Winu Closure: Surface Water Management Plan Update 2023 Memorandum

Date	September 3, 2024		
To	Emma McGivern	**From**	Damon Hortle, Peter Crichton
Project No	311012-01475	**Doc No**	311012-01477-TM-HY-023

Introduction

This document describes the methodology and results of the assessment of the Probable Maximum Flood (PMF), 0.02% AEP (1:5000 AEP) and 0.10% AEP (1:1000 AEP) closure events at proposed Winu mine site (herein referred to as the Site). The assessment of the flooding events have been undertaken to develop conceptual water management requirements and aid in the establishing the closure design event.

The model suite used in the assessment has been previously detailed in the Winu Operational Surface Water Management Plan Update 2023 (311012-01475-REP-HY-018). 311012-01475-REP-HY-018 should be referred to for basic model setup and parameters, with any deviations from the inputs detailed in that report presented below for clarity.

Probable Maximum Precipitation (PMP)

PMP is defined as 'the theoretical greatest depth of precipitation that is physically possible over a particular catchment' (WMO, 1986). PMP estimation was undertaken using the recommended methods for Australia as outlined in ARR2019 (Ball et al., 2019).

Bureau of Meteorology (BoM) (2005) Revised Generalised Tropical Storm Method (GTSMR) was utilised to generate the PMP rainfall depths in Table 1. The GTSMR is applicable to the northern two-thirds of Australia where it is assumed that the causative mechanism of the PMP would be a tropical storm (refer to Figure 1). The GTSMR method is applicable for durations from 24 hours to 120 hours and was undertaken for the Coastal Zone. Areal-reduced coastal summer values based on the 250 km^2 regional catchment were used, due to the connectivity of the dune subcatchments during the PMF event.

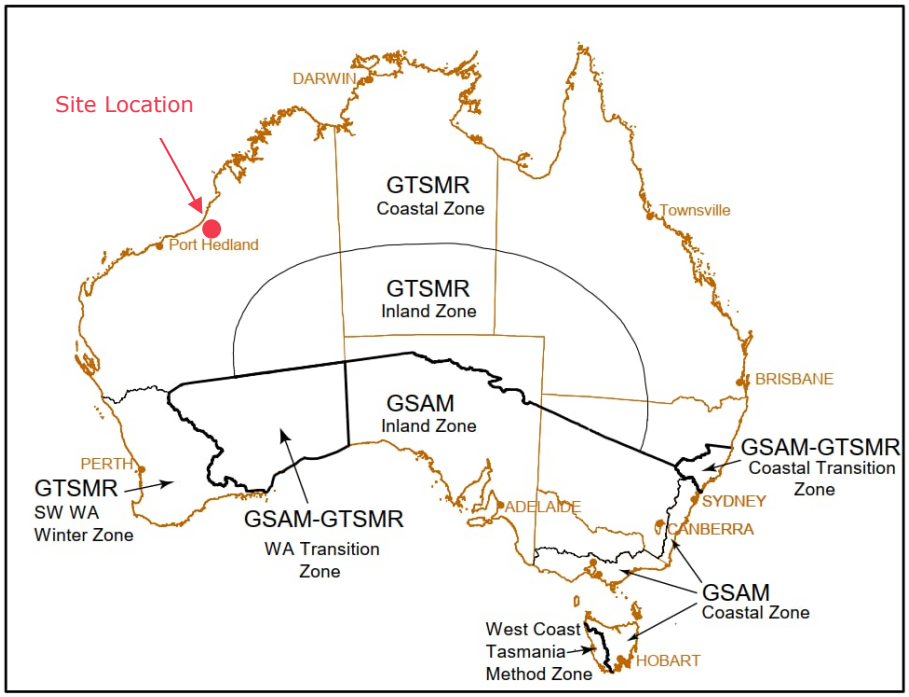


Figure 1. GTSMR Zones (BoM, 2005)

Table 1. PMP Rainfall Depths

Duration (Hours)	Rainfall Depth (mm)	Method
24	1,220	GTSMR
72	2,150	GTSMR
120	2,510	GTSMR

Probable Maximum Flood

The ARR2019 guidelines describe a PMF event as a flood estimate that has a negligible chance of being exceeded, representing the upper limit of flood magnitude for a particular catchment for the given PMP rainfall.

The PMF was modelled by applying the PMP rainfall depths (Table 1) in the hydraulic model (TUFLOW) and the critical duration was found by assessing the deepest inundation at critical locations. As the catchments at the Winu mine site are internally draining (i.e., endorheic basins), the depth of ponding is runoff volume dominant. Hence, due to the magnitude of rainfall and low losses in the PMF event, the critical event is informed by the length of the storm duration and total rainfall depth.

Given the internally draining landforms (volume dominant) and negligible loss values for the PMF event, temporal variability within design storm durations was expected to be low, resulting in little difference in estimated peak flood elevations. Accordingly, and given the conceptual nature of the assessment, the Coastal Average Variability Method (AVM) (BoM, 2005) temporal pattern was adopted for modelling all events of the Site.

1:1000 AEP and 1:5000 AEP events

The 1:1000 AEP event rainfall depth was extracted from IFD data obtained from BoM (2016) and areally reduced based on the 250 km^2 catchment with parameters from the ARR Datahub

(Babister *et al.,* 2016). The 1:5000 AEP event rainfall depth was calculated by interpolation using the 1:1000 AEP, 1:2000 AEP and AEP of PMP estimate, 1:4,000,000 AEP, (BoM, 2005) using the Siriwardena and Weinmann (1998) procedure. Depth interpolation was carried out between areal-reduced very rare and (already areal-reduced) PMP depths. Table 2 lists the areally-reduced and interpolated rainfall depths simulated in the direct rainfall function of the TUFLOW model.

Table 2. 1:5000 AEP and 1:1000 AEP Rainfall Depths

Duration (Hours)	1:5000 AEP Rainfall Depth (mm)	1:1000 AEP Rainfall Depth (mm)
24	506	397
72	567	460
120	589	473

Model Setup

The PMF event modelling incorporates a Burst Initial Loss (IL_B) of 0 mm and a Continuing Loss (CL) of 3 mm/hr. This aligns with guidance from Book 8 Chapter 4 of Australian Rainfall and Runoff (Ball et al., 2019) for Western Australia and consideration of probability-neutral design values. The approach assumes pre-burst PMP rainfall will saturate the soil, and the area's shallow silcrete geology may lead to perched groundwater conditions, reducing infiltration capacity. Interpolation between the 1:2000 AEP (62.4 mm IL_B, 10 m/hr *CL*) and PMP IL_B and *CL* loss estimates was calculated to estimate the loss parameters of the 1:5000 AEP Event. The TUFLOW model setup parameters are listed in Table 3.

Table 3. TUFLOW model setup parameters

Parameter	Adopted	
Grid Size	20 m, Sub-Grid Sampling (SGS): 5 m	
Manning's *n* roughness	Natural catchment: 0.04	
Temporal Pattern	Coastal Average Variability Method (AVM) (BoM, 2005)	
PMF Rainfall Losses	Burst Initial Loss (IL_B) (mm)	0
	Continuing Loss (CL) (mm/hr)	3
1:5000 AEP Rainfall Losses	Burst Initial Loss (IL_B) (mm)	54.9
	Continuing Loss (CL) (mm/hr)	9.2
1:1000 AEP Rainfall Losses	Burst Initial Loss (IL_B) (mm)	64.1
	Continuing Loss (CL) (mm/hr)	10
Outflow Boundary Conditions	Normal depth at model boundary, (HQ in TUFLOW) simulated sufficiently downstream as to not impact model results	

It is understood that all mine infrastructure, except for the Waste Rock Landform (WRL) and Mine Pit will be removed and rehabilitated at closure to reinstate pre-development conditions. Rio Tinto supplied a conceptual closure landform dataset for assessment, which contained a nominal abandonment bund offset ranging from 150 m to 200 m from the pit crest. This has been employed as the abandonment bund alignment (conceptually allowing for Zone of Instability and Factor of Safety [FoS] requirements). This is discussed in the Mine Pit Abandonment Bund Location section below.

Terrain Modifications

The drainage design of the TSF stipulated the inclusion of a 1% graded drainage channel between the WRL and TSF to separate the non-acid forming (NAF) and potentially-acid forming (PAF) runoff as pictured in Figure 2. This channel was simulated in the closure landform, draining north and south from the centre of the HST cells to the batters of the WRL.

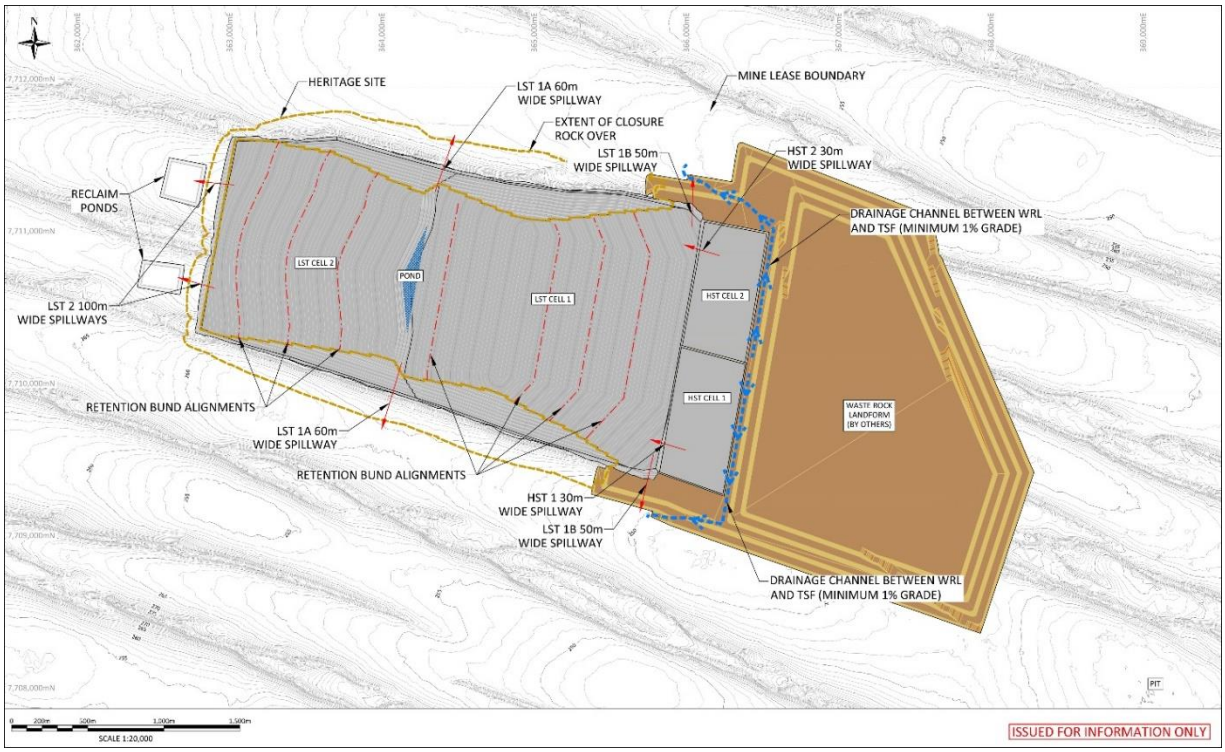


Figure 2. TSF Layout (MEM-C0007-B013-WWL-MEM-00004.00-127-032)

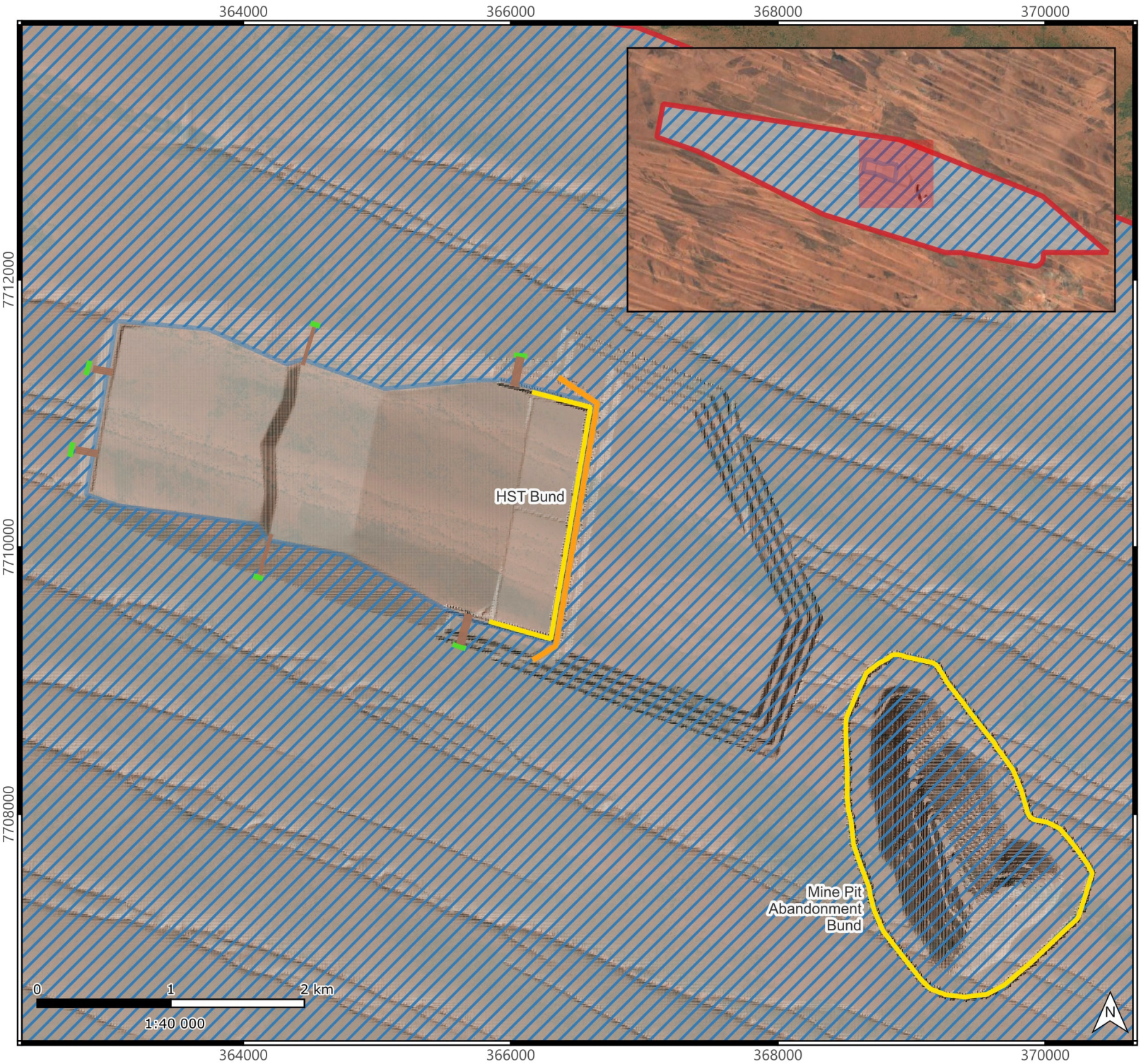
TSF runoff hydrographs

The drainage design of the TSF is managed by WWL (refer Doc: MEM-C0007-B013-WWL-MEM-00004.00-127-032). Direct rainfall was omitted for the surface area within the crests of the TSF design. TSF spillway outflow hydrographs were supplied by WWL for inclusion in the TUFLOW model. The hydrographs supplied were based on a PMP depth calculated with a catchment area of 1.7 km^2. This resulted in higher PMP depths than the Mine model depths calculated with a catchment area of 250 km^2, therefore the supplied PMP hydrographs were scaled to match the raw PMP depths with the factors presented in Table 4. Given the conceptual nature of the assessment this approach was deemed suitable to determine relative impacts.

Table 4. TSF runoff hydrograph raw PMP depth factors

Model/Factor	PMP 24h	PMP 72h	PMP 120h
TSF Model (1.7 km^2)	1377	2501	2946
Mine Model (250 km^2)	1303	2294	2707
Hydrograph factors	- 5.5%	- 9%	- 9%

The locations of the TSF spillway hydrograph inputs and the direct rainfall area are presented in Figure 3.



Winu Copper Gold Project
Surface Water Management Plan
Figure 3. TUFLOW Model Setup

Project No.	Client
311012-01475	Rio Tinto

Notes:
Project CRS: GDA94 / MGA zone 51
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Legend

- Bunds
- Drain
- TSF Outflow Locations
- TSF Outflow Spillways
- Model Extent
- Direct Rainfall

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Mine Pit Abandonment Bund Location

The zone of instability was calculated along the steepest cross-section of the Mine Pit to represent the worst-case scenario for bund wall placement. The presented section is along the southeastern Mine Pit wall. The area above the 45° line in Figure 4 represents the theoretical zone of instability for unweathered rock (Department of Industry and Resources, 1997). This zone encompasses the area with potentially unstable rock mass which is susceptible to collapse. A 25° trendline is also presented as an indication of the necessary setback if the Mine Pit wall geology were classed as weathered rock. The supplied abandonment bund alignment is set back at a maximum of approximately 35°.

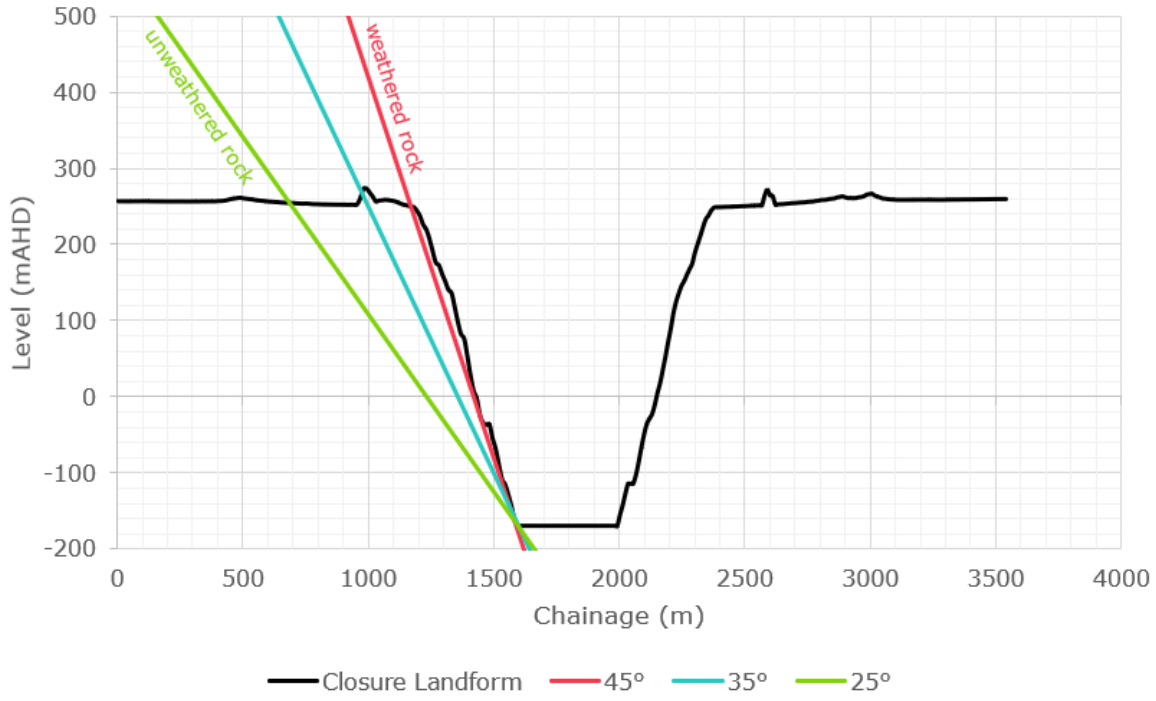


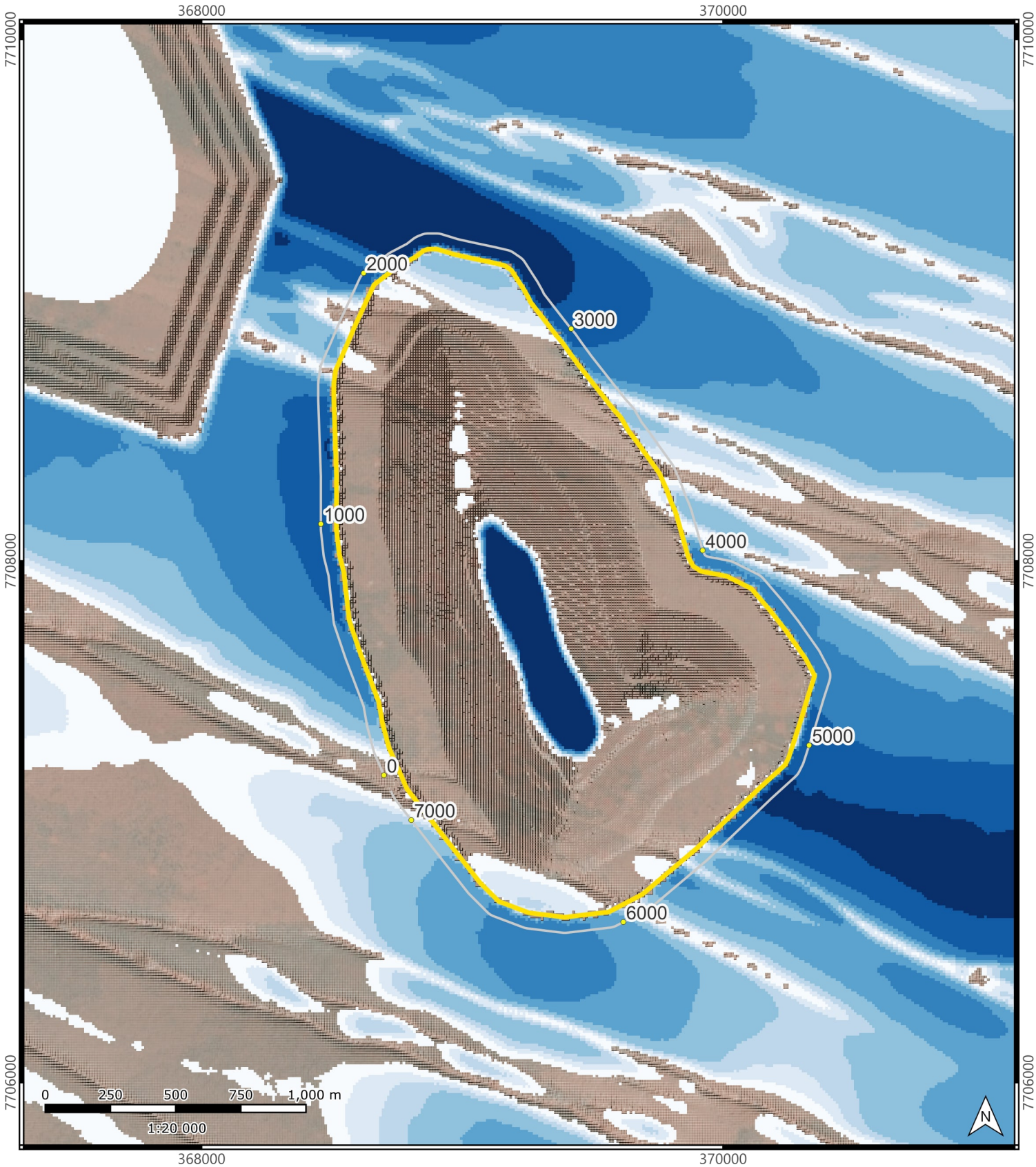
Figure 4. Estimated Zone of Instability

Model results

TUFLOW modelling was conducted for the PMF, 1:5000 AEP and 1:1000 AEP events to identify surface water management measures needed to protect final closure landforms in a range of very rare to extreme rainfall events. The results of the modelling were used to identify surface water requirements for closure compliance. Owing to the site layout and setting in an endorheic basin, the most effective surface water management approach is to install abandonment bunds around the pit to prevent ingress.

The Mine Pit and WRL are located at the low points within the endorheic basins which typify the project setting. As such, very deep ponding depths are predicted (particularly in the PMF event) due to a combination of internally draining landforms, the magnitude of the PMP rainfall and small infiltrative capacity in the assumed fully saturated antecedent conditions within the catchment.

For the PMF closure event, the abandonment bunds would be significant in height (as presented in Figure 5) with the largest bund approximately 14 m high in the 120 hour critical duration event. For comparative purposes, the 1:5000 AEP and 1:1000 AEP events were also modelled, including the 120 hour, 72 hour and 24 hour storm durations. The 24 hour duration was found the be the critical duration for the 1:5000 AEP and 1:1000 AEP events (due to the probability neutral loss estimates as stipulated in Table 3). Closure water levels and depths for all modelled events are provided in Figure 6 and Figure 7 along a long section profile around the pit bund crest. The profiles were extracted at a 60 m offset from the bund as depicted with chainages in Figure 5.



Legend

- Bund Chainages
- Long section
- Abandonment Bund

PMF 120 Hour Event Peak Flood Depth (m)

- 0.1 - 1
- 1 - 2
- 2 - 3
- 3 - 5
- 5 - 7
- 7 - 10
- 10 - 12
- > 12

Winu Closure: Surface Water Management Plan Update 2023

Figure 5: Abandonment Bund Chainages

Project No.	Client
311012-01475	Rio Tinto

Notes:
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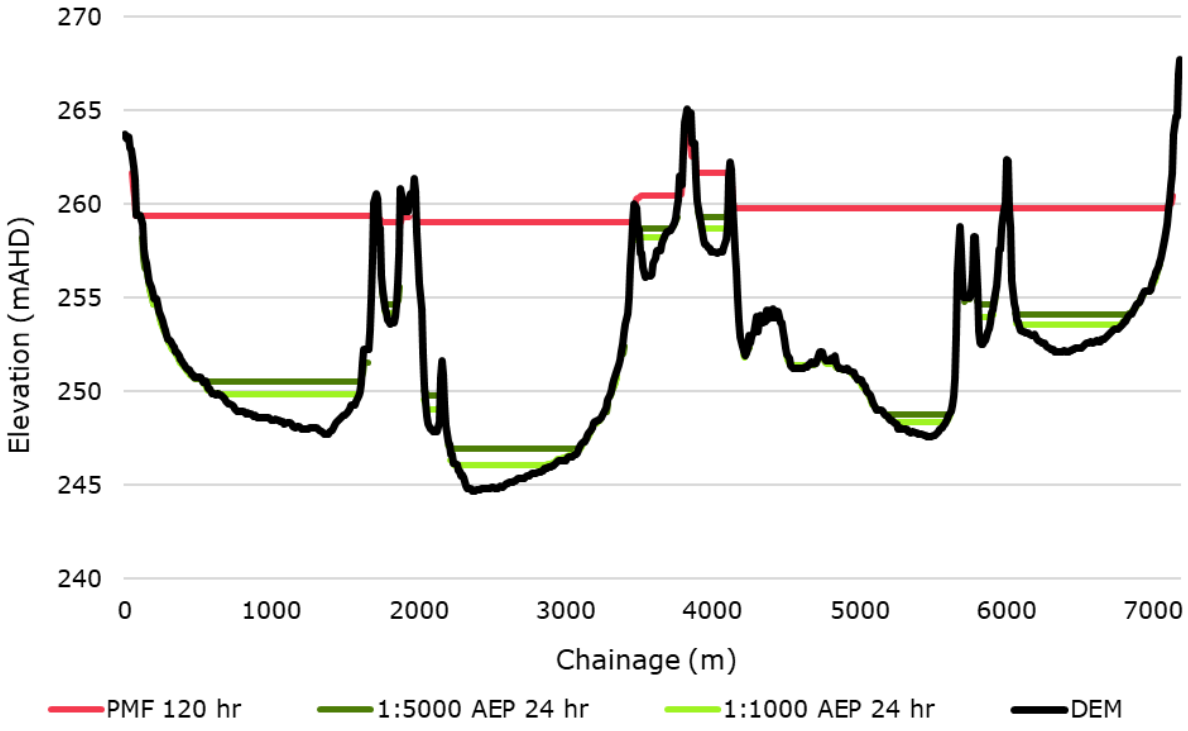

Figure 6. Abandonment Bund water levels

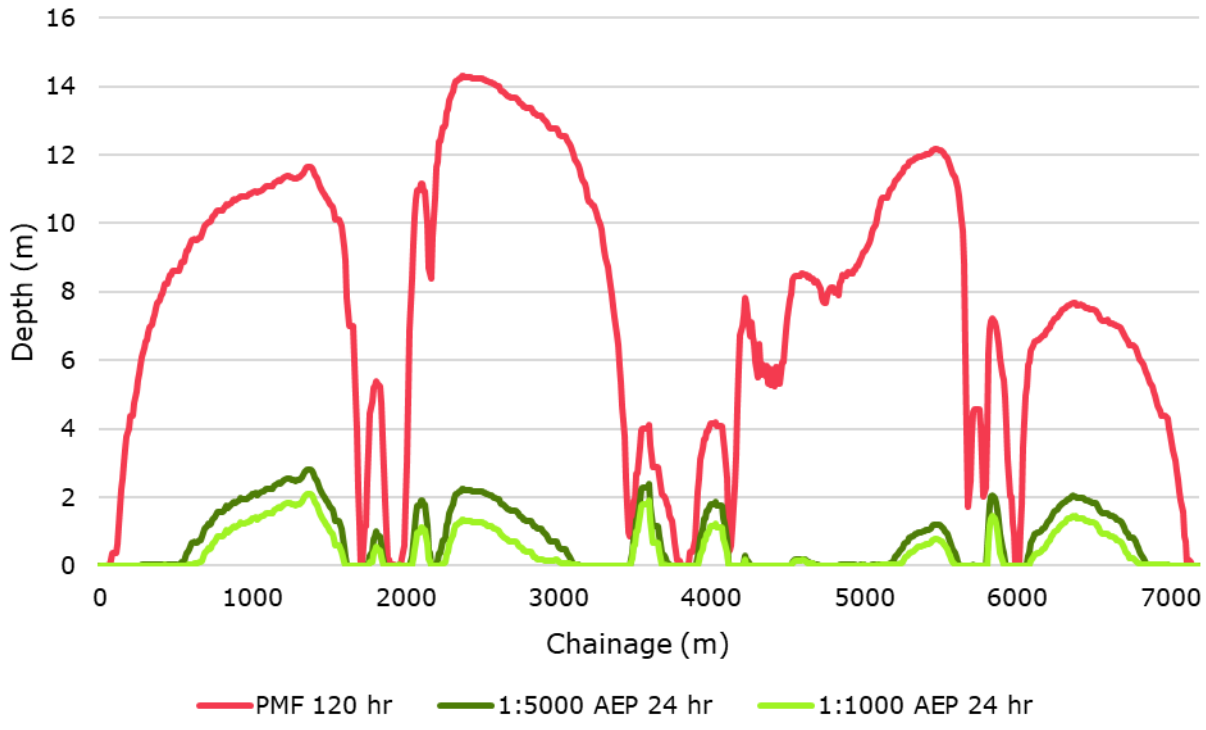

Figure 7. Abandonment Bund water depths

Conclusions

Assessment of the closure events for the Winu mine site has been undertaken by Worley using the procedures as outlined in ARR2019 (Ball et al., 2019) and the model suite developed as part of the Winu Operational Surface Water Management Plan Update 2023 (311012-01475-REP-HY-018).

The assessment has identified that due to the unique topographic landforms of the project setting, that the required abandonment bund heights are significant assuming a closure basis of design standard of the PMF event. The required bunds may be problematic to construct given available site geomaterials and the heights needed to achieve PMF immunity (maximum predicted height of approximately 14 m). Additionally, floodwater that ponds adjacent to the abandonment bunds or WRL for extended periods of time may need to be considered and designed accordingly with consultation with geotechnical specialists.

Assessment of lower magnitude (extreme to very rare) events such as the 1:5000 AEP and 1:1000 AEP predict a significant reduction in abandonment bund height requirements (approximately 3 m and 2 m respectively in height at the highest locations [assuming no freeboard allowance]).

Recommendations

Given the significant difference in abandonment bund height requirements predicted between the PMF, 1:5000 AEP and 1:1000 AEP events, it is recommended that Rio Tinto engage with the appropriate regulatory body to consider an appropriate risk-based closure design event standard for the site, given the unique topographic setting (internally draining and hence no surface-water downstream receptors). Any risks associated with a design exceedance event (i.e., pit capture) would also need to be considered to inform a risk-based approach to developing an appropriate closure design event standard.

References

Ball, J. E., Babister, M., Nathan, R., Weeks, W., Weinmann, P., Retallick, M., & Testoni, I. (2019). *Australian Rainfall and Runoff - A Guide to Flood Estimation.*

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Siriwardena, L. and Weinmann, P.E. (1998), *A technique to interpolate frequency curves between frequent events and probable maximum events.* CRCCH Research Report 98/9, Cooperative Research Centre for Catchment Hydrology.

World Meteorological Organization (1986), *Manual for Estimation of Probable Maximum Precipitation.* Second Edition. Operational Hydrology Report No. 1, WMO - No. 332.

Winu Copper Gold Project
Surface Water Management Plan
120 Hour Critical PMF Event

Project No.
311012-01475

Client
Rio Tinto

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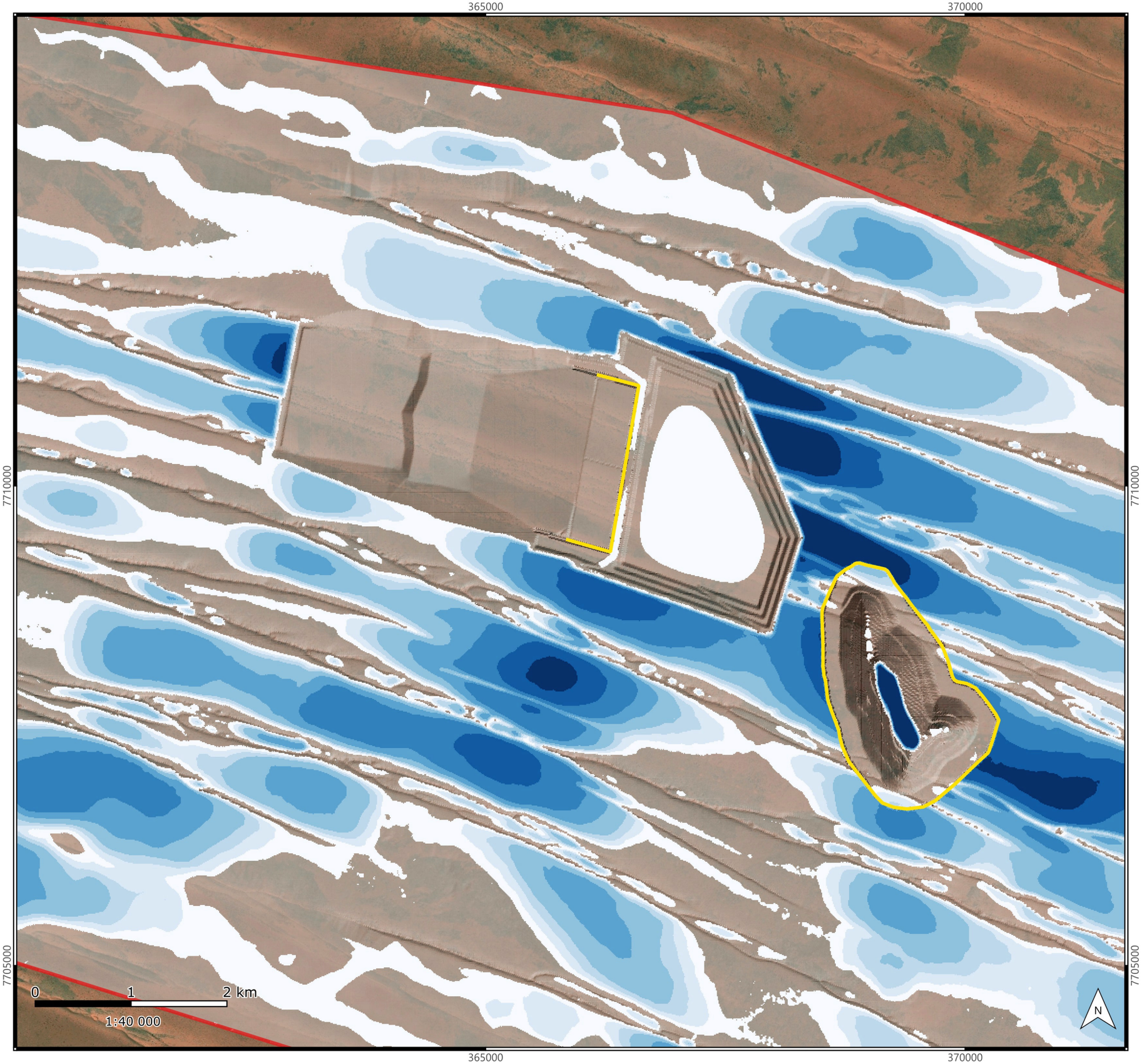

Legend

- Bunds
- Model Extent

Peak Flood Depth (m)

- 0.1 - 1
- 1 - 2
- 2 - 3
- 3 - 5
- 5 - 7
- 7 - 10
- 10 - 12
- > 12

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Winu Copper Gold Project
Surface Water Management Plan
24 Hour Critical 1:5000 AEP Event

Project No.
311012-01475

Client
Rio Tinto

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365000
370000
7710000
7705000
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1
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Legend

- Bunds
- Model Extent

Peak Flood Depth (m)

- 0.1 - 1
- 1 - 2
- 2 - 3
- 3 - 5
- 5 - 7
- 7 - 10
- 10 - 12
- > 12

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Winu Copper Gold Project
Surface Water Management Plan
24 Hour Critical 1:1000 AEP Event

Project No.
311012-01475

Client
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Legend

- Bunds
- Model Extent

Peak Flood Depth (m)

- 0.1 - 1
- 1 - 2
- 2 - 3
- 3 - 5
- 5 - 7
- 7 - 10
- 10 - 12
- > 12

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0 1 2 km
1:40 000

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