Russell Vale Colliery

Revised Underground Expansion Project

WATER MANAGEMENT PLAN

Groundwater Management Plan

RVC EC PLN 006

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PROPERTY	VALUE
Approved by	Group Environment and Approvals Manager
Document Owner	Richard Sheehan
Effective Date	

Revisions

VERSION	DATE REVIEWED	REVIEW TEAM (CONSULTATION)	NATURE OF THE AMENDMENT
D1 (V1)	05/02/2021	Claire Stephenson	First draft document for review
D2 (V1)	05/03/2021	Claire Stephenson WCL	Version updated based on WCL comments on TARPS and alignment with other plans in preparation.
D3 (V1)	14/04/2021	Claire Stephenson WCL, DAWE	Version updated based on WCL comments and alignment with updates to the Public Environment Report from comments.
D4 (V1)	30/04/2021	Claire Stephenson WCL, WNSW, EPA	Version updated based on WCL comments and comments to the WMP and Waste Management Plan from WNSW and EPA.
D5 (V1)	14/05/2021	Claire Stephenson, WCL, DAWE	Version updated based on WCL comments and comments to the USMP from DAWE
D6 (V1)	30/07/2021	Claire Stephenson David Holmes WCL	Updates in response to updates to the USMP based on BDC consultation, and updates to address DPIE comments issued 22/07/21.
D7 (V1)	25/08/2021	WCL, Claire Stephenson	Updates by WCL in response to consultation with DPIE.
Rev 0	06/12/2021	DPIE	Final as approved by DPIE on 6 December 2021.
D1 (V2)	1/04/2022	WCL, Claire Stephenson	Version updated to reflect installation of additional monitoring points and alignment to Stage 2.
D1 (V3)	08/06/2022	WCL, Claire Stephenson	Amendments made to the plan post stakeholder comment and feedback.
F1	08/06/2022	WCL, Claire Stephenson	Finalisation for submission to DPE

1. INTRODUCTION

1.1 Project Background

Wollongong Coal Limited (WCL) operates the Russell Vale Colliery (RVC) (formerly known as NRE No 1 Colliery) located approximately 8 km north of Wollongong and 70 km south of Sydney. The RVC is located on the eastern slopes of the Illawarra Escarpment. Mining has been undertaken at RVC since the 1880s, including mining within the Bulli Seam, Balgownie Seam and the Wongawilli Seam. All three seams outcrop along the Illawarra Escarpment and the seams are accessed by adits (underground mine entrances) directly into the seams. There are two main mining areas within the RVC lease area, which are referred to as Wonga East and Wonga West.

The RVC Pit Top consists of the main surface infrastructure and facilities for the colliery, including coal stockpiles, drift portals, conveyors, truck loading facilities, administration buildings and water management infrastructure. The location of the RVC and mining areas relating to this extraction plan (EP) are shown in **Figure 1-1**.

The RVC has been in 'care and maintenance' since 2015 until September 2021, when coal production from first workings commenced. Previous mine owners Gujarat NRE Coking Coal Ltd sought approval to expand the longwall mining operations at RVC in 2009, with subsequent amendments to submissions by new owners WCL in 2013 and 2019 in response to reviews undertaken by the NSW Department of Planning, Industry and Environment (DPIE). The July 2019 submission provided major changes to the project to significantly reduce impacts from subsidence, including an amended mine plan which no longer involves longwall mining.

Development Consent MP 09_0013 (the Development Consent) for the revised Russell Vale East (RVE) Underground Expansion Project (UEP) was approved by the Independent Planning Commission (IPC) of New South Wales (NSW) on 8 December 2020. The approved development involves mining of panels within the Wonga East area by means of non-caving bord and pillar mining technique only, with workings designed to be long term stable with negligible subsidence impacts.

Mining within the UEP will be completed in a staged approach, with this EP covering mining of the panels within the "Stage 1" (PC07, PC08 and PC21 to PC25) and "Stage 2" (PC27 to PC34) EP areas. These areas are defined in **Figure 1-1** and further discussed in Section 2.7 of the EP.

The RVC UEP is also subject to the requirements of the Environment Protection and Biodiversity Conservation (EPBC) Act 1999, with EPBC approval 2020-8702 being granted by the Department of Agriculture, Water and the Environment (DAWE) on 31 August 2021. The EPBC Act Approval conditions are included in Section 1.4.3 of the EP.

1.2 Purpose and Scope

This Groundwater Management Plan (GWMP) has been prepared to address the combined consolidated Development Consent conditions relevant to RVE UEP workings and the EP. The GWMP relates to the groundwater systems potentially impacted by the approved operations. This Plan was prepared as a part of the Water Management Plan (WMP) as required by **Condition B17** and the EP WMP as required by **Condition C10g (iii)**. The general conditions of the Development Consent and general information detailed in the overarching WMP ***RVC EC PLN 019*** (developed in fulfilment of **Condition B17**) also apply to this GWMP, as a sub plan of the overarching WMP, as outlined in Section

1.3 of ***RVC EC PLN 019***. This GWMP provides the specific detail on the relevant water management practices and process in compliance with the relevant Development Consent conditions detailed in **Section 2**. This plan applies to the following features overlying or adjacent to the proposed extraction areas:

- Cataract Reservoir;
- Cataract Creek;
- Bellambi Creek;
- Bellambi Gully;
- Upland swamps; and
- Groundwater resources including Hawkesbury Sandstone.

This Plan addresses:

- Monitoring;
- Reporting;
- Impact assessment;
  - Trigger levels to initiate implementation of management, remedial or contingency measures;
  - implementation of remedial or contingency measures to groundwater systems if adverse mining induced degradation is observed;
  - Access to piezometers; and
  - Rehabilitation of groundwater systems and access routes, if required.

The aim of the plan is to:

- Monitor groundwater and swamp levels and water quality within the potentially affected areas;
- Assess potential changes to swamps and groundwater systems before, during and after mining;
- Identify hydraulic characteristics of the groundwater systems within the vicinity of the proposed workings;
- Determine potential changes to groundwater systems due to coal extraction and mine dewatering operations; and
- Report on any groundwater impact simulation and validation studies.

This GWMP has been prepared on a staged basis, in accordance with **Condition A21**, consistent with the project description outlined in Section 2.2 of ***RVC EC PLN 019***. This plan applies to the operations described in Stage 1 and Stage 2a of the surface infrastructure portion of the project, where no coal rejects are generated.

1.3 Plan Preparation and Consultation

1.3.1 Preparation of the Plan

In recognition of the requirements of **Condition B17(a)**, this GWMP has been prepared by a suitably qualified and experienced person, Ms Claire Stephenson from Umwelt Environmental and Social Consultants (Umwelt). Claire has Bachelor's degrees in Science (Geology) and Forestry with a first class research honours, a Master of Business Administration and is a certified lead auditor in Environmental Management Systems (ISO 14001:2015) with Exemplar Global. Claire has over 15 years' experience in groundwater consulting across Australia, with prior experience working in agriculture and forestry. Claire has extensive experience managing complex groundwater projects to meet Local Government, State and Commonwealth regulatory requirements. Over her career Claire has developed diversified skills and experience, including field investigation programs and fieldwork involving contaminated site sampling (soil and water), bore installation for water supply and monitoring, surface water and groundwater sampling, stygofauna sampling and hydraulic testing. Along with groundwater management plans, seepage investigations, water supply studies, compliance reporting (i.e. annual reviews and trigger reviews), planning and approvals (i.e. groundwater impact assessments). As well as numerical groundwater modelling, peer review, expert advice and independent auditing.

Claire has worked extensively on projects across NSW and has a good understanding of the site groundwater regime and predicted impacts, having assisted on the groundwater components of the RVE UEP Public Environment Report (PER).

1.3.2 Consultation during the environmental assessment process

Extensive community and government consultation has been carried out prior to and during the preparation of the original environmental assessment (EA), the Revised Project Report, the Submissions Report and other project-related assessment documentation. The primary objective of consultation was to keep the community, government agencies and other stakeholders informed and involved during project development process.

Surface water impacts associated with the Colliery and Bellambi Gully Creek Diversion Works have been a key concern to the local community. Community engagement has been carried out over a number of years and is summarised in Section 4.1.2 and Section 4.1.3 of the Revised Project Report.

A complete summary of previous and ongoing government agency and stakeholder consultation is provided in Table 4.5 of the Revised Project Report. Consulted parties included the following State and local government agencies, and roads and utilities authorities:

- Department of Planning, Industry and Environment (DPIE) (now Department of Planning and Environment [DPE]);
- Department of Resources and Geosciences (DRG);
- Department of Environment and Energy (DoEE) (now Department of Agriculture, Water and Environment [DAWE]);
- NSW Environment Protection Authority (EPA);
- Wollongong City Council (WCC);
- WaterNSW;

- The former Office of Environment and Heritage (OEH) now DPIE Biodiversity Conservation Services BCS; and
- the Independent Expert Panel for Mining in the Catchment.

1.3.3 Consultation during the preparation of the Management Plan

This Plan is being prepared as a part of the WMP as required by **Condition B17** and the EP WMP as required by **Condition C10g (iii)** in consultation with:

- Department of Planning and Environment – Water (DPE Water) (deferred to Natural Resources Access Regulator [NRAR];
- NSW EPA;
- WaterNSW; and
- Wollongong City Council (WCC).

Consultation records are included in the EP WMP Appendix A, with feedback received addressed in Section 1.6 of the EP WMP.

1.4 Distribution

In accordance with **Condition F17** of the Development Consent, WCL will make this Plan publicly available on the WCL website and will be responsible for its maintenance. A hard copy will also be kept at the Russell Vale Colliery, 7 Princes Highway, Corrimal, NSW 2518.

Any revisions undertaken will be the responsibility of WCL and any notifications will be sent accordingly. WCL will not be responsible for maintaining uncontrolled copies beyond ensuring the most recent version is maintained on WCL's computer system, website, and hard copy at the Russell Vale Colliery, 7 Princes Highway, Corrimal, NSW 2518.

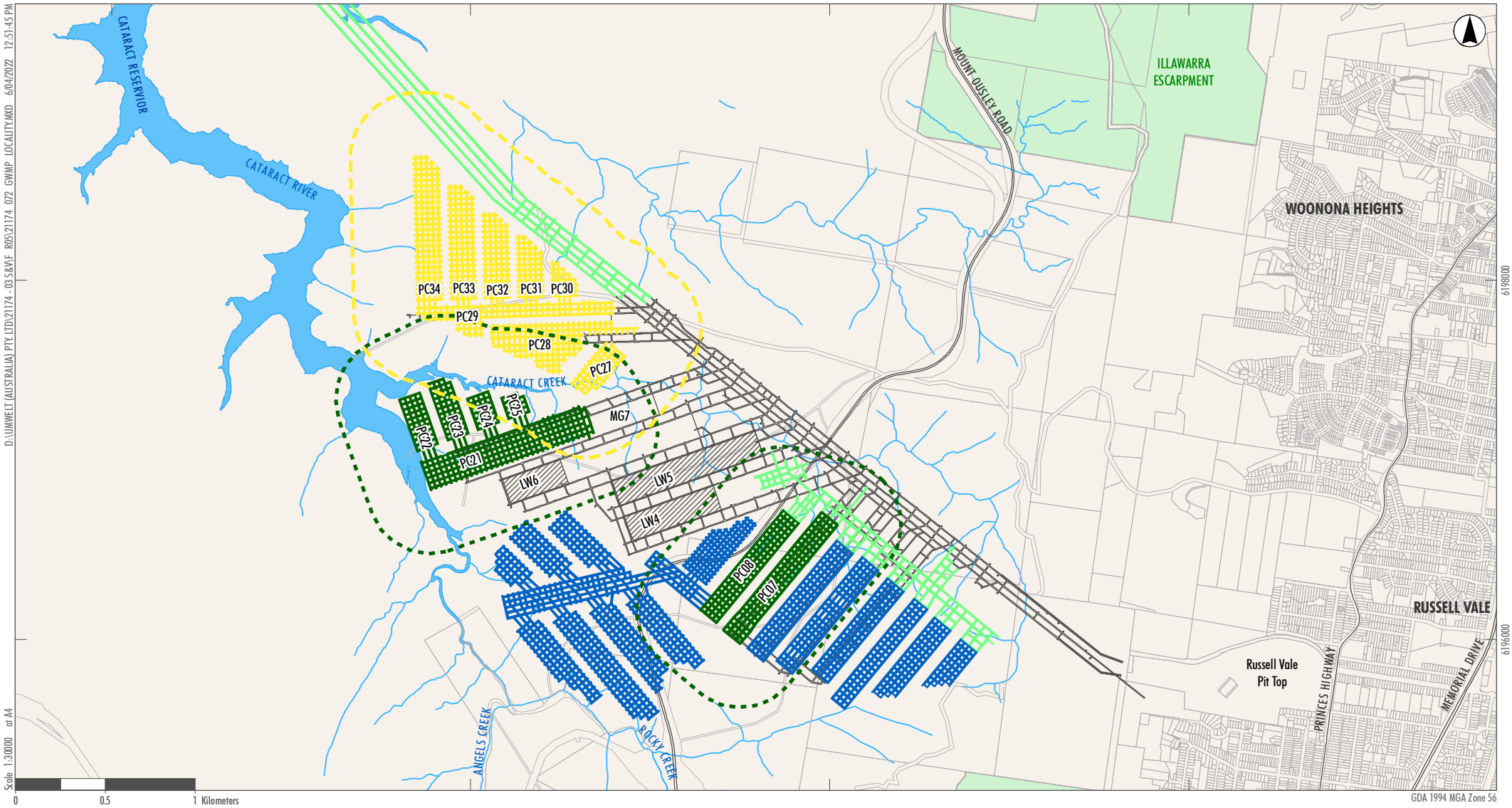


FIGURE 1.1
Mine Layout

Data source: DFSI (2020)

2. STATUTORY REQUIREMENTS

2.1 Development Consent

The GWMP has been prepared in accordance with the Development Consent conditions for the WMP B17(v) for the GWMP. The relevant Development Consent conditions are specified in **Table 1**, with reference to where each component of the condition is addressed within this Plan. This plan also covers groundwater specific requirements under condition C10 (g) (iii). Matters covered by the GWMP which are relevant to the management of groundwater features regulated by Condition C10 are detailed in **Table 2**.

Information relating to the Upland Swamps is included within this Plan for background where relevant to groundwater. However, monitoring and management requirements under condition c10(g)(v) Swamp Monitoring Program are captured separately under the Upland Swamp Monitoring Program (USMP) (RVC EC PLN 008).

Table 1 Groundwater Management Plan Development Consent Conditions B17

Development Consent Condition	Where addressed in this Plan
A1 - OBLIGATION TO MINIMISE HARM TO THE ENVIRONMENT In addition to meeting the specific performance measures and criteria established under this approval, the Applicant must implement all reasonable and feasible measures to prevent, and if prevention is not reasonable and feasible, minimise, any material harm to the environment that may result from the construction and operation of the project, and any rehabilitation required under this consent.	This document and other associated management plans, including WMP, EP WMP, Subsidence Monitoring Plan, Biodiversity Management Plan and Upland Swamp Ecological Monitoring Plan
B17 (v) Groundwater Management Plan	
Detailed baseline data of groundwater levels, yield and quality for groundwater resources potentially impacted by the development;	**Section 4** and **Section 5**
Detailed description of the groundwater management system	**Section 8.2**
Groundwater performance criteria, including trigger levels for identifying and investigating any potentially adverse groundwater impacts associated with the development, on: • regional and local aquifers (alluvial and hard rock); and • groundwater supply for other water users such as licensed privately-owned groundwater bores;	**Section 8.4**
A program to monitor and evaluate: • compliance with the relevant performance measures listed in Table 3 and the performance criteria in this plan; • water loss/seepage from water storages into the groundwater system	**Section 7** and **Appendix F**

Development Consent Condition	Where addressed in this Plan
• groundwater inflows, outflows and storage volumes, to inform the Site Water Balance; • the hydrogeological setting of any nearby alluvial aquifers and the likelihood of any indirect impacts from the development; and • the effectiveness of the groundwater management system.	
Reporting procedures for the results of the monitoring program, including notifying other water users of any elevated results.	**Sections 7** and **9.3**
Trigger action response plan to respond to any exceedances of the groundwater performance criteria, and repair, mitigate and/or offset any adverse groundwater impacts of the development.	**Section 8** and **Appendix G** and **Appendix H**
Program to periodically validate the groundwater model for the development, including an independent review of the model every 3 years, and a comparison of monitoring results with modelled predictions.	**Section 7.5**

Table 2 Groundwater Management Plan Development Consent Conditions – C10g (iii) Extraction Plan Water Management Plan

Development Consent Condition	Where addressed in this Plan
Water Management Plan which has been prepared in consultation with WCC, EPA, DPIE Water and WaterNSW, which provides for the management of potential impacts and/or environmental consequences of the proposed underground workings on watercourses and aquifers, including: • detailed baseline data on: - surface water flows and quality in water bodies that could be affected by subsidence, including Cataract River, Cataract Creek and all major associated tributaries: - groundwater levels, yield and quality in the region;	**Section 3.5**, **Section 4** and **Section 5** for groundwater. Refer EP WMP for surface water.
• surface and groundwater impact assessment criteria, including trigger levels for investigating any potentially adverse impacts on water resources or water quality;	**Section 6**, **Section 8**, **Appendix F**, **Appendix G** and **Appendix H.** Refer EP WMP for surface water.
• a surface water monitoring program to monitor and report on: - stream flows and quality; - stream and riparian vegetation health; and - channel and bank stability;	Refer EP WMP for surface water.

Development Consent Condition	Where addressed in this Plan
• a groundwater monitoring program to monitor and report on: - springs, their discharge quantity and quality, as well as associated groundwater dependent ecosystems; - groundwater inflows to the underground mining operations; - the height of groundwater depressurization; - background changes in groundwater yield/quality against mine-induced changes, in particular, on groundwater bore users in the vicinity of the site; - permeability, hydraulic gradient, flow direction and connectivity of the deep and shallow groundwater aquifers; and - impacts of the project on upland swamps (refer to condition C10(v) below) and other groundwater dependent ecosystems;	**Section 7**
• 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 8** and refer to EP WMP
• a program to validate the surface water and groundwater models for the project, and compare monitoring results with modelled predictions; and	**Section 7** and refer to EP WMP
• a plan to respond to any exceedances of the surface water and groundwater assessment criteria;	**Section 8** and **Appendix F**. Refer EP WMP for surface water.

2.2 Statement of Commitment

The following statements of commitment as outlined in **Table 3.**

Table 3 Groundwater Management – Statements of Commitment

Development Consent Condition	Timing	Where addressed in this Plan
The existing Russell Vale East Water Management Plan will be reviewed and updated in consultation with DPIE-Water, WaterNSW and DPIE-Planning and the updated plan will be implemented for the Revised Preferred Project. The updated plan will include the proposed approach to the updating of the groundwater model for use in the verification of monitoring.	Within 3 months of approval and ongoing	Refer to EP WMP

Development Consent Condition	Timing	Where addressed in this Plan
The existing groundwater monitoring network will continue to be utilised to monitor impacts associated with the Revised Preferred Project. The existing groundwater monitoring program will be reviewed and updated to reflect the Revised Preferred Project as part of an update to the existing Russell Vale East Water Management Plan. The groundwater monitoring program will include monitoring of groundwater levels, water quality, mine water inflows, pumping volumes and stream flows. The ongoing collection and interpretation of the data will be used to update the TARP trigger levels and the groundwater model as required.	Within 3 months of approval and ongoing	**Section 7**
Existing monitoring and management measures associated with the mining of longwalls 4 to 6, as set out in the existing Russell Vale East Water Management Plan and LW5 Water Management Plan will remain in place.	Ongoing, with regular review of the results, effectiveness and ongoing need for monitoring as set out in the Water Management Plan	Captured within this document
WCL will obtain WALs, or alternative mechanisms agreed in consultation with the Natural Resources Access Regulator, for all groundwater or surface water take in the course of mining.	Ongoing	Refer EP WMP

2.3 Relevant Legislation

The legislation relevant to this GWMP is consistent with that included in the EP WMP.

2.3.1 Water Management Act 2000

Water take associated with the RVE UEP is required to be licensed under the NSW *Water Management Act 2000*. Wollongong Coal holds a current Water Access Licence (WAL36488) for 515ML (units) per year within the Sydney Basin Nepean Groundwater Source - Nepean Management Zone 2 and were successful in a bid for a further allocation of 100 units within this groundwater source in early 2020. Wollongong Coal therefore holds sufficient allocation to account for the predicted maximum groundwater inflows to Russell Vale Colliery workings of 288ML/year (refer **Section 6**).

As discussed later in **Section 6**, the peak reduction in baseflow for Cataract River, Cataract Creek and Bellambi Creek combined is predicted to be very small, with the volume apportioned to the RVE UEP being between 2.3ML/year and 6ML/year.

Wollongong Coal currently holds sufficient licences to account for the volume of predicted water take at Russell Vale Colliery. These licences are however held in the water sharing plan relevant to groundwater sources only.

Full details on water licensing is included in the EP WMP.

2.4 Guidelines and Policies

This plan has been prepared with reference to the following documents:

- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC 2000)
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality – Water Quality Framework (ANZG 2018)
- Approved Methods for Sampling and Analysis of Water Pollutants in New South Wales (DEC, 2004)
- Australian Standard/New Zealand Standard (AS/NZS) 5667:1998 Parts 1, 4 and 6
- Barnett B., Townley L.R., Post V., Evans R.E., Hunt R.J., Peeters L., Richardson S., Werner A.D., Knapton A., Boronkay A. (2012), *Australian groundwater modelling guidelines: Waterlines report*, National Water Commission, Canberra
- Groundwater Monitoring and Modelling Plans – Introduction for prospective mining and petroleum activities (NSW Department of Industry, Water (DPIE Water) 2014)
- National Water Quality Management Strategy Guidelines for Groundwater Protection in Australia (ARMCANZ/ANZECC)
- National Water Quality Management Strategy (Department of Environment and Energy (DoEE) 2015)
- NSW State Groundwater Policy Framework Document (NSW Department of Land and Water Conservation [DLWC])
- NSW State Groundwater Quality Protection Policy (DLWC)
- NSW State Groundwater Quantity Management Policy (DLWC) Draft
- NSW Groundwater Dependent Ecosystem Policy (DLWC)
- Murray-Darling Basin Commission Groundwater Quality Sampling Guidelines Technical Report No 3 (MDBC).

3. GENERAL INFORMATION

3.1 Previous Mining

RVC is one of a number of underground coal mines within the Southern Coalfield. Other mining operations include Appin, West Cliff, North Cliff, Metropolitan, Tahmoor and Dendrobium mines. Regionally, the closest active mining operations include the Appin Mine located approximately 13 km to the northwest, operating in the Bulli Seam, and Dendrobium Colliery located approximately 12 km south west, operating in the Wongawilli Seam.

Underground mining has been undertaken at RVC since the 1880s, with extraction having occurred in the Bulli, Balgownie and Wongawilli Seams. These coal seams were accessed directly from the Illawarra escarpment via adit entries directly into the target coal seams. There are 24 known adits or portals into the Illawarra escarpment at RVC associated with historical mining activities. Three of these adit entries are associated with the mining of the Wongawilli Seam and will be utilised in future operations.

Within the Bulli Seam, bord and pillar mining, pillar extraction and numerous longwall panels have largely exhausted the Bulli Seam resource in the eastern part of the colliery lease holding. Bulli Seam mining in the RVE UEP area was effectively finished by the 1950s. Eleven longwall panels were mined in the Balgownie Seam between 1970 and 1982. Three short longwall panels (**Figure 1-1**) were mined in the Wongawilli Seam between 2012 and 2015 in the RVE UEP area. The effects of historical mining have therefore been experienced across the RVE UEP area over a long period of time.

Figure 1-1 shows the previous mining areas within and in the vicinity of the RVE UEP area. The primary historical longwall mining related impacts are associated with subsidence and groundwater.

3.2 Climate

RVC operates an Automated Weather Station (AWS) at the RVC Pit Top (**Figure 1-1**) for the purpose of collecting meteorological data and informing environmental management activities at the Pit Top.

Rainfall data at site has been monitored since November 2013 to present. **Table 4** includes a summary of site rainfall data and monthly rainfall trends are shown in **Figure 3-1**. Site rainfall monitoring indicates that the annual rainfall at RVC has varied from 866 mm (2019) to 1,756 mm (2015), with an average annual rainfall of 1,115.70 mm/year. Average monthly rainfall at site is around 59.83 mm to 157.75 mm; however, this can vary between 20 mm/month to 202 mm/month (10th and 90th percentile range).

Longer term rainfall data is also available from the Scientific Information for Land Owners (SILO) database of historical climate records for Australia (Queensland Government 2022). SILO interpolates rainfall records from available stations for an area within 100 km of the coordinates Latitude -34.35/Longitude 150.85. The historical average monthly rainfall data collected by SILO between 01/01/1900 to 01/01/2022 is shown in **Table 4**. The table shows the historical regional data has an average annual rainfall of 1,259.600 mm/year.

Table 4 Long Term Average and 2021 Climate Data

Rainfall (mm)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Historical Average (Site)	73.53	87.64	190.79	107.33	81.03	125.57	61.98	122.91	46.40	83.86	64.93	69.74	1115.70
2021Rainfall (Site)	25.90	8.20	*	*	3.21	48.68	4.55	0.00	37.11	112.23	56.45	60.25	-
Historical Average (SILO)	141.07	162.40	150.35	125.62	118.87	124.36	94.67	79.31	71.59	93.80	109.04	113.11	1384.18
2021 Rainfall (SILO)	131.00	112.4	289.3	18.10	143.20	55.80	28.00	66.00	41.50	94.50	176.40	103.40	1259.60

*Note: * no rainfall data collected at AWS in March and April 2021*

On average, February is the wettest month and September is the driest month. Regionally, January is typically the warmest month, with July the coolest. SILO historical regional data has an average annual pan evaporation of 1,365 mm/year (Queensland Government 2020).

The cumulative rainfall departure (CRD) has been calculated for site data and the longer term SILO data, as presented in **Figure 3-1** and **Figure 3-2**. CRD graphically shows trends in recorded rainfall compared to long-term averages and provides a historical record of relatively wet and dry periods. A rising trend in slope in the CRD graph indicates periods of above average rainfall, a declining slope indicates periods when rainfall is below average, and a level slope indicates average rainfall conditions. As shown in **Figure 3-1**, based on the short term site data, the area experienced below average rainfall from around 2016 to 2018, after which time the site experienced variable rainfall. When comparing to longer term trends (**Figure 3-2**) the data shows a more prolonged period of below average rainfall has been experienced in the region since 1990.

Figure 3-1 Cumulative Rainfall Departure (Site)

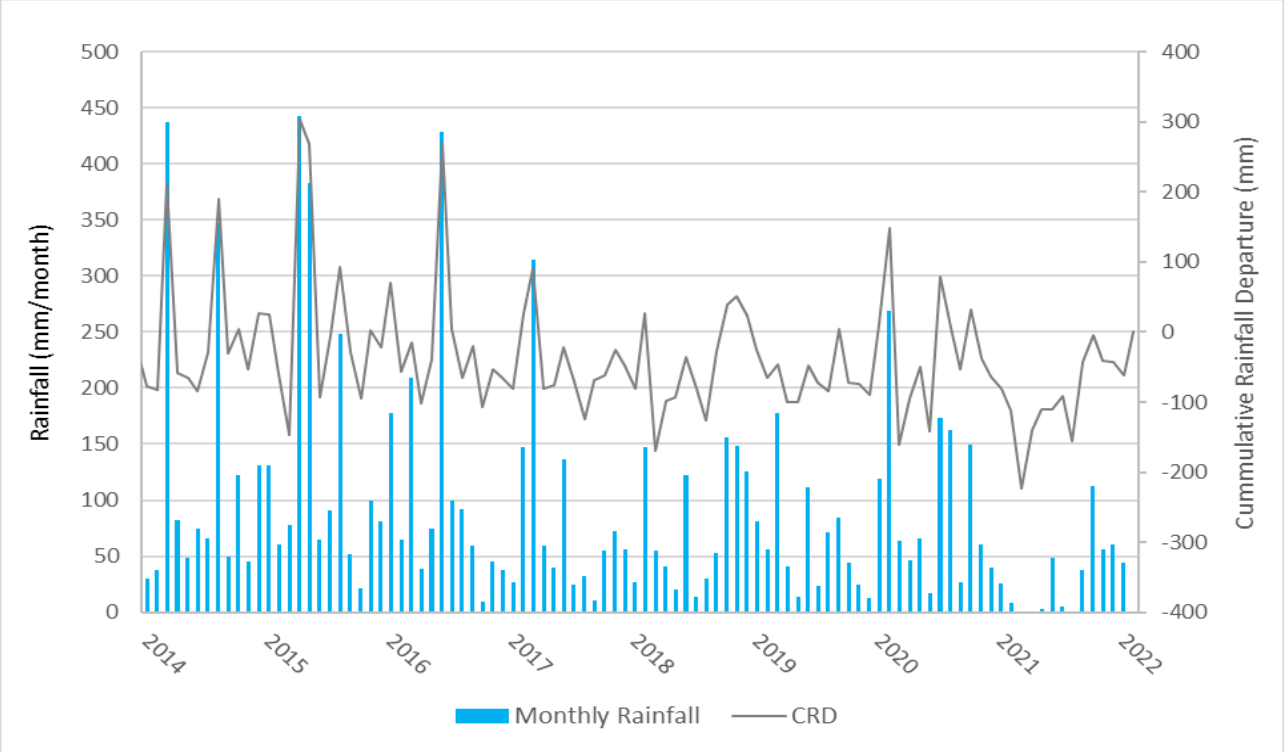
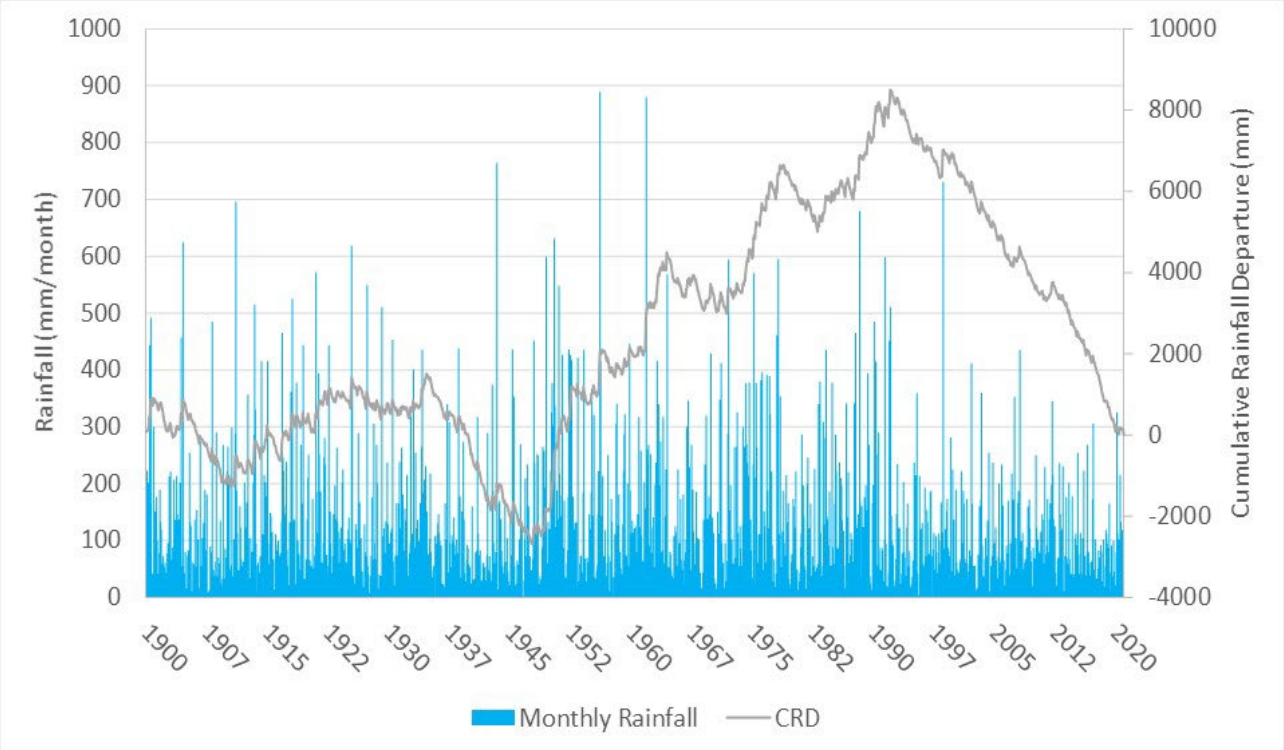


Figure 3-2 Cumulative Rainfall Departure (SILO)



3.3 Hydrology

RVE UEP is located within the Upper Nepean Catchment declared Metropolitan Special Area under the Water NSW Act, which forms part of Greater Sydney's drinking water supply catchment. The main drainage lines within and downstream of RVE UEP are Cataract Creek, Cataract River and Bellambi Creek (refer **Figure 1-1**). Bellambi Gully is also present at the base of the escarpment and flows to the ocean to the east. These streams are ephemeral and intermittent, only flowing for short periods following rain. The upper reaches occur on the sandstone benches and upper ridges before passing through steep slopes and into the main channels of the corresponding creeks. Due to the topography, these tributaries do not tend to support pools.

RVE UEP is situated within the upper catchment of the Cataract Reservoir, beyond the full supply level of the reservoir. The reservoir is an artificial storage formed by Cataract Dam and has a maximum capacity of 97,190 ML. Cataract Reservoir has a total catchment area of approximately 127.8 km². Full details on the surface water conditions relevant to RVE UEP are outlined within the EP WMP.

3.4 Geology

3.4.1 Regional geology

RVE UEP is located in the southern extent of the Permo-Triassic Sydney Basin. Within RVE UEP, the strata dip at between 1 in 25 and 1 in 30 to the west-north-west from its outcrop on the Illawarra Escarpment. A summary of the geological units within the RVE UEP is provided in **Table 5** and mapped surface geology shown in **Figure 3-3**.

As shown in **Figure 3-3,** Triassic age Hawkesbury Sandstone is present on the surface over most of RVE UEP. The Bald Hill Claystone that underlies the Hawkesbury Sandstone outcrops in Cataract Creek and its tributaries. The Bulgo Sandstone that underlies the Bald Hill Claystone outcrops along the main channel of Cataract Creek on both sides of Mount Ousley Road (SCT 2019).

The Pit Top Area occurs at the base of the Illawarra Escarpment, below the outcrop of the Bulli Seam and Wongawilli Seam. According to the Wollongong 1:50k geology mapping, the geology at surface across the Pit Top Area comprises the Permian aged Woonona Coal Member (Piy) overlying the Erins Vale Formation (Pie) and Unanderra Coal Member (Pip). The Woonona Coal Member comprises interbedded coal, carbonaceous siltstone, claystone and tuffaceous claystone that dips to the north-west. The 1:50k geology mapping indicates Quaternary alluvium is present over 800 m east of the site along the coastline. Local site geotechnical assessment by Terra Insight (2020) indicates the potential for alluvium or colluvium localised along Bellambi Gully, unconformably overlying the Permian coal measures. Drill hole BH201 indicated the presence of silty sandy clay and clayey gravel down to 5 m depth beneath fill material and overlying weathered Permian coal measures (Terra Insight, 2020).

3.4.2 Structural geology

Regional mapping of faults, folds and dykes based on the Southern Coalfields 1:100k mapping and site-specific mapping is shown in **Figure 3-3**.

Igneous intrusions are present across the RVE UEP including a series of dykes and a large sill (Bulli Sill Complex) to the east and north of Wonga East (refer **Figure 3-3**) (NRE 2014). The main structural features are the South Bulli Syncline and the Corrimal Fault south of the RVE UEP. As reported by GeoTerra/GES (2020), the Corrimal Fault has a 1.3 to 3.0 m displacement in the vicinity of the workings within the Bulli Seam and a maximum recorded displacement of 28.7 m within a 20 m wide faulted zone. The Corrimal Fault trends in a south-east north-west direction and is located to the west of LW4 and LW5 but passes through LW6 (approximately 340 m) then phases out to the north of LW6. The fault is not interpreted to be present between the proposed bord and pillar workings and Cataract Reservoir (SCT 2019).

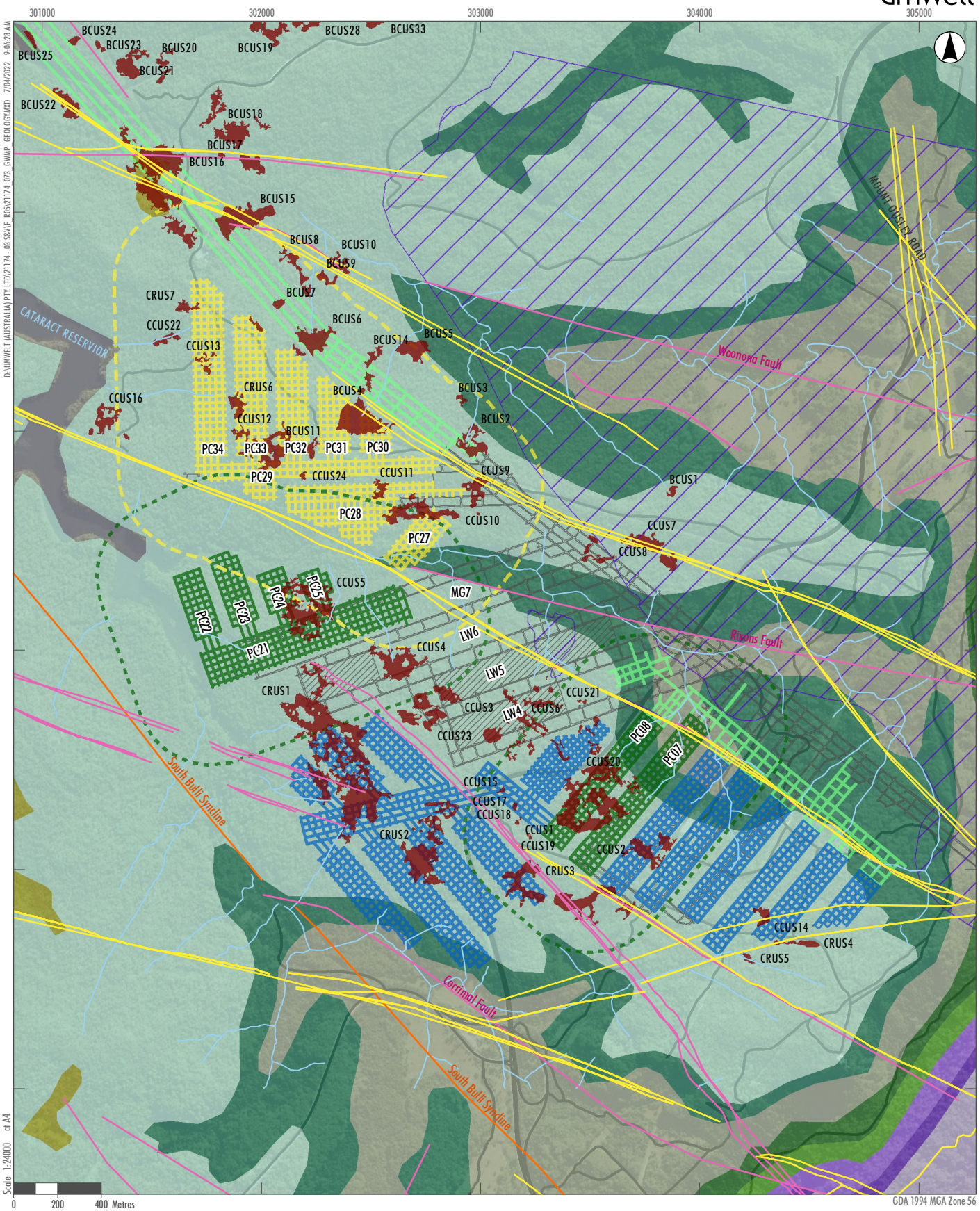
A north-west south-east trending splay off the Corrimal Fault (associated with Dyke D5) and a south-west north-east fault (associated with Dyke D6) are also located to the south of the eastern block of workings, with the D6 fault crossing under Cataract River, to the west of the proposed eastern block (GeoTerra/GES 2020). No known or observed groundwater inflows have been associated with any faults intersected by the workings at Wonga East in the Bulli, Balgownie or Wongawilli Seams (SCT 2019).

The north-west south-east trending Rixon's Pass Fault is shown at surface on the 1:100,000 geological map to be sub-parallel to Cataract Creek (refer **Figure 3-3**); however, no trace of it has been identified in the Bulli or Balgownie workings.

Table 5 Site Geology

Age	Formation	Group	Lithology	Thickness in Project area
Quaternary		Swamps	Upland swamps comprise sandy and silty sediments transported by overland flow from the weathered Triassic sandstones. The swamps generally comprise a basal layer of yellow or grey mineral sandy loams overlain by an organic horizon to highly organic spongy black peats.	A few cm up to 2 m in RVE UEP
		Alluvium/ Colluvium	Localised along some creeks, gullies. Within the Pit Top Area it can comprise silty sandy clay and clayey gravel.	Up to 5 m deep
Triassic	Hawkesbury Formation		The bedded to massive quartzose sandstone with grey shale lenses up to several metres thick is uppermost in the stratigraphic sequence in the western extent of RVE UEP. It can contain up to 4% manganiferous siderite and up to 0.5% of iron sulfide (principally marcasite) with minor solid solution incorporation of nickel, zinc and manganese sulfides.	absent to 181 m thick
	Narrabeen Group	Newport and Garie Formations	The Newport and Garie Formations are exposed in reaches of Cataract Creek and localised areas on the eastern extent of RVE UEP. The Newport Formation has interbedded grey shales and sandstones and has a variable thickness across RVE UEP. The Garie Formation is generally around 3m thick and contains cream to brown, massive, characteristically oolitic claystone with a relatively constant thickness across RVE UEP.	4.6 – 36 m thick
		Bald Hill Claystone	Present at surface in localised areas on the eastern extent of RVE UEP. Typically chocolate brown to red brown kaolinitic marker bed claystone with silty and sandy grey and mottled grey - brown zones with a relatively constant thickness over the Application Area. It predominantly consists of 50 - 75% kaolinite with hematite and siderite as accessories.	17 – 42 m thick
		Bulgo Sandstone	Present at surface in localised areas on the eastern extent of RVE UEP. Thickly bedded, medium to coarse grained lithic sandstone with occasional conglomerate and shale.	113 – 154 m thick
		Stanwell Park Claystone	Greenish-grey mudstone and sandstone, with a general thickening of the claystone to the north west.	15 – 26 m thick
		Scarborough Sandstone	Thickly bedded sandstone with shale and sandy shale lenses up to several metres thick.	16 – 31 m thick
		Wombarra Claystone	Has a similar lithology to the Stanwell Park Claystone and generally thickens to the south east.	35 – 61 m thick
		Coal Cliff Sandstone	Shales and mudstones contiguous with the underlying Bulli seam and varies from a quartzose sandstone in the east to a more shale/mudstone dominated unit in the west.	8 – 13 m thick

Age	Formation	Group	Lithology	Thickness in Project area
Permian	Illawarra Coal Measures		The Illawarra Coal Measures consist of interbedded shales, mudstones, lithic sandstones and coal seams, including the Bulli Seam, Loddon Sandstone, Balgownie Seam, Lawrence Sandstone, Eckersley Formation, Wongawilli Seam and Kembla Sandstone.	~ 200 m thick



Legend

- Stage 2 Area PC27-34
- Stage 1 Areas PC07-08 and PC21-25
- EP2 Layout PC27-34
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- Existing Wongawilli Seam Workings
- Wongawilli Seam First Workings (Approved under MP09_0013)
- Road
- Drainage Line
- Upland Swamp
- Sill
- Fold
- Dyke
- Fault

Surface Geology:

- Qs - Swamp Sediments
- TRh - Hawkesbury Sandstone
- TRnz - Bald Hill Claystone
- TRnbu - Bulgo Sandstone
- TRnsp - Stanwell Park Claystone
- TRnc - Coal Cliff Sandstone
- Pis - Sydney Group
- Pnc - Trinkey Formation Claystone
- Pnw - Wombarra Claystone

FIGURE 3.3

Surface Geology

Image Source: ESRI (2021) Data source: DFSI (2020)

3.5 Hydrogeology

3.5.1 Hydrogeology Summary

The main hydrogeological units within the RVE UEP area include:

- Quaternary alluvium and colluvium
- Quaternary swamps including upland swamps and headwater swamps
- Hawkesbury Sandstone:
  - Shallow weathered Hawkesbury Sandstone
  - Deeper Hawkesbury Sandstone
- Narrabeen Group
- Illawarra Coal Measures, including the Bulli Seam and Balgownie Seam previously mined, and Wongawilli Seam that was mined in LW4 to LW6 and is the target seam for future operations at RVE UEP
- Basement - sedimentary sequence underlying the Wongawilli Seam.

Discussion on each of the groundwater bearing units is summarised below. Knowledge of the groundwater systems is provided by a network of shallow Open Standpipes (OSPs) and Vibrating Wire Piezometers (VWPs) across the RVE UEP.

Quaternary Alluvium and Colluvium

At the top of the escarpment, due to the steep topography and limited alluvium within the Cataract Reservoir storage, there is no notable groundwater bearing stream-based alluvium within the RVE UEP.

Alluvial and colluvial deposits may also occur along Bellambi Gully in the Pit Top area. Drill hole data (BH201) collected by Terra Insight (2020) indicates the presence of silty sandy clay overlying extremely weathered Permian coal measures. Drill holes across the Pit Top area outside of the creek alignment indicate the presence of clay-rich residual soil to around 3 m to 4 m depth, overlying weathered Permian coal measures (siltstone and shale).

Within the Pit Top Area a shallow water table was intercepted around 4 m below ground within the fill material, sediments and weathered Permian coal measures (Terra Insight, 2020). In 2021 three shallow monitoring bores were installed in December 2021 within the Pit Top area, including one bore localised near Bellambi Gully. Water was intersected during drilling of the bore near Bellambi Gully; however, no sampling has yet been undertaken on the recently installed bores.

Quaternary Swamps

Quaternary unconsolidated alluvial and colluvial sediments are present within both valley fill and headwater upland swamps (refer **Figure 3-3**).

The existing site monitoring network includes piezometers within the swamp deposits across RVE UEP. Based on drill data collected at site from the swamp piezometers, the swamps within the RVE UEP comprise humic sands and clayey sands generally less than 2 m thick, overlying weathered Hawkesbury Sandstone.

Hawkesbury Sandstone

The Hawkesbury Sandstone outcrops over most of the lease area although it has been partially eroded in the central valley of Cataract Creek where the upper Bulgo Sandstone is exposed.

The Hawkesbury Sandstone is the main aquifer in RVE UEP along with the coal seams. The low groundwater flow rates within the Hawkesbury Sandstone are primarily horizontal, with minor vertical leakage due to the dominant horizontal bedding planes and bedding discontinuities interspersed with generally poorly connected vertical joints.

Narrabeen Group

The Triassic aged Narrabeen Group underlies the Hawkesbury Sandstone and occurs at surface in localised areas along the escarpment and in localised areas where the Hawkesbury Sandstone has been eroded away near Cataract River, Cataract Creek and Bellambi Creek.

The Narrabeen Group includes sandstone units (i.e. Bulgo Sandstone, Scarborough Sandstone and Coal Cliff Sandstone) interbedded with low permeability claystones (i.e. Bald Hill Claystone, Stanwell Park Claystone and Wombarra Claystone). The Narrabeen Group lithologies have significantly lower yielding aquifers compared to the Hawkesbury Sandstone, with very minor productive supplies obtained in the Southern Coalfield due to its generally deeper elevation below surface and its very low permeability.

Within the RVE UEP area, the lower portions of the Narrabeen Group have already been locally fractured and depressurised above the existing Wongawilli, Bulli and Balgownie seam workings. Previous investigations into the goaf effects have been conducted across the site and surrounding mines. As reported by GeoTerra (2012), packer testing was conducted at the site monitoring locations and showed a reduction in permeability with depth. The Stanwell Park Claystone also recorded a lower permeability compared to the sandstone units despite goaf effects within the area.

Illawarra Coal Measures

The Illawarra Coal Measures are the primary economic sequence of interest in the Sydney Basin, and consist of interbedded sandstones, shale and coal seams. Within the RVE UEP area, historical mining targeted the Bulli Seam and Balgownie Seam, with more recent longwall mining within the Wongawilli Seam (LW 4-6).

The coal seams outcrop to the east of the RVE UEP along the base of the escarpment, and dip approximately 2° towards the north-west. There are three main coal seams within the RVE UEP area:

The Bulli Seam is around 2 to 4.7 m thick and occurs around 205 m to 290 m below surface within the RVE UEP. The Bulli Seam has historically been extensively worked by longwall and bord and pillar methods within the region. The Bulli Seam overlies the Loddon Sandstone that is 5.5 to 13.6 m thick and in turn overlies the Balgownie Seam.

The Balgownie Seam is around 0.8 to 1.5 m thick and has some localised longwall extraction within the RVE UEP. The Balgownie Seam is separated from the underlying Wongawilli Seam by around 10.6 to 24.7 m of interburden (sandstone/siltstone).

The Wongawilli Seam is around 6.2 to 10.5 m thick based on the combined thickness across multiple seam splits. The Wongawilli Seam has been mined at LW4-6 within the RVE UEP. The seam

is around 250 to 380 m below surface and around 24 to 36 m below the Bulli Seam. The Wongawilli Seam is the target seam for the proposed bord and pillar workings with a proposed mining height of 2.4 m in the basal section of the Wongawilli Seam.

The coal seams are the main groundwater bearing unit within the Illawarra Coal Measures, due to secondary porosity associated with fractures and cleats. The interburden material (siltstone, sandstones and shale) generally exhibits low permeability. The permeability of the coal seams has been assessed at site and within the region and has been found to vary spatially and with depth.

The permeability of the Permian strata is also influenced by goaf effects and natural fracturing and faulting. The Bulli, Balgownie and Wongawilli seams have been fractured and depressurised to varying degrees by the existing workings.

3.5.2 Groundwater Users

The RVE UEP is located within the Metropolitan Special Area and forms part of the Sydney drinking water supply catchment. There are no private water supply works located within the Cataract Reservoir catchment or along Bellambi Gully.

3.5.3 Groundwater Dependent Ecosystems

Biosis (2020) undertook an assessment of the potential for the study area to support groundwater dependent ecosystems (GDEs), using the Australian Government's Bureau of Meteorology, Groundwater Dependent Ecosystems Atlas (GDE Atlas) (BOM 2018), a download of metadata from State of NSW, and the NSW Office of Water Risk Assessment guidelines for groundwater dependent ecosystems (Serov *et al.* 2012). No areas reliant on the surface expression of groundwater are mapped within the study area according to the GDE Atlas or metadata (DPI Water 2016). Water Observations from Space mapping was also reviewed (**Figure 4-1**), which shows a low occurrence of water at surface (percentage of observations with water present at surface, based on satellite imagery since 1987).

Some small areas of mapped plant communities have been mapped within RVE UEP as having moderate to high GDE potential, as shown in **Figure 4-1**. Each of the plant communities occur on Hawkesbury Sandstone, or Bulgo Sandstone where it occurs at surface. Areas of shallow water table are potentially accessible by the roots of the vegetation. Areas of water table more than 10 m below the surface are generally considered to be inaccessible to all but the deepest rooted vegetation. Discussion on the shallow water table and the monitoring program targeting the potential GDE areas is included in **Section 5**.

Upland swamp communities have also been identified within the RVE UEP area (refer **Figure 4-1**). Discussion on the swamp stratigraphy and monitoring program are included in **Section 3** and **Section 4**, respectively. Details on the swamp ecology are included within the Biodiversity Management Plan.

The Hawkesbury Sandstone also provides baseflow contributions to surface water features where gradients enable this. Details on the surface water baseline data and monitoring program are included within the EP WMP.

3.6 Ecohydrological Model

The conceptual ecohydrological model for RVE UEP was prepared based on previous studies conducted at the site including the groundwater impact assessment (GeoTerra/GES 2020),

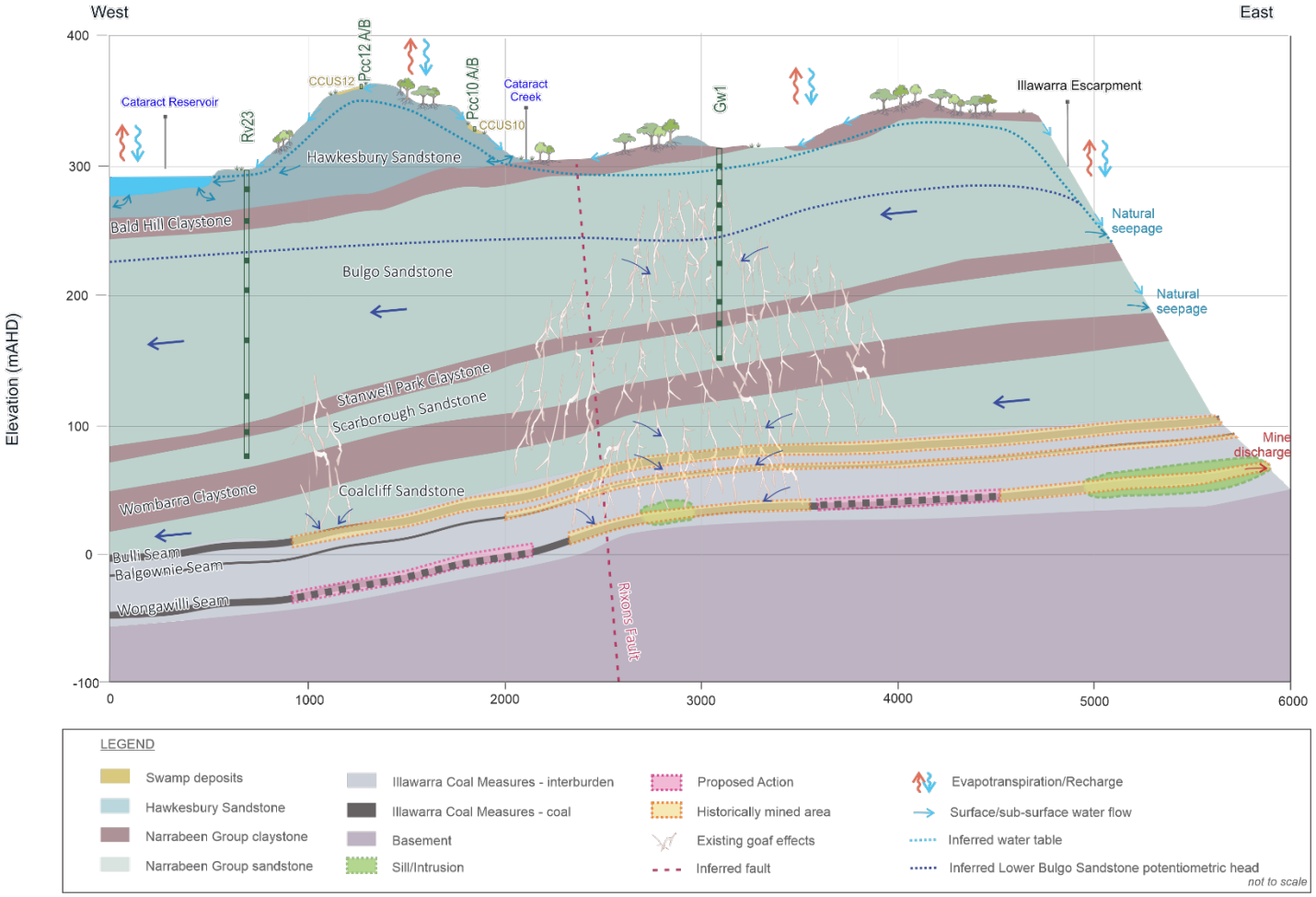
surface water assessment (Umwelt 2019) and ecological assessment (Biosis 2020). The conceptual model has been represented for RVE UEP in **Figure 3-4**. The figure shows the main stratigraphic units, recharge and discharge processes, ecological receptors and inferred groundwater conditions during mining and post closure.

The main ecohydrological features relevant to RVE UEP include:

- Creeks overlying and in vicinity of RVE UEP:
  - Cataract Creek - a fourth order stream associated with Cataract Reservoir. Channel invert elevations for Cataract Creek fall from approximately 340 to 285 mAHD. The creek is incised into the Hawkesbury Sandstone that contributes baseflow where hydraulic gradients enable this.
  - Cataract River - a regulated fourth order stream under the NSW Water Management Act 2000. It has a length of approximately 6.7 km from its headwaters to the full supply level of Cataract Reservoir. Channel invert elevations fall from approximately 430 to 285 mAHD. The creek is incised into the Hawkesbury Sandstone that contributes baseflow where hydraulic gradients enable this. Future bord and pillar do not underlie the Cataract River.
  - Bellambi Creek - a third order stream upstream for the first 5.5 km, then fourth order draining to the Cataract Reservoir. The creek is approximately 6.4 km long from its headwaters to the full supply level of Cataract Reservoir and has a catchment area of 9.3 km². Channel invert elevations fall from approximately 453 to 286 mAHD. The creek is incised into the Hawkesbury Sandstone that contributes baseflow where hydraulic gradients enable this. RVE UEP workings do not underlie or interact with the main Bellambi Creek stream channel.
  - Bellambi Gully - occurs on the lower slopes of the Illawarra Escarpment and flows east towards the Pacific Ocean. The gully has an elevation of 400 mAHD along the escarpment, declining down to 30 mAHD to the east around Corrimal where it flows past residential, recreational, commercial and light industrial facilities. Geology along the gully is mapped as the Sydney Group and Erins Vale Formation that underlie the Illawarra Coal Measures. Quaternary alluvium is mapped along the creek further to the east, outside of the mine lease area.
- Alluvium, colluvium and regolith – within the Pit Top Area, recent geotechnical drilling identified the presence of clayey gravels along the alignment of Bellambi Gully. Elsewhere across the site, drilling identified the presence of fill material and clay-rich residual soil overlying weathered Permian coal measures (siltstone and shale). Groundwater was detected in the shallow water table within the sediments and weathered Permian coal measures. Based on the site geology and historical land use, it is anticipated that the groundwater exhibits similar water quality to the Permian coal measures. No impacts to groundwater have been previously identified for the approved operations. The RVE UEP will involve upgrades to surface infrastructure around the Pit Top Area. However, no new activities that could interfere with the shallow water table (i.e. excavation or water storage) will be undertaken at site.

- Swamps – shallow upland swamps in the RVE UEP area extend to approximately 2 m depth and overly weathered Hawkesbury Sandstone. The swamps are recharged from rainfall and shallow flow, with trends influenced by climatic conditions and potentially by surface subsidence impacts from historical longwall mining. The swamps at site are generally hydraulically separated from the lower Hawkesbury Sandstone regional water table. Depressurisation due to first workings or the future RVE UEP bord and pillar is not predicted to cause additional impacts to swamp water conditions.
- Hardrock Aquifer systems:
  - Hawkesbury Sandstone – main aquifer in the region that provides baseflow contributions where incised along creeks and reservoirs. Groundwater flow is generally to the north, but with localised flow towards the escarpment and towards incised creeks. The Hawkesbury Sandstone is hydraulically separated from the underlying Bulgo Sandstone and deeper lithologies by the Bald Hill Claystone, except where the claystone is fractured by subsidence or eroded away in the channel of Cataract Creek. Localised drawdown within the Hawkesbury Sandstone has been observed associated with historical and existing mining at site.
  - Narrabeen Group – interbedded sandstones and low permeability claystones that inhibit downward seepage. Drawdown is observed within the RVE UEP area within the sandstone units (i.e. Bulgo Sandstone) in response to current and historical mining. This is due to goaf effects from longwall mining that resulted in increased permeability of overlying strata.
  - Permian Coal Measures – groundwater occurrence largely associated with the coal seams via secondary porosity. Groundwater within the coal measures is expected to be extensively depressurised by historical operations. Water quality within the coal seams is generally alkaline with fresh to brackish water quality and some trace metals.

Figure 3-4 Ecohydrological Model



4. SWAMP BASELINE DATA

4.1 Swamp Monitoring Network

Swamps are present at surface across the RVE UEP area, as presented on **Figure 4-1**.

The existing swamp monitoring network across RVE UEP has been progressively installed since 2012 and covers 18 swamps within RVE UEP (BCUS4, BCUS11, CCUS1, CCUS2, CCUS3, CCUS4, CCUS5, CCUS6, CCUS10, CCUS11, CCUS12, CCUS14, CCUS20, CCUS21, CRUS1, CRUS2, CRUS3 and CRUS6). The network comprises:

- 8 monitoring locations equipped with soil moisture probes
- 6 locations equipped with shallow piezometers
- 22 locations equipped with soil moisture probes and shallow piezometers
- 2 locations near swamps equipped with shallow piezometers

Details on the swamp monitoring network are shown in **Table 6** and locations are shown in **Figure 4-1**. **Table 6** includes details on the relevant swamp site, intake lithology and type of monitoring point. The monitoring program includes collection of daily timeseries data of soil moisture changes with depth with the soil moisture probes, recording water levels 6 hourly with level loggers in selected piezometers, and two monthly manual water level monitoring. When water is present, water quality monitoring is also conducted, including monitoring of environmental water tracers, with two monthly field testing of physiochemical properties (i.e. electrical conductivity and temperature) and quarterly sampling and laboratory analysis for major ions. Details on swamp monitoring in entirety are contained in the Upland Swamp Monitoring Program (USMP) (RVC EC PLN 008).

Figure 4-1 presents the currently installed monitoring locations for swamps relative to historical mine operations and approved future bord and pillar. As shown in **Figure 4-1**, swamps CRUS1, CCUS3, CCUS4 and CCUS6 occur within proximity to the completed longwall mining (LW4 to LW6) that experienced subsidence impacts. Negligible subsidence impacts are predicted as part of future approved bord and pillar within the Wongawilli Seam at RVE UEP.

Table 6 Water Monitoring Network for Swamps

Site ID	Swamp Site	Installed	Easting GDA94 Z56	Northing GDA94 Z56	Ground Level mAHD[1]	TOC magl[2]	Screen mbgl[3]	Intake Lithology[4]	Type[5]
PB4A	BCUS4	Nov-14	302382	6198016	340.8	1.35	1.17 – 1.59	HC / WS	SM and PZ
PB4B	BCUS4	Nov-14	302431	6198020	337.0	1.56	0.35 – 0.77	HC / WS	SM and PZ
PB4C	BCUS4	May-12	302460	6198060	333.0	1.22	0.25 – 0.63	HSC / WS	PZ
PB4D	BCUS4	Nov-14	302526	6198018	333.6	1.45	0.35 – 0.60	HSC / WS	SM and PZ
PCc10A	CCUS10	Nov-14	302625	6197639	329.1	1.62	0.30 – 0.59	HSC / WS	SM and PZ
PCc10B	CCUS10	Nov-14	302691	6197672	337.4	1.57	0.48 – 0.98	HSC / WS	SM and PZ
PCc12A	CCUS12	Nov-14	302047	6197858	361.6	1.65	0.27 – 0.72	CS / WS	SM and PZ
PCc12B	CCUS12	Nov-14	302038	6197964	366.5	1.59	0.11 – 0.27	WS	SM and PZ
PCc2	CCUS2	May-12	303745	6196080	371.4	0.96	1.10 – 1.63	HSC / WS	SM and PZ
PCc3	CCUS3	May-12	302820	6196810	351.9	1.26	0.70 – 1.12	SC / WS	PZ
PCc4A	CCUS4	Oct-14	302678	6196900	342.4	1.35	1.11 – 1.62	HSC / WS	PZ
PCc4B	CCUS4	Oct-14	302604	6196877	342.1	1.04	1.34 – 1.95	HSC / WS	SM and PZ
PCc4C	CCUS4	Oct-14	302579	6196931	340.1	1.71	0.77 – 1.11	HSC / WS	SM and PZ
PCc4D	CCUS4	Mar-12	302615	6196925	339.5	1.60	0.45 – 0.94	SC / WS	SM and PZ
PCc5A	CCUS5	May-12	302110	6197150	315.2	1.41	0.70 – 1.20	HSC / WS	SM and PZ
PCc5B	CCUS5	May-12	302245	6197250	299.2	1.39	0.80 – 1.23	HSC / WS	SM and PZ
PCc5C	CCUS5	Oct-14	302234	6197073	319.5	1.46	0.50 – 0.84	HSC / WS	PZ
PCc5D	CCUS5	Oct-14	302295	6197172	307.7	1.72	0.73 – 1.22	HSC / WS	SM and PZ
PCc6	CCUS6	Mar-12	303165	6196790	351.0	1.33	0.70 – 1.12	WS	PZ
PCr1A	CRUS1	Mar-12	302330	6196625	349.3	1.70	0.30 – 0.49	HSC / WS	SM and PZ
PCr1B	CRUS1	Oct-14	302247	6196655	337.3	1.57	0.44 – 0.69	HSC / WS	SM and PZ
PCr1C	CRUS1	Oct-14	302229	6196762	341.7	1.32	0.65 – 1.15	HSC / WS	SM and PZ
PCr1D	CRUS1	Oct-14	302263	6196879	346.4	1.36	0.22 – 0.38	SC / WS	PZ
SP1	Near CCUS6	Mar-12	303245	6196955	331.6	1.36	0.10 - 0.57	SC / WS	PZ
SP2	Near CCUS3 & CCUS4	Mar-12	302830	6196905	346.0	1.66	0.55 - 1.02	SC / WS	PZ
PCc1A*	CCUS1	Jul-21	303382	6196263	TBC	1.35	0.5 - 2	Swamp	SM and PZ
PCc1B*	CCUS1	Jul-21	303512	6196355	TBC	-	-	Swamp	SM
PCc1C*	CCUS1	Jul-21	303609	6196292	TBC	1.65	0.5 – 2	Swamp	SM and PZ
PCc11*	CCUS11	Jul-21	302531	6197700	TBC	-	-	Swamp	SM
PCc14A*	CCUS14	Jul-21	304311	6195771	TBC	0.895	0.5 – 2	Swamp	SM and PZ

Site ID	Swamp Site	Installed	Easting GDA94 Z56	Northing GDA94 Z56	Ground Level mAHD[1]	TOC magl[2]	Screen mbgl[3]	Intake Lithology[4]	Type[5]
PCc14B*	CCUS14	Jul-21	304276	6195820	TBC	-	-	Swamp	SM
PCc20*	CCUS20	Jul-21	303513	6196568	TBC	0.925	0.5 – 2	Swamp	SM and PZ
PCc21*	CCUS21	Jul-21	303481	6196772	TBC	-	-	Swamp	SM
PCc6B*	CCUS6	Jul-21	303020	6196609	TBC	0.810	0.5 - 2	Swamp	SM and PZ
PCr2*	CRUS2	Jul-21	302784	6196158	TBC	-	-	Swamp	SM
PCr3*	CRUS3	Jul-21	303177	6195925	TBC	-	-	Swamp	SM
PCr6*	CRUS6	Jul-21	301928	6198123	TBC	-	-	Swamp	SM
PB11*	BCUS11	Jul-21	302220	6197915	TBC	-	-	Swamp	SM

** Locations indicative only, to be surveyed* *TBC – to be confirmed with site survey*

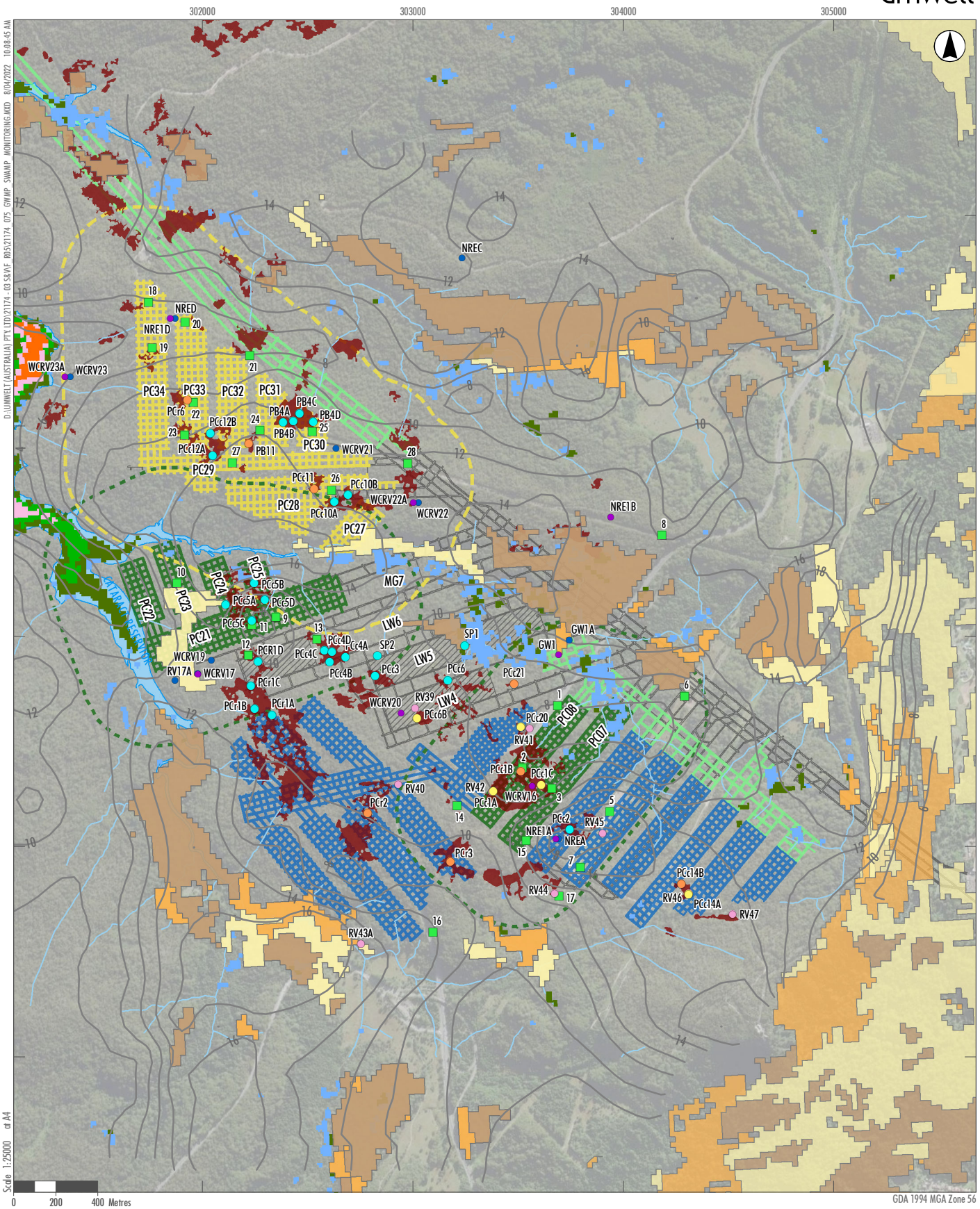
Notes: 1. Ground level based on DEM

2. TOC – Top of Casing in magl – meters above ground level

3. mbgl – meters below ground level

4. WS – weathered sandstone *HC – humic clay* *CS – clayey sand*
HSC – humic sandy clay *SC – sandy clay*

5. SM – soil moisture *PZ - piezometer*



Legend

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- Existing Wongawilli Seam Workings
- Wongawilli Seam First Workings (Approved under MP09_0013)
- Drainage Line
- Upland Swamp
- Interpolated Depth to Groundwater - Sep 2019 (2m)
- Groundwater Monitoring Site OSP
- Groundwater Monitoring Site VWP
- Proposed Monitoring Site OSP
- Proposed Swamp Monitoring Site SM
- Proposed Swamp Monitoring Site SM and PZ
- Swamp Monitoring Site SP
- Subsidence Monitoring GNSS Unit

Potential Terrestrial GDEs:

- High Potential GDE
- Moderate Potential GDE
- Low Potential GDE

Potential Aquatic GDEs:

Water Observations from Space (%)

- 1
- 20
- 40
- 60
- 80

FIGURE 4.1

Swamp Monitoring Network

Image Source: ESRI (2021) Data source: DFSI (2020); Bioregional Assessment Program (2020)

4.2 Swamp Monitoring

4.2.1 Soil Moisture and Water Levels

Monitoring of the soil moisture and water level within swamp deposits has been conducted in RVE UEP at swamps BCUS4, CCUS10, CCUS12, CCUS4, CCUS5 and CRUS1 since 2012. Over 2021, additional monitoring locations were installed at swamps CCUS1, CCUS14, CCUS20, CCUS21, CRUS2 and CRUS6 (refer **Section 4.1**).

Soil moisture is measured with Odyssey SM probe which measures the dielectric constant of moist soil to determine the moisture content. Probes are typically 1 m deep with five sensors typically at 10, 30, 50, 70 and 90 cm below surface. The observed soil moisture trends are presented in **Appendix B** compared to total monthly rainfall at site. The data shows a good correlation between increasing moisture content in response to rainfall events, with the highest rainfall generally occurring within the summer to autumn months from February to March (refer **Section 3.2**). Some data gaps are visible intermittently in the graphs in **Appendix B**. These are due to instrument error related to the age of equipment; the swamp soil moisture probes were replaced across the site in November 2020 to enable ongoing monitoring.

Water level trends for site monitoring piezometers show a good correlation to rainfall trends, with water levels in the swamps rising to at or near surface generally in response to rainfall (i.e. over 100 mm/month). The timing of this response varies between sites, with a one-to-two-month lag between the rainfall event and water level response noted when reviewing data obtained to date. Across the RVE swamp monitoring network the available manual dipped water levels indicate unsaturated conditions approximately 47% of the time. For periods when the swamps are saturated, the median (50th percentile) of readings indicates water present around 0.57 m below surface.

The swamps are recharged from rainfall and shallow surface flow; however, the site data also shows variability in the response to rainfall between the different swamp monitoring locations (refer to **Appendix B** and **Appendix H**). Dry bore conditions generally correspond to low rainfall periods (i.e. below 10th percentile of monthly rainfall, 20 mm rainfall per month), and appears to be more prevalent for monitoring points at the edge of swamp clusters. Other factors such as the slope aspect and localised disturbance (i.e. tracks and historical subsidence impacts) also influences water level and soil moisture conditions.

The swamps at site are generally perched, meaning they are hydraulically separated from the lower Hawkesbury Sandstone regional water table. There are existing paired bores within the underlying Hawkesbury Sandstone at swamps CRUS1 (PCr1D and RV18), BCUS4 (PB4C and RV21), CCUS2 (PCc2 and NRE A) and CCUS6 (PCc6, SP1, RV20). The baseline data for the open standpipes are presented in **Appendix D** and show that the water heads in the Hawkesbury Sandstone are generally 1.5 m to 28.9 m below surface.

Further discussion on the soil moisture and water trends for selected individual swamps with longer periods of monitoring is included below. The discussion is included to provide background on the pre-existing impacts to the groundwater regime and the current groundwater conditions, prior to commencement of the RVE UEP.

Swamp BCUS4

There are three sites monitoring soil moisture in swamp BCUS4 (PB4A, PB4B and PB4D). All three sites show fluctuations in response to rainfall. PB4B has a constant high soil moisture percentage at depths of 70 and 90 cm below surface. In comparison, PB4A and PB4D fluctuate between moist and dry, likely due to their location on the edge of the swamp whereas PB4B is closer to the centre. Swamp BCUS4 overlies the RVE Stage 2 EP area.

A soil moisture profile is shown in **Figure 4-2** for site PB4A near swamp BCUS4 from readings collected in January 2017, and the monthly average soil moisture for data collected since 2014. The figure shows that the soil moisture content continues to increase with depth up to 75 percent at 90 cm below surface. The depth to the water table at swamp BCUS4 recorded at PB4A ranges from 2 to 152 cm below surface. The results show an increase in soil moisture with depth that likely relates to influence of evaporation at surface and evapotranspiration by swamp vegetation. These trends are consistent with trends observed at other swamp locations. The influence of evaporation/evapotranspiration at surface is further demonstrated in the monthly averages (**Figure 4-2**) where the soil moisture near surface is lowest in the hotter summer months. This seasonal variability is visible at all depths but does decrease with depth, with readings at 90 cm depth indicating a soil moisture (on average) of between 80 % to 90 %, but can range between 70 % and 94 % (5th/95th percentile).

Groundwater level trends for PB4C and nearby Hawkesbury Sandstone bore RV21 are shown in **Figure 4-3**. RV21 is screened within the upper Hawkesbury Sandstone from 9 m to 22 m below surface, with PB4C 0.77 m deep and screened within swamp deposits. **Figure 4-3** shows groundwater levels within the upper Hawkesbury Sandstone have been recorded 8 m to 13 m below surface since monitoring began in 2014. This indicates swamp BCUS4 is hydraulically separated from the Hawkesbury Sandstone water table based on available data. Monitoring at BCUS4 provides a useful reference site of current soil moisture and swamp water level conditions for site swamps unaffected by initial workings under the RVE UEP.

Figure 4-2 Soil moisture profile: PB4A at BCUS4 for set date (left) and average monthly (right)

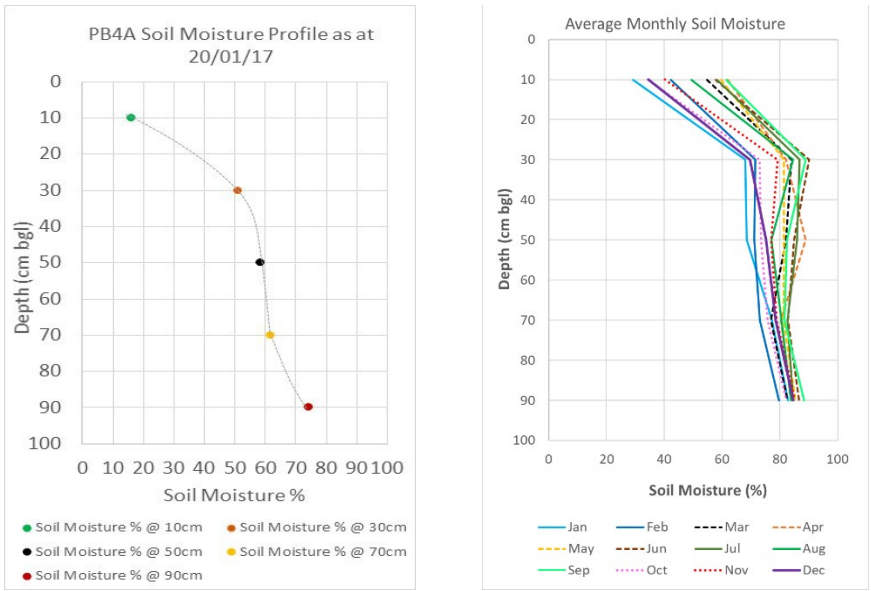
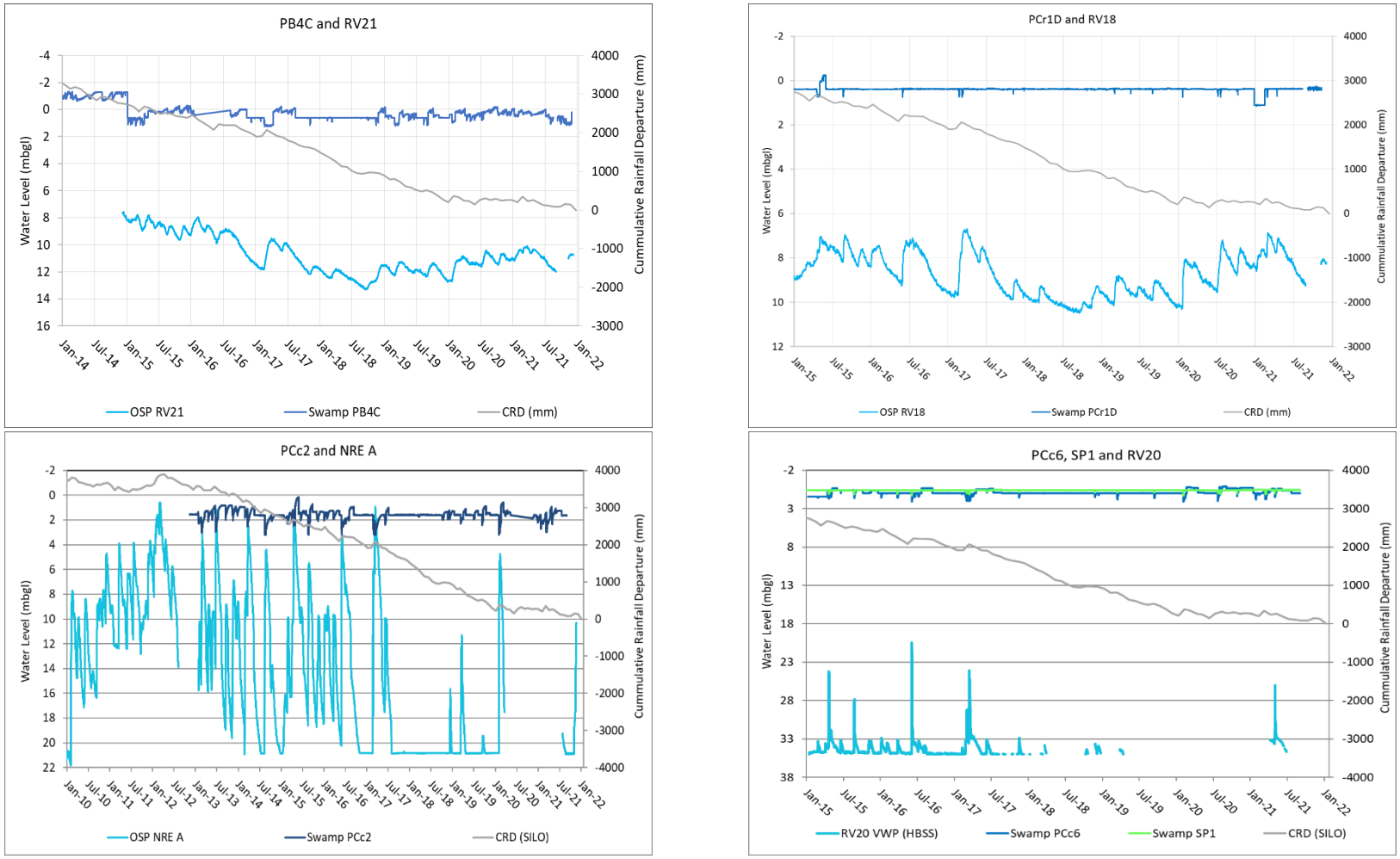


Figure 4-3 Paired bores in swamps and underlying Hawkesbury Sandstone



Swamp CCUS2

There is one water level monitoring site in swamp CCUS2 (PCc2). Groundwater level monitoring is also recorded at nearby monitoring points NRE A and NRE1A (VWP). Water levels within PCc2 are generally at or near the base of the piezometer, with water level rise recorded in response to periods of significant rainfall (i.e. over 100 mm/month).

Groundwater level trends for PCc2 and nearby Hawkesbury Sandstone bore NRE A are shown in **Figure 4-3**. NRE A is screened within the upper Hawkesbury Sandstone from 24 m to 47 m below surface, while PCc2 is 1.63 m deep and is screened within swamp deposits. **Figure 4-3** shows groundwater levels within the upper Hawkesbury Sandstone have fluctuated rapidly compared to all other bores, with levels recorded at surface to 22 m below surface since monitoring began in 2009. These trends have previously been reported as being due to pre-existing tension cracks from historical longwall mining that have increased the vertical connectivity in this area and resulted in localised enhanced recharge to the Hawkesbury Sandstone (GeoTerra/GES 2020). This relationship is represented in the ecohydrological section (**Figure 3-4)**. No new subsidence impacts are predicted for future operations at RVE UEP as it only involves bord and pillar.

Additional monitoring is now undertaken, with a soil moisture probe installed in 2021, along with a paired bore within the upper Hawkesbury Sandstone near CCUS2 at RV45.

Swamp CCUS3

There is one monitoring site in swamp CCUS3 (PCc3). The site has been recorded as dry since installation in 2012. The monitoring piezometer extends to 1.2 m depth within sandy clay and weathered sandstone and the site overlies historical workings, including LW5. There is no pre-mining site data available to verify the cause for these dry conditions. Mining commenced in the area in the 1880s, with Bulli Seam workings active until the 1950's, Balgownie Seam longwall workings until 1982 and Wongawilli Seam workings (LW4 to LW6) active between 2012 and 2015.

Groundwater modelling of historical groundwater conditions by GeoTerra (2020) and HydroAlgorithmics (2020a) predicted the presence of shallow water table (within 5 m of surface) in the Hawkesbury Sandstone near PCc3. Swamp water conditions were not modelled due to the perched nature of these systems. The Hawkesbury Sandstone groundwater levels were predicted to have been drawn down over 10 m below surface following longwall mining in the area. Localised drawdown in the Hawkesbury Sandstone was also predicted in the area due to depressurisation with the RVE UEP mine, but no additional impacts on swamp CCUS3 were predicted beyond those already experienced.

Swamp CCUS4

There are three sites monitoring soil moisture in swamp CCUS4 (PCc4B, PCc4C and PCc4D). All three sites show fluctuations in response to rainfall. PCc4C and PCc4D are relatively moist ranging between 10 and 90 cm below surface. In comparison, PCc4B is relatively dry, likely due to its location on the edge of the swamp whereas PCc4C and PCc4D are closer to the centre. Swamp CCUS4 will not overlie active RVE UEP workings but does overlie the Wongawilli Seam LW6 that was actively mined until 2015, as well as previous historical mining within the Bulli and Balgownie seams. The soil moisture data has been collected since 2014 and is representative of groundwater conditions pre-commencement of RVE UEP; however, there is no unimpacted pre-mining data is available for comparison.

Swamp CCUS5

There are three sites monitoring soil moisture in swamp CCUS5 (PCc5A, PCc5B and PCc5D). All three sites show fluctuations in response to rainfall. PCc5B has a high soil moisture percentage at 30 and 90 cm below surface, but drier at 50 and 70 cm below surface suggesting alternating soil horizons. PCc5D is relatively moist between 30 and 90 cm below surface, with the highest moisture percentage at 30 cm below surface. In comparison, PCc5A is relatively dry, likely due to its location on the edge of the swamp whereas PCc5B and PCc5D are closer to the centre. Swamp CCUS5 will overlie RVE UEP.

Swamp CCUS6

There is one monitoring site near swamp CCUS6 (PCc6); however, this monitoring location is not directly within the mapped swamp. An additional two piezometers (SP1 and SP2) are also located near CCUS6 and intersect the surficial Hawkesbury Sandstone.

Site PCc6 has been recorded as dry since installation in 2012. The monitoring piezometer extends to 1.2 m depth within sandy clay and weathered sandstone and the site overlies historical longwall workings including Wongawilli Seam LW4. It is noted that monitoring points SP1 and SP2 near CCUS6 have also been recorded as dry since monitoring commenced in 2012, both overlying LW5. This likely relates to the shallow construction of these piezometers (less than 1 m depth).

There are currently no open standpipes near swamp CCUS6 within the Hawkesbury Sandstone water table. Therefore, trends have been compared to groundwater head readings within the deeper Hawkesbury Sandstone from nearby VWP RV20 (at 35 m depth). The results show a separation of around 30 m between swamp levels and the potentiometric surface in the deeper Hawkesbury Sandstone. Groundwater level trends between the paired sites are shown in **Figure 4-3**.

Groundwater modelling of historical groundwater conditions conducted by GeoTerra (2020) and HydroAlgorithmics (2020a) predicted the presence of shallow water table (within 5 m of surface) in the Hawkesbury Sandstone near PCc6. Swamp water conditions were not modelled due to the perched nature of these systems. Groundwater in the Hawkesbury Sandstone was predicted to have been drawn down over 10 m below surface following longwall mining in the area. Localised drawdown in the Hawkesbury Sandstone was also predicted in the area due to depressurisation with the RVE UEP mine, but no additional impacts on swamp CCUS6 were predicted beyond those already experienced.

Additional monitoring locations have been installed over 2021 for CCUS6 to monitor swamp water levels and moisture levels within an area of mapped swamp (PCc6B). In addition, a proposed standpipe to characterise the water table conditions in the Hawkesbury Sandstone (RV43A) and monitor potential changes with future mining.

Swamp CCUS10

There are two sites monitoring soil moisture in swamp CCUS10 (PCc10A and PCc10B). Both sites show fluctuations in response to rainfall, with the highest moisture content between 50 and 90 cm below surface. Swamp CCUS10 will overlie RVE UEP, but not in the initial year of operations. Monitoring at CCUS10 provides a useful reference site of current soil moisture conditions for site swamps unaffected by initial workings under the RVE UEP.

Swamp CCUS12

There are two sites monitoring soil moisture in swamp CCUS12 (PCc12A and PCc12B). Both sites show minor fluctuations in response to rainfall and are relatively dry in comparison to other swamps. PCc12A is only moist at 50 to 90 cm below surface, while PCc12B is only moist at 70 to 90 cm below surface. Monitoring at CCUS12 provides a useful reference site of current soil moisture conditions for site swamps unaffected by initial workings under the RVE UEP.

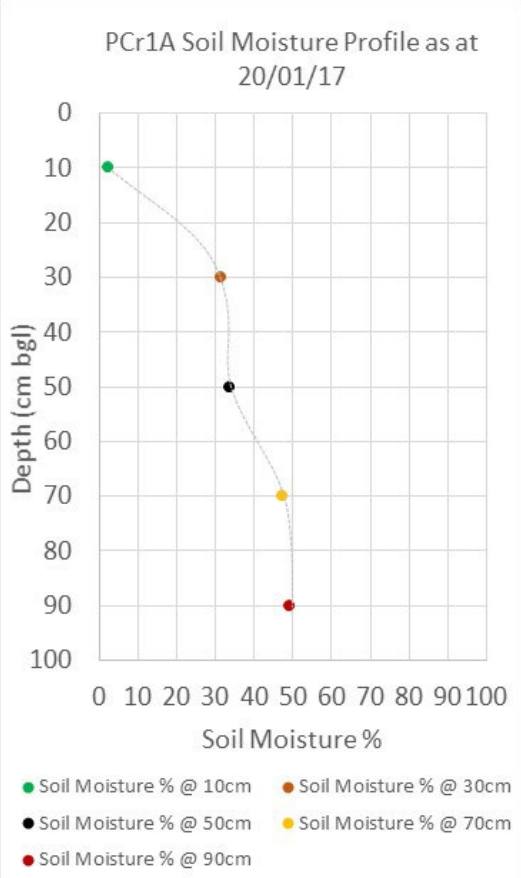
Swamp CRUS1

There are three sites monitoring soil moisture in swamp CRUS1 (PCr1A, PCr1B and PCr1C) and water levels are recorded at PCr1D. All three soil moisture sites show fluctuations in response to rainfall. PCr1B has a high soil moisture percentage at 10 and 90 cm below surface. PCr1C is relatively moist between 10 and 90 cm below surface. In comparison, PCr1A has large fluctuations between 100 percent moist and dry conditions, possibly due to its location on the edge of the swamp whereas PCr1B is closer to the centre. Swamp CRUS1 will overlie RVE UEP.

Groundwater level trends for PCr1D and nearby Hawkesbury Sandstone bore RV18 are shown in **Figure 4-3**. RV18 is screened within the upper Hawkesbury Sandstone from 8 m to 20 m below surface, and PCr1D is 0.38 m deep and screened within swamp deposits. **Figure 4-3** shows groundwater levels within the upper Hawkesbury Sandstone have been recorded 6 m to 11 m below surface since monitoring began in 2015. This indicates swamp CRUS1 is hydraulically separated from the Hawkesbury Sandstone water table based on available data.

A soil moisture profile is shown in **Figure 4-4** for site PCr1A near swamp CRUS1, which is present above historical mining (i.e. LW6). The figure shows the soil moisture content increases with depth to 50 cm below surface where it stabilises at 50 percent. The depth to the water table at swamp CRUS1 is recorded at the PCr1A piezometer, about 250 m to the north, as being generally unsaturated. When water is present it can range from 23 to 47 cm below surface. The results show an increase in soil moisture with depth that likely relates to influence of evaporation at surface and evapotranspiration by swamp vegetation.

Figure 4-4 Soil moisture profile - PCr1A at CRUS1



4.2.2 Water Quality

Water quality monitoring of shallow swamp piezometers has occurred since March 2012. A summary of the swamp water quality data is presented in **Table 7** and timeseries pH and EC trends shown in **Figure 4-5** and **Figure 4-6**, respectively. The swamp water quality is generally acidic to neutral (pH 3.3 – 8.5) and fresh (EC 23 – 420 µS/cm). Full water quality results are contained in **Appendix C**. Baseline data up to December 2020 has been used for the derivation of the triggers.

Table 7 Swamp Water Quality Data Summary to December 2020

Analyte	ANZG 2018 95% species protection default guideline	Swamp Data				
		Range	Median	5th Percentile	95th Percentile	Population
Field Data						
pH	6.5 - 8.5	3.3 - 8.5	5.0	3.8	6.3	402
EC (µS/cm)	125 - 2200	23 - 420	93	56	193	402
Temp (°C)	-	10.0 - 21.7	15.0	11.3	19.2	402
Total Dissolved Solids (mg/L)	50	18 - 273	60	36	126	377
Dissolved Oxygen (% Sat)	85 - 110	28.2 - 101.3	65.0	34.4	94.8	207
Dissolved Oxygen (mg/L)	-	1.9 - 9.8	6.0	3.0	9.0	402
Oxidation Reduction Potential (E_h) (mV)	-	-6.5 - 553.7	264.0	41.5	405.6	402
Resistivity (Ohms.cm)	-	2840 - 40000	13513	6106	22727	376

Figure 4-5 Swamp Field pH to December 2021

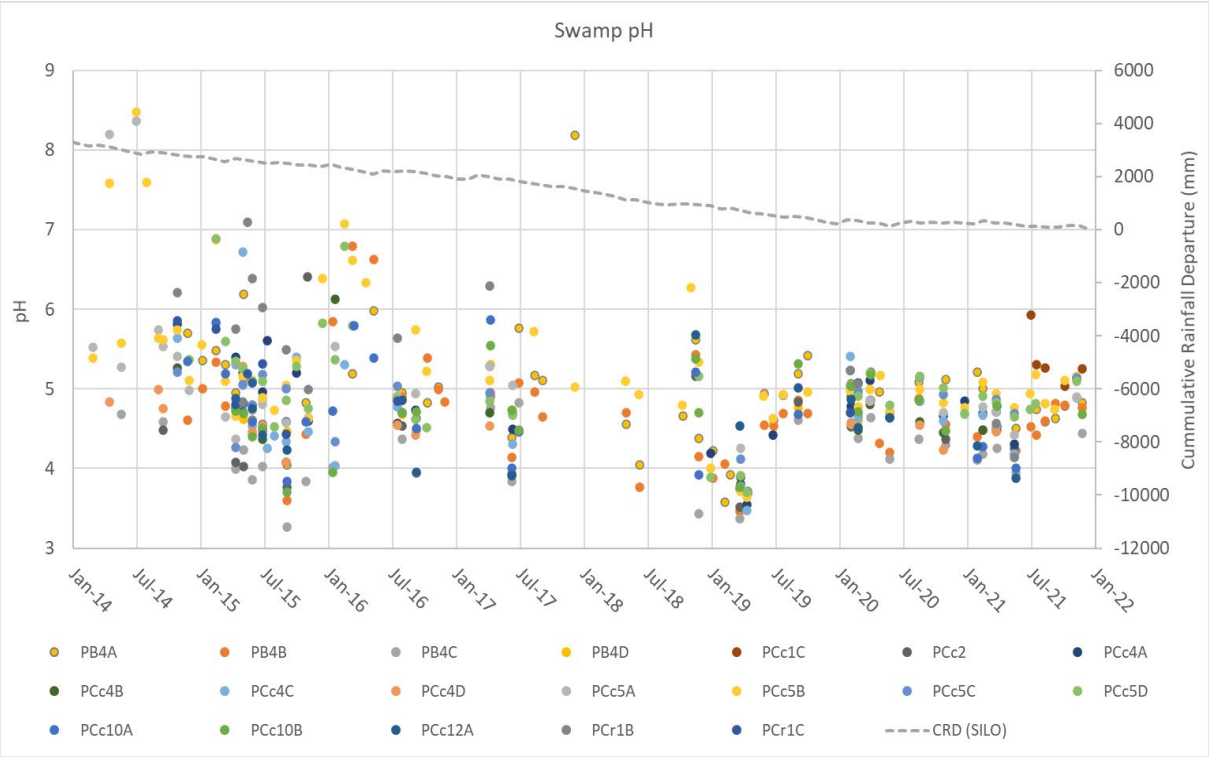
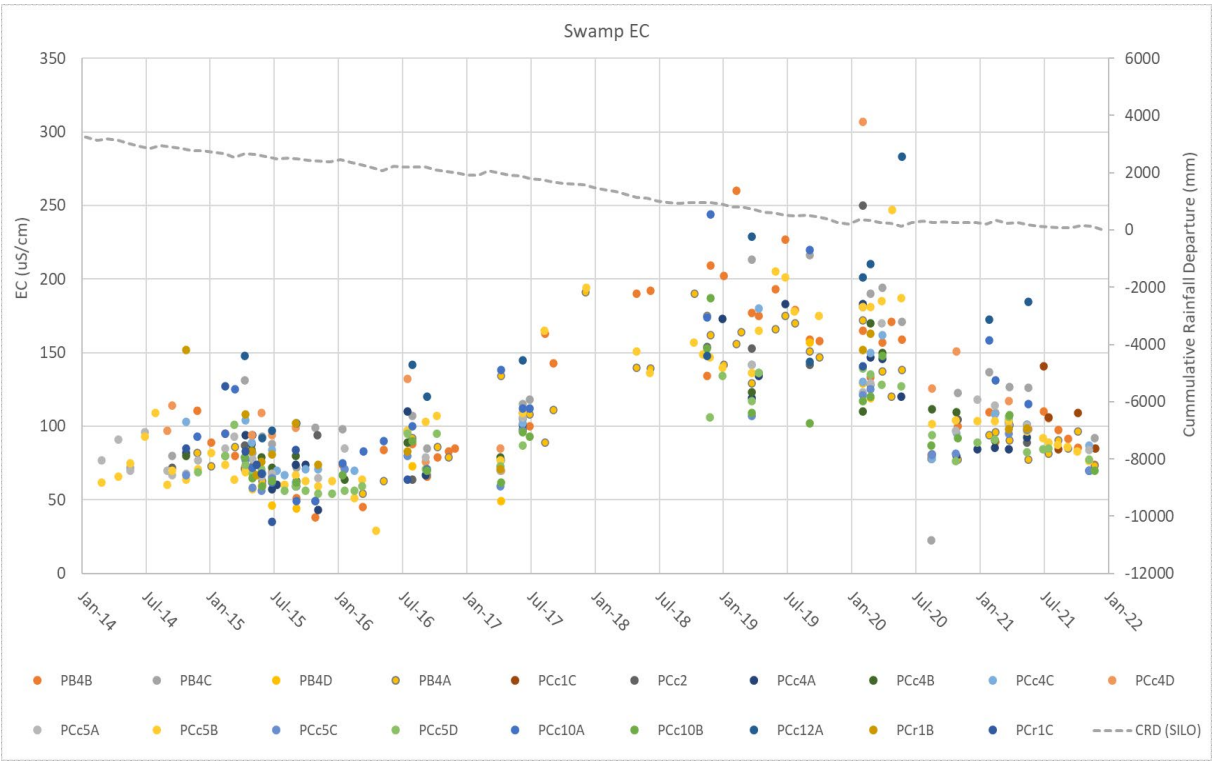


Figure 4-6 Swamp Field EC to December 2021



5. GROUNDWATER BASELINE DATA

5.1 Pit Top Area Groundwater Monitoring

In accordance with **Condition B17** and **Condition F5 (a)/ Schedule 2** of the Development Consent, WCL is required to detail any baseline data of groundwater levels, yield and quality for groundwater resources potentially impacted by the development. The project also involves upgrades to the surface facilities within the Pit Top Area; however, as outlined in **Section 3.6** and **Section 6.1**, additional impacts to groundwater are considered unlikely.

No impacts to groundwater have been previously identified for the approved Pit Top Area activities, likely due to the site geology (detailed in **Section 3.4**) and absence of a productive aquifer. As discussed in **Section 3.4** and **Section 3.6**, the geology within the Pit Top Area comprises the Permian Woonona Coal Member. Drill holes across the site reported by Terra Insight (2020) show the lithology comprises weathered Permian coal measures (siltstone and shale) and fill material at surface. The geotechnical investigation by Terra Insight (2020) also identified potential alluvium or colluvium localised along Bellambi Gully. Drill logs indicate the alluvium and colluvium comprises low permeability clays, unconformably overlying weathered Permian coal measures. No groundwater monitoring bores occur within the Pit Top Area.

Baseline data and monitoring within the Pit Top Area includes surface water monitoring and geotechnical assessments. Details on the surface water monitoring program for the surface facilities are captured in the Colliery Pit Top Water Management Plan. Further work will also be undertaken to assess potential impacts on groundwater conditions within the Pit Top Area. Three shallow groundwater open standpipe piezometers were installed in 2021 to monitor for any potential impacts. Details of the location and construction of the OSPs are detailed in **Table 8.**

5.2 Extraction Area Groundwater Monitoring Network

Wollongong Coal has an extensive groundwater monitoring network across RVE UEP that targets multiple groundwater units, including:

- 23 open standpipes (OSP) within the shallow Triassic strata, to depths of between 5 m to 53 m below surface
- 16 vibrating wire piezometer (VWP) locations with sensors across the Hawkesbury Sandstone and Narrabeen Group within the RVE UEP area
- VWPs with sensors in the Hawkesbury Sandstone, Narrabeen Group and Permian coal measures to the west of the RVE UEP area

Details on the current bore and VWP network are included in **Table 8** and locations shown in **Figure 5-1**. Due to the limited access in the catchment, and to limit disturbance to the catchment, the majority of drilling has been positioned along cleared access tracks.

The piezometers were installed between 2009 and 2021, after obtaining regulatory approval. They were established with accurate surface datum levels and groundwater levels or pressures are recorded at least 12 hourly, whilst field groundwater parameters (pH, EC) are monitored at least bi-monthly, (every two months), with water samples sent for a full laboratory analysis at least annually.

It is considered that the site has an adequate network to capture current and initial potential groundwater impacts.

Table 8 Groundwater Monitoring Network

Site ID	Type[1]	Easting GDA94 Z56	Northing GDA94 Z56	Ground Level mAHD	Screen/ Sensor Depth mbgl	Geology[2]	Year Installed
GW1 A	OSP	303742	6196983	311.7	21-27	HBSS/BGSS	2012
NRE A	OSP	303692	6196033	376.18	24-47	Upper HBSS	2009
NRE C	OSP	303233	6198797	362.72	18-24	Upper HBSS	2009
NRE D	OSP	301870	6198509	348.83	40-52	Upper HBSS	2009
NRE E	OSP	296727	6202286	329.24	26-29	Upper HBSS	2009
NRE F (NE 3)	OSP	294803	6201954	359.27	~ 20	Upper HBSS	2009
NRE G	OSP	296949	6201954	363.03	50-53	Upper HBSS	2009
RV18	OSP	302041	6196884	339.6	8-20	Upper HBSS	2014
RV19	OSP	301867	6196787	312.1	10-18.4	Upper HBSS	2014
RV21	OSP	302633	6197894	349.81	9-22.65	Upper HBSS	2014
RV22A	OSP	303026	6197634	342.66	7-37.35	Upper HBSS	2014
RV23A	OSP	301370	6198233	296.84	7-26.4	NPFM	2014
RV39	OSP	302936	6196635	372.99	26-35	HBSS	2021
RV40	OSP	302920	6196297	392.795	35-44	HBSS	2021
RV41	OSP	303540	6196564	346.073	26-35	HBSS	2021
RV42	OSP	303373	6196264	375.04	14-23	HBSS	2021
RV44	OSP	303666	6195790	375.05	5-14	HBSS	2021
RV45	OSP	303930	6195965	376.01	8-17	HBSS	2021
RV46	OSP	304277	6195733	390.51	17-26	HBSS	2021
RV47	OSP	304526	6195665	397.66	17-26	HBSS	2021
PB1	OSP	306358	6196133	47.35	5.5-14.5	Fill/Weathered Basement	2021
PB2	OSP	306778	6195779	26.72	5-8	Fill/Weathered Basement	2021
PB3	OSP	306405	6195559	47.128	8.5-14.5	Fill/Weathered Basement	2021
GW1 (NRE1 GW01)	VWP	303693	6196913	318.20	18	BGSS	2012
					30	BGSS	2012
					45	BGSS	2012
					63	BGSS	2012
					93	BGSS	2012
					125	BGSS	2012
					140	SPCS	2012
					165	SBSS	2012
NRE 3	VWP	294803	6201954	360.23	100	HBSS	2009

Site ID	Type[1]	Easting GDA94 Z56	Northing GDA94 Z56	Ground Level mAHD	Screen/ Sensor Depth mbgl	Geology[2]	Year Installed
(905)					130	HBSS	2009
					155	HBSS	2009
					255	BGSS	2009
NRE1A*	VWP	303680	6196034	376.23	45	HBSS	2009
					60	BHCS	2009
					75	BGSS	2009
					140	BGSS	2009
NRE1B	VWP	303939	6197567	372.69	27.5	HBSS	2009
					43	BHCS	2009
					63	BGSS	2009
					168	BGSS	2009
NRE1D (939)	VWP	301870	6198509	348	70	HBSS	2009
					90	BHCS	2009
					110	BGSS	2009
					160	BGSS	2009
RV16	VWP	303567	6196288	362.3	21.8	HBSS	2014
					51.8	BHCS	2014
					91.8	BGSS	2014
					131.8	BGSS	2014
					161.8	BGSS	2014
					196.8	SPCS	2014
					241.8	SBSS	2014
RV17	VWP	301979	6196818	333.4	20	HBSS	2014
					40	NPFM	2014
					60	BGSS	2014
					79.5	BGSS	2014
RV20	VWP	302944	6196635	374.27	35	HBSS	2014
					65	HBSS	2014
					85	BHCS	2014
					105	BGSS	2014
					134	BGSS	2014

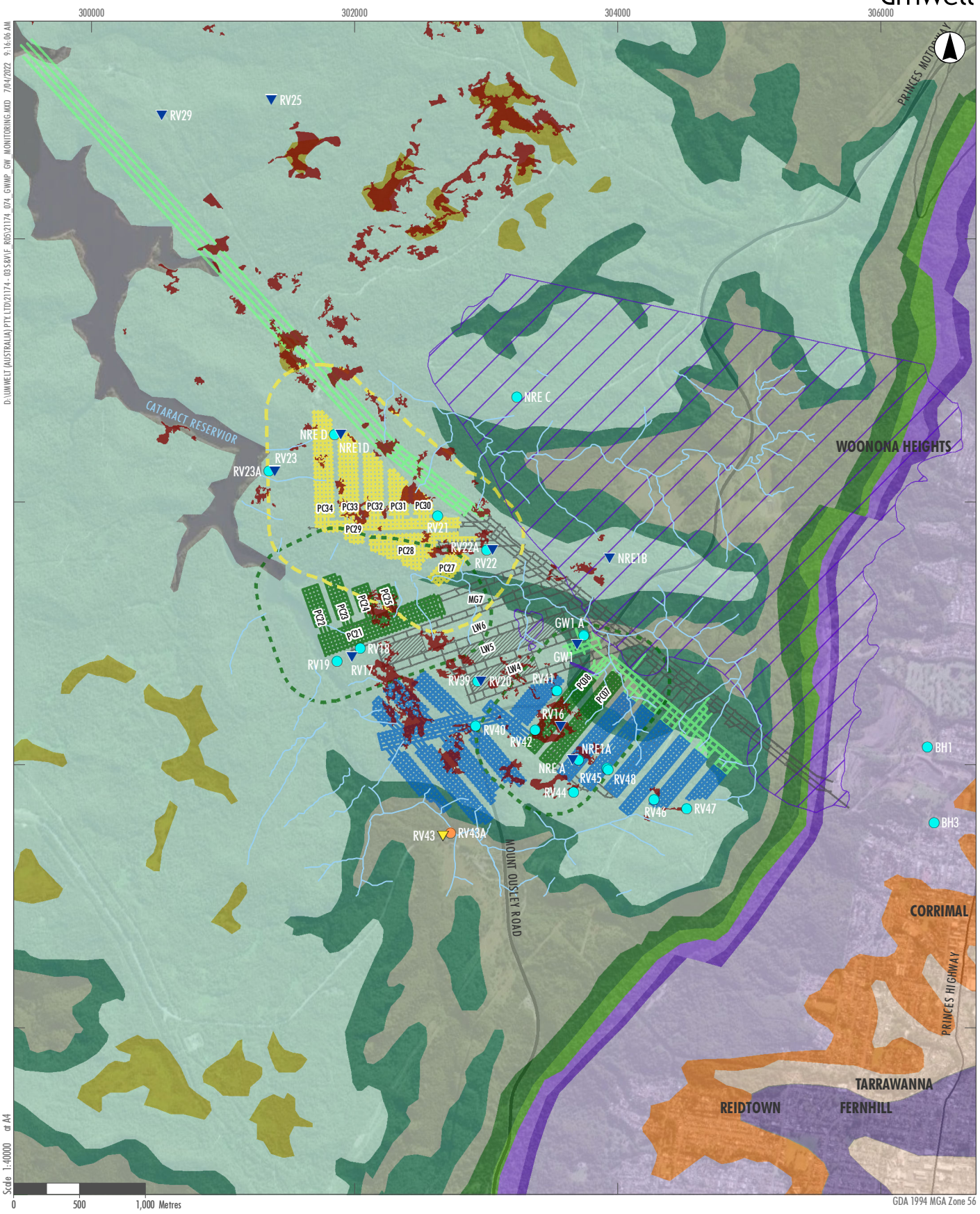
Site ID	Type[1]	Easting GDA94 Z56	Northing GDA94 Z56	Ground Level mAHD	Screen/ Sensor Depth mbgl	Geology[2]	Year Installed
RV22	VWP	303026	6197634	342.66	25	HBSS	2014
					50	BHCS	2014
					75	BGSS	2014
					100	BGSS	2014
					140	BGSS	2014
					175	BGSS	2014
					230	SBSS	2014
RV23	VWP	301370	6198233	296.84	20	NPFM	2014
					40	BHCS	2014
					70	BGSS	2014
					90	BGSS	2014
					130	BGSS	2014
					170	BGSS	2014
					200	SPCS	2014
					220	SBSS	2014
RV24	VWP	301004.6	6201932	397.7	85	HBSS	2018
					110	HBSS	2018
					125	BHCS	2018
					220	BGSS	2018
					300	SPCS	2018
					325	WMCS	2018
					430	WWCO	2018
RV25	VWP	301367	6201056	386.6	65	HBSS	2018
					100	HBSS	2018
					127	BHCS	2018
					150	BGSS	2018
					257	BGSS	2018
					320	WMCS	2018
					381	BUCO	2018
					423	WWCO	2018
RV27	VWP	298743	6201421	350.9	135	HBSS	2020
					149	NPF	2020
					178	BHCS	2020
					315	BGSS	2020
					330	SPCS	2020
					380	SBSS	2020
					475	WWCO	2020

Site ID	Type[1]	Easting GDA94 Z56	Northing GDA94 Z56	Ground Level mAHD	Screen/ Sensor Depth mbgl	Geology[2]	Year Installed
RV29	VWP	300533	6200938	386.7	90	HBSS	2018
					120	HBSS	2018
					140	BHCS	2018
					240	BGSS	2018
					295	SPCS	2018
					350	WMCS	2018
					443	WWCO	2018
RV35	VWP	291578	6205739	306.0	90	HBSS	2020
					155	HBSS	2020
					195	BHCS	2020
					300	BGSS	2020
					395	SPCS	2020
					422	SBSS	2020
					446	BUCO	2020
					485	WWCO	2020
RV36	VWP	291880	6203229	332.0	75	HBSS	2020
					100	HBSS	2020
					116	HBSS	2020
					255	BGSS	2020
					300	BGSS	2020
					324	BGSS	2020
					371	SBSS	2020
					405	WMCS	2020

Notes: 1. ***OSP*** *– Open Standpipe*
VWP *– Vibrating Wire Piezometer*

2. ***HBSS*** *– Hawkesbury Sandstone*
BHCS *– Bald Hill Claystone*
BGSS *– Bulgo Sandstone*
SPCS *– Stanwell Park Claystone*
SBSS *– Scarborough Sandstone*
NPFM *– Newport Formation*
BUCO *– Bulli Coal*
WMCS *– Wombarra Claystone*
WWCO *– Wongawilli Coal*

* *NRE1A VWP failed in 2017 repaired in 2021*



Legend

- Stage 2 Area PC27-34
- Stage 1 Areas PC07-08 and PC21-25
- EP2 Layout PC27-34
- EP1 Layout PC07-08 and PC21-25
- Future Wongawilli Seam Workings (not subject to this EP)
- Existing Wongawilli Seam Workings
- Wongawilli Seam First Workings (Approved under MP09_0013)
- Road
- Drainage Line
- Upland Swamp
- Sill

Monitoring Locations:

- VWP Monitoring Site
- OSP Monitoring Site
- VWP Proposed Monitoring Site
- OSP Proposed Monitoring Site

Surface Geology:

- Qa
- Qs - Swamp Sediments
- TRh - Hawkesbury Sandstone
- TRnz - Bald Hill Claystone
- TRnbu - Bulgo Sandstone
- TRnsp - Stanwell Park Claystone
- TRnc - Coal Cliff Sandstone
- Pis - Sydney Group
- Pnc - Trinkey Formation Claystone
- Pnw - Wombarra Claystone
- Pip
- Pie

FIGURE 5.1

Groundwater Monitoring Network

Image Source: ESRI (2021) Data source: DFSI (2020)

5.3 Groundwater Monitoring

5.2.1 Hawkesbury Sandstone

Groundwater Levels

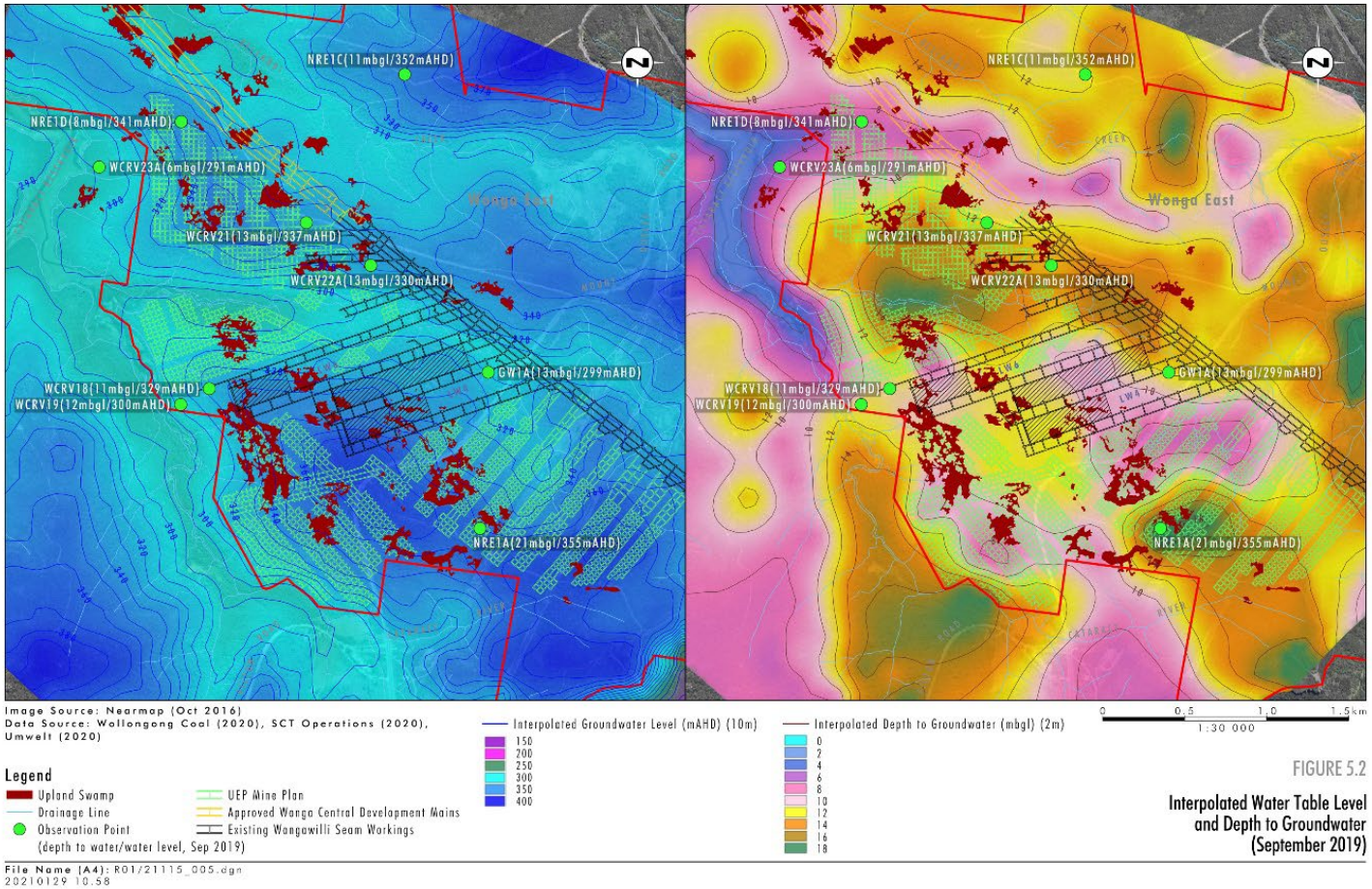
Groundwater levels within the Hawkesbury Sandstone are monitored across RVE UEP within open standpipes and VWPs (refer **Section 5.1**). Hydrographs of baseline water levels are presented in **Appendix D** and interpolated groundwater levels and depth to groundwater based on observation data from September 2019 are presented in **Figure 5-2**.

Based on the site data and drill logs, groundwater within the Hawkesbury Sandstone was first intersected around 17 to 48 m below surface across RVE UEP. Groundwater heads show confined to semi-confined conditions, with a general downward gradient within the unit. The groundwater level trends show good correlation to rainfall trends. Mining related drawdown (and recovery) within the Hawkesbury Sandstone has also been observed in localised areas around historical longwall extraction but water levels have generally recovered.

As shown in **Figure 5-2**, shallow groundwater levels within the RVE UEP area are generally around 13 m below surface. Relatively shallow groundwater levels (2 m to 6 m below surface) are interpolated along incised rivers and near the Cataract Reservoir to the northwest. Deeper groundwater levels are seen towards the south-east, at around 21 m below surface.

The Hawkesbury Sandstone is recharged from rainfall where it occurs at outcrop. Ephemeral perched water tables within the upper 20 m of the Hawkesbury Sandstone can occur following extended rainfall recharge periods. Groundwater within the shallow strata discharges as baseflow to streams where it is incised and gradients enable this, as well as downward seepage (refer **Figure 5-2**). Evapo-transpiration losses from deep and shallow rooted vegetation would also reduce the phreatic surface of the shallow water table to varying degrees. Discharge also likely occurs across the escarpment face under natural conditions.

Figure 5-2 Interpolated Water Table Level and Depth of Groundwater (Sep 2019)



Groundwater Quality

Groundwater quality monitoring of the open standpipes within the Hawkesbury Sandstone across RVE UEP has occurred since December 2009. A summary of the Hawkesbury Sandstone water quality data is presented in **Table 9** and timeseries pH and EC trends shown in **Figure 5-3** and **Figure 5-4**, respectively. Baseline data up to December 2020 has been used for the derivation of the triggers.

Water quality in the Hawkesbury Sandstone within the RVE UEP area generally has low salinity (45 – 685 µS/cm) with relatively acidic to neutral pH (2.7 – 8.2) and sulphate concentration of around 2 to 404 mg/L.

As shown in **Table 9** the water quality within the Hawkesbury Sandstone exceeds the ANZG 2018 95% Species Protection Level for Freshwater Aquatic Ecosystem for a range of analytes. Full water quality results are shown in **Appendix E**.

Table 9 Hawkesbury Sandstone Water Quality Data Summary to December 2020

Analyte	ANZG 2018 95% species protection default value (mg/L)	Hawkesbury Sandstone Data				
		Range	Median	5th Percentile	95th Percentile	Population
Field Data						
pH	6.5-8.5	2.7 - 8.2	5.0	3.7	6.5	388
EC (uS/cm)	125-2200	45 - 685	135	72	376	386
Temp (°C)	-	13.0 - 24.2	17.0	15.0	19.8	307
Total Dissolved Solids (mg/L)	50	29 - 356	85	45	241	297
Turbidity (NTU)	6-50	0.3 - 2074	15.0	2.6	411.8	187
Dissolved Oxygen (% Sat)	85-110	11 - 101.8	54.0	27.2	88.8	201
Dissolved Oxygen (mg/L)	-	1.0 - 9.1	5.0	2.9	8.1	307
Oxidation Reduction Potential (E_h) (mV)	-	1.9 - 563.9	301.0	39.8	441.1	307
Resistivity (Ohms.cm)	-	2109 - 24390	8969	3432	16850	296
Laboratory Data						
Total Dissolved Solids (mg/L)	-	36 - 4320	102	50	257	194
Sodium (mg/L)	-	6 - 558	12.0	9.0	34.3	195
Calcium (mg/L)	-	1 - 134	4.9	1.0	32.5	171
Potassium (mg/L)	-	0.3 - 38.0	1.0	1.0	32.5	126
Magnesium (mg/L)	-	1 - 10	2.2	1.0	9.0	194
Chloride (mg/L)	-	10 - 88	22.5	14.7	72.3	195
Fluoride (mg/L)	-	0.1 - 2.2	0.1	0.1	0.2	83
Sulphate (mg/L)	-	2 - 404	22.0	3.0	56.6	195

Analyte	ANZG 2018 95% species protection default value (mg/L)	Hawkesbury Sandstone Data				
		Range	Median	5th Percentile	95th Percentile	Population
Bicarbonate (mg/L)	-	1 - 1540	2.0	1.0	98.8	150
Filtered Iron (mg/L)	-	0.010 - 31.90	0.300	0.050	16.80	142
Filtered Manganese (mg/L)	1.9	0.006 - 4.240	0.200	0.018	1.705	195
Filtered Copper (mg/L)	0.0014	0.001 - 0.095	0.005	0.001	0.010	160
Filtered Lead (mg/L)	0.0034	0.001 - 0.209	0.002	0.001	0.066	145
Filtered Zinc (mg/L)	0.008	0.005 - 0.665	0.043	0.010	0.178	192
Filtered Nickel (mg/L)	0.011	0.001 - 0.099	0.004	0.001	0.018	178
Filtered Aluminium (mg/L)	0.055	0.010 - 2.000	0.290	0.010	0.860	175
Filtered Arsenic (mg/L)	0.024	0.001 - 0.097	0.001	0.001	0.011	76
Filtered Lithium (mg/L)	-	0.001 - 0.293	0.001	0.001	0.028	125
Filtered Barium (mg/L)	-	0.003 - 0.420	0.012	0.005	0.224	194
Filtered Strontium (mg/L)	-	0.004 - 0.646	0.026	0.005	0.107	192
Total Iron (mg/L)	-	0.02 - 10400	13.60	0.177	49.010	194
Total Manganese (mg/L)	-	0.013 - 218.0	0.230	0.028	2.186	195
Total Nitrogen (mg/L)	0.5	0.100 - 103.0	0.600	0.200	4.335	174
Total Phosphorus (mg/L)	0.025	0.010 - 620.0	0.030	0.010	0.375	139
Silicon (mg/L)	-	0.320 - 14.40	7.120	4.416	10.820	177
Dissolved Organic Carbon (mg/L)	-	1.00 – 22.00	2.00	1.000	8.100	133

Figure 5-3 Hawkesbury Sandstone Field pH to December 2021

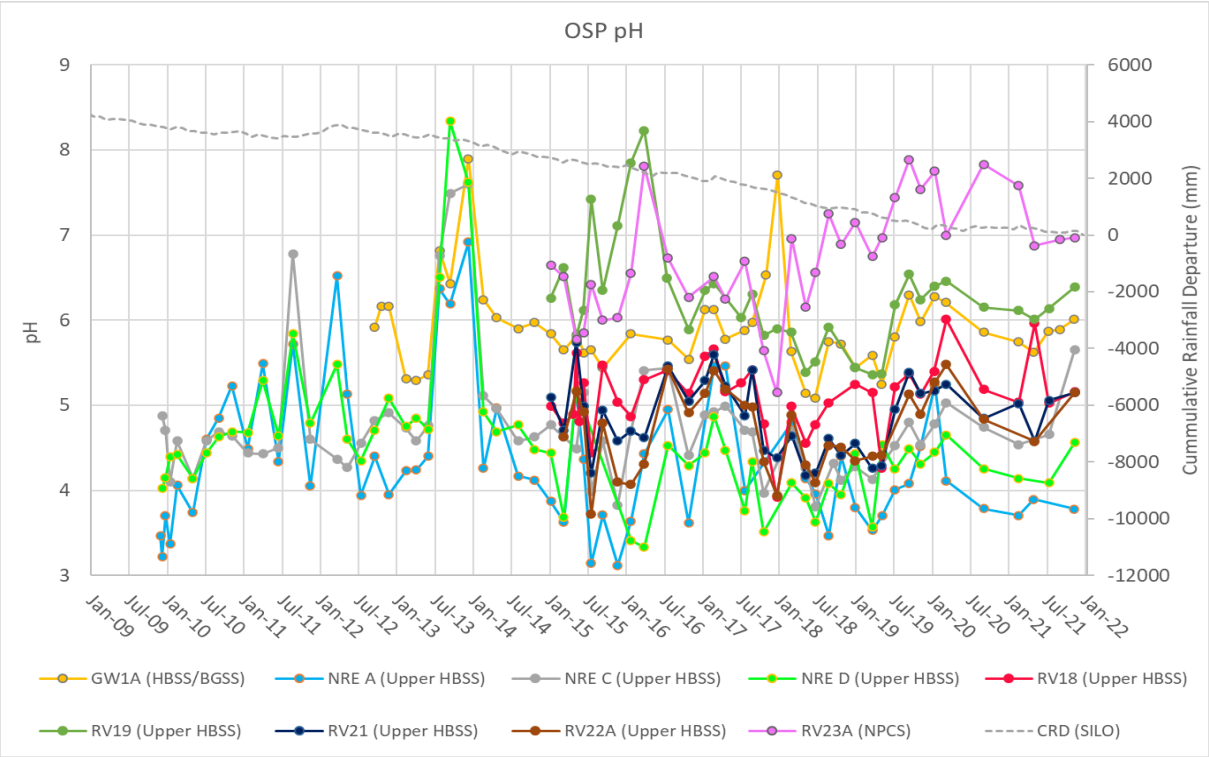
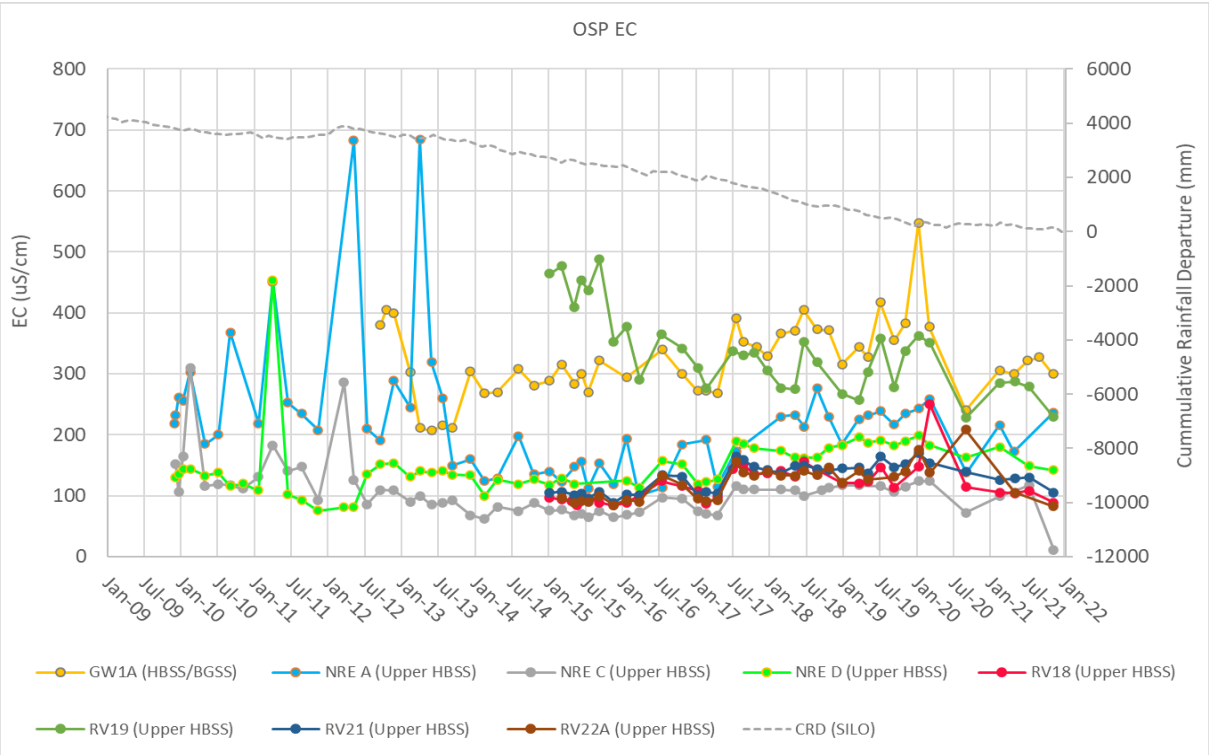


Figure 5-4 Hawkesbury Sandstone Field EC to December 2021



5.2.2 Narrabeen Group

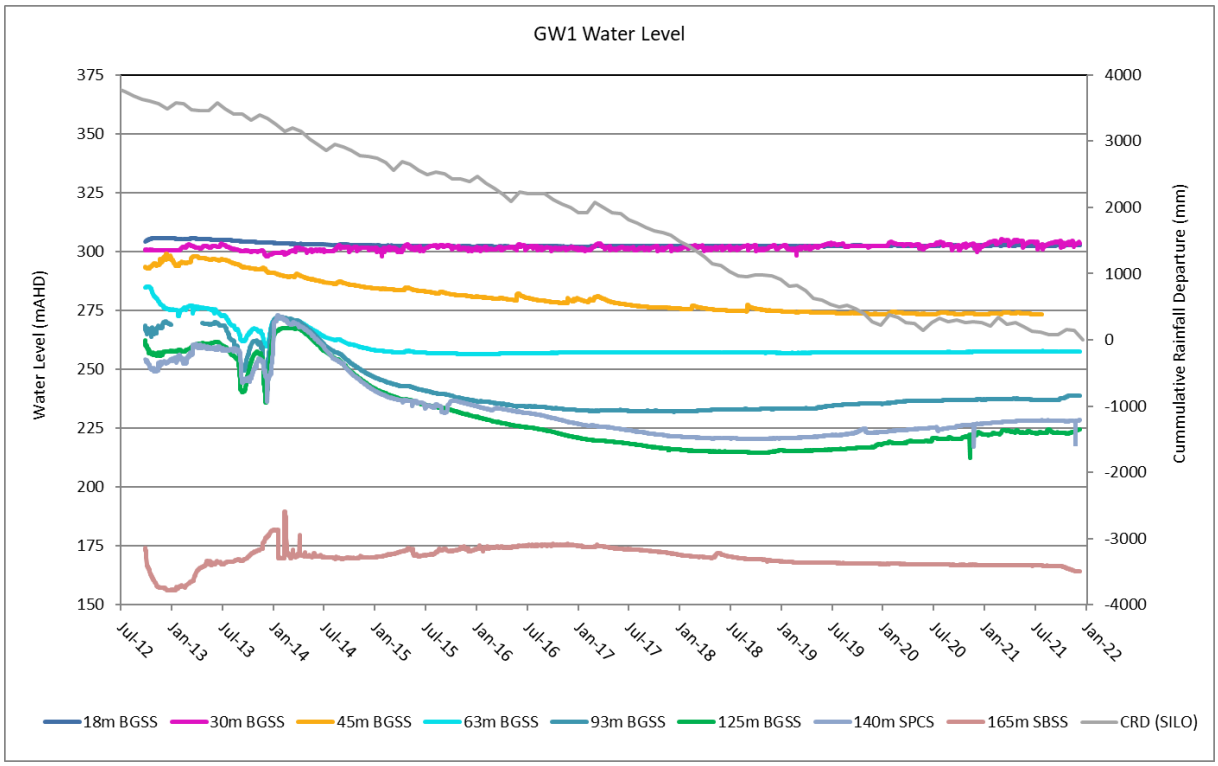
Groundwater Levels

Groundwater levels within the Narrabeen Group are monitored across RVE UEP within ten VWPs (refer **Section 5.15.1**). Hydrographs of baseline water levels are presented in **Appendix D**. Total head profiles showing groundwater heads at different depths and strata are also presented in **Appendix D**.

Based on the site data and drill logs, groundwater within the Narrabeen Group is intersected around 17 to 48 m below surface across RVE UEP. Groundwater heads show confined to semi-confined conditions, with a general downward gradient within the unit. Groundwater monitoring within RVE UEP also shows a general downward gradient and depressurisation in response to the historic mining. To illustrate this, a hydrograph for VWP GW1 is shown in **Figure 5-5** and a total head profile shown in **Figure 5-6**.

Figure 5-5 shows that water levels in the Bulgo Sandstone rapidly changed during the period of active mining from 2012 to 2015. With recovery of groundwater conditions in the underground workings during the period of care and maintenance, levels continued to gradually decline until 2018. Minor recovery in the Bulgo Sandstone is observed from 2018 to 2021.

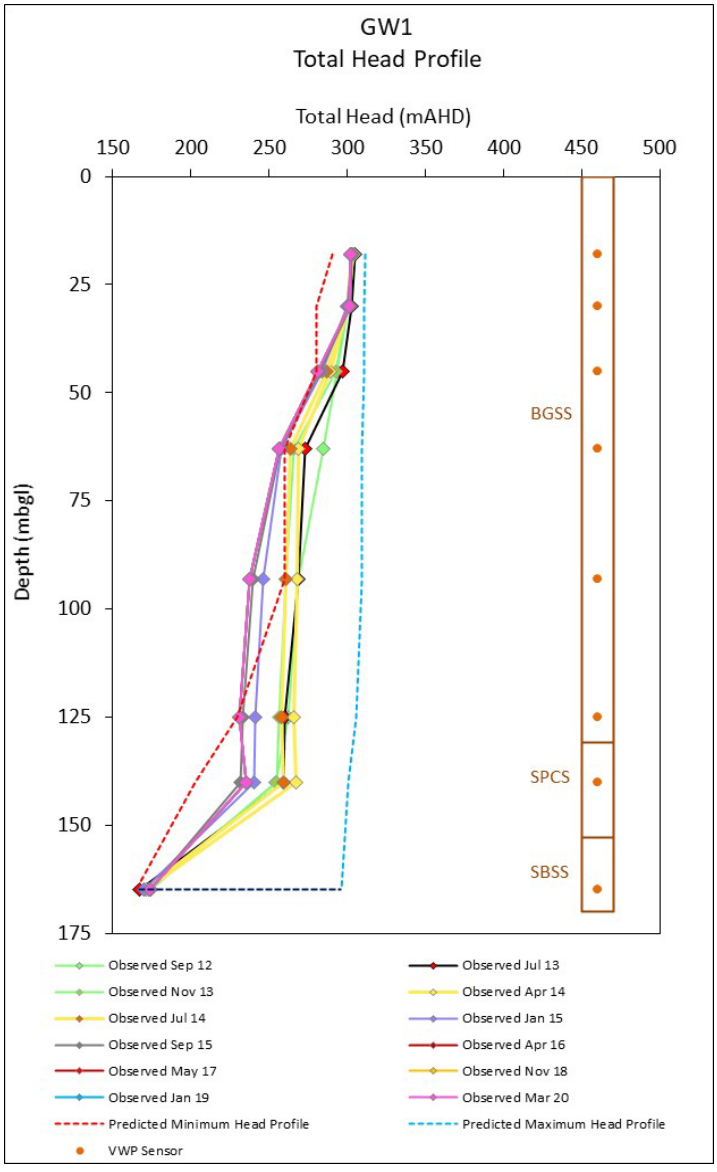
Figure 5-5 GW1 VWP Hydrograph



The total head profile in December 2015 to monitor GW1 (**Figure 5-6**) shows the groundwater head at different depths and strata within the Narrabeen Group, to help illustrate the vertical gradients. The profile shows a reduction in groundwater head with depth, illustrating a downward gradient.

Where it occurs at surface, the Narrabeen Group is recharged by rainfall and surface water storage areas. Where the Hawkesbury Sandstone is underlain by the Bald Hill Claystone it generally inhibits vertical flow to the underlying Bulgo Sandstone. However, within the RVE UEP area there are localised areas where the Bald Hill Claystone has been impacted by historical mining (goaf effects) and facilitates vertical flow and recharge via downward seepage. Groundwater within the uppermost Bulgo Sandstone discharges as baseflow to streams where the topography is incised and gradients enable this. Discharge also likely occurs across the escarpment face under natural conditions.

Figure 5-6 GW1 Total Head Profile



Groundwater Quality

Groundwater within the Bulgo Sandstone has been recorded at Appin Mine monitoring point S2080 as moderately saline (median of 5,660 µS/cm) with a relatively neutral pH (median of 6.95) and sodium-bicarbonate type water (HGEO 2018), which is considered representative of the Bulgo Sandstone water quality. There is currently no site water quality data for the Bulgo Sandstone; however, the new OSPs installed in December 2021 as part of the monitoring program includes additional bores in order to obtain baseline data for the Bulgo Sandstone.

5.2.3 Permian Coal Measures

Groundwater Levels

New OSPs were installed in December 2021 within the Permian coal measures within RVE UEP. The new OSPs that form part of the monitoring network are outlined in **Section 5.2**.

The Balgownie, Bulli and Wongawilli Seams have previously been mined and therefore significant depressurisation has likely occurred in the strata over time. However, recovery and ponding of water within the historical workings has been observed, including within the Bulli Seam workings west of Cataract Reservoir, the Cordeaux workings and Bulli Colliery bord and pillar workings.

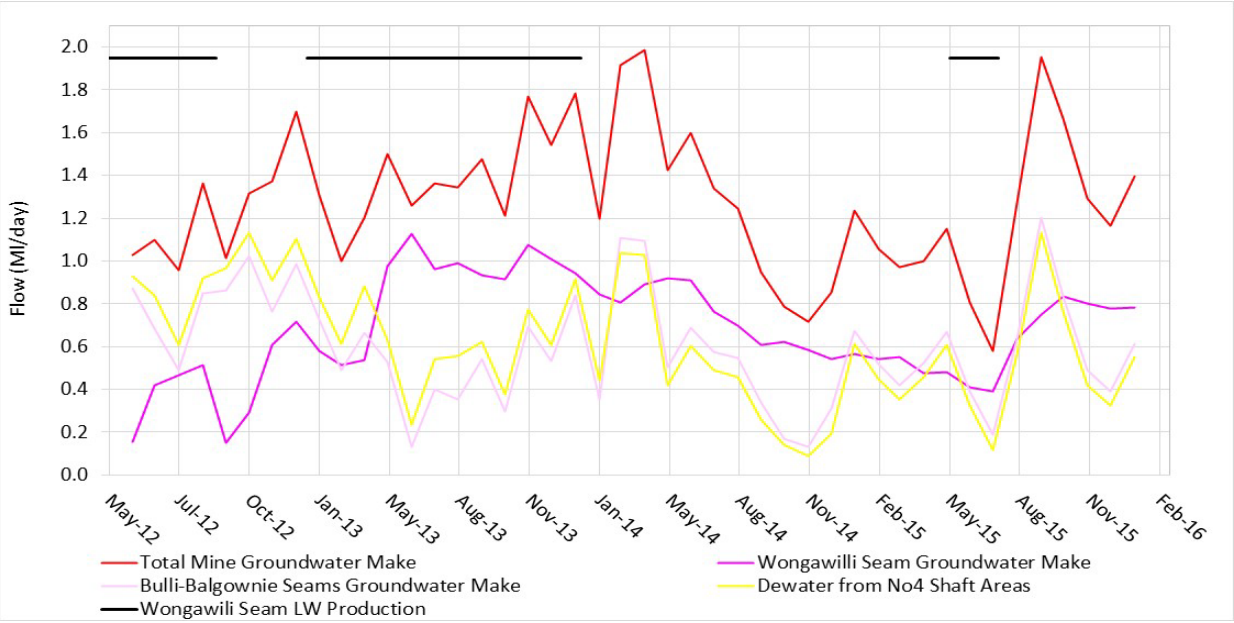
Groundwater within the Permian coal measures is recharged by rainfall where the seams outcrop along the escarpment, as well as downward seepage from the overlying Narrabeen Group. Downward seepage is restricted by the low permeability claystones within the Narrabeen Group, but is possible where the claystones are absent or exhibit goaf effects from historical and approved longwall mining. Discharge is via downward seepage, natural seepage along the escarpment (where gradients enable this), as well as abstraction with mining.

5.2.4 Underground Dewatering (Mine Inflows)

Reported groundwater inflows into the existing workings at Russell Vale have been relatively low, generally at around 1.1 ML/day for the whole mine and 0.4 ML/day for the Wongawilli Seam (SCT 2019a). This is down from 1.4 ML/day for the whole mine at the end of 2016 (SCT 2019a). Approximately up to 0.6 ML/day is currently pumped out at the RVC Pit Top. Estimated groundwater inflows within the mine water balance are presented in **Figure 5-7**.

It is assessed there is no free drainage into the existing workings at RVE UEP (including historical workings) as they are currently depressurised and essentially dry, apart from a few small ponded areas at the down dip end of the old workings where the dewatering pump is not able to extract the water, until it 'spills' into a down gradient section of the workings (SCT Operations 2014). Monitoring of water pump-out from the RVE workings indicates there is no observed associated short term increase in mine water make from the current RVE workings following significant rain in the Cataract Creek, Cataract River or Bellambi Creek catchments.

Figure 5-7 Mine Inflows – Monthly Average (2012 – 2016)



Groundwater Quality

AGL (2013) characterised the groundwater quality within the coal measures based on observed data in the region and indicated groundwater is generally alkaline with saline water quality, sulfate concentrations of up to 202 mg/L and some metals at low concentrations. WCL have collected a full suite of water quality data from the underground workings since 2020, which is summarised in **Table 10**.

As shown in **Table 10,** the mine water quality is generally alkaline (pH 7.7 – 9.4) (8.2/9.3 for 5th/95th percentiles) and relatively brackish (2,360 – 5,790 µS/cm) (5,226 µS/cm 95th percentile).

Water quality analysis indicates the mine inflow contains bicarbonate of up to 2,700 mg/L and sulfate of up to 204 mg/L. As well as dissolved metals with up to 0.107 mg/L of copper, 0.039 mg/L of nickel and 0.159 mg/L zinc. The available data indicates water within the mine inflows is generally consistent with water quality characterised for the Illawarra Coal Measures in the region by AGL (2013). However, some instances of higher concentrations of metals are noted.

Table 10 Permian Coal Measures Water Quality Summary

Analyte	Mine Inflow Range (Median)[1]	Illawarra Coal Measures (AGL,2013)	Geochemical assessment of rejects (WCL, 2020)
EC (µS/cm)	2,360 – 5,790 (3,400)	6,130 – 36,100	85 – 214 (soil)
pH	7.7 – 9.4 (8.8)	8 - 9	8.2 – 9.6 (soil)
Bicarbonate (mg/L)	1,210 – 2,700 (1,554)	3,360 – 16,400	700 – 13,700 mg/kg (soil)
Sulfate (mg/L)	1 – 204 (31)	<1 – 202	60 – 170 mg/kg (soil)

Analyte	Mine Inflow Range (Median)[1]	Illawarra Coal Measures (AGL,2013)	Geochemical assessment of rejects (WCL, 2020)
Aluminium (mg/L)	0.01 – 0.12 (0.03)	<LOR – 0.07	<LOR – 0.8 mg/L (water extract)
Antimony (mg/L)	0.00 – 0.13 (0.01)	-	<LOR – 0.08 mg/L (water extract)
Arsenic (mg/L)	0.002 – 0.269 (0.018)	<LOR – 0.03	<LOR – 1.8 mg/L (water extract)
Molybdenum (mg/L)	0.01 – 0.09 (0.05)	<LOR – 0.10	<LOR – 0.06 mg/L (water extract)
Copper (mg/L)	0.001 – 0.107 (0.010)	<LOR – 0.03	<LOR (water extract)
Nickel (mg/L)	0.001 – 0.039 (0.003)	<LOR – 0.02	<LOR (water extract)
Zinc (mg/L)	0.005 – 0.159 (0.016)	<LOR – 0.07	<LOR (water extract)

Note: *1. Site mine inflow data collected from February to December 2020*

5.4 Reject Material

Reject material comprises Permian coal measures separated during coal processing to improve the overall quality of the product coal through a dry separation process. The process of removing the reject material from the product coal does not involve the use of any chemical treatment processes.

Wollongong Coal conducted geochemical testing of existing reject material at site that was derived from the Wongawilli Seam and interburden material (i.e. Kembla Sandstone, shale and coaly shale). Twelve samples were collected for testing. The geochemical assessment found the rejects tested are likely to be non-acid forming (NAF) and have a high factor of safety with respect to potential acid generation. Analysis of the reject samples found they had an alkaline pH of 8.2 to 9.6, low electrical conductivity of 85 to 214 µS/cm, with less than 10 mg/kg of chloride (WCL 2019). Samples also contained between 60 to 170 mg/kg of soluble sulfate with a low total sulfur content of 0.005 to 0.2 %. Water extract testing found concentrations of soluble metals were generally below or close to the laboratory limit of reporting (LOR), but higher readings were recorded for one sandstone sample (REA08) with up to 0.08 mg/L antimony and 1.8 mg/L arsenic recorded. The quality of water from the rejects is largely consistent with the water quality within the Illawarra Coal Measures, however some samples can record slightly higher concentrations of specific metals (i.e. aluminium and arsenic). Spatial variability of rock geochemistry is expected and the slight differences between monitored groundwater quality and the results from the reject testings are considered unlikely to significantly impact on water quality within the Wongawilli Seam workings once groundwater levels recover. A summary of the results is shown in **Table 10**.

WCL have committed to undertaking the operations at RV UEP in a staged approach under Development Consent MP09_0013, as outlined in the Project Descriptions of the Environmental Management Plans under development. Specifically, WCL assessed the financial viability of the Coal Processing Plant (CPP) during stage 1 of the operations and determined that this CPP is not required at this time.

WCL applied to the Department to approve the staging of the waste and water management plans in accordance with Schedule 2, Condition A21 (a) of the Development Consent which states that:

> *With the approval of the Planning Secretary, the Applicant may:*
>
> *Prepare and submit any strategy, plan or program required by this consent on a staged basis (if a clear description is provided as to the specific stage and scope of the development to which the strategy, plan or program applies, the relationship of the stage to any future stages and the trigger for updating the strategy, plan or program).*

5.5 Private Bores

RVE UEP is located within the Metropolitan Special Area and forms part of the Sydney drinking water supply catchment. There are no private water supply works located within the Cataract Reservoir catchment. There are also no registered private water supply works located along Bellambi Gully.

6. POTENTIAL GROUNDWATER IMPACTS

6.1 Pit Top Area Groundwater Impacts

The RVE UEP area includes the existing approved Russell Vale Pit Top Area. The Pit Top Area has been in use since the later 1800's and the site currently comprises:

- **Top bench** – mine dam, fire dam, pumps, water pipes, water tanks, fire trail, access roads, electrical cables and power supply, stormwater diversion drainage channels, stormwater drainage pipes, retaining walls and benching, portable buildings, old redundant shed, original 1887 portal, 1918 ventilation tunnel, Gibson's portal, numerous closed adits, rubber tyred vehicle portal, ventilation portal, conveyor portal, steel-cored belt portal, ventilation fan, 'Castle' offices, muster room, administration building, car parking areas, workshop/store, external storage areas, vehicle wash down bay, bathhouses, transformers, conveyor transfer and RV1 conveyor.
- **Stockpile Area** – access road, truck washes, weightometer, unmade roads, contractor's lunchroom, contractor's bathhouse, stockpile control office and workshop. Old bathhouse workshop, clarifier tanks and associated infrastructure, truck loading bins and conveyors, stockpile area 1, coal processing area, stormwater pipes, Bellambi Gully Diversion pipe, weirs, dirty water system pipes, sumps and swales, water pipes, electrical cables and power supply, Dam 1, Dam 2, Stormwater Control Dam, Highway Dam, pump sheds, fencing, and automated monitoring systems.

Within the Pit Top Area, there have been no known activities undertaken that result in the take or interception of groundwater (i.e. abstraction bores). Therefore, no impacts related to drawdown in groundwater within the Pit Top Area are anticipated.

The Pit Top Area includes the storage and management of potential contaminant sources, including mine water, process material and chemical storage associated with site offices and workshop. Measures are in place to manage potential contaminants on site, including:

- Dirty water storage dams at the Pit Top Area are lined with impermeable material (i.e. clay);
- The main Storm Water Control Dam (SWCD) has been engineered with a seepage collection drain within the dam wall, which collects seepage at LDP 3 and then pumps it back into the SWCD; and
- Chemicals and hydrocarbons are stored in bunds and/or bunded areas designed to Australian Standards, and any spills are cleaned up promptly to prohibit migration into the groundwater table.

Further works have been undertaken to assess potential impacts on groundwater conditions within the Pit Top Area. Three shallow groundwater open standpipe piezometers have been installed in 2021 to monitor for any potential impacts. Details of the location and construction of the OSPs are detailed in **Table 8**.

The Project will involve changes to the existing site surface infrastructure within the Pit Top Area, including:

- Redesign of the Pit Top layout to relocate infrastructure to more shielded locations to reduce amenity impacts.

- Extension to the height of existing bunds, construction of new bunds and noise walls within the existing surface infrastructure area for improved noise mitigation.
- Construction of a new truck loading facility and associated conveyors.

As detailed in the WMP, measures will be put in place to manage and control surface water flow and sediments. All water and sediment captured on site will be stored and appropriately managed in accordance with the Surface Facilities Water Management Plan and the Environmental Protection Licence (EPL 12040) requirements.

6.2 Groundwater Modelling

A Groundwater Impact Assessment was conducted by GeoTerra/GES (2020) and peer reviewed by Dr Noel Merrick (HydroAlgorithmics 2020b). The impact assessment and review included development of a MODFLOW numerical groundwater model and uncertainty analysis by HydroAlgorithmics (2020a) (peer reviewed by Dr Frans Kalf) in order to predict the cumulative impacts.

6.2.1 Cumulative Impact

Modelling predicted there will not be any superposition of drawdown cones between the Russell Vale and Appin/Dendrobium mining areas. Therefore, there is no cumulative depressurisation resulting from the proposed bord and pillar workings and other adjoining active mines. However, there are cumulative impacts associated with the existing approved operations at Russell Vale Colliery, Cordeaux workings and Bulli Colliery and their residual impacts and recovery post closure. These cumulative historical impacts are captured within the groundwater assessment and modelling by GeoTerra/GES (2020) and HydroAlgorithmics (2020a).

Full details on the modelling and impact assessment predictions are included in GeoTerra (2020) and HydroAlgorithmics (2020a).

6.3 Existing Groundwater Impacts

Historical mining at site resulted in depressurisation within the Permian coal measures, Narrabeen Group and drawdown in the Lower Hawkesbury Sandstone in localised areas. These impacts were caused by subsidence and goaf effects associated with the longwall mining method, and groundwater extraction with mine progression. Recovery in groundwater levels has been observed over time, but residual impacts are present, including:

- Fracturing and subsequent increase in hydraulic conductivity within the Illawarra Coal Measures above the Wongawilli Seam, as well as the Narrabeen Group up to the Bulgo Sandstone in areas of longwall mining in the Wongawilli and Balgownie Seams and secondary extraction in the Bulli Seam. In some localised areas where extraction occurred across the three coal seams, multi-seam goaf effects have been identified as extending to the Lower Hawkesbury Sandstone.
- Groundwater inflows to the existing workings. Approximately 0.6 ML/day on average is currently pumped out of the Russell Vale workings (i.e. LDP2); however historically, higher levels of inflows were reported and modelled during the mining of LWs 4-6.

- Depressurisation around the active mine area and areas that have experienced goaf effects. This includes depressurisation within the Illawarra coal seams, localised around active mine areas. Areas showing some recovery with water ponding in historical workings include Bulli Seam workings west of Cataract Reservoir, the Cordeaux workings and Bulli Colliery bord and pillar workings. Depressurisation is also observed within the sandstone units of the Narrabeen Group, localised around active mine areas. Short-term localised depressurisation also occurred within the Lower Hawkesbury Sandstone.
- Reduction in natural seepage and flow to the escarpment with depressurisation during active mining, as well as development of preferential seepage pathways with adits and portals.
- Localised changes in groundwater quality within the Hawkesbury Sandstone, visible as iron staining along incised creeks that receive baseflow contributions from groundwater.
- There is no evidence of subsidence near Cataract Reservoir to suggest there are any existing links between RVE UEP and the Cataract Reservoir. No further linkages are expected in the future.

6.3.1 Impacts Post Closure

Post-closure, groundwater levels within the coal measures will recover back towards pre-mining conditions over time. Due to the long history of mining within the region (since the 1800s) the pre-mining conditions are not well understood within the region. It is anticipated that if groundwater conditions recover back to natural conditions there is potential for natural seepage from the escarpment. Therefore, the existing adit opening may form a potential pathway for additional localised seepage post closure.

The Wongawilli Seam and mined areas dip to the west from the existing mine entry adit located on the Illawarra Escarpment at the RVC Pit Top. The existing underground workings would eventually fill with groundwater, possibly up to the level of the adit and spill from the adit to the Bellambi Gully catchment. The recovery of groundwater levels within the Wongawilli Seam localised around the Pit Top is therefore defined by the lowest adit outflow point at 117 mAHD.

6.3.2 Mine Sealing

The installation of seals to isolate areas can be conducted as specific mining areas are completed, with the seals containing monitoring, drainage and sampling facilities to allow water accumulation behind the seals to be monitored, sampled and managed while current areas are mined.

The final sealing of the mine requires bulkheads to be installed that ensure that any water reporting to the mine will be controlled. However, a return to natural seepage from the Permian and Triassic strata where it occurs at outcrop along the Illawarra escarpment would be expected once groundwater levels recover. This process is further detailed in the Adit Discharge Management Plan in accordance with Condition A19 of MP09_013.

Trigger mechanisms that will initiate the decision to abandon other remedial techniques and commence the installation of bulkheads either to isolate areas or to seal the mine are to be defined as part of the mine closure plan.

6.4 UEP Additional Impacts

This section presents a summary of the predicted groundwater impacts based on the groundwater assessment conducted by GeoTerra/GES (2020) that present a base case of predicted impacts due to the UEP, as well as the MODFLOW-USG base case and uncertainty analysis conducted by HydroAlgorithmics (2020a) that presents a range of predicted impacts based on specified uncertainty bounds.

6.4.1 Groundwater Inflows

The GeoTerra/GES (2020) modelling predicts mine inflows of around 288 ML/year for the basecase model, with the current uncertainty analysis indicating inflows are likely as not to be about 294 ML/year for the RVE UEP. This is similar to observed inflows for existing operations, measured at around 219 ML/year between 2013 and 2014 but less than the peak modelled Wongawilli Seam groundwater make during the mining of LW5. The predicted mine inflows vary over time, and will be continually refined as new data becomes available and modelling updated.

The total licensable volume is predicted to be around 288 ML/year under the Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011 (Groundwater WSP). Wollongong Coal holds a Water Access Licence (WAL) for the groundwater source of 615 ML, which more than covers the predicted take.

6.4.2 Depressurisation

Depressurisation due to the RVE UEP mine plan is expected or modelled to be greatest within the Wongawilli Seam and immediate overburden where it occurs within the immediate footprint of the proposed workings. The areal extent of the 2 m drawdown contour within the Wongawilli Seam at the end of the proposed mining extends a maximum of 0.5 km to the north of the main headings. The uncertainty analysis predicted drawdown within the Wongawilli Seam due to the RVE UEP mine plan could extend up to 2 km from the proposed workings. This includes drawdown associated with delayed recovery within the existing mine workings and represents a temporal impact, as opposed to a change in the drawdown extent due to the RVE UEP. The modelled results are also based on additional impact from the end of LW6, so account for residual cumulative impacts from existing operations.

There is minimal transgression of depressurisation within the overlying strata associated with RVEUEP mining, due to the lack of any additional goaf development or subsidence due to the proposed bord and pillar mining method. Maximum drawdown of up to 50 m above the Wongawilli Seam is predicted to occur just to the north of the Mains out to a distance of approximately 0.5 km from the proposed workings. As the overlying Balgownie and Bulli seams have also previously been mined, significant depressurisation has occurred historically. Results show maximum predicted drawdown of up to 5 m within the Balgownie Seam with the RVE UEP mine plan, localised over the proposed bord and pillar workings (GeoTerra/GES 2020).

The Bulli Seam has been mined over a very long period of time over a large regional area. Within the Russell Vale area where there is over 100 years of historical mining activity, unsaturated voids still exist and continue to be drained. Recovery within the mined workings is

predicted to be delayed with the RVE UEP mining but would have no significant effect on the long-term recovery.

6.4.3 Water Table Drawdown

The shallower water table is predicted to be largely unaffected by the RVE UEP bord and pillar workings. This is because the workings do not result in a change in existing connective cracking/goaf effects, so groundwater impacts are largely localised to within 50 m above the Wongawilli Seam. However, around LWs 4 to 6, where multi-seam mining has previously occurred, the existing goaf effects extend into the Hawkesbury Sandstone.

The base case modelling by GeoTerra/GES (2020) and uncertainty analysis by HydroAlgorithmics (2020a) predicted a localised area of water table drawdown above LWs 4 to 6. This predicted drawdown relates to approved longwall mining, with the RVE UEP potentially causing a delay in timing in recovery of water levels and a slight increase in drawdown where drawdown has already occurred due to the delay in commencement of recovery. In the absence of any subsidence impacts which affect the water holding capacity within the swamps, no additional impacts to swamps already impacted by historical mining are predicted as a result of the proposed bord and pillar mining.

6.4.4 Water Storage Interaction

The water storage areas relate to the reservoirs and lakes. There is no subsidence near Cataract Reservoir to provide a causal pathway for groundwater. No further linkages between RVE UEP and Cataract Reservoir are expected.

6.4.5 Baseflow Losses

RVE UEP will have no perceptible subsidence impacts. No direct impacts to surface features are expected to result from mining, with the exception of the Pit Top works which are further addressed in the Russell Vale Colliery Pit Top Biodiversity Management Plan. The groundwater assessment predicted minor indirect impact associated with predicted drawdown in a localised area. Uncertainty analysis by HydroAlgorithmics (2020a) predicted negligible baseflow reduction along Cataract Creek of around 2.1 ML/year (0.0058 ML/day), with uncertainty bounds (10th and 90th percentile) of 1.3 ML/year (0.0036 ML/day) to 3.4 ML/year (0.0093 ML/day). Negligible baseflow reduction was also predicted in the uncertainty analysis (50th percentile) for Cataract River of around 1.0 ML/year (0.0027 ML/day) and 0.7 ML/year (0.0019 ML/day) along Bellambi Creek. These modelled annual changes for the Cataract River and Bellambi Creek will be practically unobservable and likely reflect model computational changes between the runs. Details on the surface water monitoring program are contained in the EP WMP.

6.4.5 Groundwater Quality

Due to the very low level of predicted subsidence, and by association, the minimal overburden fracturing that could develop as a result of the proposed bord and pillar workings, no observable pH or iron hydroxide changes are anticipated in the shallow strata during active mining.

7. MONITORING PROGRAM

7.1 Swamp Monitoring

The existing swamp water level, water quality and soil moisture monitoring network is outlined earlier **Section 4.1**.

Details on swamp monitoring in entirety are contained in the USMP (RVC EC PLN 008). General details on the swamp water level, water quality and soil moisture monitoring program are included in **Appendix F,** which refers to monitoring requirements prior to mining, during mining and post closure. The specific installation and monitoring requirements for each swamp in potential areas of impact are set out in the Upland Swamp Monitoring Plan.

Details on the swamp ecological monitoring program are captured separately within the Upland Swamp Monitoring Plan and Biodiversity Management Plan.

The Extraction Plans developed under Condition C10 of the Development Consent will detail specific swamp monitoring requirements and TARPs related to potential impacts on swamps from the 'second workings' covered by those plans.

7.2 Groundwater Monitoring

The groundwater monitoring network is outlined in **Table 8** and shown in **Figure 5-1**. Additional monitoring locations are proposed to assist in future model updates and mine closure planning, as presented in **Table 11** and shown in **Figure 5-1**. This includes an additional two VWPs and one open standpipe within the Bulgo Sandstone. **Table 11** includes indicative locations, to be confirmed based on land accessibility and agreement with the regulatory authority. The proposed additional sites will be installed in year two, to enable collection of data to inform the future model update.

Details are included on the likely construction, geology and purpose of the additional monitoring locations. The proposed monitoring locations include additional sites within the Permian coal measures, Narrabeen Group and Hawkesbury Sandstone to characterise current local groundwater conditions and monitor response to depressurisation and the vertical head gradient.

During the installation of the monitoring points additional data on hydraulic properties will be collected to inform future updates to the groundwater model. With the installation of the VWPs, downhole geophysics will be conducted, and drill core collected for analysis of vertical and horizontal hydraulic conductivity. Packer testing will also be conducted to collect hydraulic properties across the various geological units. Head tests will also be conducted on newly installed open standpipes where water is present and sufficient to conduct a test.

Table 11 Proposed Additional Groundwater Monitoring Sites

Site ID	Type[1]	Easting GDA94 Z56	Northing GDA94 Z56	Screen/ Sensor Depth mbgl	Geology[2]	Install Timing[2]	Purpose
RV43 A	OSP	302700	6195481	9-15 m	BGSS	Year 2	Located in cleared area near Picton Road, along Cataract Creek and mapped high potential GDE. To characterise depth to groundwater and water characteristics for future model updates. As well as verify trends with paired VWP RV43.
RV43	VWP	302691	6195477	Various to ~ 270 m	BGSS, SPCS, CCSS, BUCO, WWCO	Year 2	Located in cleared area near Picton Road, outside of immediate mine area in order to intersect coal measures. Enable ongoing monitoring of groundwater level and vertical head profile response to mining and recovery post closure.
RV48	VWP	304375	6196676	Various to ~ 250 m	BHCS, BGSS, SPCS, CCSS, BUCO, WWCO	Year 2	Located north of site, aiming to avoid historical mining in order to intersect coal measures. Enable ongoing monitoring of groundwater level and vertical head profile response to mining and recovery post closure.

Notes: 1. ***OSP*** *– Open Standpipe* ***VWP*** *– Vibrating Wire Piezometer*
2. ***HBSS*** *– Hawkesbury Sandstone* ***BHCS*** *– Bald Hill Claystone* ***BGSS*** *– Bulgo Sandstone* ***SPCS*** *– Stanwell Park Claystone* ***SBSS*** *– Scarborough Sandstone* ***BUCO*** *– Bulli Coal Seam* ***WWCO*** *– Wongawilli Coal Seam*
3. *Indicative install timing, Year 1 is within the first year of operations, Year 2 is within the second year of operations.*

Details on the groundwater monitoring program are included in **Appendix F** and outline that basement groundwater level/head pressure data will be monitored in the existing and proposed OSPs as well as the existing and proposed VWP arrays. The OSP and VWP bores will have pressure transducers installed to read at least 12 hourly, and will be downloaded bi-monthly as outlined in **Appendix F**. During logger downloads, the field pH and EC will be measured from the OSPs with calibrated handheld meters, whilst sampling for laboratory analysis of the waters will be conducted quarterly.

Appendix F refers to monitoring requirements prior to mining, during mining and post closure. The monitoring frequency and triggers designated during mining apply to bores located within 500 m of the bord and pillar footprint. Bores located further than 500 m from the bord and pillar footprint will remain monitored at a pre-mining frequency. With the progression of mining resulting in a bore that was within 500 m of the bord and pillar footprint becoming further than 500 m away, it will be monitored at the post-mining frequency. The specific groundwater monitoring bores within 500 m of the bord and pillar will be designated within the extraction management plan. The timing of installation of proposed monitoring locations (refer **Table 11**) will be prioritised based on active mine areas as specified within the extraction management plan.

Groundwater level and quality triggers are defined in **Appendix G** and **Appendix H,** with triggers assigned for swamp piezometers, shallow groundwater and deep groundwater. Triggers are defined for the existing monitoring bores and additional proposed bores. Trigger criteria have also been assigned to identify changes in the vertical groundwater head profile monitored by the VWPs.

The established water quality triggers can be applied to any newly installed monitoring locations within the Hawkesbury Sandstone. As the water level triggers are site specific and there is limited data on the Bulgo Sandstone, a minimum of twelve months of data will be collected in order to establish water level trigger levels and water quality triggers for any newly installed monitoring locations.

The groundwater monitoring program will be linked to the subsidence monitoring program and analysis will enable direct correlation of any groundwater impact with subsidence. The use of GNSS units located at targeted locations along the panel and at locations proximate to sensitive nearby features and can also be used to detect subsidence changes in near real-time which can also inform the analysis of groundwater monitoring results.

Water quality monitoring, including collection and analysis of environmental water tracers (EC, temperature and major ions), will be conducted before, during and after the period of extraction associated with the RVE UEP, as outlined in **Appendix F**.

Water quality monitoring will be conducted monthly for analysis of field parameters of pH, EC, DO, ORP and temperature for early detection of water quality changes. Full water quality analysis will be conducted consistent with current monitoring, which includes the field parameters plus suspended solids, major ions, metals and nutrients will be conducted on a two to three monthly basis, as outlined in **Appendix F**. The water quality analysis will be increased with a full metals suite on an annual basis, to include boron, cadmium, copper, mercury, selenium and silver.

A summary of the water quality analytes and terminology is outlined below:

- **Field analysis:** includes field analysis of environmental water tracer physio- chemical properties: pH, EC, DO, ORP and temp.
- **Discrete:** includes field analysis of pH, EC, DO, ORP and temp, as well as laboratory analysis of major ions as environmental water tracers. Includes analysis of TDS, TSS, major ions (Na, K, Ca, Mg, Cl, SO_4), F, HCO_3, $CaCO_3$, NO_3, Total N, Total P, Total alkalinity, filtered DOC and dissolved metals Al, P, Cu, Pb, Zn, Ni, Sb, Fe, Mn, Mo As, Li and Ba.

- **Full metals suite**: includes field analysis of pH, EC, DO, ORP and temp, as well as discrete laboratory analysis suite **plus** laboratory analysis of additional dissolved metals B, Cd, Co, Hg, Se and Ag.

7.3 Mine Water

RVC has developed procedures as part of an In-Rush Hazard Management Plan to manage the potential risk of in-rush from:

- water stored in decommissioned adjacent workings;
- water stored in completed WCL workings;
- mining under surface water bodies; and
- intersection with bores or gas drainage holes.

Flow meters have been strategically located throughout the mine to enable reliable measurement of water pumped in and out of the workings to assist in the identification of groundwater make and water accumulation as mining progresses and inform the site water balance. Due to the inherent complexity associated with underground water movement and inflows from historical workings, the water balance will be informed by numerical groundwater modelling. This modelling will be updated over time based on collection of new data.

Ongoing monitoring of mine inflow water volumes and quality will also be conducted daily to inform the site water balance, verify characterisation of mine inflow water quality and for future updates to the groundwater model. The capture of incidental water is an important component of the site's water balance. If mine water is pumped to underground storages, then pumped volumes will also be recorded via flow meters or other suitable gauging apparatus. Flow meters will be in place for daily volumetric flow monitoring to inform the site water balance.

Water samples of pumped (dewatered) mine water will be collected monthly for field analysis with the objective of providing an early indication of any mixing with (lower salinity) natural groundwater. Samples will also be collected for discrete analysis on a quarterly basis during active mining. The water quality analytical suite will be the same as that adopted for groundwater monitoring bores. To summarise, the seepage monitoring program will include:

- metering the volume of water pumped from the mining areas using flow meters or other suitable gauging apparatus at local collection point and at the outflow discharge point;
- monthly to bi-monthly monitoring quality of mine inflow water (including environmental water tracers for physiochemical properties and major ions with field analysis, discrete and full suite) in accordance with current underground mine water monitoring regime; and
- correlation of rainfall records with mining area seepage records/model estimates so that the groundwater and any surface water/shallow alluvial incidental take can be separated.

7.4 Cataract Reservoir

The mine inflow volume monitoring and water quality analysis, outlined in **Section 7.3,** can also be used to determine if any potential linkages have formed between RVE UEP and the Cataract Reservoir.

7.5 Groundwater Model Verification

Within three years from the date of commencement of mining operations, an independent review of the groundwater model will be undertaken to determine the validity of the groundwater model predictions and will include a comparison of monitoring results with modelled predictions. This includes comparison between observed and modelled groundwater level trends and mine inflow volumes.

Additionally, if the observed data indicates significant divergence from the model predictions, an updated groundwater model will be constructed to better replicate current trends and for simulating future mining and recovery.

8. MANAGEMENT, MITIGATION AND REMEDIATION MEASURES

8.1 Swamp Management System

The swamp management system at RVE UEP consists of:

- swamp water monitoring program described in **Section 7.1** with further detailed contained in the Extraction Plans;
- swamp subsidence monitoring program described in the Extraction Plans;
- ecological monitoring program described in the Upland Swamp Ecological Monitoring Plan prepared for each EP and Biodiversity Management Plan; and
- surface water monitoring program described in the EP WMP.

Details on the swamp ecological monitoring program are captured separately within the Upland Swamp Ecological Monitoring Plan and Biodiversity Management Plan. The Extraction Plans developed under Condition C10 of the Development Consent will detail specific swamp monitoring requirements and TARPs related to potential impacts on swamps from the 'second workings' covered by those plans.

8.2 Groundwater Management System

The groundwater management system at RVE UEP consists of:

groundwater monitoring program described in **Section 7.2** with further detailed contained in the Extraction Plans;

- subsidence monitoring program described in the Extraction Plan;
- management of the groundwater inflows into the underground workings as described earlier and in the EP WMP; and
- management and monitoring of adit outflows as described in the EP WMP.

Groundwater mitigation and remediation measures include mine inflows and mine sealing, as described in **Section 8.2.2**.

8.2.1 Pit Top Area Groundwater Management

In accordance with **Condition B17(v)/ Schedule 2** of the Development Consent, WCL is required to provide a detailed description of the groundwater management system for the RVC pit top area. The project involves upgrades to the surface facilities within the Pit Top Area; however, as outlined in **Section 3.6** and **Section 6.1**, impacts to groundwater are considered unlikely.

No impacts to groundwater have been previously identified for the approved Pit Top Area activities, likely due to the site geology (detailed in **Section 3.4**) and absence of a productive aquifer.

Measures in place to manage possible groundwater impacts from water loss or seepage include:

- Dirty water storage dams at the pit top lined with impermeable material (i.e. clay);

- The main Storm Water Control Dam (SWCD) has been engineered with a seepage collection drain within the dam wall, which collects seepage at LDP 3 and then pumps it back into the SWCD; and
- Chemicals and hydrocarbons are stored in bunds and/or bunded areas and any spills are cleaned up promptly to prohibit migration into the groundwater table.
- Further work will also be undertaken to assess potential impacts on groundwater conditions within the Pit Top Area. Three shallow monitoring bores were installed within the Pit Top Area in December 2021.The bore construction and lithology information is to be compiled and the locations to be surveyed to provide accurate groundwater elevation data. Ongoing routine water level and quality monitoring will be conducted and results analysed to assess and monitoring any potential impacts.

8.2.2 Mine Inflows and Dewatering Water

Investigations will be instigated if the rate of groundwater inflow significantly increases for a period of greater than seven days. There is considered to be a significant increase if the inflow rate increases to more than 1 ML/day, above the inflow rates that were generally occurring at the time. An exception to this is where dewatering volumes are influenced by dewatering of water stored in historical workings to minimise inrush risk, or due to variability in pump rates due to equipment maintenance.

Application of an appropriate technique to manage an abnormal inflow to the mine will be determined by agreement with all stakeholders based on the advice of hydrogeologists and ground consolidation technical experts.

The mine has used materials in ground control applications and inflow control applications in the past and will apply these as appropriate to regain control of inflows should the need arise.

Selection of the optimum application and combination of materials and techniques will depend on the nature and magnitude of the inflow, expert advice and stakeholder input.

The company would work closely with specialist ground support and polyurethane resin (PUR) injection companies with appropriate experience in chemical injection techniques for consolidation of unstable and porous ground and in the use of such measures to control ground water flows.

The In-rush Hazard Management Plan details methodologies relating to grout and PUR based solutions to localised inflow situations and defines the capability of each product used for ground consolidation and water control, MSDS documents, technical specifications as well as case studies of applications where each product and sealing technique would be most effective.

Pro-active responses based on projected inflows mean that actions may be considered and planned at the time, with reference to pre-planned scenarios.

In addition to underground sealing of inflows it may be practical to undertake sealing works from the surface, depending on specific environmental factors related to the proposed work.

With predicted inflows for the RVE UEP mine plan, at any point in the progress of mining the Review Team will take appropriate early remedial action that is anticipated to negate the need to activate the defined response to an actual trigger.

PUR and grout is available at short notice. However, with the exception of localised occurrences, it is not considered to be necessary to maintain stocks of materials as these may be very circumstance-specific, and, with the time afforded by forward projection of inflows, their application and acquisition should not be a matter of urgency.

Ground consolidation would be made available to be rapidly deployed to water control activities if necessary.

Operators will be trained to conduct supporting activities for contract drillers and PUR injection personnel.

WCL will require water access licences (WALs) under the *Water Management Act 2000* to authorise the taking of groundwater in the course of mining operations. RVC is located within the Sydney Basin Nepean Water Source under the Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011. Groundwater inflows to the mine will be taken from this water source.

WC holds sufficient allocation to account for the predicted maximum groundwater inflows to RVC workings of 288 ML/year. Mine inflows removed/dewatered from the workings will be managed under the site water balance system outlined in the WMP.

As discussed in **Section 6**, the peak reduction in baseflow for Cataract River, Cataract Creek and Bellambi Creek combined is predicted to be very small, with the volume apportioned to the RVE UEP being between 2.3 ML/year and 6 ML/year based on groundwater modelling. WC currently holds sufficient licences to account for the volume of predicted water take at RVC. These licences are however held in the water sharing plan relevant to groundwater sources only.

8.2.3 Mine Sealing

The installation of seals to isolate areas can be conducted as specific mining areas are completed, with the seals containing monitoring, drainage and sampling facilities to allow water accumulation behind the seals to be monitored, sampled and managed while current areas are mined.

The final sealing of the mine requires bulkheads to be installed to manage seepage. Trigger mechanisms that will initiate the decision to abandon other remedial techniques and commence the installation of bulkheads either to isolate areas or to seal the mine will be defined as part of the mine closure plan.

8.3 Trigger Action Response Plan

The groundwater TARP, as presented in **Appendix G**, has been designed to illustrate how the various predicted impacts, monitoring components, performance measures and responsibilities are structured to achieve compliance with the relevant statutory requirements, and the framework for management and contingency actions.

8.4 Trigger Criteria

The trigger criteria are based on the existing trigger criteria for RVC, with baseline data used to set trigger values and consideration of current predicted impacts due to the RVE UEP. The

triggers are set on the basis that readings outside these ranges represent a potential change in conditions that 'may' indicate an impact. Level 2 triggers are a sign of a potential change, but the reading may be within natural variability. Level 3 triggers are set at a level which is statistically unlikely to occur due to natural variability based on historic monitoring. An exceedance of a level 3 trigger may still be due to natural variability and may not have any adverse environmental impacts but warrants further investigation based on it being unlikely based on past monitoring.

Specific to the RVE UEP, the main predicted future impacts relate to drawdown and depressurisation within the Permian coal measures and Narrabeen Group with mine progression; localised potential drawdown in the Hawkesbury Sandstone related to historical goaf effects; and potential impacts associated with mine inflow water quality and underground rejects storage (refer **Section 6**). The first workings for future operations are considered unlikely to cause subsidence impacts and no additional impacts to swamps are predicted. In accordance with the conditions of the Development Consent (Table 6), subsidence impacts performance measures will be monitored and assessed and captured within the Extraction Plan. The swamp and groundwater monitoring captured within this management plan will be utilized to help inform the subsidence monitoring and assessment.

The groundwater trigger levels and criteria are summarised in **Table 12** and detailed further in **Appendix G** and **Appendix H**. The table includes proposed triggers for mine inflow water quality, which are based on current baseline mine inflow water quality as presented in **Table 10**. Triggers for physio-chemical properties of pH and EC, as well as SO_4 are proposed for early detection of potential changes in water quality and source with progression of mining.

Triggers are also proposed for metals (Al, As, Mo and Sb) that were identified through laboratory leachate analysis as potentially becoming mobilized under acidic conditions. These triggers have been applied to provide an early indicator of unexpected changes in water quality or water source. However, it should be noted that no impacts to water quality and metals concentrations are expected due to mine progression, with the interburden material exhibiting a high buffering capacity with alkaline conditions.

Moisture monitoring is not proposed to be used as a trigger due to variability between and within monitoring points. However, soil moisture data will be collected at each representative swamp location within the mine area to inform investigation processes should swamp vegetation or swamp groundwater level Trigger Criteria be exceeded. Full details on the monitoring program for swamps are included in the Upland Swamp Management Plan.

Additional groundwater monitoring points have been proposed to inform future model updates and mine closure planning, to be installed in Year 2. Once installed, default triggers have been proposed for the initial 12 months of monitoring, as outlined in **Table 12** and **Appendix H**. The proposed groundwater triggers are based on baseline monitoring and predicted impacts, with monitoring changes and/or specific triggers continuing to be developed as monitoring matures and becomes refined in consultation with key stakeholders and subject to approval by relevant departments. After the initial 12 months of monitoring, refined triggers for the new monitoring sites will be proposed, where required, and documented in the Annual Review.

Table 12 Groundwater Trigger Criteria

Area	Trigger Criteria
Swamps	pH - 5th and 95th percentile of baseline swamp data (all RVE swamps)
	EC – 95th percentile of combined baseline swamp data (all RVE swamps)
	SWL – 95th percentile of site-specific baseline depth to groundwater, calculated with dry readings excluded
Hawkesbury Sandstone	pH - 5th and 95th percentile of baseline data (all RVE OSPs)
	EC – 95th percentile of combined baseline data (all RVE OSPs)
	WL – 95th percentile of site-specific baseline water levels ***New sites: initial trigger based on maximum 2 m groundwater level decline over 12 month period***
Bulga Sandstone	pH – 5th and 95th percentile of baseline data after 12 months of data collection. ***New sites: initial trigger based on Hawkesbury Sandstone trigger***
	EC – 95th percentile of baseline data after 12 months of data collection. ***New sites: initial trigger based on Hawkesbury Sandstone trigger***
	WL – 95th percentile of site-specific baseline water levels after 12 months of data collection. ***New sites: initial trigger based on maximum 2 m groundwater level decline over 12 month period***
Hawkesbury Sandstone and Narrabeen Group	Groundwater head – vertical groundwater head profile per VWP location (site-specific), based on baseline and predicted vertical groundwater head for the RVE UEP
Permian coal measures - Mine Inflow Volumes	Mine pump volumes within predicted mine inflow range
Permian coal measures - Mine Inflows Quality	pH - minimum and maximum of site baseline mine inflow data
	EC - 95th of site baseline mine inflow data
	Sulfate – 95th of site baseline mine inflow data
	Dissolved Al - 95th of site baseline mine inflow data
	Dissolved As - 95th of site baseline mine inflow data
	Dissolved Mo - 95th of site baseline mine inflow data
	Dissolved Sb - 95th of site baseline mine inflow data

8.5 Response to TARP Criteria Exceedances

The TARP presented in **Appendix H** has been designed to illustrate how the various predicted impacts, monitoring components, performance measures, and responsibilities are structured to achieve compliance with the relevant statutory requirements, and the framework for management and contingency actions. **Table 13** below outlines the trigger level definitions to be applied to the TARPs provided within **Appendix H**.

Table 13 Trigger Levels

TRIGGER LEVEL	DESCRIPTION
Level 1 - Normal	Monitoring indicates performance criteria are satisfied. Operations continue as normal.
Level 2 - Warning	Minor or persistent changes in monitoring results indicate potential alteration of the environment (could be natural or mining related) or impacts outside of predictions. Internal investigation of potential causes required to determine if there is potential to cause material harm due to mining operations. Exceedances of subsidence triggers may result in implementation of adaptive management measures.
Level 3 - Exceedance	Significant change in monitoring results indicates a likely alteration of the environment (could be natural or mining related) or impacts outside of predictions. Investigation into potential causes required to determine if material harm has been caused due to mining operations. External notification of potential incident required for TARPs. Exceedances of subsidence triggers likely to result in implementation of adaptive management measures.

Whilst significant impacts are not predicted, the TARPs provide a process of tiered and escalating trigger levels/performance triggers for performance measures should subsidence and associated impacts be greater than predicted/approved. If monitoring indicates a trigger has been exceeded, investigations will be undertaken to identify the cause of the particular criteria exceedance and may require management measures to be implemented as outlined in this section and **Appendix H**.

Where Level 3 trigger criteria are exceeded, WCL will inform DPE and WaterNSW of the trigger criteria exceedance and proposed response as per the TARP. Investigation into the cause of the trigger exceedance will be instigated within one week of trigger exceedance being noted and will be informed by any advice received from DPE and WaterNSW.

Note: Level 3 Performance Measure TARP triggers do not, of themselves, constitute an incident or non-compliance under the Development Consent. Investigations following a Level 3 trigger will determine whether an exceedance or non-compliance of the performance measures or Development Consent conditions is likely or has occurred.

An investigation will be undertaken into the potential cause by a suitably qualified person. The investigation will be commenced within one week of the trigger exceedance. The investigation may include additional groundwater level and quality monitoring, as well as review of groundwater level and quality trends for other relevant sites and climatic conditions.

For swamps, the investigation will also include comparison to soil moisture/swamp water level reference sites, such as any swamps that have been unaffected by operations (i.e. greater than 350 m from second workings). The use of environmental tracers and swamp specific water balances may also be used where these investigation tools are identified as likely to inform the investigation process.

For more complex investigations where additional monitoring is required (as will be likely for the monitoring of impacts on swamps), longer investigation periods are likely to be required and a final investigation report will be provided within a reasonable timeframe as agreed with regulators.

DAWE, DPE– Water, Water NSW and BCD will be informed of the investigation outcomes within one month of assessment completion.

The requirement, need and potential cost/benefit of a mitigation plan with be discussed with DPE and WaterNSW and any other relevant stakeholders identified by these agencies. If required, site specific mitigation, or Corrective Management Action (CMA) plans may include:

- description of the impact to be managed;
- results of the investigations;
- aims and objections for the plan;
- specific actions required to mitigate/manage the issue;
- timeframes for implementation;
- roles and responsibilities;
- identification of and gaining appropriate approvals from government agencies; and
- providing a consultation and communication plan.

The mitigation or remediation plans will outline methods to ensure that ongoing impacts are reduced to levels below the impact assessment criteria as quickly as possible.

8.6 Potential Incident Notifications

Level 3 triggers in the TARPs under this management plan are set at a level that *may* indicate more than 'trivial' environmental harm. Where monitoring indicates a Level 3 Performance Measure TARP trigger related to biodiversity or groundwater values has been exceeded but the cause of the trigger being exceeded is unclear, DPE and Water NSW will be notified of a *potential* incident. All *potential* incident notifications related to biodiversity features will be sent to DPE and BCD. *Potential* incident notifications related to surface or groundwater impacts or which may have consequent impacts of groundwater or surface water will also be provided to Water NSW.

The notification will include the same matters required to be included in an Incident Notification as required by Condition F9 including the development (including the development application number and name) and set out the location and nature of the potential incident.

The investigation process will also consider any remedial action that may be required.

8.7 Contingency Plan

All works in the Metropolitan Special Area require WaterNSW approval, and there is a requirement for compliance with the Sydney Catchment Authority Water Supply Catchment Special Areas Standard Conditions for Entry (SCA, 2001).

These requirements ensure strict limits are placed on any impacts associated with undertaking rehabilitation works on WaterNSW land.

Access to the catchment is subject to WaterNSW authorisation and is only permitted in dry weather. Therefore, proposed monitoring frequencies may be delayed due to wet weather, whilst notification and investigation timeframes commence when triggers have been confirmed by the Group Environment Manager.

The management program and TARP provide a basis for the design and implementation of any mitigation and remediation, whilst monitoring of the area's environmental aspects will provide key data when determining any requirement for mitigation or rehabilitation.

In the event that a Level 3 trigger occurs, as detailed in the TARP (contained in **Appendix G**), WCL will implement the following Contingency Plan:

- the observation will be reported to WCL's Group Environment Manager immediately;
- the observation will be recorded;
- an investigation will be undertaken to identify the cause of the observed impacts;
- WCL will report any exceedance of the performance measure to the Secretary of DPE and other relevant stakeholders immediately after WCL becomes aware of the exceedance;
- WCL will assess the exceedances of the relevant TARP and where appropriate, implement safety measures in accordance with the appropriate Management Plan/s;
- The Group Environment Manager will investigate any potential contributing factors and, where relevant, identify an appropriate action plan to manage any identified impact(s) associated with the Project, in consultation with specialists and/or relevant agencies if necessary;
- WCL will develop an appropriate action plan to manage any identified impact(s) associated with the Project, in consultation with other specialists and/or key stakeholders;
- WCL will submit the proposed course of action to the DPE for approval;
- WCL will implement the approved course of action to the satisfaction of the DPE;
- WCL will continue to monitor performance with the new action plan in place and, if successful will formalise these actions as part of a revised Management Plan; and
- contingency measures will be developed in consideration of the specific circumstances of the issue and the assessment of consequences as outlined below.

8.8 Adaptive Management

Due to the nature of the proposed bord and pillar mining, adaptive management measures can be proactive or reactive. The adaptive management plan process for the Extraction Plan is presented in **Figure 8-1**.

The Extraction Plans will include TARPs which are designed to identify circumstances where observed impacts differ from those predicted. These broadly relate to subsidence and groundwater impact predictions which form the basis of the predictions of negligible impact

and proposed monitoring framework. Departures from these predictions may indicate the potential for exceedances of performance criteria.

An exceedance of Level 2 or 3 Performance Trigger will result in a review of underground mining operations and monitoring to identify any potential causative factors for the observed trigger exceedances. Depending on the nature, magnitude and location of the trigger exceedance, precautionary adjustments to the mine plan or mining practices may be required to avoid or mitigate the risk of performance measures being exceeded.

Additionally, in accordance with Condition F4 of the Development Consent and the RVC EMS, where exceedances of criteria or performance measures has occurred, WCL will:

a) take all reasonable and feasible steps to ensure that the exceedance ceases and does not re-occur (i.e. TARPs, contingency planning).
b) 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;
c) within 14 days of the exceedance occurring, submit a report to the Secretary describing these remediation options and any preferred remediation measures or other course of action; and
d) implement remediation measures as directed by the Planning Secretary.

Additional adaptive management measures may also be required to prevent a reoccurrence of the circumstances that gave rise to the exceedance of criteria or performance measure. This may include changes to the mine plan or underground mining practices.

8.9 Site Access

Vehicle access to some monitoring sites is via existing fire trails. Other monitoring sites will be accessed by foot from the nearest fire trail.

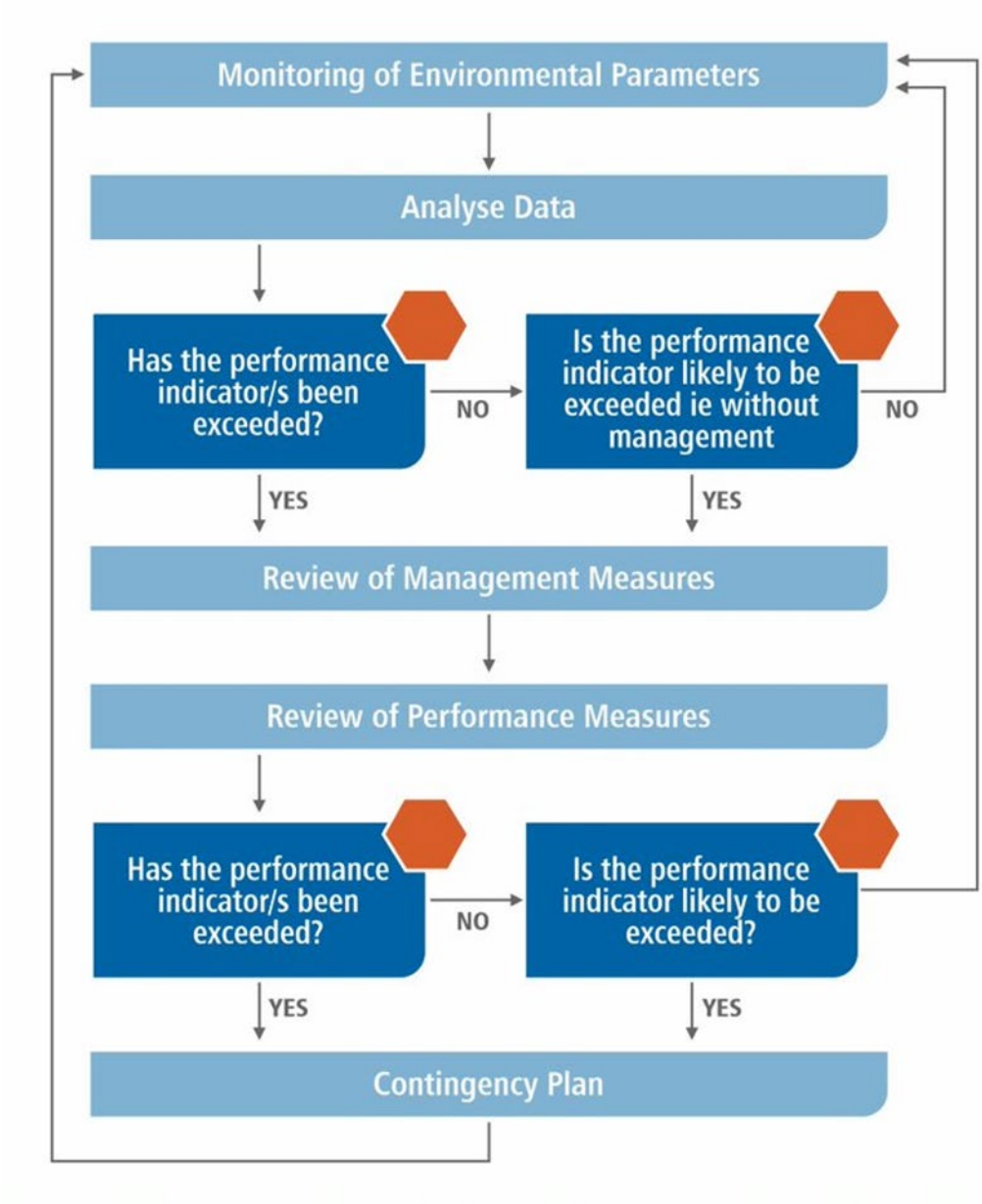


Figure 8-1 Adaptive Management Process

9. INCIDENTS, COMPLAINTS AND NON-CONFORMANCES

9.1 Incidents

The Development Consent (MP09_0013) defines:

- An 'incident' to be "*an occurrence or a set of circumstances that causes or threatens to cause material harm and which may or not be or cause a non-compliance*". Examples may include a breach of specific development consent criteria or performance measure.
- Exceedance or non-compliance as "an occurrence, set of circumstances or development that is a breach of this consent".

In both circumstances, an Incident or Non-Compliance must be attributable to the development approved under the Development Consent.

Material harm is defined in the Development Consent as:

> "Is harm to the environment that:
>
> - involves actual or potential harm to the health or safety of human beings or to the environment that is not trivial, or
> - results in actual or potential loss or property damage of an amount, or amounts in aggregate, exceeding $10,000 (such loss includes the reasonable costs and expenses that would be incurred in taking all reasonable costs and expenses that would be incurred in taking all reasonable and practical measures to prevent, mitigate or make good harm to the environmental).
>
> This definition excludes "harm" that is authorised under either this consent or any other consent."

Incidents and associated reporting requirements will be managed through established procedures set out in the EMS or, in the case of groundwater management related to subsidence impacts, the EPs. All incident notification related to groundwater features will be sent to DPE and WaterNSW.

As per Condition 26 of EPBC 2020/8702, WCL would notify DAWE in writing of any:

- incident;
- non-compliance with the conditions; or
- non-compliance with the commitments made in plans.

The notification would be given as soon as practicable, and no later than two business days after becoming aware of the incident or non-compliance.

The notification would specify:

- any condition which has been or may have been in breach
- a short description of the incident and/or non-compliance
- the location (including co-ordinates), date, and time of the incident and/or non-compliance. In the event the exact information cannot be provided, the best information available would be provided.

As per Condition 27 of EPBC 2020/8702, WCL must provide to DAWE the details of any incident or non compliance with the conditions or commitments made in plans as soon as practicable and no later than 10 business days after becoming aware of the incident or non-compliance, specifying:

- any corrective action or investigation which the approval holder has already taken or intends to take in the immediate future;
- the potential impacts of the incident or non-compliance; and
- the method and timing of any remedial action that will be undertaken by the approval holder.

9.2 Complaints Handling

Complaints will be managed through established WCL procedures and as required by **Condition F17** of the Development Consent, a copy of a complaints register (updated on a Monthly basis) will be kept on the WCL website. A summary of complaints will be available to regulatory authorities on request and provided in the Annual Review.

9.3 Reporting

Progress against the requirements of this plan will be reported regularly to the DPE and other relevant agencies as required by the Development Consent. Details on requirements on reporting, incidents, complaints and non-conformances are specified within **Appendix F**.

The notification requirements relate to the relevant regulatory authorities. No notification to water users is include, as outlined in **Section 5.5**, there are no private water supply works located within or surrounding the project area.

In accordance with the requirements of **Condition F17** of the Development Consent, the environmental performance of the colliery will be reported on the WCL website.

10. PLAN ADMINISTRATION

10.1 Roles and Responsibilities

Environment and community management is regarded as part of the responsibilities of all Colliery personnel. The roles and function of the main personnel responsible for the implementation of environmental and community management including the plans, procedures and action plans contained in this EMP are outlined in WCL's Management Operating System.

10.2 Resources Required

In accordance with the WCL SYS POL 003 Environmental Policy, Management shall ensure that the appropriate resources are made available to achieve the implementation of this Plan.

It is the role of the Group Environment Manager to ensure that these requirements are communicated to WCL Management.

10.3 Training

All training and inductions that relate to this Management Plan are to be undertaken as per the WCL training procedures.

10.3.1 Staff Training

Staff training will be undertaken as detailed in the EMS. This consists of three levels of training applicable to different types of staff:

- Level 1 – High level training on environmental requirements (management staff)
- Level 2 – Operational level training (project managers, supervisors, surface personnel, control room operators)
- Level 3 – Basic environmental awareness (underground staff, all personnel).

Targeted training will be provided as required for all workers relevant to their activities to provide them with the knowledge, skills and awareness to minimise environmental impacts where they are undertaking an activity with a high risk of potential environmental impact in accordance with **Condition A28** of the Development Consent.

The Group Environment Manager/Site Environment Representative will review the training program and monitor its implementation.

10.3.2 Inductions

All personnel, including contractors, sub-contractors and staff, are required to attend a compulsory site induction that includes an environmental component prior to commencement on site.

The environmental component will include an overview of:

- Relevant details of this Management Plan, including purpose and objectives
- Key environmental issues (e.g. activities with potential to result in environmental impacts)

- Consent Conditions, relevant licences and permits
- Specific management requirements and responsibilities, and mitigation measures
- Incident response and reporting requirements.

A record of all environmental training and inductions will be maintained and kept on site. The Group Environment Manager or delegate may authorise amendments to the induction where required to address project modifications, legislative changes or amendments to this GWMP or related documentation.

The Group Environment Manager or authorised delegate will review and endorse the induction program and monitor its implementation.

11. REPORTING, AUDIT AND REVIEW

11.1 Quarterly Monitoring Reporting

Data collected in accordance with this Plan will be reviewed by a suitably qualified person, to support early detection of trigger exceedances and potential impacts related to mine activities.

Within 20 business days of the end of each three-month monitoring period, all data collected from groundwater monitoring points over the monitoring period will be published on the WCL website and a copy of the data provided to DPE and DAWE. The data will be maintained on the WCL website for:

- at least five years after the cessation of mining for all monitoring bores within Coastal Upland Swamps;
- at least five years after the cessation of mining for other monitoring bores excepting those required to monitor groundwater recovery and potential discharge from adits; and
- the period for which the approval has effect for any monitoring site required to monitor groundwater recovery and potential discharge form adits.

Monitoring reports covering the quarterly monitoring period will be prepared by a suitably qualified person, with a summary of the results, graphical representation of trends (where relevant) and discussion on compliance with monitoring and performance criteria.

11.2 Annual Review

In accordance with Part F – Environmental management, reporting and auditing of the Development Consent, an Annual Review (AR) of the environmental performance of the Proposed Action is prepared.

The AR will:

- describe the works carried out in the past year, and the works proposed to be carried out over the current year
- include a comprehensive review of the monitoring results and complaints records of the development over the previous calendar year, including a comparison of these results against the:
  - relevant statutory requirements, limits or performance measures/criteria
  - monitoring results of previous years
  - relevant predictions in the EA documents listed in the Development Consent condition A2(c)
- identify any non-compliance or incident which occurred in the previous calendar year, and describe what actions were (or are being) taken to ensure compliance and avoid recurrence
- evaluate and report on compliance with the performance measures, criteria, and operating conditions of the development
- identify any trends in the monitoring data over the life of the development

- identify any discrepancies between the predicted and actual impacts of the development and analyse the potential cause of any significant discrepancies
- describe what measures will be implemented over the next year to improve the environmental performance of the development.

11.3 EPBC Annual Compliance Report

WCL will prepare and submit an Annual Compliance Report to DAWE as per the processes set out in Section 9.2 of the Water Management Plan.

11.4 Auditing

In accordance with **Condition F13** of the Development Consent, an Independent Environmental Audit will be undertaken by a suitably qualified auditor and include experts in any field specified by the Secretary within 12 months of the Development Consent and every three years after that.

This audit must:

- be prepared in accordance with the *Independent Audit Post Approval Requirements* (DPIE 2020 or as updated)
- be conducted by a suitably qualified, experienced and independent team of experts whose appointment has been endorsed by the Planning Secretary
- include consultation with the relevant agencies
- assess the environmental performance of the project and assess whether it is complying with the requirements in the Development Consent and any relevant EPL or Mining Lease (including any assessment, plan or program required under these approvals)
- Review the adequacy of strategies, plans or programs required under the abovementioned approvals.
- Recommend measures or actions to improve the environmental performance of the project, and/or any strategy, plan or program required under these approvals.

In accordance with Part F 14 of the Development Consent, WCL would submit a copy of the audit report, along with responses to any recommendations contained within the report to the Planning Secretary. The audit and response to recommendations would be submitted within three months of the completion of the audit unless otherwise agreed by the Planning Secretary.

11.5 Plan Revision

In accordance with Part F7 of the Development Consent, this GWMP will be reviewed within three months of:

- The submission of an incident report as per **Condition F9**
- The submission of an annual review under **Condition F11**
- The submission of an Independent Environmental Audit under **Condition F13**
- Any modification to the conditions of the Development Consent (unless the conditions require otherwise or as otherwise agreed with DPE).

The revision status of this plan is indicated in the Footer of each copy. Revisions to any documents listed within this Plan will not necessarily constitute a revision of this document.

Where revisions are required, the document would be submitted to DPE within six weeks of the review.

12. RECORDS AND DOCUMENT CONTROL

12.1 Environmental records

The EM/SER is responsible for maintaining all environmental management documents so that they are always current at the point of use.

Types of records include:

- monitoring, inspection and compliance reports/records;
- correspondence with public authorities;
- induction and training records;
- reports on environmental incidents, other environmental non-conformances, complaints and follow-up action;
- community engagement information; and
- minutes of environmental management system review meetings and evidence of any action taken.

All water management documents are subject to ongoing review and continual improvement. This includes times of change to scheduled activities or to legislative or licensing requirements.

Only the EM/SER, or delegate, has the authority to change any of the water management documentation.

12.2 Document control

The EM/SER will coordinate the preparation, review and distribution, as appropriate, of the environmental documents. During construction and operation, the environmental documents will be stored at the main site compound.

The WMP will be developed, approved, implemented and maintained in accordance with the Document Control Procedure (WCL SYS PRO 001).

13. REFERENCES

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14. GLOSSARY OF TERMS AND ABBREVIATIONS

TERMS	
Aquifer	rock or sediment capable of holding and transmitting groundwater.
Baseflow	the portion of stream flow that comes from the sum of deep subsurface flow and delayed shallow subsurface flow.
Bi-monthly	once every two months.
Bord and Pillar	Mining method comprising of a series of self-supporting roadways (or bords) within the coal seam leaving a grid of pillars of unmined coal which are designed to be stable in the long term.
Bore	a well, usually of less than 20 cm diameter, sunk into the ground and from which water is pumped. Catchment - the entire land area from which water (e.g. rainfall) drains to a specific water course or water body.
Concentration	the amount of a substance, expressed as mass or volume, in a unit volume of air. Clay - very fine-grained sediment or soil (often defined as having a particle size less than 0.002 mm (2 microns) in diameter).
Claystone	general term for a clastic sedimentary rock composed primarily of clay-sized particles (less than 1/256 millimetre in diameter).
Confined aquifer	A confined aquifer lies between two aquitards. The hydraulic head in a confined aquifer lies above the base of the upper confining layer.
Depressurisation	reduction in groundwater pore pressure (pressure head) in a confined groundwater system due to extraction of groundwater.
Drawdown	change in groundwater level in a bore or the change in water table elevation in an unconfined groundwater system, due to the extraction of groundwater.
Ecosystem	a functional unit of energy transfer and nutrient cycling in a given place, it includes all the relationships within the biotic community and between the biotic components of the system. Electrical conductivity (EC) - the ability of a substance (either solid, liquid or gas) to transmit electricity – an indicator of salinity.
Ephemeral (water body)	is a wetland, spring, stream, river, pond or lake that only exists for a short period following precipitation.
Evaporation	the loss of water as vapour from the surface of a liquid that has a temperature lower than its boiling point.

TERMS	
Evapotranspiration	the sum of evaporation and plant transpiration from the Earth's land surface to atmosphere.
First Workings	Development of main headings, gate roads, related cut throughs, and other workings for mine access and ventilation
First workings (development)	long term stable (non-caving) bord and pillar mining method that comprises a series of self-supporting roadways or 'tunnels' driven into the coal seam by a continuous miner. Method leaves a grid of pillars between the roadways, designed to provide stability to the seam void and support roof strata.
Groundwater	all waters occurring below the land surface. The upper surface of the soils saturated by groundwater in any particular area is called the water table.
Groundwater Dependent Ecosystem (GDE)	ecosystems dependant on current groundwater conditions.
Groundwater discharge	an area on the surface that intersects a groundwater aquifer, allowing it to discharge to the surface.
Hydraulic conductivity (K)	the capacity of a rock to transmit water; numerically equivalent to the rate of flow of water in an aquifer through a gradient, at the prevailing temperature. Usually expressed in units of metres per second or metres per day.
Hydrology	the study of water, particularly its movement in streams, rivers, or underground.
Intermittent	flows periodically, irregularly.
Longwall mining	underground mining of coal seams. Longwall shearer has a face of 100m or more and rotating drum that moves mechanically back-and-forth across a coal seam.
Mudstone	general term for a fine-grained sedimentary rock whose original constituents were clays or muds. Grain size is up to 0.0625 mm (0.0025 in) with individual grains too small to be distinguished without a microscope.
Open standpipe	drilled open hole to a specific depth with casing only in the top of the hole (i.e. to 6 m depth commonly). Used to monitor groundwater levels in a specific stratigraphic unit.
Overburden	subsoil and decomposed rock overlying the main rock body that is not suitable for use in the final product.

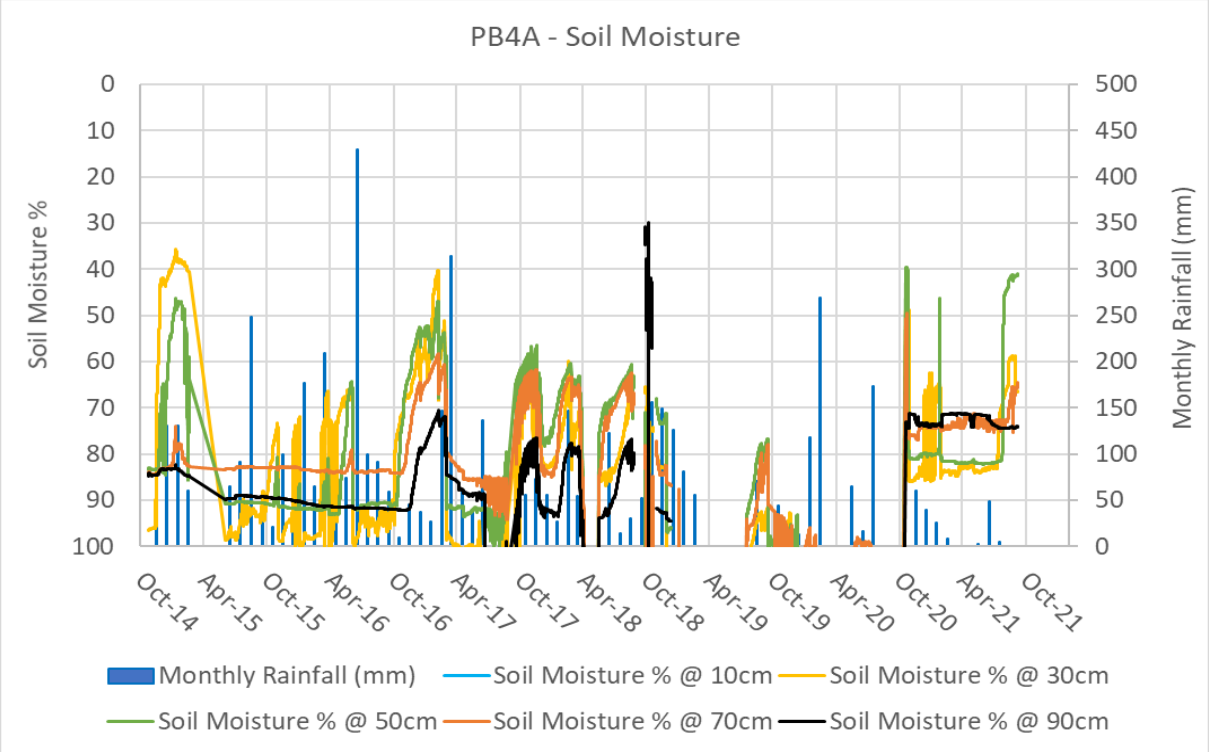
TERMS	
Perched groundwater	groundwater accumulated at an elevation above the regional aquifer water level usually above a low-permeability unit or stratum.
Permeability	a material property relating to the ability of the material to transmit water.
pH	a measure of the degree of acidity or alkalinity of a solution. expressed numerically (logarithmically) on a scale of 1 to 14, on which 1 is most acid, 7 is neutral acid, and 14 is most basic (alkaline).
Piezometer	a hole drilled and fitted with casing with a screened zone specifically designed for the monitoring of groundwater levels and water quality.
Recharge	the addition of water to an aquifer.
Recovery	the difference between the water level during the recovery period following pumping and the maximum drawdown when pumping stops.
Rehabilitation	the progressive formation of a landform after quarrying and its stabilisation with grasses, trees and/or shrubs.
Salinity	degree of salt content of water.
Sand	sediment comprising particles in 0.063mm to 2mm size range.
Sandstone	general term for sedimentary rock with grain size from 0.063 mm to 2 mm - grains may be minerals or rock fragments.
Second Workings	Extraction of coal from bord and pillar workings
Sediment	naturally occurring material that is broken down by processes of weathering and erosion and is subsequently transported.
Siltstone	general term for clastic sedimentary rock primarily composed of silt sized particles, defined as grains 1/16 - 1/256 mm.
Topography	the physical relief and contour of a region.
Total head profile	shows groundwater head at different depths and strata to illustrate vertical gradients.
Vibrating Wire Piezometer	transducer that converts a water pressure reading to a measurable frequency signal via a diaphragm, a tensioned steel wire, and an electromagnetic coil
Water level	the upper limit of the saturated zone within an unconfined rock mass, generally at atmospheric pressure. For confined aquifers the water level is represented by the pressure head of the confined zone.

TERMS	
Water quality	degree of the lack of contamination of water.

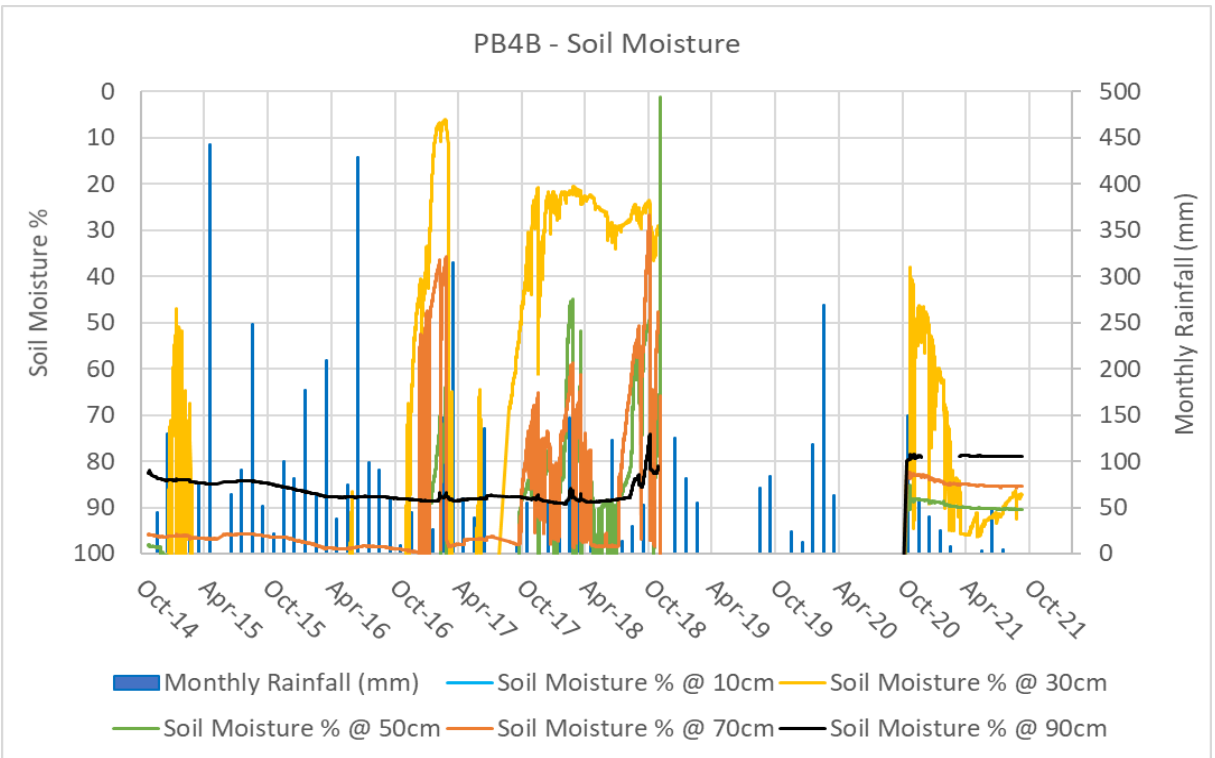
ABBREVIATIONS	
IPC	Independent Planning Commission
LGAs	Local Government Areas
LW	Longwall
Mtpa	Million tonnes per annum
OSP	Open Standpipe
PAC	Planning Assessment Commission
RPPR	Revised Preferred Project Report
ROM	Run of Mine
RVC	Russell Vale Colliery, which includes Russell Vale West and Russell Vale East
RVE	Russell Vale East
TARP	Trigger Action Response Plan
UEP	Underground Expansion Project
WCL	Wollongong Coal Limited.

APPENDIX A – SWAMP BASELINE DATA – SOIL MOISTURE

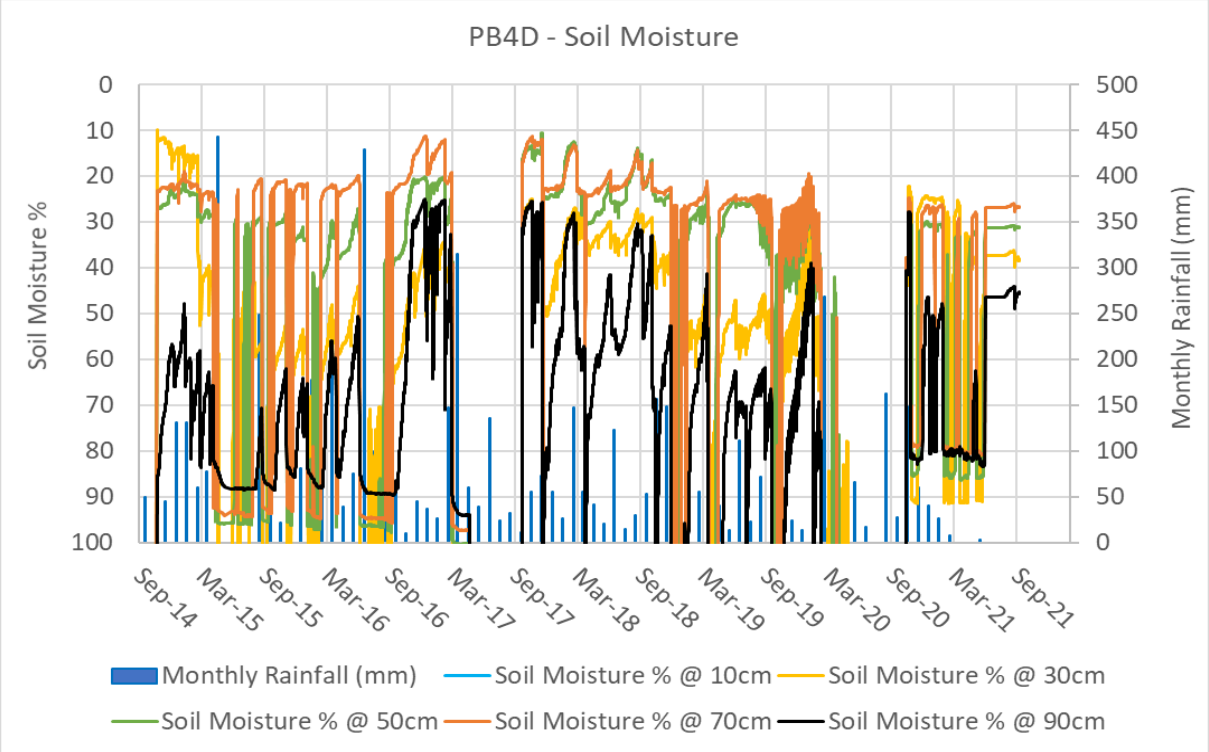
PB4 (A) near swamp BCUS4



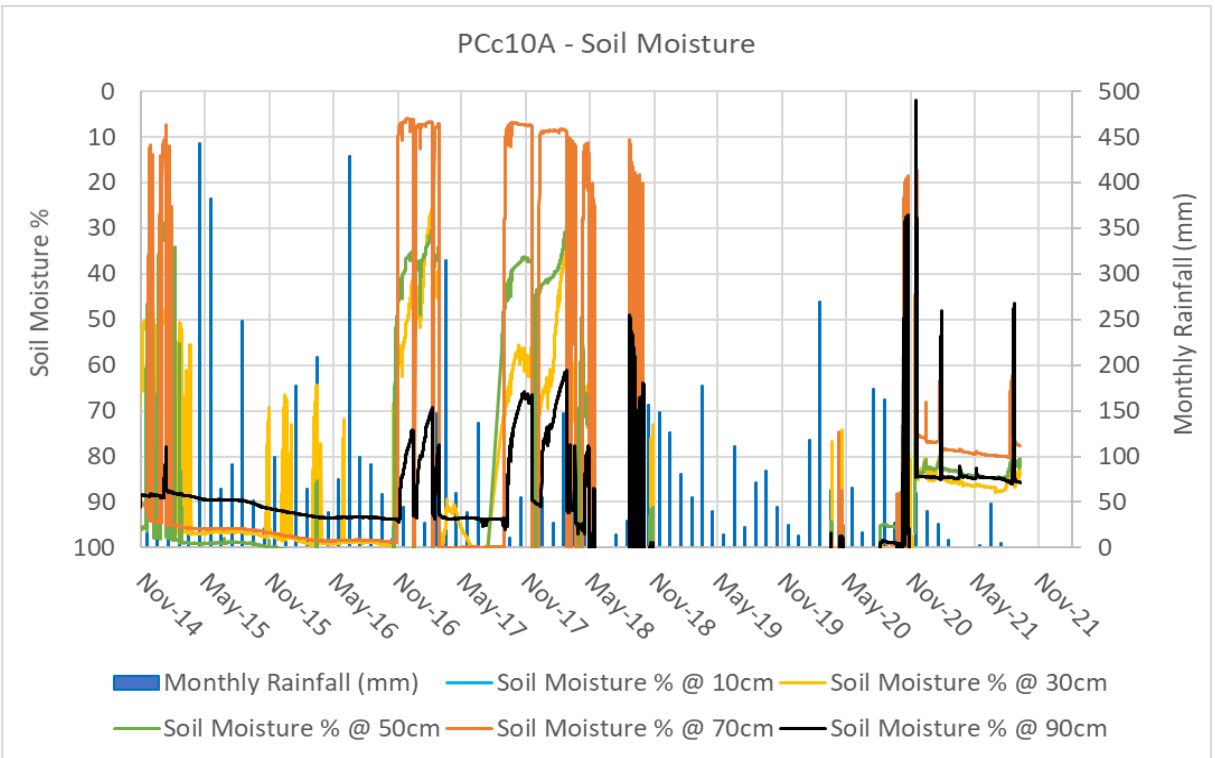
PB4 (B) near swamp BCUS4



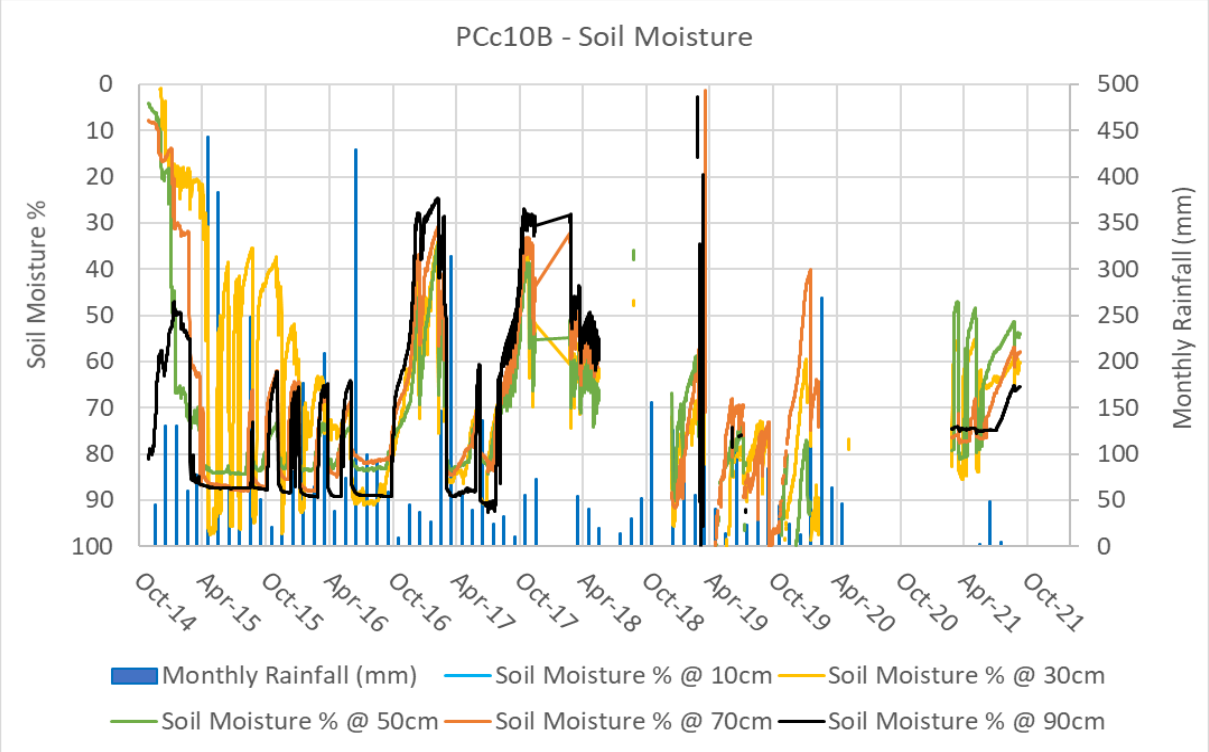
PB4 (D) near swamp BCUS4



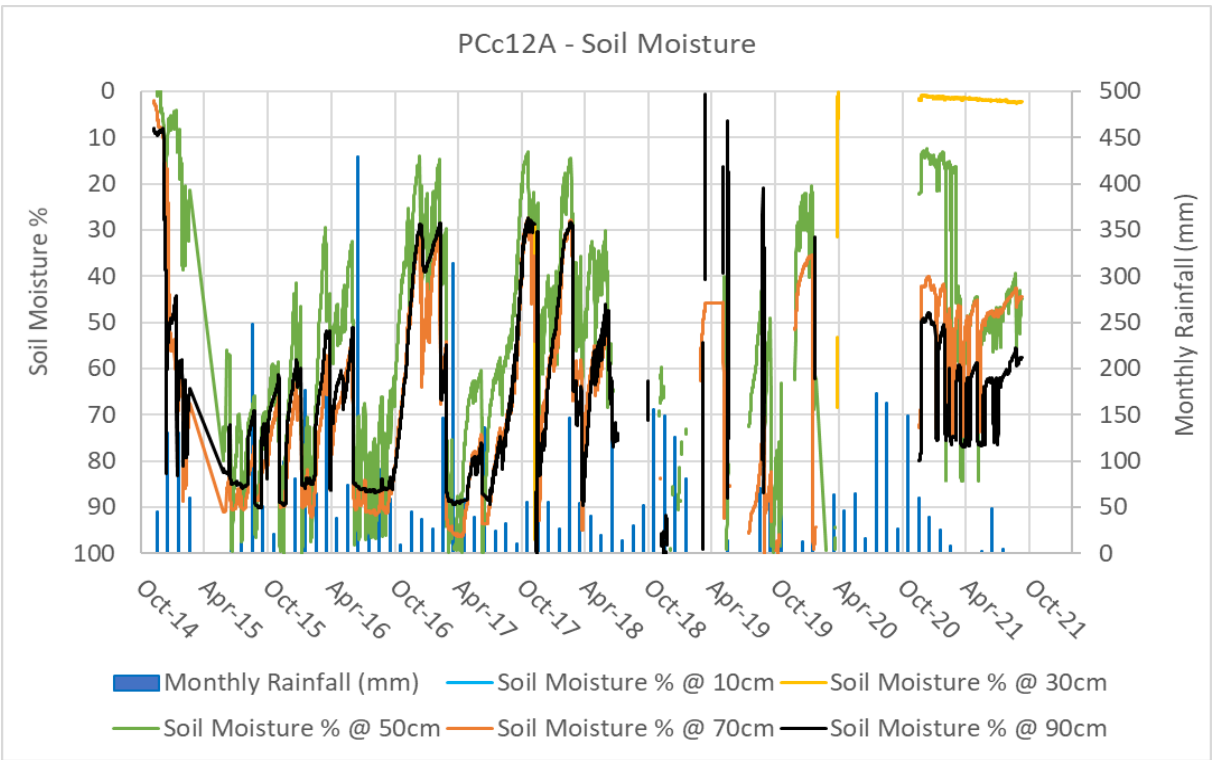
PCc10 (A) at CCUS10



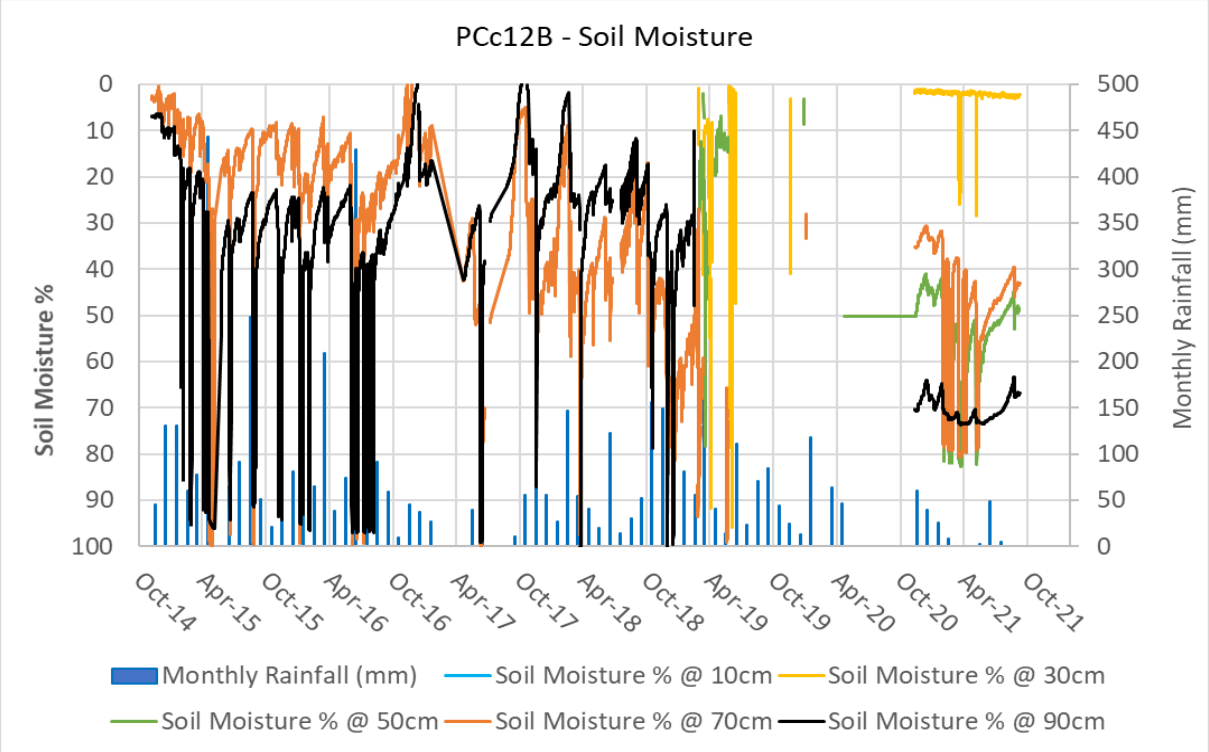
PCc10 (B) at CCUS10



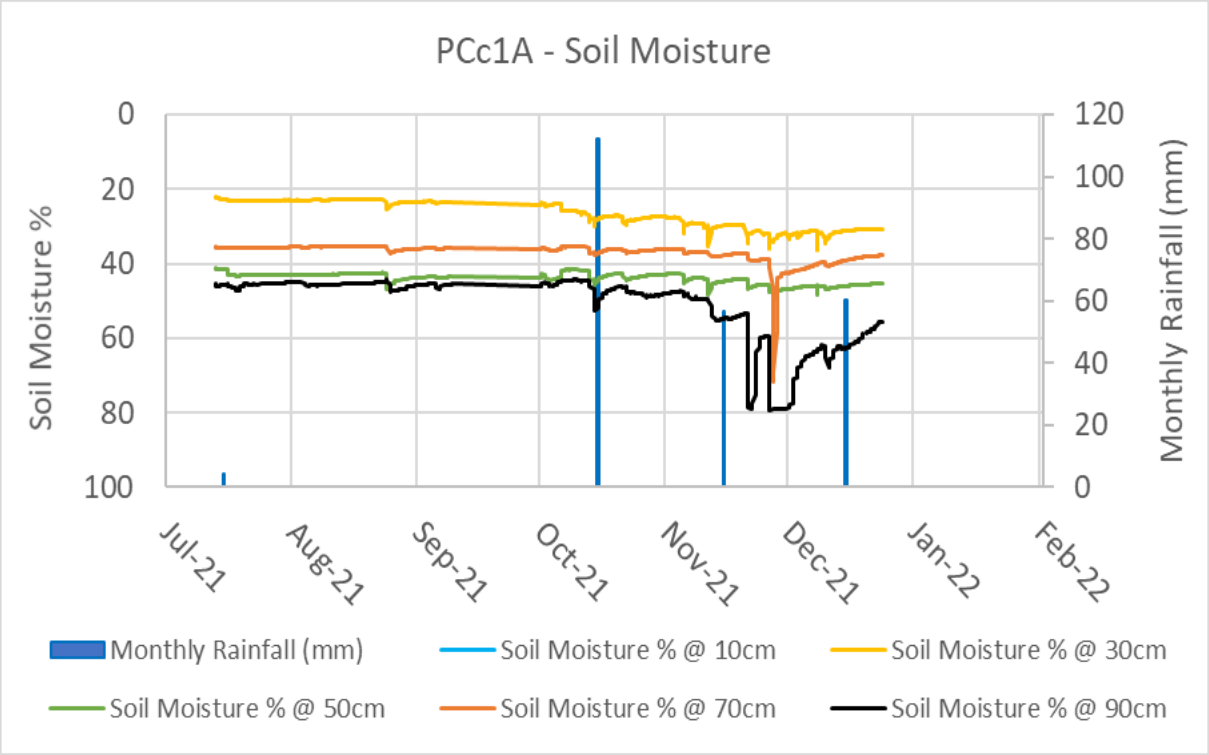
PCc12 (A) at CCUS12



PCc12 (B) at CCUS12



PCc1 (A) at CCUS1



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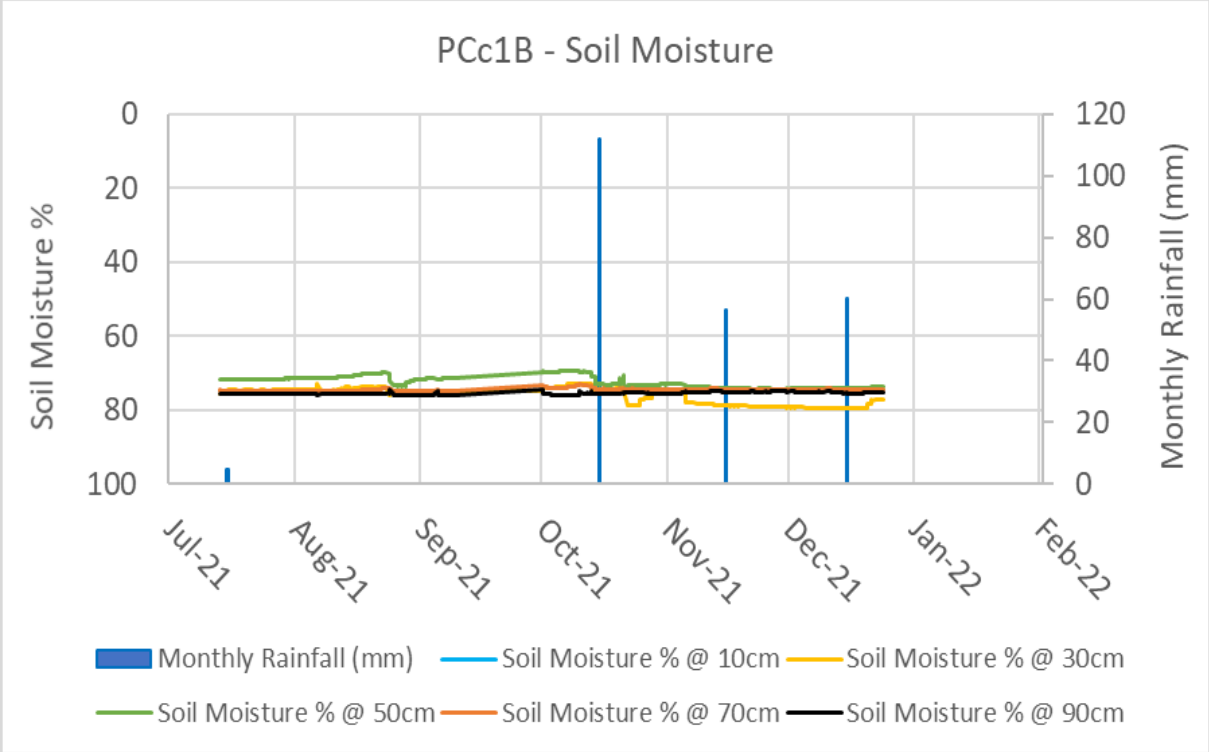
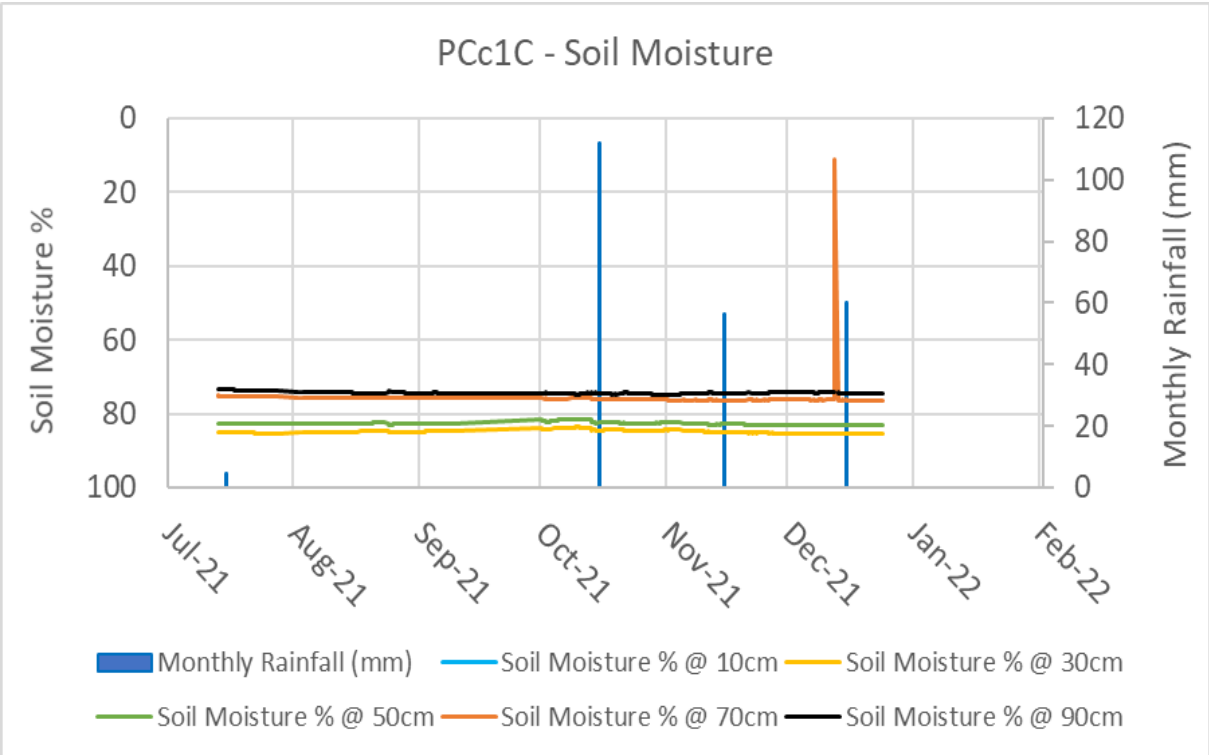
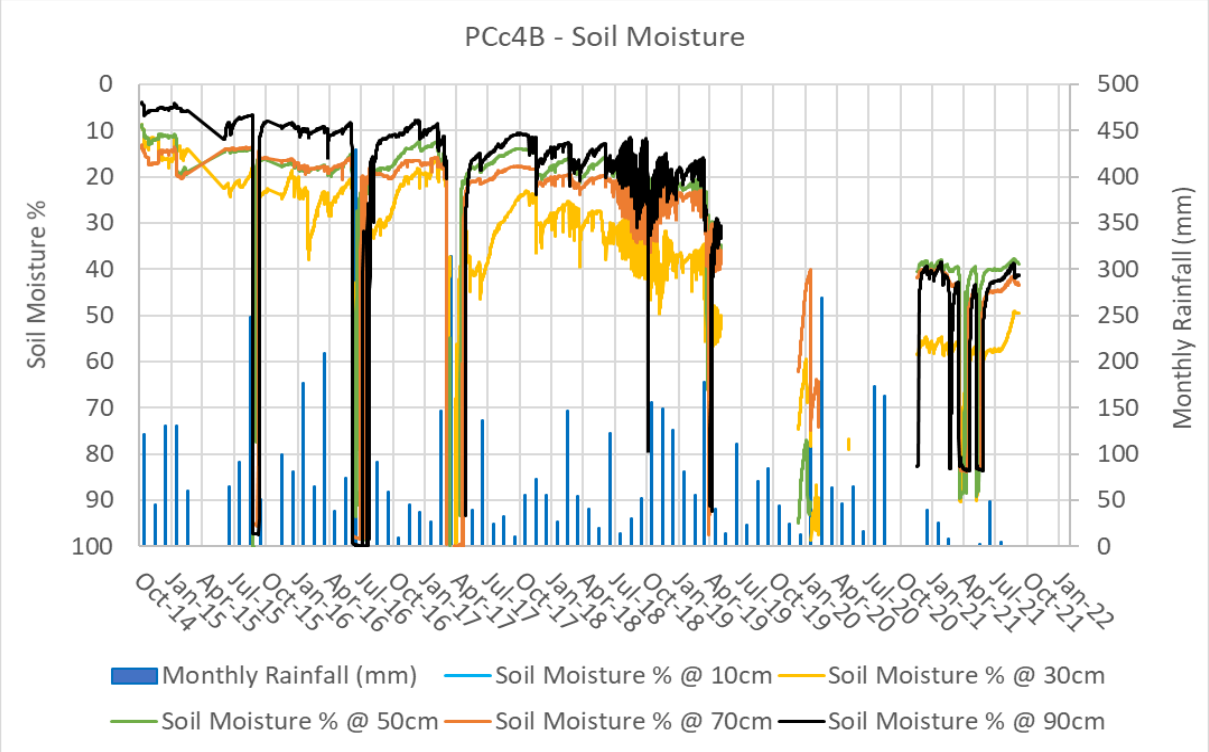


PCc1 (C) at CCUS1



PCc4 (B) at CCUS4



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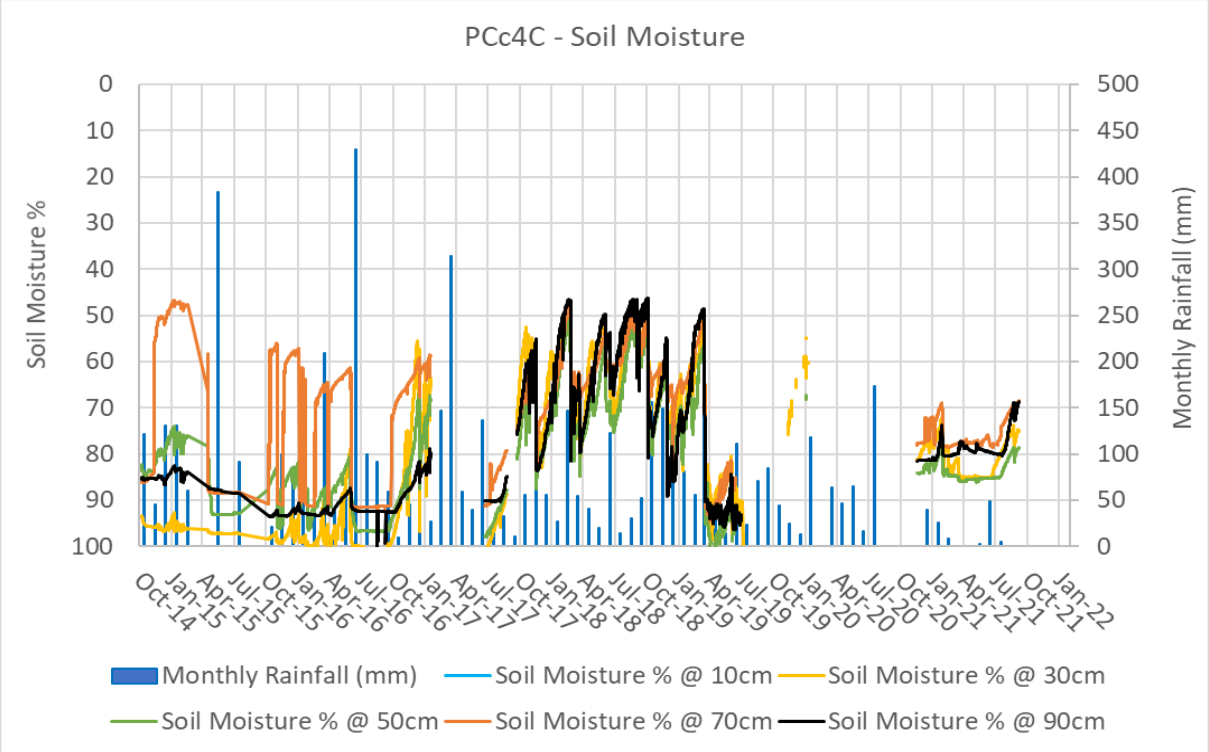
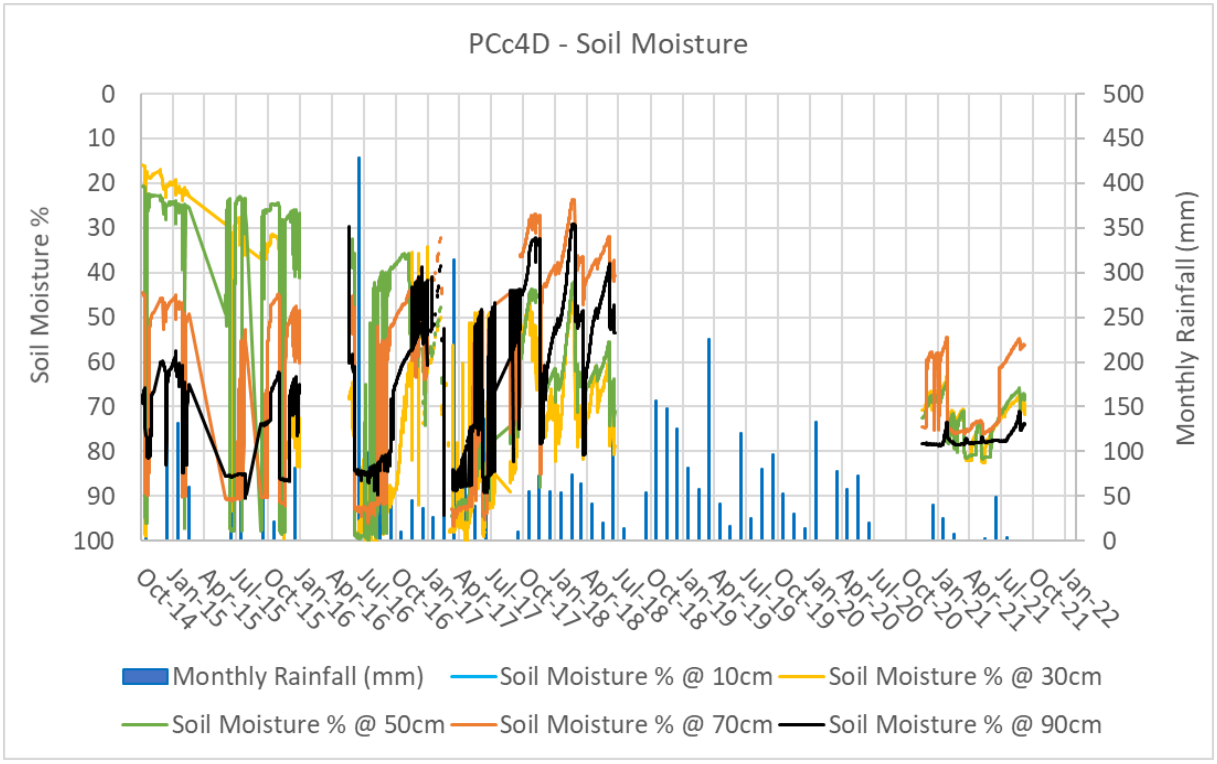
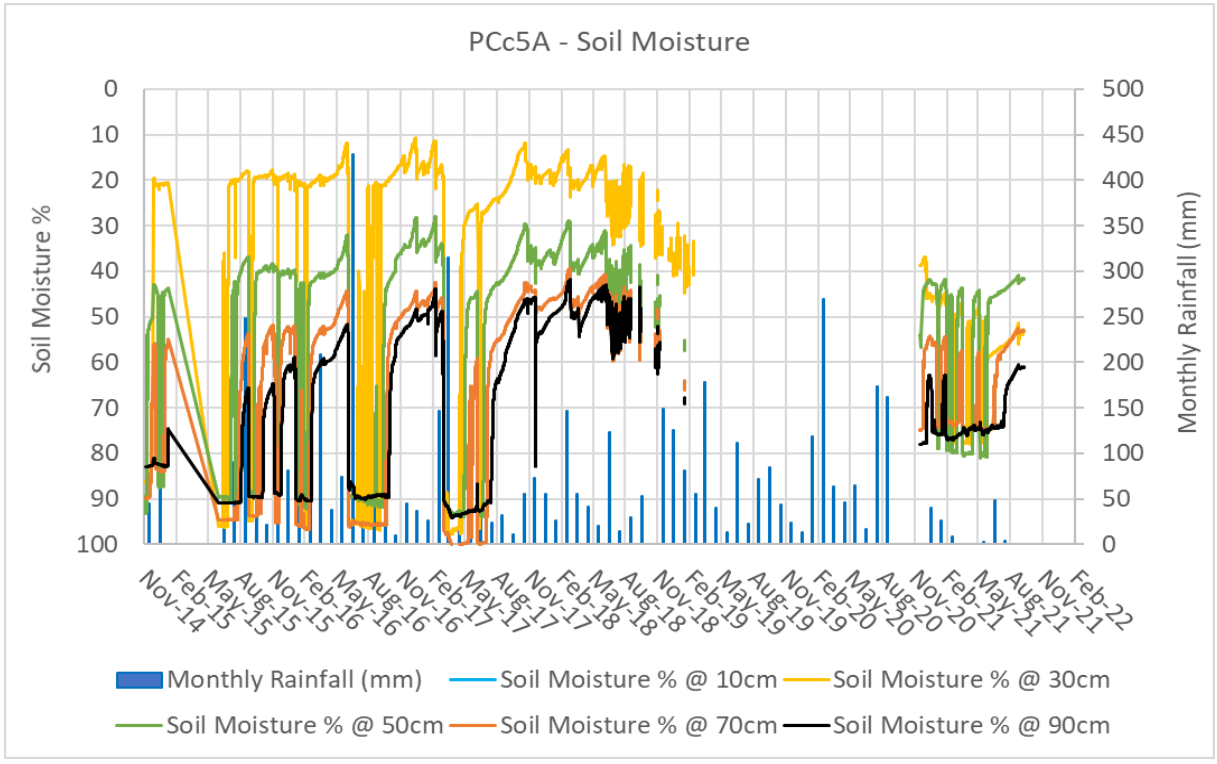


PCc4 (D) at CCUS4



PCc5 (A) at CCUS5



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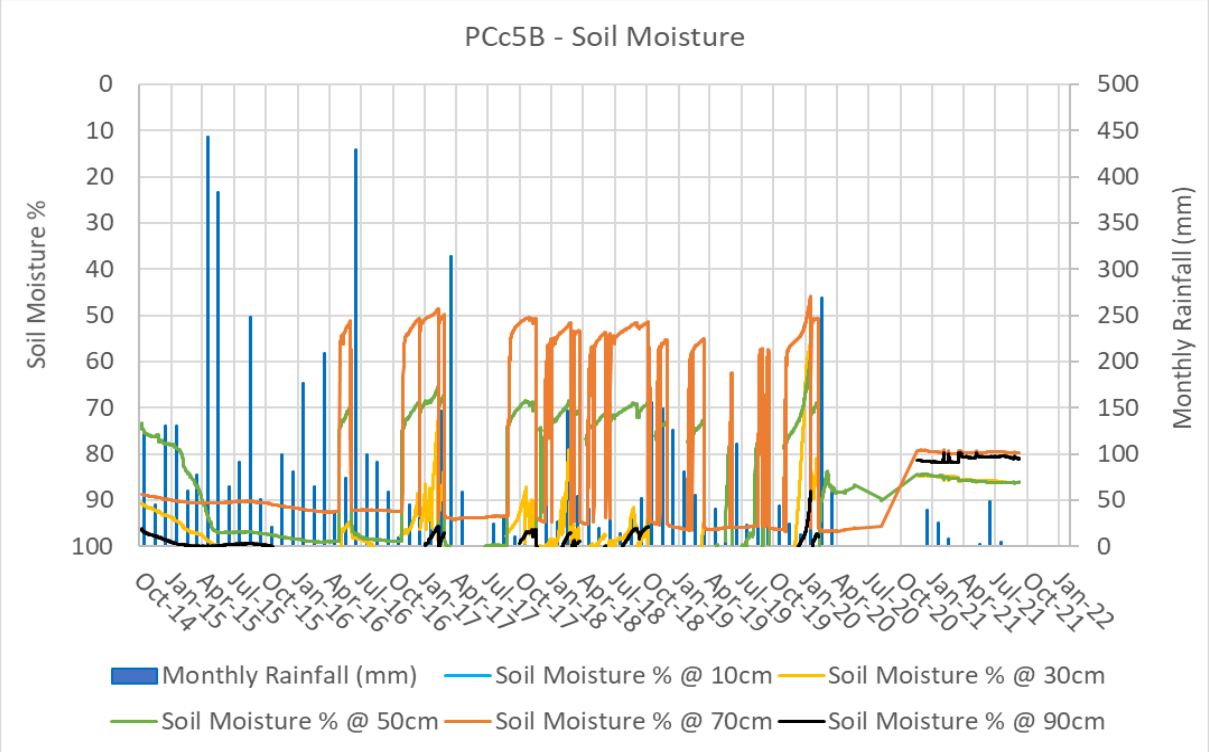

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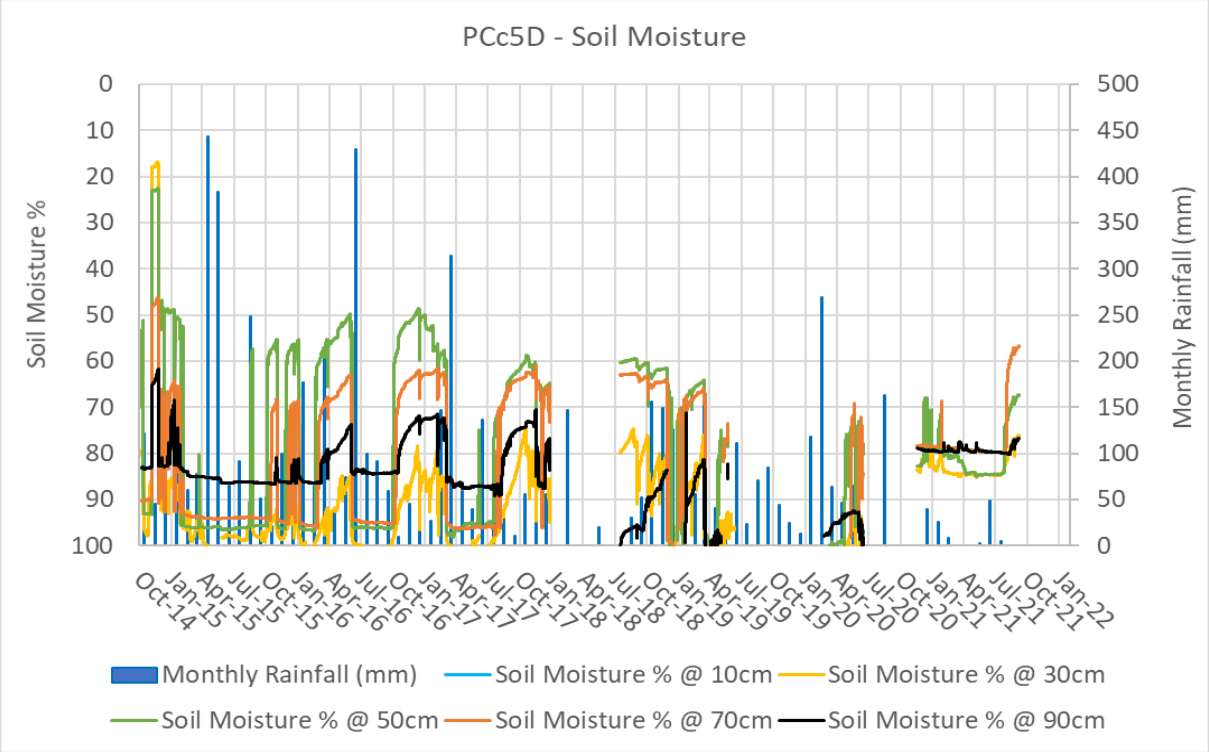
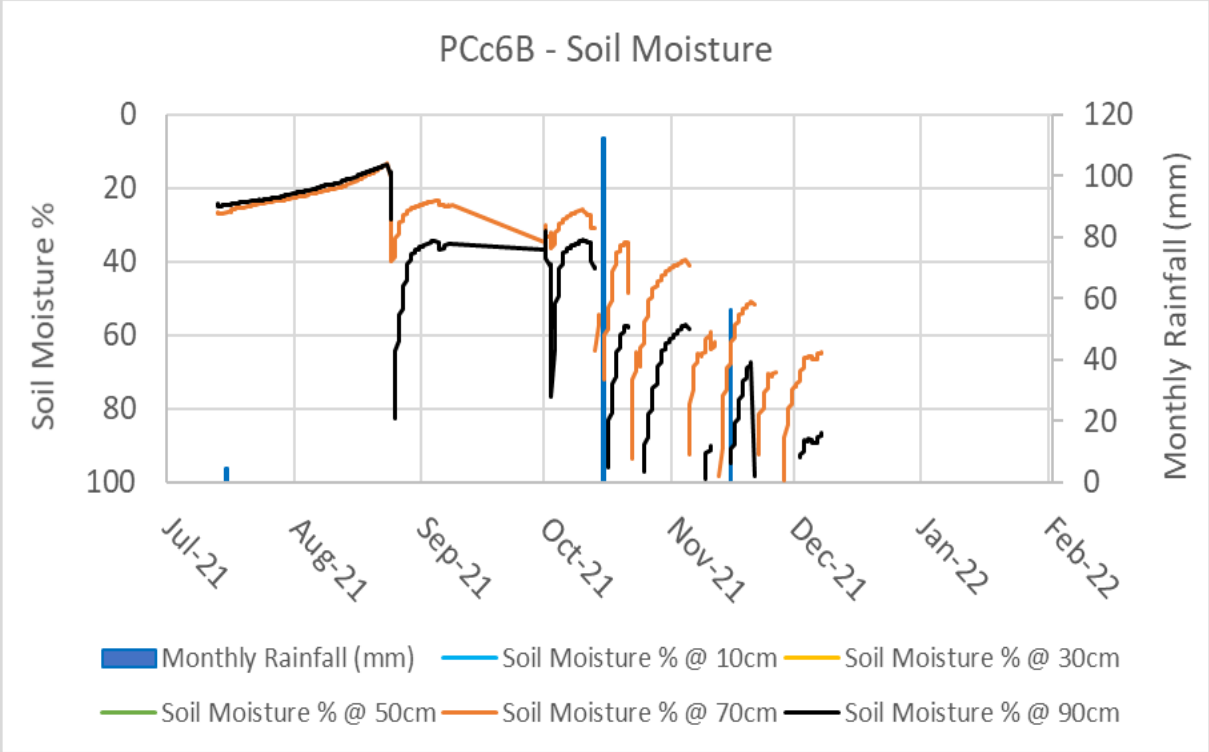
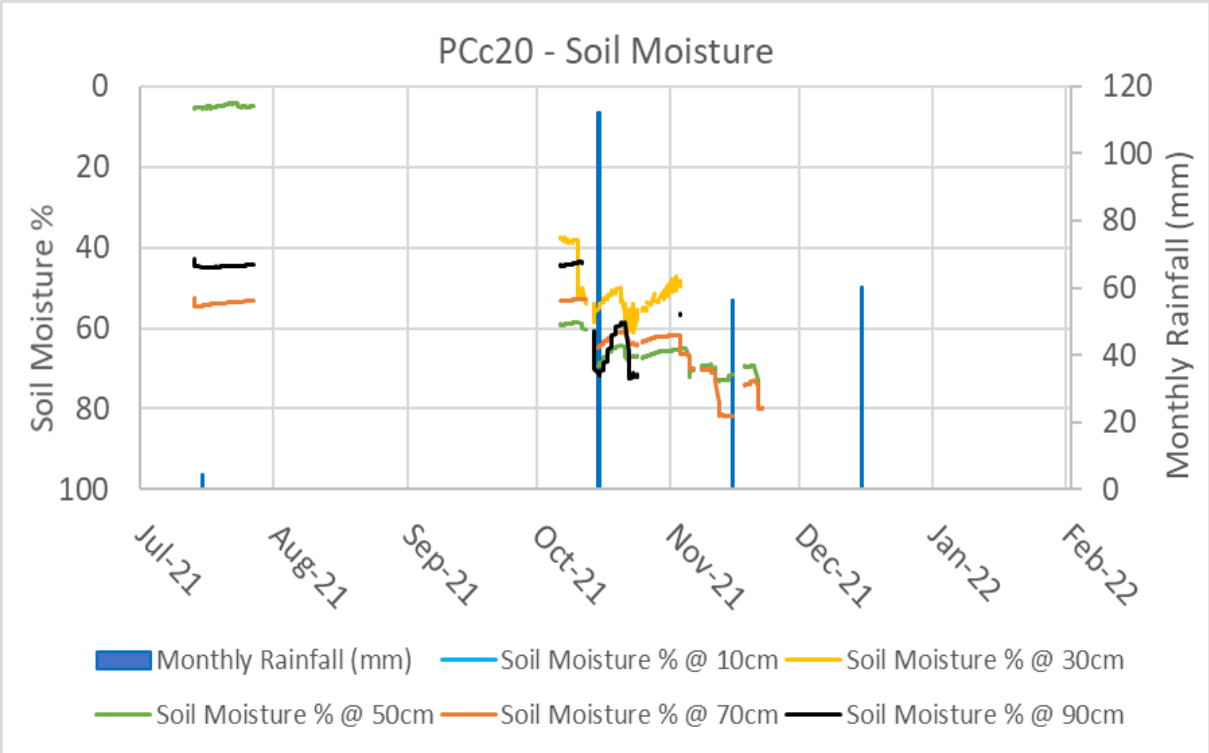


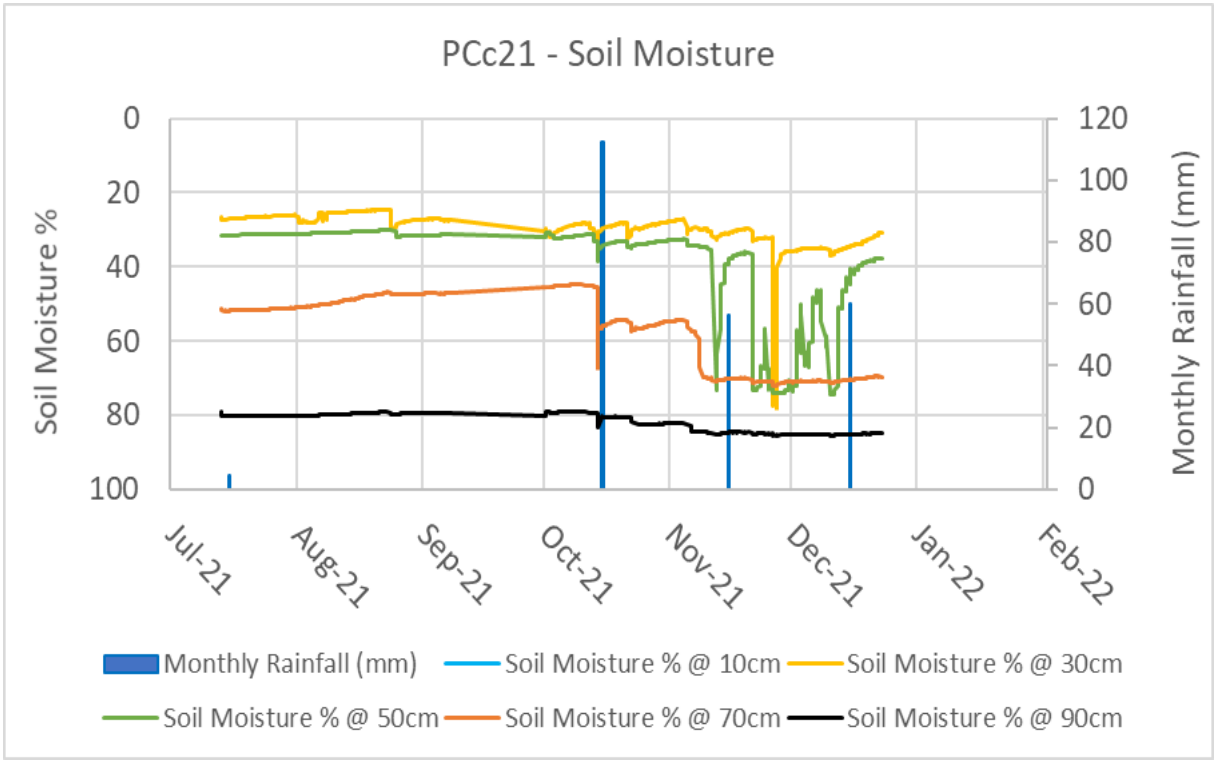
PCc6 (B) at CCUS6



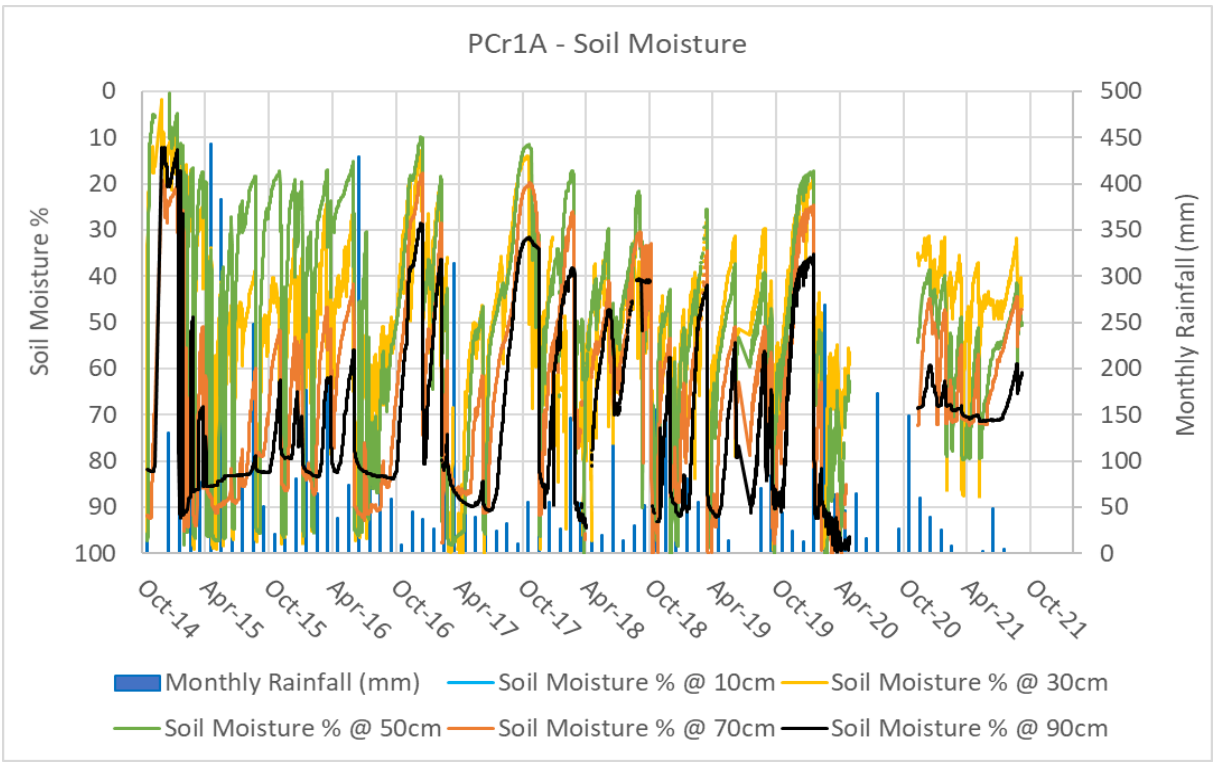
PCc20 at CCUS20



PCc21 at CCUS21



PCr1 (A) at CRUS1



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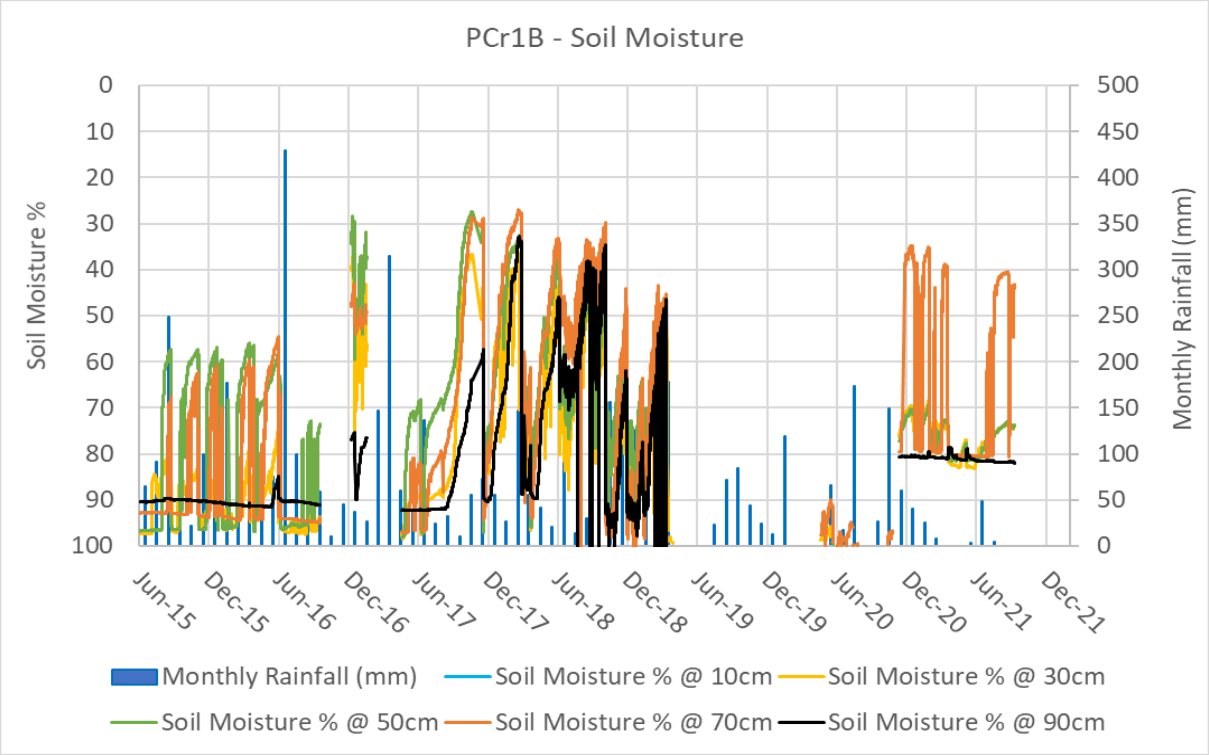
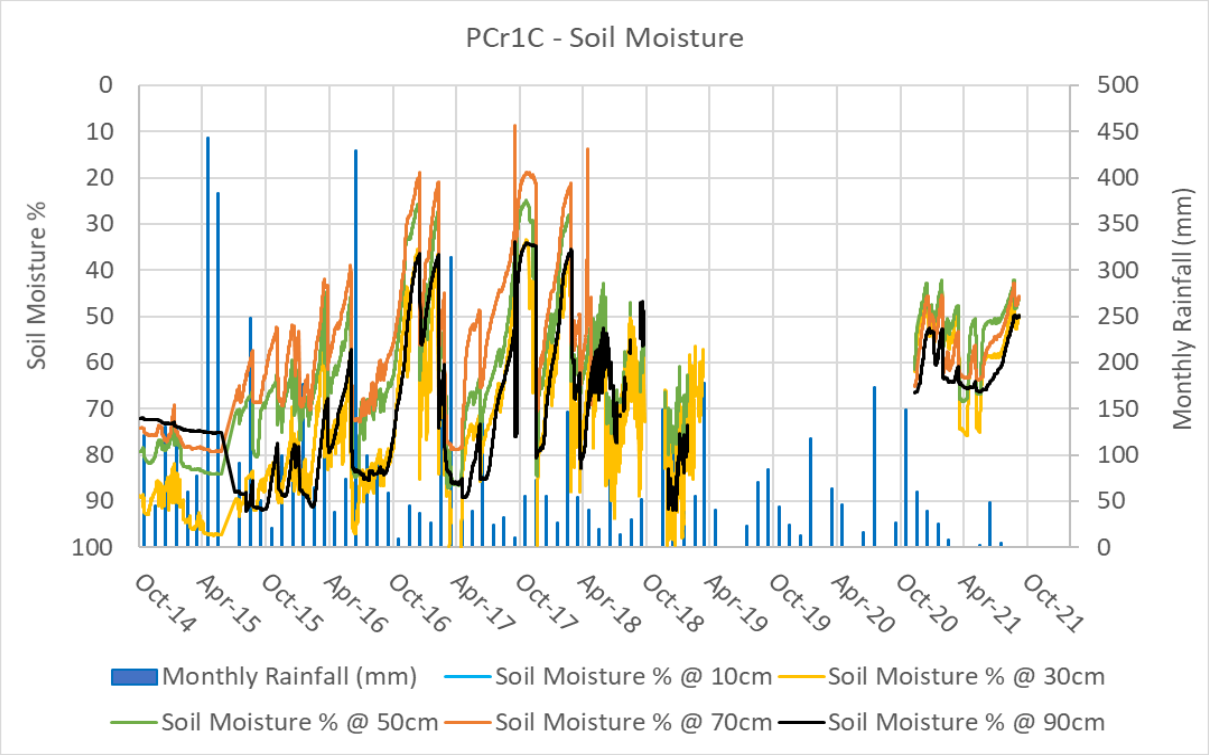
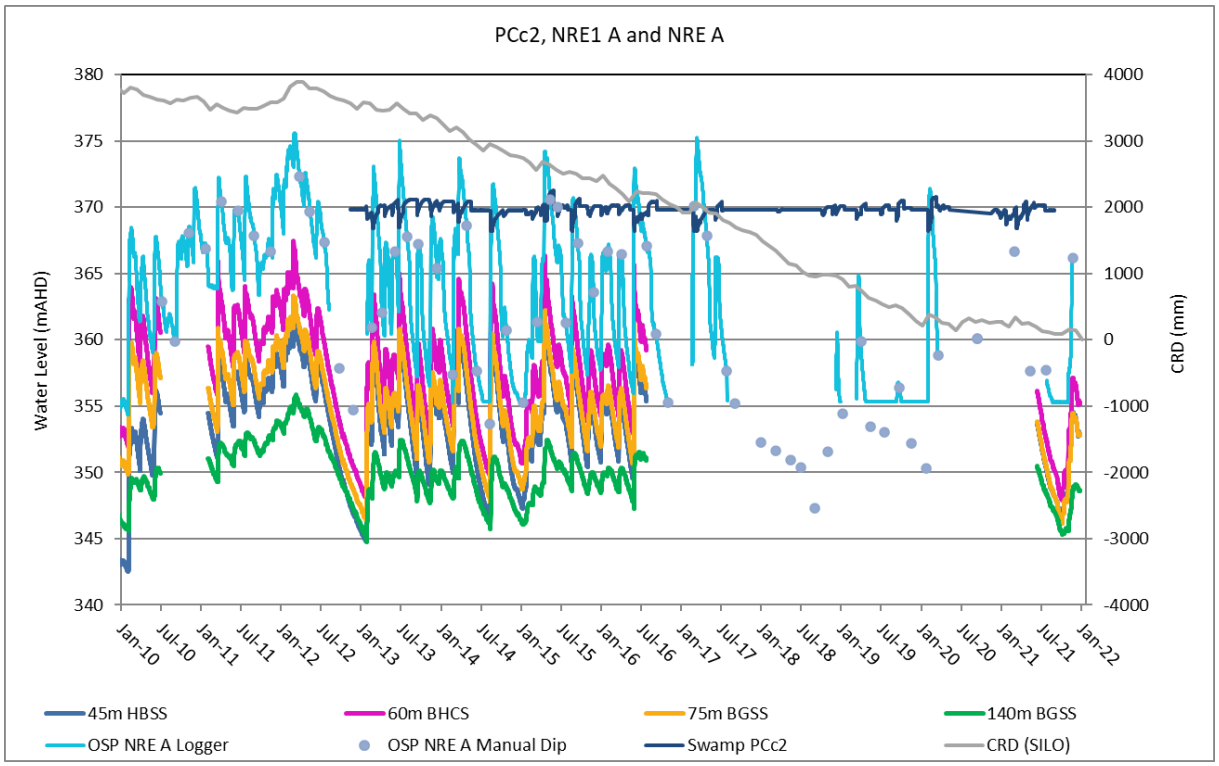


PCr1 (C) at CRUS1

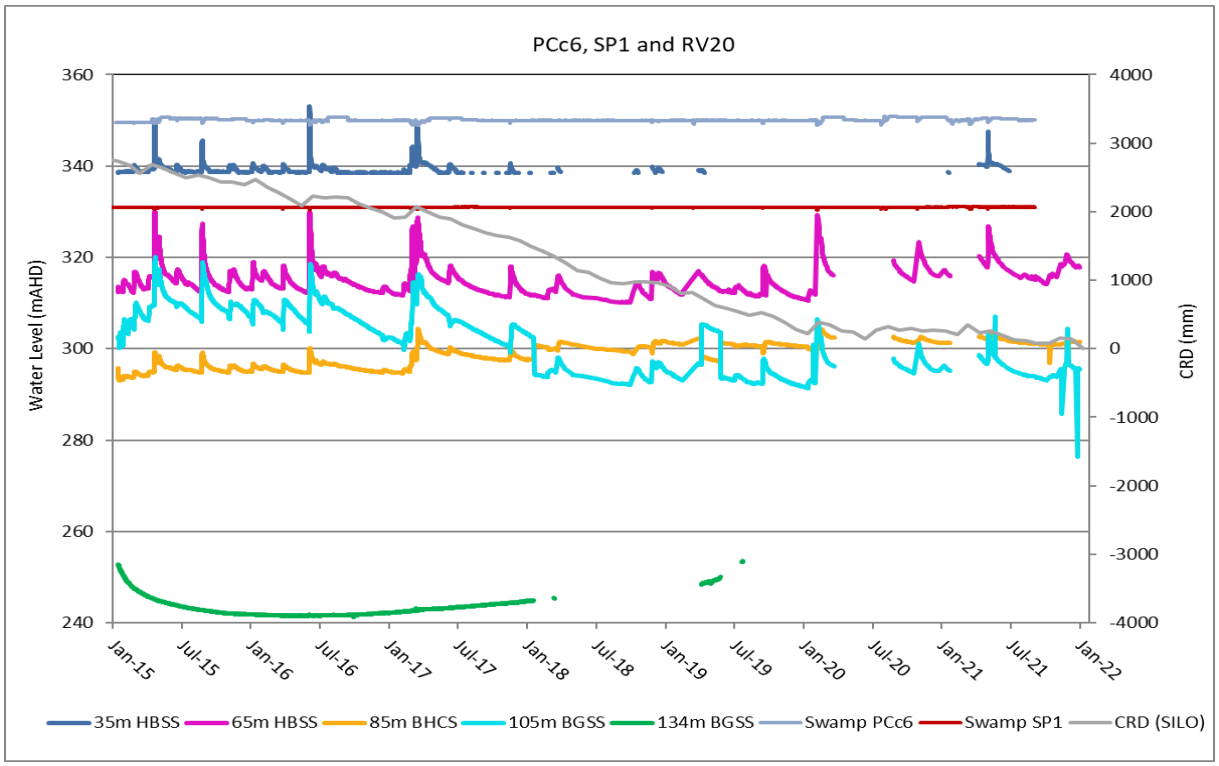


GROUNDWATER MONITORING SITES AT SWAMP LOCATIONS

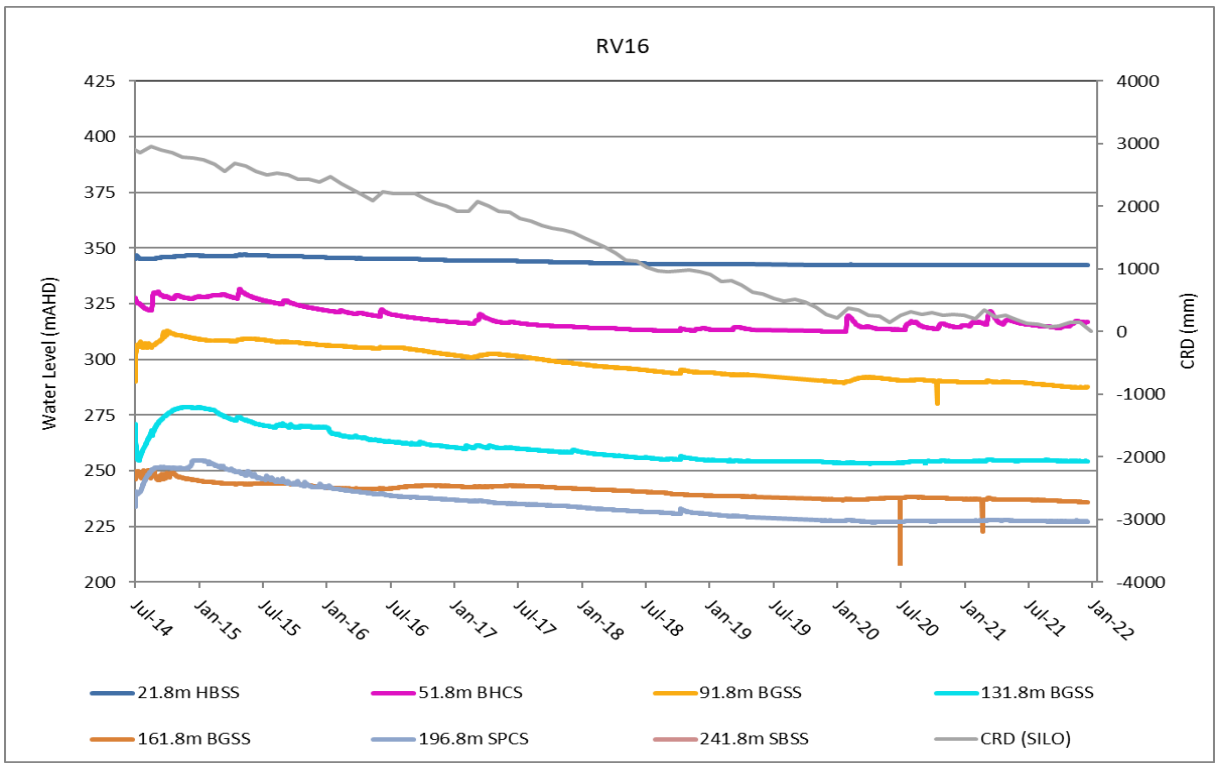
PCc2, NRE1A (OSP) and NREA (VWP) near CCUS2



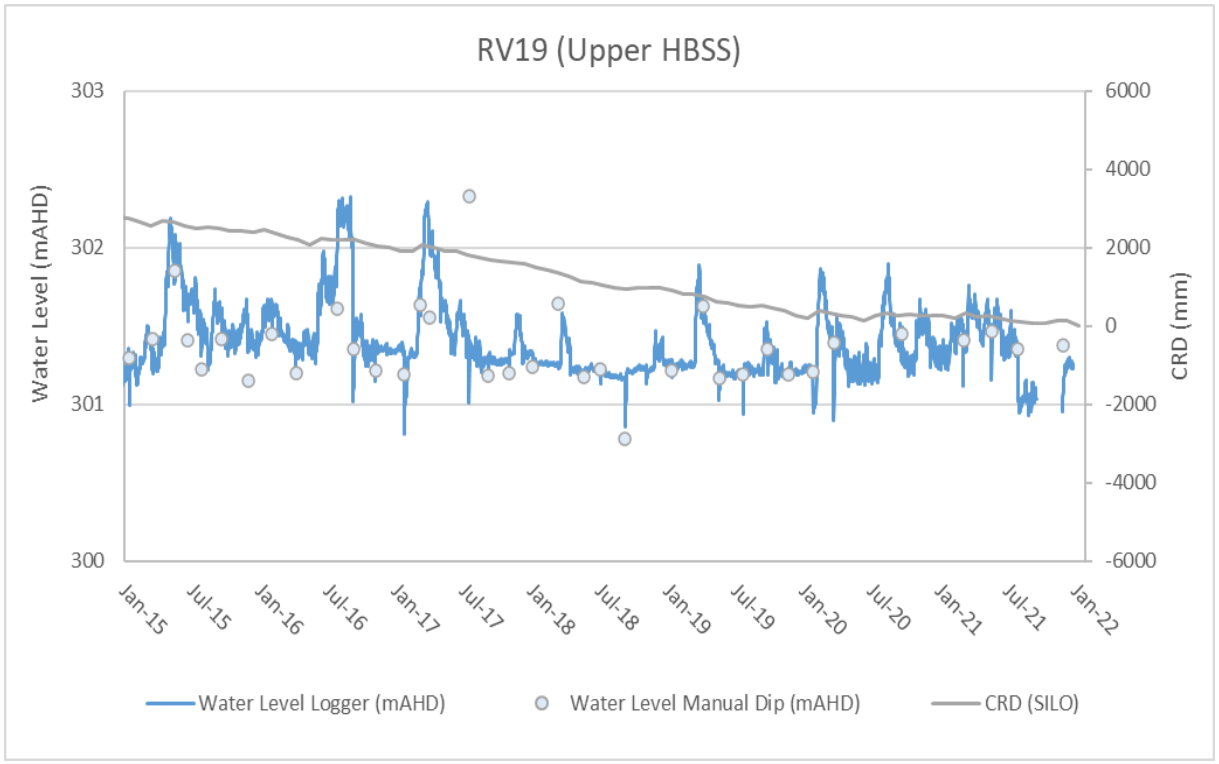
PCc6, SP1 and RV20 (VWP) near CCUS6



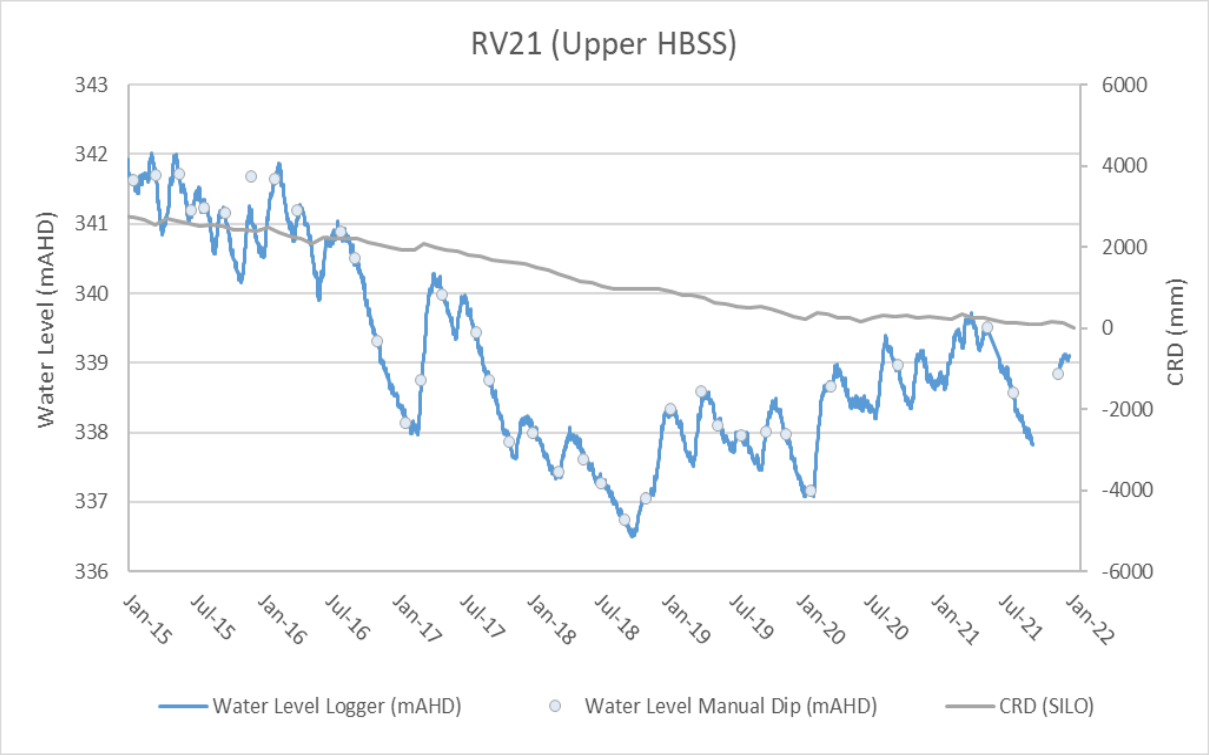
RV16 (VWP) within CCUS1



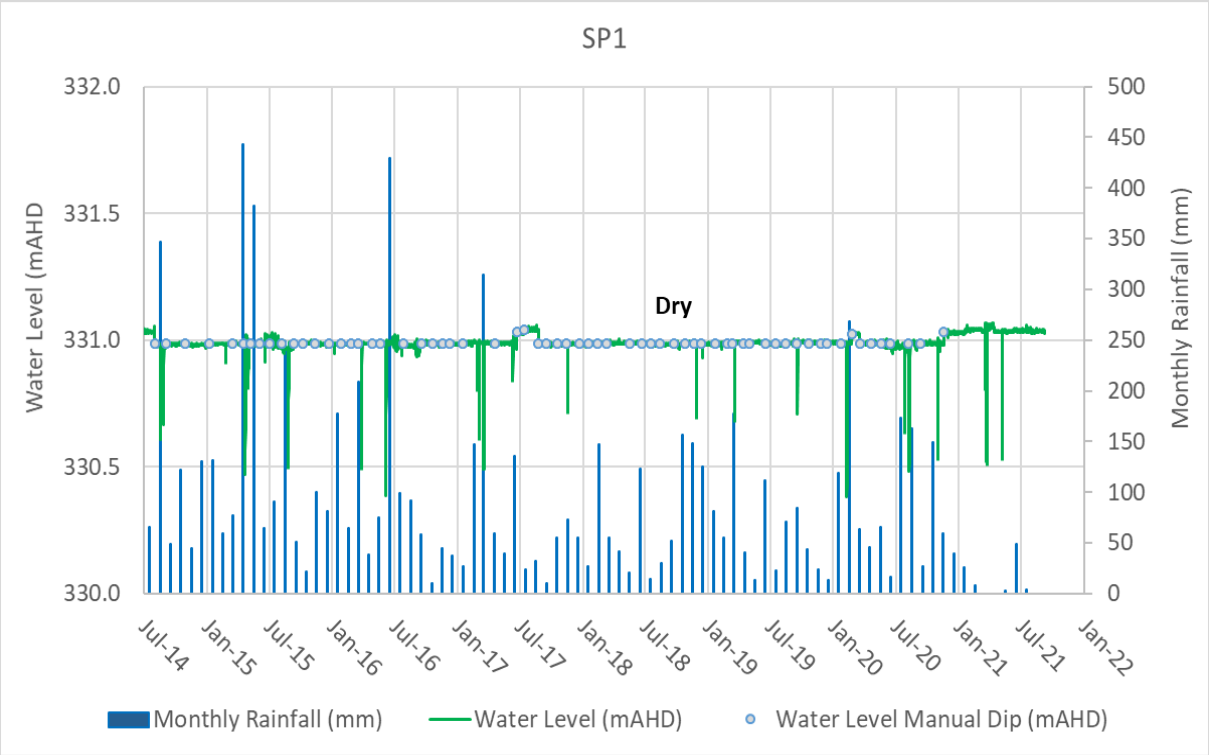
RV19 near CRUS1



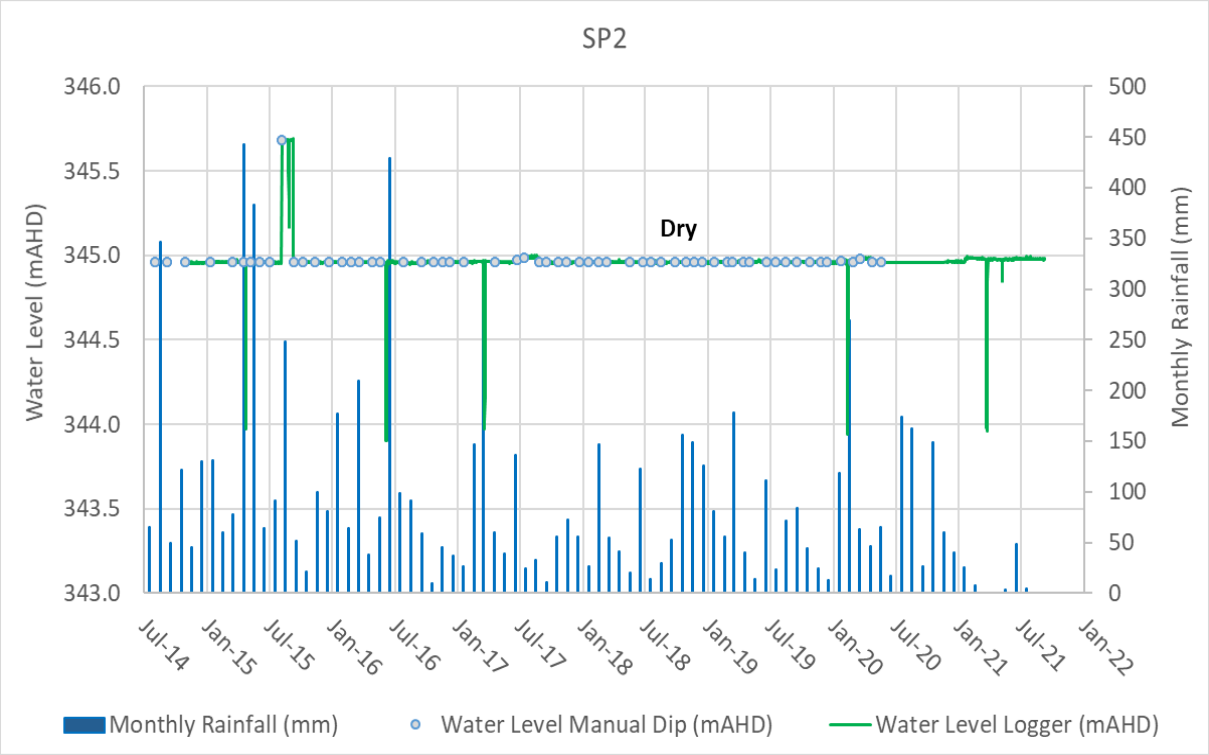
RV21 near BCUS4



SP1 near CCUS6



SP2 near CCUS4

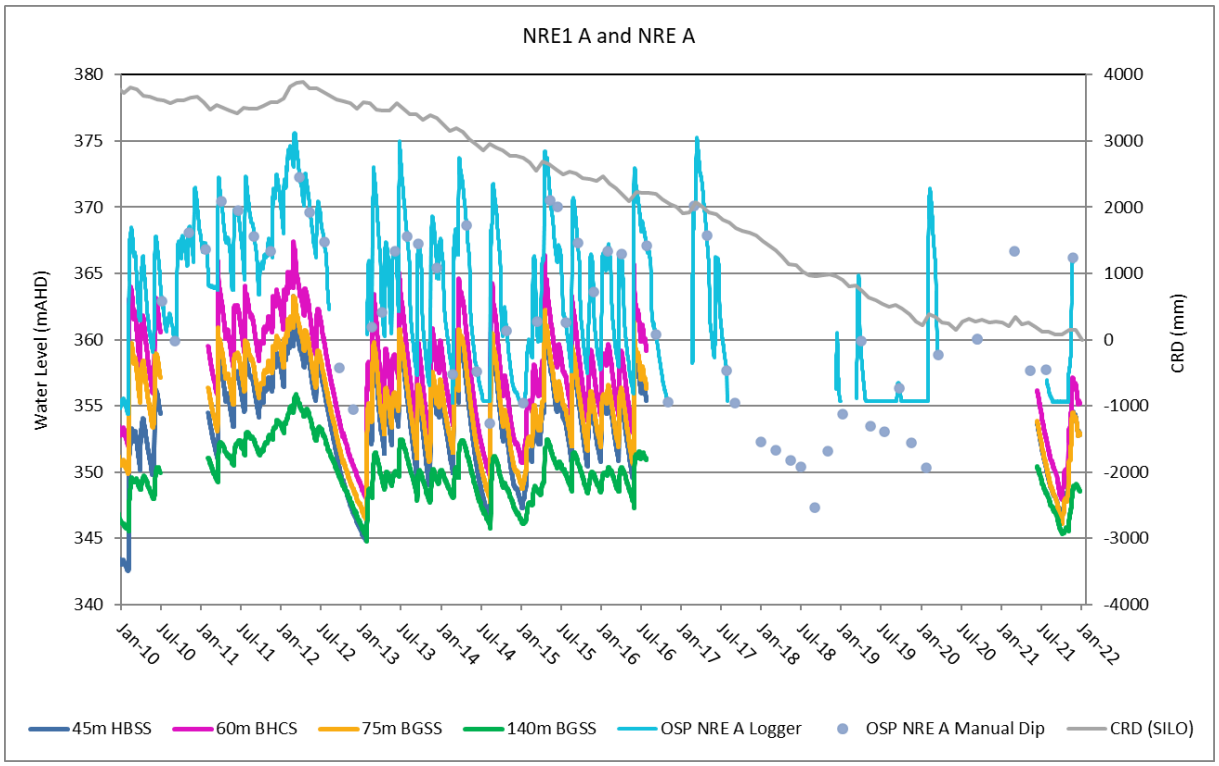


APPENDIX B – SWAMP BASELINE DATA - WATER QUALITY

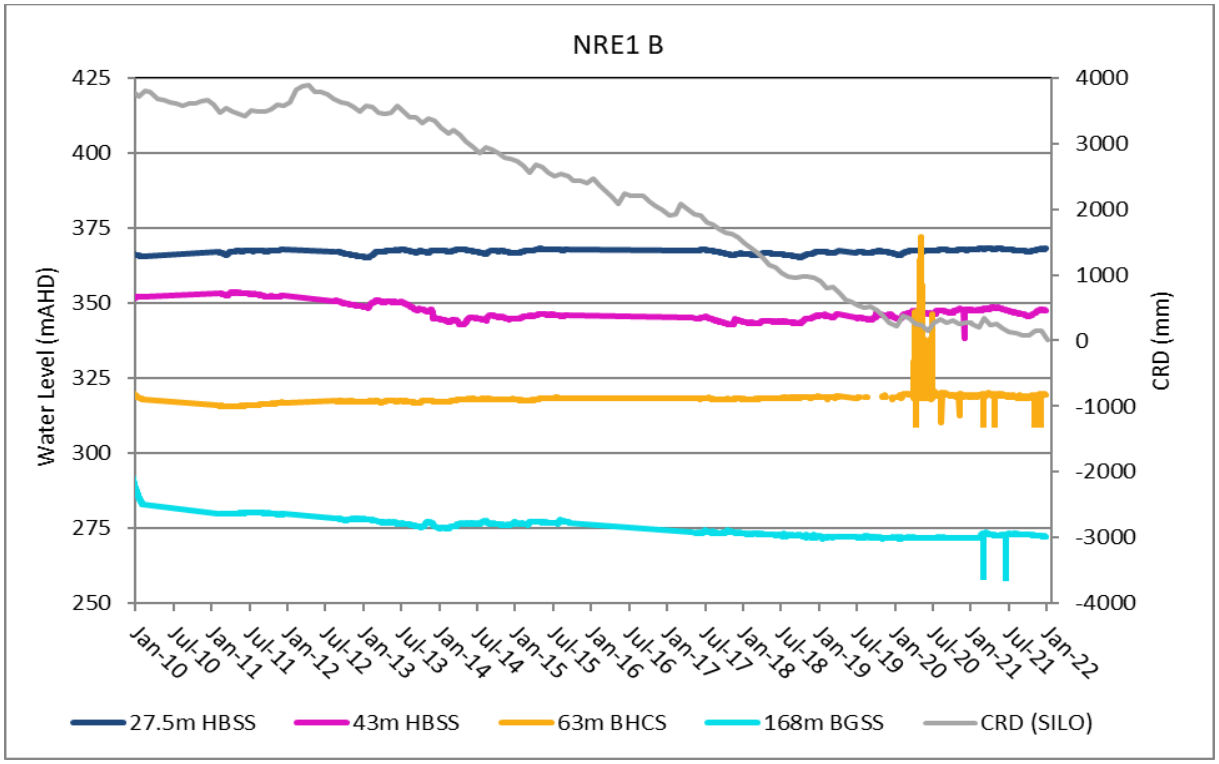
[Excel pdf output of table of **Swamp** water quality and Hawkesbury Sandstone water quality – raw data used for summary tables]

APPENDIX C – GROUNDWATER BASELINE DATA – WATER LEVEL

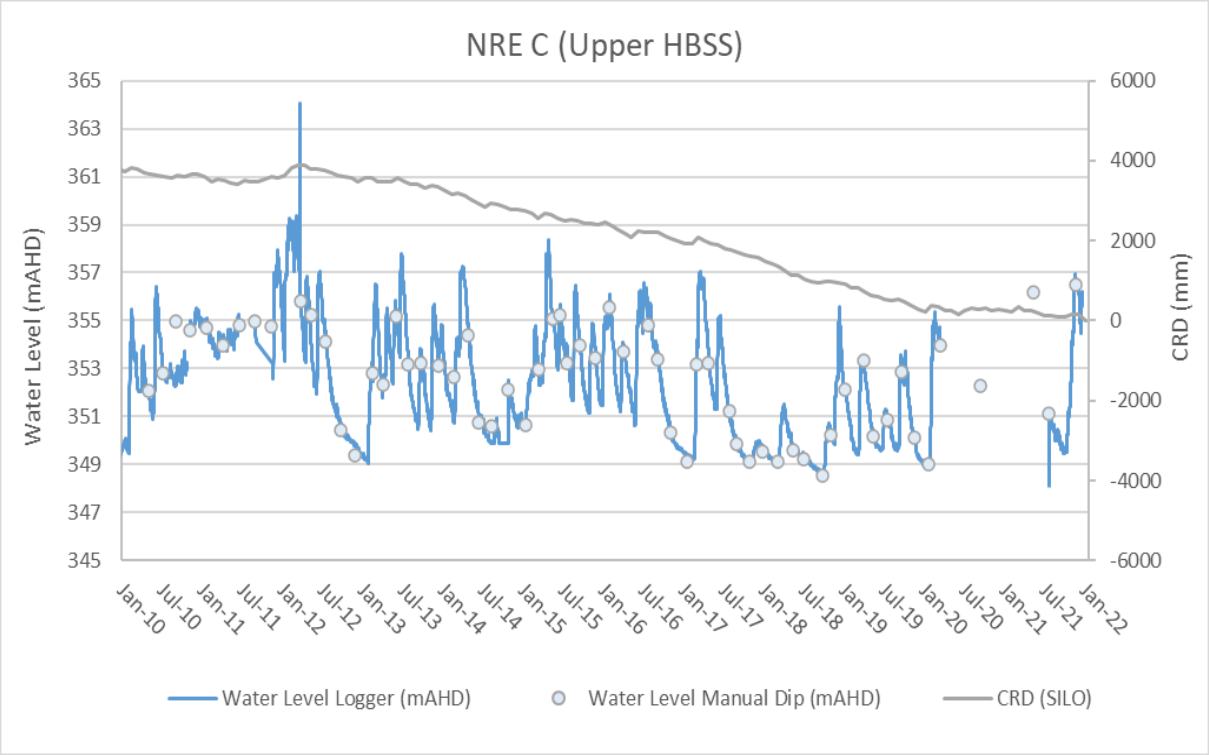
NRE A and NRE1A (VWP)



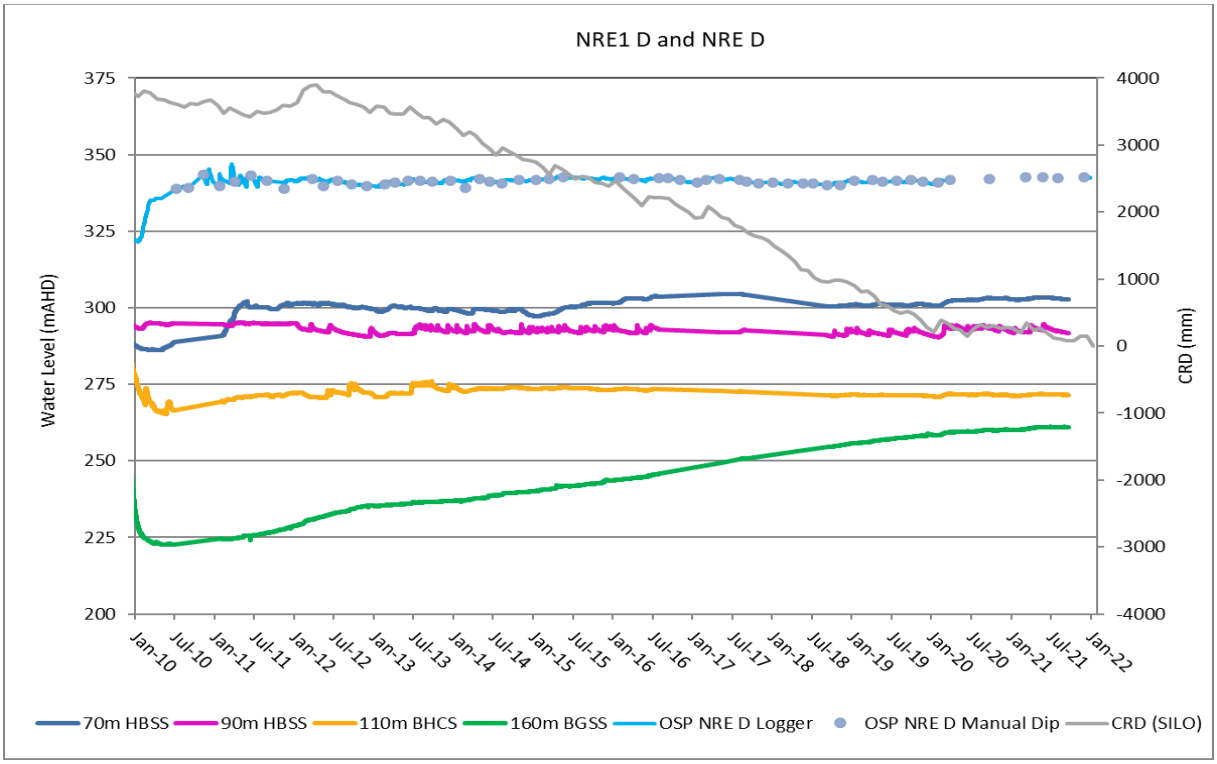
NRE1B (VWP)



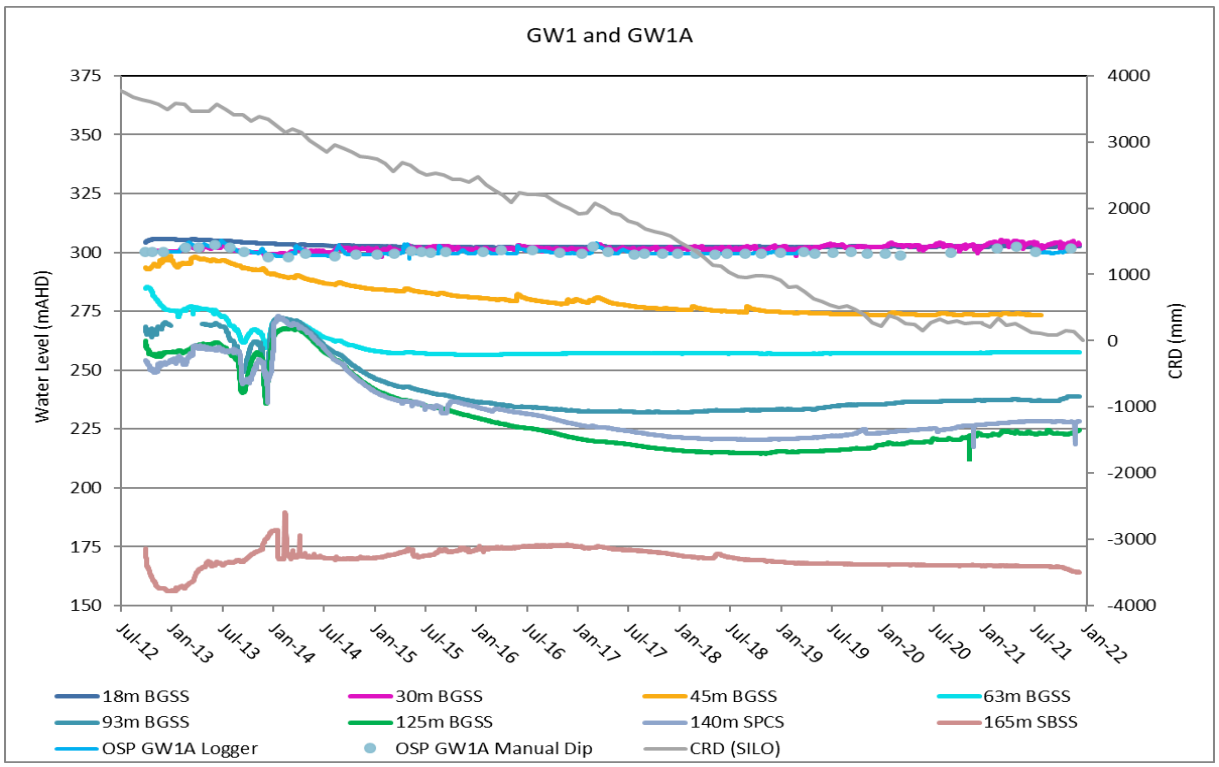
NRE C



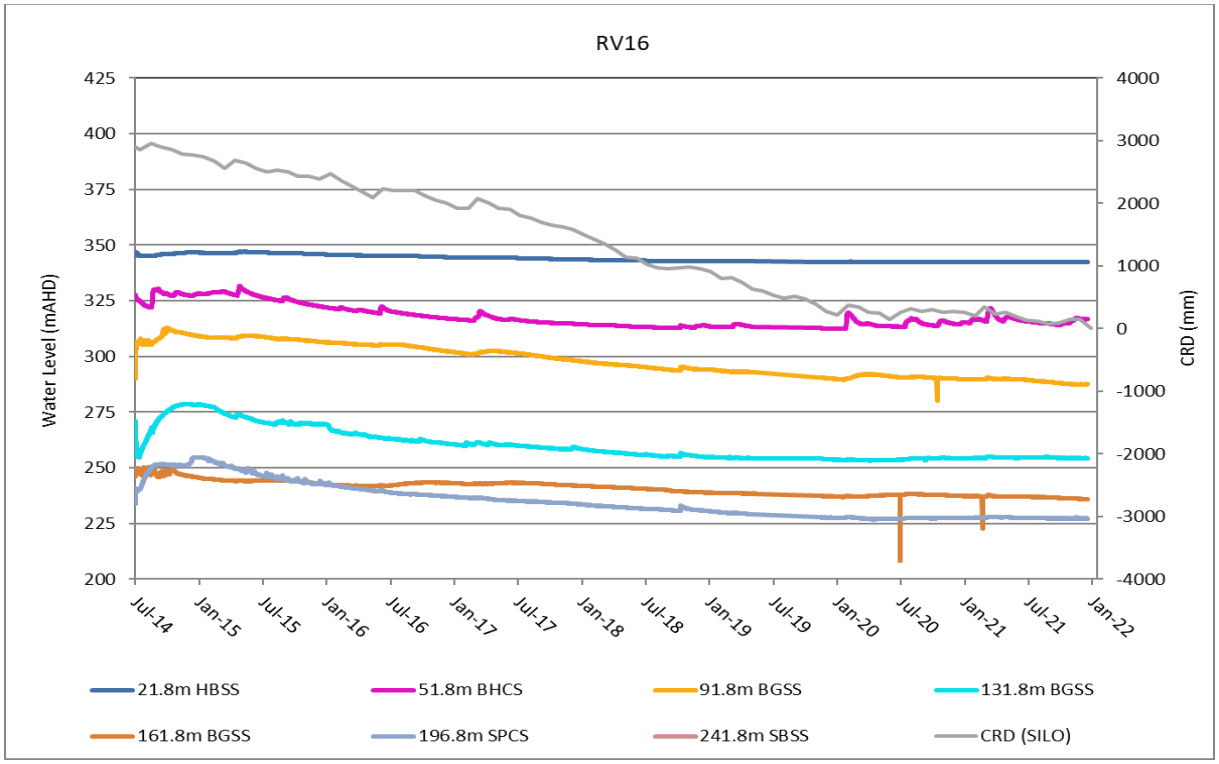
NRE D and NRE1D (VWP)



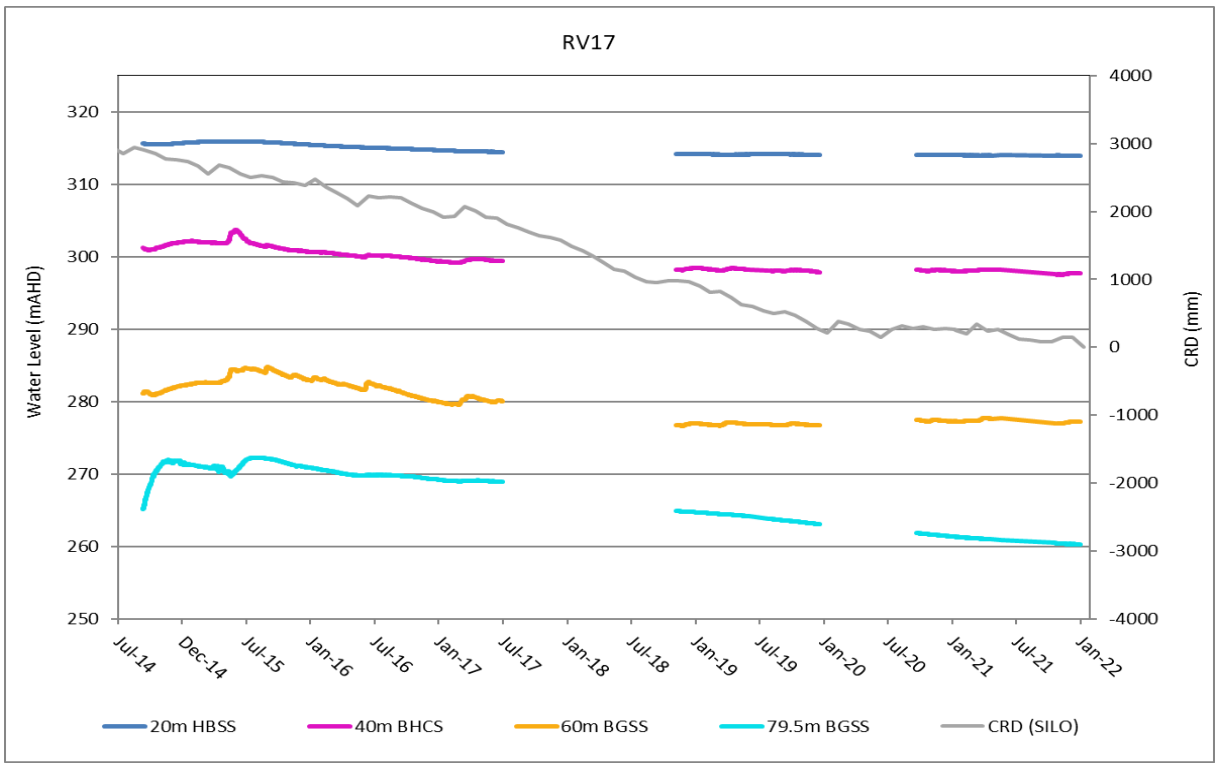
GW1A and GW1 (VWP)



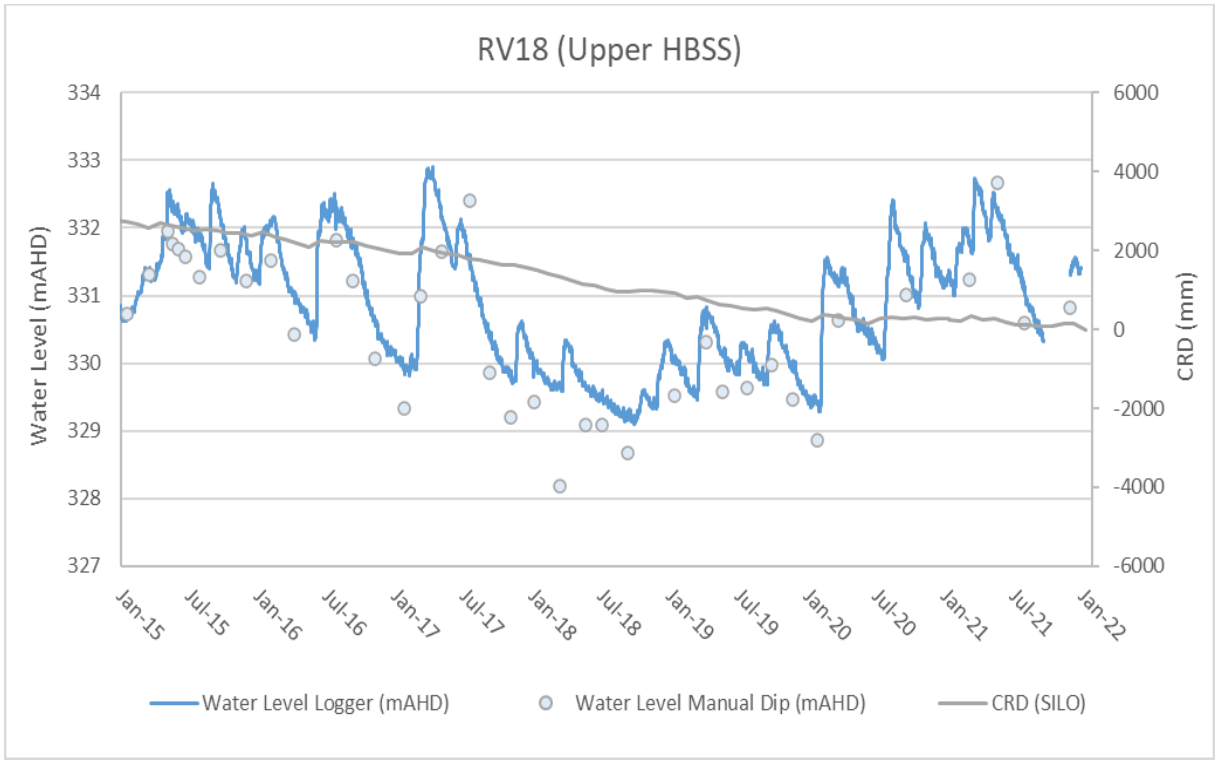
RV16 (VWP)



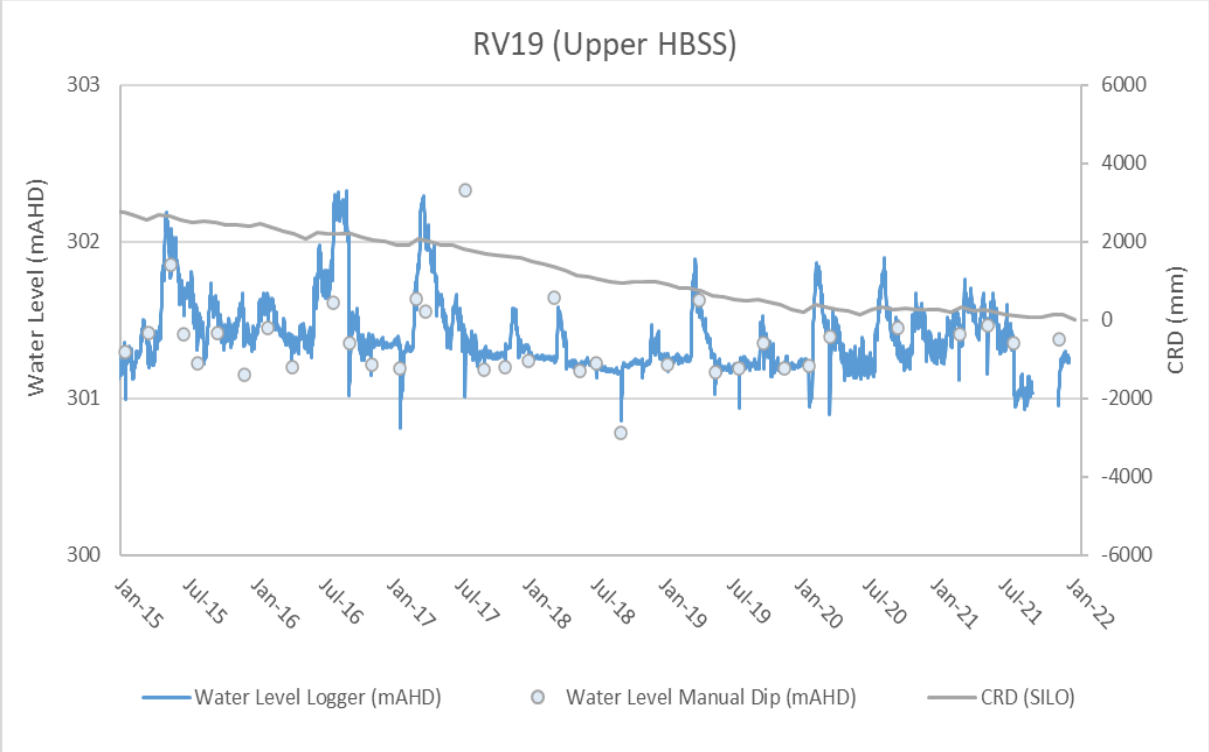
RV17 (VWP)



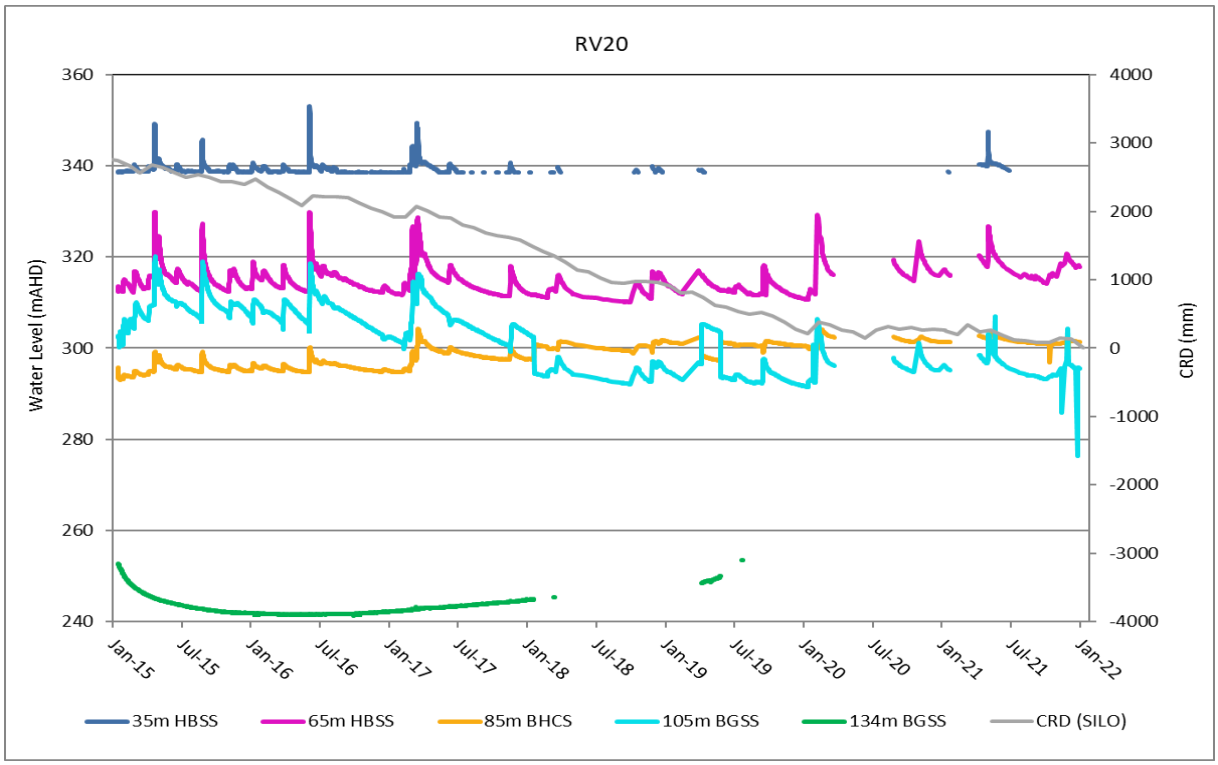
RV18



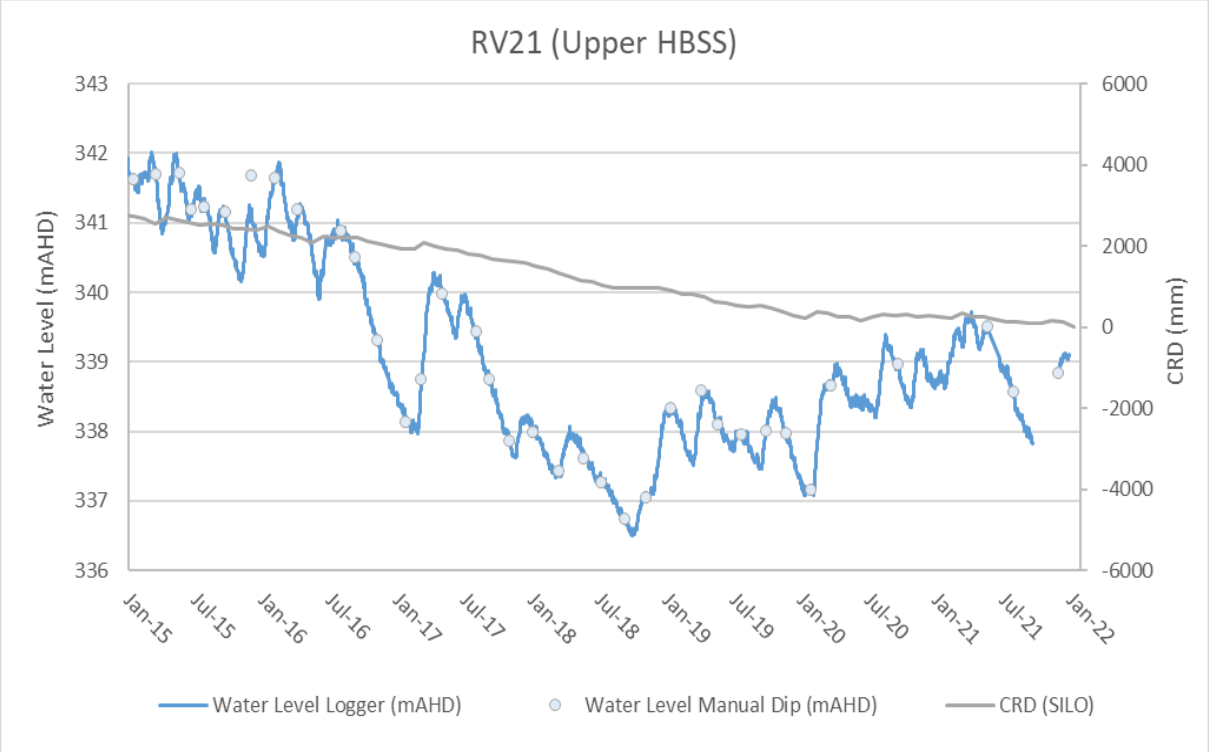
RV19



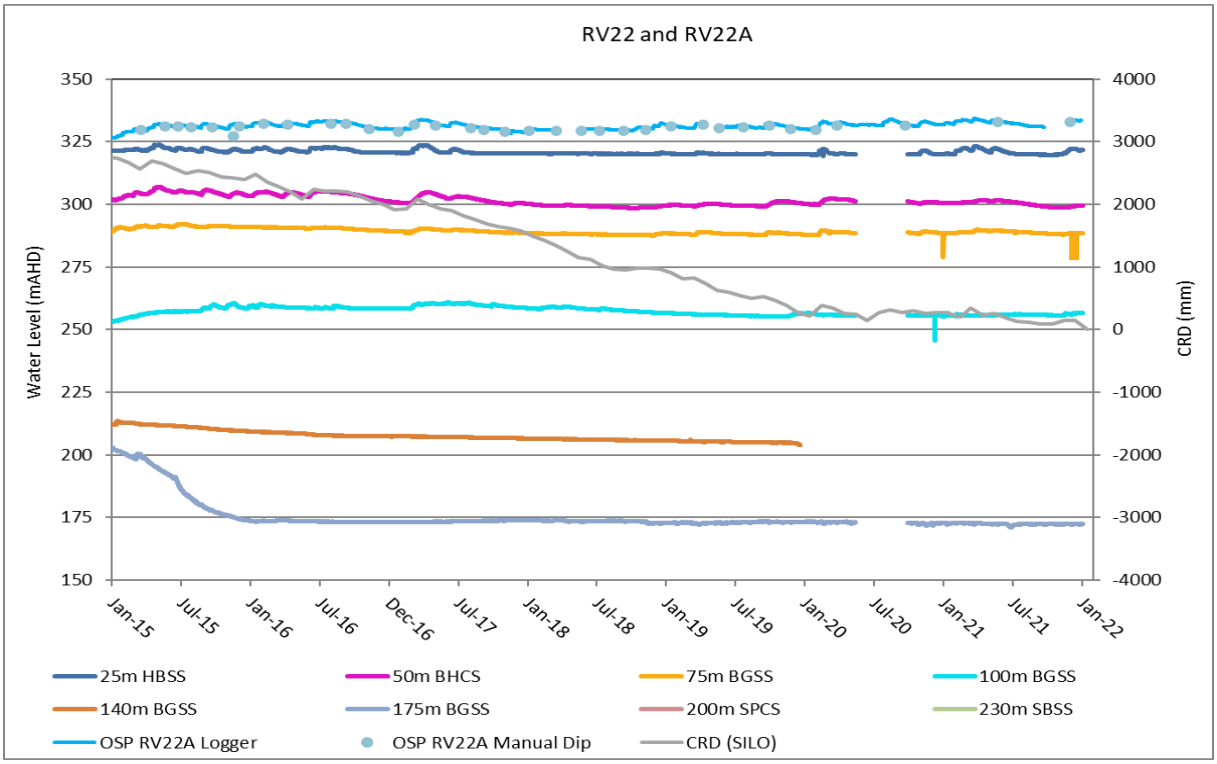
RV20 (VWP)



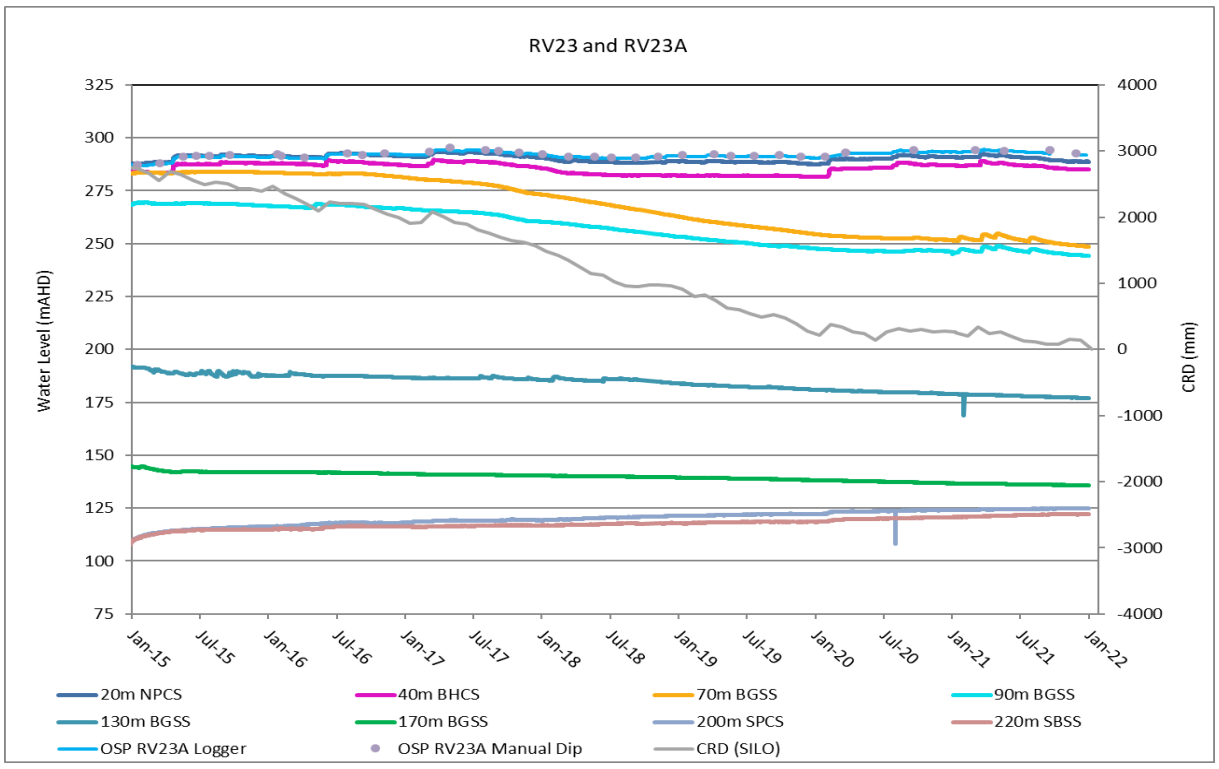
RV21



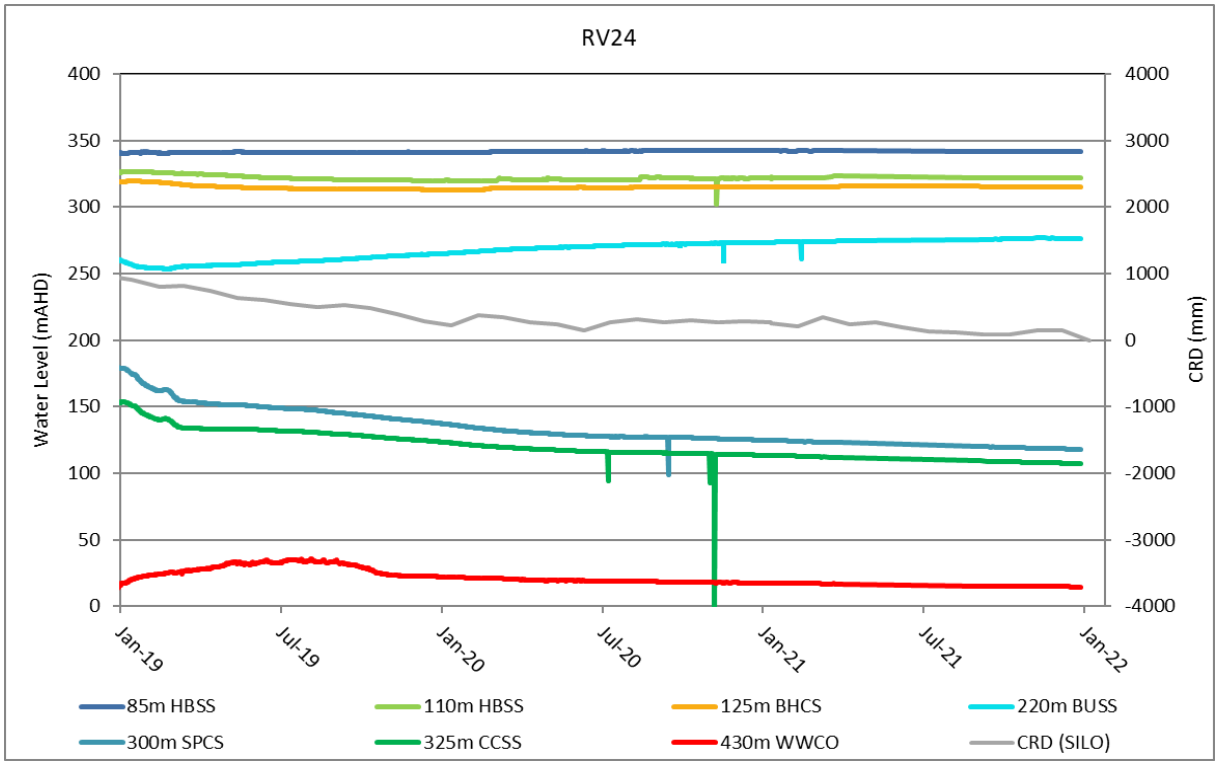
RV22A and RV22 (VWP)



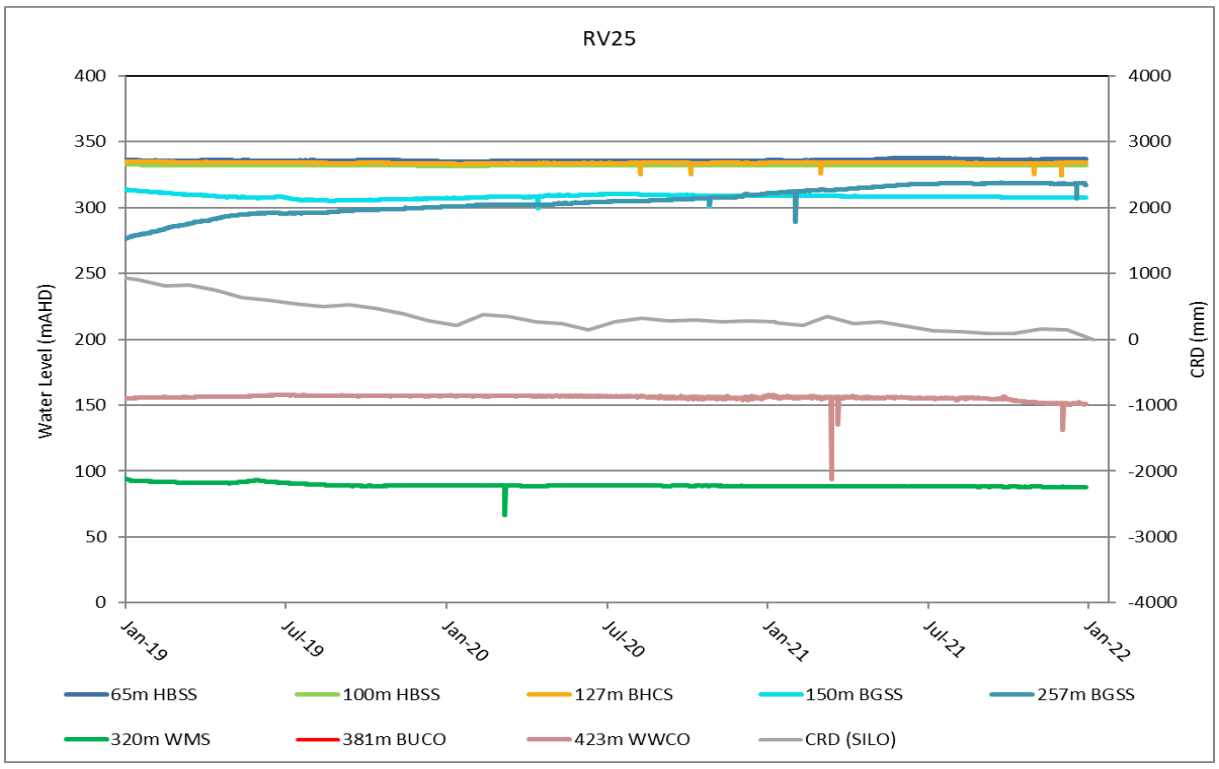
RV23A and RV23 (VWP)



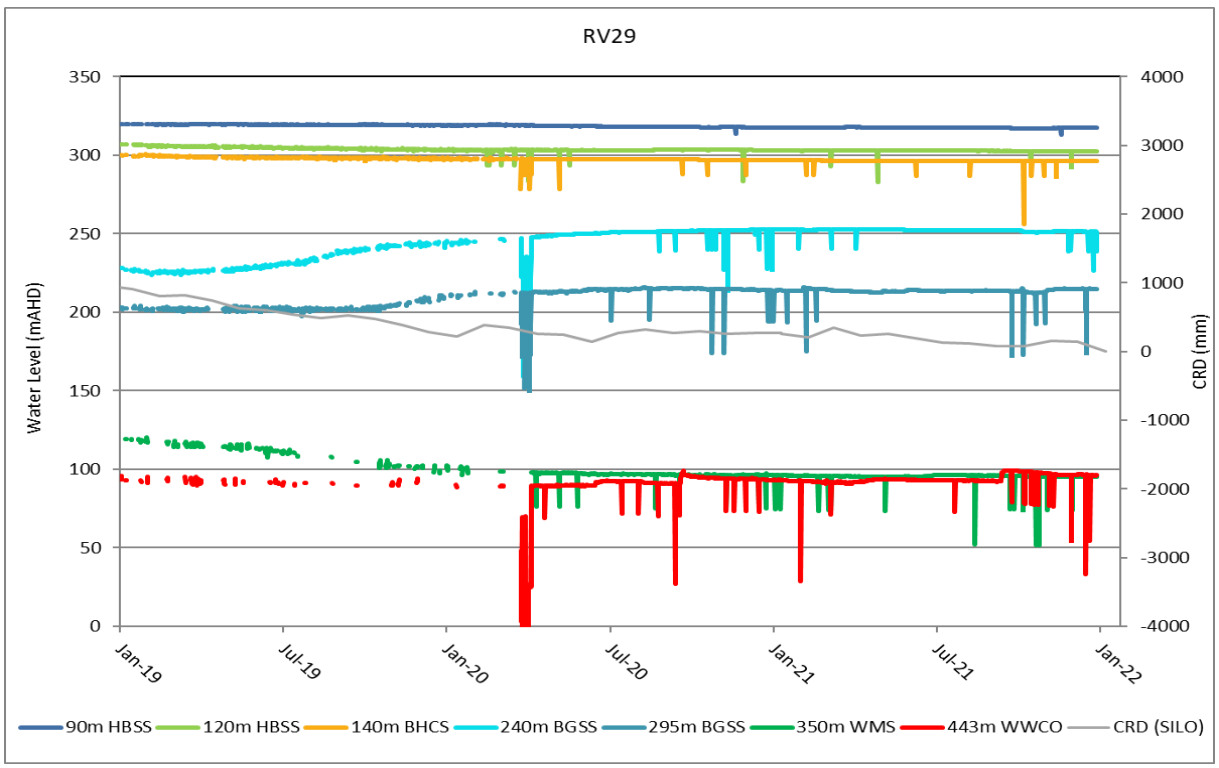
RV24 (VWP)



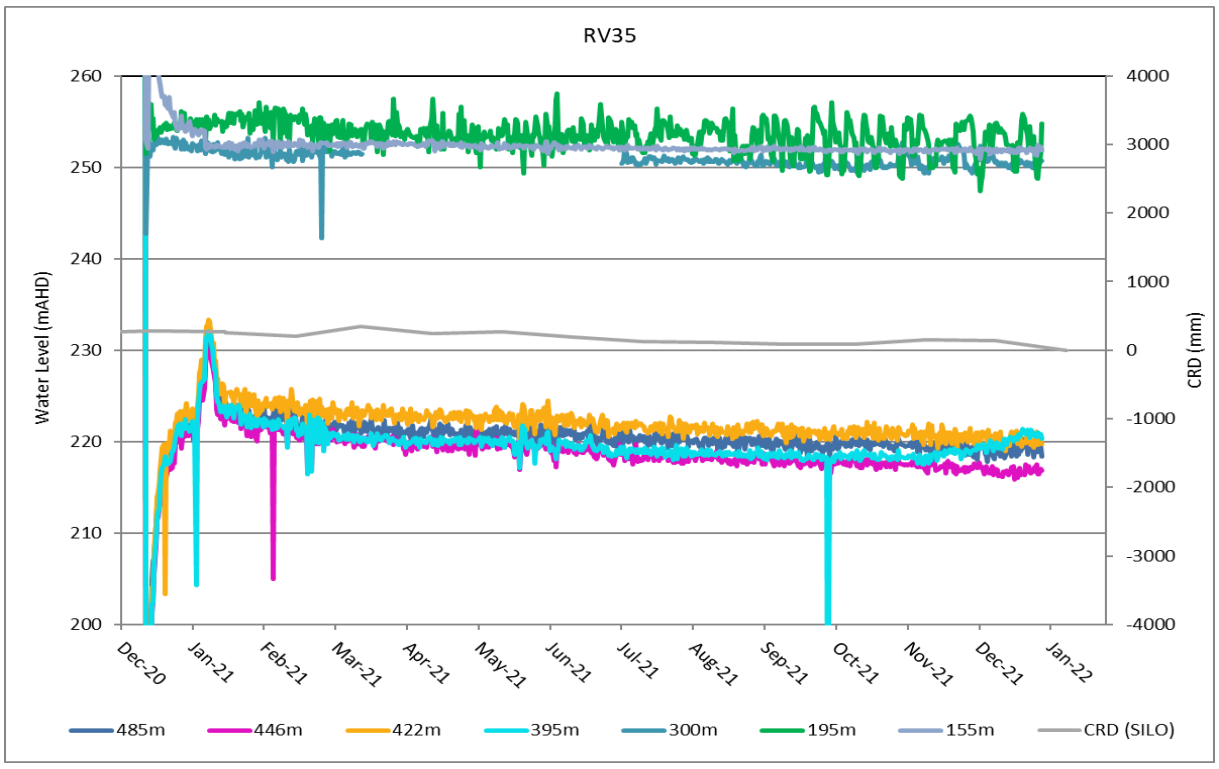
RV25



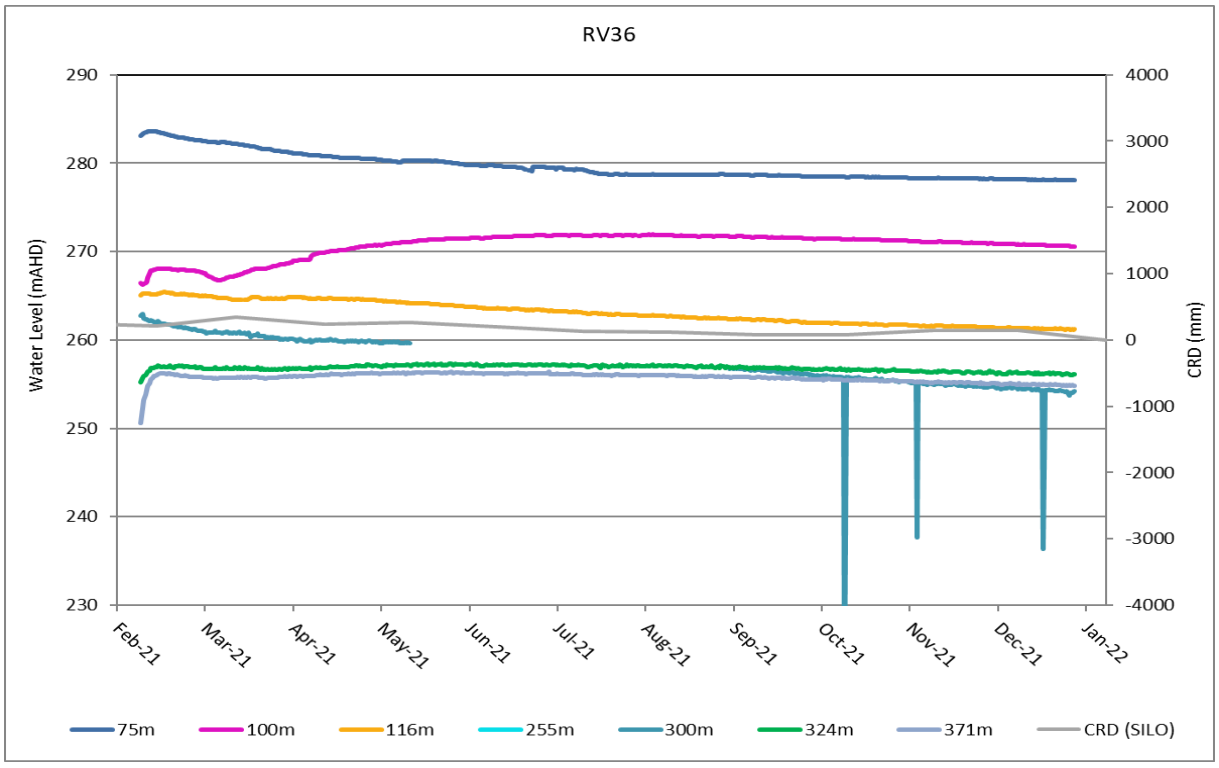
RV29 (VWP)



RV35 (VWP)



RV36 (VWP)



APPENDIX D – GROUNDWATER BASELINE DATA – WATER QUALITY

[Excel pdf output of table of **OSP** water quality and Hawkesbury Sandstone water quality – raw data used for summary tables]

APPENDIX E – GROUNDWATER MONITORING PROGRAM

Monitoring Requirement	Monitoring Location	Timing/ Frequency			Parameters	Purpose
		Prior to Mining	During Mining	Post Mining		
Monitoring of swamp soil moisture and shallow water	Swamp sites with soil moisture probes and piezometers, including: **Moisture probes and piezometers:** PB4 (A/B/D) near swamp BCUS4 PCc10 (A/B) at CCUS10 PCc12 (A/B) at CCUS12 PCc4 (B/C/D) at CCUS4 PCc5 (A/B/D) at CCUS5 PCr1 (A/B/C) at CRUS1 **Piezometers only:** PB4C near swamp BCUS4 PCc2 at CCUS2 PCc3 at CCUS3 PCc4A at CCUS4 PCc5C at CCUS5 PCc6 at CCUS6 PCr1D at CRUS1	Daily – water level monitoring with logger set at 6 hourly interval and downloaded and dipped 2 monthly (once every two months) 2 monthly – field analysis Quarterly – discrete analysis Annual – full metals suite analysis	Daily – water level monitoring with logger set at 6 hourly interval and downloaded and dipped monthly in swamps being actively undermined 2 monthly – field analysis Quarterly – discrete analysis Annual – full metals suite analysis	Daily – water level monitoring with logger set at minimum 12 hourly interval and downloaded and dipped for an agreed period (minimum 1 year) after the swamp is undermined 2 monthly – field analysis Quarterly – discrete analysis	**Field analysis*** **Discrete#** **Full metals suite^**	Verify predicted swamp water level/moisture response and water quality changes to existing operations and inform future model iterations and updates. Verify predicted swamp water level/moisture response to mine closure.

Monitoring Requirement	Monitoring Location	Timing/ Frequency			Parameters	Purpose
		Prior to Mining	During Mining	Post Mining		
	Shallow piezometers near swamp locations, including: SP1 near CCUS6 SP2 near CCUS3 and CCUS4	Daily – water level monitoring with logger set at 6 hourly interval and downloaded and dipped 2 monthly (once every two months) 2 monthly – field analysis Quarterly – discrete analysis	Daily – water level monitoring with logger set at 6 hourly interval and downloaded and dipped monthly in swamps being actively undermined 2 monthly – field analysis Quarterly – discrete analysis	Daily – water level monitoring with logger set at minimum 12 hourly interval and downloaded and dipped for an agreed period (minimum 1 year) after the swamp is undermined 2 monthly – field analysis Quarterly – discrete analysis	**Field analysis*** **Discrete#**	Identify if current dry conditions may change with the cessation of longwall mining and recovery, and changes in climatic conditions.
	Installation of additional swamp soil moisture probes and water piezometers at identified swamp locations: PCc1 A (SM & PZ)/B(SM)/C(SM & PZ) at CCUS1 PCc6 B (SM & PZ) at CCUS6 PCc11 (SM) at CCUS11 PCc14 A (SM & PZ)/B (SM) at CCUS14 PCc20 (SM & PZ) at CCUS20 PCc21 (SM) at CCUS21	Daily – water level monitoring with logger set at 6 hourly interval and downloaded and dipped bi-monthly 2 monthly – field analysis of piezometers Quarterly – discrete analysis of piezometers Annual – full metals suite analysis	Daily – water level monitoring with logger set at 6 hourly interval and downloaded and dipped monthly in swamps being actively undermined. 2 monthly – field analysis of piezometers Quarterly – discrete analysis of piezometers Annual – full metals suite analysis	Daily – water level monitoring with logger set at minimum 12 hourly interval and downloaded and dipped for an agreed period (minimum 1 year) after the swamp is undermined. 2 monthly – field analysis of piezometers Annual – discrete analysis of piezometers	**Field analysis*** **Discrete#** **Full metals suite ^**	Verify predicted swamp water level/moisture response to existing operations and inform future model iterations and updates. Verify predicted swamp water level/moisture response to mine closure.

Monitoring Requirement	Monitoring Location	Timing/ Frequency			Parameters	Purpose
		Prior to Mining	During Mining	Post Mining		
	PCr2 (SM) at CRUS2 PCr3 (SM) at CRUS3 PCr6 (SM) at CRUS6 PB11 (SM) at BCUS11					
Monitoring of groundwater levels and head gradients near swamps	Swamp monitoring paired open standpipes and VWPs at existing locations NRE1A and NREA near CCUS2 RV16 within CCUS1 RV20 near CCUS6 RV19 near CRUS1 RV21 near BCUS2 and BCUS4 RV39 near CCUS6 and CCUS3 RV40 near CCUS17 and CRUS2 RV41 near CCUS20 RV42 near CCUS1 RV44 within CRUS3 RV45 near CCUS2 and CRUS3	Daily – water level monitoring with logger set at 6 hourly interval and downloaded and dipped (for open standpipes) bi-monthly 2 monthly – field analysis for open standpipes Quarterly – discrete analysis for open standpipes Annual – full metals suite analysis	Daily – water level monitoring with logger set at 6 hourly interval and downloaded and dipped (for open standpipes) monthly in areas being actively undermined 2 monthly – field analysis for open standpipes Quarterly – discrete analysis for open standpipes Annual – full metals suite analysis	Daily – water level monitoring with logger set at 12 hourly interval and downloaded and dipped (for open standpipes) bi-monthly for an agreed period (minimum 1 year) after the area is undermined Quarterly – field analysis for open standpipes for an agreed period (minimum 1 year) after mining is completed Annual – discrete analysis for open standpipes for an agreed period (minimum 1 year) after mining is completed	**Field analysis*** **Discrete#** **Full metals suite ^**	Verify predicted groundwater level and swamp water level/moisture response to existing operations and inform future model iterations and updates. Assess head gradients and recharge/discharge processes in relation to the swamps. Verify predicted groundwater level and swamp water level/moisture response to mine closure. Assess head gradient changes and recharge/discharge processes in relation to the swamps post closure

Monitoring Requirement	Monitoring Location	Timing/ Frequency			Parameters	Purpose
		Prior to Mining	During Mining	Post Mining		
	RV46 near CCUS14 RV47 near CRUS4					

Monitoring Requirement	Monitoring Location	Timing/ Frequency			Parameters	Purpose
		Prior to Mining	During Mining	Post Mining		
Monitoring of groundwater levels and head gradients near swamps to inform future model updates and mine closure planning	Installation of additional paired monitoring points near swamps: RV39 near CCUS6 and CCUS3 RV40 near CCUS17 and CRUS2 RV41 near CCUS20 RV42 near CCUS1 RV44 near CRUS3 RV46 near CCUS14	Daily – water level monitoring with logger set at 6 hourly interval and downloaded and dipped (for open standpipes) bi-monthly 2 monthly – field analysis for open standpipes 2 monthly – discrete analysis for open standpipes within first 12 months of installation, reducing to quarterly frequency Annual – full metals suite analysis	Daily – water level monitoring with logger set at 6 hourly interval and downloaded and dipped (for open standpipes) monthly in areas being actively undermined 2 monthly – field analysis for open standpipes 2 monthly – discrete analysis for open standpipes within first 12 months of installation, reducing to quarterly frequency Annual – full metals suite analysis	Daily – water level monitoring with logger set at 6 hourly interval and downloaded and dipped (for open standpipes) bi-monthly for an agreed period (minimum 1 year after the area is undermined) 2 monthly – field analysis for open standpipes for an agreed period (minimum 1 year) after mining is completed Annual – discrete analysis for open standpipes for an agreed period (minimum 1 year) after mining is completed	**Field analysis*** **Discrete#** **Full metals suite ^**	Verify predicted groundwater level and swamp water level/moisture response to existing operations and inform future model iterations and updates. Assess head gradients and recharge/discharge processes in relation to the swamps.
Monitoring of existing groundwater sites	Open standpipes: NRE A, NRE C, NRE D, GW1A, RV18, RV19, RV21, RV22A, RV23A	Daily – water level monitoring with logger set at 6 hourly interval and downloaded and dipped 2 monthly 2 monthly – field analysis for open standpipes	Daily – water level monitoring with logger set at 6 hourly interval and downloaded and dipped monthly in areas being actively undermined 2 monthly – field analysis for open standpipes	Daily – water level monitoring with logger set at 6 hourly interval and downloaded and dipped (for open standpipes) bi-monthly for an agreed period (minimum 1 year after the area is undermined)	**Field analysis*** **Discrete#** **Full metals suite ^**	Verify predicted groundwater level response to existing operations and inform future model iterations and updates. Verify predicted groundwater level recovery response.

Monitoring Requirement	Monitoring Location	Timing/ Frequency			Parameters	Purpose
		Prior to Mining	During Mining	Post Mining		
		Quarterly – discrete analysis for open standpipes Annual – full metals suite analysis	Quarterly – discrete analysis for open standpipes Annual – full metals suite analysis	2 monthly – field analysis for open standpipes for an agreed period (minimum 1 year) after mining is completed Annual – discrete analysis for open standpipes for an agreed period (minimum 1 year) after mining is completed		
Monitoring of existing groundwater sites	VWPs: NRE1B, NRE1D, GW1, RV16, RV17, RV20, RV22, RV23, RV24, RV25, RV27, RV29, RV35 and RV36	Daily – water level monitoring with logger set at 6 hourly interval and downloaded 2 monthly	Daily – water level monitoring with logger set at 6 hourly interval and downloaded monthly in areas being actively undermined	Daily – water level monitoring with logger set at 6 hourly interval and downloaded 2 monthly for an agreed period (minimum 1 year after the area is undermined)	Water level/pressure	Verify predicted groundwater level response to existing operations and inform future model iterations and updates. Verify predicted groundwater level recovery response.
Establishment and monitoring of additional targeted monitoring sites to inform future Model updates and mine closure planning	Installation of additional monitoring locations Open standpipes: RV43A VWPs: RV43 and RV48	Daily – water level monitoring with logger set at 6 hourly interval and downloaded and dipped (for open standpipes) 2 monthly 2 monthly – field analysis for open standpipes	Daily – water level monitoring with logger set at 6 hourly interval and downloaded and dipped (for open standpipes) monthly in areas being actively undermined	Daily – water level monitoring with logger set at 6 hourly interval and downloaded and dipped (for open standpipes) 2 monthly for an agreed period (minimum 1 year after the area is undermined)	**Field analysis*** **Discrete#** **Full metals suite ^**	Verify predicted groundwater levels and response to existing operations and inform future model iterations and updates. Characterise groundwater conditions and changes relevant to

Monitoring Requirement	Monitoring Location	Timing/ Frequency			Parameters	Purpose
		Prior to Mining	During Mining	Post Mining		
		2 monthly – discrete analysis for open standpipes within first 12 months of installation, reducing to quarterly frequency Annual – full metals suite analysis	2 monthly – field analysis for open standpipes 2 monthly – discrete analysis for open standpipes within first 12 months of installation, reducing to quarterly frequency Annual – full metals suite analysis	2 monthly – field analysis for open standpipes for an agreed period (minimum 1 year) after mining is completed Annual – discrete analysis for open standpipes for an agreed period (minimum 1 year) after mining is completed		nearby GDEs and subsidence monitoring (where applicable) Verify predicted groundwater level recovery response.
Inflows to existing underground workings – volume and quality	Mine workings	Daily volumetric flow monitoring of mine inflow and discharge Monthly – field analysis Quarterly – full metals suite analysis	Daily volumetric flow monitoring of mine inflow and discharge Monthly – field analysis Quarterly – full metals suite analysis	-	**Field analysis*** **Full metals suite ^**	Verify predicted groundwater inflows to existing operations and inform future model iterations and updates. Monitor water quality trends for early identification of changes compared to current mine inflow water quality.
Adit seepage monitoring and inspection – seepage rate and water quality	Mine workings	-	-	In accordance with the Adit Discharge Water Management Plan: Daily volumetric flow monitoring of discharge	**Field analysis*** **Full metals suite ^**	Visualise and verify post closure seepage conditions.

Monitoring Requirement	Monitoring Location	Timing/ Frequency			Parameters	Purpose
		Prior to Mining	During Mining	Post Mining		
				Monthly – field analysis for an agreed period (minimum 1 year) after mining is completed Quarterly – full metals analysis for an agreed period (minimum 1 year) after mining is completed		

*** *Field analysis:*** *includes field analysis of pH, EC, DO, ORP and temp*

 # *Discrete:* *includes field analysis of pH, EC, DO, ORP and temp. As well as laboratory analysis of TDS, TSS, major ions (Na, K, Ca, Mg, Cl, SO4), F, HCO_3, $CaCO_3$, NO_3, Total N, Total P, Total alkalinity, filtered DOC and dissolved metals Al, P, Cu, Pb, Zn, Ni, Sb, Fe, Mn, Mo As, Li and Ba.*

^ *Full metals suite* *: includes field analysis of pH, EC, DO, ORP and temp. As well as discrete laboratory analysis suite* ***plus*** *laboratory analysis of additional dissolved metals B, Cd, Co, Hg, Se and Ag*

APPENDIX F - TRIGGER ACTION RESPONSE PLAN

NOTE: These TARPs (including the duration for which these TARPs apply to monitoring at specific locations) are subject to more detailed triggers as set out in approved Extraction Plans for LW 6 and approved Second Workings. To the extent of any inconsistency between these TARPs and TARPs contained in an approved EP, the EP provisions apply.

Feature	Trigger Monitoring Location	Unit	Timing/ Frequency During Mining	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
Swamp water quality	Existing swamp piezometers: PB4 B near swamp BCUS4 PCc10 (A/B) at CCUS10 PCc12 A at CCUS12 PCc2 at CCUS2 PCc4 (C) at CCUS4 PCc5 (B) at CCUS5 PCr1 (B) at CRUS1 For newly installed swamp piezometers refer to USMP	EC	Field analysis when piezometers are manually dipped: • Every 2 months prior to and after swamp is mined under; • Monthly during period when swamp is mined under.	Detection of potential impact to swamp water conditions due to mine activities	Level 1: No exceedance of Level 2 or Level 3	Continue monitoring.	Report negligible impact in routine reporting.	Russell Vale Colliery (Group Environment Manager)
					Level 2: One reading above the trigger level of 193 µS/cm	1. Review sampling methodology/ equipment to verify if the reading is representative. If not, resample and test within 7 days of the result. 2. If the data is representative, review weather station data, groundwater quality and level data and subsidence monitoring to identify whether further investigation is warranted. If an impact due to mining is identified progress to Level 3.	1. One week 2. Two weeks to assess whether further investigation is required. Commence investigation if exceedance of Level 3 criteria identified (see Level 3 reporting requirements). 3. One to two months depending on timing of review of second data period.	Russell Vale Colliery (Group Environment Manager)

Feature	Trigger Monitoring Location	Unit	Timing/ Frequency During Mining	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
					Level 3: Two consecutive readings above the trigger of 193 µS/cm	1. Inform DPE and Water NSW 2. Investigate and report on the cause of the trigger exceedances (e.g. climatic, systemic, failure) 3. Inform DPE and WaterNSW of investigation outcomes 4. Identify mitigation options 5. Review monitoring frequency and parameters 6. Report potential impact, and response, within six monthly reporting	1.One week 2. Commence within one week 3. One month 4. Commence works within 2 months 5. One month 6. Six monthly reporting in accordance with Extraction Plan approval	Russell Vale Colliery (Group Environment Manager)

**Swamp Water Level Triggers: Water level trigger - (in mbgl) – specified in Appendix G*

Feature	Trigger Monitoring Location	Unit	Timing/ Frequency During Mining	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
Swamp water quality	Existing swamp piezometers: PB4 B near swamp BCUS4 PCc10 (A/B) at CCUS10 PCc12 A at CCUS12 PCc2 at CCUS2 PCc4 (C) at CCUS4 PCc5 (B) at CCUS5 PCr1 (B) at CRUS1 For newly installed swamp	pH	Field analysis when piezometers are manually dipped: • Every 2 months prior to and after swamp is mined under; • Monthly during period when swamp is mined under.	Detection of potential impact to swamp water conditions due to mine activities	Level 1: No exceedance of Level 2 or Level 3	Continue monitoring.	Report negligible impact in routine reporting.	Russell Vale Colliery (Group Environment Manager)
					Level 2: One reading outside of the trigger range of 3.8 to 6.3	1. Review sampling methodology/ equipment to verify if the reading is representative. If not, resample and test within 7 days of the result. 2. If the data is representative, review weather station data, groundwater quality and level data and subsidence monitoring to identify whether further investigation is warranted. If an impact due to mining is identified progress to Level 3.	1. One week 2. Two weeks to assess whether further investigation is required. Commence investigation if exceedance of Level 3 criteria identified (see Level 3 reporting requirements). 3. One to two months depending on timing of review of second data period.	Russell Vale Colliery (Group Environment Manager)

Feature	Trigger Monitoring Location	Unit	Timing/ Frequency During Mining	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
	piezometers refer to USMP				Level 3: Two consecutive readings outside of the trigger range of 3.8 to 6.3	1. Inform DPE and Water NSW 2. Investigate and report on the cause of the trigger exceedances (e.g. climatic, systemic, failure) 3. Inform DPE and WaterNSW of investigation outcomes 4. Identify mitigation options 5. Review monitoring frequency and parameters 6. Report potential impact, and response, within six monthly reporting	One week 2. Commence within one week 3. One month 4. Commence works within 2 months 5. One month 6. Six monthly reporting in accordance with Extraction Plan approval	Russell Vale Colliery (Group Environment Manager)

**Swamp Water Level Triggers: Water level trigger - (in mbgl) – specified in Appendix G*

Feature	Trigger Monitoring Location	Unit	Timing/ Frequency During Mining	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
Swamp water levels	Existing swamp piezometers: PB4 B near swamp BCUS4 PCc10 (A/B) at CCUS10 PCc12 A at CCUS12 PCc2 at CCUS2 PCc4 (C) at CCUS4 PCc5 (B) at CCUS5 PCr1 (B) at CRUS1 For newly installed swamp piezometers refer to USMP	Water level	Daily – water level monitoring with logger set 6 hourly interval. Data downloaded and manually dipped: • Every 2 months prior to and after swamp is mined under; • Monthly during period when swamp is mined under.	Detection of potential impact to swamp water conditions due to mine activities	Level 1: Water level readings consistently above the water level trigger* or levels below trigger during periods of low rainfall (<20 mm/month)	Continue monitoring.	Report negligible impact in routine reporting.	Russell Vale Colliery (Group Environment Manager)
					Level 2: One monthly water level reading below the water level trigger following a month of rainfall above 20 mm/month	1. Review sampling methodology/ equipment to verify if the reading is representative. If not, resample and test within 7 days of the result. 2. If the data is representative, review weather station data, groundwater quality and level data and subsidence monitoring to identify whether further investigation is warranted. If an impact due to mining is identified progress to Level 3.	1. One week 2. Two weeks to assess whether further investigation is required. Commence investigation if exceedance of Level 3 criteria identified (see Level 3 reporting requirements). 3. One to two months depending on timing of review of second data period.	Russell Vale Colliery (Group Environment Manager)

Feature	Trigger Monitoring Location	Unit	Timing/ Frequency During Mining	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
					Level 3: Two consecutive monthly water level readings below the water level trigger* following a month of rainfall above 20 mm/month	1. Inform DPE and Water NSW 2. Investigate and report on the cause of the trigger exceedances e.g. climatic, systemic, failure) 3. Inform DPE and WaterNSW of investigation outcomes 4. Identify mitigation options 5. Review monitoring frequency and parameter 6. Report potential impact, and response, within six monthly reporting	1. One week 2. Commence within one week 3. One month 4. Commence works within 2 months 5. One month 6. Six monthly reporting in accordance with Extraction Plan approval	Russell Vale Colliery (Group Environment Manager)

**Swamp Water Level Triggers: Water level trigger - (in mbgl) – specified in Appendix G*

Feature	Trigger Monitoring Location	Unit	Timing/ Frequency During Mining	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
Hawkes-bury Sandstone water quality	Existing open standpipes: NRE A, NRE C, NRE D, GW1A, RV18, RV19, RV21, RV22A Newly installed open standpipes: RV40, RV41, RV42, RV45, RV46, RV47	EC	2 monthly – field analysis for open standpipes Quarterly – discrete analysis for open standpipes	Detection of potential impact to Hawkesbury Sandstone water due to mine activities	Level 1: No exceedance of Level 2 or Level 3 triggers	Continue monitoring.	Report negligible impact in routine reporting.	Russell Vale Colliery (Group Environment Manager)
					Level 2: One reading above the trigger level of 376 µS/cm	1. Review sampling methodology/ equipment to verify if the reading is representative. If not, resample and test within 7 days of the result. 2. If the data is representative, review weather station data, groundwater quality and level data and subsidence monitoring to identify whether further investigation is warranted. If an impact due to mining is identified progress to Level 3.	1. One week 2. Two weeks to assess whether further investigation is required. Commence investigation if exceedance of Level 3 criteria identified (see Level 3 reporting requirements). 3. One to two months depending on timing of review of second data period.	Russell Vale Colliery (Group Environment Manager)

Feature	Trigger Monitoring Location	Unit	Timing/ Frequency During Mining	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
					Level 3: Two consecutive readings above the trigger level of 376 µS/cm	1. Inform DPE and Water NSW 2. Investigate and report on the cause of the trigger exceedances (e.g. climatic, systemic, failure) 3. Inform DPE and WaterNSW of investigation outcomes 4. Identify mitigation options 5. Review monitoring frequency and parameters 6. Report potential impact, and response, within six monthly reporting	1. One week 2. Commence within one week 3. One month 4. Commence works within 2 months 5. One month 6. Six monthly reporting in accordance with Extraction Plan approval	Russell Vale Colliery (Group Environment Manager)

**Swamp Water Level Triggers: Water level trigger - (in mbgl) – specified in Appendix G*

Feature	Trigger Monitoring Location	Unit	Timing/ Frequency During Mining	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
Hawkes-bury Sandstone water quality	Existing open standpipes: NRE A, NRE C, NRE D, GW1A, RV18, RV19, RV21, RV22A Newly installed open standpipes: RV40, RV41, RV42, RV45, RV46, RV47	pH	2 monthly – field analysis for open standpipes Quarterly – discrete analysis for open standpipes	Detection of potential impact to Hawkesbury Sandstone water due to mine activities	Level 1: No exceedance of Level 2 or Level 3 triggers	Continue monitoring.	Report negligible impact in routine reporting.	Russell Vale Colliery (Group Environment Manager)
					Level 2: One reading outside of the trigger range of 3.7 to 6.5	1. Review sampling methodology/ equipment to verify if the reading is representative. If not, resample and test within 7 days of the result. 2. If the data is representative, review weather station data, groundwater quality and level data and subsidence monitoring to identify whether further investigation is warranted. If an impact due to mining is identified progress to Level 3.	1. One week 2. Two weeks to assess whether further investigation is required. Commence investigation if exceedance of Level 3 criteria identified (see Level 3 reporting requirements). 3. One to two months depending on timing of review of second data period.	Russell Vale Colliery (Group Environment Manager)

Feature	Trigger Monitoring Location	Unit	Timing/ Frequency During Mining	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
					Level 3: Two consecutive readings outside of the trigger range of 3.7 to 6.5	1. Inform DPE and Water NSW 2. Investigate and report on the cause of the trigger exceedances (e.g. climatic, systemic, failure) 3. Inform DPE and WaterNSW of investigation outcomes 4. Identify mitigation options 5. Review monitoring frequency and parameters 6. Report potential impact, and response, within six monthly reporting	1. One week 2. Commence within one week 3. One month 4. Commence works within 2 months 5. One month 6. Six monthly reporting in accordance with Extraction Plan approval	Russell Vale Colliery (Group Environment Manager)

**Swamp Water Level Triggers: Water level trigger - (in mbgl) – specified in Appendix G*

Feature	Trigger Monitoring Location	Unit	Timing/ Frequency During Mining	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
Hawkes-bury Sandstone water levels	Existing open standpipes: NRE A, NRE C, NRE D, GW1A, RV18, RV19, RV21, RV22A Newly installed open standpipes: RV40, RV41, RV42, RV45, RV46, RV47	Water level	Monthly manual dipped water level in areas being actively undermined	Detection of potential impact to Hawkesbury Sandstone water due to mine activities	Level 1: No exceedance of Level 2 or Level 3 triggers	Continue monitoring.	Report negligible impact in routine reporting.	Russell Vale Colliery (Group Environment Manager)
					Level 2: One monthly water level reading below the water level trigger	1. Review sampling methodology/ equipment to verify if the reading is representative. If not, resample and test within 7 days of the result. 2. If the data is representative, review weather station data, groundwater quality and level data and subsidence monitoring to identify whether further investigation is warranted. If an impact due to mining is identified progress to Level 3.	1. One week 2. Two weeks to assess whether further investigation is required. Commence investigation if exceedance of Level 3 criteria identified (see Level 3 reporting requirements). 3. One to two months depending on timing of review of second data period.	Russell Vale Colliery (Group Environment Manager)

Feature	Trigger Monitoring Location	Unit	Timing/ Frequency During Mining	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
					Level 3: Two consecutive monthly water level readings below the water level trigger	1. Inform DPE and Water NSW 2. Investigate and report on the cause of the trigger exceedances (e.g. climatic, systemic, failure) 3. Inform DPE and WaterNSW of investigation outcomes 4. Identify mitigation options 5. Review monitoring frequency and parameters 6. Report potential impact, and response, within six monthly reporting	1. One week 2. Commence within one week 3. One month 4. Commence works within 2 months 5. One month 6. Six monthly reporting in accordance with Extraction Plan approval	Russell Vale Colliery (Group Environment Manager)

**Swamp Water Level Triggers: Water level trigger - (in mbgl) – specified in Appendix G*

Feature	Trigger Monitoring Location	Unit	Timing/ Frequency During Mining	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
Bulgo Sandstone water quality	Newly installed open standpipes, which may include: RV43A and RV44	EC	2 monthly – field analysis for open standpipes	Verification of characterisation of Bulgo Sandstone water quality and detection of changes in quality post mining and closure, outside of predicted impacts	Level 1: No exceedance of Level 2 or Level 3 triggers	Report negligible impact in routine reporting.	Report negligible impact in routine reporting.	Russell Vale Colliery (Group Environment Manager)
					Level 2: One reading above the trigger level of 376 µS/cm within the first 12 months of installation	1. Review sampling methodology/ equipment to verify if the reading is representative. If not, resample and test within 7 days of the result. 2. If the data is representative, review weather station data, groundwater quality and level data and subsidence monitoring to identify whether further investigation is warranted. If an impact due to mining is identified progress to Level 3.	1. One week 2. Two weeks to assess whether further investigation is required. Commence investigation if exceedance of Level 3 criteria identified (see Level 3 reporting requirements). 3. One to two months depending on timing of review of second data period.	Russell Vale Colliery (Group Environment Manager)

Feature	Trigger Monitoring Location	Unit	Timing/ Frequency During Mining	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
					Level 3: Two consecutive readings above the trigger level of 376 µS/cm within the first 12 months of installation	1. Inform DPE and Water NSW 2. Investigate and report on the cause of the trigger exceedances 3. Inform DPE and WaterNSW of investigation outcomes 4. Identify mitigation options 5. Review monitoring frequency and parameters 6. Report potential impact, and response, within six monthly reporting	1. One week 2. Commence within one week 3. One month 4. Commence works within 2 months 5. One month 6. Six monthly reporting in accordance with Extraction Plan approval	Russell Vale Colliery (Group Environment Manager)

**Swamp Water Level Triggers: Water level trigger - (in mbgl) – specified in Appendix G*

Feature	Trigger Monitoring Location	Unit	Timing/ Frequency During Mining	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
Bulgo Sandstone water quality	Newly installed open standpipes, which may include:	pH	2 monthly – field analysis for open standpipes	Verification of characterisation of Bulgo Sandstone water quality and detection	Level 1: No exceedance of Level 2 or Level 3 triggers	Continue monitoring.	Report negligible impact in routine reporting.	Russell Vale Colliery (Group Environment Manager)

Feature	Trigger Monitoring Location	Unit	Timing/ Frequency During Mining	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
	RV43A and RV44			of changes in quality post mining and closure, outside of predicted impacts	Level 2: One reading outside of the trigger range of 3.7 to 6.5 within the first 12 months of installation	1. Review sampling methodology/ equipment to verify if the reading is representative. If not, resample and test within 7 days of the result. 2. If the data is representative, review weather station data, groundwater quality and level data and subsidence monitoring to identify whether further investigation is warranted. If an impact due to mining is identified progress to Level 3.	1. One week 2. Two weeks to assess whether further investigation is required. Commence investigation if exceedance of Level 3 criteria identified (see Level 3 reporting requirements). 3. One to two months depending on timing of review of second data period.	Russell Vale Colliery (Group Environment Manager)
					Level 3: Two consecutive readings outside of the trigger range of 3.7 to 6.5 within the first 12 months of installation	1. Inform DPE and Water NSW 2. Investigate and report on the cause of the trigger exceedances	1. One week 2. Commence within one week 3. One month 4. Commence works within 2 months 5. One month 6. Six monthly reporting in accordance with	Russell Vale Colliery (Group Environment Manager)

Feature	Trigger Monitoring Location	Unit	Timing/ Frequency During Mining	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
						(e.g. climatic, systemic, failure) 3. Inform DPE and WaterNSW of investigation outcomes 4. Identify mitigation options 5. Review monitoring frequency and parameters 6. Report potential impact, and response, within six monthly reporting	Extraction Plan approval	

**Swamp Water Level Triggers: Water level trigger - (in mbgl) – specified in Appendix G*

Feature	Trigger Monitoring Location	Unit	Timing/ Frequency During Mining	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
Bulgo Sandstone water levels	Newly installed open standpipes, which may include:	Water level	Monthly manual dipped water levels	Detection of changes in Bulgo Sandstone groundwater level post	Level 1: No exceedance of Level 2 or Level 3 triggers	Continue monitoring.	Report negligible impact in routine reporting.	Russell Vale Colliery (Group Environment Manager)

Feature	Trigger Monitoring Location	Unit	Timing/ Frequency During Mining	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
	RV43A and RV44			mining and closure, outside of predicted impacts	Level 2: One monthly water level reading below the water level trigger	1. Review sampling methodology/ equipment to verify if the reading is representative. If not, resample and test within 7 days of the result. 2. If the data is representative, review weather station data, groundwater quality and level data and subsidence monitoring to identify whether further investigation is warranted. If an impact due to mining is identified progress to Level 3.	1. One week 2. Two weeks to assess whether further investigation is required. Commence investigation if exceedance of Level 3 criteria identified (see Level 3 reporting requirements). 3. One to two months depending on timing of review of second data period.	Russell Vale Colliery (Group Environment Manager)
					Level 3: Two consecutive monthly water level readings below the water level trigger	1. Inform DPE and Water NSW 2. Investigate and report on the cause of the trigger exceedances	1. One week 2. Commence within one week 3. One month 4. Commence works within 2 months 5. One month 6. Six monthly reporting in accordance with	Russell Vale Colliery (Group Environment Manager)

Feature	Trigger Monitoring Location	Unit	Timing/ Frequency During Mining	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
						(e.g. climatic, systemic, failure) 3. Inform DPE and WaterNSW of investigation outcomes 4. Identify mitigation options 5. Review monitoring frequency and parameters 6. Report potential impact, and response, within six monthly reporting	Extraction Plan approval	

**Swamp Water Level Triggers: Water level trigger - (in mbgl) – specified in Appendix G*

Feature	Trigger Monitoring Location	Unit	Timing/ Frequency During Mining	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
Groundwater levels and vertical head profile	Existing VWPs: NRE1B, NRE1D, GW1, RV16, RV17, RV20, RV22, RV23, RV24,	Water level	Daily – water level monitoring with logger set at 6 hourly interval and downloaded	Impact on groundwater levels and vertical head profile due to mining	Level 1: No exceedance of Level 2 or Level 3 triggers	Continue monitoring.	Report negligible impact in routine reporting.	Russell Vale Colliery (Group Environment Manager)

Feature	Trigger Monitoring Location	Unit	Timing/ Frequency During Mining	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
	RV25, RV27, RV29, RV35 and RV36		monthly in areas being actively undermined	impacts/subsidence impacts beyond those already predicted.	Level 2: Detection of a significant change in vertical head gradient at one VWP sensor, as indicated by movement of the head profile below (to the left) of the minimum predicted head profile and baseline observation data (refer Appendix G)	1. Review condition of the VWP equipment. 2. If the data is representative, review climate trends, groundwater trends within other sensors and nearby monitoring locations and subsidence monitoring to identify whether further investigation is warranted. If an impact due to mining is identified progress to Level 3.	1. One week 2. Two weeks to assess whether further investigation is required. Commence investigation if exceedance of Level 3 criteria identified (see Level 3 reporting requirements). 3. One to two months depending on timing of review of second data period.	Russell Vale Colliery (Group Environment Manager)

Feature	Trigger Monitoring Location	Unit	Timing/ Frequency During Mining	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
					Level 3: Detection of a significant change in vertical head gradient at more than one VWP sensor, as indicated by movement of the head profile below (to the left) of the minimum predicted head profile and baseline observation data across multiple sensor levels (refer Appendix G)	1. Inform DPE and Water NSW 2. Investigate and report on the cause of the trigger exceedances 3. Inform DPE and WaterNSW of investigation outcomes 4. Identify mitigation options 5. Review monitoring frequency and parameters 6. Report potential impact, and response, within six monthly reporting	1. One week 2. Commence within one week 3. One month 4. Commence works within 2 months 5. One month 6. Six monthly reporting in accordance with Extraction Plan approval	Russell Vale Colliery (Group Environment Manager)

**Swamp Water Level Triggers: Water level trigger - (in mbgl) – specified in Appendix G*

Feature	Trigger Monitoring Location	Unit	Timing/ Frequency During Mining	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
Groundwater levels and vertical head profile	Newly installed VWPs, which may include: RV43 and RV48	Water level	Daily – water level monitoring with logger set at 6 hourly interval and downloaded monthly	Impact on groundwater levels and vertical head profile due to mining impacts/subsidence impacts and recovery post mining, beyond those already predicted.	Level 1: No exceedance of Level 2 or Level 3 triggers	Continue monitoring.	Report negligible impact in routine reporting.	Russell Vale Colliery (Group Environment Manager)
					Level 2: Detection of a significant change in vertical head gradient at one VWP sensor, as indicated by movement of the head profile below (to the left) of the minimum predicted head profile.	1. Review condition of the VWP equipment. 2. If the data is representative, review climate trends, groundwater trends within other sensors and nearby monitoring locations and subsidence monitoring to identify whether further investigation is warranted. If an impact due to mining is identified progress to Level 3.	1. One week 2. Two weeks to assess whether further investigation is required. Commence investigation if exceedance of Level 3 criteria identified (see Level 3 reporting requirements). 3. One to two months depending on timing of review of second data period.	Russell Vale Colliery (Group Environment Manager)

Feature	Trigger Monitoring Location	Unit	Timing/ Frequency During Mining	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
					Level 3: Detection of a significant change in vertical head gradient at more than one VWP sensor, as indicated by movement of the head profile below (to the left) of the minimum predicted head profile.	1. Inform DPE and Water NSW 2. Investigate and report on the cause of the trigger exceedances (e.g. climatic, systemic, failure) 3. Inform DPE and WaterNSW of investigation outcomes 4. Identify mitigation options 5. Review monitoring frequency and parameters 6. Report potential impact, and response, within six monthly reporting	1. One week 2. Commence within one week 3. One month 4. Commence works within 2 months 5. One month 6. Six monthly reporting in accordance with Extraction Plan approval	Russell Vale Colliery (Group Environment Manager)

**Swamp Water Level Triggers: Water level trigger - (in mbgl) – specified in Appendix G*

Feature	Trigger Monitoring Location	Unit	Timing/ Frequency During Mining	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
Underground workings	Mine inflows	Inflow	Daily volumetric flow monitoring of mine inflow and discharge	Inflows volumes to underground workings is in line with predictions and captured by appropriate water licences.	Level 1: Mine pump volumes are within predicted mine inflow range (< 1ML/day) – excluding changes in dewatering volumes to manage inrush risk or due to equipment maintenance.	Continue monitoring.	Report negligible impact in routine reporting.	Russell Vale Colliery (Group Environment Manager)
					Level 2: Increase in flow rate of >1ML/day (above predictions) for 4 successive days from active mining areas - excluding changes in dewatering volumes to manage	1. Review equipment to verify if the reading is representative. If not, remeasure. 2. If the data is representative, review mine water quality and inflow data, ground water data and geotechnical/subsidence records to identify any adverse trends that may indicate any adverse trends that may indicate an impact beyond previous predictions. If an	1. One week 2. Two weeks to assess whether further investigation is required. Commence investigation if exceedance of Level 3 criteria identified (see Level 3 reporting requirements). 3. One to two months depending on timing	Russell Vale Colliery (Group Environment Manager)

Feature	Trigger Monitoring Location	Unit	Timing/ Frequency During Mining	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
					inrush risk or due to equipment maintenance.	impact due to mining is identified progress to Level 3.	of review of second data period.	
					Level 3: Increase in flow rate of >1ML/day (above predictions) for 7 successive days from active mining areas - excluding changes in dewatering volumes to manage inrush risk or due to equipment maintenance.	1. Inform DPE and Water NSW 2. Investigate and report on the cause of the trigger exceedances 3. Inform DPE and WaterNSW of investigation outcomes 4. Identify mitigation options 5. Review monitoring frequency and parameters 6. Report potential impact, and response, within six monthly reporting	1. One week 2. Commence within one week 3. One month 4. Commence works within 2 months 5. One month 6. Six monthly reporting in accordance with Extraction Plan approval	Russell Vale Colliery (Group Environment Manager)

**Swamp Water Level Triggers: Water level trigger - (in mbgl) – specified in Appendix G*

Feature	Trigger Monitoring Location	Unit	Timing/ Frequency During Mining	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
Underground workings	Mine inflows	pH	Monthly – field analysis Quarterly – discrete analysis	Underground mine water quality will not impact current beneficial use of groundwater in Permian coal measures	Level 1: No exceedance of Level 2 or Level 3 triggers	Continue monitoring.	Report negligible impact in routine reporting.	Russell Vale Colliery (Group Environment Manager)
					Level 2: One reading outside of the trigger range of 7.7 to 9.4	1. Review sampling methodology/ equipment to verify if the reading is representative. If not, resample and test within 7 days of the result. 2. If the data is representative, review mine water quality and inflow data, groundwater data and geotechnical/subsidence records to identify any adverse trends that may indicate an impact beyond previous predictions. If an impact due to mining is identified progress to Level 3.	1. One week 2. Two weeks to assess whether further investigation is required. Commence investigation if exceedance of Level 3 criteria identified (see Level 3 reporting requirements). 3. One to two months depending on timing of review of second data period.	Russell Vale Colliery (Group Environment Manager)

Feature	Trigger Monitoring Location	Unit	Timing/ Frequency During Mining	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
					Level 3: Two consecutive readings outside of the trigger range of 7.7 to 9.4	1. Inform DPE and Water NSW 2. Investigate and report on the cause of the trigger exceedances (e.g. climatic, systemic, failure) 3. Inform DPE and WaterNSW of investigation outcomes 4. Identify mitigation options 5. Review monitoring frequency and parameters 6. Report potential impact, and response, within six monthly reporting	1. One week 2. Commence within one week 3. One month 4. Commence works within 2 months 5. One month 6. Six monthly reporting in accordance with Extraction Plan approval	Russell Vale Colliery (Group Environment Manager)

**Swamp Water Level Triggers: Water level trigger - (in mbgl) – specified in Appendix G*

Feature	Trigger Monitoring Location	Unit	Timing/ Frequency During Mining	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
Underground workings	Mine inflows	EC	Monthly – field analysis Quarterly – discrete analysis	Underground mine water quality will not impact current beneficial use of groundwater in Permian coal measures	Level 1: No exceedance of Level 2 or Level 3 triggers	Continue monitoring.	Report negligible impact in routine reporting.	Russell Vale Colliery (Group Environment Manager)
					Level 2: One reading above the trigger level of 5,226 µS/cm	1. Review sampling methodology/ equipment to verify if the reading is representative. If not, resample and test within 7 days of the result. 2. If the data is representative, review mine water quality and inflow data, groundwater data and geotechnical/subsidence records to identify any adverse trends that may indicate an impact beyond previous predictions. If an impact due to mining is identified progress to Level 3.	1. One week 2. Two weeks to assess whether further investigation is required. Commence investigation if exceedance of Level 3 criteria identified (see Level 3 reporting requirements). 3. One to two months depending on timing of review of second data period.	Russell Vale Colliery (Group Environment Manager)

Feature	Trigger Monitoring Location	Unit	Timing/ Frequency During Mining	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
					Level 3: Two consecutive readings above the trigger level of 5,226 µS/cm	1. Inform DPE and Water NSW 2. Investigate and report on the cause of the trigger exceedances (e.g. climatic, systemic, failure) 3. Inform DPE and WaterNSW of investigation outcomes 4. Identify mitigation options 5. Review monitoring frequency and parameters 6. Report potential impact, and response, within six monthly reporting	1. One week 2. Commence within one week 3. One month 4. Commence works within 2 months 5. One month 6. Six monthly reporting in accordance with Extraction Plan approval	Russell Vale Colliery (Group Environment Manager)

**Swamp Water Level Triggers: Water level trigger - (in mbgl) – specified in Appendix G*

Feature	Trigger Monitoring Location	Unit	Timing/ Frequency During Mining	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
Underground workings	Mine inflows	Sulfate	Quarterly – discrete analysis	Underground mine water quality will not	Level 1: No exceedance	Continue monitoring.	Report negligible impact in routine reporting.	Russell Vale Colliery

Feature	Trigger Monitoring Location	Unit	Timing/ Frequency During Mining	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
				impact current beneficial use of groundwater in Permian coal measures	of Level 2 or Level 3 triggers			(Group Environment Manager)
					Level 2: One reading above the trigger level of 167 mg/L	1. Review sampling methodology/ equipment to verify if the reading is representative. If not, resample and test within 7 days of the result. 2. If the data is representative, review mine water quality and inflow data, groundwater data and geotechnical/subsidence records to identify any adverse trends that may indicate an impact beyond previous predictions. If an impact due to mining is identified progress to Level 3.	1. One week 2. Two weeks to assess whether further investigation is required. Commence investigation if exceedance of Level 3 criteria identified (see Level 3 reporting requirements). 3. One to two months depending on timing of review of second data period.	Russell Vale Colliery (Group Environment Manager)

Feature	Trigger Monitoring Location	Unit	Timing/ Frequency During Mining	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
					Level 3: Two consecutive readings above the trigger level of 167 mg/L	1. Inform DPE and Water NSW 2. Investigate and report on the cause of the trigger exceedances (e.g. climatic, systemic, failure) 3. Inform DPE and WaterNSW of investigation outcomes 4. Identify mitigation options 5. Review monitoring frequency and parameters 6. Report potential impact, and response, within six monthly reporting	1. One week 2. Commence within one week 3. One month 4. Commence works within 2 months 5. One month 6. Six monthly reporting in accordance with Extraction Plan approval	Russell Vale Colliery (Group Environment Manager)

**Swamp Water Level Triggers: Water level trigger - (in mbgl) – specified in Appendix G*

Feature	Trigger Monitoring Location	Unit	Timing/ Frequency During Mining	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
Underground workings	Mine inflows	Dissolved Al	Quarterly – full metals analysis	Underground mine water quality will not impact current beneficial use of groundwater in Permian coal measures	Level 1: No exceedance of Level 2 or Level 3 triggers	Continue monitoring.	Report negligible impact in routine reporting.	Russell Vale Colliery (Group Environment Manager)
					Level 2: One reading above the trigger level of 0.11 mg/L	1. Review sampling methodology/ equipment to verify if the reading is representative. If not, resample and test within 7 days of the result. 2. If the data is representative, review mine water quality and inflow data, groundwater data and geotechnical/subsidence records to identify any adverse trends that may indicate an impact beyond previous predictions. If an impact due to mining is identified progress to Level 3.	1. One week 2. Two weeks to assess whether further investigation is required. Commence investigation if exceedance of Level 3 criteria identified (see Level 3 reporting requirements). 3. One to two months depending on timing of review of second data period.	Russell Vale Colliery (Group Environment Manager)

Feature	Trigger Monitoring Location	Unit	Timing/ Frequency During Mining	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
					Level 3: Two consecutive readings above the trigger level of 0.11 mg/L	1. Inform DPE and Water NSW 2. Investigate and report on the cause of the trigger exceedances (e.g. climatic, systemic, failure) 3. Inform DPE and WaterNSW of investigation outcomes 4. Identify mitigation options 5. Review monitoring frequency and parameters 6. Report potential impact, and response, within six monthly reporting	1. One week 2. Commence within one week 3. One month 4. Commence works within 2 months 5. One month 6. Six monthly reporting in accordance with Extraction Plan approval	Russell Vale Colliery (Group Environment Manager)

**Swamp Water Level Triggers: Water level trigger - (in mbgl) – specified in Appendix G*

Feature	Trigger Monitoring Location	Unit	Timing/ Frequency During Mining	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
Underground workings	Mine inflows	Dissolved As	Quarterly – full metals analysis	Underground mine water quality will not impact current beneficial use of groundwater in Permian coal measures	Level 1: No exceedance of Level 2 or Level 3 triggers	Continue monitoring.	Report negligible impact in routine reporting.	Russell Vale Colliery (Group Environment Manager)
					Level 2: One reading above the trigger level of 0.03 mg/L	1. Review sampling methodology/ equipment to verify if the reading is representative. If not, resample and test within 7 days of the result. 2. If the data is representative, review mine water quality and inflow data, groundwater data and geotechnical/subsidence records to identify any adverse trends that may indicate an impact beyond previous predictions. If an impact due to mining is identified progress to Level 3.	1. One week 2. Two weeks to assess whether further investigation is required. Commence investigation if exceedance of Level 3 criteria identified (see Level 3 reporting requirements). 3. One to two months depending on timing of review of second data period.	Russell Vale Colliery (Group Environment Manager)

Feature	Trigger Monitoring Location	Unit	Timing/ Frequency During Mining	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
					Level 3: Two consecutive readings above the trigger level of 0.03 mg/L	1. Inform DPIE and Water NSW 2. Investigate and report on the cause of the trigger exceedances (e.g. climatic, systemic, failure) 3. Inform DPE and WaterNSW of investigation outcomes 4. Identify mitigation options 5. Review monitoring frequency and parameters 6. Report potential impact, and response, within six monthly reporting	1. One week 2. Commence within one week 3. One month 4. Commence works within 2 months 5. One month 6. Six monthly reporting in accordance with Extraction Plan approval	Russell Vale Colliery (Group Environment Manager)

**Swamp Water Level Triggers: Water level trigger - (in mbgl) – specified in Appendix G*

Feature	Trigger Monitoring Location	Unit	Timing/ Frequency During Mining	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
Underground workings	Mine inflows	Dissolved Mo	Quarterly – full metals analysis	Underground mine water quality will not impact current beneficial use of groundwater in Permian coal measures	Level 1: No exceedance of Level 2 or Level 3 triggers	Continue monitoring.	Report negligible impact in routine reporting.	Russell Vale Colliery (Group Environment Manager)
					Level 2: One reading above the trigger level of 0.09 mg/L	1. Review sampling methodology/ equipment to verify if the reading is representative. If not, resample and test within 7 days of the result. 2. If the data is representative, review mine water quality and inflow data, groundwater data and geotechnical/subsidence records to identify any adverse trends that may indicate an impact beyond previous predictions. If an impact due to mining is identified progress to Level 3.	1. One week 2. Two weeks to assess whether further investigation is required. Commence investigation if exceedance of Level 3 criteria identified (see Level 3 reporting requirements). 3. One to two months depending on timing of review of second data period.	Russell Vale Colliery (Group Environment Manager)

Feature	Trigger Monitoring Location	Unit	Timing/ Frequency During Mining	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
					Level 3: Two consecutive readings above the trigger level of 0.09 mg/L	1. Inform DPE and Water NSW 2. Investigate and report on the cause of the trigger exceedances (e.g. climatic, systemic, failure) 3. Inform DPE and WaterNSW of investigation outcomes 4. Identify mitigation options 5. Review monitoring frequency and parameters 6. Report potential impact, and response, within six monthly reporting	1. One week 2. Commence within one week 3. One month 4. Commence works within 2 months 5. One month 6. Six monthly reporting in accordance with Extraction Plan approval	Russell Vale Colliery (Group Environment Manager)

Feature	Trigger Monitoring Location	Unit	Timing/ Frequency	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
Underground workings	Mine inflows	Dissolved Sb	Quarterly – full metals analysis	Underground mine water quality will not impact current beneficial use of groundwater in	Level 1: No exceedance of Level 2 or Level 3 triggers	Continue monitoring.	Report negligible impact in routine reporting.	Russell Vale Colliery (Group Environment Manager)

Feature	Trigger Monitoring Location	Unit	Timing/ Frequency	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
				Permian coal measures	Level 2: One reading above the trigger level of 0.03 mg/L	1. Review sampling methodology/ equipment to verify if the reading is representative. If not, resample and test within 7 days of the result. 2. If the data is representative, review mine water quality and inflow data, groundwater data and geotechnical/subsidence records to identify any adverse trends that may indicate an impact beyond previous predictions. If an impact due to mining is identified progress to Level 3.	1. One week 2. Two weeks to assess whether further investigation is required. Commence investigation if exceedance of Level 3 criteria identified (see Level 3 reporting requirements). 3. One to two months depending on timing of review of second data period.	Russell Vale Colliery (Group Environment Manager)

Feature	Trigger Monitoring Location	Unit	Timing/ Frequency	Purpose	Criteria	Action/ Reporting	Reporting	Responsibility
					Level 3: Two consecutive readings above the trigger level of 0.03 mg/L	1. Inform DPE and Water NSW 2. Investigate and report on the cause of the trigger exceedances (e.g. climatic, systemic, failure) 3. Inform DPE and WaterNSW of investigation outcomes 4. Identify mitigation options 5. Review monitoring frequency and parameters 6. Report potential impact, and response, within six monthly reporting	1. One week 2. Commence within one week 3. One month 4. Commence works within 2 months 5. One month 6. Six monthly reporting in accordance with Extraction Plan approval	Russell Vale Colliery (Group Environment Manager)

**Swamp Water Level Triggers: Water level trigger - (in mbgl) – specified in Appendix G*

APPENDIX G – WATER LEVEL TRIGGERS

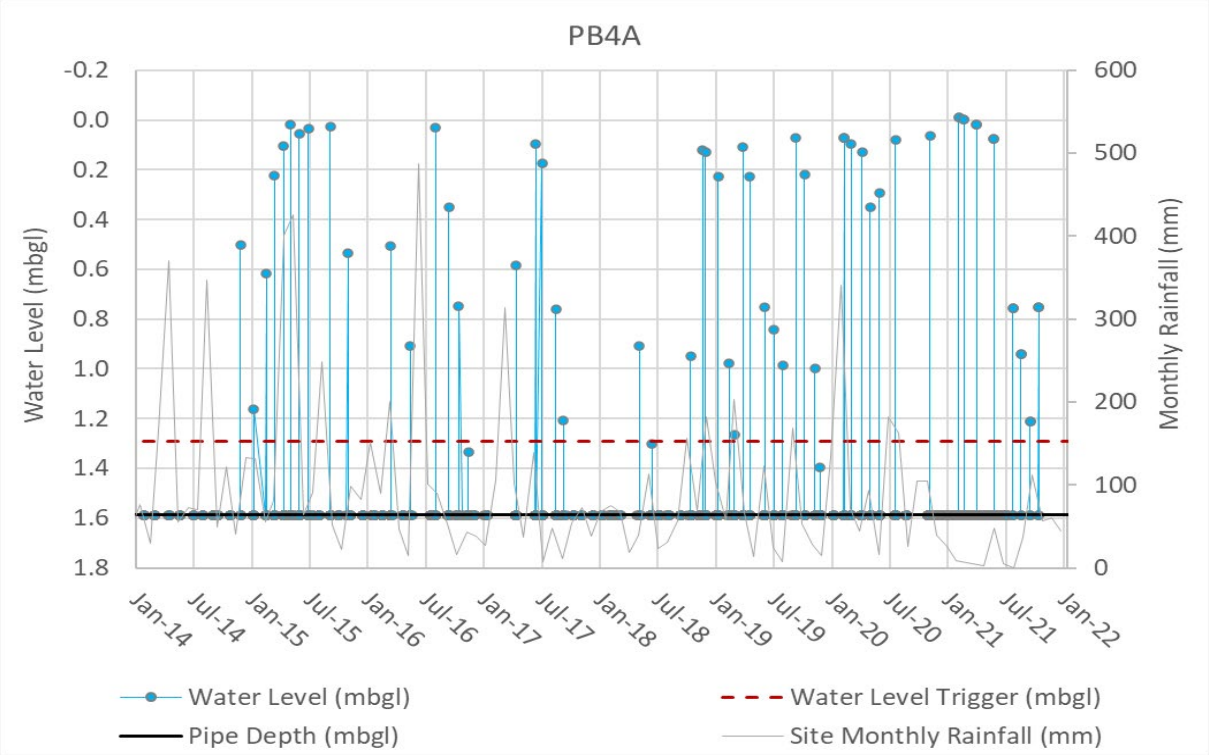
Swamp Water Level Trigger

Swamp Trigger Site	Trigger Level			
	Field pH[1]	Field EC (µS/cm)[2]	Standing Water Level[3] (mbTOC)	Standing Water Level (mbgl)
PB4A	3.8 – 6.3	193	2.64	1.29[3]
PCc10A			2.22	0.56[3]
PCc10B			2.57	0.90[3]
PCc12A			2.37	0.70[3]
PCc2			2.56	1.60[3]
PCc4C			2.98	1.05[3]
PCc5B			2.70	1.13[3]
PCr1B			2.26	0.68[3]
Newly installed swamp piezometers: PCc1A PCc1B PCc6B PCc14A PCc20	3.8 – 6.3	193	-	0.57[4]

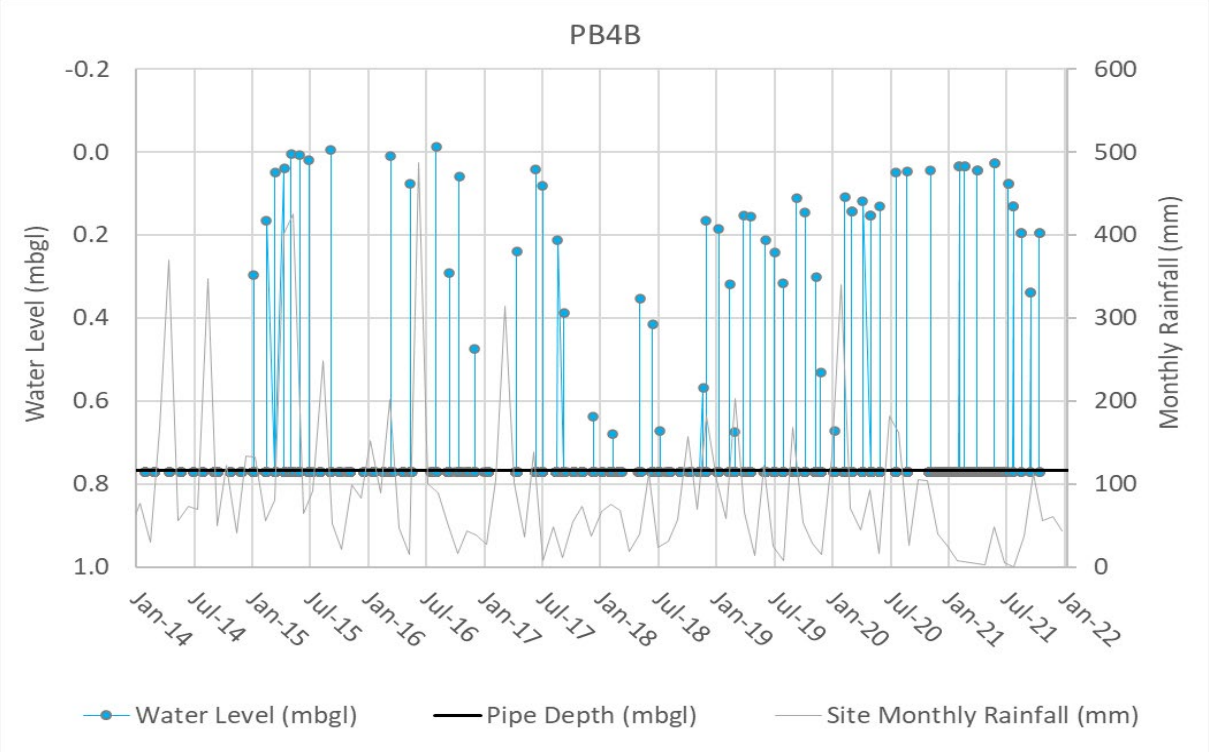
Notes:

1. pH trigger based on 5th and 95th percentile baseline data for RVE swamps. Trigger criteria of consecutive readings (based on criteria level) recorded outside trigger level for prescribed trigger bores
2. EC trigger based on 95th percentile baseline data for RVE swamps. Trigger criteria of consecutive readings (based on criteria level) recorded outside trigger level for prescribed trigger bores
3. Standing water level (water depth) trigger based on individual bore 95th percentile baseline depth to groundwater (below groundwater level and top of casing). Trigger criteria of consecutive manual readings recorded outside trigger level (based on criteria level) and not related to natural rainfall trends – as indicated by monthly rainfall of less than 20 mm the month prior
4. Standing water level (water depth) trigger based on 50th percentile baseline data for RVE swamps water level (below groundwater level and top of casing). Trigger criteria of two consecutive manual readings recorded outside trigger level (based on criteria level) and not related to natural rainfall trends – as indicated by monthly rainfall of less than 20 mm the month prior

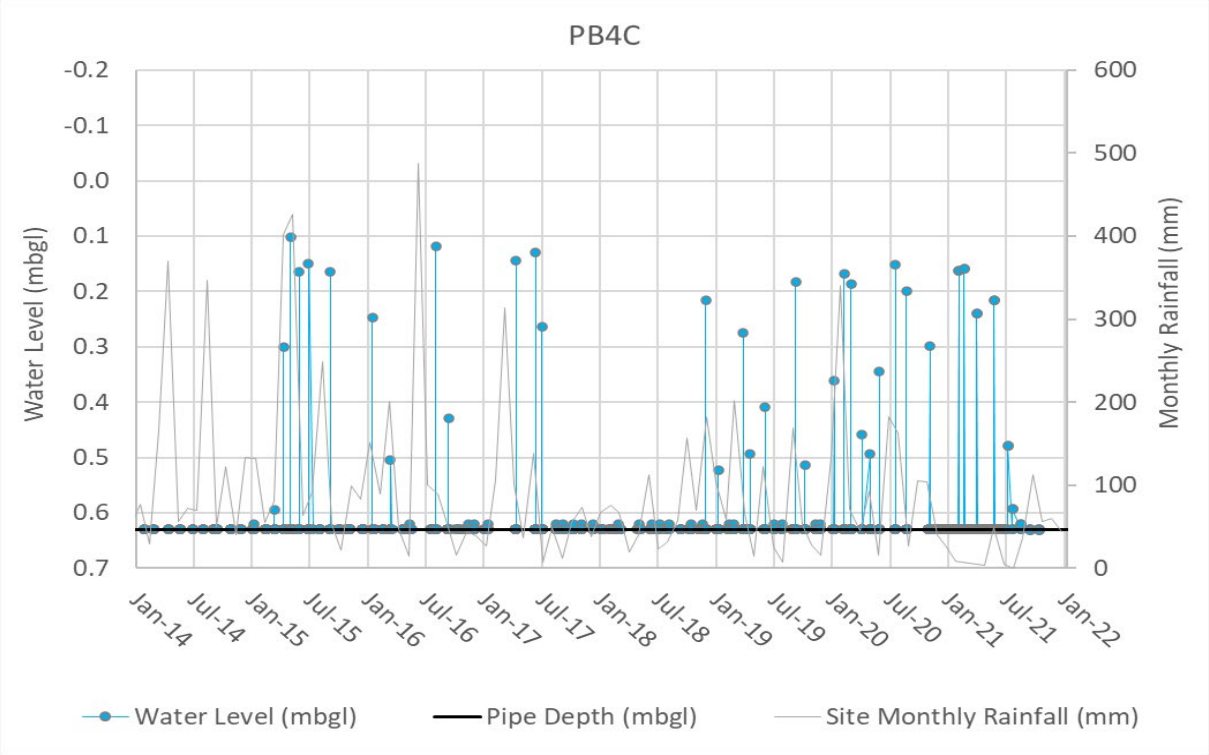
PB4A near BCUS4



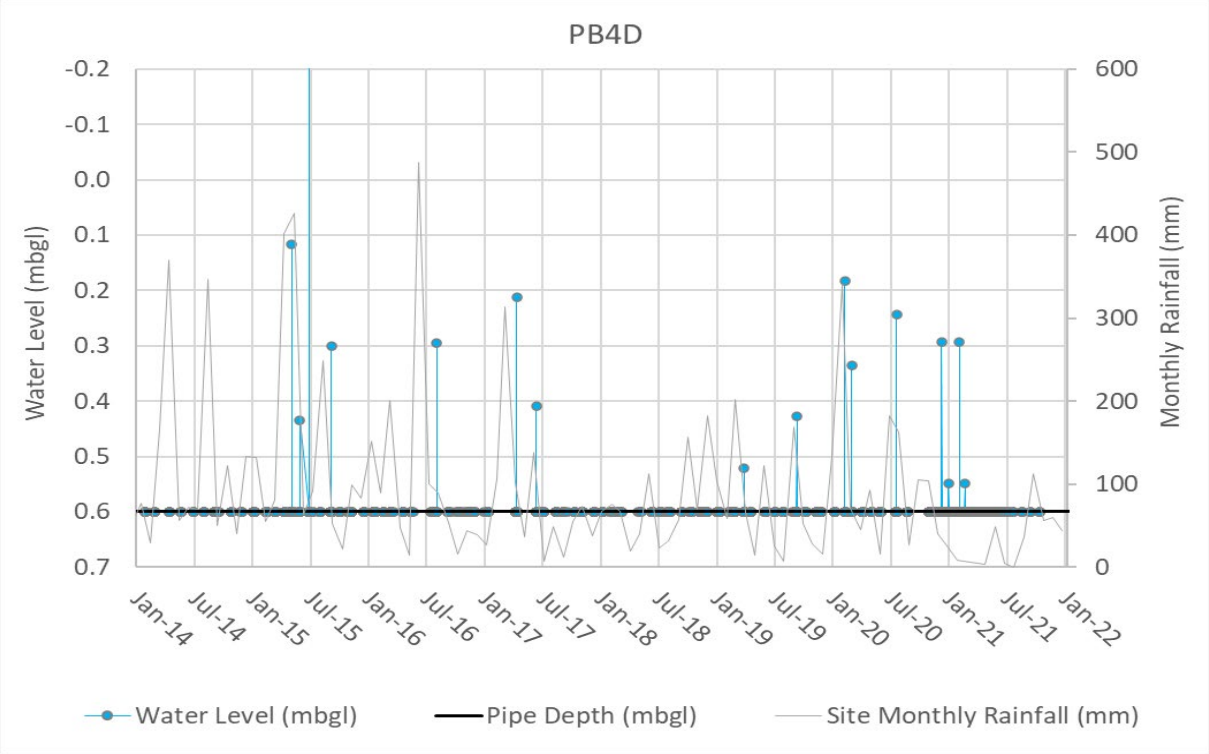
PB4B near BCUS4



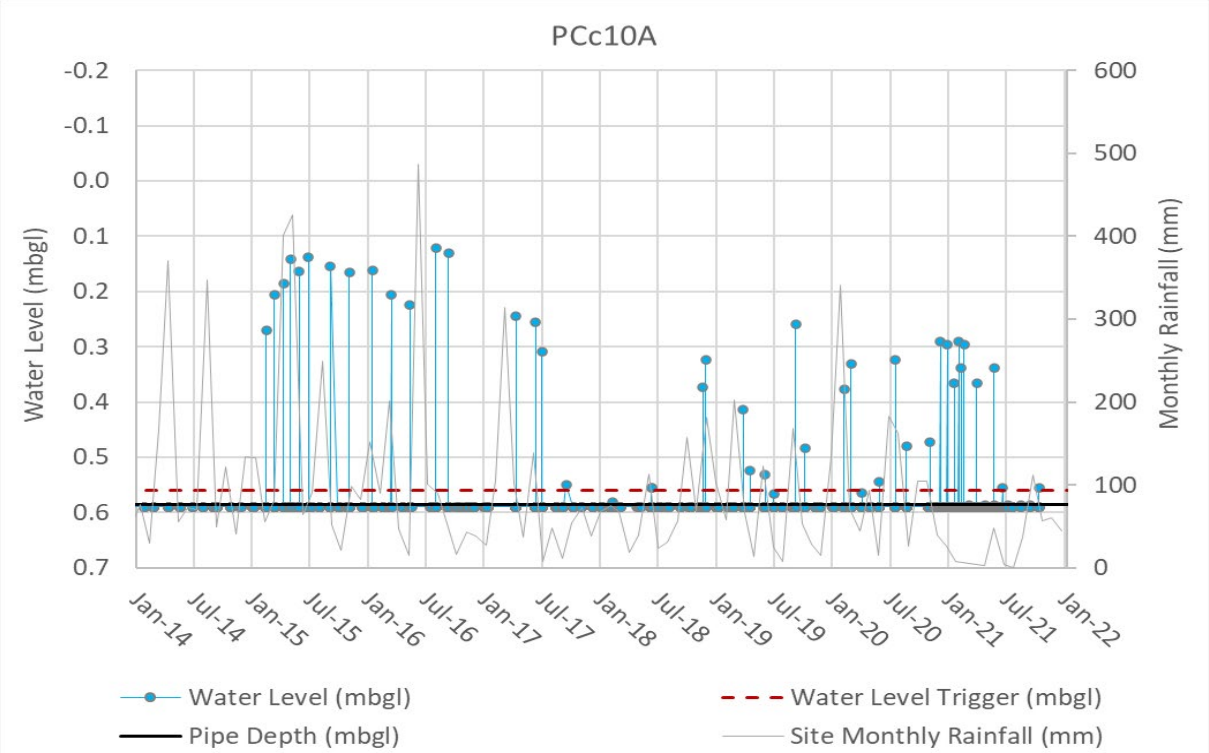
PB4C near BCUS4



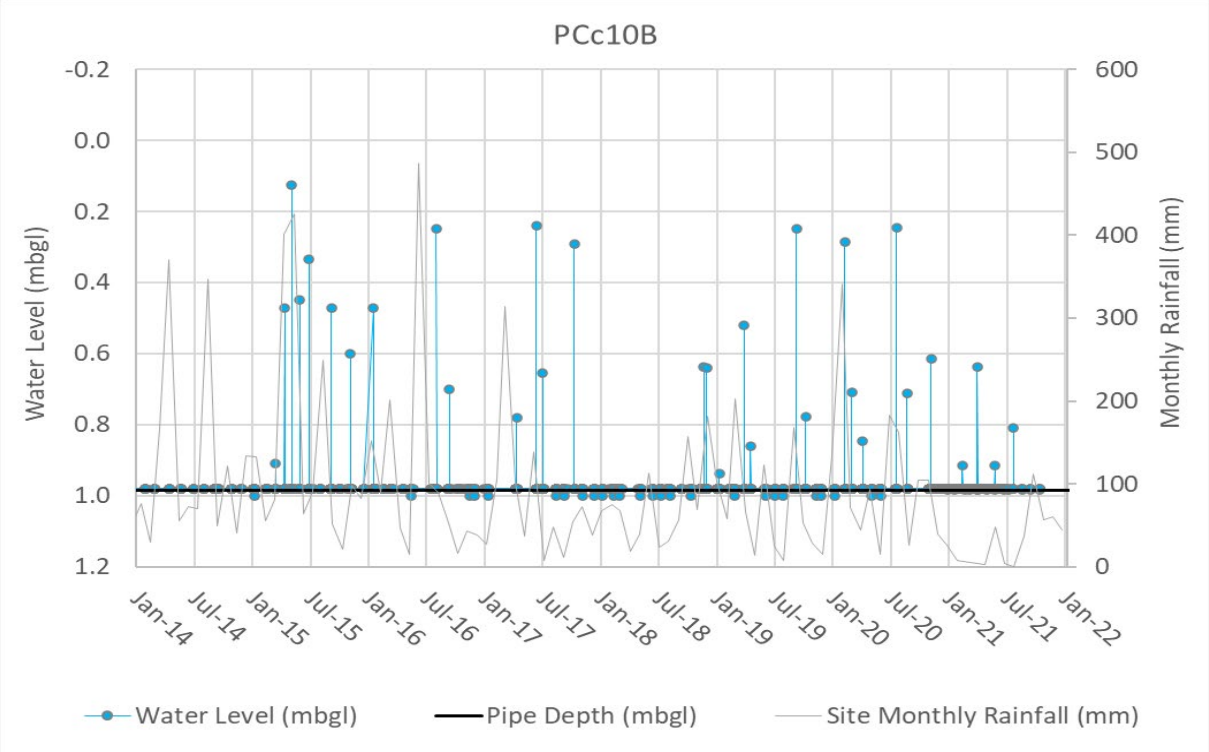
PB4D near BCUS4



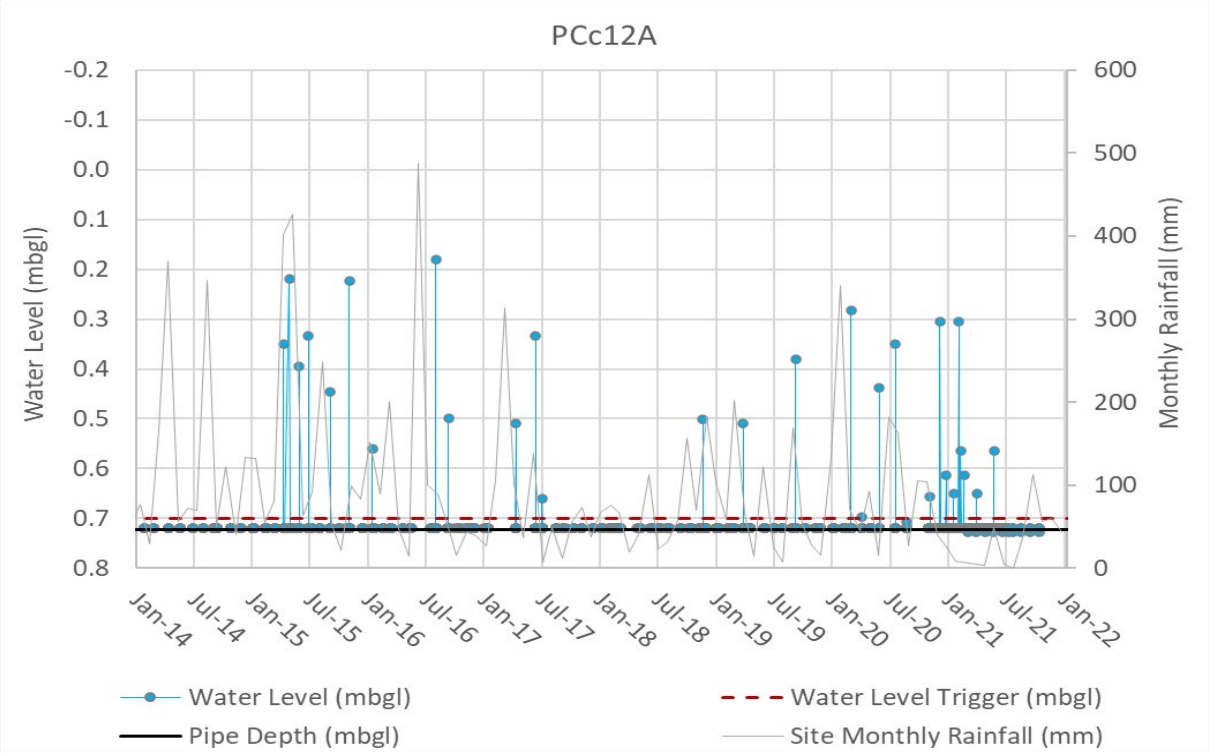
PCc10A near CCUS10



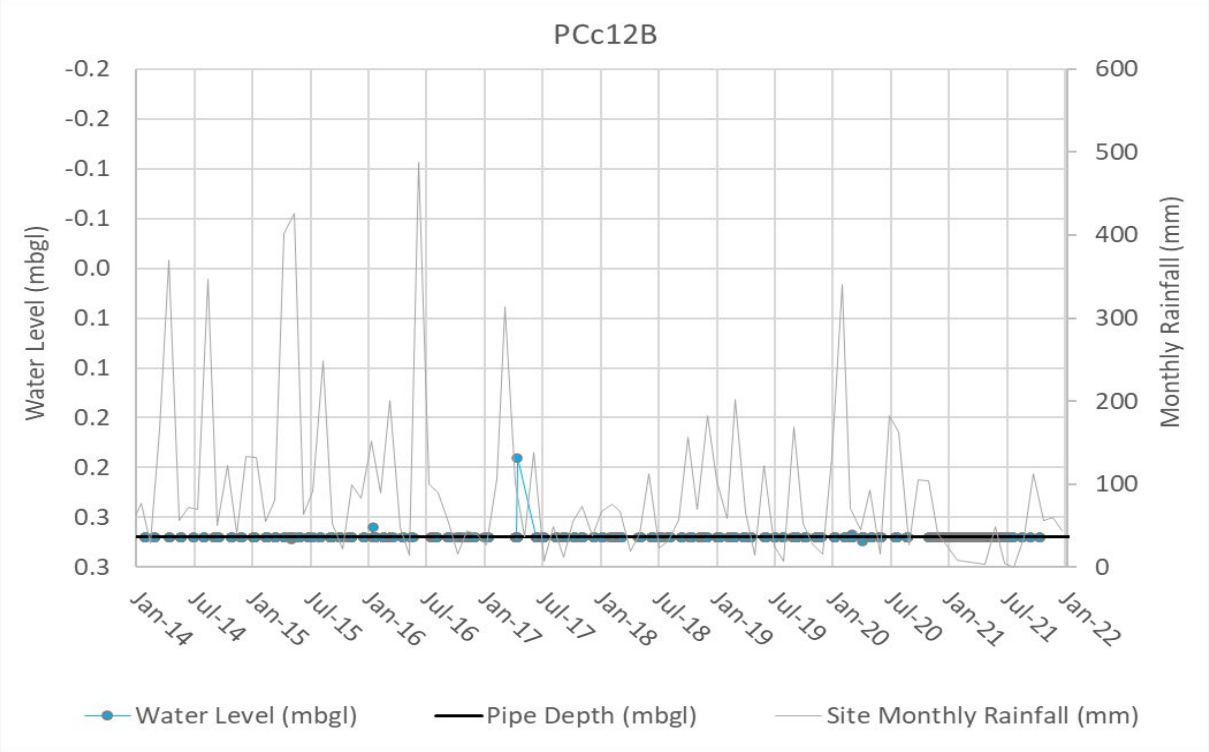
PCc10B near CCUS10



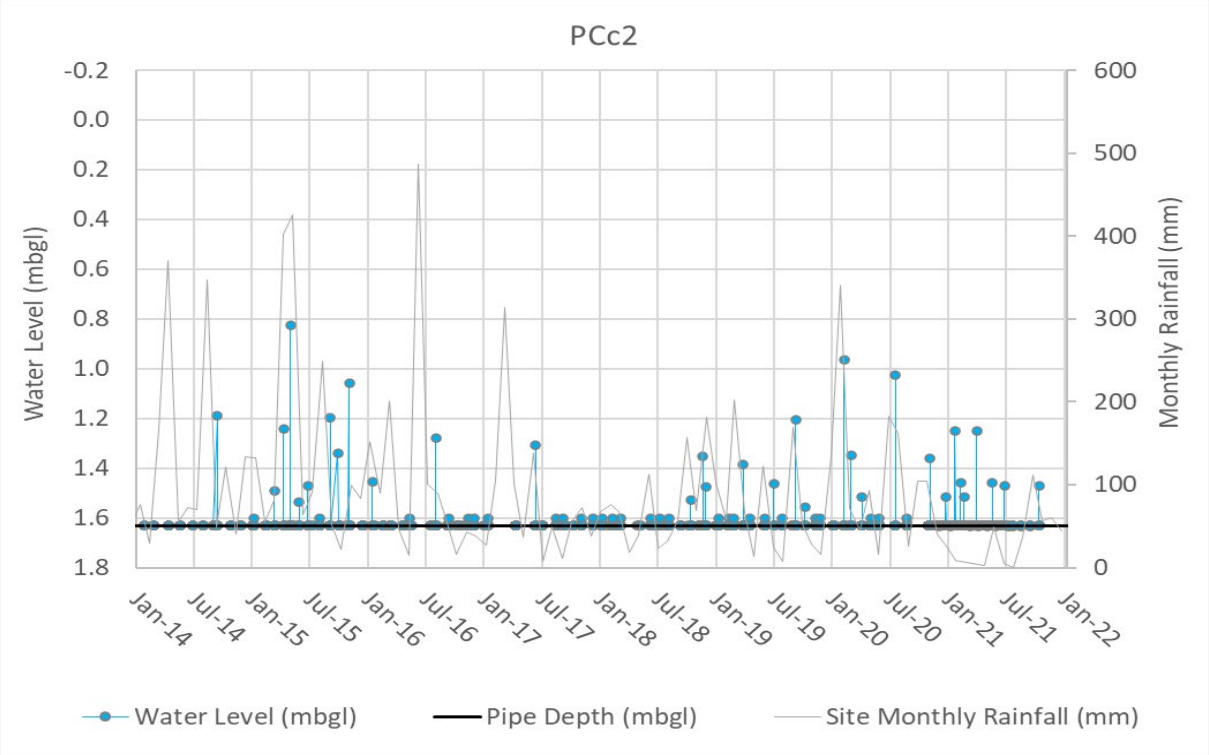
PCc12A near CCUS12



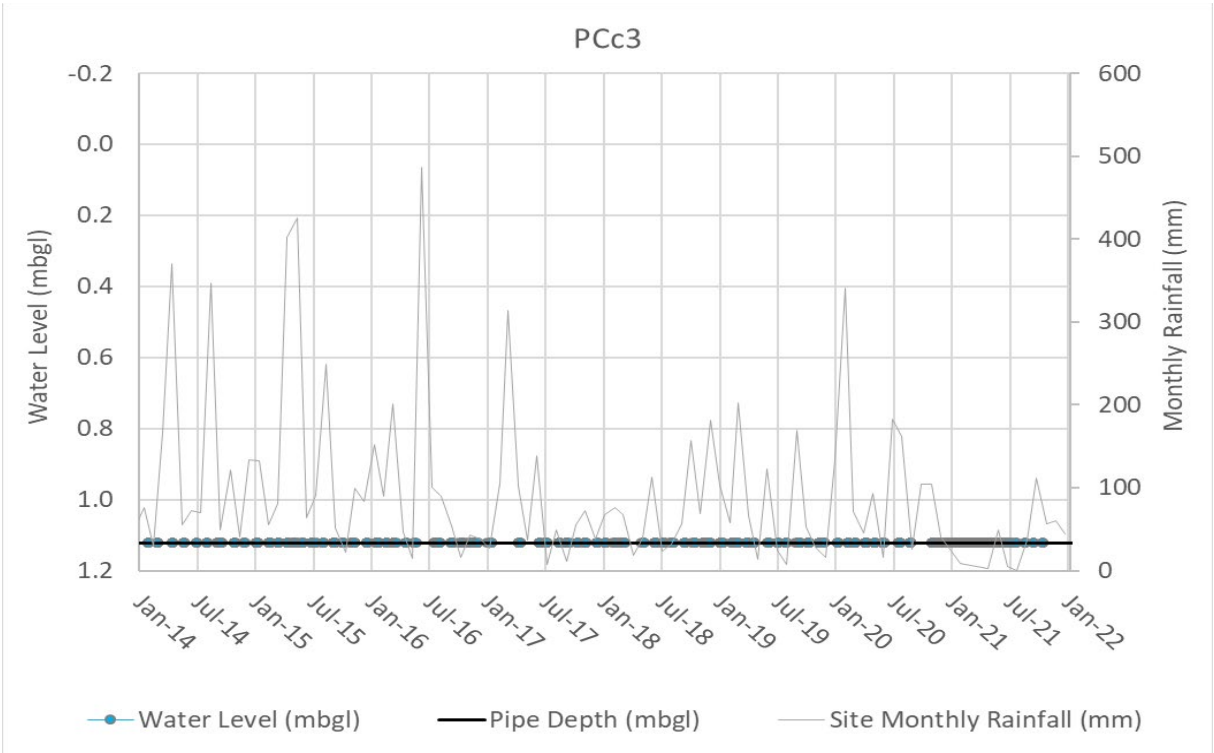
PCc12B near CCUS12



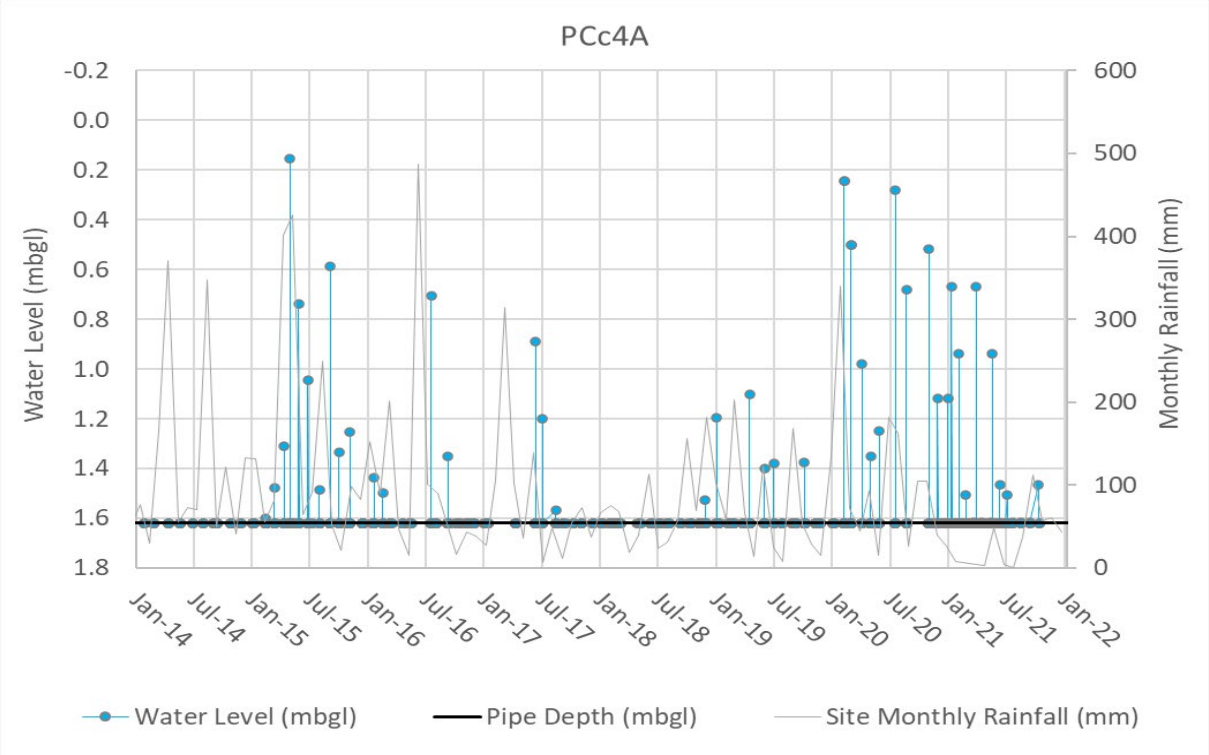
PCc2 near CCUS2



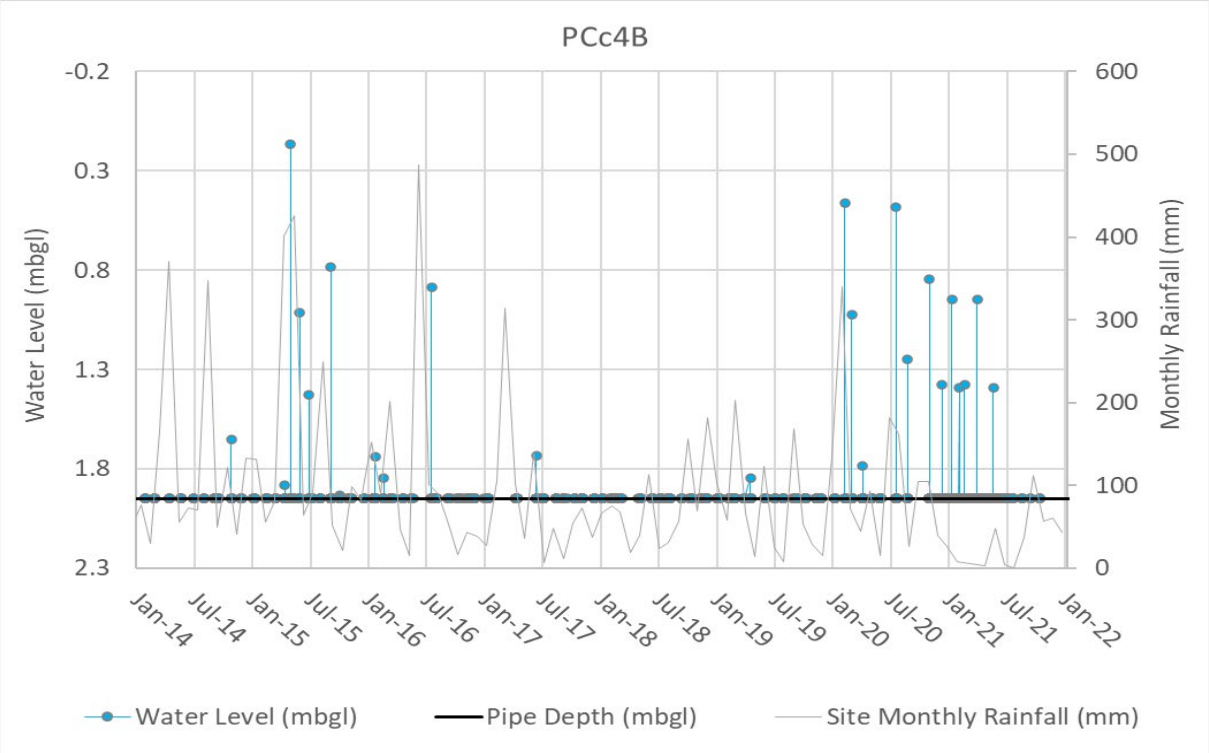
PCc3 near CCUS3



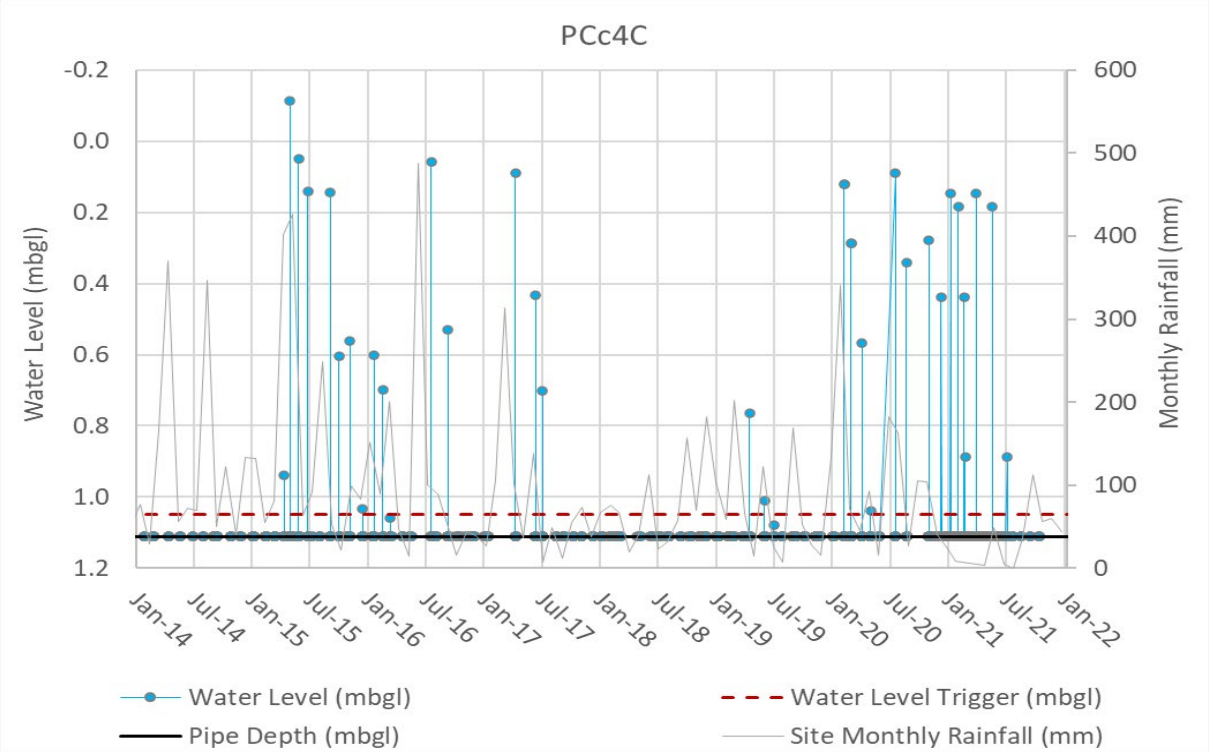
PCc4A near CCUS4



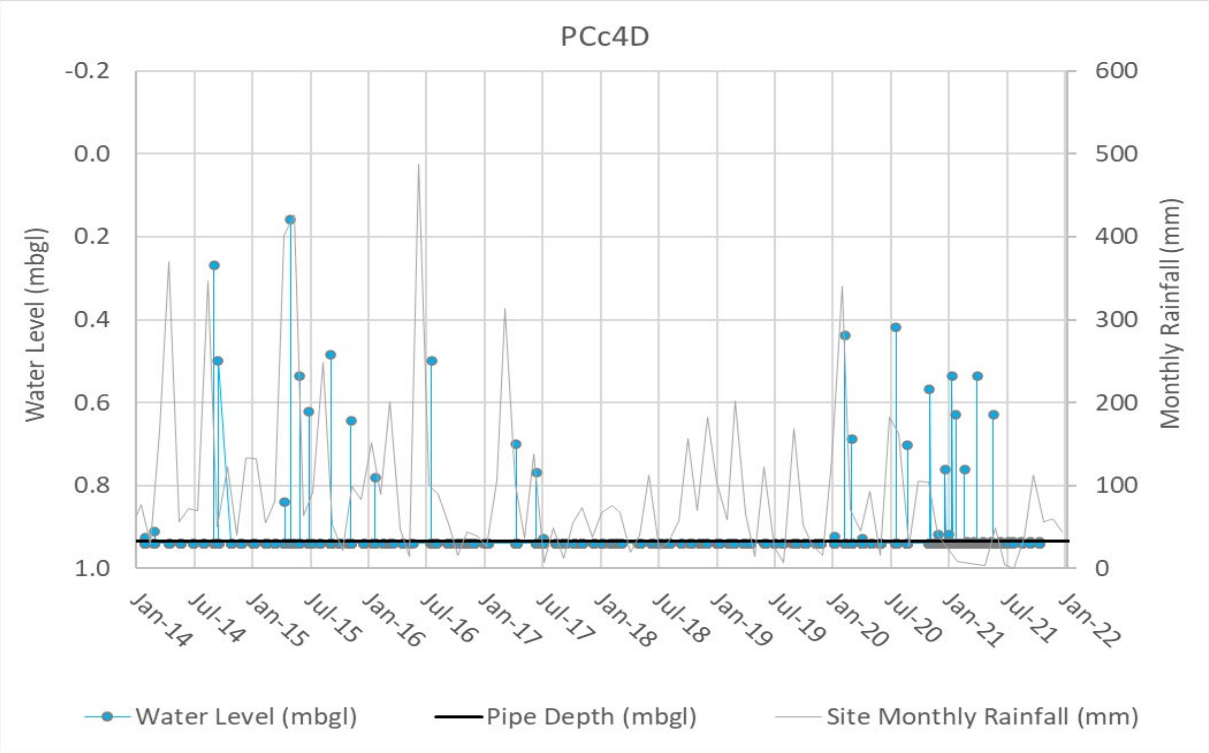
PCc4B near CCUS4



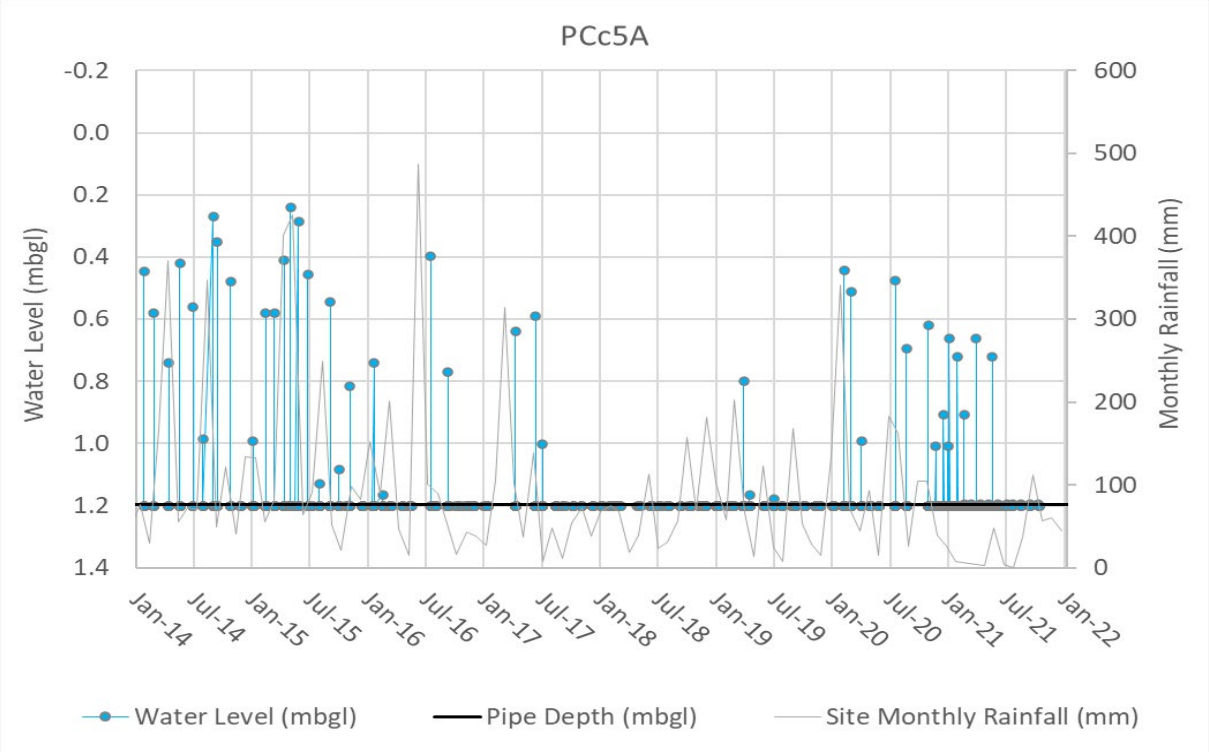
PCc4C near CCUS4



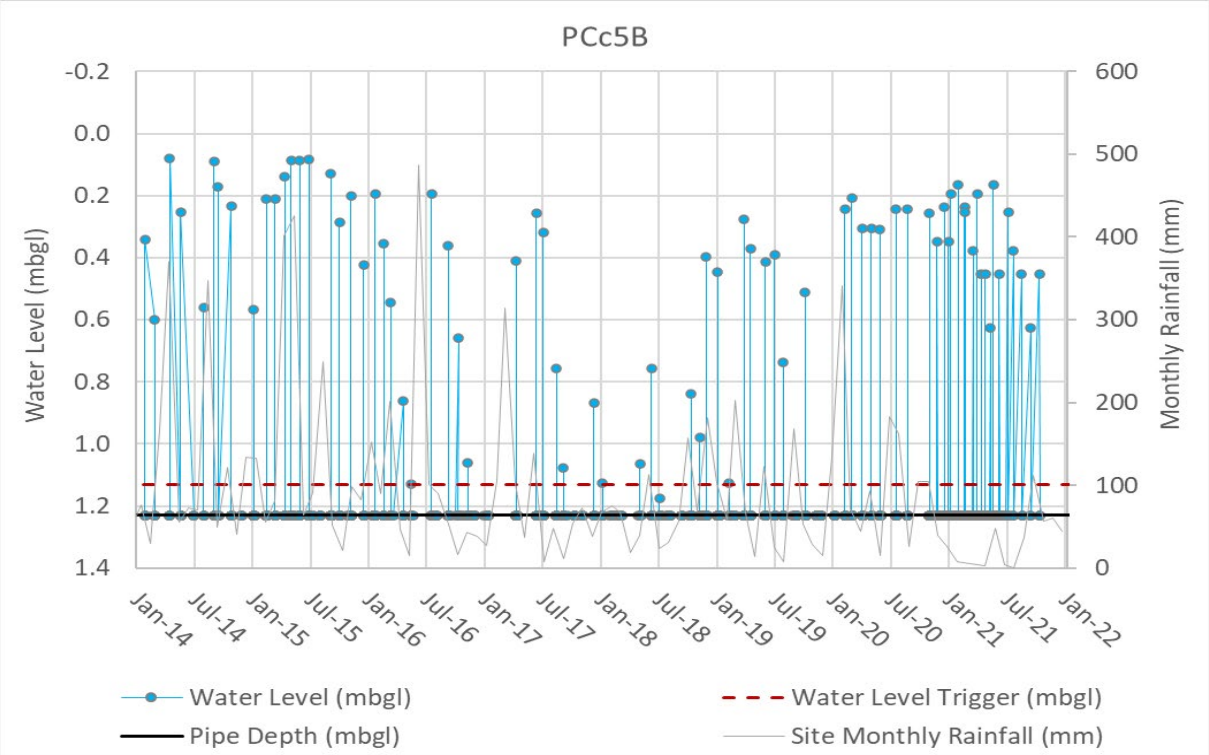
PCc4D near CCUS4



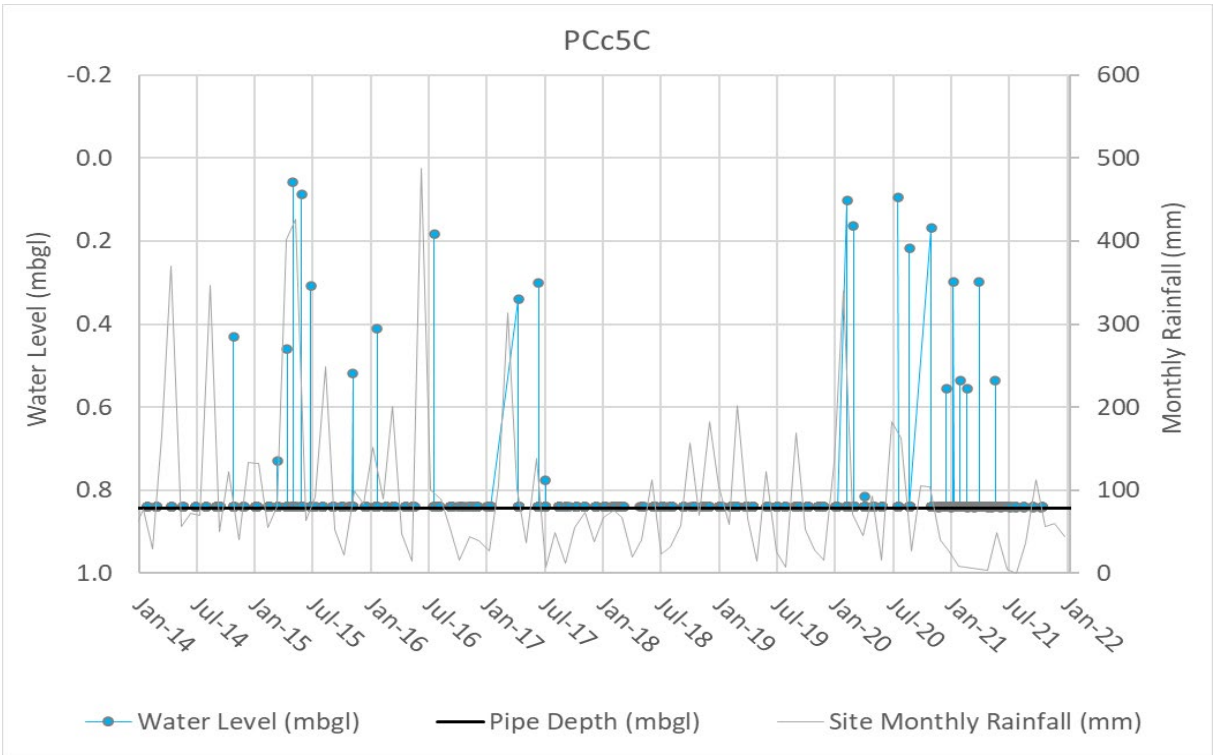
PCc5A near CCUS5



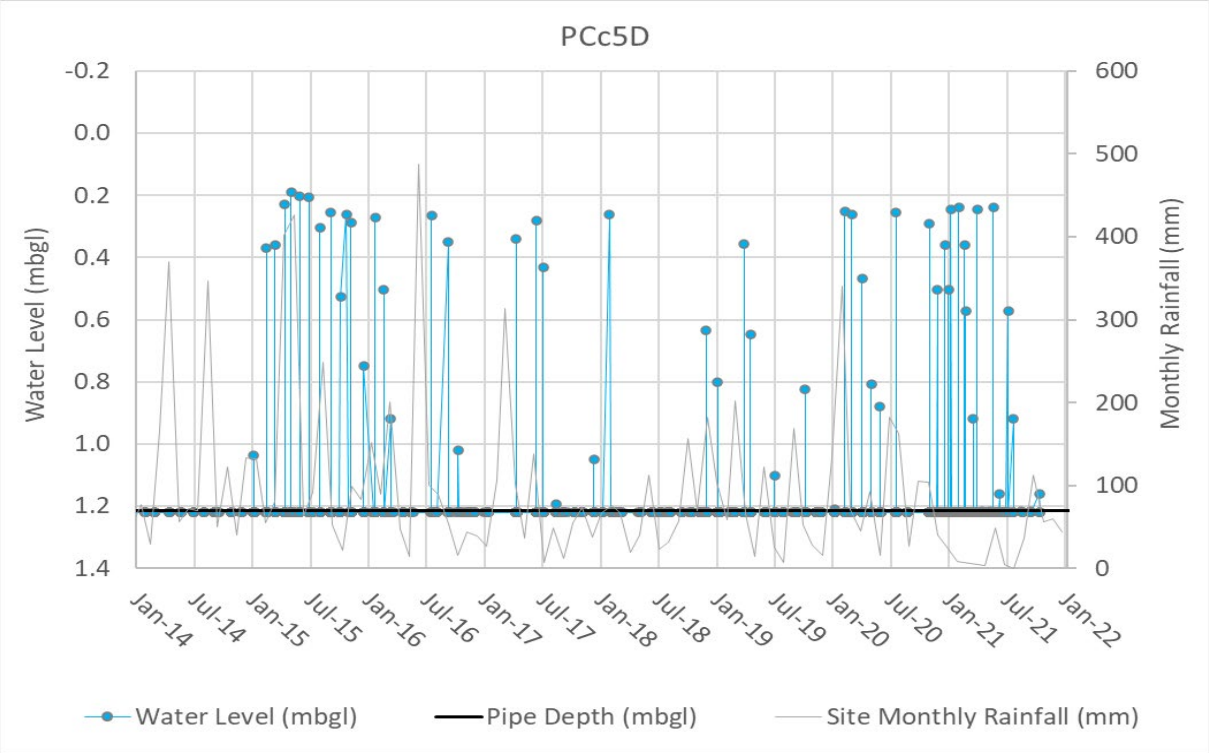
PCc5B near CCUS5



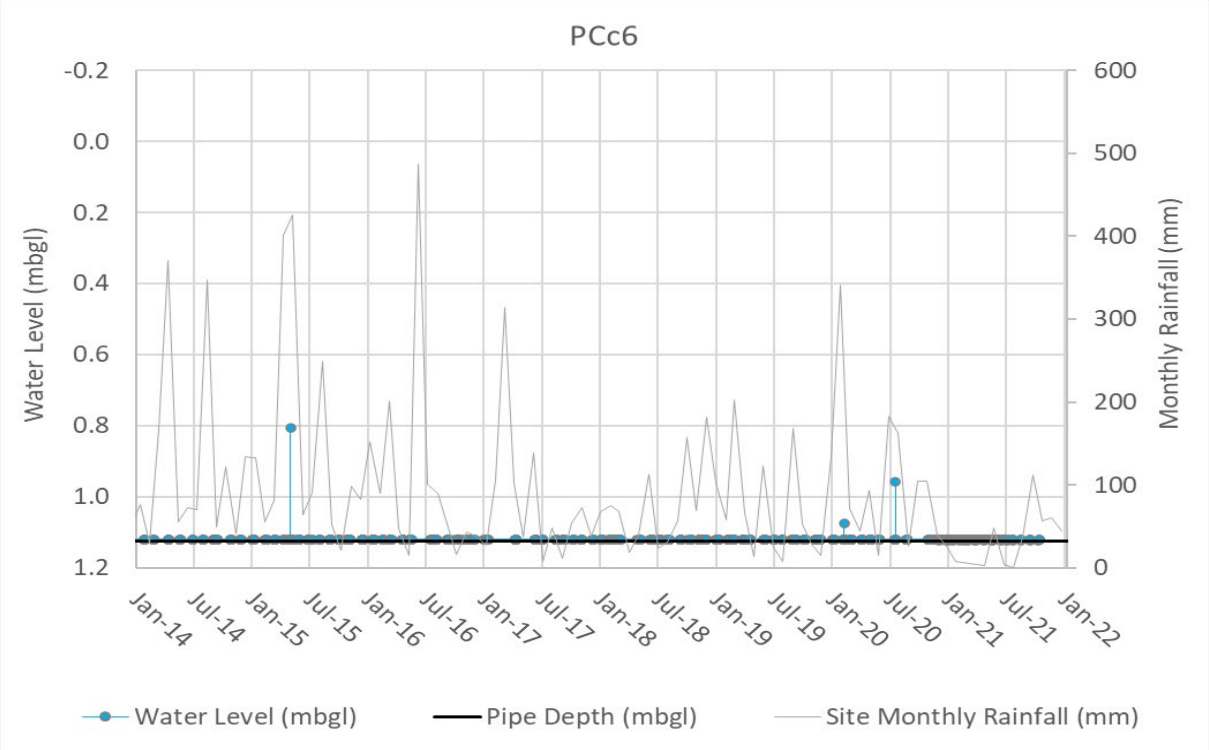
PCc5C near CCUS5



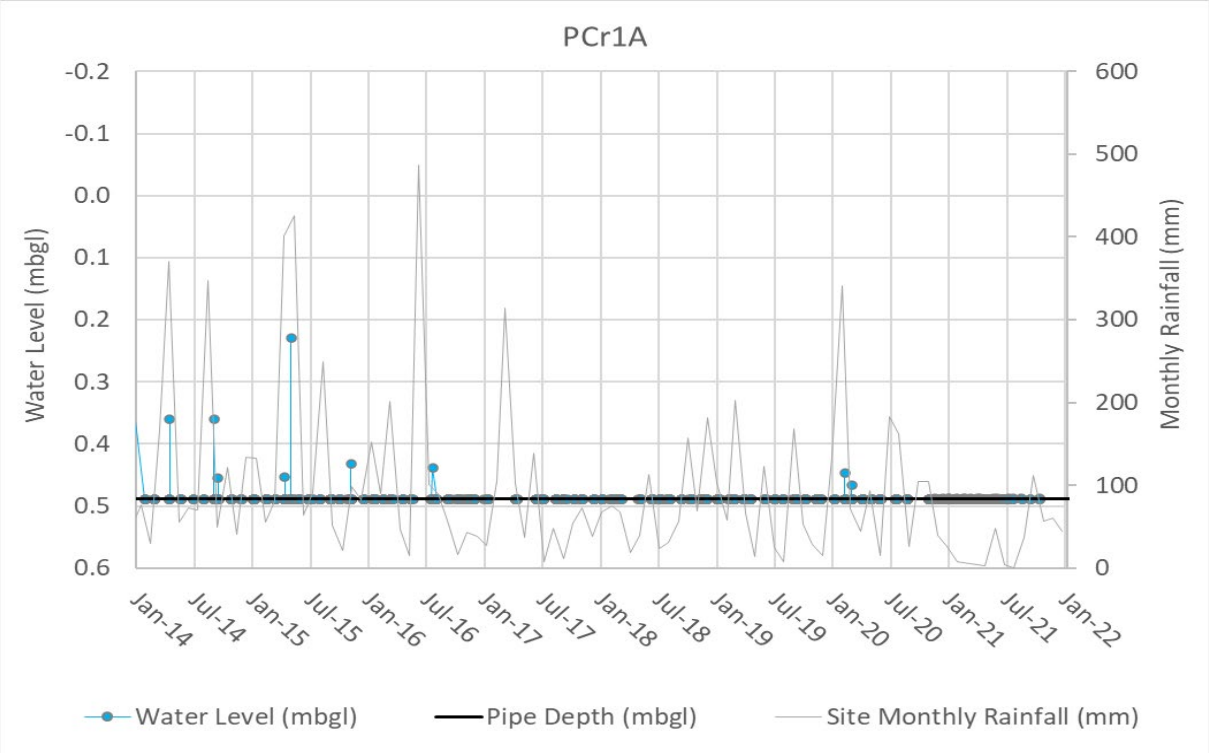
PCc5D near CCUS5



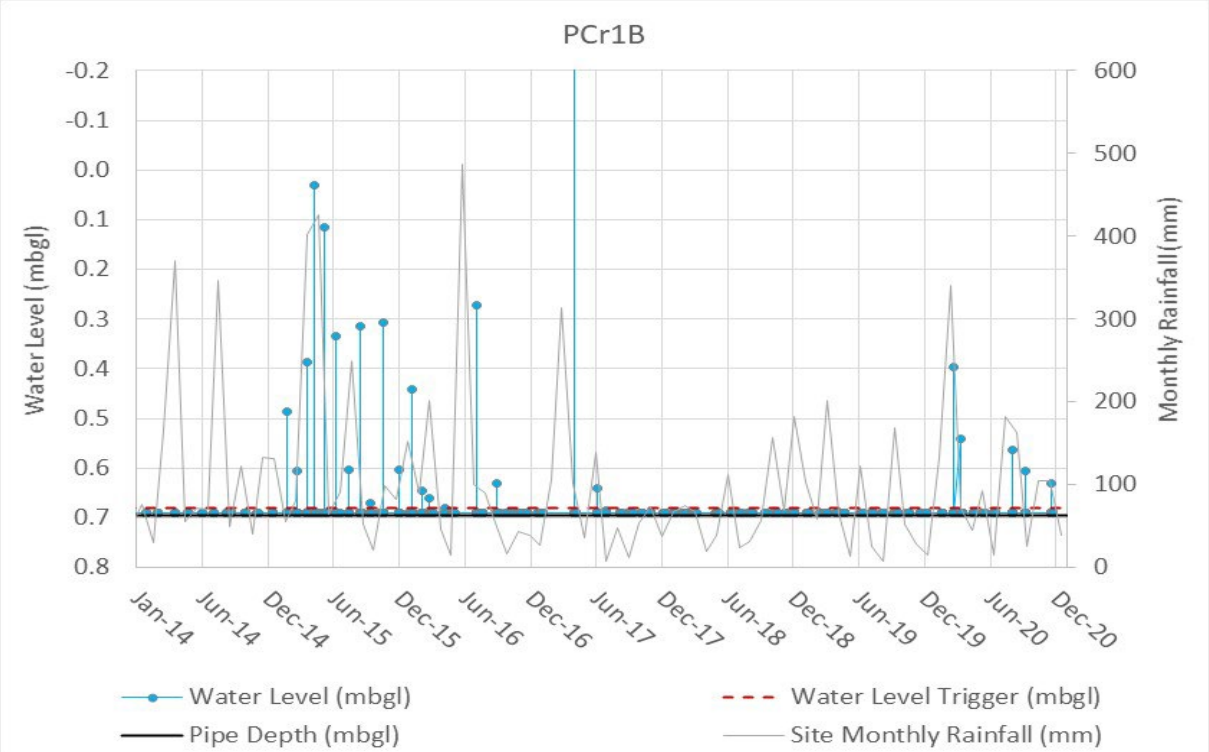
PCc6 near CCUS6



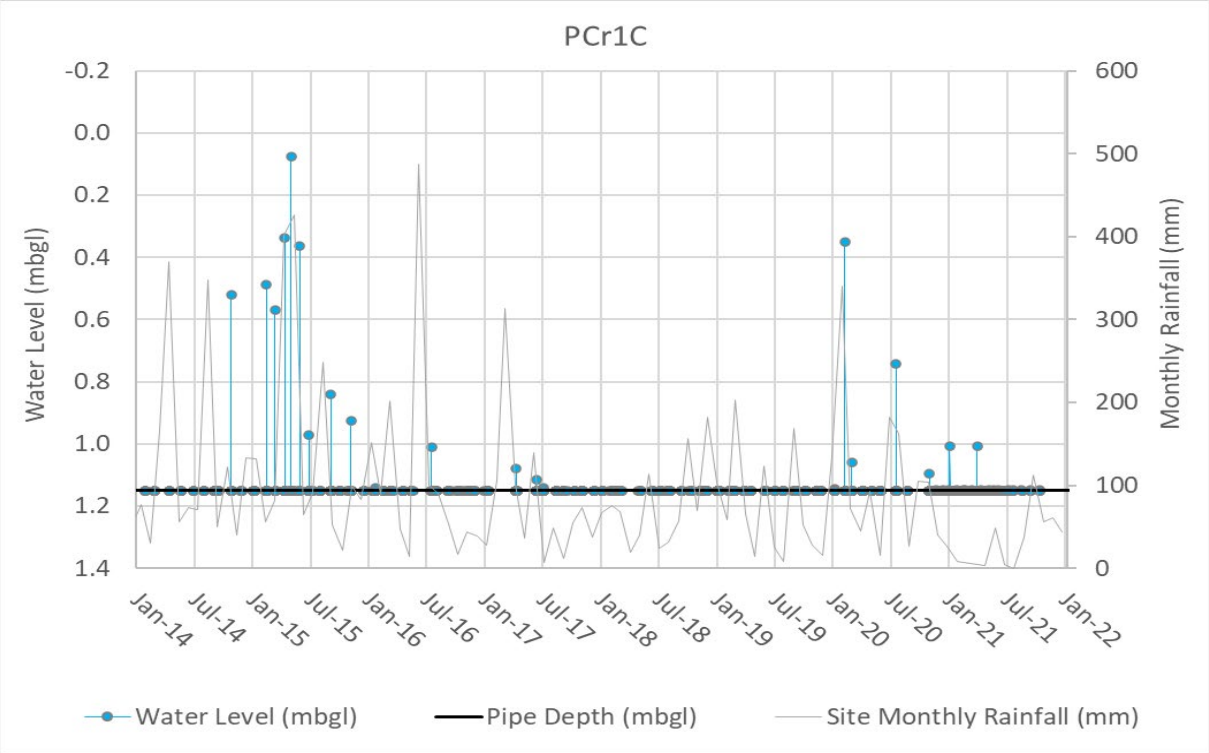
PCr1A near CRUS1



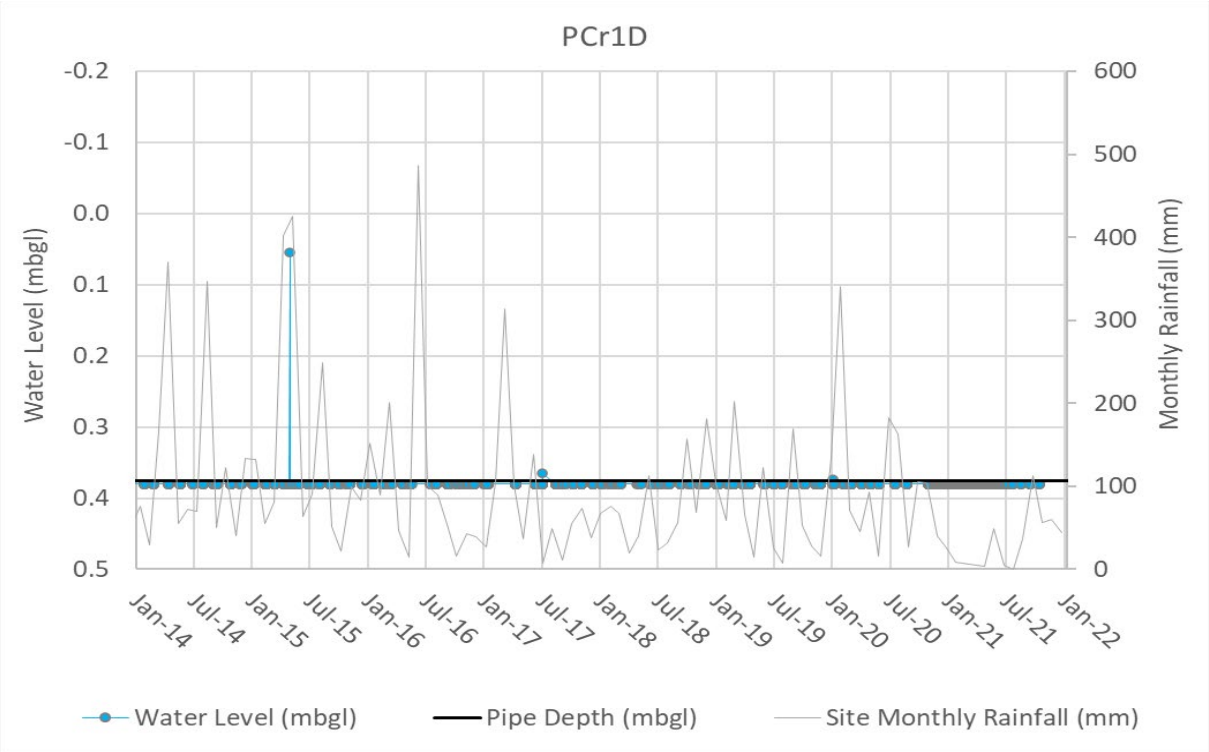
PCr1B near CRUS1



PCr1C near CRUS1



PCr1D near CRUS1



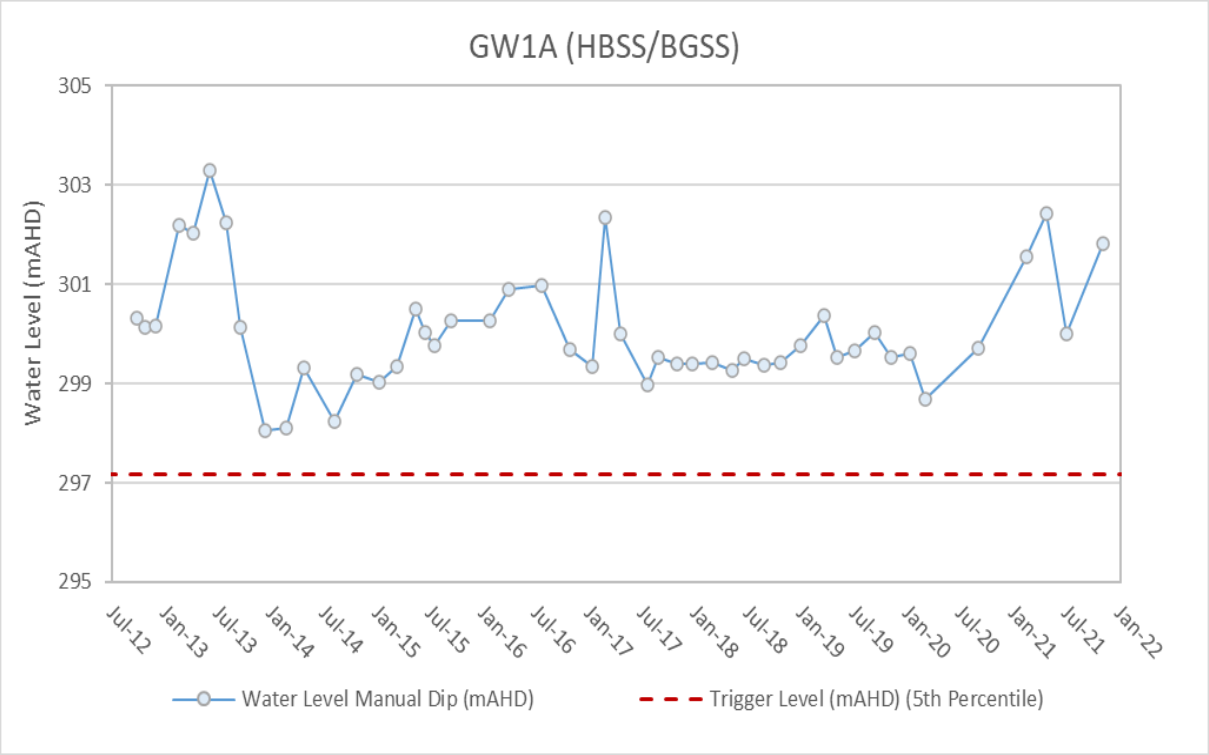
OPEN STANDPIPE GROUNDWATER TRIGGERS

Hawkesbury Sandstone Bore	Trigger Level			
	Field pH[1]	Field EC (µS/cm)[2]	Standing Water Level[3] (mbTOC)	Water Level[3] (mAHD)
GW1A	3.7 – 6.5	376	14.5	297.2
NRE A			26.7	349.5
NRE C			14.8	347.9
NRE D			10.9	338.0
RV18			12.0	327.6
RV19			11.9	300.2
RV21			13.9	336.0
RV22A			14.8	327.8

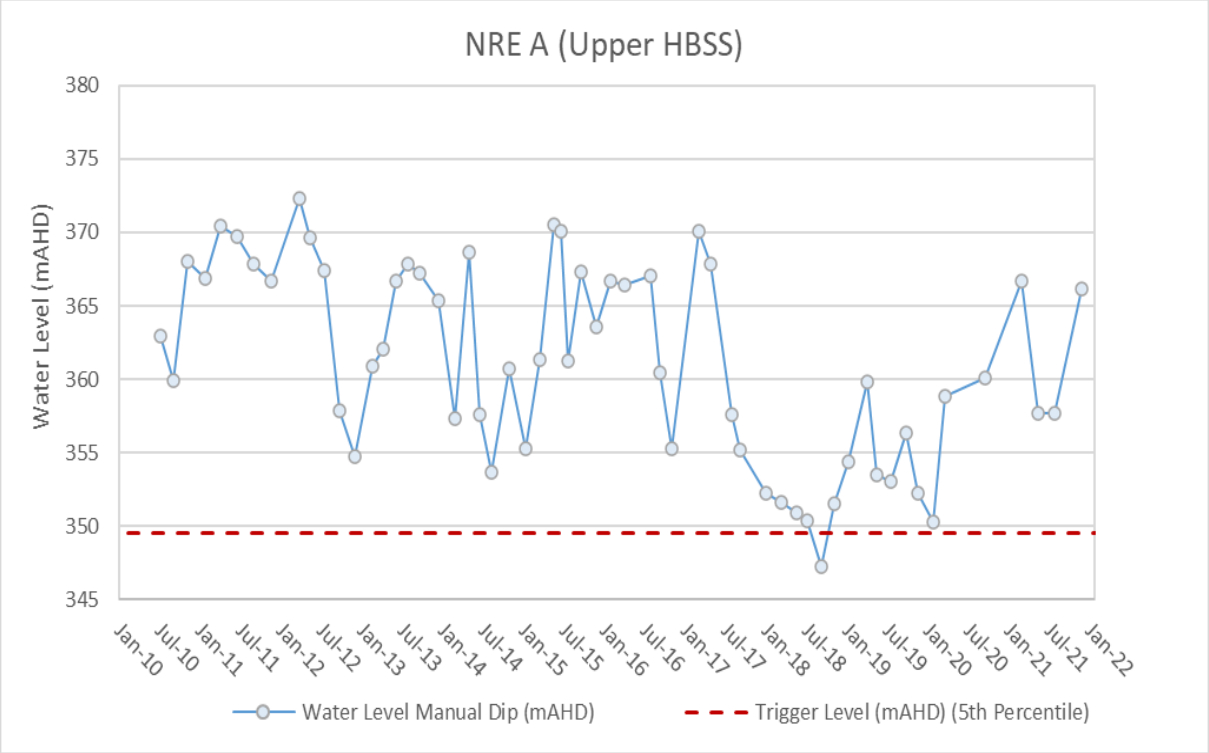
Notes:

1. pH trigger based on 5th and 95th percentile baseline data for RVE Hawkesbury Sandstone bores. Trigger criteria of two consecutive readings recorded outside trigger level for prescribed trigger bores
2. EC trigger based on 95th percentile baseline data for RVE Hawkesbury Sandstone bores. Trigger criteria of two consecutive readings recorded outside trigger level for prescribed trigger bores
3. Water level trigger based on individual bore 5th percentile baseline water level (elevation). Trigger criteria of two consecutive manual readings recorded outside trigger level.

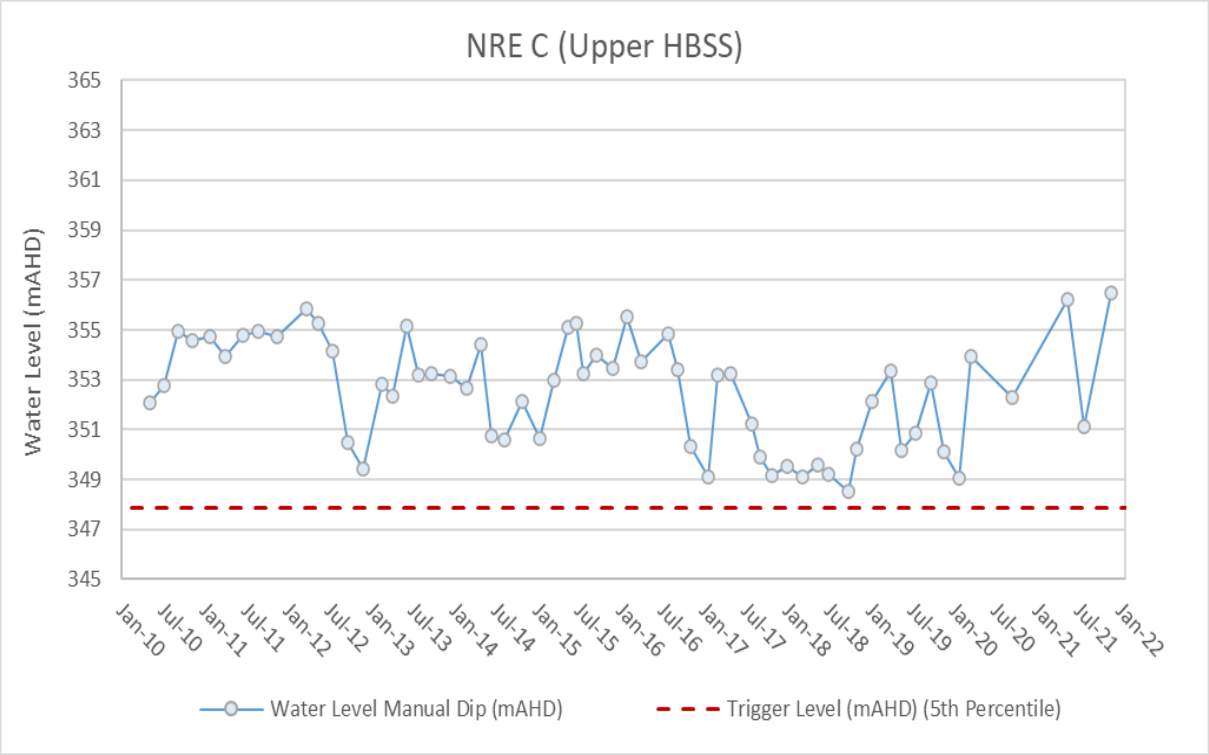
GW1A



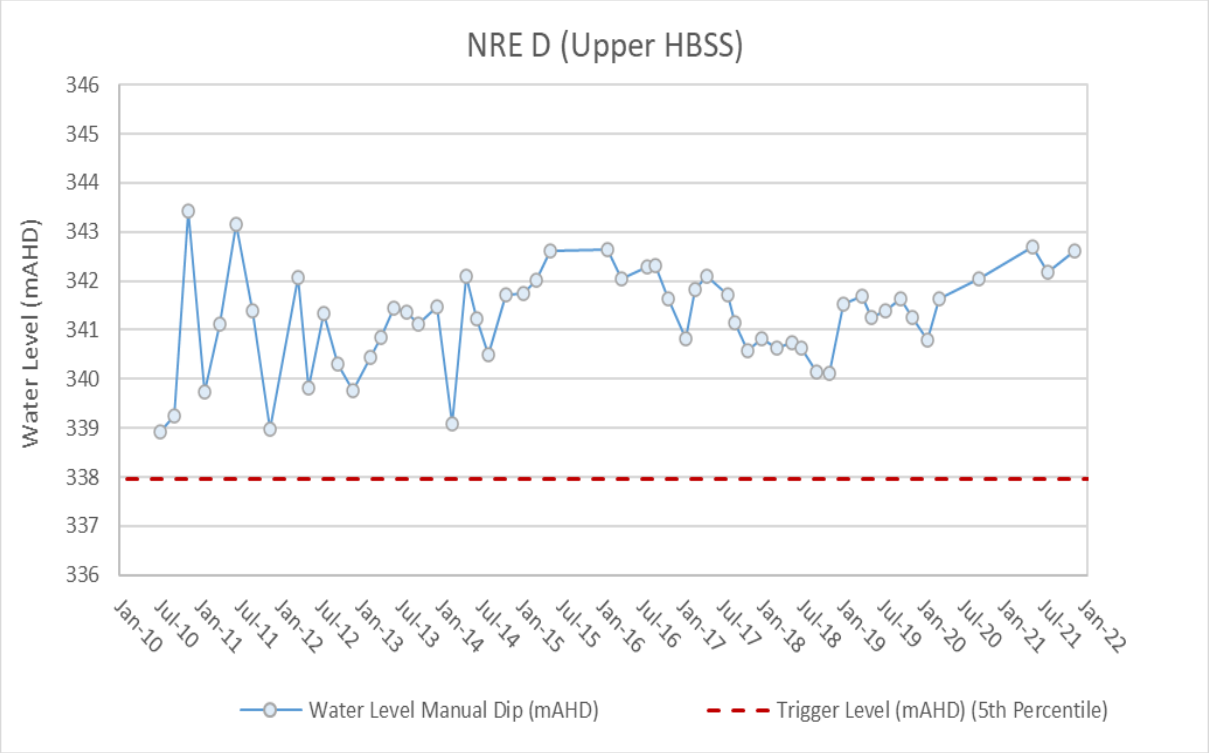
NRE A



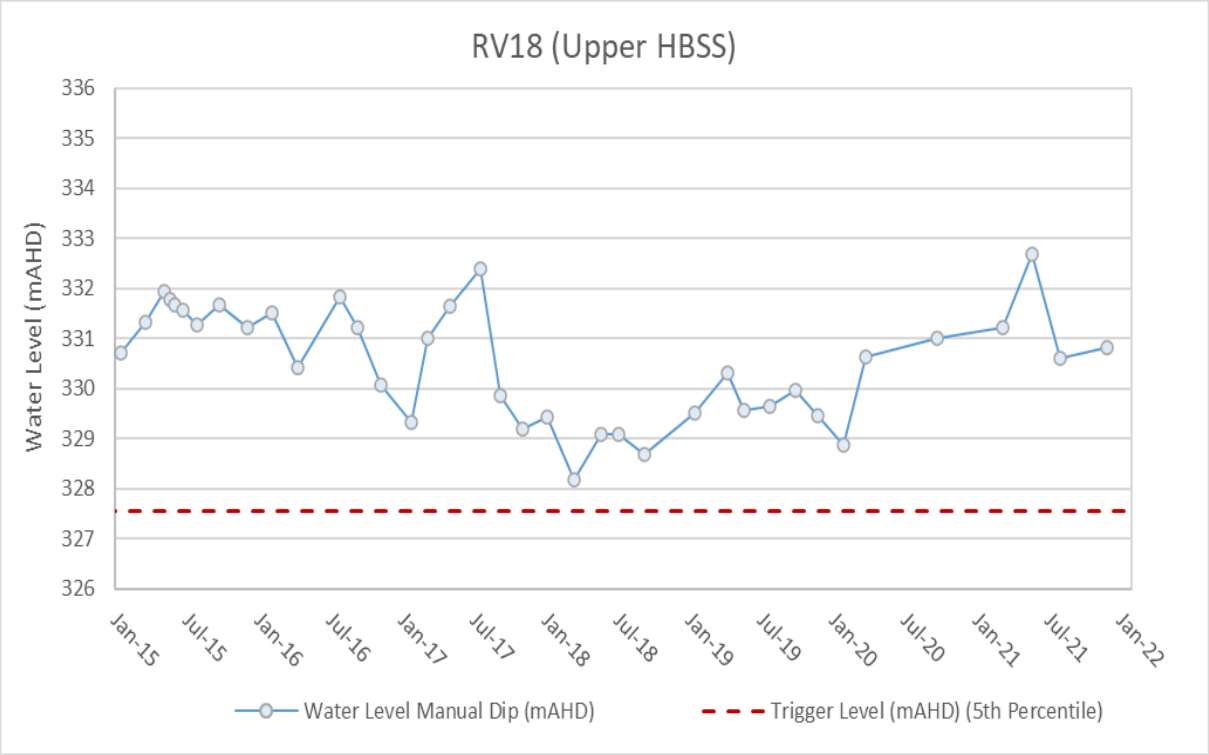
NRE C


NRE C (Upper HBSS)
Water Level (mAHD)
365
363
361
359
357
355
353
351
349
347
345
Jan-10
Jul-10
Jan-11
Jul-11
Jan-12
Jul-12
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Jul-19
Jan-20
Jul-20
Jan-21
Jul-21
Jan-22
Water Level Manual Dip (mAHD)
Trigger Level (mAHD) (5th Percentile)

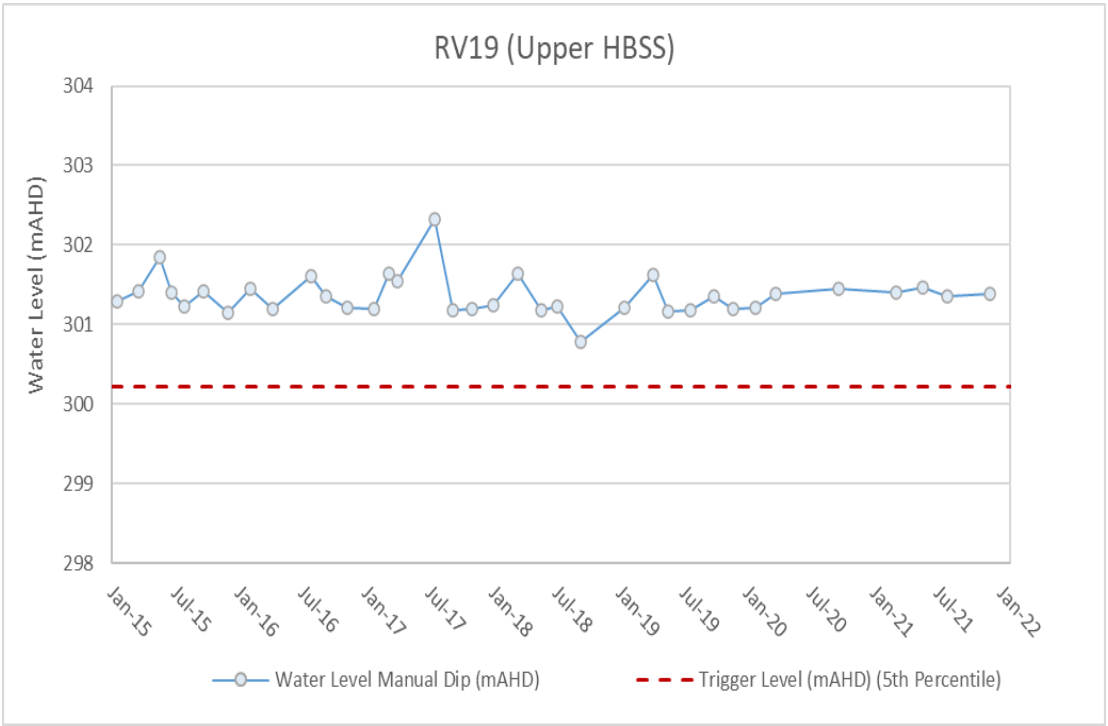
NRE D


NRE D (Upper HBSS)
Water Level (mAHD)
346
345
344
343
342
341
340
339
338
337
336
Jan-10
Jul-10
Jan-11
Jul-11
Jan-12
Jul-12
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Jan-18
Jul-18
Jan-19
Jul-19
Jan-20
Jul-20
Jan-21
Jul-21
Jan-22
Water Level Manual Dip (mAHD)
Trigger Level (mAHD) (5th Percentile)

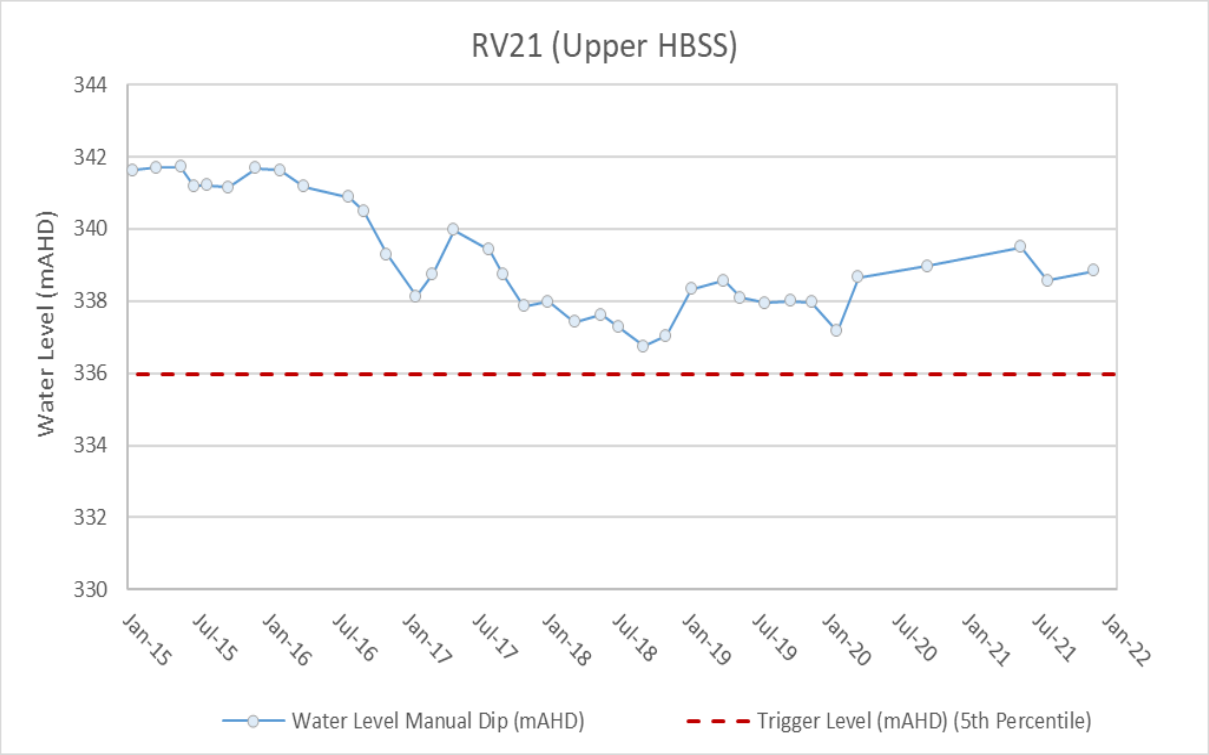
RV18



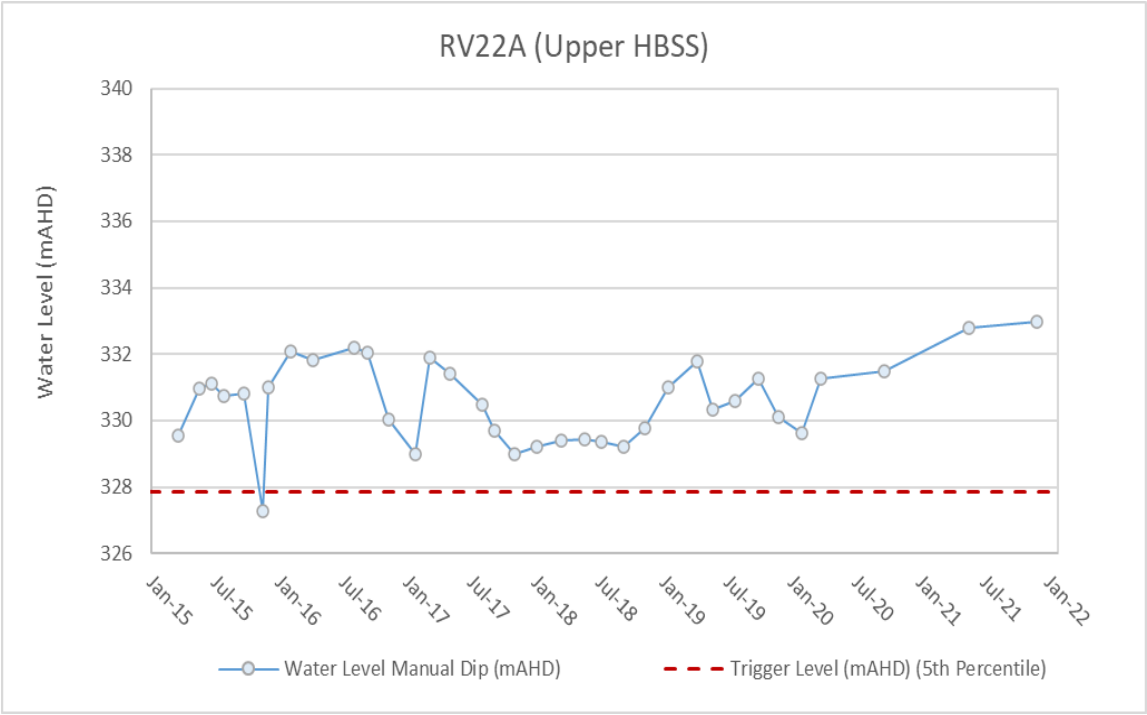
RV19



RV21

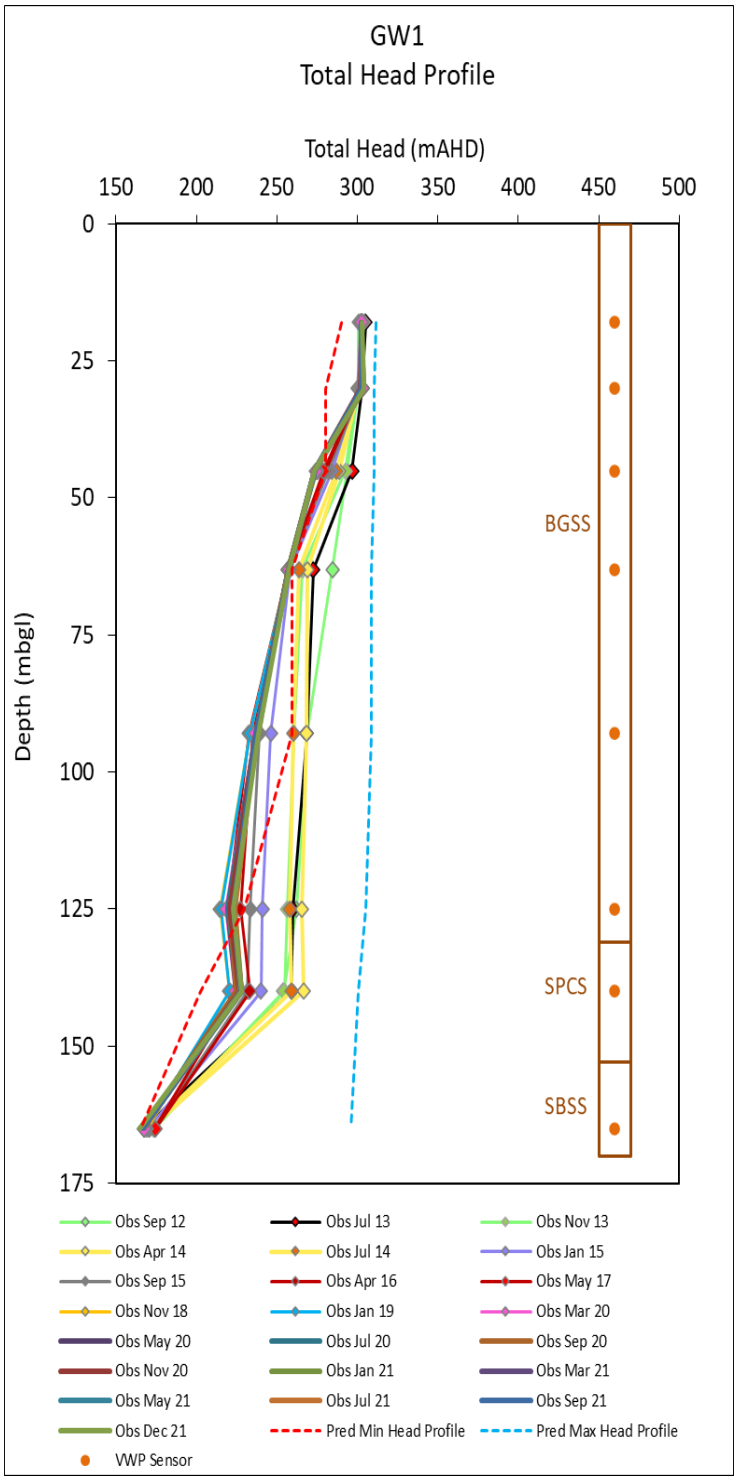


RV22A

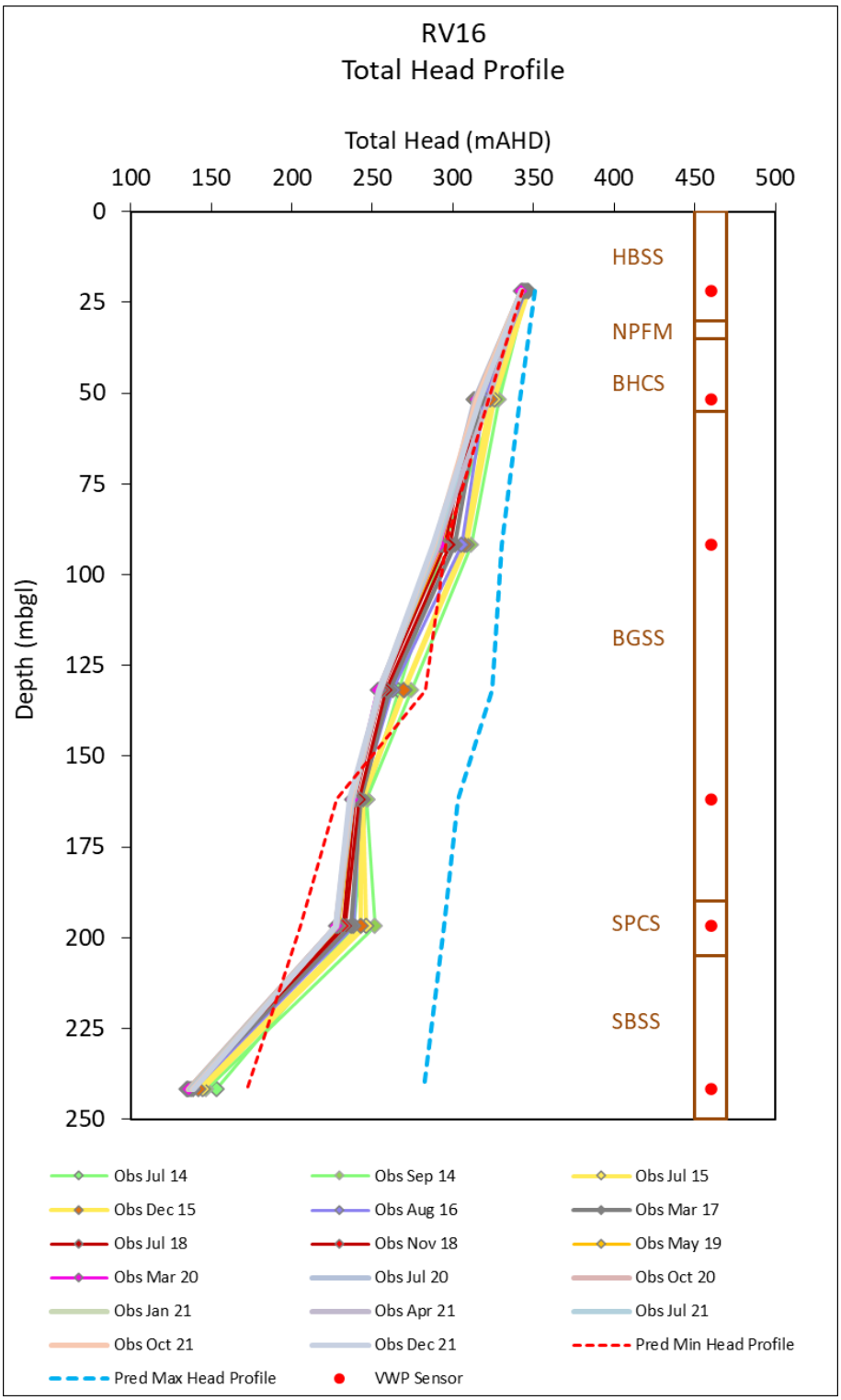


VWP GROUNDWATER LEVEL TRIGGERS

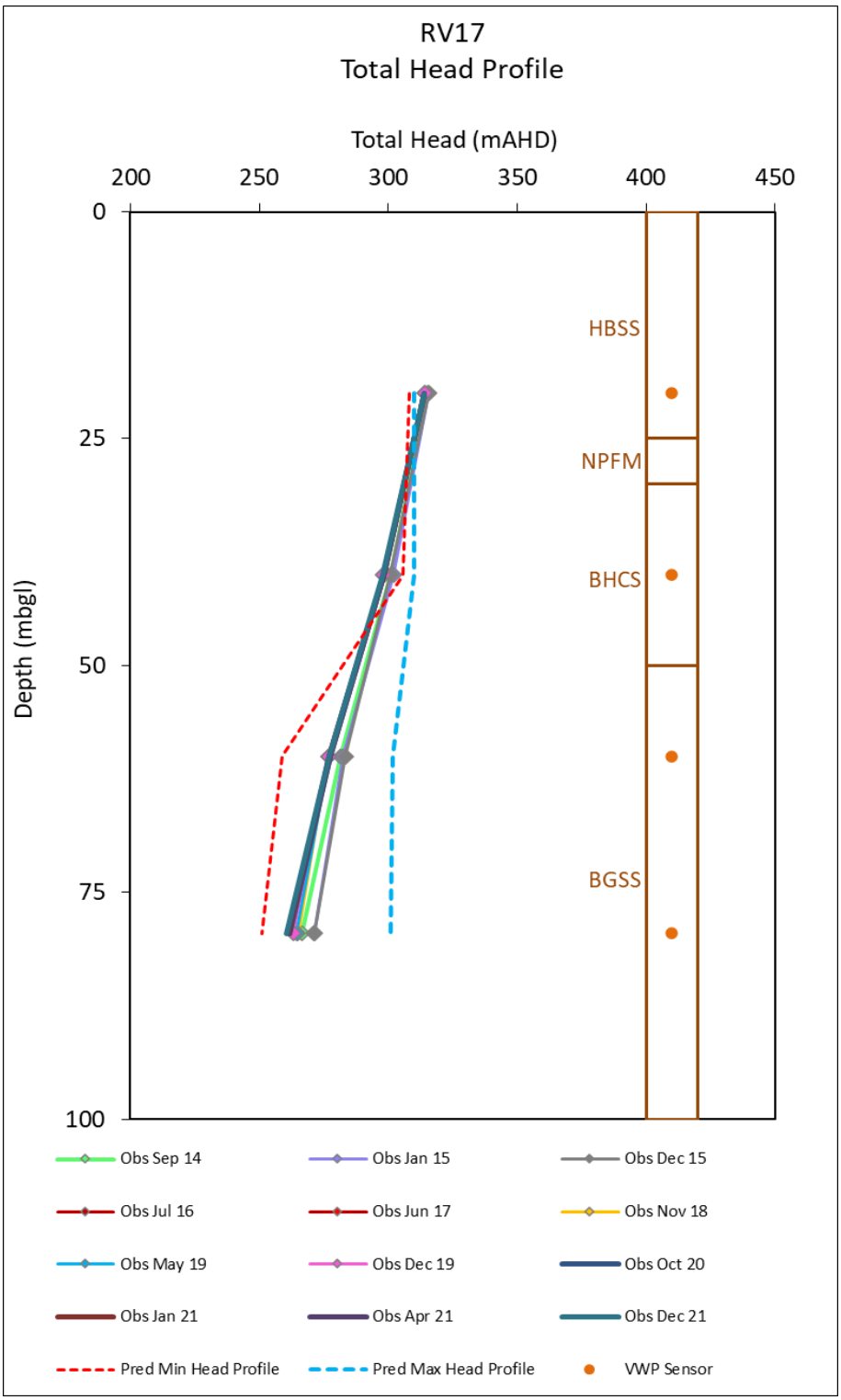
GW1 (VWP)



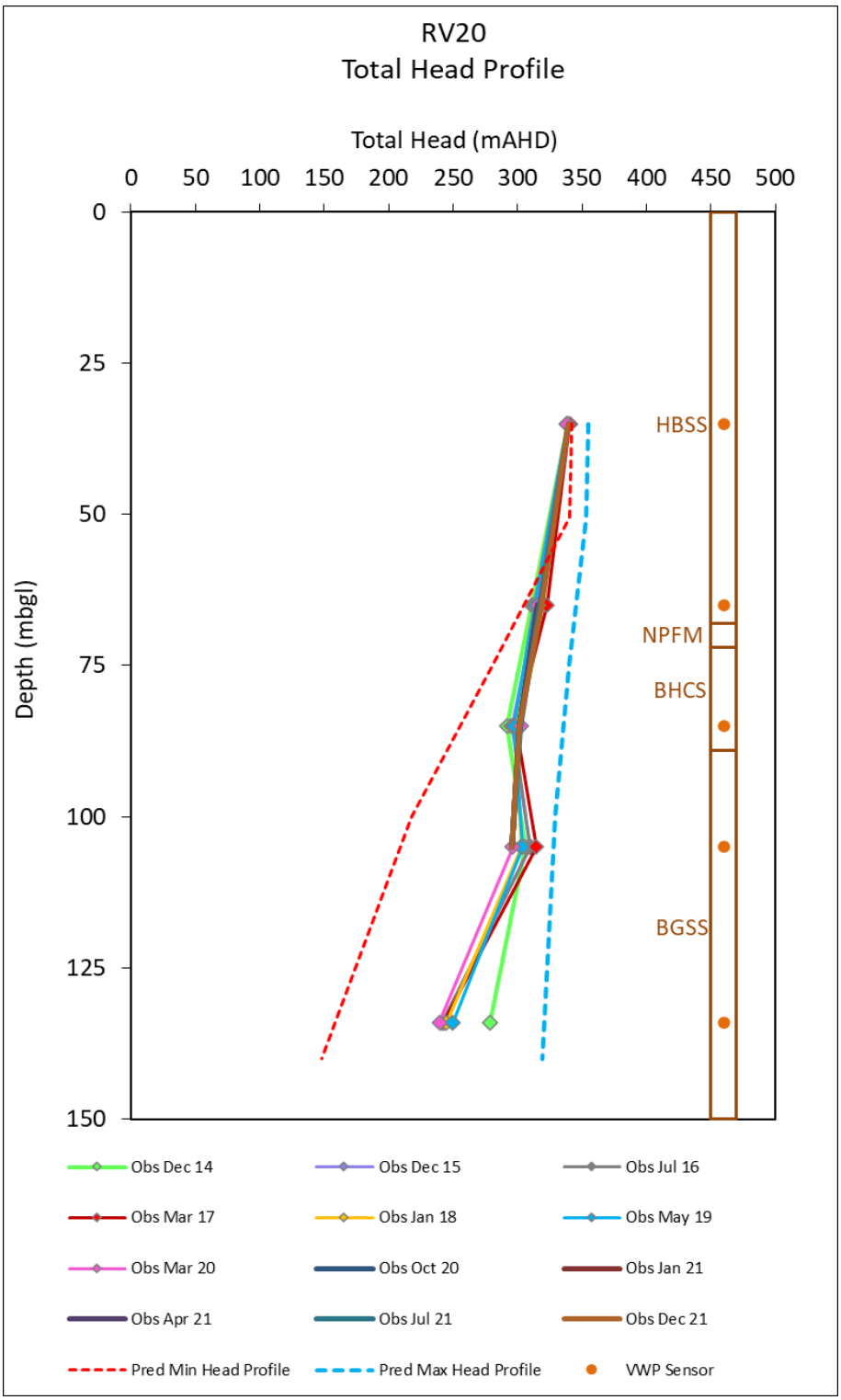
RV16 (VWP)



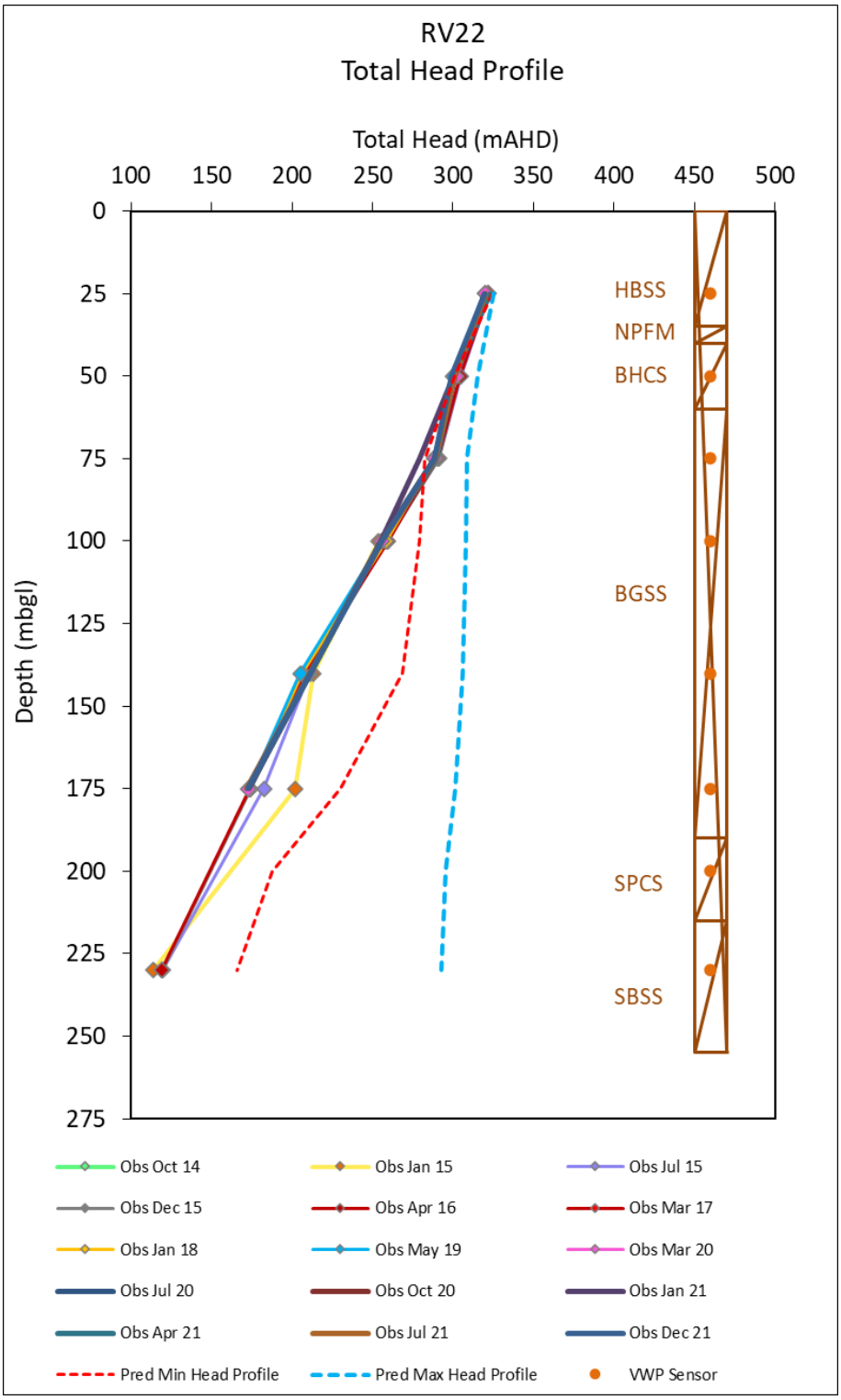
RV17 (VWP)



RV20 (VWP)



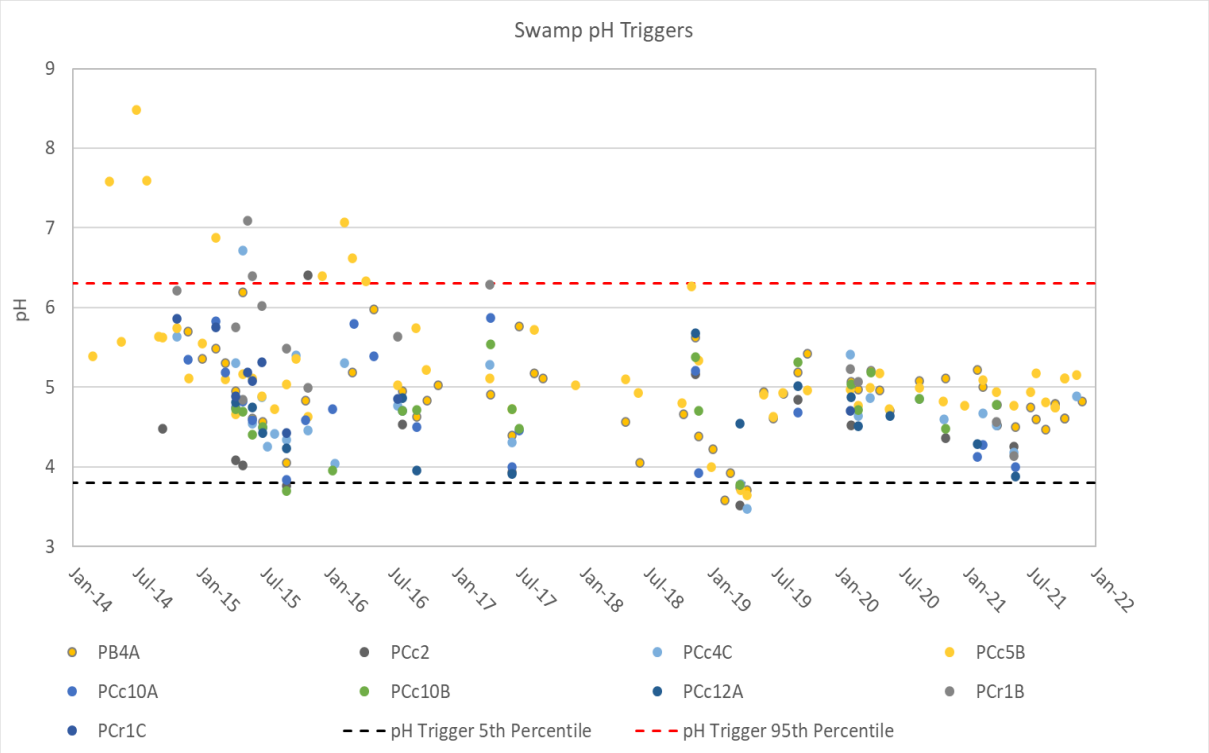
RV22 (VWP)



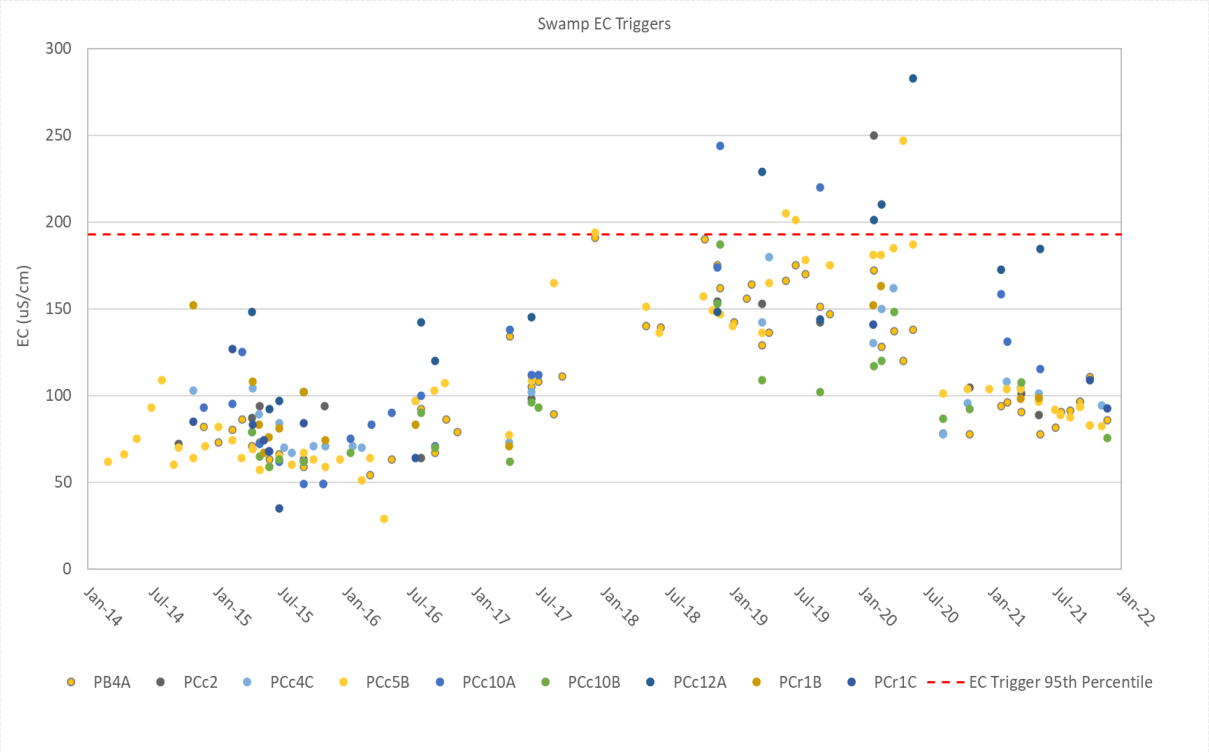
APPENDIX H – GROUNDWATER QUALITY TRIGGERS

SWAMP WATER QUALITY TRIGGERS

pH Triggers

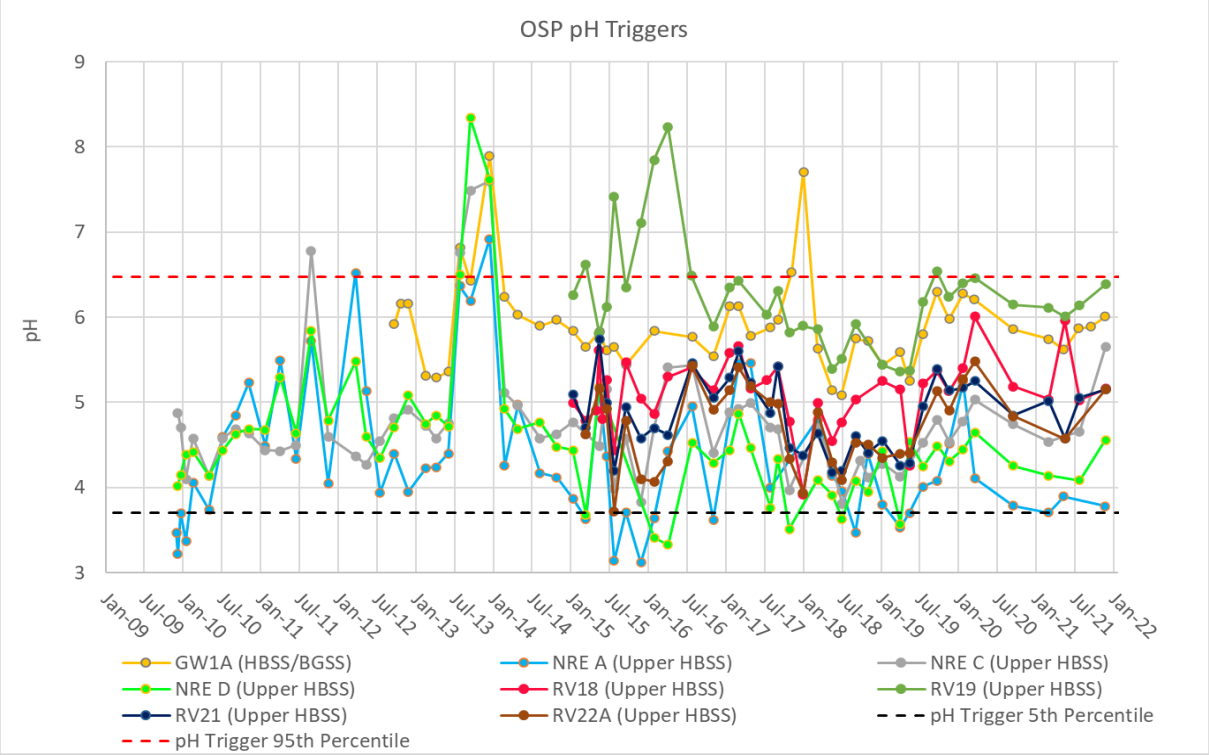


EC Triggers



OPEN STANDPIPE WATER QUALITY TRIGGERS

pH Triggers



EC Triggers