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Memorandum

27 October 2023

Subject: **Eastern Pilbara Hub Water Balance - 2023 Forecast Surplus Discharge Assessment**
Attention: **James Jordan – Superintendent Neuman Hydrogeology (BHP)**

1 Introduction

1.1 Background

The Eastern Pilbara Surplus Water Strategy has been developed to support the sustainable management of surplus mine water discharge from local BHP mining operations in the Eastern Pilbara region of Western Australia. The strategy is supported by water balance modelling which enhances BHP's understanding of local surface and hydrogeological responses to various management scenarios, particularly relating to the discharge of surplus mine water and controlled discharges from Ophthalmia Dam.

Water balance modelling undertaken in 2020 and 2021 by EMM Consulting (EMM) informed water impact assessments for Part IV environmental approval applications for the Orebody 32 Below Water Table (OB32 BWT) and Western Ridge (WR) proposals, which included forecast surplus mine water discharge to Ophthalmia Dam from OB32 BWT (EMM 2020) and WR (EMM 2021).

The *Eastern Pilbara Hub Water Balance: OB32 Surplus Water GoldSim Modelling – Stochastic and Sensitivity Assessments* was undertaken by EMM (2023) in response to feedback from the OB32 Surplus Water identification phase study (IPS) independent peer review. One of the main outcomes of the sensitivity analysis was a recommended change to the saturated hydraulic conductivity (K) in the model from 7 m/d to 49 m/d, based on a review of previous model performance and alignment with field observations of water levels, salinity, and hydraulic properties of the Ethel Gorge aquifer system.

1.2 Project objectives

BHP has updated the forecast Eastern Pilbara Hub (EPH) surplus discharge scenarios previously assessed to reflect updated forecast dewatering rates from existing approved dewatering operations, proposed dewatering at OB32 BWT and WR, and increased dewatering at Jimblebar, to support the Jimblebar Part IV approval application. This surplus mine discharge scenario is referred to as *2023 Forecast Surplus Discharge*. The purpose of this assessment is to:

- apply the recommended hydraulic conductivity (K) from the 2022 sensitivity analysis (EMM 2022)
- update the water balance with the 2023 Forecast Surplus Discharge scenario to demonstrate the response of Ophthalmia Dam and the associated groundwater levels and salinity.

2 Model parameters

2.1 Updates

2.1.1 Hydraulic Conductivity

The mean hydraulic conductivity of the groundwater modelling components was changed from 7 m/d to 49 m/d. For comparative purposes, results are presented for the updated water balance for both 7 m/day and 49 m/day.

2.1.2 Surplus water discharge

The 2023 Forecast Surplus Discharge adopted for the Jimblebar Hub, Whaleback and Eastern Ridge mining operations in the water balance assessment is presented in Figure 2.1 below. The cumulative forecast surplus discharge is presented in Figure A.1.

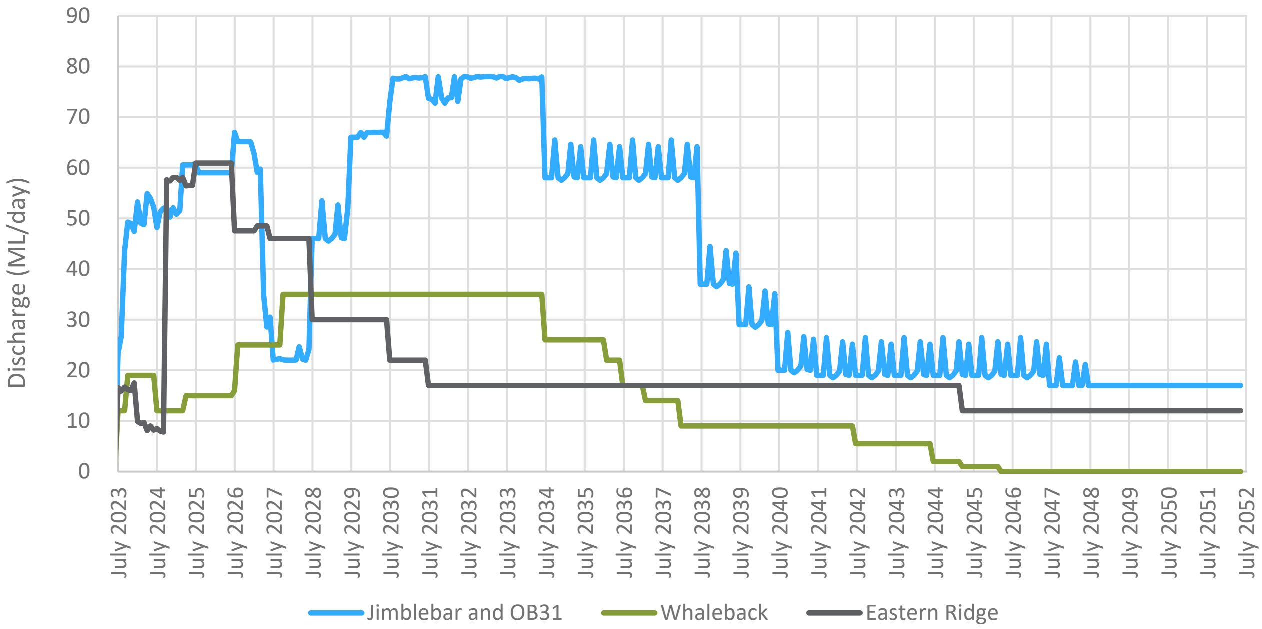

Figure 2.1 2023 Forecast Surplus Discharge

2.2 Overview of applied parameters

The parameters applied to the modelling assessments are presented in Table 2.1 below. The justification and background on the parameters and modelling approaches is documented in *Eastern Pilbara Hub Water Balance – Integrated water balance model review and Ophthalmia Dam water management capacity scenarios* (EMM 2020).

Table 2.1 Water balance model parameters for 2023 assessment

Parameter (units)	Value	Comment
Global settings and data		
Simulation dates	July 2023 to June 2053	
Climate data (includes daily rainfall, pan evaporation and MLake evaporation)	20-year average climatic conditions (2001 to 2020 SILO historical data)	Looped to achieve 30-year simulation timeframe.
Ophthalmia Dam parameters		
Dam seepage rate	Non-linear area-based seepage function	As per EMM (2020)
Catchment inflow factor	1.0	As per EMM (2020)
Stage-area-volume relationship	Defined from BHP (2014)	As per EMM (2020)
Spillway elevation (mRL)	513.5	As per EMM (2020)
C-wall valve discharge rate	Derived rating curve (135 ML/day capacity limit) 3-months from August	As per EMM (2020)
Fortescue River streamflow	20-year average climatic conditions (2001 to 2020)	Looped to achieve 30-year simulation
Groundwater model parameters		
Saturated hydraulic conductivity (K) (m/day)	49	As per EMM (2023)
Specific yield, Sy (%)	6.0	As per EMM (2020)
Upstream boundary inflow (m^3/day)	1500	As per EMM (2020)
Evaporation depth, De (m)	2.0	As per EMM (2020)
Evapotranspiration cut-odd depth, d2 (m)	4.8	As per EMM (2020)
Riverbed permeability (mm/d)	100	As per EMM (2020)
Borefield abstraction	Zone 1 – 2.7 ML/day Zone 2 – 7.4 ML/day Zone 3 – 0.0 ML/day Zone 4 – 2.8 ML/day Zone 5 – 0.1 ML/day	As per EMM (2020)
OB23 and OB25 Pit 3 Dewatering and Discharge to infiltration Ponds	15 ML/day	As per EMM (2020)
TDS mass balance parameters		
River TDS concentration (mg/L)	40	As per EMM (2020)
Rainfall TDS concentration (mg/L)	2.2	As per EMM (2020)
Upstream groundwater inflow concentration (mg/L)	1000	As per EMM (2020)
Surplus water discharge salinity	Jimblebar 750 mg/L Eastern Ridge 950 mg/L Whaleback 550 mg/L	As per EMM (2020)

3 Results

Outcomes from the modelling described in Section 2 above are presented in Appendix A. Outputs are provided for realisation 13, which is consistent with the EMM (2020) reporting (which was used to support the OB32 BWT Part IV approval application).

Key findings from this modelling are:

- The updated water balance includes an increased period of higher surplus water discharge to Ophthalmia Dam (when compared to the previous modelling to support the OB32 BWT and Western Ridge proposals), which leads to an associated increase in dam storage during this period (Figure A.2).
- The simulated water salinity in Ophthalmia Dam remains within historical values and ranges between approximately 50 and 1500 mg/L TDS, with no trend over time (Figure A.4).
- Simulated groundwater levels in all five monitoring zones remain within historical ranges and the 4 m trigger level in the Eastern Pilbara Water Resource Management Plan (EPWRMP) (Figure A.6 – A.10).
- Simulated groundwater salinity in all five monitoring zones increases over time, with the 49 m/d aquifer hydraulic conductivity model scenario predicting a smaller increase in salinity, which is more aligned with historical observations (Figure A.6 – A.10).
- Predictions of groundwater salinity in both the 7 m/d and 49 m/d scenarios remain below the EPWRMP trigger level of 3000 mg/L TDS in all monitoring zones.

4 Limitations and assumptions

As defined in EMM (2020), there are a range of limitations and assumptions associated with the water balance model, particularly pertinent to the representation of the groundwater system, which should be acknowledged when interpreting the model results and outputs. The water balance modelling approach has largely been developed to:

- provide an efficient and integrated approach to simulate the ‘linked’ surface and groundwater systems
- understand the potential influence of changes to the dam water balance and therefore groundwater seepage from the dam, on the downstream groundwater system.

The modelling approach is not explicitly designed equivalent to a numerical groundwater model and, by definition, is a simplified representation of a complex system.

The model simulations and outputs relating to the groundwater system are best used to interpret potential trends and responses to changes in operations, particularly for comparing relative changes between scenarios, rather than to be interpreted as accurate predictions of future groundwater levels and TDS concentrations.

The water balance for Ophthalmia Dam has been shown, through the model performance review process, to provide a good level of agreement between observed and simulated water volumes and TDS concentrations. The key uncertainties for the dam balance largely relate to the unmeasured components of inflow contributions from the ungauged portion of the dam catchment and seepage losses.

5 Closing

We hope this memorandum for the 2023 Forecast Surplus Discharge assessment adequately address your requirements. If you have any questions of require any additional information, please do not hesitate to contact me.

Yours sincerely

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References

BHP, 2014. Ophthalmia Dam Volume Calculation, Perth, WA: BHP.

EMM, 2020. Eastern Pilbara Hub Water Balance: Integrated water balance model review and Ophthalmia Dam water management capacity scenarios.

EMM, 2021. Western Ridge – Water Balance Modelling Assessment.

EMM, 2023. Eastern Pilbara Hub Water Balance: OB32 Surplus Water GoldSim Modelling – Stochastic and Sensitivity Assessments

Appendix A
PR7 modelling results

EMM
creating opportunities

A.1 2023 Forecast Surplus Discharge Ophthalmia Water Balance Figures

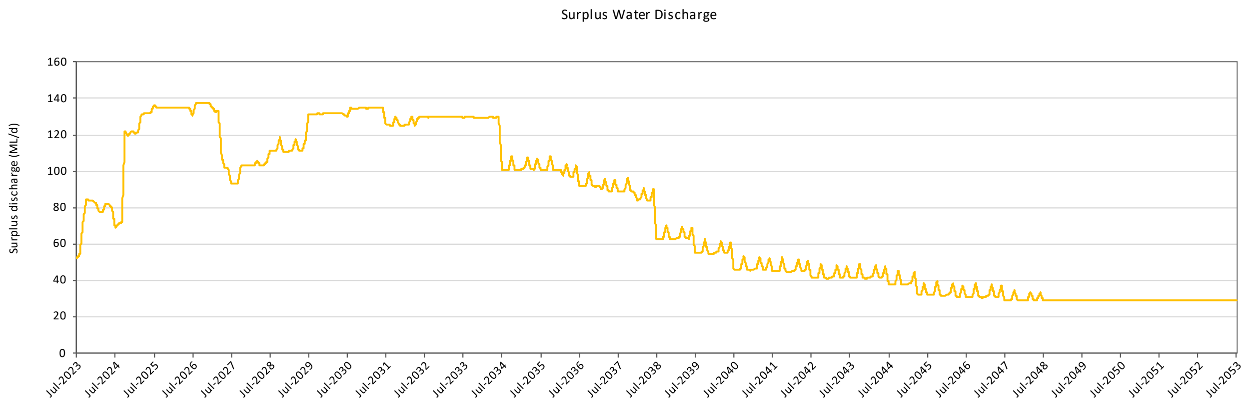


Figure A.1 Surplus Water Discharge (2023 Forecast Surplus Discharge, Realisation 13)

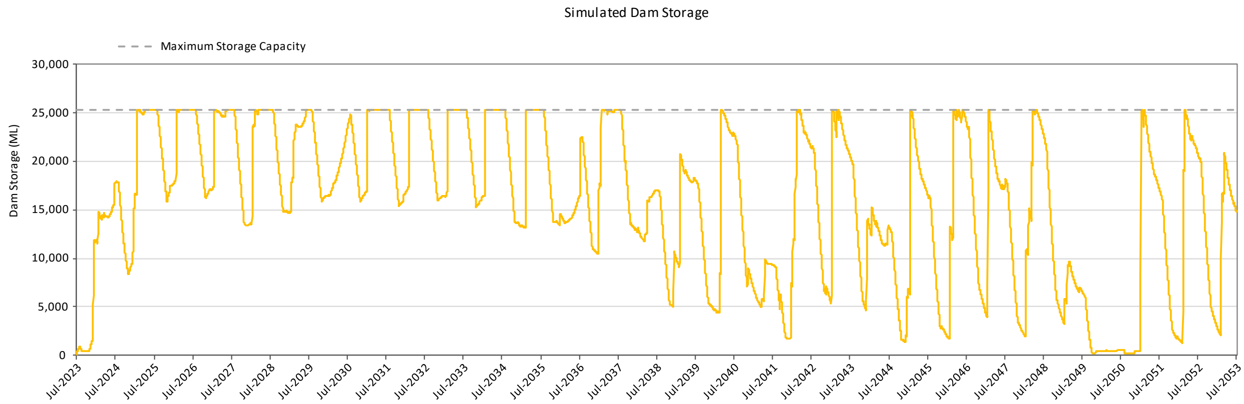


Figure A.2 Simulated Dam Storage (2023 Forecast Surplus Discharge, Realisation 13)

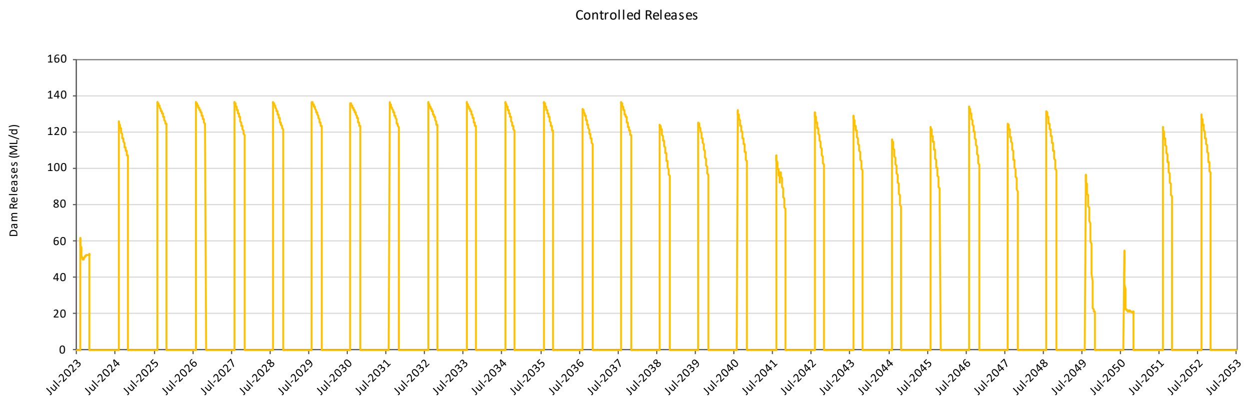


Figure A.3 Controlled Releases (2023 Forecast Surplus Discharge, Realisation 13)

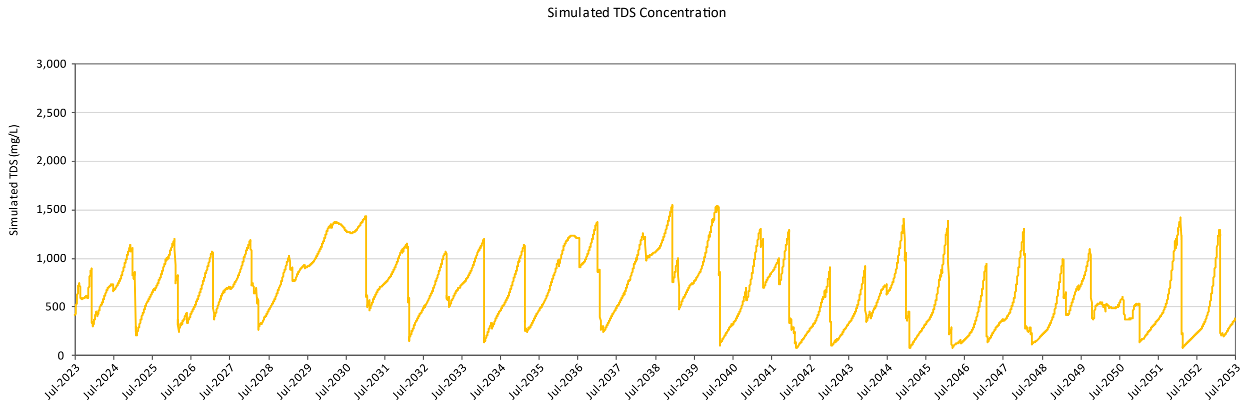


Figure A.4 Simulated TDS Concentration (2023 Forecast Surplus Discharge, Realisation 13)

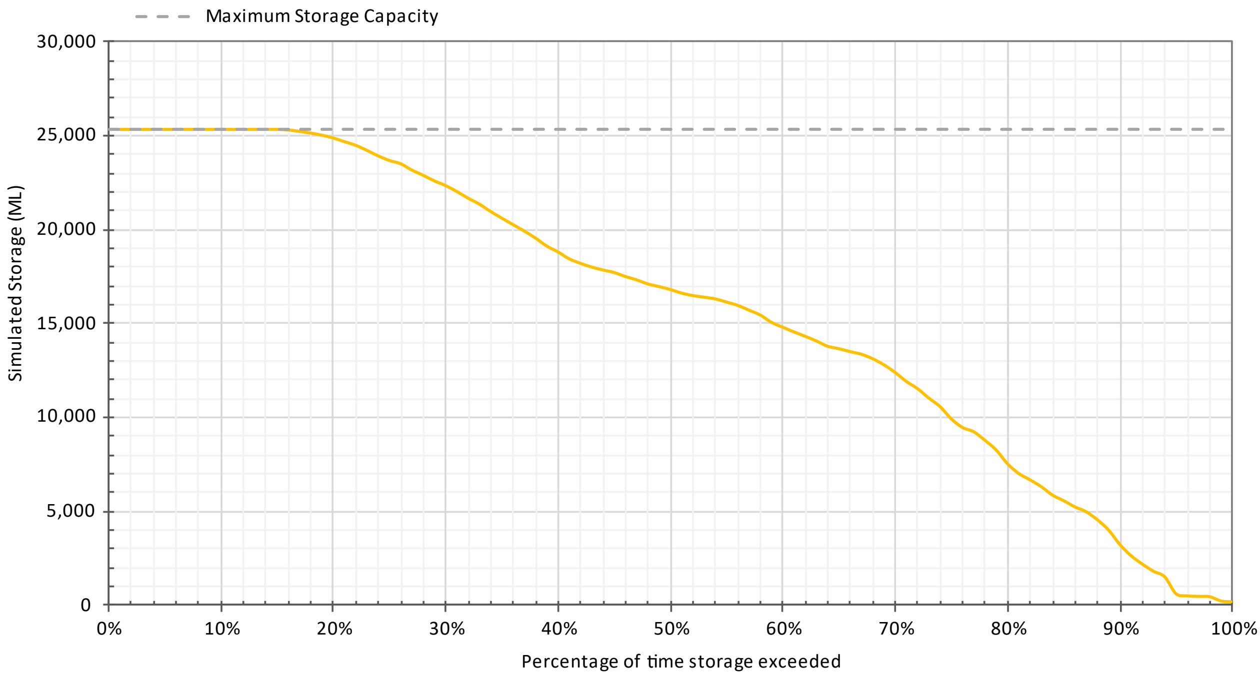


Figure A.5 Storage Duration Curve (2023 Forecast Surplus Discharge, Realisation 13)

A.2 2023 Forecast Surplus Discharge Simulated Groundwater and Salinity Figures

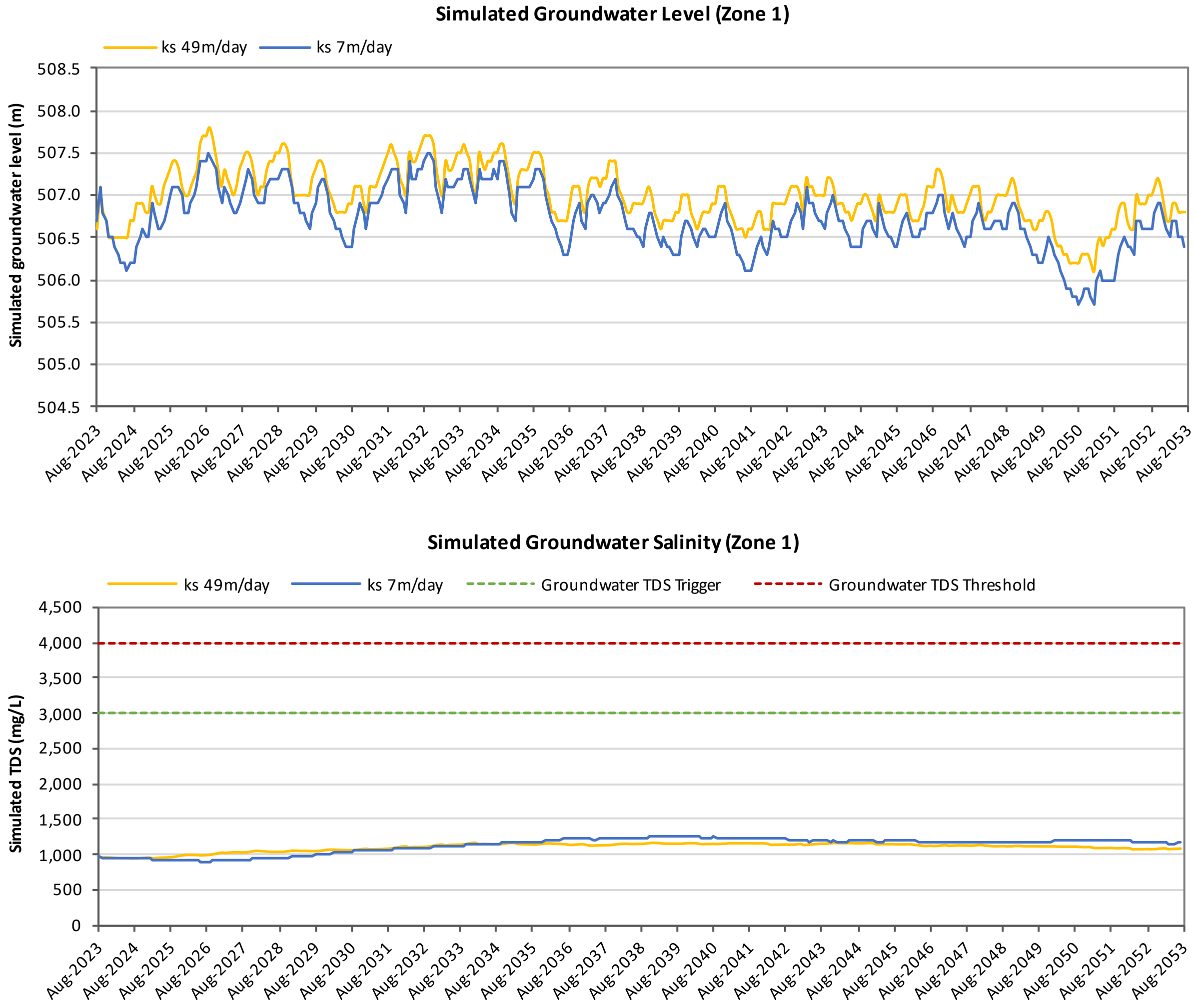
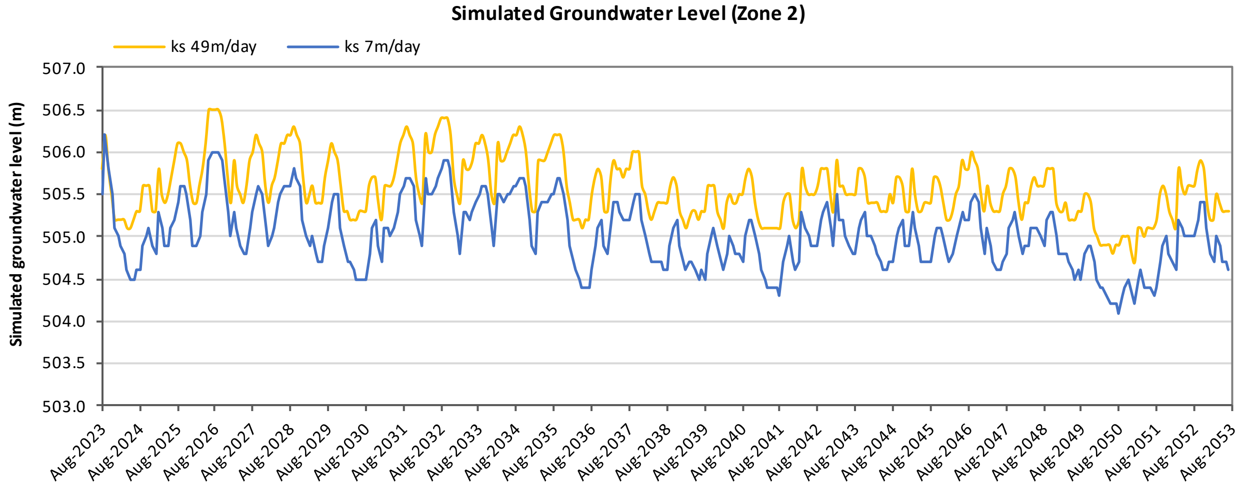


Figure A.6 Simulated model zone 1 groundwater level and salinity (2023 Forecast Surplus Discharge, Realisation 13)



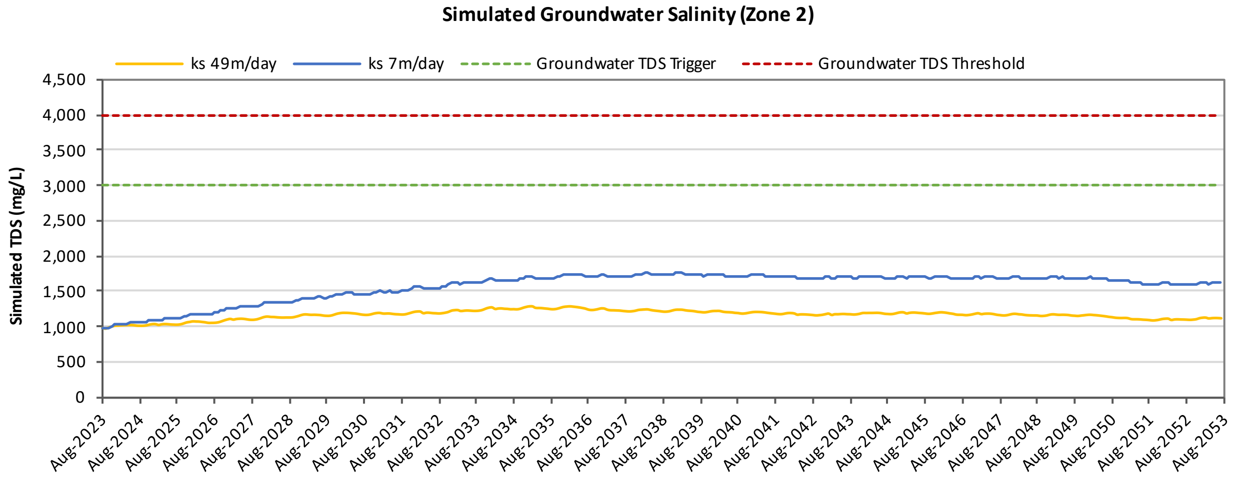
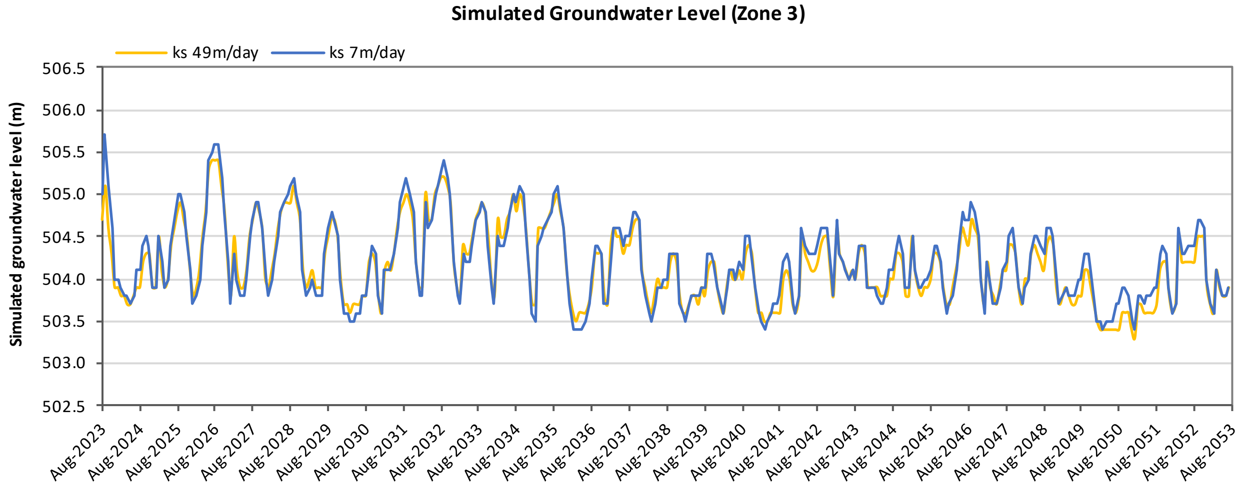


Figure A.7 **Simulated model zone 2 groundwater level and salinity (2023 Forecast Surplus Discharge, Realisation 13)**



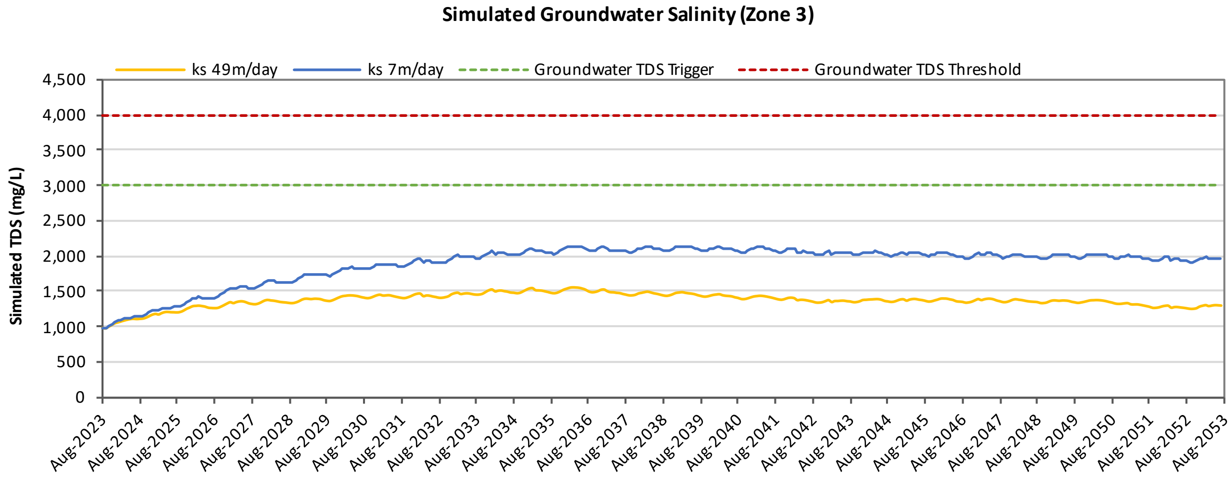
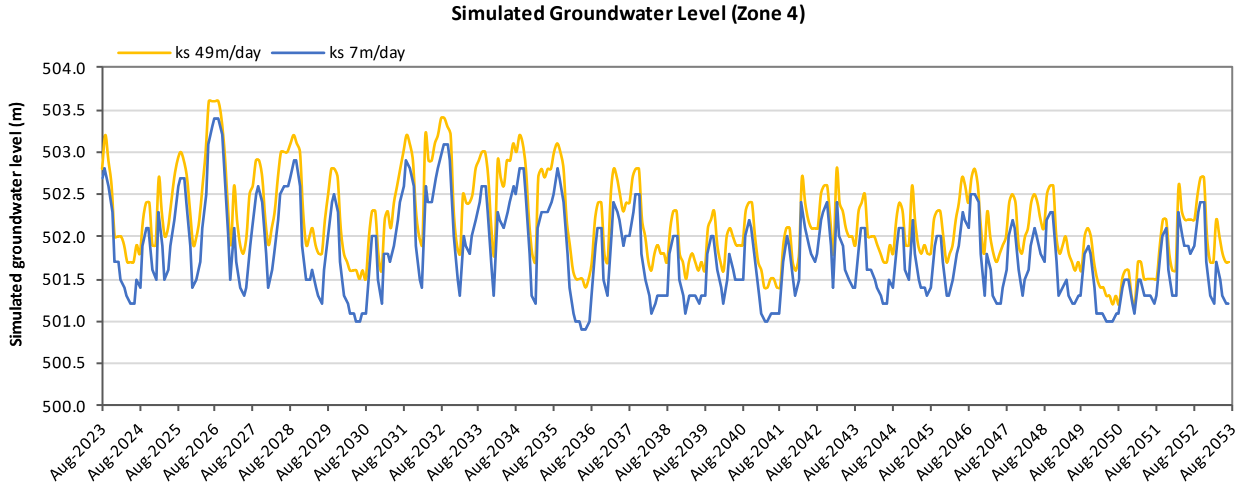


Figure A.8 Simulated model zone 3 groundwater level and salinity (2023 Forecast Surplus Discharge, Realisation 13)



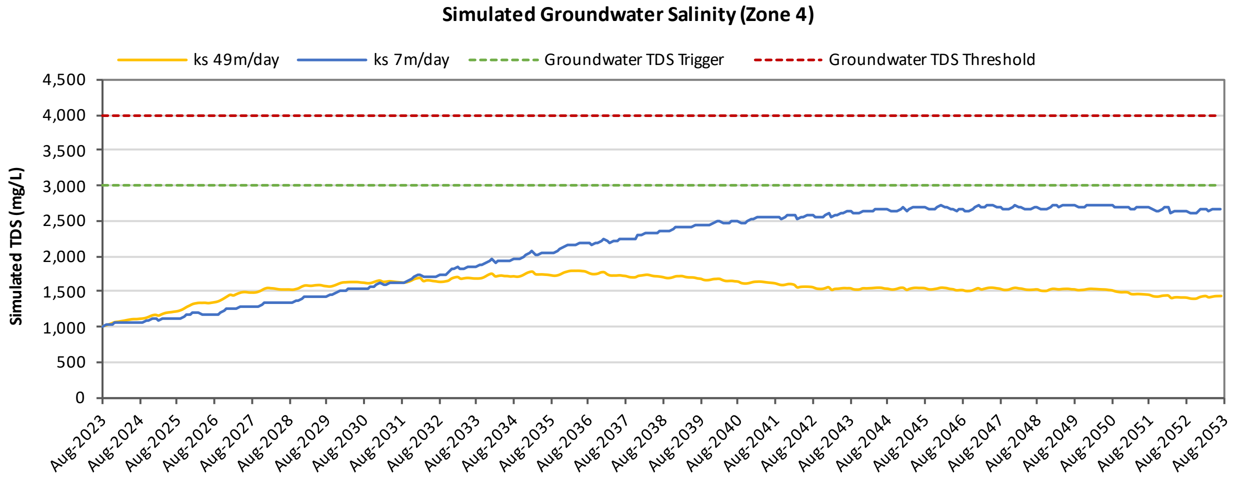
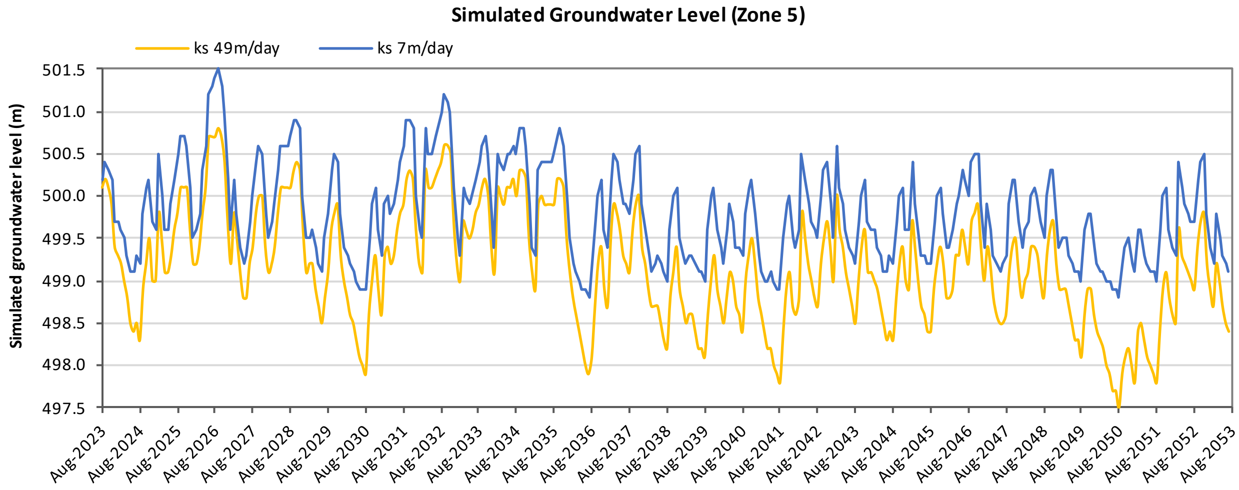


Figure A.9 Simulated model zone 4 groundwater level and salinity (2023 Forecast Surplus Discharge, Realisation 13)



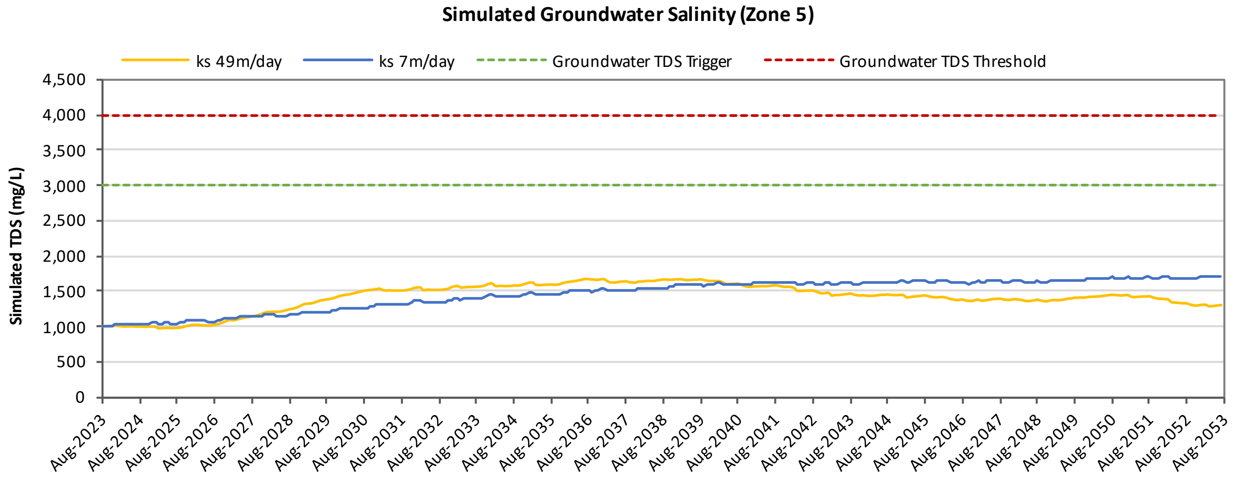


Figure A.10 Simulated model zone 5 groundwater level and salinity (2023 Forecast Surplus Discharge, Realisation 13)