



## Memo

**To:** Karin Bankin  
**From:** Lorraine Silva, Rob Harrison and Craig Wicenciak [WSP Australia Pty Ltd]  
**Subject:** **Phase A Flinders Road *Empodisma* peatlands (TEC / GDE) Impact Assessment**  
**Our ref:** PS221297-WSP-BNE-MNG-TM-0001-RevA  
**Date:** 15 April 2025

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## 1. Introduction

WSP Australia Pty Ltd (WSP) has undertaken an initial hydrological assessment of a potential occurrence of a threatened ecological community (TEC / EPBC Act; GDE (BC Act) (*Empodisma* peatlands of southwestern Australia) at Alcoa of Australia Limited (Alcoa's) Willowdale Mine, south of Perth. The *Empodisma* peatland (TEC/GDE) is located at the Flinders mine pit region, and is thought to be a groundwater-dependent ecosystem (GDE) either directly or indirectly dependent on groundwater in this catchment.

The objective of interim high-level Phase A Technical Memorandum is to:

- confirm the *Empodisma* peatlands (TEC / GDE) is hydraulically connected to groundwater
- estimate (i) groundwater elevations, and (ii) water through-flow rates for the *Empodisma* peatlands (TEC / GDE) for Scenarios 1 to 3 to assist in understanding mining-induced ecological impacts assessments for the *Empodisma* peatlands (TEC / GDE), and
- present WSP's preliminary understanding and expectations of potential impacts of mining operations on the *Empodisma* peatlands (TEC / GDE) (if any).

A summary of the scenarios assessed and presented in this Phase A Technical Memorandum as well as those which will be carried out in Phase B is presented in **Table 1.1**.

Table 1-1 Summary of all scenarios to be assessed

Scenario number	Study phase	Year	Haul road included in assessment	Mining conditions	Technical deliverable
Scenario 1	Phase A and Phase B <sup>†</sup>	September 2023	No	Baseline	This Technical Memorandum (and potentially Phase B Tech Memo)
Scenario 2		December 2024	No	Current	
Scenario 3		December 2024	Yes	Current	
Scenario 4A	Phase B	2029	Yes	Future mining in year 2029	

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WSP acknowledges that every project we work on takes place on First Peoples lands. We recognise Aboriginal and Torres Strait Islander Peoples as the first scientists and engineers and pay our respects to Elders past and present.

Scenario number	Study phase	Year	Haul road included in assessment	Mining conditions	Technical deliverable
Scenario 4B		TBC	Yes	Current and inclusive of mining within FCA24A WLD Flinders 12, 14 & 19 (refer Figure 1).	Phase B Tech Memo
Scenario 5		2039	Yes	Future rehabilitation year 2039	
Scenario 6		2029	No	Future mining year 2029	
Scenario 7		2039	No	Future rehabilitation year 2039	

**Note:** † Reported outcomes of the Phase A assessments presented in this document may be updated as the Phase B assessments (which will be reported in a separate document)

## 2. Assessment outcomes

A summary of the key outcomes of hydrogeological assessments for Scenario 1 to 3 are summarised in the following bullet points and table. The methodology, considerations and outcomes of the hydrogeological assessments are presented in detail in **Appendix A**.

- Based on the above and using the definitions expressed in Richardson, et al. (2011), the Flinders mine pit *Empodisma* peatlands (TEC / GDE) is thought to constitute an aquatic (wetland) surface expression GDE. The current listing status of the *Empodisma* peatland (TEC / GDE) as a threatened ecological community under the EPBC Act and being a GDE under the BC act will require ongoing monitoring as part of a site-specific management plan.
- Phase B will deepen the understanding of potential mining impacts on this *Empodisma* peatlands (TEC / GDE) and assist in the development of risk profile for an *Endangered* ecological community. This risk profile will inform a site-specific management strategy such as a rule of thumb, which could include guidelines like designated buffers or percentages of cleared areas within the catchment, and help determine the appropriate proximity at which mining activities can occur relative to the *Empodisma* peatlands (TEC / GDE).
- Land use changes in the *Empodisma* Peatlands (TEC / GDE) sub-catchment between Scenario 1, Scenario 2 and Scenario 3 are minimal, resulting in only minor differences in groundwater model outcomes, namely:
  - (i) groundwater elevations, and
  - (ii) *Empodisma* Peatlands (TEC / GDE) throughflow water discharges.

These changes in groundwater elevations and throughflow water discharges pose minimal risk to the *Empodisma* Peatlands (TEC / GDE).

- Changes of modelled climate (i.e., rainfall to represent different seasons) had a greater influence on water balances than changes of land use (refer **Figure A. 6 of Appendix A**).
- During the wet season, the groundwater table is expected to interact ('connect with') surface water in the *Empodisma* Peatlands (TEC / GDE), invoking direct hydraulic connection with the *Empodisma* Peatlands (TEC / GDE) (refer to **Figure 2-1**). This suggests the *Empodisma* peatlands (TEC / GDE) is a surface expression GDE, with levels of flowthrough discharge reflective of variance in rainfall in-turn affecting groundwater recharge amounts.
- During the dry season, the elevation of the groundwater table falls, invoking hydraulic disconnection between surface water and groundwater beneath the *Empodisma* peatlands (TEC / GDE) (**Figure 2-1**). WSP's modelling however, suggests the groundwater table remains 'in connection' with the *Empodisma* peatlands (TEC / GDE) root zone, and it is expected to contribute to maintaining the ongoing health and condition of the *Empodisma* peatlands (TEC / GDE).
- Mining activities are likely to marginally increase the elevation of the groundwater table due to increased groundwater recharge in response to reduced vegetation cover and reduced transpiration rates across the catchment.

- Due to the flow through capacity of the *Empodisma* Peatlands (TEC / GDE), any increased groundwater table levels will be surface expressed and flowthrough the *Empodisma* Peatlands (TEC / GDE) (natural process of the wetland GDE). As such, changes associated with the haul road are unlikely to result in any:
  - permanent inundation of *Empodisma* Peatlands (TEC / GDE) vegetation, whereby plants would die from waterlogging / saturation, and/or
  - change to the *Empodisma* Peatlands (TEC / GDE) overall health and condition.
- **Construction and operation of the Flinders haul road in the catchment is not expected to noticeably impact groundwater elevations or water flow through (and discharge from) the TEC. As such, no noticeable or measurable impact upon the *Empodisma* Peatlands (TEC / GDE) is expected for Scenarios 2 and 3.**

Table 2-1 Summary of impacts (if any) for each scenario

Scenario	Date	Flinders Road included in scenario	Mining conditions	Predicted change in groundwater elevation	Expected impact on the Flinders Crossing <i>Empodisma</i> Peatlands (TEC / GDE)
Scenario 1	September 2023	No	Baseline	-- <sup>†</sup>	--
Scenario 2	December 2024	No	Current	Negligible	Nil (not measurable).
Scenario 3	December 2024	Yes	Current	Negligible	Nil (not measurable).

**Note:** <sup>†</sup> base case scenario hence no predicted changes

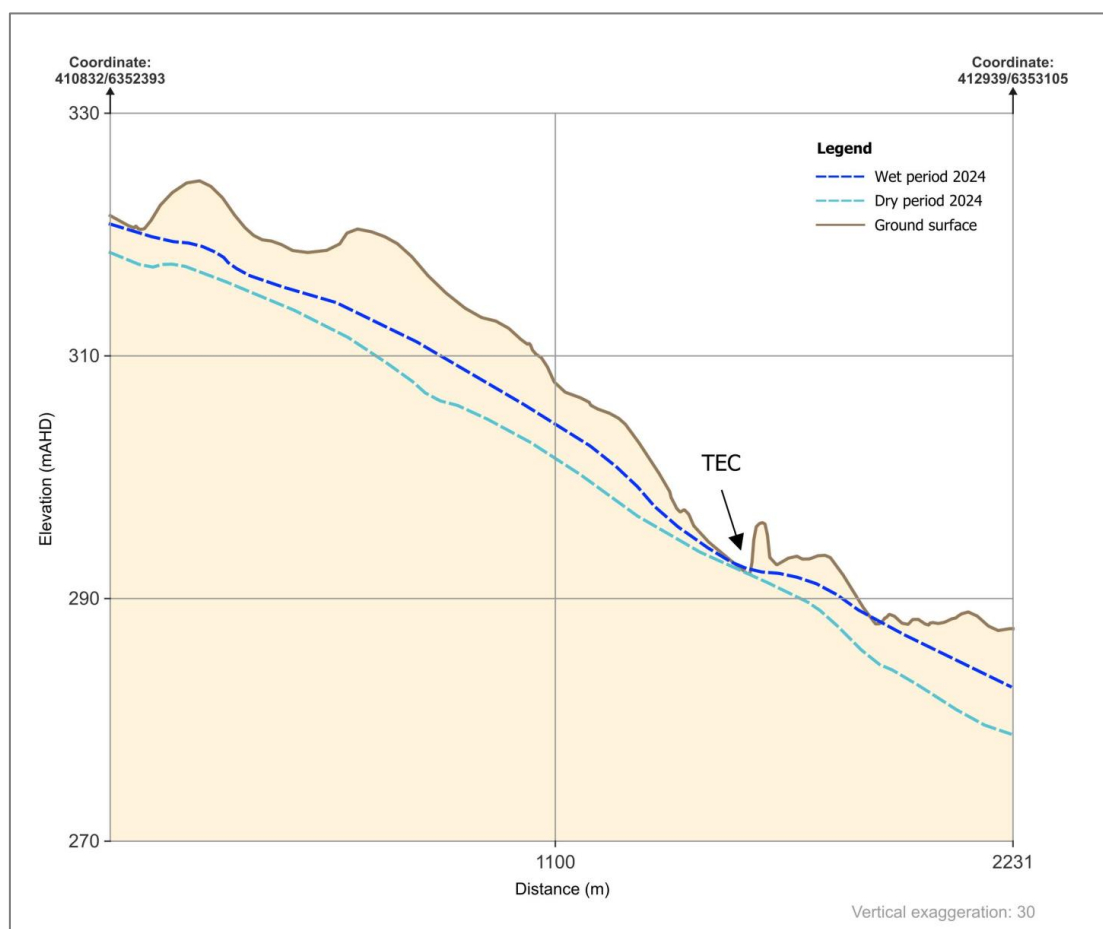


Figure 2-1 Cross-section for modelled groundwater elevations for both dry and wet periods, showing *Empodisma* Peatlands (TEC / GDE)

### 3. Closing

We trust that the above is sufficient for continued operations. Should you require anything further, please do not hesitate to hesitate to contact the undersigned to discuss.

Regards



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Principal Hydrogeologist

## References

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## Appendix A Hydrogeological setting and assessment

A brief overview of the key hydrogeological considerations used in those assessment outcomes detailed in **Table 2-1** and includes:

- an overview of the hydrostratigraphic behaviour of the various geological units at and surrounding the Flinders mine pit *Empodisma* Peatlands (TEC / GDE)
- an overview of the hydrometeorology of the area
- a summary of the hydraulic parameters (and their values) of various hydrostratigraphic units included in the numerical groundwater model
- details of the development, paramaterisation and calibration of the numerical models constructed for this assessment, and
- a summary of the various assessment outputs.

The location of the study is shown in **Figure A. 1**.

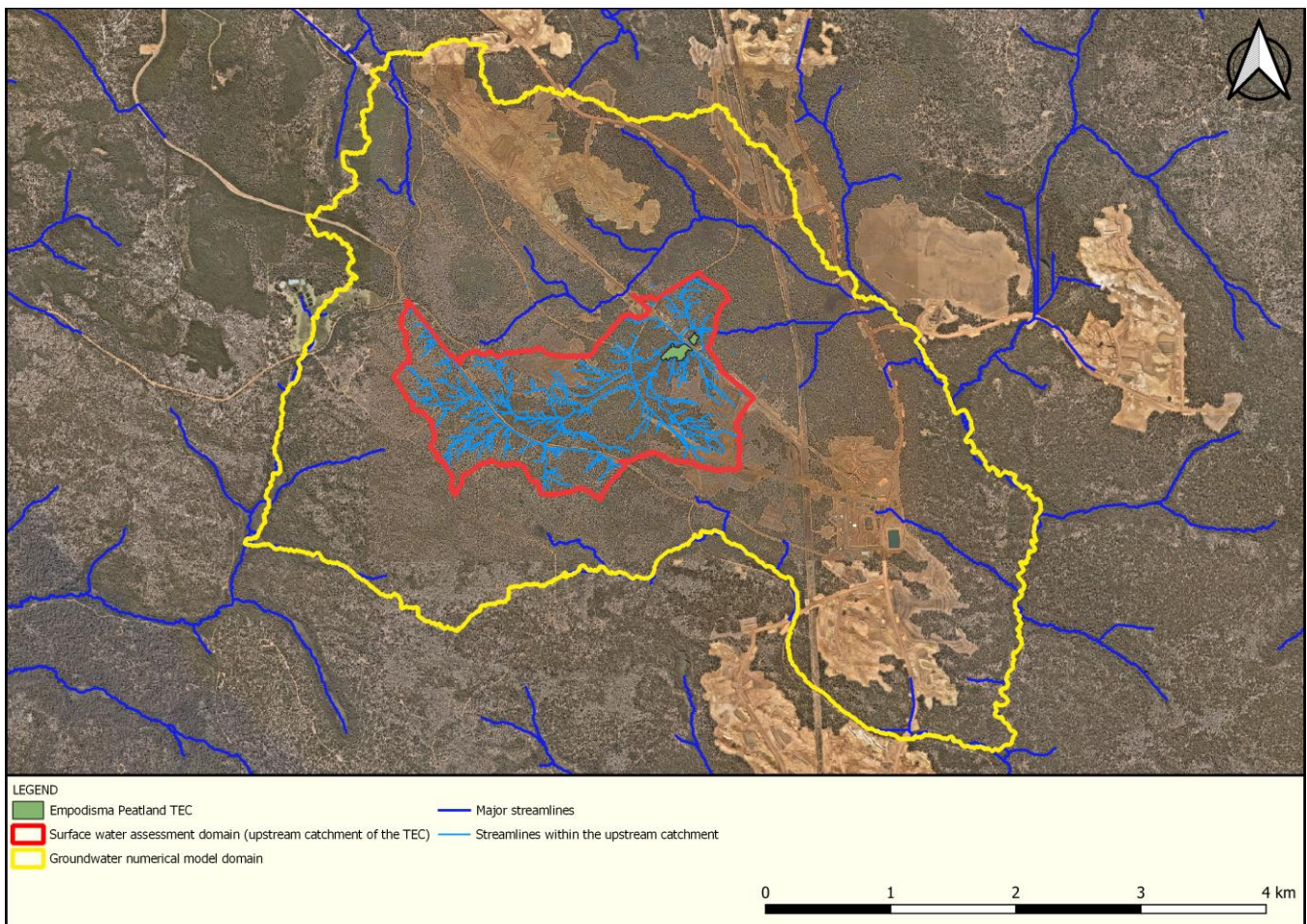


Figure A. 1 Location of the Empodisma Peatland (TEC / GDE) (green shading and provided by Alcoa), Flinders Road upstream sub-catchment (red line) and natural drainage lines within the sub-catchment (light blue lines), streamlines including ephemeral (dark blue), groundwater numerical model (yellow line) and cleared areas as of September 2024. (imagery: Nearmap, 2024 [September])

## A.1 Hydrostratigraphic units

A summary of the various hydrostratigraphic units and their behaviours at and in the vicinity of the *Empodisma* peatlands (TEC / GDE) is presented in **Table A. 1**.

Table A. 1 Summary of field investigation and calibrated model hydraulic parameters

Geological unit <sup>†</sup>	Observed depth range (mbgl) (min – max depth)	Hydrogeological characterisation	Recharge	Flow mechanism	Discharge
Overburden	0 – 10	Unconfined ('water table') <b>aquifer</b> . May include some perched occurrences of groundwater.	Rainfall infiltration	Porous flow.	Transpiration + downward seepage / leakage.
Caprock	0 – 10	<b>Aquitard</b> with varying (including very high) vertical leakage rates.		Fracture flow ± minor porous flow.	
Bauxite	0 – 17	Unconfined ('water table') <b>aquifer</b> .	Seepage from caprock + overburden	Porous flow.	Transpiration, + downward seepage / leakage + discharge to local waterways.
Clay	3 – 30	<b>Leaky aquitard</b> .	Seepage from caprock + overburden	Porous flow.	
Weathered granite	17 – 45	Low permeability <b>aquifer</b> , albeit with moderate to high storage.	Seepage from overlying units plus some horizontal throughflow.	Porous flow ± fracture flow.	Expected to discharge to local waterways and outflow to more regional groundwater flow systems.
Granite	<35	Generally a low permeability and storage <b>aquifer</b> typified by low yields.		Flow via fracture networks	

**Note:** <sup>†</sup> dykes, faults and other structural features have not been considered as yet, but will be included if further lithological and structural information is made available.

## A.2 Hydrometeorology

Average annual rainfall isohyets indicate around 500 mm in the north-east to 1,300 mm along the western margin of the Darling Plateau. Most rainfall occurs between the months of May and October.

Long term average rainfall and maximum temperatures at Karnet and Dwellingup Bureau of Meteorology (BoM) stations are presented in **Figure A. 2** and **Figure A. 3**.

Estimates of groundwater recharge from rainfall infiltration using the chloride mass balance method suggests such recharge varies between about 45 and 61 mm/year, decreasing from the western to eastern boundary of the development envelope (GHD, 2022).

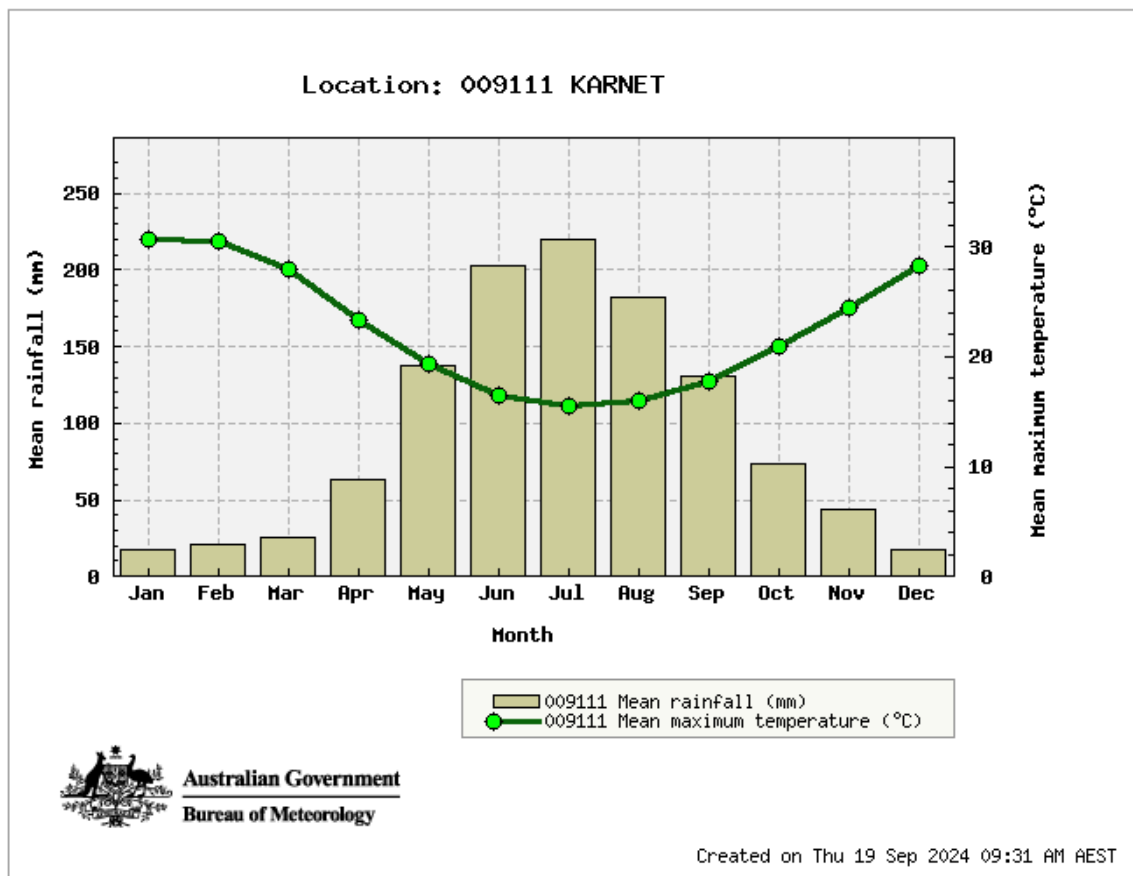


Figure A. 2 Long term average rainfall and maximum temperature at the BoM Karnet weather station (1960 – 2025)

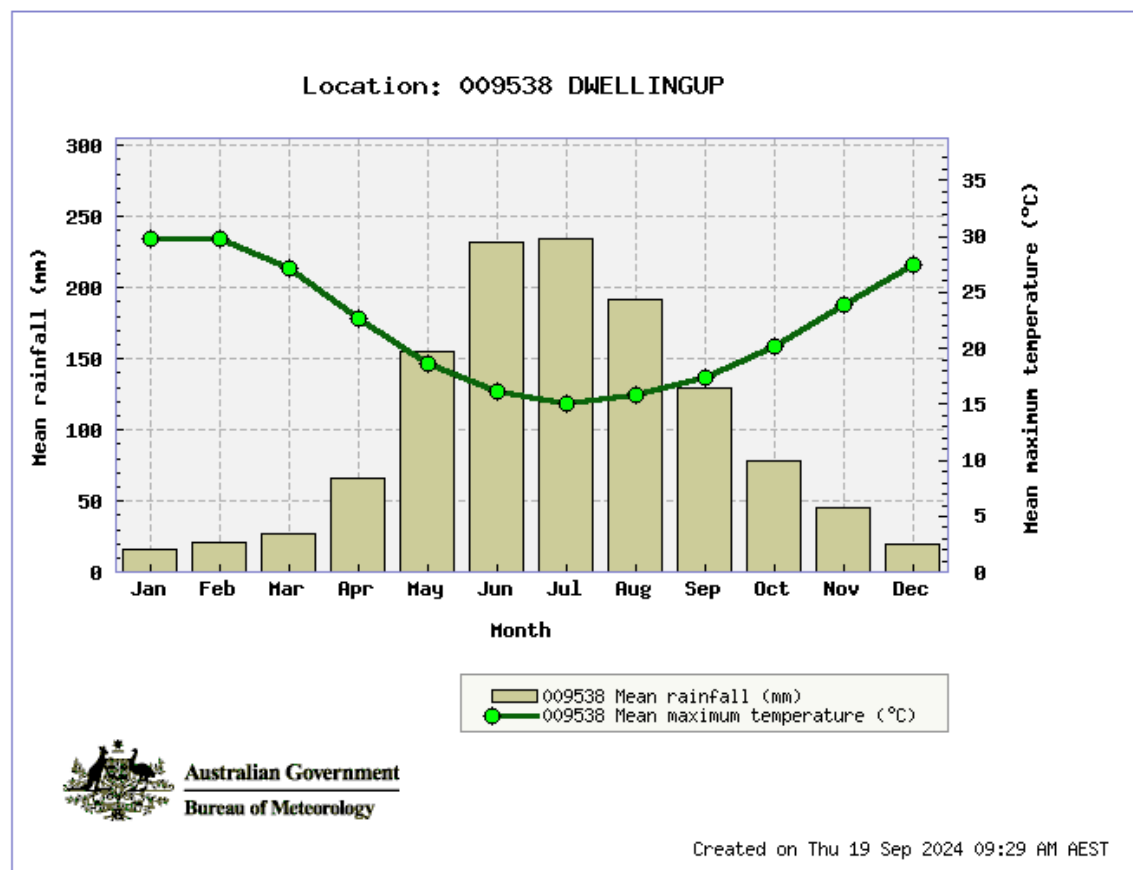


Figure A. 3 Long term average rainfall and maximum temperature at the BoM Dwellingup weather station (1935 – 2024)

### A.3 Groundwater modelling

WSP developed both *WetSpass*<sup>TM</sup> and *FEFLOW* numerical models to assess whether Alcoa’s mining activities may affect the health of the *Empodisma* Peatland TEC at the Flinders Crossing by altering the hydrological and hydrogeological conditions in the catchment in which the *Empodisma* peatlands (TEC / GDE) is situated.

*WetSpass*<sup>TM</sup><sup>1</sup> (Batelaan and Smedt, 2001) was used to estimate groundwater recharge rates and transpiration ‘losses’ from the catchment in which the Flinders mine pit *Empodisma* peatlands (TEC / GDE) is situated, in particular the magnitudes of these mechanisms and their potential changes associated with mining-induced land-use changes in a basin. Transpiration is recognised as the primary variable in both pre- and post-mining catchment hydrodynamics, particularly that of groundwater recharge, hence WSP focused on replicating this as best as possible in the assessments presented in this Technical Memorandum.

*FEFLOW*, a finite element modelling code developed by the WASY Institute in Germany (DHI-WASY) (Diersch, 2014), was used to estimate groundwater elevations, discharge locations and flow rates in the Flinders mine pit *Empodisma* Peatlands (TEC / GDE). *FEFLOW* can simulate saturated and unsaturated groundwater flow under complex boundary conditions, with its use of the finite element formulation of the groundwater flow equation allowing for efficient discretisation of the numerical grid for the study area and representation of a complex geological setting.

Recharge and evapotranspiration components estimated from *WetSpass*<sup>TM</sup> were incorporated into the *FEFLOW* model (refer to **Figure A. 4**) to evaluate potential changes in groundwater dynamics, numerically replicating the changes in groundwater recharge mechanisms associated with mining activities, thereby providing insight as to potential hydrological and hydrogeological impacts of mining on the *Empodisma* peatlands (TEC / GDE) .

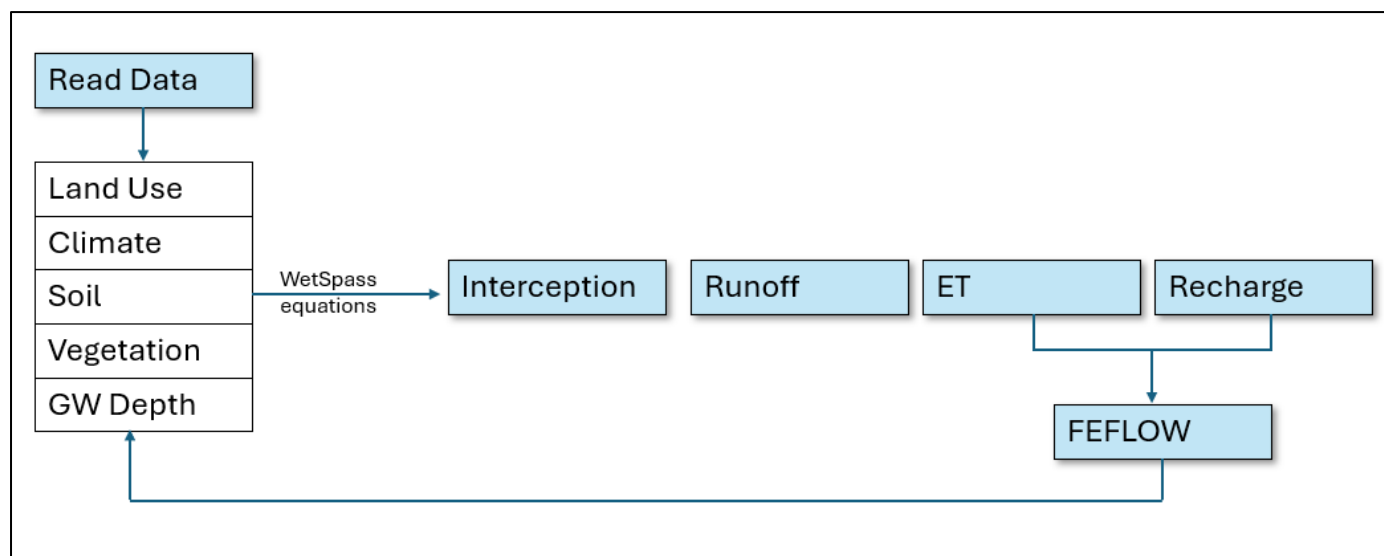


Figure A. 4 Numerical groundwater model workflow chart.

#### A.3.1 Input data

Input data used to develop and parameterise (‘construct’) the *WetSpass*<sup>TM</sup> and *FEFLOW* numerical models are listed in **Table A. 2** and shown in **Figure A. 5**. Land uses and their percentages used in this assessment are also summarised in **Figure A. 6**. The components of these models were developed using the horizontal datum, Geocentric Datum of Australia 1994 (GDA 94 / MGA zone 50), and the vertical datum, Australian Height Datum (AHD), for all geospatial input data.

<sup>1</sup> *WetSpass*<sup>TM</sup> is a physically based distributed methodology for estimating the long-term average, spatiotemporally variable components of the water balance: groundwater recharge, surface runoff, and actual evapotranspiration. Based on dispersed data, it solves the water balance equation cell by cell for the vegetated area, bare soil, open water, and impermeable surfaces, allowing for the calculation of surface runoff, actual evapotranspiration, and groundwater recharge for seasonal periods.

Table A. 2 Data sources for the WetSpass™ and FEFLOW models

Input parameter	Period	Data source	Spatial reference	File name
Elevation (topography)	2023	LIDAR	1 m x 1 m	<i>Alcoa_Merged_20230119_Tile9of10_1m_clipped.tiff</i>
Leaf-area index	2022	Calculated using satellite imagery	30 m x 30 m	<i>2022_2021349LC08_SR_cal_LAI.tif</i>
Land use	2022 – 2025	Alcoa (2025a)	-	<i>WillowdaleClearingTo202412_GDA2020z50.shp</i>
Vegetation mapping	2022 – 2023	Mattiske Consulting Pty Ltd (2021)	-	<i>Havel Vegetation Mapping.shp</i>
Geological model	-	WSP (2025), populated by Alcoa’s exploration and monitoring bore drilling data	-	<i>Hydrostratigraphic Model for Empodisma peatlands (TEC / GDE) .</i>
Groundwater monitoring data	2022 – 2025	Alcoa (2025b)	-	<i>DCMP Summary Bores Monitoring Data_v4_20250318.xlsx</i>

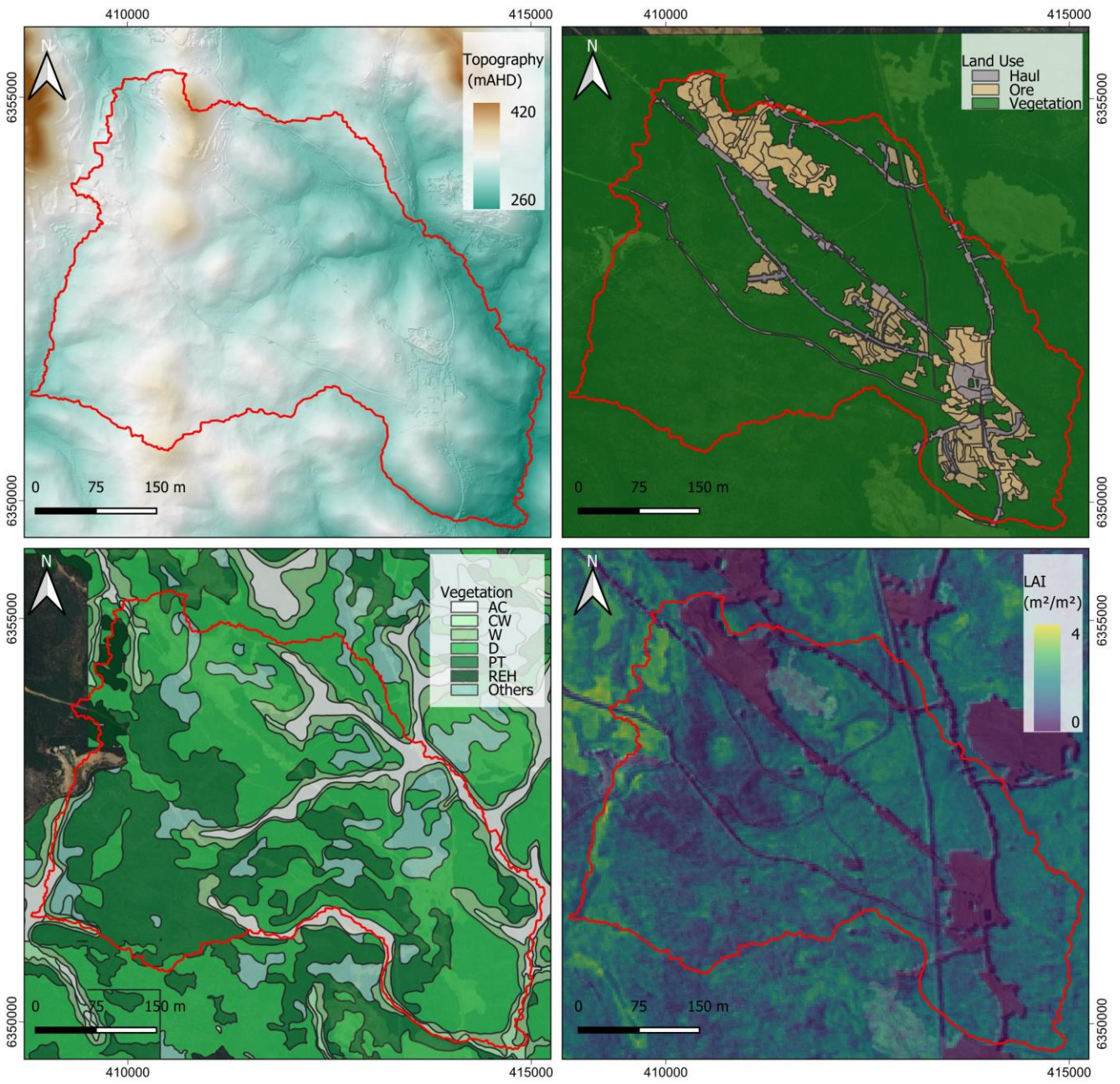


Figure A. 5 Inputs components WetSpas™

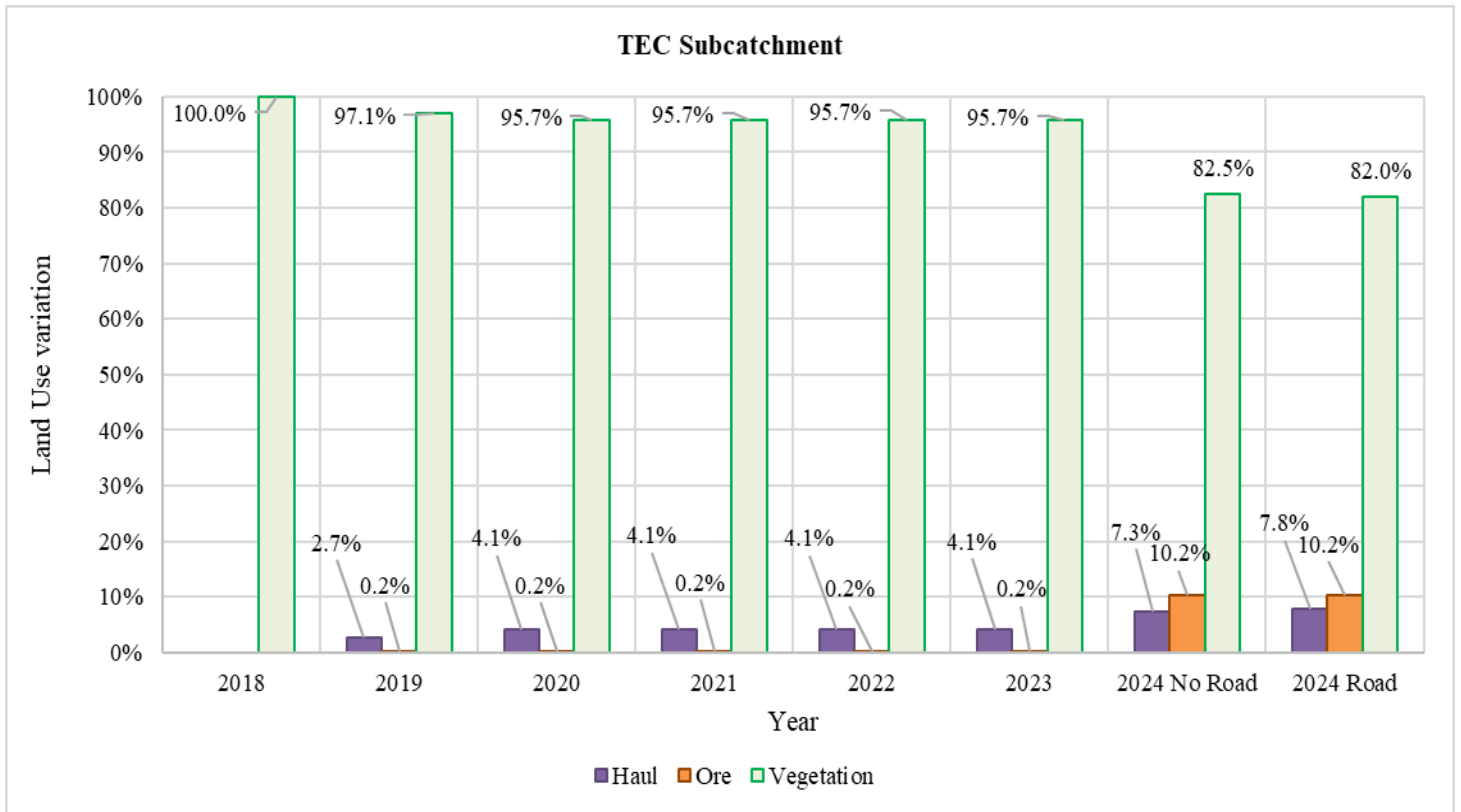


Figure A. 6 Land use changes over 2018-2024 in the study area

### A.3.2 WetSpass™ model parameterisation, calibration and assumptions

Input parameters and their accompanying values used to estimate seasonal variations of transpiration used in the numerical application *WetSpass™* are spatialised and vary across the site. The average values for the study are summarised below.

- Catchment area: 20.2 km<sup>2</sup>.
- Leaf-area index: 1.5 m/m.
- Root depth: 40 m.
- Vegetation height: 28 m.
- Manning’s ‘n’ for surface water runoff: 0.10.
- Evaporative depth: 0.5 m.
- Depth of groundwater: 6 m.

Calibration of the *WetSpass™* model parameters was done using climate and land use data from 2024. To assist with this process, the study area was divided into nine sub-catchments (refer to **Figure A. 7**) with the Flinders mine pit *Empodisma* peatlands (TEC / GDE) located in sub-catchment 4. Sub-catchments 2 and 3, which are natural (‘undisturbed’ areas) were used as reference conditions for model calibration, the outcomes of which are summarized in **Table A. 3** and shown in **Figure A. 8**.

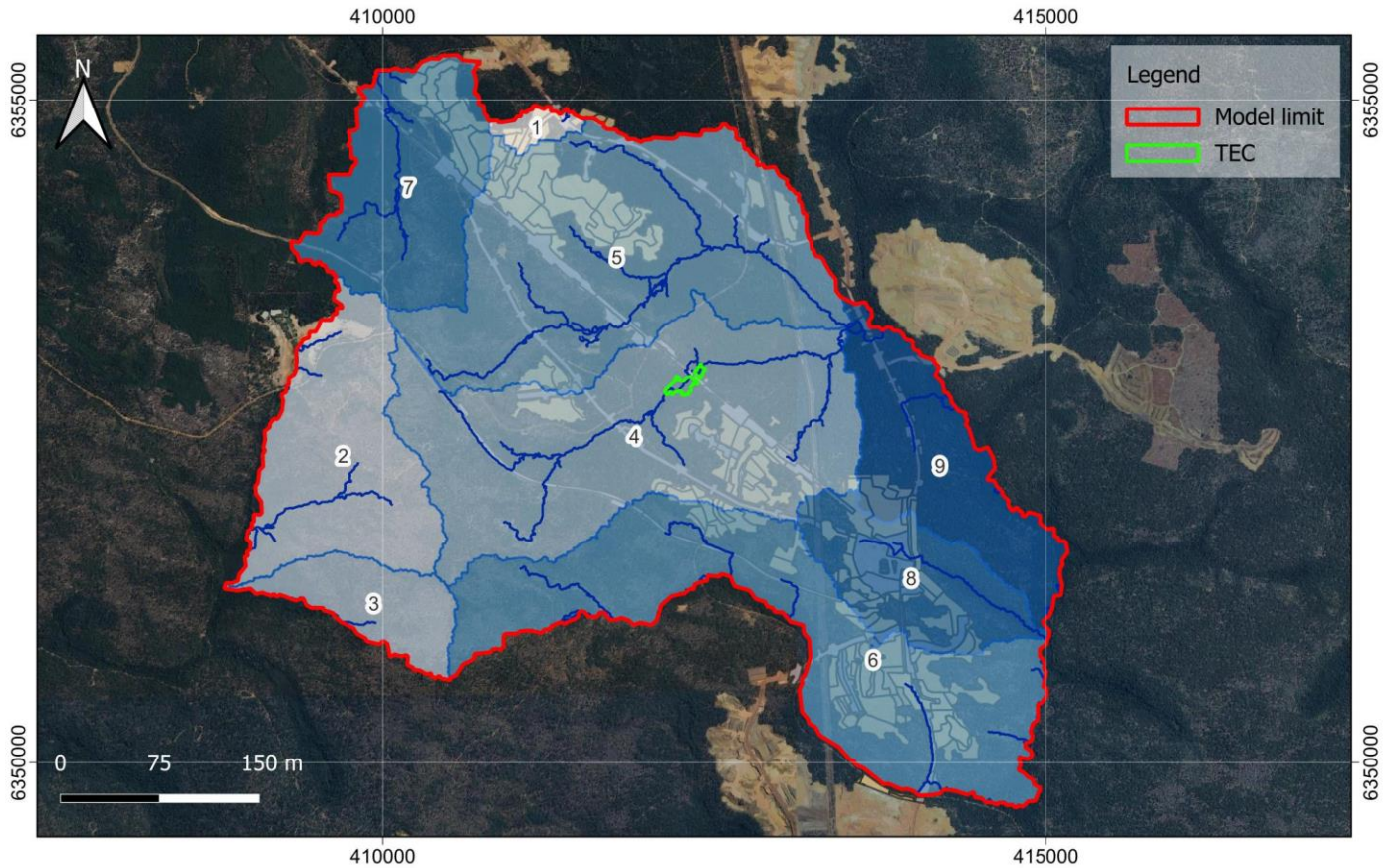


Figure A. 7 WetSpass™ model and calibration sub-catchments

Table A. 3 WetSpass™ model conditions

Sub-catchment	Rainfall (mm/year)	Interception (% of rainfall)	Runoff (% of rainfall)	Evapotranspiration* (% of rainfall)	Recharge (% of rainfall)	Transpiration* (% of rainfall)
1	1137.8	1	10	43	46	5
2		4	12	76	8	32
3		5	12	72	11	31
4		4	14	80	6	30
5		3	13	70	14	24
6		3	13	71	14	26
7		3	12	68	17	26
8		2	15	59	25	19
9		4	14	80	2	31

\* Evaporation + transpiration = evapotranspiration

The following data and assumptions were applied during the calibration of the *WetSpass™* numerical model.

- Values for rainfall interception, runoff, transpiration, and recharge used, are summarised in **Table A. 4**. These values are considered somewhat ‘typical’ for natural catchments which have not been subject to mining activities.

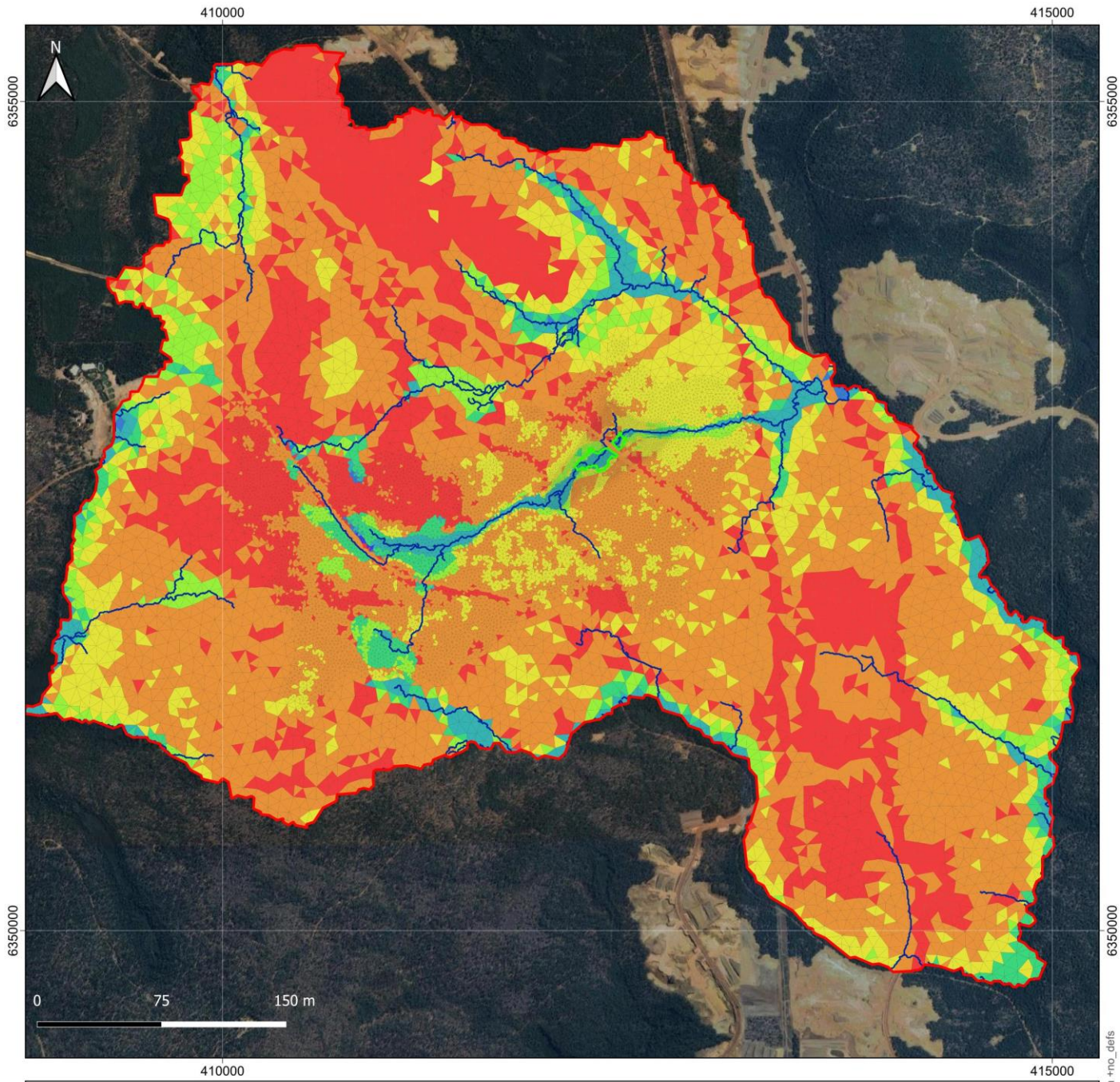
Table A. 4 Conceptual reference values for water balance

Component	Rainfall range (mm/year)	Rainfall percentage (%)	Source
Interception	80 – 229	4 – 21	Macfarlane, et al. (2018)
Evapotranspiration	433 – 1018	40 – 100	Macfarlane, et al. (2018)
Transpiration	231 – 505	21 – 46	Macfarlane, et al. (2010) and (2018).
Recharge	65 – 274	6 – 25	Lee, et al. (2024)
Runoff	44 – 165	4 – 15	WSP (2023)

- Cleared areas were considered up to September 2024.
- Manning’s Roughness Coefficient was applied proportionally to the leaf area index (LAI).  
[An LAI value of 0.05 corresponds to the minimum coefficient, while LAI values equal to or greater than 3 correspond to the maximum coefficient.]
- Soil water storage is accessed by the extensive rooting systems throughout the Jarrah Forest, reaching depths of 40 m or more (Dell et al., 1983 cited in Grigg (2017)).
- In those areas where stripping and mining was or had been completed, calculated runoff was added to the recharge values.
- The road was modelled as a "bare area", where transpiration and recharge were reduced while runoff and evaporation increased. In terms of surface area, however, this change was minimal, resulting in:
  - a 0.5% reduction in vegetation cover, and
  - consequently, minimal to negligible meaningful impact on water dynamics.

The *WetSpass<sup>TM</sup>* model also considered:

- where the groundwater table was less than 1 m below ground surface then rainfall recharge was ‘zero’ (i.e., the soil was saturated with infiltration now negligible and surface water runoff now the dominant water flux)
- any surface water runoff in the mined areas was negligible, and
- all surface water flow in the pits is ‘lost’ via infiltration, constituting groundwater recharge for the near-surface unconfined aquifer(s).



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	Model limit	<b>CLIENT</b>	
	Potential Empodisma Peatland	Alcoa of Australia Ltd (Alcoa)	
<b>WetSpass result (mm/year)</b>		<b>PROJECT</b>	
	< -2800	Alcoa Flinders Area Assessment	
	-2800 - -2500	<b>TITLE</b>	
	-2500 - -1700	WetSpass result - InFlow OutFlow (mm/year)	
	-1700 - -1400	<b>CONSULTANT</b>	
	-1400 - -1000		YYYY-MM-DD 2025-03-24
	-1000 - -676	DESIGNED	PH
	-676 - -310	PREPARED	PH
	-310 - 55	REVIEWED	LS
	55 - 421	APPROVED	LS
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Figure A. 8 WetSpass™ inflow and outflow calibration distribution – 2024

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### A.3.3 FEFLOW model parameterisation, calibration and assumptions

Assumptions adopted during the development ('construction') and calibration of the *FEFLOW* numerical groundwater flow model included the following.

- Groundwater elevations considered in Scenario 1 were an average of all measurements collected and provided to WSP for 2024; i.e., elevations considered measurements collected during both the dry period (April) and wet period (September).  
Groundwater elevations from 2024 were used as this data set was the most comprehensive and included measurements from the greatest number of groundwater monitoring bores (37), including having the greatest spatial coverage in the catchment.
- A three-level mesh refinement was applied to the numerical model as summarised in the following bullet points and shown in **Figure A. 9**:
  - Level 1 (high resolution) – within and around the Flinders mine pit *Empodisma* peatlands (TEC / GDE) area with 5 m edge lengths.
  - Level 2 (moderate resolution) – covering the *Empodisma* peatlands (TEC / GDE) catchment area with 25 m edge lengths.
  - Level 3 (low resolution) – applied to external parts of the model (more distant from the *Empodisma* peatlands (TEC / GDE)) with 80 m edge lengths.
- Vertical model discretisation was based on the geological model of the study area (refer to **Figure A. 9** and file reference in **Table 2-1** in the main body text of this Technical Memorandum).
- Initial and 'final' (i.e., calibrated) hydraulic conductivity values used in the numerical groundwater flow model is presented in **Table A. 5**.

Table A. 5 Summary of field investigation and FEFLOW calibrated model hydraulic parameters

Geological unit	Field investigation estimates (WSP, 2024)			Calibrated value (m/day)
	Minimum (m/day)	Average (m/day)	Maximum (m/day)	
<b>Horizontal hydraulic conductivity</b>				
Alluvium	--	--	--	17.3
Soils – upper slopes	0.06	0.5	10	8.6
Soils – mid slopes	0.02	0.2	4.0	
Soils – lower slopes	0.001	0.013	1.6	
Duricrusts	0.2	--	1.0	6.9
Bauxite				6.0
Clay	--	0.01	--	0.5
Basement – weathered	0.17	0.59	1.6	0.7
Fresh bedrock - granite	--	--	--	0.01
<b>Vertical hydraulic conductivity</b>				
Alluvium	--	--	--	17.3
Soils – upper slopes	--	--	--	8.6
Soils – mid slopes	--	--	--	
Soils – lower slopes	--	--	--	
Duricrusts	--	--	--	6.9
Bauxite	--	--	--	6.0
Clay	--	--	--	0.05

Geological unit	Field investigation estimates (WSP, 2024)			Calibrated value (m/day)
	Minimum (m/day)	Average (m/day)	Maximum (m/day)	
Basement – weathered	0.1	--	0.2	0.07
Fresh bedrock – granite	--	--	--	0.01

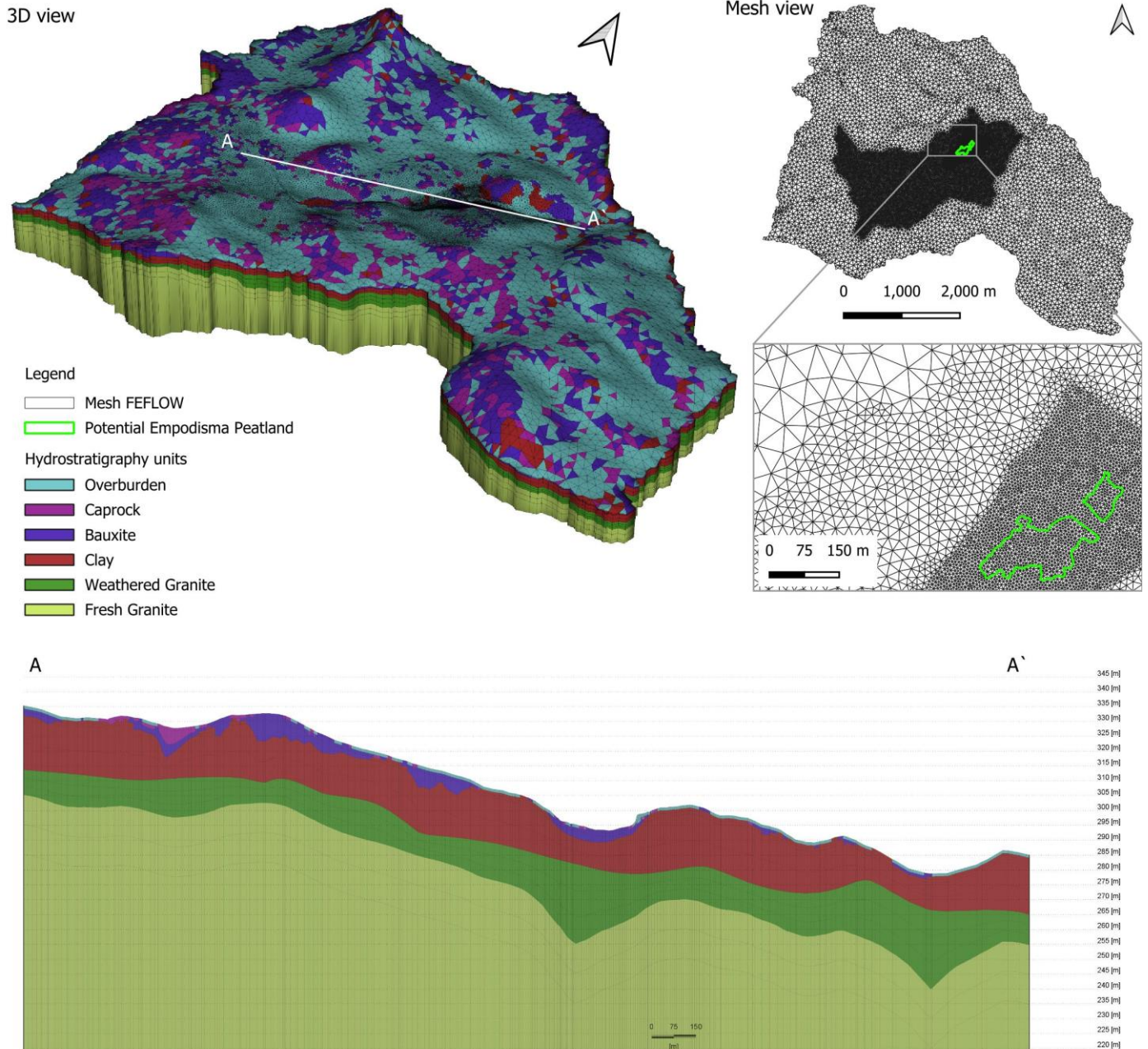


Figure A. 9 FEFLOW model mesh and hydrostratigraphic units

— The FEFLOW numerical groundwater flow model was calibrated under steady-state conditions considering Richard's flow equation<sup>2</sup> for unsaturated or variably saturated groundwater flow. Groundwater elevations used for calibration were the average of those values recorded in April and September 2024, while recharge rates were derived from *WetSpas*<sup>TM</sup> outputs.

<sup>2</sup> For further information refer to [FEFLOW 7.2 Documentation - Unsaturated Flow](https://download.feflow.com/html/help72/feflow/08_ProblemSettings/Flow/unsaturated_flow.html), ([https://download.feflow.com/html/help72/feflow/08\\_ProblemSettings/Flow/unsaturated\\_flow.html](https://download.feflow.com/html/help72/feflow/08_ProblemSettings/Flow/unsaturated_flow.html)).

Model calibration focused on adjusting the hydraulic conductivity values of the various geological units so that modelled groundwater elevations under steady-state conditions best approximated that groundwater profile estimates from the ‘averaged’ April and September 2024 groundwater elevations.

Observed versus modelled groundwater elevations for each of the groundwater monitoring bores in the catchment in which the Flinders mine pit *Empodisma* peatlands (TEC / GDE) is located is shown in **Figure A. 10**; this figure shows model estimates of groundwater elevations are generally between 1 and 3 m higher than the averaged (and theoretically inferred) April and September 2024 groundwater surface considered for calibration purposes.

Root-mean square (RMS) and normalised root-mean square (nRMS) errors are also shown on **Figure A. 10**. These values are both less than 10% suggesting these outcomes are acceptable.

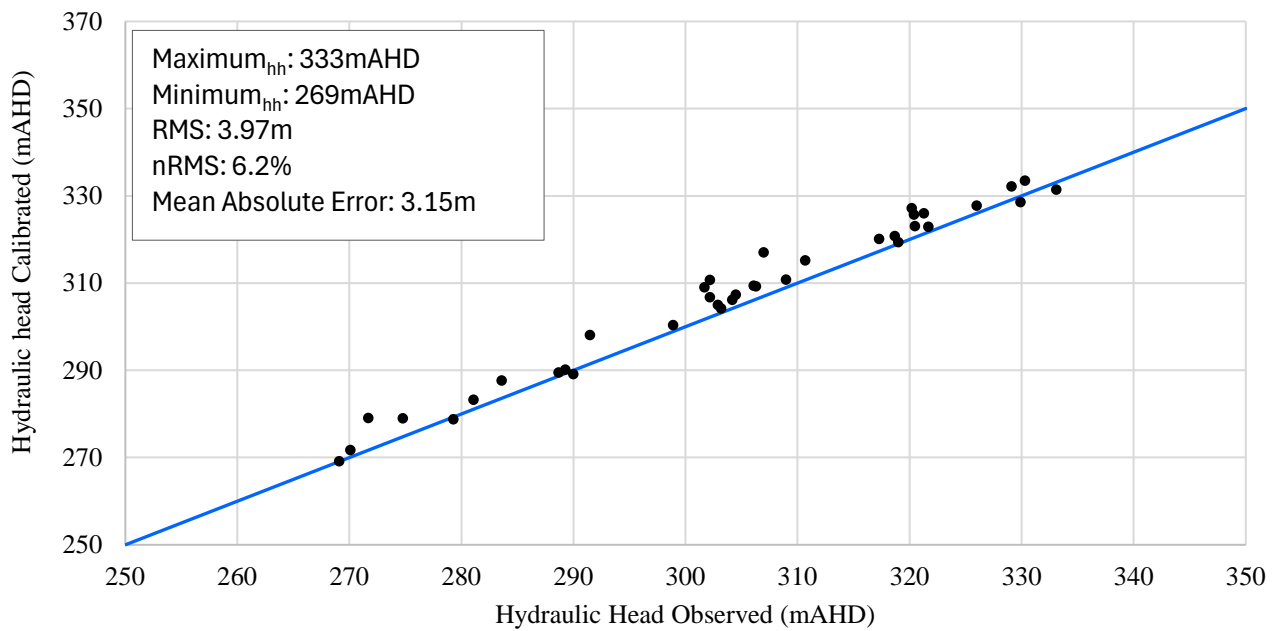


Figure A. 10 Modelled V’s observed groundwater elevations and model calibration statistics

### A.3.4 Phase A assessment outcomes

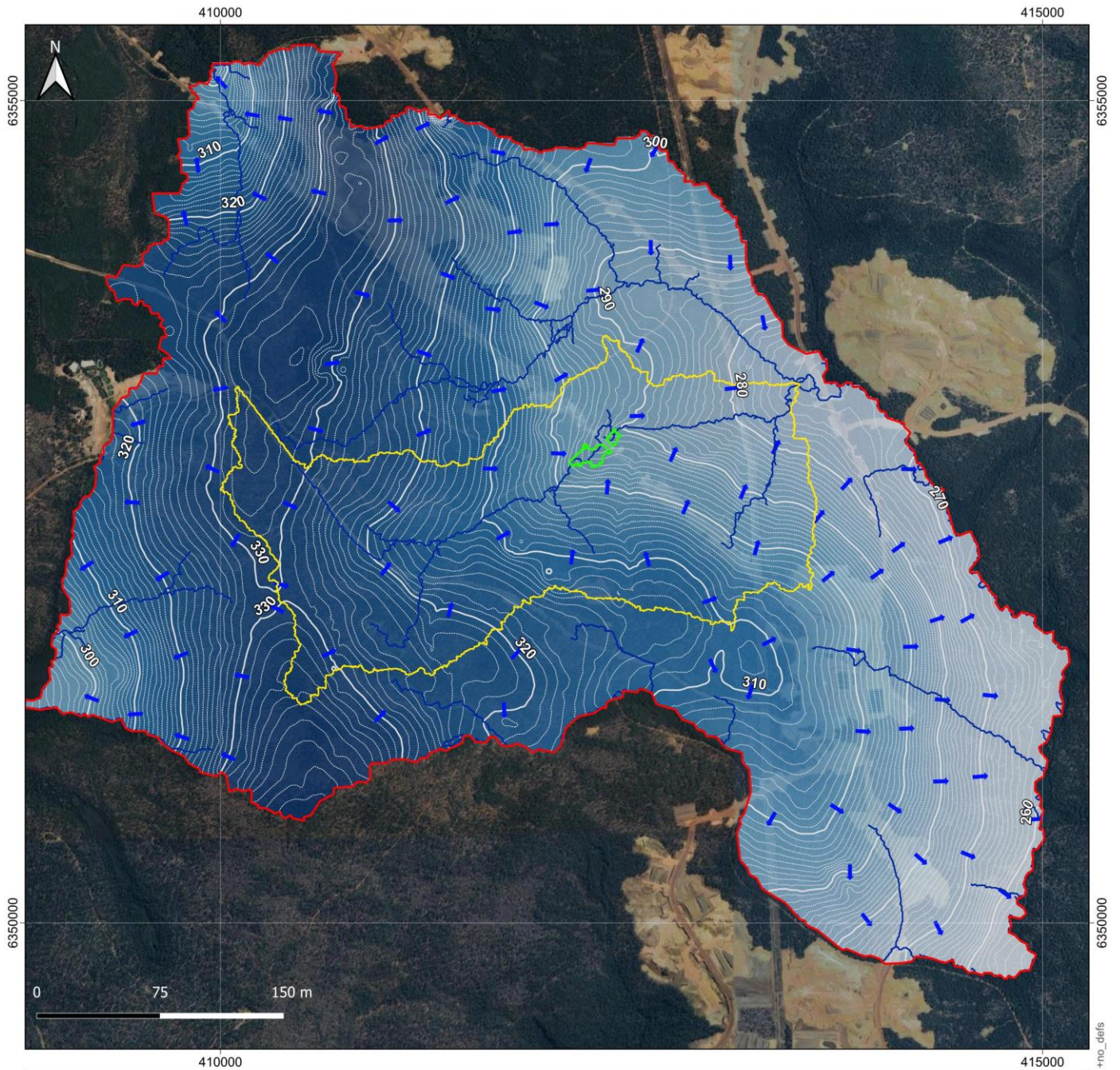
Calibrated values from both the *WetSpass<sup>TM</sup>* and *FEFLOW* models were used to inform those numerical simulations for Scenario 1 (September 2023), Scenario 2 (September 2024, without the haul road), and Scenario 3 (September 2024 with the haul road). A summary of the various land uses and water balance fluxes for each of these scenarios are summarised in **Table A. 6** whilst modelled water table elevation contours for each scenario are presented in **Figure A. 11**, **Figure A. 12** and **Figure A. 13** respectively.

Table A. 6 Summary of field investigation and *FEFLOW* calibrated model hydraulic parameters

Scenario	Land Use	Area (%)	Rainfall (mm/year)	Transpiration* (mm/year) [% of rainfall]	Recharge (mm/year) [% of rainfall]	Runoff (mm/year) [% of rainfall]	Evaporation * (mm/year) [% of rainfall]
1 [Sep 2023]	Haul road	7.3%	952.6	302.4	11.0	133.4	505.8
	Ore production	10.2%		[31.7]	[1.2]	[14.0]	[53.1]
	Vegetation	82.5%					
2 [Sep 2024, no haul road]	Haul road	7.3%	1137.8	333.1	70.1	154.5	580.1
	Ore production	10.2%		[29.3]	[6.2]	[13.6]	[51.0]
	Vegetation	82.5%					

Scenario	Land Use	Area (%)	Rainfall (mm/year)	Transpiration* (mm/year) [% of rainfall]	Recharge (mm/year) [% of rainfall]	Runoff (mm/year) [% of rainfall]	Evaporation * (mm/year) [% of rainfall]
3 [Sep 2024 with haul road]	Haul road	7.8%	1137.8	332	68.7	155.9	581.2
	Ore production	10.2%		[29.2]	[6.0]	[13.7]	[51.1]
	Vegetation	82.0%					

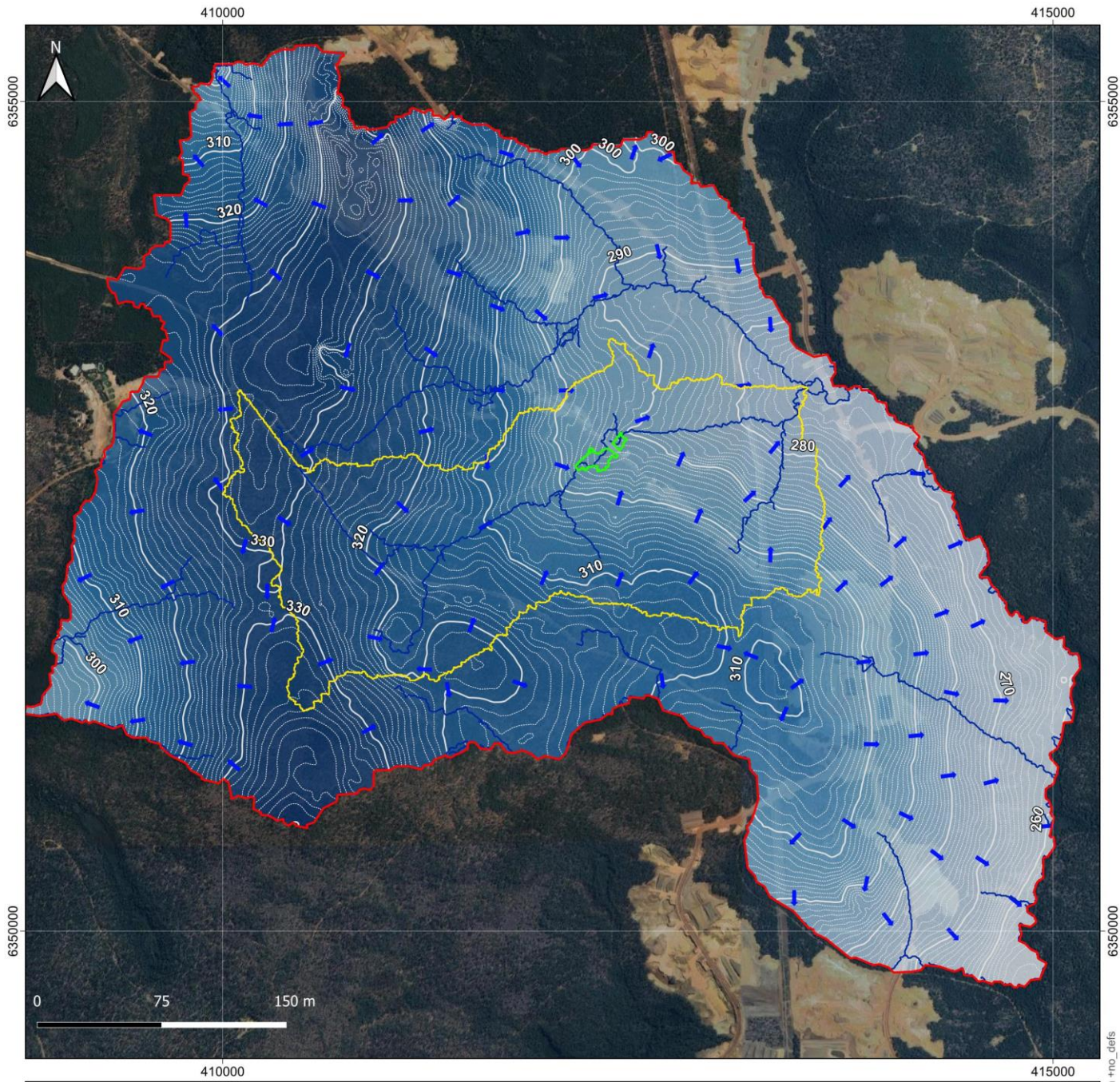
\* Evaporation + transpiration = evapotranspiration



<b>Legend</b>		<p>↑ Flow direction</p> <p>Contours (m AHD)</p> <p>— 10 m AHD</p> <p>— 1 m AHD</p> <p>Groundwater elevation (m AHD)</p> <p>340</p> <p>255</p>		<p>© WSP Australia Pty Ltd ("WSP") Copyright in the drawings, information and data recorded ("the information") is the property of WSP. This document and the information are solely for the use of the authorised recipient and this document may not be used, copied or reproduced in whole or part for any purpose other than that which it was supplied by WSP. NCSI Certified Quality System to ISO 9001. © APPROVED FOR AND ON BEHALF OF WSP Australia Pty Ltd.</p>	
— Stream line	— Model limit			<p>CLIENT</p> <p><b>Alcoa of Australia Ltd (Alcoa)</b></p>	
— Potential Empodisma Peatland	— Subcatchment			<p>PROJECT</p> <p><b>Alcoa Flinders Area Assessment</b></p>	
				<p>TITLE</p> <p><b>Groundwater modelled - Simulation September/2023 - Scenario 1</b></p>	
		<p>CONSULTANT</p> <p><b>wsp</b> www.wsp.com</p>		<p>YYYY-MM-DD</p> <p>2025-03-24</p>	
				<p>DESIGNED</p> <p>PH</p>	
				<p>PREPARED</p> <p>PH</p>	
				<p>REVIEWED</p> <p>LS</p>	
				<p>APPROVED</p> <p>LS</p>	
		<p>PROJECT NO</p> <p><b>PS221297</b></p>		<p>REV.</p> <p><b>A</b></p>	

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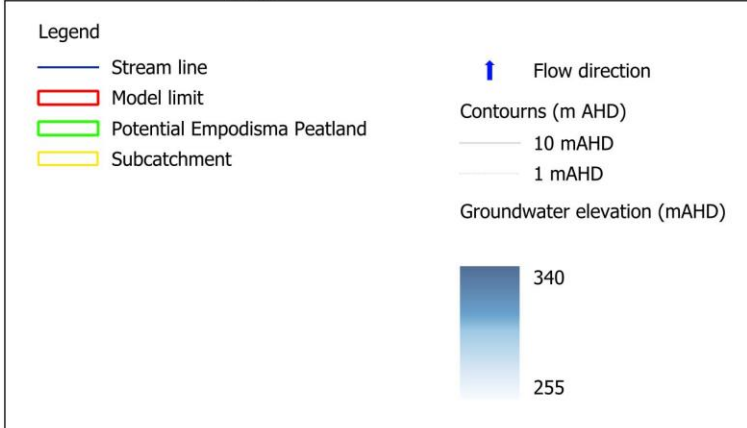
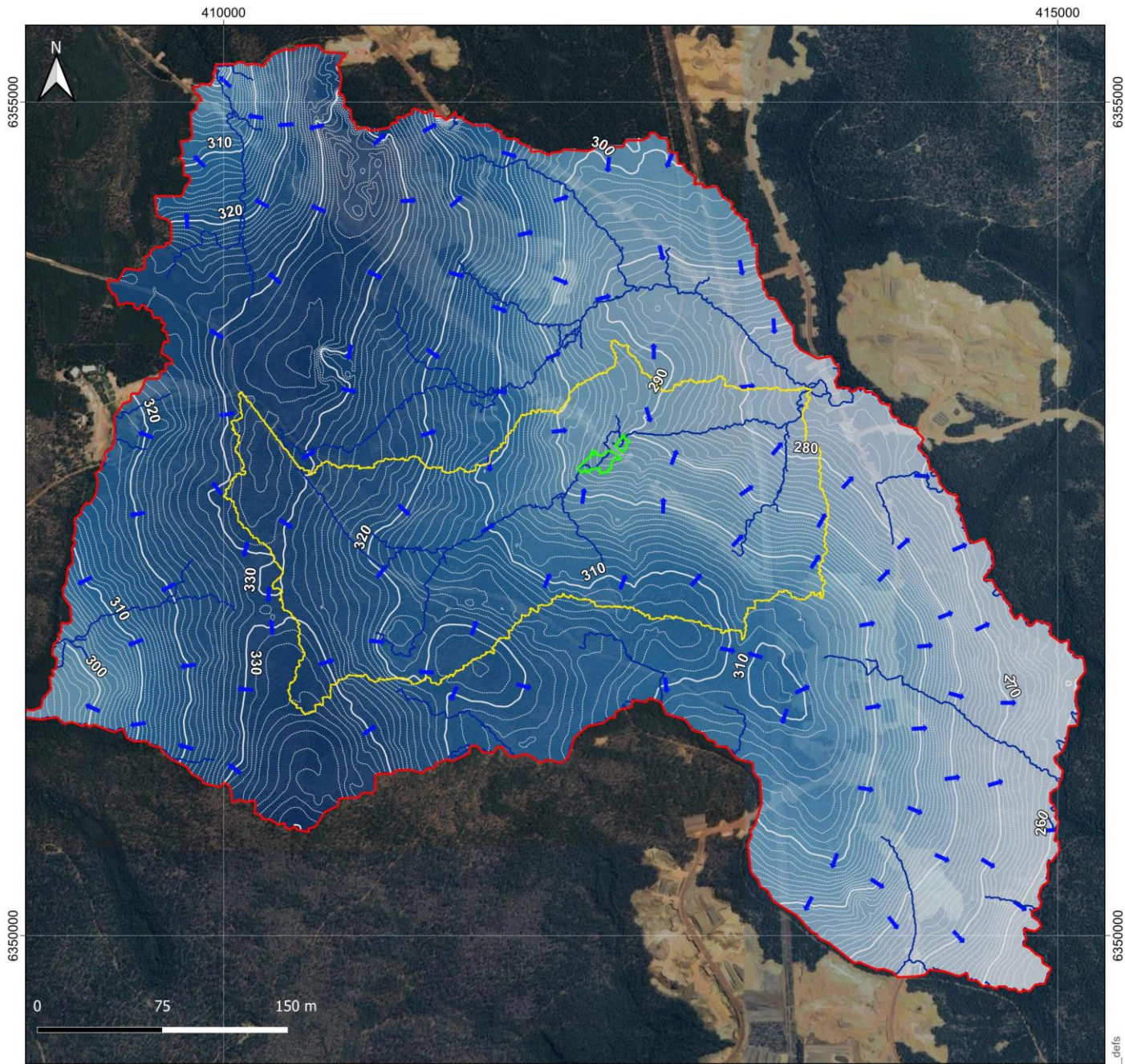
Figure A. 11 Modelled groundwater elevations – Scenario 1



<b>Legend</b> Stream line Model limit Potential Empodisma Peatland Subcatchment		Flow direction Contours (m AHD) 10 m AHD 1 m AHD Groundwater elevation (mAHD) 																				
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Figure A. 12 Modelled groundwater elevations – Scenario 2



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CLIENT  
Alcoa of Australia Ltd (Alcoa)

PROJECT  
Alcoa Flinders Area Assessment

TITLE  
**Groundwater modelled - Simulation September/2024 - Road - Scenario 3**

CONSULTANT	YYYY-MM-DD	2025-03-24
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	PREPARED	PH
	REVIEWED	LS
	APPROVED	LS

PROJECT NO  
**PS221297**

REV.  
**A**

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Figure A. 13 Modelled groundwater elevations – Scenario 3

The difference between groundwater elevations is shown for the following scenario combinations:

- Scenario 1 (baseline) vs Scenario 2 (clearing December 2024 and no road) (**Figure A. 14**)
- Scenario 1 (baseline) vs Scenario 3 (clearing December 2024 and road) (**Figure A. 15**), and
- Scenario 2 (clearing December 2024 and no road) vs Scenario 3 (clearing December 2024 and road) (**Figure A. 16**).

The difference maps show the no significant difference in groundwater elevations between Scenario 2 and 3. And any difference is primarily due to changes in rainfall (and not land use i.e. cleared areas).

A topographic section from the calibrated steady-state *FEFLOW* numerical model showing the inferred wet and dry season groundwater table elevation (again based on that limited monitoring data provided) is show in **Figure A. 17**. This figure suggests that during the wet season, groundwater levels are connected to that (surface) water in the Flinders mine pit *Empodisma* peatlands (TEC / GDE), in this case expressing as groundwater discharge along:

- some of the stream reach immediately upgradient of the *Empodisma* peatlands (TEC / GDE) , and
- along the margins of the *Empodisma* peatlands (TEC / GDE) In contrast, during the dry season the elevation of the groundwater table declines, invoking hydraulic disconnection between surface water and groundwater beneath the Flinders mine pit *Empodisma* peatlands (TEC / GDE), albeit with groundwater remaining ‘in connection’ and interacting with the TEC root zone. During this period, transpiration rates peak, and the roots extract significant amounts of water from the aquifer, further lowering groundwater levels and decreasing surface seepage.

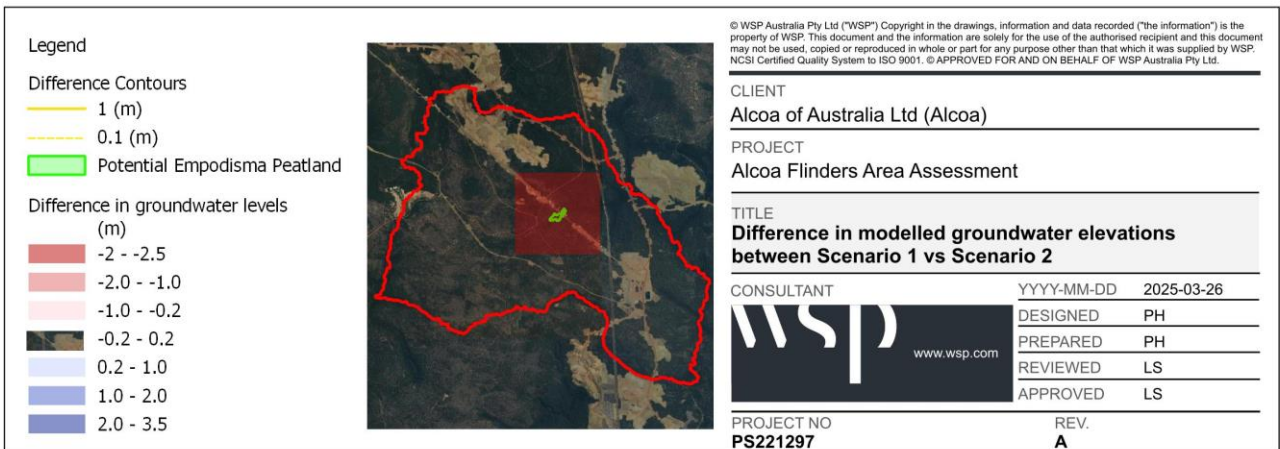


Figure A. 14 Difference in modelled groundwater elevations between Scenario 1 (baseline) vs Scenario 2 (clearing December 2024 and no road)

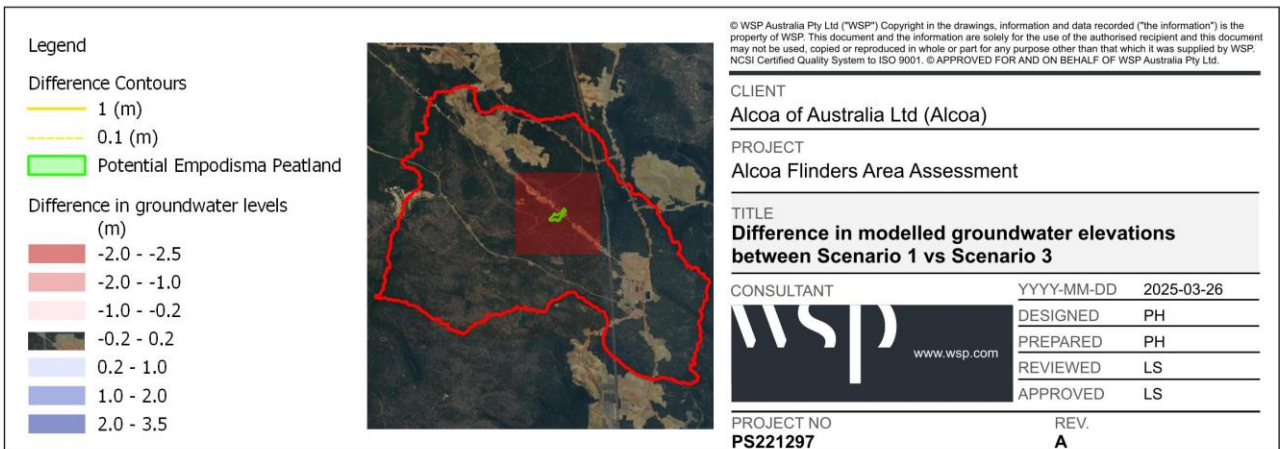
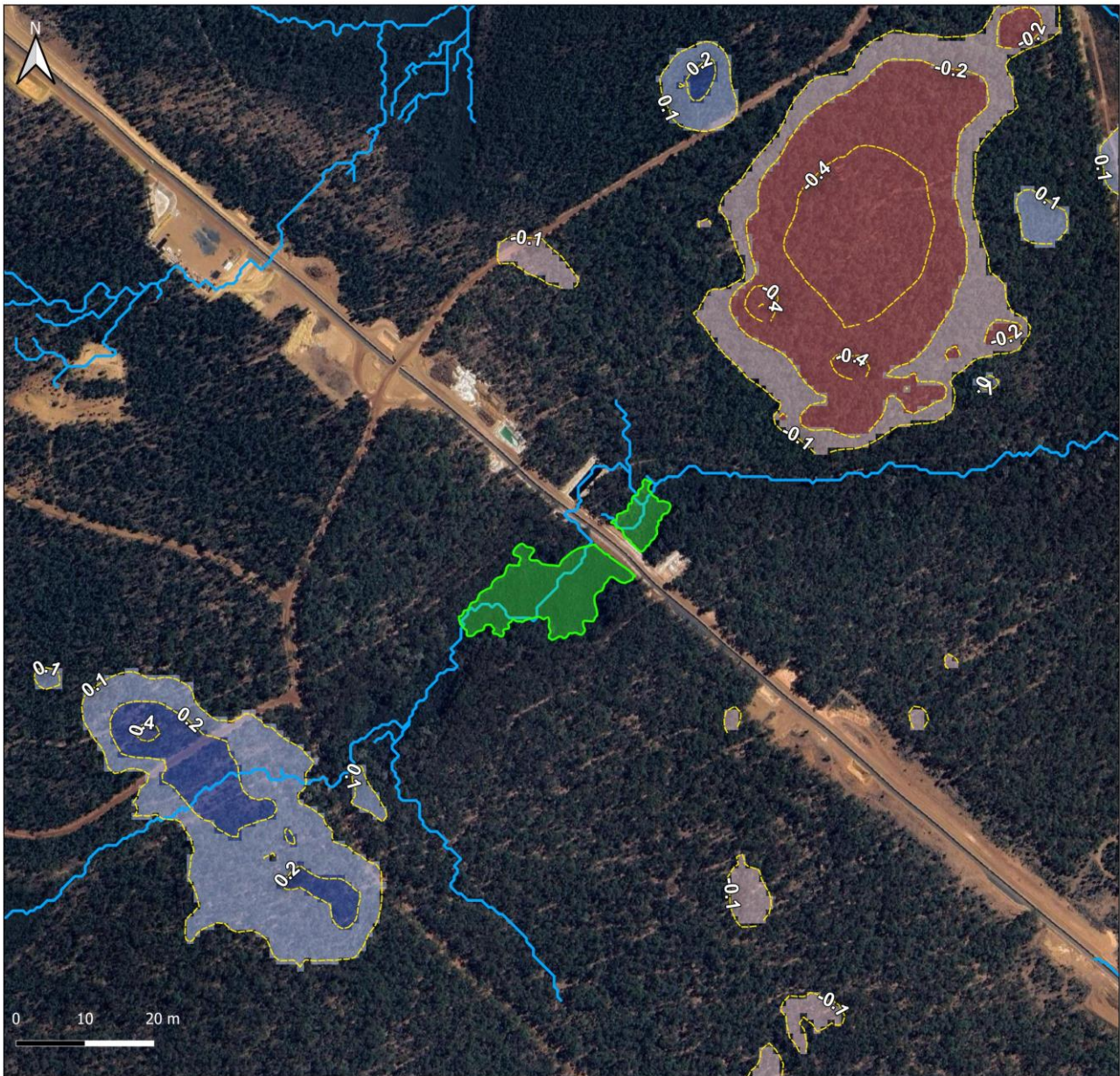


Figure A. 15 Scenario 1 (baseline) vs Scenario 3 (clearing December 2024 and road)

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<p><b>Legend</b></p> <p><b>Difference Contours</b></p> <ul style="list-style-type: none"> <li><span style="border-bottom: 1px solid yellow; width: 20px; display: inline-block;"></span> 1 (m)</li> <li><span style="border-bottom: 1px dashed yellow; width: 20px; display: inline-block;"></span> 0.1 (m)</li> <li><span style="background-color: #90EE90; border: 1px solid black; width: 20px; height: 10px; display: inline-block;"></span> Potential Empodisma Peatland</li> </ul> <p><b>Difference in groundwater levels (m)</b></p> <ul style="list-style-type: none"> <li><span style="background-color: #F08080; width: 20px; height: 10px; display: inline-block;"></span> -0.2 - 0.4</li> <li><span style="background-color: #FFB6C1; width: 20px; height: 10px; display: inline-block;"></span> -0.2 - -0.1</li> <li><span style="background-color: #8B4513; width: 20px; height: 10px; display: inline-block;"></span> -0.1 - 0.1</li> <li><span style="background-color: #ADD8E6; width: 20px; height: 10px; display: inline-block;"></span> 0.1 - 0.2</li> <li><span style="background-color: #6495ED; width: 20px; height: 10px; display: inline-block;"></span> 0.2 - 0.4</li> </ul>			<p><small>© WSP Australia Pty Ltd ("WSP") Copyright in the drawings, information and data recorded ("the information") is the property of WSP. This document and the information are solely for the use of the authorised recipient and this document may not be used, copied or reproduced in whole or part for any purpose other than that which it was supplied by WSP. NCSI Certified Quality System to ISO 9001. © APPROVED FOR AND ON BEHALF OF WSP Australia Pty Ltd.</small></p> <p><b>CLIENT</b> Alcoa of Australia Ltd (Alcoa)</p> <p><b>PROJECT</b> Alcoa Flinders Area Assessment</p> <p><b>TITLE</b> <b>Difference in modelled groundwater elevations between Scenario 2 vs Scenario 3</b></p> <table border="1"> <tr> <td><b>CONSULTANT</b></td> <td>YYYY-MM-DD</td> <td>2025-03-26</td> </tr> <tr> <td></td> <td>DESIGNED</td> <td>PH</td> </tr> <tr> <td></td> <td>PREPARED</td> <td>PH</td> </tr> <tr> <td></td> <td>REVIEWED</td> <td>LS</td> </tr> <tr> <td></td> <td>APPROVED</td> <td>LS</td> </tr> </table> <p><b>PROJECT NO</b> PS221297</p> <p><b>REV.</b> A</p>	<b>CONSULTANT</b>	YYYY-MM-DD	2025-03-26		DESIGNED	PH		PREPARED	PH		REVIEWED	LS		APPROVED	LS
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Figure A. 16 Scenario 2 (clearing December 2024 and no road) vs Scenario 3 (clearing December 2024 and road).

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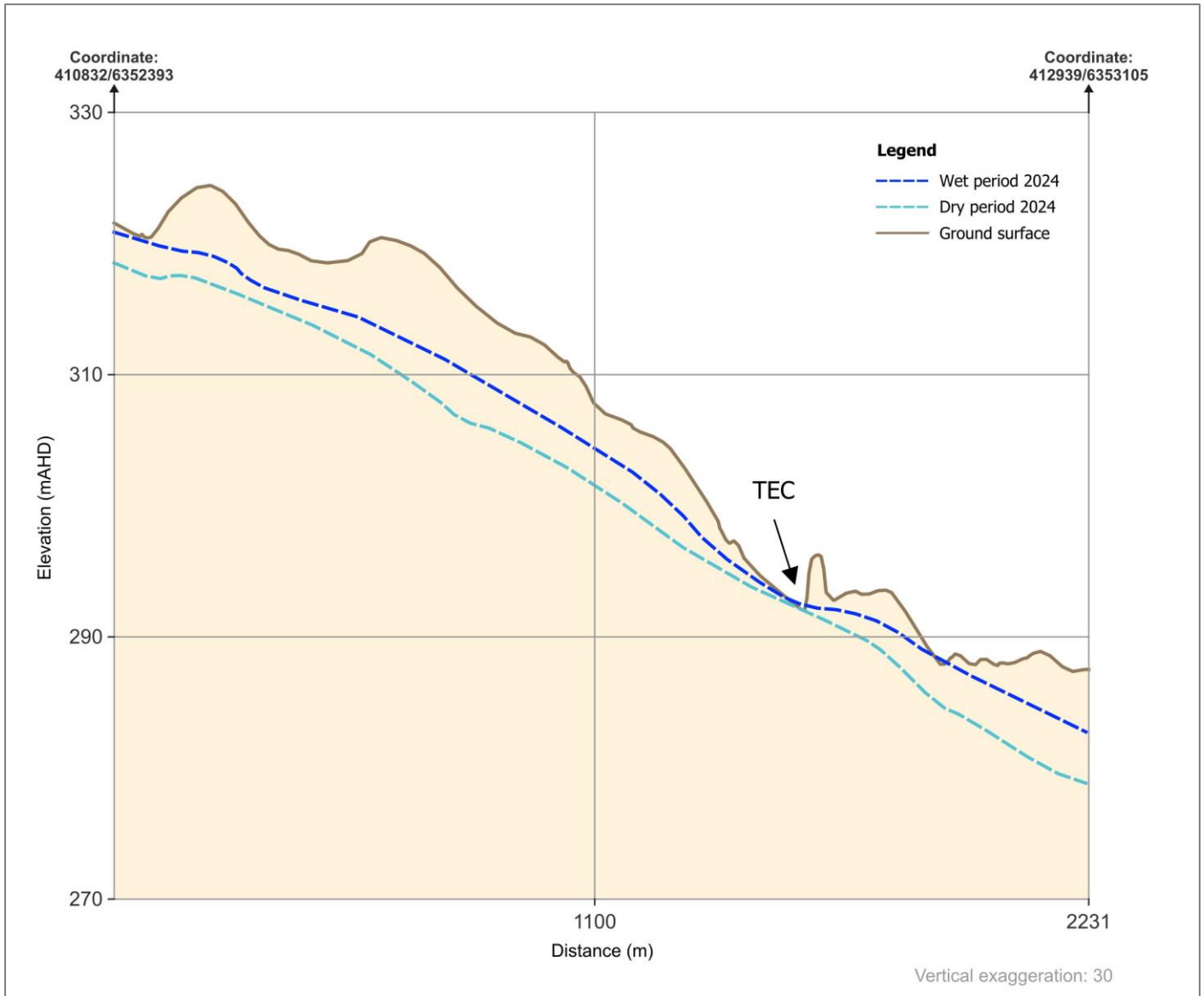


Figure A. 17 Cross-section for modelled groundwater elevations for both dry and wet periods

Modelled baseflow components for each scenario of Phase A are also shown in **Figure A. 18** and **Figure A. 19**.

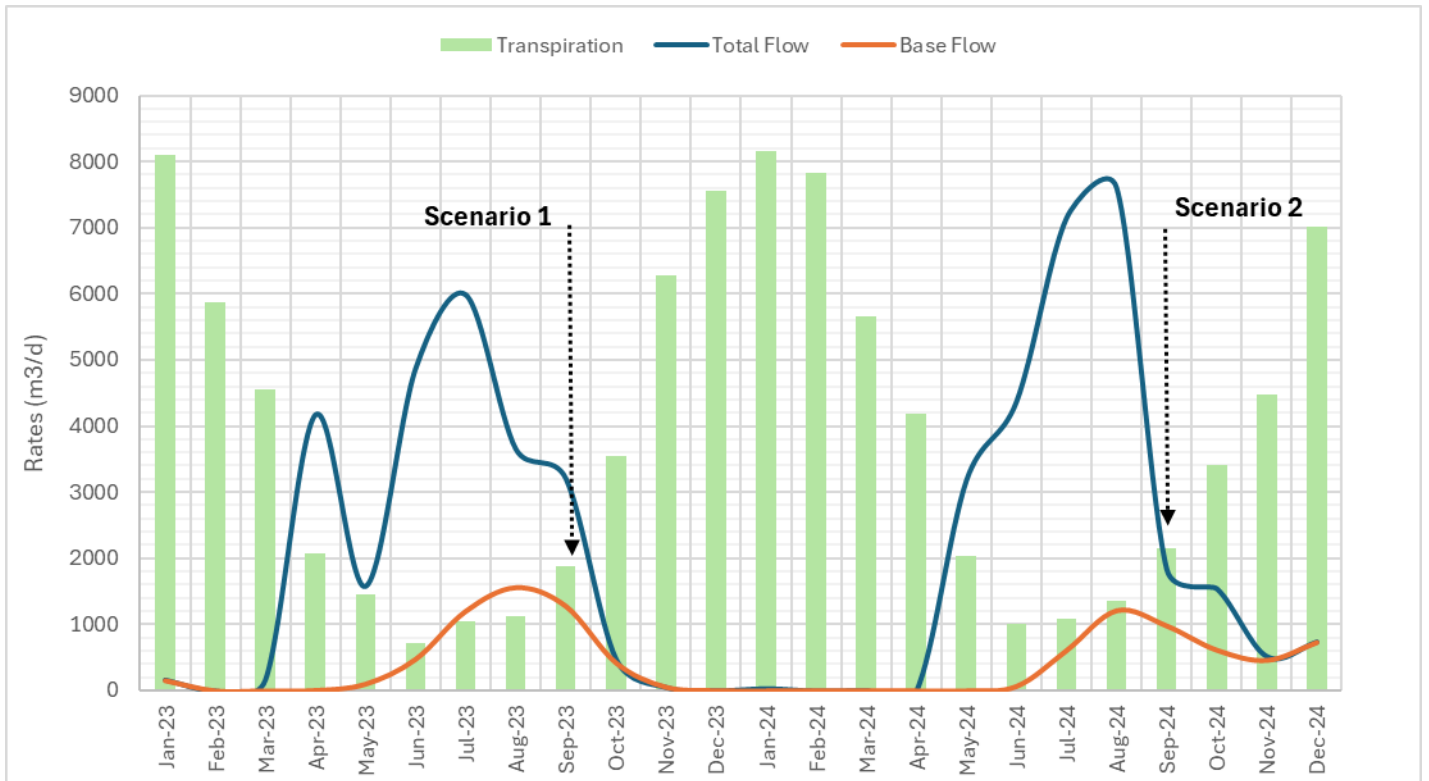


Figure A. 18 Estimated rates for 2023 and 2024 – Scenarios 1 and 2

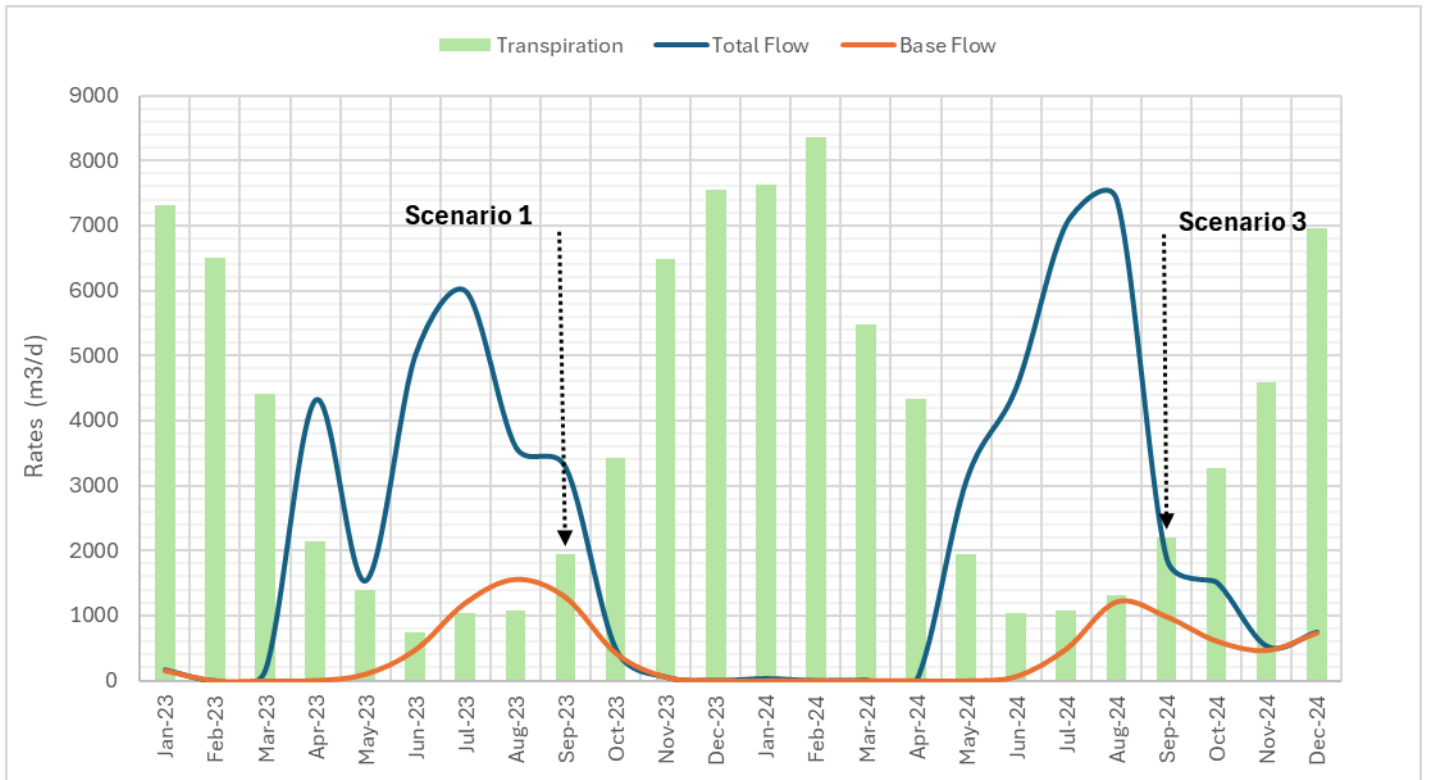


Figure A. 19 Estimated rates for 2023 and 2024 – Scenarios 1 and 3