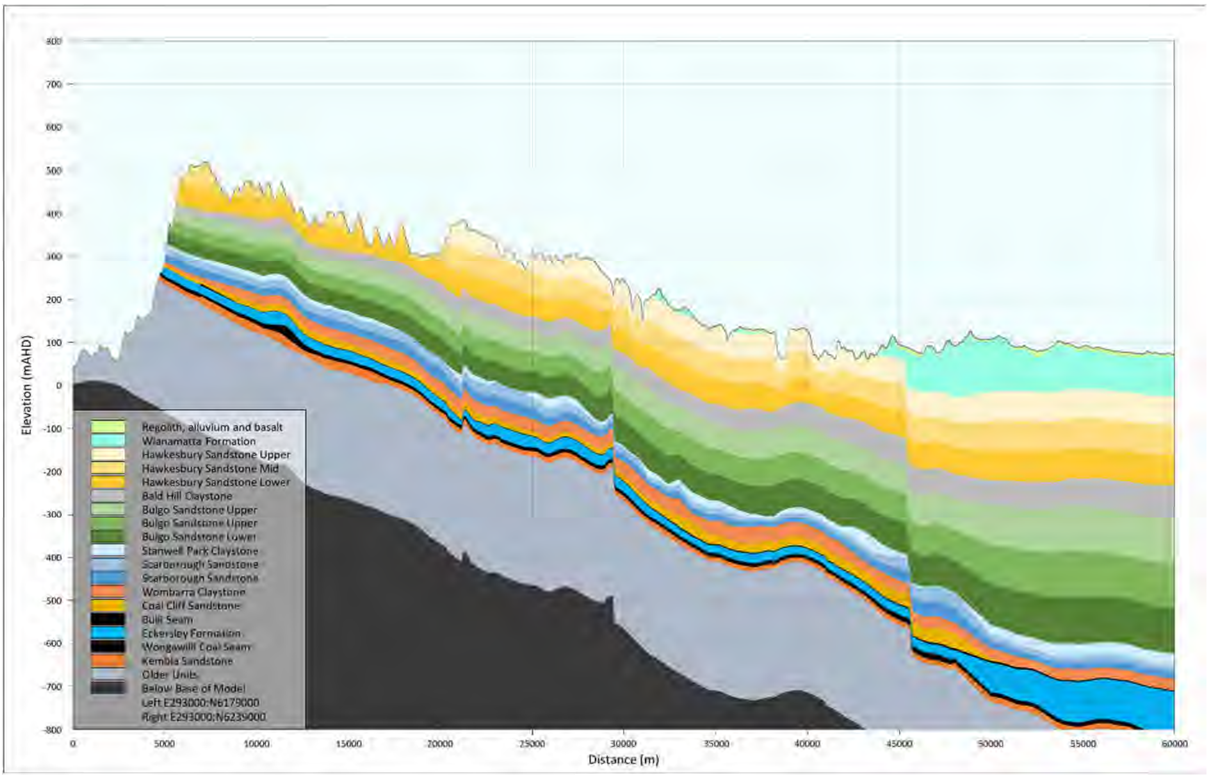
Cross-Section EE-EE'



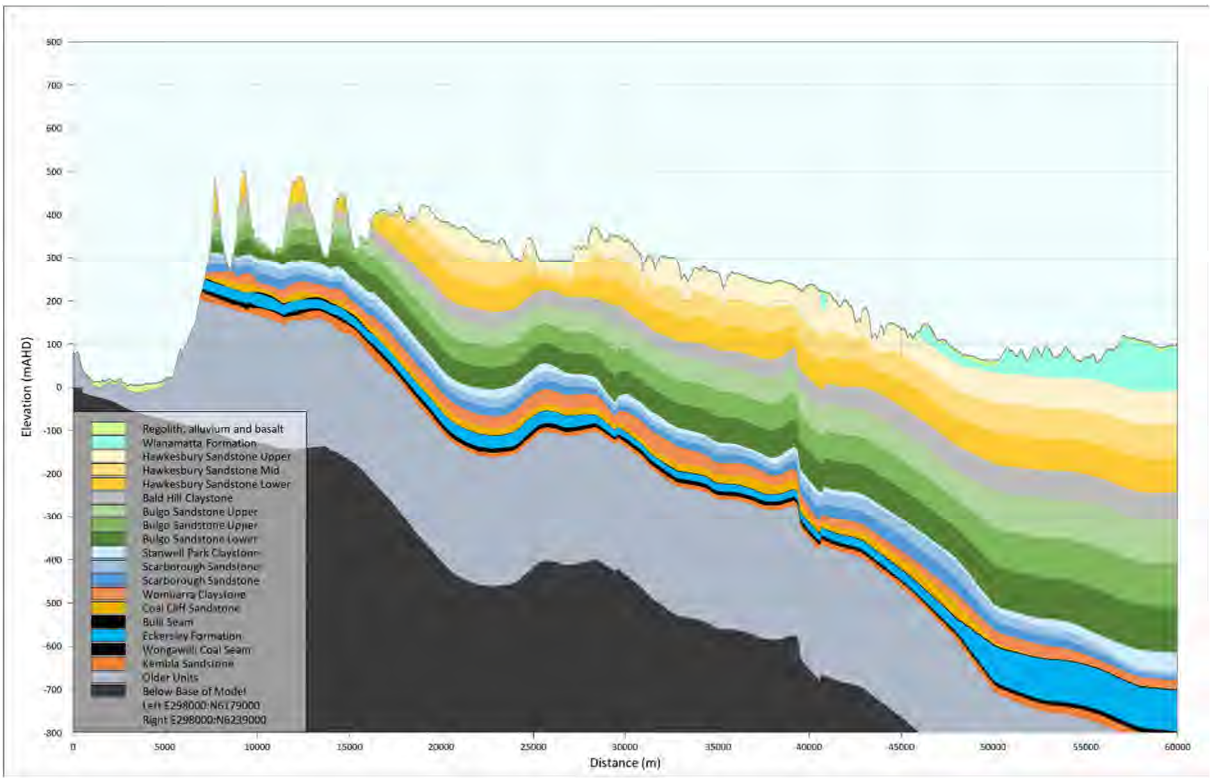
Cross-Section FF-FF'



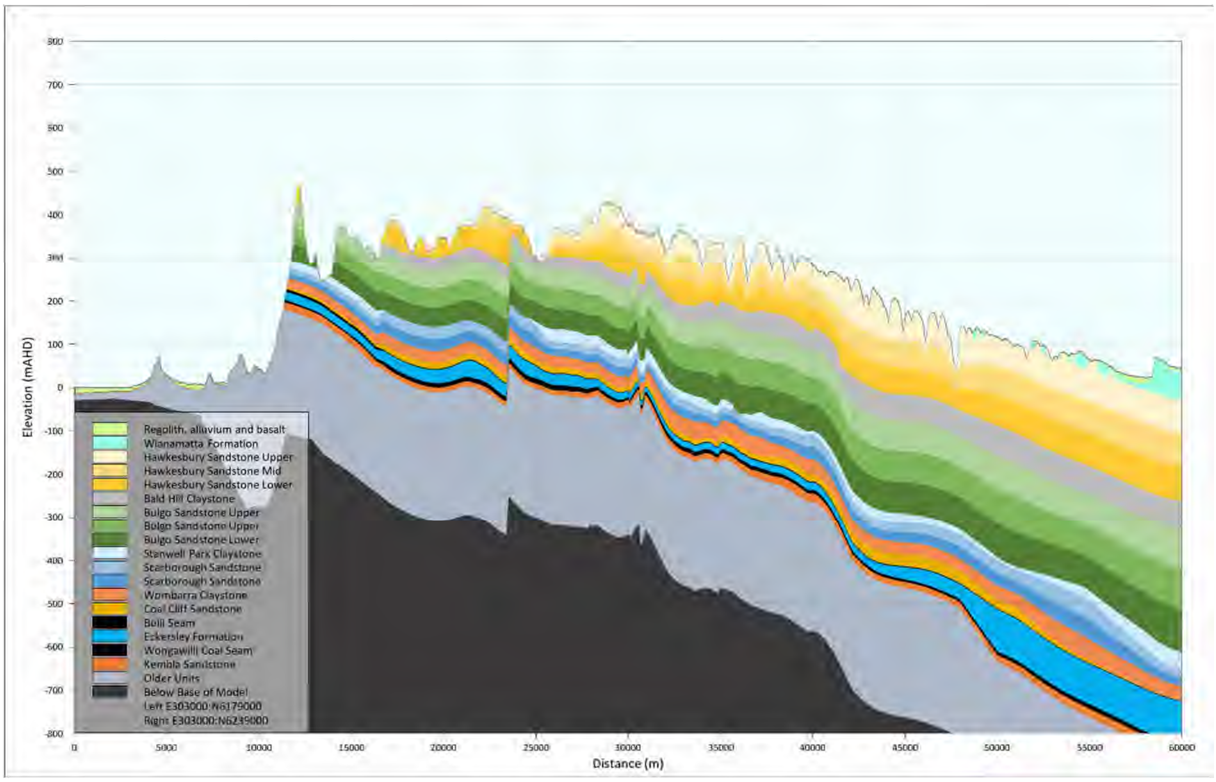
Cross-Section GG-GG’



Cross-Section HH-HH’



Cross-Section II-II'



Cross-Section JJ-JJ'

APPENDIX B

Calibration Bores and Average Residuals

Bore ID	Easting	Northing	Mode Layer	Average Residual
A3GW1B	292997	6210540	4	12.3
A3GW1C	292997	6210540	4	41.4
A3GW2A	293674	6210776	4	7.8
A3GW2C	293674	6210776	4	46.0
A3GW3A	293974	6210832	4	-0.1
A3GW3C	293974	6210832	4	50.2
A3GW4A	293640	6209537	4	0.4
A3GW4B	293640	6209537	4	31.6
A3GW5B	294222	6210572	4	23.1
A3GW5C	294222	6210572	4	55.3
A3GW6A	294482	6209688	4	1.0
A3GW6C	294482	6209688	4	56.0
A3GW7A	292988	6210942	4	0.0
A3GW7C	292988	6210942	4	52.9
A3GW8A	293646	6209862	4	2.9
A3GW8C	293646	6209862	4	47.6
EAW7_BGSS2	291374	6217922	8	-11.0
EAW7_HBSS1	291374	6217922	2	-8.8
EAW7_HBSS2	291374	6217922	5	-56.2
EAW7_SBSS1	291374	6217922	11	2.8
EAW7_SBSS2	291374	6217922	12	2.0
F6GW4A_512	312531	6216694	12	-30.7
GR27	297111	6216174	4	54.5
GR28	296752	6216617	4	55.9
GR70	296778	6217610	4	45.5
GW008537	277989	6211214	3	8.4
GW008548	277099	6209867	3	26.8
GW011200	275607	6210735	5	55.3
GW011234	275883	6209314	3	-6.5
GW011299	275291	6209454	3	8.9
GW022245	273516	6207685	8	-8.9
GW032443	276415	6206336	5	16.2
GW035753	276668	6209703	5	9.1
GW037860	275178	6209914	5	3.0
GW042788	280417	6210315	5	-88.6
GW043154	275295	6211427	3	36.0
GW062644_1	294099	6182113	1	-14.9

Bore ID	Easting	Northing	Mode Layer	Average Residual
GW062644_2	294099	6182113	1	-15.1
GW062645_1	293809	6181397	1	-1.0
GW062645_2	293809	6181397	1	-5.1
GW062646_1	293549	6181607	1	12.7
GW062646_2	293549	6181607	1	13.0
GW062647	293537	6182131	1	-16.7
GW062648_1	294158	6181744	1	-8.2
GW062648_2	294158	6181744	1	-8.2
GW075051_1	293653	6230678	1	-3.0
GW075051_2	293653	6230678	1	-2.9
GW075052	293780	6230814	1	10.0
GW075054	294182	6230146	1	-3.1
GW075056_1	294319	6229794	1	-3.4
GW075056_2	294319	6229794	1	-3.3
GW075057_1	292003	6230930	2	2.5
GW075057_2	292003	6230930	2	2.8
GW075098	292997	6210540	7	-52.2
GW075409	273772	6209569	16	87.0
GW075409_1	273774	6209555	1	2.4
GW075409_2	273774	6209555	5	9.3
GW075410	273034	6210587	16	24.4
GW075410_1	273000	6210570	1	0.9
GW075411	274232	6210996	16	65.1
GW075411_1	274240	6211004	4	20.6
GW104090	278208	6215913	5	49.6
GW105356	277217	6200741	3	52.8
GW107140	283491	6224497	5	-59.5
GW108242	263166	6201260	8	-21.7
GW108276	271905	6224809	5	44.7
GW108389	268657	6187413	5	23.2
GW108414	267201	6189096	6	10.2
GW108415	277750	6200567	5	9.2
GW108451	271400	6185153	6	19.1
GW108542	267804	6187586	6	-10.4
GW108615	273015	6222473	5	44.3
GW108667	276603	6229529	5	-4.0
GW108765	267838	6190765	5	19.5

Bore ID	Easting	Northing	Mode Layer	Average Residual
GW108786	269560	6225662	5	-4.5
GW108826	271577	6187194	5	17.3
GW108842	282500	6204716	5	-14.0
GW108907	288602	6218547	16	-21.3
GW108908	275336	6233491	5	10.8
GW108930	272663	6191760	5	41.9
GW108981	276641	6210801	5	10.6
GW109010	278173	6211781	5	-23.2
GW109012	270596	6218276	3	61.1
GW109032	271824	6206636	4	91.8
GW109159	280600	6211398	1	-70.0
GW109163	273788	6224577	5	42.8
GW109203	274797	6212250	5	18.6
GW109224	279140	6211222	5	-21.4
GW109257	276603	6205052	4	-15.9
GW109278	286012	6210468	5	7.7
GW109279	286688	6210293	6	-3.4
GW109315	292422	6224028	2	11.0
GW109630	275883	6209314	4	21.5
GW109950	276471	6200106	1	35.9
GW110185	274345	6221032	5	59.7
GW110230	267317	6189032	6	16.7
GW110231	267574	6188751	8	-6.2
GW110300	274632	6223345	5	20.1
GW110413	291837	6224389	5	-21.3
GW110435	279215	6209715	5	-10.3
GW110436	279363	6209869	5	-32.6
GW110550	283788	6218949	16	-104.6
GW110562	274626	6226744	5	30.0
GW110586	288755	6226962	1	-3.9
GW110587	288139	6227101	2	-20.7
GW110613	281442	6215610	5	-10.5
GW110669	275711	6210081	4	31.5
GW110671	288717	6216340	16	-47.5
GW110708	284529	6227139	5	-47.3
NGW10	276952	6217333	5	-32.7
NGW11	277105	6217625	5	-14.6

Bore ID	Easting	Northing	Mode Layer	Average Residual
NGW3	275027	6216750	15	-10.1
NGW4	275790	6216826	15	-22.7
NGW5	276124	6216327	15	-27.9
NGW6	276403	6216681	6	-29.2
NGW7	277027	6216591	5	-26.2
NGW9	277737	6217131	5	-3.4
NRE3_BGSS1	294803	6201954	8	74.0
NRE3_HBSS2	294803	6201954	3	46.5
NRE3_HBSS3	294803	6201954	5	71.2
P1	276603	6210937	4	46.0
P10A	279054	6213915	4	-0.3
P10B	279052	6213917	4	-2.7
P10C	279055	6213922	4	-11.8
P11	279246	6214229	4	-0.2
P12A	277771	6216561	4	-24.9
P12B	277776	6216560	4	-24.5
P12C	277781	6216559	4	-22.0
P13A	278180	6216550	4	-25.1
P13B	278175	6216554	4	-26.2
P13C	278170	6216558	4	-24.0
P14A	278398	6216536	1	-1.2
P14B	278393	6216534	4	-25.0
P14C	278397	6216542	4	-24.8
P14D	278391	6216540	4	-26.5
P15A	278550	6216426	4	-24.9
P15B	278545	6216423	4	-24.8
P15C	278556	6216427	4	-25.0
P15D	278561	6216431	4	-24.6
P16A	277370	6215105	4	5.6
P16B	277370	6215105	4	-0.9
P16C	277370	6215105	4	-10.3
P17	277935	6217185	4	-19.6
P18A	279286	6211706	4	23.4
P18B	279290	6211708	4	22.6
P19A	278269	6213441	4	4.6
P19B	278275	6213440	4	4.4
P2	277068	6211638	4	26.1

Bore ID	Easting	Northing	Mode Layer	Average Residual
P20A	278293	6211145	4	38.4
P20B	278293	6211145	4	39.2
P21A	278764	6211767	4	33.2
P21B	278761	6211767	4	33.1
P22	278812	6211809	4	33.0
P23	279187	6211749	4	23.7
P24A	279076	6211773	4	28.3
P24B	279080	6211773	4	29.3
P25	279008	6211778	4	31.0
P26	278702	6211758	4	32.8
P27	278667	6211740	4	33.0
P28A	278605	6211698	4	33.3
P28B	278606	6211700	4	32.7
P29A	278275	6213445	4	-4.7
P29B	278961	6213713	4	-1.1
P3	277855	6211741	4	25.1
P30	278861	6213633	4	-1.7
P31A	278086	6213250	4	5.9
P31B	278084	6213247	4	5.2
P32	278391	6213397	4	6.7
P33A	278730	6213572	4	-1.1
P33B	278733	6213570	4	0.3
P34A	277829	6212999	4	16.3
P34B	277832	6213001	4	16.6
P35	277954	6213134	4	10.0
P36	278554	6213519	4	0.1
P4	277190	6213721	4	32.8
P40A	277621	6216160	4	-19.6
P40B	277621	6216160	4	-20.6
P40C	277621	6216160	4	-23.8
P40D	277621	6216160	4	-27.9
P41A	279167	6216068	2	-0.1
P41B	279167	6216068	4	-13.1
P41C	279167	6216068	4	-26.6
P41D	279167	6216068	4	-27.9
P41E	279167	6216068	4	-21.9
P41F	279167	6216068	4	-22.5

Bore ID	Easting	Northing	Mode Layer	Average Residual
P5	276610	6214305	4	19.3
P6	280250	6210700	4	-70.0
P7	278945	6209713	4	22.8
P8	279400	6209887	4	-24.8
P9_V1	278843	6213724	1	-2.2
P9_V2	278843	6213724	1	-3.1
P9_V3	278843	6213724	3	-6.3
P9A	278843	6213724	4	-0.5
P9C	278835	6213717	4	-1.2
PHGW2A_182	312322	6217752	3	-3.0
PM01_218	309971	6217271	5	35.8
PM02_220	310650	6218509	9	11.8
PT1	277358	6207495	1	-36.4
PT2	277396	6207663	2	12.5
PT4	276872	6207332	2	8.8
REA1	278362	6207827	16	26.0
REA2	278441	6206332	16	-12.0
REA3	277821	6206453	NA	-9.9
REA4	277651	6206835	NA	-21.1
REA5	277424	6206769	NA	-4.6
REA6	278643	6207215	16	-1.5
REA7	278035	6207307	16	-15.3
S1183	284603	6224088	16	-18.8
S1185	285630	6222694	17	-19.0
S1189_683	288526	6225112	15	36.6
S1274	289902	6226042	3	83.3
S1499_478	287668	6210479	17	80.6
S1543	297025	6217066	7	-60.0
S1567_522	292172	6215939	4	-6.0
S1733	293865	6208136	8	-4.8
S1752	292649	6209302	9	-42.9
S1778	294900	6218077	12	-82.3
S1852_574	290534	6216837	5	36.6
S1857_475	294674	6218972	9	-79.3
S1885_203	291504	6192668	8	-27.2
S1885_260	291504	6192668	8	-32.9
S1885_280	291504	6192668	12	-40.5

Bore ID	Easting	Northing	Mode Layer	Average Residual
S1885_288	291504	6192668	12	-12.3
S1885_296	291504	6192668	12	-48.7
S1885_314	291504	6192668	13	-54.9
S1885_340	291504	6192668	15	-68.6
S1885_51	291504	6192668	4	47.2
S1885_93	291504	6192668	4	22.9
S1886_38	295884	6191720	12	33.1
S1889_10	292245	6192980	4	95.8
S1889_123	292245	6192980	4	24.5
S1889_158	292245	6192980	8	16.0
S1889_269	292245	6192980	8	-23.1
S1889_289	292245	6192980	12	-14.5
S1889_305	292245	6192980	12	-13.4
S1889_347	292245	6192980	15	-29.8
S1890_119	292637	6192491	8	12.3
S1890_213	292637	6192491	8	-16.4
S1890_245	292637	6192491	12	-4.0
S1890_263	292637	6192491	12	-1.2
S1890_281	292637	6192491	13	1.4
S1890_311	292637	6192491	15	-81.2
S1890_73	292637	6192491	4	20.4
S1892_113	291014	6193952	8	-8.9
S1892_191	291014	6193952	8	-33.6
S1892_231	291014	6193952	12	-16.3
S1892_257	291014	6193952	12	-18.6
S1892_49	291014	6193952	4	13.7
S1892_8	291014	6193952	4	38.9
S1902_15	295241	6190780	9	37.8
S1902_35	295241	6190780	12	56.3
S1902_55	295241	6190780	11	44.3
S1902_75	295241	6190780	14	69.2
S1907_11	293212	6191943	5	22.0
S1907_169	293212	6191943	8	11.0
S1907_204	293212	6191943	12	26.7
S1907_209	293212	6191943	12	26.5
S1907_21	293212	6191943	5	20.5
S1907_256	293212	6191943	15	-101.3

Bore ID	Easting	Northing	Mode Layer	Average Residual
S1907_65	293212	6191943	8	37.4
S1908_10	288926	6193601	4	74.1
S1908_154	288926	6193601	4	20.0
S1908_201	288926	6193601	8	-40.0
S1908_276	288926	6193601	8	-107.4
S1908_412	288926	6193601	17	-3.8
S1910_125	289387	6194176	4	-12.2
S1910_169	289387	6194176	8	-25.9
S1910_247	289387	6194176	8	-34.1
S1910_273	289387	6194176	12	-34.0
S1910_313	289387	6194176	12	-49.7
S1910_9	289387	6194176	4	49.8
S1911_135	288803	6192549	4	-3.4
S1911_187	288803	6192549	8	-22.7
S1911_229	288803	6192549	8	-76.3
S1911_277	288803	6192549	8	-52.1
S1911_301	288803	6192549	12	-52.1
S1911_331	288803	6192549	13	-77.7
S1911_68	288803	6192549	4	28.6
S1913_137	289028	6218729	11	-36.9
S1913_194	289028	6218729	12	-47.0
S1913_447	289028	6218729	3	21.6
S1913_473	289028	6218729	9	35.4
S1913_505	289028	6218729	17	40.5
S1913_559	289028	6218729	15	19.9
S1914_147	289370	6192512	4	-2.1
S1914_187	289370	6192512	8	-10.2
S1914_300	289370	6192512	12	-48.6
S1914_330	289370	6192512	12	-63.6
S1925_10	289252	6193041	4	91.6
S1925_144	289252	6193041	4	-9.8
S1925_202	289252	6193041	8	-31.4
S1925_295	289252	6193041	8	-82.5
S1925_320	289252	6193041	12	-78.9
S1925_342	289252	6193041	12	-85.7
S1925_383	289252	6193041	15	-80.4
S1926_10	289660	6193445	4	73.0

Bore ID	Easting	Northing	Mode Layer	Average Residual
S1926_139	289660	6193445	4	14.6
S1926_192	289660	6193445	8	9.6
S1926_289	289660	6193445	8	-37.0
S1926_313	289660	6193445	12	-41.0
S1926_337	289660	6193445	12	-43.7
S1926_378	289660	6193445	15	-65.6
S1927_133	290066	6192211	4	-24.6
S1927_176	290066	6192211	8	-25.3
S1927_254	290066	6192211	8	-36.1
S1927_270	290066	6192211	12	-49.2
S1927_316	290066	6192211	12	-105.7
S1927_9	290066	6192211	4	72.0
S1929_114	290011	6193398	8	-32.7
S1929_207	290011	6193398	8	-37.1
S1929_236	290011	6193398	12	-37.7
S1929_260	290011	6193398	12	-41.2
S1929_76	290011	6193398	4	-20.5
S1929_8	290011	6193398	4	6.0
S1930_123	290367	6193583	8	-15.6
S1930_168	290367	6193583	8	-20.8
S1930_219	290367	6193583	8	-24.4
S1930_248	290367	6193583	12	-31.3
S1930_260	290367	6193583	12	-38.5
S1930_273	290367	6193583	12	-34.7
S1930_45	290367	6193583	4	-1.1
S1930_87	290367	6193583	4	-35.8
S1930_9	290367	6193583	4	29.9
S1931_120	290336	6192890	5	-42.0
S1931_136	290336	6192890	6	-27.6
S1931_151	290336	6192890	8	-3.0
S1931_157	290336	6192890	8	3.2
S1931_245	290336	6192890	8	-25.3
S1931_279	290336	6192890	12	-48.2
S1931_301	290336	6192890	12	-105.9
S1932_148	288863	6191505	8	16.2
S1932_194	288863	6191505	8	-7.1
S1932_234	288863	6191505	8	-18.0

Bore ID	Easting	Northing	Mode Layer	Average Residual
S1932_264	288863	6191505	12	-8.5
S1932_272	288863	6191505	12	-15.1
S1932_281	288863	6191505	12	-2.5
S1932_318	288863	6191505	14	-99.1
S1932_346	288863	6191505	17	-101.0
S1932_48	288863	6191505	4	40.4
S1932_9	288863	6191505	4	62.5
S1932_96	288863	6191505	4	29.5
S1934_38	292128	6192398	4	60.2
S1934_55	292128	6192398	4	44.1
S1934_65	292128	6192398	4	49.8
S1936_123	291547	6217768	4	-33.2
S1936_192	291547	6217768	4	-42.8
S1936_278	291547	6217768	8	26.5
S1936_347	291547	6217768	8	22.9
S1936_422	291547	6217768	8	15.2
S1936_456	291547	6217768	12	45.7
S1936_468	291547	6217768	12	52.6
S1936_556	291547	6217768	15	-70.3
S1936_65	291547	6217768	4	-5.8
S1941_126	287181	6216341	4	-38.9
S1941_201	287181	6216341	4	-50.3
S1941_284	287181	6216341	8	24.4
S1941_355	287181	6216341	8	38.8
S1941_432	287181	6216341	15	95.7
S1941_463	287181	6216341	12	14.0
S1941_472	287181	6216341	12	33.7
S1941_487	287181	6216341	12	68.1
S1941_555	287181	6216341	15	21.7
S1941_596	287181	6216341	17	78.7
S1941_65	287181	6216341	11	9.7
S1947_502	286745	6215509	3	-61.7
S1954_245	285466	6216904	3	-25.6
S1954_273	285466	6216904	4	4.1
S1954_359	285466	6216904	4	-34.8
S1957_518	287632	6215513	4	-66.0
S1969_10	293998	6193986	5	50.2

Bore ID	Easting	Northing	Mode Layer	Average Residual
S1969_128	293998	6193986	8	-1.5
S1969_179	293998	6193986	8	-9.8
S1969_200	293998	6193986	12	12.0
S1969_217	293998	6193986	12	6.6
S1969_235	293998	6193986	12	2.3
S1969_24	293998	6193986	5	38.9
S1969_44	293998	6193986	5	34.0
S1969_83	293998	6193986	8	0.4
S1992_142	293732	6192707	8	11.0
S1992_172	293732	6192707	12	22.3
S1992_182	293732	6192707	12	13.3
S1992_192	293732	6192707	12	15.1
S1992_241	293732	6192707	15	-50.8
S1992_48	293732	6192707	8	28.1
S1992_8	293732	6192707	5	6.7
S1992_92	293732	6192707	8	15.6
S1994_14	293865	6192982	5	7.8
S1994_148	293865	6192982	8	-13.2
S1994_174	293865	6192982	12	55.7
S1994_186	293865	6192982	12	53.8
S1994_199	293865	6192982	12	53.8
S1994_250	293865	6192982	15	16.3
S1994_55	293865	6192982	8	20.6
S1994_99	293865	6192982	8	13.7
S1995_384	288212	6193662	15	-42.6
S1996_159	298772	6207843	4	27.3
S1996_219	298772	6207843	8	19.3
S1996_274	298772	6207843	8	10.3
S1996_313	298772	6207843	8	6.4
S1996_373	298772	6207843	12	-22.9
S1996_439	298772	6207843	14	-32.0
S1996_478	298772	6207843	15	-36.6
S1996_82	298772	6207843	4	51.5
S1997_132	306997	6212764	4	43.0
S1997_218	306997	6212764	8	91.2
S1997_24	306997	6212764	4	103.4
S1997_292	306997	6212764	8	34.0

Bore ID	Easting	Northing	Mode Layer	Average Residual
S1997_372	306997	6212764	8	47.0
S1997_429	306997	6212764	12	89.5
S1997_441	306997	6212764	12	83.2
S1997_511	306997	6212764	15	67.7
S1997_68	306997	6212764	4	87.0
S1998_381	287751	6194273	15	-33.3
S1998_407	287751	6194273	3	-51.0
S1999_313	289233	6190844	15	-18.7
S1999_342	289233	6190844	17	-45.1
S2000_357	290161	6191011	15	-29.2
S2001_65	288463	6192020	4	37.3
S2004_340	290538	6190795	15	-66.6
S2004_372	290538	6190795	17	-96.7
S2006_140	287263	6194204	4	10.6
S2006_192	287263	6194204	8	-18.5
S2006_244	287263	6194204	8	-35.1
S2006_302	287263	6194204	8	-45.6
S2006_320	287263	6194204	12	-48.6
S2006_329	287263	6194204	12	-48.9
S2006_370	287263	6194204	15	-45.5
S2006_396	287263	6194204	17	-29.5
S2006_72	287263	6194204	4	28.4
S2007_360	287591	6193719	14	-23.4
S2007_386	287591	6193719	17	-22.4
S2009_100	287828	6193092	4	2.9
S2009_132	287828	6193092	4	-0.4
S2009_185	287828	6193092	8	-2.2
S2009_220	287828	6193092	8	-22.4
S2009_261	287828	6193092	8	-42.3
S2009_295	287828	6193092	12	-26.0
S2009_309	287828	6193092	12	-24.5
S2009_366	287828	6193092	15	-5.8
S2009_68	287828	6193092	4	26.7
S2010_371	292273	6196658	17	-35.5
S2011_360	292055	6197166	15	-38.2
S2011_385	292055	6197166	17	-38.2
S2019_325	291898	6195914	15	-56.2

Bore ID	Easting	Northing	Mode Layer	Average Residual
S2019_351	291898	6195914	17	-65.7
S2036_374	300016	6206726	15	-14.9
S2036_411	300016	6206726	17	-15.3
S2057_691	284047	6221149	16	3.5
S2059_113	293246	6194795	8	14.2
S2059_151	293246	6194795	8	0.8
S2059_195	293246	6194795	8	-8.8
S2059_221	293246	6194795	12	-50.7
S2059_242	293246	6194795	12	-58.2
S2059_263	293246	6194795	12	-45.8
S2059_33	293246	6194795	5	41.4
S2059_340	293246	6194795	17	-87.9
S2059_61	293246	6194795	5	19.7
S2059_79	293246	6194795	5	24.1
S2060_110	288629	6215792	4	-3.5
S2060_267	288629	6215792	4	-53.2
S2064_235	285967	6195946	8	-69.0
S2064_285	285967	6195946	8	-39.7
S2064_373	285967	6195946	15	73.2
S2064_401	285967	6195946	17	1.3
S2070_361	287619	6192813	15	-95.2
S2071_365	287027	6193201	15	-38.0
S2071_392	287027	6193201	17	-41.4
S2073_359	284405	6197510	15	-33.3
S2073_385	284405	6197510	17	-45.2
S2076_401	288651	6197693	15	-22.8
S2076_428	288651	6197693	17	-35.2
S2080_417	289803	6215342	12	3.5
S2080_440	289803	6215342	3	21.3
S2080_447	289803	6215342	4	34.3
S2080_499	289803	6215342	3	-70.0
S2080_95	289803	6215342	10	95.3
S2082_377	285488	6197607	15	-26.6
S2087_185	295752	6217628	4	-11.0
S2087_238	295752	6217628	8	-29.4
S2087_313	295752	6217628	8	-12.6
S2087_394	295752	6217628	8	-8.9

Bore ID	Easting	Northing	Mode Layer	Average Residual
S2087_419	295752	6217628	12	-3.2
S2087_440	295752	6217628	12	-1.3
S2087_55	295752	6217628	4	36.9
S2106	285056	6218762	15	16.4
S2129_722	283453	6217968	16	1.6
S2132	283609	6214020	16	88.4
S2133	284168	6218810	17	37.5
S2149_121	282415	6215044	4	-14.1
S2149_262	282415	6215044	8	50.2
S2149_326	282415	6215044	8	50.1
S2149_65	282415	6215044	4	7.1
S2150	282971	6214153	16	70.9
S2151_552	283019	6215017	9	-63.6
S2151_BUCO	283019	6215017	15	-30.7
S2151_WWCO	283019	6215017	17	-25.7
S2152	284156	6215534	16	82.5
S2157_135	283212	6215968	4	41.8
S2157_207	283212	6215968	4	-18.8
S2157_284	283212	6215968	4	-23.4
S2157_368	283212	6215968	8	31.8
S2157_418	283212	6215968	8	41.3
S2157_468	283212	6215968	8	35.1
S2157_518	283212	6215968	10	27.6
S2157_568	283212	6215968	12	28.0
S2157_626	283212	6215968	15	20.2
S2158_111	283778	6212690	4	-34.1
S2158_218	283778	6212690	8	25.8
S2158_295	283778	6212690	8	34.3
S2158_377	283778	6212690	8	60.3
S2158_404	283778	6212690	12	65.6
S2158_44	283778	6212690	4	-19.6
S2158_473	283778	6212690	15	68.6
S2158_65	283778	6212690	4	-36.6
S2159	283040	6214663	16	48.8
S2160_164	284717	6213651	4	-89.9
S2160_226	284717	6213651	8	1.9
S2160_320	284717	6213651	8	22.0

Bore ID	Easting	Northing	Mode Layer	Average Residual
S2160_367	284717	6213651	10	-3.3
S2160_415	284717	6213651	12	64.5
S2160_479	284717	6213651	15	76.6
S2160_87	284717	6213651	4	-55.8
S2164_BUCO	283894	6214831	15	67.4
S2165_112	288766	6226269	4	-26.4
S2165_168	288766	6226269	4	-26.5
S2165_257	288766	6226269	4	-41.8
S2165_328	288766	6226269	8	3.6
S2165_40	288766	6226269	2	-18.0
S2165_414	288766	6226269	8	5.3
S2165_500	288766	6226269	8	-2.9
S2165_586	288766	6226269	10	-6.0
S2165_694	288766	6226269	15	26.8
S2165_765	288766	6226269	17	-46.2
S2173_198	287589	6223237	4	-49.6
S2173_369	287589	6223237	8	0.2
S2173_451	287589	6223237	8	25.9
S2173_533	287589	6223237	8	23.1
S2173_554	287589	6223237	10	19.3
S2173_596	287589	6223237	12	50.9
S2177_150	291122	6225144	4	-29.6
S2177_220	291122	6225144	4	-25.0
S2177_283	291122	6225144	8	-17.9
S2177_358	291122	6225144	8	-18.5
S2177_434	291122	6225144	8	-11.9
S2177_44	291122	6225144	4	-49.3
S2177_462	291122	6225144	10	-19.5
S2177_510	291122	6225144	12	-7.6
S2177_80	291122	6225144	4	-27.7
S2187_302	295522	6197121	15	-1.8
S2187_331	295522	6197121	17	84.1
S2188_145	296605	6195670	8	23.7
S2188_197	296605	6195670	8	83.4
S2188_235	296605	6195670	12	49.2
S2188_245	296605	6195670	12	110.1
S2188_256	296605	6195670	12	67.0

Bore ID	Easting	Northing	Mode Layer	Average Residual
S2188_304	296605	6195670	15	21.2
S2188_335	296605	6195670	17	22.0
S2188_45	296605	6195670	5	63.4
S2188_93	296605	6195670	8	38.7
S2192_140	289827	6193849	4	-7.8
S2192_175	289827	6193849	8	35.6
S2192_260	289827	6193849	8	40.0
S2192_278	289827	6193849	10	-4.5
S2192_50	289827	6193849	4	12.4
S2192_95	289827	6193849	4	-5.2
S2194_10	288515	6190979	5	43.3
S2194_55	288515	6190979	4	1.5
S2206_401	290893	6199308	15	-34.4
S2206_426	290893	6199308	17	-5.1
S2207_372	291808	6195324	15	-73.4
S2207_397	291808	6195324	17	-103.3
S2208_143	292801	6195037	8	-2.4
S2208_219	292801	6195037	12	-27.2
S2208_229	292801	6195037	12	-22.9
S2208_307	292801	6195037	17	-73.2
S2211_317	293247	6194106	15	-39.8
S2211_350	293247	6194106	18	-98.5
S2212_154	293535	6194403	8	1.2
S2212_215	293535	6194403	8	-6.8
S2212_239	293535	6194403	12	-3.1
S2212_250	293535	6194403	12	-2.6
S2212_260	293535	6194403	12	-6.3
S2212_289	293535	6194403	15	-73.4
S2212_320	293535	6194403	17	-35.7
S2212_370	293535	6194403	19	-27.1
S2212_64	293535	6194403	5	19.1
S2212_92	293535	6194403	8	18.7
S2220_140	289827	6193831	4	-41.0
S2220_50	289827	6193831	4	37.4
S2220_95	289827	6193831	4	2.7
S2280_60	285758	6215275	4	-28.1
S2280_99	285758	6215275	17	-47.6

Bore ID	Easting	Northing	Mode Layer	Average Residual
S2282_100	288787	6215032	4	-32.4
S2282_60	288787	6215032	4	-14.3
S2283_100	288999	6214636	4	-34.9
S2283_60	288999	6214636	4	-15.2
S2284_100	289176	6214454	4	-42.8
S2284_60	289176	6214454	4	-31.6
S2285_100	289248	6214558	4	-39.8
S2285_60	289248	6214558	4	-24.9
S2286_100	289329	6214721	4	-27.4
S2286_60	289329	6214721	4	-11.5
S2288_280	292821	6195049	15	-54.5
S2288_77	292821	6195049	8	18.6
S2291_394	289004	6196840	15	-17.5
S2291_419	289004	6196840	17	-31.1
S2306_10	288643	6192484	4	70.3
S2306_30	288643	6192484	4	56.5
S2306_50	288643	6192484	4	31.1
S2306_70	288643	6192484	4	11.4
S2307_10	288666	6192425	4	75.0
S2307_22	288666	6192425	4	62.9
S2307_35	288666	6192425	4	52.0
S2307_50	288666	6192425	4	35.2
S2308_135	289958	6218476	4	-25.6
S2308_200	289958	6218476	5	-44.1
S2308_378	289958	6218476	8	22.8
S2308_503	289958	6218476	11	64.6
S2308_514	289958	6218476	12	38.8
S2308_70	289958	6218476	3	16.4
S2309_112	287690	6194933	4	16.8
S2309_159	287690	6194933	4	8.6
S2309_198	287690	6194933	8	-28.2
S2309_256	287690	6194933	8	-38.1
S2309_315	287690	6194933	8	-55.6
S2309_350	287690	6194933	12	-52.9
S2309_360	287690	6194933	12	-53.1
S2309_387	287690	6194933	15	-43.2
S2309_413	287690	6194933	17	11.2

Bore ID	Easting	Northing	Mode Layer	Average Residual
S2309_65	287690	6194933	4	35.1
S2313_131	287609	6192816	4	-32.9
S2313_182	287609	6192816	8	6.6
S2313_49	287609	6192816	4	37.0
S2314_128	288194	6192470	8	-3.8
S2314_29	288194	6192470	4	-0.6
S2315_144	288187	6218051	4	-42.9
S2315_224	288187	6218051	5	-71.8
S2315_292	288187	6218051	7	14.3
S2315_358	288187	6218051	8	39.9
S2315_445	288187	6218051	9	22.3
S2315_519	288187	6218051	12	18.4
S2315_576	288187	6218051	15	-40.4
S2315_65	288187	6218051	3	21.1
S2333_130	290697	6197087	7	-12.2
S2333_191	290697	6197087	8	-14.6
S2333_251	290697	6197087	9	-18.3
S2333_266	290697	6197087	11	-20.2
S2333_288	290697	6197087	12	-22.6
S2333_339	290697	6197087	15	-29.2
S2333_364	290697	6197087	17	-28.7
S2333_49	290697	6197087	5	-19.5
S2333_68	290697	6197087	5	-20.1
S2333_86	290697	6197087	6	-14.8
S2335_15	289725	6192749	4	33.4
S2335_25	289725	6192749	4	32.9
S2335_30	289725	6192749	4	23.2
S2335_40	289725	6192749	4	13.2
S2335_50	289725	6192749	5	30.1
S2336_32	289722	6192758	4	23.8
S2337_25	290021	6193412	4	-18.7
S2337_36	290021	6193412	4	-30.2
S2337_47	290021	6193412	4	-41.7
S2338_25	290012	6193407	4	-18.6
S2338_42	290012	6193407	4	-30.0
S2338_50	290012	6193407	4	-36.6
S2340_102	285468	6197979	5	-5.9

Bore ID	Easting	Northing	Mode Layer	Average Residual
S2340_148	285468	6197979	5	-13.2
S2340_195	285468	6197979	7	-22.2
S2340_232	285468	6197979	8	-24.0
S2340_270	285468	6197979	8	-23.2
S2340_307	285468	6197979	9	-22.6
S2340_344	285468	6197979	12	-25.0
S2340_383	285468	6197979	15	-17.2
S2340_56	285468	6197979	4	36.5
S2340_65	285468	6197978	1	38.3
S2340_BUCO	285468	6197978	15	-20.5
S2341_145	287474	6195150	5	14.8
S2341_185	287474	6195150	6	-27.2
S2341_221	287474	6195150	7	-30.4
S2341_257	287474	6195150	8	-38.6
S2341_293	287474	6195150	9	-37.4
S2341_329	287474	6195150	11	-49.0
S2341_372	287474	6195150	15	-46.9
S2341_401	287474	6195150	15	-44.3
S2341_50	287474	6195150	4	45.2
S2341_97	287474	6195150	5	17.1
S2341A_10	287489	6195138	3	76.1
S2341A_26	287489	6195138	3	59.9
S2341A_42	287489	6195138	4	55.9
S2341A_59	287489	6195138	4	36.8
S2345_144	285357	6196095	5	1.0
S2345_185	285357	6196095	7	-25.0
S2345_221	285357	6196095	8	-22.4
S2345_257	285357	6196095	8	-21.9
S2345_293	285357	6196095	9	-38.5
S2345_329	285357	6196095	12	-36.8
S2345_371	285357	6196095	15	-33.3
S2345_55	285357	6196095	4	26.9
S2345_99	285357	6196095	5	5.3
S2345A_10	285360	6196097	3	78.2
S2345A_25	285360	6196097	3	61.8
S2345A_40	285360	6196097	4	54.8
S2348_105	286451	6196462	5	16.4

Bore ID	Easting	Northing	Mode Layer	Average Residual
S2348_145	286451	6196462	5	11.3
S2348_192	286451	6196462	7	-23.3
S2348_227	286451	6196462	8	-24.8
S2348_262	286451	6196462	8	-25.3
S2348_297	286451	6196462	9	-29.3
S2348_333	286451	6196462	12	-31.4
S2348_376	286451	6196462	15	-31.6
S2348_403	286451	6196462	17	-20.8
S2348_55	286451	6196462	4	47.3
S2348A_10	286451	6196465	3	72.4
S2348A_25	286451	6196465	3	67.5
S2348A_40	286451	6196465	4	65.6
S2351_14	290050	6191178	4	58.0
S2351A_29	290054	6191175	4	56.7
S2352_127	286265	6195393	5	8.1
S2352_202	286265	6195393	7	-20.8
S2352_235	286265	6195393	8	-26.4
S2352_265	286265	6195393	8	-28.5
S2352_298	286265	6195393	9	-38.3
S2352_337	286265	6195393	12	-42.9
S2352_378	286265	6195393	15	-43.3
S2352_410	286265	6195393	18	-63.3
S2352_55	286265	6195393	4	42.6
S2352_91	286265	6195393	4	11.1
S2354_42	289731	6191414	4	58.4
S2355_10	288136	6194878	3	67.4
S2355_25	288136	6194878	3	54.3
S2355_43	288136	6194878	4	42.8
S2355_60	288136	6194878	4	36.4
S2357_10	286810	6196992	3	68.9
S2357_27	286810	6196992	3	60.7
S2357_42	286810	6196992	3	57.9
S2357_56	286810	6196992	4	37.4
S2361_10	286278	6195811	3	71.7
S2361_27	286278	6195811	3	62.0
S2361_42	286278	6195811	3	54.9
S2361_60	286278	6195811	4	24.5

Bore ID	Easting	Northing	Mode Layer	Average Residual
S2362_10	285773	6195823	3	66.0
S2362_22	285773	6195823	3	58.5
S2362_41	285773	6195823	4	42.1
S2362_58	285773	6195823	4	19.1
S2365_10	286042	6196449	3	71.5
S2365_25	286042	6196449	3	63.5
S2365_41	286042	6196449	4	55.9
S2365_64	286042	6196449	4	23.8
S2373_10	292043	6200899	3	91.5
S2373_27	292043	6200899	3	73.4
S2373_43	292043	6200899	3	66.2
S2373_60	292043	6200899	4	65.9
S2376_107	288400	6192527	5	-6.0
S2376_169	288400	6192527	7	37.2
S2376_29	288400	6192527	4	24.6
S2377_112	288333	6192020	5	-7.5
S2377_187	288333	6192020	7	2.5
S2377_27	288333	6192020	4	63.2
S2379_108	288313	6191141	7	-13.8
S2379_30	288313	6191141	5	7.2
S2379_50	288313	6191141	5	-5.5
S2398_108	289073	6192164	5	20.1
S2398_147	289073	6192164	5	-16.0
S2398_171	289073	6192164	6	67.0
S2398_190	289073	6192164	7	51.9
S2398_233	289073	6192164	8	6.7
S2398_30	289073	6192164	3	91.9
S2398_69	289073	6192164	4	54.9
S2412_107	289201	6191807	5	34.2
S2412_146	289201	6191807	6	83.9
S2412_173	289201	6191807	6	75.6
S2412_192	289201	6191807	7	29.1
S2412_232	289201	6191807	8	16.4
S2412_30	289201	6191807	3	106.6
S2412_69	289201	6191807	4	75.8
S2435_100	288081	6192412	7	9.1
S2435_25	288081	6192412	5	-13.0

Bore ID	Easting	Northing	Mode Layer	Average Residual
S2435_60	288081	6192412	6	-5.9
S2436_25	288314	6191500	5	-16.1
S2436_65	288314	6191500	7	-1.7
S2436_93	288314	6191500	7	-10.6
S2436B_35	288313	6191500	6	3.3
S2436C_45	288320	6191501	6	-4.4
S2442A_114	292789	6193213	6	54.6
S2442A_127	292789	6193213	7	53.1
S2442A_200	292789	6193213	9	-30.7
S2442A_80	292789	6193213	5	91.1
S2443_113	292176	6193027	5	91.9
S2443_138	292176	6193027	6	77.8
S2443_155	292176	6193027	7	63.9
S2443_225	292176	6193027	9	-38.7
S2487_120	290707	6191689	5	0.7
S2487_150	290707	6191689	6	-33.9
S2487_165	290707	6191689	7	-15.5
S2487_30	290707	6191689	4	65.7
S2487_75	290707	6191689	5	28.9
S2488A_125	285106	6226549	3	-45.3
S2488A_175	285106	6226549	4	-32.5
S2488A_254	285106	6226549	5	-38.1
S2488A_313	285106	6226549	6	-6.0
S2488A_338	285106	6226549	6	8.4
S2488A_452	285106	6226549	8	17.1
S2488A_566	285106	6226549	10	33.4
S2488A_592	285106	6226549	11	4.1
S2488A_624	285106	6226549	12	-1.3
S2488A_685	285106	6226549	14	-93.6
S2524_134	290405	6219106	4	-32.1
S2524_164	290405	6219106	5	-67.8
S2524_285	290405	6219106	7	-40.4
S2524_323	290405	6219106	7	-38.1
S2524_361	290405	6219106	8	106.5
S2524_40	290405	6219106	3	-10.2
S2524_87	290405	6219106	3	-12.5
TBC_147	273439	6207667	5	-8.5

Bore ID	Easting	Northing	Mode Layer	Average Residual
TBC01_398	276749	6206665	15	71.6
TBC02_398	278063	6205637	15	16.0
TBC040C_BH	275696	6204642	12	-41.2
TBC040C_H1	275696	6204642	1	-43.0
TBC040C_H2	275696	6204642	3	-42.9
TBC040C_H3	275696	6204642	5	-41.0
TBC05_395	277242	6204183	7	-24.3
TBC05_416	277242	6204183	12	-26.6
TBC09__30	278513	6202084	1	44.4
TBC09__75	278513	6202084	2	29.6
TBC09_182	278513	6202084	15	2.3
TBC09_192	278513	6202084	8	2.3
TBC09_322	278513	6202084	8	-14.9
TBC09_343	278513	6202084	8	-16.1
TBC09_357	#N/A	#N/A	#N/A	-26.4
TBC09_381	278513	6202084	10	-27.6
TBC09_391	278513	6202084	15	-24.7
TBC09_397	278513	6202084	17	-29.8
TBC10	278364	6203479	17	-35.8
TBC10_2	278364	6203479	9	-29.3
TBC12	279040	6205549	12	-70.3
TBC12_3	279040	6205549	15	-54.5
TBC14_7	280494	6202695	3	6.0
TBC15_2	279129	6203915	12	-40.9
TBC15_392	280494	6202695	15	-18.8
TBC16_386	276782	6205632	15	23.0
TBC16_8	276782	6205632	15	26.0
TBC18_117	279608	6204502	1	-12.6
TBC18_164	279608	6204502	5	-9.7
TBC18_179	279608	6204502	3	-15.9
TBC18_198	279608	6204502	8	-11.3
TBC18_282	279608	6204502	8	-14.6
TBC18_366	279608	6204502	8	-38.2
TBC18_377	279608	6204502	13	-32.0
TBC18_404	279608	6204502	15	-29.6
TBC18_426	279608	6204502	17	-45.0
TBC18_432	279608	6204502	17	-31.1

Bore ID	Easting	Northing	Mode Layer	Average Residual
TBC18_70	279608	6204502	1	-17.8
TBC19_1	277206	6202083	17	-25.2
TBC19_384	277206	6202083	15	-26.3
TBC20_105	280926	6204067	2	7.1
TBC20_141	280926	6204067	5	9.2
TBC20_194	280926	6204067	3	7.8
TBC20_211	280926	6204067	8	2.3
TBC20_293	280926	6204067	8	-0.8
TBC20_375	280926	6204067	8	6.1
TBC20_397	280926	6204067	13	-15.2
TBC20_411	280926	6204067	7	-2.2
TBC20_434	280926	6204067	17	4.4
TBC20_439	280926	6204067	4	-9.0
TBC20_70	280926	6204067	2	13.6
TBC21_425	279536	6203983	17	-28.5
TBC22_1	274631	6202893	17	-15.8
TBC22_362	274631	6202893	9	-13.0
TBC23__95	277483	6201427	1	7.9
TBC23_119	277483	6201427	1	7.2
TBC23_143	277483	6201427	5	9.8
TBC23_172	277483	6201427	15	1.0
TBC23_187	277483	6201427	8	0.2
TBC23_241	277483	6201427	8	-3.3
TBC23_295	277483	6201427	8	-5.8
TBC23_350	277483	6201427	11	-11.4
TBC23_371	277483	6201427	4	-20.0
TBC23_381	277483	6201427	15	-17.0
TBC23_387	277483	6201427	17	-13.7
TBC24__95	274763	6204163	1	-10.0
TBC24_117	274763	6204163	1	-14.2
TBC24_139	274763	6204163	5	-14.9
TBC24_168	274763	6204163	6	-12.9
TBC24_185	274763	6204163	8	-17.3
TBC24_240	274763	6204163	8	-16.9
TBC24_295	274763	6204163	8	-17.9
TBC24_350	274763	6204163	13	-20.2
TBC24_371	274763	6204163	15	-19.9

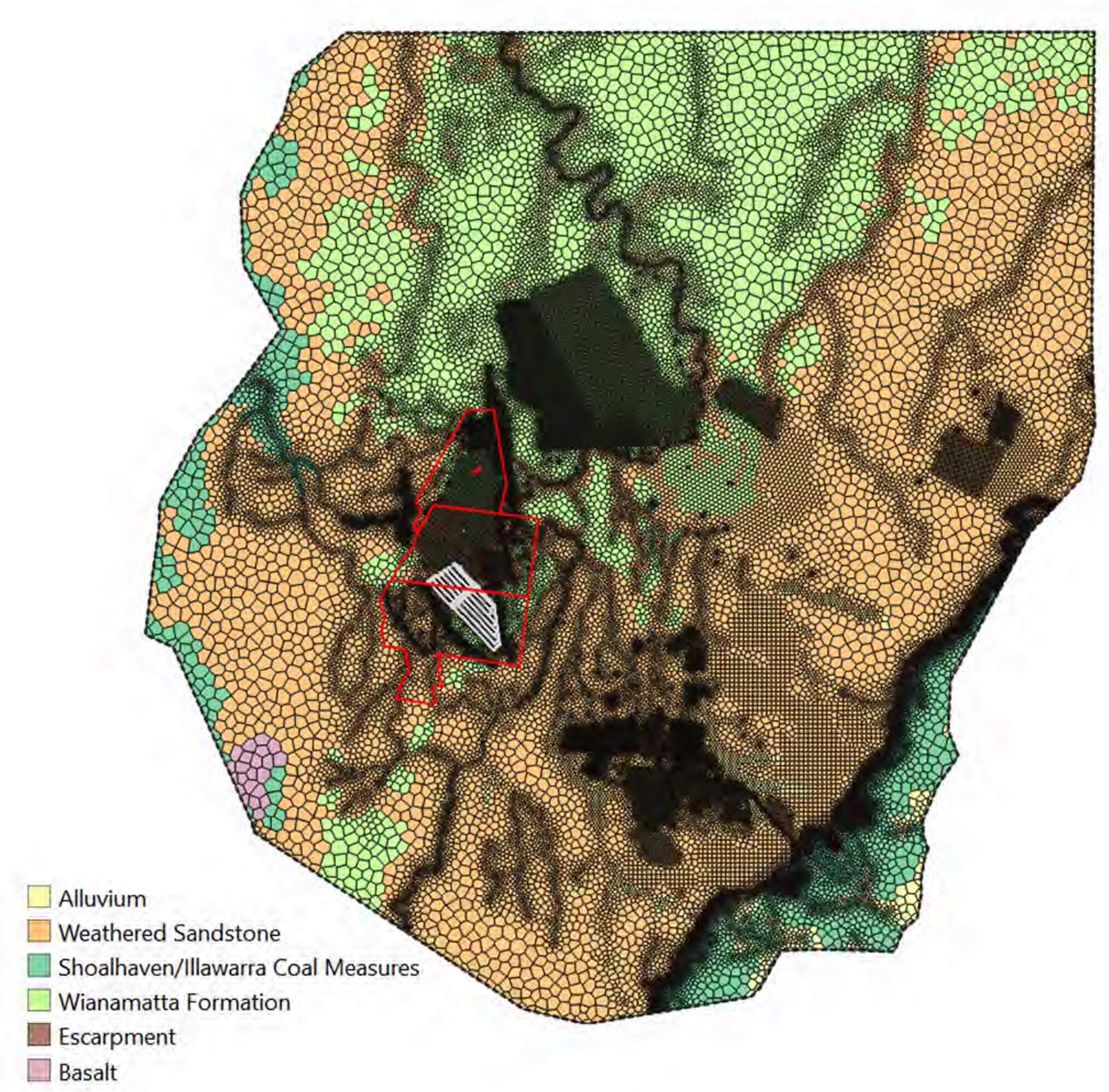
Bore ID	Easting	Northing	Mode Layer	Average Residual
TBC24_384	274763	6204163	16	-22.4
TBC24_391	274763	6204163	17	-23.1
TBC25_440	281337	6208024	16	-82.7
TBC25_7	281337	6208024	16	25.2
TBC26_135	281593	6207054	5	-0.2
TBC26_176	281593	6207054	5	-3.5
TBC26_191	281593	6207054	16	0.2
TBC26_211	281593	6207054	8	-8.6
TBC26_278	281593	6207054	8	-6.9
TBC26_344	281593	6207054	8	2.7
TBC26_409	281593	6207054	13	12.5
TBC26_432	281593	6207054	15	-71.3
TBC26_440	281593	6207054	16	-17.2
TBC26_460	281593	6207054	16	-40.9
TBC26_95	281593	6207054	1	-0.4
TBC27_132	275715	6202211	5	0.7
TBC27_169	275715	6202211	5	0.1
TBC27_181	275715	6202211	16	-5.8
TBC27_198	275715	6202211	8	-4.3
TBC27_253	275715	6202211	8	-5.5
TBC27_306	275715	6202211	8	-15.0
TBC27_362	275715	6202211	13	-19.0
TBC27_384	275715	6202211	16	-18.8
TBC27_396	275715	6202211	15	-15.2
TBC27_400	275715	6202211	17	-16.0
TBC27_95	275715	6202211	1	8.1
TBC32_200	277231	6204723	8	-32.5
TBC32_237	277231	6204723	8	-35.8
TBC32_257	277231	6204723	8	-18.7
TBC32_294	277231	6204723	8	-38.1
TBC32_314	277231	6204723	8	-19.5
TBC33_113	275194	6205395	1	3.8
TBC33_161	275194	6205395	5	-12.4
TBC33_173	275194	6205395	16	-28.0
TBC33_190	275194	6205395	8	-63.7
TBC33_247	275194	6205395	8	-73.7
TBC33_306	275194	6205395	8	-72.0

Bore ID	Easting	Northing	Mode Layer	Average Residual
TBC33_363	275194	6205395	11	-33.7
TBC33_384	275194	6205395	16	-21.4
TBC33_408	275194	6205395	16	-14.0
TBC34_113	272955	6205075	4	67.6
TBC34_161	272955	6205075	4	58.0
TBC34_176	272955	6205075	16	29.8
TBC34_196	272955	6205075	8	41.4
TBC34_245	272955	6205075	8	37.3
TBC34_294	272955	6205075	8	34.4
TBC34_343	272955	6205075	8	-8.4
TBC34_364	272955	6205075	16	-18.5
TBC34_382	272955	6205075	16	-20.0
TBC34_65	272955	6205075	1	71.6
TBC39_106	273439	6207667	5	0.6
TBC39_172	273439	6207667	5	-18.2
TBC39_188	273439	6207667	8	-73.4
TBC39_243	273439	6207667	8	-72.9
TBC39_299	273439	6207667	8	-69.6
TBC39_354	273439	6207667	11	-22.2
TBC39_375	273439	6207667	16	-6.0
TBC39_402	273439	6207667	16	0.8
TNC28_095	278773	6212357	2	3.0
TNC28_195	278773	6212357	5	-11.0
TNC28_245	278773	6212357	6	3.5
TNC28_270	278773	6212357	8	-7.6
TNC28_430	278773	6212357	11	43.2
TNC28_490	278773	6212357	15	23.2
TNC29_060	278277	6213463	2	2.5
TNC29_165	278277	6213463	5	-14.0
TNC29_182	278277	6213463	8	-8.4
TNC29_215	278277	6213463	8	-11.6
TNC29_383	278277	6213463	11	30.8
TNC29_442	278310	6213510	15	75.0
TNC36_169	277269	6215382	8	-26.9
TNC36_214	277269	6215382	8	-64.8
TNC36_412	277269	6215382	16	-62.8
TNC36_463	277269	6215382	16	-81.5

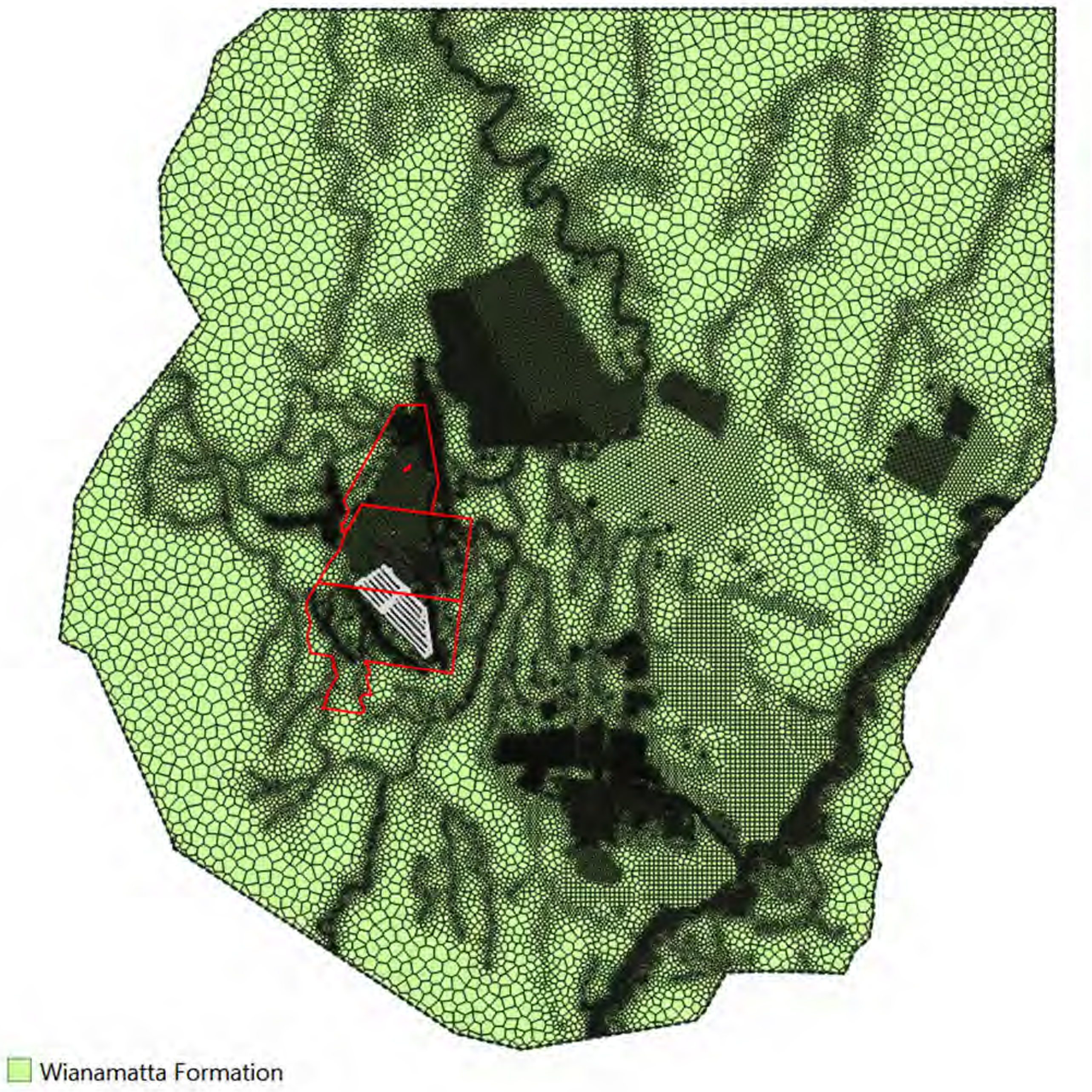
Bore ID	Easting	Northing	Mode Layer	Average Residual
TNC36_65	277269	6215382	1	15.7
TNC36_97	277269	6215382	3	-4.1
TNC40_111	279004	6214521	5	-16.4
TNC40_225	279004	6214521	5	-28.8
TNC40_252	279004	6214521	16	45.4
TNC40_27	279004	6214521	1	-4.3
TNC40_352	279004	6214521	8	-17.1
TNC40_482	279004	6214521	11	-10.7
TNC40_501	279004	6214521	16	27.3
TNC40_65	279004	6214521	2	-12.9
TNC43_111	280077	6212671	5	-24.8
TNC43_213	280077	6212671	5	-29.0
TNC43_240	280077	6212671	8	-15.1
TNC43_332	280077	6212671	8	-22.2
TNC43_405	280077	6212671	8	-30.0
TNC43_476	280077	6212671	3	-39.6
TNC43_65	280077	6212671	2	-38.2
WC_54	291547	6217768	4	47.0
WC_95	287181	6216341	4	84.1
WD01-190	278099	6214828	5	-20.0
WD01-210	278099	6214828	5	-37.4
WD01-230	278099	6214828	5	-39.1
WD01-300	278099	6214828	8	13.8
WD01-330	278099	6214828	8	66.5
WD01-350	278099	6214828	8	63.6
WD01-70	278099	6214828	1	-3.9
WD01-90	278099	6214828	2	-8.2

APPENDIX C

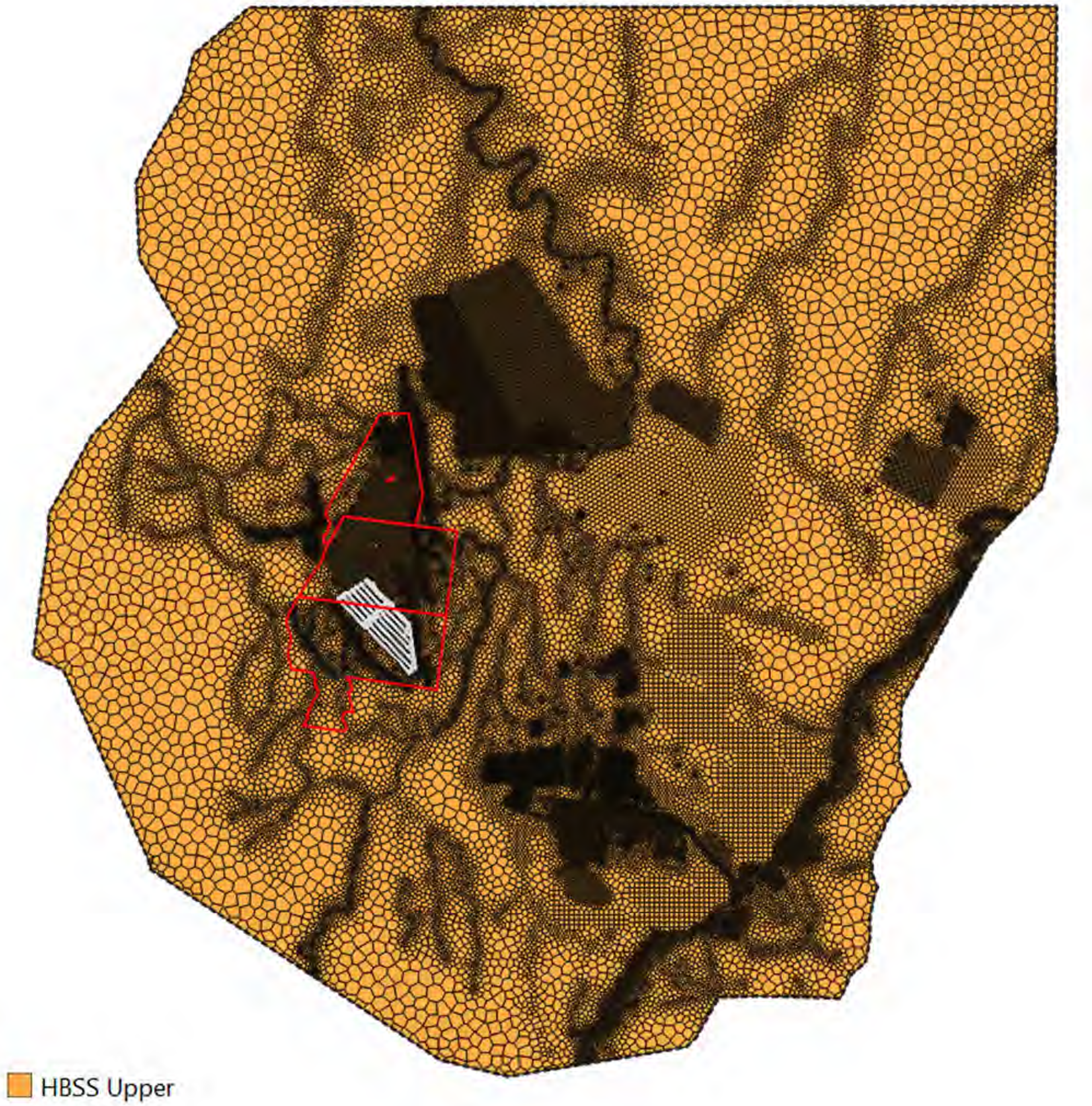
Modelled Hydraulic Property Zones



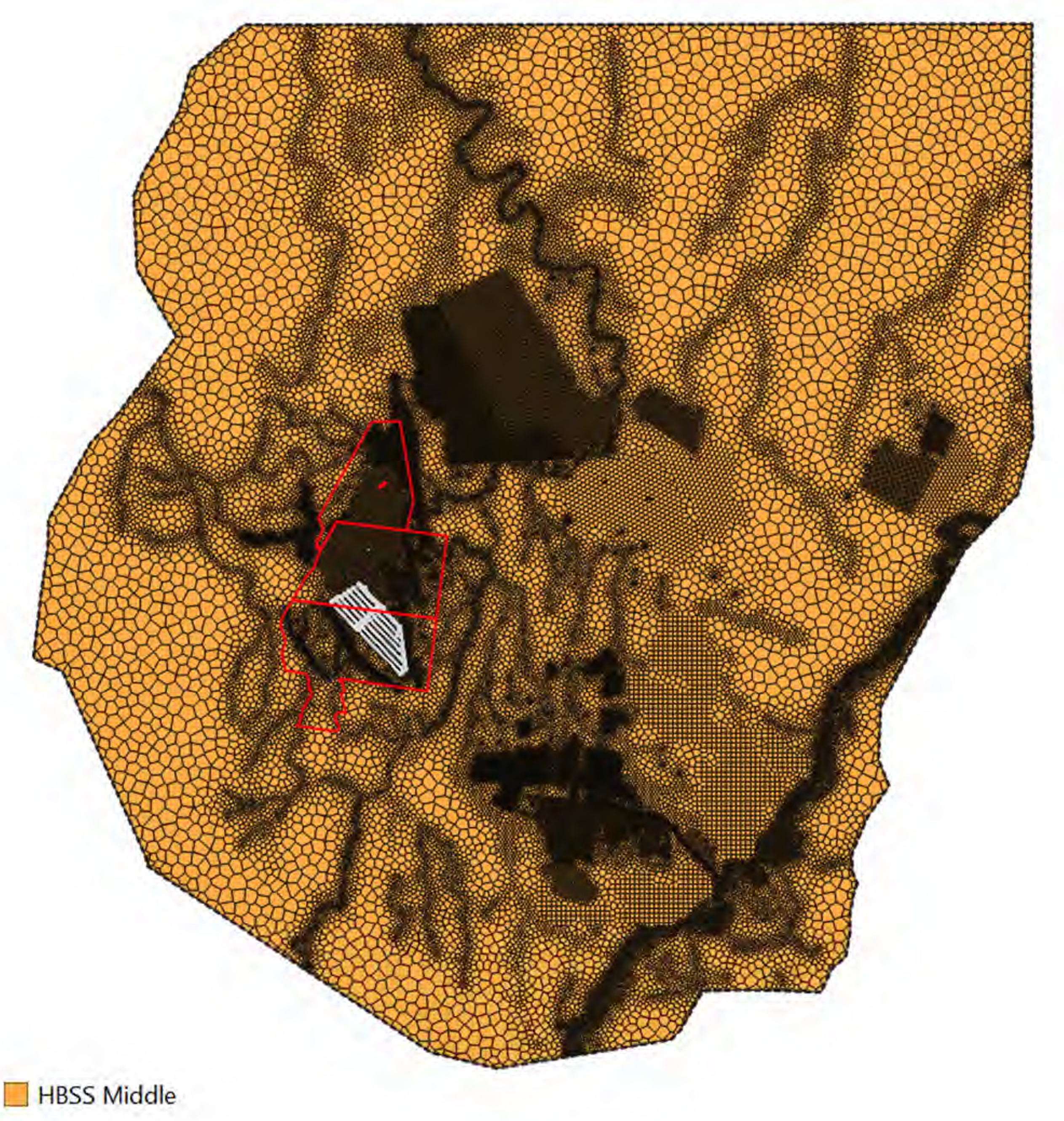
C1- Hydraulic Property Zones- Layer 1



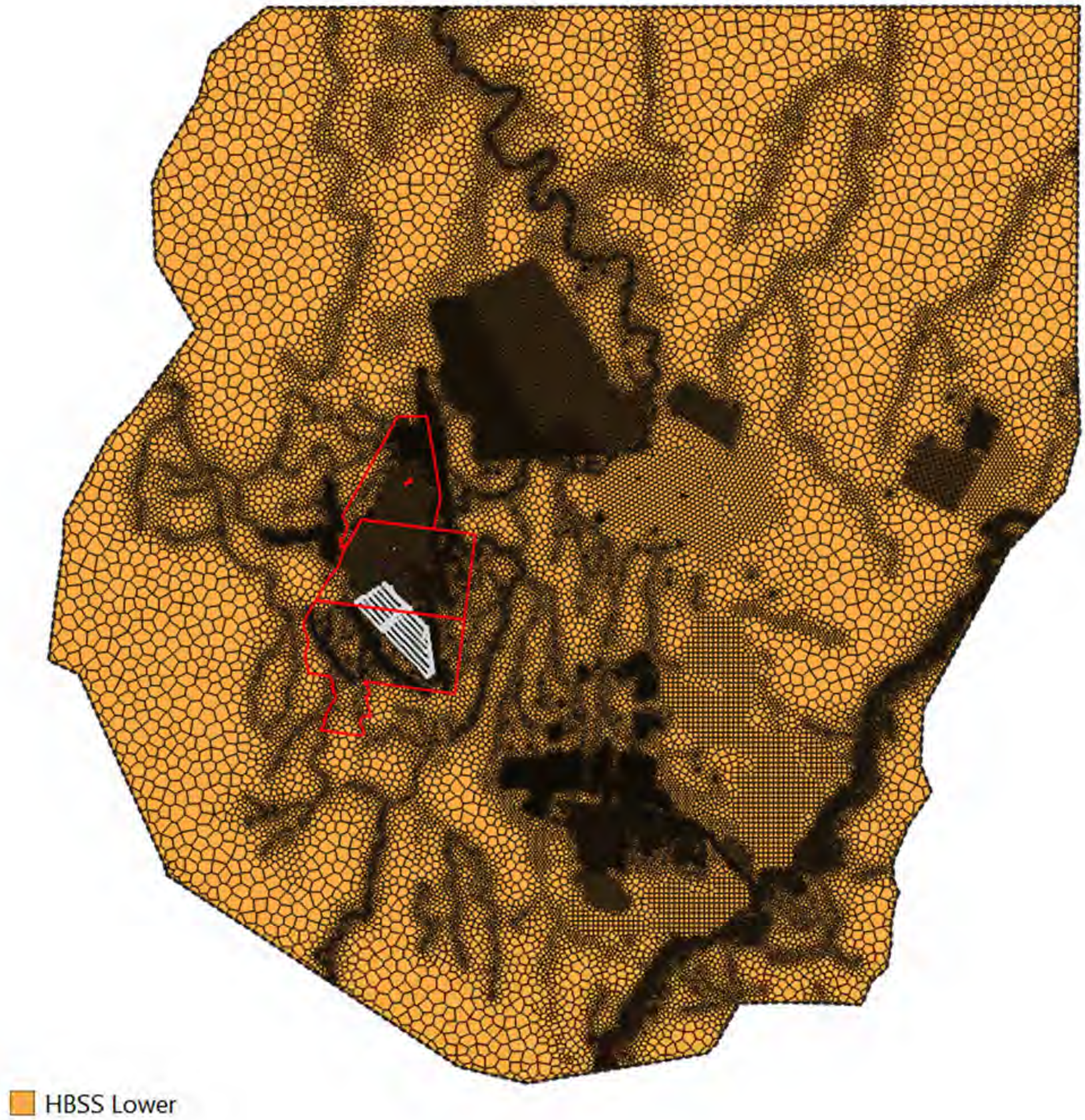
C2- Hydraulic Property Zones- Layer 2



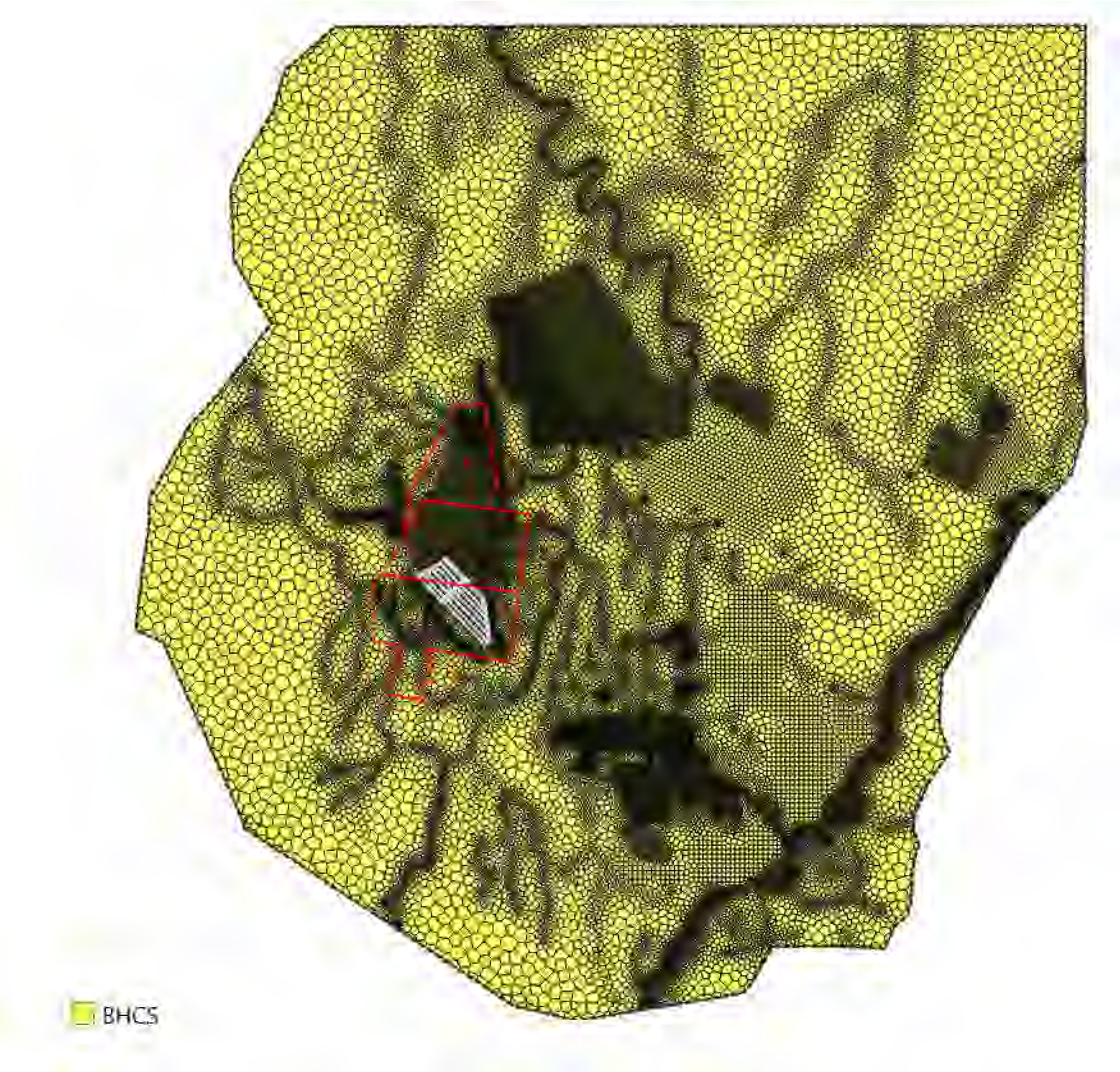
C3- Hydraulic Property Zones- Layer 3



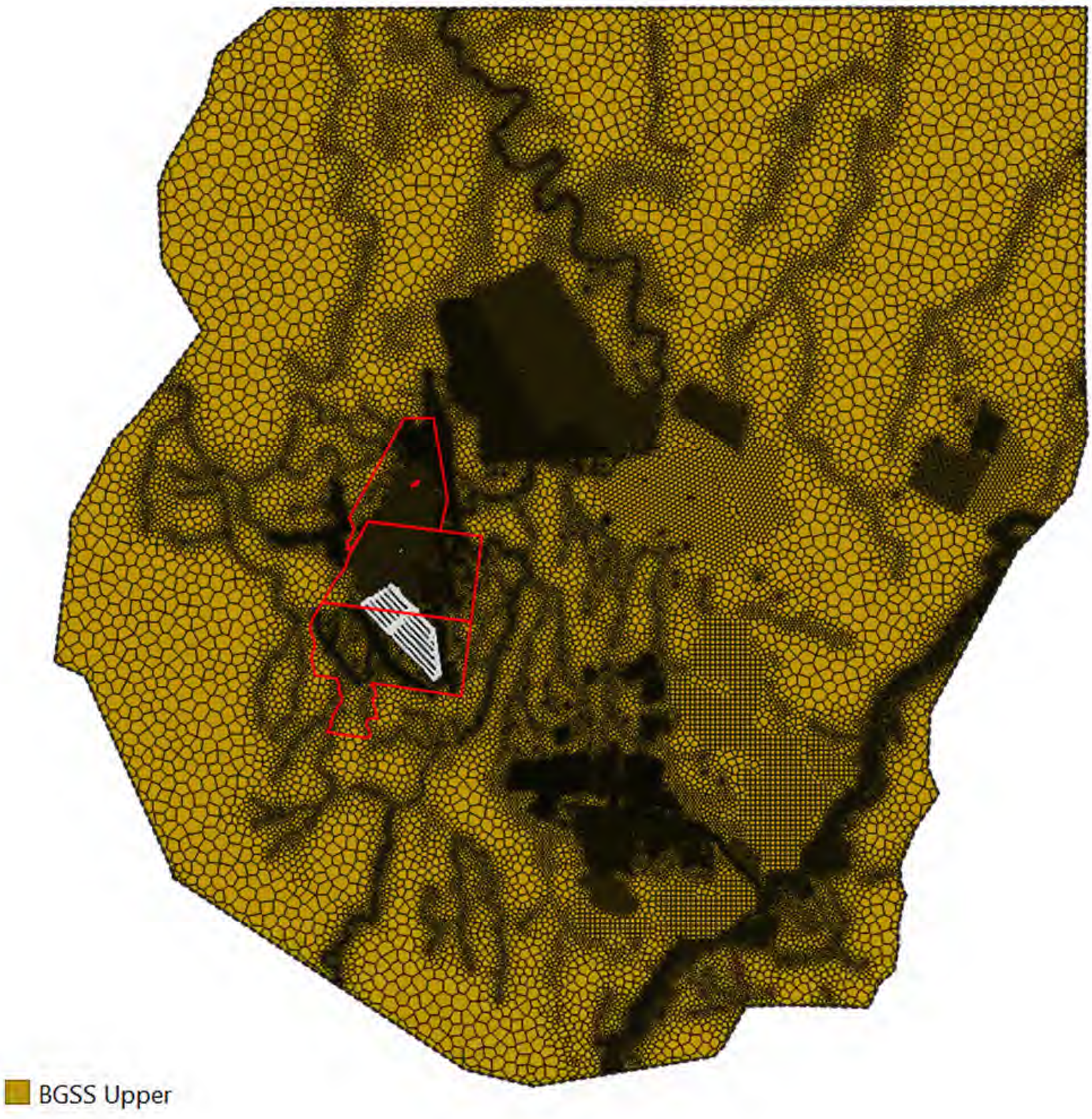
C4- Hydraulic Property Zones- Layer 4



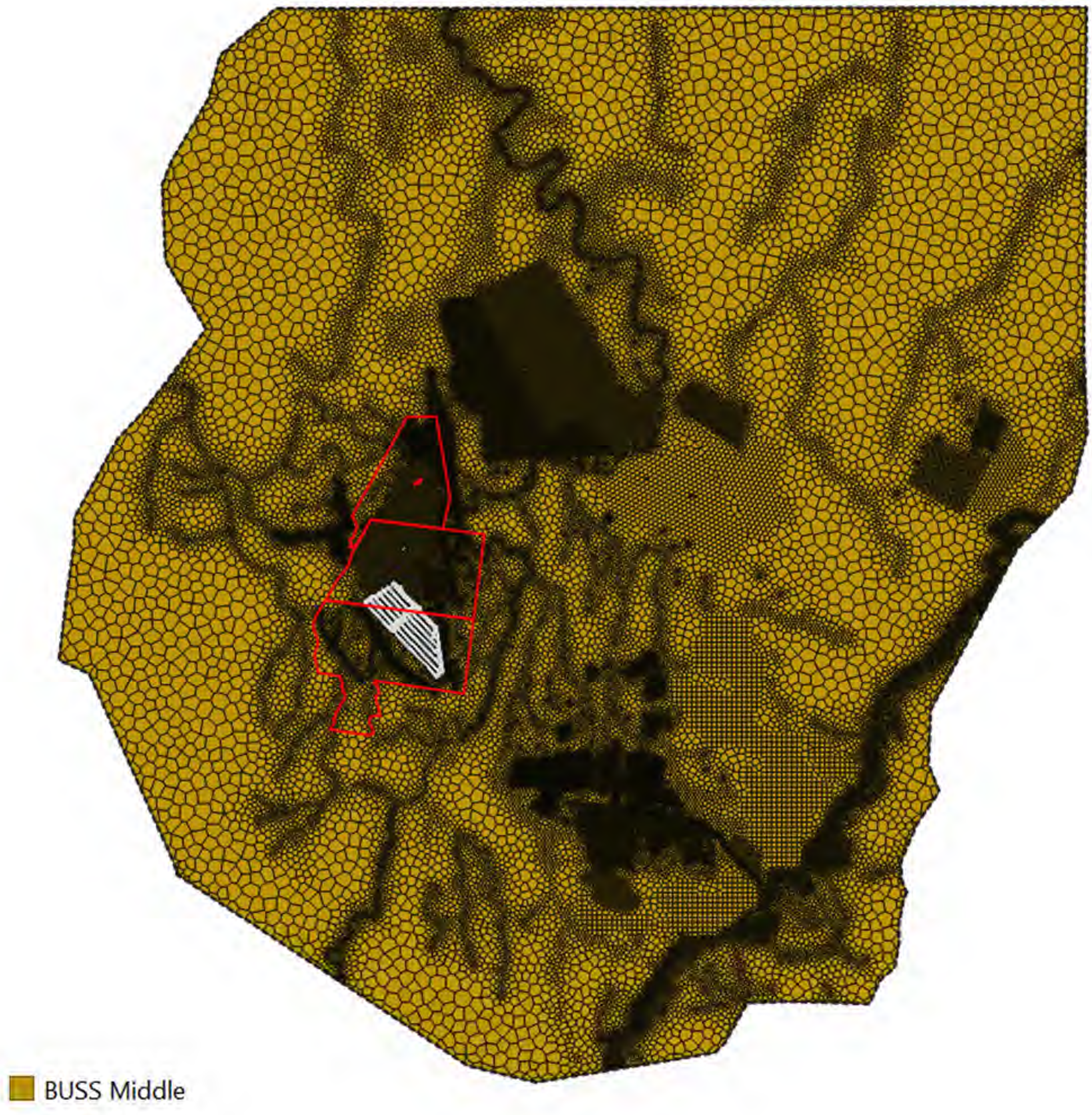
C5- Hydraulic Property Zones- Layer 5



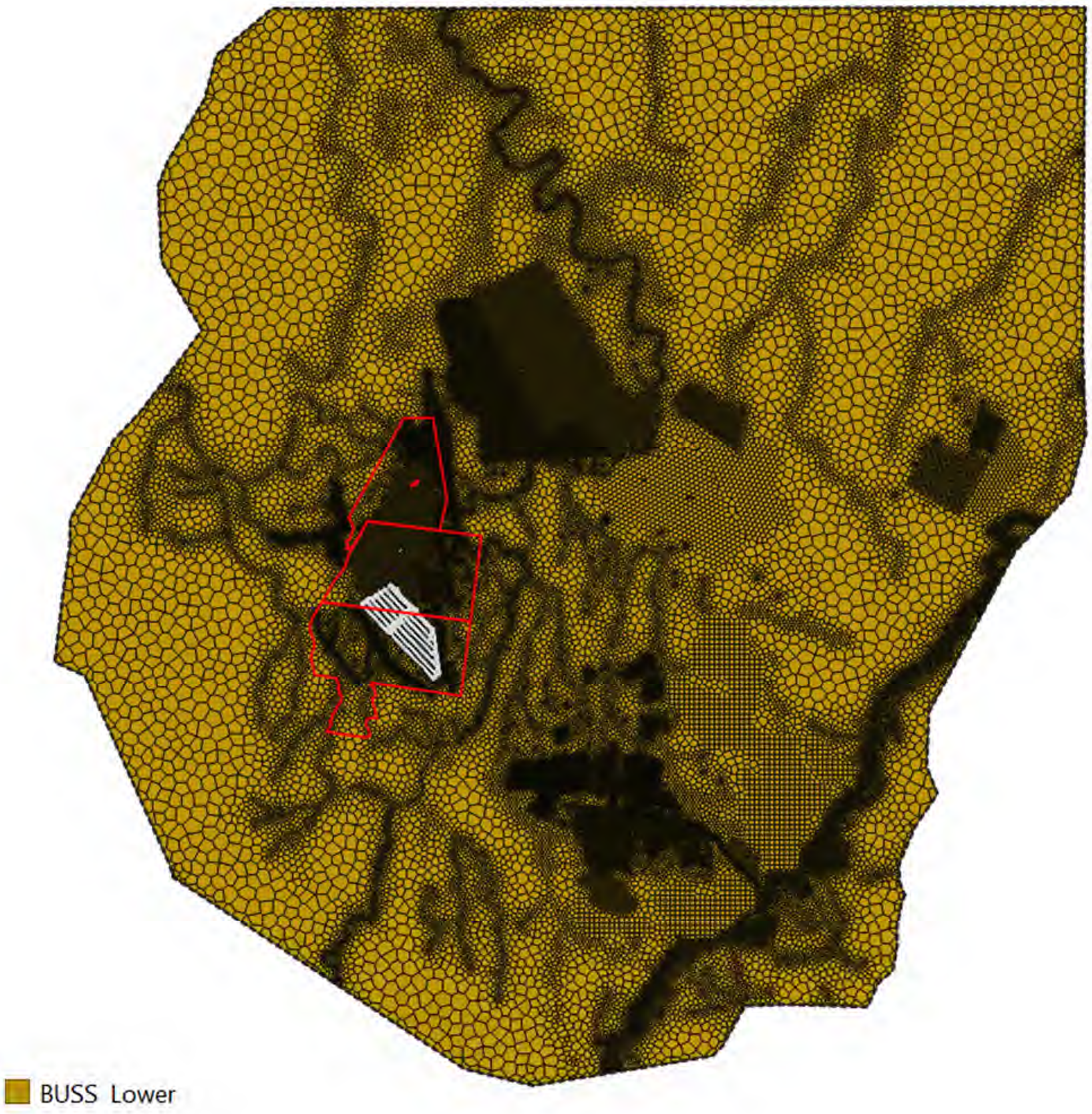
C6- Hydraulic Property Zones- Layer 6



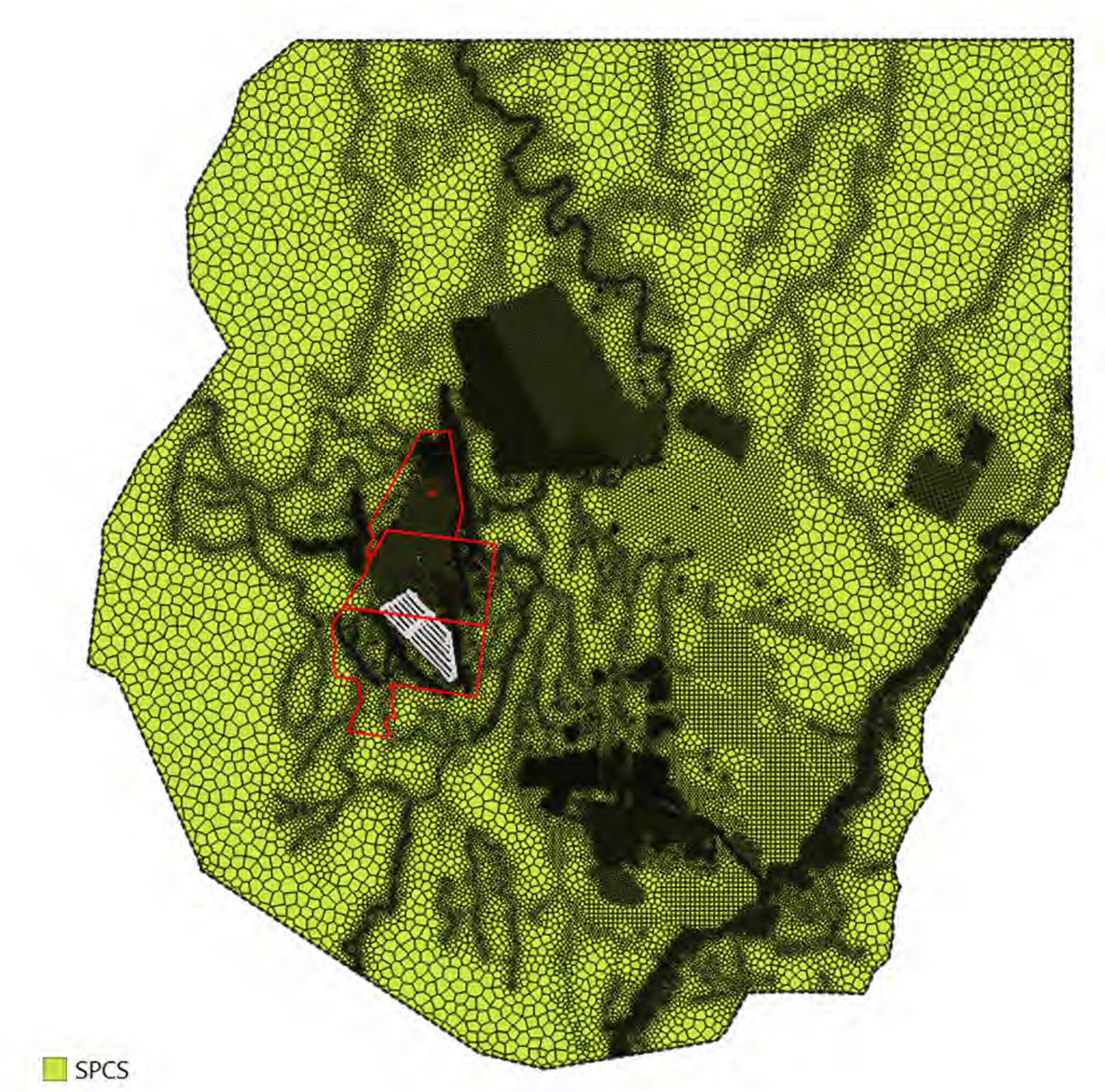
C7- Hydraulic Property Zones- Layer 7



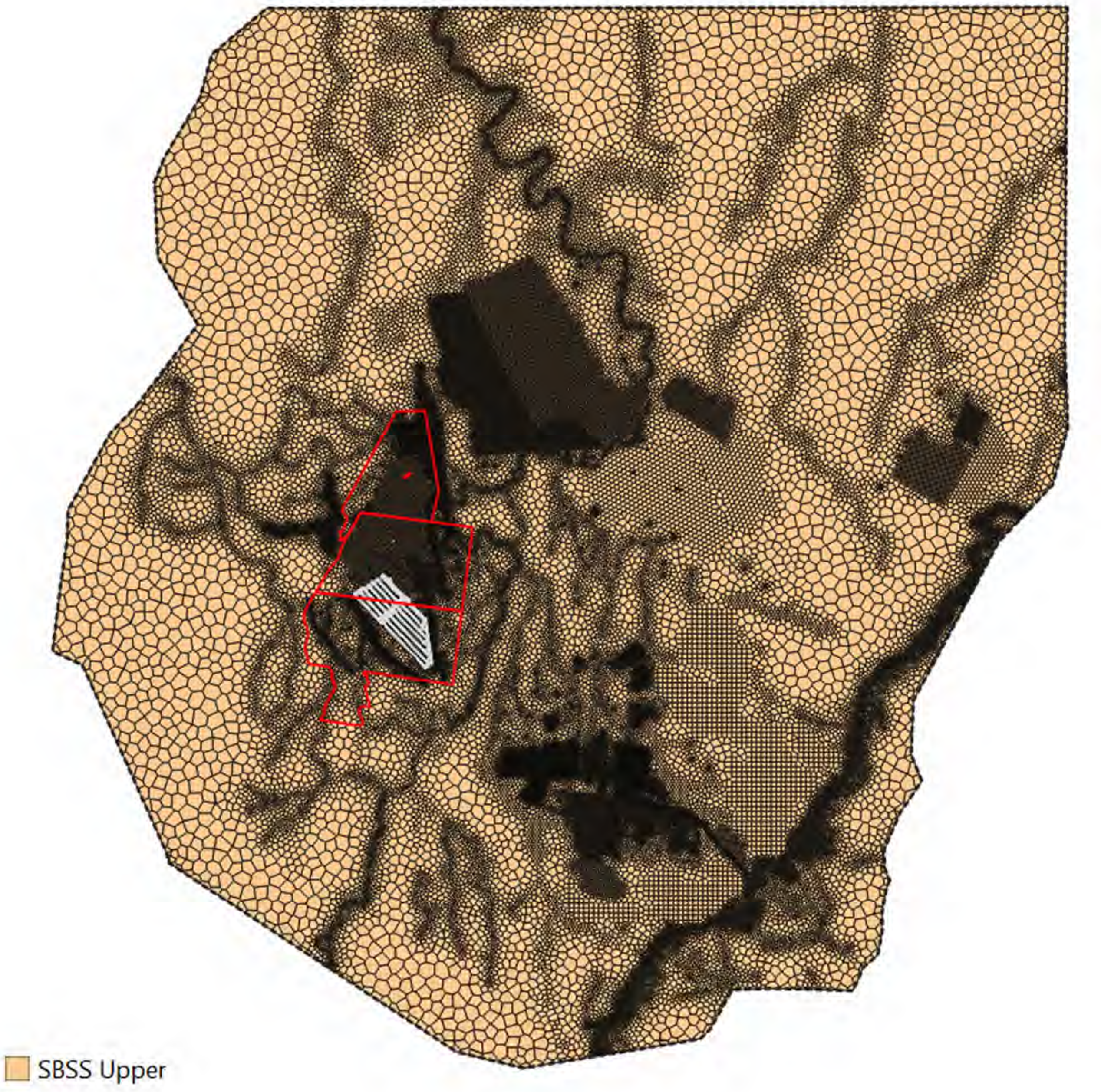
C8- Hydraulic Property Zones- Layer 8



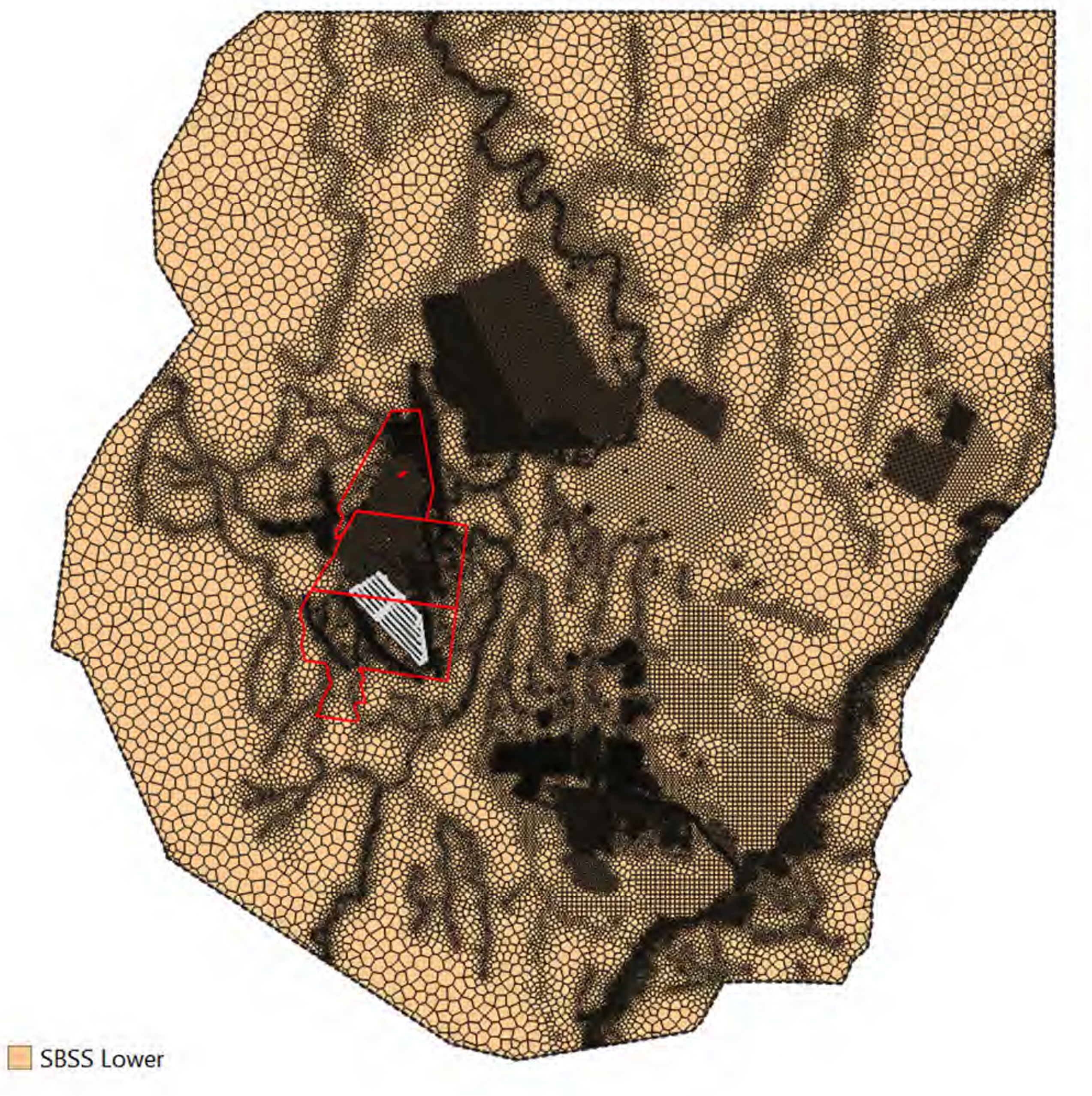
C9- Hydraulic Property Zones- Layer 9



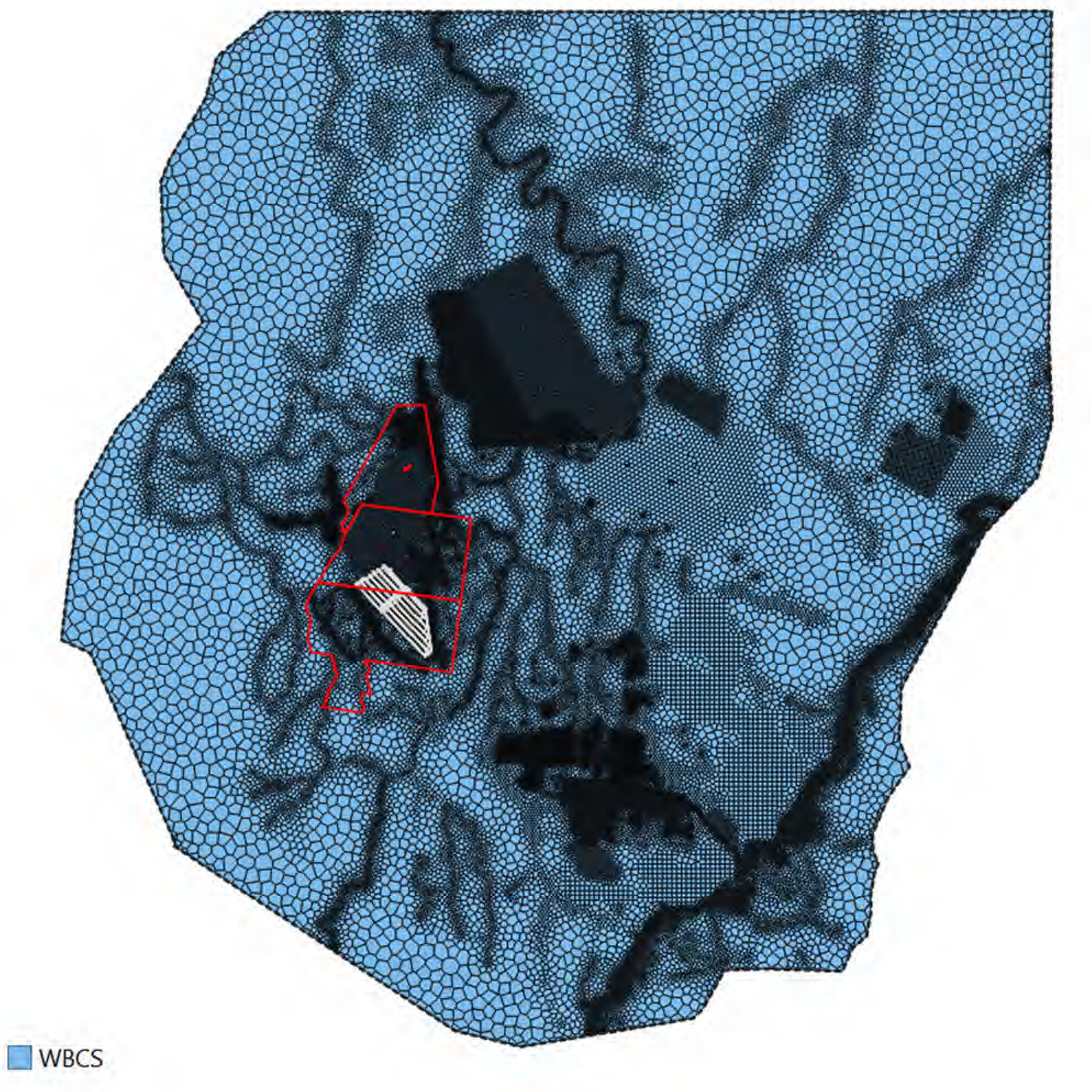
C10- Hydraulic Property Zones- Layer 10



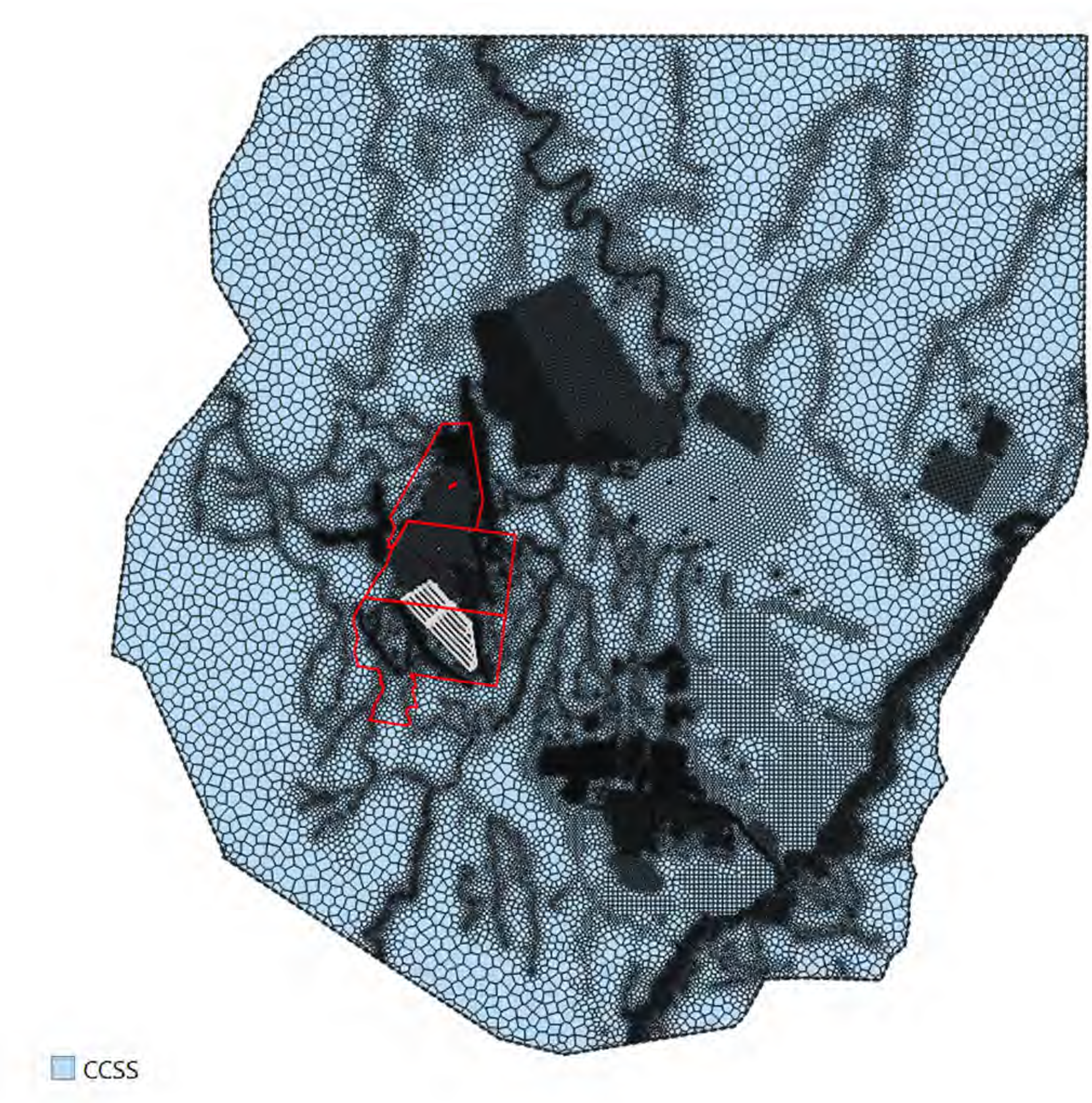
C11- Hydraulic Property Zones- Layer 11



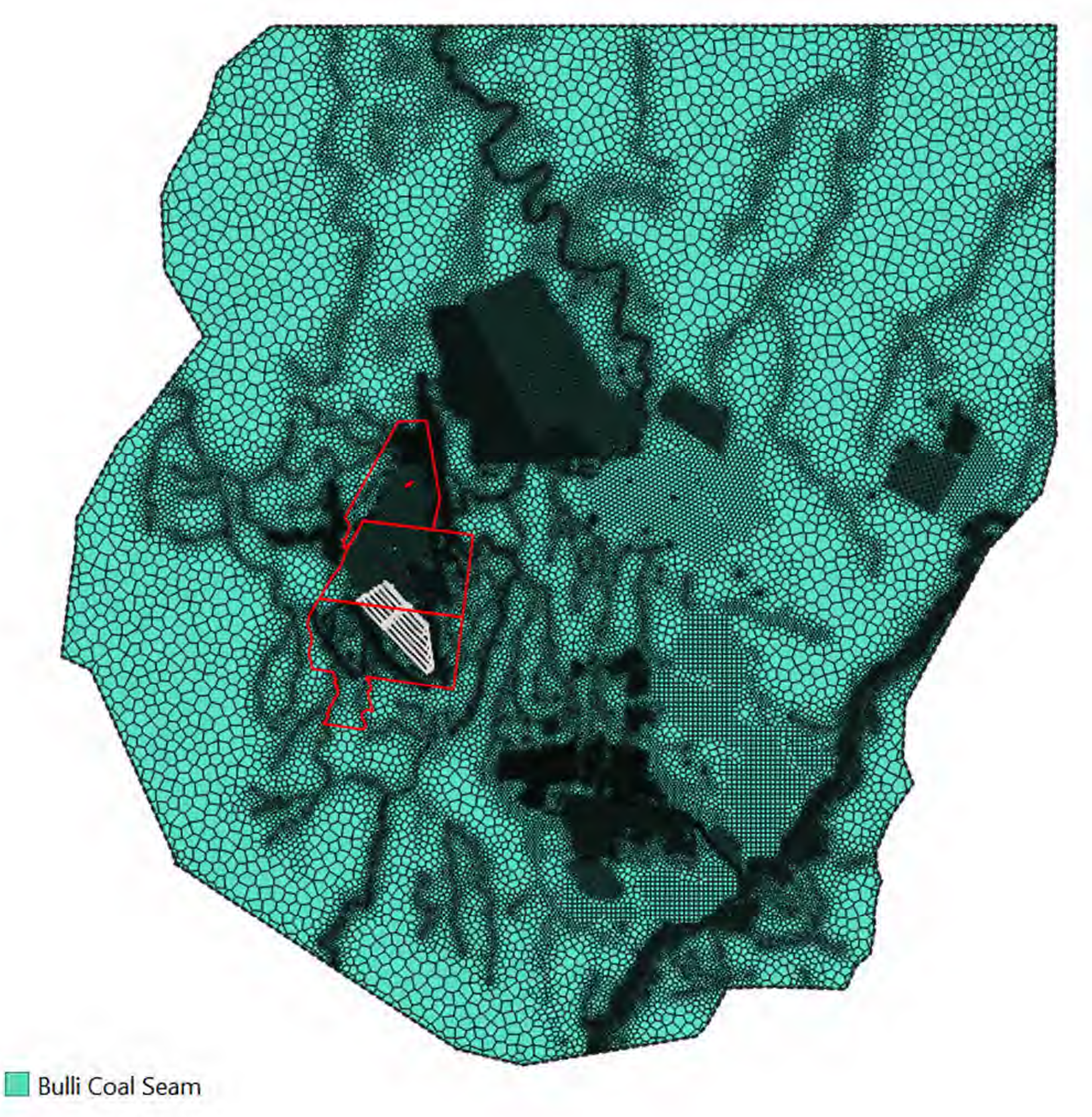
C12- Hydraulic Property Zones- Layer 12



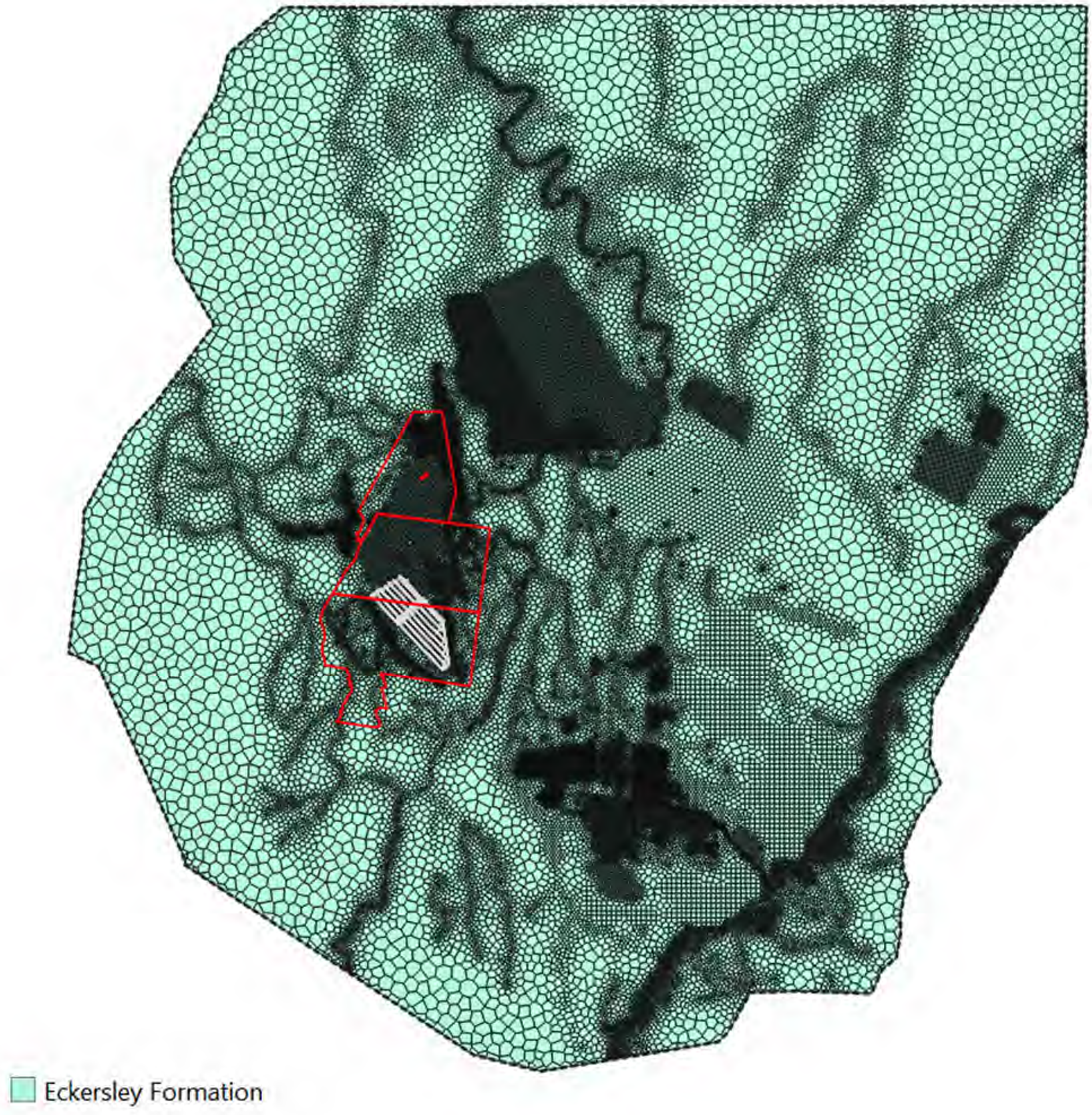
C13- Hydraulic Property Zones- Layer 13



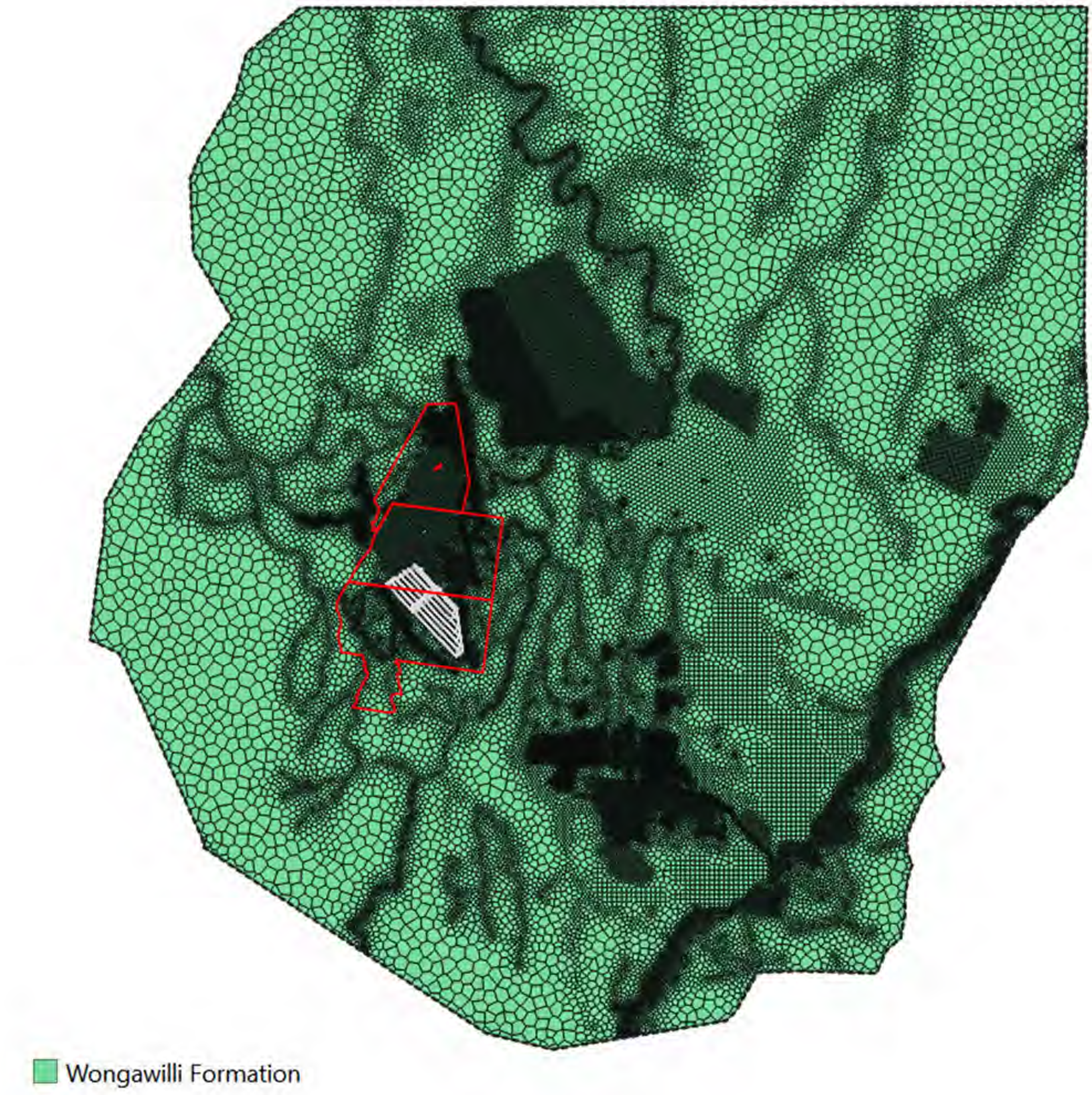
C14- Hydraulic Property Zones- Layer 14



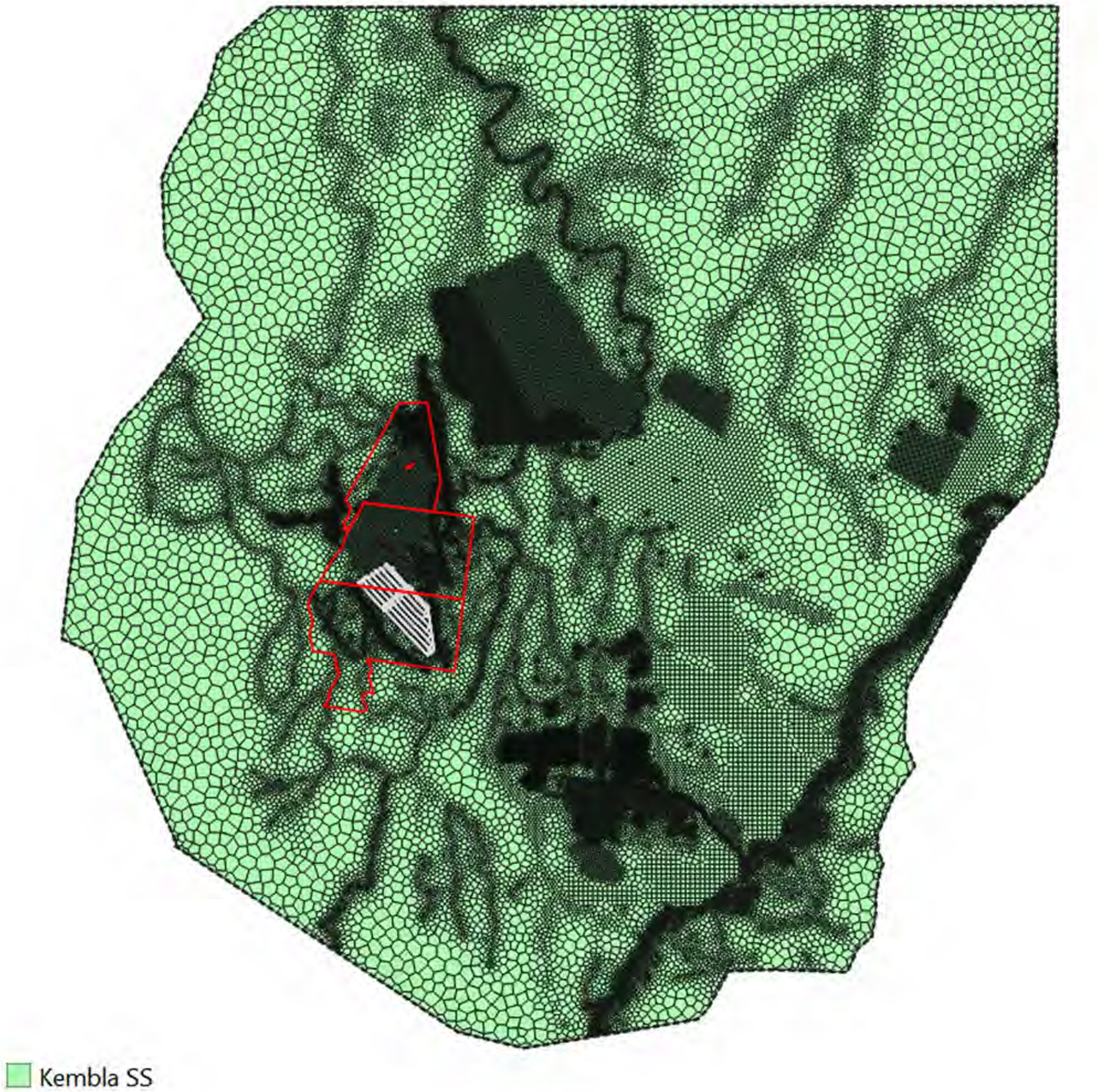
C15- Hydraulic Property Zones- Layer 15



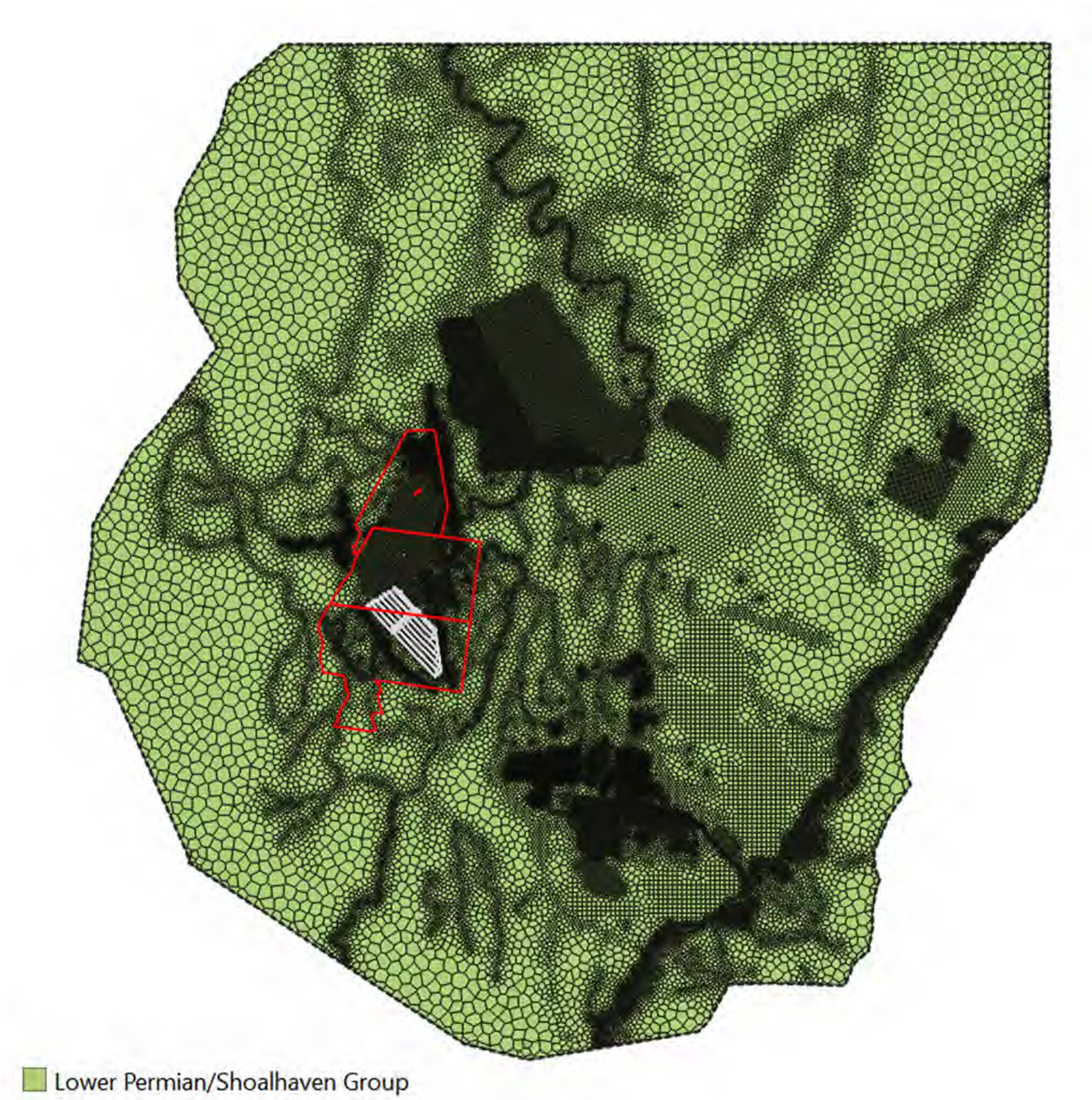
C16- Hydraulic Property Zones- Layer 16



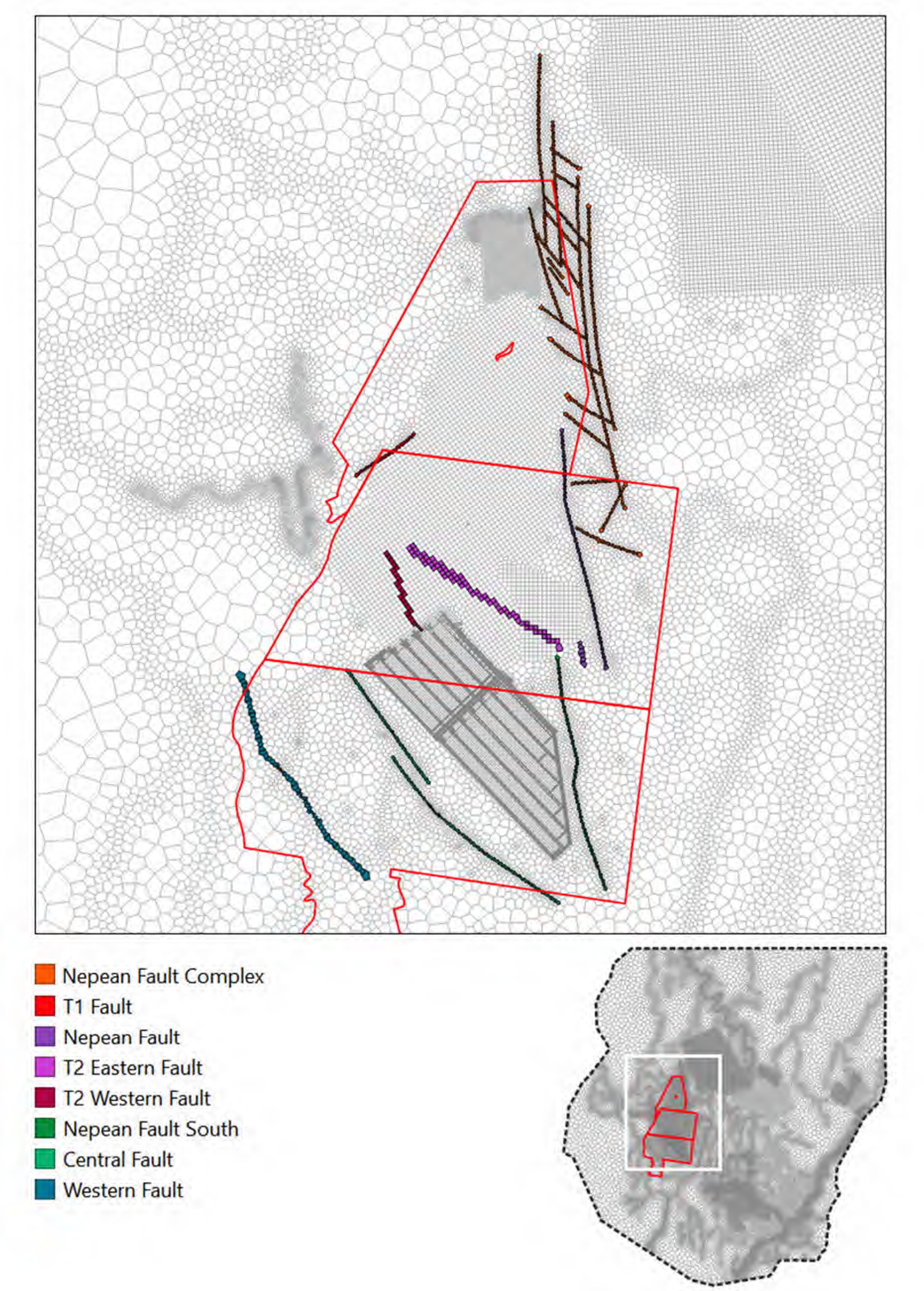
C17- Hydraulic Property Zones- Layer 17



C18- Hydraulic Property Zones- Layer 18



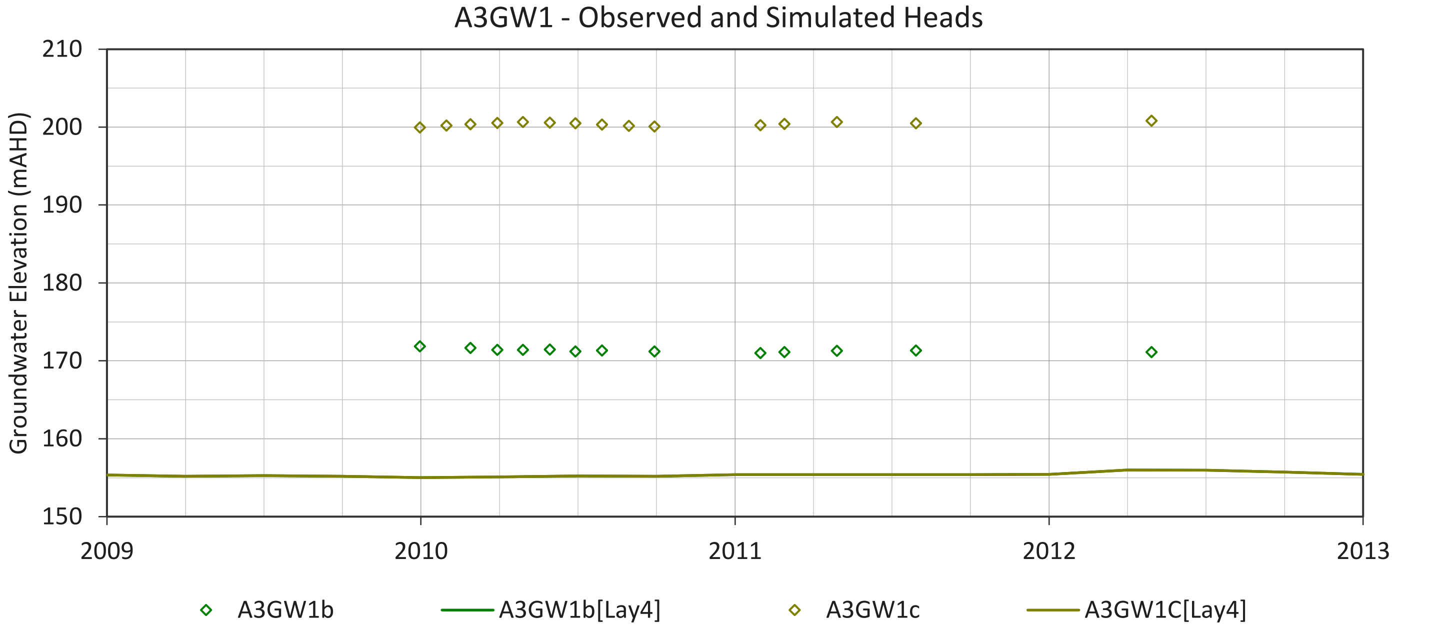
C19- Hydraulic Property Zones- Layer 19

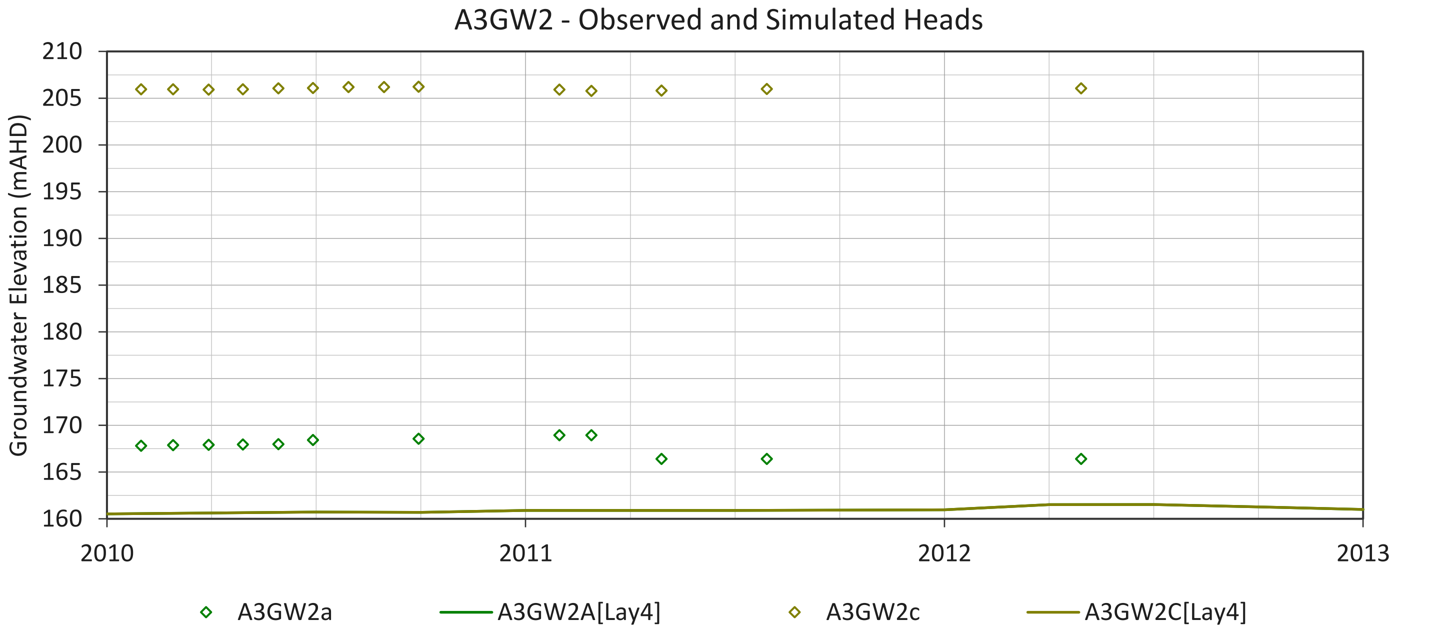


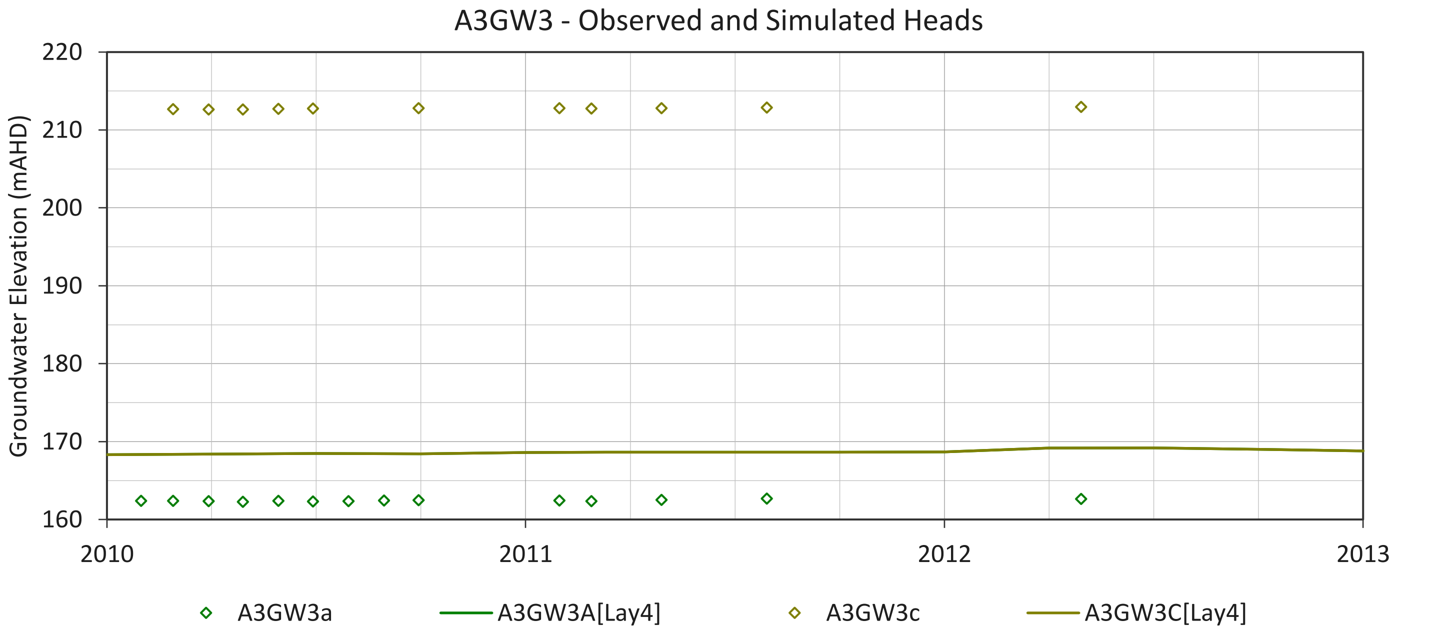
Fault Zones- Layer 1 to 19

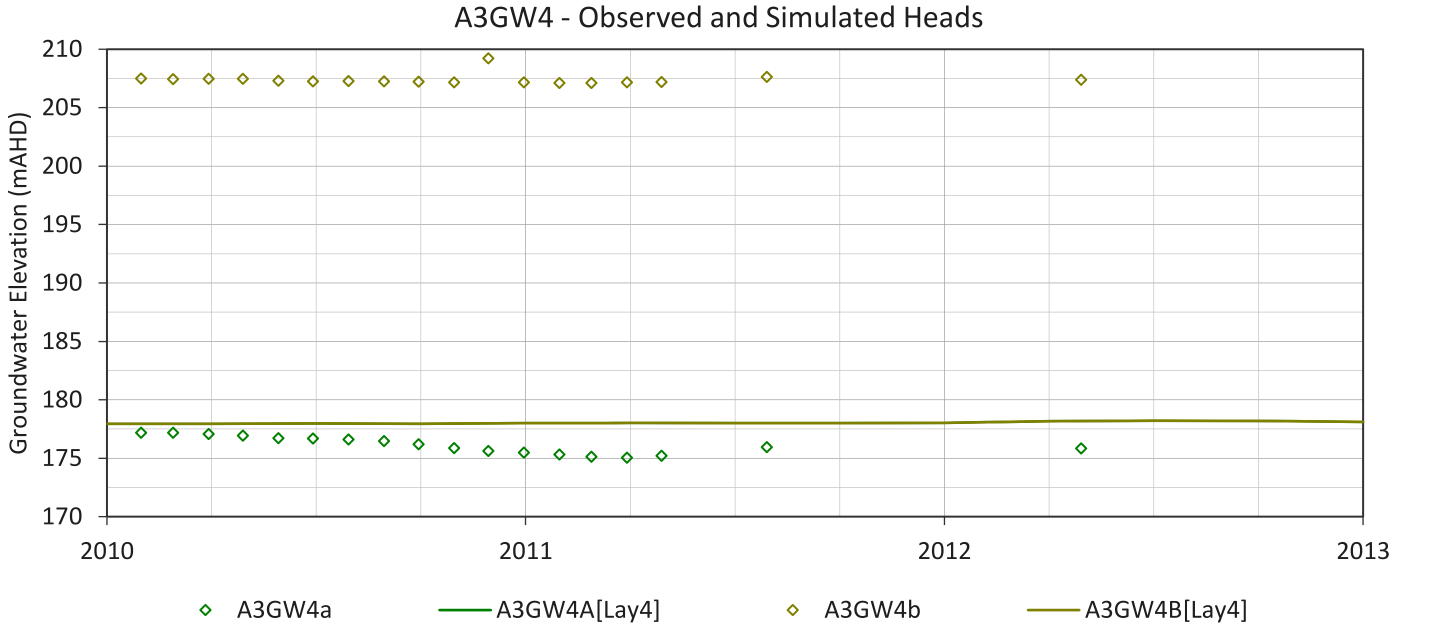
APPENDIX D

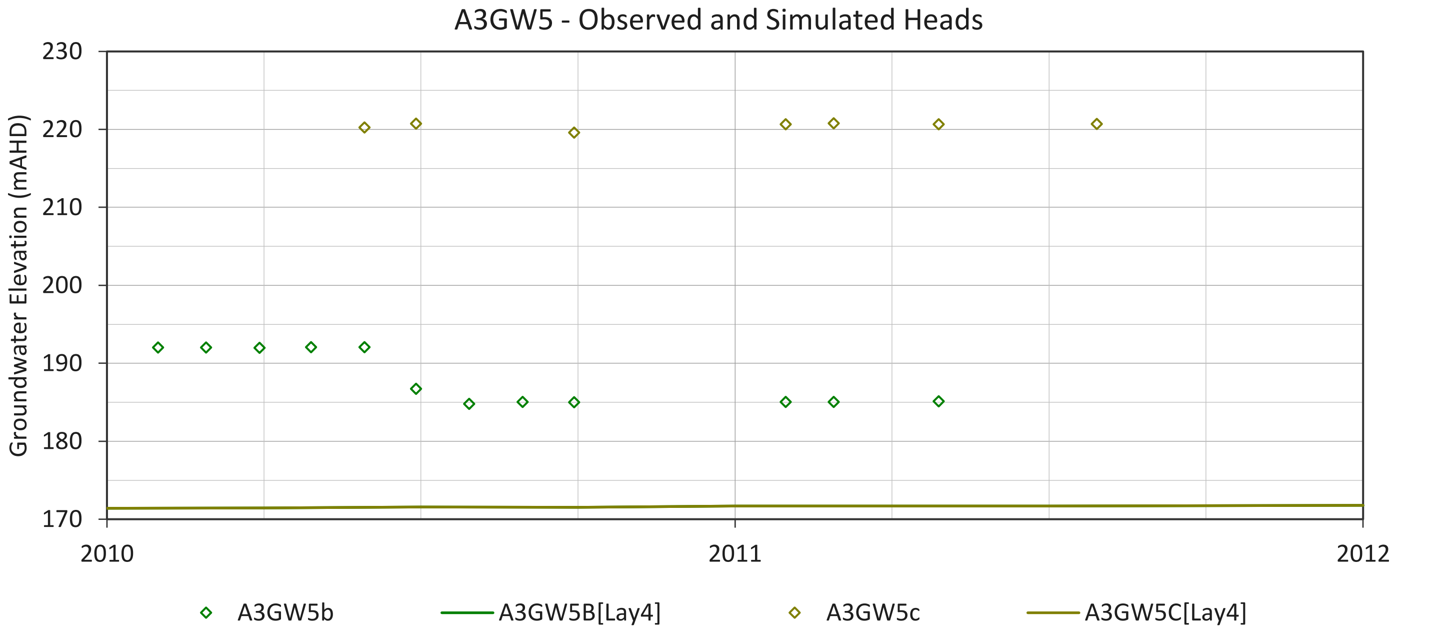
Calibration Hydrographs

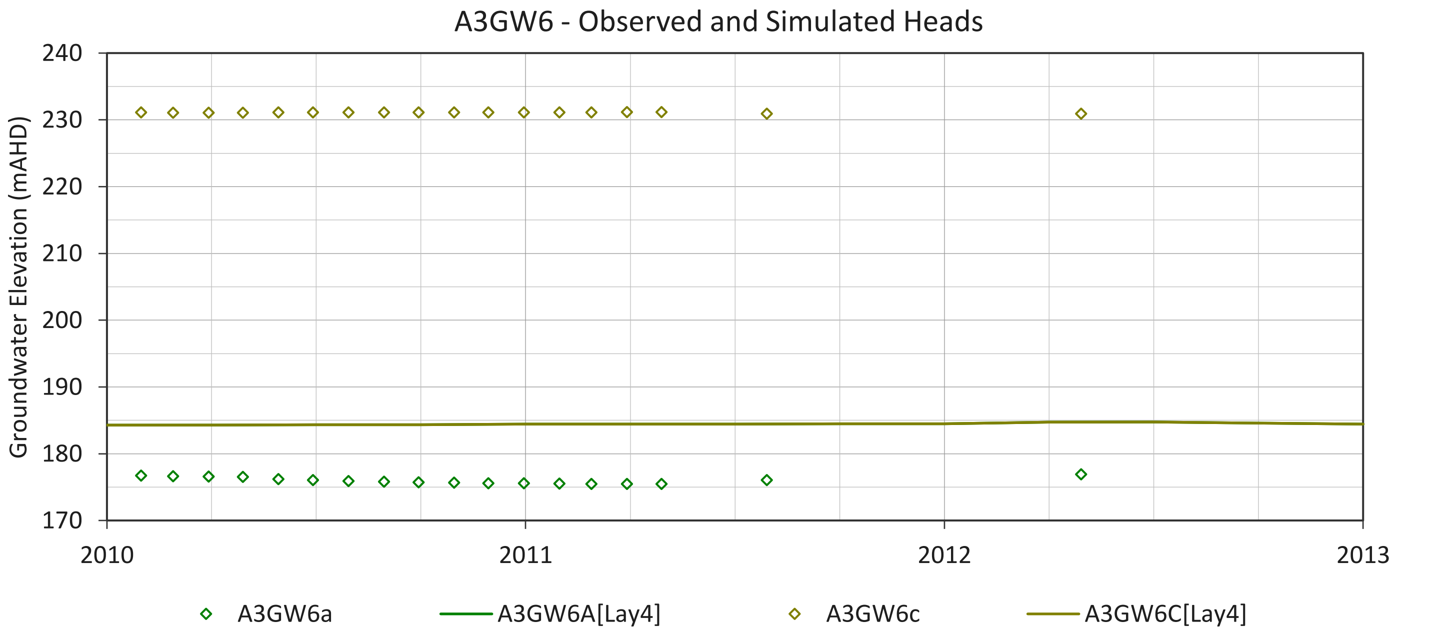

A3GW1 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
210
200
190
180
170
160
150
2009
2010
2011
2012
2013
A3GW1b
A3GW1b[Lay4]
A3GW1c
A3GW1C[Lay4]

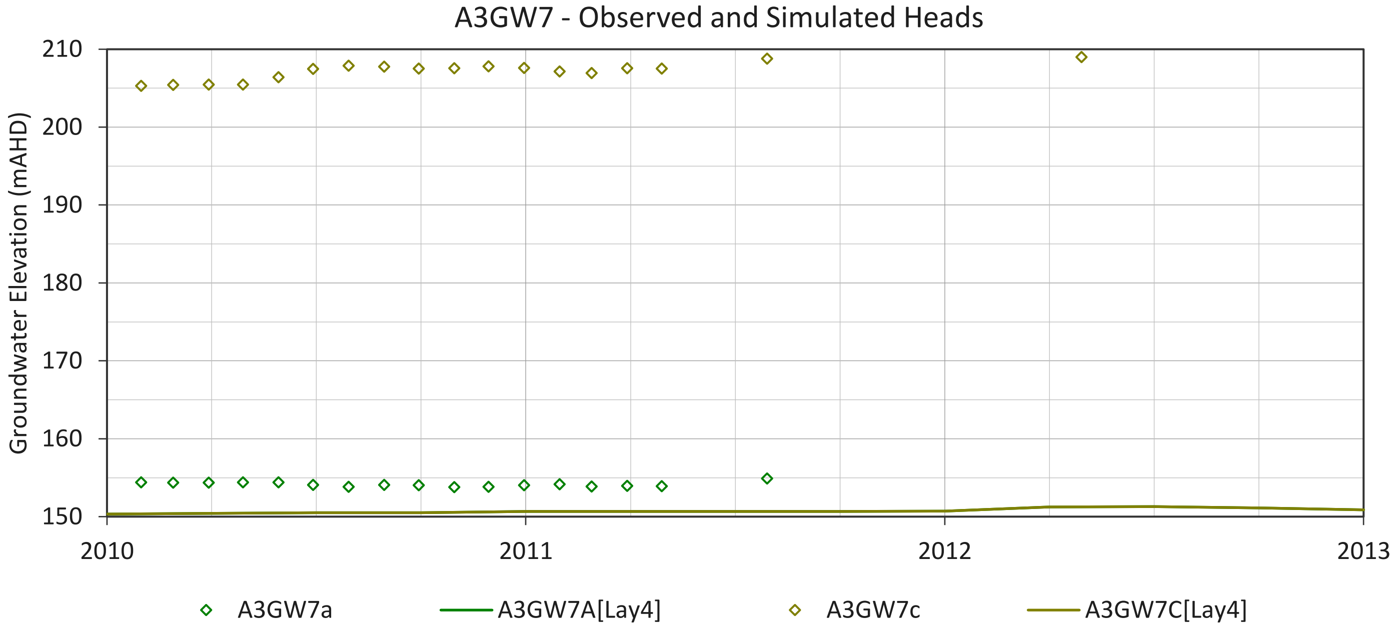

A3GW2 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
210
205
200
195
190
185
180
175
170
165
160
2010
2011
2012
2013
A3GW2a
A3GW2A[Lay4]
A3GW2c
A3GW2C[Lay4]


A3GW3 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
220
210
200
190
180
170
160
2010
2011
2012
2013
A3GW3a
A3GW3A[Lay4]
A3GW3c
A3GW3C[Lay4]


A3GW4 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
210
205
200
195
190
185
180
175
170
2010
2011
2012
2013
A3GW4a
A3GW4A[Lay4]
A3GW4b
A3GW4B[Lay4]


A3GW5 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
230
220
210
200
190
180
170
2010
2011
2012
A3GW5b
A3GW5B[Lay4]
A3GW5c
A3GW5C[Lay4]


A3GW6 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
240
230
220
210
200
190
180
170
2010
2011
2012
2013
A3GW6a
A3GW6A[Lay4]
A3GW6c
A3GW6C[Lay4]


A3GW7 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
210
200
190
180
170
160
150
2010
2011
2012
2013
A3GW7a
A3GW7A[Lay4]
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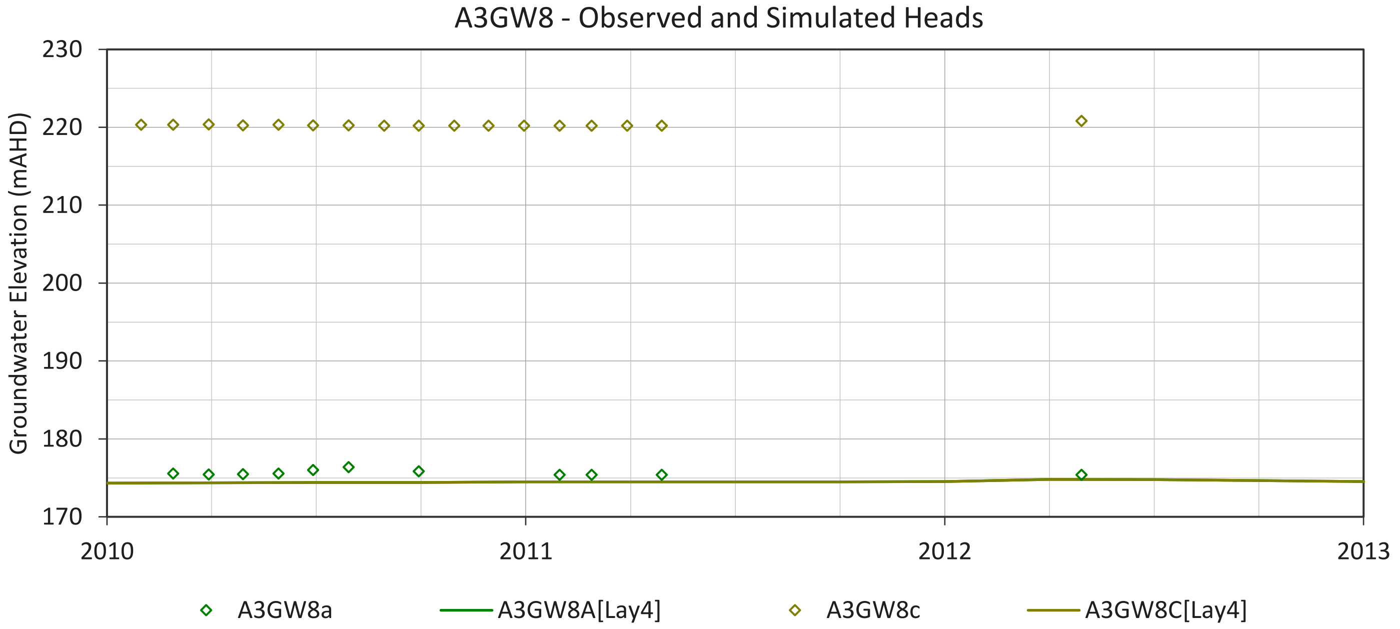
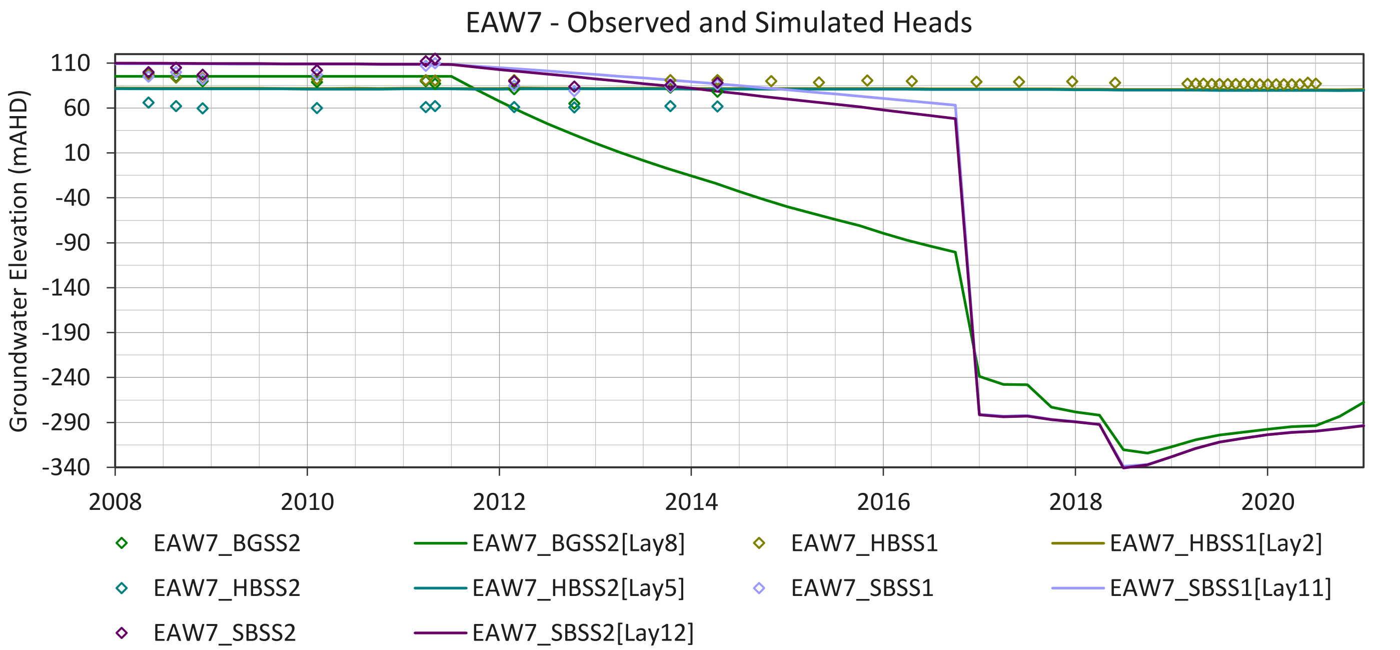
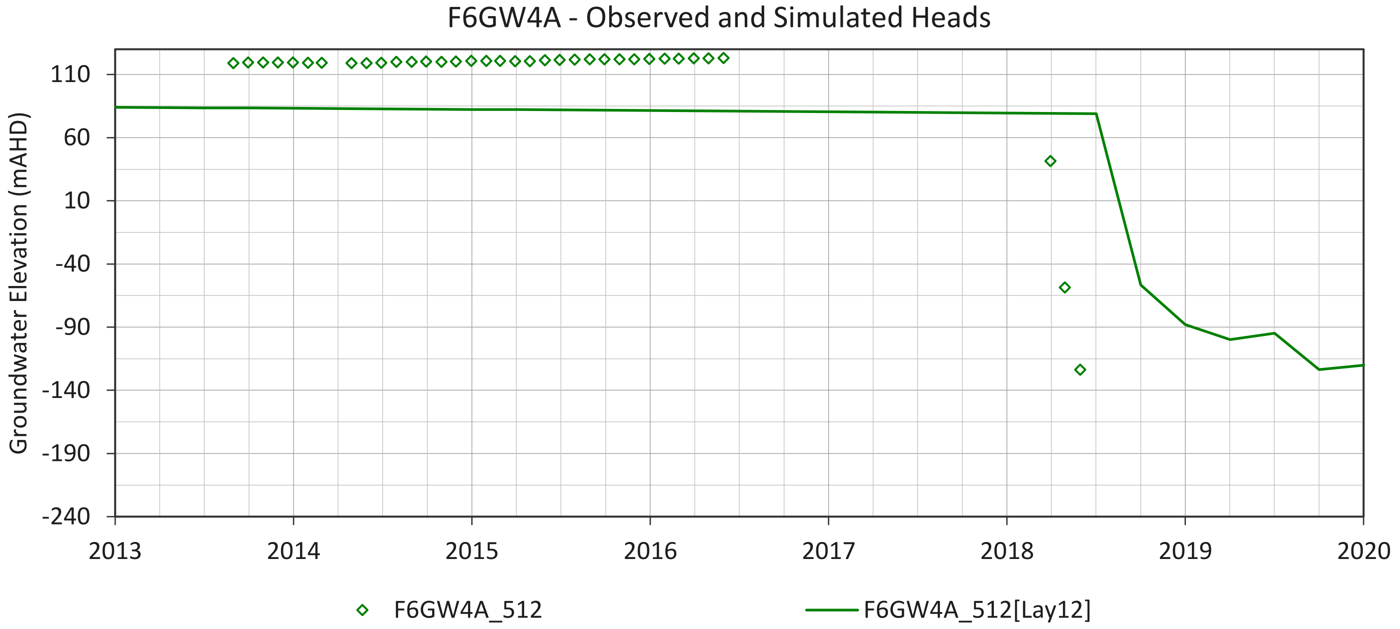
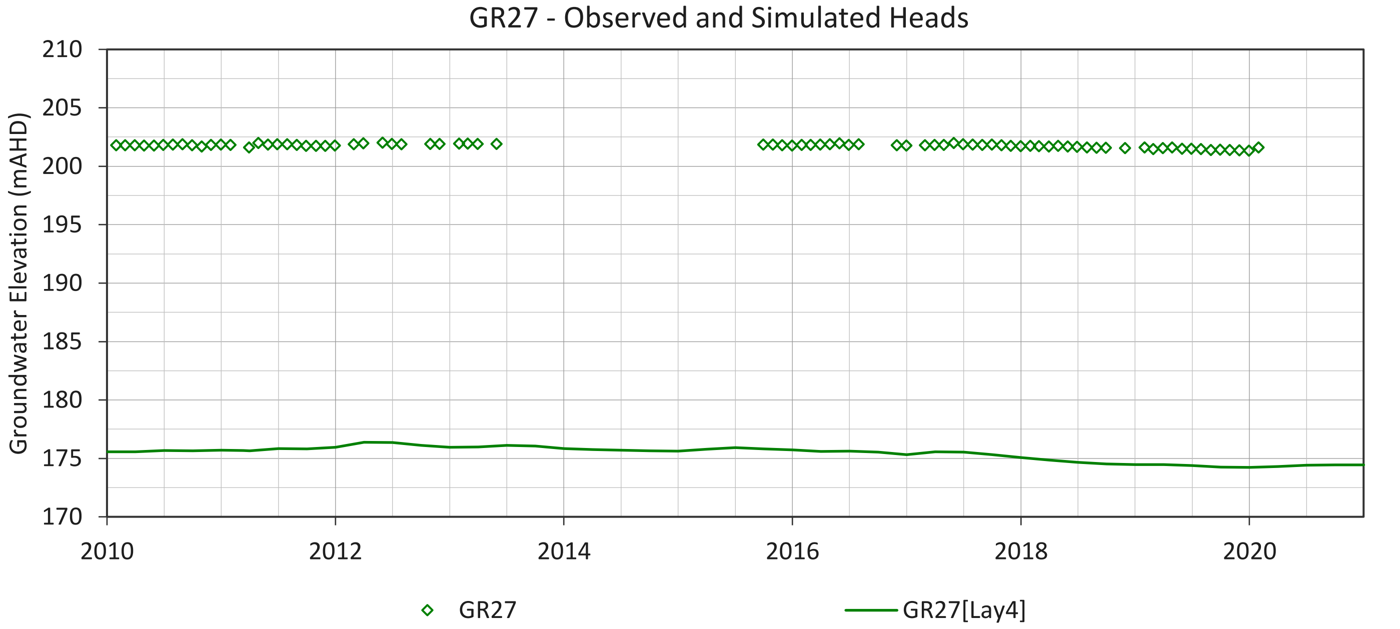
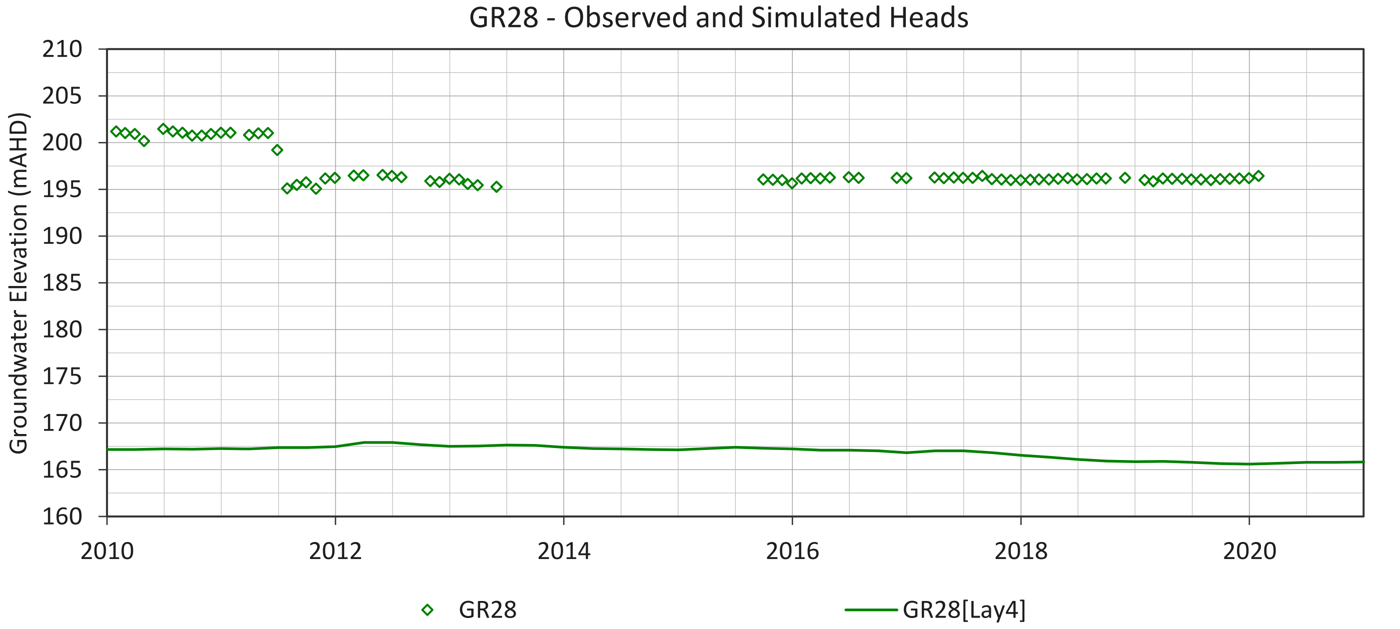
A3GW7C[Lay4]

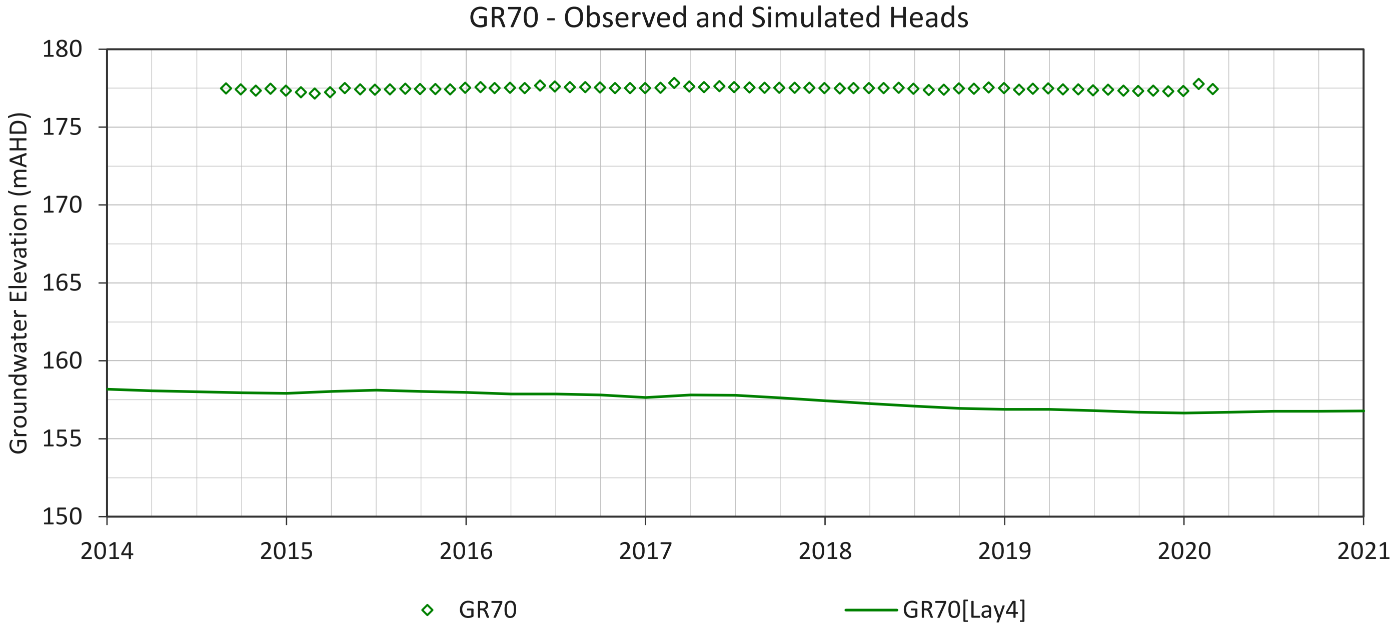

A3GW8 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
230
220
210
200
190
180
170
2010
2011
2012
2013
A3GW8a
A3GW8A[Lay4]
A3GW8c
A3GW8C[Lay4]

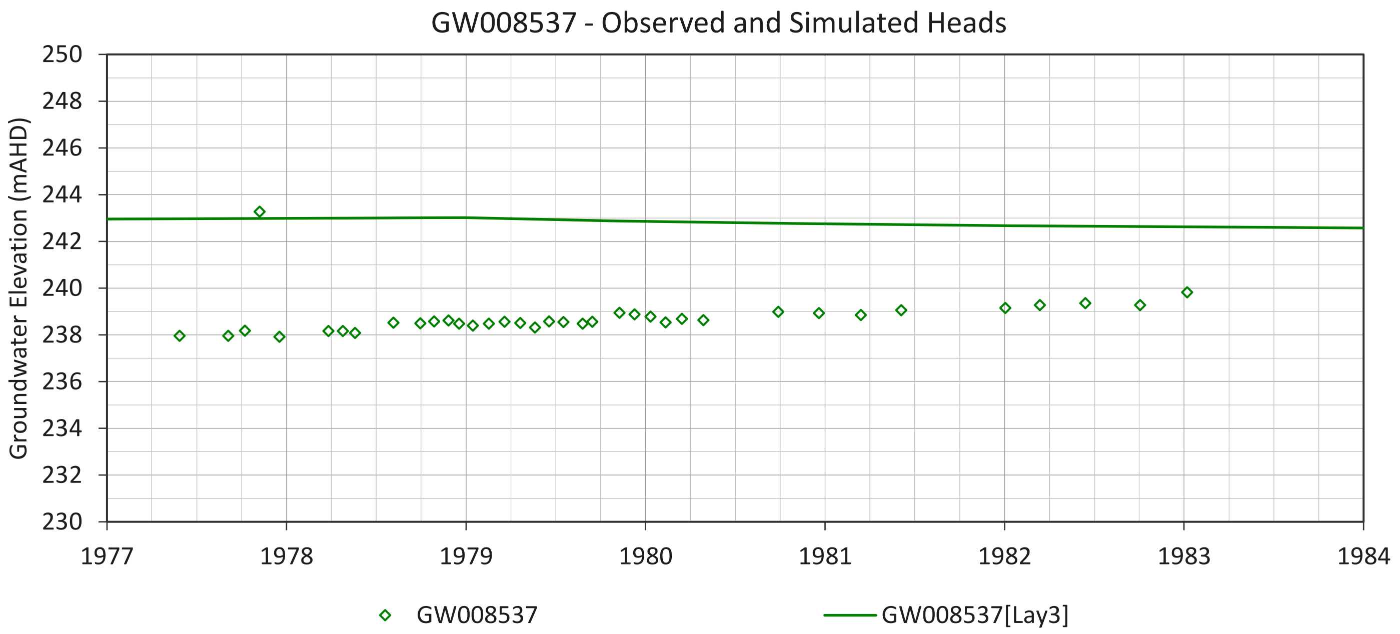

EAW7 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
110
60
10
-40
-90
-140
-190
-240
-290
-340
2008
2010
2012
2014
2016
2018
2020
EAW7_BGSS2
EAW7_BGSS2[Lay8]
EAW7_HBSS1
EAW7_HBSS1[Lay2]
EAW7_HBSS2
EAW7_HBSS2[Lay5]
EAW7_SBSS1
EAW7_SBSS1[Lay11]
EAW7_SBSS2
EAW7_SBSS2[Lay12]

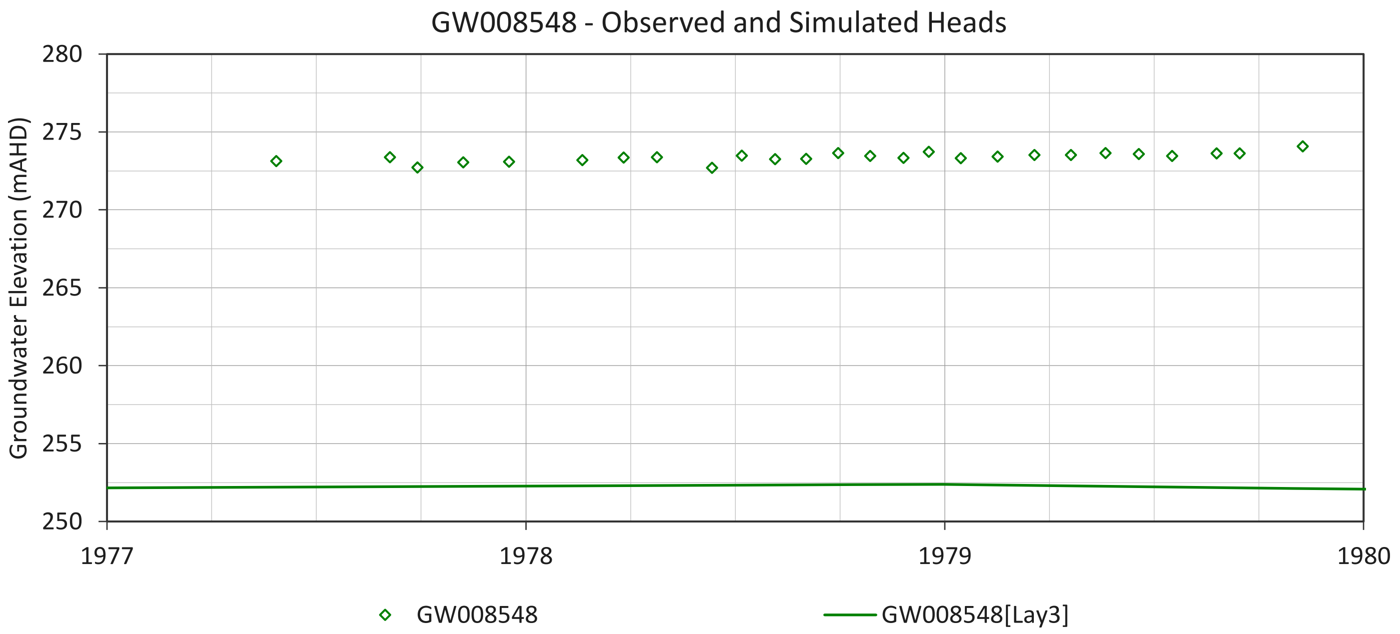

F6GW4A - Observed and Simulated Heads
Groundwater Elevation (mAHD)
110
60
10
-40
-90
-140
-190
-240
2013
2014
2015
2016
2017
2018
2019
2020
F6GW4A_512
F6GW4A_512[Lay12]

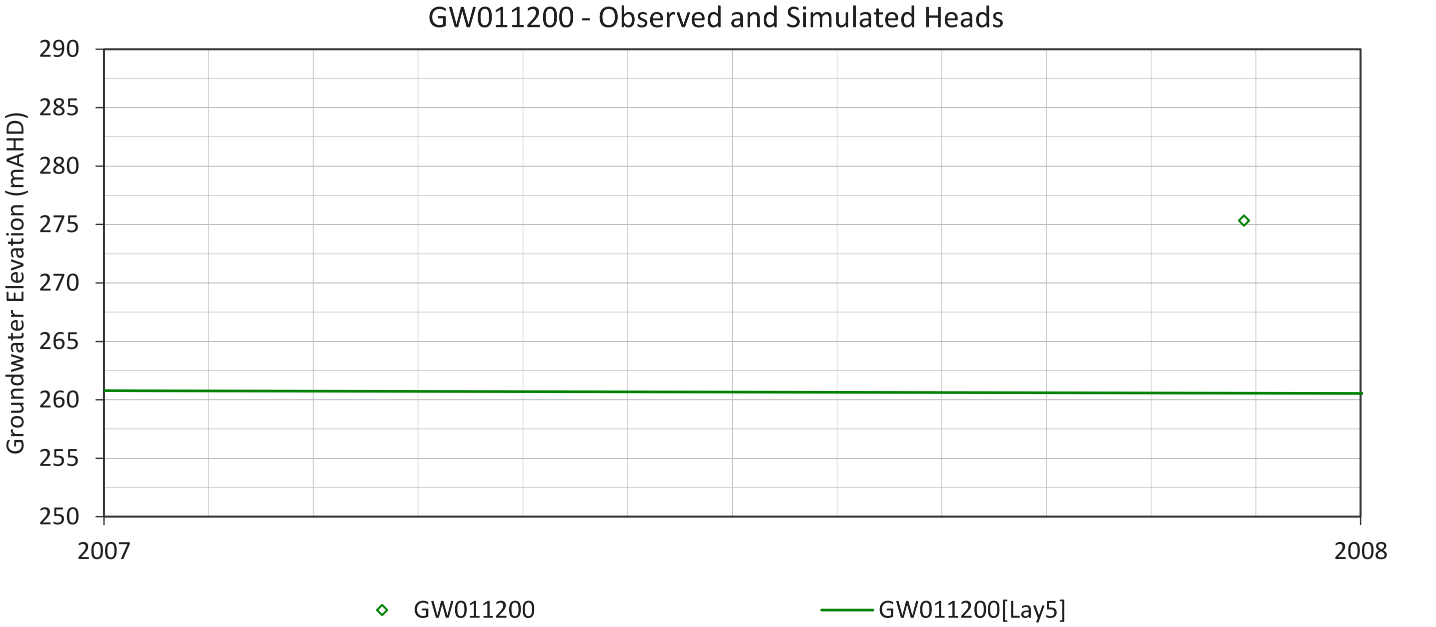

GR27 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
210
205
200
195
190
185
180
175
170
2010
2012
2014
2016
2018
2020
GR27
GR27[Lay4]

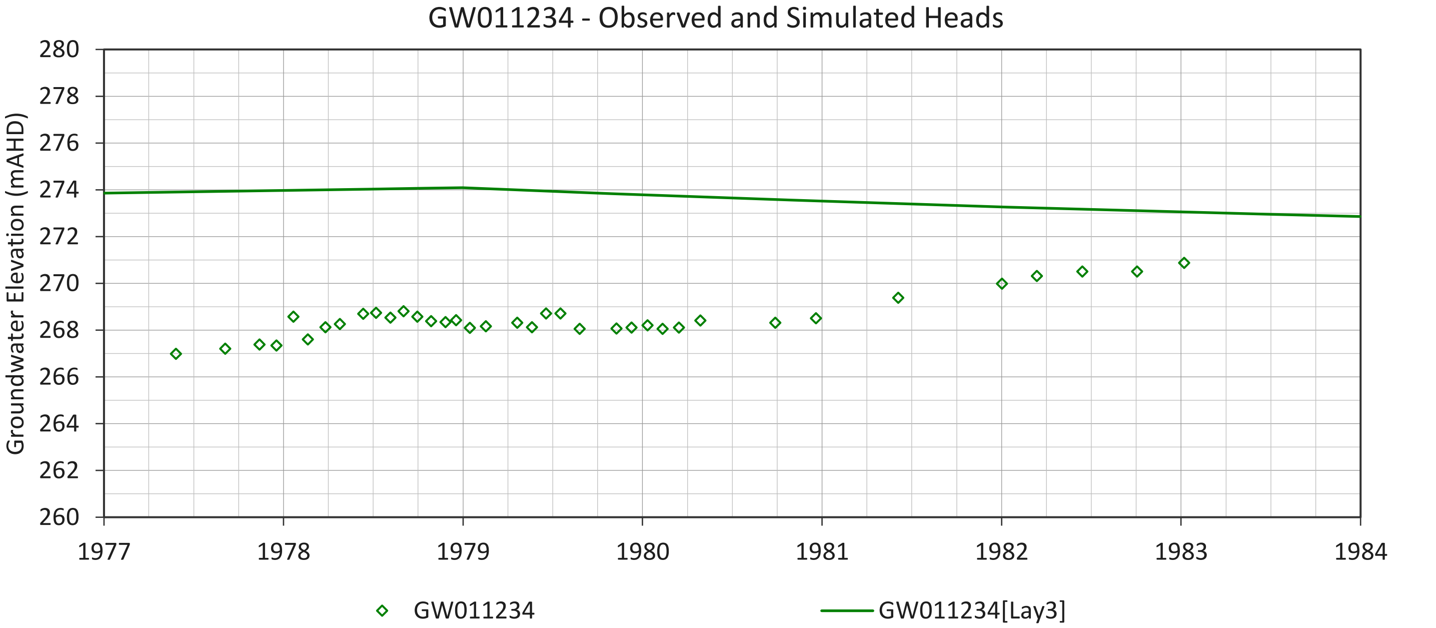

GR28 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
210
205
200
195
190
185
180
175
170
165
160
2010
2012
2014
2016
2018
2020
GR28
GR28[Lay4]

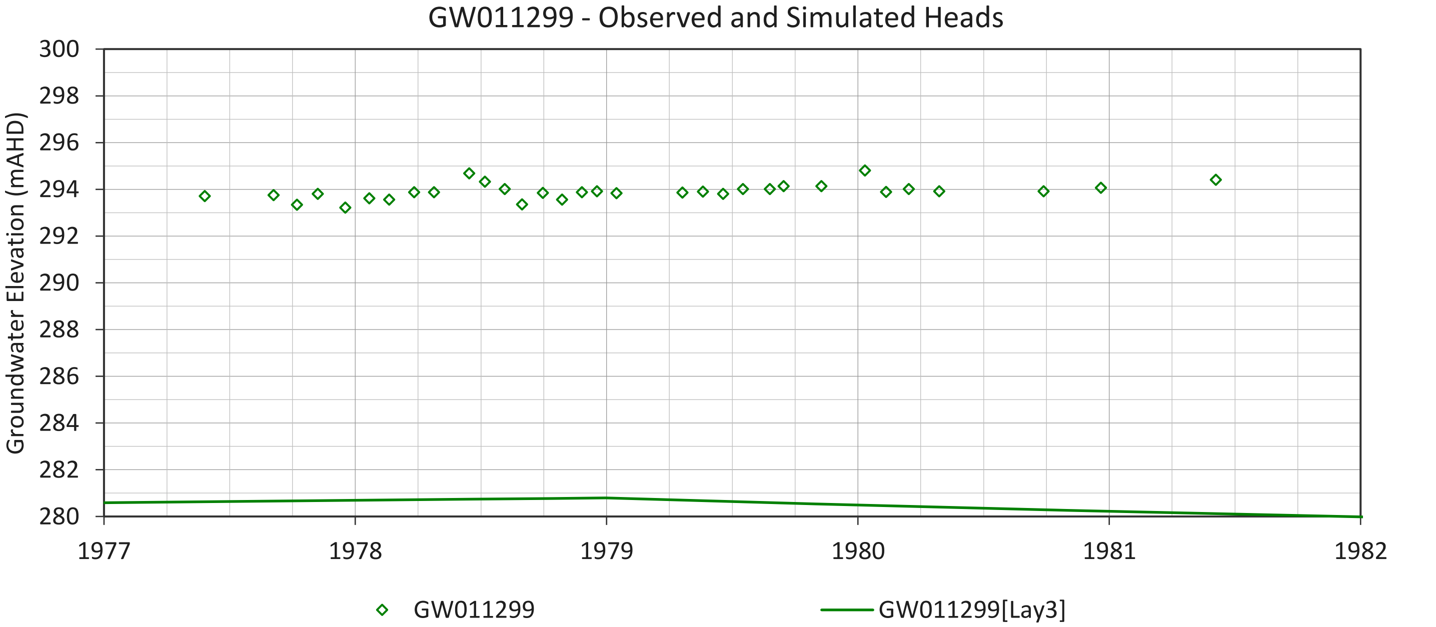

GR70 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
180
175
170
165
160
155
150
2014
2015
2016
2017
2018
2019
2020
2021
GR70
GR70[Lay4]

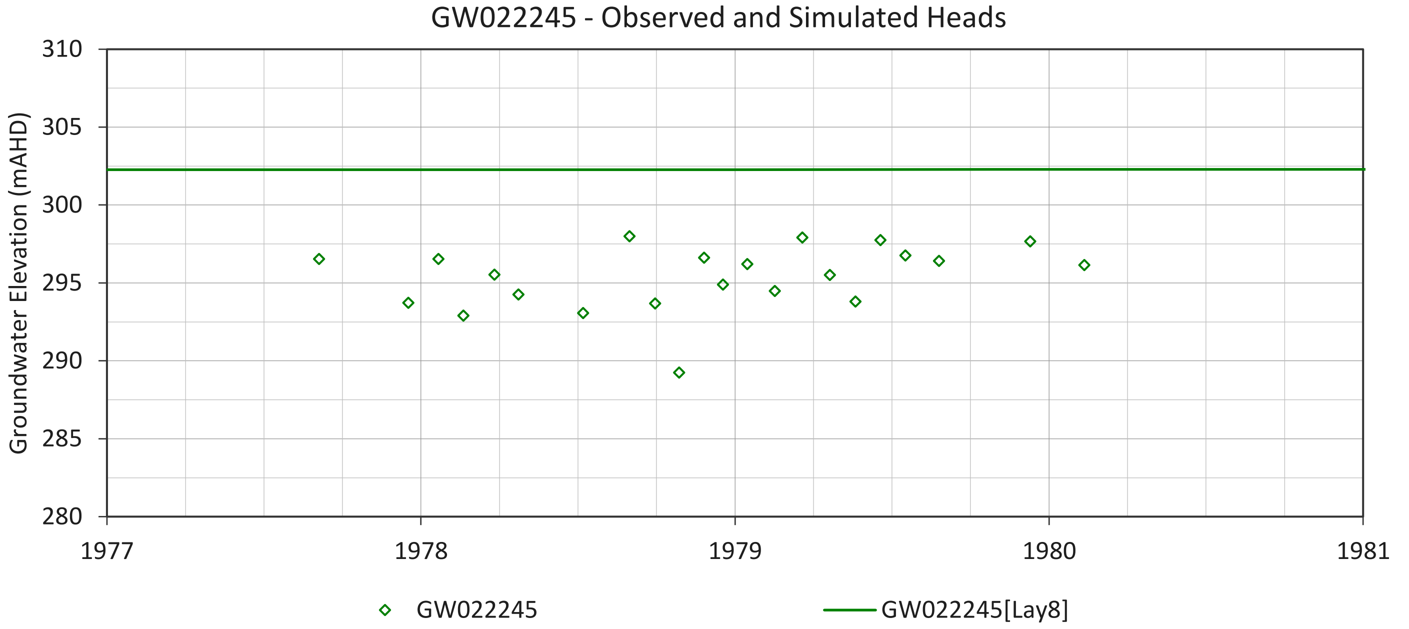

GW008537 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
250
248
246
244
242
240
238
236
234
232
230
1977
1978
1979
1980
1981
1982
1983
1984
GW008537
GW008537[Lay3]

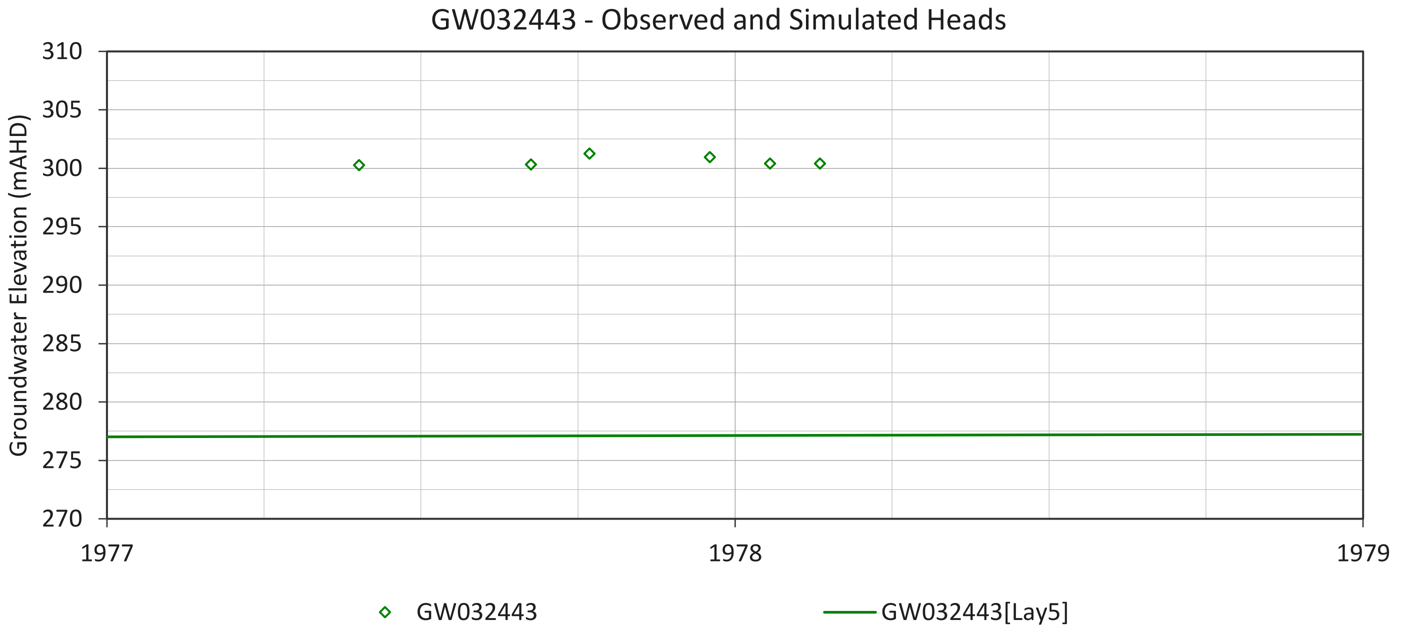

GW008548 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
280
275
270
265
260
255
250
1977
1978
1979
1980
GW008548
GW008548[Lay3]

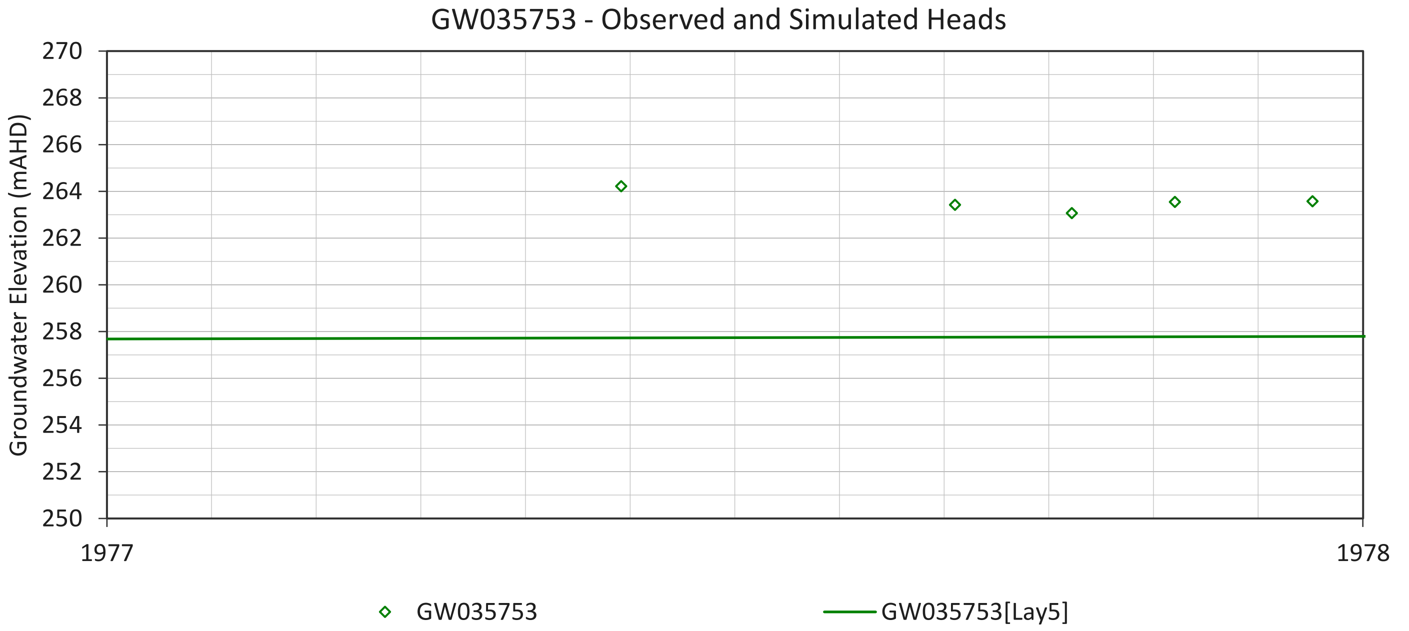

GW011200 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
290
285
280
275
270
265
260
255
250
2007
2008
GW011200
GW011200[Lay5]

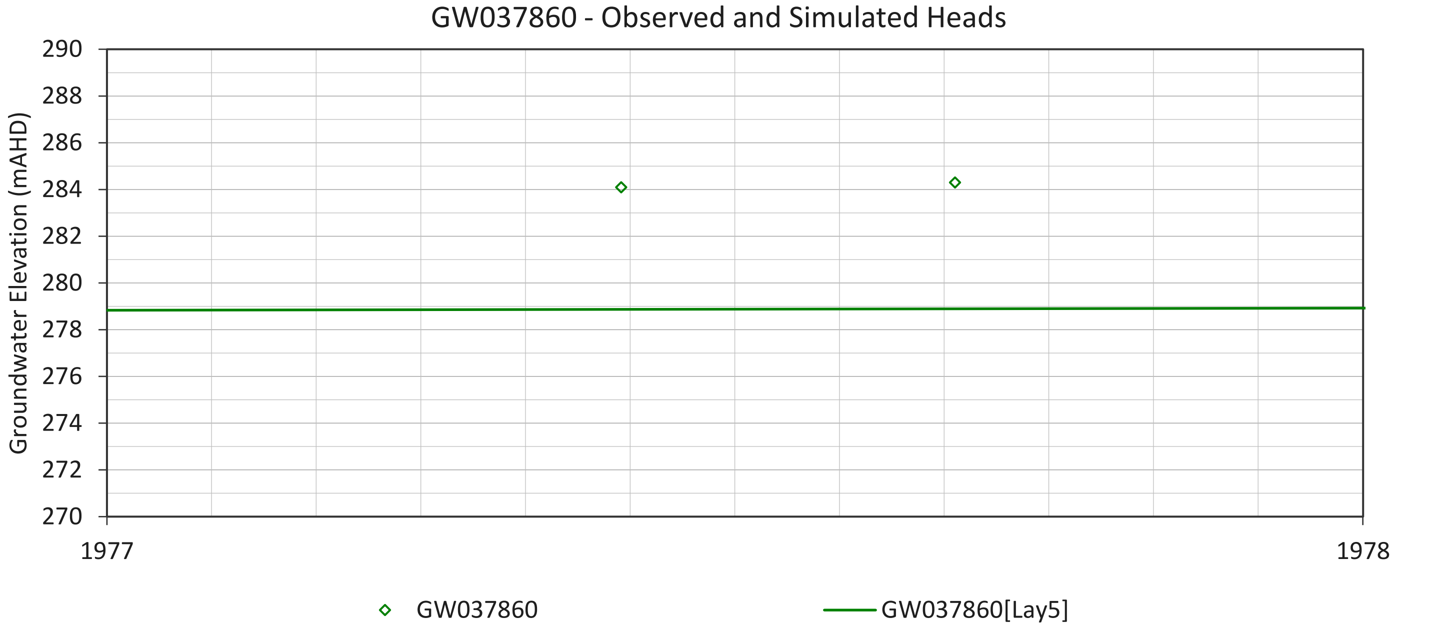

GW011234 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
280
278
276
274
272
270
268
266
264
262
260
1977
1978
1979
1980
1981
1982
1983
1984
GW011234
GW011234[Lay3]

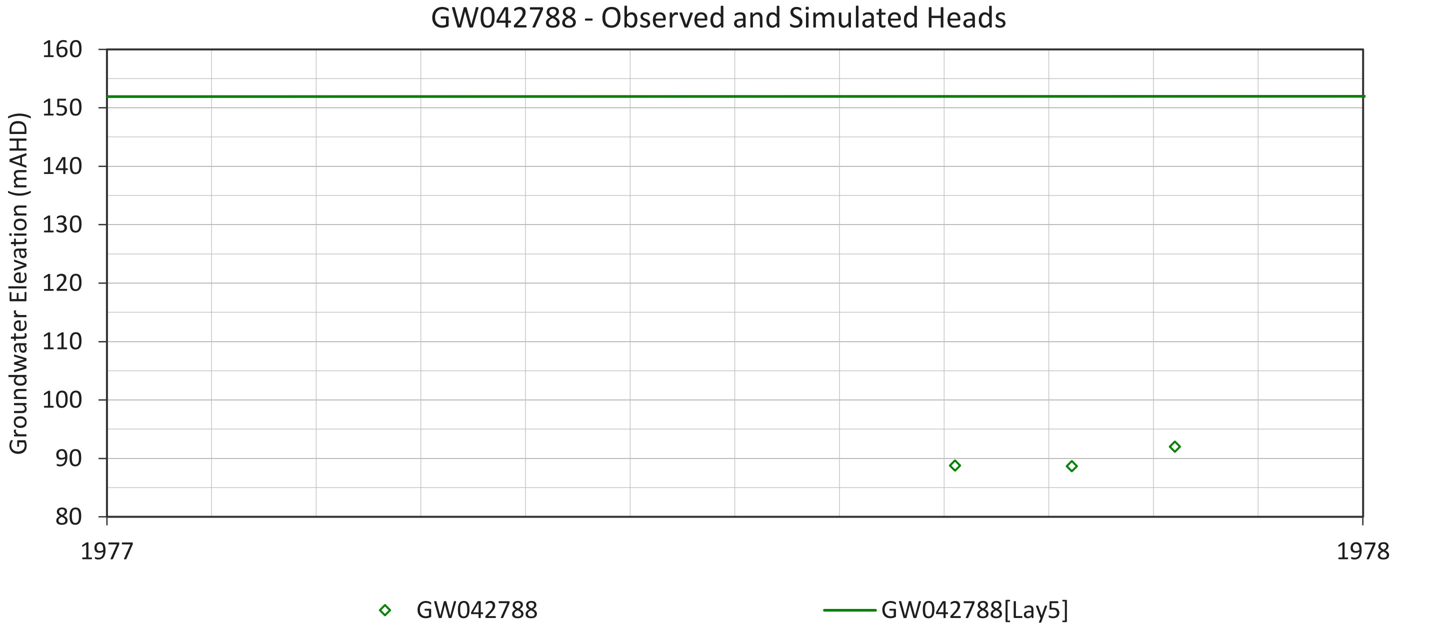

GW011299 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
300
298
296
294
292
290
288
286
284
282
280
1977
1978
1979
1980
1981
1982
GW011299
GW011299[Lay3]

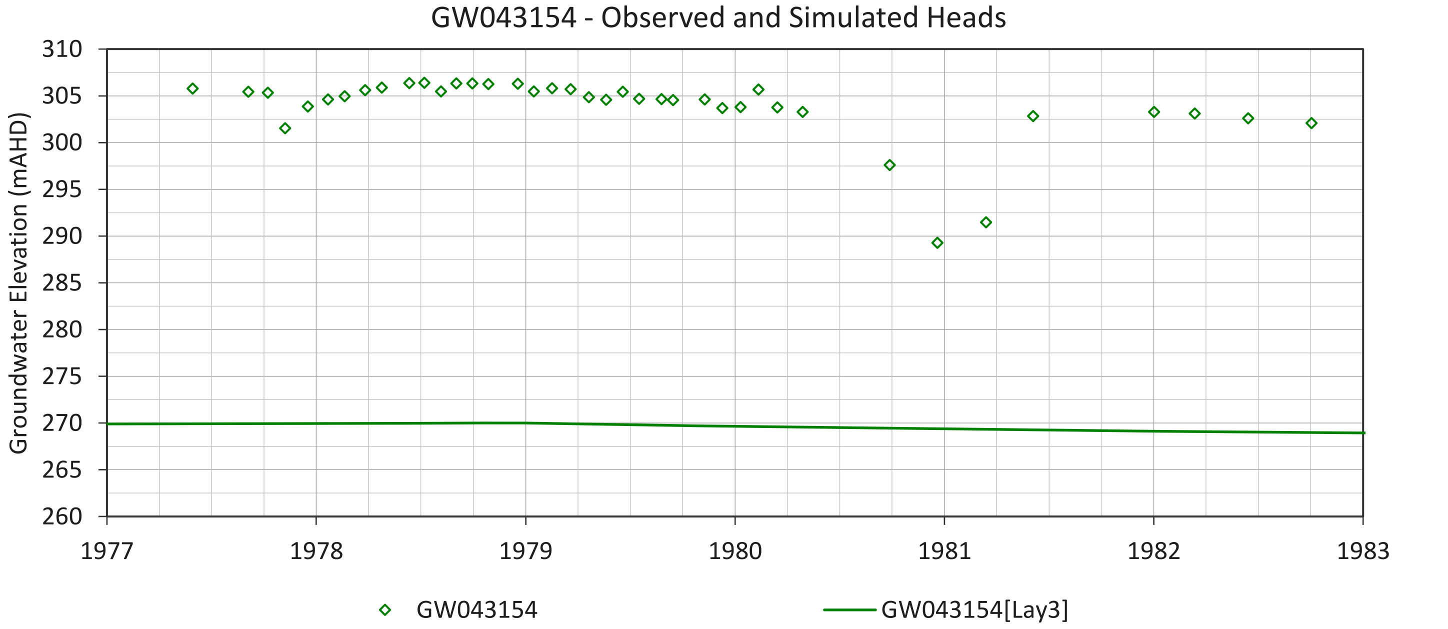

GW022245 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
310
305
300
295
290
285
280
1977
1978
1979
1980
1981
GW022245
GW022245[Lay8]

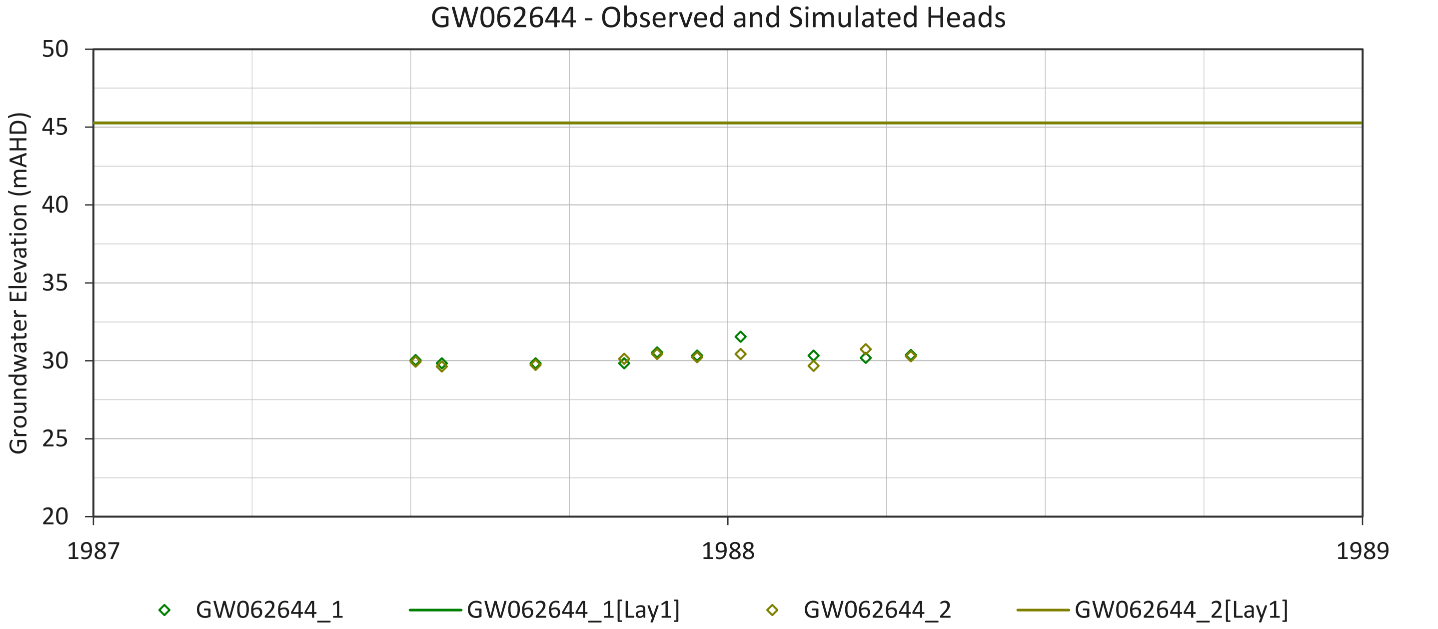

GW032443 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
310
305
300
295
290
285
280
275
270
1977
1978
1979
GW032443
GW032443[Lay5]

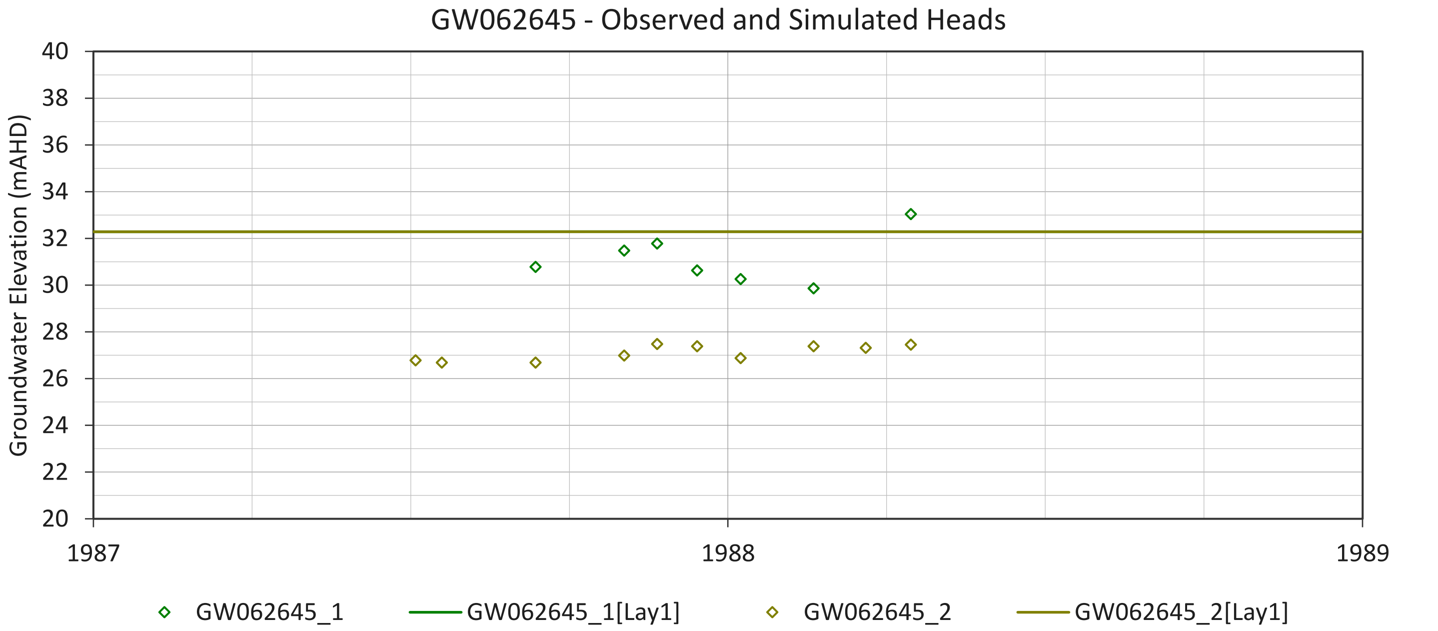

GW035753 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
270
268
266
264
262
260
258
256
254
252
250
1977
1978
GW035753
GW035753[Lay5]

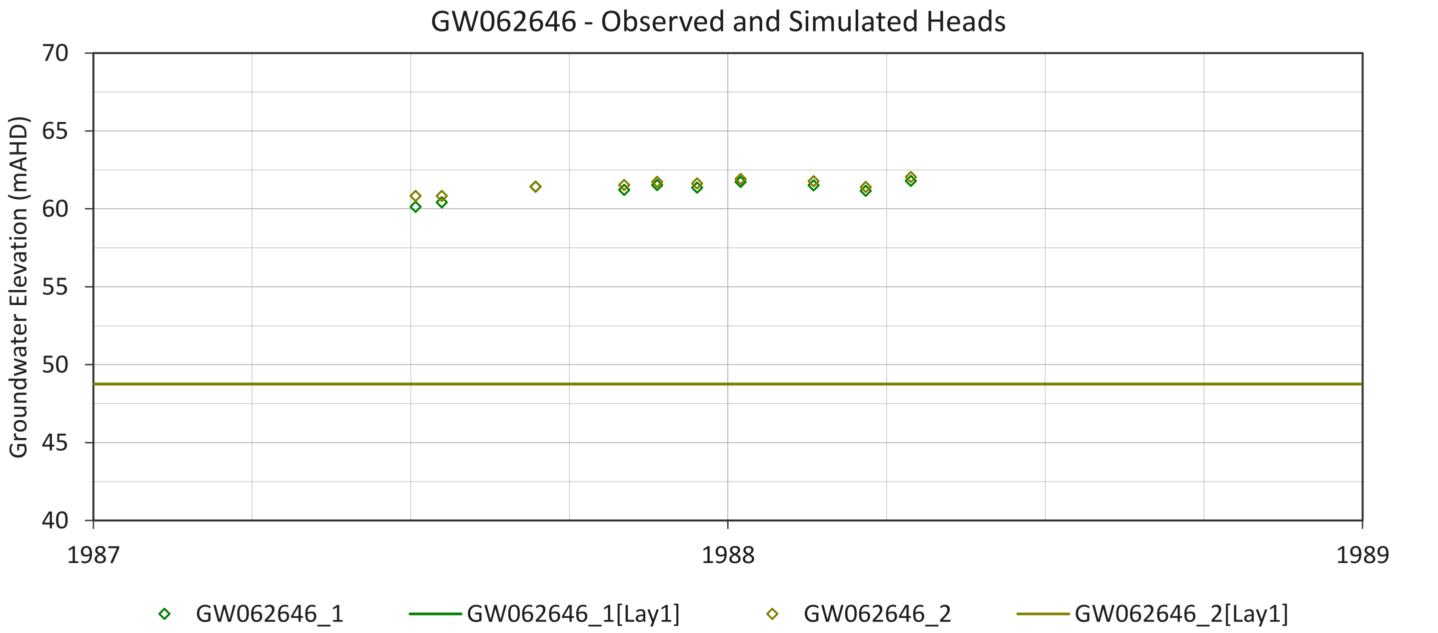

GW037860 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
290
288
286
284
282
280
278
276
274
272
270
1977
1978
GW037860
GW037860[Lay5]

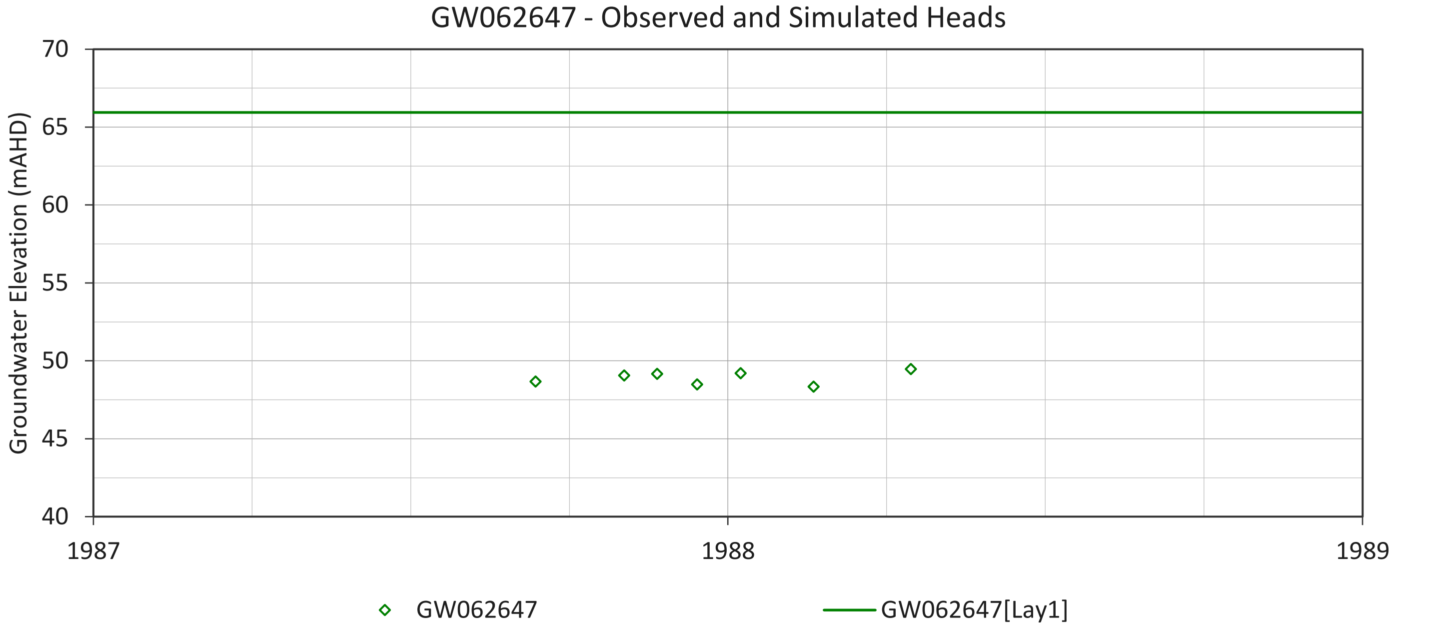

GW042788 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
160
150
140
130
120
110
100
90
80
1977
1978
GW042788
GW042788[Lay5]

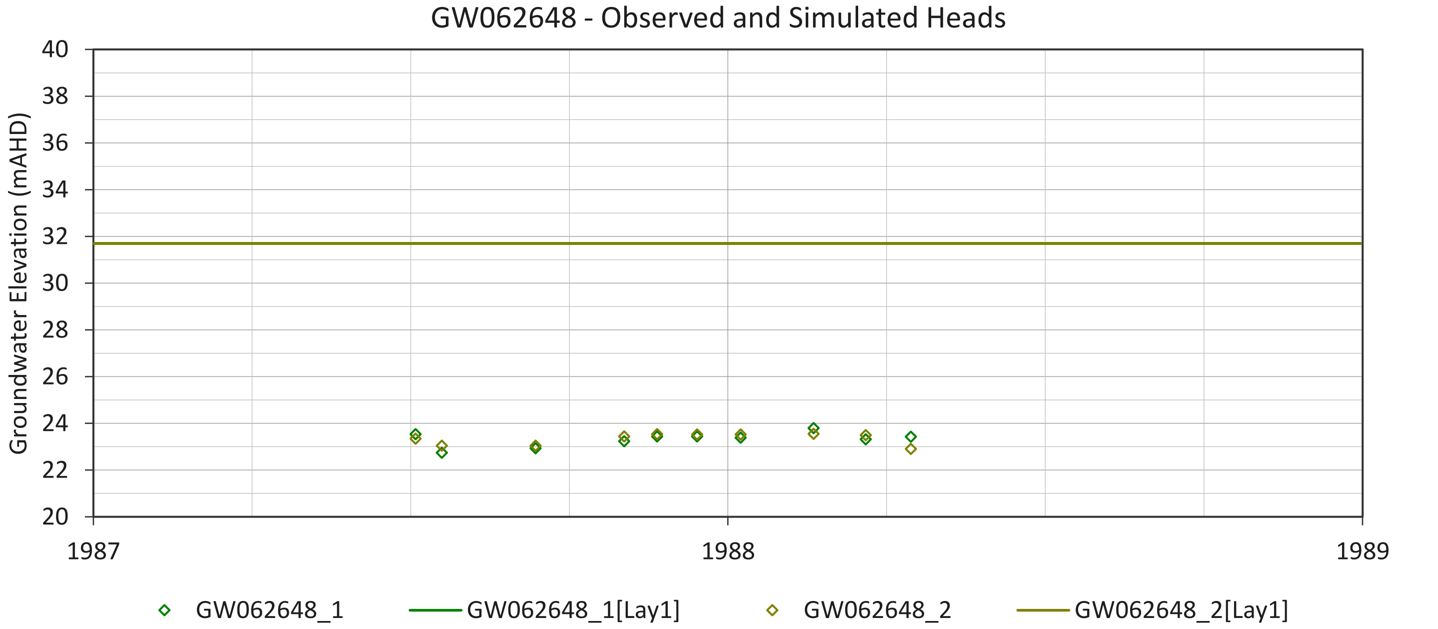

GW043154 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
310
305
300
295
290
285
280
275
270
265
260
1977
1978
1979
1980
1981
1982
1983
GW043154
GW043154[Lay3]

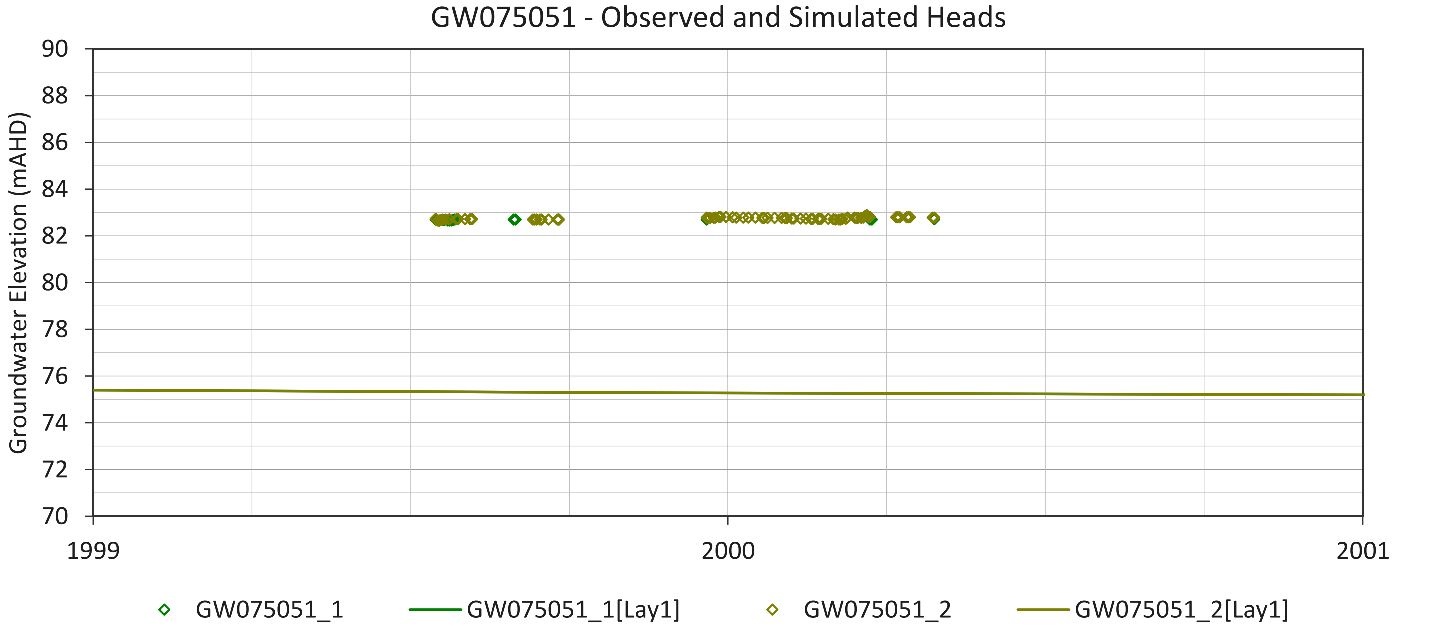

GW062644 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
50
45
40
35
30
25
20
1987
1988
1989
GW062644_1
GW062644_1[Lay1]
GW062644_2
GW062644_2[Lay1]

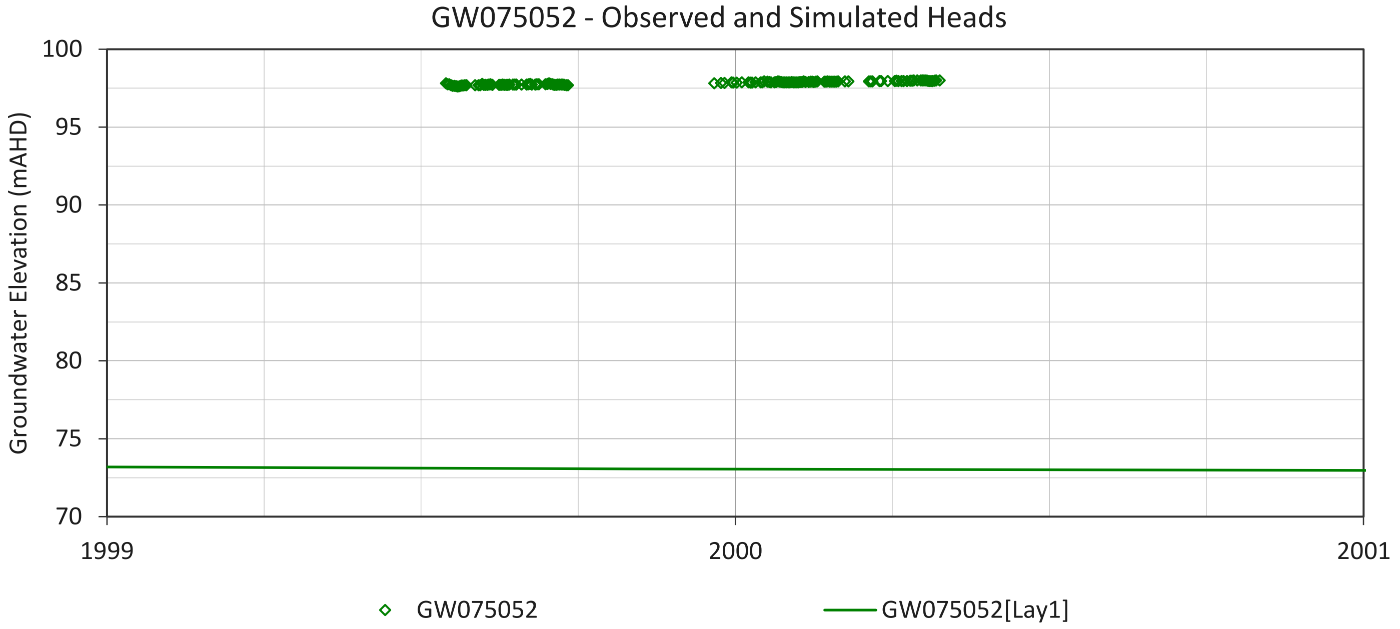

GW062645 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
40
38
36
34
32
30
28
26
24
22
20
1987
1988
1989
GW062645_1
GW062645_1[Lay1]
GW062645_2
GW062645_2[Lay1]

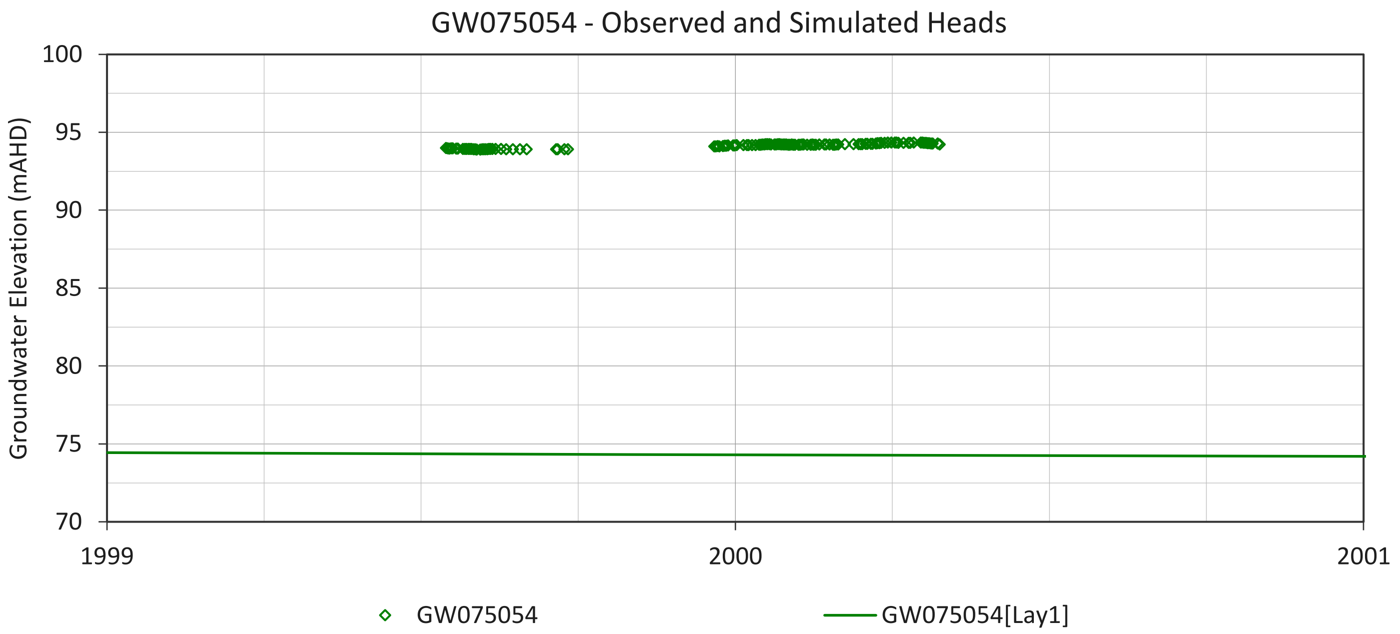

GW062646 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
70
65
60
55
50
45
40
1987
1988
1989
GW062646_1
GW062646_1[Lay1]
GW062646_2
GW062646_2[Lay1]

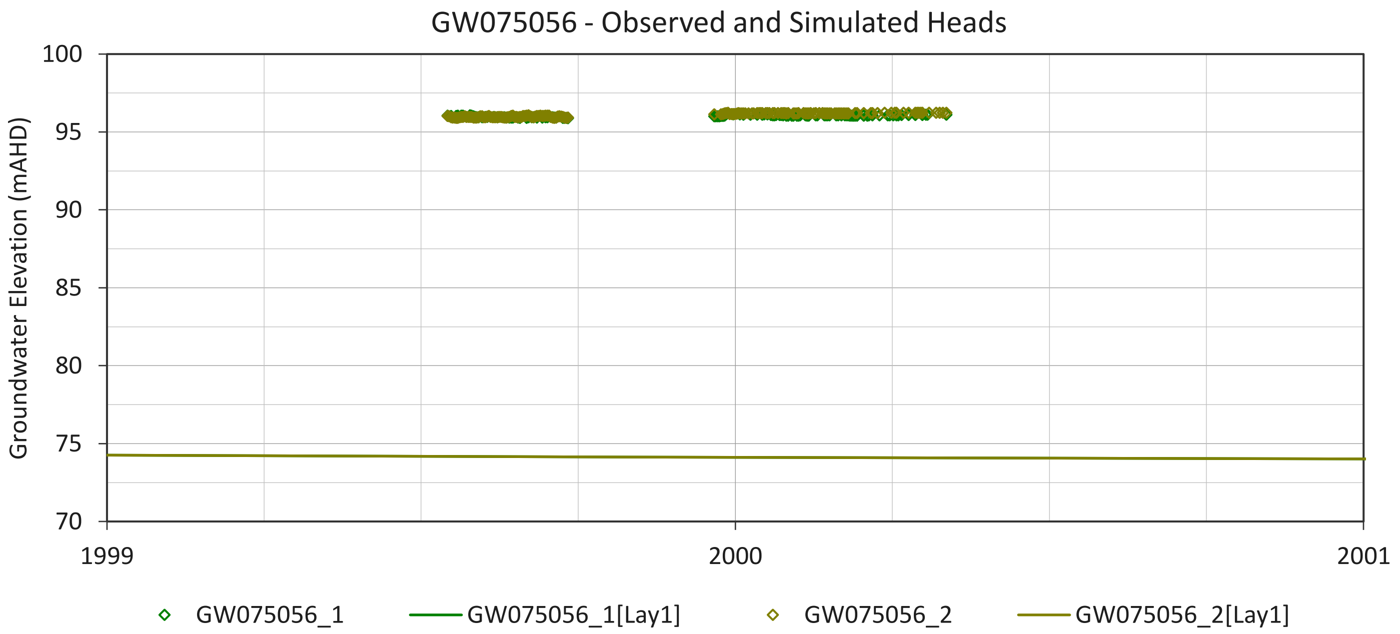

GW062647 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
70
65
60
55
50
45
40
1987
1988
1989
GW062647
GW062647[Lay1]

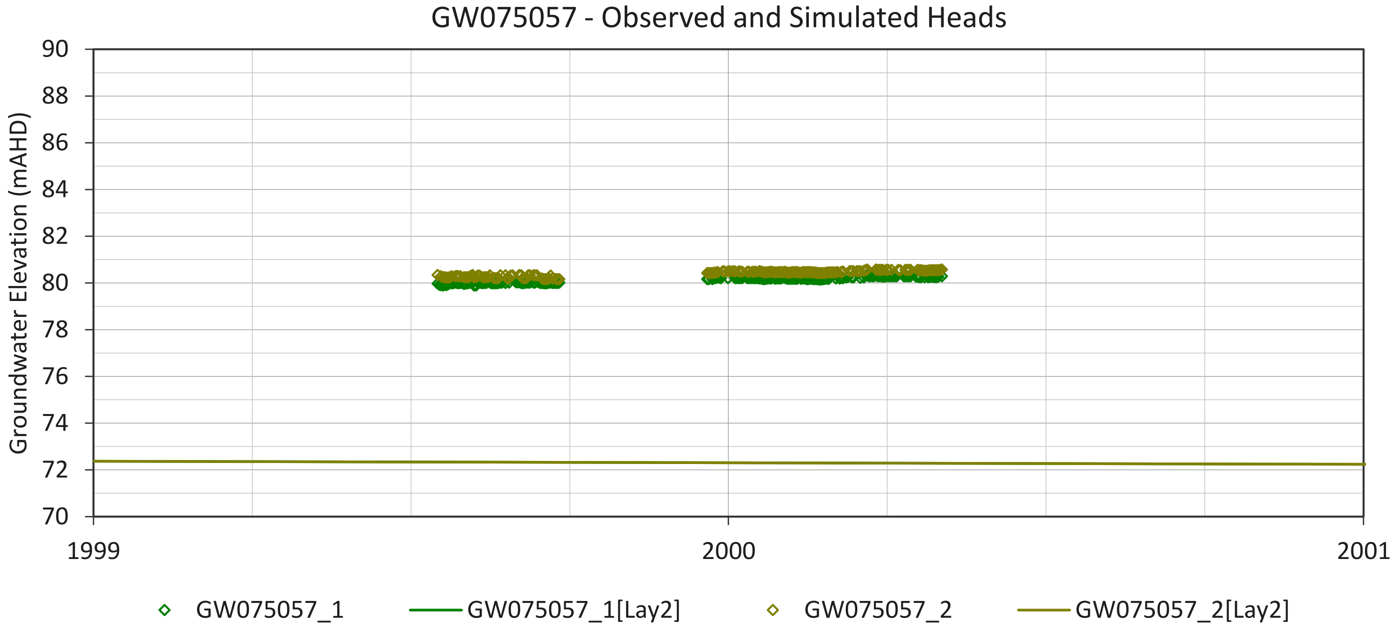

GW062648 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
40
38
36
34
32
30
28
26
24
22
20
1987
1988
1989
GW062648_1
GW062648_1[Lay1]
GW062648_2
GW062648_2[Lay1]

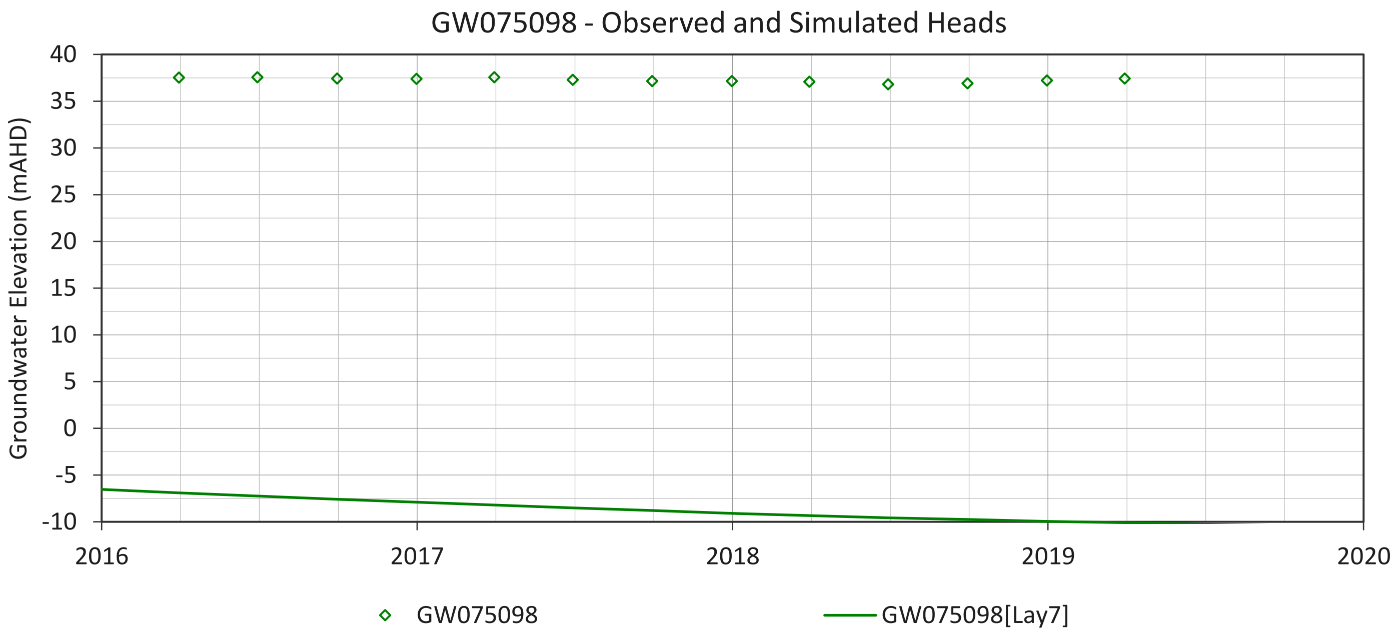

GW075051 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
90
88
86
84
82
80
78
76
74
72
70
1999
2000
2001
GW075051_1
GW075051_1[Lay1]
GW075051_2
GW075051_2[Lay1]

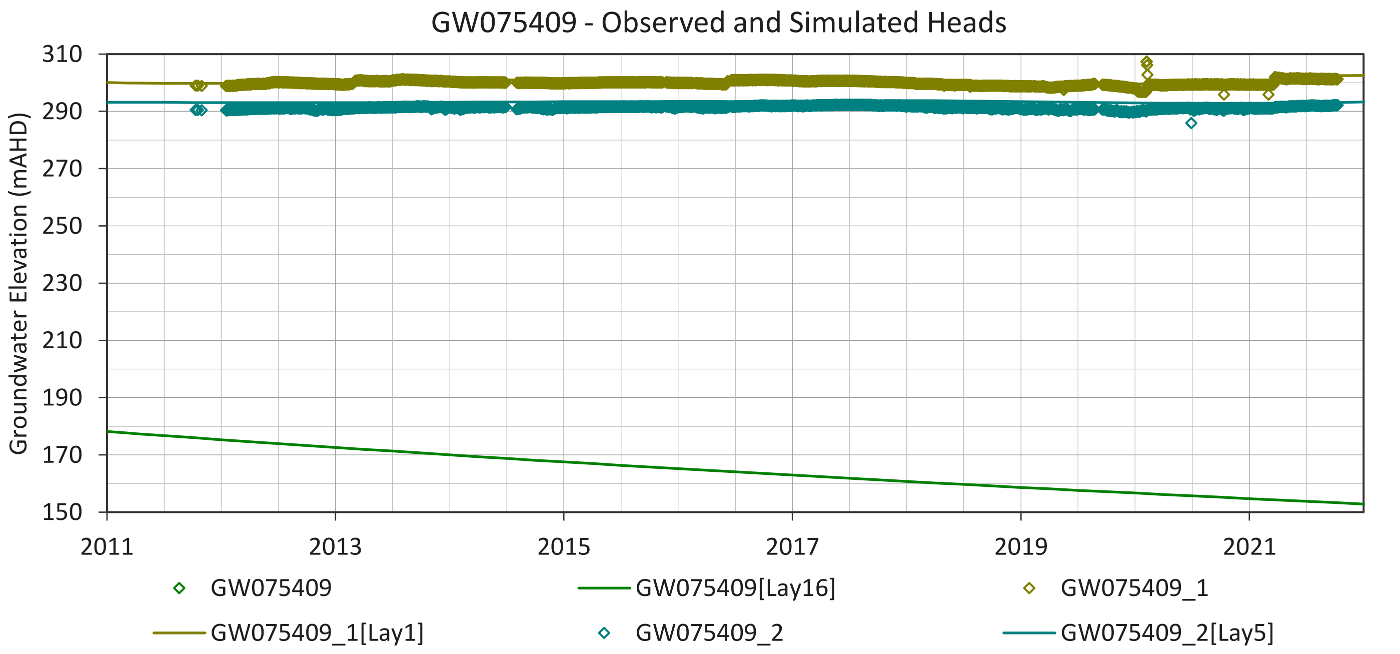

GW075052 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
100
95
90
85
80
75
70
1999
2000
2001
GW075052
GW075052[Lay1]

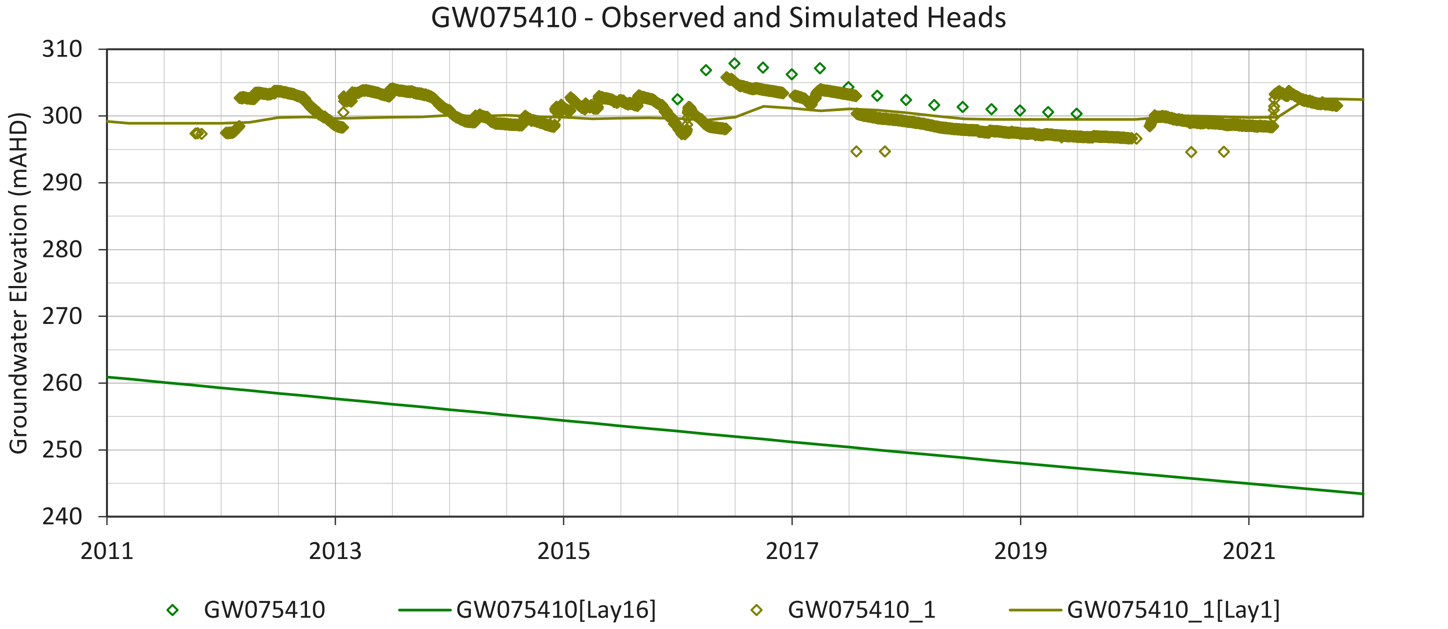

GW075054 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
100
95
90
85
80
75
70
1999
2000
2001
GW075054
GW075054[Lay1]

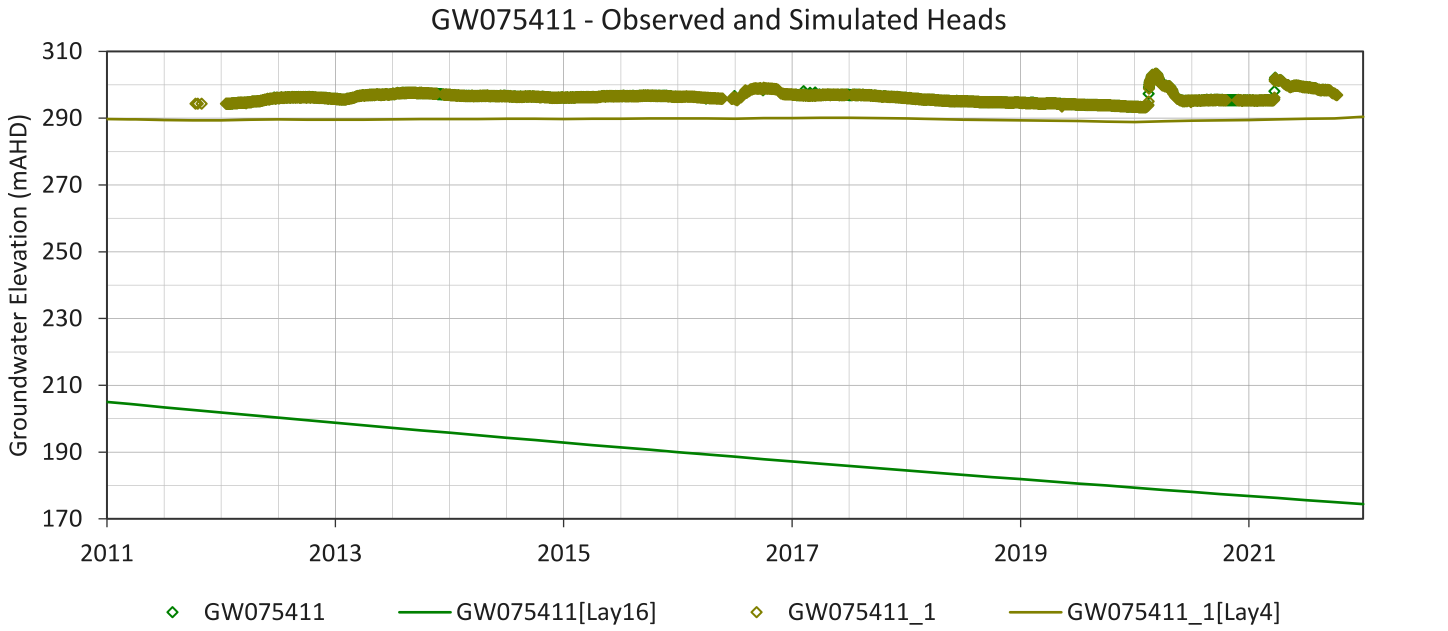

GW075056 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
100
95
90
85
80
75
70
1999
2000
2001
GW075056_1
GW075056_1[Lay1]
GW075056_2
GW075056_2[Lay1]

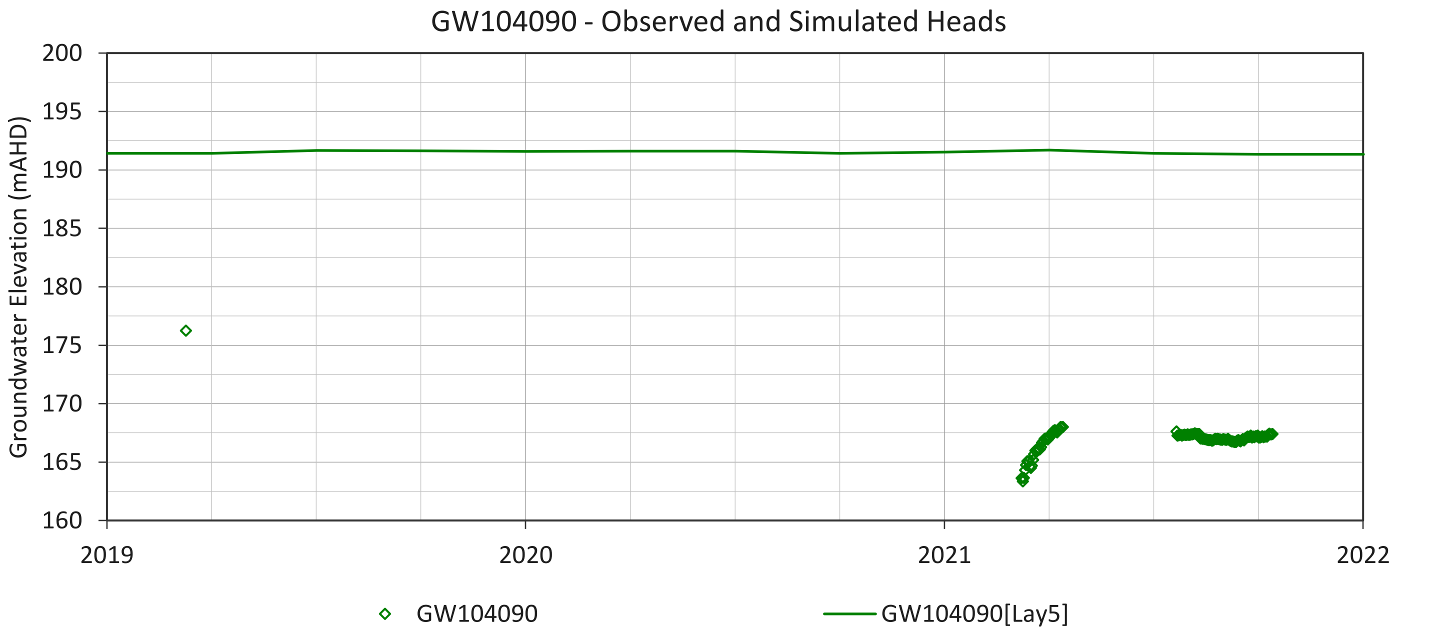

GW075057 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
90
88
86
84
82
80
78
76
74
72
70
1999
2000
2001
GW075057_1
GW075057_1[Lay2]
GW075057_2
GW075057_2[Lay2]

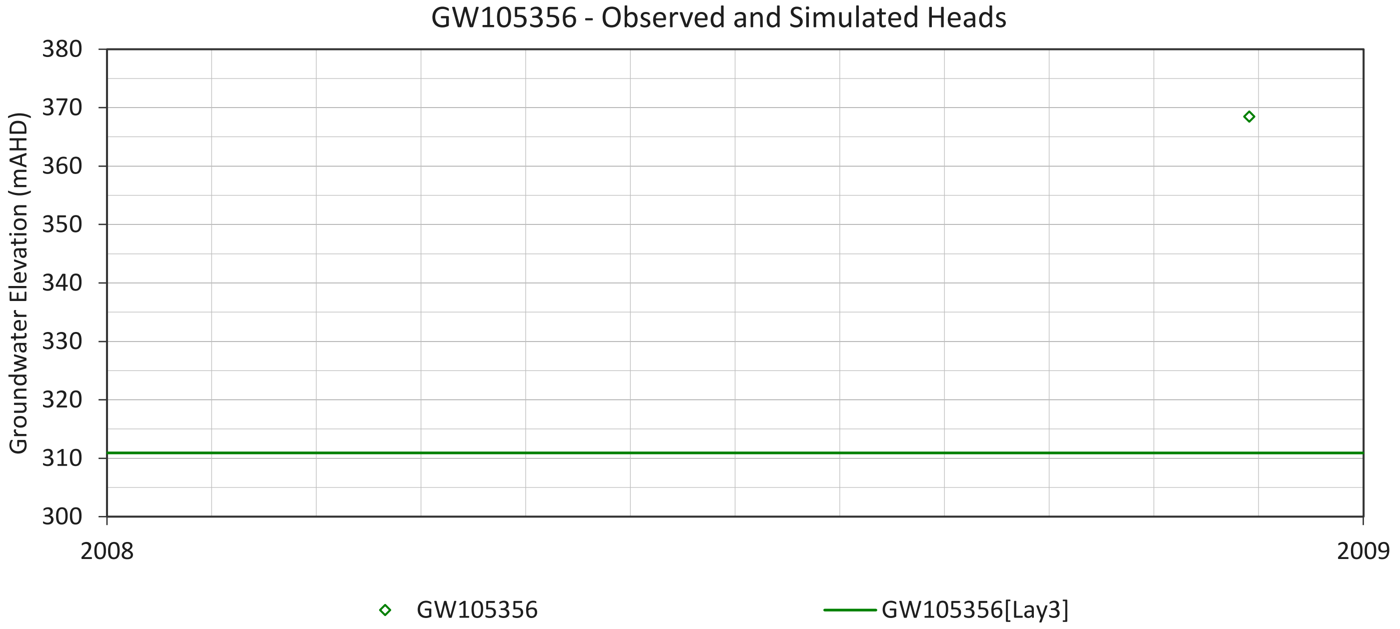

GW075098 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
40
35
30
25
20
15
10
5
0
-5
-10
2016
2017
2018
2019
2020
GW075098
GW075098[Lay7]

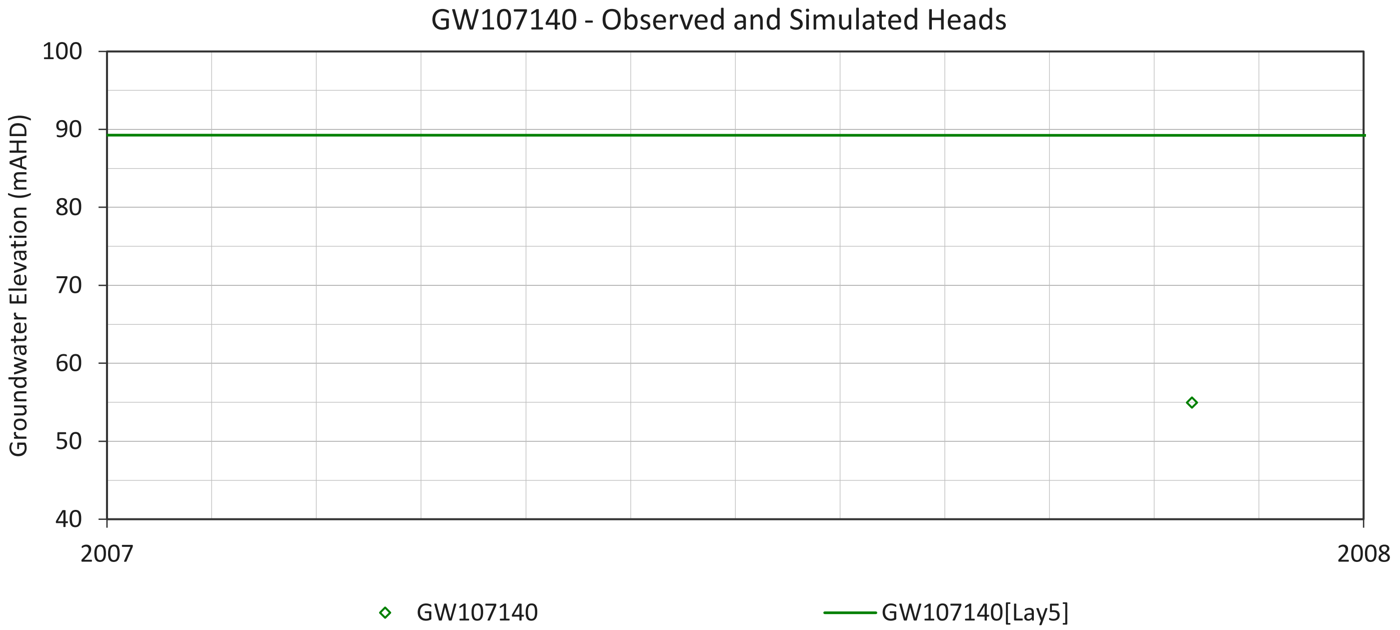

GW075409 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
310
290
270
250
230
210
190
170
150
2011
2013
2015
2017
2019
2021
GW075409
GW075409[Lay16]
GW075409_1
GW075409_1[Lay1]
GW075409_2
GW075409_2[Lay5]

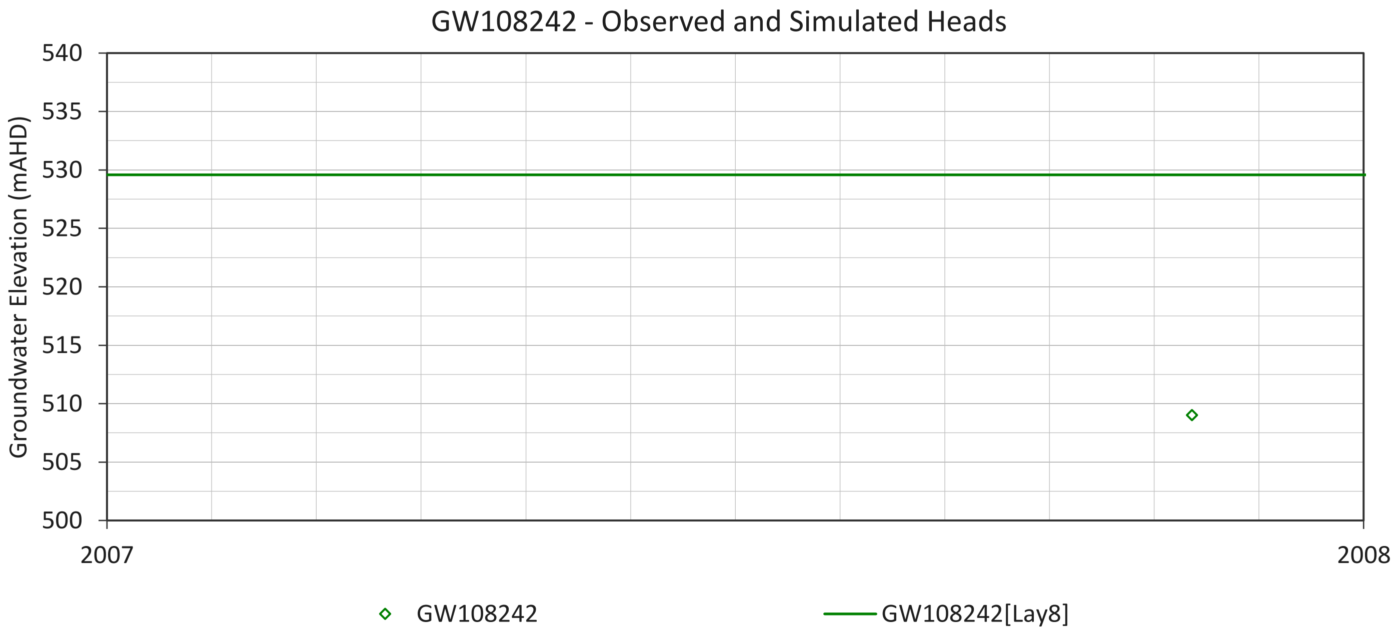

GW075410 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
310
300
290
280
270
260
250
240
2011
2013
2015
2017
2019
2021
GW075410
GW075410[Lay16]
GW075410_1
GW075410_1[Lay1]

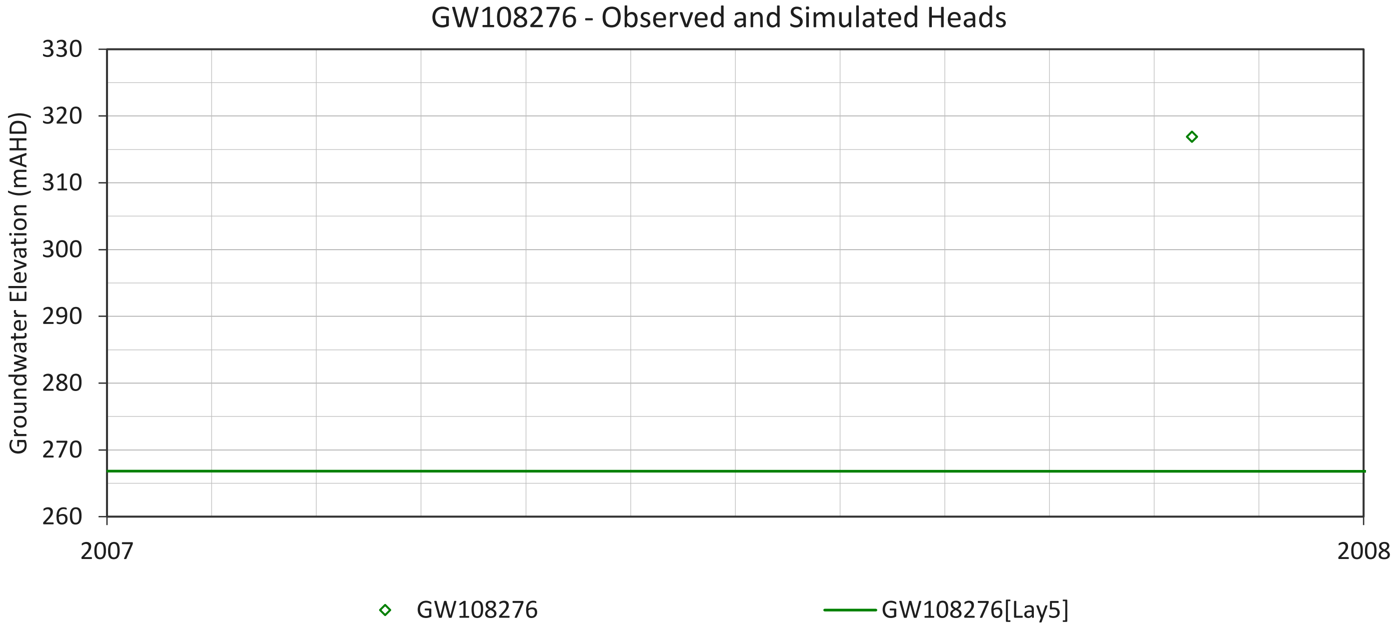

GW075411 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
310
290
270
250
230
210
190
170
2011
2013
2015
2017
2019
2021
GW075411
GW075411[Lay16]
GW075411_1
GW075411_1[Lay4]

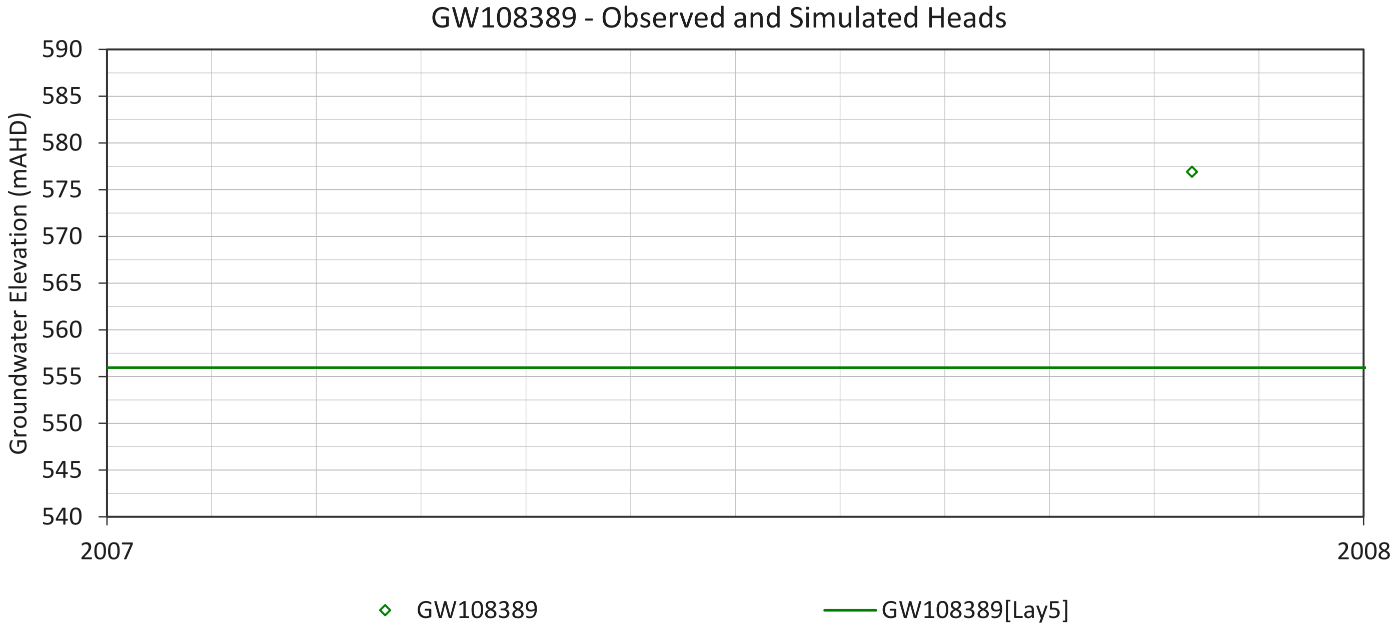

GW104090 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
200
195
190
185
180
175
170
165
160
2019
2020
2021
2022
GW104090
GW104090[Lay5]

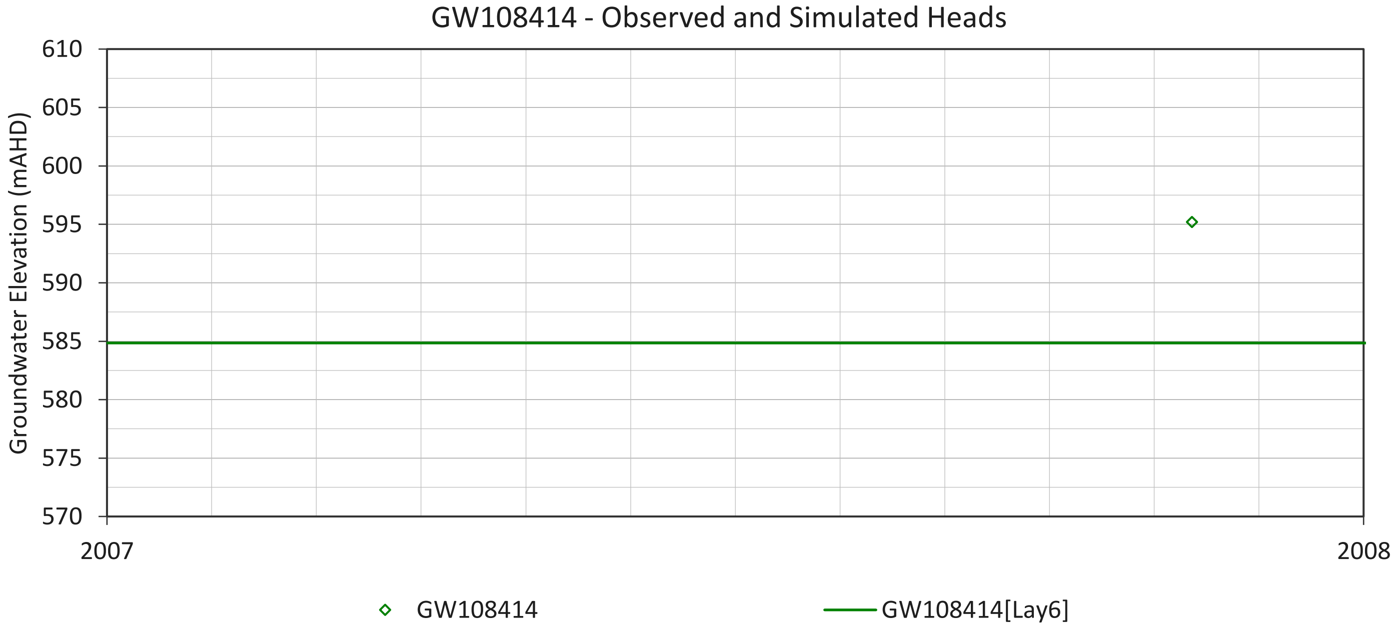

GW105356 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
380
370
360
350
340
330
320
310
300
2008
2009
GW105356
GW105356[Lay3]

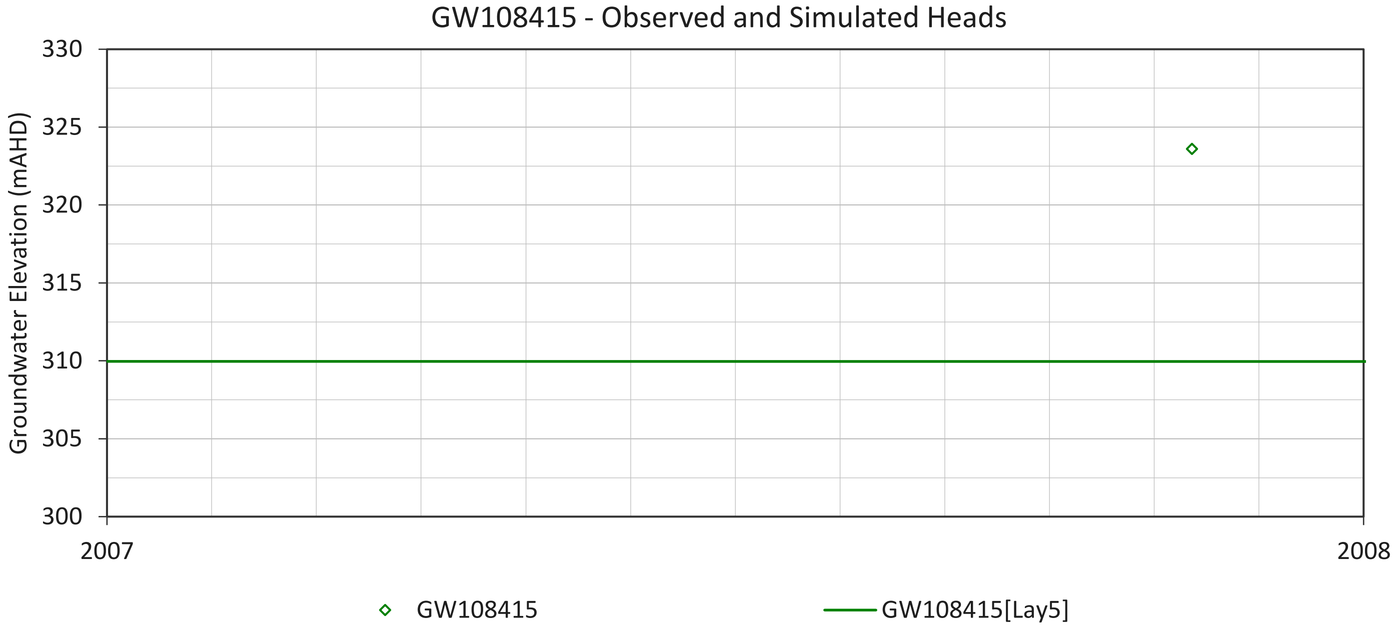

GW107140 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
100
90
80
70
60
50
40
2007
2008
GW107140
GW107140[Lay5]

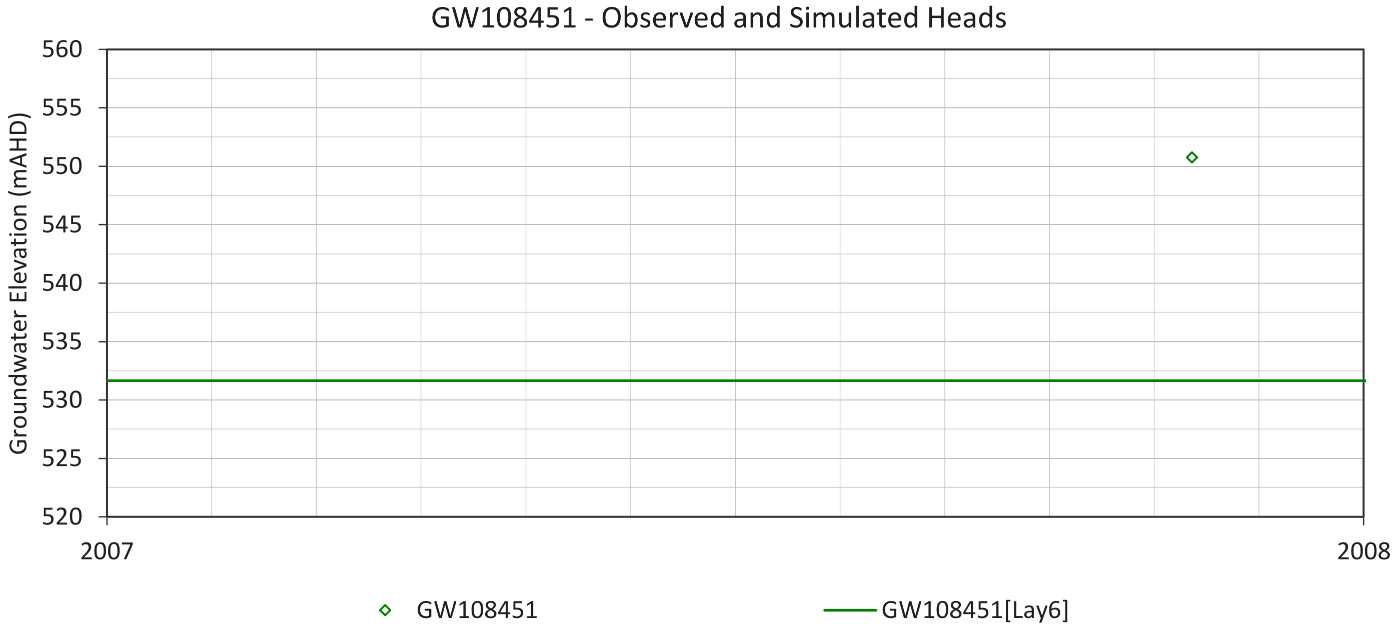

GW108242 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
540
535
530
525
520
515
510
505
500
2007
2008
GW108242
GW108242[Lay8]

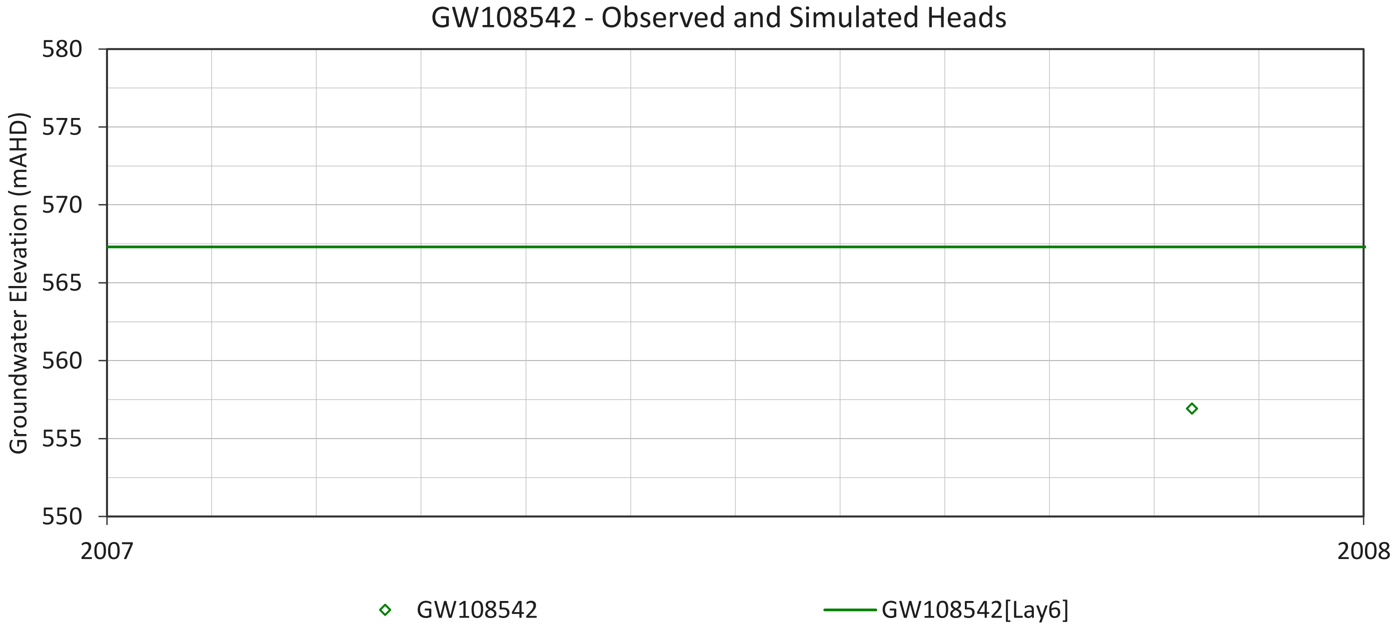

GW108276 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
330
320
310
300
290
280
270
260
2007
2008
GW108276
GW108276[Lay5]

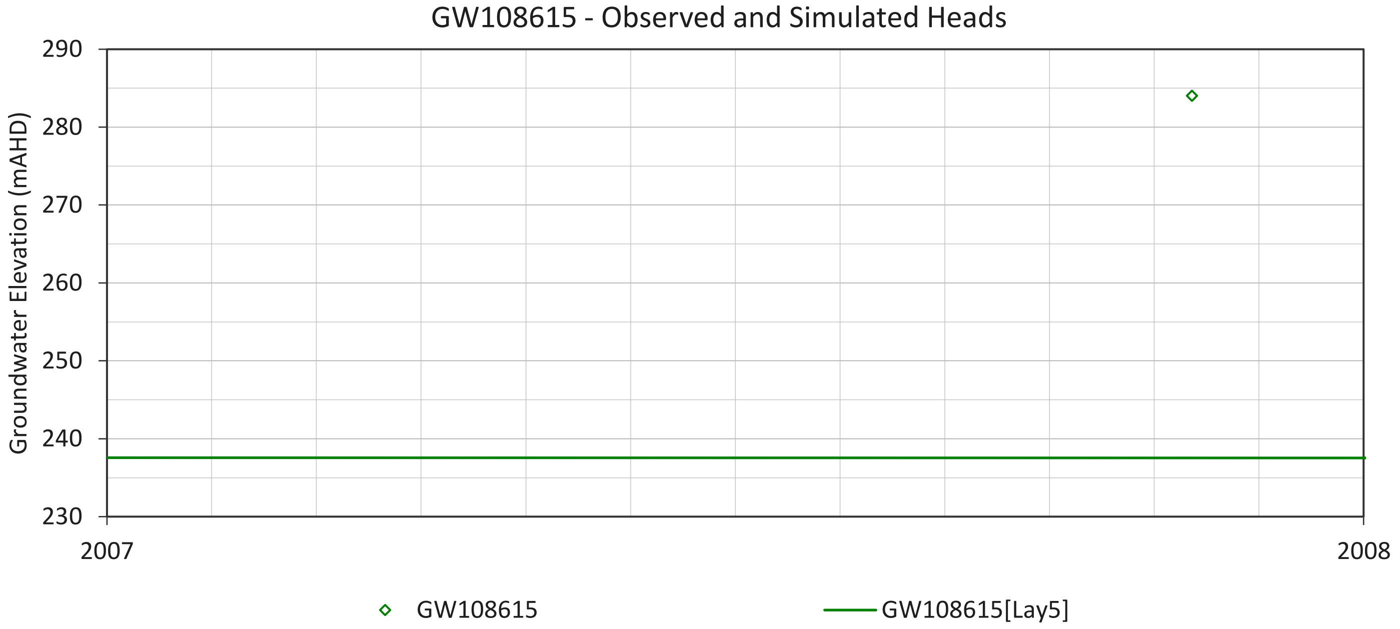

GW108389 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
590
585
580
575
570
565
560
555
550
545
540
2007
2008
GW108389
GW108389[Lay5]

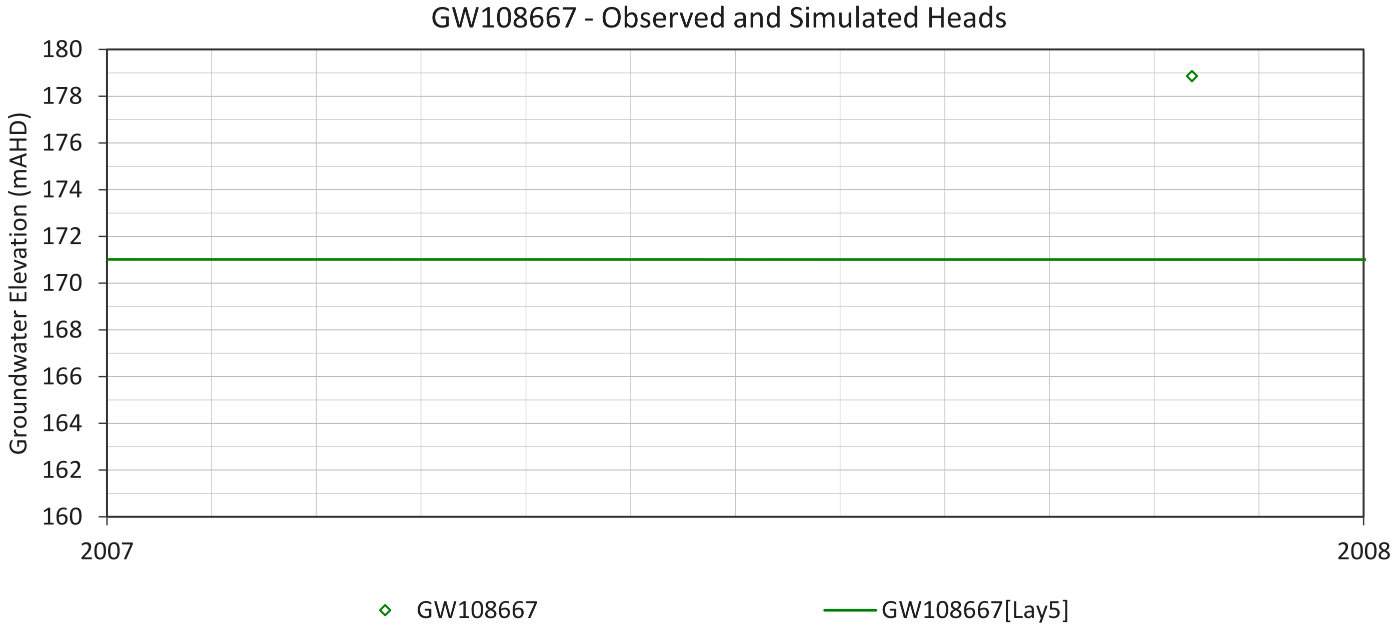

GW108414 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
610
605
600
595
590
585
580
575
570
2007
2008
GW108414
GW108414[Lay6]

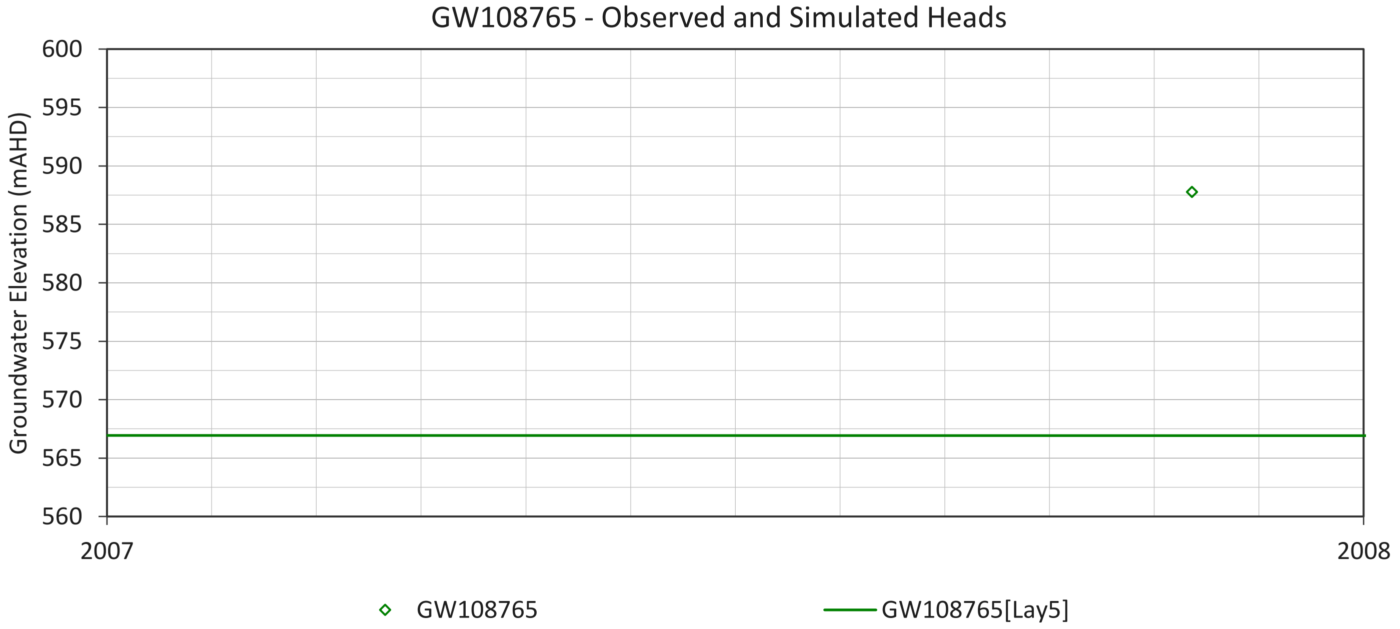

GW108415 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
330
325
320
315
310
305
300
2007
2008
GW108415
GW108415[Lay5]

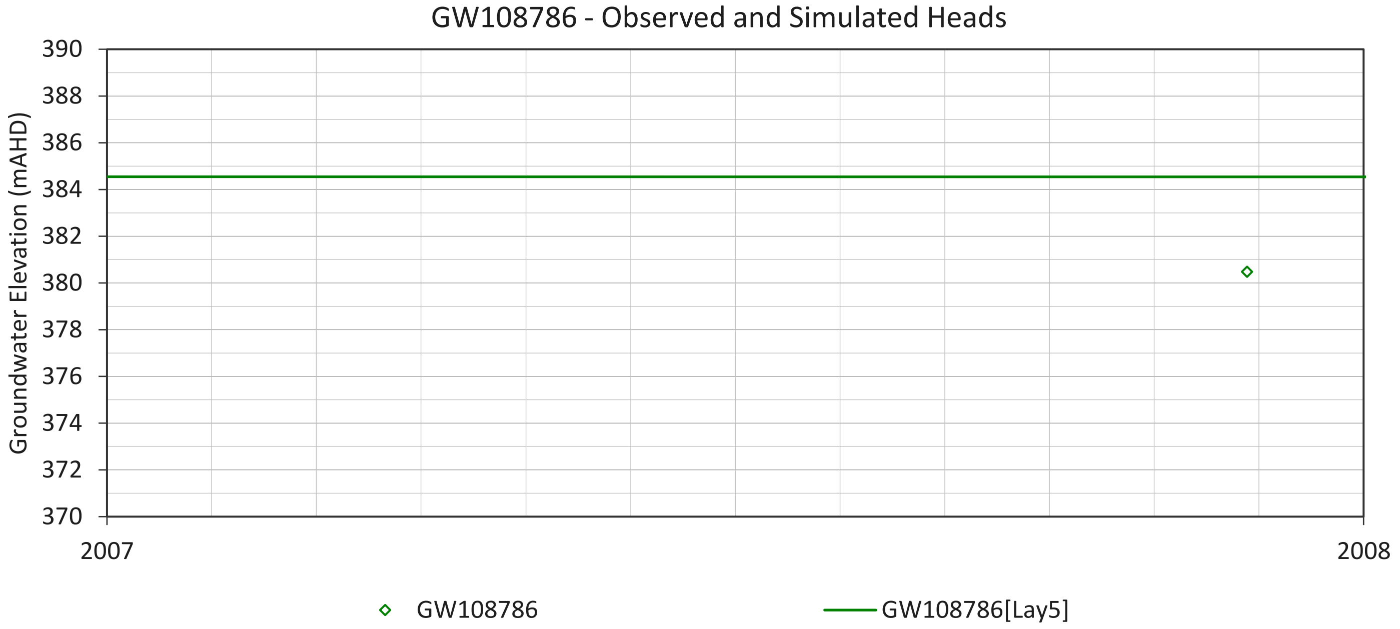

GW108451 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
560
555
550
545
540
535
530
525
520
2007
2008
GW108451
GW108451[Lay6]

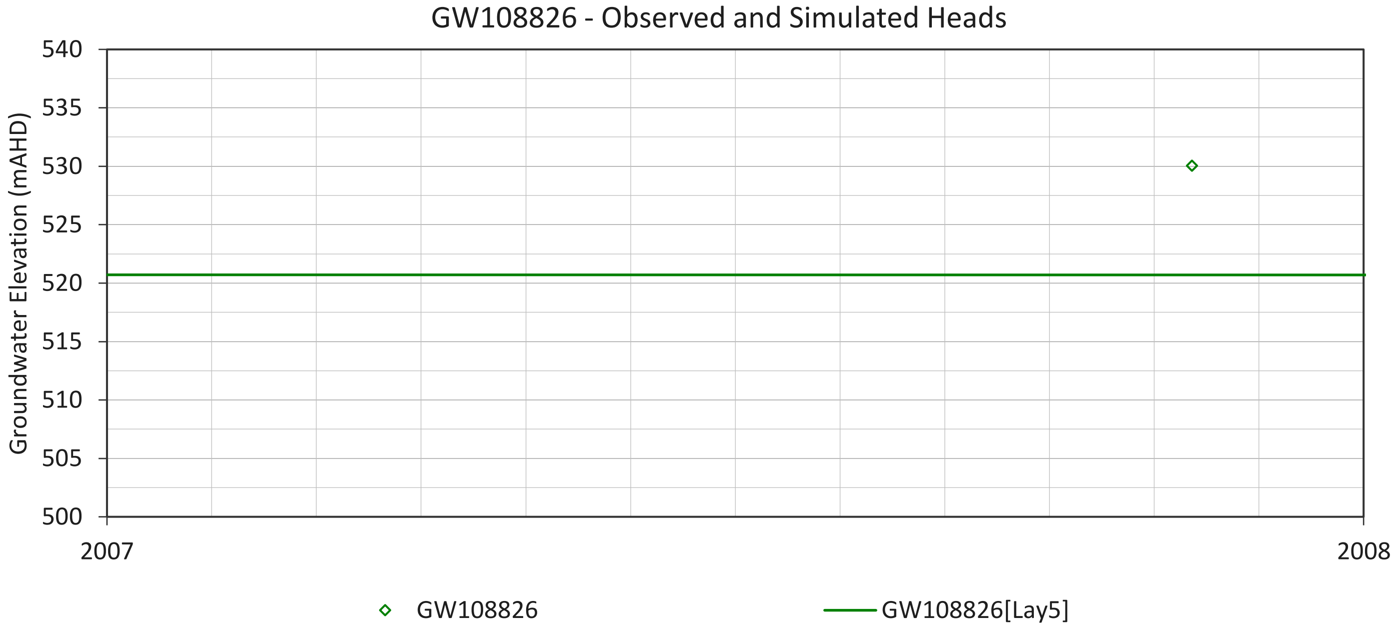

GW108542 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
580
575
570
565
560
555
550
2007
2008
GW108542
GW108542[Lay6]

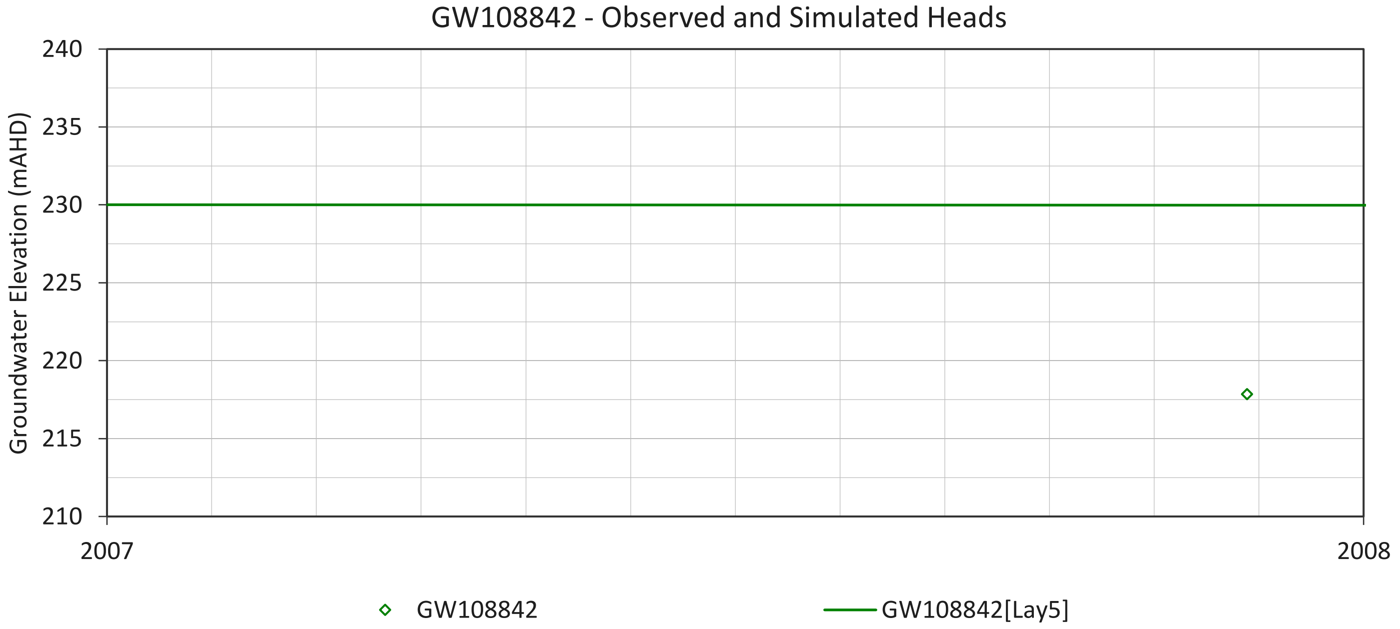

GW108615 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
290
280
270
260
250
240
230
2007
2008
GW108615
GW108615[Lay5]

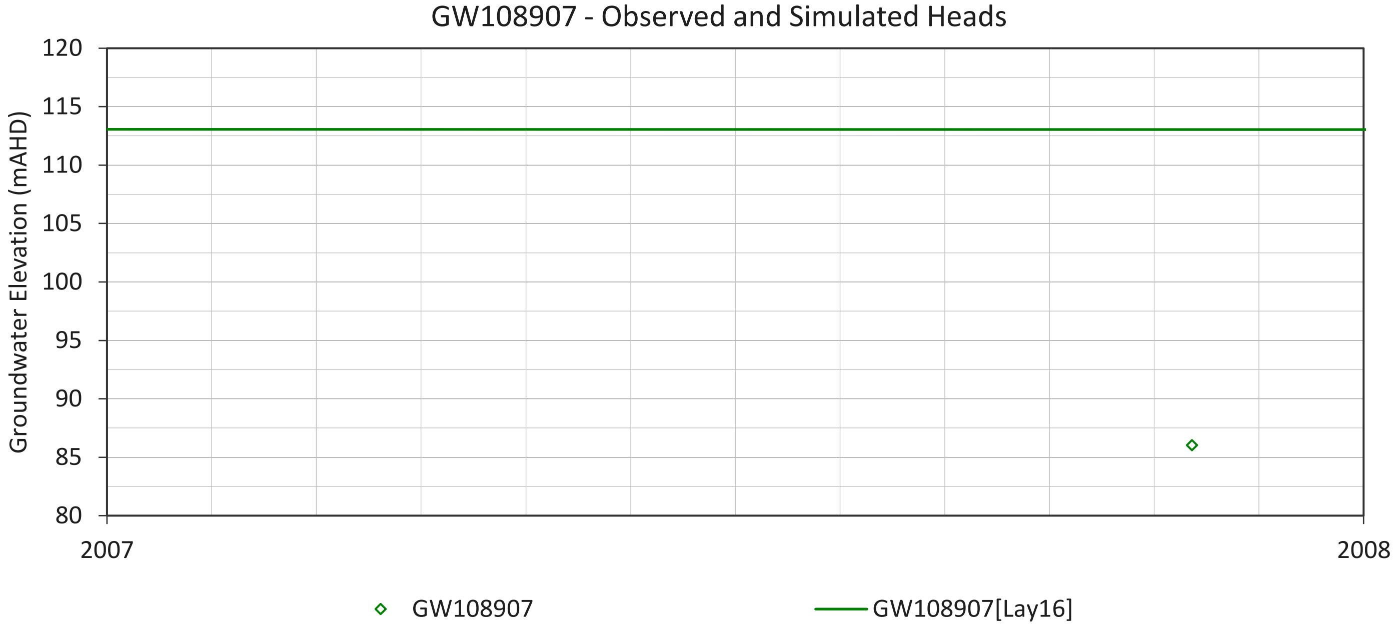

GW108667 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
180
178
176
174
172
170
168
166
164
162
160
2007
2008
GW108667
GW108667[Lay5]

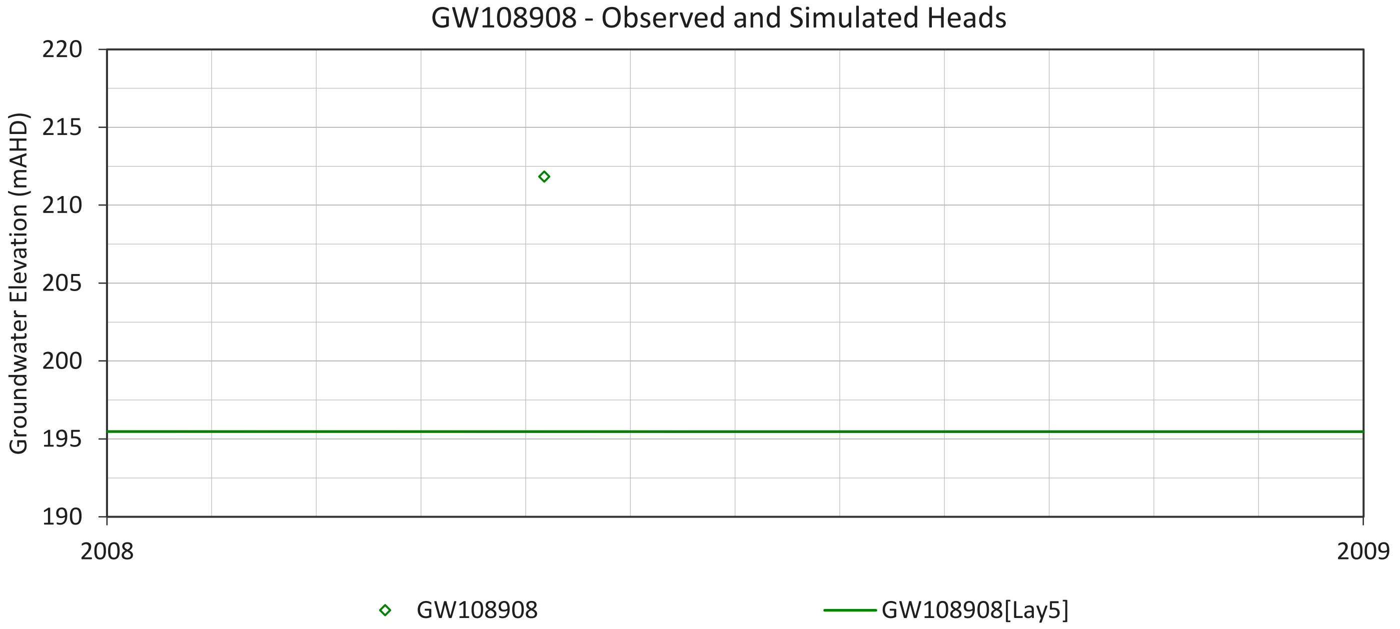

GW108765 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
600
595
590
585
580
575
570
565
560
2007
2008
GW108765
GW108765[Lay5]

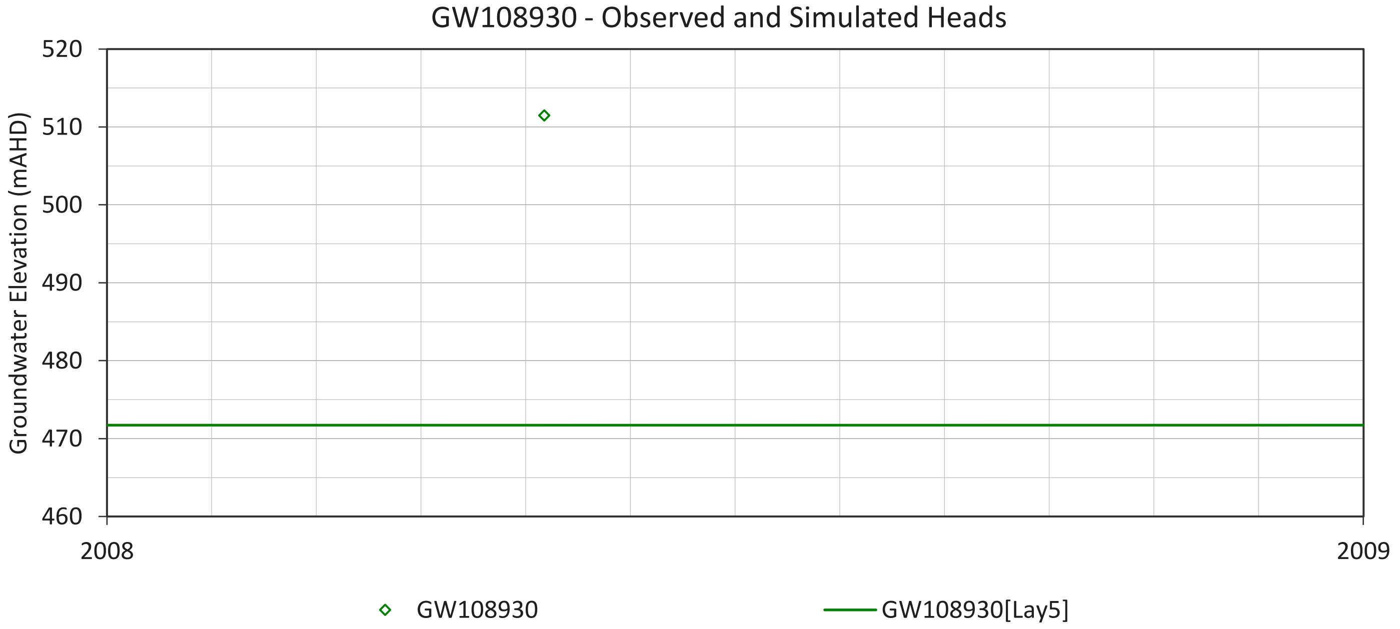

GW108786 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
390
388
386
384
382
380
378
376
374
372
370
2007
2008
GW108786
GW108786[Lay5]

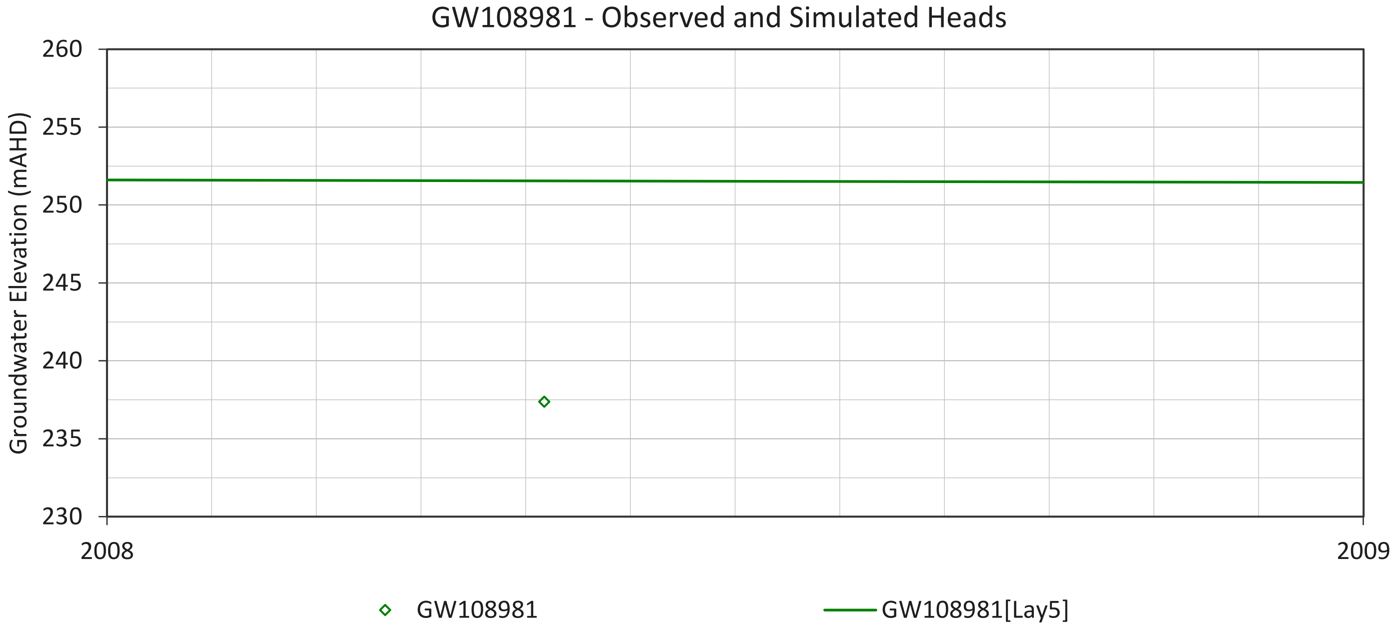

GW108826 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
540
535
530
525
520
515
510
505
500
2007
2008
GW108826
GW108826[Lay5]

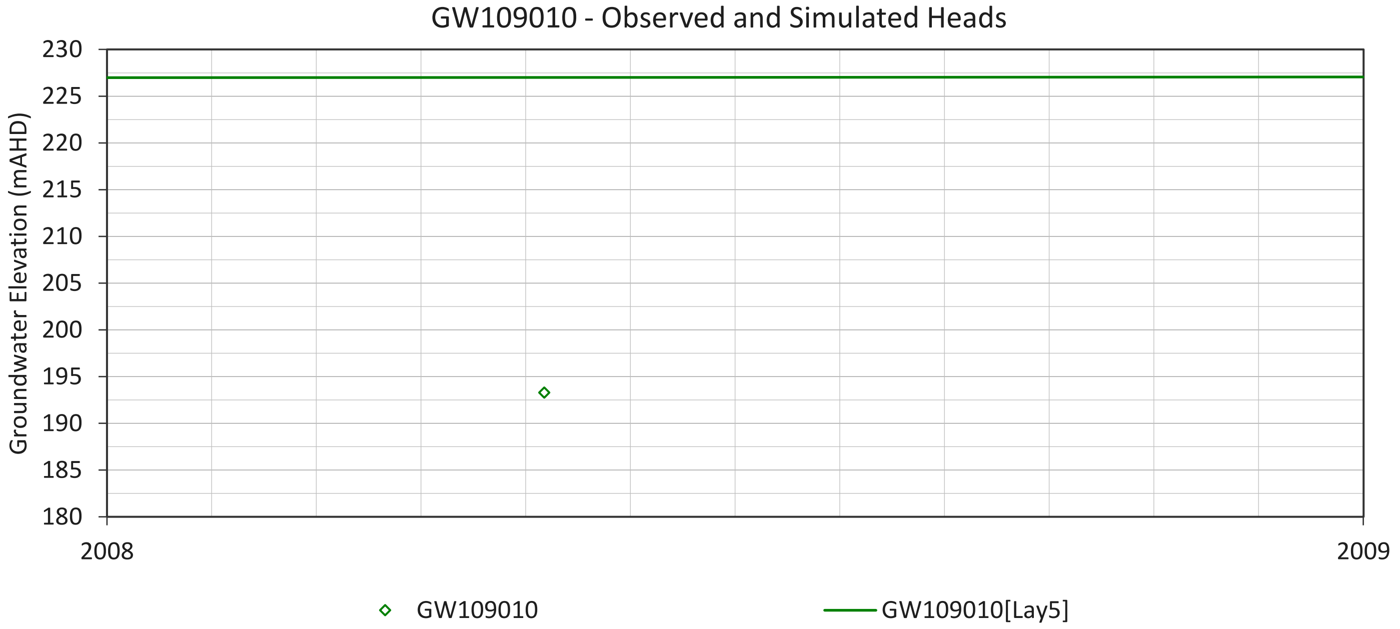

GW108842 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
240
235
230
225
220
215
210
2007
2008
GW108842
GW108842[Lay5]

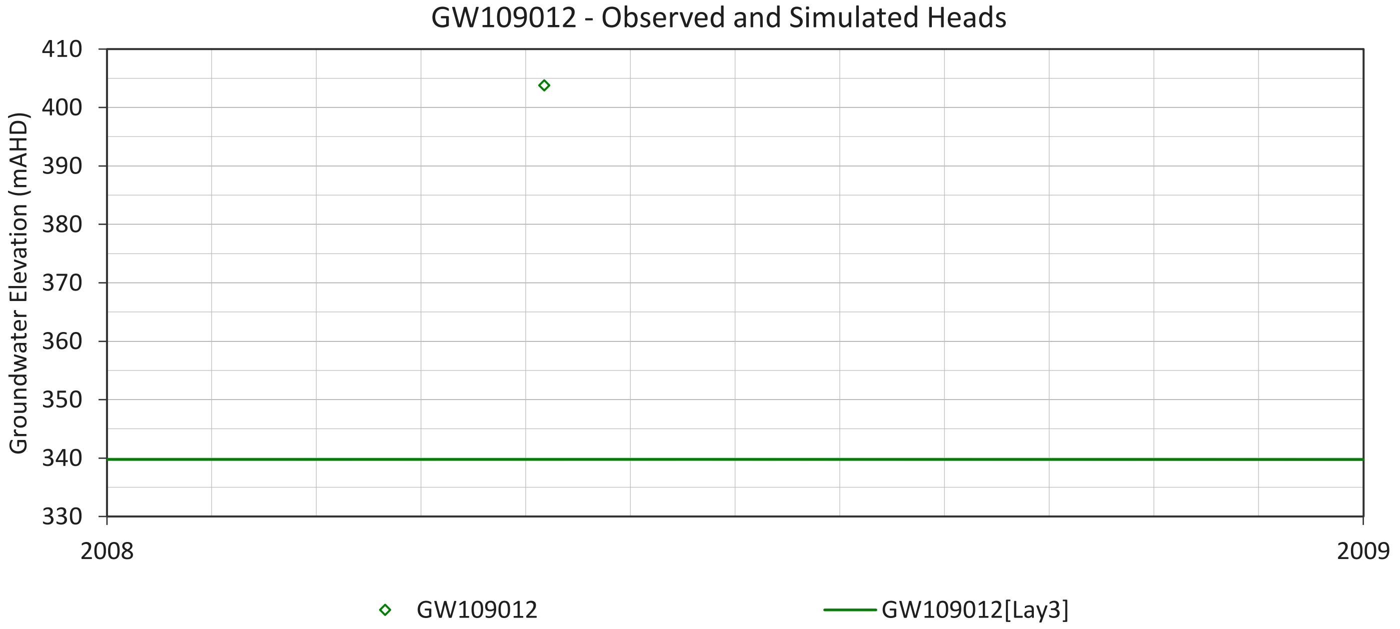

GW108907 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
120
115
110
105
100
95
90
85
80
2007
2008
GW108907
GW108907[Lay16]

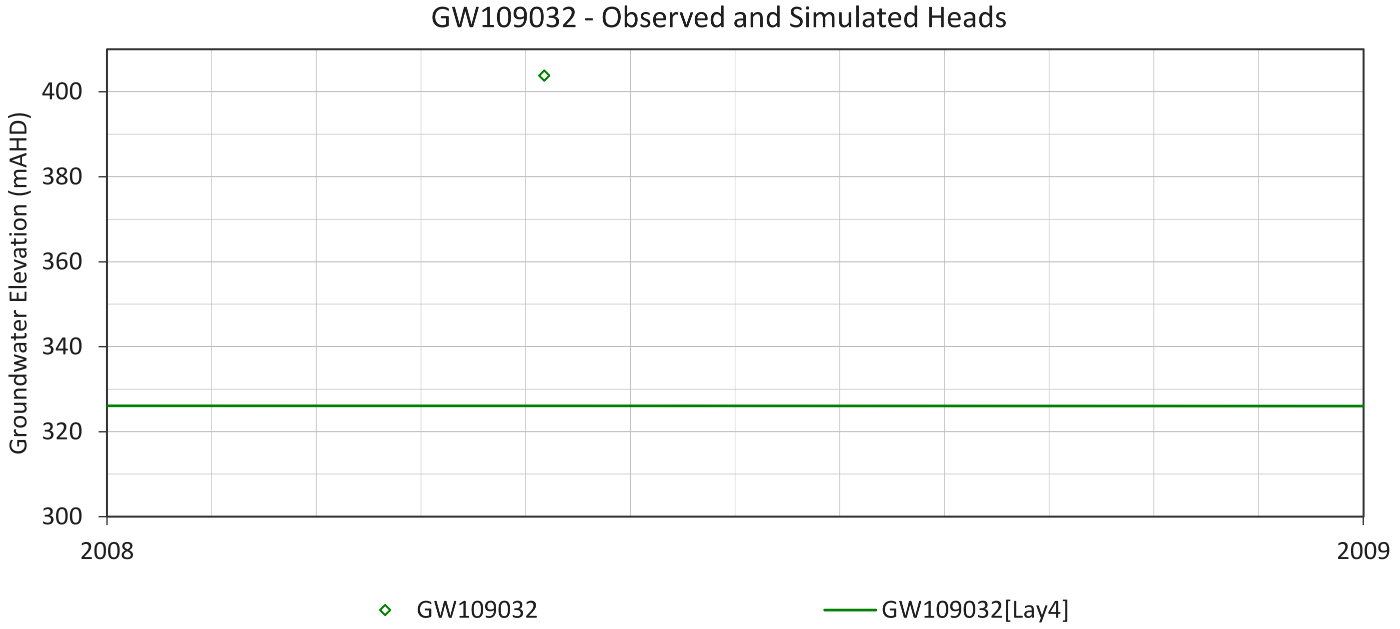

GW108908 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
220
215
210
205
200
195
190
2008
2009
GW108908
GW108908[Lay5]

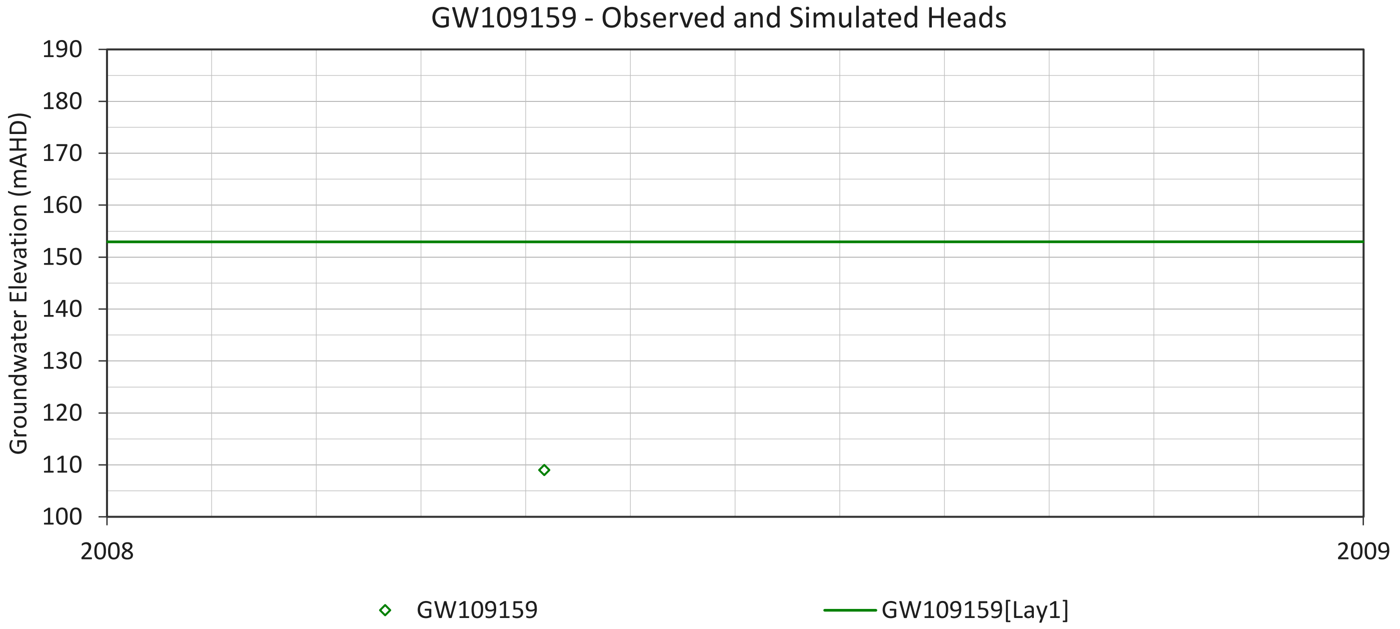

GW108930 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
520
510
500
490
480
470
460
2008
2009
GW108930
GW108930[Lay5]

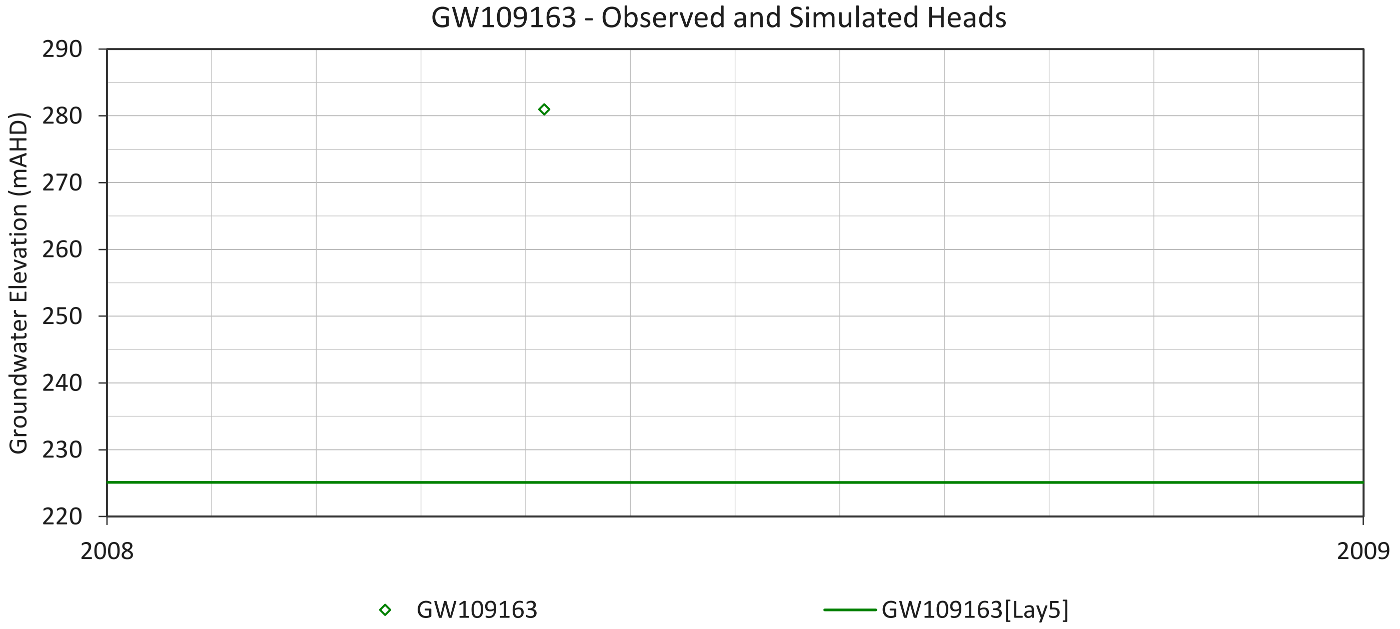

GW108981 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
260
255
250
245
240
235
230
2008
2009
GW108981
GW108981[Lay5]


GW109010 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
230
225
220
215
210
205
200
195
190
185
180
2008
2009
GW109010
GW109010[Lay5]

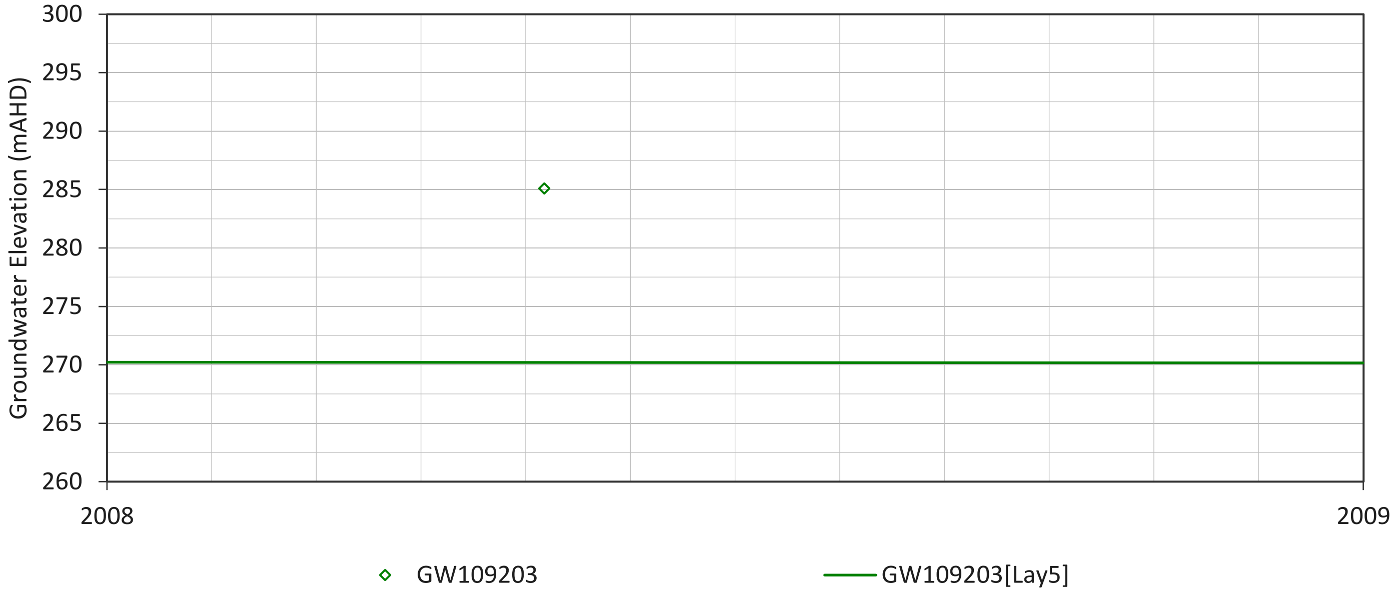

GW109012 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
410
400
390
380
370
360
350
340
330
2008
2009
GW109012
GW109012[Lay3]


GW109032 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
400
380
360
340
320
300
2008
2009
GW109032
GW109032[Lay4]

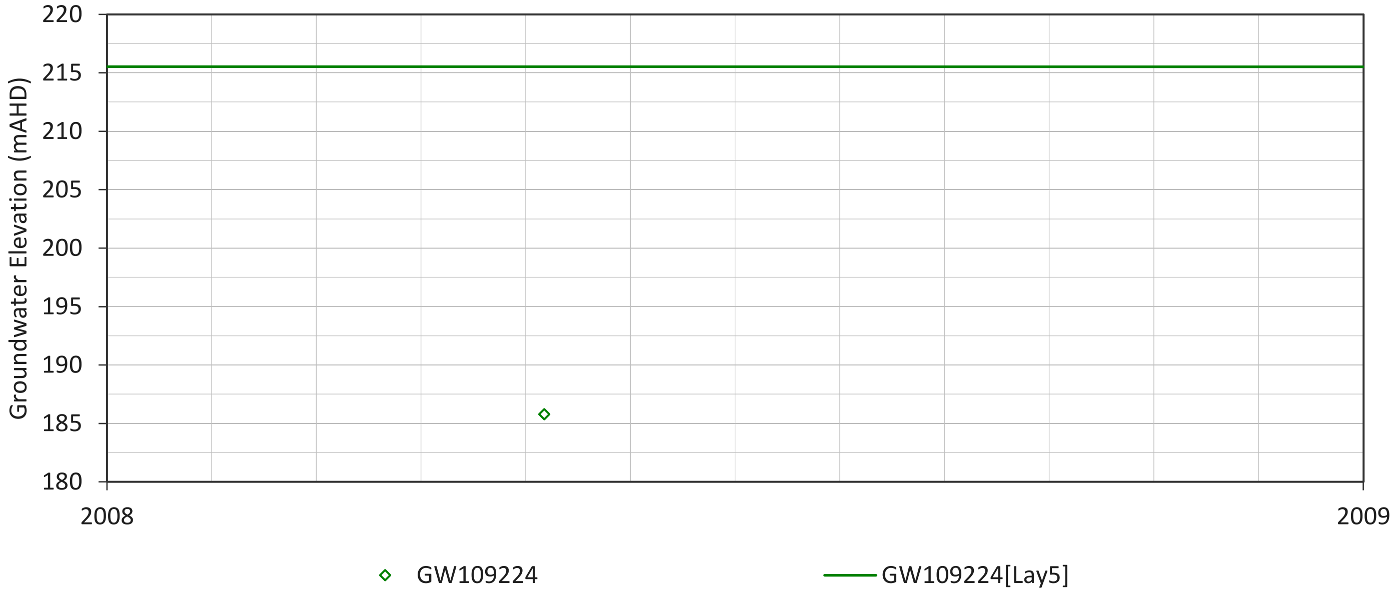

GW109159 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
190
180
170
160
150
140
130
120
110
100
2008
2009
GW109159
GW109159[Lay1]


GW109163 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
290
280
270
260
250
240
230
220
2008
2009
GW109163
GW109163[Lay5]

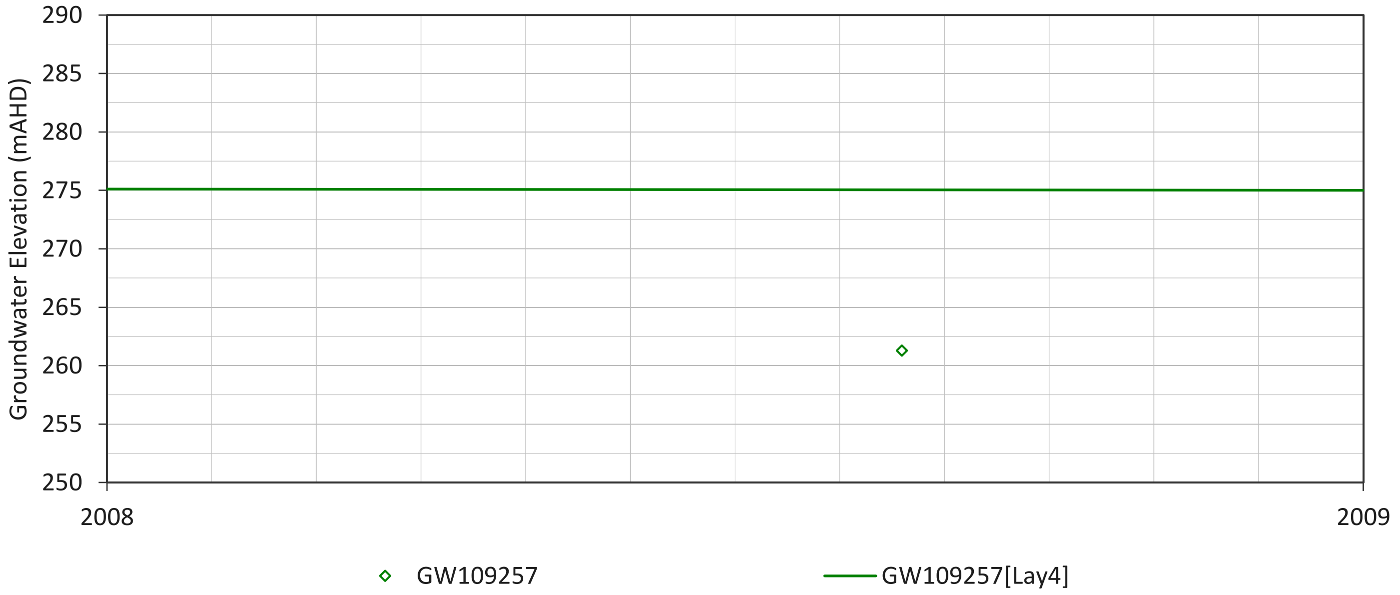
GW109203 - Observed and Simulated Heads

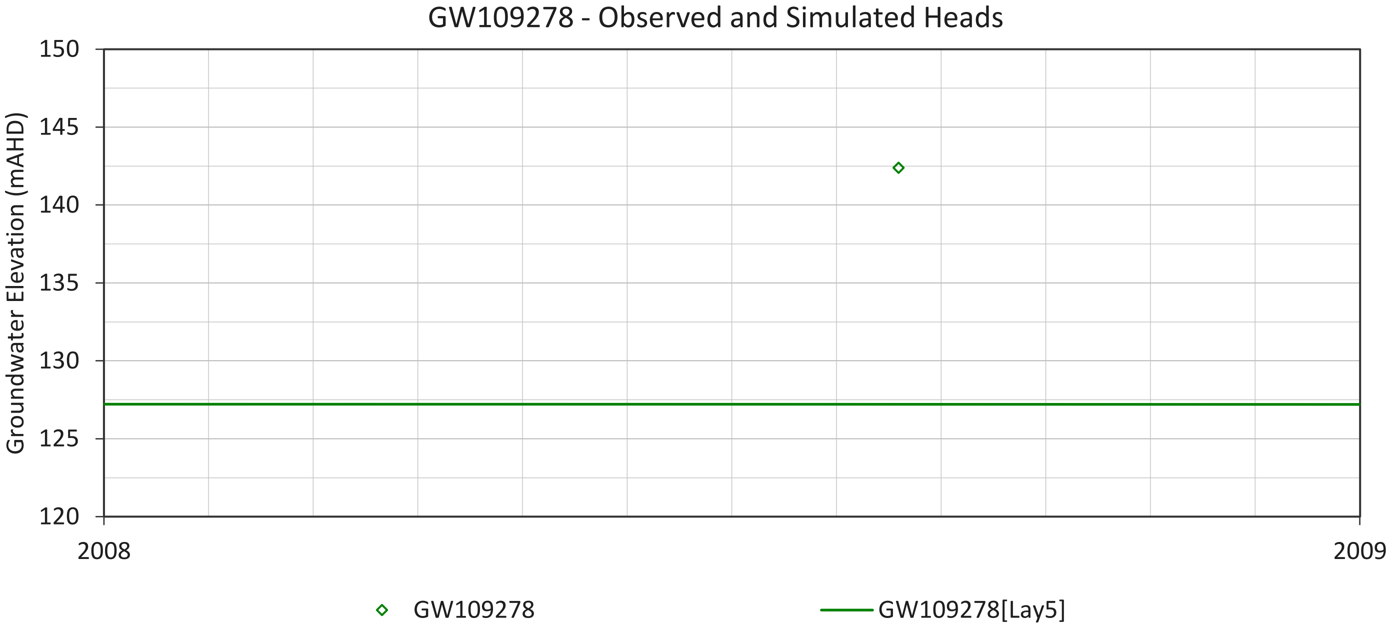


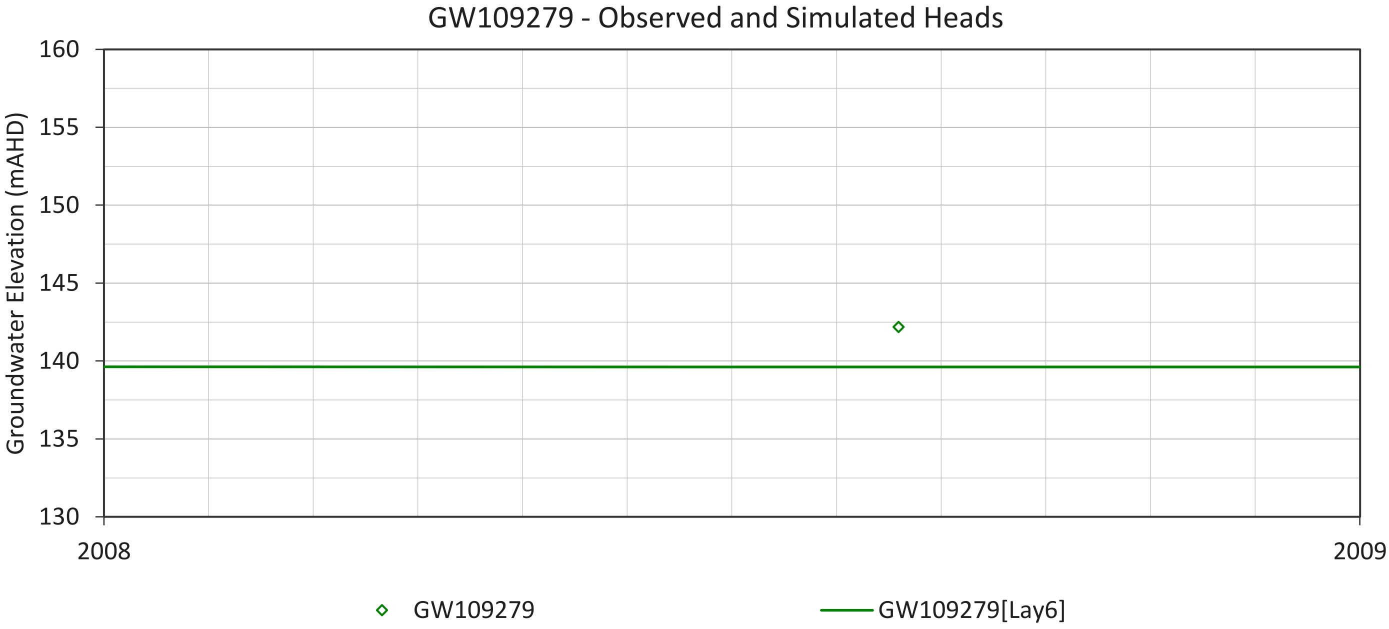
GW109224 - Observed and Simulated Heads

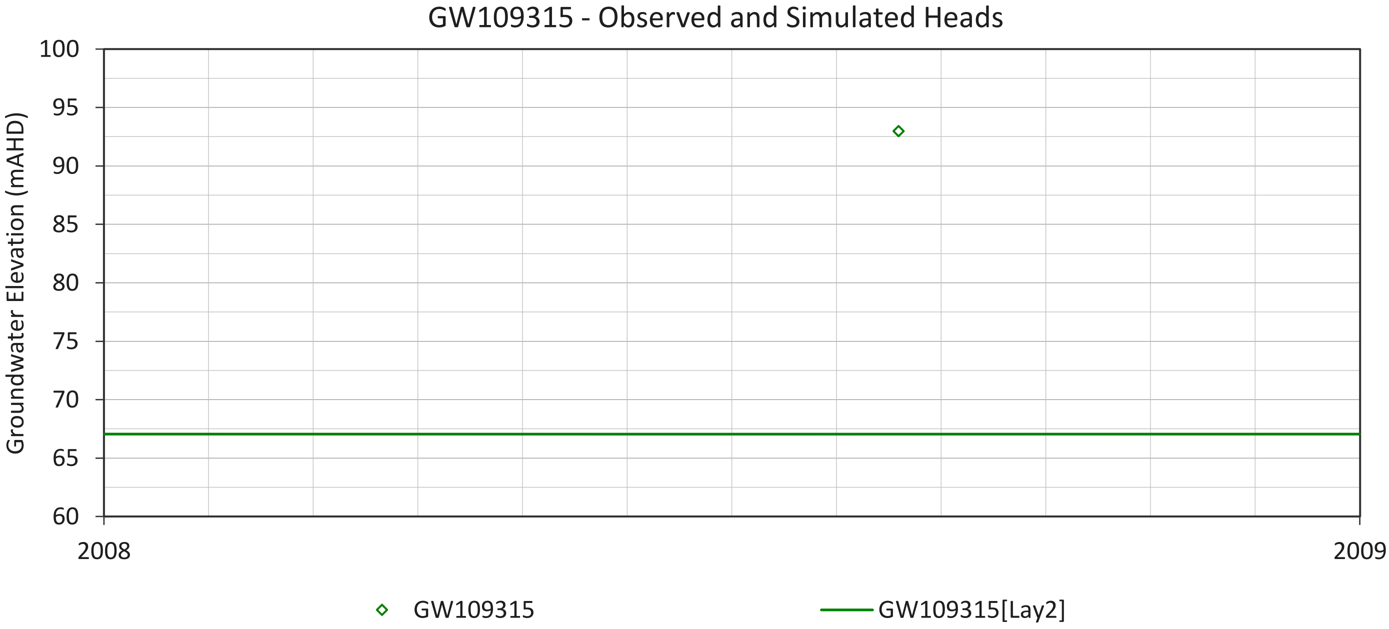


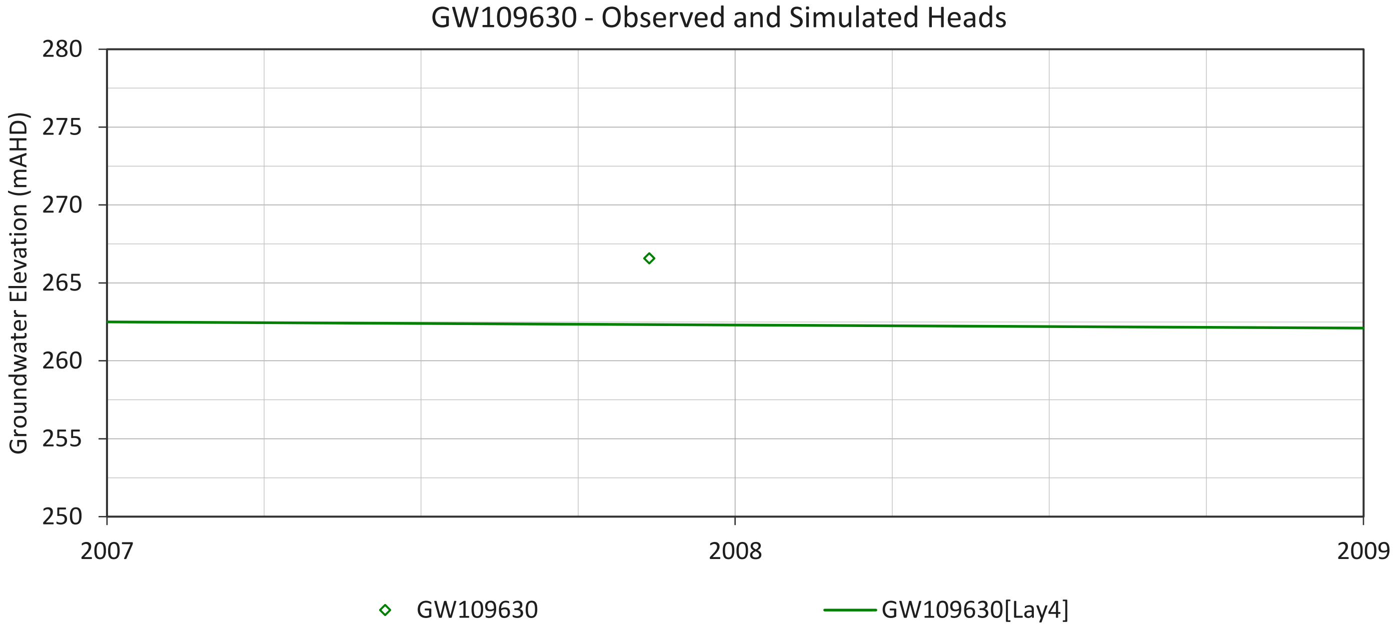
GW109257 - Observed and Simulated Heads

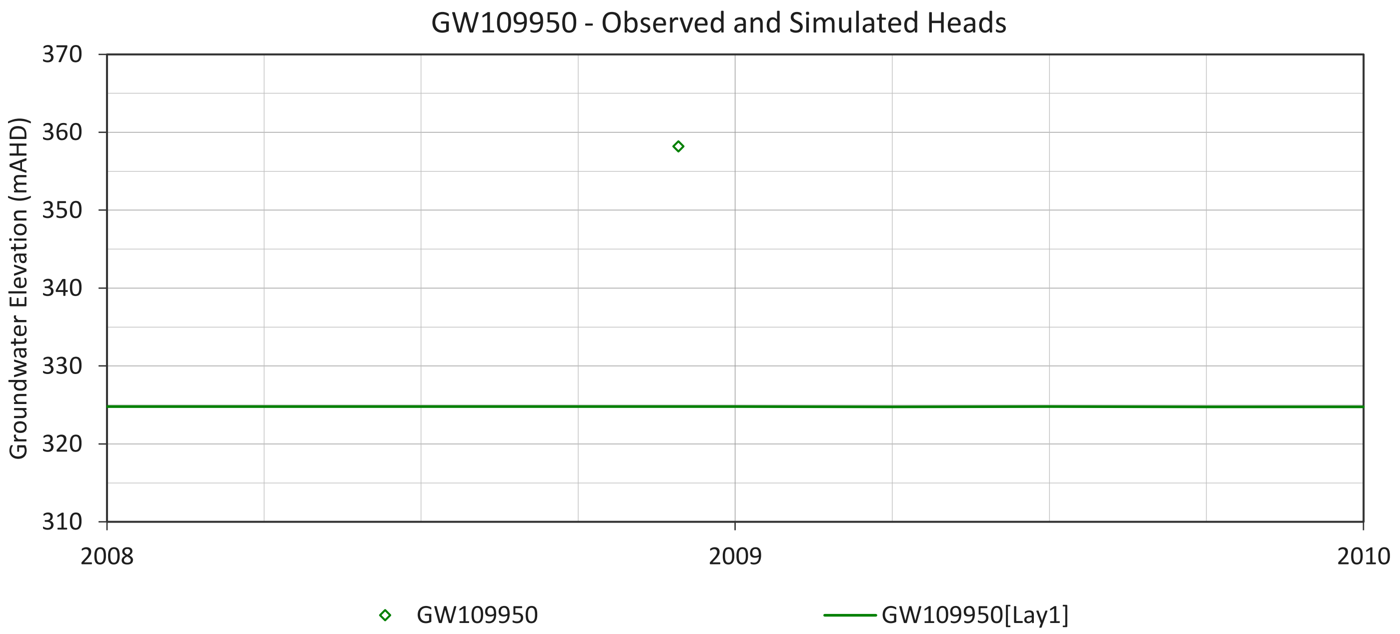


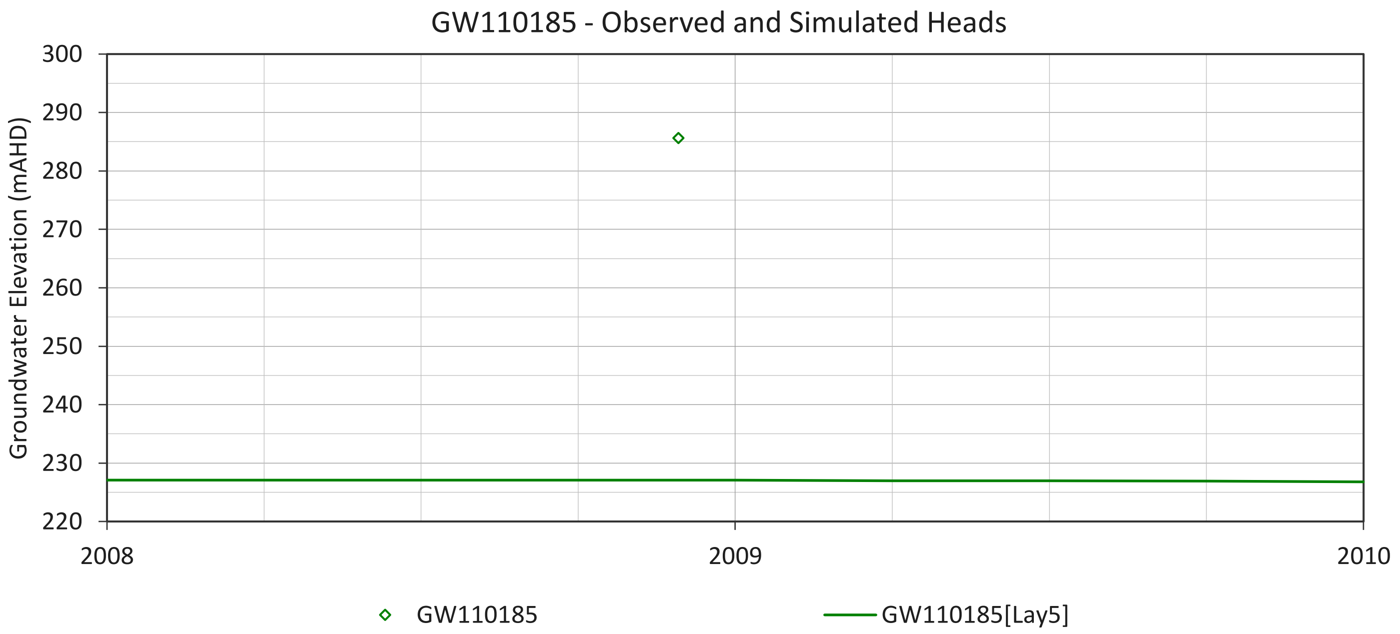

GW109278 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
150
145
140
135
130
125
120
2008
2009
GW109278
GW109278[Lay5]

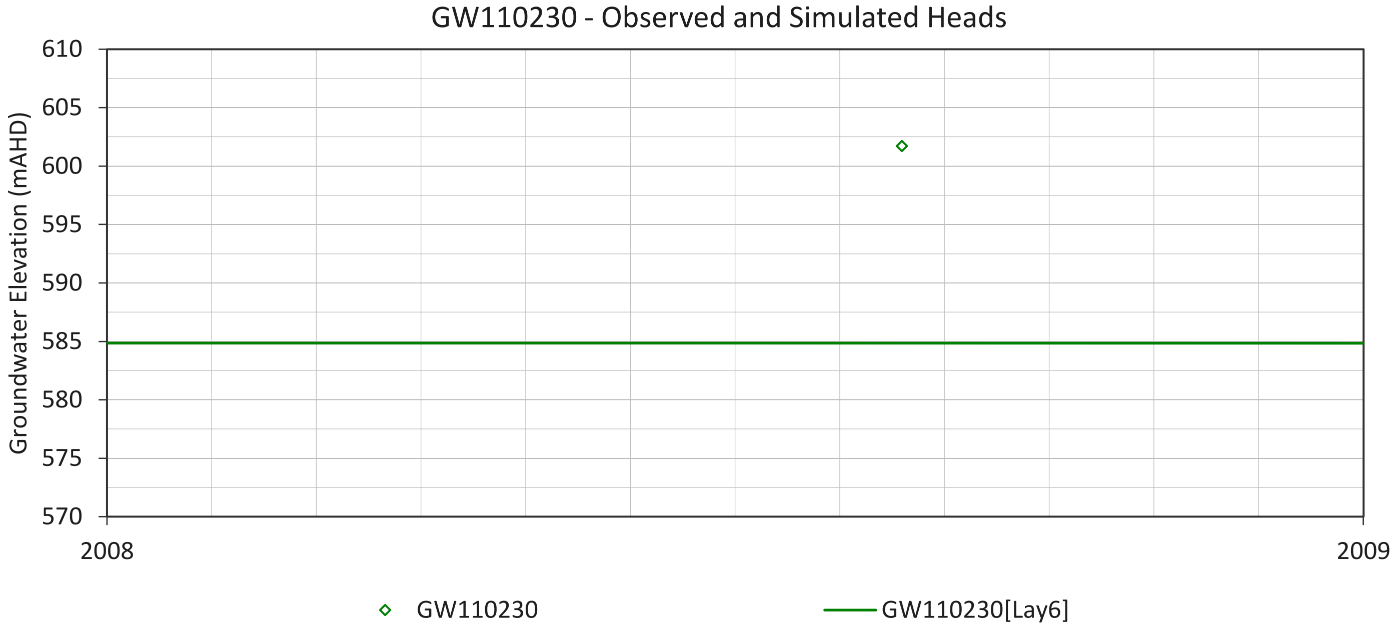

GW109279 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
160
155
150
145
140
135
130
2008
2009
GW109279
GW109279[Lay6]

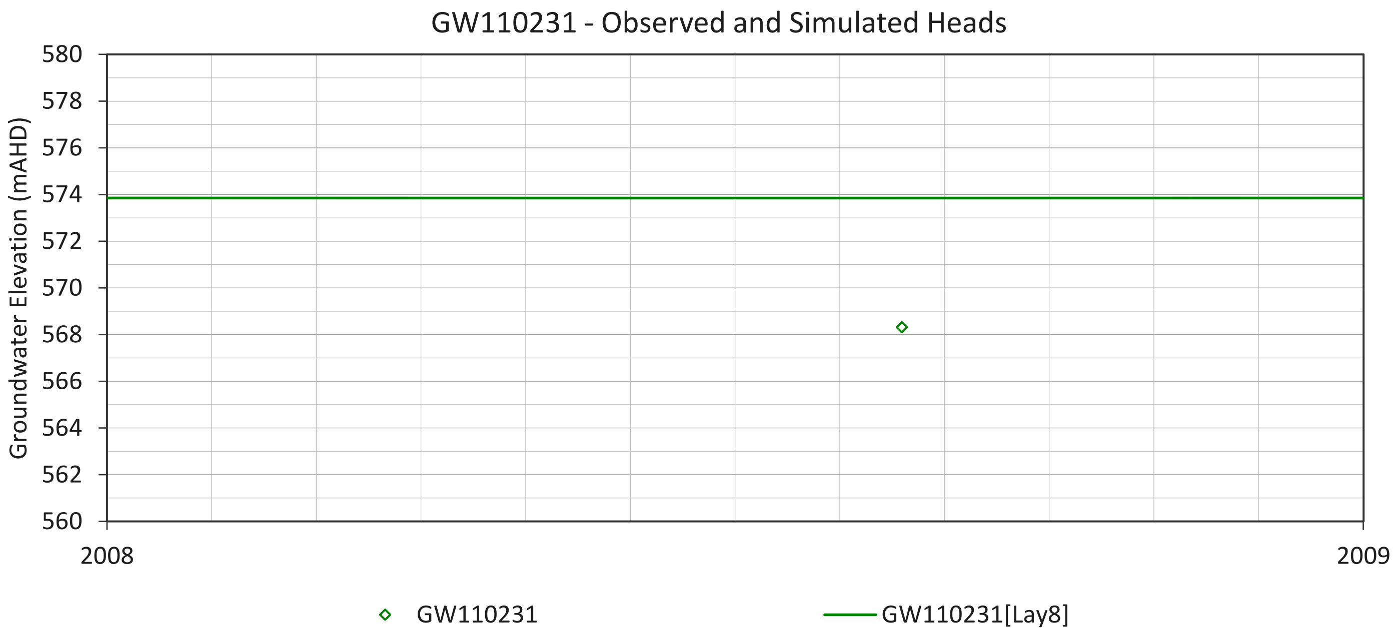

GW109315 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
100
95
90
85
80
75
70
65
60
2008
2009
GW109315
GW109315[Lay2]

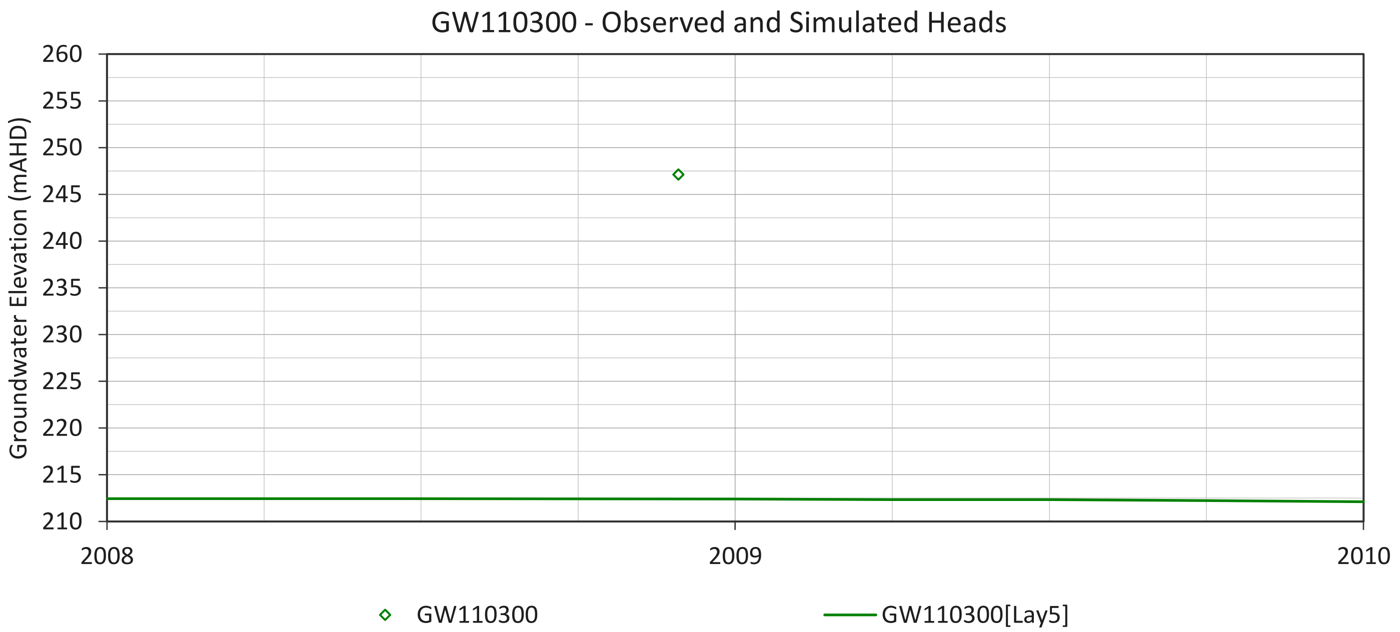

GW109630 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
280
275
270
265
260
255
250
2007
2008
2009
GW109630
GW109630[Lay4]

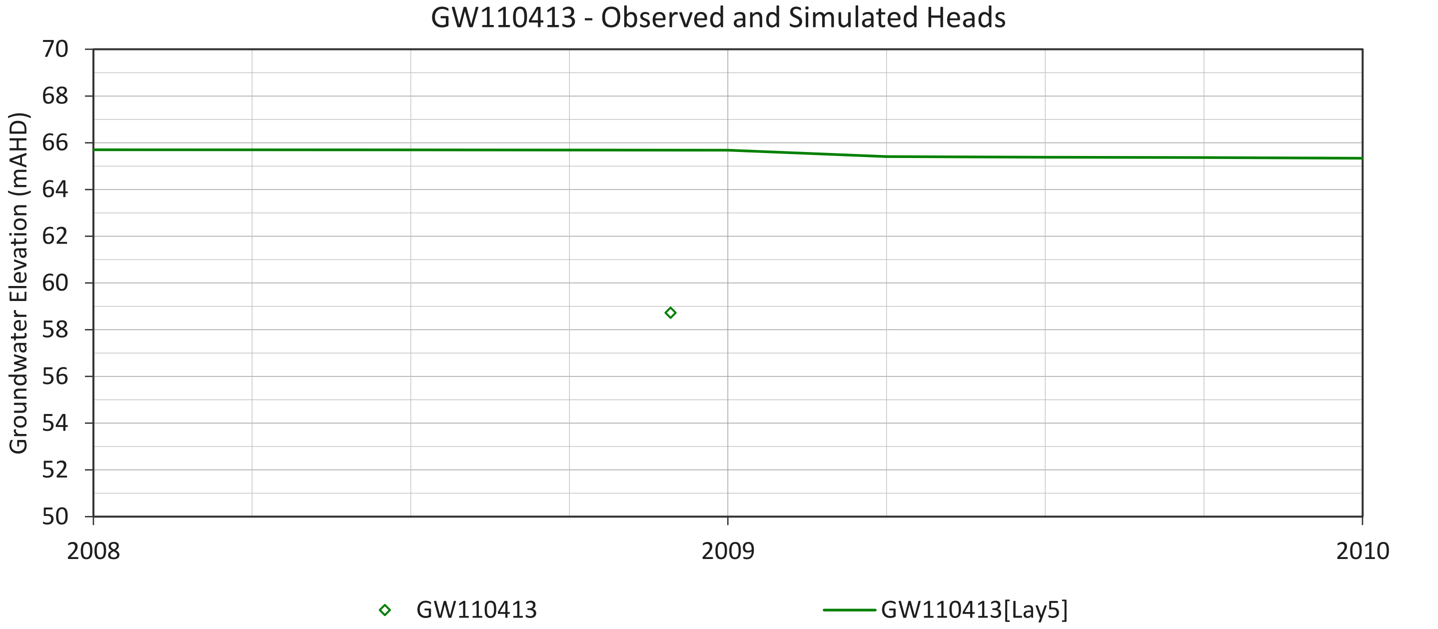

GW109950 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
370
360
350
340
330
320
310
2008
2009
2010
GW109950
GW109950[Lay1]

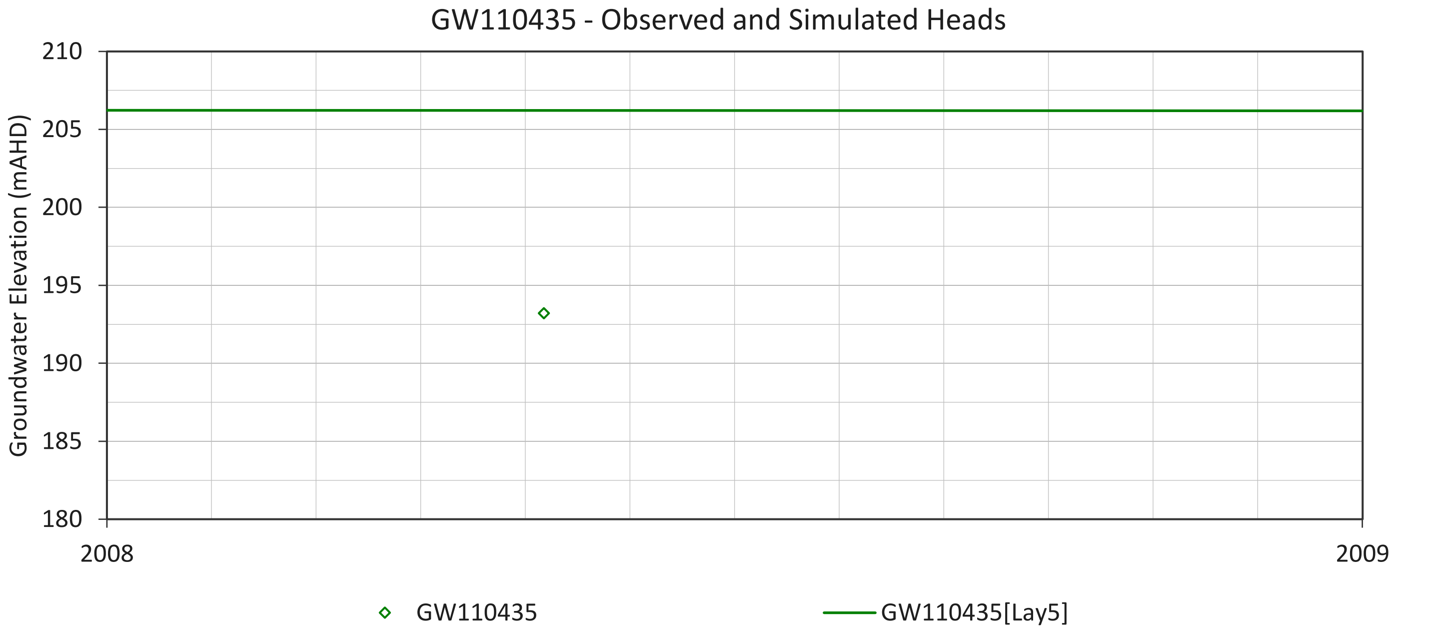

GW110185 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
300
290
280
270
260
250
240
230
220
2008
2009
2010
GW110185
GW110185[Lay5]

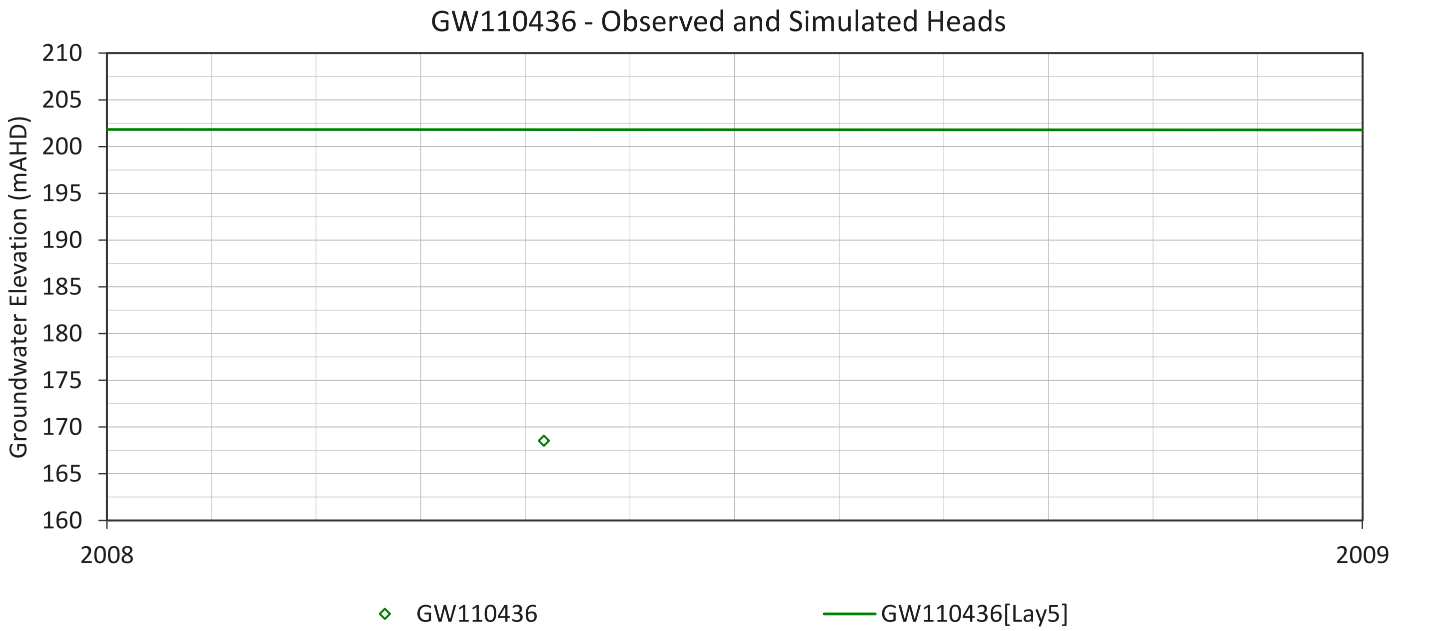

GW110230 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
610
605
600
595
590
585
580
575
570
2008
2009
GW110230
GW110230[Lay6]

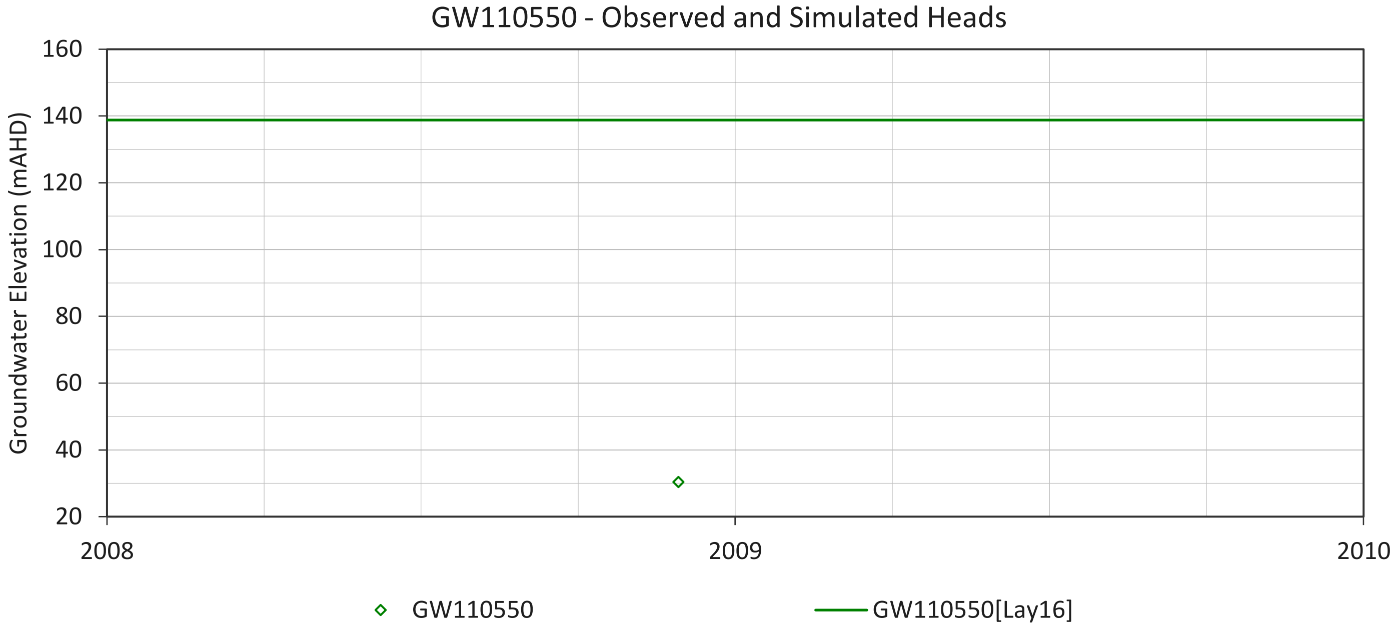

GW110231 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
580
578
576
574
572
570
568
566
564
562
560
2008
2009
GW110231
GW110231[Lay8]

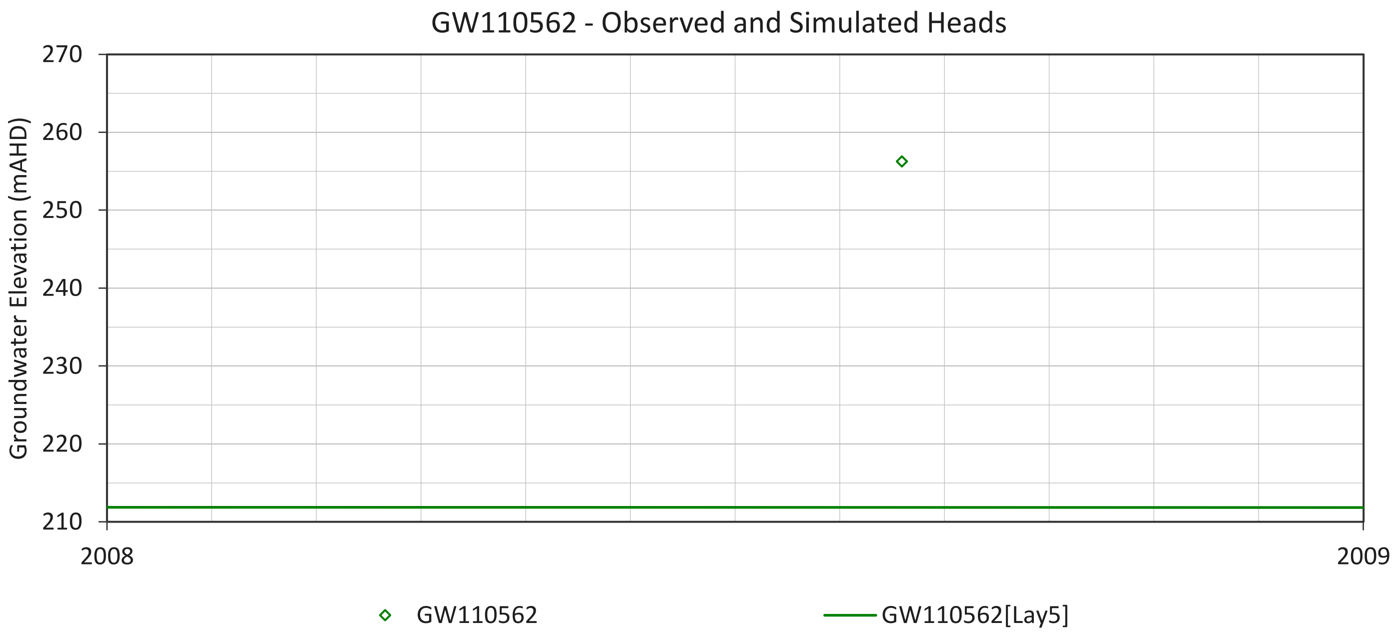

GW110300 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
260
255
250
245
240
235
230
225
220
215
210
2008
2009
2010
GW110300
GW110300[Lay5]

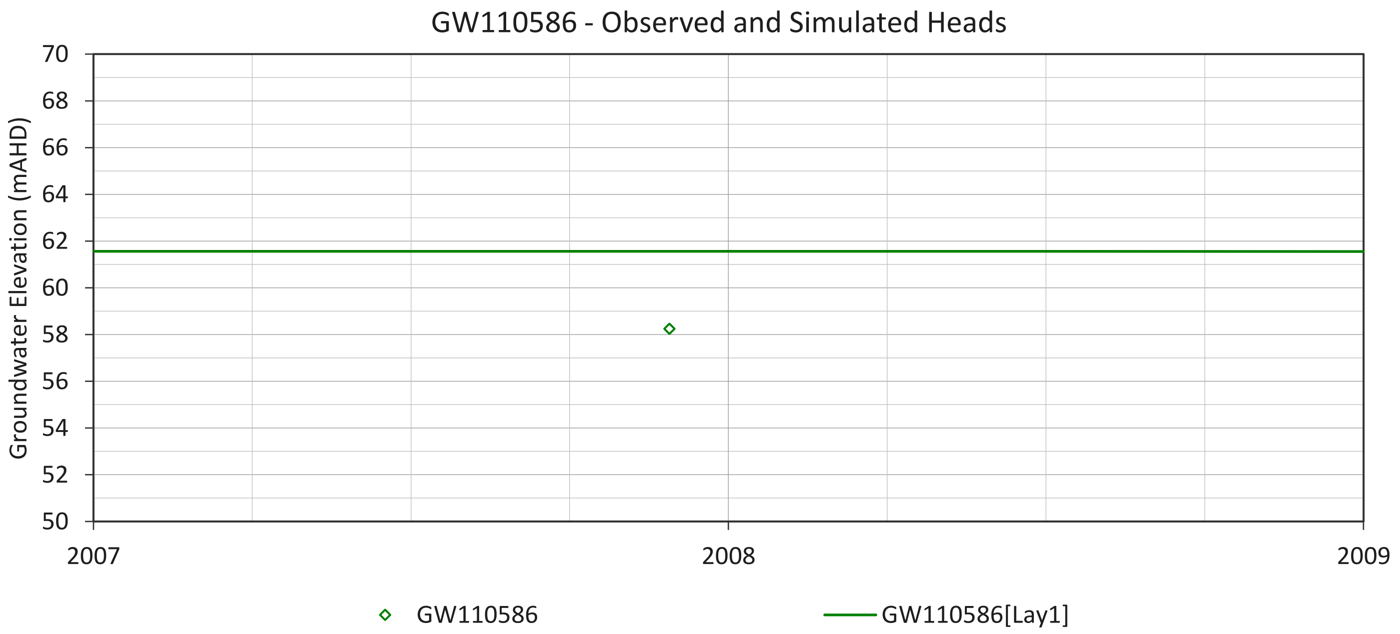

GW110413 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
70
68
66
64
62
60
58
56
54
52
50
2008
2009
2010
GW110413
GW110413[Lay5]

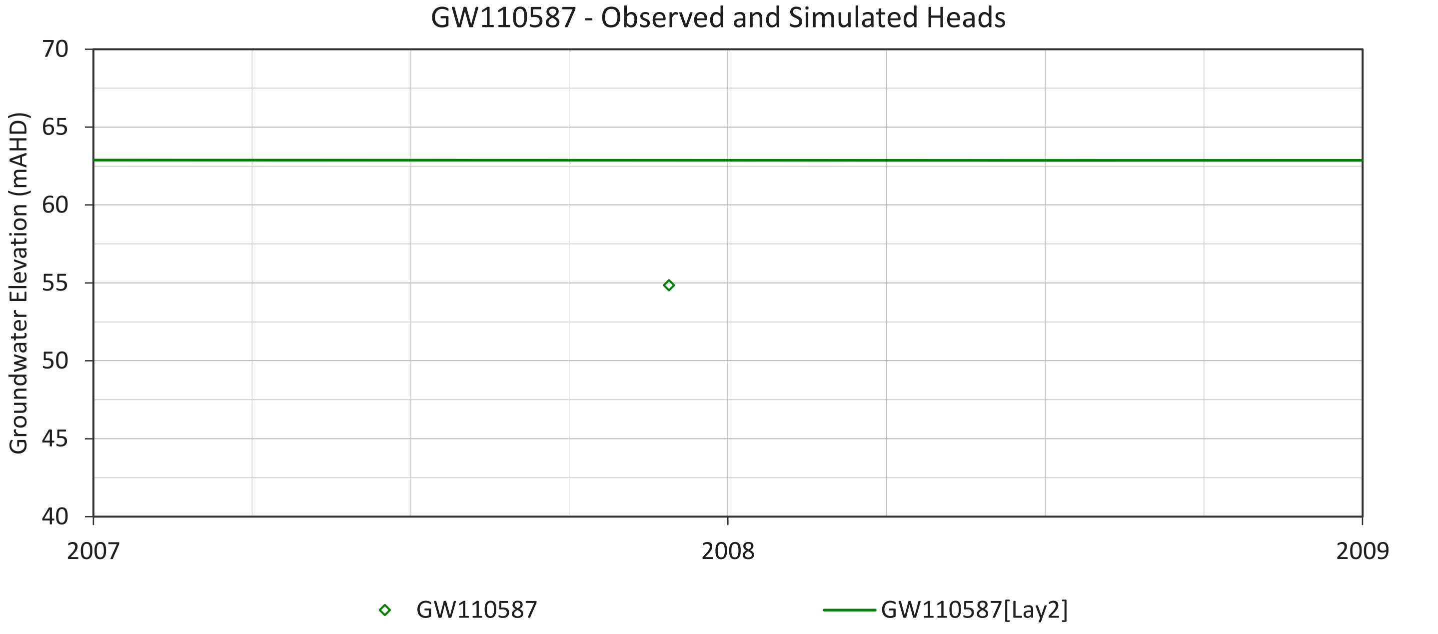

GW110435 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
210
205
200
195
190
185
180
2008
2009
GW110435
GW110435[Lay5]

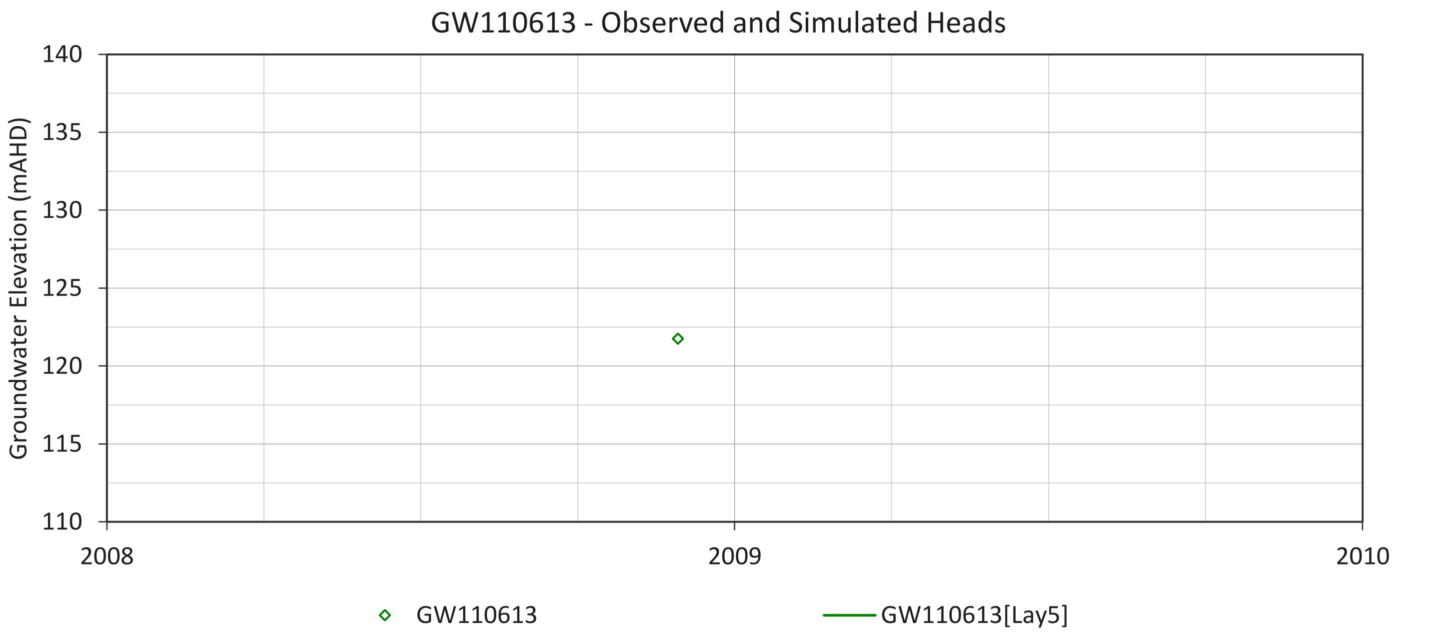

GW110436 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
210
205
200
195
190
185
180
175
170
165
160
2008
2009
GW110436
GW110436[Lay5]

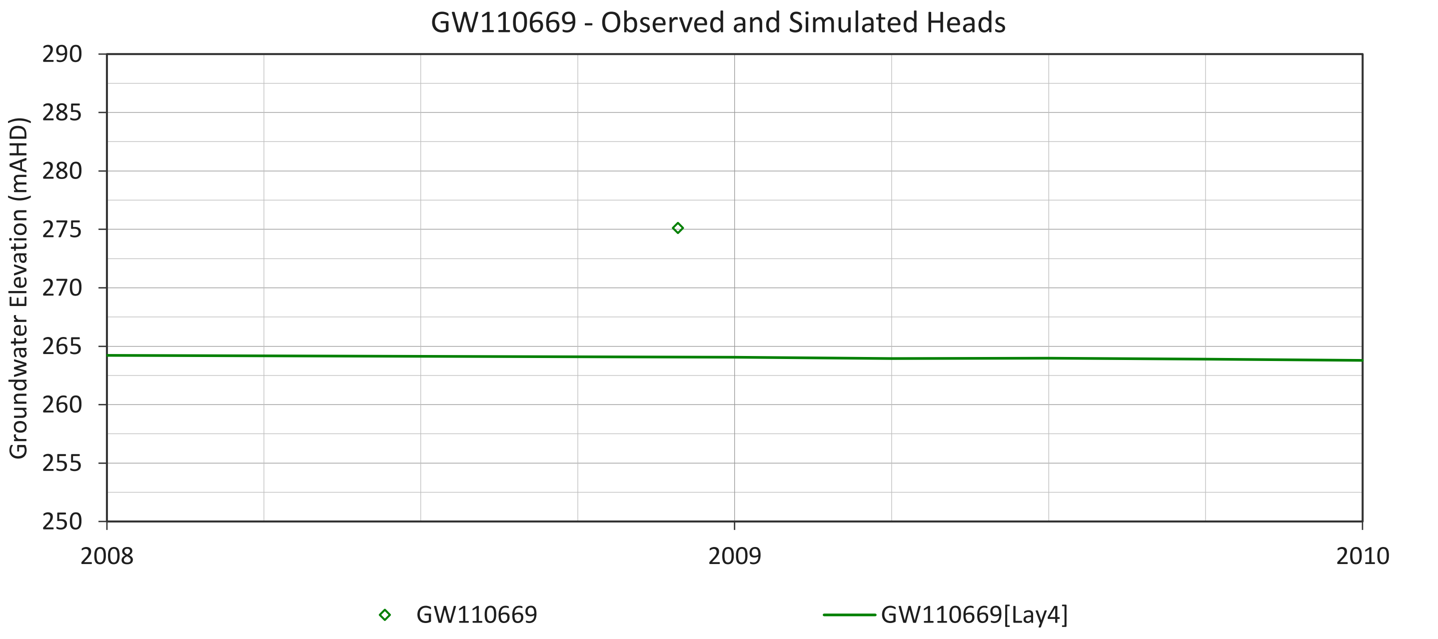

GW110550 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
160
140
120
100
80
60
40
20
2008
2009
2010
GW110550
GW110550[Lay16]

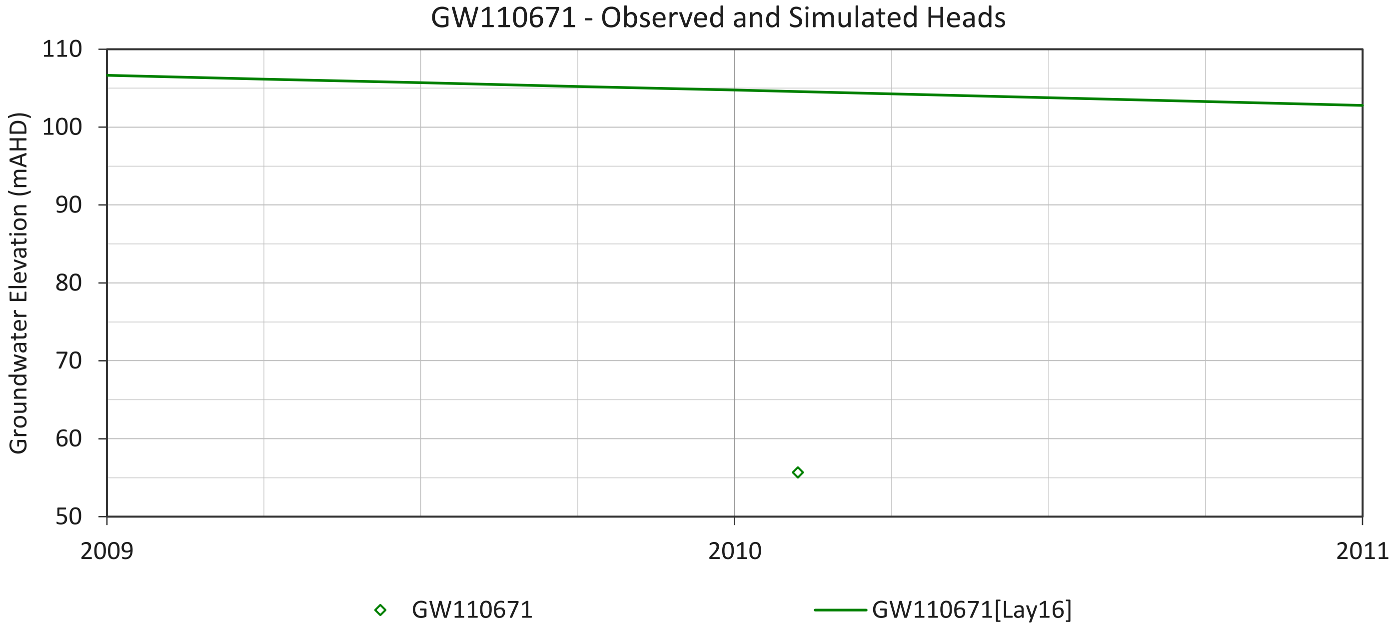

GW110562 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
270
260
250
240
230
220
210
2008
2009
GW110562
GW110562[Lay5]

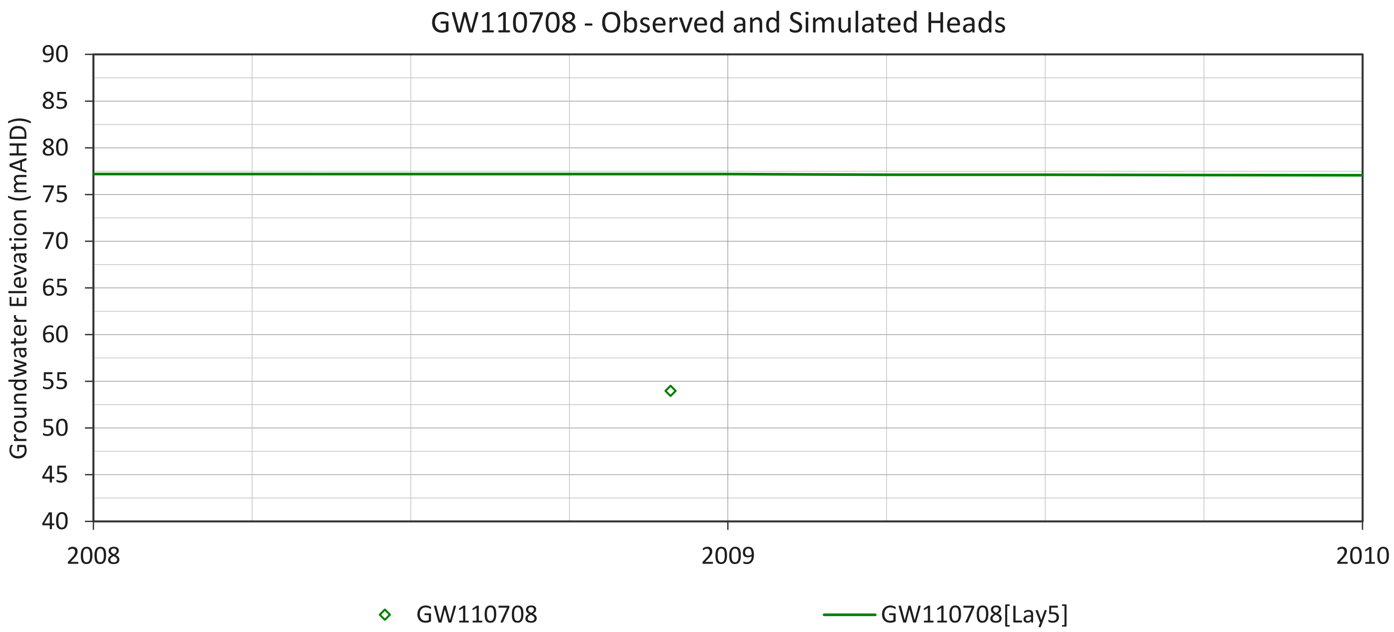

GW110586 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
70
68
66
64
62
60
58
56
54
52
50
2007
2008
2009
GW110586
GW110586[Lay1]

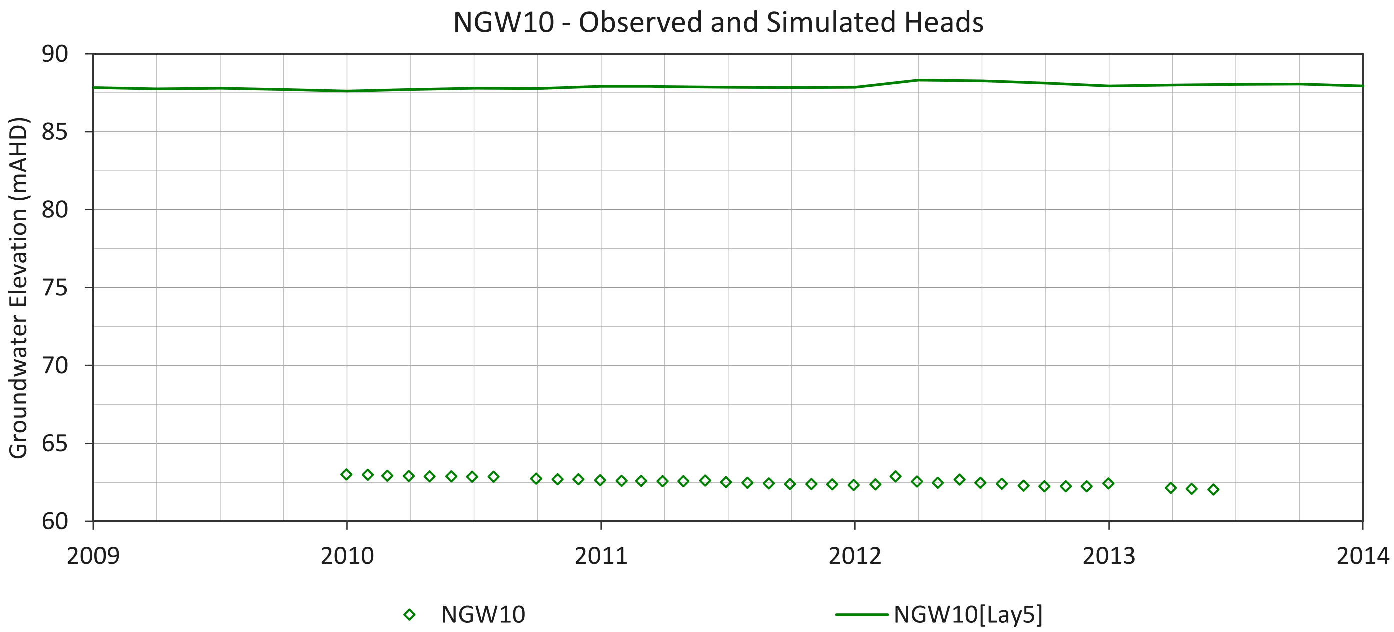

GW110587 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
70
65
60
55
50
45
40
2007
2008
2009
GW110587
GW110587[Lay2]

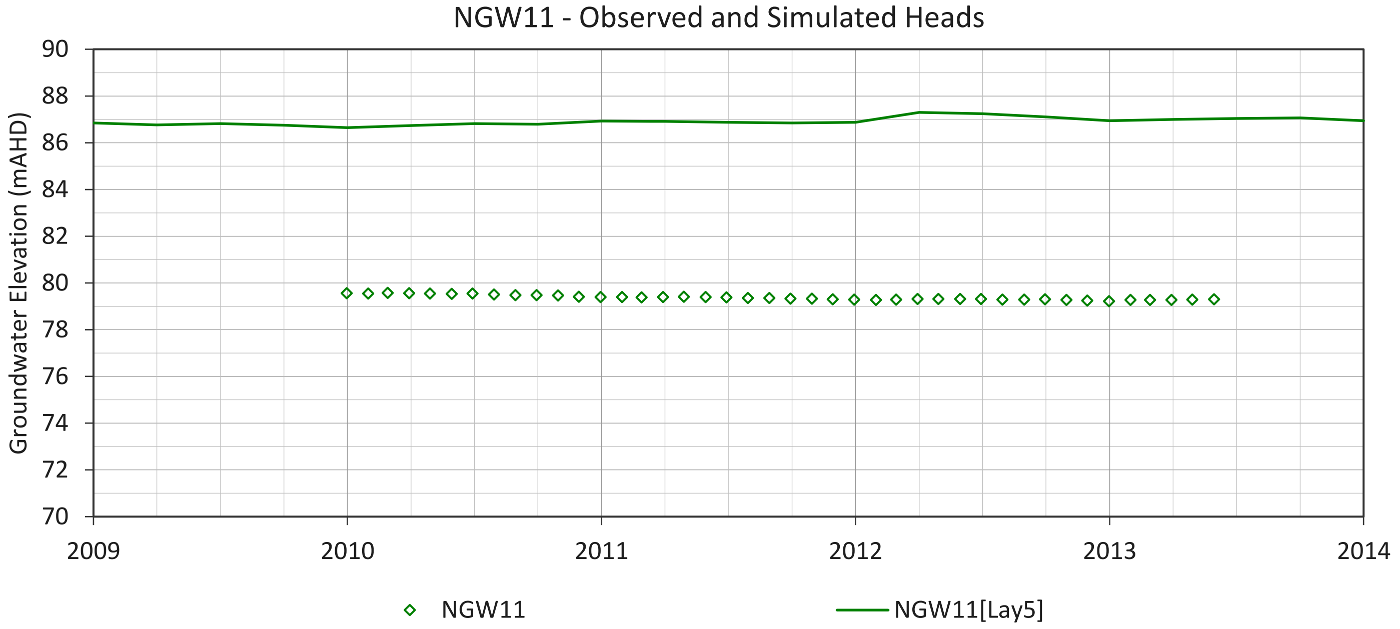

GW110613 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
140
135
130
125
120
115
110
2008
2009
2010
GW110613
GW110613[Lay5]

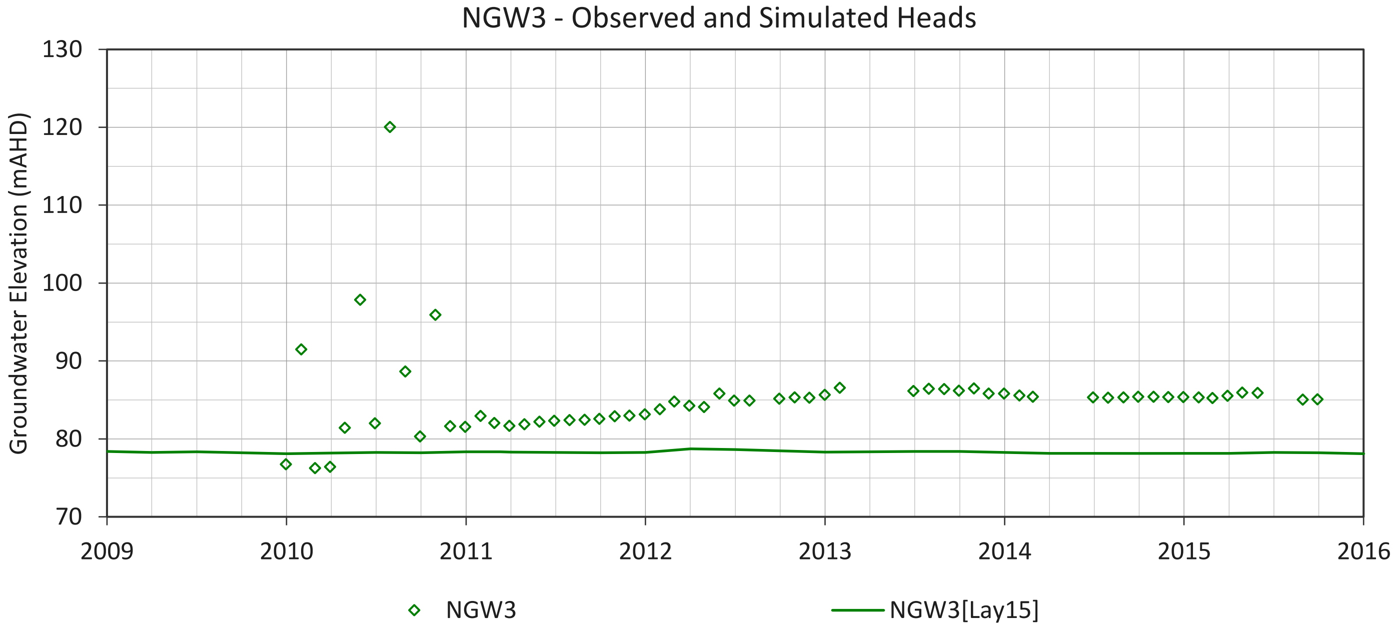

GW110669 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
290
285
280
275
270
265
260
255
250
2008
2009
2010
GW110669
GW110669[Lay4]

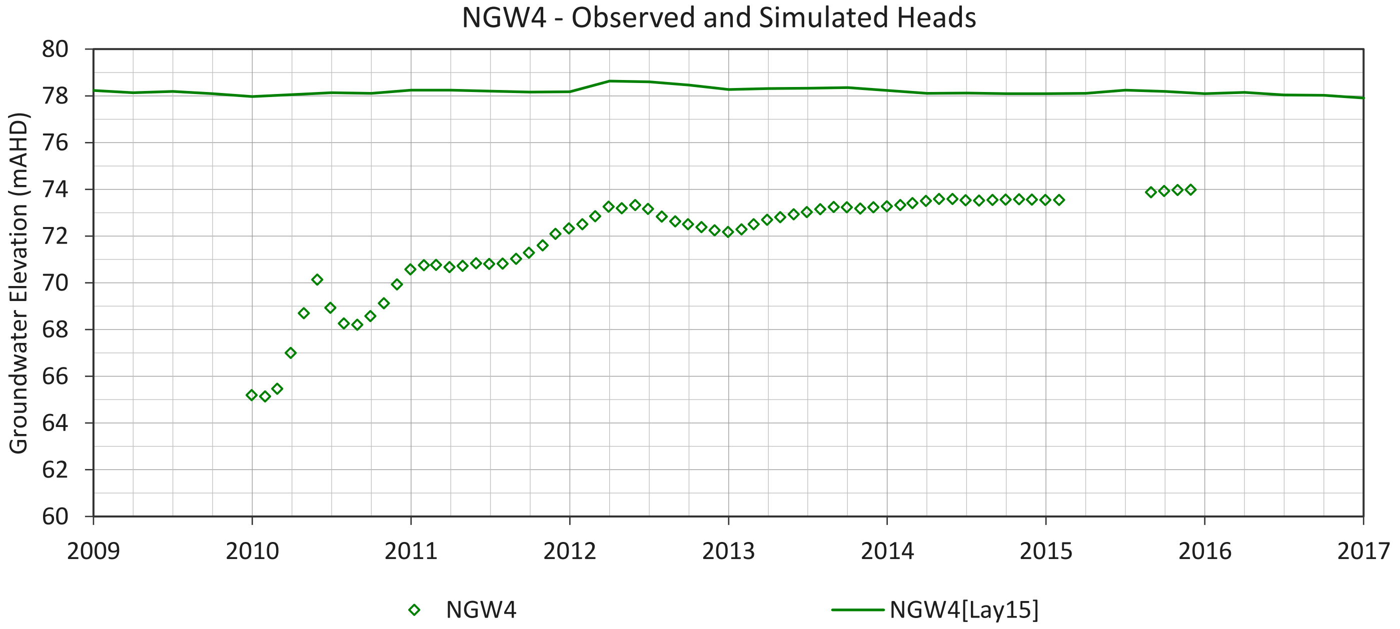

GW110671 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
110
100
90
80
70
60
50
2009
2010
2011
GW110671
GW110671[Lay16]

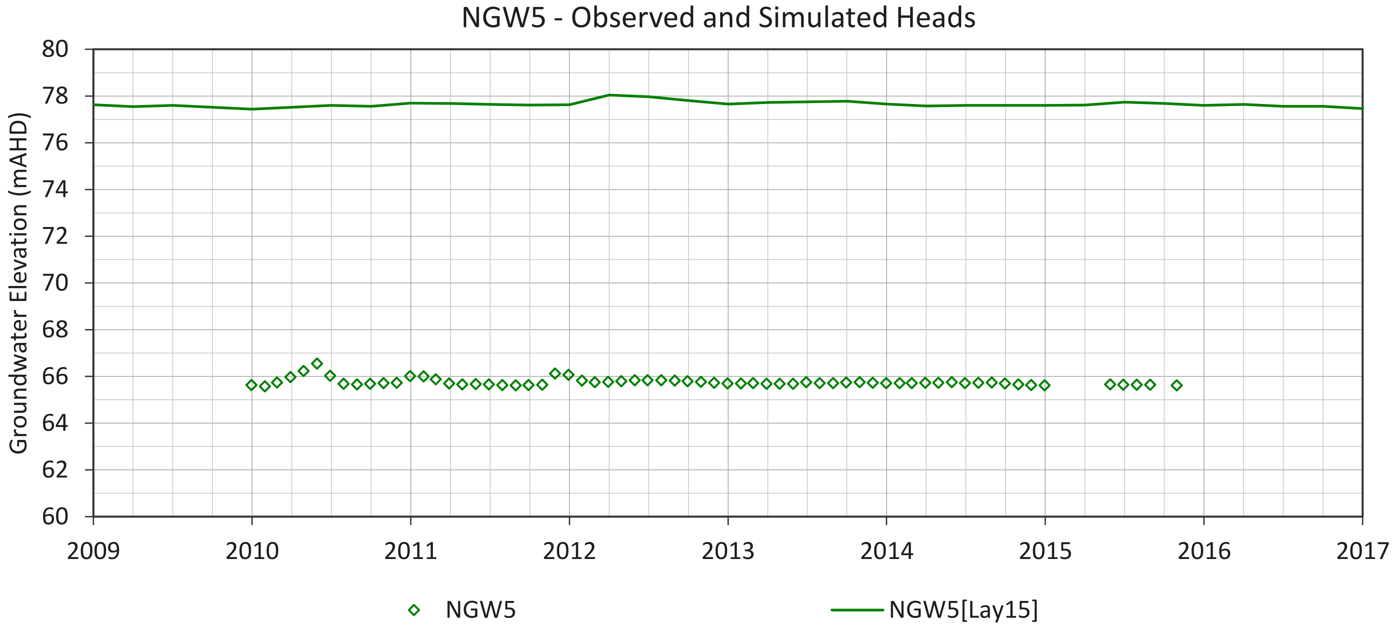

GW110708 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
90
85
80
75
70
65
60
55
50
45
40
2008
2009
2010
GW110708
GW110708[Lay5]

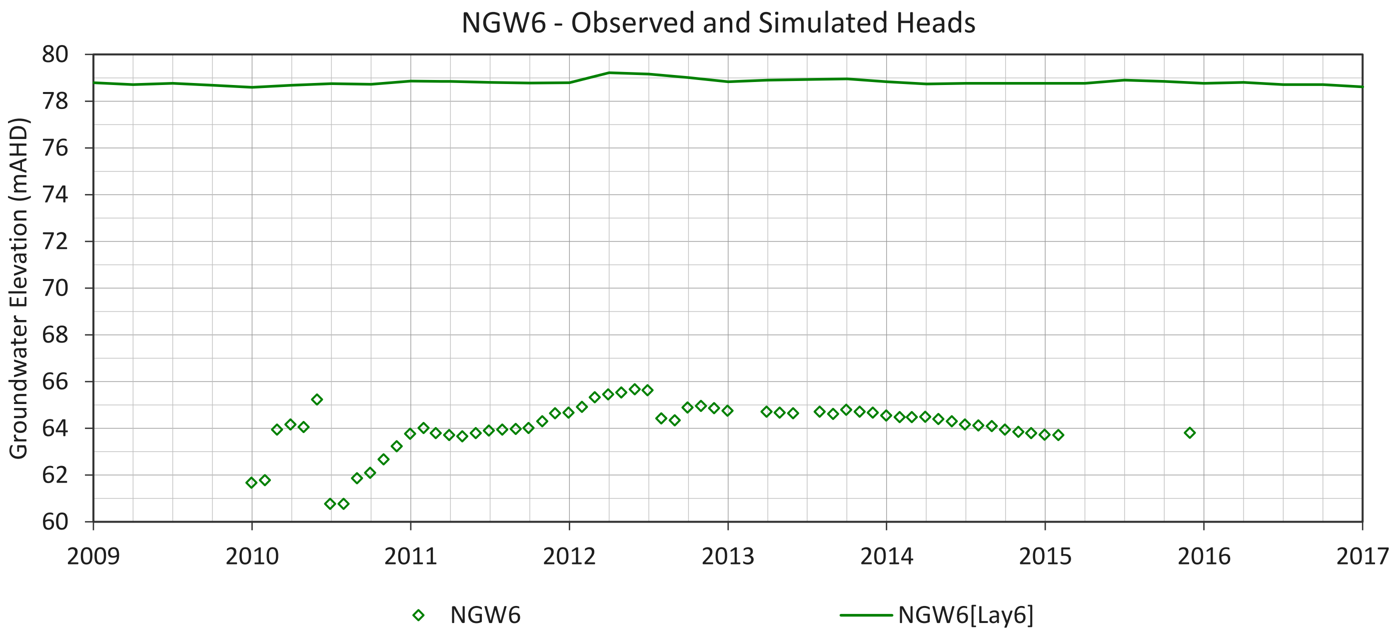

NGW10 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
90
85
80
75
70
65
60
2009
2010
2011
2012
2013
2014
NGW10
NGW10[Lay5]

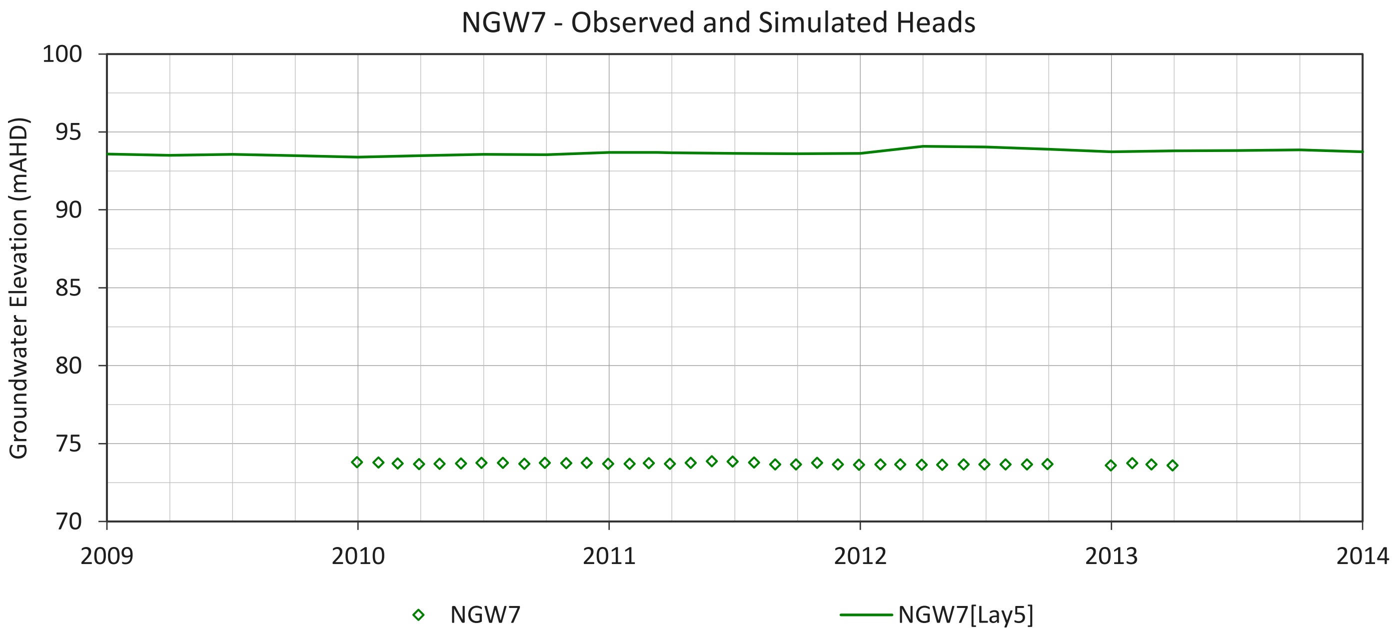

NGW11 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
90
88
86
84
82
80
78
76
74
72
70
2009
2010
2011
2012
2013
2014
NGW11
NGW11[Lay5]


NGW3 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
130
120
110
100
90
80
70
2009
2010
2011
2012
2013
2014
2015
2016
NGW3
NGW3[Lay15]

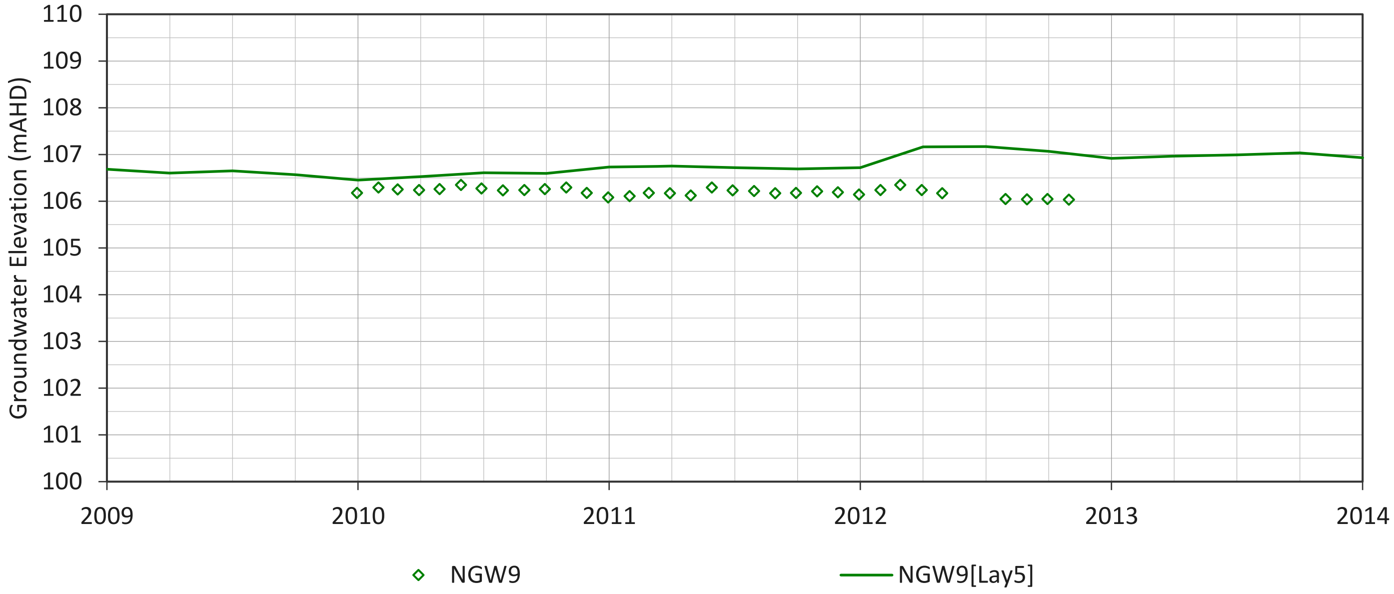

NGW4 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
80
78
76
74
72
70
68
66
64
62
60
2009
2010
2011
2012
2013
2014
2015
2016
2017
NGW4
NGW4[Lay15]


NGW5 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
80
78
76
74
72
70
68
66
64
62
60
2009
2010
2011
2012
2013
2014
2015
2016
2017
NGW5
NGW5[Lay15]

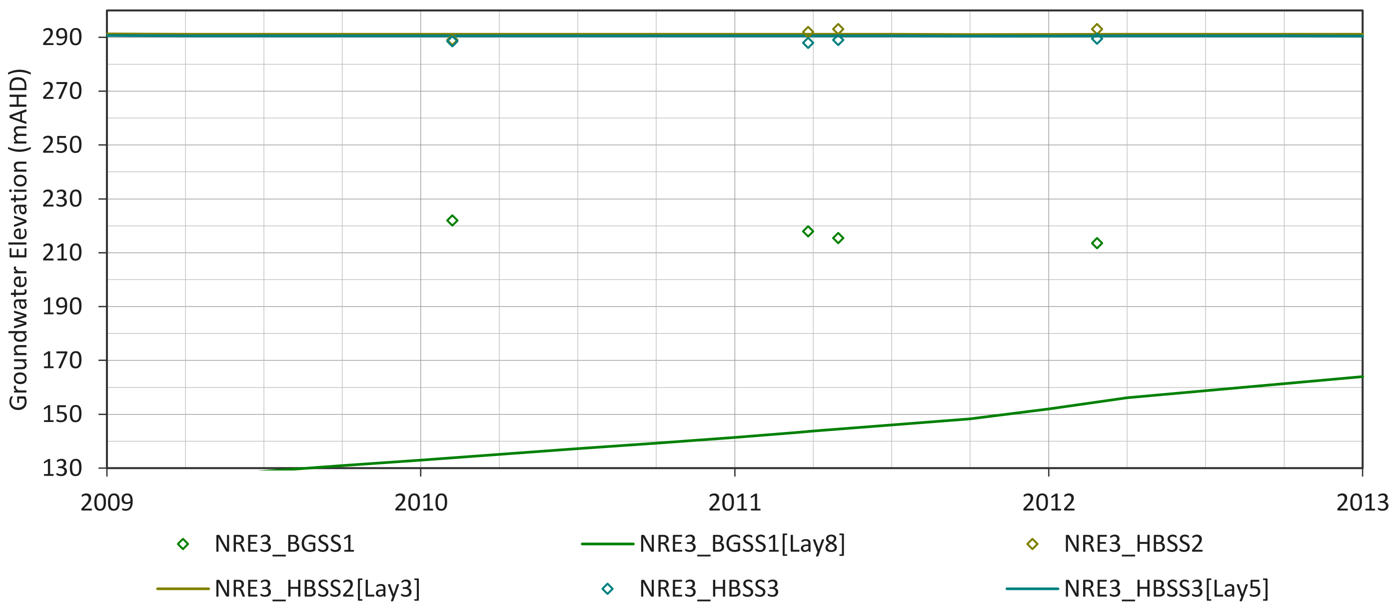

NGW6 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
80
78
76
74
72
70
68
66
64
62
60
2009
2010
2011
2012
2013
2014
2015
2016
2017
NGW6
NGW6[Lay6]


NGW7 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
100
95
90
85
80
75
70
2009
2010
2011
2012
2013
2014
NGW7
NGW7[Lay5]

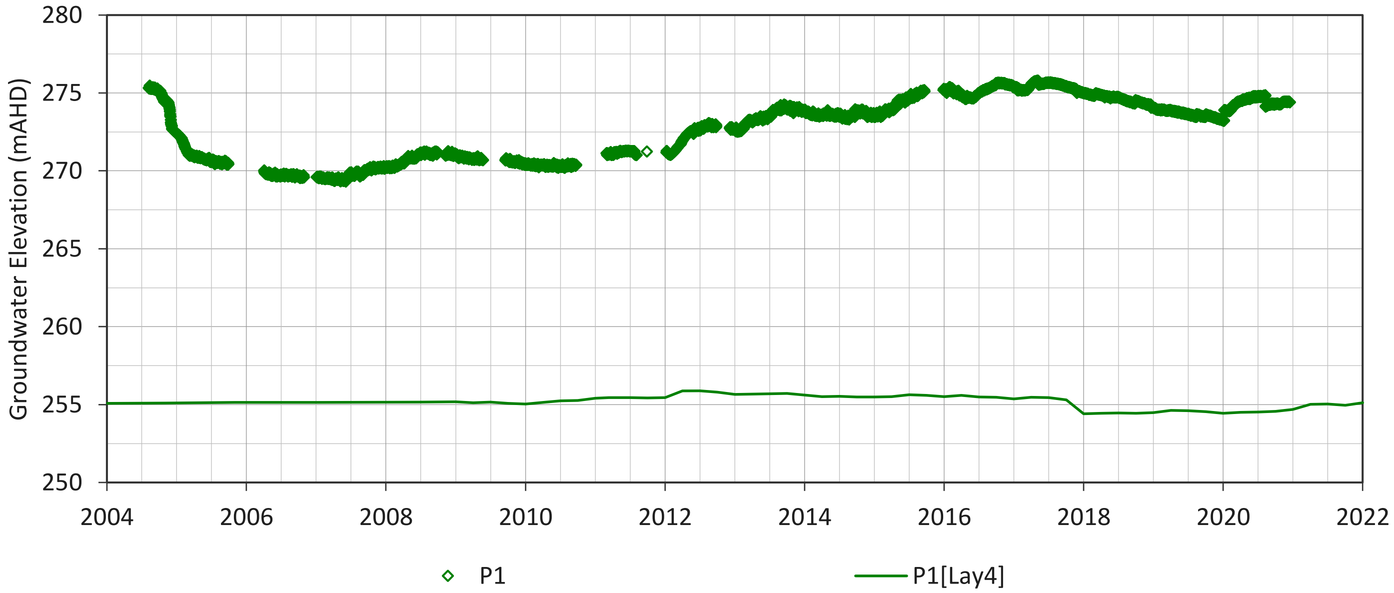
NGW9 - Observed and Simulated Heads

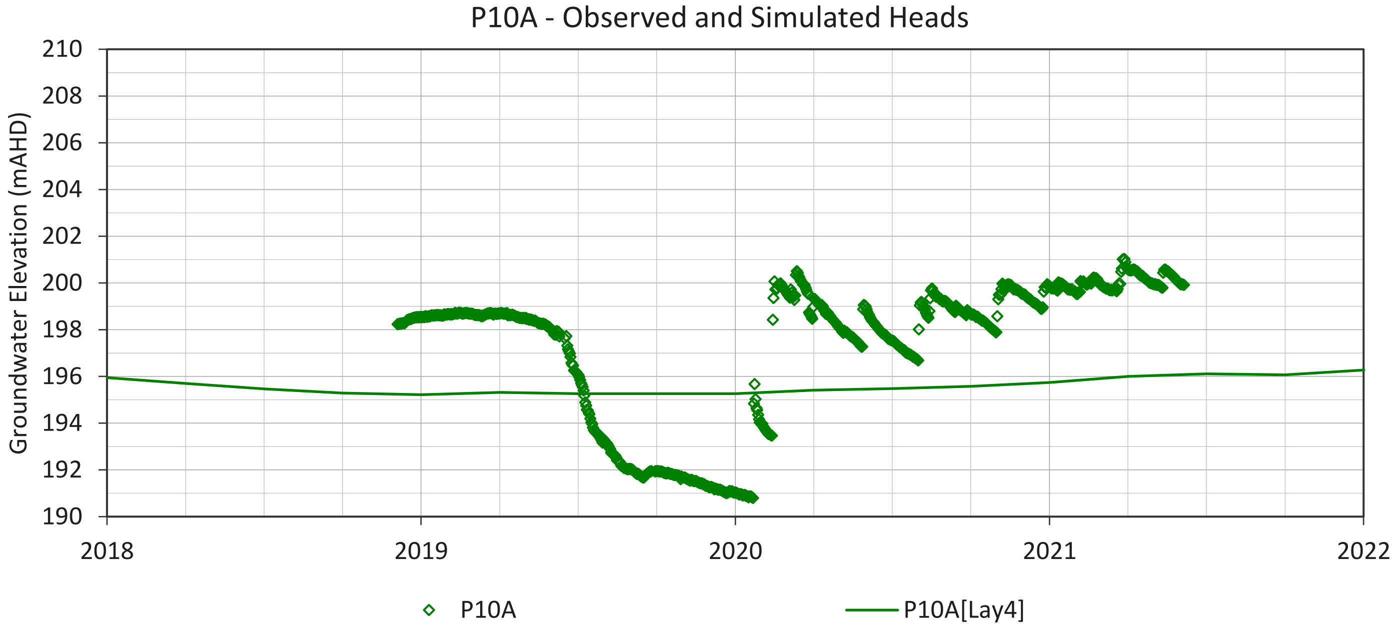


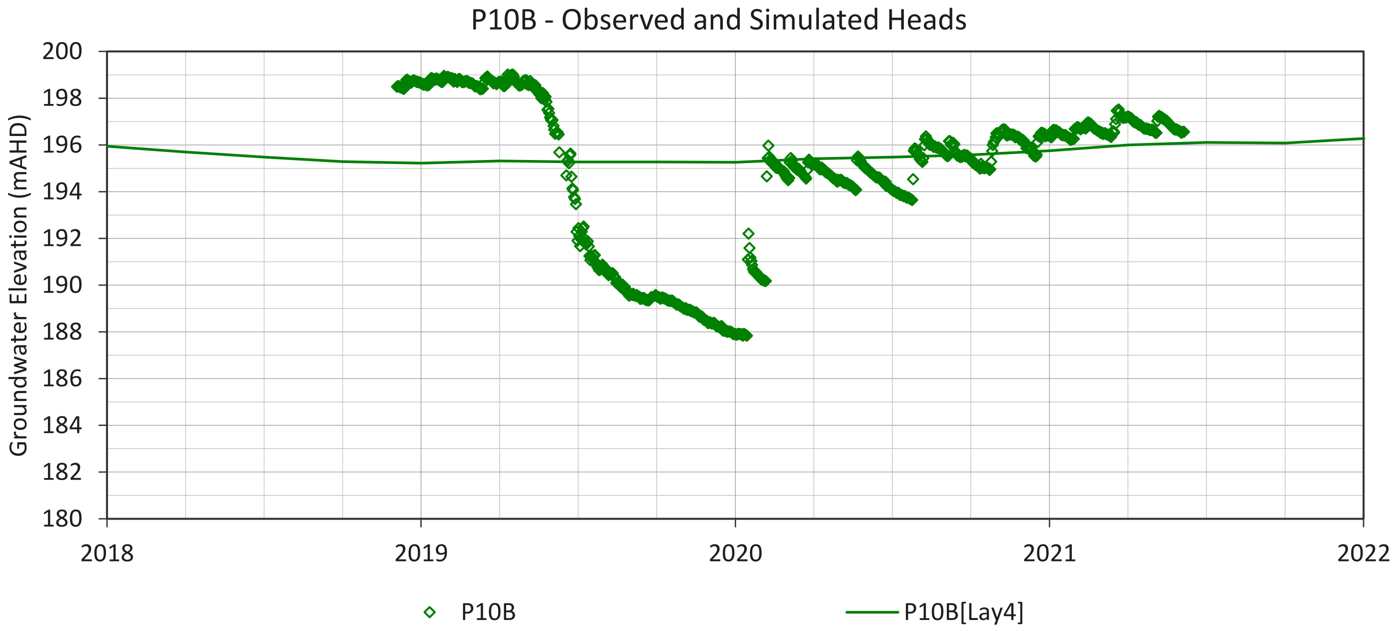
NRE3 - Observed and Simulated Heads

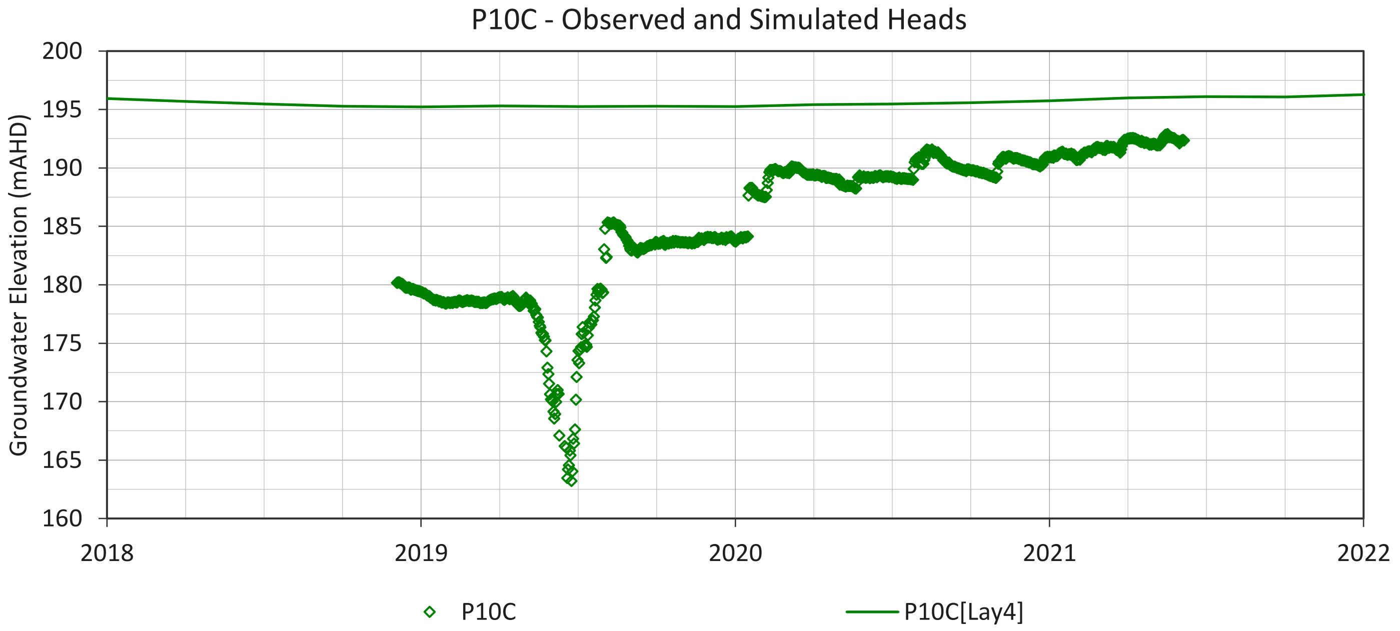


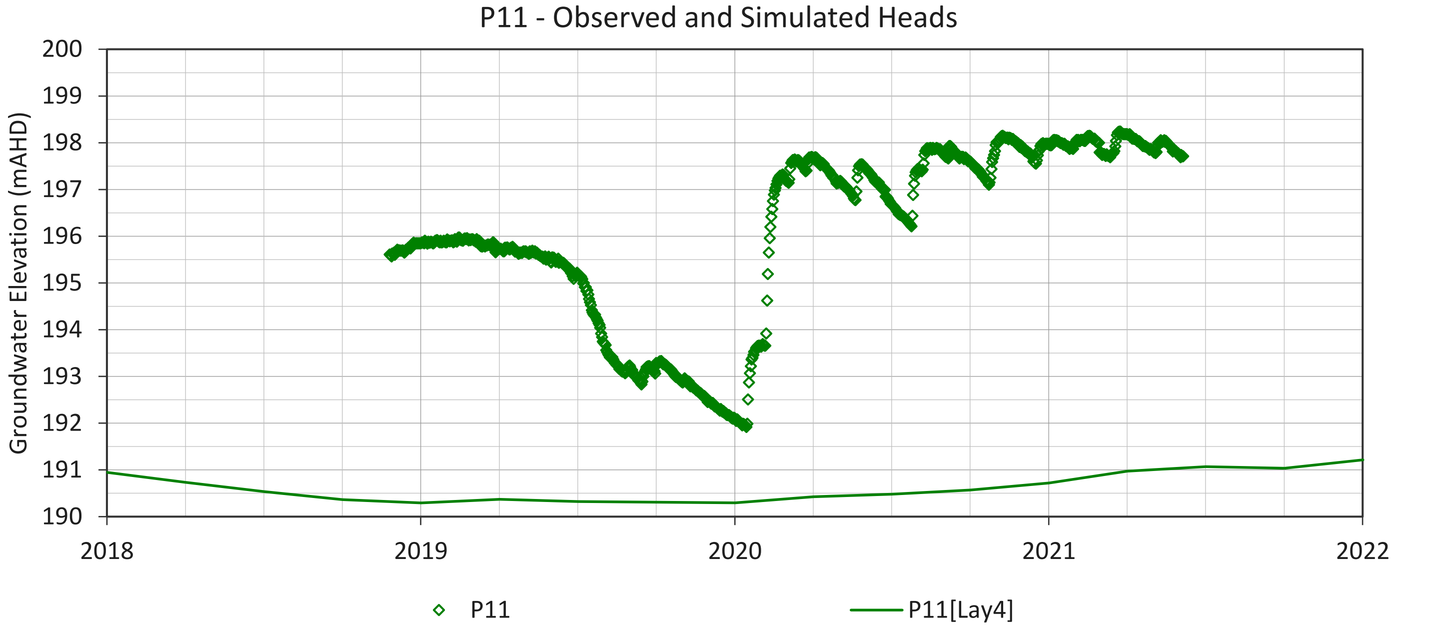
P1 - Observed and Simulated Heads

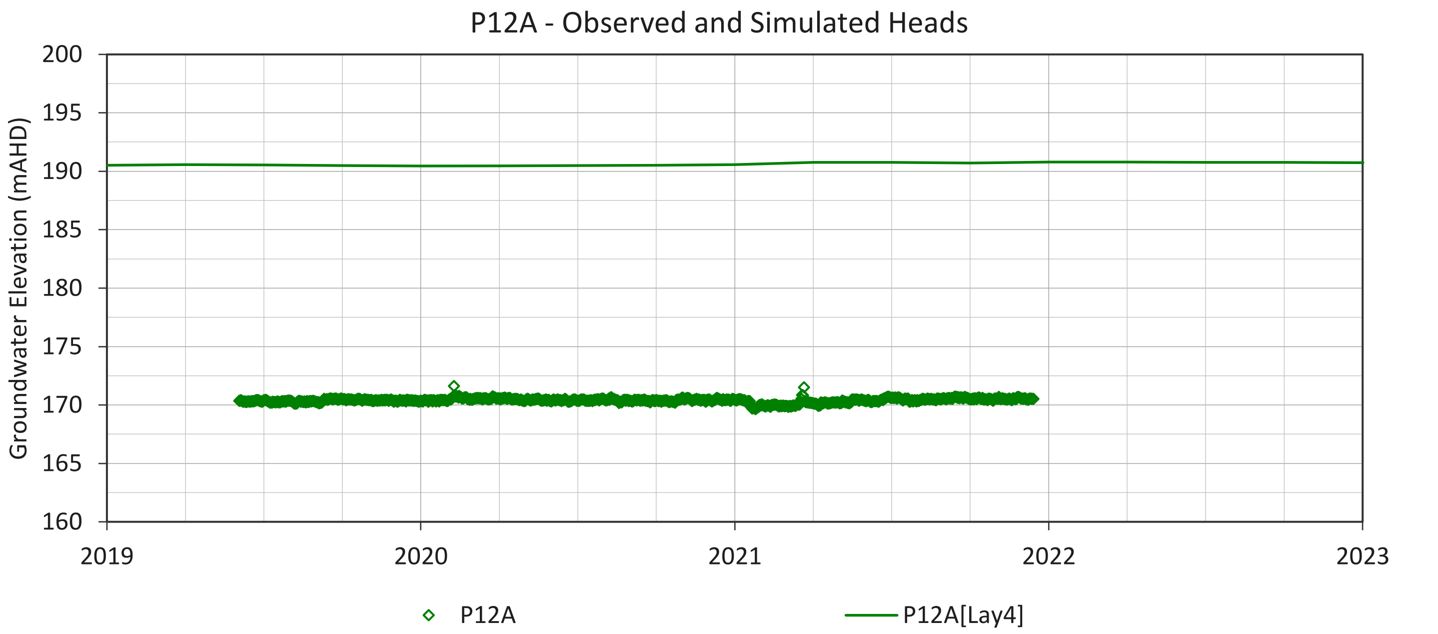


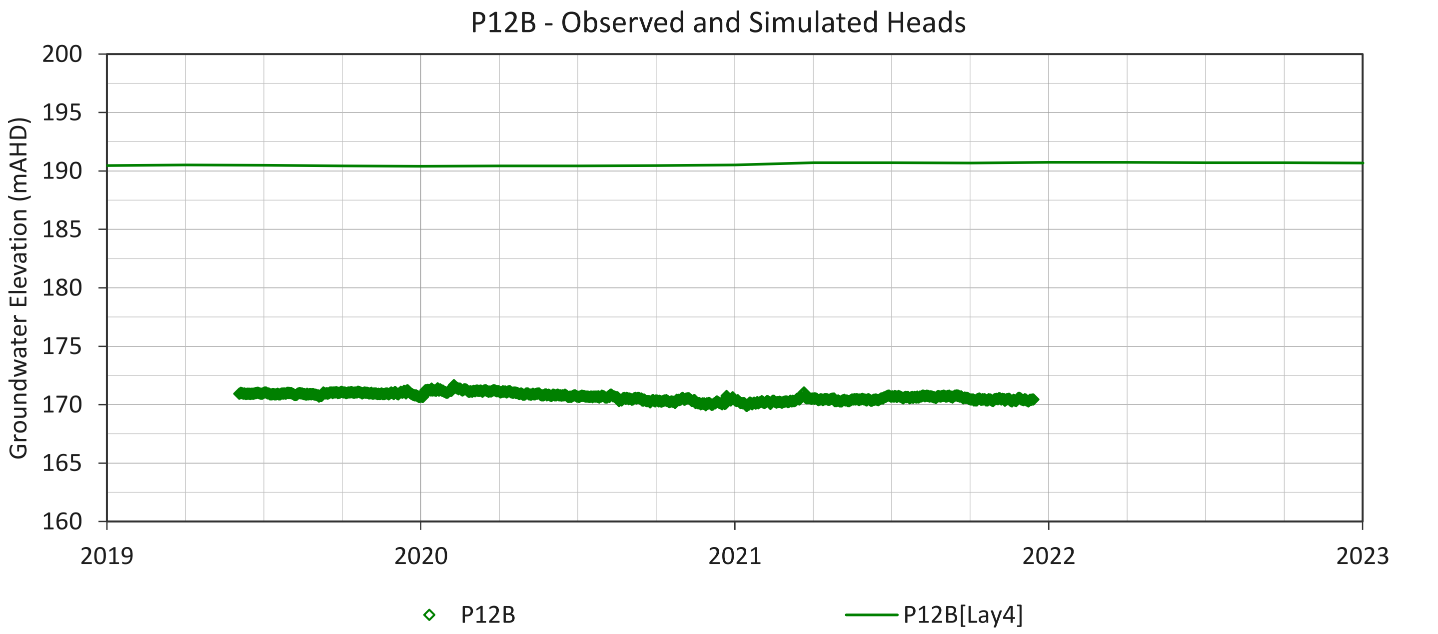

P10A - Observed and Simulated Heads
Groundwater Elevation (mAHD)
210
208
206
204
202
200
198
196
194
192
190
2018
2019
2020
2021
2022
P10A
P10A[Lay4]

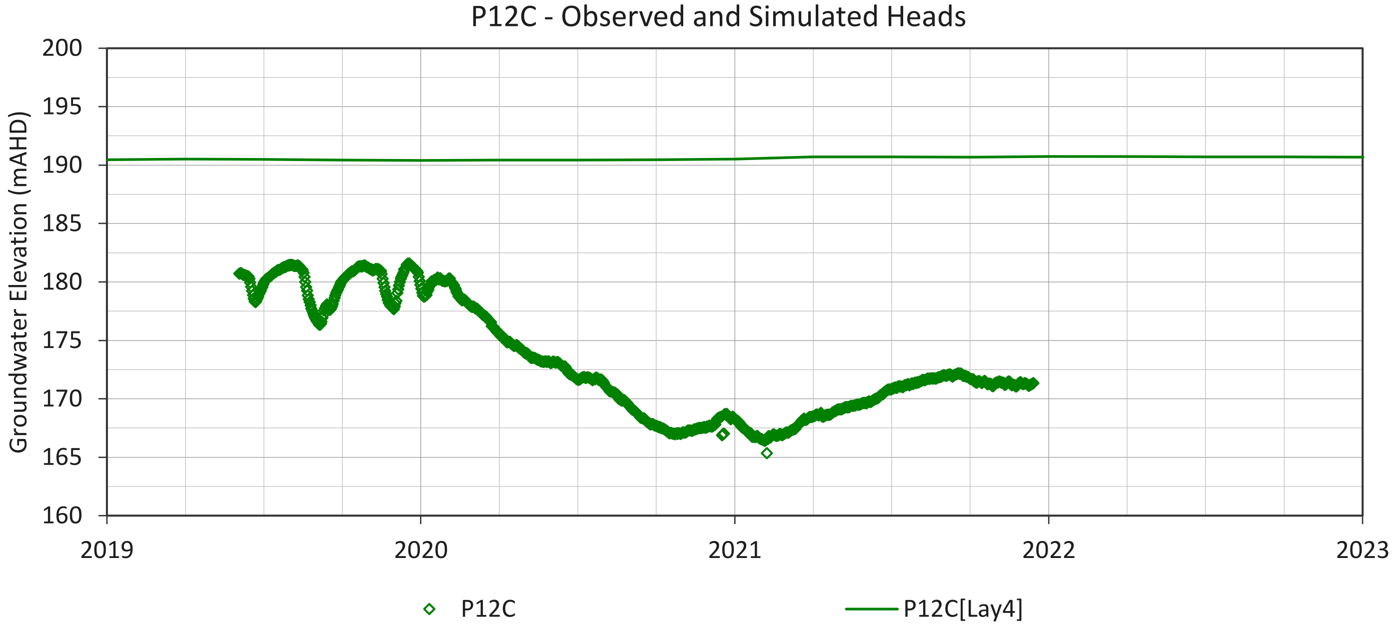

P10B - Observed and Simulated Heads
Groundwater Elevation (mAHD)
200
198
196
194
192
190
188
186
184
182
180
2018
2019
2020
2021
2022
P10B
P10B[Lay4]

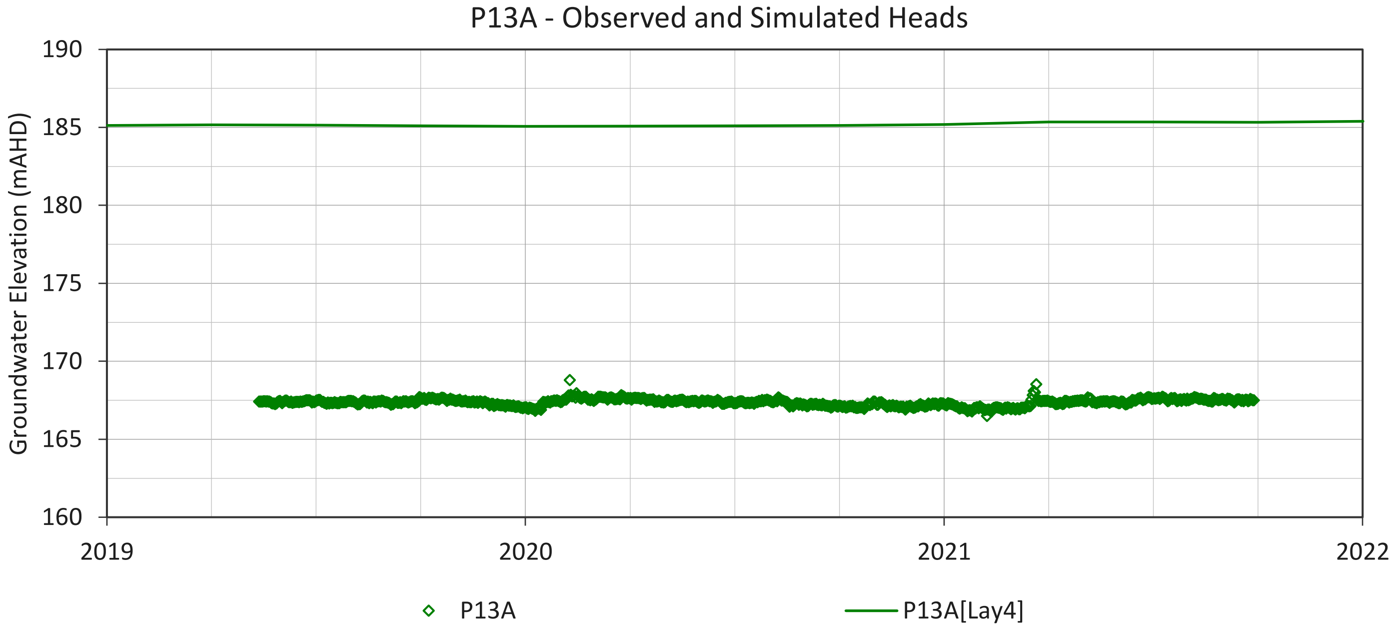

P10C - Observed and Simulated Heads
Groundwater Elevation (mAHD)
200
195
190
185
180
175
170
165
160
2018
2019
2020
2021
2022
P10C
P10C[Lay4]

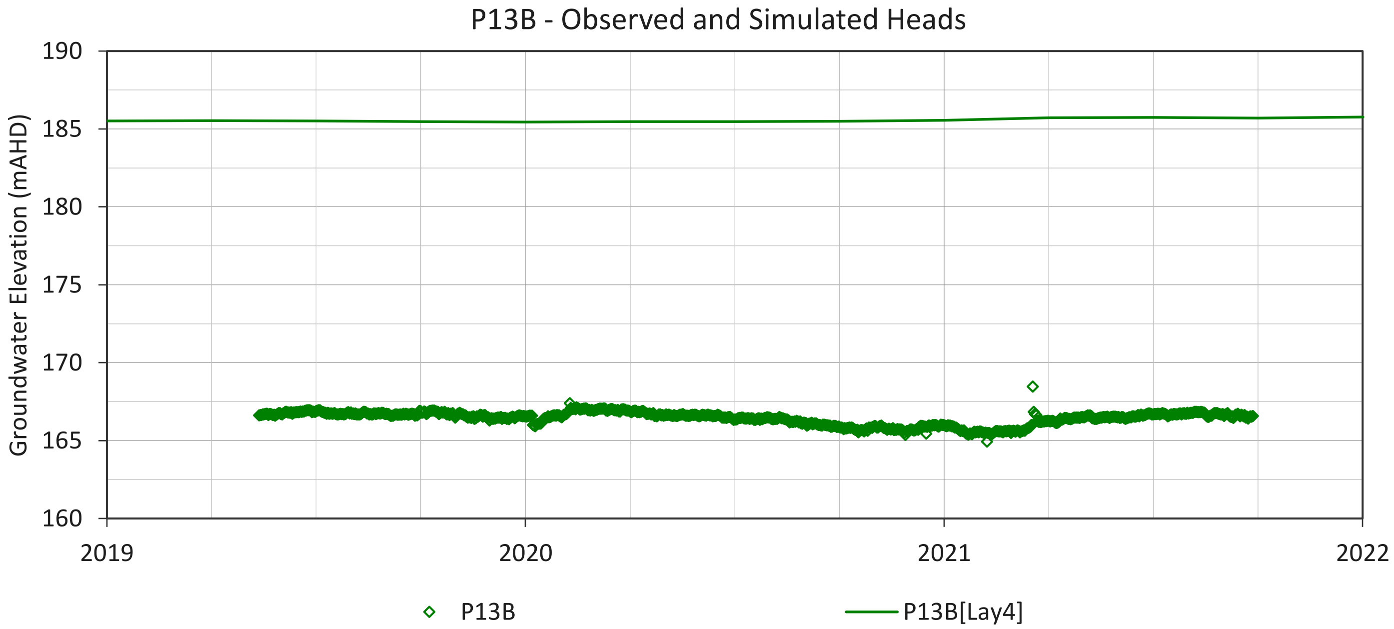

P11 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
200
199
198
197
196
195
194
193
192
191
190
2018
2019
2020
2021
2022
P11
P11[Lay4]

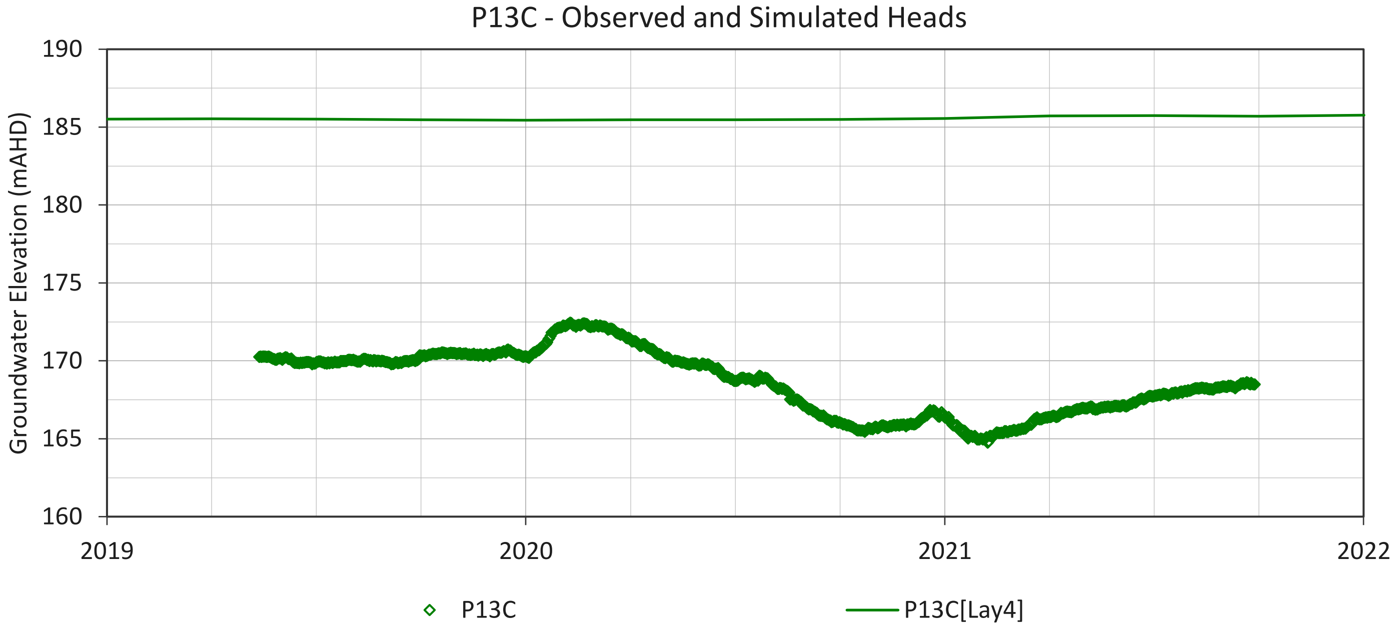

P12A - Observed and Simulated Heads
Groundwater Elevation (mAHD)
200
195
190
185
180
175
170
165
160
2019
2020
2021
2022
2023
P12A
P12A[Lay4]

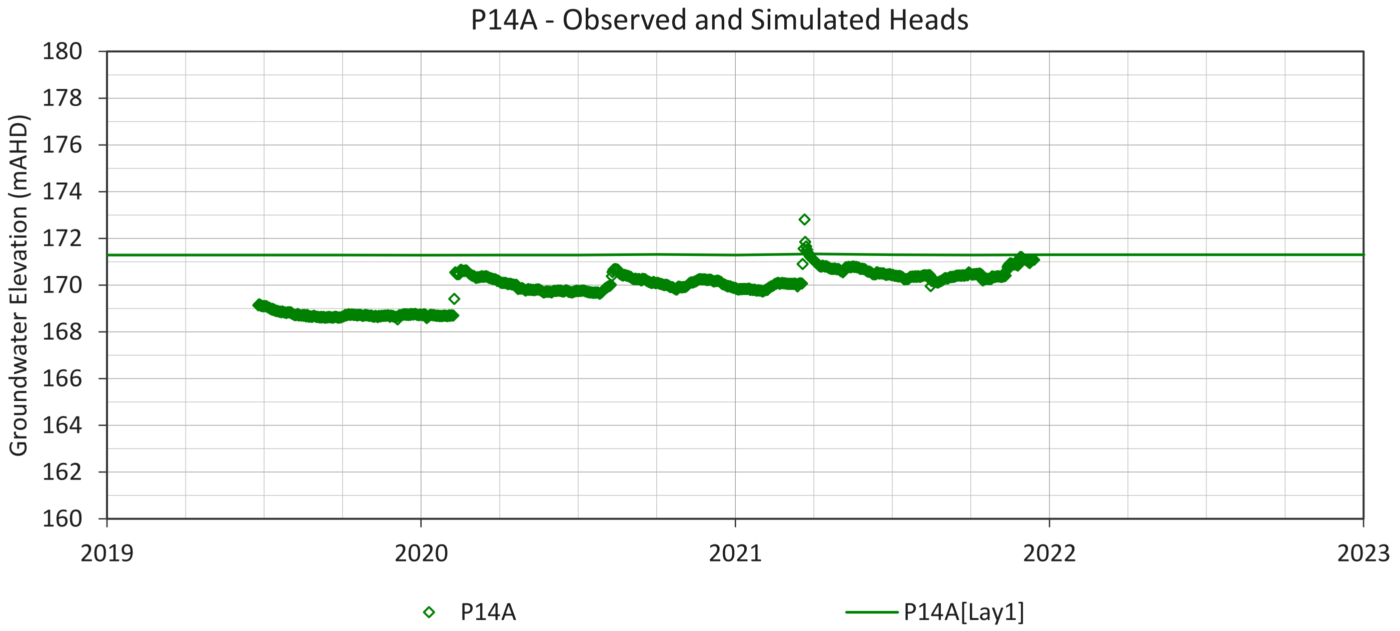

P12B - Observed and Simulated Heads
Groundwater Elevation (mAHD)
200
195
190
185
180
175
170
165
160
2019
2020
2021
2022
2023
P12B
P12B[Lay4]

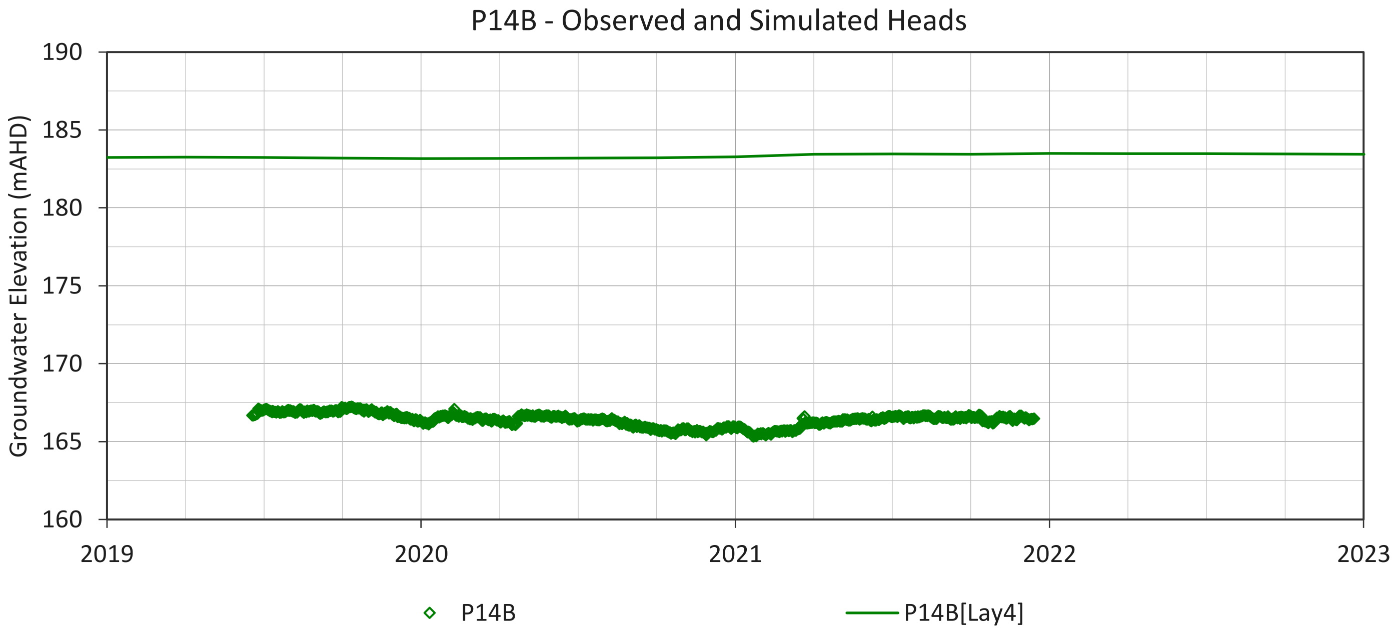

P12C - Observed and Simulated Heads
Groundwater Elevation (mAHD)
200
195
190
185
180
175
170
165
160
2019
2020
2021
2022
2023
P12C
P12C[Lay4]

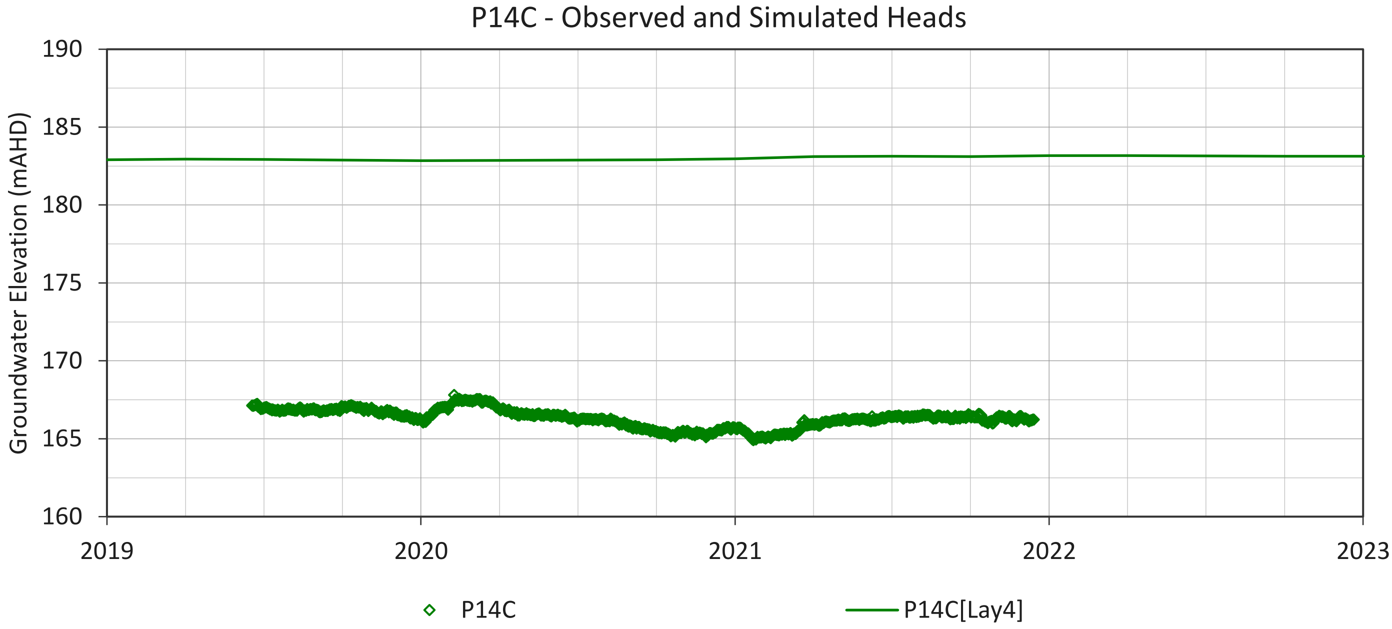

P13A - Observed and Simulated Heads
Groundwater Elevation (mAHD)
190
185
180
175
170
165
160
2019
2020
2021
2022
P13A
P13A[Lay4]

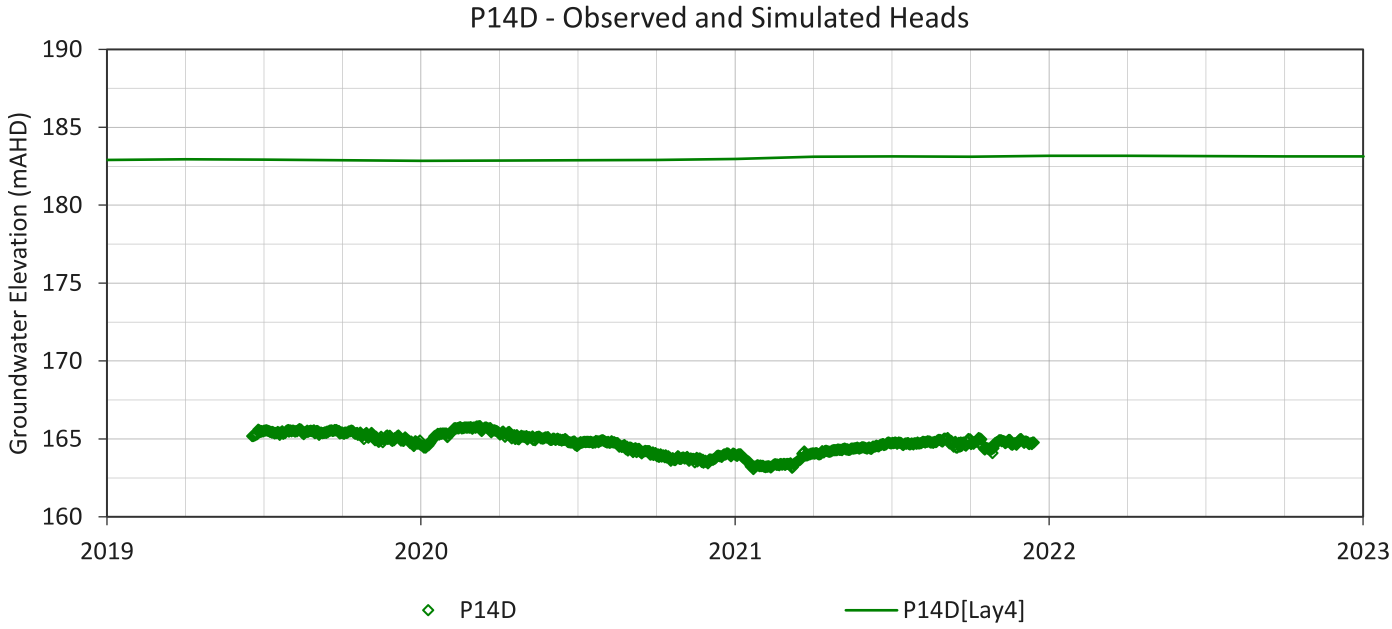

P13B - Observed and Simulated Heads
Groundwater Elevation (mAHD)
190
185
180
175
170
165
160
2019
2020
2021
2022
P13B
P13B[Lay4]

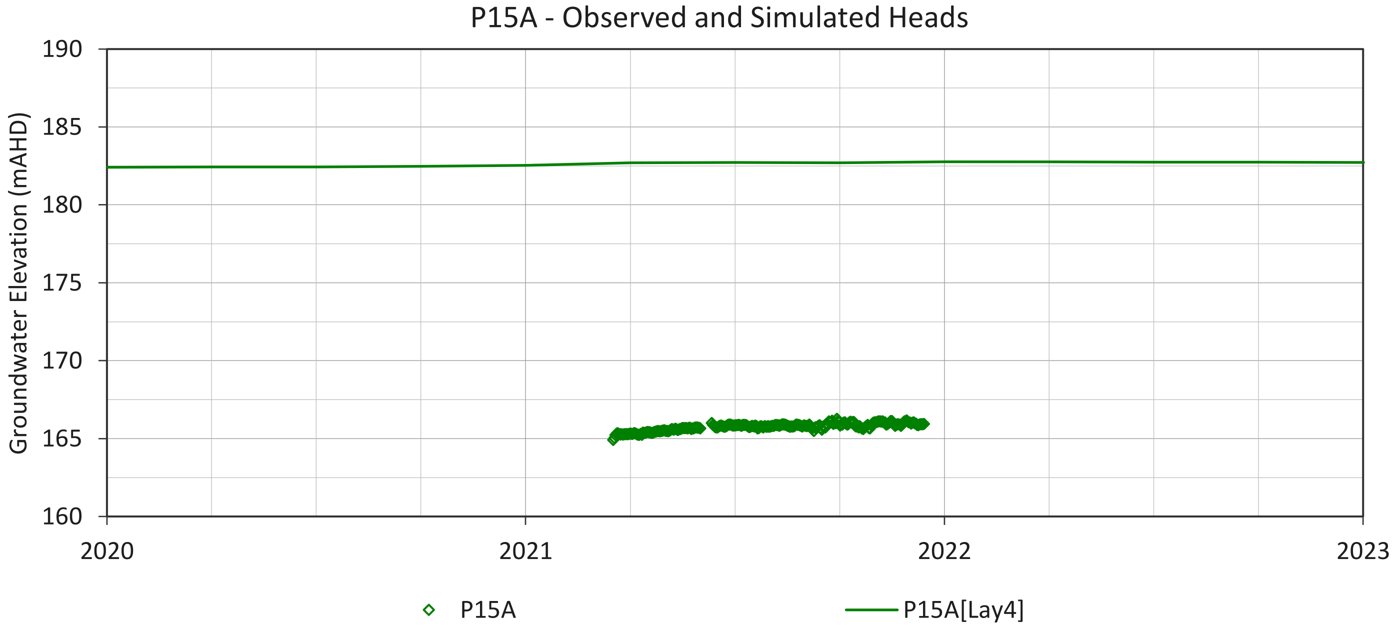

P13C - Observed and Simulated Heads
Groundwater Elevation (mAHD)
190
185
180
175
170
165
160
2019
2020
2021
2022
P13C
P13C[Lay4]

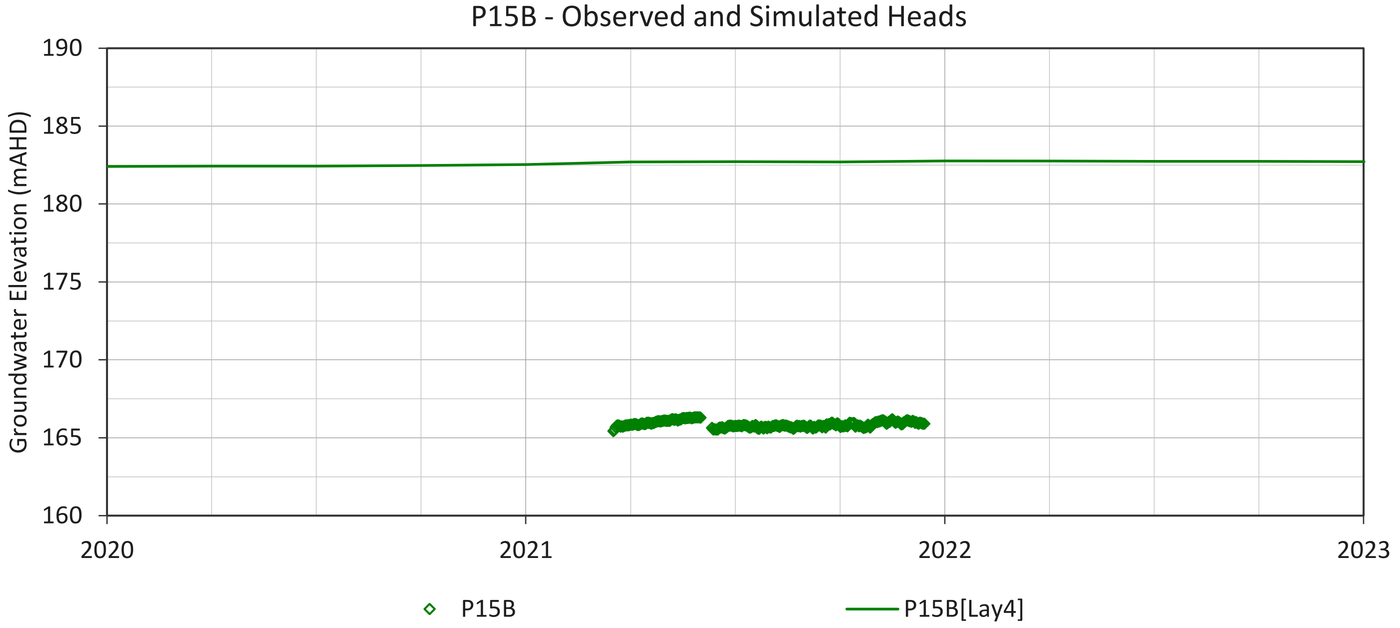

P14A - Observed and Simulated Heads
Groundwater Elevation (mAHD)
180
178
176
174
172
170
168
166
164
162
160
2019
2020
2021
2022
2023
P14A
P14A[Lay1]

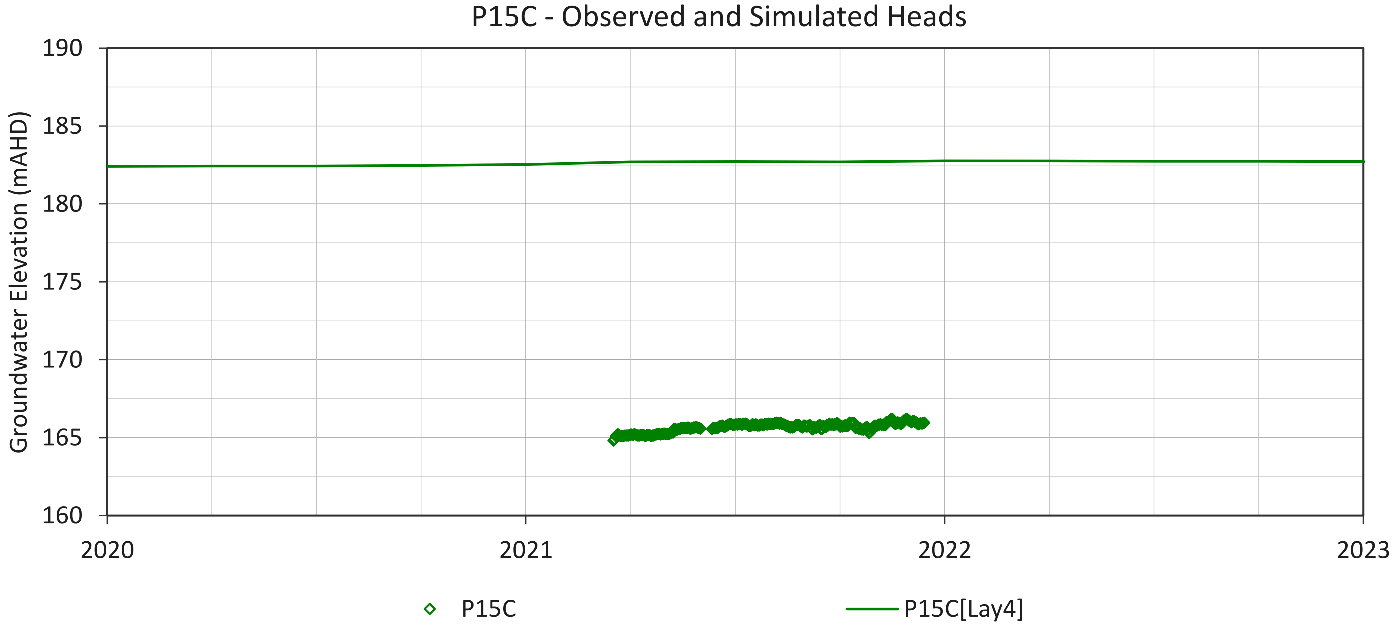

P14B - Observed and Simulated Heads
Groundwater Elevation (mAHD)
190
185
180
175
170
165
160
2019
2020
2021
2022
2023
P14B
P14B[Lay4]

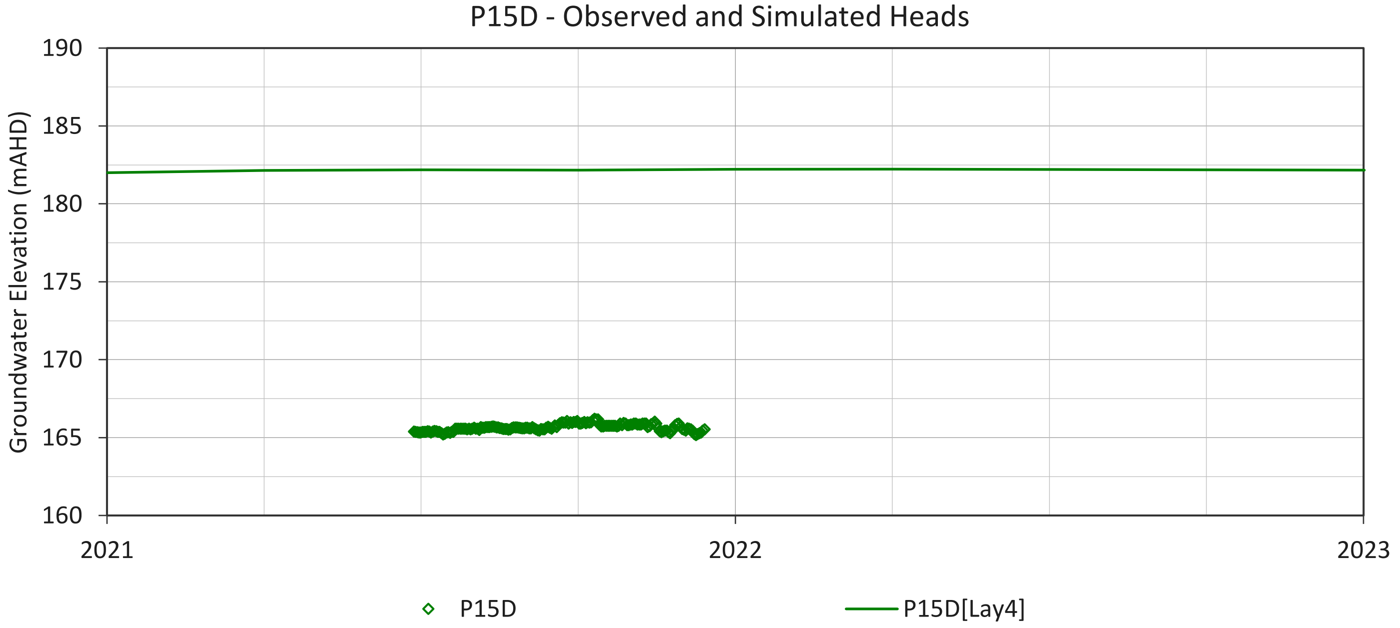

P14C - Observed and Simulated Heads
Groundwater Elevation (mAHD)
190
185
180
175
170
165
160
2019
2020
2021
2022
2023
P14C
P14C[Lay4]

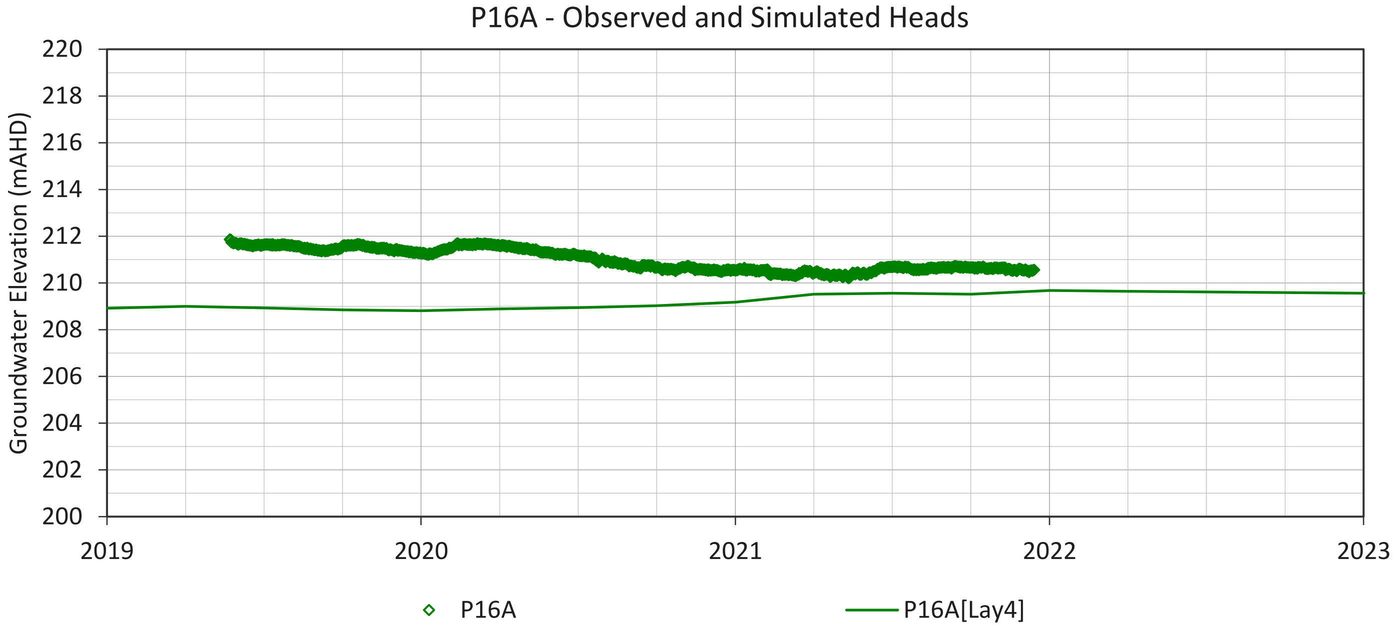

P14D - Observed and Simulated Heads
Groundwater Elevation (mAHD)
190
185
180
175
170
165
160
2019
2020
2021
2022
2023
P14D
P14D[Lay4]

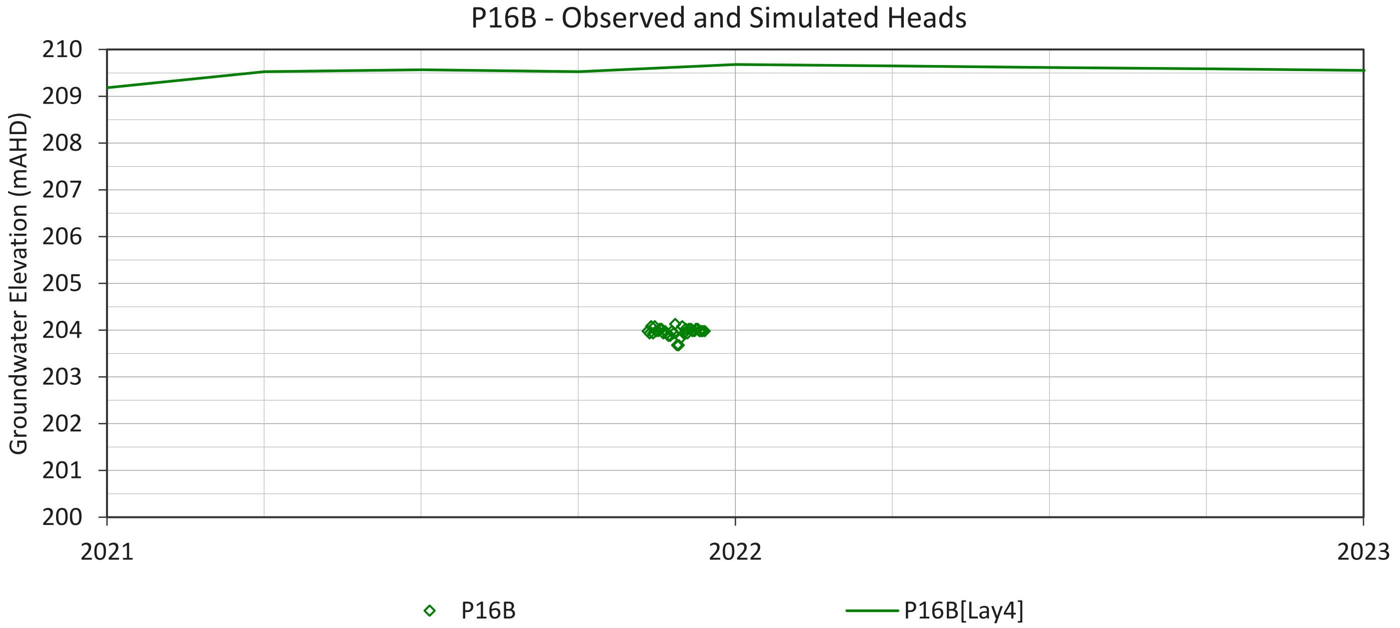

P15A - Observed and Simulated Heads
Groundwater Elevation (mAHD)
190
185
180
175
170
165
160
2020
2021
2022
2023
P15A
P15A[Lay4]

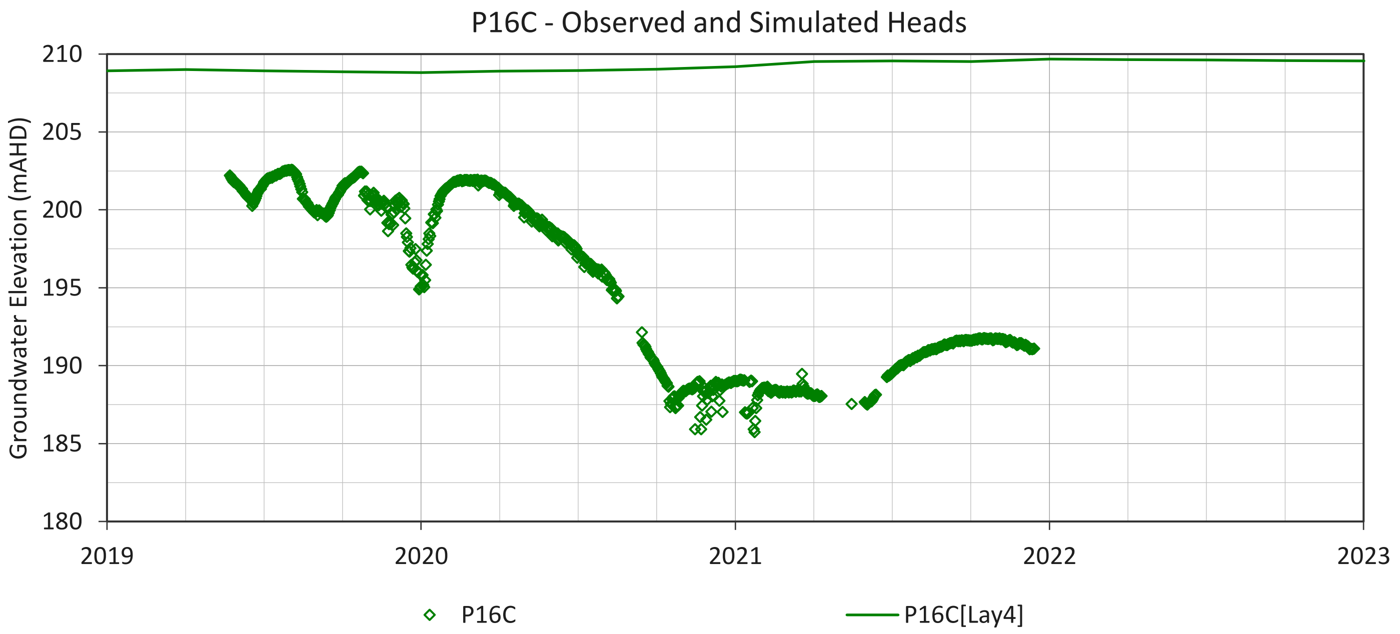

P15B - Observed and Simulated Heads
Groundwater Elevation (mAHD)
190
185
180
175
170
165
160
2020
2021
2022
2023
P15B
P15B[Lay4]

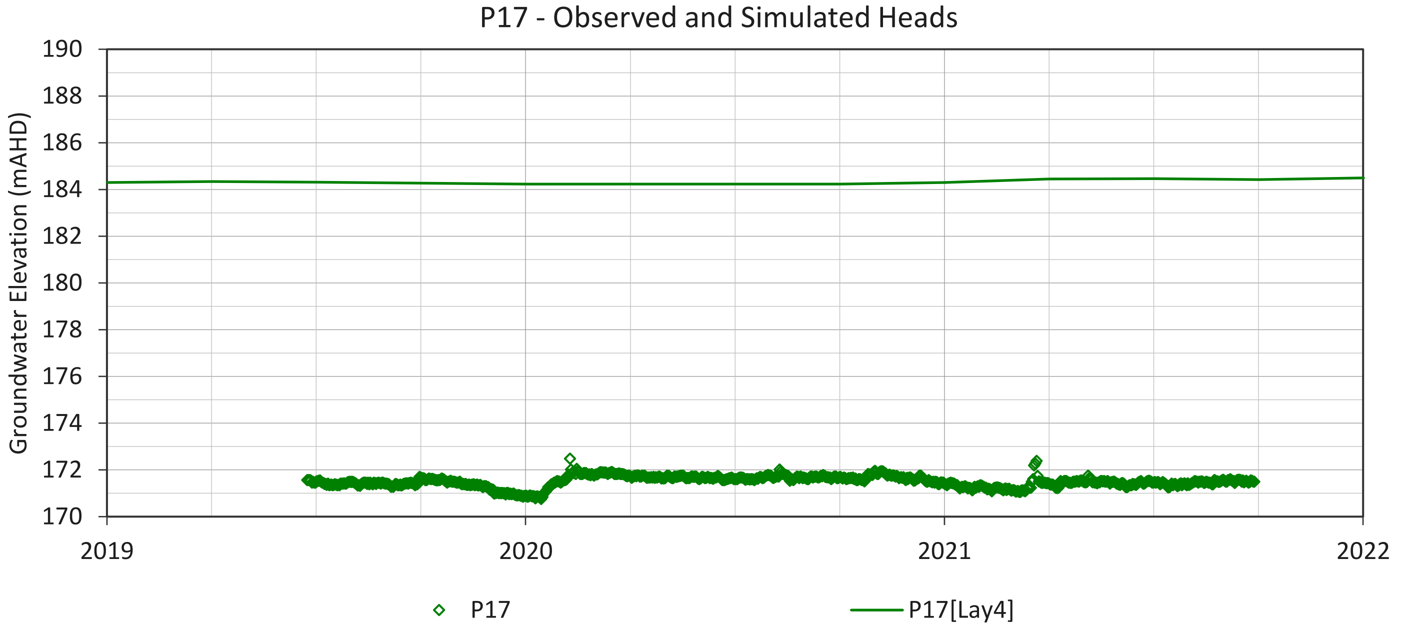

P15C - Observed and Simulated Heads
Groundwater Elevation (mAHD)
190
185
180
175
170
165
160
2020
2021
2022
2023
P15C
P15C[Lay4]

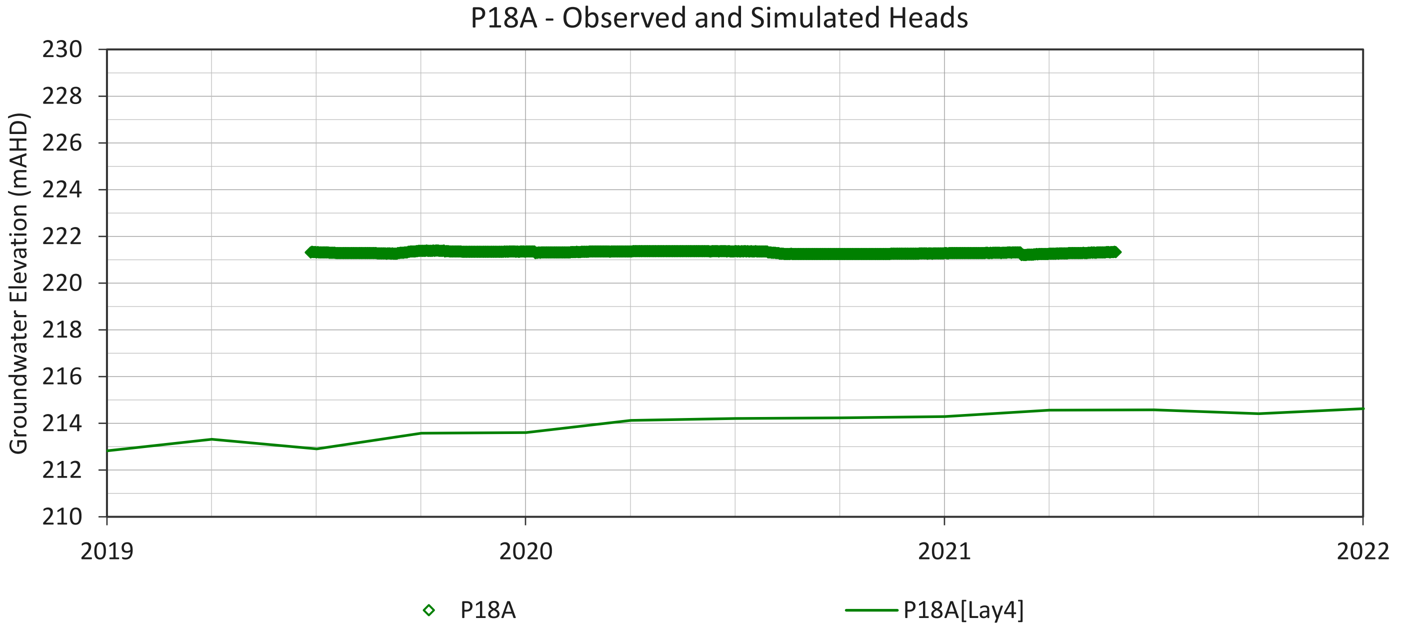

P15D - Observed and Simulated Heads
Groundwater Elevation (mAHD)
190
185
180
175
170
165
160
2021
2022
2023
P15D
P15D[Lay4]

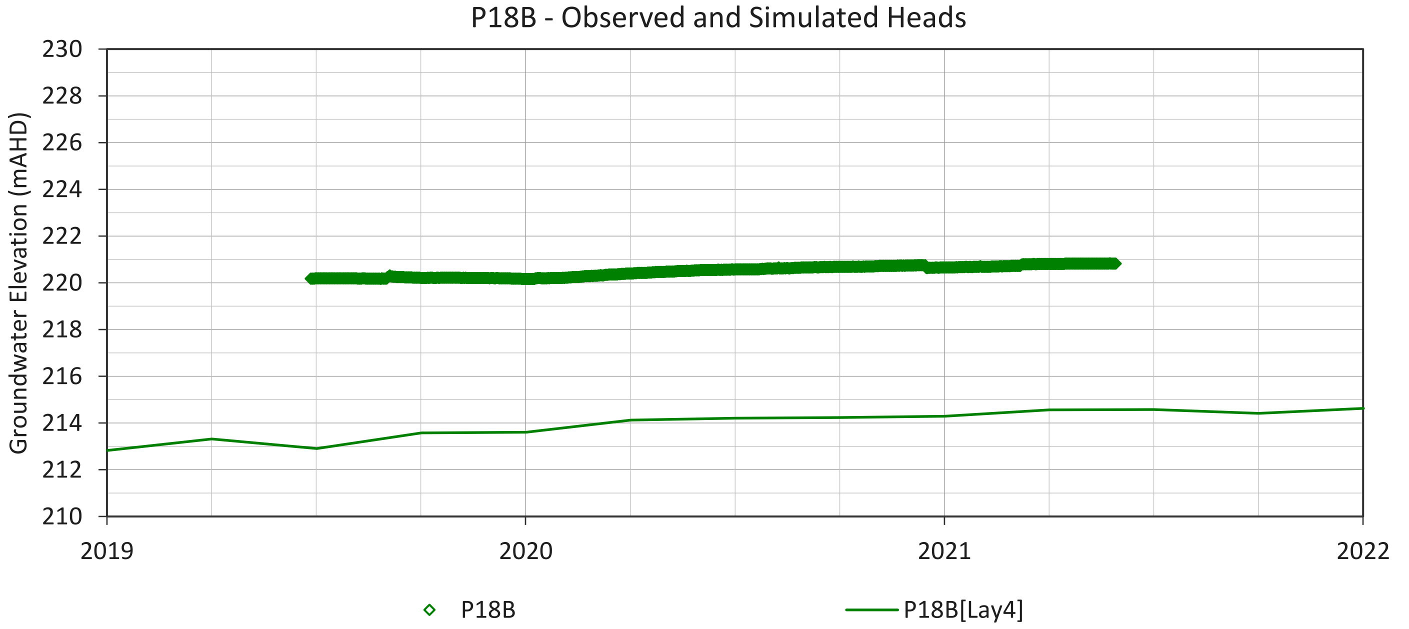

P16A - Observed and Simulated Heads
Groundwater Elevation (mAHD)
220
218
216
214
212
210
208
206
204
202
200
2019
2020
2021
2022
2023
P16A
P16A[Lay4]

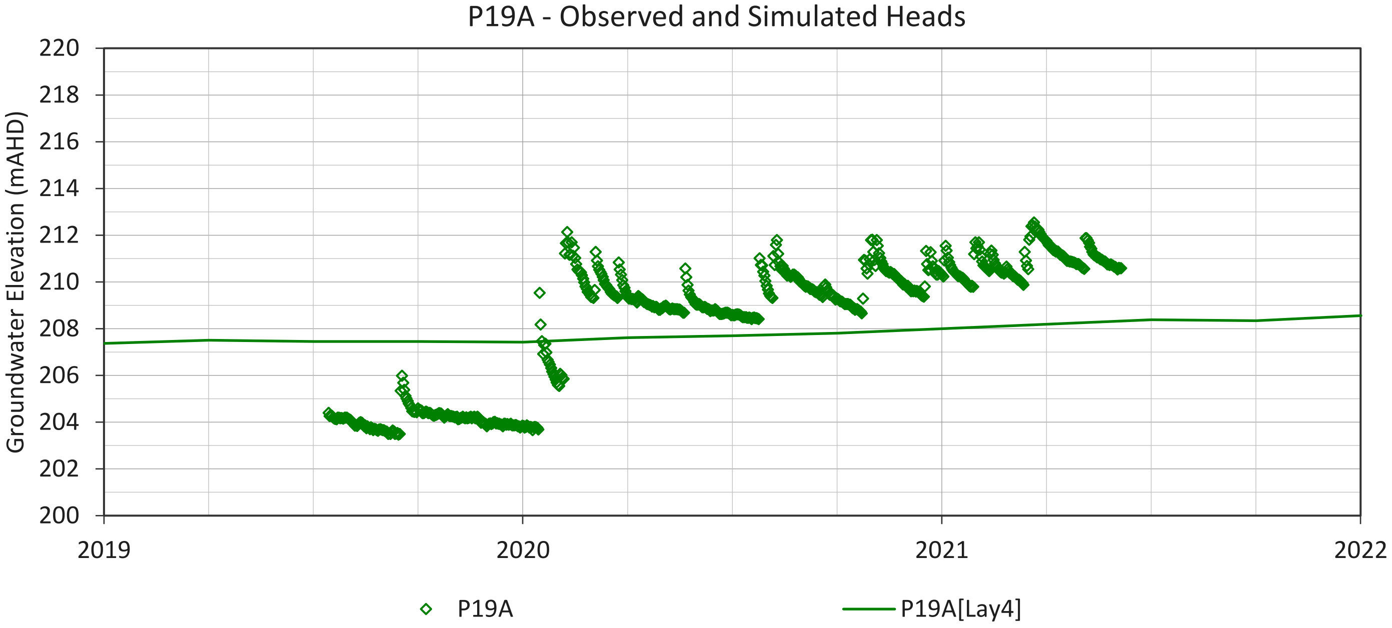

P16B - Observed and Simulated Heads
Groundwater Elevation (mAHD)
210
209
208
207
206
205
204
203
202
201
200
2021
2022
2023
P16B
P16B[Lay4]

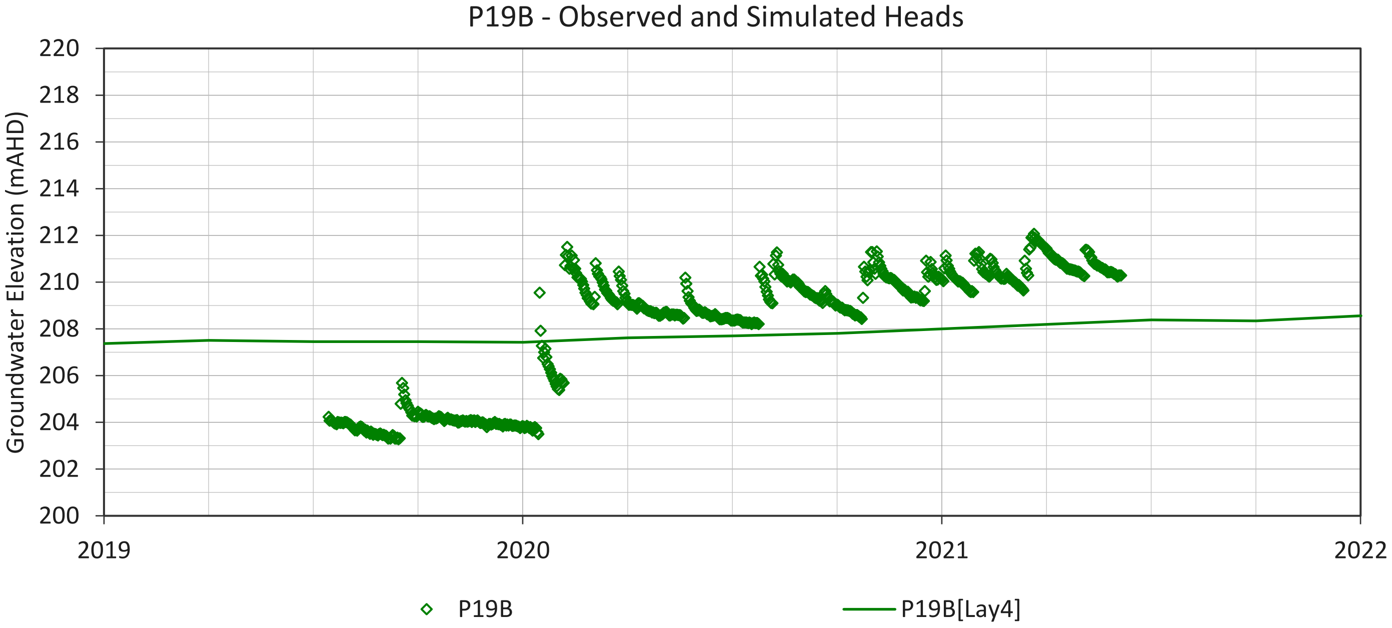

P16C - Observed and Simulated Heads
Groundwater Elevation (mAHD)
210
205
200
195
190
185
180
2019
2020
2021
2022
2023
P16C
P16C[Lay4]

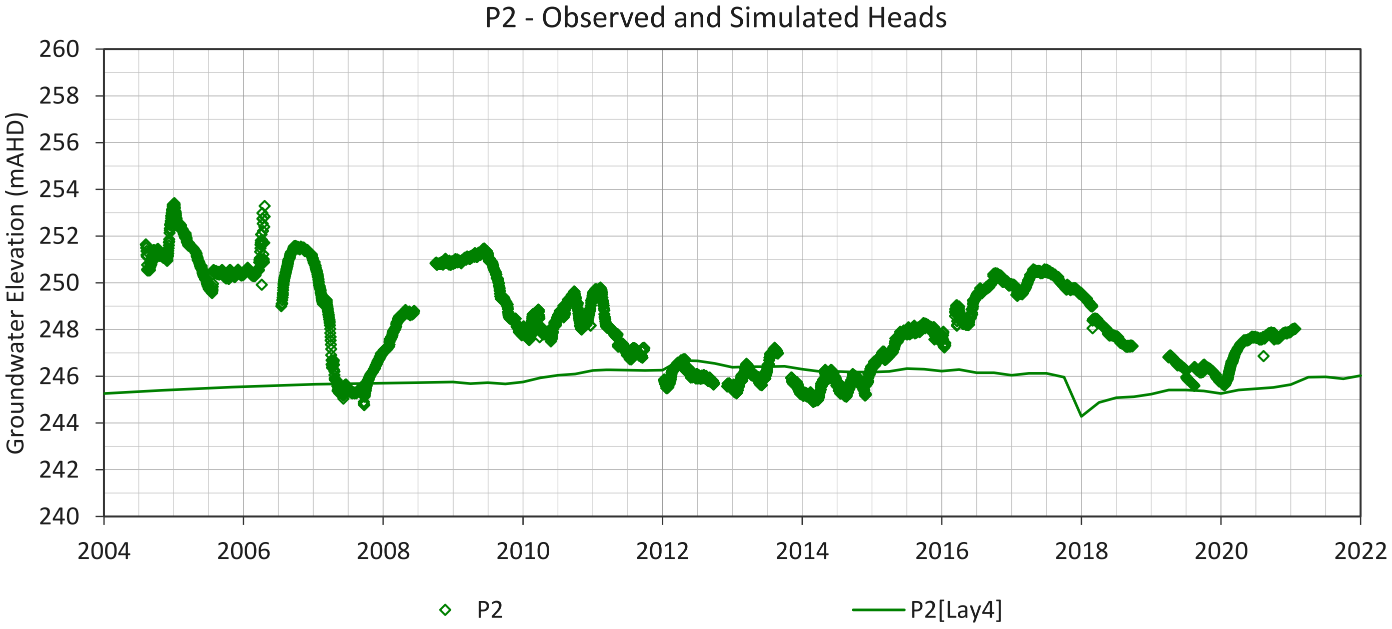

P17 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
190
188
186
184
182
180
178
176
174
172
170
2019
2020
2021
2022
P17
P17[Lay4]

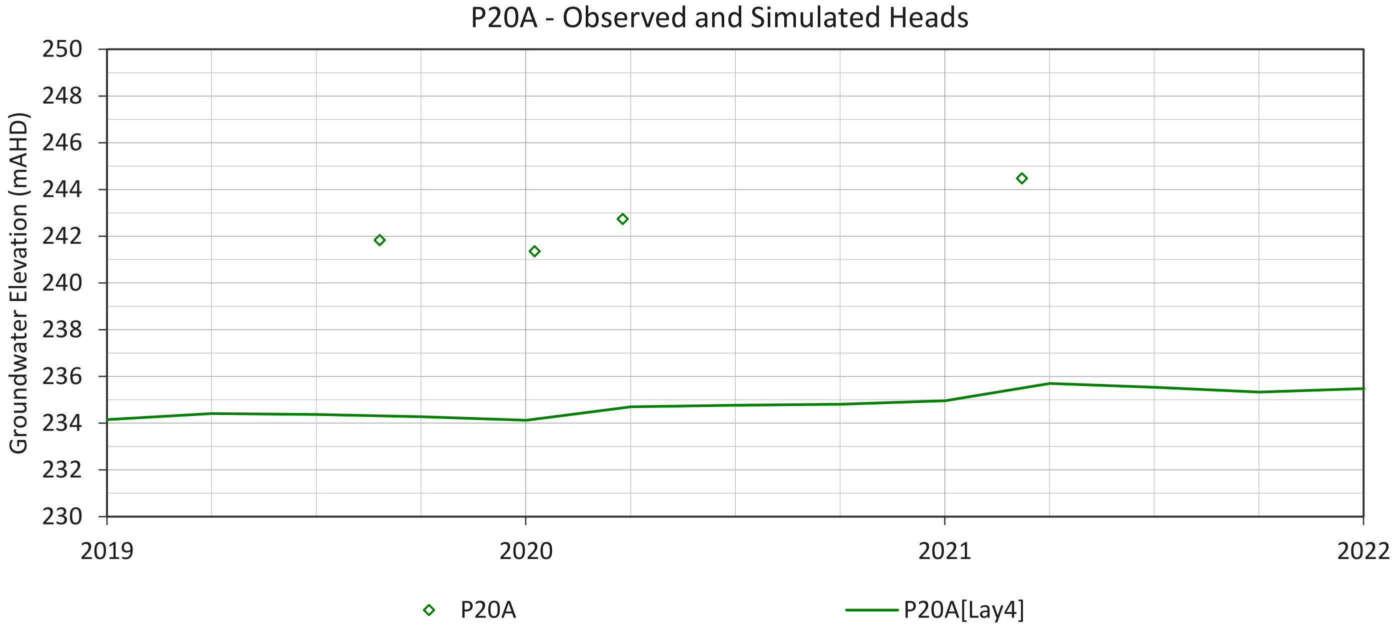

P18A - Observed and Simulated Heads
Groundwater Elevation (mAHD)
230
228
226
224
222
220
218
216
214
212
210
2019
2020
2021
2022
P18A
P18A[Lay4]

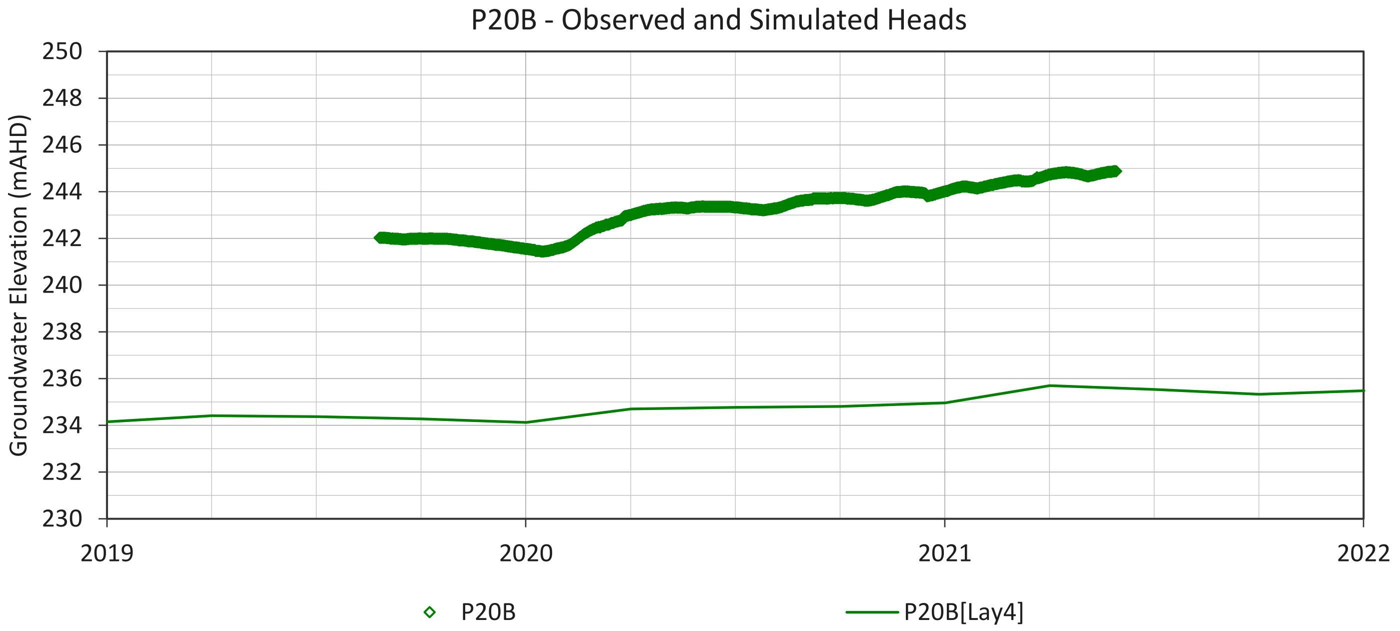

P18B - Observed and Simulated Heads
Groundwater Elevation (mAHD)
230
228
226
224
222
220
218
216
214
212
210
2019
2020
2021
2022
P18B
P18B[Lay4]

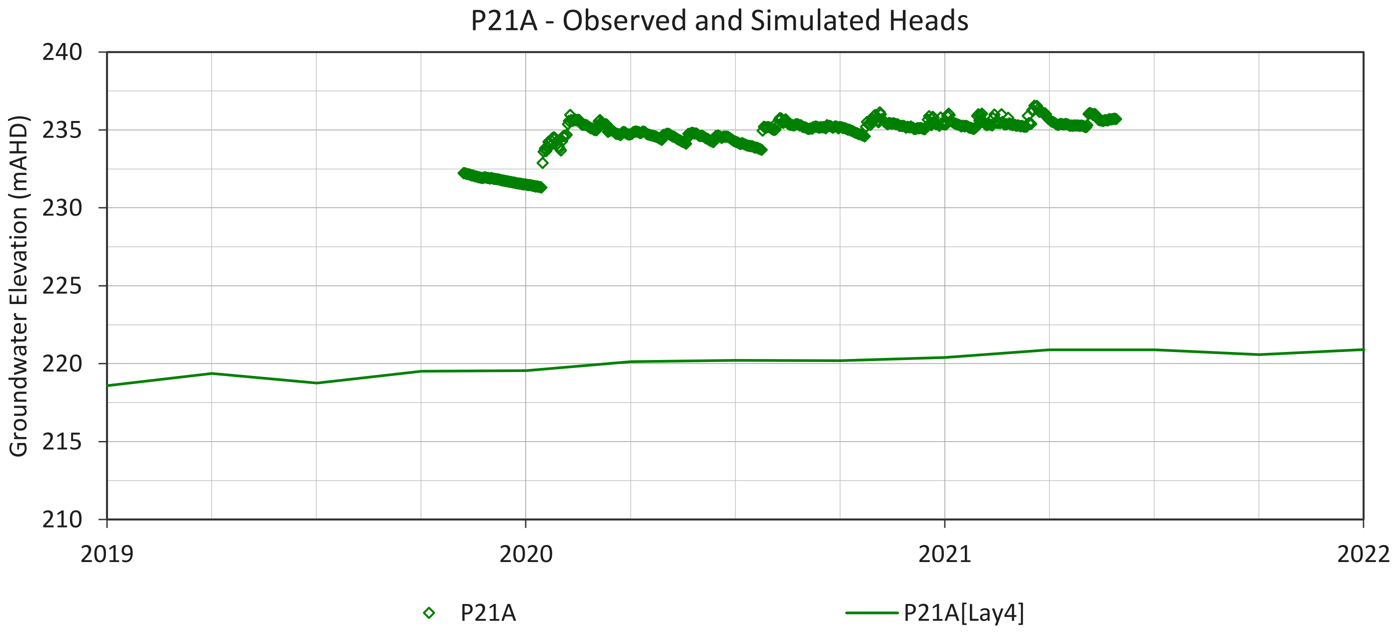

P19A - Observed and Simulated Heads
Groundwater Elevation (mAHD)
220
218
216
214
212
210
208
206
204
202
200
2019
2020
2021
2022
P19A
P19A[Lay4]

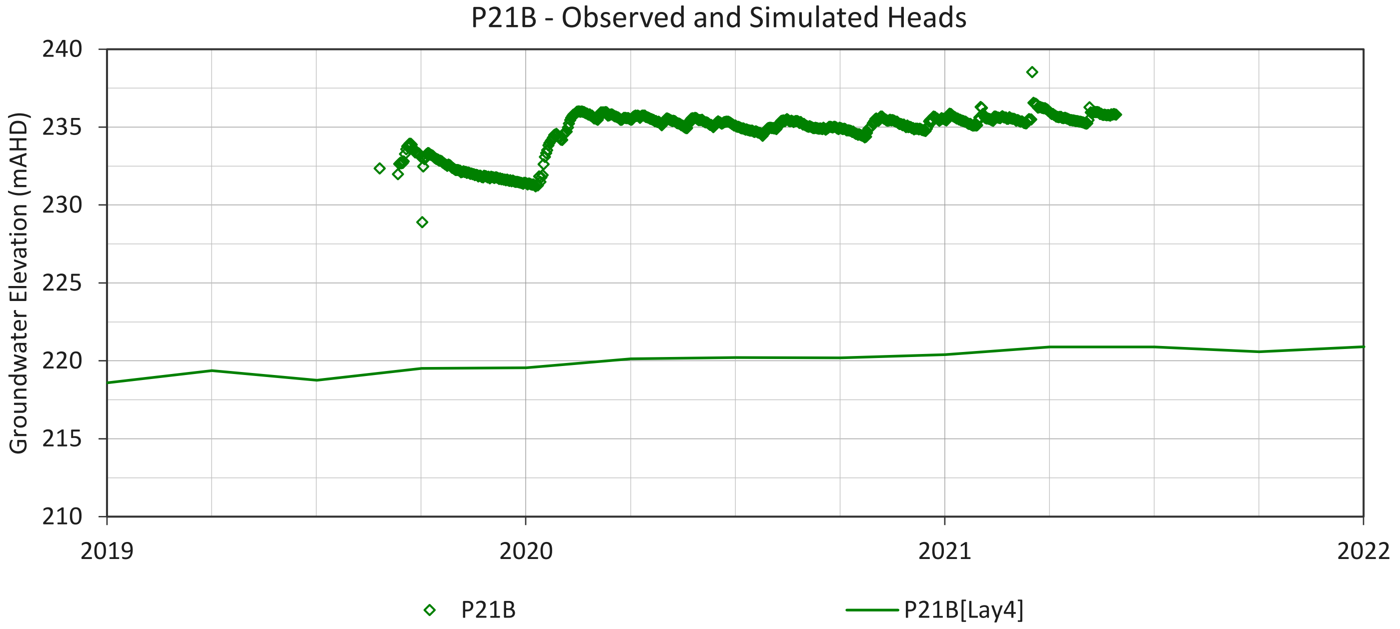

P19B - Observed and Simulated Heads
Groundwater Elevation (mAHD)
220
218
216
214
212
210
208
206
204
202
200
2019
2020
2021
2022
P19B
P19B[Lay4]

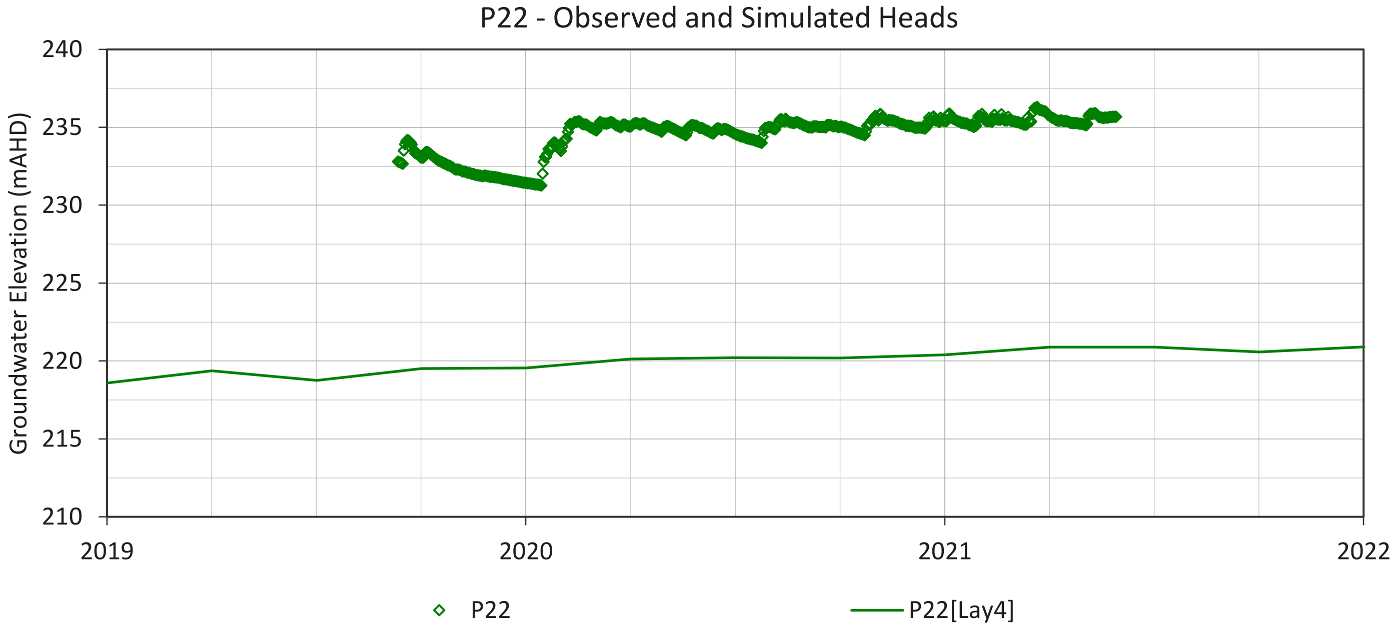

P2 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
260
258
256
254
252
250
248
246
244
242
240
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
P2
P2[Lay4]

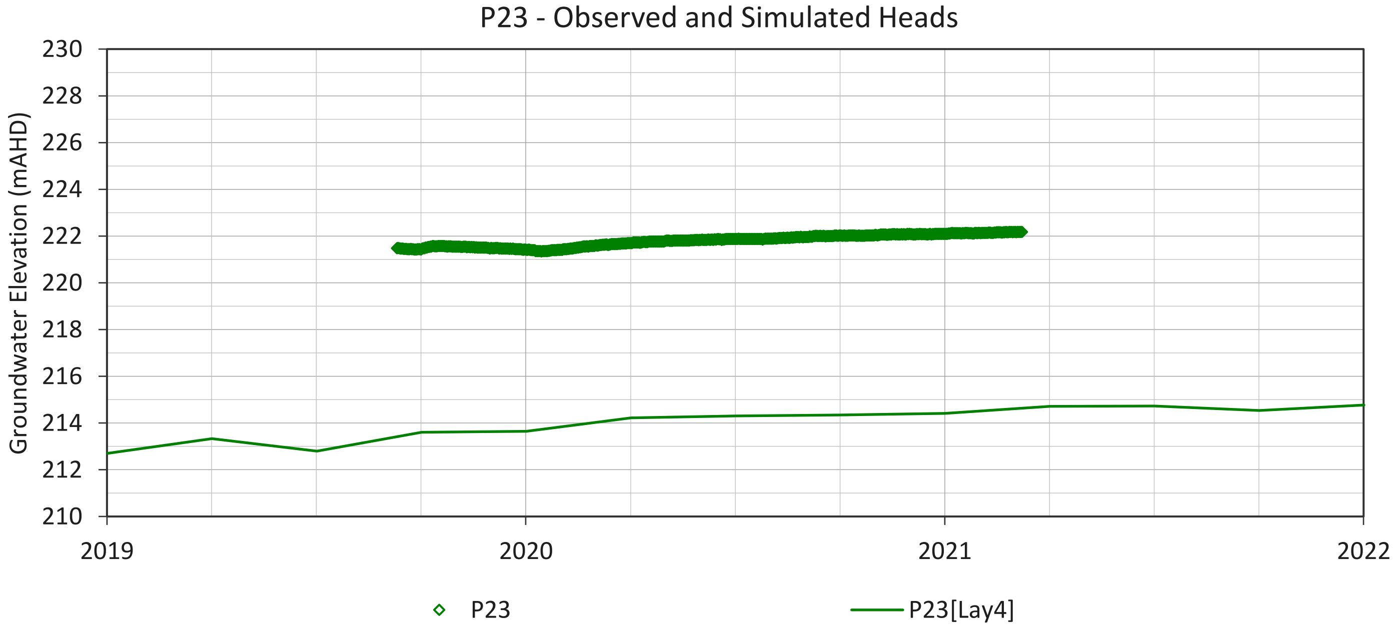

P20A - Observed and Simulated Heads
Groundwater Elevation (mAHD)
250
248
246
244
242
240
238
236
234
232
230
2019
2020
2021
2022
P20A
P20A[Lay4]

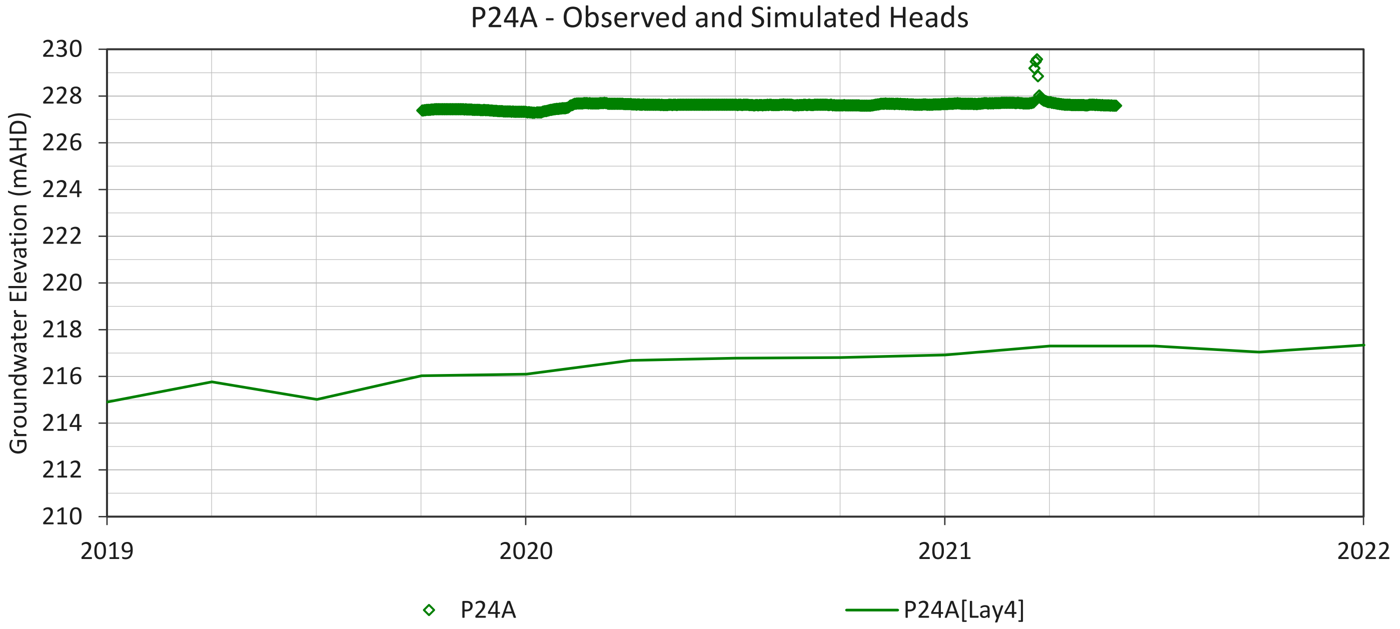

P20B - Observed and Simulated Heads
Groundwater Elevation (mAHD)
250
248
246
244
242
240
238
236
234
232
230
2019
2020
2021
2022
P20B
P20B[Lay4]

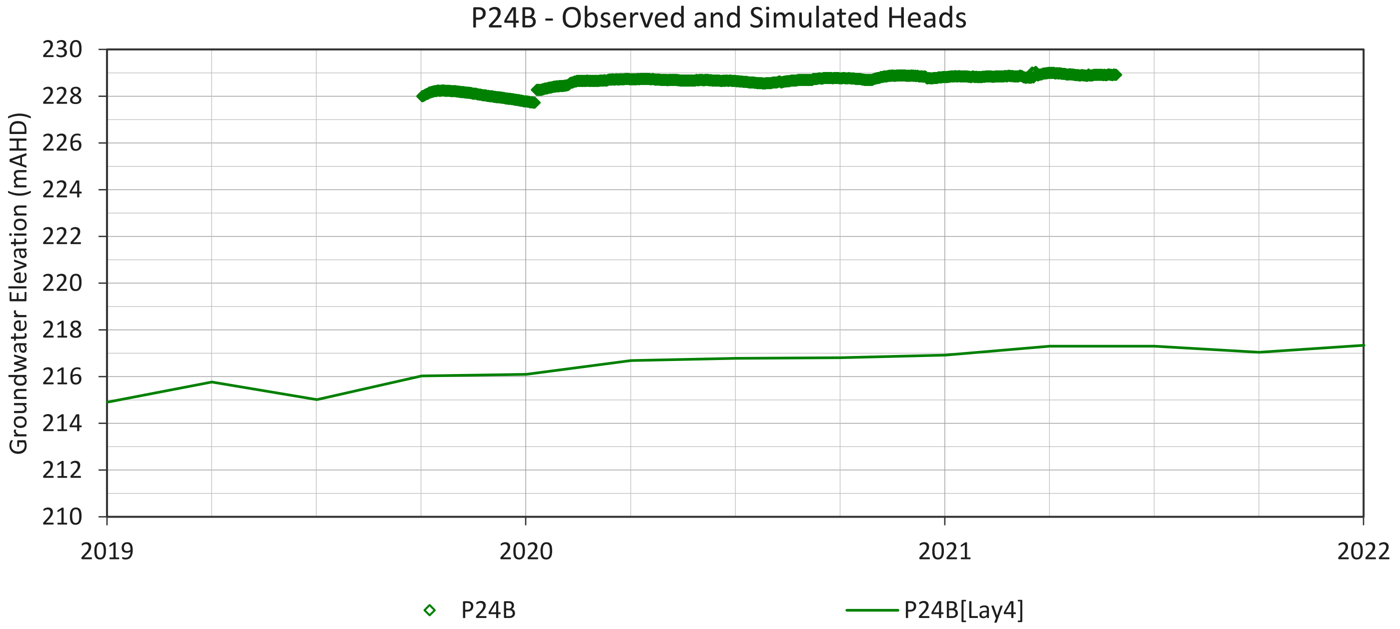

P21A - Observed and Simulated Heads
Groundwater Elevation (mAHD)
240
235
230
225
220
215
210
2019
2020
2021
2022
P21A
P21A[Lay4]

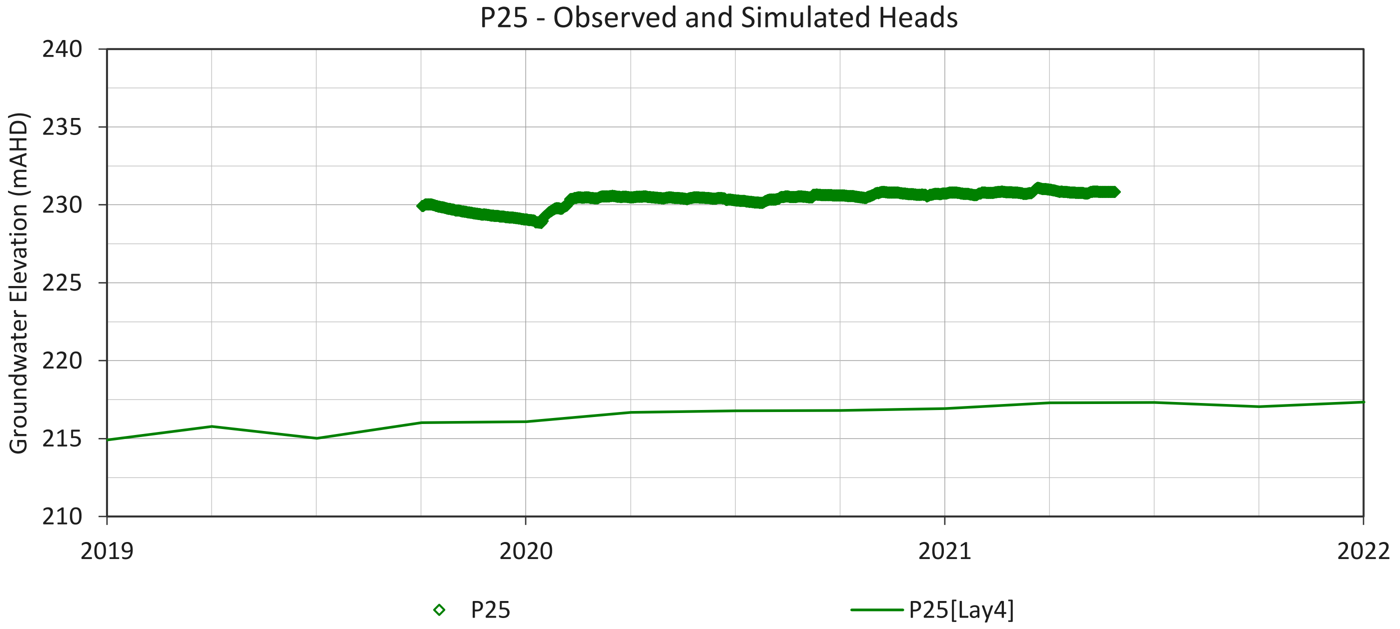

P21B - Observed and Simulated Heads
Groundwater Elevation (mAHD)
240
235
230
225
220
215
210
2019
2020
2021
2022
P21B
P21B[Lay4]

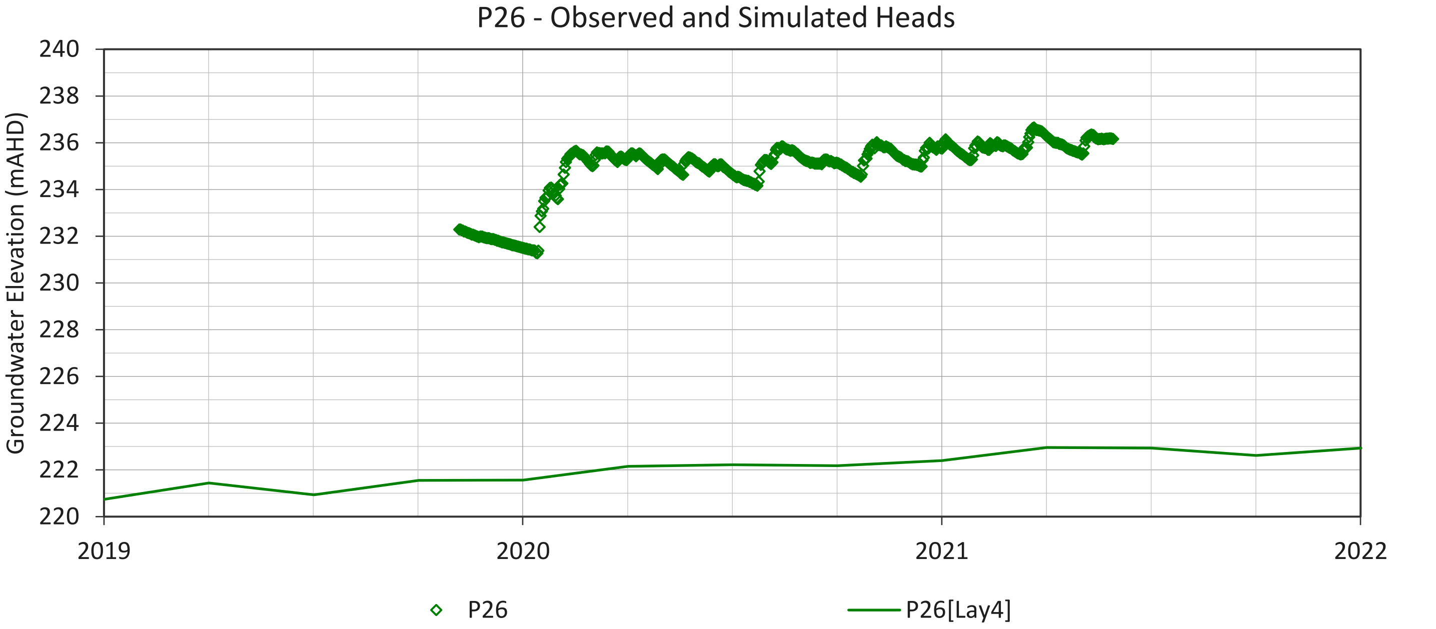

P22 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
240
235
230
225
220
215
210
2019
2020
2021
2022
P22
P22[Lay4]

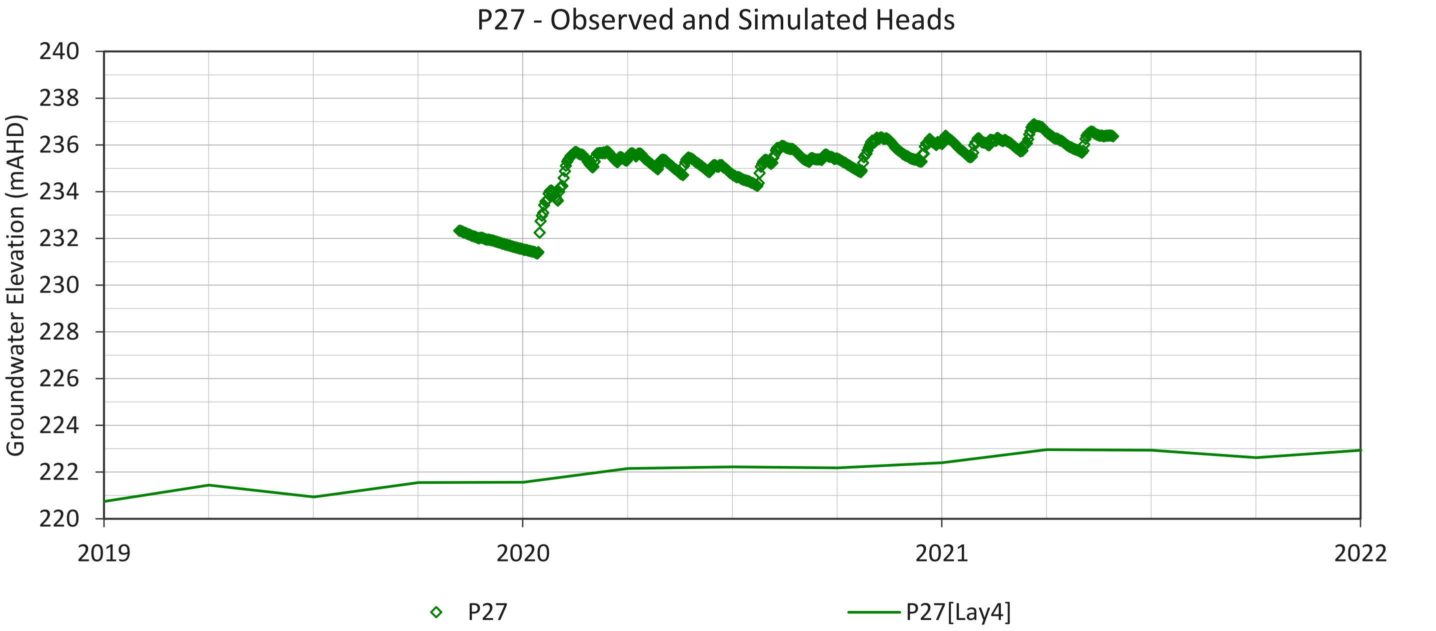

P23 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
230
228
226
224
222
220
218
216
214
212
210
2019
2020
2021
2022
P23
P23[Lay4]

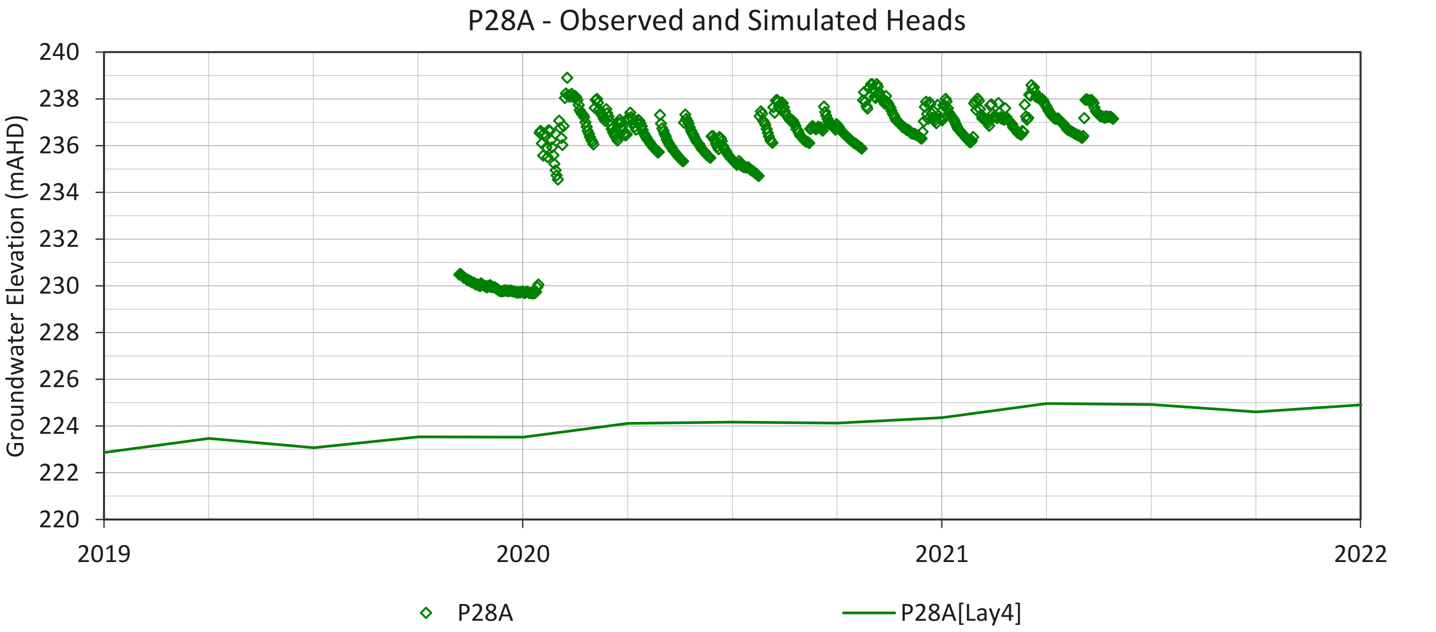

P24A - Observed and Simulated Heads
Groundwater Elevation (mAHD)
230
228
226
224
222
220
218
216
214
212
210
2019
2020
2021
2022
P24A
P24A[Lay4]

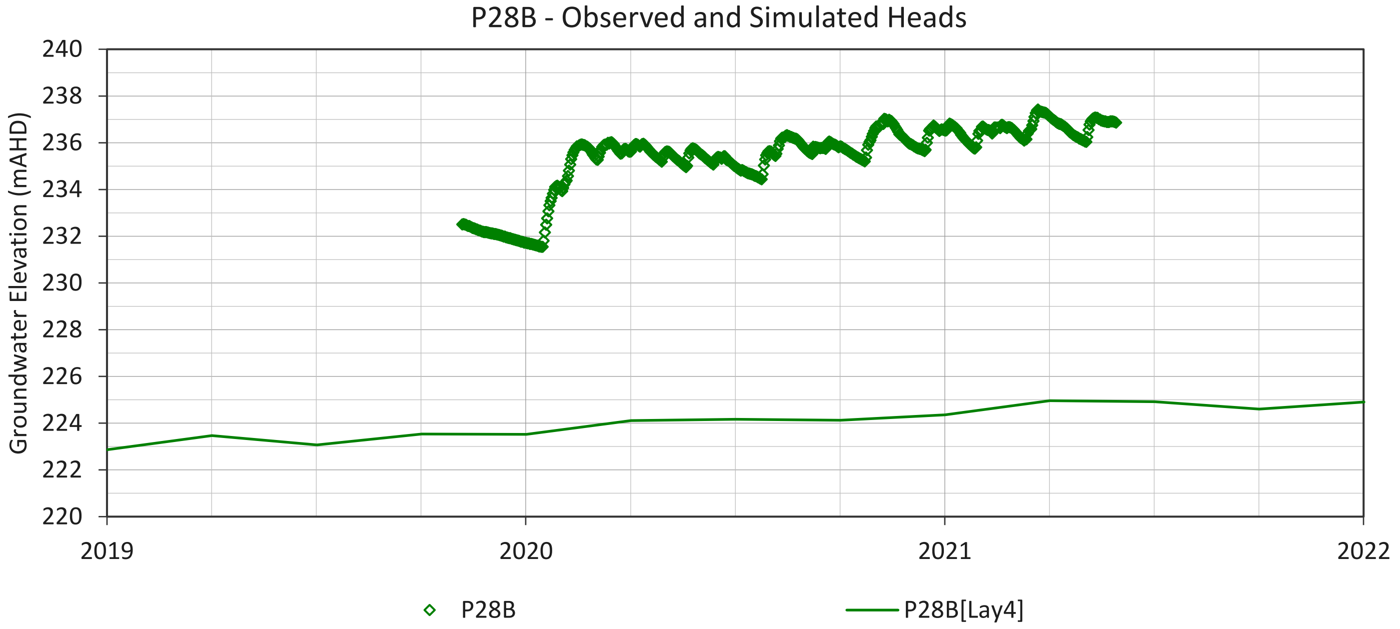

P24B - Observed and Simulated Heads
Groundwater Elevation (mAHD)
230
228
226
224
222
220
218
216
214
212
210
2019
2020
2021
2022
P24B
P24B[Lay4]

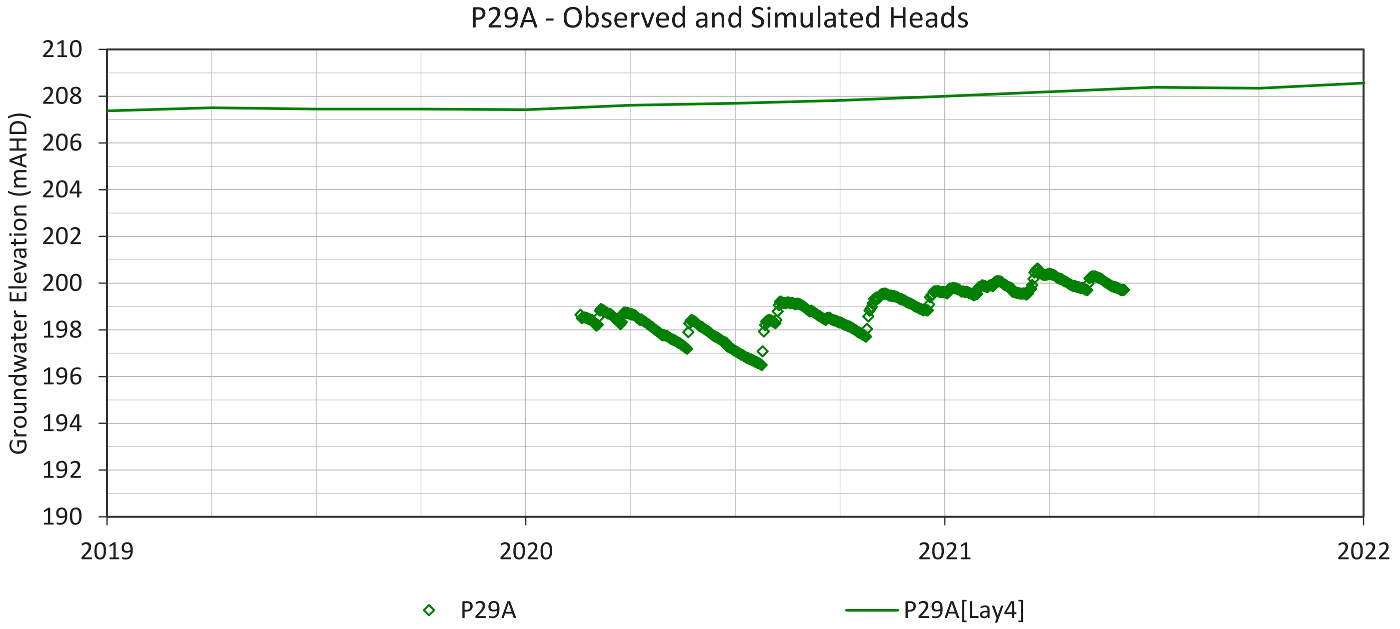

P25 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
240
235
230
225
220
215
210
2019
2020
2021
2022
P25
P25[Lay4]

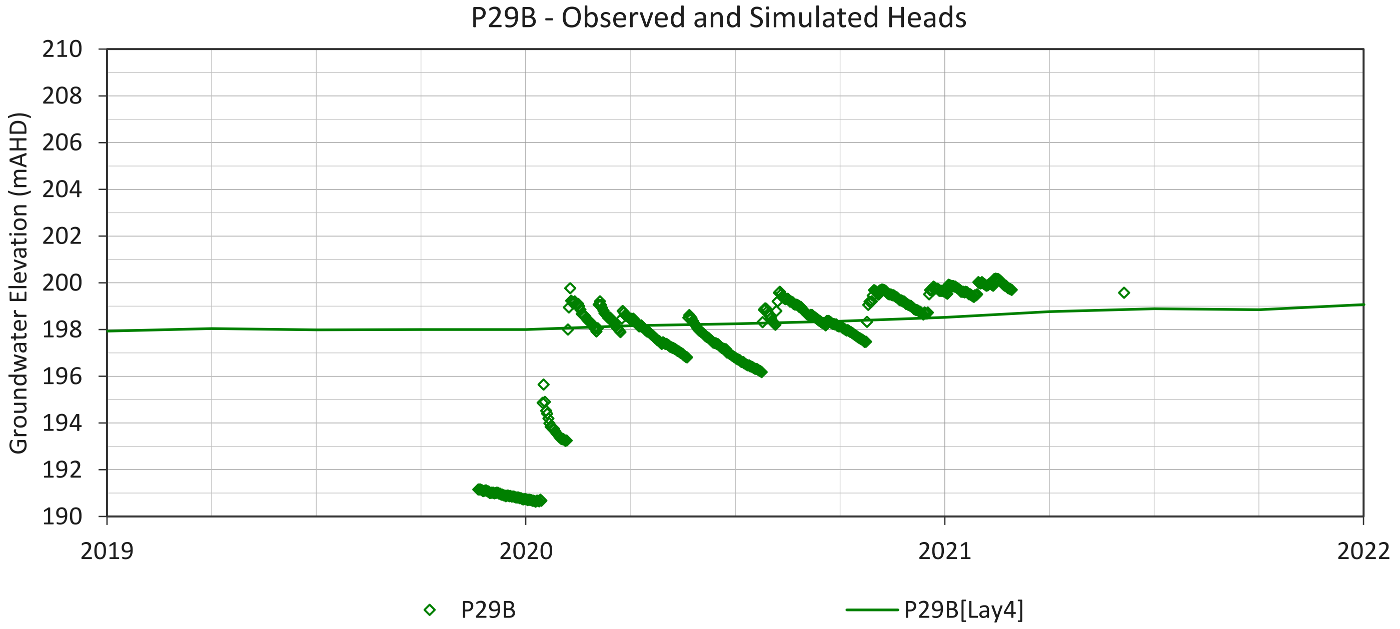

P26 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
240
238
236
234
232
230
228
226
224
222
220
2019
2020
2021
2022
P26
P26[Lay4]

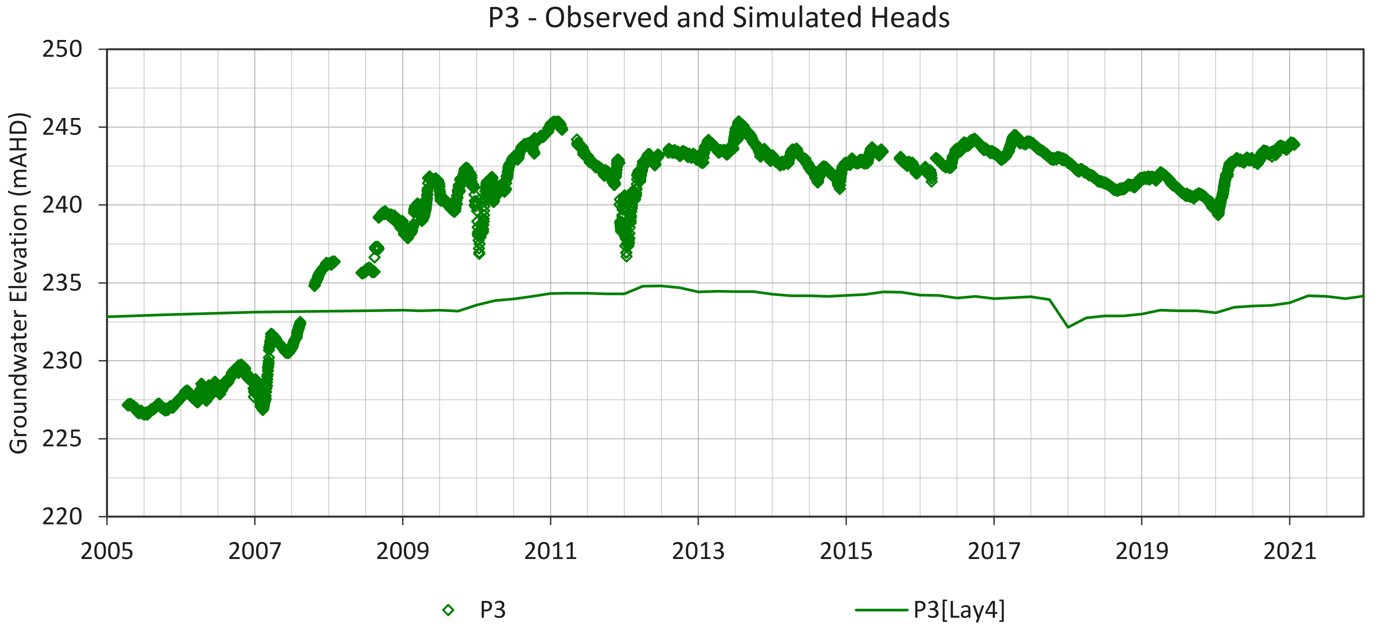

P27 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
240
238
236
234
232
230
228
226
224
222
220
2019
2020
2021
2022
P27
P27[Lay4]

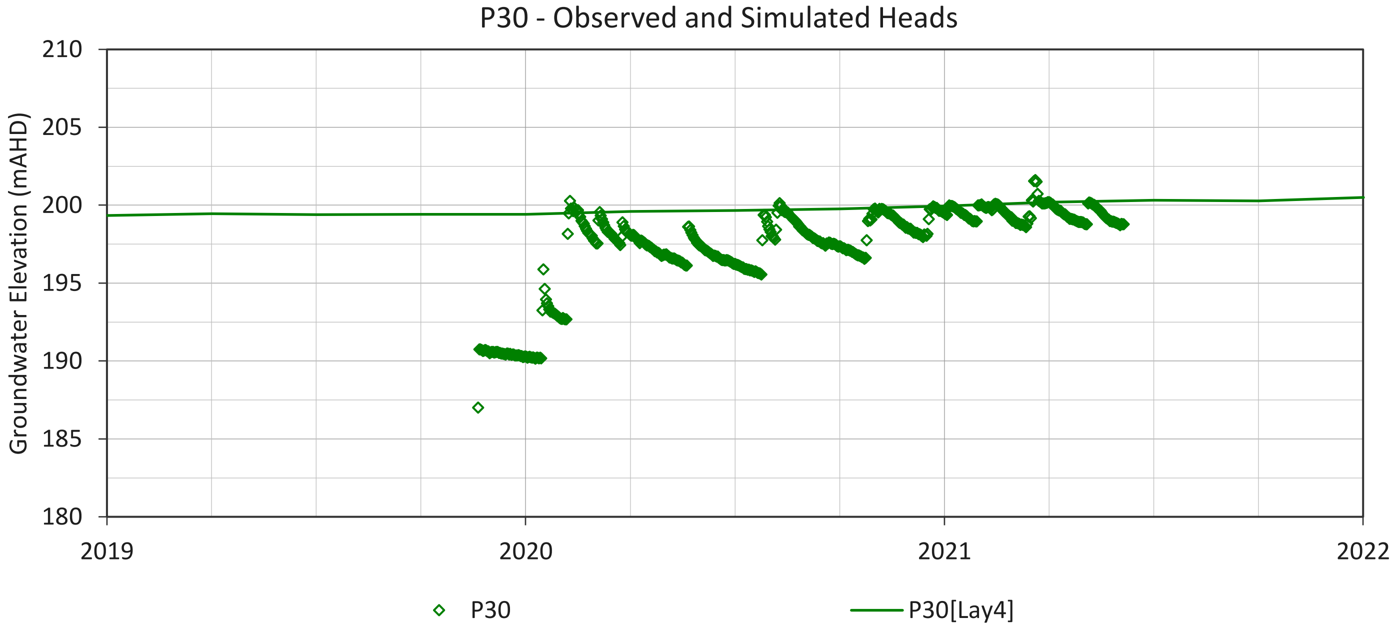

P28A - Observed and Simulated Heads
Groundwater Elevation (mAHD)
240
238
236
234
232
230
228
226
224
222
220
2019
2020
2021
2022
P28A
P28A[Lay4]

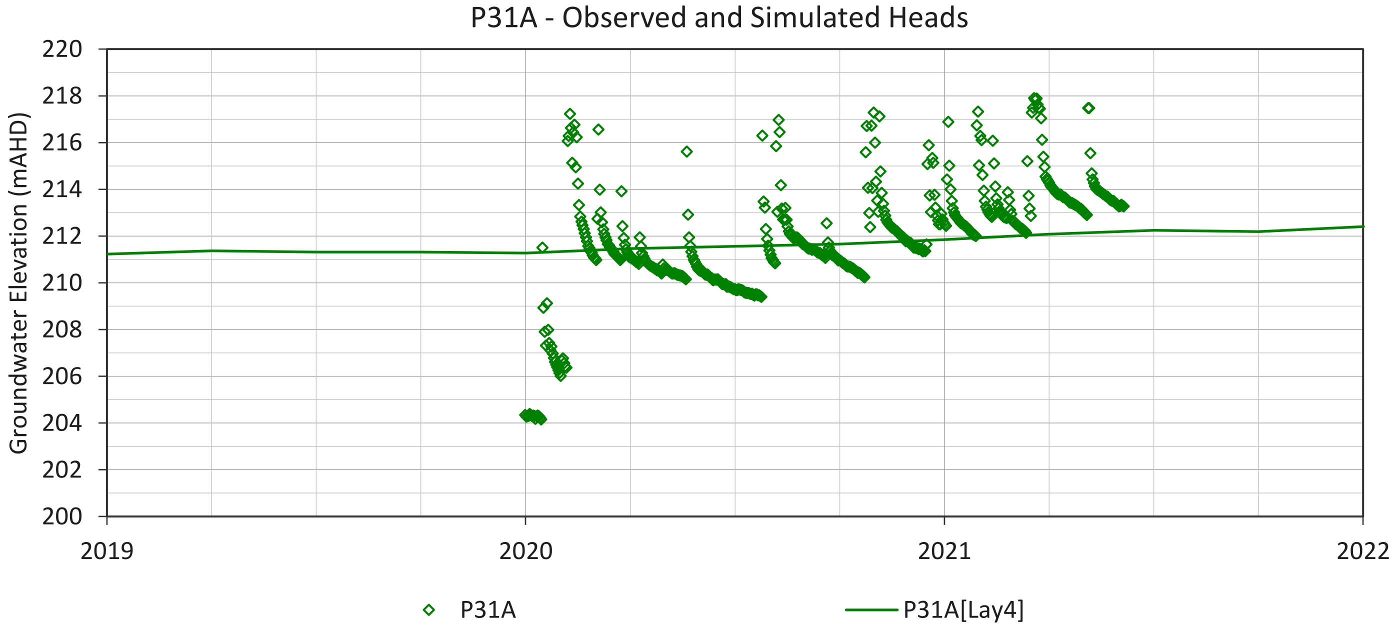

P28B - Observed and Simulated Heads
Groundwater Elevation (mAHD)
240
238
236
234
232
230
228
226
224
222
220
2019
2020
2021
2022
P28B
P28B[Lay4]

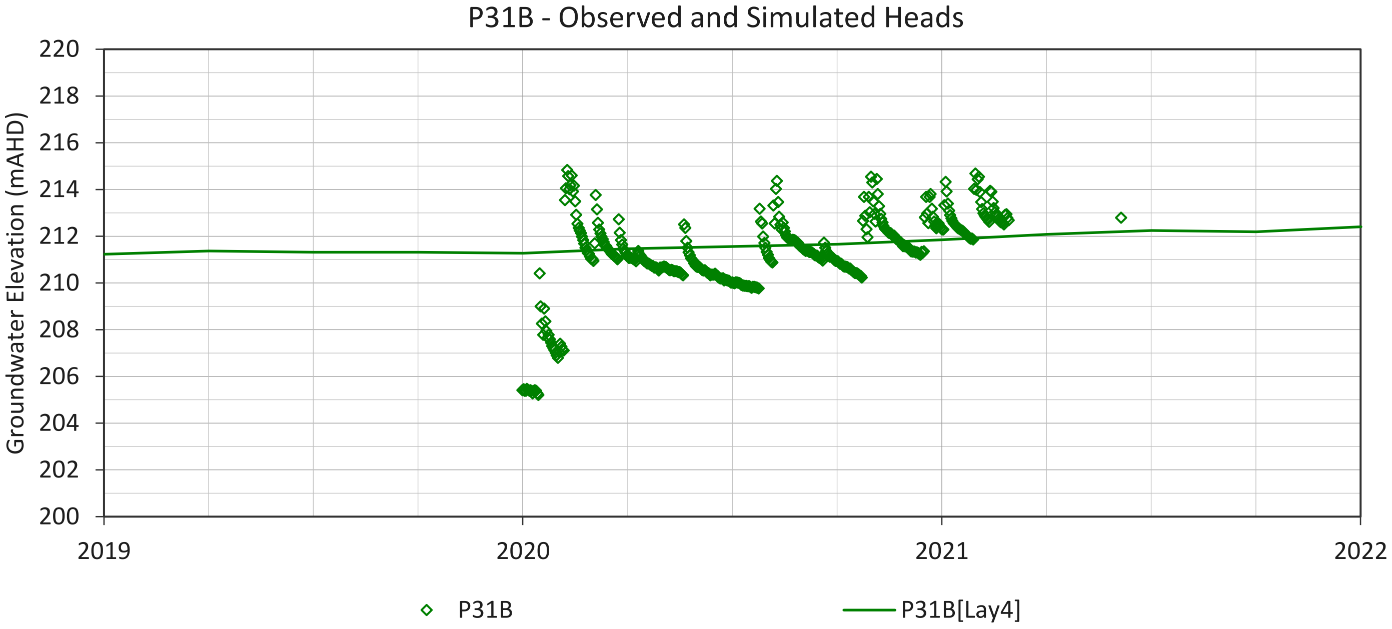

P29A - Observed and Simulated Heads
Groundwater Elevation (mAHD)
210
208
206
204
202
200
198
196
194
192
190
2019
2020
2021
2022
P29A
P29A[Lay4]

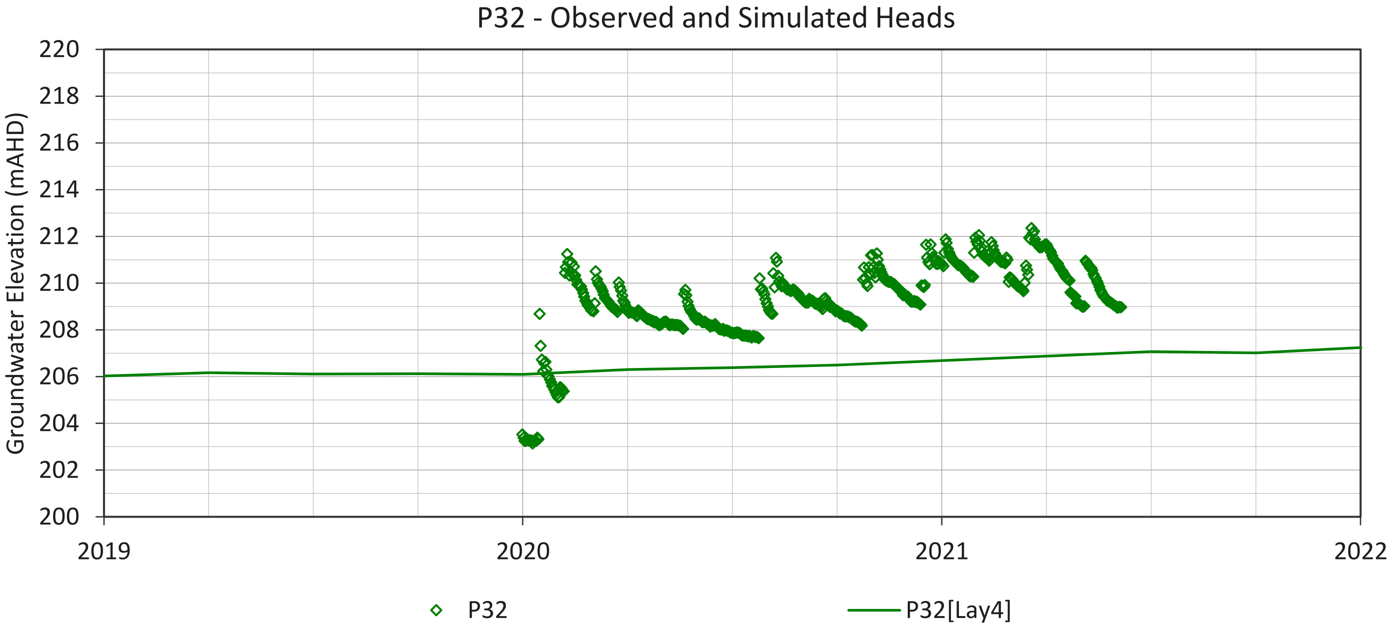

P29B - Observed and Simulated Heads
Groundwater Elevation (mAHD)
210
208
206
204
202
200
198
196
194
192
190
2019
2020
2021
2022
P29B
P29B[Lay4]

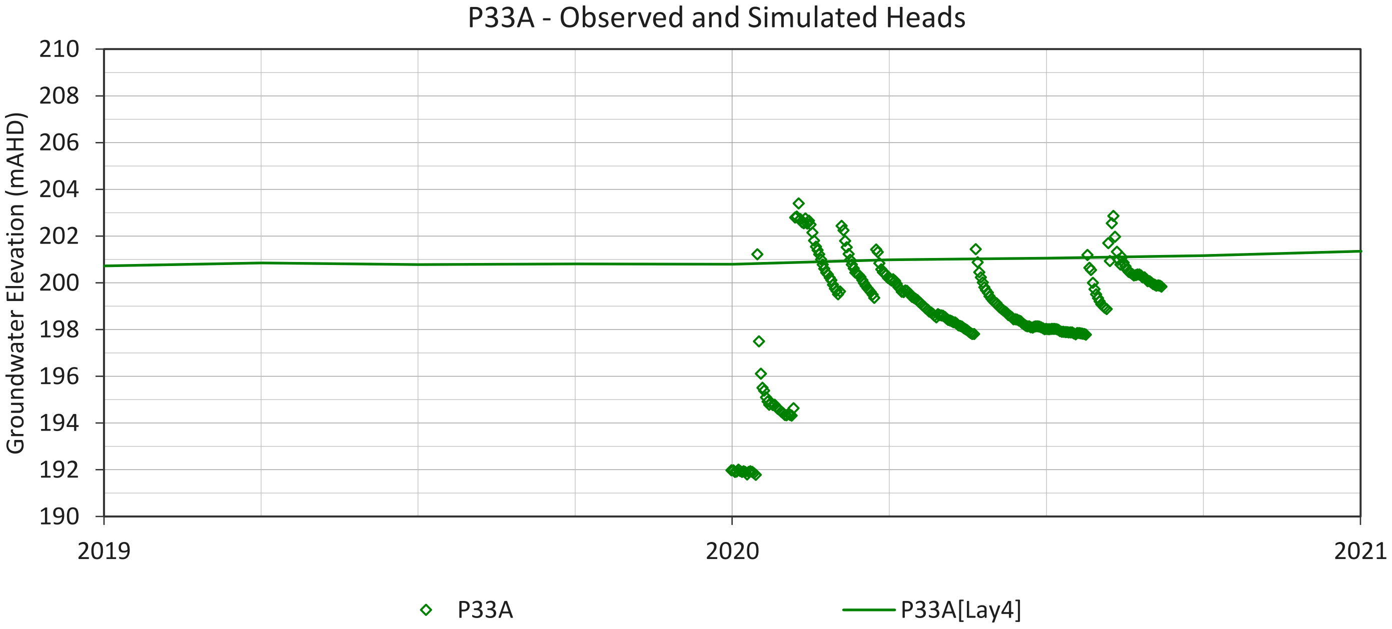

P3 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
250
245
240
235
230
225
220
2005
2007
2009
2011
2013
2015
2017
2019
2021
P3
P3[Lay4]

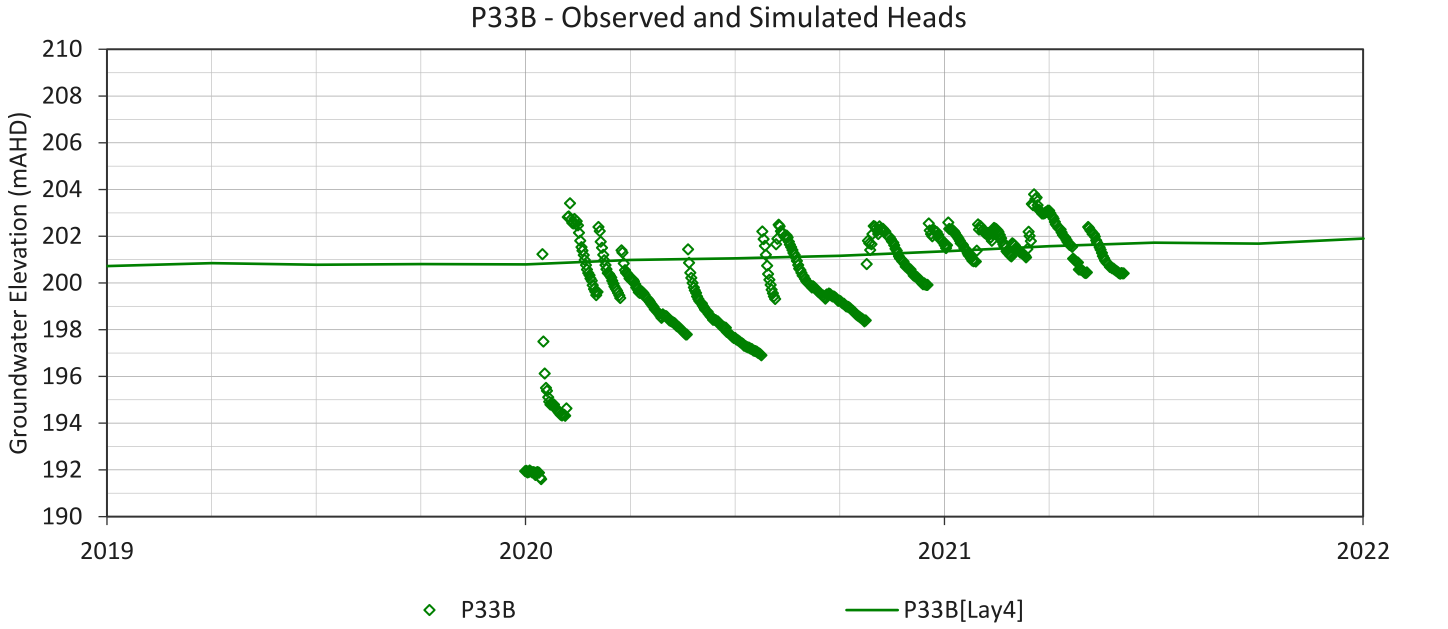

P30 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
210
205
200
195
190
185
180
2019
2020
2021
2022
P30
P30[Lay4]

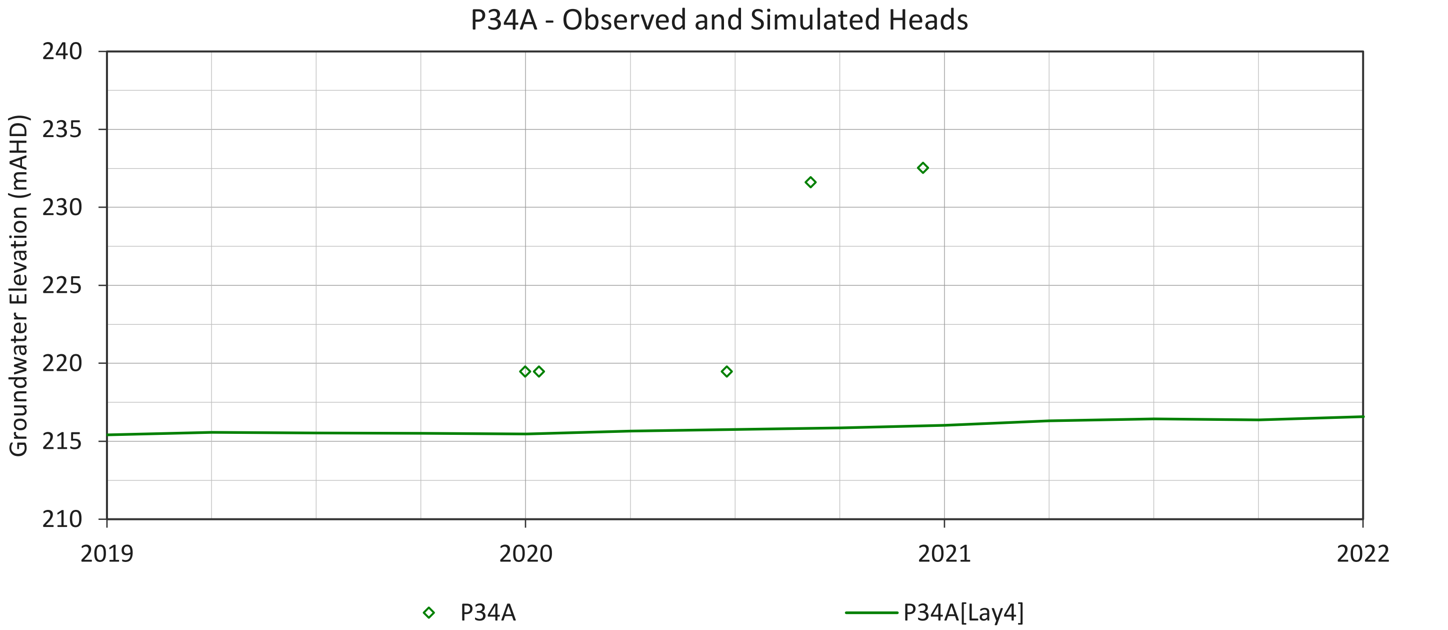

P31A - Observed and Simulated Heads
Groundwater Elevation (mAHD)
220
218
216
214
212
210
208
206
204
202
200
2019
2020
2021
2022
P31A
P31A[Lay4]

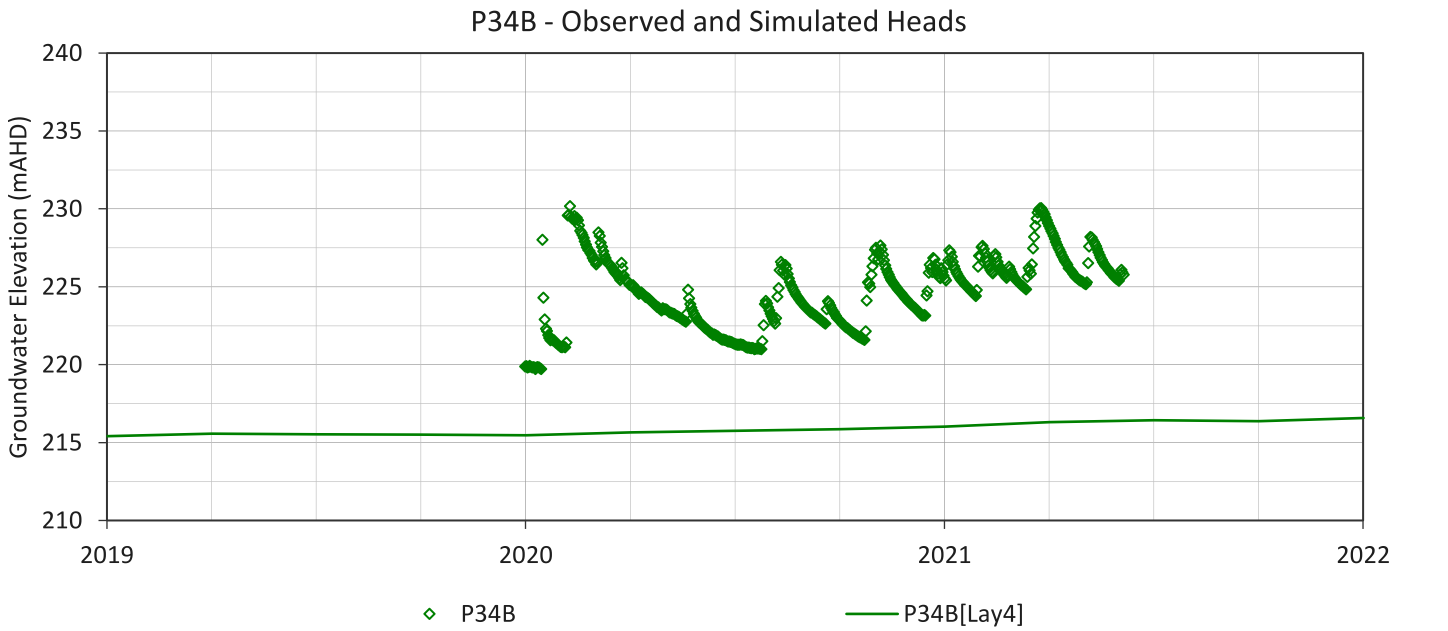

P31B - Observed and Simulated Heads
Groundwater Elevation (mAHD)
220
218
216
214
212
210
208
206
204
202
200
2019
2020
2021
2022
P31B
P31B[Lay4]

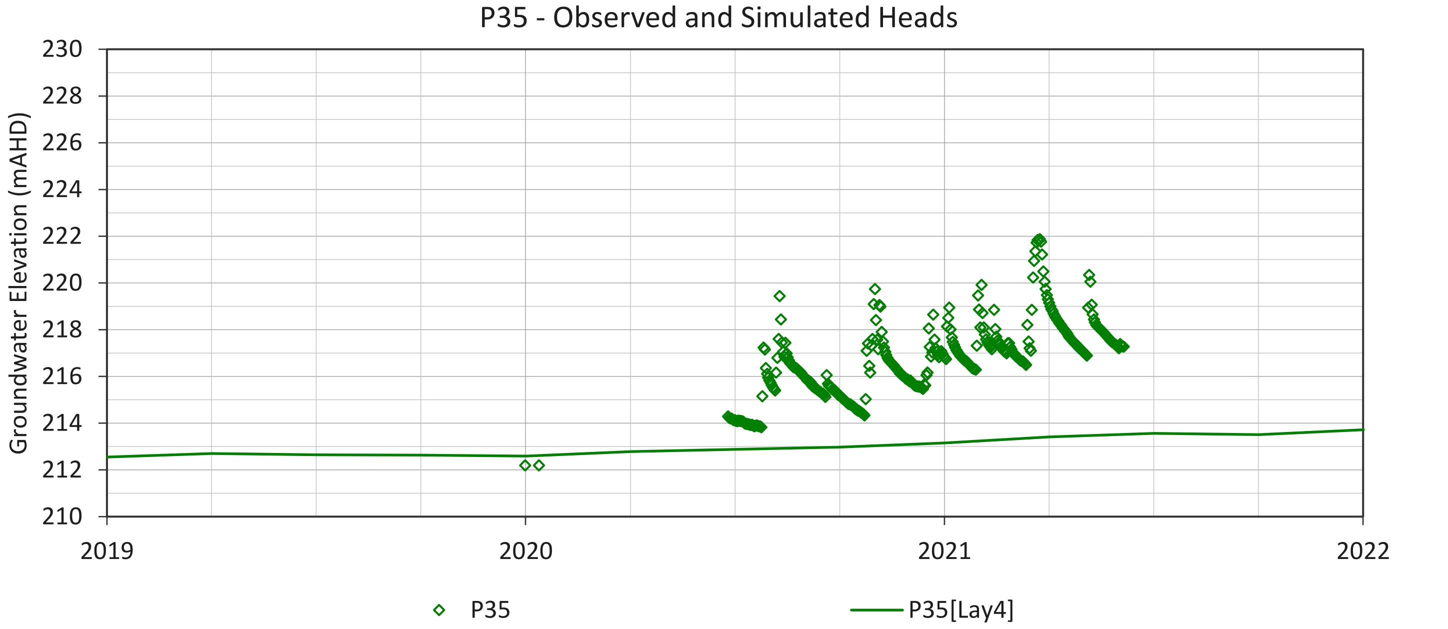

P32 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
220
218
216
214
212
210
208
206
204
202
200
2019
2020
2021
2022
P32
P32[Lay4]

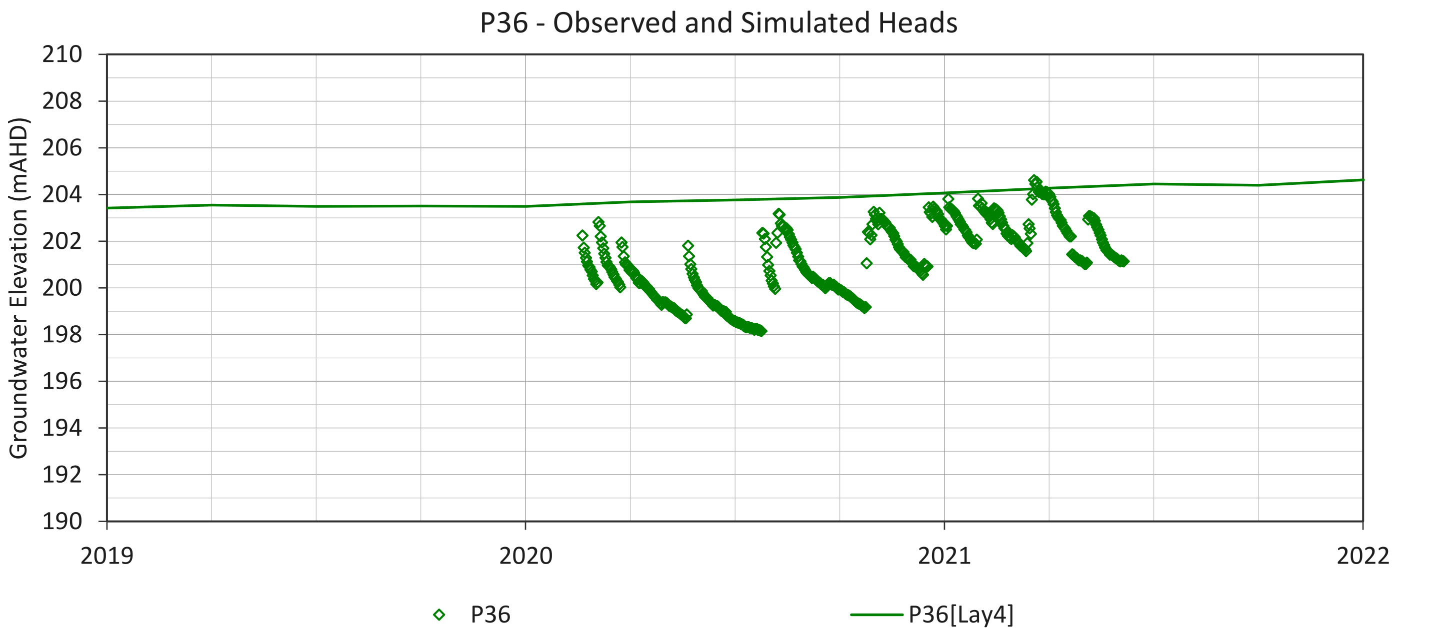

P33A - Observed and Simulated Heads
Groundwater Elevation (mAHD)
210
208
206
204
202
200
198
196
194
192
190
2019
2020
2021
P33A
P33A[Lay4]

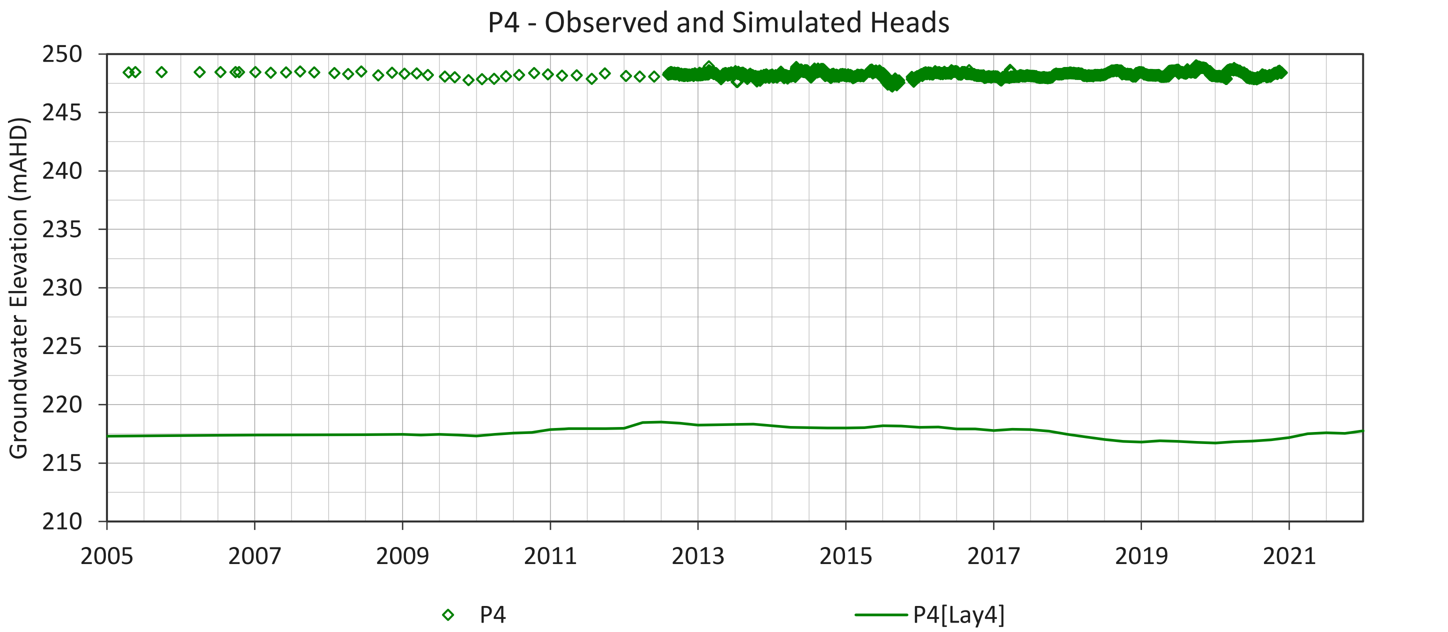

P33B - Observed and Simulated Heads
Groundwater Elevation (mAHD)
210
208
206
204
202
200
198
196
194
192
190
2019
2020
2021
2022
P33B
P33B[Lay4]

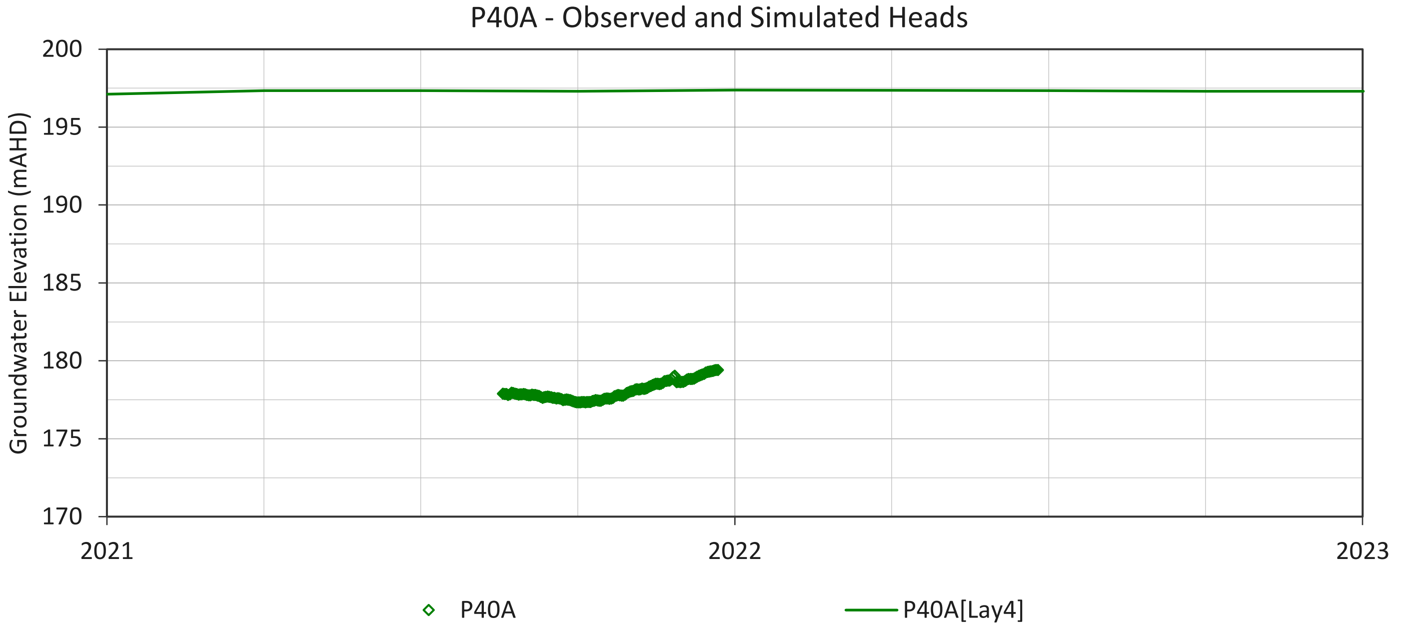

P34A - Observed and Simulated Heads
Groundwater Elevation (mAHD)
240
235
230
225
220
215
210
2019
2020
2021
2022
P34A
P34A[Lay4]

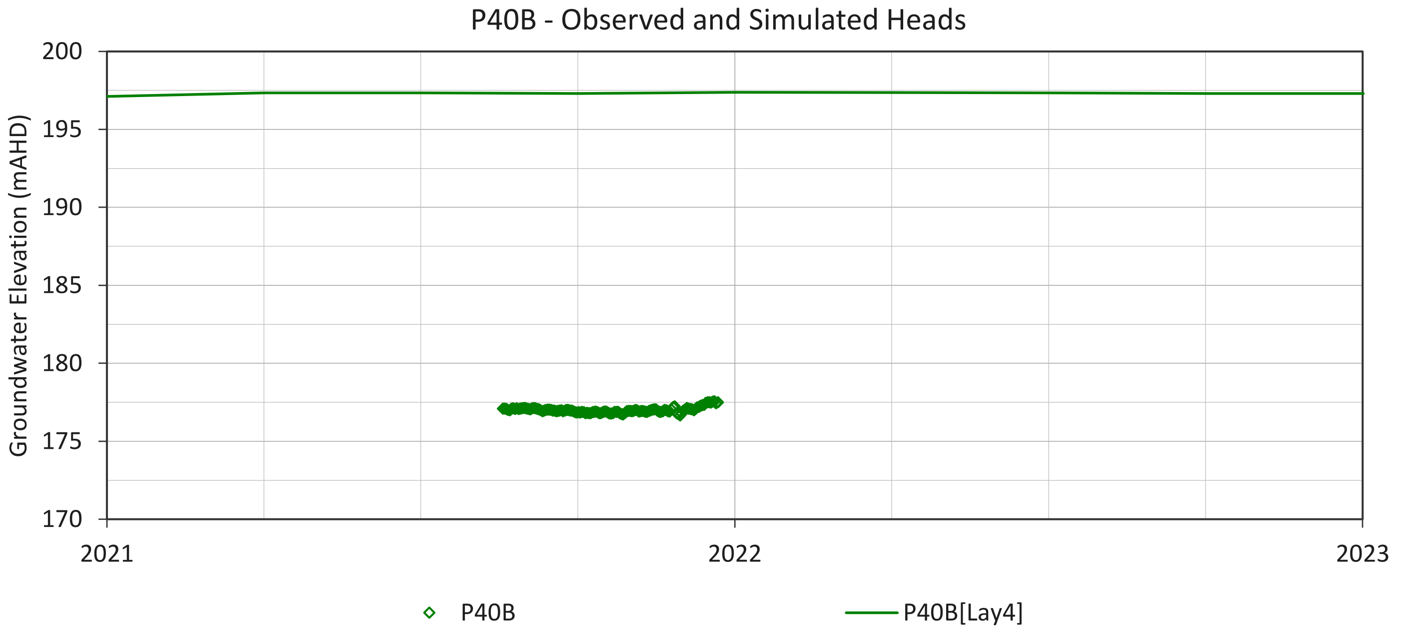

P34B - Observed and Simulated Heads
Groundwater Elevation (mAHD)
240
235
230
225
220
215
210
2019
2020
2021
2022
P34B
P34B[Lay4]

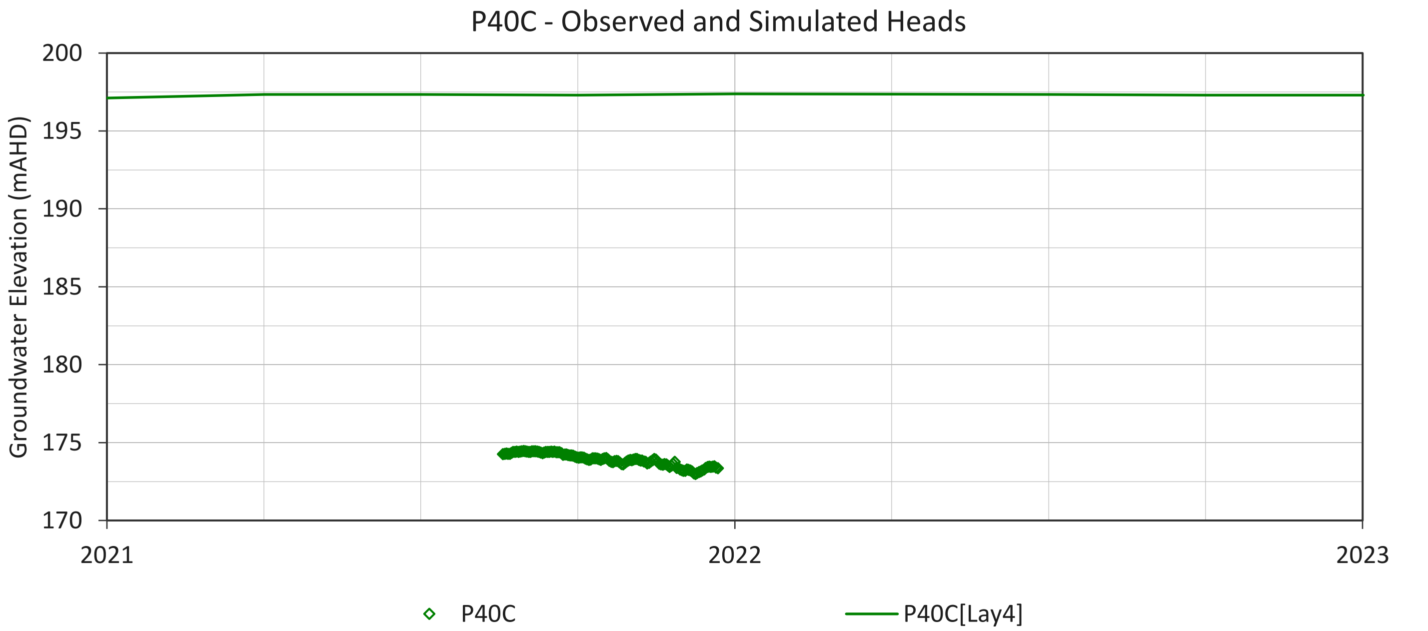

P35 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
230
228
226
224
222
220
218
216
214
212
210
2019
2020
2021
2022
P35
P35[Lay4]


P36 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
210
208
206
204
202
200
198
196
194
192
190
2019
2020
2021
2022
P36
P36[Lay4]

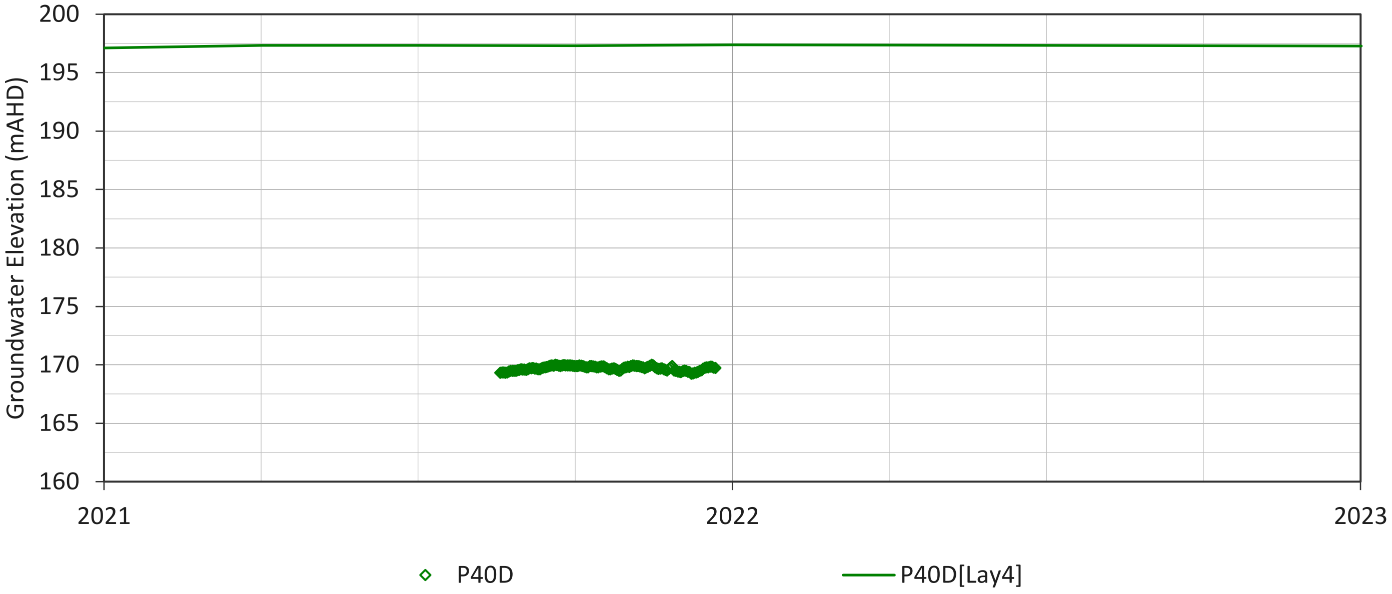

P4 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
250
245
240
235
230
225
220
215
210
2005
2007
2009
2011
2013
2015
2017
2019
2021
P4
P4[Lay4]


P40A - Observed and Simulated Heads
Groundwater Elevation (mAHD)
200
195
190
185
180
175
170
2021
2022
2023
P40A
P40A[Lay4]

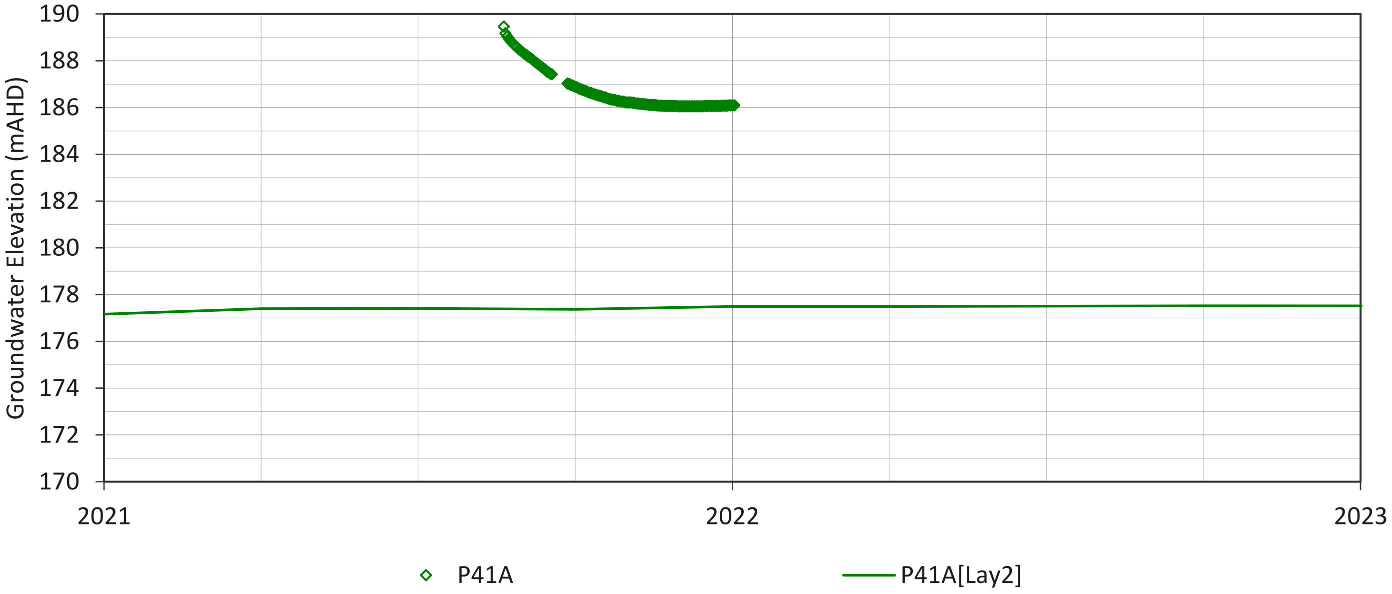

P40B - Observed and Simulated Heads
Groundwater Elevation (mAHD)
200
195
190
185
180
175
170
2021
2022
2023
P40B
P40B[Lay4]


P40C - Observed and Simulated Heads
Groundwater Elevation (mAHD)
200
195
190
185
180
175
170
2021
2022
2023
P40C
P40C[Lay4]

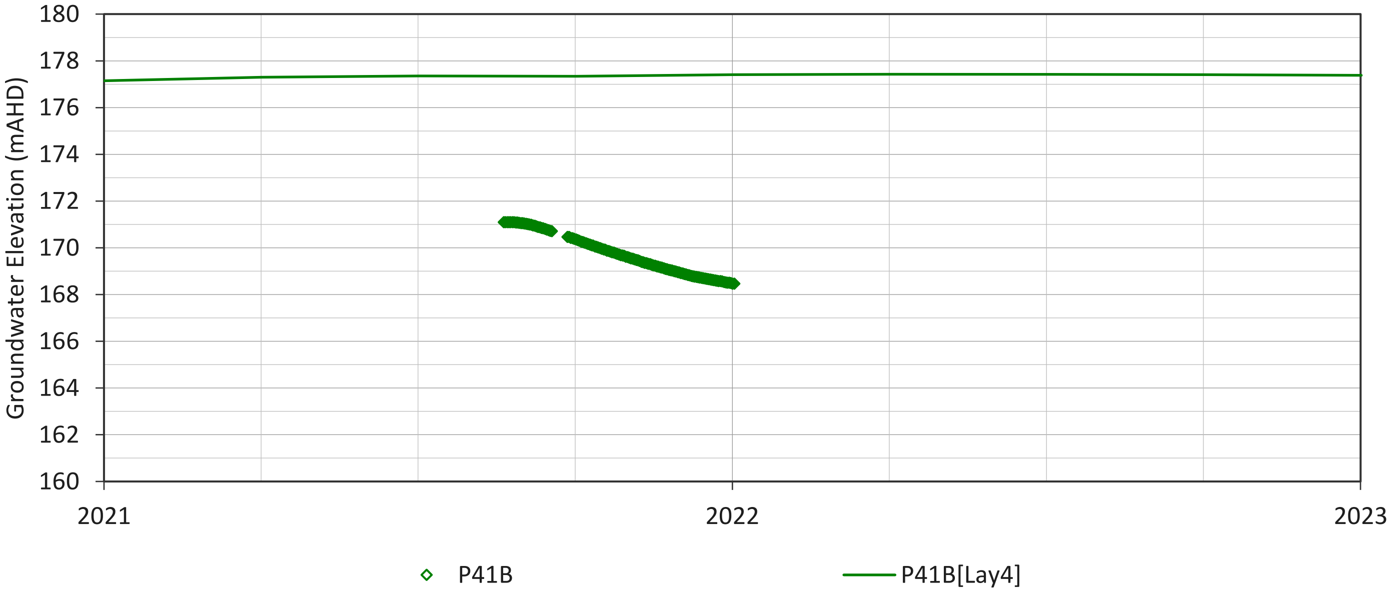
P40D - Observed and Simulated Heads

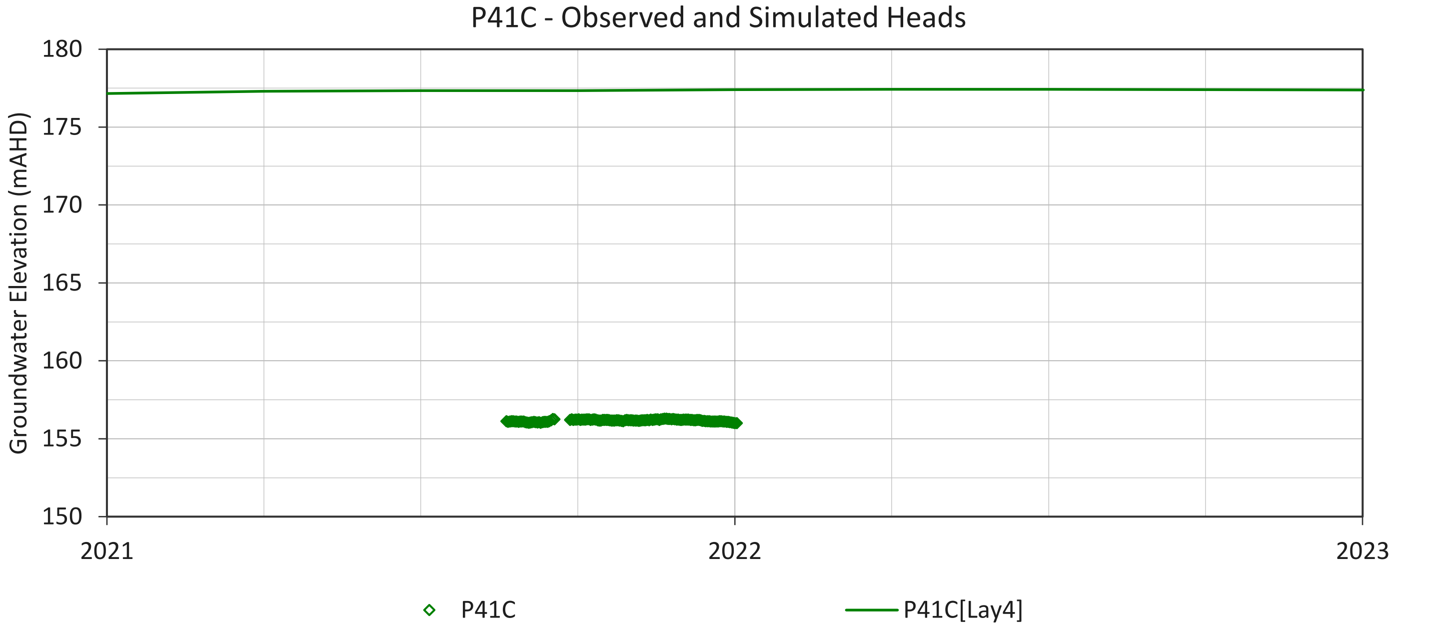


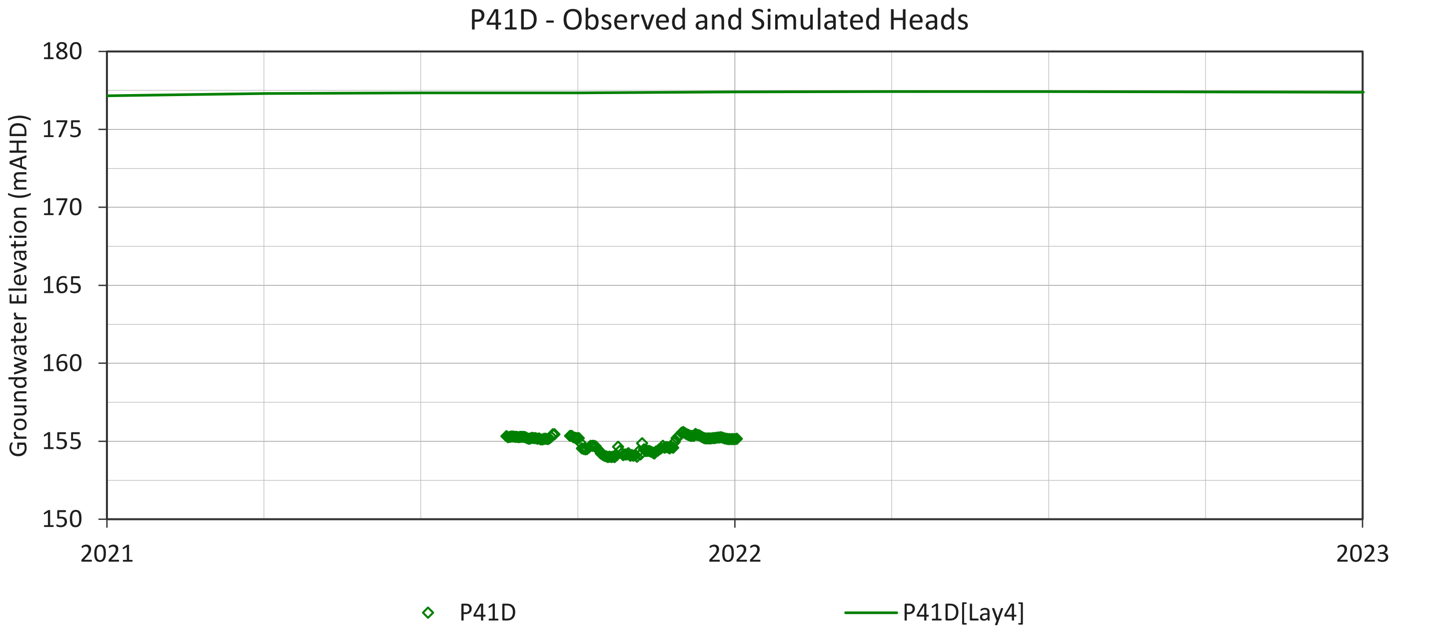
P41A - Observed and Simulated Heads

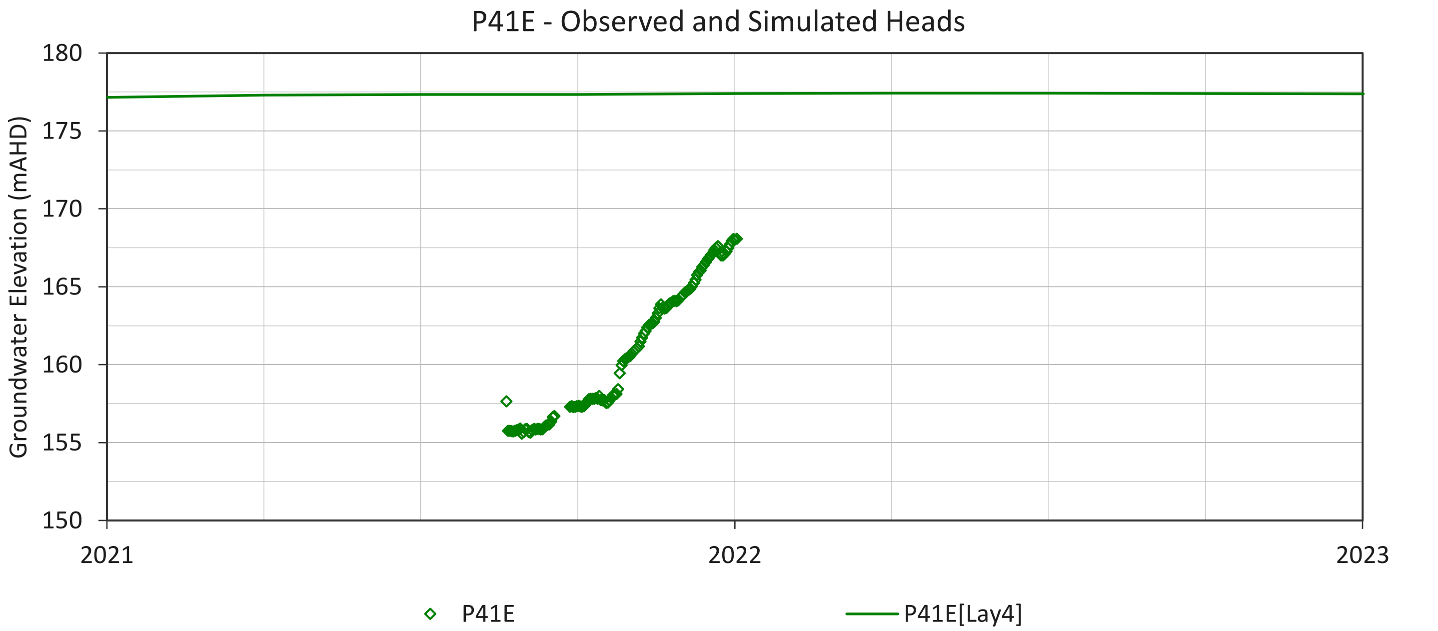


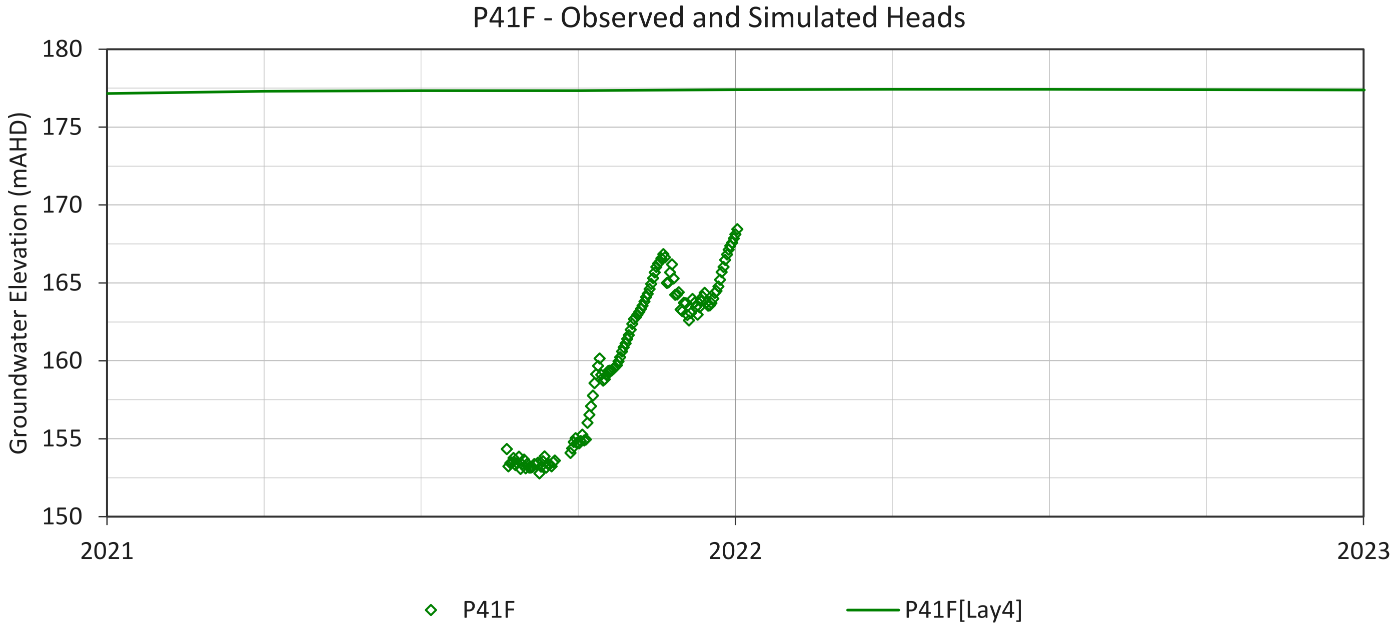
P41B - Observed and Simulated Heads

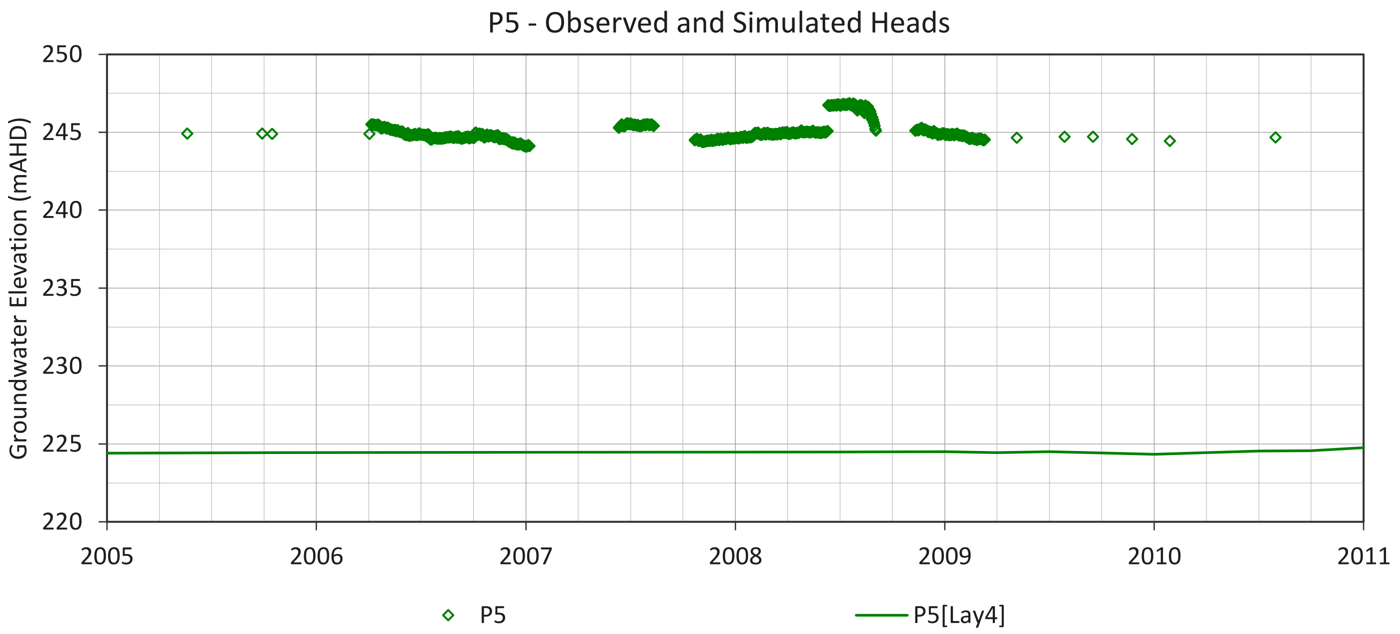


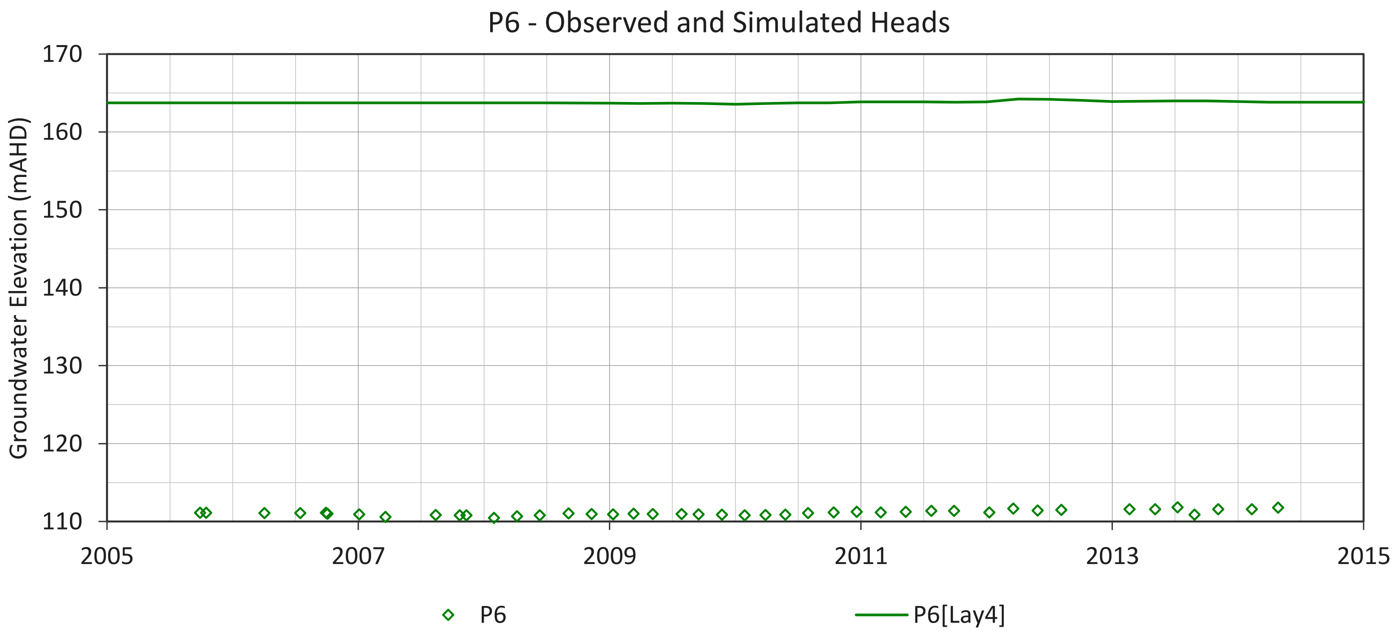

P41C - Observed and Simulated Heads
Groundwater Elevation (mAHD)
180
175
170
165
160
155
150
2021
2022
2023
P41C
P41C[Lay4]

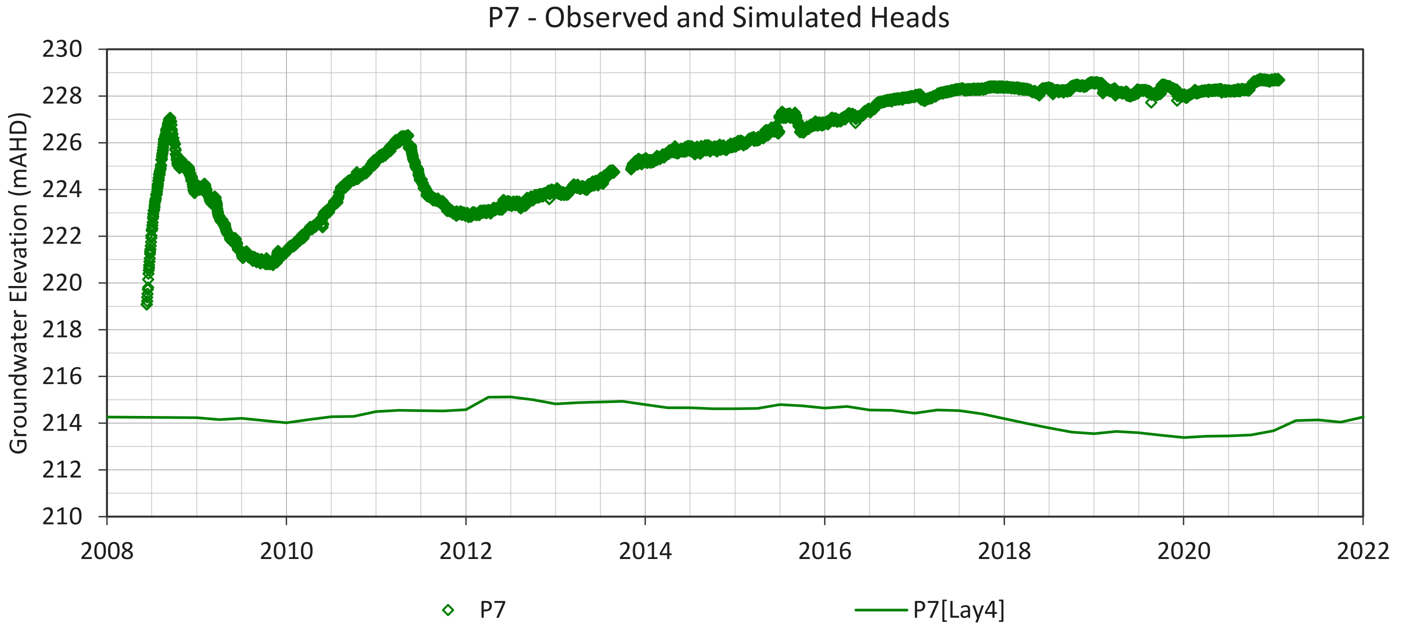

P41D - Observed and Simulated Heads
Groundwater Elevation (mAHD)
180
175
170
165
160
155
150
2021
2022
2023
P41D
P41D[Lay4]

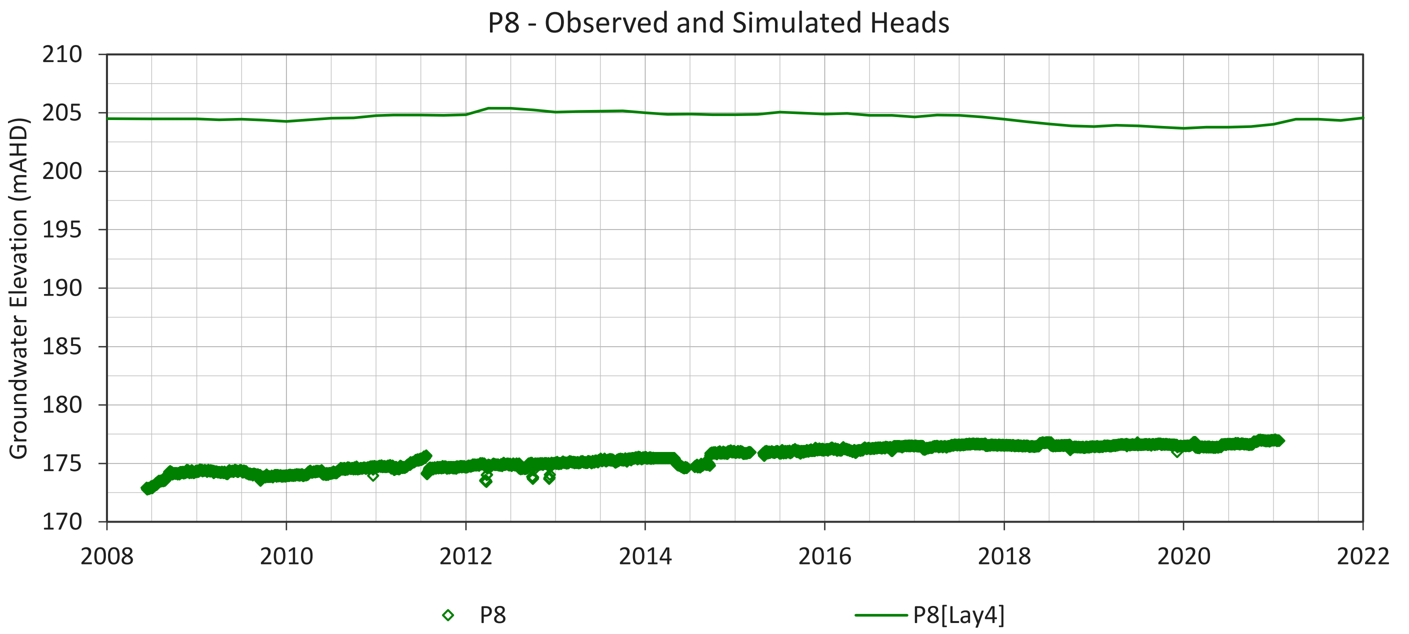

P41E - Observed and Simulated Heads
Groundwater Elevation (mAHD)
180
175
170
165
160
155
150
2021
2022
2023
P41E
P41E[Lay4]

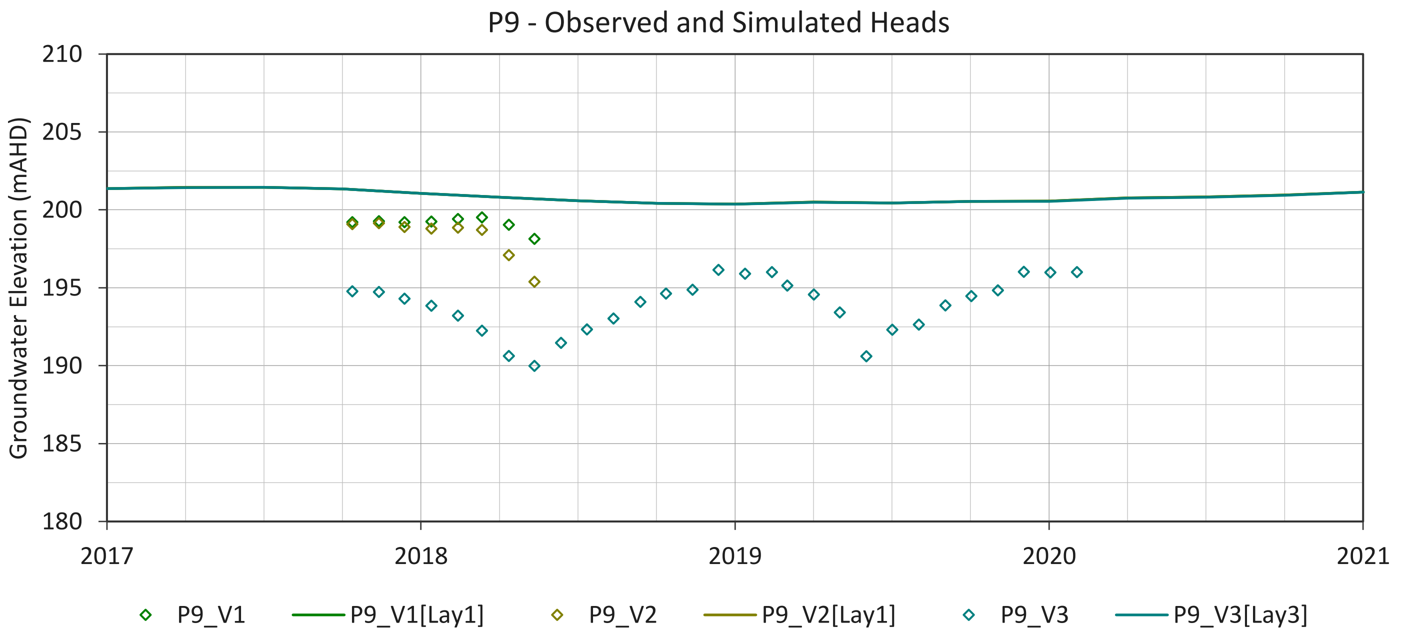

P41F - Observed and Simulated Heads
Groundwater Elevation (mAHD)
180
175
170
165
160
155
150
2021
2022
2023
P41F
P41F[Lay4]

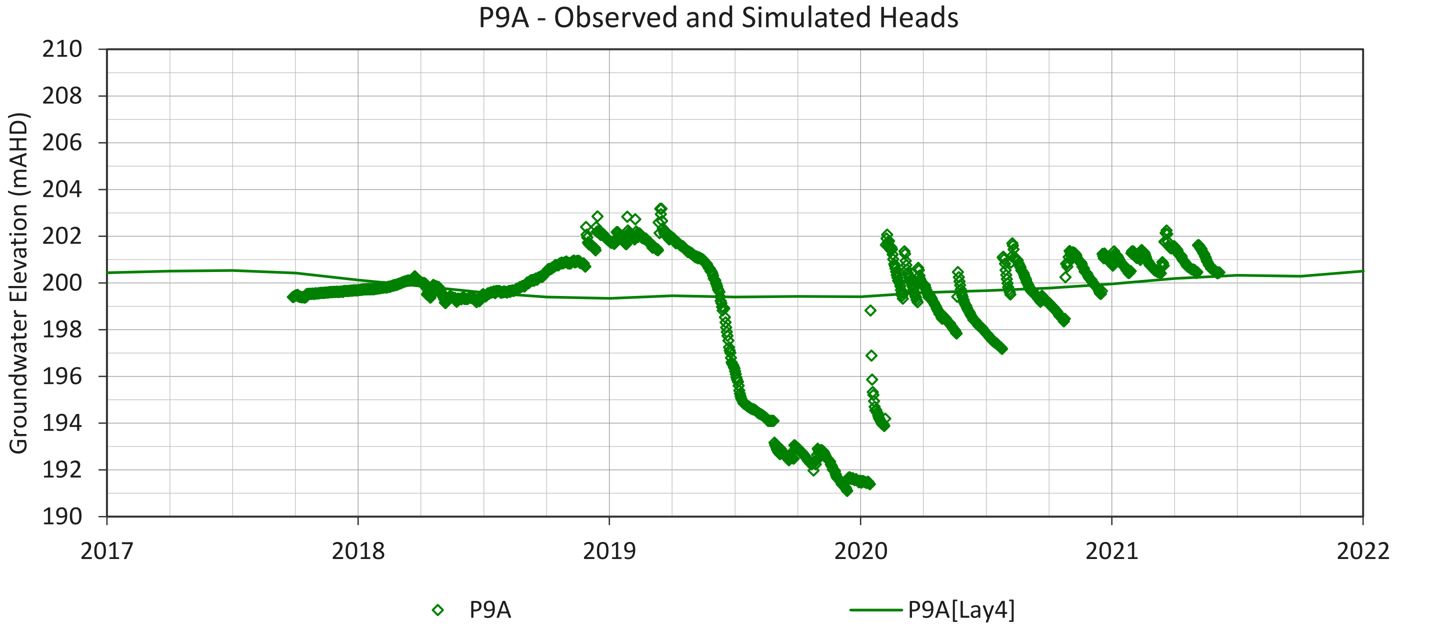

P5 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
250
245
240
235
230
225
220
2005
2006
2007
2008
2009
2010
2011
P5
P5[Lay4]

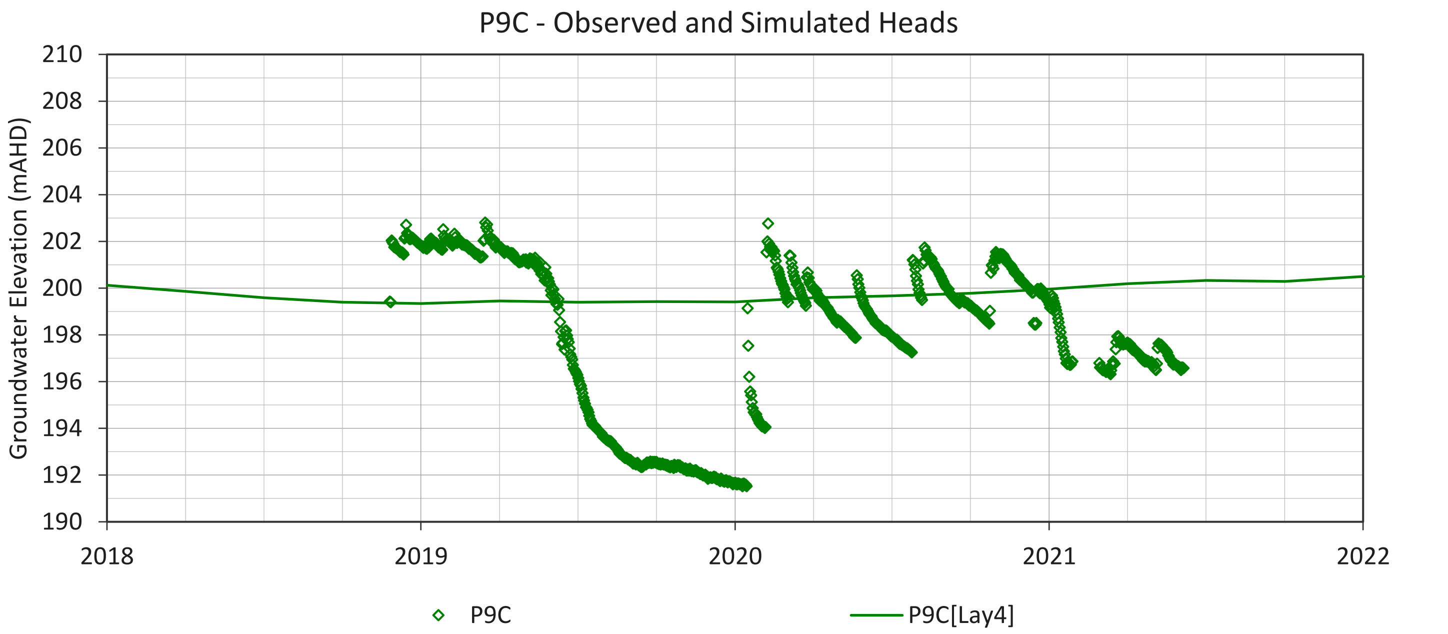

P6 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
170
160
150
140
130
120
110
2005
2007
2009
2011
2013
2015
P6
P6[Lay4]

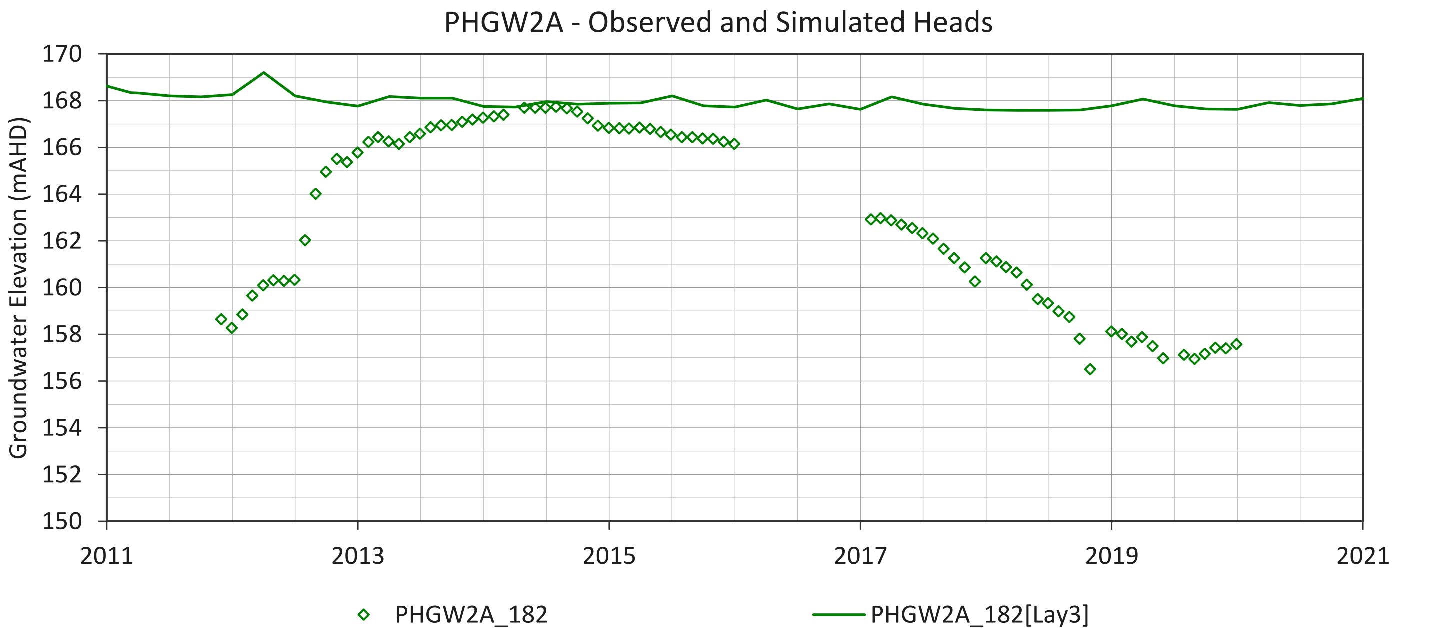

P7 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
230
228
226
224
222
220
218
216
214
212
210
2008
2010
2012
2014
2016
2018
2020
2022
P7
P7[Lay4]

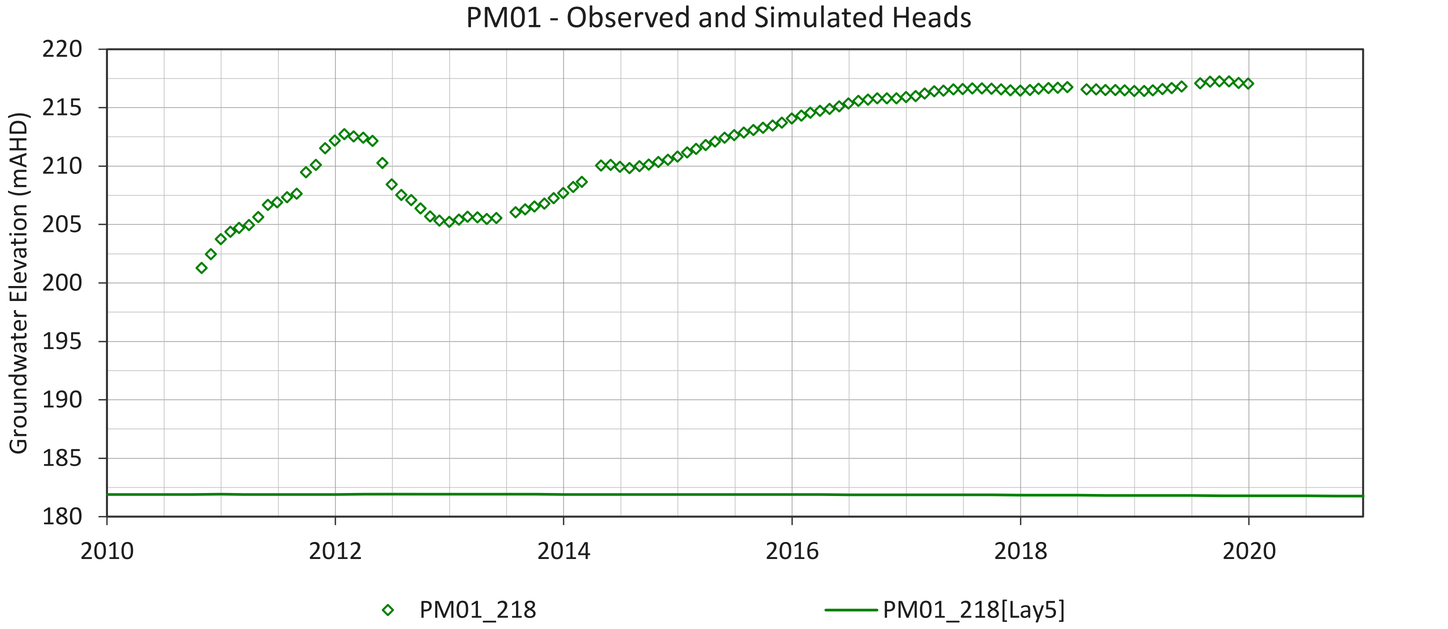

P8 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
210
205
200
195
190
185
180
175
170
2008
2010
2012
2014
2016
2018
2020
2022
P8
P8[Lay4]

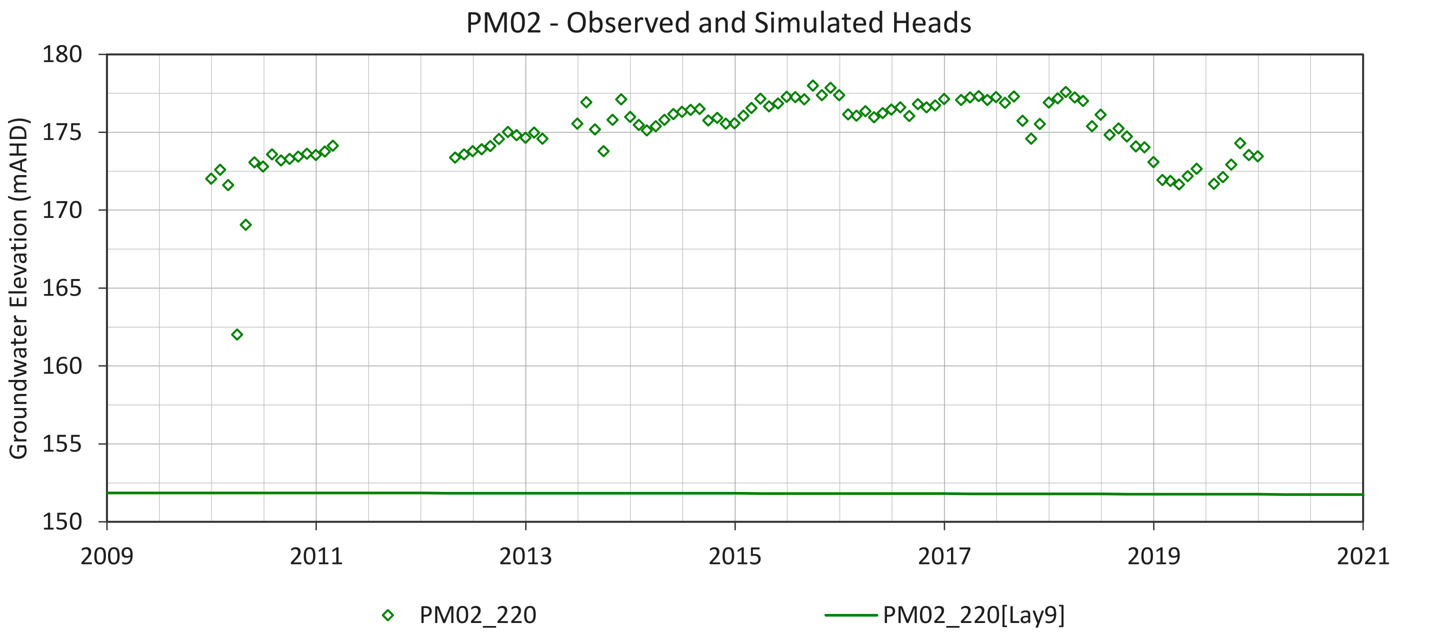

P9 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
210
205
200
195
190
185
180
2017
2018
2019
2020
2021
P9_V1
P9_V1[Lay1]
P9_V2
P9_V2[Lay1]
P9_V3
P9_V3[Lay3]

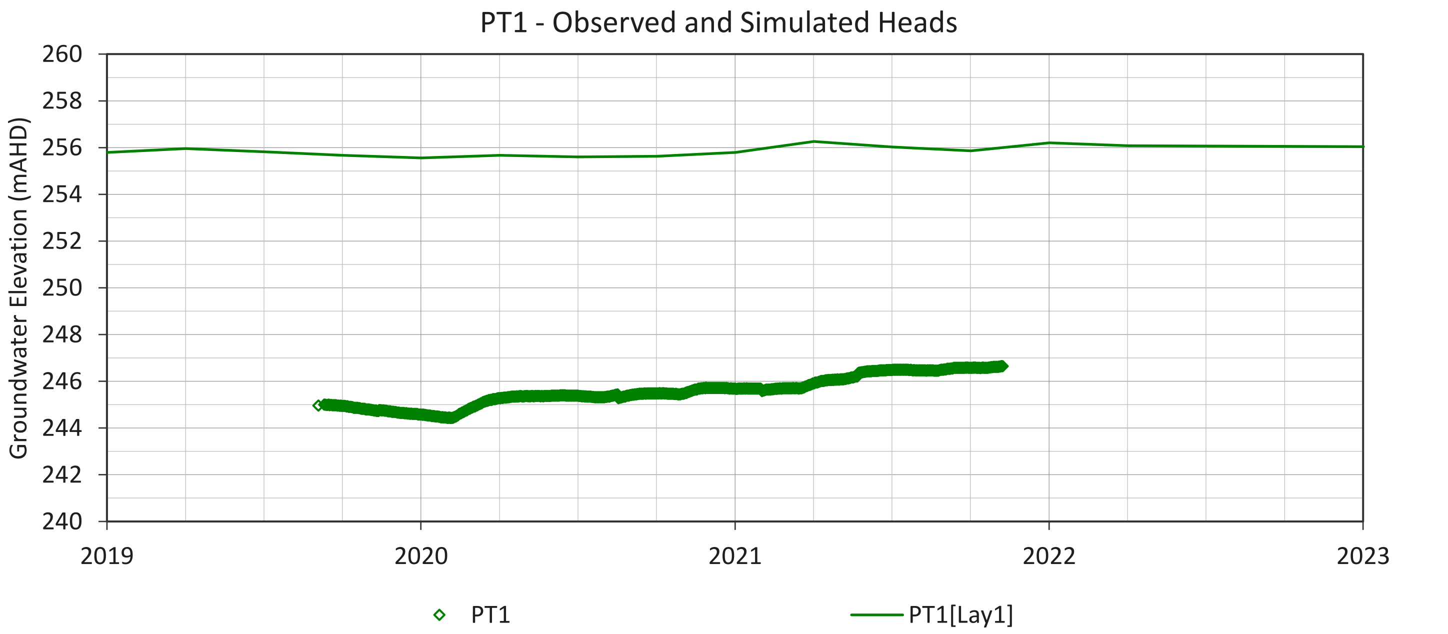

P9A - Observed and Simulated Heads
Groundwater Elevation (mAHD)
210
208
206
204
202
200
198
196
194
192
190
2017
2018
2019
2020
2021
2022
P9A
P9A[Lay4]

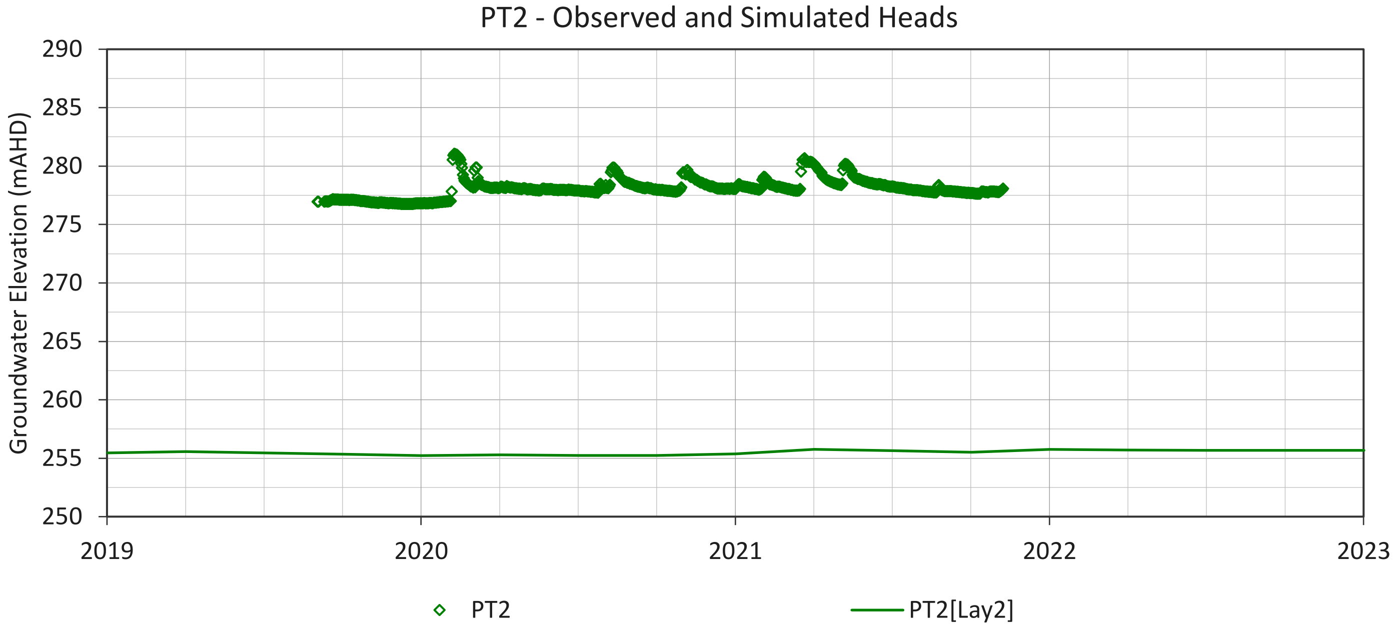

P9C - Observed and Simulated Heads
Groundwater Elevation (mAHD)
210
208
206
204
202
200
198
196
194
192
190
2018
2019
2020
2021
2022
P9C
P9C[Lay4]

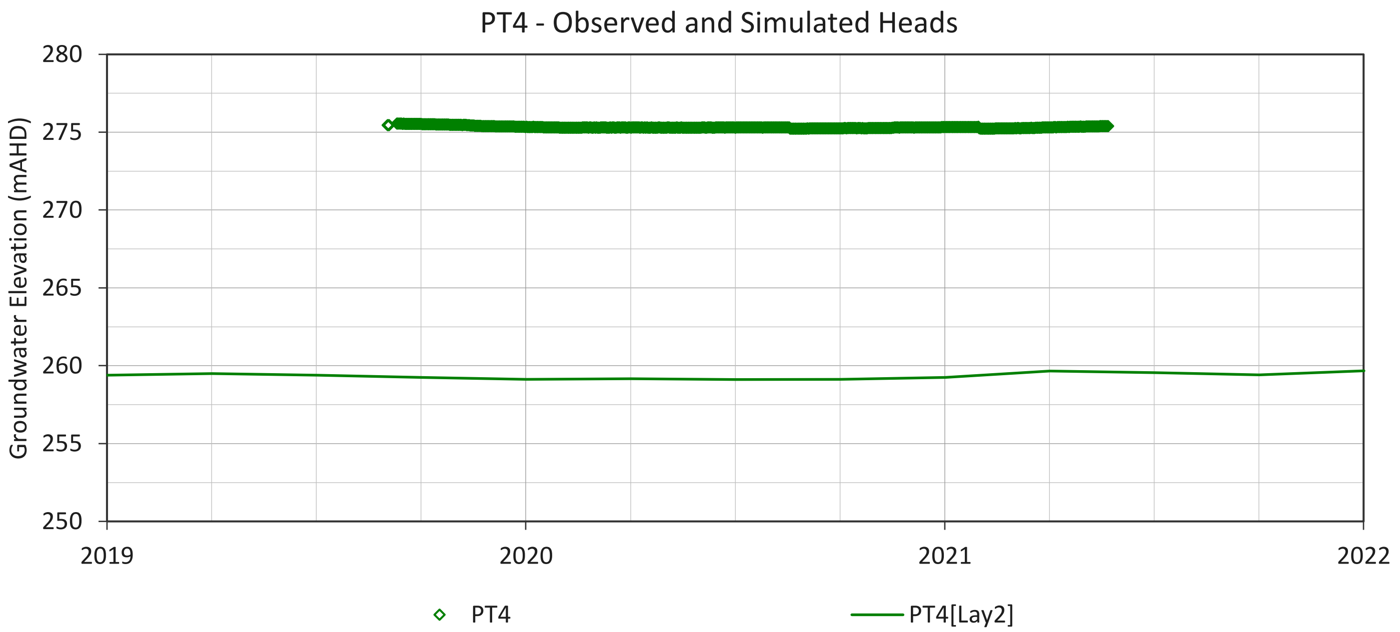

PHGW2A - Observed and Simulated Heads
Groundwater Elevation (mAHD)
170
168
166
164
162
160
158
156
154
152
150
2011
2013
2015
2017
2019
2021
PHGW2A_182
PHGW2A_182[Lay3]

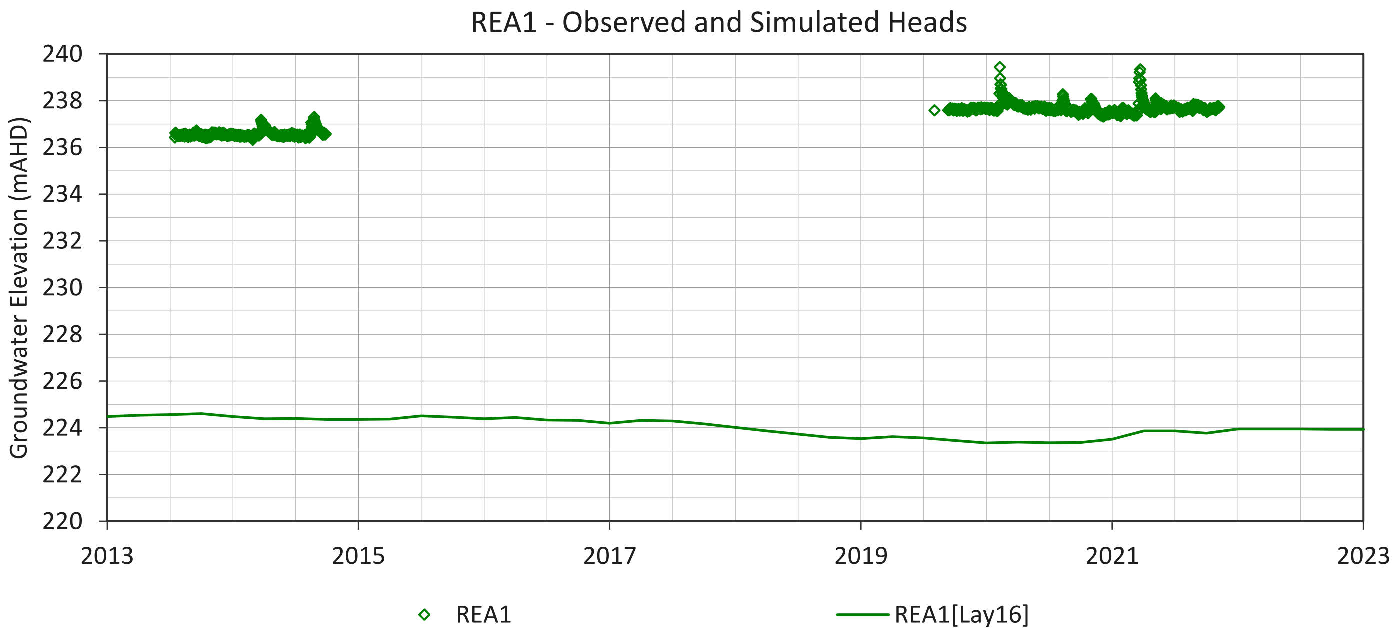

PM01 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
220
215
210
205
200
195
190
185
180
2010
2012
2014
2016
2018
2020
PM01_218
PM01_218[Lay5]

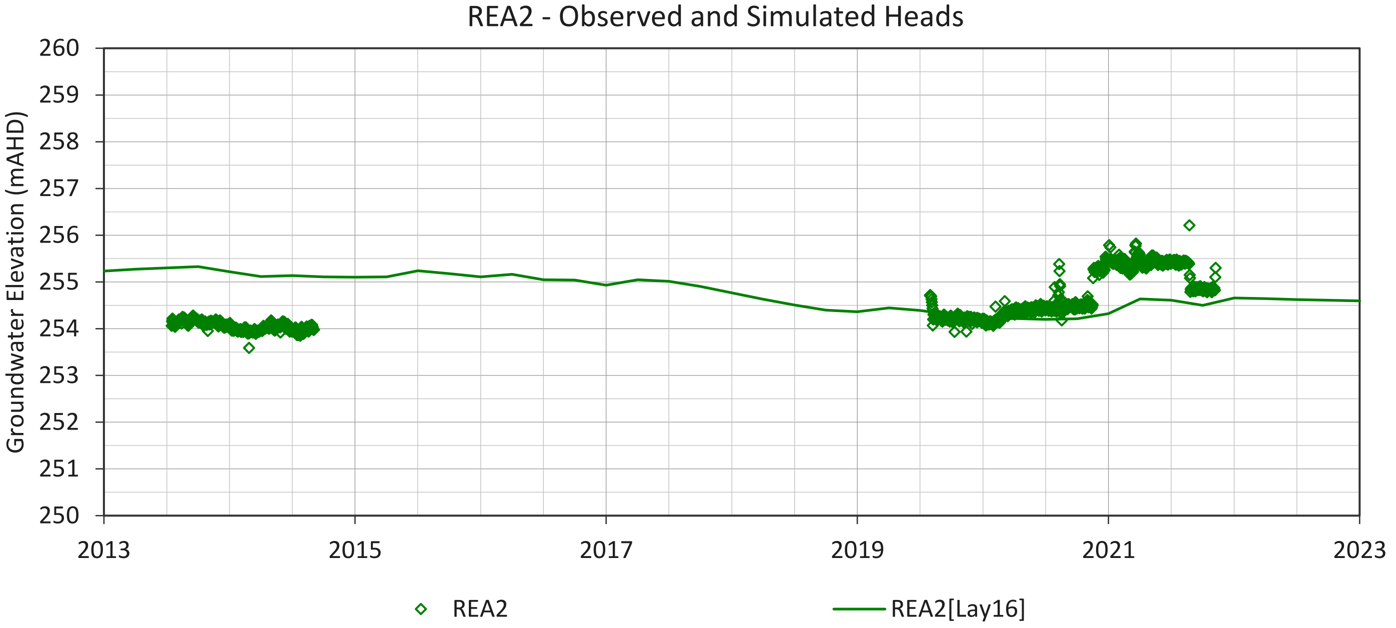

PM02 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
180
175
170
165
160
155
150
2009
2011
2013
2015
2017
2019
2021
PM02_220
PM02_220[Lay9]


PT1 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
260
258
256
254
252
250
248
246
244
242
240
2019
2020
2021
2022
2023
PT1
PT1[Lay1]

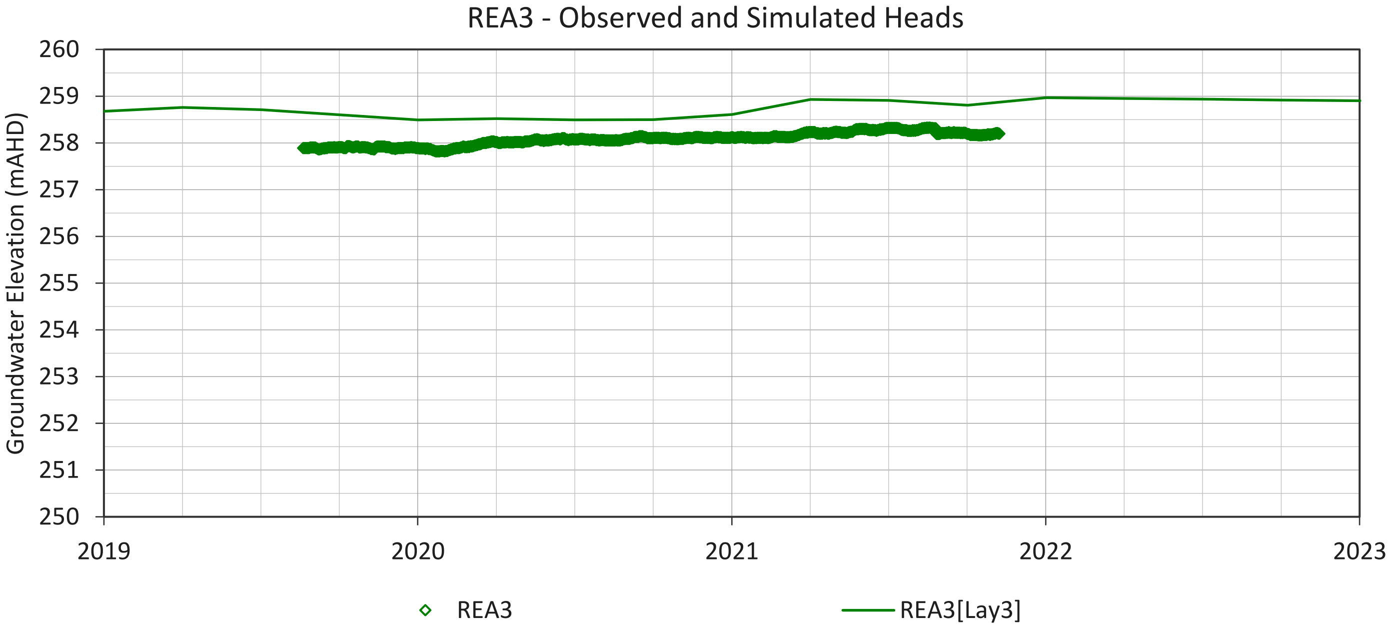

PT2 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
290
285
280
275
270
265
260
255
250
2019
2020
2021
2022
2023
PT2
PT2[Lay2]


PT4 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
280
275
270
265
260
255
250
2019
2020
2021
2022
PT4
PT4[Lay2]

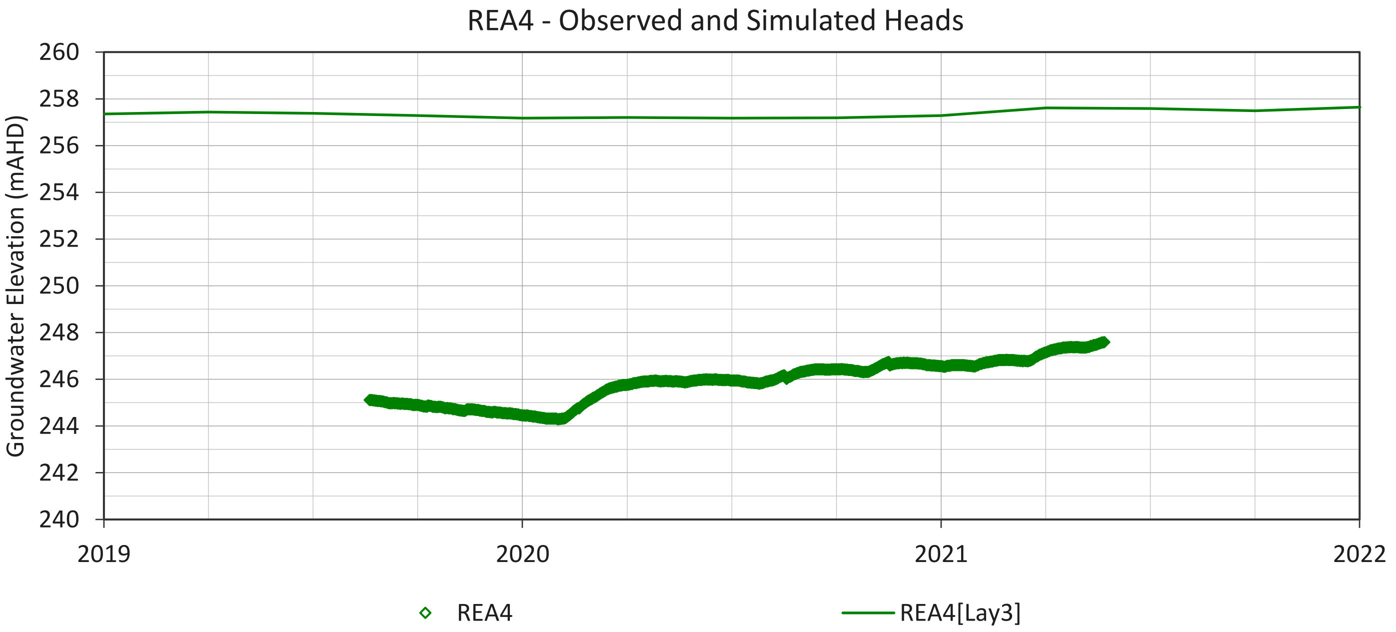

REA1 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
240
238
236
234
232
230
228
226
224
222
220
2013
2015
2017
2019
2021
2023
REA1
REA1[Lay16]



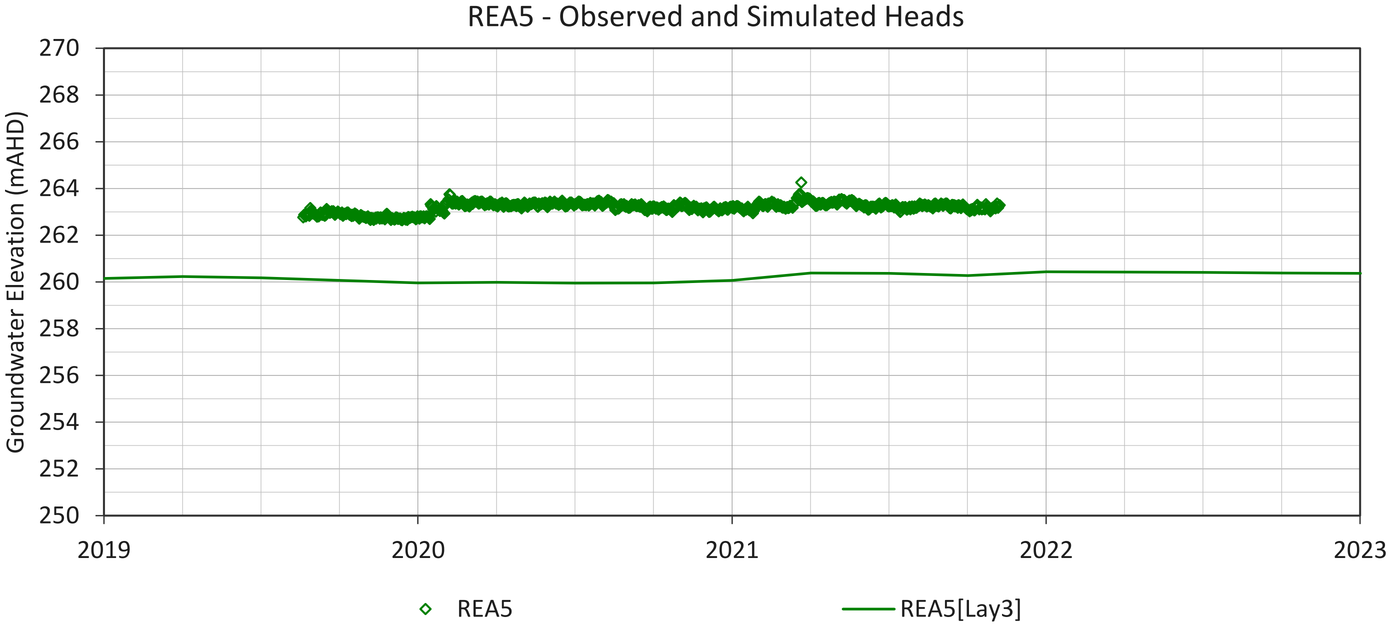
REA2 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
260
259
258
257
256
255
254
253
252
251
250
2013
2015
2017
2019
2021
2023
REA2
REA2[Lay16]

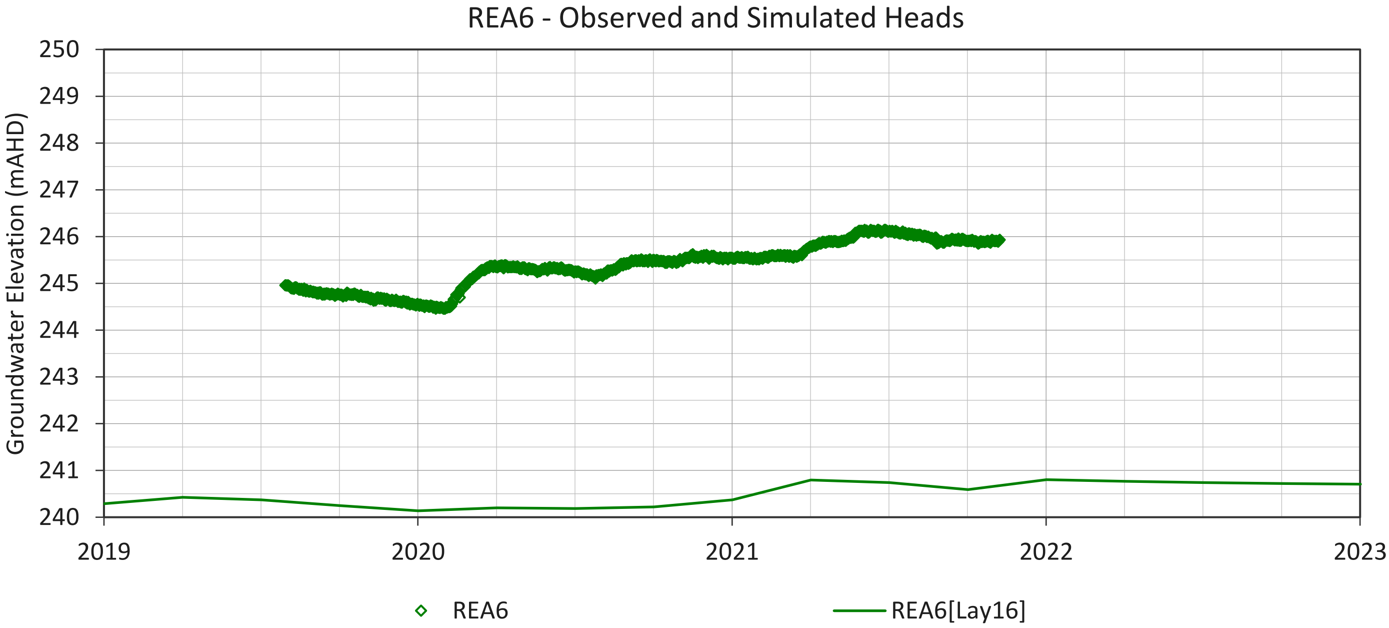


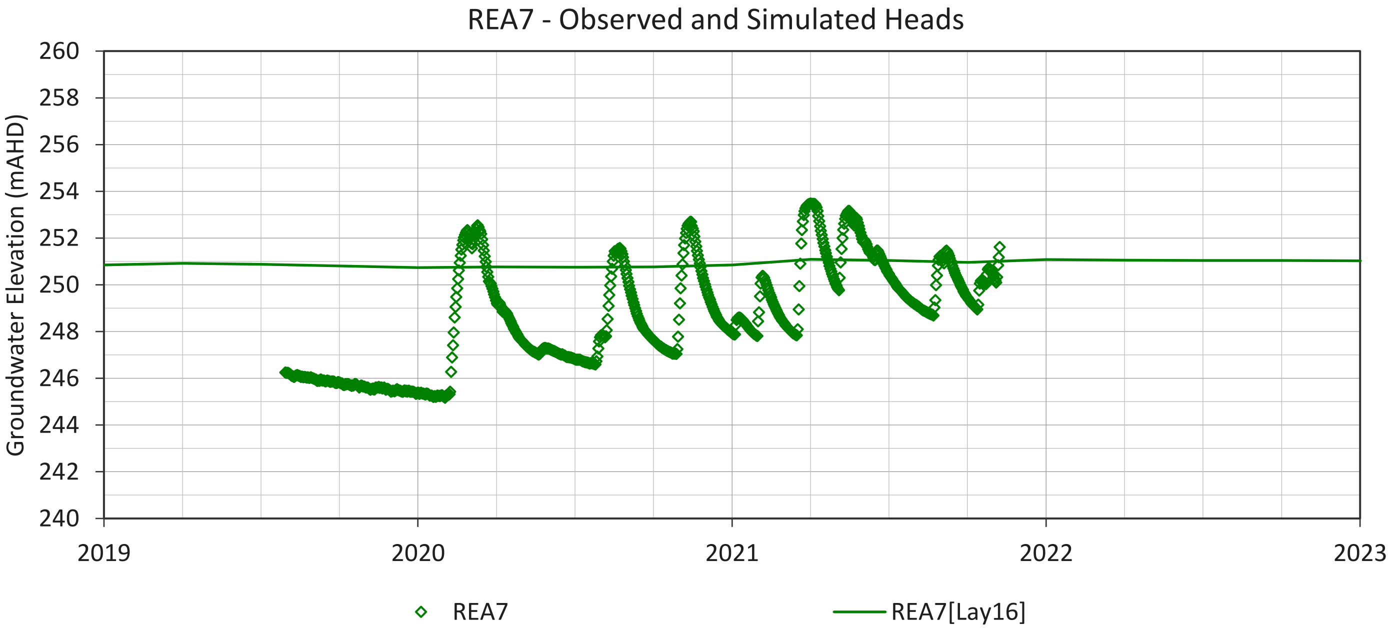
REA3 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
260
259
258
257
256
255
254
253
252
251
250
2019
2020
2021
2022
2023
REA3
REA3[Lay3]

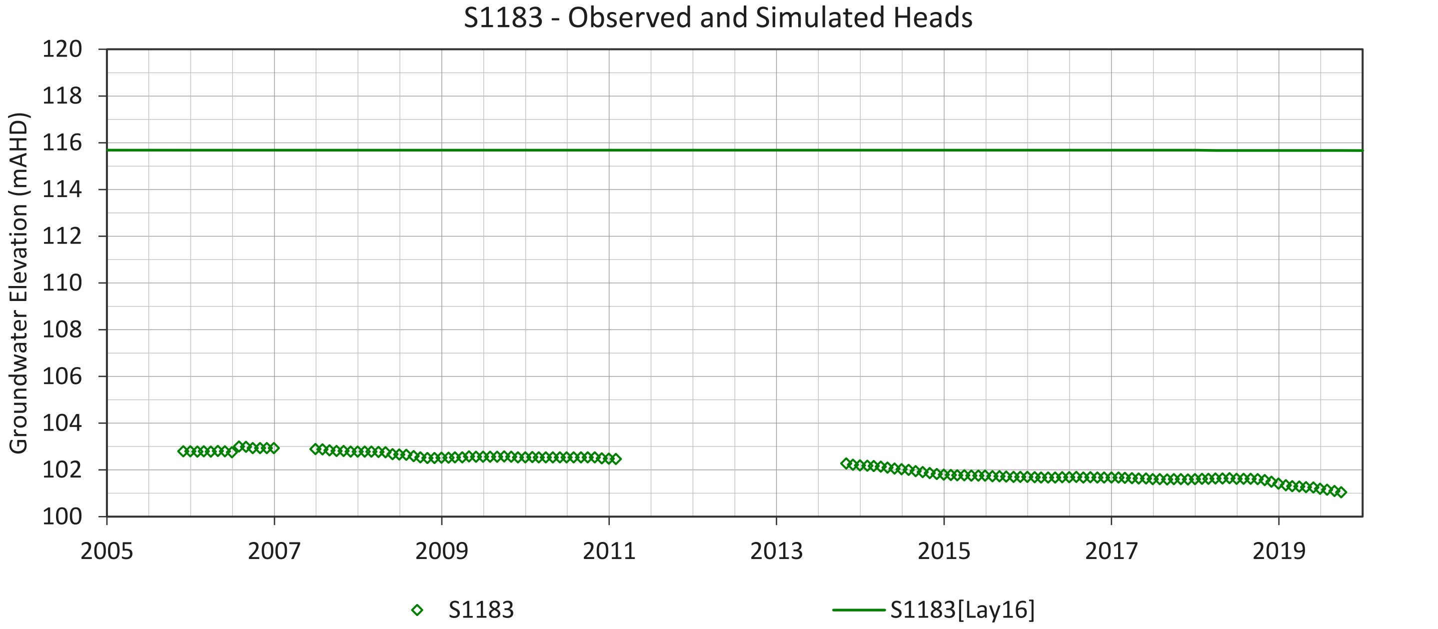


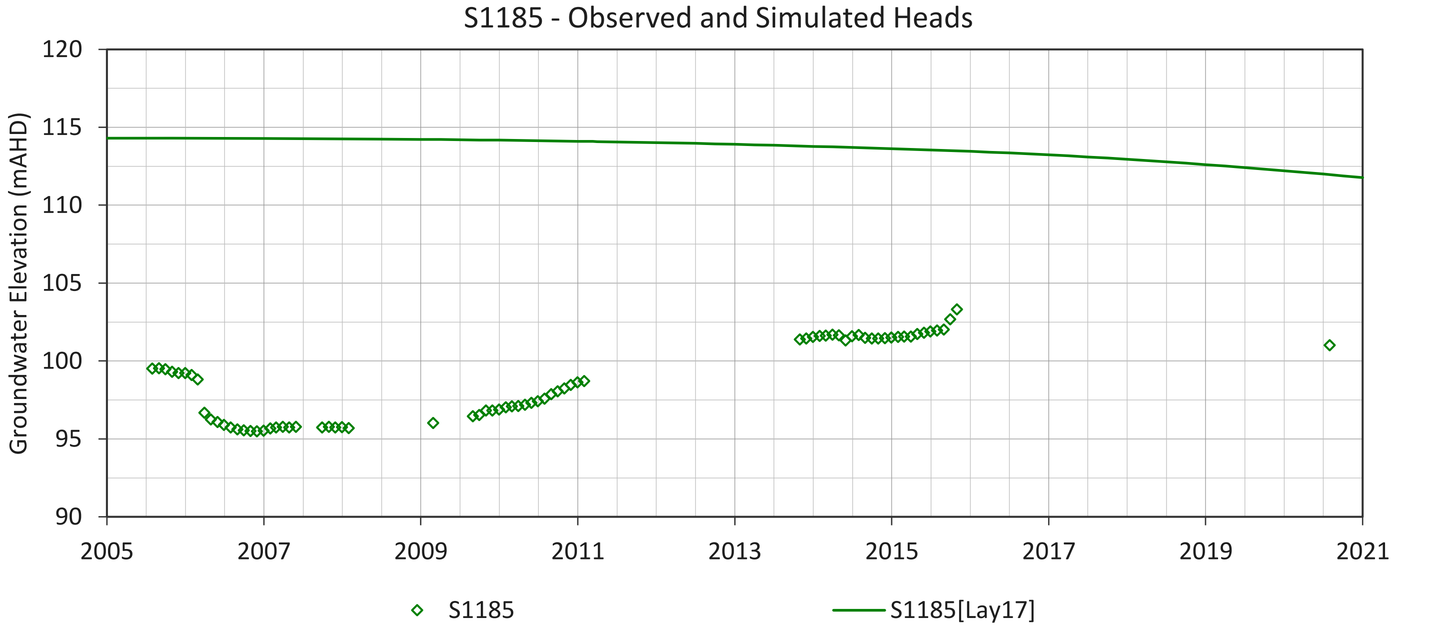
REA4 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
260
258
256
254
252
250
248
246
244
242
240
2019
2020
2021
2022
REA4
REA4[Lay3]

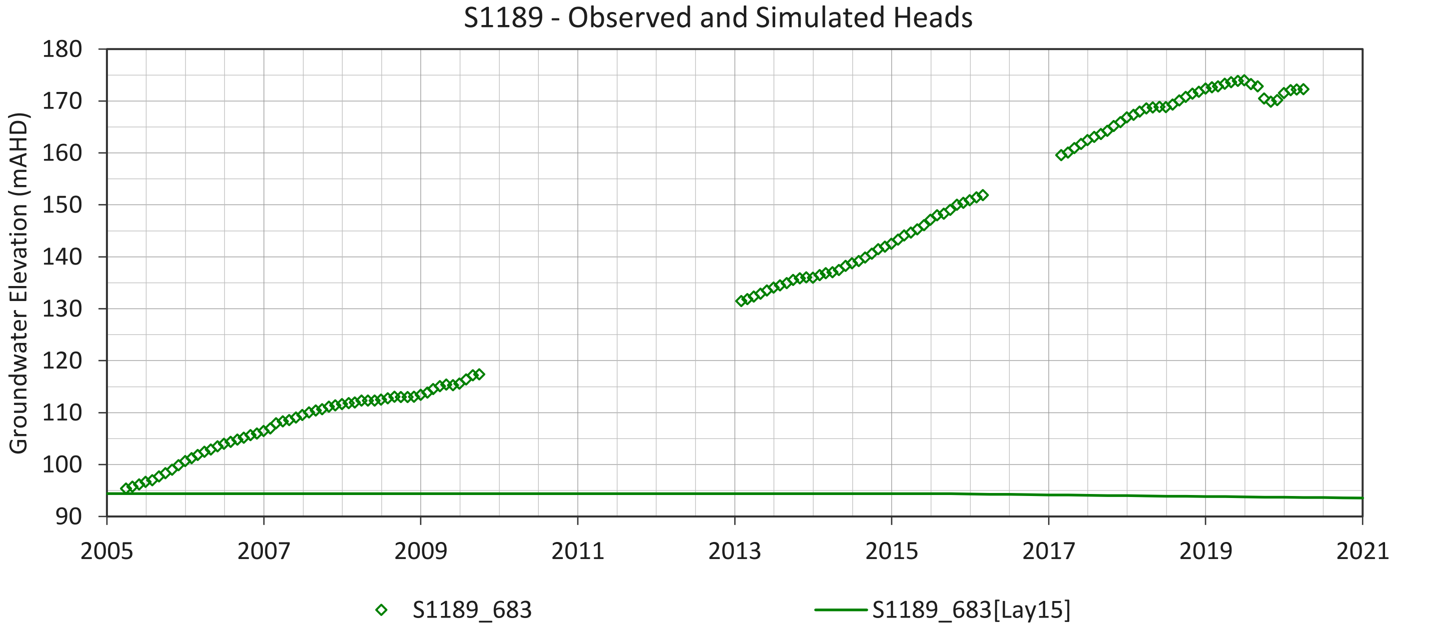

REA5 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
270
268
266
264
262
260
258
256
254
252
250
2019
2020
2021
2022
2023
REA5
REA5[Lay3]

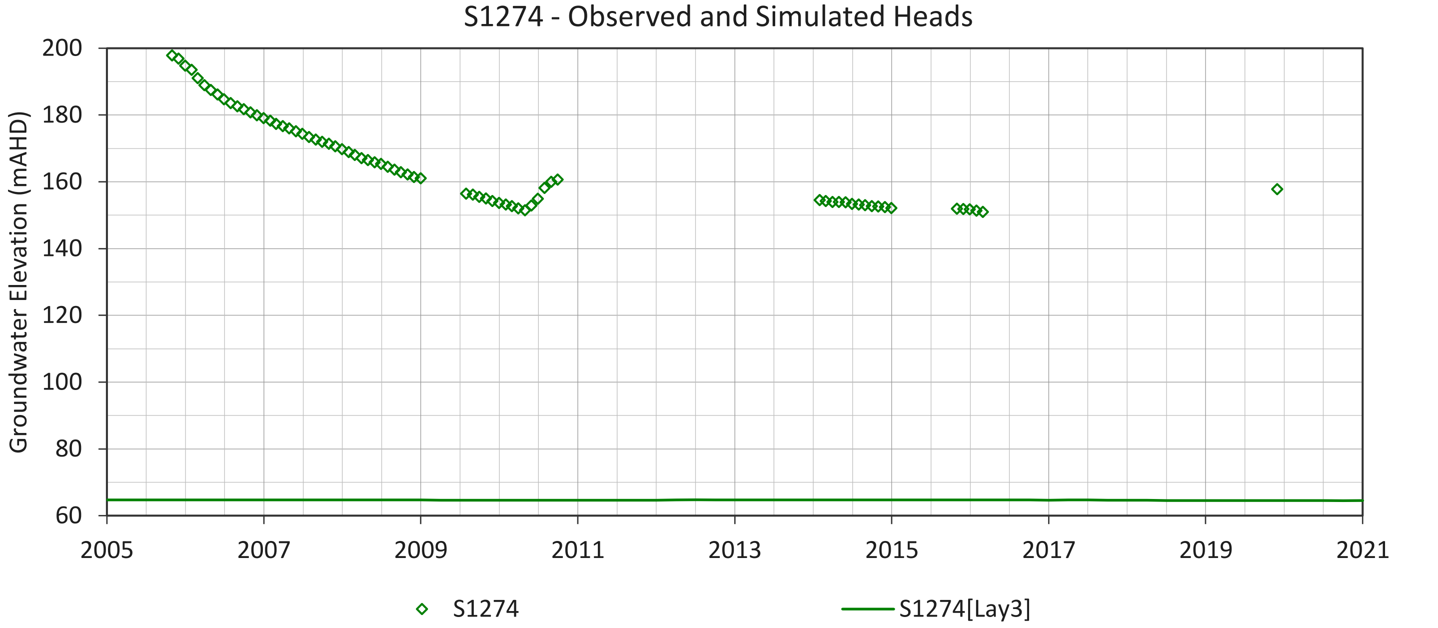

REA6 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
250
249
248
247
246
245
244
243
242
241
240
2019
2020
2021
2022
2023
REA6
REA6[Lay16]

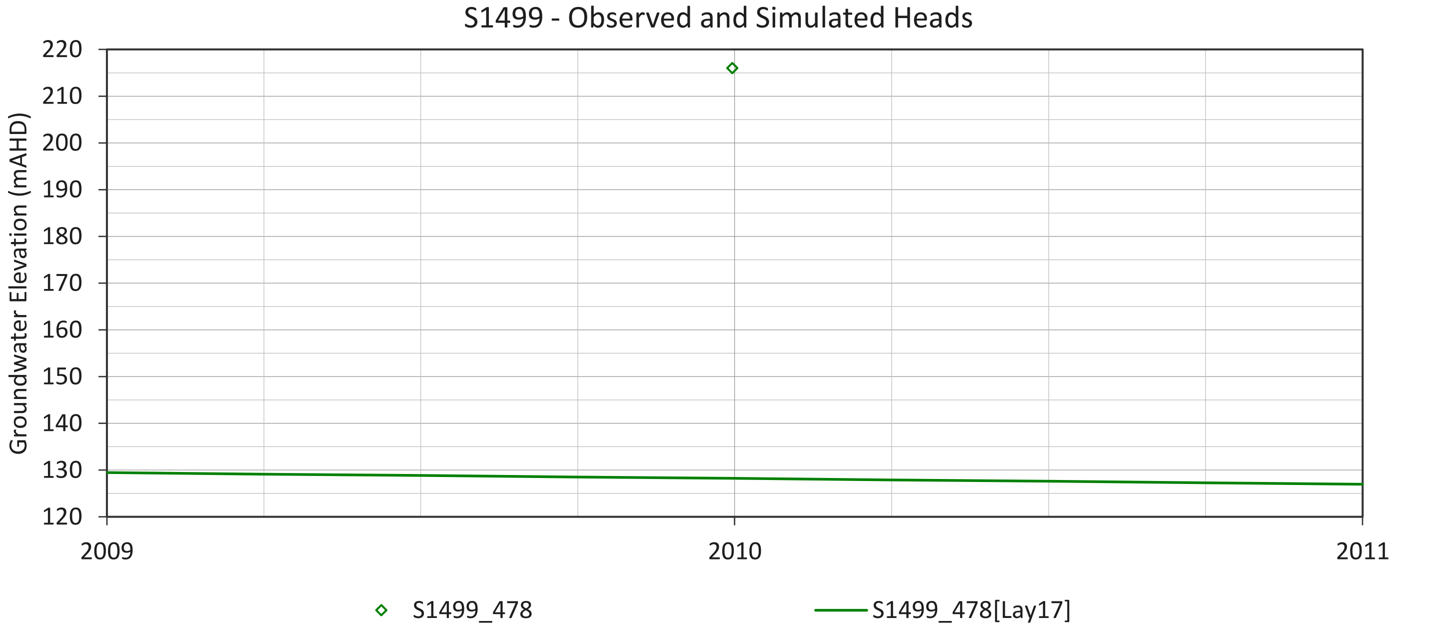

REA7 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
260
258
256
254
252
250
248
246
244
242
240
2019
2020
2021
2022
2023
REA7
REA7[Lay16]

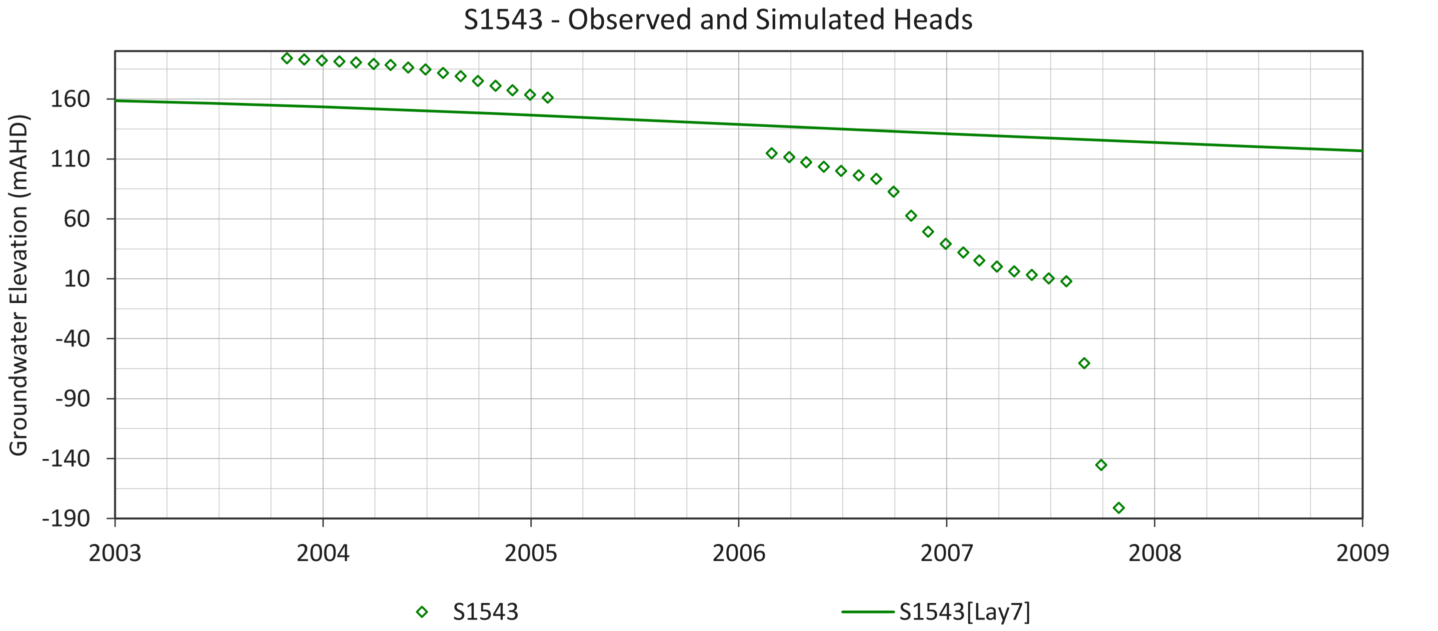

S1183 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
120
118
116
114
112
110
108
106
104
102
100
2005
2007
2009
2011
2013
2015
2017
2019
S1183
S1183[Lay16]

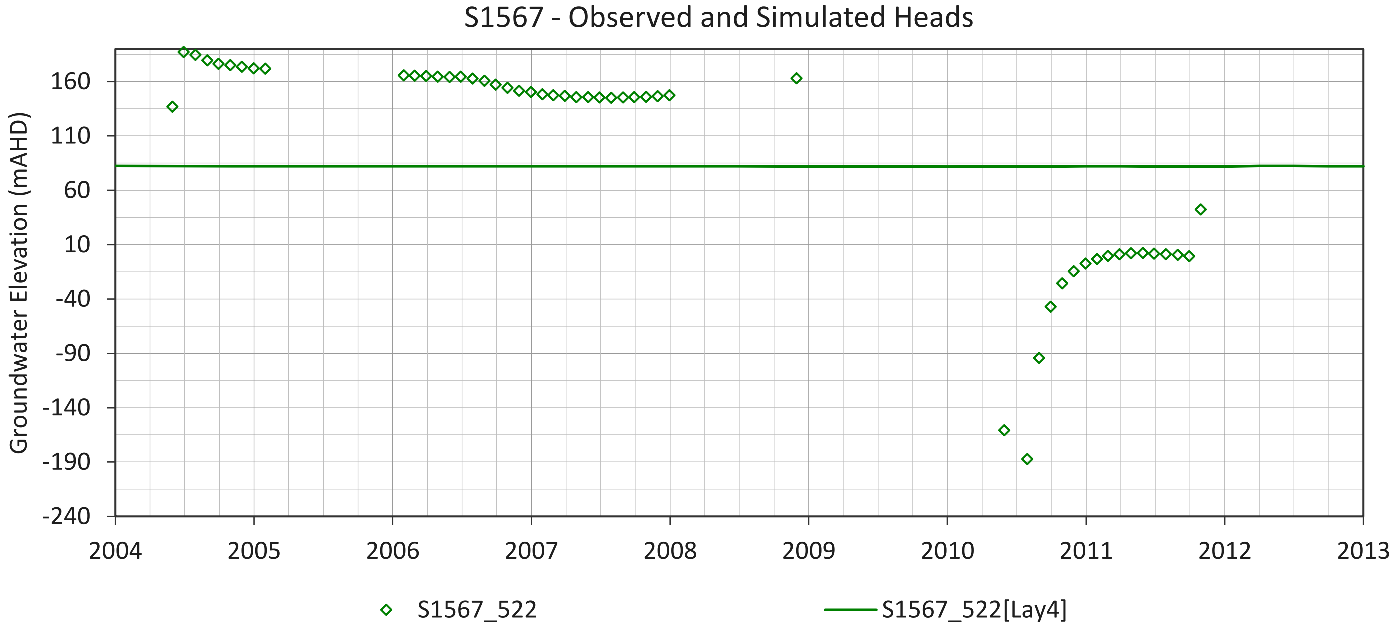

S1185 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
120
115
110
105
100
95
90
2005
2007
2009
2011
2013
2015
2017
2019
2021
S1185
S1185[Lay17]

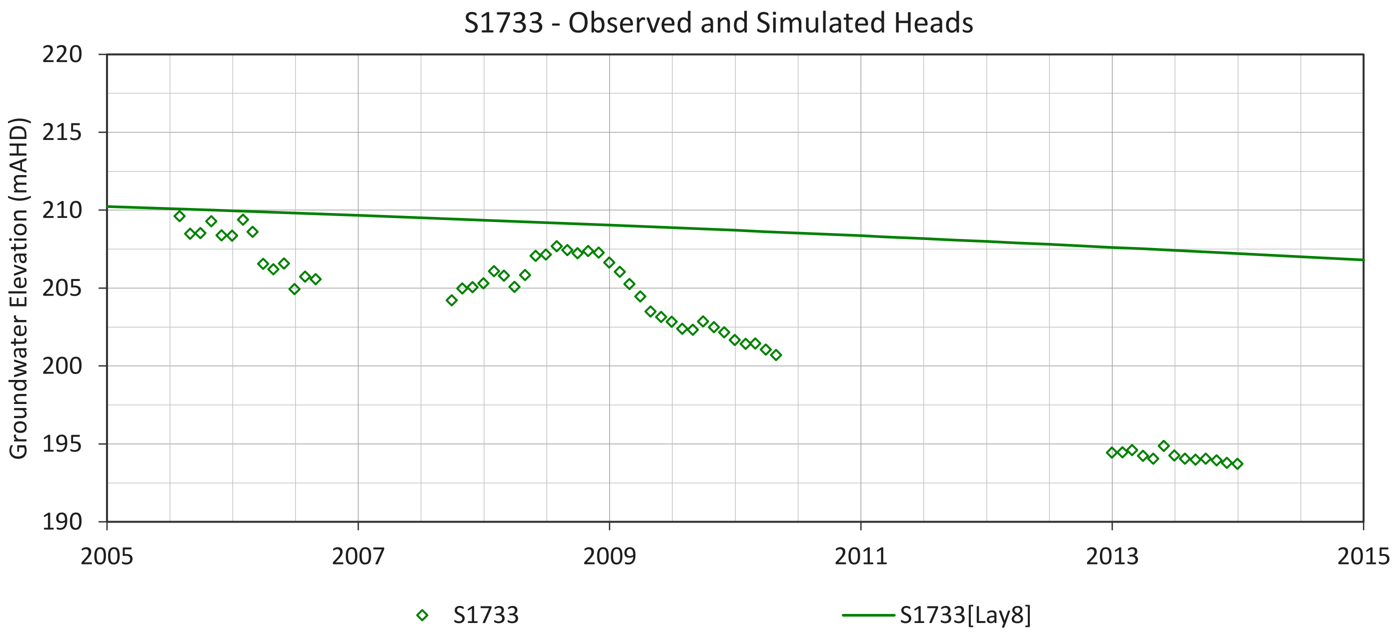

S1189 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
180
170
160
150
140
130
120
110
100
90
2005
2007
2009
2011
2013
2015
2017
2019
2021
S1189_683
S1189_683[Lay15]

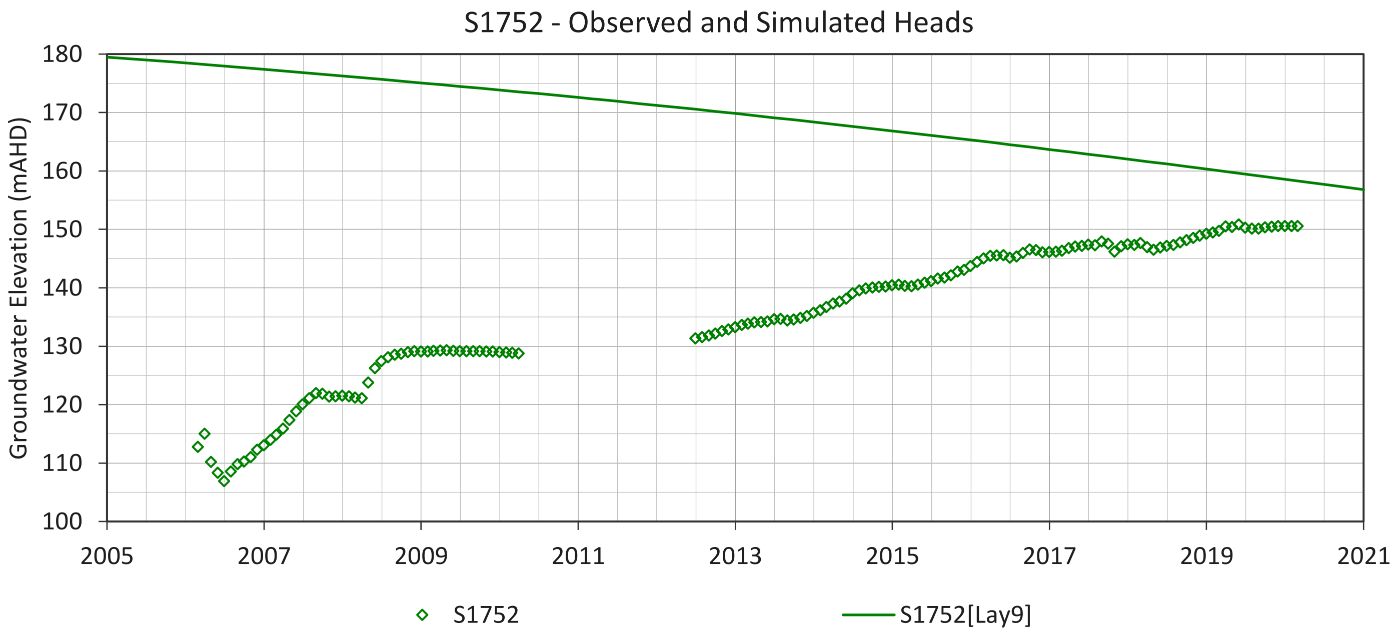

S1274 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
200
180
160
140
120
100
80
60
2005
2007
2009
2011
2013
2015
2017
2019
2021
S1274
S1274[Lay3]

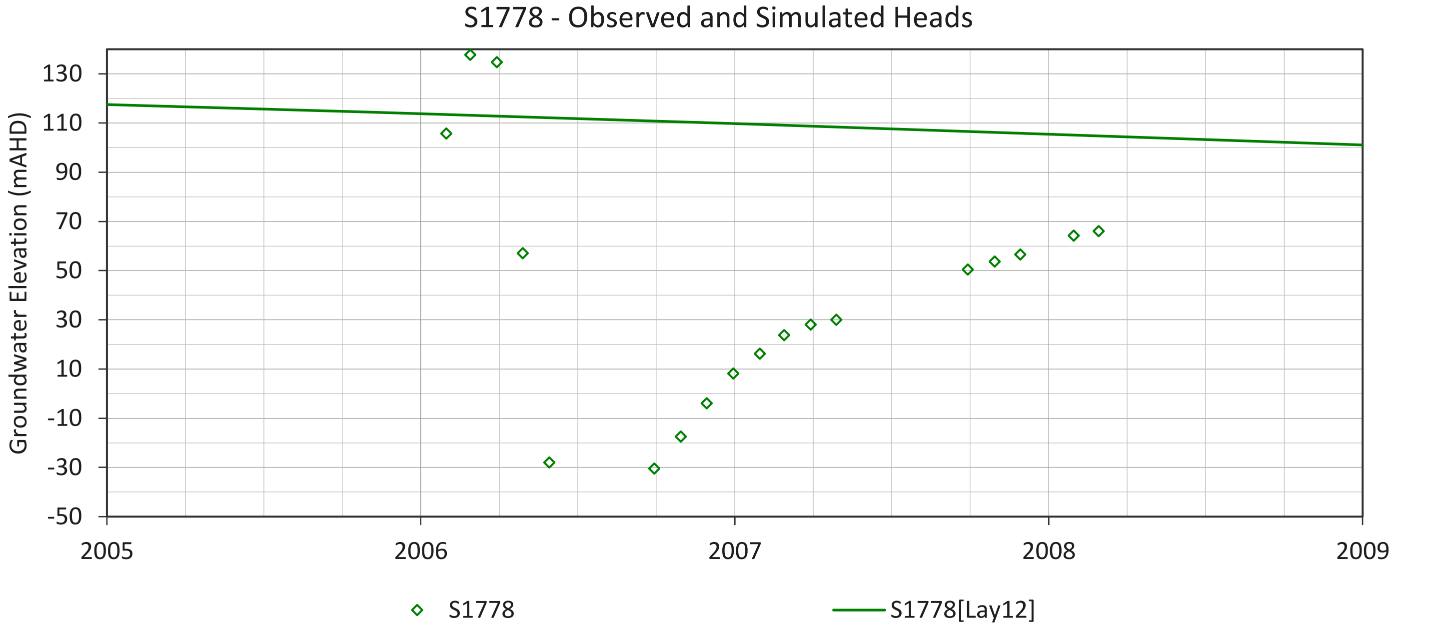

S1499 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
220
210
200
190
180
170
160
150
140
130
120
2009
2010
2011
S1499_478
S1499_478[Lay17]

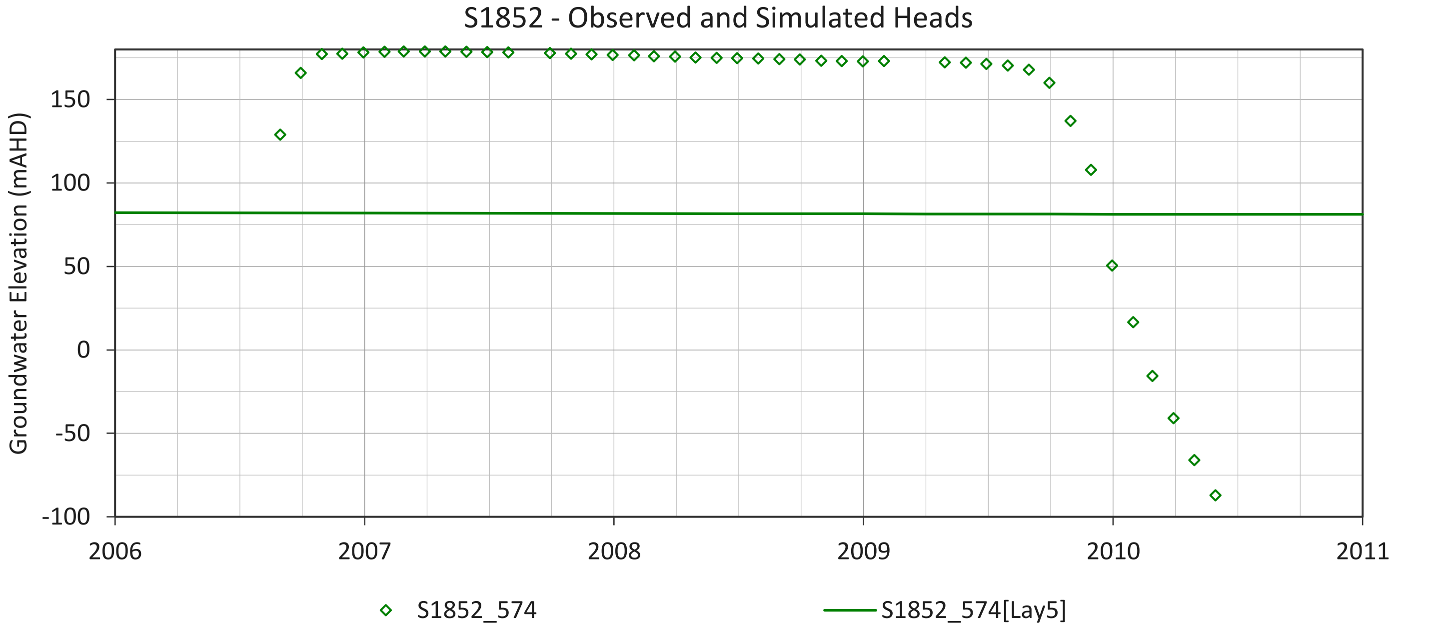

S1543 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
160
110
60
10
-40
-90
-140
-190
2003
2004
2005
2006
2007
2008
2009
S1543
S1543[Lay7]

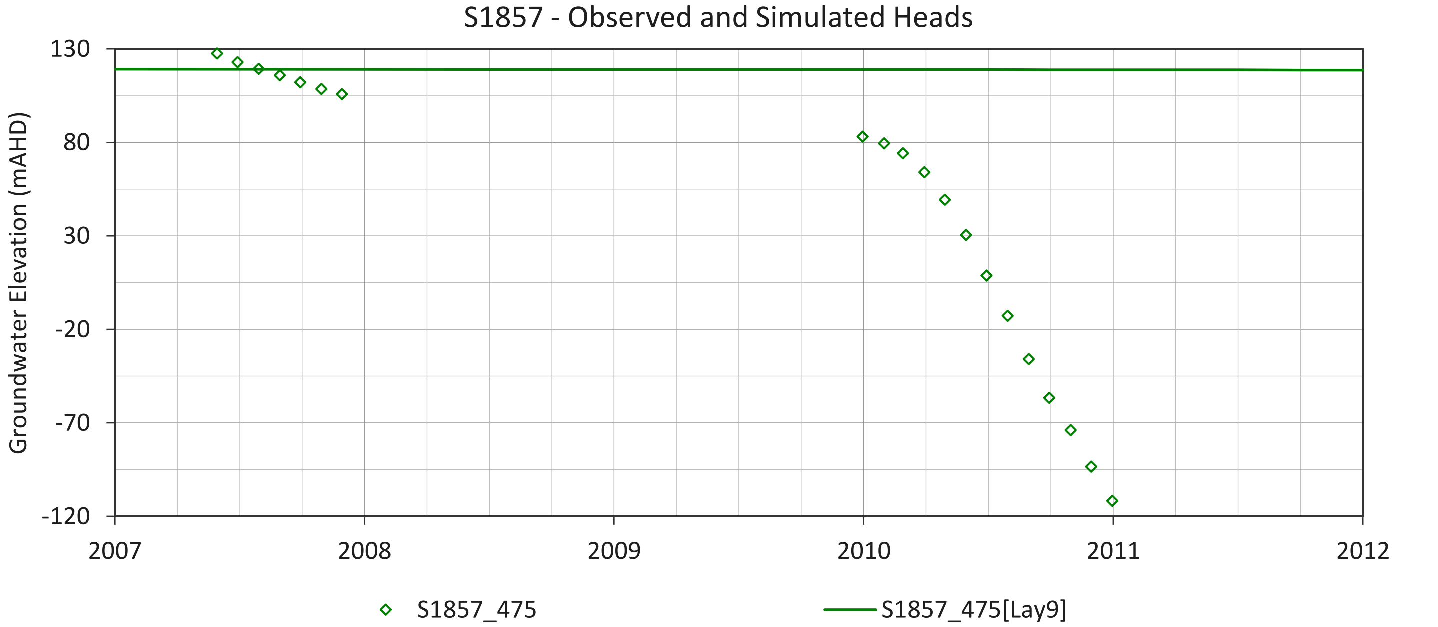

S1567 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
160
110
60
10
-40
-90
-140
-190
-240
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
S1567_522
S1567_522[Lay4]

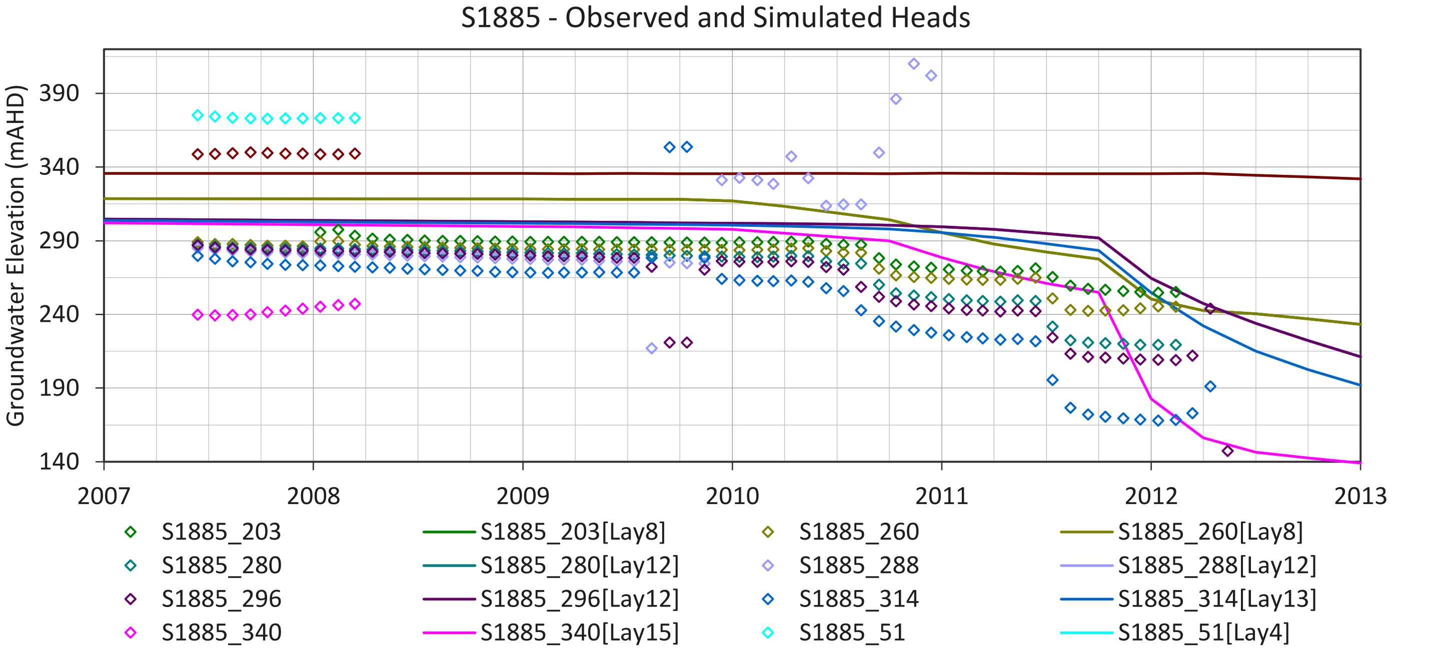

S1733 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
220
215
210
205
200
195
190
2005
2007
2009
2011
2013
2015
S1733
S1733[Lay8]

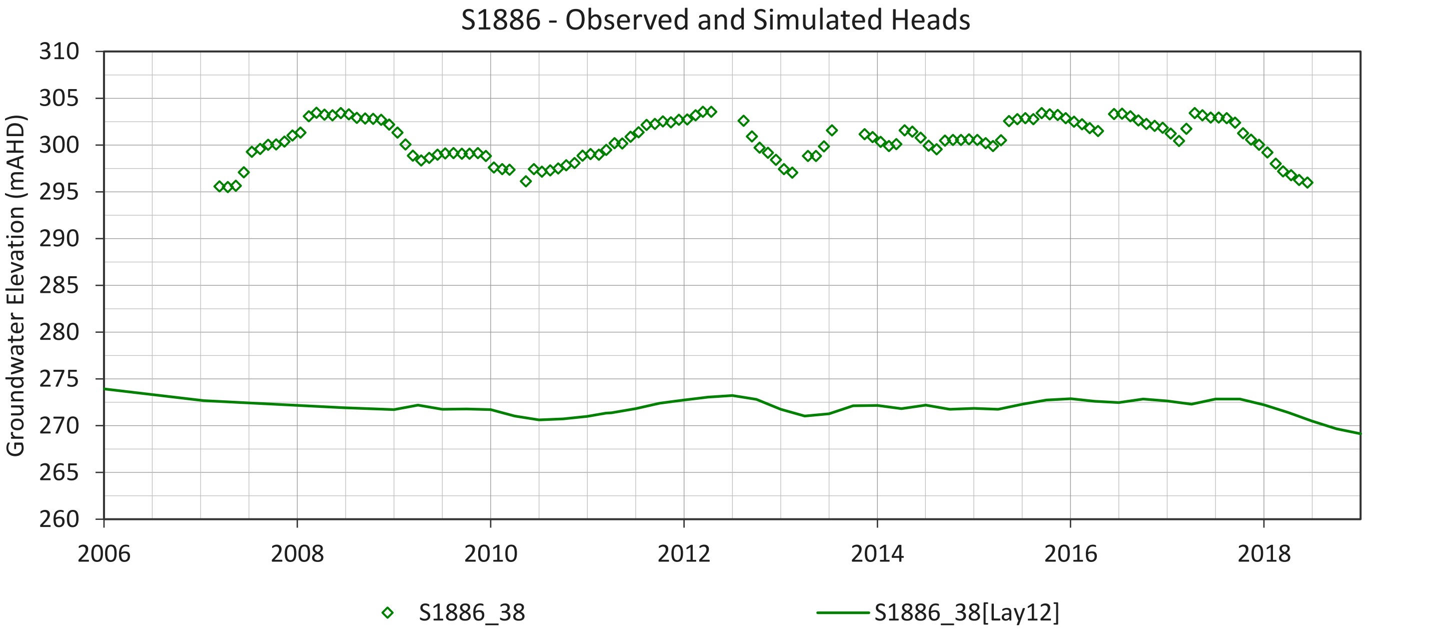

S1752 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
180
170
160
150
140
130
120
110
100
2005
2007
2009
2011
2013
2015
2017
2019
2021
S1752
S1752[Lay9]

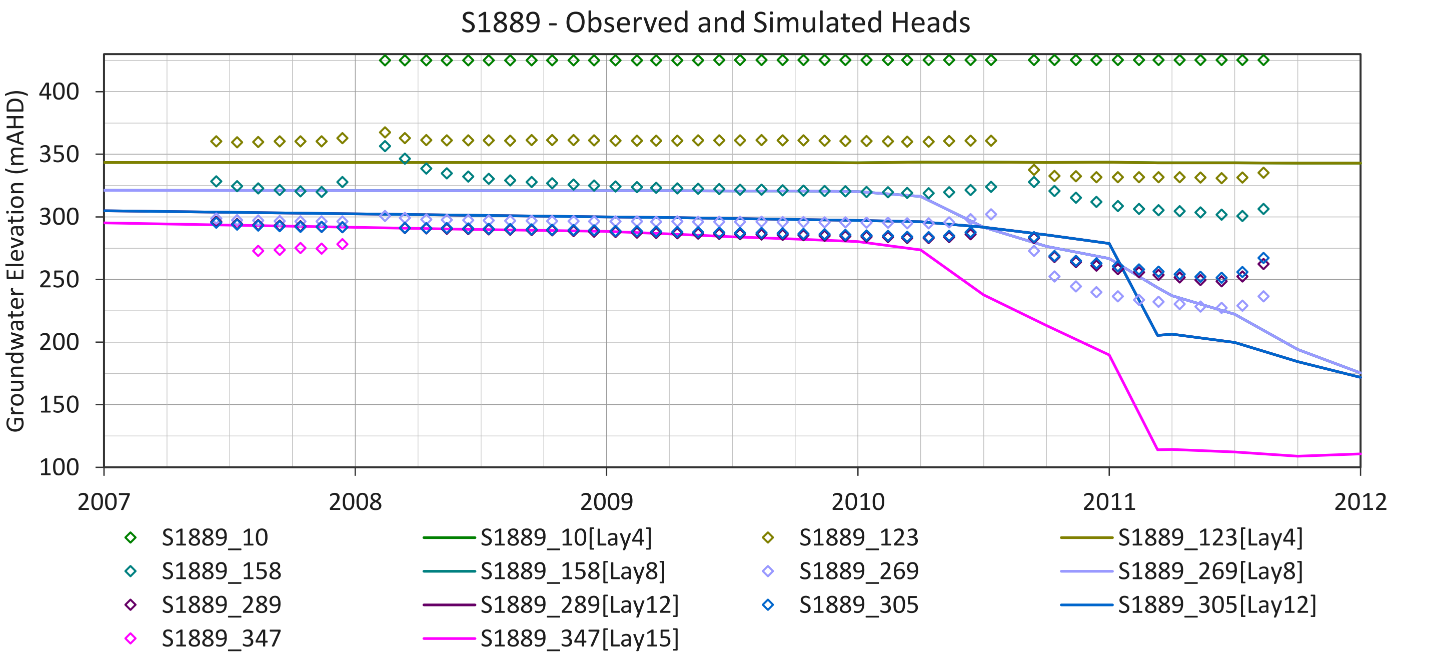

S1778 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
130
110
90
70
50
30
10
-10
-30
-50
2005
2006
2007
2008
2009
S1778
S1778[Lay12]


S1852 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
150
100
50
0
-50
-100
2006
2007
2008
2009
2010
2011
S1852_574
S1852_574[Lay5]

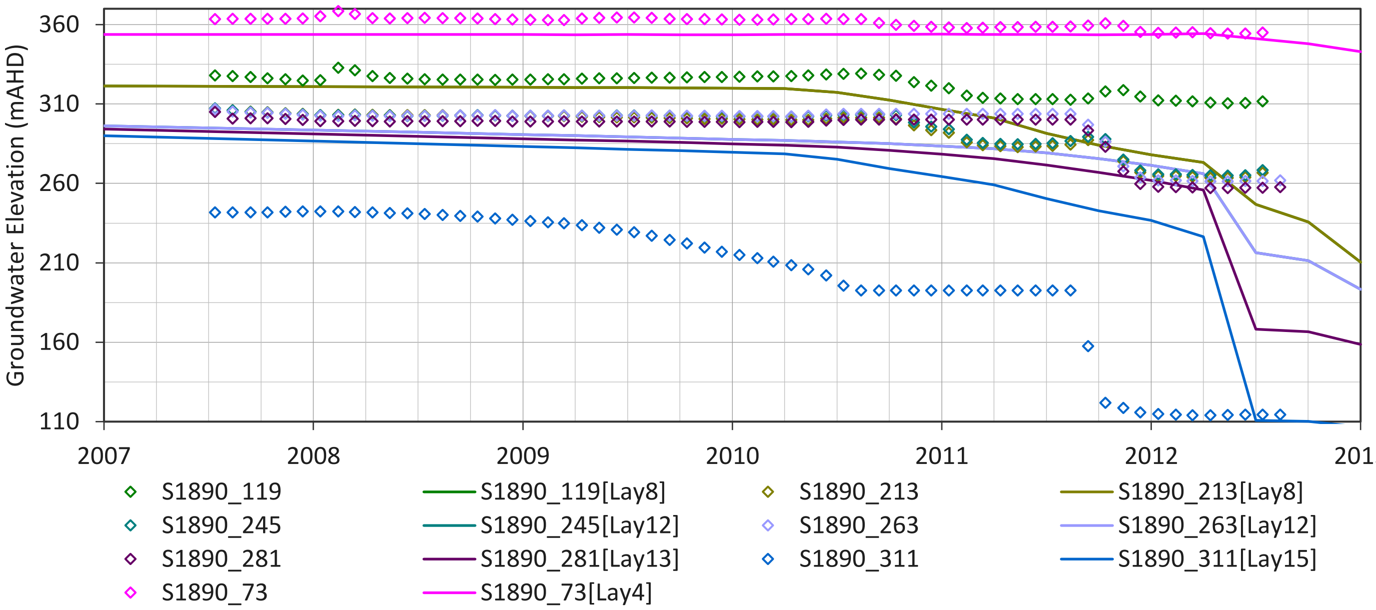

S1857 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
130
80
30
-20
-70
-120
2007
2008
2009
2010
2011
2012
S1857_475
S1857_475[Lay9]


S1885 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
390
340
290
240
190
140
2007
2008
2009
2010
2011
2012
2013
S1885_203
S1885_203[Lay8]
S1885_260
S1885_260[Lay8]
S1885_280
S1885_280[Lay12]
S1885_288
S1885_288[Lay12]
S1885_296
S1885_296[Lay12]
S1885_314
S1885_314[Lay13]
S1885_340
S1885_340[Lay15]
S1885_51
S1885_51[Lay4]

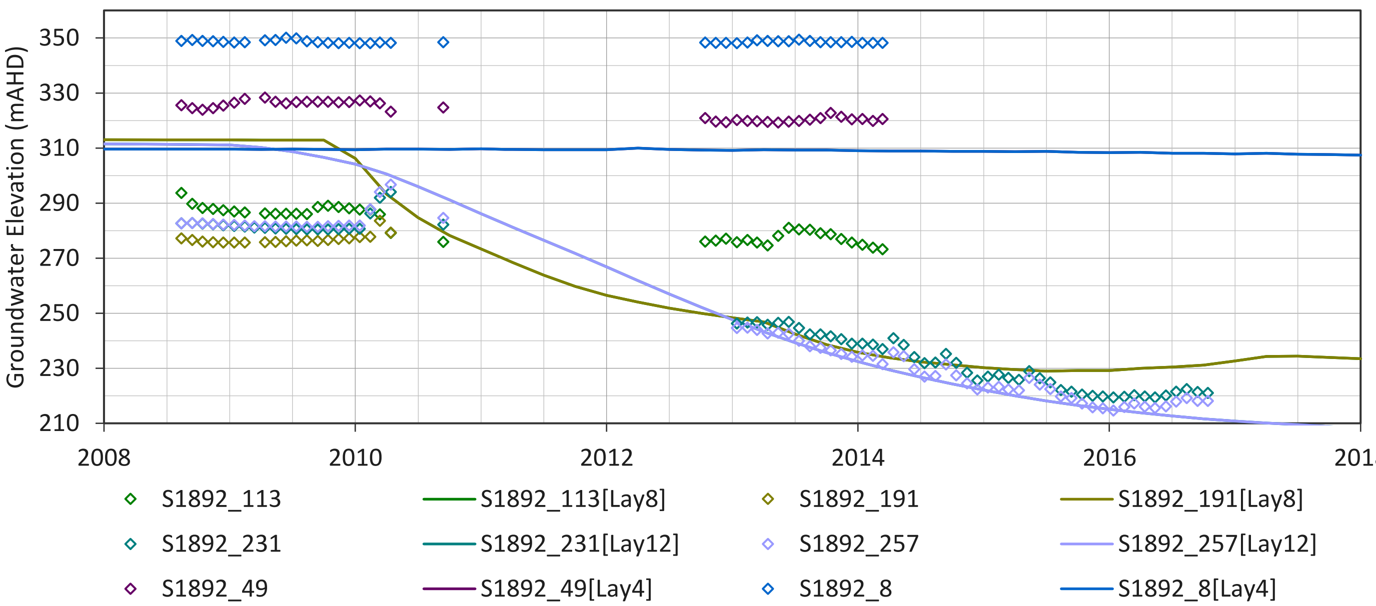

S1886 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
310
305
300
295
290
285
280
275
270
265
260
2006
2008
2010
2012
2014
2016
2018
S1886_38
S1886_38[Lay12]


S1889 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
400
350
300
250
200
150
100
2007
2008
2009
2010
2011
2012
S1889_10
S1889_10[Lay4]
S1889_123
S1889_123[Lay4]
S1889_158
S1889_158[Lay8]
S1889_269
S1889_269[Lay8]
S1889_289
S1889_289[Lay12]
S1889_305
S1889_305[Lay12]
S1889_347
S1889_347[Lay15]

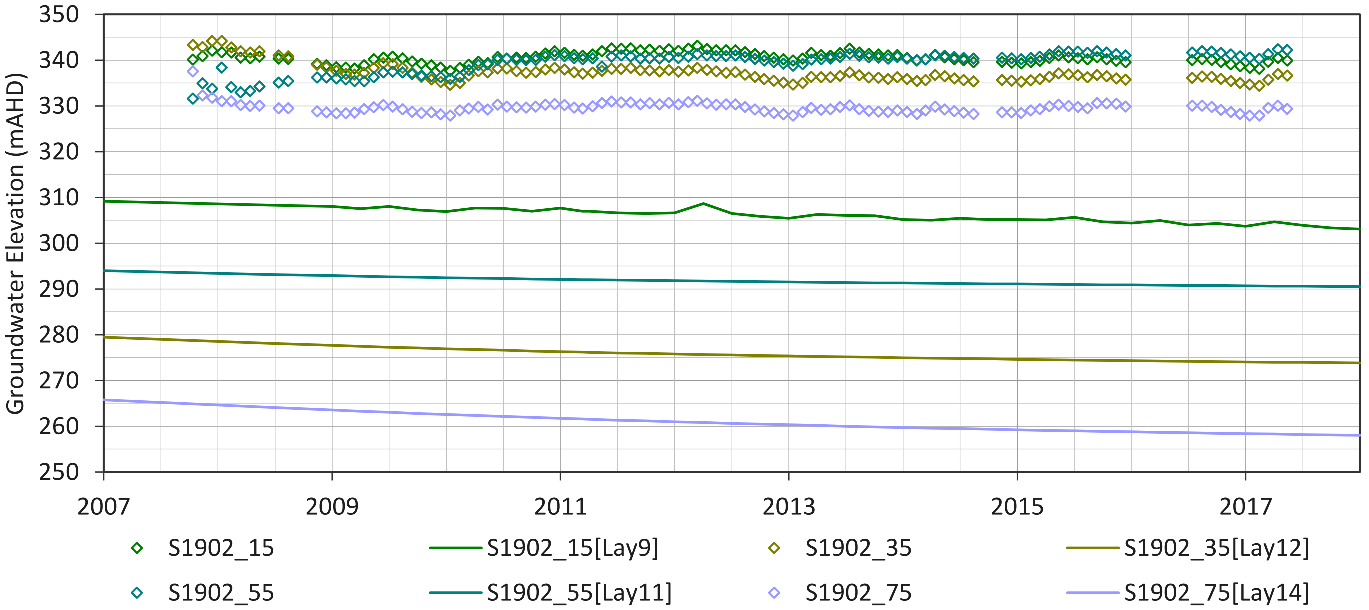
S1890 - Observed and Simulated Heads

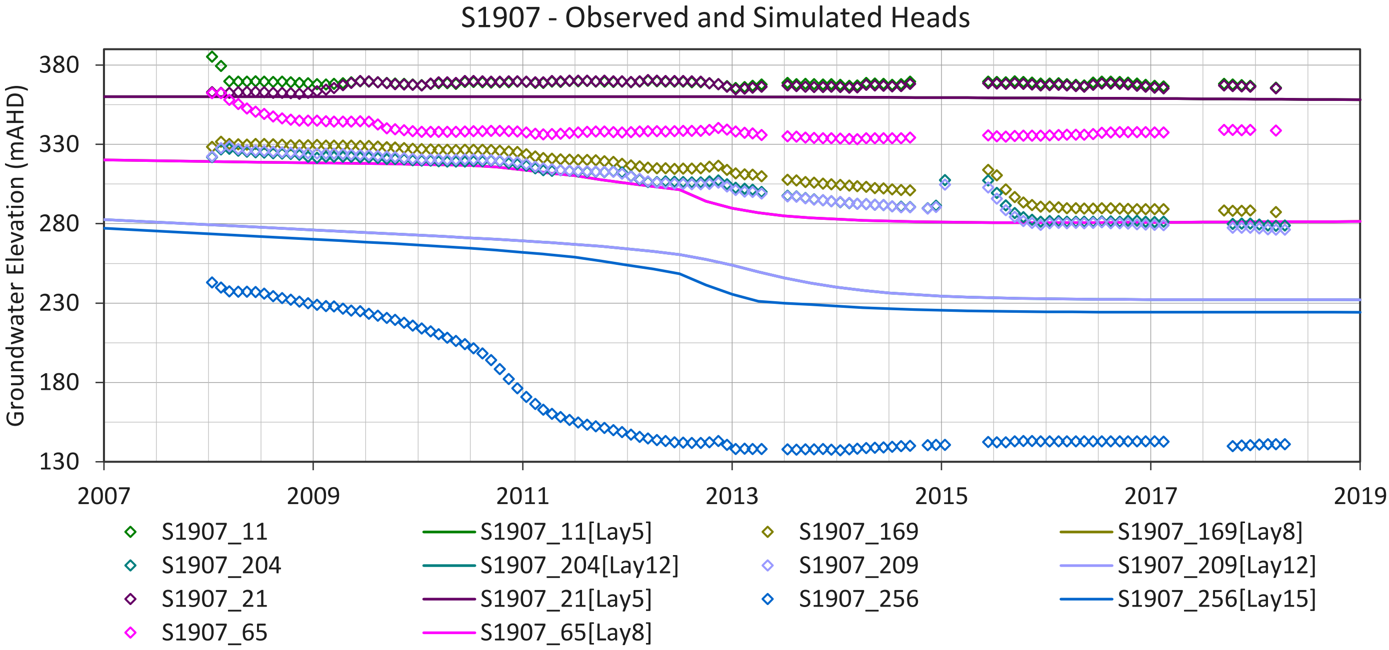


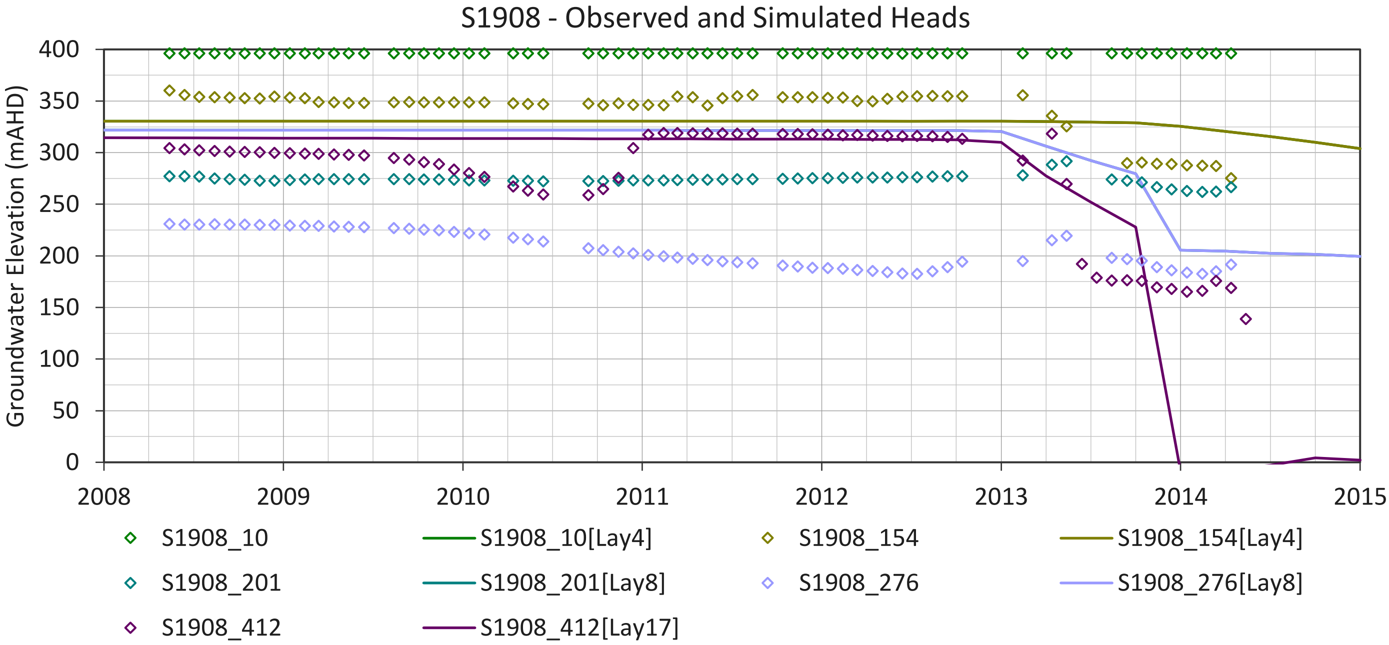
S1892 - Observed and Simulated Heads

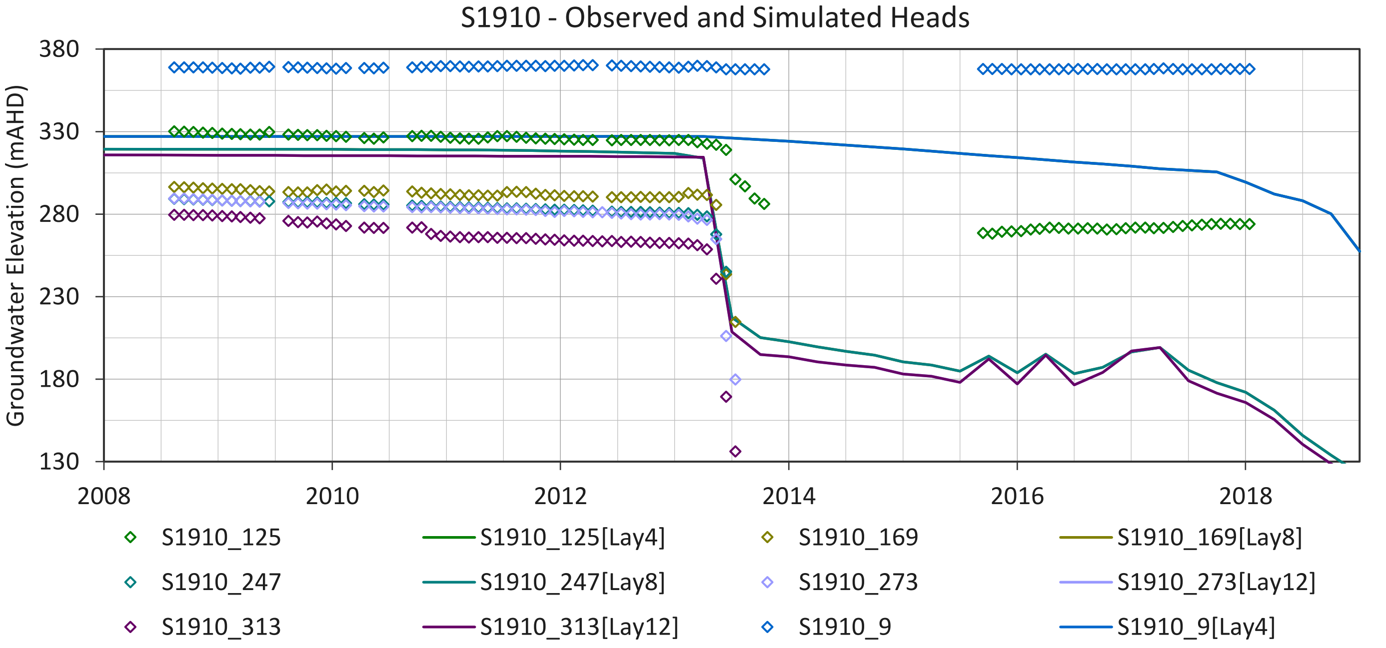


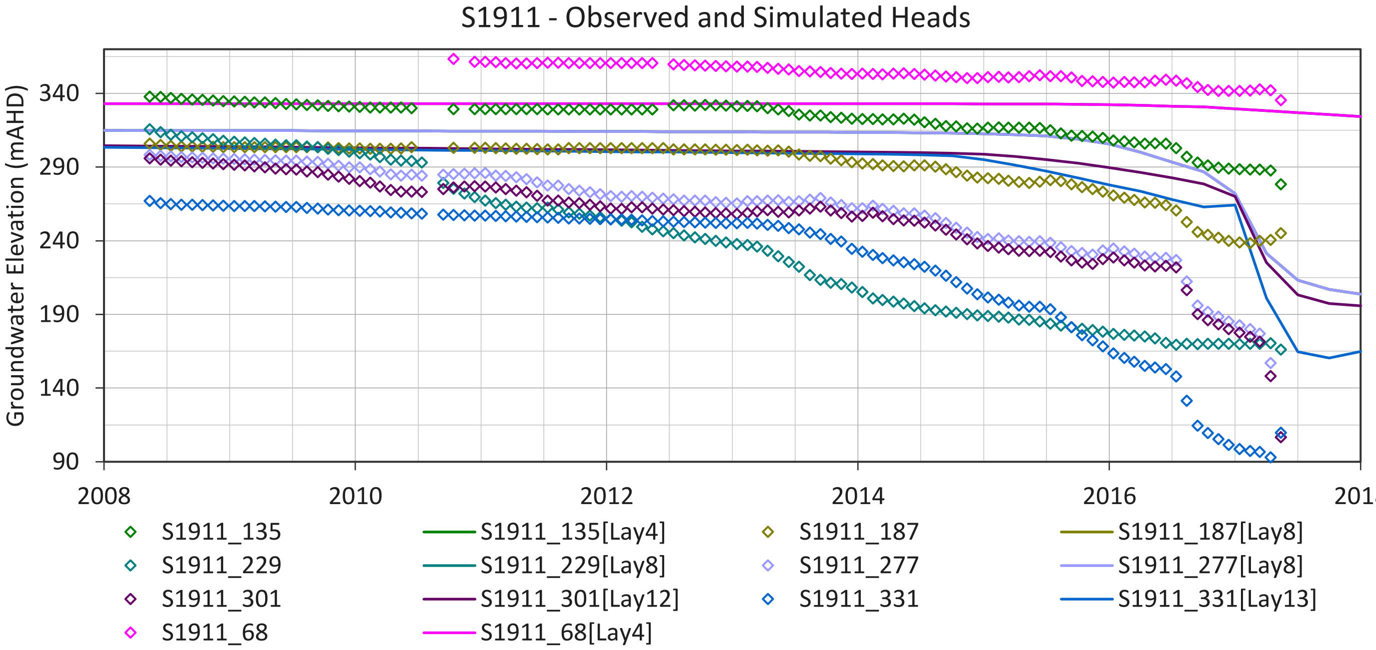
S1902 - Observed and Simulated Heads

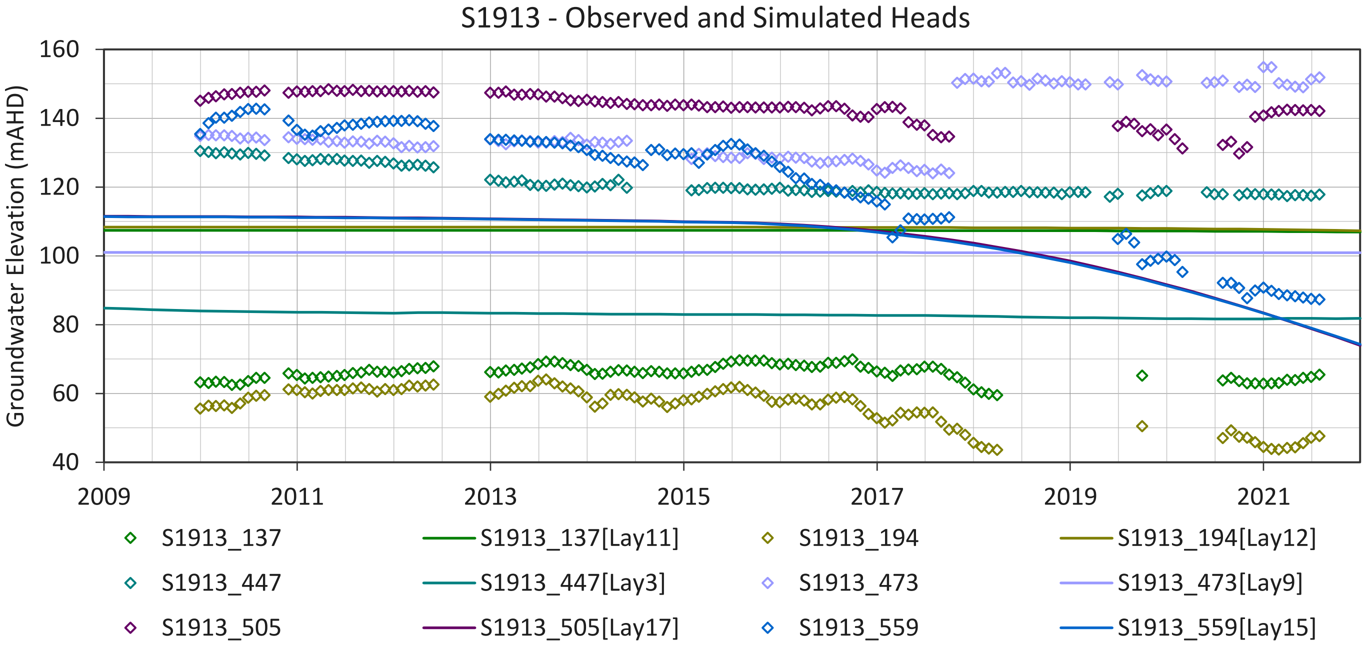


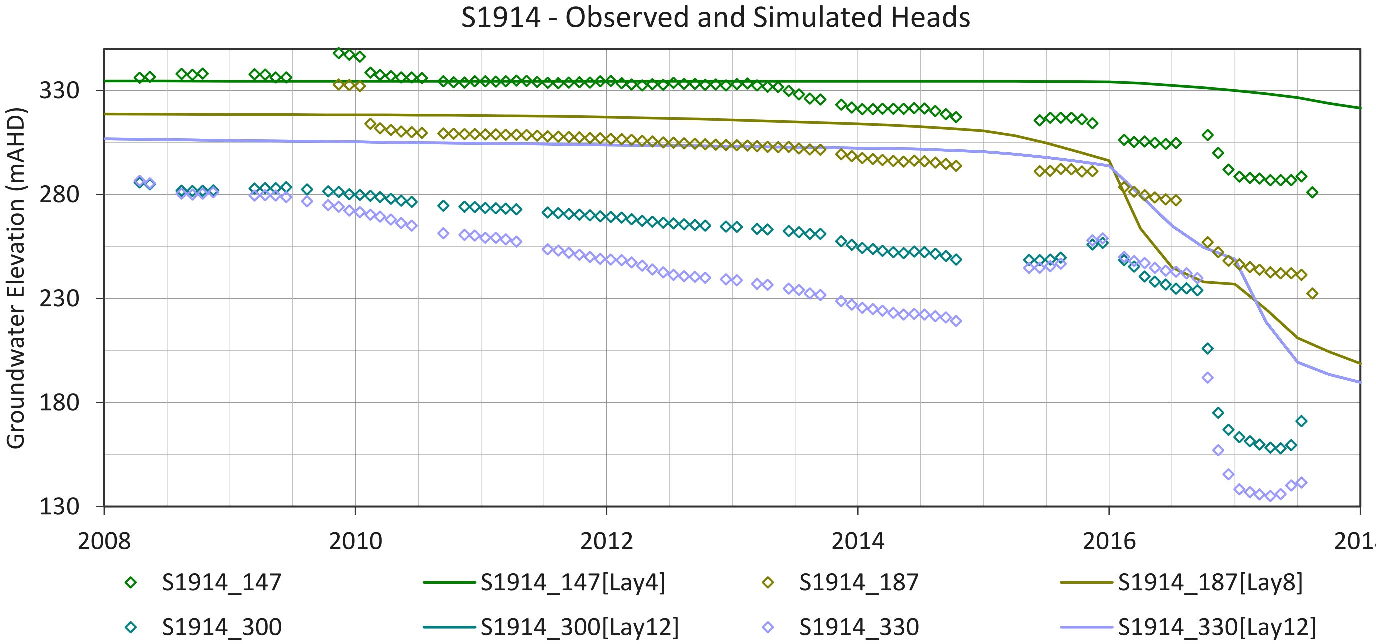

S1907 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
380
330
280
230
180
130
2007
2009
2011
2013
2015
2017
2019
S1907_11
S1907_11[Lay5]
S1907_169
S1907_169[Lay8]
S1907_204
S1907_204[Lay12]
S1907_209
S1907_209[Lay12]
S1907_21
S1907_21[Lay5]
S1907_256
S1907_256[Lay15]
S1907_65
S1907_65[Lay8]

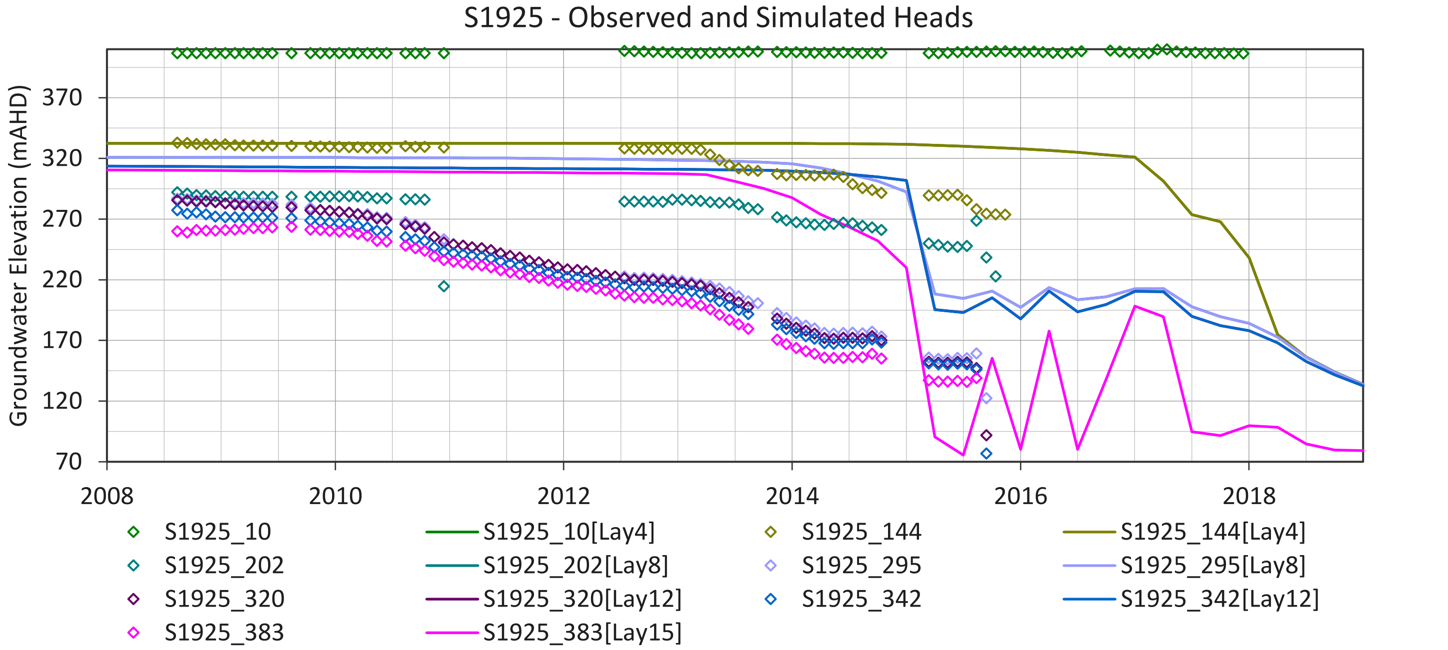

S1908 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
400
350
300
250
200
150
100
50
0
2008
2009
2010
2011
2012
2013
2014
2015
S1908_10
S1908_10[Lay4]
S1908_154
S1908_154[Lay4]
S1908_201
S1908_201[Lay8]
S1908_276
S1908_276[Lay8]
S1908_412
S1908_412[Lay17]

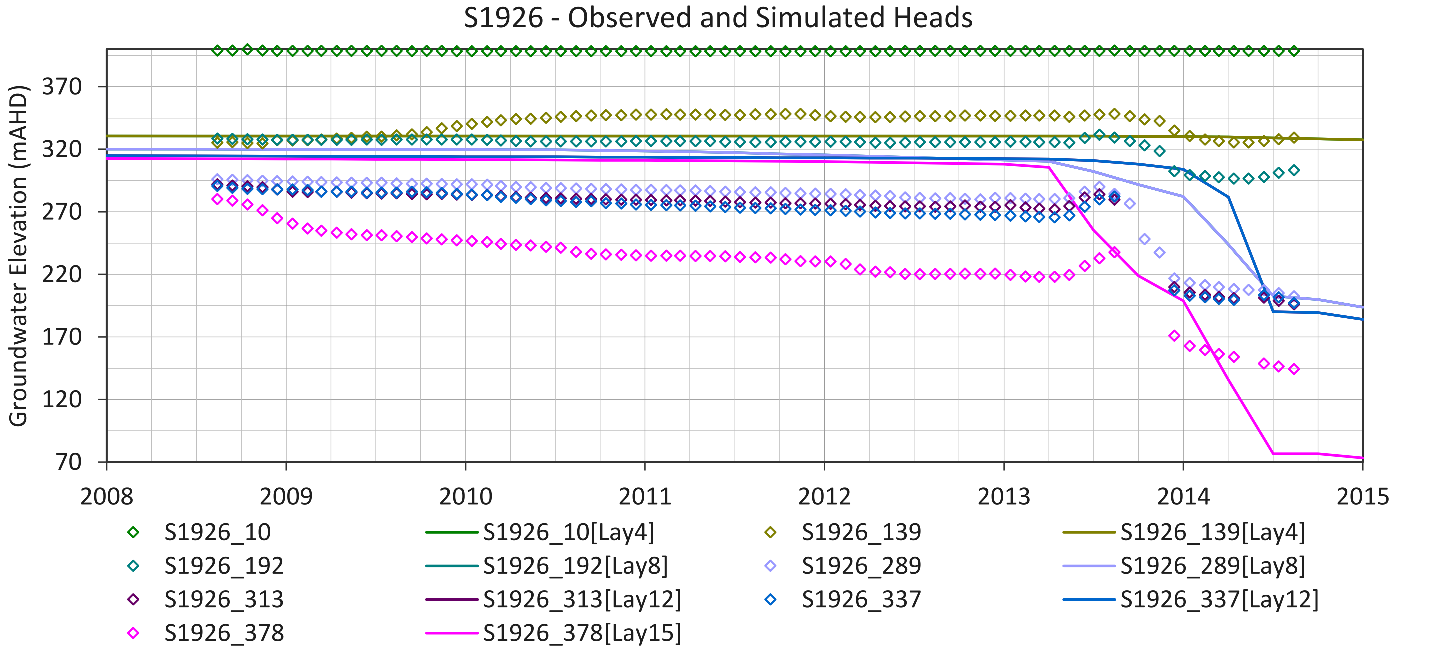

S1910 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
380
330
280
230
180
130
2008
2010
2012
2014
2016
2018
S1910_125
S1910_125[Lay4]
S1910_169
S1910_169[Lay8]
S1910_247
S1910_247[Lay8]
S1910_273
S1910_273[Lay12]
S1910_313
S1910_313[Lay12]
S1910_9
S1910_9[Lay4]

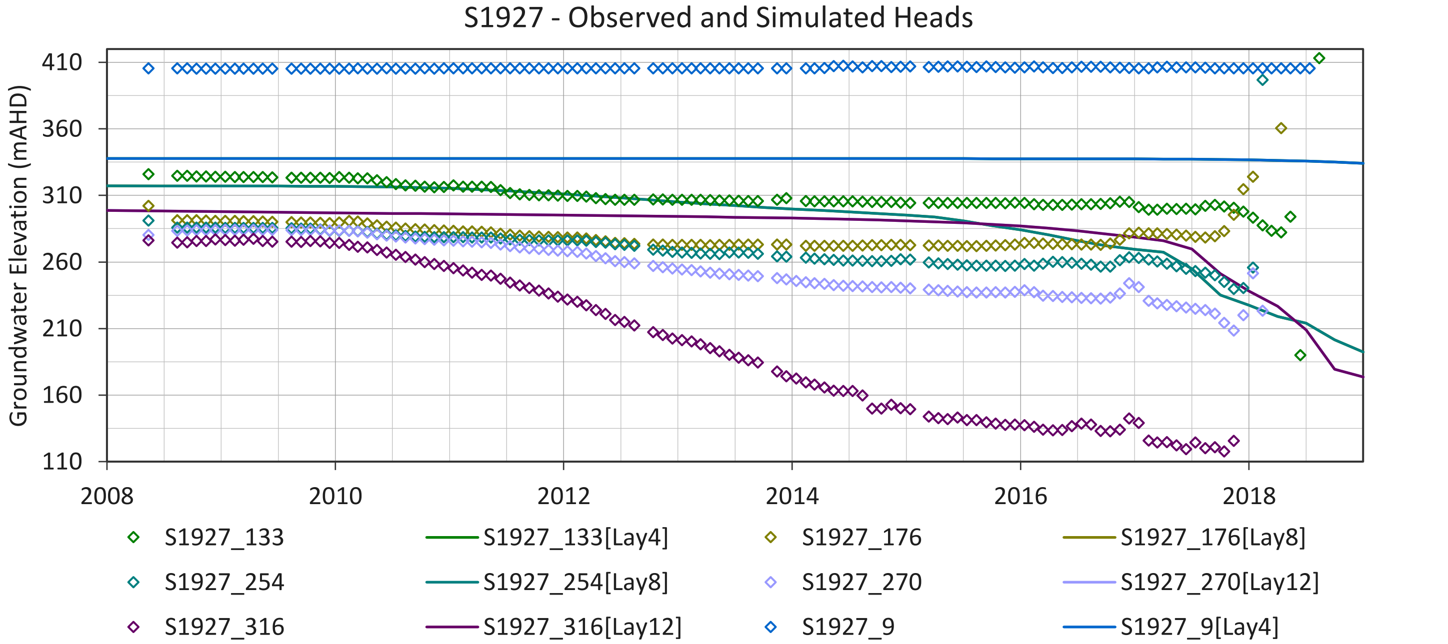

S1911 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
340
290
240
190
140
90
2008
2010
2012
2014
2016
2018
S1911_135
S1911_135[Lay4]
S1911_187
S1911_187[Lay8]
S1911_229
S1911_229[Lay8]
S1911_277
S1911_277[Lay8]
S1911_301
S1911_301[Lay12]
S1911_331
S1911_331[Lay13]
S1911_68
S1911_68[Lay4]

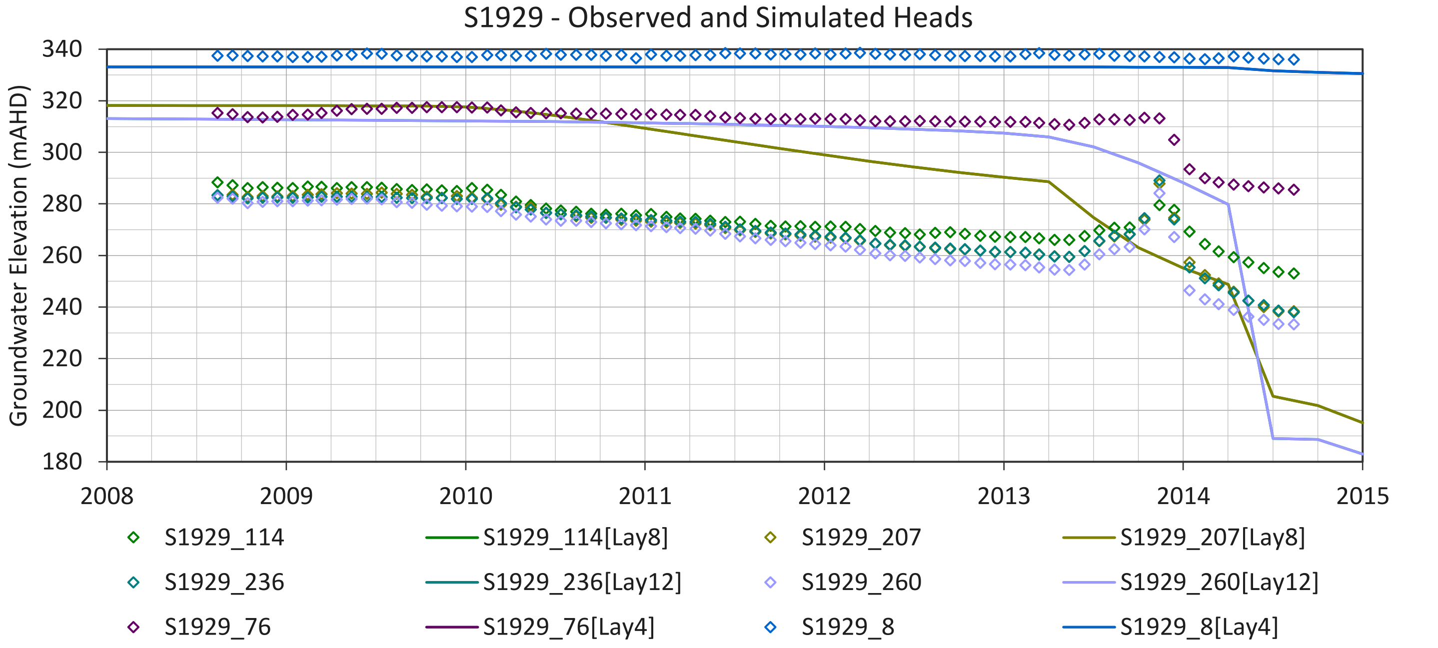

S1913 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
160
140
120
100
80
60
40
2009
2011
2013
2015
2017
2019
2021
S1913_137
S1913_137[Lay11]
S1913_194
S1913_194[Lay12]
S1913_447
S1913_447[Lay3]
S1913_473
S1913_473[Lay9]
S1913_505
S1913_505[Lay17]
S1913_559
S1913_559[Lay15]

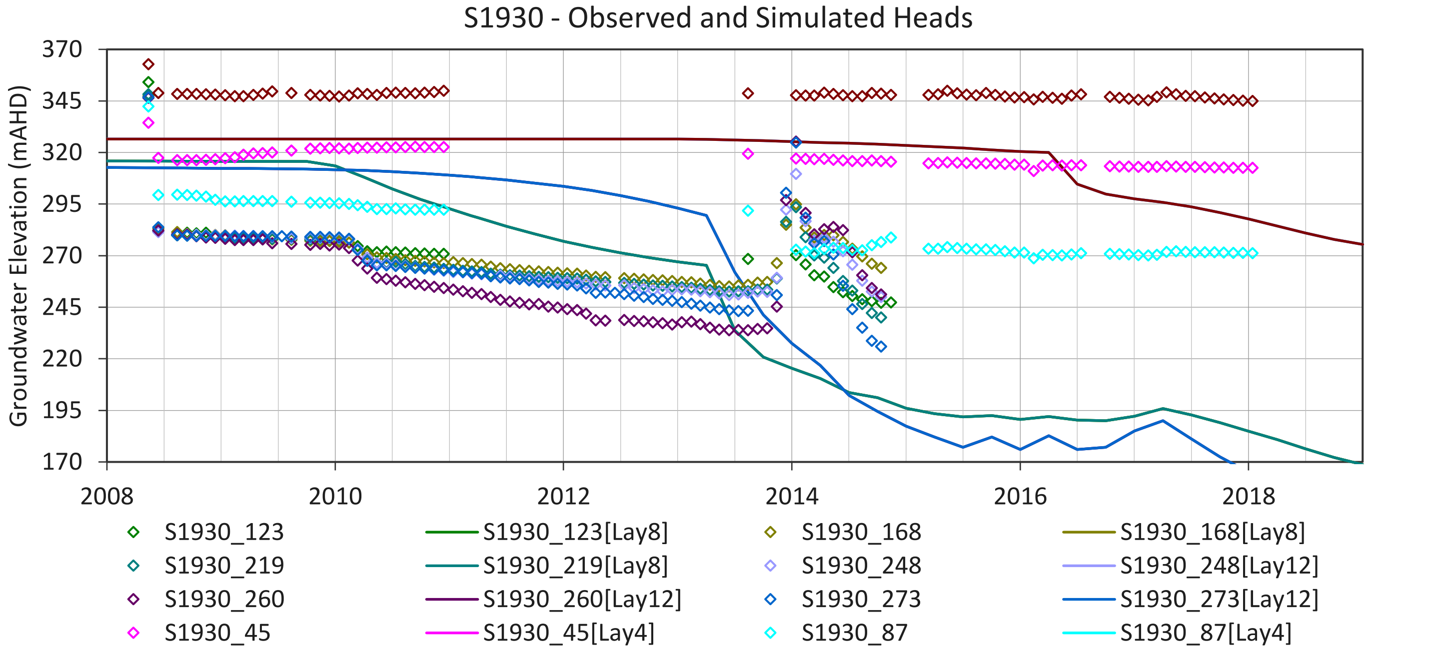

S1914 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
330
280
230
180
130
2008
2010
2012
2014
2016
2018
S1914_147
S1914_147[Lay4]
S1914_187
S1914_187[Lay8]
S1914_300
S1914_300[Lay12]
S1914_330
S1914_330[Lay12]

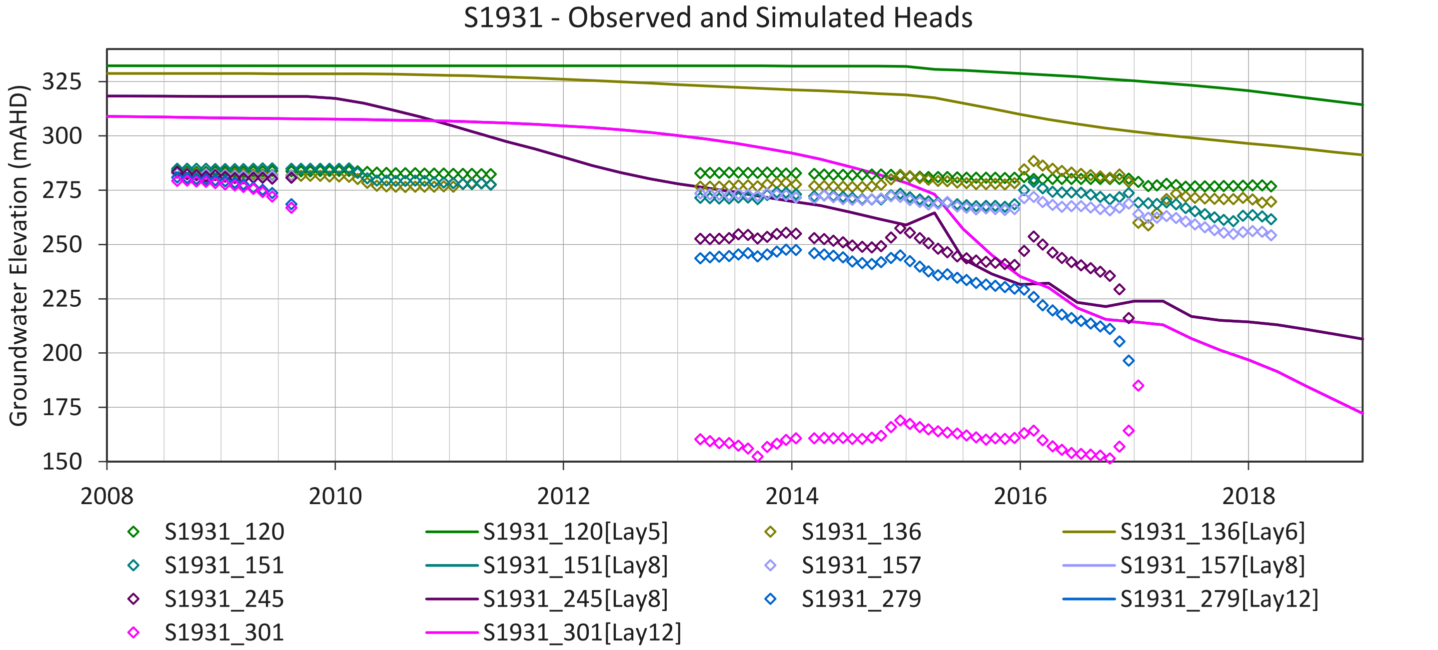

S1925 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
370
320
270
220
170
120
70
2008
2010
2012
2014
2016
2018
S1925_10
S1925_10[Lay4]
S1925_144
S1925_144[Lay4]
S1925_202
S1925_202[Lay8]
S1925_295
S1925_295[Lay8]
S1925_320
S1925_320[Lay12]
S1925_342
S1925_342[Lay12]
S1925_383
S1925_383[Lay15]

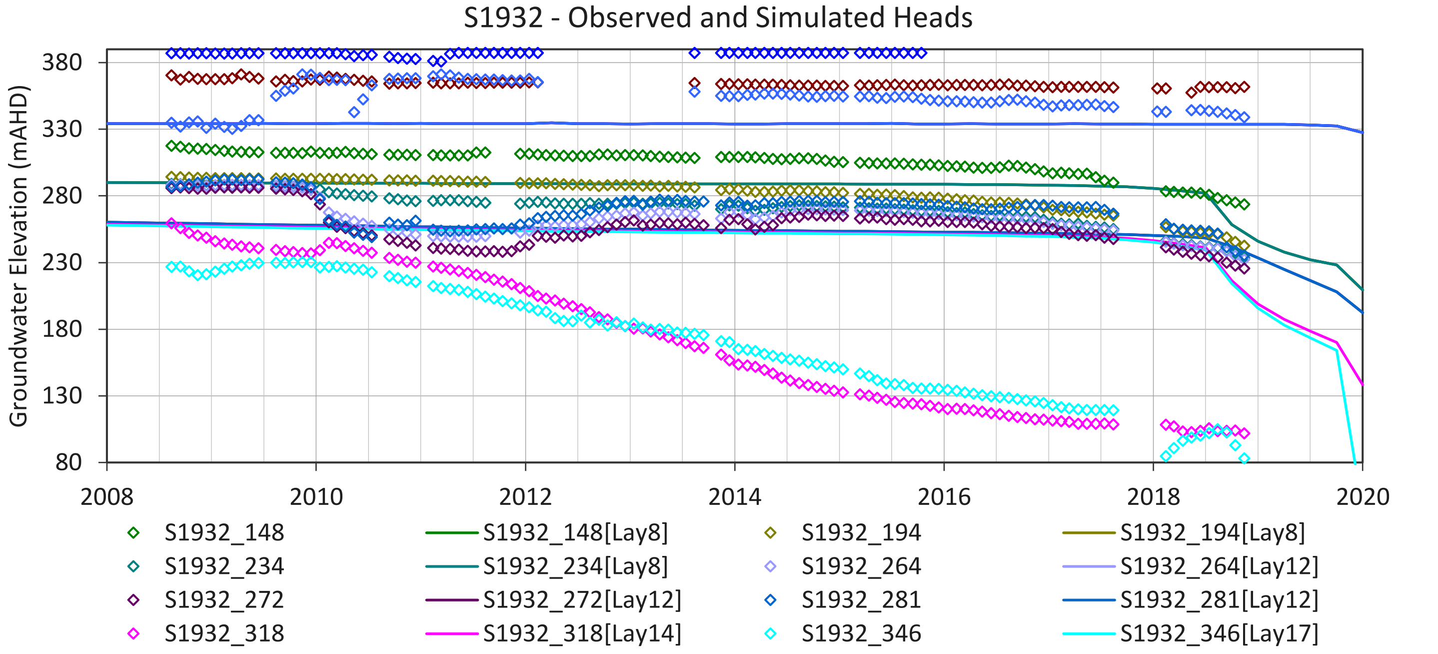

S1926 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
370
320
270
220
170
120
70
2008
2009
2010
2011
2012
2013
2014
2015
S1926_10
S1926_10[Lay4]
S1926_139
S1926_139[Lay4]
S1926_192
S1926_192[Lay8]
S1926_289
S1926_289[Lay8]
S1926_313
S1926_313[Lay12]
S1926_337
S1926_337[Lay12]
S1926_378
S1926_378[Lay15]

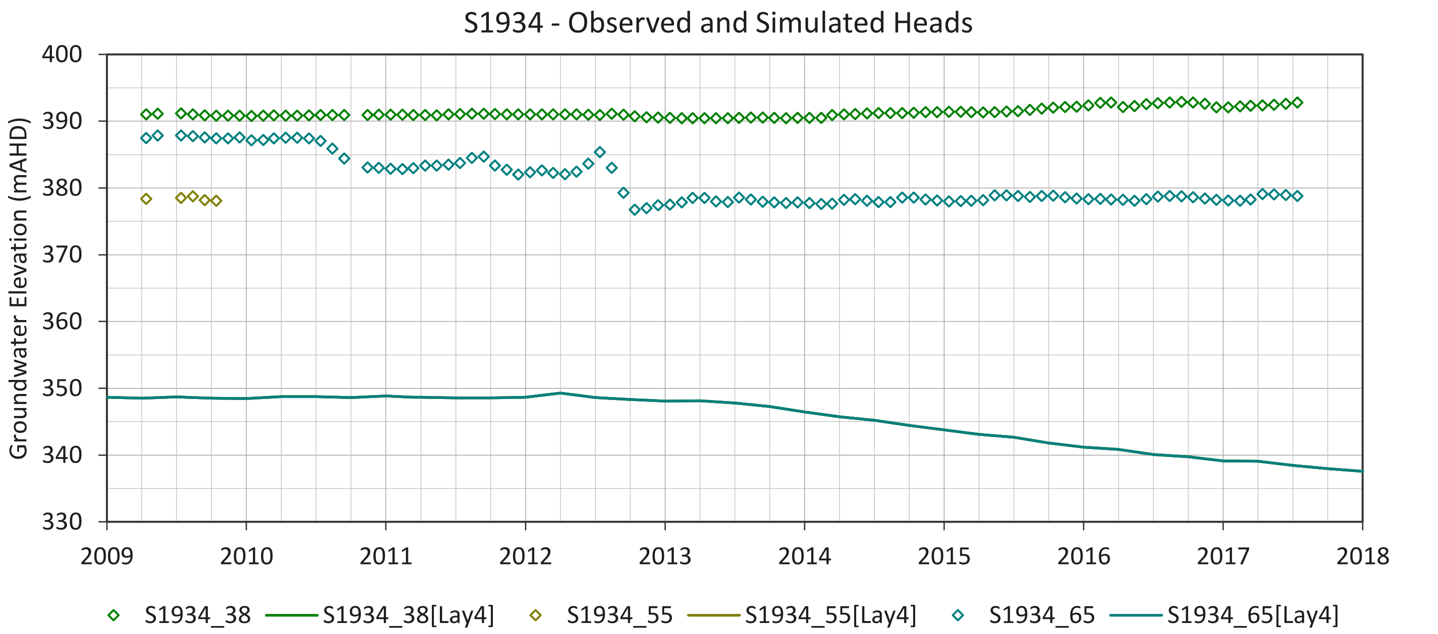

S1927 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
410
360
310
260
210
160
110
2008
2010
2012
2014
2016
2018
S1927_133
S1927_133[Lay4]
S1927_176
S1927_176[Lay8]
S1927_254
S1927_254[Lay8]
S1927_270
S1927_270[Lay12]
S1927_316
S1927_316[Lay12]
S1927_9
S1927_9[Lay4]

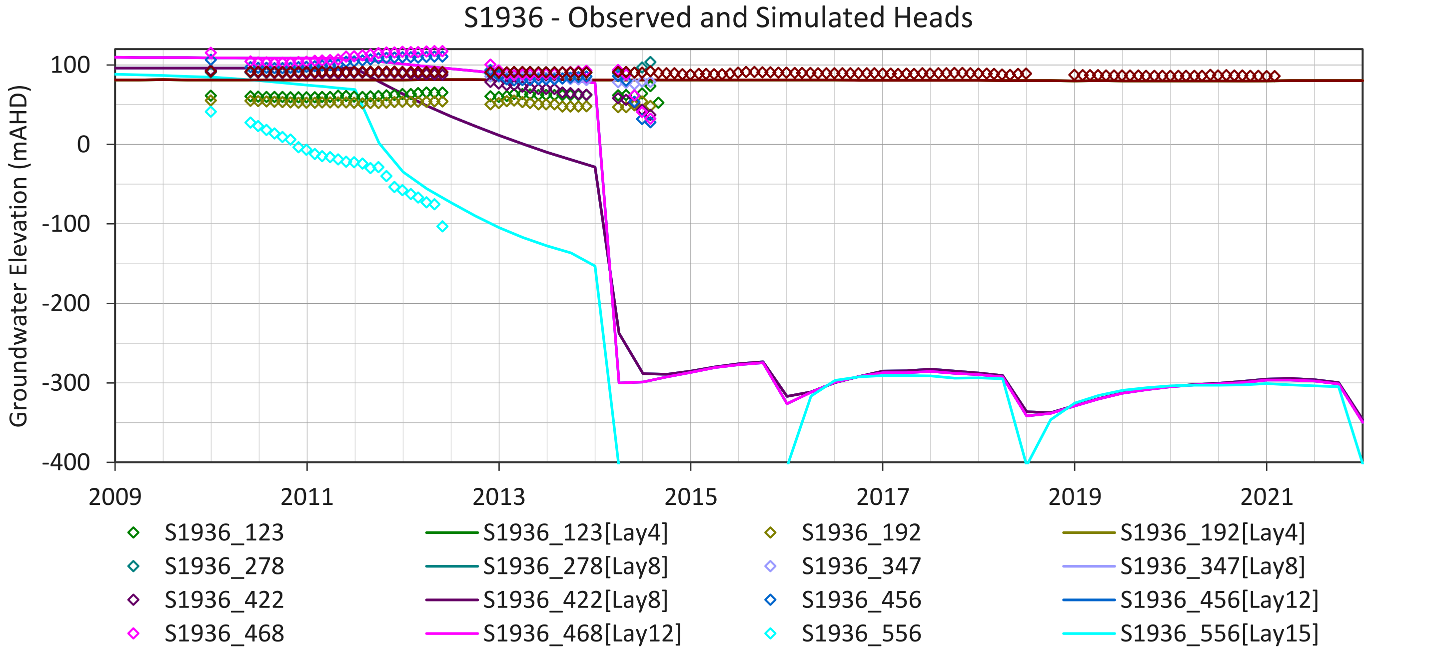

S1929 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
340
320
300
280
260
240
220
200
180
2008
2009
2010
2011
2012
2013
2014
2015
S1929_114
S1929_114[Lay8]
S1929_207
S1929_207[Lay8]
S1929_236
S1929_236[Lay12]
S1929_260
S1929_260[Lay12]
S1929_76
S1929_76[Lay4]
S1929_8
S1929_8[Lay4]

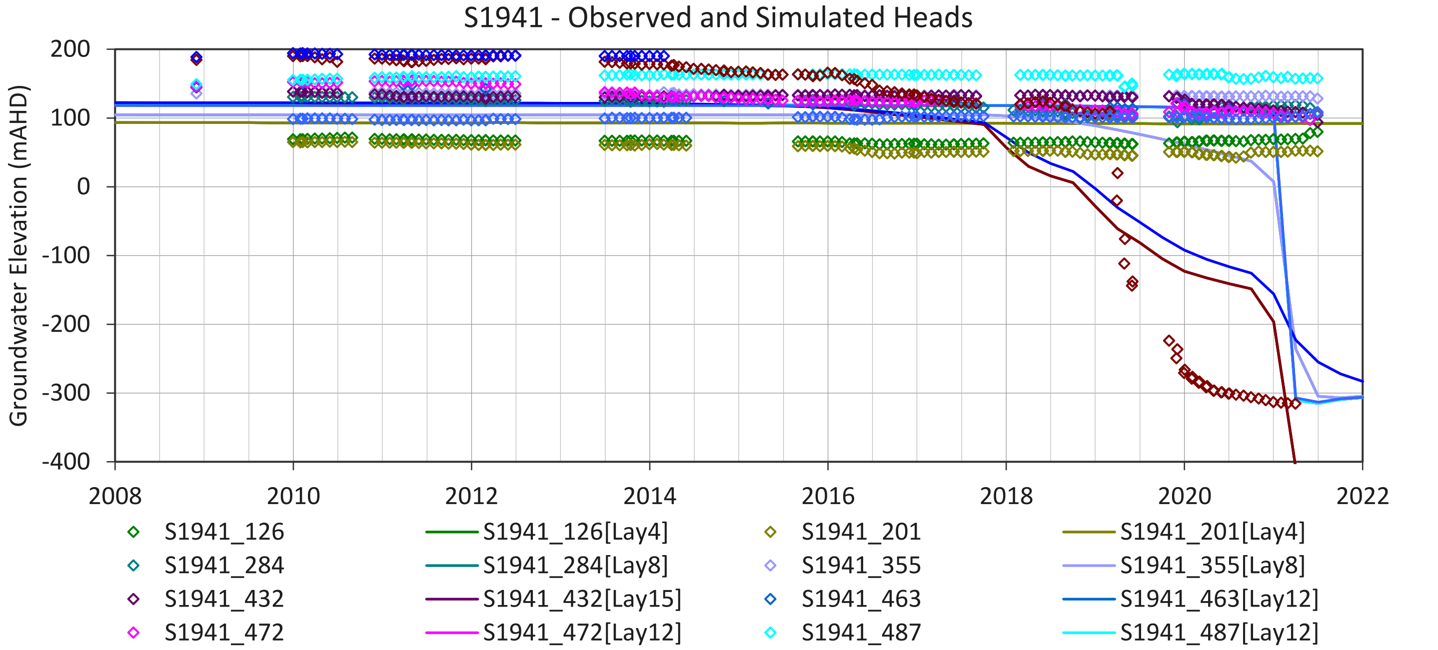

S1930 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
370
345
320
295
270
245
220
195
170
2008
2010
2012
2014
2016
2018
S1930_123
S1930_123[Lay8]
S1930_168
S1930_168[Lay8]
S1930_219
S1930_219[Lay8]
S1930_248
S1930_248[Lay12]
S1930_260
S1930_260[Lay12]
S1930_273
S1930_273[Lay12]
S1930_45
S1930_45[Lay4]
S1930_87
S1930_87[Lay4]

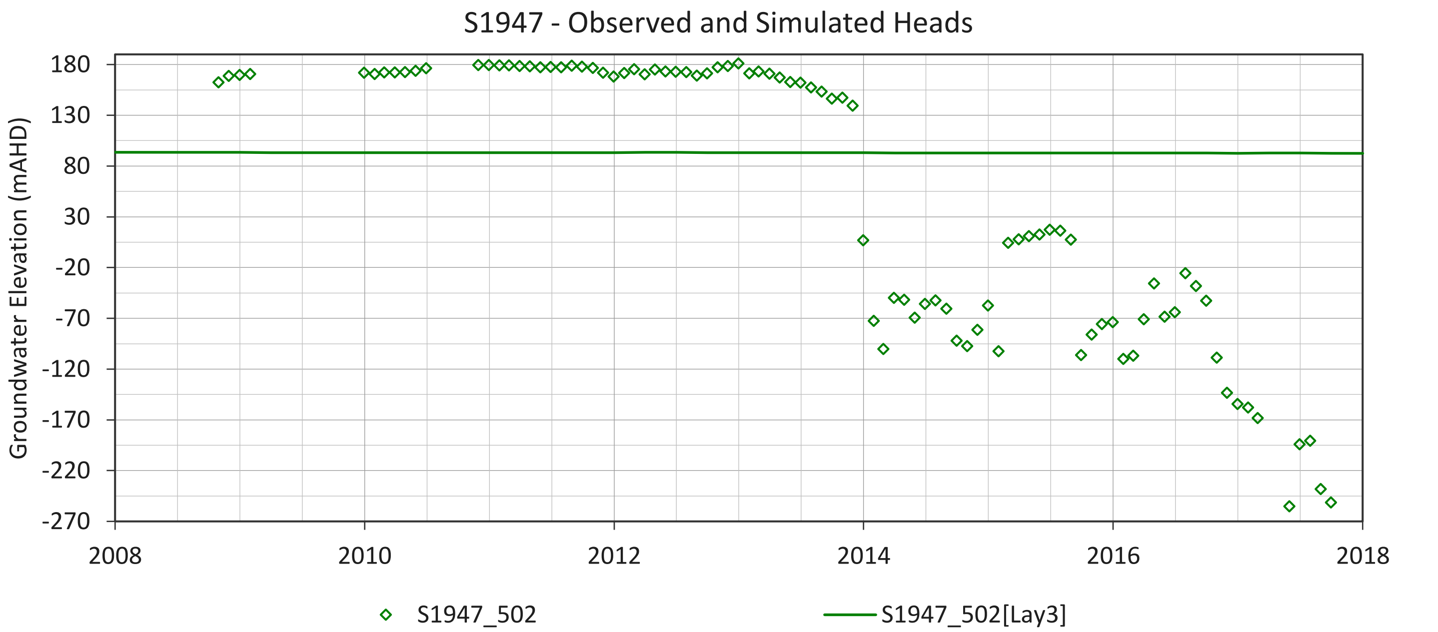

S1931 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
325
300
275
250
225
200
175
150
2008
2010
2012
2014
2016
2018
S1931_120
S1931_120[Lay5]
S1931_136
S1931_136[Lay6]
S1931_151
S1931_151[Lay8]
S1931_157
S1931_157[Lay8]
S1931_245
S1931_245[Lay8]
S1931_279
S1931_279[Lay12]
S1931_301
S1931_301[Lay12]

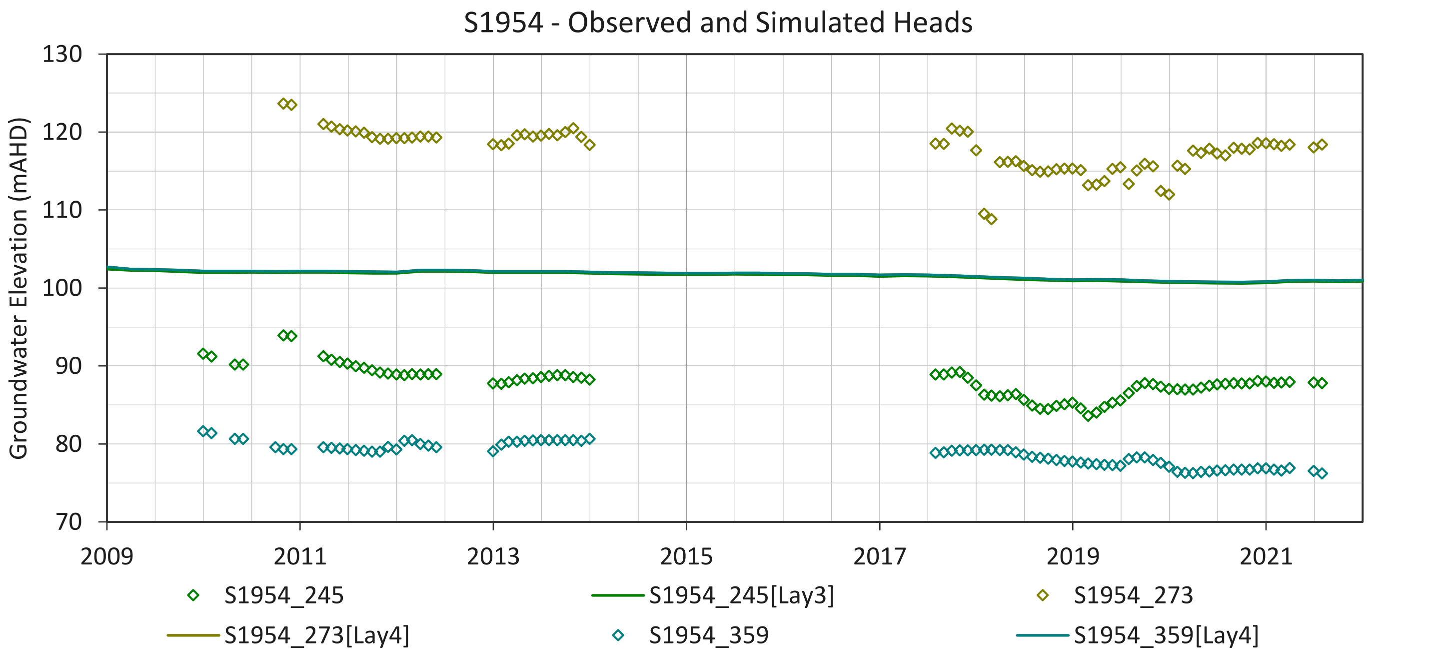

S1932 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
380
330
280
230
180
130
80
2008
2010
2012
2014
2016
2018
2020
S1932_148
S1932_148[Lay8]
S1932_194
S1932_194[Lay8]
S1932_234
S1932_234[Lay8]
S1932_264
S1932_264[Lay12]
S1932_272
S1932_272[Lay12]
S1932_281
S1932_281[Lay12]
S1932_318
S1932_318[Lay14]
S1932_346
S1932_346[Lay17]

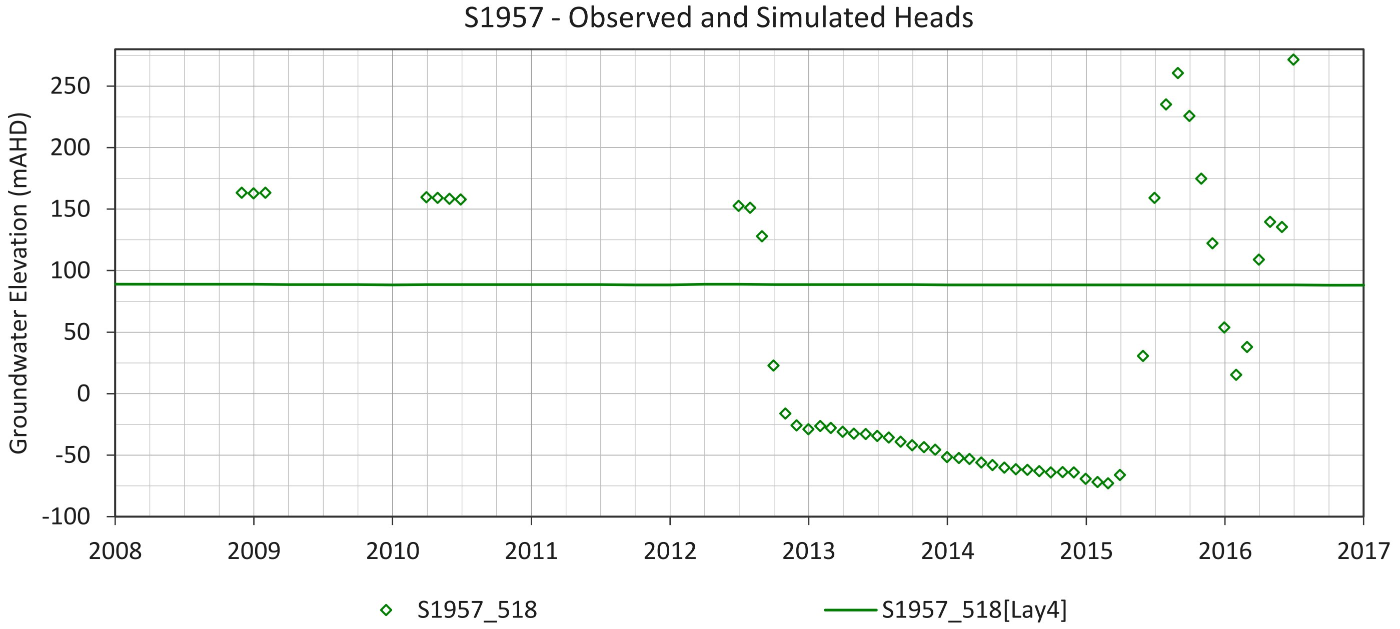

S1934 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
400
390
380
370
360
350
340
330
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
S1934_38
S1934_38[Lay4]
S1934_55
S1934_55[Lay4]
S1934_65
S1934_65[Lay4]

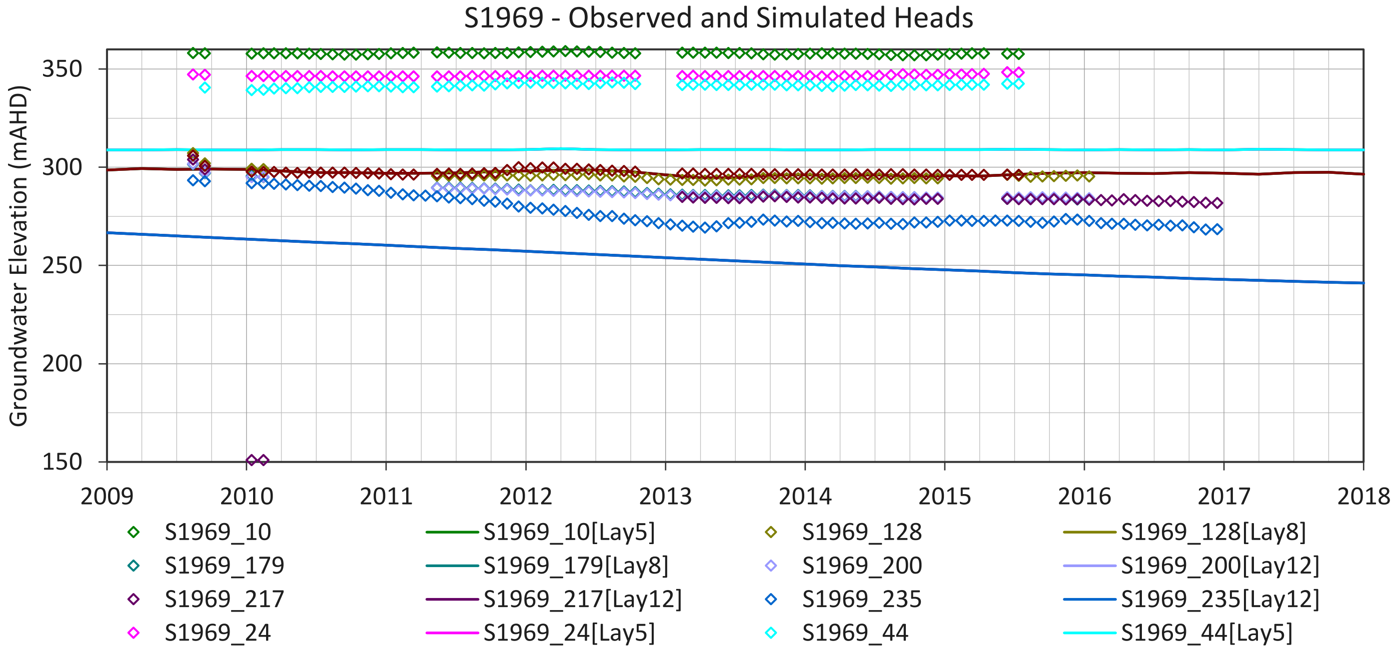

S1936 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
100
0
-100
-200
-300
-400
2009
2011
2013
2015
2017
2019
2021
S1936_123
S1936_123[Lay4]
S1936_192
S1936_192[Lay4]
S1936_278
S1936_278[Lay8]
S1936_347
S1936_347[Lay8]
S1936_422
S1936_422[Lay8]
S1936_456
S1936_456[Lay12]
S1936_468
S1936_468[Lay12]
S1936_556
S1936_556[Lay15]

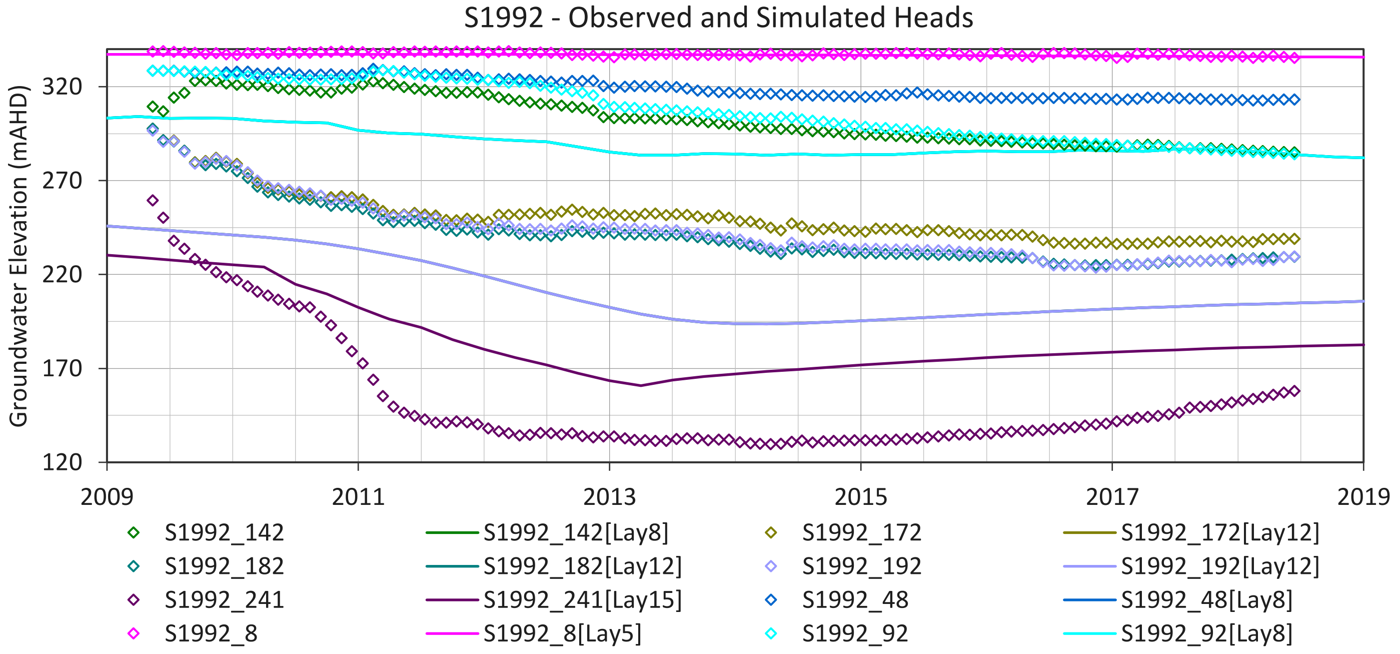

S1941 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
200
100
0
-100
-200
-300
-400
2008
2010
2012
2014
2016
2018
2020
2022
S1941_126
S1941_126[Lay4]
S1941_201
S1941_201[Lay4]
S1941_284
S1941_284[Lay8]
S1941_355
S1941_355[Lay8]
S1941_432
S1941_432[Lay15]
S1941_463
S1941_463[Lay12]
S1941_472
S1941_472[Lay12]
S1941_487
S1941_487[Lay12]

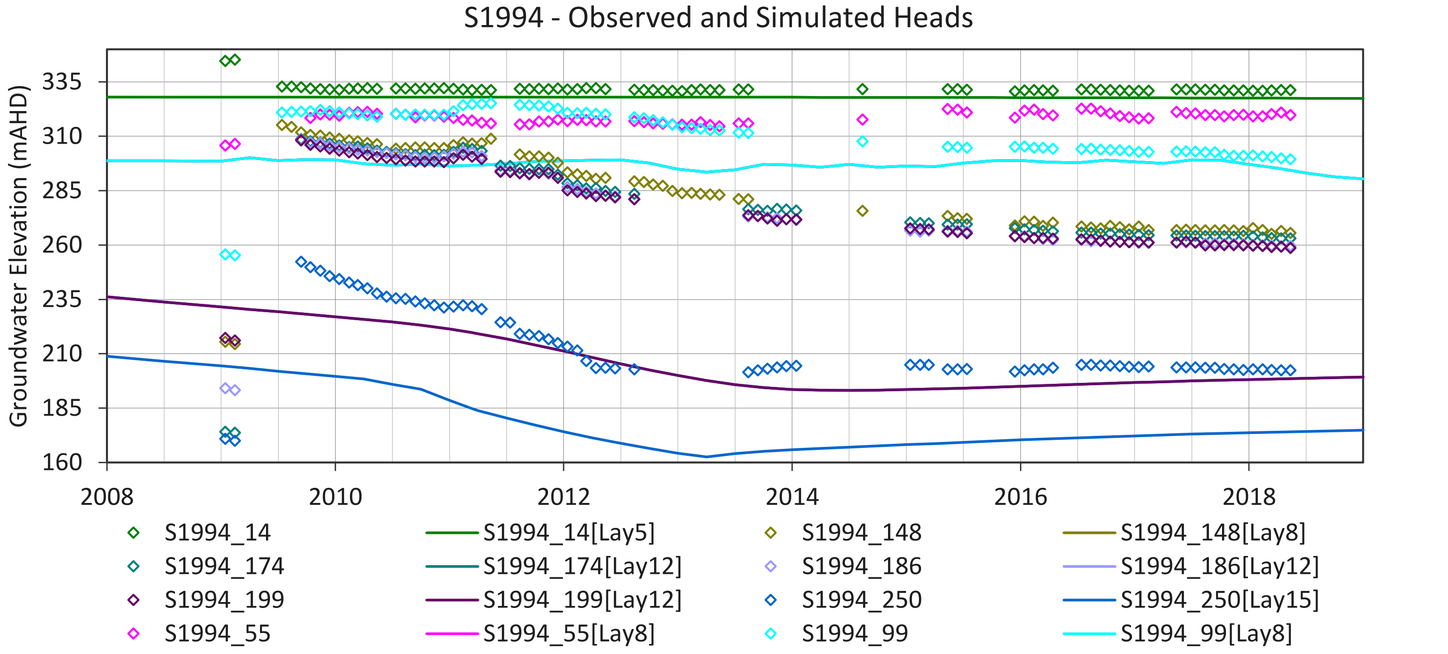

S1947 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
180
130
80
30
-20
-70
-120
-170
-220
-270
2008
2010
2012
2014
2016
2018
S1947_502
S1947_502[Lay3]

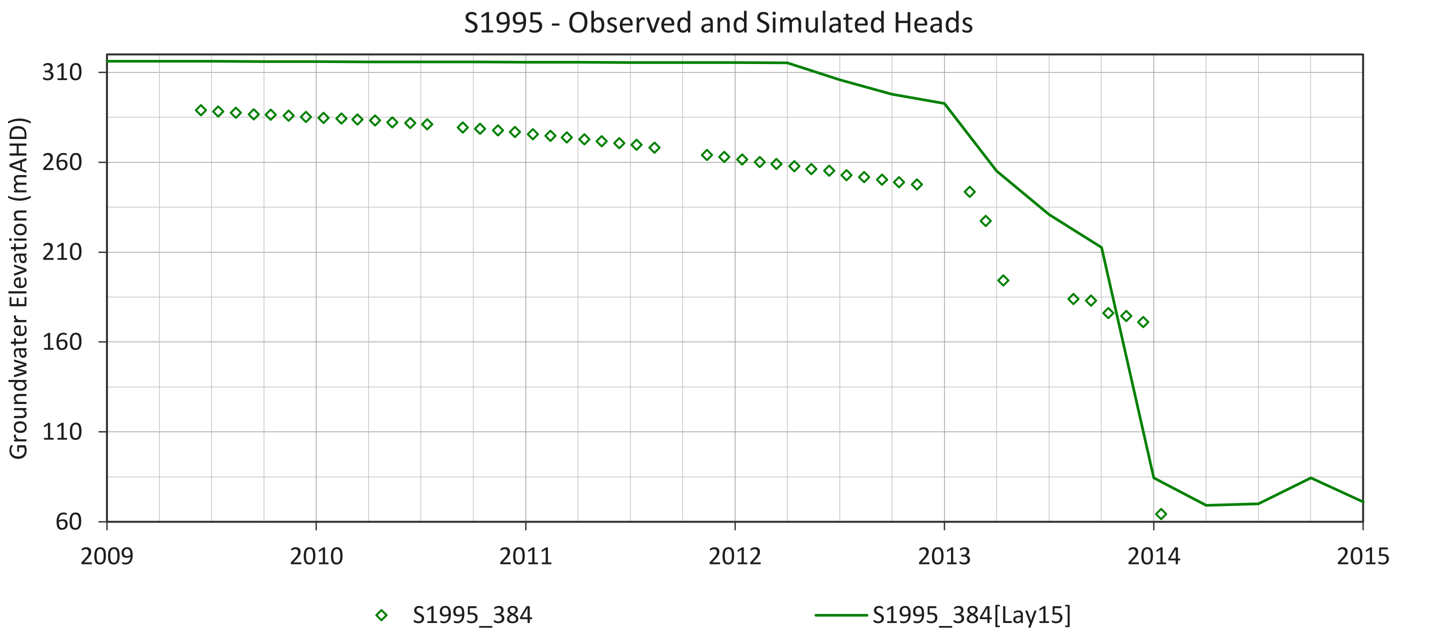

S1954 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
130
120
110
100
90
80
70
2009
2011
2013
2015
2017
2019
2021
S1954_245
S1954_245[Lay3]
S1954_273
S1954_273[Lay4]
S1954_359
S1954_359[Lay4]

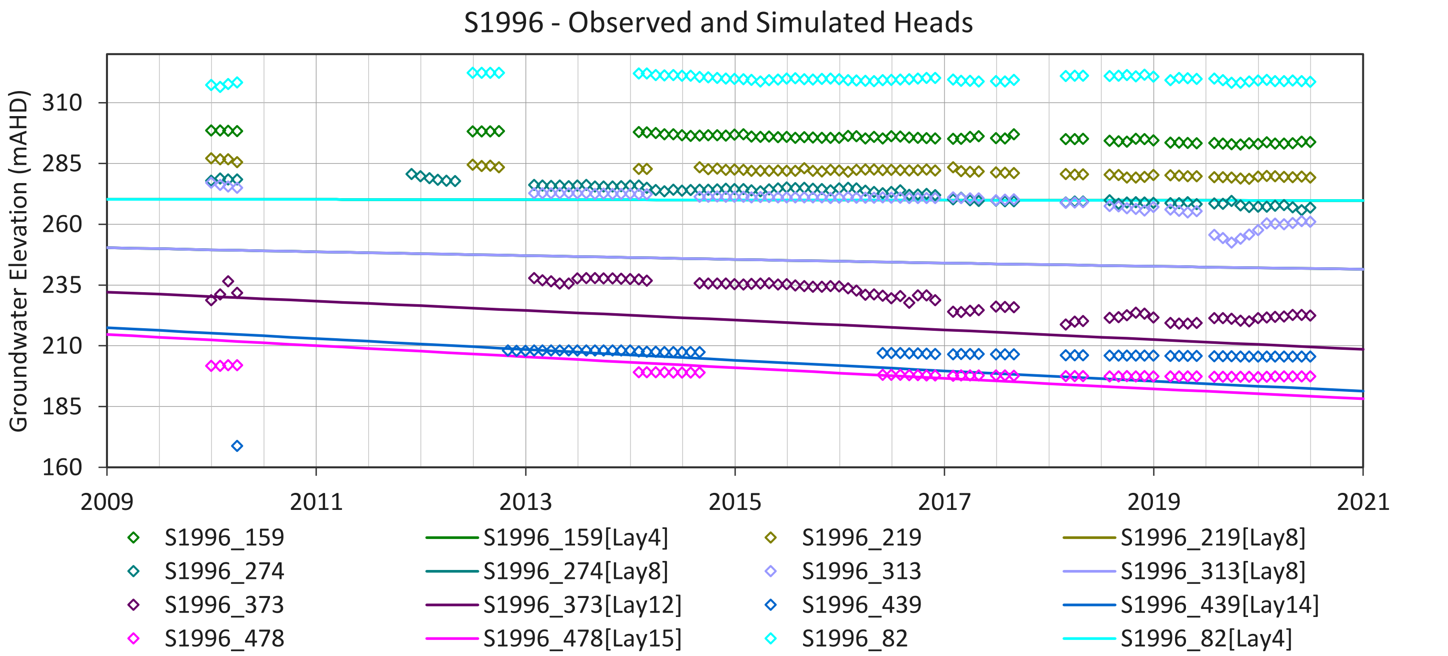

S1957 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
250
200
150
100
50
0
-50
-100
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
S1957_518
S1957_518[Lay4]

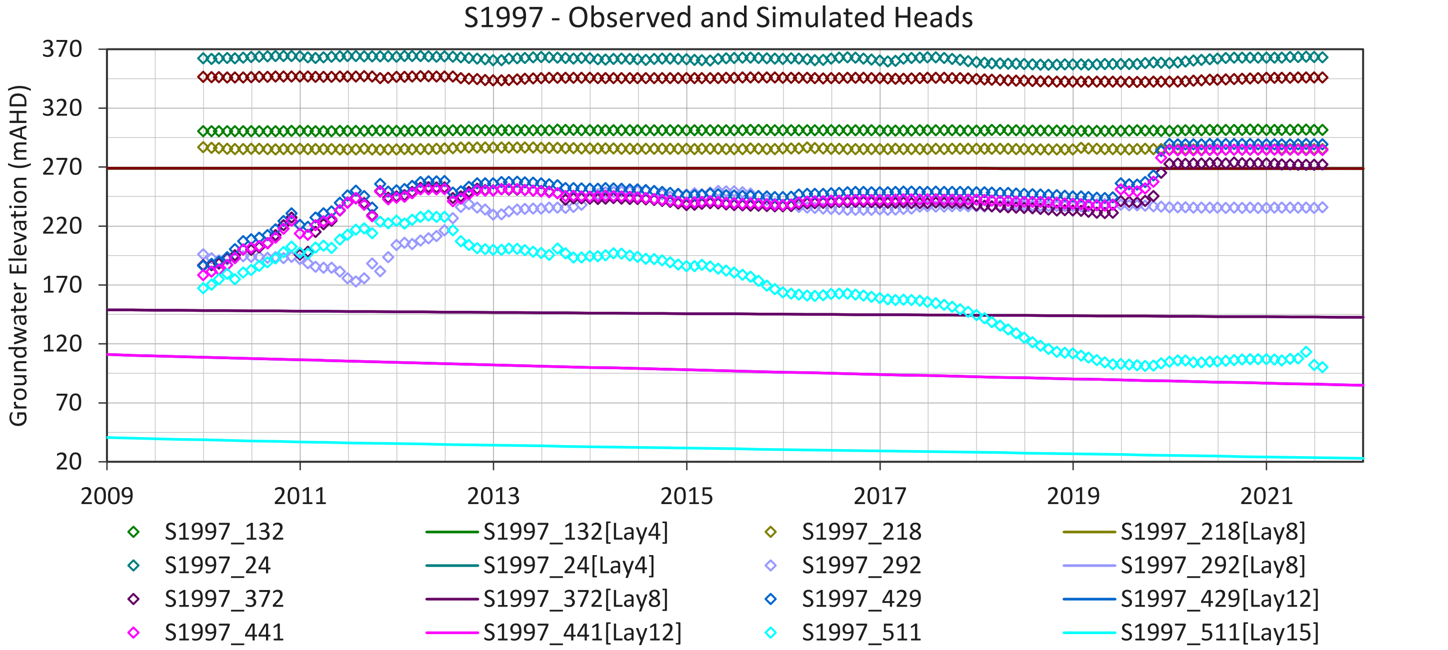

S1969 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
350
300
250
200
150
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
S1969_10
S1969_10[Lay5]
S1969_128
S1969_128[Lay8]
S1969_179
S1969_179[Lay8]
S1969_200
S1969_200[Lay12]
S1969_217
S1969_217[Lay12]
S1969_235
S1969_235[Lay12]
S1969_24
S1969_24[Lay5]
S1969_44
S1969_44[Lay5]

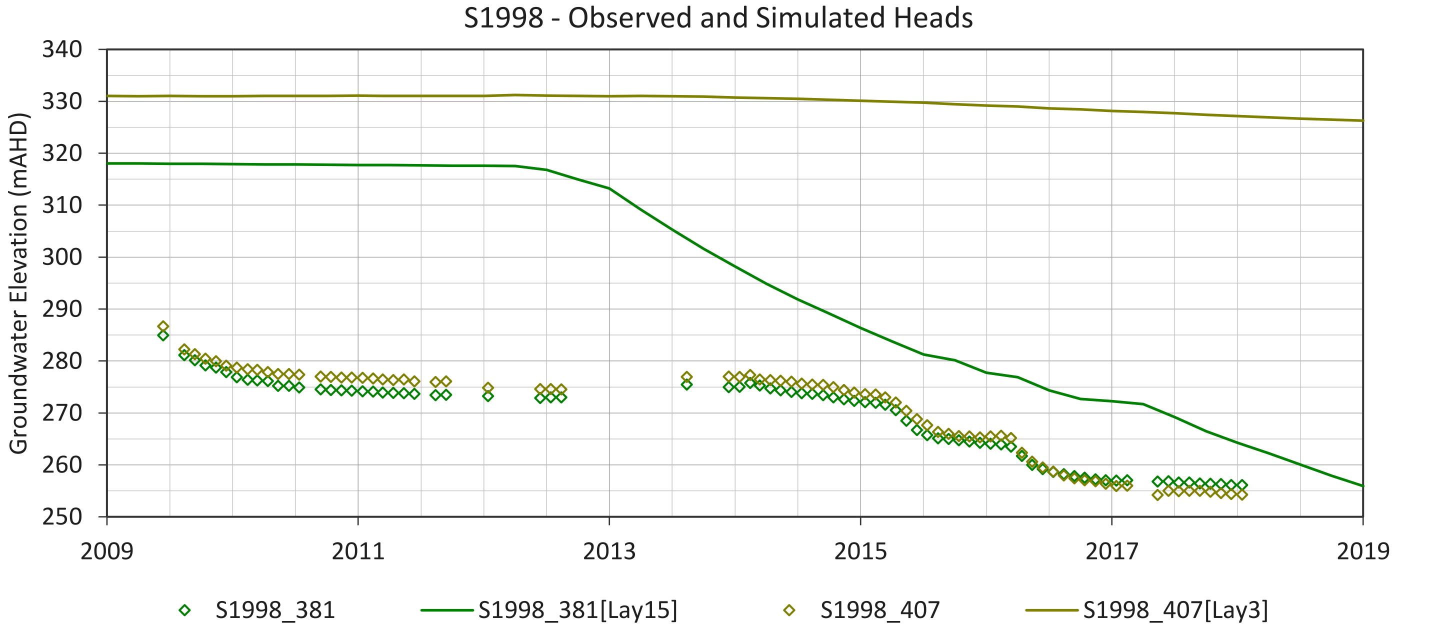

S1992 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
320
270
220
170
120
2009
2011
2013
2015
2017
2019
S1992_142
S1992_142[Lay8]
S1992_172
S1992_172[Lay12]
S1992_182
S1992_182[Lay12]
S1992_192
S1992_192[Lay12]
S1992_241
S1992_241[Lay15]
S1992_48
S1992_48[Lay8]
S1992_8
S1992_8[Lay5]
S1992_92
S1992_92[Lay8]

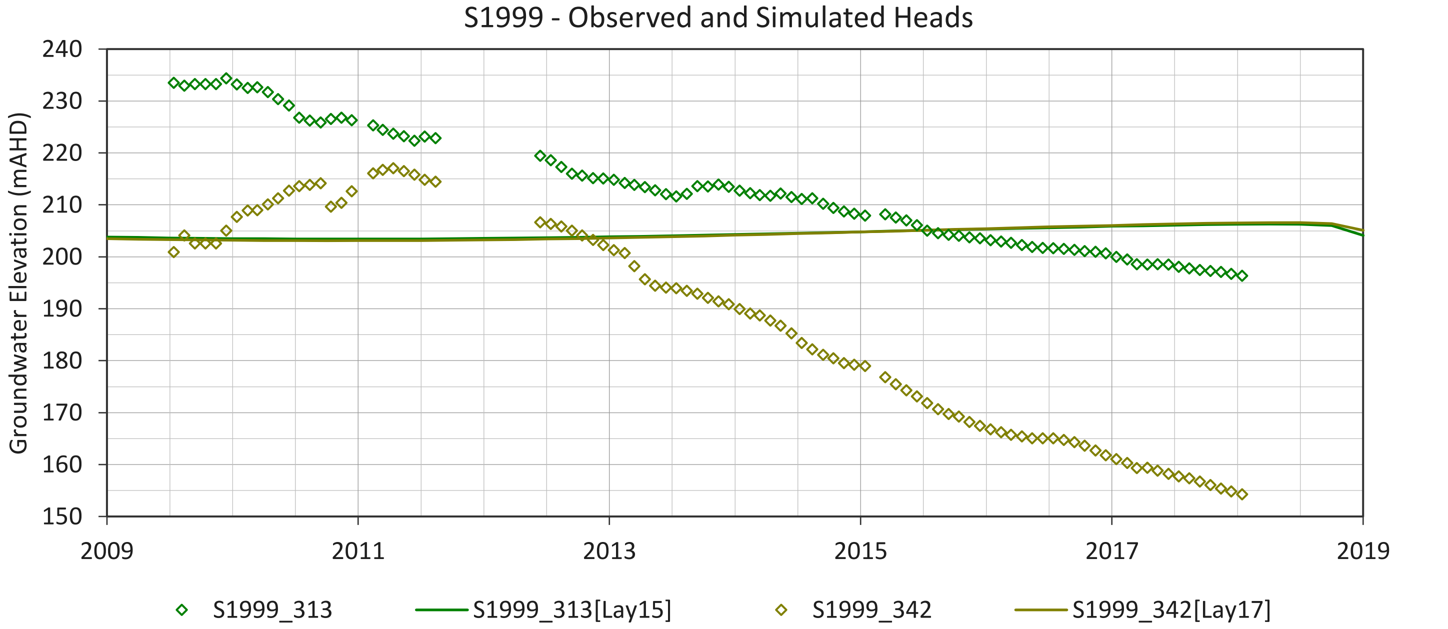

S1994 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
335
310
285
260
235
210
185
160
2008
2010
2012
2014
2016
2018
S1994_14
S1994_14[Lay5]
S1994_148
S1994_148[Lay8]
S1994_174
S1994_174[Lay12]
S1994_186
S1994_186[Lay12]
S1994_199
S1994_199[Lay12]
S1994_250
S1994_250[Lay15]
S1994_55
S1994_55[Lay8]
S1994_99
S1994_99[Lay8]

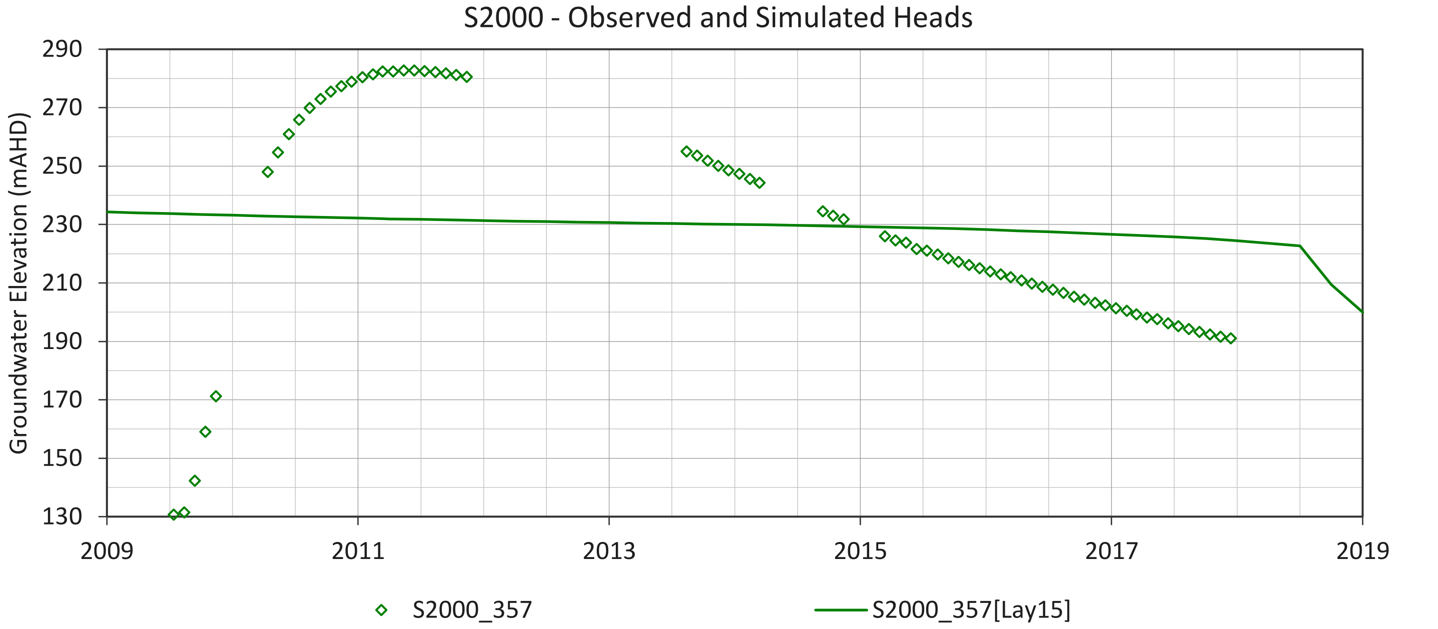

S1995 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
310
260
210
160
110
60
2009
2010
2011
2012
2013
2014
2015
S1995_384
S1995_384[Lay15]

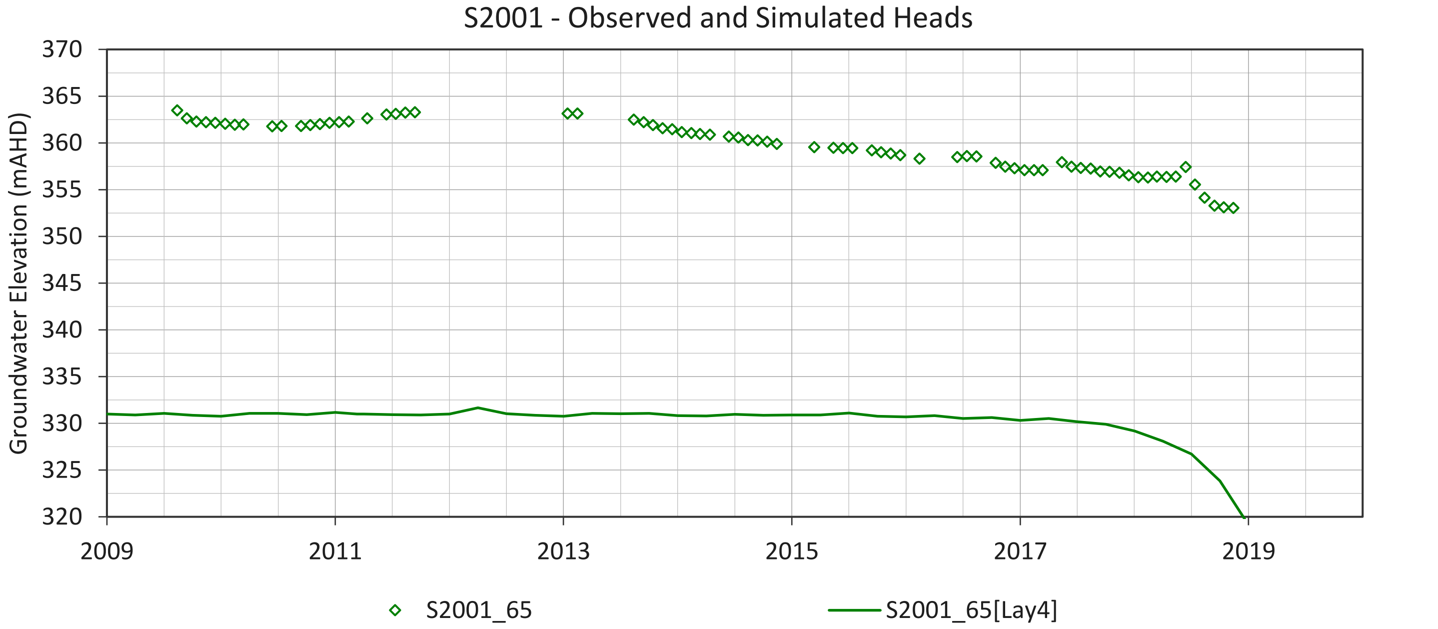

S1996 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
310
285
260
235
210
185
160
2009
2011
2013
2015
2017
2019
2021
S1996_159
S1996_159[Lay4]
S1996_219
S1996_219[Lay8]
S1996_274
S1996_274[Lay8]
S1996_313
S1996_313[Lay8]
S1996_373
S1996_373[Lay12]
S1996_439
S1996_439[Lay14]
S1996_478
S1996_478[Lay15]
S1996_82
S1996_82[Lay4]

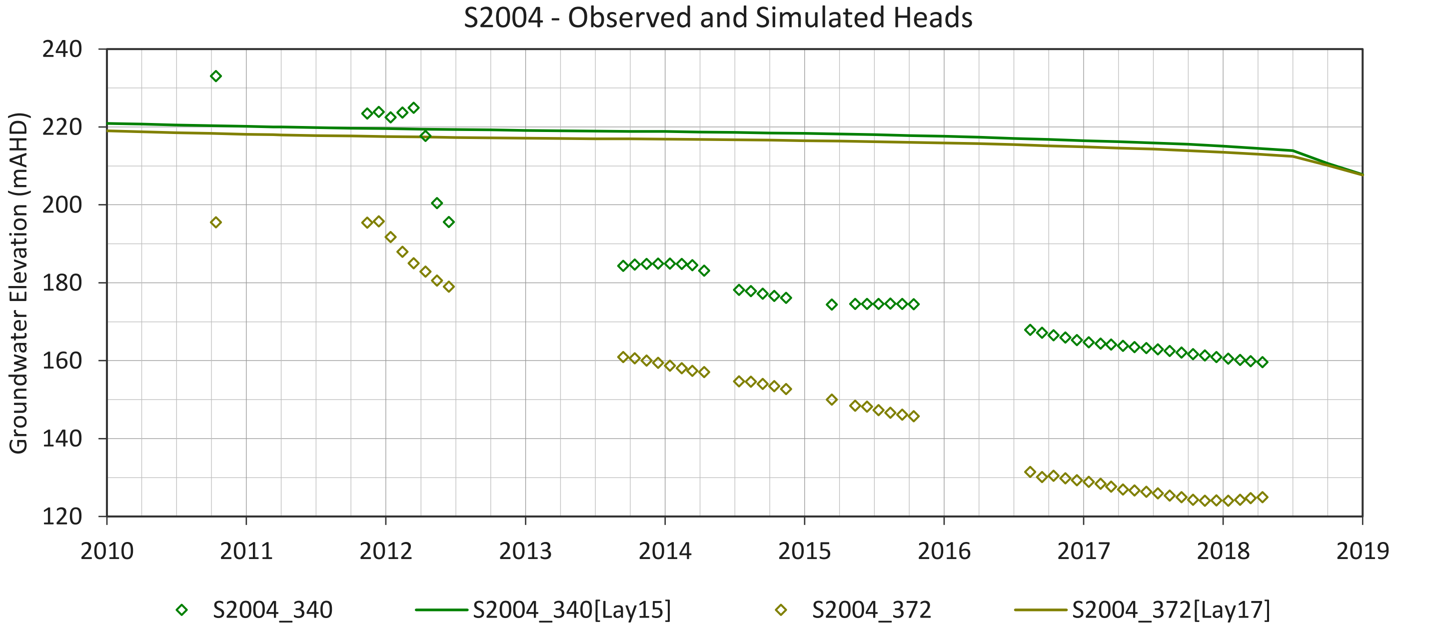

S1997 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
370
320
270
220
170
120
70
20
2009
2011
2013
2015
2017
2019
2021
S1997_132
S1997_132[Lay4]
S1997_218
S1997_218[Lay8]
S1997_24
S1997_24[Lay4]
S1997_292
S1997_292[Lay8]
S1997_372
S1997_372[Lay8]
S1997_429
S1997_429[Lay12]
S1997_441
S1997_441[Lay12]
S1997_511
S1997_511[Lay15]

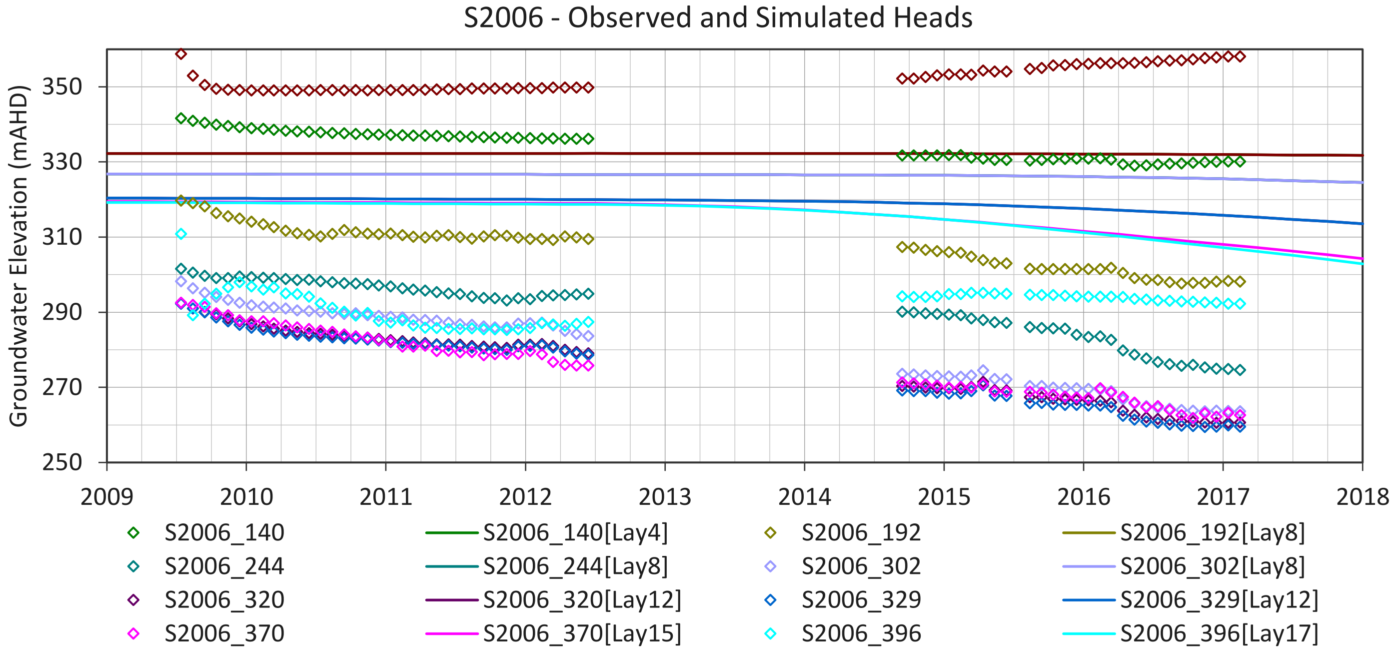

S1998 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
340
330
320
310
300
290
280
270
260
250
2009
2011
2013
2015
2017
2019
S1998_381
S1998_381[Lay15]
S1998_407
S1998_407[Lay3]

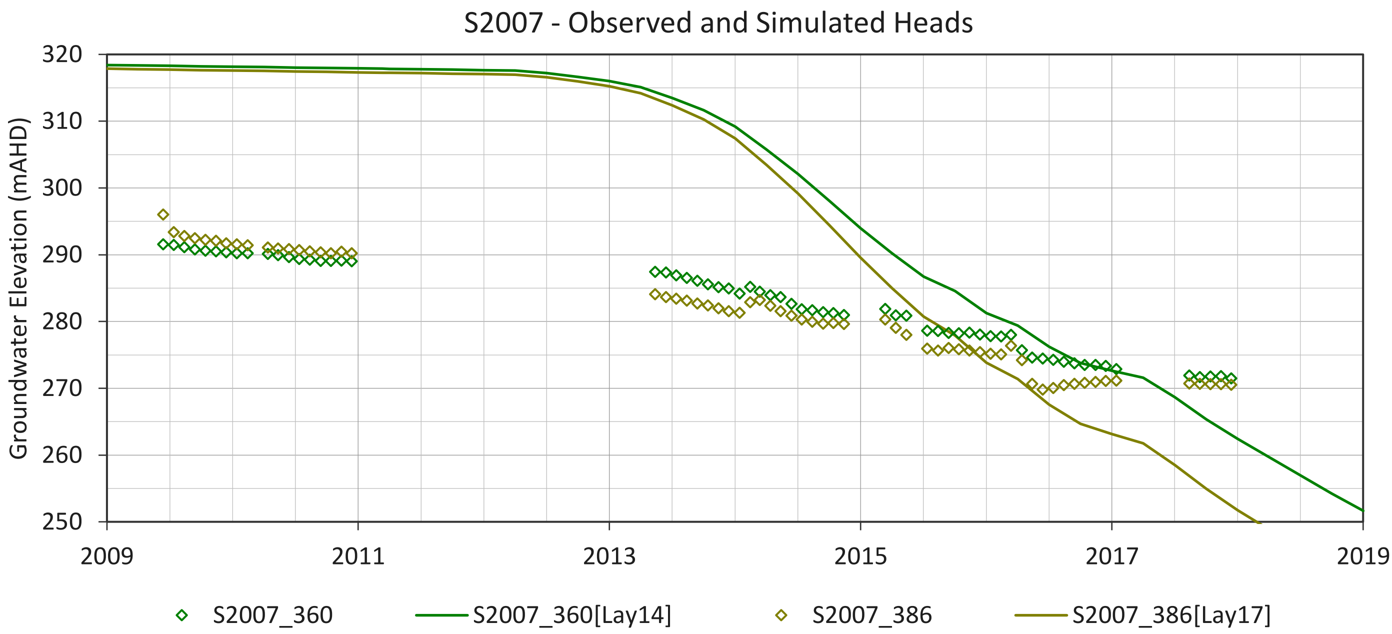

S1999 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
240
230
220
210
200
190
180
170
160
150
2009
2011
2013
2015
2017
2019
S1999_313
S1999_313[Lay15]
S1999_342
S1999_342[Lay17]

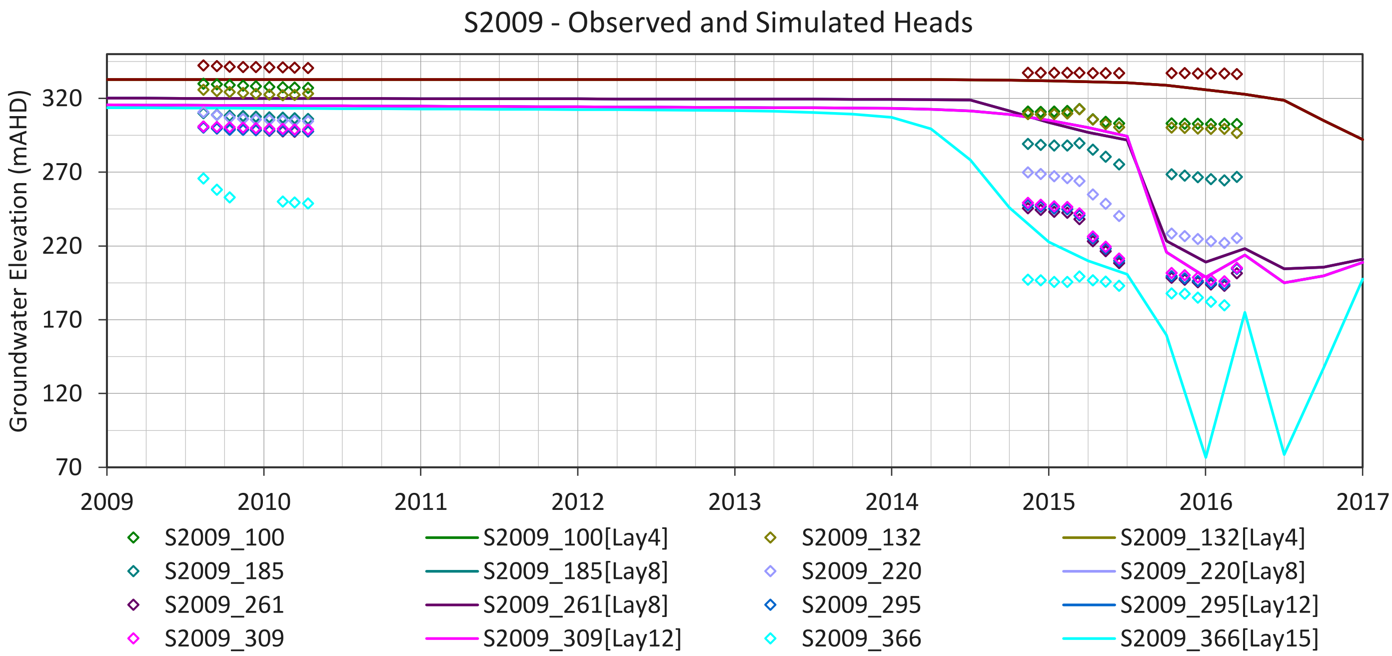

S2000 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
290
270
250
230
210
190
170
150
130
2009
2011
2013
2015
2017
2019
S2000_357
S2000_357[Lay15]

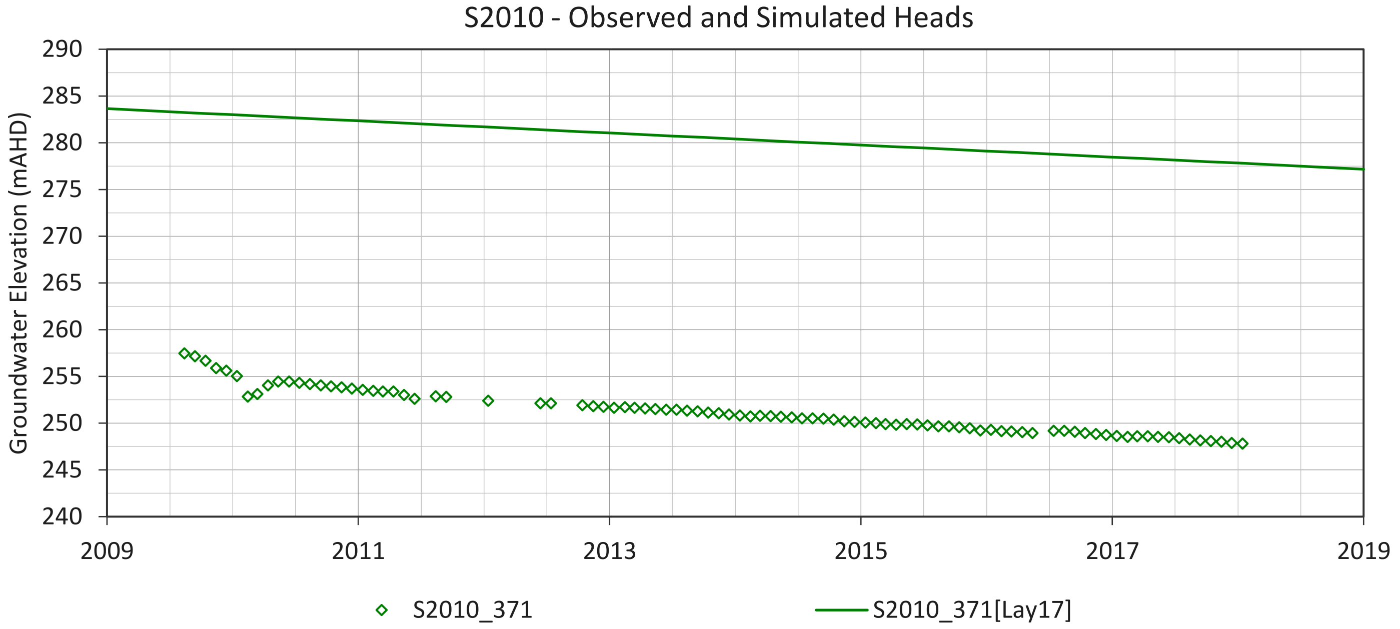

S2001 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
370
365
360
355
350
345
340
335
330
325
320
2009
2011
2013
2015
2017
2019
S2001_65
S2001_65[Lay4]

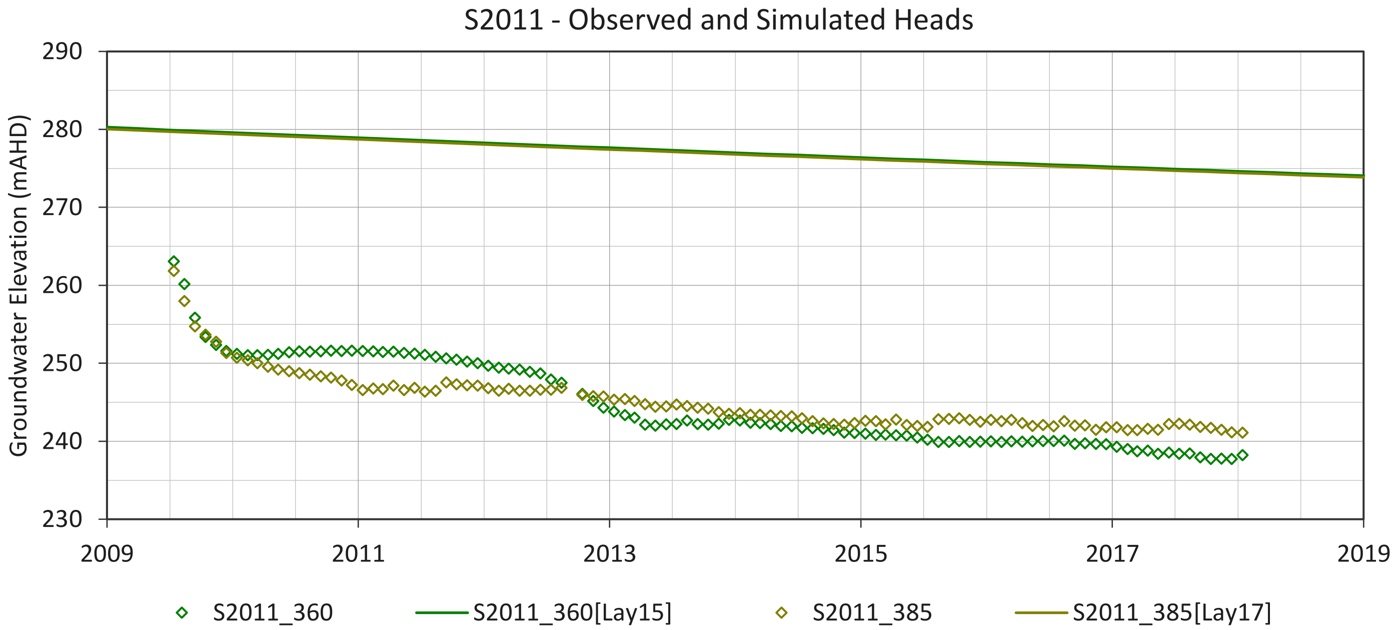

S2004 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
240
220
200
180
160
140
120
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
S2004_340
S2004_340[Lay15]
S2004_372
S2004_372[Lay17]

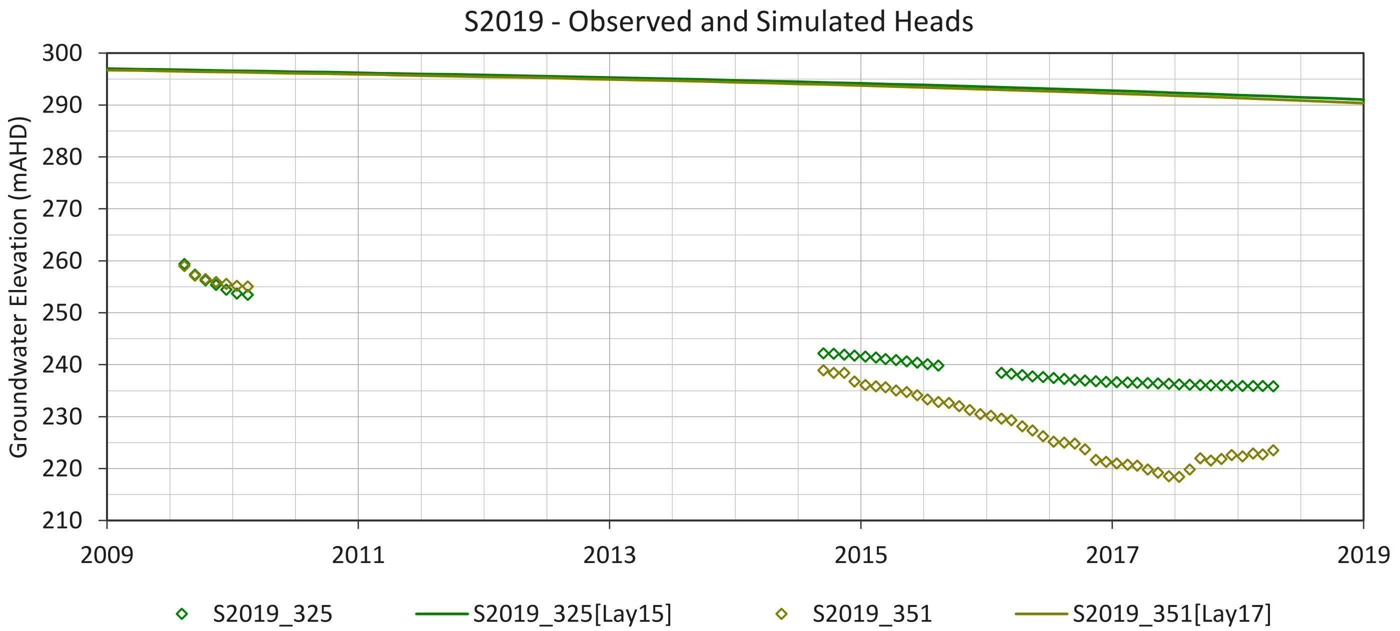

S2006 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
250
270
290
310
330
350
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
S2006_140
S2006_140[Lay4]
S2006_192
S2006_192[Lay8]
S2006_244
S2006_244[Lay8]
S2006_302
S2006_302[Lay8]
S2006_320
S2006_320[Lay12]
S2006_329
S2006_329[Lay12]
S2006_370
S2006_370[Lay15]
S2006_396
S2006_396[Lay17]

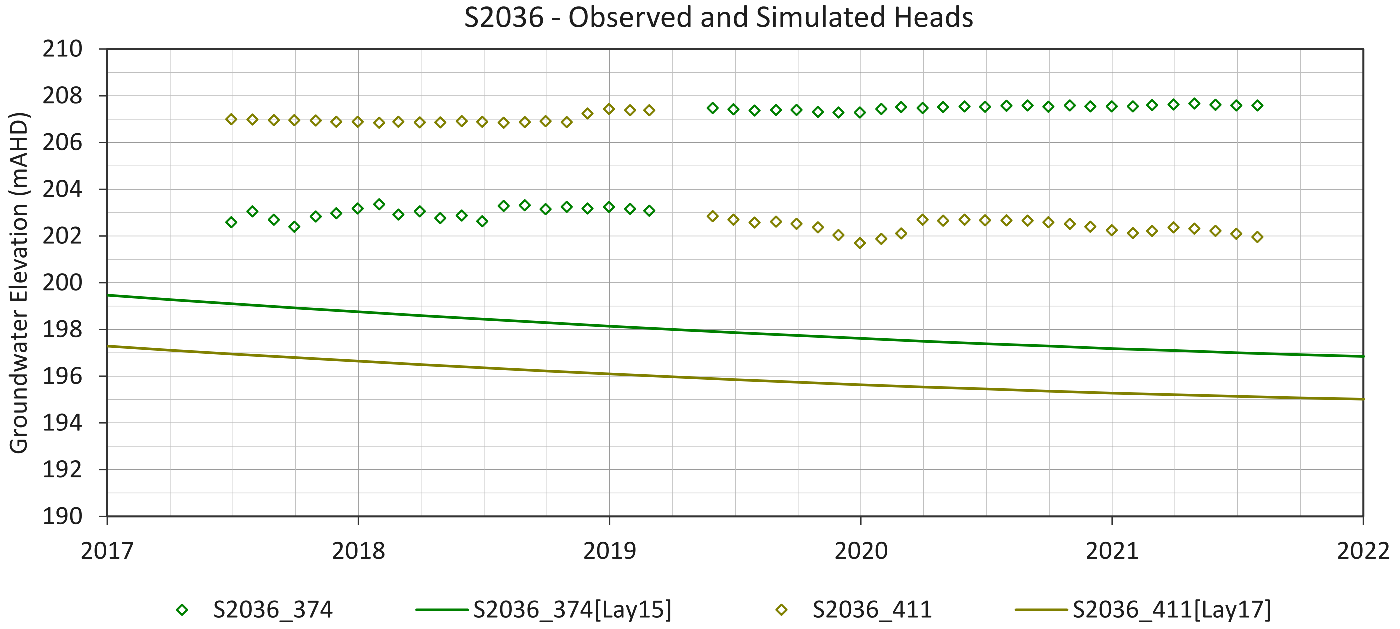

S2007 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
250
260
270
280
290
300
310
320
2009
2011
2013
2015
2017
2019
S2007_360
S2007_360[Lay14]
S2007_386
S2007_386[Lay17]

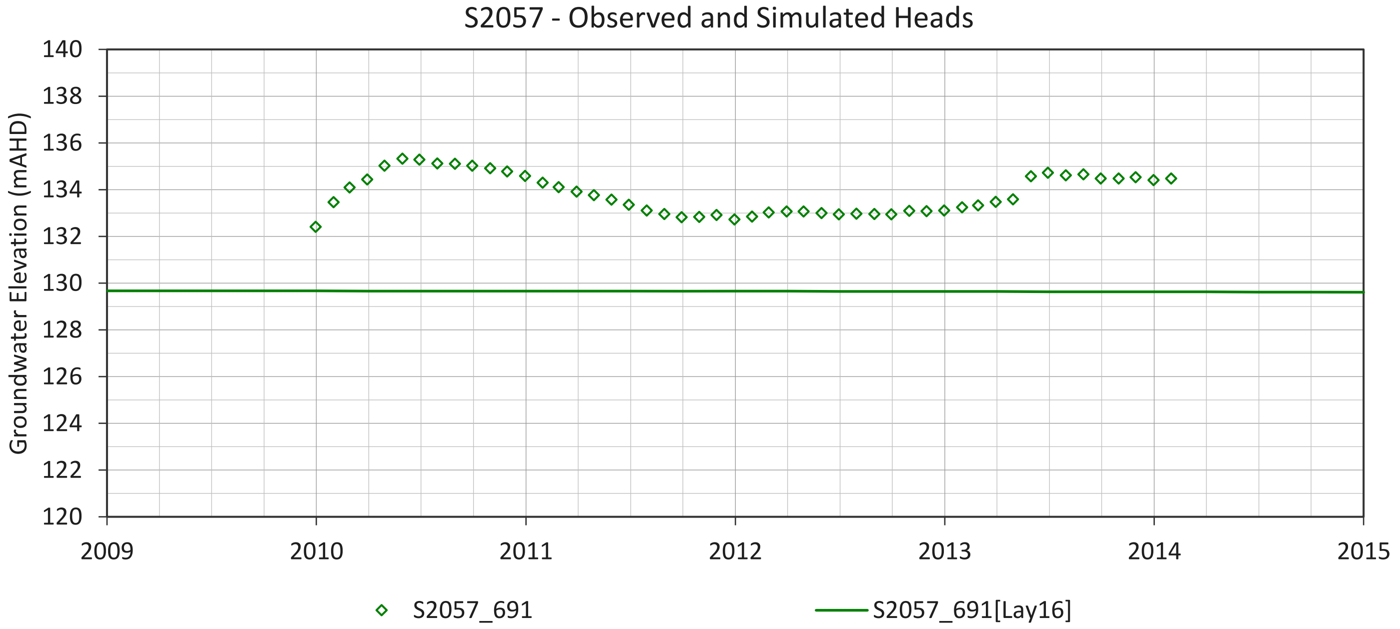

S2009 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
70
120
170
220
270
320
2009
2010
2011
2012
2013
2014
2015
2016
2017
S2009_100
S2009_100[Lay4]
S2009_132
S2009_132[Lay4]
S2009_185
S2009_185[Lay8]
S2009_220
S2009_220[Lay8]
S2009_261
S2009_261[Lay8]
S2009_295
S2009_295[Lay12]
S2009_309
S2009_309[Lay12]
S2009_366
S2009_366[Lay15]

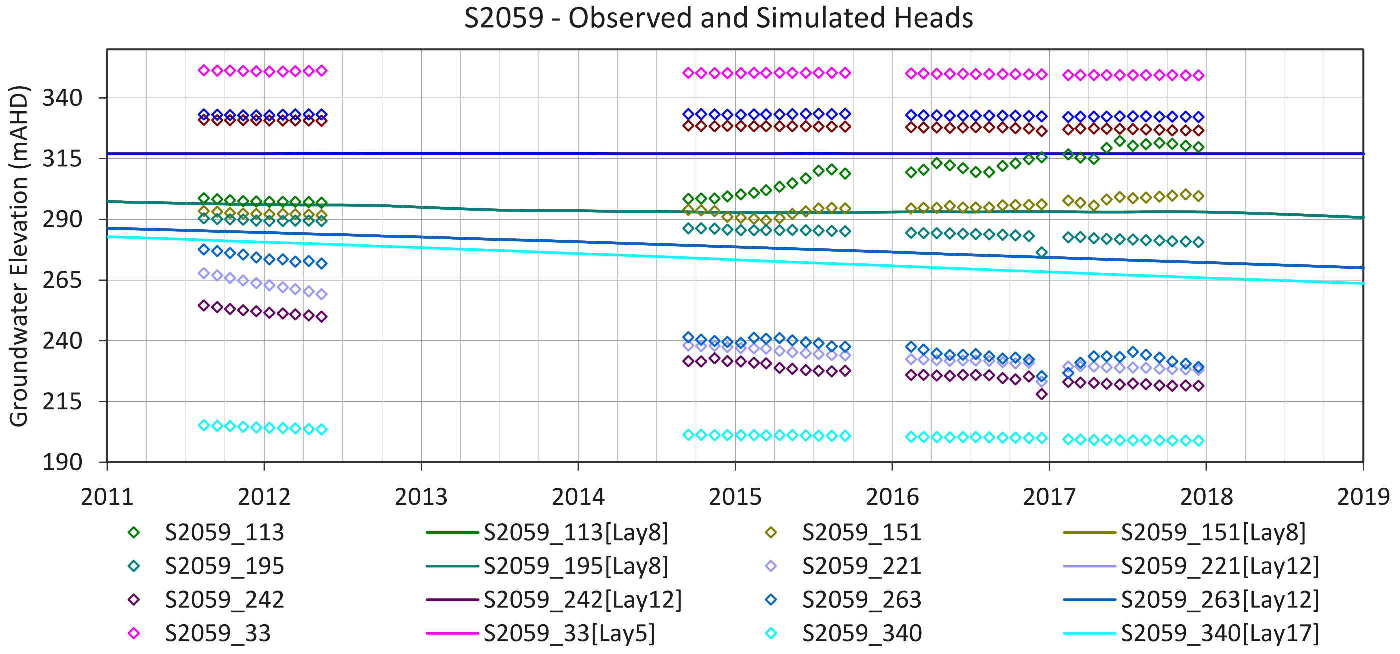

S2010 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
290
285
280
275
270
265
260
255
250
245
240
2009
2011
2013
2015
2017
2019
S2010_371
S2010_371[Lay17]

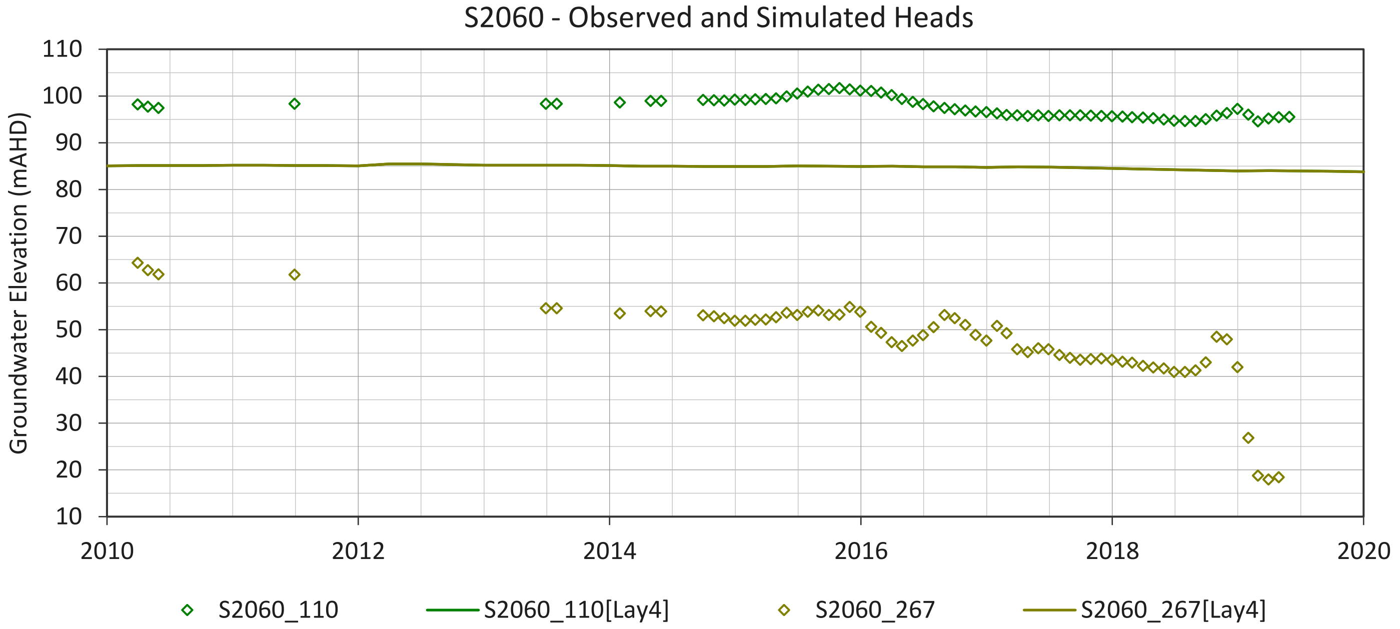

S2011 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
290
280
270
260
250
240
230
2009
2011
2013
2015
2017
2019
S2011_360
S2011_360[Lay15]
S2011_385
S2011_385[Lay17]

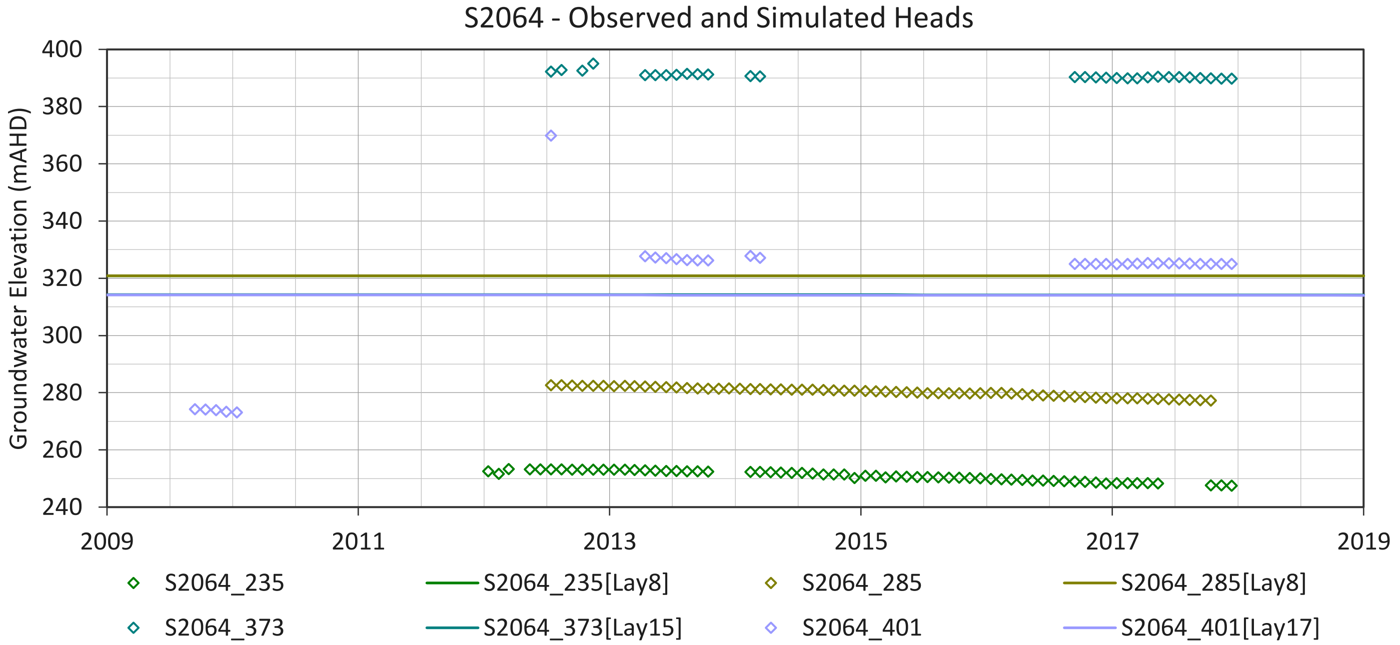

S2019 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
300
290
280
270
260
250
240
230
220
210
2009
2011
2013
2015
2017
2019
S2019_325
S2019_325[Lay15]
S2019_351
S2019_351[Lay17]

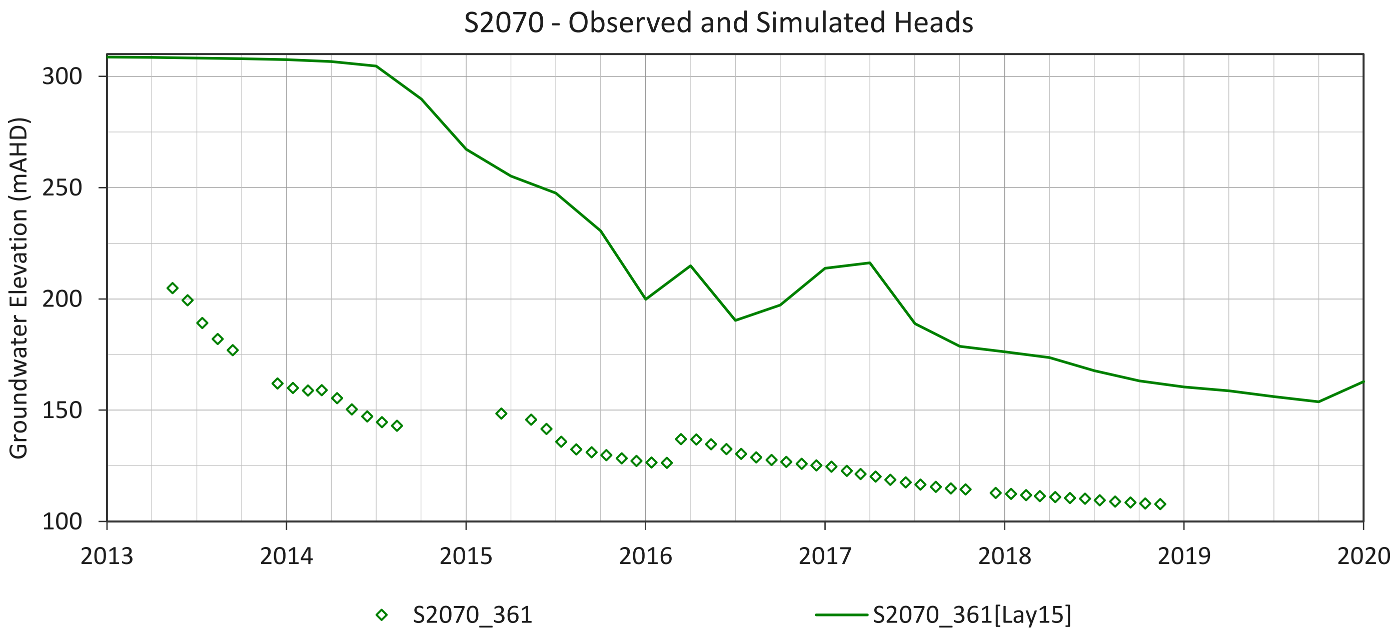

S2036 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
210
208
206
204
202
200
198
196
194
192
190
2017
2018
2019
2020
2021
2022
S2036_374
S2036_374[Lay15]
S2036_411
S2036_411[Lay17]

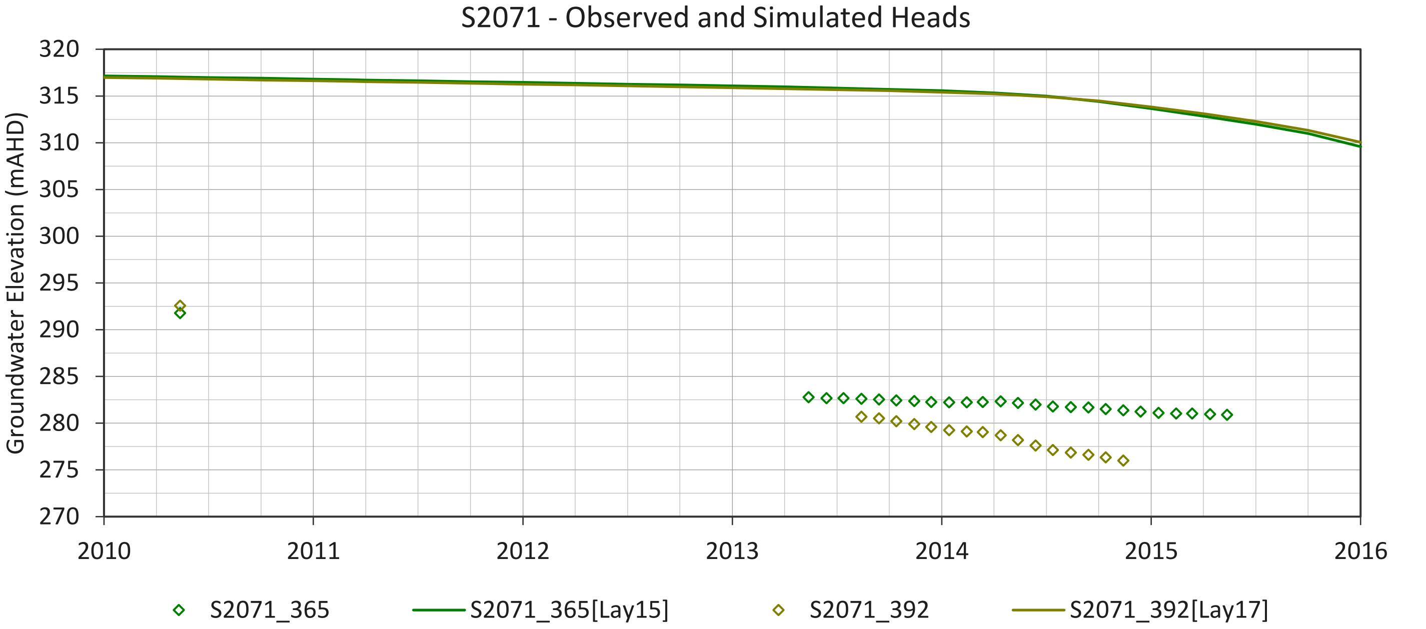

S2057 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
140
138
136
134
132
130
128
126
124
122
120
2009
2010
2011
2012
2013
2014
2015
S2057_691
S2057_691[Lay16]

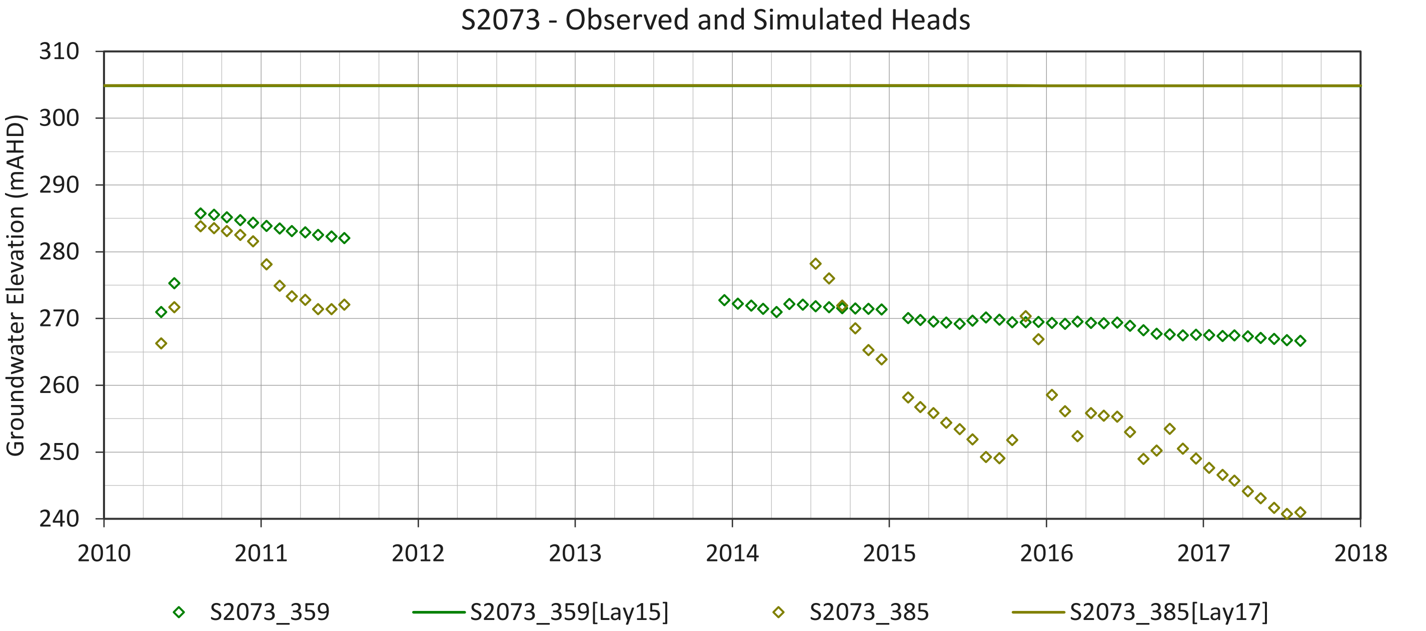

S2059 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
340
315
290
265
240
215
190
2011
2012
2013
2014
2015
2016
2017
2018
2019
S2059_113
S2059_113[Lay8]
S2059_151
S2059_151[Lay8]
S2059_195
S2059_195[Lay8]
S2059_221
S2059_221[Lay12]
S2059_242
S2059_242[Lay12]
S2059_263
S2059_263[Lay12]
S2059_33
S2059_33[Lay5]
S2059_340
S2059_340[Lay17]

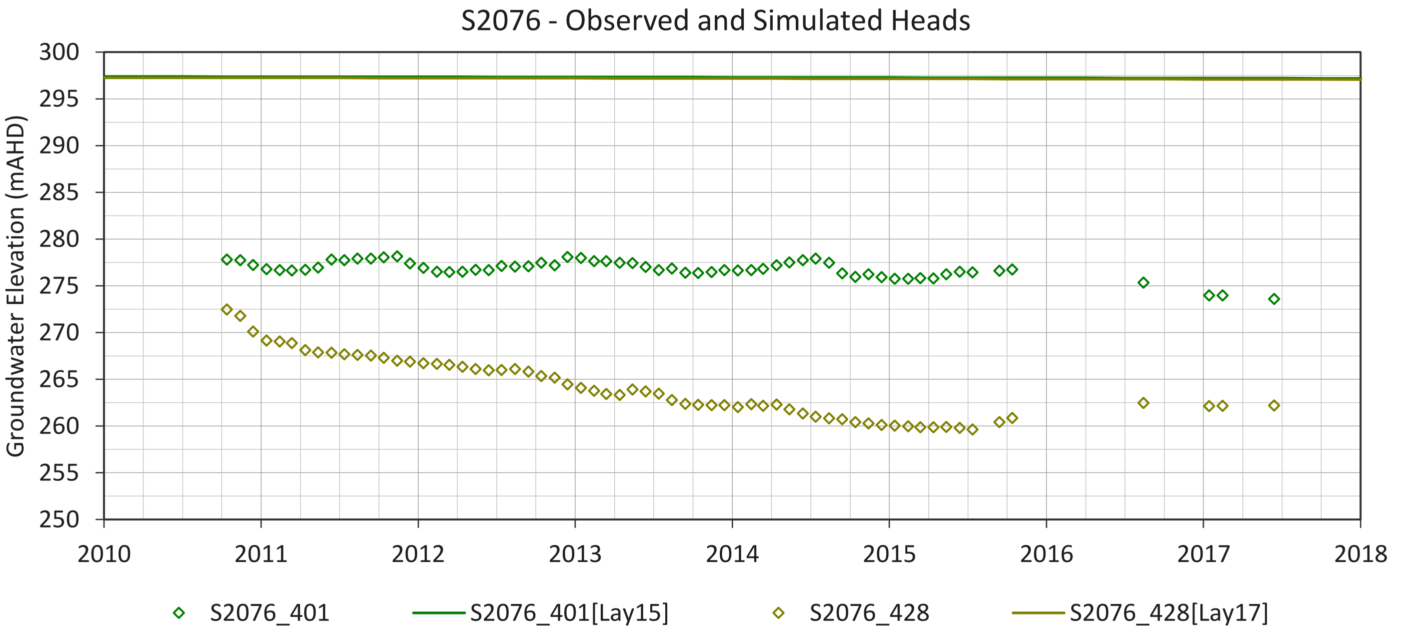

S2060 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
110
100
90
80
70
60
50
40
30
20
10
2010
2012
2014
2016
2018
2020
S2060_110
S2060_110[Lay4]
S2060_267
S2060_267[Lay4]

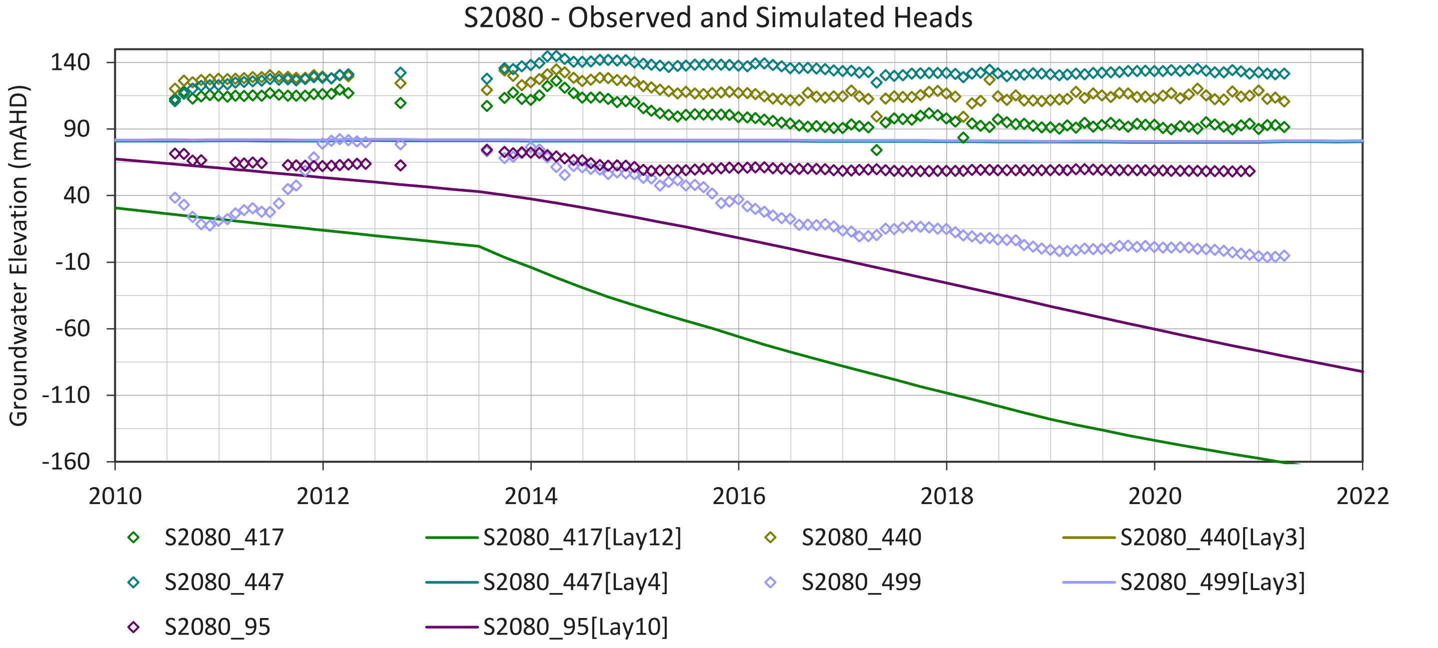

S2064 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
400
380
360
340
320
300
280
260
240
2009
2011
2013
2015
2017
2019
S2064_235
S2064_235[Lay8]
S2064_285
S2064_285[Lay8]
S2064_373
S2064_373[Lay15]
S2064_401
S2064_401[Lay17]

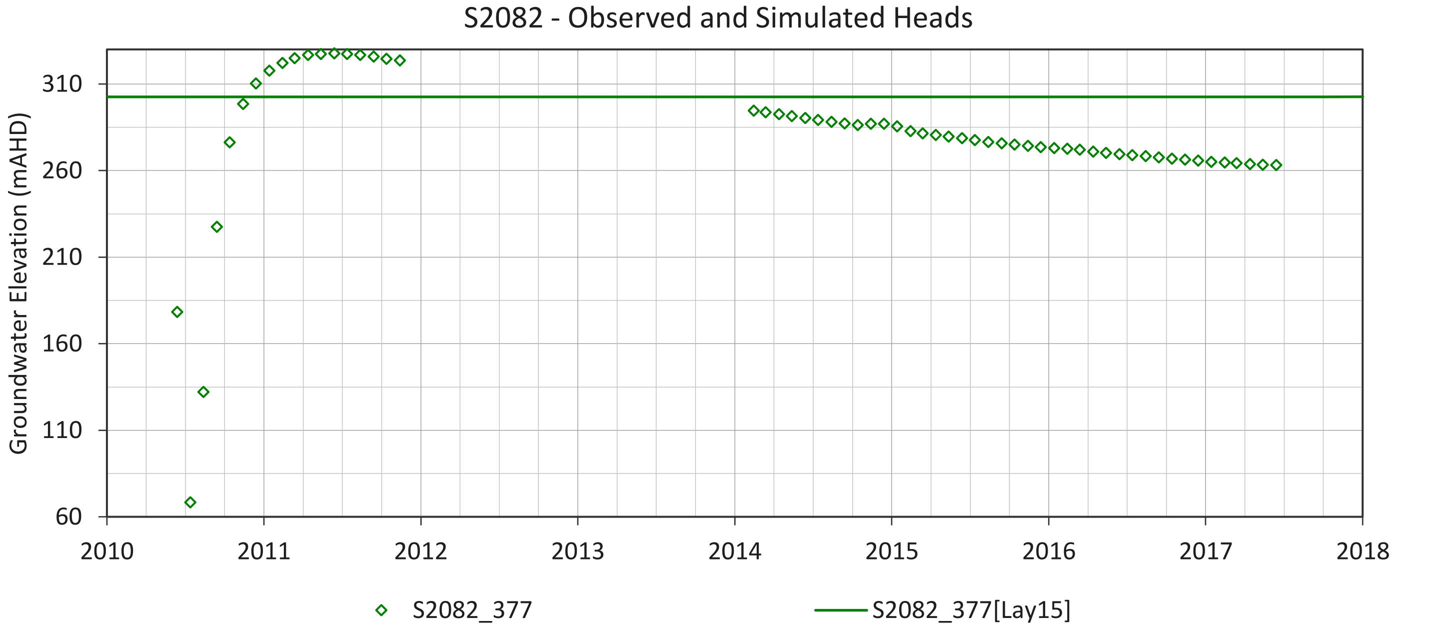

S2070 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
300
250
200
150
100
2013
2014
2015
2016
2017
2018
2019
2020
S2070_361
S2070_361[Lay15]

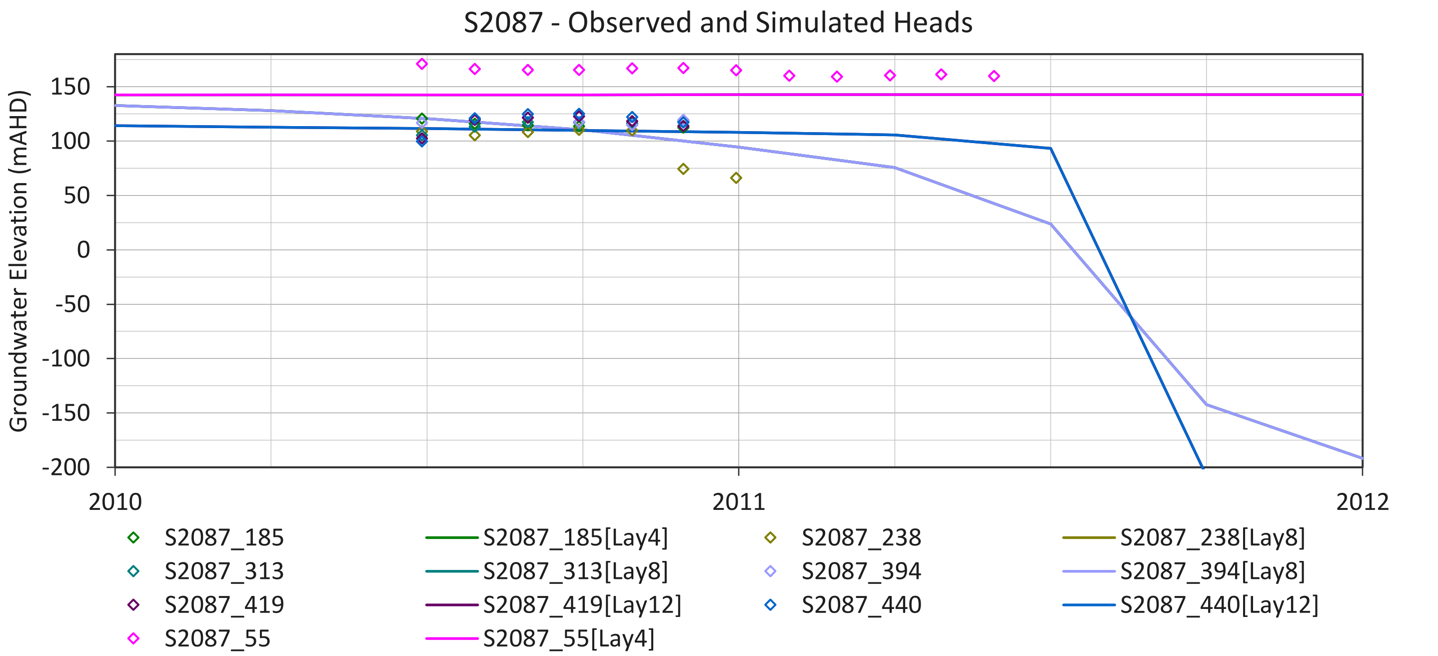

S2071 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
320
315
310
305
300
295
290
285
280
275
270
2010
2011
2012
2013
2014
2015
2016
S2071_365
S2071_365[Lay15]
S2071_392
S2071_392[Lay17]

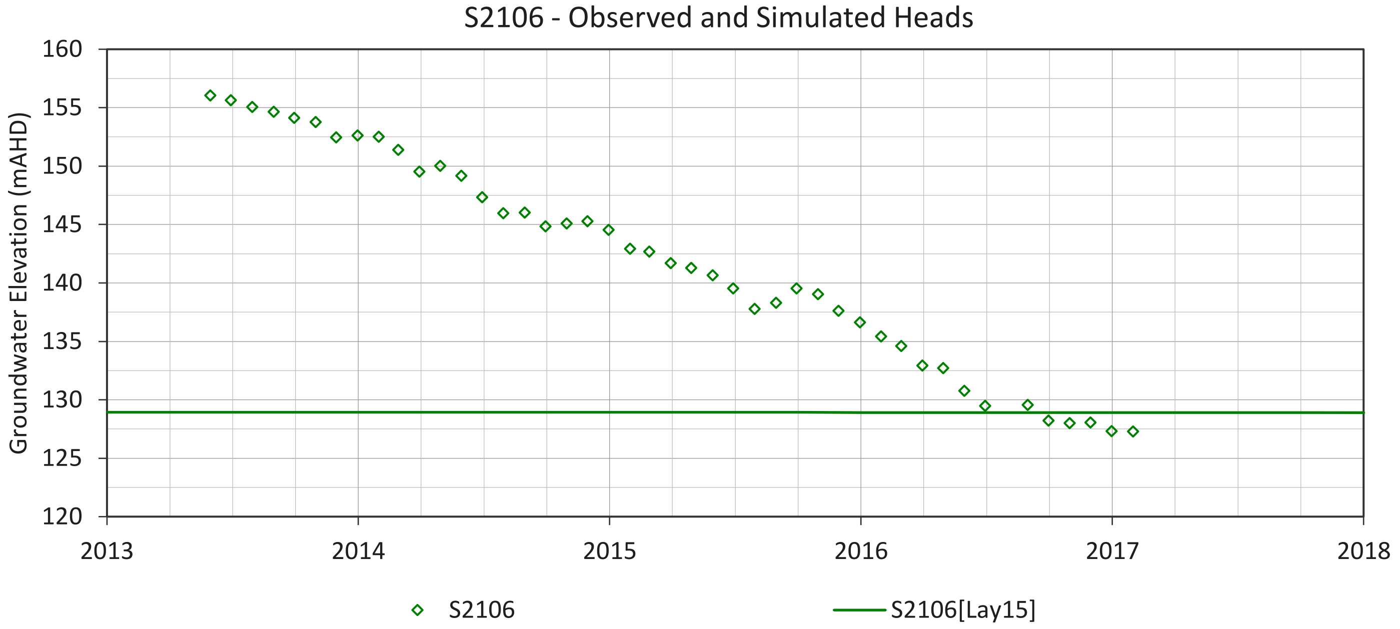

S2073 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
310
300
290
280
270
260
250
240
2010
2011
2012
2013
2014
2015
2016
2017
2018
S2073_359
S2073_359[Lay15]
S2073_385
S2073_385[Lay17]

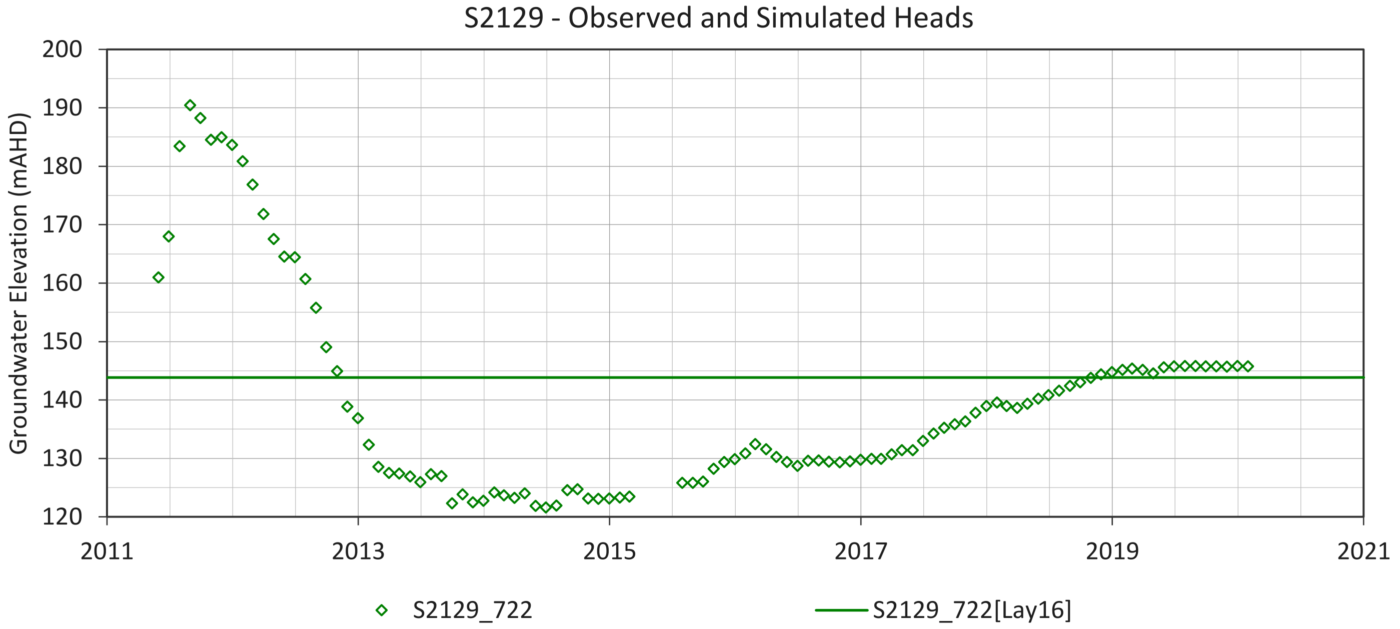

S2076 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
300
295
290
285
280
275
270
265
260
255
250
2010
2011
2012
2013
2014
2015
2016
2017
2018
S2076_401
S2076_401[Lay15]
S2076_428
S2076_428[Lay17]

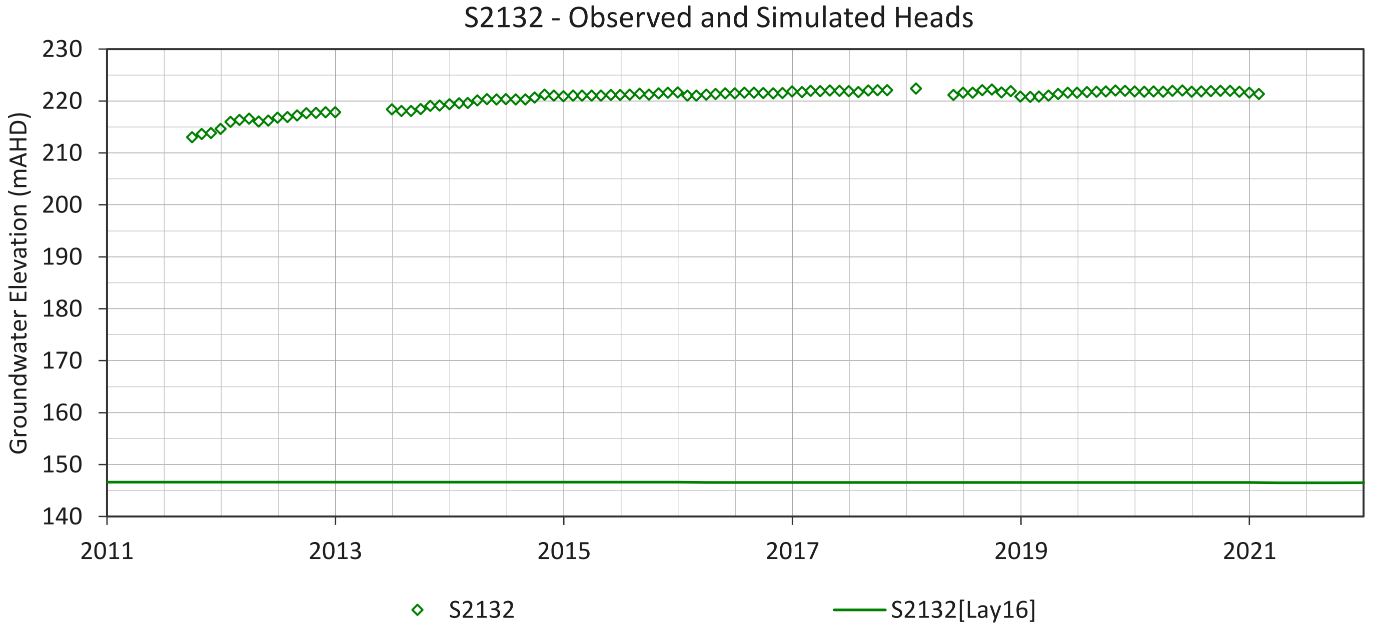

S2080 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
140
90
40
-10
-60
-110
-160
2010
2012
2014
2016
2018
2020
2022
S2080_417
S2080_417[Lay12]
S2080_440
S2080_440[Lay3]
S2080_447
S2080_447[Lay4]
S2080_499
S2080_499[Lay3]
S2080_95
S2080_95[Lay10]

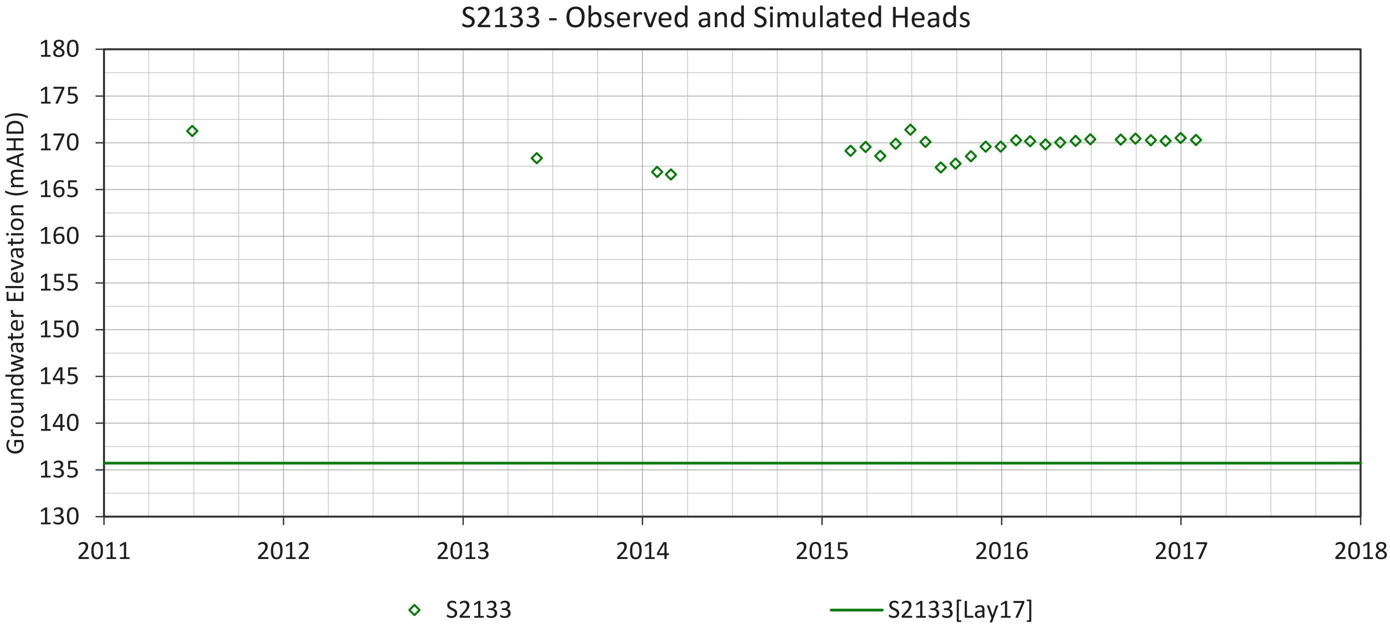

S2082 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
310
260
210
160
110
60
2010
2011
2012
2013
2014
2015
2016
2017
2018
S2082_377
S2082_377[Lay15]

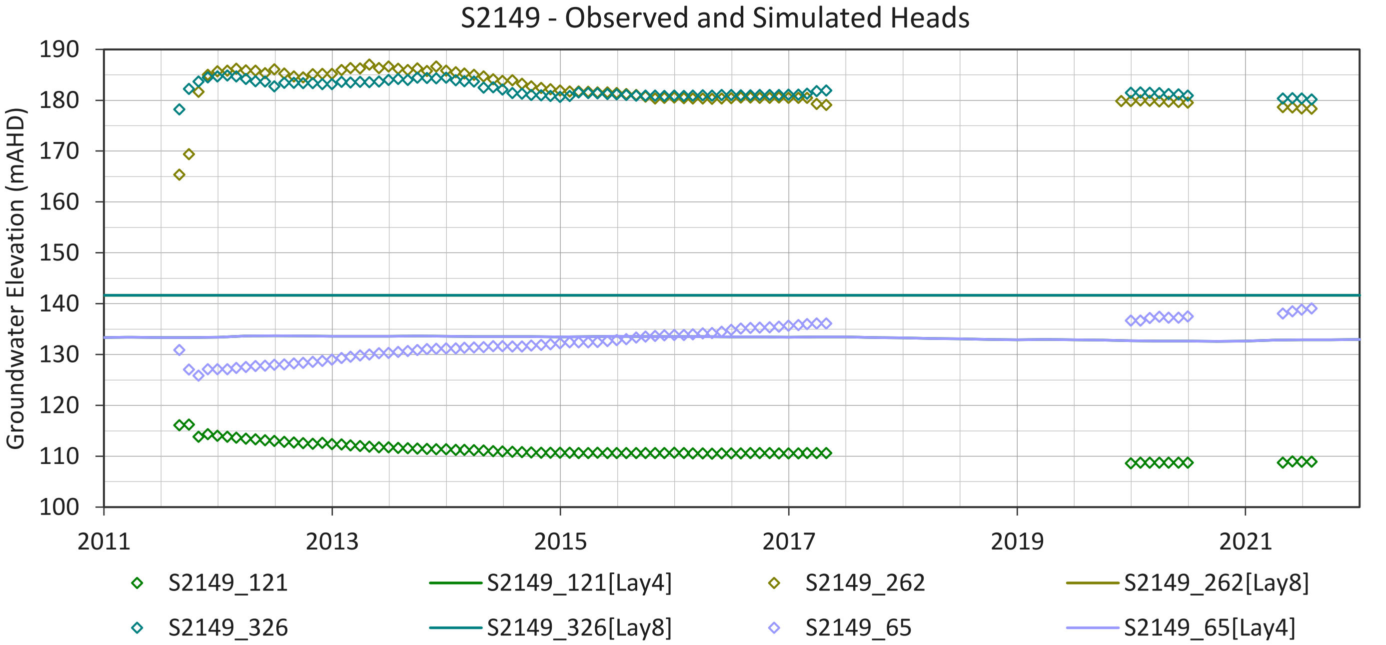

S2087 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
150
100
50
0
-50
-100
-150
-200
2010
2011
2012
S2087_185
S2087_185[Lay4]
S2087_238
S2087_238[Lay8]
S2087_313
S2087_313[Lay8]
S2087_394
S2087_394[Lay8]
S2087_419
S2087_419[Lay12]
S2087_440
S2087_440[Lay12]
S2087_55
S2087_55[Lay4]

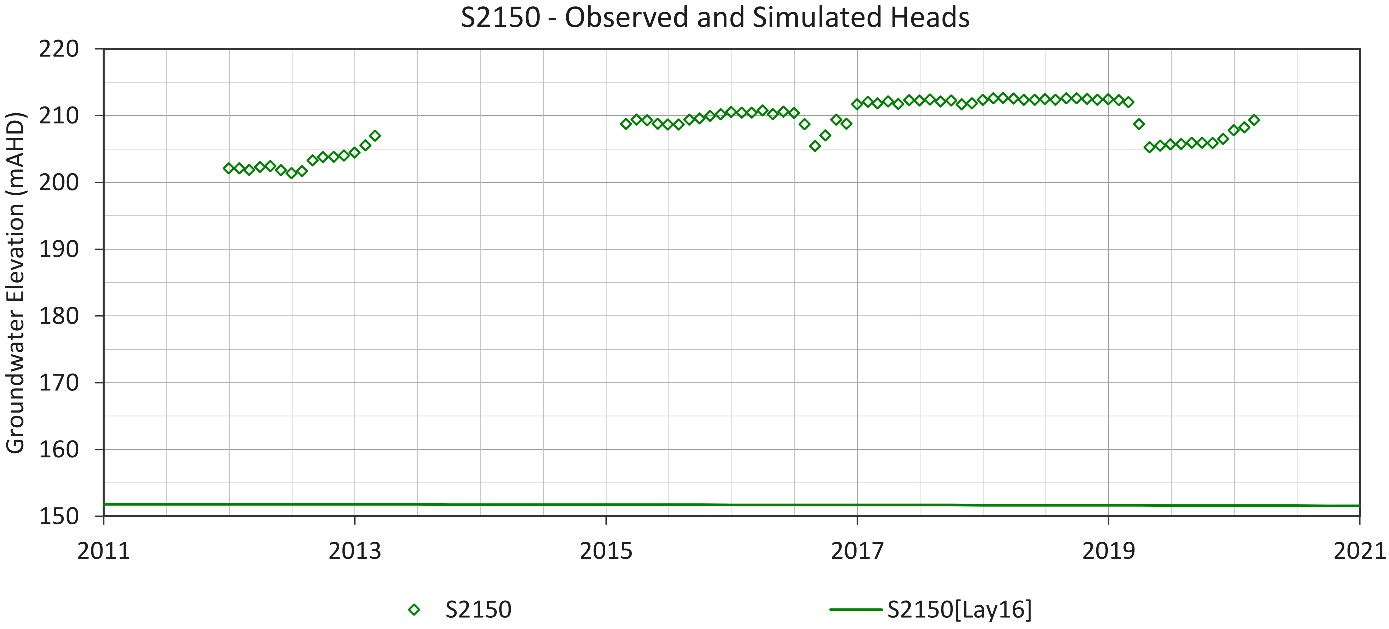

S2106 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
160
155
150
145
140
135
130
125
120
2013
2014
2015
2016
2017
2018
S2106
S2106[Lay15]

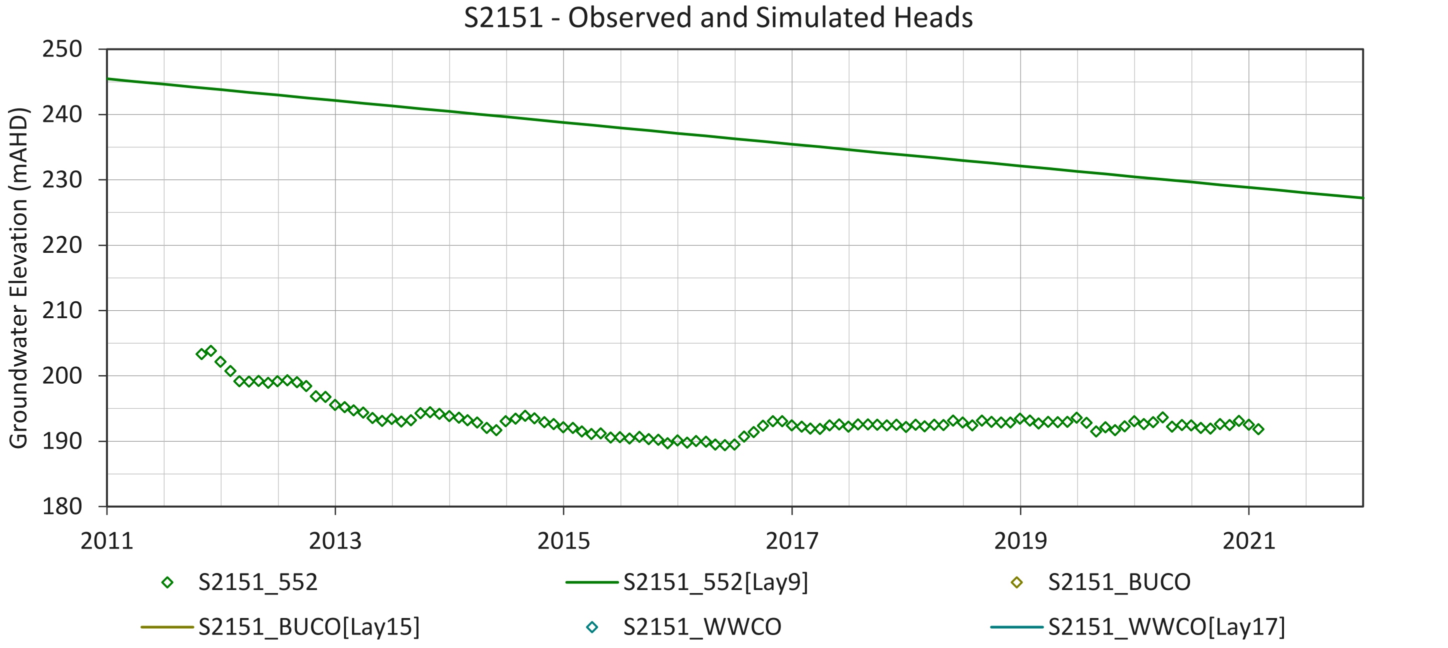

S2129 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
200
190
180
170
160
150
140
130
120
2011
2013
2015
2017
2019
2021
S2129_722
S2129_722[Lay16]

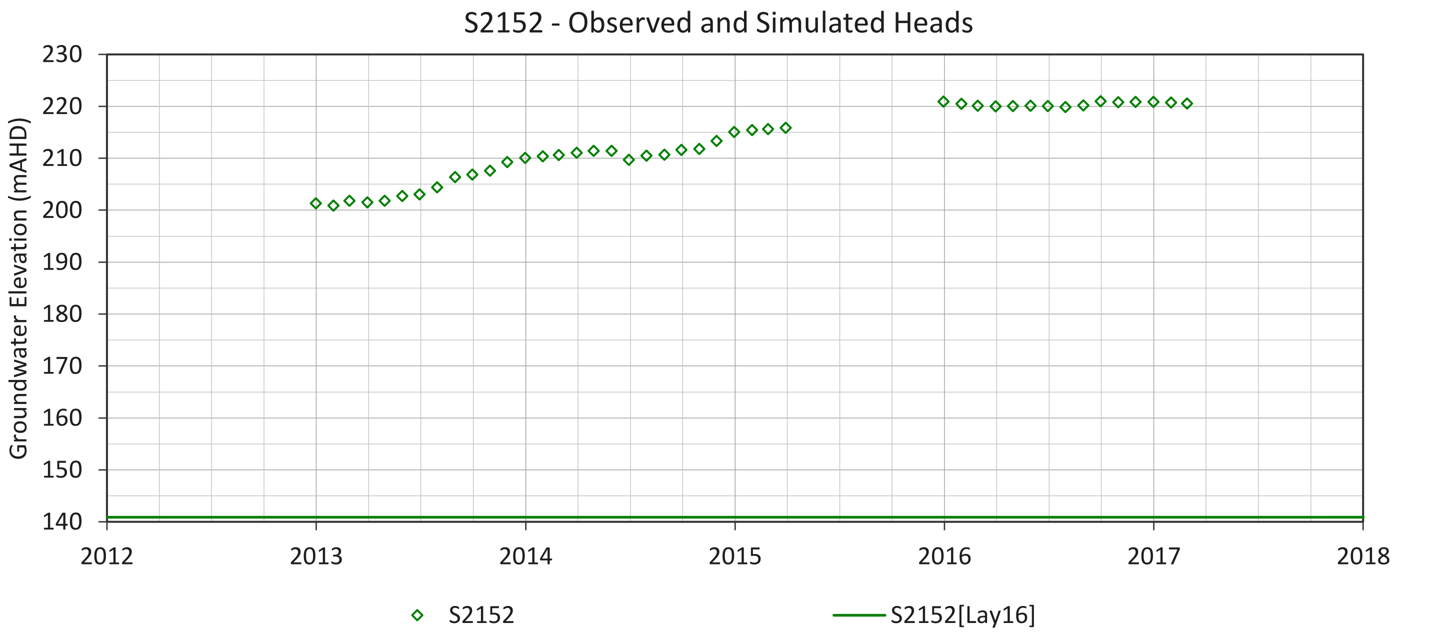

S2132 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
230
220
210
200
190
180
170
160
150
140
2011
2013
2015
2017
2019
2021
S2132
S2132[Lay16]

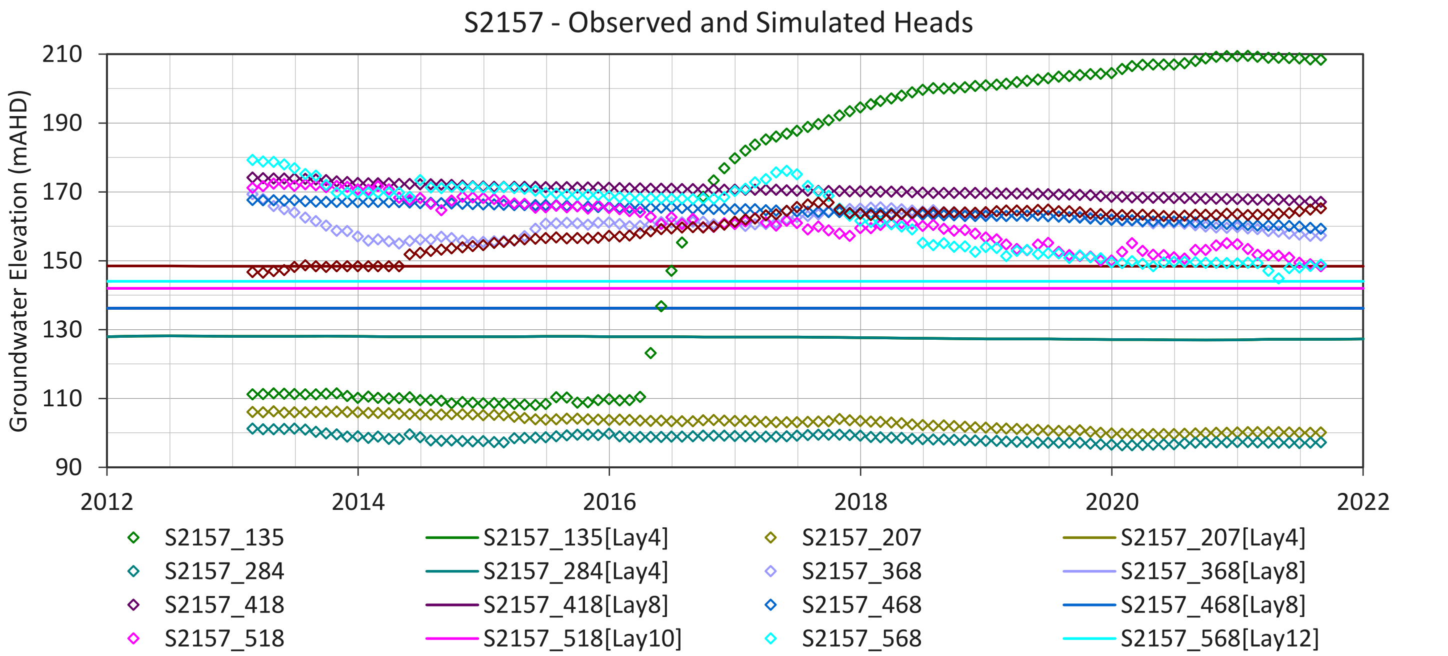

S2133 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
180
175
170
165
160
155
150
145
140
135
130
2011
2012
2013
2014
2015
2016
2017
2018
S2133
S2133[Lay17]

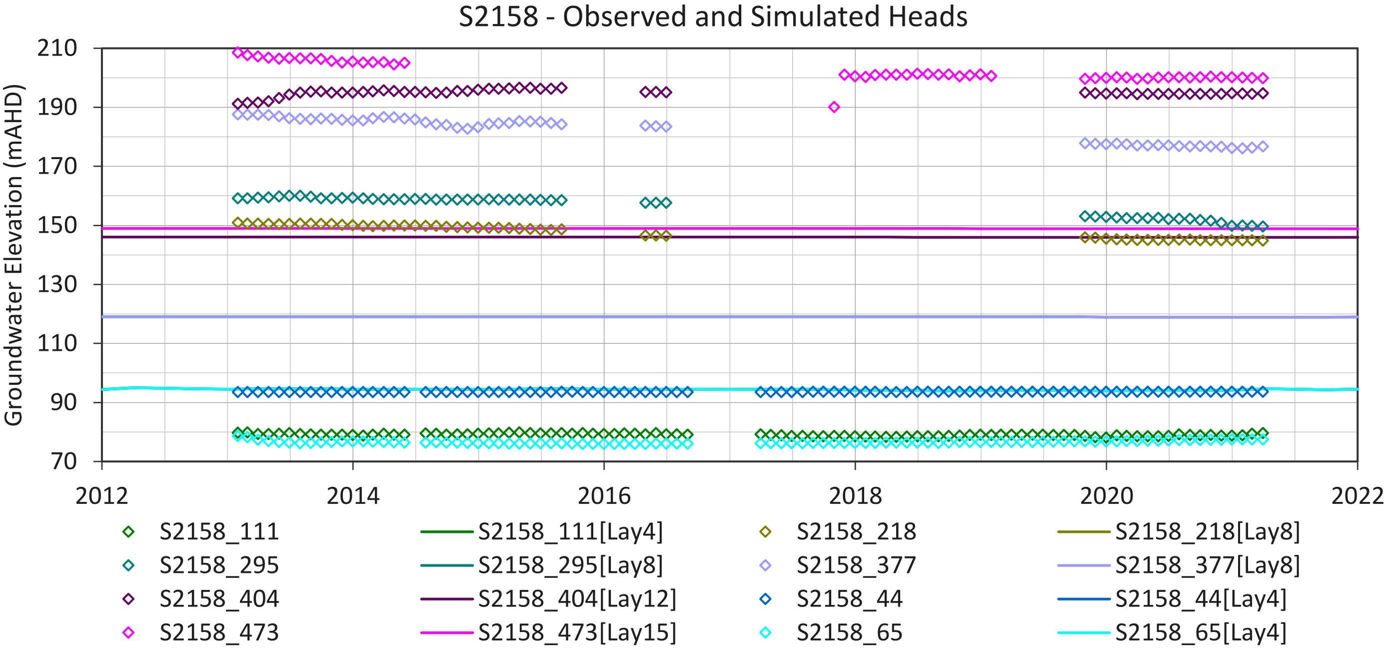

S2149 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
190
180
170
160
150
140
130
120
110
100
2011
2013
2015
2017
2019
2021
S2149_121
S2149_121[Lay4]
S2149_262
S2149_262[Lay8]
S2149_326
S2149_326[Lay8]
S2149_65
S2149_65[Lay4]

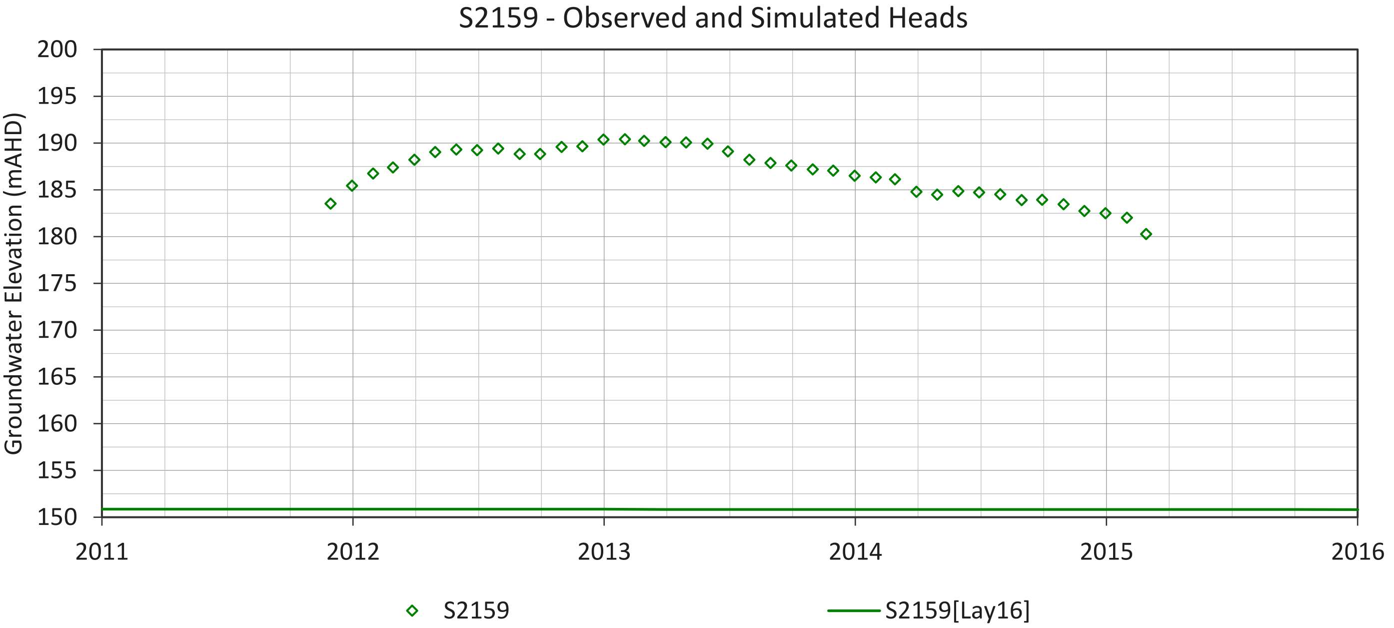

S2150 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
220
210
200
190
180
170
160
150
2011
2013
2015
2017
2019
2021
S2150
S2150[Lay16]

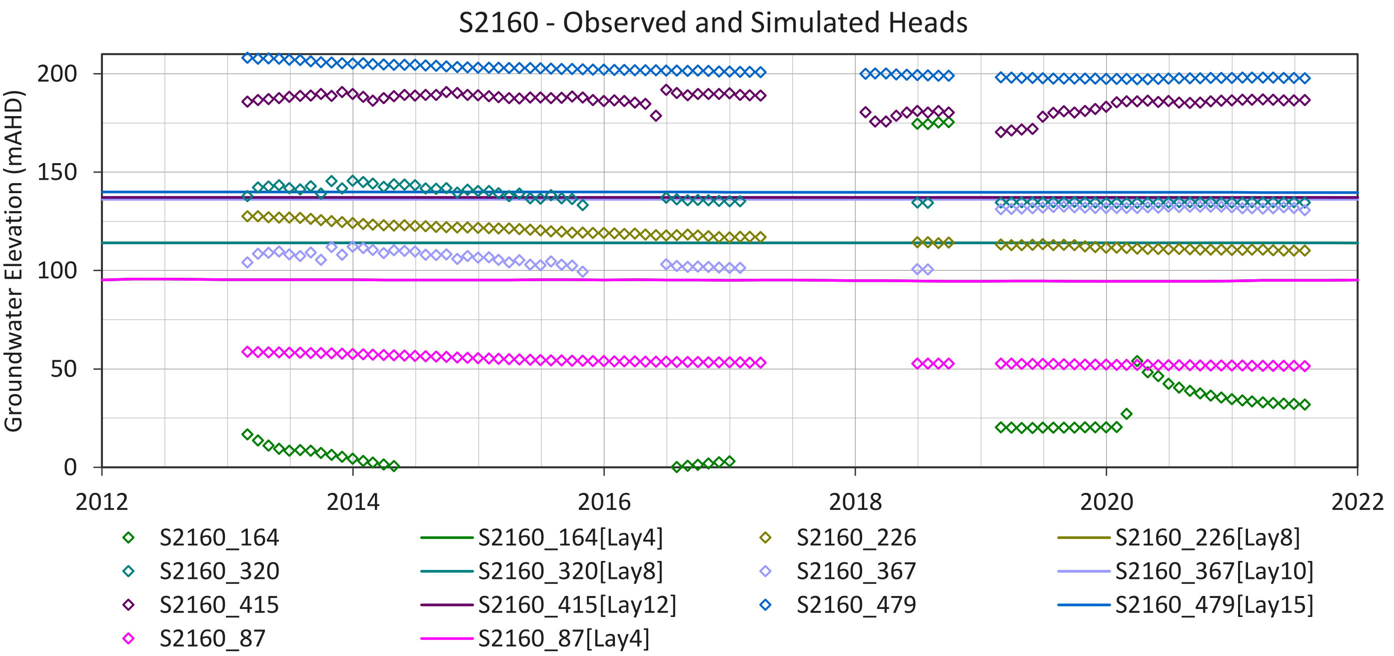

S2151 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
250
240
230
220
210
200
190
180
2011
2013
2015
2017
2019
2021
S2151_552
S2151_552[Lay9]
S2151_BUCO
S2151_BUCO[Lay15]
S2151_WWCO
S2151_WWCO[Lay17]

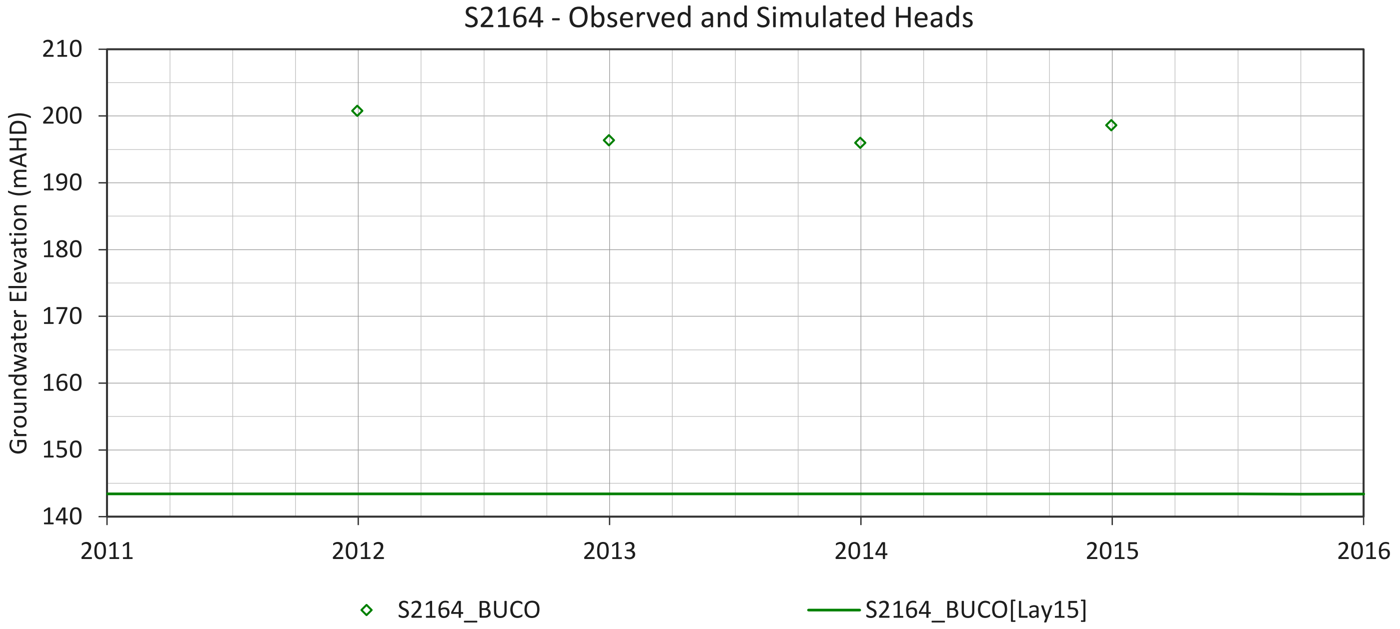

S2152 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
230
220
210
200
190
180
170
160
150
140
2012
2013
2014
2015
2016
2017
2018
S2152
S2152[Lay16]

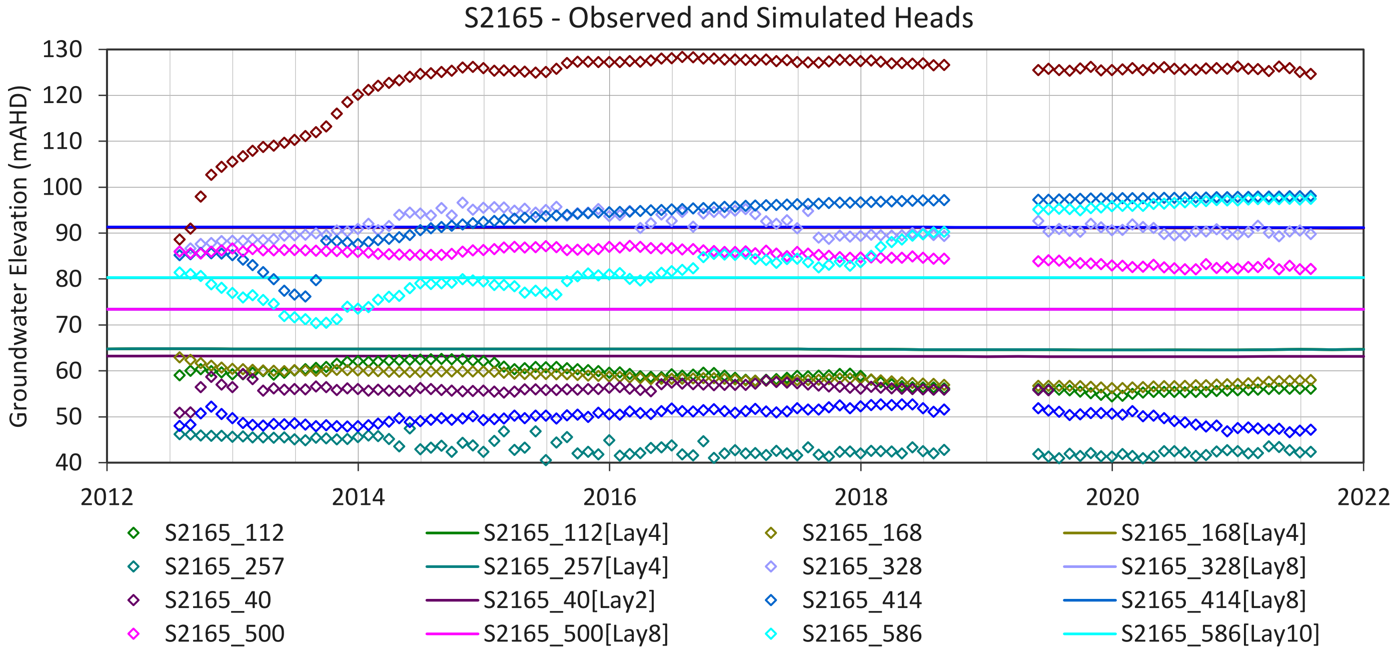

S2157 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
210
190
170
150
130
110
90
2012
2014
2016
2018
2020
2022
S2157_135
S2157_135[Lay4]
S2157_207
S2157_207[Lay4]
S2157_284
S2157_284[Lay4]
S2157_368
S2157_368[Lay8]
S2157_418
S2157_418[Lay8]
S2157_468
S2157_468[Lay8]
S2157_518
S2157_518[Lay10]
S2157_568
S2157_568[Lay12]

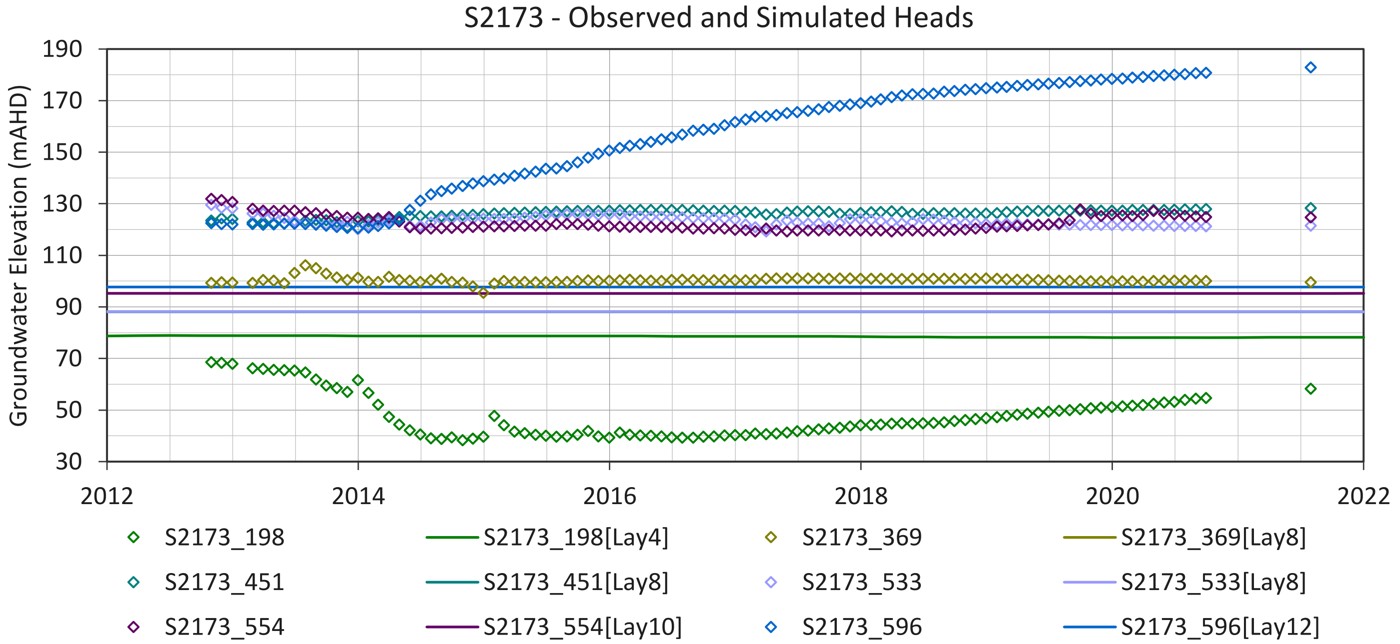

S2158 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
210
190
170
150
130
110
90
70
2012
2014
2016
2018
2020
2022
S2158_111
S2158_111[Lay4]
S2158_218
S2158_218[Lay8]
S2158_295
S2158_295[Lay8]
S2158_377
S2158_377[Lay8]
S2158_404
S2158_404[Lay12]
S2158_44
S2158_44[Lay4]
S2158_473
S2158_473[Lay15]
S2158_65
S2158_65[Lay4]

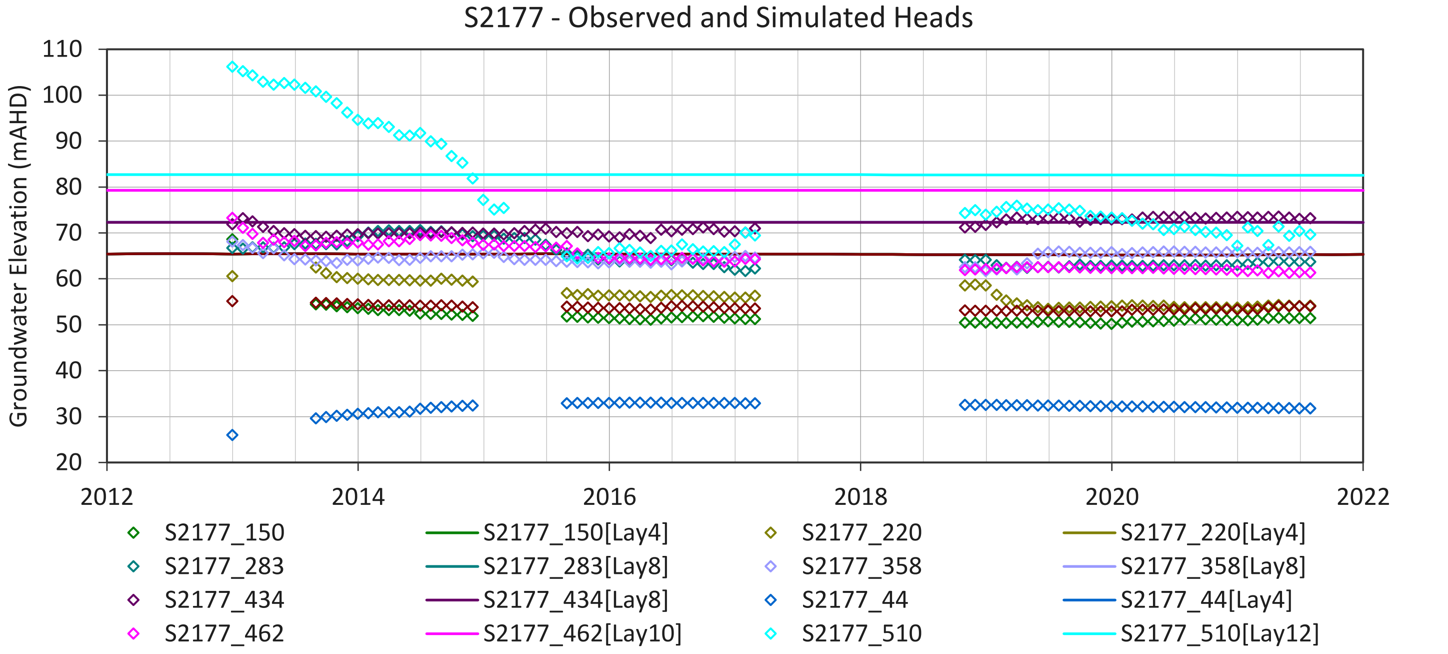

S2159 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
200
195
190
185
180
175
170
165
160
155
150
2011
2012
2013
2014
2015
2016
S2159
S2159[Lay16]

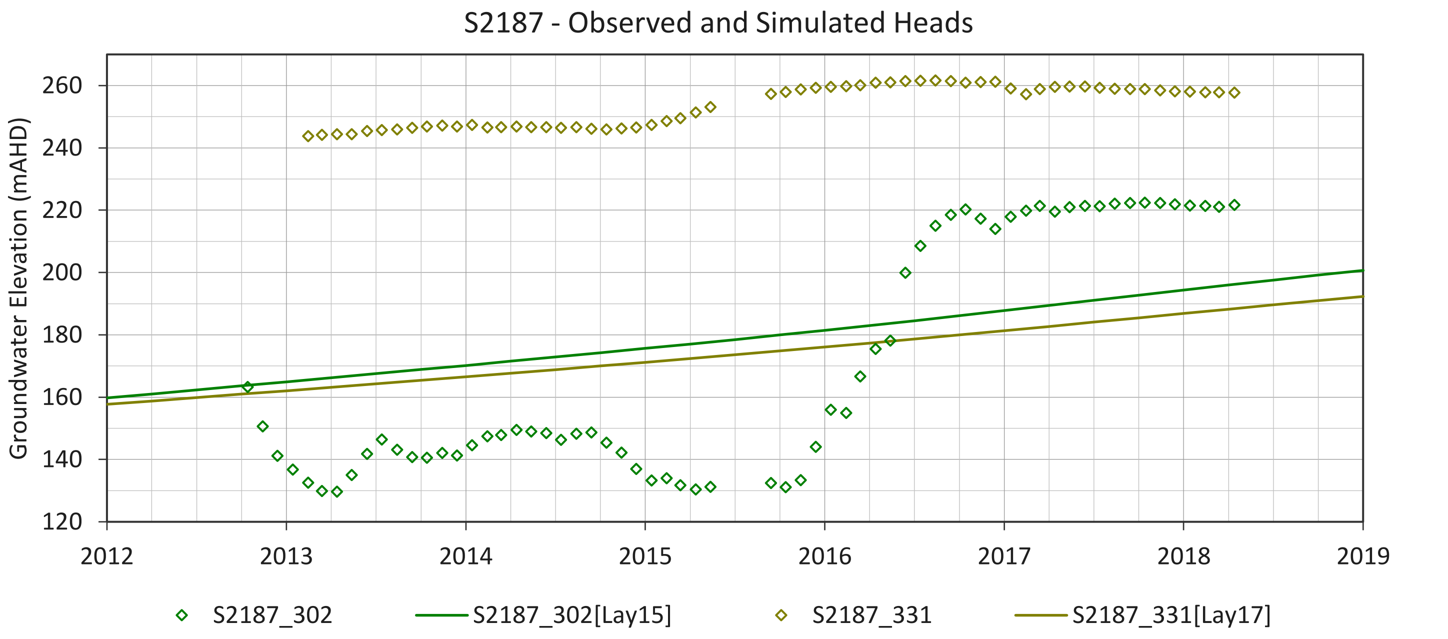

S2160 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
200
150
100
50
0
2012
2014
2016
2018
2020
2022
S2160_164
S2160_164[Lay4]
S2160_226
S2160_226[Lay8]
S2160_320
S2160_320[Lay8]
S2160_367
S2160_367[Lay10]
S2160_415
S2160_415[Lay12]
S2160_479
S2160_479[Lay15]
S2160_87
S2160_87[Lay4]

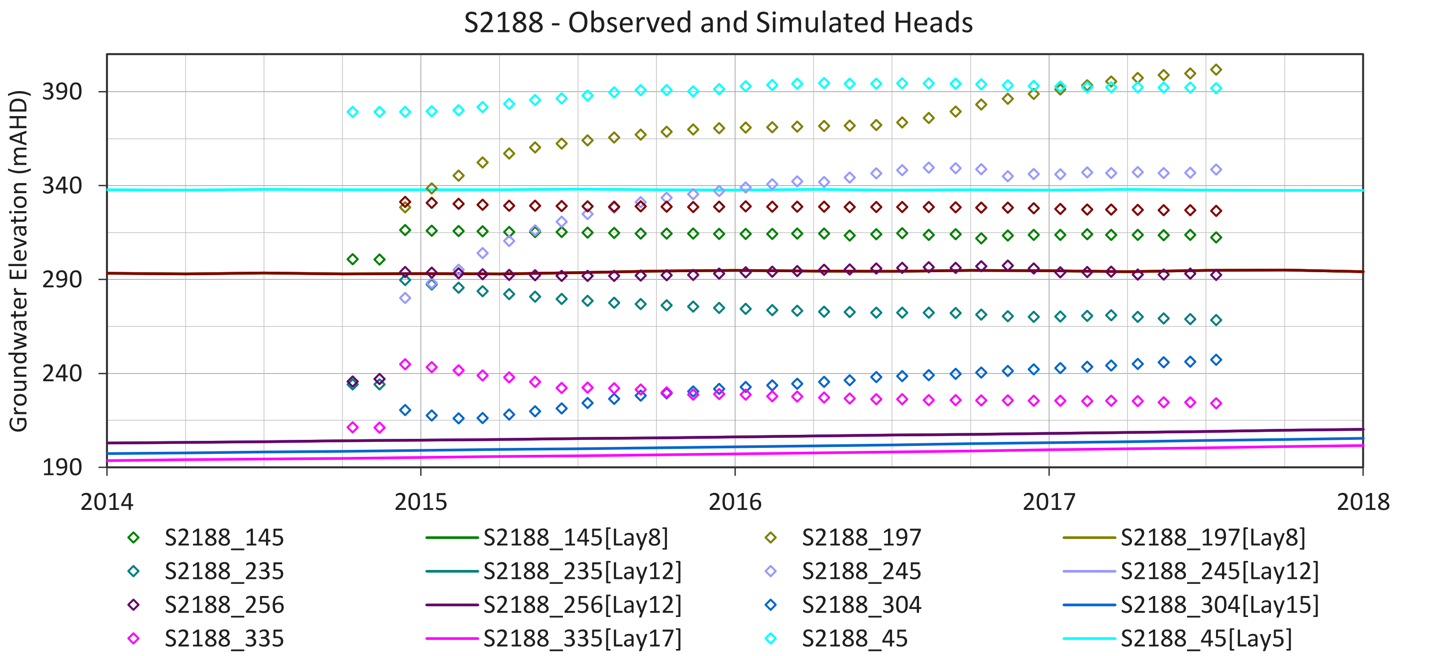

S2164 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
210
200
190
180
170
160
150
140
2011
2012
2013
2014
2015
2016
S2164_BUCO
S2164_BUCO[Lay15]

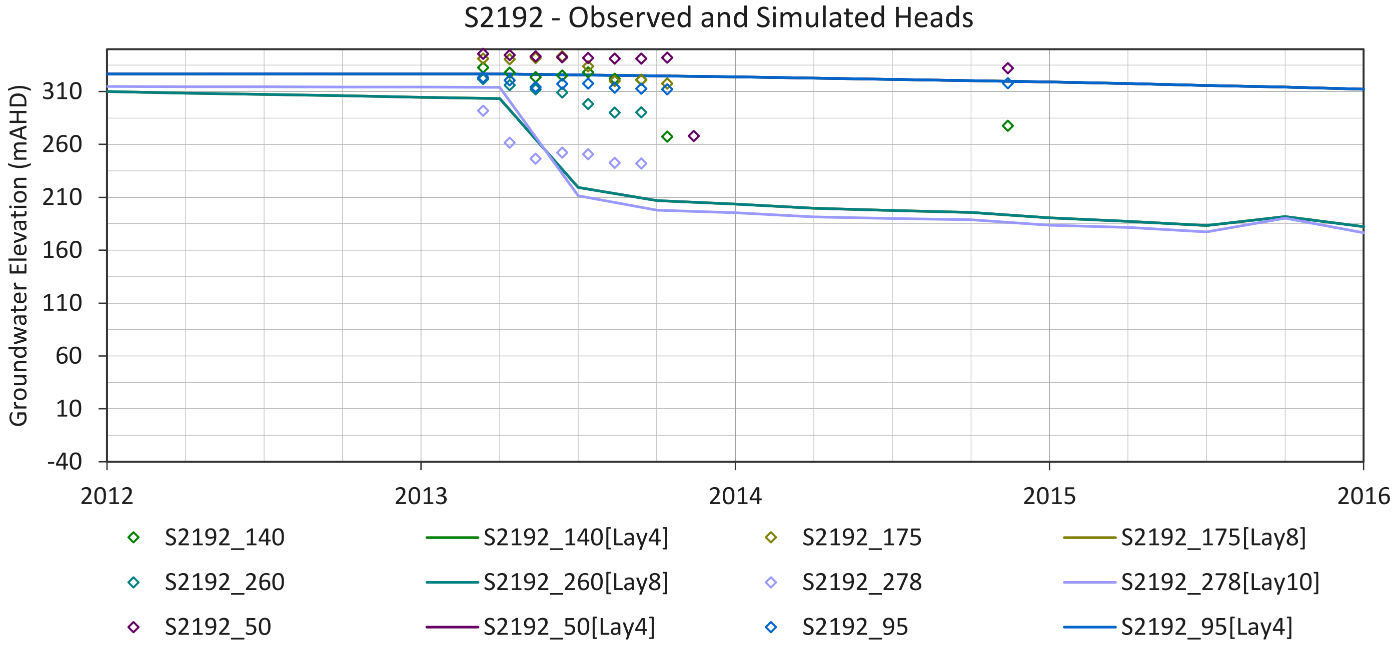

S2165 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
130
120
110
100
90
80
70
60
50
40
2012
2014
2016
2018
2020
2022
S2165_112
S2165_112[Lay4]
S2165_168
S2165_168[Lay4]
S2165_257
S2165_257[Lay4]
S2165_328
S2165_328[Lay8]
S2165_40
S2165_40[Lay2]
S2165_414
S2165_414[Lay8]
S2165_500
S2165_500[Lay8]
S2165_586
S2165_586[Lay10]

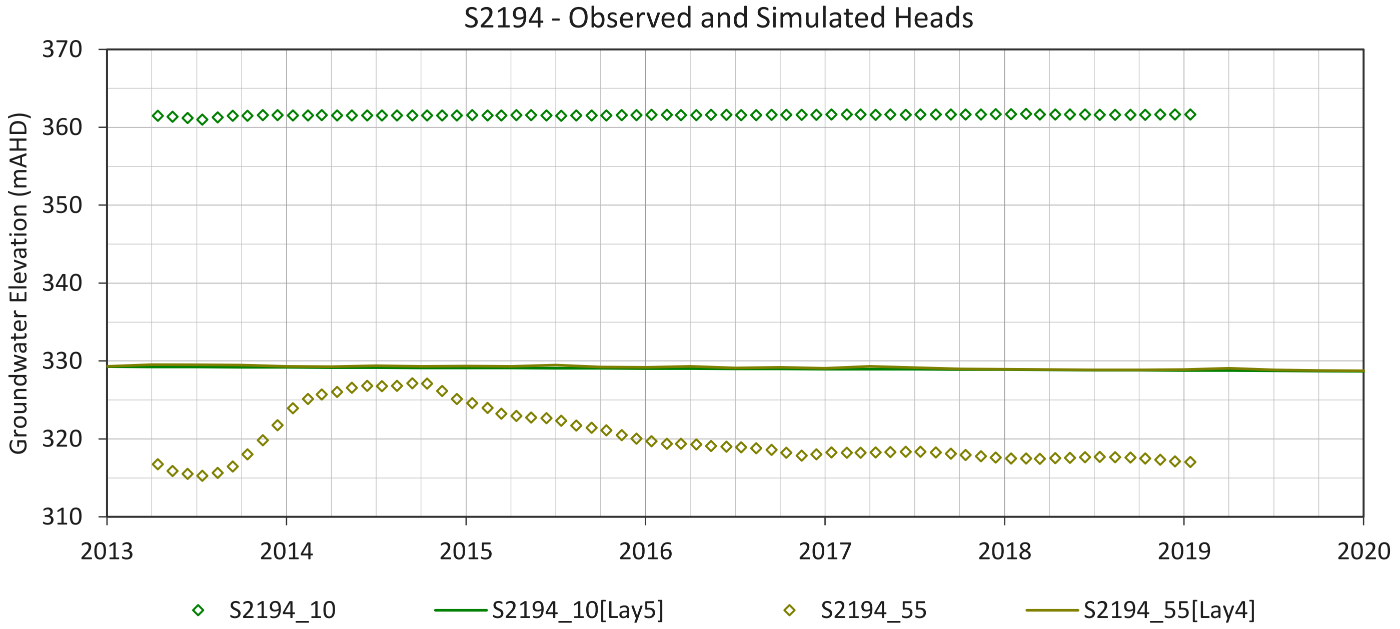

S2173 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
190
170
150
130
110
90
70
50
30
2012
2014
2016
2018
2020
2022
S2173_198
S2173_198[Lay4]
S2173_369
S2173_369[Lay8]
S2173_451
S2173_451[Lay8]
S2173_533
S2173_533[Lay8]
S2173_554
S2173_554[Lay10]
S2173_596
S2173_596[Lay12]

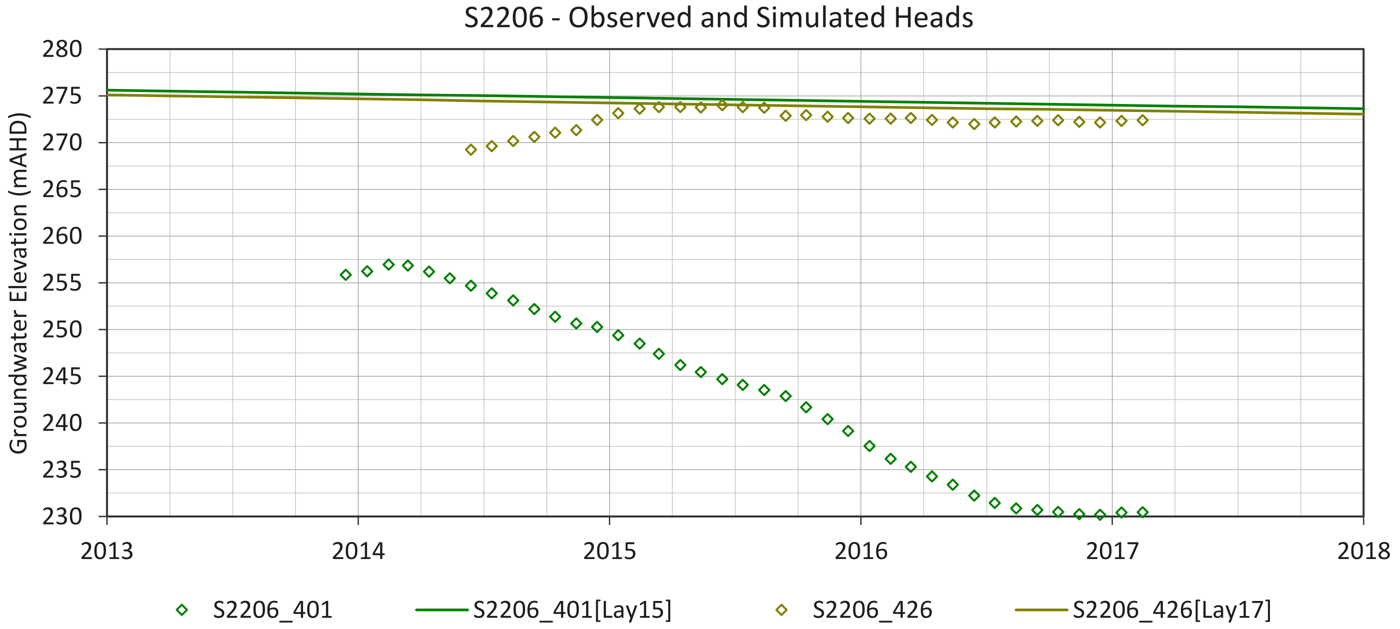

S2177 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
110
100
90
80
70
60
50
40
30
20
2012
2014
2016
2018
2020
2022
S2177_150
S2177_150[Lay4]
S2177_220
S2177_220[Lay4]
S2177_283
S2177_283[Lay8]
S2177_358
S2177_358[Lay8]
S2177_434
S2177_434[Lay8]
S2177_44
S2177_44[Lay4]
S2177_462
S2177_462[Lay10]
S2177_510
S2177_510[Lay12]

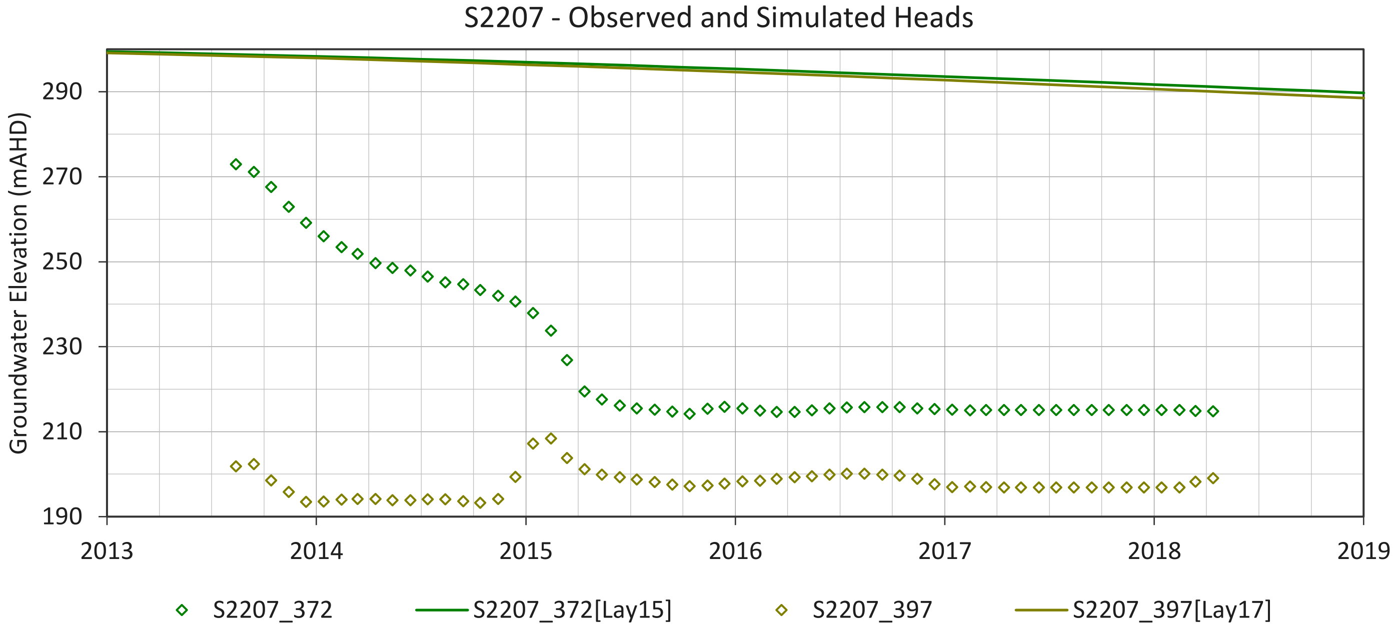

S2187 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
260
240
220
200
180
160
140
120
2012
2013
2014
2015
2016
2017
2018
2019
S2187_302
S2187_302[Lay15]
S2187_331
S2187_331[Lay17]

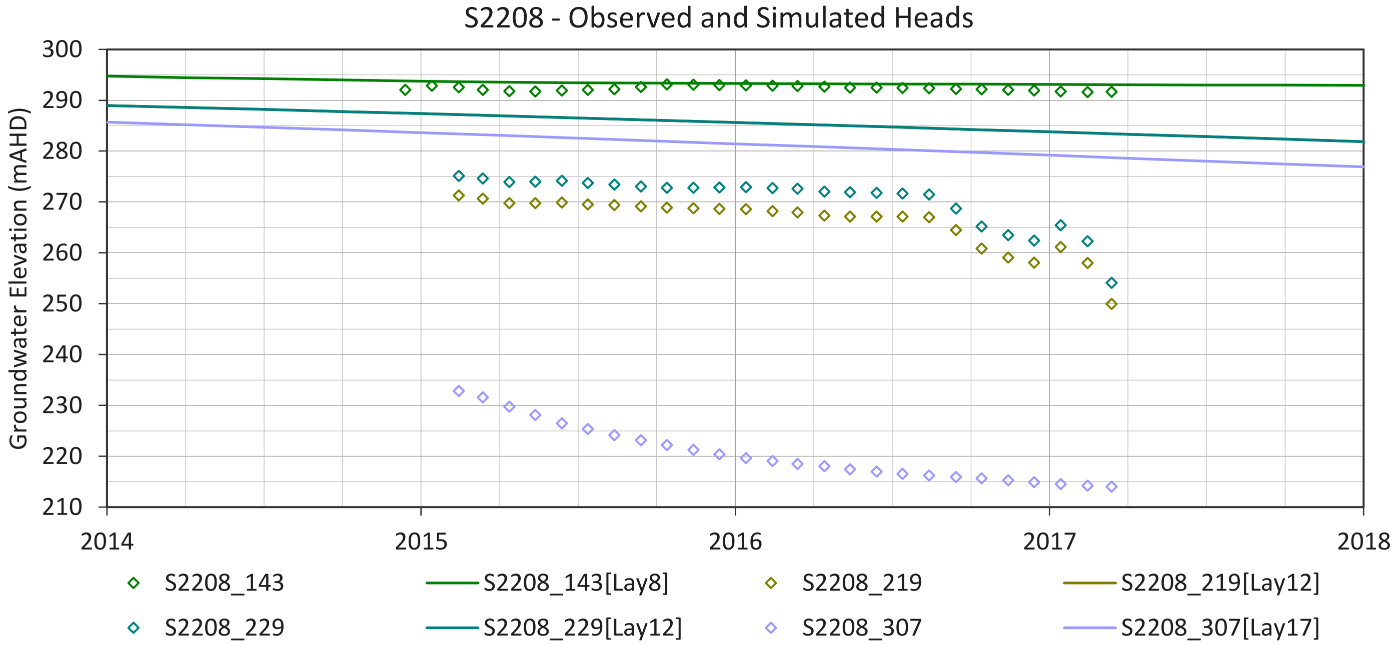

S2188 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
390
340
290
240
190
2014
2015
2016
2017
2018
S2188_145
S2188_145[Lay8]
S2188_197
S2188_197[Lay8]
S2188_235
S2188_235[Lay12]
S2188_245
S2188_245[Lay12]
S2188_256
S2188_256[Lay12]
S2188_304
S2188_304[Lay15]
S2188_335
S2188_335[Lay17]
S2188_45
S2188_45[Lay5]

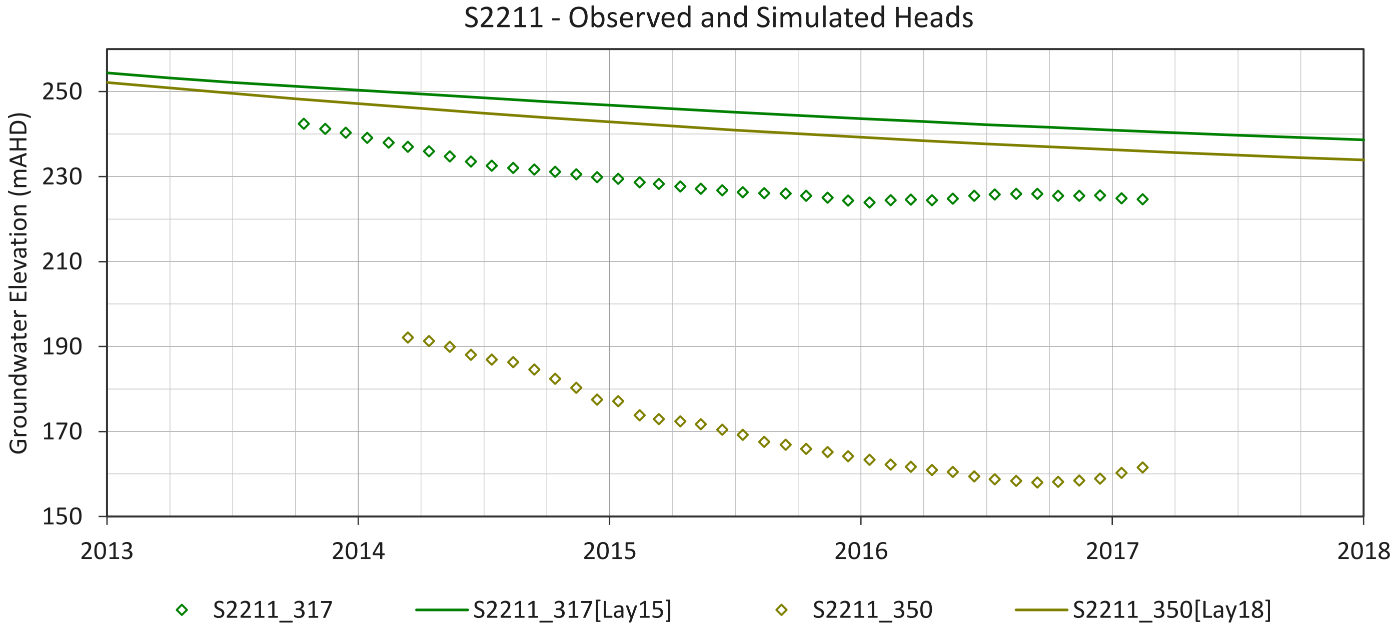

S2192 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
310
260
210
160
110
60
10
-40
2012
2013
2014
2015
2016
S2192_140
S2192_140[Lay4]
S2192_175
S2192_175[Lay8]
S2192_260
S2192_260[Lay8]
S2192_278
S2192_278[Lay10]
S2192_50
S2192_50[Lay4]
S2192_95
S2192_95[Lay4]

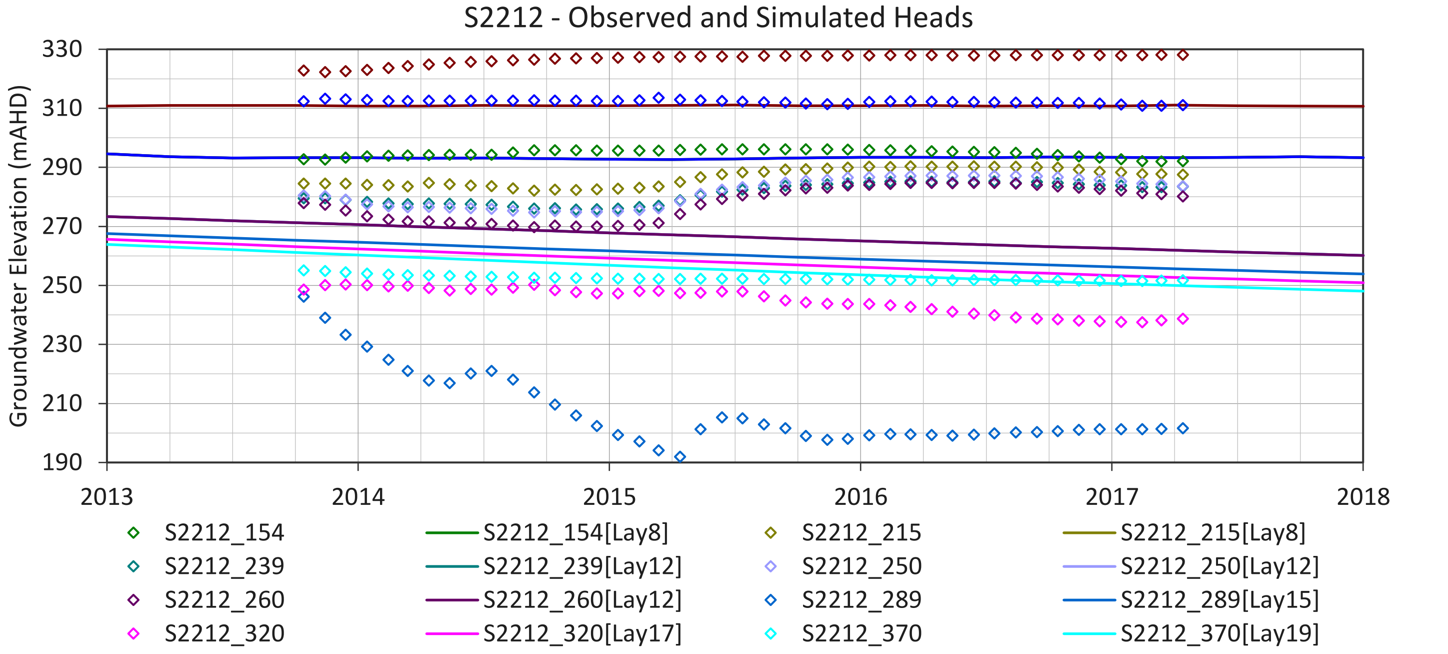

S2194 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
370
360
350
340
330
320
310
2013
2014
2015
2016
2017
2018
2019
2020
S2194_10
S2194_10[Lay5]
S2194_55
S2194_55[Lay4]

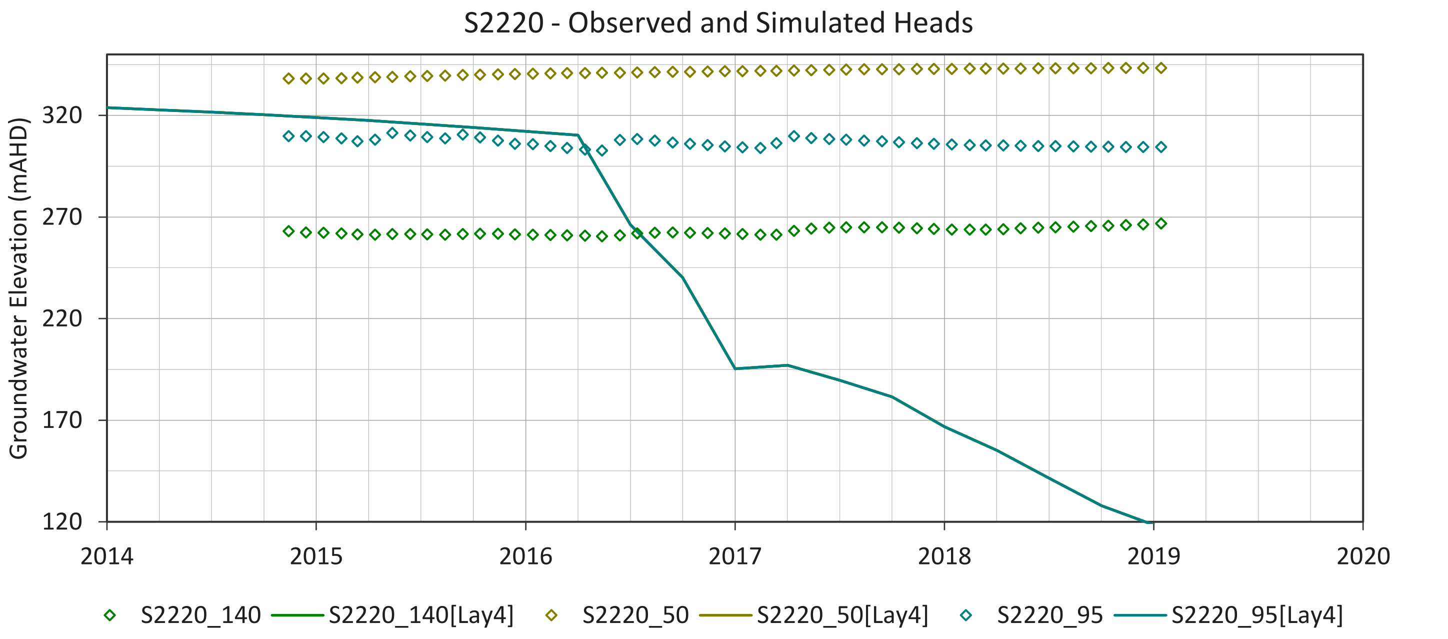

S2206 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
280
275
270
265
260
255
250
245
240
235
230
2013
2014
2015
2016
2017
2018
S2206_401
S2206_401[Lay15]
S2206_426
S2206_426[Lay17]

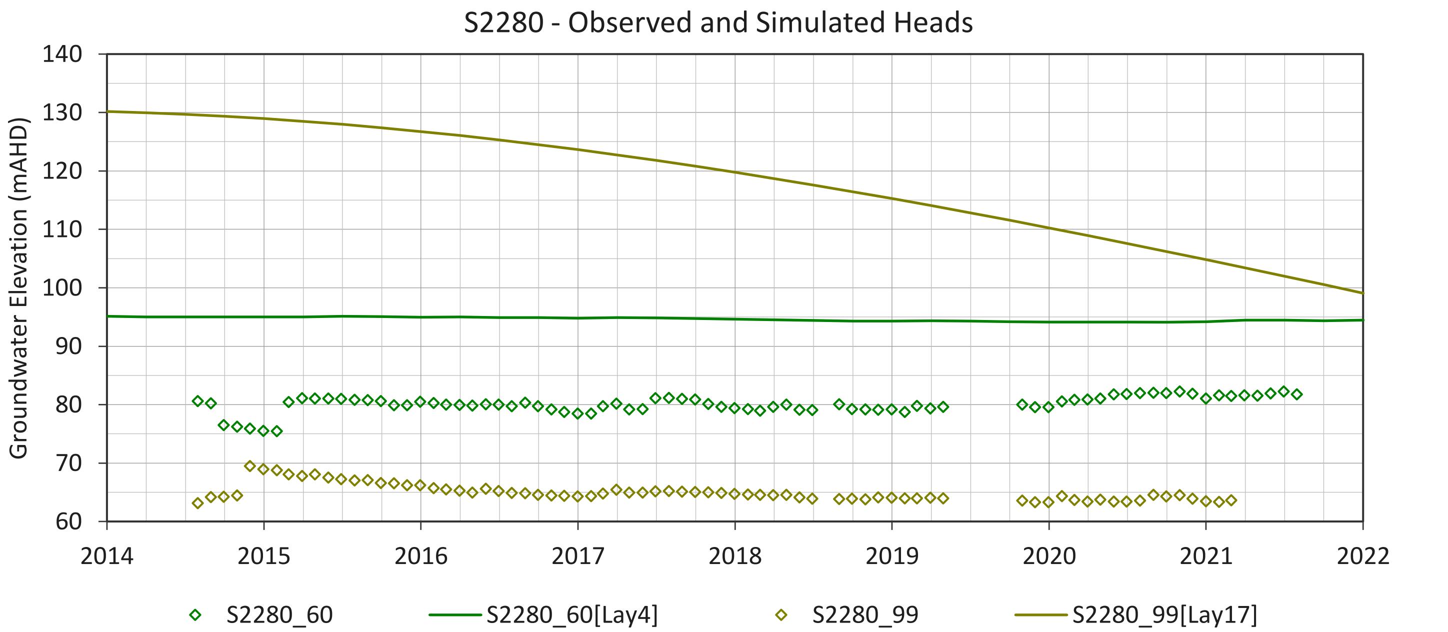

S2207 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
190
210
230
250
270
290
2013
2014
2015
2016
2017
2018
2019
S2207_372
S2207_372[Lay15]
S2207_397
S2207_397[Lay17]

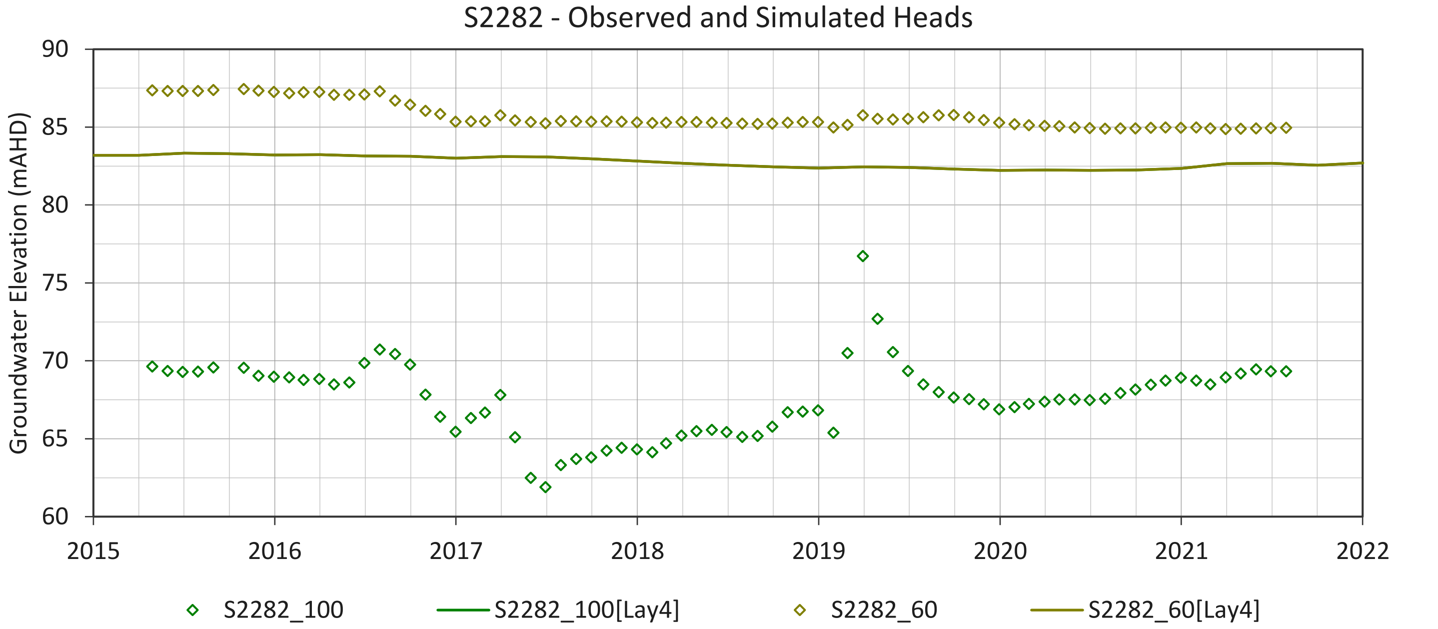

S2208 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
210
220
230
240
250
260
270
280
290
300
2014
2015
2016
2017
2018
S2208_143
S2208_143[Lay8]
S2208_219
S2208_219[Lay12]
S2208_229
S2208_229[Lay12]
S2208_307
S2208_307[Lay17]

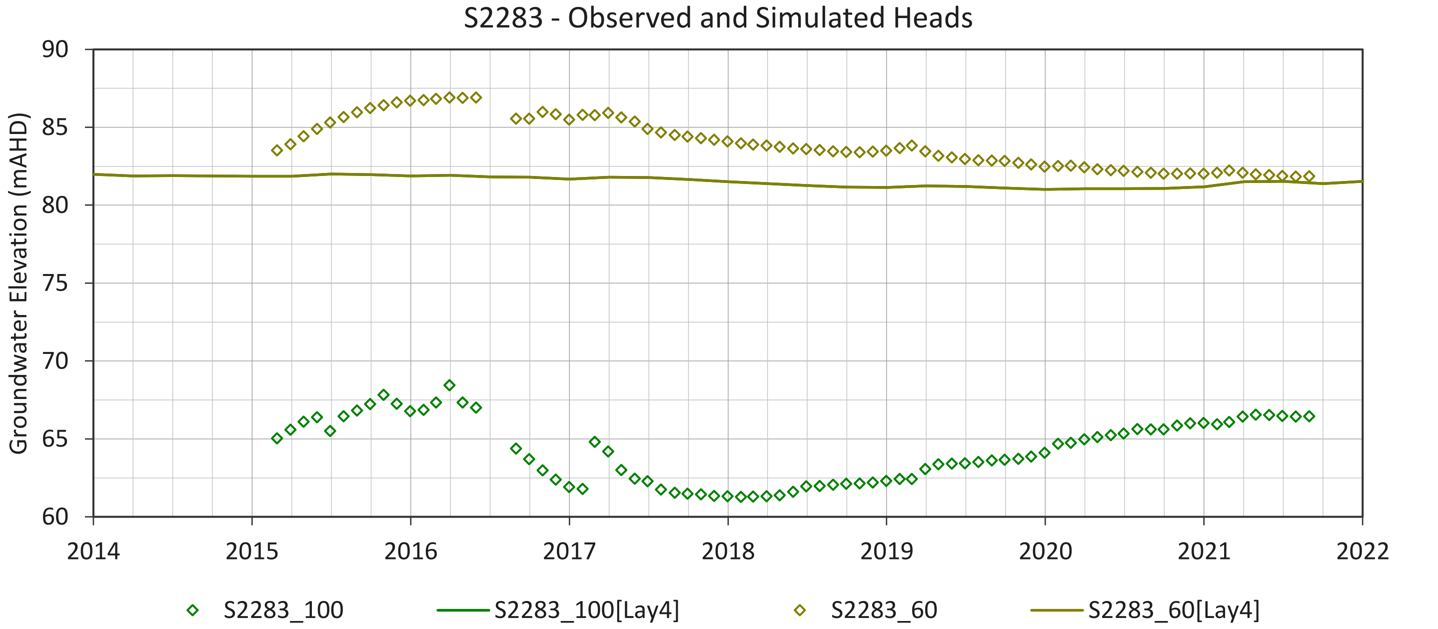

S2211 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
150
170
190
210
230
250
2013
2014
2015
2016
2017
2018
S2211_317
S2211_317[Lay15]
S2211_350
S2211_350[Lay18]

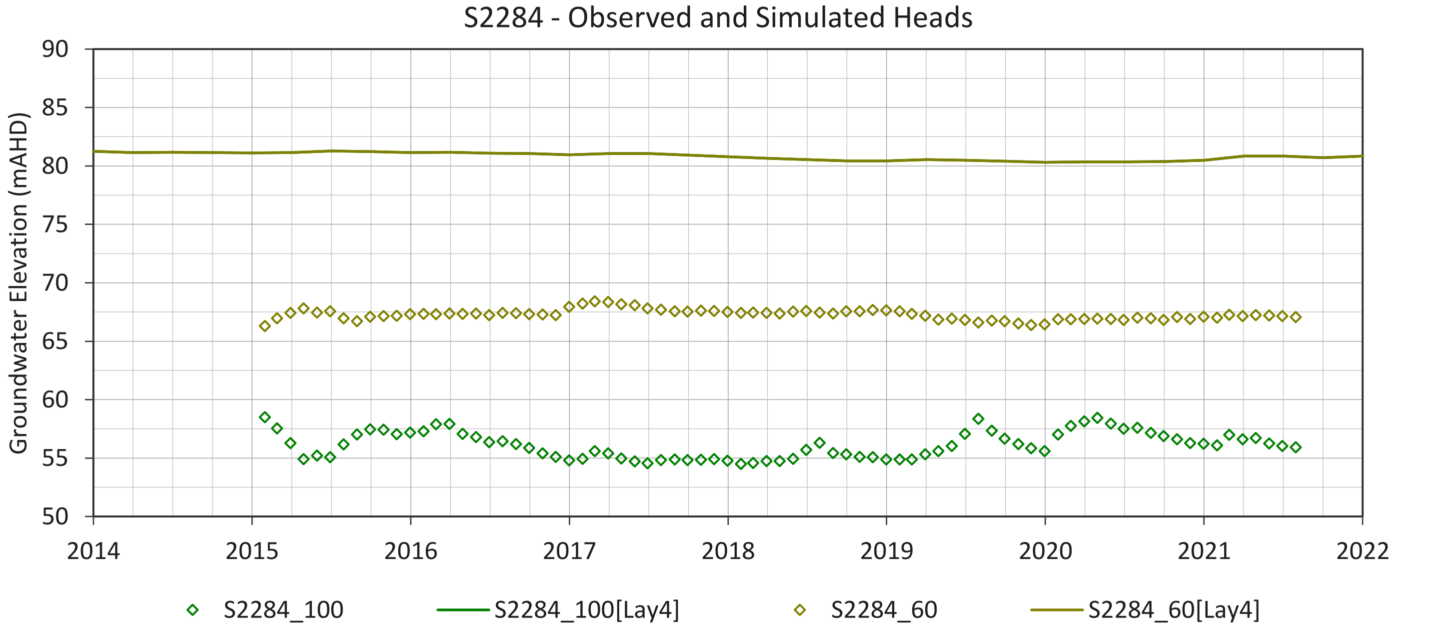

S2212 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
330
310
290
270
250
230
210
190
2013
2014
2015
2016
2017
2018
S2212_154
S2212_154[Lay8]
S2212_215
S2212_215[Lay8]
S2212_239
S2212_239[Lay12]
S2212_250
S2212_250[Lay12]
S2212_260
S2212_260[Lay12]
S2212_289
S2212_289[Lay15]
S2212_320
S2212_320[Lay17]
S2212_370
S2212_370[Lay19]

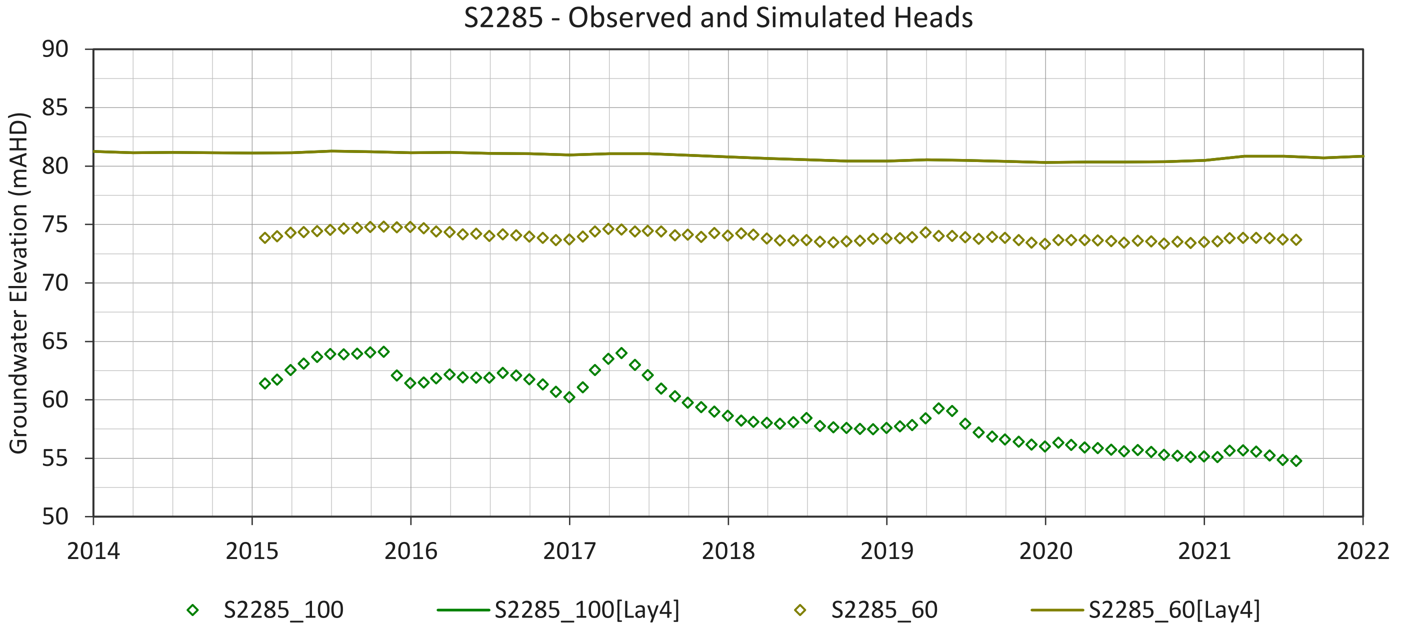

S2220 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
320
270
220
170
120
2014
2015
2016
2017
2018
2019
2020
S2220_140
S2220_140[Lay4]
S2220_50
S2220_50[Lay4]
S2220_95
S2220_95[Lay4]

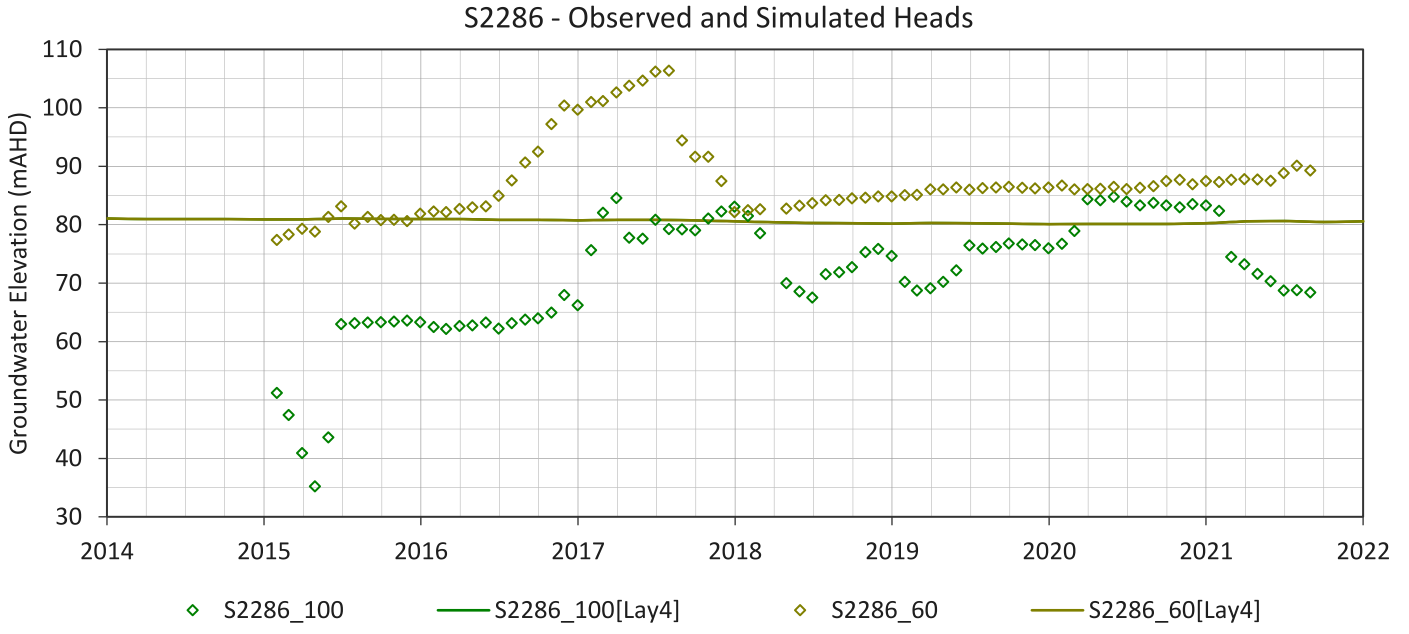

S2280 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
140
130
120
110
100
90
80
70
60
2014
2015
2016
2017
2018
2019
2020
2021
2022
S2280_60
S2280_60[Lay4]
S2280_99
S2280_99[Lay17]

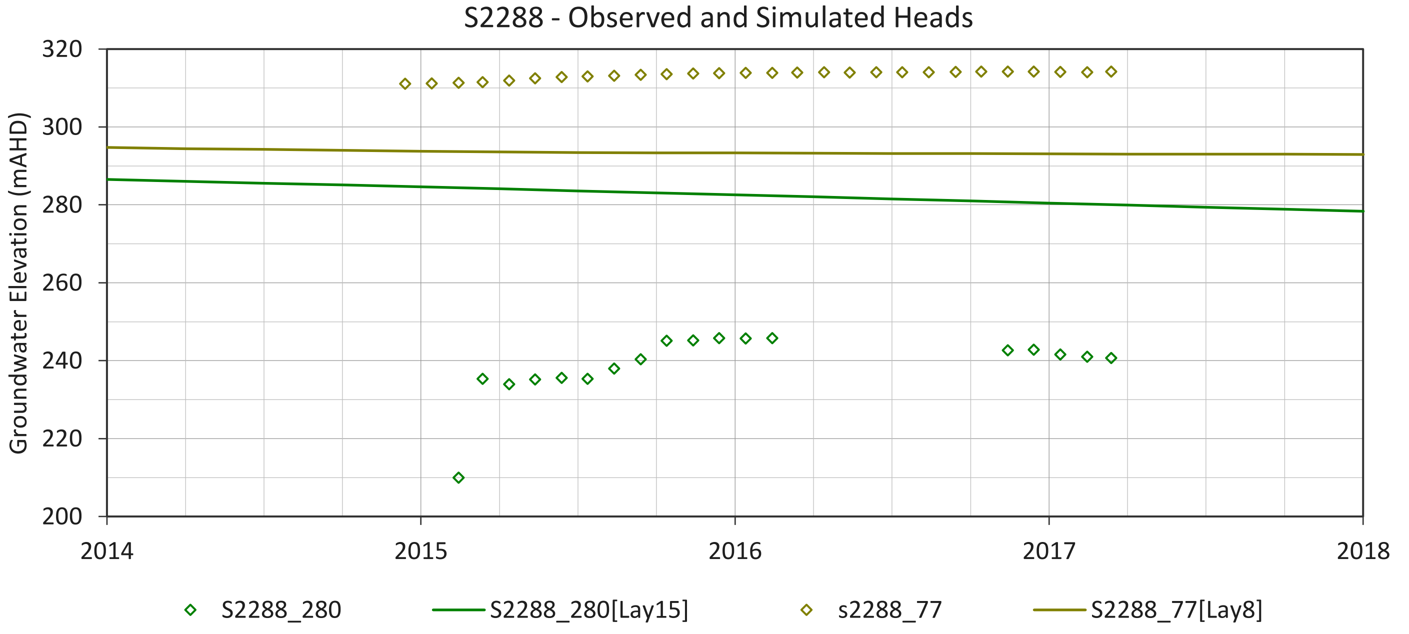

S2282 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
90
85
80
75
70
65
60
2015
2016
2017
2018
2019
2020
2021
2022
S2282_100
S2282_100[Lay4]
S2282_60
S2282_60[Lay4]

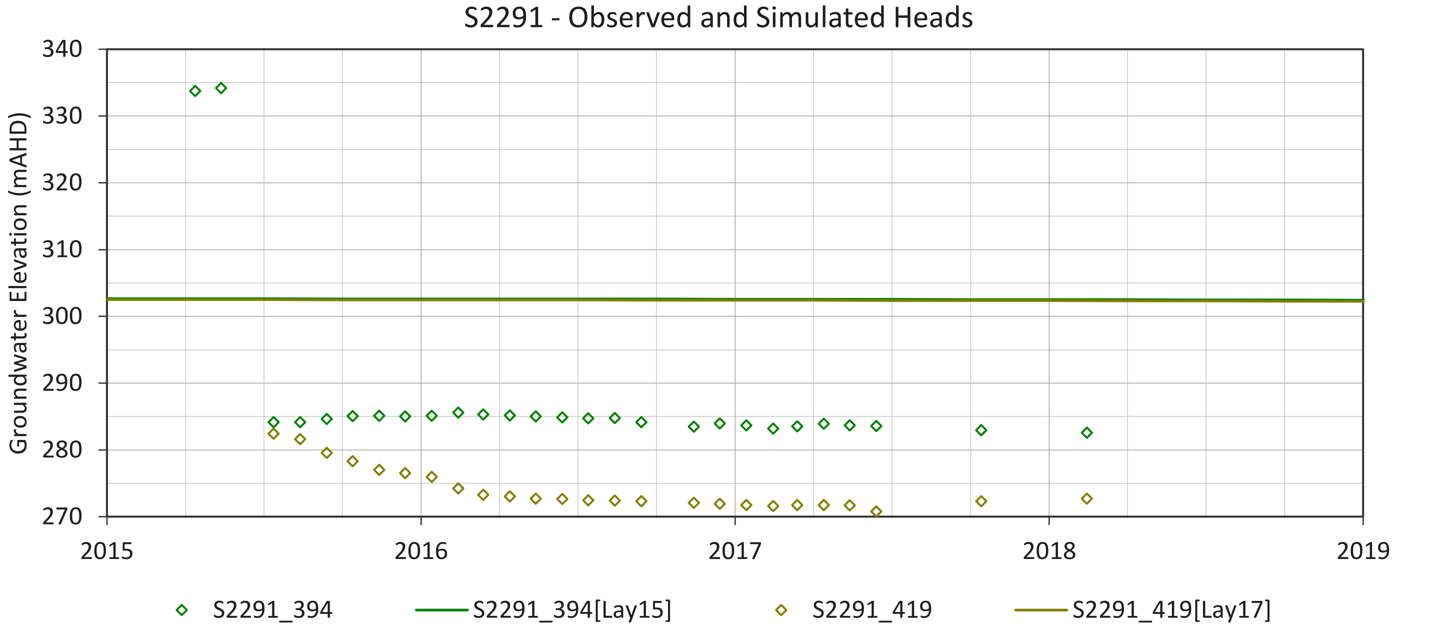

S2283 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
90
85
80
75
70
65
60
2014
2015
2016
2017
2018
2019
2020
2021
2022
S2283_100
S2283_100[Lay4]
S2283_60
S2283_60[Lay4]

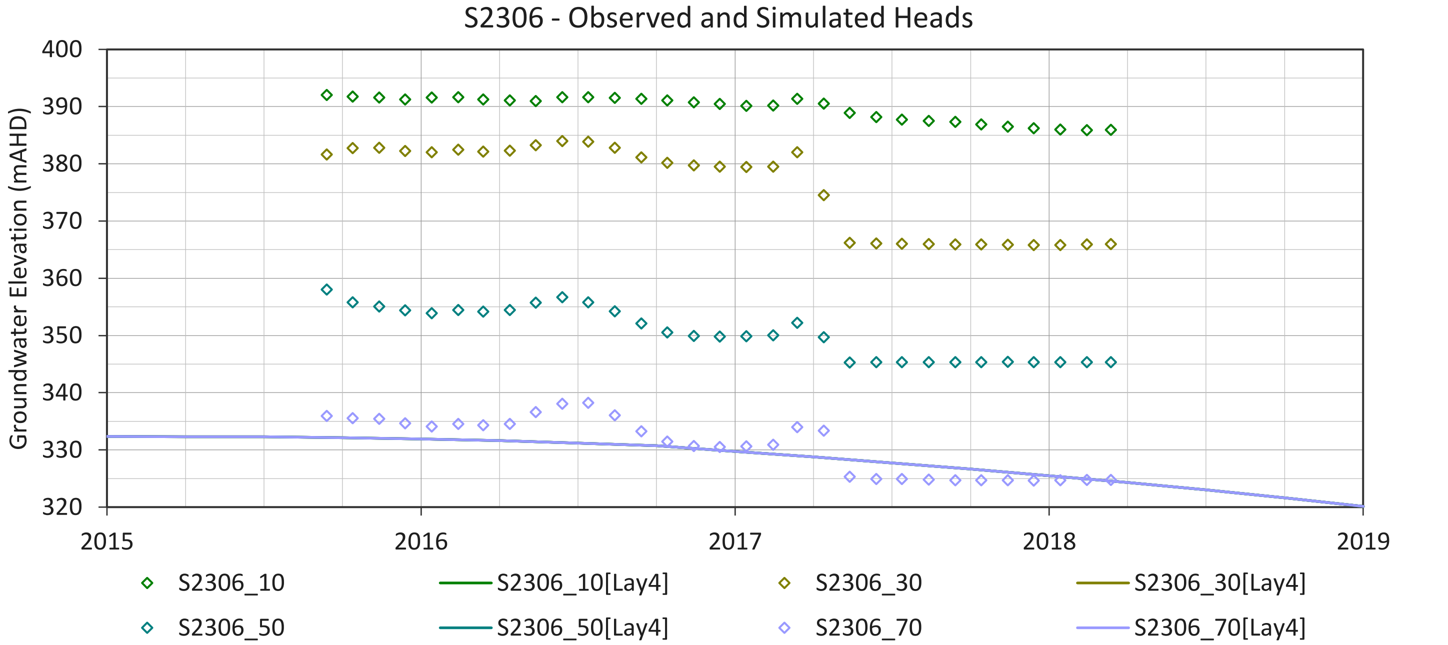

S2284 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
90
85
80
75
70
65
60
55
50
2014
2015
2016
2017
2018
2019
2020
2021
2022
S2284_100
S2284_100[Lay4]
S2284_60
S2284_60[Lay4]

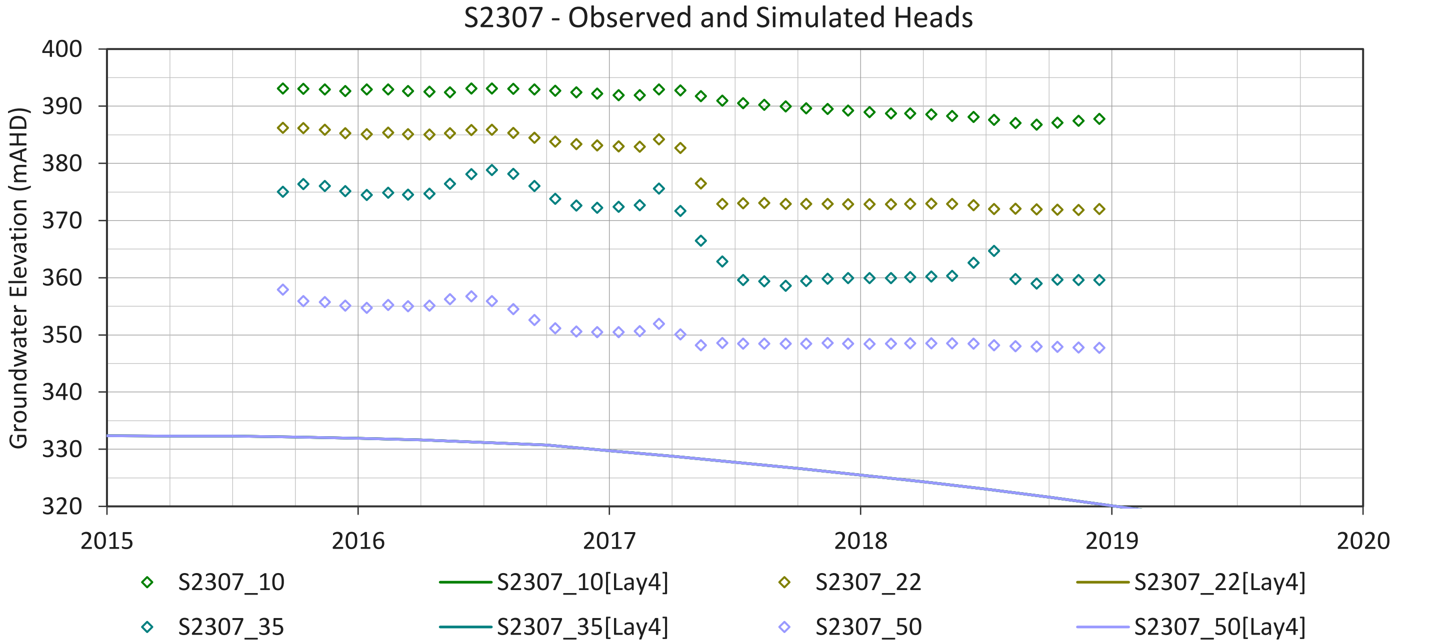

S2285 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
90
85
80
75
70
65
60
55
50
2014
2015
2016
2017
2018
2019
2020
2021
2022
S2285_100
S2285_100[Lay4]
S2285_60
S2285_60[Lay4]

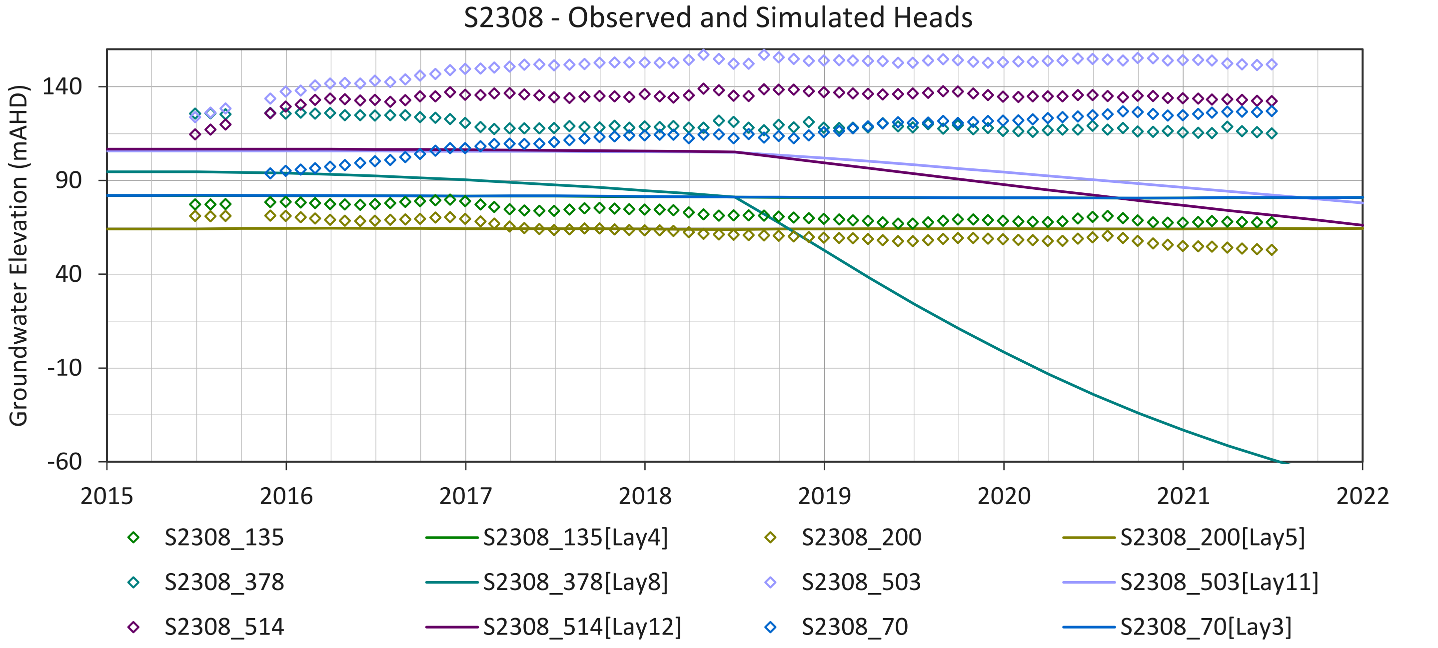

S2286 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
110
100
90
80
70
60
50
40
30
2014
2015
2016
2017
2018
2019
2020
2021
2022
S2286_100
S2286_100[Lay4]
S2286_60
S2286_60[Lay4]

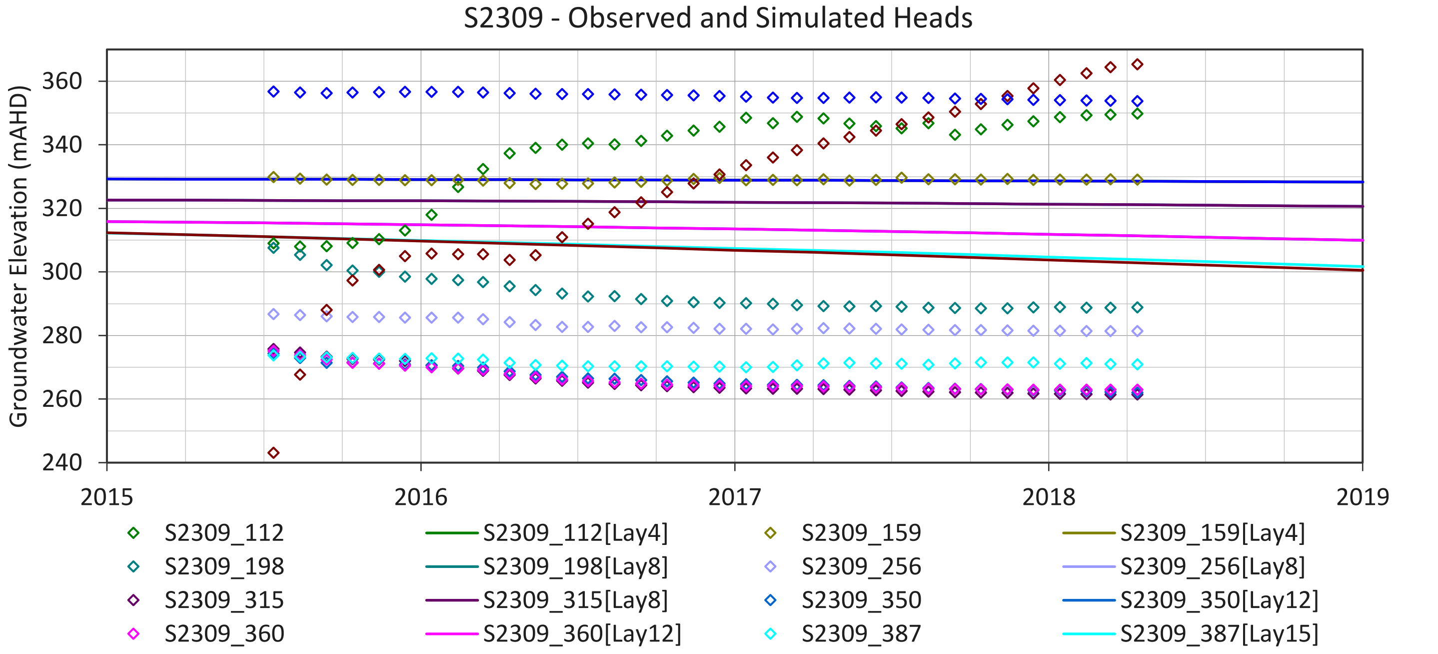

S2288 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
320
300
280
260
240
220
200
2014
2015
2016
2017
2018
S2288_280
S2288_280[Lay15]
s2288_77
S2288_77[Lay8]

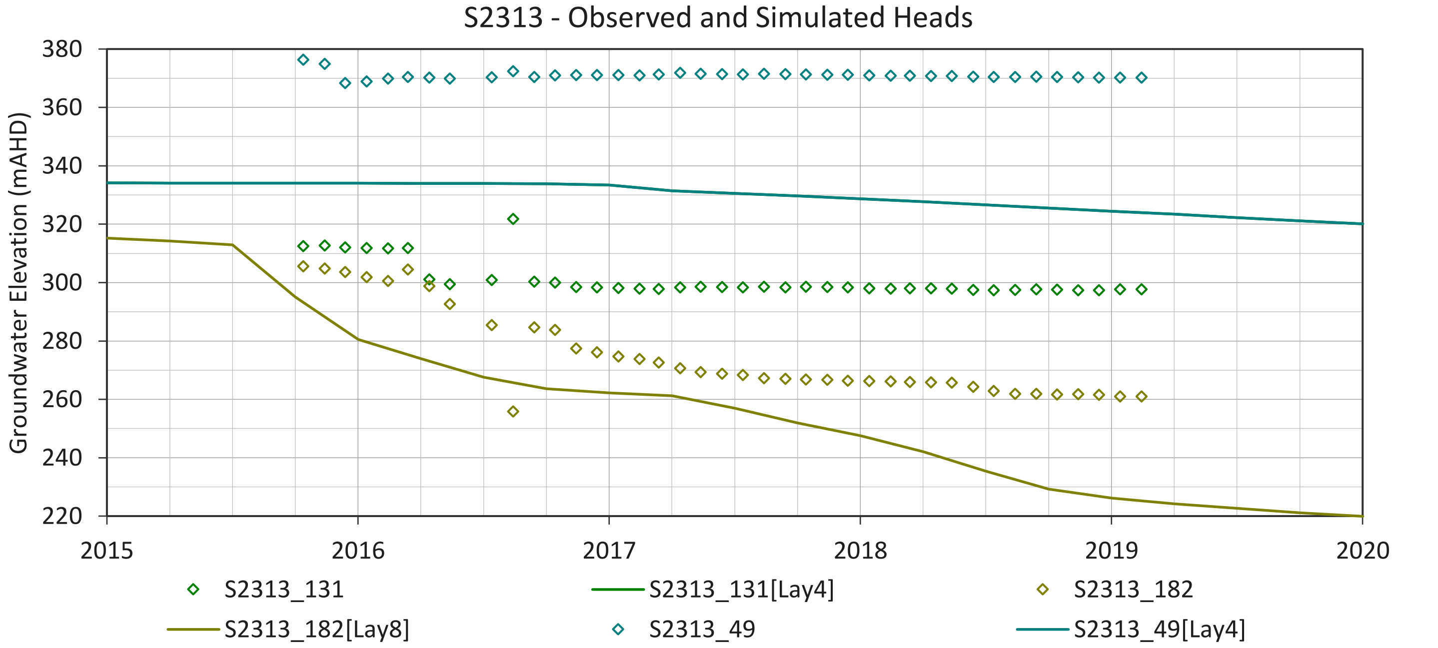

S2291 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
340
330
320
310
300
290
280
270
2015
2016
2017
2018
2019
S2291_394
S2291_394[Lay15]
S2291_419
S2291_419[Lay17]

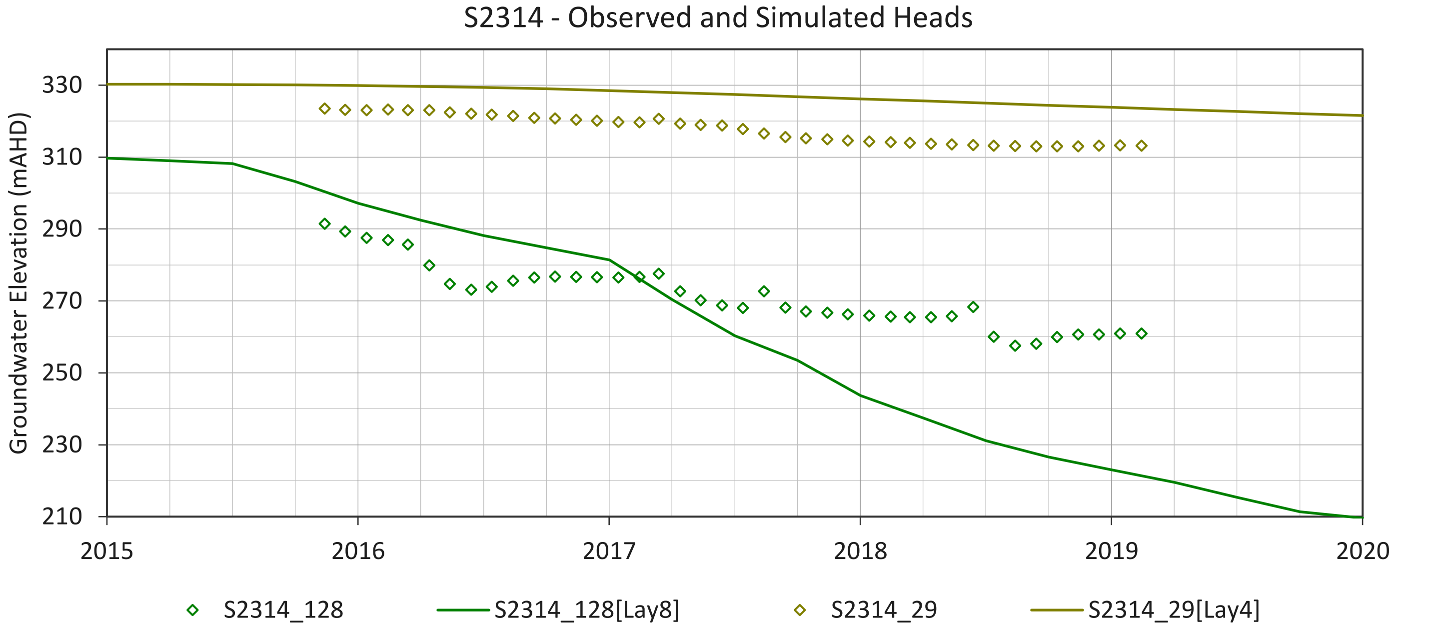

S2306 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
400
390
380
370
360
350
340
330
320
2015
2016
2017
2018
2019
S2306_10
S2306_10[Lay4]
S2306_30
S2306_30[Lay4]
S2306_50
S2306_50[Lay4]
S2306_70
S2306_70[Lay4]

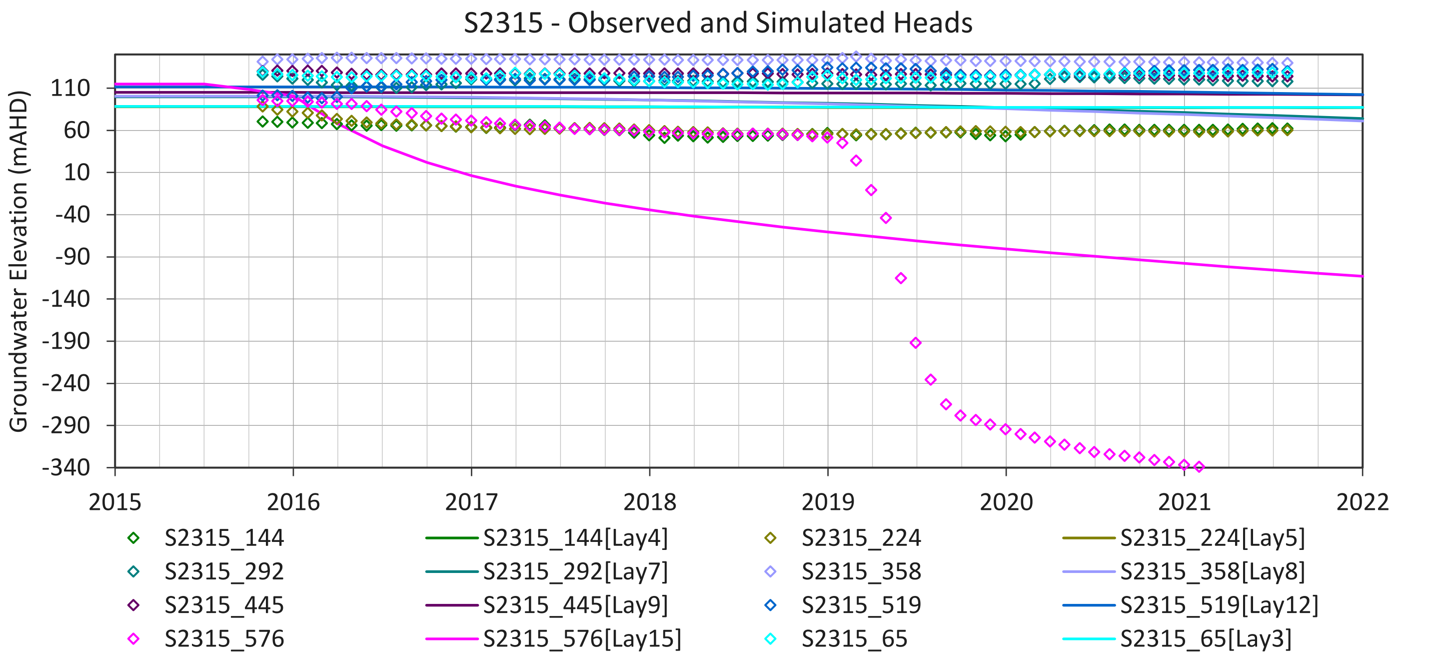

S2307 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
400
390
380
370
360
350
340
330
320
2015
2016
2017
2018
2019
2020
S2307_10
S2307_10[Lay4]
S2307_22
S2307_22[Lay4]
S2307_35
S2307_35[Lay4]
S2307_50
S2307_50[Lay4]

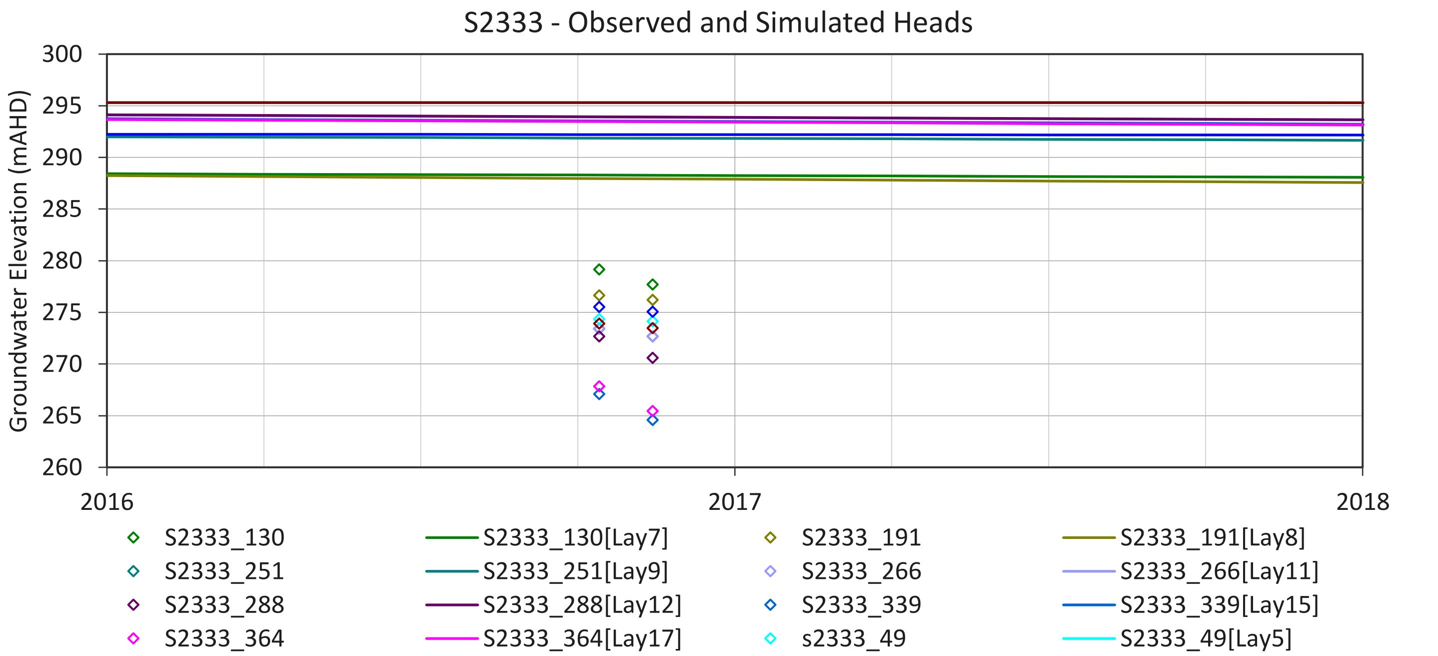

S2308 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
140
90
40
-10
-60
2015
2016
2017
2018
2019
2020
2021
2022
S2308_135
S2308_135[Lay4]
S2308_200
S2308_200[Lay5]
S2308_378
S2308_378[Lay8]
S2308_503
S2308_503[Lay11]
S2308_514
S2308_514[Lay12]
S2308_70
S2308_70[Lay3]

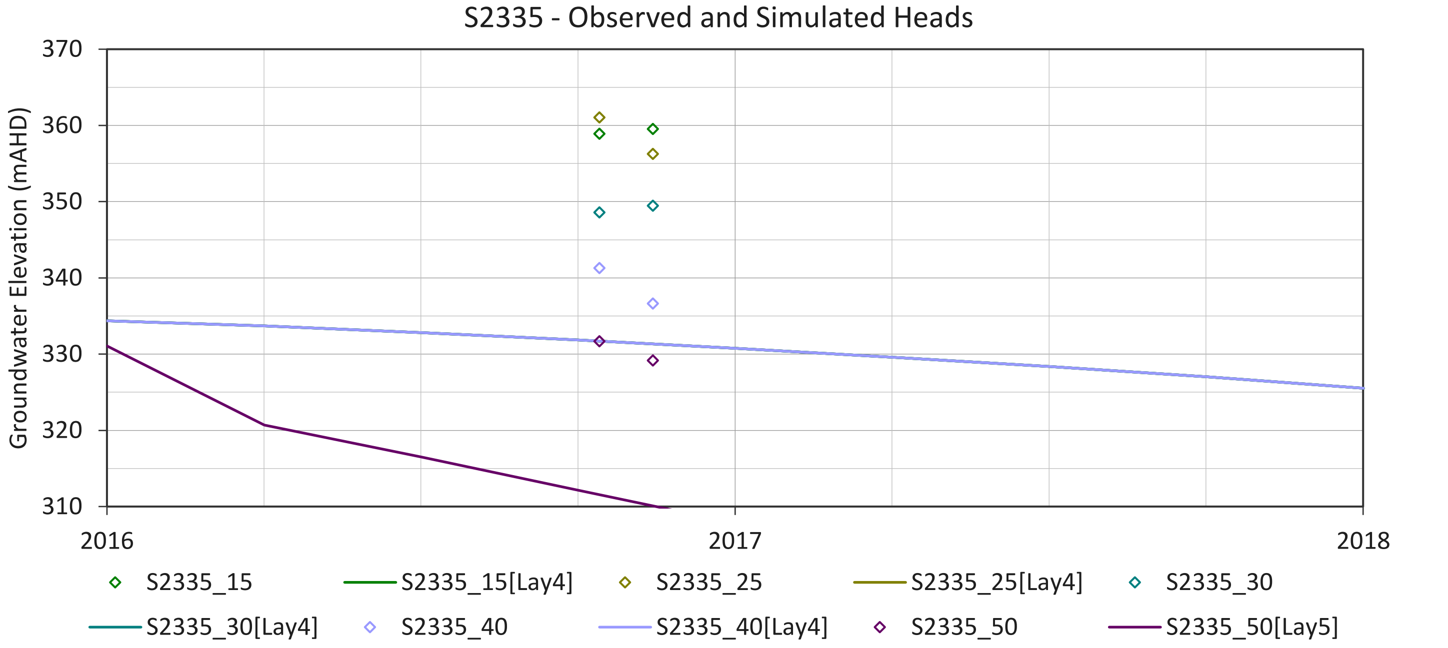

S2309 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
360
340
320
300
280
260
240
2015
2016
2017
2018
2019
S2309_112
S2309_112[Lay4]
S2309_159
S2309_159[Lay4]
S2309_198
S2309_198[Lay8]
S2309_256
S2309_256[Lay8]
S2309_315
S2309_315[Lay8]
S2309_350
S2309_350[Lay12]
S2309_360
S2309_360[Lay12]
S2309_387
S2309_387[Lay15]

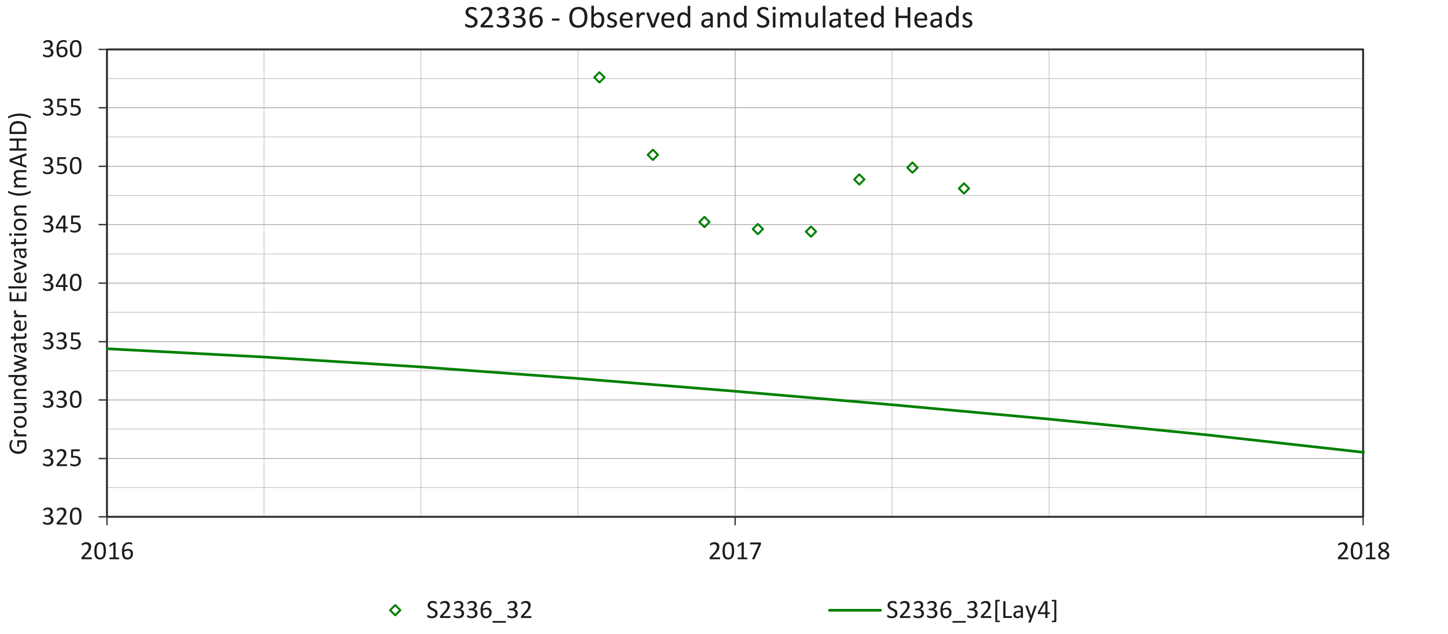

S2313 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
380
360
340
320
300
280
260
240
220
2015
2016
2017
2018
2019
2020
S2313_131
S2313_131[Lay4]
S2313_182
S2313_182[Lay8]
S2313_49
S2313_49[Lay4]

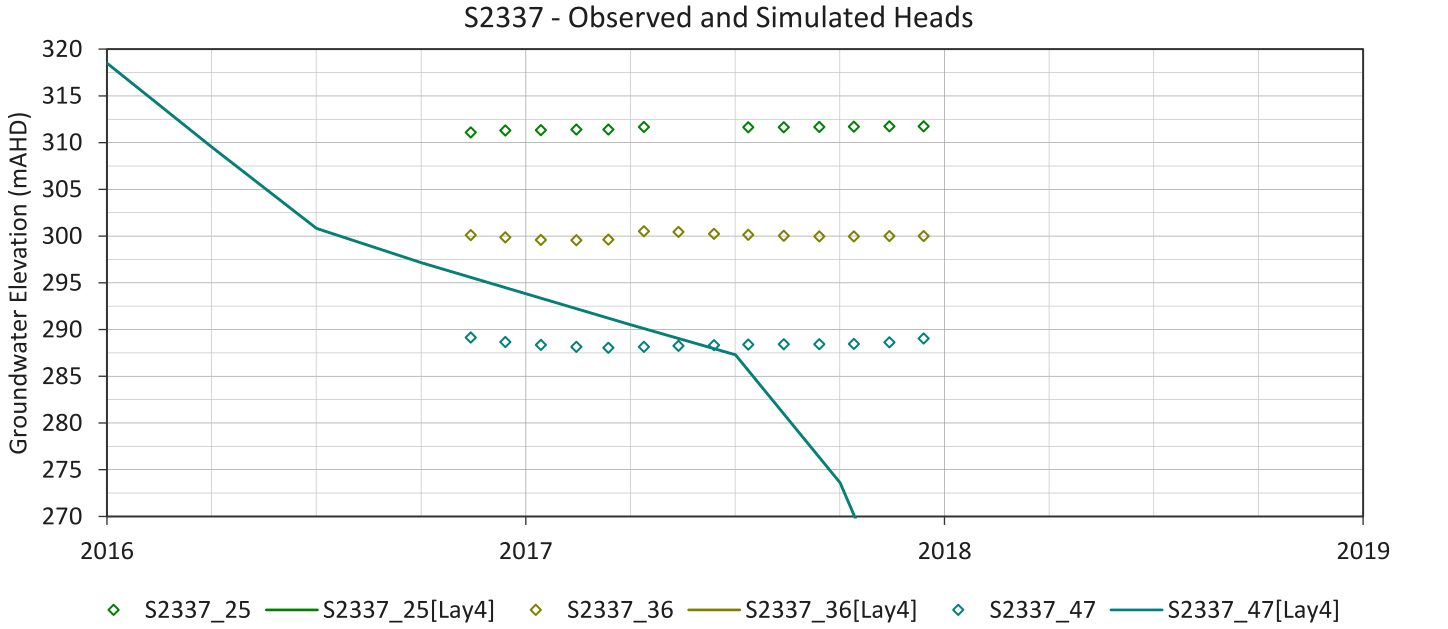

S2314 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
330
310
290
270
250
230
210
2015
2016
2017
2018
2019
2020
S2314_128
S2314_128[Lay8]
S2314_29
S2314_29[Lay4]

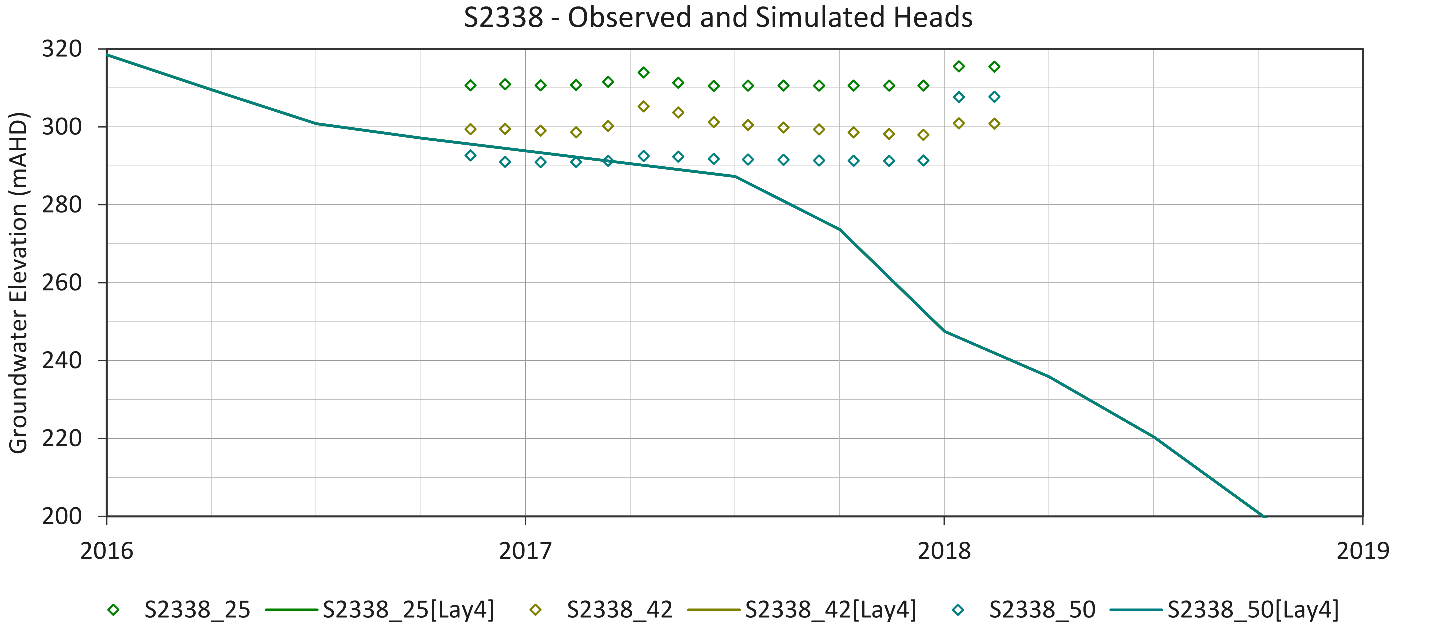

S2315 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
110
60
10
-40
-90
-140
-190
-240
-290
-340
2015
2016
2017
2018
2019
2020
2021
2022
S2315_144
S2315_144[Lay4]
S2315_224
S2315_224[Lay5]
S2315_292
S2315_292[Lay7]
S2315_358
S2315_358[Lay8]
S2315_445
S2315_445[Lay9]
S2315_519
S2315_519[Lay12]
S2315_576
S2315_576[Lay15]
S2315_65
S2315_65[Lay3]

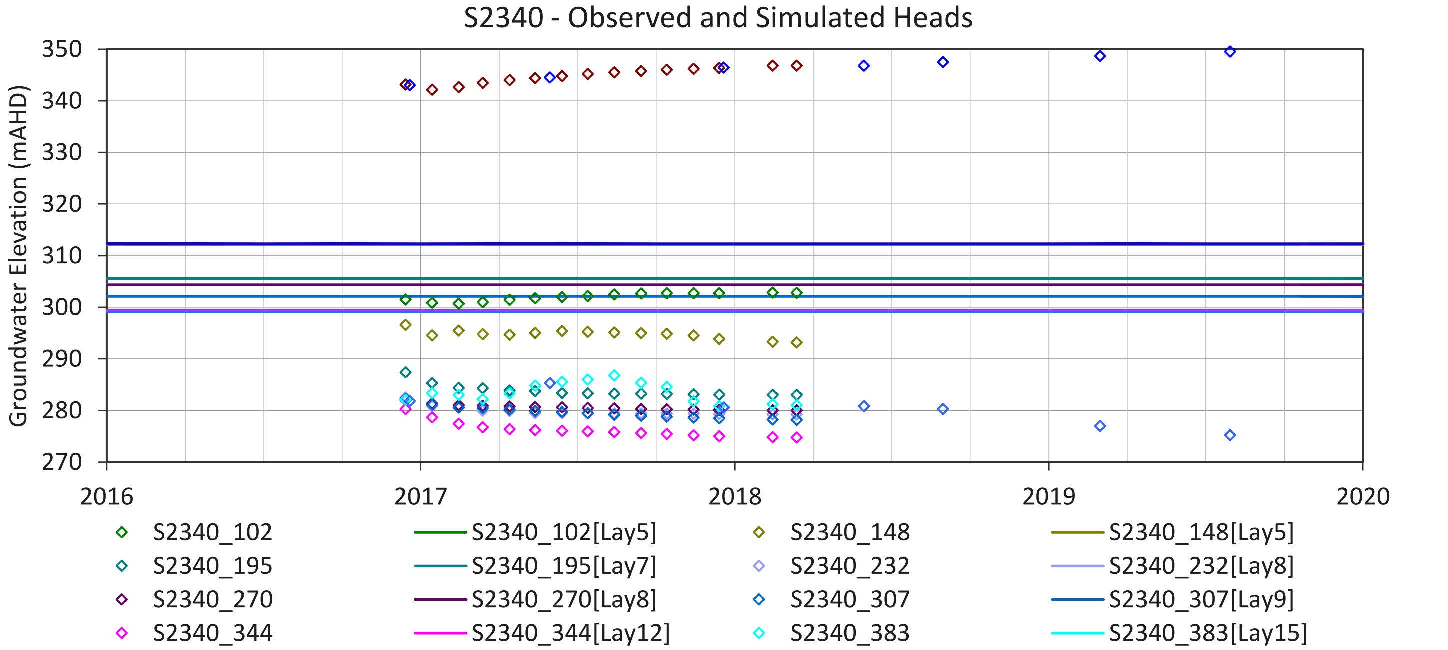

S2333 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
300
295
290
285
280
275
270
265
260
2016
2017
2018
S2333_130
S2333_130[Lay7]
S2333_191
S2333_191[Lay8]
S2333_251
S2333_251[Lay9]
S2333_266
S2333_266[Lay11]
S2333_288
S2333_288[Lay12]
S2333_339
S2333_339[Lay15]
S2333_364
S2333_364[Lay17]
s2333_49
S2333_49[Lay5]

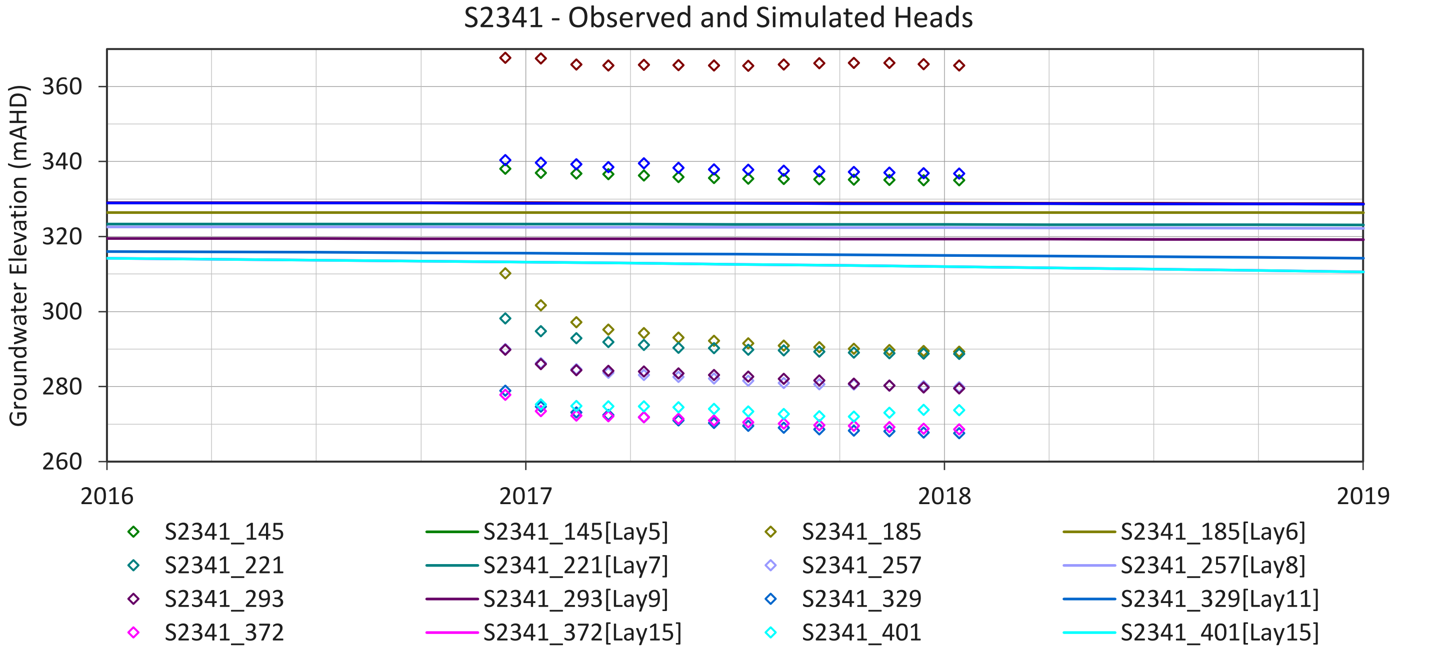

S2335 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
370
360
350
340
330
320
310
2016
2017
2018
S2335_15
S2335_15[Lay4]
S2335_25
S2335_25[Lay4]
S2335_30
S2335_30[Lay4]
S2335_40
S2335_40[Lay4]
S2335_50
S2335_50[Lay5]

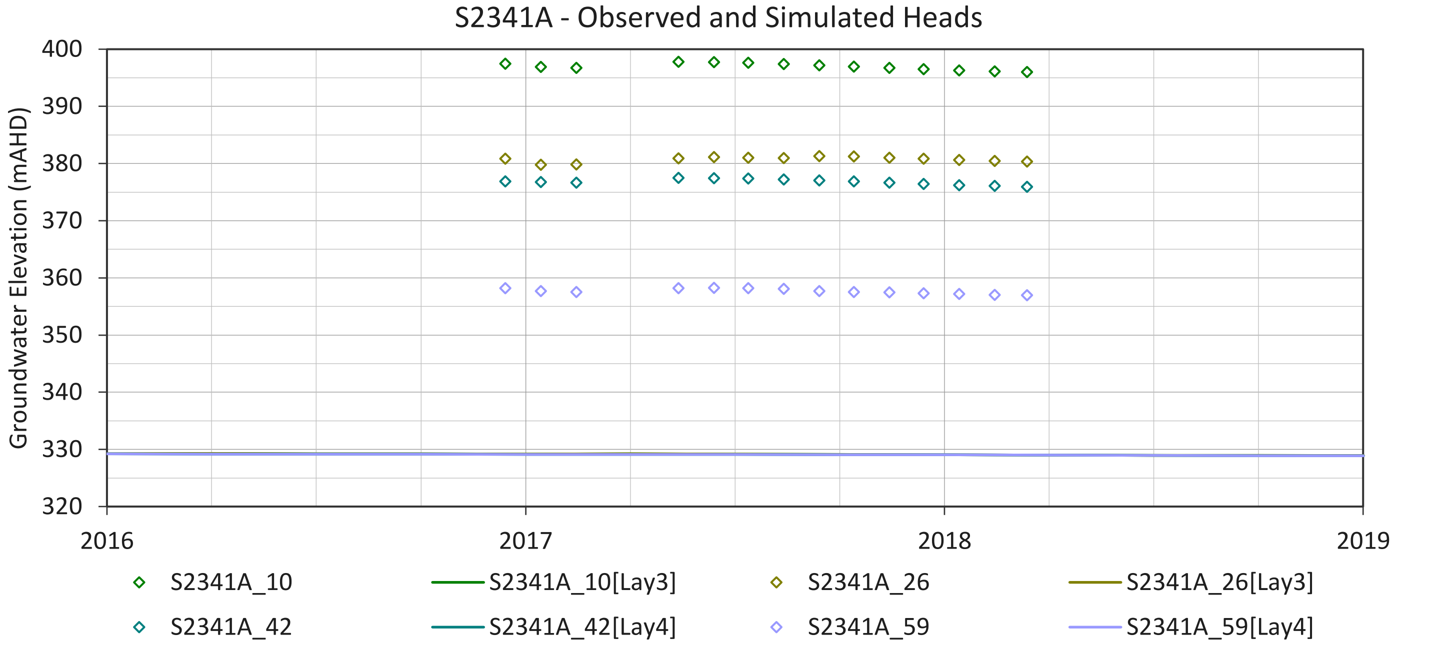

S2336 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
360
355
350
345
340
335
330
325
320
2016
2017
2018
S2336_32
S2336_32[Lay4]

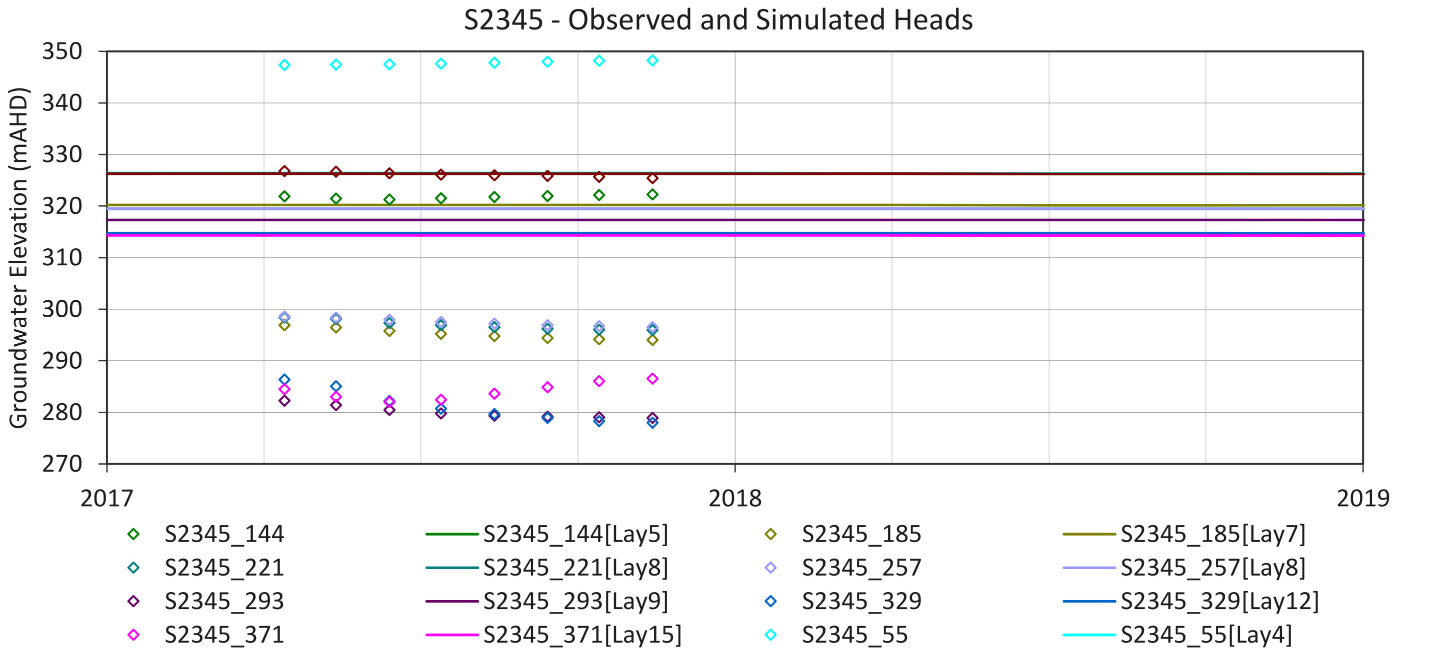

S2337 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
320
315
310
305
300
295
290
285
280
275
270
2016
2017
2018
2019
S2337_25
S2337_25[Lay4]
S2337_36
S2337_36[Lay4]
S2337_47
S2337_47[Lay4]

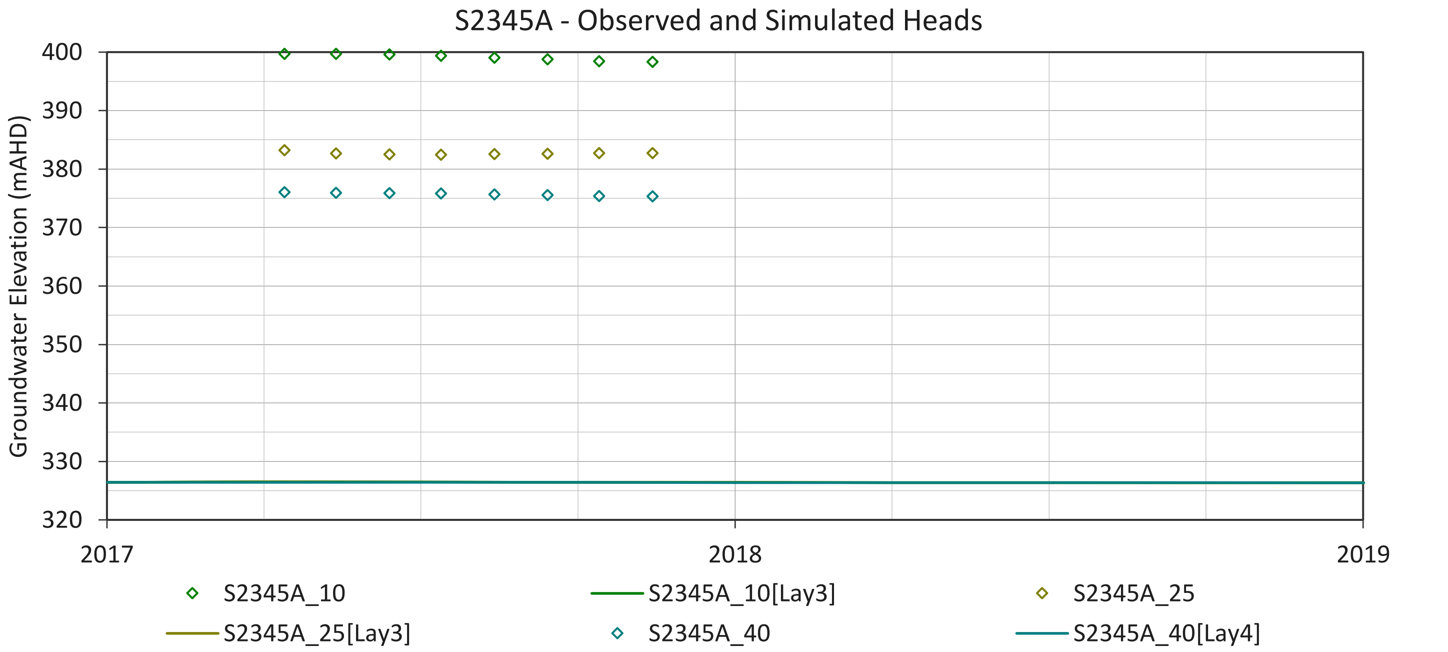

S2338 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
320
300
280
260
240
220
200
2016
2017
2018
2019
S2338_25
S2338_25[Lay4]
S2338_42
S2338_42[Lay4]
S2338_50
S2338_50[Lay4]

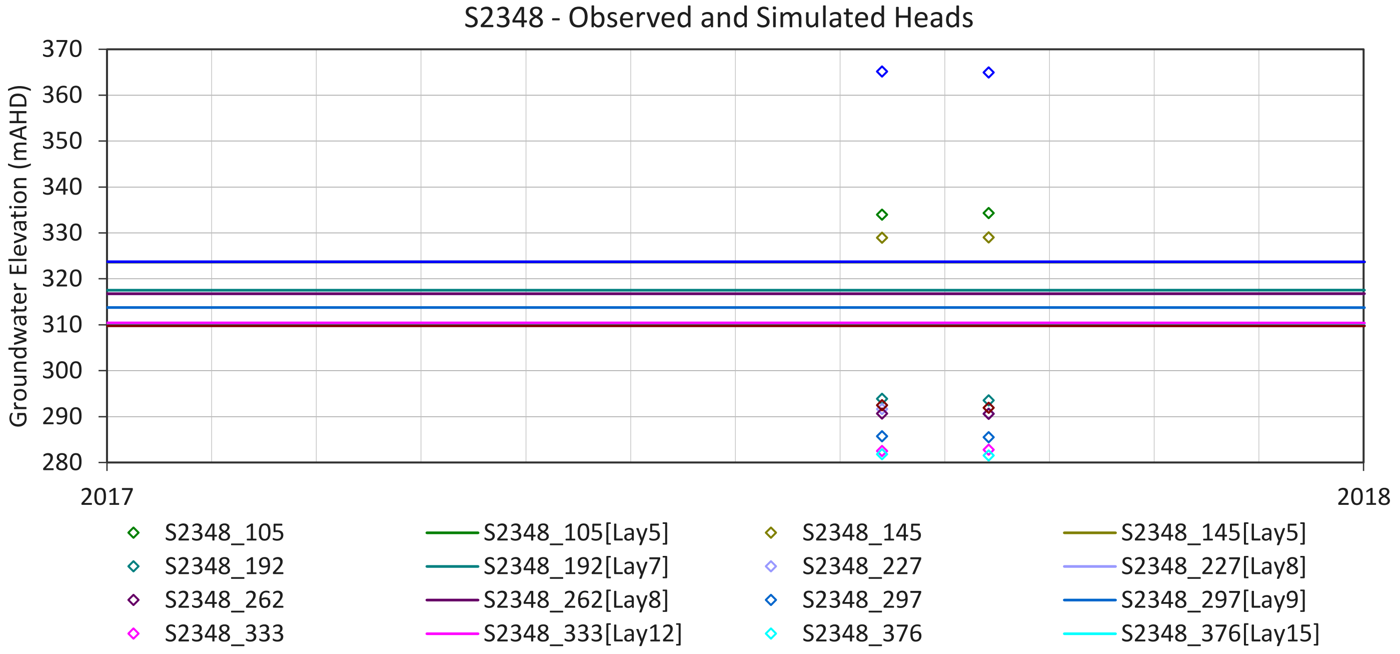

S2340 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
350
340
330
320
310
300
290
280
270
2016
2017
2018
2019
2020
S2340_102
S2340_102[Lay5]
S2340_148
S2340_148[Lay5]
S2340_195
S2340_195[Lay7]
S2340_232
S2340_232[Lay8]
S2340_270
S2340_270[Lay8]
S2340_307
S2340_307[Lay9]
S2340_344
S2340_344[Lay12]
S2340_383
S2340_383[Lay15]

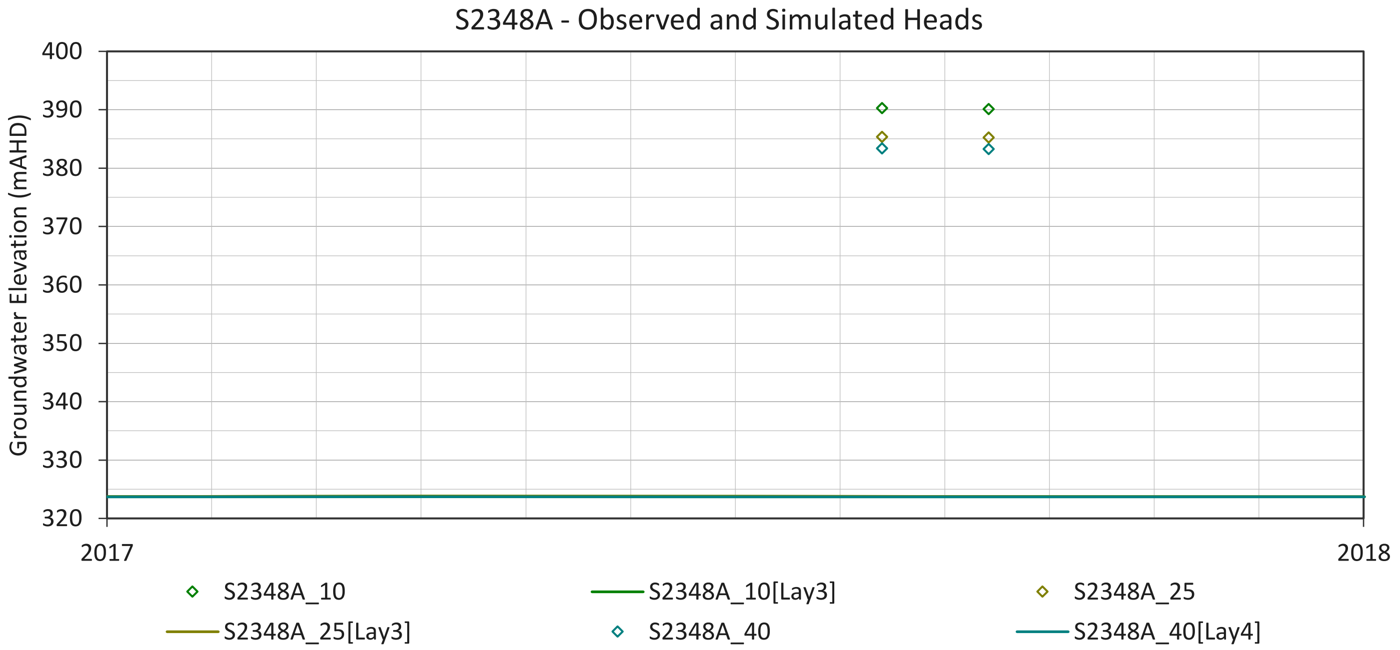

S2341 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
360
340
320
300
280
260
2016
2017
2018
2019
S2341_145
S2341_145[Lay5]
S2341_185
S2341_185[Lay6]
S2341_221
S2341_221[Lay7]
S2341_257
S2341_257[Lay8]
S2341_293
S2341_293[Lay9]
S2341_329
S2341_329[Lay11]
S2341_372
S2341_372[Lay15]
S2341_401
S2341_401[Lay15]

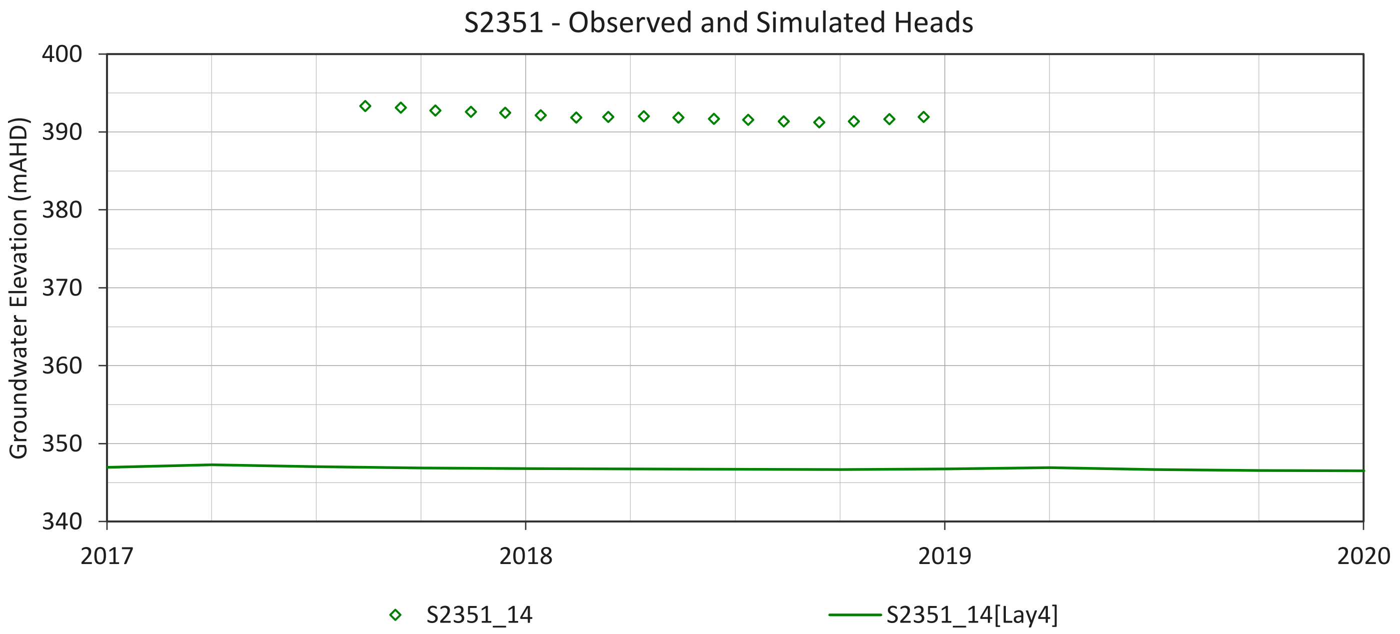

S2341A - Observed and Simulated Heads
Groundwater Elevation (mAHD)
400
390
380
370
360
350
340
330
320
2016
2017
2018
2019
S2341A_10
S2341A_10[Lay3]
S2341A_26
S2341A_26[Lay3]
S2341A_42
S2341A_42[Lay4]
S2341A_59
S2341A_59[Lay4]

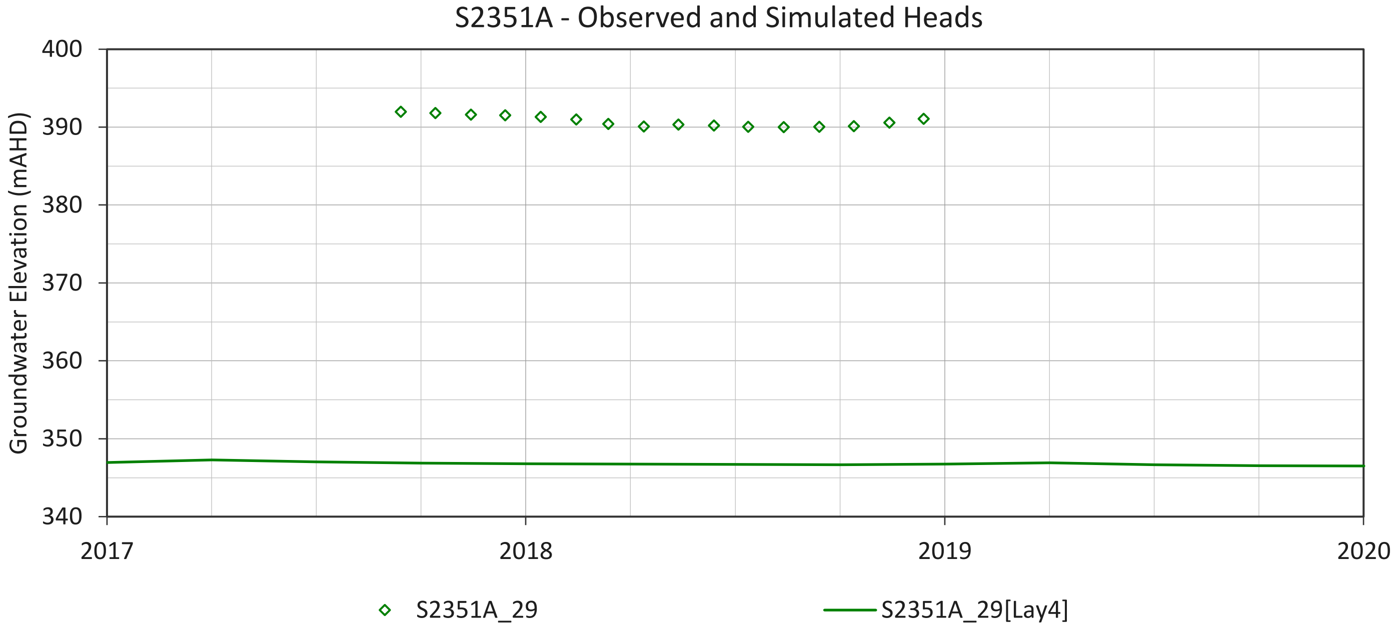

S2345 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
350
340
330
320
310
300
290
280
270
2017
2018
2019
S2345_144
S2345_144[Lay5]
S2345_185
S2345_185[Lay7]
S2345_221
S2345_221[Lay8]
S2345_257
S2345_257[Lay8]
S2345_293
S2345_293[Lay9]
S2345_329
S2345_329[Lay12]
S2345_371
S2345_371[Lay15]
S2345_55
S2345_55[Lay4]

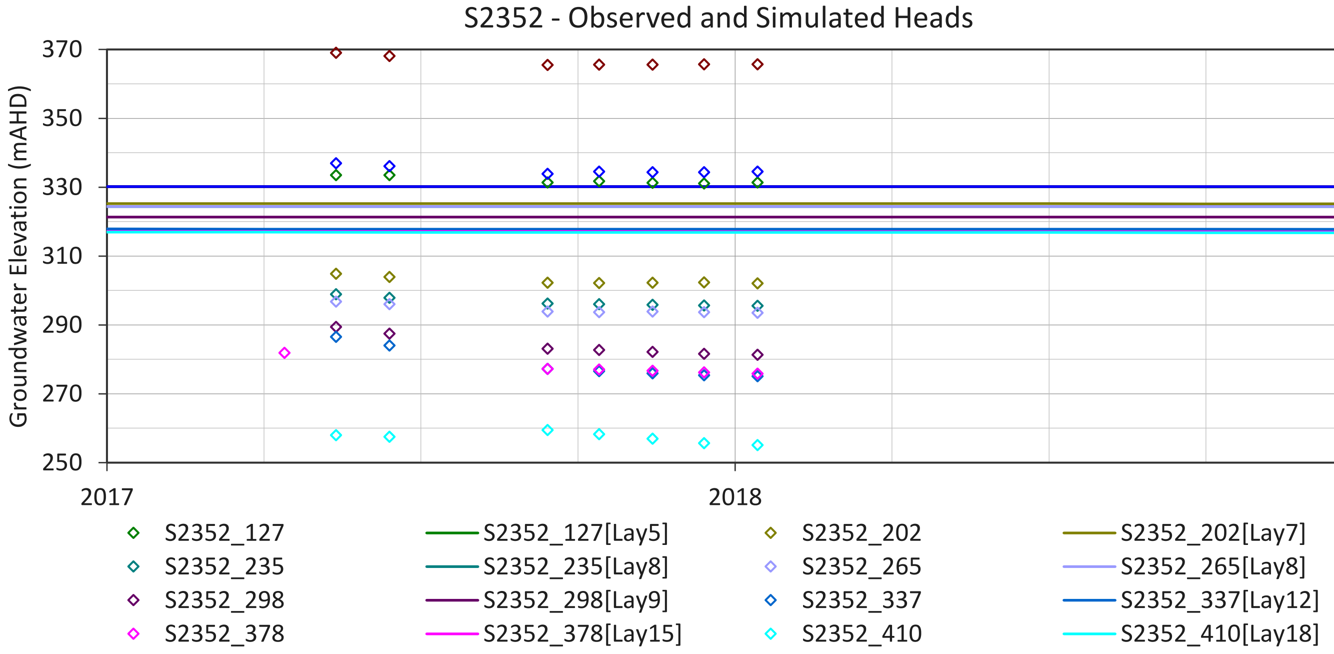

S2345A - Observed and Simulated Heads
Groundwater Elevation (mAHD)
400
390
380
370
360
350
340
330
320
2017
2018
2019
S2345A_10
S2345A_10[Lay3]
S2345A_25
S2345A_25[Lay3]
S2345A_40
S2345A_40[Lay4]

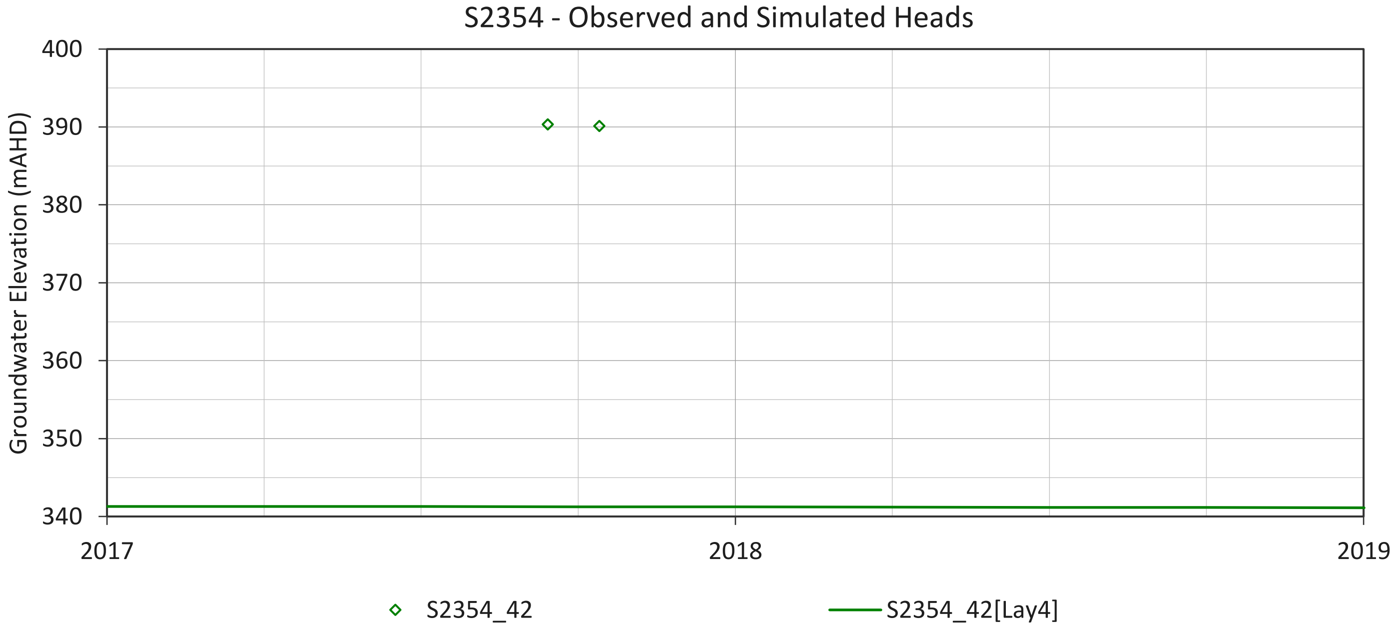

S2348 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
370
360
350
340
330
320
310
300
290
280
2017
2018
S2348_105
S2348_105[Lay5]
S2348_145
S2348_145[Lay5]
S2348_192
S2348_192[Lay7]
S2348_227
S2348_227[Lay8]
S2348_262
S2348_262[Lay8]
S2348_297
S2348_297[Lay9]
S2348_333
S2348_333[Lay12]
S2348_376
S2348_376[Lay15]

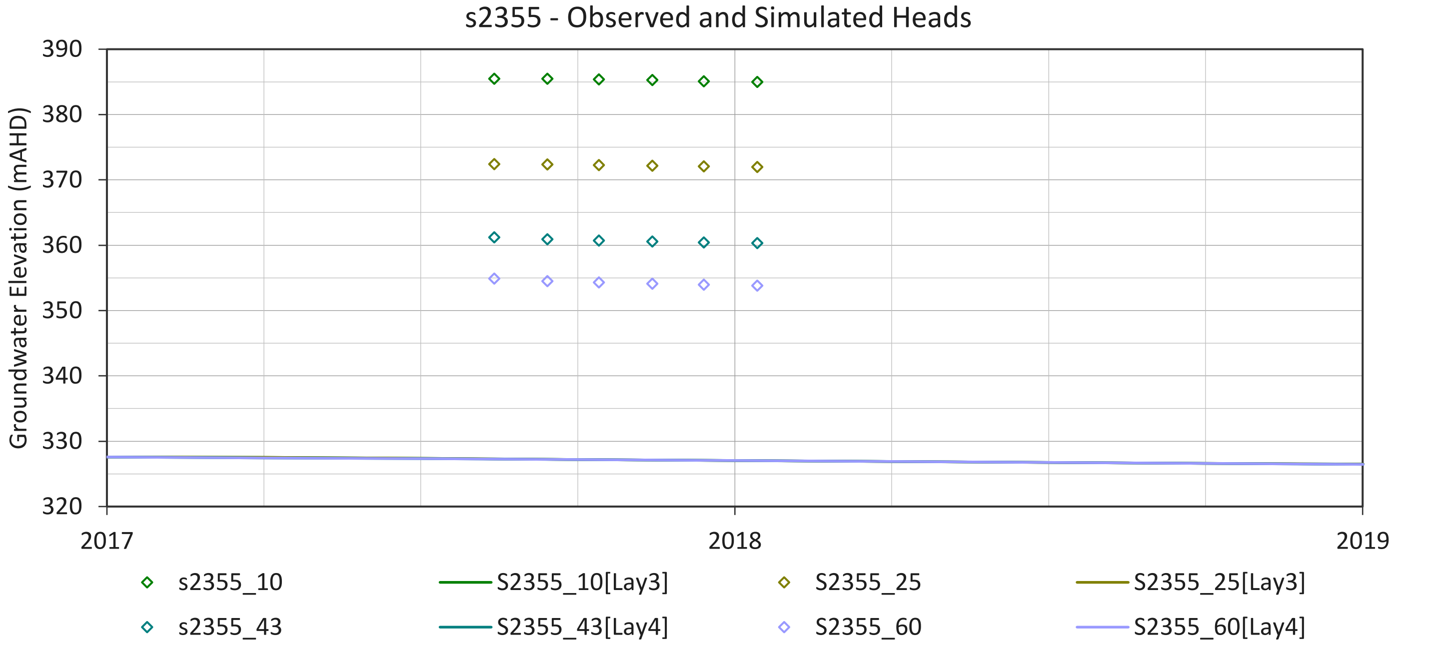

S2348A - Observed and Simulated Heads
Groundwater Elevation (mAHD)
400
390
380
370
360
350
340
330
320
2017
2018
S2348A_10
S2348A_10[Lay3]
S2348A_25
S2348A_25[Lay3]
S2348A_40
S2348A_40[Lay4]

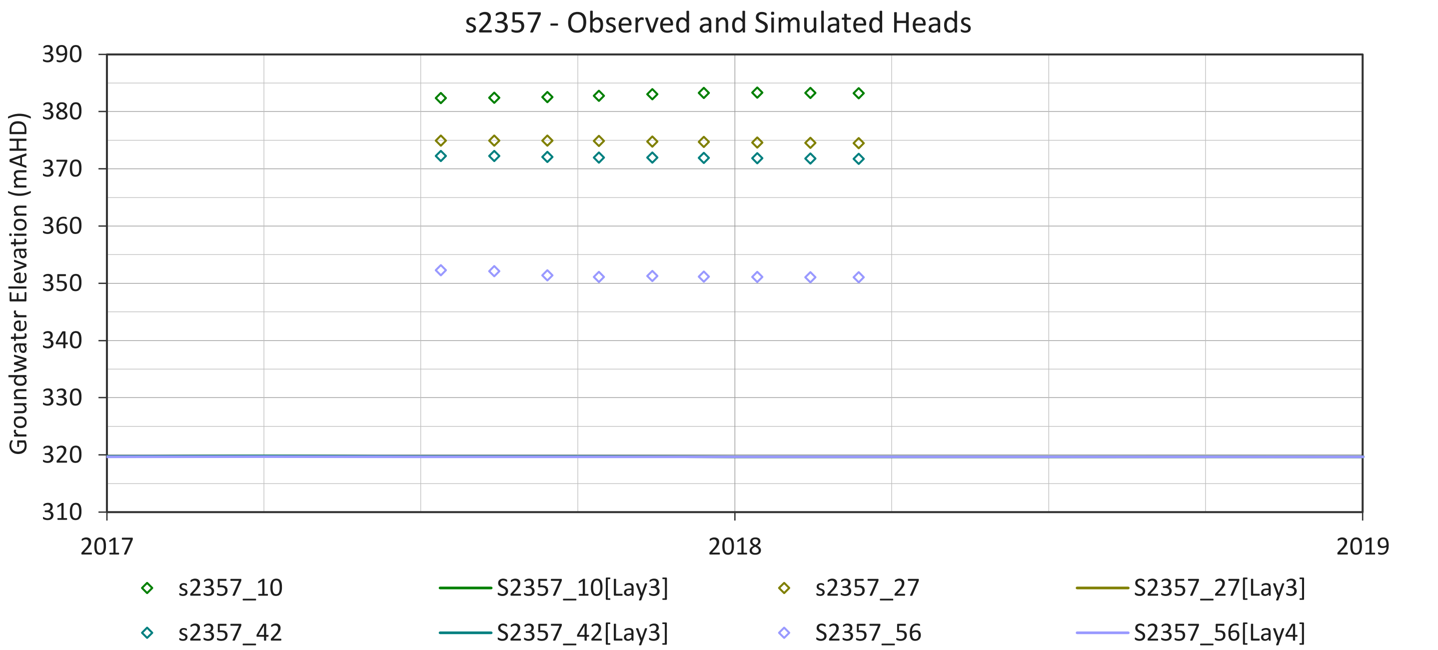

S2351 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
400
390
380
370
360
350
340
2017
2018
2019
2020
S2351_14
S2351_14[Lay4]

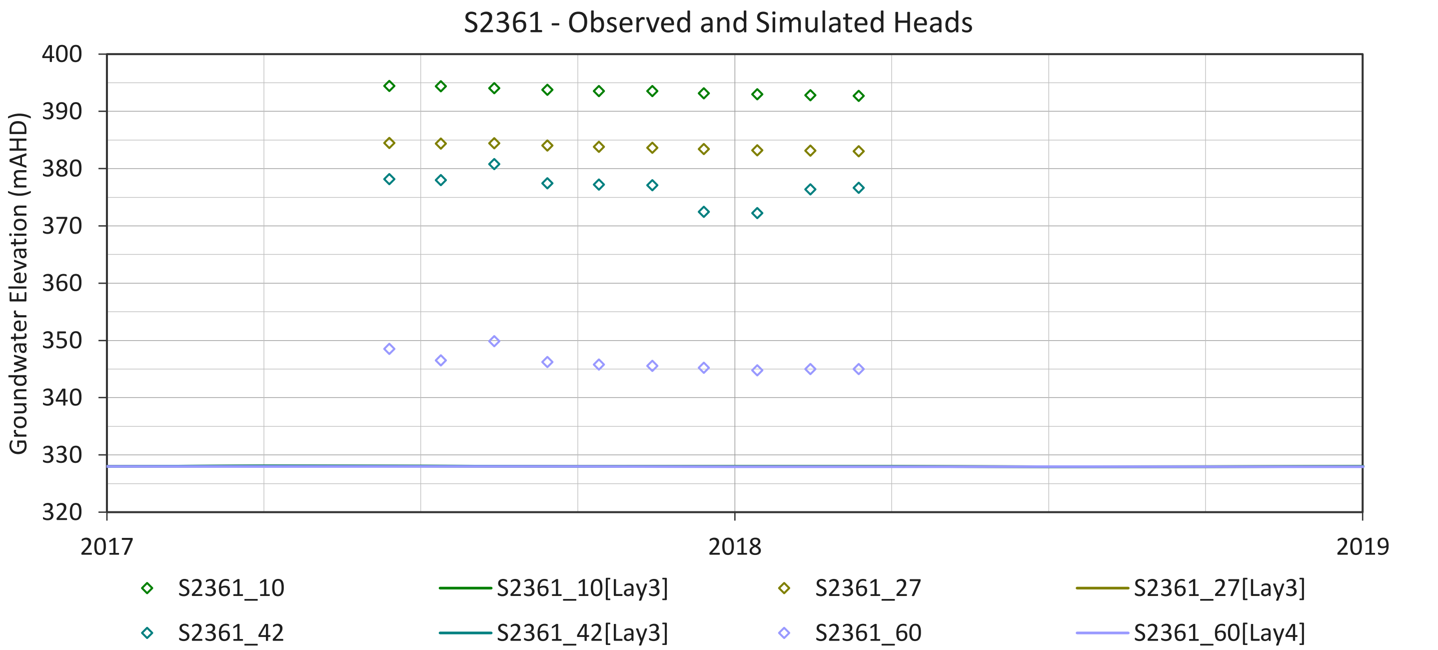

S2351A - Observed and Simulated Heads
Groundwater Elevation (mAHD)
400
390
380
370
360
350
340
2017
2018
2019
2020
S2351A_29
S2351A_29[Lay4]

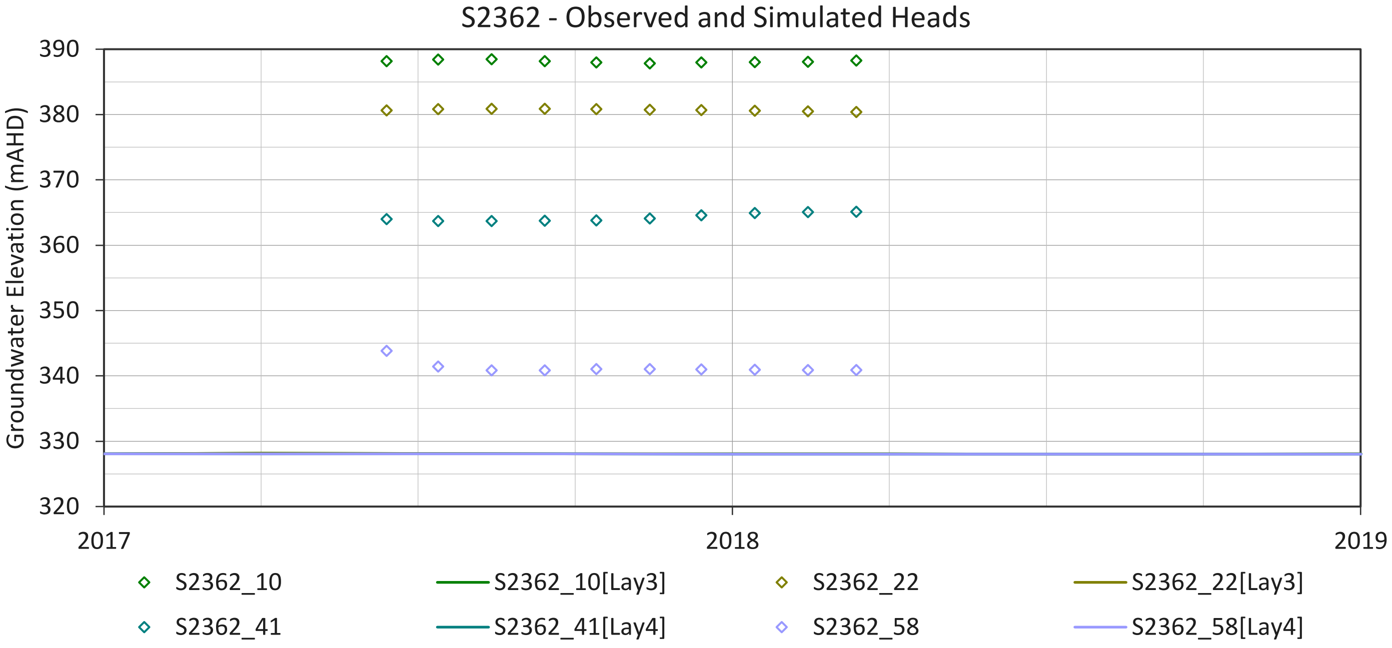

S2352 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
370
350
330
310
290
270
250
2017
2018
2019
S2352_127
S2352_127[Lay5]
S2352_202
S2352_202[Lay7]
S2352_235
S2352_235[Lay8]
S2352_265
S2352_265[Lay8]
S2352_298
S2352_298[Lay9]
S2352_337
S2352_337[Lay12]
S2352_378
S2352_378[Lay15]
S2352_410
S2352_410[Lay18]

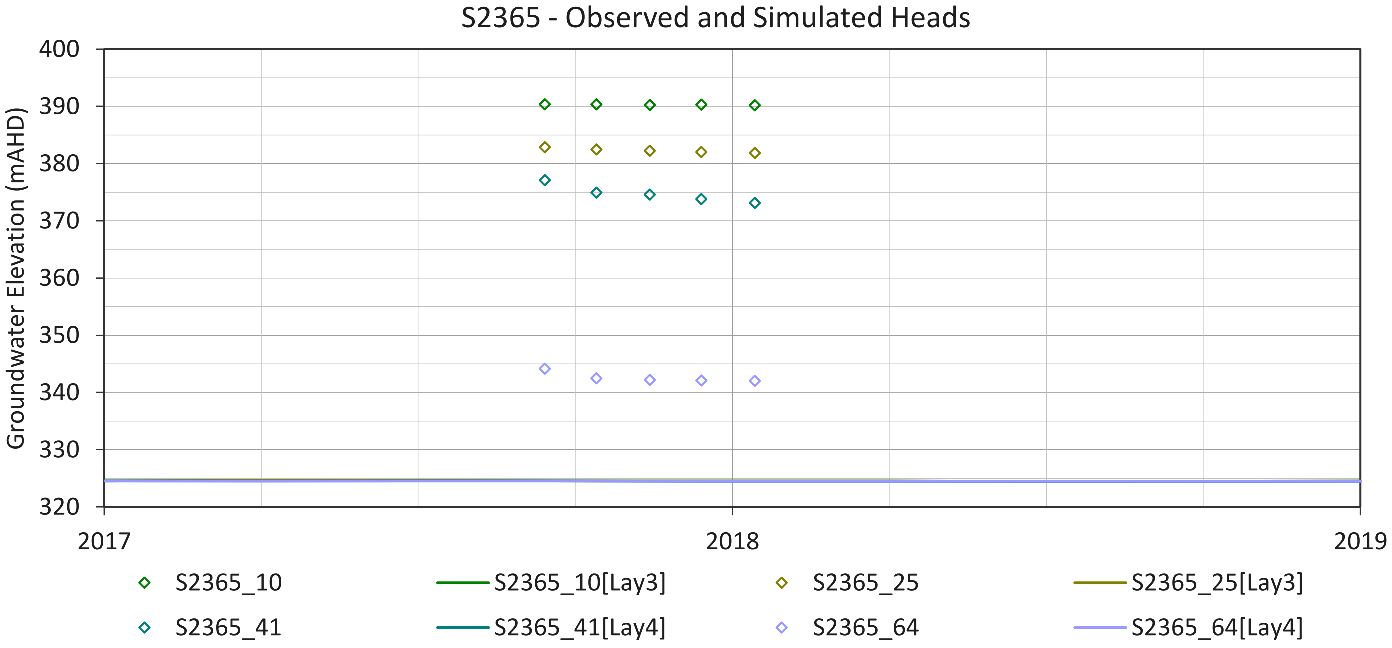

S2354 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
400
390
380
370
360
350
340
2017
2018
2019
S2354_42
S2354_42[Lay4]

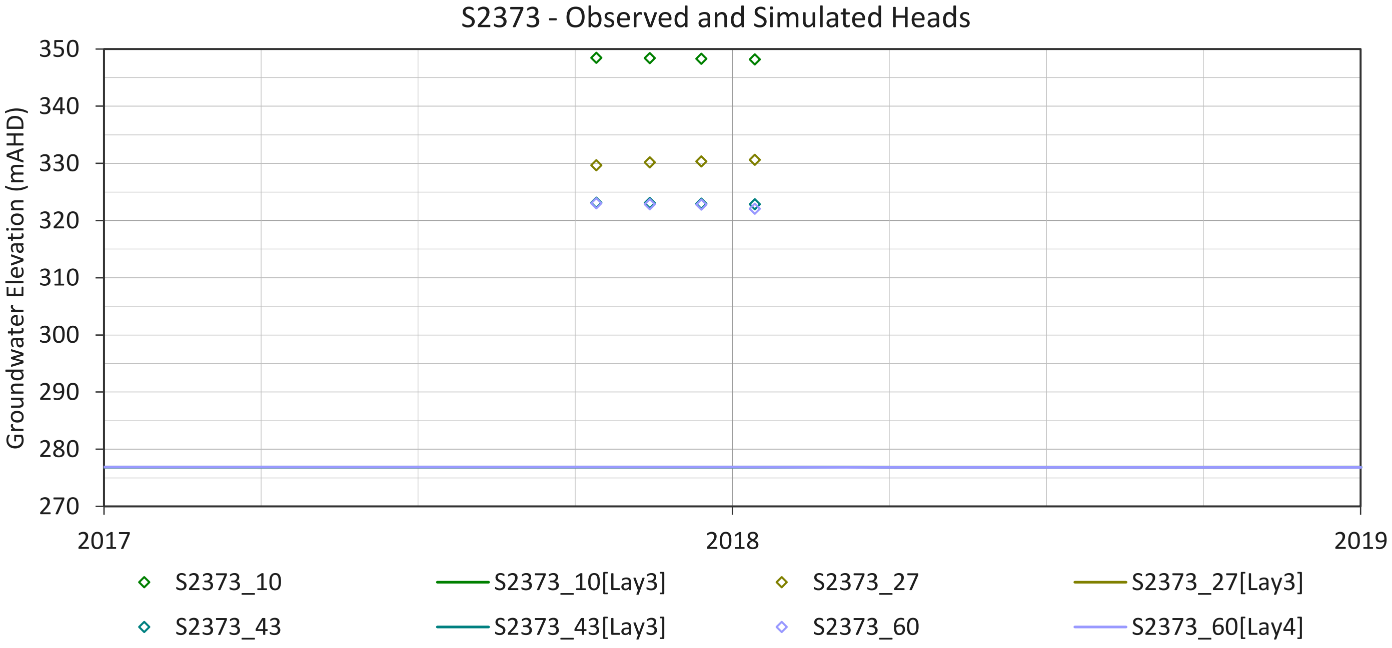

s2355 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
390
380
370
360
350
340
330
320
2017
2018
2019
s2355_10
S2355_10[Lay3]
S2355_25
S2355_25[Lay3]
s2355_43
S2355_43[Lay4]
S2355_60
S2355_60[Lay4]


s2357 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
390
380
370
360
350
340
330
320
310
2017
2018
2019
s2357_10
S2357_10[Lay3]
s2357_27
S2357_27[Lay3]
s2357_42
S2357_42[Lay3]
S2357_56
S2357_56[Lay4]

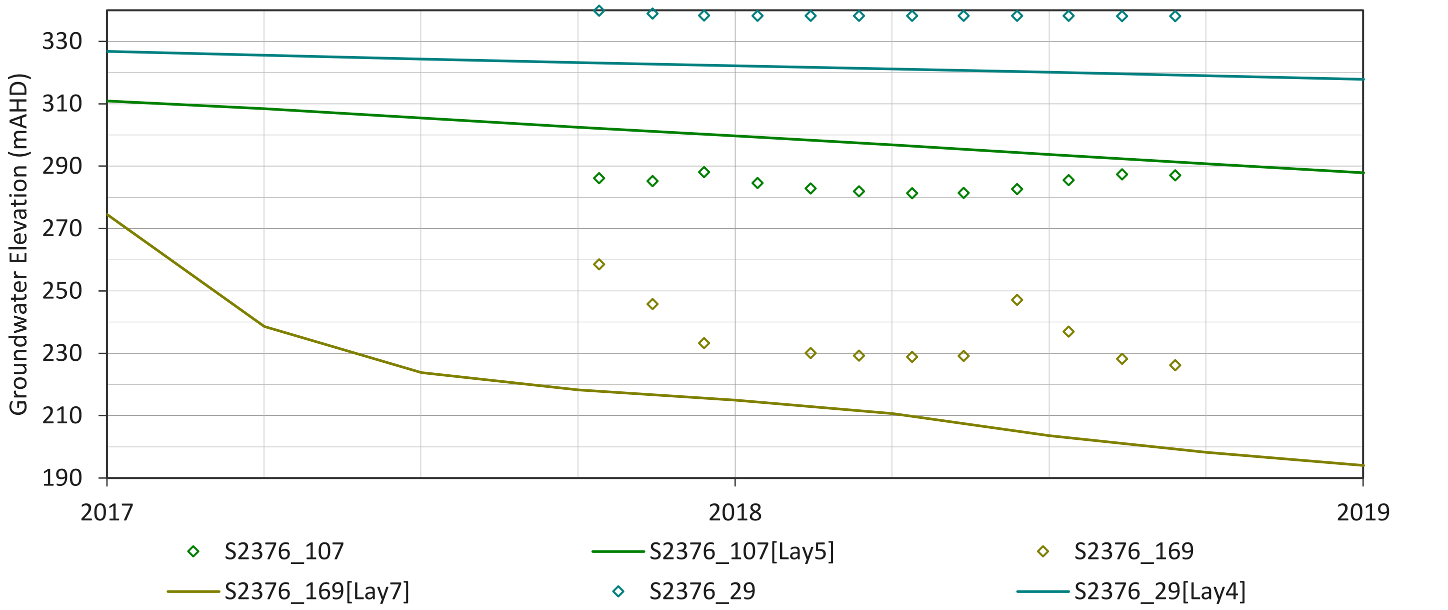

S2361 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
400
390
380
370
360
350
340
330
320
2017
2018
2019
S2361_10
S2361_10[Lay3]
S2361_27
S2361_27[Lay3]
S2361_42
S2361_42[Lay3]
S2361_60
S2361_60[Lay4]


S2362 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
390
380
370
360
350
340
330
320
2017
2018
2019
S2362_10
S2362_10[Lay3]
S2362_22
S2362_22[Lay3]
S2362_41
S2362_41[Lay4]
S2362_58
S2362_58[Lay4]

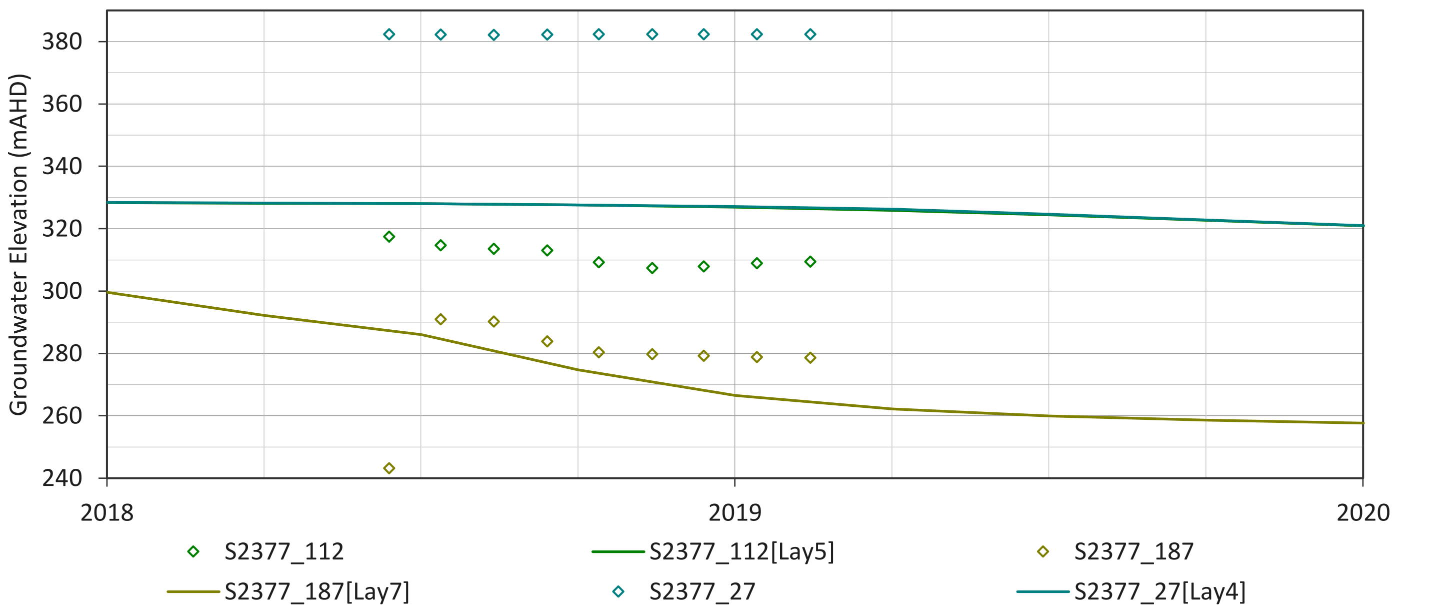

S2365 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
400
390
380
370
360
350
340
330
320
2017
2018
2019
S2365_10
S2365_10[Lay3]
S2365_25
S2365_25[Lay3]
S2365_41
S2365_41[Lay4]
S2365_64
S2365_64[Lay4]


S2373 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
350
340
330
320
310
300
290
280
270
2017
2018
2019
S2373_10
S2373_10[Lay3]
S2373_27
S2373_27[Lay3]
S2373_43
S2373_43[Lay3]
S2373_60
S2373_60[Lay4]

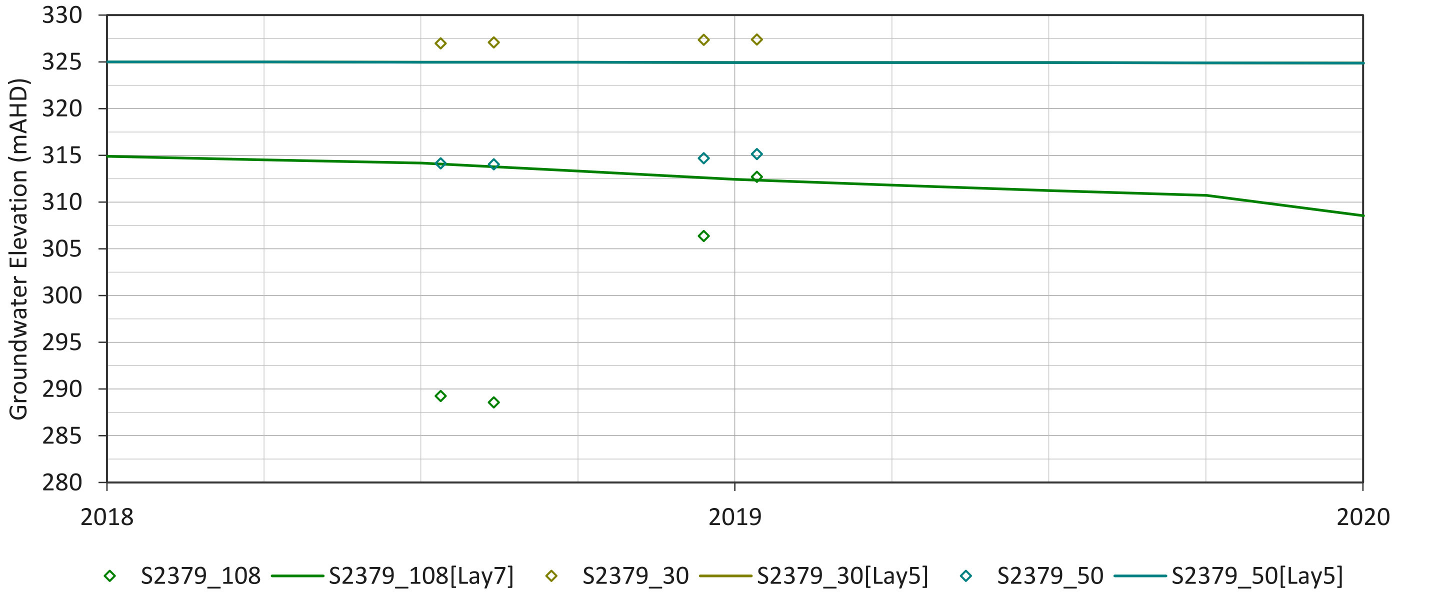
S2376 - Observed and Simulated Heads

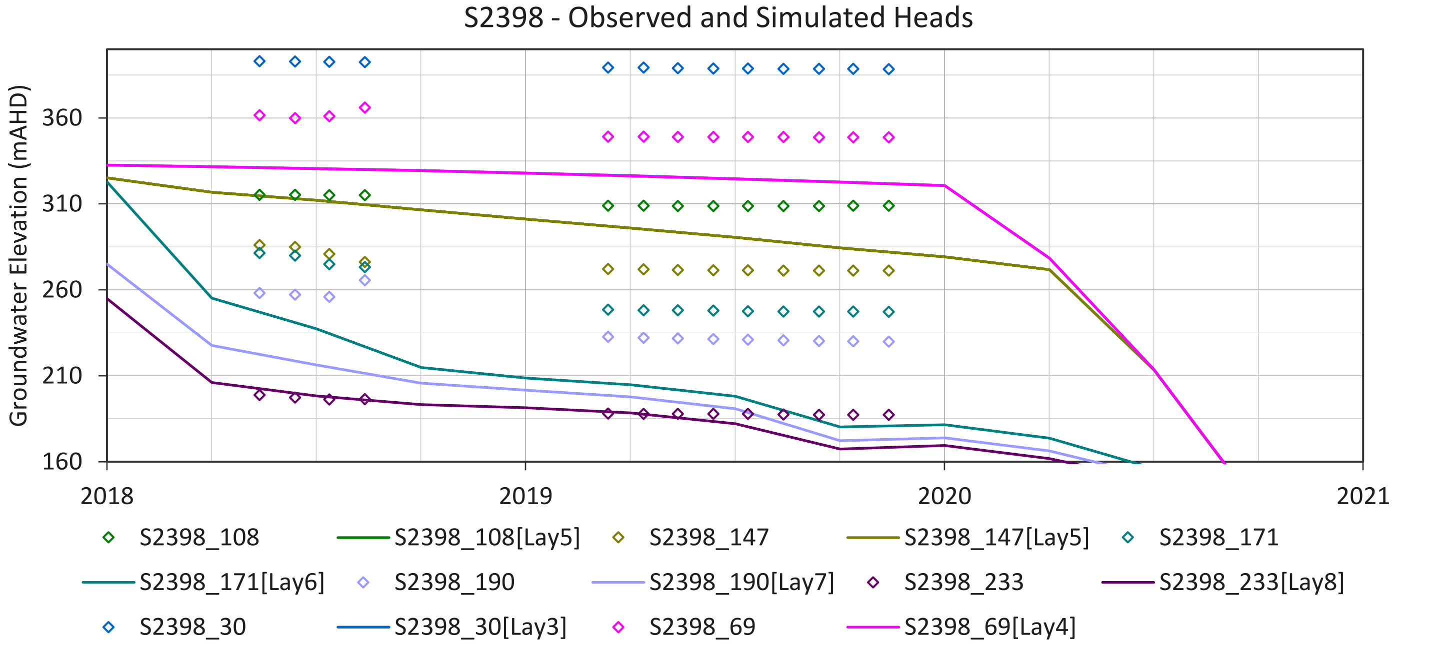


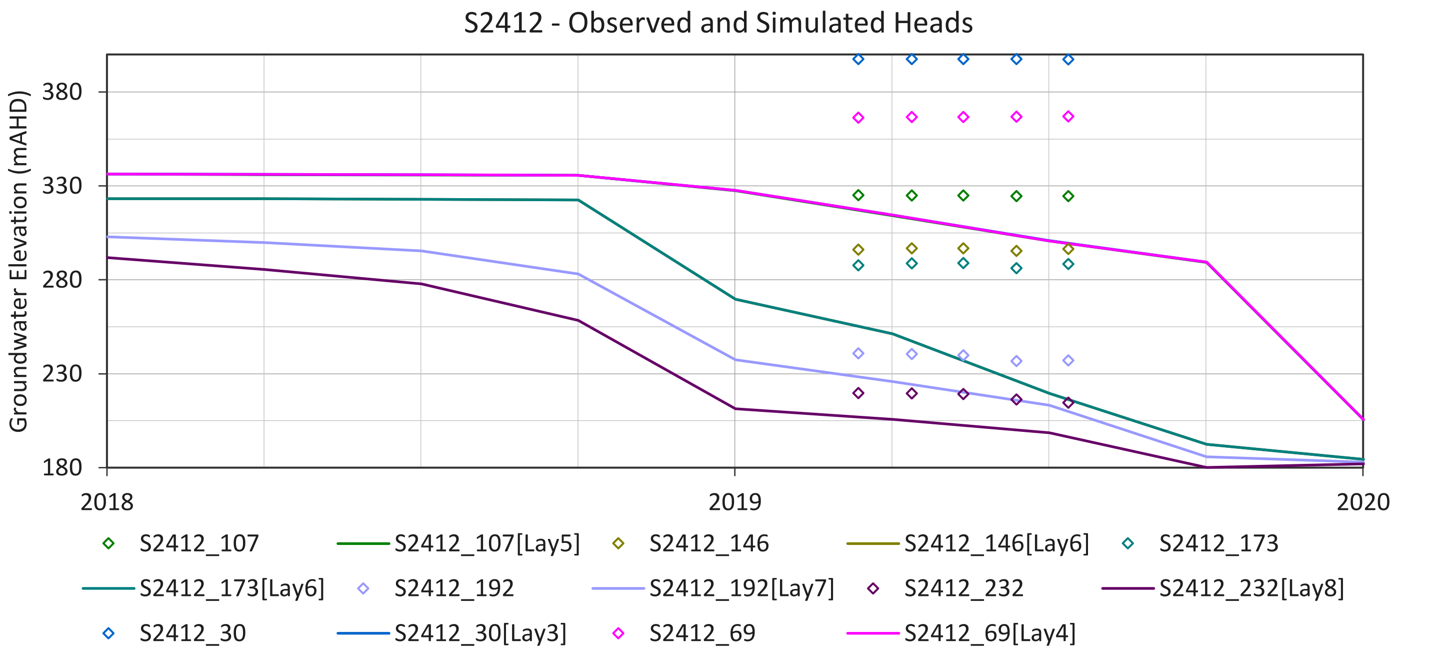
S2377 - Observed and Simulated Heads

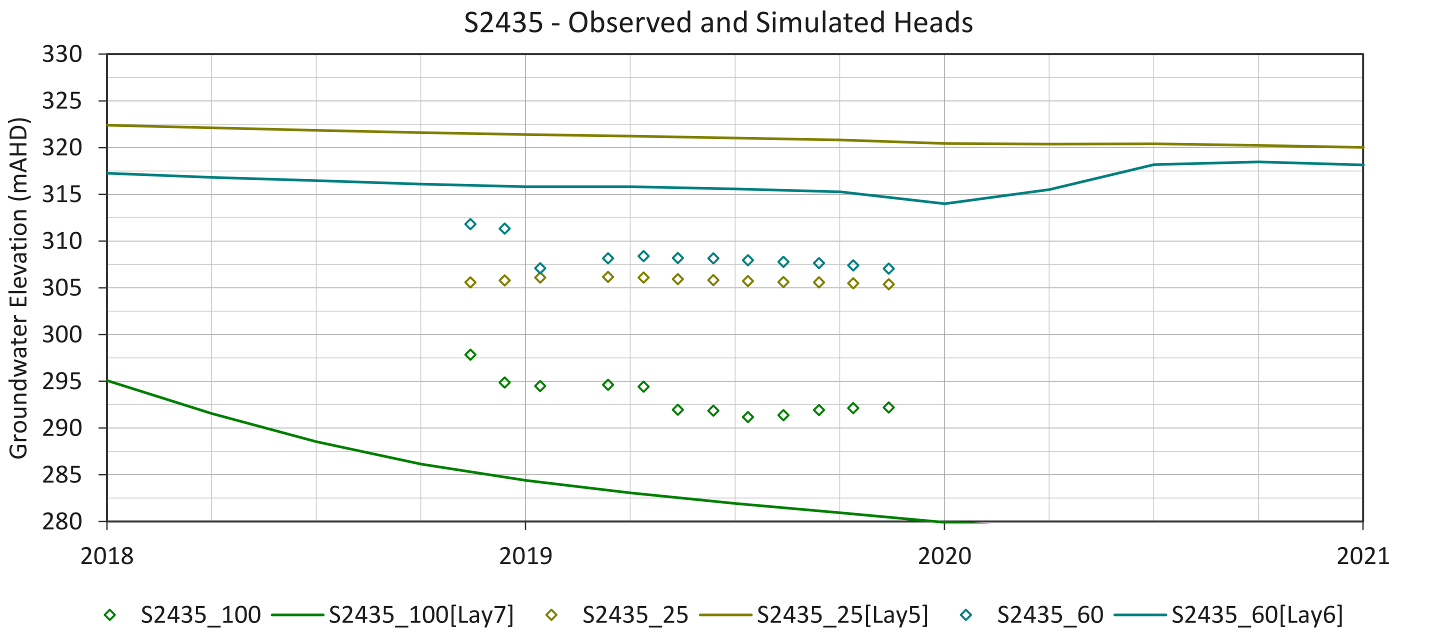


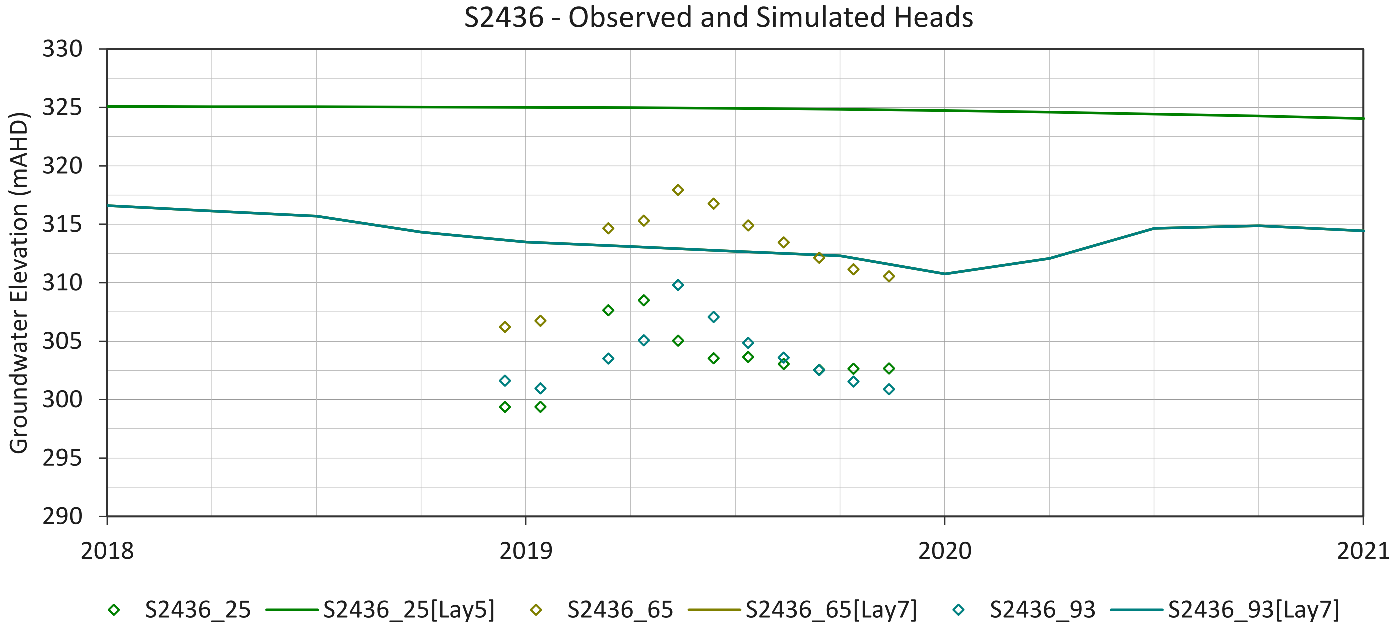
S2379 - Observed and Simulated Heads

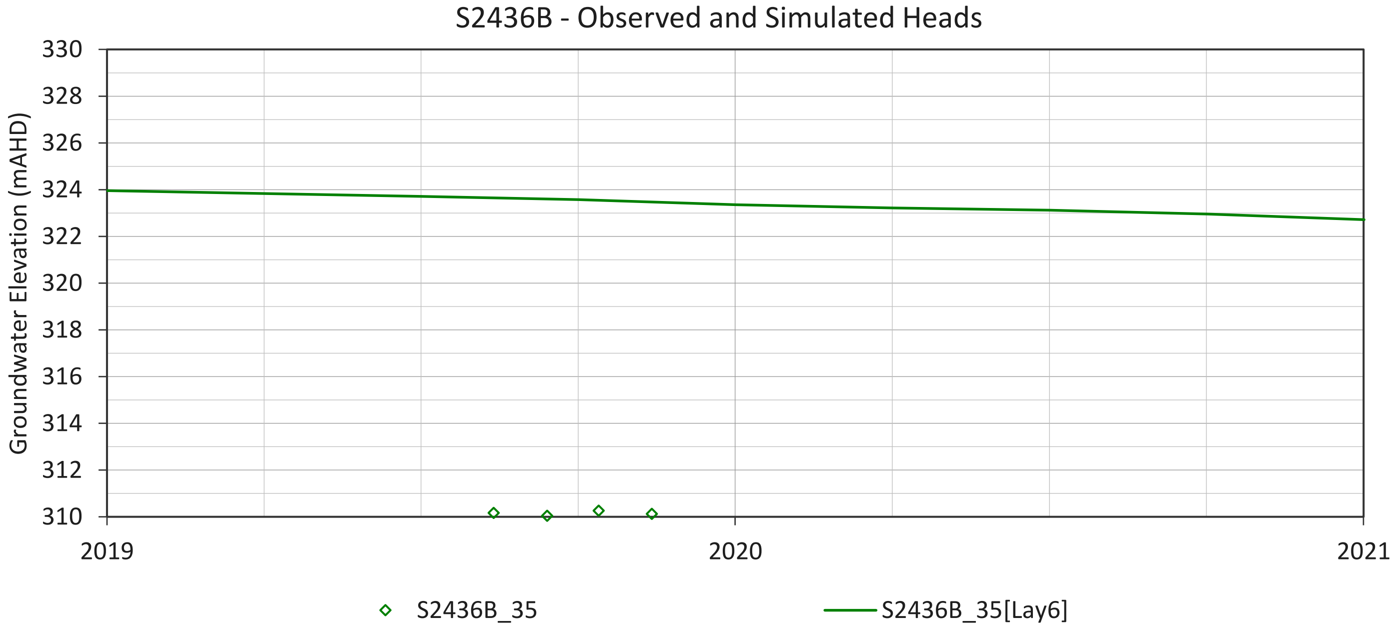


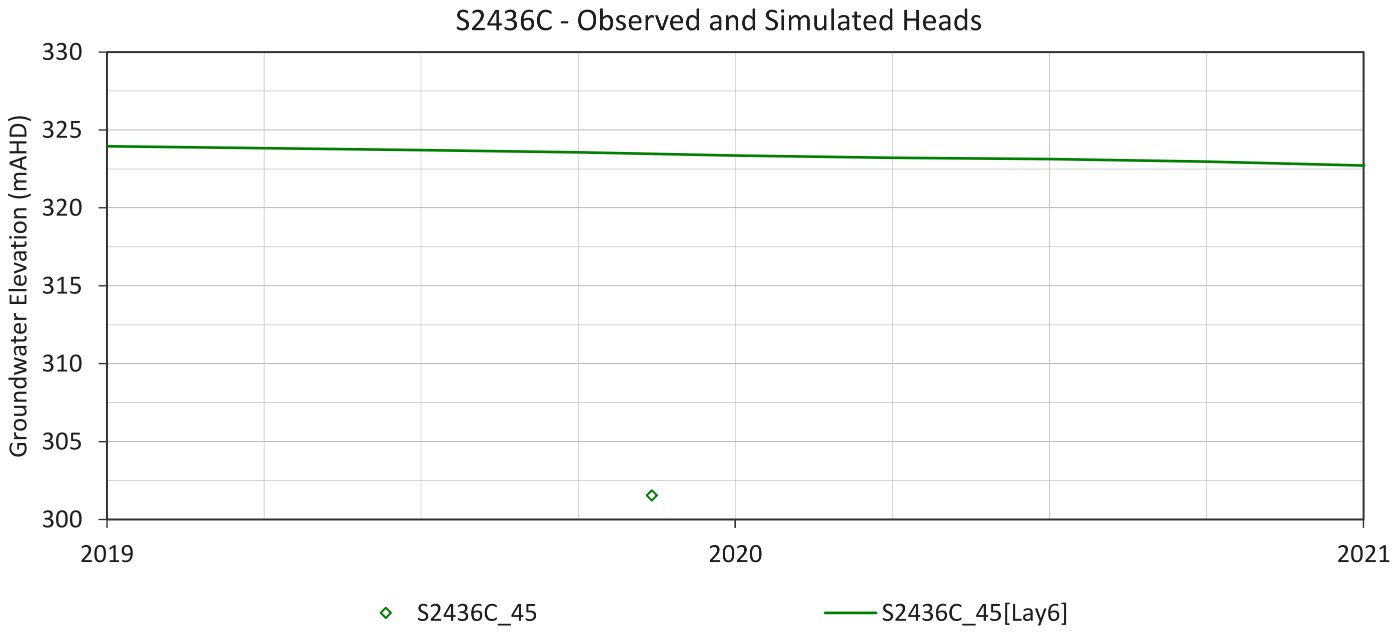

S2398 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
360
310
260
210
160
2018
2019
2020
2021
S2398_108
S2398_108[Lay5]
S2398_147
S2398_147[Lay5]
S2398_171
S2398_171[Lay6]
S2398_190
S2398_190[Lay7]
S2398_233
S2398_233[Lay8]
S2398_30
S2398_30[Lay3]
S2398_69
S2398_69[Lay4]

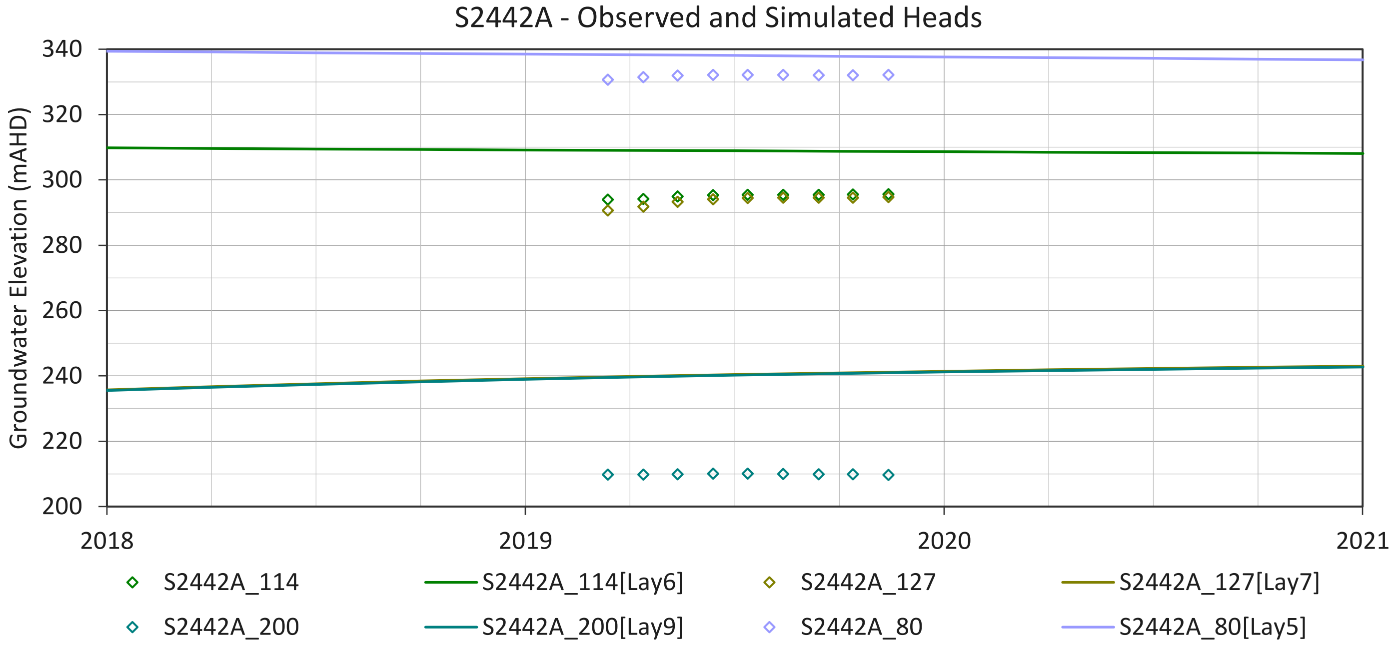

S2412 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
380
330
280
230
180
2018
2019
2020
S2412_107
S2412_107[Lay5]
S2412_146
S2412_146[Lay6]
S2412_173
S2412_173[Lay6]
S2412_192
S2412_192[Lay7]
S2412_232
S2412_232[Lay8]
S2412_30
S2412_30[Lay3]
S2412_69
S2412_69[Lay4]

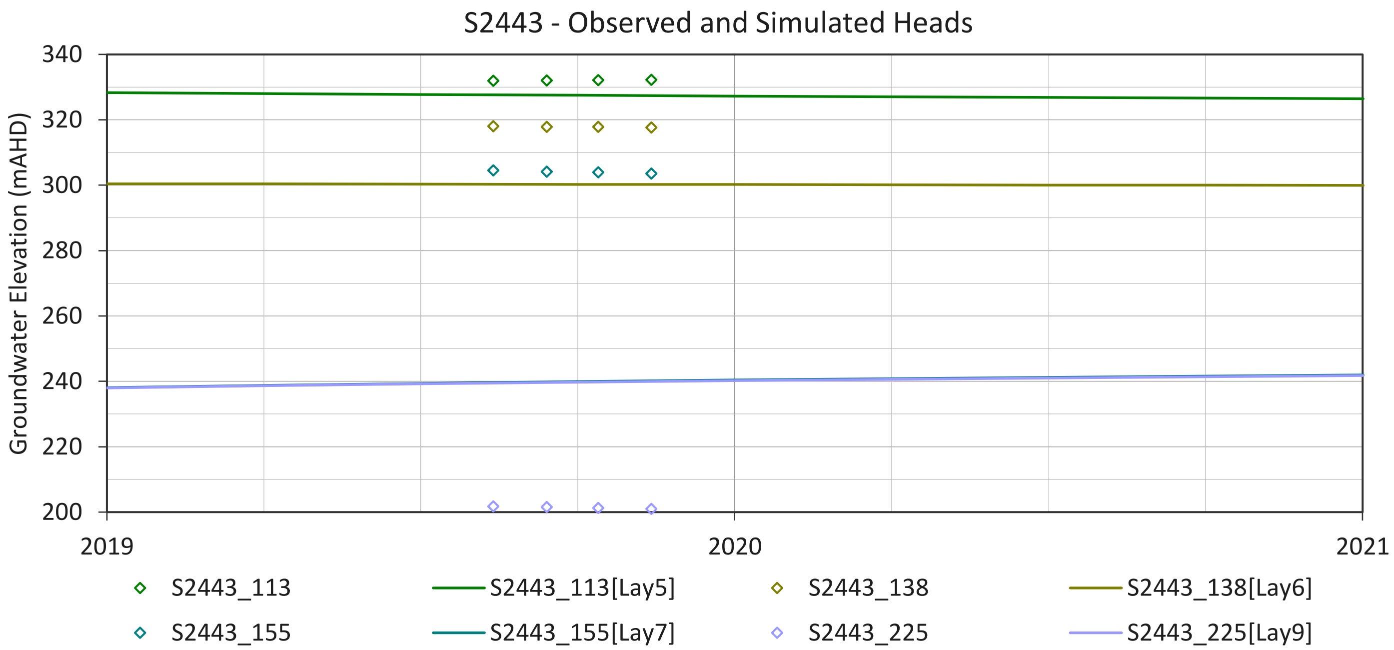

S2435 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
330
325
320
315
310
305
300
295
290
285
280
2018
2019
2020
2021
S2435_100
S2435_100[Lay7]
S2435_25
S2435_25[Lay5]
S2435_60
S2435_60[Lay6]

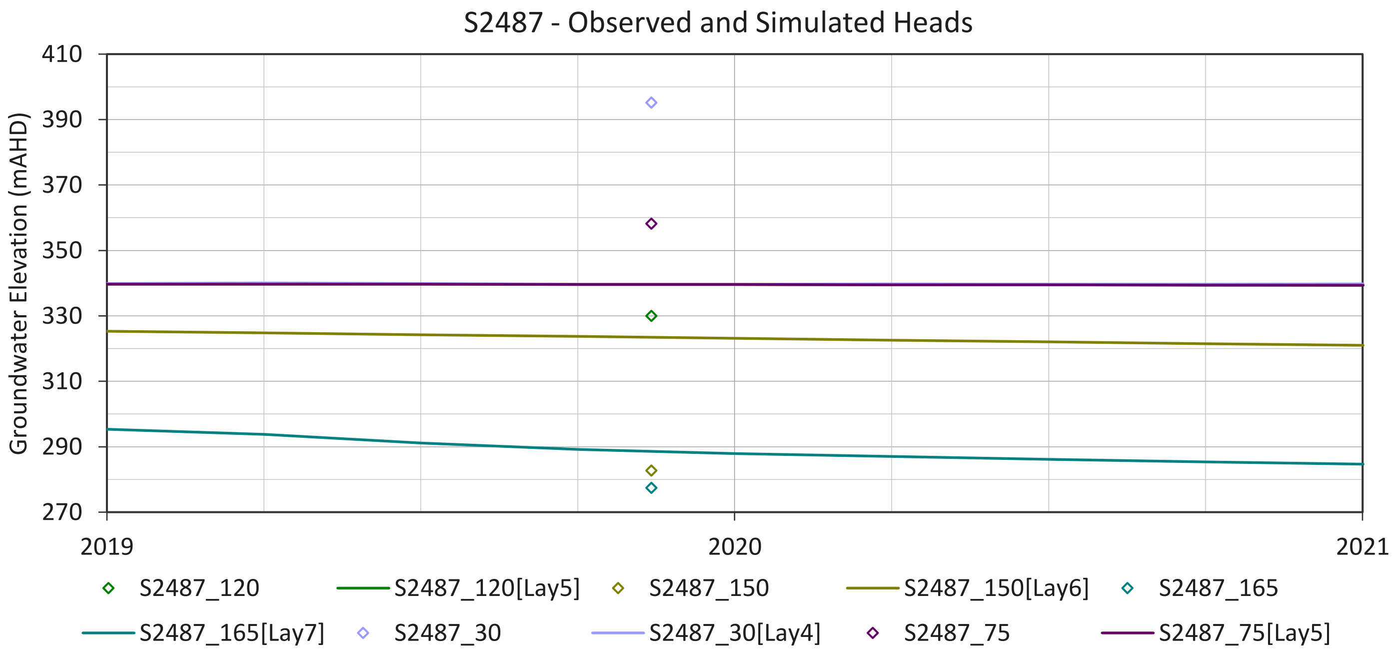

S2436 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
330
325
320
315
310
305
300
295
290
2018
2019
2020
2021
S2436_25
S2436_25[Lay5]
S2436_65
S2436_65[Lay7]
S2436_93
S2436_93[Lay7]

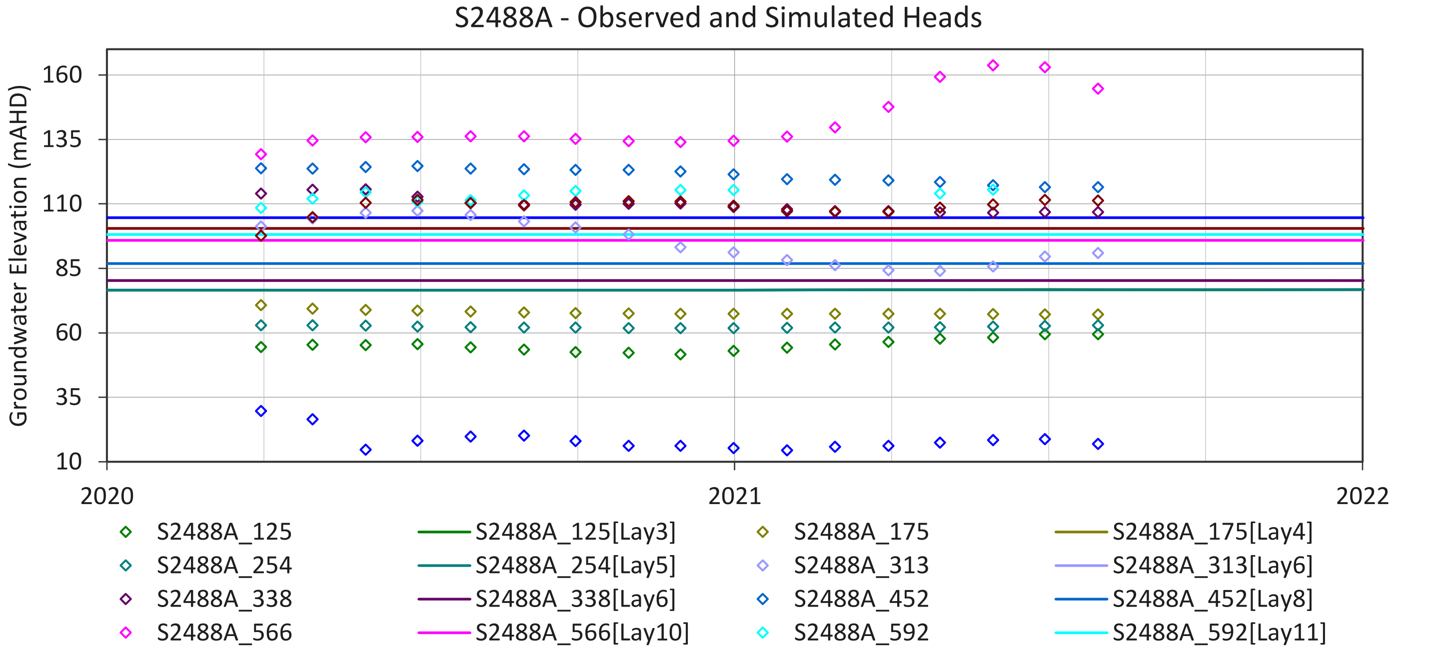

S2436B - Observed and Simulated Heads
Groundwater Elevation (mAHD)
330
328
326
324
322
320
318
316
314
312
310
2019
2020
2021
S2436B_35
S2436B_35[Lay6]

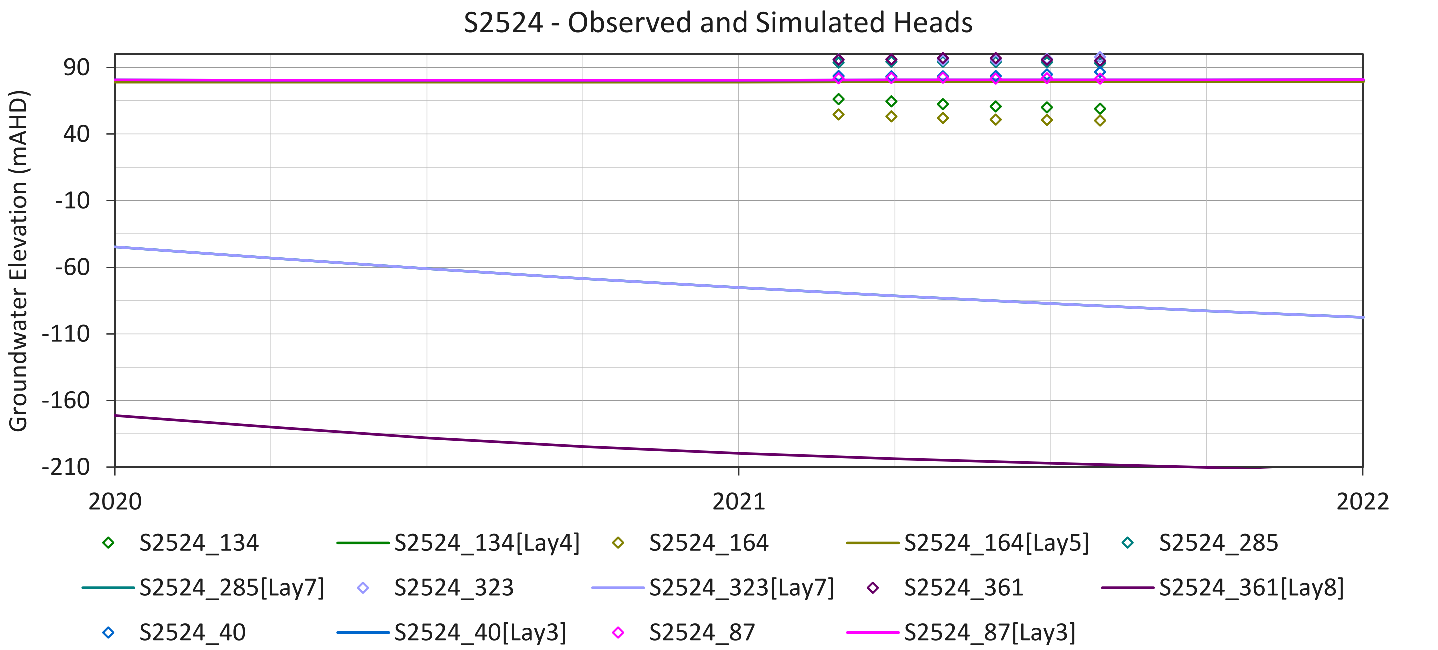

S2436C - Observed and Simulated Heads
Groundwater Elevation (mAHD)
330
325
320
315
310
305
300
2019
2020
2021
S2436C_45
S2436C_45[Lay6]

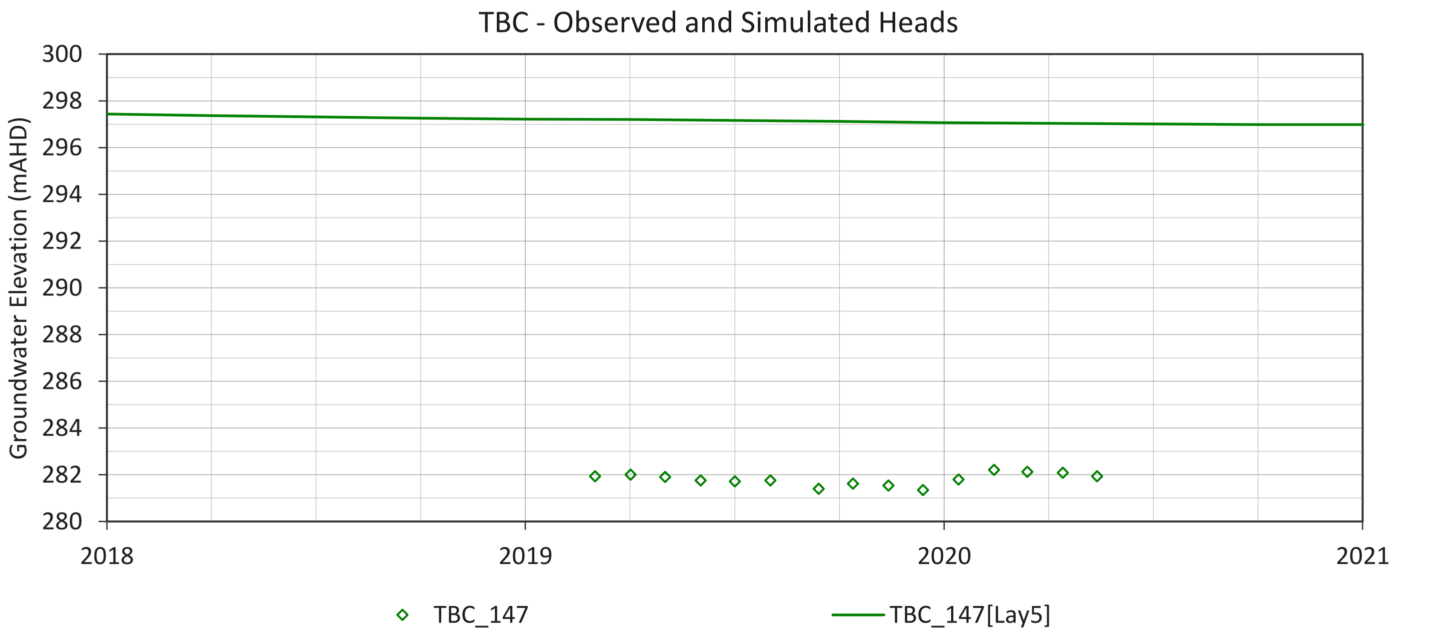

S2442A - Observed and Simulated Heads
Groundwater Elevation (mAHD)
340
320
300
280
260
240
220
200
2018
2019
2020
2021
S2442A_114
S2442A_114[Lay6]
S2442A_127
S2442A_127[Lay7]
S2442A_200
S2442A_200[Lay9]
S2442A_80
S2442A_80[Lay5]

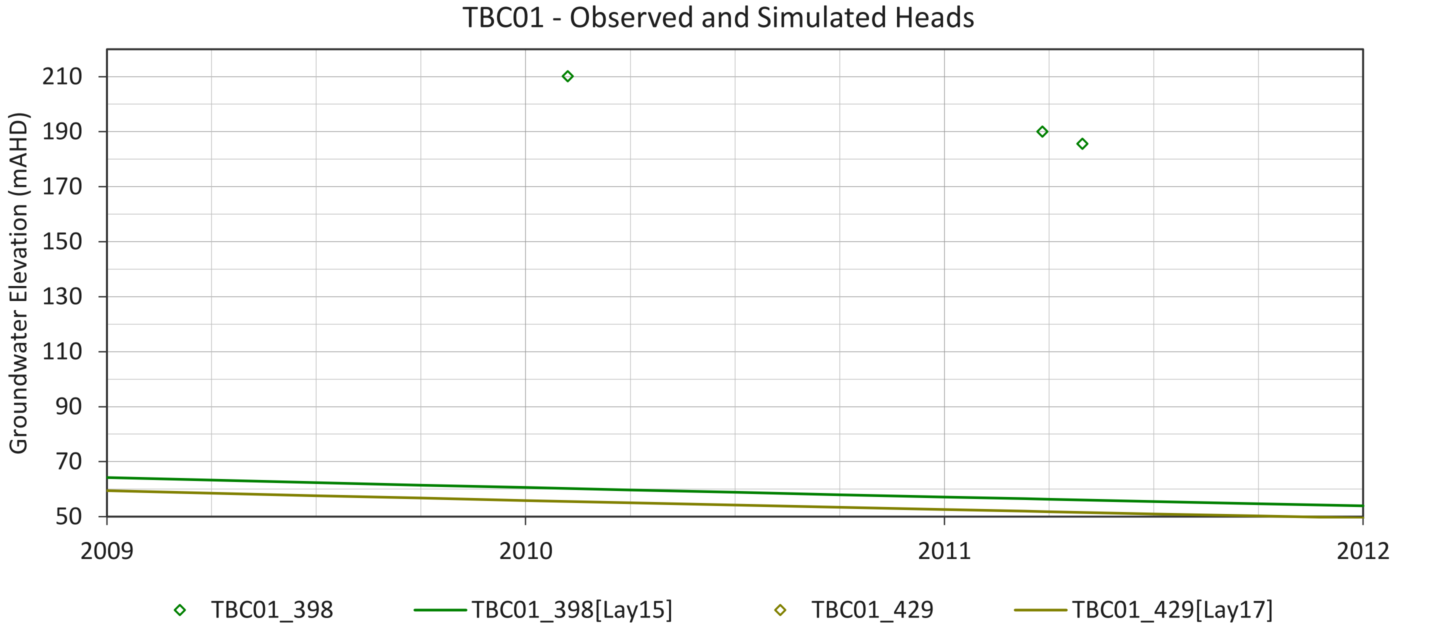

S2443 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
340
320
300
280
260
240
220
200
2019
2020
2021
S2443_113
S2443_113[Lay5]
S2443_138
S2443_138[Lay6]
S2443_155
S2443_155[Lay7]
S2443_225
S2443_225[Lay9]

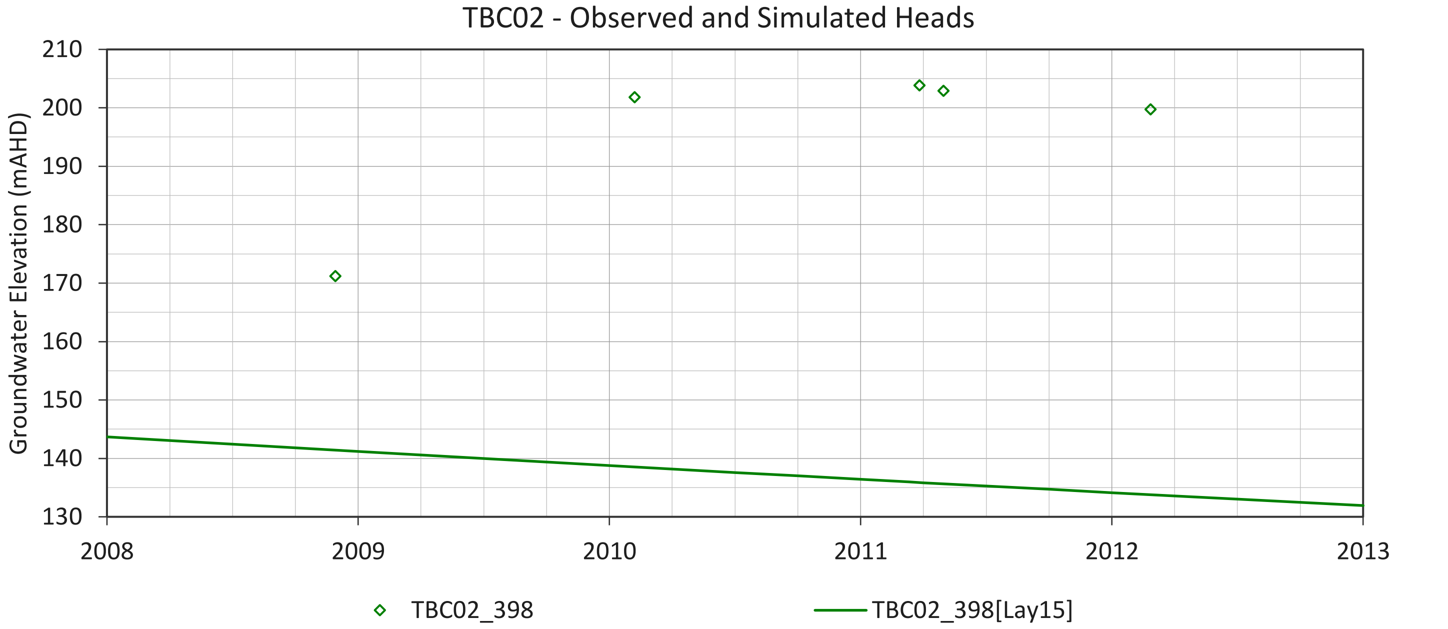

S2487 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
410
390
370
350
330
310
290
270
2019
2020
2021
S2487_120
S2487_120[Lay5]
S2487_150
S2487_150[Lay6]
S2487_165
S2487_165[Lay7]
S2487_30
S2487_30[Lay4]
S2487_75
S2487_75[Lay5]

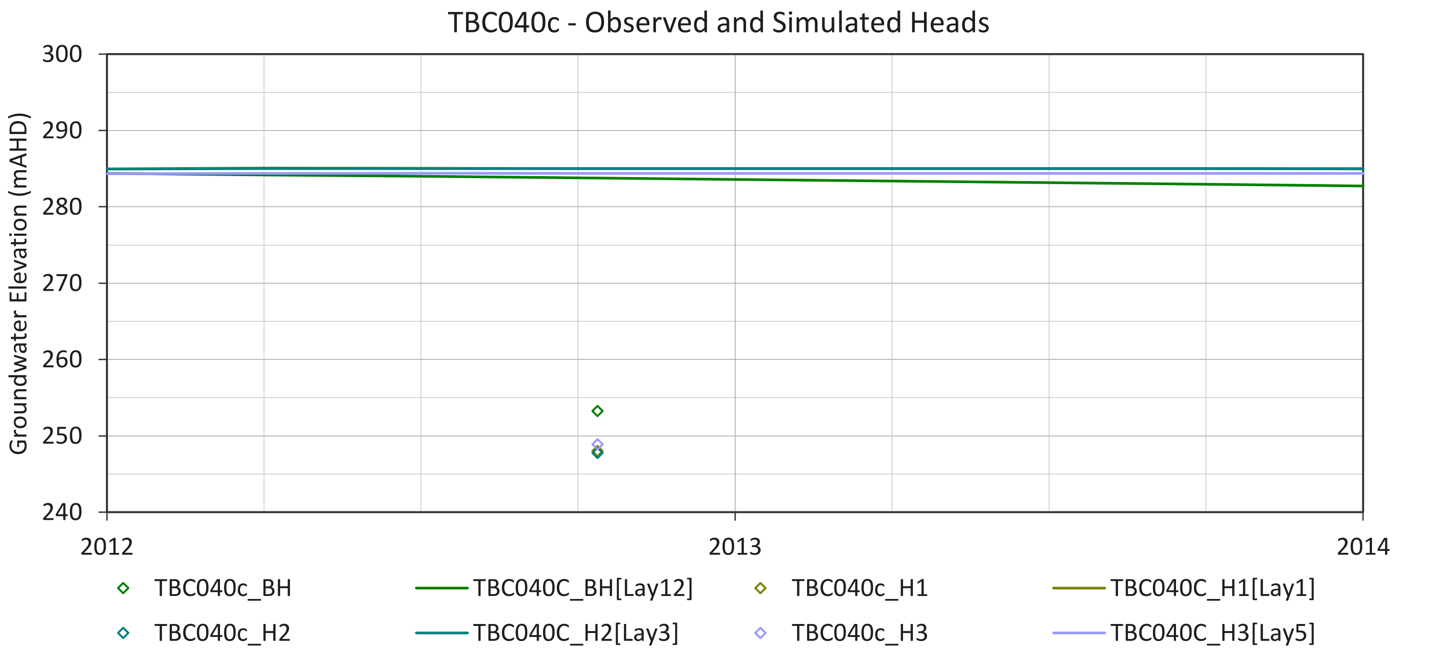

S2488A - Observed and Simulated Heads
Groundwater Elevation (mAHD)
160
135
110
85
60
35
10
2020
2021
2022
S2488A_125
S2488A_125[Lay3]
S2488A_175
S2488A_175[Lay4]
S2488A_254
S2488A_254[Lay5]
S2488A_313
S2488A_313[Lay6]
S2488A_338
S2488A_338[Lay6]
S2488A_452
S2488A_452[Lay8]
S2488A_566
S2488A_566[Lay10]
S2488A_592
S2488A_592[Lay11]

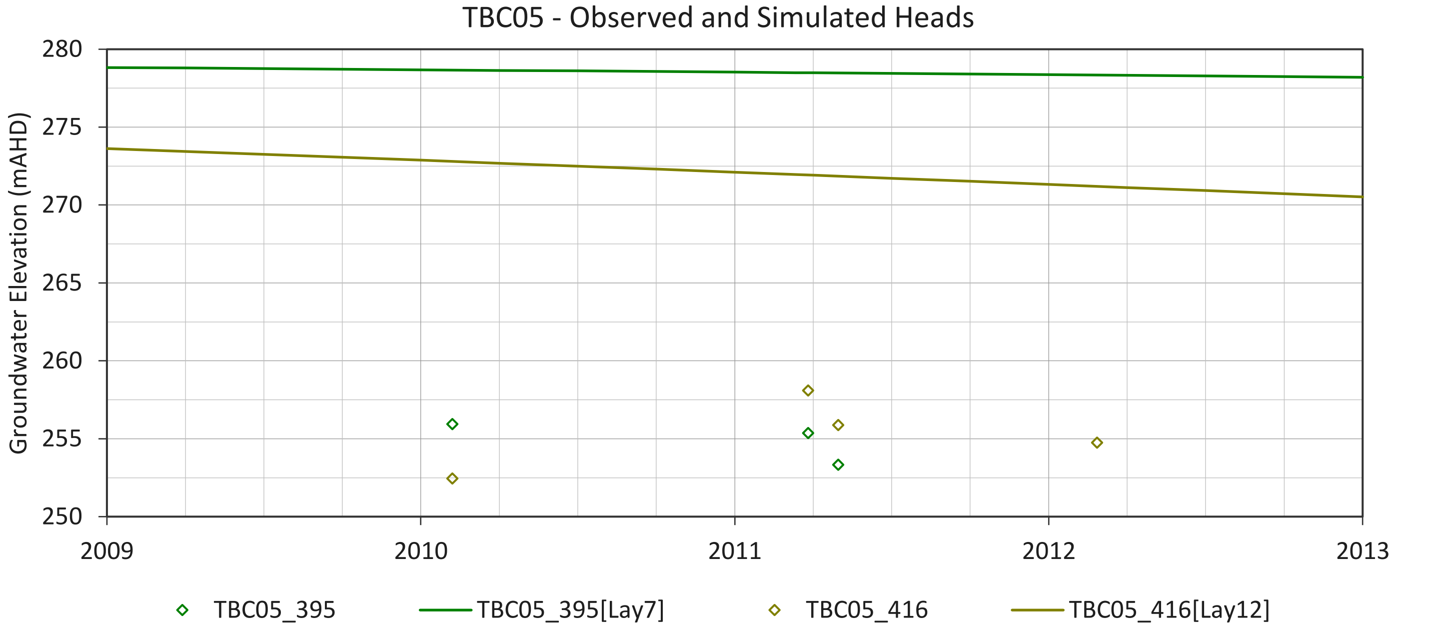

S2524 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
90
40
-10
-60
-110
-160
-210
2020
2021
2022
S2524_134
S2524_134[Lay4]
S2524_164
S2524_164[Lay5]
S2524_285
S2524_285[Lay7]
S2524_323
S2524_323[Lay7]
S2524_361
S2524_361[Lay8]
S2524_40
S2524_40[Lay3]
S2524_87
S2524_87[Lay3]

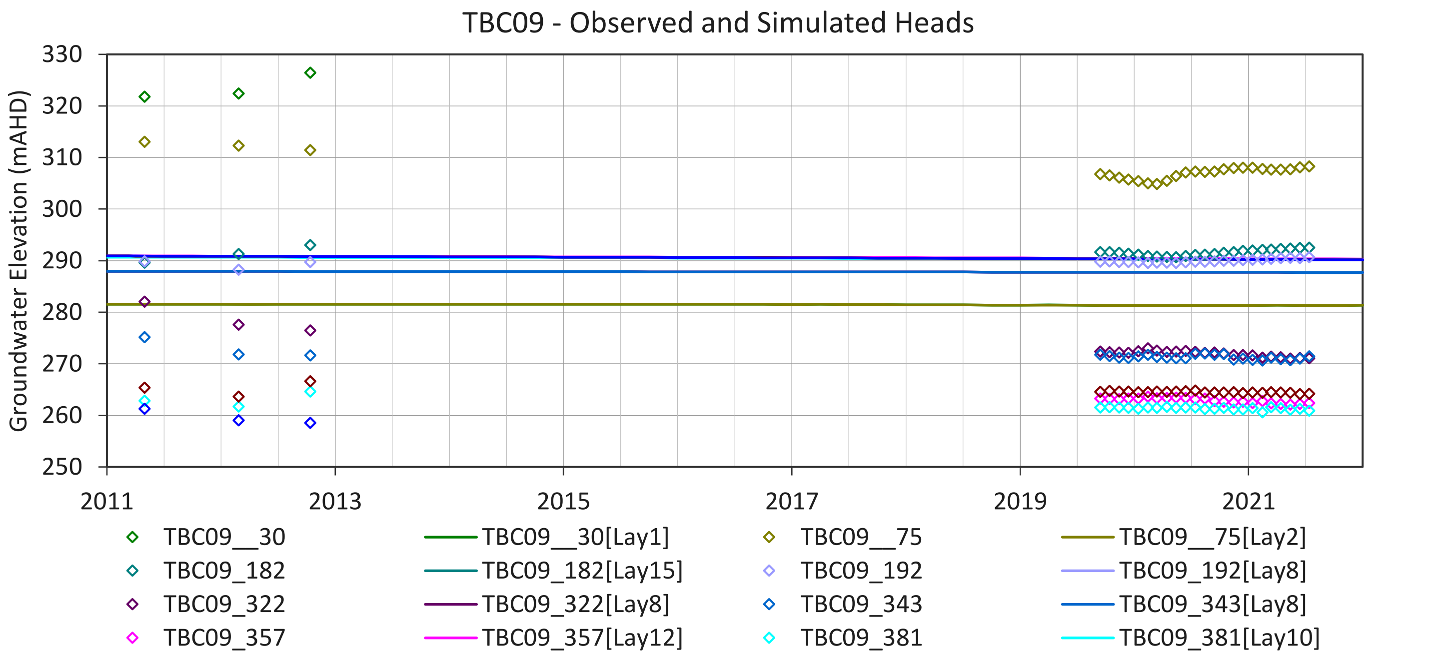

TBC - Observed and Simulated Heads
Groundwater Elevation (mAHD)
300
298
296
294
292
290
288
286
284
282
280
2018
2019
2020
2021
TBC_147
TBC_147[Lay5]

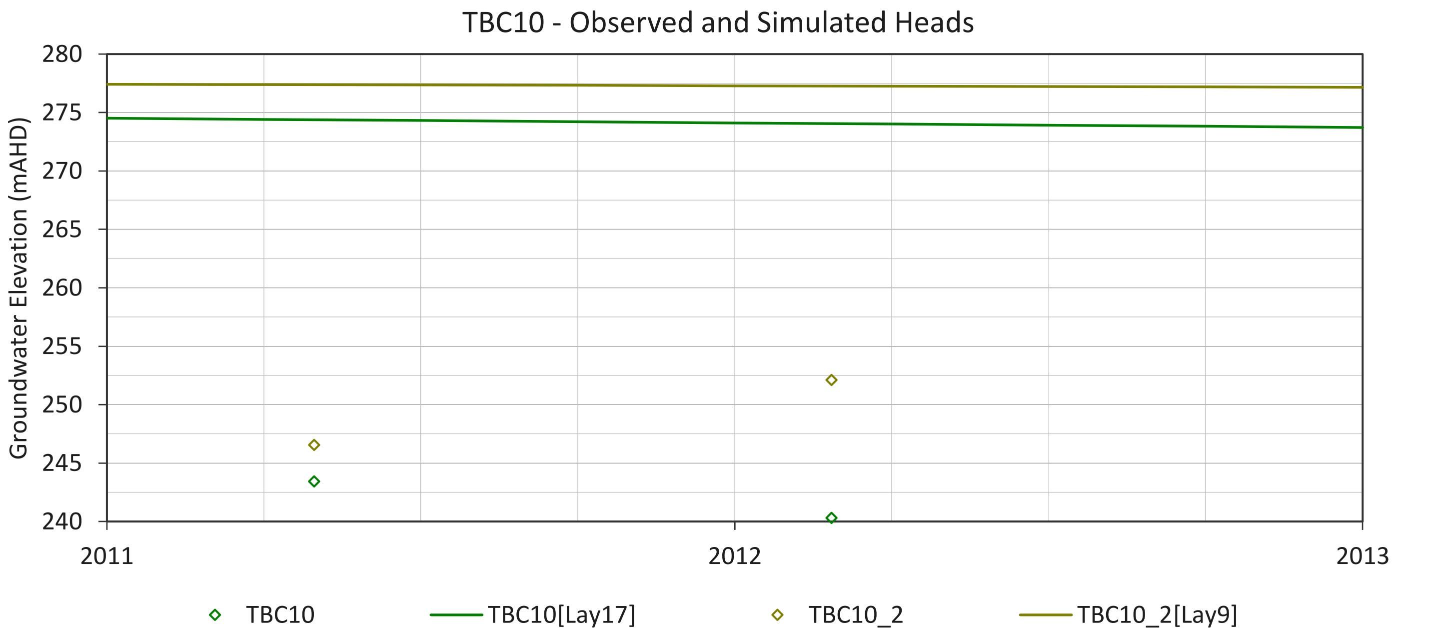

TBC01 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
210
190
170
150
130
110
90
70
50
2009
2010
2011
2012
TBC01_398
TBC01_398[Lay15]
TBC01_429
TBC01_429[Lay17]

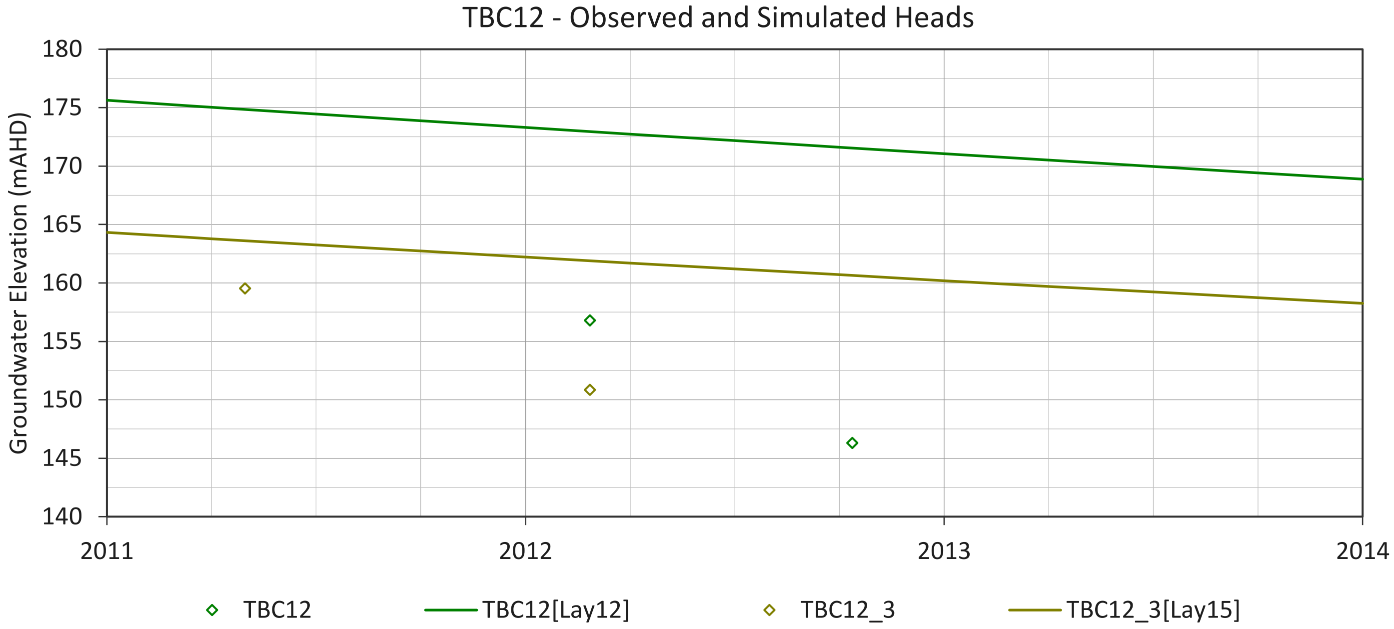

TBC02 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
210
200
190
180
170
160
150
140
130
2008
2009
2010
2011
2012
2013
TBC02_398
TBC02_398[Lay15]

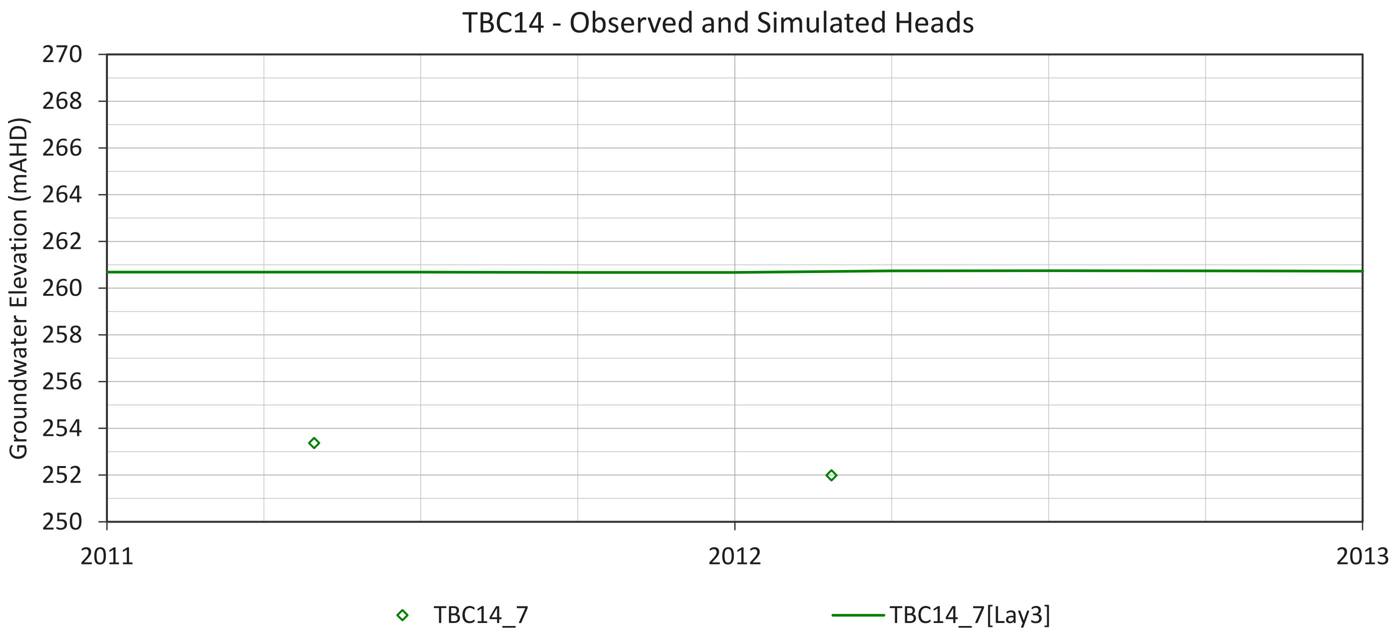

TBC040c - Observed and Simulated Heads
Groundwater Elevation (mAHD)
300
290
280
270
260
250
240
2012
2013
2014
TBC040c_BH
TBC040C_BH[Lay12]
TBC040c_H1
TBC040C_H1[Lay1]
TBC040c_H2
TBC040C_H2[Lay3]
TBC040c_H3
TBC040C_H3[Lay5]

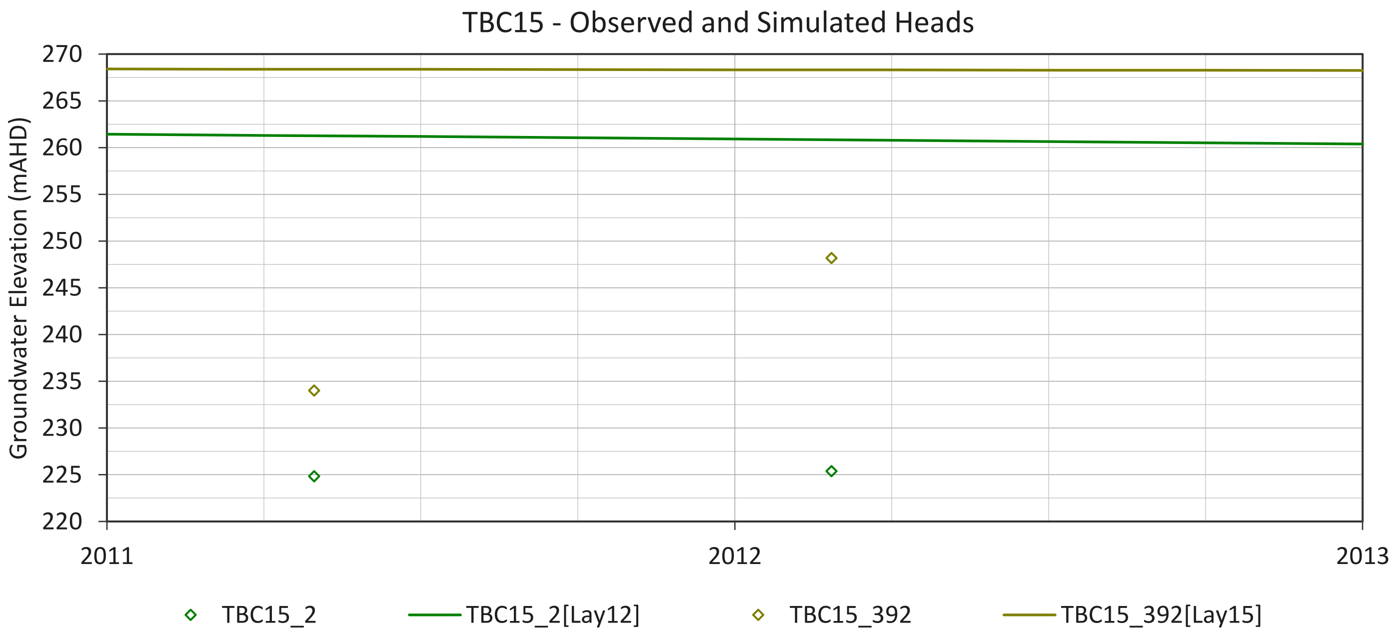

TBC05 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
280
275
270
265
260
255
250
2009
2010
2011
2012
2013
TBC05_395
TBC05_395[Lay7]
TBC05_416
TBC05_416[Lay12]

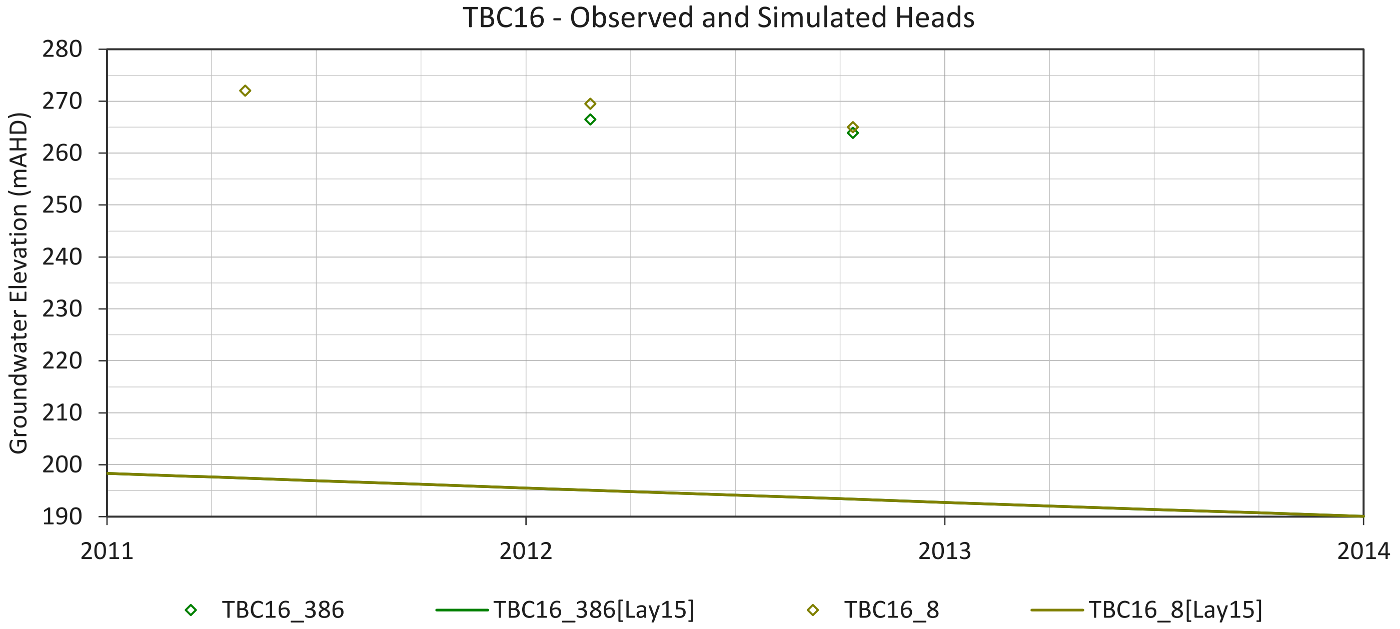

TBC09 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
330
320
310
300
290
280
270
260
250
2011
2013
2015
2017
2019
2021
TBC09__30
TBC09__30[Lay1]
TBC09__75
TBC09__75[Lay2]
TBC09_182
TBC09_182[Lay15]
TBC09_192
TBC09_192[Lay8]
TBC09_322
TBC09_322[Lay8]
TBC09_343
TBC09_343[Lay8]
TBC09_357
TBC09_357[Lay12]
TBC09_381
TBC09_381[Lay10]

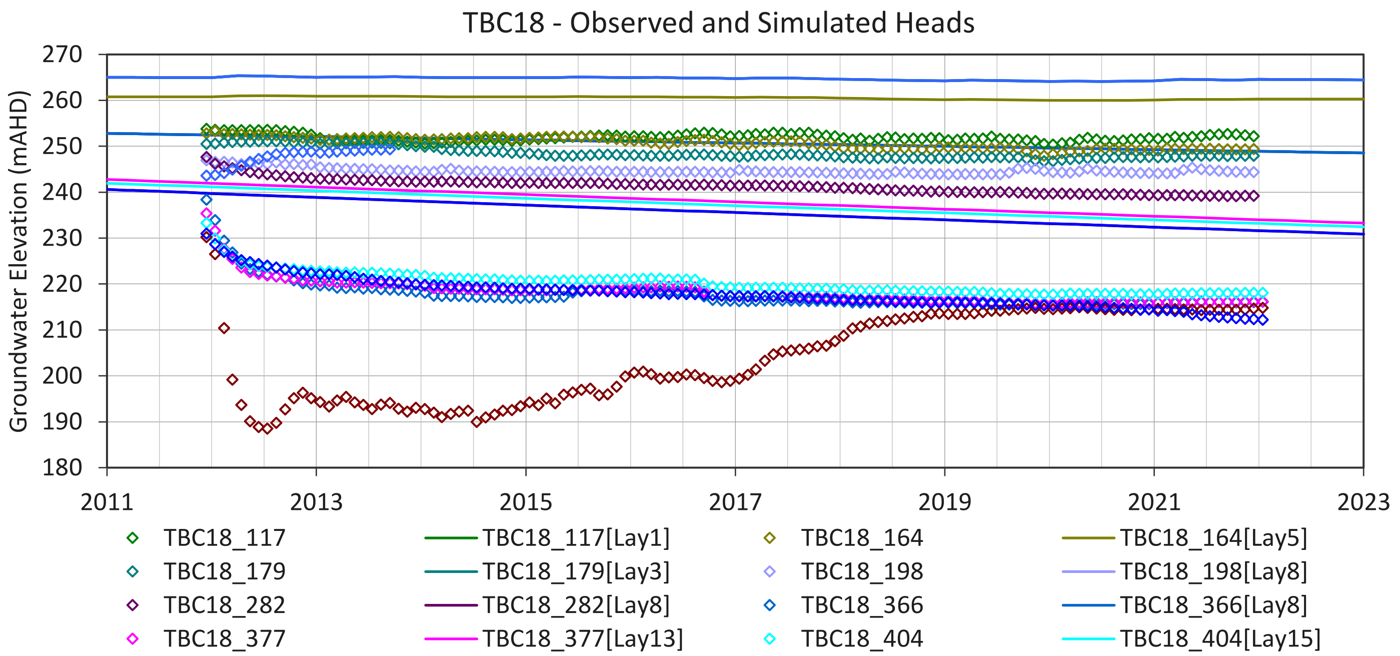

TBC10 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
280
275
270
265
260
255
250
245
240
2011
2012
2013
TBC10
TBC10[Lay17]
TBC10_2
TBC10_2[Lay9]

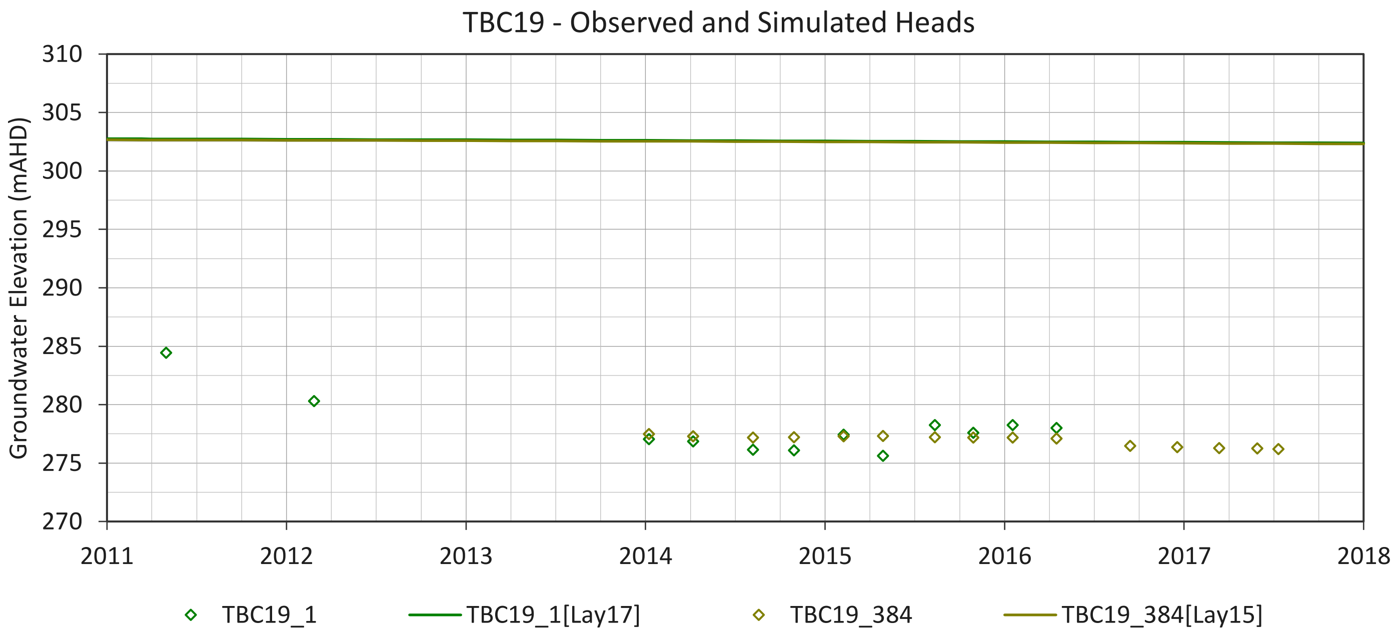

TBC12 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
180
175
170
165
160
155
150
145
140
2011
2012
2013
2014
TBC12
TBC12[Lay12]
TBC12_3
TBC12_3[Lay15]

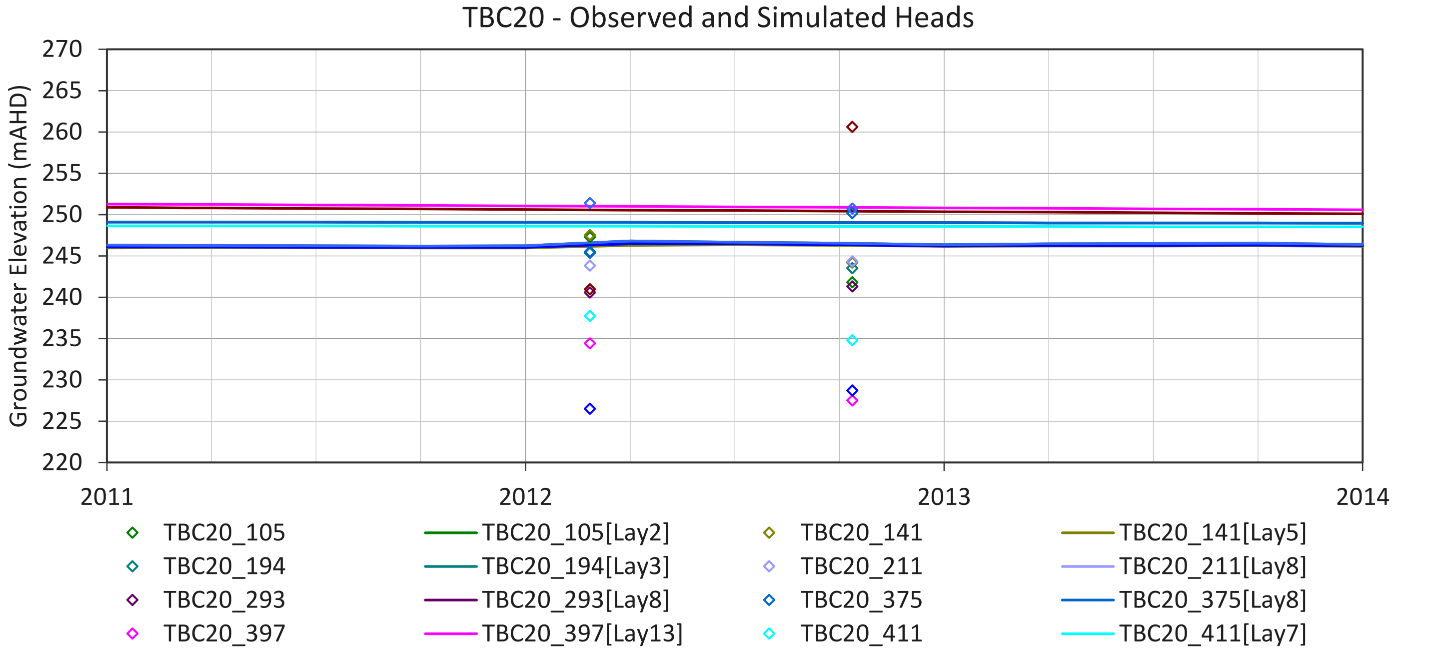

TBC14 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
270
268
266
264
262
260
258
256
254
252
250
2011
2012
2013
TBC14_7
TBC14_7[Lay3]

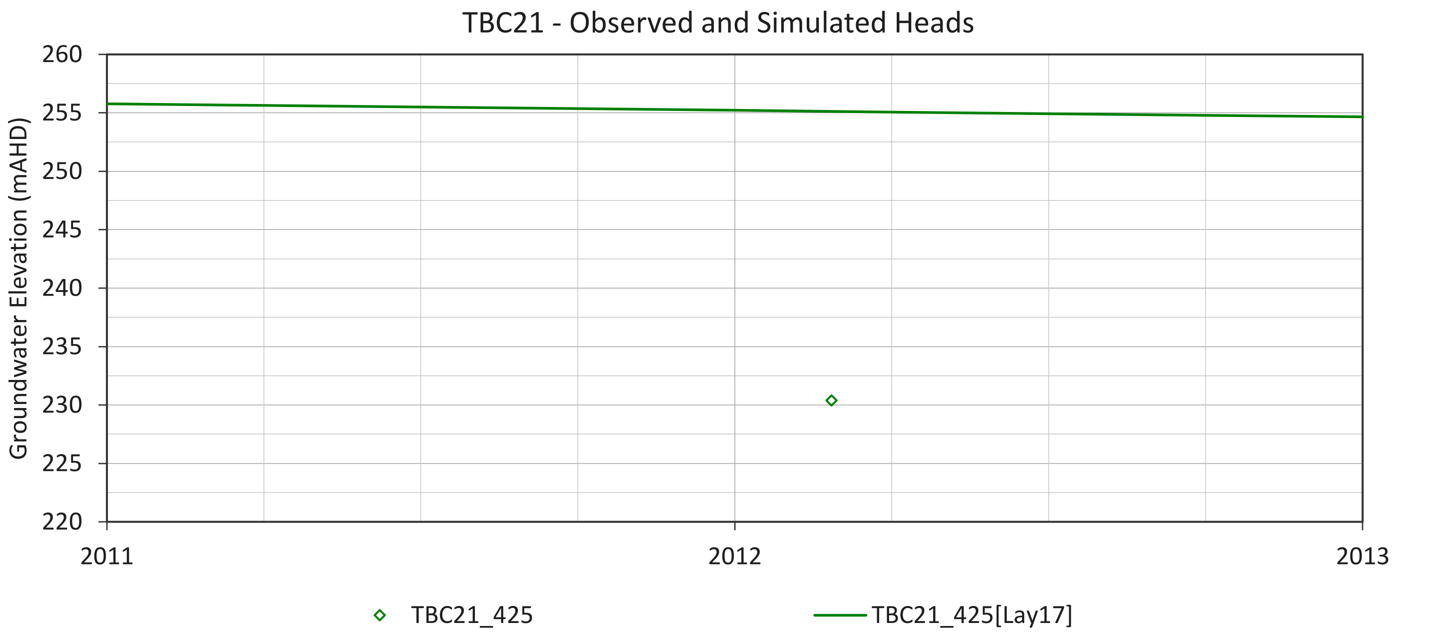

TBC15 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
270
265
260
255
250
245
240
235
230
225
220
2011
2012
2013
TBC15_2
TBC15_2[Lay12]
TBC15_392
TBC15_392[Lay15]

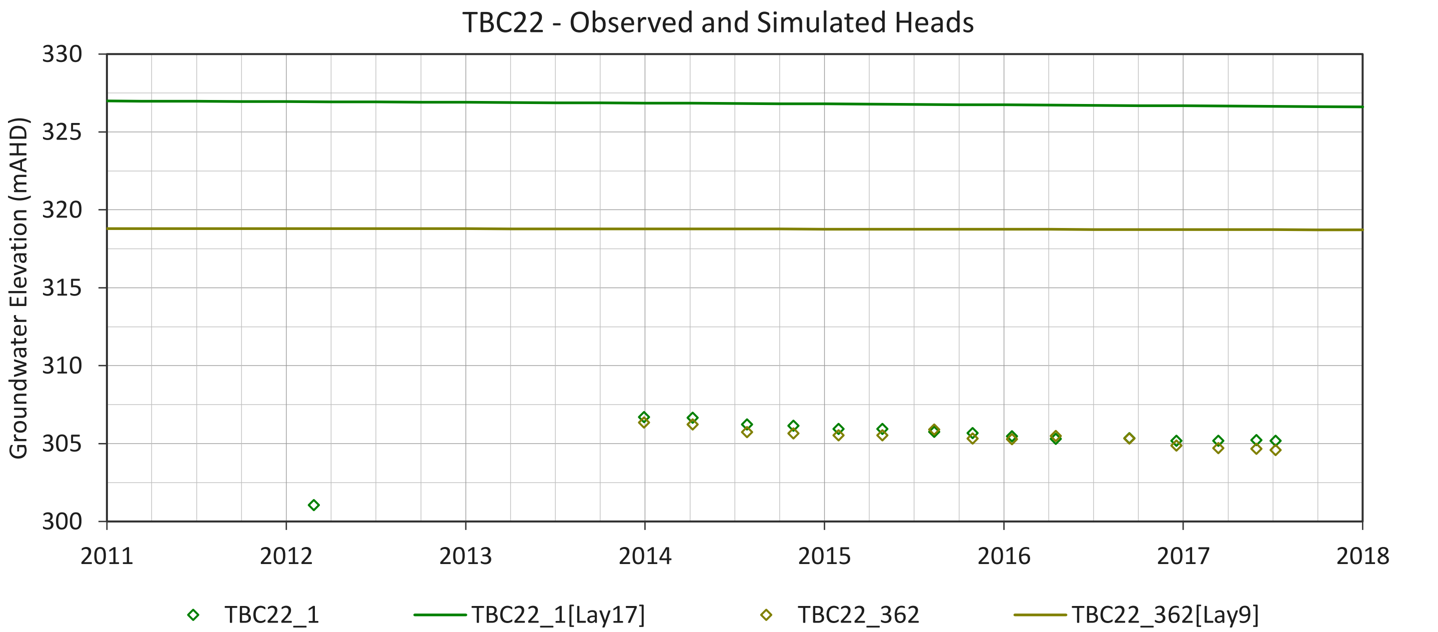

TBC16 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
280
270
260
250
240
230
220
210
200
190
2011
2012
2013
2014
TBC16_386
TBC16_386[Lay15]
TBC16_8
TBC16_8[Lay15]

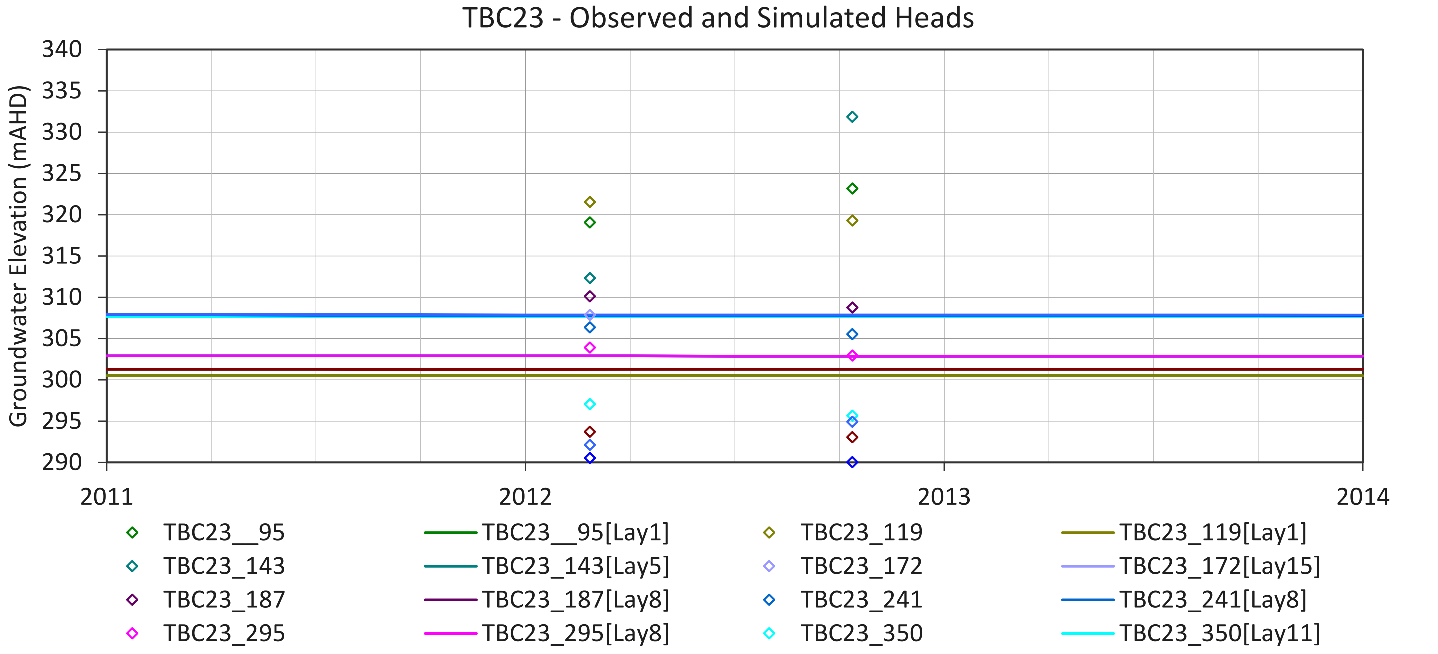

TBC18 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
270
260
250
240
230
220
210
200
190
180
2011
2013
2015
2017
2019
2021
2023
TBC18_117
TBC18_117[Lay1]
TBC18_164
TBC18_164[Lay5]
TBC18_179
TBC18_179[Lay3]
TBC18_198
TBC18_198[Lay8]
TBC18_282
TBC18_282[Lay8]
TBC18_366
TBC18_366[Lay8]
TBC18_377
TBC18_377[Lay13]
TBC18_404
TBC18_404[Lay15]

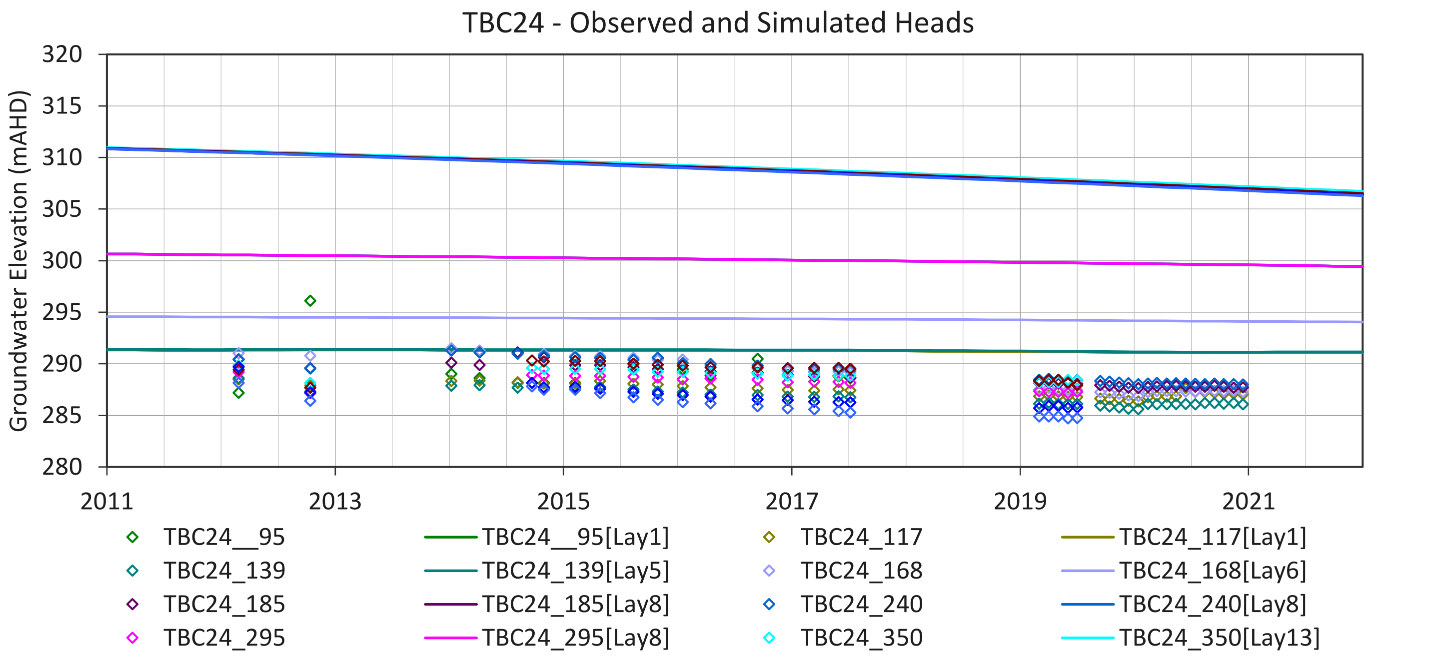

TBC19 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
310
305
300
295
290
285
280
275
270
2011
2012
2013
2014
2015
2016
2017
2018
TBC19_1
TBC19_1[Lay17]
TBC19_384
TBC19_384[Lay15]

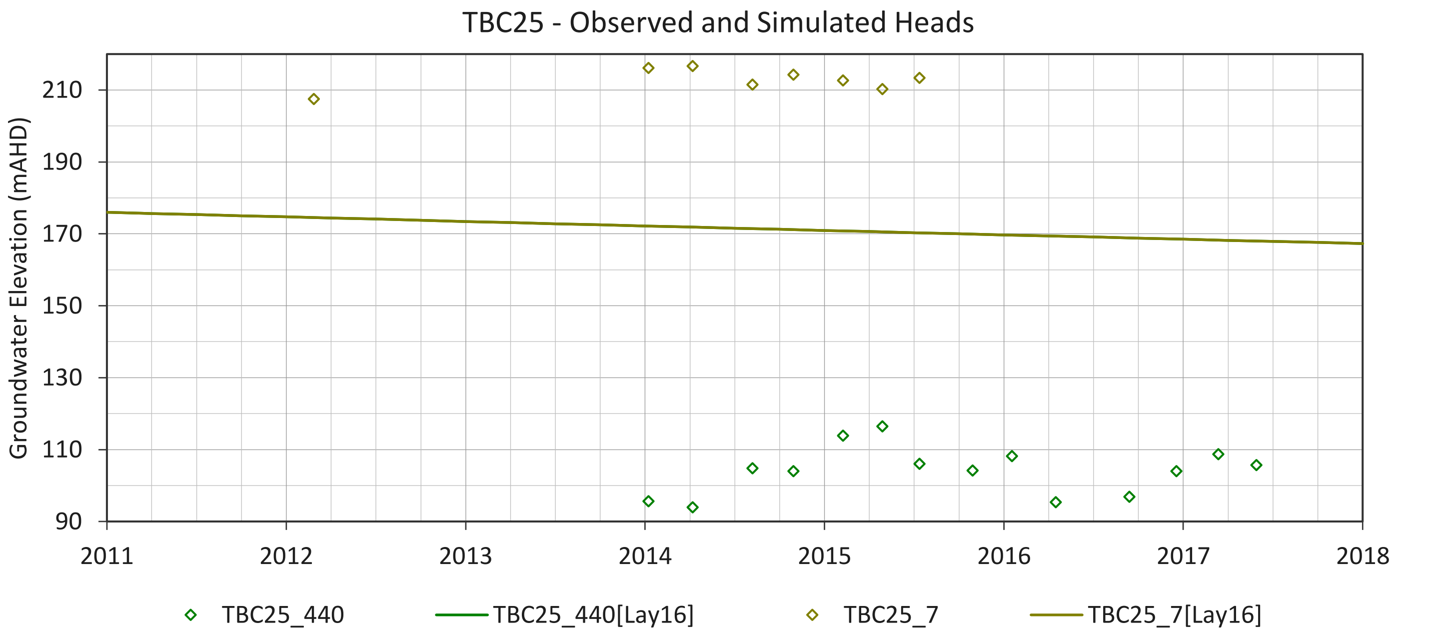

TBC20 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
270
265
260
255
250
245
240
235
230
225
220
2011
2012
2013
2014
TBC20_105
TBC20_105[Lay2]
TBC20_141
TBC20_141[Lay5]
TBC20_194
TBC20_194[Lay3]
TBC20_211
TBC20_211[Lay8]
TBC20_293
TBC20_293[Lay8]
TBC20_375
TBC20_375[Lay8]
TBC20_397
TBC20_397[Lay13]
TBC20_411
TBC20_411[Lay7]

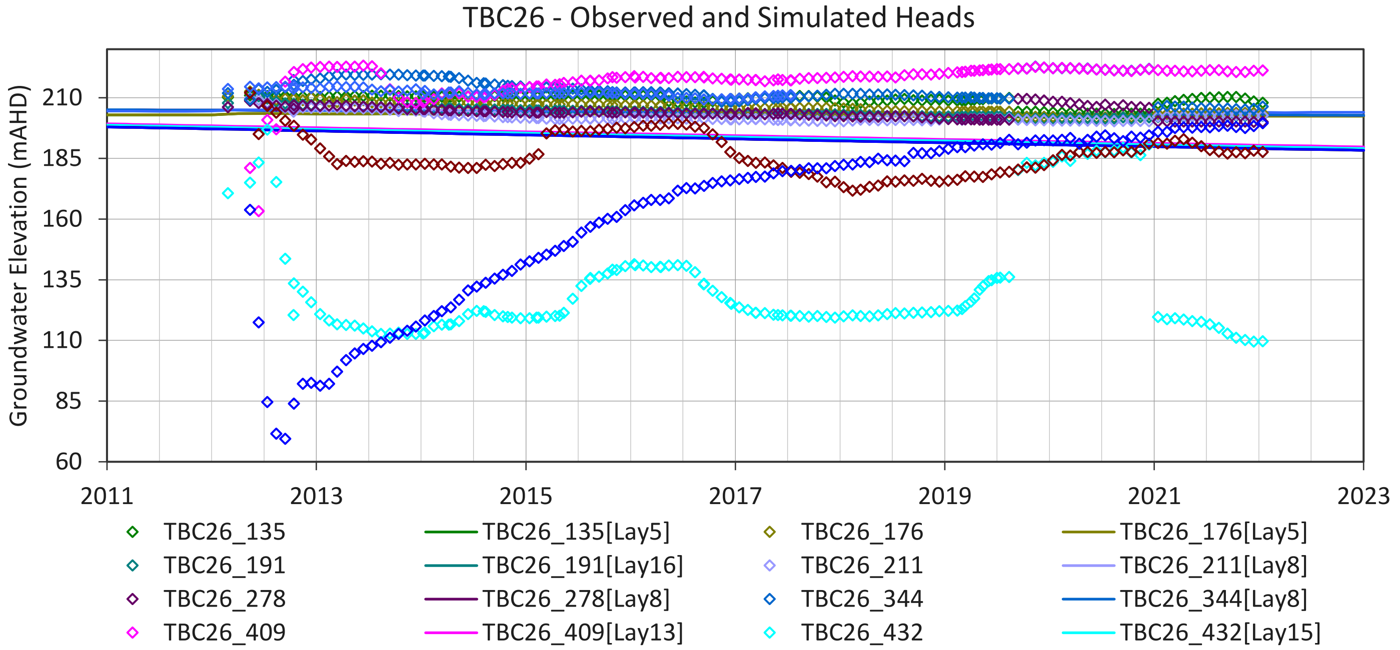

TBC21 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
260
255
250
245
240
235
230
225
220
2011
2012
2013
TBC21_425
TBC21_425[Lay17]

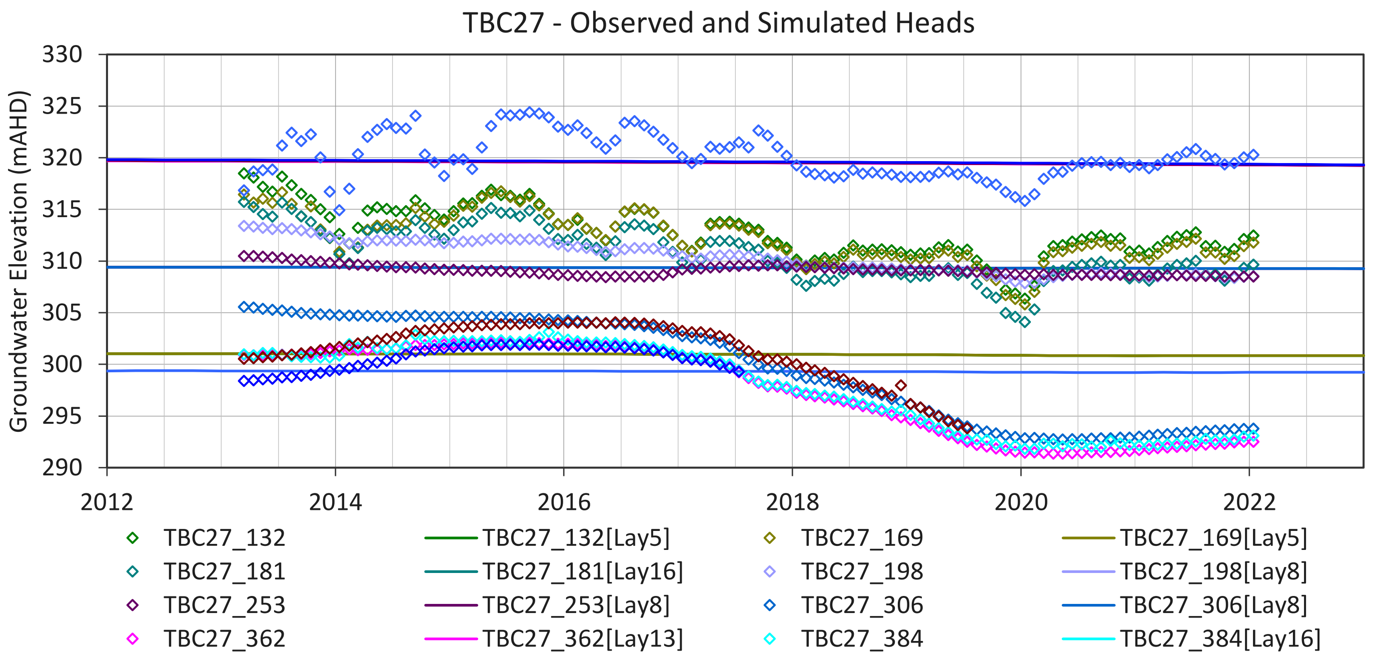

TBC22 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
330
325
320
315
310
305
300
2011
2012
2013
2014
2015
2016
2017
2018
TBC22_1
TBC22_1[Lay17]
TBC22_362
TBC22_362[Lay9]

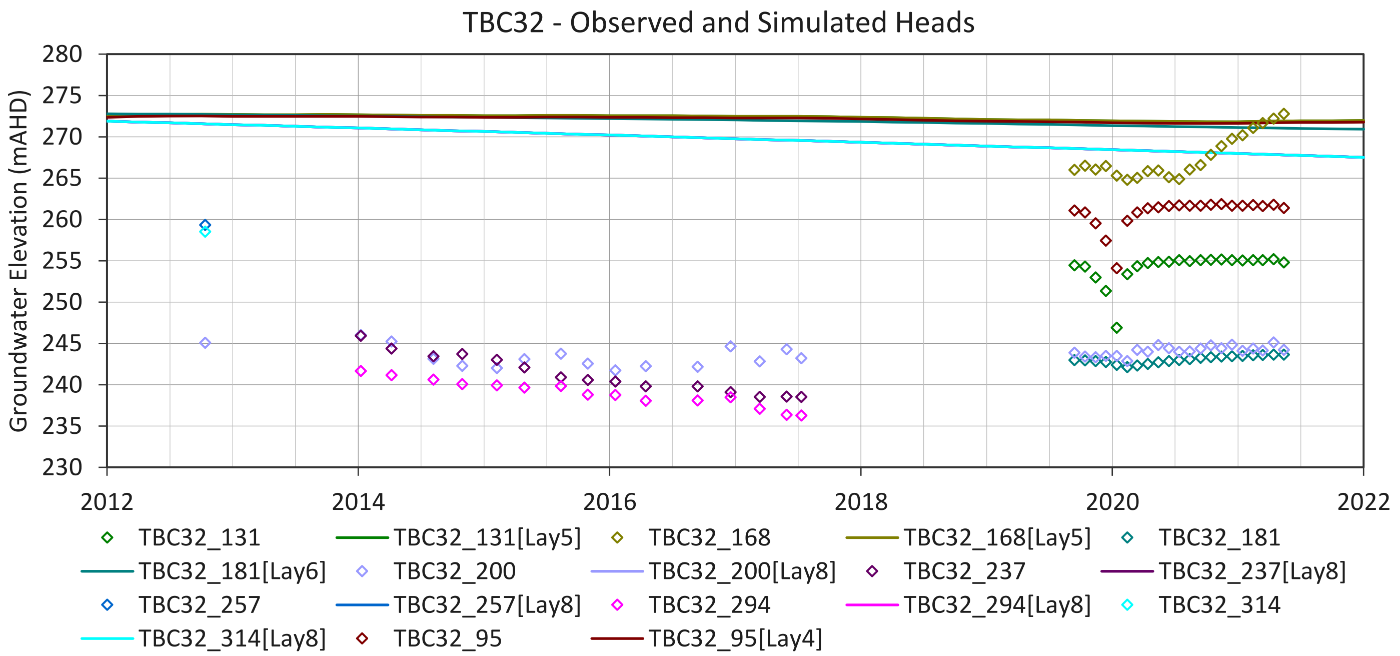

TBC23 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
340
335
330
325
320
315
310
305
300
295
290
2011
2012
2013
2014
TBC23__95
TBC23__95[Lay1]
TBC23_119
TBC23_119[Lay1]
TBC23_143
TBC23_143[Lay5]
TBC23_172
TBC23_172[Lay15]
TBC23_187
TBC23_187[Lay8]
TBC23_241
TBC23_241[Lay8]
TBC23_295
TBC23_295[Lay8]
TBC23_350
TBC23_350[Lay11]

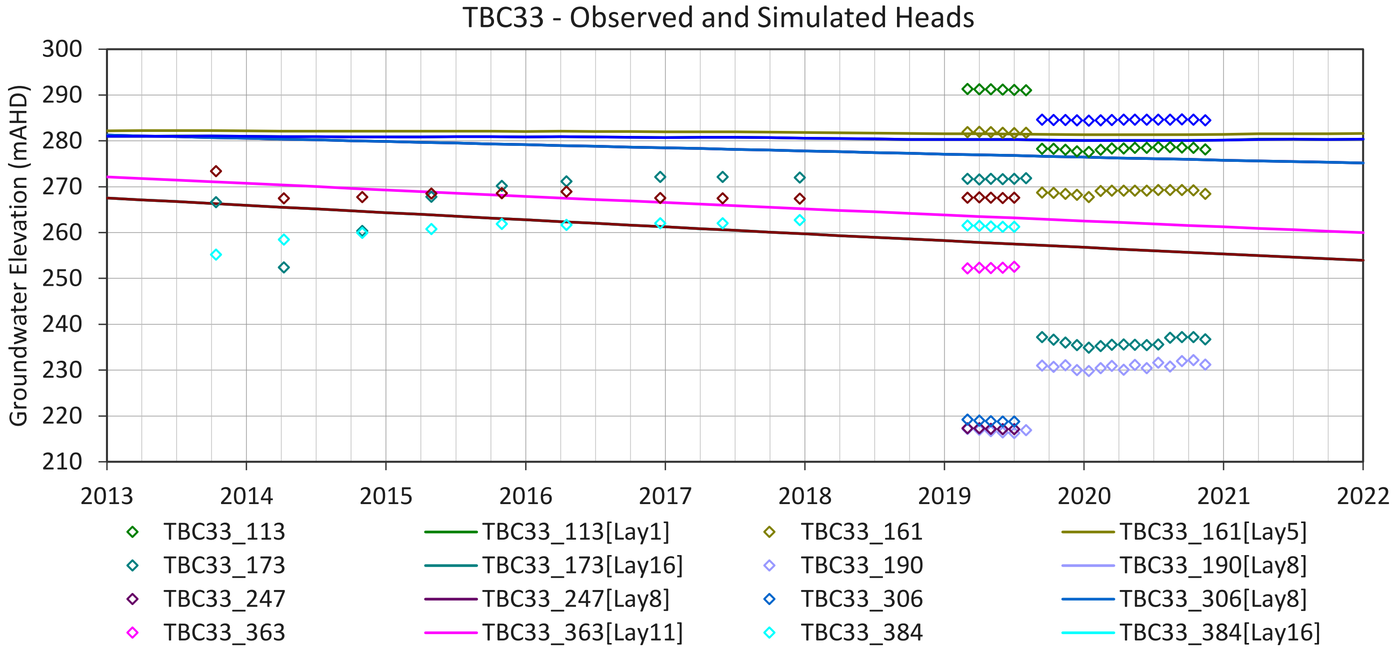

TBC24 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
320
315
310
305
300
295
290
285
280
2011
2013
2015
2017
2019
2021
TBC24__95
TBC24__95[Lay1]
TBC24_117
TBC24_117[Lay1]
TBC24_139
TBC24_139[Lay5]
TBC24_168
TBC24_168[Lay6]
TBC24_185
TBC24_185[Lay8]
TBC24_240
TBC24_240[Lay8]
TBC24_295
TBC24_295[Lay8]
TBC24_350
TBC24_350[Lay13]

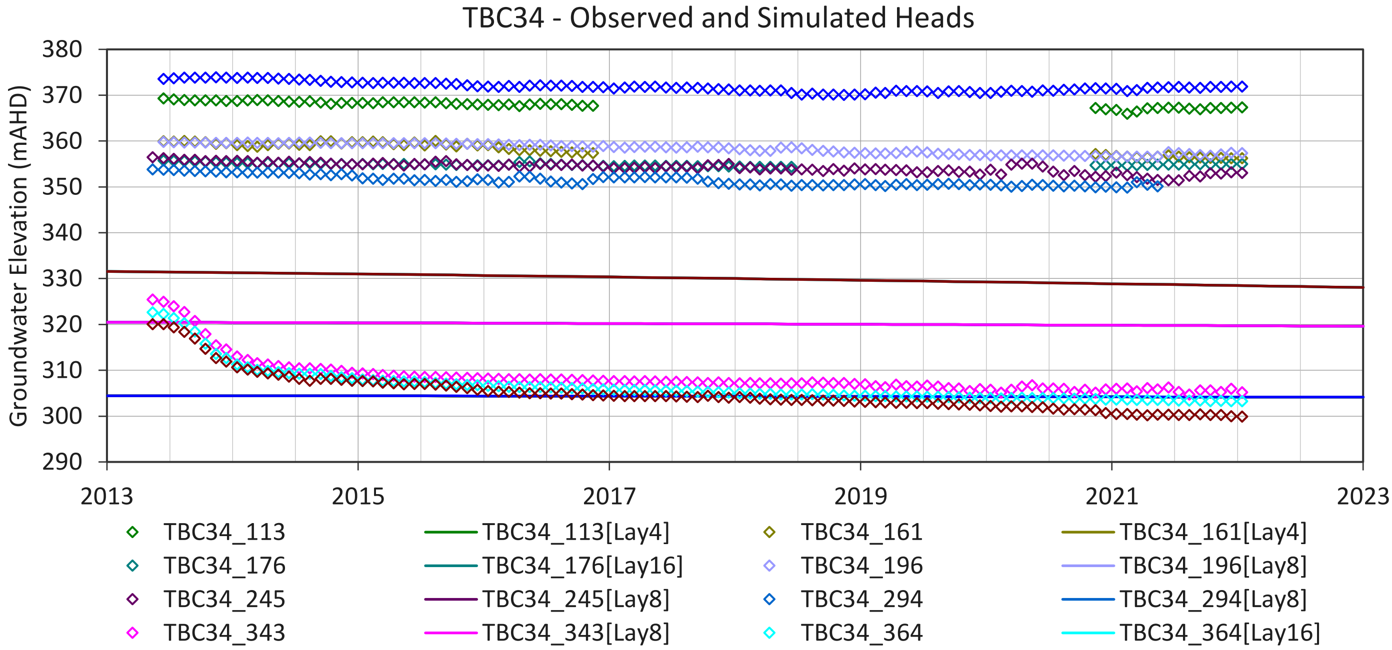

TBC25 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
210
190
170
150
130
110
90
2011
2012
2013
2014
2015
2016
2017
2018
TBC25_440
TBC25_440[Lay16]
TBC25_7
TBC25_7[Lay16]

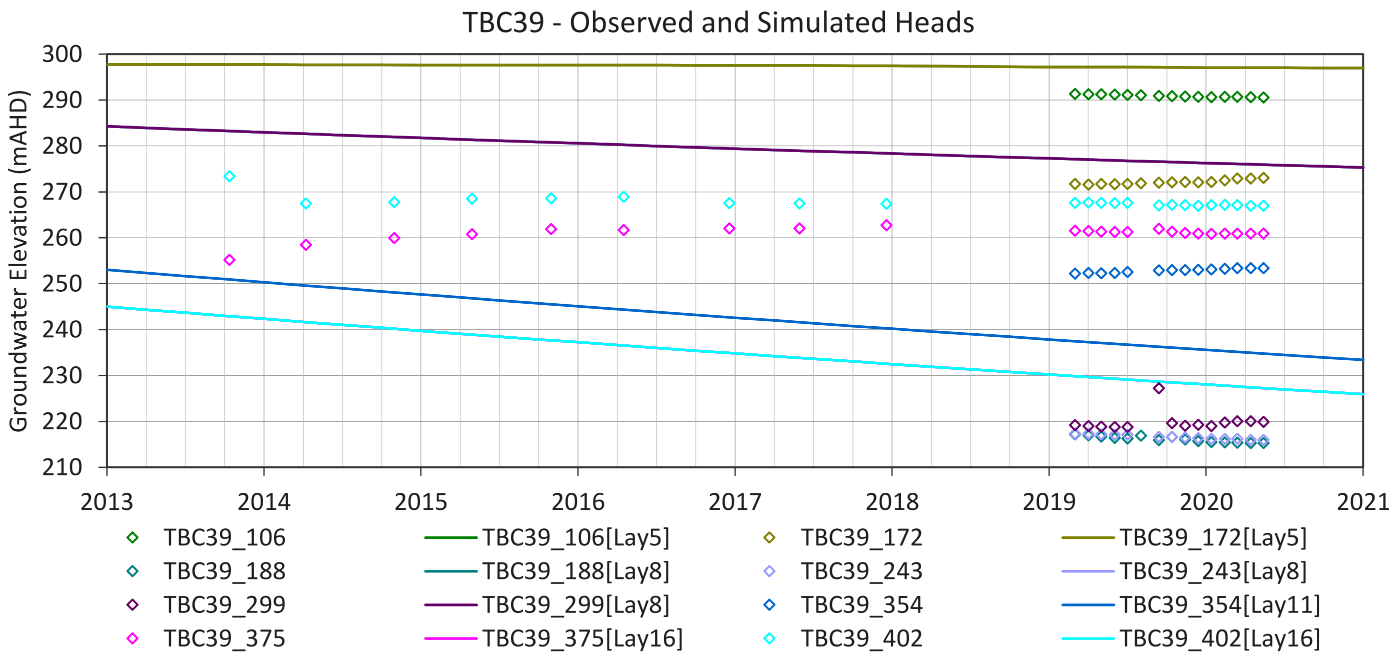

TBC26 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
60
85
110
135
160
185
210
2011
2013
2015
2017
2019
2021
2023
TBC26_135
TBC26_135[Lay5]
TBC26_176
TBC26_176[Lay5]
TBC26_191
TBC26_191[Lay16]
TBC26_211
TBC26_211[Lay8]
TBC26_278
TBC26_278[Lay8]
TBC26_344
TBC26_344[Lay8]
TBC26_409
TBC26_409[Lay13]
TBC26_432
TBC26_432[Lay15]


TBC27 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
290
295
300
305
310
315
320
325
330
2012
2014
2016
2018
2020
2022
TBC27_132
TBC27_132[Lay5]
TBC27_169
TBC27_169[Lay5]
TBC27_181
TBC27_181[Lay16]
TBC27_198
TBC27_198[Lay8]
TBC27_253
TBC27_253[Lay8]
TBC27_306
TBC27_306[Lay8]
TBC27_362
TBC27_362[Lay13]
TBC27_384
TBC27_384[Lay16]


TBC32 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
230
235
240
245
250
255
260
265
270
275
280
2012
2014
2016
2018
2020
2022
TBC32_131
TBC32_131[Lay5]
TBC32_168
TBC32_168[Lay5]
TBC32_181
TBC32_181[Lay6]
TBC32_200
TBC32_200[Lay8]
TBC32_237
TBC32_237[Lay8]
TBC32_257
TBC32_257[Lay8]
TBC32_294
TBC32_294[Lay8]
TBC32_314
TBC32_314[Lay8]
TBC32_95
TBC32_95[Lay4]


TBC33 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
300
290
280
270
260
250
240
230
220
210
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
TBC33_113
TBC33_113[Lay1]
TBC33_161
TBC33_161[Lay5]
TBC33_173
TBC33_173[Lay16]
TBC33_190
TBC33_190[Lay8]
TBC33_247
TBC33_247[Lay8]
TBC33_306
TBC33_306[Lay8]
TBC33_363
TBC33_363[Lay11]
TBC33_384
TBC33_384[Lay16]


TBC34 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
380
370
360
350
340
330
320
310
300
290
2013
2015
2017
2019
2021
2023
TBC34_113
TBC34_113[Lay4]
TBC34_161
TBC34_161[Lay4]
TBC34_176
TBC34_176[Lay16]
TBC34_196
TBC34_196[Lay8]
TBC34_245
TBC34_245[Lay8]
TBC34_294
TBC34_294[Lay8]
TBC34_343
TBC34_343[Lay8]
TBC34_364
TBC34_364[Lay16]


TBC39 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
300
290
280
270
260
250
240
230
220
210
2013
2014
2015
2016
2017
2018
2019
2020
2021
TBC39_106
TBC39_106[Lay5]
TBC39_172
TBC39_172[Lay5]
TBC39_188
TBC39_188[Lay8]
TBC39_243
TBC39_243[Lay8]
TBC39_299
TBC39_299[Lay8]
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TBC39_354[Lay11]
TBC39_375
TBC39_375[Lay16]
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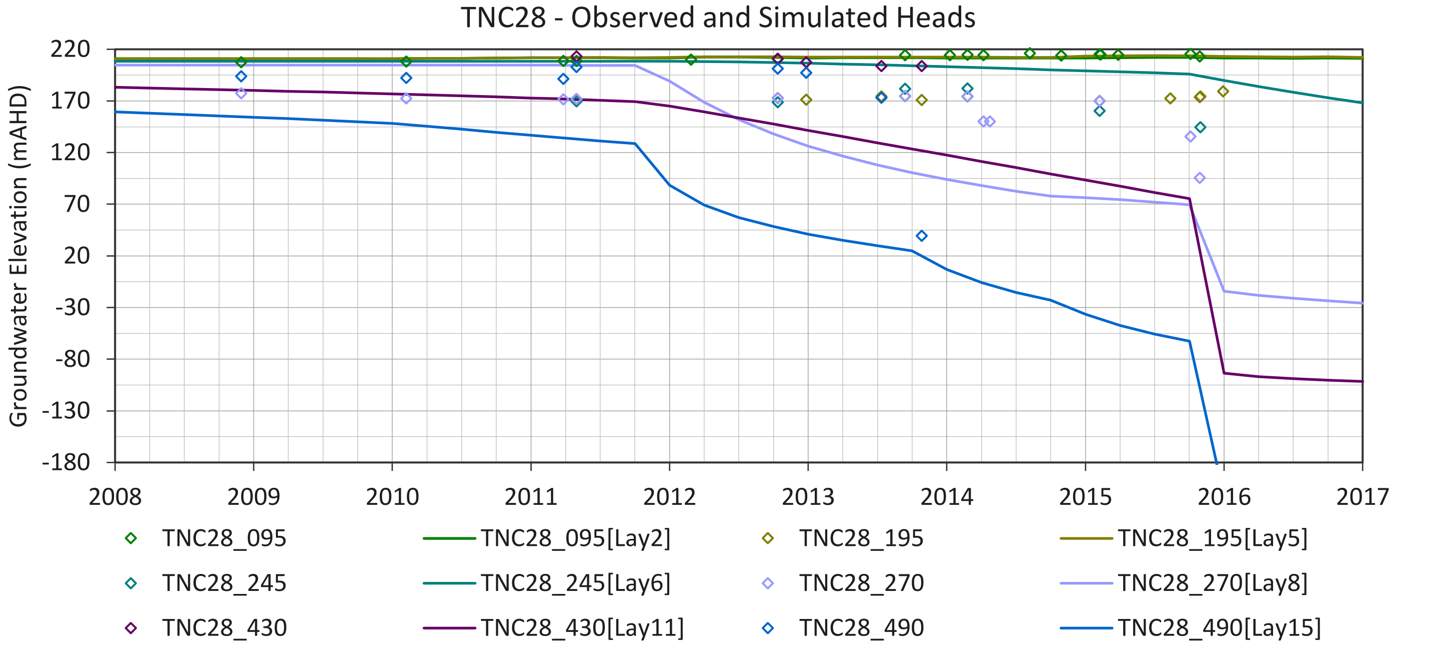
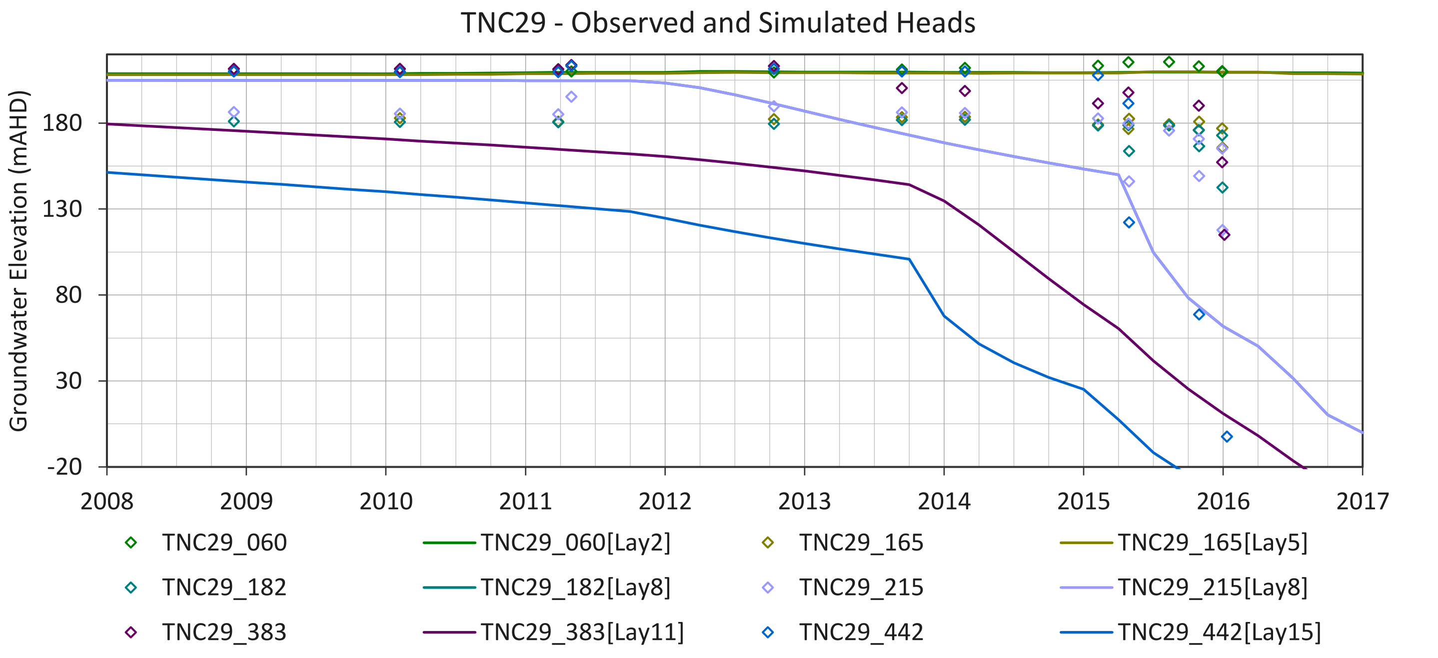

TNC28 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
220
170
120
70
20
-30
-80
-130
-180
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
TNC28_095
TNC28_095[Lay2]
TNC28_195
TNC28_195[Lay5]
TNC28_245
TNC28_245[Lay6]
TNC28_270
TNC28_270[Lay8]
TNC28_430
TNC28_430[Lay11]
TNC28_490
TNC28_490[Lay15]


TNC29 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
180
130
80
30
-20
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
TNC29_060
TNC29_060[Lay2]
TNC29_165
TNC29_165[Lay5]
TNC29_182
TNC29_182[Lay8]
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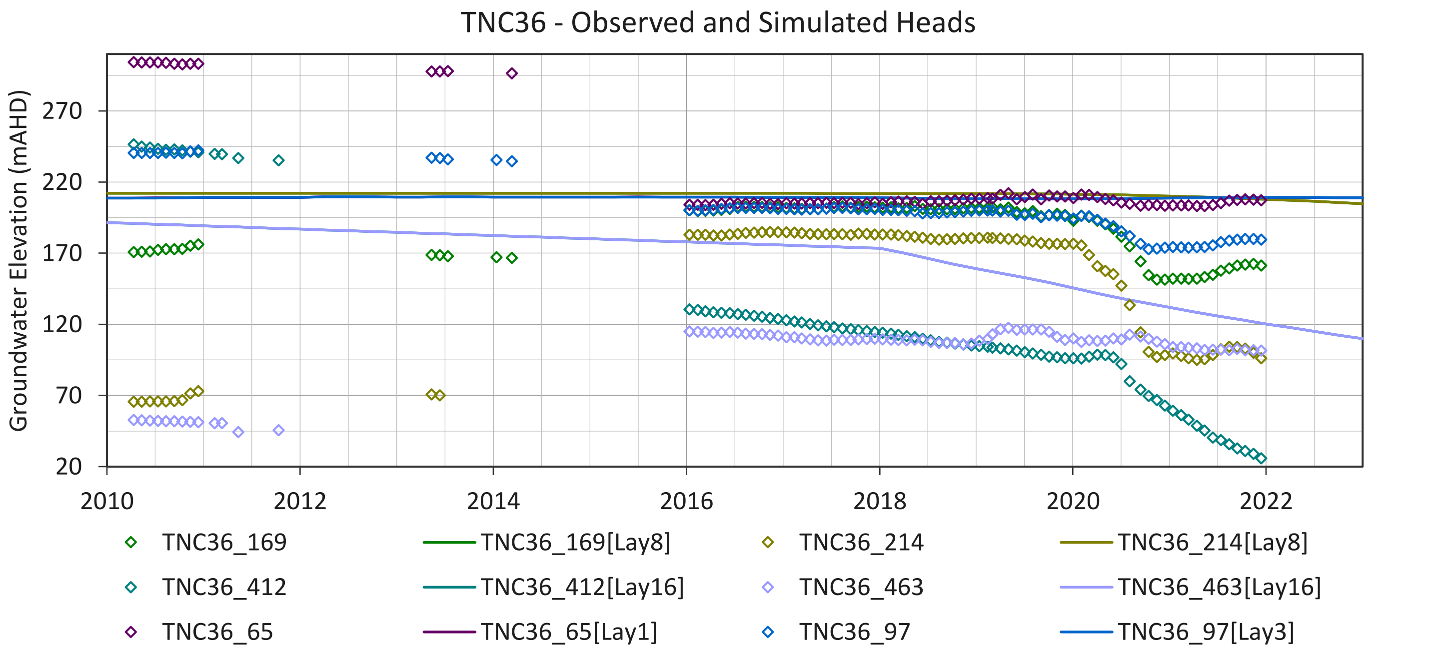
TNC36 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
270
220
170
120
70
20
2010
2012
2014
2016
2018
2020
2022
TNC36_169
TNC36_169[Lay8]
TNC36_214
TNC36_214[Lay8]
TNC36_412
TNC36_412[Lay16]
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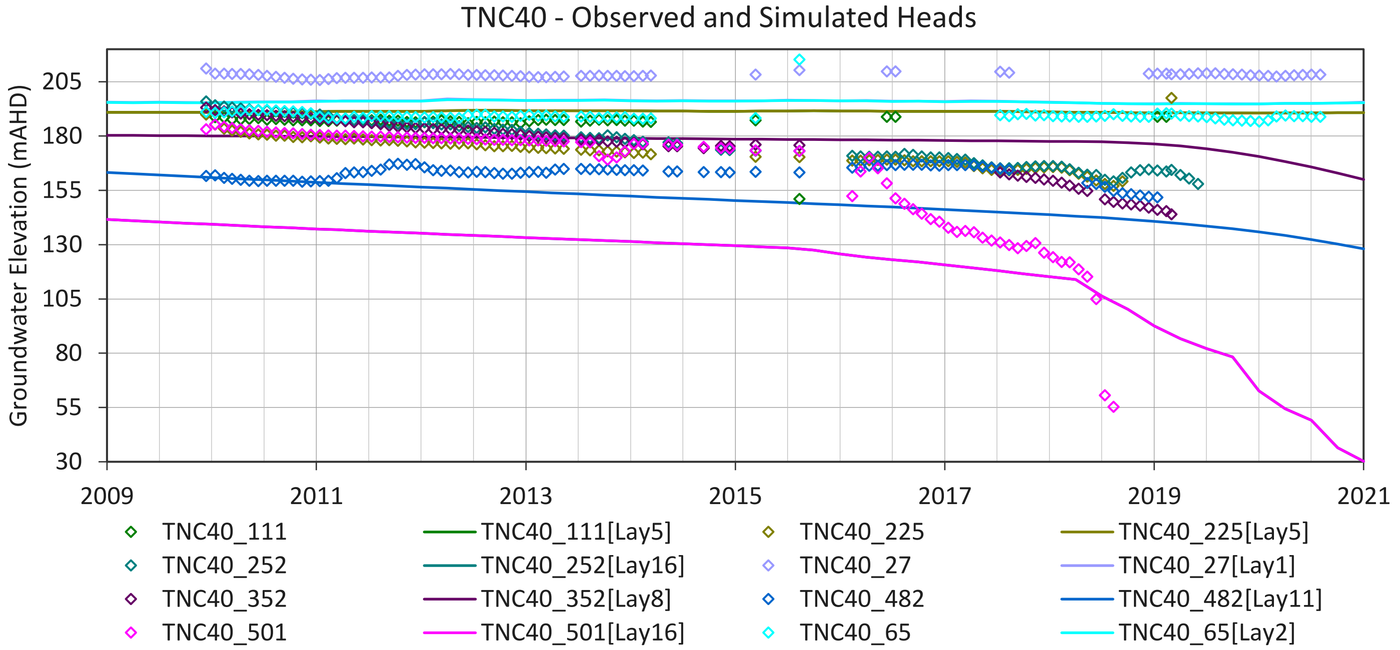
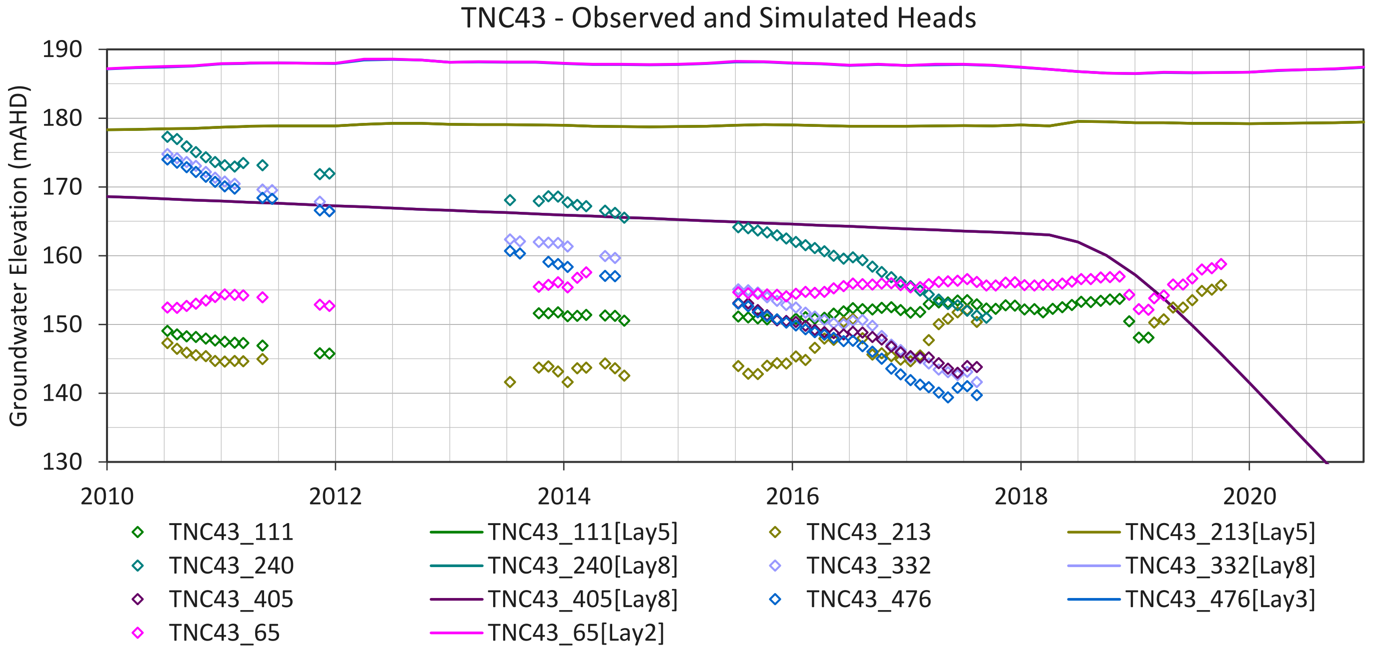
TNC36_65[Lay1]
TNC36_97
TNC36_97[Lay3]


TNC40 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
205
180
155
130
105
80
55
30
2009
2011
2013
2015
2017
2019
2021
TNC40_111
TNC40_111[Lay5]
TNC40_225
TNC40_225[Lay5]
TNC40_252
TNC40_252[Lay16]
TNC40_27
TNC40_27[Lay1]
TNC40_352
TNC40_352[Lay8]
TNC40_482
TNC40_482[Lay11]
TNC40_501
TNC40_501[Lay16]
TNC40_65
TNC40_65[Lay2]


TNC43 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
190
180
170
160
150
140
130
2010
2012
2014
2016
2018
2020
TNC43_111
TNC43_111[Lay5]
TNC43_213
TNC43_213[Lay5]
TNC43_240
TNC43_240[Lay8]
TNC43_332
TNC43_332[Lay8]
TNC43_405
TNC43_405[Lay8]
TNC43_476
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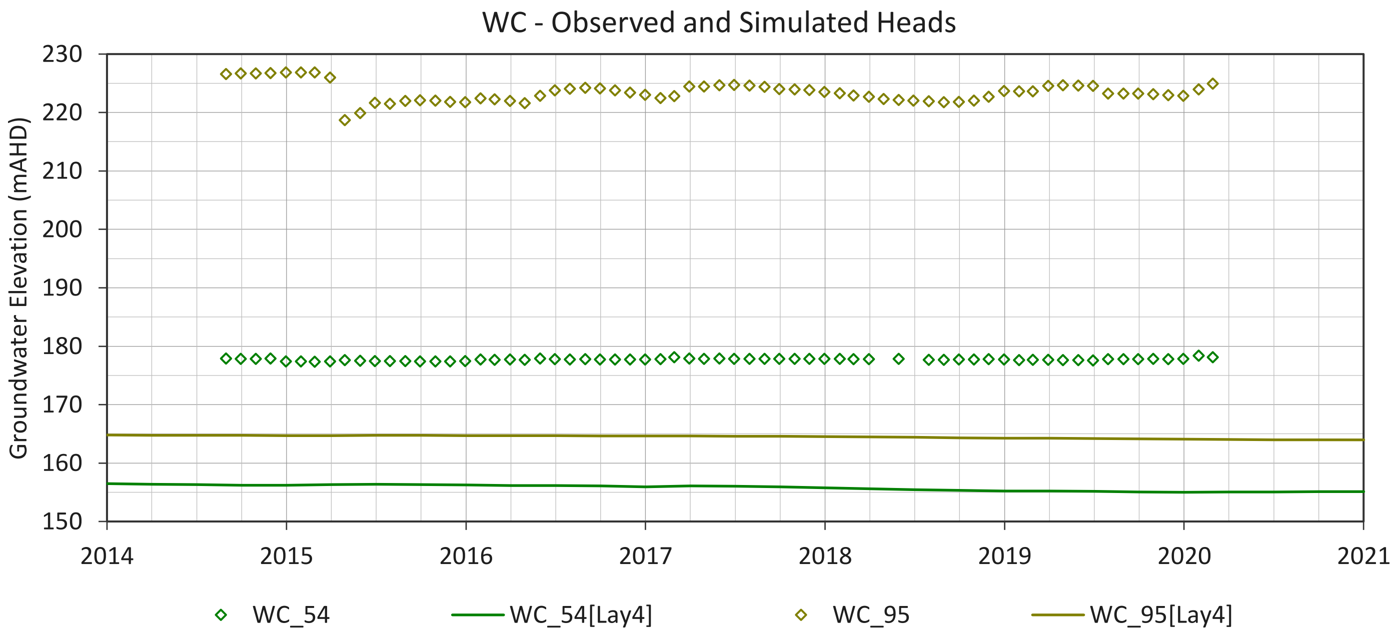
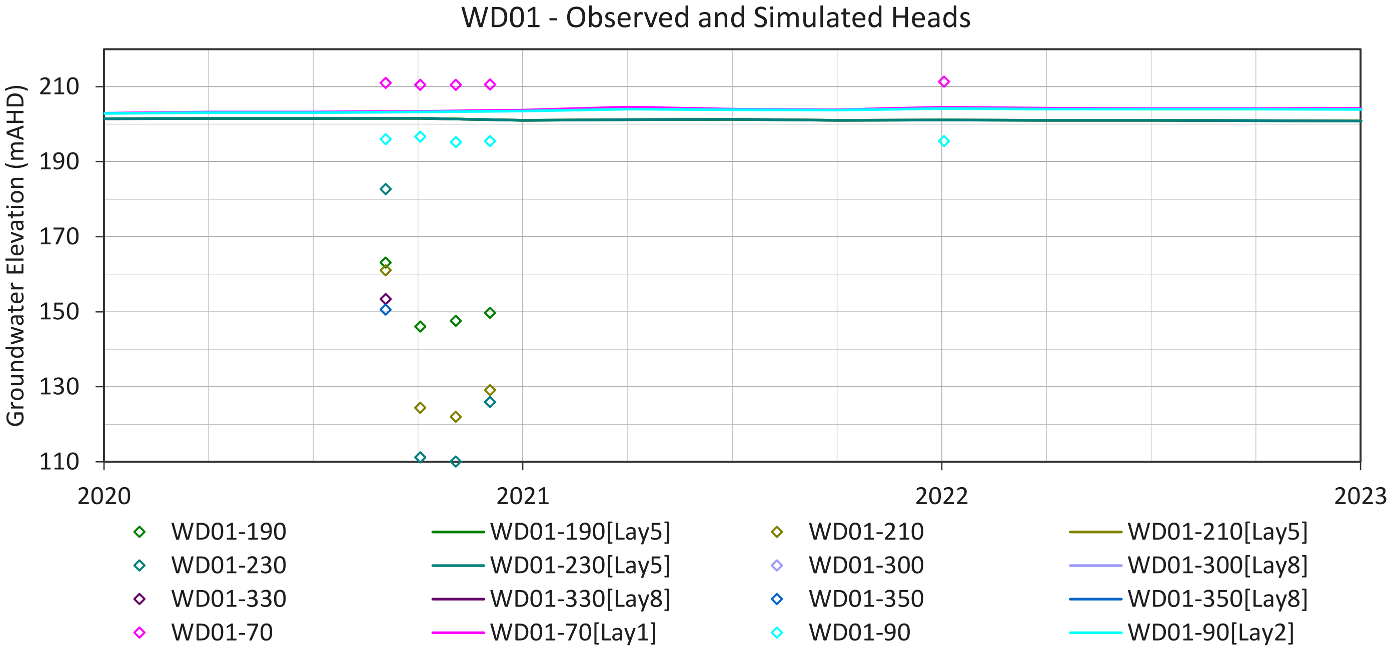
TNC43_65[Lay2]


WC - Observed and Simulated Heads
Groundwater Elevation (mAHD)
230
220
210
200
190
180
170
160
150
2014
2015
2016
2017
2018
2019
2020
2021
WC_54
WC_54[Lay4]
WC_95
WC_95[Lay4]


WD01 - Observed and Simulated Heads
Groundwater Elevation (mAHD)
210
190
170
150
130
110
2020
2021
2022
2023
WD01-190
WD01-190[Lay5]
WD01-210
WD01-210[Lay5]
WD01-230
WD01-230[Lay5]
WD01-300
WD01-300[Lay8]
WD01-330
WD01-330[Lay8]
WD01-350
WD01-350[Lay8]
WD01-70
WD01-70[Lay1]
WD01-90
WD01-90[Lay2]

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APPENDIX G

Shallow VWP Modelled Predictive Hydrographs and Trigger Levels

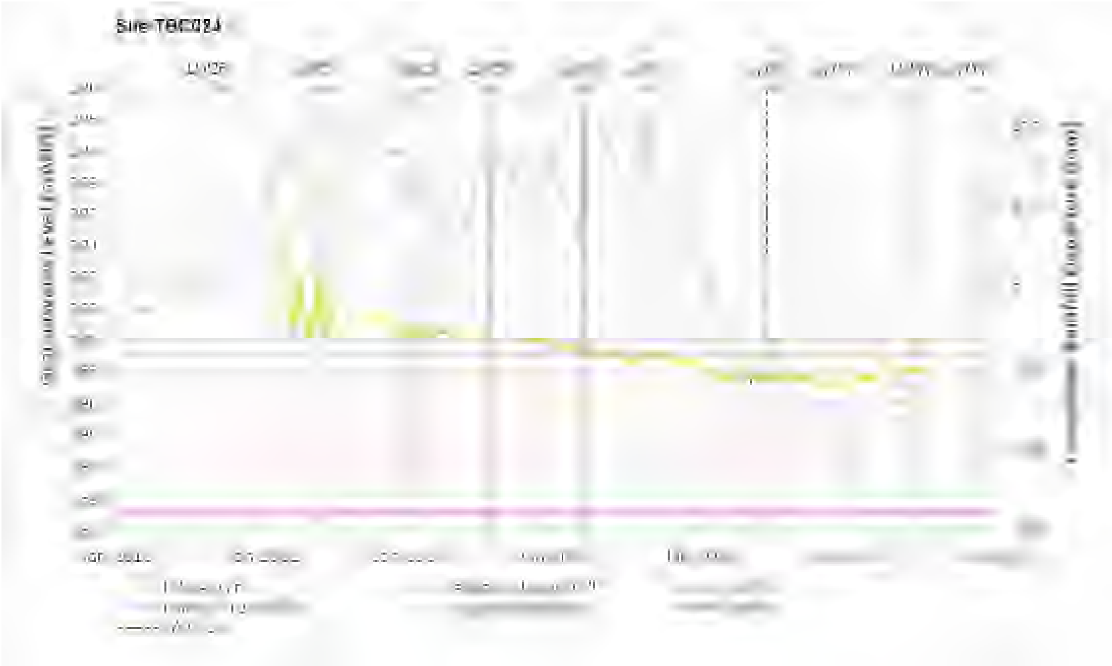


Figure G-1 TBC024-HBSS 117m Hydrograph and Proposed Trigger Levels

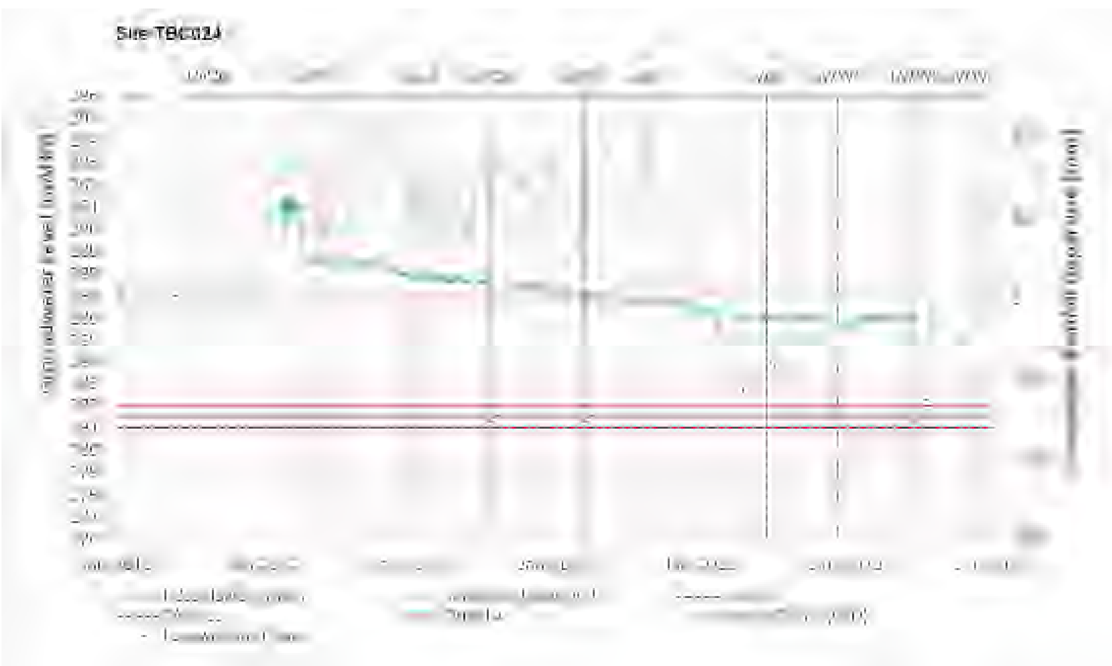


Figure G-2 TBC024-HBSS 139 m Hydrograph and Proposed Trigger Levels

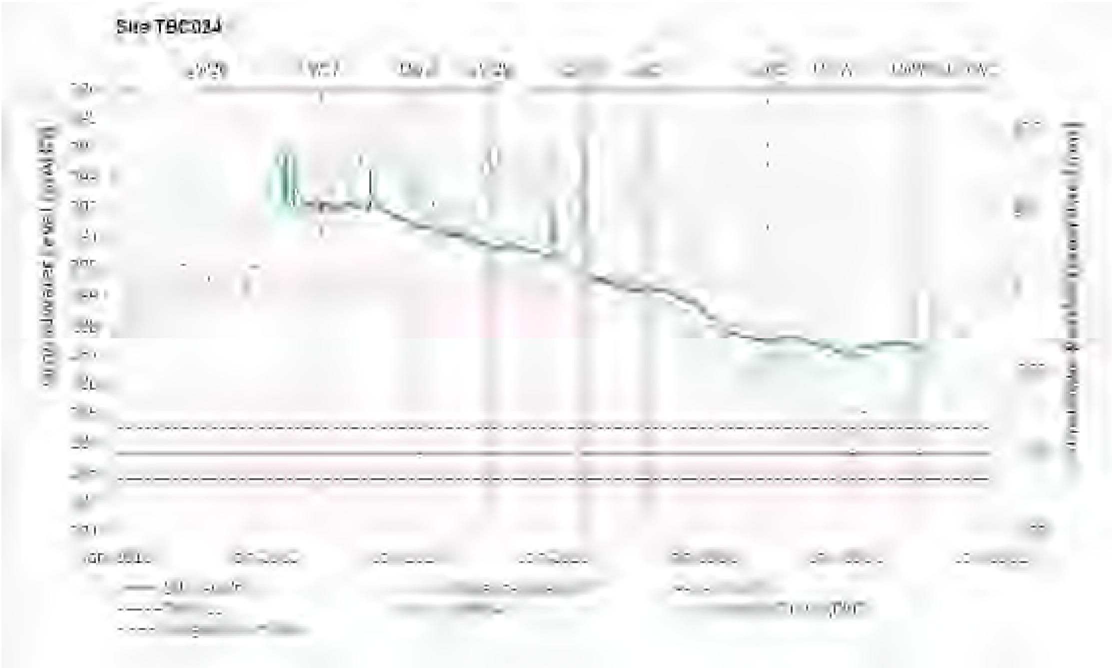


Figure G-3 TBC024-BHCS 168 m Hydrograph and Proposed Trigger Levels

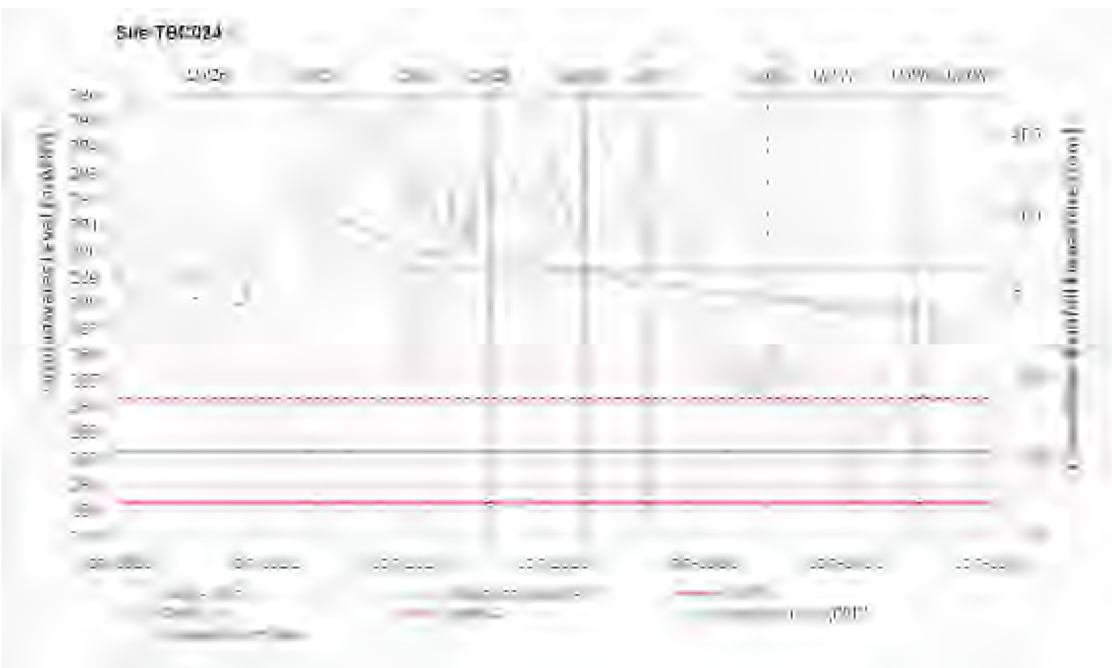


Figure G-4 TBC024-BGSS 185 m Hydrograph and Proposed Trigger Levels

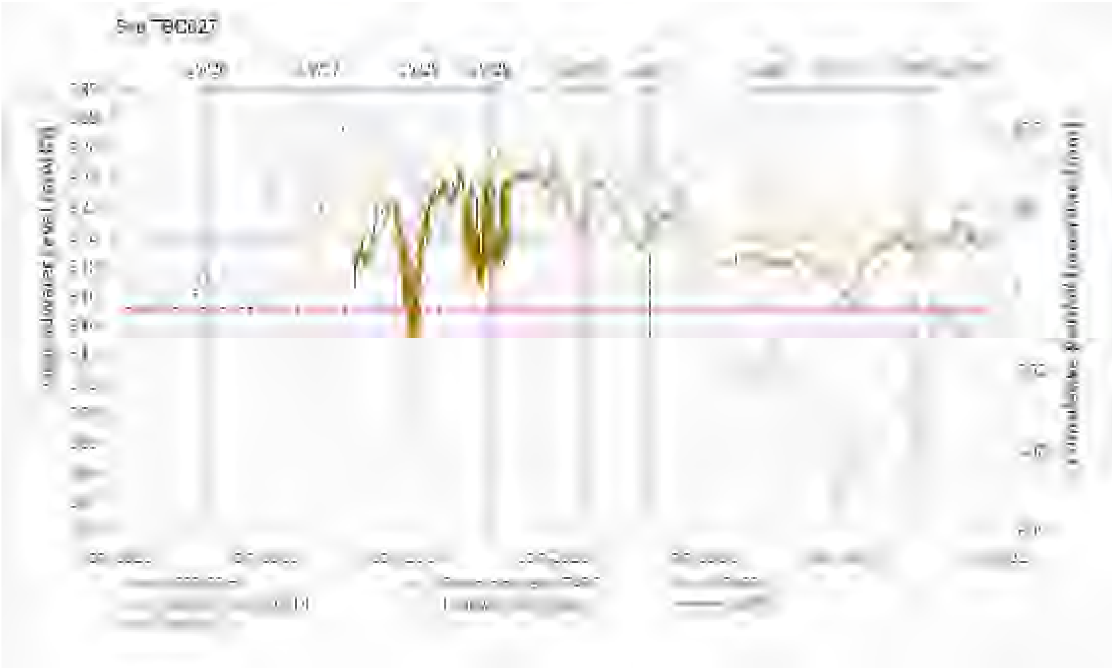


Figure G-5 TBC027-HBSS 95 m Hydrograph and Proposed Trigger Levels

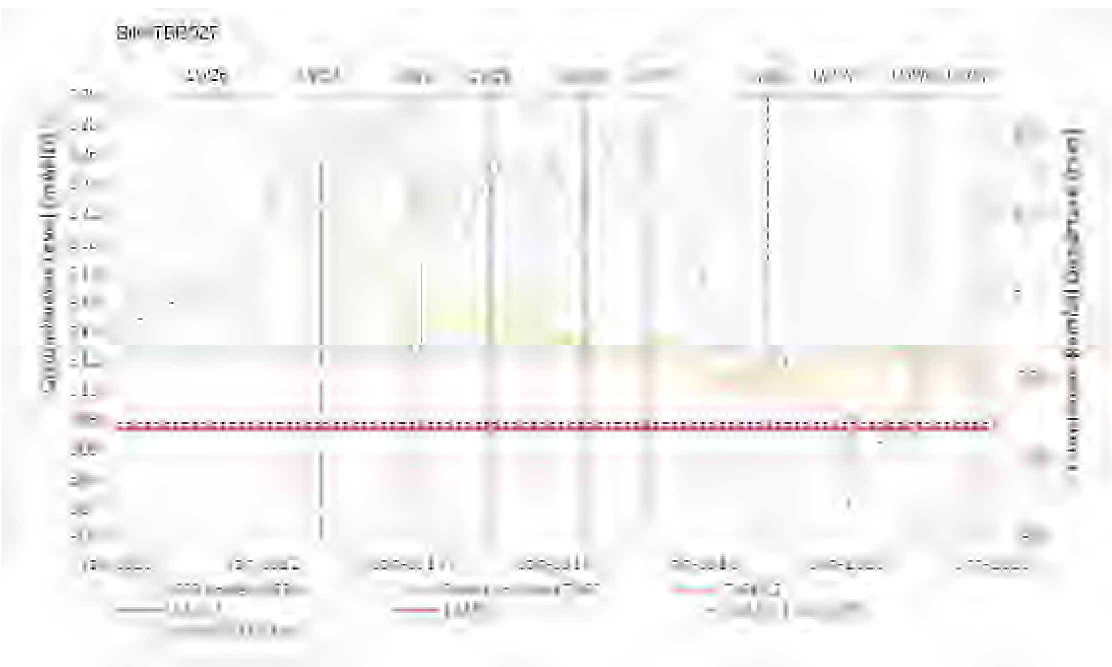


Figure G-6 TBC027-HBSS 132 m Hydrograph and Proposed Trigger Levels

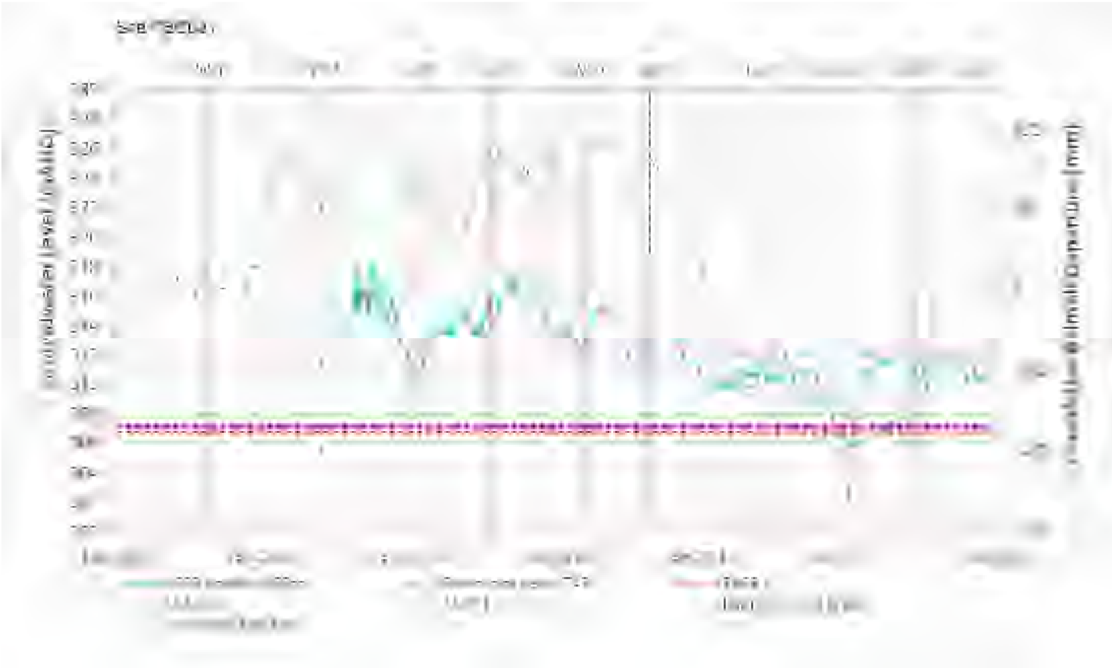


Figure G-7 TBC027-HBSS 169 m Hydrograph and Proposed Trigger Levels

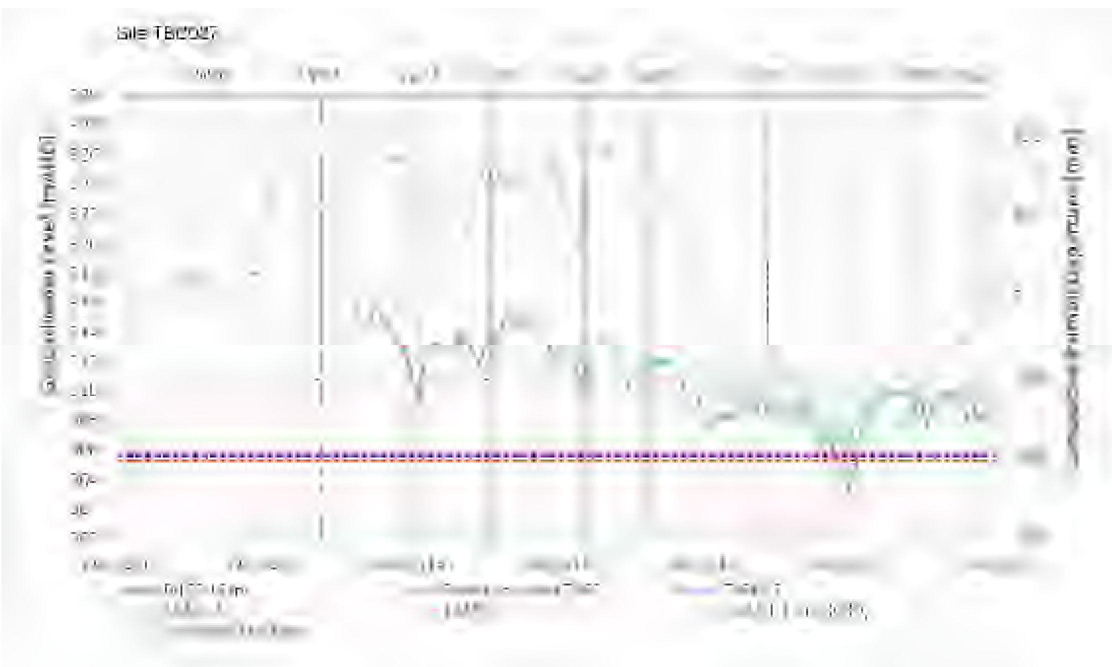


Figure G-8 TBC027-BHCS 181 m Hydrograph and Proposed Trigger Levels

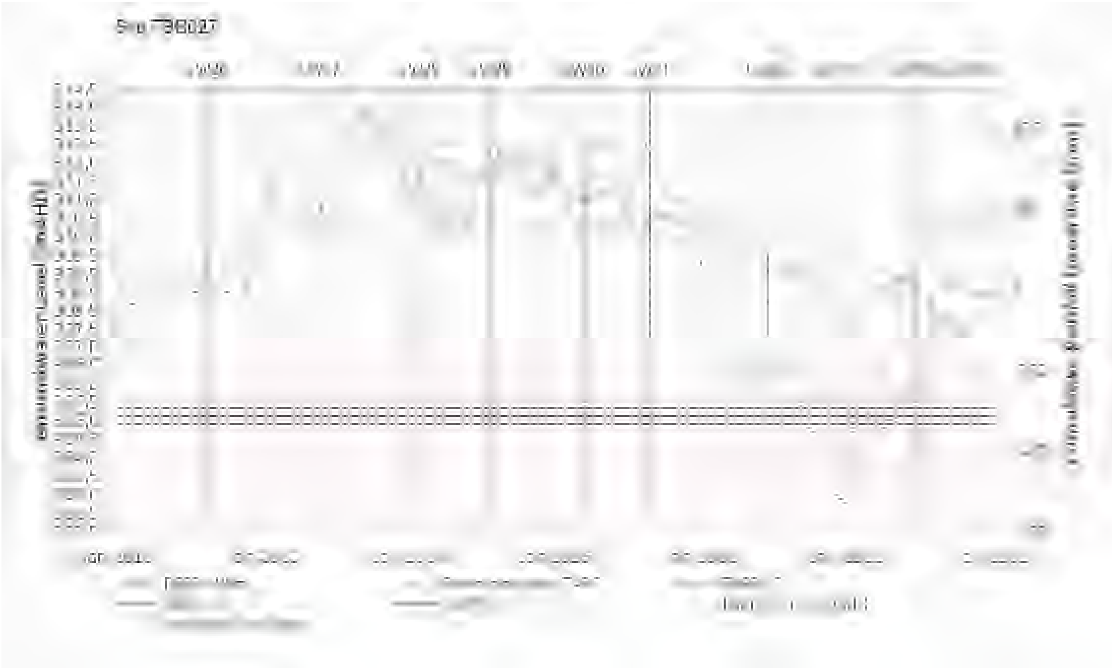


Figure G-9 TBC027-BGSS 198 m Hydrograph and Proposed Trigger Levels

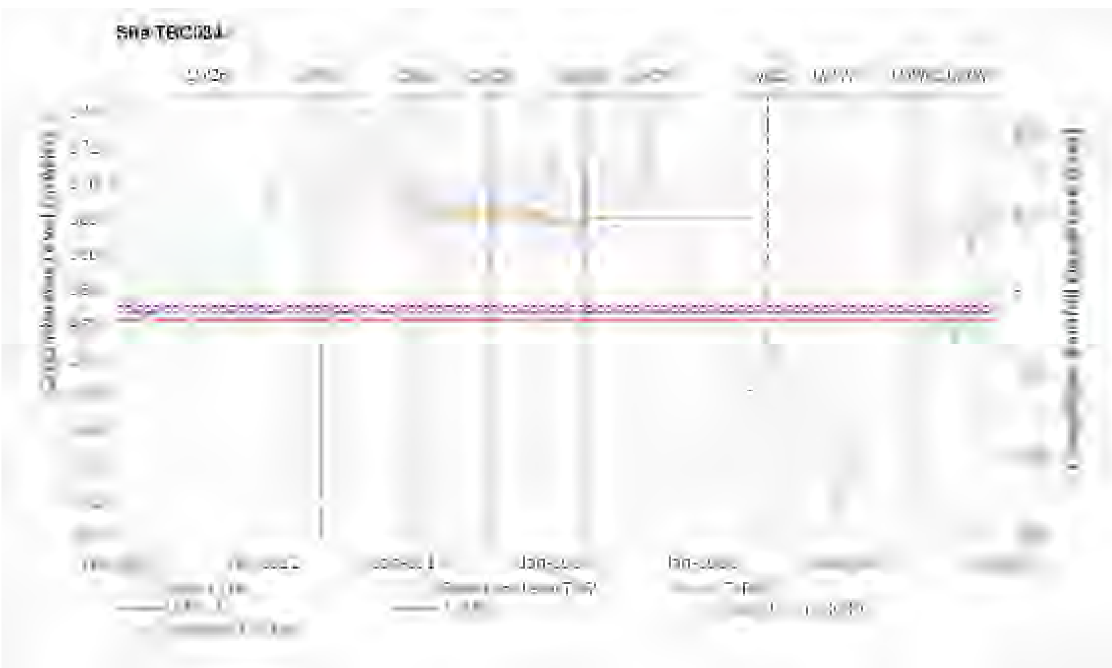


Figure G-10 TBC034-HBSS 65 m Hydrographs and Proposed Trigger Levels

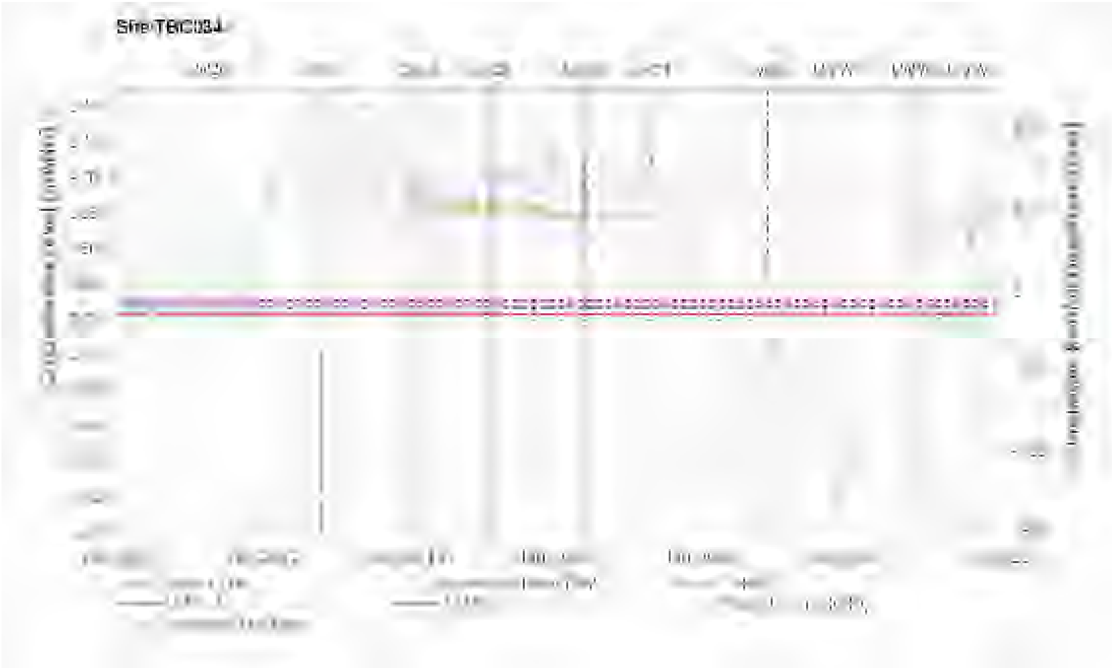


Figure G-11 TBC034-HBSS 113 m Hydrographs and Proposed Trigger Levels

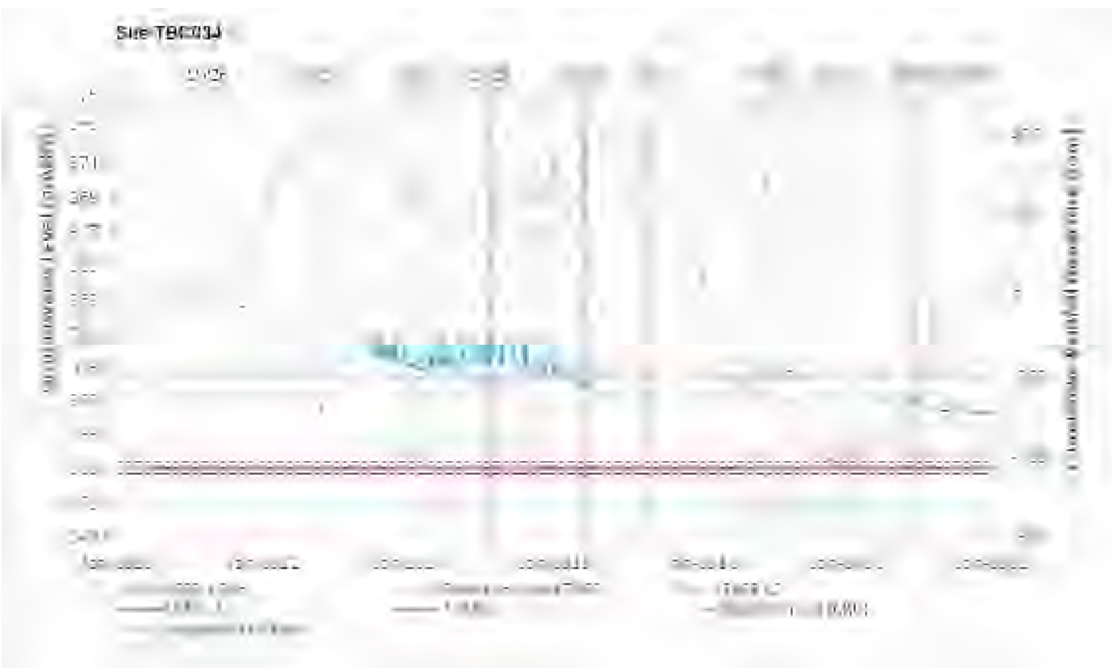


Figure G-12 TBC034-HBSS 161 m Hydrographs and Proposed Trigger Levels

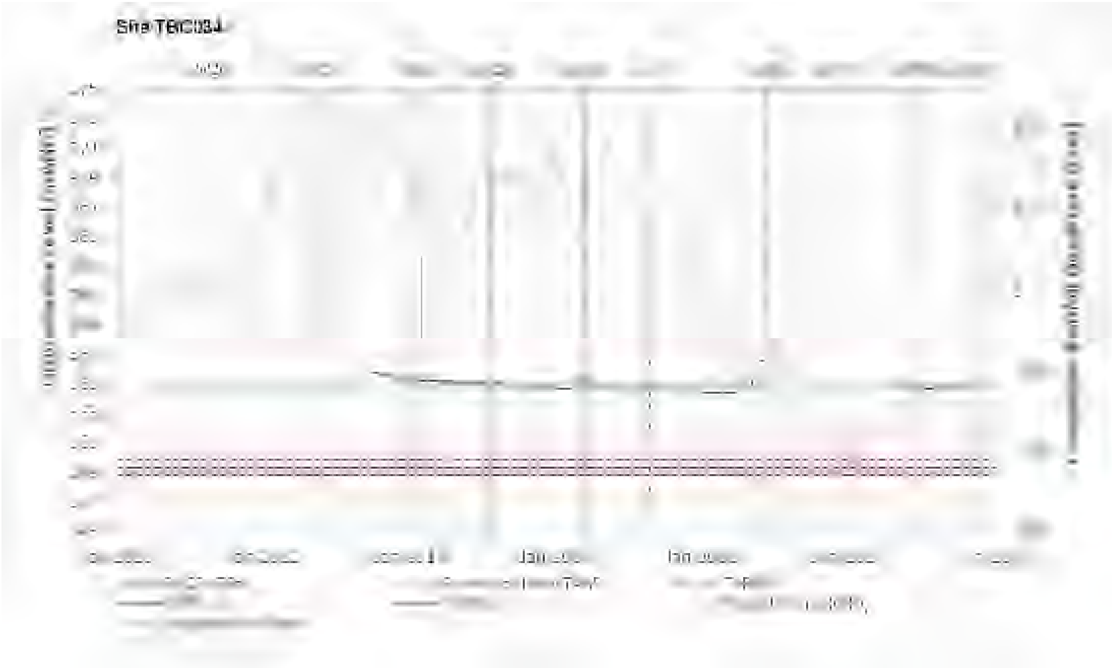


Figure G-13 TBC034-BHCS 176 m Hydrographs and Proposed Trigger Levels

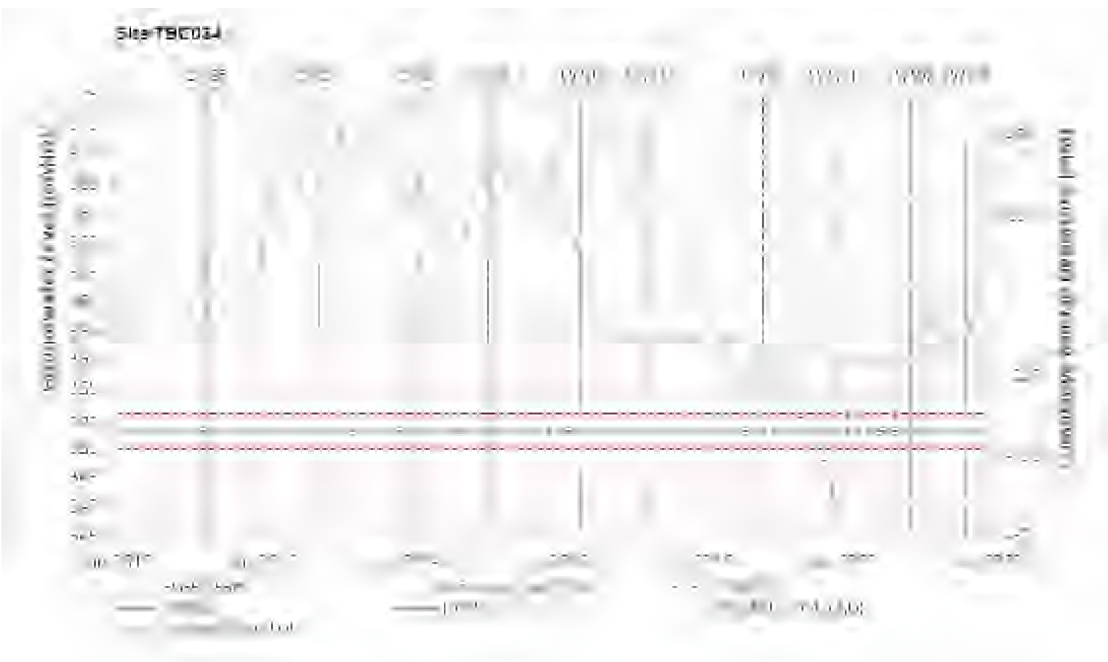


Figure G-14 TBC034-BGSS 196 m Hydrographs and Proposed Trigger Levels

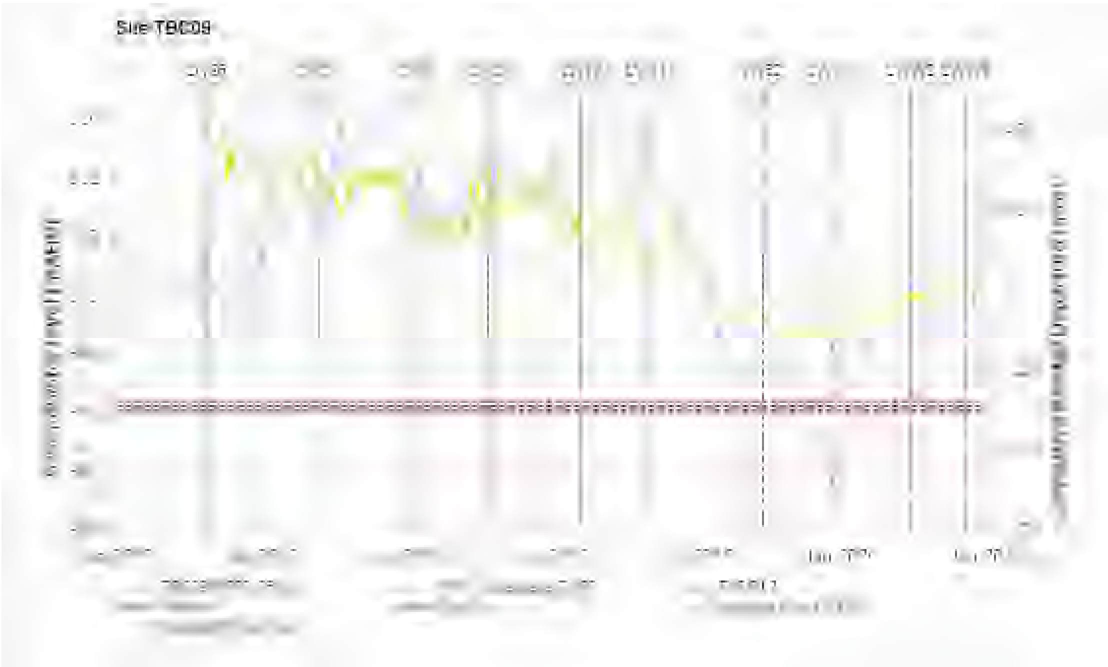


Figure G-15 TBC09-HBSS-75 m Hydrographs and Proposed Trigger Levels

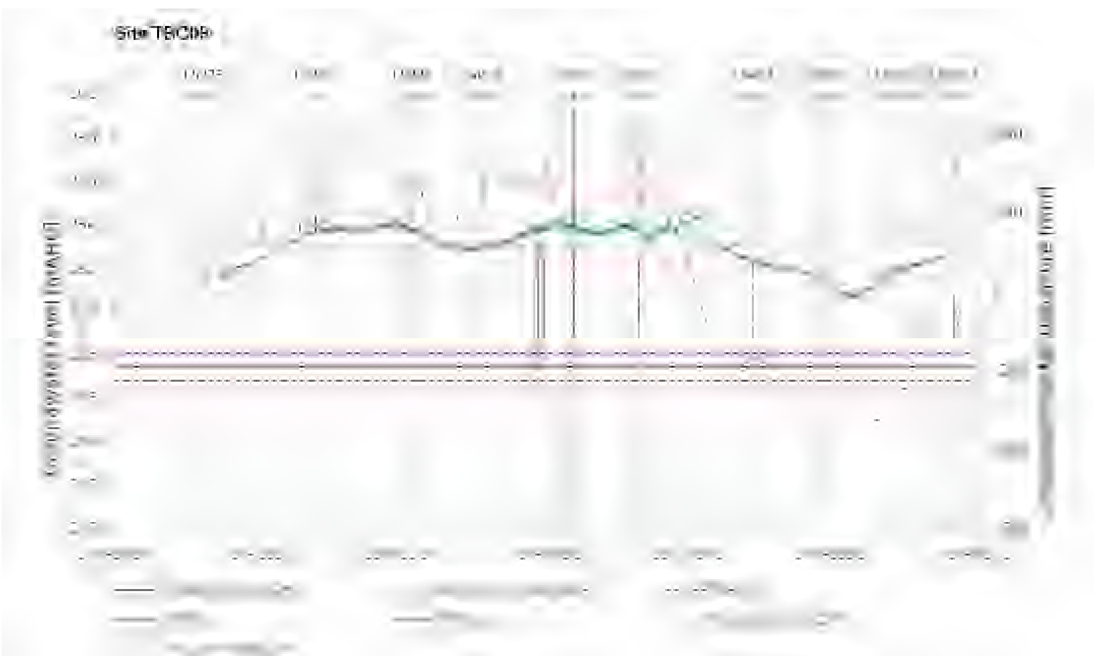


Figure G-16 TBC09-BHCS-182 m Hydrographs and Proposed Trigger Levels

FigureG-17 TBC09-BGSS-192 m Hydrographs and Proposed Trigger Levels

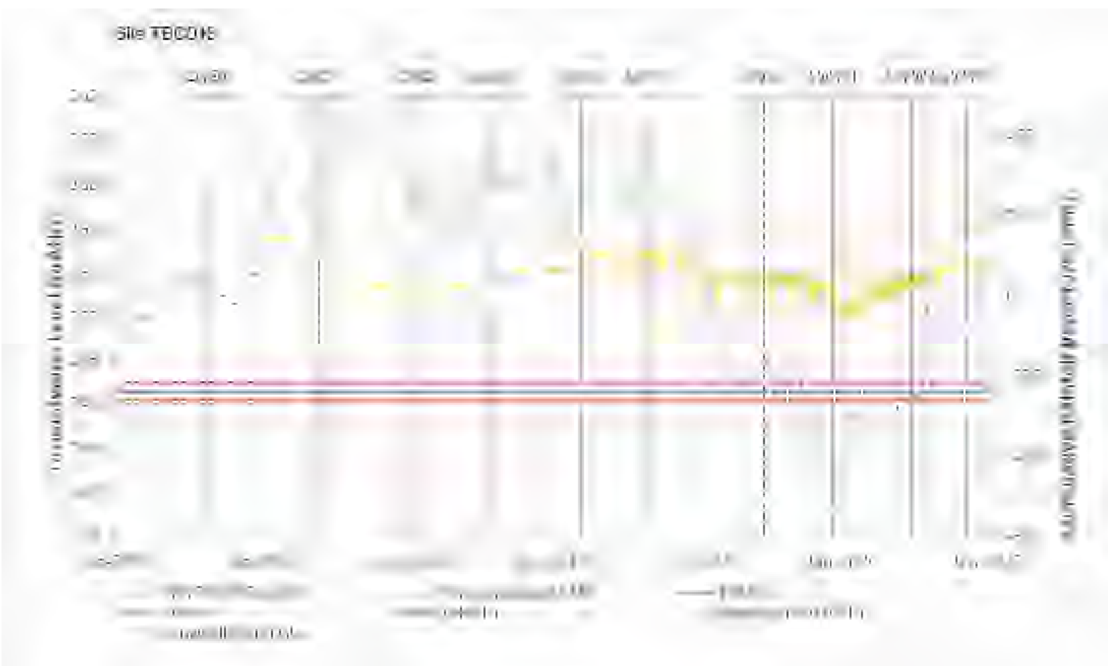


Figure G-18 TBC018 - WWFM/HBSS-117 m Hydrographs and Proposed Trigger Levels

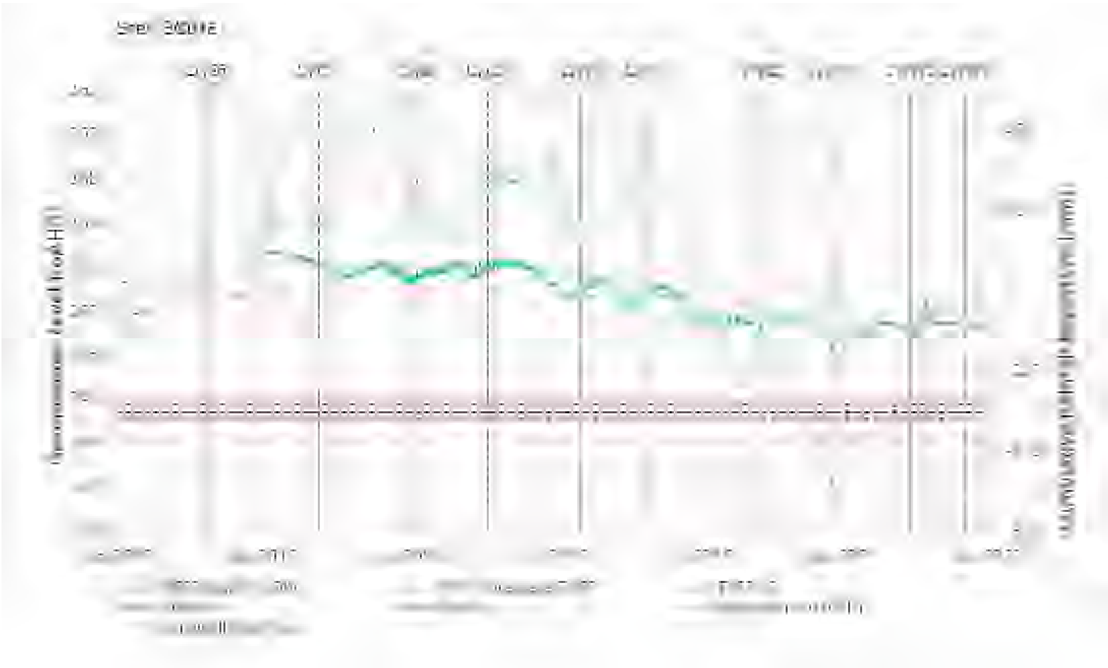


Figure G-19 TBC018 - HBSS (lower)-164 m Hydrographs and Proposed Trigger Levels

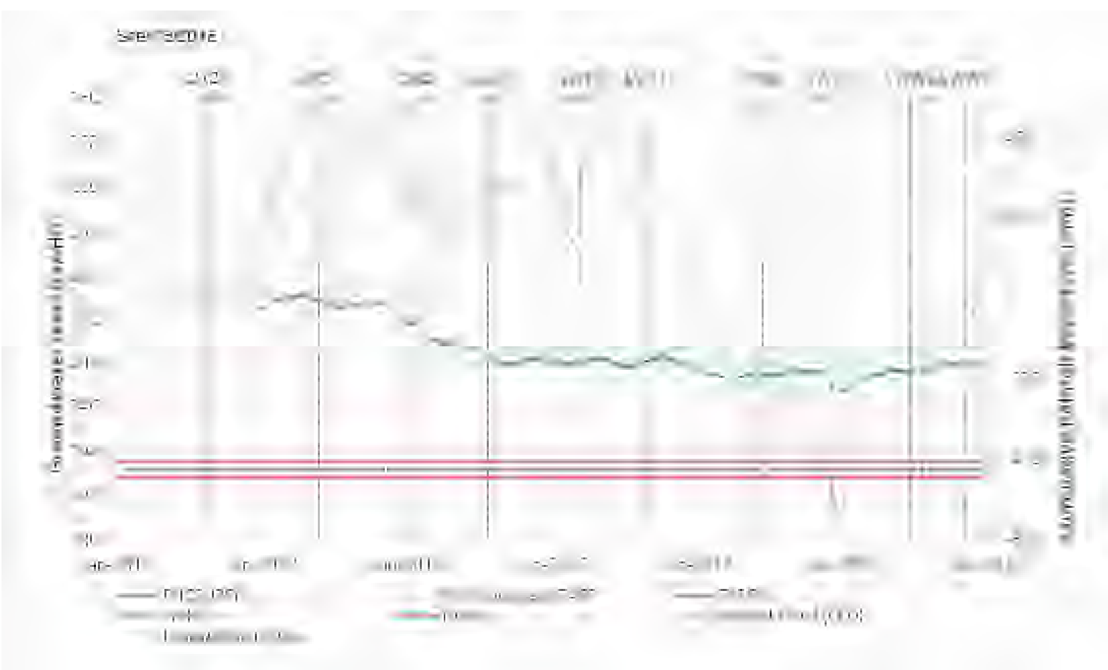


Figure G-20 TBC018 - BHCS-179 m Hydrographs and Proposed Trigger Levels

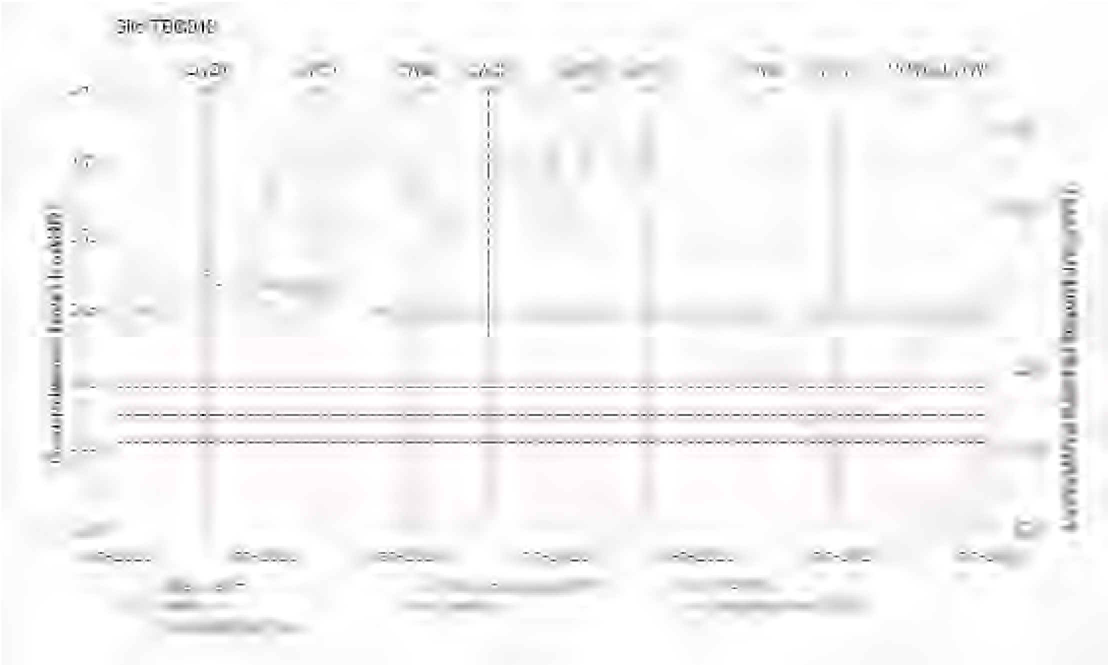


Figure G-21 TBC018 - BGSS-198 m Hydrographs and Proposed Trigger Levels

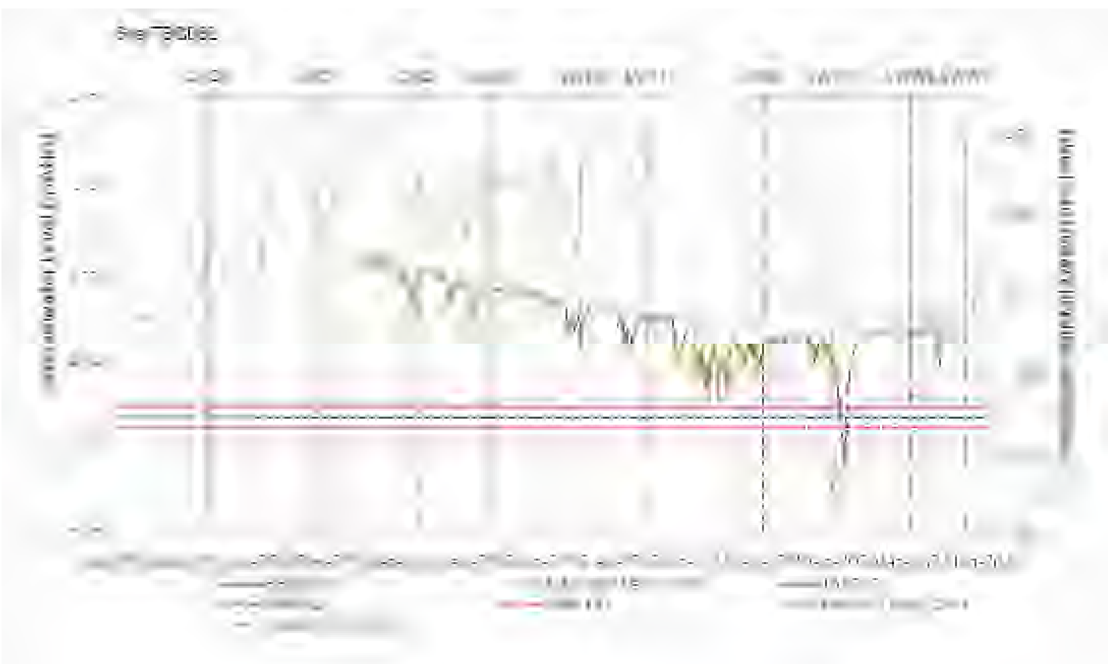


Figure G-22 TBC032 - HBSS-95 m Hydrographs and Proposed Trigger Levels

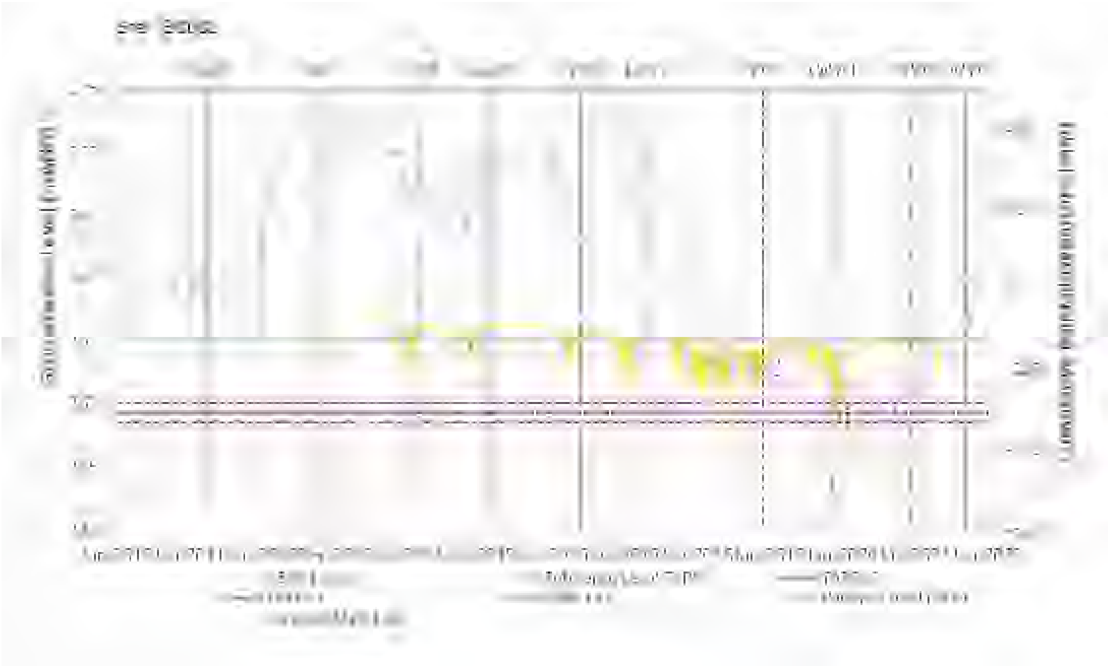


Figure G-23 TBC032 - HBSS-131 m Hydrographs and Proposed Trigger Levels

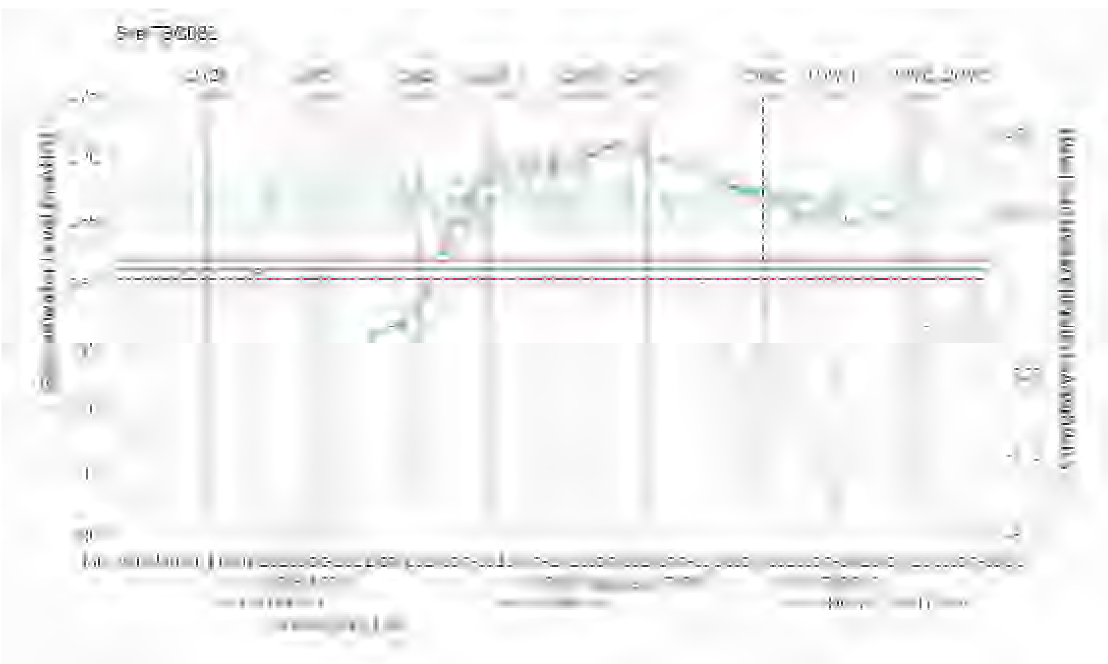


Figure G-24 TBC032 - HBSS-168 m Hydrographs and Proposed Trigger Levels

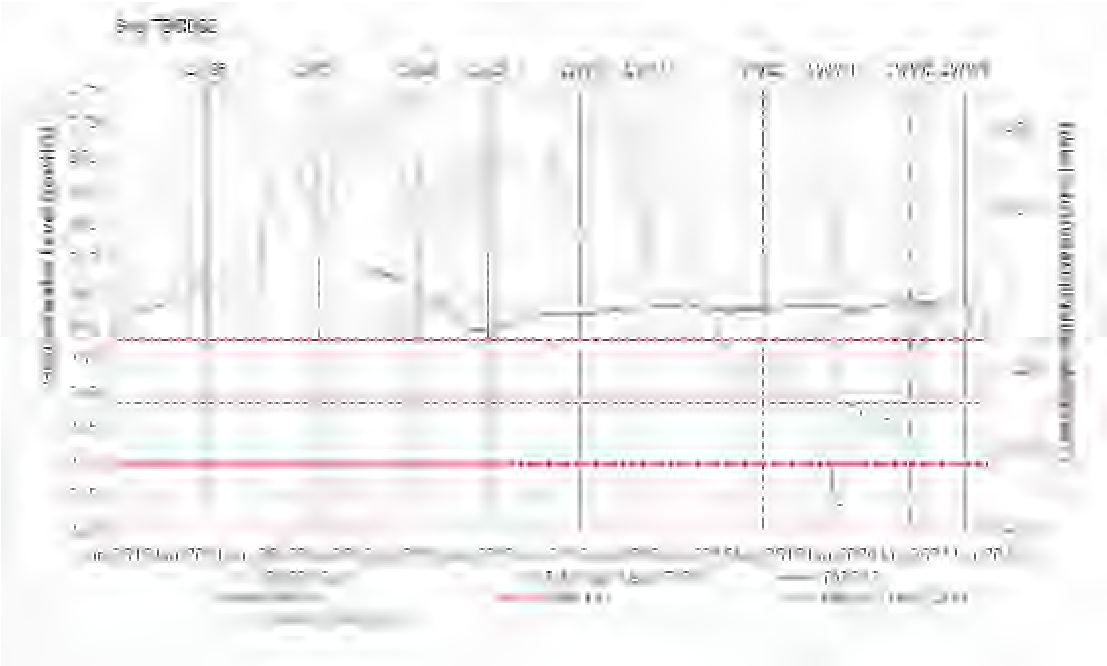


Figure G-25 TBC032 - BHCS-181 m Hydrographs and Proposed Trigger Levels

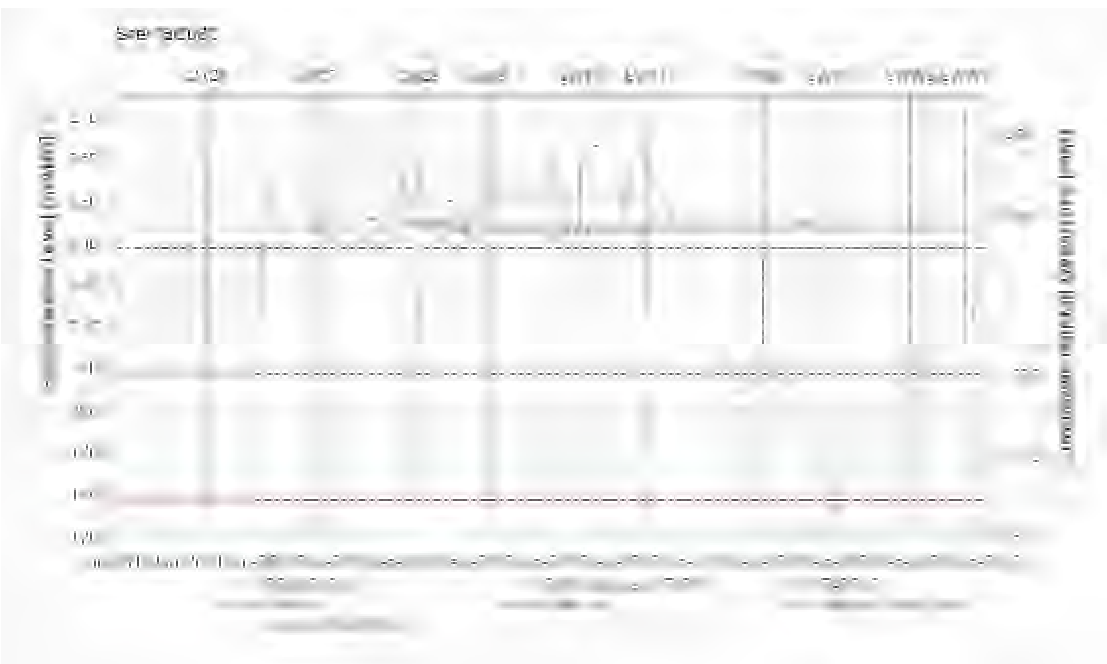


Figure G-26 TBC032 - BGSS-200 m Hydrographs and Proposed Trigger Levels

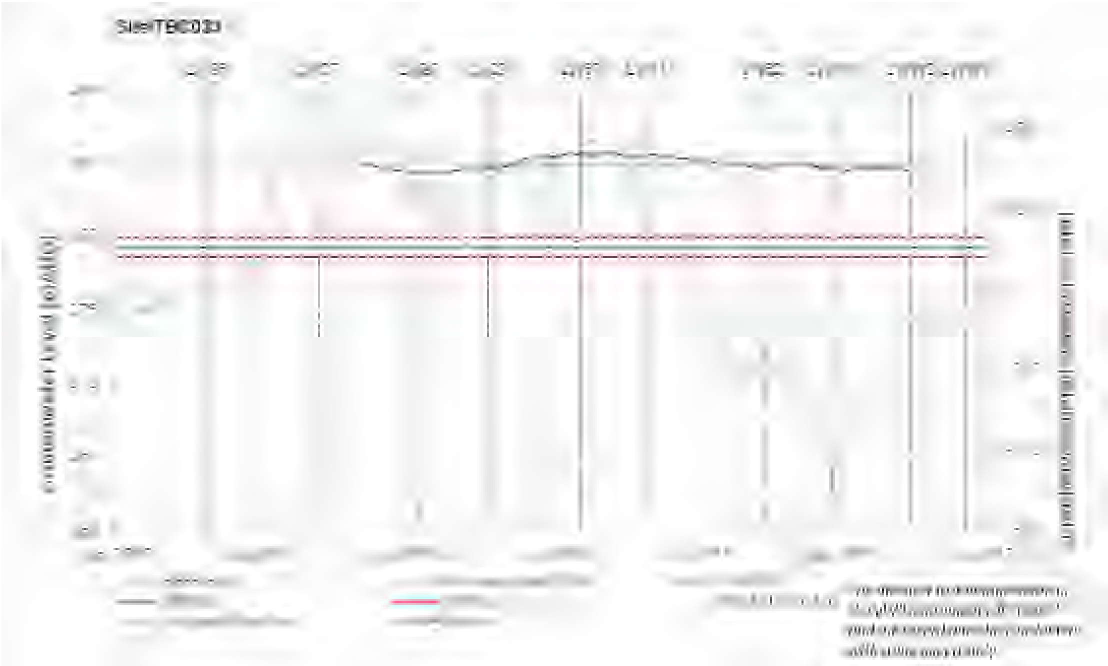


Figure G-27 TBC033 - HBSS-65 m Hydrographs and Proposed Trigger Levels

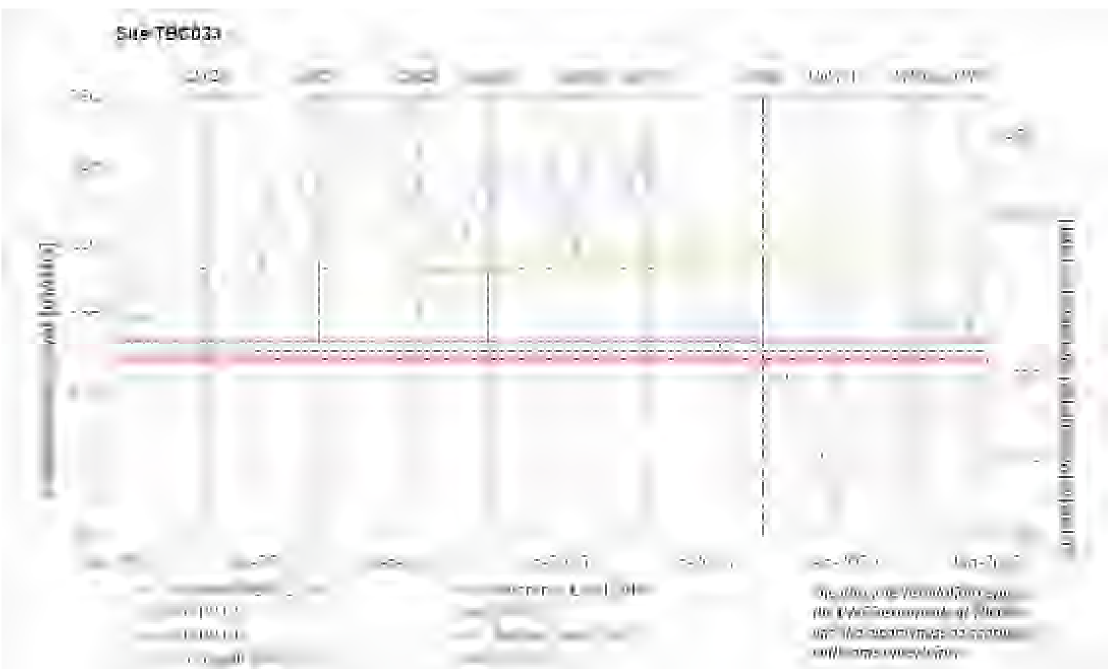


Figure G-28 TBC033 - WWFM/HBSS-113 m Hydrographs and Proposed Trigger Levels

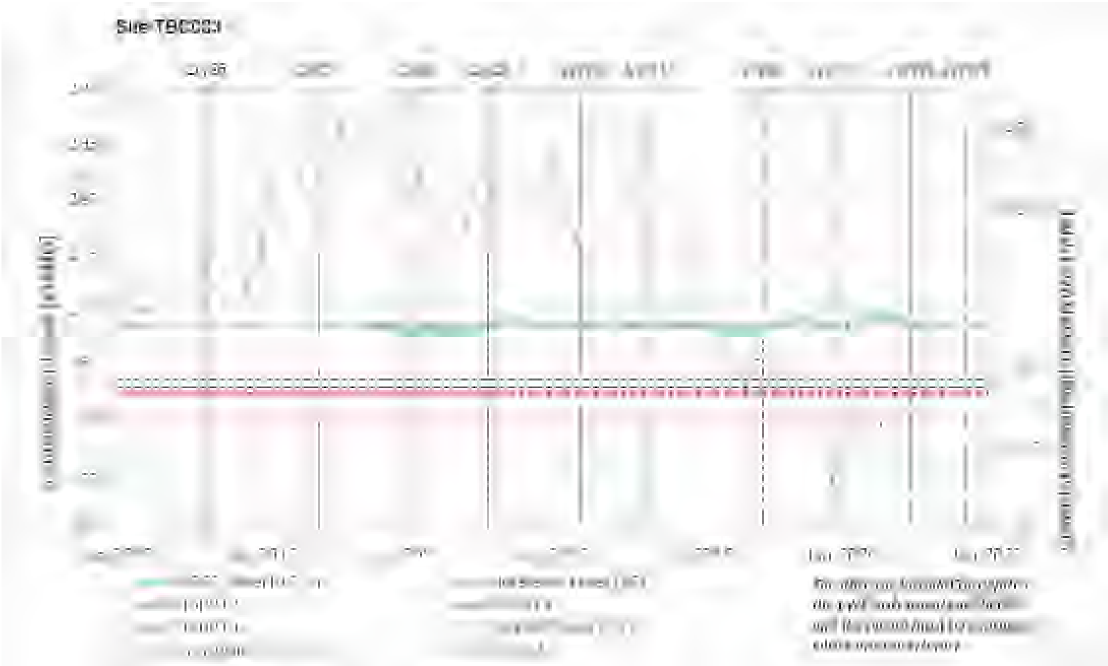


Figure G-29 TBC033 - HBSS (lower)-161 m Hydrographs and Proposed Trigger Levels

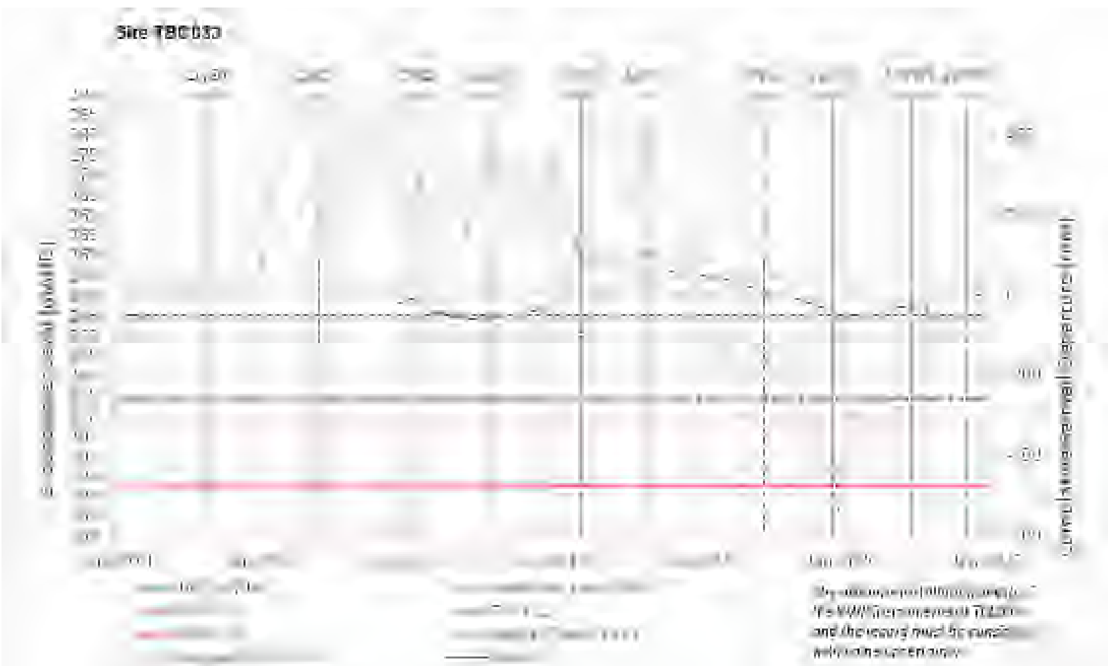


Figure G-30 TBC033 - BHCS-173 m Hydrographs and Proposed Trigger Levels

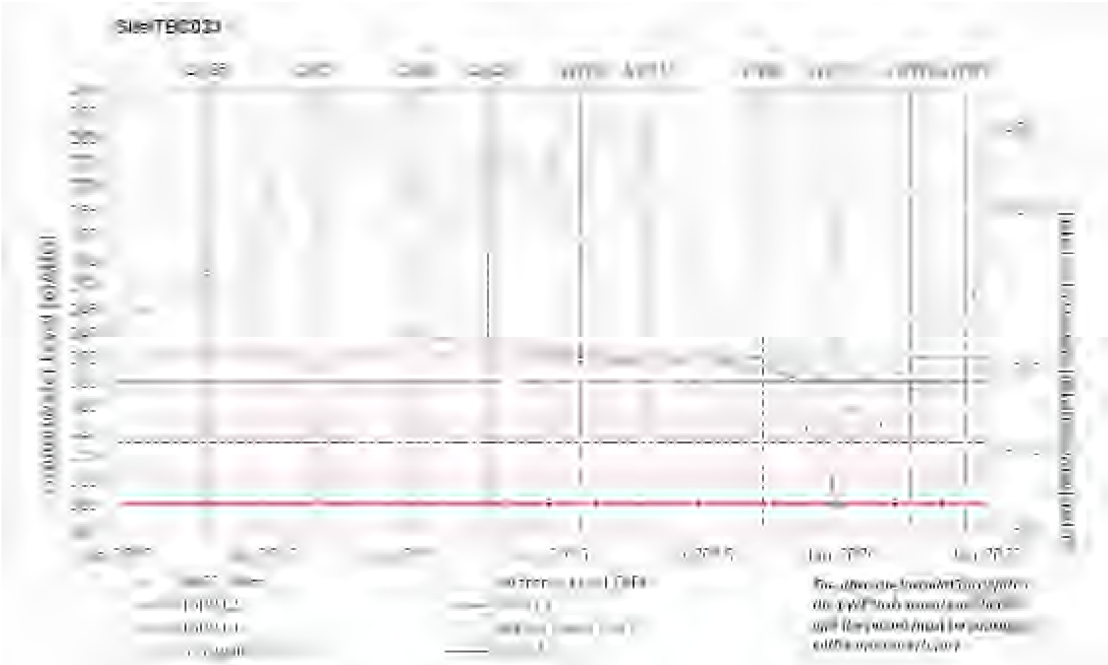
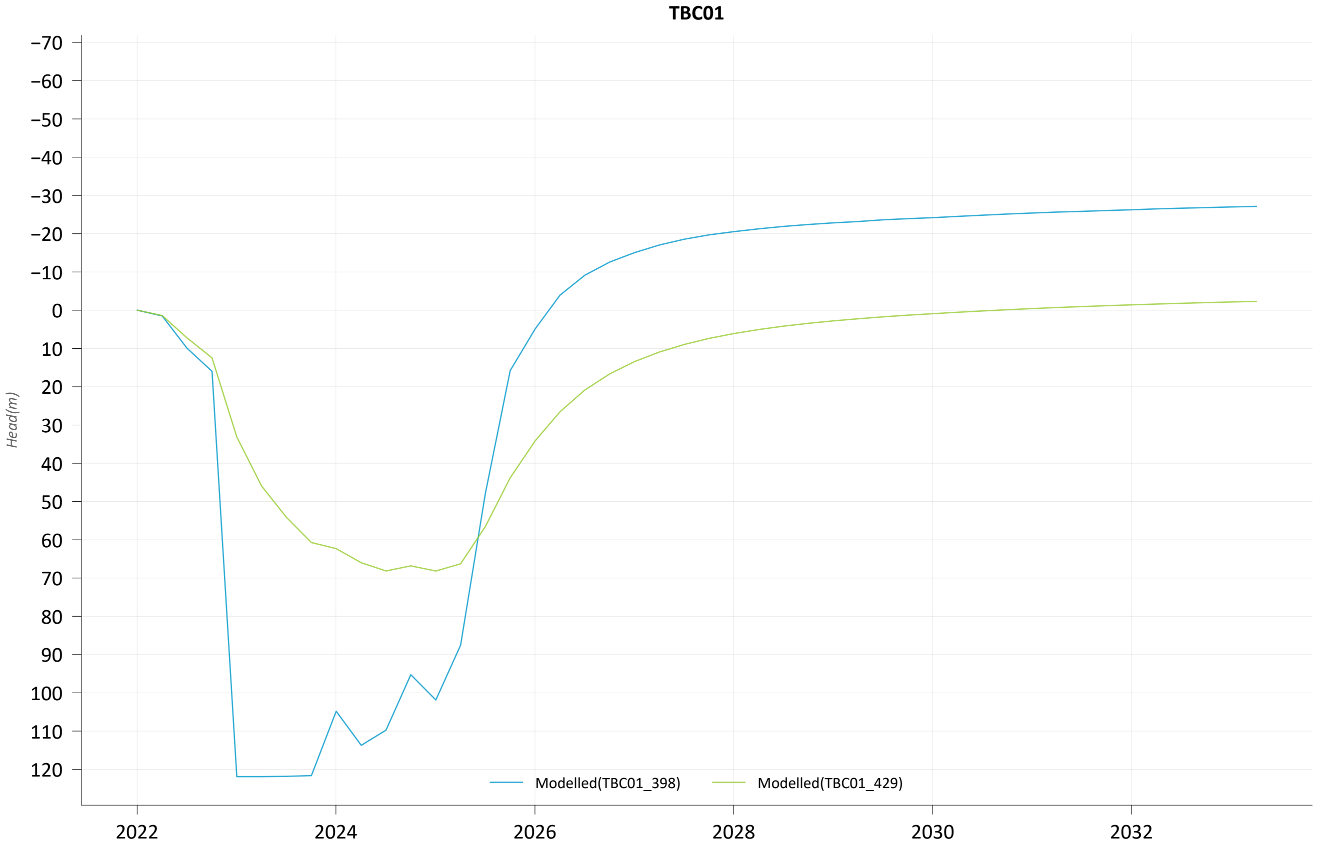
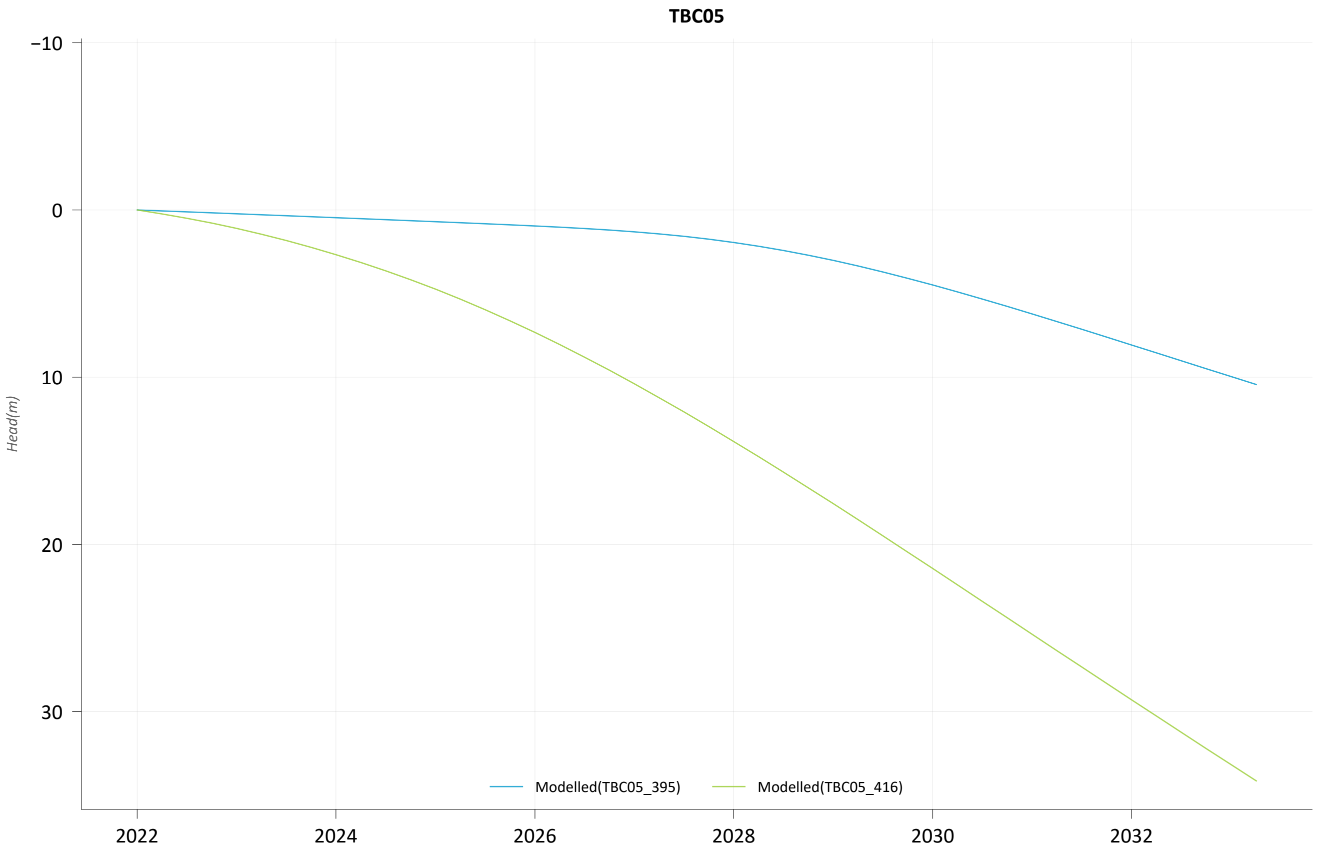


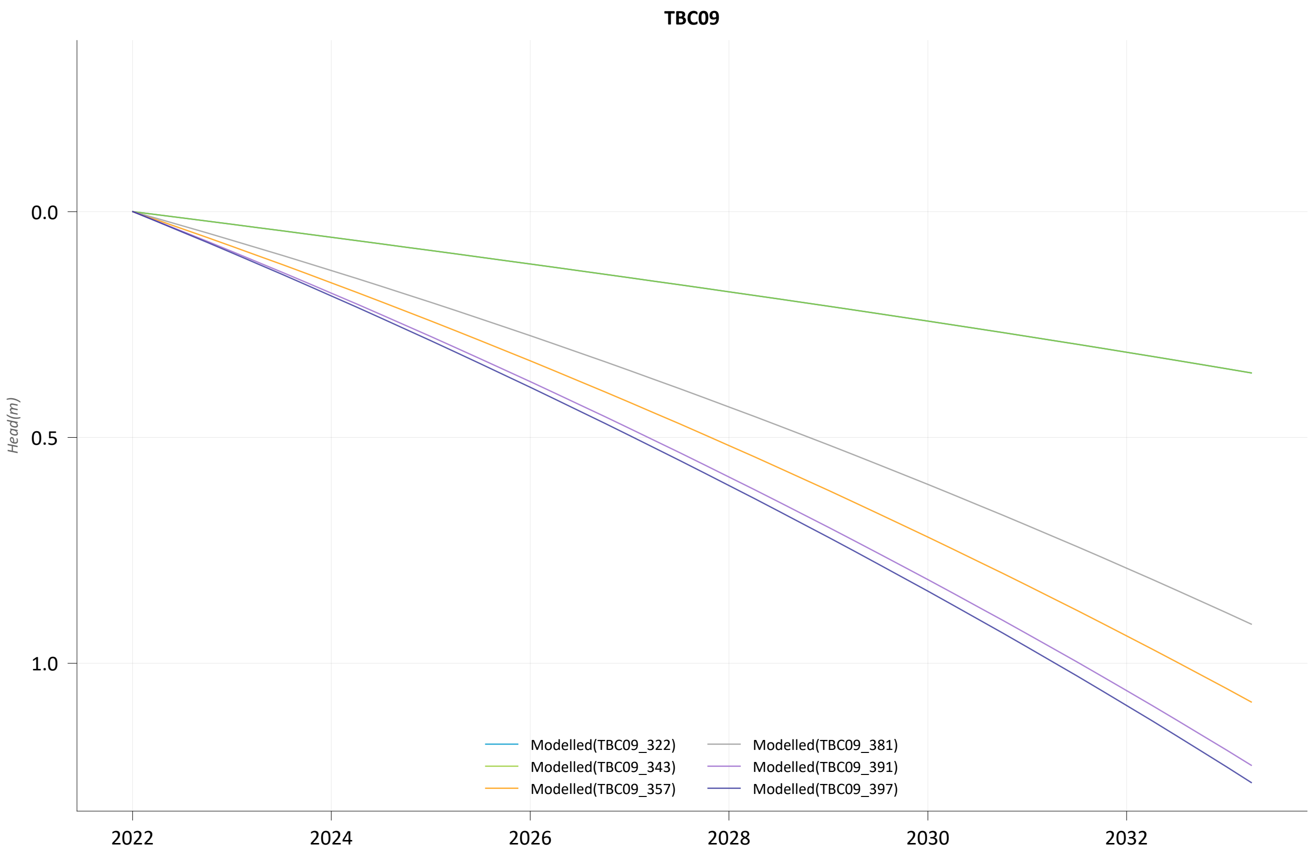
Figure G-31 TBC033 - BGSS-190 m Hydrographs and Proposed Trigger Levels

APPENDIX H

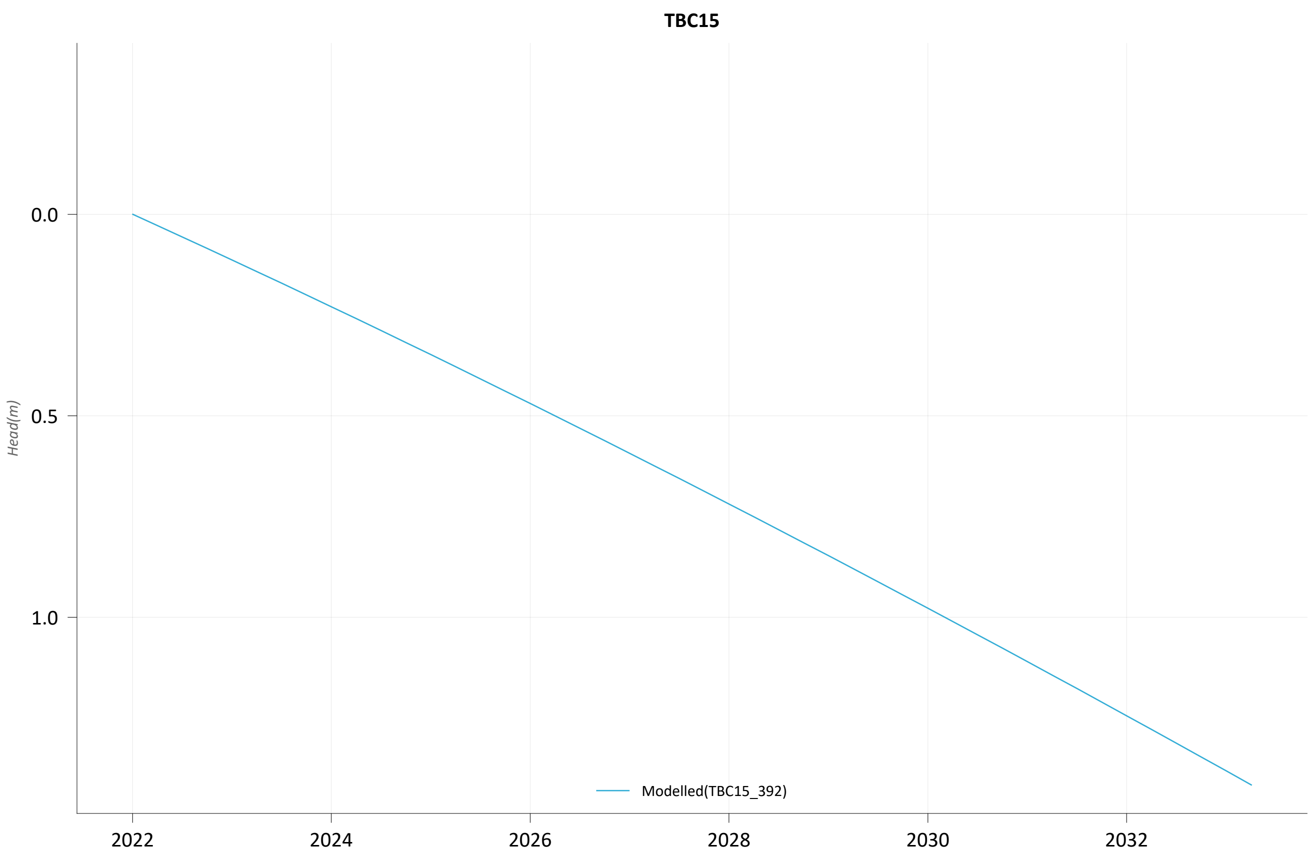
Deep VWP Modelled Predictive Hydrographs


TBC01
Head(m)
−70
−60
−50
−40
−30
−20
−10
0
10
20
30
40
50
60
70
80
90
100
110
120
2022
2024
2026
2028
2030
2032
Modelled(TBC01_398)
Modelled(TBC01_429)

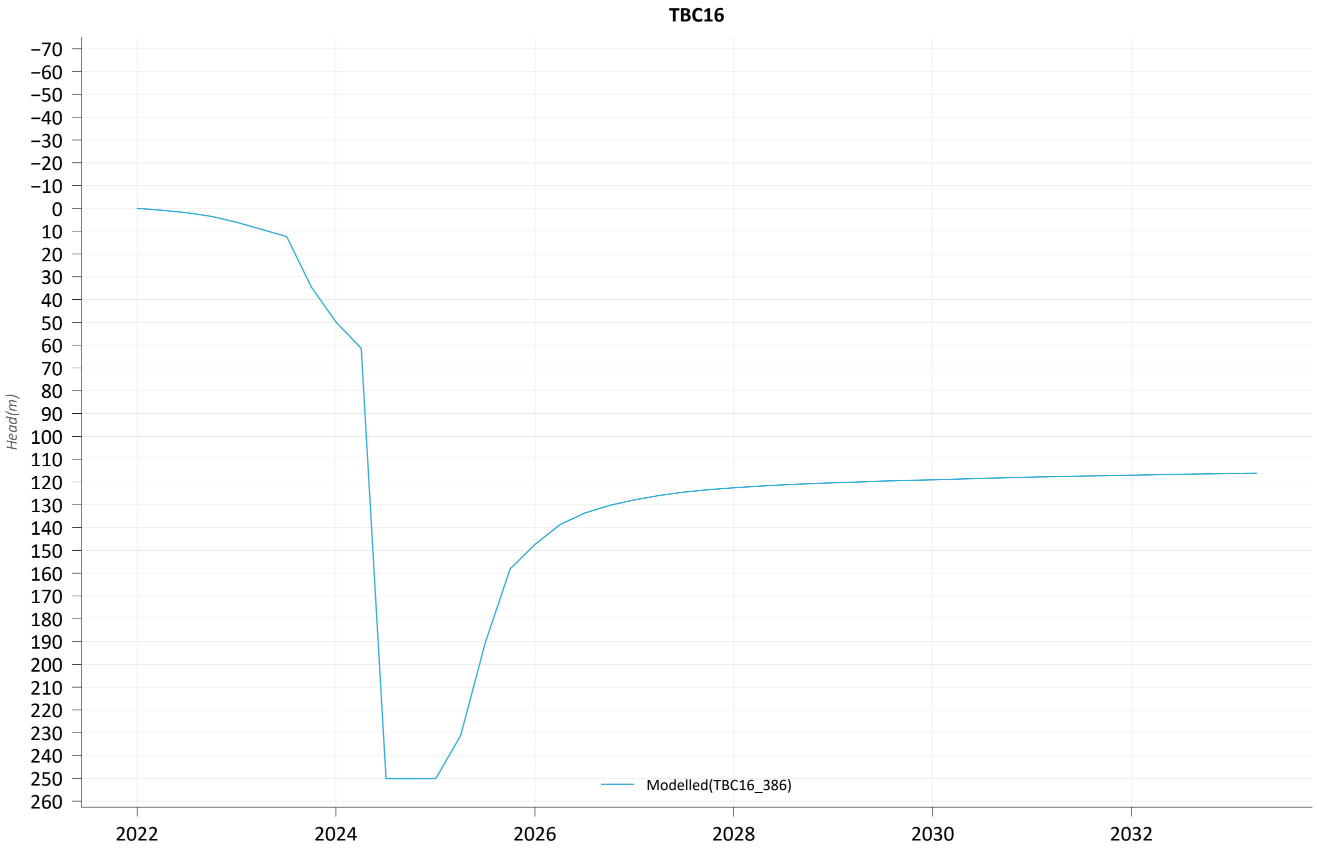

TBC05
Head(m)
−10
0
10
20
30
2022
2024
2026
2028
2030
2032
Modelled(TBC05_395)
Modelled(TBC05_416)



TBC09
Head(m)
0.0
0.5
1.0
2022
2024
2026
2028
2030
2032
Modelled(TBC09_322)
Modelled(TBC09_343)
Modelled(TBC09_357)
Modelled(TBC09_381)
Modelled(TBC09_391)
Modelled(TBC09_397)



TBC15
Head(m)
0.0
0.5
1.0
2022
2024
2026
2028
2030
2032
Modelled(TBC15_392)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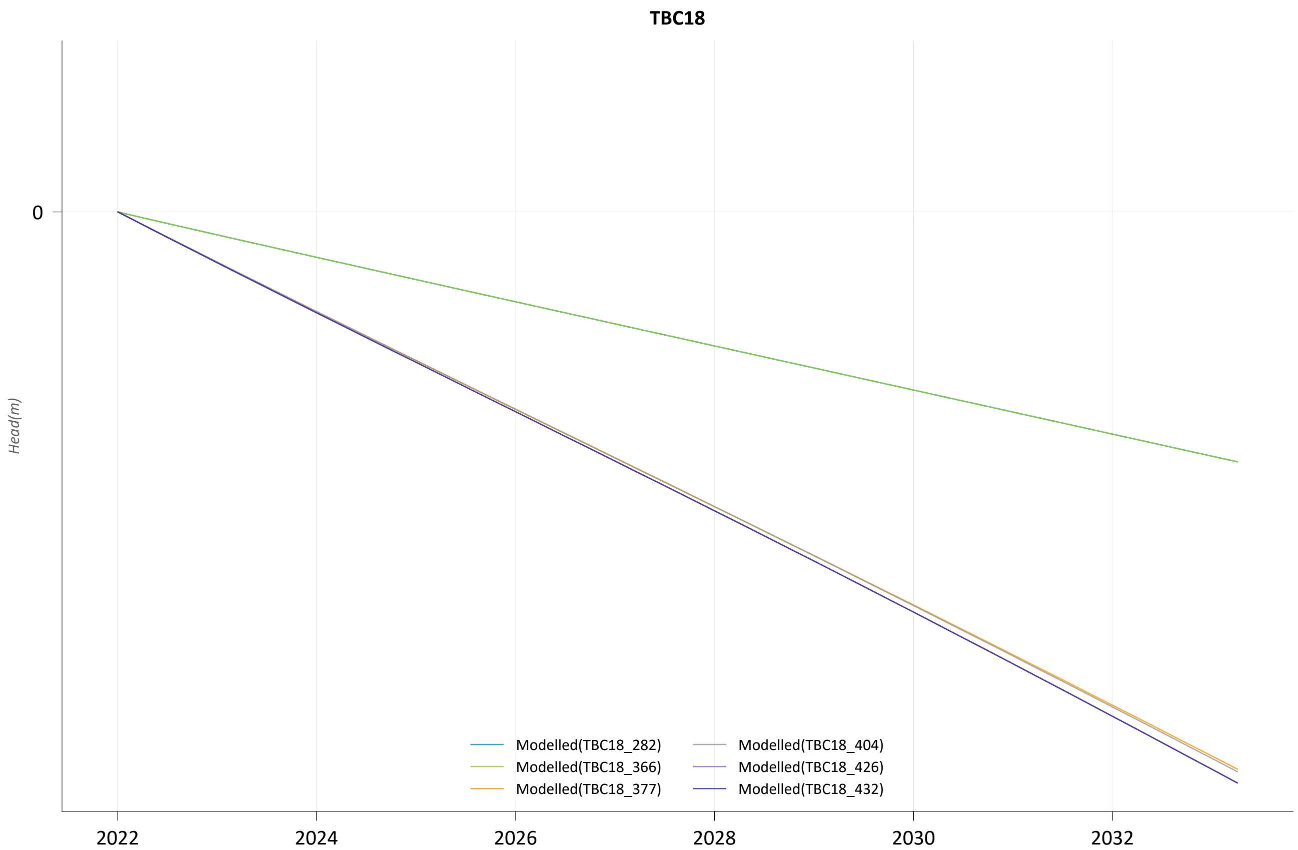
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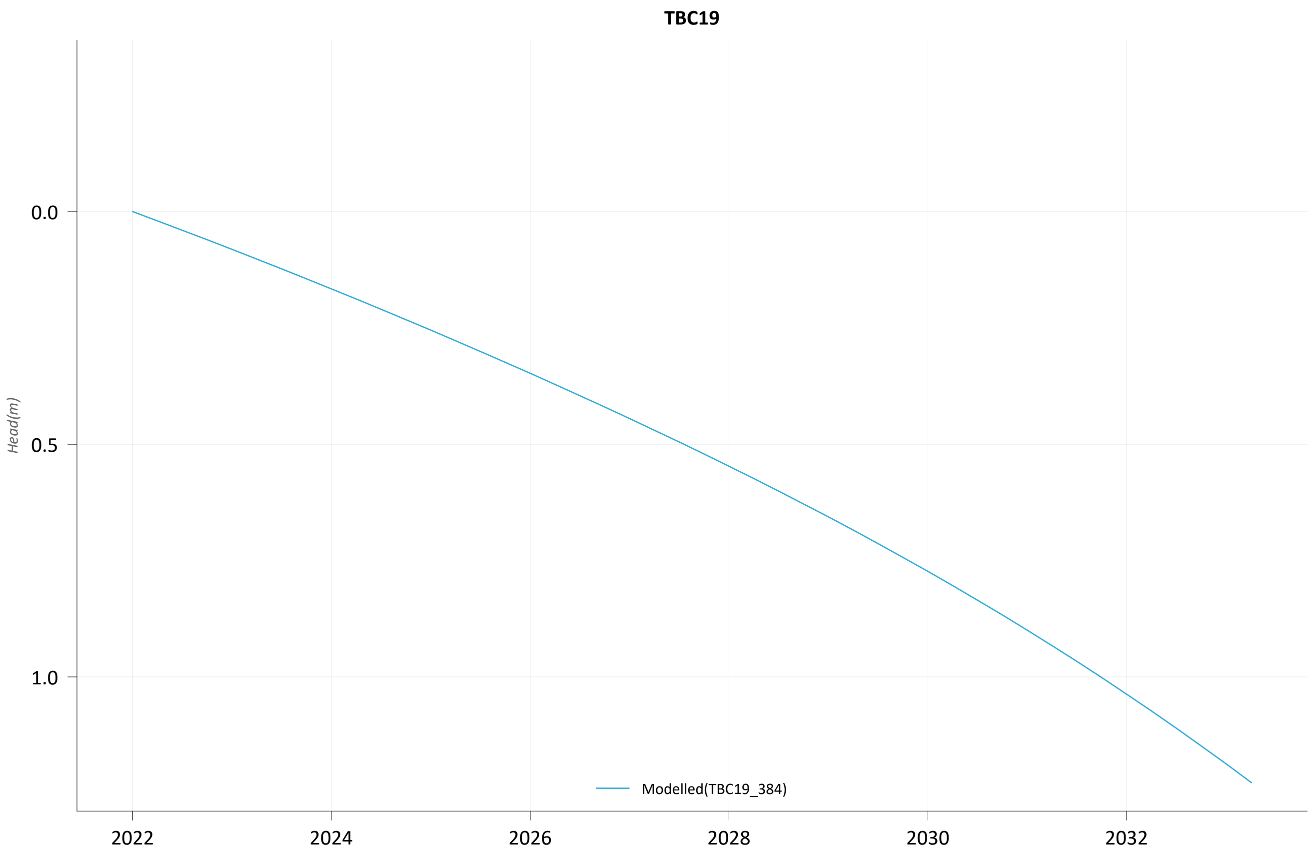
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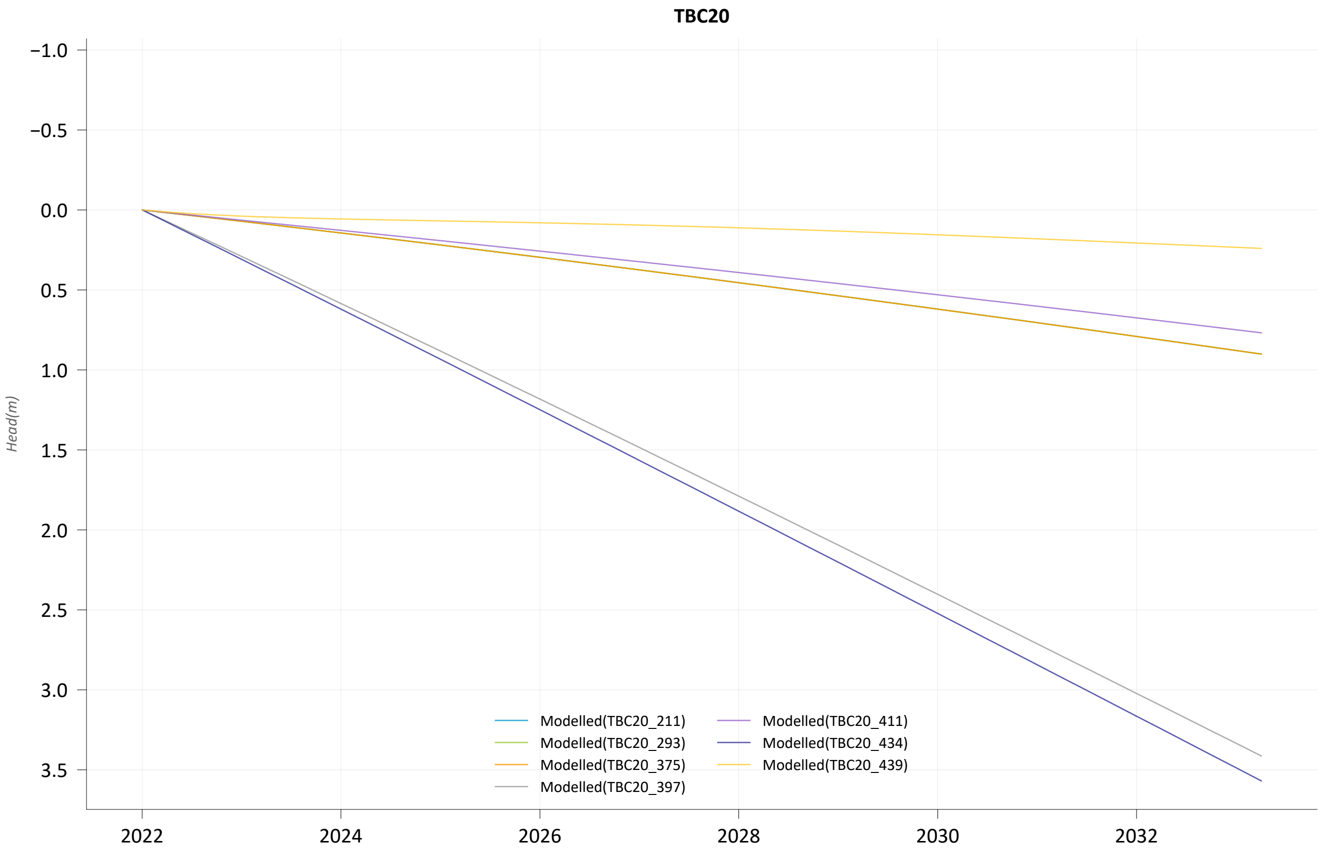
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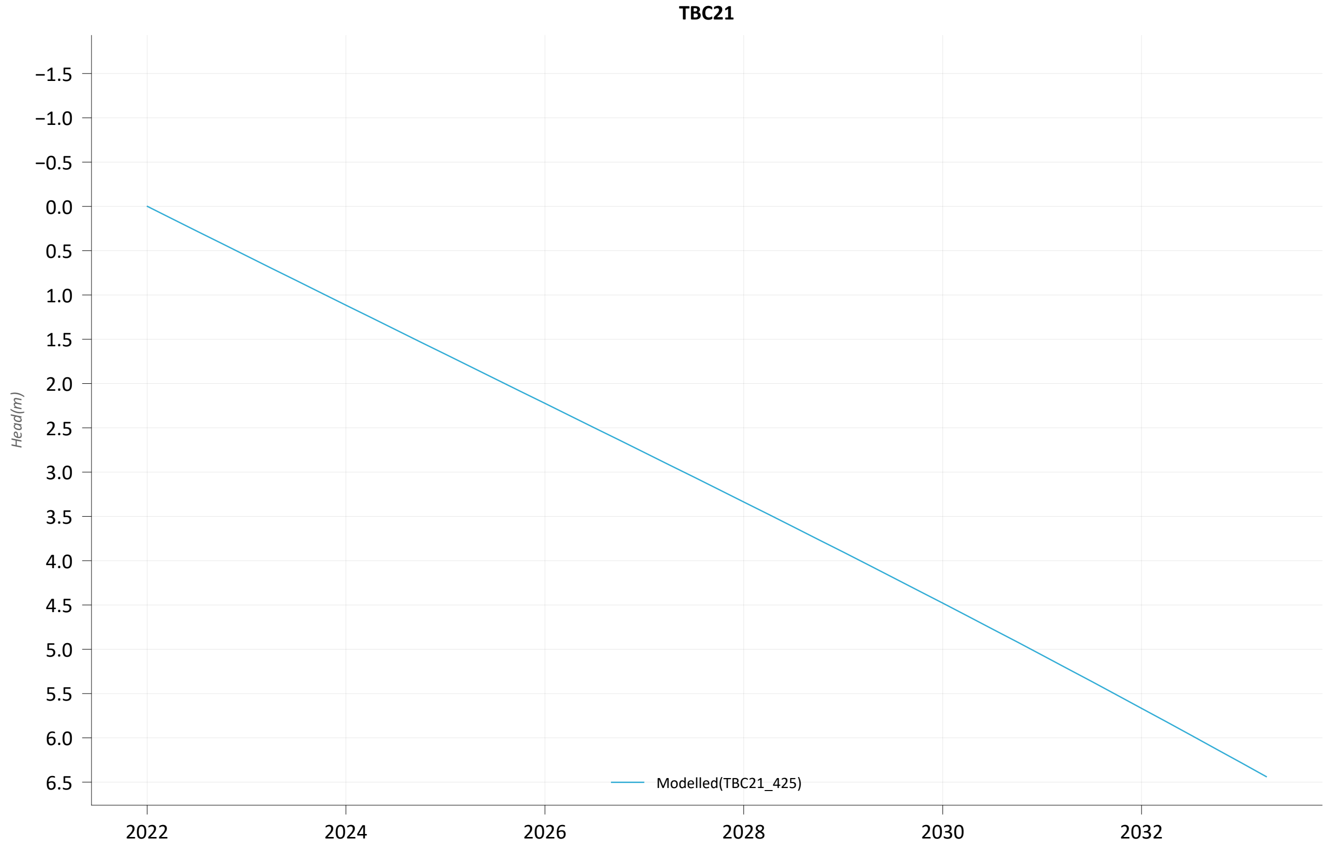
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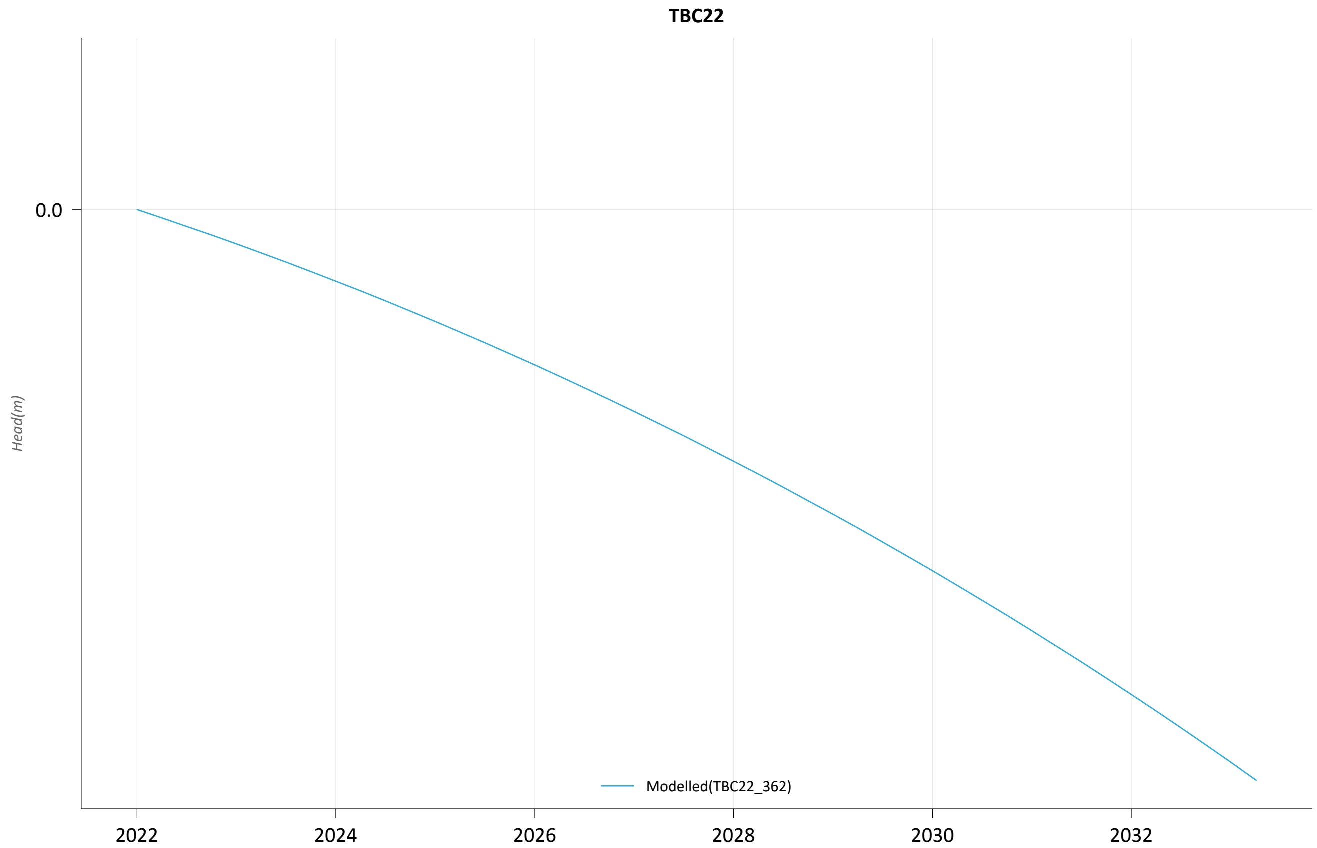
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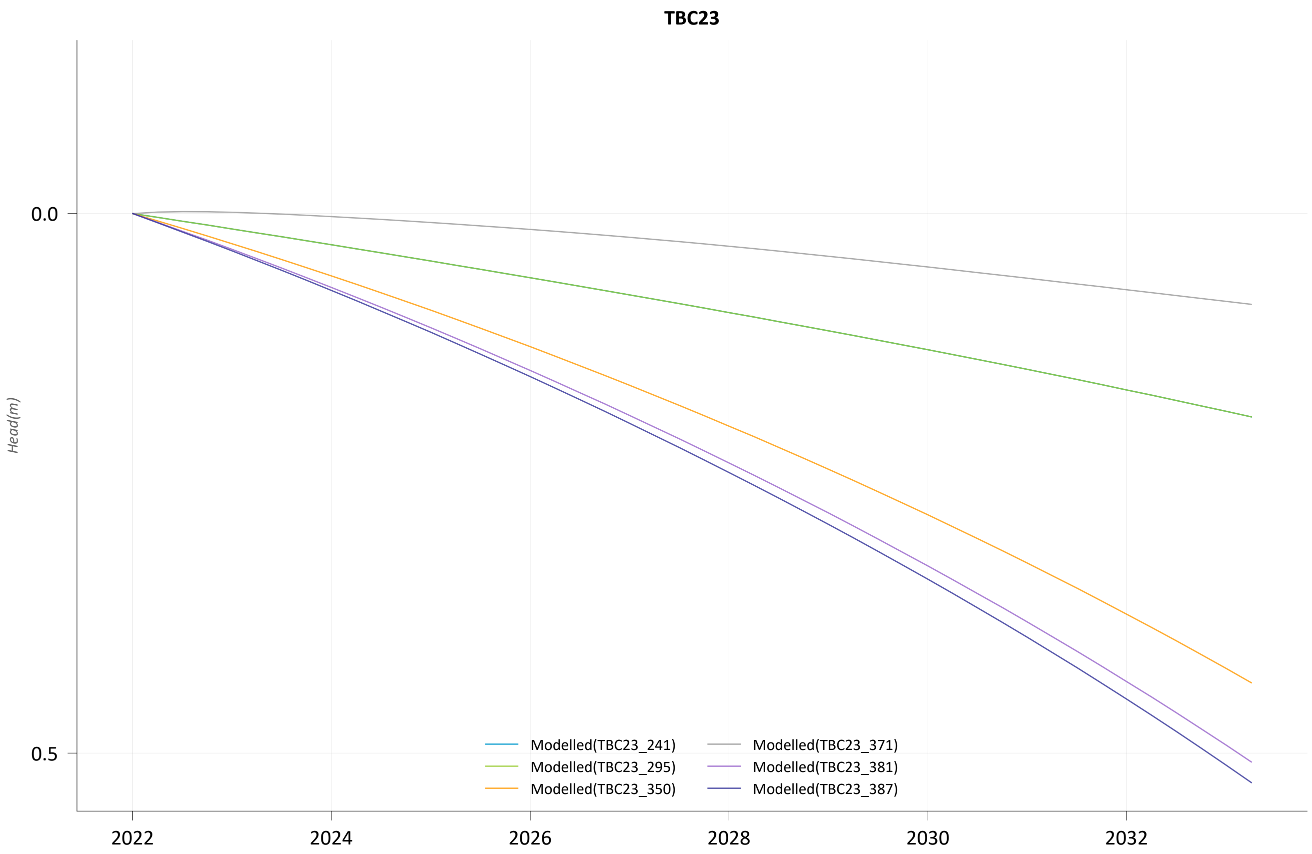
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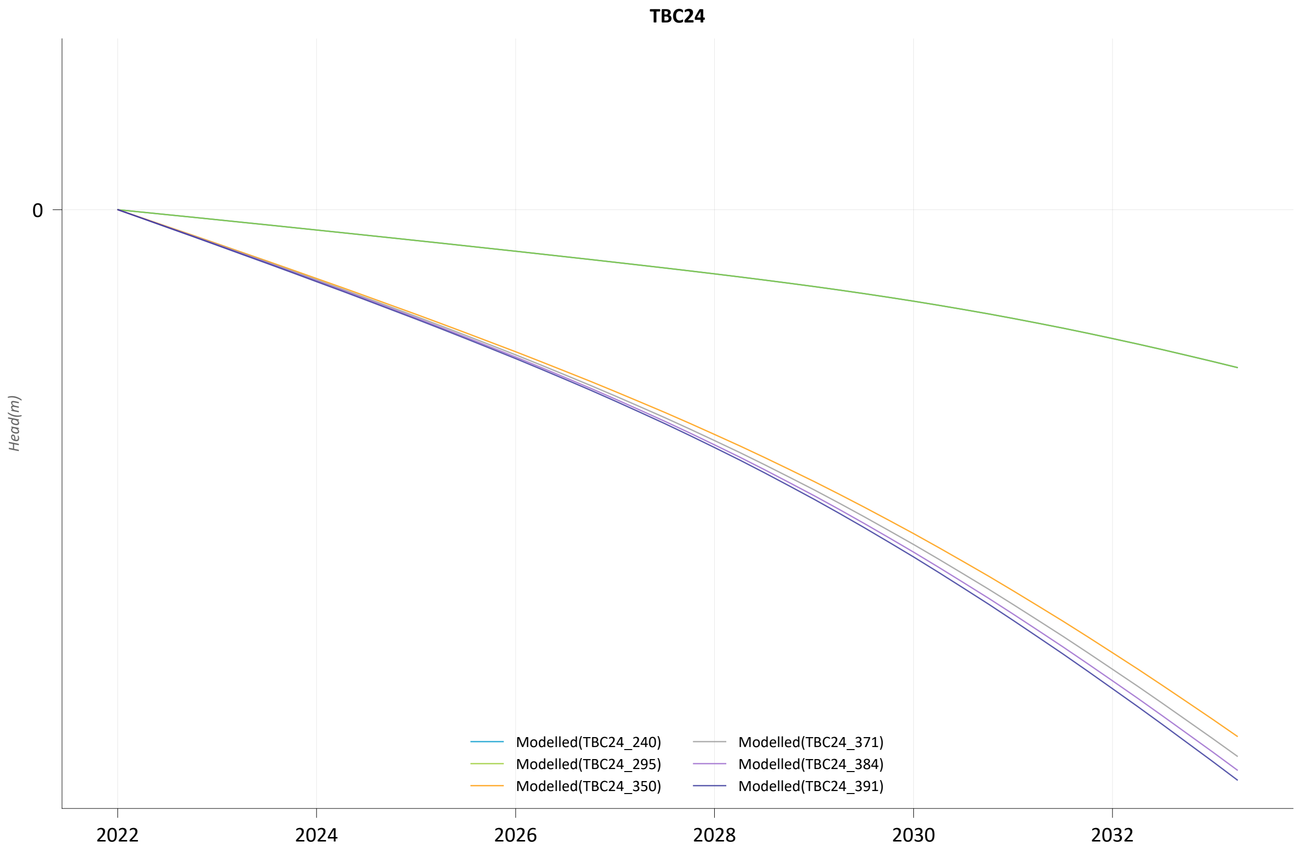
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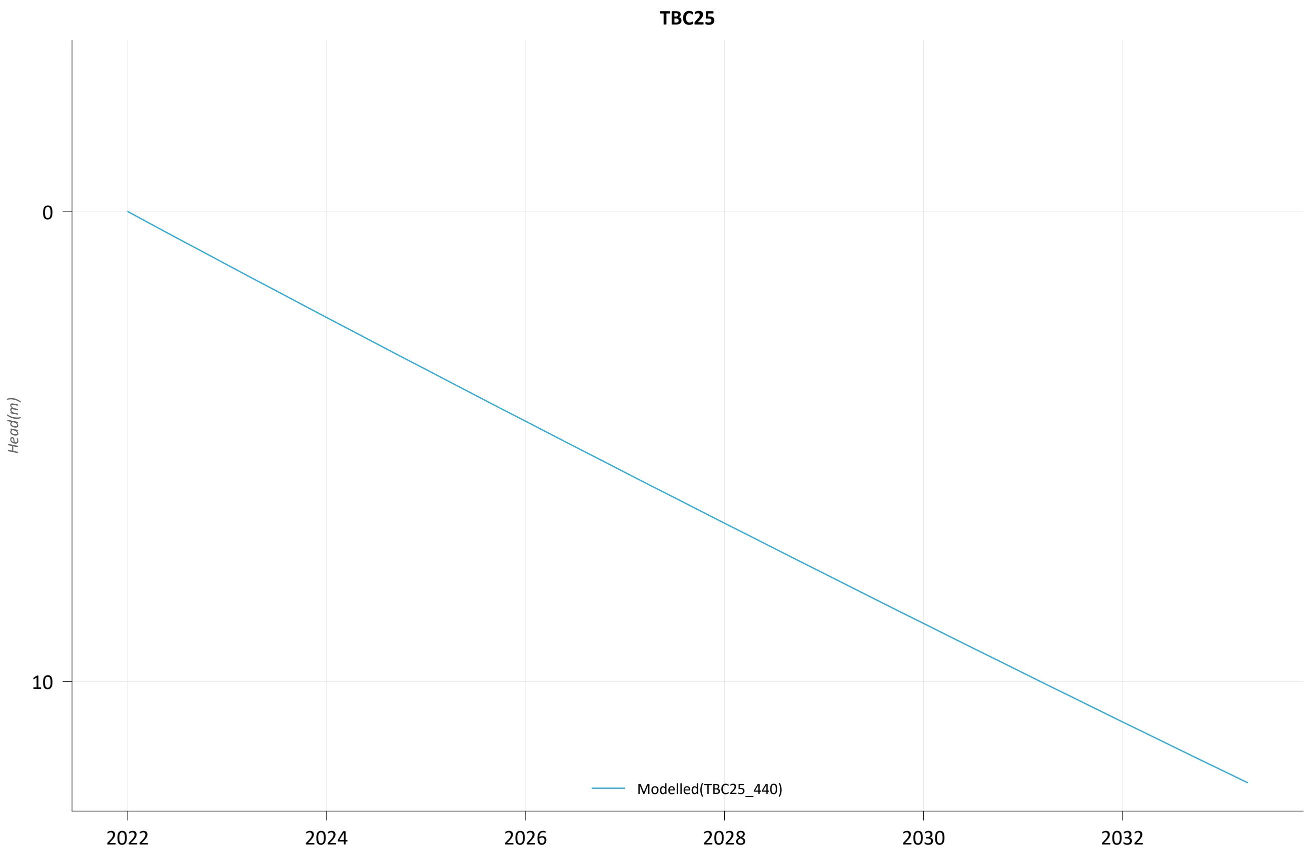
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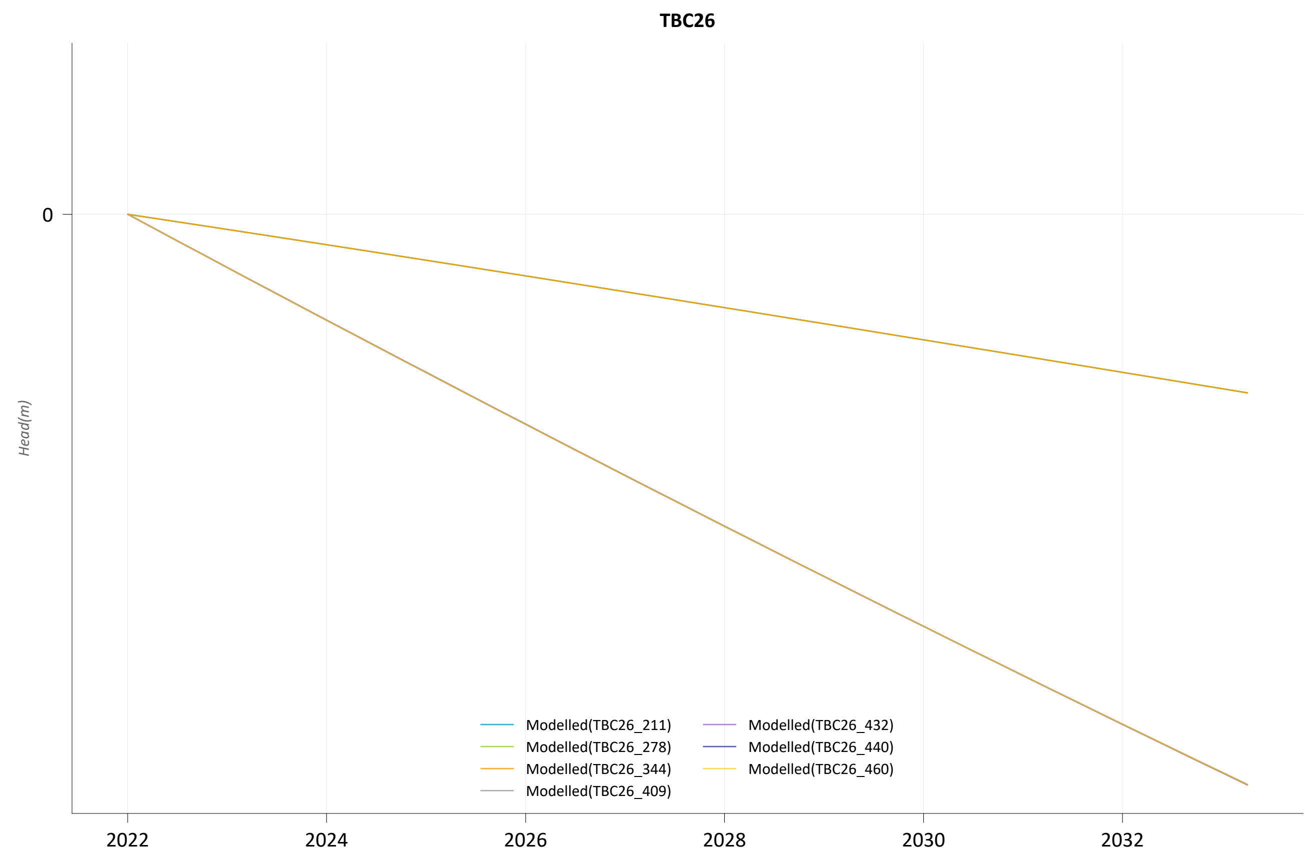
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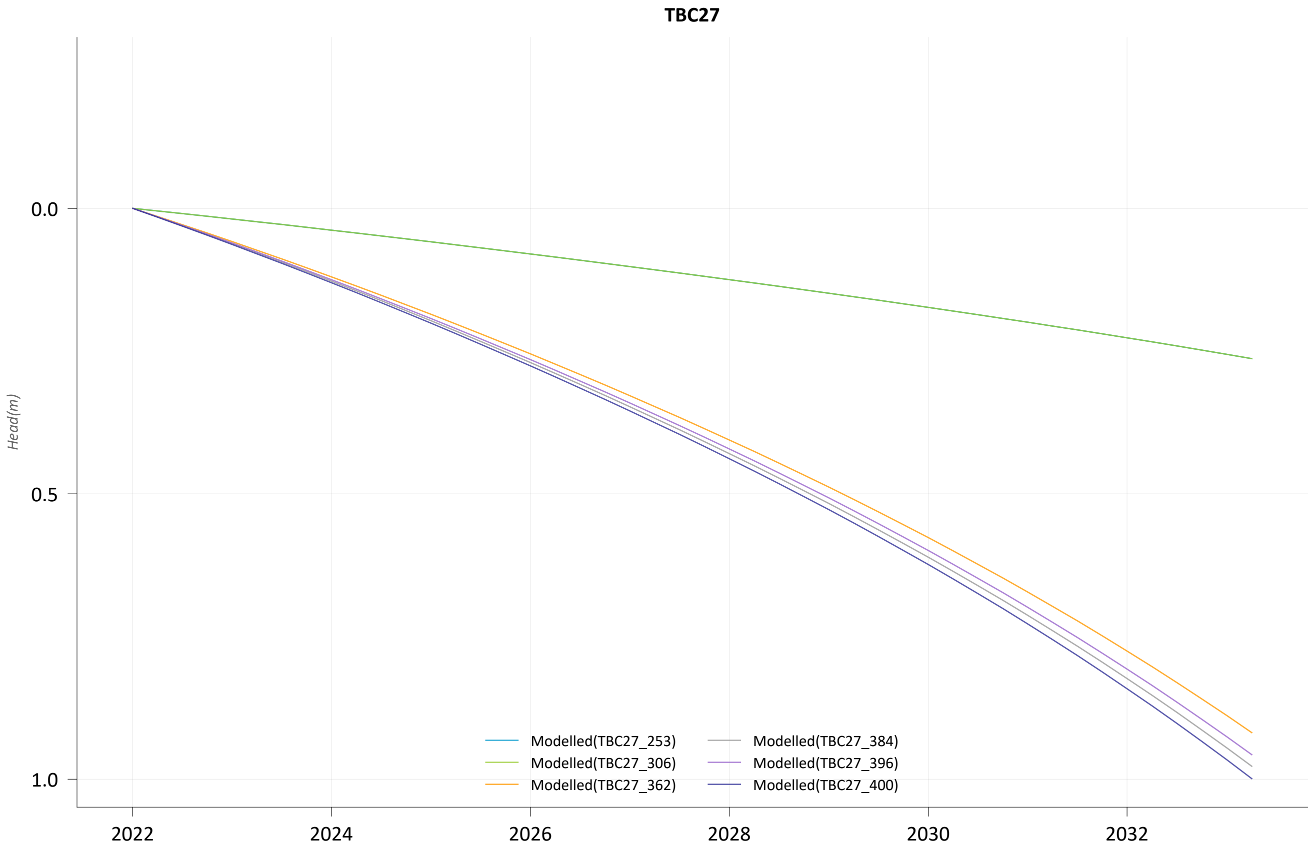
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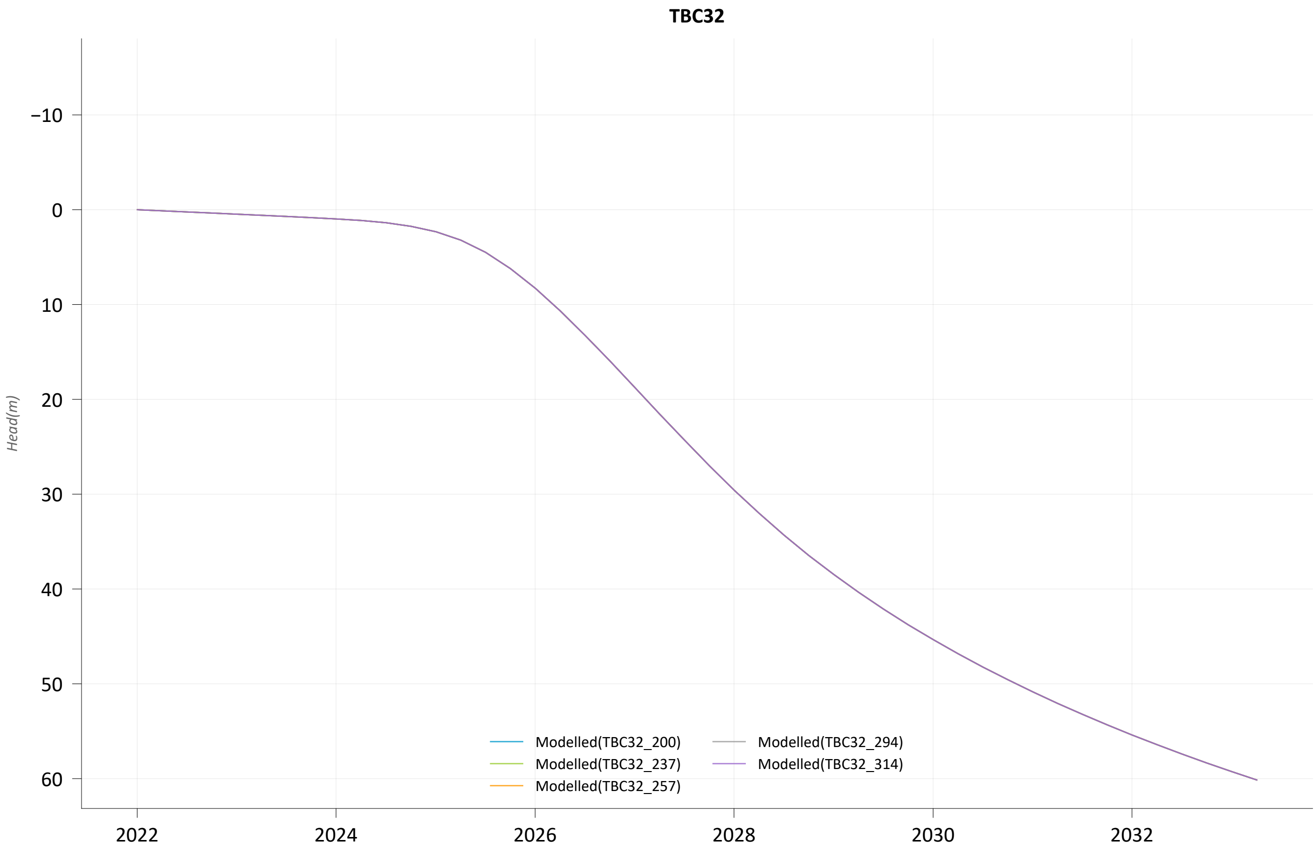
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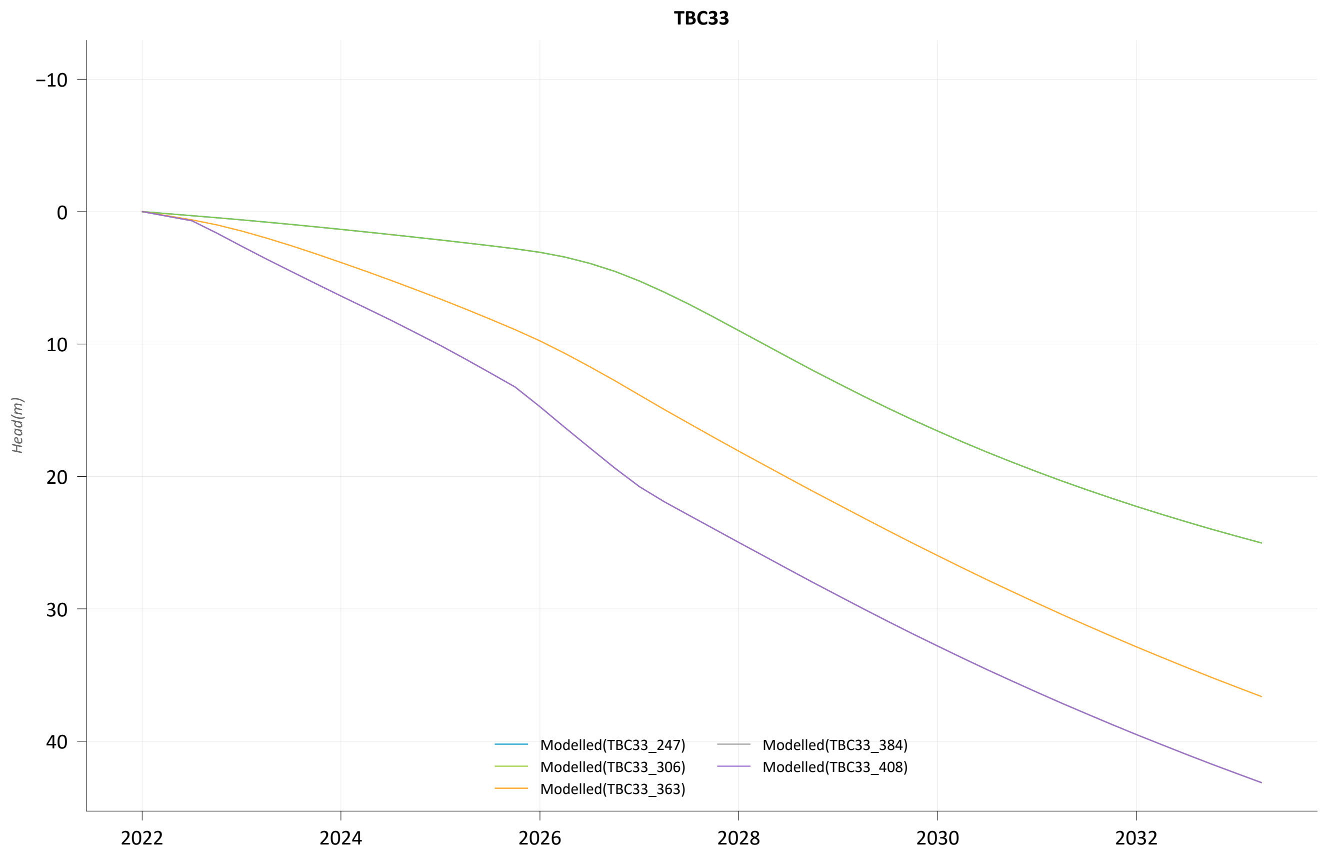

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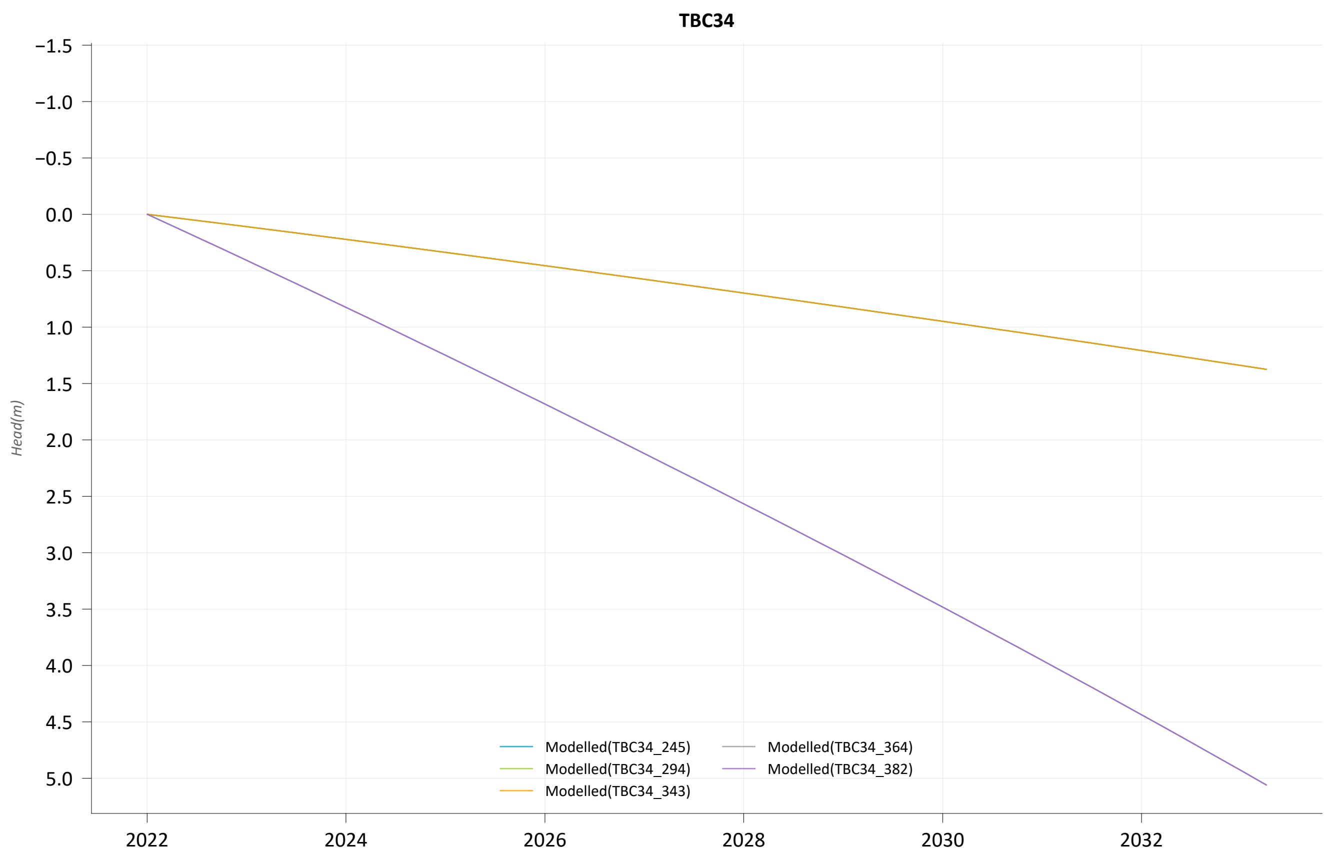

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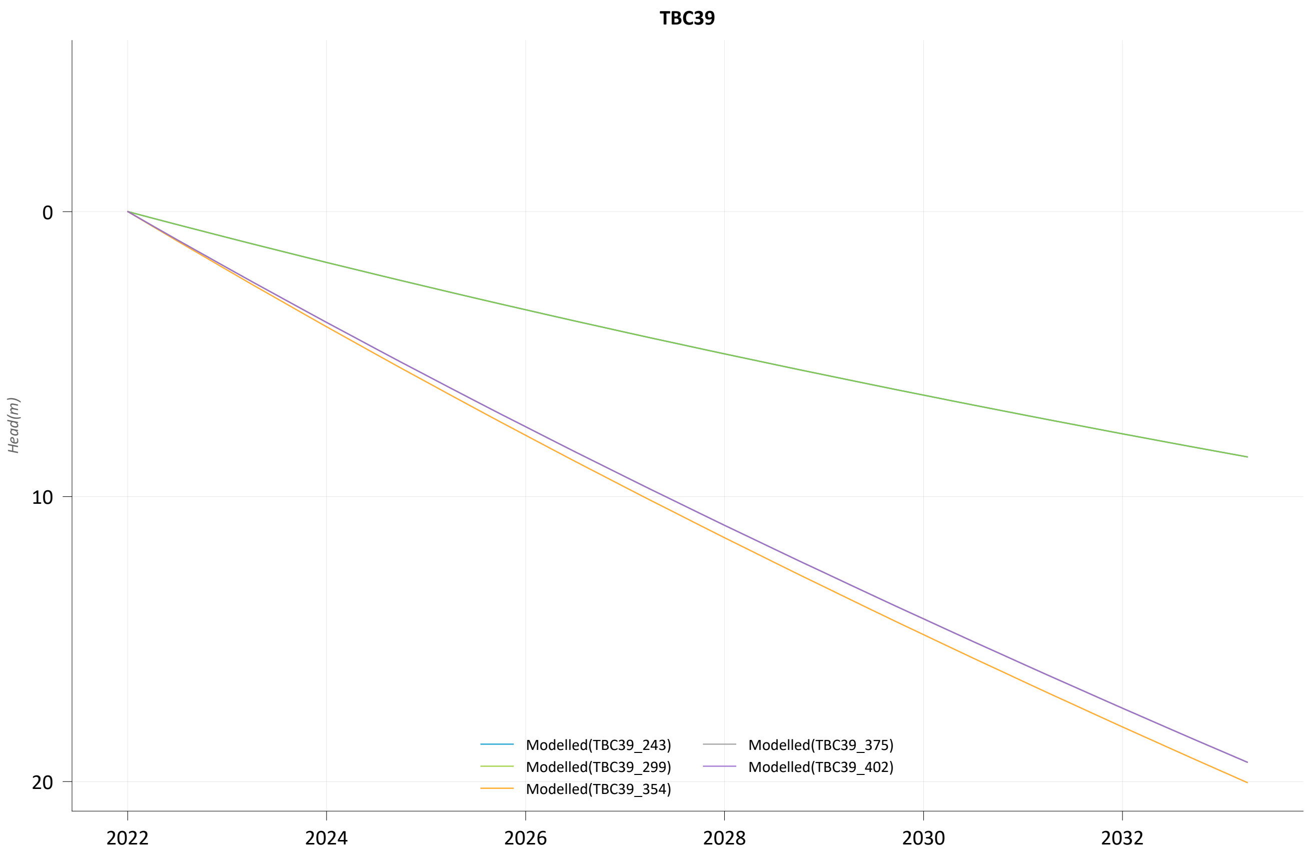
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APPENDIX F – Remediation Progress Review Report

ATC WILLIAMS

REPORT

TAHMOOR COAL PTY LTD
ABN: 97076663968

Tahmoor South LWS1A-S6A Water Management Plan

Myrtle Creek and Redbank Creek Remediation Progress Review

121171.17, R02, Rev D
May 2022

TAILINGS.WATER.WASTE.

Document Control

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Document Title:	Myrtle Creek and Redbank Creek Remediation Progress Review
File Location:	\\atcbnemvpfs01\Synergy\Synergy\Projects\121\121171 1809 Tahmoor (SIMEC) Surface Water Assistance\17 Tahmoor South LW101-106A WMP\Documents\R02\121171.17-R02d.docx
Document Number:	121171.17-R02d.docx

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Revision	Issue	Issue Date	Prepared by	Reviewed by
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B	Second Draft Issue	28/4/2022	Camilla West	Tony Marszalek
C	Third Draft Issue	9/5/2022	Camilla West	Client
D	Final Rev 1	11/5/2022	Camilla West	Client

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TAILINGS.WATER.WASTE.

1 INTRODUCTION

Myrtle Creek and Redbank Creek are situated in the Nepean River catchment. Myrtle Creek discharges directly to the Nepean River while Redbank Creek discharges to Stonequarry Creek which in turn discharges to the Nepean River.

The upper reaches of Myrtle Creek overlie older Tahmoor Mine longwall panels LW3 to LW5, LW7 to LW9, LW20 and LW21. The mid to lower reaches of Myrtle Creek overlie LW22 to LW29, while Redbank Creek overlies LW24B to LW32 (refer Map 1).

Mining of LW22 commenced in May 2004 with LW32 completed in September 2019. During mining of LW22 to LW32, subsidence related impacts occurred to Myrtle Creek and Redbank Creek. The subsidence related impacts comprised stream bed and rockbar fracturing, reduced pool water holding capacity, diversion of surface flow as subsurface flow and isolated, episodic pulses of elevated concentrations of some water quality constituents. The impacts resulted in exceedances of the surface water triggers in the Trigger Action Response Plan defined in the LW 27-30 Environmental Management Plan (Xstrata Coal, 2013), LW 31 Environmental Management Plan (Glencore, 2017) and the LW 32 Environmental Management Plan (Tahmoor Coal, 2019a).

Accordingly, Tahmoor Coal Pty Ltd (Tahmoor Coal) has developed and implemented a Corrective Management Action Plan to remediate the impact of subsidence effects to Myrtle Creek and Redbank Creek. Remediation works, comprising grout curtains and grout pattern injection, have been conducted at sites in Myrtle Creek and Redbank Creek with the aim of improving pool water holding capacity, restoring overland connective flow and improving aquatic ecosystem health and aesthetic value.

The NSW Department of Planning and Environment (DPE) – Environment, Energy and Science Group (EES) has requested an update on the progress of remediation works in Myrtle Creek and Redbank Creek including review and analysis of monitoring data demonstrating remediation outcomes.

This report details the outcomes of a surface water assessment for remediated pools comprising recession analysis and comparison of remediated pool water level records to reference site water level records. Additionally, a summary of the aquatic ecology survey results for remediated pools is provided.

The analysis has been undertaken for the following pools (refer Map 1):

- Myrtle Creek: pool 23, 20, 18, 11 and 10.
- Redbank Creek: pool RB6, RR11, RR19 and weir/pool 26.

The outcomes of the surface water analysis and aquatic ecology surveys have been used to assess the effectiveness of the remediation works in Myrtle Creek and Redbank Creek to date.

MAP 1: REDBANK CREEK AND MYRTLE CREEK REMEDIATION MONITORING SITES

2 CORRECTIVE MANAGEMENT ACTION PLAN

2.1 CMAP Program of Works

In accordance with the requirements of Section 240(1)(d) of the *Mining Act 1992*, Tahmoor Coal has developed and implemented a Corrective Management Action Plan (CMAP) in relation to exceedances of the surface water triggers in the Trigger Action Response Plan defined in the Environmental Management Plans for LW27-LW32.

The Myrtle Creek CMAP Stage 1 (Tahmoor Coal, 2017) was approved by the NSW Resources Regulator on 4 May 2018 and was completed in February 2020 (Tahmoor Coal, 2020a). The Myrtle Creek CMAP Stage 2 (Tahmoor Coal, 2020b) is currently being implemented. The Redbank Creek CMAP Stage 1 (Tahmoor Coal, 2019b) was initially approved by the NSW Resources Regulator in June 2019 and is currently being implemented.

The CMAP details the required program of works for remediation of subsidence impacts to Redbank Creek and Myrtle Creek associated with mining of LW22-LW32. The works associated with the CMAP comprise:

- high resolution stream and pool mapping;
- characterisation of the fracture network through implementation of a characterisation borehole network (Characterisation Study);
- remediation through grout injection (curtain wall and / or pattern grout injection);
- surface water, groundwater and aquatic ecology monitoring and assessment;
- stakeholder consultation; and
- quarterly reporting.

In addition, groundwater modelling has been undertaken to inform the required remediation works at specific sites.

2.2 Remediation Objectives

As defined in the Redbank Creek and Myrtle Creek CMAPs (Tahmoor Coal, 2019b; 2020b), the remediation works have been conducted with the aim of restoring the post-mining hydrological, ecological and aesthetic characteristics of Myrtle Creek and Redbank Creek to, as close as practically possible, pre-mining conditions. Specifically, the remediation works aim to:

- protect, to the greatest practicable extent, the ecological values of the area;
- as close as practicably possible, restore the post-mining ecosystem function and aquatic ecology to that of pre-mining conditions;
- improve the post-mining aesthetic conditions of the creeks;
- as close as practicably possible, restore the post-mining pool water level recession rates to pre-mining water level recession rates; and
- reduce the interaction between surface water and groundwater where this has been enhanced through mining impacts.

The assessment findings presented in this report pertain to the progress of restoring the post-mining hydrological and ecological characteristics of Myrtle Creek and Redbank Creek to, as close as practicably possible, pre-mining conditions in locations where remediation works have been conducted.

3 REMEDIATION PROGRESS ASSESSMENT METHODOLOGY

3.1 Surface Water Analysis Methodology

3.1.1 Method 1

Method 1 was adopted for assessing the effectiveness of remediation works at pools for which sufficient pre-mining and/or pre-impact water level data was recorded. Method 1 comprised assessment of whether or to what extent the pool water level recessionary behaviour has been restored to pre-impact conditions. During low rainfall conditions, the water level of an un-impacted pool is expected to decline at a similar rate from a given starting level for each dry weather event, with some seasonal variation. Mining related subsidence impacts typically result in a markedly faster water level recession than that observed during pre-impact periods. Successful remediation of an impacted pool is assessed by comparing the dry weather water level recessionary behaviour of a pool during pre-impact and post-remediation periods.

To facilitate the assessment, monitored average daily water level data for each pool was provided by Hydrometric Consulting Services (HCS) for the period of record. Rainfall data recorded at the Myrtle Creek catchment rainfall monitoring station was used to define dry weather events (refer Map 2 for location). The data recorded at the Myrtle Creek rainfall monitoring station was reviewed against rainfall data recorded at the nearby WaterNSW Lake Nerrigorang (212063) and Thurns Road (568296) rainfall stations for comparative periods. The Lake Nerrigorang station (212063) is located approximately 2.5 km to the west of the upstream reach of Myrtle Creek and the Thurns Road station (568296) is located approximately 6 km to the north-east of the downstream reach of Redbank Creek (refer Map 2 for locations). Although the WaterNSW stations are located at a distance from the remediation sites, the rainfall patterns recorded at the three stations were found to be generally consistent. As such, gaps in the Myrtle Creek rainfall record were infilled with data recorded at Thurns Road to September 2014 and Lake Nerrigorang rainfall data post September 2014 (the commencement date of Lake Nerrigorang rainfall station).

The assessment methodology adopted was as per that described in Peabody (2019) and comprised the following steps:

1. Dry weather recession events, defined as a period of at least five days where the maximum recorded total rainfall was 0.5 millimetres (mm) or less, were identified for the pre-impact and the post-remediation periods. A minimum of fifteen dry weather periods for both the pre-impact and post-remediation periods were considered necessary to undertake an adequate assessment. Of these fifteen periods, at least two needed to span ten or more days. Ideally, these periods should be spread over different seasons for a minimum of two years.
2. The average daily water level data was plotted as a series of recession curves for each dry weather recession event. The start time of each recession event was adjusted to form a single recession curve (i.e. plotted on a single time scale).
3. An interpolating exponential equation was then fitted to the derived single recession curve for the pre-impact dataset.
4. The start time for each recession event (on the single recession curve) was readjusted using the interpolating exponential equation to produce a mathematically refined recession curve for the pre-impact dataset. The refined recession curve, considered to be representative of the dry weather water level recessionary behaviour of the pre-impacted pool, was used for comparison with the post-remediation dataset.
5. For the post-remediation data, the start time for each post-remediation recession event was adjusted using the adopted pre-impact interpolating exponential equation to produce a recession curve for the post-remediation data.

The pre-impact and post-remediation recession curves were then compared to assess comparative behaviour.

3.1.2 Method 2

Method 2 was adopted for assessing the effectiveness of remediation works at pools for which sufficient pre-mining and/or pre-impact water level data to enable the use of Method 1 was not recorded. Method 2 comprised two components:

1. assessment of whether or to what extent the pool water level recessionary behaviour has been improved in relation to impact conditions; and
2. comparison of the remediated pool water level with similar, unimpacted pools (reference sites).

The component 1 assessment method comprised the following steps:

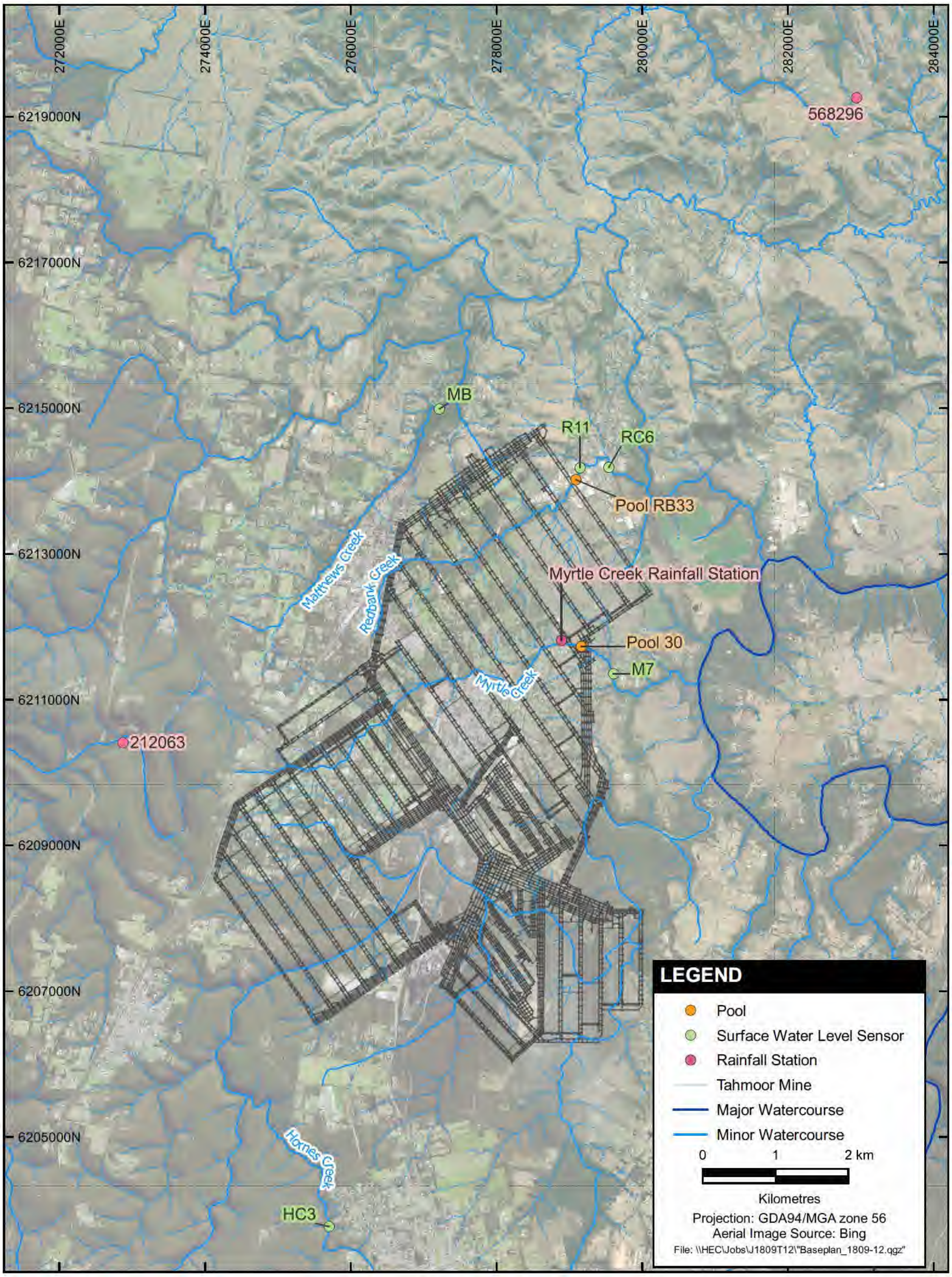
1. A minimum of two dry weather recession events, defined as a period of at least five days where the maximum recorded total rainfall was 0.5 mm or less, should be identified for the impact and the post-remediation periods.
2. The average daily water level data was plotted as a series of recession curves for each dry weather recession event. The start time of each recession event was adjusted to form a single recession curve (i.e. plotted on a single time scale).

The impact and post-remediation recession curves were then compared to assess comparative behaviour.

Component 2 assessment method comprised comparison of the post-remediation water level data with water level data recorded at a minimum of two un-impacted pools with similar hydrological and geomorphological characteristics (reference sites). The reference sites were as follows (refer Map 2 for locations):

- Myrtle Creek M7 – furthest monitoring site downstream in Myrtle Creek located beyond the zone of subsidence impacts and of flow re-emergence from upstream impacted pools.
- Redbank Creek R11 and RC6 – furthest monitoring sites downstream in Redbank Creek located beyond the zone of subsidence impacts and of flow re-emergence from upstream impacted pools.
- Hornes Creek HC3 – located in a catchment which is not influenced by any mining activities and has similar hydrological and geomorphological characteristics to that of Myrtle Creek and Redbank Creek.
- Matthews Creek MB - located upstream of potential mining influences, has a similar catchment area (8.1 km^2) to that of Myrtle Creek (7.9 km^2) and Redbank Creek (5.3 km^2) and similar hydrological and geomorphological characteristics.

The water level monitoring data for each pool was adjusted to a common datum to enable direct comparison of recessionary behaviour. A subjective assessment of the comparability of the water level characteristics for each site (i.e. water level and recessionary behaviour), following remediation of the impacted site, was then undertaken.



MAP 2: REFERENCE SITES AND RAINFALL STATIONS

TAILINGS.WATER.WASTE.

3.2 Aquatic Ecology Assessment Methodology

Aquatic ecology monitoring, conducted by Niche, was undertaken biannually between 2019 and 2021 at the following sites (refer Map 1 and Map 2 for locations):

- remediated sites: pool 20 and pool 23 and reference site: pool 30 in Myrtle Creek; and
- remediated sites: pool RR11, pool RR19 and weir/pool 26 and reference site: pool RB33 in Redbank Creek.

The aquatic ecology survey methodology and outcomes are detailed in Niche (2021a; 2021b).

Monitoring of the aquatic ecology of remediated sites in Myrtle Creek and Redbank Creek was undertaken to assess the extent of mining related impacts and to monitor the outcomes of remediation works for restoring the ecosystem function and aquatic ecology of impacted sites.

The aquatic ecological monitoring adopted the Australian Rivers Assessment System (AUSRIVAS) method and was primarily focused on macroinvertebrate monitoring. AUSRIVAS is a rapid assessment method based on the presence or absence of invertebrates, where macroinvertebrate samples from impacted sites are assessed against modelled reference sites. The AUSRIVAS method consisted of:

- aquatic habitat assessment
- macroinvertebrate survey; and
- physicochemical water quality monitoring.

4 MYRTLE CREEK REMEDIATION PROGRESS ASSESSMENT OUTCOMES

4.1 Pool 10 and Pool 11

4.1.1 Introduction

The locations of pool 10 and pool 11 are shown in Map 1. Pool 10 is a shallow, elongated pool formed in Hawkesbury Sandstone outcrop and controlled by a shallow rockbar. Pool 11, also formed in Hawkesbury Sandstone, is an incised, elongated pool controlled by a raised rockbar. Underflow beneath the rockbar was visually observed (refer Appendix A), potentially as a result of subsidence induced fracturing of the rockbar. A summary of the geomorphological characteristics of pool 10 and pool 11, following visual inspection conducted on 18 May 2021, is presented in Appendix A.

Subsidence related impacts to pool 10 and pool 11 were initially reported following mining of LW26 which was undertaken between March 2011 and October 2012. Impacts to pool 10 and pool 11 were reported as reduced pool holding capacity (GeoTerra, 2014).

4.1.2 Summary of Remediation Works

Remediation works at pool 10 and pool 11 commenced in October 2021 and were completed in December 2021. The remediation works, as informed by the ground characterisation study (SCT, 2021) and review of groundwater and surface water monitoring data, comprised a 4 metre (m) wide shallow grout curtain (perpendicular to the direction of flow) - drilling and injection to 2 m depth, 0.5 m spacing and 38 mm diameter using Spetec H100 hydrophobic polyurethane (Tahmoor Coal, 2021).

4.1.3 Surface Water Assessment Findings

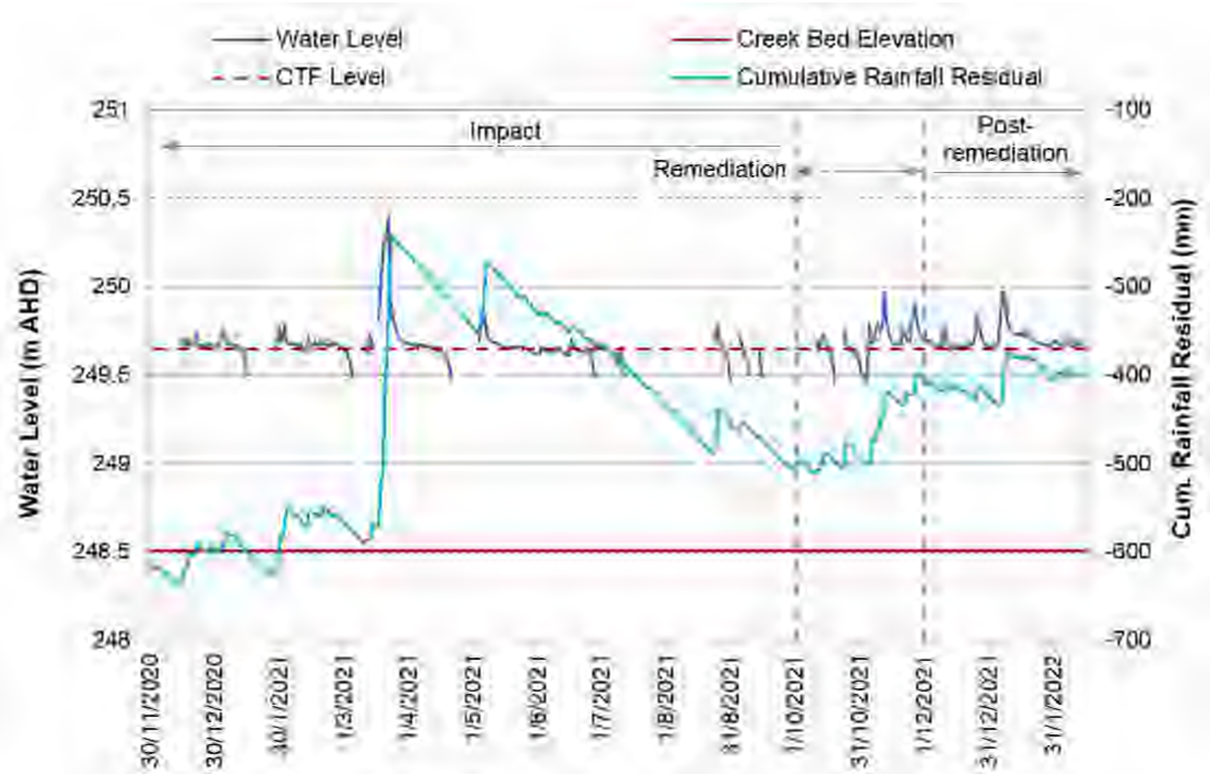
4.1.3.1 Pool 10

Water level data for pool 10 is available for the period November 2020 to February 2022. Pre-mining and/or pre-impact data was not recorded at pool 10.

Only one recession event was available for the post-remediation period and as such a recession analysis has not been conducted. Following a period of additional monitoring, with sufficient dry weather events, Method 2 was applied to assess the recessionary behaviour post-remediation in comparison to the impact period.

Graph 1 presents a graph of water level records for Myrtle Creek pool 10 in comparison with the cumulative rainfall residual[1]. The cumulative rainfall residual shown was calculated for the period March 2010 to March 2022. This period is shown as it is of notable length (more than 10 years of rainfall data) and therefore reflects variability in the rainfall record over time. Additionally, and for consistency, this period corresponds with the longest period of water level monitoring data recorded at the remediated pools.

The creek bed elevation at the base of the pool and cease to flow (CTF) level are also presented in Graph 1. Note that the CTF level refers to the point at which surface water ceases to flow over the streamflow control i.e. the lowest point on a controlling rockbar or boulder field. In the event that streamflow over the rockbar or boulder field ceases, there may still be streamflow around, through or under the rockbar / boulder field control which reports downstream of the control.



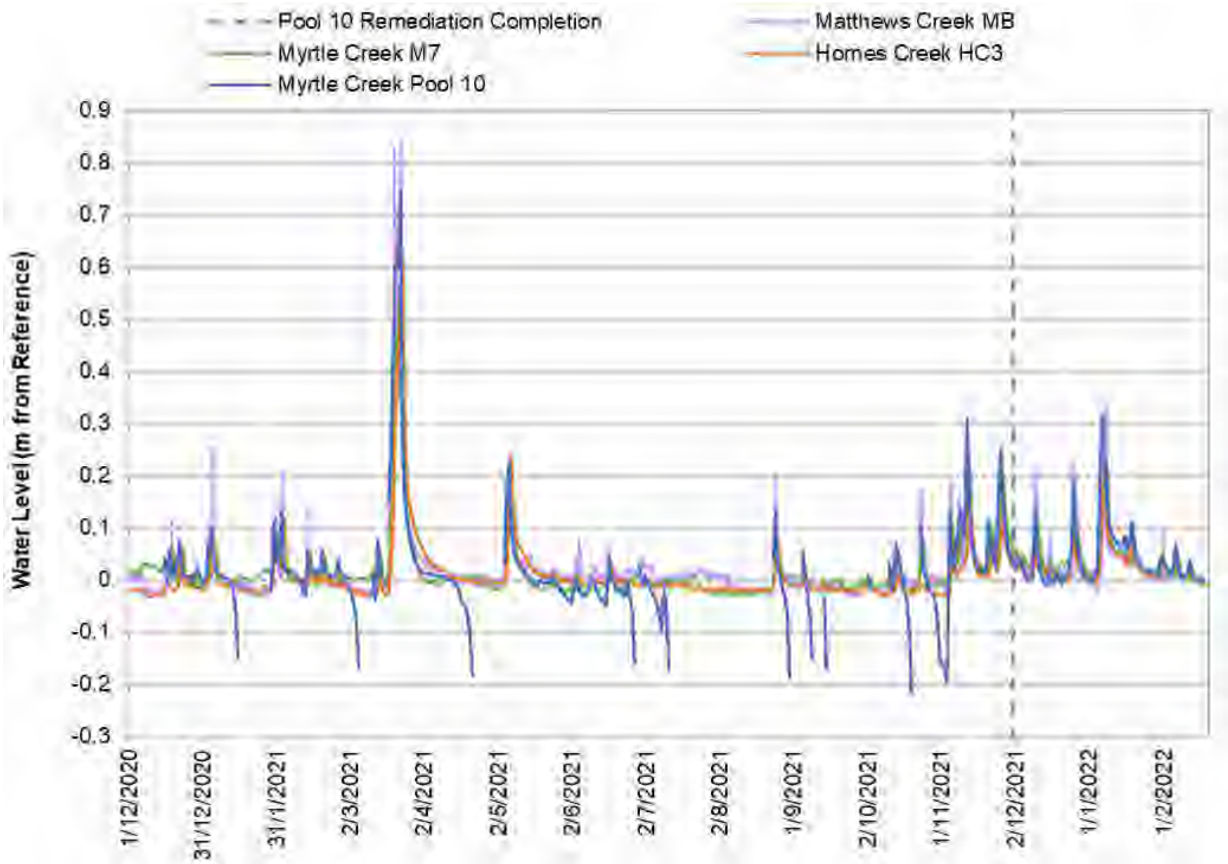
GRAPH 1: MYRTLE CREEK POOL 10 - WATER LEVEL RECORDS AND RAINFALL RESIDUAL

The data presented in Graph 1 illustrates that, prior to remediation, the water level at pool 10 regularly declined below the level of the sensor, as illustrated by gaps in the dataset. From mid-way through the remediation period to post-remediation (early November 2021 to February 2022), the water level remained continuously above the CTF level with pool 10 continuously overflowing to the downstream reach of Myrtle Creek. This period coincided with generally above average rainfall as illustrated by the increasing trend in the cumulative rainfall residual. Maintenance of the pool water level above the CTF level is considered likely due to both the remediation works and above average rainfall recorded during

[1] The cumulative rainfall residual was calculated as the cumulative deviation from the average daily rainfall where positive (upward) slope in the plot indicates periods of above average rainfall and negative (downward) slope indicates periods of below average rainfall.

this period. The data presented in Graph 1 illustrates a notable improvement in the pool water holding capacity post-remediation in comparison with the impact period.

Graph 2 presents a comparison of pool 10 water level data and reference site data for Myrtle Creek M7, Hornes Creek HC3 and Matthews Creek MB. The water level monitoring data for each pool was adjusted to a common datum to enable direct comparison of recessionary behaviour.



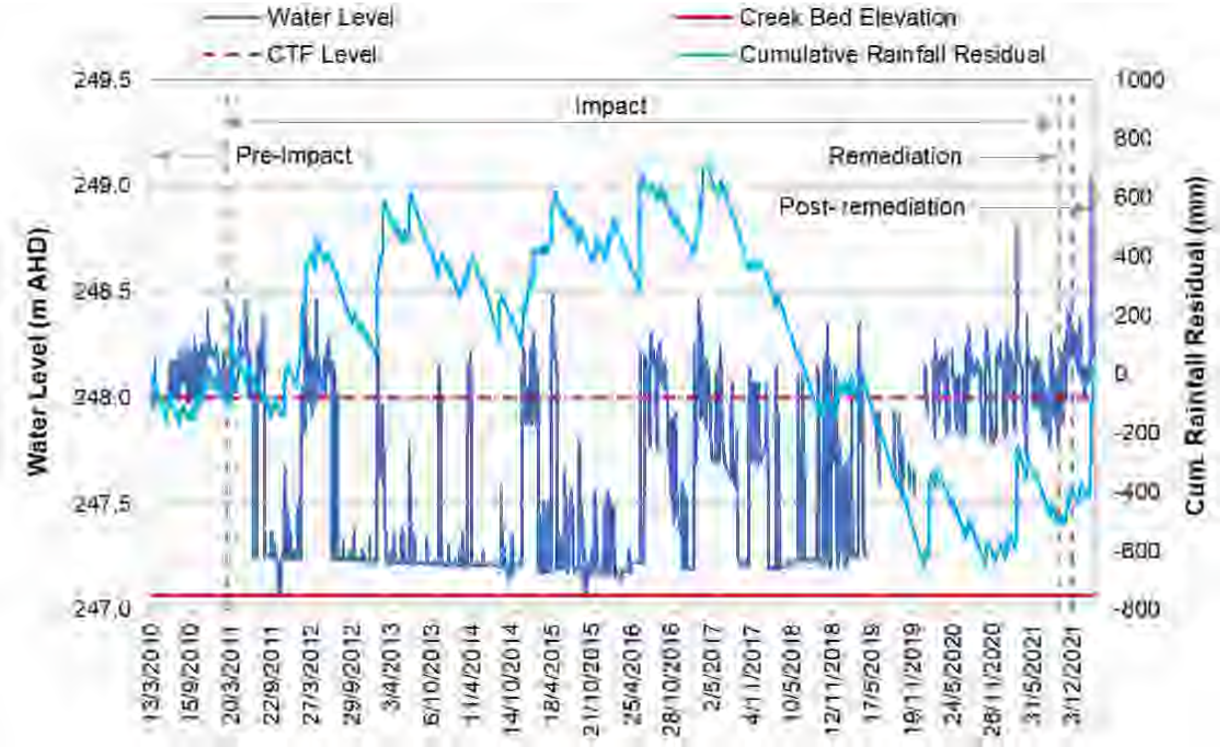
GRAPH 2: MYRTLE CREEK POOL 10 AND REFERENCE SITES - WATER LEVEL COMPARISON

The data presented in Graph 2 shows that the hydrological behaviour of reference sites Myrtle Creek M7, Hornes Creek HC3 and Matthews Creek MB were similar for the period of record although higher water levels tended to be recorded at Matthews Creek MB during rainfall events. There is an evident difference in the pre-remediation hydrological behaviour of pool 10 compared with the reference site water level behaviour. Post-remediation, the water level behaviour of pool 10 is generally consistent with that of the reference sites with similar recessionary behaviour recorded.

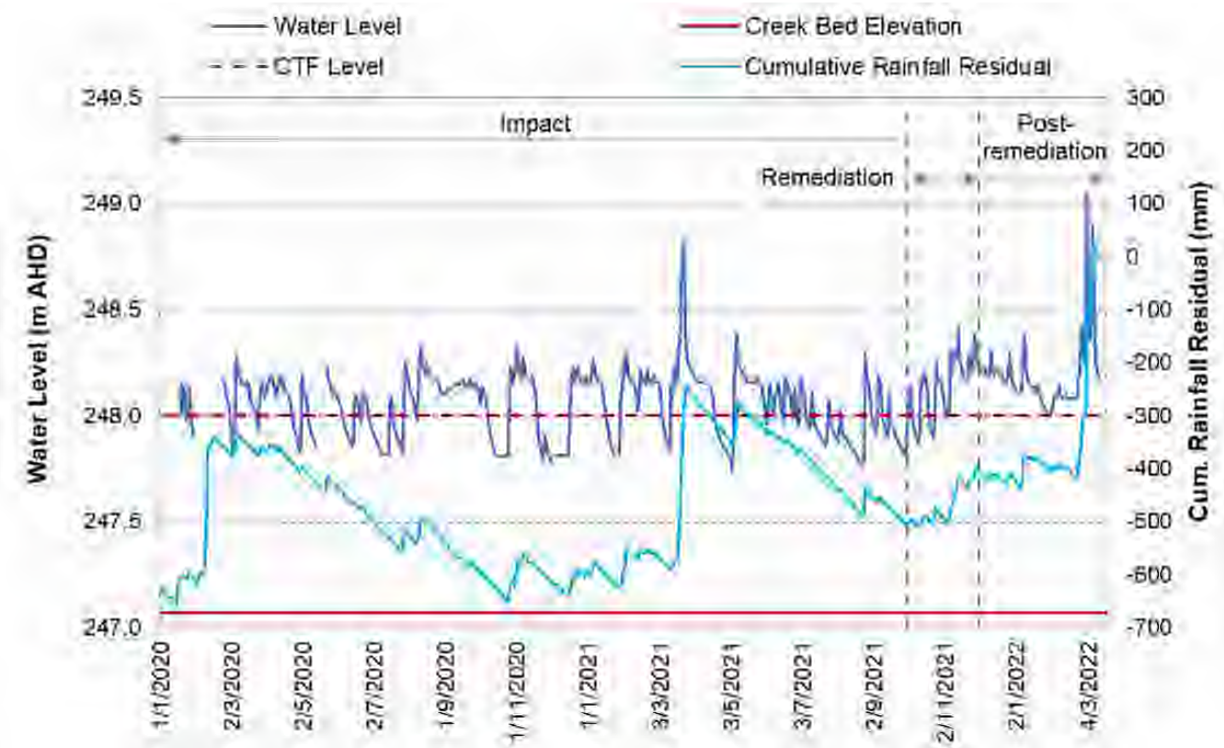
Although it is evident that there has been an improvement in the pool 10 water holding capacity post-remediation, the area has experienced above average rainfall during this period. As such, additional post-remediation monitoring data, recorded during periods of below average rainfall, is recommended to provide further confidence in the effectiveness of remediation works at pool 10.

4.1.3.2 Pool 11

Water level data for pool 11 is available for the period March 2010 to March 2022. Graph 3 (A and B) presents the water level records for Myrtle Creek pool 10 in comparison with the cumulative rainfall residual, the creek bed elevation at the base of the pool and CTF level.



GRAPH 3A: MYRTLE CREEK POOL 11 - WATER LEVEL RECORDS AND RAINFALL RESIDUAL – 2010 TO 2022

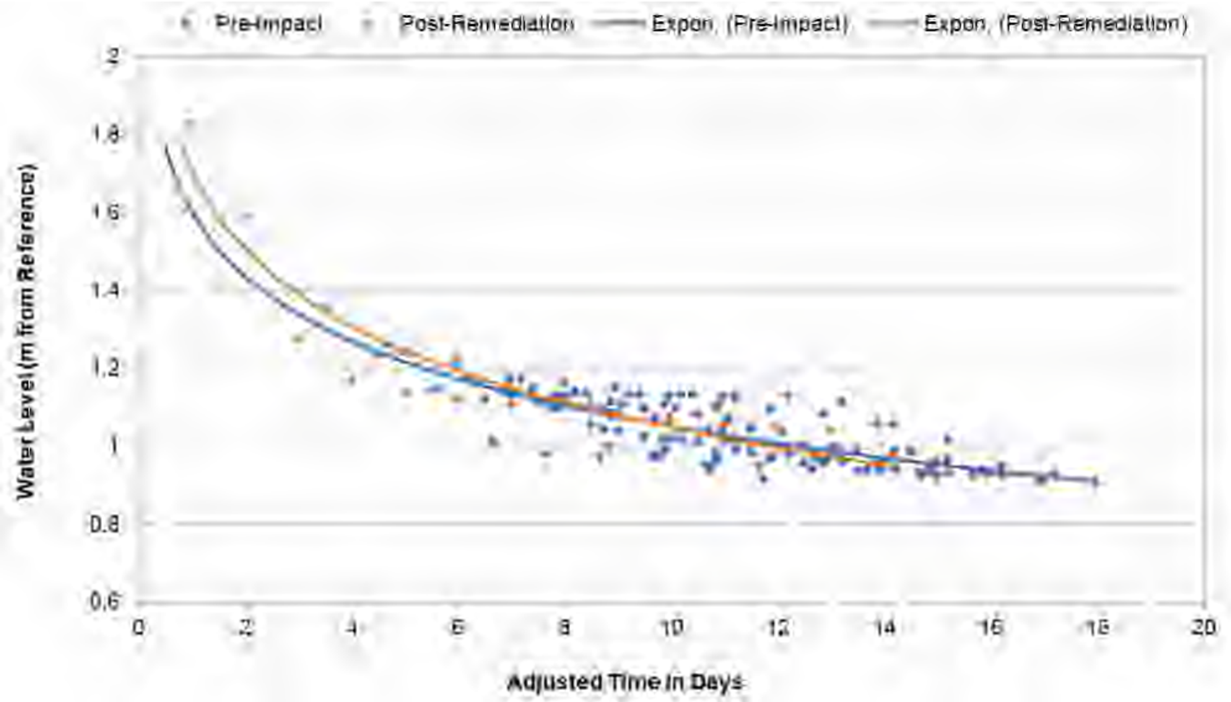


GRAPH 3B: MYRTLE CREEK POOL 11 - WATER LEVEL RECORDS AND RAINFALL RESIDUAL – 2020 TO 2022

Impacts to pool 11 were reported as occurring during mining of LW26 (March 2011 to October 2012) (GeoTerra, 2019), however, the exact date of initial impact was not recorded. During the pre-impact period prior to March 2011, the water level trended was recorded above the CTF level. Following impacts, the water level regularly and rapidly declined to a level close to the pool base. Following substantial rainfall in early 2020, the water level rose and remained elevated although declines in the water level were regularly recorded. From early 2020 to December 2021, the minimum water level recorded was 247.76 m AHD. Post-remediation, the water level has been maintained above the CTF level (248 m AHD), consistent with that recorded during the pre-impact period. It is noted that above average rainfall was recorded during this period and, as such, maintenance of the minimum water level above 248 m AHD is considered likely due to both the remediation works and above average rainfall recorded during this period.

Method 1 has been applied to preliminarily assess the water level recessionary behaviour for the pre-impact and post-remediation periods. Seventeen (17) dry weather events were assessed for the pre-impact period and three events for the post-remediation period. Note that data recorded during the period of remediation works was excluded from the assessment.

Graph 4 presents the pre-impact and post-remediation period water level records against the adjusted time in days to produce a single recession curve for each period (refer Section 3). The exponential trendline fitted to each dataset is also presented.



GRAPH 4: MYRTLE CREEK POOL 11 – METHOD 1 RECESSION CURVE COMPARISON

Graph 4 shows that the post-remediation exponential curve is generally consistent with that of the pre-impact exponential curve indicating that the water level has declined at a similar rate post-remediation to that of the pre-impact period. The outcomes of the Method 1 preliminary assessment indicate that remediation works have been effective at pool 11. It is noted, however, that only three post-remediation events were available for analysis and above average rainfall was recorded during the post-remediation period. As such, additional post-remediation monitoring data, recorded during periods of below average rainfall, is recommended to provide further confidence in the effectiveness of remediation works at pool 11.

4.2 Pool 18

4.2.1 Introduction

As shown in Map 1, pool 18 in Myrtle Creek is situated above the eastern edge of LW27. The pool is formed in Hawkesbury Sandstone outcrop and is controlled by a rockshelf extending across the width

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of the pool. A summary of the geomorphological characteristics of pool 18, following visual inspection conducted on 18 May 2021, is presented in Appendix A.

LW27 was mined between November 2012 and March 2013, however, impacts to pool 18, comprising fracturing and reduced water holding capacity, were reported as occurring during mining of LW26 (March 2011 to October 2012) (GeoTerra, 2014).

4.2.2 Summary of Remediation Works

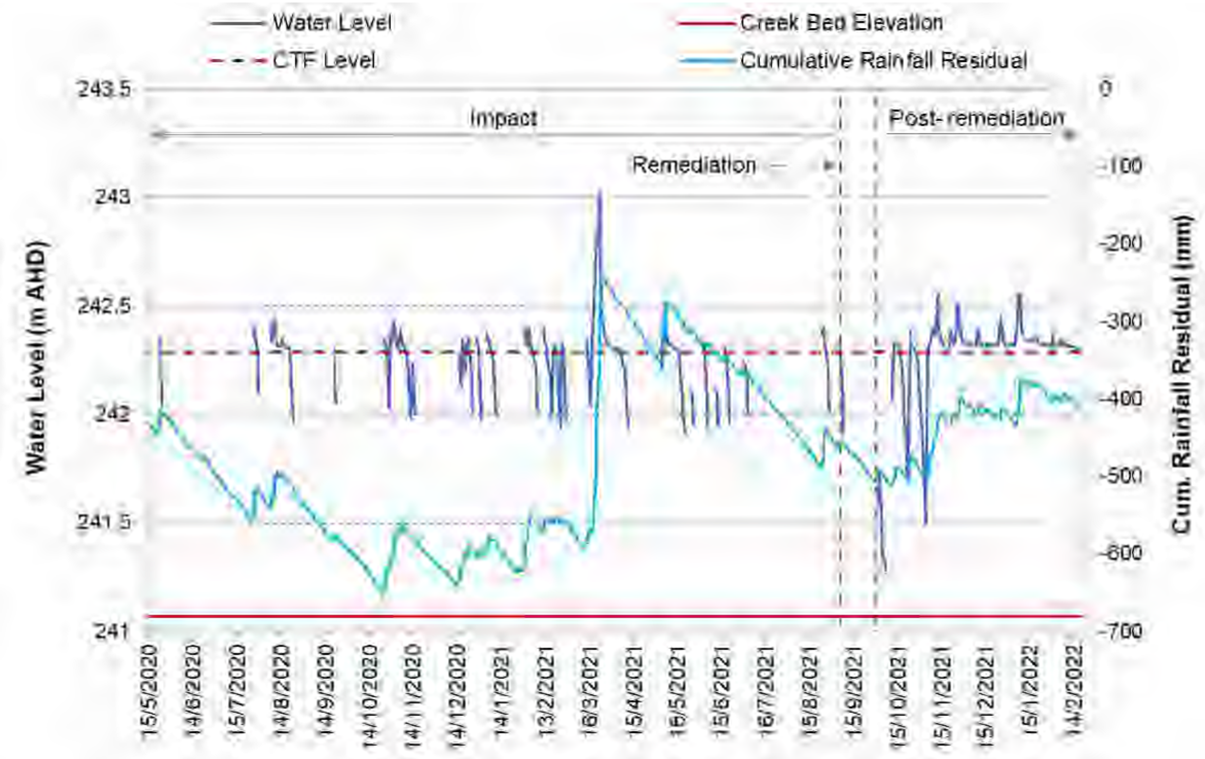
Remediation works at pool 18 commenced on 6 September 2021 and were completed on 1 October 2021. The remediation works, as informed by the ground characterisation study (SCT, 2021) and review of groundwater and surface water monitoring data, were conducted in two stages as follows (Tahmoor Coal, 2021):

1. Stage 1 – 6 metre (m) wide shallow grout curtain (perpendicular to the direction of flow): drilling and injection to 2 m depth, 0.5 m spacing and 38 mm diameter using Spetec H100 hydrophobic polyurethane.
2. Stage 2 – 32 m wide grout curtain to 6 m depth (perpendicular to the direction of flow): drilling of 17 holes (2 m spacing and 76 mm diameter) from 0 m to 6 m depth and injection with Spetec H100 hydrophobic polyurethane.

4.2.3 Surface Water Assessment Findings

Water level data for pool 18 is available for the period May 2020 to February 2022. No pre-mining data is available for pool 18. Graph 5 presents a graph of water level records for Myrtle Creek pool 18 in comparison with the cumulative rainfall residual. The cumulative rainfall residual shown was calculated for the period March 2010 to March 2022.

It should be noted that the water level sensor was relocated to a deeper part of the pool on 30 September 2021 (0.66 m deeper than previous) and hence lower water levels were subsequently recorded. Additionally, on 8 October 2021 a recession test was conducted at pool 18, following the completion of the remediation works, in which 26,000 litres (L) of water was added to the pool and the water level recorded.



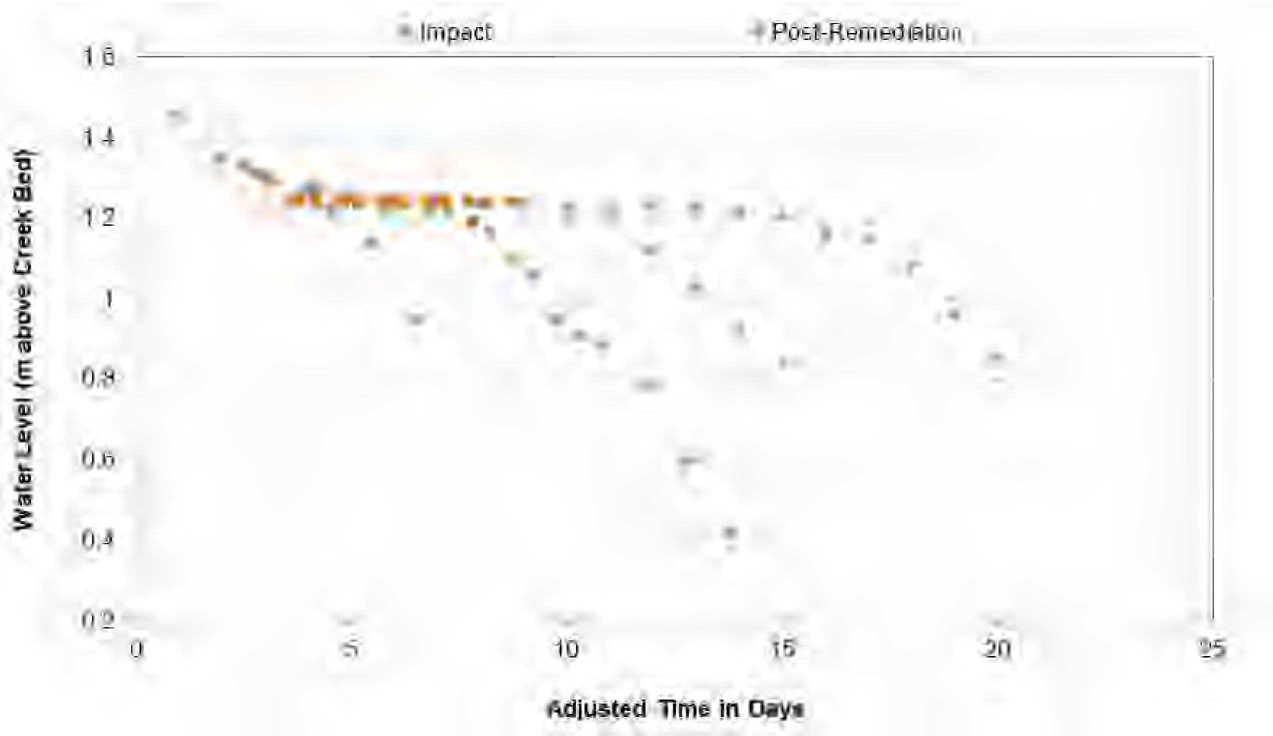
GRAPH 5: MYRTLE CREEK POOL 18 - WATER LEVEL RECORDS AND RAINFALL RESIDUAL

The data presented in Graph 5 illustrates that, prior to remediation, the water level recorded at pool 18 in Myrtle Creek regularly declined below the level of sensor, as indicated by gaps in the dataset. Following the recession test on 8 October 2021, two rapid declines in water level were recorded prior to early November 2021. As stated in Appendix A, there is notable sediment, gravel and boulder deposition in the base of pool 18. It is likely that, immediately following remediation, the moisture content of the hyporheic zone beneath the pool base was low thereby causing the higher infiltration rates.

During and following rainfall events from early November 2021, the water level remained elevated and rapid declines in water level were not recorded. It is presumed that the hyporheic zone was saturated during this period and hence infiltration rates declined. This period coincides with a period of generally above average rainfall as illustrated by the increasing trend in the cumulative rainfall residual. From mid-November 2021, the water level has been maintained continuously above the CTF level with pool 18 continuously overflowing to the downstream reach of Myrtle Creek. Maintenance of the pool water level above the CTF level is considered likely due to both the remediation works and above average rainfall recorded during this period.

In the absence of pre-mining and/or pre-impact monitoring data, Method 2 was adopted for preliminary assessment of the effectiveness of remediation works at pool 18 in Myrtle Creek.

Graph 6 presents a plot of the water level (above the creek bed elevation) for the impact and post-remediation period dry weather events against the adjusted time in days to produce a single recession curve for each dataset. Four dry weather events are plotted for the impact period and three for the post-remediation period.



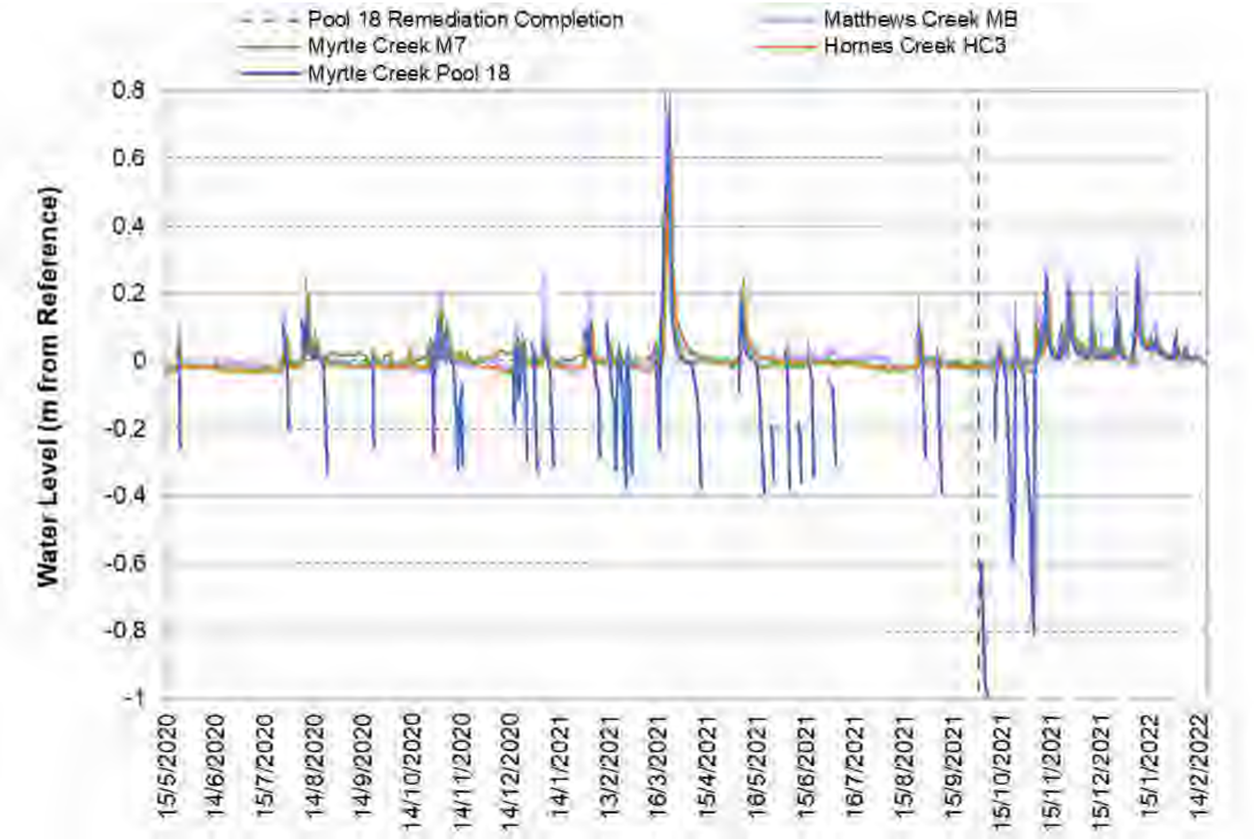
GRAPH 6: MYRTLE CREEK POOL 18 – METHOD 2 RECESSION CURVE COMPARISON

The data presented in Graph 6 indicates that the post-remediation water level has generally declined at a similar rate to the impact period water level. However, it should be noted that two of the recession events are reflective of the rapid declines that occurred during the inferred saturation of the hyporheic zone. Additionally, as the sensor was located at a higher level during the impact period, the impact period recessionary behaviour below 0.8 m depth is unknown.

Graph 7 presents a comparison of pool 18 water level data and reference site data for Myrtle Creek M7, Hornes Creek HC3 and Matthews Creek MB.

The data presented in Graph 7 shows an evident difference in the hydrological behaviour of pool 18 pre-remediation and immediately following remediation completion in comparison to the reference site water level behaviour. However, from mid-November 2021 to February 2022, coinciding with a period of above average rainfall, the water level behaviour of pool 18 was generally consistent with that of the reference sites.

The outcomes of the Method 2 assessment indicate that there has been an improvement in the pool 18 water holding capacity post-remediation, however, the area has experienced above average rainfall during this period. As such, additional post-remediation monitoring data, recorded during periods of below average rainfall, is recommended to provide further confidence in the effectiveness of remediation works at pool 18.



GRAPH 7: MYRTLE CREEK POOL 18 AND REFERENCE SITES - WATER LEVEL COMPARISON

4.3 Pool 20

4.3.1 Introduction

As shown in Map 1, pool 20 in Myrtle Creek is situated above the western edge of LW28. Pool 20 is a large, elongated pool formed in Hawkesbury Sandstone and controlled by a raised rockbar extending across the width of the pool. A summary of the geomorphological characteristics of pool 20, following visual inspection conducted on 18 May 2021, is presented in Appendix A.

LW28 was mined between April 2014 and May 2015, however, impacts to pool 20, comprising fracturing and reduced water holding capacity, were initially reported to have occurred during mining of LW27 between November 2012 and March 2014 (GeoTerra, 2015).

4.3.2 Summary of Remediation Works

Remediation works at pool 20 commenced in April 2021 and were completed on 10 September 2021. Informed by the ground characterisation study (SCT, 2021) and review of groundwater and surface water monitoring data, the remediation works were conducted in four stages as follows (Tahmoor Coal, 2021):

1. Stage 1 – 6 metre (m) wide shallow grout curtain (perpendicular to the direction of flow): drilling and injection to 2 m depth, 0.5 m spacing and 38 mm diameter using Spetec H100 hydrophobic polyurethane.
2. Stage 2 – 50 m wide grout curtain to 5 m depth (perpendicular to the direction of flow): drilling of 26 holes (2 m spacing and 76 mm diameter) from 0 m to 5 m depth and injection with Spetec H100 hydrophobic polyurethane.

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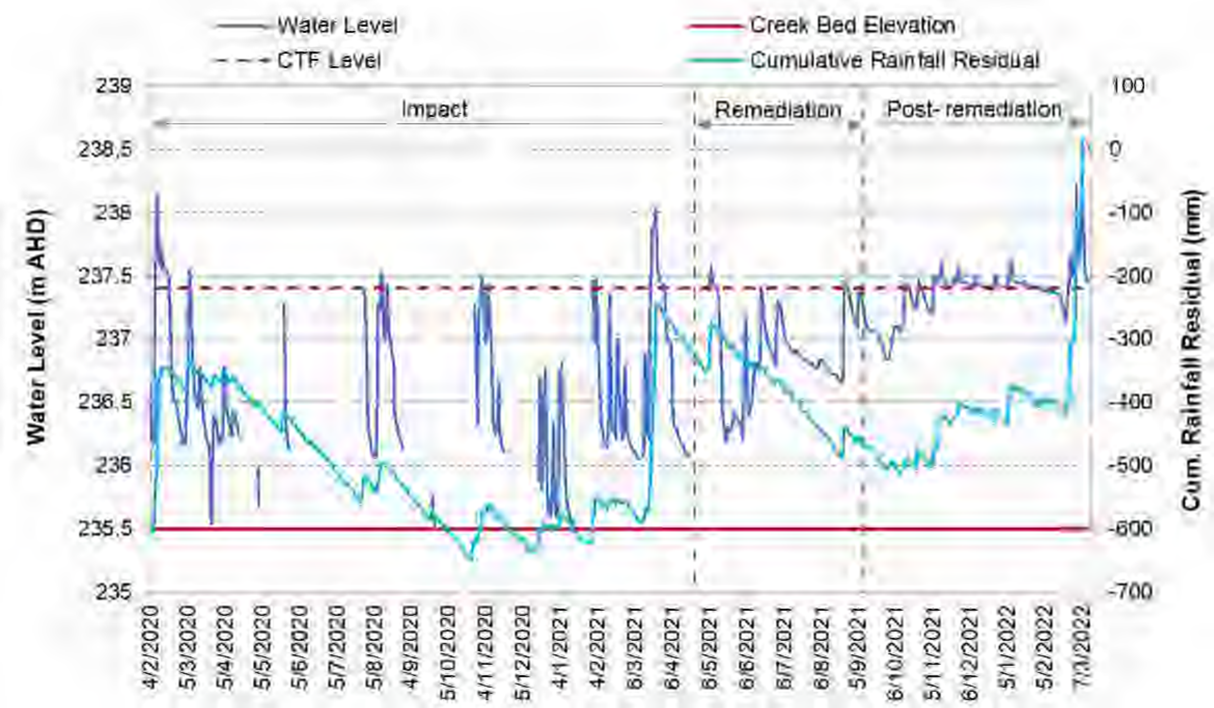
3. Stage 3 - 50 m wide grout curtain to 10 m depth (perpendicular to the direction of flow): drilling of 20 holes (2 m spacing and 76 mm diameter) from 5 m to 10 m depth and injection with Spetec H100 hydrophobic polyurethane.
4. Stage 4 - 50 m wide grout curtain to 15 m depth (perpendicular to the direction of flow): drilling of 20 holes (2 m spacing and 76 mm diameter) from 10 m to 15 m depth and injection with Spetec H100 hydrophobic polyurethane.

4.3.3 Surface Water Assessment Findings

Water level data for pool 20 in Myrtle Creek, recorded at monitoring site M20 (refer Map 1) is available for the period February 2020 to mid-March 2022. No pre-mining and/or pre-impact data is available for pool 20. Graph 8 presents a graph of water level records for pool 20 in comparison with the cumulative rainfall residual. The cumulative rainfall residual shown was calculated for the period March 2010 to March 2022. This period is shown as it is of notable length (more than 10 years of rainfall data) and therefore reflects variability in the rainfall record over time. Additionally, and for consistency, this period corresponds with the longest period of water level monitoring data recorded at the remediated pools.

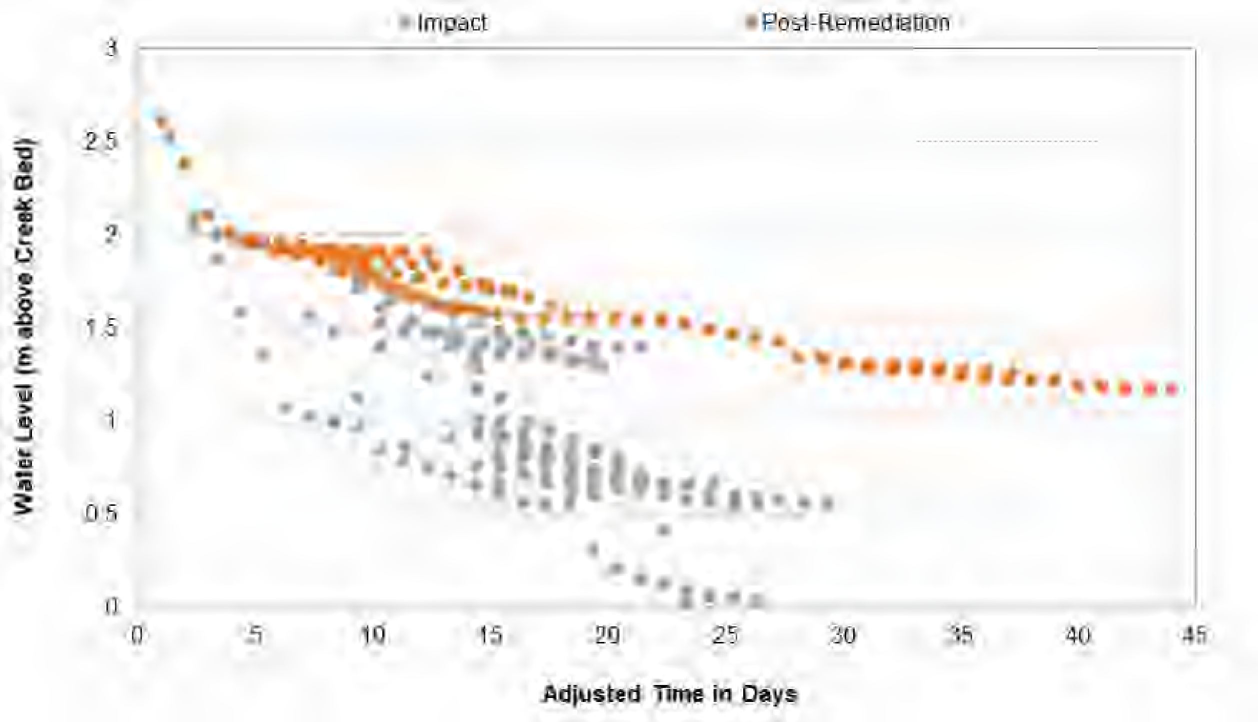


GRAPH 8: MYRTLE CREEK POOL 20 - WATER LEVEL RECORDS AND RAINFALL RESIDUAL

The data presented in Graph 8 illustrates that, prior to remediation, the water level recorded at pool 20 in Myrtle Creek regularly declined below the sensor level, as indicated by gaps in the dataset. During the remediation period, the water level remained above the level of the sensor despite a decline in the cumulative rainfall residual recorded during this period. For approximately two months post-remediation completion, the water level of pool 20 remained elevated although below the CTF level. It is noted that pool 20 is a large pool (refer Appendix A). As such, a reasonable period of above average rainfall would be required to fill the pool to the CTF level. From early November 2021, the water level remained above the CTF level with the exception of a short period in late February 2022.

In the absence of pre-mining and/or pre-impact monitoring data, Method 2 was adopted for assessment of the effectiveness of remediation works at pool 20 in Myrtle Creek.

Graph 9 presents a plot of the water level (relative to the creek bed) for the impact and post-remediation period dry weather events against the adjusted time in days to produce a single recession curve for each dataset. Eighteen (18) dry weather events are plotted for the impact period and ten (10) for the post-remediation period.



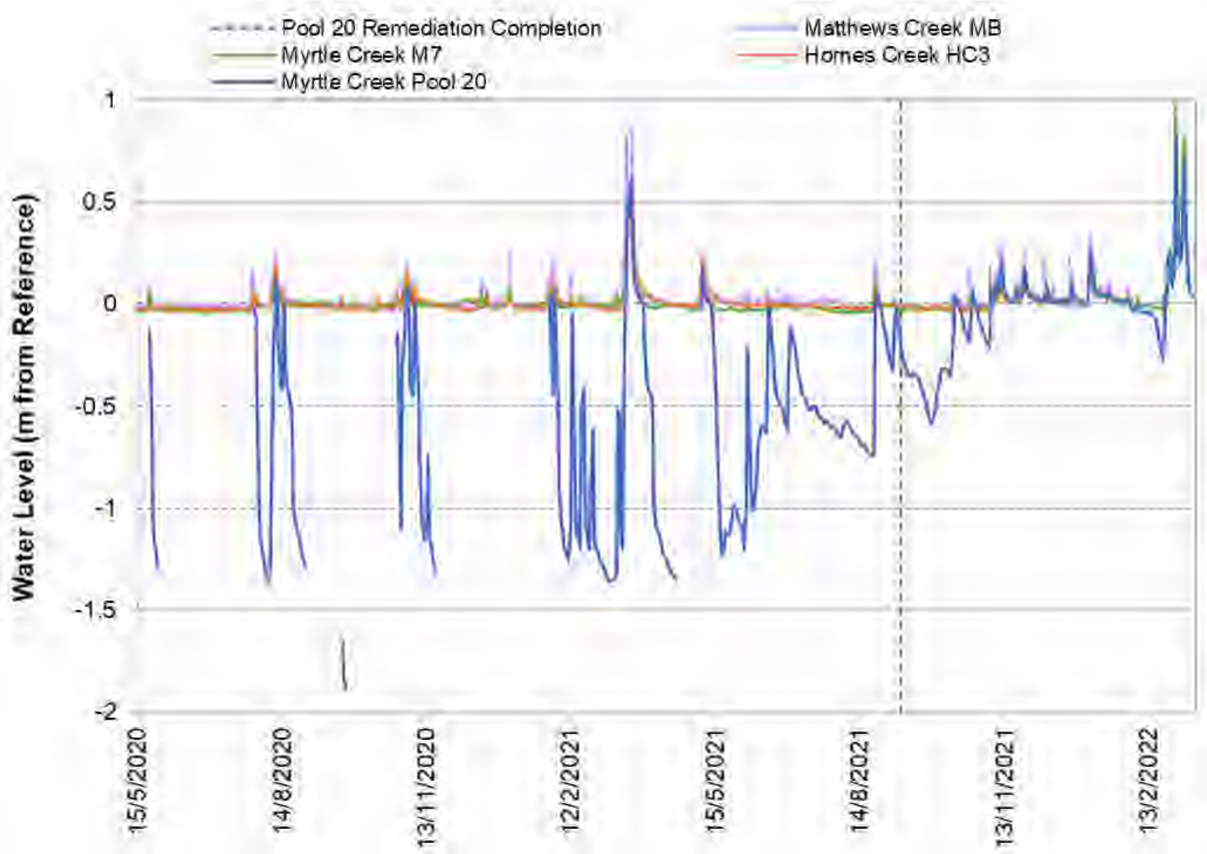
GRAPH 9: MYRTLE CREEK POOL 20 – METHOD 2 RECESSION CURVE COMPARISON

The data plotted in Graph 9 indicates that, during periods of low rainfall, the water level recorded at pool 20 post-remediation has remained at a higher level than that during the impact period and declined at a notably slower rate.

Graph 10 presents a comparison of pool 20 water level data and reference site data for Myrtle Creek M7, Hornes Creek HC3 and Matthews Creek MB.

The data presented in Graph 10 shows an evident difference in the hydrological behaviour of pool 20 pre-remediation in comparison to the reference site water level behaviour. From early November 2021 to March 2022, post-remediation and coinciding with a period of above average rainfall, the water level recessionary behaviour of pool 20 was generally consistent with that of the reference sites.

The outcomes of the Method 2 assessment indicate that there has been a notable improvement in the pool 20 water holding capacity post-remediation. As the area experienced above average rainfall during this period, it is recommended that additional post-remediation monitoring data is recorded during periods of below average rainfall to provide further confidence in the effectiveness of remediation works at pool 20.



GRAPH 10: MYRTLE CREEK POOL 20 AND REFERENCE SITES - WATER LEVEL COMPARISON

4.3.4 Aquatic Ecology Assessment Findings

The following summarises the outcomes of the aquatic ecology survey conducted in September 2021 at pool 20 and pool 30 (reference site), as detailed in Niche (2021a).

During the September 2021 survey, the reference site in Myrtle Creek (pool 30) scored in Band C indicating severely impaired conditions at a site in Myrtle Creek which has not been impacted by subsidence. This compared with a Band B score for the previous six survey events. Niche (2021a) note that the fluctuation in scores over seasons was likely related to natural variation in streamflow which resulted in altering of the aquatic habitat condition and availability, in addition to sampling variability inherent in the survey method.

During the September 2021 survey, pool 20 comprised of a shallow pool dominated by bedrock habitat. No macrophytes were observed in pool 20.

Monitoring results indicated that the water quality of pool 20 was generally consistent with other sites monitored in Myrtle Creek with the exception of pH, electrical conductivity and dissolved oxygen for which lower values were recorded at pool 20.

Based on the AUSRIVAS results, pool 20 scored in Band D which indicates an extremely impaired condition with only six different taxa observed. Pool 20 scored the lowest biotic index grade indicating the dominance of pollution tolerant macroinvertebrates and the presence of few pollution sensitive taxa.

Pool 20 recorded lower stream health results in comparison to other monitoring sites within Myrtle Creek. Niche (2021a) note that this may be indicative of a lag in recovery following remediation and the shallow nature of the pool. It is noted that the aquatic ecology survey was conducted immediately following completion of remediation works and, as such, the survey results do not represent a sufficient period of time for recovery of aquatic habitat at pool 20.

4.4 Pool 23

4.4.1 Introduction

As shown in Map 1, pool 23 in Myrtle Creek is situated above the eastern edge of LW28. The pool is formed in Hawkesbury Sandstone outcrop and is controlled by a raised rockbar extending across the width of the pool. A summary of the geomorphological characteristics of pool 23, following visual inspection conducted on 18 May 2021, is presented in Appendix A.

LW28 was mined between April 2014 and May 2015, however, impacts to pool 23, comprising fracturing of the rockbar control and reduced water holding capacity, were initially reported in April 2013 during mining of LW27 (GeoTerra, 2019b).

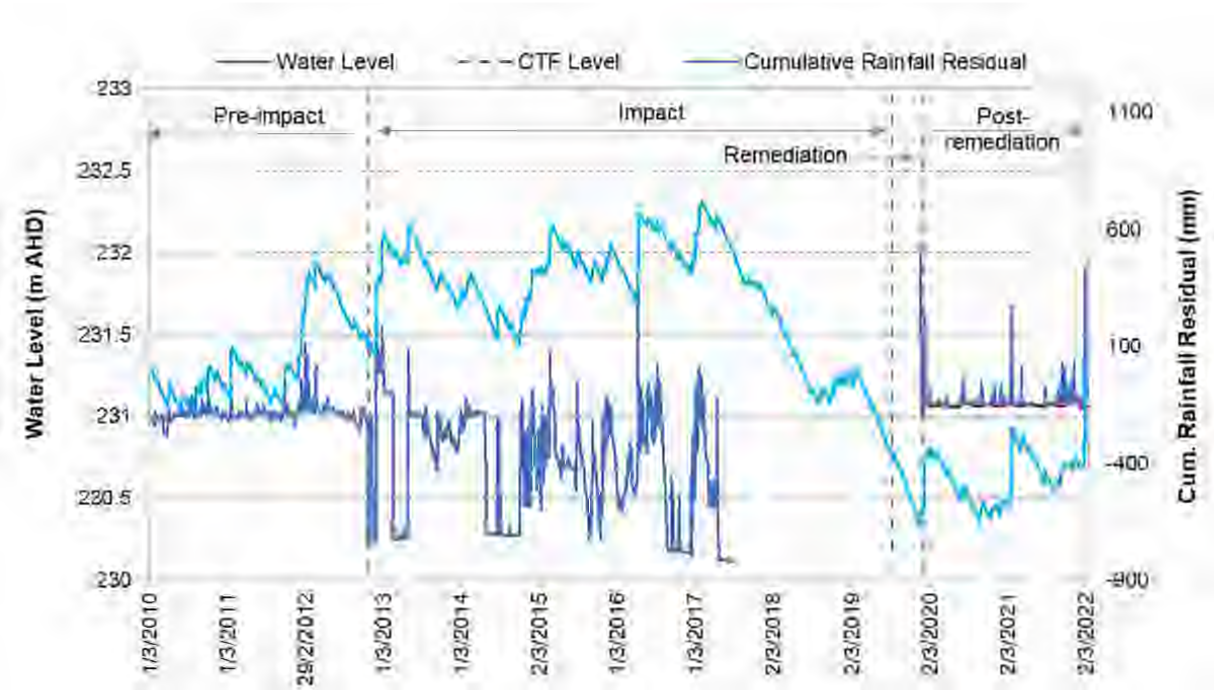
4.4.2 Summary of Remediation Works

Remediation works at pool 23 commenced in September 2019 and were completed in February 2020. The remediation works were conducted in four stages as follows (Pointe, 2020a):

1. Stage 1 – 44 m wide grout wall (perpendicular to the direction of flow): drilling of 10 holes (4 m spacing and 76 mm diameter) to a depth of 17 m below the rockbar and injection with Spetec H100 hydrophobic polyurethane.
2. Stage 2 – curtain infill injection to 2 m (perpendicular to the direction of flow): drilling of 20 holes (0.5 m spacing and 38 mm diameter) from 0 m to 2 m depth and injection with Spetec H100 hydrophobic polyurethane.
3. Stage 3 – drill and injection grid in the base of pool 23 – drilling of 37 holes (38 mm diameter) in a 14 m x 12 m grid with nodes at 2 m centres to a depth of 1 m and injection with Spetec H100 hydrophobic polyurethane; and
4. Stage 4 – curtain infill injection to 7 m (perpendicular to the direction of flow): drilling of 7 holes (76 mm diameter) from 2 to 7 m below the rockbar and injection with Spetec H100 hydrophobic polyurethane.

4.4.3 Surface Water Assessment Findings

Water level data for pool 23 in Myrtle Creek, recorded at sensor M5 (refer Map 1), is available for the period March 2010 to August 2018 and January 2020 to mid-March 2022. Graph 11 presents a graph of water level records for pool 23 in comparison with the cumulative rainfall residual. The CTF level is also presented however an accurate creek bed elevation is not available.



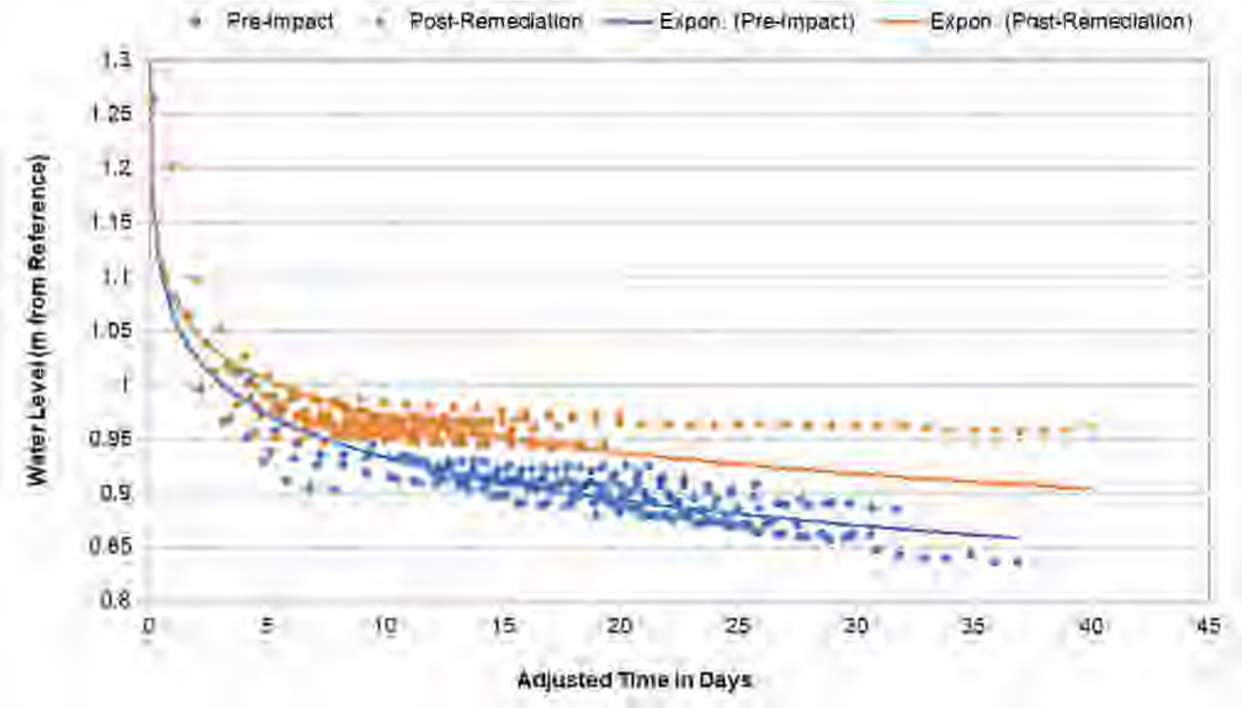
GRAPH 11: MYRTLE CREEK POOL 23 - WATER LEVEL RECORDS AND RAINFALL RESIDUAL

The data in Graph 11 shows a notable change in the water level and water level recessionary behaviour of pool 23 following subsidence impacts. Pre-impact, the water level was maintained above 230.9 m AHD. During the impact period, the water level declined below the level of the sensor on a number of occasions. Following remediation works, the pool water level has been recorded continuously above 231 m AHD, and above the CTF level, for 2 years.

During the pre-impact period the water level trended around 231 m AHD, while post-remediation, the minimum water level recorded was 231.1 m AHD. Given the slight difference in the pre-impact and post-remediation water levels, there is potential that a minor datum shift has occurred or that upsidence has resulted in a slight increase in the height of the controlling rockbar.

Method 1 has been applied to assess the water level recessionary behaviour for the pre-impact and post-remediation periods. Twenty-two (22) dry weather events were assessed for the pre-impact period and 18 events for the post-remediation period. Note that data recorded during the period of remediation works was excluded from the assessment.

Graph 12 presents the pre-impact and post-remediation period water level records against the adjusted time in days to produce a single recession curve for each period (refer Section 3). The exponential trendline fitted to each dataset is also presented.



GRAPH 12: MYRTLE CREEK POOL 23 – METHOD 1 RECESSION CURVE COMPARISON

Graph 12 shows that the post-remediation exponential curve is plotted above and is less steep than the pre-impact exponential curve indicating that the water level has declined at a slower rate post-remediation than was recorded pre-impact. This difference may be slightly over-exaggerated due to the potential datum shift, however, if the datum was adjusted, the post-remediation data would still indicate a reduction in the recession rate post-remediation. The results of the recession analysis indicate that the remediation works at pool 23 in Myrtle Creek have been effective in returning the pool water holding capacity to or better than pre-impact conditions.

4.4.4 Aquatic Ecology Assessment Findings

The following summarises the outcomes of the aquatic ecology surveys conducted between May 2019 and September 2021 at pool 23 and pool 30 (reference site), as detailed in Niche (2021a).

Pool 23 was dry in May and September 2019 prior to remediation works and was overflowing on all other survey occasions.

Monitoring results indicated that the water quality of pool 23 was similar on all survey occasions and was generally consistent with the water quality of the reference site in Myrtle Creek (pool 30 which has not been directly impacted by subsidence).

In May 2020, following remediation works, pool 23 scored in Band A based on the AUSRIVAS results indicating that the number of invertebrate families observed at pool 23 was considered similar to reference conditions. Between September 2020 and September 2021, pool 23 scored in Band B indicating that fewer invertebrate families were observed than was expected. However, the reference site in Myrtle Creek (pool 30) scored in Band B and Band C during this period indicating significantly to severely impaired conditions at a site in Myrtle Creek which has not been directly impacted by subsidence.

Pool 23 also scored higher than the reference site based on the survey results for habitat quality and ecosystem health.

Following remediation works, pool 23 has continued to provide aquatic habitat with the survey results indicating a recovery in stream health at this location.

5 REDBANK CREEK REMEDIATION PROGRESS ASSESSMENT OUTCOMES

5.1 Pool RB6

5.1.1 Introduction

As shown in Map 1, pool RB6 in Redbank Creek is situated above the maingate of LW29. The stream reach defined as pool RB6 is comprised of a series of pools formed in Hawkesbury Sandstone with notable sediment deposition and is rockbar controlled. A summary of the geomorphological characteristics of pool RB6, following visual inspection conducted on 20 May 2021, is presented in Appendix B.

LW29 was mined between May 2015 and April 2016, with fracturing of rock shelves and reduced pool holding capacity reported in GeoTerra (2016).

5.1.2 Summary of Remediation Works

Remediation works at pool RB6 commenced in July 2021 and were completed on 21 December 2021. Informed by the ground characterisation study (SCT, 2019) and review of groundwater monitoring data, the remediation works were conducted in four stages as follows (Tahmoor Coal, 2021):

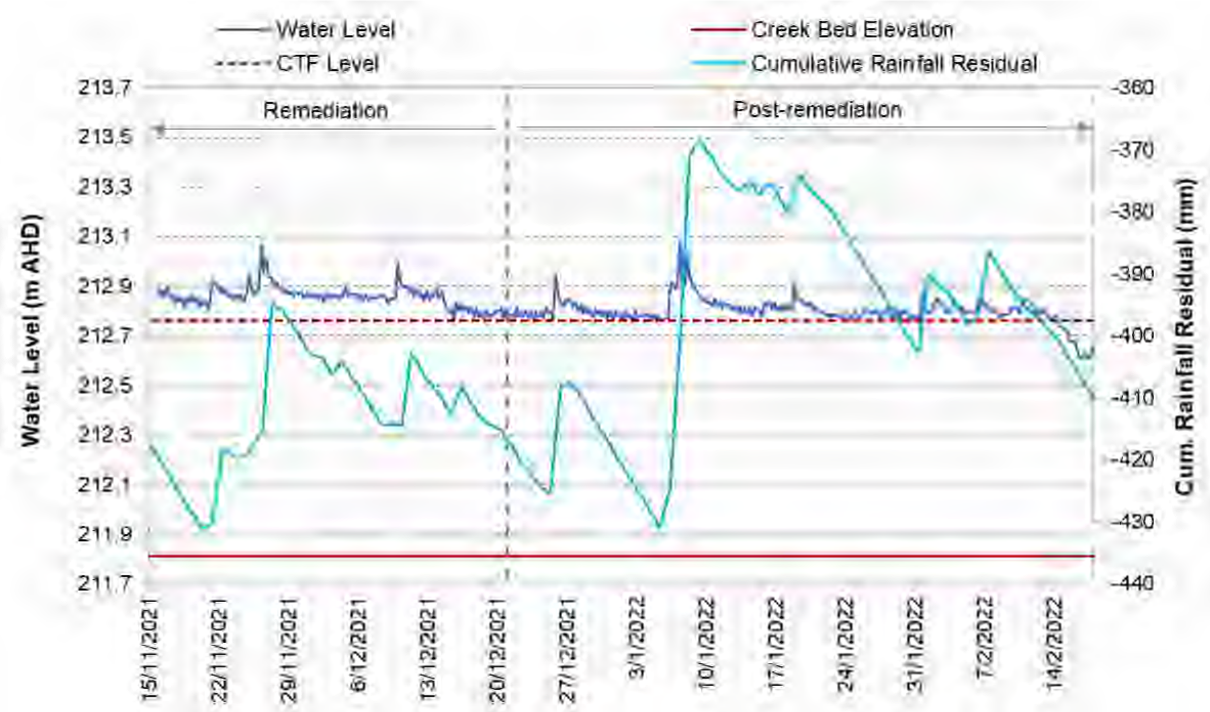
1. Stage 1 – 12 metre (m) wide shallow grout curtain (perpendicular to the direction of flow): drilling and injection to 2 m depth, 0.5 m spacing and 38 mm diameter using Spetec H100 hydrophobic polyurethane.
2. Stage 2 – 50 m wide grout curtain to 6 m depth (perpendicular to the direction of flow): drilling and injection from 0 m to 6 m depth, 2 m spacing and 76 mm diameter using Spetec H100 hydrophobic polyurethane.
3. Stage 3 - 50 m wide grout curtain to 12 m depth (perpendicular to the direction of flow): drilling and injection from 6 m to 12 m depth, 2 m spacing and 76 mm diameter using Spetec H100 hydrophobic polyurethane.
4. Stage 5 - 50 m wide grout curtain to 18 m depth (perpendicular to the direction of flow): drilling and injection from 12 m to 18 m depth, 2 m spacing and 76 mm diameter using Spetec H100 hydrophobic polyurethane.

5.1.3 Surface Water Assessment Findings

Visual inspections of pool RB6 were conducted weekly between December 2014 and March 2017. Prior to impact, pool RB6 was reported as holding water on all inspection occasions. Pool RB6 was initially reported as fractured in March 2016 although continued to hold water until January 2017. From January to March 2017, pool RB6 was reported as dry on nine of 10 inspection occasions (GeoTerra, 2019a). It is noted that the period January to March 2017 comprised the commencement of a drought (BoM, 2022).

Visual inspections of pool RB6 recommenced in 2021, prior to remediation works, and identified that the pool was dry majority of the time and only retained water after notable rainfall occurring over a 24 to 48 hour period (refer Appendix B for May 2021 photographs).

Water level data for pool RB6 in Redbank Creek is available for the period November 2021 to February 2022 which includes a portion of the remediation period and the post-remediation period. Graph 13 presents a graph of water level records for pool RB6 in comparison with the cumulative rainfall residual. The cumulative rainfall residual shown was calculated for the period March 2010 to March 2022. This period is shown as it is of notable length (more than 10 years of rainfall data) and therefore reflects variability in the rainfall record over time. Additionally, and for consistency, this period corresponds with the longest period of water level monitoring data recorded at the remediated pools.



GRAPH 13: REDBANK CREEK POOL RB6 - WATER LEVEL RECORDS AND RAINFALL RESIDUAL

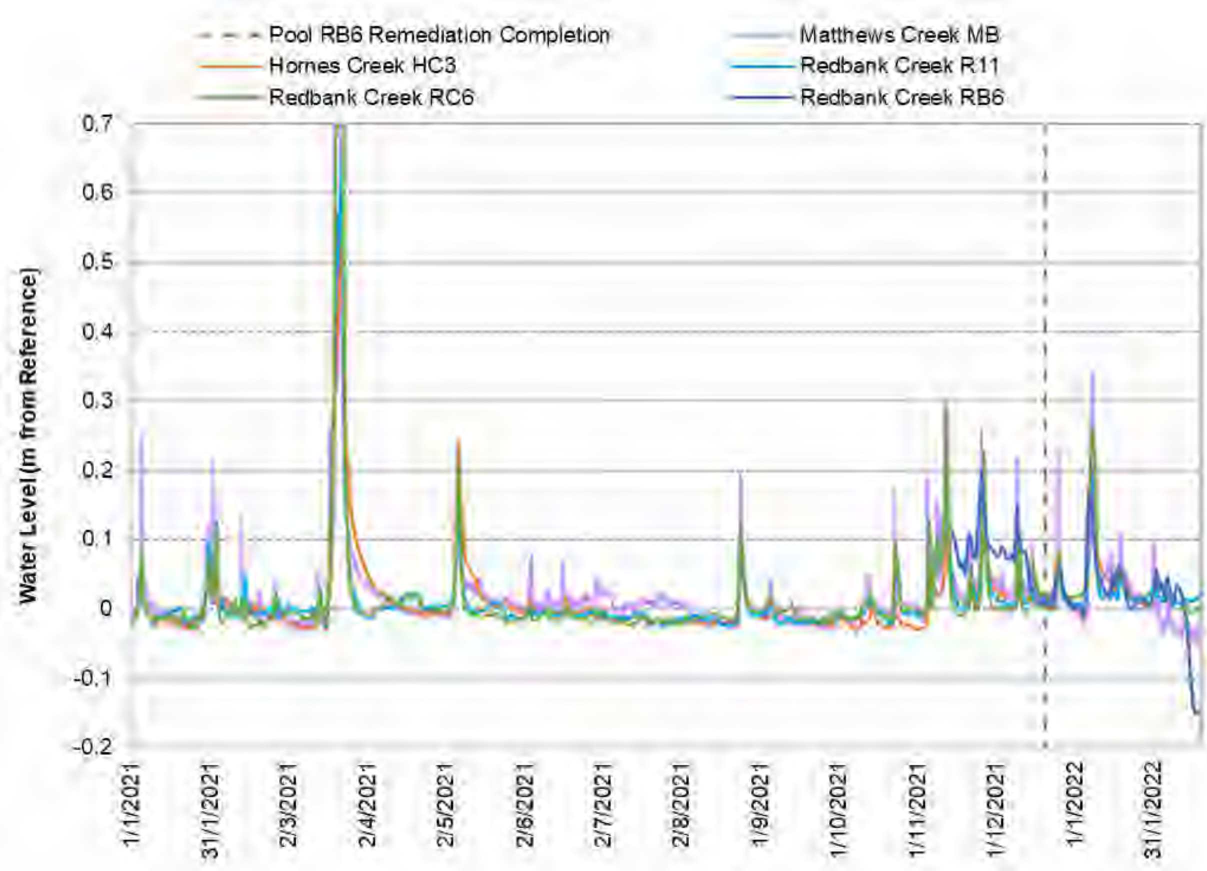
The data presented in Graph 13 shows that, during the remediation period and post-remediation, the pool water holding capacity recovered. This illustrates an evident improvement in pool RB6 water level following the completion of Stage 3 remediation works, in comparison with the visual inspection records for the impact period. The water level has been maintained above the CTF level for the majority of the monitoring period with the exception of a slight decline in water level of approximately 200 mm recorded from mid-February 2022 corresponding with a decline in the cumulative rainfall residual.

As water level monitoring data is not available for the pre-mining or impact periods, recession analysis has not been undertaken at this stage. Following a further period of monitoring in which sufficient dry weather events are available for analysis, the recessionary behaviour of pool RB6 will be compared to that of reference sites to aid in assessment of the effectiveness of remediation works at pool RB6.

Graph 14 presents a comparison of pool RB6 water level data and reference site data for Redbank Creek RC6, Redbank Creek R11, Hornes Creek HC3 and Matthews Creek MB from January 2021 to February 2022.

The data presented in Graph 14 shows that the water level recessionary behaviour of pool RB6 was generally consistent with that of the reference sites from mid-December 2021 to early February 2022. In mid-February 2022, a slight decline in water level was recorded at pool RB6 which was inconsistent in extent to that recorded at monitoring sites RC6 and R11 in Redbank Creek and somewhat inconsistent with the decline in water level recorded at Matthews Creek MB.

As only three months of monitoring data has been recorded post-remediation, additional post-remediation monitoring data is recommended to enable further assessment of the effectiveness of remediation works at pool RB6 in Redbank Creek.



GRAPH 14: REDBANK CREEK POOL RB6 AND REFERENCE SITES - WATER LEVEL COMPARISON

5.2 Pool RR11

5.2.1 Introduction

As shown in Map 1, pool RR11 in Redbank Creek is situated above LW30. The pool is formed in Hawkesbury Sandstone and is rockshelf controlled. A summary of the geomorphological characteristics of pool R11, following visual inspection conducted on 19 May 2021, is presented in Appendix B.

LW30 was mined between June 2016 and May 2017, with fracturing at pool RR11 and reduced pool holding capacity initially reported to have occurred in January 2016 during mining of LW29 (GeoTerra, 2016).

5.2.2 Summary of Remediation Works

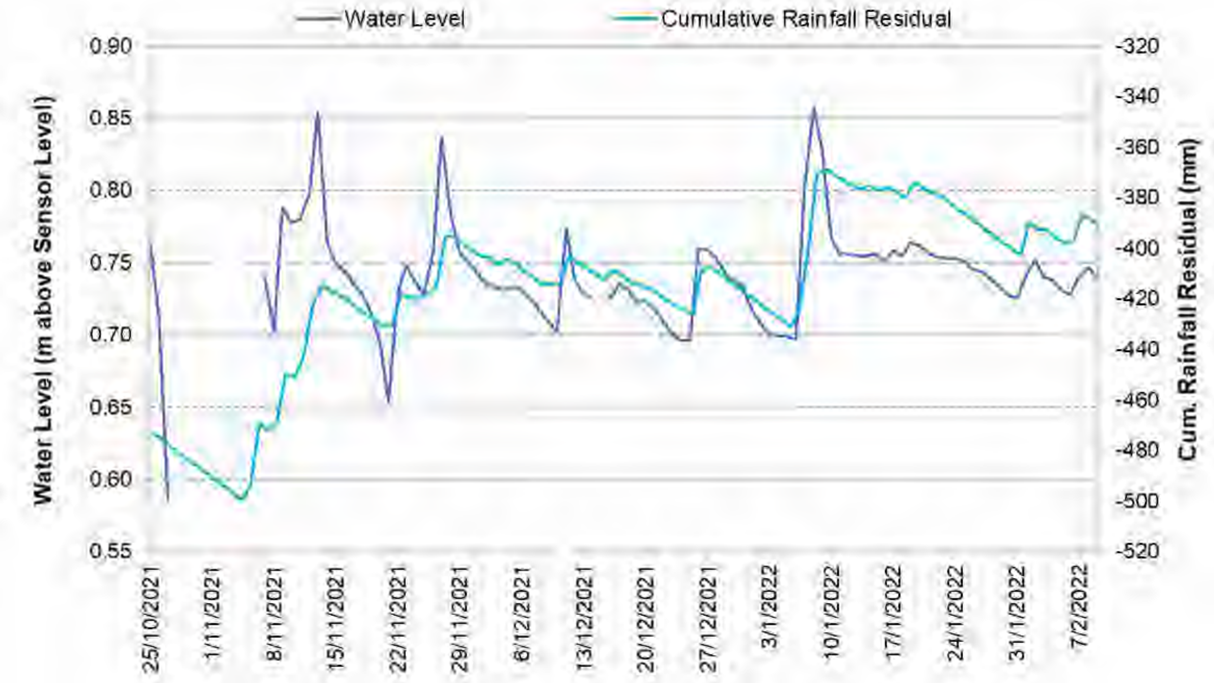
Remediation works at pool RR11 commenced in February 2020 and were completed in April 2020. Informed by the ground characterisation study (SCT, 2019) and review of groundwater monitoring data, the remediation works were conducted in one stage comprising of a 16 m wide grout wall (perpendicular to the direction of flow): drilling of 29 holes (0.5m spacing and 38 mm diameter) to a depth of 2 m and injection with Spetec H100 hydrophobic polyurethane (Pointe, 2020b).

5.2.3 Surface Water Assessment Findings

Visual inspections of pool RR11 were conducted weekly between December 2015 and September 2018. Prior to impact, pool RR11 was reported as holding water on all inspection occasions. Pool RR11 was initially reported as fractured in January 2016 although continued to hold water until January 2017. From

January 2017 to September 2018, pool RR11 was reported as dry on 25 of 27 inspection occasions (GeoTerra, 2019a). It is noted that the period of January 2017 to September 2018 has been classified as a drought (BoM, 2022).

Water level data for pool RR11 in Redbank Creek is available for the period October 2021 to February 2022, post-remediation. Graph 15 presents a graph of water level records for pool RR11 in comparison with the cumulative rainfall residual. An accurate CTF level and creek bed elevation is not available for pool RR11. The cumulative rainfall residual shown was calculated for the period March 2010 to March 2022. This period is shown as it is of notable length (more than 10 years of rainfall data) and therefore reflects variability in the rainfall record over time. Additionally, and for consistency, this period corresponds with the longest period of water level monitoring data recorded at the remediated pools.



GRAPH 15: REDBANK CREEK POOL RR11 - WATER LEVEL RECORDS AND RAINFALL RESIDUAL

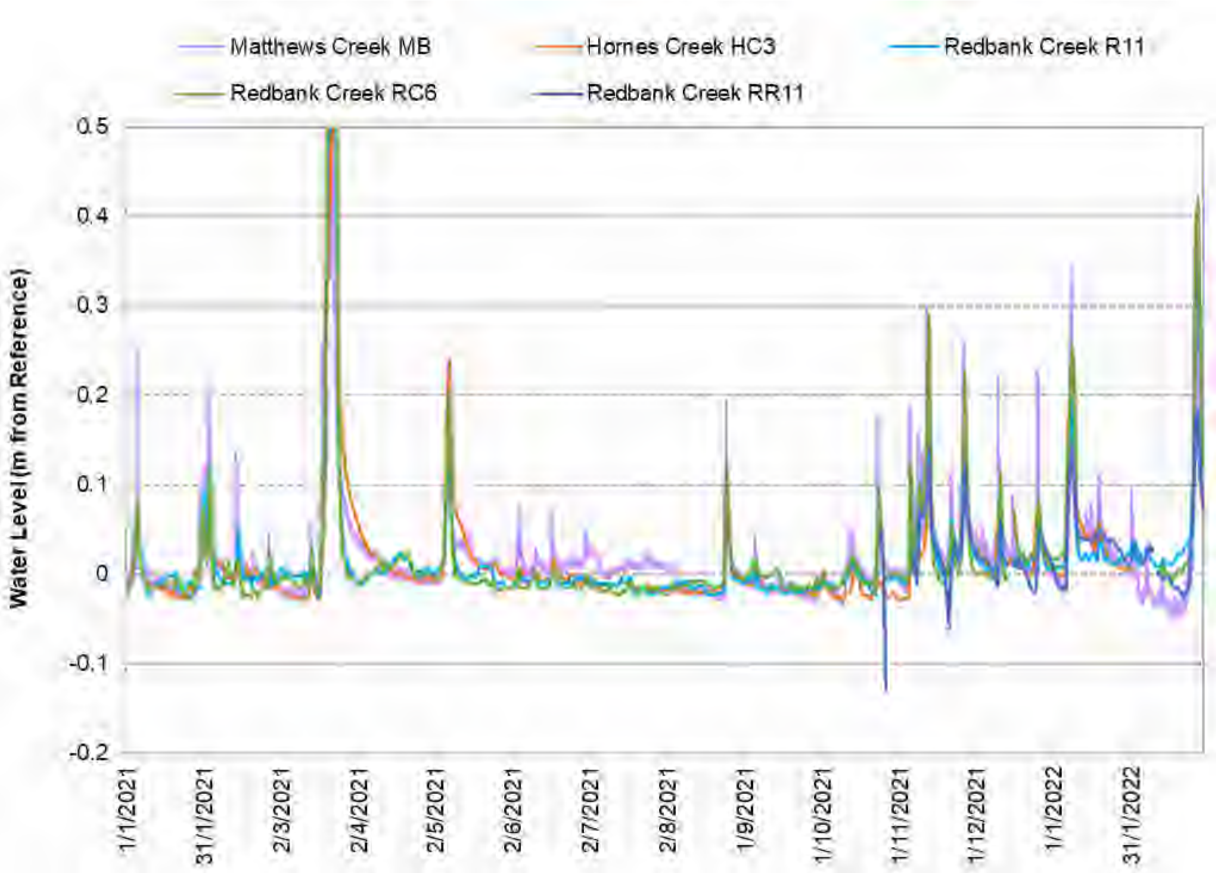
The data presented in Graph 15 shows that the pool RR11 water level averaged 0.74 m during the period October 2021 to February 2022. The water level was recorded above the level of the sensor for the majority of the monitoring period with the exception of late October 2021 to early November 2021 when the water level declined below the level of the sensor during a period of low rainfall. It is noted that pool RR11 was also holding water during a visual inspection conducted in May 2021 (refer Appendix B for photograph).

As pool RR11 water level data was not recorded during the pre-impact or impact periods, recession analysis has not been undertaken. Following a further period of monitoring in which sufficient dry weather events are available for analysis, the recessionary behaviour of pool RR11 will be compared to that of reference sites to aid in assessment of the effectiveness of remediation works at pool RR11.

Graph 16 presents a comparison of pool RR11 water level data and reference site data for Redbank Creek RC6, Redbank Creek R11, Hornes Creek HC3 and Matthews Creek MB.

The data presented in Graph 16 shows that, for the period of record, the water level recessionary behaviour of pool RR11 was generally consistent with that of the reference sites.

Additional post-remediation monitoring data is recommended to enable further assessment of the effectiveness of remediation works at pool RR11 in Redbank Creek.



GRAPH 16: REDBANK CREEK POOL RR11 AND REFERENCE SITES - WATER LEVEL COMPARISON

5.2.4 Aquatic Ecology Assessment Findings

The following summarises the outcomes of the aquatic ecology surveys conducted in autumn and spring 2021 at pool RR11 and pool RB33 (reference site), as detailed in Niche (2021b).

Monitoring results indicated that the water quality of pool RR11 was similar on both survey occasions and was generally consistent with the water quality of the reference site in Redbank Creek (pool RB33 which has not been directly impacted by subsidence) with the exception of elevated turbidity in September 2021.

Based on the AUSRIVAS results, pool RR11 scored in Band C and Band D in autumn and spring 2021 respectively indicating severely to extremely impaired stream health. The reference site pool RB33 scored in Band B and Band C indicating significantly to severely impaired stream health. However, Niche (2021b) note that aquatic ecology surveys conducted in 2007 and 2009 prior to mining indicated that Redbank Creek had significantly to extremely impaired stream health (Band B to Band D).

Pool RR11 scored low biotic index grades (less than 3) indicating a tolerance to pollution and environmental stress. However, Niche (2021b) note that this is common in low flow pool edge habitat in the region.

Few pollution sensitive taxa were observed in autumn 2021 and no pollution sensitive taxa were observed in September 2021. Niche (2021b) note that this may be the result of reduced habitat condition however could also reflect natural variability or sampling methods.

5.3 Pool RR19

5.3.1 Introduction

As shown in Map 1, pool RR19 in Redbank Creek is situated above LW31. The stream reach defined as pool RR19 is comprised of a series of shallow pools formed in a Hawkesbury Sandstone and is rockbar controlled. A summary of the geomorphological characteristics of pool RR19, following visual inspection conducted on 19 May 2021, is presented in Appendix B.

LW31 was mined between June 2017 and August 2018, with fracturing at pool RR19 and reduced pool holding capacity reported from April 2018 in GeoTerra (2019b).

5.3.2 Summary of Remediation Works

Remediation works at pool RR19 commenced in January 2021 and were completed in June 2021. Informed by the ground characterisation study (SCT, 2019) and review of groundwater and surface water monitoring data, the remediation works were conducted in five stages as follows (Tahmoor Coal, 2021):

1. Stage 1 – 6 metre (m) wide shallow grout curtain (perpendicular to the direction of flow): drilling and injection to 2 m depth, 0.5 m spacing and 38 mm diameter using Spetec H100 hydrophobic polyurethane.
2. Stage 2 – 40 m wide grout curtain to 6 m depth (perpendicular to the direction of flow): drilling and injection from 0 m to 6 m depth, 2 m spacing and 76 mm diameter using Spetec H100 hydrophobic polyurethane.
3. Stage 3 - 40 m wide grout curtain to 12 m depth (perpendicular to the direction of flow): drilling and injection from 6 m to 12 m depth, 2 m spacing and 76 mm diameter using Spetec H100 hydrophobic polyurethane.
4. Stage 4 – additional 8 m section of curtain wall to 12 m depth (perpendicular to the direction of flow).
5. Stage 5 – pattern grouting in the centre of pool RR19.

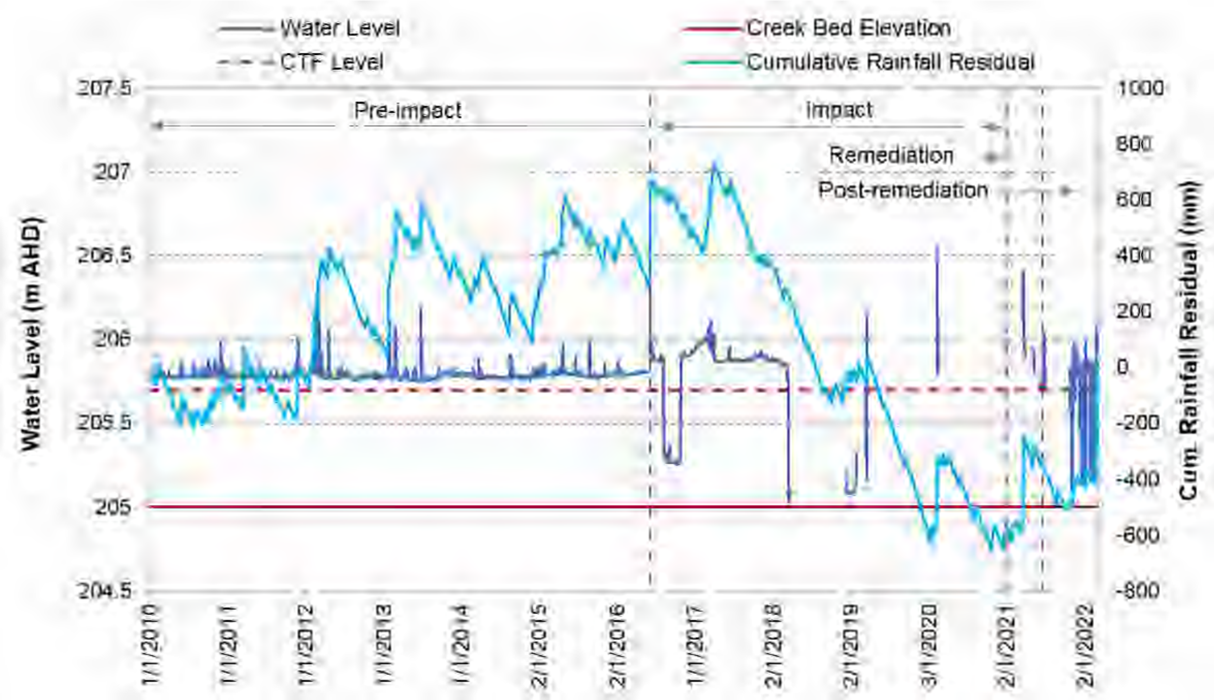
5.3.3 Surface Water Assessment Findings

Water level data for pool RR19 in Redbank Creek is available for the period January 2010 to February 2022. Graph 17 (A and B) presents the water level records for pool RR19 in comparison with the cumulative rainfall residual.

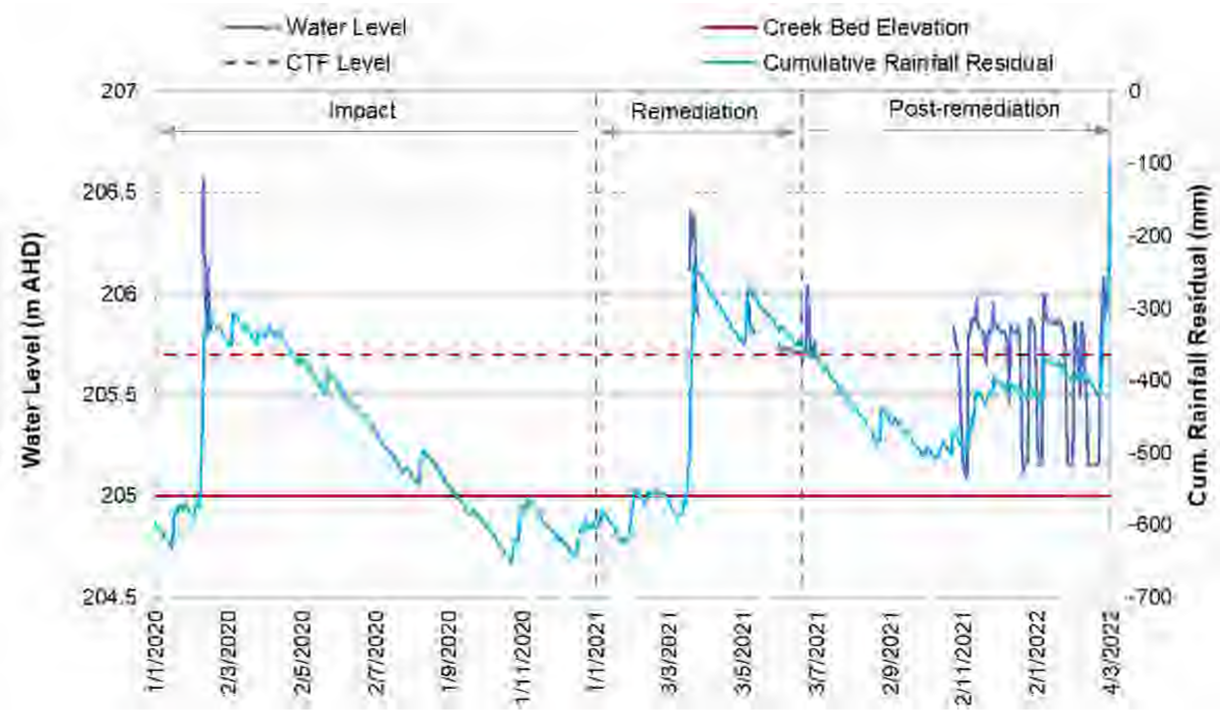
Although impacts to pool RR19 were reported as occurring during mining of LW31 (June 2017 to August 2018), the data indicates that impacts to pool RR19 water level may have occurred as early as mid-2016. Direct subsidence related impacts to pool RR19 may not have occurred as early as mid-2016, however, the decline in water level may reflect subsidence impacts to pools further upstream and/or regional groundwater depressurisation effects due to mining of LW22 to LW31.

Pre-impact, the water level was maintained above 205.8 m AHD. During the impact period, the water level regularly declined below the level of the sensor and was reported as dry on a number of occasions (GeoTerra, 2019a). Pool RR19 was dry for the majority of 2020 to mid-2021 despite substantial rainfall in early 2020 and 2021.

Post-remediation, the pool was recorded as dry until late October 2021 during a period of below average rainfall. From late October 2021, as rainfall increased, the water level rose and fell in response to rainfall events.

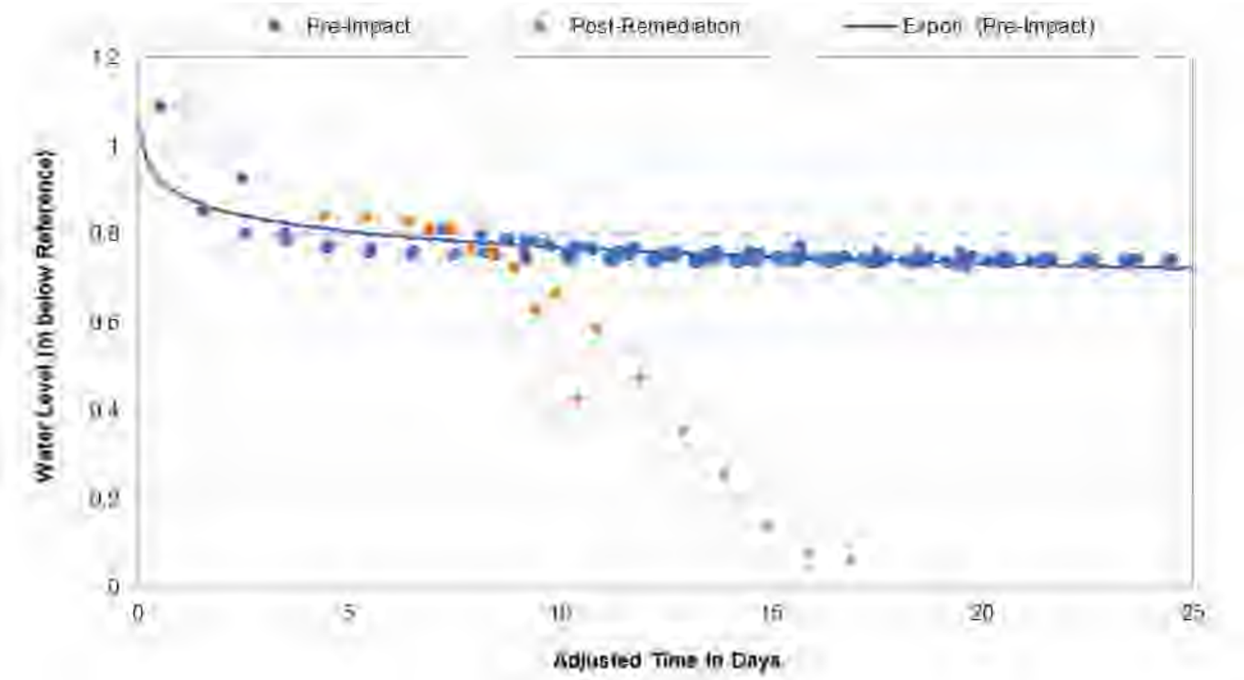


GRAPH 17A: REDBANK CREEK POOL RR19 - WATER LEVEL RECORDS AND RAINFALL RESIDUAL – 2010 TO 2022



GRAPH 17B: REDBANK CREEK POOL RR19 - WATER LEVEL RECORDS AND RAINFALL RESIDUAL – 2020 TO 2022

Method 1 has been applied to undertake a preliminary assessment of the water level recessionary behaviour comparing the pre-impact and post-remediation periods. While 15 pre-impact period dry weather events were able to be used for the assessment, due to the reduction in water level following impact, which has generally continued post-remediation, only two post-remediation dry weather events were able to be used (refer Section 3.1), hence the assessment is preliminary. For comparative purposes only, Graph 18 shows a graph of the pre-impact and post-remediation period water level records against the adjusted time in days. An exponential trendline has been fitted to the pre-impact period water level records, however, was unable to be fitted to the post-remediation water level records due to the decline in water levels.



GRAPH 18: REDBANK CREEK POOL RR19 – METHOD 1 RECESSION CURVE COMPARISON

Although preliminary only, the data presented in Graph 18 shows that, above 0.8 m, the water level recession rate post-remediation is similar to that of the pre-impact period recession rate showing an improvement of the pool holding capacity post-remediation. However, below 0.8m, the water level has declined to lower levels post-remediation than was recorded during the pre-impact period.

As only two post-remediation events were able to be assessed, the collection of additional post-remediation monitoring data, recorded during periods of low rainfall, is recommended to enable further assessment of the post-remediation recession rate of pool RR19.

As the water level regularly declined below the level of the sensor and the pool was reported as dry on a number of occasions during the impact period, insufficient data is available for the impact period to enable the Method 2 assessment to be undertaken for pool RR19.

5.3.4 Aquatic Ecology Assessment Findings

The following summarises the outcomes of the aquatic ecology survey conducted in spring 2021 at pool RR19 and pool RB33 (reference site), as detailed in Niche (2021b).

Monitoring results indicated that the water quality of pool RR19 was generally consistent with the water quality of other sites in Redbank Creek including the reference site (pool RB33 which has not been directly impacted by subsidence).

Based on the AUSRIVAS results, pool RR19 scored in Band C indicating severely impaired stream health. The reference site pool RB33 also scored in Band C in spring 2021.

Pool RR19 scored low biotic index grades (less than 2.2) indicating a tolerance to pollution and environmental stress. However, Niche (2021b) note that this is common in low flow pool edge habitat in the region.

No pollution sensitive taxa were observed in spring 2021 at pool RR19.

5.4 Weir / Pool 26

5.4.1 Introduction

Weir/pool 26 in Redbank Creek is situated above the eastern edge of LW31 (refer Map 1 for site location). The pool is formed in Hawkesbury Sandstone outcrop and is controlled by an approximately 1.5 m high concrete weir. A summary of the geomorphological characteristics of pool 26, following visual inspection conducted on 18 May 2021, is presented in Appendix B. Water level data for weir/pool 26, recorded at sensor R9, is available for the period January 2010 to present.

LW31 was mined between June 2017 and August 2018, however, impacts to the pool and weir, comprising fracturing of the weir and pool base and reduced water holding capacity, were initially reported in March 2017 during mining of LW30 (GeoTerra, 2019b).

5.4.2 Summary of Remediation Works

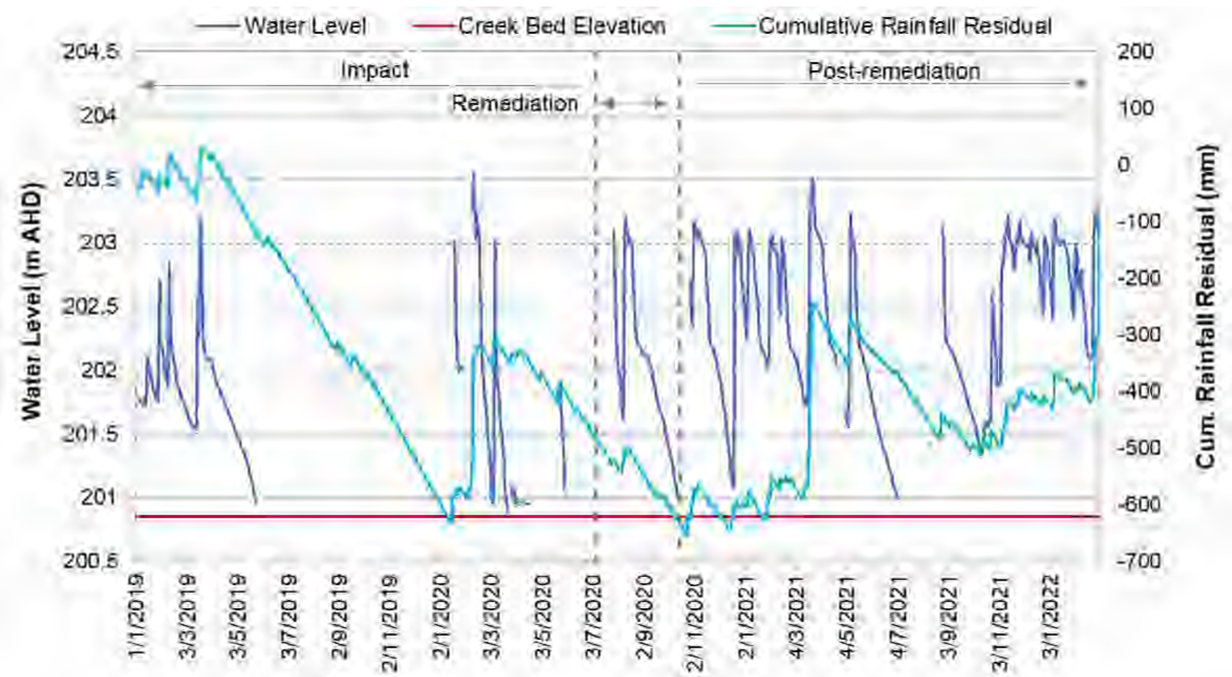
Remediation works at weir/pool 26 commenced in July 2020 and were completed in October 2020. Informed by the ground characterisation study (SCT, 2019) and review of groundwater monitoring data, the remediation works were conducted in stages as follows (Pointe, 2020c and Tahmoor Coal, 2021):

1. Weir cracks were identified and injected with Spetec H100 hydrophobic polyurethane.
2. Stage 1 – 6 metre (m) wide shallow grout curtain to 2 m depth (perpendicular to the direction of flow): drilling of 12 holes to 2 m depth (0.5 m spacing and 38 mm diameter) and injection with Spetec H100 hydrophobic polyurethane.
3. Stage 2 – 40 m wide grout curtain to 6 m depth (perpendicular to the direction of flow): drilling of 20 holes to 6 m depth (2 m spacing and 76 mm diameter) and injection with Spetec H100 hydrophobic polyurethane.
4. Stage 3 - 40 m wide grout curtain to 14 m depth (perpendicular to the direction of flow): drilling of 20 holes from 6 m to 14 m depth (2 m spacing and 76 mm diameter) and injection with Spetec H100 hydrophobic polyurethane.

5.4.3 Surface Water Assessment Findings

Graph (A and B) presents the water level records for Redbank Creek pool 26 compared with the cumulative rainfall residual.

GRAPH 19A: REDBANK CREEK POOL 26 - WATER LEVEL RECORDS AND RAINFALL RESIDUAL – 2010 TO 2022

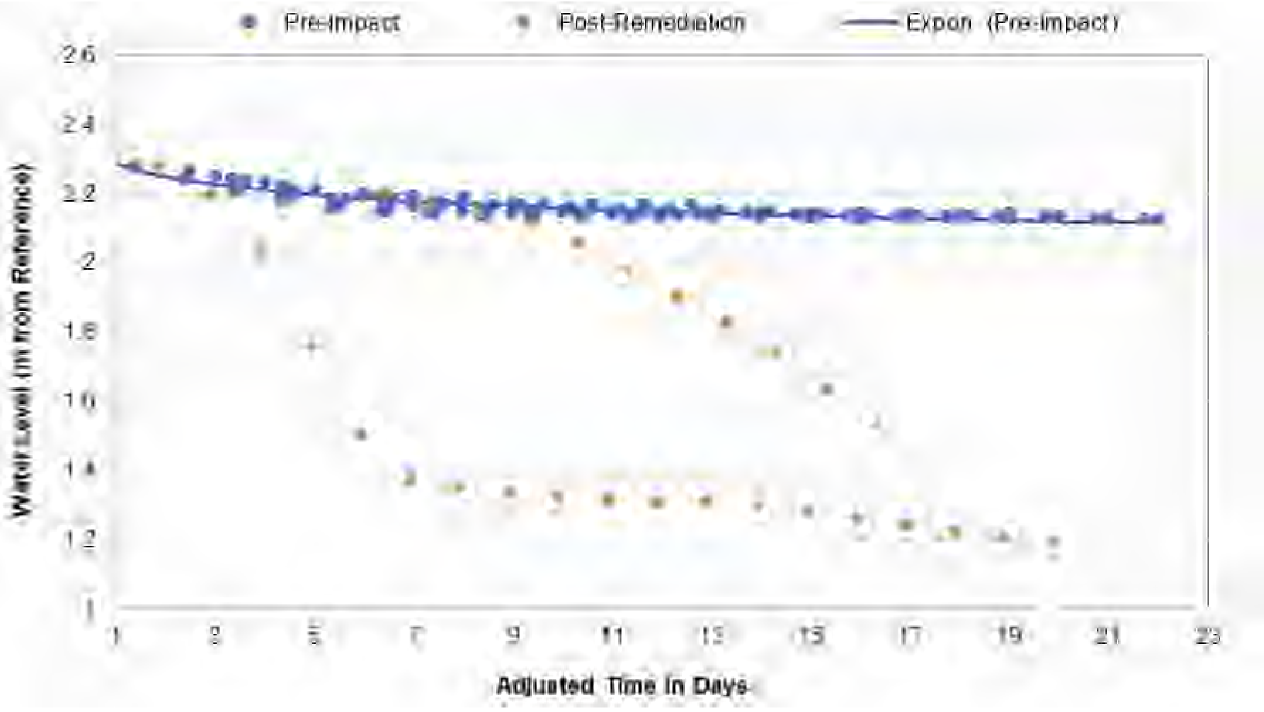


GRAPH 19B: REDBANK CREEK POOL 26 - WATER LEVEL RECORDS AND RAINFALL RESIDUAL – 2019 TO 2022

The data in Graph 19 (A and B) shows an evident change in the water level and water level recessionary behaviour of pool 26 from early 2016 and more substantially from early 2018 as rainfall declined. Prior to impact, the water level was predominately maintained above 202.97 m AHD. During the impact period, the water level declined below the level of the sensor and the pool was reported as dry on a number of occasions (GeoTerra, 2019a).

Following remediation works, the pool has held water more frequently than that during the impact period with the water level rising and falling in response to rainfall events. However, the pool water level behaviour has not returned to pre-impact conditions and the water level has at times declined to a similar minimum level (below the sensor level) to that recorded during the impact period despite above average rainfall during this period.

Method 1 has been applied to undertake a preliminary assessment of the water level recessionary behaviour comparing the pre-impact and post-remediation periods. While 24 pre-impact period dry weather events were able to be used for the assessment, only three post-remediation dry weather events were able to be used (refer Section 3.1), hence the assessment is preliminary. For comparative purposes only, Graph 20 shows a graph of the pre-impact and post-remediation period water level records against the adjusted time in days. An exponential trendline has been fit to the pre-impact period water level records, however, was unable to be fit to the post-remediation water level records due to the decline in water levels.



GRAPH 20: REDBANK CREEK POOL 26 – METHOD 1 RECESSION CURVE COMPARISON

Although preliminary only, the data presented in Graph 20 suggests that pool 26 water level declines at a similar rate post-remediation to that recorded during the pre-impact period when the water level is higher i.e. above 2.1 m local datum. Below 2.1 m local datum, the water level has declined at a faster rate and to lower levels post-remediation in comparison to the pre-impact period.

For comparative purposes, Method 2 has been applied to the recorded water level data for the impact and post-remediation periods. Graph 21 presents a plot of the water level (relative to a given reference level) for the impact and post-remediation period dry weather events against the adjusted time in days to produce a single recession curve for each dataset. Nine (9) dry weather events are presented for the impact period and 14 for the post-remediation period. The reference level adopted was the highest water level recorded during the impact period dry weather events (202.98 m AHD).

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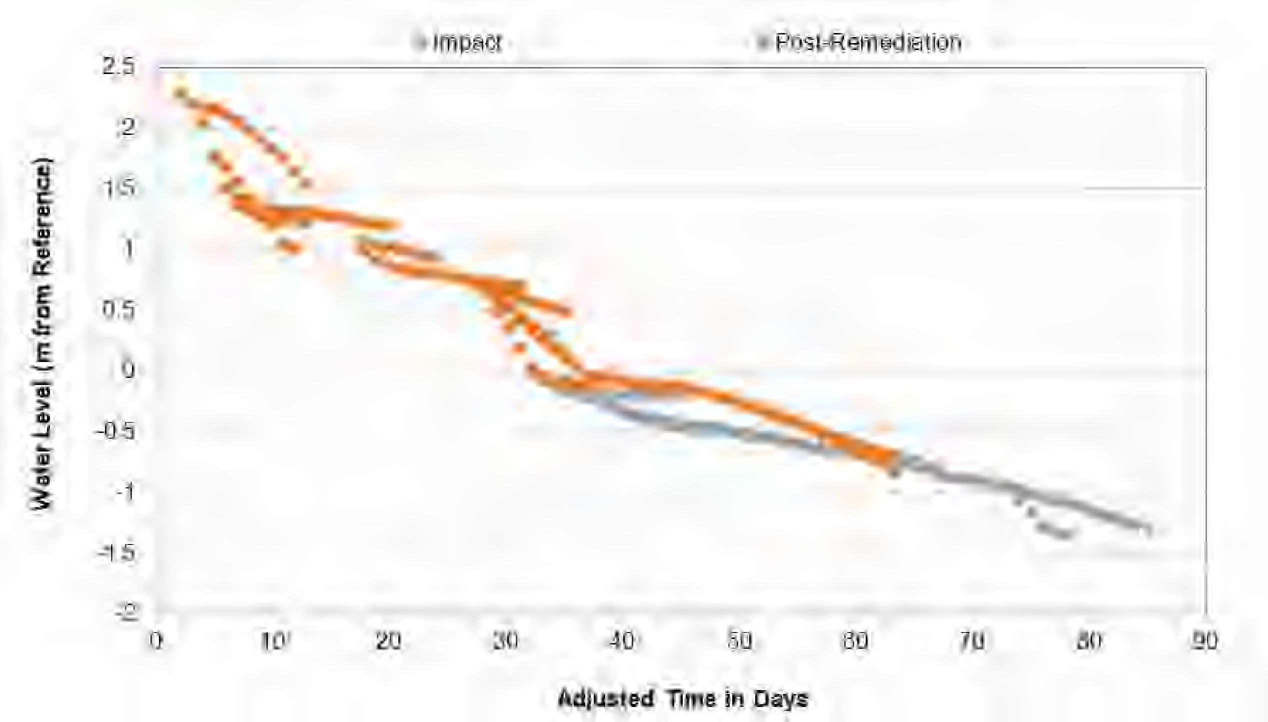

GRAPH 21: REDBANK CREEK POOL 26 – METHOD 2 RECESSION CURVE COMPARISON

The data plotted in Graph 21 shows that higher water levels (above 0 m from reference level) were recorded during the post-remediation dry weather events than were recorded during the impact period. There appears to have been a reduction in the rate of water level decline post-remediation when the water level was approximately 0 to 0.5 m below the reference level. From 0.5 m below the reference level, the water level appears to decline at a similar rate post-remediation to that recorded during the impact period. As shown in Graph 19B, the water level declined to the level of the sensor during one event post-remediation (the gap in the water level record). The full extent of this recession event is not plotted in Graph 21 because only events in which rainfall was not occurring are plotted.

Although there has been an improvement in the pool water holding capacity post-remediation, the data indicates that the pool water level has continued to decline more rapidly than during the pre-impact period. To enable further recession analysis, it is recommended that water level monitoring at pool 26 is continued and further assessment is undertaken.

5.4.4 Aquatic Ecology Assessment Findings

The following summarises the outcomes of the aquatic ecology surveys conducted in autumn and spring 2021 at weir/pool 26 and pool RB33 (reference site), as detailed in Niche (2021b).

Monitoring results indicated that the water quality of weir/pool 26 was similar on both survey occasions and was generally consistent with the water quality of the reference site in Redbank Creek (pool RB33 which has not been directly impacted by subsidence) with the exception of elevated turbidity recorded at weir/pool 26 in September 2021.

Based on the AUSRIVAS results, weir/pool 26 scored in Band B and Band C indicating moderate to severe impairment of stream health. The reference site pool RB33 also scored in Band B and Band C in autumn and spring 2021.

Weir/pool 26 scored low biotic index grades (less than 3.8) indicating a tolerance to pollution and environmental stress. However, Niche (2021b) note that this is common in low flow pool edge habitat in the region. Two pollution sensitive taxa were observed in both the autumn and spring 2021 surveys.

6 REMEDIATION PROGRESS REVIEW

The aquatic ecology survey results and outcomes of the recession analysis have been used as criteria for assessing the effectiveness of remediation works in Myrtle Creek and Redbank Creek. The effectiveness categories have been defined as:

- Low effectiveness: significantly lower ecological health score in comparison with reference site and no to little improvement in pool water holding capacity and water level recessionary behaviour.
- Low to moderate effectiveness: notably lower ecological health score in comparison with reference site and some improvement in pool water holding capacity and water level recessionary behaviour.
- Moderate effectiveness: lower ecological health score in comparison with reference site and moderate improvement in pool water holding capacity and water level recessionary behaviour.
- Moderate to high effectiveness: similar ecological health score in comparison with reference site and notable improvement in pool water holding capacity and water level recessionary behaviour.
- High effectiveness: similar to higher ecological health score in comparison with reference site and significant improvement in pool water holding capacity and water level recessionary behaviour.

Table 1 presents a summary of the effectiveness of remediation works in Myrtle Creek and Redbank Creek based on the aquatic ecology survey results and outcomes of the water level analysis. It should be noted that, for all pools except pool 23 in Myrtle Creek, the assessment of the effectiveness of remediation works is preliminary only, with additional post-remediation monitoring data required to enable further assessment.

TABLE 1: ASSESSMENT OF REMEDIATION EFFECTIVENESS TO DATE

Pool	Pool Water Holding Capacity	Water Level Recession	Aquatic Ecology	Level of Remediation Effectiveness to Date	Status of Assessment
Myrtle Creek					
Pool 10	Notable improvement – pool overflowing continuously for 2.5 months post-remediation	Similar behaviour to reference sites	No data	High (based on water level behaviour)	Preliminary assessment based on 2.5 months of post-remediation water level data – additional monitoring and assessment required
Pool 11	Moderate to high improvement – minimum water level maintained above the CTF level for over 3 months post-remediation	Similar pre-impact and post-remediation recession rates	No data	Moderate to high (based on water level behaviour)	Preliminary assessment based on 3 months of post-remediation water level data – additional monitoring and assessment required
Pool 18	Notable improvement from mid-November 2021 - pool overflowing continuously for 3 months post-remediation	From mid-November 2021, improvement in water level recessionary behaviour and similar to reference sites	No data	Moderate to high (based on water level behaviour)	Preliminary assessment based on 4.5 months of post-remediation water level data – additional monitoring and assessment required
Pool 20	Notable improvement from early November 2021 - pool overflowing for the majority of the post-remediation period	Notable improvement in water level recessionary behaviour and generally similar to reference sites	Lower ecological health score than reference site – however, only one survey conducted immediately following remediation	High (based on water level behaviour)	Preliminary assessment based on 6 months of post-remediation water level data – additional monitoring and assessment required
Pool 23	Significant improvement - pool overflowing continuously for over 2 years post-remediation	Similar pre-impact and post-remediation recession rates for the full range of recorded water levels	Higher ecological health scores than reference site – four post-remediation aquatic surveys conducted	High	Assessment complete

TABLE 1 (CONT.): ASSESSMENT OF REMEDIATION EFFECTIVENESS TO DATE

Pool	Pool Water Holding Capacity	Water Level Recession	Aquatic Ecology	Level of Remediation Effectiveness to Date	Status of Assessment
Redbank Creek					
Pool RB6	Notable improvement – pool overflowing nearly continuously for 3 months post-remediation	Notable improvement in water level recessionary behaviour (based on impact period visual inspection records) and generally similar to reference sites	No data	High (based on water level behaviour)	Preliminary assessment based on 3 months of water level data – additional monitoring and assessment required
Pool RR11	Pool holding water continuously for 3 months post-remediation	Notable improvement in water level recessionary behaviour (based on impact period visual inspection records) and generally similar to reference sites	Lower ecological health score than reference site	Moderate to high	Preliminary assessment based on 4.5 months of water level data – additional monitoring and assessment required
Pool RR19	Water level rising and falling in response to rainfall events from late October 2021 post-remediation	Some improvement in water level recessionary behaviour	Similar ecological health to reference site	Low to moderate	Preliminary assessment based on 8 months of water level data – additional monitoring and assessment required
Weir / Pool 26	Water level rising and falling in response to rainfall events post-remediation	Moderate improvement in water level recessionary behaviour	Similar ecological health to reference site	Moderate	Assessment based on 16 months of water level data – additional monitoring and assessment required

7 SUMMARY AND CONCLUSIONS

Tahmoor Coal has developed and implemented a Corrective Management Action Plan to reduce the impact of subsidence effects to Myrtle Creek and Redbank Creek. Remediation works, comprising grout curtains and pattern injection, have been conducted at sites in Myrtle Creek and Redbank Creek with the aim of improving pool water holding capacity, restoring overland connective flow and improving aquatic ecosystem health and aesthetic value.

The effectiveness of remediation works in Myrtle Creek and Redbank Creek has been assessed based on the aquatic ecology survey results and detailed analysis of water level recessionary behaviour. The assessment was undertaken for the following pools:

- Myrtle Creek: pool 23, 20, 18, 11 and 10.
- Redbank Creek: pool RB6, RR11, RR19 and weir/pool 26.

It should be noted that, for all pools except pool 23 in Myrtle Creek, the assessment of the effectiveness of remediation works is preliminary only with additional post-remediation monitoring data required to enable further assessment.

The water level data indicates that there has been an improvement in the water holding capacity of all pools post-remediation. The frequency and extent of elevated pool water levels is likely to further improve as remediation of upstream pools is conducted and connective streamflow is reinstated.

The effectiveness of remediation works in Myrtle Creek to date, in relation to improving pool water level recessionary behaviour, pool water holding capacity and ecological health, has been assessed as follows:

- Pool 10: high effectiveness based on water level analysis only;
- Pool 11 and pool 18: moderate to high effectiveness based on water level analysis only;
- Pool 20: high effectiveness based on water level analysis only; and
- Pool 23: high effectiveness.

The effectiveness of remediation works in Redbank Creek to date, in relation to improving pool water level recessionary behaviour, pool water holding capacity and ecological health, has been assessed as follows:

- Pool RB6: high effectiveness based on water level analysis only;
- Pool RR11: moderate to high effectiveness based on water level analysis only; and
- Pool RR19: low to moderate effectiveness; and
- Weir/pool 26: moderate effectiveness.

To enable further assessment of the effectiveness of remediation works, it is recommended that additional post-remediation monitoring data is recorded at all remediated pools in Myrtle Creek and Redbank Creek, with the exception of pool 23 in Myrtle Creek. A minimum of 24 months of post-remediation monitoring data is recommended prior to assessment completion.

Based on the analysis of two years of water level data recorded at pool 23 post-remediation and the results of four aquatic ecology monitoring campaigns, remediation works at pool 23 in Myrtle Creek have been effective in restoring pool water level recessionary behaviour, pool water holding capacity and ecological health to pre-mining conditions.

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APPENDIX A – MYRTLE CREEK POOL GEOMORPHOLOGICAL CHARACTERISATION

MYRTLE CREEK
POOL 10

Pool 10 – Downstream View to Rockbar Control

18 May 2021

General		
Stream	Myrtle Creek	
ID	Pool 10	
Approximate coordinates (GDA94) at downstream end of pool	278419 E 6211411 N	
Base RL	Approximately 251 m AHD	
Notable reference points	Water level sensor	
Longwall	Eastern edge of LW26	
Geomorphological Variables		
Description	Elongated pool	
Pool dimensions	Approximately 4 m wide x 20 m long	
Pool depth at overflow point	Approximately 1 m	
Hydraulic control	Rockbar	
Control features	Shallow rockbar extending across width of pool; obstructed by fallen trees and cut privet; flute holes; notable fractures; horizontal bedding planes	
Bed forms	Bedrock outcrop	
Bed material	Hawkesbury sandstone outcrop; bed not visible	
Valley shape	Left bank^: Compound stepped depositional: Approx. 1.5 m high silty/clay banks extending to heavily vegetated benched outcrop	Right bank^: Convex upwards: Approx. 8 m high, steeply inclined outcrop overlain with shallow clay/silty soil vegetation. Residential property on overbank.
Bank vegetation type and cover	Left bank^: Grass, wandering jew, vines privet, trees	Right bank^: Grass, scattered trees
Bed vegetation including debris	Fallen trees and leaf litter	
Pool tree canopy	Moderate to high canopy coverage	
Channel width	> 10 m	
Uniformity of bed profile	Not visible	
Bed scour features	Some scouring of shallow soil banks	
Bed eroding or accreting	Not visible	
Catchment landform	Partly confined valley	
Catchment Influences		
Catchment landuse	Predominately farmland to the north and residential development to the south	
Structures	N/A	
Mining related impacts	Fracturing and reduced pool water holding capacity	

^ Looking downstream

Surface Water Flow (18 May 2021)	
Pool water depth	Approximately 500 mm
Connective surface flow	Connective surface flow
Other observations	High turbidity

MYRTLE CREEK
POOL 11

Pool 11 – Upstream View from Rockbar Control

18 May 2021

Pool 11 – Downstream View from Rockbar Control

18 May 2021

General		
Stream	Myrtle Creek	
ID	Pool 11	
Approximate coordinates (GDA94) at downstream end of pool	278454 E 6211454 N	
Base RL	Approximately 249 m AHD	
Notable reference points	M4 water level sensor	
Longwall	Chain pillar between Longwall 26 and Longwall 27	
Geomorphological Variables		
Description	Elongated pool	
Pool dimensions	Approximately 4 m wide x 28 m long	
Pool depth at overflow point	Approximately 1 m	
Hydraulic control	Rockbar and boulders	
Control features	Raised rockbar extending across width of pool; weathered; horizontal bedding planes; fractures	
Bed forms	Bedrock outcrop	
Bed material	Hawkesbury sandstone outcrop and boulders; bed not visible	
Valley shape	Left bank^: Convex upwards: Approx. 1.0 m high silty/clay banks extending to gently inclined, approx. 5 m heavily vegetated outcrop	Right bank^: Irregular outcrop: Approx. 8 m high, steeply inclined, irregular outcrop. Some shallow soil and vegetation coverage. Residential property on overbank.
Bank vegetation type and cover	Left bank^: Grass, wandering jew, vines privet, trees	Right bank^: Grass, scattered trees
Bed vegetation including debris	Leaf litter	
Pool tree canopy	Moderate canopy coverage	
Channel width	> 15 m	
Uniformity of bed profile	Non-uniform	
Bed scour features	Some scouring of shallow soil banks	
Bed eroding or accreting	Variably eroding and accreting	
Catchment landform	Partly confined valley	
Catchment Influences		
Catchment landuse	Predominately farmland to the north and residential development to the south	
Structures	N/A	
Mining related impacts	Fracturing and reduced pool water holding capacity	

^ Looking downstream

Surface Water Flow (18 May 2021)	
Pool water depth	Approximately 500 mm
Connective surface flow	Connective surface flow; visible flow beneath rockbar
Other observations	High turbidity

TAILINGS.WATER.WASTE.

MYRTLE CREEK
POOL 18

Pool 18 – Upstream View of Pool

18 May 2021

Pool 18 – Downstream View of Rockbar

18 May 2021

<table>
<tr><th colspan="3">General</th></tr>
<tr><td>Stream</td><td colspan="2">Myrtle Creek</td></tr>
<tr><td>ID</td><td colspan="2">Pool 18</td></tr>
<tr><td>Approximate coordinates (GDA94) at downstream end of pool</td><td colspan="2">2788615 E
6211693 N</td></tr>
<tr><td>Base RL</td><td colspan="2">Approximately 243 m AHD</td></tr>
<tr><td>Notable reference points</td><td colspan="2">Water level sensor</td></tr>
<tr><td>Longwall</td><td colspan="2">Eastern edge of LW27</td></tr>
<tr><th colspan="3">Geomorphological Variables</th></tr>
<tr><td>Description</td><td colspan="2">Shallow, elongated pool</td></tr>
<tr><td>Pool dimensions</td><td colspan="2">Approximately 4 m wide x 30 m long</td></tr>
<tr><td>Pool depth at overflow point</td><td colspan="2">Approximately 1 m (pool base not visible)</td></tr>
<tr><td>Hydraulic control</td><td colspan="2">Rockshelf</td></tr>
<tr><td>Control features</td><td colspan="2">Elongated rockshelf extending across width of pool; some depressions and fracturing</td></tr>
<tr><td>Bed forms</td><td colspan="2">Bedrock outcrop</td></tr>
<tr><td>Bed material</td><td colspan="2">Hawkesbury sandstone outcrop; notable sediment, gravel and boulder deposition</td></tr>
<tr><td>Valley shape</td><td>Left bank^:
Compound stepped depositional:
Approx. 1.5 m high clay/silt banks, densely vegetated; extending to inclining open grassland</td><td>Right bank^:
Compound stepped depositional:
Approx. 1.5 m high clay/silt banks, densely vegetated; inclining to residential property</td></tr>
<tr><td>Bank vegetation type and cover</td><td>Left bank^:
Grass, wandering jew, privet, gum trees</td><td>Right bank^:
Grass, wandering jew, privet, willow and gum trees</td></tr>
<tr><td>Bed vegetation including debris</td><td colspan="2">Pool base not visible</td></tr>
<tr><td>Pool tree canopy</td><td colspan="2">Substantial canopy coverage</td></tr>
<tr><td>Channel width</td><td colspan="2">> 10 m</td></tr>
<tr><td>Uniformity of bed profile</td><td colspan="2">Non-uniform</td></tr>
<tr><td>Bed scour features</td><td colspan="2">Bank toe undercutting and exposed roots</td></tr>
<tr><td>Bed eroding or accreting</td><td colspan="2">Eroding</td></tr>
<tr><td>Catchment landform</td><td colspan="2">Partly confined valley</td></tr>
<tr><th colspan="3">Catchment Influences</th></tr>
<tr><td>Catchment landuse</td><td colspan="2">Predominately farmland to the north and residential development to the south</td></tr>
<tr><td>Structures</td><td colspan="2">N/A</td></tr>
<tr><td>Mining related impacts</td><td colspan="2">Fracturing and reduced pool water holding capacity</td></tr>
</table>

^ Looking downstream

Surface Water Flow (18 May 2021)	
Pool water depth	Approximately 700 mm
Connective surface flow	No connective surface flow
Other observations	N/A

MYRTLE CREEK
POOL 20

Pool 20 – Downstream View to Rockbar Control

18 May 2021

General		
Stream	Myrtle Creek	
ID	Pool 20	
Approximate coordinates (GDA94) at downstream end of pool	278714 E 6211736 N	
Base RL	Approximately 239 m AHD	
Notable reference points	Water level sensor	
Longwall	Western edge of LW28	
Geomorphological Variables		
Description	Large, elongated pool in sandstone race with plunge pool	
Pool dimensions	Approximately 9 m wide x 50 m long	
Pool depth at overflow point	Approximately 1.5 m (plunge pool); approx. 3.5 m total depth at rockbar	
Hydraulic control	Rockbar	
Control features	Raised rockbar extending across width of pool; approximately 2 m high, 5 m wide; open horizontal bedding planes; some lateral accretion	
Bed forms	Bedrock outcrop	
Bed material	Hawkesbury sandstone outcrop; weathered; flute holes; some gravel and sand	
Valley shape	Left bank^: Irregular bedrock: Approx. 5 m high irregular outcrop, horizontal bedding; extending to vegetated incline with large boulders	Right bank^: Compound stepped depositional: Approx. 2 m high stepped outcrop extending to inclined vegetated outcrop with boulders. Residential property on overbank.
Bank vegetation type and cover	Left bank^: Grass, wandering jew, privet, trees	Right bank^: Grass, wandering jew, privet, trees
Bed vegetation including debris	Some sedges; some leaf litter and twigs	
Pool tree canopy	Minor canopy coverage	
Channel width	> 10 m	
Uniformity of bed profile	Non-uniform	
Bed scour features	Some sculpting of bedrock; flute holes	
Bed eroding or accreting	Accreting	
Catchment landform	Partly confined valley	
Catchment Influences		
Catchment landuse	Predominately farmland to the north and residential development to the south	
Structures	N/A	
Mining related impacts	Fracturing and reduced pool water holding capacity	

^ Looking downstream

Surface Water Flow (18 May 2021)	
Pool water depth	Approximately 200 mm
Connective surface flow	No connective surface flow
Other observations	Notable fracturing of pool base and rock shelf

MYRTLE CREEK
POOL 23

Pool 23 – Downstream View to Rockbar Control

18 May 2021

General		
Stream	Myrtle Creek	
ID	Pool 23	
Approximate coordinates (GDA94) at downstream end of pool	278887 E 6211776 N	
Base RL	Approximately 232 m AHD	
Notable reference points	M5 water level sensor	
Longwall	Eastern edge of LW28	
Geomorphological Variables		
Description	Elongated pool	
Pool dimensions	Approximately 7 m wide x 25 m long	
Pool depth at overflow point	Approximately 800 mm (pool base not visible)	
Hydraulic control	Rockbar	
Control features	Raised rockbar extending across width of pool; approximately 7 m wide x 2.5 m long; evident fracturing	
Bed forms	Bedrock outcrop	
Bed material	Hawkesbury sandstone outcrop; bed not visible	
Valley shape	Left bank^: Irregular bedrock: Approx. 4 m high sheer outcrop, horizontal bedding; upper shallow soil layer	Right bank^: Compound stepped depositional: Approx. 4 m high benched outcrop overlain in parts with soil and vegetation; extending to residential property
Bank vegetation type and cover	Left bank^: Upper soil layer: grass, trees	Right bank^: Grass, wandering jew, privet, trees
Bed vegetation including debris	Negligible	
Pool tree canopy	Moderate canopy coverage	
Channel width	> 10 m	
Uniformity of bed profile	Not visible	
Bed scour features	Some sculpting of bedrock on left bank	
Bed eroding or accreting	Not visible	
Catchment landform	Partly confined valley	
Catchment Influences		
Catchment landuse	Predominately farmland to the north and residential development to the south	
Structures	N/A	
Mining related impacts	Fracturing and reduced pool water holding capacity during LW27 (GeoTerra, 2019a)	

^ Looking downstream

Surface Water Flow (18 May 2021)	
Pool water depth	Approximately 500 mm
Connective surface flow	Connective surface flow
Other observations	Approx. 20 m long upstream irregular rockbar with low flow channel; some flute holes

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APPENDIX B – REDBANK CREEK POOL GEOMORPHOLOGICAL CHARACTERISATION

REDBANK CREEK
POOL RB6

Pool RB6 – Upstream View of Upper Section

20 May 2021

Pool RB6 – Downstream View Mid-Section

20 May 2021

Pool RB6 – Downstream View Rockbar Control

20 May 2021

General		
Stream	Redbank Creek	
ID	Pool RB6	
Approximate coordinates (GDA94) of pool (DS)	278273 E 6213382 N	
Pool base RL	Approximately 214 m AHD	
Notable reference points	Rockbar characterization bore	
Longwall	Far east edge of LW29	
Geomorphological Variables		
Description	Series of pools in elongated reach	
Pool dimensions	Variable; < 6 m wide x < 10 m long; full reach approximately 80 m long	
Pool depth at overflow point	Approximately 1 m	
Pool hydraulic control	Rockbar	
Control features	Extends across width of pool; triangular in shape; approximately 7 m wide x 15 m long; semi-regular; one large fracture, other minor fractures; small to moderate flute holes	
Bed forms	Bedrock outcrop with substantial deposition; notable fractures	
Bed material	Hawkesbury Sandstone outcrop Upper reach – bedrock overlain with delaminated sandstone, boulders, sediment and gravel Upstream pool – bedrock overlain with soil/sediment (silty/clay) – tannic Mid to lower reach – bedrock overlain with sand/silt, some gravel – iron staining; horizontal bedding planes in outcrop; interspersed with boulders	
Valley shape	Left bank^: Largely planar: Steep outcrop, some boulders, soil coverage in parts	Right bank^: Largely planar: Steep outcrop, some boulders, soil coverage in parts
Bank vegetation type and cover	Left bank^: Grass, sedges, interspersed with trees	Right bank^: Grass, sedges, interspersed with trees
Bed vegetation including debris	Patchy grass, climbers in sections; tree branches Debris build-up at rockbar control – tree roots and branches, rubble	
Pool tree canopy	High canopy coverage	
Channel width	Low-flow channel width approximately 5 m; high flow channel width > 10 m	
Uniformity of bed profile	Non-uniform	
Bed scour features	Weathering of exposed bedrock; some soil bank undercutting	

^ Looking downstream

Geomorphological Variables	
Bed eroding or accreting	Variable
Catchment landform	Partly confined valley
Catchment Influences	
Catchment landuse	Predominately farmland with urban development in upper reaches
Structures	N/A
Mining related impacts	Fracturing observed during mining of LW29 (GeoTerra, 2016)
Surface Water Flow (20 May 2021)	
Pool water depth	Upstream pool approximately 300 mm
Connective surface flow	No visible surface flow
Other observations	N/A

REDBANK CREEK
POOL RR11

Pool RR11 – Downstream View

19 May 2021

General		
Stream	Redbank Creek	
ID	Pool RR11	
Approximate coordinates (GDA94) of pool	278366 E 6213425 N	
Pool base RL	Approximately 211.5 m AHD	
Notable reference points	N/A	
Longwall	Centre of LW30	
Geomorphological Variables		
Description	Ferruginous pool in outcrop	
Pool dimensions	Approximately 5 m wide x 10 m long	
Pool depth at overflow point	Approximately 750 mm	
Pool hydraulic control	Stepped rockshelf	
Control features	Elongated, stepped rockshelf; horizontal bedding planes	
Bed forms	Bedrock outcrop	
Bed material	Not visible	
Valley shape	Left bank^: Compound stepped depositional: Outcrop with soil and vegetation coverage	Right bank^: Compound stepped depositional: Steep outcrop, massive boulders, soil coverage at toe
Bank vegetation type and cover	Left bank^: Grass, sedges, trees	Right bank^: Grass, sedges, trees
Bed vegetation including debris	Not visible	
Pool tree canopy	Little canopy coverage	
Channel width	> 10 m	
Uniformity of bed profile	Non-uniform	
Bed scour features	Undetermined	
Bed eroding or accreting	Undetermined	
Catchment landform	Partly confined valley	
Catchment Influences		
Catchment landuse	Predominately farmland with urban development in upper reaches	
Structures	N/A	
Mining related impacts	Fracturing observed during mining of LW29 (GeoTerra, 2019a)	

^ Looking downstream

Surface Water Flow (19 May 2021)	
Pool water depth	Approximately 0.5 m; ferruginous – oily film and floc
Connective surface flow	Visible surface flow to RRS12
Other observations	N/A

REDBANK CREEK
POOL RR19

Pool RR19 - Upstream

19 May 2021

Pool RR19 - Downstream

19 May 2021

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Pool RR19 – Rockbar Control Looking Upstream

19 May 2021

General		
Stream	Redbank Creek	
ID	Pool RR19	
Approximate coordinates (GDA94)	278606 E 6213575 N	
Base RL	Approximately 207 m AHD	
Notable reference points	R8 water level sensor Water level sensor (Pointe) Remediation works	
Longwall	West edge of Longwall 31	
Geomorphological Variables		
Description	Rockshelf race with pools	
Pool dimensions	Approximately 4 m wide x 10 m long to upstream boulder field	
Pool depth at overflow point	Approximately 1 m	
Hydraulic control	Rockshelf	
Control features	Rockshelf extends along width of pool; approximately 10 m long; log jam/debris on upstream side; remediation works in place at time of inspection	
Bed forms	Rockshelf outcrop	
Bed material	Irregular rockshelf outcrop; rockbars intersecting shallow pools; deposited sediment; some boulders	
Valley shape	Left bank^: Convex upwards: approximately 3 m high, steeply sloped soil bank extending to moderately sloped convex bank and overbank	Right bank^: Compound stepped depositional: approximately 80 cm high, rockshelf ledge underlain with coarse sediment, extending to stepped outcrop with soil and vegetation coverage
Bank vegetation type and cover	Left bank^: Grass, sedges, privet, trees	Right bank^: Grass, sedges, privet, trees
Bed vegetation including debris	Minor vegetative debris upstream; log jams at downstream rockshelf	
Pool tree canopy	High canopy coverage	
Channel width	> 10 m	
Uniformity of bed profile	Non-uniform; variably contracting/expanding; slightly meandering	
Bed scour features	Erosional undercutting of sediment/soil beneath shallow rockshelf ledge; exposed roots	
Geomorphological Variables		
Bed eroding or accreting	Variable	
Catchment landform	Partly confined valley	

^ Looking downstream

Catchment Influences	
Catchment landuse	Predominately farmland with urban development in upper reaches and industrial development on left overbank and lower reach
Structures	N/A
Mining related impacts	Fracturing observed during LW31 (GeoTerra, 2019a)
Surface Water Flow (19 May 2021)	
Pool water depth	Approximately 150 mm upstream pool; approximately 100 mm downstream pool; ferruginous – oily film
Connective surface flow	No connective flow to pool RR20
Other observations	Reduction in surface flow between pool RR18 and pool RR19 – seepage and/or throughflow occurring

REDBANK CREEK
WEIR / POOL 26

Weir / Pool 26 – Looking Upstream

18 May 2021

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Weir / Pool 26 – Concrete Weir

18 May 2021

<table>
<tr><th colspan="3">General</th></tr>
<tr><td>Stream</td><td colspan="2">Redbank Creek</td></tr>
<tr><td>ID</td><td colspan="2">Weir / Pool 26</td></tr>
<tr><td>Approximate coordinates (GDA94)</td><td colspan="2">278823 E
6213627 N</td></tr>
<tr><td>Base RL</td><td colspan="2">Approximately 204 m AHD</td></tr>
<tr><td>Notable reference points</td><td colspan="2">Concrete weir
R9 water level sensor (one in upstream section and one in downstream section)</td></tr>
<tr><td>Longwall</td><td colspan="2">East edge of LW31</td></tr>
<tr><th colspan="3">Geomorphological Variables</th></tr>
<tr><td>Description</td><td colspan="2">Concrete weir constrained pool</td></tr>
<tr><td>Pool dimensions</td><td colspan="2">Approximately 5 m wide x 35 m long</td></tr>
<tr><td>Pool depth at overflow point</td><td colspan="2">Approximately 1.5 m</td></tr>
<tr><td>Hydraulic control</td><td colspan="2">Concrete weir</td></tr>
<tr><td>Control features</td><td colspan="2">Approximately 1.5 m high concrete weir extending across width of pool</td></tr>
<tr><td>Bed forms</td><td colspan="2">Bedrock outcrop overlain with deposited material</td></tr>
<tr><td>Bed material</td><td colspan="2">Hawkesbury sandstone outcrop; sediment/mud deposition; rockbar/boulder constriction dividing pool into two parts; notable fractures; instream boulders; iron staining</td></tr>
<tr><td>Valley shape</td><td>Left bank^:
Faceted/convex: rockshelf outcrop with soil/sediment layers, approximately 4 m high; extending to moderately sloped vegetated soil bank and overbank</td><td>Right bank^:
Compound erosional: outcrop largely overlain with soil bank approximately 3 m high; extending to benched outcrop with soil layers</td></tr>
<tr><td>Bank vegetation type and cover</td><td>Left bank^:
Grass, vines, privet, trees</td><td>Right bank^:
Grass, vines, privet, trees</td></tr>
<tr><td>Bed vegetation including debris</td><td colspan="2">Vegetative debris</td></tr>
<tr><td>Pool tree canopy</td><td colspan="2">Moderate canopy coverage</td></tr>
<tr><td>Channel width</td><td colspan="2">Approximately 10 m</td></tr>
<tr><td>Uniformity of bed profile</td><td colspan="2">Non-uniform</td></tr>
<tr><td>Bed scour features</td><td colspan="2">Erosion, some undercutting of soil banks; erosional sculpting of outcrop</td></tr>
<tr><td>Bed eroding or accreting</td><td colspan="2">Variable</td></tr>
<tr><td>Catchment landform</td><td colspan="2">Partly confined valley</td></tr>
</table>

^ Looking downstream

Catchment Influences	
Catchment landuse	Predominately farmland with urban development in upper reaches and industrial development on left overbank and in lower reach
Structures	Concrete weir
Mining related impacts	Reduced pool water holding capacity during LW31 (GeoTerra, 2019a)
Surface Water Flow (19 May 2021)	
Pool water depth	Approximately 20 - 30 cm; turbid; slightly ferruginous
Connective surface flow	No connective surface flow to downstream boulder field
Other observations	Seepage under concrete weir