Report

Wagerup RSA10 Hypothetical Dam Breach and Consequence Category Assessment

H374430-0000-2B0-230-0001

WGP-F-000213-000

APPROVAL TABLE					
REV	**DATE**	**DETAILS**	**NAME**	**POSITION**	**SIGNATURE**
3	10/10/2025	Issued for Use	[redacted]		

			[redacted]			
2025-10-09	3	Issued for Use				
DATE	**REV.**	**STATUS**	**PREPARED BY**	**CHECKED BY**	**APPROVED BY**	**GLOBAL IMPOUNDMENT GOVERNANCE**
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Executive Summary

This report presents the outcomes of the Hypothetical Dam Breach Assessment (HDBA) and Consequence Category Assessment (CCA) undertaken for the proposed Alcoa Wagerup Residue Storage Area RSA10 located approximately 110 km south of Perth, Western Australia. Two stages of the facility have been considered in this assessment; the Starter Facility which is 7.8 m high and stores a maximum of approximately 1.26 Mm^3 of residue material and decant water, and the Ultimate Facility which is 65.8 m high and stores approximately 25.48 Mm^3 of residue material and decant water (based on full supply level including containment of the design flood).

The assessment was undertaken to estimate the impact of a hypothetical breach of the facility due to a 'Sunny Day Breach' under normal operating conditions, and a 'Flood Induced Breach' during a major flood event. Both the Sunny Day Breach and Flood Induced Breach scenarios were modelled based on a non-Newtonian fluid using viscosity parameters derived from the Wagerup and Pinjarra Residue Mud and Residue Bypass Rheological Data (Water, Waste & Land Consulting Engineers and Scientists, 2023) and (KCB, 2025). An additional Newtonian simulation was undertaken to represent the concurrent flooding scenario, using the non-Newtonian final breach surface as a base for the Newtonian flood model. A hydrodynamic model was developed to estimate the downstream impact and extent of each breach scenario. The population and risk and potential loss of life was estimated based on this, and is summarised below with the approximate inundation area and runout distance for each scenario:

Facility	Breach Scenario	Inundation Area (km^2)	Runout Distance (km)	Population at Risk (PAR)	Potential Loss of Life (PLL)
Starter Facility	Sunny Day Breach	0.16	0.61	0.016	0.016
	Flood Induced Breach [1]	1.74	2.4	0.013	0.009
Ultimate Facility	Sunny Day Breach	0.77	0.71	0.048	0.040
	Flood Induced Breach [1]	1.70	1.1	0.072	0.056

[1] Note that reported inundation area and runout distance for the Flood Induced Breach scenario are based on the non-Newtonian releases from RSA10 only. The total inundation areas and runout distances for mixed flows under concurrent flooding conditions will be greater than those reported in this table.

Based on the outcomes of the Hypothetical Dam Breach Assessment, a Consequence Category Assessment was undertaken in accordance with the *Guidelines on the Consequence Categories for Dams* (ANCOLD, 2012), the *Global Industry Standard on Tailings Management* (GISTM, 2020), the *Tailings storage facilities in Western Australia - code of practice: Resources Safety and Environment Divisions* (DMP, 2013) and *GBL GDL003 Guide for Conducting Dam Break Analysis and Assigning Consequence Categories* (Alcoa, 2024). The Consequence Category for each facility was deemed as follows:

Facility	ANCOLD (2012)	DMP (2013)	GISTM (2020)
Starter Facility	Significant	Category 2	Significant
Ultimate Facility	High B	Category 1	High

These outcomes align with the Consequence Category Assessment undertaken in the previous FEL2.2 phase of this study (Hatch, 2024). The HDBA has been undertaken based on industry best practise using site specific inputs and Wagerup residue specific rheological data.

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1. Introduction

Alcoa of Australia (Alcoa) operates the Wagerup Alumina Refinery, an integrated bauxite mine and Alumina hydrometallurgical processing operation (Refinery), located approximately 110 km south of Perth in Western Australia. The Wagerup residue facility comprises eight operating Residue Storage Areas (RSAs) designated as RSA2 to RSA9. The residue site also contains the Refinery Water Storage Dams, a Cooling Pond, Runoff Water Storage Pond (ROWS), a sand lake and Runoff Collection Ponds (ROCPs).

Alcoa commissioned Hatch Pty Ltd (Hatch) to undertake engineering and design for a feasibility study (FEL3 level of definition) to develop a new RSA at the Wagerup Alumina Refinery to the north of RSA9. The proposed RSA10, will be located in the northwestern corner of the facility as shown in Figure 1-1.

Figure 1-1: Location of the Proposed RSA10

As part of the FEL3 study, Hatch carried out a Hypothetical Dam Breach Assessment (HDBA) and Consequence Category Assessment (CCA) for the proposed RSA10 perimeter starter embankments and the ultimate facility to RL 80 m (including allowance for capping sand layer). The downstream effects due to a hypothetical breach resulting from a 'Sunny Day Breach' (SDB) and a 'Flood Induced Breach' (FIB) event was considered for the facility.

1.1 Abbreviations and Acronyms

The following abbreviations and acronyms have been referred to in this document.

Table 1-1: Abbreviations

Term	Definition
AADT	Average Annual Daily Traffic
AEP	Annual Exceedance Probability (AEP)
ANCOLD	Australian National Committee on Large Dams
CCA	Consequence Category Assessment
DEMIRS	Department of Energy, Mines, Industry Regulation and Safety
DWER	Department of Water and Environmental Regulation
FIB	Flood Induced Breach (Scenario)
GISTM	Global Industry Standard on Tailings Management
GSDM	Generalised Short Duration Method
HDBA	Hypothetical Dam Breach Assessment
NB	No Breach (Scenario)
PAR	Population at Risk
PLL	Potential Loss of Life
RSA	Residue Storage Area
ROCP	Runoff Collection Pond
ROWS	Runoff Water Storage Pond
SDB	Sunny Day Breach (Scenario)
SSP	Shared Socioeconomic Pathway
USBR	United States Bureau of Reclamation

2. Report Objectives

The purpose of this report is to assign a CCA to both the Starter Facility and the Ultimate Facility of the proposed RSA10 to support the Works Approval to DWER/ DEMIRS. To inform the CCA, the following works were undertaken for the starter and ultimate configurations:

1. An HDBA was undertaken involving the following:
    - Collection of available survey data including aerial imagery and topographical surface elevation data.
    - Collection of design dam and storage information for the proposed RSA10 based on the FEL3 design model.
    - Collection and analysis of design rainfalls for the Flood Induced Breach and No Breach scenarios.

- In accordance with the general methods used for tailings dam runout simulations as summarised in *Breaching the gap between geotechnical and hydraulic engineering to improve tailings dam breach studies through large deformation modelling* (Llano, 2020)*, a* hydrodynamic model has been developed to simulate the breach conditions pertinent to each breach scenario.
- Comparison of dam breach parameters and outflow hydrographs corresponding to breach of the dam.
- Plots of the inundation levels and extents corresponding to the Sunny Day Breach.
- Plots of the critical flood event with ‘dam breach’ and ‘no dam breach’ scenarios to determine the incremental flood impact zone for Flood Induced Breach and No Breach scenarios.

2. The Population at Risk (PAR) and Potential Loss of Life (PLL) was estimated for the considered scenarios.
   - ANCOLD defines the itinerant PAR as the population which may be within the flood extent when the road is inundated. In lieu of definition of allowable flood conditions on roads in the ANCOLD guidelines, the Guide to Road Design Part 5B: Drainage - Open Channels, Culverts and Floodway Crossings (Austroads, 2023) has been referred to for definitions of acceptable trafficability. For small vehicles, Austroads defines:
     - The limiting hazard (product of depth and velocity) to be 0.3 m^2/s
     - The limiting still water depth to be 0.3 m
     - The limiting velocity to be 3 m/s at a shallow depth.

     In flood conditions where these values are exceeded in the pre-dambreak flood (NB scenario), the corresponding length of road is excluded from the Dambreak PAR. Roads exceeding these conditions in the Flood Induced Breach scenario have been included in the PAR estimation.
   - Permanent PAR includes the population anticipated to be at dwellings, work sites and other places where people assemble. In accordance with (ANCOLD, 2012), permanent PAR exposed to the following conditions in the pre-dambreak flood (NF scenario) can be excluded from the Dambreak PAR, and those exposed in the Flood Induced Breach scenario have been included:
     - The product of depth and velocity (DV) exceeds 0.6 m^2/s
     - The maximum depth exceeds 1.2 m
     - The maximum velocity exceeds 1.5 m/s.

In flood locations where these values are exceeded, the corresponding populations are considered to be impacted and contributing to PAR.

- The ANCOLD guidelines specify that population in areas downstream of the structure that have adequate warning of the event (at least 12 hours) may be excluded from the PAR.
- The PLL has been calculated based on the method described in Reclamation Consequence Estimating Methodology (RCEM) ‘Guidelines for Estimating Life Loss for Dam Safety Risk Analysis’ (U.S. Department of the Interior Bureau of Reclamation, 2015). USBR’s approach to estimating the consequences from a dam breach is primarily rooted in empirical interpretation of dam breach and flood event case history. The procedure utilised by USBR since 1999, as documented in Dam Safety Report No. DSO-99-06, has been based on an analysis of dam breaches, flash floods, and regional floods. The new methodology continues to rely on case history data to guide the selection of fatality rates; however, additional world-wide case histories have been added to the data set. This new methodology is very similar to USBR’s previous procedure but relies now on a graphical representation of fatality rate as a function of flood severity and warning time. Flood severity is now defined quantitatively in terms of DV.

3. A CCA was undertaken based on relevant guidelines (DEMIRS, ANCOLD and GISTM) with reference to the HDBA, the estimated PAR and PLL and the estimated severity of damage and loss based on the HDBA outcomes.

3. Proposed RSA10 Dam Information

This assessment is being undertaken for the proposed RSA10 footprint with the design details summarised in Table 3-1 for the starter and ultimate configuration.

Table 3-1: Proposed RSA10 General Information

Dam Element	Starter Facility	Ultimate Facility
Location	Wagerup Alumina Refinery, WA	
Owner of Dam	Alcoa of Australia Ltd	
Status of Dam	Residue Storage Area	
Coordinates (latitude, longitude)	-32.898, 115.868	
Storage name	RSA10	
Impoundment internal catchment area	48.9 Ha	33.5 Ha
1:100 AEP 72-hour storm event	189 mm	
Exterior dam slopes	1V:4V	1V:6H
Interior dam slopes	1V:3H	1V:4H
Construction method	Upstream embankment raises	
Maximum residue mud volume	0.71 Mm^3	20.32 Mm^3
Maximum residue sand volume (Upstream Raises)	-	5.07 Mm^3
Maximum combined residue volume	0.71 Mm^3	25.39 Mm^3
Estimated Residue mud consolidated solids content prior to failure (w/w)	68%	
Estimated operating volume of decant	23,800 m^3	15,500 m^3
Estimated 1:100 AEP 72-hour storm volume	92,400 m^3	63,400 m^3
Combined Operating and Storm Volume	116,200 m^3	78,900 m^3
Maximum Decant Volume to Crest or Liner	1.09 Mm^3	0.79 Mm^3
Maximum total volume (at maximum mud level including operating and 1:100 AEP 72-hour storm)	0.83 Mm^3	25.47 Mm^3
Estimate Full Supply Elevation	20.8	78.0
Full supply level storage	1.26 Mm^3	25.48 Mm^3
Total volume to crest	1.80 Mm^3	26.18 Mm^3
Sunny Day Breach residue mud & sand to decant volume	85% : 15%	100% : 0%
Flood Induced Breach residue mud & sand to decant volume	17% : 83%	87% : 13%
Mixed Sunny Day residue solids content by weight	62.3%	67.8%
Mixed Flood Day residue solids content by weight	20.0%	62.6%
Maximum Operating Level (MOL)	20.1 mAHD	77.6 m AHD
Proposed minimum spillway invert elevation (internal transfer to ROCP3)	21.5 mAHD	78.5 mAHD
Crest or top of liner elevation	22.0 mAHD	80.0 mAHD 79.5 mAHD (internal)
Drains to	Collins Pool, 27 km downstream	
Storage	Combination of hydraulic solar dried mud, sand used for upstream raises and liquor (decant water) located in the interior of the impoundment.	

3.1 Storage Curves

3.1.1 Starter Facility

The storage curve for the proposed RSA10 starter facility is presented in Figure 3-1. The relationship between volumetric storage and surface area is also presented in Figure 3-1.

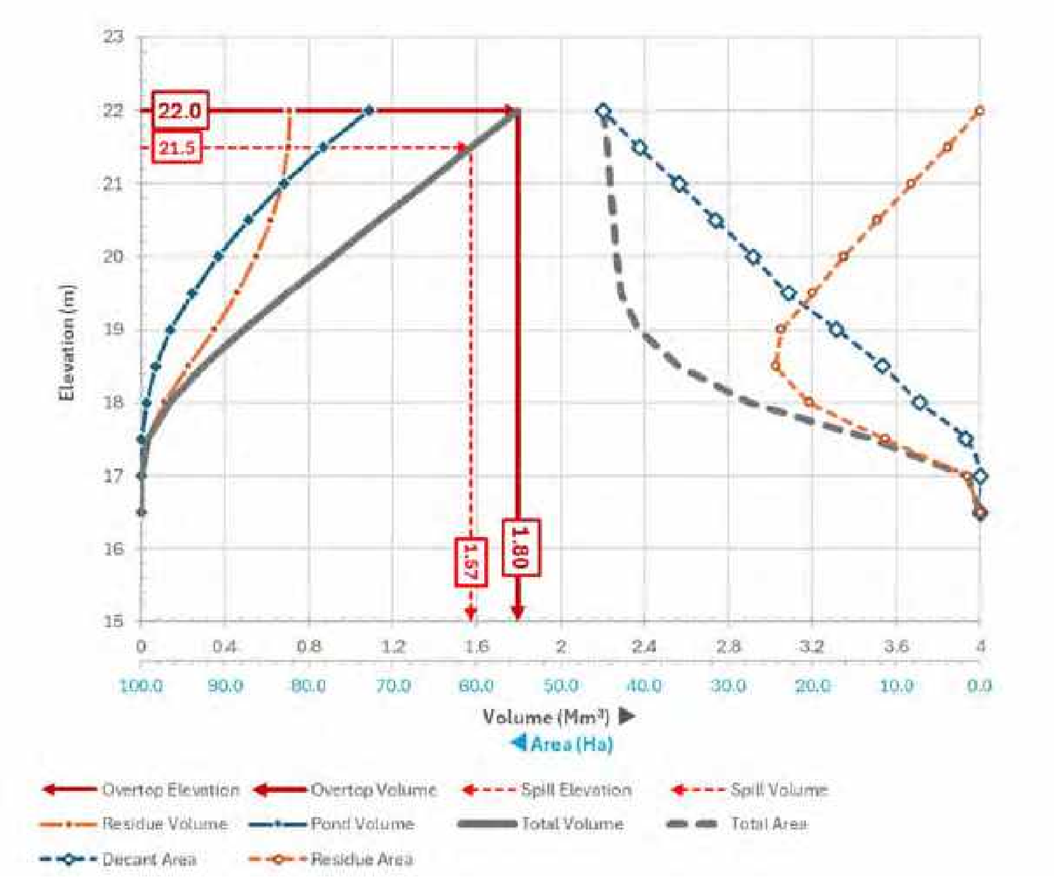


Figure 3-1: RSA10 Starter Facility Stage Storage Curve

3.1.2 Ultimate Facility

The storage curve for the proposed ultimate RSA10 facility is presented in Figure 3-2. The total catchment area of the RSA10 ultimate facility reduces to 33.5 ha from the surface area of the RSA10 starter facility presented in Figure 3-2 due to the encroachment of the 1V:6H perimeter slopes. The total area including exterior embankment batters peaks at approximately 80 ha, from a total of 48.9 ha in the starter footprint.

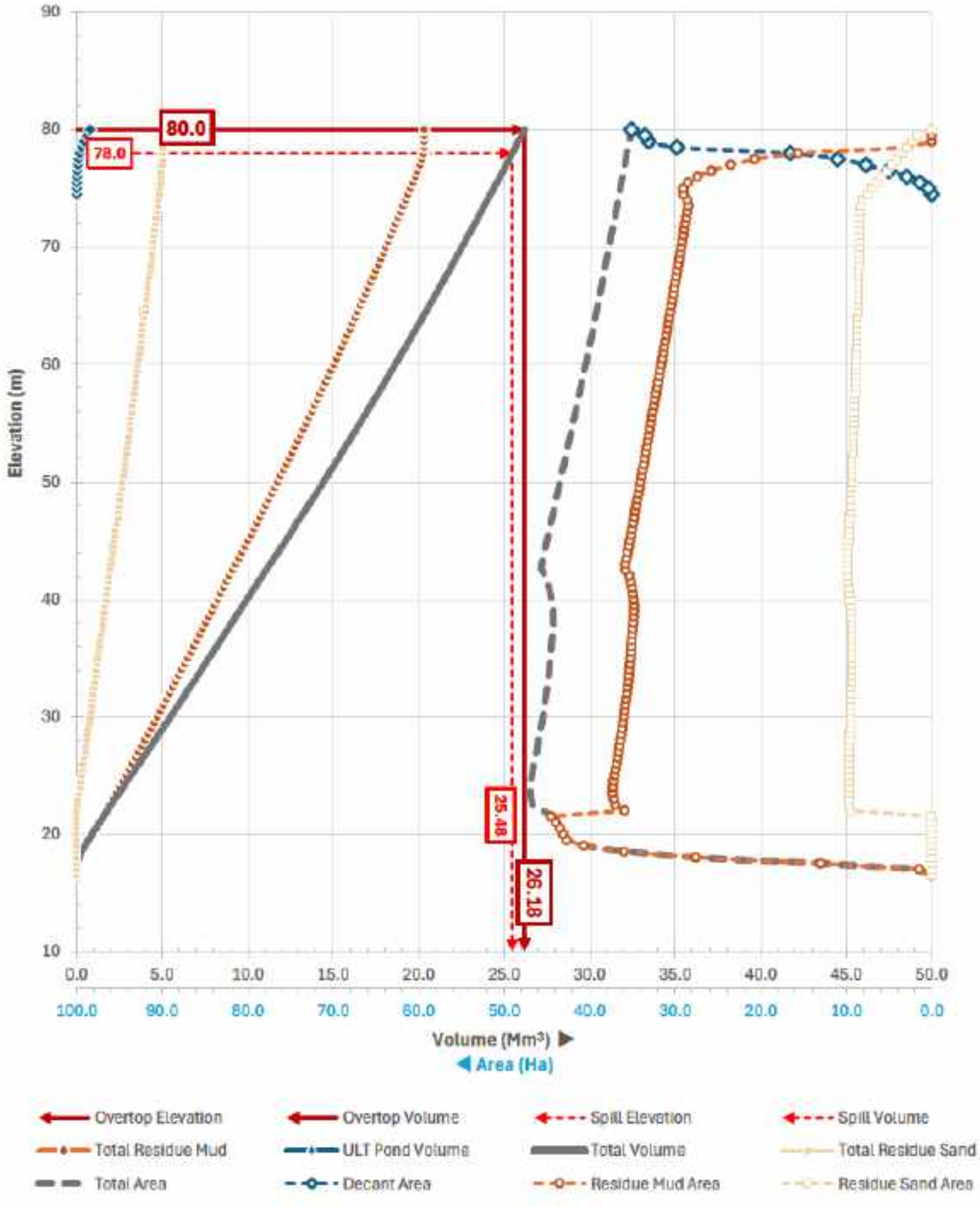


Figure 3-2: RSA10 Ultimate Facility Stage Storage Curve

4. Referenced Information

A summary of the information referenced in the development of the HDBA, the information format and the application it was used for are summarised in Table 4-1.

Table 4-1: Summary of Information Referenced in RSA10 HDBA

Ref	Item (Reference/Filename)	Format	Application
A	**Layout Information**		
A1	Aerial Imagery - Client Provided	ECW	Used to describe site layout
A2	Aerial Imagery - Bing Satellite		Used to describe site layout and identify potential population at risk in the vicinity of the mine.
B	**Topography**		
B1	RSA10 Proposed Design Surface	DEM	Incorporated in hydrological and hydraulic model
B2	5m Surface Elevation Data (Geoscience Australia, 2015)	DEM	Incorporated in hydrological and hydraulic model
C	**Guidelines**		
C1	*Guidelines on the Consequence Categories for Dams.* (ANCOLD, 2012)	PDF	Guideline for undertaking CCA.
C2	*Guidelines on Selection of Acceptable Flood Capacity for Dams* (ANCOLD, 2000)	PDF	To determine the magnitude of the dam break storm event
C3	*Guidelines on Tailings Dams – Planning, Design, Construction, Operation and Closure (Revision 1)* (ANCOLD, 2019)	PDF	Section 10.3
C4	*GBL GDL003 Guide for Conducting Dam Break Analysis and Assigning Consequence Categories (GBL)* (Alcoa, 2024)	PDF	Guideline for undertaking Dam Break Analysis
C5	*Tailings storage facilities in Western Australia - code of practice: Resources Safety and Environment Divisions* (DMP, 2013)	PDF	Guideline for undertaking CCA
C6	*Global Industry Standard on Tailings Management* (GISTM, 2020)	PDF	Guideline for undertaking CCA
E	**Software**		
E1	ESRI ArcGIS 10.7.1 & QGIS, Version 3.22.	QGZ MXD	Spatial data analysis/viewer
E2	RORB (version 6.52)	RORB	Undertake hydrological analysis of concurrent flooding catchment.
E3	TUFLOW	TUFLOW	Undertaking downstream reach analysis – assessment of potential release volumes and receiving waterway.

Ref	Item (Reference/Filename)	Format	Application
F	Other		
F1	*Appendix Report: Bauxite Residue Rheological Assessment* (Water, Waste & Land Consulting Engineers and Scientists, 2023)	PDF	Estimation of non-Newtonian parameters for benchmarking purposes.
F2	*KCB Rheological Data (WGP00184-0000-ENG-RPT-003)*	MS Excel	Contains data for Wagerup and Pinjarra Residue Mud and Residue Bypass used to derive basis for non-Newtonian input parameters
F3	*Wagerup RSA10 Dam Breach Assessment Basis of Analysis Report (WGP-F-000220-000)*	PDF	Basis of Analysis report that summarises of approach and inputs adopted for this RSA10 dam breach assessment.

5. Regulatory Requirements

The RSA10 Starter and Ultimate Facility were assessed against the *Guidelines on the Consequence Categories for Dams* (ANCOLD, 2012), *Global Industry Standard on Tailings Management* (GISTM, 2020) and *Tailings Storage Facilities in Western Australia* (DMP, 2013).

These guidelines provide direction on how to undertake a CCA, however the responsibility falls on the suitably qualified and experienced person to determine whether the assessed storage contains contaminants that have potential to cause environmental harm, and to certify the outcomes of the hazardous dam assessment accordingly. Given the alkaline nature of the liquor and mud contained with the RSA, the potential for some environmental harm is likely, although the ecological significance areas impacted by the breach zone need to be considered in the assessment.

5.1 Credible Breach Scenarios

The 'Sunny Day Breach' and 'Flood Induced Breach' dam break scenario assessments were undertaken for both the RSA10 Starter Facility and Ultimate Facility. The two scenarios are discussed in Sections 5.1.1 and 5.1.2. A preliminary FMEA (Failure Mode and Effects Analysis) has been used to inform credible failure modes. The key modes identified during the workshop were overtopping and static instability. These critical modes are presented in Table 5-1.

Table 5-1: Summary of Critical Unmitigated Risks and Residual Risks for the Starter and Ultimate Facilities from Preliminary FMEA

Risk Event	Failure Modes	Cause	Effects	Likelihood Without Controls (Controls fail or ineffective)	Maximum Severity Factor	Unmitigated Risk Rating	Residual Risk Rating (RRR)
Overtopping of western or northern perimeter embankment	Pond overtops embankment, scouring and failure to contain (FIB)	Residue sediment accumulates near decant sump, creating a blockage to decant or pump failure. Undersized decant pump or pump failure. ROCP3 full and unable to accept decant water. Extreme rainfall event, exceeding design criteria. Crest deformation resulting in loss of freeboard (poor construction/ compaction or design). Poor beaching or reverse beach development resulting in pond against embankment. Excess process water from hydraulic sand construction, poor sand placement methodology and lack of operating freeboard. Failure of upstream facility (RSA7 or ROCP3) resulting in landslide induced tsunami and bow wave overtop of embankment. Mud overfill (operational errors). Thickener bypass with excess process water reporting to RSA10 N. Failure of the sprinkler line (or header line) which fills facility with process water.	Mud and liquor run-out. Excess water and sediment reporting into downstream clean water channels and farmlands. Scour and erosion of embankment slopes. Loss of capacity to safely contain decant pond. Erosion or undercutting of RSA10 N embankments. Damage to perimeter roads, electrical and monitoring bores infrastructure. Loss of drying area and potential impacts to operations. Impacts license to operate. PAR and PLL. ROCP3 and RSA9 toe impacted and potentially resulting in erosion and instability.	Possible	3	12	6
Instability of western or northern perimeter embankment	Static failure of upstream raises (SDB).	Excess pore pressure and lower effective stress generation in the residue (undrained failure) during upstream raising. Saturation of the residue due to poor surface drainage or rapid placement (thick pouring) or dysfunctional underdrainage. Poor desiccation of the residue or saturation due to excessive decant pond. No mechanical intervention or mitigation of pond locations. Hydraulic placement of perimeter sand walls, placed rapidly and introduction of significant water. Sudden phreatic rise not detected through instrumentation or not triggered via TARP (instrumentation failure or never installed). Drained failure of the upstream raises. Loading transitions materials from dilative to contractive behaviour. Interface friction and sliding along HDPE liner interface. Excess water usage from sprinkler operations.	Slope instability of the upstream perimeter embankment, impacting the downstream areas - runout. Loss of containment. Loss of social and regulatory license to operate. Potential loss of life (PLL). Damage to perimeter roads, electrical and monitoring bores infrastructure. Loss of drying area and potential impacts to operations.	Possible	3	12	6

Note: The unmitigated risk rating considers a rating scale where no controlled actions are in place. The residual risk rating (RRR) considers existing controls already included in the design and operations which would mitigate the risk from occurring or reduce the consequence from the event.

5.1.1 *Sunny Day Breach*

The Sunny Day Breach is based on the difference between the consequences of the dam break flood and the normal conditions prior to dam breach, whereby the dam embankment fails in the absence of rainfall. This may occur due to the loss of structural integrity of the wall due to a piping failure, which progressively becomes large enough to form a breach (embankment collapse) or a static failure through the foundations or containment embankments leading to displacement in the perimeter embankment, overtopping or loss in containment of fluidised residue. The material released from a 'Sunny Day Breach' has been modelled for both the starter and ultimate facilities based on the most credible static failure due to undrained strength losses in the residue mud by adopting non-Newtonian parameters identified in Table 6-2 to simulate the mixed residue mud and released decant water properties.

5.1.2 *Flood Induced Breach*

In the Flood Induced Breach scenario, the dam embankment fails due to a catastrophic overtopping event in a major flood event where the breach in the embankment is progressively eroded and the contents are released (combination of mixed residue mud, sand and decant pond water). In addition to the FIB scenario, the 'No Breach' scenario was also modelled to allow the incremental impact of the 'Flood Induced Breach' to be identified for the purpose of calculating the PAR. This is calculated by the difference between the FIB and NB scenarios over the maximum time of 12 hours from the breach.

Due to the mixing of the residue material with the flood inflow, all material in the FIB scenario have been modelled for both the starter and ultimate facilities, using the non-Newtonian parameters identified in Table 6-3.

The *Guidelines on Selection of Acceptable Flood Capacity for Dams* (ANCOLD, 2000) provides guidance on the downstream risks associated with water and tailings dams. In accordance with the Consequence Category assigned during the FEL2.2 phase of the study, the design floods noted in Table 5-2 will be contained within the dam crest volume.

Table 5-2: Modelled Flood Summary for FIB Scenario

Facility	Assumed Consequence Category	Flood Modelled*
Starter Facility	Significant	1:1,000 AEP or Crest Flood
Ultimate Facility	High B	PMF or Crest Flood

* The design flood for assessment of the FIB was selected based on the design AEP for the Facility CCA unless this volume exceeded a crest flood scenario, whereby the crest flood was then adopted.

The modelled dam break has been initiated assuming the initial decant pond level correspond to the Extreme Storm Surge (ESS) based on a 1:1000 AEP 72-hour design storm event including allowance for a 1:10 AEP wave runup for the starter facility. The decant pond level for the ultimate case was checked for containment of a PMP (120 hr duration) event and this event corresponded to the inside crest elevation. Therefore a crest flood scenario was adopted in the FIB breach analysis.

6. Modelling Inputs

6.1 Hydrology Modelling

Hydrology modelling was undertaken to estimate the relevant hydrographs for the FIB (concurrent flooding) and No Breach scenarios within the Collins Pool catchment. Discussion of the hydrology modelling inputs are presented in Appendix A and a summary of the results for the Collins Pool hydrology is provided in Table 6-1.

Table 6-1: Summary of Hydrology Modelling Results for the Concurrent Flooding Event over the Collins Pool Catchment

	Starter Facility	Ultimate Facility
Design AEP	1 in 100 AEP *	
Climate Change Factor	15% increase in IFD rainfall based on climate change factors reflecting present-day conditions	30% increase in IFD rainfall based on climate change factors reflecting Shared Socioeconomic Pathway SSP2 and the year 2060
Design Rainfall	153.4 mm	164.7 mm
Critical Duration	24 hours (based on the Forrest Highway location, assumed to be most critical source of PAR)	

* This event was considered the most critical design event as it produces the highest incremental difference between the flood failure and no failure scenarios.

6.2 Tailings Rheological Properties

The rheological testing was provided by Alcoa as an input to the assessment. The data comprised previous dilute residue testing carried out by WWL (2023) with updates for higher solids concentration residue mud provided by KCB (2025). Figure 6-1 shows the rheological flow curves for the dilute mixed residue mud and sand based on the parameters derived from the FLOW3D calibrated box rheometer tests for the low solid material. "Box 6" dataset was used as the base case for the starter flood day failure assessment as it was understood to be the most reflective of the in-situ data at lower solids content.

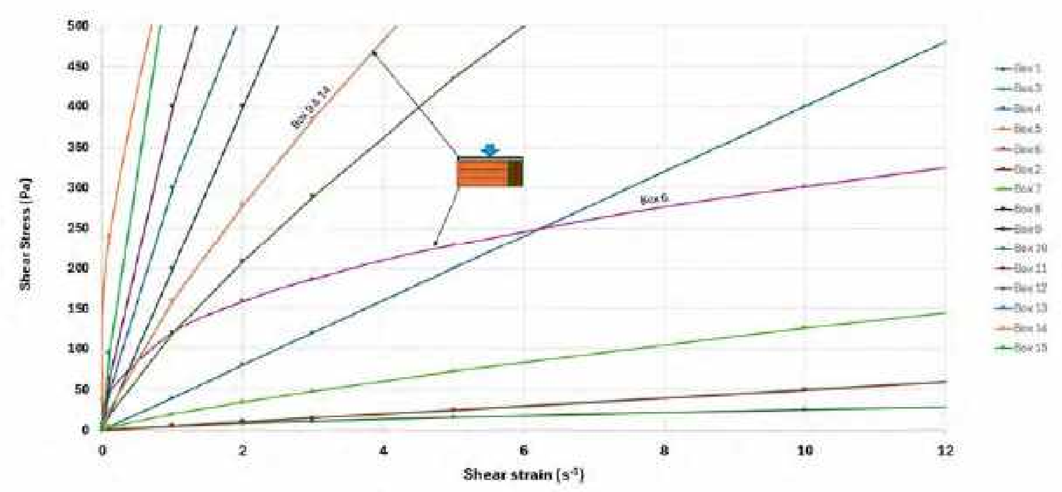


Figure 6-1: Calibrated Rheology from the “Box Rheometer” tests (source: WWL, 2023)

For the higher solids content mud (generally > 65% w/w solids) expected for the starter facility ‘Sunny Day’ breach and both ‘Sunny Day’ and ‘Flood Induced’ breaches for the ultimate case, rheological data from KCB (2025) were adopted. The dataset is a combination of recent testing on Wagerup residue at high shear rates (typically > 100 s^{-1}) with supplementary data from Kwinana residue at lower shear rates (from 1 to 50 s^{-1}) typical for dam breach. KCB have provided an interpretation of the yield stress curves at a range of solids contents for the residue mud and are presented in Figure 6-2.

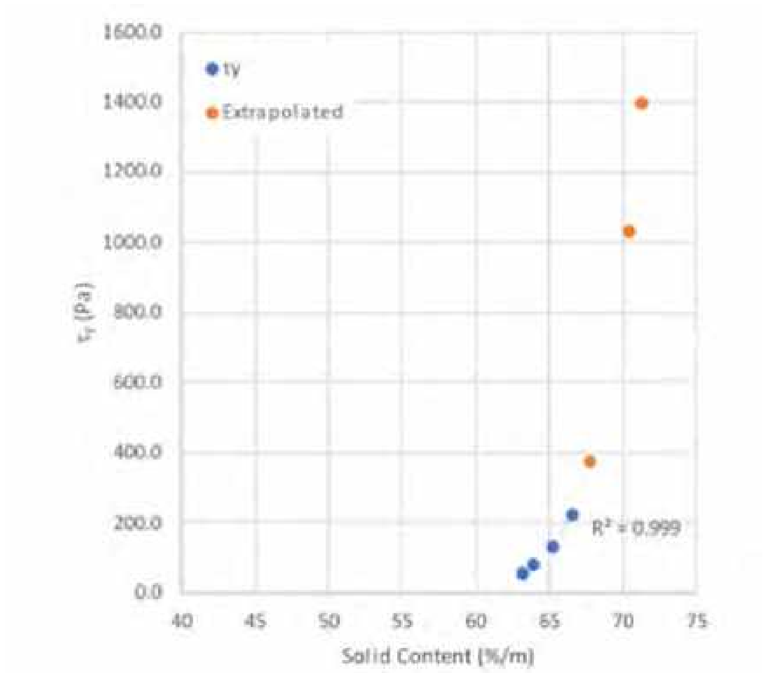
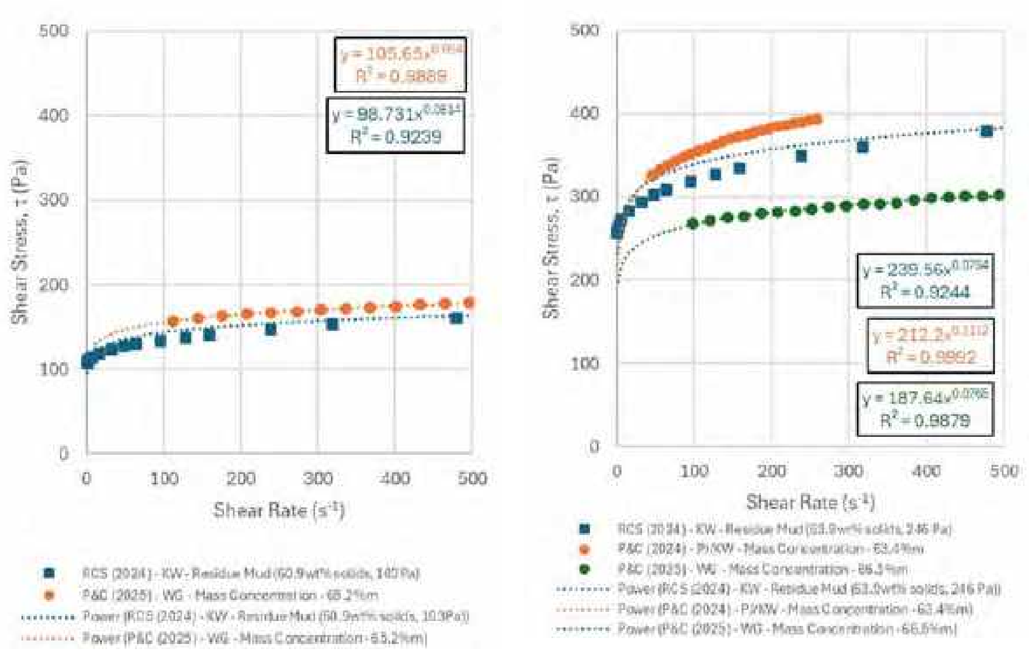


Figure 6-2: Yield Stress Data from Composite Rheological Testing (source: KCB, 2025)

Hatch carried out a review and combined the various datasets to derive flow curves for estimation of the Herschel Bulkley parameters as a key input to the TUFLOW modelling. The results confirmed that the Kwinana residue exhibits higher yield stress at a similar solids content to the Wagerup residue mud samples and was deemed to be an appropriate proxy. However minor corrections should be applied when using the Kwinana dataset to factor in variations in yield stresses at identical solids.

Comparison of the Kwinana and Wagerup residue mud at similar initial yield stress are presented in Figure 6-3.



(a) Comparison of 65.2% w/w solids Wagerup Mud to 60.9% w/w solids Kwinana Mud

(b) Comparison of 66.5% w/w solids Wagerup Residue to 63.4% and 63.9% w/w solids Kwinana Mud*

* Note that the residue mud from P&C (2024) did not state the exact location of the sample source but given filter cake was tested in the campaign, it is assumed to be from either Kwinana or Pinjarra operations.

Figure 6-3: Flow Curves for High Shear Rate Wagerup Sample versus Lower Shear Rate Kwinana Sample

The ‘Sunny Day’ and ‘Flood Day’ breach simulations were modelled incorporating non-Newtonian parameters based on mixing of the decant water volume and release mud or residue sand volume to derive composite blended solids content. The blended material solids were then compared to available flow curves to determine representative Herschel Bulkley parameters, which have been presented in Table 6-2 and Table 6-3.

Table 6-2: Non-Newtonian TUFLOW Input Parameters (Sunny Day)

Non-Newtonian Input Parameter	Value	
	Starter *	Ultimate *
Blended Solids Content	62.3%	67.8%
Estimated Shear Rate	1 - 10 s^{-1}	
Viscosity Coefficient (K)	6 $Pa.s^n$	25 $Pa.s^n$
Shear thickening exponent (n)	0.24	0.22
Lower viscosity limit	10 Pa.s	10 Pa.s
Higher viscosity limit	1,000 Pa.s	1,000 Pa.s
Yield stress (τ_y)	40 Pa	240 Pa
Bulk Density (ρ_b)	1.75	1.86

* Parameters based on KCB rheology data (KCB, 2025)

Table 6-3: Non-Newtonian TUFLOW Input Parameters (Flood Day)

Non-Newtonian Input Parameter	Value	
	Starter #	Ultimate *
Blended Solids Content	20.0%	62.6%
Estimated Shear Rate	1 - 15 s^{-1}	
Viscosity Coefficient (K)	1.5 $Pa.s^n$	20 $Pa.s^n$
Shear thickening exponent (n)	0.30	0.22
Lower viscosity limit	10 Pa.s	10 Pa.s
Higher viscosity limit	1,000 Pa.s	1,000 Pa.s
Yield stress (τ_y)	5 Pa	160 Pa
Bulk Density (ρ_b)	1.19	1.75

* Parameters based on KCB rheology data (KCB, 2025)
# Parameters based on WWL rheology data (Water, Waste & Land Consulting Engineers and Scientists, 2023)

For the ultimate cases which comprise approximately 20% residue sand to 80% mud ratio, rheological parameters (particularly yield stress) for the mud and sand mixture have been inferred to be moderately improved for the starter case where only residue mud is contained.

6.3 Geometric Failure Modelling

A geometric breach model was developed based on 2-D limit equilibrium slope stability analysis (Hatch, 2024). Geostudio Slope/W software was used to estimate the critical breach mechanisms and then input to a 3D civil model to estimate release volumes for the Starter and Ultimate Facilities under the SDB and FIB events. For the FIB scenarios, the scarp of the failure surface was flattened to approximately 1V:5H (~20%) to account for erosion as the decant pond scours the backscarp (refer Figure 6-4).

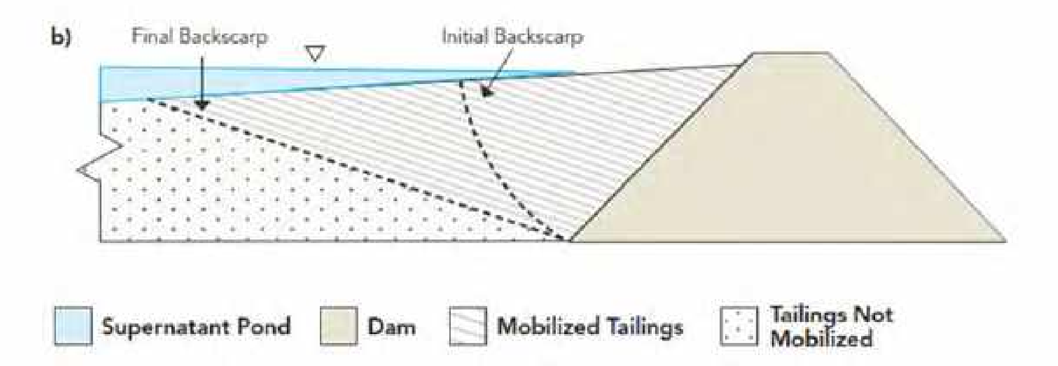
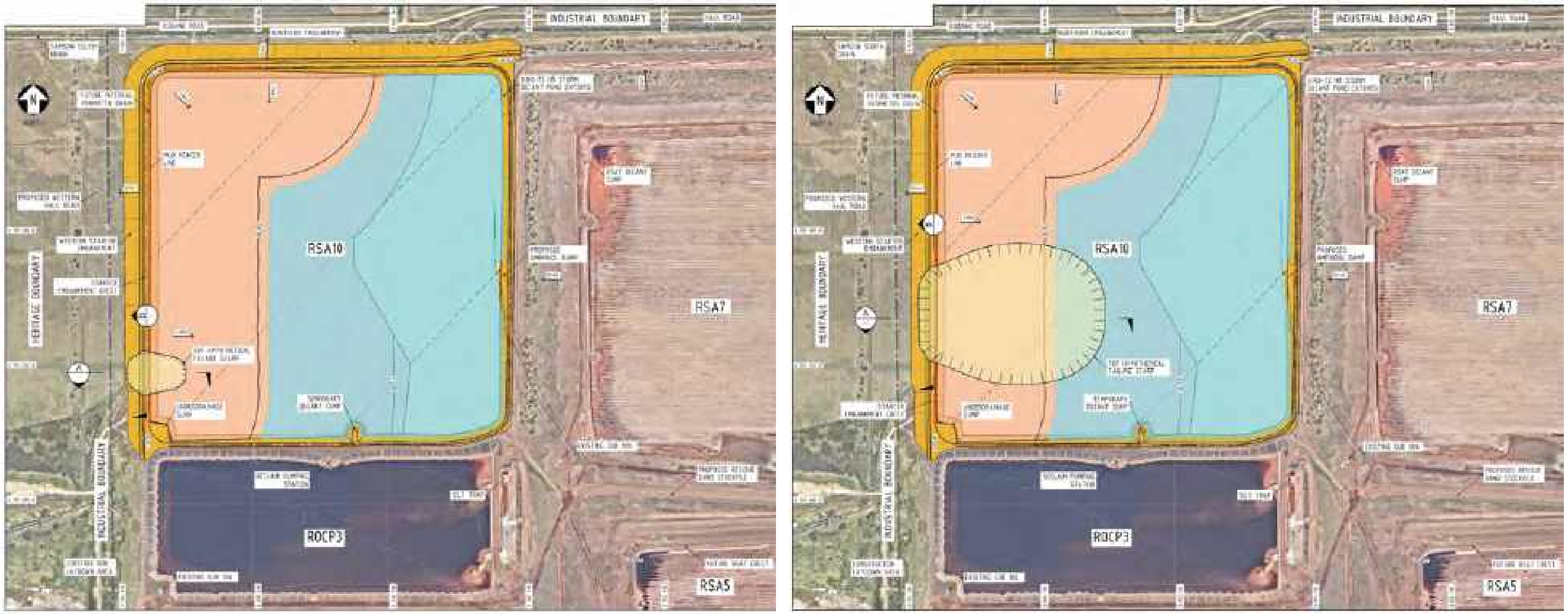


Figure 6-4: Cross Sectional Schematic of the Breach Surface for a TSF (Canadian Dam Association, 2021)

The methodology outlined in the CDA guideline (Canadian Dam Association, 2021) for Type 2A breach cases has been adopted for the SDF scenarios, using the geometry for the initial scarp with limited erosion and slumping (due to limited decant pond) and Type 1A for the FIB scenarios assuming erosion of the backscarp from inflow of the decant pond into the failure scarp. The volumes from the geometric modelling were adopted in the hydrodynamic models to estimate the total breach extent and simulate concurrent flooding impacts.

The plan and section views for the starter facility are presented in Figure 6-5 and Figure 6-6, with the ultimate facility plan and section views included in Figure 6-7 and Figure 6-8.



(a) Starter Facility SDF Plan View

(b) Starter Facility FIB Plan View

Figure 6-5: Starter Facility Breach Backscarp - Plan View

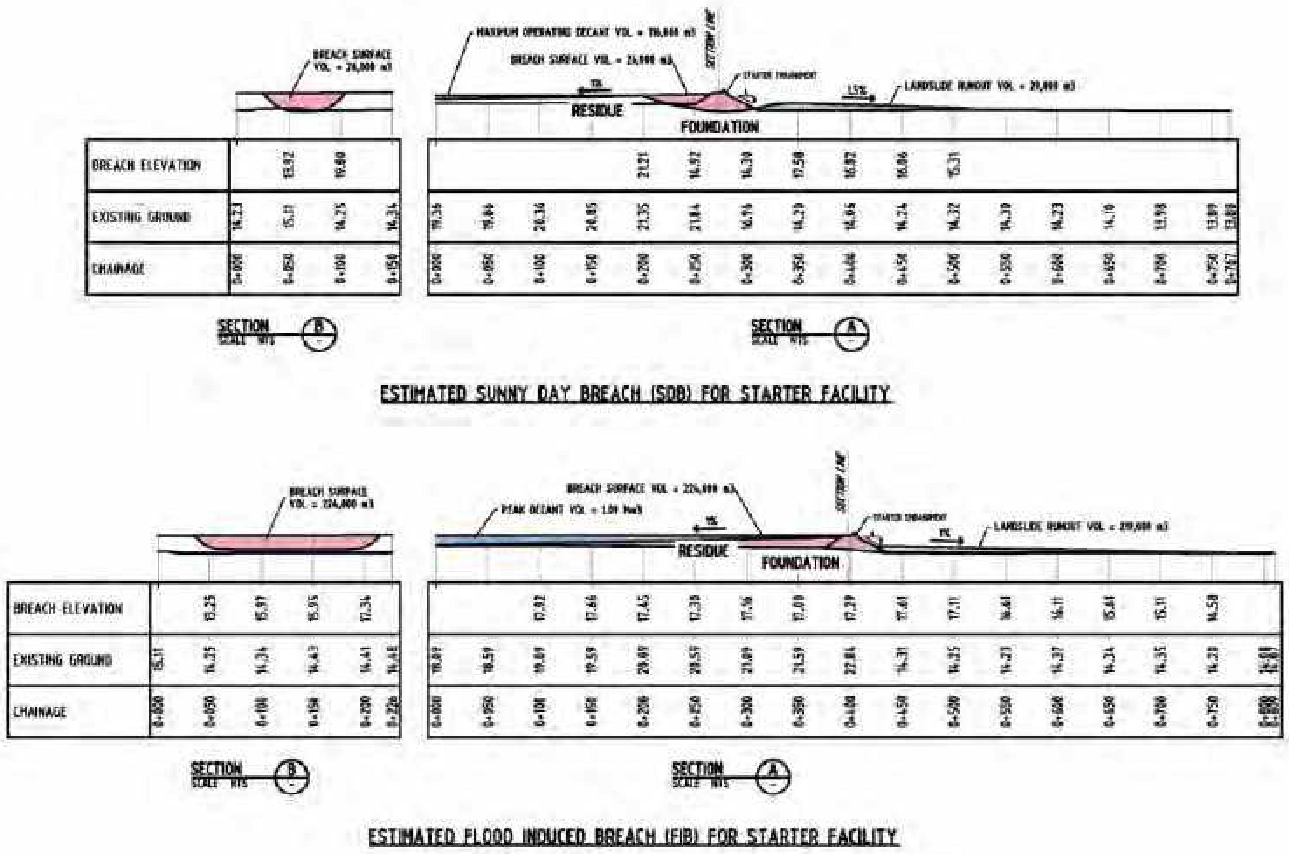
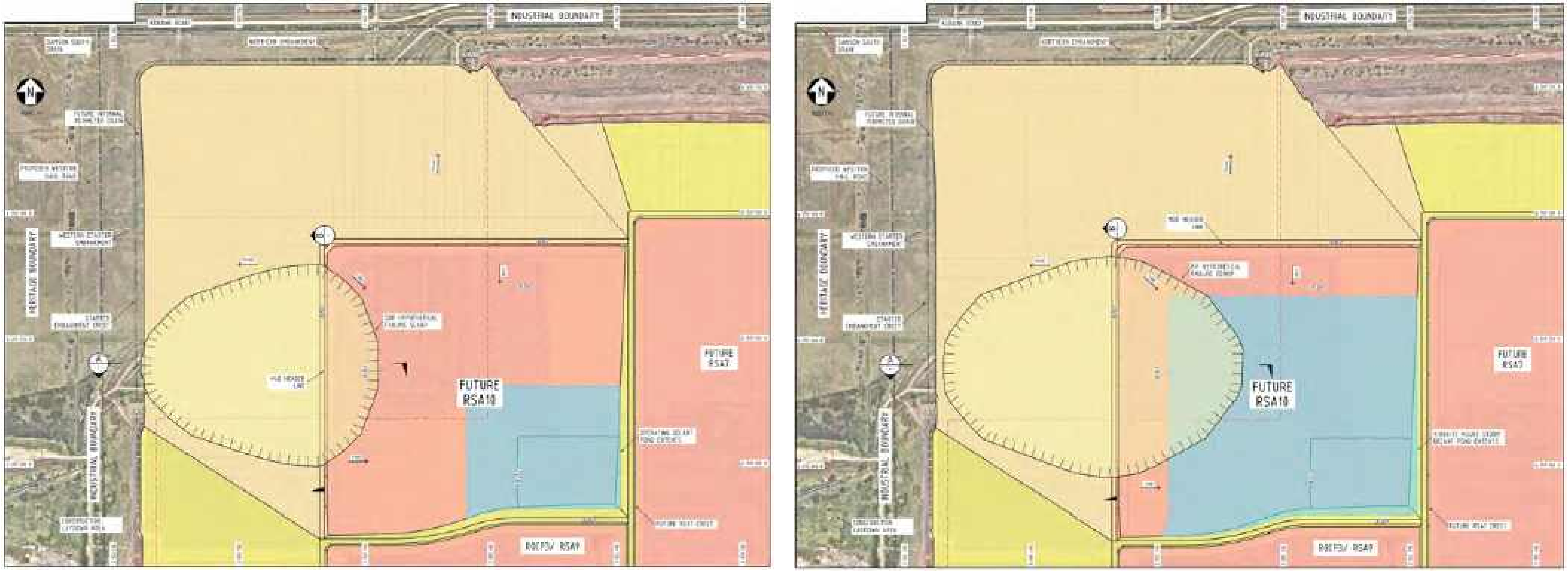


Figure 6-6: Geometric Breach Section View for Starter Facility



(a) Ultimate Facility SDB Plan View

(b) Ultimate Facility FIB Plan View

Figure 6-7: Ultimate Facility Breach Backscarp - Plan View

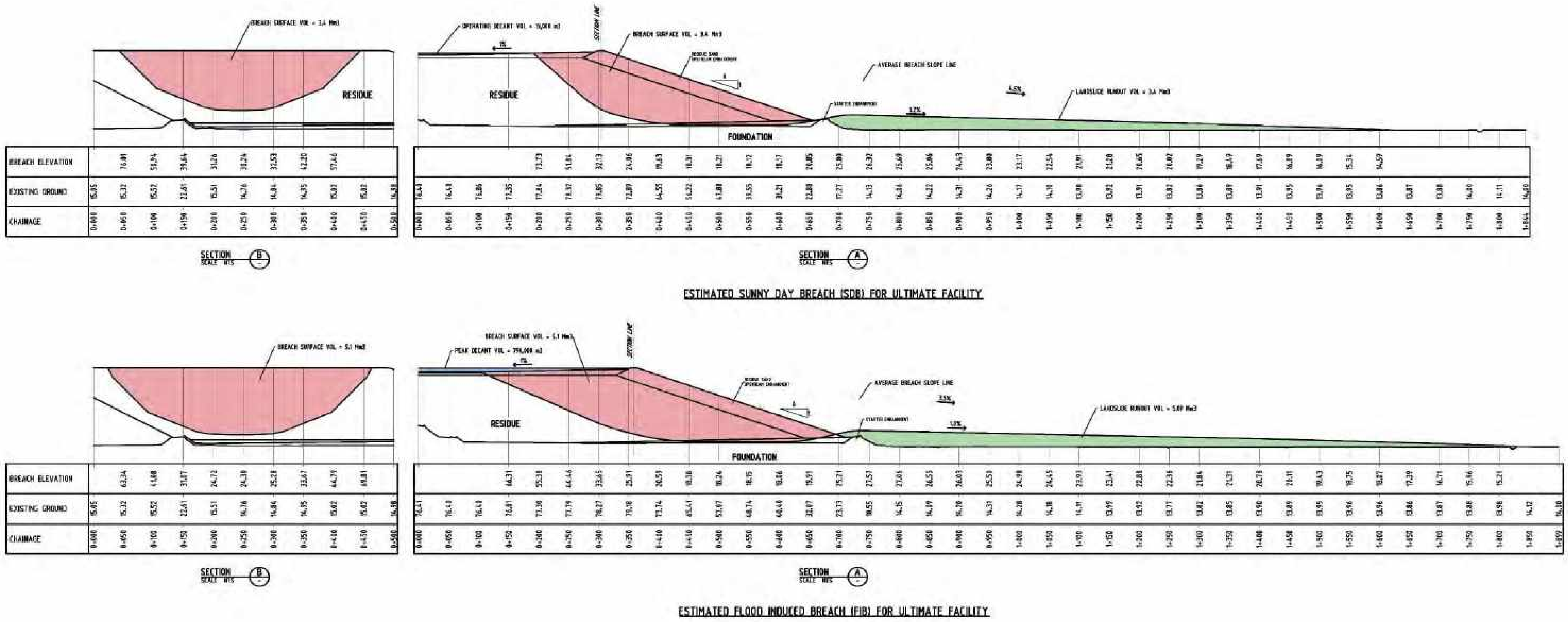


Figure 6-8: Geometric Breach Section View for Ultimate Facility

The geometric parameters of the breach were derived from hypothetical 3D model geometries inferred from the stability analysis. The breach width modelled typically ranges from 3 to 5 times the maximum depth of the failure surface.

6.4 Benchmark Release Volumes from Historic Tailings Failures

Historical tailings dam failures occurring between 1965 and 2014 were discussed and analysed in two studies, *Floods from tailings dam failures* (Rico, Benito, & Diez-Herrero, 2008) and *Tailings Dam Failures: Updated Statistical Model for Discharge Volume and Runout* (Larrauri & Lall, 2018).

Correlation analysis conducted by Piciullo et al. (2022) for a dataset of 70 historical TSF breaches used linear regression analysis to produce a relationship between stored and released tailings volumes. This work was built on previous correlation analyses conducted on the smaller datasets analysed by Larrauri and Lall (2018) and Rico et al. (2008). A summary of the three case studies and relationships for prediction of the release volume from a tailings breach is provided in Table 6-4.

Table 6-4: Correlation Between Released and Stored Volumes of TSFs and Predicted RSA10 Release Volume

Dataset	No. of Failures	Correlation[1]	r^2
Rico et al. (2008)	22	$V_R = 0.354 \times V_T^{1.01}$	0.86
Larrauri and Lall (2018)	28	$V_R = 0.332 \times V_T^{0.95}$	0.89
Piciullo et al. (2022)	70	$V_R = 0.214 \times V_T^{0.77}$	0.59

[1] Where V_R is the release volume (Mm^3) and V_T is the total stored volume (Mm^3)

The coefficient of determination (r^2) is a statistical measure that represents the proportion of variance for a dependent variable. As shown in Table 6-4, the r^2 value reduced from close to 0.9 in Larrauri and Lall (2018) and Rico et a. (2008) to 0.59 with the larger failure dataset in Piciullo et al. (2022). The difference in the uncertainty of correlation highlights the importance of understanding the underlaying dataset and level of applicability it has to the Wagerup RSA10 breach scenario.

For the recorded historic tailings dam failures presented in (Rico, Benito, & Diez-Herrero, 2008), (Larrauri & Lall, 2018) and (Piciullo, 2022), the approximate release volume (V_R) due to failure has been calculated versus the total stored impoundment volume (V_T) as presented in Table 6-5.

Table 6-5: Comparison of Geometric Model Release Volumes versus Database Predictions

Case	Breach Type	Total Volume, V_T (Mm^3)	Release Volume, V_R (Mm^3)			
			Empirical Database			Geometric Model for RSA10
			Rico et al (2008)	Larrauri and Lall (2018)	Piciullo et al. (2022)	
Starter	SDB	1.26	0.45	0.41	0.26	0.14
	FIB	1.80	0.64	0.58	0.34	1.31
Ultimate	SDB	25.48	9.32	7.19	2.59	3.42
	FIB	26.18	9.58	7.38	2.64	5.89

A comparison of the geometric release volumes from the RSA10 analysis plotted on the failure database documented in (Larrauri & Lall, 2018) and (Piciullo, 2022) is presented in Figure 6-9.

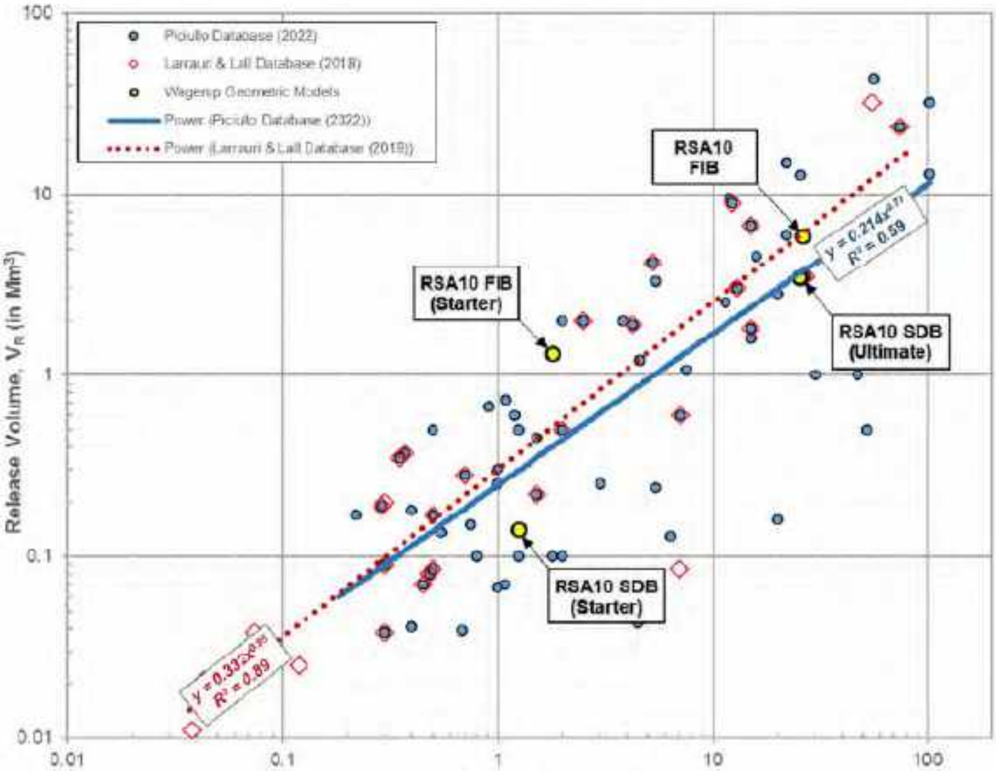


Figure 6-9: Relationship Between Release Volume and Total Stored Volume for Historical Tailings Dam Failures (Rico, Benito, & Diez-Herrero, 2008), (Piciullo, 2022) and the Wagerup Estimated Release Volumes from Geometric Stability Modelling

The results from the geometric model appear to correlate well with the empirical database, particularly for the ultimate case which plots very near the mean Rico (2008) and Piciullo (2022) estimates for SDB and FIB release volumes, respectively. As such, the method for assessing the volumes released from the facility is based on the 2D limit state geotechnical stability analysis as discussed in Section 6.3 with final release volumes as summarised in Table 6-7.

6.5 Dam Breach Modelling

The estimation of a dam breach location, dimensions and the development time of the breach are key inputs to the Hypothetical Dam Breach Assessment. These breach parameters directly affect the estimated peak flow released from the dam, as well as the possible warning time available to the downstream population. The location of the modelled dam breach for the Starter Facility and the Ultimate Facility is summarised in Table 6-6. Residue material released from the RSA10 is anticipated to flow through a channel network downstream of the RSA10 then enter a tributary and ultimately flow towards Collins Pool.

Table 6-6: Breakout Location Summary

Facility	Breach Location	Justification
Starter Facility	South-west corner (refer Figure 6-5).	Location of the lowest crest elevation along the perimeter embankment and hence where the impoundment is most likely to overtop or erode.
Ultimate Facility	Approximately 2/3 of the length along the western embankment as measured from the north-western corner of the RSA embankment crest (refer Figure 6-7).	Ultimate deposition model results in this location being most likely to overtop/erode and corresponds with the highest elevation of the facility due to eccentric raising towards the southeast to accommodate upstream construction from the west and north. This location also corresponds with the lowest natural elevation of the floor upstream of the starter embankment.

The typical 'Flood Induced' breach mechanism of an embankment dam consists of the progressive erosion of embankment material as a result of overtopping due to extreme weather event or settlement of the crest resulting in loss in freeboard, which then becomes large enough to form a full breach (embankment collapse). For 'Sunny Day' breach the critical failure mechanism is due to an undrained strength loss in the residue or foundation clays which then causes a sudden static failure of the perimeter embankment and loss of any decant pond upstream of the failure.

A summary of the target release volumes, corresponding decant water to mud/ sand volume relationship and combined mud flow solids content as presented in Section 6.3, for input to the hydrodynamic modelling is presented in Table 6-7.

The geometry of the dam breach profiles is discussed in Section 6.3. A total breach time of 0.3 hours has been adopted as per the HEC-RAS Hydraulic Reference Manual (U.S. Army Corps of Engineers, 2025) for slag/refuse type dams.

Table 6-7: Dam Breach Parameters for RSA10

Breach Parameters	Unit	Starter Facility		Ultimate Facility	
		SDB	FIB	SDB	FIB
Initial Storage Elevation	mAHD	20.1 (MOL)	22.0 (HDPE Liner level)	77.6 (MOL)	79.5 (Inside Crest level)
Initial Storage Volume (V_T)	Mm^3	1.26	1.80	25.48	26.18
Lowest Natural Ground Elevation	mAHD	14.2			
Breach Mechanism	-	Static Instability	Over-topping	Static Instability	Over-topping
Ratio of Residue : Decant		85% : 15%	17% : 83%	100% : 0%	87% : 13%
Estimated Total Release Volume (V_R)	Mm^3	0.14	1.31	3.42	5.89
Estimated Residue Release Volume (V_{Rr})	Mm^3	0.12	0.22	3.40	5.10
Estimated Decant Water Release Volume (V_{Rw})	Mm^3	0.02	1.09	0.02	0.79
Calculated Mixed Solids Content (by mass)	%	62.3	20.0	67.8	62.6
Percentage release volume versus total storage volume	%	11.0	72.8*	13.0	22.0
Breach Progression	-	Linear			

* The high percentage of release volume for the starter facility FIB is estimated due to a larger proportion of decant water versus residue mud and therefore resulting in a dilute mixture for the total release volume (i.e. 20% w/w solids for the mixed residue and decant water).

6.6 Hydraulic Modelling

A hydrodynamic model was developed in TUFLOW to simulate the hypothetical breach scenarios of the proposed RSA10 Starter and Ultimate Facility. The hydraulic model inputs and development are further discussed in Appendix B.

The hydraulic modelling results were used as the basis of the Hypothetical Dam Breach Assessment (HDBA), discussed in Section 7 and Section 8 for the Starter Facility and Ultimate Facility, respectively.

7. Results for Starter Facility

7.1 Hypothetical Dam Breach Assessment

A Hypothetical Dam Breach Assessment was undertaken based on the hydraulic modelling results to inform the social, environmental and economic components of the Consequence Category Assessment.

7.1.1 Sunny Day Breach

In the Sunny Day scenario, an estimated peak flow of 200 m^3/s from a hypothetical dam breach is expected to discharge from the proposed RSA10 based on the relevant estimated breach parameters and non-Newtonian parameters. The Sunny Day Breach hydrograph and accumulated discharge volume is presented in Figure 7-1.

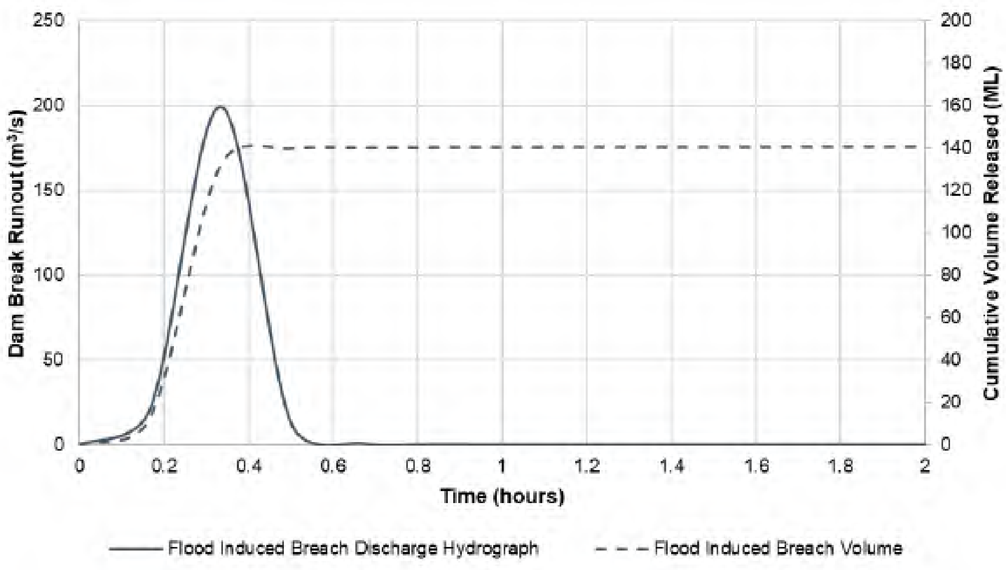


Figure 7-1: Starter Facility Sunny Day Breach Hydrograph

The maximum flood depth and maximum flood velocity for the entire model extent are provided in Appendix A. The hydraulic results for this scenario indicate that the flood extent is relatively localised in the vicinity of the RSA10 and is constrained to the eastern side of Somers Road. The area of the maximum flood extent is approximately 0.16 km^2 and the modelled runout distance reaches approximately 0.61 km to the north along the toe of the facility and 0.30 km downstream of the facility towards the west.

Based on the aerial imagery, no buildings or critical infrastructure appear to be impacted in this dam breach scenario; however, the Borehole Inspection Road immediately downstream of RSA10 which is affected. A summary of the maximum depth and maximum velocity at the key location is provided in Table 7-1.

Table 7-1: Summary of Results Starter Facility at Key Locations in the Sunny Day Breach

Location	Maximum Depth (m)	Maximum Velocity (m/s)	Time of First Inundation After Breach
Borehole Inspection Road	2.0	1.96	20 minutes

The maximum flood extent due to the SDB scenario is illustrated in Figure 7-2.

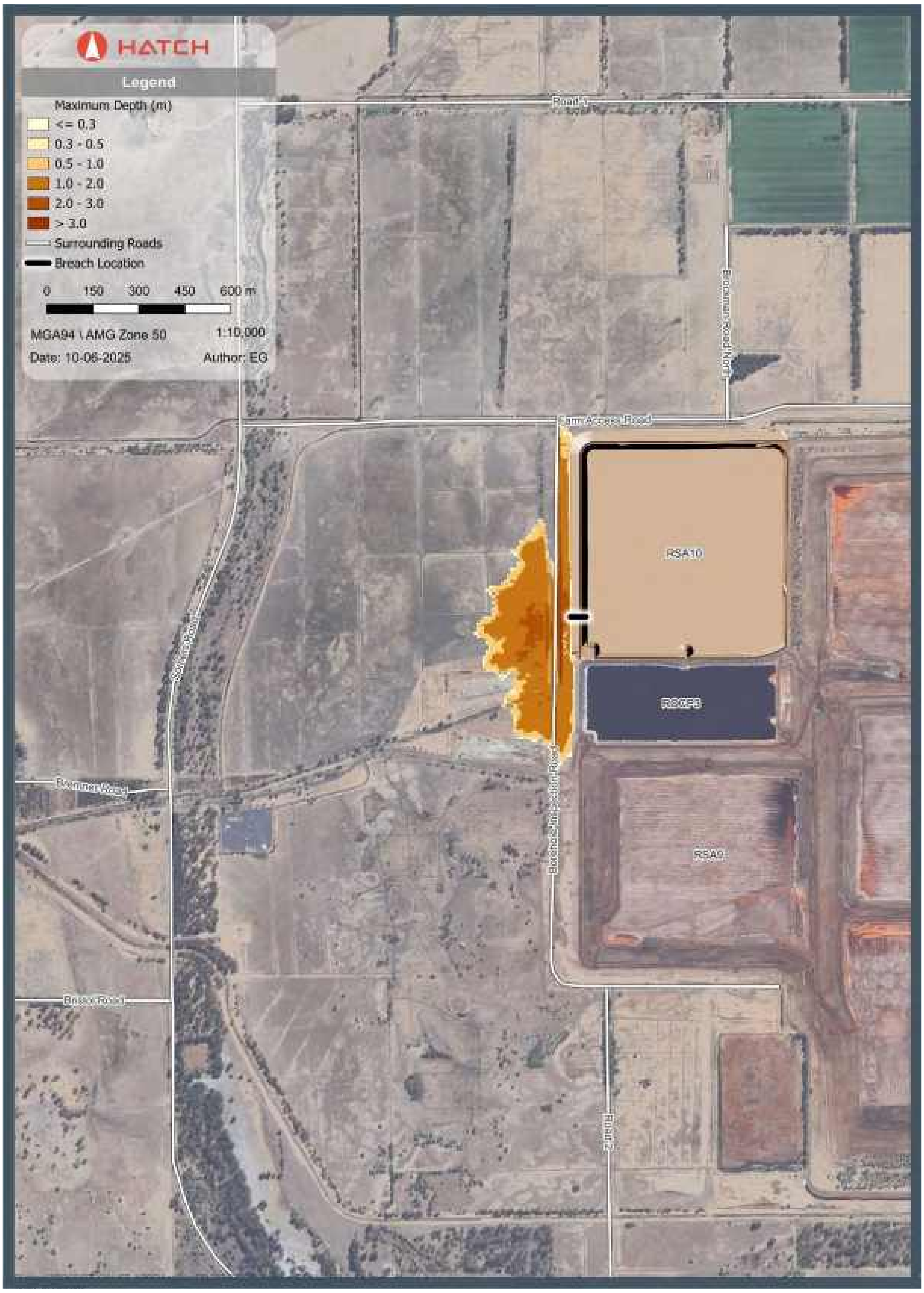


Figure 7-2: Starter Facility at Crest Elevation of RL 22 m subject to Sunny Day Breach Maximum Runout Depth and Extents

7.1.2 Flood Induced Breach

In the Flood Induced Breach scenario, an estimated peak flow of 878 m^3/s from a hypothetical breach is expected to discharge from the proposed RSA10 based on the relevant breach parameters calculated. The Flood Induced Breach hydrograph and accumulated discharge volume is presented in Figure 7-3.

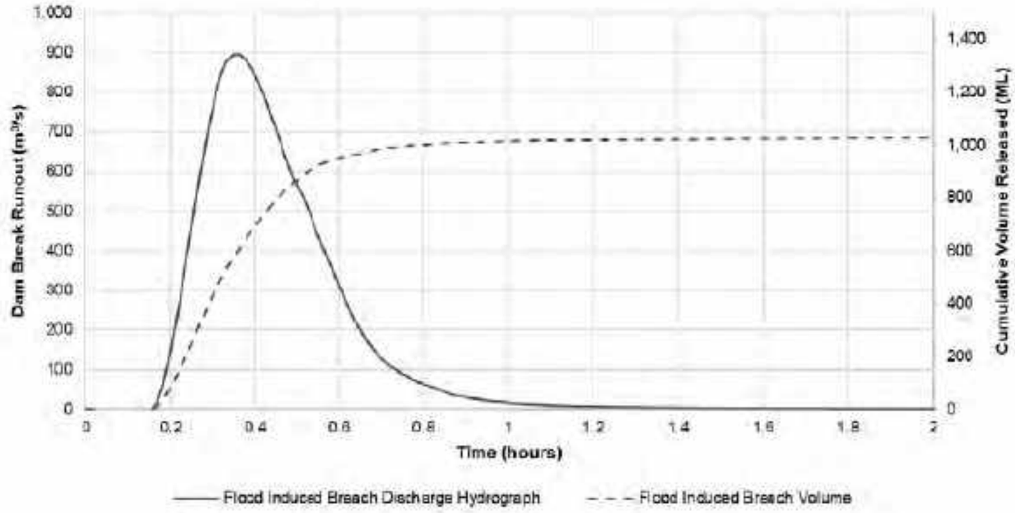


Figure 7-3: Starter Facility Flood Induced Breach Hydrograph

Modelling of the FIB scenario has been undertaken as an iterative process as follows:

1. The dam breach has been modelled as non-Newtonian flow to represent the extents of the mixed water and residue from within the dam only.
2. This final breach surface has then been applied on top of the existing topography and a Newtonian simulation of the concurrent flooding has been undertaken to conservatively replicate the total extent of any afflux by interaction of flows.

The maximum flood depth and maximum flood velocity for both the Newtonian and non-Newtonian flood extents are provided in Appendix A. These results indicate that the flood extent is widespread from the RSA10. The area of the maximum flood extents is summarised in Table 7-2.

Table 7-2: Starter Facility Maximum Downstream Areas of Impact by Dambreak

Scenario	FIB	NF (Newtonian)			Incremental Impact Area
	Non-Newtonian Flows	Newtonian Flows	Combined Flows	Total	
Area (km^2)	1.74	71.0	71.1	69.6	1.5

Hydraulic modelling of the breach indicates that several roads and structures downstream of the RSA10 are impacted to a comparable extent in both the FIB and NF scenarios.

Some roads in the vicinity of the RSA10 Starter Facility are worsened due to the impact of the facility breach, including the Borehole Inspection Road immediately downstream, the Farm Access Road and Road 2. Figure 7-4 illustrates the FIB scenario modelling results for the first 12 hours following breach initiation (after which time the Emergency Action Plan is expected to be implemented), and the full extent of the scenario. A summary of the maximum depth and maximum velocity at key locations are provided in Table 7-3.

The hydraulic modelling indicates that the Forrest Highway bridge (Codford Bridge) is not overtopped in the NB or FIB scenarios; however, surrounding sections of the highway are inundated in both scenarios.

Table 7-3: Summary of Results Starter Facility at Key Locations in the Flood Induced Breach

Location	Maximum Depth (m)	Maximum Velocity (m/s)	Time of First Inundation After Breach
Borehole Inspection Road	1.7	4.3	<10 minutes
Farm Access Road	1.1	2.8	30 minutes
Somers Road	1.4	1.5	1 hour and 30 minutes
Forrest Highway*	2.3	1.7	19 hours

*Forrest Highway bridge is not overtopped; however, the highway is inundated in both the FIB and NB scenarios.

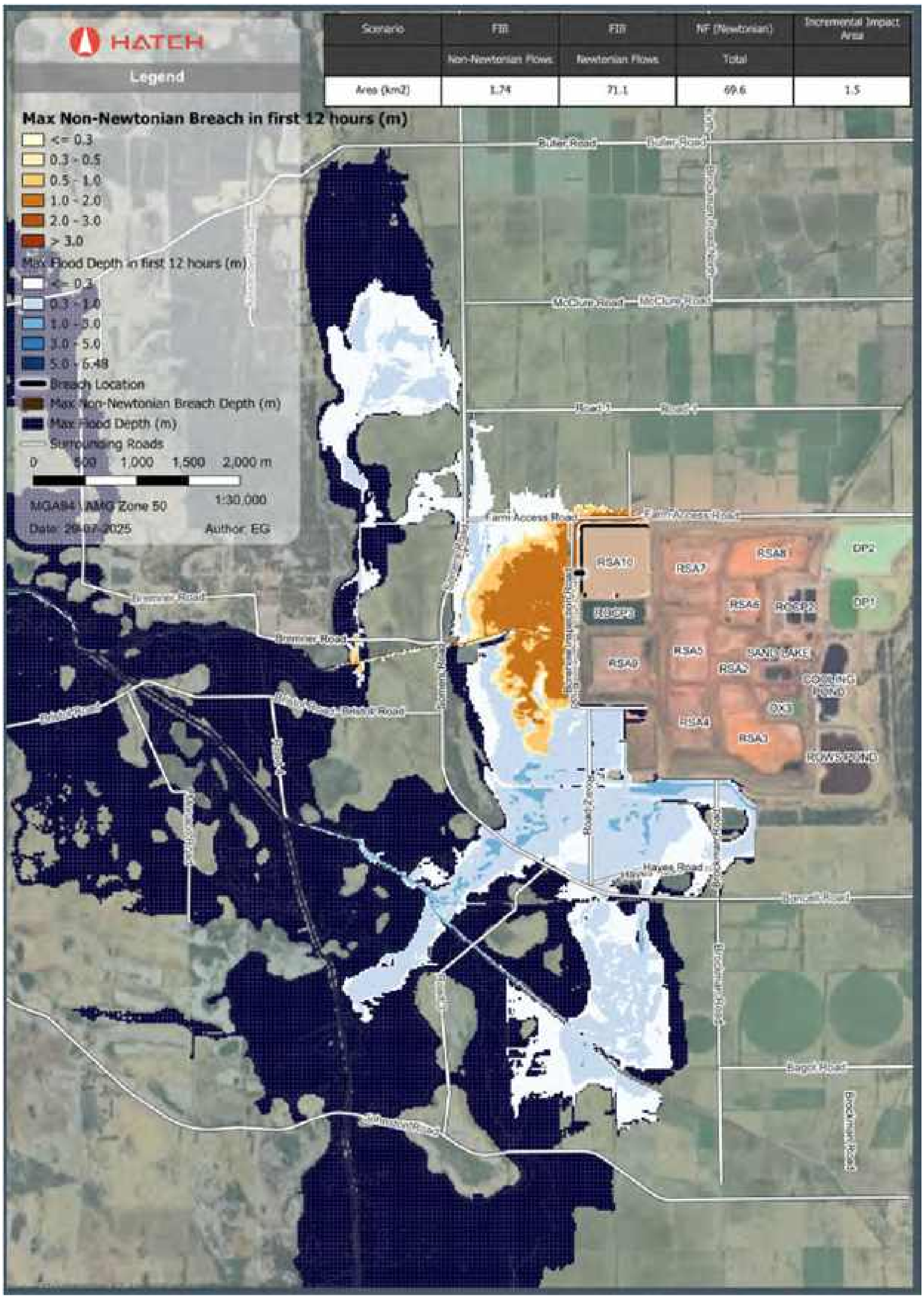


Figure 7-4: Inundation Extents under Flood Induced Breach for Starter Facility with Crest at RL 22 m and concurrent 1 in 100 AEP External Flood Event in the vicinity of RSA10

7.2 Population at Risk and Potential Loss of Life

Estimation of the PAR for all scenarios in accordance with (ANCOLD, 2012) is provided in Table 7-4. Where data was unavailable, assumptions were made regarding Average Annual Daily Traffic (AADT) and speed limits on the roads as specified in the table.

The following assumptions were made regarding the PAR estimation:

- The AADT of Somers Road was assumed to be 10% of AADT on the southwestern Highway enter in the vicinity of the road, therefore 357 vehicles/day were estimated to use this road (Main Roads Western Australia, 2020).
- Roads internal to the Alcoa site have an assumed occupancy of two passengers per vehicle.
- Public roads have an assumed 1.25 passengers per vehicle (Loader, 2017).
- The internal Wagerup road network has been based on proposed operational roads only. No consideration has been made for roads that may be constructed for the purpose of future development.
- As discussed in Section 2, the Sunny Day Breach has been modelled with non-Newtonian parameters to reflect the nature of the material released during a breach. Assessments have been based on the full extents of the breach and any depth of breach material is considered to pose a risk due to the material characteristics.
- In accordance with ANCOLD 2012, the Flood Induced Breach results have been considered up to 12 hours following breach initiation, after which time it is assumed that the Emergency Action Plan will be implemented and mitigating any further PAR or PLL.

In addition to the itinerant and permanent PAR considered, borehole monitoring activities to the west of the facility were also considered; however, assuming seven boreholes being monitored once a month for 10 minutes resulted in a negligible contribution to PAR and PLL.

The PLL has been calculated based on the method described in Reclamation Consequence Estimating Methodology (RCEM) ‘Guidelines for Estimating Life Loss for Dam Safety Risk Analysis’ (U.S. Department of the Interior Bureau of Reclamation, 2015) as discussed in Section 2.

Table 7-4: Estimation of PAR for the RSA10 Starter Facility

Assessment Parameters	Affected Roads			
	Borehole Inspection Road	Brockman Road	Farm Access Road	Somers Road
AADT	10	10	10	357
Assumed Passengers per Vehicle	2	1.25	2	1.25
Assumed Average Passengers per Day	20	13	20	447
Speed (km/h)	30	30	30	60
Sunny Day Breach				
Distance (km)	0.59	N/A	N/A	N/A
Itinerant PAR	0.016	N/A	N/A	N/A
Flood Induced Breach (Incremental) PAR				
Distance of Incremental Impact (km)	0.31	0.01	0.08	0.01
Itinerant PAR	0.009	0.000	0.002	0.002

Table 7-5: RSA10 Starter Facility PLL

Assessment Parameters	Affected Roads			
	Borehole Inspection Road*	Road 2	Farm Access Road	Somers Road
Sunny Day Breach				
Depth × Velocity (m^2/s)	0.78	N/A	N/A	N/A
Fatality Rate	1.00*	N/A	N/A	N/A
PLL	0.016*	N/A	N/A	N/A
Flood Induced Breach (Incremental) PAR				
Depth × Velocity (m^2/s)	3.035	1.400	0.347	1.200
Fatality Rate	0.003	0.0001	0.0001	0.0001
PLL	0.009*	-	-	-

* Due to the proximity of the Borehole Inspection Road to the hypothetical breach location, no warning time will be given and hence all PAR at this location is considered to be PLL.

A sensitivity assessment was undertaken to vary the timing of the concurrent flood to determine if the incremental impact to PAR was affected. This sensitivity analysis identified that the worst-case scenario for assessing PAR was earlier in the storm event before the peak of the concurrent flood reaches the RSA10 location.

A summary of the PAR and the PLL for the Starter Facility is provided in Table 7-6.

Table 7-6: Summary of PAR and PLL for the RSA10 Starter Facility

Scenario	PAR	PLL
Sunny Day Breach	0.016	0.016
Flood Induced Breach (Incremental Failure)	0.013	0.009

7.3 Consequence Category Assessment

A CCA was undertaken for the proposed RSA10 starter facility in accordance with ANCOLD (2012), GISTM (2020) and DMP (2013). An excerpt of the (ANCOLD, 2012) guideline is provided in Appendix E.

7.3.1 ANCOLD (2012) Consequence Category Assessment

The ANCOLD Guidelines on Consequence Categories for Dams (2012) provides a structured approach to determining Sunny Day and Flood Induced Breach consequence categories as a result of a possible dam break scenario. The relevant consequence criteria determined using the ANCOLD (2012) guidelines include the risk to human life and the severity of damage and loss. An assessment of the RSA10 Starter Facility hypothetical breach against these criteria is presented in the below Sections 7.3.1.1 and 7.3.1.2.

7.3.1.1 Severity of Damage and Loss

The severity of damage and loss due to the breach of the RSA10 is assessed below based on the available information in this phase.

Table 7-7: Severity of Damage and Loss to Breach of the RSA10 Starter Facility based on (ANCOLD, 2012)

Damage Type	Minor	Medium	Major	Catastrophic
Infrastructure and Economics				
Total infrastructure costs	[redacted]	[redacted]	[redacted]	[redacted]
Impact on Dam Owner's Business				
Impacts on Dam owners' business	Restrictions needed during dry periods	Restrictions needed during peak days and peak hours	Essential to maintain supply	Dissolution of business/entity
Effect on services provided by the owner	Minor difficulties in replacing services	Reduced services are possible with reasonable restrictions	Severe restrictions would be applied for at least one year	Services cannot be replaced or cannot get services from another source
Effect on continuing credibility	Some reaction but short lived	Severe widespread reaction	Extreme discontent	Total loss of confidence and credibility
Community reaction and political implications	Some reaction but short lived	Severe widespread reaction	Extreme discontent	Total loss of confidence and credibility
Impact on financial viability	Able to absorb in one financial year	Significant with considerable impact in the long term	Severe to crippling in the long term	Bankruptcy
Value of water in storage	Can be absorbed in one financial year	Loss of income for at least 1 year	Loss of income for more than 1 year	Bankruptcy
Health and Social Impacts				
Human health	<100 people affected	100 to 1,000 people affected	>1,000 people affected for greater than one month	>10,000 people affected for a year or more
Loss of services to the community	<100 people affected	100 to 1,000 people affected	>1,000 people affected for greater than one month	>10,000 people affected for a year or more
Cost of emergency management	<1000 person days	1,000 to 10,000 person days	>10,000 person days	>100,000 person days
Dislocation of people	<100 person months	100 to 1,000 person months	>1,000 person months	>10,000 person months

Damage Type	Minor	Medium	Major	Catastrophic
Dislocation of business	<20 business months	20 to 200 business months	>200 business months and some business failures	Numerous business failures
Employment affected	<100 jobs lost	100 to 1,000 jobs lost	>1,000 jobs lost	>10,000 jobs lost
Loss of heritage	Local facility	Regional facility	National facility	International facility
Loss of recreational facility	Local facility	Regional facility	National facility	International facility
Environmental Impacts				
Area of impact	< 1 km^2	< 5 km^2	< 20 km^2	> 20 km^2
Duration of impact	< 1 year	< 5 years	< 20 years	> 20 years
Stock and fauna	Discharge from dambreak would not contaminate water supplies used by stock and fauna.	Discharge from dambreak would contaminate water supplies used by stock and fauna. Health impacts not expected.	Discharge from dambreak would contaminate water supplies used by stock and fauna with contaminant uptake.	Discharge from dambreak would contaminate water supplies used by stock and fauna with contaminant uptake and measurable health impacts expected.
Ecosystems	Discharge from dambreak is not expected to impact on ecosystems. Remediation possible.	Discharge from dambreak would have short term impacts on ecosystems with natural recovery expected after one wet season. Remediation possible.	Discharge from dambreak would have significant impacts on ecosystems with natural recovery expected after several wet season. Remediation possible over many years.	Discharge from dambreak would have significant permanent impacts on ecosystems. Remediation involves altered ecosystems.
Rare and endangered species	Species exist but minimal damage expected. Recovery within one year.	Species exist with losses expected to be recovered over a number of years.	Rare and endangered species will be severely impacted. Recovery will take many years.	Endangered species will be lost from the area. Permanent loss of species will occur.

Sunny Day Breach Assessment   Flood Induced Breach Assessment

A summary of the consequence categories assigned for each of the aspects of 'Severity of Damage and Loss' considered in accordance with (ANCOLD, 2012) is provided in Table 7-8.

Table 7-8: Summary of Severity of Damage and Loss from a Breach of the Proposed RSA10

Impact	Severity of Damage and Loss		
	SDF	FIB	Overall
Infrastructure and Economics	Medium	Medium	Medium
Dam Owner's Business	Major	Major	Major
Health and Social Impacts	Minor	Minor	Minor
Environmental Impacts	Minor	Major	Major
Overall Severity of Damage and Loss	**Major**	**Major**	**Major**

7.3.1.2 *Summary of ANCOLD (2012) RSA10 Starter Facility CCA*

Based on the maximum PAR and PLL due to the RSA10 starter facility dam failure calculated in Section 7.2, and the severity of damage and loss determined in Section 7.3.1.1, a consequence category of **Significant** was assigned to the RSA10 based on (ANCOLD, 2012).

Table 7-9: ANCOLD Consequence Category for Starter Facility Based on the PAR (ANCOLD, 2012)

Population at risk	Severity of Damage and Loss			
	Minor	Medium	Major	Catastrophic
<1	Very low	Low	**Significant**	High C
>1 to <10	Significant (Note 2)	Significant (Note 2)	High C	High B
>10 to <100	High C	High C	High B	High A
>100 to <1,000	(Note 1)	High B	High A	Extreme
>1,000		(Note 1)	Extreme	Extreme

Note 1: With a PAR in excess of 100, it is unlikely damage will be minor. Similarly with a PAR in excess of 1,000 it is unlikely damage will be classified as medium.
Note 2: Change to 'High C' where there is the potential of one or more lives being lost.

☐ Sunny Day Breach Assessment ■ Flood Induced Breach Assessment

Table 7-10: ANCOLD Consequence Category for Starter Facility Based on the PLL (ANCOLD, 2012)

Population at risk	Severity of Damage and Loss			
	Minor	Medium	Major	Catastrophic
<0.1	Very low	Low	**Significant**	High C
>0.1 to <1	Significant	Significant	High C	High B
>1 to <5	(Note 1)	High C	High B	High A
>5 to <50	(Note 1)	High A	High A	Extreme
>50	(Note 1)	(Note 1)	Extreme	Extreme

Note 1: With an incremental PLL equal to or greater than one (1), it is unlikely damage will be minor. Similarly, with an incremental PLL in excess of 50 it is unlikely damage will be classified as medium.

☐ Sunny Day Breach Assessment ■ Flood Induced Breach Assessment

7.3.2 GISTM (2020) Consequence Category Assessment

GISTM (2020) provides a safe tailings facility management framework, aiming to achieve no harm to people and the environment through all phases of the facilities lifecycle. The incremental PAR and PLL was used to inform the consequence category presented in Table 7-11 which recommends a '**Significant**' consequence category is adopted for the RSA10 starter facility against GISTM (2020) guidelines.

Table 7-11: RSA10 Starter Facility Consequence Category Assessment based on GISTM (2020)

Dam Breach Consequence Classification	Incremental Losses				
	PAR	PLL	Environment	Health, Social and Cultural	Infrastructure and Economics
Low	None	None expected	Minimal short-term loss or deterioration of habitat or rare and endangered species.	Minimal effects and disruption of business and livelihoods. No measurable effect on human health. No disruption of heritage, recreation, community or cultural assets.	Low economic losses: area contains limited infrastructure or services. <US$1M.
Significant	1-10	Unspecified	No significant loss or deterioration of habitat. Potential contamination of livestock/fauna water supply with no health effects. Process water low potential toxicity. Tailings not potentially acid generating and have low neutral leaching potential. Restoration possible within 1 to 5 years.	Significant disruption of business, service or social dislocation. Low likelihood of loss of regional heritage, recreation, community, or cultural assets. Low likelihood of health effects.	Losses to recreational facilities, seasonal workplaces, and infrequently used transportation routes. <US$10M.
High	10-100	Possible (1-10)	Significant loss or deterioration of critical habitat or rare and endangered species. Potential contamination of livestock/fauna water supply with no health effects. Process water moderately toxic. Low potential for acid rock drainage or metal leaching effects of released tailings. Potential area of impact 10 km² - 20 km². Restoration possible but difficult and could take > 5 years.	500-1,000 people affected by disruption of business, services or social dislocation. Disruption of regional heritage, recreation, community or cultural assets. Potential for short term human health effects.	High economic losses affecting infrastructure, public transportation, and commercial facilities, or employment. Moderate relocation/compensation to communities. <US$100M.
Very High	100-1,000	Likely (10-100)	Major loss or deterioration of critical habitat or rare and endangered species. Process water highly toxic. High potential for acid rock drainage or metal leaching effects from released tailings. Potential area of impact > 20 km². Restoration or compensation possible but very difficult and requires a long time (5 years to 20 years).	1,000 people affected by disruption of business, services or social dislocation for more than one year. Significant loss of national heritage, community or cultural assets. Potential for significant long-term human health effects.	Very high economic losses affecting important infrastructure or services (e.g., highway, industrial facility, storage facilities, for dangerous substances), or employment. High relocation/ compensation to communities. < US$1B.
Extreme	> 1,000	Many (>100)	Catastrophic loss of critical habitat or rare and endangered species. Process water highly toxic. Very high potential for acid rock drainage or metal leaching effects from released tailings. Potential area of impact > 20 km². Restoration or compensation in kind impossible or requires a very long time (> 20 years)	5,000 people affected by disruption of business, services or social dislocation for years. Significant National heritage or community facilities or cultural assets destroyed. Potential for severe and/or long- term human health effects.	Extreme economic losses affecting critical infrastructure or services, (e.g., hospital, major industrial complex, major storage facilities for dangerous substances) or employment. Very high relocation/compensation to communities and very high social readjustment costs. >US$1B.

☐ Sunny Day Breach Assessment ■ Flood Induced Breach Assessment

7.3.3 DMP (2013) Consequence Category Assessment

The Tailings Storage Facilities in Western Australia Code of Practice (DMP, 2013) is a performance-based standard that provides factors to be considered when managing a TSF (Tailings Storage Facility). The code is used to assign a hazard rating based on the potential consequence of breach of the TSF or uncontrolled release of its contents. The RSA10 starter facility has been assessed against the Department of Mines and Petroleum (2013) hazard rating system in Table 7-12, where a rating of 'Medium' is recommended. As the starter facility has embankments between 5 m and 15 m in height, a TSF category of '**Category 2**' has been selected from Table 7-10. The TSF category is used by DMP (2013) to provide a consistent approach to hazard identification and management in Western Australia.

Table 7-12: RSA10 Starter Facility Consequence Category based on DMP (2013) Guideline

Type of Impact or Damage	Hazard Rating		
	High	Medium	Low
	Extent or severity of impact or damage		
Loss of human life or personal injury	Loss of life or injury is possible	Loss of life or injury is possible although not expected	No potential for loss of life or injury
Adverse human health due to direct physical impact or contamination of the environment (e.g., chemical or radiation denigration of water, soil, air)	Long-term human exposure is possible, and permanent or prolonged adverse health effects are expected	The potential for human exposure is limited, and temporary adverse health effects are possible	No potential for human exposure
Loss of assets due to direct physical impact or contamination of the environment (e.g., chemical or radioactive pollution of water, soil, air)	Loss of numerous livestock is possible	Loss of some livestock is possible	Limited or no potential for loss of livestock
	Permanent loss of assets (e.g., commercial, industrial, agricultural and pastoral assets, public utilities and infrastructure, mine infrastructure) is possible and no economic repairs can be made	Temporary loss of assets is possible and economic repairs can be made	Limited or no potential for destruction or loss of assets
	Loss of TSF storage capacity is possible and repair is not practicable	Loss of TSF storage capacity is possible and repair is practicable	Insignificant loss of TSF storage capacity is possible

Type of Impact or Damage	Hazard Rating		
	High	Medium	Low
	Extent or severity of impact or damage		
Damage to items of environmental, heritage or historical value due to direct physical impact or contamination of the environment (e.g., chemical or radioactive pollution of water, soil or air)	Permanent or prolonged damage to the natural environment (including soil and surface and ground water resources) is possible	Temporary damage to the natural environment is possible	Limited or no potential for damage to the natural environment
	Permanent or prolonged adverse effects on flora and fauna are possible	Temporary adverse effects on flora and fauna are possible	Limited or no potential for adverse effects on flora and fauna
	Permanent damage or loss of items of heritage or historical value is possible	Temporary damage of items of heritage or historical value is possible	Limited or no potential for damage of items of heritage or historical value

Sunny Day Breach Assessment Flood Induced Breach Assessment

Table 7-13: RSA10 Starter Facility Hazard Rating based on Embankment Height (DMP, 2013)

Maximum Embankment or Structure Height	Hazard Rating		
	High	Medium	Low
> 15 m	Category 1	Category 1	Category 1
5 - 15 m	Category 1	**Category 2**	Category 2
< 5 m	Category 1	Category 2	Category 3

Sunny Day Breach Assessment Flood Induced Breach Assessment

7.3.4 *Starter Facility - Consequence Category Assessment Summary*

The outcomes of the consequence category assessments conducted in accordance with (ANCOLD, 2012), (GISTM, 2020) and (DMP, 2013) are outlined in Table 7-14.

Table 7-14: Summary of Severity of Damage and Loss from a Breach of the Proposed RSA10 Starter Facility

Guideline	Consequence Category	
	SDB	FIB
ANCOLD (2012)	Significant	Significant
GISTM (2020)	Significant	Significant
DMP (2013)	Category 2	Category 2

8. Results for Ultimate Facility

8.1 Hypothetical Dam Breach Assessment

A Hypothetical Dam Breach Assessment was undertaken based on the hydraulic modelling results to inform the social, environmental and economic components of the CCA.

8.1.1 Sunny Day Breach

In the Sunny Day scenario, an estimated peak flow of 12,476 m^3/s from a hypothetical dam breach is expected to discharge from the proposed RSA10 based on the relevant estimated breach parameters. The Sunny Day Breach hydrograph and accumulated discharge volume is presented in Figure 8-1.

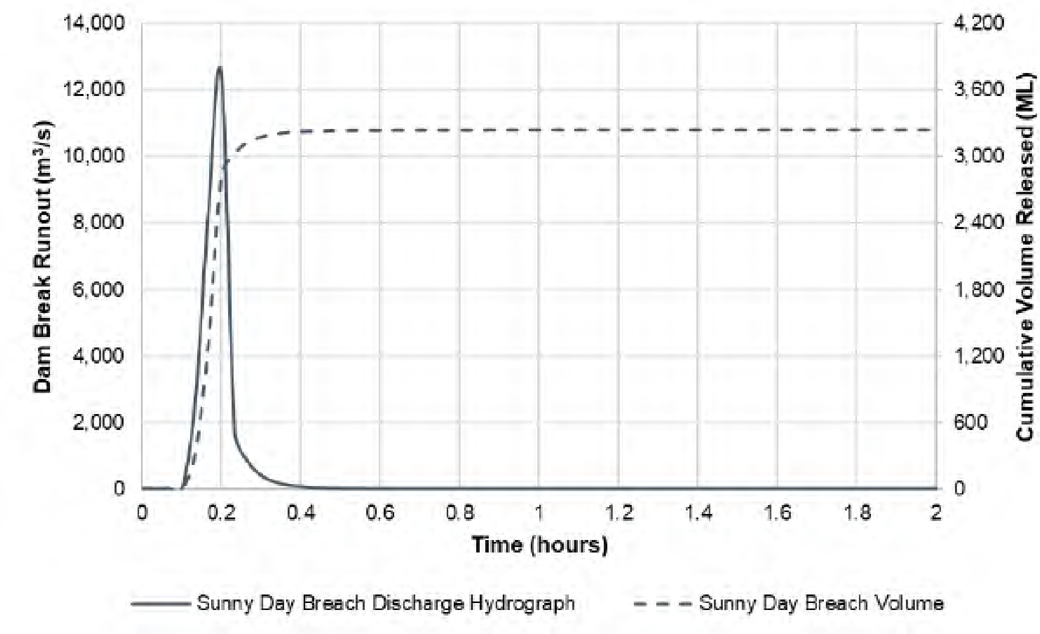


Figure 8-1: Ultimate Facility Sunny Day Breach Hydrograph

The maximum flood depth and maximum flood velocity for the entire model extent are provided in Appendix A. The hydraulic results for this scenario indicate that the flood extent is relatively localised in the vicinity of the RSA10 and remains on the eastern side of Somers Road. The area of the maximum flood extent is approximately 0.77 km^2 and the modelled runout distance reaches approximately 0.71 km downstream of the facility.

Based on the aerial imagery, no buildings or critical infrastructure appear to be impacted in this dam breach scenario; however, the Borehole Inspection Road immediately downstream of RSA10 and the Farm Access Road to the north are affected. A summary of the maximum depth and maximum velocity at key locations are provided in Table 8-1.

Table 8-1: Summary of Ultimate Facility Results at Key Locations in the SDB

Location	Maximum Depth (m)	Maximum Velocity (m/s)	Time of First Inundation After Breach
Borehole Inspection Road	8.9	8.4	< 10 minutes
Farm Access Road	3.7	3.4	20 minutes

The maximum flood extent due to the SDB scenario is illustrated Figure 8-2.

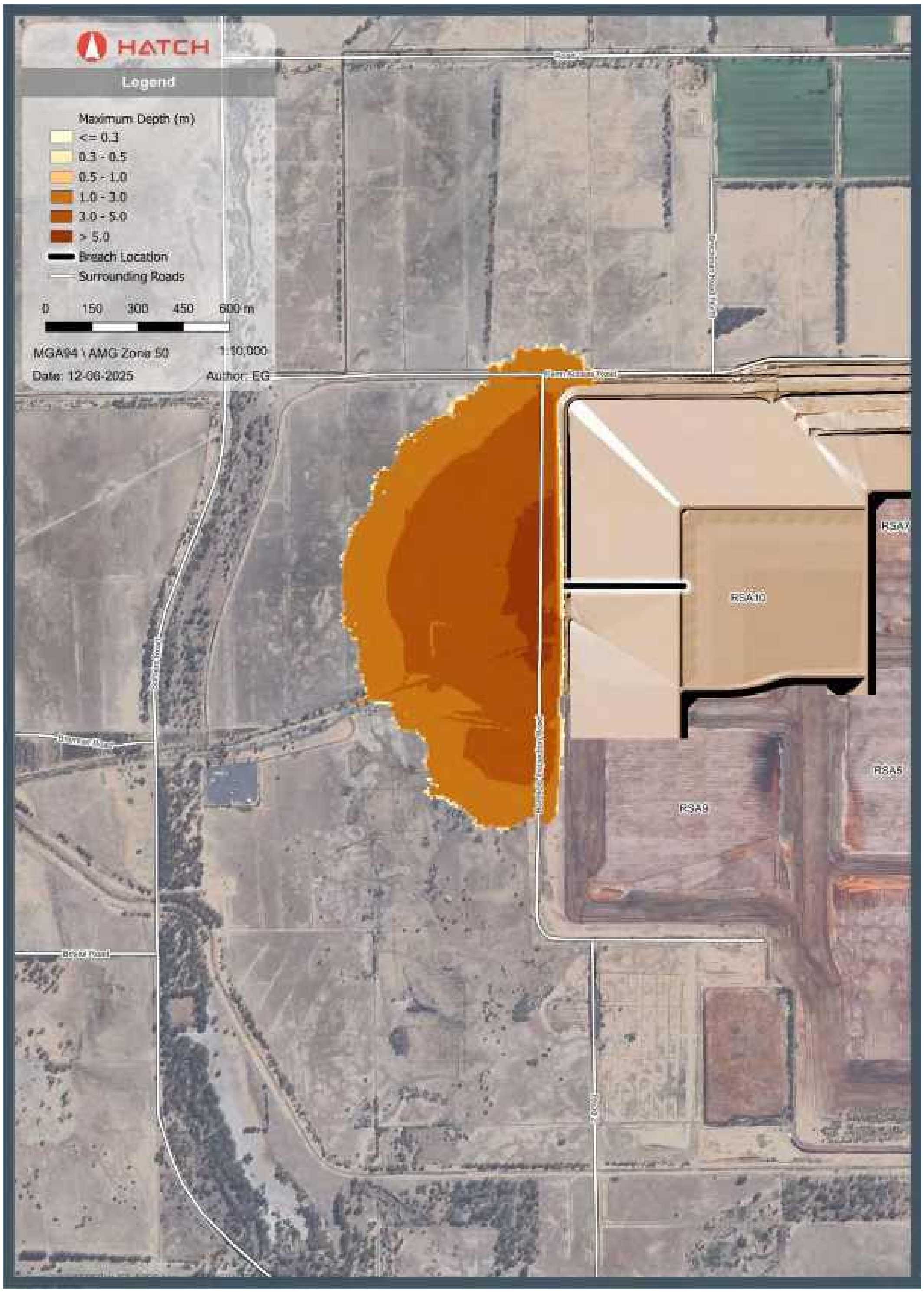


Figure 8-2: Ultimate Facility at Crest Elevation of RL 80 m subject to Sunny Day Breach Maximum Runout Depth and Extents

8.1.2 *Flood Induced Breach*

In the Flood Induced Breach scenario, an estimated peak flow of 4,271 m^3/s from a hypothetical dam breach is expected to discharge from the proposed RSA10 based on the relevant breach parameters calculated. The Flood Induced Breach hydrograph and accumulated discharge volume is presented in Figure 8-3.

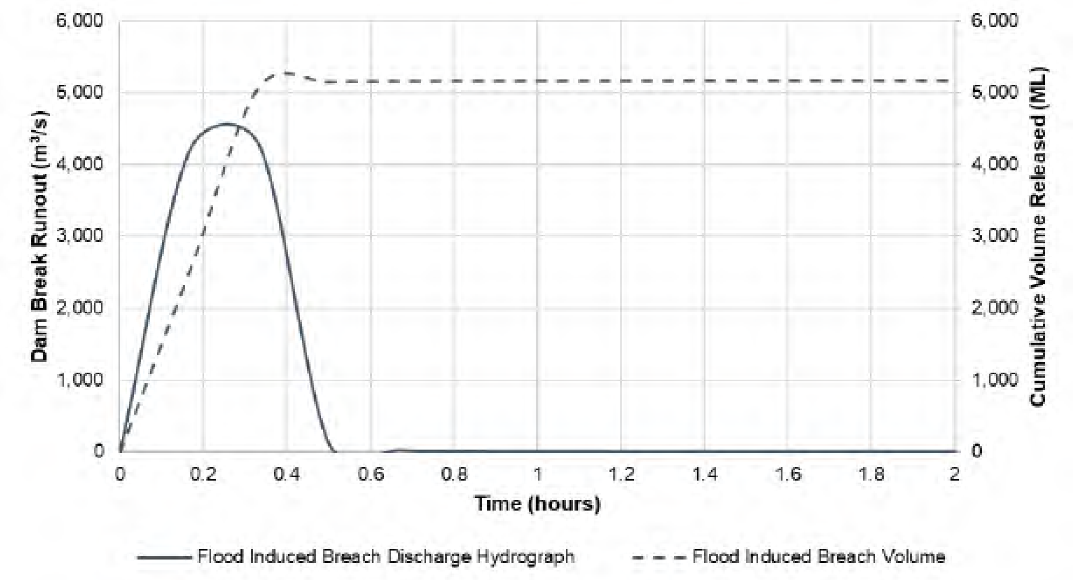


Figure 8-3: Ultimate Facility Flood Induced Breach Hydrograph

Similar to the Starter Facility, modelling of the FIB scenario for the Ultimate Facility has been modelled as an iterative process as follows:

3. The dam breach has been modelled to as non-Newtonian flow to represent the extents of the mixed water and residue from within the impoundment only.
4. This final breach surface has then been applied on top of the existing topography and a Newtonian simulation of the concurrent flooding has been undertaken to conservatively replicate the total extent of any afflux by interaction of flows.

The maximum flood depth and maximum flood velocity for both the Newtonian and Non-Newtonian flood extents are provided in Appendix A. These results indicate that the flood extents are widespread from the RSA10 to the downstream extent of the model at Collins Pool. The area of the maximum flood extent is approximately 1.70 km^2 and the modelled runout distance reaches approximately 1.1 km. The area of the maximum flood extents is summarised in Table 8-2.

Table 8-2: Flood Extents for Ultimate Facility

Scenario	FIB			NF	Incremental Impact Area
	Non-Newtonian Flows	Newtonian Flows	Total		
Area (km^2)	1.70	74.2	75.9	74.6	1.3

Hydraulic modelling of the breach indicates that several roads and structures downstream of the RSA10 are impacted in the FIB scenario. This is further discussed in Section 8.2 with the estimation of PAR and PLL. Figure 8-4 illustrates the FIB scenario modelling results for the first 12 hours following breach initiation (after which time the Emergency Action Plan is expected to be implemented). A summary of the maximum depth and maximum velocity at key locations are provided in Table 8-3.

The hydraulic modelling indicates that the Forrest Highway bridge (Codford Bridge) is not overtopped in the NB or FIB scenarios, however surrounding sections of the highway are inundated in both scenarios. The Forrest Highway is inundated in both scenarios; however, as this first occurs approximately 19 hours following breach initiation, it is assumed an emergency action plan will be implemented and road users can avoid being impacted.

Table 8-3: Summary of Results Ultimate Facility at Key Locations in the FIB

Location	Maximum Depth (m)	Maximum Velocity (m/s)	Time of First Inundation After Breach
Borehole Inspection Road	7.4	6.5	< 10 minutes
Farm Access Road	5.0	4.2	20 minutes
Somers Road	1.4	1.7	9.5 hours
Forrest Highway*	4.1	2.2	12.5 hours

*Forrest Highway bridge is not overtopped; however, the highway is inundated in both the FIB and NF scenarios.

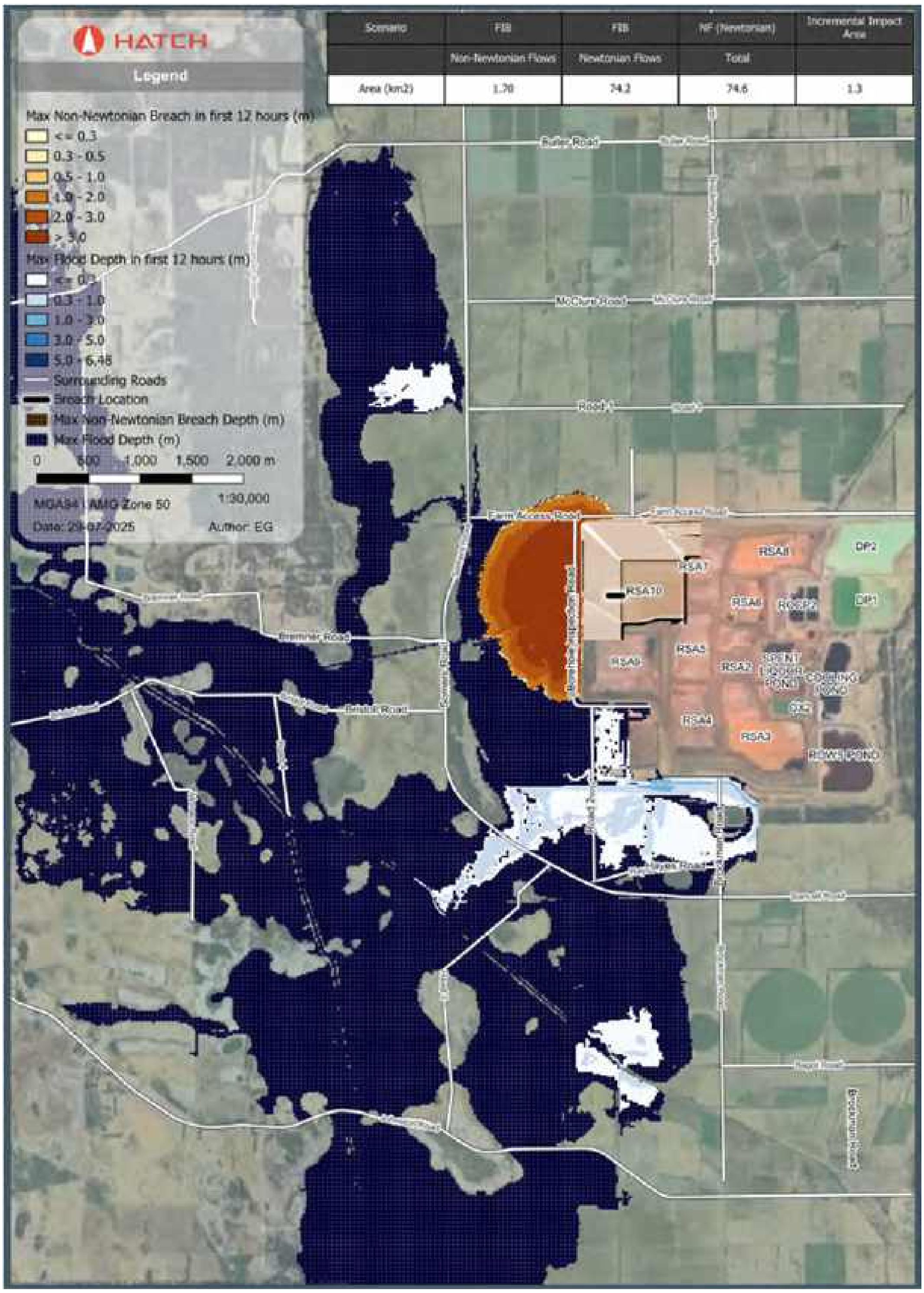


Figure 8-4: Inundation Extents under Flood Induced Breach for Ultimate Facility with Crest at RL 80 m and concurrent 1 in 100 AEP External Flood Event in the vicinity of RSA10

8.2 Population at Risk and Potential Loss of Life

Estimation of the PAR for all scenarios in accordance with (ANCOLD, 2012) is provided in Table 8-4. Where data was unavailable, assumptions were made regarding AADT and speed limits on the roads as specified in the table.

The following assumptions were made regarding the PAR estimation:

- The AADT of Somers Road was assumed to be 10% of AADT on the southwestern Highway enter in the vicinity of the road, therefore approximately 357 vehicles/day (Main Roads Western Australia, 2020).
- Roads internal to the Alcoa site have an assumed occupancy of two passengers per vehicle.
- Public roads have an assumed 1.25 passengers per vehicle (Loader, 2017).
- The internal Wagerup road network has been based on proposed operational roads only. No consideration has been made for roads that may be constructed for the purpose of future development.
- As discussed in Section 2, the Sunny Day Breach has been modelled with non-Newtonian parameters to reflect the nature of the material released during the breach. Assessments have been based on the full extents of the breach and any depth of breach material is considered to pose a risk due to the material characteristics.
- In accordance with ANCOLD 2012, the Flood Induced Breach results have been considered up to 12 hours following breach initiation, after which time it is assumed that the Emergency Action Plan will be implemented and mitigating any further PAR or PLL.

In addition to the itinerant and permanent PAR considered, borehole monitoring activities to the west of the facility were also considered; however, assuming seven boreholes being monitored once a month for 10 minutes resulted in a negligible contribution to PAR and PLL. The PLL has been calculated based on the method described in Reclamation Consequence Estimating Methodology (RCEM) ‘Guidelines for Estimating Life Loss for Dam Safety Risk Analysis’ (U.S. Department of the Interior Bureau of Reclamation, 2015) and is summarised in Figure 8-4.

Table 8-4: Estimation of PAR for the Affected Roads in the RSA10 Ultimate Facility Breach

Assessment Parameters	Affected Roads	
	Borehole Inspection Road	Farm Access Road
Average Annual Daily Traffic (AADT)	10	10
Assumed Passengers per Vehicle	2	2
Assumed Average Passengers per Day	20	20
Speed (km/h)	30	30
Sunny Day Breach		
Distance (km)	1.45	0.30
Itinerant PAR	0.040	0.008
Flood Induced Breach (Incremental) PAR		
Distance of Incremental Impact (km)	1.62	0.97
Itinerant PAR	0.045	0.027

Table 8-5: Estimation of PLL for the Affected Roads in the RSA10 Ultimate Facility Breach

Assessment Parameters	Affected Roads	
	Borehole Inspection Road	Farm Access Road
Sunny Day Breach		
Depth × Velocity (m^2/s)	39.9	1.8
Fatality Rate	1.0*	0.001
PLL	0.040	0.000
Flood Induced Breach (Incremental) PAR		
Depth x Velocity (m^2/s)	89.0	16.5
Fatality Rate	1.0*	0.4
PLL	0.045	0.011

* Due to the proximity of the Borehole Inspection Road to the hypothetical breach location, no warning time will be given and hence all PAR at this location is considered to be PLL

A sensitivity assessment was undertaken to vary the timing of the concurrent flood to determine if the incremental impact to PAR was affected. This sensitivity analysis identified that the worst-case scenario for assessing PAR was earlier in the storm event before the peak of the concurrent flood reaches the RSA10 location.

A summary of the PAR and the PLL for the Ultimate Facility is provided in Table 8-6.

Table 8-6: Summary of PAR and PLL for the RSA10 Ultimate Facility

Scenario	PAR	PLL
Sunny Day Breach	0.048	0.040
Flood Induced Breach (Incremental Failure)	0.072	0.056

8.3 Consequence Category Assessment

A CCA was undertaken for the proposed RSA10 Ultimate Facility in accordance with ANCOLD (2012), GISTM (2020) and DMP (2013). An excerpt of the (ANCOLD, 2012) guideline is provided in Appendix E for reference.

8.3.1 ANCOLD (2012) Consequence Category Assessment

The ANCOLD Guidelines on Consequence Categories for Dams (2012) provides a structured approach to determining Sunny Day Breach and Flood Induced Breach consequence categories as a result of a possible dam break scenario. The relevant consequence criteria determined using the ANCOLD (2012) guidelines include the risk to human life and the severity of damage and loss. An assessment of the RSA10 Ultimate Facility hypothetical breach against these criteria is presented in the below Sections 8.3.1.1 and 8.3.1.2.

8.3.1.1 Severity of Damage and Loss

The severity of damage and loss due to the breach from the RSA10 is assessed in Table 8-7 based on the available information in this phase.

Table 8-7: Severity of Damage and Loss due to Breach from the RSA10 Ultimate Facility based on (ANCOLD, 2012)

Damage Type	Minor	Medium	Major	Catastrophic
Infrastructure and Economics				
Total infrastructure costs	<$[redacted]	[redacted]	[redacted]	[redacted]
Impact on Dam Owner's Business				
Impacts on Dam owners' business	Restrictions needed during dry periods	Restrictions needed during peak days and peak hours	Essential to maintain supply	Dissolution of business/entity
Effect on services provided by the owner	Minor difficulties in replacing services	Reduced services are possible with reasonable restrictions	Severe restrictions would be applied for at least one year	Services cannot be replaced or cannot get services from another source
Effect on continuing credibility	Some reaction but short lived	Severe widespread reaction	Extreme discontent	Total loss of confidence and credibility
Community reaction and political implications	Some reaction but short lived	Severe widespread reaction	Extreme discontent	Total loss of confidence and credibility
Impact on financial viability	Able to absorb in one financial year	Significant with considerable impact in the long term	Severe to crippling in the long term	Bankruptcy
Value of water in storage	Can be absorbed in one financial year	Loss of income for at least 1 year	Loss of income for more than 1 year	Bankruptcy
Health and Social Impacts				
Human health	<100 people affected	100 to 1,000 people affected	>1,000 people affected for greater than one month	>10,000 people affected for a year or more
Loss of services to the community	<100 people affected	100 to 1,000 people affected	>1,000 people affected for greater than one month	>10,000 people affected for a year or more
Cost of emergency management	<1,000 person days	1000 to 10,000 person days	>10,000 person days	>100,000 person days
Dislocation of people	<100 person months	100 to 1,000 person months	>1,000 person months	>10,000 person months

Damage Type	Minor	Medium	Major	Catastrophic
Dislocation of business	<20 business months	20 to 200 business months	>200 business months and some business failures	Numerous business failures
Employment affected	<100 jobs lost	100 to 1,000 jobs lost	>1,000 jobs lost	>10,000 jobs lost
Loss of heritage	Local facility	Regional facility	National facility	International facility
Loss of recreational facility	Local facility	Regional facility	National facility	International facility
Environmental Impacts				
Area of impact	< 1 km^2	< 5 km^2	< 20 km^2	> 20 km^2
Duration of impact	< 1 year	< 5 years	< 20 years	> 20 years
Stock and fauna	Discharge from dambreak would not contaminate water supplies used by stock and fauna.	Discharge from dambreak would contaminate water supplies used by stock and fauna. Health impacts not expected.	Discharge from dambreak would contaminate water supplies used by stock and fauna with contaminant uptake.	Discharge from dambreak would contaminate water supplies used by stock and fauna with contaminant uptake and measurable health impacts expected.
Ecosystems	Discharge from dambreak is not expected to impact on ecosystems. Remediation possible.	Discharge from dambreak would have short term impacts on ecosystems with natural recovery expected after one wet season. Remediation possible.	Discharge from dambreak would have significant impacts on ecosystems with natural recovery expected after several wet season. Remediation possible over many years.	Discharge from dambreak would have significant permanent impacts on ecosystems. Remediation involves altered ecosystems.
Rare and endangered species	Species exist but minimal damage expected. Recovery within one year.	Species exist with losses expected to be recovered over a number of years.	Rare and endangered species will be severely impacted. Recovery will take many years.	Endangered species will be lost from the area. Permanent loss of species will occur.

☐ Sunny Day Breach Assessment ■ Flood Induced Breach Assessment

A summary of the consequence categories assigned for each of the aspects of 'Severity of Damage and Loss' considered in accordance with (ANCOLD, 2012) is provided in Table 8-8.

Table 8-8: Summary of Severity of Damage and Loss due to a Breach of the Proposed RSA10 Ultimate Facility

Impact	Severity of Damage and Loss		
	SDF	FIB	Overall
Infrastructure and Economics	Medium	Medium	Medium
Dam Owner's Business	Catastrophic	Catastrophic	Catastrophic
Health and Social Impacts	Minor	Minor	Minor
Environmental Impacts	Medium	Major	Major
Overall Severity of Damage and Loss	**Catastrophic**	**Catastrophic**	**Catastrophic**

8.3.1.2 *Summary of ANCOLD (2012) RSA10 Ultimate Facility CCA*

Based on the maximum PAR and PLL due to the RSA10 Ultimate Facility breach calculated in Section 8.2 and the severity of damage and loss determined in Section 8.3.1.1, a consequence category of **High B** was assigned to the RSA10 based on (ANCOLD, 2012).

Table 8-9: ANCOLD Consequence Category based on the PAR (ANCOLD, 2012)

Population at risk	Severity of Damage and Loss			
	Minor	Medium	Major	Catastrophic
<1	Very low	Low	Significant	High C
≥1 to <10	Significant (Note 2)	Significant (Note 2)	High C	**High B**
≥10 to <100	High C	High C	High B	High A
≥100 to <1,000	(Note 1)	High B	High A	Extreme
≥1,000		(Note 1)	Extreme	Extreme

Note 1: With a PAR in excess of 100, it is unlikely damage will be minor. Similarly with a PAR in excess of 1,000 it is unlikely damage will be classified as medium.
Note 2: Change to 'High C' where there is the potential of one or more lives being lost.

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Table 8-10: ANCOLD Consequence Category Based on the PLL (ANCOLD, 2012)

Population at risk	Severity of Damage and Loss			
	Minor	Medium	Major	Catastrophic
<0.1	Very low	Low	Significant	High C
≥0.1 to <1	Significant	Significant	High C	**High B**
≥1 to <5	(Note 1)	High C	High B	High A
≥5 to <50		High A	High A	Extreme
≥50		(Note 1)	Extreme	Extreme

Note 1: With an incremental PLL equal to or greater than one (1), it is unlikely damage will be minor. Similarly, with an incremental PLL in excess of 50 it is unlikely damage will be classified as medium.

☐ Sunny Day Breach Assessment ■ Flood Induced Breach Assessment

8.3.2 GISTM (2020) Consequence Category Assessment

GISTM (2020) provides a safe tailings facility management framework, aiming to achieve no harm to people and the environment through all phases of the facilities lifecycle. The incremental PAR and PLL were used to inform the consequence category presented in Table 8-11 which recommends a '**High**' consequence category is adopted for the RSA10 Ultimate Facility against GISTM (2020) guidelines.

Table 8-11: RSA10 Ultimate Facility Consequence Category Assessment based on GISTM (2020)

Dam Breach Consequence Classification	Incremental Losses				
	PAR	PLL	Environment	Health, Social and Cultural	Infrastructure and Economics
Low	None	None expected	Minimal short-term loss or deterioration of habitat or rare and endangered species.	Minimal effects and disruption of business and livelihoods. No measurable effect on human health. No disruption of heritage, recreation, community or cultural assets.	Low economic losses: area contains limited infrastructure or services. <US$1M.
Significant	1-10	Unspecified	No significant loss or deterioration of habitat. Potential contamination of livestock/fauna water supply with no health effects. Process water low potential toxicity. Tailings not potentially acid generating and have low neutral leaching potential. Restoration possible within 1 to 5 years.	Significant disruption of business, service or social dislocation. Low likelihood of loss of regional heritage, recreation, community, or cultural assets. Low likelihood of health effects.	Losses to recreational facilities, seasonal workplaces, and infrequently used transportation routes. <US$10M.
High	10-100	Possible (1-10)	Significant loss or deterioration of critical habitat or rare and endangered species. Potential contamination of livestock/fauna water supply with no health effects. Process water moderately toxic. Low potential for acid rock drainage or metal leaching effects of released tailings. Potential area of impact 10 km² - 20 km². Restoration possible but difficult and could take > 5 years.	500-1,000 people affected by disruption of business, services or social dislocation. Disruption of regional heritage, recreation, community or cultural assets. Potential for short term human health effects.	High economic losses affecting infrastructure, public transportation, and commercial facilities, or employment. Moderate relocation/compensation to communities. <US$100M.
Very High	100-1,000	Likely (10-100)	Major loss or deterioration of critical habitat or rare and endangered species. Process water highly toxic. High potential for acid rock drainage or metal leaching effects from released tailings. Potential area of impact > 20 km². Restoration or compensation possible but very difficult and requires a long time (5 years to 20 years).	1,000 people affected by disruption of business, services or social dislocation for more than one year. Significant loss of national heritage, community or cultural assets. Potential for significant long-term human health effects.	Very high economic losses affecting important infrastructure or services (e.g., highway, industrial facility, storage facilities, for dangerous substances), or employment. High relocation/ compensation to communities. < US$1B.
Extreme	> 1,000	Many (>100)	Catastrophic loss of critical habitat or rare and endangered species. Process water highly toxic. Very high potential for acid rock drainage or metal leaching effects from released tailings. Potential area of impact > 20 km². Restoration or compensation in kind impossible or requires a very long time (> 20 years)	5,000 people affected by disruption of business, services or social dislocation for years. Significant National heritage or community facilities or cultural assets destroyed. Potential for severe and/or long- term human health effects.	Extreme economic losses affecting critical infrastructure or services, (e.g., hospital, major industrial complex, major storage facilities for dangerous substances) or employment. Very high relocation/compensation to communities and very high social readjustment costs. >US$1B.

Sunny Day Breach Assessment (red outline) Flood Induced Breach Assessment (shaded)

8.3.3 *DMP (2013) Consequence Category Assessment*

The Tailings Storage Facilities in Western Australia Code of Practice (DMP, 2013) is a performance-based standard that provides factors to be considered when managing a TSF. The code is used to assign a hazard rating based on the potential consequence of a breach of the TSF or uncontrolled release of its contents. The RSA10 Ultimate Facility has been assessed against the Department of Mines and Petroleum (2013) hazard rating system in Table 8-12, where a rating of '**High**' is recommended. As the Ultimate Facility has embankments greater than 15 m in height, a TSF category of '**Category 1**' has been identified in Table 8-13. The TSF category is used by DMP (2013) to provide a consistent approach to hazard identification and management in Western Australia.

Table 8-12: RSA10 Ultimate Facility Consequence Category based on DMP (2013) Guideline

Type of Impact or Damage	Hazard Rating		
	High	Medium	Low
	Extent or severity of impact or damage		
Loss of human life or personal injury	Loss of life or injury is possible	Loss of life or injury is possible although not expected	No potential for loss of life or injury
Adverse human health due to direct physical impact or contamination of the environment (e.g., chemical or radiation denigration of water, soil, air)	Long-term human exposure is possible, and permanent or prolonged adverse health effects are expected	The potential for human exposure is limited, and temporary adverse health effects are possible	No potential for human exposure
Loss of assets due to direct physical impact or contamination of the environment (e.g., chemical or radioactive pollution of water, soil, air)	Loss of numerous livestock is possible	Loss of some livestock is possible	Limited or no potential for loss of livestock
	Permanent loss of assets (e.g., commercial, industrial, agricultural and pastoral assets, public utilities and infrastructure, mine infrastructure) is possible and no economic repairs can be made	Temporary loss of assets is possible and economic repairs can be made	Limited or no potential for destruction or loss of assets
	Loss of TSF storage capacity is possible and repair is not practicable	Loss of TSF storage capacity is possible and repair is practicable	Insignificant loss of TSF storage capacity is possible

Type of Impact or Damage	Hazard Rating		
	High	Medium	Low
	Extent or severity of impact or damage		
Damage to items of environmental, heritage or historical value due to direct physical impact or contamination of the environment (e.g., chemical or radioactive pollution of water, soil or air)	Permanent or prolonged damage to the natural environment (including soil and surface and ground water resources) is possible	Temporary damage to the natural environment is possible	Limited or no potential for damage to the natural environment
	Permanent or prolonged adverse effects on flora and fauna are possible	Temporary adverse effects on flora and fauna are possible	Limited or no potential for adverse effects on flora and fauna
	Permanent damage or loss of items of heritage or historical value is possible	Temporary damage of items of heritage or historical value is possible	Limited or no potential for damage of items of heritage or historical value

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Table 8-13: RSA10 Ultimate Facility Hazard Rating based on Embankment Height (DMP, 2013)

Maximum Embankment or Structure Height	Hazard Rating		
	High	Medium	Low
> 15 m	**Category 1**	Category 1	Category 1
5 - 15 m	Category 1	Category 2	Category 2
< 5 m	Category 1	Category 2	Category 3

☐ Sunny Day Breach Assessment ■ Flood Induced Breach Assessment

8.3.4 *Ultimate Facility - Consequence Category Assessment Summary*

The outcomes of the consequence category assessments conducted in accordance with (ANCOLD, 2012), (GISTM, 2020) and (DMP, 2013) are outlined in Table 8-12.

Table 8-14: Summary of Severity of Damage and Loss due to a Breach of the Proposed RSA10 Ultimate Facility

Guideline	Consequence Category	
	SDB	FIB
ANCOLD (2012)	High B	High B
GISTM (2020)	Significant	High
DMP (2013)	Category 1 (High)	Category 1 (Medium)

9. Uncertainty and Variability

Current practice for design flood estimation generally does not consider the uncertainties that are introduced when undertaking a Flood Frequency Analysis using short data records and extrapolating the fitted flood frequency distribution to estimate the less frequent Annual Exceedance Probability floods. This introduces significant uncertainties in estimates of the design flood. It is widely acknowledged that there is significant spatial variation in catchments and temporal and spatial variation in the antecedent catchment wetness and rainfall events that drive significant flood events.

This project has included the impact of climate change on the rainfall intensity and loss values in accordance with Australian Rainfall and Runoff (ARR) 2019. However, there are other unknown factors which may have impacts on this assessment including changes to the current temporal patterns and changes to the land use of the downstream environment (e.g., hydraulic structures, roads, bridges and properties).

Additionally, the non-Newtonian parameters to simulate the run-out from a hypothetical tailings breach are all based on the provided rheological data followed by engineering judgements which were independently reviewed and endorsed. While these assumptions may increase the uncertainty of the outcome, the results have been plotted against all reliable historical data and correlated well with those.

10. Recommendations

The HDBA was undertaken using the information and resources available at the FEL3 level of definition for the project based on site specific data and Wagerup residue rheology. In future design phases, including during operations of the facility, the following recommendations may be undertaken to improve the accuracy of the assessment.

- The GBL GDL003 Guide for Conducting Dam Break Analysis and Assigning Consequence Categories (Alcoa, 2024) was referred to in completion of this assessment. The following requirements specified in this guide should be considered in future design phases:
  - Assessment of the alkalinity of the contents of the RSA10 and the impact this has on the downstream environment through source receptor analysis.
  - Sensitivity analyses on input parameters, including breach parameters and roughness parameters.
- In lieu of geometric information for the Forrest Highway bridge, assumptions based on the available imagery have been made to reflect the impact of the bridge in the hydraulic model. It is recommended that a better estimation of geometry and size be obtained and incorporated into the HDBA in operations phases.
- Calibration of the hydrologic and hydraulic models was excluded from the scope of the HDBA. It is recommended that historical rainfall and gauge data (Harvey River - Clifton Park) in the vicinity of the model to be sourced, and the models to be calibrated gaining higher confidence from the modelling results.
- Several assumptions were made regarding the roads surrounding the RSA10 starter and ultimate facility for the purpose of estimating the PAR, specifically relating to AADT, the speed limit and the average number of passengers per vehicle. It is recommended that more accurate data be obtained and incorporated in future design phases. Furthermore, assumptions were made about several shed and warehouse structures within the flood extent of the Flood Induced Breach scenarios in relation to their purpose and whether permanent PAR may reside at the site. This should be reviewed in the subsequent revision.
- Inherent in calculating Potential Loss of Life is a broad range of assumptions regarding the level of threat to persons exposed to flood extents. The RCEM method was used to calculate the PLL based on the Persons at Risk using a depth velocity factor. It is recommended that additional factors, including duration of inundation and time of inundation is also considered as part of PLL calculation.

11. Conclusions

The Hypothetical Dam Breach Assessment for the proposed RSA10 FEL3 design considered several breach scenarios for both the starter and ultimate facilities:

- Both the Sunny Day Breach and Flood Induced Breach scenarios were modelled assuming a non-Newtonian fluid being released from the facility, with estimations of parameters based on rheology testing (WWL, 2023 and KCB, 2025).
- The Flood Induced Breach scenario was simulated as non-Newtonian fluid being released from the facility, followed by an iterative simulation of Newtonian fluid to represent the concurrent flooding event. Concurrent flooding of a 1 in 100 AEP event was incorporated in the model for the Flood Induced Breach Scenario.

Dam breach simulations were undertaken using TUFLOW, a two-dimensional hydrodynamic software. Peak flow, maximum flood depth and inundation extent have been presented in Appendix C for the RSA10 Starter Facility and Appendix D for the RSA10 Ultimate Facility.

Hypothetical Dam Breach Assessments were undertaken to estimate the impact of the modelled scenarios and to allow estimates of PAR and PLL to be determined. These estimations are summarised in Table 11-1.

Table 11-1: RSA10 PAR and PLL Summary

Breach Scenario	Starter Facility		Ultimate Facility	
	PAR	PLL	PAR	PLL
Sunny Day Breach	0.016	0.016	0.048	0.040
Flood Induced Breach	0.013	0.009	0.072	0.056

Consequence category assessments were undertaken in accordance with ANCOLD (2012), GISTM (2020) and DMP (2013) guidelines. Consequence categories for the starter and ultimate facilities are summarised in Table 11-2.

Table 11-2: RSA10 Governing Consequence Category Summary

Assessment Guideline	Starter Facility	Ultimate Facility
ANCOLD (2012)	**Significant**	**High B**
DMP (2013)	**Category 2**	**Category 1**
GISTM (2020)	**Significant**	**High**

The accuracy of the Hypothetical Dam Breach Assessment is limited to the accuracy of the available input information. Therefore, in future design and operational phases, the following recommendations are made:

- Collection and incorporation of high-resolution surface elevation data for the entire model extent.
- Collection and incorporation geometric details for the Forrest Highway bridge within the model extent.
- Calibration of the hydrologic and hydraulic model to historical data.
- Sourcing more accurate data regarding AADT, speed limits and average number of passengers per vehicle on the roads surrounding the RSA10.
- Clarification of nature of structures in the downstream flow path of the RSA10 Flood Induced Breach scenario.
- Further investigation into the non-Newtonian parameters incorporated in the model, including additional sensitivity analysis on the critical design parameters particularly at low shear rates typical of a large dam breach.

12. References

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Appendix A
Hydrology Modelling

A.1 Hydrology Modelling

Hydrology studies were undertaken to model the RSA10 catchment and the greater catchment contributing to Collins Pool for input into the FIB and NF hydraulic models.

A.1.1 RSA10 Hydrology Flood Estimation

The modelled dam breach has been initiated assuming the initial decant pond level correspond to the Extreme Storm Surge (ESS) based on a 1:1000 AEP 72-hour design storm event including allowance for a 1:10 AEP wave runup during the sunny day scenario. The decant pond level for the FIB has been checked for containment of a PMP (120 hr duration) event and this corresponds with the crest elevation of the ultimate facility. Therefore, a crest flood scenario has been adopted in the FIB analysis.

A 1 in 1,000 (0.1%) AEP event was considered for the Starter Facility, and a the 1 in 1,000,000 AEP event for the Ultimate Facility, considered design events for flood inflow assessments in accordance with (ANCOLD, 2000).

A.1.2 Collins Pool Hydrology Flood Estimation

Estimation of design flood hydrographs for the Collins Pool catchment were generated for the purpose of concurrent flooding in the FIB and NF scenarios. A 1 in 100 (1%) AEP event was applied for concurrent flooding. This event was considered the most critical design event as it produces the highest incremental difference between the Flood Induced Breach and No Breach scenarios. Simulation was performed using the runoff-routing modelling software RORB Version 6.52 (HARC, 2024), which estimates flood hydrographs from rainfall, incorporating rainfall excess and catchment routing including storage structures. Newtonian flows were assumed for the hydrology model.

The catchment contributing to the RSA10 and the 27 km downstream flow path to Collins Pool was delineated and has been presented in Figure A-12-1. The total catchment area of Collins Pool is approximately 1,272 km^2.

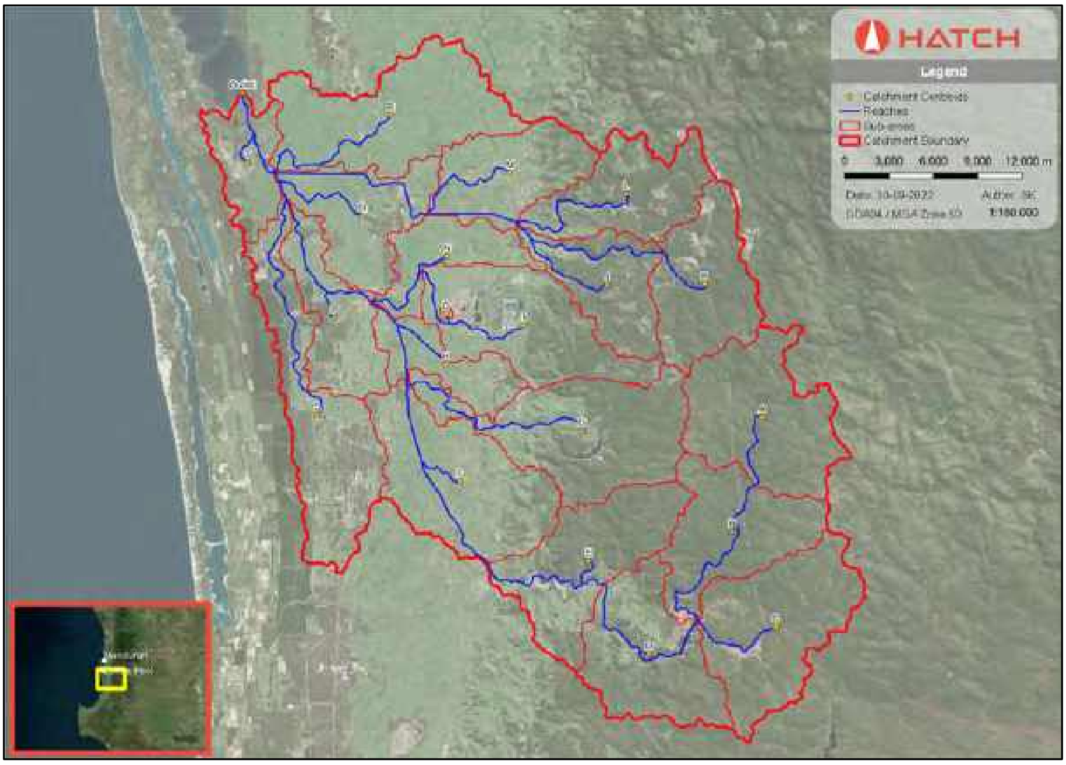


Figure A-12-1: RSA10 Catchment Delineation

A.1.3 Design Rainfall

The latest Intensity-Frequency-Duration (IFD) data was sourced from the Bureau of Meteorology (BoM) (Bureau of Meteorology, 2016) for the 1 in 100 AEP. As the area of the Collins Pool catchment is greater than 20 km^2, a spatially varying rainfall was applied to the model. Rainfall depths at the Collins Pool catchment centroid (-32.955, 115.940) are referenced in Table A-12-1. As per discussion in Section 6.1, design rainfall depths were factored for climate change for the present-day condition for Starter Facility, and based on SSP2 for the year 2060 for the Ultimate Facility.

Table A-12-1: Design Rainfall Depth for 1 in 100 (1%) AEP

Duration	Design Rainfall Depth from IFD (mm)	Design Rainfall Depth with Present-Day Climate Change Factor Applied (mm)	Design Rainfall Depth with Climate Change Factor Applied (SSP2, Year 2060) (mm)
1-hour	43.9	50.5	57.1
1.5-hour	49.4	56.3	62.7
2-hour	54.3	61.4	67.9
3-hour	63.1	70.7	77.6
4.5-hour	74.9	83.1	90.6
6-hour	85.4	93.9	102.5
9-hour	103	113.3	122.6
12-hour	118	128.6	139.2
24-hour	142	153.4	164.7
30-hour	159	171.7	184.4

A.1.4 Temporal Patterns

In accordance with the AR&R 2019 Guidelines (Ball J, 2019), as the Collins Pool catchment area exceeds 75 km^2, areal temporal patterns as downloaded from the ARR Datahub were incorporated into the RORB ensemble modelling (Babister, 2016).

A.1.5 Hydrology Model Parameters

Routing of hydrographs through a network with non-linear storage-discharge relationships is defined by two parameters, K_c and m in RORB. AR&R 2019 suggests that m, defined as the dimensionless exponent for non-linear routing, should be held constant at 0.8.

K_c is unique to the catchment, based on characteristics such as area, and accounts for the degree of hydrograph attenuation due to storage effects. In the absence of data, regional recommended methods were used. The Dyer approach to the K_c value is based on an average distance method and is recommended by RORB and was therefore used in the development of this model.

For the Collins Pool hydrology model, a K_c of 48.10 was implemented in accordance with the methodology produced by Dyer (Dyer, 1995), and an m value of 0.8 was adopted.

A.1.6 Identification of Critical Event

The RORB modelling results for Collins Pool were assessed at the location of the Forrest Highway, as this location was anticipated to be the critical location for PAR in the NF and FIB scenarios. A 24-hour event was identified to critical for both the Starter Facility concurrent flooding (based on the present-day condition) and the Ultimate Facility concurrent flooding (based on climate change for the year 2060 and SSP2). The hydrograph for the critical concurrent event for the Ultimate Facility is provided in Figure A-12-2.

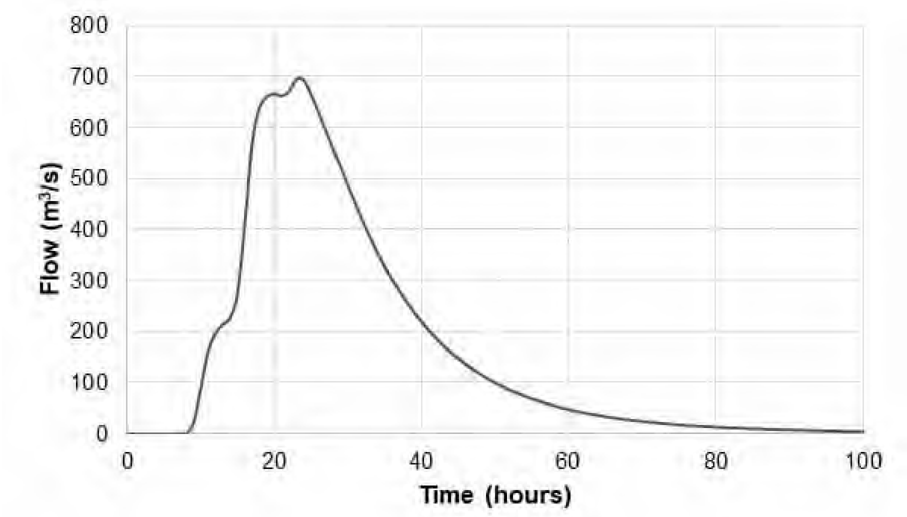


Figure A-12-2: Critical Concurrent Flooding Event for the Ultimate Facility at the Location of the Forrest Highway (1 in 100 AEP)

Appendix B
Hydraulic Modelling Inputs

B.1 Hydraulic Modelling

The hydraulic assessment undertaken for the preliminary HDBA has been conducted using the modelling software TUFLOW (Build: 2025.0.0). TUFLOW is a hydrodynamic, dynamically linked two-dimensional (2D) hydraulic modelling software that can represent complex hydraulic structures, floodplain storage and floodplain/channel interaction (TUFLOW, 2018). A 10 m grid cell size was used for the dam failure models and a 20 m grid cell size was used for the concurrent flooding models, all with quadtree to refine cells to 5m to replicate the hydraulic features at an appropriate level of accuracy while maintaining practical run time.

The Sunny Day Breach and Flood Induced Breach hydraulic assessments have been undertaken based on non-Newtonian fluid parameters as discussed in Section B.1.1.4. The Concurrent Flooding and No Failure scenarios have been undertaken based on Newtonian fluid parameters (water).

The FIB scenario for both the Starter and Ultimate Facilities have been modelled as an iterative process as follows:

5. The dam breach has been modelled to as non-Newtonian flow to represent the extents of the mixed water and residue from within the dam only.
6. This final breach surface has then been applied on top of the existing topography and a Newtonian simulation of the concurrent flooding has been undertaken to conservatively replicate the total extent of any afflux by interaction of flows.

This assumption will provide a conservative result for flood impacts downstream. TUFLOW was used to create a hydrodynamic model of the assessment study area to simulate the dam failure scenarios discussed in Section 5.1. Key inputs further to the hydraulic model are discussed in Sections B.1.1.1 to B.1.1.7.

B.1.1 Hydraulic Model Inputs

B.1.1.1 Model Extent

The 5 m surface data (Geoscience Australia, 2015) sourced for this project covers the full extent of the hydraulic model, ranging from the location of the RSA10 to Collins Pool (approximately 27 km downstream).

B.1.1.2 Inflows

Sunny Day Breach Scenario: *No rainfall inflows were required in the model as this scenario simulates the failure of the dam due to a piping or sudden static slump failure and in the absence of rainfall.*

Flood Induced Breach Scenario: The non-Newtonian parameters used in the FIB *scenario were modified to represent the mixing of water and residue. No additional direct rainfall was applied over the footprint of the dam.*

No Breach Scenario: A combination of inflow boundaries and source-area inflows were used to incorporate the concurrent flooding inflows.

B.1.1.3 Boundary Conditions

For all scenarios, the downstream boundary condition was applied at Collins Pool. The average historical water level in the Collins Pool was found to be approximately 0.61 m based on 60 years of historical data, and this was adopted as the downstream boundary condition water level. (Government of Western Australia Department of Transport, 2021).

B.1.1.4 Non-Newtonian Parameters

Input parameters to model the released material as a non-Newtonian fluid have been adopted using viscosity parameters derived from the Wagerup and Pinjarra Residue Mud and Residue Bypass Rheological Data (KCB, 2025) The parameters incorporated into the model are summarised in Table B-12-2.

Table B-12-2: Non-Newtonian TUFLOW Input Parameters (Sunny Day)

Non-Newtonian Input Parameter	Value	
	Starter	Ultimate
Blended Solids Content	62.3%	67.8%
Estimated Shear Rate	1 - 10 s^{-1}	
Viscosity Coefficient (K)	6 $Pa.s^n$	25 $Pa.s^n$
Shear thickening exponent (n)	0.24	0.22
Lower viscosity limit	10 Pa.s	10 Pa.s
Higher viscosity limit	1,000 Pa.s	1,000 Pa.s
Shear yield stress (τ_y)	40 Pa	240 Pa

Table B-12-3: Non-Newtonian TUFLOW Input Parameters (Flood Day)

Non-Newtonian Input Parameter	Value	
	Starter	Ultimate
Blended Solids Content	20.0%	62.6%
Estimated Shear Rate	1 - 15 s^{-1}	
Viscosity Coefficient (K)	1.5 $Pa.s^n$	20 $Pa.s^n$
Shear thickening exponent (n)	0.30	0.22
Lower viscosity limit	10 Pa.s	10 Pa.s
Higher viscosity limit	1,000 Pa.s	1,000 Pa.s
Shear yield stress (τ_y)	5 Pa	160 Pa

Sensitivity analyses were undertaken for the yield stress, with simulations undertaken to estimate the impact on the breach outflow extent due to a yield stress of 100 Pa, 250 Pa and 700 Pa to understand the impacts the rheology has on run-out. These were presented under an earlier revision and are shown to have a lesser impact that the estimated release volume.

B.1.1.5 Initial Conditions

The assumed initial water level within the proposed RSA10 for each facility is summarised in Table B-12-4.

Table B-12-4: Summary of the Initial Water Levels for the RSA10 HDBA Modelling Scenarios

Facility	Scenario	Initial Water Level (mAHD)
Starter Facility	Sunny Day Breach	20.1 (MOL)
	Flood Induced Breach	22.0 (crest level)
Ultimate Facility	Sunny Day Breach	77.6 (MOL)
	Flood Induced Breach	80.0 (ultimate crest level)

B.1.1.6 Roughness Values

Manning's roughness values were assigned based on the land uses observed in the aerial imagery throughout the model (Chow, 1959). The roughness values allocated for each land use type are summarised in Table B-12-5. The default roughness factor across the model was set to 'Pasture,' with other values being specified at the relevant locations.

For scenarios modelled assuming non-Newtonian fluids, a Manning's n value reflective of 'bare earth' was applied due to the anticipated impact of the released tailings material on downstream vegetation.

Table B-12-5: Manning's Roughness Values Used in RSA10 HDBA Hydraulic Model (Chow, 1959)

Land Type Description	Manning's n Value
Pasture	0.030
Asphalt	0.013
Water	0.020
Gravel	0.025
Vegetated Creek	0.045
Bare Earth	0.025

B.1.1.7 Modification to Terrain

Public domain, 5 m gridded light detection and ranging (LiDAR) surface elevation data (Geoscience Australia, 2015) covering the proposed RSA10 dam area and the extent of the downstream impact area was used in the hydraulic model. However, the relatively low resolution of the LiDAR resulted in some unexpected high points within the channels observed from the aerial imagery. Some minor post processing modifications were made to the terrain data to smooth these inconsistencies, allowing flows to be conveyed along the channels.

Furthermore, several culverts and bridges were identified in the aerial imagery, however no specific data relating to these structures was available to incorporate into the hydraulic model at the time of this study. The 5 m LiDAR data represented the top of these structures, hence blocking flows from continuing downstream of the structures. Therefore, the terrain was modified at these locations to simulate flows passing through. In future development phases of this project, it is recommended that data relevant to each of these structures is obtained to improve the accuracy of the model at these discrete locations.

B.1.1.8 Upstream Construction Modelling Limitations

A limitation of 2D-hydrodynamic modelling particular to TSFs constructed with upstream raises is the inability to model impounded material stored beneath the embankment raises. This limitation reduces the total available volume able to be modelled within the TSF. The available storage volume in the TUFLOW model is governed by the initial water (or tailings) height and ground elevation in the storage. Therefore, to ensure the total volume of available tailings storage was adequately captured by the 2D-model, the elevation of the TSF base was taken as existing ground level with no lining layer. This produced adequate extra storage volume, capturing a total volume of 28.9 Mm^3 within the RSA10 storage facility (99.3% of the total reported volume of 29.2 Mm^3).

Appendix C
Hydraulic Modelling Results - Starter Facility

LEGEND:

Maximum Depth (m)

- <= 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- > 3.0
- Breach Location
- PAR Locations - Roads
- Roads
- Alcoa-Owned Properties

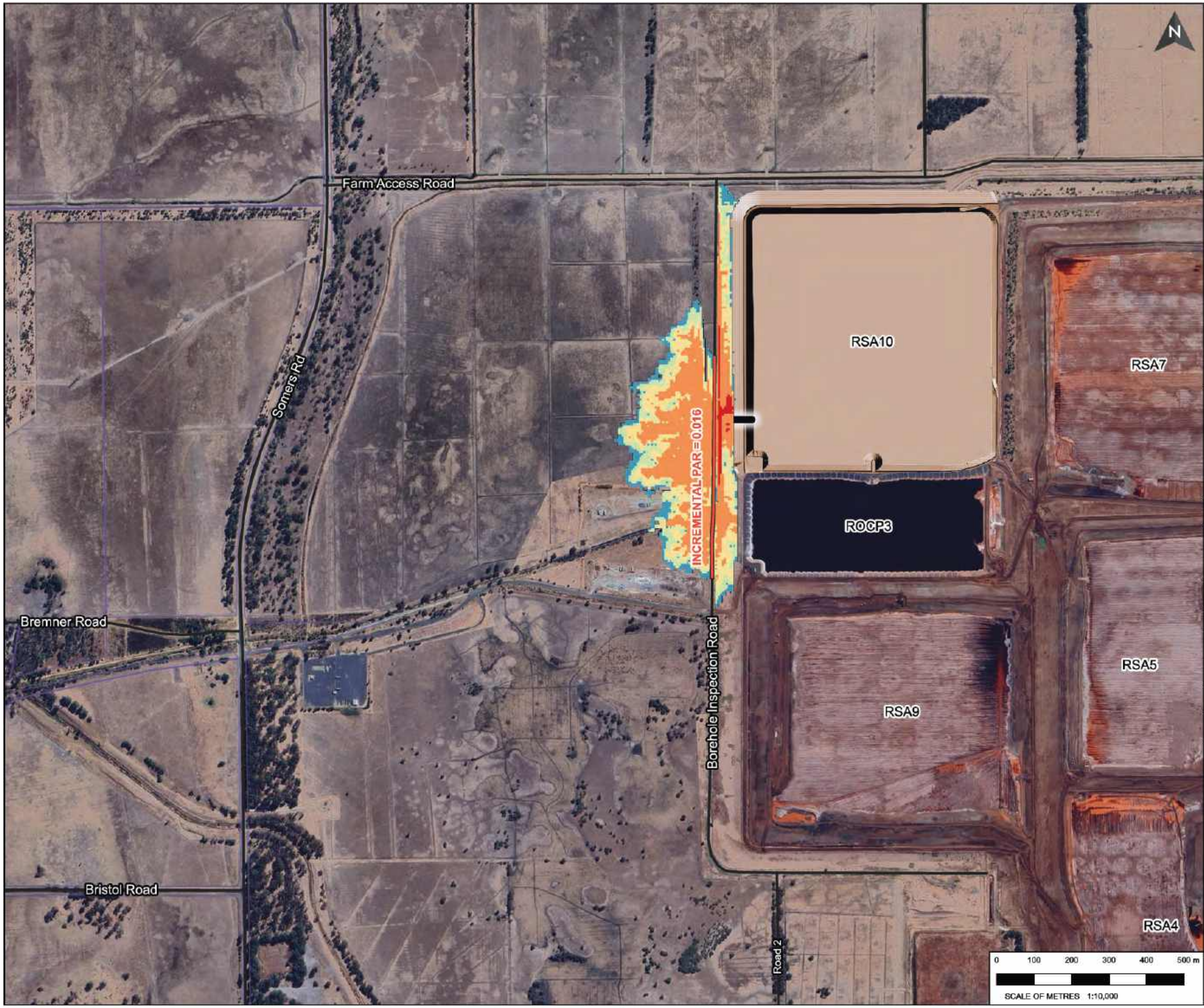
NOTES:

1. All Dimensions, Elevations and Coordinates are in metres, except where indicated otherwise.

PROJECT TITLE	Wagerup RSA10 - FEL3
PROJECT NUMBER	H374430
FIGURE NAME	Starter Facility Sunny Day Failure, Non-Newtonian Fluid
FIGURE DESCRIPTION	Maximum Depth
REVISION NUMBER	D
CREATED BY	EG
DATE	11-06-2025
PROJECTION	GDA94 / MGA zone 50
SOURCES	Google Satellite

HATCH

Hatch Pty Ltd.
ACN 59 005 630 500



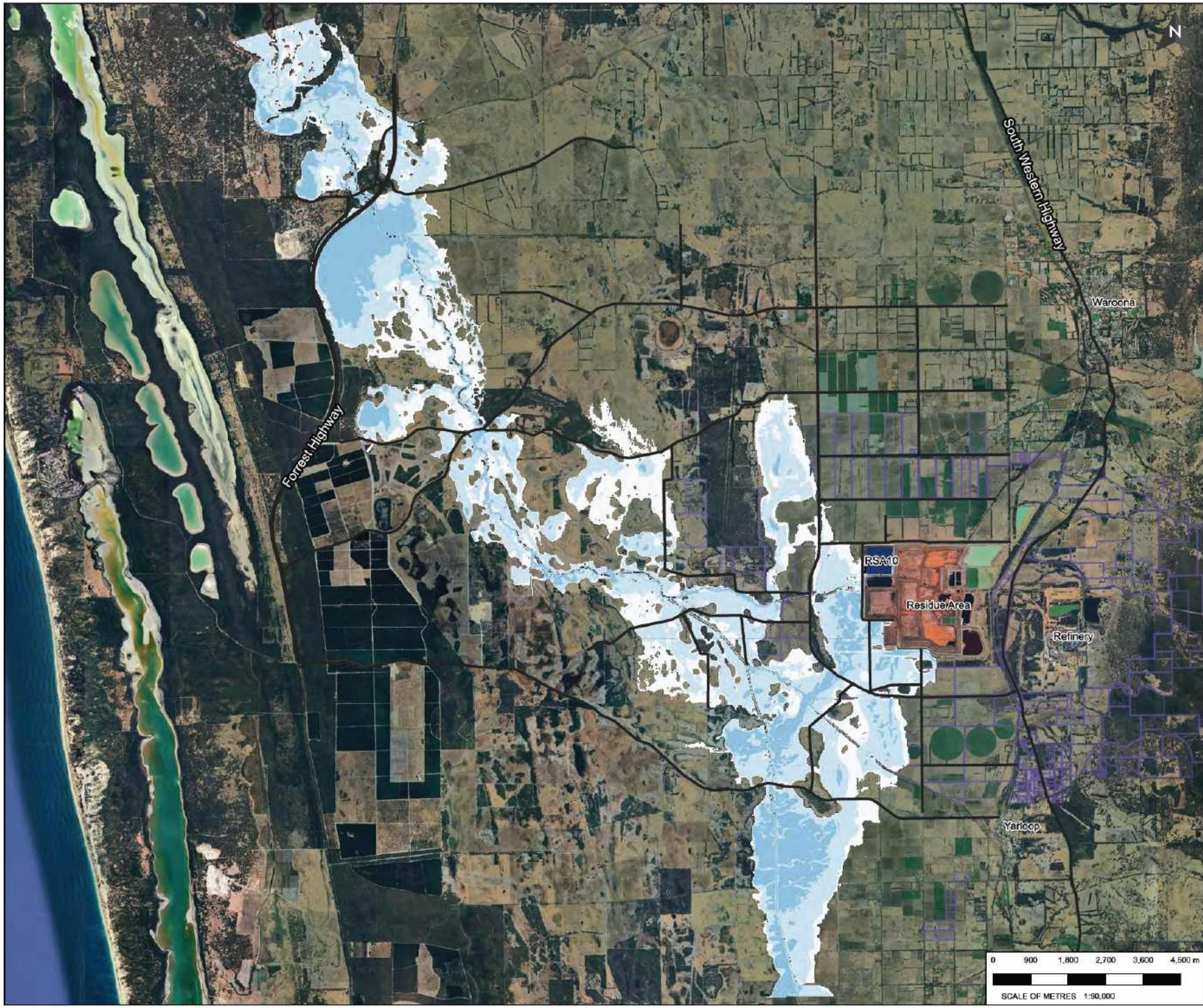
NOTES:

1. All Dimensions, Elevations and Coordinates are in metres, except where indicated otherwise.

PROJECT TITLE	Wagerup RSA10 - FEL3
PROJECT NUMBER	H374430
FIGURE NAME	Starter Facility Sunny Day Failure, Non-Newtonian Fluid
FIGURE DESCRIPTION	Maximum Hazard
REVISION NUMBER	D
CREATED BY	EG
DATE	11-06-2025
PROJECTION	GDA94 / MGA zone 50
SOURCES	Google Satellite

HATCH

Hatch Pty Ltd.
ACN 59 005 630 500



LEGEND:

Maximum Depth (m)

- <= 0.3
- 0.3 - 1.0
- 1.0 - 3.0
- 3.0 - 5.0
- 5.0 - 6.50

- Breach Location
- PAR Locations - Roads

Roads

- Alcoa-Owned Properties

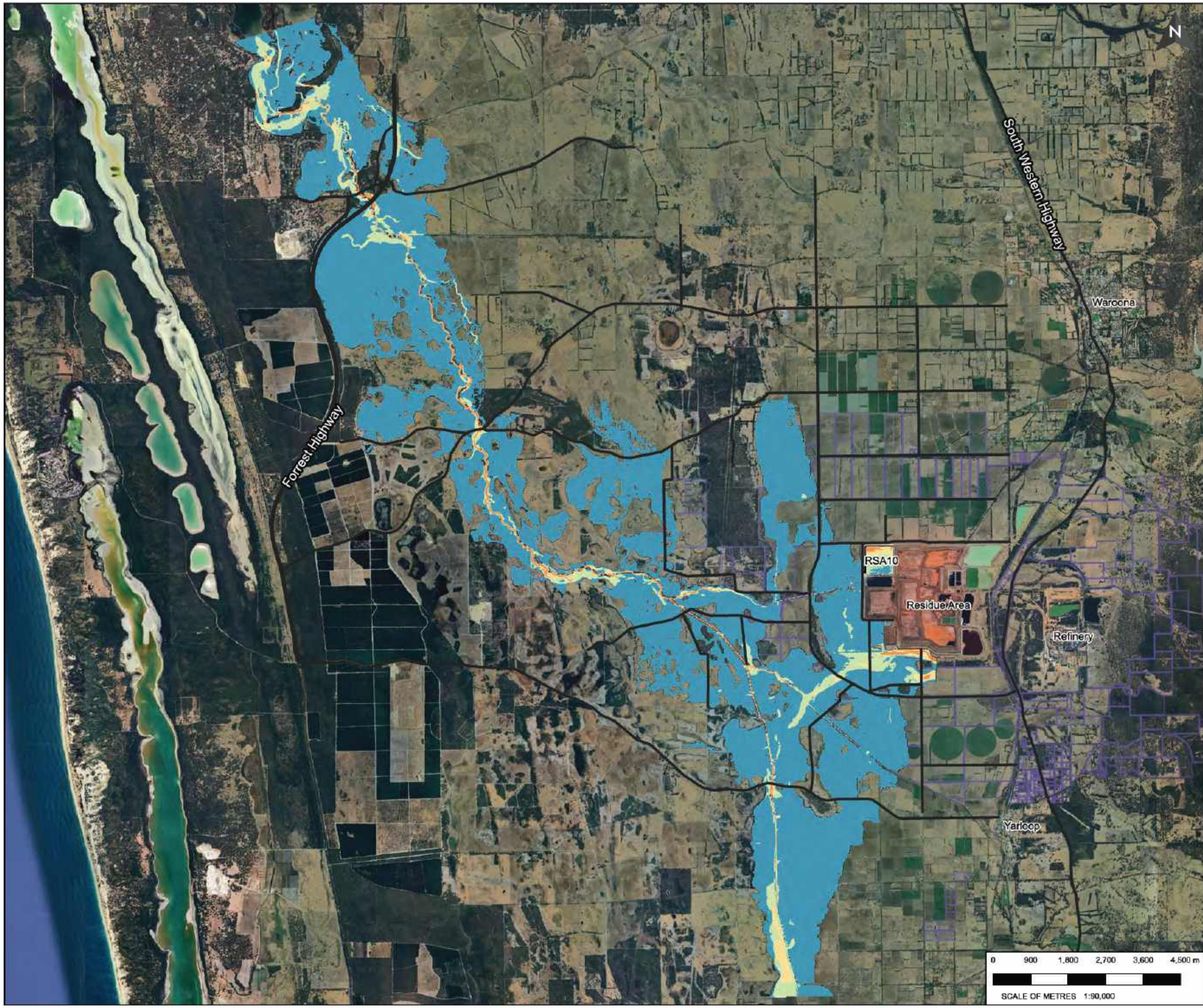
NOTES:

1. All Dimensions, Elevations and Coordinates are in metres, except where indicated otherwise.

PROJECT TITLE	Wagerup RSA10 - FEL3
PROJECT NUMBER	H374430
FIGURE NAME	Starter Facility No Failure Newtonian Fluid
FIGURE DESCRIPTION	Maximum Flood Depth
REVISION NUMBER	C
CREATED BY	EG
DATE	05-05-2025
PROJECTION	GDA94 / MGA zone 50
SOURCES	Google Satellite

HATCH

Hatch Pty Ltd.
ACN 59 005 630 500



LEGEND:

Maximum Hazard (m²/s)

- <= 0.3
- 0.3 - 0.6
- 0.6 - 1.0
- 1.0 - 5.0
- 5.0 - 6.3
- Breach Location
- PAR Locations - Roads

Roads

- Alcoa-Owned Properties

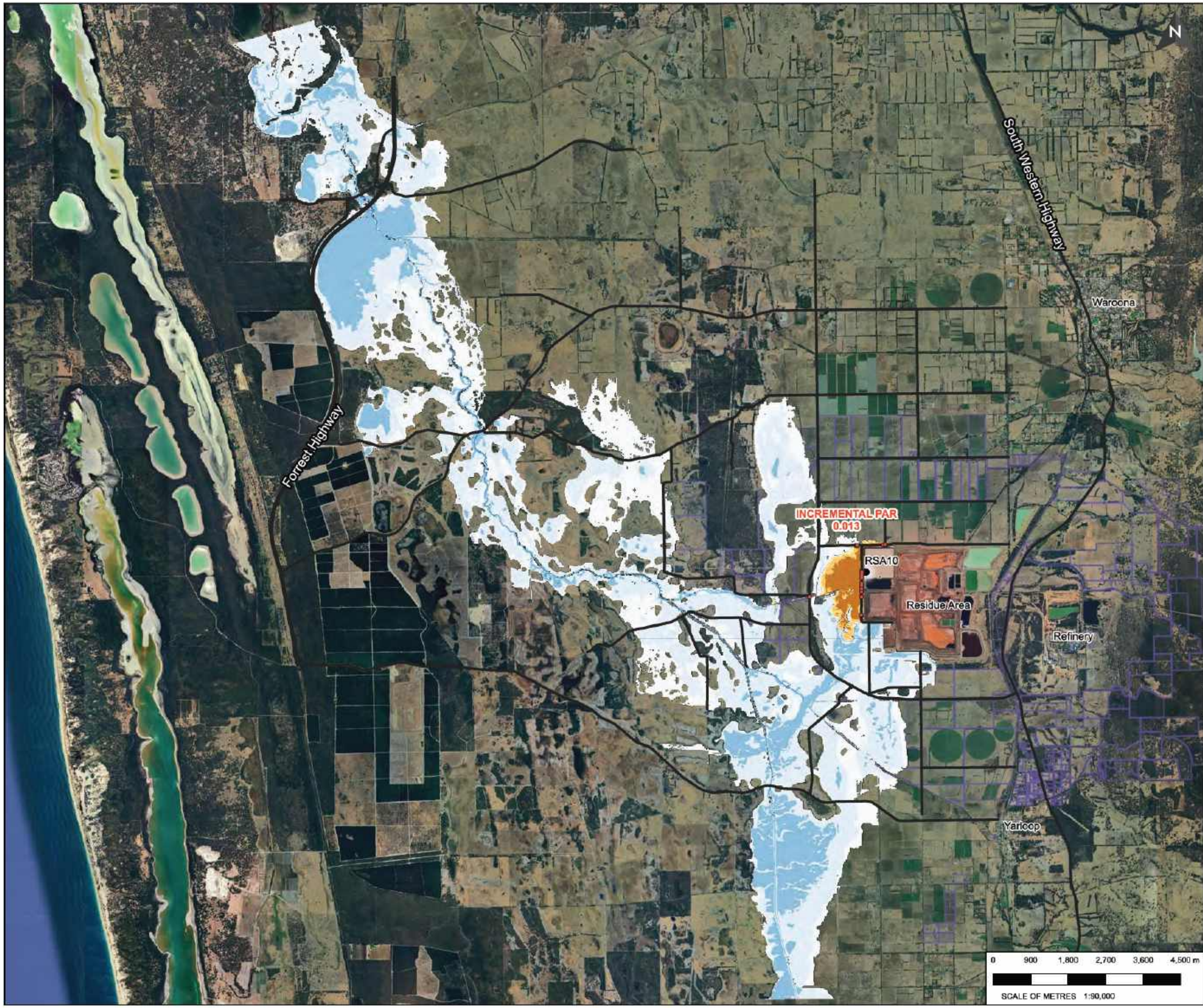
NOTES:

1. All Dimensions, Elevations and Coordinates are in metres, except where indicated otherwise.

PROJECT TITLE	Wagerup RSA10 - FEL3
PROJECT NUMBER	H374430
FIGURE NAME	Starter Facility No Failure Newtonian Fluid
FIGURE DESCRIPTION	Maximum Flood Hazard
REVISION NUMBER	C
CREATED BY	EG
DATE	05-05-2025
PROJECTION	GDA94 / MGA zone 50
SOURCES	Google Satellite

HATCH

Hatch Pty Ltd.
ACN 59 005 630 500



LEGEND:

Maximum Non-Newtonian Breach Depth (m)

- <= 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- > 3.0

Maximum Newtonian Flood Depth (m)

- <= 0.3
- 0.3 - 1.0
- 1.0 - 3.0
- 3.0 - 5.0
- 5.0 - 6.5

- Breach Location
- PAR Locations - Roads
- Roads
- Alcoa-Owned Properties

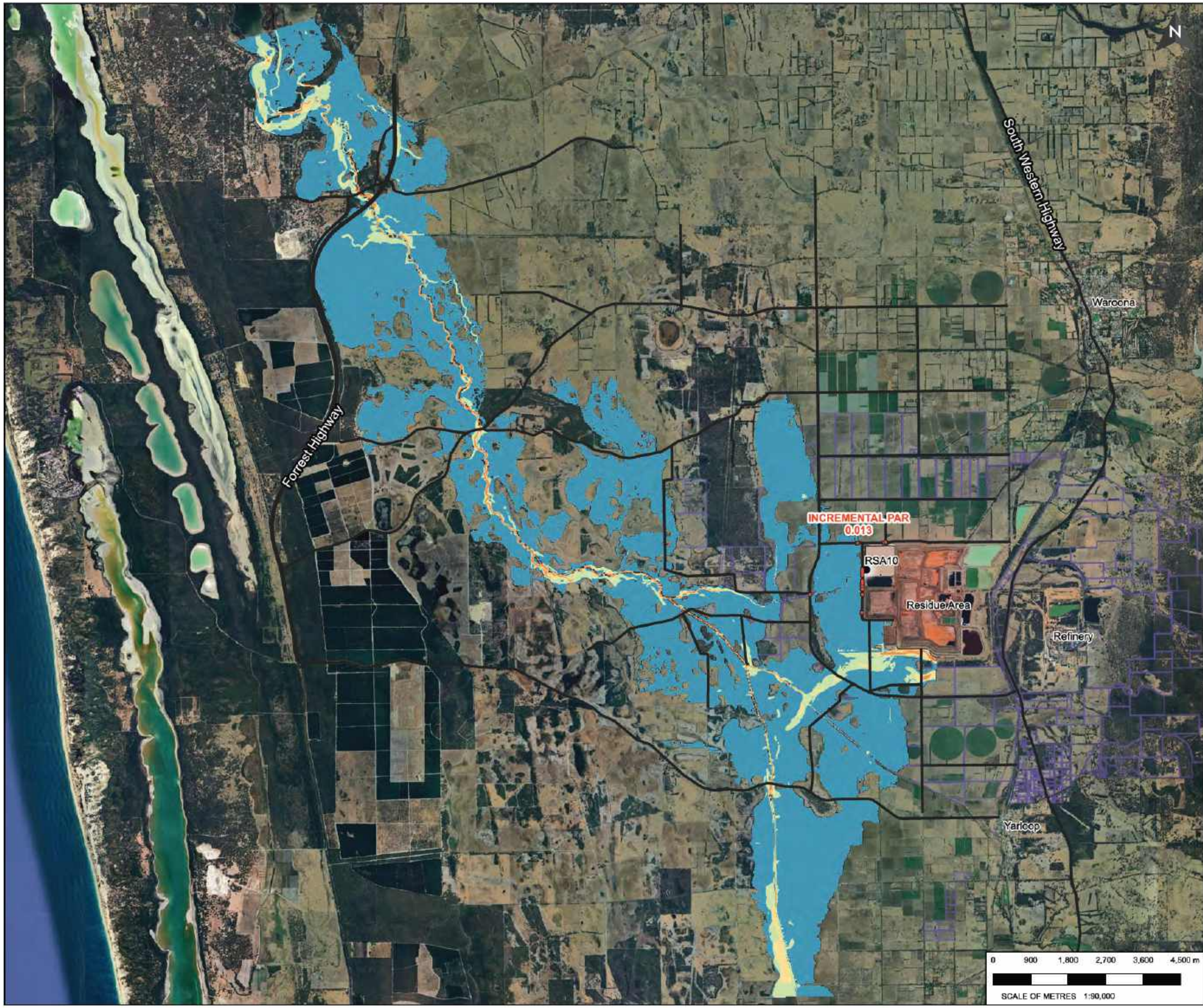
NOTES:

1. All Dimensions, Elevations and Coordinates are in metres, except where indicated otherwise.
2. Results depict Newtonian Flood with Non-Newtonian Breach Superimposed

PROJECT TITLE	Wagerup RSA10 - FEL3
PROJECT NUMBER	H374430
FIGURE NAME	Starter Facility Flood Failure
FIGURE DESCRIPTION	Maximum Flood Depth
REVISION NUMBER	D
CREATED BY	EG
DATE	12-06-2025
PROJECTION	GDA94 / MGA zone 50
SOURCES	Google Satellite

HATCH

Hatch Pty Ltd.
ACN 59 005 630 500



LEGEND:

Maximum Hazard (m2/s)

- <= 0.3000
- 0.3000 - 0.6000
- 0.6000 - 1.0000
- 1.0000 - 5.0000
- > 5.0000
- Breach Location
- PAR Locations - Roads
- Roads
- Alcoa-Owned Properties

NOTES:

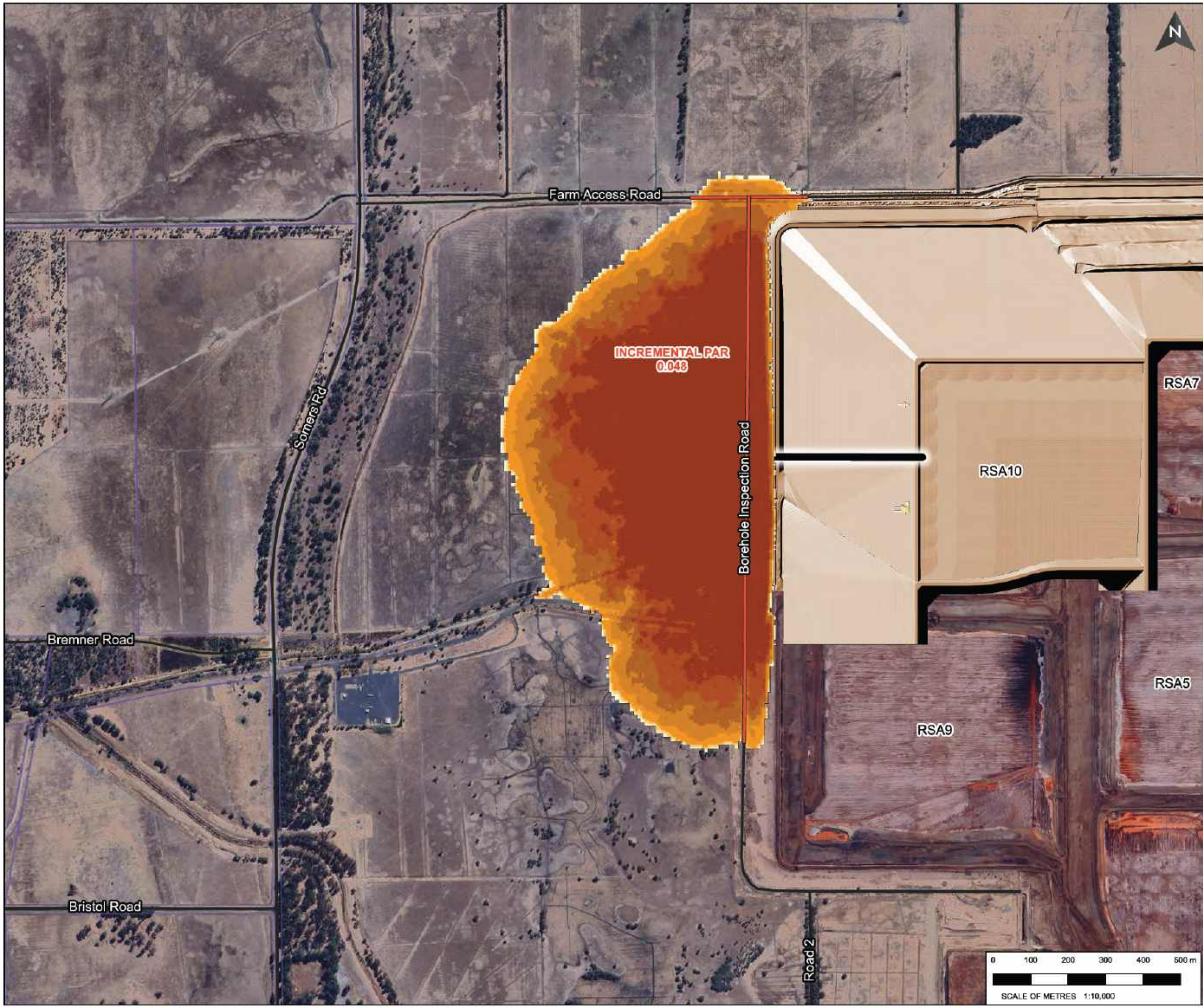
1. All Dimensions, Elevations and Coordinates are in metres, except where indicated otherwise.
2. Results depict Newtonian Flood with Non-Newtonian Breach Superimposed

PROJECT TITLE	Wagerup RSA10 - FEL3
PROJECT NUMBER	H374430
FIGURE NAME	Starter Facility Flood Failure
FIGURE DESCRIPTION	Maximum Flood Hazard
REVISION NUMBER	D
CREATED BY	EG
DATE	12-06-2025
PROJECTION	GDA94 / MGA zone 50
SOURCES	Google Satellite

HATCH

Hatch Pty Ltd.
ACN 59 005 630 500

Appendix D
Hydraulic Modelling Results - Ultimate Facility



LEGEND:

Maximum Depth (m)

- <= 0.3
- 0.3 - 0.5
- 0.5000 - 1.0000
- 1.0000 - 2.0000
- 2.0 - 3.0
- 3.0000 - 4.0000
- 4.0 - 5.0
- > 5.0
- Breach Location
- PAR Locations - Roads
- Roads
- Alcoa-Owned Properties

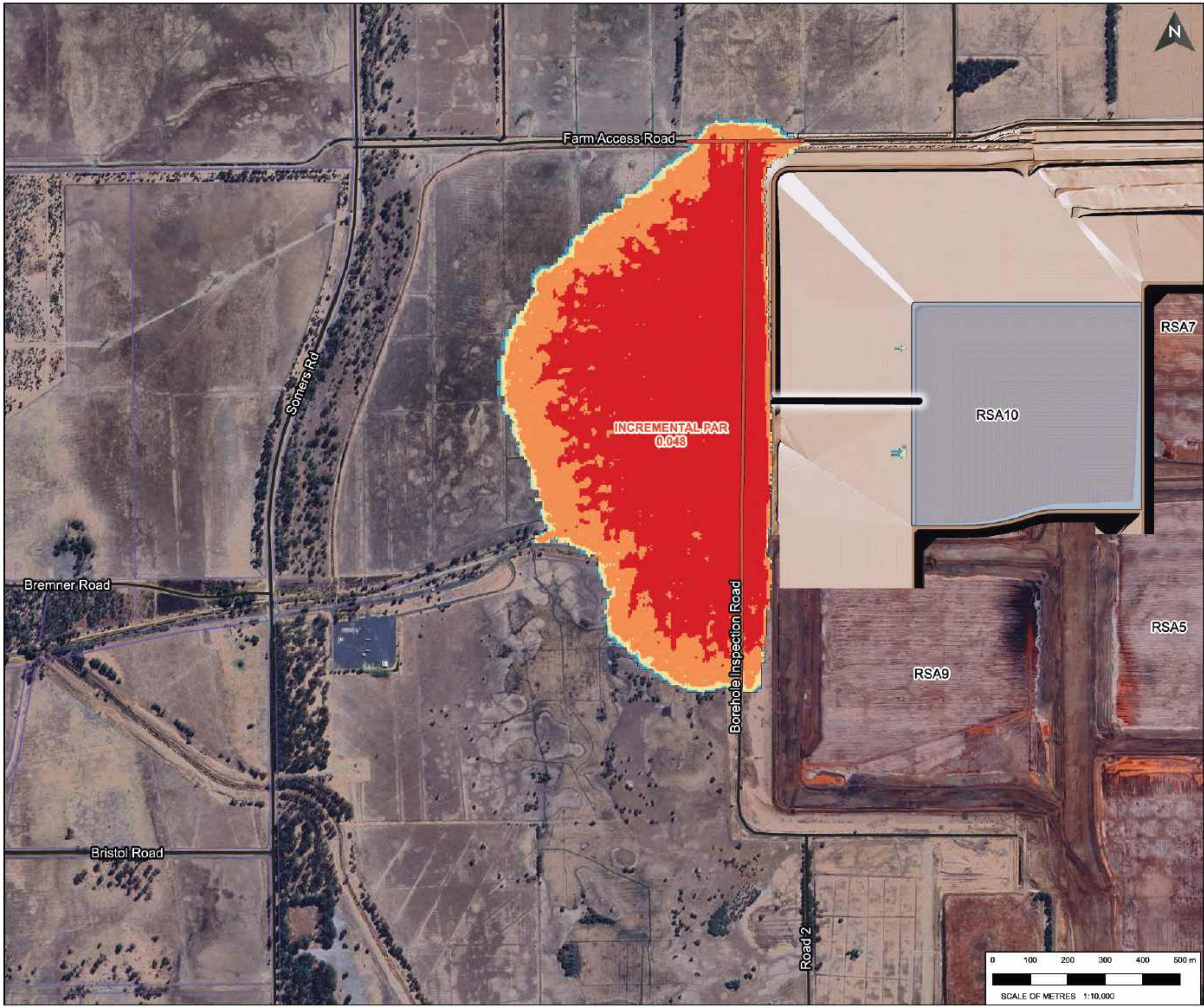
NOTES:

1. All Dimensions, Elevations and Coordinates are in metres, except where indicated otherwise.

PROJECT TITLE	Wagerup RSA10 - FEL3
PROJECT NUMBER	H374430
FIGURE NAME	Ultimate Facility Sunny Day Failure, Non-Newtonian Fluid
FIGURE DESCRIPTION	Maximum Depth
REVISION NUMBER	D
CREATED BY	EG
DATE	12-06-2025
PROJECTION	GDA94 / MGA zone 50
SOURCES	Google Satellite

HATCH

Hatch Pty Ltd.
ACN 59 005 630 500



LEGEND:

Maximum Hazard (m2/s)

- <= 0.3000
- 0.3000 - 0.6000
- 0.6000 - 1.0000
- 1.0000 - 5.0000
- > 5.0000
- PAR Locations - Roads
- Roads
- Breach Location
- Alcoa-Owned Properties

NOTES:

1. All Dimensions, Elevations and Coordinates are in metres, except where indicated otherwise.

PROJECT TITLE	Wagerup RSA10 - FEL3
PROJECT NUMBER	H374430
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REVISION NUMBER	D
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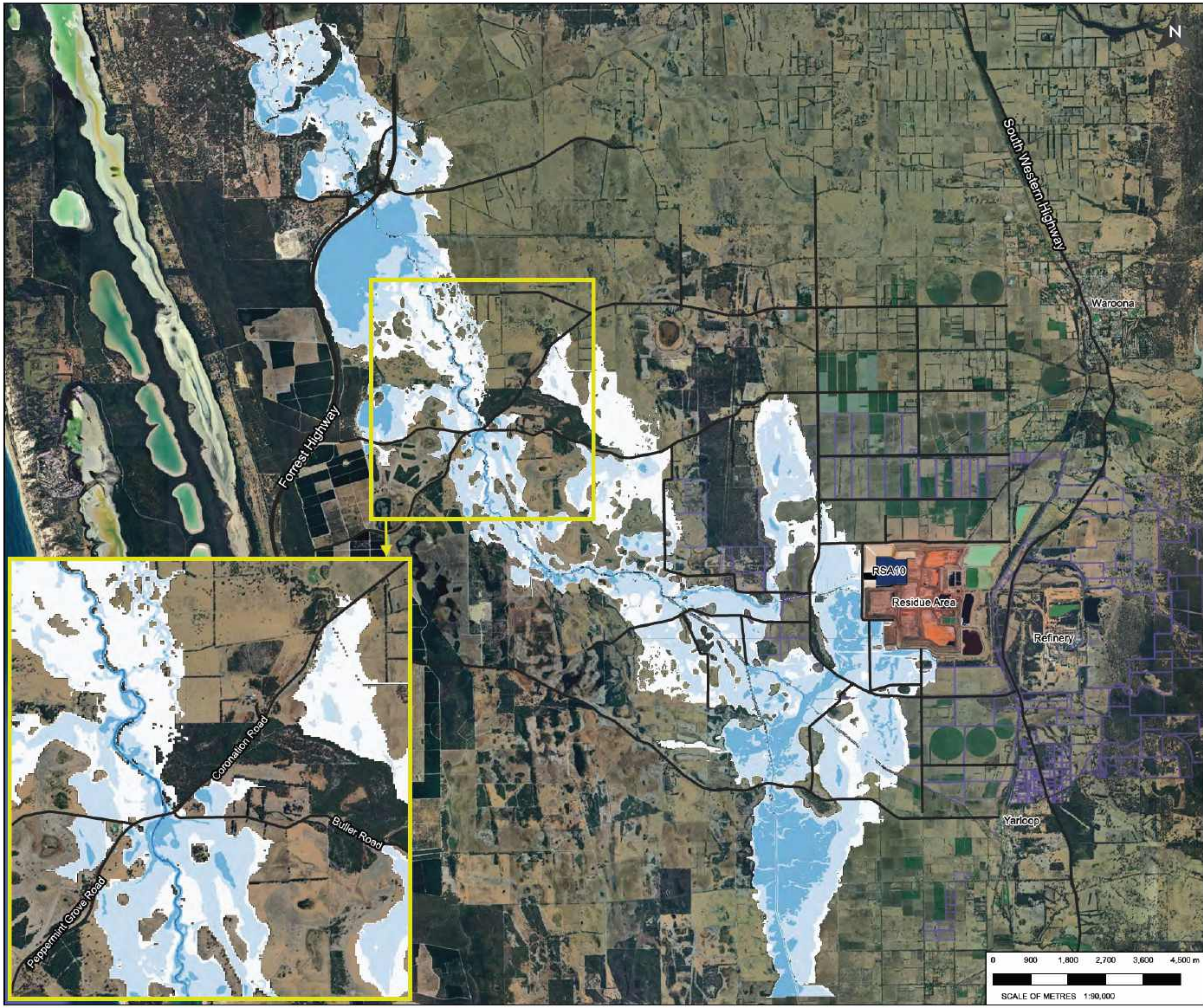
DATE	12-06-2025
PROJECTION	GDA94 / MGA zone 50
SOURCES	Google Satellite

HATCH

Hatch Pty Ltd.
ACN 59 005 630 500



LEGEND:

Maximum Depth (m)

- <= 0.3
- 0.3 - 1.0
- 1.0 - 3.0
- 3.0 - 5.0
- 5.0 - 65.03

Breach Location

Roads

Alcoa-Owned Properties

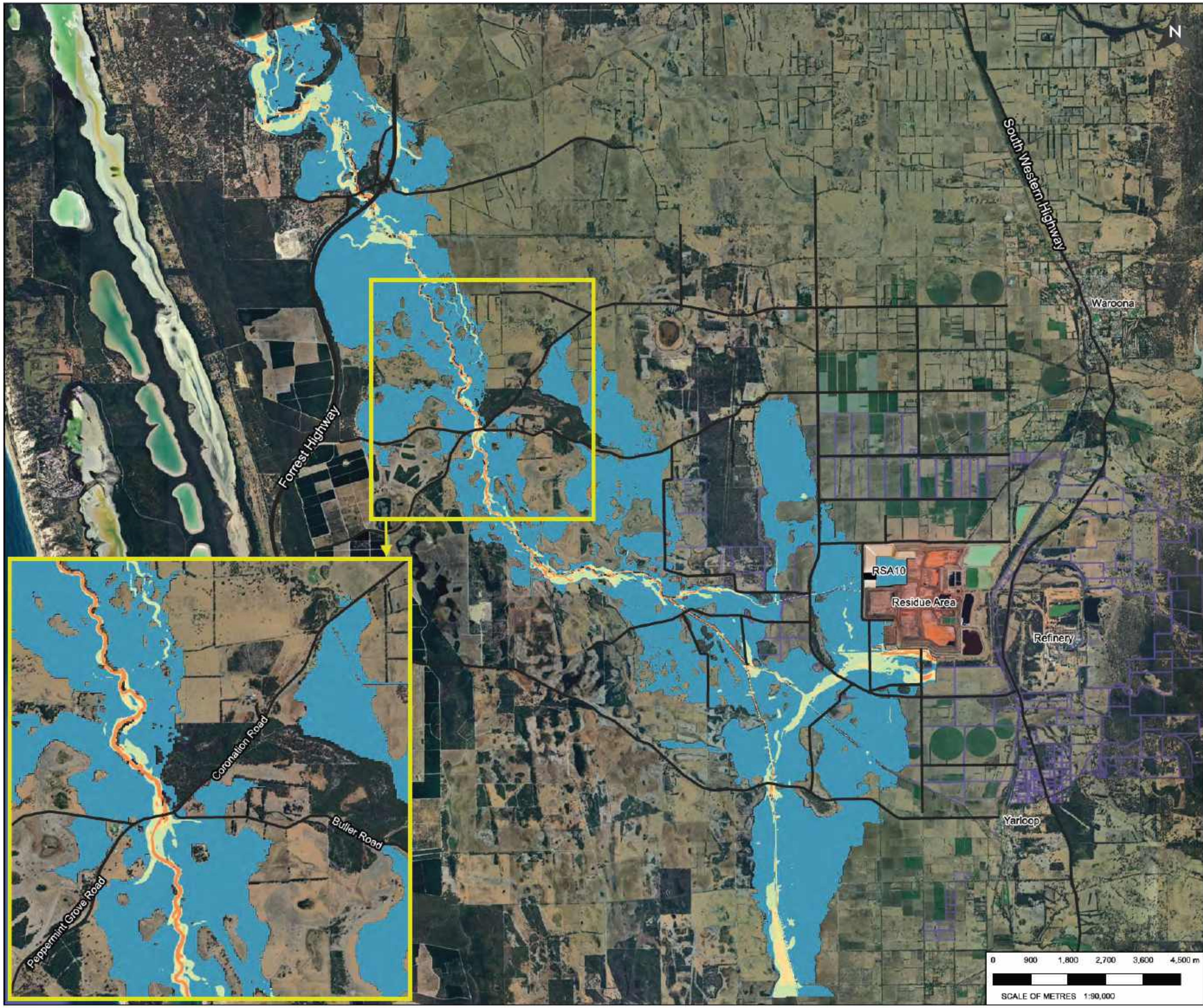
NOTES:

1. All Dimensions, Elevations and Coordinates are in metres, except where indicated otherwise.

PROJECT TITLE	Wagerup RSA10 - FEL3
PROJECT NUMBER	H374430
FIGURE NAME	Ultimate Facility No Failure Newtonian Fluid
FIGURE DESCRIPTION	Maximum Depth
REVISION NUMBER	C
CREATED BY	EG
DATE	05-05-2025
PROJECTION	GDA94 / MGA zone 50
SOURCES	Google Satellite

HATCH

Hatch Pty Ltd.
ACN 59 005 630 500



LEGEND:

Maximum Hazard (Depth x Velocity) (m^2/s)

- <= 0.3
- 0.3 - 0.6
- 0.6 - 1.0
- 1.0 - 5.0
- 5.0 - 6.1
- Breach Location

Roads

- Alcoa-Owned Properties

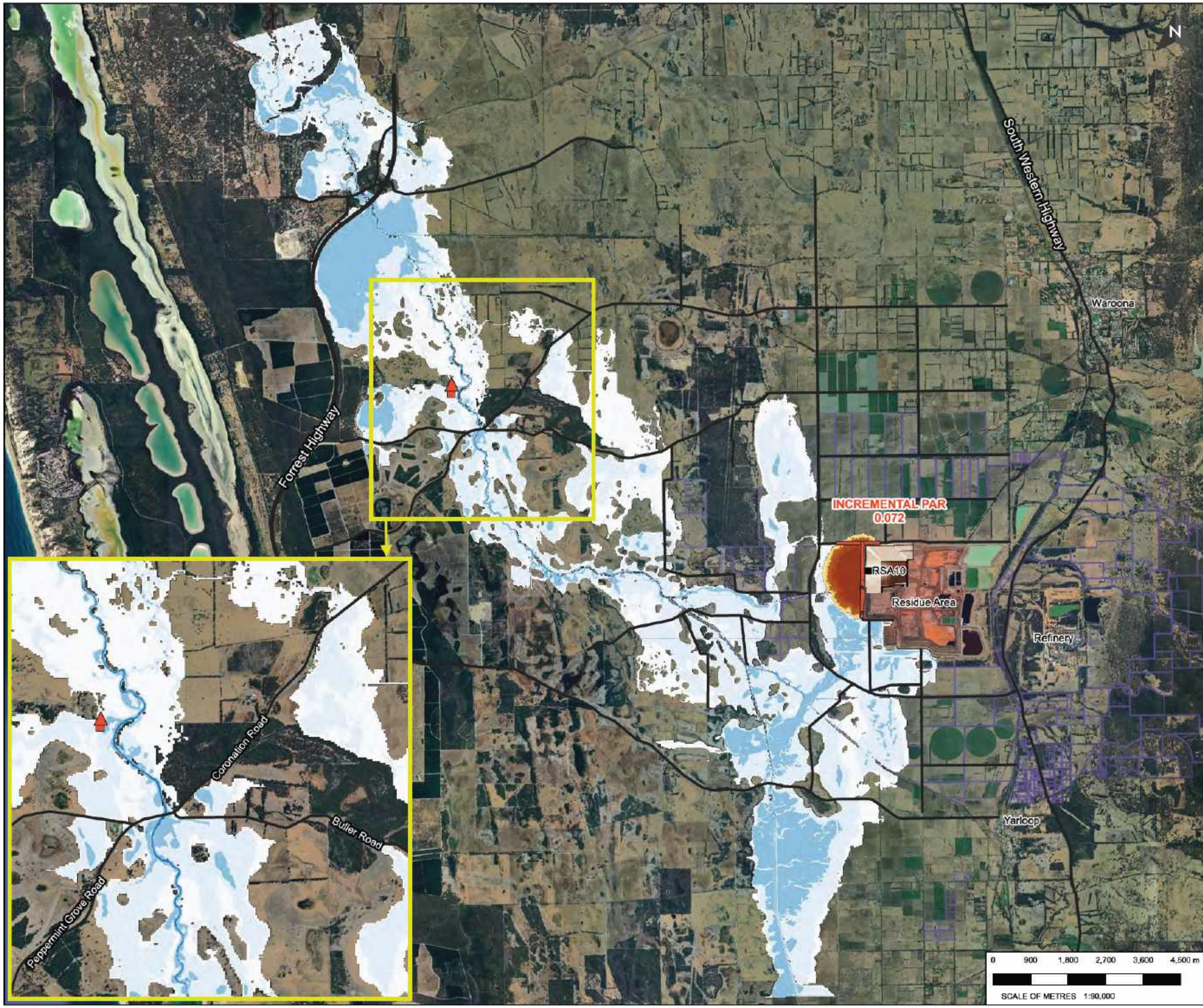
NOTES:

1. All Dimensions, Elevations and Coordinates are in metres, except where indicated otherwise.

PROJECT TITLE	Wagerup RSA10 - FEL3
PROJECT NUMBER	H374430
FIGURE NAME	Ultimate Facility No Failure Newtonian Fluid
FIGURE DESCRIPTION	Maximum Hazard
REVISION NUMBER	C
CREATED BY	EG
DATE	05-05-2025
PROJECTION	GDA94 / MGA zone 50
SOURCES	Google Satellite

HATCH

Hatch Pty Ltd.
ACN 59 005 630 500



LEGEND:

Maximum Non-Newtonian Breach Depth (m)
- <= 0.3
- 0.3 - 2.0
- 2.0 - 3.0
- 3.0 - 4.0
- 4.0 - 5.0
- > 5.0

Maximum Newtonian Flood Depth (m)
- <= 0.3
- 0.3 - 1.0
- 1.0 - 3.0
- 3.0 - 5.0
- 5.0 - 6.5

- PAR Locations - Structures
- Breach Location
- PAR Locations - Roads
- Roads
- Alcoa-Owned Properties

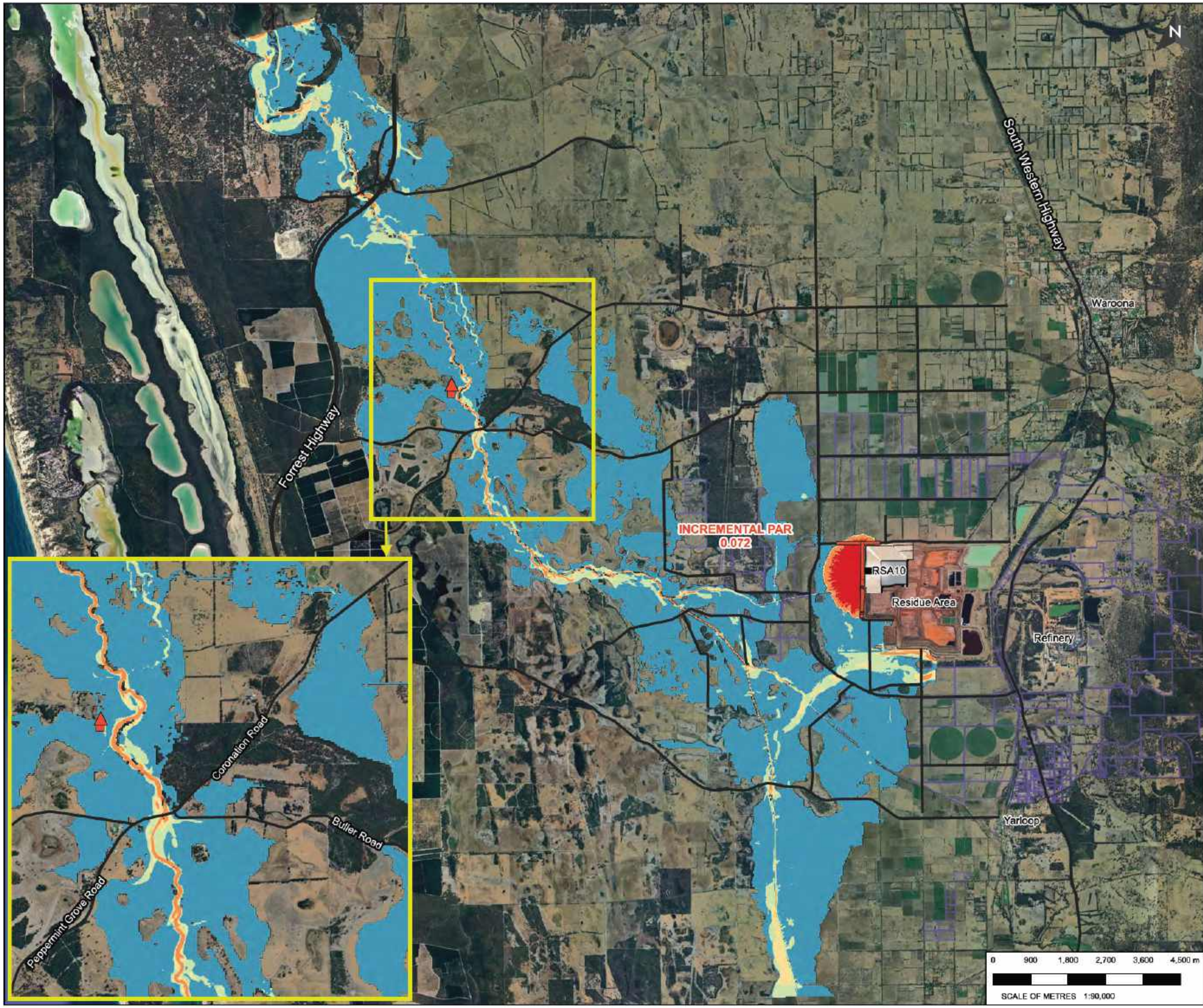
NOTES:

1. All Dimensions, Elevations and Coordinates are in metres, except where indicated otherwise.
2. Results depict Newtonian Flood with Non-Newtonian Breach Superimposed

PROJECT TITLE	Wagerup RSA10 - FEL3
PROJECT NUMBER	H374430
FIGURE NAME	Ultimate Facility Flood Failure
FIGURE DESCRIPTION	Maximum Flood Depth
REVISION NUMBER	D
CREATED BY	EG
DATE	11-06-2025
PROJECTION	GDA94 / MGA zone 50
SOURCES	Google Satellite

HATCH

Hatch Pty Ltd.
ACN 59 005 630 500



LEGEND:

Maximum Hazard (Depth x Velocity) (m2/s)

- <= 0.3000
- 0.3000 - 0.6000
- 0.6000 - 1.0000
- 1.0000 - 5.0000
- > 5.0000
- Breach Location
- PAR Locations - Structures
- PAR Locations - Roads
- Roads
- Alcoa-Owned Properties

NOTES:

1. All Dimensions, Elevations and Coordinates are in metres, except where indicated otherwise.
2. Results depict Newtonian Flood with Non-Newtonian Breach Superimposed

PROJECT TITLE	Wagerup RSA10 - FEL3
PROJECT NUMBER	H374430
FIGURE NAME	Ultimate Facility Flood Failure
FIGURE DESCRIPTION	Maximum Hazard
REVISION NUMBER	D
CREATED BY	EG
DATE	11-06-2025
PROJECTION	GDA94 / MGA zone 50
SOURCES	Google Satellite

HATCH

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ACN 59 005 630 500

Appendix E
ANCOLD CCA Requirements

E.1 ANCOLD Requirements

The ANCOLD 2012 guidelines on the consequence categories for dams provides a structured approach to determining the Sunny Day Breach and Flood Induced Breach consequence categories as a result of a possible dam break scenario.

The relevant consequence criteria determined using the ANCOLD 2012 guidelines include the risk to human life and the severity of damage and loss.

The potential severity of damages and losses were assessed based on the following categories:

- Total Infrastructure costs
- Impact on dam owner's business
- Health and social impacts; and
- Environmental impacts.

The severity level of each of these damages and losses may be classed as minor, medium, major or catastrophic with the worst-case level determining the overall consequence category. Total infrastructure costs are considered for residential and commercial as well as community infrastructure. The costs associated with replacement or repair of the dam are also included.

Table E-12-6: Total Infrastructure Costs (ANCOLD, 2012)

Damage Type	Minor	Medium	Major	Catastrophic
Total infrastructure costs	[redacted]	[redacted]	[redacted]	[redacted]

Notes:

7. Residential – total number of houses affected, some destroyed, and others damaged.
8. Commercial – including businesses and agriculture. e.g., retail, manufacturing, resources. Loss of stock and/or produce as a direct result of the flood wave.
9. Community infrastructure – such as roads, railways, power, communication, gas, water supply, sewerage, irrigation, drainage, schools, hospitals, community facilities and public buildings.
10. Dam replacement or repair cost – repairs to the embankment or wall and appurtenant works which will return the dam to its previous level of service.

Table E-12-7: Impact on Dam Owner's Business (ANCOLD, 2012)

Damage Type	Minor	Medium	Major	Catastrophic
Impacts on Dam owners' business	Restrictions needed during dry periods	Restrictions needed during peak days and peak hours	Essential to maintain supply	Dissolution of business/entity
Effect on services provided by the owner	Minor difficulties in replacing services	Reduced services are possible with reasonable restrictions	Severe restrictions would be applied for at least one year	Services cannot be replaced or cannot get services from another source
Effect on continuing credibility	Some reaction but short lived	Severe widespread reaction	Extreme discontent	Total loss of confidence and credibility
Community reaction and political implications	Some reaction but short lived	Severe widespread reaction	Extreme discontent	Total loss of confidence and credibility
Impact on financial viability	Able to absorb in one financial year	Significant with considerable impact in the long term	Severe to crippling in the long term	Bankruptcy
Value of water in storage	Can be absorbed in one financial year	Loss of income for at least 1 year	Loss of income for more than 1 year	Bankruptcy

Notes:

11. Importance to the business – loss of storage is likely to affect the service provided to some degree. It may be appropriate to increase the severity level because of the importance of the reservoir. However, a less vital water resource may lead to a reduction in the severity of the cost of replacement or repair.
12. Effect on the services provided by the owner – water supply, power or recreational facility is no longer available or disrupted to a proportion of the community supplied by the agency.
13. Effect on continuing credibility – standing or reputation of the organisation in the community.
14. Community reaction and political implications – there may be community objection to replacement of the dam. Also, the relationship between the dam owner and local, state and federal legislature.
15. Impact on financial viability – economic and legal ability; ability to meet the costs of repairs and damage; ability to meet claims from others.
16. Value of water in the storage – loss of income from the loss of stored water.

Table E-12-8: Health and Social Impacts (ANCOLD, 2012)

Damage Type	Minor	Medium	Major	Catastrophic
Human health	<100 people affected	100 to 1,000 people affected	>1,000 people affected for greater than one month	>10,000 people affected for a year or more
Loss of services to the community	<100 people affected	100 to 1,000 people affected	>1,000 people affected for greater than one month	>10,000 people affected for a year or more
Cost of emergency management	<1,000 person days	1,000 to 10,000 person days	>10,000 person days	>100,000 person days
Dislocation of people	<100 person months	100 to 1,000 person months	>1,000 person months	>10,000 person months
Dislocation of business	<20 business months	20 to 200 business months	>200 business months and some business failures	Numerous business failures
Employment affected	<100 jobs lost	100 to 1,000 jobs lost	>1,000 jobs lost	>10,000 jobs lost
Loss of heritage	Local facility	Regional facility	National facility	International facility
Loss of recreational facility	Local facility	Regional facility	National facility	International facility

Notes:

1. Human health – human health could be affected by contamination of drinking water and failure or lack of water supplies, sewage treatment works, power. Contamination of services such as food, health, recreation areas and facilities caused by the uncontrolled release of sewage, industrial or toxic waste as a result of a dam break.
2. Loss of services to the community – loss of gas/power/communications and transport. Distribution of medical supplies, food, especially perishable food items.
3. Cost of emergency management – police, Emergency Services and volunteers will incur a cost both direct and indirect.
4. Dislocation of people – people whose homes are destroyed or damaged will need to be re-housed or billeted for various times.
5. Dislocation of businesses – Businesses will be prevented from trading in the short term and may be affected in the long term.
6. Employment affected – loss of employment.
7. Loss of heritage – historic sites, both pre and post European settlement.
8. Loss of recreational facility – many communities rely, to various degrees, on bodies of water for boating, fishing and other recreational aspects, including visual relief. Other recreational facilities may be located downstream of the reservoir, e.g., golf course, sports grounds.

Table E-12-9: Environmental Impacts (ANCOLD, 2012)

Damage Type	Minor	Medium	Major	Catastrophic
Area of impact	< 1 km^2	< 5 km^2	< 20 km^2	> 20 km^2
Duration of impact	< 1 year	< 5 years	< 20 years	> 20 years
Stock and fauna	Discharge from dambreak would not contaminate water supplies used by stock and fauna.	Discharge from dambreak would contaminate water supplies used by stock and fauna. Health impacts not expected.	Discharge from dambreak would contaminate water supplies used by stock and fauna with contaminant uptake.	Discharge from dambreak would contaminate water supplies used by stock and fauna with contaminant uptake and measurable health impacts expected.
Ecosystems	Discharge from dambreak is not expected to impact on ecosystems. Remediation possible.	Discharge from dambreak would have short term impacts on ecosystems with natural recovery expected after one wet season. Remediation possible.	Discharge from dambreak would have significant impacts on ecosystems with natural recovery expected after several wet season. Remediation possible over many years.	Discharge from dambreak would have significant permanent impacts on ecosystems. Remediation involves altered ecosystems.
Rare and endangered species	Species exist but minimal damage expected. Recovery within one year.	Species exist with loses expected to be recovered over a number of years.	Rare and endangered species will be severely impacted. Recovery will take many years.	Endangered species will be lost from the area. Permanent loss of species will occur.

Notes:

1. Area of impact – land damaged by dam failure exclusive of land prone to natural flooding. For tailings dams, the damage will relate to the toxicity of the material in relation to both area of impact and the depth of penetration of the toxic materials.
2. Duration of impact – habitats may take a long time to recover (e.g., substantial erosion, deposition of flood borne materials). The duration of the impact will also relate to the toxicity of discharged material (e.g., saline, tailings, sewerage, cold water, deoxygenated water).
3. Stock and fauna – stock and fauna may ingest contaminated water/fodder. Stock may need to be removed from the area or destroyed. Contaminants may cause damage in relation to reproduction cycle. The impact on stock and fauna may not be immediately identified unless testing of food source is carried out.
4. Ecosystems – includes organisms and non-living components which interact to form a stable system. Consideration should be given to their environment, habitat, breeding grounds and food chain.
5. Rare and endangered species – information can be gained from state and federal government agencies in relation to areas known to contain rare and endangered flora and fauna.

The risk to human life is expressed as the Population at Risk (PAR) or the Potential Loss of Life (PLL). The PAR includes itinerates based on their probability of being in the flood affected zone. The severity level of damage and loss resulting from dam break was used together with the PAR to select the consequence category from Table E-12-10.

Table E-12-10: ANCOLD Consequence Category Based on the PAR (ANCOLD, 2012)

Population at Risk	Severity of Damage and Loss			
	Minor	Medium	Major	Catastrophic
<1	Very low	Low	Significant	High C
≥1 to <10	Significant (Note 2)	Significant (Note 2)	High C	High B
≥10 to <100	High C	High C	High B	High A
≥100 to <1000	(Note 1)	High B	High A	Extreme
≥1000		(Note 1)	Extreme	Extreme

Notes:

Note 1: With a PAR in excess of 100, it is unlikely damage will be minor. Similarly with a PAR in excess of 1,000 it is unlikely damage will be classified as medium.

Note 2: Change to 'High C' where there is the potential of one or more lives being lost.