S2-FGJV-ENV-PLN-0012

SNOWY 2.0 MAIN WORKS – GROUNDWATER MANAGEMENT PLAN

Approval Record			
Document preparation, review and approval		Name in print	Signature
Prepared by	Principal Hydrogeologist	R. Cresswell	
Reviewed by	Environment Consultant	S. Mitchell	
Verified by	Environmental Manager	L. Coetzee	
Approved by	Project Director	A. Betti	

Document Revision Table		
Rev.	Date	Description of modifications / revisions
A	29.11.2019	Initial draft for SHL review
B	22.05.2020	Update to reflect conditions of approval and revised environmental management measures
C	15.06.2020	Revised to address SHL comments. For consultation.
D	25.06.2020	Update to address Commonwealth conditions of approval
E	06.08.2020	Revised to address stakeholder comments
F	19.09.2020	Revised to address DAWE and DPIE comments
G	15.10.2020	Revised to address NRAR clarification

CONTENTS

TABLE OF TABLES

TABLE OF FIGURES

ABBREVIATIONS, ACROYNMS, INITIALISMS AND DEFINITIONS

Acronym	Definition
AFL	Agreement for Lease
AHD	Australian Height Datum
AIP	*Aquifer Interference Policy*
CoA	*Infrastructure Conditions of Approval (SSI 9687)*
Construction envelope	The maximum extent within which the disturbance area corridor can move to allow the final siting of infrastructure through the detailed design process
DAWE	Commonwealth Department of Agriculture, Water and the Environment
Disturbance footprint	The disturbance footprint as described in the PIR-RTS is the indicative corridor inside the larger construction envelope, where construction works required to build Snowy 2.0 can be carried out.
DOI	Department of Industry
DPIE	NSW Department of Planning, Industry and Environment
EIS	Environmental Impact Statement
EMS	Environmental Management Strategy
EPA	NSW Environment Protection Authority
EP&A Act	*Environmental Planning and Assessment Act 1979*
EP&A Regulation	*Environmental Planning and Assessment Regulation 2000*
EPL	Environmental Protection Licence
Exploratory Works	The development of an exploratory tunnel and associated infrastructure described in the Environmental Impact Statement for the Snowy 2.0 Exploratory Works (CSSI 9208) dated July 2018, and modified by the: • *Submissions Report* dated October 2018 and additional information provided to the Department on 17 October 2018, 19 November 2018 and 23 January 2019; • *Modification Report* dated 6 June 2019 and associated Submissions Report dated 2 September 2019 and amendment letter date 4 October 2019; and • *Modification Report* dated 17 October 2019 and associated Submissions Report dated 10 January 2020
Future Generation	Future Generation Joint Venture
Future Generation-PMS	Project Management System
GDE	Groundwater Dependent Ecosystem – ecosystems that require access to groundwater to meet all or some of their water requirements so as to maintain the communities of plants and animals, ecological processes they support, and ecosystem services they provide.
GMP	Groundwater Management Plan (S2-FGJV-ENV-PLN-0012) (This Plan)
IBRA	Interim Biogeographic Regionalisation for Australia
Incident	An occurrence or set of circumstances that causes or threatens to cause material harm and which may or may not be or cause a non-compliance
Kosciusko National Park	A National Park protected under the *National Parks and Wildlife Act 1974* (NSW) and managed by NSW National Parks and Wildlife Service. It covers an area of 673,543 hectares and forms part of Australia's only Alpine area
KNP	Kosciusko National Park

Acronym	Definition
Lobs Hole site	The development in the vicinity of Lobs Hole, including the GFO1 emplacement area; construction facilities (Main Yard), including workers' accommodation camp and temporary spoil emplacement areas; Main Access Tunnel and Emergency Cable and Ventilation Tunnel portals; and ancillary infrastructure including access roads, substation, cableyard and utilities.
LFB	Lachlan Fold Belt
LPF	Long Plain Fault
Main Works	The development of an underground power station and associated infrastructure described in the Environmental Impact Statement for the Snowy 2.0 Main Works (CSSI 9687) dated September 2019, and modified by the: • *Preferred Infrastructure Report and Response to Submissions – Snowy 2.0 Main Works*, dated February 2020; and • Additional information provided to the Department by EMM on 24 March 2020 and 7 April 2020
Marica site	The development in the vicinity of Marica, including the headrace surge shaft; ventilation shaft; construction facility workers' camp; and ancillary infrastructure including access roads and utilities.
MDB	Murray-Darling Basin
NSW DPI	The NSW Department of Primary Industries within Regional NSW
NPWS	National Park and Wildlife Services
NRAR	NSW Natural Resources Access Regulator
Plateau site	The development in the vicinity of the Plateau, including the instream barrier in Tantangara Creek and ancillary infrastructure including access roads and utilities.
Plateau area	The plateau area; located to the east of the Snowy Mountains Highway and spanning the area between the highway and Tantangara Reservoir, is typical of elevated alpine environments, dominated by low energy streams, gentle rolling hills and mostly flat floodplains. The plateau area includes the Plateau and Tantangara work site.
POEO Act	*Protection of the Environment Operations Act 1997*
POEO Regulation	*Protection of the Environment (General) Regulation 2009*
Project	Snowy 2.0 Main Works
Project area	The project area is the broader region within which Snowy 2.0 will be built and operated, and the extent within which direct impacts from Snowy 2.0 Main Works are anticipated. The project area does not represent a footprint for the construction works, but rather indicates an area that was investigated during environmental assessments.
Ravine area	The ravine area; located mostly to the west of the Snowy Mountains Highway, is characterised by deep gorges and steep sloping ridges, the product of incision from river flow, historic glaciation and structural movement. The ravine area includes the Talbingo, Lobs Hole and Marica work sites.
REMM	Revised Environmental Management Measures
Rock Forest site	The development on the Rock Forest property, including the Rock Forest emplacement area, logistics laydown area and ancillary infrastructure including access roads.
SC	South Coast
Submissions Report or RTS	*Main Works Preferred Infrastructure Report and Response to Submissions*
SHC Act	Snowy Hydro Corporatisation Act 1997
SHL	Snowy Hydro Limited

Acronym	Definition
SSI	State Significant Infrastructure under EP&A Act (Infrastructure Approval 9687)
SWMP	Surface Water Management Plan (S2-FGJV-ENV-PLN-0011) (Appendix A)
Talbingo Reservoir site	The development in and around the Talbingo Reservoir, including the Ravine Bay emplacement area; development at Middle Bay, including the water intake and associated structures, barge launch ramp, and construction facilities; and ancillary infrastructure, including access roads and utilities.
Tantangara Reservoir site	The development in and around the Tantangara Reservoir, including the Tantangara emplacement area; water intake and associated infrastructure; barge launch infrastructure; construction and laydown facilities, including workers' camp; fish screens; and ancillary infrastructure, including access roads and utilities.
TARP	Trigger Action Response Plan
TBM	Tunnel boring machine
VWP	Vibrating wire piezometer – a deep, sealed bore that records groundwater pressure
WAL	Water Access Licence
Water Group	The Water Group within the Department
WM Act	*Water Management Act 2000*
WM Regulation	*Water Management (General) Regulation 2011*
WMP	Water Management Plan (S2-FGJV-ENV-PLN-0010)
WSP	Water Sharing Plan
WTP	Water Treatment Plant

1. INTRODUCTION

1.1. Project Description

1.1.1. Overview

Snowy Hydro Limited (Snowy Hydro) is constructing a pumped hydro-electric expansion of the Snowy Mountains Hydro-electric Scheme (Snowy Scheme), called Snowy 2.0. Snowy 2.0 will be built by the delivery of two projects: Exploratory Works (which has commenced) and Snowy 2.0 Main Works.

Snowy 2.0 is a pumped hydro-electric project that will link the existing Tantangara and Talbingo Reservoirs through a series of new underground tunnels and a hydro-electric power station. Most of the project's facilities will be built underground, with approximately 27 kilometres of concrete-lined tunnels constructed to link the two reservoirs and a further 20 kilometres of tunnels required to support the facility. Intake and outlet structures will be built at both Tantangara and Talbingo Reservoirs.

Snowy 2.0 will increase the generation capacity of the Snowy Scheme by an additional 2,000 MW, and at full capacity will provide approximately 350,000 MWh of large-scale energy storage to the National Electricity Market (NEM). This will be enough to ensure the stability and reliability of the NEM, even during prolonged periods of adverse weather conditions.

Salini Impregilo, Clough and Lane have formed the Future Generation Joint Venture (Future Generation) and have been engaged to deliver both Stage 2 of Exploratory Works and Snowy 2.0 Main Works.

1.1.2. Construction Activities and Program

The Snowy 2.0 Main Works Project includes, but is not limited to, construction of the following:

- pre-construction preparatory activities including dilapidation studies, survey, investigations, access, etc;
- exploratory works including:
    - an exploratory tunnel to the site of the underground power station;
    - horizontal and test drilling;
    - a portal construction pad;
    - an accommodation camp;
    - barge access infrastructure;
- an underground pumped hydro-electric power station complex;
- water intake structures at Tantangara and Talbingo Reservoirs;
- power waterway tunnels, chambers and shafts;
- access tunnels;
- new and upgraded roads to allow ongoing access and maintenance;
- power, water and communication infrastructure, including:
    - a cable yard to facilitate connection between the NEM electricity transmission network and Snowy 2.0;

  - permanent auxiliary power connection;
  - permanent communication cables;
  - permanent water supply to the underground power station; and
- post-construction revegetation and rehabilitation.

The Snowy 2.0 construction program is summarised in Figure 1-1

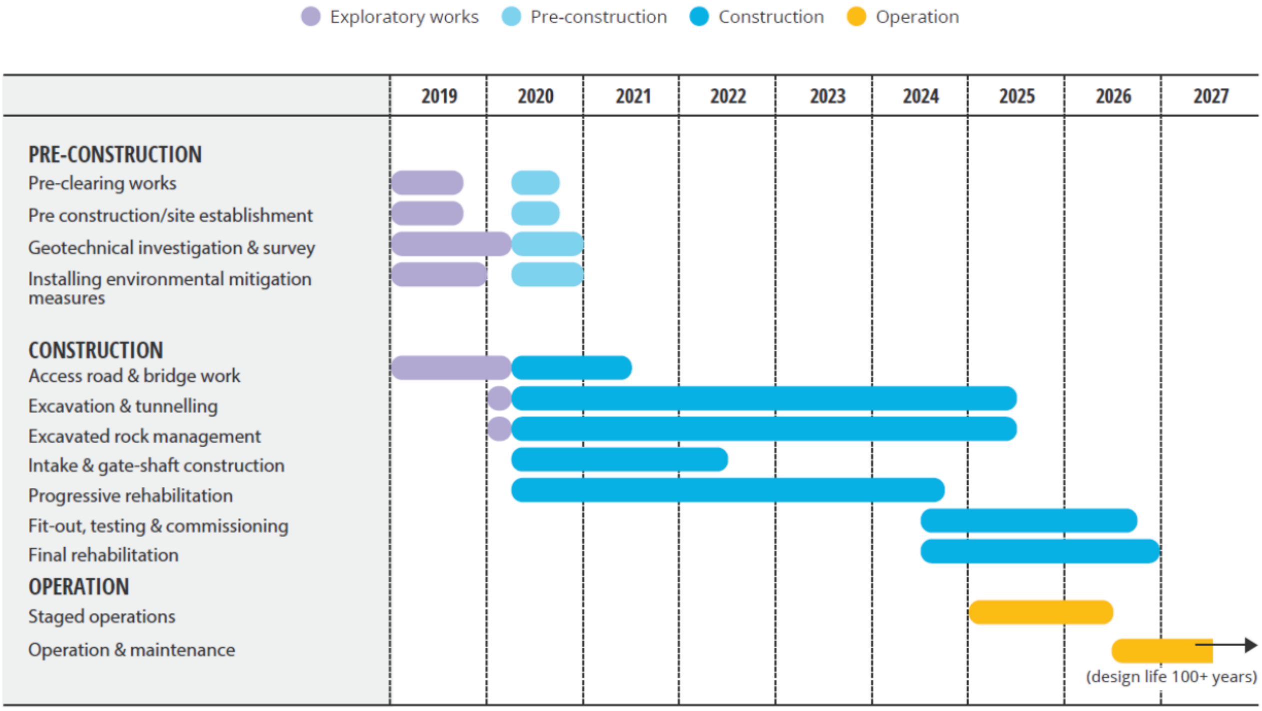


Figure 1-1: Timing of Snowy 2.0

The Snowy 2.0 Main Works Project includes numerous work sites as shown in Figure 1-2. Specifically, these are designated:

- Talbingo;
- Lobs Hole;
- Lobs Hole Ravine Road;
- Marica;
- Plateau (from Snowy Mountains Highway to Tantangara);
- Tantangara; and
- Rock Forest.

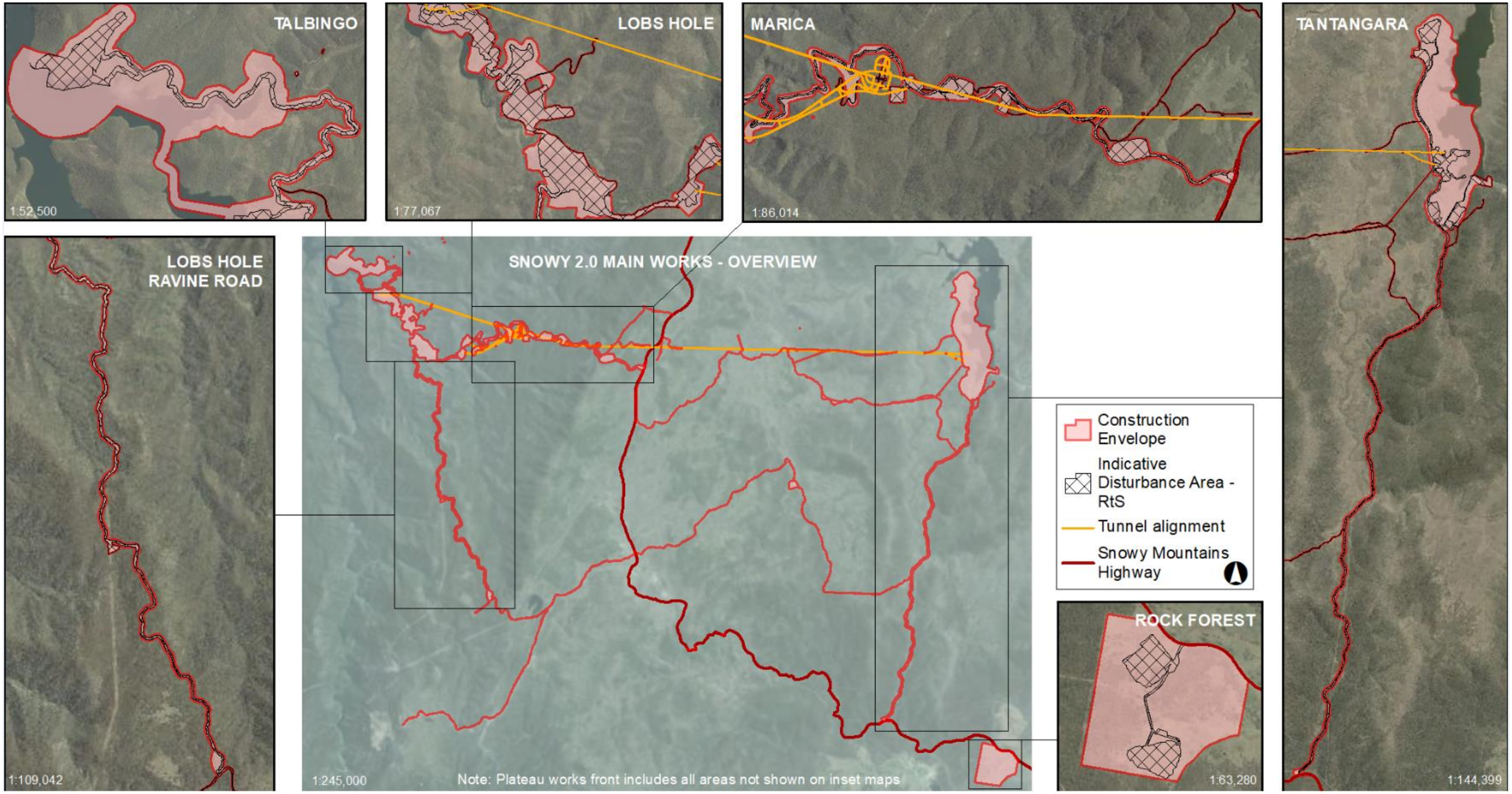


Figure 1-2: Snowy 2.0 Main Works work site

1.2. Project Approval

On 7 March 2018 the NSW Minister for Planning declared Snowy 2.0 to be State significant infrastructure (SSI) and critical State significant infrastructure (CSSI) under the *Environmental Planning and Assessment Act 1979* (EP&A Act) on the basis that it is critical to the State for environmental, economic or social reasons.

An environmental impact statement for the first stage of Snowy 2.0, the *Environmental Impact Statement Exploratory Works for Snowy 2.0* (Exploratory Work EIS) was submitted to the then Department of Planning and Environment in July 2018 and publicly exhibited between 23 July 2018 and 20 August 2018. Approval for the first stage of Snowy 2.0 was granted for Exploratory Works by the Minister for Planning on 7 February 2019. In accordance with section 5.25 of the EP&A Act, the infrastructure approval for the Exploratory Works was modified on 2 December 2019 and on 27 March 2020.

An environmental impact statement for the second stage of Snowy 2.0, the Snowy 2.0 Main Works – Environmental Impact Statement (Main Work EIS) was submitted to Department of Planning, Industry and Environment (DPIE) in September 2019 and was publicly exhibited between 26 September 2019 and 7 November 2019. A total of 222 submissions were received during the public exhibition period, including 10 from government agencies, 30 from special interest groups and 182 from the general public. In February 2020, the response to submissions (RTS or Submission Report) was issued to DPIE to address the public and agency submissions (*Snowy 2.0 Main Works - Preferred Infrastructure Report and Response to Submissions, February 2020*).

Following consideration of the Main Works EIS and RTS, approval was granted by the Minister for Planning and Public Spaces on 20 May 2020, through issue of Infrastructure Approval SSI 9687.

Further to the Infrastructure Approval, the Main Works RTS include revised environmental management measures (REMMs) within Appendix C which will also be implemented for the Project.

In addition to the State approval, a referral (EPBC 2018/8322) was prepared and lodged with the Commonwealth Department of Energy and Environment (DoEE – *now* Department of Agriculture, Water and the Environment; DAWE) under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act). The Commonwealth Minister's delegate determined on 5 December 2018 that Snowy 2.0 Main Works is a "controlled action" under the EPBC Act. The EPBC Act referral decision determined that the project will be assessed by accredited assessment under Part 5, Division 5.2 of the NSW *Environmental Planning and Assessment Act 1979*

1.3. Disturbance area

A key refinement following public exhibition of the Main Works EIS was a change to and clarification of disturbance area terminology. The revised disturbance area terminology as per the SSI-9687 Instrument, RTS and this Plan is outlined in Table 1-1, with an example of the terminology shown for Lobs Hole Ravine Road in Figure 1-3.

Table 1-1: Disturbance area terminology

Term	Definition	Reasoning
Project area	The project area is the broader region within which Snowy 2.0 will be built and operated, and the extent within which direct impacts from Snowy 2.0 Main Works are anticipated.	The project area does not represent a footprint for the construction works, but rather indicates an area that was investigated during environmental assessments.
Construction envelope	The envelope within which the disturbance area of the development may be located.	As detailed design continues, final siting of the infrastructure (i.e. the disturbance area) may move within the assessed construction envelope subject to recommended environmental management measures and provided it does not exceed the limits defined by the construction envelope.
Disturbance area	The area within the construction envelope where development may be carried out; the precise location of the disturbance area will be fixed within the construction envelope following final design.	

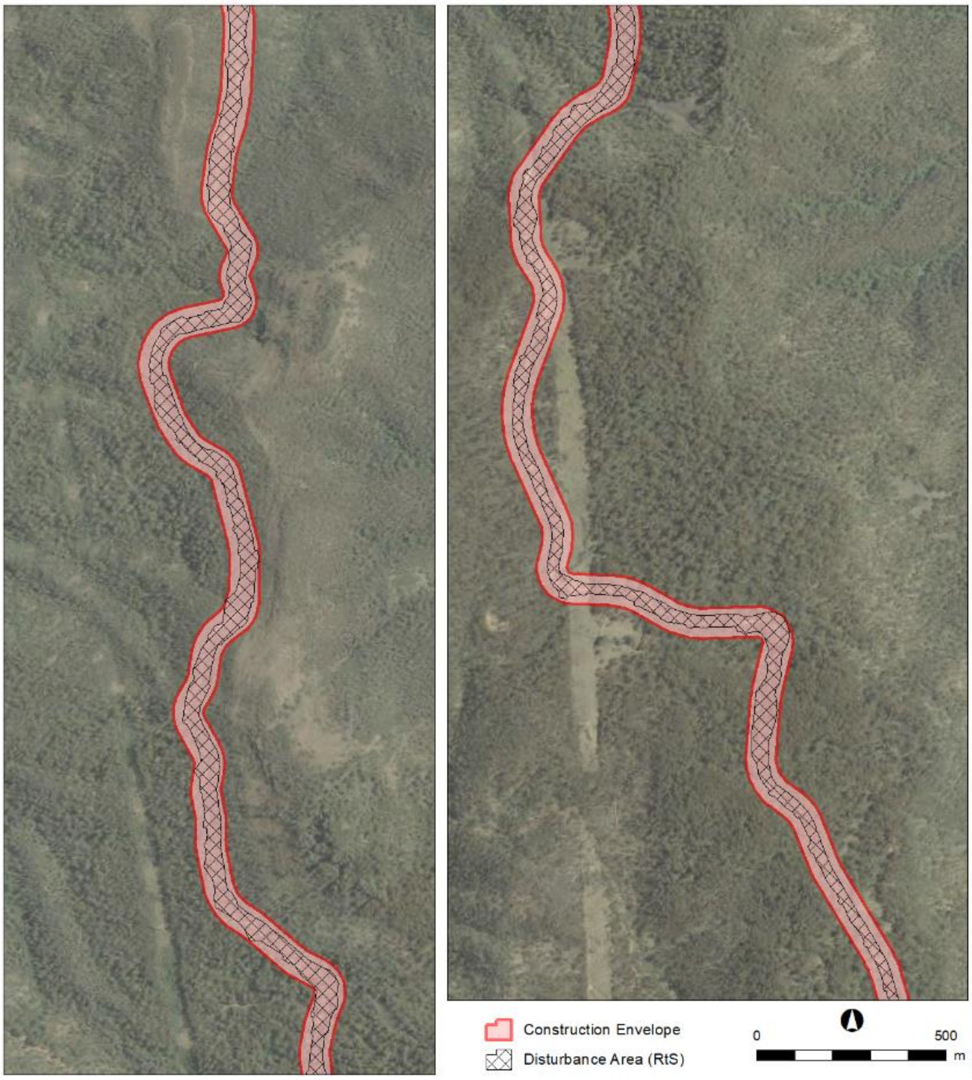


Figure 1-3: Disturbance area and construction envelope

1.4. Works within the Construction Envelope

Where project works are required to occur in locations outside of the disturbance boundary, Future Generation will review the proposed area of clearing against the limits included within condition 5 of schedule 2. The review will be undertaken to ensure that the maximum disturbance area and maximum native vegetation clearing remains within the total areas nominated within the condition. These area limits are included within Table 1-2.

All vegetation clearing which occurs on the project will be monitored regularly to record the extent of clearing which has occurred, and to ensure that the clearing limits are not exceeded.

Table 1-2: Maximum disturbance area and native vegetation clearing

Matter	Exploratory Works	Main Works	Total
Maximum Disturbance Area	126 ha	504 ha	630 ha
Maximum Native Vegetation Clearing	107 ha	425 ha	532 ha

1.5. Environmental Management System

The overall environmental management system for the Project is described in the Environmental Management Strategy (EMS). The EMS forms part of the Project Management System (Future Generation-PMS) and will include any requirements specified in the contract documents, where appropriate. All Future Generation-PMS procedures will support, interface or directly relate to the development and execution of the plan.

The management plans and post-approval documents for the project include those listed within Figure 1-4.

This Groundwater Management Plan (GMP or Plan) (S2-FGJV-ENV-PLN-0012) is an appendix to the Water Management Plan (WMP) (S2-FGJV-ENV-PLN-0010) which has been prepared for the Snowy 2.0 Main Works project, and supersedes the existing Stage 1 and Stage 2 Exploratory Works Water Management Plan. It does not address the operational phase of the project.

This Plan forms part of Future Generation's environmental management framework.

An overview of the WMP structure relative to the elements of water management is shown in Figure 1-5.

This Plan aims to transfer the relevant requirements of the Approval documents into a management plan which can be practically applied on the Project site

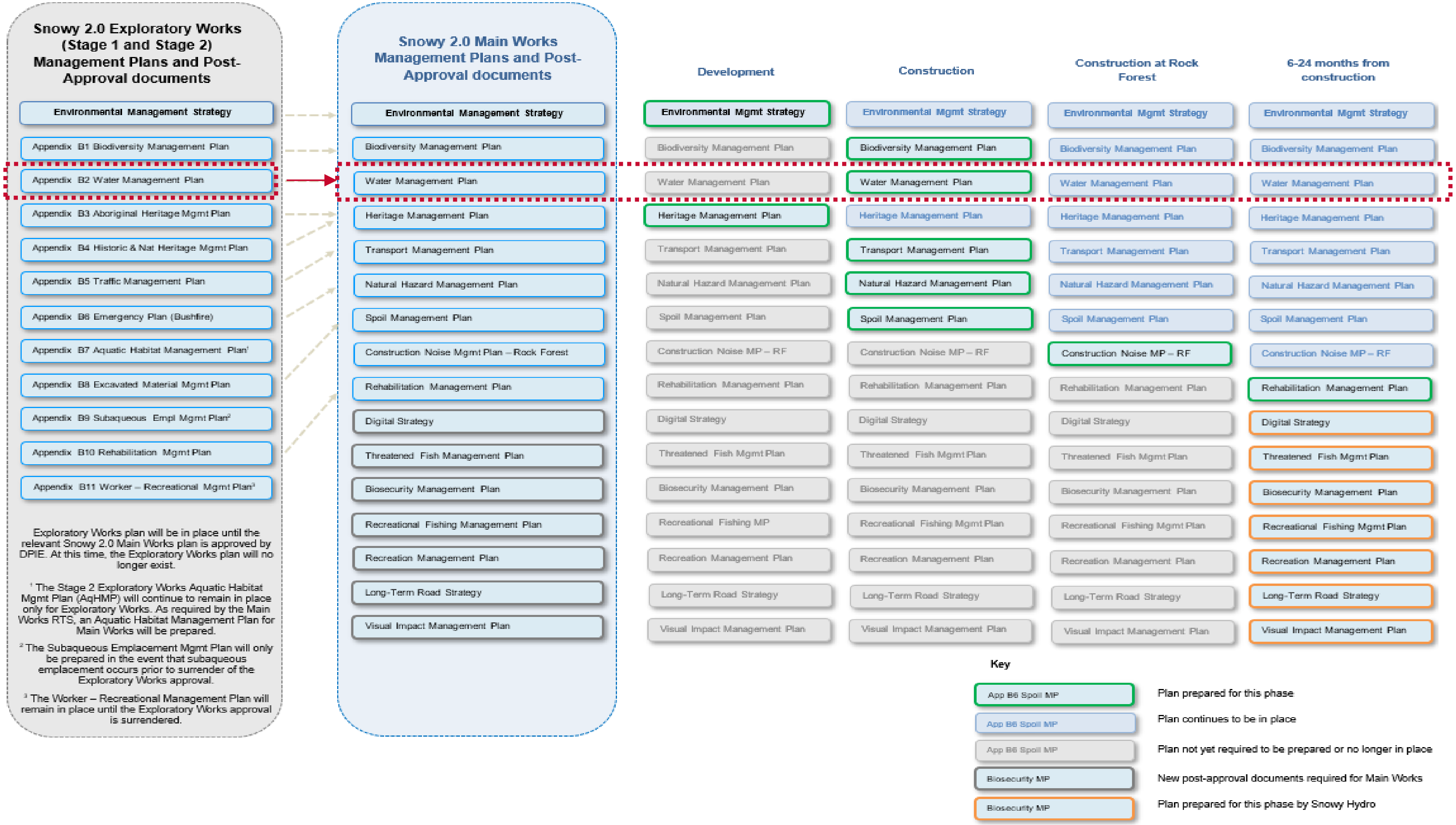


Figure 1-4: Management plans and post-approval documents with the WMP indicated

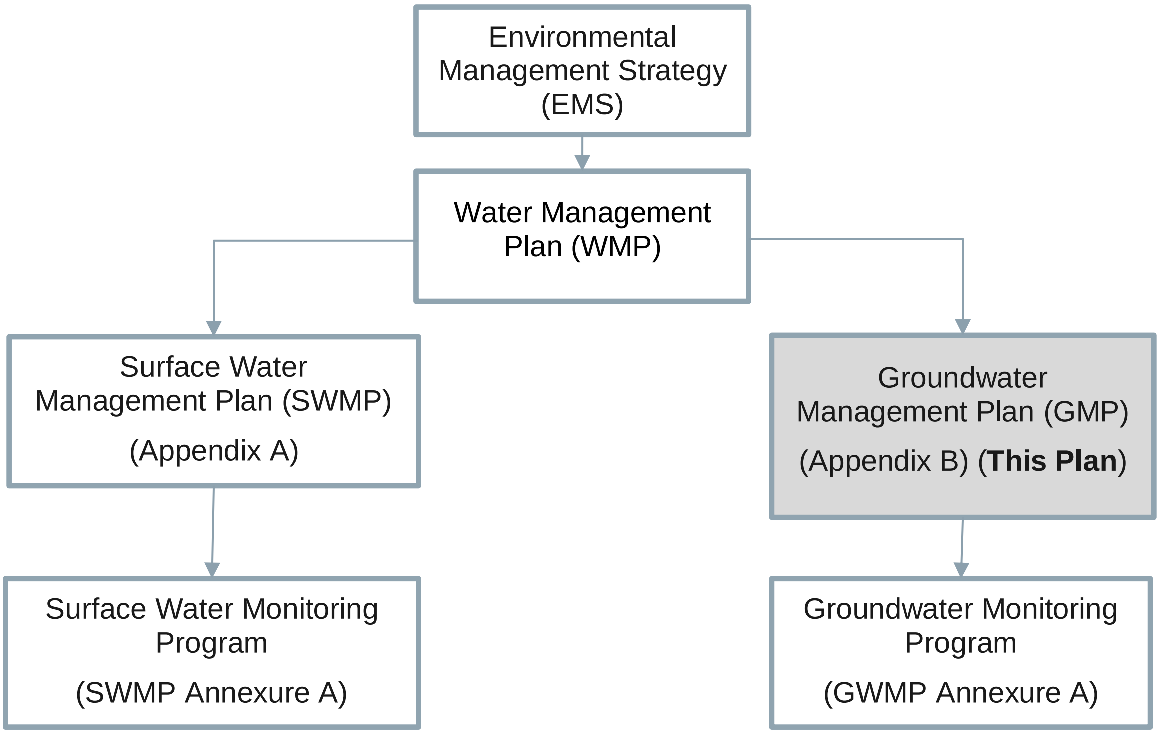


Figure 1-5: Water Management Plan Structure

1.6. Purpose and objective of this plan

The purpose of this Plan is to address the construction environmental management requirements as they relate to groundwater as detailed in the:

- Infrastructure Approval (SSI 9687) (Approval) issued for Snowy 2.0 Main Works on 21 May 2020;
- *Main Works Snowy 2.0 - Environmental Impact Statement;*
- revised environmental management measures (REMMs) within the Main Works RTS;
- the Infrastructure Approval (SSI 9208) issued for Snowy 2.0 Exploratory Works on 7 February 2019 and modified on 2 December 2019 and 27 March 2020
- *Exploratory Works for Snowy 2.0 - Environmental Impact Statement*;
- *Exploratory Works for Snowy 2.0 – Modification 1 Assessment Report;*
- *Exploratory Works for Snowy 2.0 – Modification 2 Assessment Report;*
- REMMs within the Exploratory Works RTS, Exploratory Works Modification 1 RTS, and Exploratory Works Modification 2 RTS; and
- Environmental Protection License (EPL) 21266 (*as varied 8th April, 2020*).

The key objective of this Plan is to detail management measures and inform site procedures for implementation so that groundwater impacts are minimised and within the scope permitted by the Infrastructure Approval. To achieve this, Snowy Hydro and Future Generation will implement:

- appropriate measures to address relevant conditions of approval and REMMs listed within the Submissions Report, as detailed within Section 2 of this Plan;

- appropriate measures during construction to manage and protect groundwater;
- a groundwater monitoring program during construction to assess the effectiveness of the groundwater management controls and impacts on the receiving environment; and
- corrective actions and contingency measures during construction when triggered.

Specific on-site management measures identified in this plan will be incorporated into site documents where relevant. These site-specific documents will be prepared for construction activities and will detail the management measures which are to be implemented on the ground. Construction personnel will be required to undertake works in accordance with the mitigation measures identified in the site-specific documents.

1.7. Staging

Some distinct activities require greater detail prior to commencement. Consequently, this Plan will be updated, in consultation with relevant government agencies, and submitted to DPIE prior to the commencement of specific activities as detailed in Table 1-3.

Table 1-3: Activities that require update to this GMP

Activities	Timing
Operation of Snowy 2.0 Project, including dewatering of the tailrace tunnel during operations.	Operation will be addressed through a separate Snowy Hydro framework or document.

1.8. Plan Preparation

In accordance with schedule 3, condition 31 of the Approval, the GMP has been prepared by a suitably qualified and experienced person. This plan was prepared by Dr Richard Cresswell, Eco Logical Australia.

1.9. Consultation

In accordance with schedule 3, condition 31 of the Infrastructure Approval, the WMP (which includes this GMP) is prepared in consultation with:

- NSW Environment Protection Agency (EPA)
- National Parks and Wildlife Services (NPWS)
- NSW Department of Planning, Industry and Environment – Water (DPIE – Water Group)
- Natural Resources Access Regulator (NRAR), and
- NSW Department of Primary Industries within Regional Australia (NSW DPI).

In accordance with condition 18 of the Commonwealth approval, the WMP (including this GMP) is also to be prepared in consultation with the DAWE.

Agency briefings for the WMP were held on 30 April 2020 and 7 May 2020 with EPA, NPWS, Water Group, NSW DPI and the Biodiversity and Conservation Division (BCD).

On 15th June 2020 the plan was issued to stakeholder agencies for review and comment. Comments from consultation have been incorporated into this plan where appropriate. Response to the comments have been provided back to the stakeholder agencies. Consultation is summarised in Table 1-4.

Table 1-4: Consultation undertaken for this plan

Date	Consultation	Outcomes
26/03/2020	Water Group	Agency briefing (online PowerPoint) and discussion of previous meetings held with SHL during RTS assessment.
30/04/2020	EPA, NPWS, NSW DPI, BCD, DPIE Water Group	Agency briefing (online PowerPoint) providing overview of document structure and surface water management approach.
07/05/2020	EPA, NPWS, BCD, DPIE Water Group	Agency briefing (online PowerPoint) providing overview of the development of the surface water monitoring program and groundwater monitoring program.
15/06/2020	NPWS, EPA, Water Group, NRAR, NSW DPI	GMP (revision C) including monitoring program issued to stakeholders for review and comment
08/07/2020	DAWE	Agency briefing (online PowerPoint) providing overview of document structure and water management approach.
03/08/2020	NRAR, Water Group	Amendment to groundwater monitoring network.
24/08/2020	DAWE	General clarifications on WMP

A separate document is proposed to be provided to DPIE and DAWE which details the consultation process, along with Future Generation responses to stakeholder comments and how feedback has been implemented during the action.

1.9.1. Ongoing Consultation

Future Generation will consult with stakeholders identified in schedule 3, condition 31 of the Infrastructure Approval for updates to this WMP.

Where additional monitoring infrastructure is proposed outside the construction envelope. Future Generation will review environmental constraints and consult with relevant stakeholders (i.e. NPWS for monitoring infrastructure within the KNP).

2. ENVIRONMENTAL REQUIREMENTS

2.1. Legislation

Legislation relevant to groundwater management includes:

- *Environmental Planning and Assessment Act 1979* (EP&A Act);
- *Environmental Planning and Assessment Regulation 2000* (EP&A Regulation);
- *Protection of the Environment Operations Act 1997* (POEO Act);
- Protection of the Environment (General) Regulation 2009 (POEO General Regulation);
- *Water Management Act 2000* (WM Act);
- *Water Management Amendment Act 2014* (WMA Act);
- Water Management (General) Regulation 2011 (WM General Regulation);
- Water Sharing Plan for the Murrumbidgee Unregulated and Alluvial Water Sources (2012);
- Water Sharing Plan for the NSW Murray-Darling Basin Fractured Rock Groundwater Sources (2011);
- Water Sharing Plan for the South Coast Groundwater Sources (2016); and
- *Snowy Hydro Corporatisation Act 1997* (SHC Act).

Relevant provisions of the above legislation are explained in the register of legal and other requirements included in Appendix A1 of the EMS.

2.2. Conditions of Approval

Table 2-1 details the COA that are relevant to groundwater and demonstrates where these conditions are addressed

Table 2-1: Conditions of approval relevant to groundwater

CoA	Requirement	Where addressed
Schedule 3		
15	**Potential Additional Offsets – Alpine Sphagnum Bogs and Associated Fens** The Proponent must ensure that the development does not cause any exceedances of the following performance measures in the Alpine Sphagnum Bogs and Associated Fens above the Gooandra Volcanics and Kellys Plains Volcanics: (a) negligible change to the shallow groundwater regime supporting the bogs and associated fens when compared to a suitable control site; and (b) negligible change in the ecosystem functionality of the bogs and associated fens.	GMP – Section 7.2.3 and Annexure A Section 2.5.1

CoA	Requirement	Where addressed
16	If the Planning Secretary determines that the development has caused exceedances of the performance measures in condition 15 above, the Proponent must pay additional funds to the NPWS within 3 months of the determination to offset the groundwater-related impacts of the development on the Alpine Sphagnum Bogs and Associated Fens. The Planning Secretary will determine the amount of funds the proponent must pay following consultation with the NPWS, DAWE and the Proponent; and having regard to: (a) The significance of the impacts on the bogs and associated fens; (b) The relevant values from the Biodiversity Offset Payment calculator; and (c) The likely cost of carrying out the conservation actions required to offset these impacts on the bogs and associate fens. *Note: These funds will be added to the funds paid under condition 12 (Biodiversity Offset Payments) and managed in accordance with the notes under that condition.*	Biodiversity Management Plan (S2-FGJ-ENV-PLN-0008)
28	**Water Supply** The Proponent must ensure it has sufficient water for each stage of the development; and if necessary, adjust the scale of development on site to match its available water supply. *Note: Under the Water Management Act 2000, the Proponent must obtain the necessary water licences for the development.*	WMP – Section 2.5.3 SWMP – Section 2.5.3 GMP – Section 2.5.3
29	**Water Pollution** Unless an environment protection licence authorises otherwise, the Proponent must comply with Section 120 of the POEO Act. *Note: Section 120 of the POEO Act makes it an offence to pollute any waters*	SWMP – Table 5-3: SW02, SW22, SW30 GMP – Table 5-1: GW03
30	**Water Mitigation Requirements** The Proponent must:	
	(e) minimise groundwater take from the Gooandra Volcanics and Kellys Plain Volcanics using pre and post grouting of the tunnel, to minimise the loss of stream flows in the waterways above these geological formations, including Gooandra Creek and the headwaters of the Eucumbene River;	GMP – Section 5.1 and Table 5-1: GW04 and GW05
	(o) minimise the groundwater quality impacts of the development, particularly through the design of the temporary and permanent spoil emplacement areas and all water storages on site;	GMP – Section 5.4 and Table 5-1: GW09 Spoil Management Plan (S2-FGJV-PLN-0019)
31	**Water Management Plan** Prior to the commencement of construction, the Proponent must prepare a Water Management Plan for the development to the satisfaction of the Planning Secretary. This plan must:	WMP
	(d) include a Groundwater Management Plan with: • detailed baseline data on groundwater levels, yield and quality on the aquifers that could be affected by the development, and a program to augment this baseline data over time;	This Plan GMP – Annexure A Attachment A
	• a program to validate and calibrate the groundwater model for the development as new information is collected;	GMP – Section 8.2 and Table 5-1: GW12
	• detailed criteria for determining the groundwater impacts of the development, including criteria for triggering remedial action (if necessary)	GMP – Section 6.4
	• a description of the measures that would be implemented to comply with the management requirements in condition 30 above;	GMP – Section 5 and Table 5-1

CoA	Requirement	Where addressed
	• a program to monitor and report on: – groundwater inflows to the tunnel; – water take from the groundwater bores and connected water sources; – the impacts of the development on: o regional and local (including alluvial) aquifers; o base flow to surface water sources;	GMP – Section 6.8 and Annexure A Section 2
38	The Proponent must implement the approved Water Management Plan for the development.	The Water Management Plan will be implemented for the development.
Schedule 4		
5	The Proponent may undertake monitoring outside the construction envelope of the development provided this monitoring is required under the conditions of this approval and authorised under an approved management plan.	WMP – Section 6.3.1

2.3. Revised Environmental Management Measures

During preparation of the Exploratory Works and Main Works Submission Reports, Revised Environmental Management Measures (REMMs) were developed and are included in Appendix C of the Main Works RTS and Section 8 of the Exploratory Works RTS.

The Main Works and Exploratory Works REMMs relevant to groundwater are listed in Table 2-2 and Table 2-3. In accordance with CSSI 9687, schedule 2, CoA 3, if there is any inconsistency between the Exploratory Works and Main Works documents, the most recent document will prevail to the extent of the inconsistency (i.e. Main Works).

Table 2-2: Main Works revised environmental management measures relevant to groundwater

Impact	Reference	Environmental Management Measures	Where addressed
General	WM01	A Water Management Plan will be developed for Snowy 2.0 Main Works that includes:	WMP
		• proposed mitigation and management measures for all construction water management categories;	WMP – Section 4.1 SWMP – Table 5-3 (All measures) GMP – Table 5-1 (All measures)
		• a surface and groundwater monitoring program;	GMP – Annexure A SWMP – Annexure A
		• water quality trigger action response plan;	GMP – Section 7, Annexure B, Annexure C, Annexure D SWMP – Section 6.4, Annexure B
		• reporting requirements;	WMP – Section 6.6 SWMP – Section 6.7 GMP – Section 6.8
		• corrective actions;	GMP – Section 7 SWMP – Section 6
		• contingencies; and	GMP – Table 5-1: GW13 SWMP – Section 5.3.1, Section 5.14 and Section 6.4
		• responsibilities for all management measures.	GMP – Table 5-1 SWMP – Table 5-3
General	WM02	A water monitoring program will be developed as part of the water management plan to monitor quality and quantity impacts to surface water, groundwater and reservoirs. The water monitoring program will incorporate and update the existing monitoring network and detail monitoring frequencies and water quality constituents.	GMP – Annexure A SWMP – Annexure A
Groundwater modelling	WM06	The groundwater model developed for Snowy 2.0 Main Works will be validated and, if necessary, recalibrated to new groundwater monitoring data as the monitoring record increases throughout construction. It is recommended that assessment of the monitoring record and groundwater affecting activities, along with model updates, be undertaken at least annually throughout construction and into operation until it is evident that the update frequency can be reduced.	GMP – Section 8.2
Groundwater inflow / drawdown	WM07	Where discrete high flow features are intercepted, pre-grouting and secondary grouting from the tunnel boring machines (TBMs) may be undertaken to enable tunnel construction.	GMP – Section 5.1.4, Section 5.1.5 and Table 5-1: GW05
Impacts to GDEs	ECO3	A GDE monitoring program will be implemented to assess actual impacts against predicted. If actual impacts are greater than predicted, adaptive management will be implemented.	GMP – Section 3.9, Section 4.2.4, Section 7.2.3 and Annexure A

Table 2-3: Exploratory Works revised environmental management measures relevant to groundwater

Impact	Reference	Requirement	Where addressed
Leaching/ running into groundwater/ creeks	WAT01	Management measures will be implemented to minimise potential environmental impacts to water and soil from hydrocarbon and chemical spills and leaks including: • minimising direct access to the river by construction vehicles and mechanical plant; • regular inspection of construction vehicles and mechanical plant for leakage of fuel and /or oils; • establishing a bunded area for storage of fuel and oils; • refuelling and maintenance of vehicles and mechanical plant at least 50 m from watercourses; • avoiding as far as possible re-fuelling, washing and maintenance of land-based vehicles and plant within 50 m of watercourses; • reporting spillages to the appropriate officer and immediately deploying spill containment and / or absorption kits as required to restrict its spread; • vehicles, vessels and plant would be properly maintained and regularly inspected for fluid leaks; • emergency spill kits will be kept onsite, at refuelling areas and on all vessels at all times during the Exploratory Works. The spill kit will be appropriately sized for the volume of substances on the vessel. All staff would be made aware of the location of the spill kit and trained in its use; • if any hydrocarbon spills were to occur during soil stripping, the impact will be isolated and clean-up procedures implemented; • areas to be used for long-term storage and handling of hydrocarbons and chemicals will be enclosed with concrete bunds; • chemicals will be handled and stored as per manufacturer's instructions; and • below ground, refuelling will be undertaken in dry, enclosed, bunded areas;	GMP - Section 5, Table 5-1: GW02, GW06, GW07, GW08 SWMP - Section 5.4, Table 5-3: SW36, SW37, SW38, SW39, SW40 and SW41, Annexure C (Spill Response Procedure)
Surface and groundwater	WAT02	A Surface and Groundwater Monitoring Program will be developed and implemented to monitor the effectiveness of water quality controls. The program will include:	GMP – Annexure A SWMP – Annexure A
		• establish monitoring locations to provide suitable baseline and detection monitoring of surface and groundwater parameters;	GMP – Annexure A SWMP – Annexure A
		• monitor groundwater inflows indirectly through the process water system and groundwater levels as well as groundwater quality during construction; and	GMP – Annexure A
		• set out annual monitoring requirements for Yarrangobilly Caves and plant community types potentially reliant on groundwater.	GMP – Annexure A Biodiversity Management Plan (S2-FGJ-ENV-PLN-0008)
	WAT03	Areas of groundwater inflow will be shotcreted or sealed by other methods to minimise further ingress.	GMP – Section 5.1.4, Section 5.1.5 and Table 5-1: GW05
		If groundwater is intercepted and reductions to groundwater inflows to watercourses predicted, then groundwater should be discharged to waterways. This	GMP – Section 5.3 and Table 5-1: GW13

Impact	Reference	Requirement	Where addressed
		would occur following appropriate treatment of discharge water.	
Borehole drilling	M1.6	During borehole drilling slurries used will be of appropriate grade and composition such that it poses no threat to groundwater quality should it infiltrate intersected aquifers.	GMP – Table 5-1: GW08

2.4. EPBC Approval

The EPBC Act approval for Snowy 2.0 Main Works was granted by DAWE in 2020. This approval was provided for the impact of the Snowy 2.0 Main Works Project on national heritage values of a national heritage place (Sections 15B and 15C of the EPBC Act), listed threatened species and communities (Section 18, Section 18A of the EPBC Act) and listed migratory species (Section 20, Section 20A of the EPBC Act).

Table 2-4 details the EPBC Act Approval conditions which are relevant to water and demonstrates where these conditions are addressed.

Table 2-4: Commonwealth conditions of approval relevant to water

Condition	Requirement	Where addressed
17	To minimise impacts on water resources, the approval holder must comply with conditions 30 – 32 of the NSW approval relating to water management	Refer to Table 2-1
18	The approval holder must prepare the Water Management Plan required by condition 31 of the NSW approval in consultation with the Department, before it is approved by the NSW Planning Secretary	Section 1.7
19	The Water Management Plan must include provisions to make monitoring data (excluding sensitive ecological data) available as part of the monitoring, evaluation and reporting programs required by condition 31c and 31d of the NSW approval	Section 6.8
20	Once the Water Management Plan is approved by the NSW Planning Secretary, the approval holder must implement the plan for the duration of the approval, unless otherwise agreed by the Minister in writing.	This SWMP will be implemented for the development Refer to Section 6.

2.5. Licences and Permits

2.5.1. Environment Protection Licence

Environment Protection Licence (EPL) (No. 21266) was issued as part of the Exploratory Works phase for extractive activities and includes requirements for groundwater protection. The present boundary for the Exploratory Works EPL is proposed to be expanded to encompasses both Exploratory Works and Main Works activities with the governing scheduled activity to become Electricity Generation.

The groundwater requirements in the current Project EPL (No. 21266, dated as variation 8th April, 2020; Notice Number 1592566) will be adhered to and includes groundwater monitoring. Future groundwater monitoring requirements of the EPL may differ to that detailed within this Plan, in the event of variations to the EPL. Differences may include changes to the monitoring locations; changes to the frequency of monitoring, or changes to the parameters which are required to be monitored.

Should differences arise, the monitoring requirements of the active EPL will take precedence.

2.5.2. Agreement for Lease

Snowy Hydro Limited have established an Agreement for Lease (AFL) with NPWS. A Construction Lease and Works Access Licence will be established with NPWS in order to carry the works in accordance with Main Works, Exploratory Works, CSSI 9687 and the approved management plans.

2.5.3. Water Access Licencing

Section 60A of the *Water Management Act 2000* requires that a water access licence be obtained to extract water from a water source.

Section 21 and schedule 4 of the *Water Management (General) Regulation 2018* does, however, provide exemptions for the requirement to obtain water access licences. These exemptions include: water extracted for the use as dust suppression by a public authority (clause 5); certain aquifer interference activities (i.e. pump testing a bore; or monitoring) requiring up to 3 ML of groundwater from a groundwater source (clause 7) and operation of a hydro-electric power station for the purpose of generating hydro-electric power (clause 11).

Water access licences would therefore not be required if Snowy Hydro, as the licence holder, is using the water for dust suppression, or for certain aquifer interference activities (i.e. pump testing a bore; or monitoring) with less than 3ML of groundwater take in a water year.

Any other water required for construction purposes requires a water access licence. This includes extraction for:

- interception activities (i.e. intercepted groundwater during tunnelling);
- potable uses for human consumption associated with the accommodation camp; and
- process water, via the services pipeline from Talbingo and Tantangara Reservoirs, for tunnelling and construction activities.

The Project will intercept two groundwater sources (see Figure 2-1): Lachlan Fold Belt Murray Darling Basin (LFB MDB) groundwater source and the Lachlan Fold Belt South Coast (LFB SC) groundwater source.

Snowy Hydro have secured two groundwater access licences (WAL42408, WAL42960) and a surface water specific purpose access licence (WAL42407) for the Exploratory Works Project. These three licences allow for direct and indirect take of water from the LFB MDB) groundwater source and direct take from the Upper Tumut water source (i.e. from Talbingo Reservoir).

Snowy Hydro are in the process of finalising groundwater licences via Controlled Allocation Order for additional share entitlement from the LFB MDB groundwater source (RO13-19-093), the LFB South Coast groundwater source (RO13-19-192) and a surface water specific purpose access licence (to take water from Tantangara Reservoir) for the Main Works Project. The additional allocation covers the peak predicted annual take modelled for both Main Works and Exploratory Works.

These Water Access Licenses are being processed by the Natural Resources Access Regulator (NRAR) and registration with NSW Land Registry Services (LRS) has commenced. Actual take will be reported to NRAR on an annual basis in accordance with licence conditions.

Table 2-5 summarises the licencing arrangements.

Table 2-5: Water access licences

Water Access Licence	Project	Water source	Share (ML)
WAL42407– Specific Purpose Access Licence	Exploratory Works	Upper Tumut water source	227
WAL42408 – Groundwater Licence	Exploratory Works	Lachlan Fold Belt MDB	0
WAL42960 – Groundwater Licence	Exploratory Works	Lachlan Fold Belt MDB	354
RO13-19-093 – via Controlled Allocation	Main Works	Lachlan Fold Belt MDB	3,375
RO1-19-092 – via Controlled Allocation	Main Works	Lachlan Fold Belt South Coast	1,722
Specific Purpose Access Licence (under application)	Main Works	Tantangara Water Source	In progress

2.6. Guidelines and standards

The main guidelines, specifications and policy documents relevant to this Plan include:

- Australian & New Zealand Guidelines for Fresh & Marine Water Quality (ANZG, 2018)
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ 2000);
- Australian Drinking Water Guidelines (Natural Resource Management Ministerial Council (NRMMC), 2011);
- Groundwater Dependent Ecosystems Risk Assessment Guidelines (NOW 2012d);
- NSW State Groundwater Quantity Management Policy (2001 (unpublished));
- NSW State Groundwater Quality Protection Policy (DLWC 1998);
- NSW State Groundwater Dependent Ecosystem Policy (DLWC 2002);
- Australian Groundwater Modelling Guidelines (National Water Commission 2012);
- National Water Quality Management Strategy Guidelines for Groundwater Quality Protection in Australia (NWQMS 2013);
- Department of Primary Industries Guidelines for Controlled Activities (2012);
- Environment Protection Authority (EPA): Approved methods for Sampling and Analysis of Water Pollutants in NSW (EPA 2004);
- Department of Planning and Environment (DPR): Guideline for riparian corridors on waterfront land (DPE 2012);
- Department of Water and Energy (DWE): NSW Water Extraction Monitoring Policy (DWE 2007); and
- NSW Office of Water (NoW) NSW Aquifer Interference Policy (NoW 2012).

Other reference documents include:

- *Snowy 2.0 Environmental Impact Statement Volume 3, Appendix J, Water Assessment Annexure A, September 2019;*
- *Snowy 2.0 Main Works - Preferred Infrastructure Report and Response to Submissions,* Appendix I, *Revised Water Modelling Report, February 2020;* and
- *Snowy 2.0 Main Works - Preferred Infrastructure Report and Response to Submissions,* Appendix J, *Revised Water Management Report*, February 2020

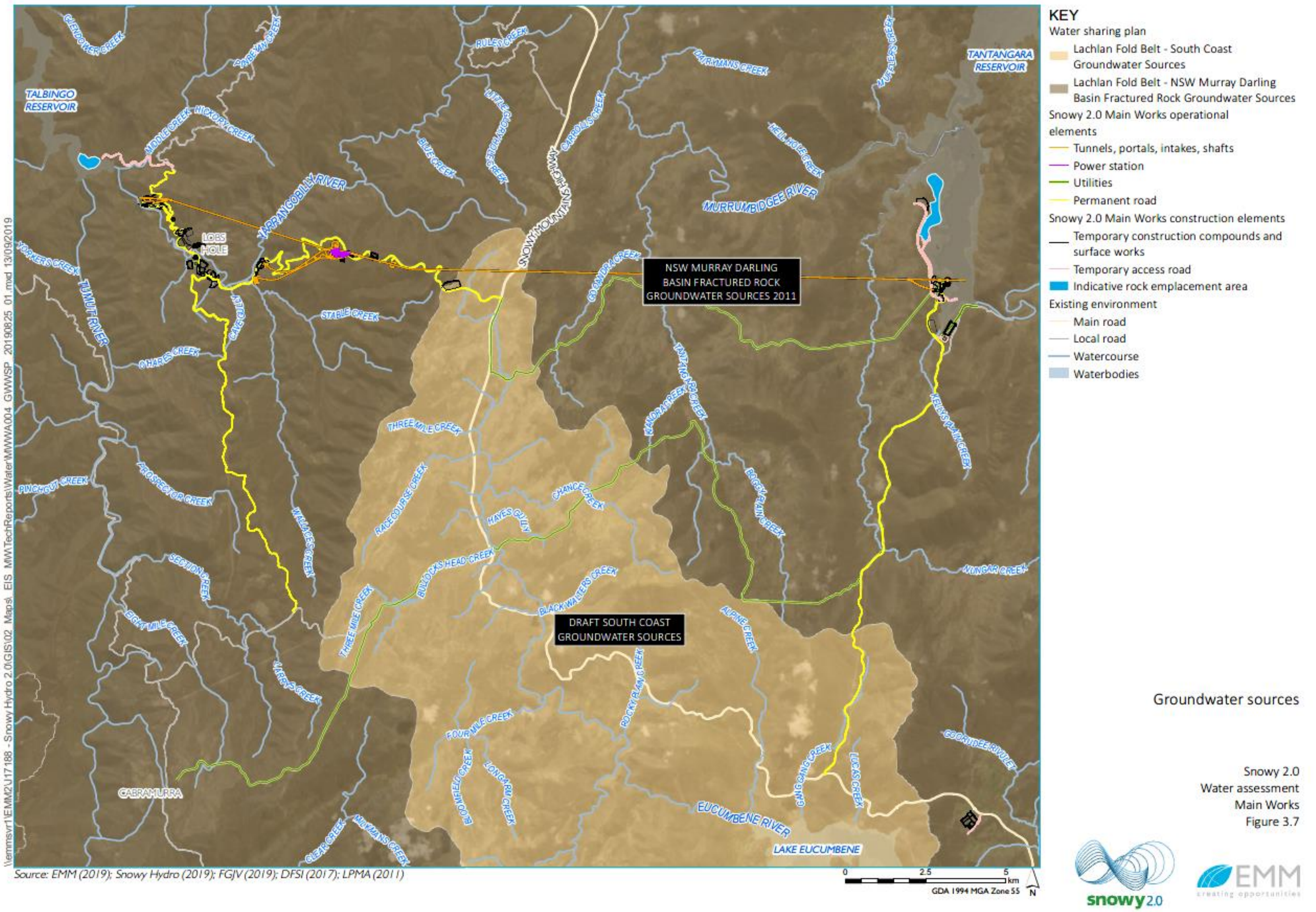


Figure 2-1: Groundwater sources intercepted by the Main Works

3. EXISTING ENVIRONMENT

The following section identifies the factors influencing groundwater within the Project area and has been summarised from the following EIS documents to provide pertinent detail relating to the Project:

- Main Works EIS Section 6.2 (Water) and Section 6.5 (Land);
- Main Works EIS Appendix J (Water assessment); and
- Main Works EIS Appendix O.1 (Palaeozoic Geodiversity Assessment) and Appendix O.2 (Cenozoic Geodiversity Assessment).

Hydrogeology across the project area has been informed by a groundwater monitoring network, designed specifically to investigate the hydrogeological conditions of the project area; developed as part of the EIS approval.

3.1. Topography and Landscape

The Snowy 2.0 Project is mostly located within the KNP and spans the NSW Western Slopes, South Eastern Highlands and Australian Alps Interim Biogeographic Regionalisation for Australia (IBRA) regions. The geomorphic history of the project area is complex and has resulted in a landscape of disrupted drainage patterns, swampy basins and erosion surfaces (Snowy Hydro 2017). This complexity is seen in the diverse landforms present in the area, ranging from valleys to mountain ranges. For the most part, the project area can be broken into two distinctive terrains: the incised ravine area and the plateau area.

The ravine area is located mostly to the west of the Snowy Mountains Highway and is characterised by deep gorges and steep sloping ridges. It is the product of incision from river flow, historic glaciation and structural movement. The ravine area includes the Talbingo, Lobs Hole, Lobs Hole Ravine Road and Marica work sites.

The plateau area is located to the east of the Snowy Mountains Highway and spans the area between the highway and Tantangara Reservoir. This area is typical of elevated alpine environments, dominated by low energy streams, gentle rolling hills and mostly flat floodplains. The plateau area includes the Plateau and Tantangara work sites.

The landscape varies from 545m AHD in the Ravine area (Lobs Hole) leading up the valleys (Marica/ Plateau zones) to the plateau topped Tantangara zone at 1524m AHD.

The Rock Forest work site is located on farm land outside the KNP; 13 km to the south of Tantangara Reservoir. No underground nor significant excavations are proposed at this site, hence there will be no impacts to groundwater and this area is not considered further for groundwater management.

3.2. Climate

The project area has an alpine climate characterised by cool summers and cold, damp and snowy winters. The highest and most consistent precipitation occurs during winter to early spring, with precipitation amounts increasing with elevation. Summer and autumn are generally drier and experience greater inter-annual variation in monthly rainfall. Summer rainfall is generally of higher intensity and of shorter duration than that in winter. Climate data for the project area has been sourced from regional Bureau of Meteorology (BoM) and Snowy Hydro rainfall gauges, as well as climate maps produced by BoM.

A summary of climate data for the ravine and plateau areas is provided in Table 3-1. Precipitation comprises rainfall and snowfall; the term rainfall has been used throughout the water assessment to maintain consistency with other sections of the Main Works EIS.

Table 3-1: Climate Summary

Parameter	Ravine area	Plateau area
Temperature[1]		
Mean annual maximum	21.3 C	12.6 C
Mean annual minimum	9.1 C	5.1 C
Annual rainfall[2]		
Highest	1315 mm/year	1,902 mm/year
Median	878 mm/year	1,158 mm/year
Lowest	382 mm/year	525 mm/year
Mean Class A pan evaporation[3]		
Annual	1,256 mm/year	
Lowest monthly	27 mm/month	
Highest monthly	206 mm/month	

1. Representative temperature for the ravine and plateau have been sourced from Snowy Hydro operated Talbingo gauge and BoM operated Cabramurra SMHEA AWS (72161) gauge.
2. Representative rainfall for the ravine and plateau areas have been sourced from Snowy Hydro operated Ravine gauge and BoM operated Yarrangobilly Caves (72141) gauge.
3. Representative pan evaporation sourced from Climate Atlas maps (BoM website).

3.3. Rainfall

The 10th, 50th and 90th percentile monthly rainfall have been calculated by BoM from the closest reliable weather station with adequate temporal records cited at Yarrangobilly Caves (Station No. 72142) and are presented in Figure 3-1. Mean monthly pan evaporation sourced from the BoM website are also shown in Figure 3-1. The long-term record indicates that rainfall generally significantly exceeds evaporation over the winter months (May to October) and recharge to shallow systems might be expected during this period. A soil moisture deficit is likely to occur from December to March, when monthly evaporation exceeds the 90th percentile rainfall and these months are likely to result in seasonal drops in connected water tables.

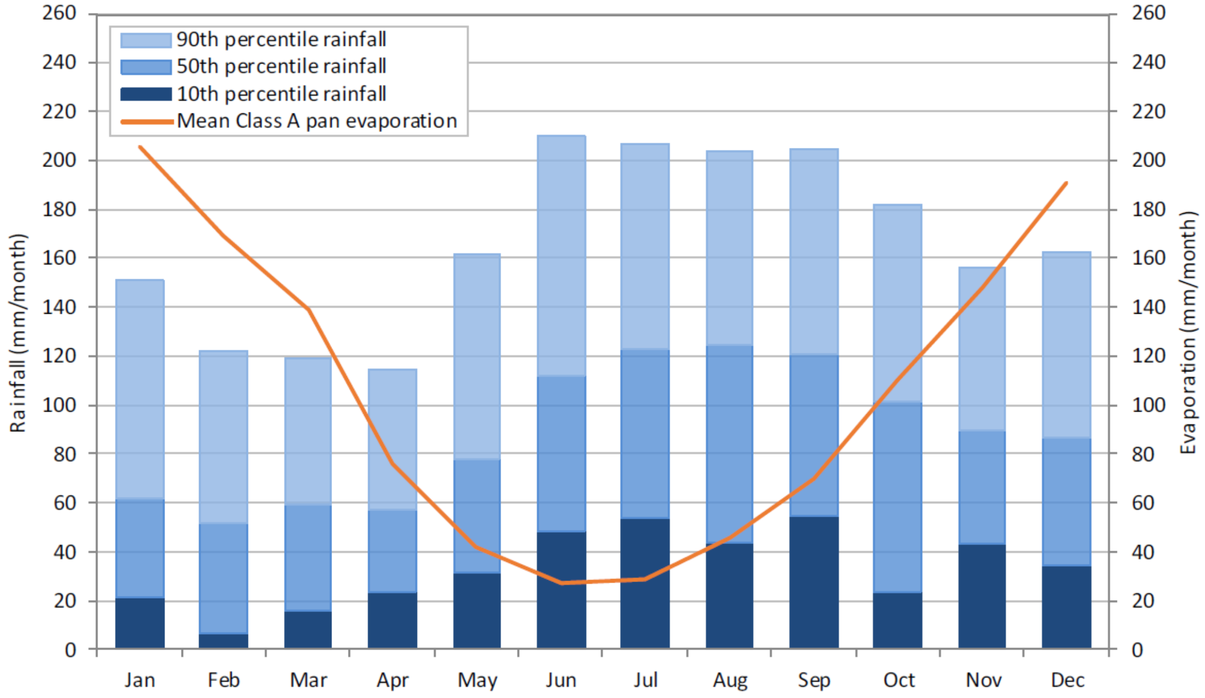


Figure 3-1: Monthly rainfall variability (BoM: 72141) and mean monthly pan evaporation

Long-term monthly rainfall totals recorded at Yarrangobilly Caves (BoM station 72141) from 1999 to March 2019 are shown in Figure 3-2. The deviation of rainfall totals over the previous 12-month period have been calculated and compared to annualised monthly average rainfall to identify and characterise periods of extended dry and wet conditions.

The horizontal line in Figure 3-2 marks the distinction between positive and negative rainfall deviation values. Positive or increasing values relate to wetter than average conditions while negative or falling values relate to drier than average conditions. These deficits and excess in rainfall can also correspond to long-term groundwater level and streamflow trends, with actual conditions reliant on the antecedent conditions of the soil profile. The trends in Figure 3-2 indicate that:

- Below average rainfall occurred between mid-2002 to late 2003, mid-2004 to early 2005, mid-2006 to late 2010, early 2013 to mid-2016 and mid-2017 to mid-2019. The most significant below average rainfall conditions occurred between mid-2006 and late 2010.
- Above average rainfall occurred between 1999 and mid-2002, April 2005 to May 2006, late 2010 to early 2013 and mid-2016 to mid-2017.

The cyclic and seasonal variability is critical in the evaluation of groundwater dependent ecosystem (GDE) functionality and provides context for baseline data collected during the EIS period.

It is noted that data collected for this EIS during 2018 and early 2019 was collected during drier than average conditions.

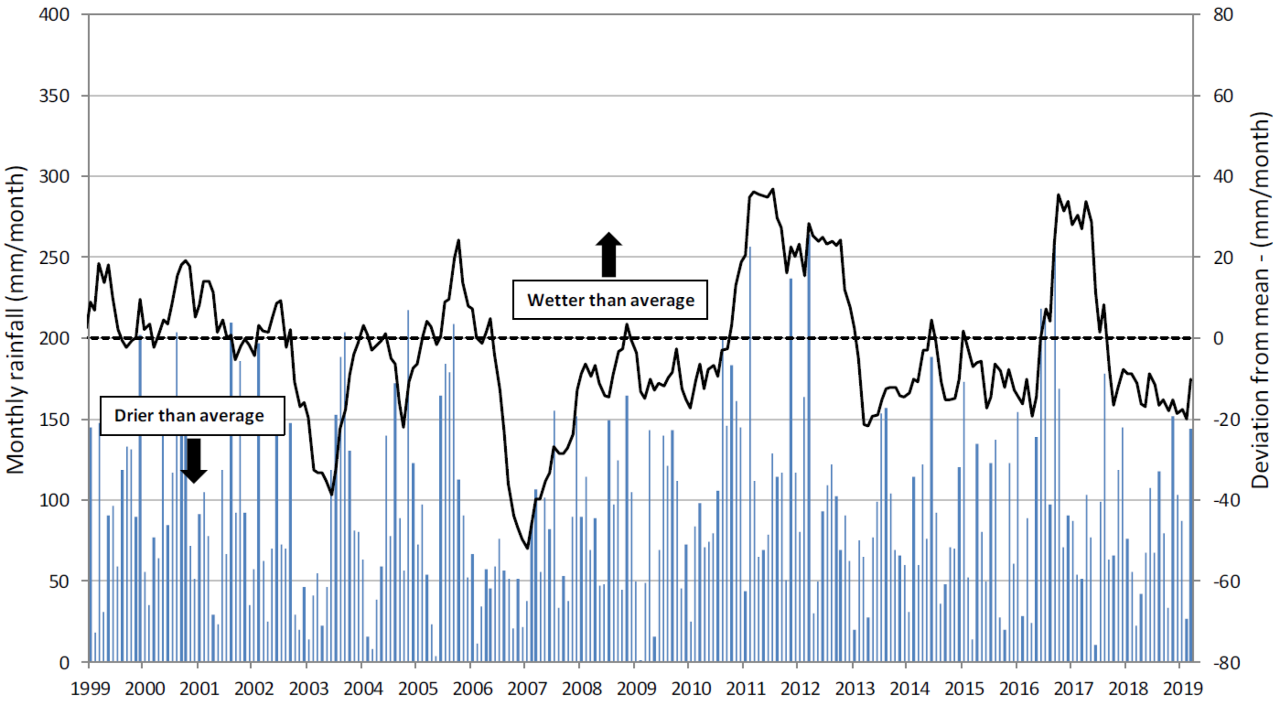


Figure 3-2: Long-term Yarrangobilly Caves (BoM: 72141) rainfall record

3.4. Bushfire

In January 2020, during the Main Works EIS application, significant bushfires occurred within the Project area and northern section of Kosciuszko National Park. The project site at Lobs Hole was severely impacted with much of the groundcover and trees burned, leaving the catchment area with bare soil and no ground protection. Other parts of the Main Works project area including the Plateau, Marica and Tantangara were also impacted by the bushfire to varying degrees.

The bushfires have led to a reduction in ground cover and increase in burnt ash material within and adjacent to the construction envelope. It is likely that, for some time, the existing pre-fire baseline water data that has been gathered and discussed in the Surface Water Management Plan (Appendix A) and Groundwater Management Plan (Appendix B) will differ to the post-fire water quality.

3.5. Geology

The Project area is located within the south-eastern portion of the Lachlan Fold Belt (LFB) of NSW. The LFB comprises a suite of Ordovician to Devonian sedimentary, igneous and metamorphic rocks that have been laid down, compacted and deformed across multiple orogenic periods (Figure 3-3).

The geology between Talbingo and Tantangara reservoirs is structurally deformed with numerous tight folds and several major faults. The region is associated with a strong north-south axial trend and strike which has a dominant control on topography and sub-surface groundwater movement.

The project intercepts two major structural blocks. These two structural blocks form distinct geological terrains: the dominantly Silurian Tumut Block in the west (the incised Ravine area), and the dominantly Ordovician Tantangara Block in the east (the raised Plateau area). The terrains are geologically and topographically separated by an escarpment caused by movement on the Long Plain Fault (LPF).

The key geological formations for each block are listed in Table 3-2 and illustrated schematically in Figure 3-3.

Table 3-2: Key geological formations

Plateau	Ravine
Tertiary Basalt, Kellys Plain Volcanics, Boggy Plain Suite, Peppercorn Formation, Tantangara Formation, Temperance Formation, Shaw Hill Gabbro and the Gooandra Volcanics	Boraig Group, Byron Range Group, Ravine Beds and Yarrangobilly Limestone. Within the Tantangara Block

Also of note, there are eight karst areas in Kosciusko National Park (KNP), all of which are developed in Silurian or Devonian limestones. These include Yarrangobilly Caves, a known GDE and karst area, and Coolemans Plain karst area. Both are recognised in the KNP Plan of Management (DEC 2014) for their cultural and natural significance.

This complex geology, and resulting topography, has resulted in a diverse soil landscape. Soils vary significantly in relation to altitude, temperature and rainfall. In particular, development of relatively fragile Alpine Humus Soils on the Plateau, across all geological materials, is recognised for the Alpine Shagnum Bogs and Associated Fens ecological communities that they support.

The EIS identified two high-risk geological formations: the Gooandra Volcanics and Kellys Plain Volcanics, both of which are located in the Plateau structural block, the Gooandra to the west adjacent to the escarpment and Kellys Plain to the east adjacent to Tantangara Reservoir. These formations have demonstrated (through pumping tests) vertical hydraulic connections between shallow and deeper horizons within each geological unit.

The Ravine area can be further delimited into the eastern and western units, with units becoming more calcareous to the west. This has implications on the groundwater transmissivity and water quality as summarised in Sections 3.6 and Section 3.11.

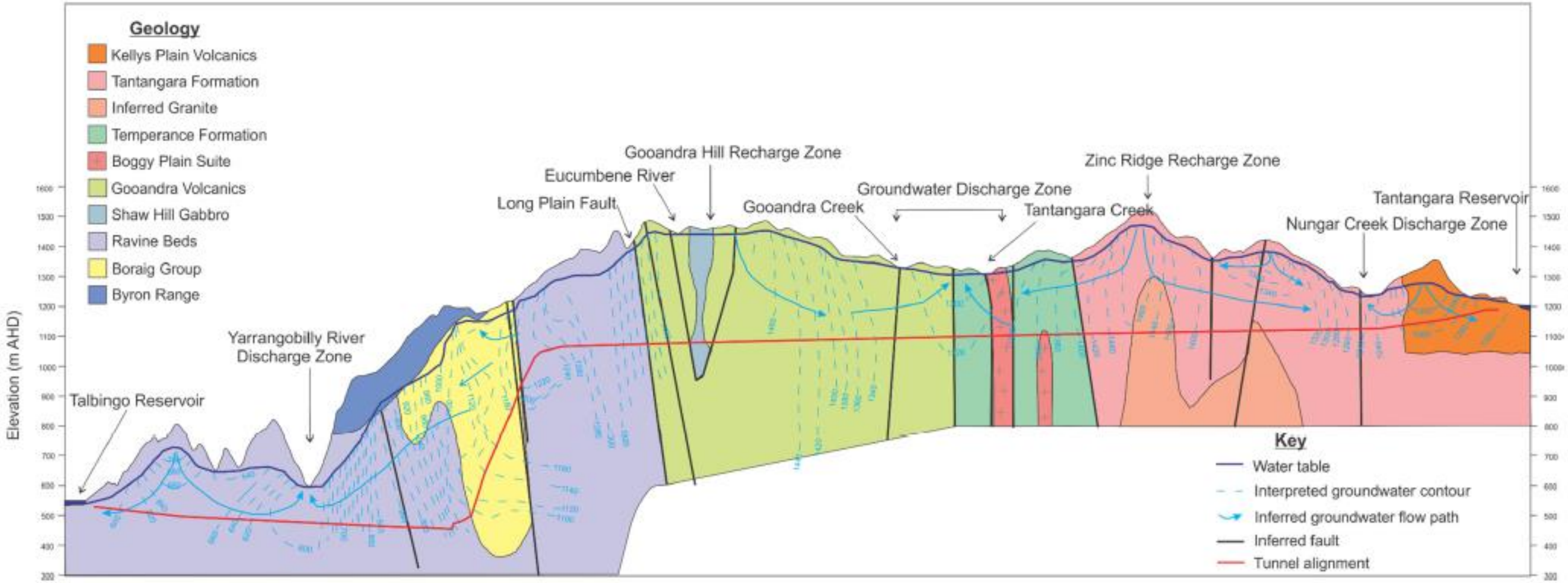


Figure 3-3: Interpreted groundwater recharge, discharge and flow patterns along the tunnel alignment

3.6. Hydrogeology and groundwater units

As defined above, most of the project area is located between the Talbingo and Tantangara reservoirs, within the Tumut (Ravine) and Tantangara (Plateau) structural blocks.

The groundwater-bearing units within the project area are defined as:

- a localised highly permeable shallow groundwater system associated with the thin basalt caps present across the Plateau area;
- a low permeability fractured rock groundwater system associated with the weathered and oxidised shallow component of the geology across the Plateau area;
- a low permeability regional fractured rock groundwater system associated with the volcanic and metasedimentary rocks across the Plateau and Ravine areas.

The hydrogeological units of the project thus transgress the geological units and may be defined as:

- Alluvium, colluvium and surficial weathered rock: These shallow units are generally highly transmissive and are recharged by moderate to high rainfall events; flooding in alluvial areas and from snow melt.
- Shallow, weathered fractured rock: These units have low to moderate permeability and are recharged by moderate to high rainfall events and snow melt when saturated soil moisture conditions are exceeded.
- Deep, fractured rock: Permeability is generally lowest in the central section of the plateau and higher in the east and western areas of the plateau. These units are recharged by infiltration of rainfall migrating through shallow groundwater systems. Groundwater flow can be downward in recharge areas and upward in discharge areas.

Localised groundwater systems are also associated with unconsolidated Quaternary alluvium and colluvium deposited along major creeks and river valleys, and in depressions across the Plateau and Ravine areas.

The deeper fractured volcanic and metasedimentary rocks form the main hydrogeological units in the project area. The groundwater in these units is accessed by various environmental users, including alpine bog/fen vegetation and deep-rooted Eucalypt species. Where it discharges it provides baseflow to gaining creeks and rivers. Groundwater within the fractured rock unit is generally fresh but low yielding when accessed by bores.

The volcanics intercepted by the project across the western Plateau area have been extensively deformed through structural movement and exhibit enhanced secondary porosity and vertical connection.

The metasedimentary units located across the remainder of the Plateau area (mostly closer to Tantangara Reservoir) and within the Ravine area are generally more massive with reduced permeabilities.

3.7. Groundwater recharge, discharge and flow

An overview of groundwater recharge, flow and discharge processes are outlined in Table 3-3.

Table 3-3: Summary of groundwater processes in the Project area

Parameter	Plateau	Ravine
Groundwater recharge	Groundwater recharge is predominantly from rainfall and snowmelt. Recharge is higher when the soil and weathered rock is saturated which generally occurs during winter and spring or after significant rainfall events.	The ravine groundwater system is largely recharged by rainfall and through flooding of the Yarrangobilly River (and storages), and the lateral movement of groundwater from higher elevations, such as from the plateau and elevated Ravine Bed outcrops.
Groundwater flow	Groundwater flow processes include: • groundwater flow within the colluvium/alluvium (when saturated) via primary porosity and within the shallow and deeper fractured rock via secondary porosity (i.e. fractures, joints and bedding planes); • regional groundwater flow towards the east, influenced by stratigraphy, dip of the strata, faulting, fractures and topography; • downward gradients mostly observed between shallow and deeper groundwater systems in recharge areas and upward gradients in discharge areas; • steeper vertical gradients where creeks/rivers are incised and escarpments occur.	Groundwater flow processes include: • groundwater flow away from the Long Plain Fault (LPF), which represents a regional high point and is considered a flow boundary with regional groundwater flow from the LPF moving east to the plateau and west to the ravine. • the bulk of groundwater movement and permeability in the shallow and deep groundwater systems determined by secondary (fracture) porosity, while permeability in the alluvium and colluvium is predominately via primary (matrix) porosity. • localised groundwater flow and direction largely controlled by stratigraphy, dip of the strata, faulting, fractures and topography.
Groundwater discharge	Groundwater discharge processes include: • drainage to surface water (as baseflow to tributaries); • evaporation from the water table where it is shallow (as seeps, springs and escarpments); • evapotranspiration from overlying GDEs (such as some alpine bogs and fens) and vegetation intercepting shallow groundwater systems; • regional groundwater throughflow toward Tantangara Reservoir in the east.	Groundwater discharge processes include: • drainage to the Yarrangobilly River and its tributaries; • evapotranspiration from overlying vegetation intercepting shallow groundwater systems; • seepage/springs and evaporation along escarpments; • regional groundwater throughflow toward Talbingo Reservoir.

3.8. Extractive Water Users

There are no registered groundwater users within the project area nor within 20 km of the Project area boundary.

3.9. Groundwater Dependent Ecosystems

3.9.1. High Priority GDE

The relevant water sharing plans do not identify any High Priority GDEs within the Project area. High priority GDEs are defined as those with high ecological value as determined in the relevant Water Sharing Plans.

The nearest High Priority GDE is the Yarrangobilly Caves which is located approximately 5 km north of the nearest infrastructure feature of the Project and is listed in the Water Sharing Plan (WSP) for the LFB Murray Darling Basin (MDB) Fractured Rock groundwater source.

3.9.2. Type 1 (Sub-surface) GDE (Stygofauna)

A stygofauna assessment by Macquarie University (2019) was undertaken as part of the RTS assessment and identified a total of five specimens, from two families, likely to be obligate (fully groundwater-dependent) stygofauna representatives, from one of the 11 fractured rock sites (TMB02A) and two of the five Alpine bog and fen sites (GH01, GH02). A further 80 specimens from five groups, with potential to be obligate stygofauna representatives, were collected from four of the 11 fractured rock sites and four of the five Alpine bog and fen sites

Limited stygofauna studies have been undertaken within fractured rock aquifers of the region, thus there is limited data for comparison. The stygofauna found in the aquifers in the Snowy 2.0 Project area are noted to be similar to those encountered in other fractured rock systems in NSW.

3.9.3. Type 2 (Aquatic) GDE

Aquatic GDEs are dependent on baseflow in non-perennial rivers and creeks. Across the Project region, all rivers comprise both runoff and baseflow components as shallow groundwater tables are consistently above creek bed elevations. All creeks are therefore considered to support Type 2 GDEs. In particular, PCT 300 occurs along drainage lines on mid-slopes across the Project area and PCTs 285, 299 and 302 occur in riparian zones and gullies (Figure 3-4) where there is likely to be some near-surface expression of groundwater (Main Works EIS, Appendix M.1-01 – Part A9)

3.9.4. Type 3 (Terrestrial) GDE

Terrestrial GDEs include vegetation that accesses groundwater to maintain ecosystem function. These are classified according to their proportional (temporal) dependence on groundwater. This classification is conceptually described and shown in Figure 3-5.

Plant communities with varying degrees of groundwater dependence within the project area are listed in Table 3-4 and shown in Figure 3-5.

Table 3-4: Terrestrial GDE

Groundwater dependence	Mapped plant community type (PCT)
Entirely/obligate dependence on groundwater	• PCT 637 - Alpine and sub-alpine peatlands, damp herbfields and fens, South Eastern Highlands Bioregion and Australian Alps Bioregion; • PCT 1225 - Sub-alpine grasslands of valley floors, southern South Eastern Highlands Bioregion and Australian Alps Bioregion.
Facultative – proportional dependence on groundwater	• PCT 285 - Broad-leaved Sally grass - sedge woodland on valley flats and swamps in the NSW South Western Slopes Bioregion and adjoining South Eastern Highlands Bioregion; • PCT 299 - Riparian Ribbon Gum - Robertsons Peppermint - Apple Box riverine very tall open forest of the NSW South Western Slopes Bioregion and South Eastern Highlands Bioregion; and

Groundwater dependence	Mapped plant community type (PCT)
	• PCT 302 - Riparian Blakely's Red Gum - Broad-leaved Sally woodland - tea-tree - bottlebrush - wattle shrubland wetland of the NSW South Western Slopes Bioregion and South Eastern Highlands Bioregion.
Facultative – opportunistic dependence on groundwater	• PCT 300 - Ribbon Gum - Narrow-leaved (Robertsons) Peppermint montane fern - grass tall open forest on deep clay loam soils in the upper NSW South Western Slopes Bioregion and western Kosciuszko escarpment; • PCT 303 - Black Sally grassy low woodland in valleys in the upper slopes sub-region of the NSW South Western Slopes Bioregion and western South Eastern Highlands Bioregion; and • PCT 679 - Black Sallee - Snow Gum low woodland of montane valleys, South Eastern Highlands Bioregion and Australian Alps Bioregion.

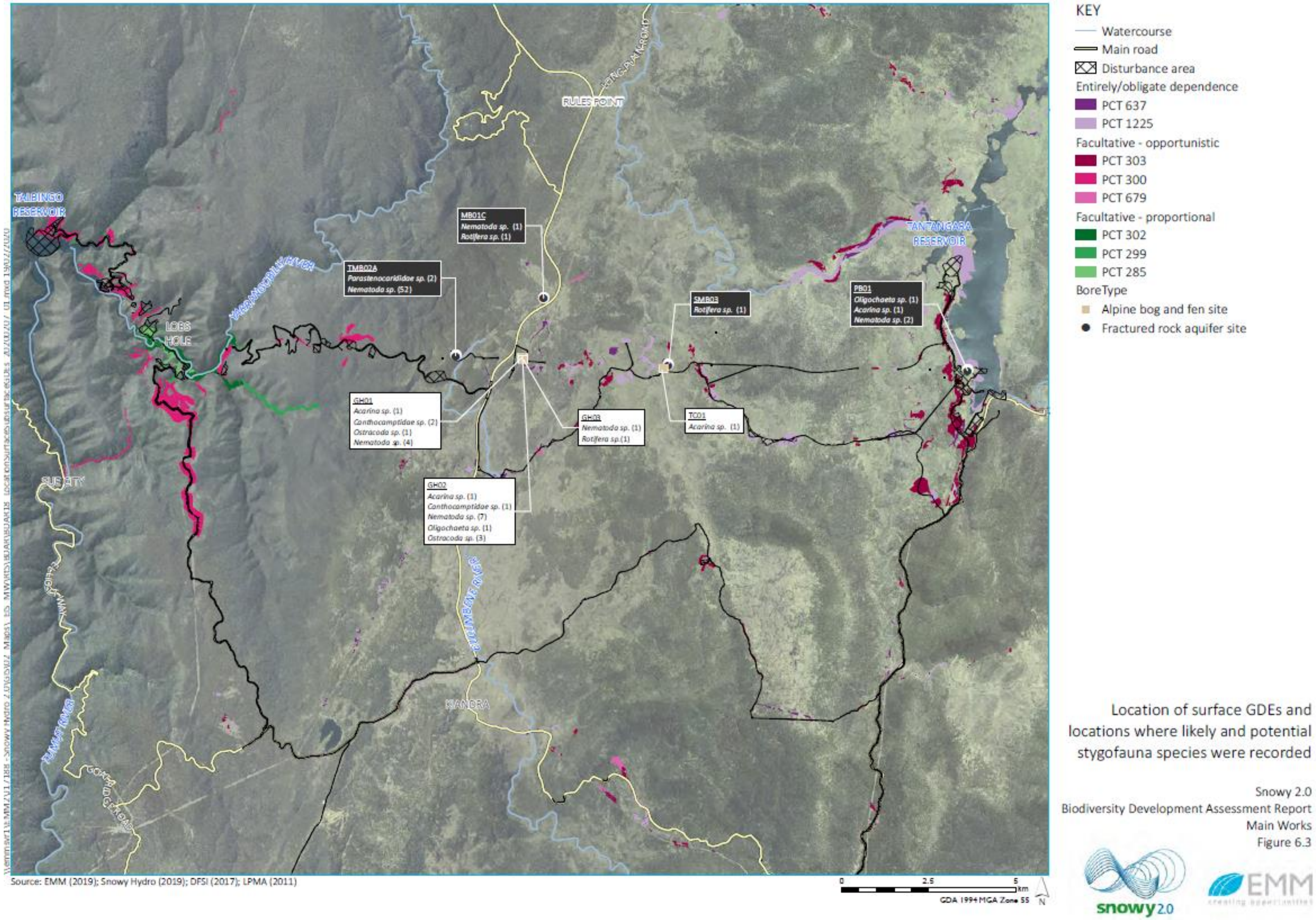


Figure 3-4: Location of terrestrial GDEs

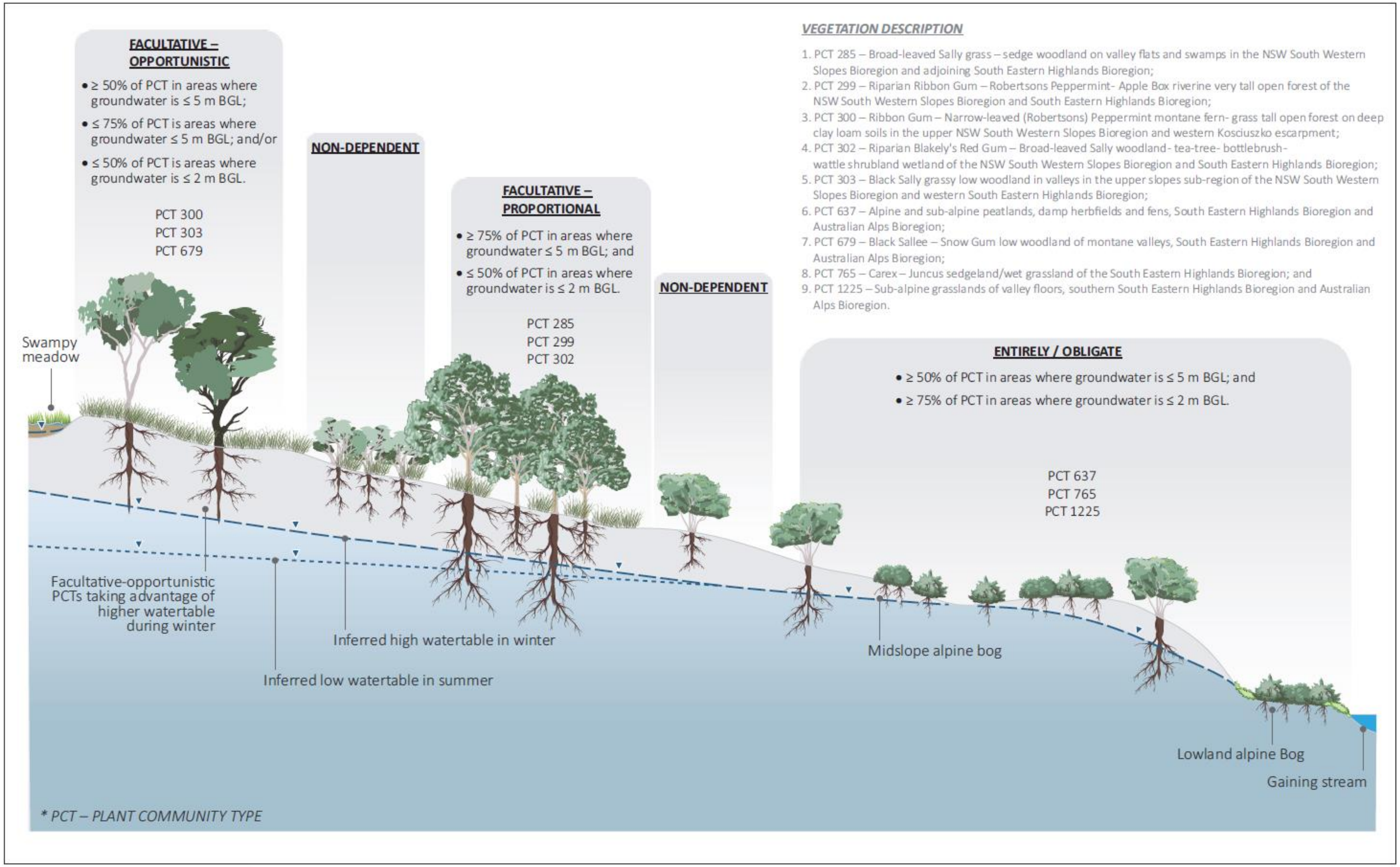


Figure 3-5: Conceptual diagram for Terrestrial GDEs

3.10. Groundwater Levels and Flow

3.10.1. Plateau

Groundwater levels within the plateau are influenced by the relief and generally mirror the topography. Groundwater levels are above the creek beds and therefore groundwater provides baseflow to all streams (gaining streams).

Along the proposed headrace tunnel transect, groundwater levels vary from approximately 1,470 m AHD in the elevated areas adjacent to the LPF in the west, to approximately 1,170 m AHD in the lower elevated area near Tantangara Creek. Overall, groundwater levels observed along the proposed tunnel alignment indicate that groundwater flow direction is generally west to east from the LPF.

Groundwater levels within monitoring bores and deduced from water pressures measured in the vibrating wire piezometers (VWPs) have generally shown fluctuations of less than 10 m during the monitoring period. Groundwater levels within the Gooandra Volcanics, Tertiary basalt, Tantangara Formation, Temperance Formation, Boraig Group, Kellys Plain Volcanics and Boggy Plain Suite generally show a moderate to strong response to rainfall events.

Vertical leakage within the Gooandra Volcanics, Tantangara Formation and Temperance Formation is variable and potentially complex with the direction of vertical leakage (i.e. upwards versus downwards) varying with location and depth within these units, but demonstrating connectivity between the shallow weathered rocks and deeper fractured rocks of the same formations.

Differences between groundwater levels within the Tertiary basalt and underlying Gooandra Volcanics suggests that the Tertiary basalt aquifer is a perched aquifer system.

Further detail regarding groundwater levels and flow within the plateau area is provided in Section 9.2.1 of the EIS water characterisation report.

3.10.2. Ravine

Groundwater levels within the ravine are influenced by the steep relief that exists across the area and generally mirrors the topography. In monitored locations within the project area, groundwater levels are above creeks and streams, therefore suggesting creeks and streams are gaining systems.

Along the proposed headrace tunnel transect, groundwater levels within the Ravine Beds vary from approximately 1,325 m AHD in the topographically elevated terrain adjacent to the LPF in the east, to approximately 570 m AHD in the topographically lower terrain near Lobs Hole. Groundwater flow direction is generally from east to west, with the LPF area acting as a groundwater divide between the ravine and plateau areas.

Groundwater levels within monitoring bores and VWPs have generally shown fluctuations of less than 10 m during the monitoring period. Groundwater levels within the ravine do not typically show an obvious response to rainfall events or flow events within the Yarrangobilly River.

Vertical leakage within the Ravine Beds is downwards with groundwater in the upper horizons of the unit recharging the deeper horizons.

Nested monitoring bores within the Boraig Group have similar groundwater elevation and trends which suggests that the top 70 m or so of Boraig Group sediments are hydraulically connected.

Groundwater levels within the Ravine Beds and Boraig Group show similar elevations and trends at one nested location (TMB01A/TMB02B) which suggests that there may be some degree of hydraulic connection between the Boraig Group and Ravine Beds at this location.

Further discussion on groundwater levels and flow within the ravine area is provided in Section 9.3.1 of the EIS water characterisation report.

3.11. Hydraulic properties

Hydraulic tests were completed to provide site-specific information on the hydraulic properties of the plateau and ravine groundwater systems. Hydraulic properties have been estimated for most of the geological formations intercepted by the tunnel alignment. Derived hydraulic properties allow estimation of groundwater ingress to the tunnel and are used in the groundwater numerical modelling to estimate potential impacts to groundwater systems and hence to groundwater-dependent users and ecosystems. Details are provided in the Water Characterisation Reports (EIS, Appendix J).

3.11.1. Plateau

Hydraulic properties within the plateau are summarised as follows:

- estimated horizontal hydraulic conductivity in the Gooandra Volcanics (mean = 0.01 m/day) are generally higher when compared to the other geological units;
- pumping tests conducted at bores installed within the Gooandra Volcanics and Kellys Plain Volcanics demonstrated vertical hydraulic connection between shallow and deeper horizons within these geological units, with vertical hydraulic conductivities comparable to horizontal hydraulic conductivities (0.01 m/day);
- pumping tests conducted at bores installed within the Temperance Formation and Boggy Plain Suite demonstrated no apparent vertical hydraulic connection between shallow and deeper horizons within these geological units and low horizontal hydraulic conductivities (10^{-5} – 10^{-7} m/day); and
- horizontal hydraulic conductivity is generally decreasing with increasing depth in all the geological units tested.

A summary of hydraulic properties for the plateau region are outlined in Table 9.1 of the EIS Water Characterisation report.

3.11.2. Ravine

Hydraulic properties within the ravine are summarised as follows:

- estimated horizontal hydraulic conductivity in the Ravine Beds West (10^{-3} m/day) are generally higher when compared to the Ravine Beds East (10-4 m/day);
- a pumping test conducted within the Ravine Beds West demonstrated a low to moderate degree of vertical hydraulic connection (10^{-4} m/day) between shallow and deeper horizons within this geological unit; and
- horizontal hydraulic conductivity generally decreases with increasing depth in all the geological units tested.

A summary of hydraulic properties for the ravine region are outlined in Table 9.3 of the EIS Water Characterisation report.

3.12. Groundwater Quality

Aquifer chemistry monitoring results to date are included in the Baseline Data presented as an Attachment to the Groundwater Monitoring Plan (Annexure A) and is summarised in Table 3-5 and below.

Table 3-5: Summary of baseline aquifer chemistry within the Project area

Parameter	Plateau	Ravine
Total dissolved solids (TDS)	Ranges from 14 mg/L (Gooandra Volcanics) to 1,610 mg/L (Temperance Formation)	Ranges from 52 mg/L (Boraig Group) to 1,540 mg/L (Ravine Beds West);
pH	Ranges from 3.5 to 13.0. pH is generally lowest in the bogs and fens and highest within the Kellys Plain Volcanics	Ranges from 4.7 to 8.1. pH is generally highest in the Ravine Beds West when compared to the other monitored geological units.
Major ions	Bicarbonate concentrations in all geological units are generally higher than other major ions with a maximum of 205 mg/L in the Temperance Formation. Calcium, magnesium, chloride, sodium and sulphate are generally less than 100 mg/L.	Bicarbonate concentrations in all geological units are generally higher than other major ions with a maximum of 1,170 mg/L in the Ravine Beds West. Calcium, magnesium, chloride, sodium and sulphate are generally less than 100 mg/L
Metals	Metal concentrations are generally low across all bores, though with aluminium, arsenic, chromium, copper and zinc measured above water quality objectives. Median values remain at or close to the objective concentrations. Concentrations decrease towards the east and only copper and zinc register above WQO levels in the Kellys Plain Volcanics. Iron can be high in the shallow groundwaters supporting the plateau bogs and fens.	Metal concentrations are low (close to or below limits of detection) across all bores, though slight exceedances of water quality objectives are occasionally recorded for most analysed metals except manganese, with zinc, aluminium, arsenic and iron commonly recorded at levels above detection limits. In the west, aluminium, arsenic and boron are observed at elevated levels. Aluminium and iron are commonly reported at levels greater than 1 ppm in the alluvium and colluvium sediments along the river valleys.

In comparison with the water quality objectives (WQOs) for SE Australian Upland Rivers (*see* Section 6.4.1.3), the plateau aquifers' baseline water chemistry indicated:

- samples collected from all plateau aquifers exceeded dissolved oxygen, ammonia, oxidised nitrogen, total nitrogen, total phosphorous and copper WQOs;
- samples collected from most formations (Gooandra Volcanics, Temperance Formation, Boggy Plain Suite, Tantangara Formation, Tertiary Basalt) also exceeded several metals including aluminium, arsenic, boron, chromium, cobalt, copper, iron, lead, vanadium and zinc WQOs;
- the Kellys Plain Volcanics only had one metal exceedance (copper);
- the shallow aquifers associated with Bogs and Fens also had low pH (<6).

In comparison with the WQOs, the ravine aquifers' baseline water chemistry indicated:

- samples collected from all bores exceeded dissolved oxygen, electrical conductivity, ammonia, oxidised nitrogen, total nitrogen, total or reactive phosphorus and several metals including aluminium, arsenic, boron, chromium, cobalt, copper, iron, nickel and zinc WQOs.

4. WATER ASPECTS AND IMPACTS

4.1. Construction Activities

An environmental aspect is an element of an organisation's activities, products, or services that has or may have an impact on the environment (ISO 14001 Environmental management systems). The relationship of aspects and impacts is one of cause and effect.

Key aspects of the Project that may result in impacts to groundwater impacts are identified in Table 4-1 (Column 1). The extent of these impacts will depend on the nature, extent and magnitude of construction activities and their interaction with the natural environment (Column 2). This is further exacerbated by environmental factors (Column 3).

Table 4-1: Project aspects and impacts relevant to groundwater

Environmental Aspects (Construction activities that may impact water)	Environmental Impacts	Environmental Factors (Conditions)
• Tunnelling (causing inflows) • Surface excavations intercepting the groundwater table • Water use and extraction • Dewatering (Discharge of groundwater to surface water, minimising recharge availability) • Refuelling and chemical handling	• Reduction in groundwater availability (quantity) • Reduction (drawdown) in groundwater levels • Reduced groundwater availability for groundwater dependent ecosystems (GDEs) • Groundwater contamination • Reduction in baseflow from groundwater to waterways	• Existing groundwater levels • Existing groundwater fluxes • Existing baseflow dependency • Geology type • Seasonal fluctuations • Existing groundwater quality

4.2. Impacts

4.2.1. Overview

The following predicted impacts are considered conservative due to the design scenario assumptions (i.e. modelling assuming unmitigated tunnel inflows) and the adoption of conservative hydraulic parameters (using relevant limits of field measurements). Therefore, it is considered that the actual tunnel ingress (and subsequent groundwater impacts) will be lower than predicted due to mitigation and management measures already proposed during construction (e.g. pre-grouting and post-grouting of key areas).

The RTS summarised the groundwater impacts as:

- Localised and regional drawdown of groundwater tables, resulting in potential impacts on:
  - Biodiversity, including GDEs, subterranean fauna and aquatic fauna
  - Baseflow to surface water features
- Changes to groundwater quality; and
- Cumulative impacts from any compounding local and regional impacts.

4.2.2. Numerical groundwater modelling

The regional numerical groundwater flow model, referred to as SH4.0, was developed for the Main Works EIS and was based on an unlined, unmitigated (i.e. no grouting) tunnelling scenario. This was done to provide a worst-case (conservative) prediction of potential impacts.

Subsequent to the Main Works EIS, refinement of the inputs into the regional groundwater model have been undertaken to better represent a more realistic outcome. These refinements have focussed on representing the predicted permeability characteristics of the concrete lining (i.e. how much groundwater inflow is expected through the segmented concrete lining of the tunnels) and better estimation of likely groundwater inflows for the immediate 15 m of tunnel construction (termed the 'face' of the TBM) prior to segmental lining installation. The representation of the inflow at the face of the TBM, a constrained inflow rate through the segmental lining (as opposed to the unconstrained inflows represented in the EIS), and the subsequent remodelling exercise, has resulted in a predicted reduction to the groundwater inflows, water table drawdown and related impacts at surface when compared to those modelled for the EIS. The revised Modelling Report submitted as part of the RTS provides further details on all updated inputs, scenarios modelled, and the scenario chosen for the reassessment of predicted impacts.

It should be noted that the hydraulic parameters of the rock to be excavated by the project has been estimated using appropriate hydrogeological techniques and pumping test methods at the groundwater bore locations. Groundwater flow in fractured rock is highly heterogeneous, however, and actual local scale and overall groundwater inflow to excavations will only be realised once the project commences and actual groundwater ingress to the tunnels are measured. The inherently fractured nature of the host rocks introduces a finite uncertainty in the modelling exercise and this will influence the intensity and duration of any impacts. The regional scale of the numerical modelling does not permit local-scale features to influence instantaneous flow and field assessment will be required to facilitate appropriate mitigation strategies when increased ingress zones are encountered.

4.2.3. Groundwater inflows

Relevant to the revised impacts, the EIS predicted that total inflows into all tunnel excavations during construction would peak at 160 L/s and reduce to approximately 85 L/s during operation. Modelling undertaken during the RTS and incorporating conservative mitigation strategies now predicts a peak during construction of 62 L/s, stabilising at 45 L/s during operation (RTS Appendix I – Revised Water Modelling Report (EMM,2020)). This modelled reduction in groundwater inflow has reduced the magnitude and extent of groundwater drawdown and associated impacts and this is summarised below in Section 4.2.4.

The revised modelling identifies a peak inflow to the tunnels during the quarter of 1 March 2024 focussed on the head race tunnel. This is the longest project component and is also excavated through the two deep rock units with the highest estimated hydraulic conductivity: the Kellys Plain Volcanics and the Gooandra Volcanics (the latter including the associated Gooandra Volcanics Fracture Zone and Shaw Hill Gabbro). Long-term inflow to the headrace tunnel is predicted to reduce during operation and stabilise at around 35 L/s (RTS Appendix I – Revised Water Modelling Report (EMM,2020)).

Considering potential average, wet and dry climate scenarios, groundwater inflows to all excavations peak at 1,874 ML, 1,952 ML and 1,835 ML on an annual basis for the average, wet and dry climate scenarios modelled, respectively, as summarised in Table 4-2.

SHL hold sufficient water access licences to account for these levels of inflow (Section 2.5.3), hence management measures are focussed on minimising environmental impacts to groundwater, specifically with respect to potential for groundwater drawdown and changes to groundwater quality.

Table 4-2: Predicted annual inflows to all excavations (RTS model) during the Main Works period

Year ending	Dry climate (ML)	Wet climate (ML)	Average climate (ML)
1 June 2019	0	0	0
1 June 2020	3	3	3
1 June 2021	392	395	393
1 June 2022	1212	1259	1212
1 June 2023	1456	1503	1475
1 June 2024	1835	1952	1874
1 June 2025	1398*	1488*	1800*

* Simulation ends 1 March 2025 and volume is for previous 9 months only

4.2.4. Groundwater level decrease

4.2.4.1. Groundwater drawdown

Groundwater flow into the excavations will result in groundwater hydraulic head drawdown developing over time. Groundwater drawdown of the water table is predicted to occur primarily near the Tantangara adit, and in the vicinity of the Gooandra Volcanics geological unit (near Gooandra Creek and the Snowy Mountains Highway). Groundwater modelling undertaken as part of the Response to Submissions (EMM, 2020) also predicts scattered pockets of water table drawdown within the Yarrangobilly River catchment. No change in groundwater level, however, was predicted at the Yarrangobilly Caves.

Predicted drawdown after 5 years of construction (for the Base Case parameterisation; EMM, 2020) is shown in Figure 4-1.

Calculated as the difference between a “null scenario” that simulates only transient climate stresses and a model run simulating construction of Snowy 2.0, the groundwater model predicted the following drawdown:

- After one year of construction almost no drawdown is predicted.
- After two years of construction a drawdown footprint is predicted near the western edge of Tantangara Reservoir, associated with the construction and excavation of the headrace tunnel. The model simulates the geological unit (Kellys Plain Volcanics) intercepted by the project at this location to have a much higher permeability (consistent with values estimated from field assessments) when compared with the majority of the model domain. A small drawdown footprint (0.5m) is also predicted around the main access tunnel for the power station.
- After three and four years of construction the drawdown footprint associated with the Kellys Plain Volcanics is predicted to expand and increase in magnitude immediately above the headrace tunnel to over 50 m. Small pockets of minor drawdown are predicted above other parts of the project with a more significant region of drawdown predicted to be growing above the headrace tunnel in the Gooandra Volcanics region (generally 2 - 5 m).
- After five years of construction the footprint of the Kellys Plain Volcanics drawdown is predicted to further expand, along with the region of drawdown above the headrace tunnel in the Gooandra Volcanics region, which is predicted to reach magnitudes of greater than 10 m.
- Groundwater levels at the Yarrangobilly Caves are not predicted to be impacted during any part of the construction.

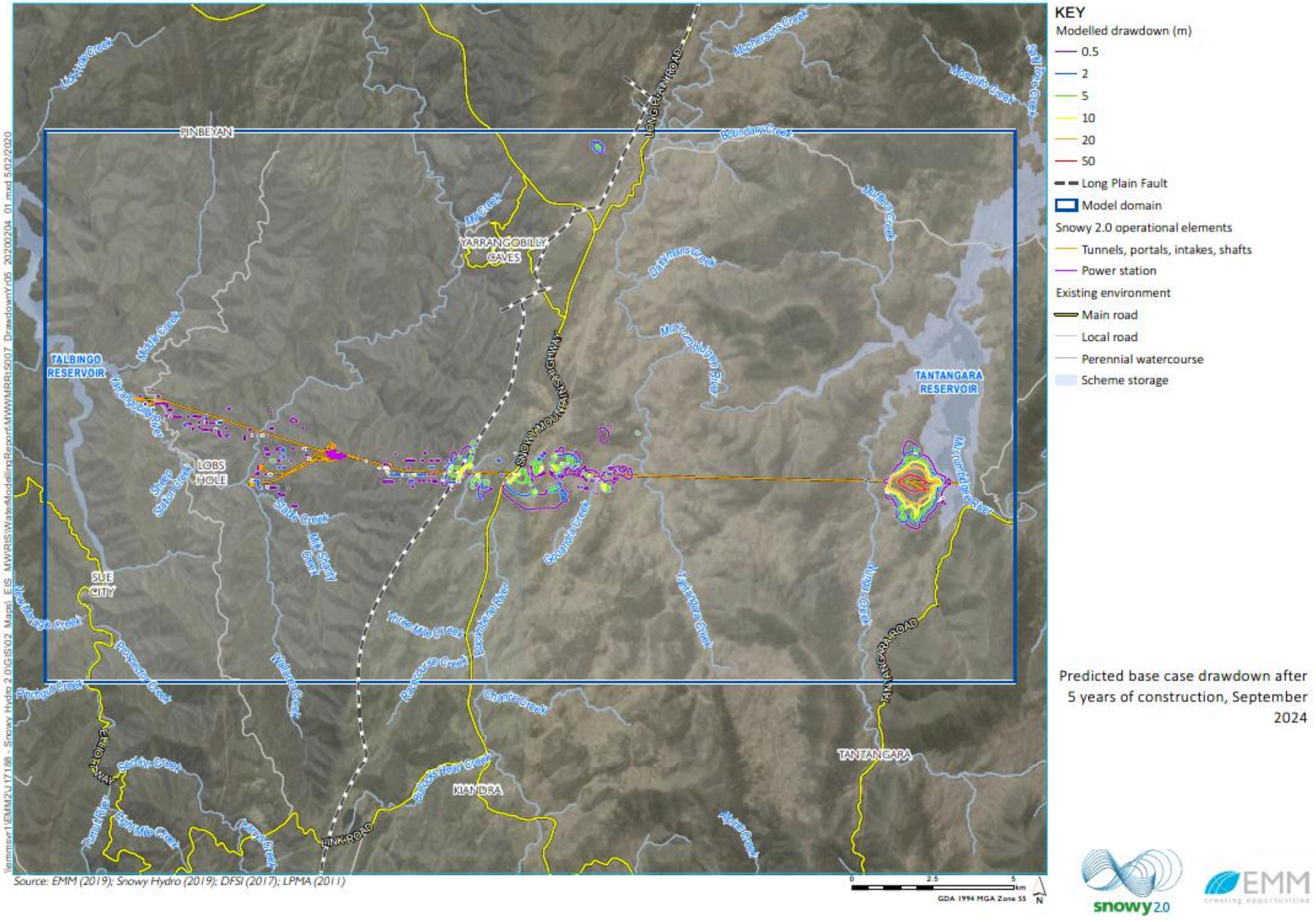


Figure 4-1: Predicted drawdown after 5 years of construction

4.2.4.2. Subsurface (Type 1) GDE: Loss of aquifer habitat

Aquifer habitat (i.e. where stygofauna may be present) is predicted to be affected. Specifically, the predicted impact to fractured-rock aquifers will likely result in drawdown, reducing the extent of habitat available to stygofauna. It is likely that predicted impacts will be restricted to an area on the Plateau bounded by Tantangara Creek in the east and the boundary of the Gooandra Volcanics in the west. Drawdown of less than 20 m is considered unlikely to have a significant effect on many stygofauna species given the ability of these species to relocate within the saturated zone. Thus, drawdown of up to 5 m would be unlikely to have any significant effect.

The stygofauna assessment by Macquarie University (2019) suggests the overall predicted impact to stygofauna will be low across the region. Species identified are not considered endemic to the local area and regionally species diversity will not be impacted.

Of note, no impact is predicted at or near the Yarrangobilly Caves or associated ecosystems.

4.2.4.3. Surface (Type 2) GDE: Reduced surface water baseflow

As a result of water table drawdown, the groundwater model predicted that localised baseflow discharges to creeks and rivers would be seen in the catchments upstream of Tantangara Reservoir, Lake Eucumbene, and Talbingo Reservoir. While inflows to the excavations are predicted to peak in the final year of construction, impacts to baseflow are predicted to develop more slowly, with peak impacts occurring several decades after the completion of construction. Long-term peak baseflow reductions are predicted to approximately match the long-term inflow rate to the power waterway.

Baseflow reduction due to tunnelling and excavation works during the construction period was predicted in Gooandra Creek and the headwaters of the Eucumbene River. The timing of the baseflow reduction will depend on the project schedule, as drawdown impacts are predicted to peak after the tunnel excavation reaches the Gooandra Volcanics, which occur in the vicinity of Gooandra Creek and the Eucumbene River headwaters. If no delays to schedule occur, Gooandra Creek baseflow reduction could begin during year 4 of construction, and Eucumbene River baseflow reductions could begin in year 5 of construction. Impacts were predicted to be still developing at the end of the construction period. No impacts to baseflow due to tunnel excavation were predicted within creek catchments other than Gooandra Creek and the Eucumbene River north of the Snowy Highway (EMM, 2020). Baseflow reductions predicted by the groundwater model during project construction are predicted to balance the ingress of groundwater to the excavated tunnels (Table 4-2), but with an approximately 3-5 year lag (Figure 4-2).

The baseflow reduction in Gooandra Creek during the excavation of the power waterway is expected to cause no discernible changes to streamflow through winter months. During March–April in the final two years of excavation there is a potential that baseflow reduction may result in reduced flow within the Gooandra Creek catchment if those construction years coincide with dry climate conditions.

Within the Eucumbene River, baseflow reduction during the construction period is expected to cause no discernible changes to streamflow.

Inflows to the tunnel excavation are predicted to increase markedly during the groundwater model year 2023 (construction year 4), rising to approximately 60 L/s when the tunnel encounters the Gooandra Volcanics before stabilising during 2024. Through the final quarter of construction, the baseflow impacts within the Gooandra and Eucumbene catchments were estimated to be in the order of 10 L/s, significantly less than the tunnel inflows. Impacts to baseflow within the Gooandra Creek catchment and within the Eucumbene River catchment upstream of Gooandra Track were predicted to increase over the final years of the construction period, reflecting a lag between the greatest tunnel inflow and the greatest baseflow impacts. The peak change in baseflow is expected to occur following completion of the project.

Specifically, during construction and in the areas directly overlying the tunnel alignment the model predicted that:

- Baseflow to Gooandra Creek may decline by up to 6%, beginning in year 4 of construction; and
- Baseflow to the Eucumbene River may decline by up to 1%, beginning in year 5 of construction, with impacts centred on the uppermost 1.5 km of the Eucumbene River headwaters.

The surface water catchment model was used to investigate the effect of these baseflow reductions on the streamflow regimes downstream of the impacted catchments, and showed that:

- Gooandra Creek will potentially change from a perennial streamflow regime to marginally ephemeral, as days with less than 0.1 ML/day streamflow at the downstream end of the creek increase from 0% to 2%; and
- North of the Snowy Highway the Eucumbene River could also become ephemeral, as days with less than 0.1 ML/day streamflow at this location increase from 0% to approximately 5-7%.

It is expected that the quickflow component of streamflow (surface runoff in response to rainfall) will not be affected by groundwater drawdown and baseflow reduction. In each catchment, the modelled impact reduced with distance downstream as flows from catchment areas unaffected by the project entered the creek system.

Figure 4-2: Baseflow reduction predicted by the groundwater model during project construction

Groundwater-dependent riparian vegetation (Type 2 GDEs), consisting of species adapted to mesic/hydric soils, are located along sections of creeks and waterways where groundwater is expressing at the surface providing baseflow. It is unlikely that drawdown of less than 5 m will impact on these areas, as some groundwater will continue to be expressed at the surface. In addition, not all groundwater will be diverted to regional aquifers, with an unknown proportion continuing to supply baseflow to these GDEs, maintaining biological integrity. Groundwater-dependent riparian vegetation is predicted to be at moderate risk of predicted impact due to groundwater drawdown.

The small impacts to baseflow, as described above, will be indiscernible in the observed data considering the interannual variability in flow in the Gooandra and Eucumbene Creeks.

Assessment of baseflow will be triggered following trigger of the groundwater level TARP (Section 7).

4.2.4.4. Surface (Type 3) GDE: Lowering of water tables

The predicted impacts to surface GDEs was determined by calculating the area of each GDE that occurs within the groundwater drawdown areas predicted by the model. It is noted that the current version of the model (SH4.0) still retains a large degree of conservativism, such that the predicted impacts are expected to exceed actual impacts given the current state of knowledge. Future iterations of the numerical model, as further relevant data is collected, will refine our understanding and the potential impact extent. The current modelling identified the following potential impacts to surface (Type 3) GDEs:

- PCTs 302, 299 and 679 may experience predicted impacts to less than 3 ha of the community, and/or may experience groundwater drawdown of less than 5 m. These GDEs are considered to be at a low risk of impacts.
- PCT 303 may experience predicted impacts to 24.70 ha of the community, representing 6% of the 409 ha of the community mapped in the survey area, while PCT 300 may experience drawdown to 6.38 ha of the community, representing 2% of the 270 ha of the community mapped in the survey area. In addition, 14.02 ha of PCT303 and 3.71 ha of PCT 300 may experience drawdown of less than 2 m, and will be unlikely to have any noticeable effect on the ability of these communities to access groundwater during periods of stress, and is therefore unlikely to result in any significant changes in the biological integrity of the GDEs. It is predicted these GDE are at low risk of impact.
- PCT 1225 may experience drawdown of >0.5 m to 10.27 ha of the community. Drawdown of more than 0.5 m may have some impact given the entirely/obligate dependence of this community on groundwater. While there is a high risk of predicted impact to some portion of the community, as defined in Serov et al. (2012), the predicted drawdown may impact on 3% of the 312 ha of this PCT mapped across the survey area, and larger patches of the community will be maintained on major watercourses such as Tantangara Creek and Nungar Creek. Overall impacts to community are expected to be low.
- PCT 637, aligned with the Alpine bogs and fens, may experience drawdown of >0.5 m to 6.93 ha of the community. This community is entirely/obligate dependent on groundwater and has a large number of hydric and mesic species that do not occur outside of this or other allied communities. The 6.93 ha that may be subject to drawdown represents 8% of the 86 ha mapped within the survey area, 0.08% of the mapped extent of the community in the Snowy Mountains (OEH 2012b) and 0.06% of the 11,100-ha mapped at a national scale (TSSC 2009). While there is a high risk of predicted impact to some portion of the community, as defined in Serov et al. (2012), the overall risk to the community and listed community is considered low.

The predicted impacts to these surface GDEs was determined through the RTS Numerical Modelling (Appendix G: Revised Biodiversity Development Assessment Report) and is presented in Table 4-3.

Table 4-3: Potentially impacted terrestrial GDEs and potential area subject to drawdown

Mapped plant community type (PCT)	GW dependency	0.5m	plus 2-5m	plus 5-20m	Plus >20m	Total
PCT 1225 - Sub-alpine grasslands of valley floors, southern South Eastern Highlands Bioregion and Australian Alps Bioregion	Entirely - obligate	9.96	0.3	0	0	10.27

Mapped plant community type (PCT)	GW dependency	0.5m	plus 2-5m	plus 5-20m	Plus >20m	Total
PCT 637 - Alpine and sub-alpine peatlands, damp herbfields and fens, South Eastern Highlands Bioregion and Australian Alps Bioregion	Entirely - obligate	6.03	0.85	.05	0	6.93
PCT 302 - Riparian Blakely's Red Gum - Broad-leaved Sally woodland - tea-tree - bottlebrush - wattle shrubland wetland of the NSW South Western Slopes Bioregion and South Eastern Highlands Bioregion	Facultative - proportional	0.71	0	0	0	0.71
PCT 299 - Riparian Ribbon Gum - Robertsons Peppermint - Apple Box riverine very tall open forest of the NSW South Western Slopes Bioregion and South Eastern Highlands Bioregion	Facultative - proportional	0.96	0.82	0.12	0	1.89
PCT 679 - Black Sallee - Snow Gum low woodland of montane valleys, South Eastern Highlands Bioregion and Australian Alps Bioregion	Facultative - opportunistic	0	0.02	0	0	0.02
PCT 303 - Black Sally grassy low woodland in valleys in the upper slopes sub-region of the NSW South Western Slopes Bioregion and western South Eastern Highlands Bioregion	Facultative - opportunistic	14.02	5.73	4.95	0	24.7
PCT 300 - Ribbon Gum - Narrow-leaved (Robertsons) Peppermint montane fern - grass tall open forest on deep clay loam soils in the upper NSW South Western Slopes Bioregion and western Kosciuszko escarpment	Facultative - opportunistic	3.71	2.17	0.49	0	6.38

Whilst potential predicted impacts are considered to be low for all plant communities, the obligate dependency of ecosystem plant community types 1225 and 637 (Alpine Bogs and Associated Fens) requires specific recognition and focus during monitoring and impact assessment and inclusion in trigger action response plans (Section 7).

4.2.5. Groundwater quality

4.2.5.1. Spills and contamination

There is the potential for the project construction works to cause contamination to the groundwater resource. This predominately encompasses either spills of hazardous materials/chemicals and/or the generation of solid or liquid waste. Examples of this include spills of hydrocarbons while refuelling or lubricants used by machinery, and generation of solid construction waste or liquid waste during tunnelling. All scenarios have the potential to impact human and environmental health depending on the type of contaminant if not managed accordingly.

Protocols for the management of contaminated soil and water during construction will be included in a construction environmental management plan (CEMP) for all construction works.

Soil investigations will also be undertaken along all proposed medium and high-risk construction disturbance areas to identify the presence of any existing contamination and assess the risks posed to the groundwater environment. Management of soil and excavation waste will be undertaken through the Spoil Management Plan.

4.2.5.2. Acid Mine Drainage

As summarised in the Main Works EIS, it was concluded that the relative rates of acidity (i.e. PAF) versus alkalinity (i.e. ANC) generation in geological formations at the site are uncertain and require further investigation, and that for many of the formations there remains insufficient information on the compositional variation.

There is potential for Acid Mine Drainage (AMD) impacts via the generation of acidic leachate from improper temporary or permanent storage of excavated PAF rock and this poses a risk to localised and wider (regional scale) groundwater environment.

To manage this risk, it is proposed that any excavated material is managed in accordance with the Spoil Management Plan (SMP). On-going monitoring in the vicinity of major excavations will recognise any changes to water quality and trigger an appropriate response.

4.3. Environmental Risk Assessment

The environmental aspects and impacts for water are further considered within Appendix A3 of the EMS. This includes a risk assessment process. The risk assessment is based on (1) the likelihood of an impact occurring as a result of the aspect; and (2) the consequences of the impact if the event occurred. These risks as well as any regulatory requirement form the basis for the groundwater mitigation measures committed to in this GMP in Section 5, below.

5. GROUNDWATER MANAGEMENT MEASURES

A range of environmental requirements and control measures are identified in the Main Works EIS, RTS and the Infrastructure Approval. Safeguards and management measures will be implemented to avoid, minimise or manage impacts on groundwater.

Potential impacts to groundwater may be divided into those potential impacts relating directly to groundwater inflows to the tunnels and other excavation works and to those potential impacts indirectly caused by those groundwater inflows, that is, impacts to the environmental function of groundwater. The former may be distinguished as part of the process water cycle; the latter as part of the natural water cycle.

A conceptual overview of the water distribution network that relates to process water is provided in Figure 5-1. Minimising risks to the natural groundwater environment critically requires minimisation of groundwater ingress to tunnels to acceptable levels. Specific safeguards and management measures to address potential groundwater impacts from the project are identified in Table 5-1. As control of groundwater inflow is the principle method to reduce potential groundwater impacts, the major components of groundwater management may thus be described in relation to the operation of the tunnel boring machine; the drill and blast excavations of the access tunnels; the excavation of the large transformer cavern and treatment of removed groundwater via water treatment plants.

5.1. Tunnel boring machine method

The tunnels for Snowy 2.0 Main Works will be excavated with a circular cross-section using three tunnel boring machines (TBMs). Each TBM will be fully equipped to perform excavation, ventilation, lining and removal of excavated material.

Groundwater will enter the tunnel during construction. The volume and flux of ingress will directly determine the potential for drawdown of water levels in the vicinity of the project corridor, including the potential to cause drawdown of groundwater near the surface. To mitigate impacts a number of controls have been identified that will reduce the actual ingress of water to the tunnels. Specifically, developing a planned excavation sequence; forward surveys of rock condition; pre- and post-grouting of the rocks as determined through the surveys; use of segmental lining for the tunnel and continuous inflow monitoring will facilitate reduced inflows to the tunnel and reduce the potential drawdown impacts.

5.1.1. Excavation sequencing

Excavation sequencing is the process of managing the order that the excavation occurs to ensure critical sections remain open for the least amount of time possible.

Early identification of critical sections of highly permeable or vertically connected formations was undertaken during assessment of the EIS. This process identified that the Gooandra Volcanics had a higher hydraulic conductivity than other geological units in the project area.

The construction program has therefore been planned such that the Gooandra Volcanics region shall be excavated late in the construction program so that the excavation would remain open for the shortest period of time.

5.1.2. Forward investigations

Surveys will be conducted ahead of each TBM to identify potentially critical areas with poor rock conditions or high fracturing intensity. Each TBM will be equipped with devices to perform the following surveys:

- geophysical seismic reflection surveys;
- geoelectrical surveys; and

- systematic probe core retrieval ahead of the advancing tunnel face.

5.1.3. Segmental lining

Each TBM will be equipped to install the segmental lining for the tunnel using the universal ring method. The ring will be 2m wide, composed of nine pre-cast concrete segments which form each ring (eight segments, one 'large size' key-segment) and which have no bolts along the longitudinal joints. One drainage relief hole will be provided in each segment to guarantee a 'drainage effect' and water pressure re-equilibrium.

This segmental lining will reduce permeability, assisting to:

- achieve acceptable head loss in the conduit;
- prevent hydraulic jacking; and
- prevent excessive leakage by seepage.

5.1.4. Pre-grouting

Pre-grouting will be conducted to reduce the hydraulic conductivity of the rock mass (minimise groundwater inflow) and improve the stability of the excavation face. This is undertaken ahead of the excavation face and will generally be carried out by:

- drilling and testing a probe hole;
- drilling and installing a crown of groutable pipes;
- injecting grout through the pipes; and
- drilling a verification probe hole.

Probe holes are drilled up to 40 m in front of the working face. Water flow through the initial holes is measured and a decision is made on the need to grout.

The number and location of the holes will depend on rock mass condition and, in cases of work performed by a TBM, on the specific configuration of the excavation head.

The grouting of soil or rock masses with cement slurries or chemical mixtures to improve their mechanical and hydraulic properties is a well-established practice in engineering.

Verification of the grout effectiveness is made by comparing inflow rates in the original probe hole to those in verification holes.

5.1.5. Post-grouting

Post-grouting may also be used to further consolidate the surrounding rock and/or prevent water ingress if required. Tunnel water inflow will be measured using in-line monitoring of flow along the constructed tunnel and will inform the decision on the need to grout.

Post grouting entails drilling sets of holes perpendicular to the tunnel, in a fan of 9 holes around the tunnel. The holes are generally drilled at an even spacing from a jumbo with hydraulic top hammer. Mechanical packers are installed and connected to a pump via hoses. Grout is then injected to reduce the total permeability of the rock mass.

5.1.6. Inflow monitoring

Groundwater inflow into the tunnels will be monitored during construction and compared to model predictions. Tunnel water inflow will be measured in the tunnel via in-line flow meters. Tunnel inflow monitoring, water treatment plant (WTP) discharges and Project water inputs re-cycled back into the tunnel will all be monitored and used to determine a simple water balance to estimate local groundwater extracted during construction. Monitoring will be undertaken at the indicated locations shown in Figure 5-1. Thus:

Groundwater inflow = WTP discharge (*flow meter C*) – Project water inputs (*flow meter E*)

Groundwater extraction will be reported on an annual basis in accordance with licence requirements (as described in Section 2.5.3).

5.2. Drill and blast operations

Access tunnels and the large cavern for the transformers will be excavated using drill and blast techniques. These excavations are not planned to be lined and high initial inflows will reduce as groundwater tables are drawn down to the invert levels. Inflows will be directed to sumps and pumped to the closest WTP for processing before entering the surface water stream, or re-cycled for use in the excavation process. The latter includes dust-suppression, cooling and cleaning.

Ingress monitoring will be undertaken as for the tunnels.

5.3. Water Treatment Plants

All groundwater encountered during tunnelling will be drawn to the surface where it will be treated via a water treatment plant (WTP).

WTPs are proposed to be installed and utilised at:

- tunnel portals for tunnel process water treatment (i.e. groundwater management);
- accommodation camps for wastewater (i.e. sewage) treatment; and
- accommodation camps for potable water consumption.

A detailed description of each of these WTPs streams is provided in the Surface Water Management Plan.

Process WTPs are specifically proposed to manage and treat intercepted groundwater from the main tunnels. That is, to collect water associated with each TBM. The process WTPs will be located at the Talbingo Main Access Tunnel (MAT) portal, Talbingo emergency egress, cabling and ventilation tunnel (ECVT) and the Tantangara portal.

The process water WTPs will be connected to a drainage system comprised of sumps and pipelines from each tunnel to the WTP at the portal surface. This process water will be treated to the water quality discharge criteria in the Project's EPL and be re-used on site or within the tunnel. Excess treated water that cannot be utilised on site or within the tunnel will be managed as surface water under the Surface Water Management Plan (SWMP).

5.4. Spoil Emplacement

The Spoil Management Plan (S2-FGJV-PLN-0019) identifies spoil management process and measures for temporary and permanent spoil emplacement areas, including measures for natural occurring asbestos (NOA) and acid and metalliferous drainage (AMD).

NOA will be placed in designated encapsulation cells at the Tantangara emplacement area. In cell formations, the NOA will be placed over an inert foundation layer and contained with a geosynthetic textile wrapping.

AMD refers to potential for rock to be potentially acid forming (PAF) through exposure of sulfide minerals. In relation to groundwater quality, the key controls that will be applied to each PAF treatment area include:

- seepage from the treatment area will be collected in a sediment basin downstream of the treatment emplacement area. Collected water will either be irrigated to the treatment (to promote evaporation) or treated in the process water treatment plant. Discharge of seepage water to the environment will be avoided. The sizing of the basins are subject to final design, and are dependent on disturbed ground extent and the utilisation of other erosion and sediment controls. The basin and all erosion and sediment controls will be designed and operated in compliance with mitigation measures in the SWMP;
- a barrier system will be installed under the stockpiles to prevent seepage from entering underlying soils and groundwater; and
- neutralised PAF material can, once validated, be safely disposed of like any other spoil

Further detail on spoil management and design is provided in the Spoil Management Plan (S2-FGJV-PLN-0019).

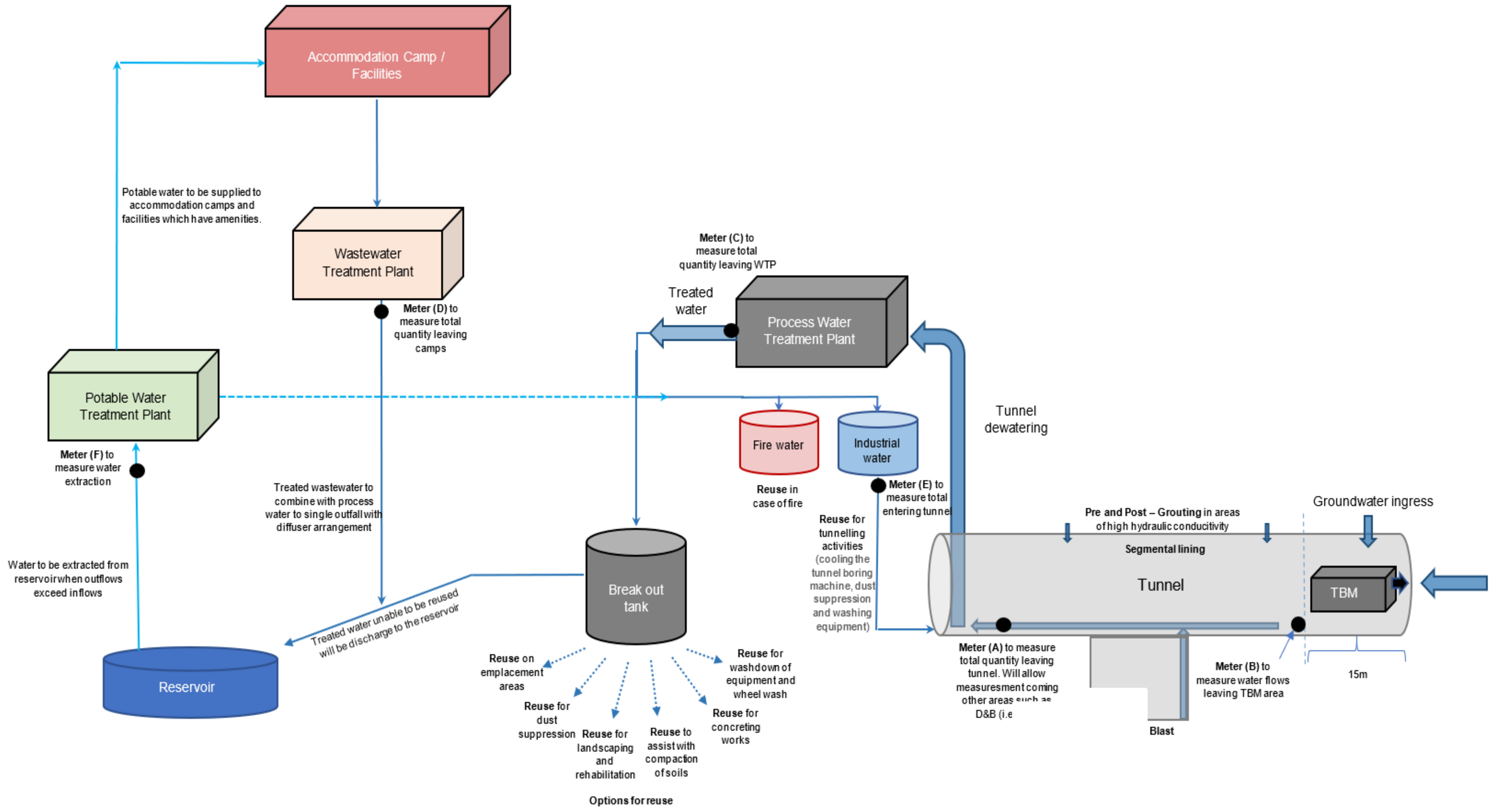


Figure 5-1: Conceptual process water management system

Table 5-1: Groundwater management measures

ID	Measure / Requirement	When to implement	Responsibility*	Source document**
General				
GW01	Training will be provided to all project personnel, including relevant subcontractors on groundwater management through inductions, toolboxes and targeted training.	Pre-construction and Construction	Contractor – EM, EC	Best Practice
Procedures and plans				
GW02	Spills and emergency response will be managed in accordance with the Emergency spill response procedure included in the Surface Water Management Plan (Appendix A of the Water Management Plan)	Construction	Contractor – All	MW REMM WM01
Groundwater management				
GW03	Groundwater discharged to reservoirs will be in accordance with the Surface Water Management Plan and unless an environmental protection licence authorises otherwise, in compliance with Section 120 of the POEO Act.	Construction	Contractor – All	CoA 29
GW04	The construction program shall be planned such that the Gooandra Volcanics region will be excavated late in the construction program.	Construction	Contractor – CM	CoA 30(e)
GW05	Where discrete high flow features are intercepted such as the Gooandra Volcanics and Kelly Plain Volcanics, pre-grouting and / or post-grouting will be undertaken to enable tunnel construction and minimise further ingress.	Construction	Contractor – CM, DM, S	CoA 30(e) MW REMM WM07 EW REMM WAT03
Groundwater contamination				
GW06	Emergency spill kits will be readily available at key construction sites across the project and workers trained in their use.	Construction	Contractor – EM, EC, CM, S	MW REMM WM01
GW07	Storage and handling of chemicals, fuels and oils will be as per manufacturer's instructions in bunded, storage areas.	Construction	Contractor – All	MW REMM WM01
GW08	During borehole drilling, slurries used will be of appropriate grade and composition such that it poses no threat to groundwater quality should it infiltrate intersected aquifers	Construction	Contractor – CM	EW REMM M1.6
GW09	Temporary and permanent emplacement areas will be managed in accordance with the Spoil Management Plan	Construction	Contractor – DM, CM, S, SS	MW CoA 30(o)
Monitoring and model validation				

ID	Measure / Requirement	When to implement	Responsibility*	Source document**
GW10	Groundwater monitoring will be undertaken in accordance with the Groundwater monitoring program (Annexure A of this Groundwater Management Plan)	Construction	Contractor – EM, EC	CoA 31(d) MW REMM WM01 MW REMM WM02 EW REMM WAT02
GW11	Groundwater level monitoring will be undertaken in accordance with the Groundwater monitoring program (Annexure A of this Groundwater Management Plan) to provide early warning for impacts beyond those assessed for: • baseflow connected waterways; • the local groundwater flow system; • local depressurisation of groundwater resources; and • groundwater dependant ecosystems. The trigger actions response plans (TARPs) will be initiated in the event that a trigger value banding is exceeded (refer to Section 7.2 of this Groundwater Management Plan)	Construction	Contractor – EM, EC	CoA 31(d) MW REMM WM01 MW REMM WM02
GW12	The groundwater model developed for Snowy 2.0 Main Works will be validated and, if necessary, recalibrated to new groundwater monitoring data as the monitoring record increases throughout construction. Review will be undertaken annually during construction and include review of the monitoring data collection frequency, in consultation with NRAR and DPIE-Water Group.	Construction	SHL	CoA 31(d) MW REMM WM06 NPWS / DPIE consultation comment on reviewing monitoring frequency
GW13	Groundwater extraction will be monitored and tracked against water access iicence limits.	Construction	Contractor – EM, EC	Water Access Licene
GW14	Adaptive management will be implemented for groundwater monitoring, including review, analysis and modification of mitigation measures if they are shown to be ineffective.	Construction	Contractor SHL	MW REMM WM01 (TARP)

** Responsibility* — *Regardless of the allocation of responsibilities within this plan, the responsible party is to be assigned in accordance with the Contract*

***Source Documents*

1. *MW RWMM – Main Works Revised Water Management Measure (Main Works RTS Appendix J Appendix C)*
2. *CoA – Condition of Approval (SSI 9687)*
3. *EW REMM – Exploratory Works Revised Environmental Management Measures (Exploratory Works RTS Chapter 8)*

Responsibility abbreviations — *CM – Construction Manager, DM – Design Manager, EM – Environmental Manager, EC – Environmental Coordinator, S – Superintendent, SS – Supervisor, All – All personnel including subcontractors*

6. COMPLIANCE MANAGEMENT

6.1. Roles and Responsibilities

Future Generation's organisational structure and overall roles and responsibilities are outlined in Section 4 of the EMS. Specific responsibilities for the implementation of mitigation measures are detailed in Section 5 of the GMP. Regardless of the allocation of responsibilities within this plan, the responsible party is to be assigned in accordance with the Contract.

6.2. Licenses and permits

Licenses and permits relevant to groundwater extraction were summarised in Section 2.5.3.

6.3. Monitoring and Inspections

6.3.1. Groundwater monitoring program

A groundwater monitoring program has been developed to monitor potential impacts to groundwater during construction of the Project to ensure compliance with this management plan. The program is an extension of the EIS baseline monitoring.

Details of the groundwater monitoring program, including detailed inspection criteria, are provided in the accompanying Groundwater Monitoring Program (the Program – Annexure A).

The Main Works monitoring program differs in fundamental ways to that developed for the Exploratory Works. Thus, whilst the Exploratory Works groundwater monitoring program was designed to provide baseline data and understanding of ambient groundwater conditions across the Project area, the Main Works monitoring program is designed to provide early warning of potential risks to assets and guidance on protection and any mitigation measures for any impacted assets. Groundwater-dependent assets critically include the Alpine Bogs and Associated Fens which are iconic ecosystems across the Plateau region.

The Main Works monitoring program will provide an extension to the Exploratory Works program and where the Exploratory Works program is considered incomplete (for example, where less than 24 months of baseline data have been collected), the Exploratory Works program will continue before switching to the Main Works program.

The objectives of the Main Work Monitoring Program are to:

- identify and quantify changes to groundwater quality and groundwater level or pressure;
- assess compliance with relevant consent and license conditions and other monitoring requirements including prescribed targets for the Project; and
- assess and modify where required the effectiveness of water mitigation measures;

The Program provides detailed inspection criteria including:

- groundwater monitoring locations;
- parameters/analytes to be monitored;
- type of monitoring;
- frequency of monitoring, and
- monitoring methodology.

Groundwater monitoring is reviewed to determine whether any actions are required due to inconsistencies between monitored and predicted data. The groundwater monitoring process measures are outlined in Table 6-1, which provides reference to the relevant trigger, action, response plan for water levels, quality and usage.

Table 6-1: Groundwater process measures

Performance measure	Monitoring sites	Frequency	Trigger	Objectives	Management Measures
Groundwater quality monitoring	Groundwater bores designated as water quality sites in the Groundwater Monitoring Plan	Quarterly groundwater quality sampling	If a parameter exceeds the nominated water quality triggers for two consecutive monitoring events	To identify (where possible) if the exceedance is naturally occurring or due to construction	Implement Groundwater Quality TARP
Groundwater level monitoring: Piezometers	Groundwater bores designated as water level sites in the Groundwater Monitoring Plan, including: Conventional bores; Vibrating wire piezometers;	Daily – 6 hourly Data collected quarterly*	If the 7 day moving average exceeds the month's established trigger level by 1 standard deviation at the impacted bore		Implement Groundwater Level TARP
Groundwater level monitoring: Standpipes	Standpipes and drive-point piezometers	Daily – 6 hourly Data collected quarterly*	If the 7 day moving average exceeds the 80th percentile level at the impacted standpipe during the months of May to October, inclusive		Implement Level 3 investigation as described under the Groundwater Level TARP
Groundwater inflow rate monitoring	As indicated in Figure 5-1	Daily – continuous collection reported as daily flux	Monthly inflow volumes exceed modelled values for three consecutive months and cumulative inflows exceed cumulative modelled inflows	To ensure the water take is within licence limits To limit the volume of groundwater take and consequent drawdown	Implement Groundwater Usage TARP

** The Project is investigating opportunities for telemetric monitoring of monitoring data. No drawdown is predicted for the first few years of the project (see Section 4.2.4) hence existing data loggers will be downloaded manually quarterly until telemetry is in place. Monitoring frequency will be continuously reviewed and data compared to model predictions, and frequency of data collection will be adapted to ensure potential significant trigger events are detected early (i.e. particularly when Tunnelling commences in high risk areas). Data collection will also be reviewed annually during groundwater model review as identified in Table 5-1: GW12.*

6.4. Trigger Levels and Methodology

All groundwater data collected prior to the commencement of construction will be used as reference baseline data against which to compare monitoring data collected during construction at all locations detailed in the monitoring program (Annexure A). Groundwater triggers have been developed in line with recommendations under the NSW Aquifer Interference Policy (NOW, 2012) and based on baseline data collection for a minimum of two years to capture a full seasonal cycle twice at an appropriate frequency and scale commensurate with the Project. This is also reflected in the provisions of the Environmental Protection Licence (Section 2.5.1).

Where baseline data has not been collected for a minimum of two years, collection will continue at that site until a baseline can be established.

6.4.1. Groundwater triggers

Four levels of groundwater trigger can be described, dependent on the level of impact observed. Thus, Level 1 (indicator) triggers are those that might be expected to occur due to the activities and which do not result in undue, or significant, stress to the system. Unpredicted triggers may correspond to sites where impacts indicate a precursor to a greater future impact and can be considered as early warning (Level 2) triggers. Level 3 triggers mark a requirement for additional investigations and possibly mitigation and are considered threshold triggers, beyond which an unpredicted or unacceptable impact can be confidently assigned.

It should be determined whether the observed impact is due to the activities or to natural external effects, and Level 2 triggers would generally instigate additional monitoring and potentially additional modelling and model re-calibration.

An additional (Level 4, or limit) trigger may also be set indicating a level at which remediation measures become mandatory.

Different triggers are set for different parameters and require specific monitoring requirements as described below (Table 6-2). Baseline conditions will be used to determine site specific trigger values (SSTVs) for water level and quality at each target measuring point. That is, for each bore and at each depth if multiple depth samplers are in place.

Table 6-2: Groundwater trigger levels

Trigger Level	Description	Groundwater Level Impact	Groundwater Quality Impact
1	Indicator triggers – levels of expected maximum response for the Project	No impacts beyond that predicted in the RtS (refer Annexure A – Groundwater Monitoring Program Attachment A and B)	No impacts beyond that predicted in the RtS (refer Annexure A – Groundwater Monitoring Program Attachment A and B)
2	Early Warning triggers – increased monitoring and assessment	Drawdown greater than predicted for the RtS or in exceedance of SSTVs (refer Annexure A – Groundwater Monitoring Program Attachment A and B)	No impacts beyond that predicted in the RtS or in exceedance of SSTVs (refer Annexure A – Groundwater Monitoring Program Attachment A and B)
3	Threshold triggers – additional investigations (including modelling) and possible mitigation implemented	Drawdown continues to exceed predicted values	Water quality may exceed baseline trigger values
4	Limit triggers – mitigation actions to be implemented	Drawdown reaches a critical approved level that requires immediate mitigation	Water quality at risk of change to beneficial use

Different triggers are set for different parameters and require specific monitoring requirements as described below.

6.4.1.1. Groundwater extraction triggers

Groundwater usage in NSW is regulated according to the financial year, also referred to as the water year. Metering equipment will be installed within the tunnel to monitor tunnel inflows. Readings will be undertaken manually (the Project are investigating opportunities for electronic monitoring) on an ongoing basis throughout construction (i.e. weekly) and recorded in a project water register.

Comparison between groundwater ingress volumes and predicted groundwater inflow, as modelled in the numerical groundwater model, will be undertaken throughout the year to ensure groundwater extraction are within permitted volumes of take from respective water sources. Actual water take will be reported to NRAR on an annual basis in accordance with water access licence conditions.

If cumulative water extraction exceeds cumulative water production published in the EIS (and subsequent Response to Submissions), review of the groundwater modelling predictions will be undertaken and assessment made of the implications on groundwater levels and pressures.

6.4.1.2. Groundwater level triggers

Groundwater level triggers will be set for two primary purposes:

1. Monitoring for project impacts (model validation) and to refine numerical model calibration
2. Monitor for asset protection.

Thus the former constitute the monitoring of the piezometer network to assess any changes in aquifer behaviour; the latter provides a means to assess potential and real impacts to groundwater dependent ecosystems.

Groundwater level triggers for each piezometer will be set as the cumulative predicted drawdown at each water level monitoring site. Predicted drawdown will be calculated from the baseline levels and updated monthly to reflect actual observed drawdowns. Monitoring will continue from the baseline program, using the existing monitoring infrastructure (using loggers and telemetry where available).

Groundwater level triggers will be updated to the date of the previous month's collected data. If the 7-day moving average of the recently collected data exceeds the previous month's trigger level by 1 standard deviation for more than 30 days, an exceedance has occurred and investigation into the exceedance to discern whether it is a natural, anthropogenic or Main Works-related exceedance is required. If the exceedance is deemed to be seasonal and/or climatically driven, the recently collected data will be incorporated into the data set and the water level triggers updated for comparison for the following monitoring event. If the exceedance is deemed to be related to Main Works, the groundwater level trigger is set at the previous month's trigger level to assess the extent of impacts thereafter.

If the exceedance is less than the predicted drawdown as defined through the SSTVs, then monitoring will continue with the revised trigger level. If the exceedance is greater than predicted, a Level 2 trigger investigation is initiated.

Groundwater Level 1 triggers are assigned where modelling has predicted a significant (>2m) impact at the bore's location due to Main Works activities as well as at baseline sites for comparison. These trigger levels have been extracted from the groundwater model and form the basis of assessment (*see* Section 7.2.1). Exceedance of Level 1 triggers instigate additional water level and/or pressure measurement and assessment and may initiate water quality sampling and assessment based on previous baseline response to water levels and potential changes to water chemistry.

Subsequently, Level 2 trigger levels are assigned to additional locations and if these levels are exceeded further investigations are carried out, including additional monitoring (level and water quality) and potentially re-assessment of conceptualisations and modelling.

If Level 3 triggers are exceeded, these indicate values at which mitigation actions should be initiated and would be contingent on recommendations from DPIE Water following expert advice.

Continued drawdown may trigger a Level 4 (threshold) response and mandatory mitigation actions.

Groundwater level triggers at GDE sites (shallow standpipes) will only be assessed against trigger values from Autumn through to Spring (May through to October) as baseline assessment has demonstrated that drying of these sites is a normal occurrence through the summer months and constitutes normal ecosystem function.

6.4.1.3. Groundwater quality triggers

Baseline collection of groundwater quality (Annexure A Attachment A) has identified two critical aspects that influence the efficacy of water quality sampling:

1. Water quality objectives are only exceeded by a constrained sub-set of analytes across all groundwaters, with most groundwaters exhibiting nutrient and metal concentrations close to, or below, limits of detection.
2. Analytes that present above WQOs exhibit similar levels (concentrations) across most groundwater units. That is, there is a broadly homogeneous (and good) water quality across the region, particularly across the Plateau, though increasing salinity is observed towards the western Ravine Beds in the Ravine area.

Combined, these characteristics mean that (i) water quality does not provide a good marker for interaquifer connectivity, nor exchange, and (ii) there is minimal risk from inter-aquifer exchange induced by changing groundwater flow regimes between geological formations as a result of the Main Works.

Further, baseline monitoring has identified significant apparent intra-sample variability, in large part due to the inherently low levels of most analytes, but also reflecting the high inter-connectedness between shallow and deep units and response to recharge events across the region. Monthly sampling at the EPL sites indicates a water quality dependency on water levels, likely reflecting the variable recharge in response to the variable rainfall across the area. This is more evident for shallow sites, but all sites show significant temporal variability in salinity and major ions that reflect climatic inputs.

These characteristics have implications on the optimal frequency of sampling and relevance of analysed parameters. Thus, water quality changes can be ascribed to correspond to significant water level changes and water levels can reasonably act as proxy for stable water quality if levels do not change beyond those observed during the baseline collection period.

Significant changes to water levels, as indicated by exceedance of Level 1 water level triggers (as described above) would trigger water quality sampling at indicative sites to check for water quality impacts. As water quality variables either do not vary significantly with time, or may show a seasonal pattern, quarterly sampling is proposed for this initial phase of analysis. Quarterly sampling would achieve comparable confidence in water quality characteristics as monthly sampling with most analytes currently analysed being very unlikely to change with time or under any perceived potential impacts.

If water quality trigger values are triggered at this restricted (Level 2) network, this would trigger additional sites to be monitored and Level 3 triggers assigned to all analytes at these bores. Repeated exceedance would instigate investigation and assessment of the causes for the triggers.

For most parameters, ANZECC trigger values have been used as the foundation for determining appropriate water quality targets (and hence triggers) to be adopted for groundwater monitoring during construction. These same default trigger values were also applied in the Main Works EIS during assessment of baseline groundwater quality, where relevant.

The following default WQO values have been adopted for the purposes of this GMP:

- physical and chemical stressors – default trigger values for upland rivers in South Eastern Australia that are reported in ANZECC/ARMCANZ (2000); and
- toxicant trigger values for the protection of 99% of freshwater aquatic species that are provided in ANZECC/ARMCANZ (2000).

In setting the groundwater quality trigger values for this plan, results from the EIS baseline monitoring were also reviewed to identify those sites where consistent exceedances were recorded against the ANZECC values. At these locations, Site-Specific Trigger Values (SSTV) will be adopted in place of the default ANZECC trigger value.

Site-specific triggers rely on a temporal trend that is sufficiently long to determine consistent variability through time. Thus, a distribution of values equally distributed around a mean value allows the determination of the standard deviation of data around that mean value. If a consistent baseline can be established, deviation from normally expected variation can be assessed by considering the number of sequential data points that exceed the normal variability in the data. Using this “control chart” approach, a trigger event may be defined when:

- A single data point exceeds the mean plus 3 standard deviations, or
- Two consecutive data points are greater than the mean plus 2 standard deviations, or
- Five successive data points are greater than the mean plus 1 standard deviation.

An example of this type of analysis is shown in Figure 6-1.

For parameters that display a skewed distribution, such as those at the limits of detection or which are impacted by systematic external events (e.g. periodic recharge from a freshwater source), it is appropriate to use equivalent percentiles to assess a trigger event. In this case, a trigger event is defined when:

- One data point exceeds the 99.87th percentile
- Two consecutive data points exceed the 97.73rd percentile, or
- Five successive data points exceed the 84.14th percentile.

This methodology is illustrated in Figure 6-2.

Where continued monitoring demonstrates a shift in variability under baseline conditions (i.e. can be demonstrated to not be due to the Project), these values will be modified to reflect the changing conditions.

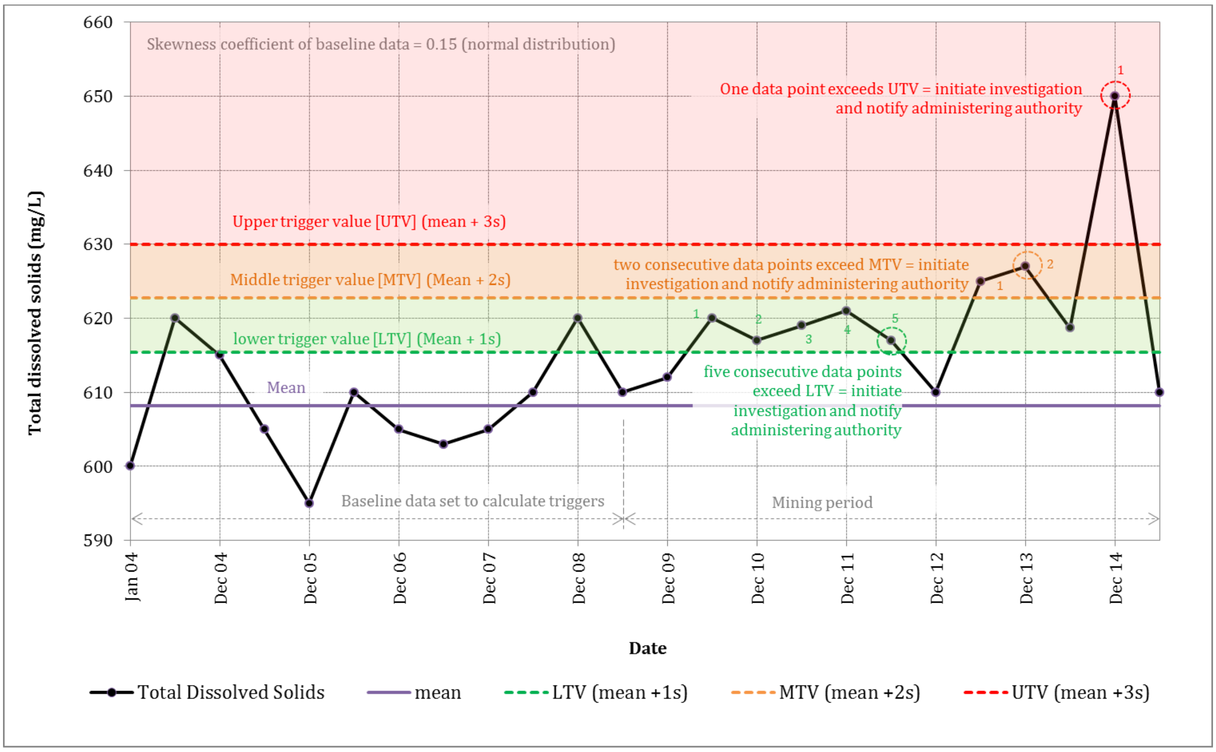


Figure 6-1: Example of a control chart for Total Dissolved Solids that had a normal baseline distribution

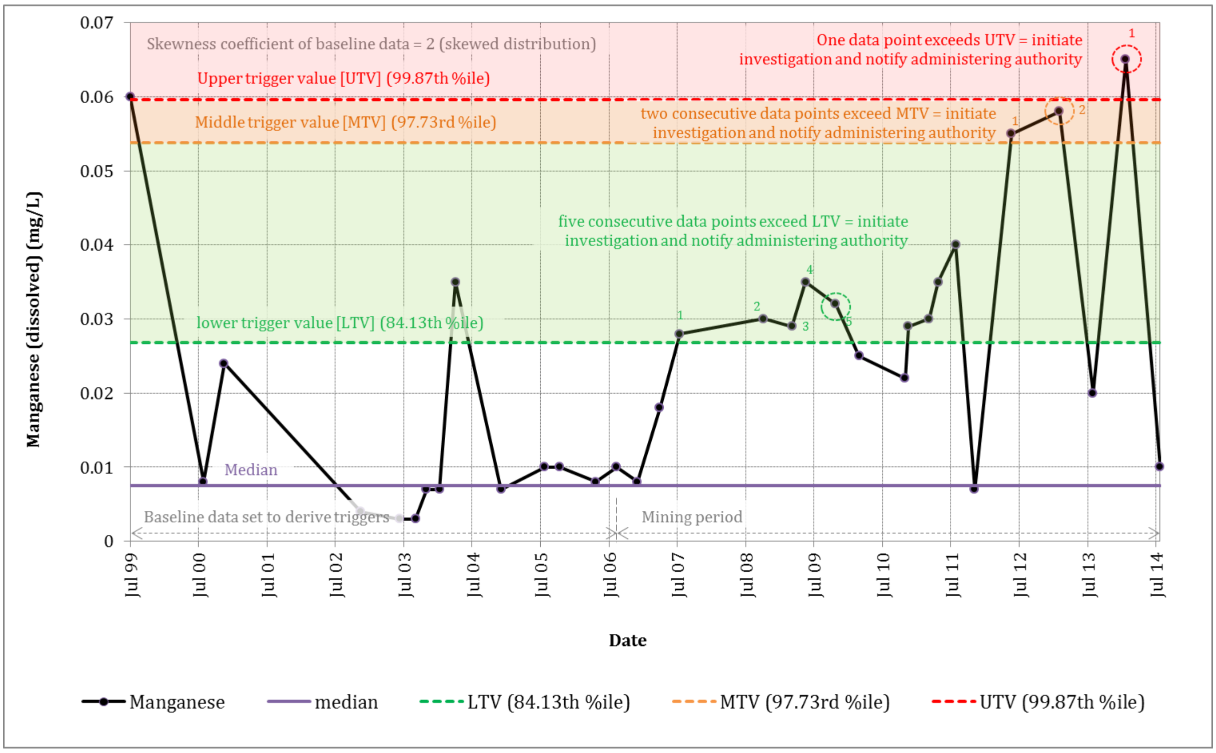


Figure 6-2: Example of a control for manganese showing a skewed baseline concentration distribution

The proposed default ANZECC target values will be adopted where appropriate across the network and are summarised in Table 6-3. The sites for which SSTVs will be identified are indicated with *SSTV* in Table 6-3 and values for SSTVs are provided by bore in the Groundwater Monitoring Program (Annexure A).

Throughout Main Works, should consistent exceedances be observed above these values and shown to not be the result of Main Works activities, a revision of this GMP will be undertaken and trigger values will be revised. If the exceedances are believed to be related to Main Works, investigation into the exceedances are required (*see* Section 7.2, *below*).

6.4.1.4. Water quality – a note on pH

The pH of waters is an indicator of the concentration of hydrogen ions. The scale is logarithmic, with values less than 7 indicating acidic waters and greater than 7 being basic. Baseline values of pH measured in groundwater samples from the monitoring network are reported in Attachment D of the Water Assessment for the EIS (EMM, 2019). The report contains statistics summarising the pH range in each geological formation. Based on the field values, pH of the groundwater typically falls within the 6.5 to 8.0 range specified as the water quality objective (WQO) value.

The control chart methodology used for salinity is not appropriate for pH as the log scale results in control lines that are too closely spaced relative to natural variability. The baseline groundwater monitoring shows pH values are commonly between pH 6 and pH 9. These values are therefore adopted as upper and lower trigger thresholds. Where results are higher than the threshold of pH 9 or lower than pH 6 then the decision tree process shown graphically in Figure 7-2 is undertaken.

It should also be noted that the upper annulus[1] of groundwater monitoring bores is commonly sealed using a grout slurry of cement and bentonite to prevent ingress of surface water. Occasionally this slurry can impact upon groundwater pH immediately around the borehole. This unintended outcome can often result groundwater samples with greater than pH 9 (and up to pH 12) for a significant period of time. If investigations determine the grout seal around any boreholes has raised pH around the boreholes it will not trigger DPIE review as there is no regional impact from the small volumes of cement[2] used in the sealing process.

[1] The volume between the outside of the borehole and the outside of the PVC bore casing

[2] Dependent on bore depth but commonly less than $1m^3$

Table 6-3: ANZECC groundwater quality trigger values and formations and parametes requiring site specific trigger values (SSTVs)

	Unit	Gooandra Volcanics	Temperance Formation	Boggy Plain Suite	Tantangara Formation	Kellys Plain Volcanics	Tertiary basalt	Plateau bogs/fens	Ravine Beds East	Ravine Beds West	Boraig Group	Yarrangobilly Caves
Field Parameters												
Dissolved oxygen	% saturation	*No Water Quality Objective Value*										
Electrical conductivity	µS/cm	30-350	SSTV	30-350	30-350	30-350	30-350	30-350	30-350	*SSTV*	30-350	30-350
pH	-	6.5-8.0	6.5-8.0	6.5-8.0	6.5-8.0	6.5-8.0	6.5-8.0	*SSTV*	6.5-8.0	6.5-8.0	6.5-8.0	6.5-8.0
Oxidation Reduction Potential	mV	*No Water Quality Objective Value*										
Turbidity	NTU	*No Water Quality Objective Value*										
Analytical results – nutrients												
Total nitrogen	mg/L	0.25	0.25	*SSTV*	0.25	0.25	0.25	*SSTV*	0.25	0.25	0.25	0.25
Reactive phosphorus	mg/L	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
Analytical results – metals (dissolved)												
Aluminium (Al)	mg/L	0.027	0.027	*SSTV*	0.027	0.027	0.027	*SSTV*	0.027	0.027	0.027	*SSTV*
Copper (Cu)	mg/L	*SSTV*	*SSTV*	*SSTV*	0.001	0.001	*SSTV*	0.001	0.001	0.001	*SSTV*	*SSTV*
Iron (Fe)	mg/L	0.34	0.34	0.34	0.34	0.34	0.34	*SSTV*	0.34	0.34	0.34	0.34
Lead (Pb)	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Manganese (Mn)	mg/L	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Nickel (Ni)	mg/L	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
Silver (Ag)	mg/L	0.000026	0.000026	0.000026	0.000026	0.000026	0.000026	0.000026	0.000026	0.000026	0.000026	0.000026
Zinc (Zn)	mg/L	*SSTV*	*SSTV*	*SSTV*	0.00246	0.00246	*SSTV*	*SSTV*	0.00246	0.00246	*SSTV*	0.002

SSTV Site specific trigger values to be calculated based on long-term statistical analysis – *see* Annexure A: Groundwater Monitoring Program

6.5. Training

All site personnel will undergo site induction training relating to groundwater management risks which have the potential to impact on groundwater resources.

Targeted training in the form of toolbox talks or specific training will also be provided to personnel with a key role in water management. Examples of training topics include:

- discharge quality parameters;
- groundwater monitoring methodology and protocols;
- groundwater dependent ecosystems;
- incident response; and
- spill management and reporting

Further details regarding the staff induction and training are outlined in Section 5 of the EMS.

6.6. Incident management

Incidents are managed in accordance with the Section 7 of the EMS and the Pollution Incident Response Management Plan (PIRMP). The investigation will include a review of events leading up to the incident and implement improved practices as required.

The Secretary and other relevant agencies will be notified of incidents in accordance with Section 7 of the EMS. Depending on the type and severity of the incident this may include notification to the Department and NPWS in writing for incidents defined under the conditions of approval, notification to the NPWS where required under the Deed of Agreement of Lease and notification to the EPA for pollution related incidents. Snowy Hydro would notify DPIE in writing immediately after they become aware of the incident on site.

6.7. Auditing

Audits will be undertaken to assess the effectiveness of water management measures and overall compliance with this GMP. Audit requirements are detailed in Section 8.3 of the EMS.

6.8. Reporting

Future Generation will report to Snowy Hydro and other agencies as detailed in Table 6-4 on groundwater management aspects related to the Project. During construction, groundwater monitoring data will be collected, tabulated and assessed against thresholds.

Table 6-4: Reporting requirements relevant to groundwater

Report	Requirement	Recipient
Reporting		
Weekly inspection	EMS Requirement Weekly inspection report undertaken by environmental advisor which includes aspects relevant to the management of water	FGJV Internal Record

Report	Requirement	Recipient
Incident Report (related to water)	Infrastructure Approval Schedule 4, CoA 6 The Proponent must notify the Department and NPWS via the Major Projects Portal immediately after it becomes aware of an incident on site. This notice must set out the location and nature of the incident.	Depending on the type and severity of the incident this may include notification to the Department and NPWS in writing for incidents defined under the conditions of approval, notification to the NPWS where required under the Deed of Agreement of Lease and notification to the EPA for pollution related incidents. Snowy Hydro will notify DPIE in writing immediately after they become aware of the incident on site.
	EPL 21266 Incident reports to be provided to EPA in accordance with EPL notification of environmental harm and written report requirements.	
EPL Monitoring Reports and Annual Review/Returns	EPL 21266 EPL monitoring reports will be prepared in accordance with the requirements of the EPL. An EPL Annual Review/Return will be prepared in respect of each EPL reporting period (typically 12 months)	EPA
Water Access Licence Report (annual)	Water Access Licence Actual water take will be reported to NRAR on an annual basis in accordance with water access licence conditions.	NRAR
Environmental Water Report (every 3 months)	Infrastructure Approval Schedule 3, CoA 31(c)(d) Commentary on the performance of the groundwater monitoring program (including rainfall data and tunnelling progress) will be documented in the quarterly environmental water report. Any incidents and key environmental issues will be documented.	Publicly available on project website
Other Aspects		
Site Water Balance	Infrastructure Approval Schedule 3, CoA 31(b) Yearly calendar revision of the Site Water Balance will be undertaken and where updates are identified, the revised Balance will be updated and included in a future revision of this WMP.	Proposed future updates to this WMP will be provided to EPA, NPWS, Water Group, NRAR and NSW DPI.
Groundwater model validation	Infrastructure Approval Schedule 3, CoA 31(d) Yearly calendar groundwater model review, validation and recalibration/update (as required/dictated by monitoring results) (undertaken by SHL).	The review will be submitted to NRAR, and the revised model will be submitted to the relevant agencies on completion.
Updates to this WMP	Section 1.7 of this WMP This WMP will be updated prior to the commencement of the following activities: • dredging, channel extraction or underwater blasting • in-reservoir emplacement works • construction works in the third year for the purposes of determining need / location of streamflow monitoring sites • Snowy 2.0 operations (a separate SHL document or framework may be prepared)	Proposed future updates to this WMP will be provided to EPA, NPWS, Water Group, NRAR and NSW DPI.

7. TRIGGER ACTION REPONSE PLANS

This section details the Trigger Action Response Plans (TARP) that has been developed for appropriate groundwater variation response. TARPs allow for prompt identification of unpredicted impacts and guide the implementation of additional management measures and corrective actions should adverse conditions arise that are attributable to construction.

Monitoring will be undertaken using a combination of methods and will require varying levels of processing and review before collected data can be used to inform assessment and decision making.

7.1. Adaptive management

Monitoring results obtained during construction will be subject to monitoring, analysis of results, review of mitigation measures (where exceedances are identified) and updates to measures and trigger values where required.

Additional or varied monitoring locations may be warranted following detailed design and during construction. Where a well becomes inoperable, damaged or within the disturbance footprint, the Environmental Manager will identify a suitable replacement in consultation with a suitably qualified hydrogeologist. Changes to monitoring locations and parameters would be approved by SHL in consultation with relevant agencies, and via EPL variation where required. Any relocation or addition of monitoring locations would trigger updating of the monitoring plan.

On-going monitoring results will inform future re-assessment of the numerical groundwater model. If a modelling up-date indicates increased drawdown over time at any location this may trigger additional montoring in the vicinity of the predicted drawdown area. The monitoring program (Annexure A) is designed to continue logging data at the majority of sites, with a retricted suite of sites used for instantaneous assessment. If any changes in excess of the predicted drawdown is registered, this would trigger expansion of the assessment suite of sites and will inform potential locations for additional monitoring sites.

7.2. Trigger Action Response Plans

In addition to the general principles described above (Section 6.4.1) for assessment of groundwater triggers, trigger action response plans (TARPs) have been developed to further investigate potential impacts to groundwater during construction of the Project.

The groundwater TARPs include:

- TARP 1 groundwater level (Annexure B)
- TARP 2 groundwater quality (Annexure C)
- TARP 3 groundwater ingress (Annexure D).

The purpose of the groundwater TARPs are to detail a standardised response procedure in the event that a trigger value banding is exceeded during a monitoring event for groundwater quantity, quality, pressures and/or levels. As groundwater take (in the form of discharged tunnel inflows) is a condition of approval, a groundwater ingress TARP is also developed.

The objectives of the TARPs are as follows:

- undertake supplementary monitoring to confirm and establish the extent of water quality or level variation;
- identify the potential cause(s) of the water quality or level variation, if possible;
- identify and implement appropriate mitigation measures to minimise on-going trigger of the water quality or level variation, if possible;

- perform due diligence when any variation is triggered; and
- meet CoA and REMMs requirements for trigger response.

7.2.1. Groundwater dependent ecosystems

Groundwater dependent ecosystems are critical assets to be protected during construction. The fundamental cause for any impacts to GDEs will be reduced access to groundwater driven by water level drop during the winter months. For this reason, potential impacts to GDEs is monitored through direct monitoring at targeted GDE locations via shallow standpipes as well as indirect monitoring via comparison of regional water levels with predicted drawdowns from the numerical modelling.

Critically, the Alpine Bogs and Associated Fens of the Plateau area have been shown during the baseline assessment (Annexure A Attachment A) to tolerate substantial groundwater drawdown during the summer months, with soil profiles drying out (e.g. Figure 7-1). Ecosystem function does not appear to be impacted by this drying, provided winter rainfall and/or subsequent spring snow-melt return groundwater levels to the surface or near surface. Thus, the critical period for high water levels (and groundwater-dependence) runs from May to October with reduced water tables outside this period expected and hence should not trigger a response.

GDE triggers, therefore, are only applicable for the critical periods between May and October.

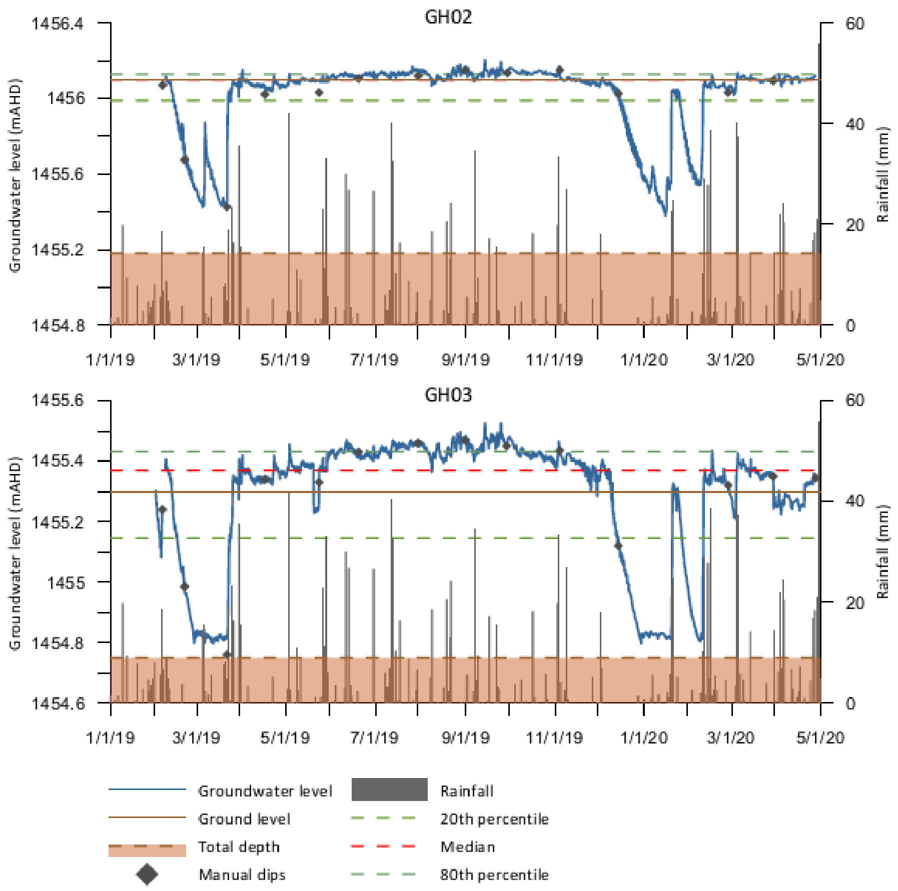


Figure 7-1: Typical water table response in the vicinity of an Alpine Bog (Gooandra Hill Bog)

7.2.2. Trigger Process

Figure 7-2 illustrates the investigation process to be followed when water level or quality results exceed values as described in Section 6.4 and itemised in the Groundwater Monitoring Program (Annexure A). The process requires review of all factors that can influence groundwater levels and quality including climatic conditions, any changes in geological conceptualisation and other physical constraints and operational conditions with the purpose to identify if there is a unique influence that has resulted in the change or if it is a result of multiple factors.

The TARP process is staged such that an initial monitored result is assessed against the relevant trigger values for that site (Stage 1). If the value exceeds the trigger value for groundwater inflow, groundwater level or groundwater quality indicators, the initial response (Stage 2) is to organise an additional measurement of that parameters at the site.

Confirmation of the initial results (Stage 3) triggers assessment by the site environmental officer for external factors, including natural or climatic variability (e.g. prolonged drought or excessive rainfall) (Stage 4) or changed site conditions (e.g. changed rate of TBM progress) (Stage 5).

If no external drivers can be identified, the potential for a construction impact is assessed (Stage 6). If it is determined that a construction activity may be responsible, or if no reason can be determined, an external third-party reviewer is engaged to repeat the assessment and make recommendations (Stage 7).

If the external reviewer has reason to believe the trigger was as a response of construction activities (or cannot determine the cause), the DPIE and NPWS will be notified (Stage 8) and further discussions undertaken to assess whether additional monitoring and/or mitigation is required. Notification to the DPIE and NPWS would occur within seven (7) days of the initial recognition of a trigger exceedance.

The external, third-party, reviewer will establish the appropriate level of trigger warning (Stage 9) based on the following principles:

1. Indicator Triggers are not considered detrimental to the environment and may reflect predicted impacts expected from the level of tunnel ingress and consequent drawdown. They may initiate an increased monitoring frequency and focus attention to potentially impacted bores. These triggers may also be set to provide verification for modelling results, typically with the use of Sentinel Bores that are expected to be impacted by construction as predicted by the numerical groundwater modelling.
2. Early Warning Triggers alert that levels or quality are trending towards potential impacts to specified assets and instigate additional statistical analysis of the data to verify trends and relationships across the network.
3. Threshold Triggers instigate mitigation activities. A detrimental trend is identified and potential for impact realised.
4. Trigger Limits can also be set for some parameters (for example, metal levels, extreme drawdown) that determine that a breach of Approval Conditions has occurred (i.e. CoA 29). Significant mitigation activities are activated.

If it is determined that a threshold trigger has been exceeded the external reviewer will provide a report to DPIE and NPWS within 30 days of the initial notification of a triggered exceedance (Stage 10). SHL will negotiate appropriate mitigation actions with DPIE and undertake any additional works within agreed timeframes.

The three groundwater TARPs outlined in Annexure B, Annexure C and Annexure D provide the basis for the corresponding trigger warning levels and consequent mitigation actions and response.

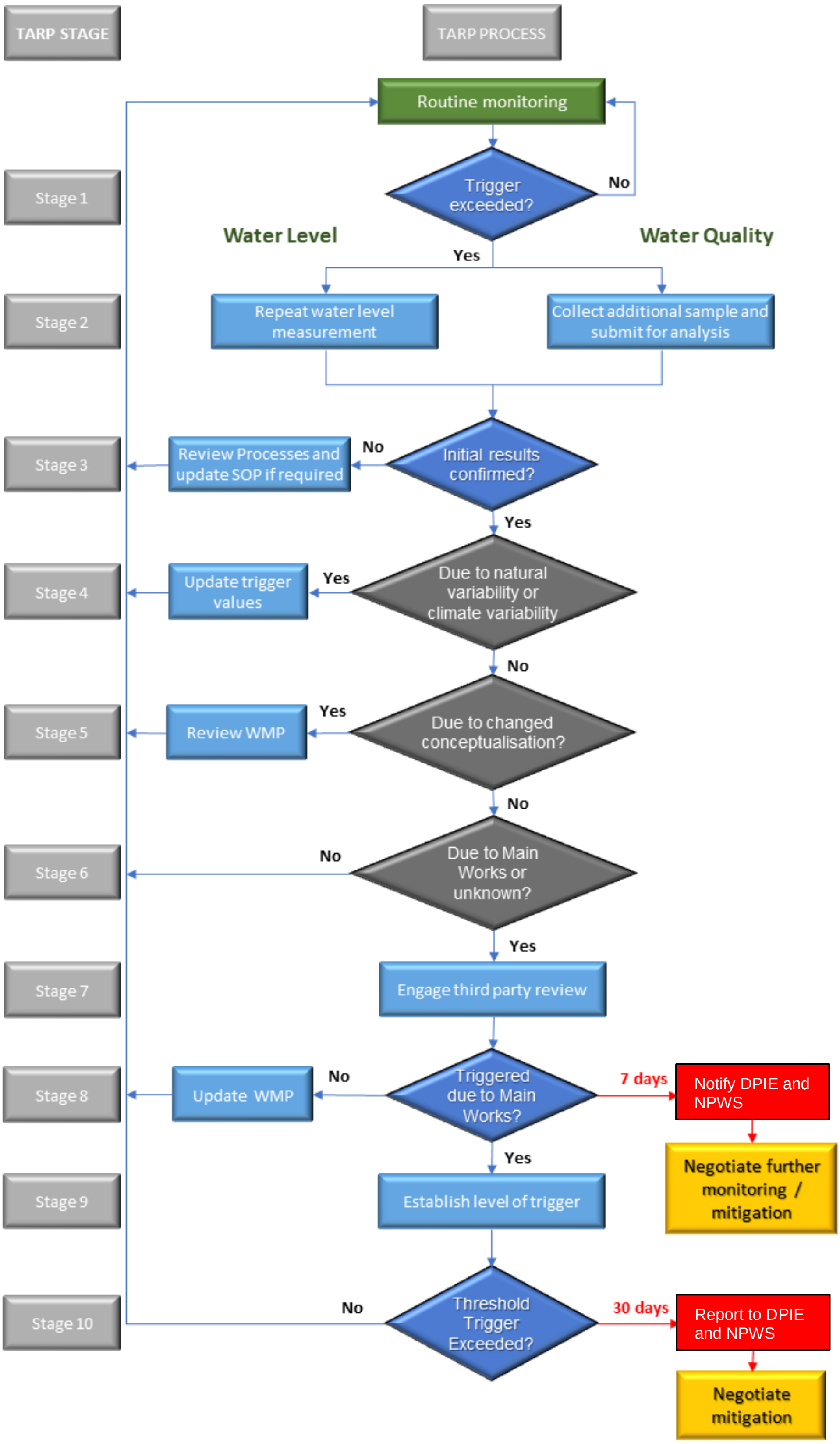


Figure 7-2: Decision tree for analysis of all trigger exceedances

The results of the trigger investigations will be reported in each Annual Review as described in Section 6.8. Consequent identified changes to baseline data or trigger levels that are not deemed a result of Main Works will trigger an update of the GMP and groundwater monitoring plan.

7.2.3. Alpine Bog and Associated Fen triggers

Shallow bores installed at identified Type 3 GDE locations (Alpine Bog and Associated Fens) have recorded shallow groundwater level variations and ecosystem health at twelve sites across the Plateau at Bullocks Hill Bog, Gooandra Hill Bog, Nungar Creek Bog and Tantangara Creek Bog. All sites record water levels in the top metre of the profile and seasonal variability demonstrates that these features dry during the summer and saturate during the winter (Annexure A). Water level variability in excess of a metre can occur between seasons, though this is generally limited by surficial discharge. All sites are characterised by six months (May to October) with water levels at or near the ground surface. Water level drawdown below the 80th percentile during these months would be considered a change (i.e. greater than a negligible change, as per CoA 15A) in the shallow groundwater regime and would trigger a Level 3 investigation as described under the groundwater level TARP (Annexure B).

The specific process at GDE sites requires consideration of biodiversity offsets if a trigger is deemed to be irreversible and the GDE function is compromised. Thus an additional trigger process is introduced that transfers responsibility of biodiversity considerations to the Biodiversity Management Plan and consideration of potential off-sets. This process is outlined in Figure 7-3.

GDE monitoring sites have been (or will be) established at a combination of: (i) identified GDEs within the predicted area of drawdown; (ii) identified GDEs outside the predicted area of drawdown, but along the tunnel alignment, and (iii) identified GDEs outside the predicted area of drawdown and at a significant distance from the project alignment. These would record shallow watertables at sites that are expected to be impacted; unlikely to be impacted and very unlikely to be impacted (baseline), respectively.

In the unlikely event that impacts are greater than predicted (Section 4.2.4), additional monitoring sites will be considered in consultation with DPIE and NPWS (Section 7.2.2 Step 8).

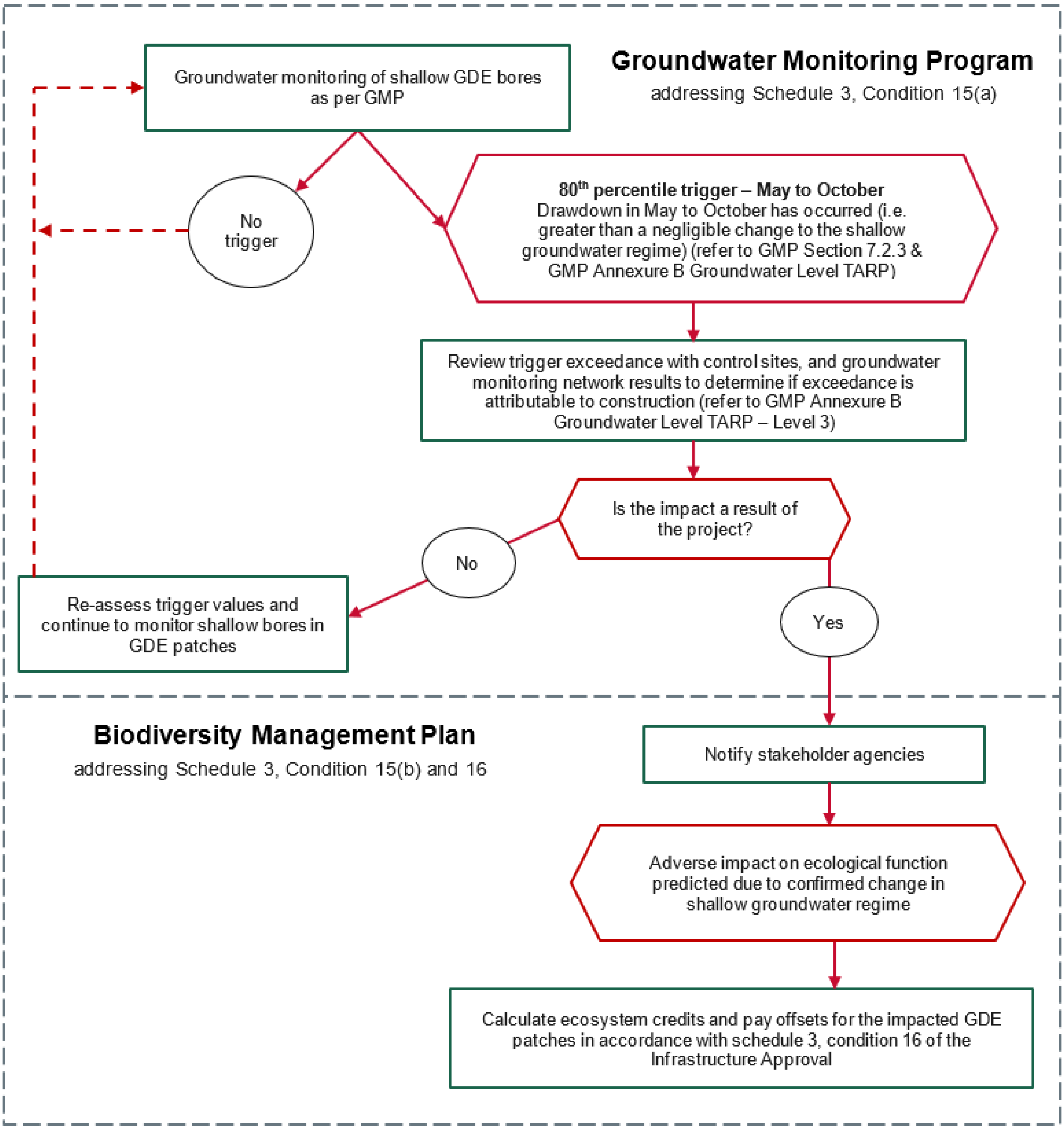


Figure 7-3: Linkage between Groundwater Level TARP and Biodiversity Management Plan

8. REVIEW AND IMPROVEMENT

8.1. Continuous improvement

This plan will be subject to continuous improvement through regular evaluation of environmental management performance against the policies, objectives and targets outlined in this plan and the project EMS in order to identify opportunities for improvement.

This review and improvement process will be designed to:

- Assess performance of the environmental management system through comparisons with objectives and targets;
- Identify opportunities for improving practices and processes;
- Determine the cause or causes of non-conformances or exceedance events;
- Develop and implement a plan of corrective and preventative action to address any non-compliances;
- Verify the effectiveness of the corrective and preventative actions; and
- Document any changes in procedures resulting from process improvement

8.2. Groundwater Model Validation

The SH4.0 model (and linked surface water SOURCE model) will be kept as a live groundwater management tool throughout construction. It will be validated and, if necessary, recalibrated to new groundwater monitoring data as the monitoring record increases.

Of particular benefit to ongoing validation of the model will be the inclusion of measured groundwater responses at the commencement of excavations and as works progress. Dewatering of excavations provides a much greater stress on the groundwater system than climate-driven stresses, and this information will enable greater accuracy in the prediction of impacts to the system.

Monitoring data will be reviewed throughout the construction period to provide validation of the groundwater model and potential requirements to increase, or decrease, the number of sampling locations and/or the analytical suites.

The review to recalibrate and update the groundwater model, and associated monitoring data collection frequency will be will be undertaken during each Annual Reporting cycle, in consultation with NRAR and DPIE Water Group.

The revised model will be submitted to the relevant agencies on completion, or as required by the REMMs and Conditions of Approval.

8.3. Groundwater Management Plan Revision

Throughout construction, there may be a need to update or revise this Plan. This may be in response to updates of the groundwater model, other elements of the project EMS or due to an update to the EPL. Plan updates will occur on an as needed basis, with conditions approved through the EPL taking precedence until any changes to the GMP are approved.

Amendments to this plan will be in accordance with the delegations outlined in the EMS. A copy of the updated plan and changes will be distributed to all relevant stakeholders in accordance with the approved document control procedure.

9. REFERENCES

ANZG 2018. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments, Canberra, ACT, Australia. Viewed [viewed 08/04/2020], [https://www.waterquality.gov.au/anz-guidelines].

Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ 2000);

Australian Drinking Water Guidelines (Natural Resource Management Ministerial Council (NRMMC), 2011);

EMM, 2019. Appendix J.1: Water Assessment for the Snowy 2.0 Main Works EIS (report #J17188 RP#86)

EMM, 2020. Modelling Report. Annexure I to Main Works Preferred Infrastructure Report and Response to Submissions

Groundwater Dependent Ecosystems Risk Assessment Guidelines (NOW 2012d);

NSW State Groundwater Quantity Management Policy (2001 (unpublished));

NSW State Groundwater Quality Protection Policy (DLWC 1998);

NSW State Groundwater Dependent Ecosystem Policy (DLWC 2002);

Australian Groundwater Modelling Guidelines (National Water Commission 2012);

National Water Quality Management Strategy Guidelines for Groundwater Quality Protection in Australia (NWQMS 2013);

Department of Primary Industries Guidelines for Controlled Activities (2012); and

Environment Protection Authority (EPA): Approved methods for Sampling and Analysis of Water Pollutants in NSW (EPA 2004).

Department of Planning and Environment (DPR): Guideline for riparian corridors on waterfront land (DPE 2012)

Department of Water and Energy (DWE): NSW Water Extraction Monitoring Policy (DWE 2007); and

NSW Office of Water (NoW) NSW Aquifer Interference Policy (NoW 2012).

ANNEXURE A – GROUNDWATER MONITORING PROGRAM

S2-FGJV-ENV-PLN-0108

SNOWY 2.0 MAIN WORKS – GROUNDWATER MONITORING PROGRAM

Approval Record			
Document preparation, review and approval		Name in print	Signature
Prepared by	Principal Hydrogeologist	R. Cresswell	
Reviewed by	Environmental Consultant	S. Mitchell	
Verified by	Environmental Manager	L. Coetzee	
Approved by	Project Director	A. Betti	Digitally signed by Antonio Betti Date: 2020.09.19 09:31:58 +10'00'

Document Revision Table		
Rev.	Date	Description of modifications / revisions
A	13.03.2020	Initial draft
B	22.05.2020	Update to reflect conditions of approval and revised environmental management measures
C	15.06.2020	Revised to address SHL comments. For consultation
D	25.06.2020	Update to address Commonwealth conditions of approval
E	06.08.2020	Revised to address stakeholder comments
F	19.09.2020	Revised to address DAWE and DPIE comments

CONTENTS

TABLE OF TABLES

TABLE OF FIGURES

1. INTRODUCTION

1.1. Context

This Groundwater Monitoring Program (Program) forms part of the Groundwater Management Plan (GMP), Water Management Plan (WMP) and Environmental Management Strategy (EMS) for construction of Snowy 2.0 (the Project).

The Program addresses the requirements of the Minister's Conditions of Approval (CoA) as approved on 21 May 2020; the Main Works Snowy 2.0 Environmental Impact Statement (EIS); the revised environmental management measures (REMMs) within the Snowy 2.0 Main Works and Exploratory Works Response to Submissions; Environmental Protection Licence (EPL) 21266, as well as all applicable guidance and legislation as described in the Groundwater Management Plan to which this is appended.

1.2. Scope

The scope of this Program is to describe how Future Generation propose to monitor the extent and nature of potential impacts to groundwater and dependent uses and ecosystems during construction of the Project. Operational monitoring and operation measures do not fall within the scope of the construction phase and therefore are not considered within this Program.

This Program provides detailed inspection criteria and responsibilities including:

- groundwater monitoring locations;
- parameters/analytes to be monitored;
- types of monitoring;
- frequency of monitoring,
- monitoring methodology; and
- data management, model verification and ownership.

1.3. Purpose and objectives

This groundwater monitoring program has been developed to monitor potential impacts to groundwater (and consequent potential impacts to groundwater dependent users, including ecosystems) during construction (Main Works) of the Project.

The objectives of the program are to:

- quantify groundwater inflow volumes to tunnels
- assess any changes to groundwater levels/pressures
- assess any changes to water quality of different groundwater aquifers
- assess groundwater conditions against nominated trigger values
- help identify, and monitor the response of, any actions required in the event of trigger value exceedances;
- assess the effectiveness of groundwater mitigation measures;
- assure compliance with relevant consent and licencing conditions and other monitoring requirements, as prescribed for the Project; and

- provide additional data for groundwater numerical modelling verification, validation and re-calibration, as required.

This Program is based on the baseline monitoring program established during the assessment of the Project EIS (EMM, 2019) and continued through baseline monitoring reports (EMM, 2020). Baseline data is provided as Attachment A to this Program.

1.4. Consultation

In accordance with schedule 3, condition 31 of the Infrastructure Approval and Main Works REMM WM01, the WMP (which includes the GMP) is to be prepared in consultation with:

- NSW Environment Protection Agency (EPA);
- National Parks and Wildlife Services (NPWS);
- Department of Planning, Industry and Environment – Water group (DPIE – Water Group);
- Natural Resources Access Regulator (NRAR); and
- NSW Department of Primary Industries (NSW DPI).

In accordance with condition 18 of the Commonwealth approval, the WMP (including the GMP) is also to be prepared in consultation with the DAWE.

The Program is proposing to utilise bores from the existing baseline monitoring network established by Snowy Hydro Limited (Snowy Hydro) during the Exploratory Works. Snowy Hydro developed this network in consultation with DPIE-Water with the objective of providing good coverage along the Project alignment across all hydrostratigrahic units and under the diverse geological conditions.

A summary of consultation undertaken during the development of the GMP and GWMP is included in Section 1.7 of the GMP.

1.5. Relationships to other documents

The overall environmental management system for the Project is described in the Environmental Management Strategy (EMS).

This Groundwater Monitoring Program forms part of Future Generation's environmental management framework as described in the EMS. An overview of the Groundwater Monitoring Program relative to the elements of water management is provided in the Groundwater Management Plan (S2-FGJV-ENV-PLN-0012).

This Program provides groundwater level and quality monitoring relevant to protection of groundwater-dependent ecosystems (GDEs). Additional monitoring and mitigation measures for ecosystems are outlined in the Biodiversity Management Plan (S2-FGJV-ENV-PLN-0008).

This Groundwater Monitoring Program monitors groundwater water levels that inform the calibration of numerical groundwater modelling that includes changes to baseflow caused by changes in groundwater levels and pressures.

1.6. Overview

Groundwater monitoring to be undertaken is summarised in Table 1-1.

Table 1-1: Groundwater monitoring

Characteristic	Proposed sampling	Frequency of sampling
Groundwater level	Groundwater Level - Direct-read data loggers	Six-hourly
Groundwater quality - general	Water quality lab samples from the suite	Quarterly, or as required by the EPL or TARPs
Compliance with groundwater extraction licence approval	Volume - Measured extraction volume (i.e. Groundwater inflow to the tunnels (and subsequent discharge via the Project WTPs).	As required by the extraction licence
Tunnel inflow monitoring	Inflow volume measurements	Dependent on tunneling program

Where a well becomes inoperable, damaged or within the works footprint, the Future Generation environment team, in consultation with Snowy Hydro and relevant agencies, will identify a suitable replacement in consultation with a suitably qualified hydrogeologist.

1.7. Physical environment

The existing physical environment is described in Section 3 of the WMP and Section 3 of the GMP and summarised below.

The Snowy 2.0 Project spans the NSW Western Slopes, South Eastern Highlands and Australian Alps Interim Biogeographic Regionalisation for Australia (IBRA) regions characterised as diverse landforms of limestone, granite and basalt valleys and mountain ranges. These landscapes vary from 545m AHD in the Lobs Hole zone leading up the valleys (Marica/ Plateau zones) to the plateau topped Tantangara zone at 1524m AHD. The Ravine area is characterised by deep gorges and steep sloping ridges. The plateau area is typical of elevated alpine environments, dominated by low energy streams, gentle rolling hills and mostly flat floodplains.

The Project area is located within the south-eastern portion of the Lachlan Fold Belt (LFB) of NSW. The LFB comprises a suite of Ordovician to Devonian sedimentary, igneous and metamorphic rocks that have been laid down, compacted and deformed across multiple orogenic periods.

The geology between Talbingo and Tantangara reservoirs is structurally deformed with numerous folds and several major faults associated with the north-south trending Long Plain Fault (LPF) zone.

The project intercepts two major geological structural blocks. These two structural blocks form distinct geological terrains: the dominantly Silurian Tumut Block in the west (the incised ravine area), and the dominantly Ordovician Tantangara Block in the east (the plateau). The terrains are separated by an escarpment caused by movement on the LPF (Figure 1-1).

The EIS identified two high risk geological formations, the Gooandra Volcanics and Kellys Plain Volcanics, both of which are located in the Plateau structural block (Figure 1-1). These formations demonstrated (through pumping tests) vertical hydraulic connections between shallow and deeper horizons within these geological units. A summary of hydraulic properties for the plateau and ravines regions are summarised in Section 3 of the GMP.

This monitoring plan aims to provide groundwater information on each of the identified geological units and specifically to provide information that informs the groundwater interpretations and supports further development of the groundwater model and protection of groundwater dependent users and ecosystems.

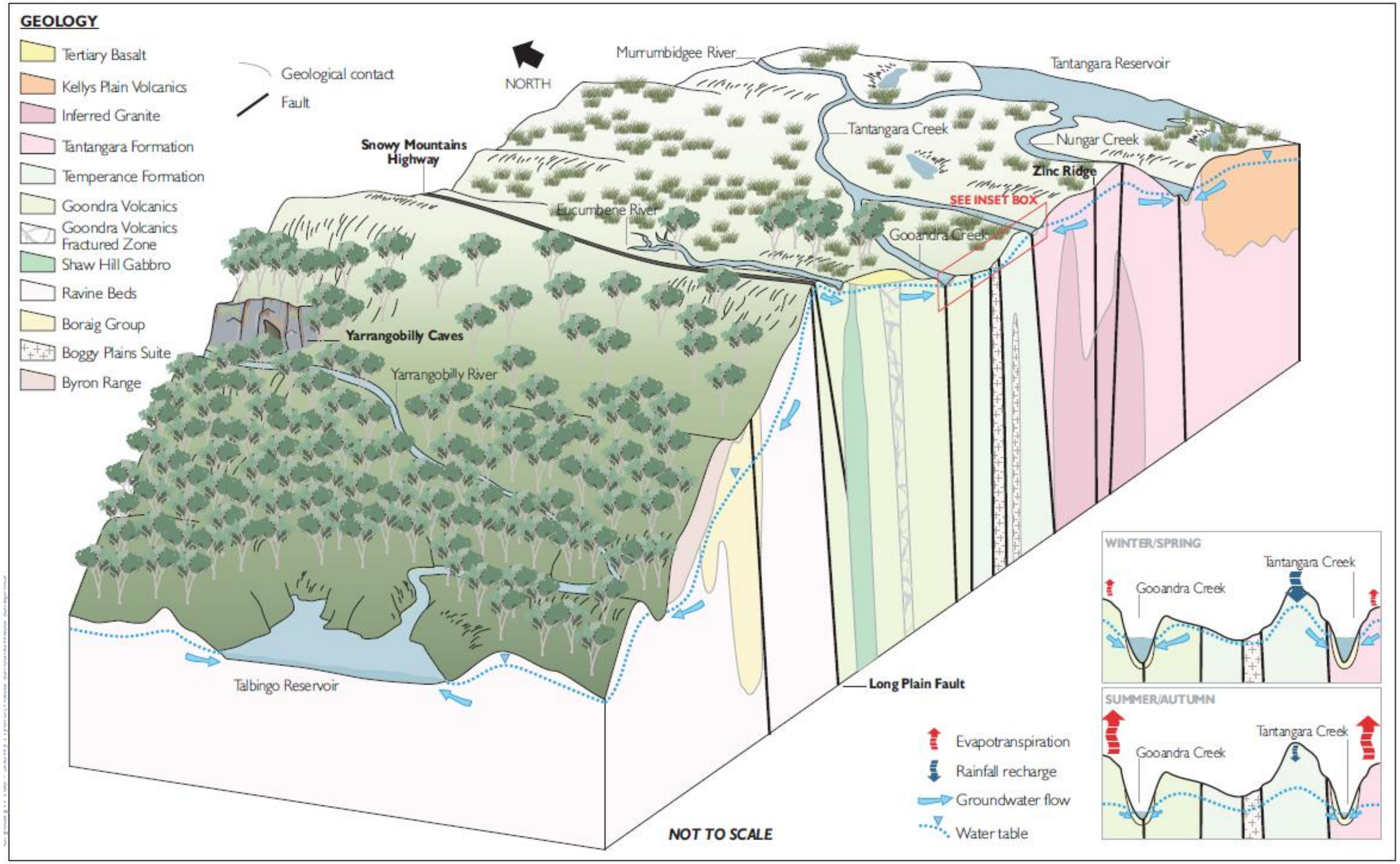


Figure 1-1: Schematic geological block diagram of the Project area showing key groundwater interactions

2. GROUNDWATER MONITORING PRINCIPLES AND DESIGN

2.1. Key Principles

To meet the objectives identified in Section 1.3, the groundwater monitoring program has been developed specifically to:

- verify the groundwater model (i.e. validate the predicted drawdown);
- monitor in areas predicted to be at high risk of groundwater drawdown, including the Kellys Plain Volcanics and Gooandra Volcanics geological formations; and
- monitor impacts to groundwater dependent ecosystems.

The following key principles were adopted:

- identification of key receptors to monitor (to ensure protection);
- use of the existing baseline network to understand natural variations and fluctuations;
- use of compliance groundwater bores north and south of the tunnel alignment in high risk areas to validate the predicted model impacts extents (the distance from the alignment was chosen to confirm the absence of impact in areas that were modelled to have no impact);
- addition of lagging indicator groundwater bores within areas of predicted impacts to verify modelled predicted impacts and provide warning for further investigation, and
- addition of shallow bores to evaluate and protect GDEs from impacts.

2.2. Network Design

For the EIS, EMM designed and implemented a dedicated project baseline groundwater monitoring network to investigate groundwater conditions in the project area. The network was developed in consultation with DPIE-Water (formerly DoI Water). The network and baseline data were reported in the EIS (Appendices J.2 and J.3).

The Project baseline groundwater monitoring network within the project area was completed over four drilling campaigns and consists of conventional groundwater monitoring bores, test production bores, vibrating wire piezometers (VWPs) and shallow drive points/auger holes. Monitoring bores, VWPs and drive points/auger holes were positioned to provide spatial coverage, investigate the major geologies and groundwater environments, and monitor potentially sensitive features. The monitoring network also consists of both background (regional) monitoring locations and targeted (local) monitoring locations along the alignment of the key proposed project features. Numerous nested sites were developed to provide information on surficial to deep connectivity along the alignment to inform the conceptualisation of the numerical groundwater model.

This Project baseline groundwater monitoring network has been adopted as the basis of the construction monitoring network. Sites have been rationalised, however, to focus on potentially high-risk areas and assets and the sampling program revised where justifiable to reduce monitoring frequency and hence impacts to the local landscape caused by intensive sampling campaigns. Critically, the numerical groundwater modelling has identified locations where additional monitoring is required, or may provide critical information to inform future iterations of the model. Hence, additional monitoring locations have been selected, guided by the key principles discussed in Section 2.1.

The Main Works monitoring network is identified in Section 2.3.

2.3. Monitoring Network

The current groundwater monitoring infrastructure for Main Works includes 98 bore constructions listed in Table 2-1. These are listed for each bore type and from west to east. Locations are shown in Figure 2-1 and Figure 2-2. The current infrastructure consists of:

- Forty-eight (48) conventional groundwater monitoring bores at 39 locations. At some locations multiple monitoring bores are installed next to one another to varying depths (nested bores). These bores are suitable for both water level and water quality sampling.
- Eight (8) test production bores used to assess indicative groundwater yields and quality at the proposed tunnel depth.
- Two (2) production bores at Lobs Hole which are used as auxiliary water supply sources.
- Four (4) shallow drive point piezometers and 12 swamp monitoring bores.
- Twenty-four (24) VWP locations with 61 depth sensors.

An additional fourteen (14) sites have been selected as part of an expanded network to monitor groundwater at GDEs and investigate groundwater conditions away from the tunnel alignment (see Section 2.4). That is, to the north and south of the existing network to assess groundwater connectivity along strike from the existing network. The focus will be on the high-risk zones of the Gooandra Volcanics and Kellys Plain Volcanics.

Table 2-1: Baseline groundwater monitoring network

Target formation	Bore ID	Ground level (m AHD)[1]	Total depth (m BGL)	Screen interval (m BGL)	Target lithology
Conventional monitoring bores					
Ravine Beds West	BH7106	613	154.1	141.1–153.1	Siltstone
	BH8101	610	68.4	53.4–65.4	Siltstone
	BH8102	608	68.6	53.6–65.6	Siltstone
	BH8105	621	58.9	43.9–55.9	Siltstone
	BH8108	629	60	45.0–57.0	Siltstone
	RSMB1	561	30	27.0–30.0	Siltstone/sandstone
	RSMB2	570	30	27.0–30.0	Siltstone/sandstone
	RSMB3	593	30	27.0–30.0	Siltstone/sandstone
	TMB01B	582	72	63.0–69.0	Siltstone
	TMB05A	603	21	12.0–18.0	Weathered Siltstone
	TMB05B	603	77	68.0–74.0	Siltstone
Boraig Group	BH5105	1,199	108.2	97.0–109.0	Ignimbrite
	BH7104	584	92.2	80.2–89.2	Ignimbrite
	MB06A	1,145	14	9.0–12.0	Weathered volcanic
	MB06B	1,145	72	64.0–70.0	Volcanic
	TMB01A	581	14	11.0–14.0	Ignimbrite
Ravine Beds East	MB12B	1,331	180	149.0–179.0	Siltstone
	MB12A	1,330	36	26.0–35.0	Weathered siltstone

Target formation	Bore ID	Ground level (m AHD)[1]	Total depth (m BGL)	Screen interval (m BGL)	Target lithology
Tertiary basalt	MB01B	1,464	7.5	5.3–6.8	Basalt
Gooandra Volcanics	BH3110	1,346	178.9	165.9–177.9	Diorite
	MB01C	1,464	52	45.0–51.0	Basalt
	MB02	1,387	150	141.0–147.0	Chloritic schist
	MB03	1,373	101	92.0–98.0	Chloritic schist
	MB11A	1,485	7.5	17.0–23.0	Weathered basalt
	SMB04	1,342	180	170.0–179.0	Chloritic schist
	SMB05	1,342	50	40.0–49.0	Basalt
	TMB02A	1,470	15	11.0–14.0	Weathered basalt
	TMB02B	1,472	200	191.0–197.0	Chloritic schist
	TMB03A	1,478	34	29.5–32.5	Weathered basalt
	TMB03B	1,478	150	141.0–147.0	Chloritic schist
	TMB04	1,346	200	191.0–197.0	Basalt
Temperance Formation	BH3102	1,383	91	82.0–88.0	Sandstone
	MB04A	1,330	30	23.0–29.0	Basalt
	MB04B	1,330	102.5	93.5–99.5	Chloritic schist
	MB07A	1,265	15	10.0–13.0	Weathered siltstone
	MB07B	1,265	60	51.0–57.0	Sandstone
	MB13A	1,382	60	50.0–59.0	Weathered siltstone
	MB13B	1,382	190	169.0–189.0	Siltstone
Temperance Formation /Boggy Plain Suite	SMB03	1,335	50	40.0–49.0	Sandstone
Boggy Plain Suite	SMB02	1,335	195	182.0–194.0	Sandstone
Tantangara Formation	BH2103	1,264	103.3	94.3–100.3	Sandstone
	BH3101	1,418	85.6	76.6–82.6	Sandstone
	MB08A	1,435	30	20.0–29.0	Weathered siltstone
	MB08B	1,436	298	277.0–297.0	Sandstone
Kellys Plain Volcanics	BH1115	1,231	55	42.0–51.0	Dacite
	BH1116	1,234	93.1	80.5–89.5	Dacite
	BH1117	1,241	65	51.9–60.9	Dacite
	BH2101	1,314	169.9	154.6–166.6	Siltstone
Test production bores					
Ravine Beds West	PB05	614	100	50.0–100.0	Siltstone
Ravine Beds East	PB09	1,330	300	200.0–300.0	Siltstone

Target formation	Bore ID	Ground level (m AHD)[1]	Total depth (m BGL)	Screen interval (m BGL)	Target lithology
Gooandra Volcanics	PB04	1,341	200	185.0–200.0	Chloritic schist
	TMB03C	1,478	250	237.0–249.0	Chloritic schist
Temperance Formation	PB10	1,382	230	210.0–230.0	Chloritic schist
Boggy Plain Suite	PB03	1,336	215	200.0–215.0	Granite
Tantangara Formation	PB06	1,436	318	298.0–318.0	Sandstone
Kellys Plain Volcanics	PB01	1,231	60	30.0–60.0	Dacite
Production bores					
Ravine Beds West[3]	EWPB1	563	96	36.0–42.0, 54.0–60.0, 90.0–96.0	Siltstone/sandstone
	EWPB3	560	60	24.0–42.0, 48.0–54.0	Siltstone/sandstone
Vibrating wire peizometers				Vertical sensor depth (m BGL)	
Ravine Beds West	BH6103	602	220	218.7, 131.2	Siltstone/sandstone
Boraig Group /Ravine Beds East	BH5104A	1187	840	673.3, 475.3, 376.3	Siltstone/sandstone
	BH5103	1272	882	765.0, 562.0, 352.0	Mixed sediments
Ravine Beds East	BH8106	1096	673	669.0, 431.0	Siltstone/sandstone
	BH5108	1141	764	666.0, 431.0, 380.3	Siltstone
	BH5107	1163	774	737.5, 554.5, 381.4	Siltstone/sandstone
	BH5110	1196	799	687.5, 435.4, 267.3	Mixed sediments
	BH5114	1287	532	491.9, 359.0, 208.5	Siltstone
	BH5115	1330	789	292.0, 192.0	Siltstone
	BH5102	1329	949	818.8, 619.1, 419.4	Siltstone/sandstone
	BH5111	1351	272	232.4, 180.7, 116.5	Siltstone/sandstone
	BH5101A	1390	1011	248.0	Siltstone
	BH4104	1484	917	628.4, 506.6	Siltstone
Gooandra Volcanics	BH4103	1471	388	335.6, 232.2, 139.5	Metatuff, Tuff, Gneiss
	BH4102	1460	534	455.6, 374.3, 246.3	Gneiss, Phyllite
	BH4101	1479	1100	883.9, 729.6, 542.5	Meta-rhyolite
	BH3108	1369	998	620.0, 342.0, 250.0	Schist
	BH3111	1502	406	354.6, 252.5, 120.5	Meta-siltstone/sandstone
Temperance Formation /Gooandra Volcanics	BH3107A	1325	237	200.2, 133.5	Siltstone/sandstone

Target formation	Bore ID	Ground level (m AHD)[1]	Total depth (m BGL)	Screen interval (m BGL)	Target lithology
Temperance Formation/Boggy Plain Suite	BH3106	1335	247	194.3, 150.1	Pyroxenite, Diorite
Tantangara Formation	BH3104	1436	339	287.0, 174.0, 72.9	Siltstone/sandstone
	BH3113	1334	234	184.8, 94.9	Meta-siltstone/sandstone
	BH2102	1246	145	107.2, 41.8	Meta-siltstone/sandstone
Drive point piezometers and narrow diameter piezometers					
Gooandra Hill Bog[2]	GH01	1,456	1	0.5–1.0	Alluvium/colluvium
	GH02	1,456	0.9	0.5–0.9	Alluvium/colluvium
	GH03	1,455	0.6	0.3–0.6	Alluvium/colluvium
Tantangara Creek Bog[2]	TC01	1,324	1	0.6–1.0	Alluvium/colluvium
	TC02	1,322	1.1	0.7–1.1	Alluvium/colluvium
	TC03	1,321	0.8	0.5–0.8	Alluvium/colluvium
Bullocks Hill Bog[2]	BP1	1,366	1.8	1.5–1.8	Alluvium/colluvium
	BP2	1,364	1.8	1.5–1.8	Alluvium/colluvium
	BP3	1,364	1.8	1.5–1.8	Alluvium/colluvium
	BP4	1,363	1.8	1.5–1.8	Alluvium/colluvium
	BH01	1,351	0.4	0.2–0.4	Alluvium/colluvium
	BH02	1,352	0.9	0.6–0.9	Alluvium/colluvium
	BH03	1,350	0.7	0.5–0.7	Alluvium/colluvium
Nungar Creek Bog/Fen[2]	NC01	1,237	0.8	0.5–0.8	Alluvium/colluvium
	NC02	1,237	1.1	0.8–1.1	Alluvium/colluvium
	NC03	1,237	1.0	0.7–1.0	Alluvium/colluvium

Notes:
1. m AHD = metres Australian Height Datum.
2. Interpreted surficial formation.
3. monitoring bores used for production only, no testing completed.

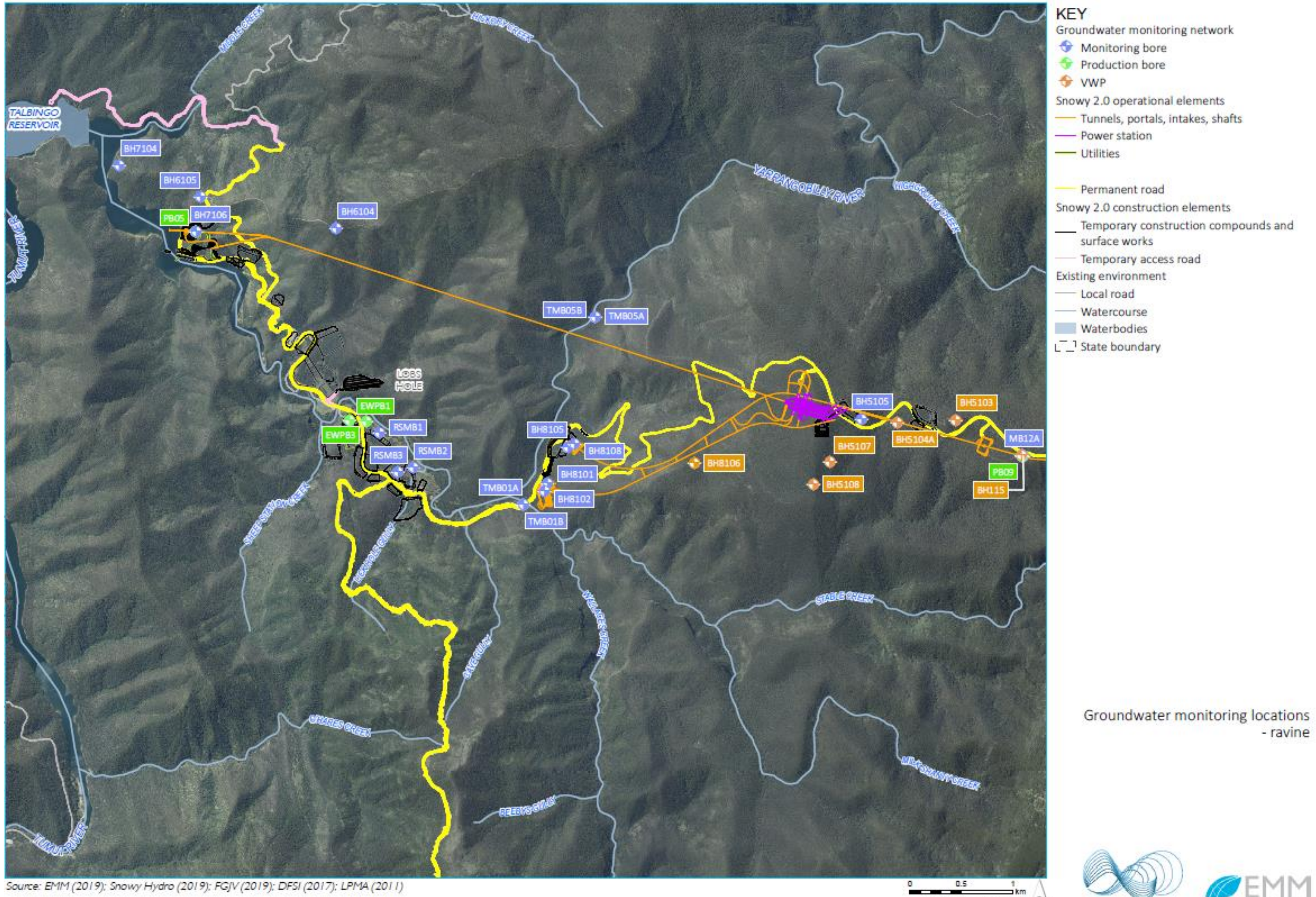


Figure 2-1: Groundwater monitoring locations - Ravine

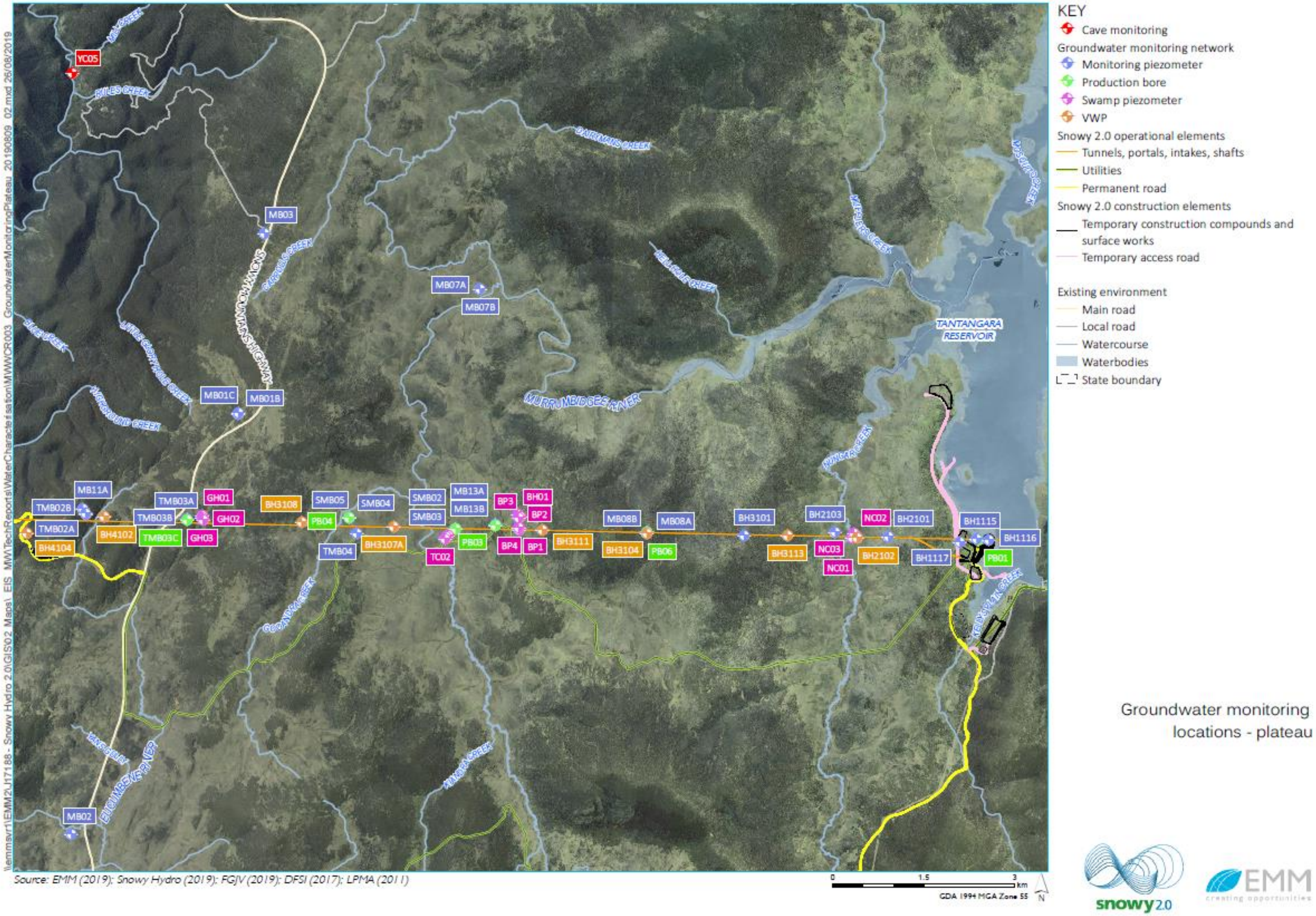


Figure 2-2: Groundwater monitoring locations - Plateau

2.4. Risk Prioritisation

Numerical groundwater modelling (model version SH4.0) for the EIS and subsequently revised for the RTS (EMM, 2020) has indicated that there are areas at risk from drawdown induced by construction activities. Risk is primarily related to drawdown in water levels in shallow groundwater systems that provide support for identified GDEs. This is predicted to particularly occur in groundwater associated with the Gooandra Volcanics and the Kellys Plain Volcanics on the Plateau as well as (to a lesser consequence) within all Ravine units. Predicted peak maximum drawdown across the region is shown in Figure 2-3 and critical areas above the Gooandra Volcanics and Kellys Plain Volcanics are expanded in Figure 2-4.

These higher risk areas are recognised in the Conditions of Approval (COA).

Specifically, Schedule 3, Clause 30(e) requires the Proponent to:

"*minimise groundwater take from the Gooandra Volcanics and Kellys Plain Volcanics using pre and post grouting of the tunnel, to minimise the loss of stream flows in the waterways above these geological formations, including Gooandra Creek and the headwaters of the Eucumbene River".*

Further, Schedule 3, Clause 15 refers to the Alpine Sphagnum Bogs and Associated Fens:

"*The Proponent must ensure that the development does not cause any exceedances of the following performance measures in the Alpine Sphagnum Bogs and Associated Fens above the Gooandra Volcanics and Kellys Plain Volcanics:*

(a) Negligible change to the shallow groundwater regime supporting the bogs and associated fens when compared to a suitable control site; and

(b) Negligible change in the ecosystem functionality of the bogs and associated fens."

The existing network includes sites that co-locate with recognised GDEs (PCT 637) (Figure 2-4). These sites have been used to define baseline conditions for bogs and associated fens across the Plateau region. These sites will be augmented by an additional 15 monitoring sites (Table 2-2) to those presented in the EIS that have been proposed in consultation with DPIE-Water and will constitute the next round of drilling and bore development (note these will be progressively installed upon approval of this GMP). A combination of deep and shallow bores will be constructed to monitor water pressure changes that are expected during the tunnel construction and to monitor shallow levels that may be impacted by the deeper water drawdown specifically in the vicinity of the potentially impacted Alpine Sphagnum Bogs and Associated Fens (Figure 2-5).

Sites will include at least one location where the bog is predicted to be impacted, as well as sites that are not. As described in Section 7.2.3 in the GMP, shallow bores installed at identified Type 3 GDE locations (Alpine Sphagnum Bog and Associated Fens: PCT 637 at Bullocks Hill Bog (bores BH01, BH02, BH03), Gooandra Hill Bog (GH1, GH02, GH03), Nungar Creek Bog (NC01, NC02, NC03) and Tantangara Creek Bog (TC01, TC02, TC03) have recorded significant shallow groundwater level variations across the Plateau area. All sites record water levels with a strong seasonal variability indicating that these features dry during the summer months and saturate during the winter (*see bore water level baseline results in* Attachment A). Water level variability in excess of a metre can occur between seasons, though variability of only a few tens of centimetres is also recorded, with all sites characterised by six months (May to October) with water levels at or near the ground surface.

Recovery of the water table to ground levels each year maintains ecosystem function, hence water level drawdown below the 80th percentile during these months can be used as a trigger for further action (*see* GMP Section 7.2.1).

Shallow bores will thus monitor the shallow surficial water table that interacts directly with the GDE. The local deeper bores will provide data to verify the predictions from the numerical modelling and are designed to penetrate to the level of the tunnel invert.

Additional monitoring locations will be progressively installed upon approval of this GMP. The exact location of each bores will be confirmed on-site and final survey locations included in a revision to the GMP where required. Three monitoring bores are proposed each bog site and two bores for the nested bored.

Table 2-2: Additional monitoring locations

Target formation	Bore ID	Bore Type	Ground level (m AHD)[1]	Total depth (m BGL)	Rationale
Gooandra Volcanics	RtS_BH1A	Conventional monitoring bore (nested)	1,392	50	Model validation
Gooandra Volcanics	RtS_BH1B	Conventional monitoring bore (nested)	1,392	316	Model validation
Gooandra Volcanics	RtS_BH2A	Conventional monitoring bore (nested)	1,395	50	Model validation
Gooandra Volcanics	RtS_BH2B	Conventional monitoring bore (nested)	1,395	314	Model validation
Gooandra Volcanics	RtS_BH3A	Conventional monitoring bore (nested)	1,431	50	Model validation
Gooandra Volcanics	RtS_BH3B	Conventional monitoring bore (nested)	1,431	344	Model validation
Gooandra Volcanics	RtS_BH4A	Conventional monitoring bore (nested)	1,397	50,	Model validation
Gooandra Volcanics	RtS_BH4B	Conventional monitoring bore (nested)	1,397	308	Model validation
Gooandra Volcanics	RtS_BH5	Shallow piezometer	1,398	<1	GDE monitoring
Gooandra Volcanics	RtS_BH6	Shallow piezometer	1,449	<1	GDE monitoring
Kellys Plain Volcanics	RtS_BH7A	Shallow piezometer	1,231	<1	Model validation
Kellys Plain Volcanics	RtS_BH7B	Conventional monitoring bore (nested)	1,231	49	Model validation
Kellys Plain Volcanics	RtS_BH8A	Shallow piezometer	1,225	<1	Model validation
Kellys Plain Volcanics	RtS_BH8B	Conventional monitoring bore (nested)	1,225	65	Model validation
Gooandra Volcanics	RtS_BH9	Shallow piezometer	1,459	<1	GDE monitoring
Gooandra Volcanics	RtS_BH10	Shallow piezometer	1,421	<1	GDE monitoring
Gooandra Volcanics	RtS_BH11	Shallow piezometer	1,354	<1	GDE monitoring
Gooandra Volcanics	RtS_BH12	Shallow piezometer	1,317	<1	GDE monitoring
Kellys Plain Volcanics	RtS_BH13	Shallow piezometer	1,269	<1	GDE monitoring

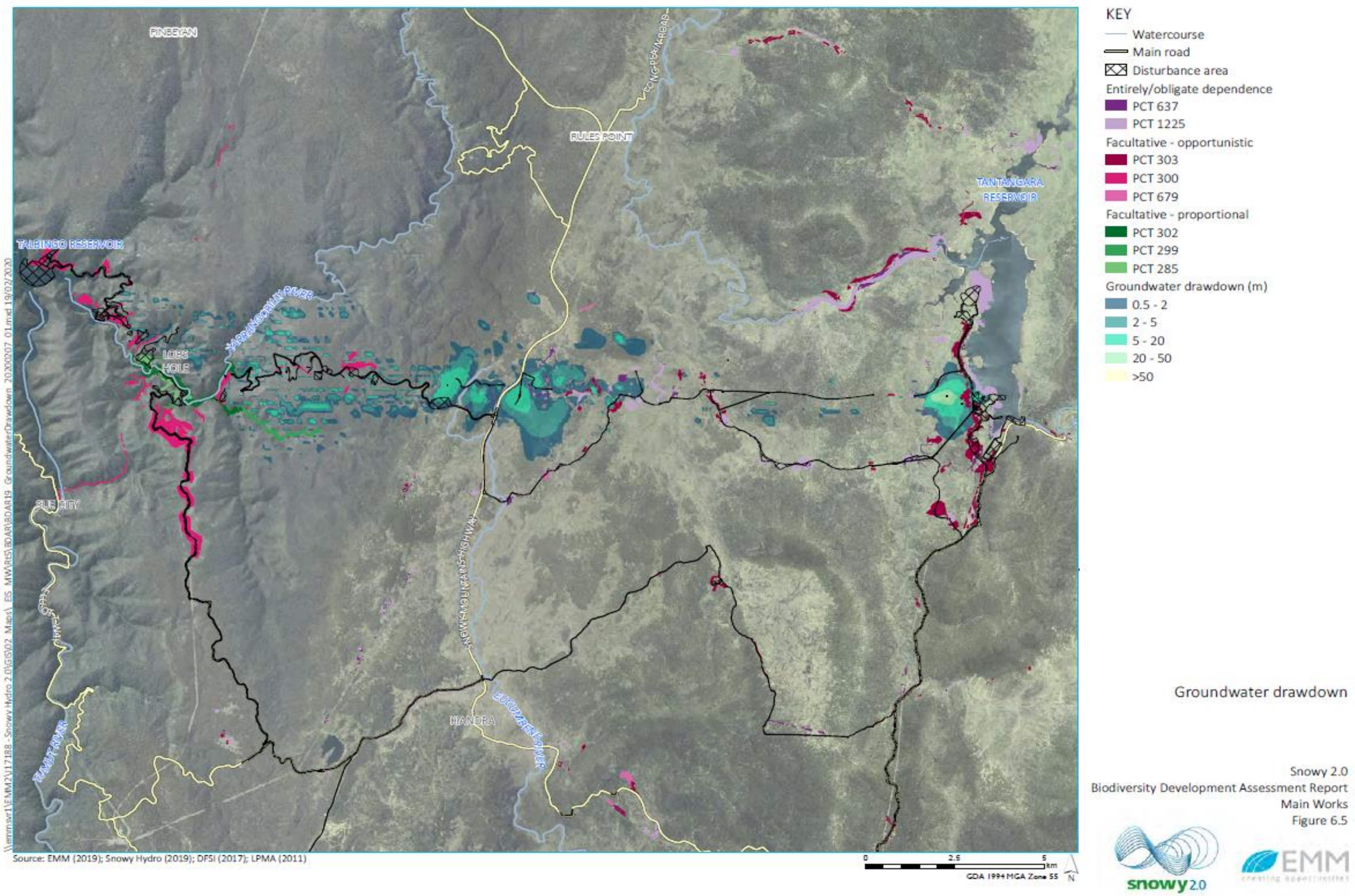


Figure 2-3: Modelled peak drawdown (model version SH4.0, RTS) in relation to potential GDEs

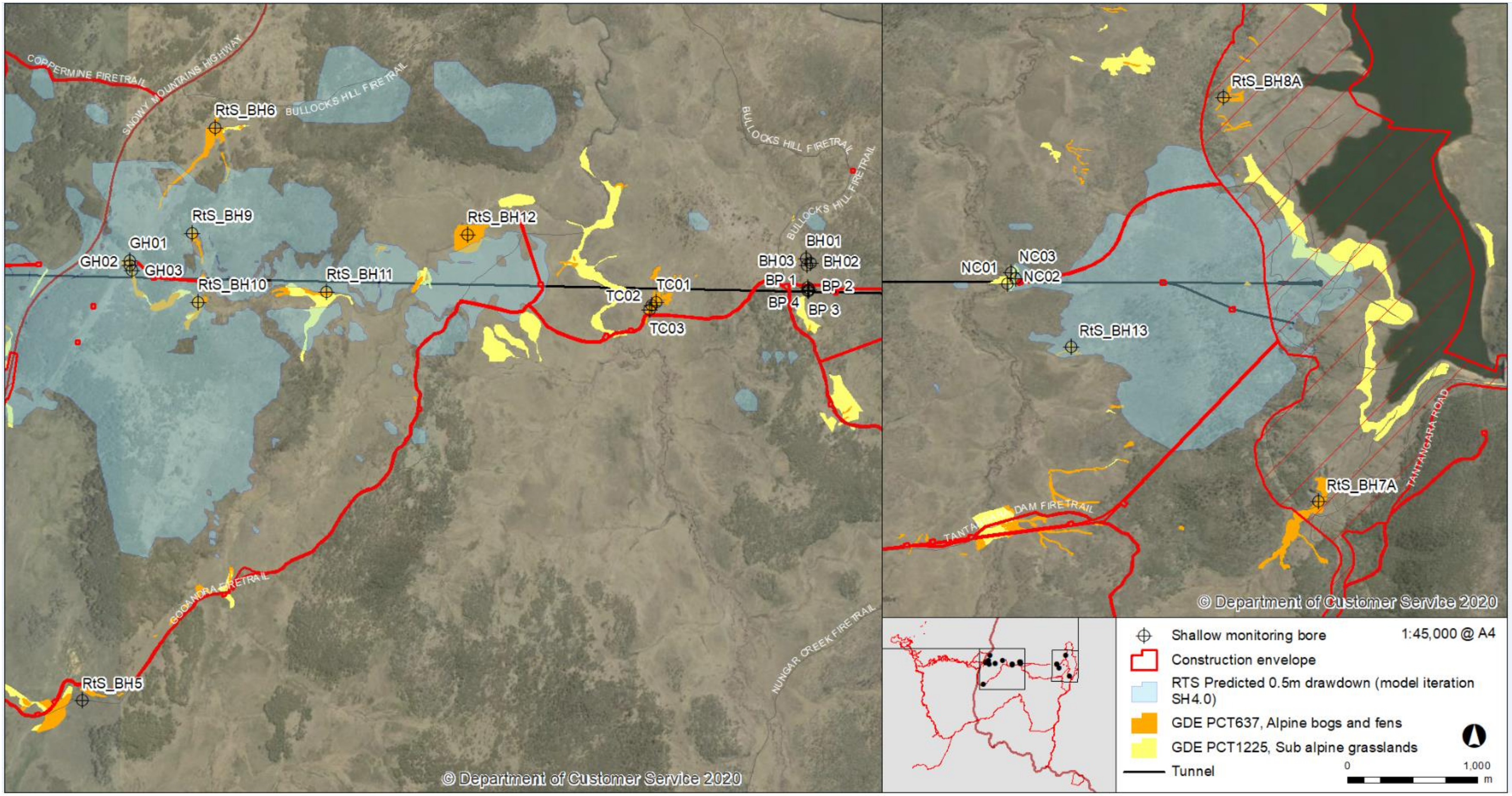


Figure 2-4: Existing and new shallow standpipes to monitor groundwater dependent ecosystem water levels

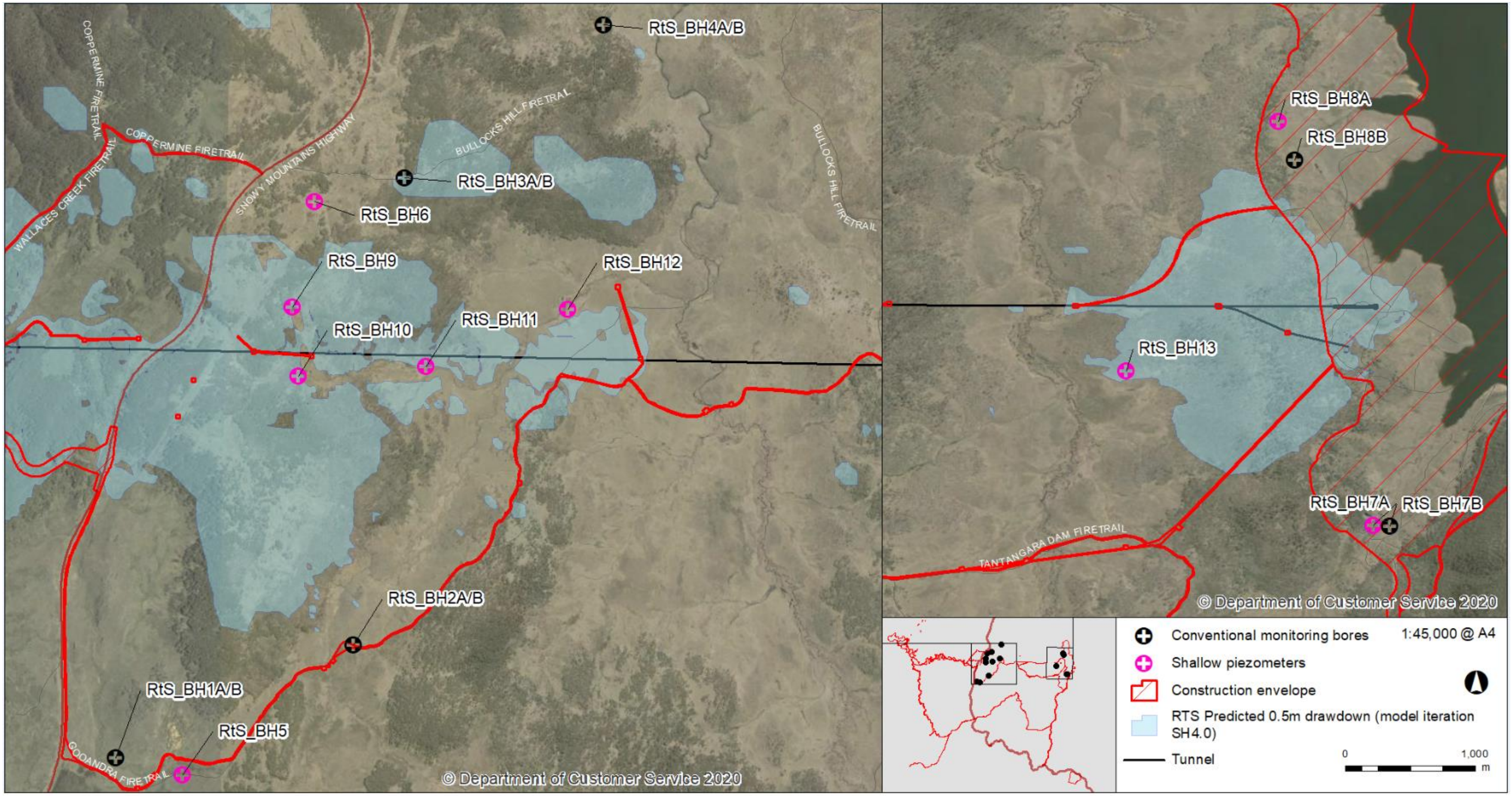


Figure 2-5: Additional groundwater monitoring locations in high risk drawdown areas

2.5. Groundwater levels

Dataloggers will be maintained from the Main Works baseline groundwater monitoring network phase (or installed in the additional monitoring locations) to provide continuous water level data collection. Dataloggers will be programmed to record at 6 hour intervals. A restricted suite of bores will be used as Indicator Trigger (Level 1) sites that will be analysed quarterly.

Monitoring frequency will be continuously reviewed and data compared to model predictions, and frequency of data collection will be adapted to ensure potential significant trigger events are detected early (i.e. particularly when Tunnelling commences in high risk areas). The Project is investigating opportunities for telemetric monitoring of monitoring data. No drawdown is predicted for the first few years of the project (see Section 4.2.4 of GMP) hence existing data loggers will be downloaded manually quarterly until telemetry is in place. Monitoring data collection frequency will also be reviewed during the annual review of the groundwater model, in consultation with NRAR and DPIE Water.

These Indicator Trigger (Level 1) sites have been selected to provide a balanced assessment of water level response from the Project and are listed in Table 2-3, and shown in Figure 2-9, Figure 2-10 and Figure 2-11.

Table 2-3: Level 1 routine monitoring bores

Target formation	Bore ID	Ground level (m AHD)[1]	Total depth (m BGL)	Screen interval (m BGL)	Target lithology
Conventional monitoring bores					
Ravine Beds West	BH8101 (EPL 3)	610	68.4	53.4–65.4	Siltstone
	RSMB2	570	30	27.0–30.0	Siltstone/sandstone
	RSMB6 (EPL 1)	581	15	11-14	Siltstone
	RSMB7 (EPL 2)	581	45	38-44	Siltstone
	RSMB8 (EPL 25)	583	15	11-14	Siltstone
	RSMB9 (EPL 4)	583	45	38-44	Siltstone
Ravine Beds East	MB12B	1,330	36	26.0–35.0	Weathered siltstone
Gooandra Volcanics	BH3110	1,346	178.9	165.9–177.9	Diorite
	MB01C	1,464	52	45.0–51.0	Basalt
	MB11A	1,485	7.5	17.0–23.0	Weathered basalt
	SMB04	1,342	180	170.0–179.0	Chloritic schist
	SMB05	1,342	50	40.0–49.0	Basalt
	TMB02A	1,470	15	11.0–14.0	Weathered basalt
	TMB02B	1,472	200	191.0–197.0	Chloritic schist
	TMB03A	1,478	34	29.5–32.5	Weathered basalt
	TMB03B	1,478	150	141.0–147.0	Chloritic schist
	TMB04	1,346	200	191.0–197.0	Basalt
Temperance Formation	MB04A	1,330	30	23.0–29.0	Basalt
Kellys Plain Volcanics	BH1117	1,241	65	51.9–60.9	Dacite
	BH2101	1,314	169.9	154.6–166.6	Siltstone

Target formation	Bore ID	Ground level (m AHD)[1]	Total depth (m BGL)	Screen interval (m BGL)	Target lithology
Test production bores					
Ravine Beds West	PB05	614	100	50.0–100.0	Siltstone
Gooandra Volcanics	PB04	1,341	200	185.0–200.0	Chloritic schist
	TMB03C	1,478	250	237.0–249.0	Chloritic schist
Kellys Plain Volcanics	PB01	1,231	60	30.0–60.0	Dacite
Vibrating wire piezometers					
Ravine Beds East	BH8106	1096	673	669.0, 431.0	Siltstone/sandstone
Gooandra Volcanics	BH4103	1471	388	335.6,232.2, 139.5	Metatuff, Tuff, Gneiss
	BH4102	1460	534	455.6, 374.3, 246.3	Gneiss, Phyllite
	BH4101	1479	1100	883.9, 729.6, 542.5	Meta-rhyolite
Temperance Formation / Gooandra Volcanics	BH3107A	1325	237	200.2, 133.5	Siltstone/sandstone
Drive point piezometers and narrow diameter piezometers					
Gooandra Hill Bog	GH01	1,456	1	0.5–1.0	Alluvium/colluvium
	GH02	1,456	0.9	0.5–0.9	Alluvium/colluvium
	GH03	1,455	0.6	0.3–0.6	Alluvium/colluvium
Tantangara Creek Bog	TC01	1,324	1	0.6–1.0	Alluvium/colluvium
	TC02	1,322	1.1	0.7–1.1	Alluvium/colluvium
	TC03	1,321	0.8	0.5–0.8	Alluvium/colluvium
Bullocks Hill Bog	BP1	1,366	1.8	1.5–1.8	Alluvium/colluvium
	BP2	1,364	1.8	1.5–1.8	Alluvium/colluvium
	BP3	1,364	1.8	1.5–1.8	Alluvium/colluvium
	BP4	1,363	1.8	1.5–1.8	Alluvium/colluvium
	BH01	1,351	0.4	0.2–0.4	Alluvium/colluvium
	BH02	1,352	0.9	0.6–0.9	Alluvium/colluvium
	BH03	1,350	0.7	0.5–0.7	Alluvium/colluvium
Nungar Creek Bog/Fen	NC01	1,237	0.8	0.5–0.8	Alluvium/colluvium
	NC02	1,237	1.1	0.8–1.1	Alluvium/colluvium
	NC03	1,237	1.0	0.7–1.0	Alluvium/colluvium
Additional monitoring locations to be progressively installed upon approval of this GMP					
Gooandra Volcanics	RtS_BH1A	1,392	50	TBC	TBC
	RtS_BH1B	1,392	316	TBC	TBC
	RtS_BH2A	1,395	50	TBC	TBC
	RtS_BH2B	1,395	314	TBC	TBC
	RtS_BH3A	1,431	50	TBC	TBC
	RtS_BH3B	1,431	344	TBC	TBC
	RtS_BH4A	1,397	50	TBC	TBC

Target formation	Bore ID	Ground level (m AHD)[1]	Total depth (m BGL)	Screen interval (m BGL)	Target lithology
	RtS_BH4B	1,397	308	TBC	TBC
	RtS_BH5	1,398	<1	TBC	Alluvium/colluvium
	RtS_BH6	1,449	<1	TBC	Alluvium/colluvium
	RtS_BH9	TBC	<1	TBC	Alluvium/colluvium
	RtS_BH10	TBC	<1	TBC	Alluvium/colluvium
	RtS_BH11	TBC	<1	TBC	Alluvium/colluvium
	RtS_BH12	TBC	<1	TBC	Alluvium/colluvium
Kellys Plain Volcanics	RtS_BH7A	1,231	<1	TBC	Alluvium/colluvium
	RtS_BH7B	1,231	49	TBC	TBC
	RtS_BH8A	1,225	<1	TBC	Alluvium/colluvium
	RtS_BH8B	1,225	65	TBC	TBC
	RtS_BH13	1,269	<1	TBC	Alluvium/colluvium

Groundwater level changes will be compared to predicted level changes from the numerical modelling as presented in Appendix B. A summary of predicted water level or pressure changes due to the Project is presented in Figure 2-6.

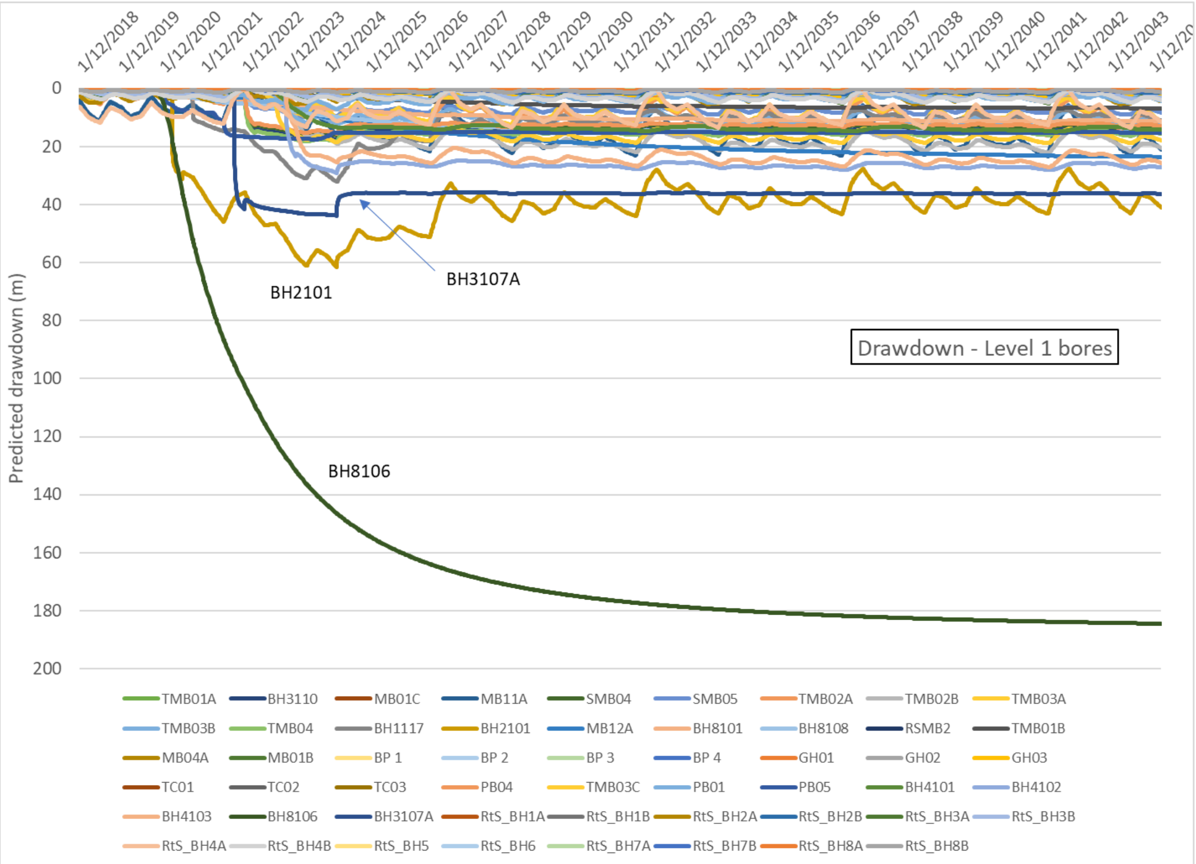


Figure 2-6: Predicted water level or pressure change for designated Level 1 monitoring bores

Groundwater level data will be compared to local rainfall records to assess any trends. Seasonal and climatic fluctuations considered within the RTS groundwater model (EMM 2020) will facilitate this assessment and comparison between groundwater level decrease and the predicted drawdown from the Project.

The assessment will determine whether the observed decrease is attributable to the Project and, if so, whether it aligns with approved predictions. Data analysis is described in Section 3.2 and monitoring reports will be produced quarterly (Section 3.6), including data summary reports presenting tabulated groundwater monitoring data collected during the reporting period.

If drawdown is identified outside of model predictions, management actions outlined in the GMP (i.e. Trigger Action Response Plan) will be initiated including (but not limited to) a review of baseline groundwater level and quality data in the relevant and surrounding monitoring bores as well as an assessment of groundwater inflow rates into the tunnel.

Drawdown in excess of that predicted will trigger data collection from an expanded bore network and will trigger water quality sampling (Section 2.6) at selected bores to confirm that no material change has occurred relative to the existing water quality conditions.

A sub-set of bores used in the baseline assessment have not been recording data for more than 24 months. Figure 2-7 and Figure 2-8 illustrate the monitoring periods for each bore. Those with less than 24 months' data will continue to be collected.

2.5.1. Groundwater dependent ecosystems

Shallow groundwater levels in standpipes located at known GDEs will be compared to the 80th percentile between the months of May and October. If drawdown is identified beyond trigger levels in areas of these GDEs during this period, actions outlined in the Groundwater level Trigger Action Response Plan (TARP) will be initiated.

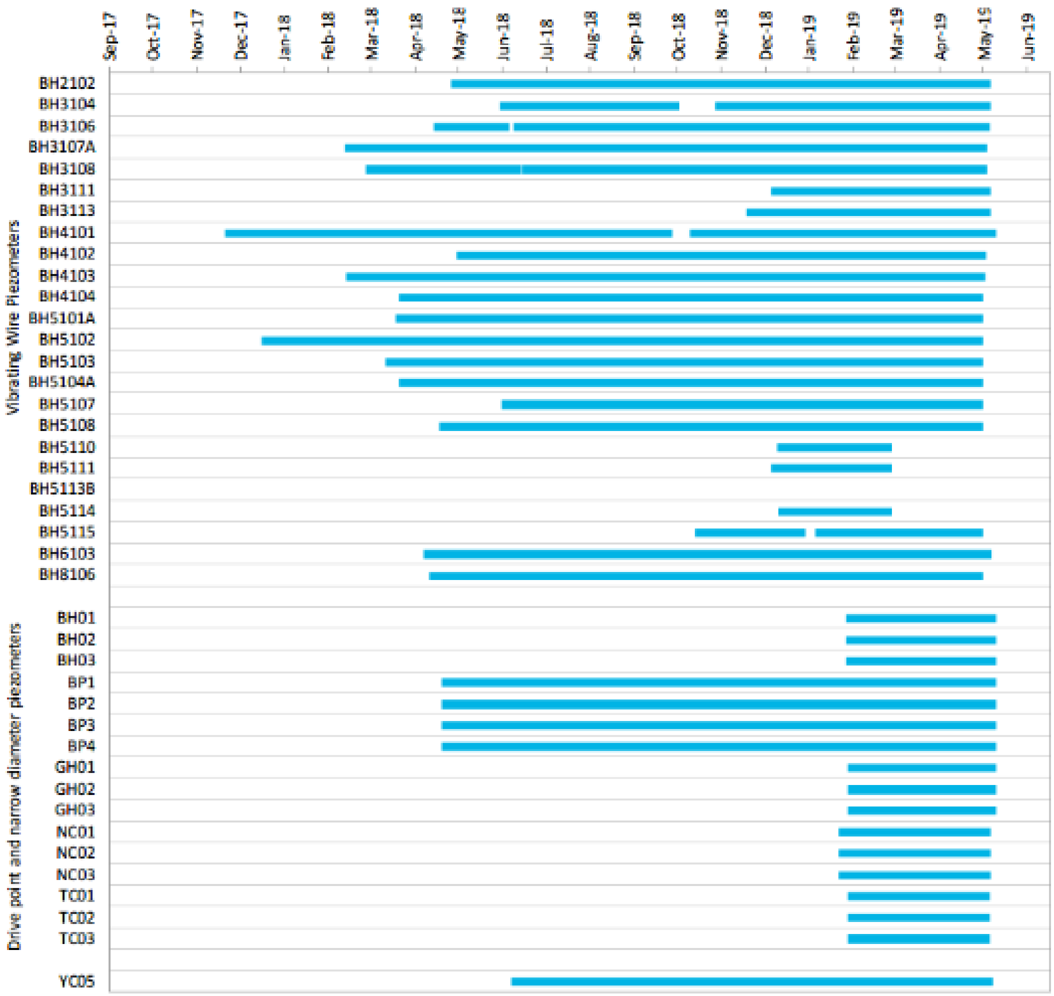


Figure 2-7: Monitoring period for the vibrating wire piezometers (*Note: monitoring has continued, refer to Attachment A)*

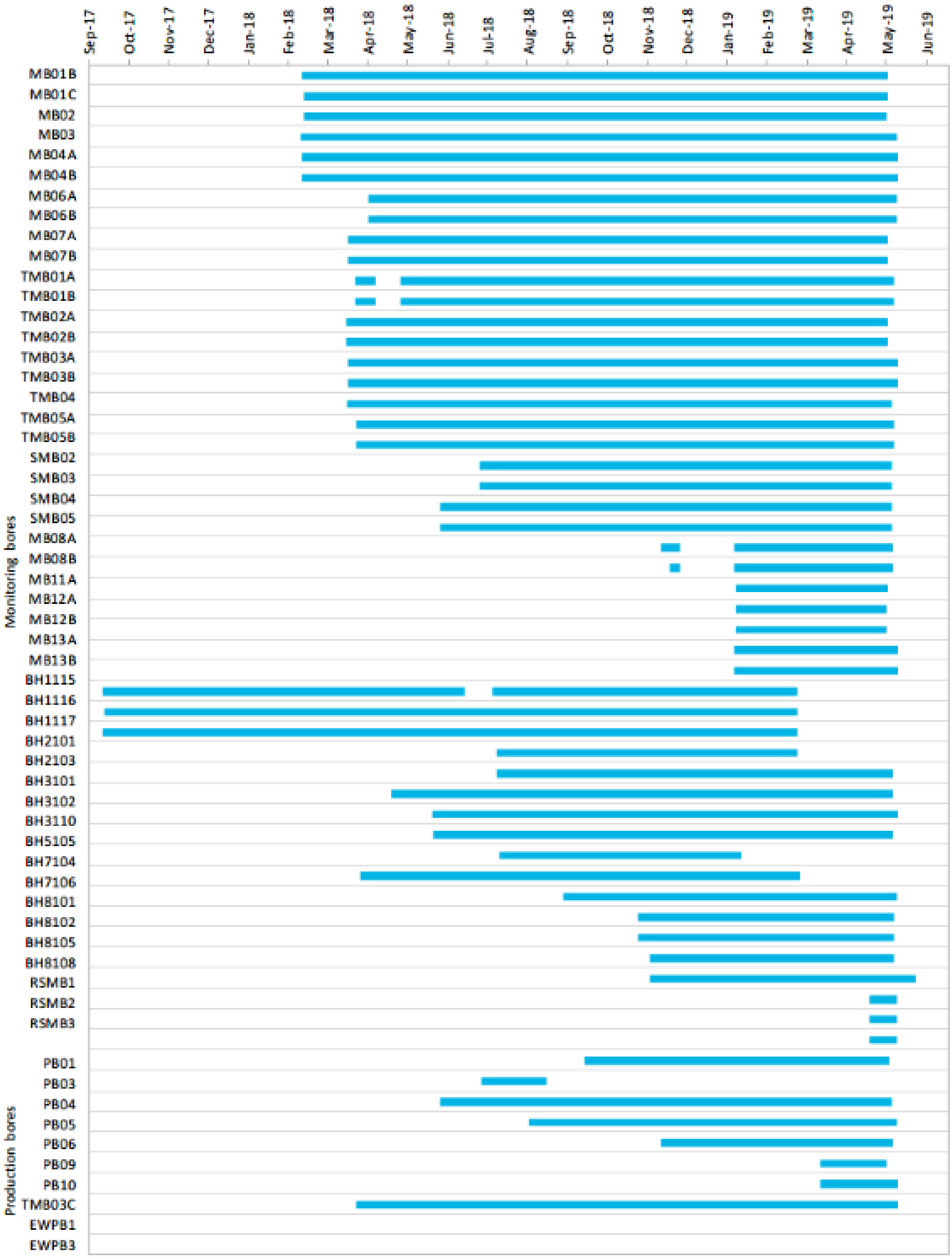


Figure 2-8: Monitoring period for the conventional monitoring bores (*Note: monitoring has continued to date, refer to Attachment A*)

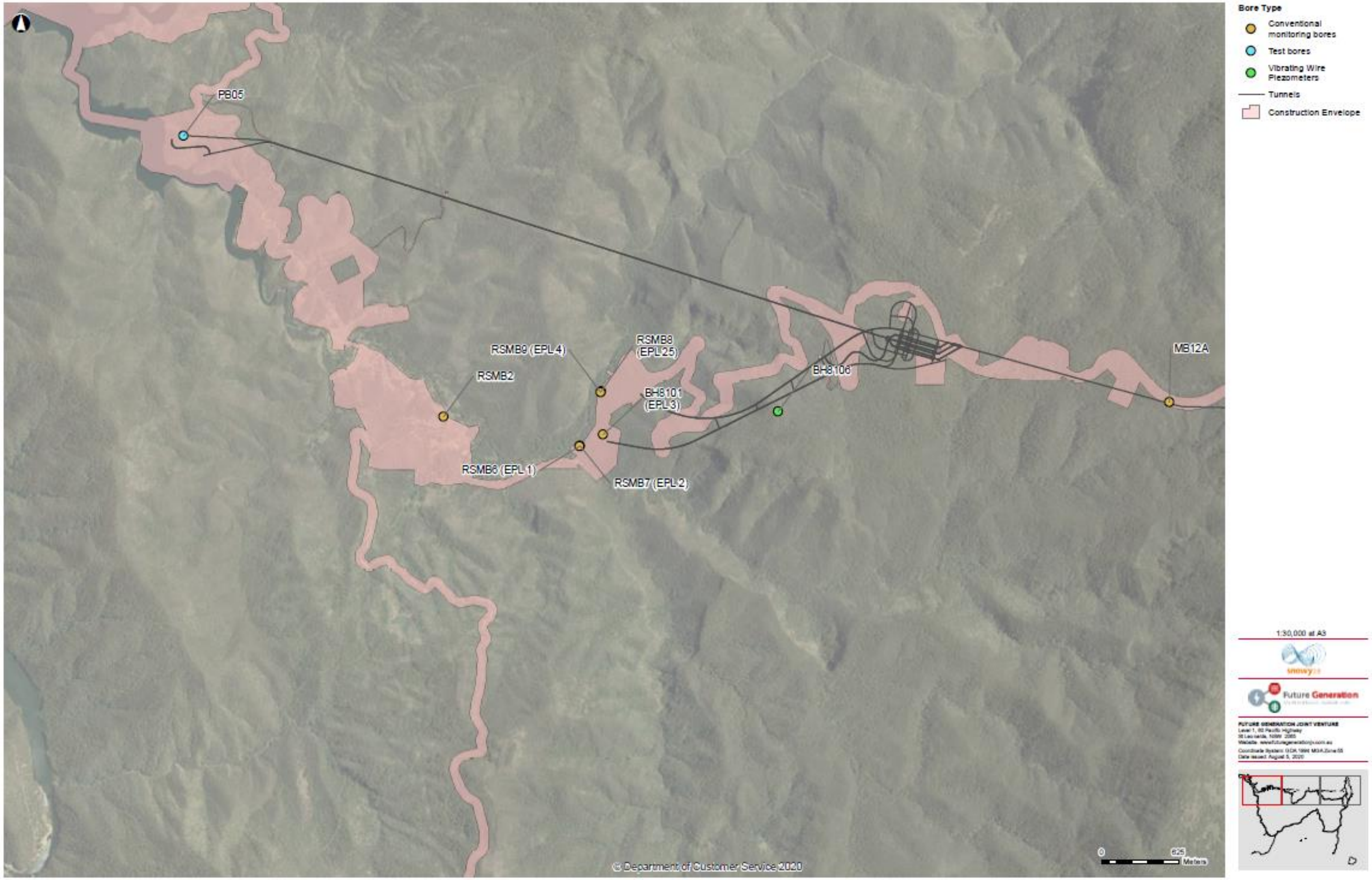


Figure 2-9: Level 1 groundwater monitoring bores (Western section)

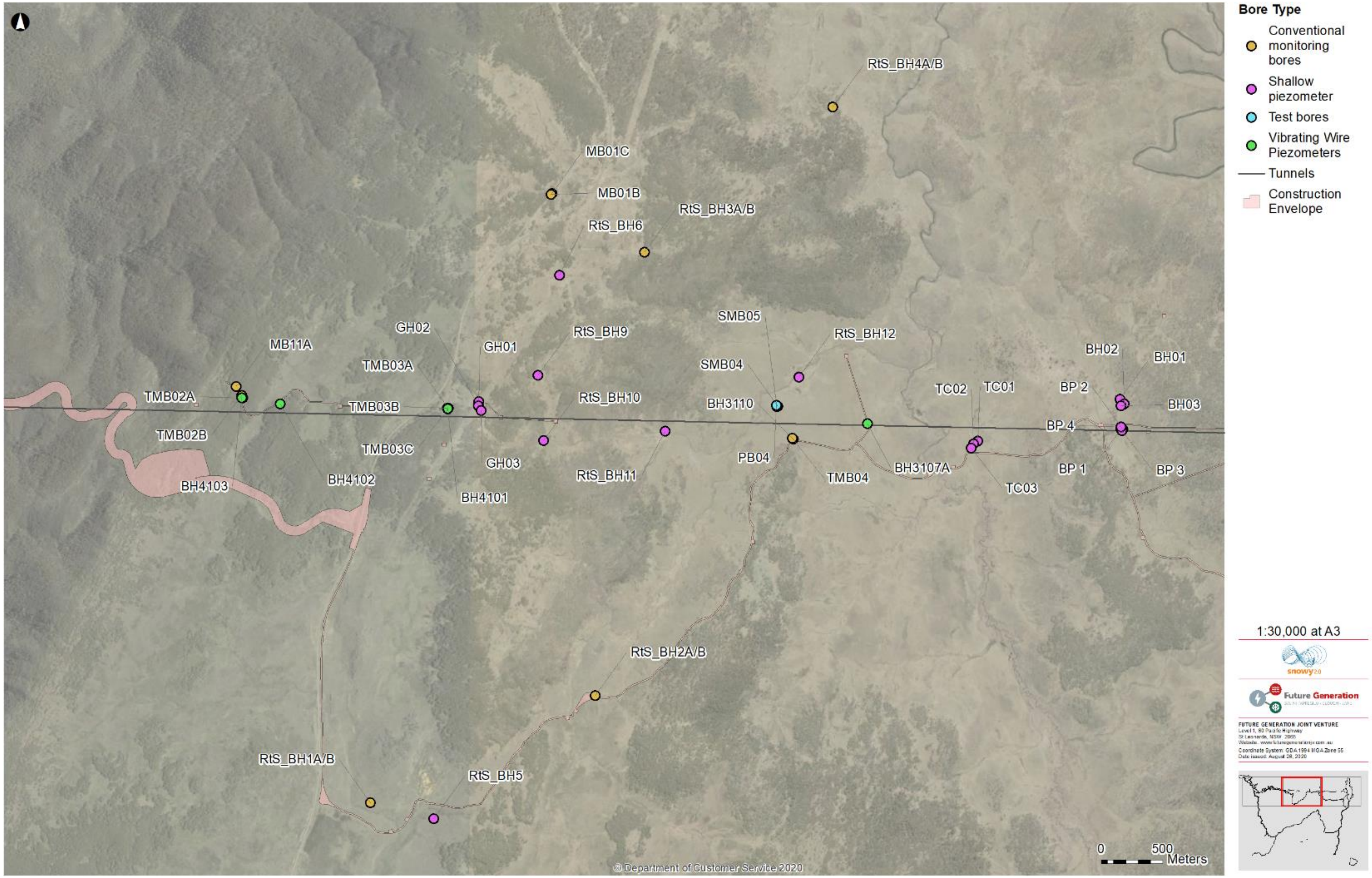


Figure 2-10: Level 1 groundwater monitoring bores (Central section)

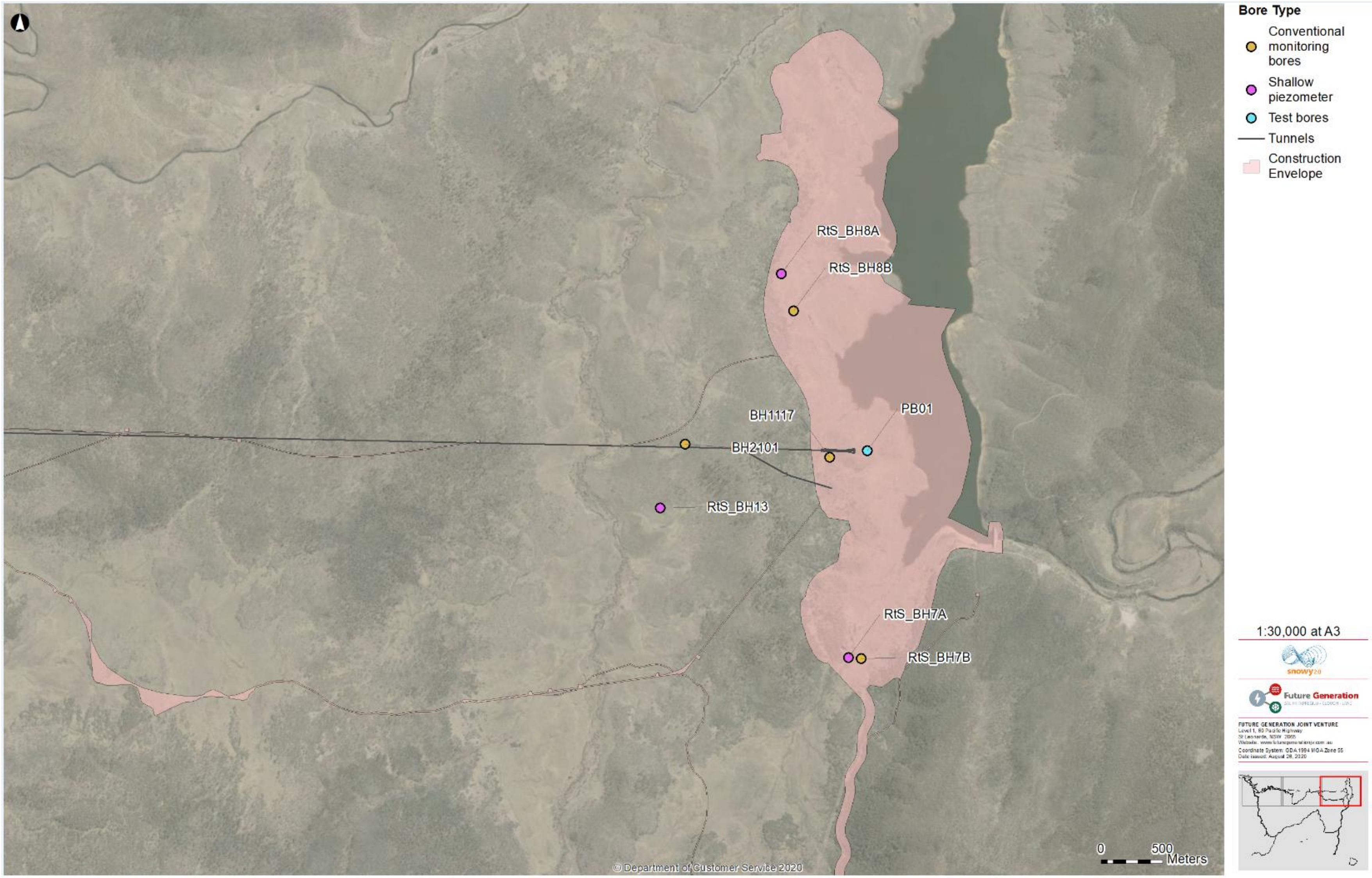


Figure 2-11: Level 1 groundwater monitoring bores (Eastern section)

2.6. Groundwater quality

Only those bores designated under the current EPL 21266 will be routinely analysed for water quality (current EPL 1, EPL 2, EPL 3, EPL 4 and EPL 25). Baseline assessment has demonstrated that water quality can be affected by seasonal changes, but these can be directly associated with water level changes. For this reason, it is proposed that sampling frequency be reduced to quarterly sampling at these EPL 21266 sites.

The sympathetic response of water quality to significant water level change also allows a significant reduction in routine sampling, such that water level changes associated with Level 1 bores can be used to guide whether water quality sampling is required, or not.

If a Level 1 water level trigger occurs, a round of water quality sampling is initiated at the triggered bore (unless the trigger occurs at a VWP site where water quality cannot be sampled) and immediate surrounding bores. Water quality analysis will indicate whether any change from baseline conditions has occurred. Sampling will be undertaken quarterly and if no change is detected after one year the bore reverts to a Level 1 condition (i.e. no further sampling).

A review after the first 12 months of construction of the monitoring program will be completed to determine the efficiency of the monitoring program and any required changes.

Parameters to be analysed will include those specified in the EPL (Table 2-4), as well as any additional parameters analysed as part of the standard suite that embraces the stipulated parameters. Thus, total aluminium, copper, iron, lead, manganese and zinc will also be analysed.

Field analysis of physico-chemical parameters (EC, pH, DO, NTU) will be compared to laboratory results to provide additional quality control.

Table 2-4: Parameters to be monitred

Pollutant	Units of measure	Units of measure	Frequency	Sampling method
Aluminium (dissolved)	micrograms per litre	µg/L	quartlery	Representative sample
Copper (dissolved)	micrograms per litre	µg/L	quartlery	Representative sample
Dissolved Oxygen (DO)	Percent saturation	% sat	quartlery	Representative sample
Electrical conductivity (EC)	Microsiemens per centimetre	µS/cm	quartlery	Representative sample
Iron (dissolved)	micrograms per litre	µg/L	quartlery	Representative sample
Lead (dissolved)	micrograms per litre	µg/L	quartlery	Representative sample
Manganese (dissolved)	micrograms per litre	µg/L	quartlery	Representative sample
Nickel (dissolved)	micrograms per litre	µg/L	quartlery	Representative sample
Nitrogen (total)	micrograms per litre	µg/L	quartlery	Representative sample
Oxidation Reducton Potential (ORP)	millivolts	mV	quartlery	Representative sample
pH	pH	pH	quartlery	Representative sample
Reactive Phosphorous	micrograms per litre	µg/L	quartlery	Representative sample
Silver (dissolved)	micrograms per litre	µg/L	quartlery	Representative sample
Turbidity	Nephelometric turbidity units	NTU	quartlery	Representative sample
Zinc (dissolved)	micrograms per litre	µg/L	quartlery	Representative sample

2.7. Baseflow

Groundwater discharge to surface water as creek baseflow will be monitored through assessment of multiple line of evidence as direct analysis is problematic, being variable both in time and space. Thus, numerical modelling (Response to Submissions, Appendix I) has simulated annual baseflow to rivers and creeks across the Project area and identified reaches of Stable Creek, Eucumbene Creek and Gooandra Creek that may undergo baseflow loss during the latter stages (post year 3) of construction of the Main Works and during operation. Combined losses to creeks feeding Yarrangobilly River may result in a 2.5% loss in baseflow at the stream gauge (station 410574) in the long term (steady state), but less than 1% loss over the first 10 years. No impact is predicted at the Murrumbidgee gauging station (410535). Loss therefore will not be discernable at the existing stream gauges for many years. Alternate sites (at creek crossings adjacent to existing or planned shallow groundwater bore installations) on the Eucumbene and Gooandra Creeks will be instrumented with pressure transducers and manual flow readings will be undertaken during routine sampling rounds to provide a proxy for continuous creek flow volumes. These records will be assessed for baseflow using a combination of:

- analysis of stream flow at the surface water gauging stations compared to simulated flow at the creek crossings;
- use of suitable hydrograph filters (e.g. Lyne & Hollick, 1979) at established stream gauge sites subsequent to each month's data collection;
- calculation of baseflow indices (BFI) using rainfall, stream and groundwater salinities at the designated streamflow sampling sites and adjacent shallow groundwater bores, and
- consideration of groundwater hydrographs and rainfall conditions.

An example of baseflow separation is provided at Figure 2-12 (reproduced from the Main Works EIS; Appendix J – Annexure A) which demonstrates a manual estimation of baseflow through comparison of streamflow with groundwater levels at a relevant shallow bore.

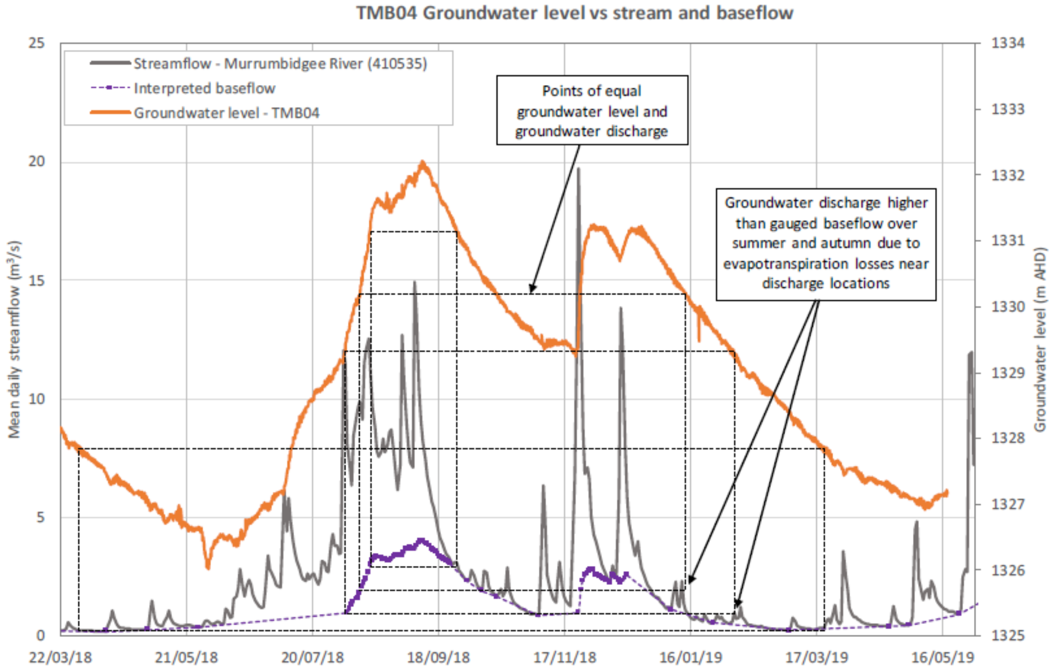


Figure 2-12 Manual baseflow separation at the gauging station (410535) on the Murrumbidgee River

Any calculated baseflow reduction greater than that predicted from the numerical groundwater modelling for the RTS (Appendix I – Part 3, Table J.1) will constitute a trigger to the Groundwater Level TARP as described in the GMP (Section 7.2.2; GMP Table 7.1).

2.8. Tunnel inflow

During construction, groundwater will be intersected and managed by capturing the water that enters the tunnels or by restricting inflow through pre grouting and / or post grouting.

Groundwater inflow into the tunnels will be monitored during construction and compared to model groundwater ingress predictions and water access licencing. The groundwater model will be updated as required based on the results of monitoring, and proposed management measures to minimise potential groundwater impacts adjusted accordingly.

2.8.1. Groundwater extraction

The groundwater sources that will be will intercepted include the Lachlan Fold Belt Murray Darling Basin (MDB) groundwater source and the Lachlan Fold Belt South Coast groundwater source. Tunnel inflow monitoring, WTP discharges and Project water inputs back into the tunnel will be monitored and used in a simple water balance approach to estimate groundwater extracted during construction. A conceptual diagram is presented in Figure 2-13 and is also described in Section 5 of the Water Management Plan

Groundwater inflow = WTP discharge (flow meter C) – Project water inputs (flow meter E)

Groundwater extraction will be monitored throughout the year throughout the year to ensure groundwater extraction is within permitted volumes of take from respective water sources and reported on an annual basis in accordance with licence requirements (described in Section 2.4.3 of the Groundwater Management Plan).

2.9. Water treatment plant monitoring

Groundwater captured during construction of the Project will be treated at process water treatment plants. The water from the treatment plants will be tested and either reused or discharged in accordance with the Surface Water Management Plan. Discharge volumes will be continuously monitored at the WTPs via calibrated flow meters, which will enable the daily measurement of the amount of water discharged from the WTPs.

Detail of the water treatment management system is provided in Section 5 of the Surface Water Management Plan.

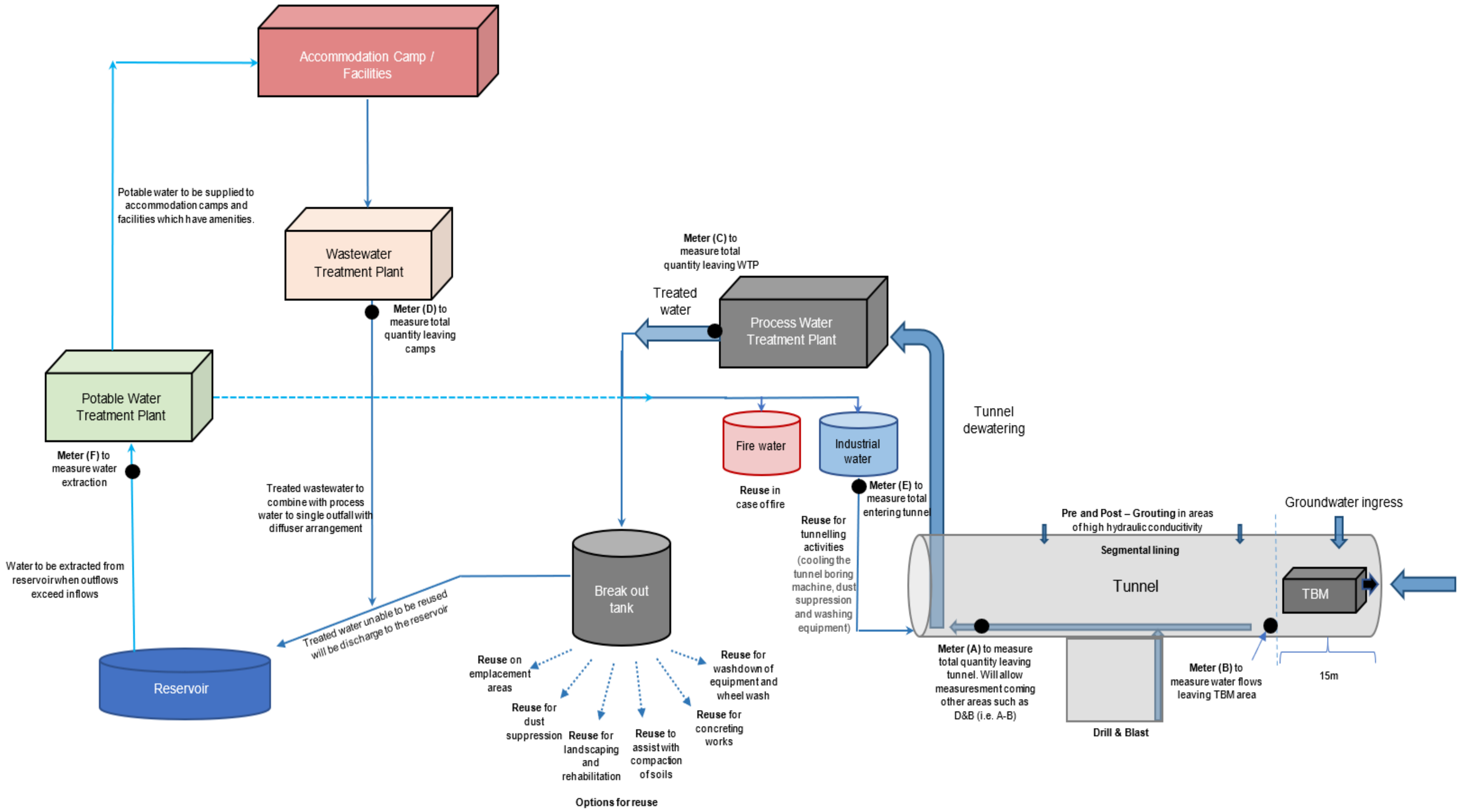


Figure 2-13: Groundwater movement

3. REVIEW AND RESPONSE

3.1. Responsibility

Sampling and testing of the groundwater monitoring network will be coordinated by Future Generation. Sample data collected by Future Generation will be analysed, investigated and reported. At all times during construction, Future Generation will be responsible for initiation of the Trigger Action Response Plans (Section 6.5 of the GMP).

3.2. Data Analysis

Results from the construction monitoring program will be compared against default criteria, the site-specific trigger values (SSTV) and groundwater modelling predictions.

Monitoring results of groundwater level will involve recorded data being compensated for barometric pressure and converted to a groundwater level measurement. Groundwater level data will be compared to local rainfall records to assess trends for reporting in Annual Reports.

Monitoring results for both groundwater levels and groundwater quality will be compared against SSTVs and reported in the monitoring reports. If results trigger a response, management actions will be implemented (Section 3.5), as required, should an initial review determine a potential impact outside of approved predictions.

The monitoring results for groundwater level and groundwater quality will be used to inform the groundwater model updates increasing the confidence level in model predictions with respect to groundwater inflow, drawdown, and aquifer chemistry. Where required the groundwater model will be calibrated to monitoring results and predictions updated.

3.3. Quality Assurance

During each sampling and reporting round, calibration and quality assurance will be carried out relevant to the data being collected as outlined in Table 3-1, below.

Table 3-1 Groundwater sampling, calibration and quality assurance procedures

Measure	Calibration process	Quality Assurance
Groundwater quality monitoring	All field analysis equipment to be calibrated prior to the field campaign and at a frequency recommended by the supplier. NATA Accredited Laboratories used for analyses.	Chain-of-command documentation to be created for each sampling campaign. Data storage and recovery procedures to follow best practice.
Groundwater level monitoring	Monthly check for data drift and aberrations (spikes, missing data) and comparison to adjacent bores for continuity and consistency.	Calibration statistics provided with reports. Long-term trends plotted and provided with each report.
Groundwater inflow rate monitoring	Cross-checking of metered and manual estimates of flow in tunnels. Data redundancy in metering through input/output checks and multiple water balance associations.	Daily recording of tunneling water production documented with tunnelling processes and activities (e.g. grouting schedules). Monthly reporting and cross-checking of groundwater take and surface water processing.

3.4. Adaptive Management

Monitoring results obtained during construction will be subject to monitoring, analysis of results, review of mitigation measures (where exceedances are identified) and updates to measures and trigger values where required.

An adaptive management approach is taken that applies observed data to influence mitigation response and system understanding. Thus, the groundwater monitoring network will record actual groundwater levels and groundwater take (via bore sensors and tunnel discharge meters, respectively) which will be used to validate and verify or re-calibrate the numerical groundwater model. Revised predicted drawdowns can then be predicted with increasing confidence and the extents of potential impacts revised accordingly.

3.5. Trigger Action Response Plan

The purpose of a TARP is to detail a standardised response procedure in the event that a trigger value is exceeded during a monitoring event for groundwater quality and/or availability (level) and/or inflow monitoring.

This allows for the prompt identification of unpredicted impacts and guide the implementation additional management measures and corrective actions should adverse conditions arise attributable to construction.

The TARP applies to all current and future groundwater monitoring locations.

The TARP response procedure is detailed Section 6.4 of the Groundwater Management Plan.

As outlined in Section 3.3, above, groundwater levels and quality will be routinely monitored across the network at bores identified for monitoring at different levels of impact. Trigger levels for pH, salinity, dissolved metals and water level for each target location have been developed using baseline data (EMM, 2019), that if exceeded will trigger investigation into the cause. In addition to these trigger thresholds the GWMP includes a trigger action response plan (TARP) that provides a process for investigation into trigger events.

3.6. Trigger values

Preference under the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018) is given to site specific guidelines determined through a comprehensive assessment of baseline data for a minimum period of two years (24 months). To date, a sub-set of bores has provided data for groundwater levels extending back to October 2017. The majority of bores have provided data since autumn 2018, with some bores only recording data since the last drilling campaign in April 2019 (EMM, 2019a). Consequently, bores that have not recorded at least 24 months data will continue to be monitored monthly until 24 months is achieved.

Those bores designated as Level 1 bores will continue to be assess for water level change on a quarterly basis. Water levels will be compared to numerical modelling results. Where measured water levels are lower than those predicted from subtraction of the predicted drawdown for the Base Case from the previous month's level, this will constitute a trigger event. Measured drawdown less than predicted will constitute a Level 1 (indicator) trigger value that does not illicit a response, except where the bore is located at a GDE, whereby drawdown greater than the 80th percentile during the winter months (May to October) will constitute a trigger event.

Tables of indicative drawdown values with time at each monitoring location are provided in Attachment B. These values should be incrementally subtracted from the relative previous month's average measured value as part of the monitoring program.

Water quality trigger values are as stipulated in Table 6-3 in the GMP, except where site-specific trigger values have been set. These are recorded in Attachment C to this Groundwater Monitoring Program.

3.7. Reporting

Future Generation will report to Snowy Hydro and other agencies on ground water monitoring aspects related to the Project. During construction, ground water monitoring data will be collected, tabulated and assessed against thresholds. Reporting will occur in accordance with Section 6.8 of the GMP.

4. REFERENCES

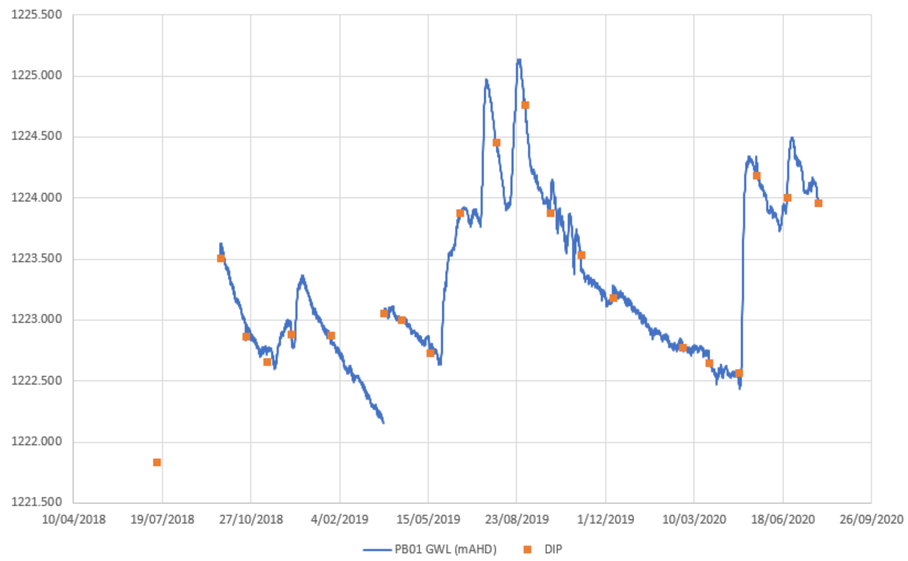
ANZG 2018. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments, Canberra, ACT, Australia. Viewed [viewed 08/04/2020], [https://www.waterquality.gov.au/anz-guidelines].

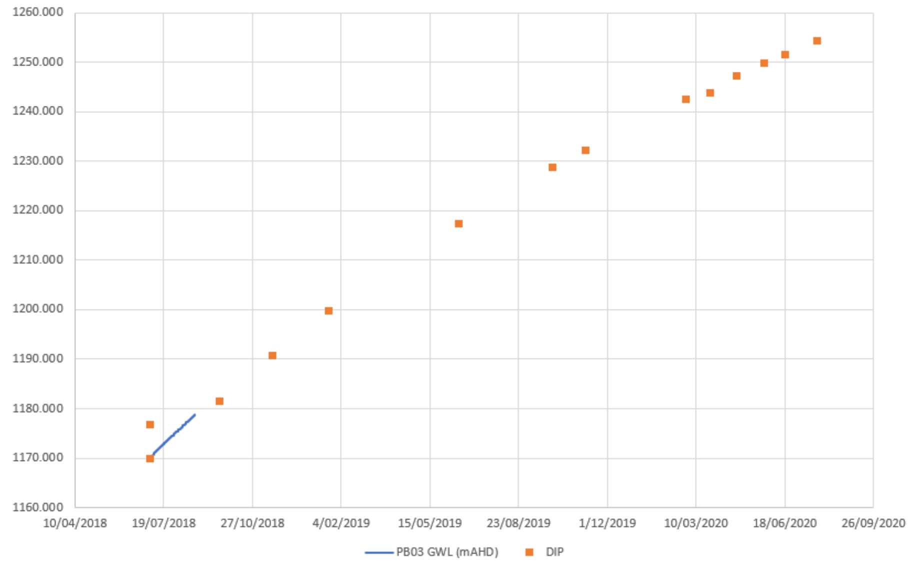
EMM, 2019. Appendix J.1: Water Assessment for the Snowy 2.0 Main Works EIS (report #J17188 RP#86)

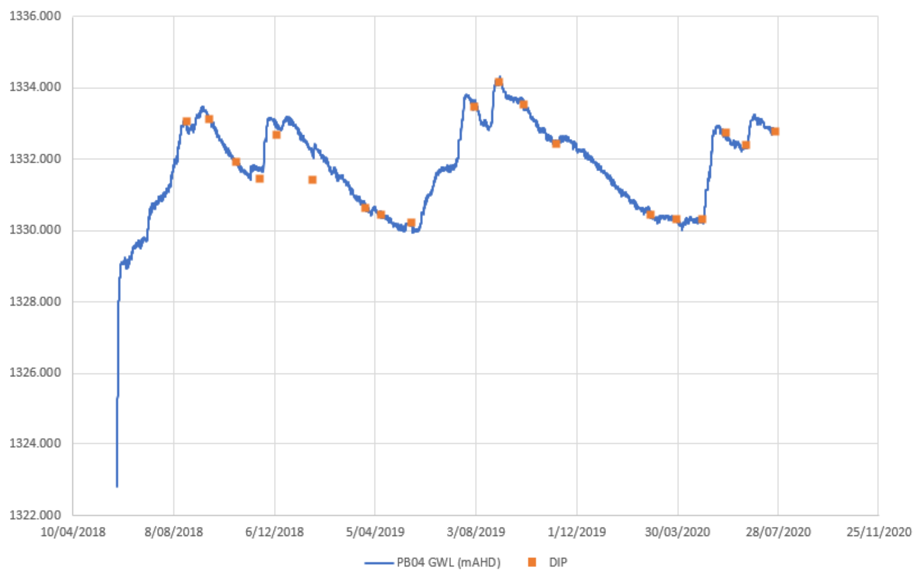
EMM, 2020. Modelling Report. Annexure I to Main Works Preferred Infrastructure Report and Response to Submissions

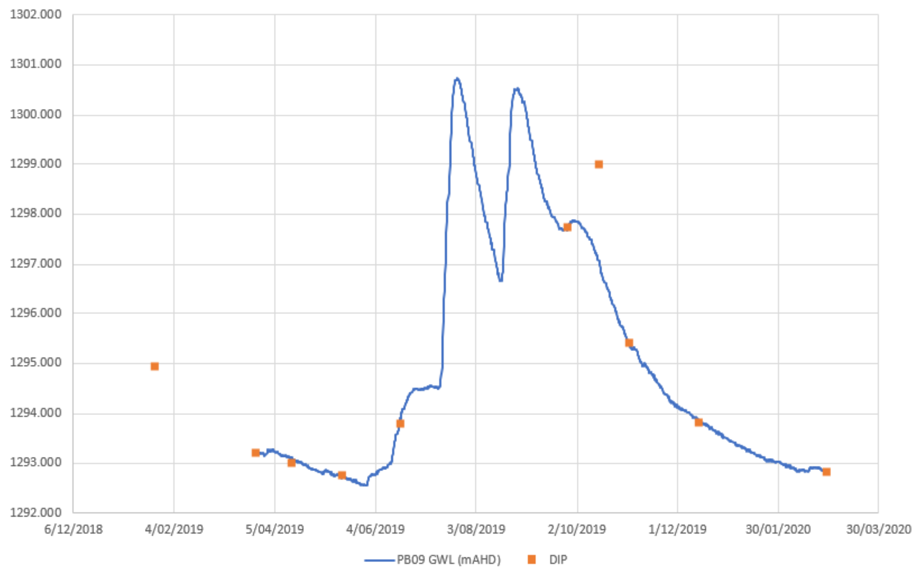
Lyne, V. & Hollick, M. 1979, "Stochastic timevariable rainfall-runoff modelling", *Proceedings of the Hydrology and Water Resources Symposium*, Perth, 10-12 September, Institution of Engineers National Conference Publication, No. 79/10, pp. 89–92.

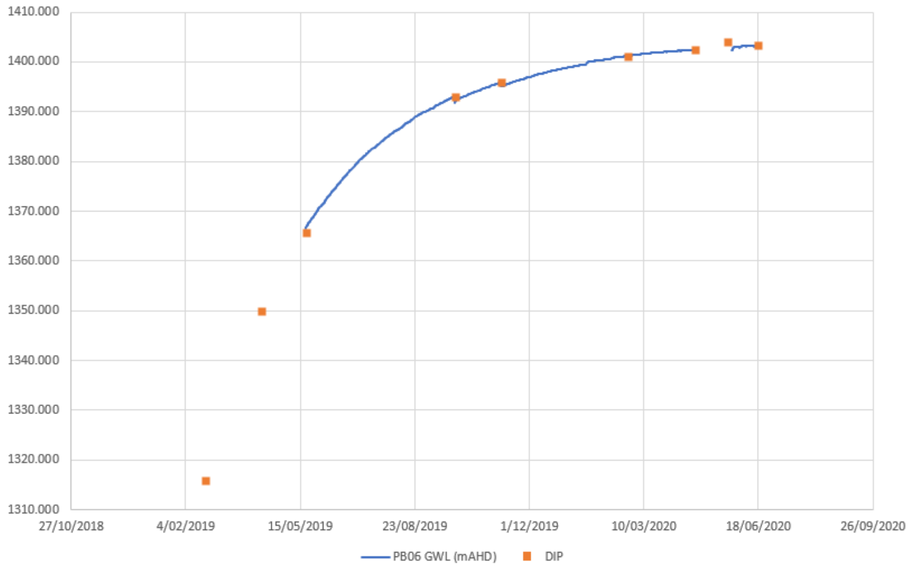
ATTACHMENT A – BASELINE LEVELS AND GROUNDWATER QUALITY


1225.500
1225.000
1224.500
1224.000
1223.500
1223.000
1222.500
1222.000
1221.500
10/04/2018
19/07/2018
27/10/2018
4/02/2019
15/05/2019
23/08/2019
1/12/2019
10/03/2020
18/06/2020
26/09/2020
PB01 GWL (mAHD)
DIP

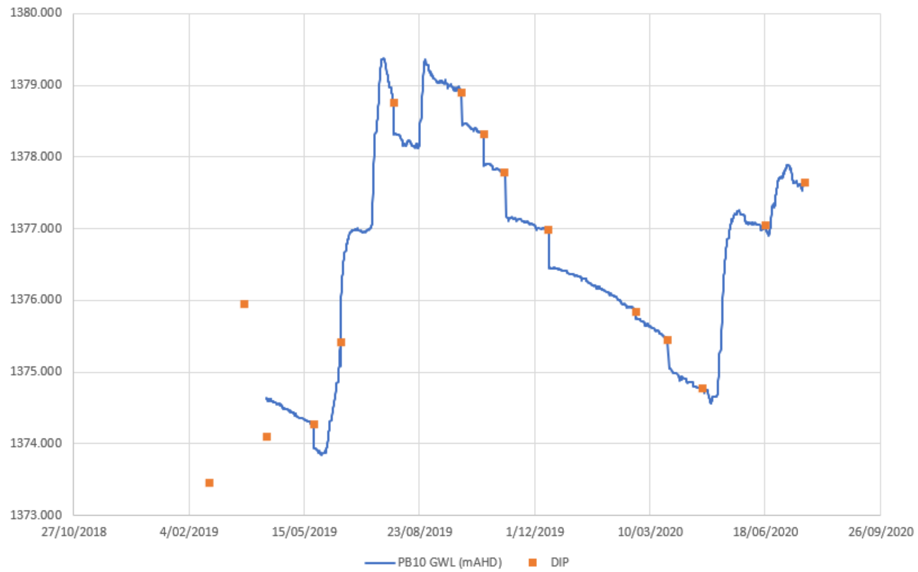

1260.000
1250.000
1240.000
1230.000
1220.000
1210.000
1200.000
1190.000
1180.000
1170.000
1160.000
10/04/2018
19/07/2018
27/10/2018
4/02/2019
15/05/2019
23/08/2019
1/12/2019
10/03/2020
18/06/2020
26/09/2020
PB03 GWL (mAHD)
DIP


1336.000
1334.000
1332.000
1330.000
1328.000
1326.000
1324.000
1322.000
10/04/2018
8/08/2018
6/12/2018
5/04/2019
3/08/2019
1/12/2019
30/03/2020
28/07/2020
25/11/2020
PB04 GWL (mAHD)
DIP

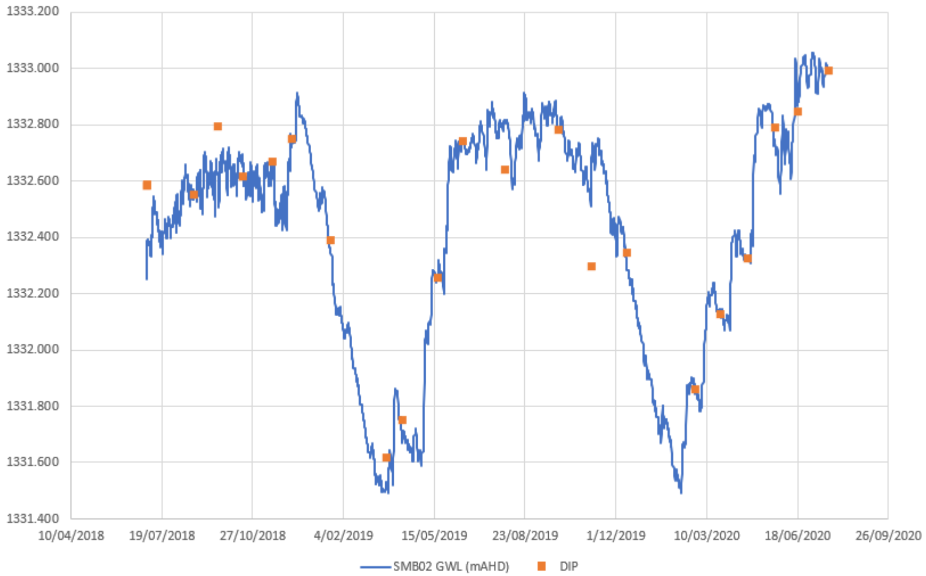

1302.000
1301.000
1300.000
1299.000
1298.000
1297.000
1296.000
1295.000
1294.000
1293.000
1292.000
6/12/2018
4/02/2019
5/04/2019
4/06/2019
3/08/2019
2/10/2019
1/12/2019
30/01/2020
30/03/2020
PB09 GWL (mAHD)
DIP



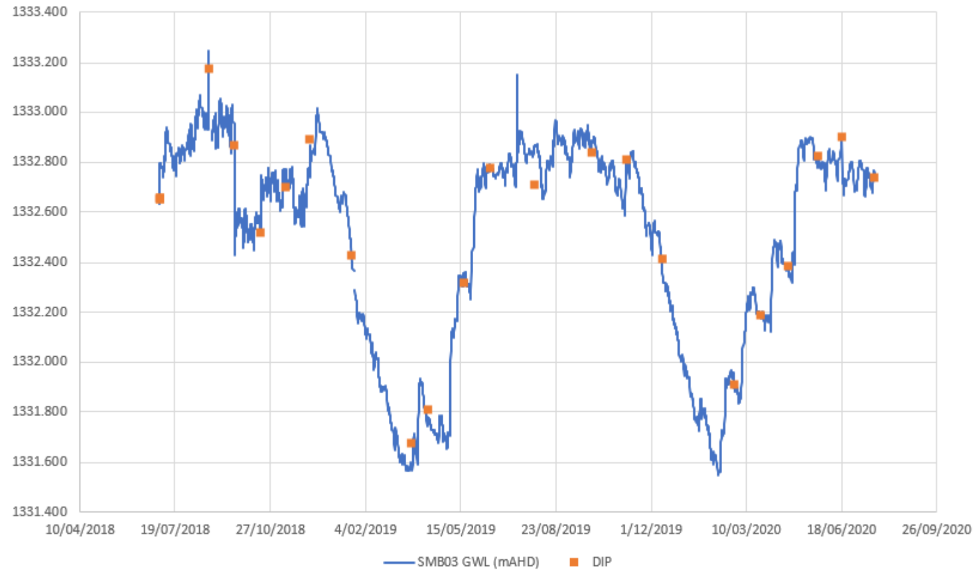
1410.000
1400.000
1390.000
1380.000
1370.000
1360.000
1350.000
1340.000
1330.000
1320.000
1310.000
27/10/2018
4/02/2019
15/05/2019
23/08/2019
1/12/2019
10/03/2020
18/06/2020
26/09/2020
PB06 GWL (mAHD)
DIP



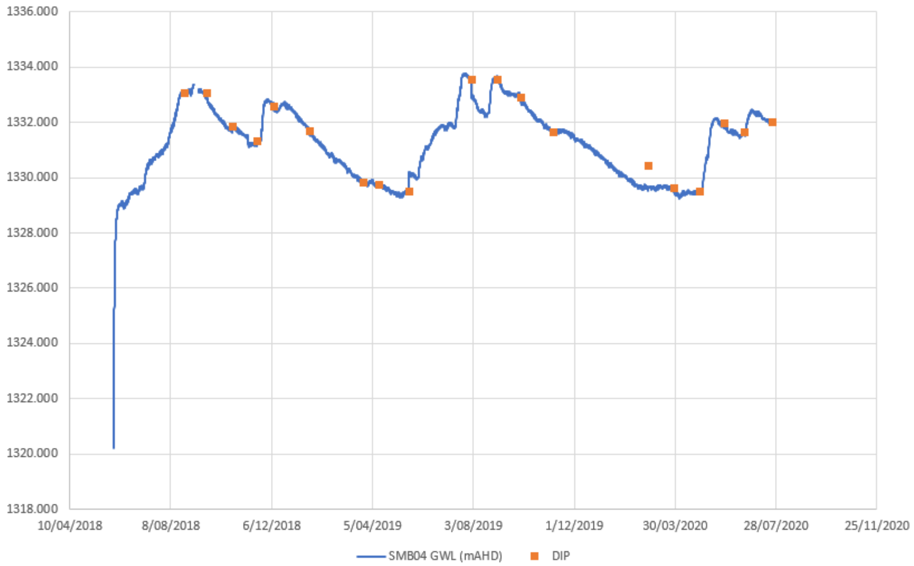
1380.000
1379.000
1378.000
1377.000
1376.000
1375.000
1374.000
1373.000
27/10/2018
4/02/2019
15/05/2019
23/08/2019
1/12/2019
10/03/2020
18/06/2020
26/09/2020
PB10 GWL (mAHD)
DIP



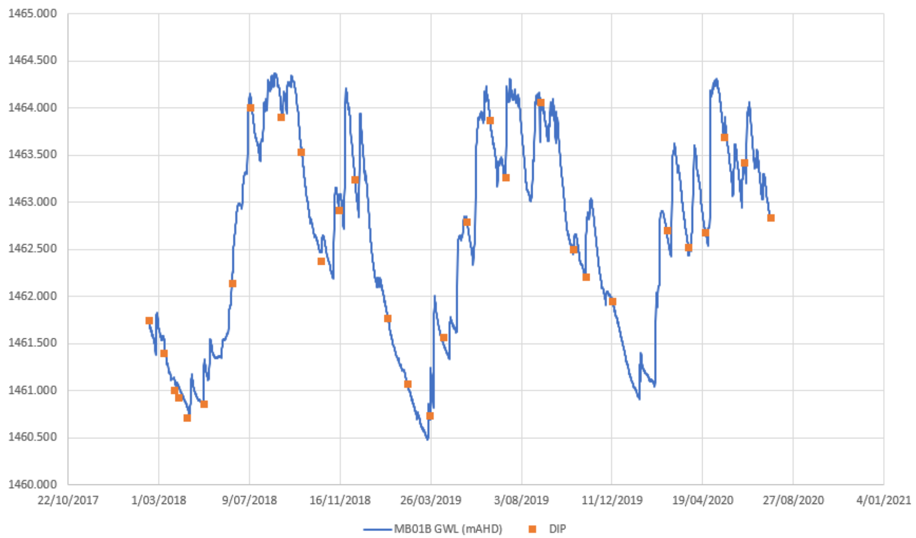
1333.200
1333.000
1332.800
1332.600
1332.400
1332.200
1332.000
1331.800
1331.600
1331.400
10/04/2018
19/07/2018
27/10/2018
4/02/2019
15/05/2019
23/08/2019
1/12/2019
10/03/2020
18/06/2020
26/09/2020
SMB02 GWL (mAHD)
DIP

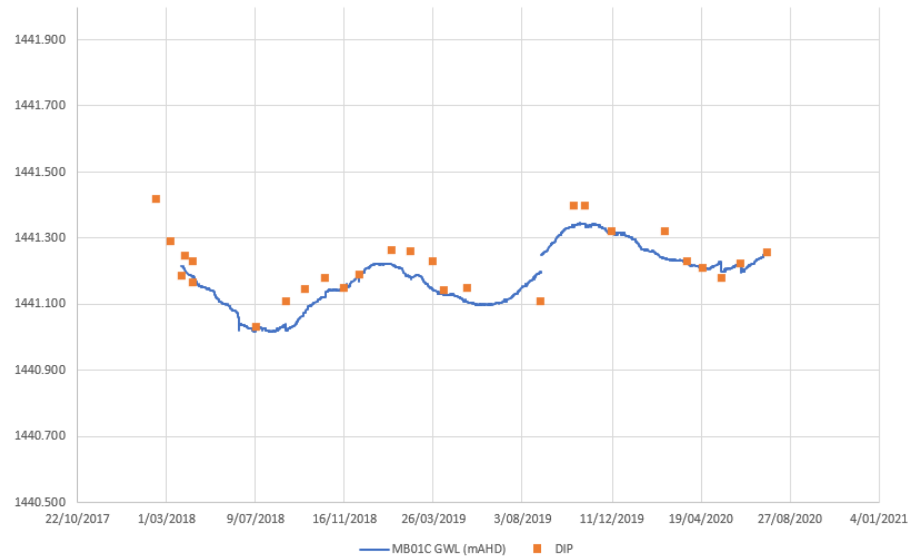


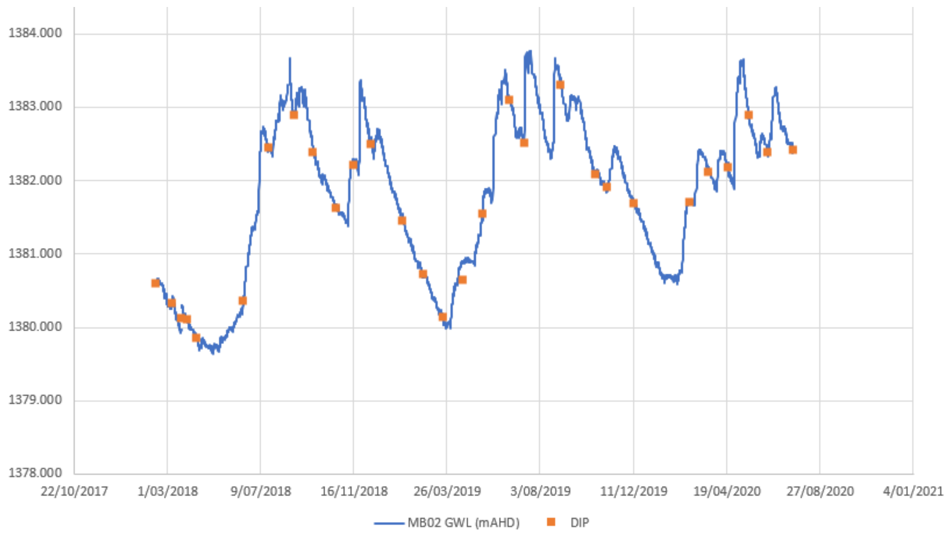
1333.400
1333.200
1333.000
1332.800
1332.600
1332.400
1332.200
1332.000
1331.800
1331.600
1331.400
10/04/2018
19/07/2018
27/10/2018
4/02/2019
15/05/2019
23/08/2019
1/12/2019
10/03/2020
18/06/2020
26/09/2020
SMB03 GWL (mAHD)
DIP

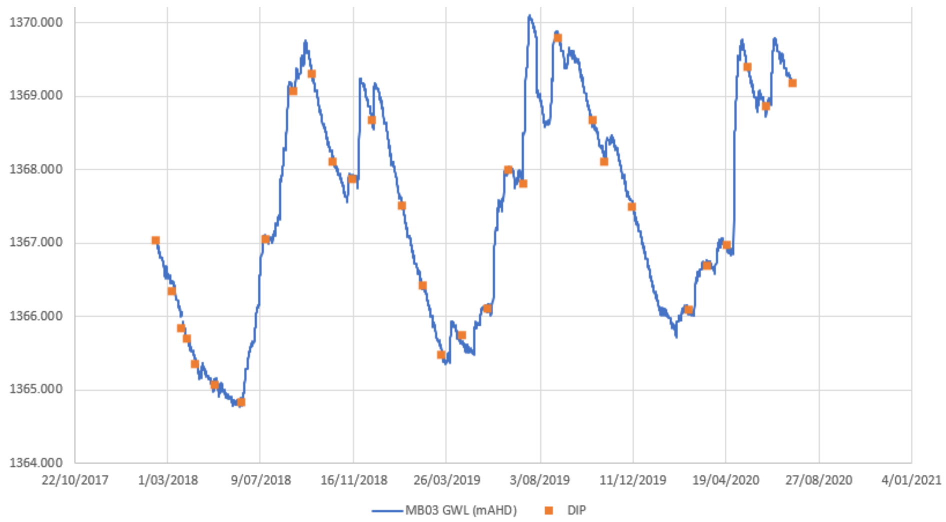

1336.000
1334.000
1332.000
1330.000
1328.000
1326.000
1324.000
1322.000
1320.000
1318.000
10/04/2018
8/08/2018
6/12/2018
5/04/2019
3/08/2019
1/12/2019
30/03/2020
28/07/2020
25/11/2020
SMB04 GWL (mAHD)
DIP

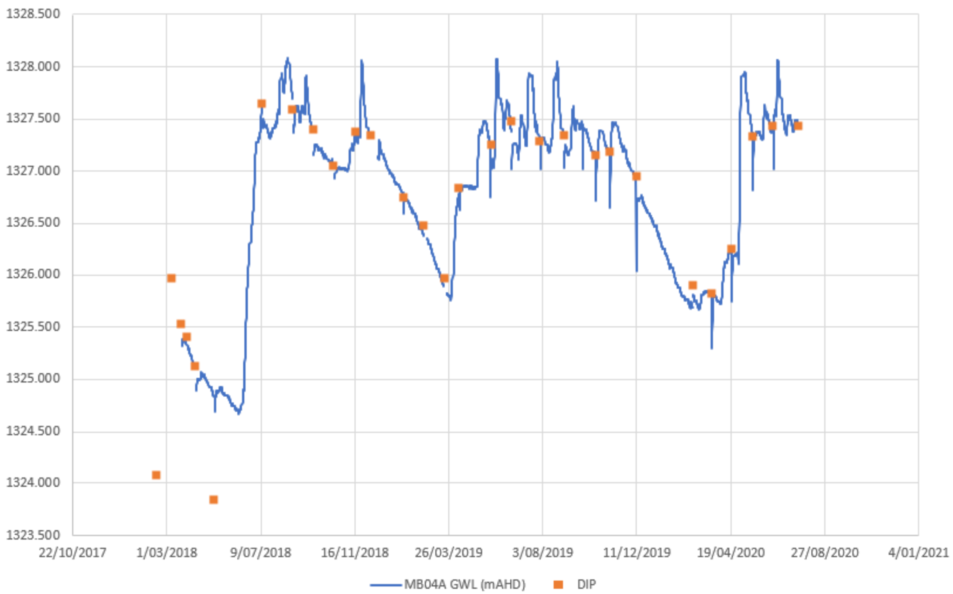

1328.000
1327.000
1326.000
1325.000
1324.000
1323.000
1322.000
1321.000
1320.000
10/04/2018
8/08/2018
6/12/2018
5/04/2019
3/08/2019
1/12/2019
30/03/2020
28/07/2020
25/11/2020
SMB05 GWL (mAHD)
DIP

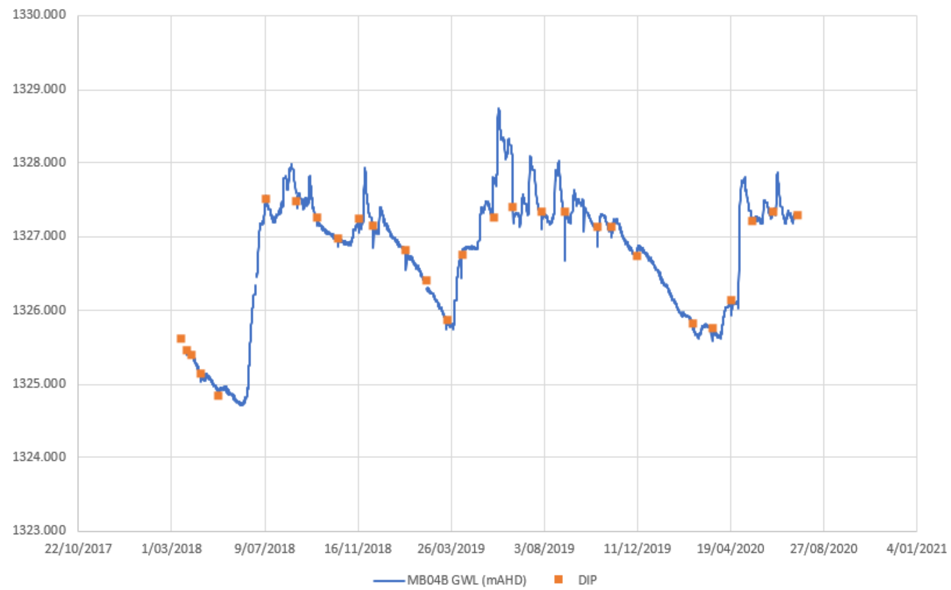

1465.000
1464.500
1464.000
1463.500
1463.000
1462.500
1462.000
1461.500
1461.000
1460.500
1460.000
22/10/2017
1/03/2018
9/07/2018
16/11/2018
26/03/2019
3/08/2019
11/12/2019
19/04/2020
27/08/2020
4/01/2021
MB01B GWL (mAHD)
DIP

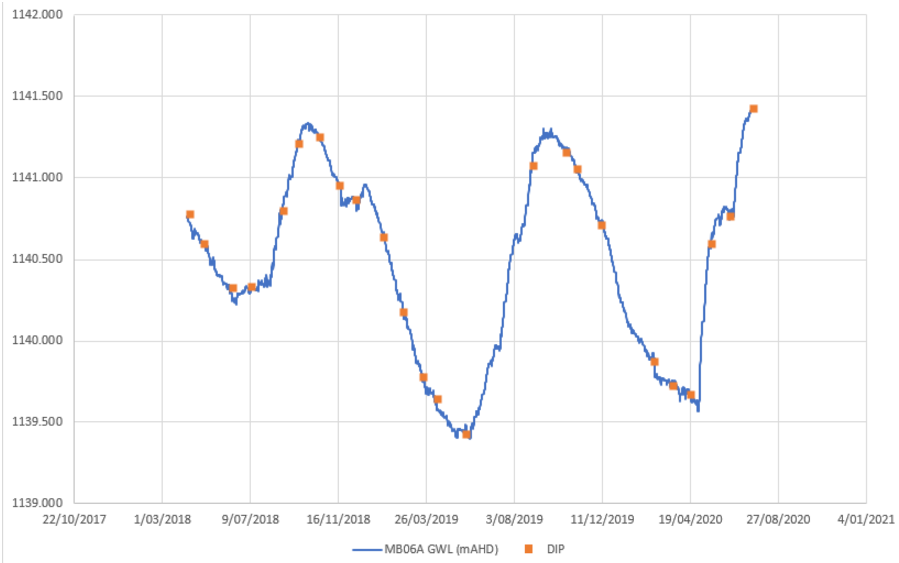

1441.900
1441.700
1441.500
1441.300
1441.100
1440.900
1440.700
1440.500
22/10/2017
1/03/2018
9/07/2018
16/11/2018
26/03/2019
3/08/2019
11/12/2019
19/04/2020
27/08/2020
4/01/2021
MB01C GWL (mAHD)
DIP


1384.000
1383.000
1382.000
1381.000
1380.000
1379.000
1378.000
22/10/2017
1/03/2018
9/07/2018
16/11/2018
26/03/2019
3/08/2019
11/12/2019
19/04/2020
27/08/2020
4/01/2021
MB02 GWL (mAHD)
DIP

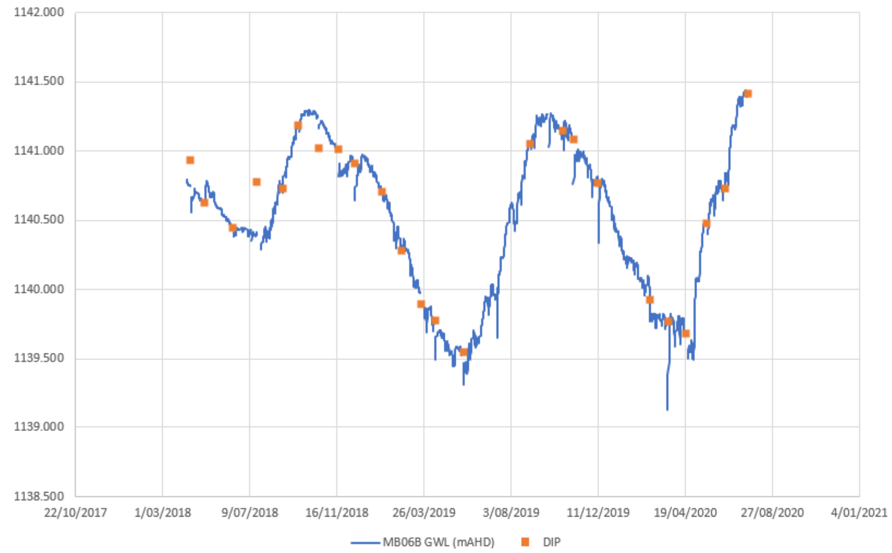

1370.000
1369.000
1368.000
1367.000
1366.000
1365.000
1364.000
22/10/2017
1/03/2018
9/07/2018
16/11/2018
26/03/2019
3/08/2019
11/12/2019
19/04/2020
27/08/2020
4/01/2021
MB03 GWL (mAHD)
DIP


1328.500
1328.000
1327.500
1327.000
1326.500
1326.000
1325.500
1325.000
1324.500
1324.000
1323.500
22/10/2017
1/03/2018
9/07/2018
16/11/2018
26/03/2019
3/08/2019
11/12/2019
19/04/2020
27/08/2020
4/01/2021
MB04A GWL (mAHD)
DIP

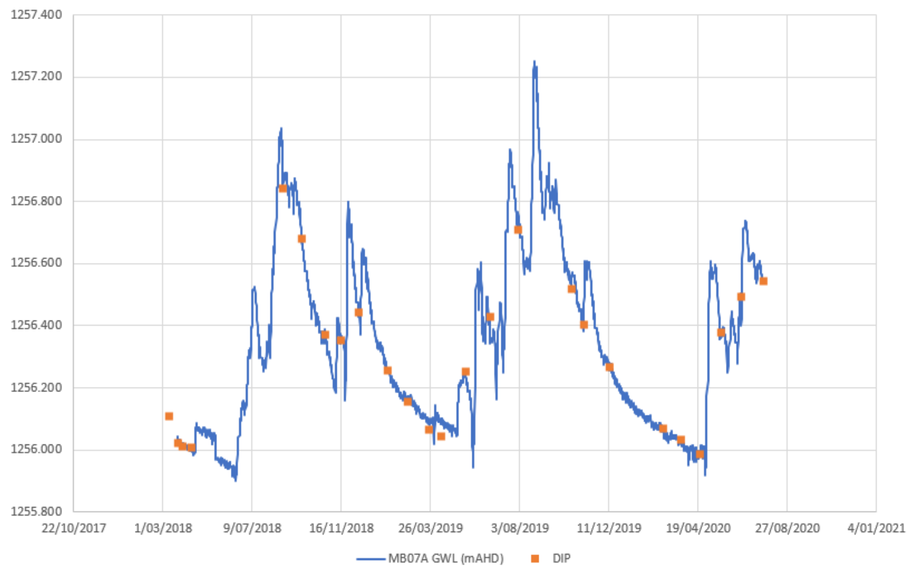

1330.000
1329.000
1328.000
1327.000
1326.000
1325.000
1324.000
1323.000
22/10/2017
1/03/2018
9/07/2018
16/11/2018
26/03/2019
3/08/2019
11/12/2019
19/04/2020
27/08/2020
4/01/2021
MB04B GWL (mAHD)
DIP



1142.000
1141.500
1141.000
1140.500
1140.000
1139.500
1139.000
22/10/2017
1/03/2018
9/07/2018
16/11/2018
26/03/2019
3/08/2019
11/12/2019
19/04/2020
27/08/2020
4/01/2021
MB06A GWL (mAHD)
DIP

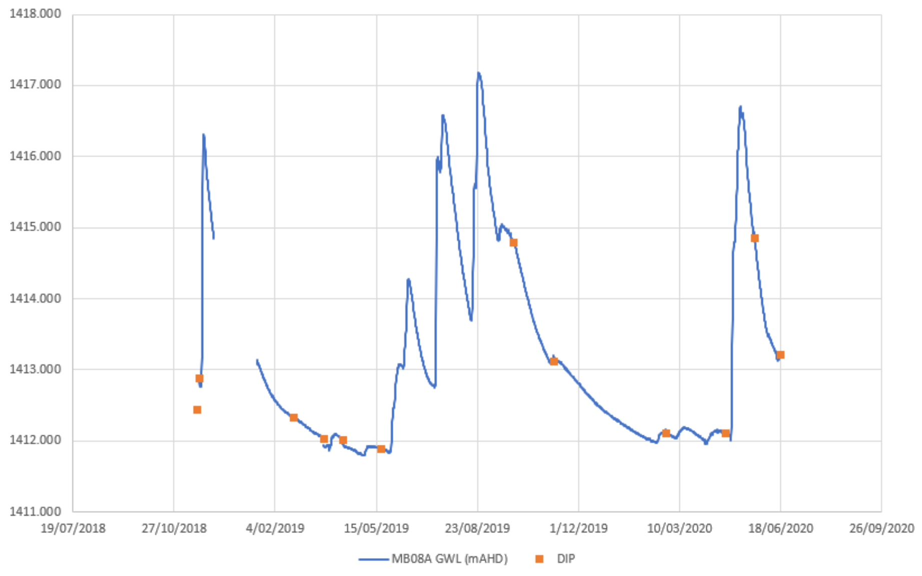


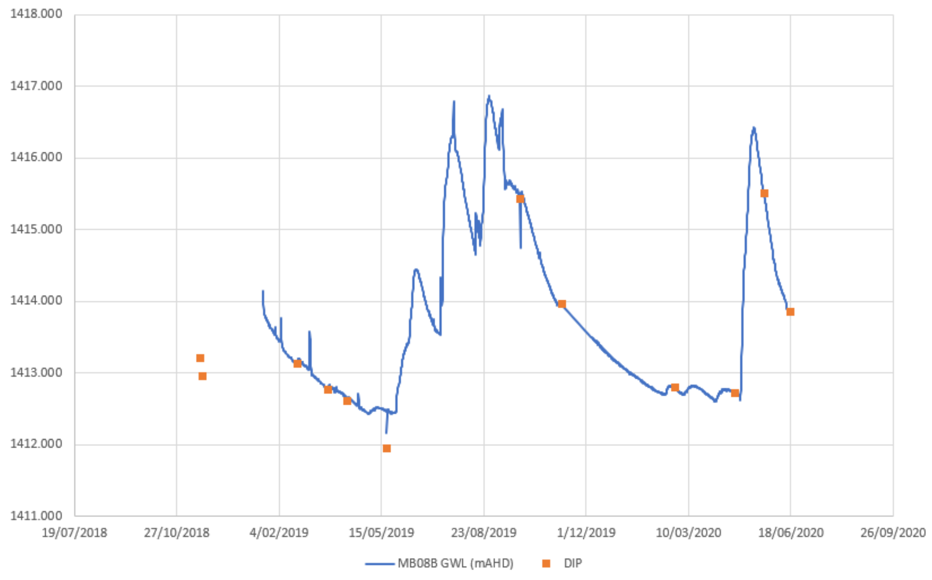
1142.000
1141.500
1141.000
1140.500
1140.000
1139.500
1139.000
1138.500
22/10/2017
1/03/2018
9/07/2018
16/11/2018
26/03/2019
3/08/2019
11/12/2019
19/04/2020
27/08/2020
4/01/2021
MB06B GWL (mAHD)
DIP

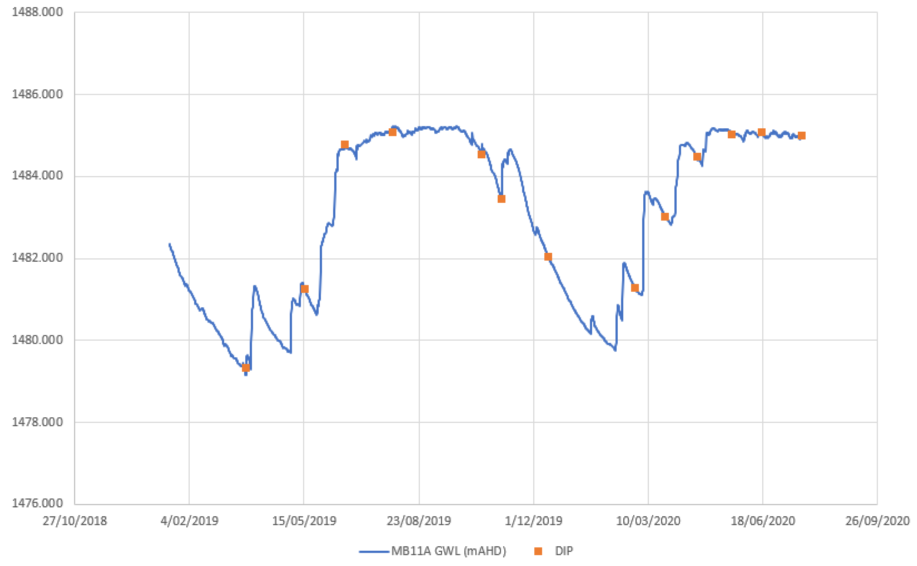


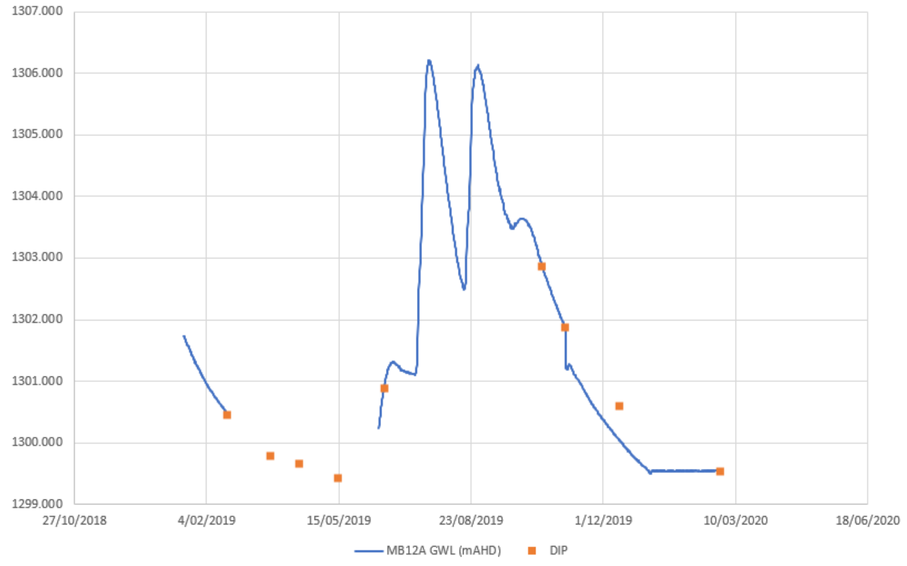
1257.400
1257.200
1257.000
1256.800
1256.600
1256.400
1256.200
1256.000
1255.800
22/10/2017
1/03/2018
9/07/2018
16/11/2018
26/03/2019
3/08/2019
11/12/2019
19/04/2020
27/08/2020
4/01/2021
MB07A GWL (mAHD)
DIP

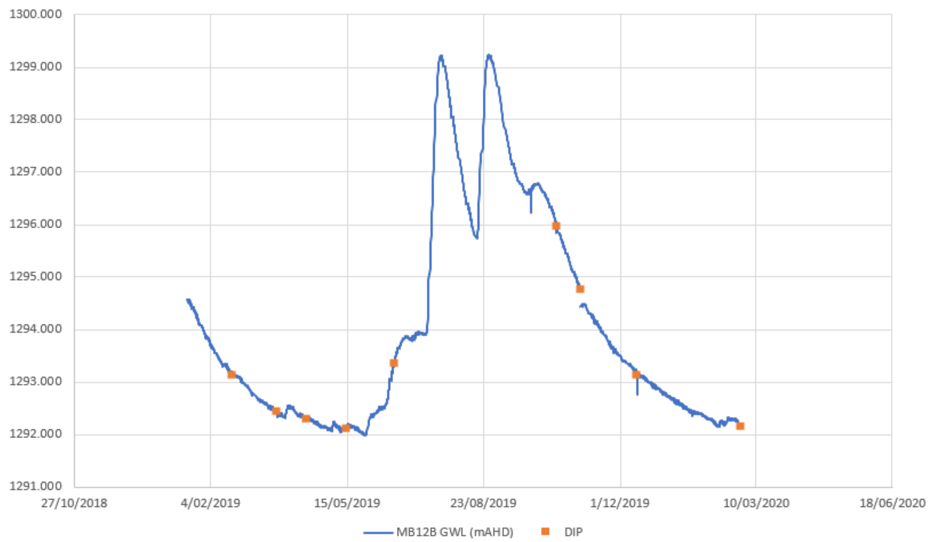
1257.200
1257.000
1256.800
1256.600
1256.400
1256.200
1256.000
1255.800
1255.600
1255.400
1255.200
22/10/2017
1/03/2018
9/07/2018
16/11/2018
26/03/2019
3/08/2019
11/12/2019
19/04/2020
27/08/2020
4/01/2021
MB07B GWL (mAHD)
DIP

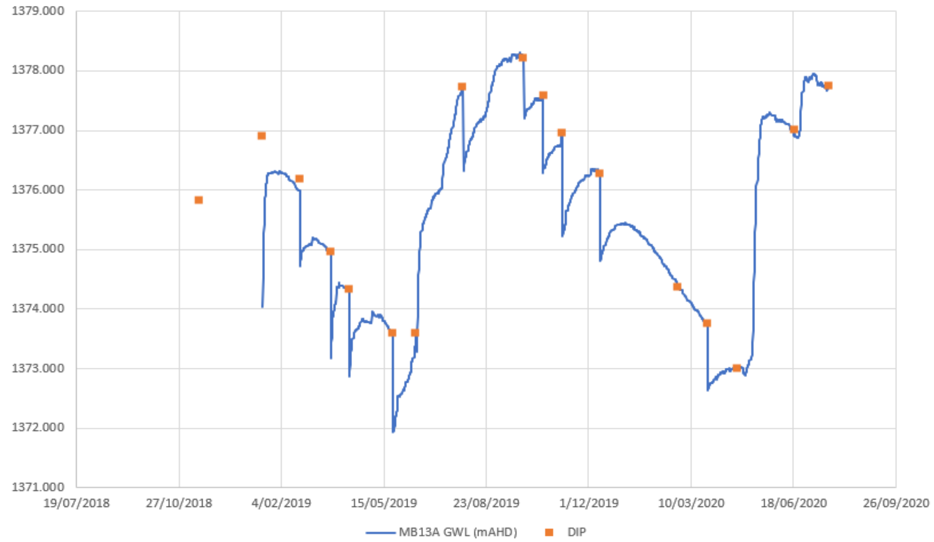

1418.000
1417.000
1416.000
1415.000
1414.000
1413.000
1412.000
1411.000
19/07/2018
27/10/2018
4/02/2019
15/05/2019
23/08/2019
1/12/2019
10/03/2020
18/06/2020
26/09/2020
MB08A GWL (mAHD)
DIP

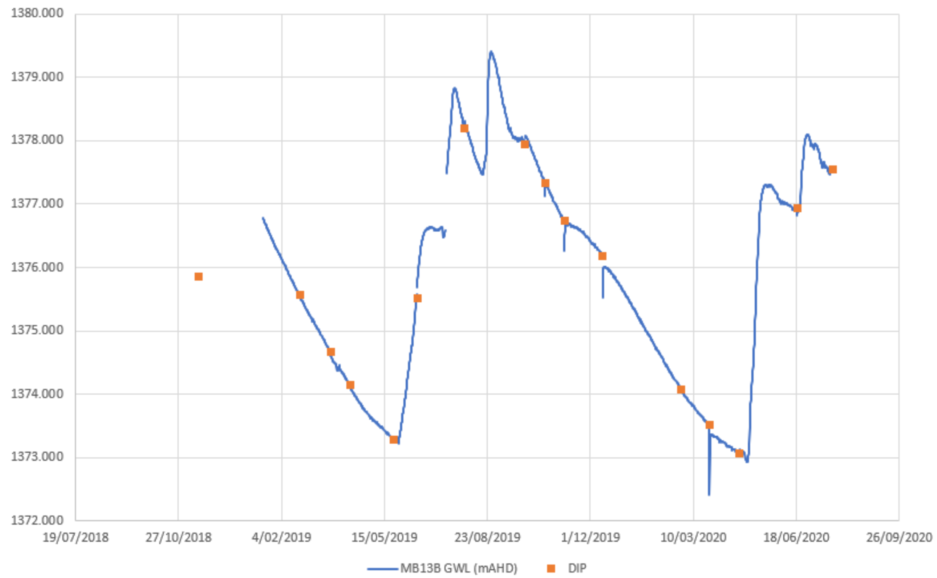

1418.000
1417.000
1416.000
1415.000
1414.000
1413.000
1412.000
1411.000
19/07/2018
27/10/2018
4/02/2019
15/05/2019
23/08/2019
1/12/2019
10/03/2020
18/06/2020
26/09/2020
MB08B GWL (mAHD)
DIP

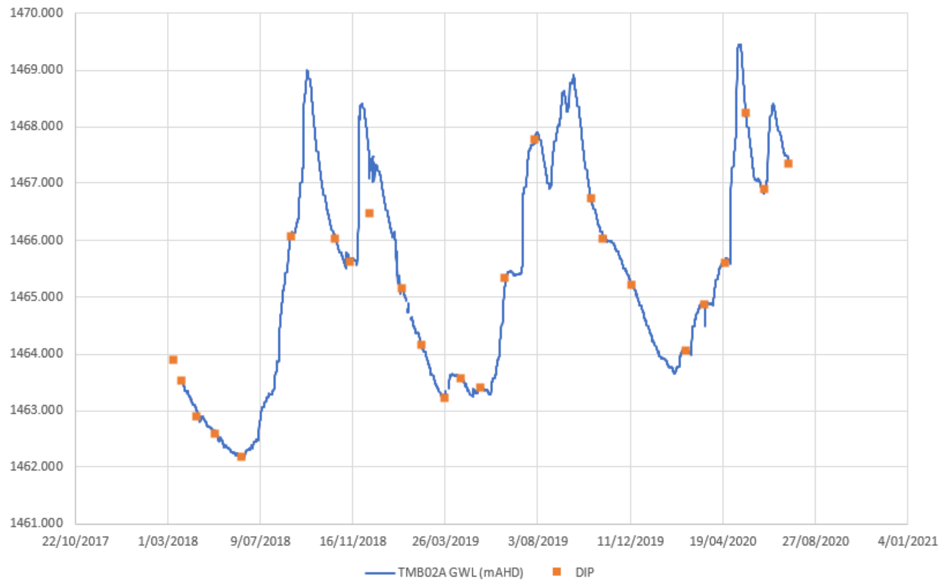

1488.000
1486.000
1484.000
1482.000
1480.000
1478.000
1476.000
27/10/2018
4/02/2019
15/05/2019
23/08/2019
1/12/2019
10/03/2020
18/06/2020
26/09/2020
MB11A GWL (mAHD)
DIP

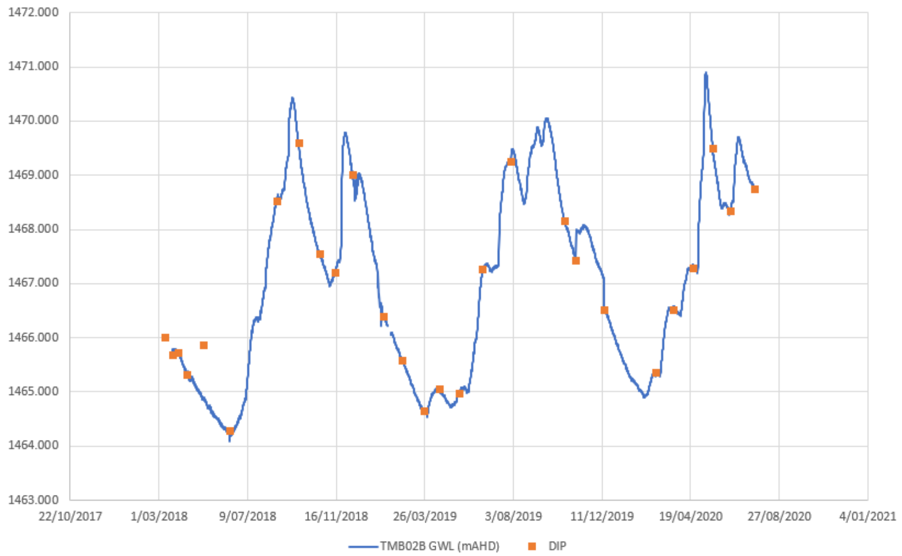

1307.000
1306.000
1305.000
1304.000
1303.000
1302.000
1301.000
1300.000
1299.000
27/10/2018
4/02/2019
15/05/2019
23/08/2019
1/12/2019
10/03/2020
18/06/2020
MB12A GWL (mAHD)
DIP

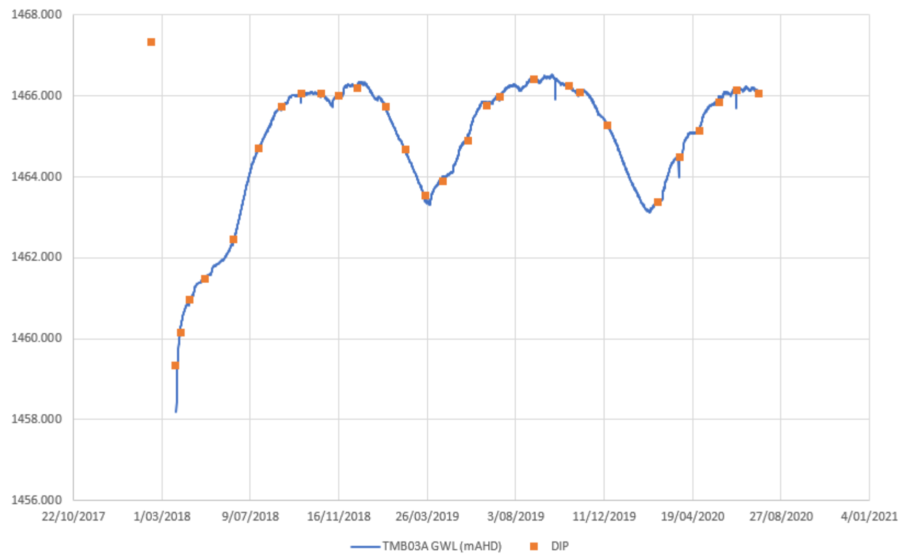

1300.000
1299.000
1298.000
1297.000
1296.000
1295.000
1294.000
1293.000
1292.000
1291.000
27/10/2018
4/02/2019
15/05/2019
23/08/2019
1/12/2019
10/03/2020
18/06/2020
MB12B GWL (mAHD)
DIP

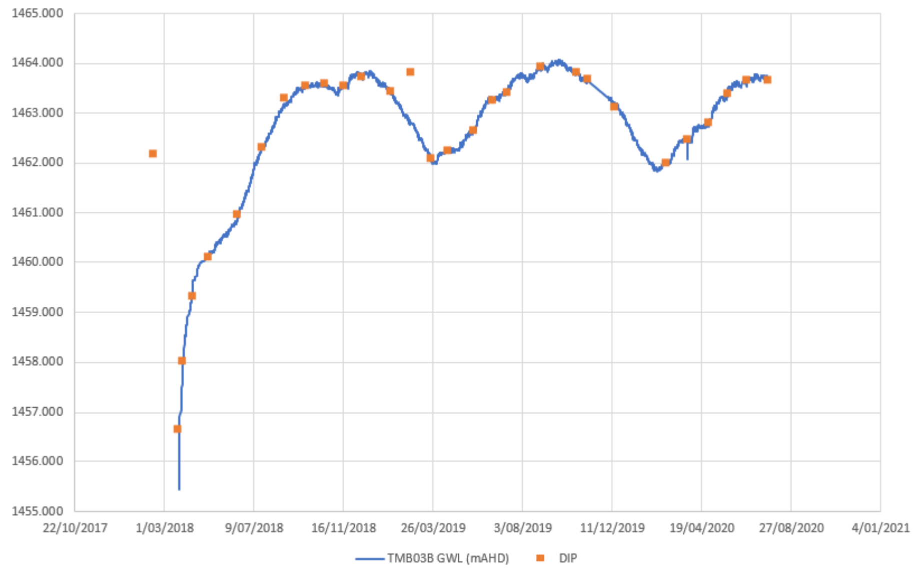

1379.000
1378.000
1377.000
1376.000
1375.000
1374.000
1373.000
1372.000
1371.000
19/07/2018
27/10/2018
4/02/2019
15/05/2019
23/08/2019
1/12/2019
10/03/2020
18/06/2020
26/09/2020
MB13A GWL (mAHD)
DIP

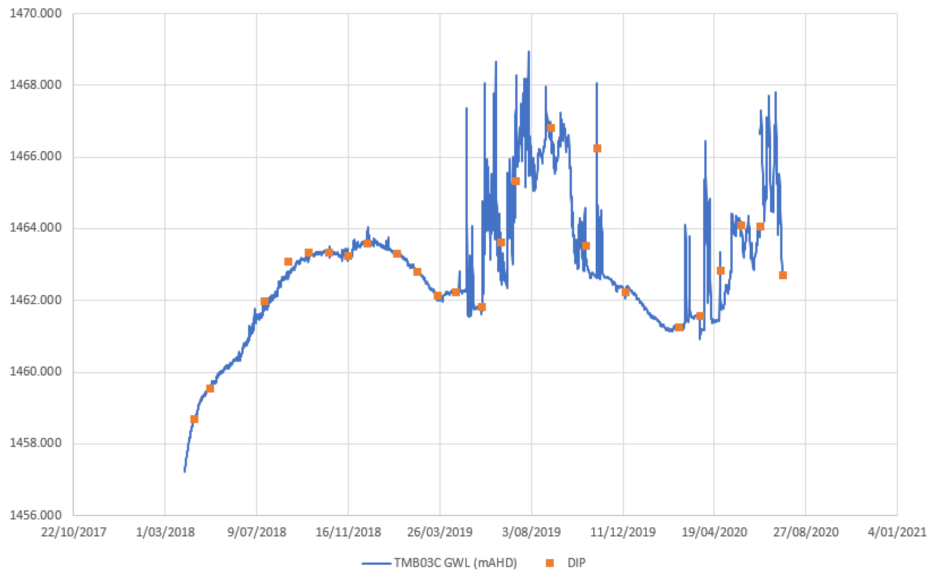

1380.000
1379.000
1378.000
1377.000
1376.000
1375.000
1374.000
1373.000
1372.000
19/07/2018
27/10/2018
4/02/2019
15/05/2019
23/08/2019
1/12/2019
10/03/2020
18/06/2020
26/09/2020
MB13B GWL (mAHD)
DIP

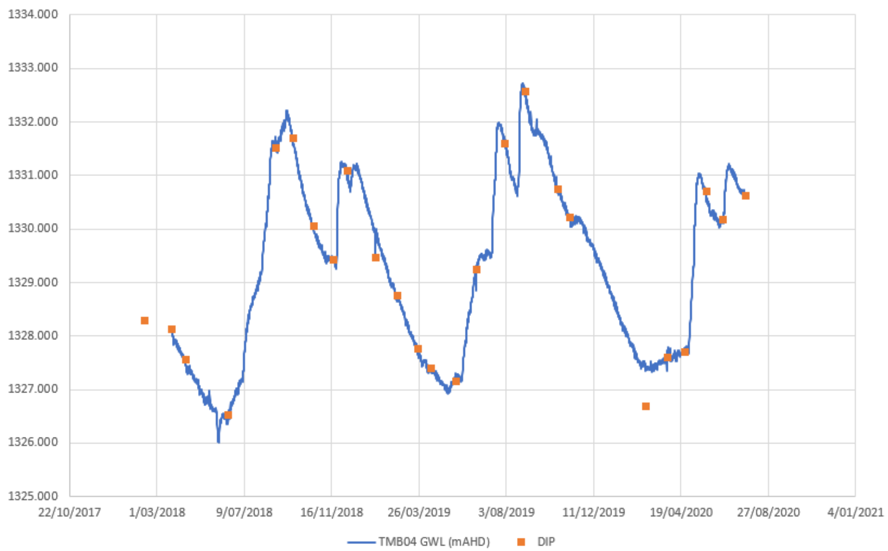

1470.000
1469.000
1468.000
1467.000
1466.000
1465.000
1464.000
1463.000
1462.000
1461.000
22/10/2017
1/03/2018
9/07/2018
16/11/2018
26/03/2019
3/08/2019
11/12/2019
19/04/2020
27/08/2020
4/01/2021
TMB02A GWL (mAHD)
DIP

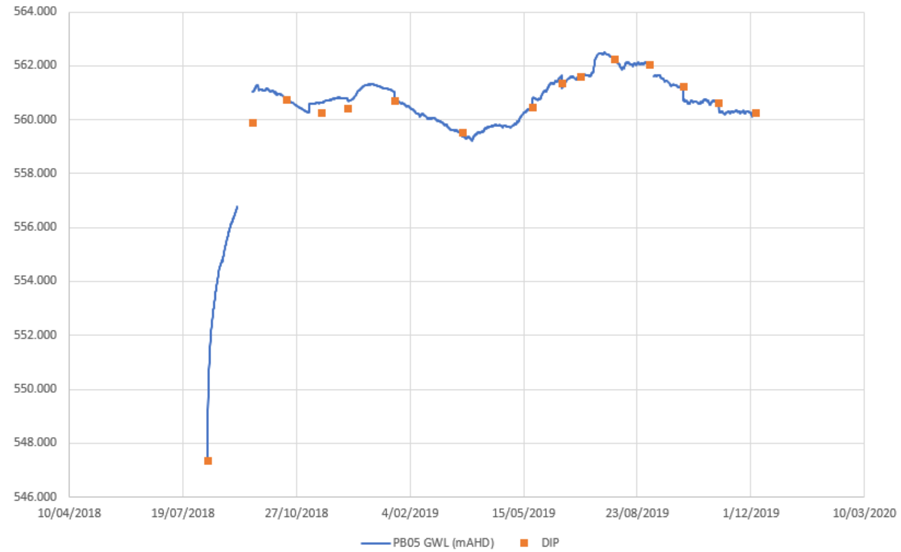

1472.000
1471.000
1470.000
1469.000
1468.000
1467.000
1466.000
1465.000
1464.000
1463.000
22/10/2017
1/03/2018
9/07/2018
16/11/2018
26/03/2019
3/08/2019
11/12/2019
19/04/2020
27/08/2020
4/01/2021
TMB02B GWL (mAHD)
DIP

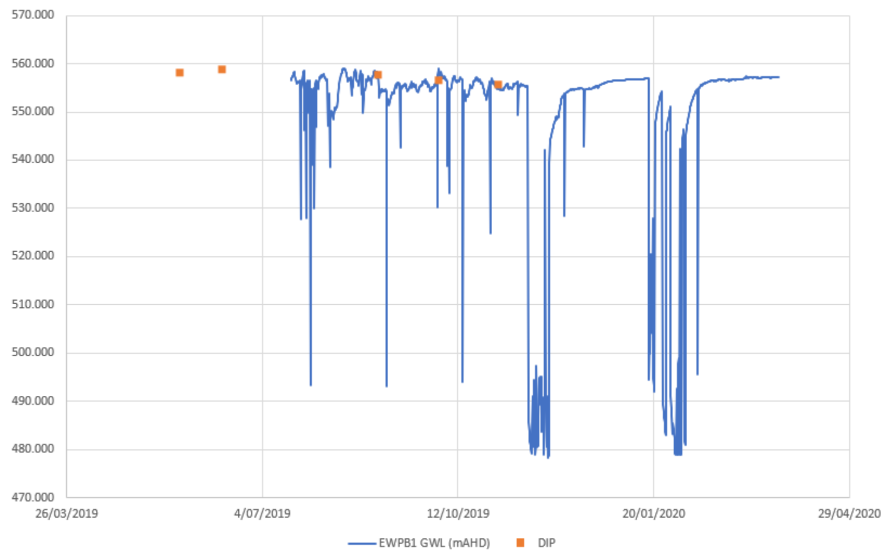

1468.000
1466.000
1464.000
1462.000
1460.000
1458.000
1456.000
22/10/2017
1/03/2018
9/07/2018
16/11/2018
26/03/2019
3/08/2019
11/12/2019
19/04/2020
27/08/2020
4/01/2021
TMB03A GWL (mAHD)
DIP

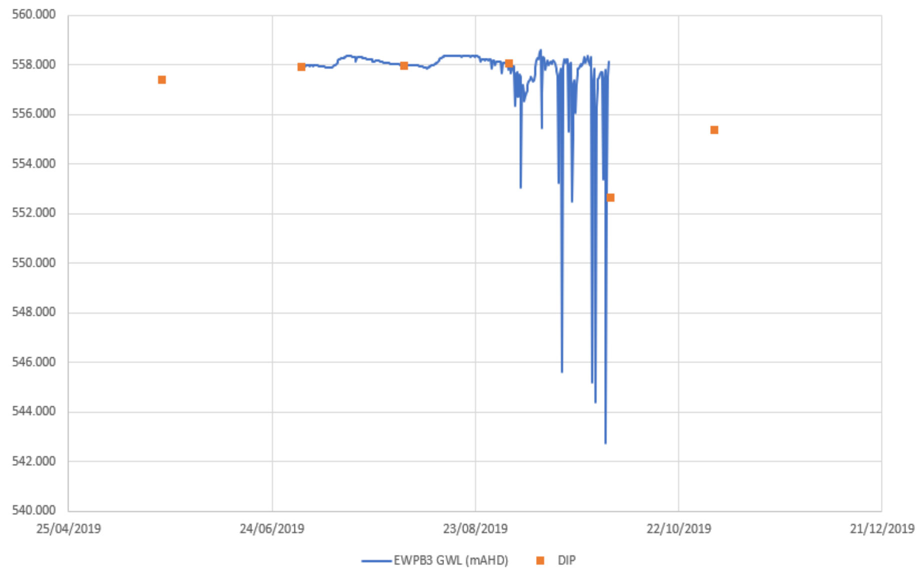

1465.000
1464.000
1463.000
1462.000
1461.000
1460.000
1459.000
1458.000
1457.000
1456.000
1455.000
22/10/2017
1/03/2018
9/07/2018
16/11/2018
26/03/2019
3/08/2019
11/12/2019
19/04/2020
27/08/2020
4/01/2021
TMB03B GWL (mAHD)
DIP


1470.000
1468.000
1466.000
1464.000
1462.000
1460.000
1458.000
1456.000
22/10/2017
1/03/2018
9/07/2018
16/11/2018
26/03/2019
3/08/2019
11/12/2019
19/04/2020
27/08/2020
4/01/2021
TMB03C GWL (mAHD)
DIP

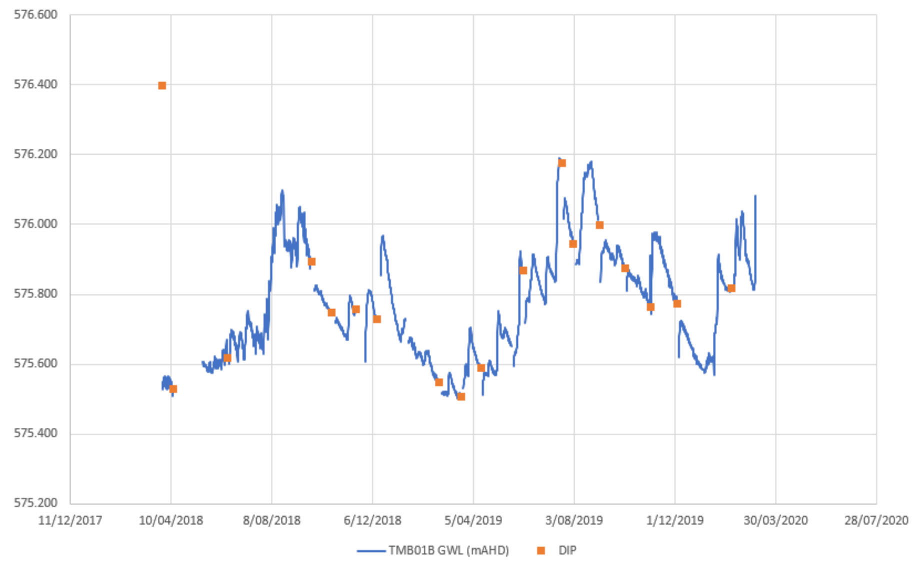

1334.000
1333.000
1332.000
1331.000
1330.000
1329.000
1328.000
1327.000
1326.000
1325.000
22/10/2017
1/03/2018
9/07/2018
16/11/2018
26/03/2019
3/08/2019
11/12/2019
19/04/2020
27/08/2020
4/01/2021
TMB04 GWL (mAHD)
DIP


564.000
562.000
560.000
558.000
556.000
554.000
552.000
550.000
548.000
546.000
10/04/2018
19/07/2018
27/10/2018
4/02/2019
15/05/2019
23/08/2019
1/12/2019
10/03/2020
PB05 GWL (mAHD)
DIP

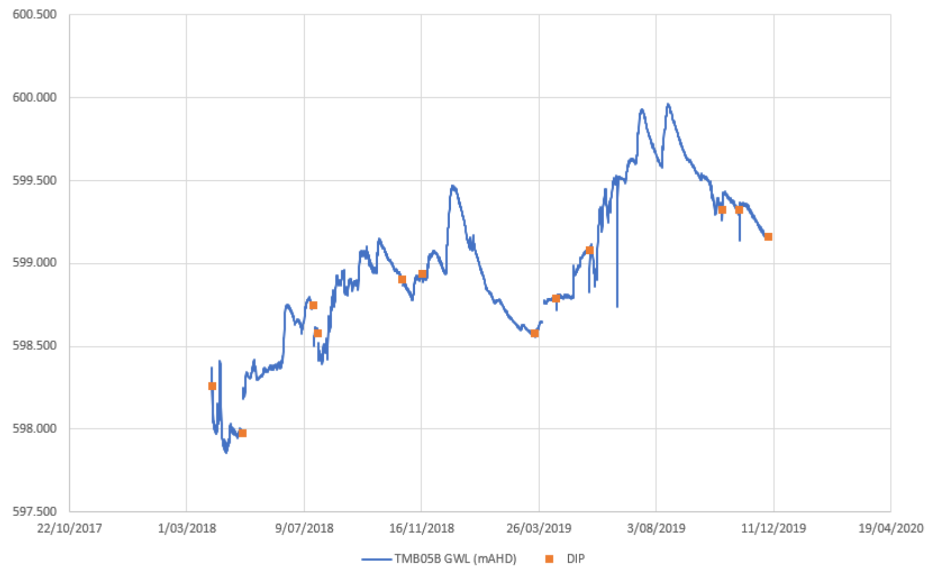

570.000
560.000
550.000
540.000
530.000
520.000
510.000
500.000
490.000
480.000
470.000
26/03/2019
4/07/2019
12/10/2019
20/01/2020
29/04/2020
EWPB1 GWL (mAHD)
DIP

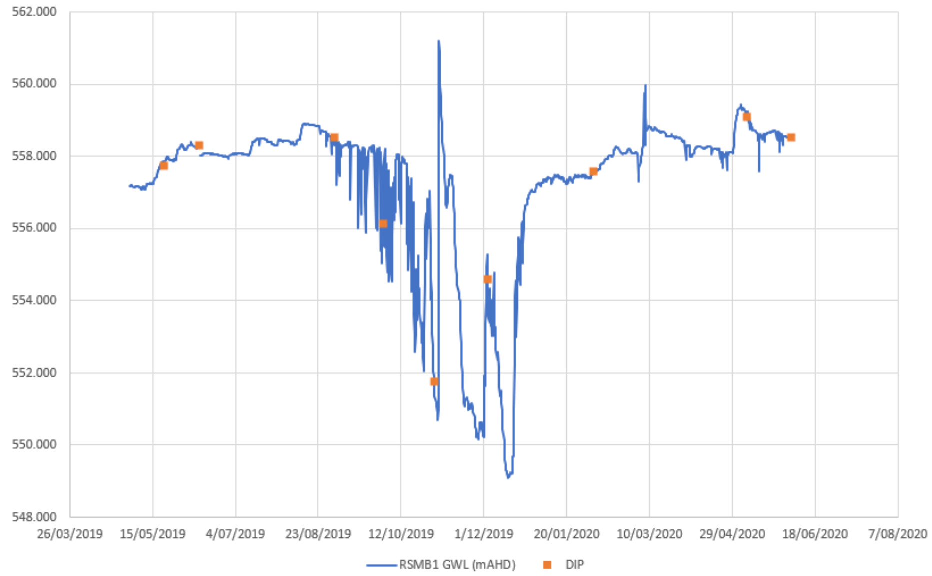

560.000
558.000
556.000
554.000
552.000
550.000
548.000
546.000
544.000
542.000
540.000
25/04/2019
24/06/2019
23/08/2019
22/10/2019
21/12/2019
EWPB3 GWL (mAHD)
DIP


577.600
577.400
577.200
577.000
576.800
576.600
576.400
576.200
576.000
575.800
575.600
11/12/2017
10/04/2018
8/08/2018
6/12/2018
5/04/2019
3/08/2019
1/12/2019
30/03/2020
28/07/2020
TMB01A GWL (mAHD)
DIP

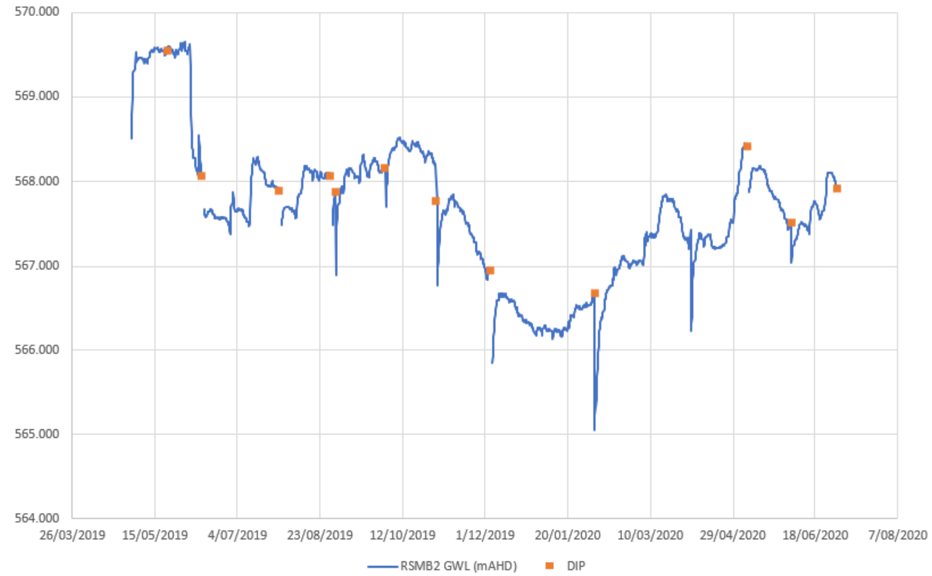

576.600
576.400
576.200
576.000
575.800
575.600
575.400
575.200
11/12/2017
10/04/2018
8/08/2018
6/12/2018
5/04/2019
3/08/2019
1/12/2019
30/03/2020
28/07/2020
TMB01B GWL (mAHD)
DIP


600.000
599.800
599.600
599.400
599.200
599.000
598.800
598.600
22/10/2017
1/03/2018
9/07/2018
16/11/2018
26/03/2019
3/08/2019
11/12/2019
19/04/2020
TMB05A GWL (mAHD)
DIP

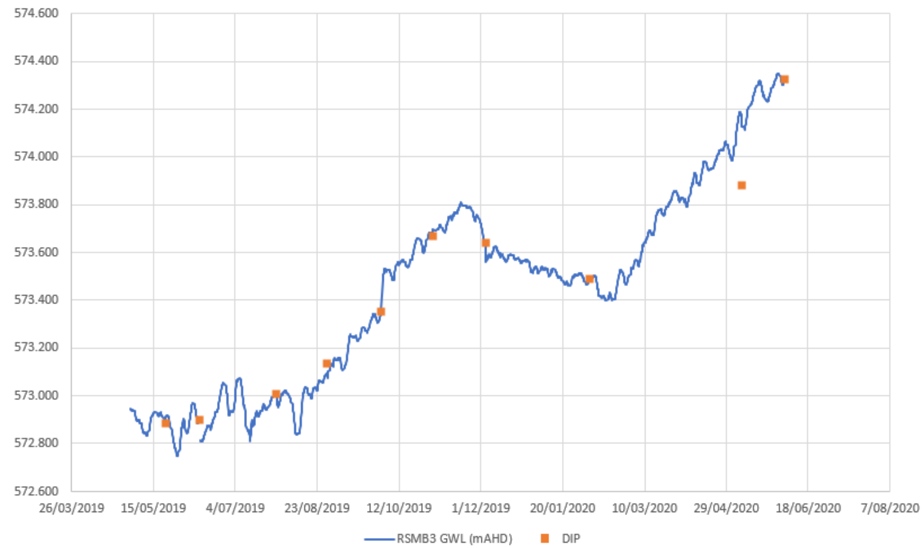

600.500
600.000
599.500
599.000
598.500
598.000
597.500
22/10/2017
1/03/2018
9/07/2018
16/11/2018
26/03/2019
3/08/2019
11/12/2019
19/04/2020
TMB05B GWL (mAHD)
DIP



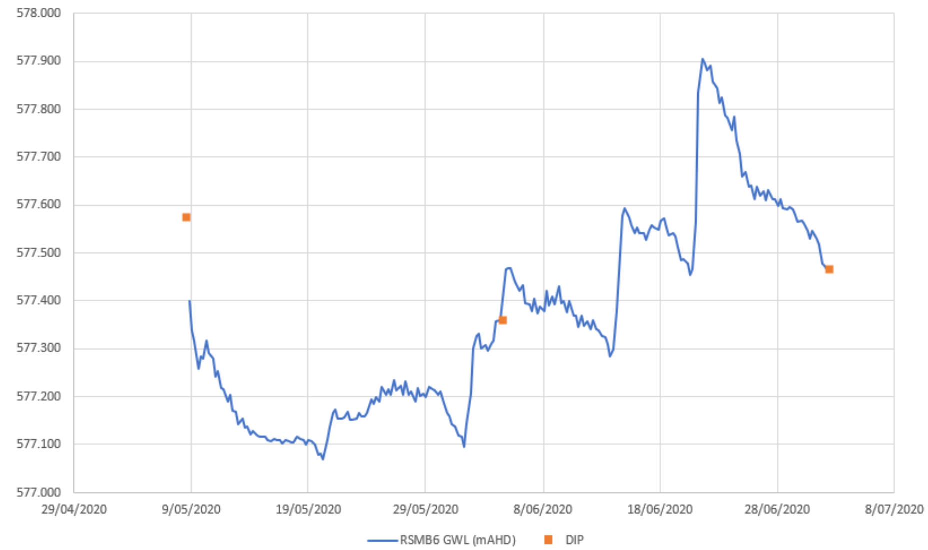
562.000
560.000
558.000
556.000
554.000
552.000
550.000
548.000
26/03/2019
15/05/2019
4/07/2019
23/08/2019
12/10/2019
1/12/2019
20/01/2020
10/03/2020
29/04/2020
18/06/2020
7/08/2020
RSMB1 GWL (mAHD)
DIP



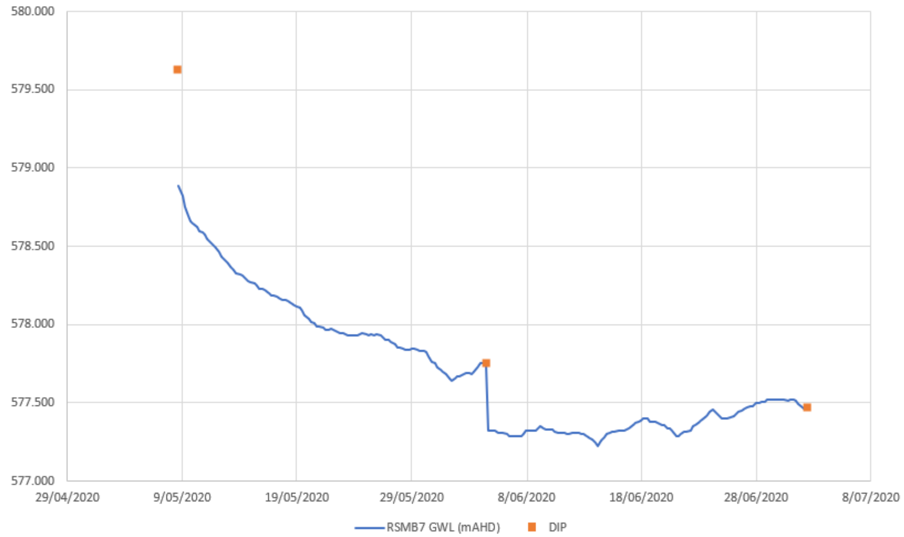
570.000
569.000
568.000
567.000
566.000
565.000
564.000
26/03/2019
15/05/2019
4/07/2019
23/08/2019
12/10/2019
1/12/2019
20/01/2020
10/03/2020
29/04/2020
18/06/2020
7/08/2020
RSMB2 GWL (mAHD)
DIP

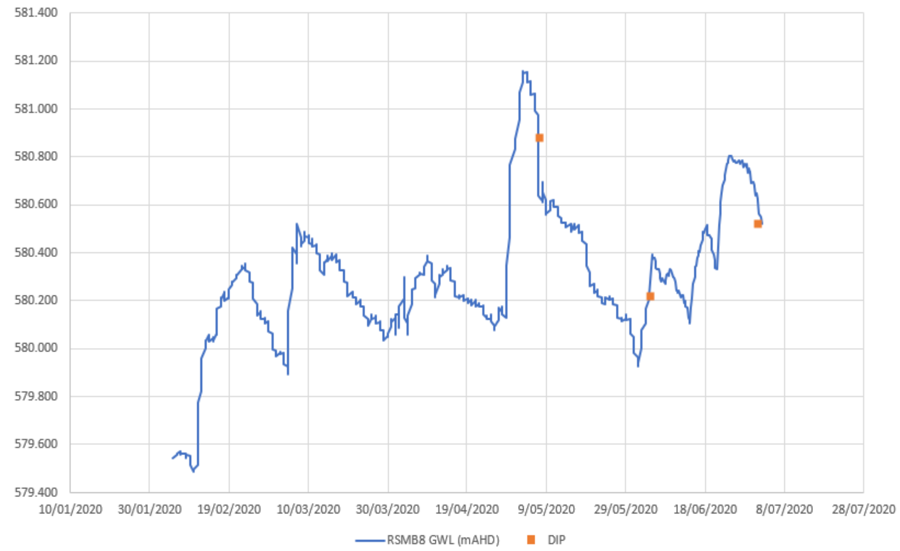


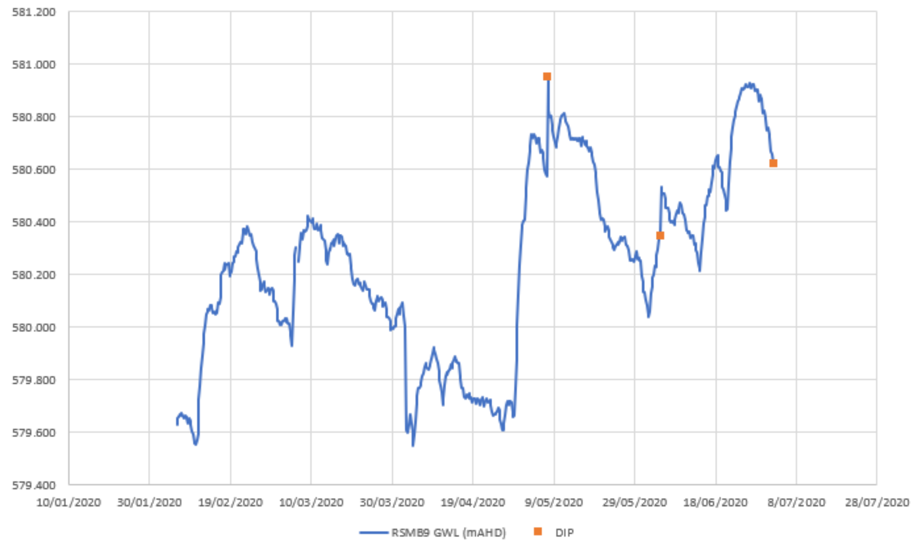
574.600
574.400
574.200
574.000
573.800
573.600
573.400
573.200
573.000
572.800
572.600
26/03/2019
15/05/2019
4/07/2019
23/08/2019
12/10/2019
1/12/2019
20/01/2020
10/03/2020
29/04/2020
18/06/2020
7/08/2020
RSMB3 GWL (mAHD)
DIP

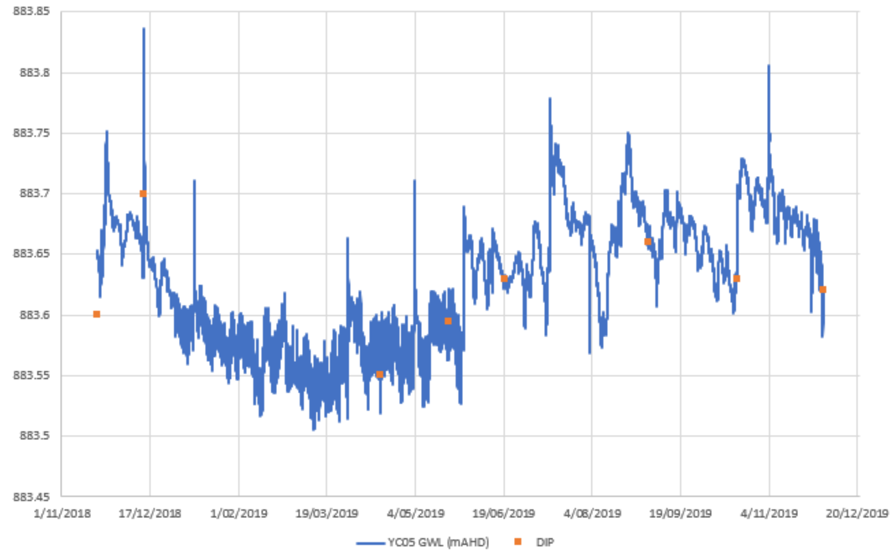


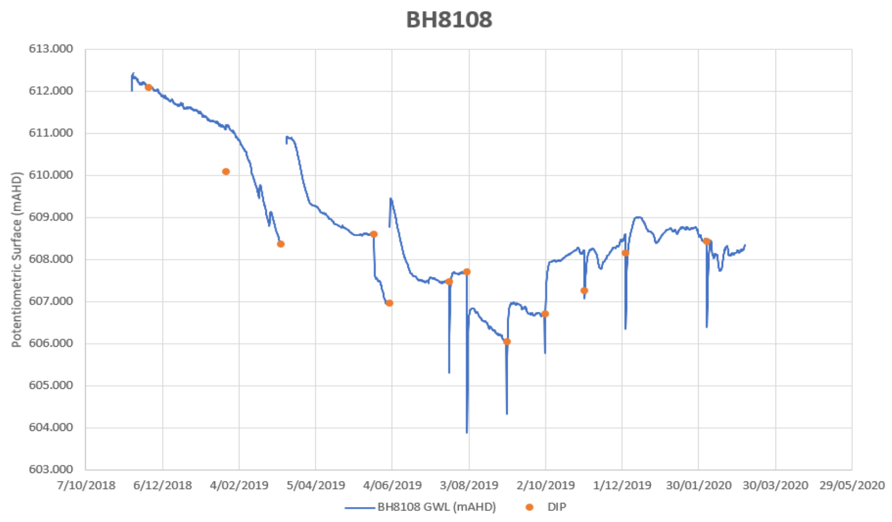
578.000
577.900
577.800
577.700
577.600
577.500
577.400
577.300
577.200
577.100
577.000
29/04/2020
9/05/2020
19/05/2020
29/05/2020
8/06/2020
18/06/2020
28/06/2020
8/07/2020
RSMB6 GWL (mAHD)
DIP

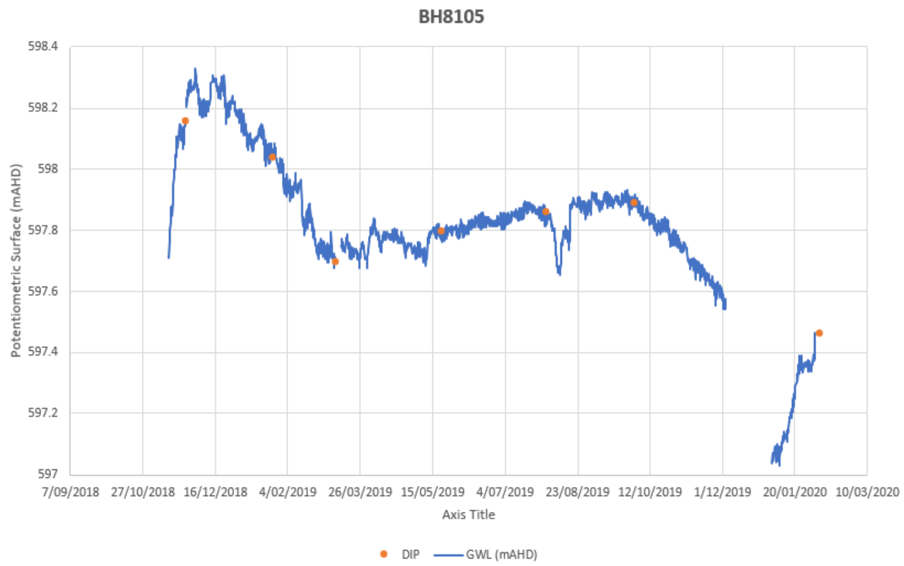

580.000
579.500
579.000
578.500
578.000
577.500
577.000
29/04/2020
9/05/2020
19/05/2020
29/05/2020
8/06/2020
18/06/2020
28/06/2020
8/07/2020
RSMB7 GWL (mAHD)
DIP

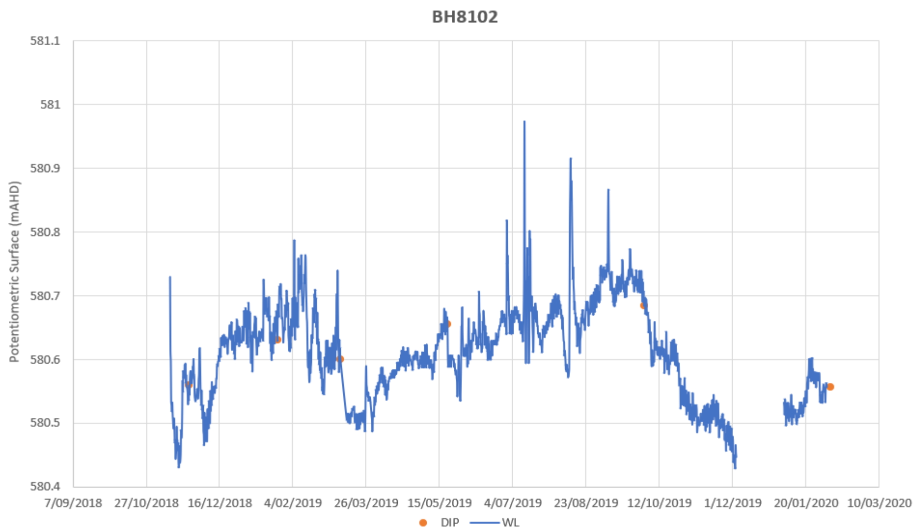

581.400
581.200
581.000
580.800
580.600
580.400
580.200
580.000
579.800
579.600
579.400
10/01/2020
30/01/2020
19/02/2020
10/03/2020
30/03/2020
19/04/2020
9/05/2020
29/05/2020
18/06/2020
8/07/2020
28/07/2020
RSMB8 GWL (mAHD)
DIP

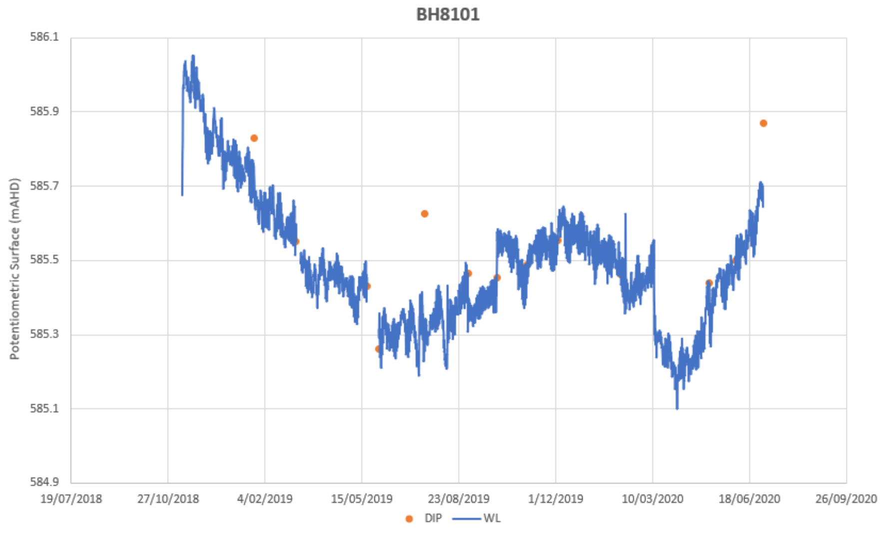

581.200
581.000
580.800
580.600
580.400
580.200
580.000
579.800
579.600
579.400
10/01/2020
30/01/2020
19/02/2020
10/03/2020
30/03/2020
19/04/2020
9/05/2020
29/05/2020
18/06/2020
8/07/2020
28/07/2020
RSMB9 GWL (mAHD)
DIP

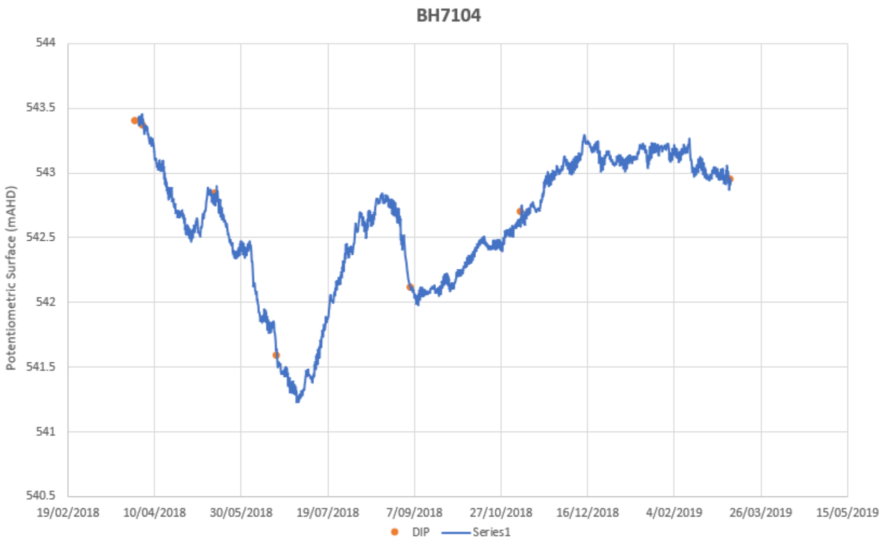

883.85
883.8
883.75
883.7
883.65
883.6
883.55
883.5
883.45
1/11/2018
17/12/2018
1/02/2019
19/03/2019
4/05/2019
19/06/2019
4/08/2019
19/09/2019
4/11/2019
20/12/2019
YC05 GWL (mAHD)
DIP

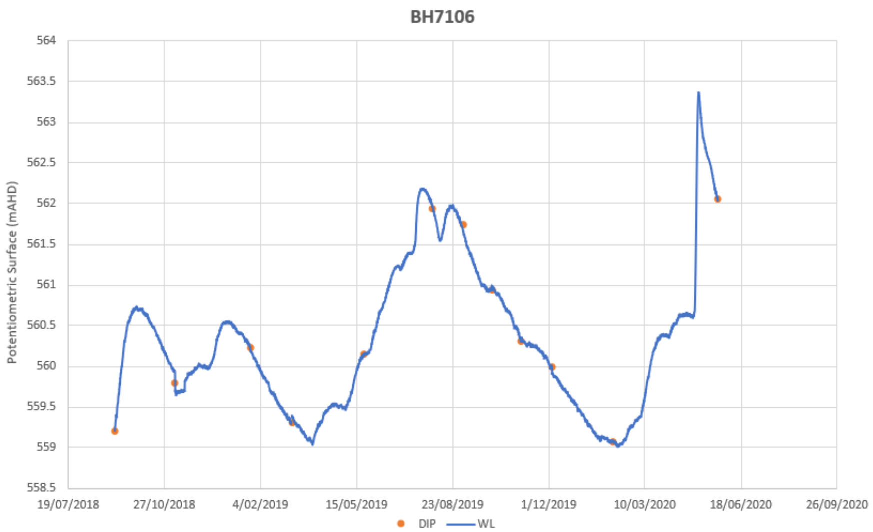

BH8108
Potentiometric Surface (mAHD)
613.000
612.000
611.000
610.000
609.000
608.000
607.000
606.000
605.000
604.000
603.000
7/10/2018
6/12/2018
4/02/2019
5/04/2019
4/06/2019
3/08/2019
2/10/2019
1/12/2019
30/01/2020
30/03/2020
29/05/2020
BH8108 GWL (mAHD)
DIP


BH8105
Potentiometric Surface (mAHD)
598.4
598.2
598
597.8
597.6
597.4
597.2
597
7/09/2018
27/10/2018
16/12/2018
4/02/2019
26/03/2019
15/05/2019
4/07/2019
23/08/2019
12/10/2019
1/12/2019
20/01/2020
10/03/2020
Axis Title
DIP
GWL (mAHD)

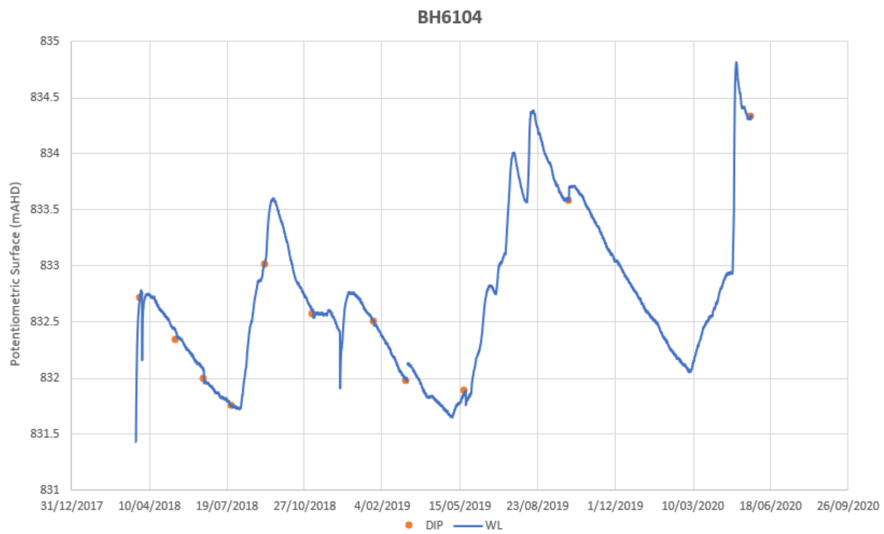

BH8102
Potentiometric Surface (mAHD)
581.1
581
580.9
580.8
580.7
580.6
580.5
580.4
7/09/2018
27/10/2018
16/12/2018
4/02/2019
26/03/2019
15/05/2019
4/07/2019
23/08/2019
12/10/2019
1/12/2019
20/01/2020
10/03/2020
DIP
WL

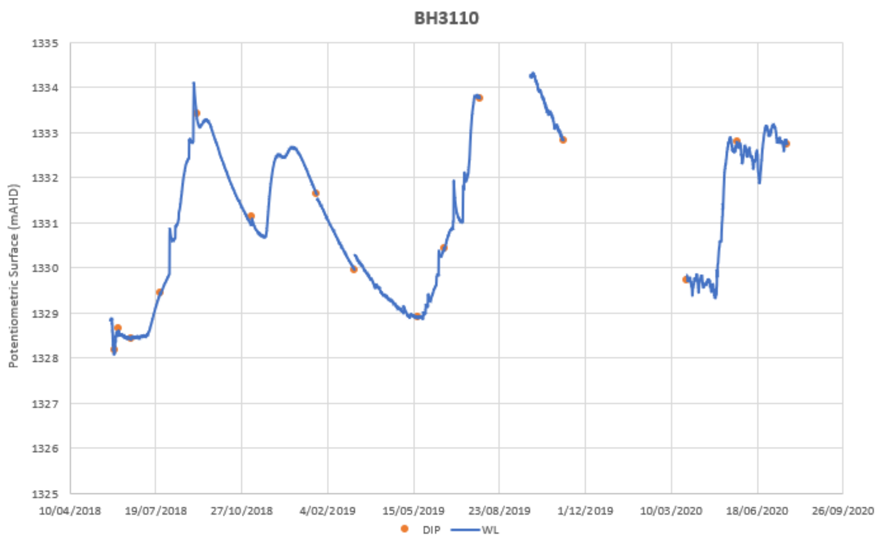

BH8101
Potentiometric Surface (mAHD)
586.1
585.9
585.7
585.5
585.3
585.1
584.9
19/07/2018
27/10/2018
4/02/2019
15/05/2019
23/08/2019
1/12/2019
10/03/2020
18/06/2020
26/09/2020
DIP
WL

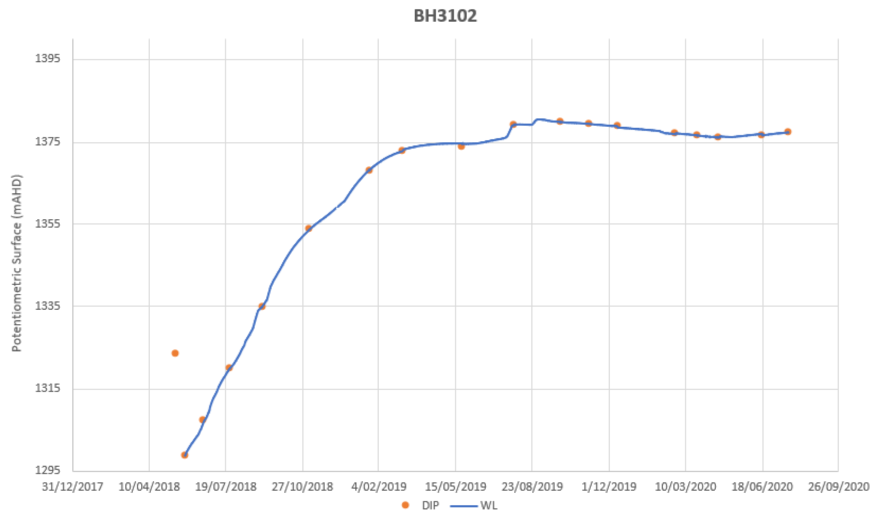

BH7104
Potentiometric Surface (mAHD)
544
543.5
543
542.5
542
541.5
541
540.5
19/02/2018
10/04/2018
30/05/2018
19/07/2018
7/09/2018
27/10/2018
16/12/2018
4/02/2019
26/03/2019
15/05/2019
DIP
Series1

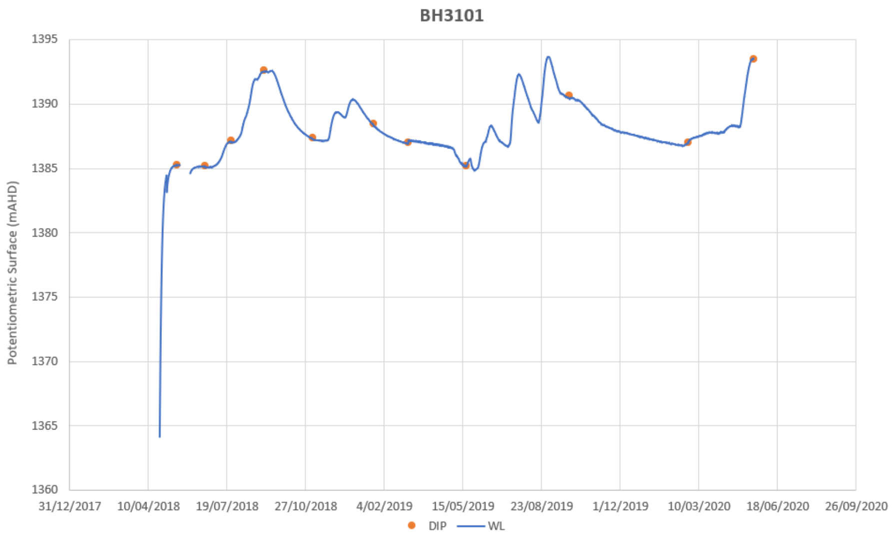

BH7106
Potentiometric Surface (mAHD)
564
563.5
563
562.5
562
561.5
561
560.5
560
559.5
559
558.5
19/07/2018
27/10/2018
4/02/2019
15/05/2019
23/08/2019
1/12/2019
10/03/2020
18/06/2020
26/09/2020
DIP
WL


BH6105
Potentiometric Surface (mAHD)
642
641
640
639
638
637
636
31/12/2017
10/04/2018
19/07/2018
27/10/2018
4/02/2019
15/05/2019
23/08/2019
1/12/2019
10/03/2020
18/06/2020
26/09/2020
DIP
WL

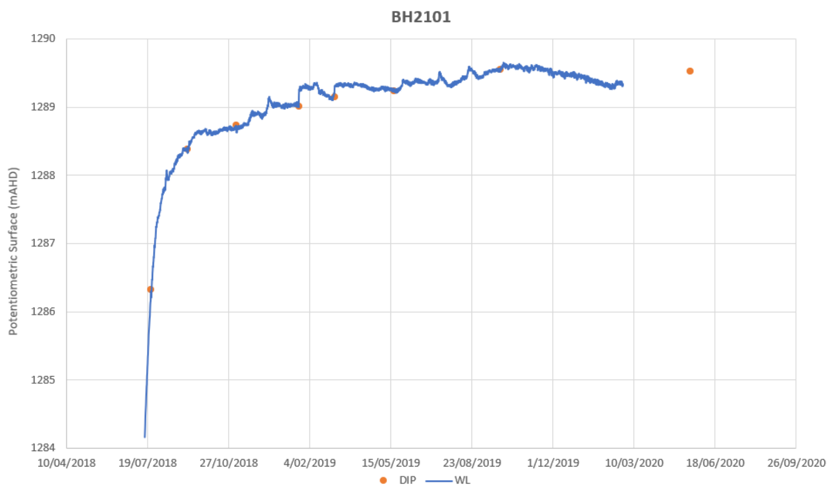

BH6104
Potentiometric Surface (mAHD)
835
834.5
834
833.5
833
832.5
832
831.5
831
31/12/2017
10/04/2018
19/07/2018
27/10/2018
4/02/2019
15/05/2019
23/08/2019
1/12/2019
10/03/2020
18/06/2020
26/09/2020
DIP
WL

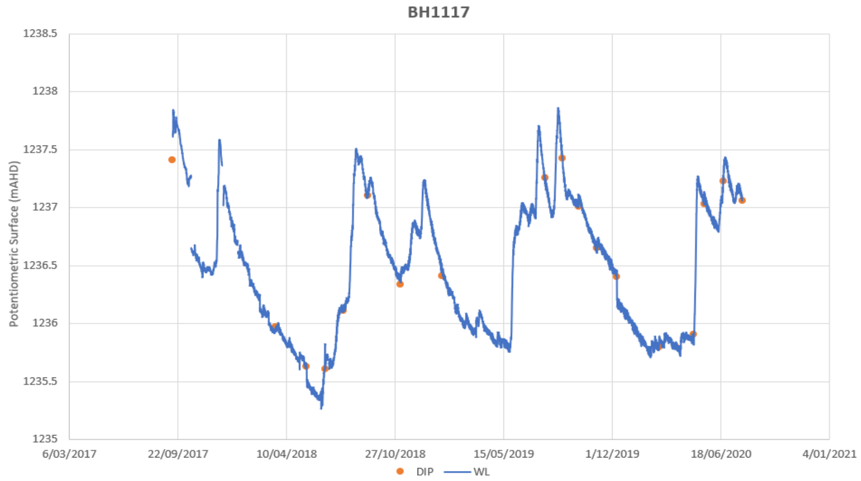

BH3110
Potentiometric Surface (mAHD)
DIP
WL


BH3102
Potentiometric Surface (mAHD)
DIP
WL

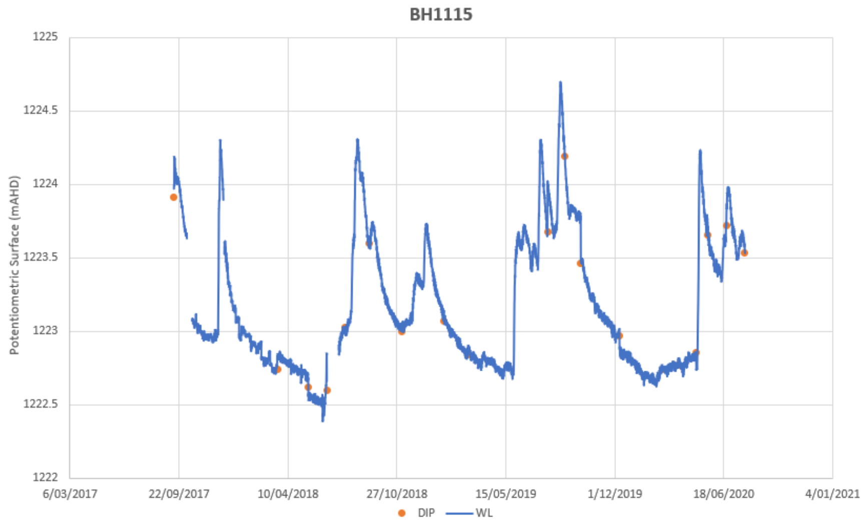

BH3101
Potentiometric Surface (mAHD)
DIP
WL

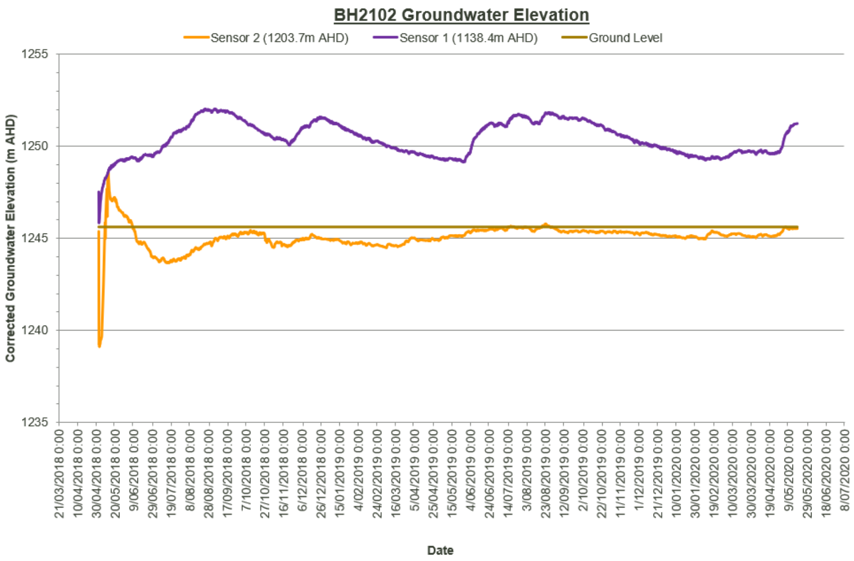

BH2103
Potentiometric Surface (mAHD)
DIP
WL

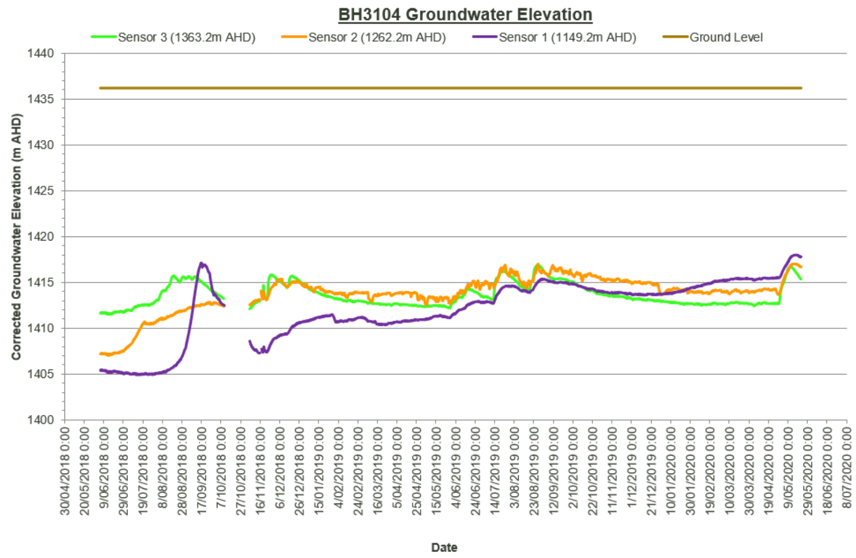

BH2101
1290
1289
1288
1287
1286
1285
1284
Potentiometric Surface (mAHD)
10/04/2018
19/07/2018
27/10/2018
4/02/2019
15/05/2019
23/08/2019
1/12/2019
10/03/2020
18/06/2020
26/09/2020
DIP
WL

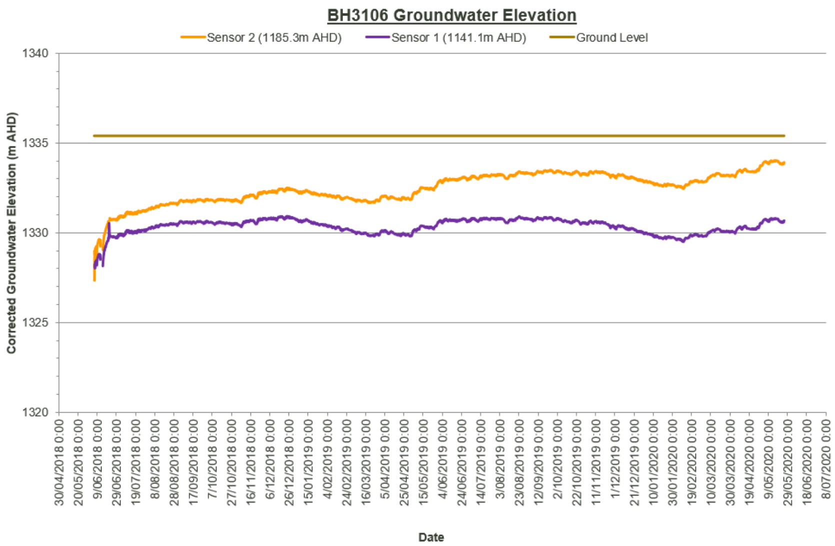

BH1117
1238.5
1238
1237.5
1237
1236.5
1236
1235.5
1235
Potentiometric Surface (mAHD)
6/03/2017
22/09/2017
10/04/2018
27/10/2018
15/05/2019
1/12/2019
18/06/2020
4/01/2021
DIP
WL

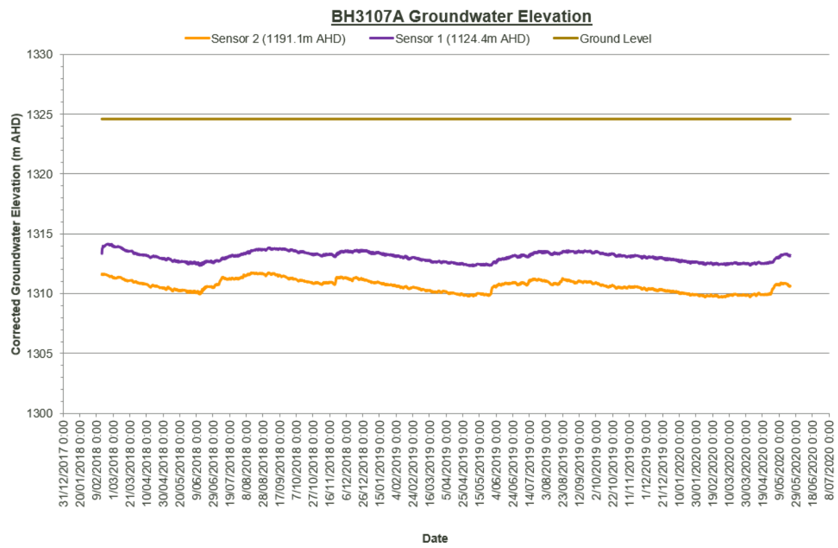

BH1116
1225
1224.5
1224
1223.5
1223
1222.5
1222
1221.5
1221
1220.5
1220
Potentiometric Surface (mAHD)
6/03/2017
22/09/2017
10/04/2018
27/10/2018
15/05/2019
1/12/2019
18/06/2020
4/01/2021
DIP
WL

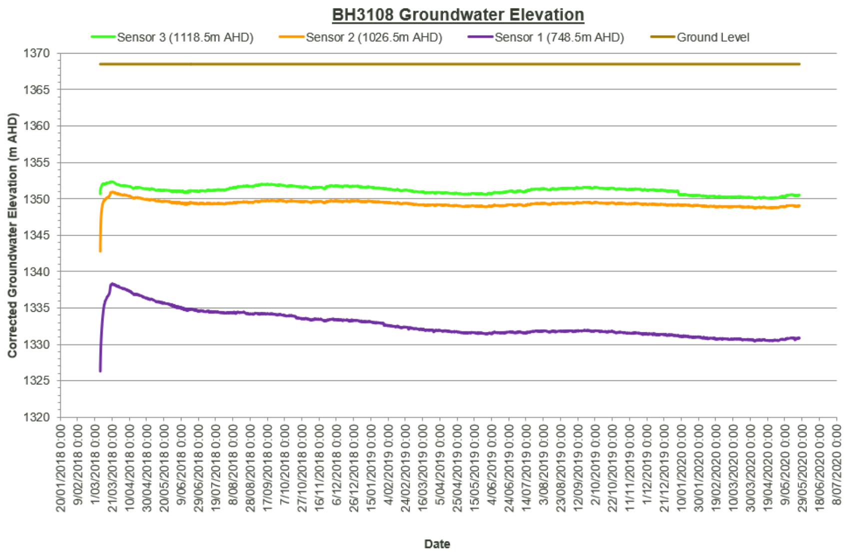

BH1115
1225
1224.5
1224
1223.5
1223
1222.5
1222
Potentiometric Surface (mAHD)
6/03/2017
22/09/2017
10/04/2018
27/10/2018
15/05/2019
1/12/2019
18/06/2020
4/01/2021
DIP
WL

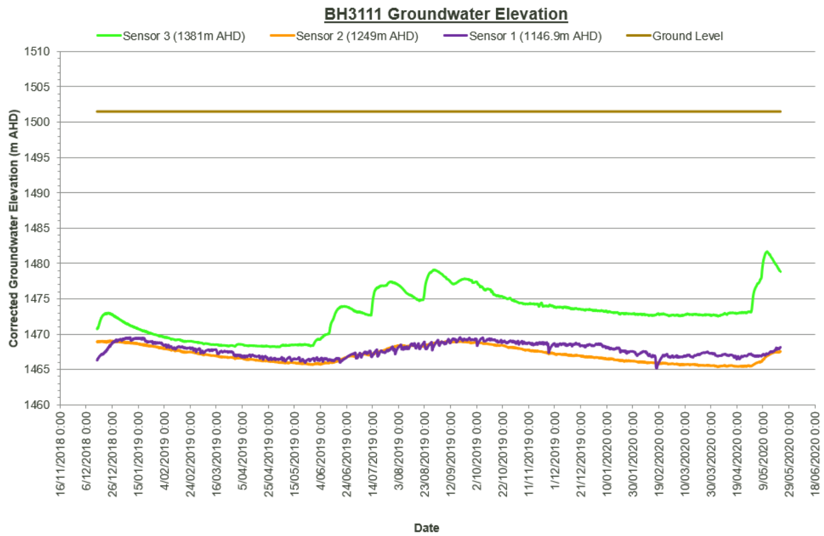

BH2102 Groundwater Elevation
Sensor 2 (1203.7m AHD)
Sensor 1 (1138.4m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
1255
1250
1245
1240
1235
Date

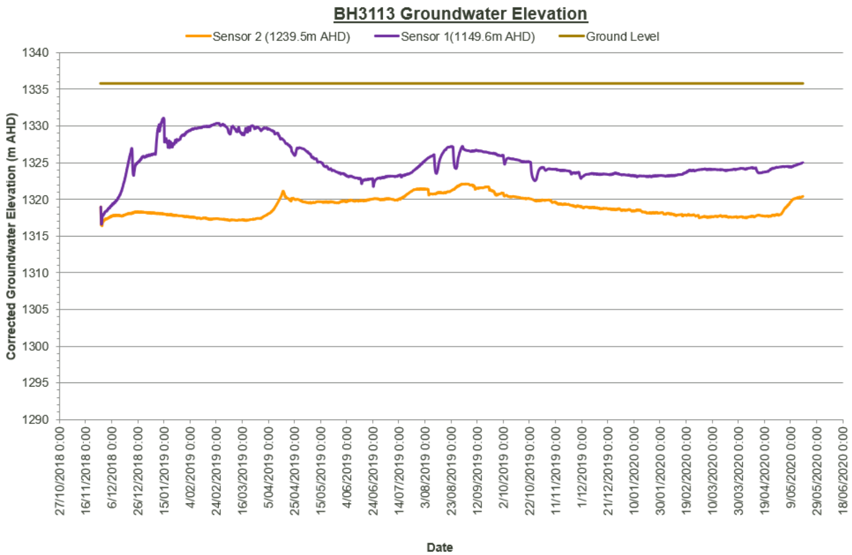

BH3104 Groundwater Elevation
Sensor 3 (1363.2m AHD)
Sensor 2 (1262.2m AHD)
Sensor 1 (1149.2m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
1440
1435
1430
1425
1420
1415
1410
1405
1400
Date

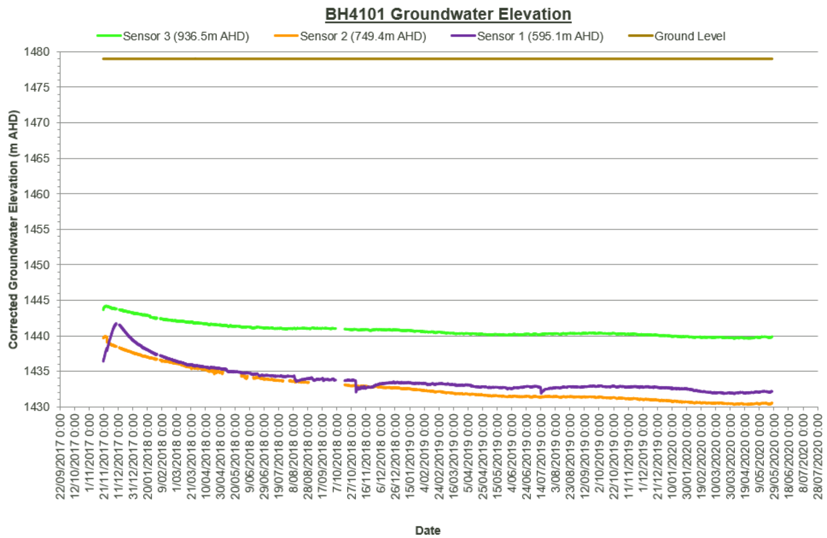

BH3106 Groundwater Elevation
Sensor 2 (1185.3m AHD)
Sensor 1 (1141.1m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
1340
1335
1330
1325
1320
Date

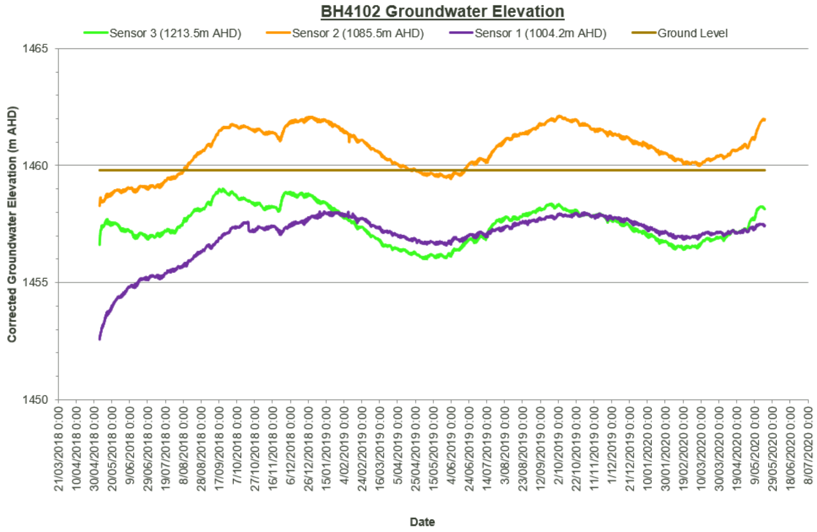

BH3107A Groundwater Elevation
Sensor 2 (1191.1m AHD)
Sensor 1 (1124.4m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
1330
1325
1320
1315
1310
1305
1300
Date

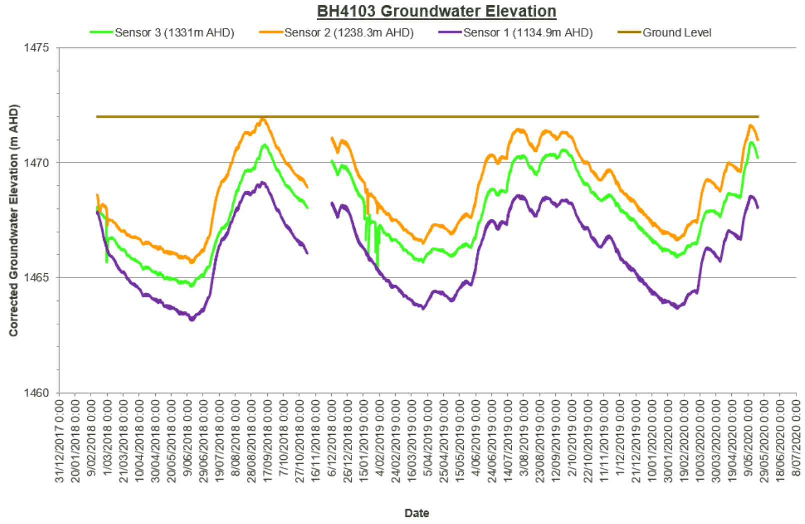

BH3108 Groundwater Elevation
Sensor 3 (1118.5m AHD)
Sensor 2 (1026.5m AHD)
Sensor 1 (748.5m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
Date

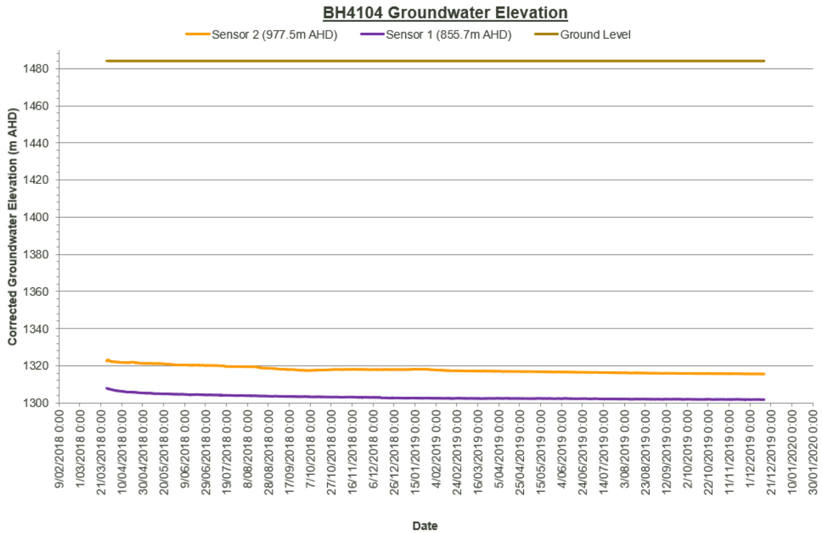

BH3111 Groundwater Elevation
Sensor 3 (1381m AHD)
Sensor 2 (1249m AHD)
Sensor 1 (1146.9m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
Date

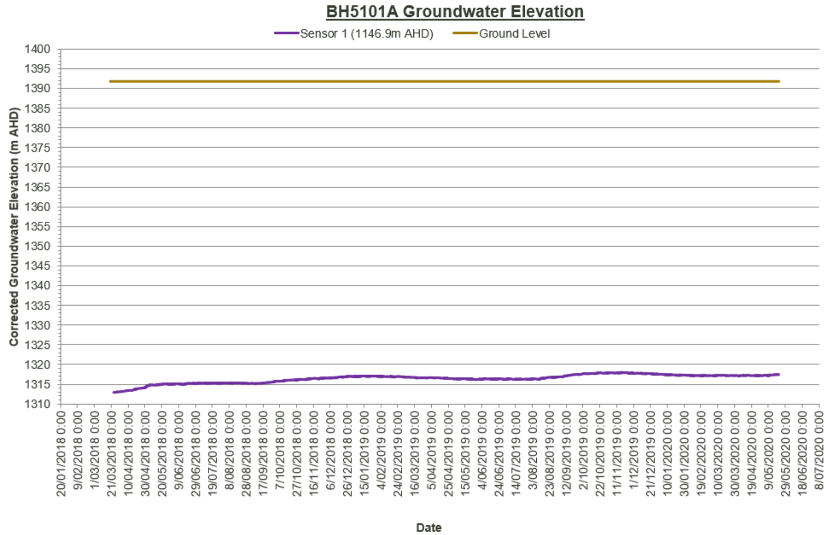

BH3113 Groundwater Elevation
Sensor 2 (1239.5m AHD)
Sensor 1(1149.6m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
Date

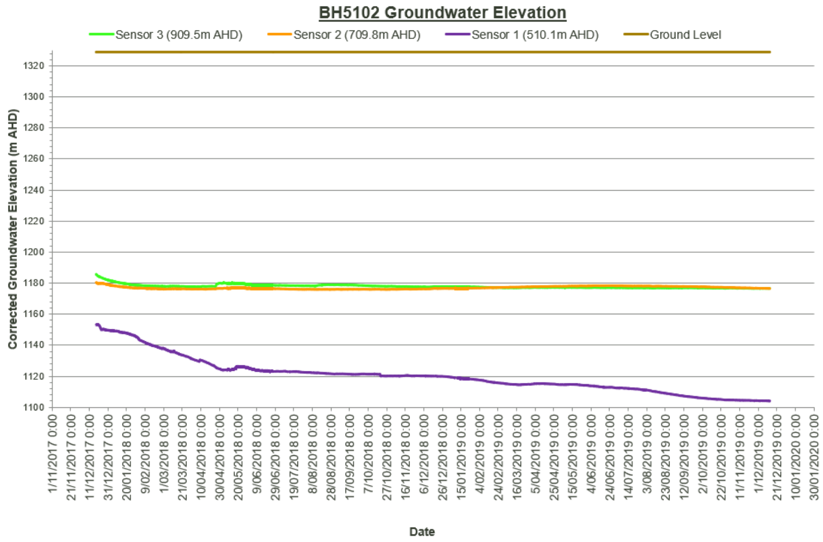

BH4101 Groundwater Elevation
Sensor 3 (936.5m AHD)
Sensor 2 (749.4m AHD)
Sensor 1 (595.1m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
Date

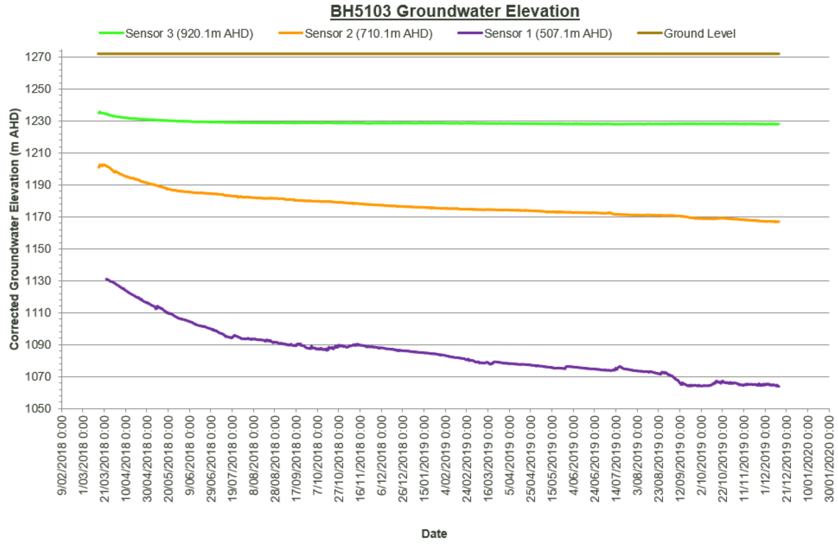

BH4102 Groundwater Elevation
Sensor 3 (1213.5m AHD)
Sensor 2 (1085.5m AHD)
Sensor 1 (1004.2m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
Date

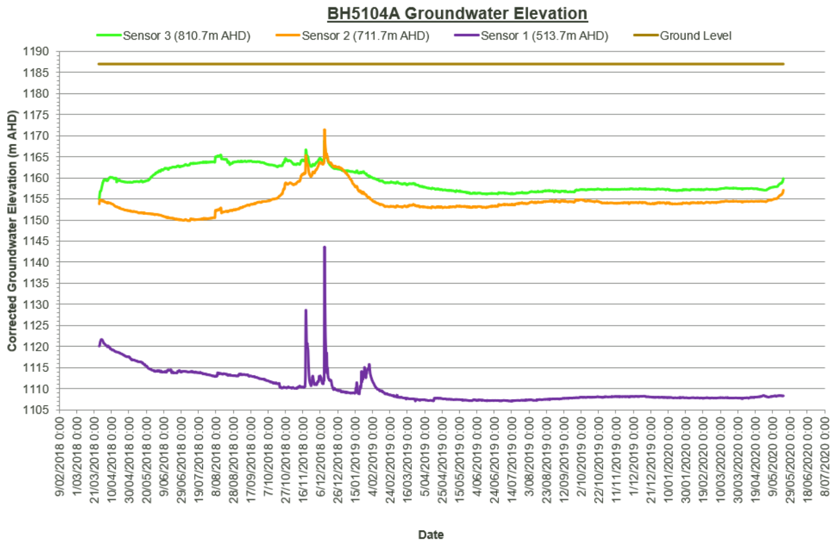

BH4103 Groundwater Elevation
Sensor 3 (1331m AHD)
Sensor 2 (1238.3m AHD)
Sensor 1 (1134.9m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
Date

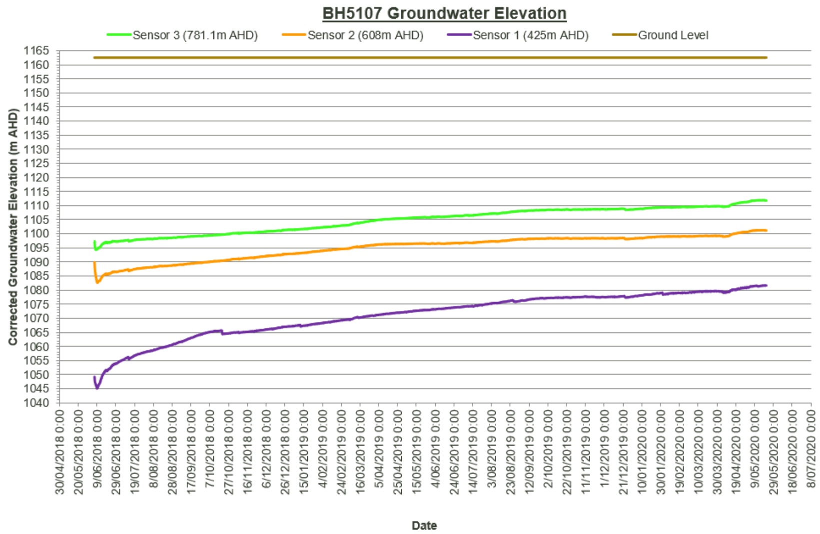

BH4104 Groundwater Elevation
Sensor 2 (977.5m AHD)
Sensor 1 (855.7m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
Date

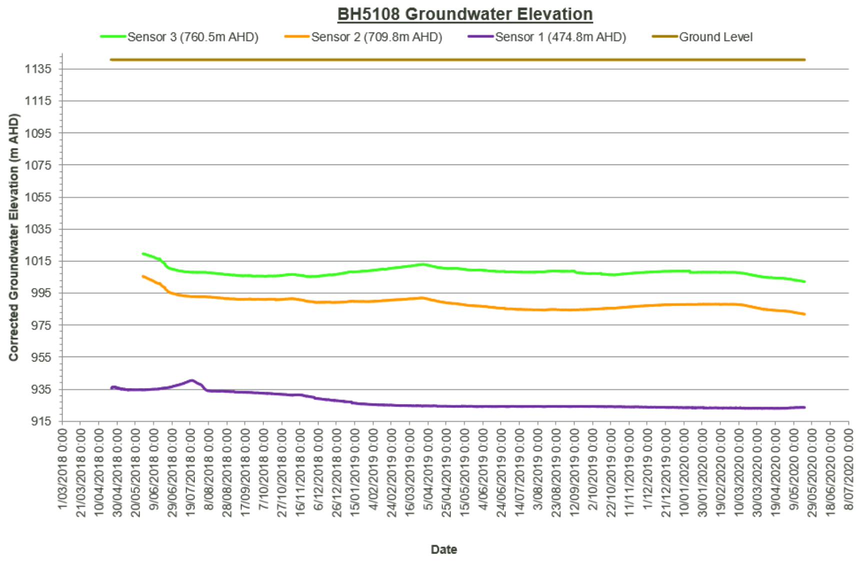

BH5101A Groundwater Elevation
Sensor 1 (1146.9m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
Date

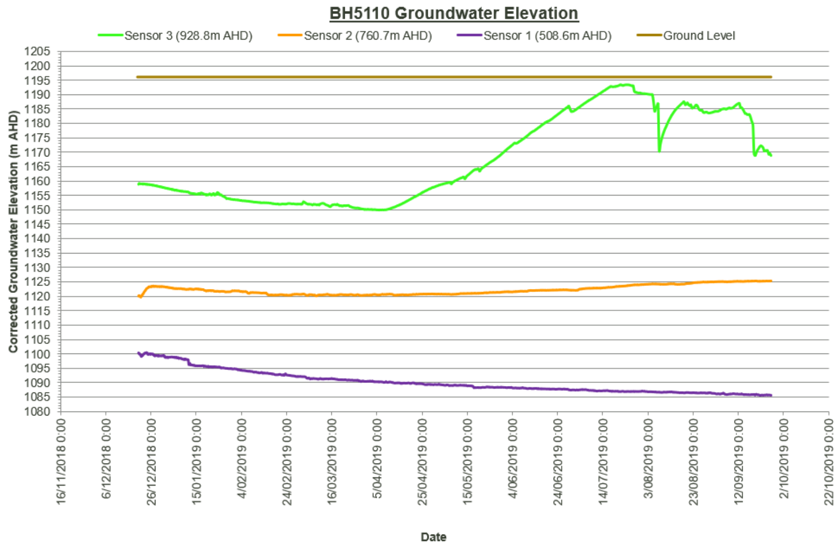

BH5102 Groundwater Elevation
Sensor 3 (909.5m AHD)
Sensor 2 (709.8m AHD)
Sensor 1 (510.1m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
Date

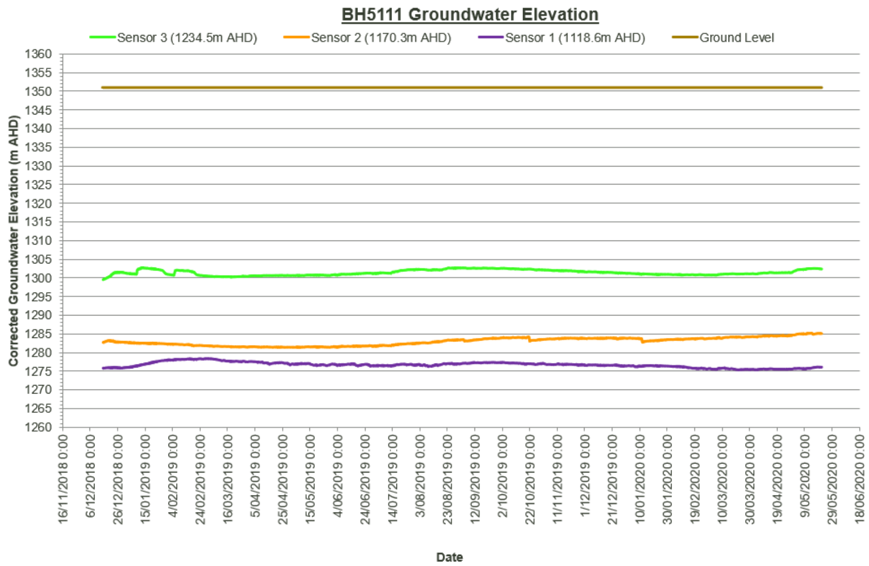

BH5103 Groundwater Elevation
Sensor 3 (920.1m AHD)
Sensor 2 (710.1m AHD)
Sensor 1 (507.1m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
Date

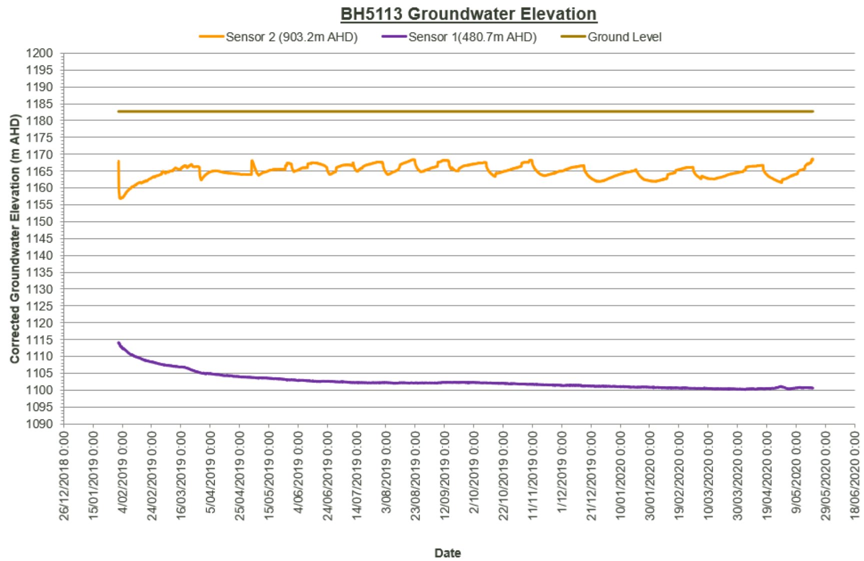

BH5104A Groundwater Elevation
Sensor 3 (810.7m AHD)
Sensor 2 (711.7m AHD)
Sensor 1 (513.7m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
Date

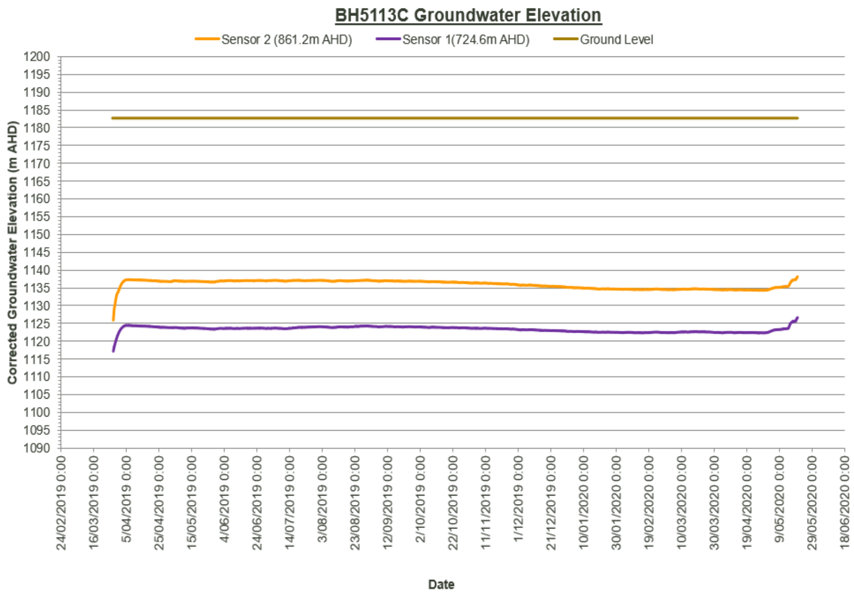

BH5107 Groundwater Elevation
Sensor 3 (781.1m AHD)
Sensor 2 (608m AHD)
Sensor 1 (425m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
Date

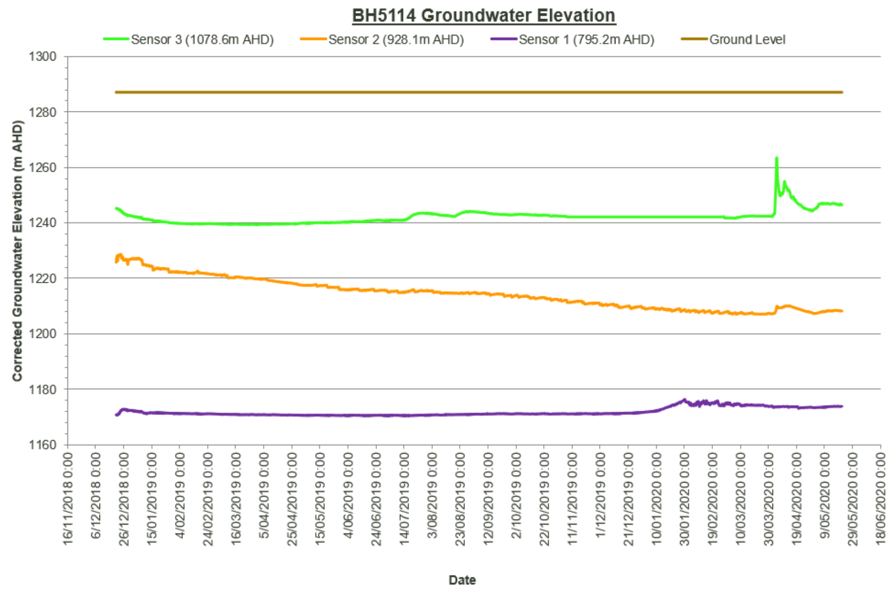

BH5108 Groundwater Elevation
Sensor 3 (760.5m AHD)
Sensor 2 (709.8m AHD)
Sensor 1 (474.8m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
Date

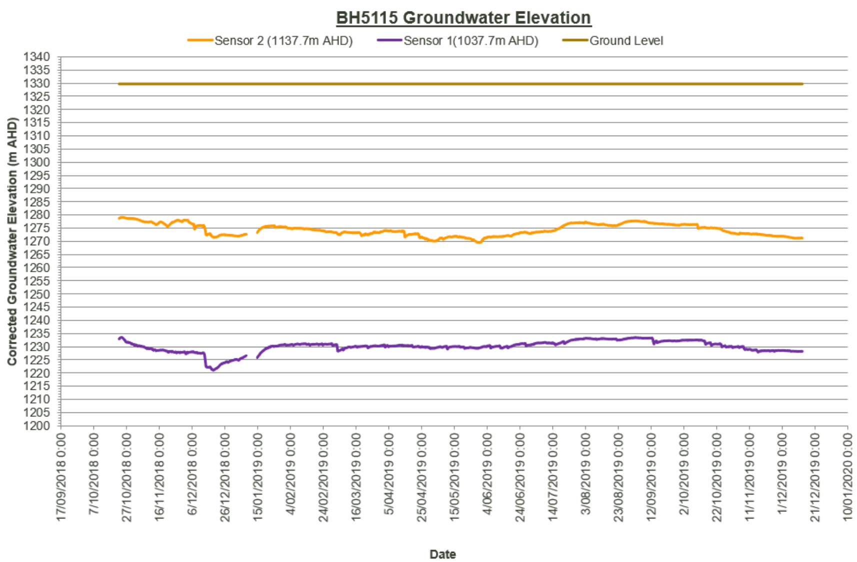

BH5110 Groundwater Elevation
Sensor 3 (928.8m AHD)
Sensor 2 (760.7m AHD)
Sensor 1 (508.6m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
Date

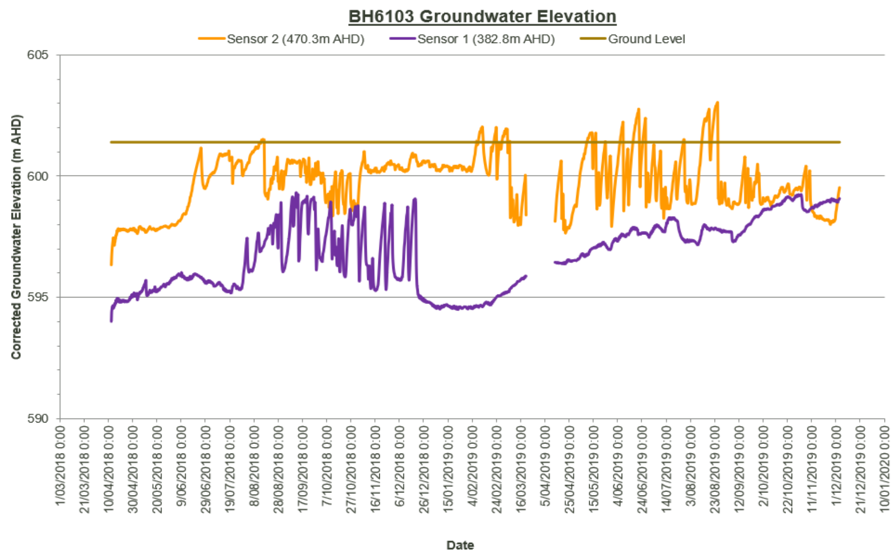

BH5111 Groundwater Elevation
Sensor 3 (1234.5m AHD)
Sensor 2 (1170.3m AHD)
Sensor 1 (1118.6m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
Date

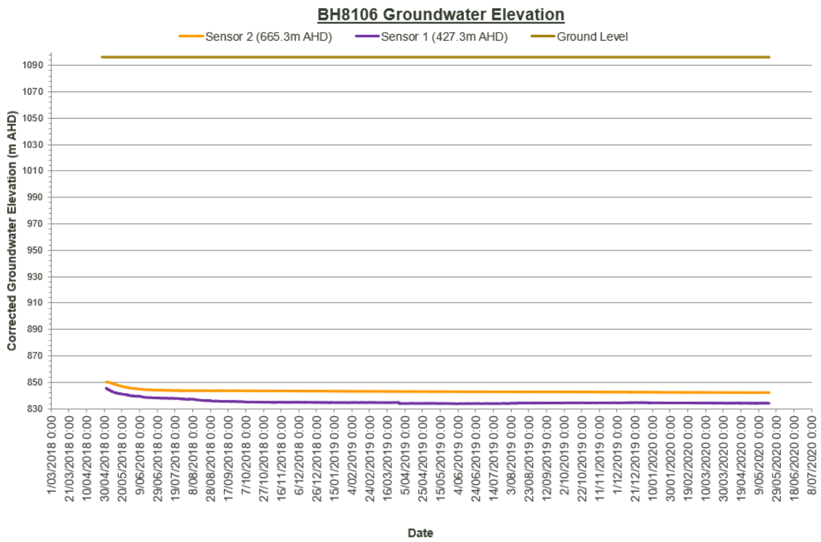

BH5113 Groundwater Elevation
Sensor 2 (903.2m AHD)
Sensor 1(480.7m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
Date


BH5113C Groundwater Elevation
Sensor 2 (861.2m AHD)
Sensor 1(724.6m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
Date

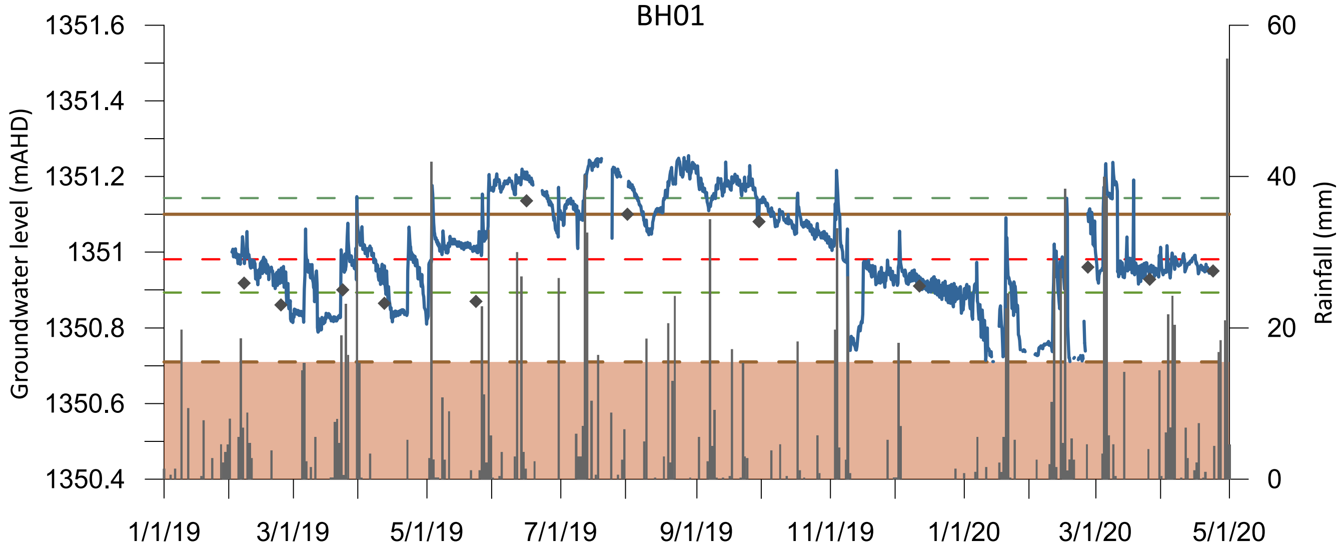

BH5114 Groundwater Elevation
Sensor 3 (1078.6m AHD)
Sensor 2 (928.1m AHD)
Sensor 1 (795.2m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
Date

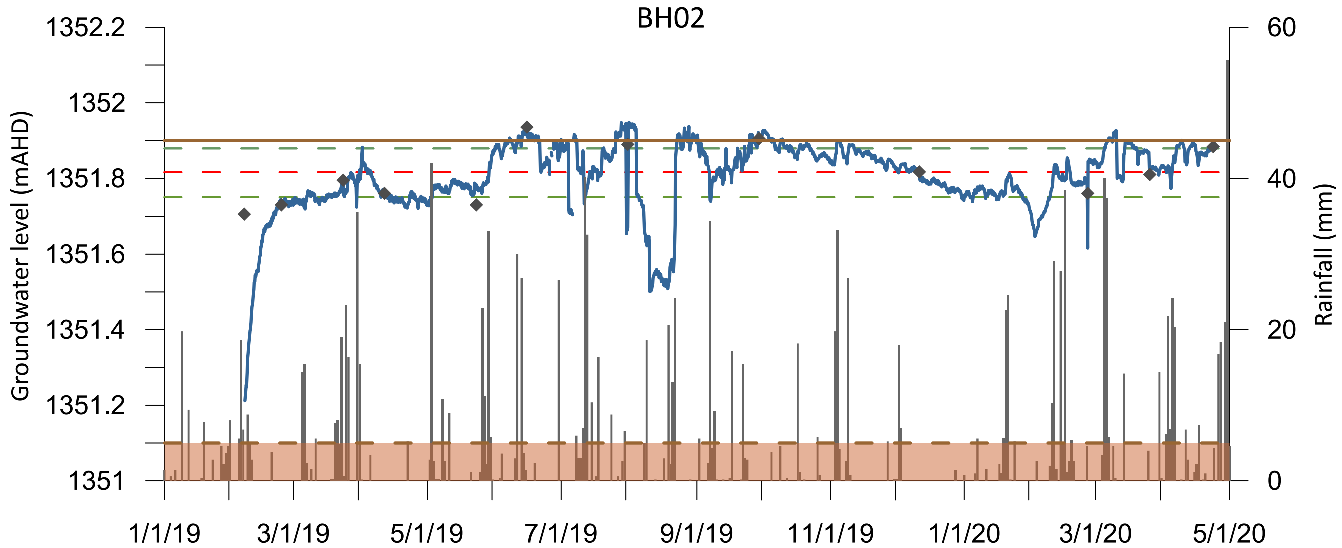

BH5115 Groundwater Elevation
Sensor 2 (1137.7m AHD)
Sensor 1(1037.7m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
Date

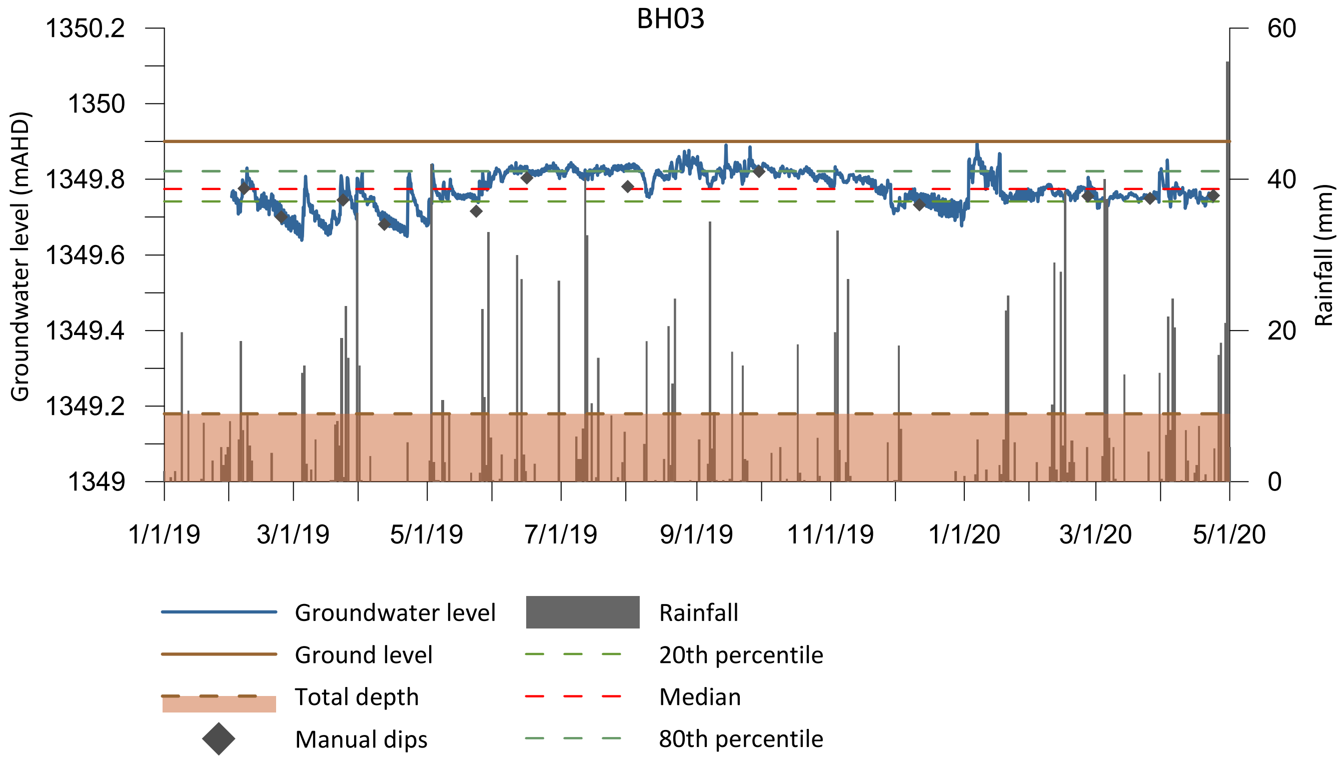

BH6103 Groundwater Elevation
Sensor 2 (470.3m AHD)
Sensor 1 (382.8m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
Date

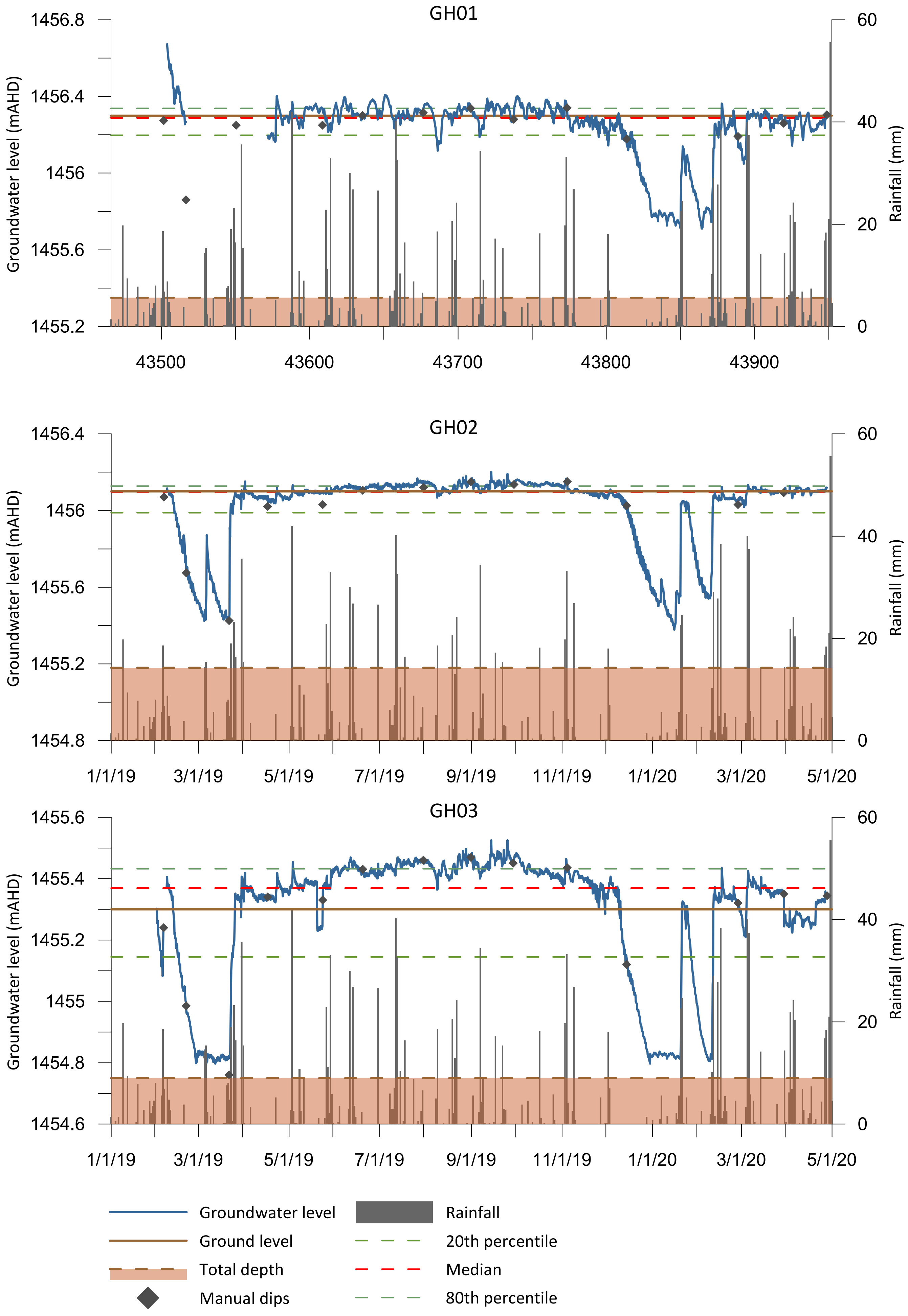


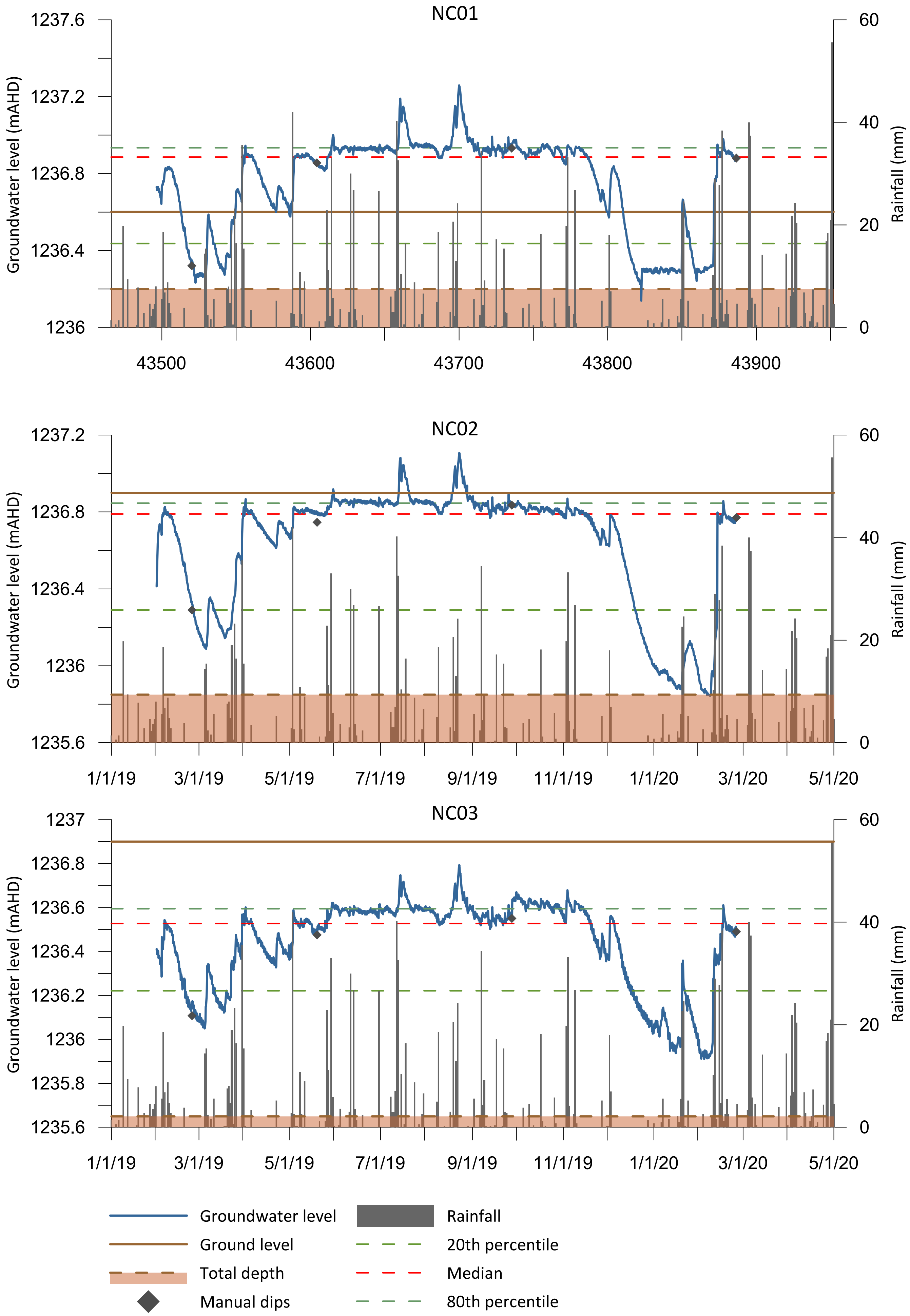
BH8106 Groundwater Elevation
Sensor 2 (665.3m AHD)
Sensor 1 (427.3m AHD)
Ground Level
Corrected Groundwater Elevation (m AHD)
1090
1070
1050
1030
1010
990
970
950
930
910
890
870
850
830
1/03/2018 0:00
21/03/2018 0:00
10/04/2018 0:00
30/04/2018 0:00
20/05/2018 0:00
9/06/2018 0:00
29/06/2018 0:00
19/07/2018 0:00
8/08/2018 0:00
28/08/2018 0:00
17/09/2018 0:00
7/10/2018 0:00
27/10/2018 0:00
16/11/2018 0:00
6/12/2018 0:00
26/12/2018 0:00
15/01/2019 0:00
4/02/2019 0:00
24/02/2019 0:00
16/03/2019 0:00
5/04/2019 0:00
25/04/2019 0:00
15/05/2019 0:00
4/06/2019 0:00
24/06/2019 0:00
14/07/2019 0:00
3/08/2019 0:00
23/08/2019 0:00
12/09/2019 0:00
2/10/2019 0:00
22/10/2019 0:00
11/11/2019 0:00
1/12/2019 0:00
21/12/2019 0:00
10/01/2020 0:00
30/01/2020 0:00
19/02/2020 0:00
10/03/2020 0:00
30/03/2020 0:00
19/04/2020 0:00
9/05/2020 0:00
29/05/2020 0:00
18/06/2020 0:00
8/07/2020 0:00
Date

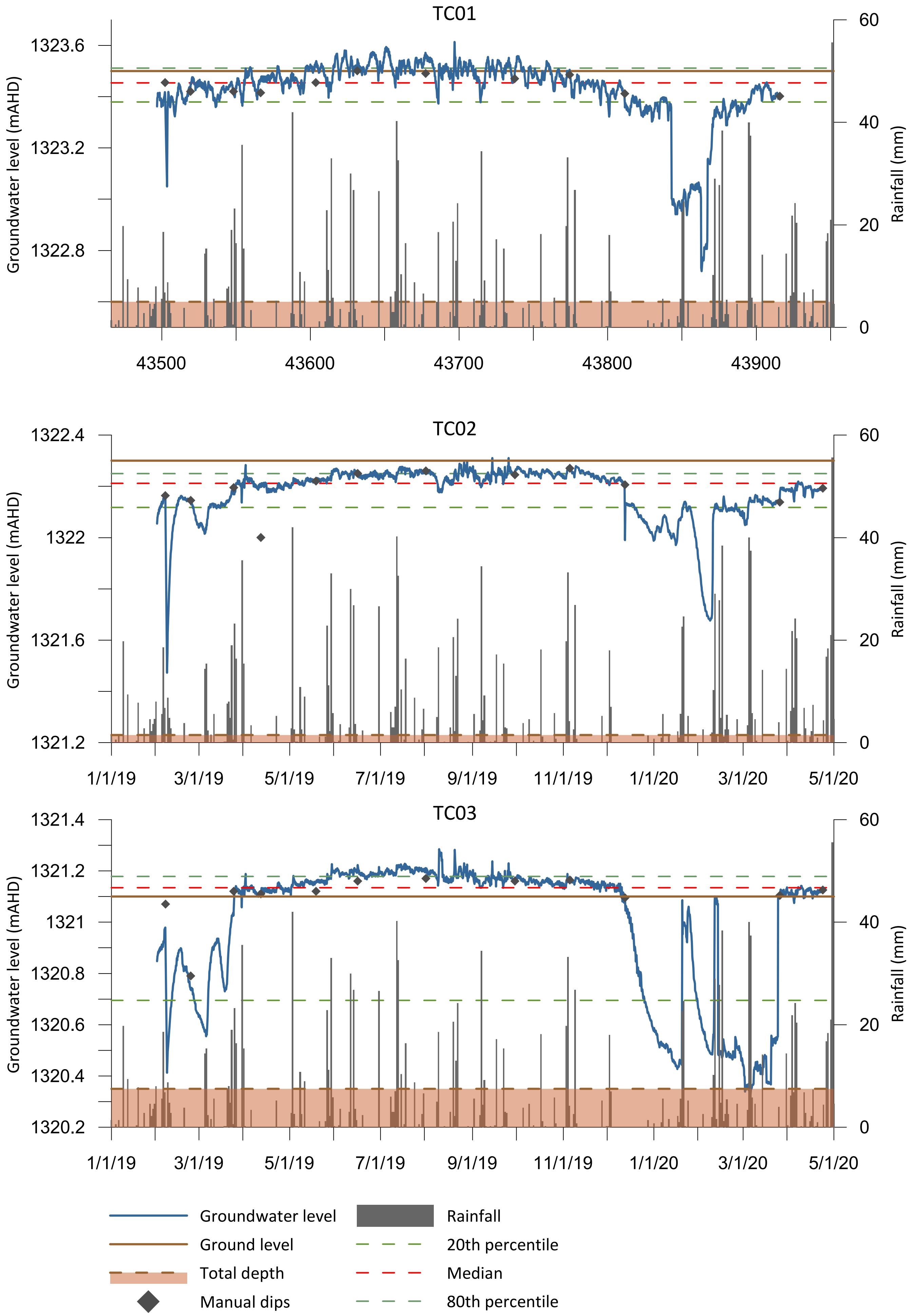

BH01
Groundwater level (mAHD)
Rainfall (mm)
1351.6
1351.4
1351.2
1351
1350.8
1350.6
1350.4
60
40
20
0
1/1/19
3/1/19
5/1/19
7/1/19
9/1/19
11/1/19
1/1/20
3/1/20
5/1/20


BH02
Groundwater level (mAHD)
Rainfall (mm)
1352.2
1352
1351.8
1351.6
1351.4
1351.2
1351
60
40
20
0
1/1/19
3/1/19
5/1/19
7/1/19
9/1/19
11/1/19
1/1/20
3/1/20
5/1/20


BH03
Groundwater level (mAHD)
Rainfall (mm)
1350.2
1350
1349.8
1349.6
1349.4
1349.2
1349
60
40
20
0
1/1/19
3/1/19
5/1/19
7/1/19
9/1/19
11/1/19
1/1/20
3/1/20
5/1/20
Groundwater level
Ground level
Total depth
Manual dips
Rainfall
20th percentile
Median
80th percentile


GH01
1456.8
1456.4
1456
1455.6
1455.2
Groundwater level (mAHD)
60
40
20
0
Rainfall (mm)
43500
43600
43700
43800
43900
GH02
1456.4
1456
1455.6
1455.2
1454.8
1/1/19
3/1/19
5/1/19
7/1/19
9/1/19
11/1/19
1/1/20
3/1/20
5/1/20
GH03
1455.6
1455.4
1455.2
1455
1454.8
1454.6
Groundwater level
Ground level
Total depth
Manual dips
Rainfall
20th percentile
Median
80th percentile


NC01
Groundwater level (mAHD)
1237.6
1237.2
1236.8
1236.4
1236
Rainfall (mm)
60
40
20
0
43500
43600
43700
43800
43900
NC02
Groundwater level (mAHD)
1237.2
1236.8
1236.4
1236
1235.6
Rainfall (mm)
60
40
20
0
1/1/19
3/1/19
5/1/19
7/1/19
9/1/19
11/1/19
1/1/20
3/1/20
5/1/20
NC03
Groundwater level (mAHD)
1237
1236.8
1236.6
1236.4
1236.2
1236
1235.8
1235.6
Rainfall (mm)
60
40
20
0
1/1/19
3/1/19
5/1/19
7/1/19
9/1/19
11/1/19
1/1/20
3/1/20
5/1/20
Groundwater level
Rainfall
Ground level
20th percentile
Total depth
Median
Manual dips
80th percentile


TC01
Groundwater level (mAHD)
1323.6
1323.2
1322.8
60
40
20
0
Rainfall (mm)
43500
43600
43700
43800
43900
TC02
1322.4
1322
1321.6
1321.2
1/1/19
3/1/19
5/1/19
7/1/19
9/1/19
11/1/19
1/1/20
3/1/20
5/1/20
TC03
1321.4
1321.2
1321
1320.8
1320.6
1320.4
1320.2
Groundwater level
Ground level
Total depth
Manual dips
Rainfall
20th percentile
Median
80th percentile

Baseline EIS Groundwater Quality

i Plateau

Table D.24 Baseline water quality results summary: Gooandra Volcanics and Temperance Formation

			Gooandra Volcanics (MB01C, MB02, MB03, MB11A, PB04, SMB04, SMB05, TMB02A, TMB02B, TMB03A, TMB03B, TMB03C, TMB04)				Temperance Formation (MB04A, MB04B, MB07A, MB07B MB13A, MB13B, SMB03, PB10)			
	Unit	**WQO value[1]**	**# Samples/ exceedances[7]**	**Min/10P[5]**	**Median**	**Max/90P[5]**	**# Samples/ exceedances[7]**	**Min/10P[5]**	**Median**	**Max/90P[5]**
Field Parameters										
Temperature	°C	-	142/0	8.0	9.4	12.7	74/0	8.7	10.2	12.7
Dissolved oxygen	%	90-110[1]	96/95	**2**	**33**	**77**	48/47	**1**	**14**	**66**
Electrical conductivity	µS/cm	30-350[1]	142/0	41	103	175	74/43	96	**420**	**1566**
pH	-	6.5-8.0[1]	139/0	5.8	7.1	8.4	72/0	6.5	7.8	8.6
Oxidising and reducing potential	-	-	142/0	-174	82	176	74/0	-227	-79	139
TDS	NTU	-	128/0	28	67	114	67/0	66	321	827
Analytical results – general										
Total hardness (as $CaCO_3$)	mg/L	-	93/0	13	36	64	54/0	35	89	321
Bicarbonate (as CaCO3)	mg/L	-	143/0	25	49	78	73/0	16	61	138
Carbonate (as $CaCO_3$)	mg/L	-	143/0	<1	<1	<1	73/0	<1	<1	<1
Hydroxide (as $CaCO_3$)	mg/L	-	143/0	<1	<1	<1	73/0	<1	<1	<1
Total alkalinity (as $CaCO_3$)	mg/L	-	143/0	25	49	78	73/0	18	64	147
Analytical results – nutrients										
Ammonia	mg/L	0.013	146/44	<0.01	<0.01	**0.04**	75/35	<0.01	0.01	**0.07**
Oxidised nitrogen	mg/L	0.015	147/78	<0.01	**0.02**	**0.22**	75/37	<0.01	0.01	**0.27**
Total kjeldahl nitrogen	mg/L	-	146/0	<0.1	<0.1	0.2	75/0	<0.1	<0.1	0.4

Table D.24 Baseline water quality results summary: Gooandra Volcanics and Temperance Formation

	Unit	WQO value[1]	Gooandra Volcanics (MB01C, MB02, MB03, MB11A, PB04, SMB04, SMB05, TMB02A, TMB02B, TMB03A, TMB03B, TMB03C, TMB04)				Temperance Formation (MB04A, MB04B, MB07A, MB07B MB13A, MB13B, SMB03, PB10)			
			# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Total nitrogen	mg/L	0.25	146/18	<0.1	<0.1	**0.4**	75/17	<0.1	0.1	**0.6**
Reactive phosphorus	mg/L	0.015	93/16	<0.01	<0.01	**0.02**	53/13	<0.01	<0.01	**0.02**
Total phosphorus	mg/L	0.020	146/66	<0.01	0.02	**0.12**	75/41	<0.01	**0.03**	**0.19**
Analytical results – major ions										
Calcium	mg/L	-	143/0	4	12	20	73/0	8	25	117
Chloride	mg/L	-	143/0	<1	<1	2	73/0	<1	6	45
Magnesium	mg/L	-	143/0	<1	2	5	73/0	1	4	7
Sodium	mg/L	-	143/0	2	6	9	73/0	4	30	112
Potassium	mg/L	-	143/0	<1	<1	2	73/0	<1	2	9
Sulphate	mg/L	-	143/0	<1	3	14	73/0	7	82	363
Cyanide	mg/L	0.004	88/0	<0.004	<0.004	<0.004	51/0	<0.004	<0.004	<0.004
Fluoride	mg/L	2.4	143/0	<0.1	<0.1	0.2	73/0	<0.1	0.4	0.7
Analytical results – metals (dissolved)										
Aluminium (Al)	mg/L	0.027	92/7	<0.01	<0.01	0.02	53/14	<0.01	0.01	**0.13**
Arsenic (As)	mg/L	0.0008[2,6]	146/68	<0.001	<0.001	**0.007**	75/32	<0.001	<0.001	**0.028**
Barium (Ba)	mg/L	-	92/0	0.004	0.015	0.026	53/0	0.005	0.036	0.141
Beryllium (Be)	mg/L	-	92/0	<0.001	<0.001	<0.001	53/0	<0.001	<0.001	<0.001

Table D.24 Baseline water quality results summary: Gooandra Volcanics and Temperance Formation

			Gooandra Volcanics (MB01C, MB02, MB03, MB11A, PB04, SMB04, SMB05, TMB02A, TMB02B, TMB03A, TMB03B, TMB03C, TMB04)				Temperance Formation (MB04A, MB04B, MB07A, MB07B MB13A, MB13B, SMB03, PB10)			
	Unit	WQO value[1]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Boron (B)	mg/L	0.09	92/1	<0.05	<0.05	<0.05	53/4	<0.05	<0.05	0.09
Cadmium (Cd)	mg/L	0.00006[6]	146/1	<0.0001	<0.0001	<0.0001	75/0	<0.0001	<0.0001	<0.0001
Total chromium (Cr)	mg/L	0.00001[3,6]	146/11	<0.001	<0.001	<0.001	75/5	<0.001	<0.001	<0.001
Cobalt (Co)	mg/L	0.0014[4]	92/0	<0.001	<0.001	<0.001	53/0	<0.001	<0.001	<0.001
Copper (Cu)	mg/L	0.001	146/83	<0.001	**0.002**	**0.011**	75/38	<0.001	**0.002**	**0.010**
Iron (Fe)	mg/L	0.3[4]	92/21	<0.05	<0.05	**1.58**	53/11	<0.05	0.05	**1.40**
Lead (Pb)	mg/L	0.001	146/4	<0.001	<0.001	<0.001	75/3	<0.001	<0.001	<0.001
Manganese (Mn)	mg/L	1.2	92/0	<0.001	0.015	0.291	53/0	<0.001	0.093	0.189
Mercury (Hg)	mg/L	0.00006[6]	146/1	<0.0001	<0.0001	<0.0001	75/1	<0.0001	<0.0001	<0.0001
Nickel (Ni)	mg/L	0.008	146/7	<0.001	<0.001	0.005	75/4	<0.001	<0.001	0.004
Selenium (Se)	mg/L	0.005[6]	92/0	<0.01	<0.01	<0.01	53/0	<0.01	<0.01	<0.01
Silver (Ag)	mg/L	0.00002[6]	92/0	<0.001	<0.001	<0.001	53/0	<0.001	<0.001	<0.001
Vanadium (V)	mg/L	0.006[4,6]	92/0	<0.01	<0.01	<0.01	53/1	<0.01	<0.01	<0.01
Zinc (Zn)	mg/L	0.0024[6]	146/86	<0.005	**0.006**	**0.015**	75/45	<0.005	**0.006**	**0.037**

Notes: 1. The WQO values for field parameters and nutrients refer to the WQO values for physical and chemical stressors in south-east Australia (upland river) that are reported in Tables 3.3.2 and 3.3.3 of ANZECC/ARMCANZ (2000).
2. For As (V).
3. For Cr (VI).
4. Refers to a low reliability WQO value.

5. If less than 10 samples are available, the minimum value is reported instead of the 10^{th} percentile value and the maximum value is reported instead of the 90^{th} percentile value.
6. Denotes WQO lower than Limit of Reporting (or laboratory detection limits). Exceedances below LOR are not identified in the baseline data.
7. An exceedance refers to any result that is above detection limit and exceeds the WQO value. Where a range is given for the WQO value, exceedances are determined in relation to the upper limit for electrical conductivity, the lower limit for dissolved oxygen and the lower and upper limit for pH.
Bold denotes WQO value is exceeded.

Table D.25 Baseline water quality results summary: Boggy Plain Suite and Tantangara Formation

	Unit	WQO value[1]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
			Boggy Plain Suite (SMB02)				Tantangara Formation (MB08A, MB08B, PB06)			
Field Parameters										
Temperature	°C	-	6/0	5.0	12.8	25.8	9/0	10.4	11.3	13.8
Dissolved oxygen	%	90-110[1]	6/6	**0**	**50**	**84**	4/4	**2**	**6**	**55**
Electrical conductivity	µS/cm	30-350[1]	6/0	173	197	225	9/0	118	246	300
pH	-	6.5-8.0[1]	6/0	7.3	7.7	8.3	9/0	6.7	7.8	8.8
Oxidising and reducing potential	-	-	6/0	-85	85	131	9/0	-249	-186	74
TDS	NTU	-	6/0	112	128	148	8/0	77	163	196
Analytical results – general										
Total hardness (as $CaCO_3$)	mg/L	-	4/0	68	76	83	9/0	41	81	86
Bicarbonate (as CaCO3)	mg/L	-	6/0	76	87	94	9/0	52	107	114
Carbonate (as $CaCO_3$)	mg/L	-	6/0	<1	<1	<1	9/0	<1	<1	16
Hydroxide (as $CaCO_3$)	mg/L	-	6/0	<1	<1	<1	9/0	<1	<1	<1
Total alkalinity (as $CaCO_3$)	mg/L	-	6/0	76	87	94	9/0	52	107	130
Analytical results – nutrients										
Ammonia	mg/L	0.013	6/1	<0.01	<0.01	**0.02**	9/2	<0.01	<0.01	**0.03**
Oxidised nitrogen	mg/L	0.015	6/3	<0.01	**0.03**	**0.44**	9/2	<0.01	<0.01	**0.02**
Total kjeldahl nitrogen	mg/L	-	6/0	<0.1	0.3	0.4	9/0	<0.1	<0.1	6.4
Total nitrogen	mg/L	0.25	6/4	<0.1	**0.3**	**0.8**	9/2	<0.1	<0.1	**6.4**

Table D.25 Baseline water quality results summary: Boggy Plain Suite and Tantangara Formation

			Boggy Plain Suite (SMB02)				Tantangara Formation (MB08A, MB08B, PB06)			
	Unit	WQO value[1]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Reactive phosphorus	mg/L	0.015	4/0	<0.01	<0.01	<0.01	9/4	<0.01	0.01	**0.02**
Total phosphorus	mg/L	0.020	6/3	<0.01	**0.03**	**0.07**	9/5	<0.01	**0.03**	**15.20**
Analytical results – major ions										
Calcium	mg/L	-	6/0	21	25	30	9/0	10	16	18
Chloride	mg/L	-	6/0	1	2	5	9/0	<1	2	3
Magnesium	mg/L	-	6/0	2	2	2	9/0	4	10	10
Sodium	mg/L	-	6/0	10	10	14	9/0	4	31	47
Potassium	mg/L	-	6/0	<1	<1	4	9/0	<1	4	6
Sulphate	mg/L	-	6/0	6	7	16	9/0	<1	30	39
Cyanide	mg/L	0.004	4/0	<0.004	<0.004	<0.004	9/0	<0.004	<0.004	<0.004
Fluoride	mg/L	2.4	6/0	0.3	0.3	0.4	9/0	<0.1	0.4	0.5
Analytical results – metals (dissolved)										
Aluminium (Al)	mg/L	0.027	4/4	**0.03**	**0.05**	**0.10**	9/2	<0.01	0.01	**0.58**
Arsenic (As)	mg/L	0.0008[2,6]	6/0	<0.001	<0.001	<0.001	9/7	<0.001	**0.004**	**0.016**
Barium (Ba)	mg/L	-	4/0	0.013	0.018	0.021	9/0	0.033	0.448	1.020
Beryllium (Be)	mg/L	-	4/0	<0.001	<0.001	<0.001	9/0	<0.001	<0.001	<0.001
Boron (B)	mg/L	0.09	4/0	<0.05	<0.05	<0.05	9/0	<0.05	<0.05	<0.05
Cadmium (Cd)	mg/L	0.00006[6]	6/0	<0.0001	<0.0001	<0.0001	9/0	<0.0001	<0.0001	<0.0001

Table D.25 Baseline water quality results summary: Boggy Plain Suite and Tantangara Formation

			Boggy Plain Suite (SMB02)				Tantangara Formation (MB08A, MB08B, PB06)			
	Unit	WQO value[1]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Total chromium (Cr)	mg/L	0.00001[3,6]	6/3	<0.001	<0.001	**0.002**	9/1	<0.001	<0.001	**0.001**
Cobalt (Co)	mg/L	0.0014[4]	4/0	<0.001	<0.001	<0.001	9/0	<0.001	<0.001	0.001
Copper (Cu)	mg/L	0.001	6/5	<0.001	**0.003**	**0.006**	9/3	<0.001	<0.001	**0.005**
Iron (Fe)	mg/L	0.3[4]	4/0	<0.05	0.06	0.10	9/1	<0.05	0.10	**0.57**
Lead (Pb)	mg/L	0.001	6/0	<0.001	<0.001	<0.001	9/1	<0.001	<0.001	**0.002**
Manganese (Mn)	mg/L	1.2	4/0	0.002	0.004	0.007	9/0	0.009	0.145	0.388
Mercury (Hg)	mg/L	0.00006[6]	6/0	<0.0001	<0.0001	<0.0001	9/0	<0.0001	<0.0001	<0.0001
Nickel (Ni)	mg/L	0.008	6/0	<0.001	<0.001	0.001	9/0	<0.001	<0.001	0.002
Selenium (Se)	mg/L	0.005[6]	4/0	<0.01	<0.01	<0.01	9/0	<0.01	<0.01	<0.01
Silver (Ag)	mg/L	0.00002[6]	4/0	<0.001	<0.001	<0.001	9/0	<0.001	<0.001	<0.001
Vanadium (V)	mg/L	0.006[4,6]	4/0	<0.01	<0.01	<0.01	9/0	<0.01	<0.01	<0.01
Zinc (Zn)	mg/L	0.0024[6]	6/6	**0.016**	**0.042**	**0.071**	9/4	<0.005	<0.005	**0.104**

Notes:
1. The WQO values for field parameters and nutrients refer to the WQO values for physical and chemical stressors in south-east Australia (upland river) that are reported in Tables 3.3.2 and 3.3.3 of ANZECC/ARMCANZ (2000).
2. For As (V).
3. For Cr (VI).
4. Refers to a low reliability WQO value.
5. If less than 10 samples are available, the minimum value is reported instead of the 10th percentile value and the maximum value is reported instead of the 90th percentile value.
6. Denotes WQO lower than Limit of Reporting (or laboratory detection limits). Exceedances below LOR are not identified in the baseline data.
7. An exceedance refers to any result that is above detection limit and exceeds the WQO value. Where a range is given for the WQO value, exceedances are determined in relation to the upper limit for electrical conductivity, the lower limit for dissolved oxygen and the lower and upper limit for pH.

Bold denotes WQO value is exceeded.

Table D.26 Baseline water quality results summary: Kellys Plain Volcanics and Tertiary basalt

			Kellys Plain Volcanics (PB01)				Tertiary basalt (MB01B)			
	Unit	WQO value[1]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Field Parameters										
Temperature	°C	-	6/0	10.4	13.8	16.0	16/0	8.6	9.1	12.3
Dissolved oxygen	%	90-110[1]	5/5	**1**	**19**	**29**	12/12	**29**	**49**	**66**
Electrical conductivity	µS/cm	30-350[1]	6/0	97	146	165	16/0	47	82	176
pH	-	6.5-8.0[1]	5/0	8.3	9.1	9.9	16/0	5.4	5.8	7.9
Oxidising and reducing potential	-	-	6/0	-105	78	205	16/0	44	116	177
TDS	NTU	-	5/0	81	96	107	13/0	31	52	104
Analytical results – general										
Total hardness (as $CaCO_3$)	mg/L	-	4/0	50	55	60	9/0	18	36	114
Bicarbonate (as CaCO3)	mg/L	-	6/0	39	63	77	15/0	22	39	63
Carbonate (as $CaCO_3$)	mg/L	-	6/0	<1	10	18	15/0	<1	<1	<1
Hydroxide (as $CaCO_3$)	mg/L	-	6/0	<1	<1	<1	15/0	<1	<1	<1
Total alkalinity (as $CaCO_3$)	mg/L	-	6/0	55	72	83	15/0	22	39	63
Analytical results – nutrients										
Ammonia	mg/L	0.013	6/3	<0.01	**0.02**	**0.08**	16/5	<0.01	<0.01	**0.09**
Oxidised nitrogen	mg/L	0.015	6/4	<0.01	**0.02**	**0.06**	16/13	<0.01	**0.04**	**0.17**
Total kjeldahl nitrogen	mg/L	-	6/0	<0.1	<0.1	0.2	16/0	<0.1	<0.1	0.6
Total nitrogen	mg/L	0.25	6/0	<0.1	<0.1	0.2	16/4	<0.1	<0.1	**0.6**

Table D.26 Baseline water quality results summary: Kellys Plain Volcanics and Tertiary basalt

			Kellys Plain Volcanics (PB01)				Tertiary basalt (MB01B)			
	Unit	WQO value[1]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Reactive phosphorus	mg/L	0.015	4/0	<0.01	<0.01	<0.01	9/2	<0.01	<0.01	**0.06**
Total phosphorus	mg/L	0.020	6/3	<0.01	**0.04**	**0.25**	16/16	**0.08**	**0.62**	**1.85**
Analytical results – major ions										
Calcium	mg/L	-	6/0	8	11	13	15/0	4	8	19
Chloride	mg/L	-	6/0	<1	1	5	15/0	<1	<1	1
Magnesium	mg/L	-	6/0	4	7	8	15/0	1	2	3
Sodium	mg/L	-	6/0	9	11	11	15/0	1	1	4
Potassium	mg/L	-	6/0	<1	<1	1	15/0	<1	<1	3
Sulphate	mg/L	-	6/0	<1	9	10	15/0	<1	2	10
Cyanide	mg/L	0.004	4/0	<0.004	<0.004	<0.004	8/0	<0.004	<0.004	<0.004
Fluoride	mg/L	2.4	6/0	<0.1	<0.1	0.2	15/0	<0.1	<0.1	<0.1
Analytical results – metals (dissolved)										
Aluminium (Al)	mg/L	0.027	4/0	<0.01	<0.01	<0.01	9/1	<0.01	0.01	**0.08**
Arsenic (As)	mg/L	0.0008[2,6]	6/0	<0.001	<0.001	<0.001	16/2	<0.001	<0.001	**0.002**
Barium (Ba)	mg/L	-	4/0	0.016	0.038	0.056	9/0	0.011	0.026	2.390
Beryllium (Be)	mg/L	-	4/0	<0.001	<0.001	<0.001	9/0	<0.001	<0.001	<0.001
Boron (B)	mg/L	0.09	4/0	<0.05	<0.05	<0.05	9/1	<0.05	<0.05	**1.06**
Cadmium (Cd)	mg/L	0.00006[6]	6/0	<0.0001	<0.0001	<0.0001	16/0	<0.0001	<0.0001	<0.0001

Table D.26 Baseline water quality results summary: Kellys Plain Volcanics and Tertiary basalt

			Kellys Plain Volcanics (PB01)				Tertiary basalt (MB01B)			
	Unit	WQO value[1]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Total chromium (Cr)	mg/L	0.00001[3,6]	6/0	<0.001	<0.001	<0.001	16/3	<0.001	<0.001	**0.002**
Cobalt (Co)	mg/L	0.0014[4]	4/0	<0.001	<0.001	<0.001	9/0	<0.001	<0.001	0.001
Copper (Cu)	mg/L	0.001	6/1	<0.001	0.001	**0.002**	16/15	**0.003**	**0.010**	**0.024**
Iron (Fe)	mg/L	0.3[4]	4/0	<0.05	<0.05	0.13	9/0	<0.05	<0.05	0.21
Lead (Pb)	mg/L	0.001	6/0	<0.001	<0.001	<0.001	16/1	<0.001	<0.001	<0.001
Manganese (Mn)	mg/L	1.2	4/0	0.019	0.022	0.038	9/0	0.004	0.012	0.137
Mercury (Hg)	mg/L	0.00006[6]	6/0	<0.0001	<0.0001	<0.0001	16/0	<0.0001	<0.0001	<0.0001
Nickel (Ni)	mg/L	0.008	6/0	<0.001	<0.001	0.001	16/0	<0.001	0.001	0.003
Selenium (Se)	mg/L	0.005[6]	4/0	<0.01	<0.01	<0.01	9/0	<0.01	<0.01	<0.01
Silver (Ag)	mg/L	0.00002[6]	4/0	<0.001	<0.001	<0.001	9/0	<0.001	<0.001	<0.001
Vanadium (V)	mg/L	0.006[4,6]	4/0	<0.01	<0.01	<0.01	9/0	<0.01	<0.01	<0.01
Zinc (Zn)	mg/L	0.0024[6]	6/0	<0.005	<0.005	<0.005	16/10	<0.005	**0.006**	**0.012**

Notes: 1. The WQO values for field parameters and nutrients refer to the WQO values for physical and chemical stressors in south-east Australia (upland river) that are reported in Tables 3.3.2 and 3.3.3 of ANZECC/ARMCANZ (2000).
2. For As (V).
3. For Cr (VI).
4. Refers to a low reliability WQO value.
5. If less than 10 samples are available, the minimum value is reported instead of the 10th percentile value and the maximum value is reported instead of the 90th percentile value.
6. Denotes WQO lower than Limit of Reporting (or laboratory detection limits). Exceedances below LOR are not identified in the baseline data.
7. An exceedance refers to any result that is above detection limit and exceeds the WQO value. Where a range is given for the WQO value, exceedances are determined in relation to the upper limit for electrical conductivity, the lower limit for dissolved oxygen and the lower and upper limit for pH.
Bold denotes WQO value is exceeded.

Table D.27 Baseline water quality results summary: Plateau bogs/fens

			Plateau bogs/fens (BH01, BH02, BH03, GH01, GH02, GH03, TC01, TC02, TC03)							
	Unit	WQO value[1]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Field Parameters										
Temperature	°C	-	9/0	16.4	17.6	24.3	-	-	-	-
Dissolved oxygen	%	90-110[1]	9/9	**0**	**13**	**22**	-	-	-	-
Electrical conductivity	µS/cm	30-350[1]	9/0	42	103	343	-	-	-	-
pH	-	6.5-8.0[1]	9/8	**4.2**	**5.7**	6.7	-	-	-	-
Oxidising and reducing potential	-	-	9/0	-135	-4	145	-	-	-	-
TDS	NTU	-	9/0	27	67	223	-	-	-	-
Analytical results – general										
Total hardness (as $CaCO_3$)	mg/L	-	8/0	2	8	90	-	-	-	-
Bicarbonate (as CaCO3)	mg/L	-	7/0	11	31	101	-	-	-	-
Carbonate (as $CaCO_3$)	mg/L	-	7/0	<1	<1	<1	-	-	-	-
Hydroxide (as $CaCO_3$)	mg/L	-	7/0	<1	<1	<1	-	-	-	-
Total alkalinity (as $CaCO_3$)	mg/L	-	7/0	11	31	101	-	-	-	-
Analytical results – nutrients										
Ammonia	mg/L	0.013	8/8	**0.02**	**0.11**	**0.54**	-	-	-	-
Oxidised nitrogen	mg/L	0.015	8/5	<0.01	**0.06**	**0.33**	-	-	-	-
Total kjeldahl nitrogen	mg/L	-	8/0	<0.1	3.8	421.0	-	-	-	-
Total nitrogen	mg/L	0.25	8/7	<0.1	**4.0**	**421.0**	-	-	-	-

Table D.27 Baseline water quality results summary: Plateau bogs/fens

			Plateau bogs/fens (BH01, BH02, BH03, GH01, GH02, GH03, TC01, TC02, TC03)							
	Unit	WQO value[1]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Reactive phosphorus	mg/L	0.015	8/1	<0.01	<0.01	**0.02**	-	-	-	-
Total phosphorus	mg/L	0.020	8/8	**0.09**	**1.73**	**74.20**	-	-	-	-
Analytical results – major ions										
Calcium	mg/L	-	8/0	1	2	26	-	-	-	-
Chloride	mg/L	-	8/0	<1	4	6	-	-	-	-
Magnesium	mg/L	-	8/0	<1	<1	6	-	-	-	-
Sodium	mg/L	-	8/0	2	7	28	-	-	-	-
Potassium	mg/L	-	8/0	<1	<1	2	-	-	-	-
Sulphate	mg/L	-	8/0	1	9	36	-	-	-	-
Cyanide	mg/L	0.004	8/0	<0.004[8]	<0.004[8]	<0.4[8]	-	-	-	-
Fluoride	mg/L	2.4	8/0	<0.1[8]	<0.1[8]	<1[8]	-	-	-	-
Analytical results – metals (dissolved)										
Aluminium (Al)	mg/L	0.027	8/6	<0.01	**0.15**	**8.63**	-	-	-	-
Arsenic (As)	mg/L	0.0008[2,6]	8/0	<0.001	<0.001	<0.01[8]	-	-	-	-
Barium (Ba)	mg/L	-	8/0	0.012	0.017	1.370	-	-	-	-
Beryllium (Be)	mg/L	-	8/0	<0.001	<0.001	<0.01[8]	-	-	-	-
Boron (B)	mg/L	0.09	8/1	<0.05	<0.05	**0.93**	-	-	-	-
Cadmium (Cd)	mg/L	0.00006[6]	8/0	<0.0001	<0.0001	<0.001[8]	-	-	-	-

Table D.27 Baseline water quality results summary: Plateau bogs/fens

	Unit	WQO value[1]	Plateau bogs/fens (BH01, BH02, BH03, GH01, GH02, GH03, TC01, TC02, TC03) # Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Total chromium (Cr)	mg/L	0.00001[3,6]	8/2	<0.001	<0.001	**0.010**	-	-	-	-
Cobalt (Co)	mg/L	0.0014[4]	8/3	<0.001	**0.002**	**0.010**	-	-	-	-
Copper (Cu)	mg/L	0.001	8/2	<0.001	<0.001	**0.010**	-	-	-	-
Iron (Fe)	mg/L	0.3[4]	8/5	<0.05	**0.75**	**2.41**	-	-	-	-
Lead (Pb)	mg/L	0.001	8/0	<0.001	<0.001	<0.01[8]	-	-	-	-
Manganese (Mn)	mg/L	1.2	8/0	0.008	0.039	0.399	-	-	-	-
Mercury (Hg)	mg/L	0.00006[6]	8/0	<0.0001	<0.0001	<0.001[8]	-	-	-	-
Nickel (Ni)	mg/L	0.008	8/0	<0.001	<0.001	**0.010**	-	-	-	-
Selenium (Se)	mg/L	0.005[6]	8/0	<0.01	<0.01	<0.1[8]	-	-	-	-
Silver (Ag)	mg/L	0.00002[6]	8/0	<0.001	<0.001	<0.01[8]	-	-	-	-
Vanadium (V)	mg/L	0.006[4,6]	8/1	<0.01	<0.01	**0.10**	-	-	-	-
Zinc (Zn)	mg/L	0.0024[6]	8/5	<0.005	**0.009**	**0.479**	-	-	-	-

Notes: 1. The WQO values for field parameters and nutrients refer to the WQO values for physical and chemical stressors in south-east Australia (upland river) that are reported in Tables 3.3.2 and 3.3.3 of ANZECC/ARMCANZ (2000).
2. For As (V).
3. For Cr (VI).
4. Refers to a low reliability WQO value.
5. If less than 10 samples are available, the minimum value is reported instead of the 10th percentile value and the maximum value is reported instead of the 90th percentile value.
6. Denotes WQO lower than Limit of Reporting (or laboratory detection limits). Exceedances below LOR are not identified in the baseline data.
7. An exceedance refers to any result that is above detection limit and exceeds the WQO value. Where a range is given for the WQO value, exceedances are determined in relation to the upper limit for electrical conductivity, the lower limit for dissolved oxygen and the lower and upper limit for pH.
8. Where more than one LOR has been used in the reporting of an analyte, the lowest and highest LOR are considered in calculating 10th percentile, median and 90th percentile values.
Bold denotes WQO value is exceeded.

ii Ravine

Table D.28 Baseline water quality results summary: Ravine Beds

	Unit	WQO value[1]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
			Ravine Beds East (MB12A, MB12B, PB09)				Ravine Beds West (PB05, BH8101, BH8102, EWPB1, EWPB3, TMB01B, TMB05A, TMB05B)			
Field Parameters										
Temperature	°C	-	14/0	10.5	12.3	13.7	33/0	13.1	15.7	21.0
Dissolved oxygen	%	90-110[1]	6/6	**0**	**7**	**15**	26/25	**0**	**5**	**74**
Electrical conductivity	µS/cm	30-350[1]	14/4	137	223	**647**	33/28	196	**677**	**2342**
pH	-	6.5-8.0[1]	14/0	5.3	6.9	7.6	33/0	7.4	7.7	9.2
Oxidising and reducing potential	-	-	14/0	-243	-103	123	33/0	-198	-153	108
TDS	NTU	-	12/0	91	145	406	32/0	139	442	1524
Analytical results – general										
Total hardness (as $CaCO_3$)	mg/L	-	14/0	65	76	156	27/0	29	99	166
Bicarbonate (as CaCO3)	mg/L	-	14/0	61	80	192	34/0	82	278	1002
Carbonate (as $CaCO_3$)	mg/L	-	14/0	<1	<1	<1	34/0	<1	<1	52
Hydroxide (as $CaCO_3$)	mg/L	-	14/0	<1	<1	<1	34/0	<1	<1	<1
Total alkalinity (as $CaCO_3$)	mg/L	-	14/0	61	80	192	34/0	82	325	1002
Analytical results – nutrients										
Ammonia	mg/L	0.013	14/2	<0.01	<0.01	**0.02**	34/29	0.01	**0.21**	**0.25**
Oxidised nitrogen	mg/L	0.015	14/5	<0.01	<0.01	**0.02**	34/19	<0.01	**0.02**	**0.26**
Total kjeldahl nitrogen	mg/L	-	14/0	<0.1	<0.1	1.6	34/0	<0.1	0.2	0.4

Table D.28 Baseline water quality results summary: Ravine Beds

	Unit	WQO value[1]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
			Ravine Beds East (MB12A, MB12B, PB09)				Ravine Beds West (PB05, BH8101, BH8102, EWPB1, EWPB3, TMB01B, TMB05A, TMB05B)			
Total nitrogen	mg/L	0.25	14/4	<0.1	<0.1	**1.6**	34/13	<0.1	0.2	**0.6**
Reactive phosphorus	mg/L	0.015	14/0	<0.01	<0.01	0.01	27/10	<0.01	<0.01	**0.05**
Total phosphorus	mg/L	0.020	14/6	<0.01	0.02	**0.56**	34/19	<0.01	**0.03**	**0.19**
Analytical results – major ions										
Calcium	mg/L	-	14/0	14	16	48	34/0	5	19	25
Chloride	mg/L	-	14/0	<1	1	12	34/0	1	12	191
Magnesium	mg/L	-	14/0	7	8	10	34/0	4	10	21
Sodium	mg/L	-	14/0	2	7	87	34/0	9	154	516
Potassium	mg/L	-	14/0	<1	<1	2	34/0	2	5	12
Sulphate	mg/L	-	14/0	<1	4	139	34/0	3	9	23
Cyanide	mg/L	0.004	14/0	<0.004	<0.004	<0.004	26/0	<0.004	<0.004	<0.004
Fluoride	mg/L	2.4	14/0	<0.1	<0.1	0.1	34/12	0.2	1.8	**4.0**
Analytical results – metals (dissolved)										
Aluminium (Al)	mg/L	0.027	14/0	<0.01	<0.01	<0.01	26/7	<0.01	0.01	**0.04**
Arsenic (As)	mg/L	0.0008[2,6]	14/5	<0.001	<0.001	**0.005**	34/28	<0.001	**0.004**	**0.037**
Barium (Ba)	mg/L	-	14/0	0.029	0.040	0.057	26/0	0.059	0.408	7.410
Beryllium (Be)	mg/L	-	14/0	<0.001	<0.001	<0.001	26/0	<0.001	<0.001	<0.001

Table D.28 Baseline water quality results summary: Ravine Beds

	Unit	WQO value[1]	Ravine Beds East (MB12A, MB12B, PB09)				Ravine Beds West (PB05, BH8101, BH8102, EWPB1, EWPB3, TMB01B, TMB05A, TMB05B)			
			# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
Boron (B)	mg/L	0.09	14/0	<0.05	<0.05	<0.05	26/20	<0.05	**0.48**	**1.54**
Cadmium (Cd)	mg/L	0.00006[6]	14/1	<0.0001	<0.0001	<0.0001	34/0	<0.0001	<0.0001	<0.0001
Total chromium (Cr)	mg/L	0.00001[3,6]	14/0	<0.001	<0.001	<0.001	34/7	<0.001	<0.001	**0.002**
Cobalt (Co)	mg/L	0.0014[4]	14/2	<0.001	<0.001	**0.002**	26/6	<0.001	<0.001	**0.002**
Copper (Cu)	mg/L	0.001	14/5	<0.001	<0.001	**0.038**	34/7	<0.001	<0.001	**0.003**
Iron (Fe)	mg/L	0.3[4]	14/4	<0.05	0.06	**26.64**	26/2	<0.05	0.12	0.25
Lead (Pb)	mg/L	0.001	14/0	<0.001	<0.001	<0.001	34/0	<0.001	<0.001	<0.001
Manganese (Mn)	mg/L	1.2	14/0	0.079	0.250	0.432	26/0	0.005	0.064	0.158
Mercury (Hg)	mg/L	0.00006[6]	14/0	<0.0001	<0.0001	<0.0001	34/0	<0.0001	<0.0001	<0.0001
Nickel (Ni)	mg/L	0.008	14/4	<0.001	0.003	**0.016**	34/2	<0.001	0.001	0.007
Selenium (Se)	mg/L	0.005[6]	14/0	<0.01	<0.01	<0.01	26/0	<0.01	<0.01	<0.01
Silver (Ag)	mg/L	0.00002[6]	14/0	<0.001	<0.001	<0.001	26/0	<0.001	<0.001	<0.001
Vanadium (V)	mg/L	0.006[4,6]	14/0	<0.01	<0.01	<0.01	26/0	<0.01	<0.01	<0.01
Zinc (Zn)	mg/L	0.0024[6]	14/6	<0.005	<0.005	**0.027**	34/15	<0.005	<0.005	**0.012**

Notes:
1. The WQO values for field parameters and nutrients refer to the WQO values for physical and chemical stressors in south-east Australia (upland river) that are reported in Tables 3.3.2 and 3.3.3 of ANZECC/ARMCANZ (2000).
2. For As (V).
3. For Cr (VI).
4. Refers to a low reliability WQO value.

5. If less than 10 samples are available, the minimum value is reported instead of the 10th percentile value and the maximum value is reported instead of the 90th percentile value.
6. Denotes WQO lower than Limit of Reporting (or laboratory detection limits). Exceedances below LOR are not identified in the baseline data.
7. An exceedance refers to any result that is above detection limit and exceeds the WQO value. Where a range is given for the WQO value, exceedances are determined in relation to the upper limit for electrical conductivity, the lower limit for dissolved oxygen and the lower and upper limit for pH.
Bold denotes WQO value is exceeded.

Table D.29 Baseline water quality results summary: Boraig Group

	Unit	WQO value[1]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
			Boraig Group (MB06A, MB06B, TMB01A)							
Field Parameters										
Temperature	°C	-	37/0	10.4	11.2	14.9	-	-	-	-
Dissolved oxygen	%	90-110[1]	28/28	**1**	**19**	**47**	-	-	-	-
Electrical conductivity	µS/cm	30-350[1]	37/15	92	265	**395**	-	-	-	-
pH	-	6.5-8.0[1]	37/0	5.7	6.7	7.7	-	-	-	-
Oxidising and reducing potential	-	-	37/0	-158	15	178	-	-	-	-
TDS	NTU	-	35/0	63	228	257	-	-	-	-
Analytical results – general										
Total hardness (as $CaCO_3$)	mg/L	-	25/0	35	51	126	-	-	-	-
Bicarbonate (as CaCO3)	mg/L	-	39/0	51	92	166	-	-	-	-
Carbonate (as $CaCO_3$)	mg/L	-	39/0	<1	<1	<1	-	-	-	-
Hydroxide (as $CaCO_3$)	mg/L	-	39/0	<1	<1	<1	-	-	-	-
Total alkalinity (as $CaCO_3$)	mg/L	-	39/0	51	92	166	-	-	-	-
Analytical results – nutrients										
Ammonia	mg/L	0.013	38/14	<0.01	<0.01	**0.04**	-	-	-	-
Oxidised nitrogen	mg/L	0.015	39/12	<0.01	<0.01	**0.03**	-	-	-	-
Total kjeldahl nitrogen	mg/L	-	38/0	<0.1	<0.1	0.2	-	-	-	-
Total nitrogen	mg/L	0.25	38/4	<0.1	<0.1	0.2	-	-	-	-

Table D.29 Baseline water quality results summary: Boraig Group

	Unit	WQO value[1]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
			Boraig Group (MB06A, MB06B, TMB01A)							
Reactive phosphorus	mg/L	0.015	25/0	<0.01	<0.01	0.01	-	-	-	-
Total phosphorus	mg/L	0.020	38/22	<0.01	**0.03**	**0.26**	-	-	-	-
Analytical results – major ions										
Calcium	mg/L	-	39/0	8	15	35	-	-	-	-
Chloride	mg/L	-	39/0	1	7	11	-	-	-	-
Magnesium	mg/L	-	39/0	2	4	9	-	-	-	-
Sodium	mg/L	-	39/0	2	30	69	-	-	-	-
Potassium	mg/L	-	39/0	<1	2	2	-	-	-	-
Sulphate	mg/L	-	39/0	<1	12	76	-	-	-	-
Cyanide	mg/L	0.004	24/0	<0.004	<0.004	<0.004	-	-	-	-
Fluoride	mg/L	2.4	39/0	<0.1	0.1	1.4	-	-	-	-
Analytical results – metals (dissolved)										
Aluminium (Al)	mg/L	0.027	24/1	<0.01	<0.01	0.02	-	-	-	-
Arsenic (As)	mg/L	0.0008[2,6]	37/13	<0.001	<0.001	**0.005**	-	-	-	-
Barium (Ba)	mg/L	-	24/0	0.080	0.106	0.812	-	-	-	-
Beryllium (Be)	mg/L	-	24/0	<0.001	<0.001	<0.001	-	-	-	-
Boron (B)	mg/L	0.09	24/8	<0.05	<0.05	**0.29**	-	-	-	-
Cadmium (Cd)	mg/L	0.00006[6]	37/0	<0.0001	<0.0001	<0.0001	-	-	-	-

Table D.29 Baseline water quality results summary: Boraig Group

	Unit	WQO value[1]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]	# Samples/ exceedances[7]	Min/10P[5]	Median	Max/90P[5]
			Boraig Group (MB06A, MB06B, TMB01A)							
Total chromium (Cr)	mg/L	0.00001[3,6]	37/14	<0.001	<0.001	**0.002**	-	-	-	-
Cobalt (Co)	mg/L	0.0014[4]	24/0	<0.001	<0.001	<0.001	-	-	-	-
Copper (Cu)	mg/L	0.001	37/19	<0.001	**0.002**	**0.005**	-	-	-	-
Iron (Fe)	mg/L	0.3[4]	24/7	<0.05	0.08	**0.57**	-	-	-	-
Lead (Pb)	mg/L	0.001	37/0	<0.001	<0.001	<0.001	-	-	-	-
Manganese (Mn)	mg/L	1.2	24/0	0.010	0.026	0.178	-	-	-	-
Mercury (Hg)	mg/L	0.00006[6]	37/0	<0.0001	<0.0001	<0.0001	-	-	-	-
Nickel (Ni)	mg/L	0.008	37/14	<0.001	0.003	**0.024**	-	-	-	-
Selenium (Se)	mg/L	0.005[6]	24/0	<0.01	<0.01	<0.01	-	-	-	-
Silver (Ag)	mg/L	0.00002[6]	24/0	<0.001	<0.001	<0.001	-	-	-	-
Vanadium (V)	mg/L	0.006[4,6]	24/0	<0.01	<0.01	<0.01	-	-	-	-
Zinc (Zn)	mg/L	0.0024[6]	37/27	<0.005	**0.007**	**0.025**	-	-	-	-

Notes: 1. The WQO values for field parameters and nutrients refer to the WQO values for physical and chemical stressors in south-east Australia (upland river) that are reported in Tables 3.3.2 and 3.3.3 of ANZECC/ARMCANZ (2000).
2. For As (V).
3. For Cr (VI).
4. Refers to a low reliability WQO value.
5. If less than 10 samples are available, the minimum value is reported instead of the 10th percentile value and the maximum value is reported instead of the 90th percentile value.
6. Denotes WQO lower than Limit of Reporting (or laboratory detection limits). Exceedances below LOR are not identified in the baseline data.
7. An exceedance refers to any result that is above detection limit and exceeds the WQO value. Where a range is given for the WQO value, exceedances are determined in relation to the upper limit for electrical conductivity, the lower limit for dissolved oxygen and the lower and upper limit for pH.
Bold denotes WQO value is exceeded.

ATTACHMENT B – SITE SPECIFIC GROUNDWATER LEVEL TRIGGERS

The Groundwater Level SSTV are based on the RTS groundwater model predicted drawdown. A nominal start date of 1st June 2020 has been chosen and this should be adjusted once the actual date of start is determined. Figure B-1, below, includes a 2 year pre-construction period, with the corresponding Table B-1 providing the predicted drawdown from the nominal start of construction.

Drawdown values should be adjusted to reflect the observed drawdown. For example, if drawdown over a given month differs by more than one standard deviation from the predicted drawdown in that month, then the following month's predicted drawdown should be determined relative to the revised level and not to the original level. This prevents unnecessary multiple activation of triggers resulting from inaccurate absolute levels determined in the modelling process.

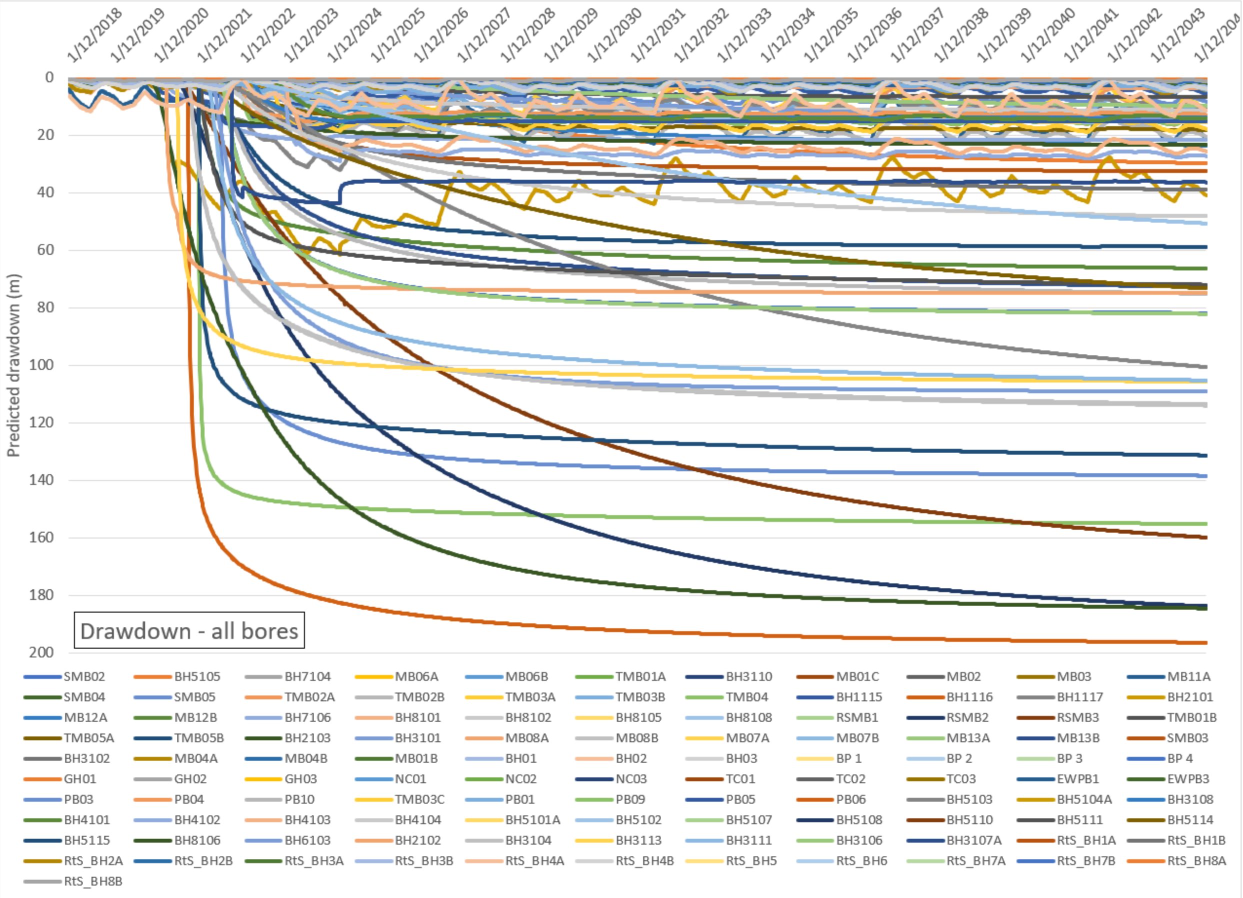


Figure B 1: Predicted drawdown for all bores from the start of construction

ATTACHMENT C – SITE SPECIFIC GROUNDWATER QUALITY TRIGGERS

Table C-1 summarises the groundwater quality trigger values at baseline water quality monitoring sites. Groundwater quality SSTVs are restricted to those bores and parameters that were routinely greater than ANZECC guidelines and where a minimum of 24 samples were collected. SSTVs are determined at the 84th percentile values of the baseline data collected. These bores / parameters with SSTVs are shaded. Unshaded cells have adopted Water Quality Objectives, however it is noted that baseline records often indicate natural exceedances of these Water Quality Objectives

Table C-1: Groundwater quality triggers

Target formation	Bore ID	# of Samples[1]	EC	pH	TN	RP	Al	Cu	Fe	Pb	Mn	Ni	Ag	Zn
Ravine Beds West	BH8101 (EPL 3)	14	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
	BH8108[2]	8	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
	RSMB1	7	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
	RSMB2	11	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
	RSMB3	8	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
	TMB01B[3]	19	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
	TMB05A	13	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
	TMB05B	13	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
	PB05	13	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
	EWPB1	8	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
	EWPB3	7	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
Boraig Group	MB06A	29	30-350	6.5-8.0	0.25	0.015	0.027	0.01	0.34	0.001	1.2	0.008	0.000026	0.02
	MB06B	28	30-350	6.5-8.0	0.25	0.015	0.027	0.006	0.34	0.001	1.2	0.008	0.000026	0.02
	TMB01A[4]	22	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.000026
Ravine Beds East	MB12B	11	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
	MB12A	11	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
Tertiary basalt	MB01B	34	30-350	6.5-8.0	0.25	0.015	0.027	0.022	0.34	0.001	1.2	0.008	0.000026	0.012
Gooandra Volcanics	MB01C	29	30-350	6.5-8.0	0.25	0.015	0.027	0.008	0.34	0.001	1.2	0.008	0.000026	0.011
	MB02	28	30-350	6.5-8.0	0.25	0.015	0.027	0.021	0.34	0.001	1.2	0.008	0.000026	0.013
	MB03	31	30-350	6.5-8.0	0.25	0.015	0.027	0.004	0.34	0.001	1.2	0.008	0.000026	0.009
	MB11A	17	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.000026
	SMB04	6	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.000026
	SMB05	6	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.000026
	TMB02A	29	30-350	6.5-8.0	0.25	0.015	0.027	0.029	0.34	0.001	1.2	0.008	0.000026	0.011
	TMB02B	26	30-350	6.5-8.0	0.25	0.015	0.027	0.009	0.34	0.001	1.2	0.008	0.000026	0.014
	TMB03A	28	30-350	6.5-8.0	0.25	0.015	0.027	0.008	0.34	0.001	1.2	0.008	0.000026	0.017

Target formation	Bore ID	# of Samples[1]	EC	pH	TN	RP	Al	Cu	Fe	Pb	Mn	Ni	Ag	Zn
	TMB03B	30	30-350	6.5-8.0	0.25	0.015	0.027	0.006	0.34	0.001	1.2	0.008	0.000026	0.015
	TMB04	27	30-350	6.5-8.0	0.25	0.015	0.027	0.018	0.34	0.001	1.2	0.008	0.000026	0.008
	PB04	6	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.000026
Temperance Formation	MB04A	29	30-895	6.5-8.0	0.25	0.015	0.027	0.019	0.34	0.001	1.2	0.008	0.000026	0.032
	MB04B	29	30-598	6.5-8.0	0.25	0.015	0.027	0.007	0.34	0.001	1.2	0.008	0.000026	0.008
	MB07A	26	30-350	6.5-8.0	0.25	0.015	0.027	0.011	0.34	0.001	1.2	0.008	0.000026	0.007
	MB07B	24	30-563	6.5-8.0	0.25	0.015	0.027	0.017	0.34	0.001	1.2	0.008	0.000026	0.039
	MB13A	15	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
	MB13B	15	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
	PB10	12	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
Boggy Plain Suite	SMB03	6	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
	SMB02	6	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
Tantangara Formation	MB08A	5	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
	MB08B	9	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
	PB06	4	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
Kellys Plain Volcanics	PB01	6	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
Gooandra Hill Bog	GH01	1	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
	GH02	1	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
	GH03	1	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
Tantangara Creek Bog	TC01	1	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
	TC02	1	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
	TC03	1	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
Bullocks Hill Bog	BH01	1	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
	BH02	1	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
	BH03	2	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246
Yarrangobilly Caves	YC05	21	30-350	6.5-8.0	0.25	0.015	0.027	0.001	0.34	0.001	1.2	0.008	0.000026	0.00246

[1] Up until and including July 2020. [2] BH8108 was originally EPL 4, but has since been decommissioned. EPL 4 is now RSMB8.
[3] TMB01B was originally EPL2, but has since been decommissioned. EPL 2 is now RSMB7. [4] TMB01A was originally EPL1, but has since been decommissioned. EPL 1 is now RSMB6.

ANNEXURE B – GROUNDWATER TARP 1 GROUNDWATER LEVEL

S2-FGJV-ENV-PLN-0147

SNOWY 2.0 MAIN WORKS – GROUNDWATER TARP 1 GROUNDWATER LEVEL

Approval Record			
Document preparation, review and approval		Name in print	Signature
Prepared by	Principal Hydrogeologist	R. Cresswell	
Reviewed by	Environmental Consultant	S. Mitchell	
Verified by	Environment Manager	L. Coetzee	
Approved by	Project Director	A. Betti	Digitally signed by Antonio Betti Date: 2020.09.19 09:32:48 +10'00'

Document Revision Table		
Rev.	Date	Description of modifications / revisions
A	29.11.2019	Initial draft for SHL review
B	29.05.2020	Revised to address Infrastructure Approval
C	15.06.2020	Revised to address SHL comments. For consultation.
D	25.06.2020	Update to address Commonwealth conditions of approval
E	06.08.2020	Revised to address stakeholder comments
F	19.09.2020	Revised to address DAWE and DPIE comments

This groundwater level TARP identified in Table B-1 should be read in conjunction with Section 7.2 of the GMP.

Table B-1: Groundwater level TARP

Trigger Level	Trigger	Action	Response
Level 1 (Indicator)	Groundwater level measurements within trigger limits	Continue to monitor levels in accordance with monitoring plan	No response required
Level 2 (Early warning)	Water level records are trending towards an exceedance, but within predicted levels	Continue to monitor levels in accordance with monitoring plan	Conduct preliminary review of activities occurring in vicinity of subject bore(s), including groundwater usage (i.e. Groundwater Usage TARP)
Level 3a (Exceedance of Threshold Trigger level)	Groundwater level measurements trigger investigation	Determine suitably qualified person[1] to conduct review Review impacts in accordance with decision tree	Report results of trigger investigation to SHL. If trigger exceedance is determined to be attributable to construction, proceed to Level 3b. If trigger response is determined not to be attributable to construction, review trigger levels and up-date monitoring plan. Report results in Annual Review
Level 3b (Exceedance identified as related to construction activities)	Groundwater level triggers due to construction activities	Engage suitably qualified person to prepare report and identify potential for impacts on a receptor	Notify DPIE and NPWS within seven days of the trigger investigation report (Level 3a Report) Provide DPIE and NPWS with a trigger exceedance report within 30 days of notification. Identify mitigation actions or revisions to trigger levels in consultation with DPIE.
Level 4 (Limit Trigger denotes Impact on receptor)	Water level drawdown impacts on a receptor (GDE)	Activate mitigation measures[2] to remediate impact to receptor	Initiate investigation into reasons for impact on receptor including assessment of environmental harm Take actions recommended by investigation.

1 In some circumstances SHL or Future Generation staff may have sufficient experience to conduct the investigation. In other circumstances a specialist may be required.
2 Mitigation measures as developed at Level 3b

ANNEXURE C – GROUNDWATER TARP 2 GROUNDWATER QUALITY

S2-FGJV-ENV-PLN-0148

SNOWY 2.0 MAIN WORKS – GROUNDWATER TARP 2 GROUNDWATER QUALITY

Approval Record			
Document preparation, review and approval		Name in print	Signature
Prepared by	Principal Hydrogeologist	R. Cresswell	
Reviewed by	Environmental Consultant	S. Mitchell	
Verified by	Environment Manager	L. Coetzee	
Approved by	Project Director	A. Betti	Digitally signed by Antonio Betti Date: 2020.09.19 09:33:10 +10'00'

Document Revision Table		
Rev.	Date	Description of modifications / revisions
A	29.11.2019	Initial draft for SHL review
B	29.05.2020	Revised to address Infrastructure Approval
C	15.06.2020	Revised to address SHL comments. For consultation.
D	25.06.2020	Update to address Commonwealth conditions of approval
E	06.08.2020	Revised to address stakeholder comments
F	19.09.2020	Revised to address DAWE and DPIE comments

This groundwater quality TARP identified in Table C-1 should be read in conjunction with Section 7.2 of the GMP.

Table C-1: Groundwater quality TARP

Level	Trigger	Action	Response
Level 1 (Indicator)	Groundwater quality measurements within trigger limits	Continue to monitor water quality parameters in accordance with monitoring plan	No response required
Level 2 (Early warning)	Rainfall events create significant runoff and recharge	Ensure salinity measurements are occurring in appropriate bores	Review monitoring records to identify influence of rainfall runoff on groundwater salinity
Level 3a (Exceedance of Threshold Trigger level)	Groundwater quality measurements trigger investigation	Engage suitably qualified person[1] to conduct review Review if the exceedance is representative of known EIS baseline/ pre-construction exceedances (GMP Annexure A Attachment A) Review impacts in accordance with decision tree	Report results of trigger investigation to SHL. If trigger exceedance is determined to be attributable to construction, proceed to Level 3b. If trigger response is determined not to be attributable to construction, review trigger levels and up-date monitoring plan. Report results in Annual Review.
Level 3b (Exceedance identified as related to construction activities)	Groundwater quality triggers due construction activities	Engage suitably qualified person to prepare report and identify potential for impacts on a receptor	Notify DPIE and NPWS within seven days of the trigger investigation report (Level 3a Report) Provide DPIE and NPWS with a trigger exceedance report within 30 days of notification. Identify mitigation actions or revisions to trigger levels in consultation with DPIE.
Level 4 (Limit Trigger denotes Impact on receptor)	Water quality changes impacts on a receptor (GDE)	Activate mitigation measures to remediate impact to receptor[2]	Initiate investigation into reasons for impact on receptor, including assessment of environmental harm Take actions recommended by investigation

1 In some circumstances SHL or Future Generation staff may have sufficient experience to conduct the investigation. In other circumstances a specialist may be required.
2 Mitigation measures as developed at Level 3b

ANNEXURE D – GROUNDWATER TARP 3 GROUNDWATER INGRESS

S2-FGJV-ENV-PLN-0149

SNOWY 2.0 MAIN WORKS – GROUNDWATER TARP 3 GROUNDWATER INGRESS

Approval Record			
Document preparation, review and approval		Name in print	Signature
Prepared by	Principal Hydrogeologist	R. Cresswell	
Reviewed by	Environmental Consultant	S. Mitchell	
Verified by	Environment Manager	L. Coetzee	
Approved by	Project Director	A. Betti	Digitally signed by Antonio Betti Date: 2020.09.19 09:33:35 +10'00'

Document Revision Table		
Rev.	Date	Description of modifications / revisions
A	29.11.2019	Initial draft for SHL review
B	29.05.2020	Revised to address Infrastructure Approval
C	15.06.2020	Revised to address SHL comments. For consultation.
D	25.06.2020	Update to address Commonwealth conditions of approval
E	06.08.2020	Revised to address stakeholder comments
F	19.09.2020	Revised to address DAWE and DPIE comments

This groundwater ingress TARP identified in Table D-1 should be read in conjunction with Section 7.2 of the GMP.

Table D-1: Groundwater ingress TARP

Level	Trigger	Action	Response
Level 1 (Indicator)	Groundwater take within license allocation	Continue to monitor levels in accordance with monitoring plan	No response required
Level 2 (Early warning)	Groundwater use trending to exceeding 80% of allocation	Identify major contributor to water usage and feasible actions to prevent usage exceeding allocation	Conduct preliminary review of groundwater usage, recent groundwater level monitoring results (i.e. Groundwater Level TARP) and determine drivers for identified trend and potential for recurrence Identify availability of additional water from relevant water source on the water market Investigate water ingress reduction measures Review recent groundwater level monitoring
Level 3a (Exceedance of Threshold Trigger level)	Groundwater usage exceeds 80% of allocation	Implement actions identified above if forecast indicates usage will exceed 100% of allocation	Report results in Annual Review. Initiate purchase of additional water entitlements if reduction measures are unsuccessful.
Level 3b (Exceedance identified as related to Main Works activities)	Groundwater modelling predicts usage will exceed 100% of allocation in the future	Initiate purchase of additional water from relevant water source on the water market	Report results in Annual Review.
Level 4 (Limit Trigger denotes Impact on receptor)	Water usage exceeds 100% of allocation	Formalise purchase water entitlements to account for exceedance	Initiate investigation into reasons for exceedance and report reports in Annual Review Notify NRAR/DPIE Water Group and provide report on reasons for exceedance Take actions recommended by investigation to prevent recurrence

ANNEXURE E – EXPLORATORY WORKS CONSOLIDATED CONDITIONS OF APPROVAL (SSI-9208)

Table B 1 details the conditions from the Exploratory Works Infrastructure Approval which are relevant to groundwater and demonstrates where these conditions are addressed or are no longer relevant.

Table B 1: Exploratory Works conditions of approval relevant to ground water (SS9208)

Condition	Requirement	Where addressed
Sch 3, Cond 31	The Proponent must ensure that it has sufficient water for all stages of the development; and if necessary, stage the development to match its available water supply. *Note: Under the Water Management Act 2000, the Proponent must obtain the necessary water licences for the development.*	GMP - Section 2.5.3
Sch 3, Cond 32	Unless an environment protection licence authorises otherwise, the Proponent must comply with Section 120 of the POEO Act. *Note: Section 120 of the POEO Act makes it an offence to pollute any waters.*	WMP - Appendix A (SWMP) GMP - Section 5
Sch 3, Cond 34	Prior to carrying out any construction, unless the Planning Secretary agrees otherwise, the Proponent must prepare a Water Management Plan for the development to the satisfaction of the Planning Secretary. This plan must: (e) include a Groundwater Management Plan with:	This Plan
	• detailed baseline data on groundwater levels, yield and quality on the aquifers that could be affected by the development;	GMP – Annexure A Attachment A (Baseline Groundwater Quality and Levels)
	• a program to augment the baseline data during the development;	GMP – Annexure A (Groundwater Monitoring Program)
	• groundwater assessment criteria, including trigger levels for investigating any potentially adverse groundwater impacts;	GMP – Section 6.4
	• a description of the measures that would be implemented to minimise the groundwater impacts of the development	GMP - Section 5
	• a program to monitor and report on: ○ groundwater inflows to the tunnel, including inflows to relevant water sources; ○ groundwater takes from the groundwater bore ○ the impacts of the development on: ▪ regional and local (including alluvial) aquifers; ▪ groundwater dependent ecosystems, stygofauna and riparian vegetation; and ▪ base flow to surface water sources;	GMP – Annexure A (Groundwater Monitoring Program) GMP – Section 6.8
	• a plan to respond to any exceedances of the trigger levels and/or assessment criteria and mitigate and/or offset any adverse groundwater impacts of the development.	GMP – Section 7